A Topography of Climate Change Research

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Introduction

Figure: Portrait of map-makers, Gerard Mercator and Jodocus Hondius (Jodocus Hondius) source: `https://commons.wikimedia.org/wiki/File:Hondius_Portrait_of_map-makers.jpg`

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Introduction

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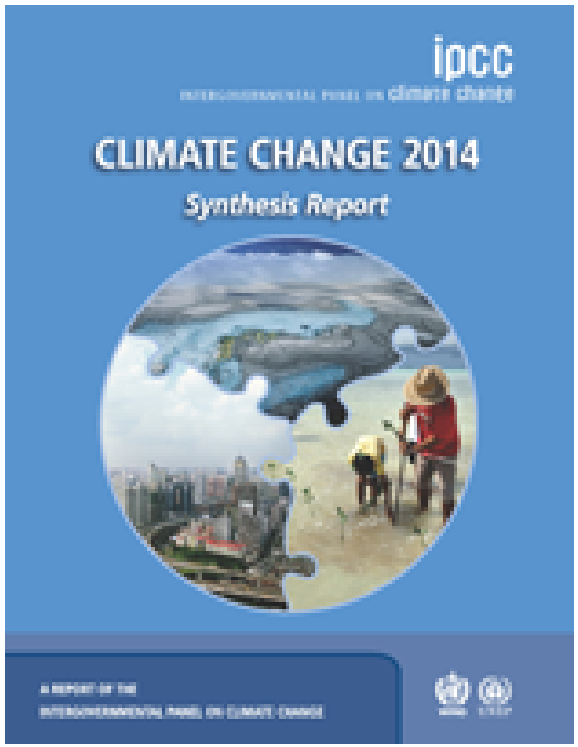
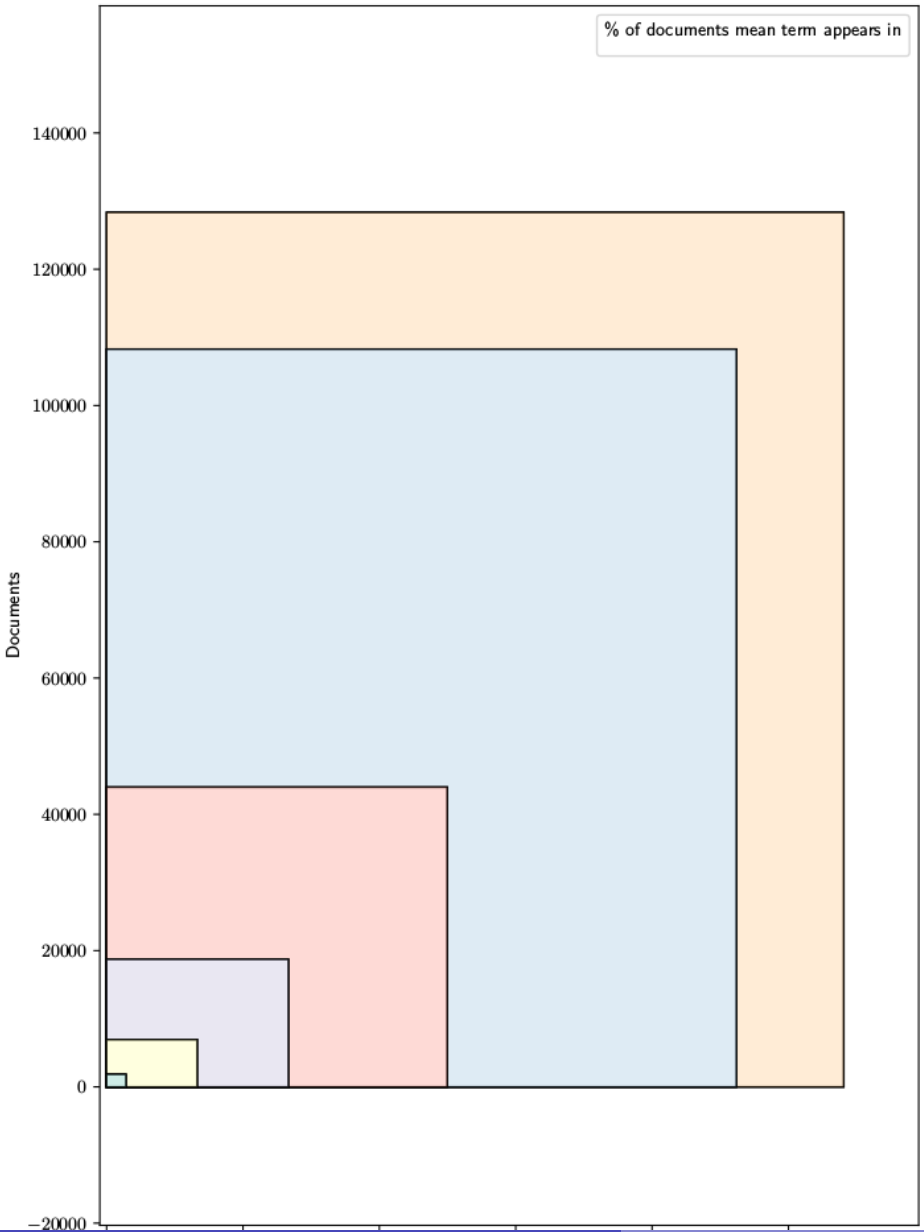
- Topography is a description of a landscape
- Topics (from the Greek , place) can describe the features of body of text

