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Département d'études anglophones

GLOBAL WARMING & BIODIVERSITY PRESERVATION: A COMPARATIVE DISCOURSE ANALYSIS OF SUMMARIES, RESEARCH AND POPULARISATION ARTICLES

MÉMOIRE DE MASTER 2
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Année universitaire 2019-2020

Acknowledgements

Without the work of linguist Kjersti Fløttum on environmental reports and Greta Thunberg's activism which highlighted the emergency of climate change on an international scale, I would never have thought of studying such a topic. Their contributions were essential to the conception of this project.

Foremost, I have to thank my research supervisor, Ms Catherine Paulin, whose assistance and dedicated involvement were key in defining the research project and accomplishing it. I would like to thank her for the numerous and useful feedbacks she has given me during these two years.

I would also like to show gratitude to Camille Demilito, Lulu Flowers and Kathryn Howells for kindly taking the time to read my work and giving me enlightening advice.

In addition, I would like to thank my parents and my sister Zoé for their constant support and helpful remarks. During these last four months, Zoé's companionship was decisive in the progression of this project.

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Introduction

Communication on the topics of climate change and biodiversity loss is crucial in order to raise awareness among world's population and to encourage action from policymakers. While many people still deny the gravity of the current and predicted effects of climate change and biodiversity loss, we cannot ignore the critical situations populations will have to face because the world is increasingly impacted by natural hazards. For instance, from 1980 to 2017 the USA had an annual average of 6.0 extreme weather events and the annual average for the most recent 5 years (2014–2018) was 12.6 events. A storm that caused $1 billion in damage in 1980 would have caused about $2.3 billion in 2010 according to the U.S. government's National Centers for Environmental Information. Since 1995, the United Nations has organised United Nations Climate Change Conferences within the Conferences of the Parties (COPs henceforth) to assess progress in dealing with climate change. In 2015, the Intergovernmental Panel on Climate Change (IPCC henceforth)[1] was asked during the COP21 in Paris to produce a report on the changes to expect when surface temperature will reach 1.5°C above pre-industrial levels. The Panel published the Special Report "Global Warming of 1.5°C" on the 8th of October 2018. The document also provides strategies for mitigating climate change.

Many recent studies have focused on the discursive features in the previous reports of the IPCC (Fløttum 2010; Budescu et al. 2009). Studying the IPCC's latest report and comparing it with other textual genres will provide useful insight on the text and language at work. How do scientists inform policymakers in the 2018 report? How is the same information conveyed in other texts which target other types of readers? The corpus comprises a summary of report produced by the IPCC in 2018 "Summary for Policymakers", the "Summary for Teachers" by the Office for Climate Education (OCE), a research paper "Risks from Climate Extremes Change Differently from 1.5°C to 2.0°C Depending on Rarity", by Slata Kharin et al. and a popularisation article "Uncertain Certainty" by Michael Le Page. To convey more depth to the analyses, I added a second set of texts dealing with a similar issue: biodiversity preservation. The corpus consists of a "Summary for Policymakers" by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), published seven months after the IPCC's summary, a research article "Worldwide Impacts of Past and Projected Future Land-use Change on Local Species Richness and

[1] An intergovernmental body of the United Nations

the Biodiversity Intactness Index" by Samantha Hill et al., and a popularisation article "Humans Are Driving One Million Species to Extinction" by Jeff Tollefson.

Analysing and comparing the discourse of different genres on this matter may enable one to evaluate the strategies used to notify readers. The purpose of this project is to analyse the extent to which climate change and biodiversity preservation discourses are standardised and how the specific genre of a text impacts the enunciation of given topics. The remainder of this paper is divided into six chapters. The first section is dedicated to the concepts and frameworks used in the definition of text analysis and the genres related to the texts of the corpus; the second chapter details the choice of the corpus, the research questions and methods of the project. The third part presents the international contexts of climate action and biodiversity preservation, and the situational characteristics of the two sets of texts. The fourth section presents observations on the expression of certainty in the corpus. The fifth chapter shares remarks on implicative structures, the expression of necessity and the use of personal pronouns in the texts. Finally, the sixth chapter links the analyses of linguistic features to the study of contextual elements in order to describe the enunciative stances expressed in the different texts.

1.The state of the art

The terms text, genre and register are crucial when discussing the analysis of texts. I will present the major theories developed around these concepts and the notions related to them. The main definitions of text will be first considered.

1.1. Key concepts

1.1.1. Text

The founder of structuralism, Ferdinand de Saussure, stated that "la langue n'est créée qu'en vue du discours"[2] (see Adam 2004: 23). Entities and concepts, which are isolated from one another, are denoted by and stored in the language while discourse links these isolated concepts with a specific situation when there is a goal of interaction and communication. Jean-Michel Adam defines discourse and thus human communication as chunks "qui vont d'un simple mot à plusieurs volumes écrits"[3] (2004: 24). To him, discourse, which can also be termed text[4], represents an act of communication. Most linguists have adopted this point of view. In *Register, Genre and Style*, Douglas Biber and Susan Conrad define text as "natural language used for communication, whether it is realised in speech or in writing" (2009: 5). Michael Halliday and Ruqaiya Hasan in *Language, Context and Text* describe it as "any instance of living language that is playing some part in a context of situation" (1991: 10); text is therefore deeply connected to interaction and meaning.

In linguistics, the conceptualisation of what a text is is often twofold. The following distinctions by Adam and by Halliday help define text as the product of series of choices among abstract units stored in language and as a tool for specific interactions. Adam describes text as an abstract and a concrete object while Halliday operates a dichotomy between a product and a process. Text is a theoretical and abstract object that forms a unit of meaning thanks to its structure, which provides a cohesion of units at a macrolevel, and its texture, which denotes a cohesion of units at a microlevel (Adam 2004: 40). Halliday's definition of text as a product is highly similar to Adam's definition of text as an abstract object: it is an output and it is a continuous process of semantic choices. The choice of a linguistic element sets the environment for the next set of elements to be chosen (1991: 11). There is therefore semantic coherence at micro- and macrolevels. Both Adam and

[2] "Language is only created for discourse".
[3] "Ranging from one spoken word to volumes of written text".
[4] Discourse refers to a process while text is the result or the product of the process. The distinction made by two linguists is explained later in the text.

Halliday reject the idea that a text could be defined as a unit “like a sentence, only bigger” (Halliday 1991: 10). On the contrary, Jacques Moeschler and Anne Reboul analyse a piece of discourse as the sum of its sentences: they do not consider it as a natural and relevant entity which deserves a specific framework of analysis:

> Le discours […] n’est pas une catégorie naturelle scientifiquement pertinente […]. Il n’y a donc pas besoin d’un traitement propre et l’économie scientifique consiste à s’en tenir à l’étude du fonctionnement d‘une catégorie naturelle scientifiquement pertinente à savoir l’énoncé (1995 : 246).[5]

This approach has not been unanimously accepted in the linguistic field: Adam (2004: 33) clearly refutes Moeschler and Reboul’s perspective and terms it as a “position réductrice”.[6]

> Un premier mouvement de réduction amène les auteurs à assimiler tout texte/discours à une grande phrase[…] analysable de la même manière que les micro-unités. Cela permet d’esquiver ou même de nier les différences profondes de niveau de complexité et l’incidence du global (textuel et générique) sur le local.[7]

In order to achieve detailed text analyses in my research project, an approach to different interacting levels of meanings will be adopted and most importantly, I will focus on the perspective of interaction. According to Adam (2004: 40), text is also an empirical and concrete object; it embodies a complete utterance and is tied with interaction. In the “process” perspective, Halliday defines text as the output of an interactive event. As it will be examined in detail in the next section, the relationship between text and context is central in several text analyses. The two duos of linguists, Biber and Conrad, and Halliday and Hasan have developed conceptual frameworks revolving around this relationship. “The context of communication is encapsulated in the text through a systematic relationship between the social environment and the functional organisation of language” (Biber and Conrad 2009: 11-12). Context and text both carry meanings and symbols related to a society; they are in a dialogical relationship. The importance of interdiscursivity can be added to the notion of discourse. Adam (2004: 40) uses this term which conveys the fact that a piece of discourse should not only be considered as a situation of interaction but it should be studied in relation with other pieces of discourse of a given community to denote the diversity of human discursive practices. Thus, a more detailed and relevant analysis of a text is possible when the culture in which it is produced is also taken into account. Adam

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5 “Discourse […] is not a scientifically relevant natural category […]. Thus, there is no need for a proper processing and the scientific economy consists of only dealing with the study of the functioning of natural scientifically relevant category, namely utterance”.

6 “Reductive position”.

7 “A first move of reduction leads the authors to liken every text/discourse to a large sentence that can be analysed as micro-units. It enables to elude and even deny the differences of the level of complexity and the impacts of the global aspect [textual and generic] on the local ones”.

rejects a "grammaire de texte"[8] that only considers textual features and does not provide clear limits between the different types of texts. The notion of genre, which is the topic of the next section, is more adequate to analyse a text as it does not only account for the structure, the textual elements or the interaction that the text reports but also how this specific interaction is classified in the culture.

1.1.2. Genre

Genre is a key concept when analysing a text. This section will first consider the link between genre and community. Later, the different classifications of genres will be under study, as much as several aspects of context and two linguistic frameworks used to describe context will be presented. Finally, I will consider broader categories which could encompass genres. Genre plays a major role in several disciplines and its role in the discourse community in which it was created is often taken into consideration in regard to its conceptualisation. Defining community and how genre is inscribed within it will be a useful first step.

In linguistics, the bond between genre and community is frequently established. Halliday and Hasan adopt a social-semiotic perspective in *Language, Context, and Text*. Halliday and Hasan's approach of sign systems is thus a study of social and pragmatic meaning. They call their linguistic perspective "social-semiotic" because culture is a social system which comprises a social structure and the latter is in relationship with language: it is expressed and interpretable thanks to language (1991: 3). "Culture is itself more specifically describable as an integrated body of the total set of meanings available to a community: its semiotic potential" (1991: 99). The semiotic potential is the range of signs available to convey all possible meanings in a culture. The semiotic potential includes "ways of doing, ways of being, and ways of saying" (1991: 101). This set of meanings is expressed through significant situational values, such as age, wealth or education, and it defines them at the same time. Significant situational values are associated within the culture of a given community; they help to set the hierarchical order. The perception of these values thanks to the semiotic potential provides the framework for the unfolding exchange of meanings in a given situation. Every situation is thereby embedded in a culture. Conversely, meanings are legitimised by the situation (1991: 101). The semantic potential is a subset of the semiotic potential; it is the expression of culture through "ways of saying" only: it excludes

[8] "Grammar of texts".

ways of being and doing and is defined by all the possible values of the context of the situation.

Halliday and Hasan's structure is interesting but Swales provides a sharper definition regarding genres and communities, as he states that genres are attributed to discourse communities and not to speech communities. This concept enables to target more specifically the communities of the participants of texts and thus to draw more detailed analyses. This paragraph presents Swales' concept of discourse community in more detail. A speech community is described as an "evolving term" (1998: 23). In Swales' approach, a speech community differs from a discourse community in three ways. The first is the medium: members of a literary community are more likely to communicate with other members in distant places or with past productions while members reacting to speech events will not be able to react to interactions produced a long time before the events occurred. The second aspect is related to the respective goals of the communities. A speech community is perceived in a sociolinguistic perspective and its "primary determinants of linguistic behaviour are social" while a discourse community is perceived as a socio-rhetorical element and its primary determinants are functional (1998: 24). The gathering of the latter is goal-motivated in the first place and socialisation is understood to be a secondary aspect in this type of community. Finally, a speech community is described as centripetal, it usually unites members while a discourse community is centrifugal and "tends to separate people into occupational or speciality-interest groups" (1998: 24). Speakers become part of a speech community by birth, adoption or accident whereas the members of a discourse community are "recruited by persuasion, training or relevant qualification" (1998: 24). Swales adds defining characteristics regarding a discourse community which has a broadly agreed set of common public goals. Nevertheless, tensions over time may become too great and cause the dissolution of the community. Its members use the mechanisms of intercommunication defined by the community to convey information and feedback mainly. The community possesses at least one genre for communicating. A discourse community has a specific lexis and the members of a discourse community do not all share the same level of expertise. They all start as novices and need to learn the practices of the community, its genres and its lexis in order to become members and they need to fully master these elements to be considered experts of the discourse community. Individuals can belong to several discourse communities concomitantly. Swales states that there is at least one genre per discursive community; the next paragraph deals with different means to distinguish genres.

There are several approaches to genre classification; Adam mentions Matthias Dimter's classification of genres in approximately 1100 categories. This categorisation seems complicated and difficult to integrate and study. Adam rejects the theory of general topology in order to describe texts and genres, but he conceives the idea of topologies associated to a specific community. Other scholars define the diversity of genres as almost endless. Mikhail Bakhtin is considered as one of the instigators of the discussion about genre. Bakhtin's opinion on the diversity of genres is that the variety of genres is infinite because the variety of human activities is inexhaustible as well, and every sphere of this human activity has a set of genres which gain diversity and complexity when the sphere is studied in more detail (see Adam 2004 : 88). In the same vein, Jean-Paul Bronckart states that genres cannot be part of a stable classification even though they are intuitively recognised by the members of the community because the human activities they refer to are almost unlimited; they differ in goal, specific social purpose, cognitive processes mobilised among other features. The linguistic units at work cannot be the only tool used to classify them (see Adam 2004: 90). Genres are constrained by norms which help the participants of communicative events to find their ways in the exchange and anticipate forthcoming elements (Hyland 2013: 1; Hyland 2015: 33; O'Sullivan et al. 1994: 128; Halliday 1989: 9). This argument could be explained by Wittgenstein's theory of family resemblance. Texts of one genre have properties in common but these are not always the same from one text to another. Swales describes this theory as the precursor to the prototype approach of categories which was initially developed in detail by Eleanor Rosch (Swales 1998: 51). Genre represents the ideal type while an actual text fits within the genre to various degrees; there can be very marginal or rare types of texts that are still part of the genre. Jean-Claude Beacco's reflection on "les genres discursifs"[9] (2004) also includes the prototypical aspect of genre. To summarise the linguist's approach, analysts should pay attention to the norms of the community and the use of metalinguistic terms for ordinary, daily interactions in order to find the repertoires of interactions shared in the community. In those repertoires, which are modes of constitution and transmission of societal meaning, analysts can find the linguistic elements that characterise genres. The aim is to explain and interpret linguistic elements in contexts of interaction. This approach is quite similar to Biber and Conrad's approach, which will be later detailed. The first angle used by Beacco to apprehend the concept of genre is the meaning encapsulated in the notion of genre in "A Typology of English Texts" (1989). In this article, Biber presents a multidimensional analysis of texts in a corpus of 481 texts linked to 23 major genres. In this article and in *Variation across Speech*

[9] "Discursive genres".

and Writing (1995), Biber uses the terms "genre" and "type of text". "Genres are the text categories readily distinguished by mature speakers of a language […] these categories are defined primarily on the basis of external format" (1989: 5-6) while types of texts are groups of texts identified by the groups of linguistic features which express particular dimensions in the text. The main groups or clusters of linguistic features that the texts possess are then used to identify their functional roles. The notion "type of text" is not developed in *Register, Genre and Style* and thus will not be used in this research project. In *Register, Genre and Style*, Biber and Conrad use the register and genre perspectives when analysing the linguistic elements and the functional roles of texts. As mentioned above, their approach, which guides an important part of my research, will be developed later. Finally, a classification of genres which aims at being logical by only considering textual elements and norms will be rejected in this project because it may be contradictory when the analyst wants to acknowledge all the aspects of a text. As discussed above, many linguists underline the importance of social activities and norms in the conception of genre. Furthermore, each text depends on its production circumstances and other elements of its context of situation. Therefore, a functional approach to text analysis based on the context of the text and the functions of language at work will be used here. It represents an enlightening perspective for the study of the corpus and the categorisation of the texts since the possibilities of classifying genres are almost infinite. I will therefore apply a study of genre within a pragmatic approach. The next paragraph focuses on the connection between context and community and its role in the conception of genre.

When studying a text and its role in a community, its context is highly important, but this notion is broad and calls for clarification. Halliday divides context into four elements: the context of situation, the context of culture, textual features and intertextuality. Adam's approach offers a similar categorisation: "environnement extralinguistique", "environnement linguistique immédiat", "connaissances générales présumées partagées" and "intertextualité"[10] (2004 : 124-5). Context of situation will be first described. Bronislaw Malinowski coined this term in an article published in 1923 as he reflected on how to translate without altering the signification of messages when studying foreign communities. Malinowski developed this concept as he observed populations in the Trobriand Islands; translating dialogues and stories was not sufficient to convey the meanings created and exchanged in the situations of communication, which is the reason why he created the notions of context of situation and context of culture, which explains "the environment of a

[10] "Extralinguistic environment; immediate linguistic environment; assumed shared general knowledge; intertextuality".

text" (see Halliday 1991: 6-7). The use of language is linked to a situation and the actions embedded in it. Conversely, the actions in the situation convey meaning thanks to the culture. The meanings that are not expressed by the words uttered and those that are encapsulated in the situation and in the cultural notions need to be accounted for when the ethnographer describes foreign populations or translates a text from a dead-language. John R. Firth developed a framework for the notion of context of situation in order to describe all types of texts in a more general way. Inspired by these frameworks, Halliday conceived the three features of the context of situation: field, tenor and mode which are intended to encompass a maximum of the features of a text in order to characterise its role in a particular discourse community and thus its genre. Halliday's conception of genre translates the idea that, most of the time, speakers and writers adapt to situations and are able to understand the messages conveyed because they anticipate them as they become aware of the aspects and the features of a particular genre (1991:9). The field of discourse designates the nature of the social action in process: the exchange happening between the participants. The tenor of discourse refers to the participants of the text, their roles in the text, their social statuses and the relationships they share. The mode of discourse accounts for the role of the language used, the structure of the message, what it achieves and whether it is written or pronounced. Without providing a framework, Adam (2004 : 124) refers to an equivalent of context of situation "environment extralinguistique : contexte ou situation d'interaction socio-discursive, c'est-à-dire […] une situation d'énonciation et situation d'interprétation (décalées ou non dans le temps et/ou l'espace)"[11]. Biber and Conrad's approach in *Register, Genre and Style* shares some similarities with Halliday and Hasan's theory regarding the analysis of a text: the description of the context plays a major role and there is a functional relation between text and context. Biber and Conrad developed a structure of situational characteristics very similar to the features of the context of situation, based on several frameworks used in previous studies conducted by Halliday, Crystal and Davy, Hymes and Basso. Biber and Conrad (2009: 40) present a detailed framework that unfolds in seven parts. The participants are divided into two categories: the addressor[12], the producer of the text or the person transmitting it, and the addressee, the receptor of the text. Both can be singular or plural. They can represent an institution or be unidentified. The addressees of a text can be un-enumerated; for instance, the number of people who will hear a speech broadcast on the radio or read a novel can only be estimated. The social

[11] "Extralinguistic environment: context or situation of socio-discursive interaction, which means situation of enunciation and situation of interpretation (possibly displaced in time and/or in space)".
[12] Following Biber and Conrad's terminology, I will use "addressor" in the remainder of this paper, instead of "addresser".

characteristics of the participants, such as age, education, profession, should be specified. The addressor and the addressee can be the same person; if the text is a monologue or a diary for instance. For a soliloquy on stage, there are on-lookers who constitute the third possible type of actor of the text. In the same vein as Hasan and Halliday, Biber and Conrad indicate the relations among the participants of the interaction: in the social hierarchy, their personal relationships outside of the context of the text and the shared knowledge they have. People and situations will not be referred to in the same way if the addressee already knows them or not. When I talk with someone who has already met my sister, I can mention her by using her name or saying “my sister”, whereas, if the interlocutor does not know I have a sister or we have not exchanged much information about our families, I will have to use “my sister” and not her name. Otherwise it is highly probable that the addressee will not know to whom I refer. The discourse will not be the same if specialists of the topic interact together on this subject or if one specialist interacts with non-specialists on the same topic. A conversation about breeds of dogs will not be the same among vets or between a vet and his family who are not vets. The channel of communication is another criterion: whether the text is written or spoken, furthermore whether it is a conversation on the phone or a speech broadcasted on the radio or, whether it is a handwritten text or published in a newspaper. The medium strongly influences the production circumstances which need to be accounted for as well. In a written text, the author chooses his/her words more cautiously than in a casual conversation. The reception by the addressee depends on the medium of the text as well. The next category of situational characteristics is the setting of the situation of the text. It should be accounted for as the linguistic features of the text will be influenced by whether or not the addressor and the addressee are localised in the same time span and place, whether the place is private or public and whether the text is set in a contemporary time or in a specific historical period. The sixth category of situational characteristics consists of the communicative purposes of the text. The primary goal of the text needs to be analysed: whether the purpose is to describe, entertain, explain, persuade, etc. Sometimes a text has different parts with different purposes, these significant changes of communicative purposes indicate different sub-registers in the register of the text; the changes are then called specific communicative purposes. Another parameter of communicative purposes is the take of the addressor on factuality: whether s/he wants to convey facts, fiction or his/her opinion. Lastly, the expression of the stance of the addressor should be mentioned. It includes the expressions of personal attitude and epistemic stance. The epistemic stance is defined by Biber and Conrad as “the extent to which information is certain or generalisable, or explanations of the source of the information” (2009: 46). The last parameter of situational characteristics is the topic; it obviously impacts the choice of words. This detailed framework of the context of situation is the one I will use in my project as it allows for a more inclusive and systematic picture of the context of a text than Halliday and Hasan's framework.

The next aspect of context is related to cultural background. Halliday calls it context of culture. The actions and words exchanged in the context of situation gain meaning from the culture shared by the participants. Halliday does not provide a framework to depict this type of context as the diversity of cultures, each with its own idiosyncrasies, does not allow for an exhaustive approach. Nevertheless, any relevant information on the cultural background should be added to the description of the context of situation. In Adam's terminology (2004 : 125), this is referred to as "les connaissances générales présumées partagées : représentations psychosociales et préconstruits culturels de sujets inscrits dans l'histoire et dans l'intersubjectivité"[13] (2004 : 125). Biber and Conrad (2009) do not include this type of context in the framework they present in *Register, Genre and Style*. However, if necessary, I plan on adding cultural background to my analyses even though it is not part of Biber and Conrad's approach. Presumably, there are not many required elements for this category when the production under study is created by the culture in which the analyst evolves.

The third type of context is concerned with intertextual contextualisation. The elements of the text produced before and after a particular textual production are part of the context. Indeed, coherence is essential in the progression of a text. Adam (2004: 125) shares Georges Kleiber's reference that context requires memory; the linguistic context, extralinguistic situation and general knowledge are all processed mentally and possess the "statut de représentation interne"[14]. Linguistic elements mentioned earlier in the text become part of the "mémoire discursive ou textuelle"[15]. They are entities of the text which can be modified by deictics and anaphorical markers for example.

The final aspect of context is intertextuality. Previous texts may bear influence on the reception of following texts. Allusive reference to classic or former texts participates to the meaning of the text under study. Halliday gives the example of classroom activities and lessons. The teacher bases his/her lesson on what has been presented and carried out earlier and assumes the pupils remember what has been covered and consequently that they are able to understand the lesson or the activity presented by the teacher.

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[13] "Assumed shared general knowledge: psychological representations and cultural preconstructed entities of subjects inscribed in time and intersubjectivity".

[14] "Status of internal representation".

[15] "Discursive or textual memory".

In the theories presented above, context has a major role in the study of a text. The elements of context are tightly connected to the linguistic features of the text. Biber and Conrad link linguistic features to situational characteristics by functional forces. They study text in the perspectives of genre, register and style. I will get back to the register perspective at a later point. In Biber and Conrad's approach, the elements indicating genre are genre markers. They appear mostly at the beginning and at the end of the text and are conventional. They usually occur only once in the text. The linguists emphasise the importance of the comparison of different genres and registers in order to gain a better understanding of the object studied. Halliday links the features of the context of situation with the meta-functions of the text. Functions are not only a way of using language, they are part of its fundamental properties (1991:18). It is very difficult to pinpoint which element provides what function in an utterance. Analyses from different angles and perspectives are required to contribute to the whole interpretation of the utterance. Contextual features are realised by the functional components of the semantic system. "Language is so designed that the variables field, tenor and mode will be inevitably encapsulated into the text through the simultaneous encoding of the experiential, interpersonal and textual meanings [respectively]" (1991: 102). In the second part of *Language, Context, and Text,* Hasan (1991: 102) develops context of situation into configurational context (CC) which is a specific context of situation. A CC is a specific set of values that realises the field, tenor and mode features. "A particular CC is known by the set of meanings associated with it. It is this set of meaning that we refer to as 'genre-specific semantic potential'". A CC is not a specific situation but a type of situation. When considering a test of French vocabulary in class and a test of German vocabulary in class, they both belong to the same CC because no obligatory feature of context or of meaning changes: it is the same type of situation. Hasan presents genre as a genre-specific potential; it is the verbal expression of the CC and it is linked to the obligatory elements of the structure of a CC. Sometimes the meanings conveyed by the text are influenced by non-linguistic elements such as the social distance between the participants of the situation. The interaction will not be the same if the participants know each other and if there is a marked social hierarchy. Although Halliday and Hasan's functional approach provides an interesting and useful framework for text analysis, it is Biber and Conrad's framework which will be used in this project as it offers a detailed framework to analyse the context of a text and tools to study the functions and conventions at work.

There are larger categories than genres and the latter are divided into subsets as well. Swales (1998: 59) states that some types of texts are not genres but are pre-genres or they belong to a higher-order category. For instance, casual conversation “is too persuasive and too fundamental to be usefully considered as a genre. It is a pre-generic ‘form of life’”. As it is too general and frequent, it cannot be classified as a genre. According to Biber and Conrad (2009: 34), many conversations cannot be categorised as genres because they are not structured by genre conventions and it is more adequate to study them in a register perspective. Swales categorises narration as a pre-genre as well as it is found in many registers and is a temporal succession focused on the description of the agents of the events instead of the events themselves. Some broad categories that could be conceptualised as genres like a letter are not genres but higher-order categories. They are designated by the means used to establish communication; however, the characteristics change too greatly from one text to another. For instance, there are many different types of letters with different purposes that would form one (pre-)genre according to Swales; he calls this category a “multi-generic generalisation” (1998: 61). Ren (2010: 86-87) uses the term “multi-generic” in another manner. According to the linguist, texts are multi-generic when they combine several genres which fulfil different sub-goals in the text for the benefit of one main goal. More multi-generic texts are found than mono-generic texts. Multi-genres become mono-genres once they are institutionalised. Ren gives the example of Walt Whitman instigating free verse which has been broadly used later and is now considered a genre but it was not conceptualised as such when the poet wrote *Leaves of Grass*. Biber and Conrad’s approach to genre and the analysis of text via genres and registers encompasses more accurately the goal and sub-goals of a text which are linked to the contexts of situation and of culture. In my opinion, Ren’s approach here is too abstract and limited. At what point of time can a text be referred to as institutionalised? It is not possible to know all types of commonly used texts in a community, nor to assess whether a text, its structure and its goals are validated by most members of the community at the time of reflection. Taking into account the context of production and transmission of a text is essential in its analysis and offers more nuance. Biber and Conrad consider that any kind of text can be analysed but, in order to analyse a text in the genre perspective, it needs to be complete or considered as a whole. When an uncomplete text is studied, the linguists use the register perspective. The next section presents the main difference between genre and register and it aims at characterising register.

1.1.3. Register

The differences between genres and registers can be understood according to several different theories. Swales (1998: 41) mentions the traditional use of register and a weak will to tackle genre, a notion which appeared later in the discipline. Theories either use one of the two terms or make a distinction between the two notions (Biber and Conrad: 21-2). Halliday and Hasan use both terms in *Language, Context, and Text*. They seem to have a slightly different conception of the terms but they do not state it so explicitly. They define text, culture, context, texture, structure, register and genre by detailing the relationships between them. However, they do not specify the distinction between register and genre. Swales (1998) explains that James Martin specified a distinction in Halliday and Hasan's approach at a later stage.

> Genres are realised through registers and registers in turn are realised through language […]. Genres are how things get done, when language is used to accomplish them. They are from literary to far from literary forms […] The term genre is used here to embrace each of the linguistically realised activity types which comprise so much of our culture (see Swales 1998: 40).

Genres are used for the analysis of discourse structure: they "have beginnings, middles and ends of various kinds" (Adam 1998: 41). They enable social processes through language. Swales (1998: 42) summarises Barbara Couture's distinction between the constraints of register and genre: "register imposes constraints at the linguistic levels of vocabulary and syntax, whereas genre constraints operate at the level of discourse structure". As it has previously been stated, to study a text in a genre perspective, the latter needs to be complete or considered as such. On the contrary, excerpts or portions of a text can be studied in a register perspective. There are different levels of register analysis: the analyst can use a general register or a specific register. There will be much more linguistic variation in a general register than in a specific one (Biber and Conrad 2009: 32-33). Biber and Conrad oppose functions to conventions. Genres denote specific conventions while registers are more linked to the situational characteristics of the text.

> "From a register perspective, identifying the core linguistic features that are pervasive in this kind of writing (e.g., long noun phrases, nominalisations, passive verbs), and explaining the preference for those linguistic features in functional terms by reference to the production circumstances of writing and the typical communicative purposes of [a type of text] (2009: 19).

After a presentation of the main differences between genre and register, I will now provide more elements concerning the notion of register with the perspective developed by Halliday, and Biber and Conrad. Register is presented as a semantic concept by Halliday.

> It is "a configuration of meanings that are typically associated with particular situational configuration of field, tenor and mode. But since it is a configuration of meanings, a register must also, of course, include expressions, the lexico-grammatical and phonological features, that typically accompany or realise these meanings" (Halliday and Hasan 1998: 39).

In Biber and Conrad's theory, register is represented by register markers and register features. They are both pervasive linguistic features and they are found in text samples or complete texts. They will be more frequent in certain registers than in others. Given register markers do not often appear in certain registers and are conventional while register features appear in several registers and are functional (Biber and Conrad 2009: 55). Genre markers usually appear once in a specific place in the text, which would correspond to the example of "once upon a time" designated as an indexical feature of register in Halliday's approach. Register features may not be obvious to spot when reading a text, but if they are compared to the rest of linguistic features present or absent in other texts and other registers, by linking the linguistic features to the situational characteristics in functional relationships, they can shed light on the purpose of the text and the intent of the authors. There are close registers with only a small number of possible meanings available.

I have drawn a non-exhaustive presentation of how text, genre and register are conceptualised and used for text analysis in linguistics and in other disciplines. Particular attention on the theories and frameworks developed by Halliday and Hasan in *Language, Context, and Text* and by Biber and Conrad in *Register, Genre, and Style* has been paid. Biber and Conrad's approach to the analysis of texts through register and genre perspectives will be used in my project. The next section is dedicated to a non-exhaustive presentation of the literature on the genres of report, summary, research and popularisation papers.

1.2. The literature on the three genres

1.2.1. Research article

The genre of the research article has been widely studied in linguistics and in other disciplines (see Swales 1980: 131-2). I will first present some elements regarding its structure and then, I will discuss some findings concerning its purposes as well as the core linguistic features used in order to realise those purposes.

This genre has evolved through time and it varies across fields (van Enk and Power 2017: 1). Indeed, according to Anneke van Enk and Kate Power's study, some scientific articles have the conventional Introduction Method Results Discussion (IMRD) structure and others do not. Biber and Conrad (2009: 129) describe the purposes of the four sections as following: the introduction describes what is known about the area of research and what information the survey will provide, the methods part reports the data and framework used, the results section reports the outcome of the study, and finally the discussion interprets the results and gives a conclusion. Each part has specific purposes and thus a specific distribution of linguistic features. Swales (1990: 141) proposes three main rhetorical moves in the introduction: establishing the territory of research then establishing a niche by, for instance, providing counterclaims, or identifying a gap, and the last move is to occupy the niche by outlining the purpose of the study and announcing the results of the survey. These three main moves comprise other moves that are not systematically used. However, the structure of the research article is not enough to define the genre. As mentioned above, the IMRD structure is not systematically found in research articles and as Fløttum (2005: 30) states, the genre of the research article is defined by more than a "straightforward structure to be identified and imitated by students". Indeed, even though the variation is synchronically and diachronically high, texts are still attributed to the same genre because, according to Biber and Conrad (2009: 166), the main purpose, "conveying of the results of scientific inquiry", does not change. Their description of the specific purposes of the research article is the following one:

> Research articles published in academic journals must present new findings and convince readers of the trustworthiness of the research and the significance of the findings relative to what is already known about the topic; the readers are expected to already have expert background in the research area and so they are relatively equal in status to the writer (2009: 113).

In contrast, Greg Myers (1989), Jean Parkinson and Ralph Adendorff (2005: 283) present the writer of the text as inferior to the readers who are inscribed in the scientific community. The writer is in a position of deference and inferiority because s/he wants to have the value of his/her findings acknowledged by the community and the reader. As stated by Eva Thue Vold (2006:2) and Ken Hyland (1996: 4), the research article is not only designed in order to inform about theories and phenomena but also, to convince the reader and establish the reputation of the writer in the community. Hyland (1996: 2) presents Myers' conception of the research article: while writers make claims and seek recognition from their readers, they may "challenge existing assumptions of the discipline and undermine colleagues' research agendas". To avoid offending the members of their discourse communities, they resort to politeness and hedging when writing research articles. Those elements have been widely studied (Thue Vold 2006: 63). For instance, Jean Parkinson and Ralph Adendorff (2005), inspired by Brown and Levinson's theory of politeness (1987), study linguistic features that express positive and negative politeness. The researcher makes claims limited to him/herself, uses impersonal constructions and hedging. Parkinson and Adendorff (2005) thus reveal what linguistic devices are used in order to express objectivity and convince the readers of the veracity of the experiments. Nominalisations and passive forms mainly put the object of the study and the actions of the scientist at the forefront and erase his/her agency in the text; in that way the focus is on the study and not on the writer (2005: 291-2). Ken Hyland has extensively studied interaction in academic writing and one of its aspects is hedging. Hedges are central in academic writing. This device expresses tentativeness and possibility (Hyland 1996: 1). Hedges enable the writer to avoid completely committing to a proposition and they "open a discursive space for the readers to dispute interpretations" (Hyland 2015: 35). In "Genre, Discipline and Identity", Hyland (2015: 34) finds through the study of a corpus of research articles that in hard science articles the writers "seek to downplay their role to highlight the phenomena under study, replicability of research activities and the generality of the findings". They distance themselves with passive voice, attributing agency to inanimate objects and the use of dummy it subjects. I mention the particularity of hard science research articles because the articles of the corpus studied in this project belong to this "category".

In "Writing without Conviction. Hedging in Scientific Research Articles", Hyland presents two main categories of hedging: content-oriented and reader-oriented hedges. Accuracy and writer-oriented hedges are comprised in content-oriented hedges and the accuracy-oriented devices are themselves split into attributive and reliability types. "Content-oriented hedges mitigate […] what the writer says about the world and what the world is thought to be like" (Hyland 1996: 9). In Hyland's framework, passive structures are a part of the hedging devices and they are not independently studied as is the case in Adendorff and Parkinson's study. Functions of the different types of hedges in Hyland's approach may overlap when studying a corpus; the linguist calls this phenomenon "indeterminacy" (1996: 7). A given device does not always provide the same interpretation or function and one form can convey several functions in a specific situation. Furthermore, a type of device is not systematically expressed by the same linguistic elements. To determine types and identify the phenomena, Hyland (1996: 7) uses the perspective of "fuzzy-sets" with clear examples at the core of the membership of a type and members at the periphery when the interpretation and boundaries with other types are unclear. Thus, the different categories of content-oriented hedges are mostly expressed by precision adverbs (*quite, barely, generally*), judgemental epistemic verbs (*assume, predict, appear*), epistemic adjectives (*probable*), content disjunct adverbs (*presumably, possibly, apparently*), impersonal phrasings as grammatical subjects, passives and attribution to literature. Reader-oriented hedges are often expressed via epistemic lexical verbs (*propose, believe, calculate*), personal attribution, reference to methods and modes, and offering alternatives via conditionals and indefinite articles. These categories of hedging have been studied in different genres (Adendorff and Parkinson 2005). They encompass elements of different grammatical categories, often expressing epistemic modality which is the variable degree of commitment of the writer to the truth value of a proposition. Epistemic modality which will be developed later is one of the main elements that is analysed in this project. Linguistic elements highlighted in the research article by Hyland and Andendorff and Parkinson have been described. Finally, I will present the linguistic elements assessed by Biber and Conrad. They (2009: 116-7) compare the frequency of linguistic features in newspapers and in academic prose, which comprises textbooks and research articles. They conclude that, in academic prose, past tense, present tense and modal verbs are not so common, time and place adverbials, questions and personal pronouns are rare but linking adverbials are very common because of the interpretation at work. There is a focus on nouns and complex noun phrases with adjectives as well.

Several elements used to describe and analyse the genre of the research article were presented in this section. They provide useful elements of reflexion and some of them will be further developed in my analyses later in this project.

1.2.2. Report

During the preparation of this project, the research articles that were selected mentioned "public report" and "public report in environmental studies" (Harvey 1995), "report for decision making" (Rude 1995) and "public science report" (Whithaus 2012). Regarding the characteristics and functions of the texts described in these studies, I selected these writings to define the report genre associated with two texts of the corpus: the two summaries for policymakers and the "Summary for Teachers". They share many common features, even though the studies do not offer a complete and homogenous description, because many aspects depend on the analysed texts and the authors' perspectives. Nevertheless, this selection provides starting elements to define the genre of report. It can be added that Carolyn Rude (1997: 78) observed that this type of genre has not been frequently studied. She carried out a survey of 17 textbooks for scientific and technical students and noted a recurring lack of clarity between the boundaries of this kind of genre compared with others (1995: 170). Analysing the linguistic features, context and content in more detail will provide clarity about the texts as well.

Anamaria Harvey (1995), Carl Whithaus (2012) and Carolyn Rude (1997) present the report as a written document produced by scientists or specialists for decision making structures. Harvey (1995: 191) characterises public reports as always originating from an external request by the group of decision makers, with the goal of "document[ing] reliable predictability in forecasts and recommendations issued" and the purpose to "persuade persons in office to implement measures proposed". She conducted a survey on reports in hard and soft sciences from which she concluded that the public report is a sort of exchange between specialists of a given subject and mixed audiences. The specialists represent the authority of knowledge which was commissioned for the study and provides expert assistance to the requesting party which has the power for decision making. The interaction can be conflictive if, for example, the knowledge provided by the specialists is in contradiction with national views and interest or if the results of the report affect the moral or political value systems of the country. As she describes the public report in environmental science, Harvey (1995: 192) underlines the fact that scientists write for the scientific community in order to become or remain "respected and prestigious members of the discipline and discursive community", and they act as social agents in the way that they inform groups within society and "produce 'texts' that may effectively resolve differences in knowledge and contribute to the improvement of living conditions". Rude (1997: 88) states that even though the report provides scientific assessment, it is mostly oriented toward the future and represents a tool for policy. It is interesting to remark that the scientific results are interpreted through the lens of social responsibility. Both Whithaus and Harvey define this genre as available to the public and journalists while Rude (1995: 170) characterises it as mostly internal and rarely public. According to the researcher (Rude 1995: 170-1), the report for decision making has no standard outline except for introduction, discussion and conclusion; the genre is less conventionalised than other genres such as proposals and scientific reports. Reports studied by Whithaus (2012: 105) have an Introduction Method Result and Discussion (IMRD) structure which is commonly used in scientific papers. The reports are presented as peer-reviewed texts but in the context of policy making and state action. The linguistic features attributed to this genre are presented in detail in Harvey's study (1995). There is a frequent use of nominalisation, impersonal constructions, epistemic stance, markers of prediction and explanation. Personal pronouns are very rare. Graphs and diagrams have explanatory and proving functions (Whithaus 2012: 106; Harvey 1995: 196). Rude (1997: 88) states that the visuals and style encourage reading and the organisation of the texts emphasises issues and options rather than the methods and results. The presentation of several "if/then" scenarios, which help policy makers and scientists to build up hypotheses and therefore better conceptualise the future, should be added as potential elements of the genre.

The elements collected represent a basis for the understanding and analysis of the texts, I will later be more specific in the analyses developed. In order to better analyse the two summary for policymakers and the “Summary for Teachers”, attention should be paid to the summary as a genre as well and will thus be presented in the next section. The “Summary for Teachers” presents elements that are associated with popularisation articles as well. This genre will be presented in the last section of this chapter.

1.2.3. Summary

The genre of the summary and the activity of summarising are very common in daily life. The Oxford English Dictionary (2020) defines the term summary as “a shortened statement or account which gives only the main or essential points of something, not the details; an abridgement, digest, synopsis”. The term also refers to the action or fact of summarising an element. The Centre National de Ressources Textuelles et Lexicales defines a summary as a “texte court qui récapitule à des fins didactiques ce qu’il faut retenir d’un sujet, d’un auteur, d’un livre”[16] (2020).

This frequently used exercise has been studied in different academic fields for different purposes. Some researchers aim at finding the most reliable system in order to automatically summarise texts (Mani et al. 1999; Maybury 1995; Kupiec and Schuetze 2004) and others study the process of human summarisation for pedagogical purposes in the development of language skills (Brown and Day 1983; Brown et al. 1985; Howard et al. 2010) and for English as a Second Language teachings (Chen and Su 2012). The literature dealing with summary as a genre in a linguistic perspective is quite scarce; this could be explained by the fact that summarisation can be applied to any text and thus is very broad in its application and difficult to define precisely. Indeed, Mark Maybury (1995: 735) defines the summary as “[a text that] distills the most important information from a source (or sources) to produce an abridged version of the original information for a particular user(s) and task(s)”. This quotation underlines the fact that the summary is naturally specific to its source text but also to its addressees and other situational characteristics and functions it is related to. In that manner, it is always quite specific and this would explain why it has not

[16] “Short text which sums up for pedagogical needs what must be remembered from a subject, an author or a book.”

been much studied as a linguistic object. Nevertheless, I will provide some elements to characterise this object of study.

Mani et al. list different functions in a summary. The summary can stand in place of the source and thus offers an informative function. It can indicate the topics dealt with in the source text which is the indicative function and it can also offer some criticism on the source which is the evaluative function (1999: 77). Several processes and required skills have been identified in the process of summarisation. According to Yuan-Shan Chen and Shao-Wen Su, to write a "good summary" one needs to "understand the text, select the most important information, delete the minor and redundant details, combine similar ideas into categories and write in his/her own words" (2012; 184). Ann Brown and Jeanne Day (1983: 2) following Van Dijk and Kintsch's work (1977) have identified six macro-rules used during summarisation: they are processes of deletion, generalisation and integration. There are two rules of deletion: one concerns minor elements and the other redundant elements. The authors then present two rules which "involve the substitution of a superordinate term or event for a list of items or actions." The fifth rule is the selection of topic sentences in the source text and the sixth is the invention of topic sentences if they are absent from the source text.

The compression of the source text is also crucial when dealing with the summary. In their study, Howard et al. (2010: 181) define the summary as "restating and compressing the main points of[…]text in fresh language and reducing the summarised passage by at least 50%." Carol Sherrard (1986) mentions Lydall's work (1931) which recommends a length of a third of the source text. In her study, Sherrard did not impose constraints on the length of the summaries to be produced and in average they represented a 50% reduction compared to the length of the original texts. On the other hand, Brown and Day asked for 60 words summaries for 500 words texts, which represents approximately one eighth of the source text. The rate of compression affects the final result of the summary.

I have presented a few elements to describe summary as a genre and its main functions have been highlighted.

1.2.4. Popularisation article

In the 19th century, scientists who had conducted studies would write the text that would inform a large audience; nowadays popularisation articles are mainly written by specialised journalists, as stated by Kevin Nwogu (1991: 112).The writer of the popularisation article does not only provide the reader with more accessible vocabulary compared to the specialised terms found in research articles, according to Maurizio Gotti, (2014: 23), there is a recontextualisation process that implies relevant changes in the roles taken on by the actors and institutions involved. Popularisation also explains the social meaning of scientific and technological discoveries. Swales (1998: 126) mentions Fahnestock's approach to popularisation: the writer celebrates rather than validates the findings of scientists, s/he does not leave it to the readers to interpret the value of the information reported. As they place the social value of science for lay audience, journalists use evaluative terms which can be influenced "by the public interest, market demands, newspaper ideological slant and competition from other types of media" (Gotti 2014: 27). Myers (2003: 266) revaluates the boundary of this genre. Usually popularisation is conceptualised as a simplified and distorted translation of the production of experts for an audience that receives the information like a "blank slate". The linguist refutes this "canonical view" and specifies that the gap between experts in a specific field and non-specialist audience is occupied by intermediate participants, for example, a General Practitioner learns from scientific articles without being an expert in the field and informs his/her patients who are even less informed about a specific topic. Katarzyna Molek-Kozakowska (2017: 93) depicts popularisation article as divided between the principles of journalistic objectivity and neutrality, and "the common model of journalism aimed at increasing the readership and competitiveness of a given media outlet in the market". She studied how the headlines of popularisation articles in the *New Scientist* use different devices to attract the readers' attention; it is quite different from the objective and impersonal characteristic features of the previous genres that have been mentioned. She observed the use of modifiers, superlative and comparative adjectives, adverbs, personal pronouns, imperative and questions. Epistemic modality which conveys an idea of vagueness can be found, as well as, neologisms, metaphors or idiomatic expressions which present information that is aligned with everyday experience so that the readers can understand better. As they compared different linguistic elements between research articles, textbooks and popularisation articles, Parkinson and Adendorff (2005: 293) found that passives forms were not so frequent in popularisation articles and that writer-oriented hedging was the most present type of hedging in the popularisation articles (2005: 297). By attributing claims to other scientists and experts, journalists express objectivity.

