

# A Topography of Climate Change Research

Max Callaghan

with Jan Minx, Piers Forster

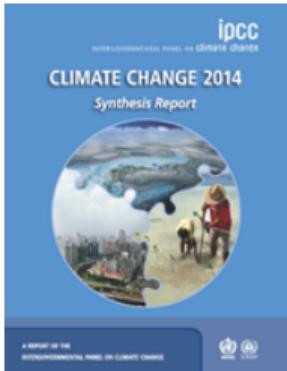


January 27, 2019

# Introduction



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

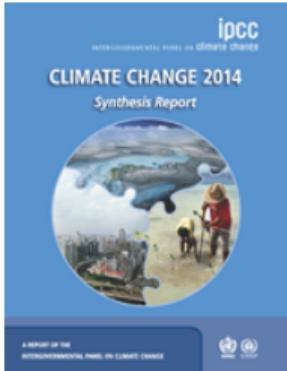


- The IPCC has a *cartographic* role at the science policy interface (Edenhofer and Minx, 2014; Edenhofer and Kowarsch, 2015)

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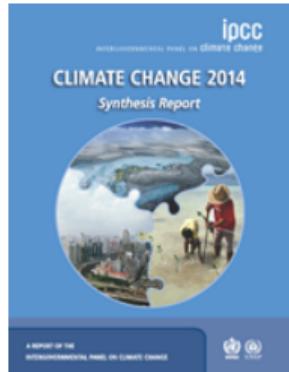
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- A topography is a description of a landscape



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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

# Outline

1 Motivation

2 Methods

3 Results

## 1 Motivation

## 2 Methods

## 3 Results

## Context - Big Literature

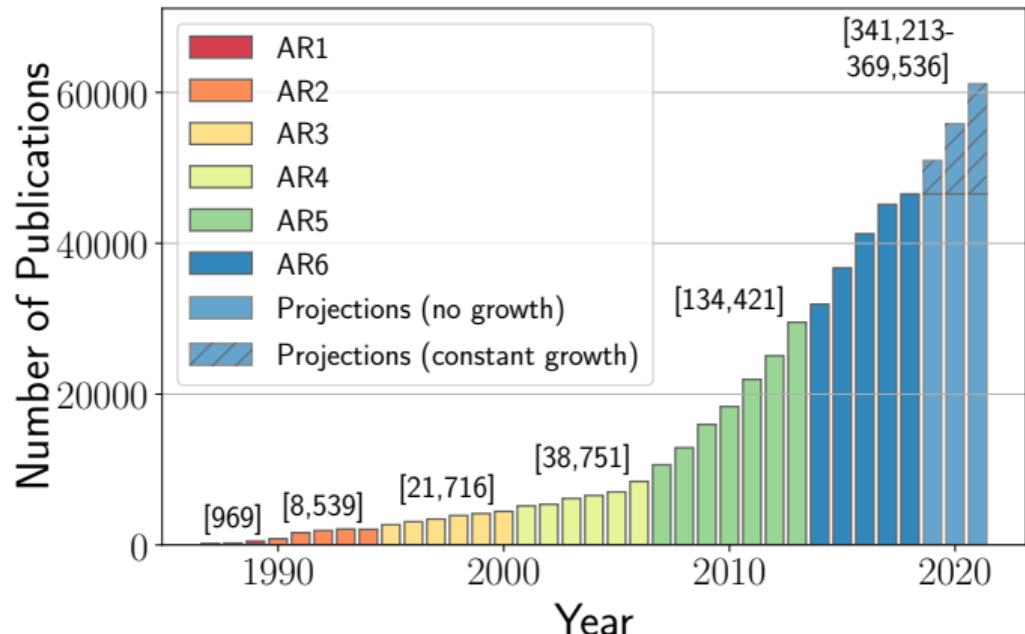


Figure: Articles on climate change in the Web of Science

A challenge for

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

# The IPCC in the age of Big Literature

- 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

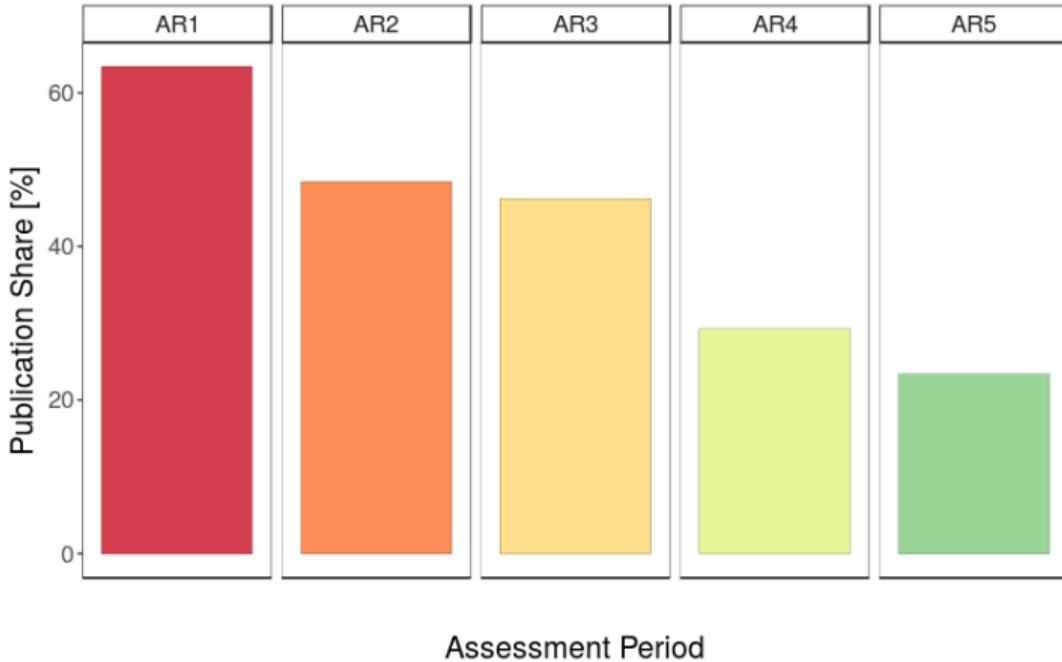


Figure: (Minx et al., 2017)

