A Topography of Climate Change Research

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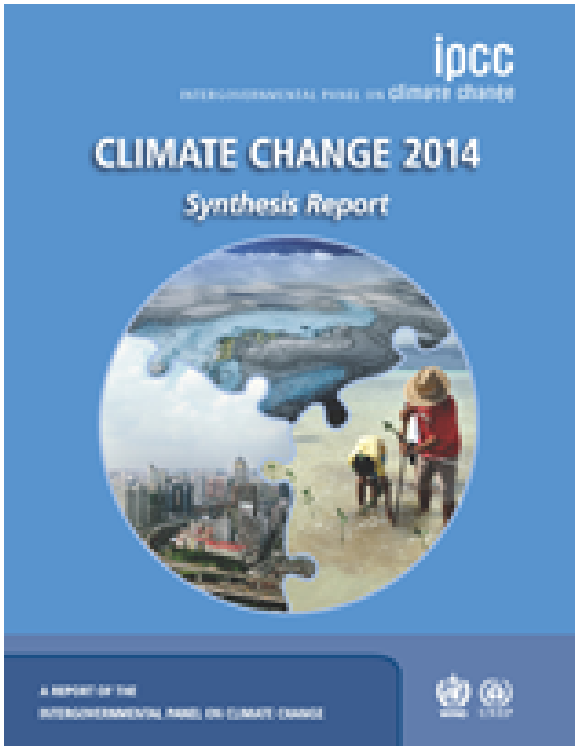
Context



- To contribute evidence-based policy-making on climate change, the IPCC aims to *comprehensively* assess
- These assessments should be aim to balance legitimacy, credibility and relevance (Cash and Clark, 2001)

Motivation

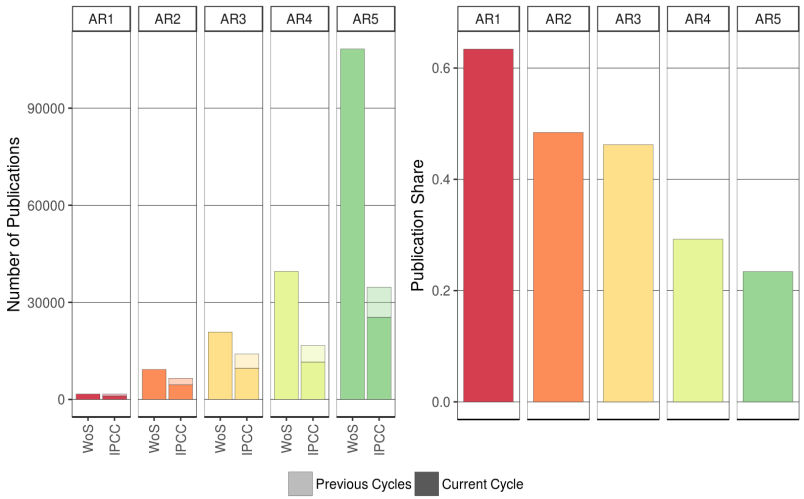
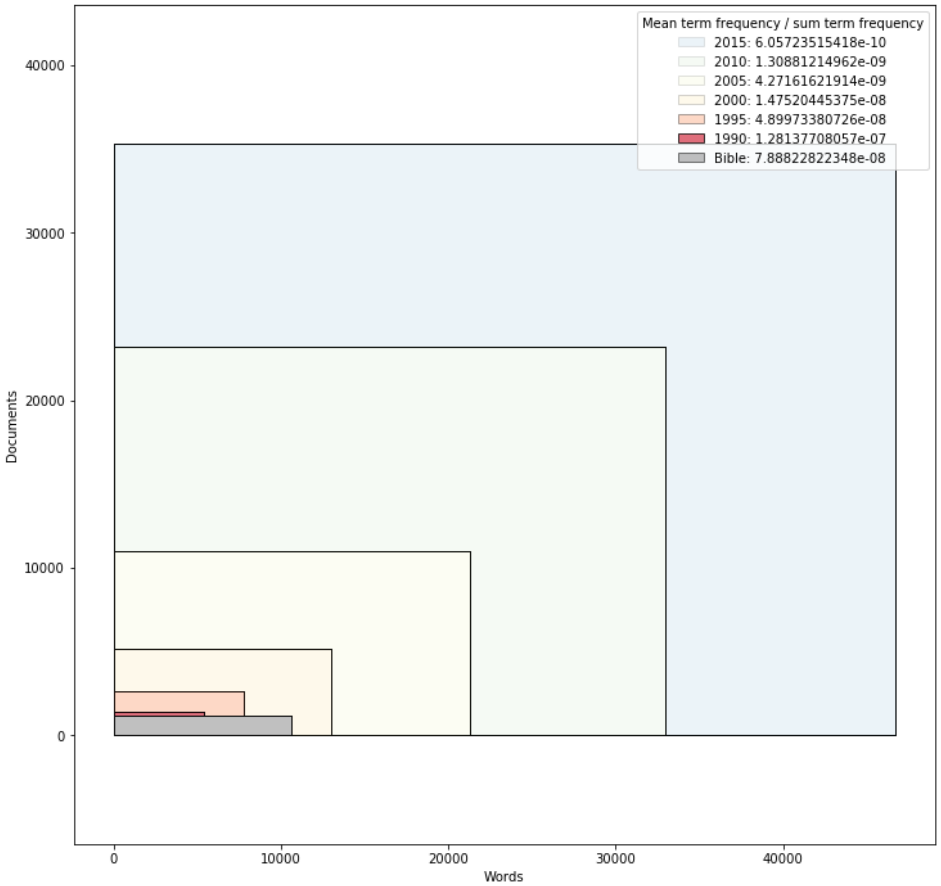


Figure: Source: Minx et al. (2017)

- Comprehensive, credible and relevant assessments become more challenging as the literature grows

To understand, and to aid, scientific assessments of climate change, we need to machine read the literature

Approach - Words, words, words



- Topic modelling is a way of reducing the dimensionality of a corpus of documents
- A large matrix of documents x words is factorised by a matrix of topics x words and a matrix of topics x documents (Lee and Seung, 1999)
- Topics describe the latent structure of the document corpus