Four main genres to which the texts of the corpus can be linked have been briefly presented. The next chapter presents the research questions drawn from the knowledge and methods acquired in the present section.

2. Research project

2.1. Corpus

The emergency statuses of climate change and biodiversity preservation are gradually more obvious as we witness the increase of life threatening events and notice the disappearance of more species regularly.[17] The impact of human activities on climate and biodiversity is now broadly acknowledged. Communication on climate change and biodiversity loss is a key factor in limiting the forthcoming effects of these environmental deregulations. Fortunately, there is a growing awareness about these topics through the communication that has been deployed lately. One intergovernmental report drew considerable media attention at the end of 2018. "Global Warming of 1.5°C", one of the latest Special Reports of the Intergovernmental Panel on Climate Change (IPCC), was published online on the 8th October 2018. This document was requested after the signing of the Paris Agreement at the end of the 21st Conference of the Parties (COP21) in Paris in December 2015. State representatives agreed on keeping global warming well below 2°C compared to pre-industrial levels and to limit global warming to 1.5°C. They invited the IPCC to produce a report that assessed the impact of a warming of 1.5°C. The Paris Agreement (2015) and the publication of this report have received a lot of media coverage. The mixed results presented by the IPCC's report have been underlined by many newspapers and scientists. This document has sounded the alarm: we know for certain that world citizens and ecosystems will experience the effects of climate change in the next decades and that some parts of the world have already been impacted. Humanity has about a decade to modify its habits in order to avoid the harshest consequences that have been estimated. After reading several research papers written by Kjersti Fløttum, I decided to position my research project in the discourse analysis of texts related to climate change. In many articles, the linguist studies several linguistic features in order to compare and evaluate how language is used when dealing with topics regarding the future of the planet. The "Summary for Policymakers" of the IPCC's Special Report "Global Warming of 1.5°C" represents an interesting object of study because the international collective of authors synthesises the research recently carried out on the effects of global warming and uses specific linguistic devices to express certainty. Actors involved in the design of policy are familiar with climate change issues, but they are unaware of all the studies and do not have the scientific expertise to fully

[17]For instance, the annual increase of insurance toll linked to extreme weather events in the USA since the 1980s and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)' latest report on biodiversity, published in May 2019, which states that natural ecosystems have lost about half of their area and a million of species are at risk of extinction.

understand every scientific report. The IPCC's report is mostly designed for scientists while the summary of the report is written for decision makers; the policymakers need to be able to understand the degree of certainty of given phenomena and their consequences in order to make the most efficient decisions for the states that they represent. Therefore, the IPCC developed the two scales of "confidence" and the "assessed likelihood of outcome" which express various degrees of certitude without being influenced by the use of everyday language. Last year, I decided to compare the "Summary for Policymakers" with the "Summary for Teachers" by the Office for Climate Education (OCE) because they have a similar structure, summarise the same report and differ in terms of targeted audiences. The "Summary for Teachers" does not use the two scales and, in addition, specialised terms are used scarcely. These two elements are the most obvious differences among the two texts. The text seems to belong to popularisation writing while the "Summary for Policymakers" is more akin to scientific research writing. Thus, to compare these two texts, which have different registers and apparently constitute two subgenres of the genre of summary of scientific report for non-scientific specialists, I analyse "Uncertain Certainty", a popularisation article published after the IPCC's report and "Risks from Climate Extremes Change Differently from 1.5°C to 2.0°C Depending on Rarity", a research paper which was published a few months before the IPCC's work and that provides data used in the report and in the "Summary for Policymakers". In order to give more depth to my analyses, I decided to add a second set of texts dealing with a similar issue: biodiversity preservation. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published in May 2019 a global assessment report on biodiversity and ecosystems. Described as the IPCC of biodiversity (Ministère de l'enseignement supérieur 2020), this intergovernmental organisation of 134 members works in association with the United Nations but is not part of this organisation as the IPCC is. This document is the product of a process similar to the ones used by the IPCC when they create their reports. This report on biodiversity is the most extensive one since 2005 and it is the first time such a comprehensive report is generated on biodiversity thanks to intergovernmental cooperation. The IPBES released a "Summary for Policymakers", I therefore decided to compare those two intergovernmental productions published only seven months apart. This "Summary for Policymakers" is also equipped with a specific scale of certainty. There is no "Summary for Teachers" based on this report for now, which may be explained by the fact that it is the first global assessment of the IPBES. Furthermore, the IPBES is not as established as the IPCC because it was created more recently (2012) compared to the IPCC (1988). Thus, there are only three texts in this set: the "Summary for Policymakers", a popularisation article, "Humans Are Driving One Million Species to Extinction", and a research paper "Worldwide Impacts of Past and Projected Future Land-use Change on Local Species Richness and the Biodiversity Intactness Index". The popularisation paper was published on the website of the *Scientific American*; an online and printed popularisation magazine like the *New Scientist*, in which "Uncertain Certainty" was published. Both popularisation articles present the main ideas of the reports and were published shortly after the releases of the reports. The second research paper was published in the index bioRxiv; an online archive of preprints of natural life science. The authors make projections on a global scale as the scientists do in the other research article, "Risks from Climate Extremes Change Differently from 1.5°C to 2.0°C Depending on Rarity". These articles can be defined as part of the "hard sciences" domain. The IPCC's and the IPBES' reports are based on studies from "hard" and "soft" sciences. I wanted to make sure that the two scientific papers were as similar as possible; I therefore picked two articles used in the reports, displaying the IMRD structure and presenting several models of predictions on global scales in "hard sciences".

2.2. Hypotheses and methods

The research project offers a qualitative and quantitative analysis of the seven texts under study. The analysis is qualitative as I analyse texts by "hand" as termed by Biber and Conrad (2009: 73); it is quantitative as I compare the frequency of the distribution of linguistic features observed through the texts. The main research question of this project is as follows: what is the enunciative commitment of the authors in the different texts? More specific questions that contribute to the enlightenment of the former are presented in the next lines. Since the main communicative purpose of the summaries and of the other texts is to inform about projections regarding global warming and estimations of biodiversity loss, how are certainty and uncertainty expressed and evaluated? The issues dealt with require a drastic change in humans' manner of using nature's resources, to what extent are the texts either descriptive or prescriptive? And thus, are the summaries for policymakers as "neutral, policy-relevant but not policy-prescriptive" as claimed by the IPCC? Is the "Summary for Teachers" more or less committed compared to the "Summaries for Policymakers"? Are the authors' stances different in the popularisation and research papers? If yes, in what manner?

To provide some answers to these questions, I follow Biber and Conrad's approach as I consider the contexts of the texts and some of their linguistic features in order to define their purposes. I will present the situational characteristics of each text in the next chapter. I do not take into account as many linguistic features as Biber and Conrad do in their analyses, nor do I study a great amount of texts as it is the case in the multidimensional analysis presented in *Register, Genre and Style*. Nevertheless, linking context, linguistic features and functions appears essential when analysing texts for different readers on such crucial issues. Since this is a small-scale analysis, I will not identify register features and genre markers. I will study the distribution of linguistic features associated with the expressions of certainty, necessity, condition and interaction. I will then observe what the patterns of use denote regarding the authors' enunciative stances. When studying linguistic features, I use a functionalist perspective: I study how linguistic elements are used in the context of the texts and I resort to functionalist frameworks. I mainly focus on the expression of certainty through *epistemic modality* and *evidentiality*. To describe those elements in the corpus, I use Monika Bednarek's functionalist framework of *epistemological positioning* (2006) which encompasses the *degree of commitment to a proposition content*, the *source of knowledge* and the *basis of knowledge* among other elements. *Epistemic modality*, also termed the *degree of commitment to propositional content*, is analysed in more detail with Halliday's systemic functional grammar framework (1985). As the summaries for policymakers present specific scales used to express *certainty*, it is decisive to study them in regard with their connection to other linguistic elements expressing *epistemic modality* in given sentences. The texts deal with the state of the natural world and the possibilities of its future state: they represent collected data and projections. I would like to get a better understanding of the different manners the authors use to present the origins of their knowledge. These notions will be developed in detail in chapter 4. Projections in the texts are often presented in hypotheses with modal auxiliary *would*, this distribution is also studied in this research project. Since the texts deal with pressing matters, some call for action should be present in the texts as well, but at the same time, some of those texts are supposed to be informative and not prescriptive. Thus, I also search some elements expressing necessity. Finally, it may be useful to study how addressors use personal pronouns to present themselves to the readers and the kind of relations they create with them. I present some observations regarding these three elements in chapter 5. The texts of the corpus do not have the same lengths, I therefore use relative frequency in order to provide more informing results. I compare the results of the studies among the texts dealing with the same topics and among the texts of the same registers dealing with the two topics. This research project only entails seven texts so it does not provide a large-scale analysis with systematic conclusions regarding the studied genres but the initial study of four texts is deepened with the addition of a second set of texts on a similar issue.

The titles of the different texts of the corpus are abbreviated for greater legibility of the tables and examples. The research articles are renamed **RAclim** for “Risks from Climate Extremes Change Differently from 1.5°C to 2.0°C Depending on Rarity” by Kharin et al. and **RAbio** for “Worldwide Impacts of Past and Projected Future Land-use Change on Local Species Richness and the Biodiversity Intactness Index” by Hill et al.. Summaries for policymakers are abbreviated **SPMclim** for the “Summary for Policymakers” by the IPCC and **SPMbio** for the “Summary for Policymakers” by the IPBES. The “Summary for Teachers” by the OCE is named **STclim**. Finally, popularisation articles are named **PAclim** for “Uncertain Certainty” by Le Page and **PAbio** for “Humans Are Driving One Million Species to Extinction” by Tollefson.

As a first step in this project, I will now provide more information on the histories of the IPCC and of the IPBES and the recent context of climate action and biodiversity preservation (in 3.1.). The second step will consist in describing the two sets of texts (in 3.2. and 3.3.) according to the framework of situational characteristics that has been developed by Biber and Conrad (2009).

3. Context

3.1. From the creation of the Intergovernmental Panel on Climate Change to the coronavirus crisis: a timeline

The evolution of international cooperation regarding climate change and biodiversity preservation will be briefly presented in this section. The Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by the World Meteorological Organisation (WMO) a specialised agency of the United Nations, and the United Nations Environment Programme (UNEP), whose mission is to provide leadership and encourage partnership in caring for the environment. The IPCC comprises three Working Groups and one Task Force. Working Group I is dedicated to the study of the physical science basis of climate change, Working Group II focuses on climate change impacts, adaptation and vulnerability and Working Group III deals with the mitigation of climate change. The permanent Task Force on National Greenhouse Gas Inventories develops a methodology for the calculation and reporting of national greenhouse gas emissions and removals. The IPCC can set other Task Forces for limited periods of time on specific topics. The IPCC's goal is to provide scientific information to governments in order to develop climate policy and to help international negotiation on the matter. The IPCC does not carry out its own surveys. The scientists of the Panel assess the scientific literature produced and present it in Assessment Reports and Special Reports. Assessment Reports display the latest knowledge on the climate, its impacts and possible solutions.[18] Method Reports are produced as well: they present guidelines for the inventory of greenhouse gas emissions. The Synthesis Report produced at the end of an assessment cycle integrates data from Assessment and Special Reports.[19] In 1990, the First Assessment Report of the IPCC was published just before the second World Climate Conference in Geneva. This gathering represented "a critical step on the road to a treaty on climate change" (IUCC 1993). At the end of the Conference, 137 participant states recognised that climate change was a common concern of humankind and that all states were concerned but at different levels. They also acknowledged that measures had to be adopted and that developed countries should invest more than developing countries because the latter are less responsible for the production of greenhouse gases and in a less stable economic situation. In 1992, the United Nations

[18] The first Assessment Report was published in 1990, the second in 1995, the third in 2001, the fourth in 2007, the fifth in 2014 and the sixth is planned for 2022.
[19] The sixth cycle of assessment of the IPCC, 2015-2022, consists of three Special Reports published in October 2018, August 2019 and September 2019; one Methodology Report in May 2019 and there will be one Assessment Report from each Working Group in April, July and October 2021, and finally a Synthesis Report is planned in June 2022.

Framework Convention on Climate Change (UNFCCC) was presented for ratification at the UN Conference on Environment and Development in Rio de Janeiro. It came into force in 1994. The signatories of this treaty are Parties; they are countries and the European Union. Since then they have met annually at Conferences of the Parties (COPs) to negotiate multilateral responsibility for climate change.

In 1997 the Kyoto Protocol was adopted; it is the world's first greenhouse gas reduction treaty. It has been ratified by 192 parties and came into force in 2005. Its first commitment period was from 2008 to 2012; it constrained 37 countries to the average reduction of five percent of their greenhouse gas emissions compared to the 1990 levels and eight percent for EU countries. The United States did not participate and Canada left in 2011. A second commitment period was set from 2013 to 2020 with an average reduction of 18 percent. COP15 in Copenhagen was a disappointment for many because expectations were high: a climate change mitigation plan was to be agreed upon according to the Bali Road Map set in COP13. However, the Copenhagen Accord recognised that while it was important to stay under the 2°C of global warming, there was no legal binding in the accord and there was no given date indicating when the commitment would be obligatory. The Paris Agreement that was produced during the COP21 in Paris in 2015 was historical as "for the first time [it] brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so" (UNFCCC). It is binding for all Parties and has a specific target to limit global warming well below 2°C compared to the pre-industrial levels and to try to limit this phenomenon to 1.5°C. The treaty became binding when the 55 states which represent 55% of the greenhouse gases emission producers signed it; it came into force in 2016. Currently 183 among the 197 Parties have ratified it. Each Party that set a target for emission reduction or limitation, has called a nationally determined contribution. When the Paris Agreement was signed, the Parties asked the IPCC for a Special Report about a global warming of 1.5°C; the publication date was set for 2018. On 8th October 2018, the IPCC published the Special Report "Global Warming of 1.5°C" which emphasises the need to limit global warming to 1.5°C. A year later, in May 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released the "Global Assessment Report on Biodiversity and Ecosystem Services" which indicates the state of knowledge on past, present and possible future multi-scale interactions between people and nature. It is presented as "the most comprehensive [report] ever completed. It is the first intergovernmental Report of its kind and builds on the landmark Millennium Ecosystem Assessment of 2005, introducing innovative ways of evaluating evidence". (IPBES 2019)

The IPBES was created in 2012. It is composed of 134 member states and many non-member states such as civil society, NGOs and private firms which can take part as observers. The IPBES is not a body of the United Nations, unlike the IPCC, but its Secretariat is provided by the UNEP and the IPBES is destined to work jointly with the IPCC. Since its creation, the IPBES has already produced several reports.[20] Even though the Paris Agreement is the most ambitious treaty regarding climate change mitigation so far and it was preceded and followed by several intergovernmental reports produced for governments, it is not effective enough as the populations of many countries are very slow in changing their habits, and therefore in reducing their greenhouse gas emissions, as has been observed by many scientists and civilians alike. For decades, the IPCC has provided information for international organisation regarding climate change and recently the IPBES has joined it to underline the importance of biodiversity preservation but governments are not the sole entities relying on these contributions; civil society has recently expressed its concern about these issues more strongly. The weekly school strikes initiated by the young climate activist Greta Thunberg on 20th August 2018 have gradually received media coverage and have spread throughout Europe and the world. She has since spoken at international meetings. Among them, the World Economic Forum in Davos in January 2019, where she mentioned the IPCC's latest report: "according to the IPCC, we are 12 years away from not being able to undo our mistakes", and the COP24 in Katowice, Poland in December 2018. Several global climate school strikes were held in more than 125 countries. Greta Thunberg's initiative led to a massive awakening of civil society. Local branches of Youth for Climate and Fridays For Future have produced many social and political initiatives in a short time and civil disobedience has taken place in many locations.[21] These groups rely heavily on Greta's interventions and on public scientific reports, such as the IPCC's and IPBES' latest reports, when they voice their concern about the future and emphasise the need to act quickly. Although these series of events have imposed some pressure on governments—many declared a climate emergency in 2019—this is not sufficient to influence states to seriously commit to the cause and the consequences of anthropogenic

[20] To date, 8 IPBES assessments have been completed, among them: Regional Assessment Report on Biodiversity and Ecosystem Services for the Americas, Regional Assessment Report on Biodiversity and Ecosystem Services for Africa and Assessment Report on Land Degradation and Restoration.

[21] Youth for Climate Strasbourg has produced a text by which candidates to the 2019 European elections, who ratify it, pledge to take into account the impact of every decision they will take in their next mandate in order to reduce the production of greenhouse gases and to avoid at all cost to increase it. In Paris on 19th April, around 2000 protestors stayed at the Ministry for the Ecological and Inclusive Transition and blocked the access to the headquarters of Total, EDF and Société Générale and from 15th to 22nd April, the climate activist group Extinction Rebellion blocked several symbolic places in London.

activities are increasingly negative as years pass. As the coronavirus started to spread in Europe, Greta and Youth For Climate branches asked the activists to listen to the science and stop protests in order to respect physical distancing. The global school strike planned on the 13th of March was cancelled before lockdown was declared in France. Later, Greta stated that she hoped we would treat the crisis of climate change as seriously as we are currently treating the coronavirus crisis. This pandemic shows at the same time how much we depend on nature (during lockdown farmers had not enough workforce to pick and transport their yearnings), how vulnerable we are against nature (a virus born in an Asian country is now killing populations around the world) and how much pressure we put on nature and its ecosystems. In a guest article on the IPBES' website, the executive co-Chairs and two other scientists state that humans are the only species responsible for the formation of covid-19. This pandemic is a direct consequence of anthropogenic activities "particularly our global financial and economic systems, based on a limited paradigm that prizes economic growth at any cost". Pressure on habitat induced by "rampant deforestation, uncontrolled expansion of agriculture, intensive farming, mining and infrastructure development" put species in difficulty to adapt to their environment and these situations are favourable to the formation of pathogens (IPBES 2020). Human pressure on ecosystems and our vulnerability and dependency towards nature are underlined in the key messages of the IPBES' "Summary for Policymakers" published last year. Unfortunately, they are currently illustrated on a global scale. This crisis slows down intergovernmental interactions on these topics: COP26 on climate change and COP15 on biodiversity were respectively planned in December and October 2020 and are now postponed to 2021. Nevertheless, this pandemic offers the possibility to reflect on human activities and their consequences on ecosystems: some political organisations and scientists published their leads on the possibilities to restart the economy by considering environmental goals set on international levels. Annika Hedberg, who is the Head of the Sustainable Prosperity for Europe Programme at the European Policy Centre, wrote that "greater sustainability is an answer to the crisis, not 'a nice-to-have' once it is over" (Hedberg 2020). Since the pandemic is quite recent but also critical, it will be interesting to observe how the IPCC will present it in its sixth Assessment Report planned in 2022.

3.2. The situational characteristics of the texts regarding climate change

The situational characteristics will be detailed according to Biber and Conrad's (2009) framework. The results are presented in tables in the following pages in order to highlight the similarities and differences among the texts of the two sets. As stated by the two linguists, the description of situational characteristics and linguistic features is cyclical; it is possible to find more elements about the former by describing the latter and vice versa. In the first part, I will present the four texts of the first corpus dedicated to climate change, before presenting the second group of texts dealing with biodiversity in section 3.3. Each column designates a text while the lines enumerate the different situational aspects which could be specified about the texts. In section 3.2., the scientific article "Risks from Climate Extremes Change Differently from 1.5°C to 2.0°C Depending on Rarity" by Kharin et al. is placed in the first column and its title is shortened by "RAclim". The second column is dedicated to the IPCC's "Summary for Policymakers" and is entitled "SPMclim"; the third column is the OCE's "Summary for Teachers" is named "STclim". The last column is entitled "PAclim", it refers to the popularisation article.

3.2.1 Participants

Table 1 presents the addressors' roles and the types of addressees targeted in each text dealing with climate change.

	RAbio	SPMclim	STclim	PAclim
Addressor(s)	Plural 6 research scientists among them, 5 work for the Canadian government in Environment and Climate Change Canada (ECCC)[22] 4 of them have worked or currently collaborate with the IPCC[23]	Institutional the Intergovernmental Panel on Climate Change (IPCC) 61 drafting authors 19 editors Scientists and policy experts Technical Support Unit of Working Group I	Institutional the Office for Climate Education (OCE)[24] 1 coordinator 7 authors 5 copy editors Scientists and educators Technical Support Unit of Working Group I	Singular 1 staff reporter at the weekly popular science magazine *New Scientist*[25]
Addressees	Unenumerated			
	Other research scientists	Policymakers who requested the report during the COP21, state representatives in the next COPs and any policymaker	Teachers and persons interested in leading teaching activities on climate change	Readers interested in the climate issue without expertise regarding the matter

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[22] ECCC is the lead federal department for environmental issues in Canada. It acts in partnership with territories, provinces and Indigenous People in Canada and works in collaboration with international partners as well. The Department is in charge of monitoring, science-based research, the enforcement of environmental laws and policy and regulatory development. It informs Canadians about the protection of their land and the way to ensure a clean and safe environment at present and for the future.

[23] They all work or worked in IPCC's Working Group I.

[24] The OCE started in March 2018; it is funded by public and private funds provided by French and German partners and it has partnerships with local and national entities in 60 countries. Its goal is to produce resources and tools for teachers to spread education and knowledge of climate issues around the world.

[25] *New Scientist* deals with topics in psychology, climate change, technology, physics, chemistry, etc. It reports international current events and discoveries in a scientific perspective. The magazine is based in London and has several offices in the United States and in Australia.

3.2.2. Relation among addressors and addressees

Table 2 defines the displays the relations between addressors and addressees only; it does not depict relations among addressors nor relations among addressees.

<table>
<tr><th></th><th>RAbio</th><th>SPMclim</th><th>STclim</th><th>PAclim</th></tr>
<tr><td rowspan="2">Interactiveness</td><td colspan="4">No direct interaction</td></tr>
<tr><td>Addressees can address comments to one of the authors: Xuebin Zhang</td><td colspan="2">Addressees can address comments to a given contact</td><td>Addressees transmit comments which will be published in a dedicated section of the next issue</td></tr>
<tr><td>Social roles</td><td>Different social statuses

The addressors seek approval from the scientific community and thus other scientists; the addressors are inferior to them in terms of social roles.</td><td>No strong difference of social statuses

The IPCC benefits from the UN prestige and presents authoritative works. As far as the IPCC are informed, they have no power over governments. Government representatives at the COPs are in position of power: they can implement laws that countries have to abide by.</td><td>No strong difference of social statuses

Addressees are free to use the resources provided by the addressors; there is no constraints</td><td>A slight difference of social statuses

The addressor needs to satisfy the readers, who are customers, by providing clear, precise and useful information</td></tr>
<tr><td>Personal relationships</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">Shared knowledge</td><td colspan="4">No personal knowledge shared</td></tr>
<tr><td>Scientific knowledge is shared by addressors and addressees; addressors provide new elements they want the addressees to validate</td><td colspan="3">The addressor provides most of the scientific knowledge to the addressees</td></tr>
</table>

3.2.3. Channel

Table 3 details the channel used by the addressors to communicate with the addressees. All texts are typed, they present different non-textual elements. Their structures and lengths are also specified.

	RAbio	SPMclim	STclim	PAclim
Mode	Writing			
Specific medium	Typed			
Non-textual elements	Graphs and tables		Graphs, illustrations and photographs	Photographs
Source	Accessible online on *Earth's Future*[26] website	Accessible online on the IPCC's website	Accessible online on the OCE's and IPCC's websites	Accessible in printed version and online on *New Scientist*'s website
Length (number of pages)	12	32	24	4
Structure	Abstract Conventional IMRD structure Bibliography	Acknowledgements Introduction 4 sections Glossary	Introduction 4 sections Glossary List of resources Presentation of the OCE	Standfirst By-line 7 questions and their answers

[26] *Earth's Future* is an online open-access journal; its "contributions focus on Earth as an interconnected, evolving system to inform researchers, policy makers and the public on the science of the Anthropocene" (Earth's Future). It is one of the twenty journals of the American Geophysical Union group. This international non-profit scientific association comprises 60,000 members in 137 countries. Its purpose is to promote discovery in Earth and space science for the benefits of humanity.

3.2.4. Setting

Table 4 shows the conditions to access the texts. “Time and place shared” refers to an instant transmission from the addressor to the addressees. Since the texts are published in journals and online, the place of production and reception is not shared by the addressors and addressees.

	RAbio	SPMclim	STclim	PAclim
Time and place shared	Not physically shared			
Tome period	Contemporary			
Place	Public			Addressees need to purchase a printed copy or to buy a subscription to the magazine

3.2.5. Production circumstances

Table 5 depicts the production circumstances of each text: production processes, places, and dates of publication.

	RAbio	SPMclim	STclim	PAclim
Production process	Peer-reviewed Manuscript received by the AGU group: 5th January 2018 Manuscript revised: 27th March 2018 Manuscript accepted: 16th April 2018 First publication online: 20th April 2018	Production detailed on the IPCC's website 4 Lead Author Meetings about the report and the summary 3 review sessions[27] Approval of the text line-by-line by IPCC's government members[28]	Information not available Collective writing and editing process	Information not available Individual writing and editing process
Place of publication	American Geophysical Union (AGU), Washington, United Sates	World Meteorological Organisation (WMO), Geneva, Switzerland	Office for Climate Education (OCE), Paris, France	New Scientist, London, United Kingdom
Date	April 2018	October 2018	December 2018	December 2018

[27] The IPCC has worked with 42,001 written review comments submitted by 796 individual expert reviewers and 65 governments from the scientific community and governments.

[28] The meeting was held during the IPCC's 48th Session in Incheon, Republic of Korea from the 1st to the 6th of October 2018.

3.2.6. Communicative purposes

Table 6 presents the communicative purposes of each text on climate change. It displays the general and specific purposes with the types of factuality used and the addressors' stances.

	RAbio	SPMclim	STclim	PAclim
General purpose	Informational: reporting and explaining			
Specific purposes	Helps the scientific community by providing material for reflection on climate change	Summarises the 600-pages report for decision makers meeting at COP24 and other policymakers	Summarises the 600-pages report for teachers	Clarifies figures associated with global warming
Factuality	Facts and projections			
Stance	Epistemic		Slightly attitudinal	Mostly attitudinal

3.2.7. Topic

Table 7 shows the general and specific topics dealt with in each text.

	RAbio	SPMclim	STclim	PAclim
General	Consequences of global warming of 1.5°C and 2°C	Consequences of global warming of 1.5°C and 2°C and possibilities of mitigation and adaptation		Figures about global warming
Specific	Analyses the differences in the risks of extreme daily temperatures and extreme daily precipitation amounts under different warming limits	Assesses the impacts of global warming of 1.5°C and 2°C on human and natural environments, presents current and emerging mitigation and adaptation options and their linkages with sustainable development, poverty and social inequalities	Assesses the impacts of global warming of 1.5°C and 2°C on human and natural environments and presents current and emerging mitigation and adaptation options	Asks seven basic questions about global warming and the target of 1.5°C and answers to them

3.3. The situational characteristics of the texts regarding biodiversity

In the following sections, the situational characteristics of the three texts gathered around the topic of biodiversity will be presented. Each column designates a text while the lines enumerate the different situational characteristics which could be specified about the texts. In the first column, the scientific article “Worldwide impacts of past and projected future land-use change on local species richness and the Biodiversity Intactness Index” is shortened “RAbio”. The second column is dedicated to the IBPES’ “Summary for Policymakers” and the last column presents the characteristics regarding the popularisation article “Humans are driving 1 million species to extinction”.

3.3.1 Participants

Table 8 presents the addressors' roles and the types of addressees targeted in each text dealing with biodiversity.

	RAbio	SPMbio	PAbio
Addressor(s)	Plural 10 research scientists Work in collaboration with UNEP-WCMC[29], the Natural History Museum in London and Imperial College London One of whom, Andy Purvis, is one of the authors of the SPM[30] of the IPBES	Institutional the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 29 authors[31] 2 graphic designers 3 overall review editors 19 members of management committee gave guidance for the redaction	Singular One US correspondent at *Nature*[32] covering mostly energy and environment
Adressees	Unenumerated		
	Other research scientists	Policymakers and civil society	Readers interested in the biodiversity issue without expertise regarding the matter

[29]"UN Environment Programme World Conservation Monitoring Centre is a world leader in biodiversity knowledge. It "works with scientists and policymakers worldwide to place biodiversity at the heart of environment and development decision-making to enable enlightened choices for people and the planet." (UNEP-WCMC 2020)

[30] "Summary for Policymakers".

[31] 145 expert authors assisted by 310 contributing authors joined for the conception of the entire report. The report is based on more than 15,000 scientific references and indigenous knowledge.

[32] *Nature* is a British multidisciplinary scientific journal, first published in 1869. It is one of the most renowned scientific journals.

3.3.2. Relation among addressors and addressees

Table 9 defines the relations between addressors and addressees; it does not depict relations among addressors nor relations among addressees.

	RAbio	SPMbio	PAbio
Interactiveness	No direct interaction		
	Readers can post comments on bioRxiv's[33] page dedicated to the article	Addressees can address comments to a given contact	
Social roles	Different social statuses The addressors seek approval from the scientific community and thus other scientists; the authors are inferior to them in terms of social roles. *The fact that the article is not peer-reviewed and is available on an online platform lessens this dichotomy.*	No strong difference of social statuses The IPBES is an intergovernmental body composed of 134 members. It is not as well established as the IPCC but its report, which is the most comprehensive work on biodiversity so far, is an authoritative work. As far as the IPBES are informed, they have no power over governments. Government representatives are in position of power: they can implement laws that countries have to abide by.[34]	A slight difference of social statuses The addressor needs to satisfy the readers, who are customers, by providing clear, precise and useful information.
Personal relationships	None		
Shared knowledge	No personal knowledge shared		
	Scientific knowledge is shared by addressors and addressees; addressors provide new elements they want the addressees to validate	The addressor provides most of the scientific knowledge to the addressees	

[33] BioRxiv is a free online archive and distribution service for unpublished preprints in the life sciences. Authors can make their findings immediately available to the scientific community and receive feedback on draft manuscripts before they are submitted to journals. Articles are not peer-reviewed or edited. "However, all articles undergo a basic screening process for offensive and/or non-scientific content and for material that might pose a health or biosecurity risk and are checked for plagiarism.[…] An article may be posted prior to, or concurrently with, submission to a journal but should not be posted if it has already been accepted for publication by a journal" (bioRxiv 2020).

[34] One of the main functions of the IPBES is to design policy for governments and ensure effective communication with them while the IPCC only occupies an informative role. The implication of the IPBES in decision-making with governments is more explicit compared to the IPCC's. It is stipulated in the texts of the IPBES' creation but it is still limited.

3.3.3. Channel

Table 10 details the channel used by the addressors to communicate with the addressees. All texts are typed, they present different non-textual elements. Their structures and lengths are also specified.

	RAbio	SPMbio	PAbio
Mode	Writing		
Specific medium	Typed		
Non-textual elements	Tables, graphs and chloropleth maps	Photographs, graphs, tables and illustrations	Photograph
Source	Accessible online on bioRxiv's website	Accessible online on the IPBES' website	Accessible online on *Scientific American*'s and *Nature*'s websites and in the printed version of *Nature*[35]
Length (number of pages)	12	60	1
Structure	Abstract and keywords Conventional IMRD structure Bibliography Figures	Foreword Key statements from key partners Acknowledgments Table of contents Key messages 4 sections 4 appendices: conceptual framework, definitions, expression of confidence and knowledge gaps	Standfirst By-line Body text with 2 headings

[35] The article was published in *Nature* and *Scientific American*. Many articles found online in the *Scientific American* are extracted from *Nature* journal. *Scientific American* joined Nature Publishing Group (NPG) in 2009 and became part of Springer Nature in 2015. Springer Nature is a leading global research, educational and professional publisher.

3.3.4. Setting

Table 11 shows the conditions to access the texts. “Time and place shared” refers to an instant transmission from the addressors to the addressees. Since the texts are published in journals and online, the place of production and reception is not shared by the addressors and addressees.

	RAbio	SPMbio	PAbio
Time and place shared	Not physically shared		
Time period	Contemporary		
Place	Public		

3.3.5. Production circumstances

Table 12 depicts the production circumstances of each text: production processes, places, and dates of publication.

	RAbio	SPMbio	PAbio
Production process	Information not available Not peer-reviewed	Production detailed on the IPBES' website 3 author meetings about the report and the summary 2 review sessions for the report and the SPM[36]	Information not available Individual writing and editing process
Place of publication	Cold Spring Labour Laboratory, Laurel Hollow, United Sates[37]	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Bonn, Germany	Springer Nature, New York, United Sates
Date	May 2018	May 2019	May 2019

[36] The IPBES has worked with 13,700 written review comments submitted by 225 expert reviewers, among them 26 Governments, and the European Union on behalf of its 28 members. The SPM was reviewed a third time by the Governments before the seventh session of Plenary.
The final meeting was held during the seventh session of the Plenary of the IPBES in Paris, France from the 29th of April to the 4th of May 2019. The SPM and the chapters of the global assessment report were discussed throughout the week and approved on the last day.
[37] Cold Spring Labour Laboratory is a not-for-profit research and educational institution.

3.3.6. Communicative purposes

Table 13 depicts the communicative purposes of each text on biodiversity. It displays the general and specific purposes with the types of factuality used and the addressors' stances.

	RAbio	SPMbio	PAbio
General purpose	Informational: reporting and explaining		
Specific purposes	Helps the scientific community by providing material for reflection on the impact of human land-use on biodiversity	Summarises the 1800-pages report which critically assesses the state of knowledge on multi-scale interactions between people and nature	Presents the main findings of the report produced by the IPBES
Factuality	Facts and projections		
Stance	Epistemic		No overt stance

3.3.7. Topic

Table 14 shows the general and specific topics dealt with in each text.

	RAbio	SPMbio	PAbio
General	Estimates the past and future impacts of human land-use on terrestrial species communities	Assesses the state of knowledge on past, present and possible future multi-scale interactions between people and nature	Presents the publication and production of an intergovernmental report
Specific	Details a specific database (PREDICTS) used to model historical and future impacts of land-use change and human population on local species richness, community abundance, and biodiversity intactness using a mixed-effects modelling structure	Assesses the relationships between humans and nature; the current status and trends in nature and drivers of change; the goals for conserving and sustainably using nature; and scenarios that lead to a sustainable future	Presents the report of the IPBES and summarises its main findings by mainly quoting scientists and persons involved in intergovernmental organisations

4. The expression of knowledge

In order to analyse the linguistic features of the seven texts under study, I will focus mainly on the expression of knowledge in this chapter. *Epistemic modality* or the expression of *certainty* will be developed in 4.1., then I will present analyses regarding the distribution of *evidentiality* in 4.2., and, in the last part, I will present some remarks regarding the interaction between *epistemic modality* and *evidentiality*. Before detailing the linguistic analyses, it is important to specify that the whole texts were not analysed. I focused on body texts and the captions of figures and tables. I did not analyse the texts integrated in graphs and tables because they are not always sentences or words: many numbers are shared and they are not relevant in my analyses. I did not consider the sentences in the sections dedicated to bibliographies, acknowledgements and messages of key partners because these parts do not correspond to the main purposes of the texts, they are additional elements. The “Summary for Teachers” by the OCE includes activity tasks designed for teachers and pupils. I did not analyse these elements either because they do not present knowledge but give instructions. The “Summary for Policymakers” of the IPBES presents key messages which are repeated and detailed in later parts. I did not analyse the first part including these key messages because they are not associated with confidence terms which are present in the second part. I made this choice because these confidence terms represent specific tools used by the authors to express the confidence they have about given findings: it is essential to this research project which focuses on the expression of certainty. When the number of words for each text was required in the analyses, I did not count the words in the parts that have not been analysed.

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Word count	5045	10593	5048	2476	3332	12630	857

Table 15. Word count of each text in the corpus.

In the following sections, several tables present the frequencies of modal devices in specific texts. They are expressed in percentages; those percentages were run down to the nearest whole number to mitigate readability.

In texts about estimations and projections regarding elements that are vital to human life on earth, the expression of certainty is key and studying how authors commit to the elements they present is most interesting. My analyses are set in a functionalist approach:

I study the forms and uses of linguistic elements to find the different purposes among the texts.

To do so, I study how the addressors present the evidences of their knowledge and the degree of commitment they express to those statements. In order to describe these elements, I use Monika Bednarek's framework (2006), which enables referencing of different ways of expressing knowledge. She defines knowledge as "referring to (true or false) information of which speakers/writers are aware, and to which they refer in their proposition (including those encapsulated in nominalisations) (2006: 655). Among other elements, Bednarek refers to *evidentiality* and *epistemic modality*. The linguist mentions a narrow and a broad definition of *evidentiality*. The narrow definition is that "evidentials express the kind of evidence a person has for making factual claims", which is borrowed from Anderson (1986). Some languages have specific grammatical morphemes encoding the type of evidence of the knowledge expressed in a given statement and many studies were dedicated to these grammaticalised expressions. The broad definition mainly corresponds to Chafe's (1986) "attitudes towards knowledge": evidence is one of the epistemological considerations that are linguistically encoded but there is also, for example, the degree of certainty expressed by the addressor and his/her surprise regarding the piece of knowledge. To refer to this broader definition, Bednarek uses the *epistemological positioning* (EP). The EP is composed of several elements to account for the addressors' different attitudes towards knowledge. There is a clear distinction between *epistemic modality* and *evidentiality* even though they are correlated. Some expressions of *epistemic modality* are not compatible with all types of evidence and vice versa; the latter is entitled *basis of knowledge* by Bednarek for more clarity. Thus, the narrow definition of *evidentiality* referred to earlier in the paragraph is the *basis of knowledge* in Bednarek's framework: it marks the type of evidence available to the writer. Another element in Bednarek's framework is the *source* of information which indicates who is responsible for the content of the utterance. The statement is either attributed to the writer of the text or to another person or entity. Bednarek's concept of *certainty of knowledge* corresponds to what is usually called *epistemic modality*; she equates both terms in her article (2006: 637). *Certainty of knowledge* indicates "how certain the speaker/writer is of his/her knowledge" (2006: 637). Bednarek also presents *mirativity*, when the writer presents the acquired piece of information as expected or unexpected, and the *extent of knowledge*, which specifies when knowledge is somehow limited. I will use the first three concepts *source, basis and certainty of knowledge* in this research project. First I will consider the degrees of commitment of the writers towards their knowledge, or *epistemic modality*, in the corpus.

4.1. The *certainty of knowledge*

To provide a more refined analysis, I will use the framework developed by MAK Halliday in which the orientation and degree of modality are specified. It is defined in *An Introduction to Functional Grammar* (1985) and, for instance, put into practice in the study of *epistemic modality* in medical research papers by Yang et al. (2015). Halliday does not use the term *epistemic modality* in his book but he equates it to his concept of *probability*. This framework measures the orientation and the value of the modality expressed in a given sentence: whether it is implicit or explicit and whether it is objective or subjective. The orientation of an expression of modality "conveys the writer's responsibility for the modal meaning through various linguistic forms and reveals the subjectivity or objectivity of a modal expression from the perspective of the source of modality" (Yang 2015: 2). A modal expression is subjective when the addressor is showing that s/he is the source of modality and it is objective when the addressor suggests the possibility of an objective event and presents the fact to the addressee without being the source of the modality. The term implicit refers to the expression of modality being in the same clause as the propositional content and the term explicit is used when modality is expressed in a separate clause. Thus, the expression of modality is either explicit subjective (ES) when the addressor presents him/herself as the source of knowledge and expresses it in a separate clause, implicit subjective (IS), when the addressor presents the possibility of an event and indicates him/herself as the source of this statement in the same clause, implicit objective (IO), when the addressor states in the same clause the degree of possibility of an event without being the source of this knowledge, or explicit objective (EO), when the addressor states the degree of possibility of an event in a separate clause and associates a different source to it than him/herself. I will present orientations and their constructions found in the corpus in the following sections. The possible values of modality are low, median or high: they show a differentiation in degrees of certainty expressed by the addressors. The values of modality belong to a scale and should not be conceptualised as discrete entities. However, I used these three values which have been used in other frameworks for a more eloquent analysis. Yang et al. respectively associate low, median and high values to *possibly*, *probably* and *certainly*. Halliday and Yang et al. do not refer to *evidentiality* and thus do not distinguish between the degree of commitment of the writer to the propositional content and the type of knowledge s/he bases her/his statement on. Even though the relation among those two terms has been widely debated and there is no real common agreement regarding it, I would like to account for those two aspects as much as possible in my analysis. In the following section, I will present the different types of orientation of *epistemic modality* found in the corpus.

4.1.1. Explicit subjectivity

Explicit subjectivity is conveyed by an epistemic lexical verb with a first-person subject in a separate clause. There are only two occurrences of this type in the corpus; it is in each research article. The first occurrence is of low value: *assume* does not express certainty but, rather, a lack of certainty. *Project* rather denotes a high value of modality.

> Here **we assume that** the location parameter and the log of the scale parameter depend linearly on the global mean temperature. (RAclim)
>
> However, a brighter future is possible; SSP1/RCP2.6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity—in this scenario **we project that** biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100. (RAbio)

These two occurrences in the corpus show that the texts under study do not emphasise the writers' stances. The writers mainly express certainty and the lack of it with objective devices and implicit subjectivity. In research articles, the addressors also want to present their text as objectively as possible. However, as discussed in the presentation of the genre of the research article in 1.2.1., they also anticipate the reader's questions and counter-points and specify their position and choices of reasoning in a humble manner when they use hedging devices. As will be seen later in the analysis, the texts display more objective expressions of modality and impersonal presentations of the projections.

4.1.2. Implicit subjectivity

Implicit subjectivity is expressed by modal auxiliaries. Halliday's framework attributes *must, will, should, may* to the expression of *probability*. Halliday classifies *must* as high value, *will* as median and *may* as low. In Yang et al.'s study, *could* and *might* are also associated with the expression of *epistemic modality* with a low value and Bednarek references *could* as low *epistemic modality* as well. She classifies *will* as high value which I will follow in this project because *will* is described in most linguistic approaches as the auxiliary used to make predictions. Thus, it has a high value of *certainty*. I will now present the distribution of the four auxiliaries *will*, *may*, *could* and *might* within the corpus. There are a few occurrences of *must* and *should* in the texts but they are not used for the expression of *certainty*: their use will be discussed at a later point.

4.1.2.1. High and low values

Text		RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
High value	Occ.	7	9	30	18	4	14	8
	%	33	27	79	64	50	37	73
Low value	Occ.	14	24	8	10	4	24	3
	%	67	73	21	36	50	63	27

Table 16. The proportion of high and low value of implicit subjectivity in each text.

Will is the epistemic modal auxiliary most present in popularisation texts. It accounts for 73% of the epistemic modal auxiliaries in the popularisation article about biodiversity and 64% of the epistemic modal auxiliaries in popularisation about climate change. In the "Summary for Teachers", the addressors use *will* the most with 79%. The other texts display more epistemic modal auxiliaries of low value. A preliminary conclusion from this observation would be that the authors of popularisation texts express more certainty in an implicit subjective way than the authors of the other texts. The latter are more focused on the scientific presentation of their findings and underline the lack of certainty due to the margins of error in projections and the fact that most of the projections regarding the issues of climate change and biodiversity depend on human actions as stated by the IPCC: "achieving ambitious mitigation goals will require active, goal-directed efforts aiming explicitly for specific outcomes and incorporating new information as it becomes available [...] This shifts the focus of uncertainty from the climate outcome itself to the level of mitigation effort that may be required to achieve it"(2018).

