

A Topography of Climate Change Research

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Mercator Research on Global Commons and Climate Change
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Introduction



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

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- Topography is a description of a landscape

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Introduction



- Topography is a description of a landscape
- Topics (from the Greek τοπος, place) can describe the features of a body of text

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

Outline

- 1 Motivation
- 2 Approach
- 3 Results
- 4 Conclusions

Literature growth

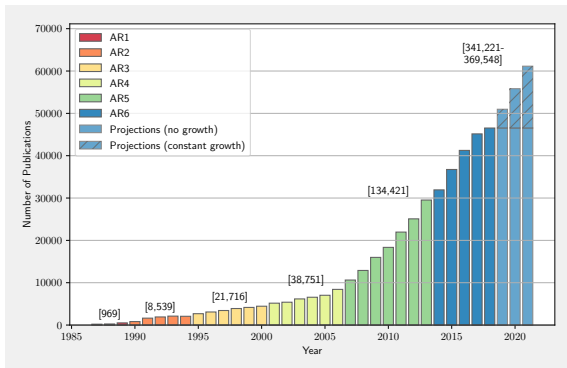
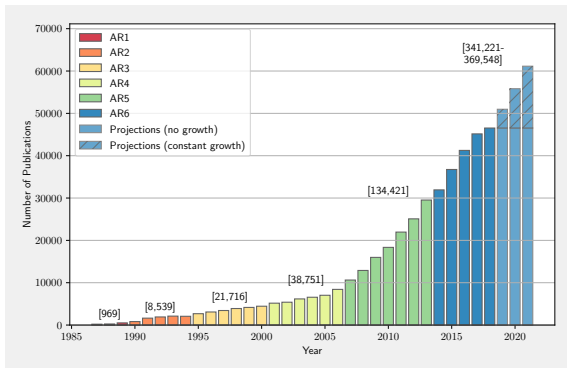


Figure: Updated from Minx et al. (2017)

Literature growth



- The Literature on climate change has grown, and continues to grow

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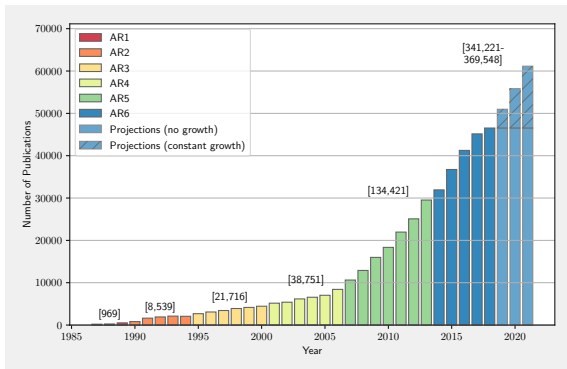


Figure: Updated from Minx et al. (2017)

- The Literature on climate change has grown, and continues to grow
- A general understanding of the literature becomes ever more difficult

Literature growth

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

Literature growth

- We entrust the IPCC with providing a *comprehensive* and *transparent* assessment of the literature
- Although IPCC reports cite ever greater numbers of papers, this number decreases in proportion to the number of papers in literature

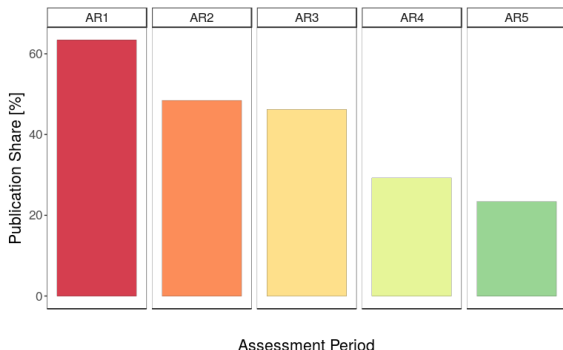


Figure: (Minx et al., 2017)

Research Questions

- What is the literature about?

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- Does the IPCC cite some areas of the literature more than others?

