A Topography of Climate Change Research

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The massive expansion of scientific literature on climate change challenges the Intergovenmental Panel on Climate Change (IPCC)'s ability to assess the science according to its objectives. Moreover, the number and variety of papers hinders researchers of the science-policy interface from making objective judgements about those IPCC assessments. In this paper, we present a novel application of a machine-reading approach to model the topical content of papers on climate change. This dynamic topic model provides the basis for a *topography* of climate change literature. The thematic development of the field is outlined and used to inform an analysis of the topics which are better and less well covered by IPCC reports.

To deal with the wicked problem of climate change, international policy-makers need the IPCC. The IPCC makes maps.

The IPCC sees its role as to "assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to [...] climate change" [1]. This role is vital for.... Making maps [2]

The task of the IPCC has beome much more difficult with big literature

Further, it has been pointed out that, in the age of "big literature", providing assessments that are comprehensivene, objective and transparent has become much more difficult [3]. Is the map up to date, does it cover everything?

The IPCC, its reports and processes have been the object of study before. These are also hampered problems of scale though

Various researchers have attempted to do empirical research on the assessment reports, and processes of the inter. alia. the IPCC [4] [5]. Policy makers, when asked about their interactions with the IPCC call for a greater focus on solutions [6]

Some literature exists on bibliometrics and climate change, but tends not to deal with text

Bibliometrics e.g. [7] [8]

Text based approaches are usually of a smaller scope [9] or methodological contributions [10]

The scale of the problem in context

The scale of the challenge is depicted in figure 1. Less than two thousand documents relevant to climate change were published before the first assessment report (see Methods for data, exclusions and processing). These documents contained 3,528 unique terms, each of which was used on average in 0.49% of documents. In the three complete years since the publication of AR5, 128,357 documents have been published, containing 86,419 unique terms, used on average in 0.12% of documents. To put this into context, the 1,189 chapters of the Bible contain a vocabulary of 11,977 unique words. Put another way, the 236,634 publications published in AR5 and AR6 are significantly larger than the 178,118 publications recorded in the first volume of the 'Catalogue of Scientific Papers', compiled by the Royal Society to record the entirety of scientific output from 1800 to 1863 [11]

Machine reading to deal with scale problems in the making and assessing of maps

Clearly, if the IPCC is to continue producing comprehensive assessments, it has to engage in machine-reading in order to remain anchored to the wider literature. Without such an approach, it becomes harder to justify which ever-diminishing proportion of the wider literature is included in assessments. Similarly, it becomes harder to criticise, with quantitavely evidenced claims, the outcomes of assessment processes.

Dimension reduction makes possible the description in reduced form, and with less human bias, unmanageably large datasets

[12] [13]

This reduced form description makes comparisons more useful, when cutting the dataset.

Machine reading is a supplement to assessment-making and not free from bias; a topography is not a map

Machine reading approaches can of course not replace the task of human assessment-making. The contribution that could be made, though, is to pre-process the literature, producing a topographical map, used to navigate the literature while producing a more detailed assessment with human judgement.[[]] In fact this happens already - when IPCC authors search for literature on a topic, the results which appear on the search engine they use will be subject to algorithms based on

