

A Topography of Climate Change Research

Max Callaghan

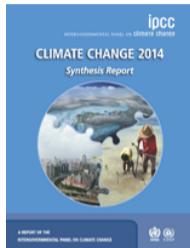
with Jan Minx, Piers Forster



January 27, 2019

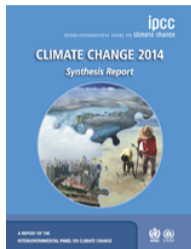


Figure: Portrait of map-makers, Gerardus Mercator and Jodocus Hondius (Jodocus Hondius) source: Wikipedia Commons



- The IPCC has a *cartographic* role at the science policy interface (Edenhofer and Minx, 2014; Edenhofer and Kowarsch, 2015)

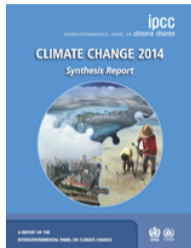
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- The IPCC has a *cartographic* role at the science policy interface (Edenhofer and Minx, 2014; Edenhofer and Kowarsch, 2015)

- A topography is a description of a landscape
- Topics (from the Greek “topos”, place) can describe the features of a body of text

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1 Motivation

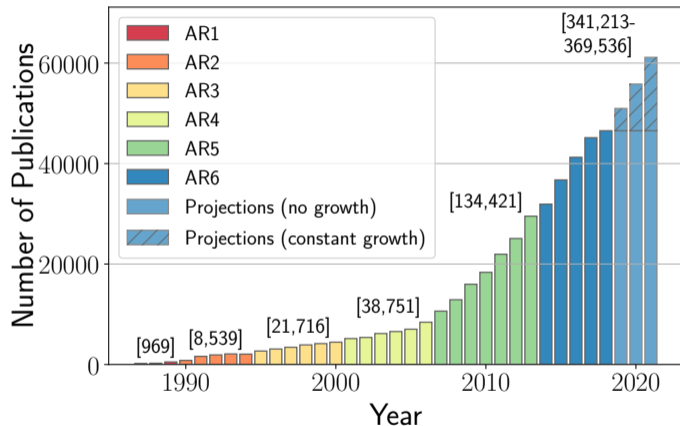
2 Methods

3 Results

1 Motivation

2 Methods

3 Results



A challenge for

- Global environmental assessments
- Our understanding of global environmental assessments
- Evidence synthesis more generally

Figure: Articles on climate change in the Web of Science

- We entrust the IPCC with providing a *comprehensive* and *transparent* assessment of the literature

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- Although IPCC reports cite ever greater numbers of papers, this number decreases in proportion to the number of papers in literature

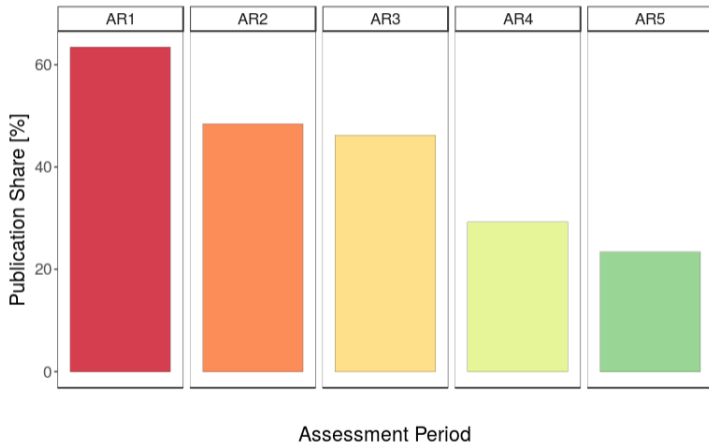


Figure: (Minx et al., 2017)

What Do We Know About the IPCC?



- The social sciences are seen as under-represented in IPCC reports

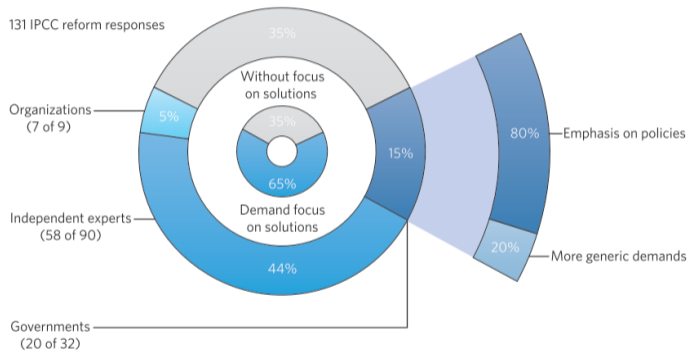


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- (Bjurström and Polk, 2011) are often cited as evidence of this under-representation, e.g. as demonstrating “a powerful bias to the natural sciences in the construction of ‘IPCC knowledge’ ”
Hulme and Mahony (2010)