Context



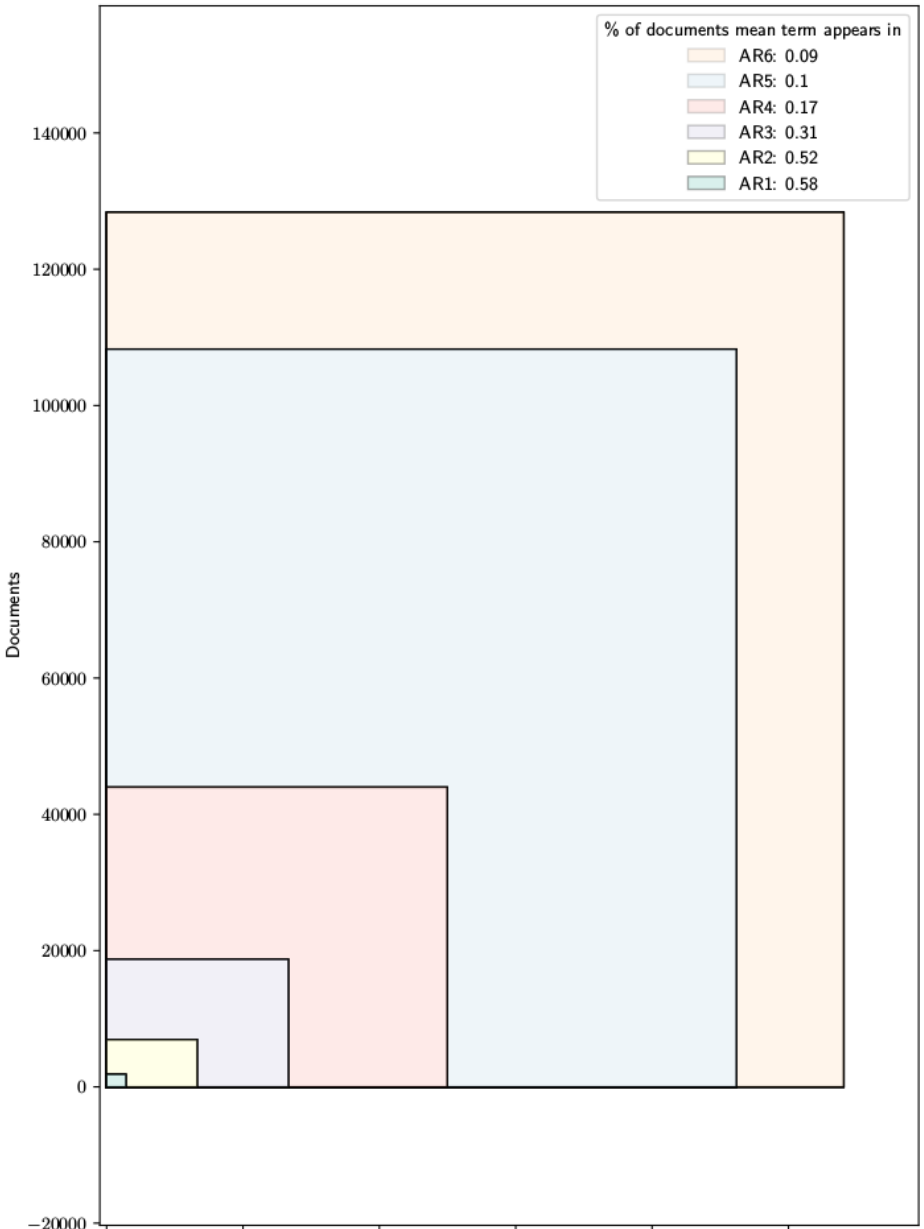
- To contribute evidence-based policy-making on climate change, the IPCC aims to *comprehensively* assess scientific literature on climate change
- These assessments should be aim to balance legitimacy, credibility and relevance (Cash and Clark, 2001)

