A Topography of Climate Change Research

Max Callaghan

callaghan[at]mcc-berlin.net

Mercator Research on Global Commons and Climate Change
School of Earth and Environment, University of Leeds

May 6, 2019

Introduction

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

Introduction

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

- Topography is a description of a landscape

Introduction

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

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

Outline

Literature growth

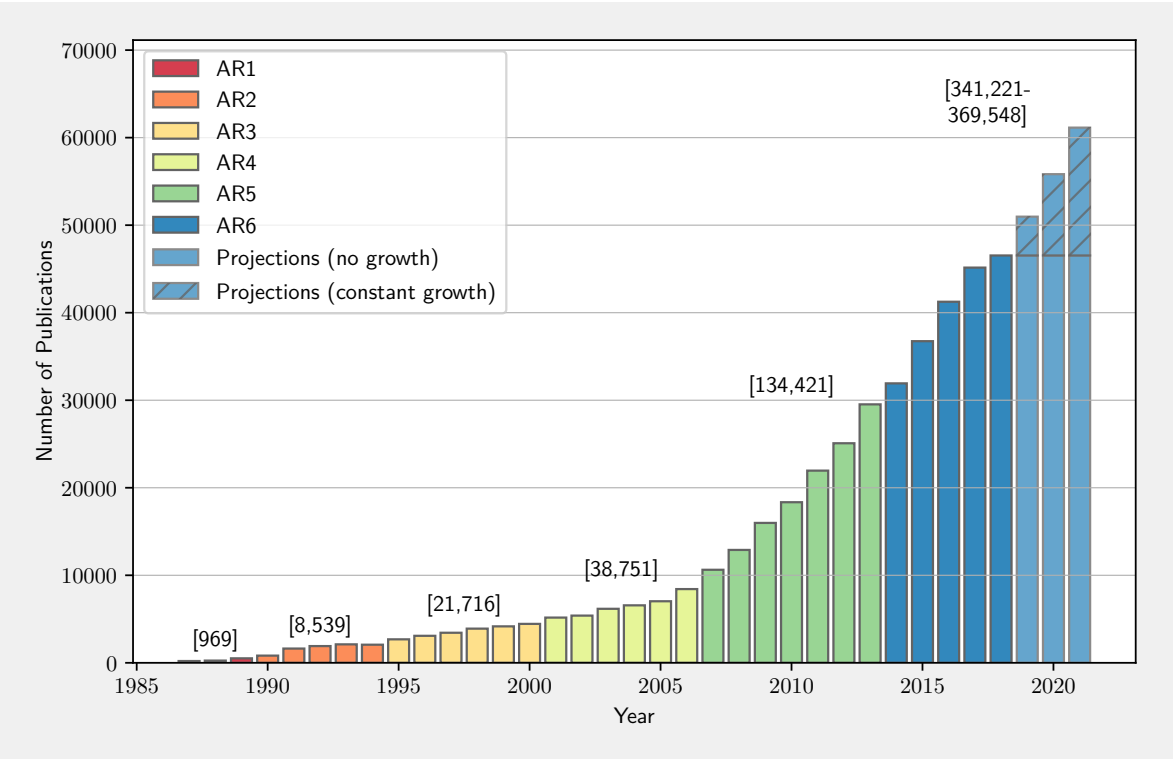
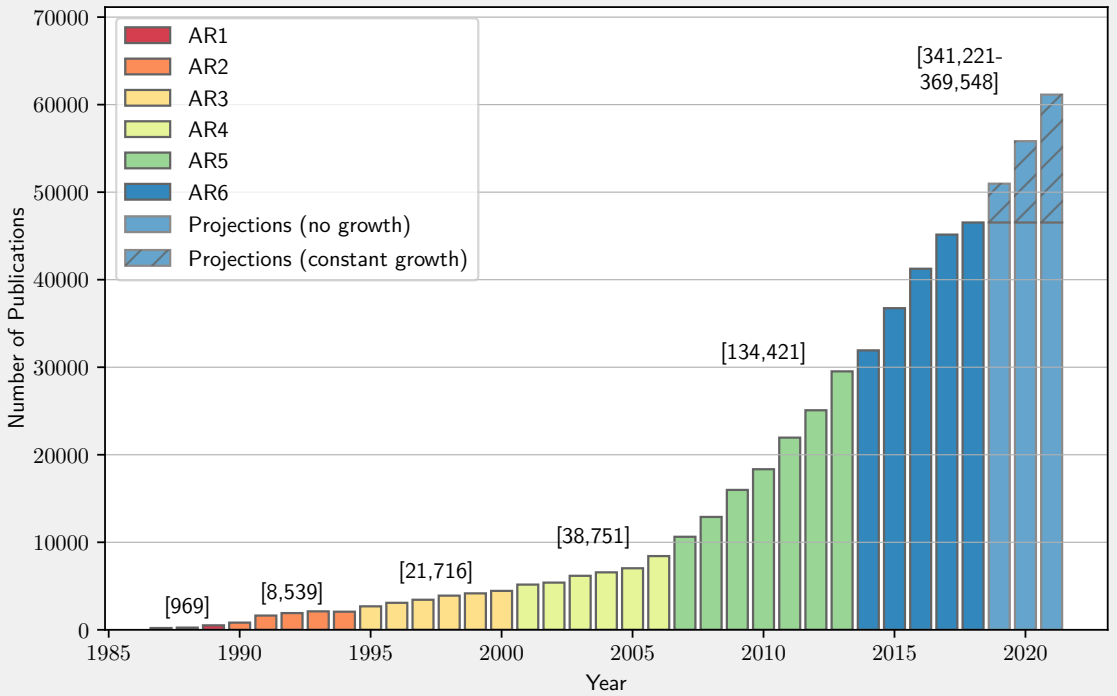


Figure: Updated from Minx et al. (2017)

Literature growth



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

Figure: Updated from Minx et al. (2017)

Literature growth

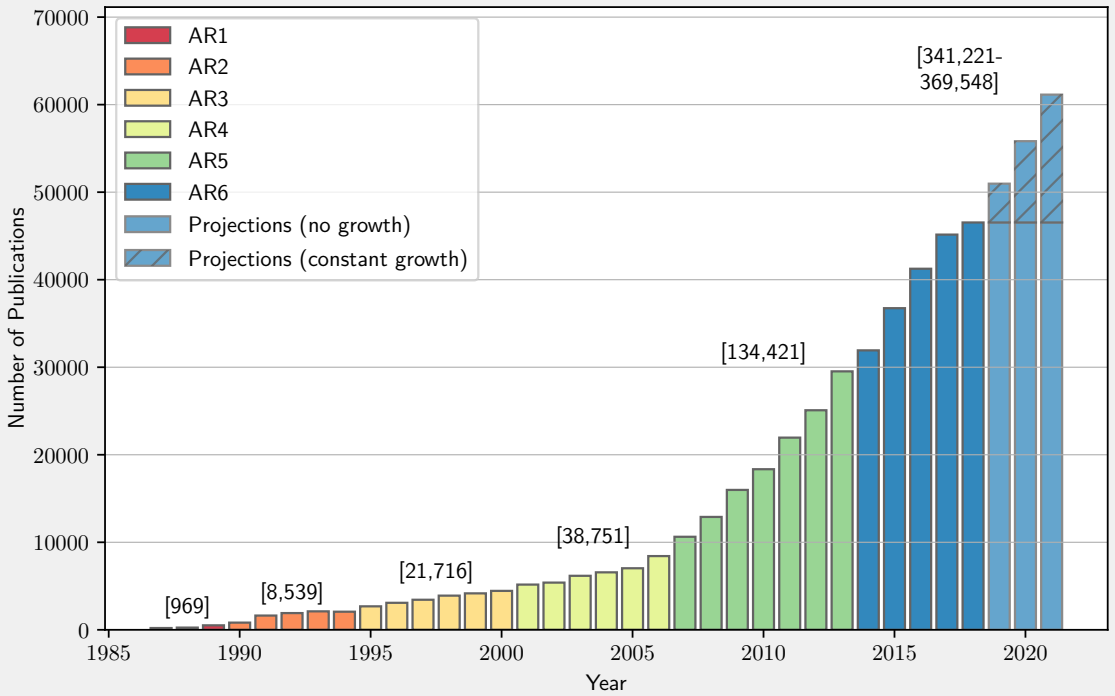


Figure: Updated from Minx et al. (2017)

- 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

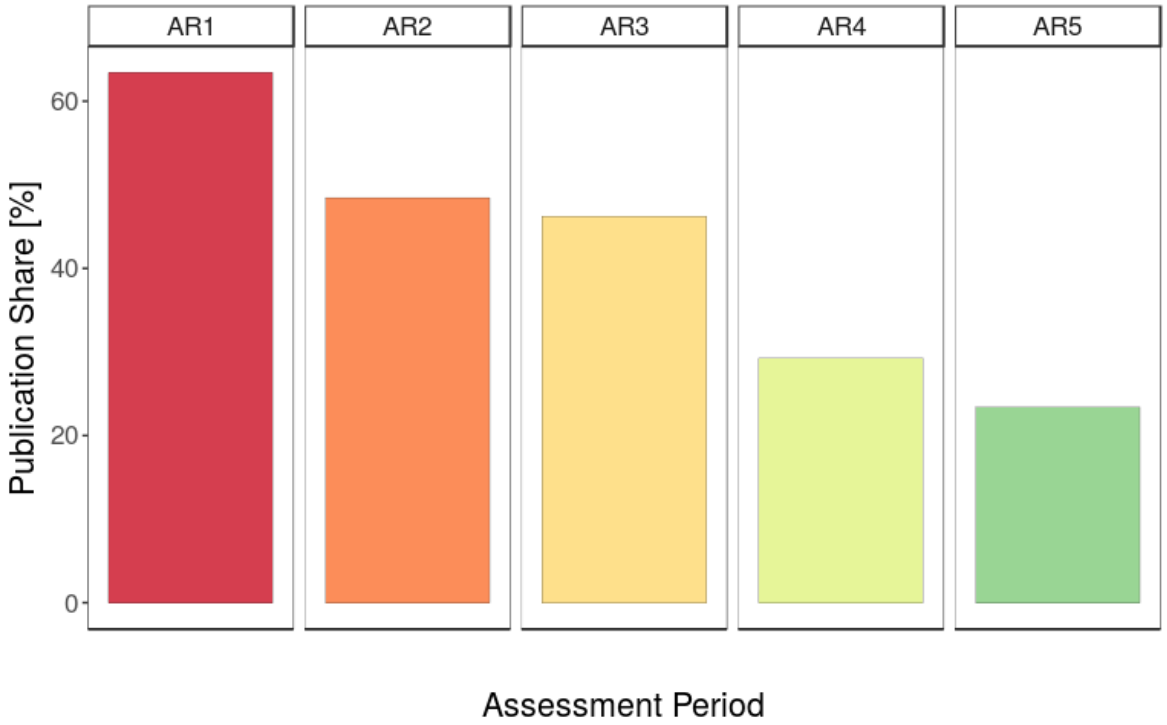


Figure: (Minx et al., 2017)

Research Questions

- What is the literature about?

