nature climate change

ARTICLES

PUBLISHED ONLINE: 12 OCTOBER 2015 | DOI: 10.1038/NCLIMATE2824

# Linguistic analysis of IPCC summaries for policymakers and associated coverage

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**The Intergovernmental Panel on Climate Change (IPCC) Summary for Policymakers (SPM) is the most widely read section of IPCC reports and the main springboard for the communication of its assessment reports. Previous studies have shown that communicating IPCC findings to a variety of scientific and non-scientific audiences presents significant challenges to both the IPCC and the mass media. Here, we employ widely established sentiment analysis tools and readability metrics to explore the extent to which information published by the IPCC differs from the presentation of respective findings in the popular and scientific media between 1990 and 2014. IPCC SPMs clearly stand out in terms of low readability, which has remained relatively constant despite the IPCC's efforts to consolidate and readjust its communications policy. In contrast, scientific and quality newspaper coverage has become increasingly readable and emotive. Our findings reveal easy gains that could be achieved in making SPMs more accessible for non-scientific audiences.**

Given the magnitude of the problem, as well as the diverse set of audiences the IPCC reports to, the way in which findings have been communicated to—and received by—the media has sparked considerable controversy[1,2], epitomizing the sharp divide between communicating within the scientific community and conveying findings to the media[3]. Crucially, IPCC SPMs can be seen as reporting from experts in one field (scientists) to experts in different fields (scientists from other fields and policymakers), with all the disciplines and sub-disciplines each of these fields contain. The IPCC's efforts to consolidate and readjust its communications policy illustrate the challenges this creates. The IPCC's remit is to synthesize and communicate the current state of climate research to governments and policymakers at all levels[4]. Its findings should be communicated in a way that can be understood by a non-scientific audience[5]. One of its key principles is to be policy-relevant, but not policy-prescriptive[6]. We would therefore expect SPMs to reflect these principles by adopting a clear and neutral language that can be understood by a non-specialist audience. At the same time, it is of crucial importance how the print media interpret the results presented by the IPCC, as pivotal agents in science communication[7] to the general public. Previous research has focused on the way in which IPCC probabilistic statements are interpreted[8,9], and on the discursive construction of the IPCC in national newspapers[10] and social media coverage[11,12], including the influence of grammatical and word choices[13].

The purpose of this study is to analyse the language that has been used in IPCC SPMs as well as a sample of popular science journals and UK and US national (quality and tabloid) newspapers on the launch of the IPCC assessment reports ($N = 1{,}010$; see Supplementary Table 1) between 1990 and 2014. We focus on two dimensions of this communication process. The Flesch Reading Ease (FRE) algorithm[14,15] enables us to assess the comprehension of IPCC SPMs and related print media coverage. The algorithm is based on the assumption that text containing longer sentences and more complex words is more difficult to comprehend. The content analysis software DICTION[16] allows us to assess the degree of optimism—and therefore the tone—of different bodies of text. Both are widely established metrics that have been used in a variety of contexts ranging from paediatrics[17] to accounting research[18,19].

FRE scores by publication type for the period 1990–2014 are presented in Fig. 1. Average scores reflect that all four publication types target different audiences, employ a different language and transmit different messages. Mean scores across tabloid newspapers (*Daily News, The Mirror, The Sun*) and quality newspapers (*New York Times, Washington Post, The Independent, The Times*) are relatively low compared to the way in which these publications cover other issues[14]. This is unsurprising given that the launch of an IPCC report is a very specific event referring to a complex phenomenon. For scientific publications, only editorials and news articles of *Nature* and *Science* were considered. They occupy a middle-ground between IPCC SPMs and quality newspaper coverage. IPCC SPMs and tabloid coverage on the launch of the reports clearly stand out, with mean FRE scores of 20 and 50, respectively (Fig. 1).

However, changes can be observed over time in some publication types (Fig. 2; see also Supplementary Fig. 1). Readability of quality newspapers and scientific publications peaks in 2007, possibly as a result of a relatively high share of opinion pieces linked to increased public concern triggered by major media events around the time, such as the Stern Review[20] and the Nobel Peace Prize awarded to Al Gore and the IPCC[21]. The Fourth Assessment Report in 2007 is also the first IPCC Report to receive considerable coverage by tabloid newspapers included in our sample.