Motivation - Big Literature



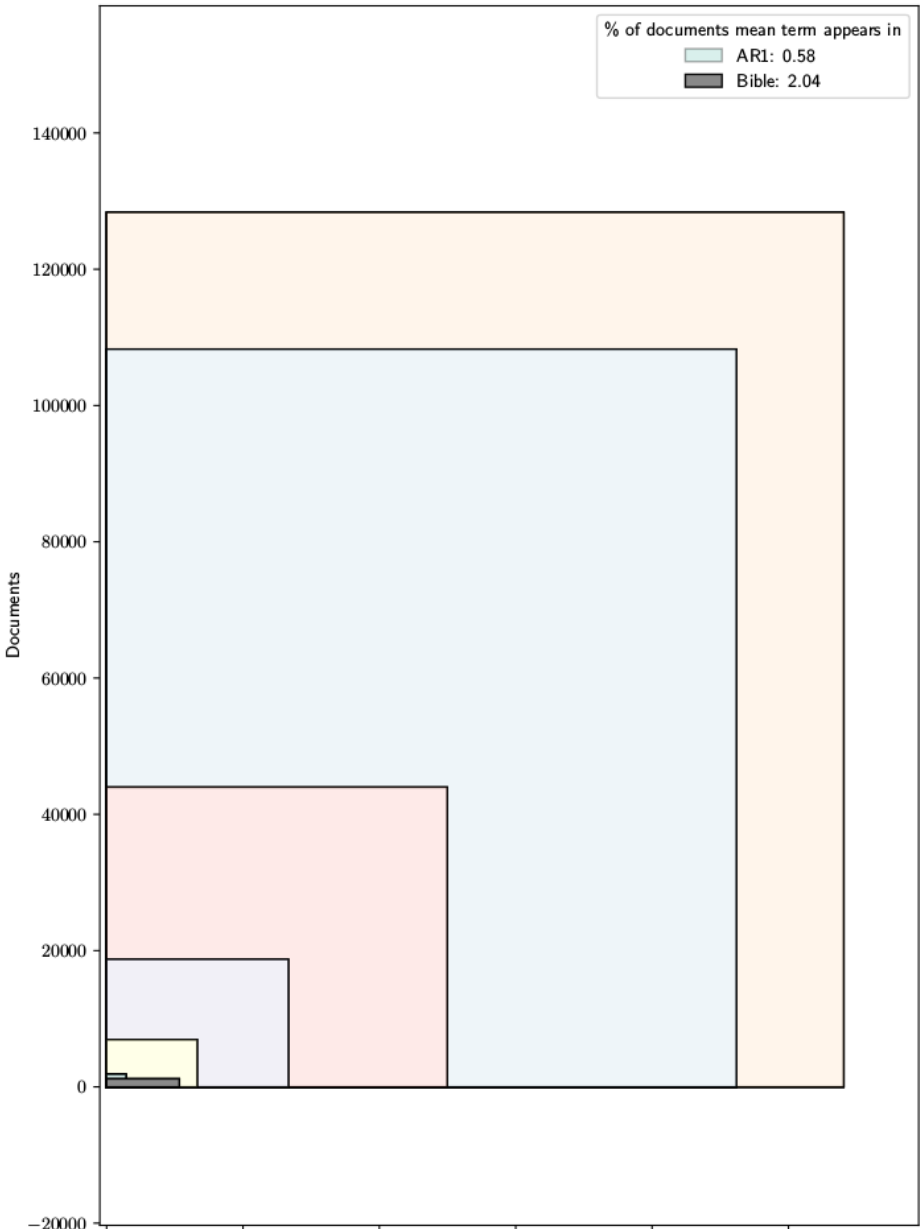
A matrix of documents x words

Motivation - Big Literature



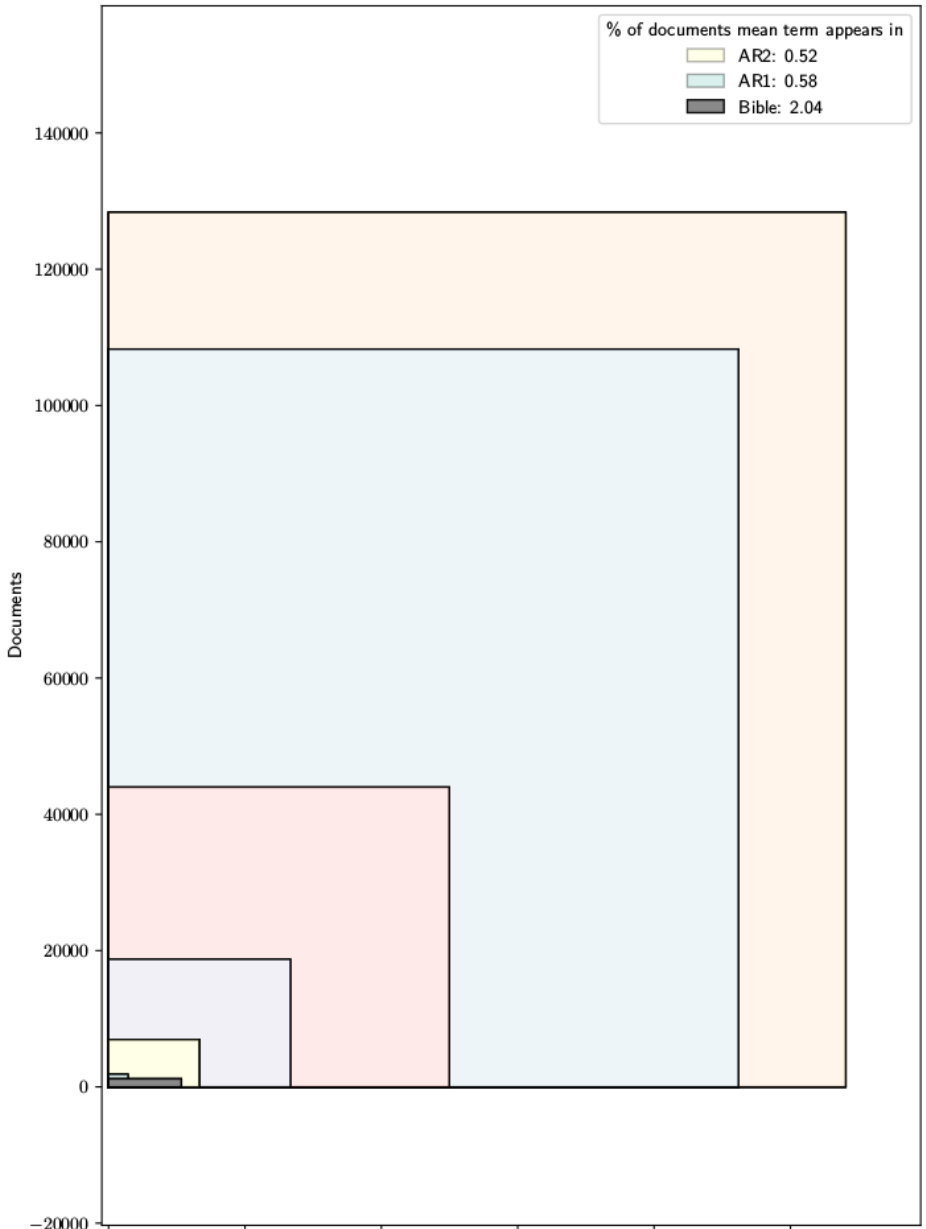
AR1: 1,848 documents x 3,528 words

Motivation - Big Literature



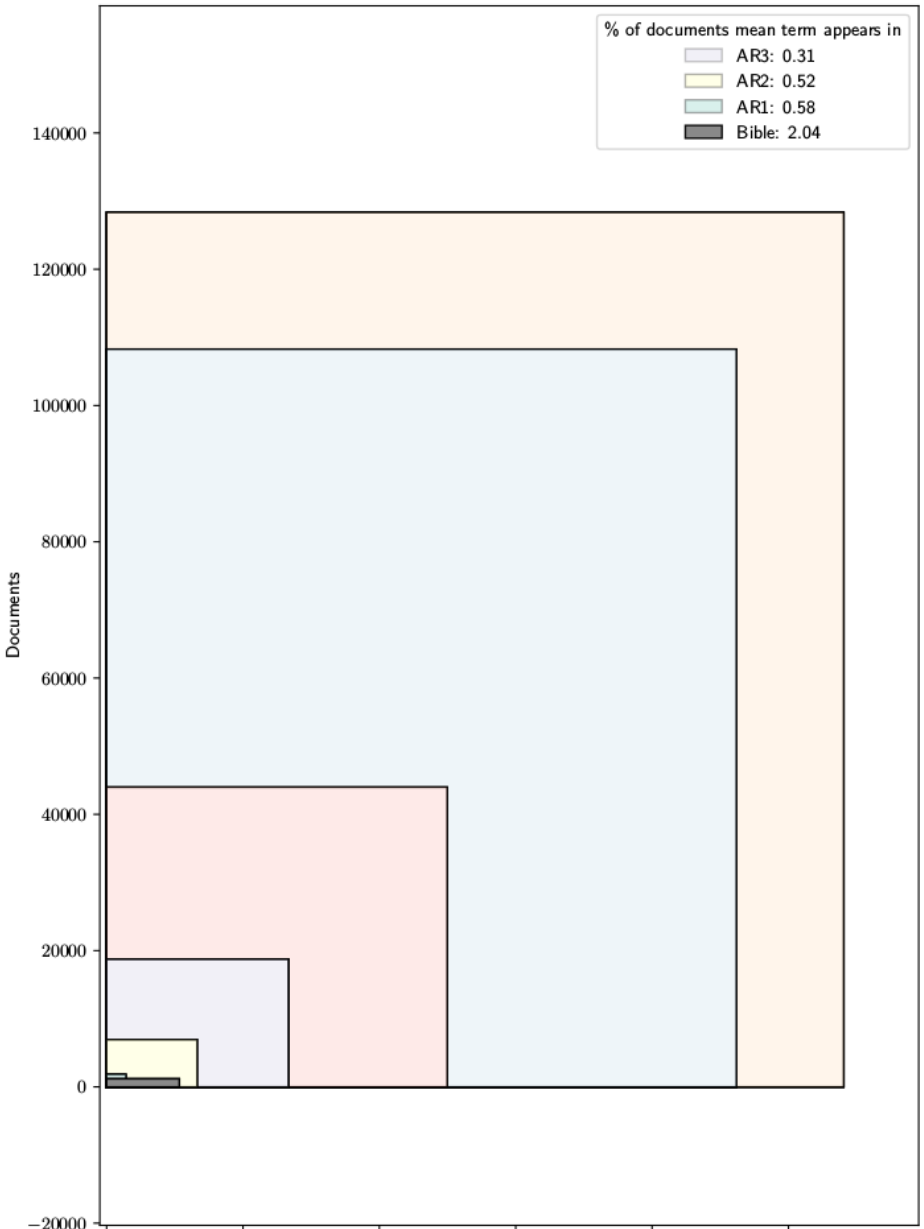
The Luther Bible: 1,189 documents (chapters) x 11,973 words