Research Questions

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

Data - Words, words, words

	AR1	AR2	AR3	AR4	AR5	AR6
Documents	1167	8539	21716	38750	134413	201606
Words	2000	12480	23346	34637	71867	94746
New words	change (560)	oil (287)	downscaling (217)	sres (234)	biochar (1791)	mmms (313)
	climate (428)	deltac (283)	degreesc (187)	petm (95)	redd (1113)	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

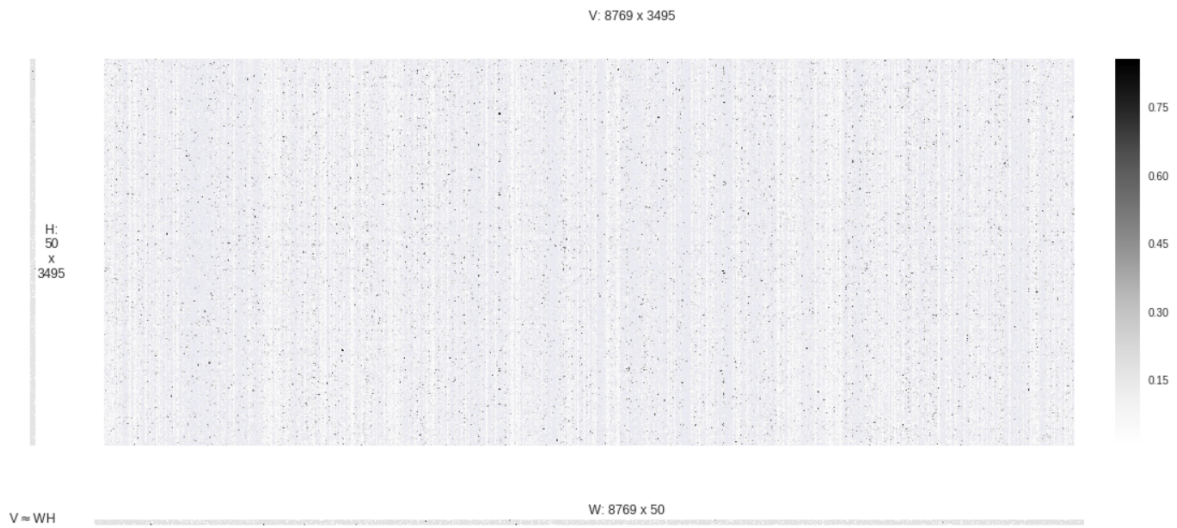
Approach - What is the matter?

- 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



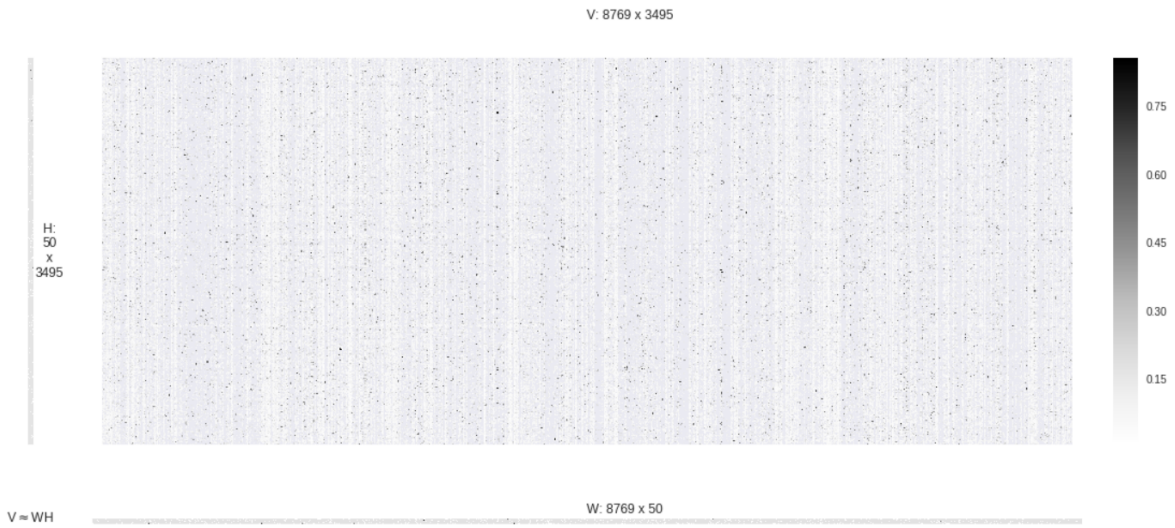
Approach - What is the matter?

- 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
- 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

$V_{i\mu}$ 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



Topics and Disciplines

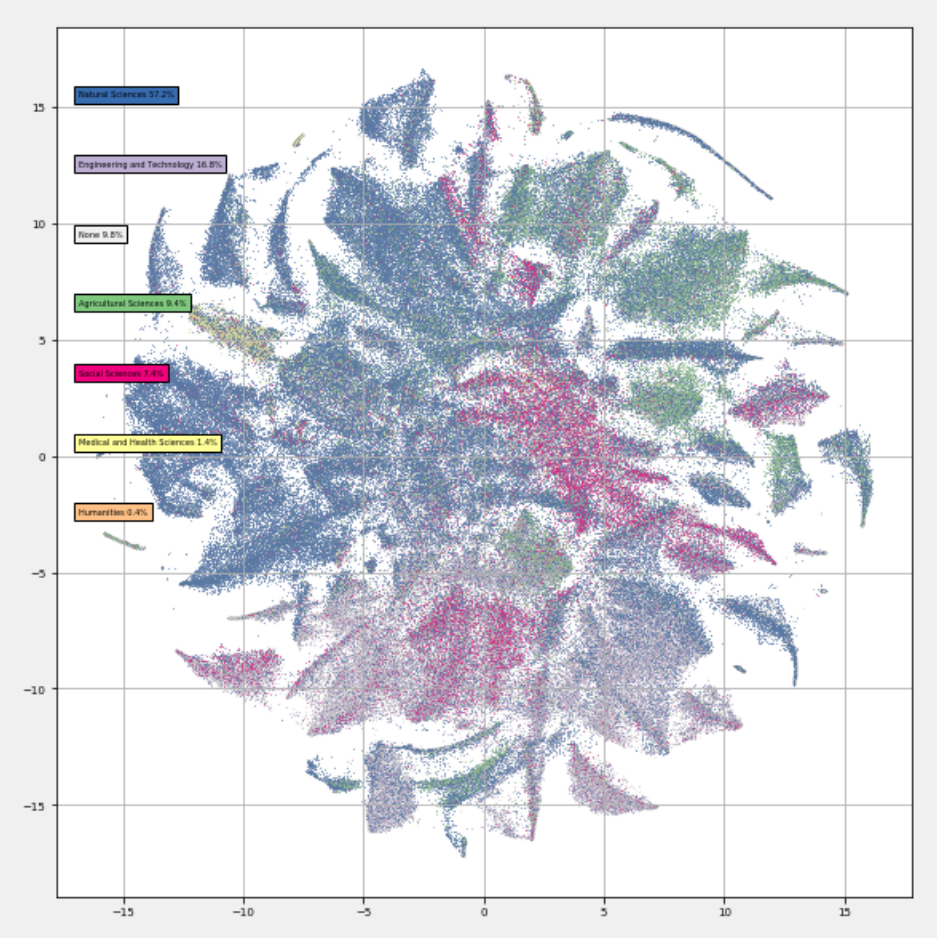
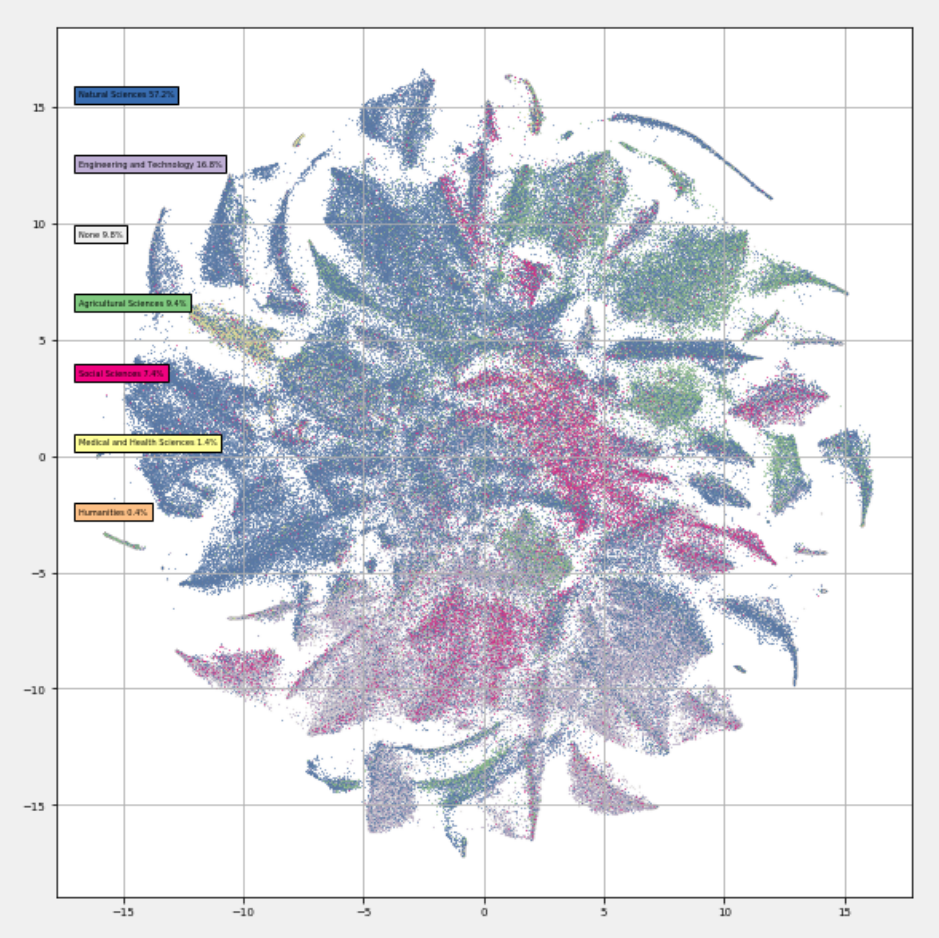