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Embed the social sciences in climate policy

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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)

## COMMENT

IN FOCUS Celebrating Mark Catesby, cataloguer of North America's wildlife p20  
BOOK A compelling exploration of memory and forgetting p21  
ANTHROPOLOGY DNA analysis of palm tree transplant supports Aboriginal myth p22  
LAW LIFE Discovery "evokes a special kind of ecstasy – it is almost like falling in love" p23



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

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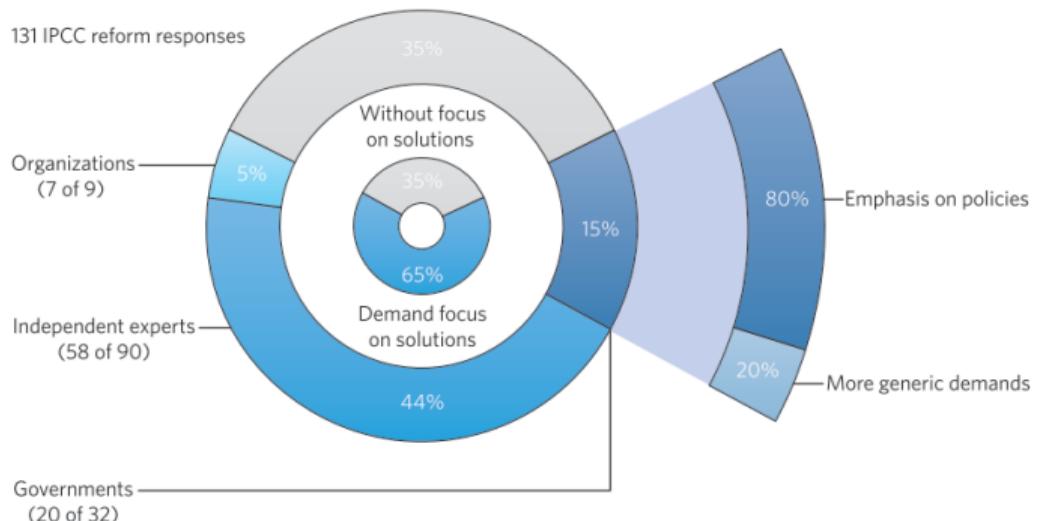


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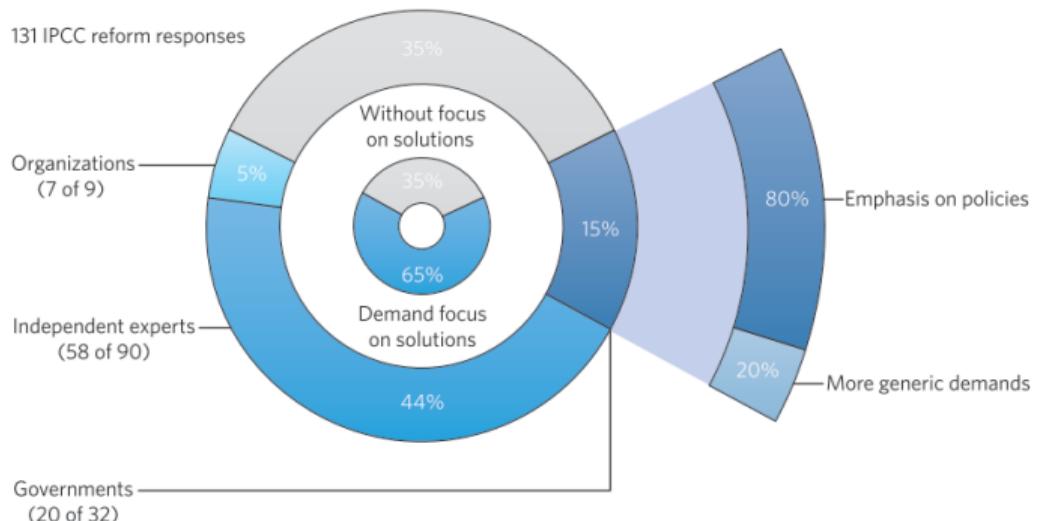
# The Age of Climate Solutions?



- Demand for solutions is increasing

Figure: (Kowarsch et al., 2017)

# The Age of Climate Solutions?



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

Figure: (Kowarsch et al., 2017)

1 Motivation

2 Methods

3 Results

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

# Words, words, words

	<b>AR1</b>	<b>AR2</b>	<b>AR3</b>	<b>AR4</b>	<b>AR5</b>	<b>AR6</b>
<b>Years</b>	1986-1989	1990-1994	1995-2000	2001-2006	2007-2013	2014-
<b>Documents</b>	1,167	8,539	21,716	38,750	134,413	201,606
<b>Unique words</b>	2,000	12,480	23,346	34,637	71,867	94,746
<b>New words</b>	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)

## Approach - What is the matter?

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

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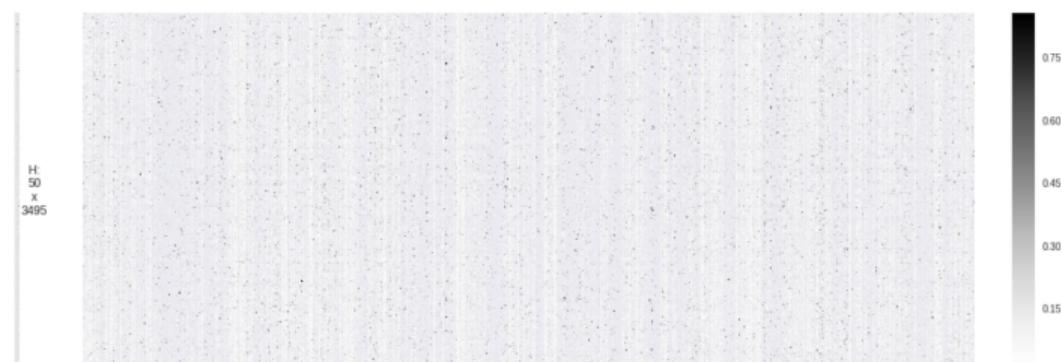
$V_{i\mu}$  is a term frequency-inverse document frequency matrix of *stemmed* terms