Approach - Words, words, words

$$V_{i\mu}$$

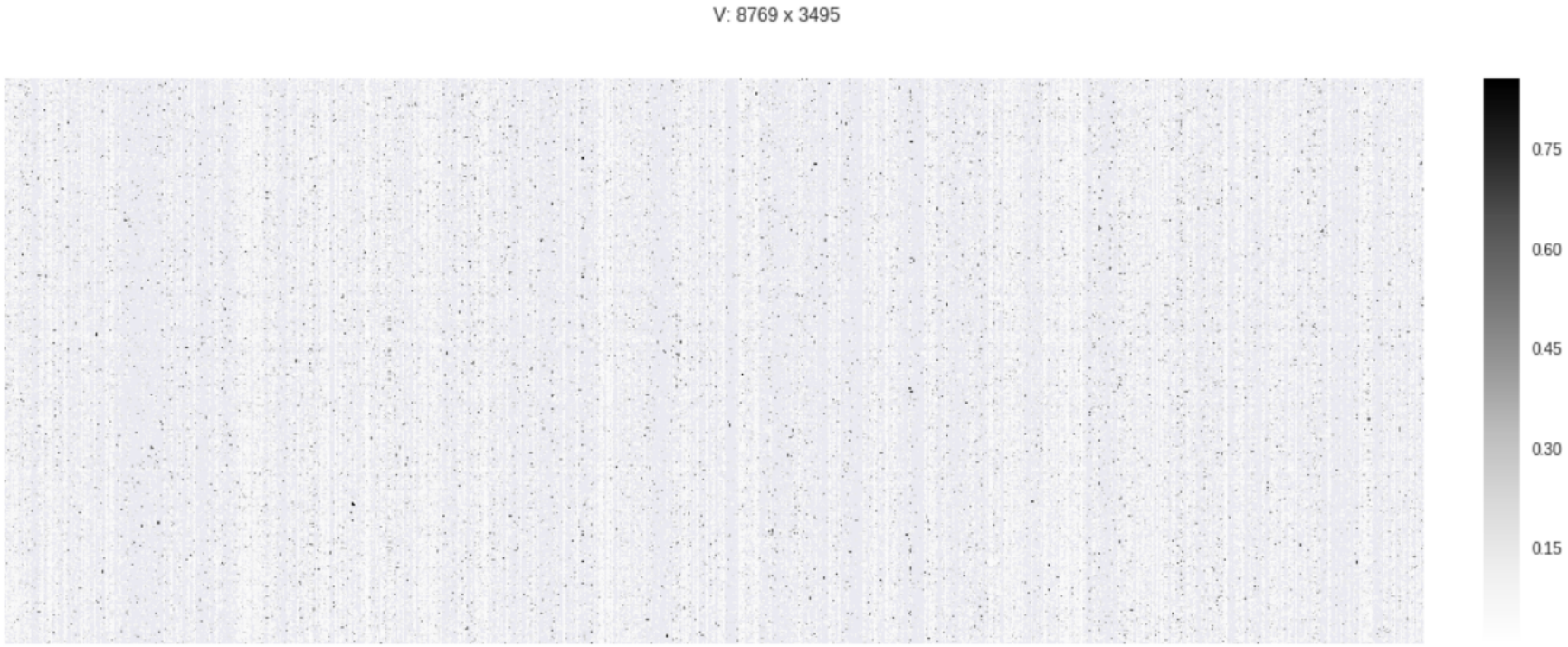


Figure: A topic model of 3495 documents on climate change from the year 2000

Approach - Words, words, words

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

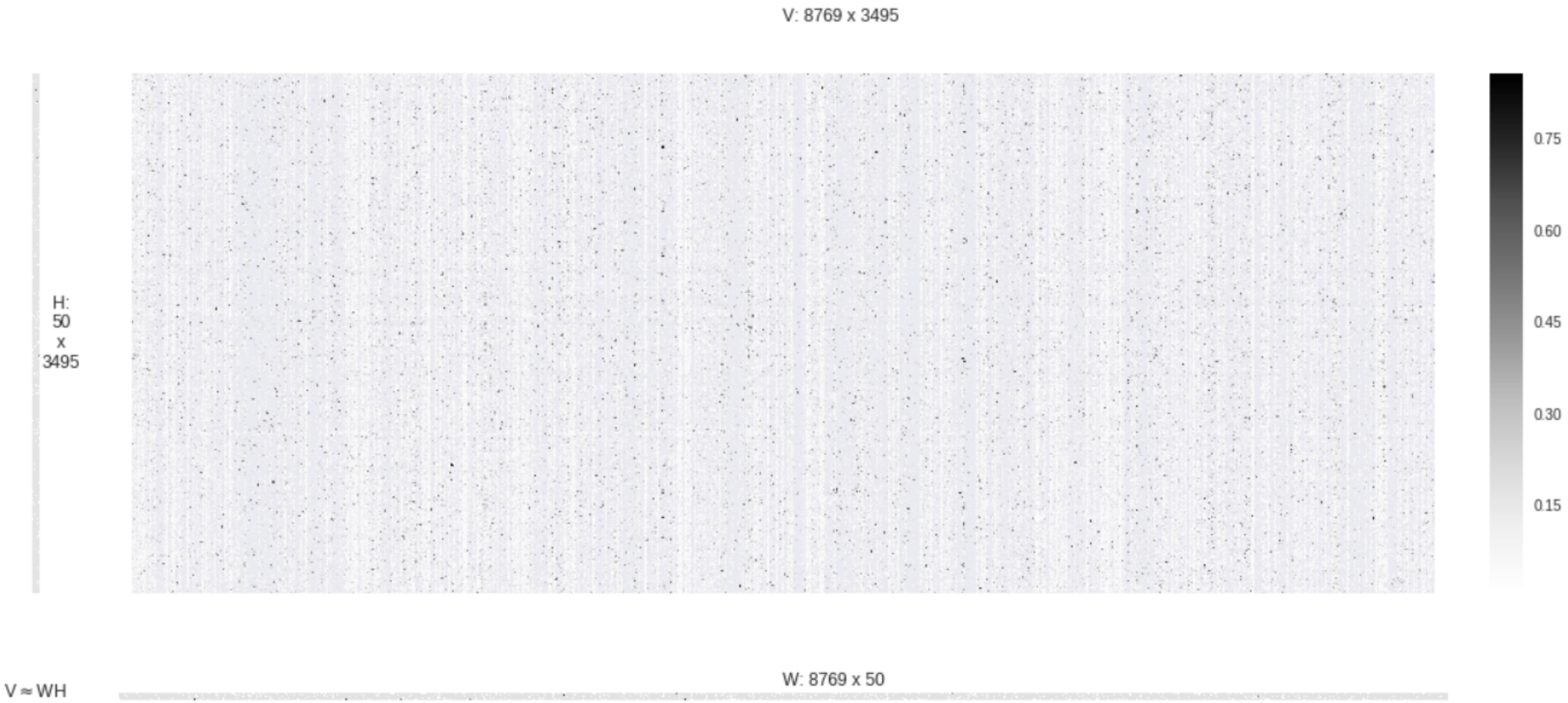
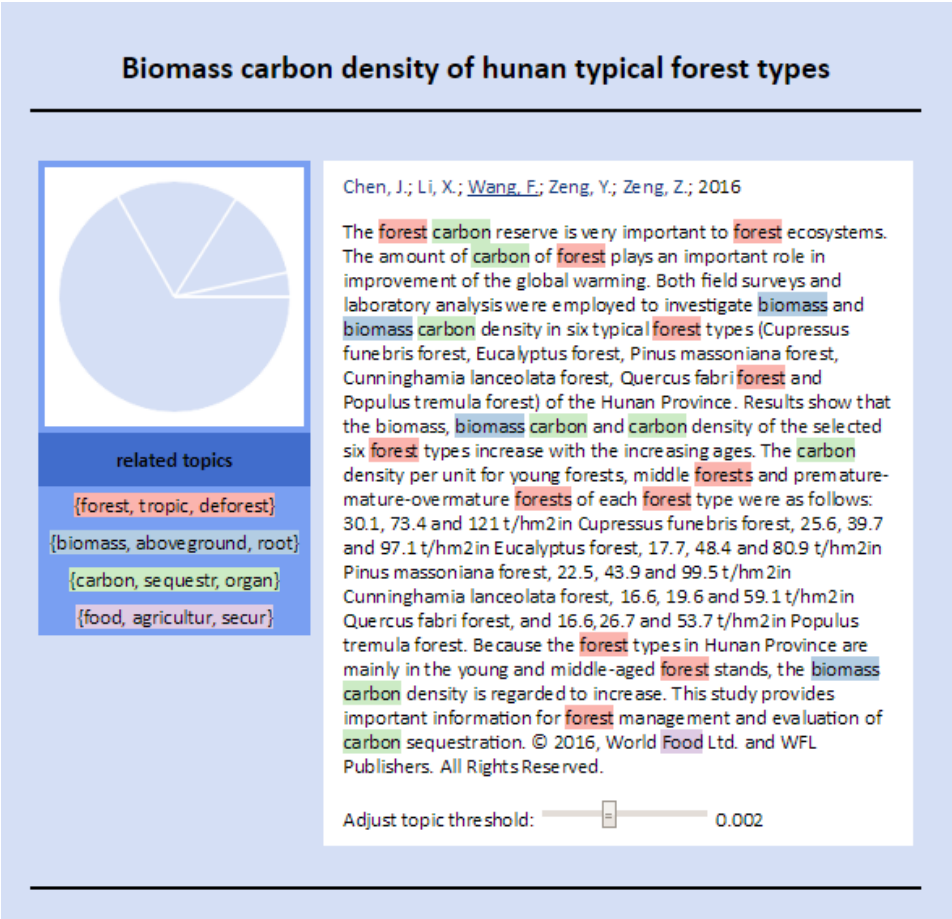


Figure: A topic model of 3495 documents on climate change from the year 2000

Research Questions

- What topics are discovered endogenously from a corpus of $>$ 200,000 abstracts on climate change?
- How do these topics describe the structure of the literature?
- Which topics have grown recently?
- Which topics are better and less well represented in IPCC assessment reports?