As specified in the paragraph above, the other texts which present scientific findings to their community (research articles) or to the decision-making community (summaries for policymakers) use more low value auxiliaries of *epistemic modality*. The next paragraphs are dedicated to the analysis of the specific uses of each low value auxiliary.

a) May

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Occurrences	7	10	3	0	3	12	1
%	33	29	8	0	38	32	9

Table 17. The proportion of modal auxiliary *may* compared to the rest of the epistemic modal auxiliaries in each text.

Most occurrences of *may* are mergers as defined by Coates in *the Semantics of Modal Auxiliaries* (1983) and in an article written with Geoffrey Leech (1979). They do not classify modality in the same manner as Halliday does but their approach of *may* offers an enlightening vision on its frequent use in scientific writings. In the case of a merging *may*, the possibility does not only prevail on the propositional content as it is the case in *epistemic possibility*—as Leech and Coates term *epistemic modality*- but the sentence can be interpreted as if the possibility concerns the subject. Coates and Leech define *root possibility* as the absence of external obstacles which enables the possibility of something to happen to the subject. This is most generally expressed with the modal auxiliary *can*. This in-between situation is called *merger* in Coates and Leech's writings. There is indeterminacy between those two meanings and choosing one or the other to interpret a given passage does not change much of its general interpretation. The linguists provide four possible paraphrases to verify whether it is an *epistemic possibility* meaning and two to check if it is a *root possibility* meaning. They are applied below to the same sentence extracted from the research article about climate change.

> Nevertheless, a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit **may** be useful. (RAclim)

Epistemic possibility:

> Nevertheless, a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit may **possibly** be useful.
>
> Nevertheless, a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit may **well** be useful.
>
> **It may be that** a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit **will be**useful.

> **It may be that** a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit **is** useful.

Root possibility:

> Nevertheless, a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit **can** be useful.
>
> **It is possible for,** a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1.5°C limit **to be** useful.

Because of the frequency of indeterminacy for *may* but also for *might* and *could* regarding the expression of *hypothetical possibility* and *epistemic possibility*, I decided to use Halliday's framework and reference all auxiliaries expressing low probability as devices presenting low implicit subjectivity of *epistemic modality* even if another meaning could sometimes also be added.

However, in the "Summary for Teachers", occurrences of *may* clearly convey *epistemic modality*. *May* is associated with expressions of modalities different from *epistemic modality*:

> Species are migrating towards cooler environments - poleward or to greater depths in the ocean, and poleward or uphill on land, but **may not be able to** move readily (eg due to habitat fragmentation) or fast enough. (STclim)
>
> For instance, in the case of sea level rise, the populations of some low-lying islands **may ultimately have to** permanently relocate. (STclim)

b) Might

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Occurrences	2	2	0	3	0	1	0
%	10	6	0	11	0	3	0

Table 18. The proportion of modal auxiliary *might* compared to the rest of the epistemic modal auxiliaries in each text.

Might is less present than *may* in the texts. For example, its use is so sporadic in the summaries for policymakers, that it is intriguing that respectively two and one occurrences are present in the two texts.

> Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that **might** not be achievable given considerable implementation challenges (medium confidence). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 3.3, 4.3.7, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4} (SPMclim)

A possible interpretation is that *might* in the first sentence is the hypothetical form of *may*. It is used because it is in a relative subordinate clause and the tense of this clause is ruled by the presence of a hypothetical *would* in the superordinate clause.

> Knowledge gaps include insufficient data to calculate specific climate resilience-enhancing investments from the provision of currently underinvested basic infrastructure. Estimates of the costs of adaptation **might** be lower at global warming of 1.5°C than for 2°C. (SPMclim)

In this sentence, *might* could be easily replaced by *may*. I infer that the authors chose to use *might* instead of *may* because they acknowledge very explicitly the lack of data and thus certainty. Their stance is quite tentative in this sentence.

> Loss of diversity, such as phylogenetic and functional diversity, can permanently reduce future options, such as wild species that **might** be domesticated as new crops and be used for genetic improvement {2.3.5.3}. (SPMbio)

In the "Summary for Policymakers" by the IPBES, *might* is used only once. The expression of futurity linked to an example seems again to impose the hypothetical form of *may* as the auxiliary is in a relative clause.

Might is sometimes presented as used for a lower probability than the one expressed by *may* or to convey more politeness but Coates (1983) found in her observations that they are quite interchangeable. In this present research project, *might* is less used than *may* except in one popularisation article.

Might is associated to *may* in one of the research articles, this association enables the authors to humbly denote the efficiency of their framework.

> One approach that **might** help to avoid overstating changes in risk **may** be to determine risk ratios not just for single events, but as a function of rarity, as in Figure 4. (RAclim)

c) Could

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Occurrences	5	13	5	7	1	11	2
%	24	38	13	25	13	29	18

Table 19. The proportion of modal auxiliary *could* compared to the rest of the epistemic modal auxiliaries in each text.

The use of *could* is quite similar to the use of *may* in the “Summary for Policymakers” by the IPCC while there is only one specific use of this auxiliary in the other “Summary for Policymakers”.

> Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet **could** result in multi-metre rise in sea level over hundreds to thousands of years. (SPMclim)

> Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration **could** provide co-benefits such as improved biodiversity, soil quality, and local food security. (SPMclim)

> Economic, institutional and socio-cultural barriers **may** inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (high confidence). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2} (SPMclim)

Could is used for phenomena induced by humans and other factors which are not. As I read these three sentences above, *may* and *could* can be replaced by one another without much change in the meanings of the sentences. In the three sentences, the auxiliaries denote possible outcome in the future.

	May	*Might*	*Could*
Occurrences	10	2	12
Part A	2	0	0
Part B	1	0	6
Part C	5	0	4
Part D	2	2	2

Table 20. The distribution of modal auxiliaries of low value in the “Summary for Policymakers” by the IPCC.

Could is not in part A of the “Summary for Policymakers” by the IPCC. This part presents the concept of climate change and how it is estimated to have evolved so far. In part B, the writers present the projections about global warming of 1.5°C and 2°C, their impacts and associated risks; *could* is more used than *may.* Finally, the IPCC present scenarios of methods consistent with a global warming of 1.5°C in part C and strategies consistent with sustainable development to eradicate poverty in part D, they almost use as many *may* and *could* in each part.

However, in the “Summary for Policymakers” by the IPBES, *could* is used in only one part of the text and it refers only to what human actions and decisions would enable to do. The auxiliary is used in part D where the writers make propositions for policymaking. Here, low probability is mostly used to formulate tentative and polite propositions. In the “Summary for Policymakers” of the IPCC, *could* is in most parts of the text and is quite interchangeable with *may* as is explained above.

The “Summary for Teachers” also presents propositions of actions with *could*:

> Major investments will be needed to realise these transitions, including in developing countries. These **could** be complemented by government legalisation such energy standards or a price on carbon. (STclim)

In the research article about climate change, the majority of the forms of *could* are used to express the possible inconsistencies between projections and observations or among estimations:

> As modelled warming in the warm extremes is somewhat faster than observed, future increases in the frequency of current climate warm extremes **could** be smaller than reported here. (RAclim)

For discourse cohesion, I did not count *could* when it is used as the past form of *can;* there are only two occurrences in the corpus.

4.1.2.2. Other remarks about auxiliaries in the different texts

	Will	*May*	*Might*	*Could*	the 4 modals
Frequency in the discussion section	86	71	50	40	67

Table 21. The proportion of each modal auxiliary in the discussion part of the RAclim text.

67% of the epistemic modal auxiliaries in the research article about climate change are in the discussion section. Here, it is obvious that the writers present their opinion in the last part of their article and use the implicit subjective structure to do so. Even though *will* is not the most present auxiliary in the article, it is the most used in this part. Thus, the authors express more low modality throughout the article and the last part of the text is quite firm, even if it starts with much tentativeness as the scientists present the efficiency of their framework with the association of *might* and *may* as discussed above.

4.1.3. Implicit objectivity

Implicit objectivity is expressed in different manners according to Yang et al.'s study. The expansion of the predicator encompasses passive forms and adjectives linked to infinitive forms such as *be projected to* and *be estimated to*. Modal adverbs and modal adjectives also denote implicit subjectivity.

4.1.3.1. Expansion of the predicator

The phrases *be expected to, be projected to, be predicted to, be estimated to, be likely to,* etc. inform the reader on the writer's *basis of the knowledge*—which will be developed further in 4.2—and on the degree of his/her commitment to the clausal content. In my own estimations, *be expected to, be predicted to, be projected to* and *be modelled to* convey a high degree of certainty while *be estimated to* is less certain. Hence, I classify *be expected to, be predicted to, be projected to* and *be modelled to* as high value of modality and *be estimated to* as median value. In the IPCC's "Summary for Policymakers", *be likely to* corresponds to 66-100% of an outcome to happen thus it is median value because 66% is quite close to 50% and the interval is large. In the same text, *be unlikely to* represents 0-33% of likelihood for an outcome to occur so I classified it as very low value because it conveys a weaker certainty than *possibility*.

Text/ Expansion of the predicator		RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
	Total	2	48	9	0	10	22	0
Expected to	Occ.	1	3	5	0	2	8	0
	%	50	6	56	0	20	36	0
Predicted to	Occ..	0	0	2	0	4	0	0
	%	0	0	22	0	40	0	0
Projected to	Occ..	1	36	0	0	1	10	0
	%	50	75	0	0	10	45	0
Modelled to	Occ..	0	1	0	0	0	0	0
	%	0	2	0	0	0	0	0
High value	%	100	84	78	0	70	81	0
Estimated to	Occ..	0	3	1	0	2	3	0
	%	0	6	11	0	20	14	0
Likely to	Occ..	0	3	1	0	1	1	0
	%	0	6	11	0	10	5	0
Median value	%	0	12	22	0	30	19	0
Unlikely to	Occ..	0	2	0	0	0	0	0
	%	0	4	0	0	0	0	0
Low value		0	4	0	0	0	0	0

Table 22. The distribution of expansions of the predicator in the corpus, expressed in absolute (Occ.) and relative (%) values.

The relative values correspond to the proportion of a given phrase compared to other expansion of the predicator phrases found in one text. The total of expansions of the predicator for each text is indicated in the second line. The other lines represent the absolute and relative values of certain expansions of the predicator for each text.

Be projected to occurs frequently in the “Summary for Policymakers” by the IPCC while the other texts diversify more their use of expansion of the predicator as can be seen in the table above. Even though the “Summary for Teachers” summarises the same text as the “Summary for Policymakers” does, the authors do not use the phrase *be projected to*; they mainly use *be expected to* and *be predicted to.* These phrases refer more to a mental process than to a type of scientific or technical process which enables to make the predictions, in contradiction with *be modelled to* and *be projected to* which connote the scientific process at the origin of the prediction. In fact, *be predicted to* is used in neither of the summaries for policymakers, perhaps because this term is too vague since it does not indicate the process at the origin of the piece of information. However, almost half of the devices used in the research article on biodiversity are *be predicted to*. Since the authors make projections with a database called “PREDICTS”, the use of *be predicted to* in this scientific article seems justified. The research article on climate change presents only two elements of expansion of the predicator. Neither of the popularisation articles express *certainty* with the device in question. All the texts use objective implicit structure to mainly express high value of modality. Median epistemic modality represents a third in the research article on biodiversity otherwise it corresponds to a fifth or less in the texts containing expansions of the predicator. Only the “Summary for Policymakers” by the IPCC uses low values as is apparent in the table.

4.1.3.2. Modal adverbs

Implicit objective epistemic modality is also expressed via modal adverbs; there are very few modal adverbs in the whole corpus. I categorise *clearly*, *in fact* and *actually* as denoting high value, *probably* and *likely* as adverbs of median value of epistemic modality while *potentially* and *perhaps* convey a low value.

Text/ Adverb	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Clearly	1	0	0	0	0	0	0
In fact	1	0	3	1	0	0	0
Actually	0	0	1	1	0	0	0
Probably	0	0	0	2	1	0	0
Likely	0	0	0	0	0	1	0
Potentially	1	1	1	0	1	2	0
Possibly	0	1	0	0	0	0	0
Perhaps	0	0	0	2	0	1	0
High value	2	0	4	2	0	0	0
Median value	0	0	0	2	1	1	0
Low value	1	2	1	2	1	2	0

Figure 23. The distribution of modal adverbs in the seven texts.

In the corpus, there are adverbs attached to adjectives:

> In 2015, agricultural support **potentially** harmful to nature amounted to $100 billion in countries belonging to the Organization for Economic Cooperation and

Development, although some subsidy reforms to reduce unsustainable pesticide uses and adjust several other consequential development practices have been introduced {2.1.9.1, 6.4.5}. (SPMbio)

And adverbs attached to verbs:

Non-regulatory alternatives are also important, and **potentially** include technical assistance—especially for small-holders—and appropriate economic incentive programs, for example, some payment for ecosystem services programmes and other non-monetary instruments {5.4.2.1}. (SPMbio)

As presented in the preceding section, *likely* is found in the structure of the expansion of the predicator several times. There is one occurrence in which it appears in another construction with the modal auxiliary *will*.

Ocean mining, while relatively small, has expanded since 1981 to ~ 6,500 offshore oil and gas installations worldwide in 53 countries (60 per cent in the Gulf of Mexico by 2003) and **likely** will expand into the Arctic and Antarctic regions as the ice melts {2.1.11}. (SPMbio)

I referenced *in fact* as a modal adverbial phrase. The following excerpt shows how emphatic the popularisation article is, especially when it presents attributed sentences. There are two adverbial phrases followed by a comparative phrase amplified by the phrase *ever before*. This accumulation of the expressions of certainty, immediacy and necessity expresses the urgent character of the topic.

"We in fact have to act immediately in a larger way than ever before." (PAclim)

In fact is the device the most used in the corpus, it denotes high value of certainty but also enables the writer to nuance and emphasise his/her statement:

This lack of sensitivity will, **in fact,** become apparent earlier for events that are rarer in the 1.0°C world. (RAclim)

There are as many modal adverbs of high value (40%) as there are of low value (40%) while median value adverbs represent 20%. The popularisation article on climate change has the most diversified distribution of modal adverbs and the "Summary for Teachers" is by far the text which expresses the most certainty.

4.1.3.3. Modal adjectives

Text/ Adjective	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Likely	0	9	0	0	0	0	0
Plausible	0	0	0	2	3	0	0
Potential	0	10	2	1	0	0	0
Possible	0	2	3	0	3	2	0
Median value	0	9	0	0	0	0	0
Low value	0	12	5	3	6	2	0

Table 24. The distribution of the occurrences of modal adjectives in the corpus.

Most of the adjectives are attributive and are used as direct modifiers of noun phrases.

> Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including **potential** shifts in their geographic range (high confidence). (SPMclim)

> While we are increasingly confident that the low end of the **plausible** range can be ruled out, there is a long tail of high values that cannot. (PAclim)

There are very few occurrences in which adjectives work as predicate of subject: they represent only 9% of the modal epistemic adjectives. The rest function as attributive.

> However, a brighter future is **possible**; SSP1/RCP2.6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity—in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100. (RAbio)

> Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are **possible** (high confidence). {1.4, 4.3, 4.5}. (SPMclim)

The majority of the adjectives present in the corpus are used to express low epistemic modality, only the “Summary for Policymakers” by the IPCC presents 37% of median value and 63% of adjectives expressing low value of *epistemic modality*. The IPCC’s “Summary for Policymakers” gathers 56% of the modal epistemic adjectives found in the corpus. The research article on climate change and the popularisation article on biodiversity do not contain any modal adjectives.

4.1.3.4. Conclusions on implicit objectivity

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Total	5	68	19	9	18	27	0
Expansion of predicator							
Occurrences	2	48	9	0	10	22	0
Proportions	40	71	47	0	56	82	0
Adverb							
Occurrences	3	1	4	6	2	3	0
Proportions	60	1	21	67	11	11	0
Adjective							
Occurrences	0	19	6	3	6	2	0
Proportions	0	28	32	33	33	7	0

Table 25. The distribution of expansions of the predicator, adverbs and adjectives in the corpus in absolute values (occurrences) and in proportion for each text compared to the two other types of phrases.

The popularisation article about biodiversity does not contain any device of implicit objectivity and the other popularisation article only displays a few modal adverbs and adjectives. The summaries for policymakers mainly use expansion of the predicator (71% for SPMclim and 82% for SPMbio), this use seems to occur more in order to specify the process which enables to make predictions and assess the probability of the outcomes rather than express the degree of probability of the outcomes themselves since a majority of them connote high value. To express the degree of probability, the writers use numbered information and, more precisely, in the summaries for policymakers they use “confidence terms” —these tools will be detailed in 4.1.6. The IPCC’s “Summary for Policymakers” has many more adjectives than adverbs while this is the opposite for the IPBES’ “Summary for Policymakers”. The “Summary for Teachers” and the research article on biodiversity also use more expansions of the predicator than modal adverbs but the contrasts between the three categories are less sharp. The “Summary for Teachers” has the most diversified distribution. The research article on climate change uses slightly more adverbs than expansions of the predicator.

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Total	5	68	19	9	18	27	0
Expansion of predicator							
High	2	40	7	0	7	18	0
Median	0	6	2	0	3	4	0
Very low	0	2	0	0	0	0	0
Adverb							
High	2	0	4	2	0	0	0
Median	0	0	0	2	1	1	0
Low	1	2	0	2	1	2	0
Adjective							
Median	0	7	0	0	0	0	0
Low	0	12	4	3	6	2	0

Table 26. The distribution of the occurrences of modal epistemic values in the texts.

The high value of *epistemic modality* is the most found in implicit objective constructions with 57%, most of it is expressed by expansions of predicator. Low value is the second value mostly used: it represents 26% of the values expressed by implicit objective constructions. It is mostly expressed by adverbs and adjectives, especially in the IPCC's "Summary for Policymakers".

4.1.4. Explicit objectivity

Explicit objectivity is encoded by several constructions. However, they do not appear often in this corpus. The following table presents the distribution of the four structures in the corpus.

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Extraposition with adjectives	0	0	1	1	0	0	1
Extraposition with nominalisations	1	0	0	0	1	0	0
Epistemic lexical verbs	0	3	0	3	1	5	0
Epistemic lexical verbs in v-ing form	2	0	0	0	0	0	0

Table 27. The distribution of the four structures of explicit objectivity in the corpus with absolute values.

Explicit objectivity can be expressed by extrapositions with modal adjectives. It represents 14% of the explicit objective constructions used.

> Even if we are unsure of the exact value of the climate's sensitivity to carbon dioxide and other greenhouse gases, **it is clear that** what matters is how much is in the atmosphere. (PAclim)

> **It is true that** at the current rate of emissions we will exceed the report's "most likely" remaining carbon budget in roughly 12 years. (PAbio)

> **It's estimated that** the additional emission reduction actions to limit warming to 1.5°C compared to 2°C would reduce premature deaths from air pollution by 100-200 million over the course of this century. (STclim)

The popularisation article on climate change uses two occurrences of high value of *epistemic modality* while the "Summary for Teachers" uses a low value device.

Explicit objectivity is also expressed by the nominalisation of modal adjective or verbs introducing propositional content. It is only found once in each research article at a low value of modality. This represents 10% of the structures of this orientation of *epistemic modality*.

> **The implication is that** risk assessment will depend critically on an understanding of the thresholds for the occurrence of extremes and kinds of extremes at which vulnerability increases sharply. (RAclim)

> **The core assumption is that** the relationships between the drivers and biodiversity estimated from these data remain constant over time (Purvis et al2018). (RAbio)

Epistemic lexical verbs with an inanimate subject referring to the data, results or findings represent 62% of the explicit objective constructions of *epistemic modality*. This is something that will be analysed in more detail section 4.2. for now I only consider the value of the different modal lexical verbs used with inanimate subjects.

Text/ Verb	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Suggest	0	1	0	3	1	5	0
Imply	0	2	0	0	0	0	0

Table 28. The distribution of modal lexical verbs with inanimate subjects in the corpus with absolute values.

Suggest is found in most of the texts, it is associated with the results of the authors in the research article on biodiversity:

> Because the Artic is rapidly heating up, NASA's figures **suggest** there has been nearly 0.1°C more warming across the planet than the Met Office's do. (PAclim)

It is also associated with the findings of other scientists in the popularisation article on climate change and with projections and phenomena in the summaries for policymakers:

> Model-based projections of global mean sea level rise (relative to 1986-2005) **suggest** an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C of global warming, 0.1 m (0.04-0.16 m) less than for a global warming of 2°C (medium confidence). (SPMclim)

> Available data **suggest** that genetic diversity within wild species globally has been declining by about 1 per cent per decade since the mid-19th century; and genetic diversity within wild mammals and amphibians tends to be lower in areas where human influence is greater (established but incomplete) {2.2.5.2.6}. (SPMbio)

> The systems transitions consistent with adapting to and limiting global warming to 1.5°C include the widespread adoption of new and possibly disruptive technologies and practices and enhanced climate-driven innovation. These **imply** enhanced technological innovation capabilities, including in industry and finance. (SPMclim)

In their study, Yang et al. (2015) do not mention modal verbs in the progressive form introducing a clause but I found a few occurrences and think they take part in the expression of *epistemic modality* in an objective way.

They are only used in the research article on climate change with two occurrences of *suggesting*:

> The scale parameter decreases for cold extremes in areas where snow and sea ice retreat, **suggesting** moderately lower variability in the warmer world in these areas but little change elsewhere. (RAclim)

The expression of *epistemic modality* in an explicit objective manner is more frequent in the corpus than explicit subjectivity but it is much less important than implicit subjectivity and objectivity.

4.1.5. The lexical expression of certainty and uncertainty

There is no lexical expression of certainty or uncertainty in the popularisation article on biodiversity. The other popularisation article delineates mainly uncertainty:

> Except it isn't–and that **is just the beginning of** the confusion. (PAclim)

> The uncertainty **starts here**. (PAclim)

The idea of gradation is also expressed:

> **Adding to** the confusion are all sorts of other pollutants that we are pumping into the atmosphere, some of which have a cooling effect. (PAclim)

> This not only makes it **harder** to determine how much warming CO2 causes, but also to work out what we need to do to limit warming, because it depends on how levels of these pollutants change too. (PAclim)

> While we are **increasingly** confident that the low end of the plausible range can be ruled out, there is a long tail of high values that cannot. (PAclim)

And three occurrences expressing high degree can be found:

> Amid **the morass of** confusing and conflicting numbers, two things remain crystal clear. (PAclim)

> The **huge** unknown is how long this will take. (PAclim)

> The **biggest** uncertainty by far is us, namely what exactly we do over the next century. And the uncertainty cuts both ways: we could be underestimating how fast the world will warm and what the effects will be. (PAclim)

In the research article on climate change, the authors use several lexical expressions of uncertainty regarding consistency and, in the summaries for policymakers, the identification of knowledge gaps is also expressed lexically. A few examples are listed below.

> This consistency **provides a measure of confidence** in future projections, at least on a large scale. (RAclim)

> Changes in cold extremes are such that the preindustrial 1-in-20-year event becomes a 1-in-50-year event in the current climate and less than a 1-in-200-year event for global warming of 2°C or greater (though we note that the estimates of such large return period values are associated **with larger uncertainty**). (RAclim)

> The proportion of insect species threatened with extinction is **a key uncertainty**, but available evidence supports a tentative estimate of 10 per cent (established but incomplete) {2.2.5.2.4}. (SPMbio)
>
> However, the consequences of changes often depend on details of the ecosystem, **remain hard to predict and are still understudied** (established but incomplete) {2.2.5.2.3}. (SPMbio)
>
> **Knowledge gaps remain** in the integrated assessment of the economy-wide costs and benefits of mitigation in line with pathways limiting warming to 1.5°C. {2.5.2; 2.6; Figure 2.26} (SPMclim)
>
> Carbon cycle and climate system **understanding is still limited** about the effectiveness of net negative emissions to reduce temperatures after they peak (high confidence). {2.2, 2.3.4, 2.3.5, 2.6,4.3.7, 4.5.2, Table 4.11} (SPMclim)

4.1.6. The specific scales used by the IPCC and the IPBES

In the introduction of the "Summary for Policymakers", the IPCC refers to the use of two scales in the text in order to express confidence related to an outcome and if the confidence is high, to denote the assessed likelihood of a well-defined past or future outcome. The IPCC has used scales to express confidence about its key statements and findings in previous reports. Those scales are often reassessed by scientists assigned to the task by the IPCC. For instance, a Cross-Working Group Meeting on Consistent Treatment of Uncertainties in July 2010 determined most of the current scales, also used in the fifth Assessment Report. Sometimes, the confidence terms are assessed by other organisations: the InterAcademy Council published an independent review of the IPCC in 2010. Since the IPBES is more recent, the work on the scales is not as developed yet. Nevertheless, both organisations provide guidelines that are available on their websites. The aim of these guidenotes is to assist the authors in the "consistent treatment of uncertainties across all working groups" (Mastrandrea 2010: 1) to thus provide more transparency in their work. These guidelines meticulously detail the scales and how they should be used. They also indicate what the writers should prioritise and anticipate in the writing process. For the IPCC, two metrics are used to express certainty in key findings and the authors are encouraged to use these scales as early as possible in their writing. These tools are present in the "Summary for Policymakers" and in the report.

Confidence is "the validity of a finding based on the type, amount, quality and consistency of evidence (e.g. mechanistic understanding, theory, data, models, expert judgement) and the degree of agreement between different lines of evidence." (Mastrandrea 2010: 3) The type, amount, quality and consistency of evidence are termed as "limited", "medium, or "robust" and the degree of agreement is expressed by "low", "medium" or high". When a finding has high agreement and robust evidence, the authors present a level of confidence. When findings have high agreement or robust evidence, authors assign confidence or quantified certainty when possible, or they assign the term of agreement or of evidence ("robust", "medium", "low", etc.). There are other possible situations, but they are not expressed in the "Summary for Policymakers" and will thus not be detailed here (see the depiction of evidence and agreement statements and their relationship to confidence in Appendix). Confidence is qualitatively expressed by "very low", "low", "medium", "high" and "very high", in italics within brackets. In the IPCC's "Summary for Policymakers", the authors only used only *very high*, *high* and *medium*. Likelihood is the other metric used by the IPCC. It "provides calibrated language for describing quantified uncertainty. It can be used to express a probabilistic estimate of the occurrence of a single event or of an outcome (based on statistical analysis of observations or model results, or expert judgement)". (Mastrandrea 2010: 3) Likelihood terms are used for a range from "virtually certain", to denote 99-100% of probability, to "extremely unlikely", to express 0-5% of probability (see the detailed table of the IPCC in Appendix). In the "Summary for Policymakers", the authors only used "likely" (66-100%) and "unlikely" (0-33%) in italics, either in the construction of expansion of the predicator as detailed in 4.1.1.3. or as an adverb associated with the noun *range*.

With these terms used to refer to evidence of varying agreement and type, among other elements, the authors provide consistent assessment of confidence and likelihood but the readers do not know whether all lines of arguments agree and if they are numerous or if there is only one robust line of argument. There is the same uncertainty for the reader when the scale of the IPBES is under scrutiny. The IPBES use four terms to express their level of confidence regarding a finding. The level of confidence is also "based on the quantity and quality of evidence and the level of agreement regarding that evidence". (IPBES 2018: 41) "Well established" is used when there is much evidence and high agreement in "a comprehensive meta-analysis" or high agreement among multiple independent studies. "Unresolved" is applied when there are multiple independent studies but there is low agreement among them. "Established but incomplete" is assigned to findings with limited evidence but general agreement or the existing studies address the matter imprecisely. Finally, "inconclusive" applies to limited or no evidence with a recognition of major knowledge gaps and little agreement (see the four-box model for the assessment of confidence by the IPBES in Appendix). Thus, as the addressees read the "Summary for

Policymakers" they know that the authors have followed a thorough process to stipulate how certain and in which ways they are confident about a particular finding. However, most of the time, the addressees cannot know when they read the summary, if there are multiple independent lines of evidence or one robust study which enable the writers to pronounce themselves more or less confident about the finding. These elements are more developed in the report itself. There is a reference to specific parts of the reports for each discussed finding in each summary. The reports provide more information on the process of determining confidence about a finding. Analysing in what ways confidence terms are used in the reports compared to their presentation in the summaries for policymakers would offer an enlightening element to the study of the expression of certainty by the IPCC and the IPBES but it could not be carried in this project due to time constraints.

Scales of likelihood and confidence are used in the reports of other agencies. For example, in the US Global Change Program's "Climate Science Special Report" published in 2017, the authors use the scales of confidence and likelihood defined in the same words used by the IPCC and state that the authors of the report described overall reliability by using the two metrics developed by the IPCC (USGCRP 2018: 7).

The IPCC's and the IPBES' scales of confidence are expressed in italics within brackets inside or next to the sentences. The terms of likelihood are found within and without brackets in the writings of the IPCC. The IPCC specifies the level of confidence 181 times for 338 sentences which translates into a distribution of 54% of confidence terms compared to the number of sentences. The IPBES presents 179 terms for 316 sentences in its summary, which translates into a proportion of 57%. I have to admit that, as I was reading and analysing both texts, it seemed to me that the use of confidence terms was more systematic in the text of the IPCC than in the text of the IPBES. Perhaps some parts of the text of the IPBES are very dense with those terms while others are not. A more specific study of the repartition of those terms across the two summaries would provide more insight on the expression of certainty by the authors in the texts.

As the phrases *high confidence* and *low confidence* appear once each, outside brackets, the reader may wonder why the writers chose to present confidence terms in a different manner only twice: perhaps to emphasise the certainty about those predictions or they could be inconsistencies. However, two review sessions were dedicated to the proofreading of the "Summary for Policymakers" and it was approved line by line before its publication in October 2018, thus inconsistency seems quite unlikely to me. However, there are other sentences about predictions of precipitations, temperatures, melting of ice and other phenomena with comparative phrases about 2°C and 1.5°C and confidence terms are indicated within brackets next to the sentences. Furthermore, in the first extracted sentence below *generally* seems to diminish the specificity of the application of *low confidence* regarding the projection of heavy precipitation. This expression is perhaps a way to underline the fact that there are different lines of evidence and that there is an important lack of agreement among them.

> There is generally **low confidence** in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions. (SPMclim)
>
> There is **high confidence** that the probability of a sea ice-free Arctic Ocean during summer is substantially lower at global warming of 1.5°C when compared to 2°C. (SPMclim)

It is interesting to see how confidence terms are associated with other expressions of *certainty*. I will now focus on the association with implicit subjectivity and implicit objectivity which were studied earlier.

		May	*Might*	*Could*	*Will*	Total
Occurrences		10	2	12	9	33
Confidence	Very high	0	0	0	0	0
	High	5	0	2	8	15
	Medium	3	1	6	0	10

Table 29. The association of confidence terms with each epistemic modal auxiliary in absolute values in the "Summary for Policymakers" by the IPCC.

As can be seen in the table above, *may* is used in more sentences determined by *high confidence* than in those specified by *medium confidence.* This contradicts in some way the low value of *epistemic modality* which is attributed to this auxiliary in the framework I use. However, the auxiliary *could* is more associated with *medium confidence* than with *high confidence* and *will* is only associated with *high confidence* almost every time it is used. Thus, a possible conclusion could be that *may* is used to denote more certainty by the IPCC than when they use *could* or that the use of confidence terms is not directly linked to the use of epistemic modal auxiliaries in the sentence.

		May	*Might*	*Could*	*Will*	Total
Occurrences		12	1	11	14	38
Confidence	Well established	0	0	1	2	3
	Established but incomplete	2	0	5	3	10

Table 30. The association of confidence terms with each epistemic modal auxiliary in absolute values in the "Summary for Policymakers" by the IPBES.

The IPBES uses even fewer confidence terms with epistemic modal auxiliaries than the IPCC even though they use a few more auxiliaries in their text. This observation supports the hypothesis that the use of confidence terms is disassociated from the expression of *epistemic modality* with implicit subjectivity in the summaries for policymakers. There are very few *well established* and a few more *established but incomplete*. *Will* is more associated with *established but incomplete* than with *well established*. And *may* and *could* are mostly assigned with *established but incomplete* and not with *well established*.

		Be projected to	*Be expected to*	*Be estimated to*	*Be predicted to*	*Be likely to*	*Be unlikely to*	Total
Occurrences		36	3	3	0	1	2	45
Confidence	Very high	0	0	0	0	0	0	0
	High	14	0	0	0	1	1	16
	Medium	19	2	1	0	0	2	24

Table 31. The association of confidence terms with each expansion of the predicator in absolute values in the "Summary for Policymakers" by the IPCC.

		Be projected to	*Be expected to*	*Be predicted to*	*Be estimated to*	*Be likely to*	Total
Occurrences		10	8	0	3	1	22
Confidence	Well established	4	3	0	0	1	8
	Established but incomplete	4	2	0	2	0	8

Table 32. The association of confidence terms with each expansion of the predicator in absolute values in the "Summary for Policymakers" by the IPBES.

The IPCC definitively associate more implicit objective epistemic modality phrases than the IPBES. 67% of the expansion of the predicator are specified by confidence terms in the

IPCC's text while 36% of the expansion of the predicator found in the IPBES' text are associated with confidence terms.

The phrases *be projected to* and *be expected to* have been associated with the high value of *epistemic modality* when presenting the framework of analysis. As the tables above indicate, *be projected to* is attributed to almost as much *high confidence* (39%) as *medium confidence* (53%) in the IPCC's text and the proportion of association of this phrase with the terms *well established* and *established but incomplete* in the IPBES' text is the same (40% each). Regarding *be expected to*, the IPCC associate it with *medium confidence* twice (67%) and not with *high confidence* and the IPBES associate it more with *well established* (36%) than with *established but incomplete* (25%) even though the proportions are quite close.

To conclude, the IPCC associate more sentences denoting implicit subjective and implicit objective epistemic modality with confidence terms than the IPBES. I interpret the use of epistemic modality inside sentences and the use of confidence terms outside those sentences as unrelated in most cases.

4.1.7. Conclusions on the expression of certainty of knowledge

The following tables present the frequencies of the different orientations of *epistemic modality* for each text. I have ordered the columns of the tables from explicit subjectivity which is the overt commitment of the addressor towards an epistemic statement to implicit subjective modality then objective modality because among both the source of the epistemic modality is not as overt. Explicit objective modality is in fourth position because it clearly marks the source of epistemic modality as external to the addressor and this is also the case in most of the occurrences with lexical expression of *certainty* (LEXI).

Orientation/ Text	ES	IS	IO	EO	LEXI
RAclim	3	**62**	15	12	9
SPMclim	0	28	**57**	4	11
STclim	0	**62**	31	2	5
PAclim	0	54	17	8	21
RAbio	3	28	**62**	7	0
SPMbio	0	**50**	35	7	8
PAbio	0	**100**	0	0	0

Table 33. The frequency of the different orientations of *epistemic modality* for each text.

Orientation / Text	ES	IS	IO	EO	LEXI
RAclim	3	**62**	15	12	9
RAbio	3	28	**62**	7	0
SPMclim	0	28	**57**	4	11
SPMbio	0	**50**	35	7	8
STclim	0	**62**	31	2	5
PAclim	0	**54**	17	8	21
PAbio	0	**100**	0	0	0

Table 34. The frequency of the different orientations of *epistemic modality* for each text. The texts are gathered according to their attributed genre.

Implicit subjectivity is the most used orientation of *epistemic modality* in the corpus.

Implicit objectivity is the second most used orientation of epistemic modality in the texts. The expansion of the predicator which indicates the process at the origin of the certainty is used in great proportion in the IPCC's "Summary for Policymakers" and there are also several occurrences in the other texts. Only the popularisation article on climate change relies solely on modal adverbs and the research article on climate change uses slightly more modal adverbs than expansions of the predicator.

Explicit subjectivity is only found in scientific research articles. By using these structures, the writers specify their stance and reasoning in order to take responsibility and anticipate the readers' questions as has been presented in the explanation of hedging in section 1.2.1. Hedging is quite frequent in the texts, but I cannot use it to reference the occurrences in this project but I am fully aware of its presence in most of the texts, except for the popularisation articles. Hedges are often linked to the expression of low certainty, as lexemes conveying hedging were presented in 1.2.1.

The research articles do not have the same proportions of different orientations. This may be explained by the specificities of the disciplines and/or the styles of the authors and the topics of their texts. For example, the research article on climate change mentions the presence of uncertainty lexically while the other article does not.

As stated above, the "Summary for Policymakers" by the IPCC heavily relies on the use of expansion of the predicator while the "Summary for Policymakers" by the IPBES displays more modal auxiliaries. The "Summary for Teachers" uses in majority modal auxiliaries and they are mostly of high value: the "Summary for Teachers" express more confidence than the other texts. The popularisation article on climate change is the text that has the most varied use of modal devices while the other popularisation article only uses modal auxiliaries. This is quite striking at first, since they both belong to the same genre. This strong distinction can be explained by the fact that the popularisation article is less conventionalised than, for example, the research article genre as was described in section 1.2. The style of the two popularisation magazines from which the articles are extracted are quite different as well. The *New Scientist* is quite vivid and diversified while the *Scientific American* has a more serious outline and historically, it was one of the first popularisation magazines. At first, scientists wrote popularisation articles based on their findings. Nowadays specialised writers produce popularisation articles about the findings of other scientists. The popularisation article on climate change has a more conversational tone and thus uses more diversified devices which conveys a more personal tone as would be found in an informal conversation. The popularisation article on biodiversity has a repetitive pattern of "someone/such report says that … ". This article was first published in *Nature* which is a scientific journal, the nature of this journal can explain why the tone of writer is more impersonal and it is apparent because he does not diversify the use of structures expressing *epistemic modality*. On the other hand, modal auxiliaries are categorised as implicit subjective modality so they express some engagement from the writer in the expression of modality. Here, it is important to mention that most of the modal auxiliaries found in the article convey modality in statements attributed to other sources by the author. Thus, it is not sufficient to count modal auxiliaries to determine the expression of subjectivity or objectivity by authors in given texts; it is also necessary to study specifically to which source those auxiliaries are attributed. These attributions of information will be discussed in more detail in the next section.

4.2. The *sources* and *bases of knowledge*

In her study, Monika Bednarek uses the notions of *sourcing* and *basis of knowledge*. The *source* of a proposition "refers to the source to which knowledge can be attributed" and *basis of knowledge* refers to the evidence of the source's knowledge. (2006:639) Bednarek states that, in news writing, the *source* is commonly either the writer of the text called Self or a third party, named Other. It is also the case in the scientific texts that I study here. Bednarek presents an interplay between *sourcing* and *basis of knowledge*: a piece of information from Other is an *attribution* while an *averral* encompasses what comes from Self. The sentence below, is used to explain the repartition of *sources* in *attributions* and *averrals*:

> "We can no longer say that we did not know," she said. (PAbio)

She (IPBES executive secretary Anne Larigauderie or Other) is the *source* of "we can no longer say that we did not know" and the writer (Jeff Tollefson or Self) is the *source* of "'we can no longer say that we did not know,' she said". Every *attribution* is an *averral* because Self states that someone else said something: Self is responsible for the act of *attribution* and the content of the *attribution* has another *source* first. A *based averral* is an *averral* containing a *basis of knowledge* and a *non-based averral* is a piece of information expressed without its evidence. If I use the example above, a *non-based averral* will be "we can no longer say that we did not know".

To describe the *basis* of the *source*'s *knowledge*, Bednarek uses five categories: PERCEPTION, GENERAL KNOWLEDGE, PROOF, OBVIOUSNESS and UNSPECIFIED. PERCEPTION designates mental perception and inference, but also sensory perception and what Bednarek calls "showing". She does not provide an example of this last type in her article but, as will be explained later, I found some *bases of knowledge* of this type in my corpus. She considers those three elements under the same heading because there is mostly a difference of conceptualisation among them but ultimately, they are quite similar. An example from the corpus for the category of PERCEPTION would be:

> That is the message many **seem** to have taken from the latest IPCC report—but that is not quite what the report says. (PAclim)

Seem denotes the perception of the writer who is the *source*. The first meaning of *seem* is linked to sensory perception. However, in this sentence, the use of *seem* reflects more the mental process of the writer, who gathered information from the way several persons expressed themselves. He thus infers what many persons understood from the report.

OBVIOUSNESS conveys the perception of Self without a real idea of the process implied: the *basis* of the writer's *knowledge* "lies in the obviousness or self-evidence of what is modified" (2006: 641).

> Even if we are unsure of the exact value of the climate's sensitivity to carbon dioxide and other greenhouse gases, **it is clear that** what matters is how much is in the atmosphere. (PAclim)

Bednarek classified occurrences including *emerge* in the category UNSPECIFIED because there is no clear indication about the type of the process at the origin of knowledge. As will be shown later, I decided to classify *evidentiality* expressed by *emerge* in PROOF. GENERAL KNOWLEDGE marks the propositional content "of what is modified as based on what is regarded as part of the communal epistemic background shared by the audience and the writer" (2006: 640). I decided to use the terms "shared knowledge" instead of "general knowledge" because I focus on knowledge which is common to a discourse community: either the world community or a scientific or a political community. "General" is too vague, and the discourse community is not delineated in that manner.

> **The prevailing view** is that it will take many centuries or millennia. (PAclim)

PROOF is described as external, "hard proof" for Self to draw conclusions from.

> **The IPBES report finds** that the average abundance of native plants, animals and insects has fallen by at least 20% since 1900 because of invasive species. (PAbio)

The distinction with PERCEPTION is quite tenuous and it is the case in many contexts. Bednarek stipulates in her study that the limits between each category are sometimes fuzzy: they should be conceptualised as belonging to a cline rather than clearly delineated categories. This will be exemplified in the next sections. The linguist gathers these categories in three larger ones by making distinctions between the *bases* "inside" and "outside" Self. *Bases* "outside" Self are external to Self and they are construed as "publicly accessible opposed to the writers' own subjective experience." "The writers' own subjective experience" refers to *bases* "inside" Self. (2006: 648) Thus, OBVIOUSNESS and PERCEPTION are *based averrals* with *bases* "inside" Self, PROOF and GENERAL KNOWLEDGE are *averrals* with *bases* "outside" Self and ATTRIBUTIONS[38] encompass *bases* "outside" Self and a *source* which is other than Self. Even though this framework is designed for the analysis of news writing, it proved useful when analysing scientific texts. Some precisions and manipulations are necessary, but the tools enable a global vision of the distribution of *evidentiality* in the texts. I will mention these choices progressively in my analyses when required. I count ATTRIBUTION as a type of basis of knowledge because it represents the basis of knowledge for Self.

In scientific writing, there are also descriptions of the processes used to acquire knowledge which are not associated with the expression of a specific piece of information. I added this category as *basis of knowledge* even though it does not characterise directly an element of knowledge because it still participates in expressing where knowledge comes from. For example, elements expressing the acquisition of knowledge are linked to

[38] Unlike the other categories, *attribution* is not in capital letters in Bednarek's framework because it denotes another *source of knowledge* and marks a distinction between *averral* and *attribution*. However, it specifies a type of *basis of knowledge* for Self as well, thus, in this research project, I reference *attributions* as types of *basis of knowledge* for Self which leads to the presentation of this category of *basis of knowledge* in capital letters.

information presented in other sections of the same texts. In this section, there are also two parts dedicated to interesting phenomena found in the scientific texts: these elements are to some extent close to *evidentiality* but were not referenced as such. Firstly, the specific distribution of braces and brackets in scientific texts is particular. Secondly, the authors use linguistic elements to describe how they present their texts to their readers. I decided to present some of these structures because they contain elements used to express PERCEPTION in very similar configurations.

In the following sections, I present tables for the distribution of each category of *basis*. To do so, I calculated the frequency of occurrences of a type of *basis* compared to the rest of the occurrences of all *bases* in one text. The results are expressed in percentage and run down to the closest whole number for greater legibility.

4..2.1. OBVIOUSNESS

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
%	2	0	0	4	0	0	0

Table 35. Distribution of the occurrences of OBVIOUSNESS compared to other *bases* in texts.

A few occurrences of obviousness are found in the corpus. There are two phrases in the popularisation article on climate change and one in the research article on climate change.

> Amid the morass of confusing and conflicting numbers, two things remain **crystal clear**. (PAclim)
>
> **Clearly**, the relative changes in probability are larger for rarer, more extreme events. (RAclim)

In the first sentence, the writer amplifies the expression of the *basis of knowledge clear* by using the compound adjective *crystal clear*. In the second sentence, the adverb *clearly* qualifies the *basis of knowledge* expressed in the rest of the sentence. The reader knows that the propositional content is evident for the writer but does not really know how this content is initially acquired by the *source*.

4.2.2. PERCEPTION

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
%	24	0	0	6	20	5	4

Table 36. Distribution of the occurrences of PERCEPTION compared to other *bases* in texts.

PERCEPTION designates the basis of an *averral* which is inside Self. There are few occurrences of sensory perception and mental perception and some sentences with occurrences denoting the idea of “showing” in the corpus.