- 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

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

$V$  is approximated by the product of  $W$  and  $H$

$V: 8769 \times 3495$



$V \approx WH$

$W: 8769 \times 50$

# Doc Topic Example

ecosystem, net, productivity	community, microbial, composition	uncertainty, estimate, parameter	trend, station, significant	stress, response, gene
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Topic Doc	ecosystem net productivity	community microbial composition	uncertainty estimate parameter	trend station significant
doc1	0.022	0.017	0.011	0.009
doc2	...	...	...	...
doc3	...	...	...	...

Doc Topic Matrix

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

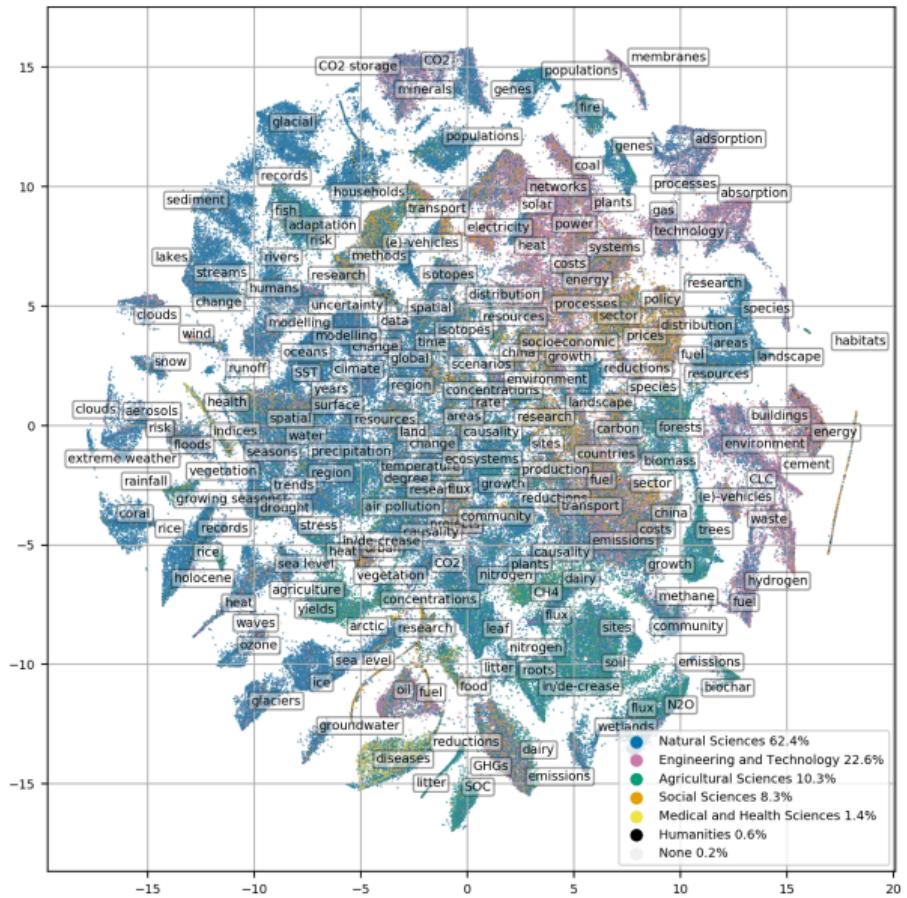
Term Doc	ecological	ecosystem	recent	community
doc1	3	2	2	2
doc2	...	...	...	...
doc3	...	...	...	...
doc4	...	...	...	...