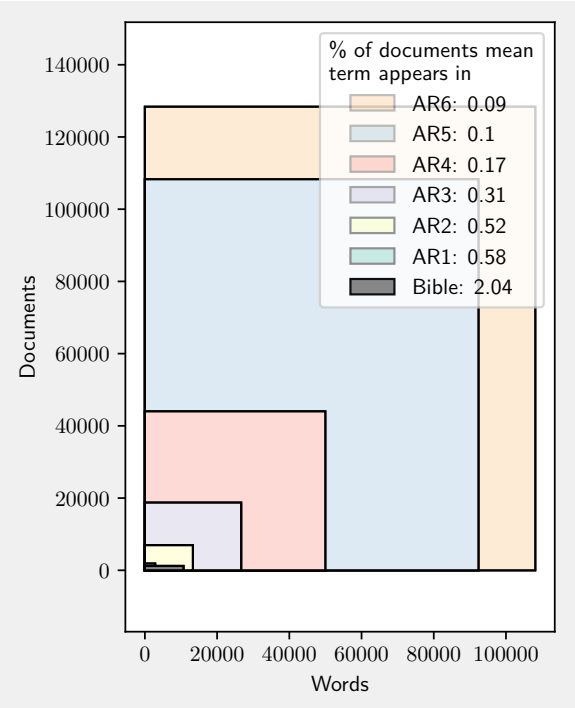

Figure 1: The volume and variety of literature on climate change has grown to unmanageable proportions. Each box represents a document-term matrix (unique documents x unique terms) of the abstracts written in each assessment period. The percentage of documents in which the average word occurs in is given in the key.

the processing of millions of records of article text and metadata. This can be done in a much more systematic way when scientists perform directed analyses of the literature at scale.

This study's contribution. Overarching themes, structure of the literature, development, relation to IPCC

This study demonstrates how dynamic topic modelling can be used to gain an overview of an otherwise unmanageably large set of literature. This overview, or topography, describes the thematic development of the climate change literature and, in a novelly systematic way, examines how comprehensively the IPCC has been able to engage with it. In pulling together strands from text-mining, bibliometrics, and the study of science and policy, this study advances our understanding of the literature on climate change and the role of the IPCC in communicating this to policy makers.

Results

The topic-document correlation network is densest in AR2 and 3 but becomes more fragmented over time

(partly: Model less good at describing literature later on)

Working groups are clustered together [dynamics], with topics like [x] containing documents across working groups and topics like [y] important network nodes

Sustainability has been an increasingly important theme in an overarching topic about environmental sciences

(compare to biochar, which is much more recent)

Physical science topics tend to be the oldest, and the most well represented topics

Adaptation and impact studies have seen a lot of growth but are well represented in IPCC reports

New topics around negative emissions and urban form are very recent and not well represented in IPCC reports.