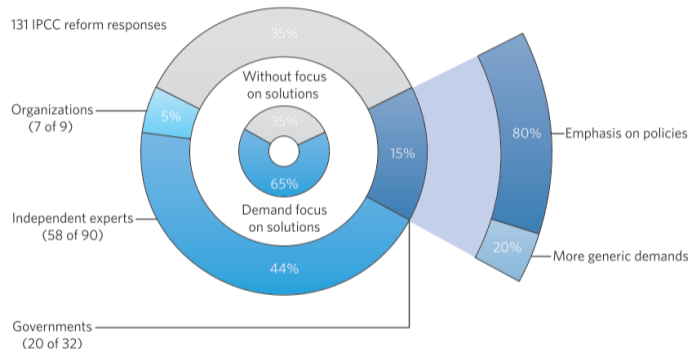
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- The evidence is simply the relative shares of the different disciplines in IPCC citations





- Demand for solutions is increasing

Figure: (Kowarsch et al., 2017)



- Demand for solutions is increasing
- We know little about the supply of solutions in the literature

Figure: (Kowarsch et al., 2017)

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To understand the representation of social science and solutions relevant knowledge in IPCC reports, we look at journal classification and document abstracts

Data:

400,000 papers on climate change from the Web of Science (query following Grieneisen and Zhang (2011)), matched with 70,000 IPCC citations (Using Doc2Vec)

Topic modelling:

We use topic modelling (with NMF (Lee and Seung, 1999)) to understand the thematic content of papers

Topographic mapping:

We project the documents' topical locations into 2 dimensions using t-SNE (van der Maaten and Hinton, 2008)

Measuring representation:

We compare the proportions of categories of documents in the whole of the literature with the subset of the literature that is cited by the IPCC

	AR1	AR2	AR3	AR4	AR5	AR6
Years	1986-1989	1990-1994	1995-2000	2001-2006	2007-2013	2014-
Documents	1,167	8,539	21,716	38,750	134,413	201,606
Unique words	2,000	12,480	23,346	34,637	71,867	94,746
New words	change (560)	oil (287)	downscaling (217)	sres (234)	biochar (1,791)	mmms (313)
	climate (428)	deltac (283)	degreesc (187)	petm (95)	redd (1,113)	cop21 (234)
	co2 (318)	whole (256)	ncep (130)	amf (88)	cmip5 (679)	c3n4 (214)
	climatic (289)	tax (254)	fco (107)	sf5cf3 (86)	cmip3 (587)	sdg (187)
	model (288)	landscape (249)	pfc (98)	clc (81)	mofs (299)	zika (182)
	atmospheric (281)	alternative (243)	otcs (98)	embankment (81)	sdm (297)	ndcs (168)
	effect (280)	availability (242)	dtr (95)	cwd (79)	mof (275)	indc (164)
	global (224)	life (239)	nee (89)	etm (75)	biochars (252)	indcs (134)

Table: Growth in climate change literature

Data from WoS Core Collection, query following Grieneisen and Zhang (2011)

- Topic modelling (Blei et al., 2012) describes a suite of algorithms to discover the latent semantic content of documents

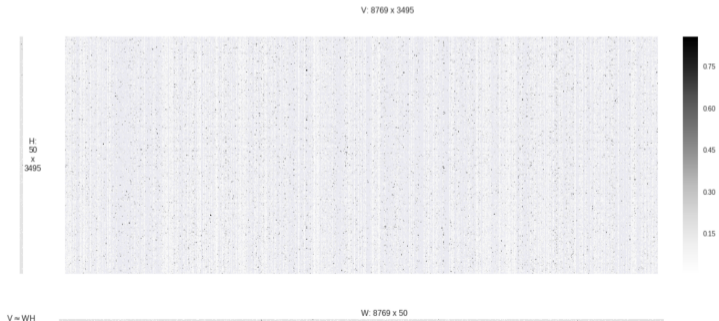
Approach - What is the matter?