Data - Words, words, words

	AR1	AR2	AR3	AR4	AR5	AR6
Documents	625	7623	16395	34510	117758	128266
Words	1380	12409	20453	32644	67064	74196
New words	change (296)	loss (552)	downscaling (197)	sres (217)	biochar (1752)	mmms (192)
	climate (262)	efficiency (515)	degreesc (145)	petm (95)	redd (1058)	c3n4 (132)
	model (168)	mol (439)	ncep (130)	amf (87)	cmip5 (656)	cop21 (107)
	effect (160)	ambient (417)	otcs (87)	sf5cf3 (81)	cmip3 (569)	cmip6 (104)
	co2 (156)	coal (404)	nee (87)	cwd (74)	wrf (334)	zika (75)
	atmospheric (152)	photosynthetic (393)	fco (80)	embankment (72)	mofs (288)	brgdgts (71)
	climatic (133)	concern (381)	hadcm2 (78)	aod (69)	sdm (283)	twitter (68)
	global (131)	chamber (353)	dtr (75)	clc (69)	gosat (281)	jing (66)

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

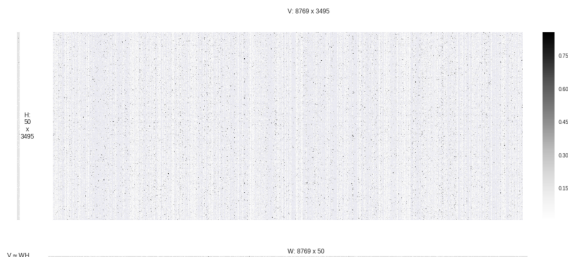
Approach - What is the matter?

- 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

$V_{i\mu}$ 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



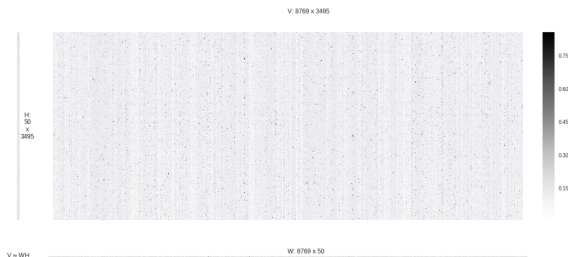
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- I follow Greene and Cross (2016) in using NMF to generate static models of time windows (ARs 1-6) and a topic model of these topic models to generate dynamic topics, which describe topics across time

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Topics and Disciplines

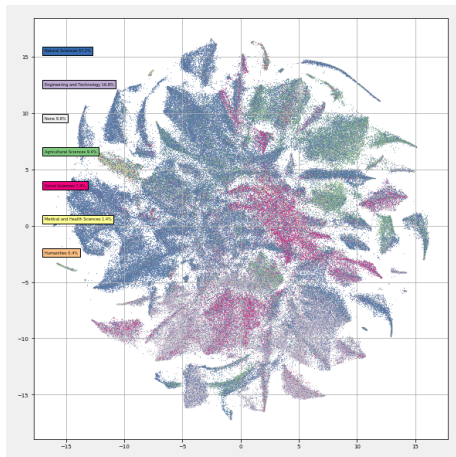
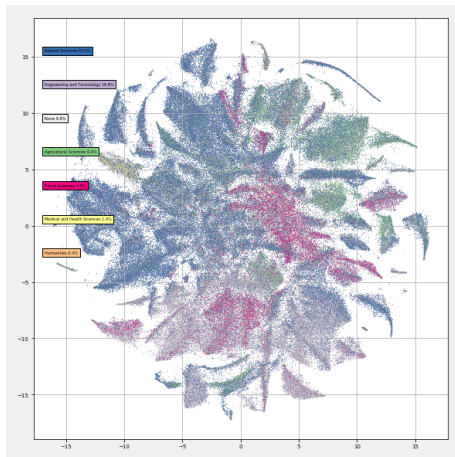


Figure: A map of the literature on climate change. Document positions are obtained by reducing the topic scores to two dimensions via t-SNE. Documents are coloured by web of science discipline category. See SI table for topic composition of each grid square.

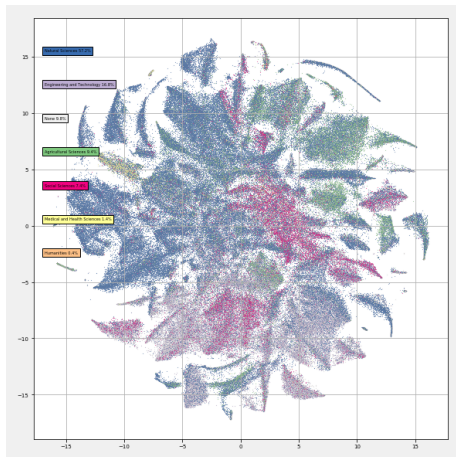
Topics and Disciplines



- Corpus mainly natural sciences

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Topics and Disciplines



- Corpus mainly natural sciences
- Topic space maps to disciplinary structure, with cross-cutting topic areas, e.g. social science and engineering

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Disciplinary representation

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

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Embed the social sciences in climate policy

David G. Victor calls for the IPCC process to be extended to include insights into controversial social and behavioural issues.