In contrast, readability of IPCC SPMs does not follow this trend. Although no significant differences in readability scores can be identified in mean scores between the five different assessment periods, descriptive statistics show that mean readability scores

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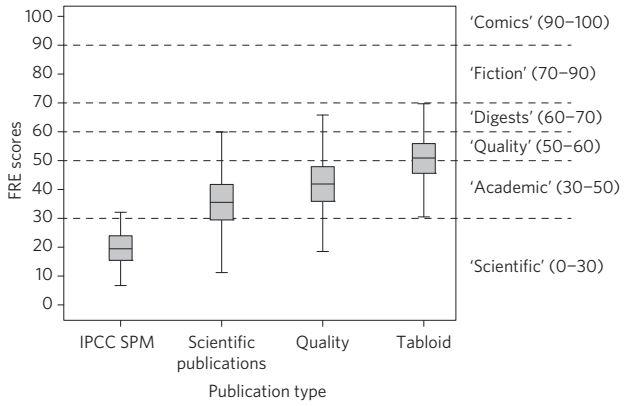


**Figure 1 | Box-and-whisker plots showing FRE scores for IPCC SPMs and scientific publications (*Nature* and *Science*) as well as quality (*The Independent*, *The Times*, *New York Times*, *Washington Post*) and tabloid newspapers (*The Mirror*, *The Sun*, *Daily News*) related to the launch of IPCC assessment reports from 1990 to 2014.** On the right-hand side are typical FRE ranges for different types of publications.

for the First Assessment Report (AR1) SPMs are notably higher than for those of later assessment periods. This decrease might reflect the increasing complexity of the underlying science over time. At the same time, later SPMs might assume a higher degree of prior knowledge on behalf of the reader. For example, the initial sections of the AR1 Working Group 1 SPM (*'Introduction: what is the issue?'*, FRE 44.1; *'What are the greenhouse gases and why are they increasing?'*, FRE 37.4) provide a more general introduction to the subject area and are clearly aimed at a non-expert audience. As such, readability scores of these sections are notably higher than the remainder of this SPM. No such passages, introducing the basic underlying science in layman's terms, can be found in later SPMs. However, this decrease in readability over time is not a uniform trend across the different Working Groups (WGs). WG2 and WG3 show clear downward trends, whereas readability of WG1 SPMs remains relatively stable over time. In line with previous studies[22], these differences between Working Groups show that natural sciences are not necessarily the most difficult ones to communicate to general audiences.

In addition to the link between scientific fields and writing styles, another more pragmatic reason could be that WG2 and WG3 are much more diverse in terms of the scientific fields they draw from than the relatively homogeneous WG1[23]. Likewise, findings from WG2 and WG3 might be exposed more directly to pressures arising from the remit to be policy-relevant but policy-neutral[6]. This diversity of scientific fields and policy implications might result in a greater need to compromise, in turn resulting in longer and more complex sentences. The AR5 WG3 SPM is the least readable document across the entire sample, with a FRE score of 6.7.

A different pattern can be identified in the readability of synthesis reports (SYR) over time. Again, the AR1 synthesis report shows the highest readability score. However, readability drops sharply in AR2,