Figure: A map of the literature on climate change. Document positions are obtained by reducing the topic scores to two dimensions via t-SNE Documents are coloured by web of science discipline category. See SI table for topic composition of each grid square

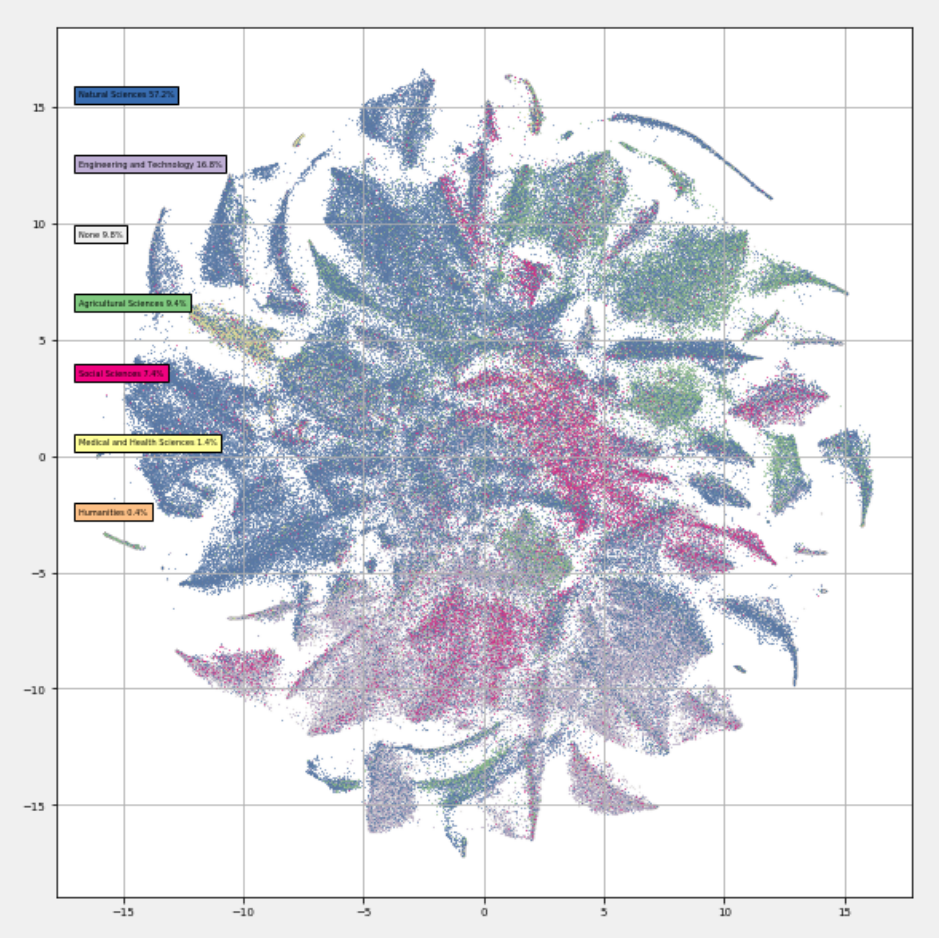
Topics and Disciplines



- Corpus mainly natural sciences

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

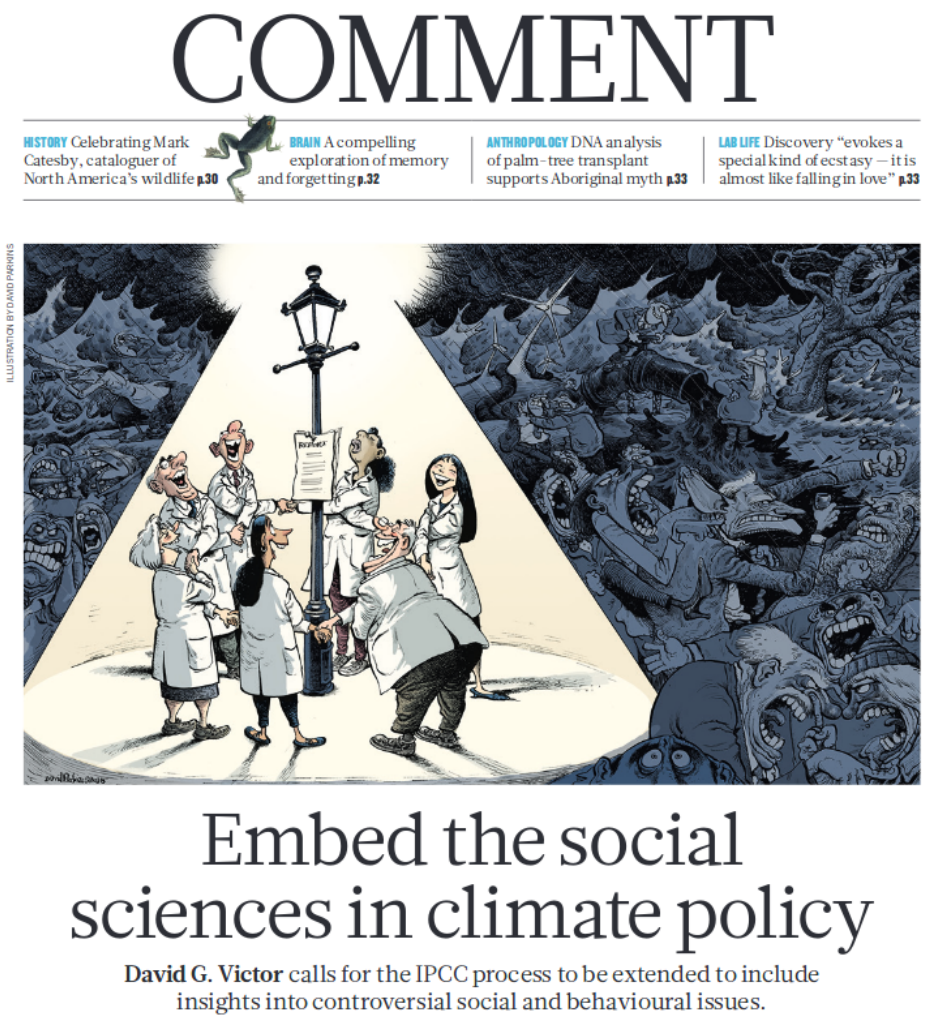
Figure: A map of the literature on climate change. Document positions are obtained by reducing the topic scores to two dimensions via t-SNE Documents are coloured by web of science discipline category. See SI table for topic composition of each grid square

Disciplinary representation

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

Disciplinary representation

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



COMMENT

HISTORY Celebrating Mark Catesby, cataloguer of North America's wildlife **p.30** | **BRAIN** A compelling exploration of memory and forgetting **p.32** | **ANTHROPOLOGY** DNA analysis of palm-tree transplant supports Aboriginal myth **p.33** | **LAB LIFE** Discovery "evokes a special kind of ecstasy — it is almost like falling in love" **p.33**

ILLUSTRATION BY DAVID PARKINS

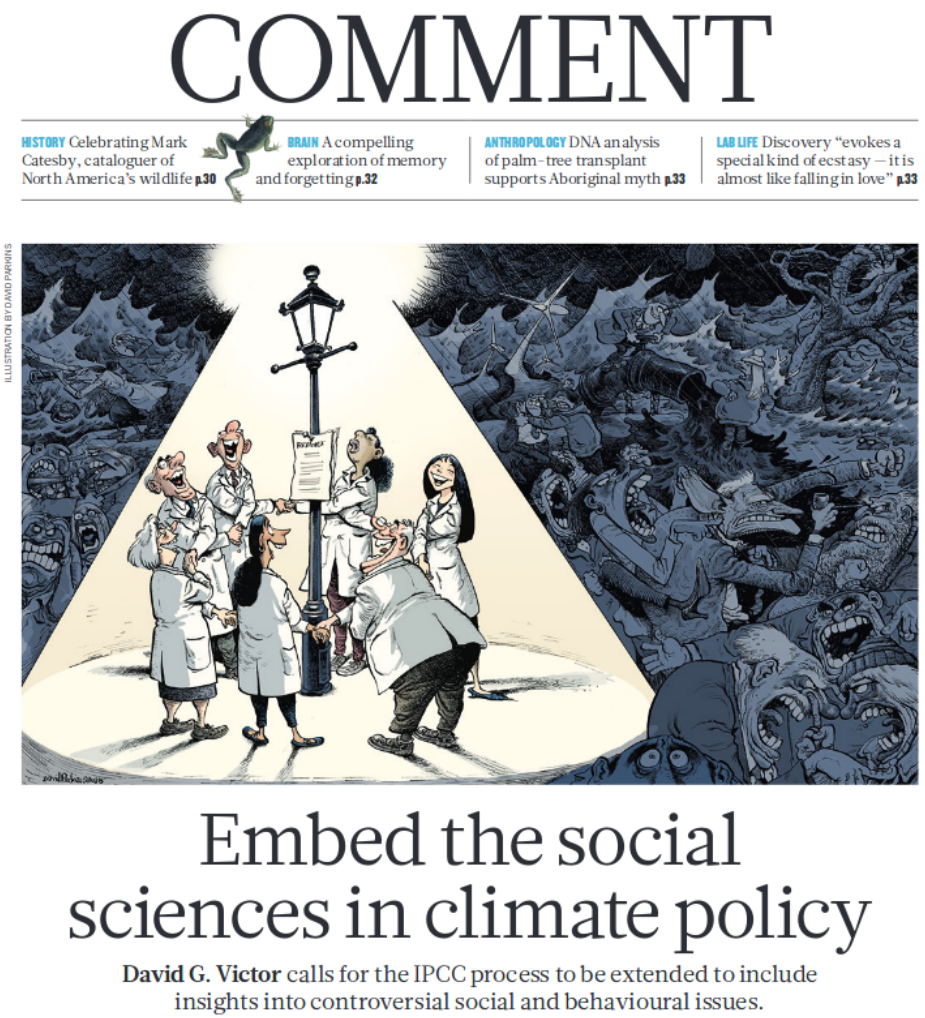
Embed the social sciences in climate policy

