UNMAPPING THE UNCERTAINTIES IN CLIMATE SCIENCE

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Tässä tutkielmassa tutkin Hallitustenvälisen ilmastonmuutospaneelin (IPCC) kolmea ensimmäistä raporttia kielitieteellisestä ja institutionaalisesta näkökulmasta. Ilmastonmuutoksen alkuperästä ei ollut varmuutta ennen paneelin neljännen raportin julkaisua 2007. Ovatko ensimmäisten raporttien epävarmuusilmaisujen määrä ja laatu vaikuttaneet siihen, ettei kansainvälinen yhteisö nähnyt pakottavaa syytä toimia ilmastokriisin puhkeamisen estämiseksi? Miten raportteja laadittaessa on ohjattu epävarmuuksien käsittelyä?

Raporteissa on useita osioita ja ne seuraavat toisiaan 5–6 vuoden välein. Tutkin työryhmän I tekstejä, jotka muodostavat kahden muun työryhmän raporttien ilmastotieteellisen perustan. Seuraamalla niiden muodostamaa ajallista jatkumoa voin havaita muutoksia epävarmuuden ilmaisuissa. Lopuksi vertaan löytämiäni tuloksia paneelin kokous- ja istuntoraporttien aineistoihin. Työryhmä I ei tee tutkimusta, vaan arvioi uuden tutkimuksen tasoa ja tuloksia. Sen vuoksi runkoteksti sisältää useita konteksteja, joissa epävarmuuden ilmauksia voi esiintyä. Esipuheet ja kokousraportit sisältävät yhteenvetoa arvioista, ja kokousraporteissa on tutkijoiden ja poliitikkojen välistä vuoropuhelua. Niistä teen diskurssianalyysiä; ”Radiative Forcing of Climate Change” -luvut (eli tutkimuksen runkoteksti, yhteensä 75409 sanaa) tutkin korpusmenetelmällä käyttäen Pythonia ja AntConc-sovellusta.

Raporteissa on epävarmuuden/varmuuden ilmaisuja enemmän kuin tieteellisessä tekstissä keskimäärin (Hyland, 1998). Numeraaliset estimaatit ja approksimaattorit ovat tärkeitä. Apuverbit tukevat sekä tutkimusarvioita että estimaatteja, samoin verbit ”suggest” (’ehdottaa’, ’antaa ymmärtää’); ja ”estimate” (’arvioida’, ’laskea’). Koska epävarmuuden/varmuuden, luottamuksen ja todennäköisyyden ilmaisut ovat päätöksenteossa keskeisiä, raporteissa on myös turvauduttu ”epävarmuuskielen” (’uncertainty language’) käyttöön. Sen avulla raporttien keskeiset tulokset esitetään kompaktisti ja ohjatusti poliitikoille sisällyttämällä sanoja kuten ”confidence”, (’luottamus’), ”agreement” (’yksimielisyys’), ”evidence” (’todiste’), ”likely” (’todennäköinen’), ”unlikely” (’epätodennäköinen’) sulkeissa tekstikappaleisiin. Myöhempien (2001 jälkeen ilmestyneiden) raporttien poliitikoille suunnatuissa yhteenvedoissa tämä kielenkäytön piirre on jo keskeinen. Määrällisen tutkimuksen mukaan epävarmuusilmaisuja ja luottamuksen/epävarmuuden/todennäköisyyden skaalaamista ”epävarmuuskielen” edellytysten mukaan käytettiin jo toisessa (1995) ja kolmannessa raportissa (2001) myös itse tieteen tasoa käsittelevissä luvuissa.

Silti raporteissa ilmaistu epävarmuus ei juuri vaikuttanut poliitikkojen ilmaisuihin ilmastonmuutoksen vaarallisuudesta tai todellisuudesta saman aikavälin (1990–2001) kokousraporteissa. Syy tämänhetkiseen ilmastokriisiin – ja ilmastopolitiikan kriisiin – ei löydy nimenomaan ilmastotieteen sisältämästä epävarmuudesta, eikä sen ilmaisu eri tavoin näytä olleen keskeinen vaikuttaja päätöksenteossa. Esitän lopuksi kysymyksen: Miten tulevaisuuden riskejä ja niiden sisältämää epävarmuutta (myös: niiden todennäköisyyttä) on kuvattava, jotta niihin varauduttaisiin tehokkaasti?

Contents

1. Introduction

Science plays an increasingly important role in today's societies. It carves our lives through affecting our decision-making processes. Right now, due to the global pandemic, our decision making involves questions like whether to self-isolate or not, always to wear a face mask while out or not, or whether to use disinfectants and hand gel instead of constant hand washing. Science helps us make these decisions, and hopefully, keeps us safe.

Of global relevance is also climate change. In can be regarded less acute and dramatic: perhaps due to economic reasons, there has even existed a willingness to play down the discussion of its epistemology, causes, and effects. Today, however, a widely spread consensus that climate change is anthropogenic exists, and since we have experienced extreme temperatures and other extreme weather-related phenomena in many parts of the globe in recent years, this consensus has deepened, especially among the young. In a survey published by the BBC (27th January 2021): 'Climate Change: Global poll finds most believe it is a 'global emergency'' young readers' opinions about climate change were viewed. In the article, a wish was expressed that the opinions of the young partakers from all around the world would usher 'the world leaders to take action' against what 64 % of the respondents thought to be 'a climate change emergency' (BBC Newsround, 2021).

The active efforts of climate scientists have spread the message – that greenhouse gas emissions should be as drastically reduced as possible to cut the rising curve in global temperatures –since 1979 (public.wmo.int), and an international organisation (IPCC) was created in 1988 for this purpose under the auspices of the United Nations Environment Programme and the World Meteorological Organisation. The IPCC (the Intergovernmental Panel on Climate Change) had as its initial task to

> prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change; the social and economic impact of climate change, and potential response strategies and elements for inclusion in a possible future international convention on climate (IPCC, no date, in 'About History of the IPCC').

In shorter terms, that is: 'to provide policymakers with regular scientific assessments on the current state of knowledge about climate change' (ibid).

Since then, the IPCC claims that it has 'delivered … the most comprehensive scientific reports about climate change produced worldwide', often in conjunction with the United Nations Climate Change Conferences:

> [The IPCC has] produced a range of Methodology Reports, Special Reports and Technical Papers, in response to requests for information on specific scientific and technical matters from the United Nations Framework Convention on Climate Change (UNFCCC), governments and international organizations (Ibid.).

I see no reason to go against these claims or doubt the epistemological validity of these reports. Yet, there is no single way to describe those who are climate change sceptics; nor is there a straightforward way to describe those who mainly believe in it and their subsequent acts. For example, Davidson et.al. (2019) attempted to 'unpack the … relationships by associating climate change beliefs, demographic variables and identity factors with rates of adoption of specific climate-mitigative practices' among Canadian farmers, most of whom are sceptical about man-made climate change. On the other hand, Karakas (2020) researched the ways in which 'socioeconomic ideologies and partisan politics are explained to be relevant factors in voting behaviour in climate change related issues.'

It can, however, be agreed that climate change is a well-established fact among scientists and scientific organisations (climate.nasa.gov., no date). But in which ways have these reports delt with epistemological issues in the context of audiences that spread far beyond the boundaries of the scientific community?

When scientific texts enter public media, they may also, for multiple reasons, go through other kinds of significant changes. In their discussion about the science-media interface, Hans Peter Peters et al. (2008) make the following statement:

> It is, therefore, not a random malfunction but a systematic feature that the meanings of scientific messages change when they are reconstructed by journalism for the public sphere. Accuracy problems, identified in so many studies that compare media stories with the scientific reality, are only the tip of the iceberg in that respect. (Peters et al., 2008, p. 269.)

There has been a range of positive developments in the science-media interface since then. Like Peters et.al., I connect these developments to 'the interaction of two fundamental trends of modern societies: the development toward a knowledge society and the development toward a media society' (Peters et al., 2008, p. 272).

When the research community actively uses the platforms provided by the social media to cause perlocutionary effects in their new, much widened audience the scientists can modify the texts themselves. Reporting the scientific research results for the public they 'act as journalists', and possibly cause 'malfunction' and 'accuracy problems'. The IPCC is not an unresourceful media communicator of its science but an authority even, and in this paper, I try and reveal what does the IPCC as an institution look like, and how does it discuss epistemology in the first three Assessment Reports.

John Swales (1990) studied the characteristics of scientific writing as a genre in a university setting. The IPCC reports have multiple features that comply to those characterisations, but they also have features that are specific answers to the challenges in their own environment: from the scientific field to socio-economic and political decision-making; from the institutional context combining the reaches of WMO and UN, as defined by the UNFCCC, to providing globally and regionally relevant knowledge to a global, versatile audience, for example. These contextual considerations necessarily cause the reports to be modified in manners that may differ from scientific articles written for peer review. Moreover, the reports are assessments of up-to-date research, and not publications of research done by the authors themselves: IPCC does not do research. So, the language used to convey the epistemological issues does not describe a straightforward path form research questions to results in a two-, or even three-dimensional setting, but always has one more dimension.

Genre studies are also relevant, because the institutional, i.e., the discourse community context, is heavy. Also, the modification processes the reports undergo last for years, and comprise also of expert review and government representative review[1]. The processes are made (relatively) transparent by the IPCC. In other words, the reports follow the practices of a heavily institutionalised discourse community and comply to a genre, and/or develop further a genre, that deals with scientific reporting, also of uncertainties in science, with global relevance and outreach.

I am very concerned about climate change and therefore, my main research questions follow from the historical fact that the first three reports did not cause enough climate action to curb the warming/unbalancing of the climate system. How could this be explained, in terms of the linguistic practices, and specifically in the epistemologically minded expressions, in these early reports? From this question, a host of others follow: How does the IPCC position itself as i) a scientific community, ii) an institution with a global outreach, iii) an influencer, or an authority (with a stance). How does it negotiate its roles within the community and outside of

[1] See 'PROCEDURES FOR THE PREPARATION, REVIEW, ACCEPTANCE, ADOPTION, APPROVAL AND PUBLICATION OF IPCC REPORTS', available at ipcc-principles-appendix-a-final.pdf.

it (as understood, e.g., in Hyland, 1998)? I conduct a mixed-method research on these issues. I study the first three IPCC Assessment Reports: their respective ‘Radiative Forcing (of Climate) -chapters, qualitatively and quantitatively.

I also looked at words which relate to the ‘making of science’, and furthermore, occur frequently in the reports. The differences in hedging practices between the reports are highlighted in some cases. These derive partly from philosophy of science as I understand it, and data.

Some of my own worries and thoughts about climate change are included in the text below in italics and square brackets. These reflect my own, deeply felt disappointment in climate action. In its reporting, the IPCC clings to rules of objectivity and non- policy prescriptivity. My comments may sometimes break these rules and the restrictions set by the genre of academic writing.

In the following Background-chapter, some studies to hedging and discourse-community practices are introduced, as well as the IPCC as an institution.

2. Background

In his influential study 'Hedging in Scientific Research Articles' Ken Hyland (1998) proposes the following:

> The writer or speaker's judgements about statements and their possible effects on interlocutors is the essence of hedging[2], and this clearly places epistemic modality at the centre of our interest (Hyland, 1998, p. 2).

and further:

> Because judgements about truth and falsehood, certainty and doubt, probability and possibility play such an important role in our lives, they allow a wide range of lexical, grammatical and strategic realisations (ibid., p. 3).

Some of those 'lexical, grammatical and strategic realisations' which 'occur at the surface phenomena of the texts' are called hedges (ibid., p. 3):

> In sum, [in this study] hedges are the means by which writers can present a proposition as an opinion rather than a fact: items are only hedges in their epistemic sense, and only then when they mark uncertainty (ibid., p. 5).

Considering that the perlocutionary force[3] of climate change reports may be of utmost importance for the well-being of today's societies, and that they are produced at the request of not only scientific communities but governments and international organisations – with the specific aim to mainly enhance the protective stance towards the Earth's atmosphere and our communities – I find the epistemological study of some of these reports compelling. In the words of Peters et al.: 'As a matter of respect for public discourse and for the media audience, scientific sources have to find ways to combine their strategic visibility goals with quality criteria regarding message content' (2008, p. 275). Even if the 'strategic visibility goals' may be highly ethical in the case of climate change reporting, the ways 'the message content' has been built, and especially, the expressions that are used to express uncertainty, can be guided by multiple factors even in scientific writing. I do not expect that hedges in the IPCC reports

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[2] In the context of hedging, also 'stance' is important to mention. It means 'interactional and interactive […] language that conveys the attitudes of writers to their material and readers and that is used to create a more accessible and persuasive text' (Hyland, 2005a in Hyland & Jiang, 2016).

[3] Austin 1975, p. 107 –109; in Kissine 2008:

> 'perlocutionary act[s] always include some consequences'; *perlocutionary acts are 'what we bring about or achieve by saying something'*. In the terms distinguished above, perlocutionary acts should thus be understood as causal relations between two events, the cause being the production of an utterance by the speaker. (p. 1191. Italics by SR.)

are used to express ‘opinion[s] rather than fact[s]’. Yet I think that hedging is in close connection to how ‘the quality criteria regarding message content’ gets to be determined.

Garry Plappert (2017) lifts up the possibility of finding novel ways to hedge contents in scientific papers. He makes the following questions about frequently occurring items:

> (1) What types of epistemic claim are highly frequent items typically involved in making?
>
> (2) Are these claims typically hedged or not? And,
>
> (3) If they are, do we find the ‘usual suspects’ of hedging or not?

Through this radically corpus driven approach, he tries to demonstrate the following:

> … it is possible to discover previously unidentified hedging devices, before finally concluding that the ‘usual suspects’ of study, such as modal adjectives and phraseological chunks like ‘it is probable that’, may have a more peripheral role in hedging in scientific writing, and particularly in the discipline of genetics, than might currently be assumed (pp. 428–429).

I find this study inspiring in the way allows for new hedges to be found. The IPCC reports deploy “uncertainty language” to i) assess the accuracy and relevance of the results in climate science and ii) to express the level of agreement in the scientific community on those assessments. As Hyland understands one important role of hedging to be a face-saving act within the scientific community, I could expect that the ways to hedge the epistemological claims[4] a scientist uses to be pre-determined, well-established and identifiable: i.e., ‘the usual suspects’. Garry Plappert allows novel ways of examination into hedges, and it is this open-mindedness; quality of novelty; that I also need to try and discover the origins of ‘the uncertainty language’ use.

The IPCC scientific community involved in climatology also aims to help achieve the UNFCCC (United Nation Framework Convention on Climate Change) Paris Agreement 2015 goal to ‘strengthen the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty’ (Government of Canada –webpage, (no date), in ‘United Nation Framework Convention on Climate Change and the Paris Agreement’) through influencing the decision-making processes of politicians. Such impressive targets

[4] I define epistemology in this context thus: It is the consistency with which observations, and expressions of observations, can represent the real world. These ‘expressions of observations’, or evidence, lead to knowledge that is factual.

render the study the beginnings and development of this “uncertainty language” extremely relevant. What kinds of frequent expressions in the early reports were used, and what caused the IPCC working units to begin the modification process of language in these reports? Because of these questions I step outside of the study of the ‘usual’ hedging devices.

If I consider the ‘more peripheral role of ‘the usual suspects’ in Plappert’s study to refer to hedging being used as a rhetorical device to create a positive rapport with the audience, I might also view some of my findings ‘peripheral’. But, more accurately, the ‘Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties’ (available at https://www.ipcc.ch/library/), drafted by M. D. Mastrandrea et. al (2010), outlines how ‘an uncertainty language’ was created for the purposes of ‘develop[ing] expert judgements … and for evaluating and communicating the degree of certainty in findings of the assessment process’ … Further, this effort to ‘calibrate language’ has as its goal to ‘create a common approach through all IPCC working units’ (Mastrandrea et al., 2010, p. 2). I think that the IPCC seeks to express an unequivocal approach to climate change, climate change related phenomena and their global effects so that an up-to date scientific ‘stronghold’ of uniformly approved information will guide the decision-makers all over the world, and therefore the amount of uncertainty in the reports, and how it is expressed, are not peripheral but focal factors. Everything counts.

The IPCC has a tall order, and this might be an instance of personal gains of scientists, as ‘members of a discourse community[5]’ being supposedly suppressed to minimum (c.f. Hyland, 1998 p. 16; Swales, 1990 pp. 53–54) and maybe, indirectly, those of policymakers, too: there is less room for personal interpretation of hedging devices if they are calibrated using numerical basis. Yet, the attention paid to socially relevant factors that affect the reception of scientific knowledge in a community are maximised (Hyland, 1998 p. 15). These two parameters tangibly affect, not only the hedging practices, but the very structure in these reports: the deep-level science is separated from the SPMs (Summaries for Policy Makers) for easier access. The reports are written for wide audience, and the needs of it are carefully

[5] Following in the footsteps of John Swales, I define a discourse community in short thus: It is a group of people that is aligned by locality, focality, or a combination of the two. The group shares a set of common linguistic practices and has common goals (Swales, 2017). Swales has updated the concept and found one of its aspects crucial: the ability to realign writer, audience, and text into such a configuration that can be foregrounded and scrutinized (Porter, 1992, in Swales, 2017). Discourse communities have often been linked with genre studies, but my goal is not to reveal if these IPCC reports are actually on their way to develop into a genre of their own.

considered throughout the production process of these reports (see, for example pp. 12–14 in this paper).

Mastrandrea et als' 'Guidance Note' already has received some criticism in the academic circles and evoked discussion about the various uses of "uncertainty language". Collins & Nerlich (2016) start their critique by asking "How certain is 'certain'?" and explore the reception of the "calibrated language" used in IPCC reports in English language media. Janzwood (2020), for his part, criticises the implementation of the framework for being inconsistent throughout the series of some more recent publications, especially in Special Reports, and between the main bodies of the text and summaries.

In the first three IPCC Assessment Reports I expect to find the beginnings of the developments in the epistemological and/or probabilistic expressions that represent the movement away from Hyland's 'classical suspects', or even Plappert's terminology-related ones, to ones that are more calculated (often numerically expressed), or more importantly, conformed and calibrated 'evidence/agreement, confidence and likelihood expressions' (Janswood's (2020, p. 2) description of Mastrandrea et al.'s work (2010)).

This approach leads me also towards a study of "discourse community" practices. I will use Swales's 1990 text *Genre Analysis: English in Academic and Research Settings* to arrive at a plausible explanation to such a detailed and, judging by its superficial features, uncompromising hedging practice (or "calibrated uncertainty language use") that seems to prevail in the IPCC Reports. However, I find that Hyland (1998) already opens similar discussions from multiple points of view.

I quote J. Donald Hughes's paper: 'Climate Change: A History of Environmental Knowledge', 2010, in *Capitalism Nature Socialism*; (in full length in Appendix 1.1., p. 84):

> **[---] theories have been developed and tested all along, but these periods do seem to follow an emergent dialectic, and the public debate on the relationship between science and society has unmistakably intensified in the most recent decades.** (Hughes 2010, pp. 1 – 2, my bolding, SR.)

With these references to a) 'an emergent dialectic', b) 'discourse community practices' and c) Hyland's more classical hedging devices, also drawing some inspiration from Plappert's effort to reveal new hedges, and Swales's genre study, I aim to explore the epistemological and probabilistic vocabulary and expressions as they appear in the early IPCC climate change reports. I will concentrate not only on **the linguistic features** used in the practices of hedging knowledge but also on **the methodological and temporal settings** in which they appear. In addition to these two major featuring elements in this study, I expect to find the expressions of motivations the lead authors of the various IPCC reports give[6], and use those to extend on the discussion on the relationship between science and society.

The first part of this chapter introduced questions about the interrelation between developments in hedging practices, scientific knowledge, and institutions, society, and social media. The second part discusses the IPCC in more detail before I introduce the methods I use.

2.1. Background: the IPCC

The dual roles the IPCC plays in assessing and publishing the best available scientific knowledge about climate change on the one hand; and offering a platform for policymakers to be informed of climate change and its impacts, and evaluating the range and efficacy of the policymakers' subsequent decisions to stall, and/or, to adapt to the climate change and its consequences, on the other (see https://www.ipcc.ch/about/ for more information) make the IPCC Reports more complex than research articles in general. The IPCC working units are committed to perform their complex task objectively and without being policy prescriptive. The scientific, institutional, and socio-political context are relevant. The IPCC is, due to its intergovernmental contacts, and constant and comprehensive expert reviewing system; *the* key actor that guides the contemporary climate change policies worldwide: it has already achieved authority position in climate science, even if it does not conduct research itself:

> [The IPCC] was set up in 1988 by the World Meteorological Organization and United Nations Environment Programme to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. The IPCC does not conduct its own research. It identifies where there is agreement in the scientific community, where there are differences of opinion and where further research is needed. It is a partnership between scientists and policymakers and it is this that makes its work a credible source of information for policymakers. IPCC assessments are produced according to procedures that ensure integrity, in line with the IPCC's overarching principles of objectivity, openness and

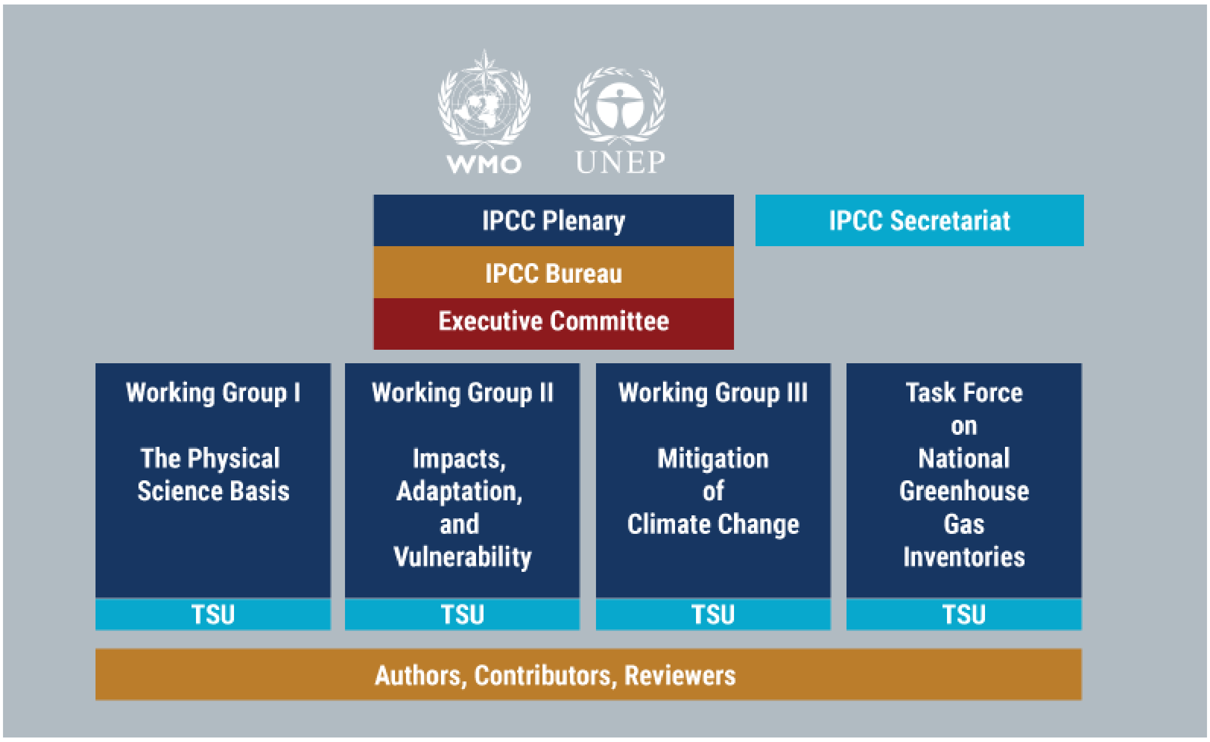
[6] The IPCC can be praised for its transparency. Most session and meeting reports are available at https://archive.ipcc.ch/meeting_documentation/meeting_documentation.shtml. In these, the discourse that took place during the production process of the major reports can be followed.

> transparency. IPCC reports are policyrelevant, but not policy-prescriptive. (IPCC, 2020, in ‘The IPCC and the Sixth Assessment cycle’)

The IPCC reports show a complex structure and have contents from many separate fields of study – which have, furthermore, been adapted to inform both expert and inexpert readers. A full-blown Assessment Report includes the contributions of three IPCC Working Groups: Working Group I are responsible ‘for assessing the physical science of climate change’ (description available at https://www.ipcc.ch/working-group/wg1/) in both global and regional level, with underpinnings both to Working Group II, which “assesses the impacts, adaptation and vulnerabilities related to climate change’ (https://www.ipcc.ch/working-group/wg2/), and Working Group III, who ‘focus[es] on climate change mitigation, assessing methods for reducing greenhouse gas emissions, and removing greenhouse gases from the atmosphere’ (https://www.ipcc.ch/working-group/wg3/). All these Working Groups write up, assess, and review their works partly independently, partly as a group:

> Representatives of IPCC member governments meet one or more times a year in Plenary Sessions of the Panel. They elect a Bureau of scientists for the duration of an assessment cycle. Governments and Observer Organizations nominate, and Bureau members select experts to prepare IPCC reports. They are supported by the IPCC Secretariat and the Technical Support Units [TSUs] of the Working Groups [WGs] and Task Force [on National Greenhouse Gas Inventories: TFI].

Fig 1) The structure of the IPCC (IPCC, no date, in ‘About Structure of the IPCC’)



Despite the robustness and complexity of the products themselves, and the elaboration in production cycles I conduct a mixed methods study on chosen material. I compare the linguistic hedging practicalities and frequently occurring words with epistemic modalities in the first three reports to indicate what developments took place before the implementation of the ‘uncertainty language’. I use a corpus-related approach to identify hedged expressions in the IPCC FAR (First Assessment Report, 1990), SAR (Second Assessment Report, 1995) and TAR (Third Assessment Report, 2001). For acquainting myself more superficially with the data on the later IPCC reports AR4, AR5), I use the previously mentioned studies by Janzwood, 2020 and Mach, Mastrandrea, Freeman, Field, 2017; for more insights and further discussion about the reception of the implemented uncertainty language my source is Collins & Nerlich, 2016.

Many of the features of the IPCC material caused me to reconsider the efficacy of a corpus-based, or a corpus-driven study. However, I now move on to describe how I chose my data and how I conducted qualitative analysis and corpus-based research on it.

3. Methods

The IPCC designates its first publication thus: "Climate Change: The IPCC 1990 and 1992 Assessments. IPCC First Assessment Report Overview and Policymaker Summaries and 1992 IPCC Supplement". In other words, FAR is a compilation of several, partly overlapping works, and displays parts which have already undergone a 24-month assessment process.

As stated earlier, the IPCC Reports come in various forms and numbers (the IPCC Library is 'a repository of IPCC Assessment Reports, Special Reports, Methodology Reports, Technical Papers and reports from IPCC Expert meetings'). To be able to, from all material, choose the relevant data, I needed to dig into the five main Assessment Reports, or, if Synthesis Reports (see below) were available, into those.

I reiterate: Whenever deemed necessary, an input of Technological, Methodology and Supplementary Materials can be drafted and added either to inform and guide the production process of the major reports or to complement the text. As also the production cycle of any main report spans over a period of almost six years (the first assessment report; FAR, was published 1990, the last; Sixth Synthesis Report 2022, has yet to come out) – the production process itself, as well as the contents may undergo some tangible changes. So, the reports are the produce of multiple working groups, supporting teams and "task forces" (deployed if necessary) working together in a time frame of five to six years in a lively international, intergovernmental, and yet scientifically informed environment.

The Appendixes 1.2., and 1.3. on pp. 84–85 show the scope of the newest fledgling, the state-of-the-art Synthesis Report Six. The quotes[7] reveal the heavy structure each major report has. An example in Appendix 1.3., p. 85, highlights the institutionalised nature and intricacies in the production process in these IPCC reports. It describes how the Work Group I prepared itself for the task of writing up their very latest outcome, published in August 2021 (the Final Synthesis Report, which combines the works of each Working Group and includes a Summary for Policymakers (SPM), is due for release in May 2022).

[7] To discuss the institutional context and the minutely followed procedures during the production of the reports I use lengthy quotes from various IPCC sources. I understand that long quotes negatively affect the flow of this thesis, but the source texts are highly polished and reflect concentrated expression. The IPCC has a voice and style of its own; it has ambition and means to realise it. I do not wish to misinterpret their message or leave out any relevant information. From these lengthy extracts I aim to reveal the motivations which underlie the movement away from "normally hedged" scientific text to text which builds its epistemological claims on restricted, calibrated word choices and expressions based on probability-calculus.

The above reveal some relevant aspects of the IPCC protocol that have affected my choice of corpus material. To find texts that have hedging practices as they were prior the implementation of ‘uncertainty language’ only the material that has been drafted and published before the year 2010 will do. The lack of ‘uncertainty language’ does not mean that the process would have been less severe, though. Quotes that describe the workload of the production teams in the making of the very First Assessment Report (or ‘Climate Change: The IPCC Scientific Assessment’) from 1990 can be found in Appendix 1.4., p. 85.

The amount and scope of ambition in the co-ordinating lead authors’, lead authors’, contributing authors’, and the Working Groups’ efforts have been vast from the start. I also notice that even though the IPCC does not conduct research itself, it does not shy away from claiming to be the scientific authority. For these reasons, I find that the IPCC has dual roles that cannot be defined in any straightforward manner: from a philosophical point of view, what is the role of science and scientists? To know best? To tell us how to live our lives? In this methodology-chapter I open discussion from this point of view, too.