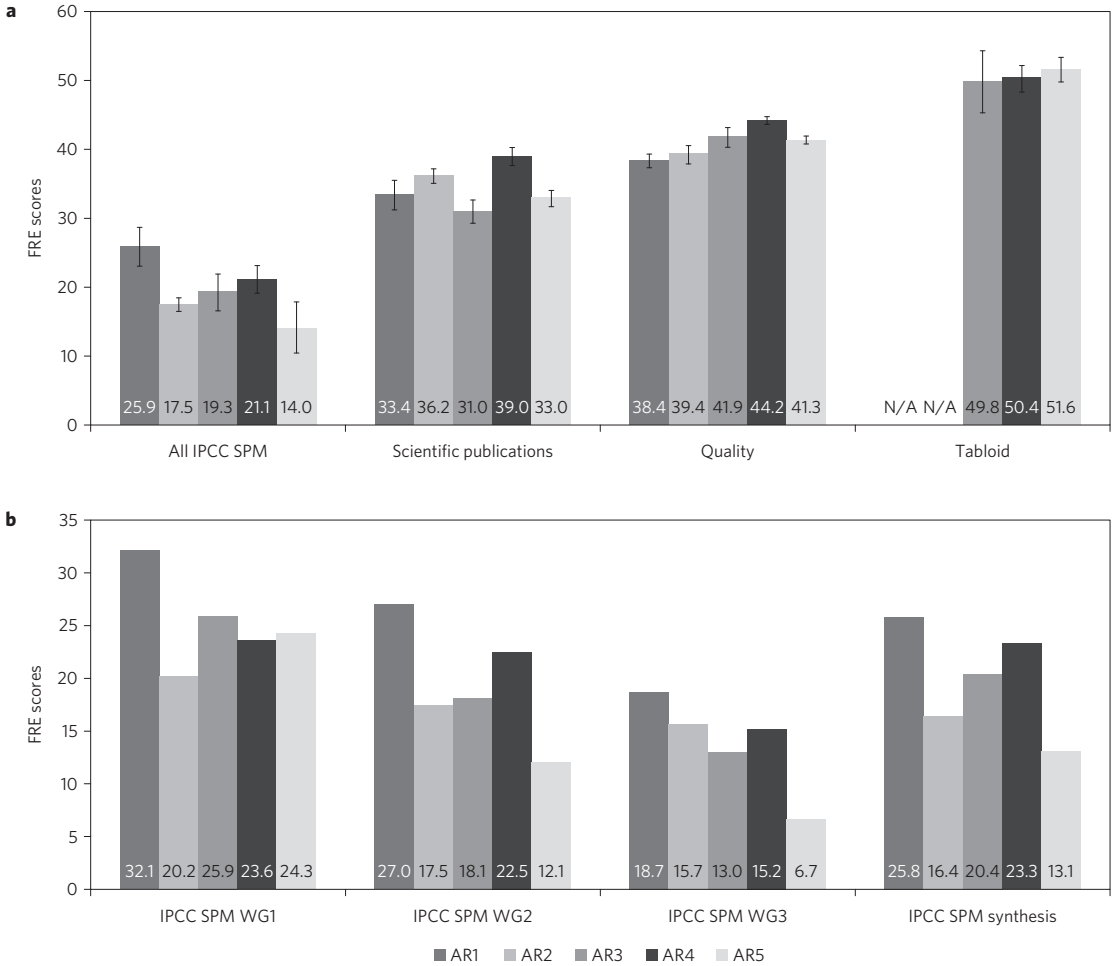


**Figure 2 | Mean FRE scores over time for IPCC SPMs and scientific publications, as well as quality and tabloid newspapers related to the launch of IPCC assessment reports from 1990 to 2014. a**, Overall mean FRE scores for the four publication types (with standard errors). **b**, FRE scores for the individual IPCC SPMs for each WG and synthesis report (or equivalent).

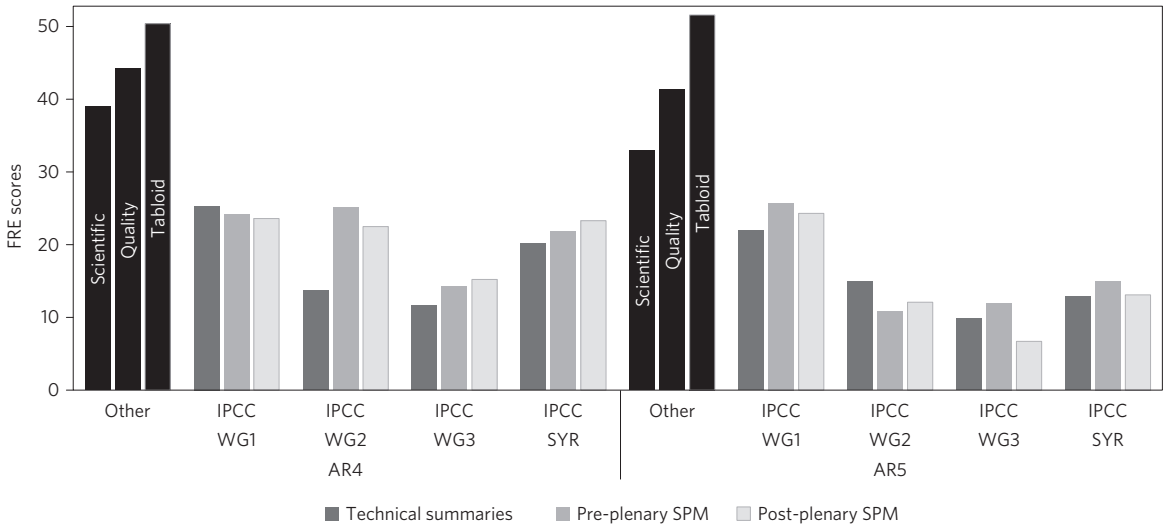


**Figure 3 | Comparison of FRE scores for pre- and post-plenary AR4 and AR5 IPCC SPMs as well as TSs.** We found no significant differences in mean scores between pre- and post-plenary versions as well as TSs. For illustration, mean scores for AR4 and AR5 are also included for the other three publication types (black bars).

subsequently recovering in AR3 and, in particular, AR4—albeit remaining at a level that is lower than in AR1. There is another sharp drop in readability from AR4 to AR5, which is not surprising given the low readability scores of AR5 WG3 and WG2. The average readability score across the three Working Groups for each assessment report is very close to the readability score of the synthesis SPM for each assessment report. This observation is consistent with the fact that the synthesis report draws most of its text from the other Working Group's SPMs.