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2 Methods

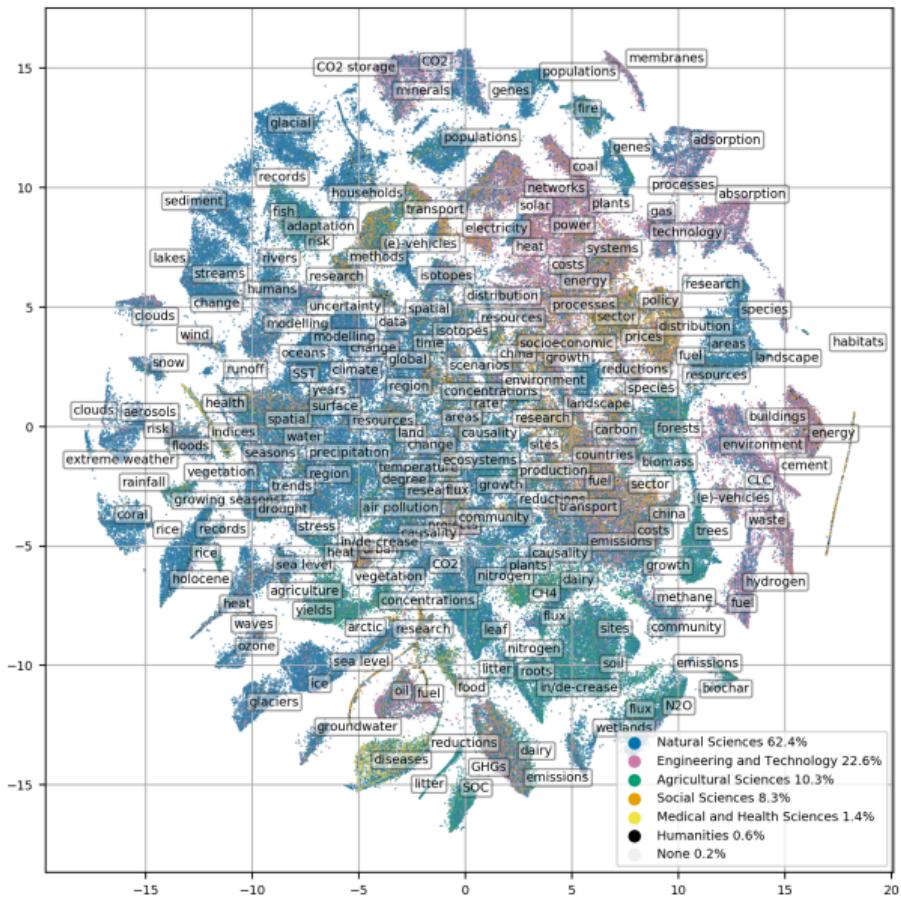
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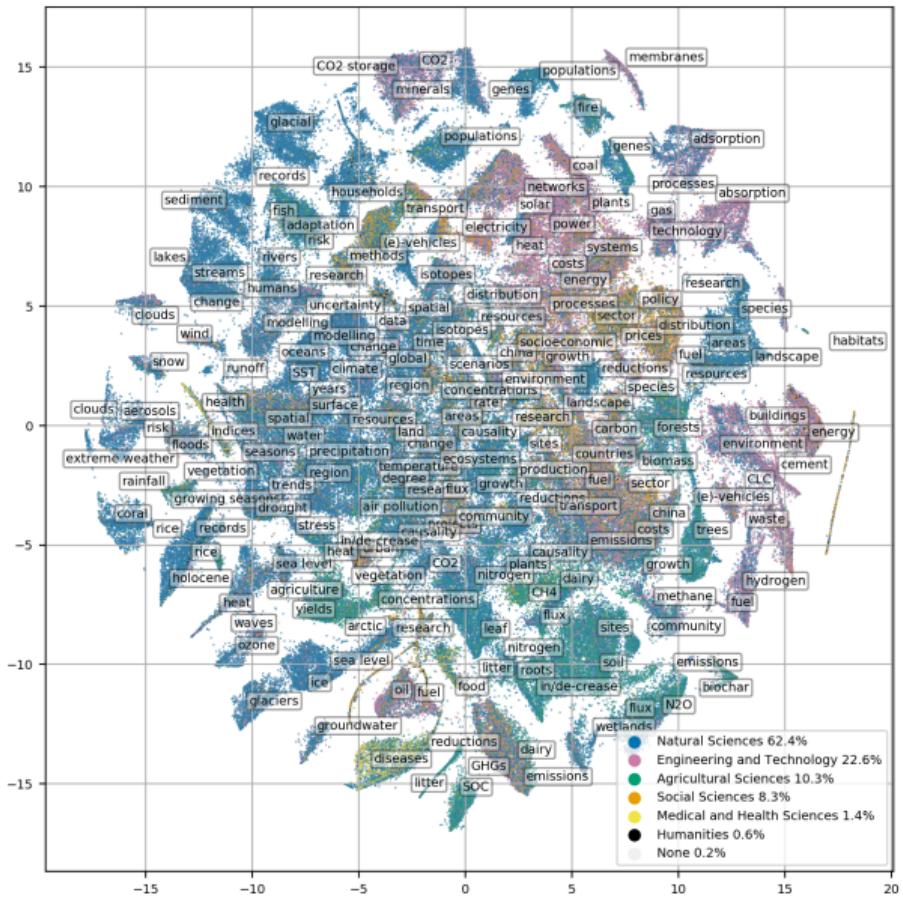
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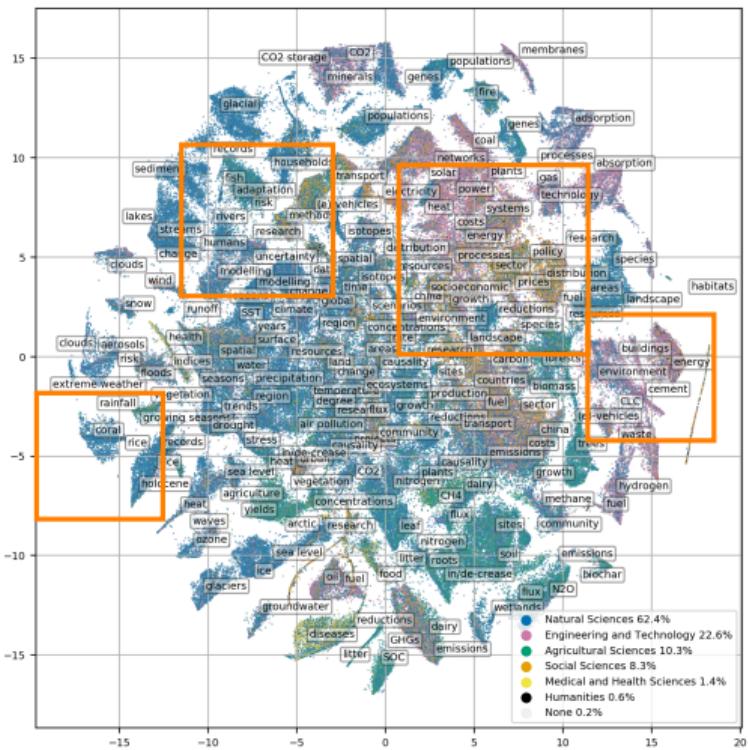


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  - Each dot is a document, and documents with similar topic vectors are close together in the 2-dimensional space