Sensory perception is expressed in the following sentence:

> These maps **look** very similar to those of 20-year events shown in Figure 2. (RAclim)

Look very similar to denotes the process through which the writer can state that the maps are similar to maps expressing projections of risk events predicted to occur every 20 year. It is different from:

> These maps **are** very similar to those of 20-year events shown in Figure 2.

By the use of *look* instead of *are*, the reader gains supplemental information that similarity among the maps is based on appearance and that the writers can draw conclusions thanks to their visual perceptions. *Shown* also adds information regarding the *basis of knowledge*.

Mental perception or inference is used when the addressor draws conclusions from what s/he knows. The following sentence belongs to this category:

> **Following current trajectories** this is likely to happen around 2040—sufficiently close that many scientists and politicians have adopted a somewhat different definition of hitting 1.5°C. (PAclim)

In this sentence, the writer makes an inference; he states the probability of something to happen at a specific date. He is able to make the inference because he bases himself on the current trajectories, he would not be able to make such a prediction without these elements.

Showing is not completely clear according to Bednarek’s explanations but I found many examples including *indicate* and *show* which refer to a perception of the *source*:

> The global map of present-day abundance-based biodiversity intactness (here illustrated through SSP3/RCP7.0) **shows** relatively low values throughout much of Western Europe and Eastern North America; however, the lowest levels are seen in areas where high population density overlaps with high land conversion, for instance, much of India and Northern China (Figure 3). (RAbio)

Nevertheless, there are some sentences in the research article on climate change which made me question the distinction between PERCEPTION and PROOF:

> In the case of both temperature and precipitation extremes, there is an overall shift toward higher values, corresponding to an increase in the location parameter, **reflecting** warming in the case of temperature and an increase in intensity in the case of precipitation. (RAclim)
>
> The scale parameter decreases for cold extremes in areas where snow and sea ice retreat, **suggesting** moderately lower variability in the warmer world in these areas but little change elsewhere. (RAclim)

In these two sentences, the authors interpret the results of their calculations. These results are publicly accessible and so, are external to the *sources*, who are the scientists who wrote the text: those results constitute "hard proof". They were produced by very specific calculations which were detailed and justified earlier in the article. The presentation and justifications of the methods used to calculate elements participate in the objectivity of the authors' approach. Furthermore, the authors present those results with agency: *suggest* denotes a mental process and should be associated to an animated subject but here the phenomenon is presented as imposing interpretation onto the authors and the readers. Thus, the addressors distance themselves as much as possible from their interpretations and present them as accessible to anyone who observes the results. However, the addressee reads that the authors drew conclusions from what they observed in their results thus there are visual and mental perceptions at work on publicly accessible hard proof. To me, here PERCEPTION and PROOF are quite close: elements of both categories are combined and the distinction between the two is very tenuous. I found that mental perception prevails over the external nature of the elements discussed. This remains an interpretation presented as imposed by the results, the writers do not use a structure which would express more explicitly their relation in the interpretation such as:

> **We** conclude from the decrease of the scale parameter for cold extremes in areas where snow and sea ice retreat, **that there will be** moderately lower variability in the warmer world in these areas but little change elsewhere.

The manner in which the authors express their conclusions as they present the produced data is linked to the tradition of research writing where objectivity prevails and agency is usually attributed to results and concepts in order to diminish the scientists' presence and thus their subjectivity.

I classify those sentences found in the article on climate change as PERCEPTION rather than PROOF because the subjective aspect of the interpretation is a little stronger to me even if it is presented as highly external to the *source*.

I will present one more occurrence of a way to express PERCEPTION in a non-conventional manner:

> Global mean abundance-based BII in 2015 **is estimated to** be 0.785 (Table 1), with all regions apart from Central Africa predicted to have a value of less than 0.90 (the proposed safe limit: Steffen et al 2015). (RAbio)

Here, the *basis of knowledge* does not contain the expression of an evidence that is read or seen by the writer. Instead, the table shows predictions for given data and the writers offer the reading and interpretation of these tables in the results section. They use the vocabulary of prediction because this is what their calculations are designed for. The action of reading the table is implicit, thus, the perception of the results of the calculations is also implied and this phenomenon belongs to PERCEPTION. Results of calculations are presented in tables and figures for more clarity because multiple values were processed. There is a fine line because, as stated before, the calculations are justified and presented as objective. Therefore, their results represent external hard proof publicly accessible, which corresponds to the concept of PROOF in Bednarek's framework. However, in the context of reading results from tables and drawing conclusions, the situation also belongs to PERCEPTION.

PERCEPTION is mostly found in the results and discussion sections of the research articles because the authors describe the tables and figures which present the results of their calculations. On the contrary, summaries for policymakers which also contain graphs and other figures do not describe explicitly in their body texts what is represented in the tables and figures because these elements are present for illustrative purposes mostly, as the texts are the syntheses of many studies[39]. Their body texts are not dedicated to the analysis and the descriptions of the figures. However, captions in the "Summary for Policymakers" by the IPBES draw some conclusions which correspond to PERCEPTION:

[39] For example, in the "Summary for Policymakers" by the IPCC, only four scenarios of mitigation to 1.5°C are represented in a figure while none of 2°C is depicted. The figure is illustrative but does not comprehend all possible scenarios, the authors only chose a few of them.

Figure 1. Global trends in the capacity of nature to sustain contributions to good quality of life from 1970 to the present, which **show** a decline for 14 of the 18 categories of nature's contributions to people analysed.

PERCEPTION is found in one of the popularisation articles, it is used to express the author's perception of scientific authors (see example in 4.2.) and it is absent from the other texts. The "Summary for Teachers" contains figures with recapitulating elements but there are no specific numbers to analyse and present to the reader.

4.2.3. PROOF and SHARED KNOWLEDGE

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
PROOF	0	0	0	14	8	2	64
SHARED KNOWLEDGE	17	0	54	17	1	0	0
PROOF /SHARED KNOWLEDGE	0	92	0	0	0	92	0

Table 37. Distribution of the occurrences of PROOF and SHARED KNOWLEDGE compared to other bases in texts.

The distinction between PROOF and SHARED KNOWLEDGE is quite tenuous in scientific writing; I will present the particularities of those two categories in the next paragraphs.

PROOF is mostly represented in the popularisation articles. The author of the article on climate change mentions a few studies and what knowledge they transmit while the second article mainly bases the expression of knowledge on referring to scientific studies and the findings they made.

A <u>1990</u> report concluded that limiting global warming to 1 °C would be safer than a 2°C cap. (PAclim)

But as an October report on this target by the Intergovernmental Panel on Climate Change (IPCC) makes clear, it is not a safe limit. (PAclim)

The report also **finds** that agricultural activities have had the largest impacts on ecosystems that people depend on for food, clean water and a stable climate. (Pabio)

The reporting verbs *concluded* and *makes clear* and their subjects bear the marks of *bases of knowledge*. Every study and report mentioned are qualified by an adjective or determined by a nominal group or a clause when they are first introduced in the texts (they are underlined in the examples). There is one occurrence in which the author refers to several unidentified studies, in this case, no adjective or nominal phrase is added to the noun *studies*:

> **Studies converge** on the most likely value being 3°C, but with plausible values ranging from under 2°C to more than 5°C. (PAclim)

This example is close to SHARED KNOWLEDGE because of the indefiniteness of the studies and the idea of unity expressed by *converge*.

In the research article on biodiversity, the results of the authors' analyses presented in the abstract were referenced as PROOF. This presentation is referenced as PROOF because it is distinguished from the process of interpretation of the results presented in the results and discussion parts which belongs to PERCEPTION as presented above.

> SSP4/RCP3.4 (with high biofuel mitigation**) is predicted to** see two times the decrease in abundance-based biodiversity intactness and three times the decrease in local species richness between 2015-2100 as **is predicted for** SSP4/RCP6.0 (with lower levels of mitigation). (RAbio)

There are also two references to other studies which I count as PROOF because they are external evidence to the writers:

> This decision allowed Newbold et al (2015) **to estimate** that land use and related pressures have reduced average local species-richness across the world's terrestrial assemblages by 13.6%, with most of the decline concentrated in the 20th century. (RAbio)

In the scientific research community, scientists base their theories and calculations on what has previously been discovered. In the scientific texts studied in this corpus, it is sometimes unclear whether a *basis* inscribes a piece of information in the categories of PERCEPTION or PROOF, when authors present the results of their studies, but also in PROOF or SHARED KNOWLEDGE, when scientists mention the results of others' studies. This is especially the case in the summaries of reports because the authors of the reports focus on the data which was produced by the whole scientific community and they present a global assessment of the studies. The summaries are written by scientists who took part in the writing processes of the reports and they belong to the same organisation. There is no part in the texts where the writers state what *they* exactly did except in the captions because the figures and tables are the products of their syntheses. I decided to reference mentions of *basis of knowledge* as SHARED KNOWLEDGE and PROOF for the summaries for policymakers when the origin is not clearly stipulated and attributed to a vague entity.

> In energy systems, **modelled global pathways (considered in the literature)** limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b) generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (high confidence). (SPMclim)
>
> **In 1.5°C pathways with no or limited overshoot,** low-emission energy sources are **projected** to have a higher share, compared with 2°C pathways, particularly before 2050 (high confidence). (SPMclim)
>
> For terrestrial systems, **most studies indicate that** South America, Africa and parts of Asia will be much more significantly affected than other regions, especially in scenarios that are not based on sustainability objectives (see Figure SPM.8 as an example). (SPMbio)
>
> **A summary of the evidence related to the components of pathways to sustainability suggests that** there are five overarching types of management interventions, or levers, and eight leverage points that are key for achieving transformative change (Figure SPM.9; D3 and D4 above) {5.4.1, 5.4.2}. (SPMbio)

Since the IPBES also include indigenous knowledge, the scientific community is sometimes extended to knowledgeable people in aboriginal populations but usually SHARED KNOWLEDGE designates knowledge of the international community of hard and soft sciences researchers.

There is only one occurrence in the summary for policymakers by the IPBES were the authors present a specific study and the knowledge it provided to its readers:

> **The Living Planet Index**, <u>which synthesises</u> trends in vertebrate populations, **shows** that species have declined rapidly since 1970, with reductions of 40 per cent for terrestrial species, 84 per cent for freshwater species and 35 per cent for marine species (established but incomplete) {2.2.5.2.4}. (SPMbio)

The other occurrences designate the type of study or prediction but not the producers and this is why I conceptualise them as SHARED KNOWLEDGE because the authors emphasise the knowledge gained by the scientific community thanks to studies and they give elements about the nature of these studies but not who conceived them. Once again, the distinction is quite thin.

> In **modelled** 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal **shows** a steep reduction in all pathways and would be reduced to close to 0% (0–2% interquartile range) of electricity (high confidence). (SPMclim)

Pathways in the IPCC's and IPBES' texts designate scenarios. The IPCC presents scenarios of emissions for a global warming which does not overshoot 1.5°C or they overshoot this temperature in limited proportions, or they overshoot 2°C. They do not use other terms than *pathway* compared to the IPBES which uses more *scenarios*, but also *pathways* and *trajectories* a few times. The use of the term is stricter in the IPCC's summary because the pathways are at the core of the answer to the question asked at the COP21 in 2015 and that is at the origin of this Special Report. The variety in the IPBES' text could be explained by the fact that it is a global assessment and not a report answering one specific question. To present the outcomes of different scenarios to policymakers is always useful but it is not the focus of this text.

There are three occurrences with *emerge* in the corpus, I referenced them with PROOF because they are external proof for the writers to interpret, so the proximity with PERCEPTION is undeniable.

> A similar picture also **emerges** from an entirely separate line of evidence. (SPMbio)

Since the writer of the popularisation article on climate change explains how scientific knowledge concerning climate change is acquired, there are several phrases which belong to SHARED KNOWLEDGE in this text. Some examples below:

> **The prevailing view** is that it will take many centuries or millennia. (PAclim)

> Antarctica is already losing ice much faster than expected. (PAclim)

In the first sentence *prevailing view* encompasses most of the scientific opinions regarding the time it will take for the world to be 3 or 4°C warmer and sea levels to rise above 20 metres. In the second sentence, the author refers to a phenomenon which is known by scientists and laypersons thanks to scientific measurements and the projections are not consistent with what is measured. This sentence contains a connection between two types of knowledge concerning the scientific community.

The "Summary for Teachers" is a text which summarises a report written by another organisation. The authors of the "Summary for Teachers" specify in the introduction where the data originate from. Because the origin of the data presented in the introduction is not used to qualify elements of knowledge, I did not count it as SHARED KNOWLEDGE but DESCRIPTION OF ACQUISITION OF KNOWLEDGE. The distribution of this category will be detailed later. In the body text, there are occurrences of *basis of knowledge* belonging to SHARED KNOWLEDGE; they are mainly adjectives. They denote the estimations and models which have not been effected by the OCE but can be accessed by them as by many other persons. The OCE take information from the IPCC's report which presents everything as part of SHARED KNOWLEDGE. As stated before, the studies and data discussed in the IPCC and IPBES summaries are between PROOF and SHARED KNOWLEDGE. However, I referenced the evidence mentioned in the "Summary for Teachers" as solely SHARED KNOWLEDGE because the actual proof for the writers of the OCE is the report of the IPCC. The pieces of evidence in the IPCC's report become SHARED KNOWLEDGE for the readers.

> However, **estimates** vary as to what the timing and size of these contributions will be. (STclim)
>
> **Current estimates** range between 25 centimetres to over a meter by 2100, depending in part on how much we emit in the future. (STclim)

4.2.4. ATTRIBUTION

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Attribution hearsay	3	0	0	19	0	0	32
Attribution indetermined	0	0	0	4	0	0	0

Table 38. Distribution of the occurrences of ATTRIBUTION compared to other bases in texts.

ATTRIBUTIONS encompass propositions uttered by another *source* than Self and thus represent external *bases* for Self. *Say* is the reporting verb is mainly found in articles presenting ATTRIBUTIONS. This verb is used with and without quotation marks. The presentation in the popularisation article on biodiversity is intriguing because some sentences have quotations marks while others do not, even though the structure is the same.

> **“**We have never had a single unified statement from the world’s governments that unambiguously makes clear the crisis we are facing for life on Earth,**” says Thomas Brooks**, chief scientist at the International Union for Conservation of Nature in Gland, Switzerland, who helped to edit the biodiversity analysis. (PAbio)

> Despite those shortcomings, the IPBES report will help to set the agenda when governments negotiate new conservation goals for the next decade at the UN Convention on Biodiversity next year, **says Brooks**. (PAbio)

The variation is intriguing; perhaps the author made a stylistic choice.

Other reporting verbs are also used in the popularisation article on climate change as shown below whereas the popularisation article on biodiversity only uses the verb *say*.

> Earlier this year, some climate scientists **warned** that we could be greatly underestimating the risks and that if the planet did warm by at least 2°C, it might be impossible to stop it warming several further degrees. (PAclim)

Bednarek does not mention the use of quotation marks in her article. I conceptualise a quotation of someone’s speech or writings as ATTRIBUTION because to reproduce the exact words used by someone else severely diminishes the active role of Self. The *source* of the text presents the statements of another *source*. Here, the quotation only applies to a part of the sentence but this partial quotation should also be classified as ATTRIBUTION.

> About 75% of the planet’s land and 66% of its ocean areas have been **“**significantly altered**”** by people, driven in large part by the production of food, **according** to the IPBES report, which will be released in full later this year. (PAbio)

There is another type of ATTRIBUTION in the popularisation article on climate change:

> Climate change deniers have gleefully pointed out that **we have been told** several times before **that** there are just X years to save the planet. (PAclim)

> Just about every article you’ll read about climate change is full of numbers, starting with 1.5°C, the number **that we are told** represents the maximum temperature rise we can allow and still avoid the worst effects of global warming. (PAclim)

The use of passive constructions with we, *we have been told that* and *that we are told* implies that the scientific community and the media repeat the scientists' opinions and findings for the global community but there is no clear identification of the *source* as opposed to the other ATTRIBUTIONS referenced. In the first sentence, there is another type of ATTRIBUTION as well, *climate change deniers* is the *source* of *we have been told several times before that there are just X years to save the planet.* The reporting verb *pointed out* expresses the *basis of knowledge* available to the writer who is the *source* of the whole sentence: *Climate change deniers have gleefully pointed out that we have been told several times before that there are just X years to save the planet.*

It is also interesting to analyse the use of other *bases of knowledge* in ATTRIBUTIONS:

> "We have never had **a single unified statement from the world's governments that unambiguously makes clear** the crisis we are facing for life on Earth," says Thomas Brooks, chief scientist at the International Union for Conservation of Nature in Gland, Switzerland, who helped to edit the biodiversity analysis. (PAbio)

Because Brooks mentions a statement from a more or less identified *source* it is difficult to choose between PROOF or ATTRIBUTION. I would classify it as an ATTRIBUTION because the interpretation of Brooks is severely limited as the statement *unambiguously makes clear* what we face.

4.2.5. DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
For the text	51	8	46	0	71	18	0
Shared knowledge	3	0	0	27	0	0	0
In other studies	0	0	0	8	0	0	0

Table 39. Distribution of occurrences of ACQUISITION OF KNOWLEDGE compared to other bases in texts.

The description of the acquisition of knowledge is essential in scientific discourse because the way the authors gained knowledge is key when assessing the accuracy and quality of a study or experiment and thus their results. In research articles with the traditional IMRD structure, the methods part is completely dedicated to the narration of the stages effected in order to design the calculations to gain the desired knowledge. As can be seen in the table, the DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE represents more than half of the *basis of knowledge* in research articles, which is in alignment with the tradition in scientific discourse community. Writers want to diminish their personal implication in the studies and demonstrate how objective and justified their approaches are. Thus, in research articles, the methods section is often long and presents the different steps leading to the production of knowledge aimed at by the authors. The expressions in those sentences are not associated to specific expressions of knowledge but they definitively need to be categorised as *evidentiality*. The *basis of knowledge* in this nature is mainly expressed by passive constructions which imply the action of the scientists or the machines.

> The statistical models linking biodiversity to drivers **are underpinned by** a large global and taxonomically broad database of terrestrial ecological communities facing land-use pressures (Hudson et al 2014, 2017). (RAbio)
>
> The global mean temperature change **is defined here** relative to the global mean temperature in years 1861–1880 of the historical simulations, which is a period with little volcanic activity and when the cumulative emissions of greenhouse gases from human activity remain small compared to the present. (RAclim)

The authors also explicitly present what they did by using the first person plural personal pronoun with an activity verb, but the proportion is much smaller compared to passive constructions in the texts studied.

> **We use** multimodel median values, which are less sensitive to outliers than the multimodel mean values. (RAclim)
>
> First, **we apply** the PREDICTS modelling framework for the first time to the five Shared Socioeconomic Pathways (SSPs: Riahi et al 2017) developed as part of the sixth round of Intergovernmental Panel on Climate Change (IPCC) reports. (RAbio)

There are a few occurrences with an inanimate subject such as a study or a model:

> <u>The simulations</u> **include** both the historical simulations (years 1860–2005) and future climate projections (years 2006–2100) under different greenhouse gas and aerosol forcing scenarios, namely, RCP 2 6, 4 5, and 8 5 (see ref van Vuuren et al , 2011 for details). (RAclim)
>
> <u>The compositional similarity model</u> **followed** the framework outlined in De Palma (2018). (RAbio)

Since the popularisation article on climate change asks and answers several questions regarding the evolution of climate change and how it can be measured, there has to be descriptions of the acquisitions of knowledge without specific elements of knowledge. The acquisition of knowledge is mainly expressed when the author presents, among other elements, how different organisations measure temperatures and what data is kept for measuring the progression of climate change. This leads to the presentation of the acquisition of knowledge for the scientific community which I distinguish from the specification for acquisitions of knowledge for particular studies. Their distributions are presented in the table above. In the examples below, the first sentence refers to scientific community while the second presents elements for specific individual studies:

> We get an idea of how this temperature is changing from thousands of weather stations on land, and from ships and buoys at sea. (PAclim)

> **The HarCRUT temperature record**, **maintained by** the UK's Met Office, simply **leaves** the Artic **out**. (PAclim)

In the introduction of the "Summary for Teacher", the writers explain that the text is the summary of the IPCC's report and they explain how the report was written and who did it.

> The IPCC works by **assessing already published literature** rather than conducting its own scientific research. (STclim)

> **Taking two years to produce and written by 74 scientists** from 40 countries, the report was finalised and adopted by all IPCC member governments in Korea in October 2018. (STclim)

In the summaries for policymakers, I mostly found elements in the captions.

> Figure SPM.1 | Panel a: **Observed** monthly global mean surface temperature (GMST, grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) change and **estimated** anthropogenic global warming (solid orange line up to 2017, with orange shading **indicating assessed** likely range). (SPMclim)

> Figure 6. Summary of progress towards the Aichi Targets. Scores are based on a quantitative analysis of indicators, a systematic review of the literature, the fifth National Reports to the Convention on Biological Diversity and the information available on countries' stated intentions to implement additional actions by 2020. (SPMbio)

4.2.6. Referencing with braces and brackets

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
{}	0	30	0	0	0	73	0
()	14	7	0	0	49	6	0

Table 40. Distribution of the occurrences of brackets and parentheses compared to the number of sentences per text.

Attention should be paid to those typographic elements which enable different textual functions and mostly because the use of braces in the summaries for policymakers is quite peculiar. The braces enable references to the appropriate chapters of the reports for more information regarding what is mentioned in the summaries. There are 102 series of references within braces for 338 sentences in the “Summary for Policymakers” by the IPCC and 232 references to chapters of the report between braces in the summary by the IPBES for 318 sentences. This represents a striking difference between the two texts which can be explained by the fact that the report of the IPBES (1500 pages) is much longer than the report of the IPCC (600 pages). The IPBES’ report is a global assessment report while the IPCC’s report is a Special report: the latter is designed for a specific question while the former must offer a comprehensive and possibly exhaustive view on the elements regarding biodiversity preservation. They do not have the same goals and the coverage of the IPBES’ report is more extended, especially because the text is the second intergovernmental report and the last international global report was in 2005. Braces are not used in the other texts of the corpus.

Concerning brackets, in the summaries for policymakers, I did not reference the pairs of brackets which contain the scales of confidence because it is something different and it was explained in 4.1.. In this section, I only referenced the brackets used to refer to figures and tables displayed in the texts under scrutiny and the brackets referring to other studies with the main author’s name and the year of publication. In the research articles of the corpus, most of the references in brackets seem to support the claims made by the authors or they correspond to the studies addressees should read for more elements on the concepts used in the articles which are not always defined in the analysed texts.

> The fixed effects model structure was selected using backwards stepwise selection based upon AIC values **(Zuur et al 2009).** (RAbio)

These probability ratios **are referred to as** “risk ratios” **in the event attribution literature (e.g. NAS 2016),** even though they do not characterize relative risks in a very comprehensive way. (RAclim)

Thus, I referenced the use of brackets indicating a year as PROOF, SHARED KNOWLEDGE or DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE when appropriate. It can be added that there is a sharp distinction of proportion of this type of brackets among the two research articles which can be explained by the fact that the research article on biodiversity discusses its methodology and results in comparison with other articles produced by the same authors.

Our global estimate of mean abundance-based BII, at 0. 785, is somewhat lower than the 0.846 estimated by **Newbold et al. (2016).** (RAbio)

On the contrary, the authors of the research article on climate change do not compare it to other studies but they refer to frameworks they have adopted in former studies.

We follow the approach of **Kharin et al. (2013)** and references therein for the analysis of climate extremes.

As the authors of the research article on biodiversity detail the protocol to acquire knowledge, they make references to other studies (38 for 105 sentences) more frequently than the writers of the research article on climate change (28 for 153 sentences).

The scientists also refer to the figures and tables in the texts with brackets; these elements were most of the time linked to PERCEPTION.

A comparison of abundance-based BII in 2015 and 2050 reveals increases over much of Western Europe but declines over much of Central and Southern Africa **(Figure 4).**

In the research articles, it represents a small amount of the brackets used for references inside or outside the texts compared to the summaries for policymakers. These types of references show the importance of illustration of calculations and analyses to justify the authors’ conclusions.

In the “Summary for Teachers”, the authors refer twice to the report “Global Warming of 1. 5°C” in square brackets even though they specified in the introduction that the information presented in this summary were extracted from the report.

It would lead to the relocation of up to 10. 4 million people **[Special Report 5°C, Chapter 3, p8].**

4.2.7. Precisions regarding the presentation of the results for the addressees

In connection to the use of brackets indicatinf appropriate figures and tables to read, the authors in the captions of their figures and tables produce sentences which are quite similar to sentences denoting PERCEPTION but they have other functions in the texts. I decided to highlight this aspect but not to reference it as part of *evidentiality* because it differs from it since the sentences have an explanatory and not a describing function.

Several constructions containing the verbs *show* and *indicate* are used to describe the tables and what they represent. The first sentence describes the figures displayed in the table, what the values of the figures mean for the predictions of the scientists:

> The SSP/RCP combinations allow the examination of how differing socioeconomic scenarios will impact biodiversity at global and regional scales SSP1/RCP2.6 **shows** both an overall global positive response in biodiversity intactness and broadly consistent positive responses within regions (Figure 1B). (RAbio)

Other sentences explain to the reader what the lines and colours used for the representations of the results mean and do not offer the interpretations of these results. *Show* and *indicate* are not used to express projections or interpretations but to present figures and guide the readers.

> PDFs estimated for the preindustrial climate (**black curves**), and for 1°C (**blue**), 1.5°C (**green**), and 2°C (**red**) global warming **are shown.** (RAclim)

> Trend from 1800 to 2100. Extent of variation between SSP/RCP future projections **indicated by shaded areas**. (RAbio)

> The image in the centre of the above figure **shows** the global overlap between 1) land areas traditionally owned, managed , used or occupied by indigenous peoples; 2) formally designated protected areas; and 3) remaining terrestrial areas with very low human intervention (areas that score <4 on the Human Footprint Index). (SPMbio)

4.2.8. Conclusions on the use of *bases of knowledge* in the corpus

Texts	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
OBVIOUSNESS	2	0	0	4	0	0	0
PERCEPTION	17	0	0	6	20	5	4
PROOF	7	0	0	14	8	2	64

SHARED KNOWLEDGE	17	0	54	17	1	0	0
PROOF/SHARED KNOWLEDGE	0	92	0	0	0	75	0
ATTRIBUTION	3	0	0	24	0	0	32
DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE	54	8	46	35	71	18	0

Table 41. Distribution of types of *basis of knowledge* compared to other bases in texts.

The different types of ATTRIBUTIONS and DESCRIPTIONS OF THE ACQUISITION OF KNOWLEDGE are displayed under a common heading for each category.

In this section, I presented the classification of *evidentiality* into six categories and mentioned two other aspects which are linked to a certain extent to *evidentiality*. In some cases, choices of classification are less evident than in other cases, but the study still offers a global view on the distribution of the different *bases of knowledge* in the corpus.

PERCEPTION is mostly used in the two research articles; the authors present their interpretations as they read the results of their calculations. Another *basis of knowledge* which is the most represented in the research articles is the DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE. The fact that these two bases are mostly found in research articles corresponds to the tradition of scientific research community and the aims of research articles which is to present in a detailed manner how the scientists designed their studies in order to justify the consistency and quality of their work. Occurrences of the DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE are relatively important in the "Summary for Teachers" because there are not many occurrences of *evidentiality* in the text and the only other type of *basis of knowledge* is also represented by a few occurrences only. Once the authors of this summary have specified that most of the information comes from another report, they do not specify further the origin of the pieces of information they present in the text because the global source is the IPCC's report which synthesises studies. The summaries for policymakers do not have a large proportion of DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE because the working groups have synthesised many studies for the reports that specifying the sources would diminish the legibility of the summaries. Nevertheless, they enable readers to get more information by specifying which part of the reports correspond most to the statements by indicating those references within braces. The popularisation article on climate change presents some aspects of the way PROOF and SHARED KNOWLEDGE are acquired because it is part of the questions linked to climate change, which the article aims at answering. The “Summary for Policymakers” by the IPBES has a more diversified distribution of *bases of knowledge* compared to the summary produced by the IPCC. This difference could be explained by the fact that the reports do not have the same goals: one of them is a global assessment report presenting all acquired knowledge regarding biodiversity while the other answers one specific question in a very detailed manner. The IPBES is also more recent than the IPCC; it was founded 24 years later. Perhaps the IPBES display a less strict way to present knowledge than the IPCC because it is their first global assessment and they do not benefit from several reports and evaluations of them over three decades as the IPCC do. Finally, the popularisation articles present antagonised distributions of *bases of knowledge*: the popularisation article on climate change has the most diversified use of *bases of knowledge* in the corpus while the other popularisation article does not present so many different types of *bases of knowledge*. This can be explained by the fact that the genre of the popularisation article is not as conventionalised in terms of linguistic terms and structure as the genre of the research article is for instance. Furthermore, the popularisation article on biodiversity was first published in *Nature* which is a science journal, therefore it follows a scientific and impersonal way of presenting information which has already been mentioned when studying the expression of *certainty*.

4.3. *Basis of knowledge* and *certainty*

It would be enlightening to study the distribution of *epistemic modality* and *evidentiality* together within the corpus; to see if certain types of *basis* are more frequent with certain orientations or values of *epistemic modality*. I will not be able to present such analyses in this research project due to time constraints. Nevertheless, I would like to express a remark regarding the meaning of *epistemic modality* expressed with different *sources*.

When the writers use epistemic modal phrases to present their interpretations of their results, the verbs *suggest, reflect, indicate* are used with subjects denoting modelled phenomena and figures. In fact, such verbs target what the authors present tentatively and demonstrate the fact that the addressors accentuate objectivity by not expressing explicitly their presence.

> The scale parameter decreases for cold extremes in areas where snow and sea ice retreat, **suggesting** moderately lower variability in the warmer world in these areas but little change elsewhere. (RAclim)

While in the popularisation articles, the authors associate reporting verbs with higher epistemic value *makes clear*, *conclude* to other sources and thus the value of the *epistemic modality* expressed does not come from the same *source*.

> A 1990 report **concluded** that limiting global warming to 1 °C would be safer than a 2°C cap. (PAclim)

4.4. Conclusions on the expression of knowledge

Observations regarding the expression of knowledge through *certainty, bases and sources of knowledge* were presented in this chapter. These elements help characterising the authors' stances towards climate change and biodiversity preservation. As was pointed out in different parts of the chapter, there are possible extensions of the study of expressing knowledge in the texts. Other elements of study can be added to inform on the addressors' enunciative commitment: among them the expression of necessity, implications and the use of personal pronouns will be presented in the next chapter.

5. Other linguistic analyses

In this chapter, I will present my observations on implicative constructions and the modal auxiliary *would* (5.1.), the expression of necessity (5.2.), and the distribution of personal pronouns in the corpus (5.3.).

5.1. Implications

5.1.1. *Would*

In the different studies I have read, *would* is not described as one of the modal auxiliaries used to express *epistemic modality*. Nevertheless, it is relevant to comment its use in the corpus because it is linked to projections. As the IPCC stated it: many projections are conditional and depend on other outcomes and the authors must be careful about the way they express probabilities (IPCC 2018: 77). Larreya and Rivière (2014) describe *would* with a "valeur de conditionnel"; it is the "conséquence d'une hypothèse non réelle"[40]. The addressor positions him/herself regarding the true or false character of the hypothesis. It denotes an implication: the predicate is linked to a condition. The hypothesis can be irreal or very unlikely (114-5). According to Larreya and Rivière, the context should reveal to the addressee whether the hypothesis is irreal or unlikely. Quirk et al. (2010: 233-4) describe a similar possible interpretation of *would*: the modal auxiliary can mark a hypothetical meaning with an unreal condition and sometimes this unreal sense is weakened to express something similar to "improbability". The linguists add that sometimes the condition is implicit. Larreya and Rivière (2014: 86) also present implicative modality which is part of epistemic modality: it does not encode a degree of probability, but necessity is based on an implication, therefore, there is a condition. However, there is no specified link between *would* and implicative modality in Rivière and Larreya's framework. Thus, in this section, I will focus on the uses of *would* and implications expressed in sentences with epistemic modal auxiliaries studied in 4.1..

Text	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
%	6	24	50	9	3	6	2

Table 42. The distribution of *would* in the corpus.

The proportion of occurrences of *would* in each text is calculated in comparison with the number of occurrences in the other texts.

[40] "Value of conditional; it is the consequence of an unreal hypothesis".

When reading the summaries for policymakers, the addressees know the global context of the documents and their goals which are to present current states of affairs and make projections. These predictions depend on what could happen but there are many uncertainties regarding linked factors, thus the writers present hypotheses. When the writers use *would* in hypotheses instead of *will*, which conveys a higher degree of probability than *would*, they echo the tradition of scientific discourse where writers present information in a tentative and humble manner and do not seek to unduly influence their readers. In these projections, especially in the summaries for policymakers, many parameters influence the outcomes of given hypotheses and many of the outcomes will depend on the choices of decisionmakers who are the readers mainly targeted by those texts. The outcomes will depend on their choices to implement laws and actions aligned with the intergovernmental predictions. Nevertheless, other factors can influence the results as well, therefore it reinforces the use of tentative elements, like *would*, which are frequently present in scientific discourse. When comparing the distribution of *will* and *would,* more occurrences of *will* are found in the IPBES' summary, whereas the IPCC's text contains more occurrences of *would.* This distribution could be explained by the slightly different purposes of the reports from which the summaries are produced. The IPCC's Special Report shows different scenarios regarding global warming of 1.5°C and 2°C while the IPBES' global assessment report is more focalised on presenting the current state of affairs in the world rather than detailed predictions for the following years -at least not in the summary, there may be more specific predictions with hypotheses in the report itself. The "Summary for Teachers" presents many hypotheses as well, linked to scenarios of 1.5°C and 2°C global warmings.

I classified the uses of *would* in three types: hypotheses with low probability, irreal hypotheses and past form of *will* used in indirect reported speech.

	Low probability hypothesis	Irreal hypothesis	Past form of *will*
%	89	10	1

Table 43. The different uses of *would* in the corpus.

Only 10% of the occurrences denote a situation that is clearly irreal:

> In fact, <u>without greenhouse gases</u>, the average temperature of Earth's surface **would** be about -18°C rather than the present average of 1.5°C. (STclim)

Similarly, it is likely that at least 6 species of ungulate (eg, the Arabian Oryx and Przewalski's Horse) **would** now be extinct or surviving only in captivity <u>without conservation measures</u>. (SPMbio)

There is one past form of *will* used in indirect speech but *would* could also be used in the deduced direct speech:

A 1990 report concluded that limiting global warming to 1 °C **would** be safer than a 2°C cap. (PAclim)

Would is associated with other elements which express conditions and thus implication. The most common manner to express a condition is a subordinate clause including *if*.

If you were doing a bungee jump, this would be equivalent to the length of rope with which you would exactly smash into the ground. (PAclim)

However, the addressors use other phrases to present conditions and *if* represents a small portion of the elements used to express implication. I did not have enough time to reference thoroughly the proportions of the different devices used to express implications in the texts; however, I will present some representative examples. There are many deverbal nouns and progressive forms of verbs implying "if global community did …":

Future climate-related risks **would** be reduced **by the upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by both incremental and transformational adaptation** (high confidence). (SPMclim)

The sentence can be approximately rephrased as follows: *if the decision making community worked to improve and accelerate climate mitigation both incrementally and transformationally then climate related risks would be reduced.* With the construction they adopted, the authors refer to the global community without explicitly mentioning them, and in doing so they use a polite way to make suggestions without targeting anyone in particular.

There are some occurrences of the anaphoric *such* and demonstrative pronouns referring to elements presented in the preceding sentences which indicate a condition in connection with the predicate expressed via the modal *would* in given sentences:

1.5°C pathways that include low energy demand (e.g., see P1 in Figure SPM.3a and SPM.3b), low material consumption, and low GHG-intensive food consumption have the most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs (high confidence). **Such pathways** would reduce dependence on CDR. (SPMclim)

This would involve large and rapid emission reductions worldwide and throughout society, including changes in behaviour and lifestyles. (STclim)

Like the other modal auxiliaries studied in 4.1., the degree of probability expressed by *would* is not linked to the confidence terms specific to the IPCC's and IPBES' texts. As can be seen in the table below, the distribution of confidence terms with sentences containing *would* is quite varied:

Confidence terms	*Very high*	*High*	*Medium*	No confidence term
%	10	52	38	0

Table 44. The proportions of the associations of confidence terms with sentences including *would* in the IPCC's "Summary for Policymakers".

Confidence terms	*Well established*	*Established but incomplete*	No confidence terms
%	40	20	40

Table 45. The proportions of the associations of confidence terms with sentences including *would* in the IPBES' "Summary for Policymakers".

Few occurrences associate clauses containing *would* with others containing *even if*.

Even if we can somehow stop all carbon dioxide (CO2) emissions to the atmosphere immediately, global temperatures **would** stabilise but not decline—it takes centuries or millennia for the CO2 already present in the atmosphere to be removed by natural processes. (STclim)

Pathways reflecting these ambitions **would** not limit global warming to 1.5°C, **even if** supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (high confidence). (SPMclim)

In this type of structure, *would* expresses certainty regarding what will happen. The addressors do not offer hypotheses of low probability anymore but rather state the limits of their hypotheses. In the two examples above, the writers underline the limits of the potentials of their scenarios.

5.1.2. Implication and epistemic modal auxiliaries

I will now describe some elements regarding implications and epistemic modal auxiliaries. *If* is the subordinator the most used in implications with other epistemic modal auxiliaries.

> **If** emissions keep increasing, it **will** be less than 50 years before CO2 levels are double pre-industrial levels. (PAclim)

Condition can also be expressed by *unless:*

> An estimated 5% of the planet's species would be threatened with extinction by 2 °C of warming above preindustrial levels—a threshold that the world could breach in the next few decades **unless** greenhouse gas emissions are drastically reduced. (PAbio)

And there are descriptions of the results of specific actions with nominalisations in -ING:

> **Directing** finance towards investment in infrastructure for mitigation and adaptation could provide additional resources. (SPMclim)

Another implicative structure which is presented by Larreya and Rivière (2014: 122) and entitled contingent by Quirk et al (2010: 1111) is the "proportionality or equivalence of tendency or degree between two situations". Graham Ranger terms it as correlative structure. There are several occurrences with a fronted comparative form in the popularisation articles and in the "Summary for Teachers".

> **The more** CO2 and other greenhouse gases we release into the atmosphere, **the more** global temperatures will rise. (STclim)

> **The more** action on emissions reductions made now, **the less** will be the need to employ these risky measures. (STclim)

> First, we have to reduce net global emissions to zero, and **the faster** we do it **the better** off we will all be. (PAclim)

I found a different construction that expresses a form of correlation:

> Poverty and disadvantage are expected to **increase** in some populations **as** global warming **increases**; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (medium confidence). (SPMclim)

The subordinator *as* which refers to time and cause, linked to the verbs *increase* in both clauses helps expressing the correlation in the sentence.

But I did not find many constructions of correlation containing the subordinator *as* in the corpus.

> **As** the world gets **hotter**, most of the downsides of global warming, from coral bleaching to more severe flooding, will **grow ever greater**. (PAclim)

As conveys a meaning of cause to the clause which is presented before the superordinate clause. These elements are presented with futurity denoted by the modal auxiliary *will* and the expression of increase, in both clauses, via the verb phrases *gets hotter* and *grow greater* containing comparative forms—the latter is even amplified by the adverb *ever*.

The parallel construction with a fronted comparative form accentuates the importance and connection between the two predicates while the other structure with *as* is less expressive. The first structure is typical of popularisation texts which are more direct and emphatic than scientific writings.

To conclude, this section displays some observations on the use of *would* and different types of implicative structures found in the corpus. More detailed analyses could be carried out by considering more precisely the different types of implications across the different texts.

5.2. The expression of necessity

So far, I focused on the addressors' presentations of knowledge, their projections. But what I discovered as I read the texts is quite alarming and humans have a limited amount of time to reverse the situation. How is this need for action expressed when it is mentioned?

I analysed the distribution of *must*, *need* and *require* in the corpus because these were the most striking elements expressing necessity when I read the texts but there may be other expressions. To study this expression of modality, I did not keep Halliday's framework (1985: 695-6) because the distinction between obligation and necessity is not clearly explained in his work. It must be added that the presentation of this framework is illustrative in Halliday's book: not all phrases of modality of obligation are presented. The linguist classifies *must* as a modal auxiliary of obligation. *Must* encodes a high value of obligation. Halliday adds *need* to the list of modal operators of high value and does not mention the lexical verb *require* in the active form, but it is referenced as a passive form for the high value of obligation in his framework. Furthermore, it seems that *need* is referenced as a high value modal operator but there are only examples with non-assertive statements. However, I only found assertive statements using *need* in the corpus. Thus, I will refer to *need* as a lexical verb as well. I will therefore use Quirk et al.'s framework of modality in this section but will keep the high value of modality attributed to this modal auxiliary and these two verbs by Halliday. According to Quirk et al.'s framework, the occurrences of *must*, *need* and *require* found in the texts denote *root necessity*: they convey necessity for the targeted actions or entities and the statements can be rephrased by "it is necessary/essential for …". *Need* and *require* are not mentioned in Quirk et al.'s work because they are not modal auxiliaries but they participate in conveying the meaning of *root necessity* in the studied sentences. I will provide a few observations in this section.

	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio	Total
Must	0	0	0	1	1	0	0	2
Need	2	0	24	2	1	0	1	30
Require	1	8	12	1	1	3	1	27

Table 46. The distribution of the occurrences of each verb per text.

I did not count the nominalised forms of such verbs but it should be mentioned that the "Summary for Policymakers" by the IPCC does not present many occurrences of *need* as a verb but there are more occurrences of it as a noun. In the following example, the use of *needs* is mainly associated with investments and the reminder to consider human and biodiversity needs when mitigating.

> Investment **needs** for such complementary policies are only a small fraction of the overall mitigation investments in 1.5°C pathways. (SPMclim)

Requirements is used to stipulate that the scenarios displayed in the text are illustrative but not designed for any specific action. This assertion shows the IPCC's descriptive attitude, which is aimed at not imposing anything on their readers.

> These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate **requirements**. (SPMclim)

Modal auxiliary *must* represents 3% of the expression of necessity while lexical verbs *need* and *require* respectively account for 51% and 46%. The proportion of modal auxiliary *must* is very small. *Must* is used twice in the corpus: once in the popularisation article, as the writer emphasises what must be known about climate change, and in the research article on biodiversity, to define the best calculations and concepts to provide projections.

> To work out what that means, we **must** first know where we are now. The uncertainty starts here. (PAclim)

The sentence can be rephrased as follows: *to work out what that means, **it is necessary for** us to first know where we are now.*

In the two research articles, the three verbs studied are only used to present better manners to design calculations in the scientists' experiments. There is no link with the necessity to mitigate. The authors only present the results of their calculations and do not want to impose anything on their readers; the core of their studies is to produce the most accurate and reliable projections. Very few operators of necessity are used in each text.

> Moreover, the relative changes in probability are larger for rarer, more extreme events, implying that risk assessments **need** to carefully consider the extreme event thresholds at which vulnerabilities occur. (RAclim)

There is a striking use of *we need* in all popularisation texts. In the "Summary for Teacher", *we need* associated with a verb denoting action (and sometimes with a modal auxiliary) accounts for 63% of the occurrences with *need* in the text, and 50% of the occurrences with *need* in the corpus.

> To stabilise global temperature, we **need** to effectively stop emitting CO to the atmosphere. (STclim)

> Firstly, we **need** to reduce global energy, materials and food demand. (STclim)

The rest of the occurrences are mainly used with elements which need to be considered:

> Finally, the resulting greenhouse gas emissions **need** to be considered when implementing adaptation measures to avoid competing goals, such as adaptation efforts leading to increased emissions. (STclim)

On the contrary, the IPCC's "Summary for Policymakers" which summarises the same report does not have many occurrences of *need* and uses *require* more. *Require* is always used with a modal, mostly *would,* and the verb denotes what would be needed if a particular element happened or was decided.

> C.3.5 If deployed at large scale, they **would require** governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (medium confidence). (SPMclim)
>
> D.1.2 Reversing warming after an overshoot of 0.2°C or larger during this century **would require** upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (medium confidence). (SPMclim)

Require is mostly found in the "Summary for Teachers", it is used with inanimate subjects while 60% of the occurrences of *need* designate global community with *we need*.