Negative emissions in special report on 1.5, demand side chapter in AR6

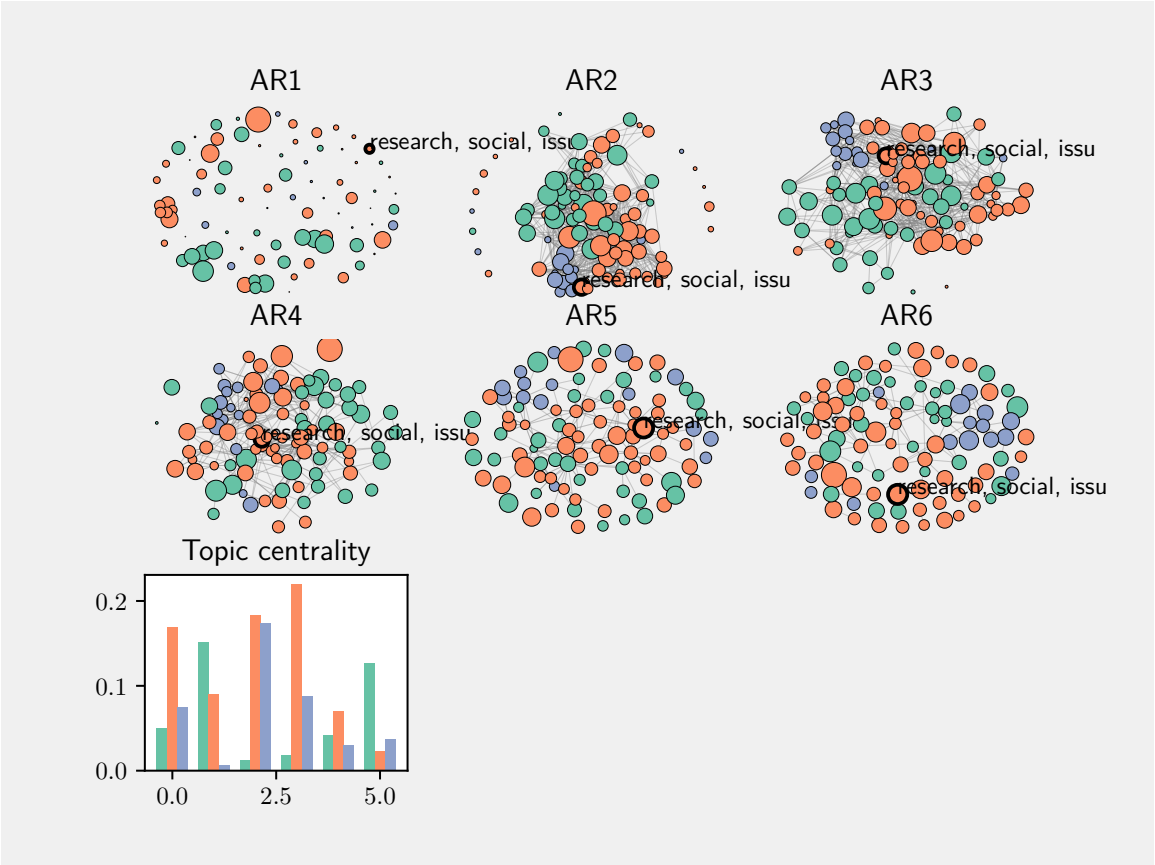

Figure 2: The development of the topic-document correlation network over IPCC assessment periods.