Figure: (David G. Victor, 2015)

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- Bjurström and Polk (2011) even name biases in IPCC citation patterns

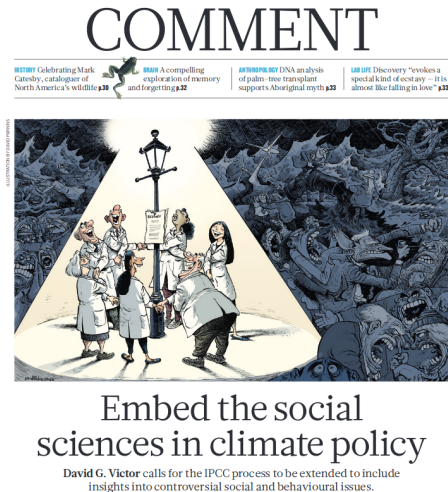


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- Bjurström and Polk (2011) even name biases in IPCC citation patterns
- These statements are based on observed disciplinary makeup of IPCC citations

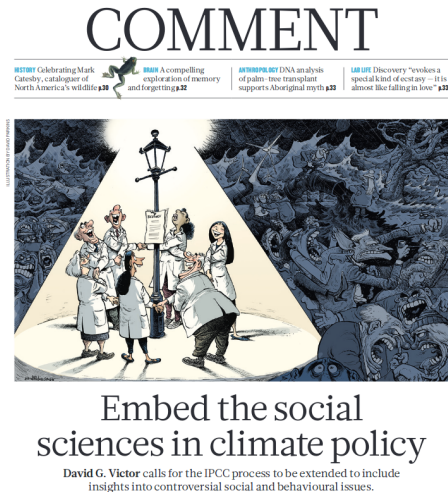
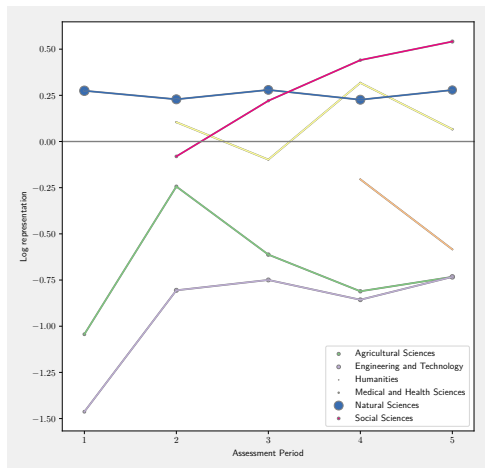


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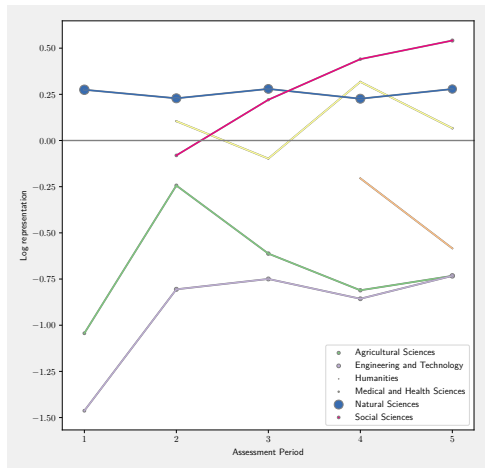
Disciplinary representation



- Natural sciences have remained a large part of the literature and well-represented in IPCC reports.