> Limiting global warming to 1.5°C is not impossible but **requires** strong and immediate policies. (STclim)

Regarding the summaries for policymakers, there are more occurrences in the text of the IPCC compared to the summary of the IPBES. Even though the IPBES' missions of "undertaking authoritative assessments, generating robust knowledge inclusive of local and indigenous perspectives, supporting policy and developing capacity-building across continents" (IUCN 2020) represent a more explicit commitment regarding policymaking than the IPCC's, the authors of the IPBES' summary express less necessity - at least with the three verbs studied here. However, those are not the only elements which would allow one to gain a better understanding of how the addressors present policymaking and concrete solutions. There are probably more elements in the report itself. Furthermore, the IPBES' text is a global assessment which offers a global view whereas the IPCC's Special Report answers one question. This distinction could explain why *require* is used more in the IPCC's text because the writers present more specific situations and their conditions. Other elements could be studied to observe the expression of necessity in more detail. For example, in the sentence below *require* is accompanied by *rapid* and *immediate* which amplifies the influence of *require* and denotes more necessity than the use of *require* without such adjectives.

> All climate model trajectories show that limiting human-induced climate change to well below 2°C <u>requires</u> **immediate, rapid** reductions in greenhouse gas emissions or a reliance on substantial carbon dioxide removal from the atmosphere. (SPMbio)
>
> Limiting global warming **requires** limiting the total cumulative global anthropogenic emissions of CO2 since the pre-industrial period, that is, staying within a total carbon budget (high confidence). (SPMclim)

To conclude, there are very few occurrences of necessity in the texts except for *require* in the IPCC's "Summary for Policymakers" and *require* and *need* in the "Summary for Teachers". This is quite striking because they summarise the same report but the "Summary for Policymakers" only presents estimations and what some of them imply and lets the readers decide whether actions are needed. On the other hand, the "Summary for Teachers", by the frequent use of *we need* which refers to the international community, presents projections and expresses to its readers the need to act in order to reduce global warming. This specifies for the addressees what they and the global community need to consider for mitigation. Furthermore, no occurrence of *must,* or other elements I have focused on in this project, denotes obligation as presented in Quirk et al.'s framework. The linguists (2010: 225) define the modality of obligation as denoting the influence of the speaker or human activities. it differs from *root necessity* which expresses necessity for elements while obligation or compulsion refers to the addressor's authority. This modality is expressed at median value in recommendations formulated by five occurrences of *should* in the corpus.

> Biodiversity **should** be at the top of the global agenda alongside climate, said Anne Larigauderie, IPBES executive secretary, in a 6 May press conference in Paris, France.

These occurrences denote recommendations from the sources: they target what is not done yet but which is recommended or considered necessary by the addressor. The "Summary for Teachers" and the popularisation article on biodiversity both present two occurrences of *should* and there is one occurrence in the "Summary for Policymakers" by the IPBES. Thus, not only popularisation texts but also the intergovernmental summary on biodiversity makes a recommendation for its readers.

By studying the distribution of two modal auxiliaries and two lexical verbs in the corpus, it appears that necessity is expressed in small proportion in the scientific texts of research and summaries for policymakers while it is more frequent in the popularisation texts. Recommendations which expresses the median value of obligation are mostly found in popularisation texts.

5.3. The distribution of personal pronouns

	RAclim	SPMclim	STclim	PAclim	RAbio	SPMbio	PAbio
Occ.	11	0	36	38	9	0	6
%	0.22	0	0.71	1.5	0.27	0	0.7

Table 47. The distribution of the occurrences of *we* in absolute values (occ.) and the proportion of *we* compared to the entire texts (%).

The study of the distribution of first-person pronouns in the texts participates to describing the attitude authors take regarding the issues dealt with. I will present some observations regarding the distributions of *we* and *you* in the corpus. *I* was not found in the texts.

In the research articles, the writers use *we* to designate themselves. They communicate their approach and what they calculated. They take responsibility for their acts and do not include their readers in the use of *we*.

> **We** show that global warming of 2°C would result in substantially larger changes in the probabilities of the extreme events than global warming of 1. 5°C. (RAclim)

On the contrary, in popularisation articles, *we* is used in an inclusive manner and targets the global community. As can be read in the table above, the popularisation article on biodiversity contains a smaller part of the occurrences, which can be explained by the fact that the text is much shorter than any other text in the corpus. All occurrences of *we* are in reported speech, while in the popularisation article on climate change, the author frequently uses *we* to refer to the global community and therefore presents himself as the source of this act of targeting the global community. This is opposed to the use *we* in reported speech in the popularisation article on biodiversity which attributes the targeting of the global community by the use of *we* to scientists. Thus, Jeff Tollefson, the writer of the popularisation article on biodiversity, expresses a weaker commitment than Michael Le Page, the author of the other popularisation article.

> At present, **we** have lots of ways of capturing carbon on a small scale, but no technology that works on the stupendous scale required to reverse decades of fossil fuel burning. (PAclim)

> “**We** can no longer say that **we** did not know,” she said. (PAbio)

The use of *you* in the popularisation article on climate change participates in the expression of more commitment on the part of the author of the popularisation article on climate change compared to the role of the author of the article on biodiversity where *you* is absent. *You* is found ten times in the popularisation article on climate change; it gives a conversational tone, the writer addresses himself to someone.

> Confused? It’s not just **you**. (PAclim)

It represents a means for the author to attract the reader’s attention. *You* is also used as an informal manner to talk about generalities in a conversation.

> If **you** rack up a lot of debt, the only way to repay it–to get the temperature back down after an overshoot–is to reduce the level of carbo dioxide in the atmosphere by removing vast quantities of it. (PAclim)

The “Summary for Teachers” presents mainly *we* in an inclusive use which designates the global community and there are a few occurrences of *we* used only to refer to the writers and what they present to their readers in the text.

> Below **we** explain the different types of climate impacts, and why some locations and populations are more at risk than others. (STclim)

We is not found in the summaries for policymakers, even though those texts present decisive projections to the international community. The authors’ presentations focus on phenomena and projections. The absence of *we* expresses the addressors’ desire to remain impersonal and objective. The phenomena have consequences on the planet and human solutions which can be applied but the texts do not explicitly link these projections and solutions to the readers or the writers.

Therefore, the absence of first- and second-person personal pronouns in intergovernmental summaries participates in the absence of commitment from the authors toward the contents of the texts but also distances readers from the projections presented in the texts. Other elements could participate in the creation of commitment, but they were not studied in this project. The first-person personal pronouns used in both research articles denote the presence of the authors and their responsibility in the calculations and the results presented in the texts. Even though they are mitigated by, for instance, the use of passive forms as was mentioned in the observations of *epistemic modality* and *evidentiality* in chapter 4. Finally, the distribution of first- and second-person personal pronouns in the popularisation texts is quite varied. The "Summary for Teachers" seldom designates its authors but most of the time *we* is used to target the global community and therefore the readers and any other human being. *We* targeting the global community is found in both popularisation articles but the difference in the *sources* to which the occurrences of *we* are attributed—shows the difference of register and situational characteristics between the two articles of the same genre. The popularisation article on biodiversity attributes the use of *we* to scientists and entities different from the author while the popularisation article on climate change attributes the targeting of world community by scientists and also by the author of the text.

5.4. Conclusions

Some observations regarding hypotheses, the expression of necessity, and the use of first- and second-person pronouns were presented in this chapter. Some distinctions were drawn among the particularities of each genre and sometimes between the texts of the same genre. Nevertheless, the distinctions and functions of the texts could be more developed in another study by detailing aspects of what has been studied and other elements such as subjective vocabulary.

6. Finding functional forces via situational characteristics and linguistic features

In chapters 4 and 5, I presented the distribution of different linguistic elements among the seven texts. In this section, I will establish connections with some of the situational characteristics of each text presented in 3.2. and 3.3. with the distribution of the linguistic features in order to partly describe and differentiate the texts and their functions. This section presents a number of elements to synthesise this research project. I will first present remarks on the research articles and the summaries for policymakers because they share several similarities, then I will focus on the popularisation articles and finally, the "Summary for Teachers".

6.1. Research articles

Both research articles a large use of the implicit subjective orientation of epistemic modality expressing mostly a low value. This is accompanied by a systematic use of *merger may*, and occasional occurrences of *we*. Such elements denote the expression of deference in line with the tradition of scientific writing. The authors do not demonstrate high confidence regarding their reasoning. This is the reason why low value of implicit subjectivity is dominant in the two texts. The explicit subjective epistemic modality with *we* is only found in these texts, but in a very small proportion. The first-person plural personal pronoun *we* is also found several times when the authors present the different stages of their calculations. *We* is always used in an exclusive manner in order to designate the authors: they take full responsibility for their choices which led to specific experiments. However, the addressors also express objectivity in their texts: PERCEPTION is mostly found in the research articles when reading the results of the authors' calculations. Conclusions are imposed on the scientists as they read the results of their calculations: this mechanism is a tool to imply that any reader would draw the same conclusions. The frequent use of passive constructions and occurrences of explicit objective epistemic modality with inanimate subjects enable the authors to diminish their role and attribute more agency to the concepts and figures at work. Many occurrences denote *evidentiality* and the proportion of the DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE is the most important in these two texts: this resonates with one of the objectives of scientific writing which is to specify how the data was collected. The authors need to justify the quality of their findings. To do so, they explain in detail how the results were obtained and let the readers judge the quality of their work. The expression of necessity is also used in this perspective: necessity is very seldomly mentioned in the texts and only targets the conception of more accurate calculations. The occurrences are not used to express any necessity to act in accordance with the projections of the articles: either to limit global warming to 1.5°C for fewer risk events (RAclim) or to privilege a type of scenario for a more efficient preservation of biodiversity (RAbio). Frequent references to other studies when mentioning concepts used in the calculations enable the authors to show the scientific discourse community that they start with notions and elements shared inside the community. And from these works, they produce justified experiments which should belong to the community if other scientists acknowledge their quality and justified existence. The expression of deference, the justification of the quality of the results from reasoned experiments and the objectivity attached to concepts and results are elements the addressors use to gain the approval of the scientific discourse community. The authors show deference, respect and rigour in their work so that their experiments will be considered parts of scientific shared knowledge.

Among the research articles, there are some dissimilarities in the distribution of the observed linguistic features. All modal auxiliaries are found in the discussion section of the article on climate change, SHARED KNOWLEDGE is found in this text whereas more PROOF is expressed in the research article on biodiversity, and expansions of the predicator are more frequent in this text as well. The important use of modal auxiliaries in the discussion section could be a particularity of the discipline of climatology. Perhaps, the authors allow themselves to take a more personal approach in this section while, in biodiversity studies, the authors use this type of orientation in every section of the texts. This difference could also solely be a particularity between the texts under scrutiny. A study dedicated to the analysis of many research articles in biodiversity studies and climatology would provide a more refined answer to this supposition. The addressors recurrently use PROOF in the article on biodiversity because they discuss their previous studies and how these works differ from the results of their latest reasoning. The addition of comparisons echoes the tradition of scientific writing which seeks the most accurate calculations and results. More expansions of the predicator in this research article in contrast with the other article can be explained by the fact that the results come from the database called PREDICTS. Therefore, *to be predicted to* is a phrase which could be used several times to present the results of the calculations allowed by the database. Higher use of expansions of the predicator could also be a particularity of biodiversity studies. Again, a dedicated study of large corpora of climate change and biodiversity research articles would be necessary to draw some conclusions.

Thus, the authors of the research articles studied in this project present objective reports with agency mainly directed at concepts. There is a focus on the reasonings at work and the stages which led to the production of specific results that are then analysed. More involvement from the authors is denoted in these texts compared to the authors' investment in the summaries for policymakers as will be seen in the following section. However, the addressors are solely focused on the scientific process and its results. Nothing is expressed regarding the action of the global community to respond to the projections the scientists produced: very specific goals focused on the acquisition of knowledge are presented in the research articles.

6.2. Summaries for policymakers

Similarly to the other texts in the corpus, except for the research articles, explicit subjective epistemic modality is not found in the summaries for policymakers. Explicit objectivity is also found in a small proportion; the texts mainly use implicit subjectivity and implicit objectivity. Added to the absence of personal pronoun *we*, this conveys the authors' distant stance towards the contents of the texts: it denotes objectivity. A low value of epistemic modality in implicit subjective and implicit objective constructions is also dominant, except for expansions of the predicator which express a high value of epistemic modality in great majority. The expression of distance and a low value of epistemic modality participate in the expression of deference which belongs to the conventions of scientific discourse. The type of *evidentiality* mostly used is what I classified as PROOF/SHARED KNOWLEDGE; it represents the data produced by numerous studies available in the scientific community. The compilations of the available data are synthesised in intergovernmental reports and then represent shared knowledge of the scientific community. Frequent usage of specific confidence terms and of references to specific parts of the reports are found in both texts. The particular confidence terms were conceived to improve the transmission of knowledge and guarantee clarity: they show the seriousness of the organisations' works. In line with the tradition of presenting reliable proof, the addressors frequently link findings and hypotheses to specific parts of the reports with references in braces and they do not refer to specific studies or to only very few. They proceed in this manner because the reports are the products of compilations of scientific knowledge and not of a few specific analyses. These elements denote clarity and rigour from the authors. Presentation of knowledge is the focus of the texts. Necessity is expressed in a small quantity in the two texts, it refers to what will be required when a given hypothesis happens. Observed occurrences expressing necessity only link phenomena and no specific entities or human beings are targeted. The weak presence of necessity and so, the small importance of action expressed compared to the presentation of scientific knowledge is inscribed in the conventions of scientific writing.

This is something quite different from the expression of necessity expressed in the "Summary for Teachers" by the OCE, as will be discussed later.

Several dissimilarities are found among the two summaries: implicit objective epistemic modality is more frequent in the IPCC's summary while implicit subjectivity is more abundant in the IPBES' text. There are more references to chapters of the IPBES' report than there are references to the IPCC's report. The IPBES' summary shows a more diversified use of terms to designate scenarios compared to the IPCC's and the *bases of knowledge* are more varied in the IPBES' text. More diversification in the IPBES' text compared to the IPCC's summary can be explained by the fact that the summaries do not synthesise the same types of reports. The IPBES' report is a global assessment report which condenses the available data regarding the loss and preservation of biodiversity around the world, even in indigenous communities. The report deals with many issues and aims at being as comprehensive as possible. On the other hand, the IPCC's report is a Special Report: it answers one question in detail. Perhaps more diversification on the part of the IPBES could be induced by its relative recency compared to the IPCC. This is the first global assessment regarding the international community produced by this intergovernmental platform. The IPBES may not have as many conventions directing the writing process yet. Or, perhaps, as they are not directly part of the United Nations and slightly more independent than the IPCC, they benefit from fewer restrictions.

Therefore, the addressors of the summaries for policymakers present scientific data in a scientific traditional manner by mostly denoting objective, precise and distant stances towards the issues and focusing on the synthesis of global knowledge. The IPBES' summary shows more diversification in its use of studied linguistic features compared to the IPCC's text.

6.3. Popularisation articles

Both popularisation articles regularly use ATTRIBUTION as a *basis of knowledge* to present information: the authors rely on the statements of scientists to share knowledge. They summarise experts' works and opinions for laypersons. High value of *epistemic modality* is mostly found in these two texts (around two thirds of implicit subjective modality compared to one third of the same orientation in the other texts) and in the "Summary for Teachers", which presents features of_popularisation writing. Furthermore, objective modality is the orientation the least found in both articles. The distribution of the different orientations of epistemic modality and the high value of this modality convey the addressors' involvement in the texts.

The popularisation article on biodiversity presents the least diversified distribution of linguistic features studied in this project, whereas the popularisation article on climate change displays the most varied distribution of linguistic elements. However, both texts belong to the same genre of popularisation article. As stated in 1.2.4, popularisation articles do not have a fixed structure like, for instance, research articles. The purpose of the text shapes its genre, but the distribution of linguistic features can highly diverge from one text to another. The social role of the authors in popularisation articles is to present information regarding scientific progress and knowledge on scientific matters. Their presentations need to satisfy the readers who bought the magazines. Regarding the two texts under scrutiny, their different registers are obvious because of the strong differences in the distribution of their linguistic features and their different purposes. Several elements diverging from highly conventionalised genres are found in the article on climate change. For instance, it presents an important frequency of lexical certainty. The addressor expresses his knowledge with images and therefore offers a more vivid explanation to his readers. The article asks straightforward questions that the readers are supposed to ask themselves and provides answers for them. Furthermore, personal pronouns *we* and *you* are frequently used, and they refer to the global community. They do not exclusively refer to the writer as it is the case in the research articles. In that manner, readers are more directly targeted. The article on climate change also offers the most diversified use of *bases of knowledge* and expressions of *certainty.* All the elements presented above denote a conversational tone. The readers are directly targeted and the author resorts to vivid explanations with a diversified use of structures. This is more similar to the structure of informal conversation in which addressors express themselves without drafting their communication for a specific period of time. In this manner, the author does not follow a restricted number of structures to express himself as it can be the case in highly conventionalised technical genres such as research articles. The text gives the impression of a lively interaction with the readers. The opposition between the lively tone of the popularisation article on climate change and the more distant approach of the article on biodiversity can be explained by their different topics and the magazines they were published in. The article on climate change explains several facts and methods used to acquire knowledge on global warming while the article on biodiversity mainly presents the IPBES' latest report. The former is extracted from a popularisation magazine created for laypersons interested in science's latest progress; it has a very personal and sometimes informal tone. On the other hand, the latter is published in a magazine which used to publish popularisation articles by the scientists who carried the studies several decades before and the journal is now designed for laypersons. However, its prior purposes, which were more conventionalised and linked to the justification of the acquisition of knowledge, still influence its editorial policy.

6.4. Summary for teachers

The “Summary for Teachers” synthesises the IPCC’s Special Report “Global Warming of 1.5°C” therefore it recaps knowledge gathered by the scientific community on global warming, as it is presented in the IPCC’s “Summary for Policymakers”. However, both texts do not use the same distribution of linguistic elements. Instead of using no personal pronouns like the “Summary for Policymakers”, the “Summary for Teachers” shows the largest use of *we* in the corpus. The pronoun mostly designates the global community. Here, the aspect of a popularisation text clearly addressing its readers and making clear what global community needs to do is obvious: by repeatedly referring to the global community with the personal pronoun *we,* the authors target everyone. There is also an important use of *would* and implicative structures, which participates in the frequent expression of condition because the Special Report compares the consequences of global warmings of 1.5°C and 2°C for different scenarios. They present possibilities to the global community. This text shows the highest use of occurrences of *need* and 62% of implicit subjective modality compared to other orientations with almost 80% of high value modality. In that manner, the addressors convey overtly a committed stance: they explicitly present facts, include themselves when they express the necessity to act and underline the priorities at work to the readers who are mostly teachers. It is important to convey clear messages because the addressees will teach pupils who represent a large part of the global population. Hence, the emphasis on urgency and what is at stake. For the addressees, the addressors do not need to present in detail the evidence of their knowledge. In the introduction of the text, the writers specify which text was summarised and give some elements about it and this is sufficient. The transmission of facts and projections to the readers is more important. Thus, this text summarises the same report as the IPCC’s “Summary for Policymakers” does but they show completely different uses of linguistic features: the focus is no longer on a succession of possible hypotheses and systematic references to parts of reports presenting detail on these matters but there is an emphasis on priorities and the necessity to act. The differences between the two summaries can be explained by the fact that the texts do not target the same types of readers and so, do not correspond to the same conventions because the different discourse communities they interact with have different traditions and codes. The intergovernmental summaries for policymakers are produced for decision makers. They are restrained by the tradition of scientific discourse, the prestige of the institutions of the United Nations and of the participating states and by the texts establishing the roles of the Panels. The Panels are only informative: they have no power over the states. On the other hand, the Office for Climate Education is a nongovernmental charitable organisation, it depends in a smaller proportion on the conventions of international diplomacy. It is surprising that more emphasis on action and urgency is expressed in texts designed for people who are not in positions of power and whose role is to transfer knowledge. On the other hand, summaries for policymakers are conceived for representatives who can bring change in their countries by designing laws and creating devices to implement these decisions. They can even implement laws for the international community. Representatives work on other political aspects and are not climate and biodiversity experts. Thus, they have a very limited amount of time dedicated to those issues and need clear and precise elements regarding the elaboration of laws that would help in these fields. Specifically describing what is required to limit damage should be a priority since there is a decade left to act and drastic changes are required. The recent crisis of the coronavirus has shown that instantaneous and direct communication between medical scientists and decisionmakers is possible. The latter needed to make drastic decisions in a very short period of time in order to save lives and diminish the impacts of sanitary and economic consequences on their nations. They acted rapidly and enforced laws which regulated populations in order to save lives. The projections presented in the summaries for policymakers depict critical situations to occur in a few decades. Humanity will have to face crises as hard as the coronavirus more frequently and many other risk events will be more frequent as well. Drastic decisions are also needed to preserve human lives. However, to make a real difference, the changes need to be applied before risk events and pandemics are more frequent. Perhaps the coronavirus crisis and the interaction among political and scientific spheres across the world will inspire intergovernmental platforms in their following communications to be more direct and committed in their reports, even if it signifies departing from certain conventions of scientific writing which usually connote seriousness and legitimacy.

Conclusion

This research project first presents the main concepts and frameworks used in order to qualify the enunciative stance of the addressors of the corpus as they present projections on global warming and biodiversity loss. The context of international climate action and biodiversity preservation was briefly summarised, and the situational characteristics of the texts were specified in tables. Linguistic features expressing epistemological positioning, necessity, implication and interaction among addressors and addressees were studied in chapters 4 and 5. The final chapter offers a synthesis of the different elements analysed in this research project and presents some elements regarding the purposes of the texts and the writers' commitments . Several possibilities of extending the analysis in order to provide more specific answers were pointed out through the project. The texts associated with specific genres display expressions of elements traditionally associated with the genres. The research articles denote deference, objectivity and precision. The intergovernmental summaries of scientific reports also convey precision to a certain extent because they are the results of large-scale data compilations, they express objectivity and caution. The popularisation articles are more different in their stances because the genre is less conventionalised. Both articles rely on experts' statements and mainly make clear and confident statements. Finally, it is worth mentioning the different stances in the two summaries synthesising the same report. The text designed for addressees in positions of transmitting knowledge, the "Summary for Teachers", is more direct and practical than the "Summary for Policymakers", which is conceived for addressees who can rapidly implement change. The IPCC's and IPBES' reports predict that risk events and critical sanitary situations will become more frequent and will have harsher economic impacts on societies in the next decades. The recent crisis saw the frequent interactions of scientists and political actors and the almost instantaneous implementation of measures according to experts' advice. For now, no drastic change regarding the environment has been decided and it could be partly linked to the cautious and distant stances expressed in intergovernmental reports that follow conventions of the scientific discourse community in order to be recognised as part of the discourse community. After witnessing the interactions held between scientific experts and political actors and the quickness of reaction in the recent crisis, will the intergovernmental platforms produce more direct statements in which their commitment is more personal and clear in order to rapidly induce effective change?

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Appendix 1 Occurrences analysed in the corpus

The occurrences analysed in the corpus were classified according to the category and the text.

Certainty

Explicit subjectivity

RAclim

Here we assume that the location parameter and the log of the scale parameter depend linearly on the global mean temperature.

RAbio

However, a brighter future is possible; SSP1/RCP2.6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity—in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100.

Implicit subjectivity

Will

RAclim

This lack of sensitivity will, in fact, become apparent earlier for events that are rarer in the 1.0°C world.

Here we showed that changes in the magnitude of risk ratio, which could be considered as a lower boundary for relative risk changes assuming that the consequences of extreme events will not decrease, are dependent on the rarity of the extreme event in the current climate as well as the amount of additional global warming beyond the present (with larger RR for rarer events).

Substantially greater complexity for risk assessment will arise in the context of compound events.

The implication is that risk assessment will depend critically on an understanding of the thresholds for the occurrence of extremes and kinds of extremes at which vulnerability increases sharply.

Because different extremes will affect different sectors in very different ways, risk assessment will also depend critically on what society values and on the metrics of loss.

Ultimately, the choice will be application dependent.

SPMclim

A.2 Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (high confidence), but these emissions alone are unlikely to cause global warming of 1.5°C (medium confidence). (Figure SPM.1) {1.2, 3.3, Figure 1.5}

On longer time scales, sustained net negative global anthropogenic CO2 emissions and/ or further reductions in non-CO2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (medium confidence) and will be required to minimize sea level rise (high confidence). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}

Sea level will continue to rise well beyond 2100 (high confidence), and the magnitude and rate of this rise depend on future emission pathways.

B.2.2 Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (high confidence).

B.3.3 High-latitude tundra and boreal forests are particularly at risk of climate change-induced degradation and loss, with woody shrubs already encroaching into the tundra (high confidence) and this will proceed with further warming.

B.6 Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (high confidence).

D.3 Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (high confidence). {1.4, 4.3, 4.5}

While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (high confidence) (Figure SPM.4) {2.5, 4.5, 5.4}

STclim

Three Special Reports will be published in the current (sixth) IPCC assessment cycle:

—— Global warming of 1.5°C

—— Climate Change and Land

—— Ocean and Cryosphere in a Changing Climate

Below we introduce this concept, together with the notion of uncertainty in how climate will change in the future.

However, estimates vary as to what the timing and size of these contributions will be.

Uncertainty in forecasts of future climate also derives from different estimates for the amount of global warming that will result from a given increase of greenhouse gases in the atmosphere – i.e. just how sensitive the climate system is to our emissions.

The increase in temperature is and will continue to impact on biodiversity and ecosystems.

The effect of warming on biodiversity will depend on the temperature eventually reached and at which rate it will be reached.

Our CO2 emissions will remain in the atmosphere for centuries to millennia, maintaining the warmer temperatures long after these emissions cease.

Adaptation is made more difficult because we can’t predict exactly how the climate will change in a given place in future.

The amount of global warming depends both on past emissions of greenhouse gases and on those we will emit in the coming years.

In general, the more warming the greater the risks and impacts will be.

Sea level rise by 2100 will be 10 cm higher if global warming reaches 2,0°C instead of 1.5°C.

As explained in Section B, even if we stop emitting greenhouse gases immediately sea levels will keep rising over these time-scales due to ocean inertia.

A global warming of 1.5°C is not “safe” - the physical risks and impacts will be large.

However, the risks will be substantially lower than at warming of 2°C.

Adaptation is still required at 1.5°C, although efforts required will be smaller than at 2°C.

There will be limits to what can be achieved through adaptation at both 1.5°C and 2°C, in which the physical changes in climate overwhelm our abilities to deal with them.

The physical changes and impacts will vary by location.

The more CO2 and other greenhouse gases we release into the atmosphere, the more global temperatures will rise.

Unfortunately, the slow removal of CO2 from the atmosphere means that global temperatures will remain warmer for centuries to millennia even after we completely stop emitting CO2.

The impacts of overshooting and then stabilising at 1.5°C will be more different to those of reaching 1.5°C without overshoot, due to the different rates of change and the different maximum warming level reached.

If we delay action now, more rapid emissions reduction will be needed in the future to limit warming to the same level, and these emissions reduction will be more costly.

What happens in the next ten years will be critical.

Given the inertia of the global economic system, it will be very difficult to achieve the emission reductions at scale and rates required, without using methods of removing CO2 from the atmosphere.

Major investments will be needed to realise these transitions, including in developing countries.

The more action on emissions reductions made now, the less will be the need to employ these risky measures.

Transitions will be needed in the way to produce and consume energy, materials and food, in our use of land (including agriculture), in our transportation system and in industry.

These system transitions will be unprecedented in scale and will require large investments.

PAclim

And the uncertainty cuts both ways: we could be underestimating how fast the world will warm and what the effects will be.

As the world gets hotter, most of the downsides of global warming, from coral bleaching to more severe flooding, will grow ever greater.

But as we don’t know for sure at what temperatures any of these will kick in, this doesn’t help establish a “safe” limit.

If we stop building on coasts doomed to disappear under the waves and start adapting our homes to cope with far greater weather extremes, we will save many lives.

On current trends, the first year to exceed 1.5°C above the 1850 to 1900 average will probably occur in the 2020s.

Temperatures will drop a little again when it passes.

A reasonable definition is that we will go over the limit when the average, long-term temperature rise exceeds 1.5°C.

Even if we can get the temperature back down, the impacts will be more serious if we go past 1.5°C because there will be faster warming over the next few decades.

Warming will be amplified as vast, reflective ice sheets melt and are replaced by dark land and water that absorb most sunlight, for example.

If emissions keep increasing, it will be less than 50 years before CO_2 levels are double pre-industrial levels.

How high will the seas rise?

The huge unknown is how long this will take.

The prevailing view is that it will take many centuries or millennia.

If it stays warm, there will be bigger sea level rises in the 22nd century and beyond.

It is true that at the current rate of emissions we will exceed the report's "most likely" remaining carbon budget in roughly 12 years.

First, we have to reduce net global emissions to zero, and the faster we do it the better off we will all be.

RAbio

Our results suggest that strong climate change mitigation through biofuel production will detrimentally impact biodiversity: SSP4/RCP3.4 (with high biofuel mitigation) is predicted to see two times the decrease in abundance-based biodiversity intactness and three times the decrease in local species richness between 2015-2100 as is predicted for SSP4/RCP6.0 (with lower levels of mitigation).

However, a brighter future is possible; SSP1/RCP2. 6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity – in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100.

Indicators that embody explicit links between drivers and biodiversity provide the potential for estimating how the state of the indicator has changed beyond the temporal range for which direct observations are available, enabling estimation not only of how the state of nature has changed up to now, but also how it will change in possible futures (eg Nicholson et al 2012; IPBES Scenarios & Modelling assessment (IPBES 2016); Visconti et al 2015; Purvis et al 2018).

The SSP/RCP combinations allow the examination of how differing socioeconomic scenarios will impact biodiversity at global and regional scales SSP1/RCP2.6 shows both an overall global positive response in biodiversity intactness and broadly consistent positive responses within regions (Figure 1B).

SPMbio

Management decisions that take those evolutionary changes into account will be noticeably more effective (established but incomplete) {Box 2.5}.

The specific actions taken will typically be case-specific and therefore will require careful assessment of evolutionary potential and consequences.

Ocean mining, while relatively small, has expanded since 1981 to ~ 6,500 offshore oil and gas installations worldwide in 53 countries (60 per cent in the Gulf of Mexico by 2003) and likely will expand into the Arctic and Antarctic regions as the ice melts {2.1.11}.

This indicates that many species are unable to cope locally with the rapid pace of climate change, through either evolutionary or behavioural processes, and that their continued existence will also depend on the extent to which they are able to disperse, to track suitable climatic conditions, and to preserve their capacity to evolve (well established) {2.2.5.2.5}.

Many of these changes can have significant impacts on a number of important economic sectors, and cascading effects for other components of biodiversity. Island nations, in particular those in East Asia and the Pacific region, will be most vulnerable to sea-level rise (1m) as projected by all climate change scenarios, {2.1.1.7.1} which will displace close to 40 million people {2.1.1.7.1; 2.2.7.1.8}.

The incorporation by society of the value of nature's contributions to people will entail shifts in governance even within private supply chains, for instance when civil society certifies and helps to reward desired practices, or when States block access to markets because of undesirable practices {2.1.7}.

25. The adverse impacts of climate change on biodiversity are projected to increase with increasing warming, so limiting global warming to well below 2°C would have multiple co-benefits for nature and nature's contributions to people and quality of life; however, it is projected that some large-scale land-based mitigation measures to achieve that objective will have significant impacts on biodiversity (established but incomplete) {4.2, 4.3, 4.4, 4.5}.

For terrestrial systems, most studies indicate that South America, Africa and parts of Asia will be much more significantly affected than other regions, especially in scenarios that are not based on sustainability objectives (see Figure SPM.8 as an example).

Novel communities, where species will co-occur in historically unknown combinations, are expected to emerge (established but incomplete) {4.2.1.2., 4.2.4.1}

Substantial climate change-driven shifts of terrestrial biome boundaries, in particular in boreal, subpolar and polar regions and in (semi-)arid environments, are projected for the coming decades; a warmer, drier climate will reduce productivity in many places (well established) {4.2.4.1}.

However, given that most urban growth between now and 2030 will take place in the Global South, major sustainability challenges include creatively and inclusively addressing the lack of basic infrastructure (water, sanitation and mobility), the absence of spatial planning, and the limited governance capacity and financing mechanisms.

Those challenges also offer opportunities for locally-developed innovation and experimentation, which will create new economic opportunities.

PAbio

Without drastic action to conserve habitats, the rate of species extinctions—already tens to hundreds of times higher than the average across the last ten million years—will only increase, says the analysis by a United Nations-backed panel, the International Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Without “transformative changes” to the world’s economic, social and political systems to address this crisis, the IPBES panel projects that major biodiversity losses will continue to 2050 and beyond.

About 75% of the planet’s land and 66% of its ocean areas have been “significantly altered” by people, driven in large part by the production of food, according to the IPBES report, which will be released in full later this year.

Agricultural threats to ecosystems will only increase as the world’s population continues to grow, according to the IPBES analysis.

The world can reverse this biodiversity crisis, the report says, but doing so will require proactive environmental policies, the sustainable production of food and other resources and a concerted effort to reduce greenhouse-gas emissions.

Despite those shortcomings, the IPBES report will help to set the agenda when governments negotiate new conservation goals for the next decade at the UN Convention on Biodiversity next year, says Brooks.

“Then we will need to see implementation across all sectors of society,” he says. “That’s when we will see a difference.”

May

RAclim

Nevertheless, a simple framework that compares only the probabilities of temperature and precipitation extremes associated with a 2°C warming limit versus a 1. 5°C limit may be useful.

This simple concept may therefore provide a powerful tool for high-level cost-benefit analysis.

One approach that might help to avoid overstating changes in risk may be to determine risk ratios not just for single events, but as a function of rarity, as in Figure 4.

While changes in risk ratio are dependent on the rarity of extreme event that is referenced, changes in the magnitude or return levels of extreme events may not be as sensitive, at least for extreme warm temperatures.

For systems that fail when there is exceedance above a fixed threshold, the magnitude of exceedance may be secondary; in those cases, simple metrics that reflect changes in probability may be sufficient.

On the other hand, for systems in which the extent of damage is dependent on both magnitude and frequency, for example, when larger changes in magnitude for a given event frequency lead to more extensive crop damage or larger numbers of people at risk, more complex metrics that recognize the impacts of change in both frequency and magnitude may be needed.

SPMclim

On longer time scales, sustained net negative global anthropogenic CO2 emissions and/ or further reductions in non-CO2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (medium confidence) and will be required to minimize sea level rise (high confidence). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}

Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (high confidence). {3.2, 3.4.4, 3.6.3, Cross-Chapter Box 8 in Chapter 3}

B.5.4 Depending on future socio-economic conditions, limiting global warming to 1.5°C compared to 2°C may reduce the proportion of the world population exposed to a climate change-induced increase in water stress by up to 50%, although there is considerable variability between regions (medium confidence).

These options are technically proven at various scales but their large-scale deployment may be limited by economic, financial, human capacity and institutional constraints in specific contexts, and specific characteristics of large-scale industrial installations.

Economic, institutional and socio-cultural barriers may inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (high confidence). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2}

Afforestation and bioenergy may compete with other land uses and may have significant impacts on agricultural and food systems, biodiversity, and other ecosystem functions and services (high confidence).

These may increase uneven distributional impacts between countries at different stages of development (medium confidence). {2.3.5, 4.4.5, 5.4.2}

Innovation policies may be more effective when they combine public support for research and development with policy mixes that provide incentives for technology diffusion. (high confidence) {4.4.4, 4.4.5}.

STclim

Species are migrating towards cooler environments - poleward or to greater depths in the ocean, and poleward or uphill on land, but may not be able to move readily (e.g. due to habitat fragmentation) or fast enough.

For instance, in the case of sea level rise, the populations of some low-lying islands may ultimately have to permanently relocate.

In addition, use of methods to remove CO2 from the atmosphere may end up being required.

RAbio

Although climate change is expected to have severe detrimental impacts to biodiversity – which are not quantified in these results – it is important to consider how the climate change mitigation itself may also impact biodiversity.

Purvis et al (2018) discuss some remaining reasons why our modelling approach may still be overestimating BII; the most important in the context of this paper is that our models do not consider biotic effects of climate change or other drivers that have a different spatial pattern from land use and human population density.

Study-level means of human population density and agricultural suitability were included as control variables, to avoid possible biases (e.g., sampling may be more thorough in studies conducted in more densely-populated regions).

SPMbio

These wild relatives represent critical reservoirs of genes and traits that may provide resilience against future climate change, pests and pathogens and may improve current heavily depleted gene pools of many crops and domestic animals {2.2.3.4.3}.

Almost half (47 per cent) of threatened terrestrial mammals, excluding bats, and one quarter (23 per cent) of threatened birds may have already been negatively affected by climate change in at least part of their distribution (birds in North America and Europe suggest effects of climate change in their population trends since the 1980s) (established but incomplete) {2.2.6.2}.

Reduced, declining and unequal access to nature's contributions to people may, in a complex interaction with other factors, be a source of conflict within and among countries (established but incomplete).

Economic instruments that may be harmful to nature include subsidies, financial transfers, subsidized credit, tax abatements, and prices for commodities and industrial goods that hide environmental and social costs.

Goals for conserving and sustainably using nature and achieving sustainability cannot be met by current trajectories, and goals for 2030 and beyond may only be achieved through transformative changes across economic, social, political and technological factors.

"Moderate" (the overall global trend is positive, but insubstantial or insufficient, or there may be substantial positive trends for some aspects of the element, but little or no progress for others; or the trends are positive in some geographic regions, but not in others).

Several examples illustrate the interdependencies between nature and the Sustainable Development Goals. For example, nature and its contributions may play an important role in reducing vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters, although anthropogenic assets are also involved (established but incomplete).

“Partial support” means that the overall global status and trends are positive, but still insubstantial or insufficient; or there may be substantial positive trends for some relevant aspects, but negative trends for others; or the trends are positive in some geographic regions, but negative in others.

In a post-2020 global biodiversity framework, placing greater emphasis on the interactions between the targets of the Sustainable Development Goals {4.6, 3.7} may provide a way forward for achieving multiple targets, as synergies (and trade-offs) can be considered.

Consequently, large-scale land-based mitigation measures may jeopardize the achievement of other Sustainable Development Goals that depend on land resources (well established) {4.5.3}.

Some incentives and regulations may contribute to positive changes at both the production and consumption ends of supply chains, such as the creation, improvement and implementation of voluntary standards, certification and supply-chain agreements (eg, the Soy Moratorium) and the reduction of harmful subsidies.

Regulatory mechanisms could also address the risks of co-option and lobbying, where commercial or sectoral interests may work to maintain high levels of demand, monopolies and continued use of pesticides and chemical inputs {5.3.2.1}.

PAbio

Scientists may quibble about some of the extinction estimates and other details, but the report doesn’t pull punches when it describes how humans have altered Earth’s ecosystems, says Stuart Pimm, an ecologist at Duke University in Durham, North Carolina.

Might

RAclim

We considered the possibility that the shape parameter ξ might also vary with global mean temperature but found that allowing it to be linearly dependent on ΔT did not improve the goodness of fit as judged by standard likelihood ratio tests, suggesting little appreciable change in the shape parameters due to warming.

One approach that might help to avoid overstating changes in risk may be to determine risk ratios not just for single events, but as a function of rarity, as in Figure 4.

SPMclim

Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (medium confidence). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 3.3, 4.3.7, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4}

Estimates of the costs of adaptation might be lower at global warming of 1.5°C than for 2°C.

SPMbio

Loss of diversity, such as phylogenetic and functional diversity, can permanently reduce future options, such as wild species that might be domesticated as new crops and be used for genetic improvement {2.3.5.3}.

Could

RAclim

Note that the risk ratios computed from these “median” PDFs could be slightly different from the median values of the risk ratios computed from PDFs fitted to individual model runs.

As modelled warming in the warm extremes is somewhat faster than observed, future increases in the frequency of current climate warm extremes could be smaller than reported here.

On the contrary, modelled warming in the cold extremes is somewhat slower than observed; hence, future decreases in the frequency of cold extremes could be greater than reported here.

For example, record high summer temperature and record low rainfall amount have been used to illustrate some of the differences in Australian climate extremes that could be expected in a 1.5°C or 2°C world (King et al , 2017).

Here we showed that changes in the magnitude of risk ratio, which could be considered as a lower boundary for relative risk changes assuming that the consequences of extreme events will not decrease, are dependent on the rarity of the extreme event in the current climate as well as the amount of additional global warming beyond the present (with larger RR for rarer events).

SPMclim

Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years.

These instabilities could be triggered at around 1.5°C to 2°C of global warming (medium confidence). (Figure SPM.2) {3.3.9, 3.4.5, 3.5.2, 3.6.3, Box 3.3}

Poverty and disadvantage are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (medium confidence). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 4.2.2.2, 5.2.1, 5.2.2, 5.2.3, 5.6.3}

Many small island developing states could experience lower water stress as a result of projected changes in aridity when global warming is limited to 1.5°C, as compared to 2°C (medium confidence). {3.3.5, 3.4.2, 3.4.8, 3.5.5, Box 3.2, Box 3.5, Cross-Chapter Box 9 in Chapter 4}.

For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions (medium confidence). {Box 3.5, 3.3.1, 3.4.5.3, 3.4.5.6, 3.4.11, 3.5.4.9}

In addition, the level of non-CO2 mitigation in the future could alter the remaining carbon budget by 250 GtCO2 in either direction (medium confidence). {1.2.4, 2.2.2, 2.6.1, Table 2.2, Chapter 2 Supplementary Material}

C.3.4 Most current and potential CDR measures could have significant impacts on land, energy, water or nutrients if deployed at large scale (high confidence).

Feasibility and sustainability of CDR use could be enhanced by a portfolio of options deployed at substantial, but lesser scales, rather than a single option at very large scale (high confidence). (Figure SPM.3b) {2.3.4, 2.4.4, 2.5.3, 2.6, 3.6.2, 4.3.2, 4.3.7, 4.5.2, 5.4.1, 5.4.2; Cross-Chapter Boxes 7 and 8 in Chapter 3, Table 4.11, Table 5.3, Figure 5.3}

C.3.5 Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration could provide co-benefits such as improved biodiversity, soil quality, and local food security. If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (medium confidence). (Figure SPM.4) {2.3.3, 2.3.4, 2.4.2, 2.4.4, 3.6.2, 5.4.1, Cross-Chapter Boxes 3 in Chapter 1 and 7 in Chapter 3, 4.3.2, 4.3.7, 4.4.1, 4.5.2, Table 2.4}

D.5.1 Directing finance towards investment in infrastructure for mitigation and adaptation could provide additional resources. This could involve the mobilization of private funds by institutional investors, asset managers and development or investment banks, as well as the provision of public funds.

STclim

Decline in the global fisheries catch could be twice as large at 2°C than 1.5°C, and there would be smaller reductions in yields of key food crops of maize, rice and wheat at 1.5°C than at 2°C.

This could be assisted by changes and food consumption (reducing meat and dairy consumption, and reducing in food waste), and transport choices (e.g. flying less).

In the construction sector, use of low-emission building materials, such as wood, could help reduce emissions.

These could be complemented by government legalisation such energy standards or a price on carbon.

With clear benefits to people and natural ecosystems, limiting global warming to 1.5°C compared to 2°C could go hand in hand with ensuring a more sustainable and equitable society.

PAclim

And the uncertainty cuts both ways: we could be underestimating how fast the world will warm and what the effects will be.

That could trigger tipping points that cannot be quickly reversed, such as the die-off of the Amazon rainforest.

Earlier this year, some climate scientists warned that we could be greatly underestimating the risks and that if the planet did warm by at least 2°C, it might be impossible to stop it warming several further degrees.

The budgets could be 650 gigatons lower or higher, depending on climate sensitivity and the historical baseline, meaning we might already have exceeded even the biggest budget.

In other words, even if we limited warming to 1.5°C, much of the ice in Greenland and West Antarctica could still be lost, which would be enough to raise sea levels 5 metres or more.

Without a change of course, we are actually heading for a world that is 3 or 4°C warmer, which could lead to seas rising more than 20 metres.

Antarctica is already losing ice much faster than expected, and a 2016 study based on a computer model of its ice sheets suggests the seas could rise by up to 3 metres by 2100.

RAbio

Cropland sites that could not be classified in this manner were dropped from the analysis.

All three of these difficulties arise from sensible practical decisions taken in the face of resource constraints, but could potentially be overcome with further work.

SPMbio

In many cases, the best strategy could be to simply maintain the ability of natural populations to respond evolutionarily on their own - rather than through direct human manipulation of evolution.

In the short term (before 2030), all decision makers could contribute to sustainability transformations, including through enhanced and improved implementation and enforcement of effective existing policy instruments and regulations, and the reform and removal of harmful existing policies and subsidies (well established).

Collaborative implementation of priority governance interventions (levers) targeting key points of intervention (leverage points) could enable transformative change from current trends towards more sustainable ones.

Implementing existing and new instruments through place-based governance interventions that are integrative, informed, inclusive and adaptive, using strategic policy mixes and learning from feedback, could enable global transformation.