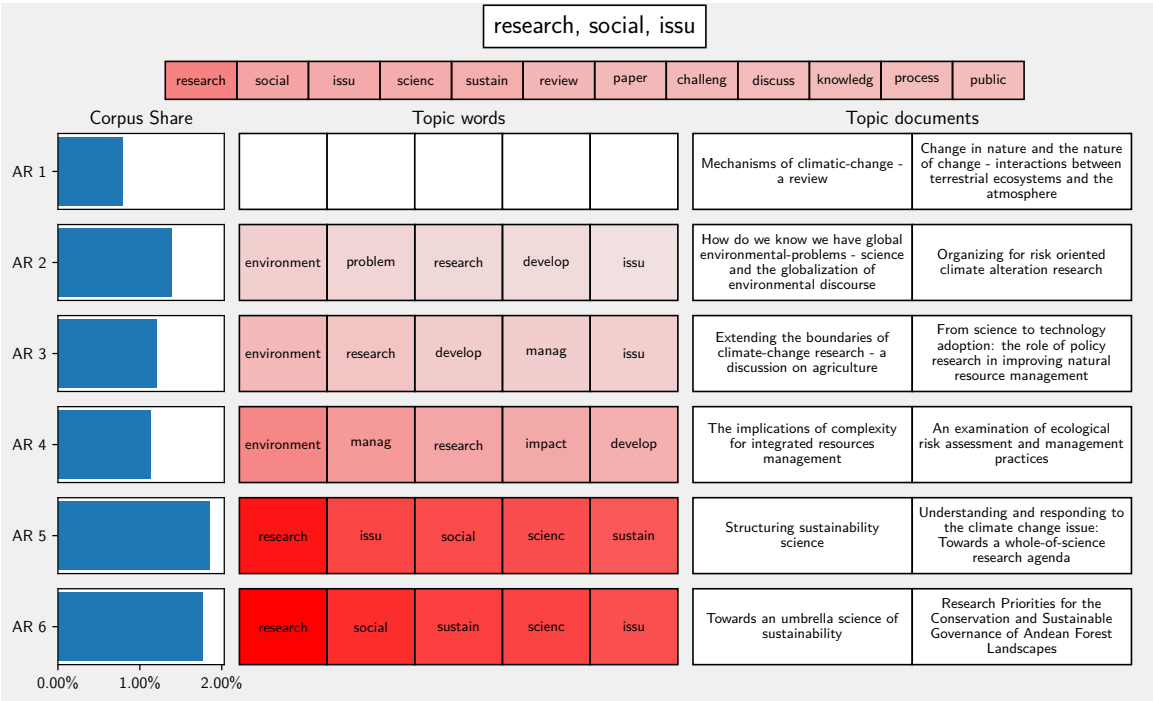
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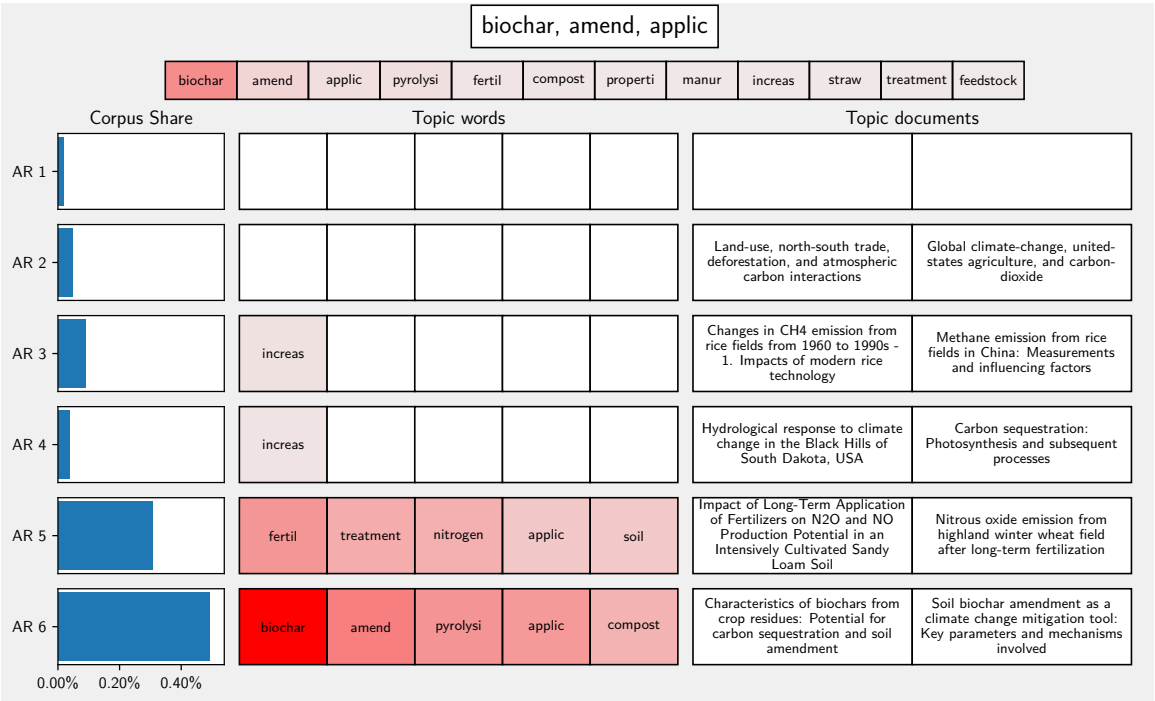
Figure 3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Topic words
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AR 2
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AR 4
AR 5
AR 6
Land-use, north-south trade, deforestation, and atmospheric carbon interactions
Global climate-change, united-states agriculture, and carbon-dioxide
Changes in CH4 emission from rice fields from 1960 to 1990s - 1. Impacts of modern rice technology
Methane emission from rice fields in China: Measurements and influencing factors