The readability of Technical Summaries (TSs), pre-plenary and post-plenary SPMs for each WG in AR4 and AR5 were compared (Fig. 3). TSs are intended to capture the most important scientific aspects of the full Working Group assessment report; they are longer than SPMs and include pointers to the chapters and sections where the full assessment can be found[24]. The pre-plenary SPM is a confidential draft that is sent to governments for a final review a few months before the WG and IPCC session that approves and accepts the SPM (thus making it post-plenary after copyediting) and the assessment report respectively. The plenary process is important to the SPM because its 'approval' means that the material has been subjected to detailed line by line discussion and agreement between government delegates and authors. Being more scientific, one would expect TSs to be less readable than SPMs and, given the line by line approval, one would expect pre-plenary SPMs to be less readable than post-plenary SPMs. This logical pattern is observed only twice (AR4 WG3 and SYR), and its reverse once (AR5 WG2), with one more occasion when the readability of the TS is higher than that of the SPMs (AR4 WG1). In all other instances (five out of eight cases), TS readability is lower than SPMs readability, expect for AR5 WG3 post-plenary SPM (which is exceptionally low). When comparing pre- and post-plenary SPMs, in five out of eight cases, the readability is lowered by the plenary process. We compared each change in AR4 and AR5 SPM readability (from pre- to post-plenary) with IPCC plenary discussions as reported by the Earth Negotiation Bulletin[25] (see Supplementary Table 2). We found a strong relationship between political mood and SPM readability. When political tensions and disagreements are high (AR4 WG1, WG2 and AR5 WG1, WG3, SYR) readability is lowered. When plenary sessions are characterized by efficient organization, constructive and straightforward exchange, and a good spirit of cooperation (AR4 WG3, SYR and AR5 WG2), readability is increased. It is worth highlighting AR5 WG3 as the largest decrease in readability after plenary in our sample ($\Delta$FRE = −5.3); Earth Negotiation Bulletin reporting of this plenary session shows the political nature of discussions characterizing line by line approval as 'arduous' and 'concerns of countries often expressed in the UNFCCC [United Nations Framework Convention on Climate Change] context leaking into the IPCC plenary'.

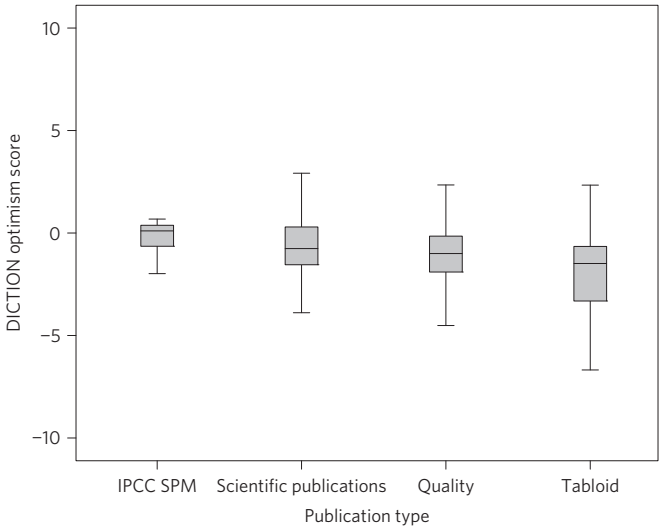


**Figure 4 | Box-and-whisker plots displaying DICTION optimism scores for IPCC SPMs, scientific publications, quality and tabloid newspapers related to the launch of IPCC assessment reports from 1990 to 2014.**

Clear differences can also be identified between the different publication types as well as over time in terms of DICTION optimism scores (Fig. 4). Starting with the assumption that IPCC SPMs adopt a language that is neutral in tone, we have used the mean optimism score across all IPCC SPMs as a benchmark for our assessment. For all other documents, raw DICTION scores were converted into $Z$-scores, expressing the deviation of the score of each individual document from the mean score of IPCC SPMs, divided by the standard deviation. We can therefore identify how the tone of related media coverage differs from the original SPMs. Supplementary Table 3 provides illustrative examples of coverage with corresponding readability and optimism scores.