These practices could be enhanced through well-structured regulations, incentives and subsidies, the removal of distorting subsidies {2.3.5.2, 5.3.2.1, 5.4.2.1, 6.3.2}, and – at landscape scales – by integrated landscape planning and watershed management.

Regulatory mechanisms could also address the risks of co-option and lobbying, where commercial or sectoral interests may work to maintain high levels of demand, monopolies and continued use of pesticides and chemical inputs {5.3.2.1}.

Such options could help reduce food waste, overconsumption, and the demand for animal products that are produced unsustainably, which could have synergistic benefits for human health (established but incomplete) {5.3.2.1, 6.3.2.1}.

Additional tools could include both non-market and market-based economic instruments for financing conservation, including for example payment for ecosystem services, biodiversity offset schemes, blue-carbon sequestration, cap-and-trade programmes, green bonds and trust funds and new legal instruments, such as the proposed international, legally binding instrument on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction under the United Nations Convention on the Law of the Sea (established but incomplete) {6.3.3.2, 6.3.3.1.3, 5.4.2.1, 5.4.1.7}.

Governments could reform subsidies and taxes to support nature and its contributions to people, removing perverse incentives and instead promoting diverse instruments such as payments linked to social and environmental metrics, as appropriate (established but incomplete) {6.4.1}.

Trade agreements and derivatives markets could be reformed to promote equity and prevent the deterioration of nature, although there are uncertainties associated with implementation (established but incomplete) {6.4.4}.

PAbio

An estimated 5% of the planet's species would be threatened with extinction by 2 °C of warming above preindustrial levels—a threshold that the world could breach in the next few decades unless greenhouse gas emissions are drastically reduced.

Earth could lose 16% of its species if the average global temperature exceeds 4.3 °C.

Implicit objectivity

Expansion of the predicator

Be expected to

RAclim

The extremes are defined as annual maximum daily maximum and annual minimum daily minimum temperatures as well as annual maximum 1-day precipitation accumulations that are expected to occur once every 20 years in the current climate (1. 0°C global warming relative to preindustrial).

SPMclim

It is also expected to drive the loss of coastal resources and reduce the productivity of fisheries and aquaculture (especially at low latitudes).

Poverty and disadvantage are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several jundred million by 2050 (medium confidence). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 4.2.2.2, 5.2.1, 5.2.2, 5.2.3, 5.6.3}

B.6.2 Adaptation is expected to be more challenging for ecosystems, food and health systems at 2°C of global warming than for 1.5°C (medium confidence).

STclim

Under high levels of warming, very intense hurricanes are expected to occur more frequently, although the overall number of hurricanes is expected to reduce.

Heavy rainfall events are expected to occur more often at high latitudes in the northern hemisphere at 2°C compared to 1.5°C.

On land, the area of risk from major ecosystem change is expected to be around 50% lower at 1.5°C than at 2°C.

Around 70 to 90% of coral reefs are expected to be lost at 1.5°C compared to 99% at 2°C of warming.

RAbio

In this paper we examine 1) how terrestrial species communities have been impacted over the last thousand years of human development and 2) how plausible futures defined by alternative socio-economic scenarios are expected to impact species communities in the future.

Although climate change is expected to have severe detrimental impacts to biodiversity – which are not quantified in these results – it is important to consider how the climate change mitigation itself may also impact biodiversity.

SPMbio

Future targets are expected to be more effective if they take into account the impacts of climate change, including on biodiversity, and action to mitigate and adapt to climate change {4.6, 3.7}.

Likewise, large bioenergy crop or afforested areas are expected to compete with areas set aside for conservation, including restoration, or agriculture (established but incomplete).

In contrast, the benefits of avoiding and reducing deforestation and promoting restoration can be significant for biodiversity (well established) and are expected to have co-benefits for local communities (established but incomplete) {4.2.4.3}.

Climate change and business-as-usual fishing scenarios are expected to worsen the status of marine biodiversity (well established) {4.2.2.2, 4.2.2.3.1}.

Regions such as North America and Europe are expected to have low conversion to crops and continued reforestation {4. 1.5, 4.2.4.2}.

Novel communities, where species will co-occur in historically unknown combinations, are expected to emerge (established but incomplete) {4.2.1.2., 4.2.4.1}

For marine systems, impacts are expected to be geographically variable, with many fish populations projected to move poleward due to ocean warming, meaning that local species extinctions are expected in the tropics (well established) {4.2.2.2.1}.

Along coastlines, the upsurge in extreme climatic events, sea level rise and coastal development are expected to cause increased fragmentation and loss of habitats.

Be predicted to

STclim

At the same time, global population is growing rapidly, predicted to rise from 7. 6 billion today to 8.5-10 billion by 2050, and urbanising, with urban-dwellers predicted to rise by 2 billion people in the next three decades.

RAbio

Our results suggest that strong climate change mitigation through biofuel production will detrimentally impact biodiversity: SSP4/RCP3.4 (with high biofuel mitigation) is predicted to see two times the decrease in abundance-based biodiversity intactness and three times the decrease in local species richness between 2015-2100 as is predicted for SSP4/RCP6.0 (with lower levels of mitigation).

Newbold et al (2015) also inferred that four different RCP x IAM combinations had very different implications for biodiversity by 2100: average species-richness was predicted to fall by a further 3.4% under MESSAGE 8.5 but to increase by 1.9% under MINICAM 4.5.

Global mean abundance-based BII in 2015 is estimated to be 0; 785 (Table 1), with all regions apart from Central Africa predicted to have a value of less than 0.90 (the proposed safe limit: Steffen et al 2015).

For instance, when examining the projections for SSP3/RCP7.0 and SSP5/RCP8.5, most African regions show declines in both biodiversity intactness and local species richness, whereas some Asian and European regions are predicted to see an overall improvement in biodiversity (Figures 1D, 1G, 2D & 2G).

Be projected to

RAclim

For example, over the global land area, the probability of a warm extreme that occurs once every 20 years on average in the current climate is projected to increase 130% and 340% at the 1.5°C and 2°C.

SPMclim

B.1.2 Temperature extremes on land are projected to warm more than GMST (high confidence): extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about 4°C at 2°C, and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C (high confidence).

The number of hot days is projected to increase in most land regions, with highest increases in the tropics (high confidence). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

B.1.3 Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C of global warming in some regions (medium confidence).

Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C of global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (medium confidence).

Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C compared to 1.5°C global warming (medium confidence).

As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming (medium confidence). {3.3.1, 3.3.3, 3.3.4, 3.3.5, 3.3.6}

B.2 By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (medium confidence).

B.3 On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C.

Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans (high confidence). (Figure SPM.2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}

B.3.1 Of 105,000 species studied, 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (medium confidence).

B.3.2 Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1ºC of global warming, compared with 13% (interquartile range 8–20%) at 2°C (medium confidence).

This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C (medium confidence). {3.4.3.1, 3.4.3.5}

Limiting global warming to 1.5°C rather than 2°C is projected to prevent the thawing over centuries of a permafrost area in the range of 1.5 to 2.5 million km2 (medium confidence). {3.3.2, 3.4.3, 3.5.5}

B.4 Limiting global warming to 1.5°C compared to 2ºC is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (high confidence).

Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems (high confidence). {3.3, 3.4, 3.5, Box 3.4, Box 3.5}

B.4.2 Global warming of 1.5°C is projected to shift the ranges of many marine species to higher latitudes as well as increase the amount of damage to many ecosystems.

The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (high confidence).

Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (high confidence) with larger losses (>99%) at 2ºC (very high confidence).

B.4.3 The level of ocean acidification due to increasing CO2 concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C, impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, for example, from algae to fish (high confidence). {3.3.10, 3.4.4}

B.4.4 Impacts of climate change in the ocean are increasing risks to fisheries and aquaculture via impacts on the physiology, survivorship, habitat, reproduction, disease incidence, and risk of invasive species (medium confidence) but are projected to be less at 1.5ºC of global warming than at 2ºC.

B.5 Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. (Figure SPM.2) {3.4, 3.5, 5.2, Box 3.2, Box 3.3, Box 3.5, Box 3.6, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2}

B.5.2 Any increase in global warming is projected to affect human health, with primarily high confidence negative consequences (high confidence).

Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (very high confidence) and for ozone-related mortality if emissions needed for ozone formation remain high (high confidence).

Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (high confidence). {3.4.7, 3.4.8, 3.5.5.8}

B.5.3 Limiting warming to 1.5°C compared with 2ºC is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America, and in the CO_2-dependent nutritional quality of rice and wheat (high confidence).

Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (high confidence). {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4}

B.5.5 Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century (medium confidence).

Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2°C (medium confidence). {3.5.2, 3.5.3}

Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (high confidence). {3.3.1, 3.4.5, Box 3.5, Table 3.5, Cross-Chapter Box 9 in Chapter 4, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}

For limiting global warming to below 2°C CO_2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).

In 1.5°C pathways with no or limited overshoot, low-emission energy sources are projected to have a higher share, compared with 2°C pathways, particularly before 2050 (high confidence).

In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (high confidence).

C.2.3 CO_2 emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 65–90% (interquartile range) lower in 2050 relative to 2010, as compared to 50–80% for global warming of 2°C (medium confidence).

C.3.2 In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 $GtCO_2\ yr^{-1}$ in 2030, 2050, and 2100, respectively, while agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 $GtCO_2\ yr^{-1}$ in these years (medium confidence).

D.5.3 Global model pathways limiting global warming to 1.5°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD2010 between 2016 and 2035, representing about 2.5% of the world GDP (medium confidence). {4.4.5, Box 4.8}

RAbio

SSP4/RCP3.4 forecasts the greatest impact to average local species richness of all the SSP/RCP combinations with an average loss of 13% of local species richness projected to have occurred by 2100.

SPMbio

Globally, paved road lengths are projected to increase by 25 million kilometres by 2050, with nine tenths of all road construction occurring within least developed and developing countries.

For example, climate change is projected to greatly increase the number of species under threat, with fewer species expanding their ranges or experiencing more suitable climatic conditions than the number of species experiencing range contraction or less suitable conditions (established but incomplete) {4.2, 3.2}.

25. The adverse impacts of climate change on biodiversity are projected to increase with increasing warming, so limiting global warming to well below 2°C would have multiple co-benefits for nature and nature's contributions to people and quality of life; however, it is projected that some large-scale land-based mitigation measures to achieve that objective will have significant impacts on biodiversity (established but incomplete) {4.2, 4.3, 4.4, 4.5}.

However, the land areas required for bioenergy crops (with or without carbon capture and storage), afforestation and reforestation to achieve the targeted carbon uptake rates are projected to be very large {4.2.4.3., 4.5.3}.

26. Biodiversity and nature's regulating contributions to people are projected to decline further in most scenarios of global change over the coming decades, while the supply and demand for nature's material contributions to people that have current market value (food, feed, timber and bioenergy) are projected to increase (well established) {4.2, 4.3} (for example, see Figure SPM.8).

Climate change alone is projected to decrease ocean net primary production by between 3 and 10 per cent, and fish biomass by between 3 and 25 per cent (in low and high warming scenarios, respectively) by the end of the century (established but incomplete) {4.2.2.2.1}.

Important regulating contributions of nature, such as coastal and soil protection, crop pollination and carbon storage, are projected to decline (established but incomplete) {4.2.4, 4.3.2.1}.

For marine systems, impacts are expected to be geographically variable, with many fish populations projected to move poleward due to ocean warming, meaning that local species extinctions are expected in the tropics (well established) {4.2.2.2.1}.

Coral reefs are projected to undergo more frequent extreme warming events, with less recovery time in between, declining by a further 70–90 per cent at global warming of 1.5°C, and by more than 99 per cent at warming of 2°C, causing massive bleaching episodes with high coral mortality rates (well established) {4.2.2.2.2}.

Be modelled to

SPMclim

In electricity generation, shares of nuclear and fossil fuels with carbon dioxide capture and storage (CCS) are modelled to increase in most 1.5°C pathways with no or limited overshoot.

Be estimated to

SPMclim

A.1 Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C.

By the end of 2017, anthropogenic CO2 emissions since the pre-industrial period are estimated to have reduced the total carbon budget for 1.5°C by approximately 2200 ± 320 GtCO2 (medium confidence).

C.2.6 Additional annual average energy-related investments for the period 2016 to 2050 in pathways limiting warming to 1.5°C compared to pathways without new climate policies beyond those in place today are estimated to be around 830 billion USD2010 (range of 150 billion to 1700 billion USD2010 across six models).

STclim

The number of people living in poverty today is estimated to be 1.5 billion.

RAbio

Global mean abundance-based BII in 2015 is estimated to be 0; 785 (Table 1), with all regions apart from Central Africa predicted to have a value of less than 0.90 (the proposed safe limit: Steffen et al 2015.

Global mean local species richness in 2015 is estimated to have been 0. 901.

SPMbio

The threat of extinction is also accelerating: in the best-studied taxonomic groups, most of the total extinction risk to species is estimated to have arisen in the past 40 years (established but incomplete) {2.2.5.2.4}.

As a result of human-caused changes in community composition, naturally occurring species in local terrestrial ecosystems worldwide are estimated to have lost at least 20 per cent of their original abundance on average, with hotspots of endemic species tending to have lost even more (established but incomplete) {2.2.5.2.3}.

At least 107 highly threatened birds, mammals and reptiles (e.g., the Island Fox and the Seychelles Magpie-Robin) are estimated to have benefited from invasive mammal eradication on islands {3.2.2}.

Be likely to

SPMclim

Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (high confidence) (Figure SPM.1) {1.2}

STclim

If these emissions continue at current rates, we are likely to reach 1.5°C of warming of between 2030 and 2052–an additional 0. 5°C from today's level warming.

Global warming is likely to reach 1.5°C between 2030 and 2052, if warming continues at the current rate.

RAbio

The major factor is likely to be that our models of compositional similarity are able to incorporate more pressures than did those of Newbold et al (2016) because we use the full set of pairwise comparisons rather than using only a subset.

SPMbio

24. To achieve the Sustainable Development Goals and the 2050 Vision for Biodiversity, future targets are likely to be more effective if they take into account the impacts of climate change (well established) {3.2, 3.3}.

Be unlikely to

SPMclim

A.2 Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (high confidence), but these emissions alone are unlikely to cause global warming of 1.5°C (medium confidence). (Figure SPM.1) {1.2, 3.3, Figure 1.5}

A.2.1 Anthropogenic emissions (including greenhouse gases, aerosols and their precursors) up to the present are unlikely to cause further warming of more than 0.5°C over the next two to three decades (high confidence) or on a century time scale (medium confidence). {1.2.4, Figure 1.5}

Modal adverbs

Clearly

RAclim

Clearly, the relative changes in probability are larger for rarer, more extreme events.

In fact

RAclim

This lack of sensitivity will, in fact, become apparent earlier for events that are rarer in the 1.0°C world.

STclim

We are not on track to limit warming to 1.5°C, in fact, current emission reduction pledges made by nations in the Paris Agreement would lead to warming of 3-4°C by the end of this century.

PAclim

“We in fact have to act immediately in a larger way than ever before.”

Actually

STclim

There are two ways we can achieve this : We can actually reduce our emissions to zero; Or we can effectively do so by substantially reducing them and then offsetting remaining emissions by using technology and/or biological means to remove CO2 from the atmosphere – with the net effect being as though we were not CO2 emitting at all.

PAclim

Without a change of course, we are actually heading for a world that is 3 or 4°C warmer, which could lead to seas rising more than 20 metres.

Probably

PAclim

On current trends, the first year to exceed 1.5°C above the 1850 to 1900 average will probably occur in the 2020s.

So focusing on arbitrary deadlines is probably not the best way to sum up the science.

RAbio

Several factors probably contribute to this difference.

Likely

SPMbio

Ocean mining, while relatively small, has expanded since 1981 to ~ 6,500 offshore oil and gas installations worldwide in 53 countries (60 per cent in the Gulf of Mexico by 2003) and likely will expand into the Arctic and Antarctic regions as the ice melts {2.1.11}.

Potentially

RAclim

This potentially brings about another dimension of complexity as to which metric, probability of fixed magnitude or magnitude at a fixed frequency, most effectively conveys information about changes in risk to users such as policymakers.

SPMclim

B.5.3 Limiting warming to 1.5°C compared with 2ºC is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America, and in the CO2-dependent nutritional quality of rice and wheat (high confidence).

STclim

Increasing acidity has a wide range of potentially harmful consequences for marine organisms, shown to impact the immune systems of shellfish and formation of the skeletons of corals and specific plankton.

RAbio

All three of these difficulties arise from sensible practical decisions taken in the face of resource constraints, but could potentially be overcome with further work.

SPMbio

In 2015, agricultural support potentially harmful to nature amounted to $100 billion in countries belonging to the Organization for Economic Cooperation and Development, although some subsidy reforms to reduce unsustainable pesticide uses and adjust several other consequential development practices have been introduced {2.1.9.1, 6.4.5}.

Possibly

SPMclim

D.5.5 The systems transitions consistent with adapting to and limiting global warming to 1.5°C include the widespread adoption of new and possibly disruptive technologies and practices and enhanced climate-driven innovation.

Perhaps

PAclim

Twelve years to save the planet. Warming of 3°C, or perhaps 5°C if we don’t take drastic action now.

This is perhaps the toughest question in all of climate science. Carbon dioxide directly warms the planet by trapping more of the sun’s heat.

SPMbio

In fisheries, subsidies to increase and maintain capacity, which in turn often lead to the degradation of nature, constitute perhaps a majority of the tens of US$ billions spent on supports {5.3.2.5}.

Modal adjectives

Likely

SPMclim

A.1 Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C.

A.1.1 Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (likely between 0.75°C and 0.99°C) higher than the average over the 1850–1900 period (very high confidence).

Estimated anthropogenic global warming matches the level of observed warming to within ±20% (likely range).

Estimated anthropogenic global warming is currently increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (high confidence). {1.2.1, Table 1.1, 1.2.4}

Figure SPM.1 | Panel a: Observed monthly global mean surface temperature (GMST, grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) change and estimated anthropogenic global warming (solid orange line up to 2017, with orange shading indicating assessed likely range).

Orange dashed arrow and horizontal orange error bar show respectively the central estimate and likely range of the time at which 1.5°C is reached if the current rate of warming continues.

The grey plume on the right of panel a shows the likely range of warming responses, computed with a simple climate model, to a stylized pathway (hypothetical future) in which net CO2 emissions (grey line in panels b and c) decline in a straight line from 2020 to reach net zero in 2055 and net non-CO2 radiative forcing (grey line in panel d) increases to 2030 and then declines.

The vertical error bars on right of panel a) show the likely ranges (thin lines) and central terciles (33rd – 66th percentiles, thick lines) of the estimated distribution of warming in 2100 under these three stylized pathways.

Vertical dotted error bars in panels b, c and d show the likely range of historical annual and cumulative global net CO2 emissions in 2017 (data from the Global Carbon Project) and of net non-CO2 radiative forcing in 2011 from AR5, respectively.

Plausible

PAclim

A common measure of climate sensitivity is how much warming would occur in the decades and centuries after a doubling of CO2 levels. Studies converge on the most likely value being 3°C, but with plausible values ranging from under 2°C to more than 5°C.

While we are increasingly confident that the low end of the plausible range can be ruled out, there is a long tail of high values that cannot.

RAbio

In this paper we examine 1) how terrestrial species communities have been impacted over the last thousand years of human development and 2) how plausible futures defined by alternative socio-economic scenarios are expected to impact species communities in the future.

These scenarios detail five plausible global futures based upon socio-economic factors such as wealth, population, education, technology, and reliance on fossil fuels, and can be combined with Representative Concentration Pathway (RCP) scenarios to consider climate mitigation strategies.

Potential

SPMclim

B. Projected Climate Change, Potential Impacts and Associated Risks

Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (high confidence). {3.4.7, 3.4.8, 3.5.5.8}

Different portfolios face different implementation challenges and potential synergies and trade-offs with sustainable development. (high confidence) (Figure SPM.3b) {2.3.2, 2.3.4, 2.4, 2.5.3}

Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO2 over the course of this century and more thereafter (medium confidence).

These pathways were selected to show a range of potential mitigation approaches and vary widely in their projected energy and land use, as well as their assumptions about future socio-economic developments, including economic and population growth, equity and sustainability.

These improvements signal a potential system transition in electricity generation. (Figure SPM.3b) {2.4.1, 2.4.2, Figure 2.1, Table 2.6, Table 2.7, Cross-Chapter Box 6 in Chapter 3, 4.2.1, 4.3.1, 4.3.3, 4.5.2}

C.3.1 Existing and potential CDR measures include afforestation and reforestation, land restoration and soil carbon sequestration, BECCS, direct air carbon capture and storage (DACCS), enhanced weathering and ocean alkalinization.

C.3.4 Most current and potential CDR measures could have significant impacts on land, energy, water or nutrients if deployed at large scale (high confidence).

Some 1.5°C pathways show potential trade-offs with mitigation for SDGs 1 (poverty), 2 (hunger), 6 (water) and 7 (energy access), if not managed carefully (high confidence). (Figure SPM.4) {5.4.2; Figure 5.4, Cross-Chapter Boxes 7 and 8 in Chapter 3}

Figure SPM.4 | Potential synergies and trade-offs between the sectoral portfolio of climate change mitigation options and the Sustainable Development Goals (SDGs).

STclim

The largest potential future

Regional key risks and potential for risk reduction with current adaptation.

PAclim

Then there are potential tipping points such as the shutdown of the Atlantic current that warms northern Europe.

Possible

SPMclim

D.3 Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (high confidence). {1.4, 4.3, 4.5}

While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (high confidence) (Figure SPM.4) {2.5, 4.5, 5.4}

STclim

It aims to provide policymakers with regular assessments of the scientific understanding of climate change, including possible impacts and options for adapting to them, and means of reducing greenhouse gas emissions.

While limiting global warming to 1.5°C is still possible – we not are already committed to this by our past GHG emissions, we would have to act very rapidly to achieve this goal.

RAbio

However, a brighter future is possible; SSP1/RCP2. 6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity – in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100.

Indicators that embody explicit links between drivers and biodiversity provide the potential for estimating how the state of the indicator has changed beyond the temporal range for which direct observations are available, enabling estimation not only of how the state of nature has changed up to now, but also how it will change in possible futures (eg Nicholson et al 2012; IPBES Scenarios & Modelling assessment (IPBES 2016); Visconti et al 2015; Purvis et al 2018).

Study-level means of human population density and agricultural suitability were included as control variables, to avoid possible biases (eg, sampling may be more thorough in studies conducted

in more densely-populated regions).

SPMbio

The scores for the targets are based on a systematic assessment of the literature and a quantitative analysis of the indicators, where possible.

Alternative models and measures of economic welfare (such as inclusive wealth accounting, natural capital accounting and degrowth models) are increasingly considered as possible approaches to balancing economic growth and the conservation of nature and its contributions and to recognizing trade-offs, the pluralism of values, and long-term goals (established but incomplete) {6.4.5}.

Explicit objectivity

Extraposition with adjectives

STclim

It's estimated that the additional emission reduction actions to limit warming to 1.5°C compared to 2°C would reduce premature deaths from air pollution by 100-200 million over the course of this century.

PAclim

Even if we are unsure of the exact value of the climate's sensitivity to carbon dioxide and other greenhouse gases, it is clear that what matters is how much is in the atmosphere.

PAbio

It is true that at the current rate of emissions we will exceed the report's "most likely" remaining carbon budget in roughly 12 years.

Extraposition with nominalisations

RAclim

The implication is that risk assessment will depend critically on an understanding of the thresholds for the occurrence of extremes and kinds of extremes at which vulnerability increases sharply.

RAbio

The core assumption is that the relationships between the drivers and biodiversity estimated from these data remain constant over time (Purvis et al. 2018).

Epistemic lexical verbs

Suggest

SPMclim

B.2.1 Model-based projections of global mean sea level rise (relative to 1986–2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C of global warming, 0.1 m (0.04–0.16 m) less than for a global warming of 2°C (medium confidence).

PAclim

Because the Artic is rapidly heating up, NASA's figures suggest there has been nearly 0.1°C more waring across the planet than the Met Office's do.

Computer models suggest the world was already up 0.2°C warmer before 1850.

Antarctica is already losing ice much faster than expected, and a 2016 study based on a computer model of its ice sheets suggests the seas could rise by up to 3 metres by 2100.

RAbio

Our results suggest that strong climate change mitigation through biofuel production will detrimentally impact biodiversity: SSP4/RCP3.4 (with high biofuel mitigation) is predicted to see two times the decrease in abundance-based biodiversity intactness and three times the decrease in local species richness between 2015-2100 as is predicted for SSP4/RCP6.0 (with lower levels of mitigation)

SPMbio

Those proportions suggest that, of an estimated 8 million animal and plant species (75 per cent of which are insects), around 1 million are threatened with extinction (established but incomplete) {2.2.5.2.4}.

Habitat loss and deterioration, largely caused by human actions, have reduced global terrestrial habitat integrity by 30 per cent relative to an unimpacted baseline; combining that with the longstanding relationship between habitat area and species numbers suggests that around 9 per cent of the world's estimated 5.9 million terrestrial species – more than 500,000 species – have insufficient habitat for long-term survival, and are committed to extinction, many within decades, unless their habitats are restored (established but incomplete){2.2.5.2.4}.

Available data suggest that genetic diversity within wild species globally has been declining by about 1 per cent per decade since the mid-19th century; and genetic diversity within wild mammals and amphibians tends to be lower in areas where human influence is greater (established but incomplete) {2.2.5.2.6}.

Almost half (47 per cent) of threatened terrestrial mammals, excluding bats, and one quarter (23 per cent) of threatened birds may have already been negatively affected by climate change in at least part of their distribution (birds in North America and Europe suggest effects of climate change in their population trends since the 1980s) (established but incomplete) {2.2.6.2}.

32. A summary of the evidence related to the components of pathways to sustainability suggests that there are five overarching types of management interventions, or levers, and eight leverage points that are key for achieving transformative change (Figure SPM.9; D3 and D4 above) {5.4.1, 5.4.2}.

Imply

SPMclim

These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (medium confidence). {2.3, 2.4, 2.5, 4.2, 4.3, 4.4, 4.5}

C.2.4 The urban and infrastructure system transition consistent with limiting global warming to 1.5°C with no or limited overshoot would imply, for example, changes in land and urban planning practices, as well as deeper emissions reductions in transport and buildings compared to pathways that limit global warming below 2°C (medium confidence).

Epistemic lexical verbs in v-ing form

RAclim

We considered the possibility that the shape parameter ξ might also vary with global mean temperature but found that allowing it to be linearly dependent on ΔT did not improve the goodness of fit as judged by standard likelihood ratio tests, suggesting little appreciable change in the shape parameters due to warming.

The scale parameter decreases for cold extremes in areas where snow and sea ice retreat, suggesting moderately lower variability in the warmer world in these areas but little change elsewhere.

Lexical expression of certainty and uncertainty

RAclim

This consistency provides a measure of confidence in future projections, at least on a large scale.

Changes in cold extremes are such that the preindustrial 1-in-20-year event becomes a 1-in-50-year event in the current climate and less than a 1-in-200-year event for global warming of 2°C or greater (though we note that the estimates of such large return period values are associated with larger uncertainty).

Uncertainty increases correspondingly, as can be seen from the increase in the multimodel spread of RR values between the 1. 5°C and 2. 0°C global warming levels.

SPMclim

There is generally low confidence in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions.

There is high confidence that the probability of a sea ice-free Arctic Ocean during summer is substantially lower at global warming of 1.5°C when compared to 2°C.

Uncertainties in the climate response to CO2 and non-CO2 emissions contribute ±400 GtCO2 and the level of historic warming contributes ±250 GtCO2 (medium confidence).

Uncertainties in the size of these estimated remaining carbon budgets are substantial and depend on several factors.

The rates of system changes associated with limiting global warming to 1.5°C with no or limited overshoot have occurred in the past within specific sectors, technologies and spatial contexts, but there is no documented historic precedent for their scale (medium confidence). {2.3.3, 2.3.4, 2.4, 2.5, 4.2.1, 4.2.2, Cross-Chapter Box 11 in Chapter 4}

The literature on total mitigation costs of 1.5°C mitigation pathways is limited and was not assessed in this Report.

Knowledge gaps remain in the integrated assessment of the economy-wide costs and benefits of mitigation in line with pathways limiting warming to 1.5°C. {2.5.2; 2.6; Figure 2.26}

Carbon cycle and climate system understanding is still limited about the effectiveness of net negative emissions to reduce temperatures after they peak (high confidence). {2.2, 2.3.4, 2.3.5, 2.6,4.3.7, 4.5.2, Table 4.11}

Information about the net impacts of mitigation on sustainable development in 1.5°C pathways is available only for a limited number of SDGs and mitigation options.

Only a limited number of studies have assessed the benefits of avoided climate change impacts of 1.5°C pathways for the SDGs, and the co-effects of adaptation for mitigation and the SDGs.

Adaptation finance consistent with global warming of 1.5°C is difficult to quantify and compare with 2°C.

Knowledge gaps include insufficient data to calculate specific climate resilience-enhancing investments from the provision of currently underinvested basic infrastructure.

More recently there is a growing understanding of the scale and increase in non-governmental organizations and private funding in some regions (medium confidence).

STclim

Uncertainty in forecasts of future climate also derives from different estimates for the amount of global warming that will result from a given increase of greenhouse gases in the atmosphere – i.e. just how sensitive the climate system is to our emissions.

Adaptation is made more difficult because we can't predict exactly how the climate will change in a given place in future.

A key difficulty in efforts to adapt to climate change is that future changes in climate are often uncertain.

Given the lack of scientific knowledge around this ambitious new temperature goal at the time, the IPCC was formally invited to produce a Special Report on Global Warming of 1.5°C.

PAclim

Except it isn't–and that is just the beginning of the confusion.

The uncertainty starts here.

But as we don't know for sure at what temperatures any of these will kick in, this doesn't help establish a "safe" limit.

Adding to the confusion are all sorts of other pollutants that we are pumping into the atmosphere, some of which have a cooling effect.

This not only makes it harder to determine how much warming CO2 causes, but also to work out what we need to do to limit warming, because it depends on how levels of these pollutants change too.

While we are increasingly confident that the low end of the plausible range can be ruled out, there is a long tail of high values that cannot.

Amid the morass of confusing and conflicting numbers, two things reman crystal clear.

The huge unknown is how long this will take.

The biggest uncertainty by far is us, namely what exactly we do over the next century. And the uncertainty cuts both ways: we could be underestimating how fast the world will warm and what the effects will be.

To work out what that means, we must first know where we are now. The uncertainty starts here.

Even these numbers conceal the uncertainty.

SPMbio

The proportion of insect species threatened with extinction is a key uncertainty, but available evidence supports a tentative estimate of 10 per cent (established but incomplete) {2.2.5.2.4}.

"Uncertain relationship" means that the relationship between nature and/or nature's contributions to people and the achievement of the target is uncertain. "Unknown" indicates that there is insufficient information to score the status and trends.

Adaptive approaches, including learning from experience, monitoring and feedback loops, contribute to preparing for and managing the inevitable uncertainties and complexities associated with social and environmental changes (established but incomplete) {6.2, 5.4.2}.

Trade agreements and derivatives markets could be reformed to promote equity and prevent the deterioration of nature, although there are uncertainties associated with implementation (established but incomplete) {6.4.4}.

Local declines of insect populations such as wild bees and butterflies have often been reported, and insect abundance has declined very rapidly in some places even without large-scale land-use change, but the global extent of such declines is not known (established but incomplete) {2.2.5.2.4}.

Bases of knowledge

OBVIOUSNESS

RAclim

Clearly, the relative changes in probability are larger for rarer, more extreme events.

PAclim

Even if we are unsure of the exact value of the climate's sensitivity to carbon dioxide and other greenhouse gases, it is clear that what matters is how much is in the atmosphere.

Amid the morass of confusing and conflicting numbers, two things reman crystal clear.

PERCEPTION

RAclim

We see that for Paris, a preindustrial climate (1861–1880) 1-in-20-year warm temperature extreme occurs about 4 times more frequently (about once every 5 years) in the climate that is 1°C warmer than preindustrial.

These maps look very similar to those of 20-year events shown in Figure 2.

The difference in the risk ratios between 20-year and 10-year events (Figure S4) shows similar results, indicating once again that the relative changes in probability are larger for rarer, more extreme events.

Similar tendencies are seen when considering the rarer 50-year extreme events.

In general, the patterns of change in risk ratio with the rarity of event seen in these two regions mirror changes seen in other regions.

A similar, although much less pronounced, phenomenon is observed for extreme precipitation events.

This lack of sensitivity will, in fact, become apparent earlier for events that are rarer in the 1.0°C world.

Differences in the risk ratio values for different types of extremes and for different event probabilities are apparent.

Uncertainty increases correspondingly, as can be seen from the increase in the multimodel spread of RR values between the 1. 5°C and 2. 0°C global warming levels.

In the case of both temperature and precipitation extremes, there is an overall shift toward higher values, corresponding to an increase in the location parameter, reflecting warming in the case of temperature and an increase in intensity in the case of precipitation.

The scale parameter decreases for cold extremes in areas where snow and sea ice retreat, suggesting moderately lower variability in the warmer world in these areas but little change elsewhere.

On the other hand, the scale parameter for extreme precipitation increases, indicating higher variability.

The risk ratio comparing the likelihood of warm extremes at the 1. 5°C warming level relative to the present level is larger than one everywhere, which indicates more frequent occurrence of those extremes, with larger values in lower latitudes and the highest values over oceans.

PAclim

Following current trajectories this is likely to happen around 2040—sufficiently close that many scientists and politicians have adopted a somewhat different definition of hitting 1.5°C.

That is the message many seem to have taken from the latest IPCC report—but that is not quite what the report says.

The seemingly equivalent figure in the latest report is 420 gigatons.

RAbio

Historical trend lines reveal a dramatic decrease in average local biodiversity following the Industrial Revolution, with 75% of the reduction to date in both biodiversity intactness and local species richness occurring post-1800.

Global mean abundance-based BII in 2015 is estimated to be 0.785 (Table 1), with all regions apart from Central Africa predicted to have a value of less than 0.90 (the proposed safe limit: Steffen et al. 2015).

Global mean local species richness in 2015 is estimated to have been 0.901.

The SSP/RCP combinations allow the examination of how differing socioeconomic scenarios will impact biodiversity at global and regional scales SSP1/RCP2.6 shows both an overall global positive response in biodiversity intactness and broadly consistent positive responses within regions (Figure 1B).

For instance, when examining the projections for SSP3/RCP7.0 and SSP5/RCP8.5, most African regions show declines in both biodiversity intactness and local species richness, whereas some Asian and European regions are predicted to see an overall improvement in biodiversity (Figures 1D, 1G, 2D & 2G).

The comparison of SSP4/RCP3 4 and SSP4/RCP6 0 allows the evaluation of the impact to biodiversity from land use changes aimed at mitigating global temperature increases (note that our framework does not assess the impacts of temperature increase themselves).

The global map of present-day abundance-based biodiversity intactness (here illustrated through SSP3/RCP7.0) shows relatively low values throughout much of Western Europe and Eastern North America; however, the lowest levels are seen in areas where high population density overlaps with high land conversion, for instance, much of India and Northern China (Figure 3).

A comparison of abundance-based BII in 2015 and 2050 reveals increases over much of Western Europe but declines over much of Central and Southern Africa (Figure 4).

Our projections of the future for biodiversity under varying plausible socio-economic scenarios reveal stark regional differences with African regions faring worse than European and Asian regions under five of the six SSP/RCP combinations.

Only SSP1/RCP2. 6 showed overall improvement in biodiversity globally and in most regions.

Our map of present-day abundance-based BII shows geographic differences from the map presented by Newbold et al. (2016).

The SSP/RCP combinations allow the examination of how differing socioeconomic scenarios will impact biodiversity at global and regional scales SSP1/RCP2.6 shows both an overall global positive response in biodiversity intactness and broadly consistent positive responses within regions (Figure 1B).

The comparison of SSP4/RCP3 4 and SSP4/RCP6 0 allows the evaluation of the impact to biodiversity from land use changes aimed at mitigating global temperature increases (note that our framework does not assess the impacts of temperature increase themselves).

This mitigation has negative impacts, causing a three times greater decrease in local species richness, and two times greater decrease in abundance-based biodiversity intactness, from 2015-2100 for SSP4/RCP3. 4 compared to that for SSP4/RCP6.0.

A comparison of abundance-based BII in 2015 and 2050 reveals increases over much of Western Europe but declines over much of Central and Southern Africa (Figure 4).

Only SSP1/RCP2. 6 showed overall improvement in biodiversity globally and in most regions.

SPMbio

Figure 1. Global trends in the capacity of nature to sustain contributions to good quality of life from 1970 to the present, which show a decline for 14 of the 18 categories of nature's contributions to people analysed.

Figure 4. Development pathways since 1970 for selected key indicators of human-environment interactions, which show a large increase in the scale of global economic growth and its impacts on nature, with strong contrasts across developed, developing, and least developed countries.

Overall, the state of nature continues to decline (12 of 16 indicators show significantly worsening trends) (well established) {3.2} (Figure SPM.6).

PAbio

"That is really the absolutely key novelty that we see here."

PROOF

RAclim

The greatest direct impacts on human society and natural systems from climate variability and change frequently result from climate and weather extremes (Easterling et al., 2000; IPCC, 2012).

Heat waves often have direct public health consequences, and changes in their intensity and duration have become an important concern for public health officials (Dunne et al. 2013; Li et al, 2017; Pal & Eltahir, 2015).

For example, increases in winter minimum temperatures pose significant threats to North American forests from southern pine beetle (Lesk et al., 2017).

Substantially greater complexity for risk assessment will arise in the context of compound events (Leonard et al. […]).

The modelled trends in annual maximum and minimum daily temperatures in the second half of the 20th century are consistent with both reanalyses and station-based estimates (Sillmann et al, 2013), although modelled warming in the warm extremes is somewhat slower than observed and that in the cold extremes is somewhat faster than observed.

Annual maximum 1-day precipitation amount has increased with surface temperature warming at a rate of about 7% per 1°C global mean temperature, close to that at which the water-holding capacity of the troposphere increases following the Clausius-Clapeyron relationship (Westra et al, 2013).

The simulated effects of anthropogenic forcing on extreme precipitation are also consistent with observed changes on average over Northern Hemisphere land (Zhang et al, 2013).

PAclim

A 1990 report concluded that limiting global warming to 1 °C would be safer than a 2°C cap.

But as an October report on this target by the Intergovernmental Panel on Climate Change (IPCC) makes clear, it is not a safe limit.

Computer models figures estimates suggest proof do not if data has been hardly handled to make conclusion with report there is the idea of reasoning and presentation of different ideas of the authors more a "he says that" than tests found but gradience so I keep like that

IPCC projections are for sea levels to go up by between 0.3 and 0.8 metres by 2100 in a world that is 1.5°C warmer, and by 0.5 to 1 metre by the end of the century if emissions keep increasing unchecked.

A 2016 study based on a computer model of its ice sheets suggests the seas could rise by up to 3 metres by 2100.

Studies converge on the most likely value being 3°C, but with plausible values ranging from under 2°C to more than 5°C.

RAbio

Our results suggest that strong climate change mitigation through biofuel production will detrimentally impact biodiversity: SSP4/RCP3.4 (with high biofuel mitigation) is predicted to see two times the decrease in abundance-based biodiversity intactness and three times the decrease in local species richness between 2015-2100 as is predicted for SSP4/RCP6.0 (with lower levels of mitigation).

SSP4/RCP3.4 forecasts the greatest impact to average local species richness of all the SSP/RCP combinations with an average loss of 13% of local species richness projected to have occurred by 2100.

SSP3/RCP7.0 – a scenario describing a globally segregated, and economically protectionist future with low climate change mitigation – has the worst impacts on abundance-based biodiversity intactness with an average loss of 26% of intactness by 2100.

However, a brighter future is possible; SSP1/RCP2. 6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity – in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100.

This decision allowed Newbold et al. (2015) to estimate that land use and related pressures have reduced average local species-richness across the world's terrestrial assemblages by 13.6%, with most of the decline concentrated in the 20th century.

Newbold et al. (2015) also inferred that four different RCP x IAM combinations had very different implications for biodiversity by 2100: average species-richness was predicted to fall by a further 3.4% under MESSAGE 8.5 but to increase by 1.9% under MINICAM 4.5.

However, most biodiversity indicators report only over a short time period leading up to the present day, because few underpinning observational time-series go back more than a few decades (Magurran et al. 2010).

The PREDICTS modelling framework focuses on the biodiversity effects of land use and related pressure (Purvis et al. 2018), as these are still the dominant current pressures on terrestrial biodiversity worldwide (Foley et al. 2005; Sala et al. 2000).

Our global estimate of mean abundance-based BII, at 0. 785, is somewhat lower than the 0.846 estimated by Newbold et al. (2016).

The major factor is likely to be that our models of compositional similarity are able to incorporate more pressures than did those of Newbold et al. (2016) because we use the full set of pairwise comparisons rather than using only a subset.

The resulting models include significant negative effects of human population density and land-use intensity on compositional similarity - variables omitted from the models of Newbold et al. (2016).

Purvis et al. (2018) discuss some remaining reasons why our modelling approach may still be overestimating BII; the most important in the context of this paper is that our models do not consider biotic effects of climate change or other drivers that have a different spatial pattern from land use and human population density.

Most obviously, we infer a markedly higher level of BII across much of Australia (compare Figure 3 with Newbold et al's Figure S4) than Newbold et al. (2016) who found surprisingly low values of BII.

Historical trend lines show that most losses in local biodiversity are relatively recent, with 75% of all loss in both abundance-based Biodiversity Intactness Index and species richness occurring post-1800.

Stark regional differences emerge in all future scenarios, with biodiversity in African regions Undergoing greater losses than Oceania, North America and the European regions.

Several factors probably contribute to this difference.

SPMbio

The Living Planet Index, which synthesises trends in vertebrate populations, shows that species have declined rapidly since 1970, with reductions of 40 per cent for terrestrial species, 84 per cent for freshwater species and 35 per cent for marine species (established but incomplete) {2.2.5.2.4}.

PAbio

These losses would undermine global efforts to reduce poverty and hunger and promote more sustainable development, the IPBES report says.

The world can reverse this biodiversity crisis, the report says, but doing so will require proactive environmental policies, the sustainable production of food and other resources and a concerted effort to reduce greenhouse-gas emissions.

Up to one million plant and animal species face extinction, many within decades, because of human activities, says the most comprehensive report yet on the state of global ecosystems.

Without drastic action to conserve habitats, the rate of species extinctions—already tens to hundreds of times higher than the average across the last ten million years—will only increase, says the analysis by a United Nations-backed panel, the International Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

The loss of species and habitats is as much a danger to life on Earth as climate change, says a summary of the report released on 6 May.

Landmark UN-backed report finds that agriculture is one of the biggest threats to Earth's ecosystems.

The report also finds that agricultural activities have had the largest impacts on ecosystems that people depend on for food, clean water and a stable climate.

The IPBES report finds that the average abundance of native plants, animals and insects has fallen by at least 20% since 1900 because of invasive species.

Without “transformative changes” to the world’s economic, social and political systems to address this crisis, the IPBES panel projects that major biodiversity losses will continue to 2050 and beyond.

That report, commissioned by IPBES, recommended that the body develop partnerships with governments and communities, and assess policies that can be implemented at local and national levels.

The report draws inextricable links between biodiversity loss and climate change.

“We have never had a single unified statement from the world’s governments that unambiguously makes clear the crisis we are facing for life on Earth,” says Thomas Brooks, chief scientist at the International Union for Conservation of Nature in Gland, Switzerland, who helped to edit the biodiversity analysis.

About 75% of the planet’s land and 66% of its ocean areas have been “significantly altered” by people, driven in large part by the production of food, according to the IPBES report, which will be released in full later this year.

Agricultural threats to ecosystems will only increase as the world’s population continues to grow, according to the IPBES analysis.

SHARED KNOWLEDGE

RAclim

Their past changes and the causes of those changes, as well as their future projections, have been widely studied (Donat et al, 2013; Handmer et al, 2012; Kharin et al, 2013; Kim et al).

Most studies examine changes in projected climate at a specific time in the future conditional on one or more greenhouse gas and aerosol forcing scenarios.

STclim

The number of people living in poverty today is estimated to be 1.5 billion.

At the same time, global population is growing rapidly, predicted to rise from 7. 6 billion today to 8.5-10 billion by 2050, and urbanising, with urban-dwellers predicted to rise by 2 billion people in the next three decades.

However, estimates vary as to what the timing and size of these contributions will be.

Current estimates range between 25 centimetres to over a meter by 2100, depending in part on how much we emit in the future.