Motivation - Big Literature



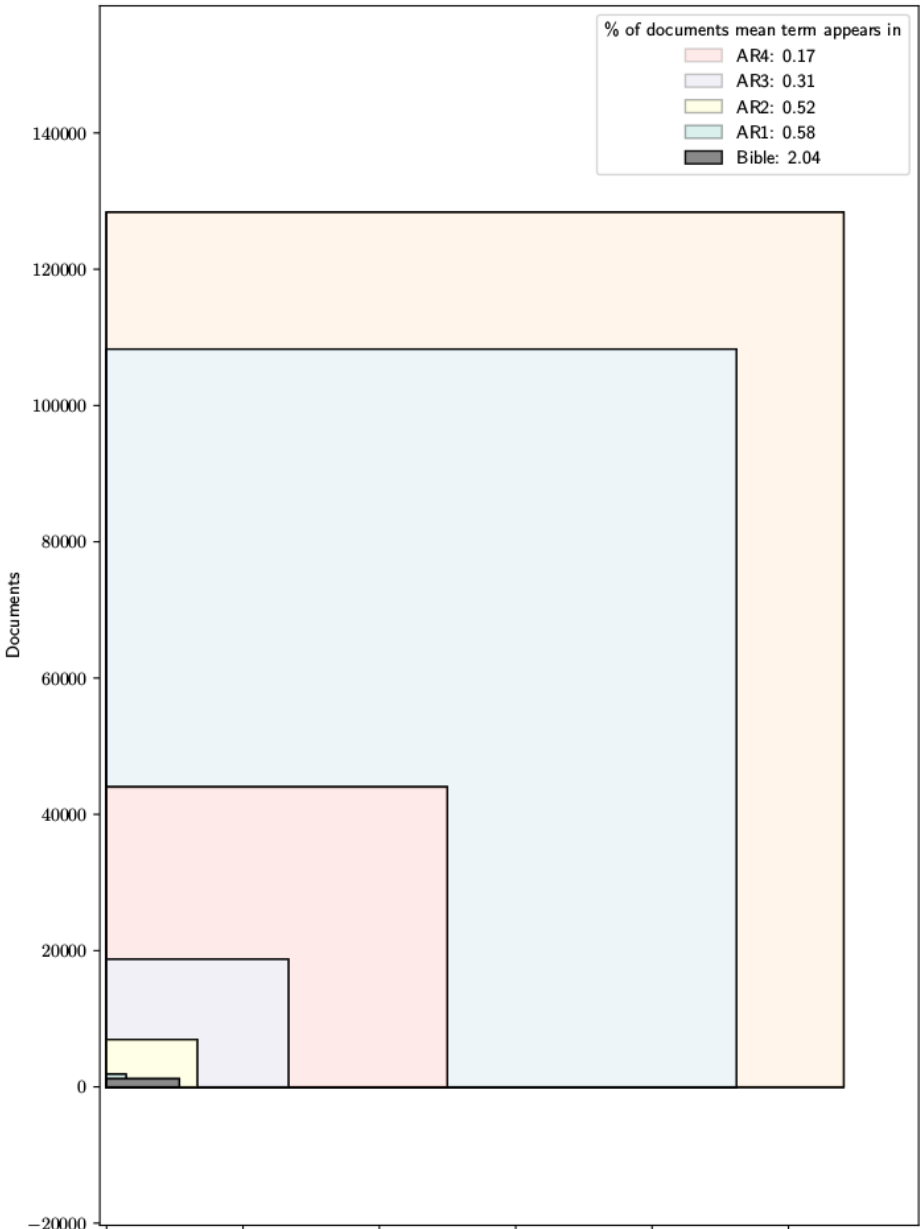
AR2: 6,941 documents x 15,781 words

Motivation - Big Literature



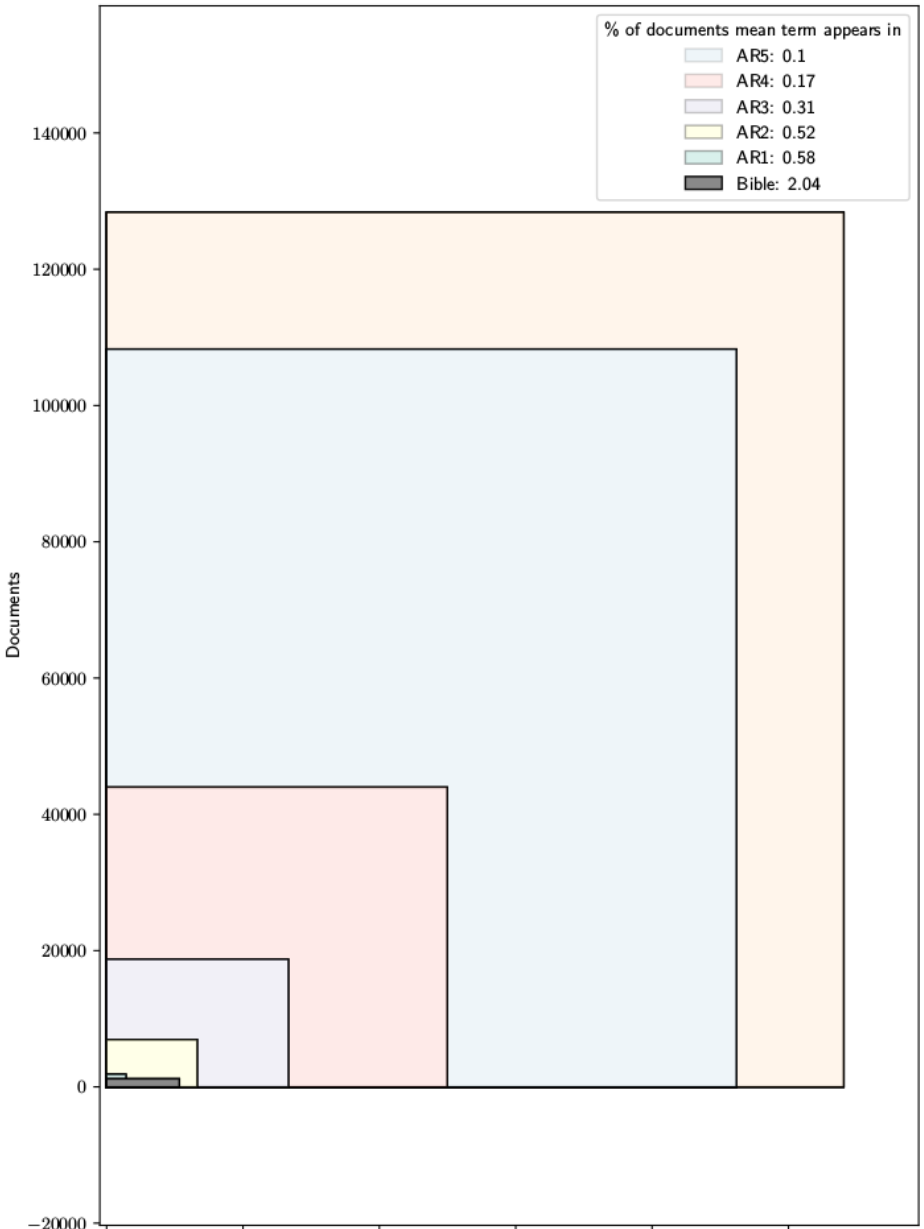
AR3: 18,728 documents x 27,730 words

Motivation - Big Literature



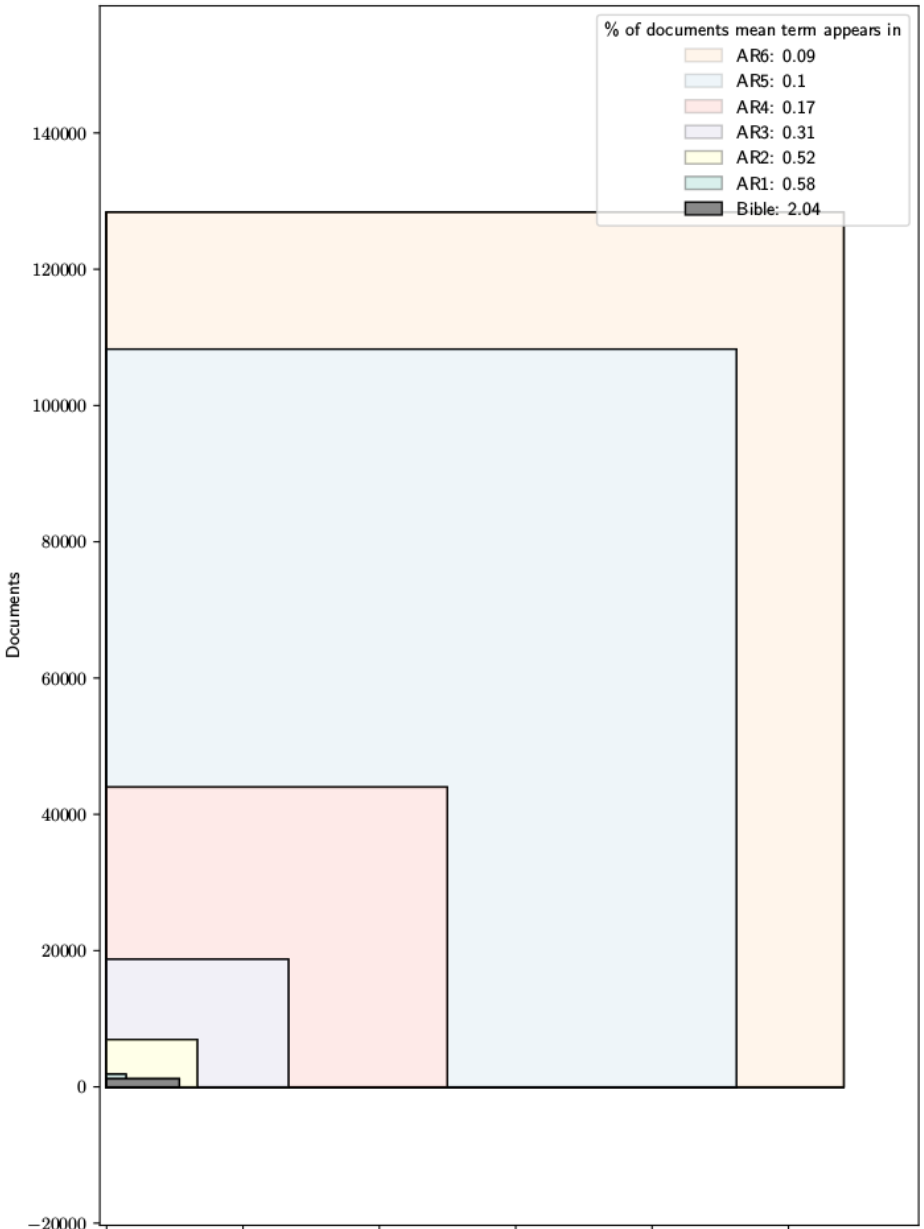
AR4: 44,000 documents x 45,388 words

Motivation - Big Literature