Furthermore, the IPCC claims to be ‘policy-relevant – as opposed to being policy-prescriptive’ (IPCC 2018, ‘Climate Change 2007 The Physical Science Basis’, p. v). It provides the policymakers with the state of the art-knowledge of climate change and its impacts in environmental, social, political, and economic context. Yet, what comes to issuing these reports and the assessing, reviewing, and remodifying the texts in those, especially for the policymakers’ summaries, the protocol could be understood to be prescriptive! As it is now evident that the Intergovernmental Panel on Climate Change gives measured guidelines to lead authors of the climate change papers (which are, however, called recommendations) and that it constantly revises those guidelines through a number of peer reviewing processes, I need to explore these guidelines and processes in depth. On the one hand, the IPCC is making the guiding, calibrating and assessment and reviewing process as transparent as possible. The relatively recent excerpt from the Meeting Report of “IPCC Expert Meeting on Communication” (2016) clearly shows that the ongoing discourses within the IPCC itself are of fundamental value. (In the quotations below, a word ‘stakeholders’ is used. This business-related word choice makes me somewhat wary.):

> This report summarizes the discussions at the Expert Meeting, which yielded a wealth of recommendations to the IPCC on how it could build on the advances it has already made in communication to ensure that its assessments are clear, accessible, actionable and relevant to all its stakeholders. The Expert Meeting was particularly timely [not

> only because, following the election of a new Bureau, work is now starting on the Sixth Assessment Report, but also] because a number of studies of how AR5 was communicated have recently appeared in the academic literature. Many of the recommendations reflect and build on decisions on the future work of the IPCC taken by the Panel at the 41st Session. Others will provide food for thought to the Panel, its members and third parties in their outreach work on the findings of the IPCC.
>
> (IPCC Expert Meeting on Communication, 2016, p. iv)

The IPCC well recognises its own problems in communicating science, as the lengthy quotation from another plenary session on the same subject reveals (For more material, see Appendix 1.5., p. 87):

> … agreement is based on science, specifically the assessments that the IPCC communicated to negotiators through the Structured Expert Dialogue and other activities at UNFCCC meetings, and also to other stakeholders. And yet the IPCC has faced growing calls from policymakers and other users to do more with its communications.
>
> IPCC assessments represent a unique cooperation between the scientific and policy communities. But even the Summary for Policymakers (SPM), the result of an intense dialogue between IPCC authors and government representatives to produce a text that is an accurate summary of the underlying scientific assessment while serving the needs of policymakers, is widely criticized as being unreadable and inaccessible for non-specialists.
>
> Is the answer to simplify the language and visual elements of the SPM to make them more accessible? Can that be done without comprising scientific accuracy? Does the IPCC need additional communications tools? Should the IPCC reconsider how it works with the media and others? What is the role of third parties in communicating IPCC products and how should the IPCC interact with them? How do users of the IPCC work with IPCC reports? How do producers of other assessments deal with these problems?
>
> To answer these and other questions, the IPCC held an Expert Meeting on Communication on 9-10 February 2016 in Oslo, Norway.
>
> […]
>
> Particular challenges exist around the treatment of uncertainty. **While fundamental to science, the language with which uncertainty is communicated to policymakers**

> **and the public can result in misunderstandings**[8]. And it is important to heed calls for **clearer, more direct messages, while remaining policy-neutral. The particular strength of an IPCC assessment derived from a dialogue between scientists and policymakers is enshrined in the approved text of an SPM; communications materials cannot deviate from that.** (IPCC Expert Meeting on Communication, 2018, p. 3. Bolding SR)

Hedging expressions and practices in these reports may reflect something of 'a mindset', a tendency, within the IPCC. They would not necessarily have undergone change unless they were subjected to internal and external critique. The ensuing implementation of an 'uncertainty language' was one answer to that critique.

Outside the scope of this excerpt from a Meeting Report, edited by **Mach (my bolding, SR)**, et al.,2016, there was also information about new ways of tending to the relationship between the IPCC and social media. For more material on this, see Appendix 1.6., p. 87:

> The Expert Meeting … was particularly timely, as the first results of academic research into the communication of AR5 were appearing, … To see how far the IPCC has come in communications, it is worth recalling that with AR5, and the related special reports, the IPCC issued its own press releases for the first time. Press releases for previous assessments had been produced by the IPCC's sponsoring organizations, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). This was because it was feared that to release a press release that necessarily highlighted some aspects of the SPM would entail a breach of the IPCC's policy-neutrality. Some enhancements to IPCC communications came not from the communications team but from the authors themselves, for instance the use of headlines statements in the Working Group I contribution to AR5 and the Synthesis Report. (Ibid., p. 2)

These quotations also highlight the continuously evolving discourse community practises within the IPCC and the ways it tries to deal with pressure from the outside. What for me is of peculiar interest, as already stated in the Introduction, is the ways in which the IPCC positions itself i) a scientific community, ii) an institution with a global outreach, iii) an influencer, or an authority (with a stance; 'relevance'). How does it negotiate its roles within the community and outside of it (as understood, e.g., in Hyland, 1998)?

[8] Hyland, (1998) speaks of interpretation. We all interpret the text in a slightly different manner – I presume that the numerical basis in the 'uncertainty language' is used so as to minimise the effects of these individual interpretations.

3.1. Hedging Praxis

I will analyse a series of earlier IPCC Reports (especially FAR, 1990; SAR, 1995; and TAR, 2001) using Python string methods to reveal hedging practices, whether they be classical or novel, and assess the understandability of the probabilities expressed through hedging constructions versus those expressed in an emergent, a more coherent and probability calculus -based constructions. FAR is the shortest, with 11912 words; SAR has 24370, and TAR 39127 words according to Python readline().method -based wordcount. I use normalised frequencies to get comparable results. I have chosen only material from the Working Group 1, as that comes, in my opinion, closest to 'communicating science' in a conservative way. It also deals with both historical data, and even if the material is used to predict future impacts, the evidential and observational basis it relies on may be stronger than the material provided by the Working Group II or Working Group III.
The work of the three groups partially overlaps and the WG1 provides the other two groups with material, forming a part of the scientific basis of their work, so the texts are significant in more than one way.

First, I create Python lists from chosen chapters in the reports (their structures are partially identical, all have the 'Radiative Forcing of Climate Change'-chapter) and count the frequencies of Hyland's classical, enlisted, well-known and widely used hedges, such as *generally, possibly, likely; appear, suggest, propose; should, may; assumption, estimate*. For a slightly more comprehensive list, in Hyland 1996, see Appendix p. 97. My first I assumption was that the numbers are not exceptional but reflect something like 'a normal amount'. Combined with vocabulary that reflects the use of models and simulations, observational methods, and relevant timelines, I expected to find the connections with the constantly developing climate change science and hypothetically, a reduction in uncertainty.

Modelling uncertainties have been a source for serious critique in the IPCC reports. In the IPCC FAR -report from 1990, a statement was made about i) the reliability of computer models in detecting climate change (as opposed to observations,) and ii) about the (contemporary) reliability of observation-based evidence pointing to human-caused climate change, and its magnitude:

> **The size of this [increased] warming is broadly consistent with predictions of climate models**, but it is also of **the same magnitude as natural climate variability. Thus** the **observed increase could be largely due to this natural variability**,

> alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. **The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more**. (IPCC FAR, 1990, p. xii)

This excerpt leaves some questions open for criticism to step in, but the IPCC -report series will reveal that the necessary developments took place and climate change became a serious issue of today's world, an emergency. I hope to detect some of those developments. Examples of model uncertainties are given in Appendix 1.7., p. 88.

The atmosphere is a very large and complex system, it absorbs sun rays (and cosmic materia), and interacts with the surface of our planet, both land and sea areas. Even if it is at present possible to have standardised data from many observation stations and nowadays equally importantly, via satellites, they will not suffice to get full coverage: some modelling is necessary to get 'the big picture'. My expertise is not adequate to identify and analyse all kinds of observation-based and/or simulated evidence, but I will try and analyse as much examples as I can to supplement my study.

The IPCC Guidance Note -data show two different approaches to inherent epistemological issues in the reports:

> The AR5 Guidance Note (Mastrandrea et al. 2010) provides Lead Authors of all three IPCC Working Groups with an approach for considering key findings in the assessment process, for supporting key findings with traceable accounts in the chapters, and for characterizing the degree of certainty in key findings with two metrics:
>
> • Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.
>
> • Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment). (Mastrandrea et al. in *Climatic Change* (2011) 108. p. 677)

How these two approaches are linguistically realised can be apprehended in two tables:

Table 1: The likelihood scale presented in the AR5 Guidance Note

Term	**Likelihood of the outcome**
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability

Term	Likelihood of the outcome
About as likely as not	33 to 66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

Additional terms that were used in limited circumstances in the AR4

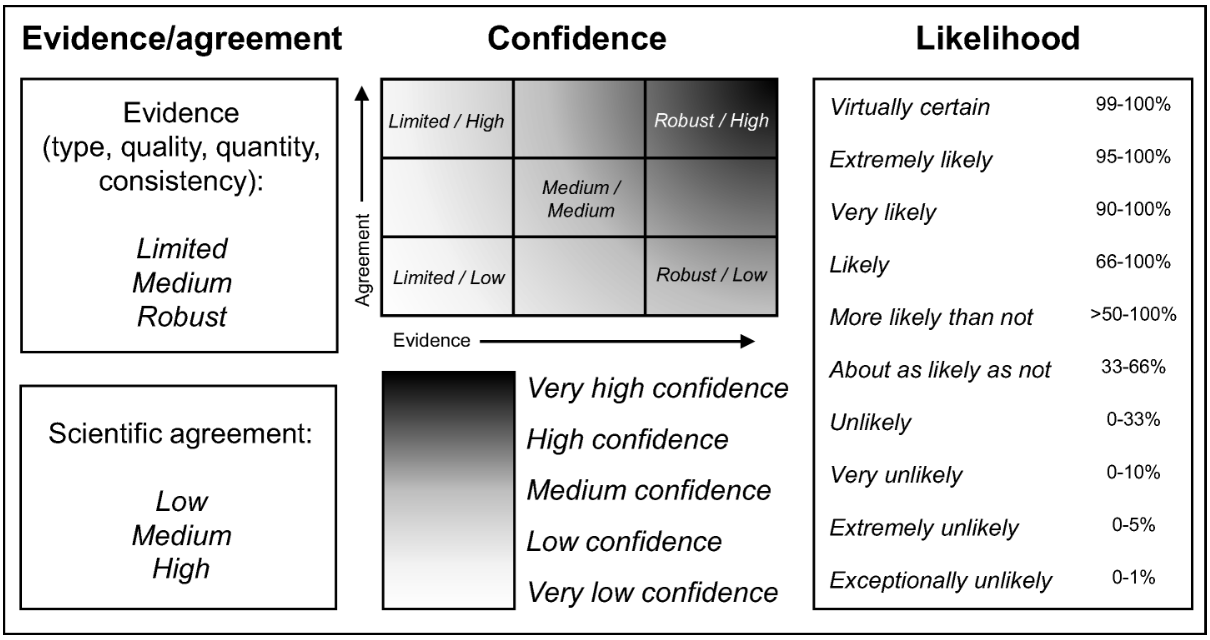
extremely likely—>95–100% probability,

more likely than not—>50–100% probability,

and extremely unlikely—>0–5% probability

may also be used in the AR5 when appropriate (Mastrandrea et al., in *Climatic Change* (2011) 108: p. 680).

Fig. 3) An illustration of the binding together of numerical probability expressions and confidence scales from Scott Janzwood, (2020):



I use the above table and illustration to guide the comparison process of hedging practices between the older and newer reports.

Is, for example, 'high scientific agreement' the best evaluation you can give or get? Or 'very high confidence'? How do we actually know how a reader outside the scientific community responds to these expressions? The scientific community is given a very important role in these assessments of ‘evidence/agreement’ and ‘confidence’. Is this, after all, an effort to show authority? A reader may respond to hedging practices from the point of view of discussing knowledge, and enjoy the rhetorical devices presented to her as part of that discussion. How to employ the readers mind in the best possible manner and cause action? Maybe these kinds of expressions best serve the allegedly calculating minds of politicians? It might be of interest to compare how Hyland’s ‘usual suspects’ and ‘stance’ comply to the restrictions in the above expressions, but I concentrate in the overall number of uncertainty related vocabulary.

For deriving hedging devices, and more importantly, any epistemological expressions that can be understood to be related to uncertainty, or approximation, auxiliaries, a variety of verbs and auxiliaries (e. g., *seem, suggest, prove. indicate, falsify, approve, minimis(z)e, can, should, might,* etc), nouns (e. g., *assumption, confidence, likelihood, prediction, proportionality, speculation, tendency*, etc), adverbs (e.g., *according to observations, comparatively, effectively, likely, necessarily, probably, relatively, significantly, unlikely*, etc), and approximators (e. g., *about, range, estimate, close to, below, less, more, somewhat, either sign, LOSU (Level Of Scientific Understanding, etc*) are listed. All the lists contain material from the data and some expressions are philosophically minded. What comes to *LOSU*, it is used in TAR and comes with quantification, for example: ‘*low LOSU*’. Much of the uncertainty in the IPCC reports deal with numerical estimates and ‘uncertainty ranges’.

What counts as an uncertainty is finally a matter for each reader to decide. As one of the most important tasks of the IPCC reports is to reduce uncertainties in climate science relating to anthropogenic climate change, I also look at much of the vocabulary that is not included in Hyland’s material. What counts as (un)successful hedging, or too much uncertain knowledge for inexpert readers could only be found out in a separate study.

Next, I describe the qualitative analysis part.

3.2. Methodology –deeper level; qualitative analysis

I believe that following the range of the IPCC Assessment Reports and choosing systematically chapters that are written by WG1 under the headline ‘Radiative Forcing (of Climate Change’) I will find material that display approximately similar contents and follow approximately similar methods. I will get an illustration of the scientific basis, the inherent levels of uncertainty and ways to express it, and temporal developments in the former two as well as in results, all of which form my research questions. But what comes to qualitative analysis, I need introductory texts and forewords and/or prefaces to find out how the IPCC as an institution discusses these issues with the larger public and sums them up.

I introduce some sample texts and my critical assessments, also in the epistemological sense, of those after close reading and doing some analysis; at times following the Discourse Analysis (DA) method, where larger chunks of text are studied, and context and/or environment play significant roles.

I define the environment thus: These three reports (published 1990, 1995, 2001) should, from a historical point of view, have caused the decisionmakers to act to curb the climate change from reaching a 'tipping point', after which predictions about the weather phenomena become unpredictable and potentially much more dangerous. During the period 1988–2001 The IPCC and decisionmakers, politicians had already met several times: UN lists 11 international climate negotiations between the years 1979–2005 (un.org, (no date)). Even if the 'anthropogenic origin' was not yet fully verified, a lot of concern was already in the air, as witnessed, for example, in the 'Summaries of National and Organisational Statements' in the first Session document from 1988 (available at https://archive.ipcc.ch/). These statements can also be compared to a very recent News Wire article headline in FRANCE24.com: 'US Congress grills oil executives over climate disinformation in day-long hearing'. The article states: 'The fossil fuel industry has had scientific evidence about the dangers of climate change since at least 1977, yet spread denial and doubt about the harm its products cause – undermining science and preventing meaningful action on climate change.'

3.2.1. Python and AntConc

The Python-searches aim to find 'classical hedges' such as *suggest, may, estimate, potential, possible, likely, probably, unlikely, about etc.* and discover vocabulary typical to the topic. I do not search for relative clauses (especially it-clauses and that-clauses), or passive structures. My aim is not to produce a fully comprehensive list of hedged expressions, but to recognise the relevant changes in the pragmatics of hedging; the emerging of the probabilistic 'uncertainty language', the prolific use of approximators, and the differences between the types of uncertainty related expressions used in each of the three reports and discuss the factors that lay behind the uses of them. Because these reports claim to be objective and none-prespriptive, some research over the uses of passive verb forms, fronted subject use, conjunctions (such as however, even if, despite…) which affect the epistemological contents of sentences would be very fruitful. However, because I am interested in the 'uncertainty language' which comprises of such nouns as 'evidence', 'agreement', confidence' and 'likelihood' and their scalars, I concentrate on these hedging practices. I am interested in increases or decreases in certainty, and simple lexical items that carry meanings linked to those, and even a bit of the philosophy of science.

The bulk text material for the Python-analysis itself is derived from FAR, SAR and TAR Chapters "Radiative Forcing of Climate". My presumption is that the key terminology is presented in the same form throughout the texts and that the reports are stylistically consistent while conveying the developments in science. As many of the academic studies point to inconsistencies in IPCC reporting, this presumption may prove to be inconclusive.

For the sake of certainty, I checked the Python-counts using AntConc_64bit (1)exe - application. For Python-functions, see Appendix 3., p.109. But I did not concentrate on identifying the different types of hedges. To categorize them is a difficult task, and for the purpose of this study, it is not so much the different types but the overall number that I am after.

I have also used AntConc collocation -function and conducted advanced searches to find out how *uncertainty* has featured in the vicinity of, for-example, computer model -related vocabulary, or when establishing the developments in the 'uncertainty language'. Also, I have tried to find ways to find the prolific number of references in these reports. How exactly the assessment process increases uncertainty-related hedging would only be thoroughly discussed if the exact number of referenced studies could be found. I, however, found no absolutely certain way to find the exact numbers.

I had other kinds of practical concerns, too. First, for some reason, the Python count for some items, such as *can* in TAR was lower in comparison to AntConc number even if I detected no duplicates in the Antconc material. I suspect that the text-files done manually have anomalies in the number of spaces between words, and some words have been falsely interpreted during the scanning process: the low quality of the IPCC oldest report scans continuously hampered the Python count-function. I tried to find ways to arrive at better results by checking spaces in the original txt.file and using the Python join()-method in building the wordlists.

I chose to use untagged textfiles in this study believing I could mainly focus on one lexical item -searches to reveal efficiently those uncertainty-related terms, that best answer for those developments in vocabulary that a relevant to developments in 'uncertainty language'. With the help of AntConc Concordance Plots, Advanced search, and collocation functions, or alternatively, using Python ngrams, I hoped to deal with longer expressions. This has proven to be difficult.

If a mechanistic approach is chosen to assess the quality of the lists of hedges I use in this study, such terms as *calculation* and *model* should be relatively unproblematic and not be included in the search items. But, due to the complexity of climate science, they come with approximations. In comparison, some results are closer to being 'certain'; as certified by in situ observations, or by a host of model studies the results of which hit approximately the same target. My expectation is that in the contexts of the forthcoming Sixth Assessment Report and the COP-26, the accuracy with which the IPCC has managed to produce its predictive models and future scenarios will, again, be discussed and scrutinised. We see how 'calculations' and 'models' and 'observations' have led to more and more certain results. It is this constant discussion of 'waxing and waning' uncertainty, where, and when it occurs, in which context, and how the amounts of it change in the temporal context of the three IPCC early reports that I look at.

I stress again, that the lists I have chosen do not represent the accuracy in the description of hedges in for example, Hyland's article "Writing Without Conviction? Hedging in Science Research Articles" (1996), or his book *Hedging in Science Research Articles* (1998). I also make a disclaimer: for me the hedges or expressions of stance in this context do not represent a writer's wish to 'establish personal reputation' as in Hyland, (1996), p. 435. The sheer numbers of authors and reviewers active in the production process of these reports acts to prevent the accumulation of personal gain. What is more, the process of assessment of the recent research in the light of up-to-date observational and modelling data and comparing the results further with those got by other researchers reduce the possibility of making gains through rhetorics.

In the next chapter, I will produce the results of my study and discuss further the institutional context. I will seriously consider the connections between the (historical) need to prove the existence of anthropogenic climate change, and evidence from observations and models. I introduce to the reader the emerging hypothesis that lacking interest in risk assessment/management in the IPCC WG 1 contributions to climate science may have cost us dearly.

4. Results

4.1. Qualitative analysis, Results

Text samples are: 1.) Introduction to FAR, 2.) Preface to SAR, 3.) Preface to TAR. In samples, b**olding** highlights hedging, uncertainty, discrepancy, unclarity; underlined text passages help to combine the parts of the sentences that I have found to be of interest. In the samples, in italics some very crucial sentences.

My own thoughts that break the scientific genre in square brackets in italics.

4.1.1. 1990: Introduction to FAR

> There are **many uncertainties** in our **predictions** particularly with regard to the timing, magnitude and regional patterns of climate change […]
>
> […]emissions resulting from human activities are **substantially** increasing the atmospheric concentrations of the greenhouse gases carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide These increases will enhance the greenhouse effect, resulting **on average in an additional warming** of the Earth's surface […]
>
> The size of this warming is broadly consistent with predictions of climate models**, but it is also of the same magnitude as natural climate variability.** Thus the observed increase **could be largely due** to this natural variability, **alternatively** this variability and **other human factors could** have offset **a still larger** human-induced greenhouse warming**.** *The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.* (IPCC FAR, 1990, p. xii)
>
> […]
>
> This report is **a summary of our understanding about predictions concerning climate change]** in 1990. **Although continuing** research **will deepen** this understanding and **require** the report **to be updated** at frequent intervals, **basic** conclusions **concerning the reality of the enhanced** greenhouse effect and its **potential to alter** global climate **are unlikely to change significantly.** **Nevertheless**, **the** **complexity** of the system **may** give rise to **surprises**. (Ibid., p. xiii)

My assessment: The first sentence tells how little is known of what the climate change will actually look like. The second sample sentence gives to us more of the concretia of climate change. But: 'resulting on average in an additional warming' is clumsy. What happens when something results 'on average' in something? How far are we from the target? Average far? Were some results, or whatever, left hanging half-way, maybe an average amount of them? 'Additional warming' is a vague amount. The third sentence opens the chasm of uncertainty.

To be or not to be, and if ‘to be’ is the right answer, the potential danger is huge. I am not sure if the latter part of the sentence: ‘alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming.’ was quite understood at that time. ‘Variability’ in this context refers to **human caused** variability; I believe: the human caused variability and other human factors combined will lead into global warming that spirals out of control? [*In hindsight, well, yes. To double the pain: Waiting for model predictions to be confirmed by observations (which may take ‘a decade or more’) may have led to procrastinating absolutely necessary climate action. Even the risk management plans were left slacking. The illocutionary act*[9] *of demanding curbing of emissions was left undone. Were these the fatal mistakes in the early IPCC reports? I think so.]*

“Basic conclusions” allude to the fact that conclusions are firmly grounded and clear. That these “basic conclusions” are “concerned with the *reality* of the enhanced greenhouse effect” is somewhat problematic to a critical reader: in previous paragraphs included in this sample we can find expressions that allude to uncertain predictions, or uncertainties concerning some essential qualities of climate change, even epistemological uncertainty.

***‘A summary of understanding* [at a point in time] about *predictions* concerning climate change […]’** changes into conclusions about reality: **‘[…] basic *conclusions* concerning the *reality* of the enhanced greenhouse effect and its *potential to alter* global climate […]’** is somewhat questionable logically, but maybe the word ‘potential’ saves the construction. But the last paragraph is a nice example **of the stance** the scientists took towards climate change. They express their carefully hedged view to the human caused climate warming but warn about surprises.

All three somewhat clumsy, and therefore vague, paragraph excerpts together lead to an ontological dispute: is there a proven case of climate change, a real causal chain from a human induced, enhanced greenhouse effect to the resulting climate change? How can changes that the ‘predicted’ greenhouse effect *may cause* “potentially alter the climate”? This would mean that the report is concerned not with the *reality* of greenhouse gas effect but “*predictions*” about its alleged “*effects*” which are i) most likely to exist ii) and have the

[9]‘[…] speech act theory was initially elaborated by Austin (1962). It introduced into philosophy (concurrently with the writings of the later Wittgenstein) what appeared at the time to be a novel idea: that the function of human speech is not merely to represent a world, truly or falsely, but equally to serve as a medium of action to bring a world into being by the talking of it (Cooren, Taylor, 1997)’ Therefore, *an illocutionary act is the act of uttering a request, an order, a promise, a threat, or other kind of expression that contains ‘seeds of action’: Saying ‘Pass me the salt, please’ is an illocutionary act.*

potential of altering the climate. Is there a reality where greenhouse gas effects exist, or only predictions? Is there an effect without a clear perpetrator, anything that can cause it? *[Causal chain is blurred. Epistemologically wobbly. 'Greenhouse effect' is a scientific fact dating back to the 19th century, so its ''potential' to cause changes in the atmosphere, changes in climate' are real. So, climate change, even if it is not significant in extent, is real. The 'predictions' about what will our future, in terms of weather-related phenomena, look like reflect the* ***reality*** *of our future more or less accurately. 'Unlikely to change significantly' is clearer, but not accurate, or certain in any sense. But at least the structure is straightforward, and the likelihood of a significant (how much is that?) change is as likely as 'unlikely' is.]*

So, we must be ready for surprises (because 'the complexity of the system' may win over science, as indicated by the adverb 'nevertheless'

[In hindsight, should we really care more of protecting the climate system, and less of the accuracy of science and do what is necessary. Right? RIGHT??? A good shepherd dog knows no science but its illocutionary acts: barking and growling, with the addition of well, nibbling the sheep at their feet, are efficient in the protection of the herd. Scientists are among the best protected people on this planet. They can afford to squabble over detail while others burn, starve, parch, or drown. But if we lose this planet, we are all a bunch of idiots and the scientists have done well to enjoy the protection they have while polishing their science. But it is always exiting to wait for 'surprises'.

How close are hedging practices to scientific obscurantism?]

4.1.2. From FAR to SAR, 1995: Preface

SAR Preface shows links to FAR, continued assessment of the science of climate change

> This report is the **most comprehensive** assessment of the science of climate change since Working Group I (WGI) of the IPCC produced its first report Climate Change: The IPCC Scientific Assessment in 1990. It enlarges and updates information contained in that assessment and also in the interim reports produced by WGI in 1992 and 1994. The first IPCC Assessment Report of 1990 concluded that *continued accumulation of anthropogenic greenhouse gases in the atmosphere* ***would lead*** *to climate change whose rate and magnitude were* ***likely*** *to have* ***important impacts*** *on natural and human systems*. The IPCC Supplementary Report of 1992, timed to coincide with the final negotiations of the United Nations Framework Convention on Climate Change in Rio de Janeiro (June 1992), added **new quantitative information on the climatic effects of aerosols but confirmed the essential conclusions** of the 1990 assessment

> **concerning our understanding** of climate and the factors affecting it. The 1994 WGI report Radiative Forcing of Climate *Change* ***examined in depth the mechanisms that govern the relative importance of human and natural factors in giving rise to radiative forcing, the "driver" of climate change.*** The 1994 report **incorporated further advances in the quantification of** the climatic effects of aerosols**, but it also found no reasons to alter in any fundamental way** those conclusions of the 1990 report which it addressed. (IPCC SAR, 1995, p. xi)

My assessment: A definition is made: This is 'the most comprehensive assessment' available of climate change: the IPCC reports are the authorities in this field. The conclusion reached by the FAR is somewhat vague: *'continued accumulation of anthropogenic greenhouse gases in the atmosphere would lead to climate change whose rate and magnitude were likely to have important impacts on natural and human systems'* is of course very concerning, but it contains a hedge 'likely' and 'fuzzy' information. The Supplementary Report (1992) gives more quantified and precise information, and the 1994 Radiative Forcing of Climate Change goes further still. Yet, the results in research on aerosols in the latter two reports happen to negatively affect the results of the FAR. The assessment states: 1.) '…[but] the essential conclusions [are confirmed] of the 1990 assessment concerning our understanding of climate and the factors affecting it.' and 2.) '…[but] no reasons [are found] to alter in any fundamental way those conclusions of the 1990 report which it addressed.' That is: some epistemological concerns have risen in the context of the FAR assessment [but nothing too serious]. What is also of interest here is the stating of an institutional context: 'The IPCC Supplementary Report of 1992, **timed to coincide with the final negotiations of the United Nations Framework Convention on Climate Change in Rio de Janeiro** (June 1992) […]' – through this, we can detect the high stakes at play.

> **Further […] observations suggest** "a **discernible** human influence on global climate", one of the **key** findings of this report, *adds an **important** new dimension to the discussion of the climate change issue* (ibid).
>
> […]

My assessment: The IPCC is supposedly objective and not policy prescriptive, and it looks to [future] 'discussions of the climate change issue.' in the light of an important new dimension. *[And wow, we have managed to discuss, and discuss, and discuss ever since…]*

The following excerpt is analysed in parts because of the complex and packed structures in it.

> An important political development since 1990 has been the entry into force of the U N Framework Convention on Climate Change (FCCC). IPCC **is recognised** as a **prime source** of scientific and technical information to the FCCC, and **the underlying aim** of this report is to provide objective information on which to base global climate change policies that will meet **the ultimate aim of the FCCC** – expressed in Article 2 of the Convention – of stabilisation of greenhouse gases **at some level** that has yet to be **quantified** but which is **defined as** one that will "prevent **dangerous** anthropogenic interference with the climate system". Because the **definition of "dangerous"** will depend on **value judgements as well as upon observable physical changes** in the climate system, such policies will not rest **on purely scientific grounds**, and the companion IPCC reports by WGII on Impacts, Adaptations and Mitigation of Climate Change, and by WGIII on Economic and Social Dimensions of Climate Change provide some of **the background information on which the wider debate will be based.** Together the three WG reports establish **a basis for an IPCC synthesis of information relevant to interpreting Article 2 of the FCCC**[10]. An important contribution of WGI to this synthesis has been an analysis of the emission pathways for carbon dioxide that **would lead to a range of hypothetical stabilisation levels**. (Ibid.)

My assessment: "IPCC is recognised as a prime source of scientific and technical information to the FCCC… *'Is recognised'* in passive: By whom? UN? Globally? 'The **underlying** aim' is unclear: why not simply 'the aim of this report is to provide **objective** information…'? The *ultimate* aim of the FCCC, on the other hand, is 'stabilisation of greenhouse gases at some level that has yet to be quantified' but which is defined as one that will 'prevent dangerous anthropogenic interference with the climate system', though. Unfortunately, the stabilisation level is 'defined' (anthropogenic interference must be prevented from becoming 'dangerous', whatever that means in exact terms) but yet, not 'quantified': so, it is possible to understand the quantifying and defining processes not having quite reached their goal. The 'evident, obvious aim' of the IPCC report is, after all, simply to assess and produce objective information, in the face of danger? The FCCC and politicians will then deal with it? This excerpt is a bit hard for me to grasp. I find some epistemological

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[10] conveng.pdf (unfccc.int): 'Article 2: Objective: The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that ould prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.'

weaknesses. Information is information, nice that it is objective. How many aims do we have, three? How hypothetical are the 'stabilisation levels', how wide the 'range'?

4.1.3. SAR Preface: how to define 'dangerous'?

> ***Because*** *the* ***definition of "dangerous"*** *will depend* ***on value judgements*** *as well as upon* ***observable physical changes*** *in the climate system,* ***such policies*** *will* ***not rest on purely scientific grounds***, and the **companion** IPCC reports by **WGII** on Impacts, Adaptations and Mitigation of Climate Change, and by **WGIII** on Economic and Social Dimensions of Climate Change provide **some of the background information** on which **the wider debate** will be based.

My assessment: Epistemological modalities seem to be straightforward, but the devil is in the details: "Dangerous" is a problematic word in scientific writing. Here it is not defined properly: something "dangerous" is "likely to injure or harm somebody, or to damage or destroy something" (oxfordlearnersdictionaries.com, no date). It belongs to the field of *risk assessment and management* to deal with something "dangerous" so as to avoid anything bad to happen. I would not define "dangerous" anew, despite there are some science-grounded ideas about the need to define adjectives in research papers to prevent too wide interpretation (Lebrun 2011, pp. 65–66). In this context, we know that extreme heat kills, fire kills, running out of clean drinking water kills. They are dangerous. The question is, how do "*such* policies that do not rest on *purely* scientific grounds" **in reality (which is where we live and, well, as far as I can understand, science and even 'values' also exist?)** respond to something potentially harmful despite economic? social? factors stepping in. The dangers of climate change are weighed in against value-judged factors – why could this not be this done so that it bases on best available scientific knowledge? This excerpt reveals to me how the institutional context; an effort to reach a wide audience and provide 'objective' (but relevant) information for 'wider debate' to be based on, can compromise the strength of the 'purely scientific ground' and make it hollow. If a drive towards 'objectivity' was less severe, if less allowances for 'debating' decision-making in 1995 were made, the necessary decision making would have followed? Would we be in a better place now?