Preliminary results - explanation



- Documents are mixtures of topics, based on the words which occur in them

Preliminary results - Map

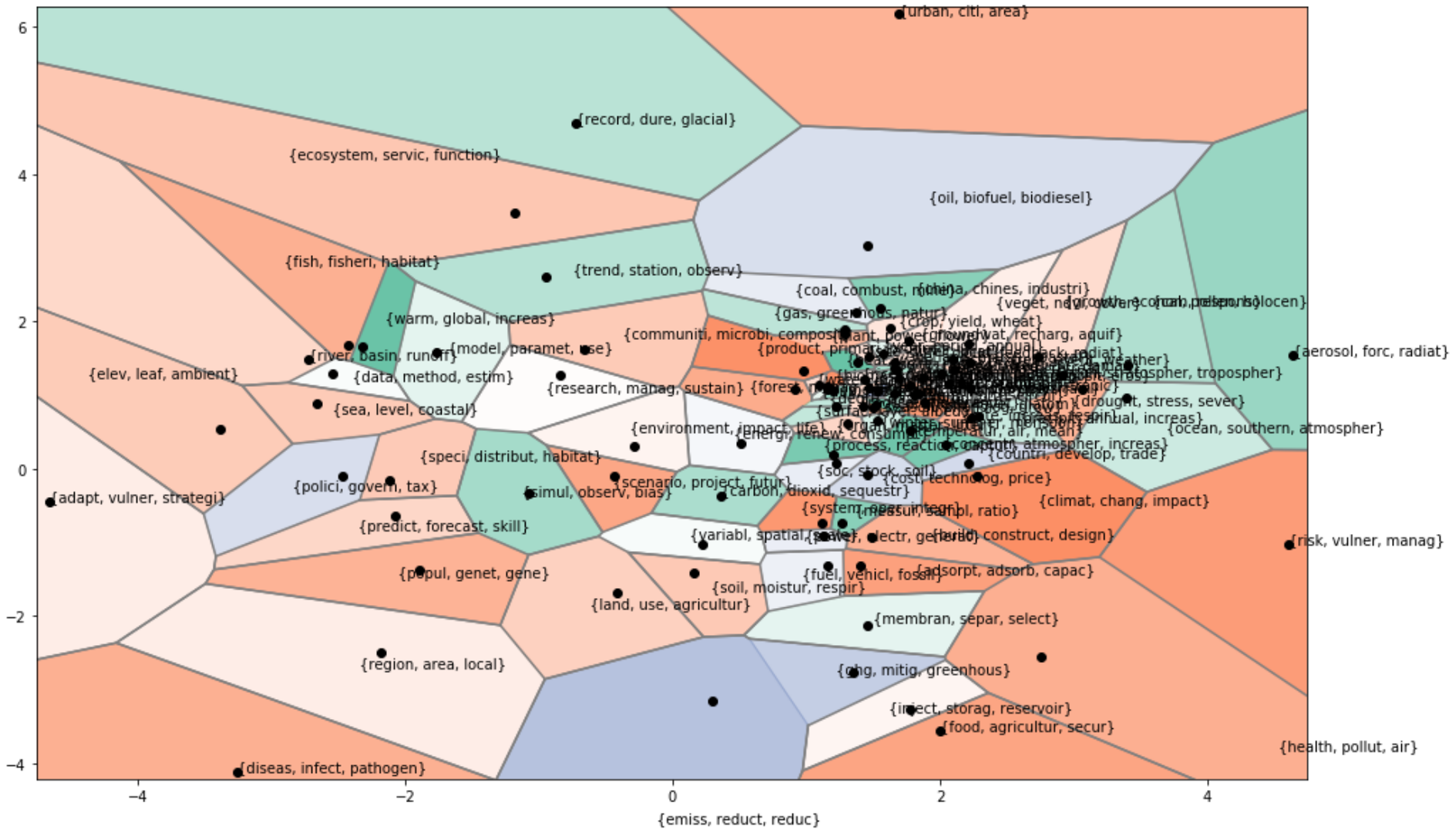
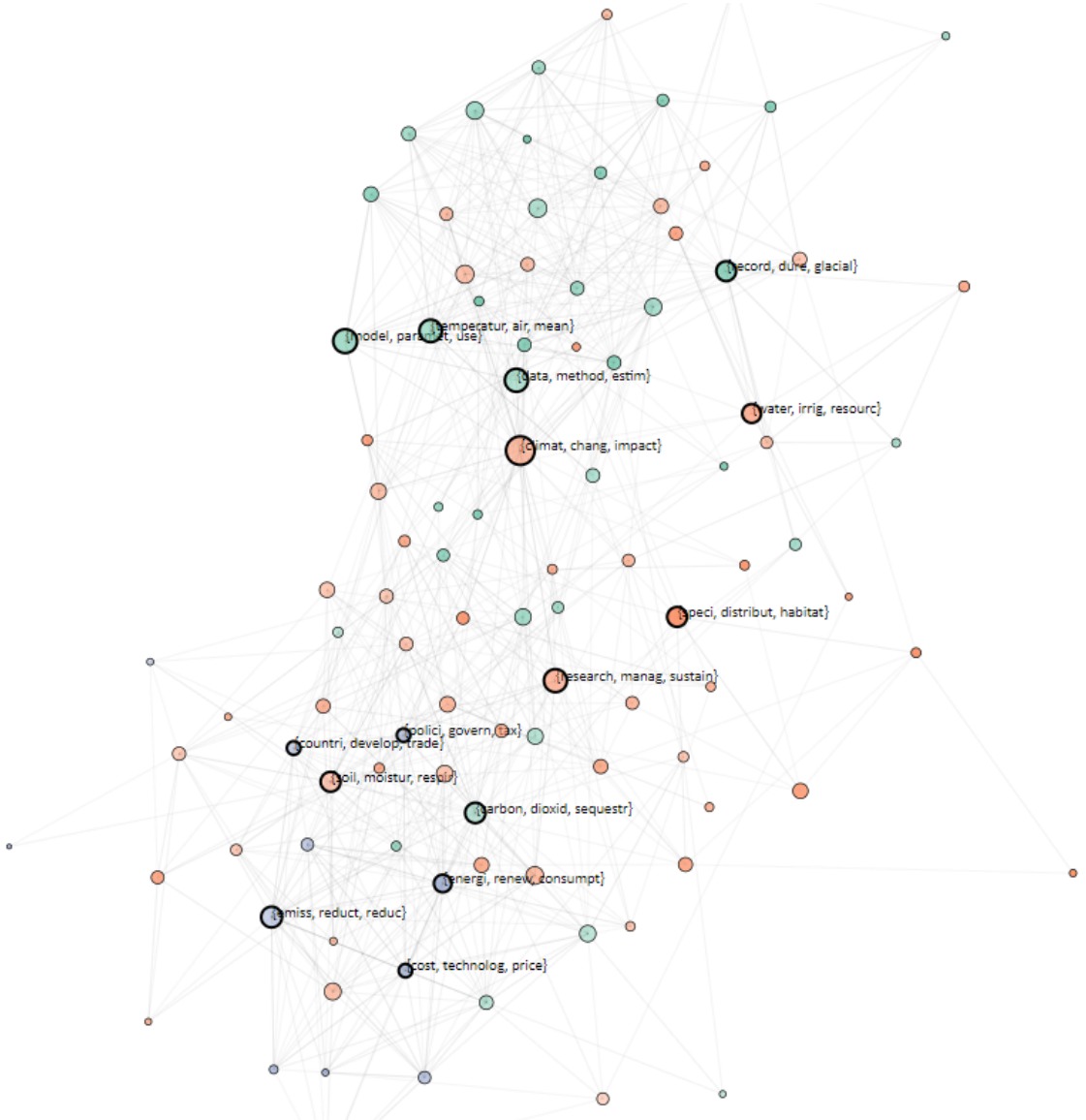
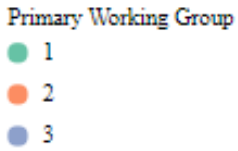


Figure: Topic Map, with topics placed according to Principal Component Analysis of topic-term matrix