Figure: The representation within the IPCC of each discipline over time

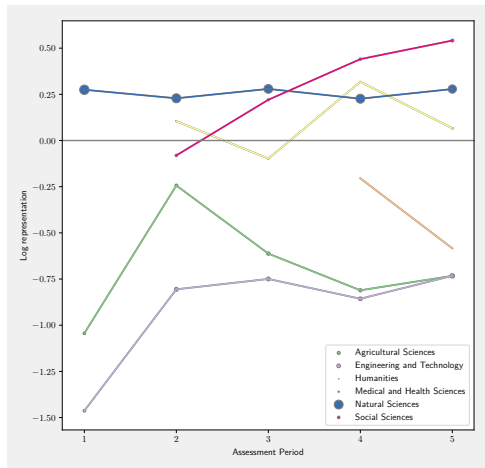
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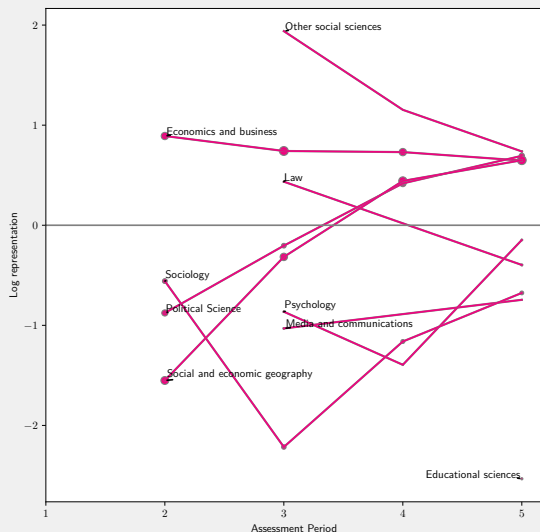
Disciplinary representation



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- The social sciences have long been over-represented
- Agricultural sciences and engineering are the most clearly under-represented (humanities make up a very small portion of the literature)

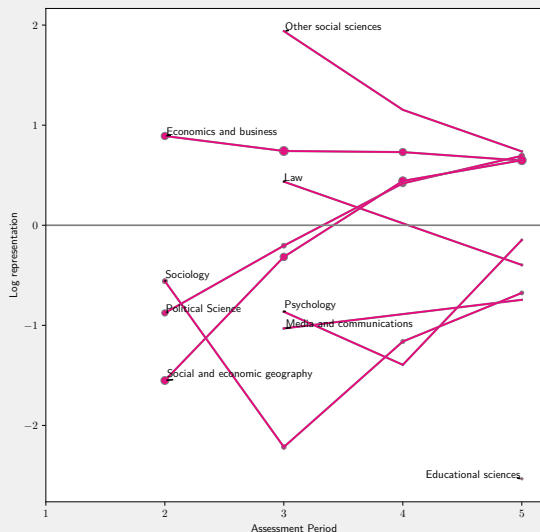
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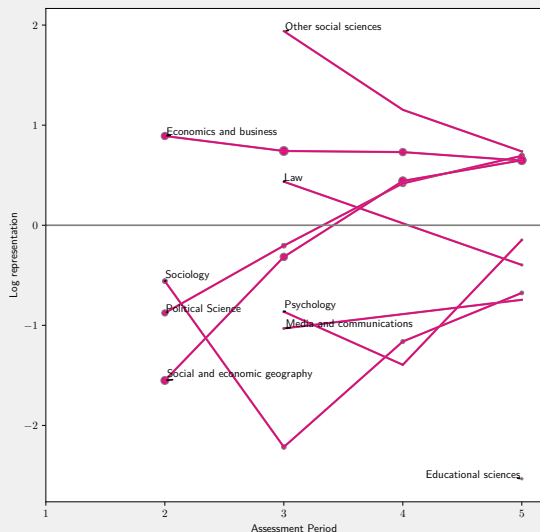
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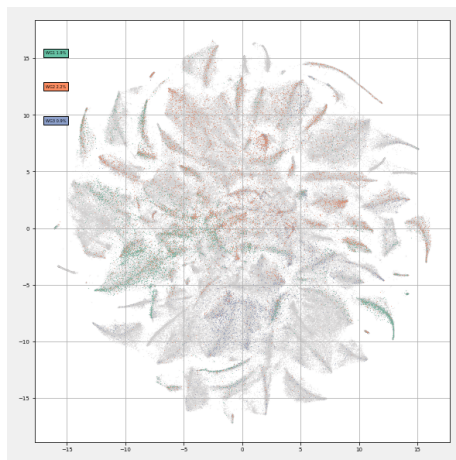
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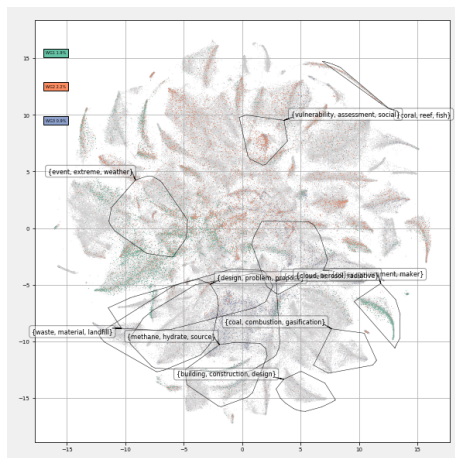
- Economics has remained over-represented
- Political science and social and economic geography large under-represented literatures that have now become over-represented
- Sociology and Psychology remain small parts of the literature that are also under-represented