[Compared to the FCCC Article 2 (p. 25), were too many allowances made? And if it be acceptable to base 'the danger of climate change' on any other value judgement than on science, then maybe we are good to say, "there is no danger in/no climate change at all, because my crystal ball', or alternatively, 'the spirit of my great great great grandad' tells me so". Scrap the observations? Whether I evaluate the truth about the climate change

through its emerging in my horoscope or not, I will not be safe from it even if I would have kissed the toe bone of a saint or another. Scientists are supposed to know this. *Is there even some euphemism here, hidden in this structure: "such policies will not rest on purely scientific grounds"? Is science put first in the tables of evaluative judgement? Does science (as represented by the work of WGI) have the most accurate description of the nature of reality of climate change? So, the 'wider debate' deviates from these crystal-clear facts,* ***because it is actually allowed to do so****? Further, 'interpreting Article 2', (see excerpt below) reminds me of legal debate. So much for the willingness to save the climate system. Interpretations of a legal article, debates, and voluntary deeds are really not the same thing. The resultant climate action must have been a disappointment to the UN, IPCC, WMO, and anyone concerned of the welfare of this planet. But what else could be expected.]*

The *accompanying* reports of (WGII, WGIII) have not so much scientific value [?], but they provide "*some* of the *background* information"? *In hindsight, this 'piece of some of the background information' included more of the vitally important information about the risk assessment and management protocols, now so horribly lacking.*

I would not personally look forward to taking part in "the wider debate". I guess that the debate circles around money. Who will pay for the costs of mitigating the climate change? That debate is dangerous because of its short-term approach.

4.1.4. SAR Preface: IPCC and FCCC

> Together the three WG reports establish **a basis for an IPCC synthesis of information relevant to interpreting Article 2 of the FCCC**. An important contribution of WGI to this synthesis has been an analysis of the emission pathways for carbon dioxide that **would lead to a range of hypothetical stabilisation levels**.

Is the perlocutionary force handed over to the FCCC? The Conventions of the Parties, and the notable presence of politicians in the IPCC Sessions and Meetings, bring the relationship of the IPCC and politicians to the fore. Yet, I must believe that deep down, these reports were meant to cause climate action. The questions surrounding scientific genre, information gathering, careful expressions, and aim towards 'objectivity while being relevant' can all be answered in the context of that. But why could not scientific text be a warning? Should not some imagination be allowed for when describing the potential, future risks, to cause action and raise the level of preparedness?

[I thank the IPCC WG1 for analysis of emission pathways. How we are managing the 'range of hypothetical stabilisation levels' in real life test-ground is intriguing to follow, at least until we get bored of reading of record-beating heat waves, droughts and floods, and the numbers of deceased, or are goners ourselves. Thank you.

When learning from experience (which is the mother of hard learning); 'dangerous' in many parts of the world, right now, means raging wildfires and flash floods; towns and villages turned into ashes, or inundated. Loss of life. 'Dangerous' is 'hazardous to life and property'. The question for politicians is: how many people can burn alive or be carried away by the flood before (costly) action is taken? That can basically be a value-based question.

I wonder if science would have been best left with the WMO; and the IPCC, with its political contacts, would have served better as a vehement and efficient, barking, growling, and if necessary, biting watch dog. In that role, they may have dared to risk more.]

All in all, the first two introductory texts are of lower quality than the actual scientific texts. However, I detect a stronger epistemological claim in the SAR: FAR Introduction starts from uncertainty and ends in potential surprises, SAR Preface starts with an authority claim and builds on knowledge. Sar also deals with social, political, and even legal (in the framework of the FCCC Article 2) factors.

4.1.5. 2001: TAR Preface

> … It [TAR] enlarges upon and updates the **information** contained in that, [SAR] and previous, reports, but primarily it assesses new information and research, produced in the last five years. The report analyses the enormous body of observations of all parts of the climate system, concluding that **this body of observations now gives a collective picture of a warming world.** The report **catalogues** the increasing concentrations of atmospheric greenhouse gases and **assesses** the effects of these gases and atmospheric aerosols in altering the radiation balance of the Earth-atmosphere system. The report assesses the **understanding** of the processes that govern the climate system and by **studying** how well the new generation of climate models represent these processes, assesses the suitability of the models for projecting climate change into the future. A **detailed** study is made of human influence on climate and whether it can be **identified with any more confidence than in 1996, concluding that there is new and stronger evidence that most of the observed warming observed over the last 50 years is attributable to human activities**. **Projections** of future climate change are presented using a **wide range** of scenarios of future emissions of greenhouse gases and aerosols. Both temperature and sea level **are projected to continue to rise** throughout the 21st century for all scenarios studied. Finally, the report looks at the gaps in information and understanding that remain and how these might be addressed. This report on the scientific basis of climate change

> is the first part of Climate Change 2001, the Third Assessment Report (TAR) of the IPCC. Other companion assessment volumes have been produced by Working Group II (Impacts, Adaptation and Vulnerability) and by Working Group III (Mitigation). An important aim of the TAR is to provide **objective information on which to base climate change policies that will meet the Objective of the FCCC, expressed in Article 2, of stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.** To assist further in this aim, as part of the TAR a Synthesis Report is being produced that will **draw from the Working Group Reports scientific** and socio-economic **information relevant to nine questions addressing particular policy issues raised by the FCCC objective.** (TAR Preface, 2001.)

My assessment: The tasks and goals of the report are clearly described. The tasks of 'cataloguing' and 'analysing' observations and 'studying' the capabilities of models to represent processes that govern climate change and projections to the future are added to the core task of assessment work. A study is made into human influence on climate and a conclusion about that is made*:' …there is new and stronger evidence that most of the observed warming over the last 50 years is attributable to human activities*.'

I detect a straightforwardness, confidence, in this Preface: *…concluding that this [enormous] body of observations now gives a collective picture of a warming world…* combines with *…there is new and stronger evidence that most of the observed warming observed over the last 50 years is attributable to human activities*.' The only less straightforward structure similar to that in SAR, is the combination of 'objective information' and 'climate change 'policies': [initial, SR] … ***scientific** and socio-economic **information relevant** to nine questions addressing **particular policy issues raised by the FCCC objective*** can be drawn from this report. So, the IPCC reports can afford 'objectivity' and policy relevance against policy prescriptivity because they are the workhorse of the UNFCCC[11] that deals with 'the particular policy issues'?

> … This report was compiled between July 1998 and January 2001, by **122 Lead Authors**. In addition, **515 Contributing Authors** submitted draft text and information to the Lead Authors. The draft report **was circulated for review by experts, with 420 reviewers submitting valuable suggestions** for improvement. This was followed **by review by governments and experts, through which several hundred more reviewers participated**. All the comments

[11] What is the United Nations Framework Convention on Climate Change? | UNFCCC -webpage points out the following: '… in 1994, when the UNFCCC took effect, there was less scientific evidence than there is now. The UNFCCC borrowed a very important line from one of the most successful multilateral environmental treaties in history (the Montreal Protocol, in 1987): it bound member states to act in the interests of human safety even in the face of scientific uncertainty.' (unfccc.int, (no date.))

> received were carefully **analysed and assimilated into a revised document for consideration at the session of Working Group I** held in Shanghai, 17 to 20 January 2001. There the **Summary for Policymakers was approved in detail and the underlying report accepted.**
>
> **Strenuous** efforts have also been made **to maximise the ease of utility of the report.** As in 1996 the report contains a Summary for Policymakers[12] **(SPM)** and a Technical Summary (TS), in addition to the main chapters in the report. The SPM and the TS **follow the same structure**, so that <u>more information on items of interest</u> in the SPM can easily be found in the TS. In turn, each section of the SPM and TS **<u>has been referenced to the appropriate section of the relevant chapter by the use of Source Information</u>**, so that material in the SPM and TS can **<u>easily be followed up in further detail in the chapters</u>**.
>
> […]

These excerpts show again the amount of work done to prepare a Working Group report and highlight the developments made 'to maximise the ease of [its] utility'. 'Uncertainty language', used especially from the AR4 (2007) onwards, is a part of the process to 'maximise ease of utility'. Quantifying uncertainty: amounts of evidence, agreement, confidence, and likelihood, and giving numerical estimates make it easier to build a 'skeleton language' that politicians and unexpert readers can follow. Moreover, the connection between core text and SPM is manifested, which in turn allow any necessary intercomparisons between the chapter paragraphs. Similar, but less compartmentalised mentions about the SPMs are in FAR and SAR Prefaces, too.

The division of labour between the UN organisations and the reliance on the compelling nature of the Montreal and Kyoto Protocols might explain the lack of more action-inducing, or from a scientific point of view, risk-taking language use in the IPCC reports. Prior to the inception of the UNFCCC, the United Nations Environment Programme UNEP, the parent organisation of the IPCC established 1972, was already in place. If looked at quantitatively, 'UNEP', '(UN)FCCC', and its binding climate protocols (Montreal Protocol, 1987; aimed mainly to protect the ozone layer, and Kyoto Protocol, 1997), appeared also in the bulk text of the reports accordingly:

FAR: 'UNEP' 4 times, Montreal Protocol 1 time;

SAR: 'UNEP' 9, Montreal Protocol 8, (UN)FCCC 4 times;

[12] Also the FAR and SAR, at least in their current form, have Summaries for Policymakers, and SAR also has a Technical Summary.

TAR: no hits.

‘UNEP’ mainly appeared in references, but in FAR, it also appeared in a reminder of internationally binding agreements, like the Montreal Protocol: (IPCC FAR 1990 p. 58). In SAR, Montreal Protocol and (UN)FCCC act as authority figures (IPCC SAR 1995, p. 76, for example), whereas ‘UNEP’ serves as a sister organisation for the WMO in references (ibid, p. 88, for example).

From these introductory text excerpts and these institutional connections, I make the following summary: FAR Preface is clumsy, and its epistemological claims are hard to come by. The anthropogenic origin of climate change could not be stated yet. Greenhouse effect is real, and warming is real, and predictions of climate change should be understood to be a huge case for concern. SAR plays with words, and institutional, social, and political connections, and places the ‘wider debate’ to the fore. UNFCCC has also been criticised for not monitoring the implementation of its articles. I see a combination of inefficiencies here. TAR Preface is more straightforward and expresses confidence. It guides the reader to search for relevant content with the aim to, through informing the decision-making processes, cause climate action. All the Prefaces have three writers, one of them, J. Houghton, appearing in all.

More of the institutional and political mixing in scientific writing in Discussion.

4.2. Quantitative Results

I chose to study relatively inclusive sets of search items. Through these I intend to get to not only the bulk of hedging items, but also some epistemological contents out of the three reports. What was the cause for the IPCC to undertake an extra task of drafting Guidance Notes for Report Lead Authors? To answer that, I need to find out as much as I can of the first three reports both qualitatively and quantitatively.

The percentages of different kinds of hedges will be summed up and compared. In Hyland’s article (1996) a percentage of above two for hedges in scientific research articles was found. I will use that as a crude basis for comparison

The focus is on the uncertainties in these reports, but due to the mixed methods I use, some questionable search results remain. Some word choices I have made for this study might not be understood as hedges at all, but they have strong epistemological connotation and act as ‘pillars’, or ‘strongholds’, when methodological considerations are made. Their negated forms would hedge a sentence in a more categorical manner, but sometimes I have included in my hedge count 'evaluations', or 'indications' of something in an unnegated form as meaning 'less than an absolutely certain outcome'. Hyland does also highlight these difficulties and the fact that the readers' always somewhat unpredictable interpretations may differ from the point of view taken by a more experienced linguist.

The over-arching process of assessing the recent research in the light of up-to-date observational and modelling data, and the fact that climate change forces researchers to take a more futuristic (that is also probabilistic) approach, influence the hedging practices in these reports alongside the scientific ambition and institutional context.

I quote The Foreword by J. T. Houghton, one of the editors of the IPCC FAR (1990):

> I am confident that the Assessment and its Summary will provide the necessary firm scientific foundation for the forthcoming discussions and negotiations on the appropriate strategy for response and action regarding the issue of climate change. It is thus, I believe, a significant step forward in meeting what is potentially the greatest global environmental challenge facing mankind. (IPCC FAR, 1990, p. xi).

In this high-stakes context, I assume that every word count, and defend my extensive lists of set-words though strictly speaking, not all of them act as hedges. The assessment process of previous studies comes with an additional load of uncertainties, and it is also against the backdrop of this added difficulty that I try to get results.

Note that when referring to chapters in IPCC SAR, I comply to the request to include the names of the Lead Authors.

4.2.1. Auxiliaries acting as hedges

set_auxiliaries = {'would', 'may', 'might', 'can', 'could', 'should', 'must', 'cannot'}

For result table, see Appendix 2.1., p. 97.

Will, shall and *must (be)* are often 'unhedged' or 'boosters' (Prince and Hyland in McLaren-Hankin, 2008, p. 644). To get a view at some core uncertainty which underlies these reports, auxiliaries are, however, important. Especially the FAR report shows large numbers of all the clearer hedging auxiliaries *can*, *may*, *would* and *could* being used widely and playing a crucial role. Even *should* occurs twice or thrice as often in FAR as in SAR or TAR. What I also find interesting is that the number of auxiliaries acting as hedges is almost identical in SAR and TAR.

Would requires a lot of discussion in FAR and other reports as it is commonly associated with future predictions and to methodological uncertainties. Whether I can, in this context, understand methodological uncertainties to be epistemological hedges is questionable – and what comes to future predictions, their uncertainty is simply an epistemological fact. *Would* is also commonly associated with syntactical hedging features, such as phrases beginning with conjunctions *although, even if, furthermore, however, if, in contrast,* et cetera. The multi-layered nature of knowledge content can be seen in the following extracts:

1.

> These results have also been used by the Marshall Institute (1989) who **suggest** that another Little Ice Age is imminent and that this **may** substantially offset **any future** greenhouse-gas-induced warming. **While one might expect such an event to occur some time in the future** the timing **cannot** be predicted. **Further** the 1.3 W m-2 solar change (which is an upper limit) is small compared with greenhouse forcing **and even if such a change occurred** over the **next few** decades, it **would be swamped** by the enhanced greenhouse effect.
>
> **There is no convincing evidence, however**, of longer time-scale effects. **In the future**, the effects of volcanic eruptions **will continue** to impose **small year-to-year fluctuations** on the global **mean temperature**. **Furthermore**, a period of **sustained** intense volcanic activity **could partially offset or delay** the effects of warming due to increased concentrations of greenhouse gases. **However, such a period would be plainly evident and readily allowed for** in any contemporary **assessment** of the progress of the greenhouse warming.
>
> **However over longer periods these solar changes would have contributed only minimally** towards offsetting the greenhouse effect on global-mean temperature because of the different time-scales on which the two mechanisms operate.
>
> The **derived cumulative effects**, derived by multiplying the **appropriate** GWP by the 1990 emissions rate, **indicates** that CO2 **will account for 61 %** of the radiative forcing over this time period.
>
> (IPCC FAR, 1990)

These paragraphs play with the stance taken by the WG 1 towards likelihoods of future events. The use of conditionals downplays some of the contents further. 'The (unlikely right now but more likely in the future (my assessment)?) case of an imminent Little Ace Age would not stop the climate change (certain but is the conditional there because the timing is uncertain, and the change would certainly be small (upper limit is 1.3WM-2)?). 'Volcanic eruptions affect the global mean temperature' (certain, some softening again takes place via the use of conditional in the next sentences. There is no certainty over the intensity of future volcanic activity). 'Over longer periods, (these) solar changes would have contributed only minimally towards offsetting the greenhouse effect on global-mean temperature (certain, because the relevant time scales are so different from each other, but why the conditional? Because the Marshall Institute most likely is wrong? Because the offset is 'however, only minimal'? Because there is no significant volcanic activity at that moment in time?). Lastly, 'CO2 will account for 61 % of the radiative forcing 'over this time period' is indicated, not certain, but there is little hedging otherwise and a surprisingly accurate numerical estimate.

These examples illustrate the difficulties in this field of science. Will there a certain outcome in the future, or: "Will an event E happen (even) if X would take place? There is not even a way to calculate the certainty of X because of Y, et cetera" be the line of thought? GWP (Greenhouse Warming Potential) itself is not an accurate measure, but a calculated potential where all the possible interactions of the various gases in the atmosphere are not yet accurately measured. The underlying uncertainty will therefore remain in the surprisingly accurate outcome, the indicated 61 %. However, these examples show that hedging, indeed, is an issue to be discussed by the IPCC teams: it is difficult to apprehend where the certainty of climate change lies because of the wide scope of issues, methodological concerns, and projections that point both to everything between large scale events and molecule-level interactions, in the past, the present, and the future:

2.) FAR

> **The distribution of emitted radiation with wavelength** is shown by the dashed curves for **a range** of atmospheric temperatures in Figure 2.1**. Unless a molecule possesses strong absorption bands** in the wavelength region of **significant emission,** it can have **little effect** on the **net radiation**.
>
> These **considerations are complicated** by the effect of naturally occurring gases **on the spectrum of net radiation** at the tropopause [...]
>
> (IPCC FAR, 1990)

3.) SAR, with a more positive stance but with methodological issues:

> **Reducing the uncertainty in emissions due to past land-use change** is therefore very important **in order to constrain the overall range of projections from carbon cycle models**. At the same time, independent estimates of the global fertilisation effect **may be used** as a **direct test** of the value used in model calculations and so **can also help to reduce uncertainties in projections**. **Estimates** of the CO2 fertilisation effect from terrestrial ecosystem models are **now becoming available** (see Chapter 9).
>
> **The method also assumes the interhemispheric differences are solely related to human activity**. Boucher's values **can be interpreted as the difference** in anthropogenic forcing between the hemispheres. **An estimate of the global mean forcing can then be made by applying the ratio** of the forcing between the two hemispheres **derived in the GCM studies and by assuming that Boucher's value for 0 to 50°N is representative of the entire Northern Hemisphere.**
>
> (D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LAL, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995)

All in all, the first two reports already show that auxiliaries which are often used as hedges are abundant in the text and they also deal with methodological allowances or difficulties. The epistemological uncertainties can further be expressed nominally or via complicated combinations of auxiliaries, approximators, larger structures (the use of conjunct clauses), lexical verbs, adjectives, and adverbs:

4. SAR reasoning:

> **A lifetime this short would require** fluxes **much larger than those estimated** from fossil fuel burning **in order to produce the observed atmospheric increase**; therefore, **the reasoning goes**, the build-up **can only** be **partly** human-induced ((D. SCHIMEL, D. ALVES, I. ENTING, M . HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LAL, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).

I also made a methodological choice affecting the way I calculate results. Nearly all hits for *can* and other auxiliaries derived from Python functions and AntConc are included. This study is taking the form of revealing the changes in proportions of the kinds of words that deal with epistemology in the three reports. Only in some cases where I understood absolute certainty was implied have I reduced the auxiliary count: A sentence like ‘There are important gaps in our understanding and too little data, so that a confident assessment of the influence of sulphur emissions on radiative forcing cannot be made. (FAR 1990, p.65)’ contains hedges everywhere else but not in the auxiliary use. Yet, as stated earlier, I do not know how any individual reader interprets the epistemological quality in any sentence in these reports.

These examples show the ways the contents surrounding the auxiliary are also hedged. This affects my own interpretation, and because I have chosen relatively large sets of search items, for the sake of doability, I need to concentrate on the above-mentioned proportional changes and accept that the quality of the results I get lack finesse. Interpreting accurately the quality of each hedging item in an environment that is affected heavily by the assessment process in these reports would be a huge effort. It took after all six years of the teams to write out their own results in each case, and in the task, hundreds and hundreds of experts from around the globe were involved.

5. TAR

Both heavily hedged excerpts are from a paragraph assessing critically former studies, computer models, and the role of satellite observations in ‘evaluating models of the indirect aerosol radiative effect’ (IPCC TAR, 2001, p. 379). More methodological concerns are indicated:

> **Therefore it seems difficult at present** to use **satellite observations to estimate** the first aerosol indirect forcing **unless some changes in cloud albedo could be tied to changes in aerosol concentrations under the assumption of constant liquid water content**. [---]
>
> **Available GCM studies suggest** that the radiative flux perturbations **associated with** the second effect **could be of similar magnitude** to that of the first effect. **There are no studies yet to confirm unambiguously** that the GCM **estimates** of the radiative impact **associated with** the second indirect **effect can be interpreted in the strict sense of a radiative forcing** (see Sections 6.1 and 6.8.2.2), and **very few observations exist as yet to support** the existence of a **significant** effect. **Therefore we refrain from giving any estimate or range of estimates** for the second aerosol indirect effect. **However**, this does not **minimise the potential importance** of this effect. (IPCC TAR, 2001)

The way to express uncertainty through a complicated and multi-layered structure confuses the hedge count -process.

Should occurred also in imperative sentences. Some cases were equally hard to interpret:

6. *Should* in central position in SAR

> **Ramaswamy et al. (1992) concluded that the globally averaged decrease** in radiative forcing due to stratospheric ozone depletion including both infrared and solar effects **represents** an indirect effect that **approximately** balanced **the globally averaged** increase in direct radiative forcing due to halocarbons during the decade of the 1980s. **Therefore, the net GWPs for ozonedepleting gases should consider** both direct and indirect terms, **together with their inherent uncertainties. Daniel et al. (1995) estimated** the indirect effects of ozone depletion upon the GWPs for halocarbons. **They assumed** that the indirect and direct radiative effects of halocarbons **can be compared** to one another **in a globally averaged sense**, **an assumption that is being tested with two- and three-dimensional models** (see Chapter 8 of WMO/UNEP, 1995; Chapter 4 of IPCC, 1994; Section 2.4 of this report; Molnar et al, 1994). ((D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LAL, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).

I see this as an example of a multitude of methodological problems that can be solved via the use of approximations and estimations, tests, averaged amounts, time scales and models, but despite the effort, some uncertainties remain in the results (‘in a globally averaged sense’]. A second example towards the end of the ’Radiative Forcing’ -chapter in SAR shows a more conclusive result – but with further epistemological concerns. The first example reveals a new expression to be used in the report – ‘the low degree of confidence’ – and points to uncertainties in simulations.

7. SAR:

> This finding, **illustrating the low degree of confidence we should have** in numerical simulations involving gases **such as** tropospheric ozone and its precursors, still holds. (Ibid.).

Also, the auxiliary *must* was used in such a way in SAR that I chose to include some examples. The second example is an expression, the third further illustrates how weaknesses in data sampling affect the epistemological strength of the outcomes necessarily for the worse:

8. *must* in SAR

> This is a direct consequence of the fact that cumulative emissions **tend to become (at the stabilisation point or beyond**) similar **no matter what the pathway**. **If** cumulative emissions are constrained to be **nearly** constant, then **what is gained early must be lost later**.
>
> **However, since the data on soot emissions have not been acquired with any standardisation of sampling or analysis techniques**, the emission factors **must** be regarded as **preliminary estimates**.
>
> (Ibid.)

So, these examples show how hedged environment in the build-up of a sentence causes the outcome to be necessarily uncertain. I arrived at the same conclusion in some cases of *cannot*-use: '[…] GWPs for the short-lived sulphur gases that are thought to contribute to negative radiative forcing through aerosol formation cannot be estimated with confidence at present (SAR 1995, p. 123)' is vaguer than the example from FAR (p. 37 in this paper). With a combination of an analysis on conjunctions, sub-clause contents and adverbs I could have arrived at another conclusion. I stress again, that my own word-based corpus searches do not yield the best results in this complex field of reporting and assessing something which can be described as cumulative state-of-the-art scientific knowledge and all the ways it is expressed. The approach I took is too naïve to reach that kind of in-depth analysis level. F

8. *Can* in TAR

> A related issue is **whether** responses to individual forcings **can** be linearly added to obtain the total response to the sum of the forcings. **Indications** from experiments that have **attempted a very limited number of combinations** are that the forcings **can** indeed be added (Cox et al., 1995; Roeckner et al., 1994; Taylor and Penner, 1994).
>
> The use of a **single global mean** vertical profile **to represent the global domain**, **instead o**f the **more rigorous** latitudinally varying profiles, **can** lead to errors of **about 5 to 10%;** [...].
>
> This [... **for partially** absorbing aerosols, the radiative effect at the surface **may be many times** that at the top of the atmosphere...] is because, **for partially absorbing aerosols**, energy is transferred directly to the atmospheric column. **Ackerman et al. (2000) point out that this can warm** the atmosphere and "burn off" clouds. **They conclude** that during the northeast monsoon (dry season over India) daytime **trade cumulus cloud cover** over the northern Indian Ocean **can be reduced by nearly half, although these results depend strongly upon the meteorological conditions and modelling assumptions."**
>
> IPCC TAR, 2001)

Two of these examples show that TAR, even though it declared some certain outcomes concerning the anthropogenic cause of the climate change, displays considered and careful expressions, often limiting to uncertainty, when assessing scientific articles about the very same issue.

However, as Hyland (1996) stated that about 2 % of all words in scientific texts have hedging properties, I trust in my revised results enough to believe that my initial hypothesis of significant changes occurring in the IPCC Reports can be scrutinized effectively enough against this number. Because the IPCC WG1 does not do research itself but acts as an assessor of the up-to-date research, whatever be the results of my calculations, they can only act as indicators. The proportional changes in uncertainty related expressions in these early climate science reports would, for me, be the best result.

It is also evident that Hyland is right when he criticises the use of corpus-driven hedging-studies for them concentrating on simple lexical items mostly. The anaphoric and cataphoric references were prolific in the text and affected the truth values of many auxiliaries. The assessment of former studies – which is the task of the IPCC – further complicated the research into the hedges by adding more layers to the texts. The use of passive verbs forms, fronted subjects, hedged sub-clauses, and contrasting conjunctions was heavy. These will, however, be largely excluded from the quantitative part of this paper for consistency, methodological difficulty, and limited scope.

The IPCC FAR -report clearly showed most auxiliary-type hedges, which in this context can be called ‘classical’. The most common were *can* and *may* in FAR and TAR, *may* and *would* in SAR, in which *can* held the third place before *could.* In FAR, *would* and *could* held the places three and four, respectively, whereas in TAR, their positions were reversed. *Might* held the last place in all reports.

Can is also often used in the description of methodological issues. The number of it could be wound down depending on the choice made over whether methodological concerns can be understood as ‘epistemological concerns’ or not. I chose to include most of the results because *can* is so prolific that its significance is hard to deny, and methodological concerns are well within the scope of the assessment process of the state-of-the-art research of climate change.

I have done my best to correct the total wordcount for the respective Python functions. The mistakes are partially caused by the poor quality in the IPCC pdf-files. Fortunately, the quality of the IPCC pdfs became better the newer the material was. In other words, my own methodological choices have not been ideal from the beginning. What comes to auxiliaries *can* and *would* the frequency calculation may well to be too high, but the use of conditionals is there, maybe to soften the overall stance. The drives of the IPCC Teams for ‘objectivity’ and the avoidance of ‘politicising climate change’, or ‘fingerpointing’ may have played a part in the choice of words in these reports (for insights on the use of conditionals in scientific writing, and especially downtoning, see for example Castelo and Monaco, (2013). Whether *‘must (be)’* should be discarded from the results is another question.

FAR shows a linear reduction in certainty to begin with: from the clear leader can to a good second may to conditionals *would*, *could*, *should*, and then, in the middle, we have more seldom used auxiliaries with little uncertainty: *must* and *cannot’*. The last is a weak conditional ‘might’.

SAR has clearly much less auxiliaries than FAR relatively speaking, but there is no beautiful linear reduction in uncertainty. The epistemologically stronger auxiliaries (*can*, *must*, *cannot*) have a lower proportion to weaker ones (conditionals *would*, *could*, *should*, and *may*, *might*) in SAR than in FAR. Uncertainty increases, or alternatively, downtoning plays a more significant role. The overall reduction in numbers suggests that maybe other kinds of epistemological expressions are used.

TAR, surprisingly, showed a more similar structure in auxiliary use as FAR, but in proportion, auxiliaries are again much less used in TAR than in FAR.

So, FAR trusts auxiliaries in epistemology description to 1.33 %, nearly double the amount in SAR, 0.68 %, and over double the amount in TAR, 0.59 %.

4.2.2. Verbs with modalities expressing epistemological issues

set_hedgesverbs = {‘conclude’, ‘validate’, ‘define’, ‘reflect’, ‘seem’, ‘suggest’, ‘prove’, ‘verify’, ‘imply’, ‘indicate’, ‘infer’, ‘appear’, ‘presume’, ‘deduce’, ‘evaluate’, ‘consider’, ‘assume’, ‘approximate’, ‘determine’, ‘contradict’, ‘speculate’, ‘hypothesise’, ‘theorise’, ‘falsify’, ‘agree’, ‘suppose’, ‘expect’, ‘disagree’, ‘approve’, ‘disapprove’, ‘rely’, ‘is based on’, ‘rests on’, ‘assess’, ‘propose’, ‘believe’, ‘ascertain’, ‘tend’, ‘postulate’, ‘caution’, ‘predict’, ‘anticipate’, ‘induce’, ‘inform’, ‘assert’, ‘experiment’, ‘present’, ‘report’, ‘show’, ‘convince’, ‘compel’}

Table in Appendix 2.2., p. 97–98. In Appendix 2.3., you can find extra discussion about logical propositions and epistemology; p. 99.

The verbs I chose come from the literature sources and data. I chose the ones that refer to uncertainty, act as hedges if negated, or express a weak stance. For example: an expression like ‘cannot be verified’ would be included. Some verbs appear neutral and/or are connected with logical propositions. *Believe* has its own special character and it is used in passive voice in FAR, the same goes for *anticipate*.

I have included inflected forms and checked whether American or British spelling is used in such verbs as theorise/theorize or maximise, maximize, for example. Gerunds are relatively rare, and I believe that is typical to the genre of scientific writing. If any forms appear in the table with an asterisk, it is an indication that inflected forms are included in the calculation, or that in the process of running the Python code, a corrected dictionary value has been protected..

As it has become clear to me that in my case the corpus-based approach is not enough to reveal multi-layered hedging mechanisms and as many of these IPCC Reports have a different writing team (The FAR Chapter 'Radiative Forcing of Climate' was written by four lead authors and 16 contributing authors), each text chapter may show different lexical and syntactical features due to personal stylistic choices. These facts, in turn, affect and may even distort the results of this study. If I consider this from the point of view of the whole series of the IPCC Reports and their writing processes, the need for Guidance Notes for authors becomes understandable. The calibrated and standardised 'uncertainty language' also serves the purpose of evening out the stylistic preferences.

Because even epistemologically neutral verbs frequently come with approximators in immediate vicinity I have decided to widen my search item sets so that the results will be more descriptive. This decision affects the accuracy of this study but will show more of the different approaches the authors of these reports have taken to assess uncertainties in their field of science. My goal is not only to discover the exact number of hedged propositions, but to understand why 'uncertainty language' calibration has been deemed necessary in the IPCC reports in the first place.

Because the verb *estimate* is very central in the developments of expressions used to describe uncertainty (levels), I have chosen to study it separately (see pp. 62–67 in this paper).

The verb *suggest* is a hedge. It hedged both the proposition contents in the texts and the former research and studies done – the very material the IPCC assesses.

Some of the verbs are connected to logical thinking and certain conclusions. From those I expected to find a negated form, and, in some cases, I did. However, I decided to include all forms of these verbs because they show a slight rising trend in the reports. *Induce* and *deduce* are strong logical terms that point straight into the strength of logically drawn conclusions made from propositions: there can hardly be a stronger claim than the one deduced form true propositions, as from true propositions, a true conclusion necessarily follows. However, in the IPCC TAR, the word also used in an empirical environment:

1. *Deduce* in TAR

> Instead ultraviolet irradiance cycles are **deduced from observations by scaling the 27-day variations to selected solar activity indices and assuming that the same scaling applies over longer time-scales** (Lean et al., 1997). (TAR, 2001)

This usage, though may be universally approved, is slightly dangerous. What comes to inductions, they point not to necessary, but evidential or observational truths. In TAR, the verb *induce* appeared 24 times against the 11 hits *deduce* gave. In comparison, the first FAR-report showed a lower frequency for these logical terms: *induce* appeared in FAR 4 times, *deduce*, zero times. I believe this detail describes the shifts in hedging practices between the reports.