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)

Disciplinary representation

- The social sciences are seen as under-represented in IPCC reports
- Bjurström and Polk (2011) even name biases in IPCC citation patterns



COMMENT

HISTORY Celebrating Mark Catesby, cataloguer of North America's wildlife **p.30** | **BRAIN** A compelling exploration of memory and forgetting **p.32** | **ANTHROPOLOGY** DNA analysis of palm-tree transplant supports Aboriginal myth **p.33** | **LAB LIFE** Discovery "evokes a special kind of ecstasy — it is almost like falling in love" **p.33**

ILLUSTRATION BY DAVID PARKINS

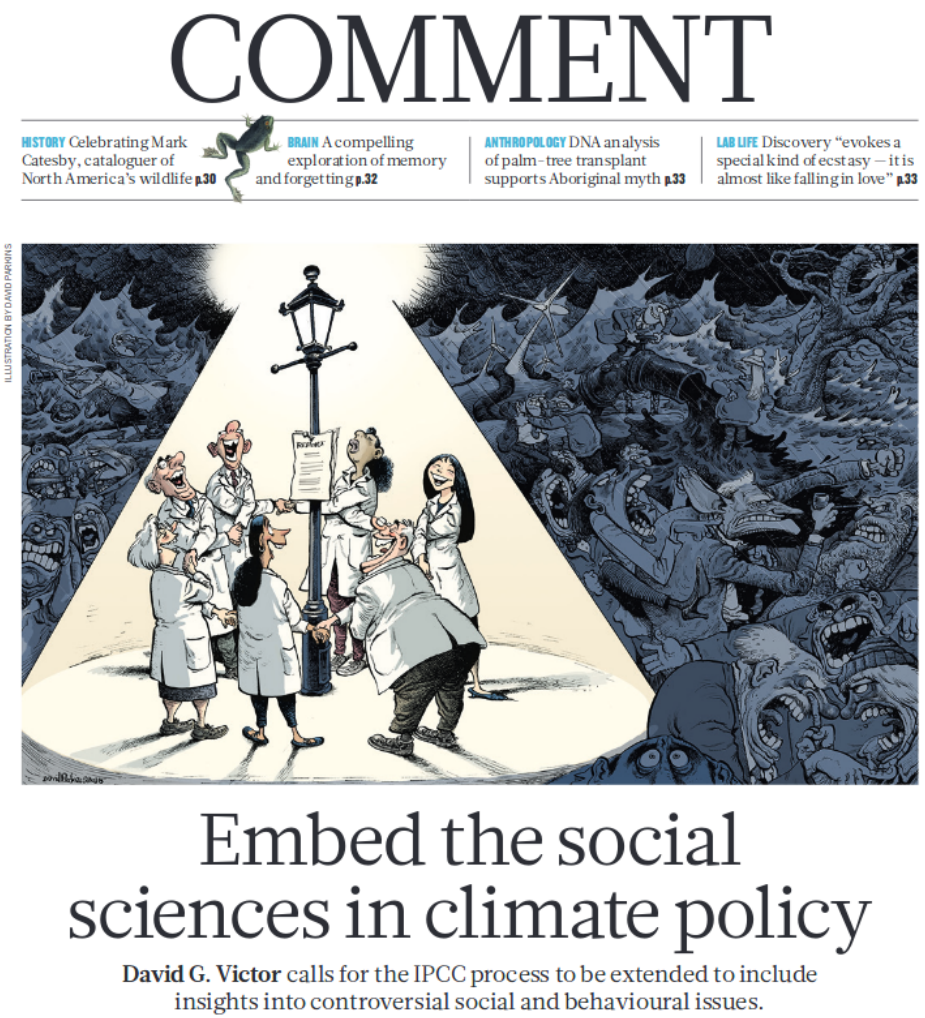
Embed the social sciences in climate policy

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)

Disciplinary representation

- The social sciences are seen as under-represented in IPCC reports
- Bjurström and Polk (2011) even name biases in IPCC citation patterns
- These statements are based on observed disciplinary makeup of IPCC citations



COMMENT

HISTORY Celebrating Mark Catesby, cataloguer of North America's wildlife **p.30** **BRAIN** A compelling exploration of memory and forgetting **p.32** **ANTHROPOLOGY** DNA analysis of palm-tree transplant supports Aboriginal myth **p.33** **LAB LIFE** Discovery "evokes a special kind of ecstasy — it is almost like falling in love" **p.33**

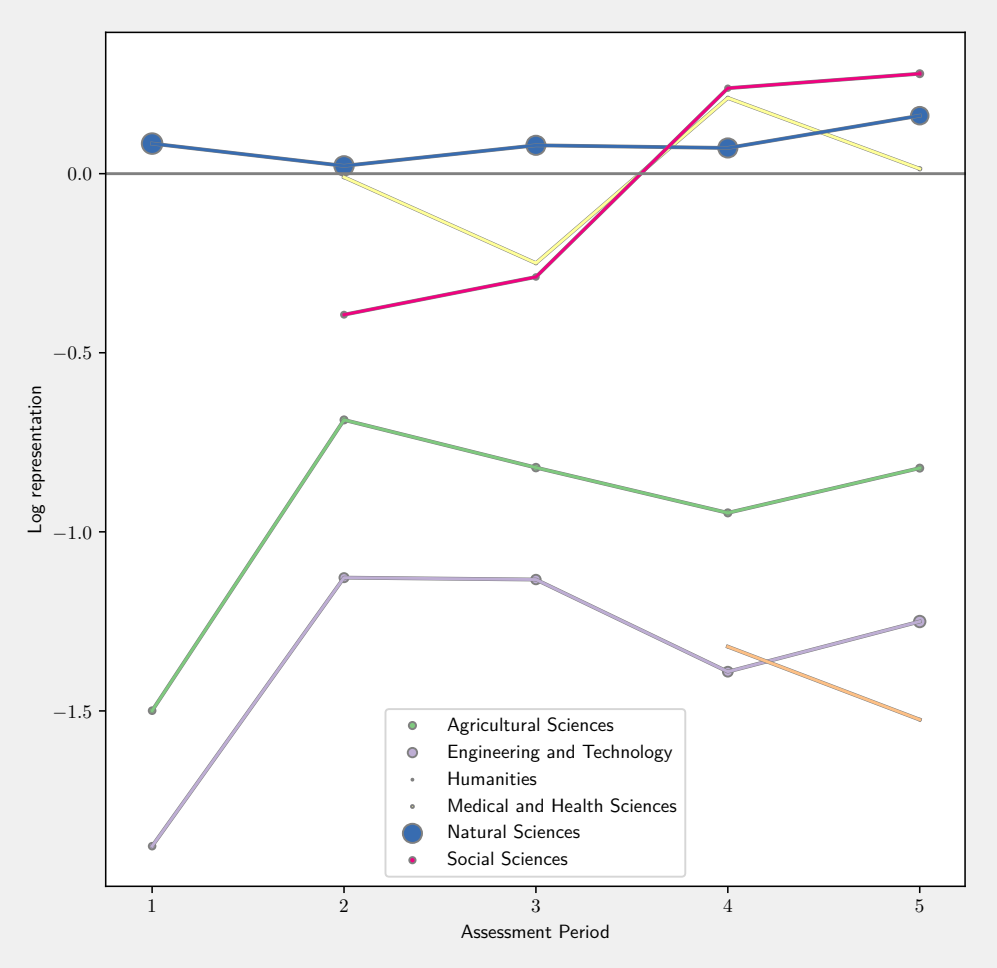
ILLUSTRATION BY DAVID PARKINS

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)

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

Disciplinary representation

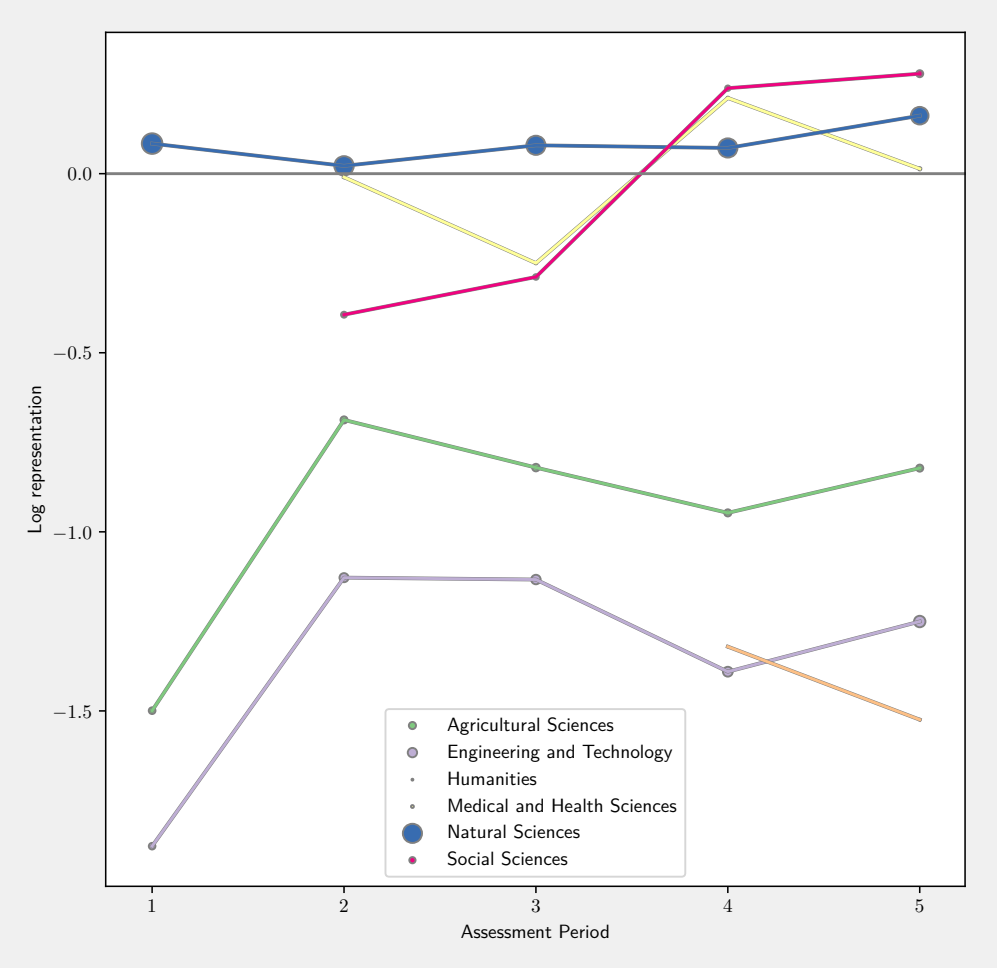


Figure: The representation within the IPCC of each discipline over time

- Natural sciences have remained a large part of the literature and well-represented in IPCC reports.
- The social sciences have long been over-represented