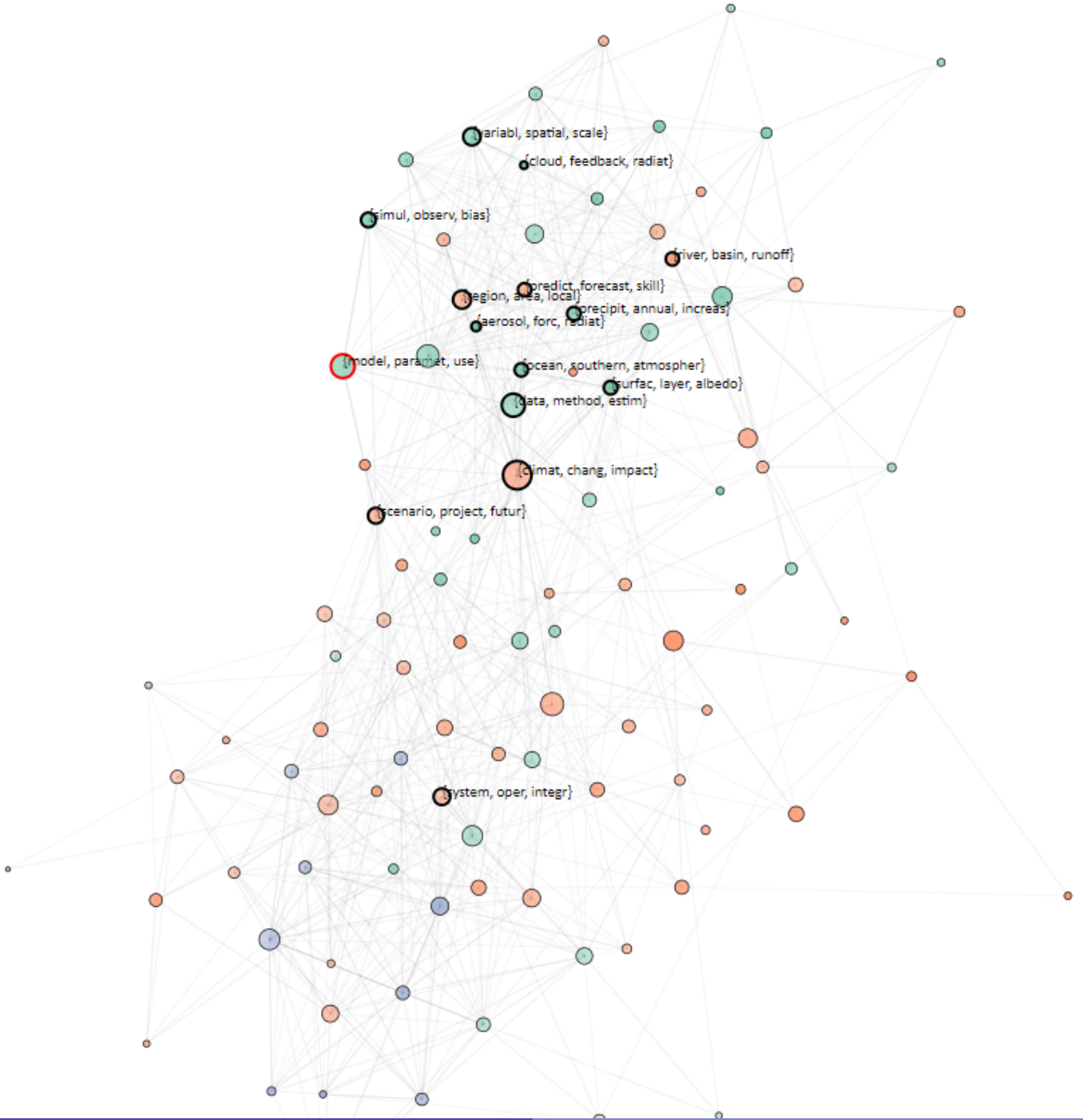
Preliminary results - structure





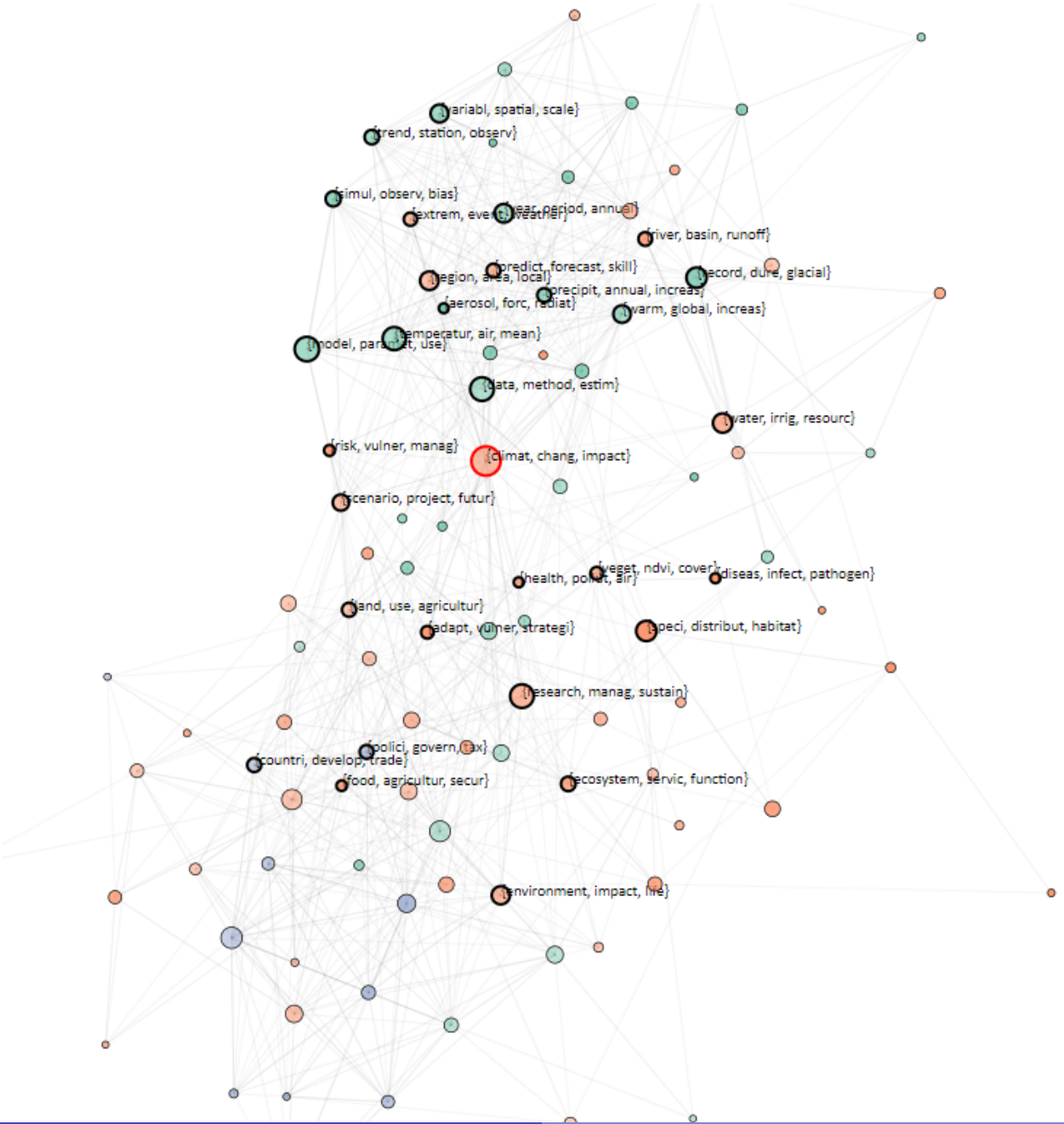
- A network of comprehensible topics is generated with 100 topics
- Topics can be matched to the IPCC working group from which the majority of the topic documents are referenced in
- Topics from the same working group are **significantly** more likely to be correlated with each other than those which are not

Preliminary results - structure - WGI



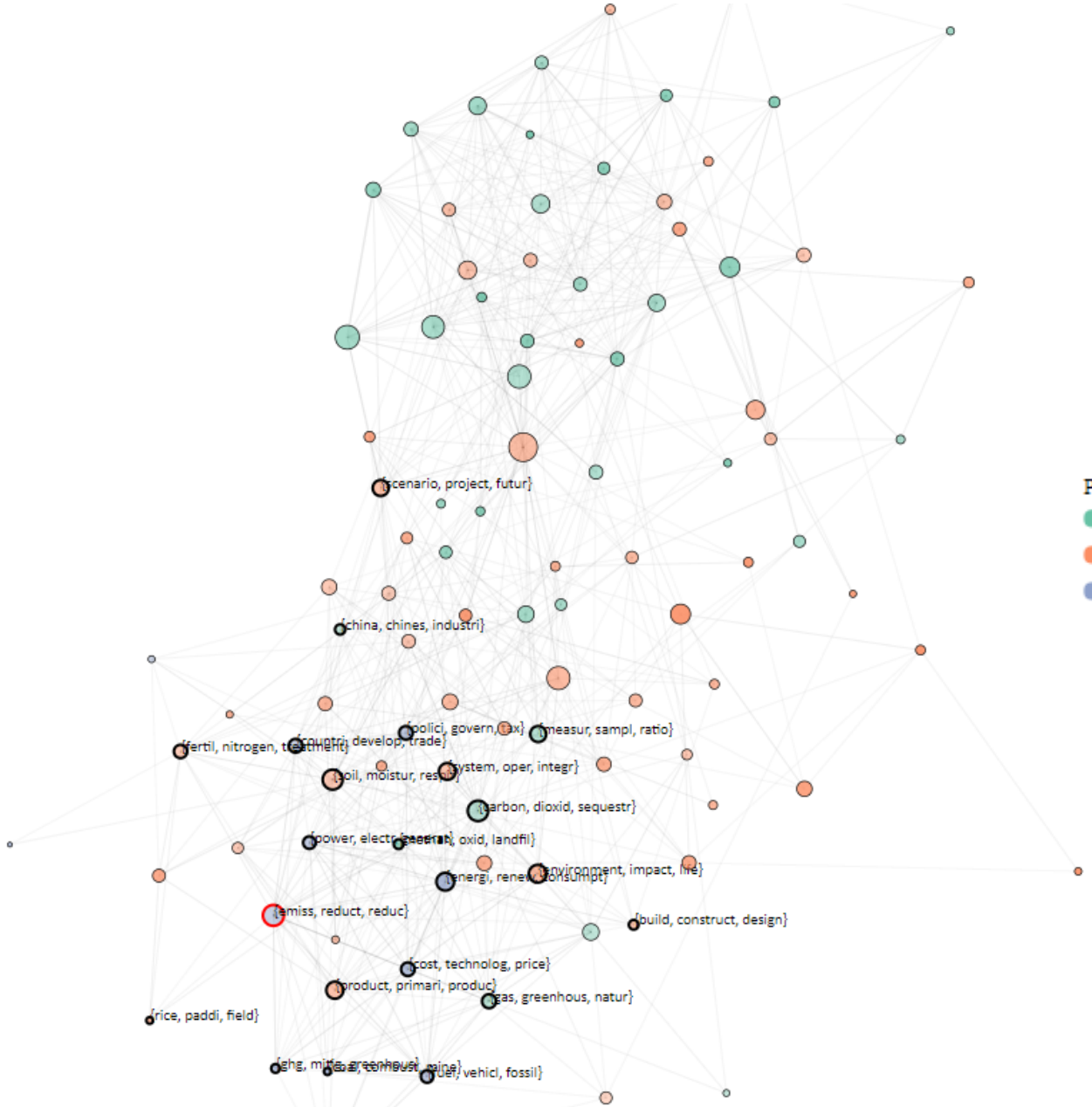
- The largest topic in WGI is on models.