Among these results is one my main findings: *suggest* shows a high increase in SAR and especially TAR despite the major result of proving the anthropogenic origin of climate change. Another very prolific approximator was *estimate*. It occurs very frequently also as a noun, and, as mentioned earlier, I chose to include it in the set of numerical approximators. I believe *estimate*, in its different forms, is one of the 'pillars' of making climate science.

I also wanted to highlight the relative frequency of some epistemologically neutral verbs, such as *show, report, reflect, inform*, or *present*. Thus, I can point out that the process of 'writing out' the most prominent results of scientific research and experimentation is a complicated task from a rhetorical and semantic point of view. Some neutral, well known words (i.e., *show, inform, present*) can add hoped for robustness to the core knowledge content. Inform did not appear in the reports. The frequency of *present* was less than half the frequency of *suggest*. *Reflect* was also used to point to existing uncertainties. On the other hand, *show* was frequently used and appeared at the top of the lists.

The three verbs, *show*, *present* and *suggest*, are mostly used in context of former studies or IPCC reports. The above result indicates that the assessment of these studies and reports differs what comes to reliability, *suggest* being the most careful of the verbs epistemologically. The main conclusion is that the scientific basis does not appear to become stronger in any absolute sense despite the successes in gaining significant results. The inherent complexity of climate science and the need to constantly develop and review methods to gather more certain knowledge from a wide scope cause the reports to necessarily contain uncertainty. The high frequencies of the approximator *estimate* and the epistemologically very loaded noun *uncertainty* will further verify this point. What success means, on the other hand, is being able to close the gaps gradually.

My first example below shows that when results obtained by observational studies differ from those based on computer models, we get an 'increase in the likelihood of uncertainty'. Another verb (*show*) is used in connection with observations than in the connection of model results (*suggest*). (What is interesting in these verbs is also that a simple phrase: 'studies show' occurs in all three reports only 7 times, whereas 'studies suggest' does not appear in FAR at all, but in SAR and TAR, 6 and 18 times respectively. In all contexts, *suggest* is nearly two times more frequent in TAR as in FAR. As stated above, I detect an increase in uncertainty; or alternatively, a very careful assessment process limiting to uncertainty; alongside the increase in the number of studies assessed. For crude AntConc results, see Appendix 1.8., p. 94.)

2. TAR; *show* versus *suggest*

> **Observational studies show** a wide range of specific extinction coefficients, αsp, (see Section 5.1.2 and Table 5.1) of **approximately 5 to 20 m2g−1 at 0.55 µm**, thus the **uncertainty** in the associated radiative forcing is **likely to be higher** than the **global model results suggest**. (IPCC TAR, 2001)

The second example shows how certainty can be added by studying further and using computer models:

> Changes in stratospheric thermal structure **may** also affect the troposphere **through dynamical interactions rather than through radiative forcing**. **Kodera (1995) suggested** that changes in stratospheric zonal wind structure, brought about by enhanced solar heating, **could interact** with vertically propagating planetary waves in the winter hemisphere to produce **a particular mode of response.** This mode, also seen in response to heating in the lower stratosphere caused by injection of volcanic aerosol, **shows** dipole anomalies in zonal wind structure which propagate down, over the winter period, into the troposphere. **Rind and Alachandran (1995) investigated** the impact of large increases in solar ultraviolet on the troposphere with a GCM (Climate Model, General Circulation Model, SR) and **confirmed** that altered refraction characteristics affect wave propagation in winter high latitudes. (IPCC TAR, 2001)

3. The third example from IPCC TAR, (2001) shows an opposite trend in certainty:

> **The factors used to correct** ACRIM-I and ACRIM-II **by Willson (1997) agree with** those derived independently by Crommelynk et al. (1995) who **derived a Space Absolute Radiometric Reference of TSI reportedly accurate to ± 0.15%**. Fröhlich and Lean (1998), **however**, **derived** a composite TSI series which **shows almost identical values in 1986 and 1996, in good agreement with a model of the TSI variability based on independent observations** of sunspots and bright areas (faculae). The difference between these two **assessments depends critically on the corrections necessary to compensate for problems of unexplained drift and uncalibrated degradation** in both the Nimbus 7/ERB and ERBS time series. **Thus, longerterm and more accurate measurements are required** before trends in

> TSI **can be monitored to sufficient accuracy for application to studies** of the radiative forcing of climate.
>
> (IPCC TAR, 2001)

The above extracts reveal the central role that assessment of the state of the art -studies on climate change, and methods used, have in the textual environment and how, consequently, uncertainties are constantly present.

4.2.3. Adverbs, prepositional phrases such as *with confidence* acting as hedges or affecting the strength of propositions; *likely* and *unlikely* also as adjectives

set_hedgesadvs = {'probably', 'likely', 'presumably', 'unlikely', 'with confidence', 'generally', 'perhaps', 'maybe', 'possibly', 'surely', 'reliably', 'arguably', 'unarguably', 'inadvertedly', 'questionably', 'unquestionably', 'without a doubt', 'virtually', 'undoubtedly', 'factually', 'counter the fact', 'practically', 'in practice', 'observationally', according to the fact', 'certainly', 'evidentially', 'according to observations', 'according to evidence', 'counter the evidence', 'experimentally', 'observedly', 'unobservedly', 'according to estimation, 'according to estimates', 'causally', 'effectively', 'in contrast', 'barely', 'inferentially', 'in fact', 'in particular', 'largely', directly', 'indirectly', 'necessarily'}

For table, see Appendix 2.4., p. 100–101.

What comes to classical hedges, such as *likely*, *unlikely*, *possibly*, *probably*, this set was quite straightforward. Even if I chose to include several possible choices to show any kind of hedging or an attempt to weaken/strengthen propositions, the results show mainly classical, familiar adverbs denoting likelihood, certainty, or possibility. The use of *likely* is increased markedly, especially it is frequent in SAR. I believe that a move towards a 'likelihood-language' is made.

Unlikely, which is a negated form of *likely*, does not frequent in the text. Maybe such propositions that are unlikely to be true, are not, in this context, worth mentioning: these reports assess the best available knowledge of climate change. I quote two heavily hedged sentences, in which 'unlikely' occurs. These show some weaknesses in methods used to calculate relevant gas concentrations and the results:

1. TAR:

> **Note also that some gases**, **for example**, trifluoromethyl iodide (CF3I) and dimethyl ether (CH3OCH3) have **very short lifetimes (less than a few** months); GWPs for **such** very short-lived gases **may need to be treated with caution**, because the gases are **unlikely** to be **evenly**

> **distributed globally**, and hence **estimates** of, **for example**, their radiative forcing **using global mean** conditions **may be subject to error**.
>
> […]
>
> **However, Forster and Shine (l997) made the important point that since there is far less** O3 in the troposphere than **near** the tropopause and in the stratosphere, the use of a constant perturbation is **unlikely** to provide **a realistic measure** of the sensitivity profile (IPCC TAR, 2001).

All three reports show a similar ratio of hedging adverbs and adverbials. However, the adverb *likely* becomes more visible in SAR and TAR. Also *rather*, an approximator and something which I call a 'softener', that can increase the 'fuzziness' of anything it is used to attribute to, becomes noticeably more frequent in TAR: it tops the list. The variety of words is slightly wider in TAR. For some reason, the FAR- report again has more restricted hedging vocabulary but the overall ratio is higher in FAR.

I did not expect to see such a low number of adverbs and adverbials, and many those I proposed in the set we not present in the texts at all. Most of the adverbs and adverbials I found via the Python functions and AntConc-checks deal with probability, or likelihood. *Likely* and *unlikely* also act as adjectives, but I do not make the difference here: the description of vocabulary interests me more in this context. 'Fuzzy' words, closer to be approximators in a literal sense, are *rather, largely,* and *generally* vs. *significantly* as a pair. The latter two, as I understand it, also denote the quality of knowledge from a writer-oriented stance. Some adverbials in the list deal with certainty and reliability: *undoubtedly*, *certainly*, *implicitly*, *reliably*. *Effectively* deals with causal relationship and like *virtually* it has, in the context of these reports, a a strong practical denotation. Both often act as approximators. *Directly* and *indirectly* again qualify the knowledge. *Necessarily* is philosophy-based and linked with both certainty, and strong correlation or causality. The above definitions are my own.

2. FAR, 1990, TAR, 2001: effectively:

> Above about 30 km, added ozone causes a decrease in surface temperature because it absorbs extra solar radiation, **effectively** robbing the troposphere of direct solar energy that would otherwise warm the surface (Lacis et al, 1990) (FAR, 1990).
>
> This constant offset from the original IS92 scenarios is **effectively** a redefinition of the natural, baseline emissions (SAR, 1995).
>
> Thus, heterogeneous conversion of SO2 to sulphate aerosol on dust or sea salt particles may **effectively** lead to sulphate becoming internally mixed with larger super-micron particles (e.g., Dentener et al., 1996) (TAR, 2001).

These reports do not use adverbs, nor adverbials, to great extend to express stance, or as hedges, but nouns, auxiliaries, conjunctions, and structural devices, for example relative clauses, passive voice, and fronted subjects. The ‘uncertainty language’ took shape around only four key nouns, and adjective phrases and attributes, i.e., ‘qualifiers’ and ‘quantifiers’ to scale them (Mastrandrea et al., 2011).

The first example shows the use of *directly* in the context of a vitally important causal relationship: ‘These absorption properties [for thermal infrared radiation, SR] are **directly** responsible for the greenhouse effect (IPCC FAR, 1990)’.

I take a long extract from FAR, where the adverb *likely* is again a centrepiece in a paragraph which shows verbs, nouns, numerical approximators and larger structures acting as hedges:

> The neglect of the dependence of the radiative term on the trace gas concentration implies small trace gas concentration changes. Further, the overlap of the infrared absorption bands of methane and nitrous oxide may be significant and this restricts the application of the GWP to small perturbations around present day concentrations. An assumption implicit in this simple approach is that the atmospheric lifetimes of the trace gases remain constant over the integration time horizon. **This [see the previous sentence, SR] is likely to be a poor assumption for many trace gases for a variety of different reasons**. For those trace gases which are removed by tropospheric OH radicals, a significant change in lifetime could be anticipated in the future, depending on the impact of human activities on methane, carbon monoxide and oxides of nitrogen emissions. For some scenarios, as much as a 50% increase in methane and HCFC 22 lifetimes has been estimated. Such increases in lifetime have a dramatic influence on the global warming potentials in Table 2.8., integrated over the longer time horizons. Much more work needs to be done to determine global warming potentials which will properly account for the processes affecting atmospheric composition and for the possible non-linear feedbacks influencing the impacts of trace gases on climate.
>
> It is recognised that the emissions of a number of [...]
>
> (IPCC FAR, 1990)

In the extracts form SAR, we can see the beginnings of a scaled ‘uncertainty/likelihood -language’, with some variation (for example, ‘is in reasonable agreement’ is a perfectly valid expression, but a deviation from the formula):

> The calculated biospheric reservoir uptake would have to be reduced by about 80% in order to achieve the global bomb radiocarbon balance. Such a reduction is **very unlikely,** as it strongly contradicts observations of bomb 14C in wood (e.g., in tree rings: Levin et al, 1985) and soils (Harrison et al, 1993**). A more likely,** albeit tentative, explanation is that previous estimates of the oceanic bomb 14C inventory compiled from the observations of the GEOSECS program (1973-78) (Broecker et al, 1985) are too high by approximately 25%. **This is slightly larger than the generally accepted uncertainty** of this quantity. Because this explanation is inconsistent with a new assessment of the oceanic observations (Broecker et al, 1995) the issue is still not fully resolved.
>
> […]
>
> Using 33 sun-like stars, they [Zhang et. al., (1994), SR] **estimate to 95% confidence** that the solar brightness increase between the Maunder Minimum and the decade of the 1980s was **likely to be 0.4 ± 0.2%.** The lower limit of 0.2% (equivalent to a radiative forcing of 0.48 Wm-2) agrees with the estimates of Lean et al. (1992) and Hoyt and Schatten (1993), while the upper **range** of 0.6% **is in reasonable agreement** with Nesme-Ribes et al. (1993) and corresponds to a radiative forcing of 1.4 Wm-2. The radiative forcing since 1850 is **likely to be no more than 50% of that since** the Maunder Minimum (see IPCC 1994). This study thus provides support

> for the conclusions reached in IPCC (1994) that solar variations of the past century are **highly likely to have been considerably smaller** than the anthropogenic radiative forcings and **expands that conclusion** to show that the variations in solar output over the coming century are **unlikely to exceed those observed** since the Maunder Minimum.
>
> (D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LAL, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995)

The third example from TAR shows how uncertainty is quantified, and how it is sometimes necessary to discuss 'the sign' of the radiative forcings:

> Because **the resultant global mean net radiative forcing** is a residual obtained by summing the shortwave and the long-wave radiative forcings **which are of roughly comparable magnitudes**, **the uncertainty in the radiative forcing is large** and **even the sign is in doubt** due to the competing nature of the short-wave and long-wave effects. The studies above **suggest, on balance**, that the shortwave radiative forcing **is likely to be of a larger magnitude than** the long-wave radiative forcing, which **indicates** that the net radiative forcing **is likely to be negative**, **although a net positive radiative forcing cannot be ruled out. Therefore a tentative range of −0.6 to +0.4 Wm−2 is adopted; a best estimate cannot be assigned as yet.**
>
> (IPCC TAR, 2001)

This excerpt also shows to me the importance of approximating in these reports.

4.2.4. The quality and quantity of knowledge: hedging and boosting nouns

set_hedgesnouns = {'likelihood', 'integration', 'gap', 'condition', 'knowledge', 'probability', 'credence', 'possibility', 'suggestion', 'evidentiality', 'inference', 'conclusion', 'proof', 'verification', trust', 'distrust', 'confidence', 'reliance', 'reliability', 'commitment', 'derivation', 'assessment', 'tendency', 'argument', 'modification', 'extract', 'sample', 'speculation', 'trend', 'level of scientific understanding', 'LOSU', 'prediction', 'assumption', 'supposition', 'theory', 'hypothesis', 'certainty', 'uncertainty', 'rationale', 'proposition', 'experiment', 'consensus', 'insufficiency', 'understanding', 'postulate', 'negation', 'agreement', 'disagreement', 'calculation', 'alternative', 'rationality', 'anticipation', 'contradiction', 'proportionality', 'contrast', 'incidence', 'chance', 'accidence', 'candidate', 'potentiality', 'potential', 'observation', 'confirmation', evidence, 'tendency', 'research', '*references to other studies, IPCC material*', 'data', 'scheme', 'fact', 'implication', 'factor', 'assessment', 'study', information', 'approach' }

Table in Appendix 2.5., pp. 101–102.

[In hindsight, where are the risk identification, assessment and management related concepts, methods, tools, and programs? The WG 2 contribution, despite having more of those, has most likely been as insufficient to cause climate action as the WG 1. Would a

combined effort have been more successful? In the newest WG1 report (published only a few weeks ago) a whole chapter is dedicated to risks in climate change.]

The list I have chosen consists of terminology used in verification and describing the scientific method. Again, it derives from literature sources, my own inclinations (i.e., how I understand the philosophy of science) and data. I pay attention to 'the quality of knowledge'. However, the task of assessing all relevant climate change science related issues in these reports increase the possibility of proliferation of hedging devises.

The aim of the IPCC Reports is to assess the latest scientific knowledge available about climate change. The lead authors seek to express an agreed basis for scientific knowledge that would be, in the first place, shared and reviewed by the most prominent experts, and from there on, shared with a global audience. This goal is hard to achieve, and due to discrepancies and disagreements in methodologies and results there exists a need to discuss and categorise the scientific knowledge from many points of view.

The 'uncertainty language in 'Guidance Note' has four key nouns: 'evidence', 'agreement', 'confidence', and 'likelihood'. 'Uncertainty' and 'certainty' can also occur in the same context. These are included in my set of search items, and some discussion on those, their relative numbers, and the occurrences of the adjectival phrases and attributes in the adjacent key expressions can be found in Appendix 2.9., p. 108–109. These first three reports were published before the deployment of the specifically scaled expressions, but does anything in them point to similar patterns and words as in the 'uncertainty language' already being tested?

In the FAR results, I paid attention to the frequent use of *uncertainty* and the fact that *data* and *evidence* came with attributes denoting insufficiency. It is difficult for me to draw a line between classical hedges and epistemological or methodological weaknesses. For example, 'there are still uncertainties in the basic spectroscopic data for many gases'; or, what to do with knowledge that is 'indicated or implied after other factors have been taken into account', as in the example below:

1. FAR:

> The increase in aerosol sulphate caused by anthropogenic SO2 emissions (Section 1 Figure 1 16) **may have caused an increase in the number of** CCN (cloud condensation nuclei, SR) **with possible subsequent influence** on cloud albedo and climate. **Cess (personal**

> **communication)** has reported changes in planetary albedo over cloudy skies **that are consistent with a larger-scale effect** of sulphate emissions. **Measurements** from the Earth Radiation Budget Experiment satellite instruments **indicate after other factors have been taken into account** that the planetary albedo over low clouds **decreases by a few per cent** between the western and eastern North Atlantic. **The implication is** that sulphate emissions from the east coast of North America are affecting cloud albedos downwind.
>
> (IPCC FAR, 1990)

How certain is, after an uncertain start, something which is "indicated by the measurements of the Earth Radiation Budget Experiment satellite instruments after other factors have been taken into account"? How certain is the ensuing implication?

It proved out that 'the Experiment satellite' was an integral part of a NASA program for investigating the energy budget between Sun, the Earth and space from 1984 to 2005 (nasa.gov). But how much do the afore mentioned uncertainties affect the quality of knowledge derived from the Experimental satellite measurements? I have no answer to these questions. As an interesting addition to this issue, I can say that satellite observations have become a very prominent and reliable tool to investigate climate change related phenomena in a global scale.

From SAR, the first glimpses of the new uncertainty language expressions were found. First, the scaling of confidence:

2. SAR:

> An intercomparison of tropospheric chemistry/transport models using a short-lived tracer showed how critical the model description of the atmospheric motions is, **finding a high degree of consistency between three dimensional models**, but distinctly different results among two dimensional models. This finding**, illustrating the low degree of confidence we should have in numerical simulations** involving gases such as tropospheric ozone and its precursors, still holds (SAR, 1995)

This example also motivated me further to continue the study of the inherent uncertainties in models and simulations.

Then a sentence containing 'uncertainty range':

3.SAR:

> **There is a large uncertainty range particularly** for the radiative forcing due to the effect of aerosols on cloud properties (D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R. SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LA, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).

An example from TAR shows how uncertainty can be scaled differently. How large the 'uncertainty of a factor of two or more' is, I know not:

4. TAR:

> As noted in previous IPCC Assessments, there are difficulties in compiling a good quantitative record of the episodic volcanic events (see also Rowntree, 1998), in particular the intensity of their forcings prior to the 1960s. Efforts have been made to compile the optical depths of the past volcanoes (SAR; Robock and Free, 1995, 1996; Andronova et al., 1999); **however, the estimated global forcings probably have an uncertainty of a factor of two or more.** Several major volcanic eruptions occurred between 1880 and 1920, and between 1960 and 1991.
>
> (IPCC TAR, 2001)

All three report excerpts above have uncertainties in quantitative data and modelling. The example from FAR (1990) below shows how 'uncertainty' itself – something which is uncertain, or only partially known to us – can be quantified and finally summed up. The subject is the description and comparison of the observation-based data and radiative transfer models. The 'relativity of knowledge' could be a case in point here:

5. FAR:

> **Uncertainties in deltaF-deltaC relationships** arise in three ways. **First**, there are still **uncertainties in the basic spectroscopic data** for many gases. In particular, data for CFCs, HFCs and HCFCs are **probably only accurate to within ±10-20%**. **Part of this uncertainty** is related to the temperature dependence of the intensities, **which is generally not known**. For some of these gases, **only cross-section data are available**. For the line intensity data that do exist, **there have been no detailed intercomparisons of results from different laboratories.** Further information on the available spectroscopic data is given by Husson (1990).
>
> **Second, uncertainties arise through details in the radiative transfer modelling**. **Intercomparisons** made under the auspices of WCRP (Luther and Fouquart, 1984) **suggest** that **these uncertainties are around ±10% (although schemes used in climate models disagreed with detailed calculations by up to 25% for the flux change at the tropopause on doubling CO2**).
>
> **made in the radiative Third, uncertainties arise through assumptions model with regard to the following**
>
> (1) **the assumed or computed vertical profile** of the concentration change. For example, for CFCs and HCFCs, results **can depend noticeably on the assumed change** in stratospheric concentration (see e g, Ramanathan et al, 1985)
>
> (11) **the assumed or computed vertical profiles of temperature and moisture in assumptions made with regard to cloudiness.** Clear sky deltaF values are **in general 20% greater** than those using realistic cloudiness
>
> (iv) **the assumed concentrations** of other gases (usually, present-day values are used) These are **important** because they **determine the overall** IR flux and because of overlap between the absorption lines of different gases
>
> (v) the indirect effects on the radiative forcing **due to chemical interactions as discussed** in Section 2 2 3. The overall effect of this **third group of uncertainties on deltaF is probably at least ±10%**
>
> (IPCC FAR, 1990)

There are uncertainties in basic data, line intensity data, laboratory results and their intercomparisons, the radiative (transfer?) model, both generally, and specifically, and even in the final amount of uncertainty. What can be relied on, in the case of data, is that too little data is available, and Husson's study can give further information. What is relied on in the case of modelling is the intercomparison by Luther and Fouquhart (1984), but this reliance is conditional – especially what comes to CO2. These kinds of descriptions of uncertainties within assumptions within uncertainties within assumptions etc. – examples could well be a case in point when considering the usefulness of a simplified and inclusive 'uncertainty language'.

Potential, though prolific, is a terminology-related hedge according to my interpretation: having the potential to behave in a certain way is not the same thing as the actual behaviour occurring. In a textual environment where deliberations towards accuracy and realistic likelihoods are required, I see no reason not to include *potential* (as a noun) in the list. What comes to *level*, it features as an integral part of the expression 'level of scientific understanding' or *LOSU*, which appears especially in TAR. *Gap* in many cases refers to 'gaps in understanding', which of course is a strong expression of epistemological concern. Likewise, *factor* can be 'a maker of science' or a part of an approximator:

6. FAR:

> Therefore, the size, number and the chemical composition of aerosol particles, as well as updraughts, determine the number of cloud droplets. As a consequence, continental clouds, especially over populated regions, have a higher droplet concentration (**by a factor of order 10**) than those in remote marine areas.
>
> (IPCC FAR, 1990)

What comes to prolificacy of the set words, I highlight that there are words which point to relative, or restricted knowledge, possibly also to multiple truths; for example, *condition*, *modification*, *alternative*, *contradiction*, et cetera. These choices again belong to the descriptive field of this study. Some words point to methodological strengths: *observation*, *scheme*, *experiment*, *sample*, *extract*, *calculation*, *derivation*, *integration*. These do not feature in the text much. *Tendency*, and *trend* – inaccurate pointers of direction – occur too, of these, *tendency* is marginal, but *trend* is clearly more important. In TAR, *range* has topped it. *Estimation* and all its derivates are hugely important in the context of all scaling activities, but I chose to include it in the set of numerical approximators due to its 'fuzziness'.

I have used this extensive list, to arrive at a descriptive picture of definitions used in these reports to inform the reader about

1. The uncertainties in knowledge.

2. The basis it rests on.

3. Certainties and likelihood in results.

4. The stance the report takes on the former three, and alternative solutions.

It is obvious that nouns are used extensively in comparison to simple adverbs as hedging devices. Nouns with philosophical denotations are marginal in numbers, but they are epistemologically relevant. Because assessment of research done by key scientists across the globe is the key task, the choice of hedging nouns seems to be restricted to some terms that help scaling the results of the reports effectively: that is, there seems to be a movement towards 'concrete' knowledge so that it is scalable in terms of (un)certainty and likelihood.

AntConc collocation -search for FAR showed very little connections with words *uncertainty* and its possible scalars like *factor*, *level*, *range*, and numeric '±' + number and/or percentage. I found zero to four cases of these. However, I chose an example that shows a very clear hedging pattern, and points to 'current range of uncertainties' from FAR. We can also understand that 'GWP' (Global Warming Potential) comes with methodological problems (and these difficulties may cause deeper epistemological concerns to arise. Does this epistemological concern affect the efficacy of this report in guiding the policy making processes, for instance? GWP's are central in the evaluation of the necessary emission reductions.):

7. FAR

> **It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single global warming potential for greenhouse gas emissions. In fact there may be no single approach which will represent all the needs of policy makers. A simple approach has been adopted here to illustrate the difficulties inherent in the concept, to illustrate the importance of some of the current gaps in understanding and to demonstrate the current range of uncertainties. However, because of the importance of greenhouse warming potentials, a preliminary evaluation is made**.
>
> (FAR, 1995)

In SAR and TAR, these were more prolific, *factor* showing the highest frequencies with 11 and 13 hits respectively in collocation with *uncertainty*. I also chose to add *approach* to my hedging nouns from data. It is 'fuzzy' in many ways. 'An approach' can denote anything from the tiniest advance to nearly hitting the target. It can also signify many kinds of fundamentally 'fuzzy' theoretical or methodological issues.

8. SAR; TAR:

> **The inventory approach to the estimation** of recent production and emissions of CFC-11 and -12 has become **increasingly uncertain** (Fisher and Midgley, 1994) (SAR, 1995).
>
> **The uncertainty associated with this estimate is necessarily high** due to the limited number of detailed studies and is estimated to be **at least a factor of three** (TAR, 2001)

'Confidence level' started to feature in SAR (3 hits), and TAR showed 8 cases of it: *level* is more seldom used to scale uncertainty in the reports, but it features in *LOSU* and similar expressions, and with *confidence*.

I have also included the frequency of bracketed references to former studies and reports. These will help me to connect some uncertainty-denoting nouns to the assessment process, though errors in the number of references remain. In this context, the 'disclaimer' I made earlier on must be revised: even if the authors of the reports have worked as a team, in many cases the authors have referred to works done by other team members or their own works. This raises the possibility of hedging contents 'for personal gains'; or maybe more so, can show that the institutional context and a strive to become 'an authority' in climate science (also as an institution) may have had an effect in the hedging praxis. (c.f. Hyland (1998), pp. 378-379).

Here the bracketed contents are not referencing but show the intercomparison of estimates in SAR assessment (1995), and newer results (2001); also showing the use of confidence level' and 'LOSU', in TAR:

9. TAR:

> The estimate for the direct sulphate aerosol forcing has also seen multiple model investigations since the SAR, resulting in more estimates being available for this assessment. It is striking that consideration of all of the estimates available since 1996 lead to the same **best estimate (–0.4 Wm−2) and uncertainty (–0.2 to –0.8 Wm−2) range** as in the previous assessment. As in the case of O3, that could be a motivation **for elevating the status of knowledge** of this forcing to **a higher confidence level**. However, there remain **critical areas of uncertainty** concerning the modelling of the geographical distribution of sulphate aerosols, spatial cloud distributions, effects due to relative humidity etc. Hence, we retain a **"low" LOSU** for this forcing.
>
> (IPCC TAR, 2001)

Another, lengthy example from TAR shows how prolific the references are and reveals problems in gaining reliable results despite the range of studies made. Four of the authors of the studies, mentioned by name in the reference, were not members of the TAR writing team.

In the middle of the paragraph, methodological uncertainty abounds. The passive voice is used/subject is fronted after the initial, slightly ambiguous subject ‘Some authors’:

10. TAR:

> **Some authors have argued that** sea salt particles may compete with sulphate aerosols as cloud condensation nuclei, thereby reducing the importance of anthropogenic sulphate in droplet nucleation **(Ghan et al., 1998; O’Dowd et al., 1999).** While this process is empirically accounted for in some of the above mentioned estimates **(e.g., Jones et al., 1999),** it certainly adds further uncertainty to the estimates. Considerable sensitivity is found to the parametrization of the autoconversion process (**Boucher et al., 1995; Lohmann and Feichter, 1997; Delobbe and Gallée, 1998; Jones et al., 1999**) which complicates matters because there is a need to “tune” the autoconversion onset in GCMs **(Boucher et al., 1995; Fowler et al., 1996**; **Rotstayn, 1999, 2000)** to which the indirect aerosol forcing is sensitive **(Jones et al., 1999; Rotstayn, 1999; Ghan et al., 2001a).** The indirect aerosol forcing is also sensitive to the treatment of the pre-industrial aerosol concentration and properties **(Jones et al., 1999; Lohmann et al., 2000**) which remain poorly characterised, the representation of the microphysics of mid-level clouds (**Lohmann et al., 2000),** the representation of aerosol size distribution **(Ghan et al., 2001a),** the parametrization of sub-grid scale clouds, the horizontal resolution of the GCM (**Ghan et al., 2001a),** and the ability of GCMs to simulate the stratocumulus cloud fields. Finally, it should be noted that all the studies discussed above cannot be considered as truly “independent” because many of them (with the exceptions of **Lohmann et al. (2000) and Ghan et al. (2001a**)) use similar methodologies and similar relationships between sulphate mass and cloud droplet number concentration. **Therefore it is suspected that the range of model results does not encompass the total range of uncertainties. In an overall sense, it can be concluded that the considerable sensitivities to the treatment of microphysical details associated with aerosol-cloud interactions, and their linkages with macroscopic cloud and circulation parameters, remain to be thoroughly explored.**
>
> (Ibid.)

The assessment process of science can be discerned through the vocabulary: most common items after *uncertainty*, *potential* and *study**[13] deal with terminology, methods, and results. Another group are philosophically and epistemologically motivated words dealing with the strength of argumentation. What is striking is that despite the fact that my list does not include only hedges of uncertainty but a much wider and more expressive vocabulary, the combination of *study** and *uncertainty* are topping the lists. So, my list deviates from that of common, or classical hedging items, but it may show that science does not come with certain, uncontested results. It is a discourse on uncertainties.

Only the Contributing Authors appear in alphabetical order on the front page of the chapter in question. Yet the number of references in the text does not correlate with the order of I in the Lead Author list, either. In FAR, the authors appear in the references much more seldom: a few times only in opposition to even dozens of times in some cases in SAR and TAR. SAR is

[13] Again, the asterisk indicates that different forms; in this case, singular and plural, have been investigated. Another reason for an asterisk to appear is that corrected Python dictionary values need to be protected when running the code.

the most transparent in its practices: The Lead Authors of each sub-chapter are mentioned separately. This increase in transparency makes the comparison of team-internal references among the Lead Authors possible. In SAR, the number of production team -internal references is lower than in TAR.

Results from my searches in Python and AntConc:

Text internal references to other studies, IPCC material: FAR, 74; SAR, 355; TAR, 527. The normalised frequencies are very high: FAR 6,212, SAR 13.039, and TAR 13.469 occurrences per one thousand words, the biggest relative growth clearly occurring between FAR and SAR.

The total number of source studies (the count from the reference list: or endnotes) is 60 in FAR. In SAR, all references top 230 pieces, in TAR, the number is over 370. In very crude terms, this might actually correlate with an increasing trend of 'uncertainty' per source study assessed. This would indicate that science does not have a beautiful linear direction of advancement, but rather it moves on in a turbulent, vortex-like configuration.