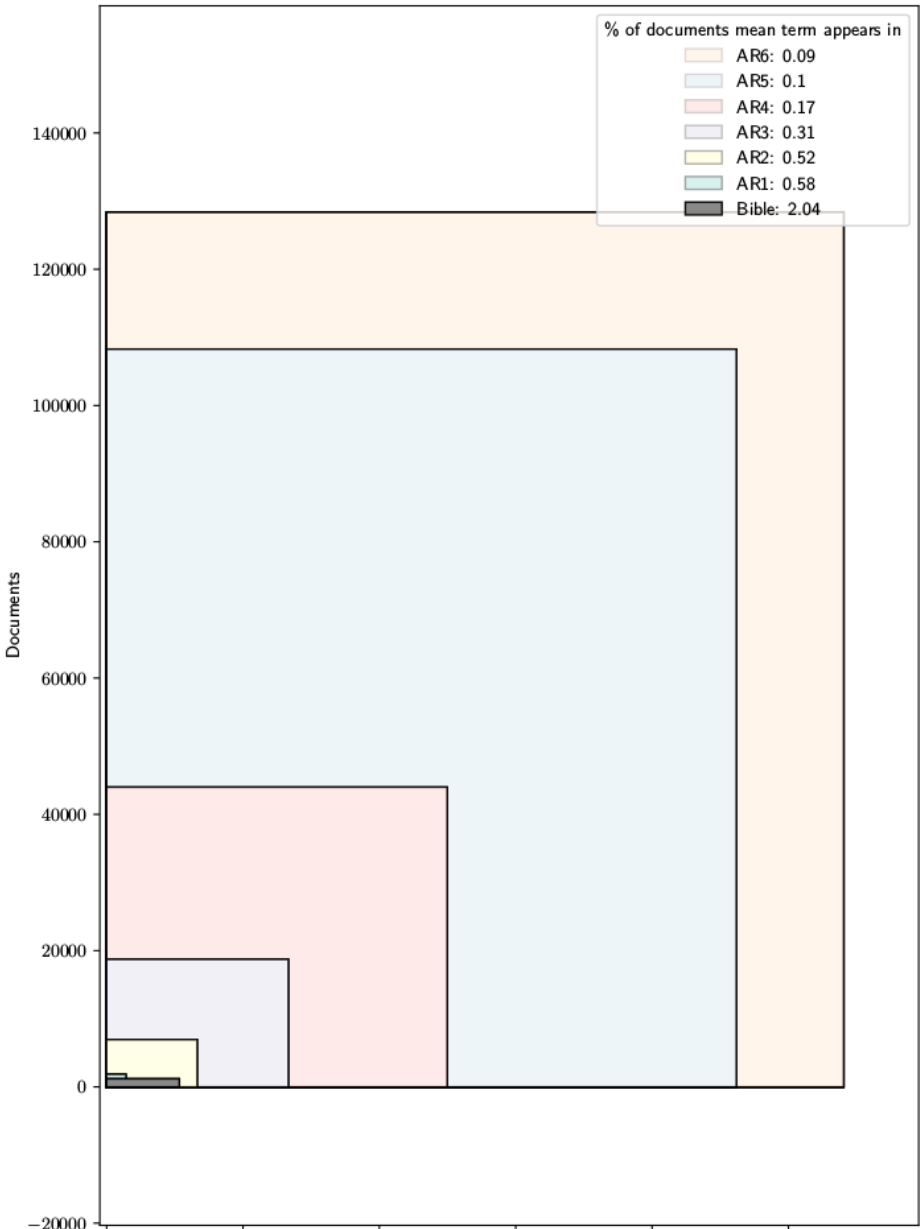
AR5: 108,277 documents x 75,553 words

Motivation - Big Literature



AR6: 128,357 documents x 86,149 words

Motivation - Big Literature

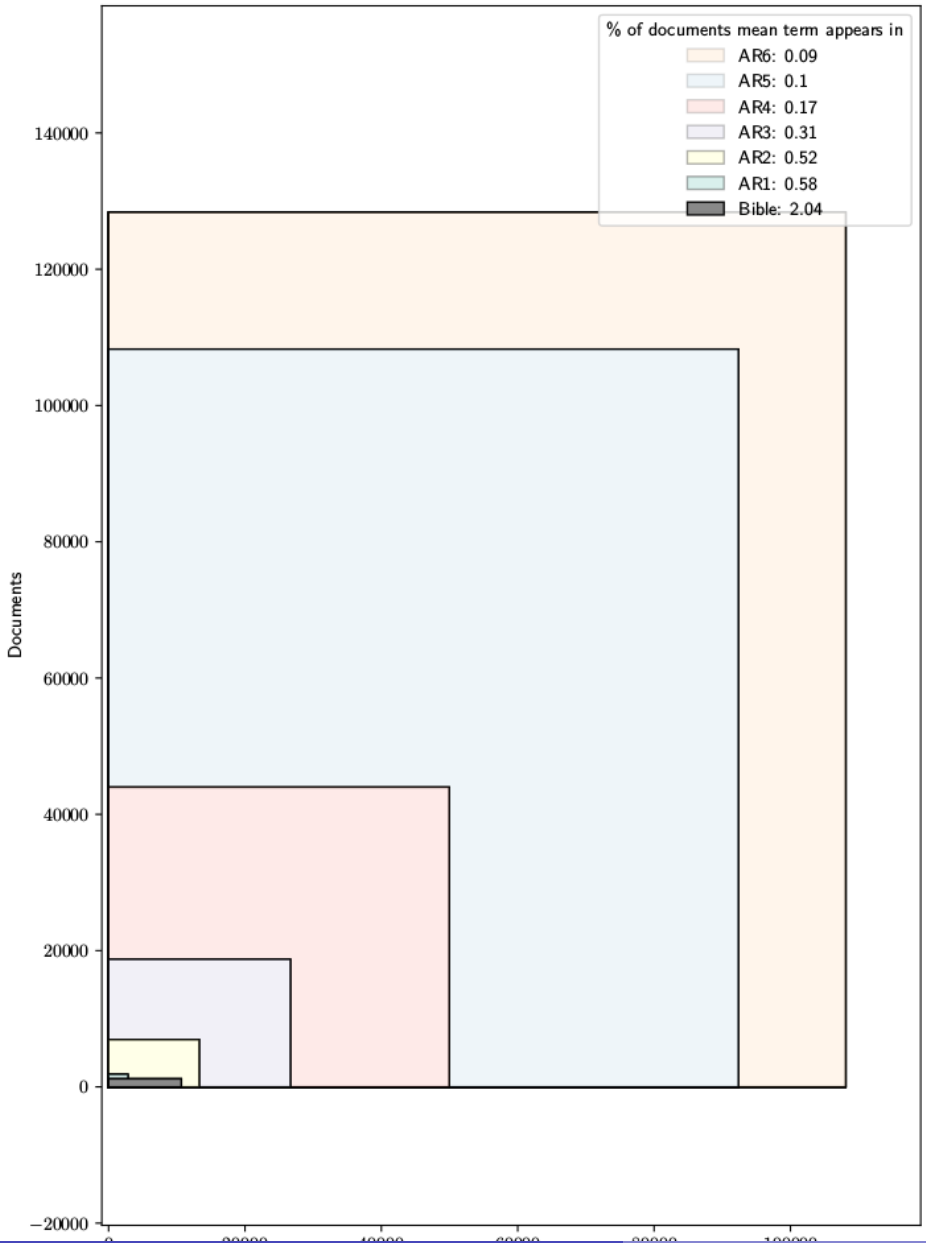


AR6: 128,357 documents x 86,149 words

- Comprehensive, credible and relevant assessments become more challenging as the literature grows (Minx et al., 2017)