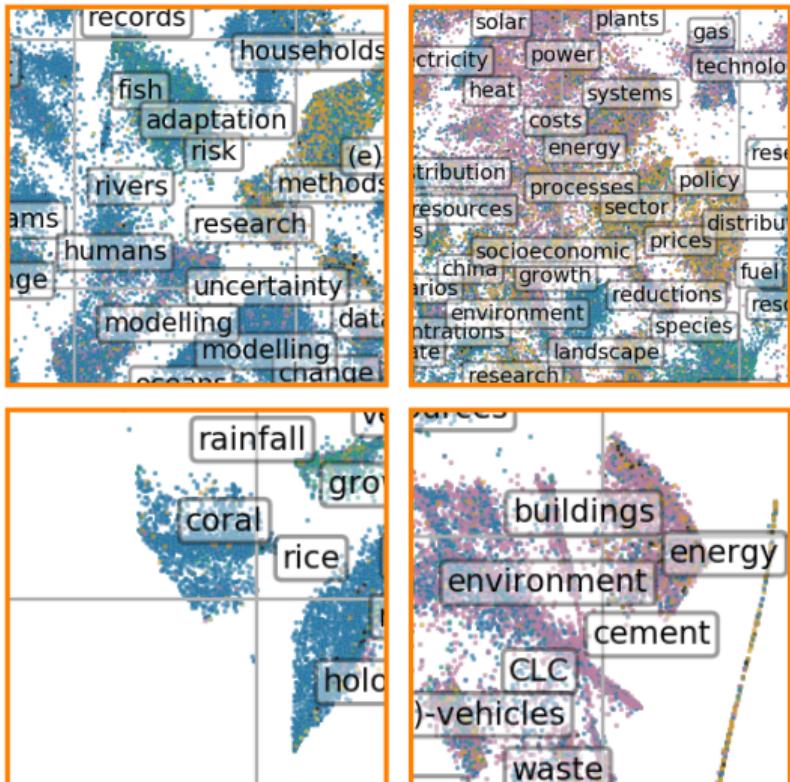
# A Topography of Climate Change Literature



- We use t-distributed stochastic neighbour embedding (van der Maaten and Hinton, 2008) to reduce documents' topic vectors to 2 dimensions
- Each dot is a document, and documents with similar topic vectors are close together in the 2-dimensional space
- We can see the preponderance of natural sciences, and the greater or lesser clustering of disciplines in certain topic areas



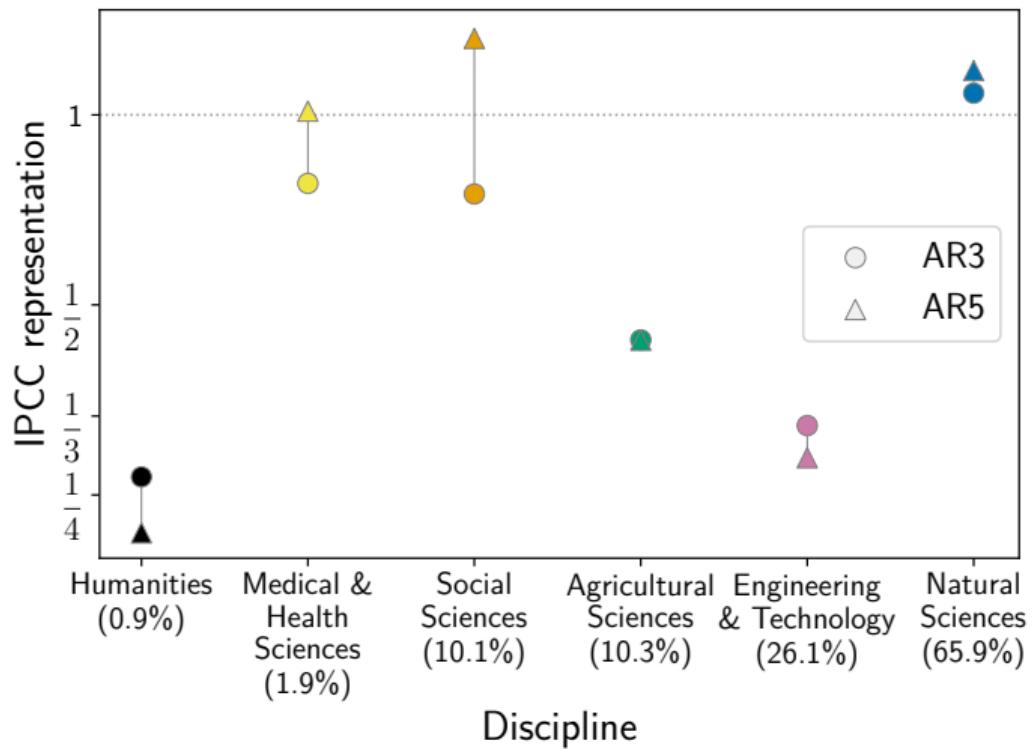
(a)



(b)