Preliminary results - structure - WGII



- The largest primarily WGII topic is on climate change impacts

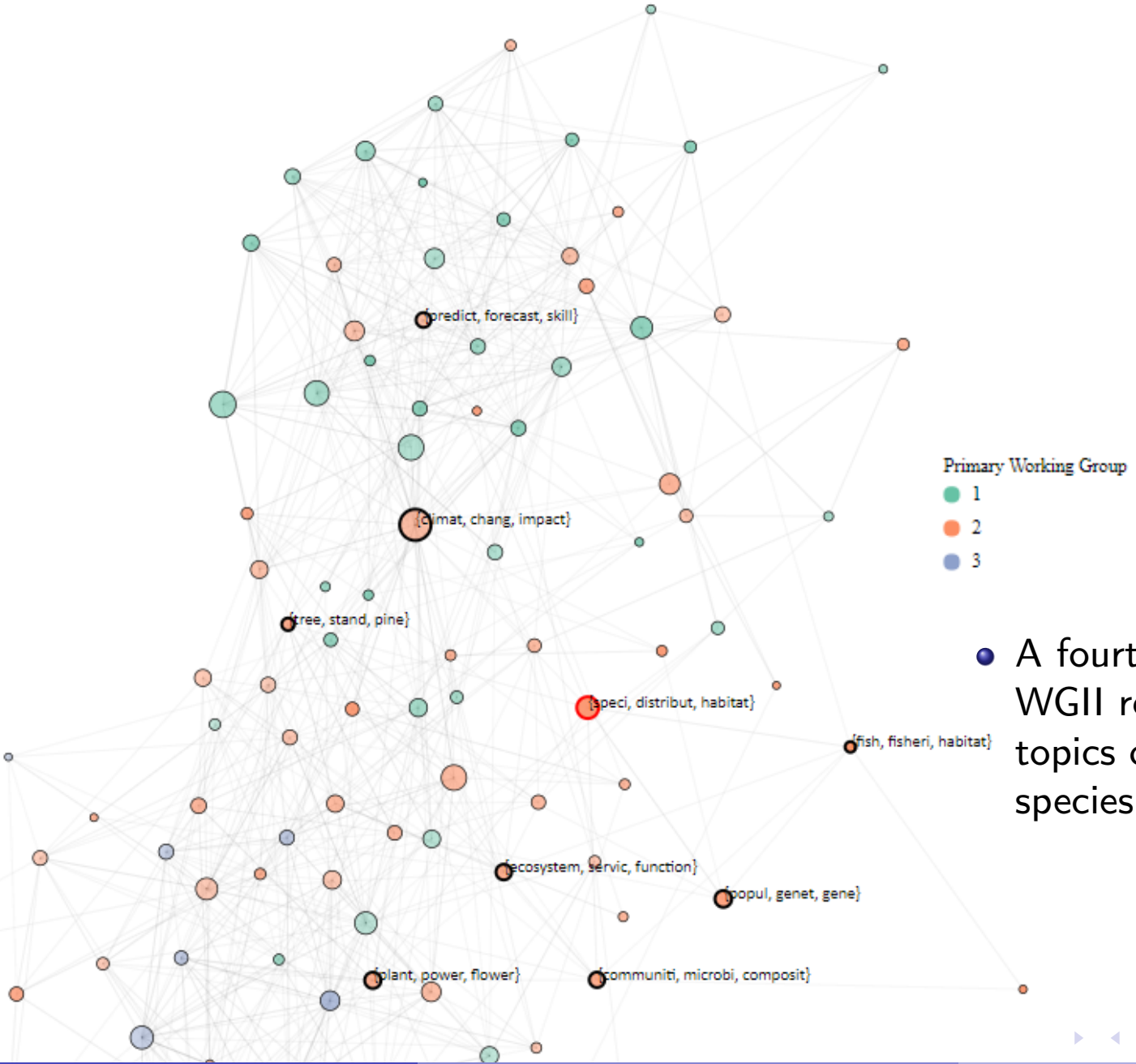
Preliminary results - structure - WGIII



Primary Working Group
- 1
- 2
- 3

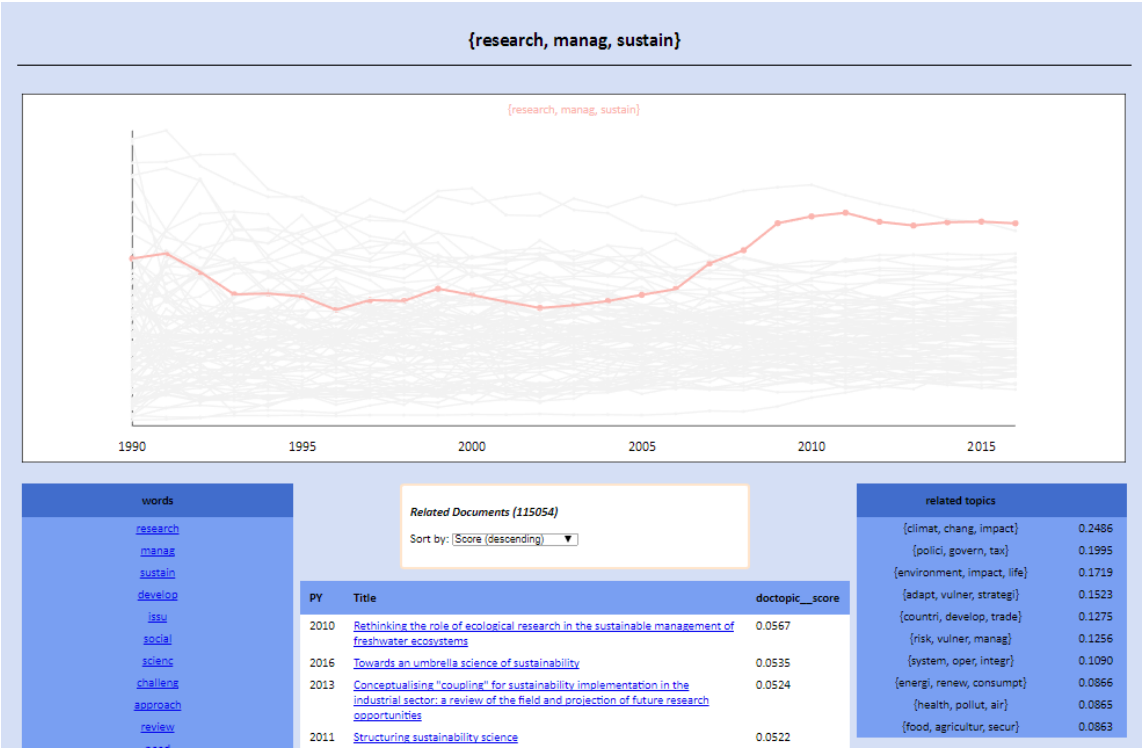
- The largest WGIII topic is on emissions reductions.

Preliminary results - structure - other clusters



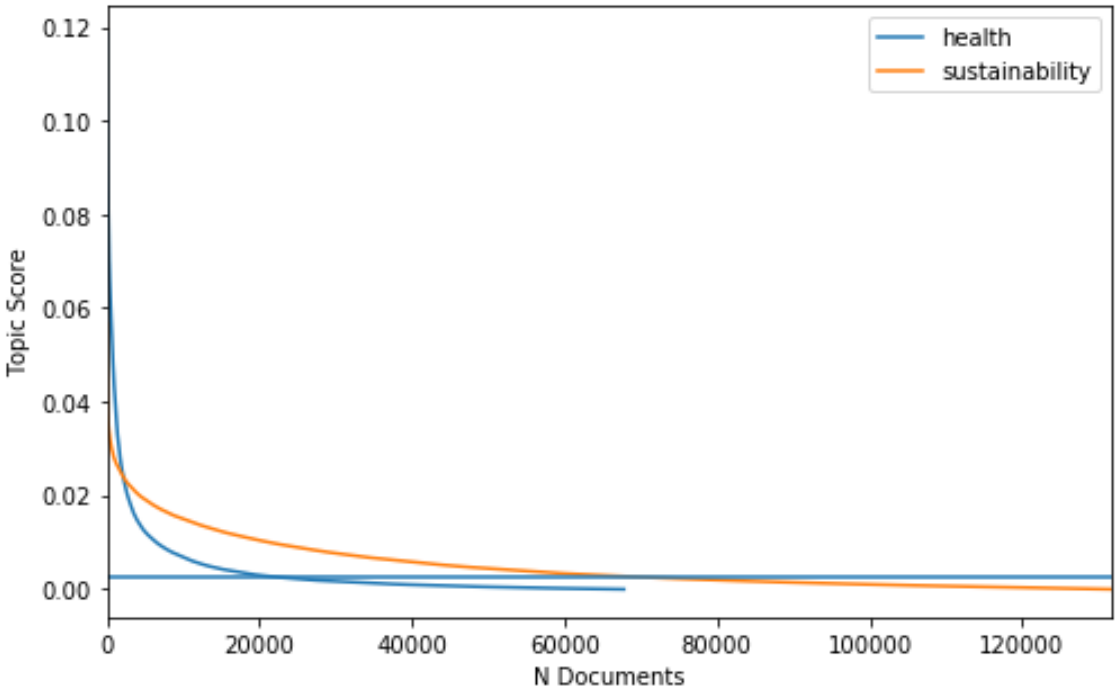
- A fourth cluster of mostly WGII references contains topics on ecosystems, species and habitats

Preliminary results - structure - Sustainability



- In later assessment periods, a large meta-topic on research priorities and sustainability emerges

Preliminary results - structure - Sustainability

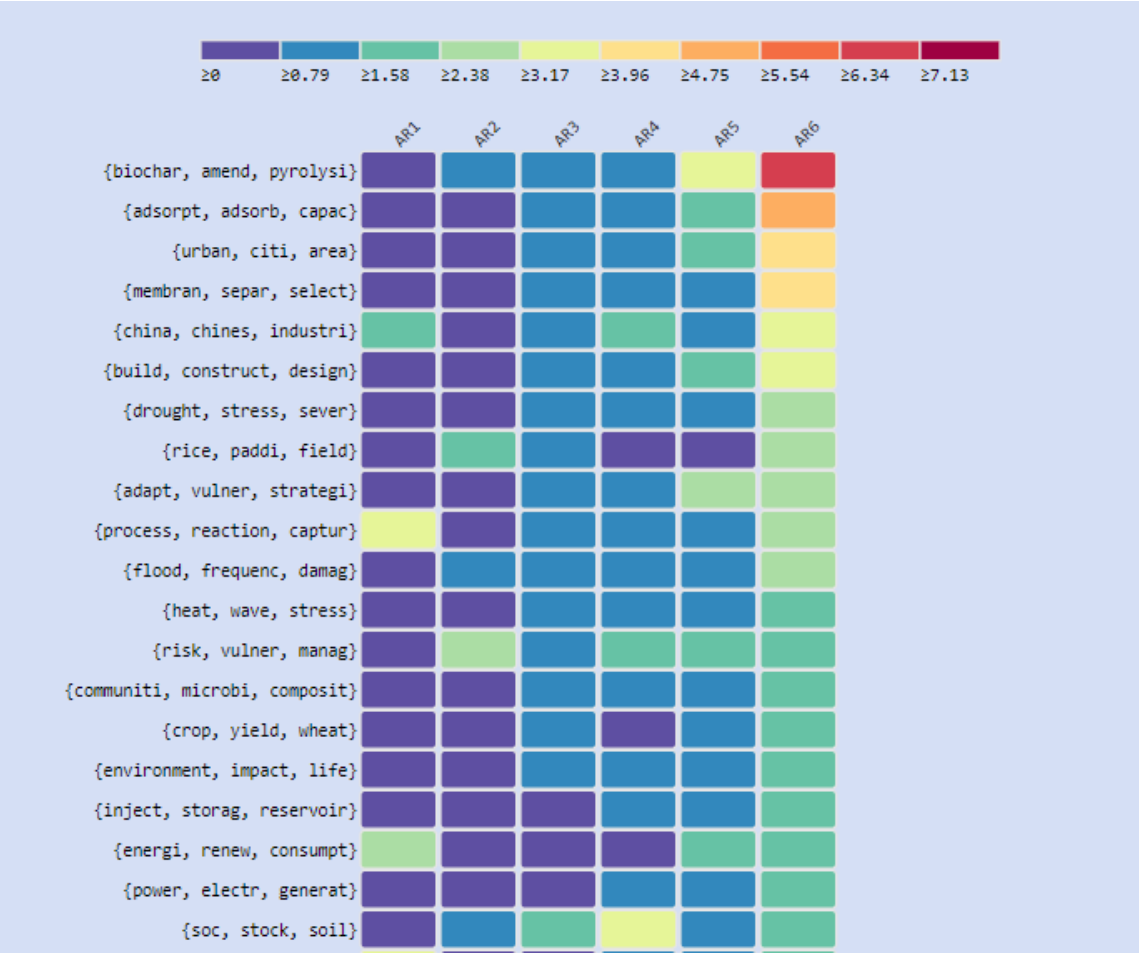


- The flatness of its distribution across documents indicates a topic that occurs