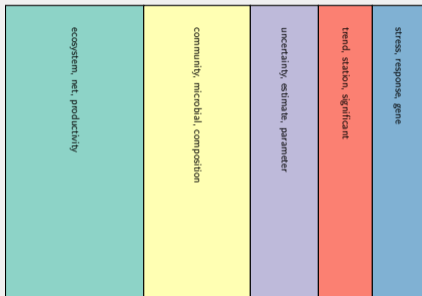
- Topic modelling (Blei et al., 2012) describes a suite of algorithms to discover the latent semantic content of documents
- NMF (Lee and Seung, 1999) is a dimensionality reduction technique that can be used for topic modelling
- Topics are distributions of words. They describe documents.
- A document's topic scores describe its association with each topic

$V_{i\mu}$ is a term frequency-inverse document frequency matrix of *stemmed* terms

$$V_{i\mu} \approx (WH)_{i\mu} = \sum_{a=1}^r W_{ia} H_{a\mu}$$

V is approximated by the product of W and H





doc₁

Ecological responses to recent climate change

There is now ample evidence of the **ecological** impacts of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of **ecosystems** and organizational hierarchies, from the species to the **community** levels. Despite continued **uncertainty** as to **community** and **ecosystem** trajectories under global change, our review exposes a coherent pattern of **ecological** change across systems. Although we are only at an early stage in the projected **trends** of global warming, **ecological** responses to recent climate change are already clearly visible.

doc₂

doc₃

Topic Doc	ecosystem net productivity	community microbial composition	uncertainty estimate parameter	trend station significant
<i>doc₁</i>	0.022	0.017	0.011	0.009
<i>doc₂</i>
<i>doc₃</i>

Doc Topic Matrix

X

Term Topic	ecological	ecosystem	recent	community
ecosystem net productivity	1.08	9.18	0	0
community microbial composition	0.19	0	0	9.76
uncertainty estimate parameter	0	0	0.01	0

Topic Term Matrix

R

Term Doc	ecological	ecosystem	recent	community
<i>doc₁</i>	3	2	2	2
<i>doc₂</i>
<i>doc₃</i>
<i>doc₄</i>

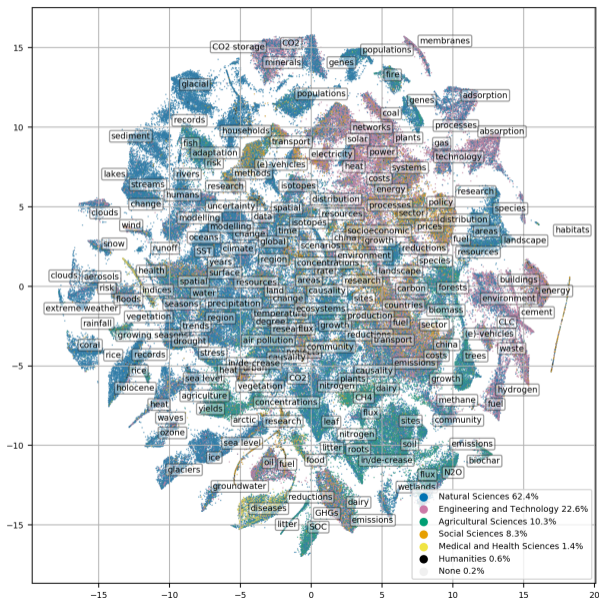
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2 Methods

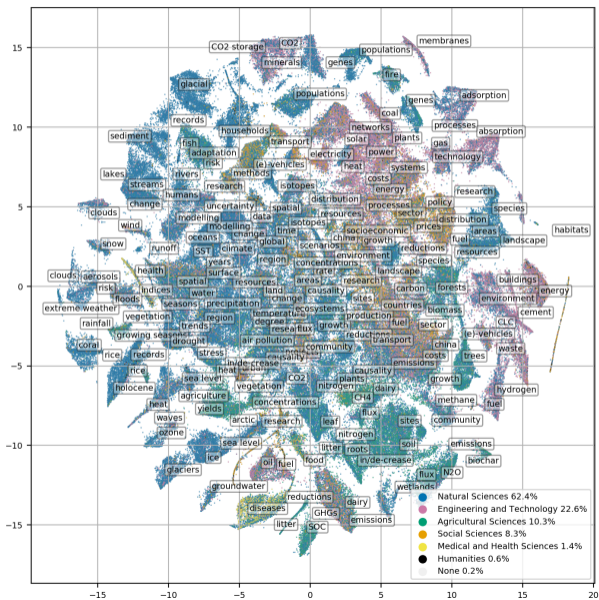
3 Results

A Topography of Climate Change Literature



- We use t-distributed stochastic neighbour embedding (van der Maaten and Hinton, 2008) to reduce documents' topic vectors to 2 dimensions