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

Approach - Words, words, words



Topic Modelling

- 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 (What is the matter?)

Approach - Words, words, words

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

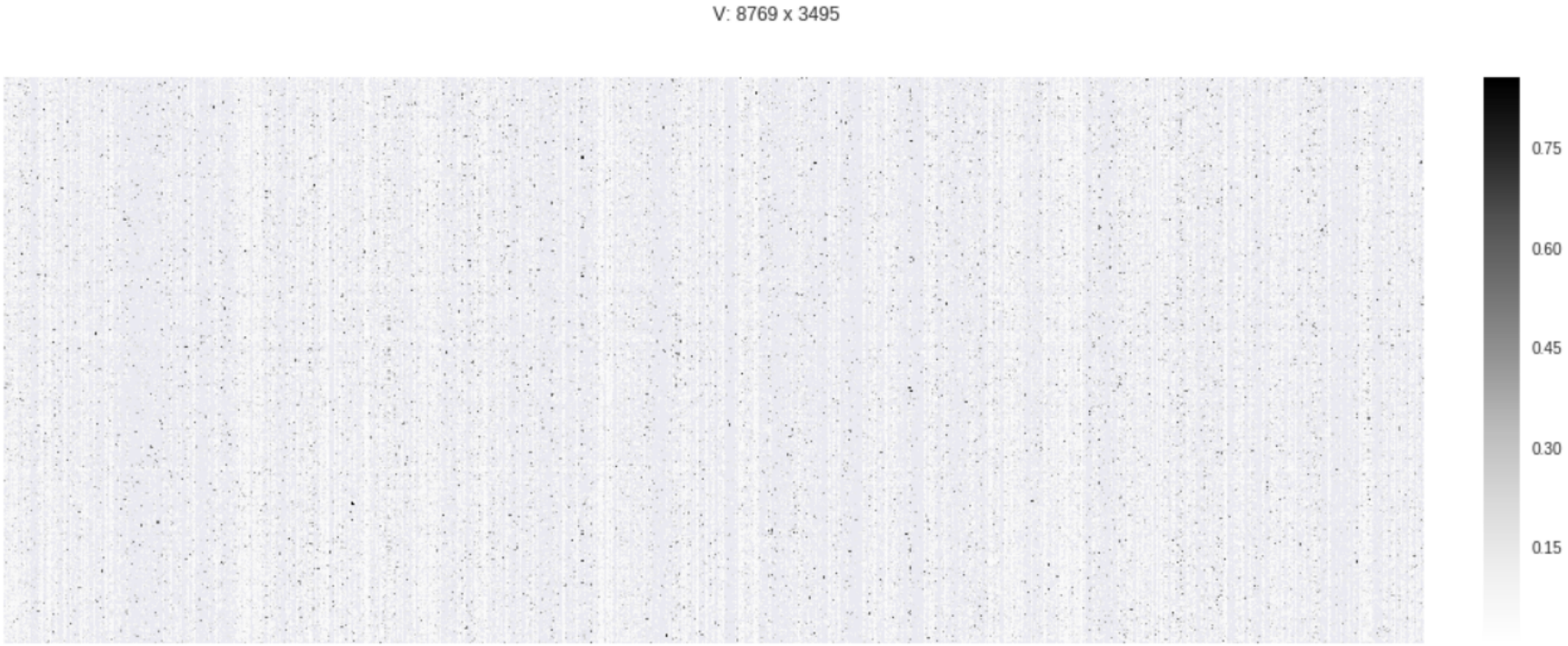
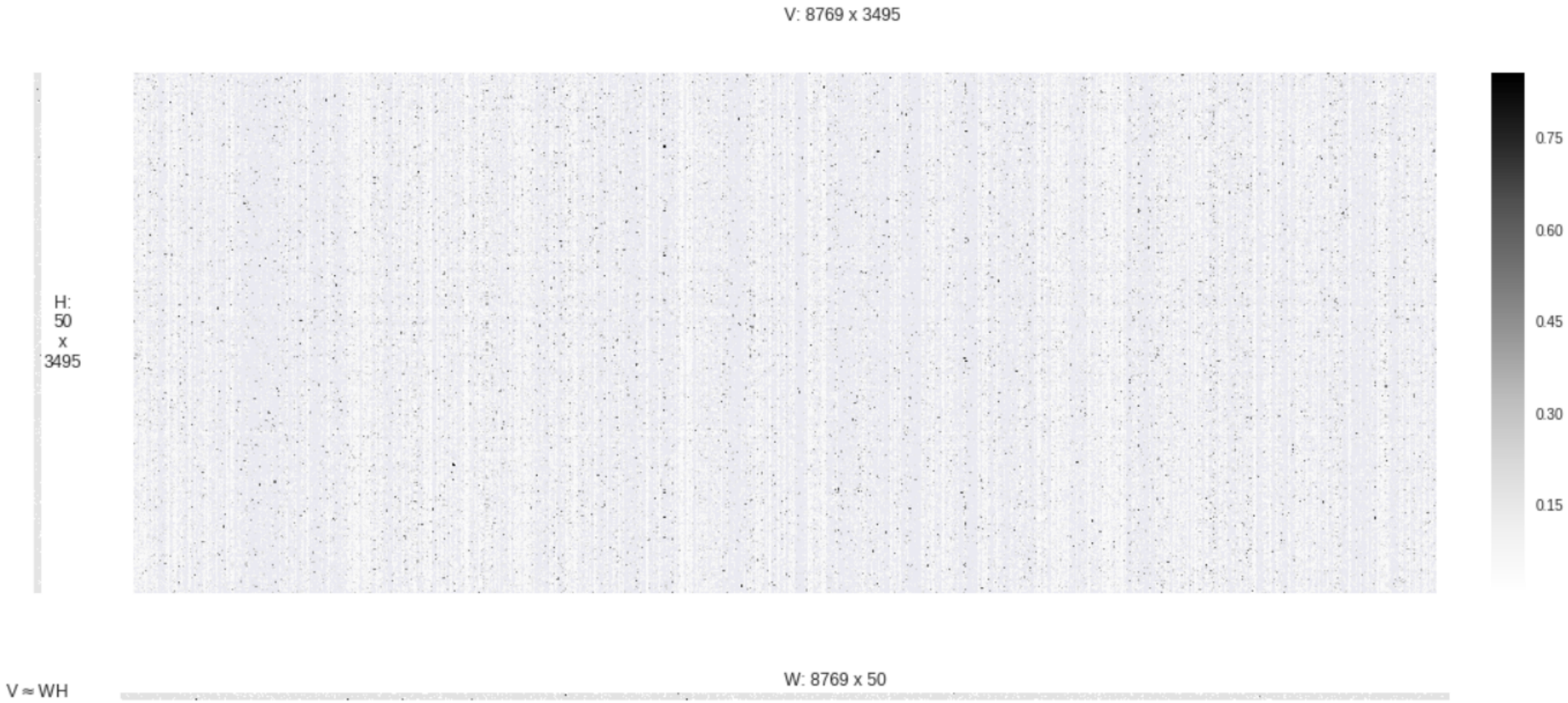