Preliminary results - structure - Sustainability

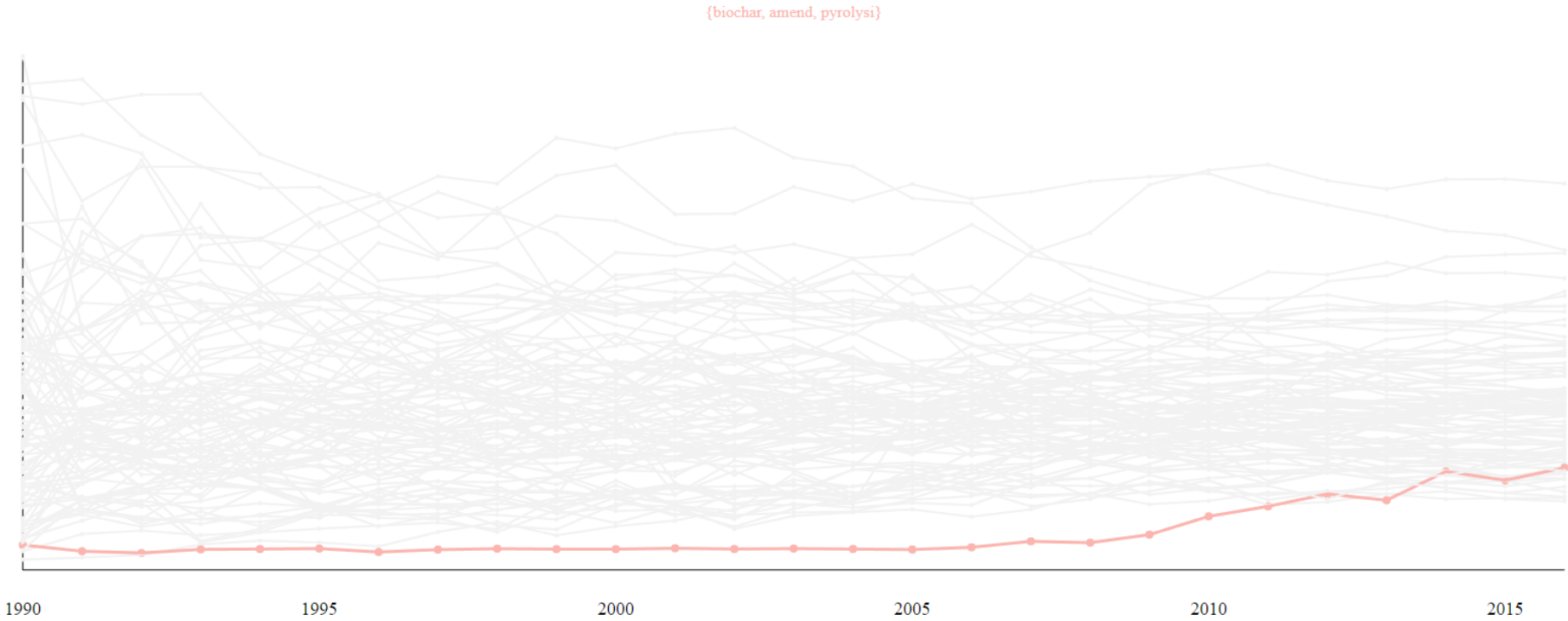
polici, govern, tax	adapt, vulner, strategi	urban, citi, area
How Research-Prioritization Exercises Affect Conservation Policy	Methodological choices in solution-oriented adaptation research: a diagnostic framework	A review of urban ecosystem services: six key challenges for future research
Role of hydrology and economics in water management policy under increasing uncertainty	When not every response to climate change is a good one: Identifying principles for sustainable adaptation	Lines of Tradition and Recent Approaches to Urban Ecology, Focussing on Germany and the USA
Informing food policy: balancing the evidence	Informed adaptation: Ethical considerations for adaptation researchers and decision-makers	Advancing understanding of the complex nature of urban systems
The identification of priority policy options for UK nature conservation	Future oriented conservation: knowledge governance, uncertainty and learning	Sustainable urban landscapes: South African perspectives on transdisciplinary possibilities
Environmental education policy research challenges and ways research might cope with them	Towards an integrated agenda for adaptation research: theory, practice and policy	A conceptual framework for addressing complexity and unfolding transition dynamics when developing sustainable adaptation strategies in urban water management

Preliminary results - growth



- Negative emissions related topics have shown strong growth since the end of AR5
- As have topics on cities and extreme weather events

Preliminary results - growth - biochar



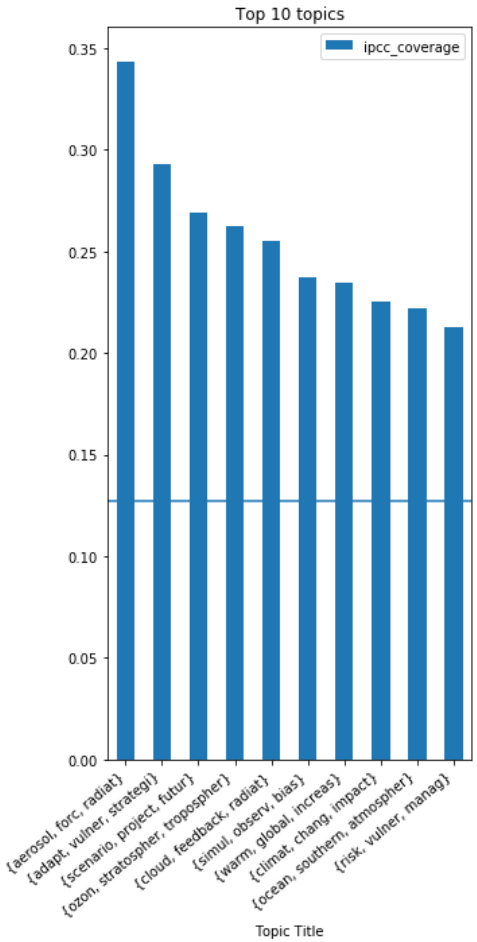
- Biochar has emerged as an entirely new topic in the last 10 years

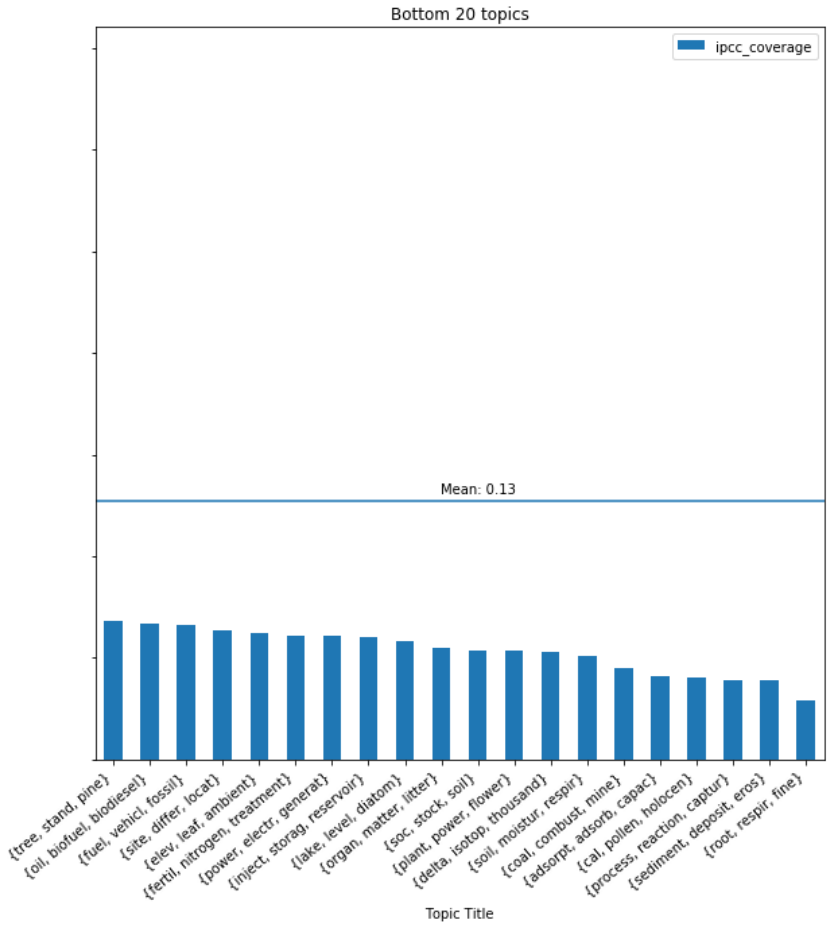
Preliminary results - gaps in coverage

How can we get a sense of which topics are better covered in IPCC reports?

- Each document d either matches or does not match an IPCC reference
- For each topic h, we can sum the scores for each category of document
- The "IPCC proportion" of each topic is the proportion of the sum of the document score accounted for by documents which match IPCC references.