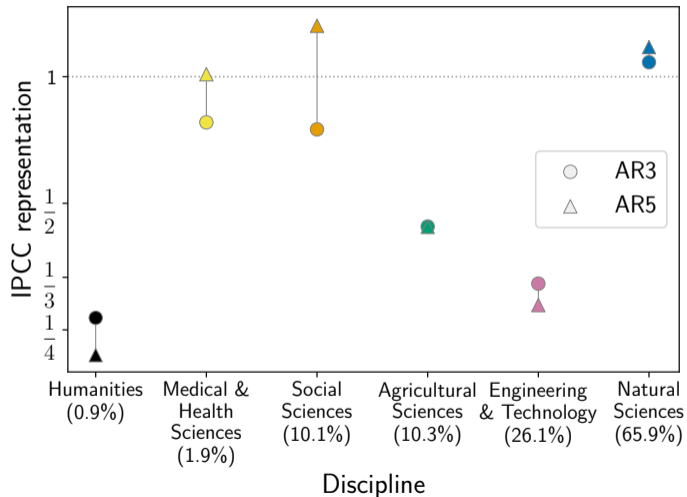
A Topography of Climate Change Literature



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- Each dot is a document, and documents with similar topic vectors are close together in the 2-dimensional space

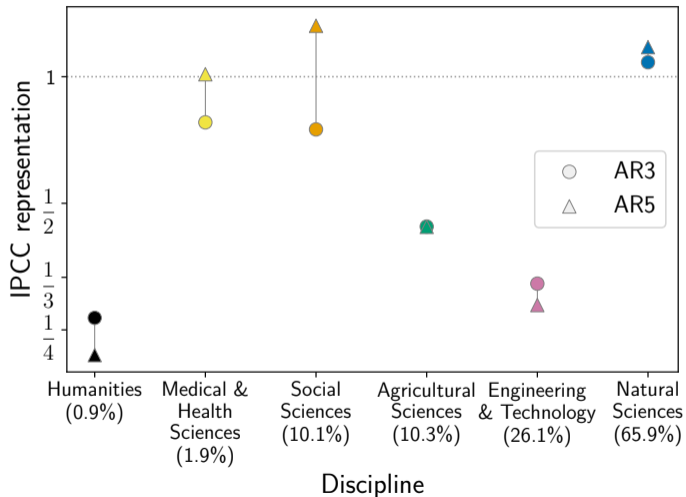
The Social Sciences are No Longer Under-Represented in IPCC reports

- The social sciences were under-represented in AR3, but by AR5 are over-represented

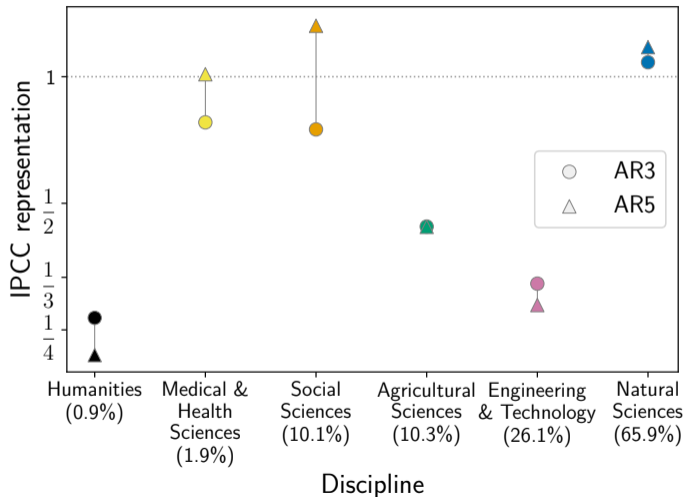


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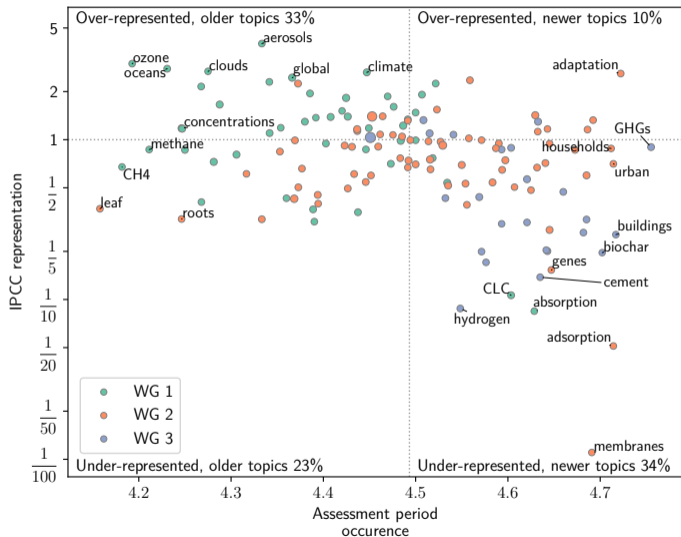
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- The share of natural science documents in IPCC citations is similar to the share in the wider literature
- Agricultural sciences and engineering & technology are under-represented