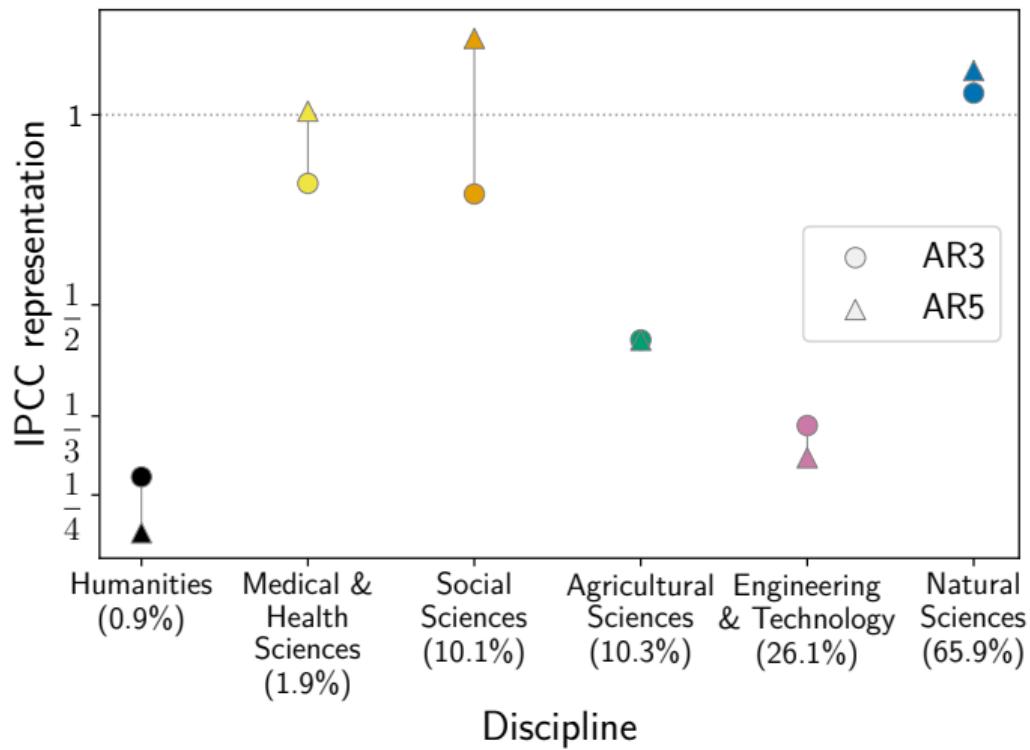
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- The social sciences were under-represented in AR3, but by AR5 are over-represented



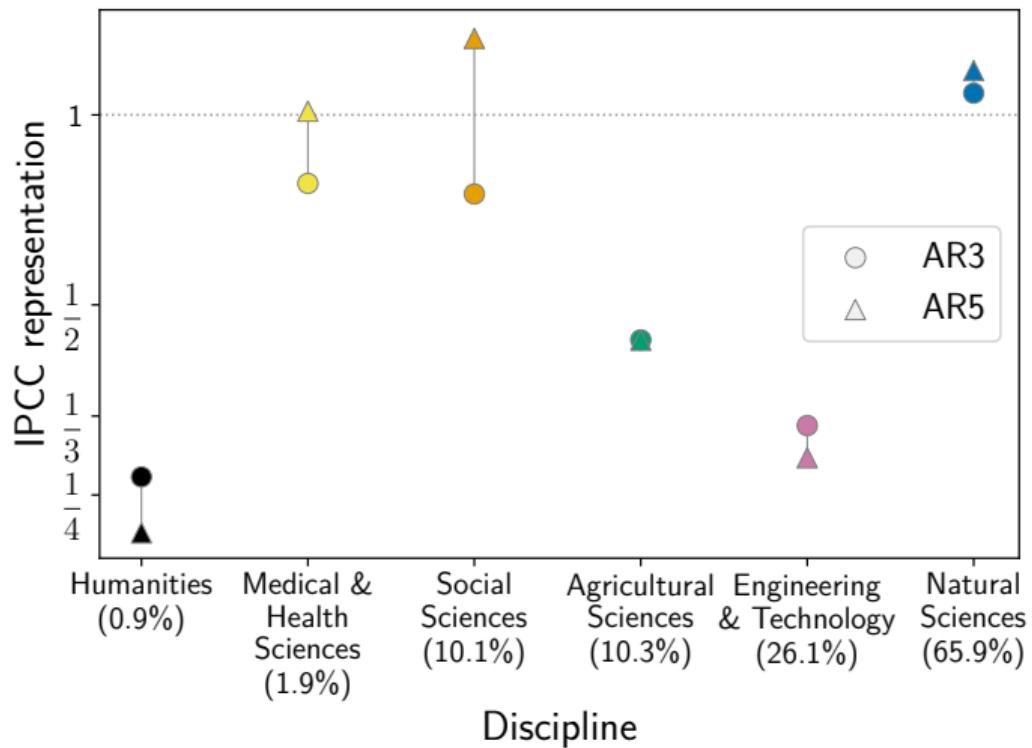
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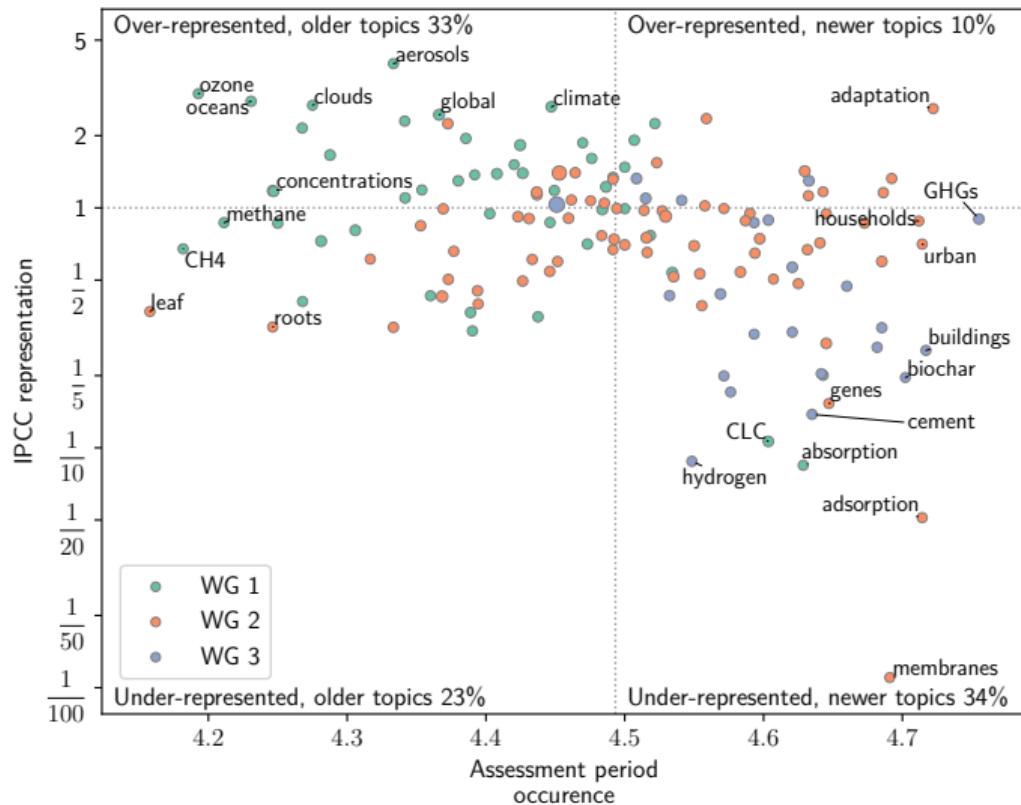