Figure: A topic model of 3495 documents on climate change from the year 2000

Approach - Words, words, words

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



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2. Match documents to reference lists from IPCC reports
3. Topic model stemmed document abstracts

Data - Query

(SO=(Climate Alert OR Climate Dynamics OR Climate Policy OR Climatic Change OR Global and Planetary Change OR Global Change Biology OR International Journal of Greenhouse Gas Control OR Mitigation and Adaptation Strategies for Global Change) OR TS=(((CO2 OR "carbon dioxide" OR methane OR CH4 OR "carbon cycle" OR "carbon cycles" OR "carbon cycling" OR "carbon budget*" OR "carbon flux*" OR "carbon mitigation") AND (climat*)) OR (("carbon cycle" OR "carbon cycles" OR "carbon cycling" OR "carbon budget*" OR "carbon flux*" OR "carbon mitigation") AND (atmospher*))) OR TS=("carbon emission*" OR "sequestration of carbon" OR "sequester* carbon" OR "sequestration of CO2" OR "sequester* CO2" OR "carbon tax*" OR "CO2 abatement" OR "CO2 capture" OR "CO2 storage" OR "CO2 sequester*" OR "CO2 sequestration" OR "CO2 sink*" OR "anthropogenic carbon" OR "captur* of carbon dioxide" OR "captur* of CO2" OR "climat* variability" OR "climat* dynamic*" OR "chang* in climat*" OR "climat* proxies" OR "climat* proxy" OR "climat* sensitivity" OR "climat* shift*" OR "coupled ocean-climat*" OR "early climat*" OR "future climat*" OR "past climat*" OR "shift* climat*" OR "shift in climat*") OR TS=("atmospheric carbon dioxide" OR "atmospheric CH4" OR "atmospheric CO2" OR "atmospheric methane" OR "atmospheric N2O" OR "atmospheric nitrous oxide" OR "carbon dioxide emission*" OR "carbon sink*" OR "CH4 emission*" OR "climat* policies" OR "climat* policy" OR "CO2 emission*" OR dendroclimatolog* OR ("emission* of carbon dioxide" NOT nanotube*) OR "emission* of CH4" OR "emission* of CO2" OR "emission* of methane" OR "emission* of N2O" OR "emission* of nitrous oxide" OR "historical climat*" OR IPCC OR "methane emission*" OR "N2O emission*" OR "nitrous oxide emission*") OR TS=("climat* change*" OR "global warming" OR "greenhouse effect" OR "greenhouse gas*" OR "Kyoto Protocol" OR "warming climat*" OR "cap and trade" OR "carbon capture" OR "carbon footprint*" OR "carbon neutral" OR "carbon offset" OR "carbon sequestration" OR "carbon storage" OR "carbon trad*" OR "changing climat*" OR "climat* warming")) NOT PY=2018

- (Haunschild et al., 2016)
- 309,697 documents

Caveats

- Not perfect query
- WoS not all peer-reviewed literature
- Missing grey literature
- Missing relevant literature not directly about climate change