Disciplinary representation

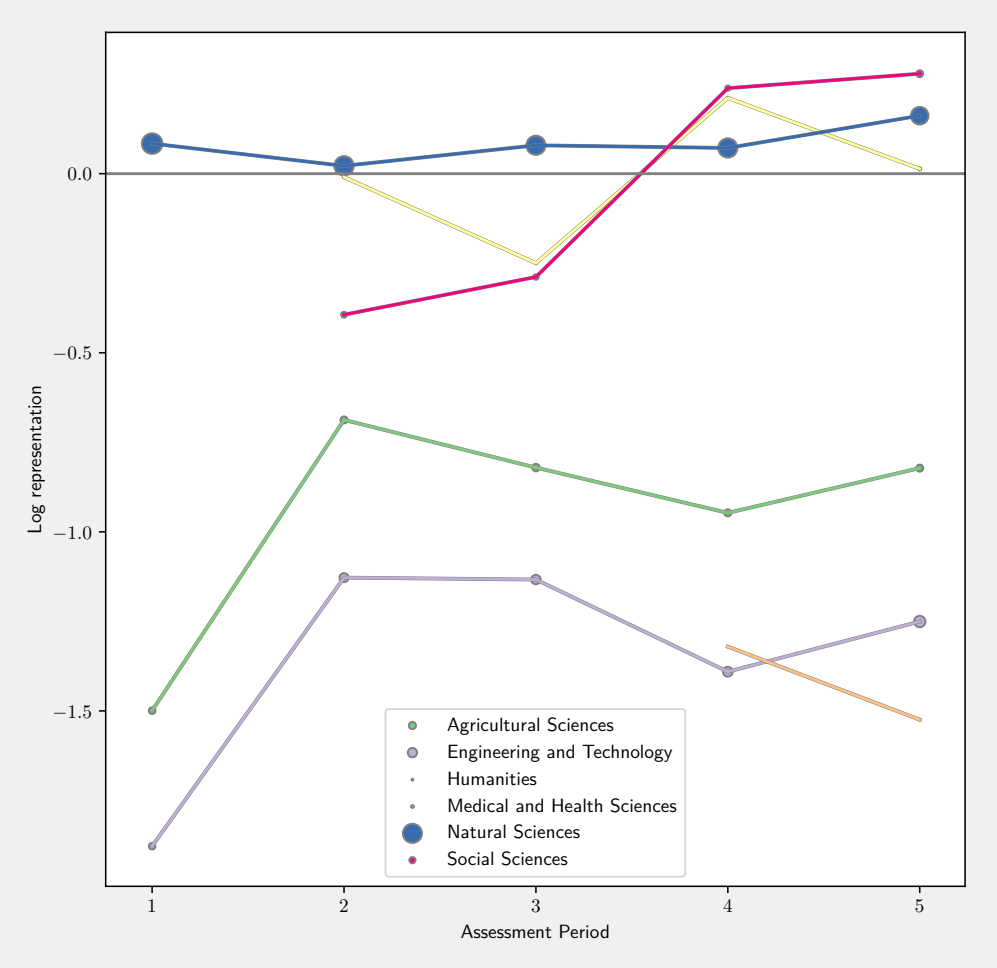
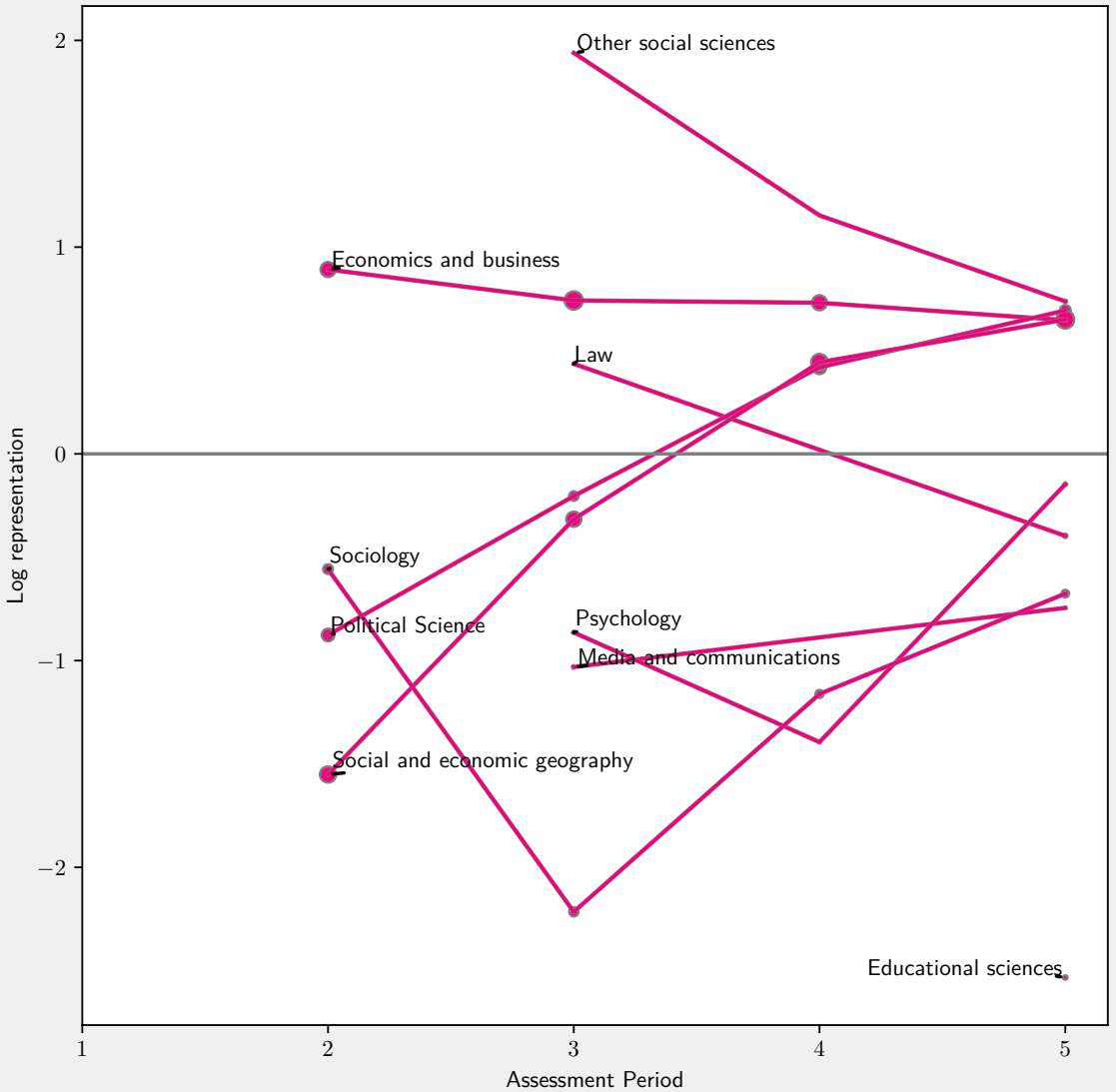


Figure: The representation within the IPCC of each discipline over time

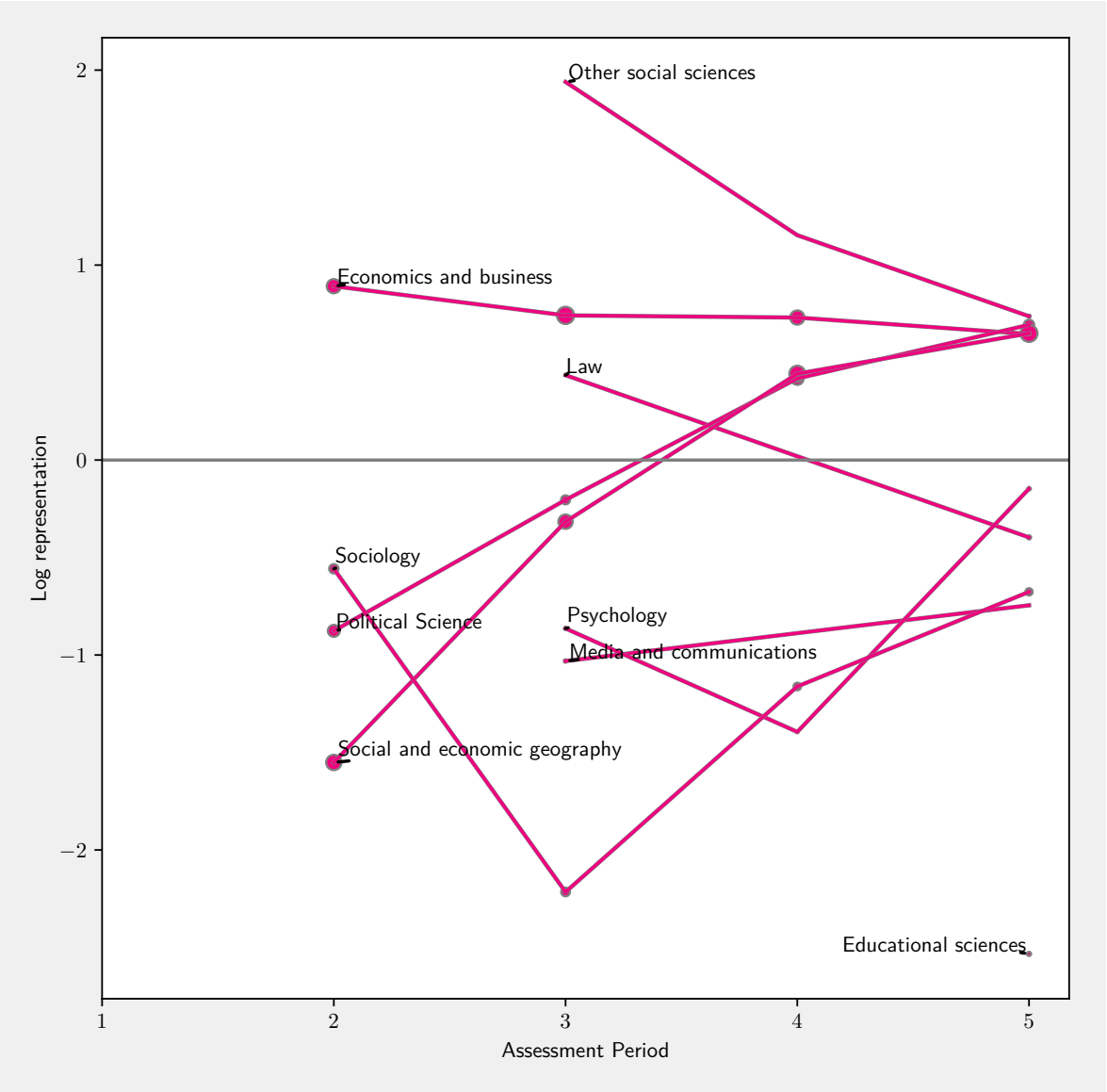
- Natural sciences have remained a large part of the literature and well-represented in IPCC reports.
- The social sciences have long been over-represented
- Agricultural sciences and engineering are the most clearly under-represented (humanities make up a very small portion of the literature)