I must also point out that I had difficulties in trying to find an accurate enough number of text-internal references. The task of assessing new research has a heavy influence on the reports, indeed; but this instance also shows that I have needed to struggle with the methods to get accurate results in some cases, whether I have use Python or AntConc. Counting references and any mentions of previous or contemporary studies by hand would have been quite a task.

Some of the qualitative and quantitative scales of probability and certainty, such as 'level of confidence' (SAR); 'level of scientific understanding'; LOSU (TAR); act as commonly created devices to hedge knowledge with the obvious aim to provide the reader with top-class assessment. The international reviewing process acts as a further 'outsider reliability check. Also, the sheer numbers of the production team members and the relatively slow publication rate act towards increasing reliability. On the other hand, I do not know what exactly the nature of the connection between the tasks of 'assessing the most-up-to-date research' and 'informing politicians and the public' is in the context of making the rhetorical choice of using the 'uncertainty language', especially in SPMs (Summaries for Policymakers). As the IPCC is very transparent in its handlings. I presume the answer could be found from the Sessions and Meetings -data.

4.2.5. The quality of knowledge: adjectives

set_hedgesadj = {‘probable’, ‘possible’, ‘particular’, ‘suggested’, ‘contradictory’, ‘conclusive’, ‘arguable’, ‘argumentative’, ‘trusted’, ‘reliable’, ‘unreliable’, ‘comparative’, ‘likely’, ‘committed’, ‘general’, ‘estimated’, ‘speculated’, ‘speculative’, ‘bounded’, ‘evidential’, ‘observational’, ‘empirical’, ‘inferential’, ‘compelling’, ‘reasonable’, ‘unlikely’, ‘certain’, ‘uncertain’, ‘predicted’, ‘established’, ‘theoretical’, ‘hypothetical’, ‘few’, ‘complete’, ‘limited’, ‘true’, ‘critical’, ‘assumed’, ‘false’, ‘preliminary’, ‘final’, ‘sufficient’, ‘tentative’, ‘proposed’, ‘experimental’, ‘testable’, ‘tested’, ‘insufficient’, ‘understood’, ‘based on’, ‘postulated’, ‘implied’, ‘negated’, ‘posited’, ‘positive’, ‘anticipated’, ‘dictated’, ‘convincing’, ‘potential’, ‘potent’, ‘wrong’, ‘unconvincing’, ‘considered’, ‘significant’, ‘reported’, ‘presented’, ‘calculated’, ‘implicit’, ‘applicable’}

For table, see Appendix 2.6., p. 103–104.

Many adjectives of my first choice are the past participle forms of verbs that deal with epistemological argumentation, relativity, and usefulness of knowledge. They were well represented in the result list: the top of my list is reserved to *possible* and *significant*, but *considered*, *based on*, *estimated*, and *calculated* were well in the top ten.

The adjectival *assumed* was straightforward enough, but I highlight the following occurrences:

1. FAR:

> Third, uncertainties arise through assumptions made in the radiative model with regard to the following (i) the **assumed** or **computed** vertical profile of the concentration change (ii) the assumed or computed vertical profiles of temperature and moisture […] (IPCC FAR, (1990))

Again, there is little that is certain in this excerpt – the example lists uncertainties. What I wanted to compare was the ‘assumed or computed [vertical profile(s)]: Are the ‘assumed’ or ‘computed’ values any different from each other what comes to their epistemological, or predictive capacities? From the text itself, I found no clear answer (see IPCC FAR pp. 53 – 54). We can understand, however, that developing modelling accuracy has been one of the key methodological issues in climate science.

Because I used untagged txt.files, I had to disregard most of the past participles. In TAR, *observed* holds the second place, but it is important in all three. *Likely* is a rising star, but it can also be an adverb and therefore, it is ambiguous. The methodological choice I made, believing mostly in simple one lexical item -searches did not pay off.

But I believe that adjectival qualifiers are best when related to

1. Possible effects, outcomes

2. Significant effects, outcomes

3. Methods, outcomes that are based on observations; or ‘likely’.

Possible in TAR has a much lower normalised frequency. *Possible* is too wide to denote probability accurately: anything with a probability between 0.01 and 0.99 is ‘possible’. FAR and SAR favour *possible* and *significant* to any other, but TAR shows a more even distribution. *Likely* becomes more frequent in SAR and TAR.

Examples from FAR showing the uses of *possible* and *significant*:

2. FAR:

> Because of oceanic thermal inertia (see Section 6), and because of the relatively short time scale of the forcing changes associated with the solar cycle **only a small fraction of possible temperature changes** due to this source can be realised (Wigley and Raper 1990). **In contrast** the sustained nature of the greenhouse forcing **allows a much greater fraction of the possible temperature change to be realised** so that the greenhouse forcing dominates.
>
> The addition of a small amount of gas capable of absorbing at this wavelength has negligible effect on the net flux at the tropopause. The effect of added carbon dioxide molecules is, however, **significant at the edges of the 15 micrometre band, and in particular around 13.7 and 16 micrometres.**
>
> In the Business as Usual Scenario, for example, its [CO2, SR] contribution to the change always exceeds 60**%. For the scenarios chosen for this analysis, the contribution of HCFC-22 becomes significant** in the next century. (FAR, 1990)

In SAR, we see *based on* used in connection to studies. However, the first example does not give certain results, but only ‘suggests’ a possible influence; the second example shows how complicated the data-sampling process is. The outcome, i.e., the decline, is (relatively) considerable, though. (The last phrase, ‘until recently the highest one-year mean growth rate [of CO2, SR] ever recorded’ is illustrative of today’s climate science, I am afraid):

3. SAR:

> However, recent studies by Tegen and Fung (1995) based on analysis of satellite observations suggest that a substantial amount (possibly 30-50%) of the soil dust burden may be influenced by human activities. No attempt has been made to estimate the global radiative forcing due to this anthropogenic component.
>
> The decline in the short time-scale growth rate (based on interannual data filtered to remove annual cycle variations and considering the mean growth rates for overlapping 12-month periods) to 0.6 ppmv/yr in 1992 is considerable when contrasted with the mean rate over 1987 to 1988 of 2.5 ppmv/yr, until recently the highest one-year mean growth rate ever recorded.
>
> (D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X.

> ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R. SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LA, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).

In TAR, we can see relativity of knowledge appearing, finally ending in an ‘estimated climate response’. A prepositional phrase ‘with a sizeable uncertainty’ is used. The quantifier *sizeable,* as well as *uncertainty*, auxiliary + verb *can affect* and *estimated* all eat up the certainty of the contents of the sentence.

4. TAR:

> Thus, relative to IPCC (1990) and over this past decade, there are now more forcing agents to be accounted for, each with **a sizeable uncertainty that can affect the estimated climate response**.
>
> (IPCC TAR, 2001)

I have again tried to find a widely representative set of adjectives. These are the kinds that might be used to qualify knowledge in a broad sense, not necessarily such that might be used to qualify especially climate science articles. I expected some logically connected expressions to feature in physical science text, but this expectation proves to be a weakness in my study. Yet I can analyse to some degree what are the stances and/or the epistemological issues like in these reports. The adjective significant (as in ‘significant emissions, forcing, effects, and impacts’ et cetera) is chosen to affect the reader. Not many of the chosen adjectives appear in the reports more than a few times. So, the ones that feature most, are most likely considered to be useful in the context of the IPCC program.

Adjectives are not the main hedging devices. Yet in the group of them, *possible* and *likely,* are chosen to denote to likelihood and *likely* as an adverb is to become a part of the ‘uncertainty language’ used in the later IPCC reports. The normalised frequency shows that *likely* is appearing in SAR already 2.3 times more often, in TAR a slightly lower ratio 1.9 can be found. It becomes apparent that SAR already shows a marked change in hedging devices. Whether this points straight towards an early deployment of ‘uncertainty language’, as displayed in the IPCC Guidance Notes, is more difficult to prove.

However, the overall number of adjectives I was interested in slightly drops: FAR shows a total of 1.10 per cent, SAR 1.02, and TAR 0.97 per cent. Because of my methodological grievances, I consider these results preliminary.

It is possible that there is movement towards qualifiers that deal with the assessment process in a more concrete way than describing something as *significant* or *possible*. Such qualifiers might also open a path towards numerical expressions of likelihood or intercomparison of certainty of outcomes especially when the assessment of an increasing number of studies is concerned. Yet, the subject (climate change science) can withhold its ‘significance’ throughout the series of three first reports: significant is very much on top of the tables. (Who wants to write about insignificant science?)

If approximators can be used in numerical context will they become more important than adjectives (with a strong epistemological meaning) in the search for most secure and up-to-date scientific information about climate change? So, can the increased uncertainty in the line of these reports, as expressed also by adjectives, be caused by

1. The sheer, and growing ambition of the IPCC aims concerning the climate science,

2. and, therefore, the constant search for more accurate methods, and more accurate results,

3. and, by an understanding among scientists that **the description of the climatological processes is not enough, but more tangible results are necessary to cause appropriate climate action?** Numerical expressions, though they cannot be expressed with a hundred per cent accuracy, but as approximations, are more solid and leave less room for personal interpretation than, for example, adjectives.

4.6.6. The amounts of knowledge and the temporal context of knowledge

1.Approximators, also numerical; and concepts related to those; the importance of ‘estimates

set_hedgesapprox = {'quantitative', 'much higher', 'amount', 'index', 'level (of *knowledge, *confidence, *simplification, *understanding)', 'measure*' 'qualitative', 'quantif*', 'precise', 'maximum', 'close', 'small', 'between', 'any', 'large*', 'much larger', 'much more', '±*', 'somewhat', 'range*', 'adequate', 'fraction*', 'at least', 'value', 'approximate', 'exact', 'order', 'sign', '(a) few', 'fraction', 'much smaller', 'limit*', '*accurate to within*', '*measure', 'less', 'fewer', 'much greater', 'below', 'precise', 'as much as', 'same', 'more', 'under', 'random*', 'nearly', 'over and above', 'strong*', 'sizeable', 'exact', 'far', 'equal*', 'same', '*specif*', 'quantit*', 'nominal', 'above', 'very', 'compare', 'decrease', 'close to', 'accurate', '*minimise', 'much less', 'roughly', 'much poorer ', 'vicinity', '*estimate', 'many', 'increase', '*minimum', 'adjust*', 'about', 'much longer', 'around', '*estimating', 'correspond', 'adequat*', 'large', 'smaller', 'add', 'reduce', 'quality', 'multi', 'range', 'similar*', 'counting', 'relative', 'average', 'mean', 'extension', 'precis*', 'size', 'much narrower', 'much', 'count*', 'rate', 'match', 'correlate'}

For Table, see Appendix 2.7. p. 104–107.

I have chosen a very large set of items for my list. The idea is not to claim that words like ‘value’, ‘level’ or ‘magnitude’ per se are approximators, but I wish to reveal how they are used to produce (only)? relatively accurate knowledge: that is, an absolute certainty of outcomes is not an achievable goal in the context of climate science studies and their evaluation. The comprehensive list derives mostly from Hyland (1996, 1998), Ferson et al. (2015) and data. Some of the items I have tried to discover through extending from the material. The list I have chosen clearly shows that approximators are a very important means of hedging in these reports, despite the list comprising of potentially controversial items. I further believe that the core, most illustrative, scientific expression in these reports, including some of the hedging (verbs excluded), is not supposed to occur through adjectives but through nouns (also concepts), and approximators. This is hard science, and what exactly is being counted and how much do we have of it, matter.

So, approximators form the single most important hedging device in the reports. In the ‘uncertainty language’, finalised and deployed a little later, in AR5, the very ‘uncertainty’ itself, in the forms of ‘evidence and agreement’ and ‘probability’/ ‘likelihood’, is being expressed quantitatively, and approximated. At the other end, we have ‘confidence’, the ‘levels’ of it, approximated through a process resembling the Delphi process. How did the IPCC Working Groups, under the guidance of their Technical Supporting Units, get there?

The numbers of approximators in the respective reports do not drop so drastically, in an absolute sense, as in other groups of potential hedges. In FAR, the two leaders are *change* and *increase*, in SAR *estimate* and *change* but in TAR we have *change* and *mean*. I understand that *change* and *increase* are not hedges but they describe the volatility, or ‘blur’, the contents of these reports in large scale. Is FAR closer to describing the actual knowledge content of climate change, whereas SAR is about ‘estimates’, and TAR about probability? In the big picture, these sequential reports are, of course, about the volatility and vulnerability of the atmosphere; the very changes that take place in it, as the sentence and excerpt below indicate:

1. SAR:

> ‘**The very high frequency changes** are too rapid to affect the climate noticeably’ (IPCC FAR, 1990).

The budget for CH4 is given in Table 2.3. The estimate for the atmospheric turnover time of CH2 has been revised to 8.6 ± 1.6 yr down from 10 ± 2 yr in the previous IPCC report. Two factors are responsible for that **change**: (a) a new estimate for the chemical removal rate (11% faster; see Section 2.2.3); and (b) the uptake by soils (included in the previous budget, but not in the calculation of the turnover time).

The radiative forcing due to **changes in ozone is more difficult to calculate** than those of the other greenhouse gases for a number of reasons. First, **ozone changes** cause **a significant change** in both solar and thermal infrared radiation. Second, the effect of stratospheric **temperature change** as a consequence of **ozone loss** in the lower stratosphere significantly modifies the radiative forcing. Finally, **uncertainty in the spatial distribution of the ozone loss**, in particular in the vertical, **introduces significant uncertainties** in the consequent radiative forcing. These issues were discussed in detail in IPCC (1994) who concluded that the adjusted radiative forcing **as a result of decreases in stratospheric ozone was about —0.1 Wm-2 with a factor of 2 uncertainty.**

(D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R. SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LA, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).

Forster and Shine (1997) have also extended the computations back to 1964 **using O3 changes deduced from surface-based observations**; combining these with **an assumption that the decadal rate of change of forcing** from 1979 to 1991 was sustained to the mid-1990s yielded a total stratospheric O3 forcing of **about −0.23 Wm−2**. Shine and Forster (1999) have revised this value to −0.15 Wm−2 for the period 1979 to 1997, choosing not to include the values prior to 1979 **in view of the lack of knowledge on the vertical profile which makes the sign of the change also uncertain.** They also revised **the uncertainty to ± 0.12 Wm−2 around the central estimate.**

(IPCC TAR, 2001)

In TAR, the top of the hit list also show *increase*, *value*, and *range*. *Large** in between acts as a qualifier. *Increase* is only twice linked to *confidence* or *uncertainty* – it tells the all-important story of increased radiative forcing that causes climate change.

'Estimate' is a key word. Because it is very frequent, I will present it in more accuracy below. However, the first excerpt shows that *estimate* can also be scaled: it occurs alone most often, but in the context of results it is used as a scientifically approved 'best estimate' of something. (That I do not know, how good a 'best estimate' is: it could potentially be an educated guess.) Yet, the increase in *estimate* may point to a more significant event in science: if we assume progress (in science) to take place when from suggestions, we can move on to quantified, even numerical estimations, we have better results (and better science)?

Uncertainty below is quantified using approximators. *Sign* is an approximator – if the sign is uncertain, we get an estimation which can reside either on the negative or positive side, widening the range of uncertainty. The second example also shows the use of ‘a factor of + numerical’ as an approximator:

2. TAR:

> […] **the uncertainty in the radiative forcing is large and even the sign is in doubt** due to the competing nature of the short-wave and long-wave effects. The studies above suggest, on balance, that the **shortwave radiative forcing is likely to be of a larger magnitude** than the long-wave radiative forcing, which indicates that the **net radiative forcing is likely to be negative, although a net positive radiative forcing cannot be ruled out**. **Therefore a tentative range of −0.6 to +0.4 Wm−2 is adopted; a best estimate cannot be assigned as yet.**
>
> (IPCC TAR, 2001)
>
> Ross et al. (1998) performed a similar measurement and modelling study **estimating** a local annual mean radiative forcing **of −2 to −3 Wm−2** in intensive biomass burning regions, indicating that the global mean radiative **forcing is likely to be significantly smaller than** in Penner et al. (1992). Iacobellis et al. (1999) model the global radiative forcing as −0.7 Wm−2 but use an emission factor for biomass aerosols that Liousse et al. (1996) suggest **is a factor of three too high,** thus a radiative forcing of −0.25 Wm−2 is **more likely**. These **estimates** neglect any long-wave radiative forcing although Christopher et al. (1996) found a discernible signal in AVHRR data from Brazilian forest fires that opposes the shortwave radiative forcing; **the magnitude of the long-wave signal** will depend upon the size, optical parameters, and altitude of the aerosol.
>
> (Ibid.)

In other words:

1. If ‘estimate’ is a move forward from ‘suggestion’ (or a guess), and a ‘quantified’, or numerical estimate better still – i.e., if calculated estimates, model simulation results, and observations are as good as it gets –

2. If ‘uncertainty’ can also be given as a quantified measure –

3. If ‘likelihood’, ‘confidence level’, or, for example, ‘the level of scientific understanding’ can further be quantified in some measurable way and –

4. If all the above allow intercomparisons between the results, and/or quantifications, arrived at by different scientists, and/or groups of scientists, in different moments of time, we have reasons to believe that the results reflect more accurate, more reliable knowledge? Knowledge that accumulates?

If I follow this line of reasoning, I arrive at an inherent claim in these IPCC reports: there in little room for personal interpretations in climate change science. The numbers speak for themselves and succeed in reflecting accurately and adequately the measured, quantified and, in the context of direct observations, also tangible results thus far; and despite the range of uncertainties remaining, this should lead to the proper climate action by policymakers.

However, the sheer number of 'uncertainty'-related expressions may seriously jeopardise this reasoning. A case in point is to understand the compartmentalisation of uncertainty: the big picture about climate change is getting clearer and clearer despite the endless complexities in details. The use of model simulations and any different kind of methods for calculating the 'best estimates' for parameters are an integral part of climate science.

This characterisation is unlikely to undergo changes (or, finally, all scientists would become redundant): hence, for policymakers' and audience's needs, an alternative approach to expressing uncertainties in climate science is created. It is not necessarily a simplification only; but it is also that. When I read through my chosen excerpts, I was delighted of the versatility of expression in them; approximators, adjectives and all. I fear something of that may also be lost. The straightforward advance usually seen in research articles (for example, IMRAD-structure[14]) is there, but it is supervened by the constant assessment process of previous works. In the process, vocabulary is also affected, the use of it guided, and finally, it is impoverished. In this context, I raise the question that Swales and Hyland have made in another form: If an institution is running by scientists it is still an institution. If this institution co-operates closely with politicians (The chairman of the IPCC, Professor B. Bolin, spoke of "a marriage between science and politics" in a climate meeting in Washington, 1990. There is the UN context, too.) will we see that the linguistic practices in science papers expected to protect an individual, or lead into individual gains, are just used to protect, and benefit an institution? I wanted to make a disclaimer on this, but, again in hindsight, being a celebrated institution and devoted to objectivity, and taking great pains to create accurate and careful expression in scientific writing have been inefficient to cause the needed climate action. *What is the root cause for this inefficiency? How to create climate responsibility?* (More discussion of changes in vocabulary in Appendices.)

I use one example from TAR a second time:

> The estimate for the direct sulphate aerosol forcing has also seen multiple model investigations since the SAR, resulting in more estimates being available for this assessment. It is striking that consideration of all of the estimates available since 1996 lead to the same best estimate (–0.4 Wm−2) and uncertainty (–0.2 to –0.8 Wm−2) range as in the previous assessment. As in the case of O3, that could be a motivation for elevating the status of knowledge of this forcing to a higher confidence level. However, there remain critical areas of uncertainty concerning the modelling of the geographical distribution of sulphate aerosols, spatial cloud distributions, effects due to relative humidity etc. Hence, we retain a "low" LOSU for this forcing."
>
> (IPCC TAR, 2001)

[14] IMRAD refers to a common framework in research articles, where Introduction-chapter is followed by Methods, Results, and Discussion -chapters.

The ‘uncertainty language’ used has been criticised for sowing confusion, especially as it has not been used concisely throughout the reports by different Working Groups (Janzwood, 2020, in *Climatic Change* (2020) 162, pp.1655–1675). Moreover, the practices of it do not necessarily seep into articles about climate change in newspapers or social media platforms, but a return to more ‘conventional’ hedges takes place (Collins & Nerlich, 2016)). However, in the IPCC Reports, it is mostly expected to be used in the Summaries for Policymakers and introductory texts (see Appendix 1.9., pp.95–96).

2. Time in the context of knowledge acquisition: past, present, and future references

set_hedgesapprox = {'past', '1986', '1987', '1988', '1989', 'interval', 'present', 'short-term', 'near-term', 'medium-term', 'long-term', '100 000*', 'millenium*', 'recent', 'decade', 'temporal', 'decades', 'far', 'prediction', 'next', 'last', 'century', 'new', '1765', 'future', 'hundred*', 'old', 'time-scale*', 'seasonal', 'periodical', 'cycle', 'temporal', 'interval', 'period', 'long term', 'short term', 'time', 'times', 'yearly', 'decadal', 'terminal', 'termly', 'industrial', 'pre-industrial', '1750', '1850', '1840', 'years', 'near', 'far', 'centuries', 'millenial', 'millenia'}

For Table, see Appendix 2.8. p. 107.

A part of the difficulty and fascination of climate science may be that it makes estimations (and even predictions (Pentti Rapeli, personal information)) about the climate of ‘past, present, and future’. The verb ‘predict’ occurs in the reports all in all 28 times, not necessarily with a clearly expressed time reference, but with ‘models’ or ‘scenarios’. Yet, ‘prediction’ may not be a first choice -word to use in science. Unlike ‘predictions’, references to ‘scenarios’, ‘model simulations’ and ‘estimates’ do not remind the reader of a crystal ball or Tarot-cards but calculated probabilities and computers:

> To estimate climate change using simple energy balance climate models (see Section 6) and in order to estimate the relative importance of different greenhouse gases **in past, present and future atmospheres** (e. g., using Global Warming Potentials, see Section 2 2 7), it is necessary to express the radiative forcing for each particular gas in terms of its concentration change.” (IPCC FAR, 1990)

In the series of reports under investigation, we have one major result: the anthropogenetic cause of climate change (The ‘final’ scientific verification can be found in the IPCC AR4, (2006), but the stance of the scientists involved in all the IPCC activities towards an impending man-made ‘climate change’ has been nothing but approving.) Here are some ways to express the focal causal link from various summaries and introductions in the FAR, SAR, and TAR respectively, as well as terminology- and likelihood language-related footnotes:

> 1.) These increases [emissions of the greenhouse gases resulting from human activities] will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.
>
> 2.) The size of this [global – mean surface air temperature increase by 0.3°C to 0.6°C over the last 100 years] warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural climate variability. Thus the observed increase could be largely due to this natural variability, alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming.
>
> 3. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.
>
> 4.) This report is a summary of our understanding in 1990. Although continuing research will deepen this understanding and require the report to be updated at frequent intervals, basic conclusions concerning the reality of the enhanced greenhouse effect and its potential to alter global climate are unlikely to change significantly. Nevertheless, the complexity of the system may give rise to surprises. (Ibid.)

These excerpts give somewhat contradictory evidence of human-caused greenhouse gas effect and the ensuing global warming from observations. That is: observations from the past 100 years do not lead into absolute certainty of the causal relationship between human induced emissions, greenhouse gas effect, and climate change. 'Greenhouse gas effect' is a real phenomenon that occurs whether human beings increase emissions to the atmosphere or not. It is the potentiality that it may, or may not have, in altering the climate system that ultimately relies on a balanced trade-off of gases in the complex Earth – atmosphere system that is more difficult to show: and, how significant is the part that human caused emissions play? The excerpts from SAR and TAR clarify first the key concept and then move on to manoeuvring of remaining uncertainties. As the assessment of contemporary research is central to these reports, we also have a timeline that consists of assessed and referenced studies. And finally, time is of the essence when trying to curb the climate change.

So, the task of assessing new research continuously in the IPCC Assessment Report -series, and the complexities in the field of climate science combined, render it impossible to arrive at certain conclusions. The increased observational capacity and developments in models bring us closer to for example, 'agreeing' on (anthropogenic) climate change. FAR showed conservative hedging practices, SAR tried a more philosophically spirited approach, but TAR showed how prolificacy in new studies, methodological developments, and somewhat contradictory results lead into an accumulation of 'uncertainty' and 'estimations' despite the push for more certainty and accuracy, and positive developments. How to influence the policymakers in the best possible way to act and curb climate change if new – and better results – come with uncertainties of their own? I no longer wonder the need to create a rhetorical device to assess

a) the contemporary results in scientific research,

b) and the (future) risks

through the use of ‘a calibrated uncertainty language’. It is also important to notice that TAR shows a closer affinity in its hedging practices to ‘risk (assessment) and management perspectives than FAR and SAR. Acknowledging that climate change is one of the greatest risks to mankind and using calibrated risk assessment language in high-stakes scientific reports go well together. So, I believe that a development towards using hedging practices that are closer to risk assessment and management in the first three IPCC reports has taken place. I use an illustrative piece of advice given in Mastrandrea et. al., (2010):

> Sound decisionmaking that anticipates, prepares for, and responds to climate change depends on information about the full range of possible consequences and associated probabilities. Such decisions often include a risk management perspective. Because risk is a function of probability and consequence, information on the tails of the distribution of outcomes can be especially important. Low-probability outcomes can have significant impacts, particularly when characterized by large magnitude, long persistence, broad prevalence, and/or irreversibility. Author teams are therefore encouraged to provide information on the tails of distributions of key variables, reporting quantitative estimates when possible and supplying qualitative assessments and evaluations when appropriate. (p.1)

The ideal of objectivity, often also described as ‘large scale international/scientific co-operation, full partnership’, etc. (see e. g. the IPCC Session 1, p. 1; IPCC Session 2, pp. 16–24) authority claims (or, given authority) and institutional context and high stakes (political, economic, health-related etc. – in global scale) force the effort to develop such an uncertainty language necessarily to be aspirational. Though the works of the IPCC Working Group I (‘The Scientific Basis of Climate Change’) are not as affiliated to describing the risks to our lives and livelihoods that a continued warming of the planet will cause, as the works of IPCC Working Groups II and III (‘The Impacts, Adaptation and Vulnerabilities Related to Climate Change’, and ‘Mitigation of Climate Change’ respectively), for the sake of consistency and equal and transparent calibration, all working groups were and still are advised to use the ‘uncertainty language’ similarly.

I have looked into the uncertainty-related expressions in the first three WG1 IPCC reports, their respective “Radiative Forcing of Climate Change” -chapter. ***They, in hindsight, are the ones that should have had the perlocutionary force to compel climate action.*** *CO_2 emissions, the single most important GG, has the biggest potential to cause radiative forcing and climate change.* Now we are here as indicated by news headlines like these: ‘Wildfires, heatwaves may be the ‘new normal’ as UN releases damning climate report’ (FRANCE24, 9th August 2021); ‘Report: Finland reacting too late to climate change security threats’ (YLE, 31st August 2021), et cetera. I summarise the results from the point of view of these present-day indications.

Uncertainty language is an attempt to affect the decision-making processes of politicians indirectly: It aims to describe any uncertainties in climate science as accurately as possible and make the scientific authority the IPCC has tangible through quantifying such parameters as expressions of shared ‘confidence’ and ‘agreement’ among scientists. The uncertainty language serves the needs of a more unexpert reader and spares their time also through the quantified ‘likelihood’ -expressions. The early reports show the developments towards such a ‘time-saving short-cut to uncertainty’.

Combining some of the aspects of qualitative and quantitative results: The Prefaces were of unequal quality, with TAR showing finally straightforward and confident language use. The bulk texts from the report-chapters were of better quality, but the assessment process rendered it difficult to arrive at secure numbers concerning hedged items: I could not detect a decrease in uncertainty from numbers directly. The IPCC trusts the utility of the ‘uncertainty language’ but the relevant decreases in climate science uncertainties show rather as an increase in confidence; more robust evidence; greater scientific agreement; and better estimates that fall within tighter margins. The break-through of model-based science is detectable in this report-series. Probabilistic calculus, and approximators are important tools. Science navigates its way through uncertainties, though they be in narrower windows, in the context of high stakes and demand for accuracy.

From the perspective of genre, to convey the decision makers of the dangers climate change already causes (and will cause in the near future) is a very important question. It is difficult to prove that uncertainty language is efficient in causing action. More of this in the last discussion-chapter.

5. Discussion

I explored some introductory text samples from the first three IPCC reports and the related IPCC meeting documents. The excerpts in the Methods-chapter of this paper already show that there is some epistemological wobbliness in the expressions concerning, for example, the anthropogenic origin of climate change. Yet, the meeting documents (‘IPCC SESSIONS & IPCC WGS SESSIONS’) from the years 1988 – 2001 show that politicians present in the meetings never doubted the reality of climate change. Even if research needed and needs to continuously reduce the uncertainties, the message had demonstrably been understood (for verification, see IPCC Session Report I, 1988, Annex III, available at https://archive.ipcc.ch/meetings/session01/first-final-report.pdf. Only one of the government representatives was skeptical).

For me, this is effectively a no brainer: to reduce and finally tackle any remaining uncertainties was one of the key tasks that scientists were given. Yet politicians revealed a profound understanding of the danger climate change will cause and expressed a need to act accordingly even if the IPCC FAR was, at that point of time, in its early stages. *[To reduce the uncertainties was therefore a redundant activity, and the ensuing 33 years' inaction by politicians and decision-makers could well be a proof of how money comes first.]*

In some scientific papers, the WG 1 has also been criticised for not using a 'right' kind of 'uncertainty language' in its assessment: the likelihood of weather-related phenomena is, even in the context of describing the scientific basis of climate change, perhaps less important than informing the public (and decisionmakers especially) of the most severe risks they impose. The ways science discusses its relevant issues with society is a matter of significance. I wish, however, not to put the blame of inertia solely on climate scientists, but to the overall neglect of our environment and the entire planet, against better knowledge. To use such parameterisation in risk assessment models that mostly rely on averages, or medians instead of also accounting for the extremes and outliers that are significantly rarer phenomena may, however, have led to the deplorably low willingness to adequately mitigate the consequences: that is, extreme heat waves will take lives because, for example, air conditioned homes are a matter or convenience, or a privilege for the few; cities have no respites included in city plans; nor adequate drainage systems to protect against flash floods; and storms can easily damage infrastructure such as electricity nets. Some scientists believe that our near future looks bleak (see for example: 'CCC: Adaptation to climate risks 'underfunded and ignored' by UK government' in Carbon Brief, 16th June 2021; similar news recently from Finland, too.)

[I wrote this text on 13th July, on the 15th, Western Germany was hit by torrential rains, flash floods and even landslides. Some villages were swept away like hit by a tsunami. The Belgian city of Liege, which lies downstream from the flood area, fears for the worst. Today, the 16th, the death toll in hardest hit area in Germany is above 100, with 1300 still unaccounted for. There are hopes that many still missing will be found in relatively good health, once the electricity and mobile networks which went down restart. Some have already attributed this

event to warming climate, but there is yet no certain way to immediately do so (YLE, 16th July 2021).]

But how should risks be addressed in scientific texts? If they are not only projections of the past and present observations projected to the future, but part of 'the scientific imagination', and more or less successful theorising (for discussion on this, see Hollis, 1994, p. 59–60), how to discuss their probability in a way that gives credibility, and illocutionary force to the texts? What happened in the past remains in the past. What will happen in the future may indeed happen to us or to our children.