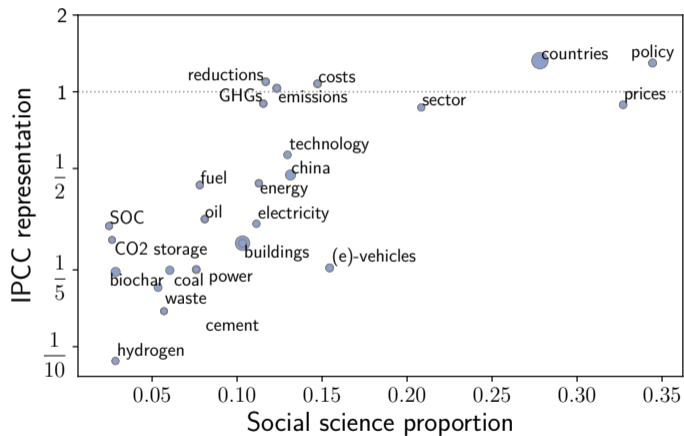


Topics on solutions are newer and under-represented



- The physical science of climate change is older and better covered
- Topics on “solutions” (although rather technical than policy) are newer and under-represented
- Newer WGII topics are better covered than newer WGIII topics

WGIII topics with little social science are under-represented



- Technical solutions topics in WGIII contain little social science research and are under-represented

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- Computer assisted methods can help the IPCC make its decisions on how to represent the literature from a more solid basis, and efficiently point to areas of growth or of under-representation

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<https://dx.doi.org/10.1038/s41558-019-0684-5>

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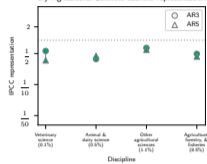
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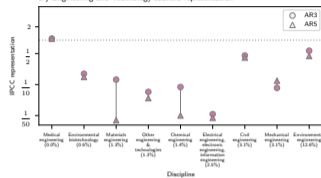
Topic disciplinary entropy and subdiscipline representation



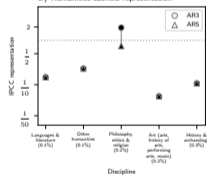
a.) Agricultural Sciences subfield representation



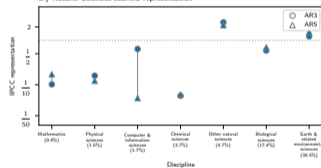
b.) Engineering and Technology subfield representation



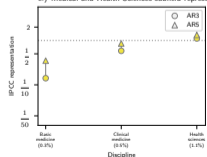
c.) Humanities subfield representation



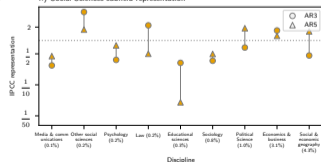
d.) Natural Sciences subfield representation

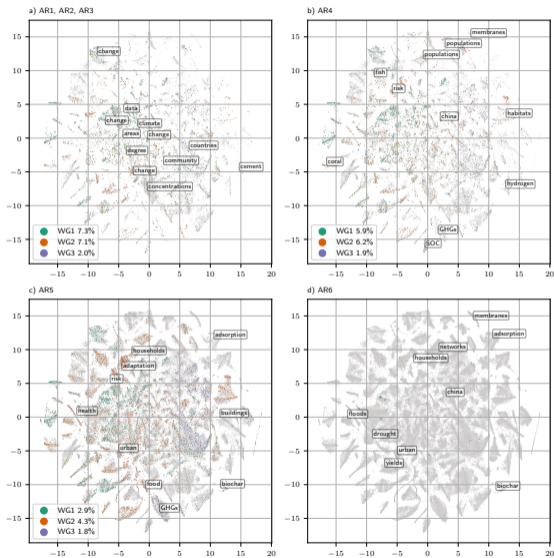


e.) Medical and Health Sciences subfield representation



f.) Social Sciences subfield representation





Social sciences and topic representation