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- Agricultural sciences and engineering & technology are under-represented

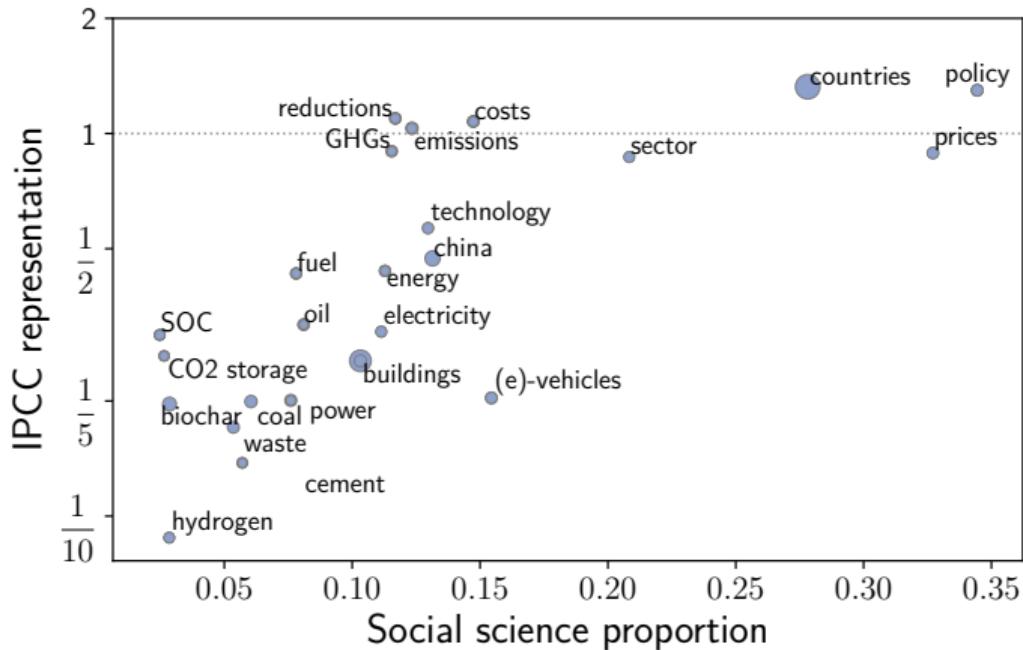


# Topics on solutions are newer and under-represented



- 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

## Conclusions

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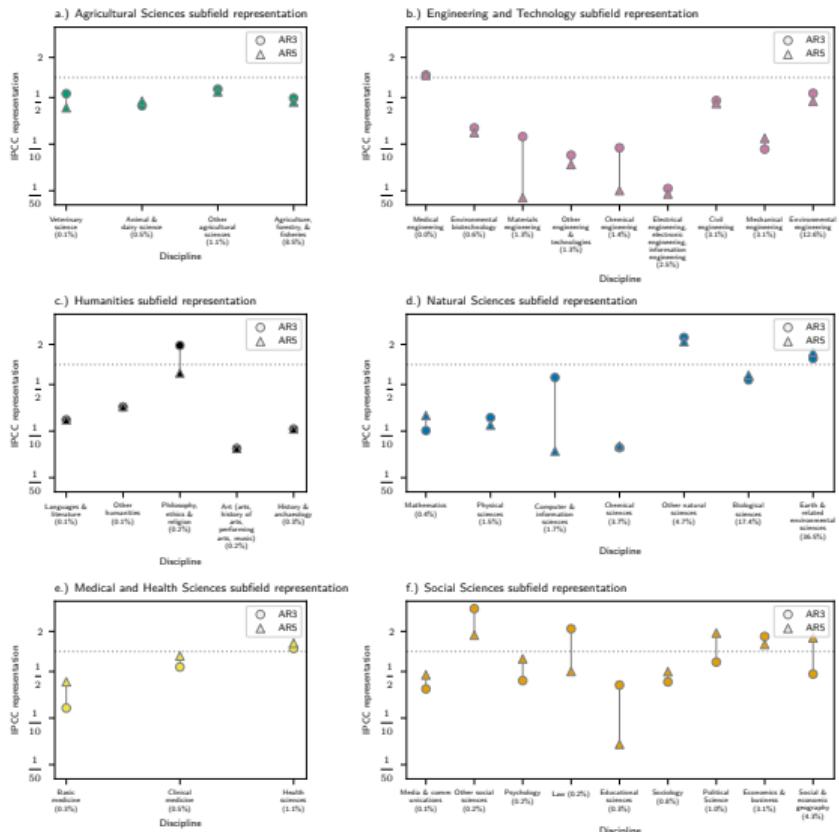