I think that such headlines about the issue of climate change which purport 'new temperature records' been hit or follow the example in today's news: 'US declares first ever water shortage for Lake Mead, its largest reservoir', in france24.com-newssite may be problematic, too. They have an air of 'the exceptional' around them, but climate change, as it progresses, means that 'exceptional' will be the new normal, as will be the everyday suffering and loss of biodiversity.

How to build a robust scientific expression around (model) predictions, is a process underway. In risk related context, the acts that follow are essential. What the IPCC did was to divide the resources at its disposal into three Working Groups, those responsible of informing the world of the scientific basis, impacts, and adaptation and mitigation of climate change. None of these WGs wanted to cause panic but emphasised the need for speedy action. All relevant data was then combined into SYRs; Synthesis Reports; and craftfully abbreviated into Summaries for Policymakers. The 'uncertainty language' was especially created to be used in the latter ones. Yet, despite the work-intensive production processes, the impact of these reports has been weak. The hoped-for action has come too little, too late.

In 1989 the Second Meeting of the IPCC in Nairobi discussed the progress done in writing out the FAR. Model uncertainties expressed by WG 1 may have been a disappointment to some participants who wished to get more data on regional impacts of climate change. The Chairman of the WG 1, Dr Jenkins, responded to a suggestion that the uncertainties attached to all model predictions could well be expressed using categorization of "the degree of certainty" as "high, medium of low". What comes to peer reviewing process of the report he admitted to the fact that also statisticians and physicists be among the peer reviewers (IPCC Report of the Second Session, 1989, pp. 10–11.). In hindsight, should also philosophers, psychologists, and cognitive and marketing scientists have been included? Risk awareness and management expertise could have saved the day?

I quote yesterday's news from FRANCE24 (31st July 2021): 'Finland is facing the worst forest fires in 50 years.'. If I think of climate change attribution science, should it be advisable, instead of referring to the past when hitting new records, always to make a future reference, too?

The early reports sought to

1.) study historical records of climate events,

2.) observe the present,

3.) and, if observations showed an increase in the events,

4.) attribute, with highest possible certainty, the increase to climate change.

This very feasible way of making science may not have been enough to cause political action. If a weather phenomenon has taken place in the (fairly) remote past, we can not necessarily attribute it to our own emissions. It just may be something that belongs to natural variation. On the other hand, if we can attribute the present events to climate change, we are already too late! If our future as a species is under threat, the future reference must be there to cause the necessary action so as to be ahead of the events. Do not look into the past, but to future. Use the (now reliable) models, accept a certain amount of uncertainty if necessary, and inform us of the worst-case scenarios. Risks, luckily, do not always come true but to be ready is wise.

[Did we come too late because we have used, in the future related context, an impotent logic? The newest, fresh-from-the-oven WG1 Assessment report is very much about risk assessment, both global, and regional. It has a special chapter dedicated to those.]

From the third session in Washington, D. C. on, we get the opening speeches of leaders of the hosting nation:

George H. W. Bush:

> I believe we should make use of what we know. We know that the future of the Earth must not be compromised. We bear a sacred trust in our tenancy here – and a covenant with those most precious to us: our children and theirs. We also understand the efficiency of incentives – and that well-informed free markets yield the most creative solutions. We must now apply the wisdom of that system, the power of those forces, in defense of the environment we cherish...

In the same context, the Chairman of the IPCC, Professor B. Bolin said:

> The large number of meetings that have taken place all around the world during the year of 1989 and particularly the Ministerial conference in Noordwijk in November of that year as will as the President of the United States greeting us at his time, show that there is now a general awareness among nations about the threat of a likely climatic change. A first phase of the politics of climate change is thereby coming to an end and we are entering second one.
>
> This new phase can be most easily characterized by a few key questions:
>
> How will my country be hit?
>
> […]

He also emphasised that even if the concept of CO2 equivalence for different gases was ‘well in hand’, uncertainties remained because there was “fundamental difficulty in model validation”. However, the range of uncertainty in the predicted global warming estimate (by “1.5. to 4.5 centigrade for the case of a doubling of CO2 in the atmosphere”) could be “somewhat reduced during the next five years”. At that moment, there was no way to predict regional impacts reliably, nor to adequately consider the effect of clouds on models. So, Bolin reflected:

> Further, I am wondering sometimes why those that consider the projections to be overestimates of future changes are considered more sensible by many politicians than those that worry about the upper part of the scientifically established uncertainty range.

Why, indeed? He also emphasised the importance of the “fossil fuel issue” (that is, how to stabilise and eventually decrease CO2 emissions) and urged it be addressed immediately and concluded: “This is one [global issue] in which the marriage of science and politics in the good sense of the word is indeed most essential.”

I quote my own words in the first paragraph from the Methodology-chapter in this very paper:

> The IPCC is, due to its intergovernmental contacts, and constant and comprehensive expert reviewing system; *the* key factor in guiding the contemporary climate change policies worldwide. It claims to meet all its obligations objectively and not to dictate political decisions while having already achieved authority position in science.

What do authorities generally do? A scientific authority knows best, is vocal in its opinions but has its hands absolutely tied what comes to action? Maybe the IPCC never was “an authority” but in word only. All actions were supposed to be taken by the governments and organisations such as the IEA or OPEC. The question is: did the IPCC act as a part of the political system from inside out rather than outside in? In the process, it made friends from right and left and failed to use its authority (which is “the power or right to give orders, make decisions and enforce obedience"), ensure that the acts needed to save the planet were taken. This line of thought clarifies why civil action, in the form of rebellion, is needed. Science does not evoke legal action. I deem the marriage of science and politics in this context an unhappy one – the offspring, adequate climate action, has never realised.

What comes to "scientific authority", it seems to be weak in the context of the 'wide world' even if knowledge be the best possible, and it is conveyed to the public and decision-makers in the best possible way. By this I do not mean that the of developing an 'uncertainty language,' and hedging practices, especially in an environment where risks are increasing, should be discarded.

I also draw further parallels between the responses by the WHO and national and local health care systems to curb the Covid-19 pandemic, and the IPCC and climate conferences. In a world where individual and corporate freedom exists, what can be done? If "freedom" paradoxically is a delimiter when something absolutely needs to be done to save the health and viability of our societies, economies – and the whole planet Earth, then "freedom" is dangerous. The governments are thereby forced to take legal action or withdraw from it. In the case of the pandemic, even financial incentives are mulled by the US Government to curb vaccine hesitancy (Foxnews, 2nd June 2021, 'Biden announces new incentives, including free beer, to reach COVID vaccination goal') https://www.foxnews.com/politics/). At the same time, we are warned by the IEA, The International Energy Association, that 'Covid recovery will drive global emissions to new heights' (rfi, 21st July 2021) – just when the IPCC is informing us that our climate has warmed much faster than its models predicted due to underestimates in the so called 'feedback mechanisms' and our chances to counteract dangerous climate change are literally slimming by the minute. Vaccine hesitancy, and allowing increases in carbon emissions are both, to me, madness, but science is not able to remove that.

I must assume that the cause for inaction is inequality; to it I also include lack of education. The improvements on that issue might also lead into science getting a stronger position in our societies when guidelines are needed. How to create the political motivation (economic growth) for equality to spread, I know not.

IPCC's parent organisations are WMO and UN. If we think that reducing poverty is the major goal of the UN, and reducing poverty is linked extremely strongly in our minds with economic growth, then the IPCC could never be against economic growth. The easiest way to create it is through providing cheap energy by burning coal. The intricate international balancing policies to keep the actual emissions at bay may never have been there.

What I also find worthy of inspection is the increased use of computer models and simulations in accruing knowledge. For me, they are methods that give results after interpretation and assessment of inherent uncertainties, but for some, they seem to equal ‘scientific knowledge’. The huge advances made in the accuracy and over all reliability of, say, climate models must have convinced many. New ‘attribution science’ relies on models. We will soon be informed by AI in our decision-making processes. What kinds of linguistic hedging expressions will guide us? Models predict ‘with the level of confidence C that a scenario S (or an event E) is likely – within the percentage range of [X ,Y] or [X, Y[– to occur in the chosen time frame T? And then, for example, a suitable risk management process can be chosen, either at regional or more global level (which are not necessarily the same)?

The recent fires and flood catastrophes show that, historically, not all models have been accurate. Nor has risk assessment/management gone right during the last 33 years. Our economies and societies are even more vulnerable than before, despite the success story of the IPCC as an institution.

Hedging in economy means the sheltering of one’s assets from a crash. Hedging in the language(s) of science means sheltering one’s methods, results and theorising from too much harmful peer critique. I believe these two are related. The IPCC opened up its reports and assessment processes, and all uncertainties in those, to peer review and panel audience (governments, organisations). Despite the openness, and the slow but resilient reducing of uncertainties, it was singled out as the most significant authority in climate change science. It was able to garner approval, fame, and funding from all around the world very quickly and become one of the most significant UN expert institutions (alongside the WHO; now more than ever because of the pandemic). Both institutions use sophisticated language to inform us of the reality we live in now, and to warn us of the dangers that lie ahead. The idea is: learn the language, do the thinking, do the appropriate risk analysis, and use the time we have efficiently to brace and protect our societies and economies (regionally and globally).

Calibrating the uncertainties and probabilities into a likelihood-language and the consistent use of such language across the series of IPCC reports was considered an issue of some importance early on. The difference between *how to assess the reality of the climate change* (scientifically, and with uncertainties and all) versus how to inform the public and policymakers in a comprehensive manner and discuss climate change issues *at large* are two different things. The latter part has also received a lot of attention. Yet, the importance of reducing overall uncertainties across the field – very much so what comes to models – has likewise been stressed repeatedly in both contexts, by the scientists themselves as well as by politicians, larger public. *So, the need to create guidelines for estimating national greenhouse gas emissions (for greater model accuracy and consistency);* ***practical dimension****; and the need to create guidelines to express any remaining uncertainties consistently across all Working Groups;* ***artful (linguistic) dimension****; have been dealt with parallelly.* If we add into this concoction the need to publish the reports in context of major climate conferences (World Climate Conferences, later Convention of the Parties; COP) (FAR in time for Malta, 1990; SAR for COP 1, 2; TAR for COP 6, 7; et cetera) we can understand the pressure the IPCC experts have been working under. Despite the stress they were increasingly pushed to use the chosen expressions of uncertainty language; to express confidence and likelihood of climate change -related phenomena with reasonable clarity, consistency, and accuracy. How efficient has this linguistic precision tool been in guiding our actions in the recent decade or so and how efficient can I expect it to be now, when we more than ever need to manage (less and less potential and more and more actual) risks, in the world where resources and assets are unevenly distributed, even scarce? I say: less efficient than observed fires, droughts, and floods. What, then, can be done to find ways to discuss risks effectively and to bring about the creation and deployment of the necessary safety mechanisms? And, has the assessment process which affects the amounts of perceived uncertainties in these reports been detrimental to the perlocutionary force of the IPCC?

[Scrapping the language: who benefits if the accurate measures are taken, who benefit if not? Depending on whether 'short term, medium term, or long-term approach is applied the answer may be different. In long term, there possibly are no beneficiaries. The regional/global distinction can also be significant in finding an answer to this question.]

I started to write this thesis paper by raising questions about the relationship between (objective) science, institutions, political decision-making, and audience in general. What comes to linguistic hedging practices, I believe that a lot of progress has been made in finding expressions to convey the increasingly accurate knowledge to politicians and audience. (See for example, a recent (26th July 2021) article in FRANCE24: 'Extreme weather smashes records as scientists convene for UN climate talks', where many of my initial questions are indirectly answered.)

But how efficient an influencer is science? If it be respected *even if the assessment process increases uncertainties and approximation*, and moreover, if ‘everybody wants a piece of it’, like in the case of the IPCC, why then has the closely related and in this case, sufficiently guided political decision-making process been slow and inefficient? Because of money, power, and corruption? Because we are too many?

A new IPCC report is only days away, undoubtedly attributing several of today’s extreme weather phenomena to human induced climate change. A new Convention of the Parties will take place, undoubtedly ‘graced by the presence’ of a Royal Highness or two. I personally look forward to drastic and efficient climate action. If this does not happen, the acclaimed IPCC has failed. Then, time has come to join the demonstrators.

This study comes with methodological grievances and uncertainties in results. But there are some results that I am certain of. For example, I have cause to grieve the little impact the two first generations of climate scientist’s work had on political stages. I have cause to grieve for this planet. I now contemplate the climate rebellion movement with great understanding and empathy, and do not in the least doubt their wisdom.

I quote Sir John Houghton a second time:

> I am confident that the Assessment and its Summary will provide the necessary firm scientific foundation for the forthcoming discussions and negotiations on the appropriate strategy for response and action regarding the issue of climate change. It is thus, I believe, a significant step forward in meeting what is potentially the greatest global environmental challenge facing mankind.
>
> Dr John Houghton
>
> Chairman, IPCC Working Group I (IPCC FAR, 1990, p. vi)

Hmmm. SR

From: https://www.france24.com/en/

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Applications:

AntConc_64bit(1)exe.

IDLE(Python 3.8. 32-bit)

Appendix 1.

1.1. Hughes (2010):

> Archival records of the history of climate change extend back through time for hundreds of thousands of years, but the knowledge of these archives and the ability to interpret them is a scientific development of the nineteenth through early twenty-first centuries. Through theoretical propositions, experimentation, study of proxy records, historical documents, and computer models that simulate the past, and potentially the future, with increasing accuracy, climatic cientists have achieved a general consensus on the process of climate change that is useful to historians as they develop interpretations of the changing relationships of human societies to the environment. The tenor of scientific discourse about climate change in the decades from the second quarter of the nineteenth century to the present has changed considerably and exhibits three major periods. Each of these periods is characterized by one of three phases of scientific effort and its relationship to society. Briefly put, they are a period of hypothesis, a period of gathering evidence and testing hypotheses, and a period of controversy over the application of apparent scientific consensus. Of course, all three of these aspects of science continued throughout recent history: **theories have been developed and tested all along, but these periods do seem to follow an emergent dialectic, and the public debate on the relationship between science and society has unmistakably intensified in the most recent decades.** (Hughes, (2010), pp. 1 – 2, my bolding, SR.)

1.2. About AR6 SYR:

> Synthesis Reports (SYRs) should "synthesise and integrate materials contained within the Assessment Reports and Special Reports" and "should be written in a non-technical style suitable for policymakers and address a broad range of policy-relevant but policy-neutral questions approved by the Panel". They are composed of two sections, a Summary for Policymakers (SPM) of 5 to 10 pages and a longer report of 30 to 50 pages.
>
> The writing of AR6 SYR will be based on the content of the three Working Groups Assessment Reports: WG1 – The Physical Science Basis, WG2 – Impacts, Adaptation and Vulnerability, WG3 – Mitigation of Climate change, and the three Special Reports: Global Warming of 1.5°C, Climate Change and Land, The Ocean and Cryosphere in a Changing Climate.
>
> It might also take into account issues considered in other global assessment (such as Intergovernmental Platform for Biodiversity and Ecosystem Services and UN Environment's Sixth Global Environment Outlook), if those issues are also addressed in the above-mentioned reports.
>
> AR6 SYR will be finalized in the first half of 2022 in time for the first global stocktake under the Paris Agreement. (https://www.ipcc.ch/report/sixth-assessment-report-cycle/)

1.3. An example of how the WG 1 plans to deliver its contribution to the AR6:

> The Intergovernmental Panel on Climate Change decides:

(1) to agree to the outline of the Working Group I contribution to the IPCC Sixth Assessment Report as contained in Annex 1 to this document.

(2) that this report assesses relevant literature, especially since the Fifth Assessment Report (AR5), in a manner consistent with the IPCC guidance on the use of literature.

(3) that the bulleted text in Annex 1 to this Decision, that resulted from the scoping process and refined through comments by the Plenary, be considered by authors as indicative.

(4) to invite the Co-Chairs of Working Group I and the Co-Chairs of WGII and WGIII to develop appropriate mechanisms to ensure the effective co-ordination of Working Group contributions to the IPCC Sixth Assessment Report, to oversee the treatment of cross-cutting themes, and to prepare a Glossary common to Working Groups I, II and III.

(5) In order to achieve this, the timetable for the production of the IPCC Working Group I contribution to IPCC Sixth Assessment Report is as follows:

15 September – 27 October 2017 Call for author nominations

29 January – 4 February 2018 Decision on Selection of authors

25 June – 1 July 2018 First Lead Author Meeting

7 – 13 January 2019 Second Lead Author Meeting

29 April – 23 June 2019 Expert Review of the First Order Draft

26 August – 1 September 2019 Third Lead Author Meeting

2 March – 26 April 2020 Expert and Government Review of the Second Order Draft

1 – 7 June 2020 Fourth Lead Author Meeting

7 December 2020 – 31 January 2021 Final Government Distribution of the Final Draft and Final Government Review of the Summary for Policy Makers

12 – 18 April 2021 Submission to the WGI Session for approval of the Summary for Policymakers and acceptance of the underlying Report

(6) that the budget for the production of the Working Group contribution to the IPCC Sixth Assessment Report is as contained in Decision (IPCC/XLVI-1) on the IPCC Trust Fund Programme and Budget.

1.4. Examples from FAR Introduction; Preface; Words from the Lead Author (IPCC FAR, 1990):

This is the final Report of Working Group 1 of the Intergovernmental Panel on Climate Change, which is sponsored jointly by the World Meteorological Organization and the United Nations Environment Programme. The report considers the scientific assessment of climate change. Several hundred working scientists form 25 countries have participated in the preparation and review of the scientific data. The result is the most authoritative and strongly supported statement on climate change that has ever been made by the international scientific community. The issues confronted with full rigour include: global warming, greenhouse gases, the greenhouse effect, sea level changes, forcing of climate, and the history of Earth's changing climate. The information presented here is of the highest quality. It will inform the necessary scientific, political and economic debates and negotiations that can be expected in the immediate future. Appropriate strategies in response too the issue of climate change can now be firmly based on the scientific foundation that the Report provides. The Report is, therefore, an essential reference for all who are concerned with climate change and its consequences. (no page number)

G.O.P. Obasi Secretary-General in the World Meteorological Organization, and M.K. Tolba; Executive Director in the United Nations Environment Programme, continue the discourse:

> This volume is based upon the findings of Working Group I, and should be read in conjunction with the rest of the IPCC first assessment report; the latter consists of the reports and policymakers summaries of the 3 Working Groups and the Special Committee, and the IPCC overview and conclusions. The Chairman of Working Group I, Dr John Houghton, and his Secretariat, have succeeded beyond measure in mobilizing the co-operation and enthusiasm of hundreds of scientists from all over the world. They have produced a volume of remarkable depth and breadth, and a Policymakers Summary which translates these complex scientific issues into language which is understandable to the non-specialist. We take this opportunity to congratulate and thank the Chairman for a job well done. (p. iii)

And finally, the lead author (J. Houghton) himself:

> Many previous reports have addressed the question of climate change which might arise as a result of man’s activities. In preparing this Scientific Assessment, Working Group I ‘ has built on these, in particular the SCOPE 29 report of 1986 2 , taking into account significant work undertaken and published since then Particular attention is paid to what is known regarding the detail of climate change on a regional level In the preparation of the main Assessment most of the active scientists working in the field have been involved One hundred and seventy scientists from 25 countries have contributed to it, either through participation in the twelve international workshops organised specially for the purpose or through written contributions A further 200 scientists have been involved in the peer review of the draft report Although, as in any developing scientific topic, there is a minority of opinions which we have not been able to accommodate, the peer review has helped to ensure a high degree of consensus amongst authors and reviewers regarding the results presented Thus the Assessment is an authoritative statement of the views of the international scientific community at this time The accompanying Policymakers’ Summary, based closely on the conclusions of the Assessment, has been prepared particularly to meet the needs of those without a strong background in science who need a clear statement of the present status of scientific knowledge and the associated uncertainties. The First Draft of the Policymakers Summary was presented to the meeting of the Lead Authors of the Assessment (Edinburgh, February 1990), and the Second Draft which emanated from that meeting was sent for the same wide peer review as the main report, including nationally designated experts and the committees of relevant international scientific programmes. A Third Draft incorporating a large number of changes suggested by peerreviewers was tabled at the final plenary meeting of Working Group I (Windsor, May 1990) at which the Lead Authors of the main report were present, and the final version was agreed at that meeting. It gives me pleasure to acknowledge the contributions of so many, in particular the Lead Authors, who have given freely of their expertise and time to the preparation of this report. All the modelling centres must be thanked for providing data so readily for the model lntercomparison. I also acknowledge the contribution of the core team at the Meteorological Office in Bracknell who were responsible for organising most of the workshops and preparing the report. Members of the team were Professor Cac Hong Xing from China, Dr Reindert Haarsma from The Netherlands, Dr Robert Watson from the USA, and Dr John Mitchell, Dr Peter Rowntree, Dr Terry Callaghan, Chris Folland, Jim Ephraums, Shelagh Varney, Andrew Gilchusl and Aileen Foreman from the UK. Particular acknowledgment is due to Dr Geoff Jenkins, the Coordinator of Working Group I who led the team Thanks VI Foreword are also due to Dr Sundararaman and the IPCC Secretariat in Geneva. Financial support for the Bracknell core team was provided by the Departments of the Environment and Energy in the UK. I am confident that the Assessment and its Summary will provide the necessary firm scientific foundation for the forthcoming discussions and negotiations on the appropriate strategy for response and action regarding the issue of climate change. It is thus, I believe, a significant step forward in meeting what is potentially the greatest global environmental challenge facing mankind. (p. v)

1.5. Developments in language:

The results of this can perhaps best be seen in the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) reached at the Conference of the Parties in December 2015 (COP21). That agreement is based on science, specifically the assessments that the IPCC communicated to negotiators through the Structured Expert Dialogue and other activities at UNFCCC meetings, and also to other stakeholders. And yet the IPCC has faced growing calls from policymakers and other users to do more with its communications.

IPCC assessments represent a unique cooperation between the scientific and policy communities. But even the Summary for Policymakers (SPM), the result of an intense dialogue between IPCC authors and government representatives to produce a text that is an accurate summary of the underlying scientific assessment while serving the needs of policymakers, is widely criticized as being unreadable and inaccessible for non-specialists.

Is the answer to simplify the language and visual elements of the SPM to make them more accessible? Can that be done without comprising scientific accuracy? Does the IPCC need additional communications tools? Should the IPCC reconsider how it works with the media and others? What is the role of third parties in communicating IPCC products and how should the IPCC interact with them? How do users of the IPCC work with IPCC reports? How do producers of other assessments deal with these problems?

To answer these and other questions, the IPCC held an Expert Meeting on Communication on 9-10 February 2016 in Oslo, Norway. The Expert Meeting brought together scientists who had worked on and communicated AR5, elected IPCC officials who will guide future assessments, communications experts, and representatives of governments and other users to discuss lessons learned from AR5 and to look to the future.

[...]

the IPCC is not like other organizations, and does not enjoy the same freedoms that they do. In further developing its communications, the IPCC must recognize both the general challenges to scientific communication and the specific constraints that it faces. After all, the value of the IPCC's work depends on its credibility; the greatest care must be taken not to erode that. While communication theory and psychology point to more effective ways to transmit information, it must be accepted that some of the science that the IPCC deals with is complex: it is important to simplify as much as possible, without oversimplifying. Particular challenges exist around the treatment of uncertainty. While fundamental to science, the language with which uncertainty is communicated to policymakers and the public can result in misunderstandings. And it is important to heed calls for clearer, more direct messages, while remaining policy-neutral. **The particular strength of an IPCC assessment derived from a dialogue between scientists and policymakers is enshrined in the approved text of an SPM; communications materials cannot deviate from that.** (IPCC Expert Meeting on Communication, 2016, p. 3. **Bolding SR**)

1.6. On the IPCC Working Groups' and Teams' communications and social media pressures:

The Expert Meeting, proposed and hosted by Norway, and chaired by Christian Bjørnæs of CICERO, was particularly timely, as the first results of academic research into the communication of AR5 were appearing, and work was starting on the next series of IPCC products, leading to the Sixth Assessment Report (AR6). To see how far the IPCC has come in communications, it is worth recalling that with AR5, and the related special reports, the IPCC issued its own press releases for the first time. Press releases for previous assessments had been produced by the IPCC's sponsoring organizations, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). This was because it was feared that to release a press release that necessarily highlighted some aspects of the SPM would entail a breach of the IPCC's policy-neutrality. Some enhancements to IPCC communications came not from the communications team but from the authors themselves, for instance the use of headlines statements in the Working Group I contribution to AR5 and the Synthesis Report. Other improvements for AR5 included:

– Responding to media questions before finalization of the reports;

– Media workshops to explain the workings of the IPCC and how it produces assessments;

> – Making IPCC communications more professional by working with outside communications experts;
>
> – Making the SPM and press releases available to media under embargo before the press conference;
>
> – Country briefings for different regions at the time of the release of the report;
>
> – Media training for Bureau members and authors;
>
> – Systematic planning of interviews with a range of authors, both face to face and remotely;
>
> – Arranging facilities for broadcasters;
>
> – Production of scientifically rigorous but compelling videos, overseen by the working group co-chairs and IPCC Chair;
>
> – Ambitious programme of outreach activities all over the world;
>
> – Cooperation with third parties producing versions of the report (“derivative products”) targeting specific sectors in specific regions;
>
> – Use of social media to publicize IPCC findings and outreach activities.
>
> This gives the IPCC a strong foundation to build on for its future communications work. But there is much more it can and should do. The two days of talks in Oslo (9–10 February 2016) yielded a rich seam of ideas for the IPCC. (Ibid., pp. 2–3)

1.7. The increased importance of developing models, gaining access to (satellite) observations and numerical data; Brohan’s HadCRUT 3:

In FAR, ‘model’ already features in relatively large proportion, but its highest relative frequency is slightly surprisingly in SAR. I expected computer modelling to increase with time, and TAR to show the biggest numbers relatively. What comes to ‘observation’(s), they cannot quite compete with computer-derived data in the instance of fast-pace and large-scale prediction production. To produce a highly reliable prediction, observations are needed to provide an accurate basis and as reference, plus super computers for calculating. Satellite-based observations show a marked increase from FAR to TAR: satellites used in meteorological observations have been sent to orbit in an accelerating pace. They provide an input of accessible and accurate data from large areas where the observatory network is missing. According to carbonbrief.org, the number of ‘climate satellites’ in 2016 was 162. My hunch is that satellite observations and computer models and simulations, and the developments in those (though relying on observational data from weather stations!) were, and will be in the future, the key factors in the accumulation of big data (see, for example, The Global Observing System, GOS; (public.wmo.int)) and it is through the co-ordinated use of all the three sources that climate scientists are able to produce the essential knowledge and predictions of the climate change. What has been the most relevant of these – which of these spearheaded the development, is not easy to answer. ‘Model*’ increase in proportion markedly in SAR; as do ‘satellite*’ (and acronyms related to satellites) in TAR.

In FAR, the total percentage of search items is half of that in SAR and TAR: 0.73 % against 1,47 %.

What comes to ‘uncertainty’ and its frequent use in these reports, ‘models’ appear in conjunction with it in 13 cases in the Advanced Context Word search in AntConc. ‘Satellite’ yielded a similar result of 2 cases.

I have included in my set acronyms of computer models. These are from IPCC FAR: ‘GCM’, ‘AGCM’, ‘EBM’, ‘OGCM’, ‘RCM’. Only GCM featured in my hit list, but it its relevant. In SAR, the list referring straight to models or numerical programs is significantly longer and more reflective of a complicated field: ‘AOGCM’, ‘CCM’, ‘ECHAM’, ‘FRAM’, ‘UGAMP’, ‘WGNE’, ‘VEMAP’, ‘PMIP’, ‘NWP’, ‘MOGUNTIA’, ‘OCCAM’, ‘GCMP’, ‘UDEBM’, ‘CGMCs’, ‘TEM’. In TAR, the list for model- or satellite-based program acronyms numbered over 60. .

‘Uncertain/ty’ or ‘uncertainties’ coincided with ‘models’, or ‘model simulations’ in SAR 5 times, in TAR 9 times in an advanced AntConc -search. From FAR, no such coincidence was found. ‘Satellite’ and acronyms for satellite programs gave 1 hit in each, SAR and TAR. Again, in FAR, none was found. With ‘calculat/ion’, ‘uncertain/ty’ occurred 1, 9, and 3 times respectively. When cross-cutting into the set I used for nouns, most interesting findings were that ‘confidence’ does not feature much with ‘models’, once in both SAR and TAR. ‘Approach’, ‘scheme’, ‘experiment’ and ‘test’ featured in the same combination relatively rarely, too. Observational uncertainty showed in SAR once, in TAR 5 times, one finding being about reduced uncertainty.

‘Calculation’ fits in better: it occurred together with ‘models’ (or with ‘model simulations’) 3, 17, and 22 times in the temporal order of the reports; and most interestingly, ‘observation’ occurred 3, 12, and 20 times respectively. There was little or no contradiction between observational and model data. A trend seems to be to seek reliance on both so that they support each other – which would lead to maximum certainty –but that does not always happen.

Some examples of 'observations' and 'models':

> The amplitude A of the radiative forcing due to solar variability (which is tied to sunspot number) is evaluated so as to give the best agreement between observed and modelled temperatures between 1861 and 1989.
>
> (IPCC FAR, 1990)
>
> There is increasing observational evidence that we understand and are able to measure and model local concentrations of OH (e.g., Poppe et al, 1994; Wennberg et al, 1994; Millier et al, 1995). However, our knowledge of the global OH distribution is still limited by our ability to model accurately the large range of conditions that determine the OH concentration (e.g., O3, NO2, hydrocarbons, cloud cover).
>
> (D. SCHIMEL, D. ALVES, I. ENTING, M. HEIMANN, R JOOS, D. RAYNAUD, T. WIGLEY (2.1) M. PRATHER, R. DERWENT, D. EHHALT, R ERASER, E. SANHUEZA, X. ZHOU (2.2) R JONAS, R. CHARLSON, H. RODHE, S. SADASIVAN (2.3) K.R. SHINE, Y FOUQUART, V. RAMASWAMY, S. SOLOMON, J. SRINIVASAN (2.4) D. ALBRITTON, R. DERWENT, L ISAKSEN, M. LA, D. WUEBBLES (2.5). Radiative Forcing of Climate Change. In IPCC SAR, 1995).
>
> Model simulations from GCMs using the observed O3 losses yield global mean temperature changes that are approximately consistent with the observations. Such a cooling is also much larger than that due to the well-mixed greenhouse gases taken together over the same time period. Although the possibility of other trace species also contributing to this cooling cannot be ruled out, the consistency between observations and model simulations enhances the general principle of an O3-induced cooling of the lower stratosphere, and thus the negativity of the radiative forcing due to the O3 loss. Going from global, annual mean to zonal, seasonal mean changes in the lower stratosphere, the agreement between models and observations tends to be less strong than for the global mean values, but the suggestion of an O3-induced signal exists.
>
> (IPCC TAR, 2001)

The single most important approximator in the context of 'model*' was 'estimate*'. Models produce results that the climate scientists understand as estimations that accurately reflect the complex reality of the atmospheric phenomena. The assessment process of, for example, model studies in these IPCC reports produces an array of current 'best estimates' to be fitted in a more or less wide 'range of uncertainty'. That there can be a narrowing in the range of uncertainty, is progress. But sometimes complexity increases with the introduction of new aspects and methods. Simply vocabulary-wise, these method-related words are very frequent and important and markedly increase along the temporal frame (for example, model is over two and a half times as frequent in TAR and SAR as in FAR.