IPCC Working Groups



- The thematic structure is also reflected in the division of labour between IPCC working groups. Documents cited by each working group appear in discrete parts of the map (which correspond also to the disciplinary structure)

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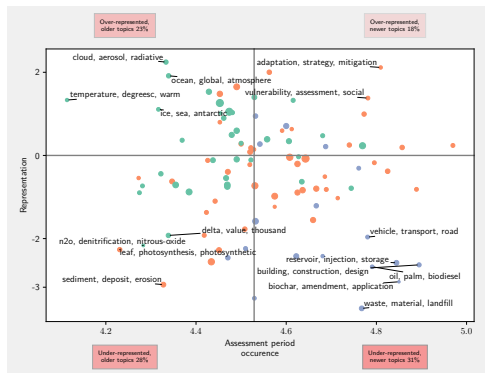
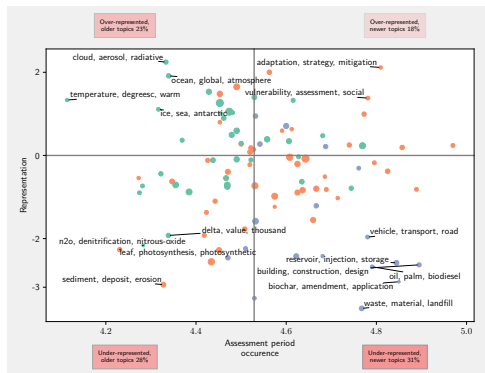


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurrence shows the assessment period in which the mean topic document was published

Newness and representation



- Those topics that deal with working group III *solutions* issues (materials and recycling, negative emissions, buildings) are in general fast growing and under-represented in IPCC reports

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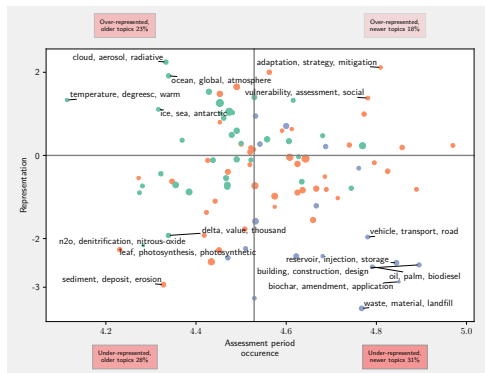


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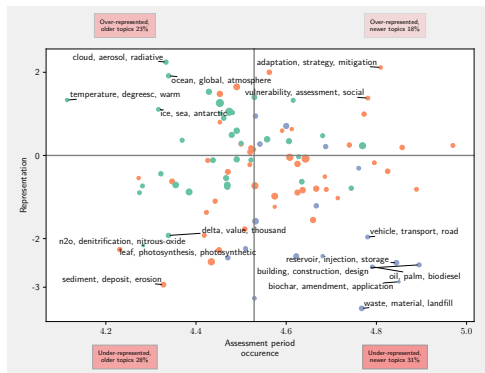


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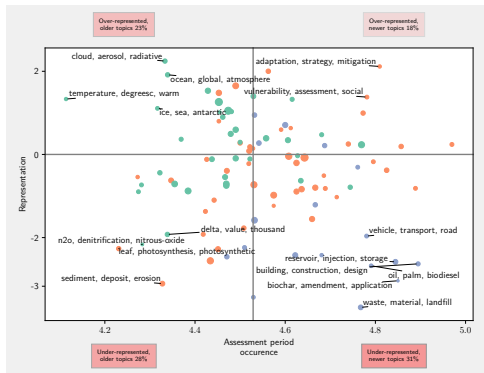