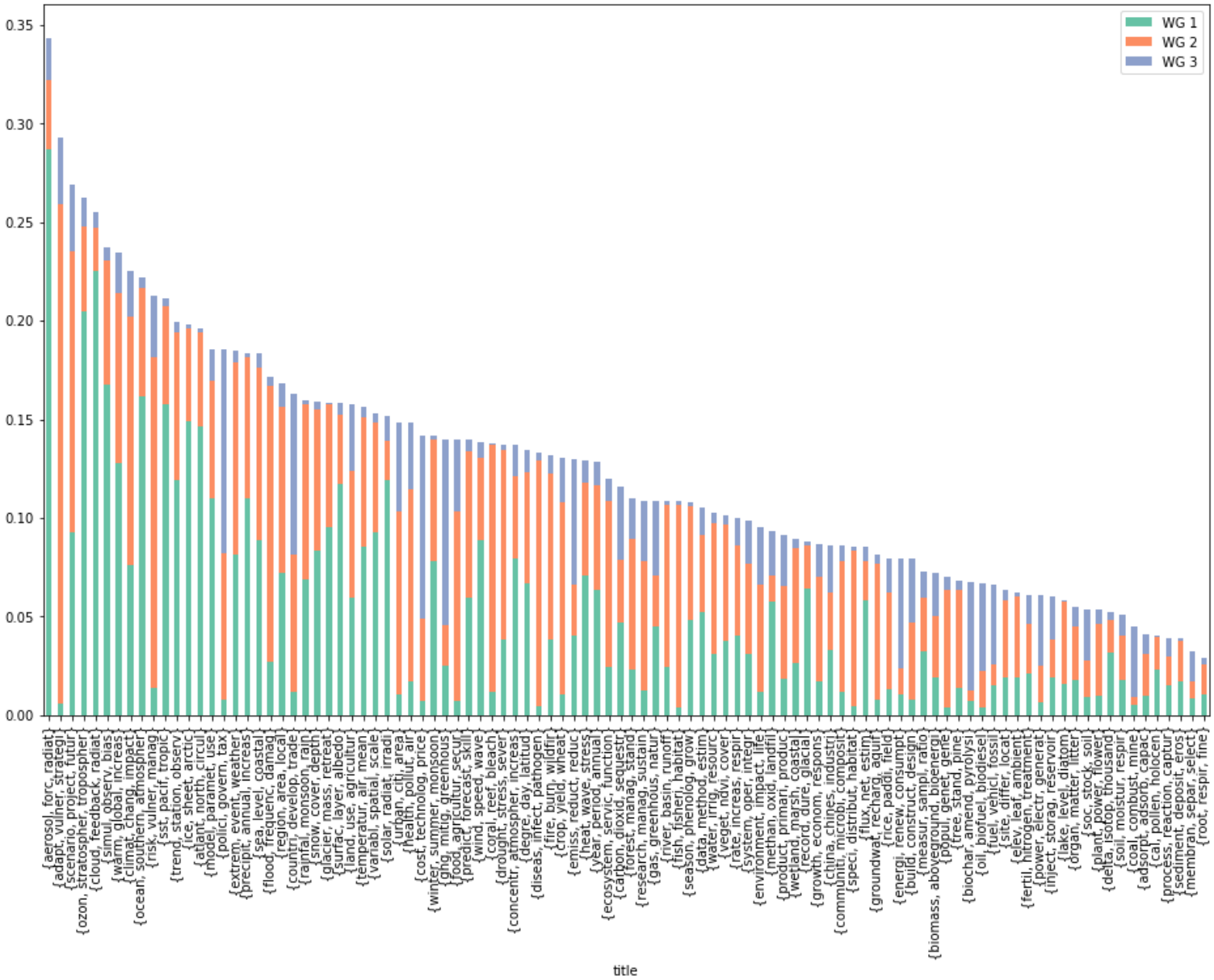
Preliminary results - gaps in coverage





- The physical science aspects of climate change, as well topics on impacts, adaptation and scenarios are well covered by the IPCC
- Topics on specific technological solutions (particularly NETs), as well as soils, are less well covered

Preliminary results - gaps in coverage



Preliminary results - Inter-working Group topics - WG 1 and 3

IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.14%	1	{winter, summer, monsoon}	0.55%	0.44%	0.01%
0.16%	2	{rainfal, monsoon, rain}	0.43%	0.56%	0.01%
0.11%	2	{season, phenolog, grow}	0.45%	0.53%	0.02%
0.16%	1	{glacier, mass, retreat}	0.60%	0.39%	0.00%
0.04%	1	{cal, pollen, holocen}	0.57%	0.42%	0.02%

Preliminary results - Inter-working Group topics - WG 1 and 3

IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.13%	3	{emiss, reduct, reduc}	0.31%	0.20%	0.49%
0.09%	1	{methan, oxid, landfil}	0.61%	0.14%	0.24%
0.11%	1	{gas, greenhous, natur}	0.41%	0.24%	0.35%
0.07%	3	{fuel, vehicl, fossil}	0.23%	0.16%	0.61%
0.12%	1	{carbon, dioxid, sequestr}	0.40%	0.28%	0.32%

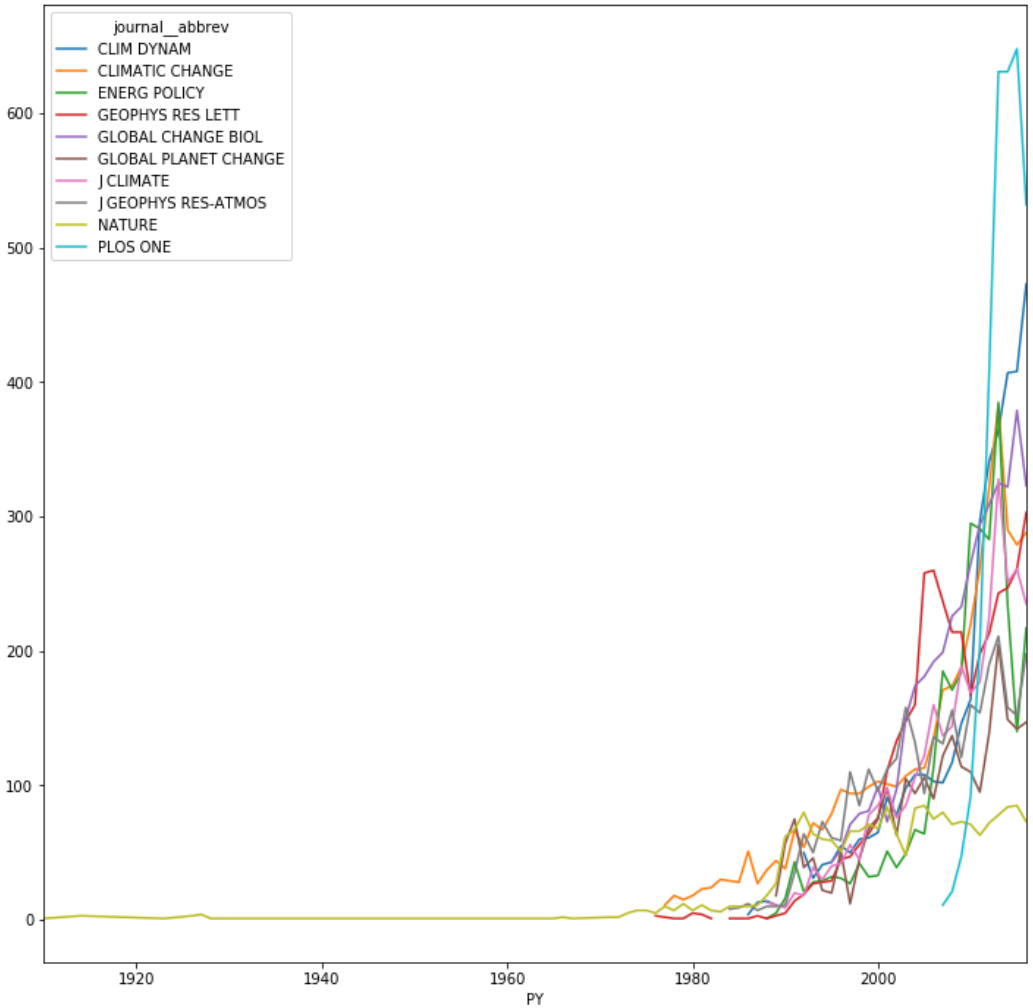
Preliminary results - Inter-working Group topics - WG 2 and 3

IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.19%	3	{polici, govern, tax}	0.04%	0.40%	0.56%
0.16%	3	{countri, develop, trade}	0.07%	0.43%	0.50%
0.08%	2	{build, construct, design}	0.10%	0.49%	0.41%
0.14%	3	{cost, technolog, price}	0.05%	0.30%	0.65%
0.15%	2	{urban, citi, area}	0.07%	0.62%	0.30%