Uncertainty in forecasts of future climate also derives from different estimates for the amount of global warming that will result from a given increase of greenhouse gases in the atmosphere – i.e. just how sensitive the climate system is to our emissions.

It's estimated that the additional emission reduction actions to limit warming to 1.5°C compared to 2°C would reduce premature deaths from air pollution by 100-200 million over the course of this century.

PAclim

The devastating storms, incredible heatwaves and rampaging wildfires we are already seeing show that what is deemed safe is a matter of degree.

The prevailing view is that it will take many centuries or millennia.

Despite this, the average temperature between 1850 and 1900 has come to be regarded as the semi-official "pre-industrial level" because that is the earliest period for which we have direct measurements.

A common measure of climate sensitivity is how much warming would occur in the decades and centuries after a doubling of CO2 levels.

Antarctica is already losing ice much faster than expected.

RAbio

Although climate change is expected to have severe detrimental impacts to biodiversity – which are not quantified in these results – it is important to consider how the climate change mitigation itself may also impact biodiversity.

SHARED KNOWLEDGE/PROOF

SPMclim

A.1.1. Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (likely between 0.75°C and 0.99°C) higher than the average over the 1850–1900 period (very high confidence).

Estimated anthropogenic global warming matches the level of observed warming to within ±20% (likely range).

Heavy precipitation when aggregated at global scale is projected to be higher at 2°C than at 1.5°C of global warming (medium confidence).

Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems (high confidence). {3.3, 3.4, 3.5, Box 3.4, Box 3.5}

In modelled 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2% interquartile range) of electricity (high confidence).

A.1.2. Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic.

Impacts on natural and human systems from global warming have already been observed (high confidence).

A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation (medium confidence). {3.4.4, 3.4.5, 4.3.2}

Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (medium confidence).

Temperature extremes on land are projected to warm more than GMST (high confidence):

The number of hot days is projected to increase in most land regions, with highest increases in the tropics (high confidence). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C of global warming in some regions (medium confidence).

Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C of global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (medium confidence).

Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C compared to 1.5°C global warming (medium confidence).

There is generally low confidence in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions.

Heavy precipitation when aggregated at global scale is projected to be higher at 2°C than at 1.5°C of global warming (medium confidence).

As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming (medium confidence). {3.3.1, 3.3.3, 3.3.4, 3.3.5, 3.3.6}

By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (medium confidence).

On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C.

Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans (high confidence). (Figure SPM.2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}

Of 105,000 species studied, 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (medium confidence).

Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1ºC of global warming, compared with 13% (interquartile range 8–20%) at 2°C (medium confidence).

This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C (medium confidence). {3.4.3.1, 3.4.3.5}

Limiting global warming to 1.5°C rather than 2°C is projected to prevent the thawing over centuries of a permafrost area in the range of 1.5 to 2.5 million km2 (medium confidence). {3.3.2, 3.4.3, 3.5.5}

Limiting global warming to 1.5°C compared to 2ºC is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (high confidence).

Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems (high confidence). {3.3, 3.4, 3.5, Box 3.4, Box 3.5}

With 1.5°C of global warming, one sea ice-free Arctic summer is projected per century.

Global warming of 1.5°C is projected to shift the ranges of many marine species to higher latitudes as well as increase the amount of damage to many ecosystems.

It is also expected to drive the loss of coastal resources and reduce the productivity of fisheries and aquaculture (especially at low latitudes).

The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (high confidence).

Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (high confidence)

The level of ocean acidification due to increasing CO2 concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C, impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, for example, from algae to fish (high confidence). {3.3.10, 3.4.4} but are projected to be less at 1.5ºC of global warming than at 2ºC.

Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. (Figure SPM.2) {3.4, 3.5, 5.2, Box 3.2, Box 3.3, Box 3.5, Box 3.6, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2}

Any increase in global warming is projected to affect human health, with primarily high confidence negative consequences (high confidence).

Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (very high confidence)

Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (high confidence). {3.4.7, 3.4.8, 3.5.5.8}

Limiting warming to 1.5°C compared with 2ºC is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America, and in the CO2-dependent nutritional quality of rice and wheat ().

Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (high confidence). {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4}

Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century (medium confidence).

Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2°C (medium confidence). {3.5.2, 3.5.3}

Adaptation is expected to be more challenging for ecosystems, food and health systems at 2°C of global warming than for 1.5°C (medium confidence).

"Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (high confidence). {3.3.1, 3.4.5, Box 3.5, Table 3.5, Cross-Chapter Box 9 in Chapter 4, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}

For limiting global warming to below 2°C CO2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).

In energy systems, modelled global pathways (considered in the literature) limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b) generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (high confidence).

In 1.5°C pathways with no or limited overshoot, low-emission energy sources are projected to have a higher share, compared with 2°C pathways, particularly before 2050 (high confidence).

In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (high confidence).

In electricity generation, shares of nuclear and fossil fuels with carbon dioxide capture and storage (CCS) are modelled to increase in most 1.5°C pathways with no or limited overshoot.

In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 GtCO2 yr−1 in 2030, 2050, and 2100, respectively, while agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 GtCO2 yr−1 in these years (medium confidence).

CO2 emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 65–90% (interquartile range) lower in 2050 relative to 2010, as compared to 50–80% for global warming of 2°C (medium confidence).

Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio.

Land-use transitions of similar magnitude can be observed in modelled 2°C pathways (medium confidence).

Additional annual average energy-related investments for the period 2016 to 2050 in pathways limiting warming to 1.5°C compared to pathways without new climate policies beyond those in place today are estimated to be around 830 billion USD2010 (range of 150 billion to 1700 billion USD2010 across six models).

Global model pathways limiting global warming to 1.5°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD2010 between 2016 and 2035, representing about 2.5% of the world GDP (medium confidence). {4.4.5, Box 4.8}

A1 Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C.

Non-CO2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C.

Pathways that limit global warming to 1.5°C with no or limited overshoot show system changes that are more rapid and pronounced over the next two decades than in 2°C pathways (high confidence).

There are multiple lines of evidence that since AR5 the assessed levels of risk increased for four of the five Reasons for Concern (RFCs) for global warming to 2°C (high confidence).

Climate models project robust differences in regional climate characteristics between present-day and global warming of 1.5°C, and between 1.5°C and 2°C

Evidence from attributed changes in some climate and weather extremes for a global warming of about 0.5°C supports the assessment that an additional 0.5°C of warming compared to present is associated with further detectable changes in these extremes (medium confidence).

Model-based projections of global mean sea level rise (relative to 1986–2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C of global warming, 0.1 m (0.04–0.16 m) less than for a global warming of 2°C (medium confidence).

One global fishery model, for example, projected a decrease in global annual catch for marine fisheries of about 1.5 million tonnes for 1.5°C of global warming compared to a loss of more than 3 million tonnes for 2°C of global warming (medium confidence). {3.4.4, Box 3.4}

These improvements signal a potential system transition in electricity generation. (Figure SPM.3b) {2.4.1, 2.4.2, Figure 2.1, Table 2.6, Table 2.7, Cross-Chapter Box 6 in Chapter 3, 4.2.1, 4.3.1, 4.3.3, 4.5.2}

Model pathways that limit global warming to 1.5°C with no or limited overshoot project a 4 million km2 reduction to a 2.5 million km2 increase of non-pasture agricultural land for food and feed crops and a 0.5–11 million km2 reduction of pasture land, to be converted into a 0–6 million km2 increase of agricultural land for energy crops and a 2 million km2 reduction to 9.5 million km2 increase in forests by 2050 relative to 2010 (medium confidence).

Modelled pathways limiting global warming to 1.5°C with no or limited overshoot project a wide range of global average discounted marginal abatement costs over the 21st century.

The economic literature distinguishes marginal abatement costs from total mitigation costs in the economy.

All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO2 over the 21st century.

Pathways that limit global warming to 1.5°C with no or limited overshoot show system changes that are more rapid and pronounced over the next two decades than in 2°C pathways (high confidence).

Studies indicate a number of challenges, including access to finance and mobilization of funds. (high confidence) {2.5.1, 2.5.2, 4.4.5}

Pathways that are consistent with sustainable development show fewer mitigation and adaptation challenges and are associated with lower mitigation costs.

SPMbio

Global indicators of ecosystem extent and condition have shown a decrease by an average of 47 per cent of their estimated natural baselines, with many continuing to decline by at least 4 per cent per decade (established but incomplete) {2.2.5.2.1}.

The threat of extinction is also accelerating: in the best-studied taxonomic groups, most of the total extinction risk to species is estimated to have arisen in the past 40 years (established but incomplete) {2.2.5.2.4}.

The proportion of species currently threatened with extinction according to the International Union for the Conservation of Nature's Red List criteria averages around 25 per cent across the many terrestrial, freshwater and marine vertebrate, invertebrate and plant groups that have been studied in sufficient detail to support a robust overall estimate (established but incomplete) {2.2.5.2.4, 3.2}.

The proportion of insect species threatened with extinction is a key uncertainty, but available evidence supports a tentative estimate of 10 per cent (established but incomplete) {2.2.5.2.4}.

Those proportions suggest that, of an estimated 8 million animal and plant species (75 per cent of which are insects), around 1 million are threatened with extinction (established but incomplete) {2.2.5.2.4}.

A similar picture also emerges from an entirely separate line of evidence.

Available data suggest that genetic diversity within wild species globally has been declining by about 1 per cent per decade since the mid-19th century; and genetic diversity within wild mammals and amphibians tends to be lower in areas where human influence is greater (established but incomplete) {2.2.5.2.6}.

Many other species, including those with opposite characteristics, are becoming more abundant locally and are spreading quickly around the world; across a set of 21 countries with detailed records, the numbers of invasive alien species per country have risen by some 70 per cent since 1970 {2.2.5.2.3}.

Almost half (47 per cent) of threatened terrestrial mammals, excluding bats, and one quarter (23 per cent) of threatened birds may have already been negatively affected by climate change in at least part of their distribution (birds in North America and Europe suggest effects of climate change in their population trends since the 1980s) (established but incomplete) {2.2.6.2}.

Island nations, in particular those in East Asia and the Pacific region, will be most vulnerable to sea-level rise (1m) as projected by all climate change scenarios, {2.1.1.7.1} which will displace close to 40 million people {2.1.1.7.1; 2.2.7.1.8}.

For terrestrial systems, most studies indicate that South America, Africa and parts of Asia will be much more significantly affected than other regions, especially in scenarios that are not based on sustainability objectives (see Figure SPM.8 as an example).

A summary of the evidence related to the components of pathways to sustainability suggests that there are five overarching types of management interventions, or levers, and eight leverage points that are key for achieving transformative change (Figure SPM.9; D3 and D4 above) {5.4.1, 5.4.2}.

Scenarios show that the pathways to sustainable fisheries entail conserving, restoring and sustainably using marine ecosystems, rebuilding overfished stocks (including through targeted limits on catches or fishing efforts and moratoria), reducing pollution (including plastics), managing destructive extractive activities, eliminating harmful subsidies and illegal, unreported and unregulated fishing, adapting fisheries management to climate change impacts and reducing the environmental impact of aquaculture (well established) {4, 5.3.2.5, 6.3.3.3.2}.

All climate model trajectories show that limiting human-induced climate change to well below 2°C requires immediate, rapid reductions in greenhouse gas emissions or a reliance on substantial carbon dioxide removal from the atmosphere.

Scenarios that include substantial shifts towards sustainable management of resource exploitation and land use, market reform, globally equitable and moderate animal protein consumption, and reduction of food waste and losses result in low loss or even recovery of biodiversity (well established) {4.2.2.3.1, 4.2.4.2, 4.3.2.2, 4.5.3}.

Sustainability scenarios that explore moderate and equitable consumption result in substantially lower negative impacts on biodiversity and ecosystems due to food, feed and timber production (well established) {4.1.3, 4.2.4.2, 4.3.2, 4.5.3}.

Zoonotic diseases are significant threats to human health, with vector-borne diseases accounting for approximately 17 per cent of all infectious diseases and causing an estimated 700,000 deaths globally per annum (established but incomplete) {3.3.2.2}.

Inland waters and freshwater ecosystems show among the highest rates of decline.

Marine ecosystems, from coastal to deep sea, now show the influence of human actions, with coastal marine ecosystems showing both large historical losses of extent and condition as well as rapid ongoing declines (established but incomplete) {2.2.5.2.1, 2.2.7.15} (Figure SPM.2).

Only 3 per cent of the ocean was described as free from human pressure in 2014 (established but incomplete) {2.2.5.2.1, 3.2.1}.

Severe impacts to ocean ecosystems are illustrated by 33 per cent of fish stocks being classified as overexploited and greater than 55 per cent of ocean area being subject to industrial fishing (established but incomplete) {2.1.11.1; 2.2.5.2.4, 2.2.7.16}.

Habitat loss and deterioration, largely caused by human actions, have reduced global terrestrial habitat integrity by 30 per cent relative to an unimpacted baseline; combining that with the longstanding relationship between habitat area and species numbers suggests that around 9 per cent of the world's estimated 5.9 million terrestrial species – more than 500,000 species – have insufficient habitat for long-term survival, and are committed to extinction, many within decades, unless their habitats are restored (established but incomplete){2.2.5.2.4}.

On land, wild species that are endemic (narrowly distributed) have typically seen larger-than-average changes to their habitats and shown faster-than-average declines (established but incomplete) {2.2.5.2.3, 2.2.5.2.4}.

Figure 3. A substantial proportion of assessed species are threatened with extinction and overall trends are deteriorating, with extinction rates increasing sharply in the past century.

Domestic varieties of plants and animals are the result of natural and human-managed selection, sometimes over centuries or millennia, and tend to show a high degree of adaptation (genotypic and phenotypic) to local conditions (well established) {2.2.4.4}.

Ten per cent of domesticated breeds of mammals were recorded as extinct, as well as some 3.5 per cent of domesticated breeds of birds (well established) {2.2.5.2.6}

These two processes have contributed to the widespread erosion of differences between ecological communities in different places, a phenomenon known as biotic homogenization or the “anthropogenic blender” (well established) {2.2.5.2.3}.

However, the consequences of changes often depend on details of the ecosystem, remain hard to predict and are still understudied (established but incomplete) {2.2.5.2.3}.

Many organisms show ongoing biological evolution so rapid that it is detectable within only a few years or even more quickly – in response to anthropogenic drivers (well established) {2.2.5.2.5, 2.2.5.2.6}.

This human-driven contemporary evolution, which has long been recognized in microbes, viruses, agricultural insect pests and weeds (well established), is now being observed in some species within all major taxonomic groups (animals, plants, fungi and microorganisms).

Such changes are known to occur in response to human activities or drivers, such as hunting, fishing, harvesting, climate change, ocean acidification, soil and water pollution, invasive species, pathogens, pesticides and urbanization (established but incomplete) {2.2.5.2.5}.

Shifts in species distribution, changes in phenology, altered population dynamics and changes in the composition of species assemblage or the structure and function of ecosystems, are evident {2.2.5.3.2, 2.2.5.2.3, 2.2.6.2} and accelerating in marine, terrestrial and freshwater systems (well established) {2.2.3.2}.

This indicates that many species are unable to cope locally with the rapid pace of climate change, through either evolutionary or behavioural processes, and that their continued existence will also depend on the extent to which they are able to disperse, to track suitable climatic conditions, and to preserve their capacity to evolve (well established) {2.2.5.2.5}.

Globally, paved road lengths are projected to increase by 25 million kilometres by 2050, with nine tenths of all road construction occurring within least developed and developing countries.

At least 107 highly threatened birds, mammals and reptiles (e.g., the Island Fox and the Seychelles Magpie-Robin) are estimated to have benefited from invasive mammal eradication on islands {3.2.2}.

Although still few and spatially localized, such cases show that with prompt and appropriate action, it is possible to reduce human-induced extinction rates (established but incomplete) {2.2.5.2.4, 4}.

For example, climate change is projected to greatly increase the number of species under threat, with fewer species expanding their ranges or experiencing more suitable climatic conditions than the number of species experiencing range contraction or less suitable conditions (established but incomplete) {4.2, 3.2}.

The general patterns at the global level – namely, declines in biodiversity and regulating contributions versus increases in the production of food, bioenergy and materials – are evident in nearly all subregions {4.2.2, 4.2.3, 4.2.4, 4.3.3}.

ATTRIBUTION

RAclim

Parties to the United Nations Framework Convention on Climate Change have agreed to hold the “increase in global average temperature to well below 2°C above preindustrial levels and to pursue efforts to limit the temperature increase to 1.5°C”.

Limiting global temperature increase to levels that would prevent “dangerous anthropogenic interference with the climate system” is the ultimate aim of the United Nations Framework Convention on Climate Change and its 195-country membership (United Nations Framework Convention on Climate Change, 2015).

PAclim

“I don’t think there’s much appetite in the community for changing this, “says Ed Hawkins at the University of Reading in the UK, who was involved in many of the relevant studies.

“With 1.5, a difference of 0.1 is a huge amount,” says Hawkins.

“Once you allow negative emissions, the carbon budget is an ill-defined concept,” says Peters.

“Everyone is confused,” says Peters.

“Scientists Say We Have 12 Years to Save the World.”

“I personally don’t like the 12 years,” says Piers Forster at the University of Leeds in the UK, one author of the report. “We in fact have to act immediately in a larger way than ever before.”

Earlier this year, some climate scientists warned that we could be greatly underestimating the risks and that if the planet did warm by at least 2°C, it might be impossible to stop it warming several further degrees.

Most carbon budgets are what Glen Peters of the Centre for International Climate Research in Norway calls “exceedance budgets”.

Climate change deniers have gleefully pointed out that we have been told several times before that there are just X years to save the planet.

PAbio

“We can no longer say that we did not know,” she said.

“We have never had a single unified statement from the world’s governments that unambiguously makes clear the crisis we are facing for life on Earth,” says Thomas Brooks, chief scientist at the International Union for Conservation of Nature in Gland, Switzerland, who helped to edit the biodiversity analysis. “That is really the absolutely key novelty that we see here.”

“We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide,” says IPBES chair Robert Watson, an atmospheric chemist at the University of East Anglia, UK.

Scientists may quibble about some of the extinction estimates and other details, but the report doesn’t pull punches when it describes how humans have altered Earth’s ecosystems, says Stuart Pimm, an ecologist at Duke University in Durham, North Carolina.

The IPBES report is solid on the science, but the panel should do more when it comes to outlining practical solutions for governments, businesses and communities, says Peter Bridgewater, an ecologist at the University of Canberra who led a separate analysis—released on 29 April—of the effectiveness of the biodiversity panel.

Despite those shortcomings, the IPBES report will help to set the agenda when governments negotiate new conservation goals for the next decade at the UN Convention on Biodiversity next year, says Brooks. “Then we will need to see implementation across all sectors of society,” he says. “That’s when we will see a difference.”

Biodiversity should be at the top of the global agenda alongside climate, said Anne Larigauderie, IPBES executive secretary, in a 6 May press conference in Paris, France. “We can no longer say that we did not know,” she said.

ATTRIBUTION UNDETERMINED

PAclim

Climate change deniers have gleefully pointed out that we have been told several times before that there are just X years to save the planet.

Just about every article you’ll read about climate change is full of numbers, starting with 1.5°C, the number that we are told represents the maximum temperature rise we can allow and still avoid the worst effects of global warming.

DESCRIPTION OF THE ACQUISITION OF KNOWLEDGE

RAclim

Changes in heavy rainfall have important consequences for multiple aspects of infrastructure design (drainage systems, roof and building envelop systems, large water control structures, etc), with the result that engineers are increasingly trying to understand and project changes in infrastructure design values.

Most studies examine changes in projected climate at a specific time in the future conditional on one or more greenhouse gas and aerosol forcing scenarios.

We use annual maximum values of daily precipitation amount (RX1day), daily maximum temperature (TXx), and daily minimum temperature (TNn) simulated by climate models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5, Taylor et al. 2012).

We follow the approach of Kharin et al. (2013) and references therein for the analysis of climate extremes.

Here we assume that the location parameter and the log of the scale parameter depend linearly on the global mean temperature.

We considered the possibility that the shape parameter ξ might also vary with global mean temperature but found that allowing it to be linearly dependent on ΔT did not improve the goodness of fit as judged by standard likelihood ratio tests, suggesting little appreciable change in the shape parameters due to warming.

We use multimodel median values, which are less sensitive to outliers than the multimodel mean values.

We consider 1°C warming as being representative of the current climate since the temperature of the warmest year on record, 2016, is about 1. 1°C above preindustrial levels (WMO, 2017).

Generalized extreme value (GEV) distributions (Coles, 2001) are fitted to annual temperature and precipitation extremes at every grid point using data from the historical (years 1860–2005) and three RCP simulations, RCP2.6, RCP4.5, and RCP8.5 (years 2005–2100) combined.

The (cumulative) GEV distribution function is given by (scientific formula).

These parameters are estimated by the method of maximum likelihood.

More flexible statistical models with additional quadratic terms in the dependence of the location and scale parameters in (2) were also tested but proved to be of little additional benefit for the goodness of fit according to the likelihood ratio tests (Table S2).

The global mean temperature change is defined here relative to the global mean temperature in years 1861–1880 of the historical simulations, which is a period with little volcanic activity and when the cumulative emissions of greenhouse gases from human activity remain small compared to the present.

Since we are primarily interested in the dependence of the distribution of annual extremes on prevailing time-averaged temperature conditions, interannual variability in the global mean annual temperature time series in each model is suppressed by applying a 21-year moving average when computing the global mean temperature changes ΔT.

The five parameters in (1) and (2), $\mu0$, $\mu1$, σ 0, σ 1, and ξ are first estimated for each of 26 models listed in Table S1 at every grid point on each model's native grid.

Data for 26 models were available for the RCP4 5 and RCP8 5 scenarios but only for 18 models for the RCP2 6 scenario.

A single model simulation for each forcing scenario is used in the present study.

Most of the results presented in the main text are obtained for samples obtained by joining together historical simulations (years 1860–2005) and all three RCP simulations, RCP2 6, RCP4 5, and RCP8 5 (years 2006–2100).

Having fitted the GEV distribution, changes in return values for a given return period or changes in return periods for a given present-day era return value (and the corresponding changes in probability of extreme events) relative to a fixed temperature level (such as the present or preindustrial) can be estimated by varying ΔT within the range of changes simulated by the CMIP5 models (including ΔT = 0, 0 5, 1.0, 1.5, and 2.0°C).

Multimodel ensemble statistics are obtained by interpolating the extreme value statistics estimated for each model on their native grids onto a common regular 1. 5° × 1.5° latitude-longitude grid.

Regional statistics are also obtained by computing spatial medians rather than spatial means.

The risk ratio is defined as the ratio of the probability of an extreme event for a specified value of ΔT to that for ΔT = 1. 0°C global mean temperature increase.

The regional estimates of changes in risk ratio are obtained by computing regional median estimates of the extreme value probabilities at a specified value of ΔT and comparing it to the probability of an extreme event at ΔT = 1. 0°C.

The uncertainty of model results is assessed by computing the multimodel interquartile (25%–75%) range that contains estimates for half of the models.

These multimodel probability density functions (PDFs) are estimated by first separately fitting GEV distributions to individual model runs and then taking the median values of the estimated GEV distribution parameters from the available model runs as the parameters for the multimodel PDFs.

Note that the risk ratios computed from these “median” PDFs could be slightly different from the median values of the risk ratios computed from PDFs fitted to individual model runs.

The extremes are defined as annual maximum daily maximum and annual minimum daily minimum temperatures as well as annual maximum 1-day precipitation accumulations that are expected to occur once every 20 years in the current climate (1. 0°C global warming relative to preindustrial).

The preindustrial climate is represented by model simulations of the period 1861–1880.

The simulations include both the historical simulations (years 1860–2005) and future climate projections (years 2006–2100) under different greenhouse gas and aerosol forcing scenarios, namely, RCP 2 6, 4 5, and 8 5 (see ref van Vuuren et al. , 2011 for details).

The intercept coefficients μ0 and σ 0 and the constant shape parameter ξ characterize the distribution of annual extremes for ΔT = 0, that is, in years 1861–1880 referred to as the “preindustrial” era.

To the extent that regional changes in extreme temperature and precipitation scale with global temperature across emission scenarios, it is possible to link regional or national impacts to specified global warming limits (Seneviratne et al, 2016).

Ultimately, risk, which represents the combined effect of the likelihood of an event and its consequences, results from a complex confluence of factors including exposure (such as changes in population and wealth) and vulnerability (Handmer et al.).

These probability ratios are referred to as “risk ratios” in the event attribution literature (e.g., NAS 2016), even though they do not characterize relative risks in a very comprehensive way.

This rate of change is reproduced in multimodel simulated projections of changes in the extreme precipitation (Kharin et al, 2013).

Historical extreme events, especially recent unprecedented events, are often used to assess human influence on extremes because of their association to high impacts (NAS, 2016).

For example, record high summer temperature and record low rainfall amount have been used to illustrate some of the differences in Australian climate extremes that could be expected in a 1. 5°C or 2°C world (King et al., 2017).

SPMclim

This Summary for Policymakers (SPM) presents the key findings of the Special Report, based on the assessment of the available scientific, technical and socio-economic literature relevant to global warming of 1.5°C and for the comparison between global warming of 1.5°C and 2°C above pre-industrial levels.

The SDGs serve as an analytical framework for the assessment of the different sustainable development dimensions, which extend beyond the time frame of the 2030 SDG targets.

The assessment is based on literature on mitigation options that are considered relevant for 1.5ºC.

The assessed strength of the SDG interactions is based on the qualitative and quantitative assessment of individual mitigation options listed in Table 5.2.

For each mitigation option, the strength of the SDG-connection as well as the associated confidence of the underlying literature (shades of green and red) was assessed.

Of 105,000 species studied, 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (medium confidence).

Impacts and/or risks for each RFC are based on assessment of the new literature that has appeared.

As in AR5, this literature was used to make expert judgments to assess the levels of global warming at which levels of impact and/or risk are undetectable, moderate, high or very high.

In energy systems, modelled global pathways (considered in the literature) limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b) generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (high confidence).

STclim

These assessments present projections of future climate change based on different scenarios of global emissions (continued growth, rapid reduction, etc) and the corresponding risks for human and natural systems.

While they lay out response options and their implications, the reports do not tell policymakers what actions to take – they are “policy relevant but not policy prescriptive”.

IPCC assessments are written by hundreds of leading scientists from around the world and formally adopted by the governments of its 195 member countries.

The IPCC works by assessing already published literature rather than conducting its own scientific research.

Taking two years to produce and written by 74 scientists from 40 countries, the report was finalised and adopted by all IPCC member governments in Korea in October 2018.

The following is a summary of the Special Report on Global Warming of 1.5°C that is specifically intended for teachers.

Adapted from the Special Report on Global Warming of 1.5°C (IPCC).

Specific examples from the Special Report on 1.5°C are given below by the type of impact.

PAclim

Shared knowledge

To work out what that means, we must first know where we are now.

Well, the best way to measure global warming would be to look at the whole by examining land, sea and atmosphere. But our measurements focus on the thin layer we live in: mean global surface temperature usually refers to the heat of the air 2 metres above the surface.

We get an idea of how this temperature is changing from thousands of weather stations on land, and from ships and buoys at sea. Each reading is checked to see whether the temperature is lower or higher that the long-term average for that place at that time of year. They are then combined to work out how the average global surface temperature is changing relative to the long-term average, or baseline.

For instance, although the weather stations on land measure the air 2 metres above the ground, marine observations are usually of sea surface temperatures. And because you can’t have fixed weather stations in an ocean full of shifting ice, we have few measurements from the Artic.

Global temperature records go back no further than 1850, but the industrial age began a century earlier.

Despite this, the average temperature between 1850 and 1900 has come to be regarded as the semi-official “pre-industrial level” because that is the earliest period for which we have direct measurements.

For instance, using different temperature records can make the budget as low as 258 gigatons or as high as 570. Even these numbers conceal he uncertainty. The budgets could be 650 gigatons lower or higher, depending on climate sensitivity and the historical baseline, meaning we might already have exceeded even the biggest budget. In addition, the report says, if wetlands release more methane and melting permafrost releases more carbon than assumed, the budgets would be 100 gigatons lower.

Earlier calculations had relied on estimated emissions over the past century and were done using a subset of computer models that slightly overestimated temperature rise. More accurate figures and better models have resulted in an increase in the amount of CO2 we can get away with emitting.

Other studies

The HarCRUT temperature record, maintained by the UK’s Met Office, simply leaves the Artic out. NASA’s GISTEMP record estimates Artic temperatures based on surrounding stations.

Almost all the scenarios considered in the IPCC report on 1.5°C target involve getting the temperature rise back under this threshold by 2100 after exceeding it by the middle of this century (8 December, p31).

The budgets in the IPCC’s latest report are something different again. They are based on when emissions hit zero in those scenarios that assume we overshot 1.5°C, but cool the planet back down by sucking carbon from the air.

RAbio

For each site, we calculated total abundance as the sum of all individuals of all species, and species richness as the number of present species.

We use the PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems) database to model impacts of land-use change and human population on local species richness, community abundance, and biodiversity intactness using a mixed-effects modelling structure.

We project model results onto the gridded outputs of six SSP/RCP scenario combinations: SSP1/RCP2 6, SSP2/RCP4.5, SSP3/RCP7.0, SSP4/RCP3.4, SSP4/RCP6.0, and SSP5/RCP8.5.

First, we apply the PREDICTS modelling framework for the first time to the five Shared Socioeconomic Pathways (SSPs: Riahi et al. 2017) developed as part of the sixth round of Intergovernmental Panel on Climate Change (IPCC) reports.

This necessitated the re-curation of sites in the PREDICTS database to be compatible with the expanded set of land-use classes used by Hurtt et al. (in prep) in their new harmonization, LUH2.

Second, we have improved the modelling of compositional similarity, enabling explanatory variables other than land use and distance to affect the compositional similarity between sites.

This difference is the clearest example of where the refined land-use classes of LUH2 are an improvement over the classes in the original land-use harmonization (Hurtt et al. 2011); much of Australia is currently Rangeland, with a much more intact biota (higher abundance, richness and compositional similarity to baseline sites) than Managed Pasture, but these two land-use classes were united as Pasture by Hurtt et al. (2011) and in Newbold et al. 's (2016) models.

Historical impacts are inferred through projection of model results onto maps of historical land use, provided by the land-use harmonization project, and gridded human population density (HYDE 3;1).

Future impacts are explored using the Shared Socio-economic Pathway (SSP) scenarios.

These scenarios detail five plausible global futures based upon socio-economic factors such as wealth, population, education, technology, and reliance on fossil fuels.

The statistical models linking biodiversity to drivers are underpinned by a large global and taxonomically broad database of terrestrial ecological communities facing land-use pressures (Hudson et al. 2014, 2017).

Once these relationships are estimated statistically, the model coefficients are then crossed with global layers of the relevant drivers for any year of interest, to produce estimates of the desired biodiversity indicator or indicators.

The PREDICTS database was designed to be compatible with the harmonized land-use classes that Hurtt et al. (2011) used in their gridded historical maps of land use from 1500-2005 and their projections of land use from 2005-2100 under each of the four Representative Concentration Pathways (RCPS: van Vuuren et al. 2011) as implemented by a set of four Integrated Assessment Models (IAMs: Harfoot et al. 2014).

More recently, the PREDICTS framework has been extended to estimate Scholes & Biggs' (2005) Biodiversity Intactness Index (BII: Newbold et al. 2016).

BII is defined as the average abundance of a taxonomically and ecologically broad set of species in an area, relative to their abundances in an intact reference ecosystem (Scholes & Biggs 2005), and has been proposed as a potential indicator of whether global ecosystems are still within a 'safe operating space' in the Planetary Boundaries framework (Steffen et al. 2015).

The global mean BII was estimated as being 84 6% (Newbold et al. 2016), which is below the proposed safe limit of 90% (Steffen et al. 2015), but no temporal trajectory of BII was estimated.

The PREDICTS database is a globally and taxonomically comprehensive database of site level measures of biodiversity within different gradients of human pressure (Hudson et al. 2017).

Site-level data was extracted from the PREDICTS database in October 2017.

Land use and land use intensity were assigned using data provided by the original source publications at the time of entry into the database.

Timber plantations were removed from the PREDICTS Plantation Forest category, and the remaining Plantation Forest sites (ie , those containing permanent woody crops such as fruit trees) were merged with Croplands Managed Pasture and Rangelands were reassigned from the PREDICTS land use class of Pasture through information found in the site descriptions provided in the original primary literature sources as well as knowledge of broad regional patterns in the density of grazing (see Appendix).

Information on the crop species under cultivation at the PREDICTS cropland sites was gleaned from the original primary literature source or from interview with the data provider.

Crop species were classified as Annual or Perennial using the TRY database (Kattge et al. 2011).

All crop species in the family Fabaceae were considered to be Nitrogen-fixing Cropland sites were classified as Annual/Perennial/Nitrogen-fixing if the majority of crops identified at each site fell into one of these classes.

Cropland sites that could not be classified in this manner were dropped from the analysis.

Site level human population density was extracted from GRUMP (CIESIN 2011).

Abundance-based compositional similarity was calculated using the asymmetric Jaccard index (Chao et al. 2005) to provide a metric detailing the proportion of individuals in a comparison site that are of species that were also present in the baseline site.

Studies that only sampled single species were excluded from the dataset.

For abundance models, where sampling effort varied among sites within a study, abundance was first rescaled assuming that diversity increased linearly with sampling effort; such studies were excluded for models of compositional similarity.

Abundance was also log transformed prior to modelling to improve the distribution; modelling with Poisson errors was not possible because, even prior to rescaling, many abundance values were not integers.

Local species richness and abundance-based compositional similarity models were run using a mixed effects modelling framework, implemented in the R package lme4 (version 1 1-14 Bates et al. 2017).

The random-effects structure was selected using Akaike's Information Criterion (AIC) values (Zuur et al. 2009.

Source, study and block level random intercepts were included within all models and a site level random intercept was employed within the species richness model to combat overdispersion.

Random slopes were not considered because they led to problems with model convergence.

Explanatory variables included in the model selection process were human population density (ln(x+1) transformed), land use, land-use intensity, and a factor combining the two (which we term LUI).

Study-level means of human population density and agricultural suitability were included as control variables, to avoid possible biases (e.g., sampling may be more thorough in studies conducted in more densely-populated regions).

All continuous variables were modelled using linear relationships.

The species richness model was modelled using a Poisson distribution and all other models used a Gaussian distribution (overall abundance having been log-transformed).

The fixed effects model structure was selected using backwards stepwise selection based upon AIC values (Zuur et al. 2009).

A matrix was constructed including all sites as rows and columns.

Pairwise comparisons between all sites were calculated for 1) compositional similarity using the asymmetric Jaccard Index (Chao et al. 2005) , 2) geographic distance (log transformed), 3) environmental distance (cube root transformed, selected over log transformation through analysis of residual variation), and 4) the difference in log human population density between sites.

Only contrasts where the baseline site in the pairwise comparison contained Primary vegetation with Minimal use intensity were included within the model.

Compositional similarity was transformed using logit transformation (to improve distribution of residuals, as compositional similarity is bounded between zero and one) and modelled against geographic distance, environmental distance, and the pairwise contrast of land uses as an interaction with human population density (of the second site in the matrix).

The difference between human population density was also included as an additive effect to quantify the impact of the change from a pristine system with no human influence to a system with human influence as this is of interest as well as the absolute impact of human population.

Pressure maps for use in projections were derived as follows.

Land use and human population density maps were obtained from the LUH2 dataset (Hurtt et al. in prep).

The age of secondary vegetation was tracked from 800 using the transition rates from Hurtt et al. (in prep), and categorised as young secondary when age < 30 years, intermediate secondary when age >30 year and <50 years, and mature secondary when age > 50 years.

A static use intensity map was produced using a model to predict likelihood of intensity through human population density and GlobCover (following Newbold et al. 2015).

Modelled coefficients were projected onto pressure maps to produce gridded maps of local species richness, total community abundance and abundance-based compositional similarity.

The abundance maps were then multiplied by the compositional similarity map to produce maps of abundance-based BII (Newbold et al. 2016).

Aggregated results for the globe and for IPBES subregions (Brooks et al2016) were calculated using arithmetic means weighted by net primary productivity for abundance results, and by vertebrate species richness for species-richness results, as in Newbold et al(2015).

Historic maps were produced from 800 to 2014 and future projections for each year from 2015 to 2100 were produced for the following SSP/RCP combinations: SSP1/RCP2.6, SSP2/RCP4.5,SSP3/RCP7.0, SSP4/RCP3.4, SSP4/RCP6.0, and SSP5/RCP8.5.

However, the Cropland, Plantation Forest and Pasture sites needed recuration to match the more detailed categories of the LUH2 projections.

The database contained 3.85 million rows of data, incorporating data on approximately 31 000 taxa from 32 000 sites and 767 studies.

The compositional similarity model followed the framework outlined in De Palma (2018).

Furthermore, because indicators based on such time series do not embody a model of how biodiversity is affected by drivers, future projections must be based on simple extrapolation of recent trends (e.g. Tittensor et al. 2014), so it is not possible to compare biodiversity outcomes from alternative future pathways

Indicators that embody explicit links between drivers and biodiversity provide the potential for estimating how the state of the indicator has changed beyond the temporal range for which direct observations are available, enabling estimation not only of how the state of nature has changed up to now, but also how it will change in possible futures (e.g. Nicholson et al. 2012; IPBES Scenarios & Modelling assessment (IPBES 2016); Visconti et al. 2015; Purvis et al. 2018).

PREDICTS estimates BII by combining two statistical models; one of overall organismal abundance relative to an intact baseline, and one of compositional similarity to an intact baseline ecosystem (Newbold et al. 2016; Purvis et al. 2018).

This optimistic scenario describes a sustainable future, broadly in line with the United Nations Sustainable Development Goals (SDGs), where population growth is minimised, global levels of education are improved, and agricultural demand is minimised through sustainable practices and behaviour (Riahi et al. 2017).

The core assumption is that the relationships between the drivers and biodiversity estimated from these data remain constant over time (Purvis et al. 2018).

Presentation of the results

RAclim

A list of the models used is provided in Table S1 in the supporting information.

For example, the shading in Figure 4b indicates the 25%–75% multimodel range of projected risk ratios over land.

PDFs estimated for the preindustrial climate (black curves), and for 1°C (blue), 1. 5°C (green), and 2°C (red) global warming are shown.

As an illustration, Figure 1 shows the multimodel median GEV distribution for the model grid box containing the birthplace of the Paris Agreement for different levels of global mean warming for annual maximum temperature, annual minimum temperature, and annual maximum 24-hr precipitation.

Figure 3 displays maps of the risk ratios for 50-year events in a format similar to Figure 2.

The vertical dotted lines show the value of the location parameter for each distribution function, while the shaded area represents 1 of 20 of the areas under each distribution and so demarcates the 20-year return value.

Changes in 20-year return values corresponding to 1°C global warming relative to preindustrial (defined here as 1861–1880) are also indicated for each quantity (1.9°C for warm temperature extremes, 2.0°C for cold temperature extremes, and 5.3% for precipitation extremes).

Legends indicate expected return periods at different warming levels of extreme events that occur once every 20 years in the preindustrial climate.

Figure 2 shows maps of the risk ratios for annual warm or cold temperature extremes and precipitation extremes that occur once in 20 years in the current climate (1°C) as compared to those at the 1.5°C and 2°C global temperature warming levels (corresponding to an additional global mean warming of 0.5°C and 1°C above the present level).

Table 1 Risk Ratio in Extreme Event Defined as the Ratio of the Event Probability at the Global Temperature Level Indicated in Column Headings (0, 1, 1.5, and 2°C Warmer Than Preindustrial) to the Probability in the Current Climate (Assumed to be 1°C Warmer Than Preindustrial).

In each section, results for 20-year and 50-year events from SREX regions are shown, along with the global and land values.

The numbers in parentheses beside the region names correspond to the region numbering in Figure 4a.

These features are displayed at a global scale in Figure 4b, which displays global land area median risk ratios for extreme precipitation and extreme temperatures of different return periods under different warming levels as compared to the current climate.

SPMclim

The level of confidence associated with each key finding is reported using the IPCC calibrated language.

The underlying scientific basis of each key finding is indicated by references provided to chapter elements.

In the SPM, knowledge gaps are identified associated with the underlying chapters of the Report.

Four illustrative model pathways are highlighted in the main panel and are labelled P1, P2, P3 and P4, corresponding to the LED, S1, S2, and S5 pathways assessed in Chapter 2.

Further characteristics for each of these pathways are listed below each pathway.

RFCs illustrate the implications of global warming for people, economies and ecosystems.

Figure SPM.1 | Panel a: Observed monthly global mean surface temperature (GMST, grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) change and estimated anthropogenic global warming (solid orange line up to 2017, with orange shading indicating assessed likely range).

Orange dashed arrow and horizontal orange error bar show respectively the central estimate and likely range of the time at which 1.5°C is reached if the current rate of warming continues.

The grey plume on the right of panel a shows the likely range of warming responses, computed with a simple climate model, to a stylized pathway (hypothetical future) in which net CO2 emissions (grey line in panels b and c) decline in a straight line from 2020 to reach net zero in 2055 and net non-CO2 radiative forcing (grey line in panel d) increases to 2030 and then declines.

The blue plume in panel a) shows the response to faster CO2 emissions reductions (blue line in panel b), reaching net zero in 2040, reducing cumulative CO2 emissions (panel c).

The purple plume shows the response to net CO2 emissions declining to zero in 2055, with net non-CO2 forcing remaining constant after 2030.

The vertical error bars on right of panel a) show the likely ranges (thin lines) and central terciles (33rd – 66th percentiles, thick lines) of the estimated distribution of warming in 2100 under these three stylized pathways.

Vertical dotted error bars in panels b, c and d show the likely range of historical annual and cumulative global net CO2 emissions in 2017 (data from the Global Carbon Project) and of net non-CO2 radiative forcing in 2011 from AR5, respectively.

The selection of impacts and risks to natural, managed and human systems in the lower panel is illustrative and is not intended to be fully comprehensive. {3.4, 3.5, 3.5.2.1, 3.5.2.2, 3.5.2.3, 3.5.2.4, 3.5.2.5, 5.4.1, 5.5.3, 5.6.1, Box 3.4}

Non-CO2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (high confidence) (Figure SPM.3a) {2.1, 2.3, Table 2.4}

The main panel shows global net anthropogenic CO2 emissions in pathways limiting global warming to 1.5°C with no or limited (less than 0.1°C) overshoot and pathways with higher overshoot.

The shaded area shows the full range for pathways analysed in this Report.

The panels on the right show non-CO2 emissions ranges for three compounds with large historical forcing and a substantial portion of emissions coming from sources distinct from those central to CO2 mitigation.

Shaded areas in these panels show the 5–95% (light shading) and interquartile (dark shading) ranges of pathways limiting global warming to 1.5°C with no or limited overshoot.

Box and whiskers at the bottom of the figure show the timing of pathways reaching global net zero CO2 emission levels, and a comparison with pathways limiting global warming to 2°C with at least 66% probability.

Figure SPM.3b | Characteristics of four illustrative model pathways in relation to global warming of 1.5°C introduced in Figure SPM.3a.

A breakdown of the global net anthropogenic CO2 emissions into the contributions in terms of CO2 emissions from fossil fuel and industry; agriculture, forestry and other land use (AFOLU); and bioenergy with carbon capture and storage (BECCS) is shown.

AFOLU estimates reported here are not necessarily comparable with countries' estimates.

These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements.

For comparison, the right-most column shows the interquartile ranges across pathways with no or limited overshoot of 1.5°C. Pathways P1, P2, P3 and P4 correspond to the LED, S1, S2 and S5 pathways assessed in Chapter 2 (Figure SPM.3a). {2.2.1, 2.3.1, 2.3.2,2.3.3, 2.3.4, 2.4.1, 2.4.2, 2.4.4, 2.5.3, Figure 2.5, Figure 2.6, Figure 2.9, Figure 2.10, Figure 2.11, Figure 2.14, Figure 2.15, Figure 2.16, Figure 2.17, Figure 2.24,Figure 2.25, Table 2.4, Table 2.6, Table 2.7, Table 2.9, Table 4.1}

The (white) areas outside the bars, which indicate no interactions, have low confidence due to the uncertainty and limited number of studies exploring indirect effects.

The bars denote the strength of the connection, and do not consider the strength of the impact on the SDGs.

RAbio

Here, we go beyond these previous analyses in two main ways.

We present estimates of how global average values of two indicators – species richness and abundance-based BII have changed between 850 and 2010, and their future trajectories to 2100 under each of six SSP/RCP combinations made available in the harmonized dataset

"Figure 1. Temporal trends in abundance-based BII at a global level and for each of the IPBES subregions. Trendlines show the average loss in BII from an unimpacted baseline. A) Trend from 1800 to 2100. Extent of variation between SSP/RCP future projections is indicated by shaded areas. B) to G).