**Table 1 | Most popular terms underlying DICTION positive/negative dictionary by publication type.**

| IPCC SPM | | Scientific publications | | Quality newspapers | | Tabloid newspapers | |
|---|---|---|---|---|---|---|---|
| Term | ΔFrequency | Term | ΔFrequency | Term | ΔFrequency | Term | ΔFrequency |
| **Risk** | **+5.19%** | **Problem** | **+1.29%** | *Power* | *+0.84%* | **Flood** | **+3.15%** |
| *Growth* | *+1.84%* | **Needed** | **+0.96%** | **Worse** | **+0.77%** | **Poverty** | **+1.57%** |
| *Important* | *+1.56%* | *Support* | *+0.87%* | **Problem** | **+0.52%** | **Threat** | **+1.46%** |
| **Vulnerable** | **+1.53%** | *Important* | *+0.69%* | *Clear* | *+0.52%* | **Blame** | **+1.42%** |
| **Negative** | **+1.52%** | *Good* | *+0.65%* | *Good* | *+0.41%* | **Worse** | **+1.31%** |
| *Enhance* | *+1.46%* | *Reason* | *+0.52%* | *Kind* | *+0.37%* | **Stop** | **+1.10%** |
| **Adverse** | **+1.46%** | *Knowledge* | *+0.52%* | **Tornado** | **+0.35%** | **Suffer** | **+1.04%** |
| **Lose** | **+1.40%** | *Strong* | *+0.49%* | *Prime* | *+0.33%* | *Truth* | *+0.97%* |
| *Health* | *+1.30%* | *Success* | *+0.49%* | *Hope* | *+0.32%* | *Prettier* | *+0.94%* |
| *Productive* | *+1.26%* | **Hard** | **+0.42%** | *Reason* | *+0.31%* | **Crises** | **+0.84%** |
| **Stress** | **+1.16%** | **Erroneous** | **+0.39%** | **Fail** | **+0.28%** | **Disaster** | **+0.78%** |
| *Qualified* | *+0.93%* | **Gross** | **+0.37%** | *Love* | *+0.27%* | **Danger** | **+0.76%** |
| *Positive* | *+0.81%* | *Sense* | *+0.37%* | **Poverty** | **+0.23%** | **Storm** | **+0.74%** |
| *Knowledge* | *+0.63%* | *Careful* | *+0.36%* | **Revolution** | **+0.23%** | **Death** | **+0.72%** |
| *Secure* | *+0.61%* | *Clear* | *+0.35%* | **Sacrifice** | **+0.23%** | *Authoritative* | *+0.54%* |

'ΔFrequency' denotes the relative frequency of a term for a specific publication type compared to the overall sample on average. For example, across the sample of tabloid coverage, 'flood' accounts for 6.65% of all mentions of terms indicating either a positive or negative outlook in the DICTION dictionary. By comparison, the relative frequency across all four publication types is 3.15% lower. DICTION terms indicating a positive (negative) outlook are shown in italics (bold).

On average, the tone of scientific publications, quality and—in particular—tabloid coverage is clearly more pessimistic than the tone found in the IPCC SPMs. In line with previous research[26], the clearest deviations can be found among tabloid newspapers. Newspapers need to turn a piece of scientific information into a piece of news, which among other aspects requires bringing future climate change consequences into the sphere of immediate interest of the reader. Using emotive language is one of the journalistic strategies for bringing the future into the immediate[27].

Linguistic differences in coverage between publication types are also reflected by the frequency of terms indicating a positive or negative outlook in the DICTION dictionary. Table 1 presents a comparison of terms according to their relative frequency in each of the four publication types. Unsurprisingly, 'risk' emerges as a central term in SPM texts: across all 20 SPMs, the term is mentioned 462 times, and thus accounts for 10% of all cases in which any of the 784 DICTION terms indicating either positive or negative outlook are mentioned. In stark contrast, the mean frequency of the term 'risk' across all four publication types is half of that. The terms with the highest differential in frequencies for SPMs compared to other publication types indicate a very measured use of language; for example, 'positive', 'negative', 'important', 'qualified' or 'knowledge' all reflect a comparatively neutral tone, even though they indicate a positive or negative outlook.

Tabloid coverage reflects a clearly different use of language. Extreme weather events ('flood', 'disaster', 'storm') and their catastrophic consequences ('poverty', 'crises', 'death') emerge as common themes. Overall, negative terms predominate, in contrast to the three other publication types, which reflect a more balanced distribution of positive and negative terms.

Beyond the differences in mean optimism scores, interesting changes over time can be identified (Fig. 5; see also Supplementary Fig. 2). Scientific publications show relatively moderate deviations from SPM optimism scores, with only little visible differences over time. In stark contrast, a downward trajectory can be identified in quality and tabloid newspapers, with the tone of coverage becoming increasingly pessimistic over time. It should be noted that the extreme score for tabloid coverage around AR3 is based on only five tabloid articles published in this period. Again, increasing levels of public awareness of climate change might have resulted in a profound change in newspaper coverage of the launch of IPCC assessment reports: related coverage can be expected to have moved from the science section towards headline news over time, in turn resulting in a less neutral—and thus more emotive—tone of this coverage. This is further supported by the fact that, over time, more extreme values—and thus an increasing polarization—can be identified in both quality and tabloid newspaper coverage. In 1990, deviations of more than one unit from mean IPCC SPM optimism scores could be found in 50% of all coverage in that year. However, this share steadily increases to 68% in 2013/14. It is interesting to note that, across the sample, FRE scores are significantly negatively correlated with DICTION optimism scores (Spearman's $\rho$; $r = -0.17$; $p < 0.001$). In other words, more readable text tends to have a more pessimistic tone.