Hydrological response to climate change in the Black Hills of South Dakota, USA
Carbon sequestration: Photosynthesis and subsequent processes
Impact of Long-Term Application of Fertilizers on N2O and NO Production Potential in an Intensively Cultivated Sandy Loam Soil
Nitrous oxide emission from highland winter wheat field after long-term fertilization
Characteristics of biochars from crop residues: Potential for carbon sequestration and soil amendment
Soil biochar amendment as a climate change mitigation tool: Key parameters and mechanisms involved
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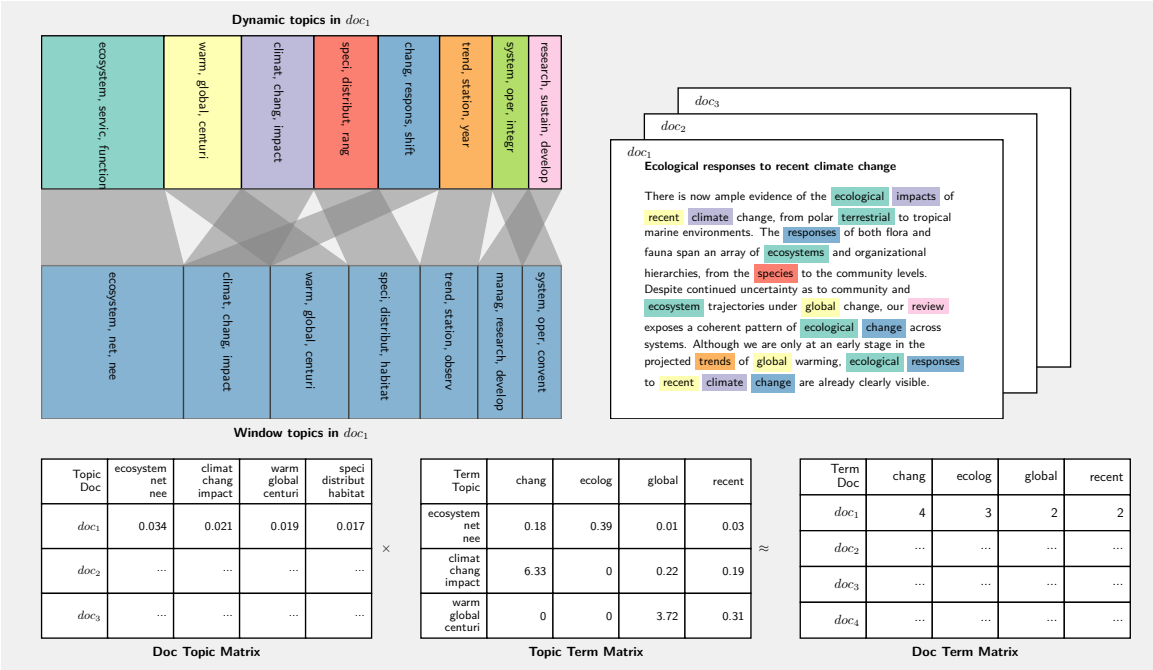
Figure 4: SI