The Social Sciences



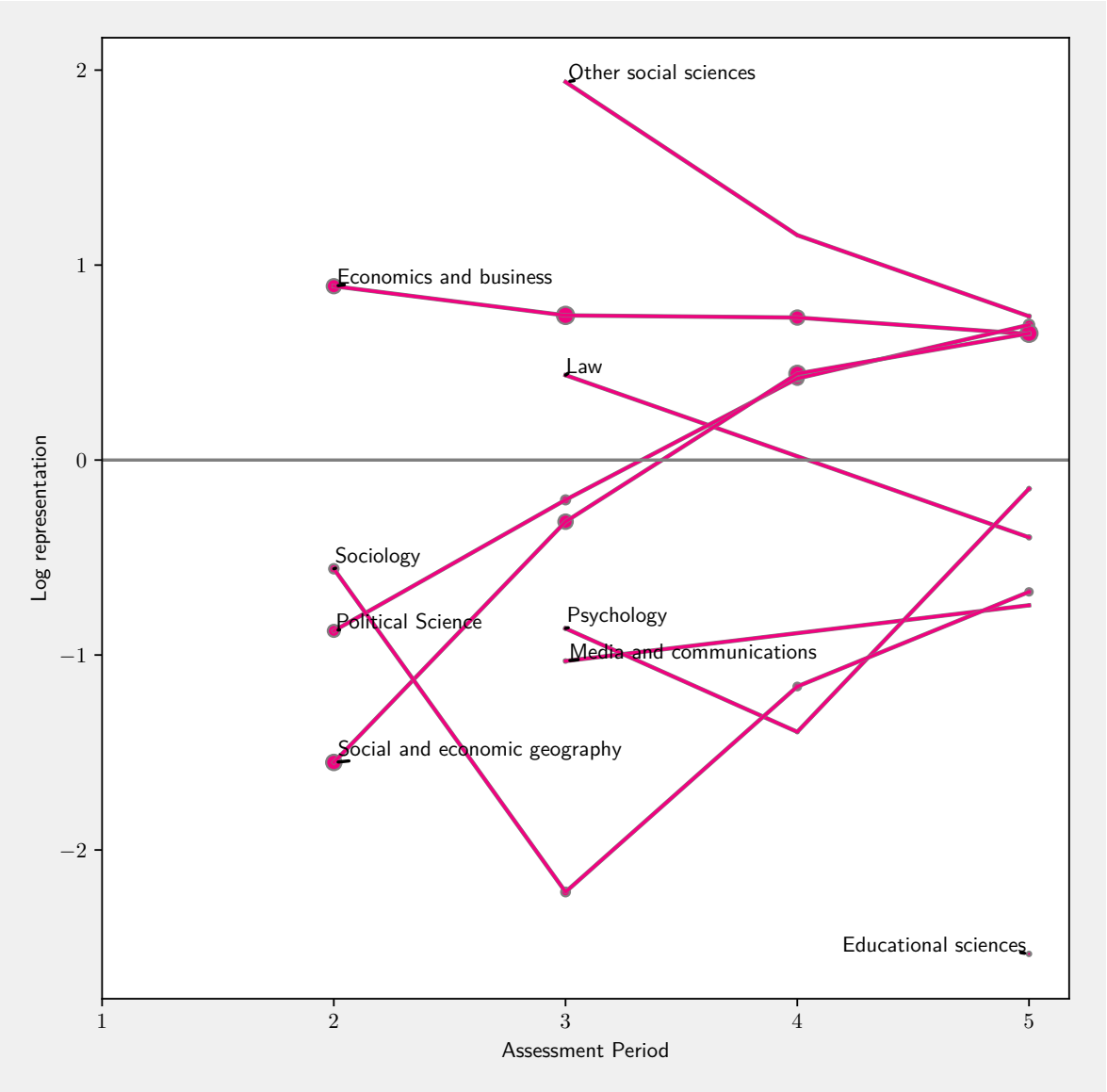
- Economics has remained over-represented

The Social Sciences



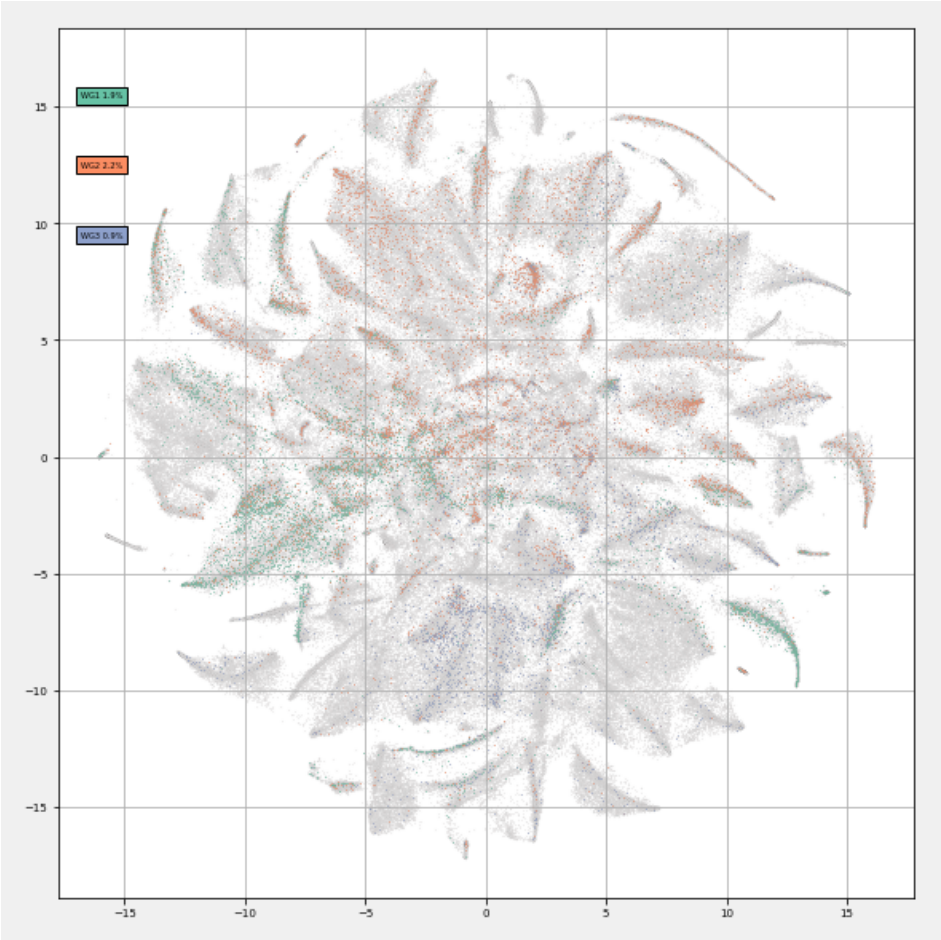
- Economics has remained over-represented
- Political science and social and economic geography large under-represented literatures that have now become over-represented

The Social Sciences



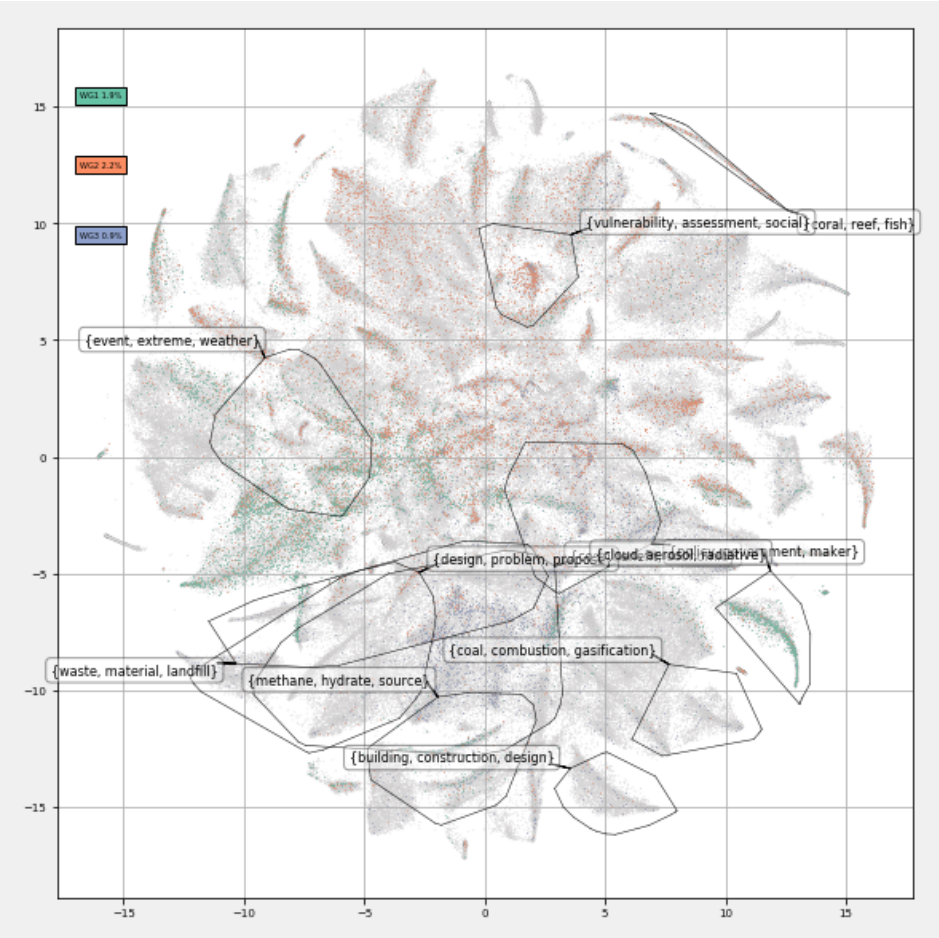
- Economics has remained over-represented
- Political science and social and economic geography large under-represented literatures that have now become over-represented
- Sociology and Psychology remain small parts of the literature that are also under-represented