Our findings have important implications for the IPCC and communication of science more generally. The IPCC needs to find ways to improve the readability of its SPMs, particularly those of WG3, but also WG2 more recently. Engaging professional science communicators as part of the negotiation of SPM texts could improve the readability of these documents, in particular given that we found that this negotiation between countries and scientists at the IPCC AR5 WG3 plenary had a further detrimental impact on the readability of their SPM. At the same time, plenaries are time-constrained events where yet another actor could potentially hinder rather than help, and add to already existing concerns that the original voice of the scientific panel could be distorted and politicized[28]. An alternative could be science communication training for parts of the panel, for example, lead authors involved in producing the pre-plenary SPM.

To a certain extent, the way in which the IPCC has addressed the treatment of uncertainties could serve as a blueprint for this process. Here, a series of guidelines were put together to assist lead authors with this topic in more recent reports[29,30], which helped to use more comprehensible and less ambiguous language. This practice could be extended to science communication more generally.

The need for more effective communication to non-scientific audiences has long been identified as a crucial challenge for the IPCC[31]. However, it has becomes particularly urgent given

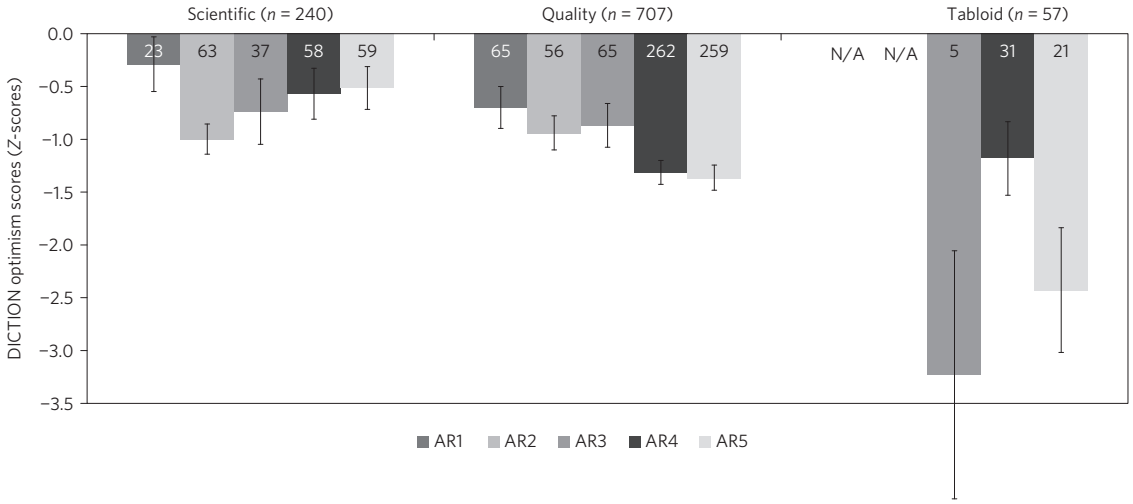


**Figure 5 | Mean DICTION optimism *Z*-scores (with standard errors) of different types of media compared to the IPCC SPMs mean over time.** Numbers on bars indicate the size of individual subsamples. Before 2001, no coverage on the IPCC could be found in any of the three tabloid newspapers included in the sample (*The Mirror*, *The Sun*, *Daily News*).

the observed trends in newspaper coverage on the topic. Our findings are in line with existing studies observing a distortion of scientific knowledge in the popular media based on various journalistic norms[32,33], in turn shaping the social construction of climate change[34]. Our findings also provide further evidence that the mainstreaming of climate change is likely to exacerbate this mismatch between scientific and wider societal understandings of climate-related knowledge: the more climate change-related news has moved beyond the science niche towards headline news in recent years, the more likely we have been to see increasingly emotive, opinionated coverage in the popular media. Thus, there is an even greater need for the IPCC to communicate its findings in a way that non-scientific audiences (including the news media as transmitters) can comprehend their findings. Despite the various obstacles to effective science communication[35,36], the readability scores of scientific publications in our sample indicate that clear improvements are possible in this regard.

## Methods

Methods and any associated references are available in the online version of the paper.