Topic / Doc	ecosystem net nee	climat chang impact	warm global centuri	speci distribut habitat
doc_1	0.034	0.021	0.019	0.017
doc_2	...	...	...	...
doc_3	...	...	...	...

Doc Topic Matrix

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Term / Topic	chang	ecolog	global	recent
ecosystem net nee	0.18	0.39	0.01	0.03
climat chang impact	6.33	0	0.22	0.19
warm global centuri	0	0	3.72	0.31

Topic Term Matrix

≈

Term / Doc	chang	ecolog	global	recent
doc_1	4	3	2	2
doc_2	...	...	...	...
doc_3	...	...	...	...
doc_4	...	...	...	...

Doc Term Matrix

Figure 5: SI

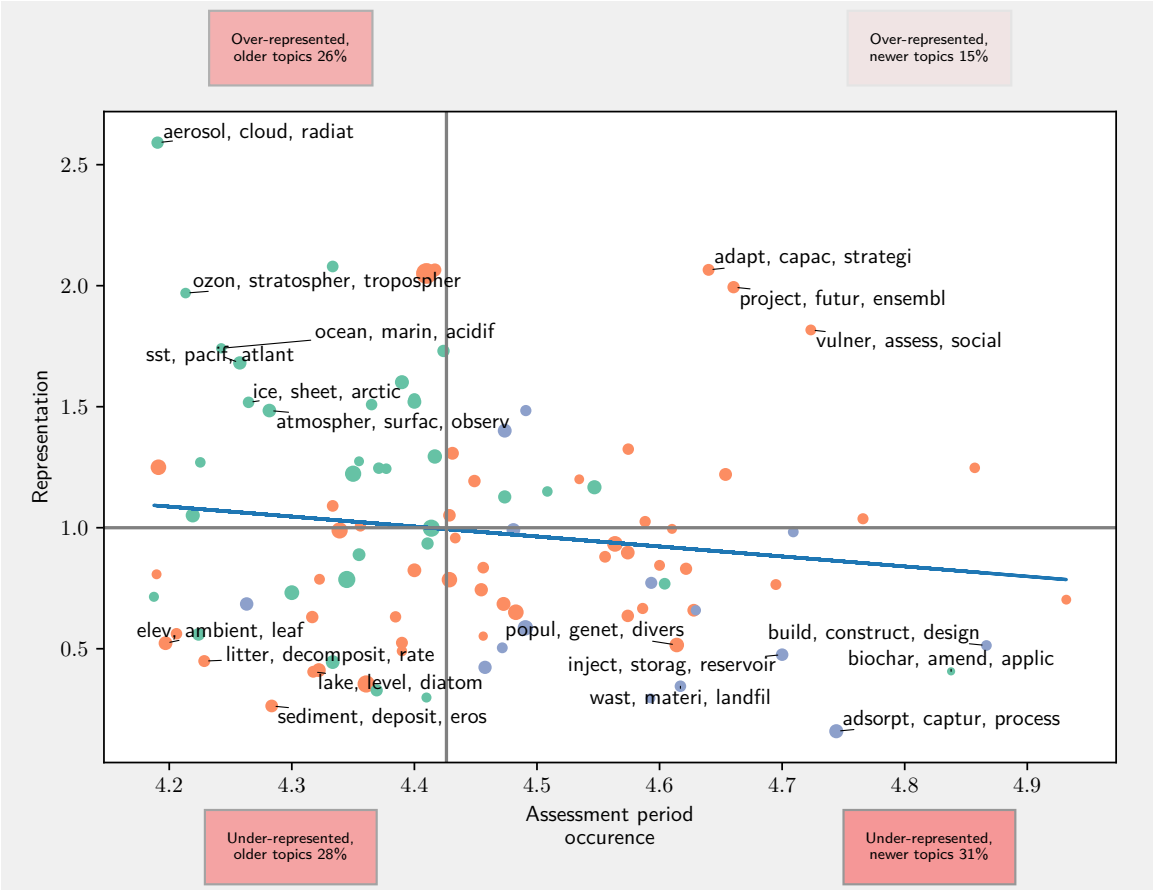
Over-represented, older topics 26%
Over-represented, newer topics 15%
aerosol, cloud, radiat
ozon, stratospher, tropospher
ocean, marin, acidif
sst, pacif, atlant
ice, sheet, arctic
atmospher, surfac, observ
adapt, capac, strategi
project, futur, ensembl
vulner, assess, social
elev, ambient, leaf
litter, decomposit, rate
lake, level, diatom
sediment, deposit, eros
popul, genet, divers
inject, storag, reservoir
wast, materi, landfil
build, construct, design
biochar, amend, applic
adsorpt, captur, process
Representation
2.5
2.0
1.5
1.0
0.5
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
Assessment period occurence
Under-represented, older topics 28%
Under-represented, newer topics 31%

Figure 6

80 # Discussion

81 **Solutions, policies and science**

82 # Methods

83 **Data**

List of Figures

References

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