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)

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)

Newness and representation

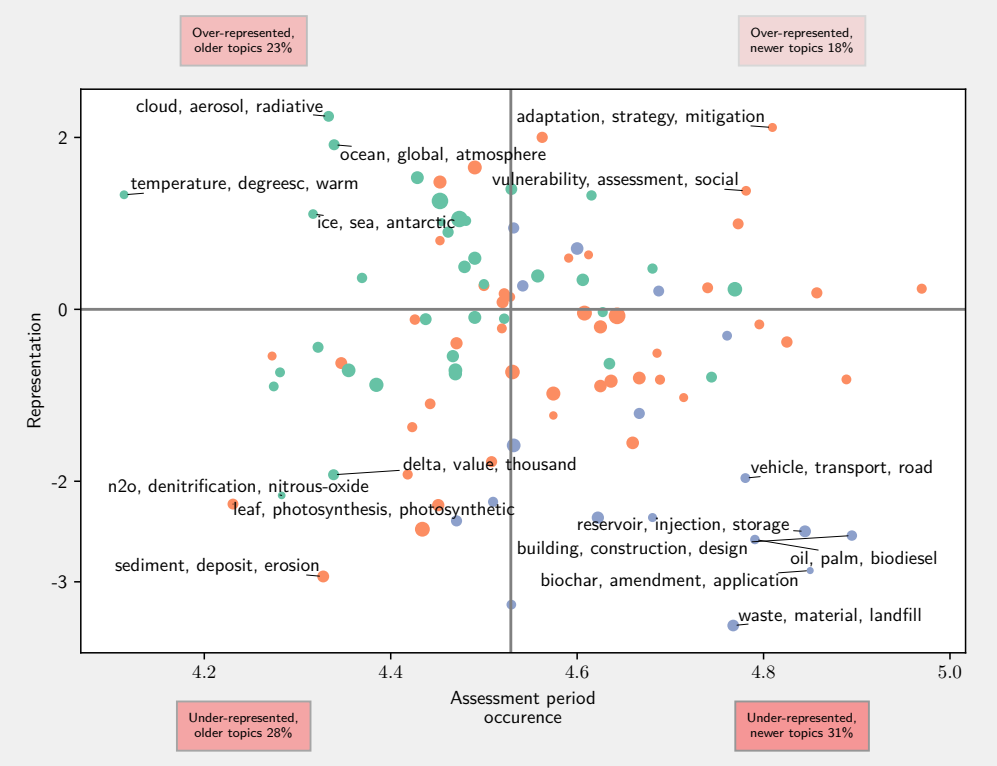


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

Newness and representation

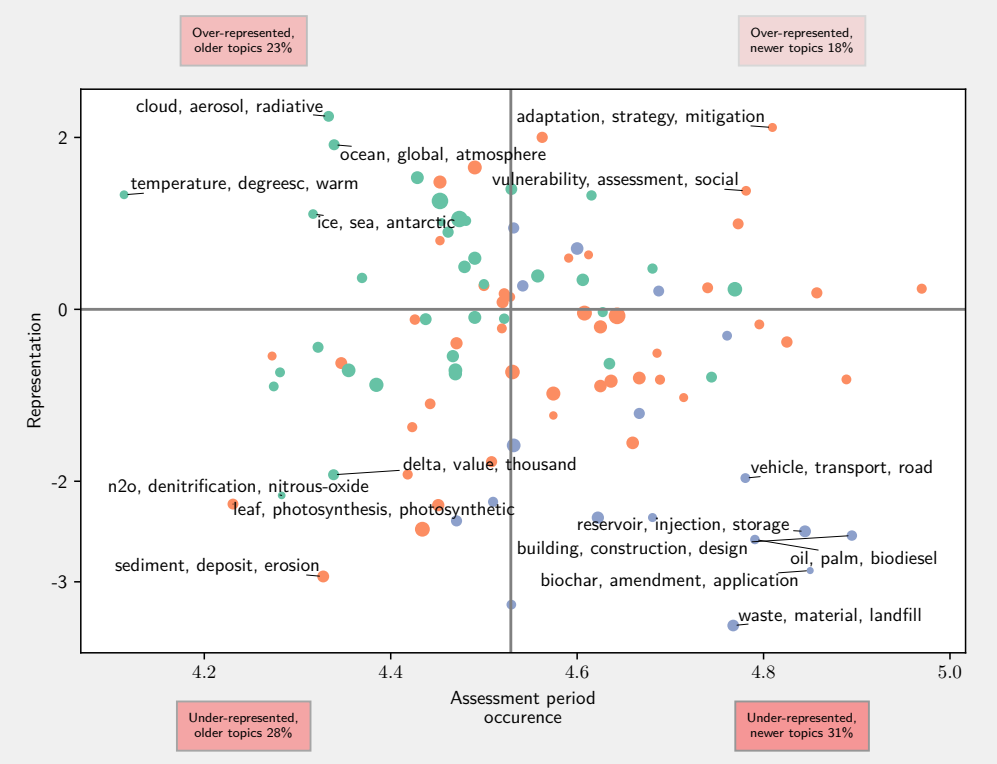


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

- 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

Newness and representation

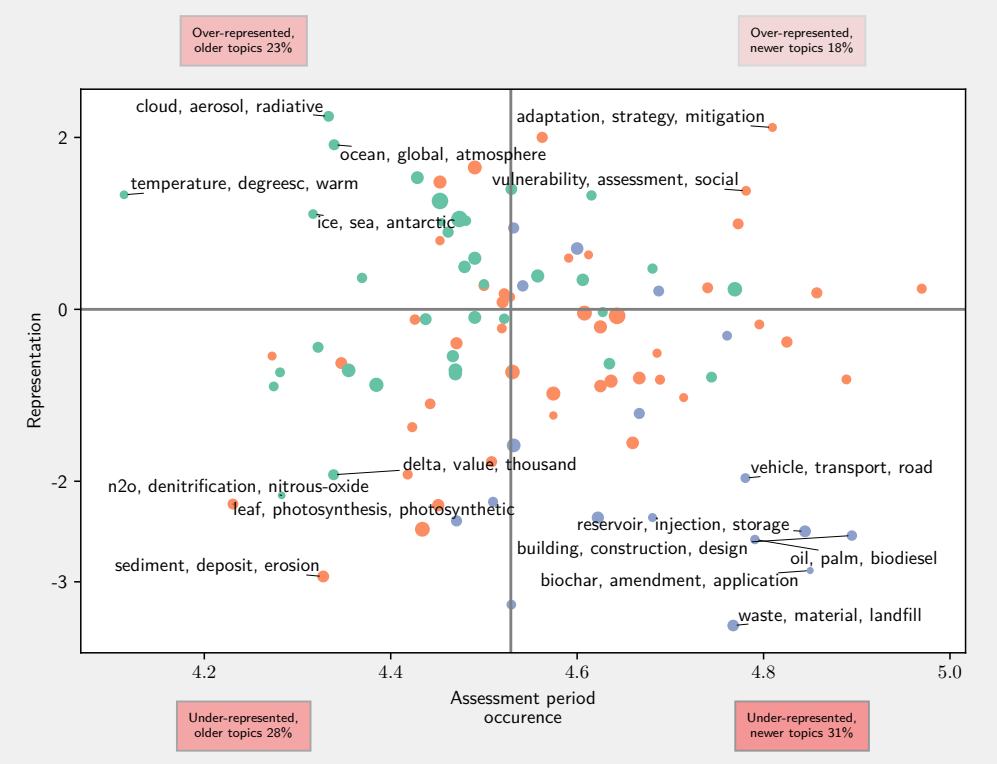


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

- 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
- Some working group III topics (on scenarios, on policies, and on international trade and cross country comparisons) are however over-represented in IPCC reports [see SI]

Newness and representation

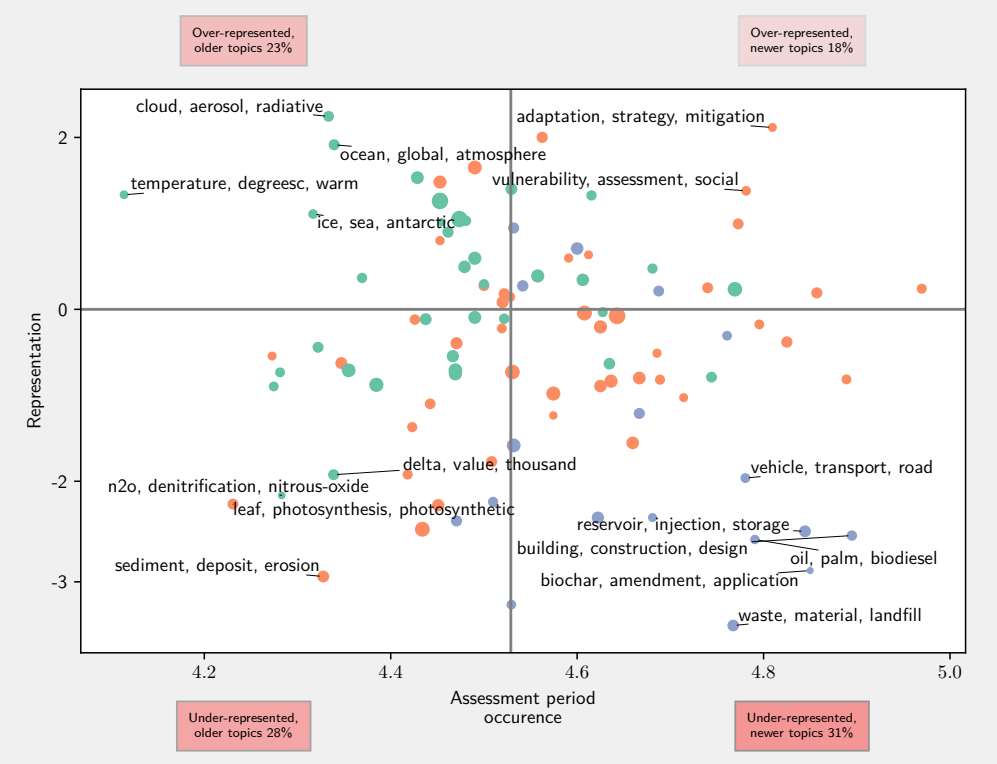


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

- 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
- Some working group III topics (on scenarios, on policies, and on international trade and cross country comparisons) are however over-represented in IPCC reports [see SI]
- Working group I topics are in general older and better represented