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- Of the newer topics that are well represented, many are on WG II issues

Conclusions

- Comparing IPCC citations to wider set of documents sheds new light on imbalances/biases within the IPCC
 - ▶ Perception of lack of social science knowledge on climate change may be justified, but implications for wider research community, not just IPCC

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 - ▶ Topics suggest that policymakers' demand for "solution" orientated scientific assessments (Kowarsch et al., 2017), may be justified, and possible to achieve with an adjustment of IPCC focus

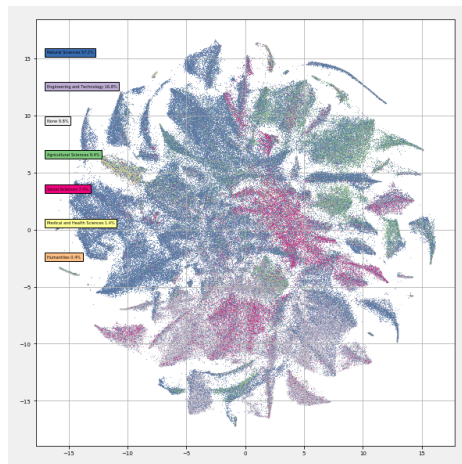
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 - ▶ Topics suggest that policymakers' demand for "solution" orientated scientific assessments (Kowarsch et al., 2017), may be justified, and possible to achieve with an adjustment of IPCC focus
- The IPCC, not a topic model, is in the best position to decide on what literature to cite
 - ▶ But, the IPCC can best make these decisions when supported by machines to find out what is out there.

Bibliography

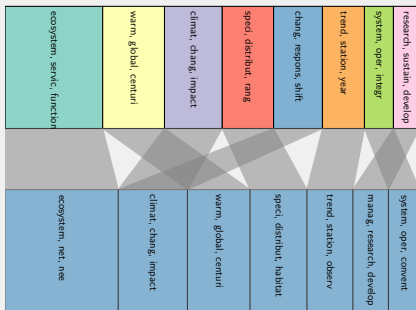
- Bjurström, A. and Polk, M. (2011). Physical and economic bias in climate change research: A scientometric study of IPCC Third Assessment Report. *Climatic Change*, 108(1):1–22.
- Blei, D., Carin, L., and Dunson, D. (2012). Probabilistic topic models. *Communications of the ACM*, 55(4):77–84.
- David G. Victor (2015). Embed the social sciences in climate policy - David Victor. *Nature*, 520:7–9.
- Greene, D. and Cross, J. P. (2016). Exploring the Political Agenda of the European Parliament Using a Dynamic Topic Modeling Approach. pages 1–47.
- Grieneisen, M. and Zhang, M. (2011). The Current Status of Climate Change Research. *Nature Climate Change*, 1:72–73.
- Kowarsch, M., Jabbour, J., Flachsland, C., Kok, M. T. J., Watson, R., Haas, P. M., Minx, J. C., Alcamo, J., Garard, J., Rioussset, P., Pintér, L., Langford, C., Yamineva, Y., von Stechow, C., O'Reilly, J., and Edenhofer, O. (2017). A road map for global environmental assessments. *Nature Climate Change*, 7(6):379–382.
- Lee, D. D. and Seung, H. S. (1999). Learning the parts of objects by non-negative matrix factorization. *Nature*, 401(6755):788–91.
- Minx, J. C., Callaghan, M., Lamb, W. F., Garard, J., and Edenhofer, O. (2017). Learning about climate change solutions in the IPCC and beyond. *Environmental Science & Policy*.

Thanks for your attention



Doc Topic Example

Dynamic topics in *doc₁*



Window topics in *doc₁*

Topic Doc	ecosystem net nee	climat chang impact	warm global centuri	speci distribut habitat
<i>doc₁</i>	0.034	0.021	0.019	0.017
<i>doc₂</i>	...	...	...	...
<i>doc₃</i>	...	...	...	...

Doc Topic Matrix

\times

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

\approx

Term Doc	chang	ecolog	global	recent
<i>doc₁</i>	4	3	2	2
<i>doc₂</i>	...	...	...	...
<i>doc₃</i>	...	...	...	...
<i>doc₄</i>	...	...	...	...

Doc Term Matrix