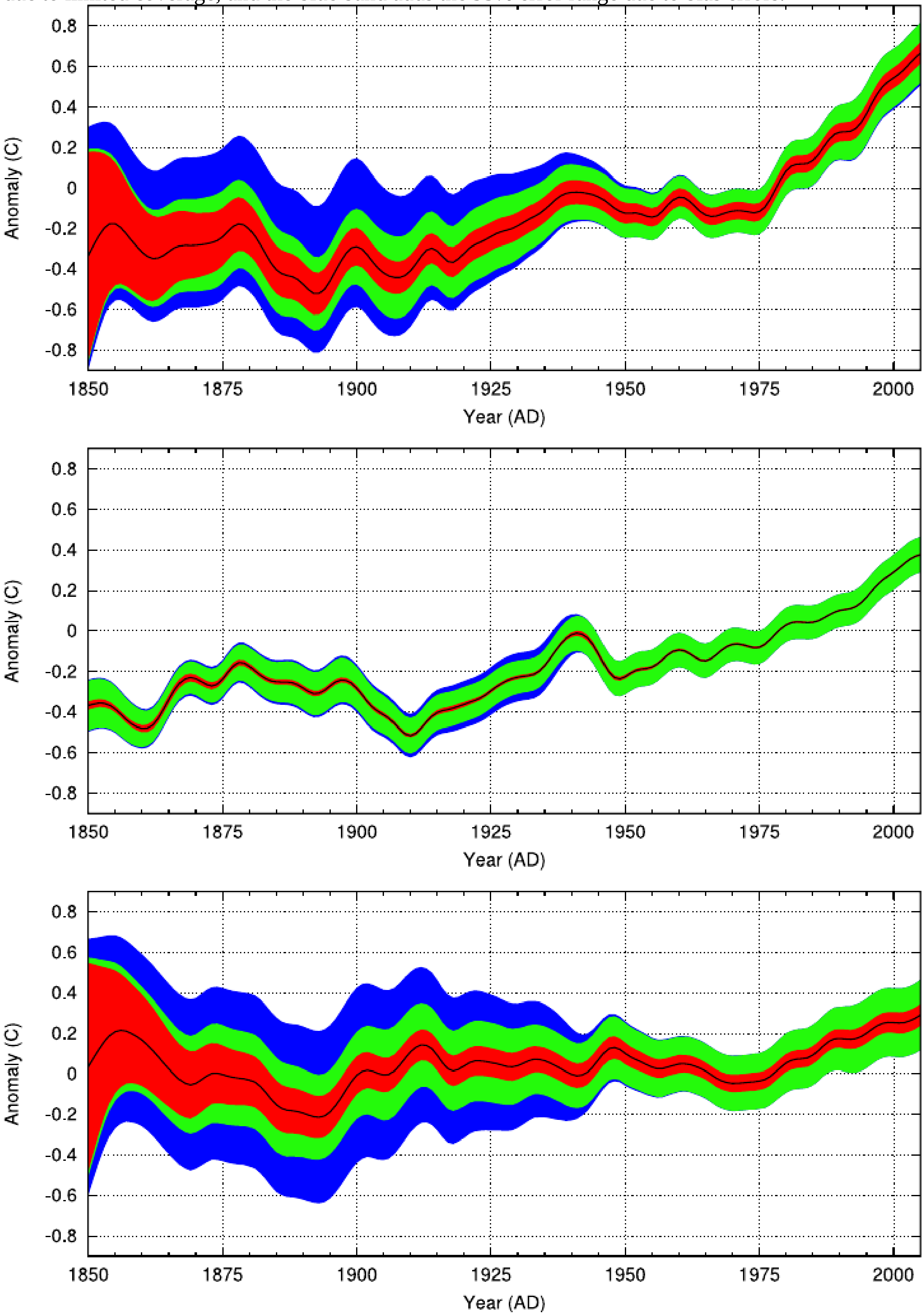
In hindsight: Where are the risk identification, assessment, and management methods, or programs? Should they have been here, too, displayed in the context of the very core science of radiative forcing, for maximum perlocutionary impact? I found no instances of the word 'risk*', nor could I find such methods, or programs as 'Monte Carlo', or 'Delphi Program' in my searches. So, some critique for limiting the contents of these Work Group 1 -reports so as that they to be 'risk adverse' in well, every way, may be justified.

set_models_observations = {‘*model’, ‘*simulation’, ‘GCM’, ‘AGCM’, ‘EBM’, ‘OGCM’, ‘RCM’, ‘AOGCM’, ‘CCM’, ‘ECHAM’, ‘FRAM’, ‘UGAMP’, ‘WGNE’, ‘VEMAP’, ‘PMIP’, ‘NWP’, ‘MOGUNTIA’, ‘OCCAM’, ‘GCMP’, ‘UDEBM’, ‘CGMCs’, ‘TEM’, ‘application*’, ‘*computer’, ‘*program’, ‘*satellite’, ‘*observation’, ‘*numerical’, '*calculation', '*scenario'}

FAR	N	Freq.	SAR	N	Freq.	TAR	N	Freq.
model*	23	1,931	model*	147	6,032	model*	203	5,188
calculat*	21	1,763	observ*	69	2,831	calcul*	99	2,53
scenario*	18	1,511	calcul*	64	2,626	observ*	88	2,249
observ*	17	1,427	scenario*	33	1,354	GCM	50	1,278
satellite*	4	0,336	simulat*	20	0,821	scenario*	37	0,946
comput*	2	0,168	satellite*	7	0,287	simulat*	28	0,716
simulat*	1	0,084	GCM	5	0,205	satellite*	28	0,716
applicat*	1	0,084	MOGUNTIA	4	0,164	comput*	21	0,537
Sum	**87**	**7,304**	comput*	3	0,123	application*	5	0,128
			numerical*	3	0,123	numerical*	4	0,102
Total	**%**	**0,73**	ECHAM	2	0,082	UARS	3	0,077
			program*	1	0,041	AOGCM	2	0,051
			Sum	**358**	**14,689**	HITRAN	2	0,051
						UGAMP	1	0,026
			Total	**%**	**1,47**	DMSP	1	0,026
						ERB-satellite	1	0,026
						Sum	**573**	**14,647**
						Total	**%**	**1,47**

In a picture below the uncertainty in a relatively recent and established computer model, HadCRUT3, which features, for example, in the IPCC AR4 -report from 2007, is explained (see Brohan et al., 2006). What I want to point out is that the uncertainty levels are harder to concentrate within the limit of ±0.2 Centigrade (normalised according to a set of stable observations from a 30-year period between 1961 – 1990), the further back in time the researchers go.

Fig. 2) Global average of land and marine components of HadCRUT3 (Centigrades): (top) land, (middle) sea, and (bottom) difference (land – sea). The black line is the best estimate value; the red band gives the 95% uncertainty range caused by sation, sampling and measurement errors; the green band adds the 95% error range due to limited coverage; and the blue band adds the 95% error range due to bias errors.



1.8. References in reports

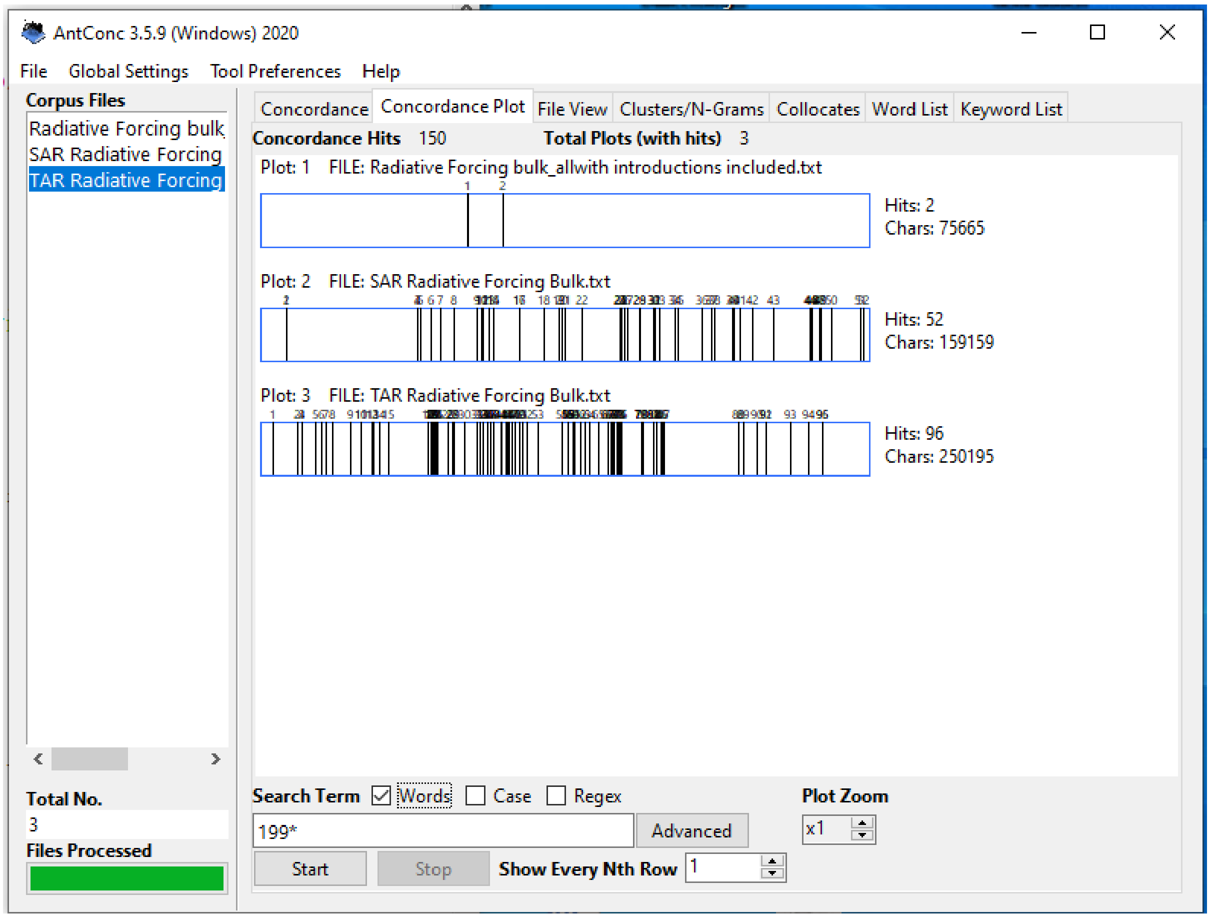
FAR assessed or referred to seven studies from the 1970's, and about four times as much from 1980's and 1990's each. The assessing process is very mild in FAR: uncertainties in the studies are often expressed through auxiliary use ('may', 'can', 'would'):

> […] additional aerosol particles may either increase or decrease local planetary albedo (e.g. Coakley and Chylck 1975, Grassl and Newiger 1982). A given aerosol load may increase the planetary albedo above an ocean surface and decrease it above a sand desert. The effect of aerosol particles on terrestrial radiation cannot be neglected, in conditions where the albedo change is small, the added greenhouse effect can dominate (Grassl 1988). (IPCC FAR, 1990).
>
> This is the final Report of Working Group 1 on the [IPCC], which is sponsored jointly by the [WMO] and the [UNEP]. The report considers the scientific assessment of climate change. [---] The result is the most authoritative and strongly supported statement on climate change that has ever been made by the international scientific community. (IPCC FAR, 1990)

And jumping to TAR:

> This report is the first complete assessment of the science of climate change since Working Group I (WGI) of the IPCC produced its second report Climate Change 1995: The Science of Climate Change in 1996. It enlarges upon and updates the information contained in that, and previous, reports, but primarily it assesses new information and research, produced in the last five years. The report analyses the enormous body of observations of all parts of the climate system, concluding that this body of observations now gives a collective picture of a warming world. The report catalogues the increasing concentrations of atmospheric greenhouse gases and assesses the effects of these gases and atmospheric aerosols in altering the radiation balance of the Earth-atmosphere system. The report assesses the understanding of the processes that govern the climate system and by studying how well the new generation of climate models represent these processes, assesses the suitability of the models for projecting climate change into the future. A detailed study is made of human influence on climate and whether it can be identified with any more confidence than in 1996, concluding that there is new and stronger evidence that most of the observed warming observed over the last 50 years is attributable to human activities. Projections of future climate change are presented using a wide range of scenarios of future emissions of greenhouse gases and aerosols. Both temperature and sea level are projected to continue to rise throughout the 21st century for all scenarios studied. Finally, the report looks at the gaps in information and understanding that remain and how these might be addressed
>
> The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change1. Many hundreds of scientists from many countries participated in its preparation and review.
>
> This Summary for Policymakers (SPM), [---] describes the current state of understanding of the climate system and provides estimates of its projected future evolution and their uncertainties.
>
> (IPCC TAR, 2001))

A simple search in Python reveals how studies have mushroomed: **bracketed references** and *study, studies,* number in FAR, in SAR, and in TAR. An Advanced AntConc Search for Context Words (*estimate, estimated, estimates, estimating, estimation, estimations, suggest,* *suggested, suggestion, suggests, suggesting, uncertain, uncertainties, uncertainty*) gave the following result **with referenced studies from ‘1990’s’:**



Screen Shot 142: references from 1990’s in the context of uncertainty, suggestions, estimates.

1.9. About ‘uncertainty-language’:

> In the more recent IPCC reports, the calibrated 'uncertainty language' has been used in Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) to provide comprehensive assessments of climate change, its impacts, and response strategies by

synthesizing and evaluating scientific understanding. A guiding principle of IPCC assessments has been to be policy relevant without being policy prescriptive (IPCC 2008). The reports are written by experts, with the objective of assessing the state of knowledge to inform decision making, and the reports undergo multiple rounds of review by experts from the scientific community and by governments to ensure they are comprehensive and balanced. For these assessments, the theme of consistent treatment of uncertainties, including the use of calibrated uncertainty language, has long cut across IPCC Working Groups. Such calibrated language aims to allow clear communication of the degree of certainty in assessment findings, including findings that span a range of possible outcomes. It also avoids descriptions of uncertainties using more casual terms, which may imply different meanings to different disciplines and/or in different languages.

Since its first report in 1990, IPCC assessments have included designated terms and other methods to communicate authors' expert judgments (Mastrandrea and Mach, 2011). Approaches have ranged from broad summary headings to calibrated scales for characterizing degrees of certainty in assessment conclusions. The overall goal has been to facilitate consistent treatment of uncertainties in characterizing and communicating the state of knowledge. Since the Third Assessment Report (2001), authors have worked from shared expert-judgment guidance. The 2013/2014 AR5, however, is the first IPCC report to adopt a single framework (Fig. 1) that could be applied consistently across working groups, spanning diverse disciplines and topics (Mastrandrea et al., 2010, Mastrandrea et al., 2011). This shared framework aimed to increase the comparability of assessment conclusions across all topics related to climate change, from the physical science basis to resulting impacts, risks, and options for response.

(Mach et al., 2017)

Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) provide comprehensive assessments of climate change, its impacts, and response strategies by synthesizing and evaluating scientific understanding. A guiding principle of IPCC assessments has been to be policy relevant without being policy prescriptive (IPCC 2008). The reports are written by experts, with the objective of assessing the state of knowledge to inform decision making, and the reports undergo multiple rounds of review by experts from the scientific community and by governments to ensure they are comprehensive and balanced. For these assessments, the theme of consistent treatment of uncertainties, including the use of calibrated uncertainty language, has long cut across IPCC Working Groups. Such calibrated language aims to allow clear communication of the degree of certainty in assessment findings, including findings that span a range of possible outcomes. It also avoids descriptions of uncertainties using more casual terms, which may imply different meanings to different disciplines and/or in different languages.

Since the First Assessment Report (FAR; IPCC 1990), IPCC Assessment Reports have used calibrated language to characterize the scientific understanding and associated uncertainties underlying assessment findings. Starting with the Third Assessment Report (TAR), guidance outlining a common approach for treatment of uncertainties across the Working Groups has been provided to all authors in each assessment cycle (Moss and Schneider 2000; IPCC 2005; Mastrandrea et al. 2010; see Mastrandrea and Mach, this issue, for further description). The purpose of each uncertainty language guidance paper has been to encourage, across the Working Groups, consistent characterization of the degree of certainty in key findings based on the strength of and uncertainties in the underlying knowledge base. In the previous IPCC assessment cycle, the Guidance Notes for Lead Authors of the IPCC Fourth Assessment Report on Addressing Uncertainties (IPCC 2005) attempted to create a common framework that could be used by all three Working Groups. It responded to divergence in usage of uncertainty language across the Working Groups in the TAR (IPCC 2001a, 2001b, 2001c) and was developed following the IPCC Workshop on Describing Uncertainties in Climate Change to Support Analysis of Risk and of Options (Manning et al. 2004). This framework further distinguished the quantitative metrics— confidence and likelihood—that had been employed by Working Groups I and II in the TAR, including revisions to the confidence scale presented in the TAR guidance paper (Moss and Schneider, 2000).

(Mastrandrea et al., 2011)

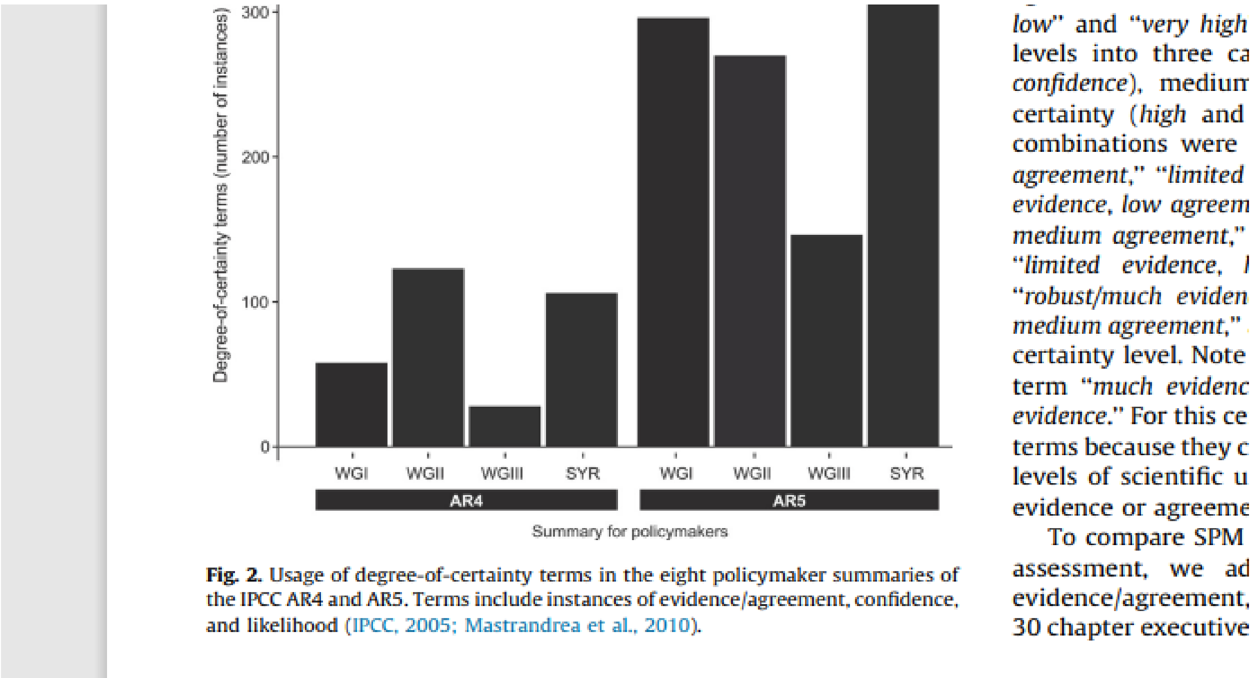


Fig. 2. Usage of degree-of-certainty terms in the eight policymaker summaries of the IPCC AR4 and AR5. Terms include instances of evidence/agreement, confidence, and likelihood (IPCC, 2005; Mastrandrea et al., 2010).

This image is from Mach et.al., 2017. The increase, though uneven, in the 'degree-of-certainty' terms after the deployment of the 'uncertainty language (from AR4 onwards) is clearly discernible. In Appendix 2.9. p. 108, I show how the uncertainty-language-items feature in Python counts.

Appendix 2: Sets and Tables

First, here is a list including some of Hyland's 'classical' hedges: *indicate*, *propose*, *would (not)*, *probably*, *usually*, *generally*, *evidently*, *possibly*, *may (not)*, *apparently*, *suggest*, *should, could, seem, about, possible, appear, essentially, might (not), relatively, likely, approximate(ly), quite, almost, possibility, assumption, estimate* (Hyland, 1996).

2.1. Auxiliaries acting as hedges:

set_auxiliaries = {'would', 'may', 'might', 'can', 'could', 'should', 'must', 'cannot'}

What comes to FAR, it shows a linear reduction in certainty: from can to conditionals would, could, should, and then to more seldom used auxiliaries. The last is a weak 'might'.

Search results for nine auxiliaries from the material: FAR = IPCC First Assessment Report, SAR = IPCC Second Assessment Report, TAR = IPCC Third Assessment Report. N = the raw frequency from material; Freq. = normalised frequency per thousand words; Total percentage = all search results combined per total word count, in percentages

FAR	N	Freq.	Sarake1	SAR	N2	Freq.3	Sarake4	TAR	N5	Freq.6
can	48	4,027		may	41	1,682		can	69	1,763
may	38	3,188		would	36	1,477		may	69	1,763
would	24	2,013		can	32	1,313		could	34	0,869
could	18	1,51		could	17	0,698		would	23	0,588
should	13	1,091		should	13	0,533		cannot	13	0,332
must	9	0,755		must	10	0,41		should	12	0,307
cannot	6	0,503		cannot	9	0,369		must	6	0,153
might	3	0,252		might	8	0,328		might	4	0,102
Sum	**159**	**13,339**		**Sum**	**166**	**6,81**		**Sum**	**230**	**5,877**
Total	**%**	**1,33**		**Total**	**%**	**0,68**		**Total**	**%**	**0,59**

2.2. Verbs with epistemological or informative connotation

set_hedgesverbs = {'conclude', 'validate', 'define', 'reflect', 'seem', 'suggest', 'prove', 'verify', 'imply', 'indicate', 'infer', 'appear', 'presume', 'deduce', 'evaluate', 'consider', 'assume', 'approximate', 'determine', 'contradict', 'speculate', 'hypothesise', 'theorise', 'falsify', 'agree', 'suppose', 'expect', 'disagree', 'approve', 'disapprove', 'rely', 'is based on', 'rests on', 'assess', 'propose', 'believe', 'ascertain', 'tend', 'postulate', 'caution', 'predict', 'anticipate', 'induce', 'inform', 'assert', 'experiment', 'present', 'report', 'show', 'convince', 'compel'}

FAR	N	Freq.	SAR	N	Freq.	Sarake	TAR	N	Freq.
show (*)	21	1,763	show	36	1,477		show	69	1,763
consider	17	1,427	suggest	33	1,354		suggest	60	1,533
(cor)relate*	13	1,091	(cor)relate	22	0,903		present	50	1,278

determine	12	1,007	present	19	0,78	(cor)relate	21	0,537
suggest	10	0,839	report	16	0,657	indicate	17	0,434
base on	9	0,756	indicate	14	0,574	determine	17	0,434
indicate	7	0,588	assume	13	0,533	assume	15	0,383
evaluate	6	0,504	imply	13	0,533	predict	14	0,358
imply	6	0,504	expect	11	0,451	report	10	0,256
assume	6	0,504	evaluate	8	0,328	deduce	10	0,256
relate*	6	0,504	assess	7	0,287	confirm	8	0,204
expect	5	0,42	determine	7	0,287	consider	8	0,204
present	4	0,336	propose	6	0,246	imply	7	0,179
assess	4	0,336	tend	5	0,205	appear	7	0,179
anticipate	4	0,336	infer	5	0,205	assess	7	0,179
believe	3	0,252	conclude	5	0,205	approximate	7	0,179
infer	2	0,168	confirm	5	0,205	conclude	6	0,153
conclude	2	0,168	reflect	4	0,164	tend	6	0,153
defin*	2	0,168	believe	4	0,164	expect	6	0,153
reflect	1	0,084	predict	3	0,123	induce	5	0,128
report	1	0,084	consider	3	0,123	reflect	4	0,102
induce	1	0,084	caution	3	0,123	evaluate	4	0,102
caution	1	0,084	appear	3	0,123	believe	4	0,102
experiment	1	0,084	validate	2	0,082	rely	3	0,077
tend	1	0,084	define	2	0,082	verify	3	0,077
contradict	1	0,084	prove	2	0,082	agree	3	0,077
appear	1	0,084	contradict	2	0,082	propose	3	0,077
compelling	1	0,084	agree	1	0,041	infer	2	0,051
predict	1	0,084	assert	1	0,041	prove	1	0,026
approximate	1	0,084	verify	1	0,041	disagree	1	0,026
disagree	1	0,084	experiment	1	0,041	**Sum**	**378**	**9,66**
restrict	1	0,084	deduce	1	0,041			
Sum	**152**	**12,763**	rely	1	0,041	**Total**	**%**	**0,97**
			approximate	1	0,041			
Total	**%**	**1,28**	seem	1	0,041			
			postulate	1	0,041			
			compelling	1	0,041			
			Sum	**263**	**10,788**			
			Total	**%**	**1,08**			

2.3. A sub-set of verbs: induce and deduce - a pair used in logical inference, logical items set_logical = {'deduce', 'induce', 'inductible', 'deductible', 'inducible', 'argue', 'argument', 'arguments', 'scientific', 'science', 'deducible', 'induction', 'deduction', 'inductions', 'deductions', 'inference', 'abduct', 'abduction', 'inferences', 'implication', 'implications', 'a priori', 'a posteriori'}

As a piece of extra knowledge, I point out to the possibility of using logical terminology to strengthen the epistemological quality of propositions. We can detect a minor increase of those in SAR and TAR. Because these terms are rare, I included some verbs, nouns and adjectives in the set.

In my lengthy example, I show how a central logical expression 'a posteriori inference' is encircled by a host of uncertainties:

> One diagnostic constraint on the total global mean forcing since pre-industrial times is likely to be provided by comparisons of model-simulated (driven by the combination of forcings) and observed climate changes, including spatially-based detection attribution analyses (Chapter 12). However, the a posteriori inference [= probability after observations are made, SR] involves a number of crucial assumptions, including the uncertainties associated with the forcings, the representativeness of the climate models' sensitivity to the forcings, and the model's representation of the real world's "natural" variations. Overall, the net forcing comprises of a large positive value due to well-mixed greenhouse gases, followed by a number of other agents that have smaller positive or negative values. Thus, relative to IPCC (1990) and over this past decade, there are now more forcing agents to be accounted for, each with a sizeable uncertainty that can affect the estimated climate response. In this regard, consideration of the "newer" forcing agents brings on an additional element of uncertainty in climate change analyses over and above those concerning climate feedbacks and natural variability (IPCC, 1990). Both the spatial character of the forcing and doubts about the magnitudes (and, in some cases, even the sign) add to the complexity of the climate change problem. (TAR, 2001)

FAR	**N**	**Freq.**	**Sarake 4**	**SAR**	**N3**	**Freq. 3**	**Sarake 8**	**TAR**	**N2**	**Freq. 2**
imply*	7	0,588		imply*	13	0,533		induce	24	0,611
induce	4	0,336		induce	11	0,451		imply	14	0,357
infer*	3	0,252		implication*	6	0,246		deduce	11	0,28
implicit	1	0,084		infer*	5	0,205		scientific	7	0,178
prior	1	0,084		prior	4	0,164		argue*	5	0,127
argument	1	0,084		scientific	3	0,123		prior	4	0,102
implication *	1	0,084		argue*	3	0,123		infer	3	0,076
a priori	1	0,084		deduce*	2	0,082		argument	1	0,025
Sum	19	1,596		argument	2	0,082		inference	1	0,025
				post	1	0,041		a posteriori	1	0,025
Total	%	0,16		inference*	1	0,041		Sum	71	1,806
				implicate	1	0,041				
				Sum	52	2,132		Total	%	0.18
				Total	%	0,21				

2.4. Hedging adverbs, adverbials; *likely* as an adjective and adverb set_hedgesadvs = {‘probably’, ‘likely’, ‘presumably’, ‘unlikely’, ‘with confidence’, ‘generally’, ‘perhaps’, ‘maybe’, ‘possibly’, ‘surely’, ‘reliably’, ‘arguably’, ‘unarguably’, ‘inadvertedly’, ‘questionably’, ‘unquestionably’, ‘without a doubt’, ‘virtually’, ‘undoubtedly’, ‘factually’, ‘counter the fact’, ‘practically’, ‘in practice’, ‘observationally’, according to the fact’, ‘certainly’, ‘evidentially’, ‘according to observations’, ‘according to evidence’, ‘counter the evidence’, ‘experimentally’, ‘observedly’, ‘unobservedly’, ‘according to estimation, ‘according to estimates’, ‘causally’, ‘effectively’, ‘in contrast’, ‘barely’, ‘inferentially’, ‘in fact’, ‘in particular’, ‘largely’, directly’, ‘indirectly’, ‘necessarily’}

FAR	N	Freq.	Sarake1	SAR	N2	Freq.3	Sarake4	TAR	N5	Freq.6
relatively	7	0,588		likely	18	0,739		rather	26	0,665
directly	6	0,504		possibly	8	0,328		likely	24	0,613
generally	5	0,42		relatively	8	0,328		necessarily	17	0,434
likely	4	0,336		largely	7	0,287		relatively	17	0,434
largely	4	0,336		directly	7	0,287		significantly	10	0,256
implicitly	4	0,336		significantly	7	0,287		in contrast	9	0,23
rather	3	0,252		probably	6	0,246		directly	8	0,204
probably	3	0,252		generally	5	0,205		generally	8	0,204
noticeably	2	0,168		unlikely	5	0,205		largely	5	0,128
indirectly	2	0,168		rather	4	0,164		certainly	4	0,102
necessarily	2	0,168		necessarily	3	0,123		probably	4	0,102
significantly	2	0,168		with confidence	3	0,123		in fact	4	0,102
effectively	1	0,084		in contrast	3	0,123		indirectly	3	0,077
certainly	1	0,084		indirectly	2	0,082		according to	3	0,077
possibly	1	0,084		comparatively	2	0,082		implicitly	2	0,051
unlikely	1	0,084		effectively	2	0,082		reliably	2	0,051
in fact	1	0,084		in fact	2	0,082		unlikely	2	0,051
in contrast	1	0,084		coincidentally	1	0,041		perhaps	2	0,051
accord. to imp.	1	0,084		noticeably	1	0,041		undoubtedly	1	0,026
Sum	**51**	**4,284**		virtually	1	0,041		observationally	1	0,026
				perhaps	1	0,041		effectively	1	0,026
Total	**%**	**0.43**		implicitly	1	0,041		accordingly	1	0,026
				as evid. by comp.	1	0,041		possibly	1	0,026
				Sum	**98**	**4,019**		hardly	1	0,026
’Likely’	**%**	**7.84**						in doubt	1	0,026
				Total	**%**	**0.40**		against obs.	1	0,026
								against meas.	1	0,026
				’Likely’	**%**	**18.37**		in acc. with	1	0,026
								in view of	1	0,026
								Sum	**161**	**4,118**
								Total	**%**	**0.41**