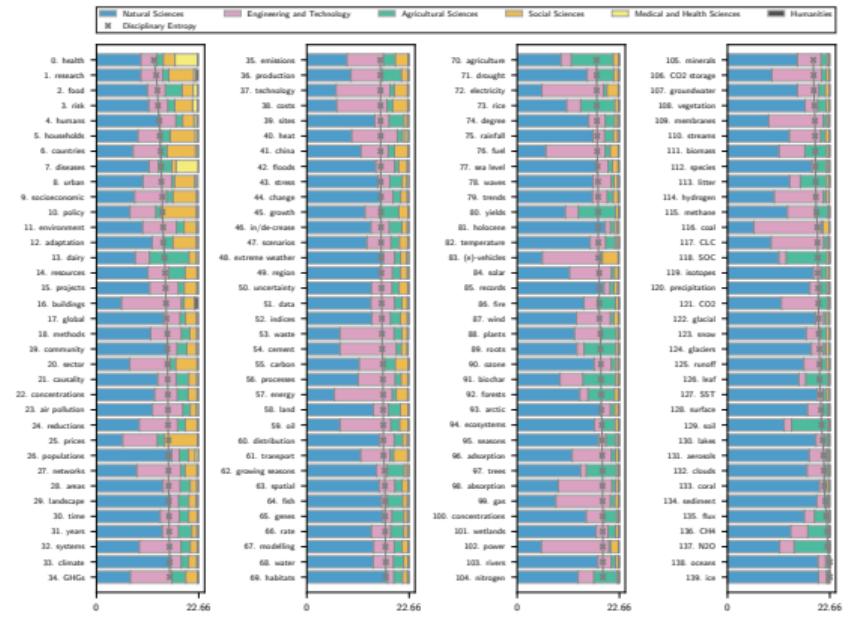
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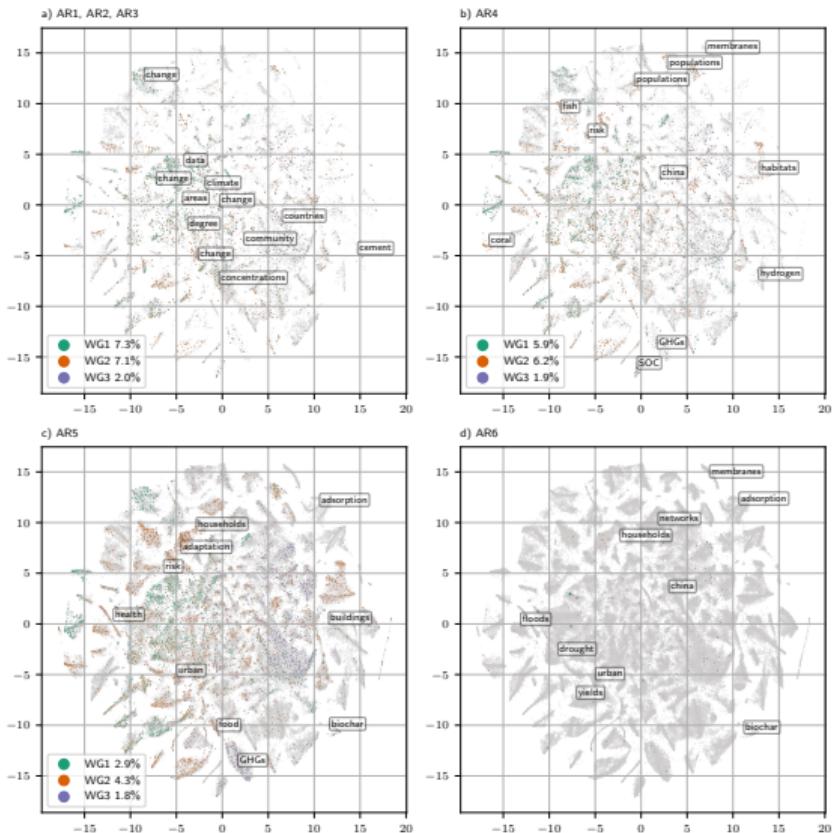
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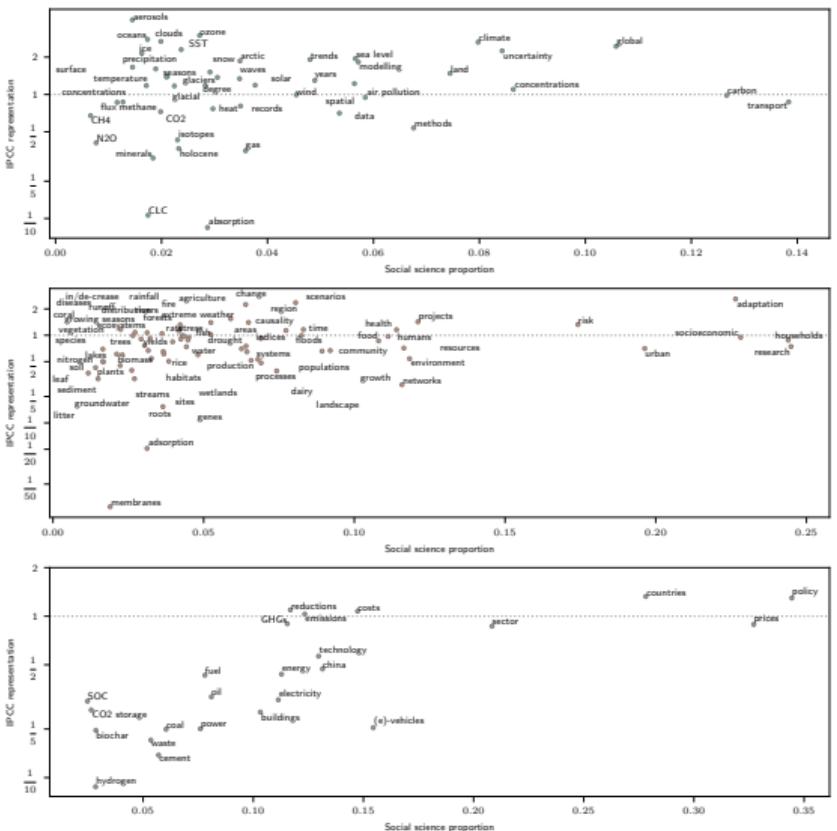
# Topic disciplinary entropy and subdiscipline representation



# Topic growth



# Social sciences and topic representation



## n Topics