Global and regional trends for each SSP/RCP projection showing results for SSP1/RCP2.6, SSP2/RCP4.5,

SSP3/RCP7.0, SSP4/RCP3.4, SSP4/RCP6.0, and SSP5/RCP8.5 respectively."

Figure 2. Temporal trends in local species richness at a global level and for each of the IPBES subregions. Trendlines show the average loss in local species richness from an unimpacted baseline. A)

Trend from 1800 to 2100. Extent of variation between SSP/RCP future projections indicated by shaded areas. B) to G). Global and regional trends for each SSP/RCP projection showing results for SSP1/RCP2.6, SSP2/RCP4.5, SSP3/RCP7.0, SSP4/RCP3.4, SSP4/RCP6.0, and SSP5/RCP8.5 respectively.

Figure 3. Abundance-based biodiversity intactness projected for 2015 under SSP3/RCP7.0.

Figure 4. Change in abundance-based BII projected to occur between 2015 and 2050 by SSP3/RCP7.0.

SPMbio

For many categories of nature's contributions, two indicators are included that show different aspects of nature's capacity to contribute to human well-being within that category.

The colour bands represent the relative global impact of direct drivers, from top to bottom, on terrestrial, freshwater and marine nature, as estimated from a global systematic review of studies published since 2005.

The circles illustrate the magnitude of the negative human impacts on a diverse selection of aspects of nature over a range of different time scales based on a global synthesis of indicators {2.2.5, 2.2.7}.

Groups are ordered according to the best estimate for the percentage of extant species considered threatened (shown by the vertical blue lines), assuming that data deficient species are as threatened as non-data deficient species.

Countries are classified according to the United Nations World Economic Situation and Prospects (https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-2019/).

Global gross domestic product has risen fourfold in real terms, with the vast majority of growth occurring in developed and developing countries (A). Extraction of living biomass (e.g., crops, fish) to meet the demand for domestic consumption and for export is highest in developing countries and rising rapidly (B). However, material consumption per capita within each country (from imports and domestic production) is highest in developed countries (C). Overall protection of Key Biodiversity Areas is rising, being highest within developed countries (D). Air pollution is highest in least developed countries (E), while the challenges of non-point-source pollution from the use of fertilizers are highest in developing countries (F). Data sources: A, E, F: www.data.worldbank.org; B, C: www.materialflows.net; D: www.keybiodiversityareas.org, www.protectedplanet.net.

The image in the centre of the above figure shows the global overlap between 1) land areas traditionally owned, managed , used or occupied by indigenous peoples; 2) formally designated protected areas; and 3) remaining terrestrial areas with very low human intervention (areas that score <4 on the Human Footprint Index).

The topics and pictures in the figure aim to illustrate, not represent, the types and diversity of the following contributions of indigenous peoples and local communities to biodiversity: (a) domestication and maintenance of locally adapted crop and fruit varieties (potatoes, Peru) and (b) animal breeds (rider and sheep, Kyrgyzstan) {2.2.4.4}; (c) creation of species-rich habitats and high ecosystem diversity in cultural landscapes (hay meadows, Central Europe) {2.2.4.1-2}; (d) identification of useful plants and their cultivation in high-diversity ecosystems (multi-species forest garden, Indonesia) {2.2.4.3}; (e) and (f) management and monitoring of wild species, habitats and landscapes for wildlife and for increased resilience ((e) - Australia, (f) - Alaska) {2.2.4.5-6}; (g) restoration of degraded lands (Niger) {3.2.4}; (h) prevention of deforestation in recognized indigenous territories (Amazon basin, Brazil) {2.2.4.7}; (i) offering alternative concepts of relations between humanity and nature (Northern Australia).

“Partial support” means that the overall global status and trends are positive, but still insubstantial or insufficient; or there may be substantial positive trends for some relevant aspects, but negative trends for others; or the trends are positive in some geographic regions, but negative in others.

"Poor/Declining support" indicates poor status or substantial negative trends at a global scale.

"Uncertain relationship" means that the relationship between nature and/or nature's contributions to people and the achievement of the target is uncertain.

"Unknown" indicates that there is insufficient information to score the status and trends.

This figure illustrates three main messages: i) the impacts on biodiversity and on nature's contributions to people (NCP) are the lowest in the "global sustainability" scenario in nearly all sub-regions, ii) regional differences in impacts are high in the regional competition and economic optimism scenario, and iii) material NCP increase the most in the regional competition and economic optimism scenarios, but this comes at the expense of biodiversity and regulating NCP.

The bars represent the normalized means of multiple models and the whiskers indicate the standard errors.

The list of actions and pathways in the following table is illustrative rather than exhaustive and uses examples from the assessment report.

Several examples illustrate the interdependencies between nature and the Sustainable Development Goals.

The targets selected are those where the current evidence and wording of the target make it possible to assess the consequences of the trends in nature and nature's contribution to people as they relate to the achievement of the target.

The scores for the targets are based on a systematic assessment of the literature and a quantitative analysis of the indicators, where possible.

Implicative structures

Would

RAclim

We show that global warming of 2°C would result in substantially larger changes in the probabilities of the extreme events than global warming of 1. 5°C.

Limiting global temperature increase to levels that would prevent "dangerous anthropogenic interference with the climate system" is the ultimate aim of the United Nations Framework

Convention on Climate Change and its 195-country membership (United Nations Framework Convention on Climate Change, 2015).

In the absence of knowledge of the critical thresholds at which high vulnerability is produced (such that exposure would almost inevitably lead to loss), there is a significant danger of inadvertently overstating changes in risk by referencing levels thresholds for extremes above those critical levels, or conversely, of understating risk by referencing levels below those critical levels.

Such an approach would provide users with insights about how risk, as measured by simple risk ratios, varies with rarity and would assist users in weighing policy options by implicitly imposing the question, what level of rarity is critical for the system that is of concern.

SPMclim

Reaching and sustaining net zero global anthropogenic CO2 emissions and declining net non-CO2 radiative forcing would halt anthropogenic global warming on multi-decadal time scales (high confidence).

Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by both incremental and transformational adaptation (high confidence).

A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation (medium confidence).

Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO2 over the course of this century and more thereafter (medium confidence).

Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence).

In modelled 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2% interquartile range) of electricity (high confidence).

The urban and infrastructure system transition consistent with limiting global warming to 1.5°C with no or limited overshoot would imply, for example, changes in land and urban planning practices, as well as deeper emissions reductions in transport and buildings compared to pathways that limit global warming below 2°C (medium confidence).

In pathways limiting global warming to 1.5°C with no or limited overshoot, the electricity share of energy demand in buildings would be about 55–75% in 2050 compared to 50–70% in 2050 for 2°C global warming (medium confidence).

In the transport sector, the share of low-emission final energy would rise from less than 5% in 2020 to about 35–65% in 2050 compared to 25–45% for 2°C of global warming (medium confidence).

The implementation of land-based mitigation options would require overcoming socio-economic, institutional, technological, financing and environmental barriers that differ across regions (high confidence).

CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence).

If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (medium confidence).

Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 GtCO2eq yr−1 (medium confidence). Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (high confidence). Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (medium confidence).

The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (high confidence).

Such pathways would reduce dependence on CDR.

If poorly implemented, CDR options such as BECCS and AFOLU options would lead to trade-offs.

Efforts along such pathways to date have been limited (medium confidence) and enhanced efforts would involve strengthened and timely action from all countries and non-state actors (high confidence).

Partnerships involving non-state public and private actors, institutional investors, the banking system, civil society and scientific institutions would facilitate actions and responses consistent with limiting global warming to 1.5°C (very high confidence).

STclim

As a consequence, the temperature of the lower atmosphere is warmer than it otherwise would be.

In fact, without greenhouse gases, the average temperature of Earth's surface would be about -18°C rather than the present average of 1.5°C.

At the present rate, global temperature would reach 1.5°C around 2040.

Even if we can somehow stop all carbon dioxide (CO2) emissions to the atmosphere immediately, global temperatures would stabilise but not decline – it takes centuries for millennia for the CO2 already present in the atmosphere to be removed by natural processes.

Sea level would continue to rise during this time as the entire ocean volume slowly expands in response to past surface warming.

In order to reduce global temperatures back down to what they were back in pre-industrial times, we would have to actively remove CO2 from the atmosphere.

While limiting global warming to 1.5°C is still possible – we are not already committed to this by our past GHG emissions, we would have to act very rapidly to achieve this goal.

A global warming of 2°C would have significantly larger impacts than a global warming of 1.5°C (1°C above today as opposed to 0,5°C).

Three times more people (420 million people) would be exposed to severe heat waves at least once every 5 years and the most impacted regions would be the Mediterranean and Sub-Saharan Africa.

This would have implications for human health, particularly in cities, which tend to be artificially warmer than their surroundings due to a “heat island” effect created by the buildings and roads.

There is also higher risk of droughts at 1.5°C than at 2°C in the Mediterranean and Southern Africa, while globally 200-300 million more people would be exposed to water shortages at 2°C than at 1.5°C.

It would lead to the relocation of up to 10. 4 million people [Special Report 1.5°C, Chapter 3, p8]

Exceeding 1.5°C increases the risk of triggering instabilities in polar ice sheets that would lead multi-meter sea level rise over centuries to millennia.

The Arctic would be effectively free of sea ice in summer a few times each decade with a 2°C warming, but only one or a few times a century under 1.5°C warming.

Decline in the global fisheries catch could be twice as large at 2°C than 1.5°C, and there would be smaller reductions in yields of key food crops of maize, rice and wheat at 1.5°C than at 2°C.

Since the level of CO_2 in the atmosphere would be lower at 1.5 than at 2°C, less CO_2 would be taken up by the ocean, and thus the increase in ocean acidity would be less at 1.5°C.

As the impacts would be larger at 2°C than 1.5°C, greater adaptation efforts would be required to deal with them.

Compared to 2°C, at 1.5°C global warming:

- Heat waves would be less frequent and with lower peak temperatures

-Sea levels would be 10 cm lower. As a consequence, low-lying coasts and islands would have greater opportunities to adapt:

- The Arctic would effectively become sea ice free in summer in the Arctic at 2°C, but would still have sea ice year-round at 1.5°C.

- The impacts on biodiversity (including biodiversity loss) for land, freshwater and coastal ecosystems would be lower. We would retain more of nature’s services for humans (pollination, clean water, etc.)

- The ocean would be less acidified, lowering the consequent risks for marine biodiversity and ecosystems – including the services they provide to humans, such as fisheries.

Given that this method, known as BECCS, would need to be implemented on a large scale, a key concern is that it would create competition with using land to grow crops for food instead of for fuel.

Greater emission reductions would be required to avoid use of carbon dioxide removal methods.

We are not on track to limit warming to 1.5°C, in fact, current emission reduction pledges made by nations in the Paris Agreement would lead to warming of 3-4°C by the end of this century.

For overshoot paths, removal of CO2 from the atmosphere would be required to bring global temperature back down to after overshooting the target level.

Given that we would need to effectively reduce CO2 emissions to zero in order to limit warming to a given level – the question becomes one of how rapidly we would need to this.

To limit warming to 1.5°C, CO2 emissions would have decrease by 45% by 2030 from their 2010 levels, and effectively reach zero in 2050.

In comparison, limiting global warming to 2°C would require CO2 emissions to decline by 20% by 2030 before effectively ceasing by around 2075.

What would we need to do?

In addition, better insulation of buildings would help reduce heating needs – buildings being responsible for around a third of global energy consumption.

Second, we would need to use energy and materials more efficiently.

Switching to electric vehicles would bring other benefits besides reducing climate impacts, including improving air quality in cities.

It's estimated that the additional emission reduction actions to limit warming to 1.5°C compared to 2°C would reduce premature deaths from air pollution by 100-200 million over the course of this century.

This would involve large and rapid emission reductions worldwide and throughout society, including changes in behaviour and lifestyles.

The good news is there is movement in the right direction in lots of these areas but we would need to do more, faster.

PAclim

How can we not know how much the world has warmed? Well, the best way to measure global warming would be to look at the whole by examining land, sea and atmosphere.

A 1990 report concluded that limiting global warming to 1 °C would be safer than a 2°C cap.

But as climate is weather averaged over many years, it would be premature to regard this as passing the limit.

A common measure of climate sensitivity is how much warming would occur in the decades and centuries after a doubling of CO2 levels.

In addition, the report says, if wetlands release more methane and melting permafrost releases more carbon than assumed, the budgets would be 100 gigatons lower.

These set out how much CO2 we can emit up to the point the temperature rise passes 1.5°C. If you were doing a bungee jump, this would be equivalent to the length of rope with which you would exactly smash into the ground.

In other words, even if we limited warming to 1.5°C, much of the ice in Greenland and West Antarctica could still be lost, which would be enough to raise sea levels 5 metres or more.

RAbio

The refinement of Hurtt et al ’s (2011) single, broad Cropland class into five LUH2 classes presented challenges for data curation and modelling, and would require a larger database to model fully, but also provides more nuanced models that better reflect - albeit still coarsely - different effects on local biodiversity.

Extending LUH2’s coverage of SSP x RCP combinations within and among IAMs, though it cannot lead to a full-matrix design (because, for instance, not all RCPs can be achieved under all SSPs) would permit much more sophisticated exploration of the differences among projections.

Aligning PREDICTS’ sites directly to the land-use classes within each IAM would reduce the potential for harmonization to cause - or to remove - differences among scenarios.

SPMbio

For example, conservation investment during the period between 1996 and 2008 reduced the extinction risk for mammals and birds in 109 countries by a median value of 29 per cent per country, while the rate of decrease in extinction risk for birds, mammals and amphibians would have been at least 20 per cent higher without conservation action in recent decades. Similarly, it is likely that at least 6 species of ungulate (e.g., the Arabian Oryx and Przewalski’s Horse) would now be extinct or surviving only in captivity without conservation measures. At least 107 highly threatened birds, mammals and reptiles (e.g., the Island Fox and the Seychelles Magpie-Robin) are estimated to have benefited from invasive mammal eradication on islands {3.2.2}. There are, however, few other counterfactual studies assessing how trends in the state of nature or pressures upon nature would have been different in the absence of conservation efforts (well established) {3.2}.

Increasing awareness of interconnectedness in the context of the environmental crisis and new norms regarding interactions between humans and nature would support that change (well established) {5.3, 5.4.3}.

25. The adverse impacts of climate change on biodiversity are projected to increase with increasing warming, so limiting global warming to well below 2°C would have multiple co-benefits for nature and nature’s contributions to people and quality of life; however, it is projected that some large-scale land-based mitigation measures to achieve that objective will have significant impacts on biodiversity (established but incomplete) {4.2, 4.3, 4.4, 4.5}.

The adverse impacts of climate change on biodiversity are projected to increase with increasing warming, so limiting global warming to well below 2°C would have multiple co-benefits for nature and nature’s contributions to people and quality of life; however, it is projected that some large-scale land-based mitigation measures to achieve that objective will have significant impacts on biodiversity (established but incomplete) {4.2, 4.3, 4.4, 4.5}.

PAbio

The report draws inextricable links between biodiversity loss and climate change. An estimated 5% of the planet’s species would be threatened with extinction by 2 °C of warming above preindustrial levels—a threshold that the world could breach in the next few decades unless greenhouse gas emissions are drastically reduced.

These losses would undermine global efforts to reduce poverty and hunger and promote more sustainable development, the IPBES report says.

With other modal auxiliaries

Will

SPMclim

On longer time scales, sustained net negative global anthropogenic CO_2 emissions and/ or further reductions in non-CO_2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (medium confidence) and will be required to minimize sea level rise (high confidence). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}

B.2.2 Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (high confidence).

D.3 Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (high confidence). {1.4, 4.3, 4.5}

STclim

In general, the more warming the greater the risks and impacts will be.
The more CO_2 and other greenhouse gases we release into the atmosphere, the more global temperatures will rise.
The more action on emissions reductions made now, the less will be the need to employ these risky measures.
Sea level rise by 2100 will be 10 cm higher if global warming reaches 2,0°C instead of 1.5°C.

If we delay action now, more rapid emissions reduction will be needed in the future to limit warming to the same level, and these emissions reduction will be more costly
As explained in Section B, even if we stop emitting greenhouse gases immediately sea levels will keep rising over these time-scales due to ocean inertia.

Unfortunately, the slow removal of CO_2 from the atmosphere means that global temperatures will remain warmer for centuries to millennia even after we completely stop emitting CO_2.

Given the inertia of the global economic system, it will be very difficult to achieve the emission reductions at scale and rates required, without using methods of removing CO_2 from the atmosphere.

PAclim

As the world gets hotter, most of the downsides of global warming, from coral bleaching to more severe flooding, will grow ever greater.

If we stop building on coasts doomed to disappear under the waves and start adapting our homes to cope with far greater weather extremes, we will save many lives.

Temperatures will drop a little again when it passes.

Even if we can get the temperature back down, the impacts will be more serious if we go past 1.5°C because there will be faster warming over the next few decades.

Warming will be amplified as vast, reflective ice sheets melt and are replaced by dark land and water that absorb most sunlight, for example.

If emissions keep increasing, it will be less than 50 years before CO2 levels are double pre-industrial levels.

If it stays warm, there will be bigger sea level rises in the 22nd century and beyond.

First, we have to reduce net global emissions to zero, and the faster we do it the better off we will all be.

SPMbio

The incorporation by society of the value of nature's contributions to people will entail shifts in governance even within private supply chains, for instance when civil society certifies and helps to reward desired practices, or when States block access to markets because of undesirable practices {2.1.7}.

PAbio

Without drastic action to conserve habitats, the rate of species extinctions—already tens to hundreds of times higher than the average across the last ten million years—will only increase, says the analysis by a United Nations-backed panel, the International Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Without "transformative changes" to the world's economic, social and political systems to address this crisis, the IPBES panel projects that major biodiversity losses will continue to 2050 and beyond.

Agricultural threats to ecosystems will only increase as the world's population continues to grow, according to the IPBES analysis.

The world can reverse this biodiversity crisis, the report says, but doing so will require proactive environmental policies, the sustainable production of food and other resources and a concerted effort to reduce greenhouse-gas emissions.

Despite those shortcomings, the IPBES report will help to set the agenda when governments negotiate new conservation goals for the next decade at the UN Convention on Biodiversity next year, says Brooks.

“Then we will need to see implementation across all sectors of society,” he says. “That’s when we will see a difference.”

May

SPMclim

On longer time scales, sustained net negative global anthropogenic CO2 emissions and/ or further reductions in non-CO2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (medium confidence) and will be required to minimize sea level rise (high confidence).

Depending on future socio-economic conditions, limiting global warming to 1.5°C compared to 2°C may reduce the proportion of the world population exposed to a climate change-induced increase in water stress by up to 50%, although there is considerable variability between regions (medium confidence).

Economic, institutional and socio-cultural barriers may inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (high confidence). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2}

Innovation policies may be more effective when they combine public support for research and development with policy mixes that provide incentives for technology diffusion.

SPMbio

In a post-2020 global biodiversity framework, placing greater emphasis on the interactions between the targets of the Sustainable Development Goals {4.6, 3.7} may provide a way forward for achieving multiple targets, as synergies (and trade-offs) can be considered.

Might

PAclim

Earlier this year, some climate scientists warned that we could be greatly underestimating the risks and that if the planet did warm by at least 2°C, it might be impossible to stop it warming several further degrees.

Could

SPMclim

Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered at around 1.5°C to 2°C of global warming (medium confidence).

Poverty and disadvantage are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (medium confidence).

Many small island developing states could experience lower water stress as a result of projected changes in aridity when global warming is limited to 1.5°C, as compared to 2°C (medium confidence).

For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions (medium confidence).

Most current and potential CDR measures could have significant impacts on land, energy, water or nutrients if deployed at large scale (high confidence).

Feasibility and sustainability of CDR use could be enhanced by a portfolio of options deployed at substantial, but lesser scales, rather than a single option at very large scale (high confidence).

Directing finance towards investment in infrastructure for mitigation and adaptation could provide additional resources.

This could involve the mobilization of private funds by institutional investors, asset managers and development or investment banks, as well as the provision of public funds.

STclim

This could be assisted by changes and food consumption (reducing meat and dairy consumption, and reducing in food waste), and transport choices (e.g. flying less).

These could be complemented by government legalisation such energy standards or a price on carbon.

With clear benefits to people and natural ecosystems, limiting global warming to 1.5°C compared to 2°C could go hand in hand with ensuring a more sustainable and equitable society.

PAclim

In other words, even if we limited warming to 1.5°C, much of the ice in Greenland and West Antarctica could still be lost, which would be enough to raise sea levels 5 metres or more.

SPMbio

In many cases, the best strategy could be to simply maintain the ability of natural populations to respond evolutionarily on their own - rather than through direct human manipulation of evolution.

Collaborative implementation of priority governance interventions (levers) targeting key points of intervention (leverage points) could enable transformative change from current trends towards more sustainable ones.

Implementing existing and new instruments through place-based governance interventions that are integrative, informed, inclusive and adaptive, using strategic policy mixes and learning from feedback, could enable global transformation.

These practices could be enhanced through well-structured regulations, incentives and subsidies, the removal of distorting subsidies {2.3.5.2, 5.3.2.1, 5.4.2.1, 6.3.2}, and – at landscape scales – by integrated landscape planning and watershed management.

Such options could help reduce food waste, overconsumption, and the demand for animal products that are produced unsustainably, which could have synergistic benefits for human health (established but incomplete) {5.3.2.1, 6.3.2.1}.

PAbio

An estimated 5% of the planet's species would be threatened with extinction by 2 °C of warming above preindustrial levels—a threshold that the world could breach in the next few decades unless greenhouse gas emissions are drastically reduced.

Earth could lose 16% of its species if the average global temperature exceeds 4.3 °C.

Necessity

Must

PAclim

To work out what that means, we must first know where we are now.

RAbio

Furthermore, because indicators based on such time series do not embody a model of how biodiversity is affected by drivers, future projections must be based on simple extrapolation of recent trends (e.g. Tittensor et al 2014), so it is not possible to compare biodiversity outcomes from alternative future pathways.

Should

STclim

We should remember, however, that while on the whole, climate impacts tend to be detrimental to human activities and ecosystems, there can be beneficial outcomes in some cases, such as longer growing seasons.

We should also bear in mind that these changes do not occur in isolation, but can interact with other unrelated factors, for the better or worse.

SPMbio

Although such market-based policy instruments as payments for ecosystem services, voluntary certification and biodiversity offsetting have increased in use, their effectiveness is mixed, and they are often contested; thus, they should be carefully designed and applied to avoid perverse effects in context (established but incomplete) {5.4.2.1, 6.3.2.2, 6.3.2.5, 6.3.6.3}.

PAbio

The IPBES report is solid on the science, but the panel should do more when it comes to outlining practical solutions for governments, businesses and communities, says Peter Bridgewater, an ecologist at the University of Canberra who led a separate analysis—released on 29 April—of the effectiveness of the biodiversity panel.

Biodiversity should be at the top of the global agenda alongside climate, said Anne Larigauderie, IPBES executive secretary, in a 6 May press conference in Paris, France.

Require

RAclim

Comparison of the costs and benefits for different warming limits requires an understanding of how risks vary between warming limits.

SPMclim

On longer time scales, sustained net negative global anthropogenic CO2 emissions and/ or further reductions in non-CO2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (medium confidence) and will be required to minimize sea level rise (high confidence). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}

Limiting global warming requires limiting the total cumulative global anthropogenic emissions of CO2 since the pre-industrial period, that is, staying within a total carbon budget (high confidence)

Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence).

The implementation of land-based mitigation options would require overcoming socio-economic, institutional, technological, financing and environmental barriers that differ across regions (high confidence).

If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (medium confidence).

Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (medium confidence).

If poorly implemented, CDR options such as BECCS and AFOLU options would lead to trade-offs. Context-relevant design and implementation requires considering people’s needs, biodiversity, and other sustainable development dimensions (very high confidence). (Figure SPM.4)

STclim

Limiting global warming to 1. 5°C is not impossible but requires strong and immediate policies.

It requires that our global CO_2 emissions be reduced to (effectively) zero over the next few decades, through large, sustained emission reduction efforts across all global regions and economic sectors.

As the impacts would be larger at 2°C than 1. 5°C, greater adaptation efforts would be required to deal with them.

Adaptation is still required at 1. 5°C, although efforts required will be smaller than at 2°C.

Greater emission reductions would be required to avoid use of carbon dioxide removal methods.

For overshoot paths, removal of CO_2 from the atmosphere would be required to bring global temperature back down to after overshooting the target level.

In comparison, limiting global warming to 2°C would require CO_2 emissions to decline by 20% by 2030 before effectively ceasing by around 2075.

A large scale up of renewable energy production is required, with renewables (including biomass, wind, hydropower and solar) to supply half to two-thirds of primary energy in 2050 to achieve the 1. 5°C target.

Given the inertia of the global economic system, it will be very difficult to achieve the emission reductions at scale and rates required, without using methods of removing CO_2 from the atmosphere.

In addition, use of methods to remove CO_2 from the atmosphere may end up being required.

These system transitions will be unprecedented in scale and will require large investments.

Systems transition requires:

-More investments in adaptation and mitigation,

-Behavior changes,

-Acceleration of technological innovation.

PAclim

At present, we have lots of ways of capturing carbon on a small scale, but no technology that works on the stupendous scale required to reverse decades of fossil fuel burning.

RAbio

The refinement of Hurtt et al 's (2011) single, broad Cropland class into five LUH2 classes presented challenges for data curation and modelling, and would require a larger database to model fully, but also provides more nuanced models that better reflect - albeit still coarsely - different effects on local biodiversity.

SPMbio

The specific actions taken will typically be case-specific and therefore will require careful assessment of evolutionary potential and consequences.

All climate model trajectories show that limiting human-induced climate change to well below 2°C requires immediate, rapid reductions in greenhouse gas emissions or a reliance on substantial carbon dioxide removal from the atmosphere. However, the land areas required for bioenergy crops (with or without carbon capture and storage), afforestation and reforestation to achieve the targeted carbon uptake rates are projected to be very large {4.2.4.3., 4.5.3}.

PAbio

The world can reverse this biodiversity crisis, the report says, but doing so will require proactive environmental policies, the sustainable production of food and other resources and a concerted effort to reduce greenhouse-gas emissions.

Need

RAclim

Moreover, the relative changes in probability are larger for rarer, more extreme events, implying that risk assessments need to carefully consider the extreme event thresholds at which vulnerabilities occur.

On the other hand, for systems in which the extent of damage is dependent on both magnitude and frequency, for example, when larger changes in magnitude for a given event frequency lead to more extensive crop damage or larger numbers of people at risk, more complex metrics that recognize the impacts of change in both frequency and magnitude may be needed.

SPMclim

Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (very high confidence) and for ozone-related mortality if emissions needed for ozone formation remain high (high confidence).

Effective governance is needed to limit such trade-offs and ensure permanence of carbon removal in terrestrial, geological and ocean reservoirs (high confidence).

Trade-offs between mitigation and adaptation, when limiting global warming to 1.5°C, such as when bioenergy crops, reforestation or afforestation encroach on land needed for agricultural adaptation, can undermine food security, livelihoods, ecosystem functions and services and other aspects of sustainable development. (high confidence) {3.4.3, 4.3.2, 4.3.4, 4.4.1, 4.5.2, 4.5.3, 4.5.4}

STclim

Finally, the resulting greenhouse gas emissions need to be considered when implementing adaptation measures to avoid competing goals, such as adaptation efforts leading to increased emissions.

The implications for sustainable development, including around food, water and human security also need to be taken into account (see Section D).

To stabilise global temperature, we need to effectively stop emitting CO to the atmosphere.

In order to stabilise global temperature, we need to effectively stop emitting CO2 to the atmosphere.

Given that this method, known as BECCS, would need to be implemented on a large scale, a key concern is that it would create competition with using land to grow crops for food instead of for fuel.

Given that we would need to effectively reduce CO2 emissions to zero in order to limit warming to a given level – the question becomes one of how rapidly we would need to this.

In both cases, a substantial global effort to reduce emissions is needed in the next few decades and without delay.

If we delay action now, more rapid emissions reduction will be needed in the future to limit warming to the same level, and these emissions reduction will be more costly.

What would we need to do?

Firstly, we need to reduce global energy, materials and food demand.

Second, we would need to use energy and materials more efficiently.

Third, we need to improve agricultural practices so as to reduce emissions and water use, including improving soil management and altering cattle diets.

We also need to reduce deforestation which together with other changes in land use, account for 12% or CO_2 emissions.

Finally, we need to transform the make-up of global energy supply.

We also need to transition transport away from fossil fuels to running on low-emission electricity.

Major investments will be needed to realise these transitions, including in developing countries.

To stabilise global warming at 1.5°C, we need to reduce our CO_2 emissions to be effectively zero in the next 30 years.

Transitions will be needed in the way to produce and consume energy, materials and food, in our use of land (including agriculture), in our transportation system and in industry.

The good news is there is movement in the right direction in lots of these areas but we would need to do more, faster.

In order to achieve these goals (including tackling climate change), we need to break the long-standing relationships between population and economic growth with greenhouse gas emissions.

And we need to overcome this while the physical impacts of climate change act to exacerbate poverty.

Climate change and sustainable development are thus intricately coupled and need to be considered together.

And we need to overcome this while the physical impacts of climate change act to exacerbate poverty.

Climate change and sustainable development are thus intricately coupled and need to be considered together.

PAclim

This not only makes it harder to determine how much warming CO2 causes, but also to work out what we need to do to limit warming, because it depends on how levels of these pollutants change too.

We need to get serious about adapting to life on a warmer planet.

RAbio

However, the Cropland, Plantation Forest and Pasture sites needed recuration to match the more detailed categories of the LUH2 projections.

PAbio

“Then we will need to see implementation across all sectors of society,” he says.

Personal pronouns

We

RAclim

As changes in risk are often associated with changes in exposure due to projected changes in local or regional climate extremes, we analyse differences in the risks of extreme daily temperatures and extreme daily precipitation amounts under different warming limits.

We show that global warming of 2°C would result in substantially larger changes in the probabilities of the extreme events than global warming of 1. 5°C.

Here we use the ratio of the probabilities of occurrence of a predefined extreme event at different levels of global warming to illustrate the differential impacts of different levels of warming on the rarity of extreme events defined with simple indicators of climate extremes.

We use annual maximum values of daily precipitation amount (RX1day), daily maximum temperature (TXx), and daily minimum temperature (TNn) simulated by climate models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5, Taylor et al).

We follow the approach of Kharin et al. (2013) and references therein for the analysis of climate extremes. Generalized extreme value (GEV) distributions (Coles, 2001) are fitted to annual temperature and precipitation extremes at every grid point using data from the historical (years 1860–2005) and three RCP simulations, RCP2.6, RCP4.5, and RCP8.5 (years 2005–2100) combined.

These parameters are estimated by the method of maximum likelihood. Here we assume that the location parameter and the log of the scale parameter depend linearly on the global mean temperature.

We considered the possibility that the shape parameter ξ might also vary with global mean temperature but found that allowing it to be linearly dependent on ΔT did not improve the goodness of fit as judged by standard likelihood ratio tests, suggesting little appreciable change in the shape parameters due to warming.

Since we are primarily interested in the dependence of the distribution of annual extremes on prevailing time-averaged temperature conditions, interannual variability in the global mean annual temperature time series in each model is suppressed by applying a 21-year moving average when computing the global mean temperature changes ΔT.

We use multimodel median values, which are less sensitive to outliers than the multimodel mean values.

We consider 1°C warming as being representative of the current climate since the temperature of the warmest year on record, 2016, is about 1. 1°C above preindustrial levels (WMO, 2017).

We see that for Paris, a preindustrial climate (1861–1880) 1-in-20-year warm temperature extreme occurs about 4 times more frequently (about once every 5 years) in the climate that is 1°C warmer than preindustrial.

Changes in cold extremes are such that the preindustrial 1-in-20-year event becomes a 1-in-50-year event in the current climate and less than a 1-in-200-year event for global warming of 2°C or greater (though we note that the estimates of such large return period values are associated with larger uncertainty).

To illustrate the regional results that are detailed in Table 1, we describe findings for two climatologically warm regions, East Africa and East Asia.

Here we showed that changes in the magnitude of risk ratio, which could be considered as a lower boundary for relative risk changes assuming that the consequences of extreme events will not decrease, are dependent on the rarity of the extreme event in the current climate as well as the amount of additional global warming beyond the present (with larger RR for rarer events).

STclim

The greenhouse effect – how are we changing our climate?

If these emissions continue at current rates, we are likely to reach 1.5°C of warming of between 2030 and 2052 – an additional 0. 5°C from today's level.

Climate says which clothes do we have to buy.

Weather forecast says what do we have to wear.

Even if we can somehow stop all carbon dioxide (CO2) emissions to the atmosphere immediately, global temperatures would stabilise but not decline – it takes centuries for millennia for the CO2 already present in the atmosphere to be removed by natural processes.

In order to reduce global temperatures back down to what they were back in pre-industrial times, we would have to actively remove CO2 from the atmosphere.

While limiting global warming to 1.5°C is still possible – we are not already committed to this by our past GHG emissions, we would have to act very rapidly to achieve this goal.

Below we explain the different types of climate impacts, and why some locations and populations are more at risk than others

In many cases, we can act to reduce impacts through an iterative process of planning and implementing measures to combat them (adaptation)

Below we introduce this concept, together with the notion of uncertainty in how climate will change in the future

By global warming we mean the increase of the average surface temperature of the whole planet.

We expect climate to cause extreme weather events – like heat waves, heavy rainfall, floods and droughts – to become more frequent and more severe.

We should remember, however, that while on the whole, climate impacts tend to be detrimental to human activities and ecosystems, there can be beneficial outcomes in some cases, such as longer growing seasons.

We should also bear in mind that these changes do not occur in isolation, but can interact with other unrelated factors, for the better or worse.

Current estimates range between 25 centimetres to over a meter by 2100, depending in part on how much we emit in the future.

Adaptation is made more difficult because we can't predict exactly how the climate will change in a given place in future.

The amount of global warming depends both on past emissions of greenhouse gases and on those we will emit in the coming years.

As explained in Section B, even if we stop emitting greenhouse gases immediately sea levels will keep rising over these time-scales due to ocean inertia.

We would retain more of nature's services for humans (pollination, clean water etc)

To stabilise global temperature, we need to effectively stop emitting CO to the atmosphere.

The more CO2 and other greenhouse gases we release into the atmosphere, the more global temperatures will rise.

Unfortunately, the slow removal of CO2 from the atmosphere means that global temperatures will remain warmer for centuries to millennia even after we completely stop emitting CO2.

There are two ways we can achieve this : We can actually reduce our emissions to zero ; Or we can effectively do so by substantially reducing them and then offsetting remaining emissions by using technology and/or biological means to remove CO2 from the atmosphere – with the net effect being as though we were not CO2 emitting at all.

We also don't know how well the method works at large scale.

We are not on track to limit warming to 1.5°C, in fact, current emission reduction pledges made by nations in the Paris Agreement would lead to warming of 3-4°C by the end of this century.

Given that we would need to effectively reduce CO2 emissions to zero in order to limit warming to a given level – the question becomes one of how rapidly we would need to this.

If we delay action now, more rapid emissions reduction will be needed in the future to limit warming to the same level, and these emissions reduction will be more costly.

What would we need to do?

Firstly, we need to reduce global energy, materials and food demand.

Second, we would need to use energy and materials more efficiently.

Third, we need to improve agricultural practices so as to reduce emissions and water use, including improving soil management and altering cattle diets.

We also need to reduce deforestation which together with other changes in land use, account for 12% or CO_2 emissions.

Finally, we need to transform the make-up of global energy supply.

We also need to transition transport away from fossil fuels to running on low-emission electricity.

To stabilise global warming at 1.5°C, we need to reduce our CO_2 emissions to be effectively zero in the next 30 years.

We are not on track to limit warming to 1.5°C, and are currently heading for 3-4°C warming by 2100.

The good news is there is movement in the right direction in lots of these areas but we would need to do more, faster.

Even without factoring in climate change, we face tremendous global challenges over the coming decades.

In order to achieve these goals (including tackling climate change), we need to break the long-standing relationships between population and economic growth with greenhouse gas emissions.

And we need to overcome this while the physical impacts of climate change act to exacerbate poverty.

PAclim

Which one can we rely on, asks Michael Le Page.

Warming of 3°C, or perhaps 5°C if we don’t take drastic action now.

Just about every article you’ll read about climate change is full of numbers, starting with 1.5°C, the number that we are told represents the maximum temperature rise we can allow and still avoid the worst effects of global warming.

The biggest uncertainty by far is us, namely what exactly we do over the next century. And the uncertainty cuts both ways: we could be underestimating how fast the world will warm and what the effects will be.

So what numbers can and can't we be certain of?

To work out what that means, we must first know where we are now. We might have as much as 0.6°C still to go before we cross the threshold–or less than 0.3°C.

How can we not know how much the world has warmed?

But our measurements focus on the thin layer we live in: mean global surface temperature usually refers to the heat of the air 2 metres above the surface.

We get an idea of how this temperature is changing from thousands of weather stations on land, and from ships and buoys at sea.

And because you can't have fixed weather stations in an ocean full of shifting ice, we have few measurements from the Artic.

Despite this, the average temperature between 1850 and 1900 has come to be regarded as the semi-official "pre-industrial level" because that is the earliest period for which we have direct measurements.

But if we are serious about trying to limit warming to 1.5°C, it really matters.

The devastating storms, incredible heatwaves and rampaging wildfires we are already seeing show that what is deemed safe is a matter of degree.

But as we don't know for sure at what temperatures any of these will kick in, this doesn't help establish a "safe" limit.

If we stop building on coasts doomed to disappear under the waves and start adapting our homes to cope with far greater weather extremes, we will save many lives.

When are we set to pass the 1.5°C limit?

A reasonable definition is that we will go over the limit when the average, long-term temperature rise exceeds 1.5°C.

At present, we have lots of ways of capturing carbon on a small scale, but no technology that works on the stupendous scale required to reverse decades of fossil fuel burning.

Even if we can get the temperature back down, the impacts will be more serious if we go past 1.5°C because there will be faster warming over the next few decades.

Adding to the confusion are all sorts of other pollutants that we are pumping into the atmosphere, some of which have a cooling effect.

This not only makes it harder to determine how much warming CO2 causes, but also to work out what we need to do to limit warming, because it depends on how levels of these pollutants change too.

While we are increasingly confident that the low end of the plausible range can be ruled out, there is a long tail of high values that cannot. Earlier this year, some climate scientists warned that we could be greatly underestimating the risks and that if the planet did warm by at least 2°C, it might be impossible to stop it warming several further degrees.

How much more co2 can we emit?

Even if we are unsure of the exact value of the climate's sensitivity to carbon dioxide and other greenhouse gases, it is clear that what matters is how much is in the atmosphere.

To try to simplify thing, climate scientists have started talking in terms of carbon budgets: how much more CO2 we can emit.

More accurate figures and better models have resulted in an increase in the amount of CO2 we can get away with emitting.

But the latest IPCC report acknowledges that budgets can vary widely for the reasons we have looked at already.

The budgets could be 650 gigatons lower or higher, depending on climate sensitivity and the historical baseline, meaning we might already have exceeded even the biggest budget.

These set out how much CO2 we can emit up to the point the temperature rise passes 1.5°C.

They are based on when emissions hit zero in those scenarios that assume we overshot 1.5°C, but cool the planet back down by sucking carbon from the air.

In other words, even if we limited warming to 1.5°C, much of the ice in Greenland and West Antarctica could still be lost, which would be enough to raise sea levels 5 metres or more.

Without a change of course, we are actually heading for a world that is 3 or 4°C warmer, which could lead to seas rising more than 20 metres.

How long do we have to turn things around?

“Scientists Say We Have 12 Years to Save the World.”

It is true that at the current rate of emissions we will exceed the report’s “most likely” remaining carbon budget in roughly 12 years. But as we have seen, carbon budget are at the midpoints of vast ranges, and the 1.5°C target itself is an arbitrary one.

We have also been here before. Climate change deniers have gleefully pointed out that we have been told several times before that there are just X years to save the planet.

“We in fact have to act immediately in a larger way than ever before.”

First, we have to reduce net global emissions to zero, and the faster we do it the better off we will all be. Second, how bad things get partly depends on how much we do to prepare. We need to get serious about adapting to life on a warmer planet.

RAbio

In this paper we examine 1) how terrestrial species communities have been impacted over the last thousand years of human development and 2) how plausible futures defined by alternative socio-economic scenarios are expected to impact species communities in the future.

We use the PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems) database to model impacts of land-use change and human population on local species richness, community abundance, and biodiversity intactness using a mixed-effects modelling structure.

We project model results onto the gridded outputs of six SSP/RCP scenario combinations: SSP1/RCP2 6, SSP2/RCP4.5, SSP3/RCP7.0, SSP4/RCP3.4, SSP4/RCP6.0, and SSP5/RCP8.5

However, a brighter future is possible; SSP1/RCP2. 6 describes a more sustainable future, where human populations are provided for without further jeopardising environmental integrity – in this scenario we project that biodiversity will recover somewhat, with gains in biodiversity intactness and species richness in many regions of the world by 2100.

Here, we go beyond these previous analyses in two main ways.

First, we apply the PREDICTS modelling framework for the first time to the five Shared Socioeconomic Pathways (SSPs: Riahi et al 2017) developed as part of the sixth round of Intergovernmental Panel on Climate Change (IPCC) reports.

Second, we have improved the modelling of compositional similarity, enabling explanatory variables other than land use and distance to affect the compositional similarity between sites.

We present estimates of how global average values of two indicators – species richness and abundance-based BII have changed between 850 and 2010, and their future trajectories to 2100 under each of six SSP/RCP combinations made available in the harmonized dataset.

For each site, we calculated total abundance as the sum of all individuals of all species, and species richness as the number of present species.

Explanatory variables included in the model selection process were human population density (ln(x+1) transformed), land use, land-use intensity, and a factor combining the two (which we term LUI).

The major factor is likely to be that our models of compositional similarity are able to incorporate more pressures than did those of Newbold et al (2016) because we use the full set of pairwise comparisons rather than using only a subset.

Most obviously, we infer a markedly higher level of BII across much of Australia (compare Figure 3 with Newbold et al.'s Figure S4) than Newbold et al (2016) who found surprisingly low values of BII.

PAbio

“We can no longer say that we did not know,” she said.

“We have never had a single unified statement from the world's governments that unambiguously makes clear the crisis we are facing for life on Earth,” says Thomas Brooks, chief scientist at the International Union for Conservation of Nature in Gland, Switzerland, who helped to edit the biodiversity analysis. “That is really the absolutely key novelty that we see here.”

“We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide,” says IPBES chair Robert Watson, an atmospheric chemist at the University of East Anglia, UK.

“Then we will need to see implementation across all sectors of society,” he says. “That’s when we will see a difference.”

You

PAclim

And because you can’t have fixed weather stations in an ocean full of shifting ice, we have few measurements from the Artic.

If you use the Met Office record and take 1850 to 1900 as the baseline, there has been around 0.9°C of warming so far.

If you rack up a lot of debt, the only way to repay it–to get the temperature back down after an overshoot–is to reduce the level of carbo dioxide in the atmosphere by removing vast quantities of it.

And once you start relying on science-fiction scenarios, you can justify a much vaster range of numbers.

If you were doing a bungee jump, this would be equivalent to the length of rope with which you would exactly smash into the ground.

“Once you allow negative emissions, the carbon budget is an ill-defined concept,” says Peters.

Appendix 2 Tables of the confidence terms

IPCC

The depiction of agreement and evidence statements and their relationship to confidence.

"A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence" Mastrandrea (2010: 3).

Table 1. Likelihood Scale

Term*	Likelihood of the Outcome
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

The scale of likelihood used to express a probabilistic estimate of the occurrence of a single event or of an outcome.

Source: Mastrandrea (2010: 3).

IPBES

The four-box model for the qualitative communication of confidence.

Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Source: IPBES (2019).

Explanations provided by the IPBES (2019: 53) are copied below.

"In this assessment, the degree of confidence in each main finding is based on the quantity and quality of evidence and the level of agreement regarding that evidence (Figure SPM.A2). The evidence includes data, theory, models and expert judgement. Further details of the approach are documented in the note by the secretariat on the information on work related to the guide on the production of assessments (IPBES/6/INF/17).

Well established: there is a comprehensive meta-analysis or other synthesis or multiple independent studies that agree.

Established but incomplete: there is general agreement, although only a limited number of studies exist; there is no comprehensive synthesis, and/or the studies that exist address the question imprecisely.

Unresolved: multiple independent studies exist but their conclusions do not agree.

Inconclusive: there is limited evidence and a recognition of major knowledge gaps."