A Topography of Climate Change Research

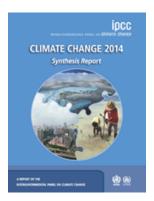
Max Callaghan



November 29, 2017

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



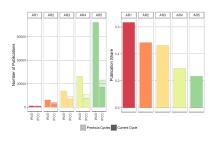


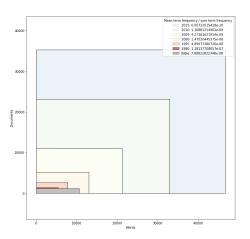
Figure: Source: Minx et al. (2017)

 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



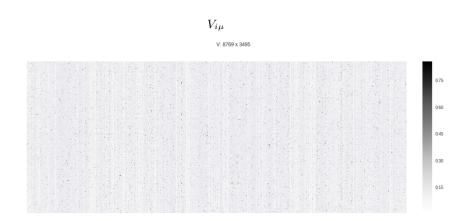


Figure: A topic model of 3495 documents on climate change from the year 2000



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

V: 8769 x 3495

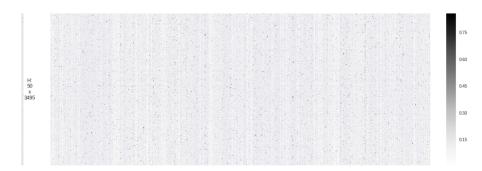


Figure: A topic model of 3495 documents on climate change from the year 2000

W: 8769 x 50

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



Biomass carbon density of hunan typical forest types

Adjust topic threshold:



(forest, tropic, deforest)

(biomass, above ground, root)

(carbon, sequestr, organ)

(food, agricultur, secur)

Chen, J.; Li, X.; Wang, F.; Zeng, Y.; Zeng, Z.; 2016

The forest carbon reserve is very important to forest ecosystems. The amount of carbon of forest plays an important role in improvement of the global warming. Both field surveys and laboratory analysis were employed to investigate biomass and biomass carbon density in six typical forest types (Cupressus fune bris forest. Eucalyptus forest. Pinus massoniana forest. Cunninghamia lanceolata forest. Quercus fabri forest and Populus tremula forest) of the Hunan Province, Results show that the biomass, biomass carbon and carbon density of the selected six forest types increase with the increasing ages. The carbon density per unit for young forests, middle forests and prematuremature-overmature forests of each forest type were as follows: 30.1, 73.4 and 12.1 t/hm2 in Cupressus fune bris forest, 25.6, 39.7 and 97.1 t/hm2in Eucalyptus forest, 17.7, 48.4 and 80.9 t/hm2in Pinus massoniana forest, 22.5, 43.9 and 99.5 t/hm2in Cunninghamia lanceolata forest, 16.6, 19.6 and 59.1 t/hm2in Quercus fabri forest, and 16.6, 26.7 and 53.7 t/hm2 in Populus tremula forest. Because the forest types in Hunan Province are mainly in the young and middle-aged forest stands, the blomass carbon density is regarded to increase. This study provides important information for forest management and evaluation of carbon sequestration. © 2016. World Food Ltd. and WFL Publishers, All Rights Reserved.

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

- 4 ロ ト 4 回 ト 4 直 ト 4 直 ・ 夕 Q (*)

Preliminary results - Map



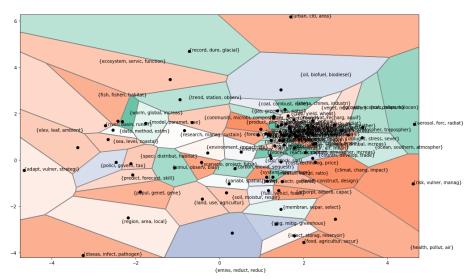


Figure: Topic Map, with topics placed according to Principal Component Analysis of topic-term matrix

Preliminary results - structure





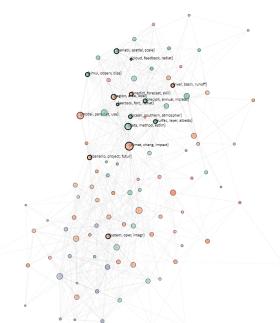
Primary Working Group

1

- 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





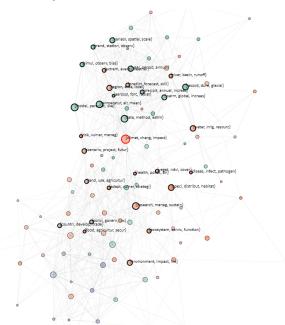
Primary Working Group

1
2

The largest topic in WGI is on models.

Preliminary results - structure - WGII





Primary Working Group

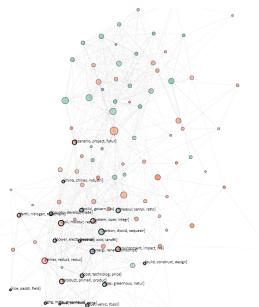
1

2

The largest primarily WGII topic is on climate change impacts

Preliminary results - structure - WGIII



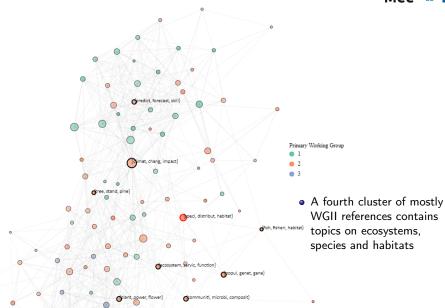


• The largest WGIII topic is on emissions reductions.