	Likely	**%**	**14.91**

2.5. Hedging nouns, nouns with epistemological, scientific connotations: ‘makers of science’

set_hedgesnouns = {‘likelihood’, ‘integration’, ‘gap’, ‘condition’, ‘knowledge’, ‘probability’, ‘credence’, ‘possibility’, ‘suggestion’, ‘evidentiality’, ‘inference’, ‘conclusion’, ‘proof’, ‘verification’, trust’, ‘distrust’, ‘confidence’, ‘reliance’, ‘reliability’, ‘commitment’, ‘derivation’, ‘assessment’, ‘tendency’, ‘argument’, ‘modification’, ‘extract’, ‘sample’, ‘speculation’, ‘trend’, ‘level of scientific understanding’, ‘LOSU’, ‘prediction’, ‘assumption’, ‘supposition’, ‘theory’, ‘hypothesis’, ‘certainty’, ‘uncertainty’, ‘rationale’, ‘proposition’, ‘experiment’, ‘consensus’, ‘insufficiency’, ‘understanding’, ‘postulate’, ‘negation’, ‘agreement’, ‘disagreement’, ‘calculation’, ‘alternative’, ‘rationality’, ‘anticipation’, ‘contradiction’, ‘proportionality’, ‘contrast’, ‘incidence’, ‘chance’, ‘accidence’, ‘candidate’, ‘potentiality’, ‘potential’, ‘observation’, ‘confirmation’, evidence, ‘tendency’, ‘research’, ‘*references to other studies, IPCC material*’, ‘data’, ‘scheme’, ‘fact’, ‘implication’, ‘factor’, ‘assessment’, ‘study’, information’, ‘approach’ }

FAR	N	Freq.	SAR	N	Freq.	TAR	N	Freq.
potential*	22	1,847	uncertainty	71	2,913	study*	163	4,166
uncertainty	14	1,175	study*	56	2,298	uncertainty	132	3,374
calculation	13	1,091	level	51	2,093	calculation	53	1,355
data	10	0,839	calculation	43	1,764	observation	53	1,355
observation	8	0,671	observation	39	1,6	data	40	1,022
evidence	8	0,671	data	37	1,518	level	35	0,895
assessment	7	0,588	trend*	22	0,903	assessment	28	0,716
trend	6	0,504	potential*	22	0,903	trend	22	0,562
assumption*	6	0,504	evidence	20	0,821	potential*	22	0,562
integration*	6	0,504	confidence	18	0,739	fact	20	0,511
agreement*	5	0,42	understanding	13	0,533	confidence*	19	0,486
level*	5	0,42	factor	12	0,492	LOSU	19	0,486
stud*	5	0,42	information	10	0,41	assumption	18	0,46
contrast	4	0,336	conclusion	10	0,41	approach*	17	0,434
information*	4	0,336	assumption	9	0,369	evidence	15	0,383
fact	3	0,252	sample	8	0,328	knowledge	14	0,358
comparison	3	0,252	fact	7	0,287	contrast	12	0,307
commitment	3	0,252	agreement	7	0,287	factor	12	0,307
theory	3	0,252	experiment	7	0,287	condition*	12	0,307
possibility	3	0,252	assessment	6	0,246	agreement	11	0,281
certainty	2	0,168	implication	6	0,246	understanding	11	0,281

research	2	0,168	knowledge	6	0,246	information	10	0,256
understanding	2	0,168	conditions	5	0,205	scheme	9	0,23
condition*	2	0,168	modification	5	0,205	experiment	9	0,23
candidate	2	0,168	suggestion	4	0,164	comparison	8	0,204
gap	2	0,168	approach	4	0,164	reliability	7	0,179
argument	1	0,084	contrast	4	0,164	alternative	7	0,179
proportionality	1	0,084	consensus	4	0,164	possibility	5	0,128
hypothesis	1	0,084	comparison	4	0,164	modification	5	0,128
credence	1	0,084	theory	3	0,123	theory	3	0,077
modification	1	0,084	argument	2	0,082	research	2	0,051
alternative	1	0,084	research	2	0,082	argument	2	0,051
confirmation	1	0,084	confirmation	1	0,041	rationale	1	0,026
contradiction	1	0,084	possibility	1	0,041	verification	1	0,026
suggestion	1	0,084	alternative	1	0,041	likelihood	1	0,026
experiment	1	0,084	integration	1	0,041	suggestion	1	0,026
implication	1	0,084	speculation	1	0,041	hypothesis	1	0,026
prediction	1	0,084	inferences	1	0,041	tendency	1	0,026
schem*	1	0,084	hypothesis	1	0,041	disagreement	1	0,026
Sum	**163**	**13,686**	rationale	1	0,041	conclusion	1	0,026
			tendency	1	0,041	derivation	1	0,026
Total	**%**	**1,37**	commitment	1	0,041	certainty	1	0,026
			scheme	1	0,041	inference	1	0,026
			prediction	1	0,041	condition	1	0,026
			contradiction	1	0,041	prediction	1	0,026
			candidate	1	0,041	contradiction	1	0,026
			credence	1	0,041	candidate	1	0,026
			proportionality	1	0,041	gap	1	0,026
			tendency*	1	0,041	credence	1	0,026
			postulate	1	0,041	proportionality	1	0,026
			Sum	**535**	**21,948**	integration	1	0,026
						Sum	**814**	**20,815**
			Total	**%**	**2,19**			
						Total	**%**	**2,08**

2.6. Adjectives as hedges: quality of knowledge

set_hedgesadj = {‘probable’, ‘possible’, ‘particular’, ‘suggested’, ‘contradictory’, ‘conclusive’, ‘arguable’, ‘argumentative’, ‘trusted’, ‘reliable’, ‘unreliable’, ‘comparative’, ‘likely’, ‘committed’, ‘general’, ‘estimated’, ‘speculated’, ‘speculative’, ‘bounded’, ‘evidential’, ‘observational’, ‘empirical’, ‘inferential’, ‘compelling’, ‘reasonable’, ‘unlikely’, ‘certain’, ‘uncertain’, ‘predicted’, ‘established’, ‘theoretical’, ‘hypothetical’, ‘few’, ‘complete’, ‘limited’, ‘true’, ‘critical’, ‘assumed’, ‘false’, ‘preliminary’, ‘final’, ‘sufficient’, ‘tentative’, ‘proposed’, ‘experimental’, ‘testable’, ‘tested’, ‘insufficient’, ‘understood’, ‘based on’, ‘postulated’, ‘implied’, ‘negated’, ‘posited’, ‘positive’, ‘anticipated’, ‘dictated’, ‘convincing’, ‘potential’, ‘potent’, ‘wrong’, ‘unconvincing’, ‘considered’, ‘significant’, ‘reported’, ‘presented’, ‘calculated’, ‘implicit’, ‘applicable’}

FAR	N	Freq.	Sarake1	SAR	N2	Freq.3	Sarake4	TAR	N5	Freq.6
possible	17	1,427		significant	29	1,19		significant	27	0,69
significant	16	1,343		possible	23	0,944		observed	26	0,665
observed	8	0,672		likely	18	0,739		likely	24	0,613
few	7	0,588		observed	16	0,657		possible	19	0,486
detailed	7	0,588		limited	10	0,41		particular	14	0,358
assumed	7	0,588		uncertain	9	0,369		uncertain	14	0,358
particular	5	0,42		general	9	0,369		few	14	0,358
corresponding	4	0,336		potential	7	0,287		consistent	13	0,332
reported	4	0,336		central	7	0,287		observational	13	0,332
potential	3	0,252		estimated	7	0,287		general	12	0,307
likely	3	0,252		preliminary	6	0,246		potential	11	0,281
reasonable	3	0,252		empirical	6	0,246		limited	11	0,281
positive	3	0,252		certain	5	0,205		central	10	0,256
appropriate	3	0,252		complete	5	0,205		assumed	7	0,179
poor	3	0,252		unlikely	5	0,205		identical	7	0,179
limited	3	0,252		observational	5	0,205		reasonable	5	0,128
convincing	3	0,252		consequent	5	0,205		predicted	4	0,102
preliminary	2	0,168		sufficient	4	0,164		empirical	4	0,102
proportional	2	0,168		reasonable	4	0,164		numerical	4	0,102
empirical	2	0,168		assumed	4	0,164		certain	4	0,102
theoretical	2	0,168		reported	4	0,164		applicable	3	0,077
necessary	2	0,168		theoretical	3	0,123		complete	3	0,077
suggested	2	0,168		few	3	0,123		reliable	3	0,077
uncertain	2	0,168		implied	3	0,123		sufficient	3	0,077
absolute	2	0,168		tentative	2	0,082		true	3	0,077
general	1	0,084		numerical	2	0,082		understood	2	0,051
implicit	1	0,084		particular	1	0,041		unlikely	2	0,051
estimated	1	0,084		experimental	1	0,041		speculative	2	0,051
insufficient	1	0,084		suggested	1	0,041		estimated	2	0,051
proposed	1	0,084		insufficient	1	0,041		shallow	1	0,026

compelling	1	0,084	compelling	1	0,041	anticipated	1	0,026
observational	1	0,084	bounded	1	0,041	suggested	1	0,026
implied	1	0,084	poor	1	0,041	published	1	0,026
probable	1	0,084	reliable	1	0,041	established	1	0,026
sufficient	1	0,084	predicted	1	0,041	poor	1	0,026
evident	1	0,084	proposed	1	0,041	implied	1	0,026
consistent	1	0,084	understood	1	0,041	theoretical	1	0,026
confident	1	0,084	true	1	0,041	tentative	1	0,026
certain	1	0,084	wrong	1	0,041	contradictory	1	0,026
unlikely	1	0,084	Sum	214	8,778	insufficient	1	0,026
consequent	1	0,084				Sum	277	7,086
	131	11,002	Total	%	1,02			
						Total	%	0,97
Total	%	1,1						

2.7. Approximators, the most important group of hedges

set_hedgesapprox = {'quantitative', 'much higher', 'amount', 'index', 'level (of *knowledge, *confidence, *simplification, *understanding)', 'measure*' 'qualitative', 'quantif*', 'precise', 'maximum', 'close', 'small', 'between', 'any', 'large*', 'much larger', 'much more', '±*', 'somewhat', 'range*', 'adequate', 'fraction*', 'at least', 'value', 'approximate', 'exact', 'order', 'sign', '(a) few', 'fraction', 'much smaller', 'limit*', '*accurate to within*', '*measure', 'less', 'fewer', 'much greater', 'below', 'precise', 'as much as', 'same', 'more', 'under', 'random*', 'nearly', 'over and above', 'strong*', 'sizeable', 'exact', 'far', 'equal*', 'same', '*specif*', 'quantit*', 'nominal', 'above', 'very', 'compare', 'decrease', 'close to', 'accurate', '*minimise', 'much less', 'roughly', 'much poorer ', 'vicinity', '*estimate', 'many', 'increase', '*minimum', 'adjust*', 'about', 'much longer', 'around', '*estimating', 'correspond', 'adequat*', 'large', 'smaller', 'add', 'reduce', 'quality', 'multi', 'range', 'similar*', 'counting', 'relative', 'average', 'mean', 'extension', 'precis*', 'size', 'much narrower', 'much', 'count*', 'rate', 'match', 'correlate'}

FAR	N	Freq.	Sarake4	SAR	N2	Freq.2	Sarake8	TAR	N3	Freq.3
change	70	5,876		estimat*	120	4,924		change	230	5,878
increase	45	3,778		change	112	4,596		mean	102	2,607
about	26	2,183		about	72	2,954		increase	98	2,505
estimat*	25	2,099		increase*	60	2,462		large*	83	2,121
scale	22	1,847		rate	57	2,339		range*	83	2,121
decrease	21	1,763		mean	57	2,339		value	81	2,07
relativ*	20	1,679		large*	52	2,134		estimate	75	1,917
more	19	1,595		high*	51	2,093		relative	68	1,738

add	19	1,595	level	49	2,011	more	67	1,712
add*	19	1,595	more	45	1,847	range	65	1,661
small	18	1,511	low*	43	1,764	small	56	1,431
large*	18	1,511	rang*	38	1,559	about	55	1,406
small*	18	1,511	range	34	1,395	less	41	1,048
relative	17	1,427	short*	34	1,395	large	37	0,946
value	16	1,343	±	32	1,313	very	33	0,843
even	15	1,259	large	29	1,19	adjust*	33	0,843
range	14	1,175	ratio	29	1,19	approximately	30	0,767
long*	14	1,175	relative*	28	1,149	smaller	28	0,716
further	13	1,091	value	27	1,108	measurement	28	0,716
mean	13	1,091	quanti*	27	1,108	further	25	0,639
range*	13	1,091	limit	25	1,026	limit*	25	0,639
great*	13	1,091	same	22	0,903	ratio	24	0,613
any	12	1,007	reduc*	22	0,903	even	23	0,588
high*	12	1,007	long*	21	0,862	same	22	0,562
compar*	12	1,007	measur*	21	0,862	any	21	0,537
above	10	0,839	even	20	0,821	maximum	21	0,537
less	10	0,839	relative	20	0,821	many	21	0,537
very	9	0,756	smaller	19	0,78	decrease	21	0,537
many	9	0,756	small	18	0,739	size	21	0,537
sign	9	0,756	size	18	0,739	quantit*	19	0,486
short	8	0,672	similar*	16	0,657	quantif*	19	0,486
large	8	0,672	less	15	0,616	measure*	18	0,46
amount	7	0,588	amount	15	0,616	level	16	0,409
between	7	0,588	less*	15	0,616	index	15	0,383
few	7	0,588	further	13	0,533	minimum	15	0,383
size	7	0,588	any	13	0,533	few	14	0,358
average*	7	0,588	very	12	0,492	(a) few	14	0,358
order	6	0,504	between	11	0,451	level (of)	14	0,358
far	6	0,504	average	11	0,451	rate	12	0,307
specif	6	0,504	many	11	0,451	order	11	0,281
reduc*	6	0,504	approximate*	10	0,41	fraction*	11	0,281
measur*	6	0,504	increase	10	0,41	between	10	0,256
low	6	0,504	short	9	0,369	fraction	10	0,256
measure	5	0,42	approximately	9	0,369	accurate	9	0,23
around	5	0,42	close*	9	0,369	accurate (to)	9	0,23
same	5	0,42	order	8	0,328	±*	9	0,23
correspond*	5	0,42	few	7	0,287	measure	8	0,204
quanti*	5	0,42	even (*)	7	0,287	far	8	0,204
limit*	5	0,42	close	6	0,246	average	8	0,204
near*	5	0,42	much	6	0,246	at least	8	0,204
minim*	5	0,42	decrease	6	0,246	amount	7	0,179
±*	4	0,336	rise	5	0,205	somewhat	7	0,179
approximate*	4	0,336	reduce	5	0,205	long	7	0,179

strong*	4	0,336	long	5	0,205	around	7	0,179
alter	3	0,252	around	4	0,164	short	7	0,179
level	3	0,252	nearly	4	0,164	approximate	7	0,179
index	3	0,252	exact	4	0,164	much less	7	0,179
below	3	0,252	below	4	0,164	sign	6	0,153
close	3	0,252	up to	4	0,164	close	6	0,153
long	3	0,252	adequat*	4	0,164	much more	6	0,153
rate	3	0,252	Maunder Minimum	4	0,164	close to	6	0,153
average	3	0,252	under	3	0,123	alter	5	0,128
fraction	3	0,252	precise	3	0,123	under	5	0,128
smaller	3	0,252	match	3	0,123	exact	5	0,128
correlate	3	0,252	above	3	0,123	comparable	5	0,128
at least	3	0,252	adequately	3	0,123	precis*	5	0,128
poor	3	0,252	fraction	3	0,123	much	4	0,102
exactly	2	0,168	index	3	0,123	vicinity	4	0,102
under	2	0,168	at least	3	0,123	quality	4	0,102
somewhat	2	0,168	compar*	3	0,123	much smaller	4	0,102
reduce	2	0,168	*alter*	3	0,123	above	3	0,077
multi*	2	0,168	max*	3	0,123	nearly	3	0,077
maxim*	2	0,168	correlate	3	0,123	reduce	3	0,077
much smaller	2	0,168	compare	2	0,082	fewer	3	0,077
much greater	2	0,168	somewhat	2	0,082	correspond	3	0,077
as much as	2	0,168	measure	2	0,082	rise	3	0,077
extreme	2	0,168	much shorter	2	0,082	as much as	3	0,077
much	1	0,084	accurat*	2	0,082	much larger	3	0,077
approximately	1	0,084	level (epistemic	2	0,082	adequat*	3	0,077
accurate	1	0,084	adequate	1	0,041	roughly	2	0,051
precise	1	0,084	roughly	1	0,041	add	2	0,051
rise	1	0,084	far	1	0,041	adequately	2	0,051
match	1	0,084	sign	1	0,041	counting	2	0,051
ratio	1	0,084	approximate	1	0,041	much greater	2	0,051
nearly	1	0,084	accurate	1	0,041	count*	2	0,051
equal	1	0,084	much less	1	0,041	below	1	0,026
maximum	1	0,084	much more	1	0,041	adequate	1	0,026
much more	1	0,084	much larger	1	0,041	exactly	1	0,026
exact	1	0,084	much longer	1	0,041	extension	1	0,026
equal*	1	0,084	much faster	1	0,041	nominal	1	0,026
much less	1	0,084	as much as	1	0,041	precise	1	0,026
rough	1	0,084	as large as	1	0,041	measuring	1	0,026
adjust*	1	0,084	(by) far	1	0,041	sizeable	1	0,026
extensive*	1	0,084	quali*	1	0,041	over and above	1	0,026
much lower	1	0,084	rough	1	0,041	much stronger	1	0,026
over	0	0	**Sum**	**1528**	**62,696**	much higher	1	0,026
Sum	**767**	**64,397**				much longer	1	0,026

			Total	**%**	**6.27**	much narrower	1	0,026
Total	**%**	**6.44**				much poorer	1	0,026
						by far	1	0,026
						minimise	1	0,026
						in the order of	1	0,026
						random*	1	0,026
						over	1	0,026
						Sum	**1946**	**49,746**
						Total	**%**	**4.97**

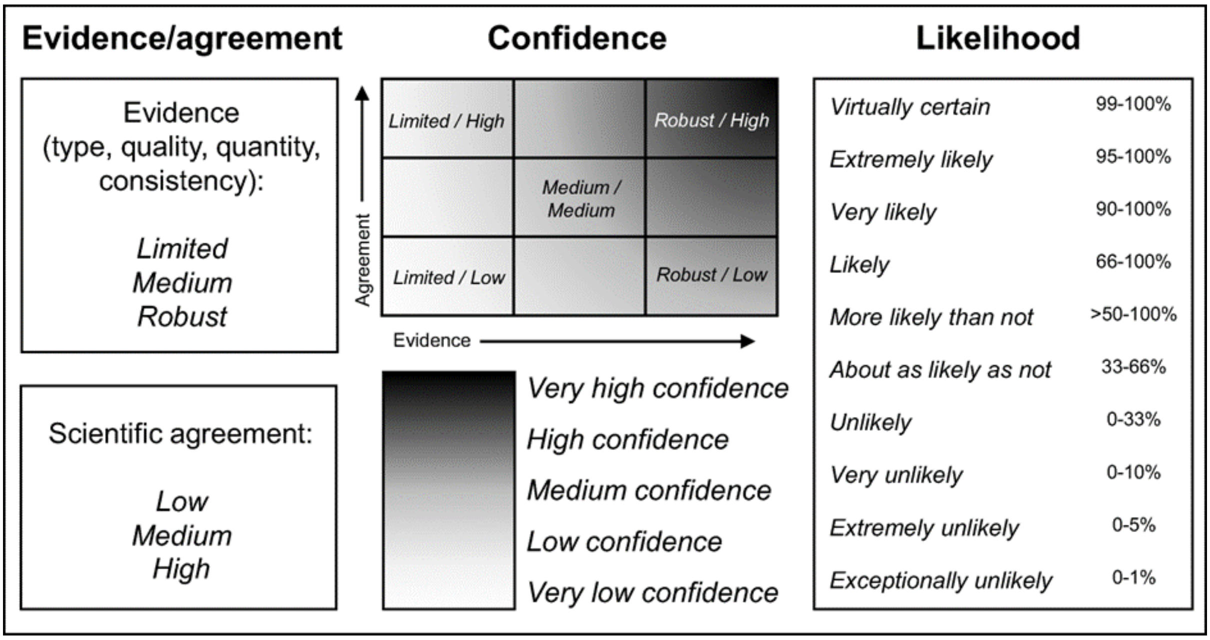
2.8. Time: past, present and future; the newest studies, concepts

FAR	N	Freq.	SAR	N	Freq.	TAR	N	Freq.
period	31	2,332	1994	227	8,337	1999	131	3,336
time	28	2,106	1995	110	4,04	1998	107	2,725
years	21	1,58	ipcc	101	3,71	sar	89	2,267
decade	19	1,429	time	48	1,763	1997	85	2,165
future	18	1,354	1992	41	1,506	1996	73	1,859
time(-)scale*	18	1,354	1993	40	1,469	2000	70	1,783
1989	17	1,279	future	28	1,028	1995	66	1,681
1988	12	0,903	recent	28	1,028	time	60	1,528
decades	10	0,752	1990	26	0,955	present	50	1,273
past	10	0,752	1991	25	0,918	period	41	1,044
present	10	0,752	new	25	0,918	pre-industrial	30	0,764
century	9	0,677	years	23	0,845	times	27	0,688
decadal	9	0,677	past	20	0,735	recent	23	0,586
cycle	9	0,677	present	18	0,661	future	22	0,56
next	8	0,602	times	17	0,624	new	20	0,509
times	8	0,602	period	15	0,551	past	20	0,509
1987	8	0,602	century	12	0,441	2001	20	0,509
far	7	0,527	decade	10	0,367	seasonal	19	0,484
last	7	0,527	pre-industrial	9	0,331	near	16	0,407
10 000	7	0,527	long-term	8	0,294	years	12	0,306
recent	5	0,376	1850	7	0,257	1986	11	0,28
1985	4	0,301	seasonal	6	0,22	industrial	11	0,28
industrial	4	0,301	industrial	5	0,184	decade	11	0,28
near	3	0,226	decadal	5	0,184	decades	11	0,28
1765	3	0,226	short-term	4	0,147	century	10	0,255

pre-industrial	3	0,226	decades	4	0,147	far	8	0,204
1986	3	0,226	near	2	0,073	temporal	8	0,204
100 000	3	0,226	centuries	1	0,037	1750	7	0,178
centuries	2	0,15	temporal	1	0,037	long-term	5	0,127
temporal	2	0,15	far	1	0,037	decadal	3	0,076
new	1	0,075	Sum	867	31,844	1850	2	0,051
near-term	1	0,075				interval	1	0,025
short-term	1	0,075	Of all 3,18 %			Sum	1069	27,223
seasonal	1	0,075						
millenium*	1	0,075				Of all 2,72 %		
Sum	303	22,794						
Of all 2.28 %								

2.9. Uncertainty language in FAR, SAR, and TAR

set_uncertainty language = {‘evidence’, ‘limited, ‘medium’, robust’, ‘low’, ‘medium’, ‘high,’ ‘agreement’, ‘confidence’, ‘likelihood’, ‘virtually certain’, ‘likely’, ‘extremely likely’, ‘more’, ‘about’, ‘unlikely’, ‘very high’, ‘very likely’, ‘very high confidence’, ‘medium confidence’, ‘low confidence’, ‘very low confidence’, ‘more likely than not’, ‘about as likely as not’, ‘very unlikely’, ‘extremely unlikely’, ‘exceptionally unlikely’}



Uncertainty language has seeped into the reports. FAR shows the least amount of uncertainty language related hedges, or expressions of ‘evidence, agreement, confidence or likelihood’, SAR already showing a clear increase in ‘uncertainty language, or likewise’ -modified expressions. Again, SAR is the leader in relative numbers. Some of the most ambiguous results are omitted, and the vocabulary is restricted to extend only over the expressions in the table above.

FAR	N	Freq.	Sarake4	SAR	N2	Freq.2	Sarake8	TAR	N3	Freq.3
evidence	8	0,601		evidence	19	0,698		likely	24	0,611
agreement	5	0,376		likely	18	0,661		low (uncertainty l.)	16	0,407
likely	4	0,301		confidence	18	0,661		confidence (uncertainty l.)	14	0,357
unlikely	1	0,075		limited	12	0,441		evidence	12	0,306
very low confidence	1	0,075		agreement	7	0,257		limited	11	0,28
limited	0	0		unlikely	5	0,184		agreement	11	0,28
confidence	0	0		very unlikely	1	0,037		confidence (as such)	4	0,102
medium	0	0		more likely	1	0,037		medium	3	0,076
robust	0	0		medium	0	0		unlikely	2	0,051
likelihood	0	0		robust	0	0		robust	2	0,051
virtually certain	0	0		likelihood	0	0		medium (LOSU)	2	0,051
extremely likely	0	0		virtually certain	0	0		likelihood	1	0,025
very likely	0	0		extremely likely	0	0		very low confidence	1	0,025
very high confidence	0	0		very likely	0	0		virtually certain	0	0
medium confidence	0	0		very high confidence	0	0		extremely likely	0	0
low confidence	0	0		medium confidence	0	0		very likely	0	0
more likely than not	0	0		low confidence	0	0		very high confidence	0	0
about as likely as not	0	0		very low confidence	0	0		medium confidence	0	0
very unlikely	0	0		more likely than not	0	0		low confidence	0	0
extremely unlikely	0	0		about as likely as not	0	0		more likely than not	0	0
exceptionally unlikely	0	0		extremely unlikely	0	0		about as likely as not	0	0
Sum	19	1,428		exceptionally unlikely	0	0		very unlikely	0	0
Total	%	0,14		Sum	81	2,976		extremely unlikely	0	0
				Total	%	0,3		exceptionally unlikely	0	0
								Sum	103	2,622
								Total	%	0,26

Appendix 3.8. Python Functions

```
from collections import Counter

import xlsxwriter



RForce_FAR = []

#punctuation = ['\n', '.', ',', '(', ')', '?', ':', ';']

#with open("C:/Users/User/Downloads/FAR 1990/Radiative Forcing bulk_allwith introductions included.txt", "r", encoding = "UTF8" ) as radiating:

  #while True:

    #line_r_force = radiating.readline()

    #if len(line_r_force) == 0:

      #break

    #for symbol in line_r_force:

      #if symbol in punctuation:

        #line_r_force = line_r_force.replace(symbol, '')

        #list_r_force = line_r_force.lower().split(' ')

    #for word in list_r_force:

      #if word != '':

        #RForce_FAR.append(word)

    #RForce_FAR.extend(list_r_force)
```

The above effort to create a list of words from the FAR txt.file was not successful. I only noticed later on that new line -characters and empty spaces littered the list and the word count was not correct. Below a more accurate function. Both functions have been created with the help of my son, Henri Rapeli, and they base on material from the Technological University of Lappeenranta.

```
RForce_FAR = []

#punctuation = ['\n', '.', ',', '%', '(', ')', '?', ':', ';', '°C', '-', 'K', '±', '+']

punctuation = ['\n', '.', ',', '(', ')', '?', ':', ';']

with open("C:/Users/User/Downloads/FAR 1990/Radiative Forcing bulk_allwith introductions included.txt", "r", encoding = "UTF8" ) as radiating:

    while True:

        line_r_force = radiating.readline()

        if len(line_r_force) == 0:

            break

        lines_r_force = "".join(u for u in line_r_force if u not in ('\n', '.', ',', '(', ')', '?', ':', ';'))

        #for symbol in line_r_force:

            #if symbol in punctuation:

                #line_r_force = line_r_force.replace(symbol, '')

        list_r_force = lines_r_force.lower().split(' ')

        for word in list_r_force:

            if word != '':

                RForce_FAR.append(word)
```

This function gave me better results that were more compatible with those derived via AntConc. In some cases, I have needed to use items in the 'punctuation-list' that have with temperature or sign to do. When I wanted to create ngrams (below, source: Internet), it was necessary not to use the '.lower()' -method.

```
print(len(RForce_FAR))



wordihotti = RForce_FAR

def generate_ngrams(wordihotti, n):

    FAR_ngrams_list = []

    for num in range(0, len(wordihotti)):

        ngram = ' '.join(wordihotti[num:num + n])

        FAR_ngrams_list.append(ngram)

    return FAR_ngrams_list
```

```
#Common auxiliary-type hedges:


hedgesaux = Counter(RForce_FAR)
set_hedgesaux =  {'would', 'may', 'might', 'can', 'could', 'should', 'must',
            'cannot'}
dict_set_hedges = {}
for key, value in hedgesaux.items():
    if key in set_hedgesaux:
        dict_set_hedges[key] = value
print(dict_set_hedges)
#dict_set_hedges['cannot'] = 3
#dict_set_hedges['would'] = 22
print(sum(hedgesaux.values()))
```

This function shows how it is possible to create a dictionary out of a Counter-object. Set_hedgesaux = keys. To get some insight into the data, I have also used the most_common -method:

```
for word in hedgesaux.most_common(300):
    print(word)
```

My son helped me to create a calculating function to find any references to studies made in 1990's, (or alternatively, in the 2000's = '02'). The numbers of references in the IPCC reports is staggering. My own problem was constant index-error. Parentheses need to be removed from 'punctuation' prior running this fuction. The resulting numbers are so high, they make me wonder.

```
referred = []
for i in range(0, len(wordihotti)):
    word = wordihotti[i]
    if len(word) > 0 and word[-1] == ')' and word[-2 : -6 : -1].isdigit() and word[-4: -6:-1] == '91':
        referred.append(word)
        print(wordihotti[i - 3], wordihotti[i -2], wordihotti[i -1], word)
print('referred = ', len(referred))


ratios = [round(v/sum(hedgesaux.values()) * 1000, 3) for v in dict_set_hedges.values()]
print(ratios)
percentage_aux_all = round(sum(dict_set_hedges.values())/sum(hedgesaux.values()) * 100, 2)
def add_normalised_frequencies(dictionary, values):
```

```
    i = 0
    for key, value in dictionary.items():
        if type(value) == list:
            dictionary[key].append(values[i])
        else:
            dictionary[key] = [value]
            dictionary[key].append(values[i])
        i += 1
```

For the function above I needed again help from Henri Rapeli. He was able to combine the calculated ratios and the total percentage to the search results.

```
print('from')
print(len(set_hedgesaux))
print('search items')
print(len(FARaux))
print('hits')
print(percentage_aux_all,'% from a total of 11921 words')
```

```
def mostcommon(dicts):
    s = sorted(dicts.items(), key = lambda k: k[-1][0], reverse = True)
    resultdict = {k: v for k, v in s}
    return resultdict
```

Here my son helped me to get feasible items into the result tables. The order is now from highest number to the lowest.

```
FARauxes = mostcommon(FARaux)

wb = xlsxwriter.Workbook('FARaux.xlsx')
ws = wb.add_worksheet('Sheet1')
row, col = 0, 0
for key, value in FARauxes.items():
    ws.write(row, col, key)
    ws.write(row, col + 1, value[0])
    ws.write(row, col + 2, value[1])
```

```
    row += 1
wb.close()
```

And finally, this function creates Excel-tables from my Python search -results. Again, I am in deep debt to my son.

SR