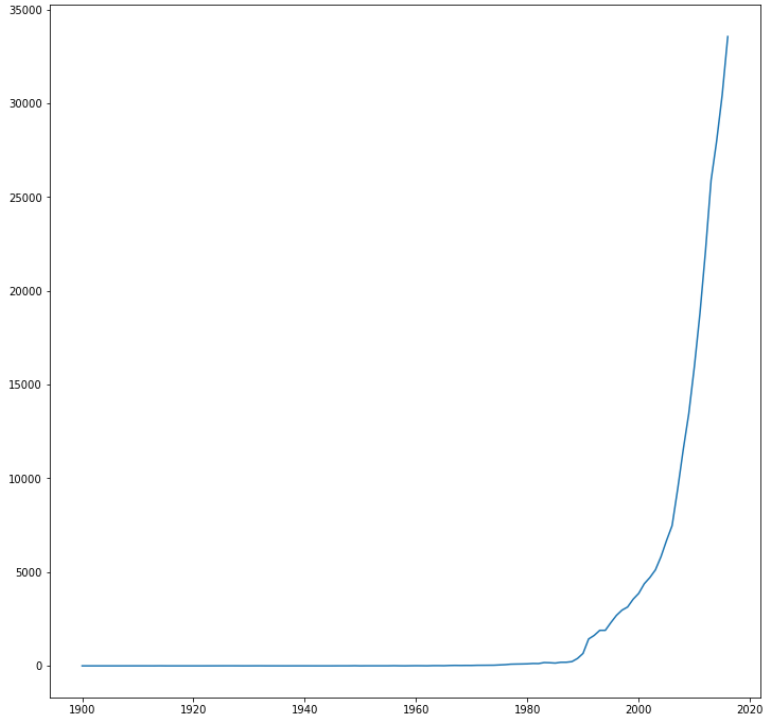
Conclusions

- Endogenously discovered topics make substantive sense of an unmanageable dataset of climate-relevant literature
- Topic modelling discovers over-arching topics such as that on sustainability and research priorities, as well as individual, fast growing topics such as biochar or CCS
- Matching documents to IPCC references, we can describe topics that belong to or bridge IPCC working groups
- Quantitative evidence is found to support policy makers' dissatisfaction with a lack of 'solution orientation' in IPCC reports (Kowarsch et al., 2017)

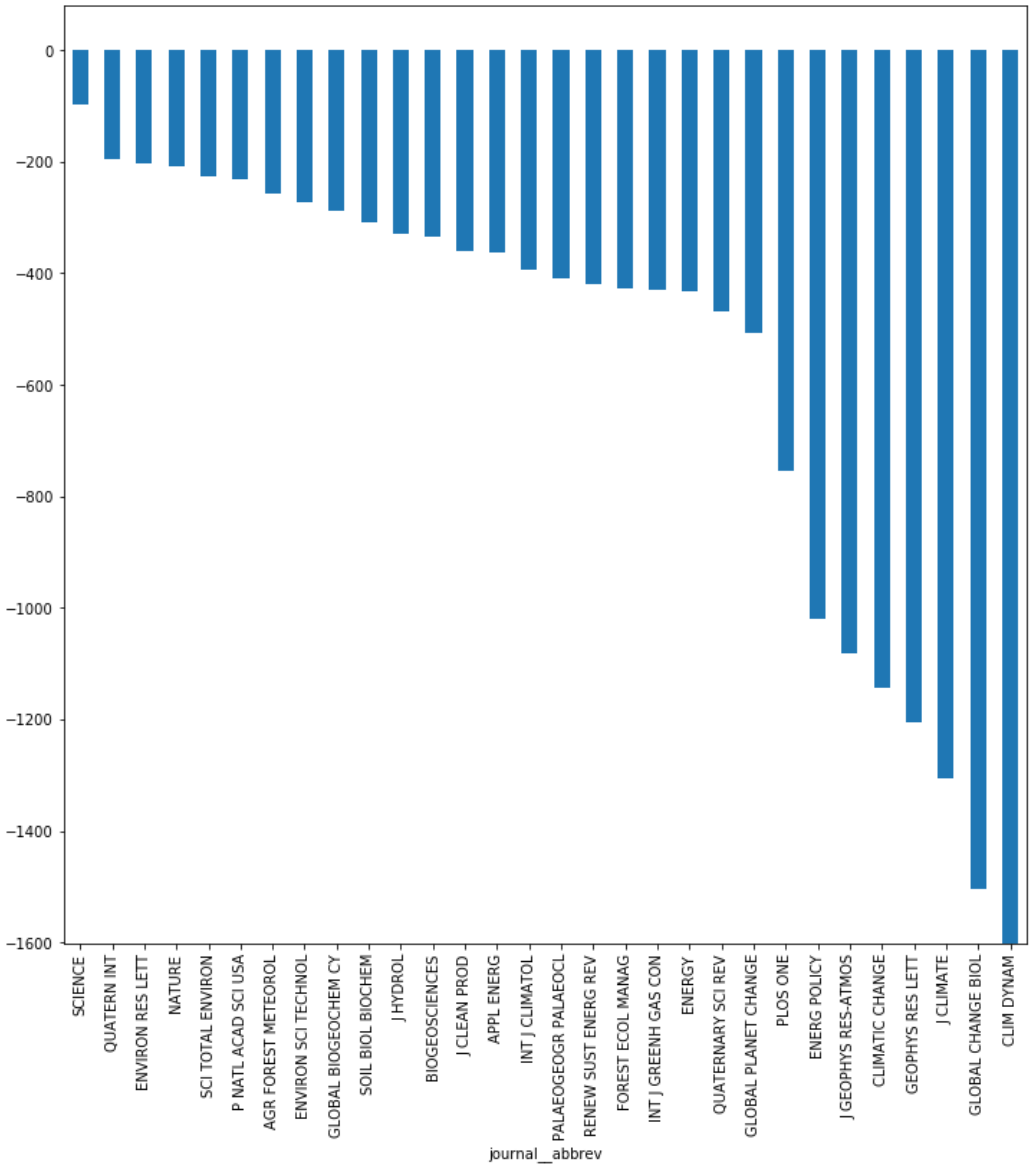
Extra results - Journals



- Nature has been publishing about climate change for a long time
- Plos One has very recently overtaken all other journals
- The number of journals has risen very steeply



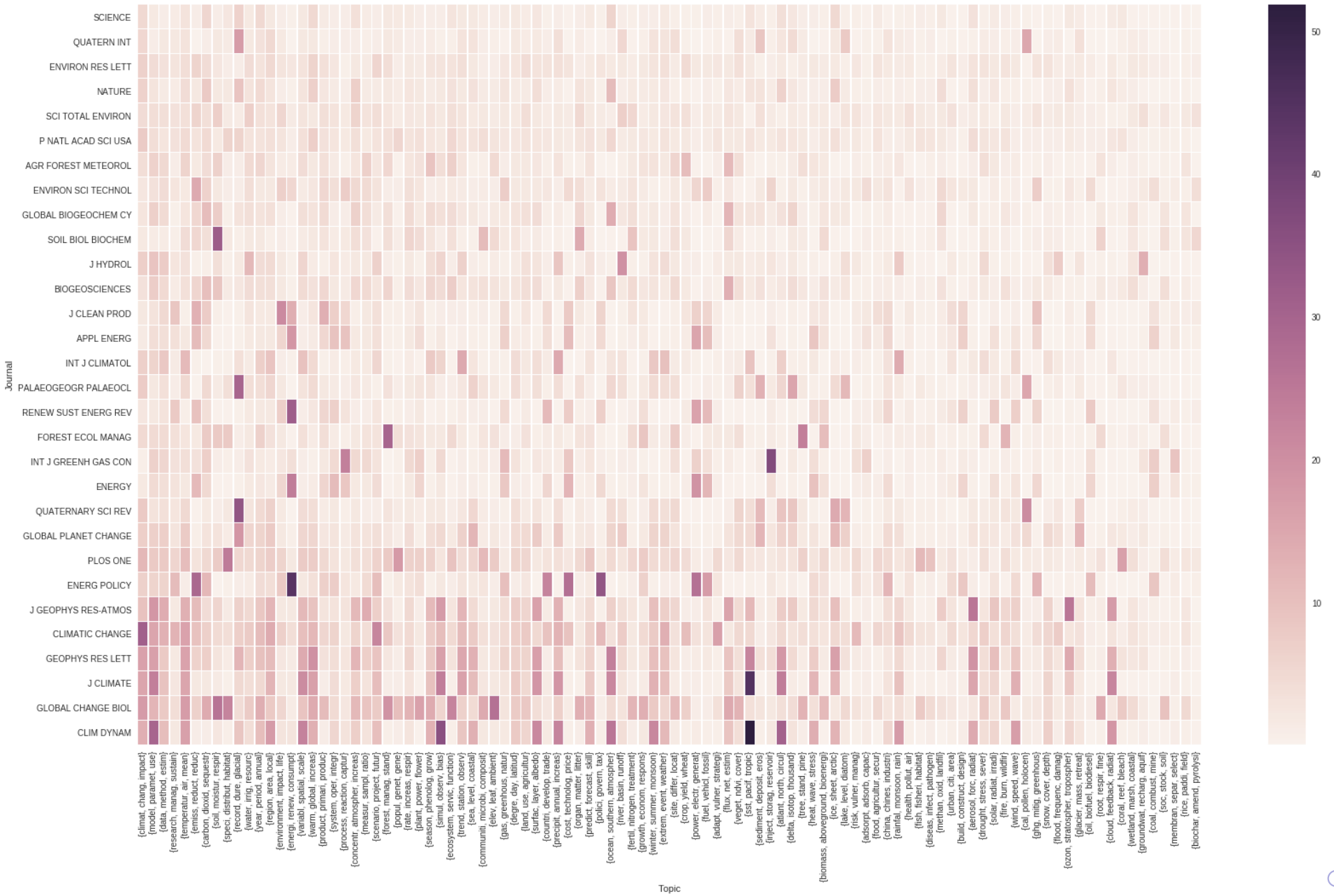
Extra results - Journals



- Journal Entropy describes the distribution of topics in a journal (Hall et al., 2008)
- High values mean the journal deals with a wider range of topics

$$H(z|c,y) = -\sum_{i=1}^{K} \hat{p}(z_i|c,y)\ log\ \hat{p}(z_i|c,y)$$

Extra results - Journals



Cash, D. W. and Clark, W. C. (2001). From science to policy : assessing the assessment process. *Social Science Research Network*, (November):1–45.

Hall, D., Jurafsky, D., and Manning, C. D. (2008). Studying the history of ideas using topic models. *EMNLP '08 Proceedings of the Conference on Empirical Methods in Natural Language Processing*, (October):363–371.

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*.