Received 14 September 2014; accepted 10 September 2015; published online 12 October 2015

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## Acknowledgements
We thank E. Ioannou and A. Gibson for valuable research assistance. We also thank participants of the workshop 'Media, the IPCC and the Cultural Politics of Climate Change' held at the University of Exeter in May 2014 for their comments on an earlier version of the manuscript. S.D. is supported by the European Research Council under the 7th Framework Programme (FP7/2007-2013)/ERC Grant agreement no. 284369 and by the UK Economic and Social Research Council (ESRC) for the Centre for Climate Change Economics and Policy (CCCEP).

## Author contributions
R.B. and B.M.-S. conceived the study. R.B., S.D. and G.N. designed the study. All co-authors contributed to analysis and writing.

## Additional information
Supplementary information is available in the online version of the paper. Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to R.B.

## Competing financial interests
The authors declare no competing financial interests.

## Methods

We conducted a linguistic analysis of IPCC SPMs and related print media coverage for each of the five assessment reports. The analysis focused on SPMs as well as leading scientific journals (*Nature*, *Science*) and UK- and US-based quality (*The Independent*, *The Times*, *New York Times*, *Washington Post*) and tabloid newspapers (*The Mirror*, *The Sun*, *Daily News*). Newspapers were selected based on type, circulation and political alignment. In an initial step, other UK-based quality newspapers such as *The Guardian* and *The Daily Telegraph* were also included in the sample for a preliminary analysis. Based on the fact that there was hardly any coverage on the IPCC linked to the first three assessment reports in *The Daily Telegraph* (no coverage at all for AR1 and AR2), we decided to select *The Times* as the quality newspaper with the highest circulation among UK centre-right publications. Resulting from this choice, we then decided to select *The Independent*—which we consider as a centre-left leaning quality newspaper—to arrive at a balanced sample. *The Independent* and *The Times* have repeatedly been used in analyses of UK-based quality newspapers in the context of climate change[34,37,38]. There would not have been a US-based quality newspaper equivalent of *The Guardian* available, and *The Independent* is the centre-left leaning quality newspaper with the second-highest circulation in the UK (after *The Guardian*). However, the inclusion of *The Guardian* would not have produced significantly different findings. Our preliminary analysis showed that although IPCC-related coverage was significantly higher in *The Guardian* when compared to the four newspapers included in the sample, overall mean readability scores for the set of Guardian articles was 40.1 and therefore very much in line with our sample of quality newspapers; likewise, DICTION optimism scores reflect the pattern identified for our sample.

For each of the assessment reports, media coverage was collected starting two months before the launch of the first Working Group report and ending two months subsequent to the launch of the synthesis report. Full-text articles were obtained from various databases, such as *LexisNexis* and *Faktiva*, and stored as simple text files for cleaning and subsequent processing. The search terms 'Intergovernmental Panel on Climate Change' and 'IPCC' were used to identify relevant articles. These were subsequently screened to exclude unrelated news articles. In particular, this included UK-based coverage on the Independent Police Complaint Commission, which is also abbreviated as IPCC. For *Nature* and *Science* coverage, research articles and review articles were excluded from the sample, given the time-lag between submission and publication, as well as clear differences in writing style. All relevant articles published between two months before the launch of the first assessment report and two months after the launch of the last assessment report were included in the sample ($N = 1{,}024$; Supplementary Table 1). In a separate analysis, the readability of AR4 and AR5 SPMs was compared with their pre-plenary versions as well as AR4 and AR5 Technical Summaries.

Cleaning consisted of the removal of special characters not recognized by the tools employed, as well as spurious space characters introduced in the middle of words by the copy-and-paste operation. The former was achieved automatically by a routine run over all documents, the latter by automatically tabulating orthographic mistakes for each document and manually opening and fixing those showing broken words errors. Finally, a third routine automatically replaced British English with American English spelling, as the latter is used by the DICTION software package.

FRE[14] scores were calculated using a Visual Basic routine processing all files in Microsoft Word 2010. MS Word 2010 implements the original FRE algorithm, which is based on the assumption that text containing longer sentences and more complex words is more difficult to comprehend. It provides a score between 0 and 100, with easy-to-read texts scoring higher than more complex ones.

The computer-based psycho-social dictionary DICTION[39] analyses semantic features of text based on 31 disjoint dictionaries containing around 10,000 words. Optimism is one of the five main constructs calculated by DICTION, and is in turn based on six of the disjoint dictionaries ([Praise + Inspiration + Satisfaction]—[Blame + Hardship + Denial]).

For each document, raw totals (number of words per category), document frequencies and standardized scores are calculated. To make raw scores comparable across publication types, all numeric results have been converted into $Z$-scores, using mean scores for IPCC SPMs as a benchmark. Namely, for the entire sample, the difference between the mean score of IPCC SPMs and the score of each individual document, divided by the standard deviation, has been used as the final measure for each document. Polysemy, that is, the occurrence of words or phrases with different but related meanings, is treated via simple statistical weighting: polysemic words produce multiple score types, proportional to the average use of the senses in texts, which are all taken into account.