Newness and representation

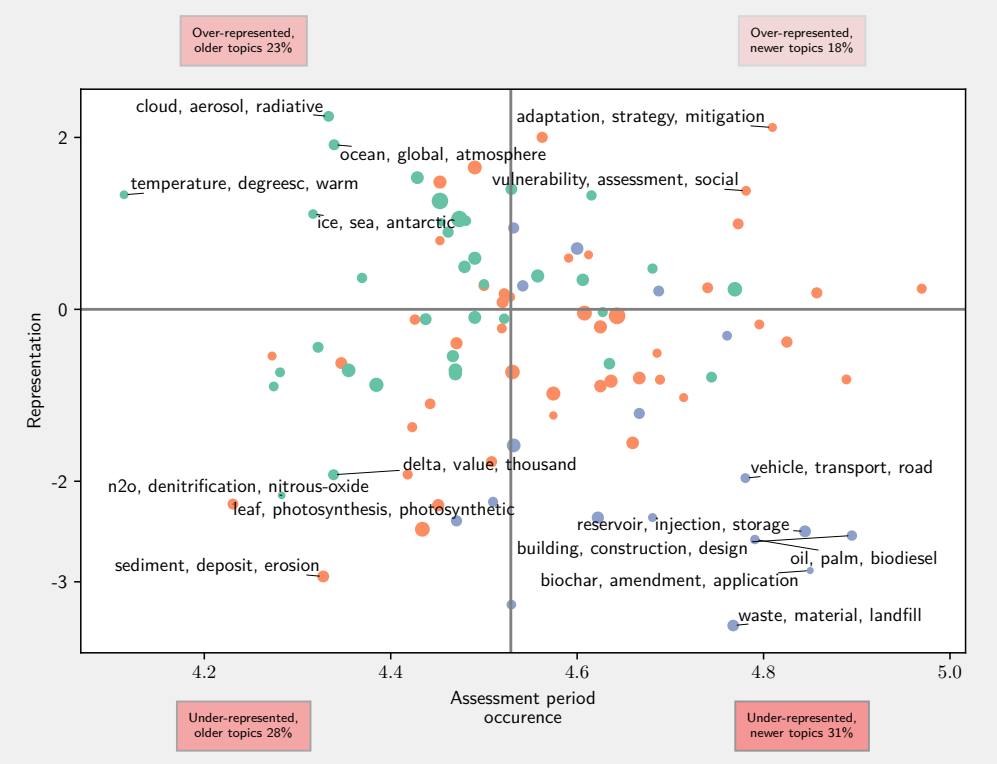


Figure: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

- 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
- Some working group III topics (on scenarios, on policies, and on international trade and cross country comparisons) are however over-represented in IPCC reports [see SI]
- Working group I topics are in general older and better represented
- 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

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
- Topic modelling enriches our understanding of the content of literature that is emerging, and that is over- or under-represented by the IPCC
  - 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

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
- Topic modelling enriches our understanding of the content of literature that is emerging, and that is over- or under-represented by the IPCC
  - 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.

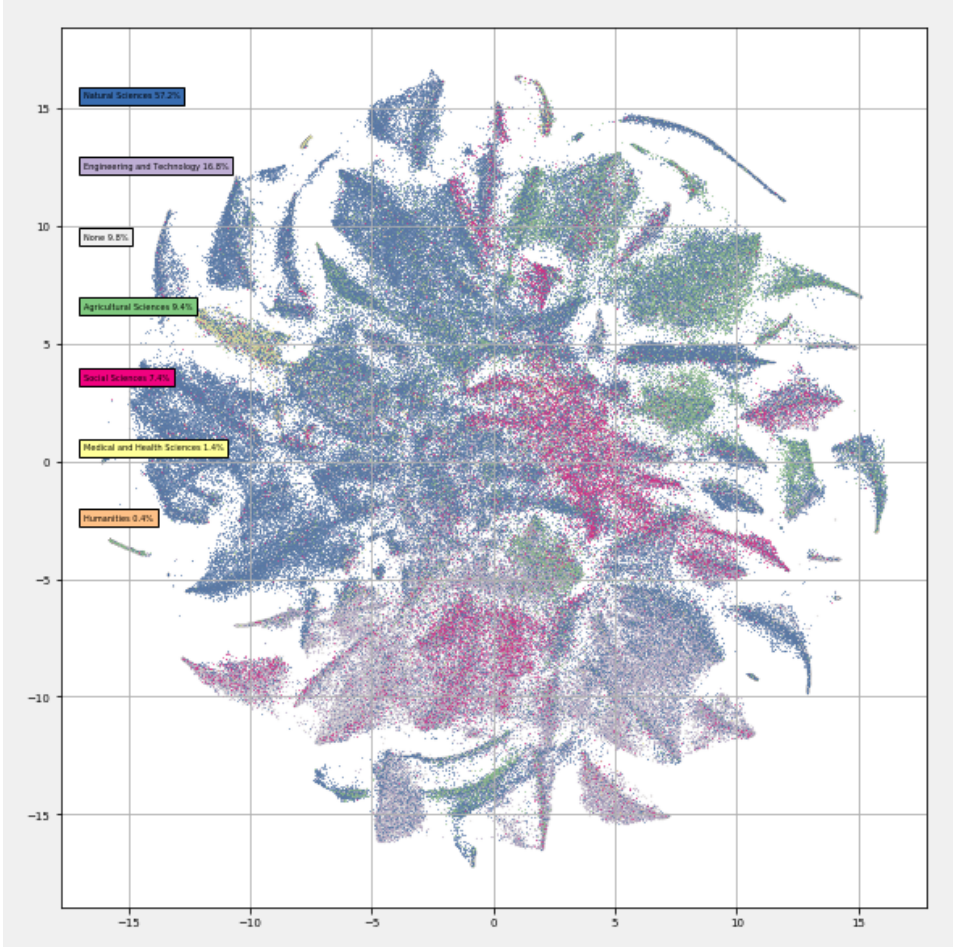
Grieneisen, M. and Zhang, M. (2011). The Current Status of Climate Change Research. *Nature Climate Change*, 1:72–73.

Kowarsch, M., Jabbour, J., Flachsland, C., Kok, M. T. J., Watson, R., Haas, P. M., Minx, J. C., Alcamo, J., Garard, J., Riousset, 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.

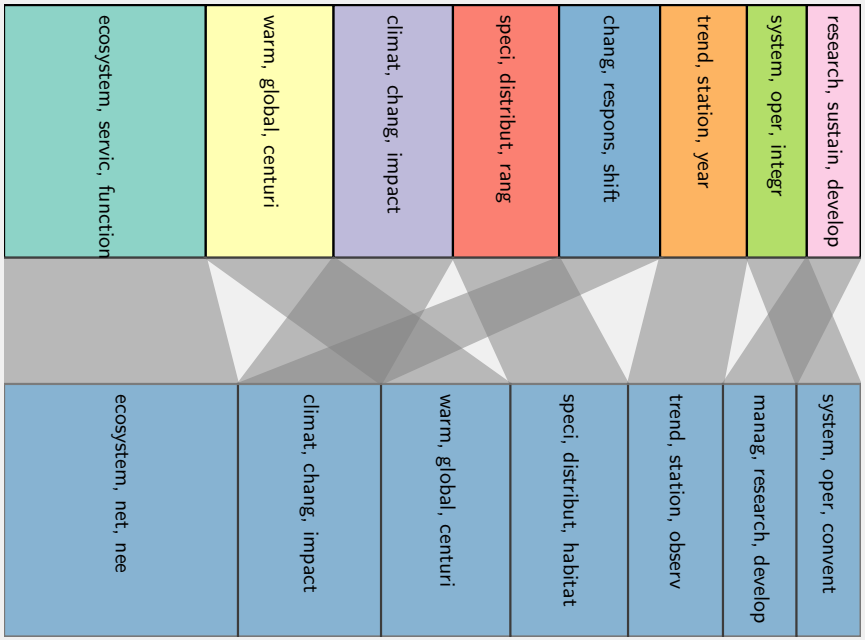
Minx, J. C., Callaghan, M., Lamb, W. F., Garard, J., and Edenhofer, O. (2017). Learning about climate change solutions in the IPCC and beyond. *Environmental Science & Policy*.

Thanks for your attention

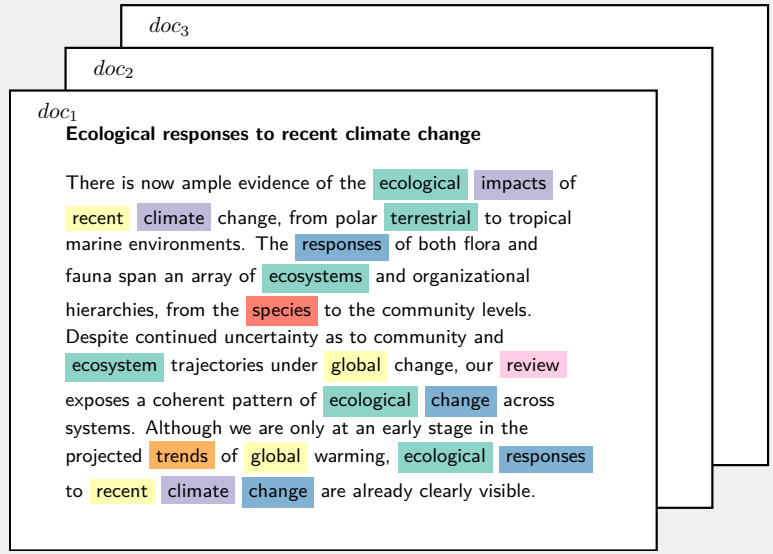


Doc Topic Example

Dynamic topics in doc_1



Window topics in doc_1



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

$\times$

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
doc_1	4	3	2	2
doc_2	...	...	...	...
doc_3	...	...	...	...
doc_4	...	...	...	...

Doc Term Matrix