Primary Working Group

Preliminary results - structure - other clusters





Preliminary results - structure - Sustainability

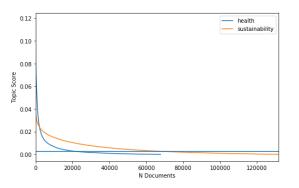




 In later assessment periods, a large meta-topic on research priorities and sustainability emerges

Preliminary results - structure - Sustainability





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

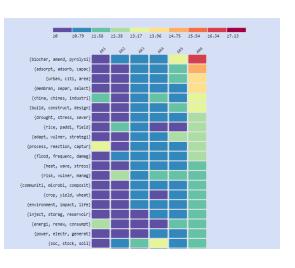
Preliminary results - structure - Sustainability



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 cli- mate change is a good one: Identifying principles for sustain- able 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, uncer- tainty and learning	Sustainable urban landscapes: South African perspectives on transdisciplinary possibilities		
Environmental education policy research challenges and ways re- search might cope with them	Towards an integrated agenda for adaptation research: theory, practice and policy	A conceptual framework for ad- dressing complexity and unfold- ing transition dynamics when de- veloping sustainable adaptation strategies in urban water man- agement		

Preliminary results - growth

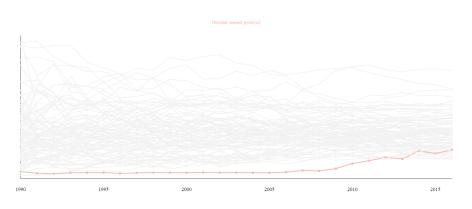




- Negative emissions related topics have shown strong growth since the end of AR5
- As have topics on cities and extreme weather events

Preliminary results - growth - biochar





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

Preliminary results - gaps in coverage

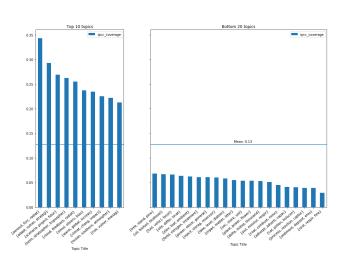


How can we get a sense of which topics are better covered in IPCC reports?

- Each document d either matches or does not match an IPCC reference
- ullet 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

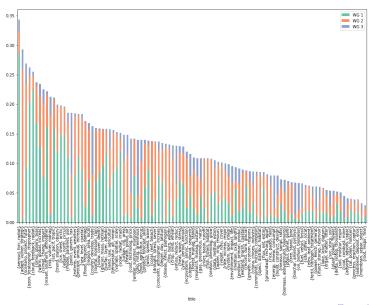




- The physical science aspects of climate change, as well topics on impacts, adaptation and scenarios are well covered by the IPCC
- Topics on specific technological solutions (particularly NETs), as well as soils, are less well covered

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%

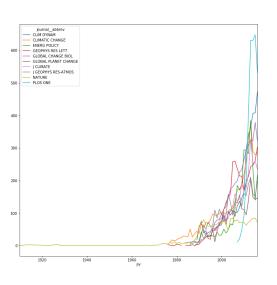
Conclusions



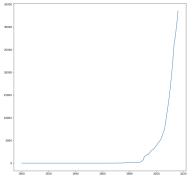
- Endogenously discovered topics make substantive sense of an unmanageable dataset of climate-relevant literature
- Topic modelling discovers over-arching topics such as that on sustainability and research priorities, as well as individual, fast growing topics such as biochar or CCS
- Matching documents 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)
- By uncovering the structure at scale of a large collection of documents, and by enabling the discovery of documents relevant to specific topics or combinations of topics, this approach can provide for more comprehensive and salient scientific assessments.

Extra results - Journals



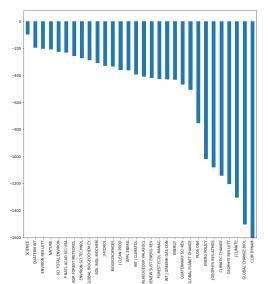


- Nature has been publishing about climate change for a long time
- Plos One has very recently overtaken all other journals
- The number of journals has risen very steeply



Extra results - Journals





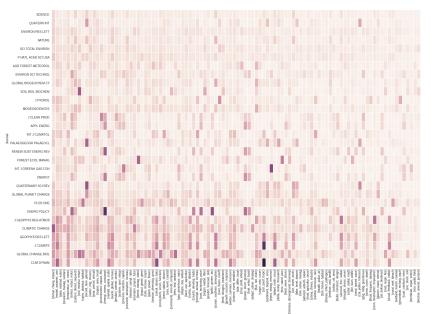
iournal abbrev

- 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





Frame Title



- 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*.