For the comparison of relative frequencies of DICTION terms (Table 1), we initially calculated raw frequencies of all terms included in the DICTION optimism/ pessimism dictionaries for all four publication types. These raw frequencies were subsequently expressed as a percentage of the sum of all occurrences of any of the terms listed in the dictionaries. The relative frequencies referred to in Table 1 then denote the difference between the frequency of a term (expressed as percentage) in a given publication type compared to its frequency across all four publication types. To calculate average frequencies across the entire sample, frequencies for the four publication types were weighted equally to avoid bias towards quality newspapers as by far the largest individual subsample ($n = 707$): $\Delta f_{\mathrm{SPM}} = f_{\mathrm{SPM}} - (f_{\mathrm{SPM}} + f_{\mathrm{Science}} + f_{\mathrm{Quality}} + f_{\mathrm{Tabloid}})/4$.

All boxplots in the figures show median scores, upper and lower quartiles, as well as minimum and maximum scores for each publication type. Kruskal–Wallis tests were conducted to assess the significance of the differences in mean scores; follow-up pairwise tests, applying Bonferroni corrections to control for Type I errors, were employed to identify significant differences between subsamples.

For the FRE score (Fig. 1) we identified clear significant differences in mean scores between publication types ($\chi^2$ (3, $N = 1{,}024$) = 175.2, $p < 0.001$). Significant differences were found between each of the subsamples ($p < 0.001$), but not within any of the four subsamples. Over time (Fig. 2) we identified significant differences between means of FRE score for the entire sample between the five assessment periods ($\chi^2$ (4, $N = 1{,}024$) = 68.1, $p < 0.001$). We also found significant differences between AR4 and all other assessment reports ($p < 0.001$ for all pairwise tests involving AR4) as well as AR5 and all other assessment reports except AR3 ($p < 0.05$ for pairwise tests with AR1 and AR2). Of the four publication types, scientific publications as well as quality newspapers showed significant differences in mean FRE scores (scientific publications: $\chi^2$ (4, $N = 240$) = 25.1, $p < 0.001$; quality newspapers: $\chi^2$ (4, $N = 707$) = 27.7, $p < 0.001$). In both cases, follow-up pairwise comparisons showed significant differences ($p < 0.05$ or lower) for AR4 with respect to other assessment reports (scientific publications: AR3 and AR5; quality newspapers: AR1, AR2 and AR5).

For the DICTION optimism score (Fig. 4) we identified clear significant differences between publication types ($\chi^2$ (3, $N = 1{,}024$) = 31.1, $p < 0.001$). Follow-up tests showed significant differences between all publication types, except between tabloid and quality newspapers, as well as between SPMs and scientific publications. No significant differences in mean optimism scores could be identified within any of the four subsamples. Over time (Fig. 5), significant differences between means of different types of media and the IPCC SPMs mean were identified between the five assessment periods ($\chi^2$ (4, $N = 1{,}024$) = 14.8, $p < 0.01$). We also found significant differences ($p < 0.01$) between AR1 and AR4 as well as AR1 and AR5. Of the four publication types, only quality newspapers showed significant differences in mean optimism scores ($\chi^2$ (4, $N = 707$) = 13.2, $p < 0.05$) between the five assessment periods. Significant differences ($p < 0.05$) between AR1 and AR4, as well as AR1 and AR5, were also found.

The research design is subject to a number of limitations. As a consequence of the text mining approach used to identify relevant articles, the sample includes not only articles exclusively focusing on the IPCC, but also coverage of other issues whereby the IPCC is only mentioned in passing. Furthermore, newspaper syndication and the influence of news wires might have biased readability and optimism scores for quality and tabloid newspaper coverage. In addition, there are two limitations linked to the use of DICTION. First, results might be distorted based on the existence of homographs[40]. For this reason, other DICTION constructs, such as its certainty score, could not be considered for this analysis. Second, DICTION has been developed in a US context and can be considered as most suitable for US-based publications. Although British English spelling was converted into American English spelling as part of pre-processing of files, construct validity might still be slightly lower for UK-based coverage.

In addition, the analysis focused on plain text versions of the documents and as such did not consider the potential impacts of illustrations or different types of formatting. Finally, the linguistic analysis was performed only on English language content, given that DICTION is limited to English language text and readability scores for other languages would not be comparable. Nevertheless, it should be kept in mind that although IPCC SPMs are published in various different languages, the English language version is the one agreed at the Plenary before it is subsequently translated into other languages.

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