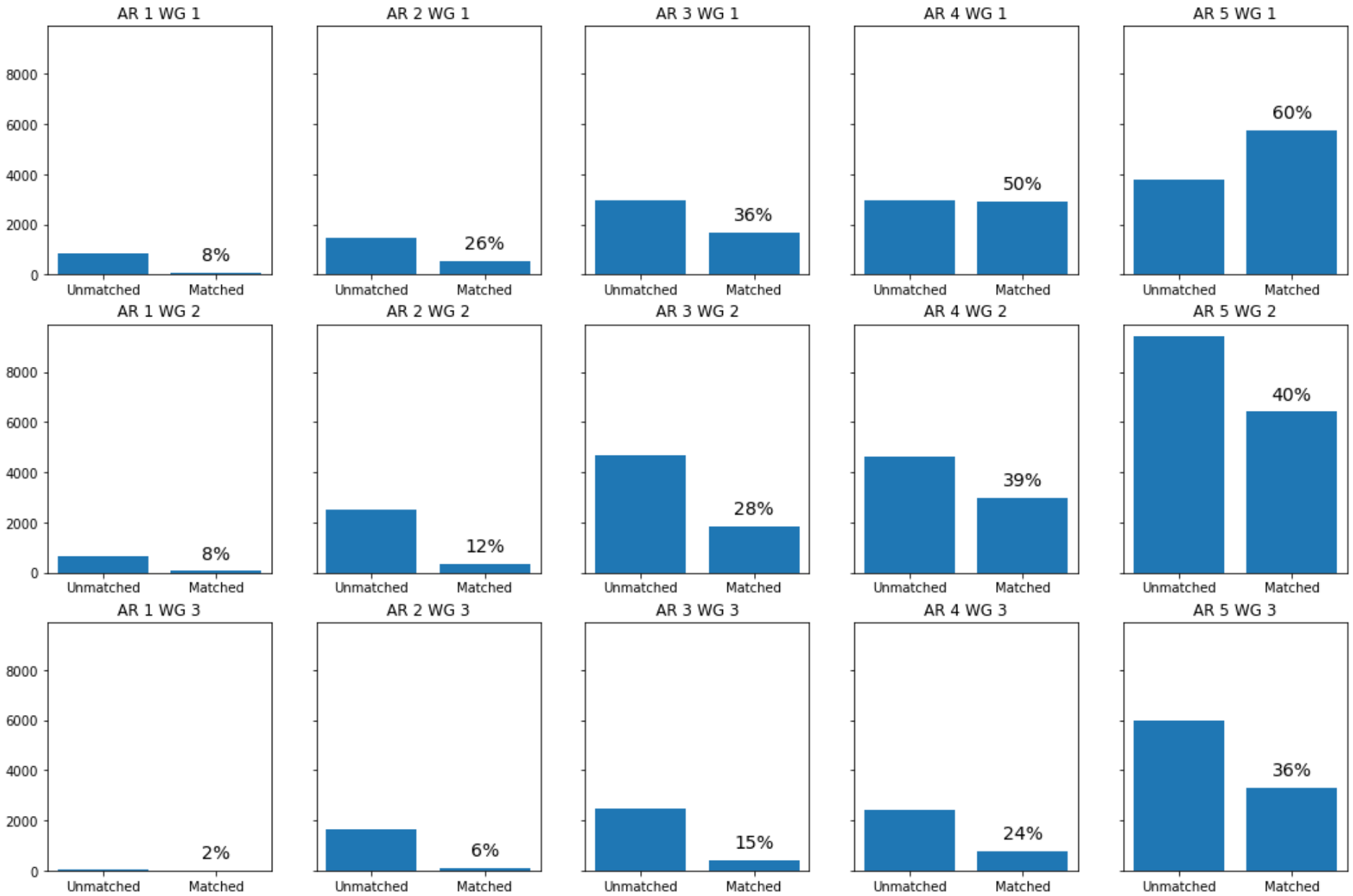
Data - IPCC References

Matching process

For each Reference:

- Check for case-insensitive title matches
- Calculate the Jaccard similarity score for two word shingles every database document containing the first word and from the same year. Match if the Jaccard score is above 0.45

Data - IPCC References



Data - Unmatched IPCC References

AR	WG	text	authors	year
2	2	Landfill gas: working with Gaia. Biodeterioration Extracts no. 4, Energy Technology Support Unit, Harwell Laboratory, Oxfordshire, UK.	Richards, K.M.	1989
1	1	Longwave cloud radiative forcing as determined from Nimbus-7 observations J Cltm , 2, 766 799	Ardanuy, P E , L L Stowe, A Gruber, M Weiss and C S Long	1989
3	2	Climate change: overview and implications for wildlife. In: Wildlife Responses to Climate Change: North American Case Studies [Schneider, S.H. and T.L. Root (eds.)]. Island Press, Washington, DC, USA, (in press).	Root, T.L. and S.H. Schneider	2001
2	3	The impact ol' global wanning on the United States: A survey of recent literature, mimco. Institute lor International Economics, Washington, DC (April).	Cline, W.R.	1993
3	2	Population-environment relations at the forested frontier of Nepal. Applied Geography, 20, 221-242.	Conway, D., K. Bhattarai, and N.R. Shrestha	2000
3	2	The Cities Project. Australian Geological Survey Organisation, Australia. Available online at http://www.agso.gov.au/geohazards/grm/cities2.html.	AGSO	1999
4	1	CLIMBER-2: A climate system model of intermediate complexity. Part I: Model description and performance for present climate.	Petoukhov, V., et al.	2000
5	1	A skill-score based evaluation of simulated Australian climate. Australian Meteorol. Oceanogr	Watterson, I., A. C. Hirst, and L. D. Rotstayn	2013
5	1	Enhanced aerosol backscatter adjacent to tropical trade wind clouds revealed by satellite-based lidar. Geophys. Res	Tackett, J. L., and L. Di Girolamo	2009
5	3	Promoting long-term invest-ments by institutional investors. OECD Journal: Financial Market Trends 1, 145 164	Della Croce R, F Stewart, and J Yermo	2011

Data - Unmatched IPCC References

37% of IPCC References could be matched to the database of climate-relevant documents

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Observations

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Observations

- The size of the literature appears to be *much* bigger than our estimate
- WG3 refers to more literature not directly about climate change, or not in peer-reviewed publications, than WG2, which refers to more than WG1

Methodology - Dynamic Topic Modelling

The topic models above assume that the topics, and the words that make them up, are stable over time. Two approaches to better model dynamic topics:

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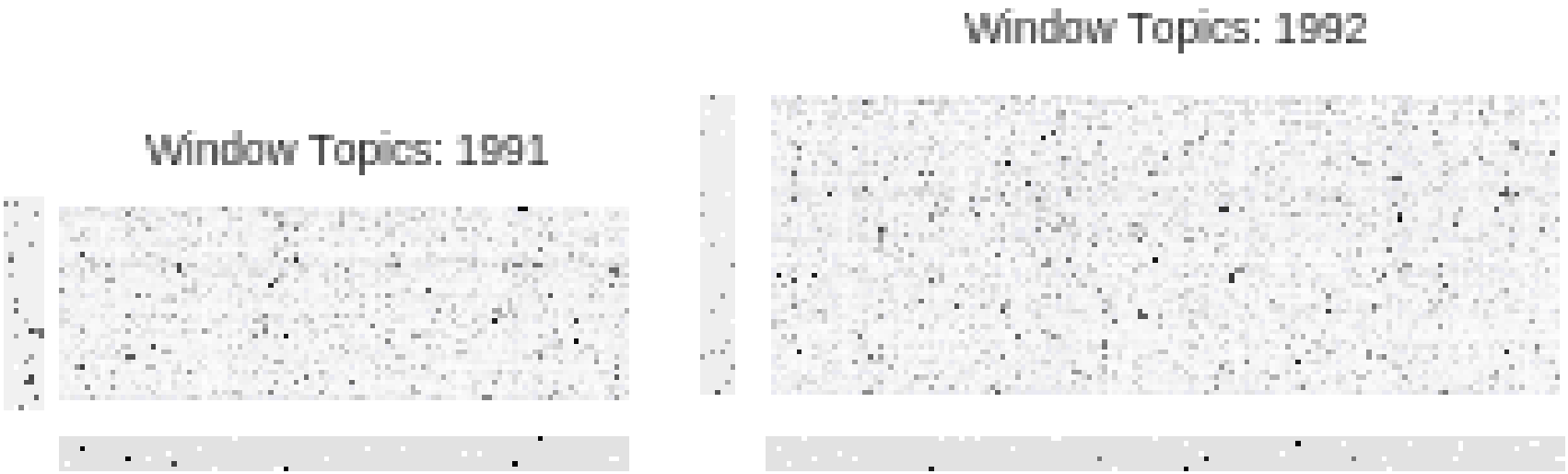
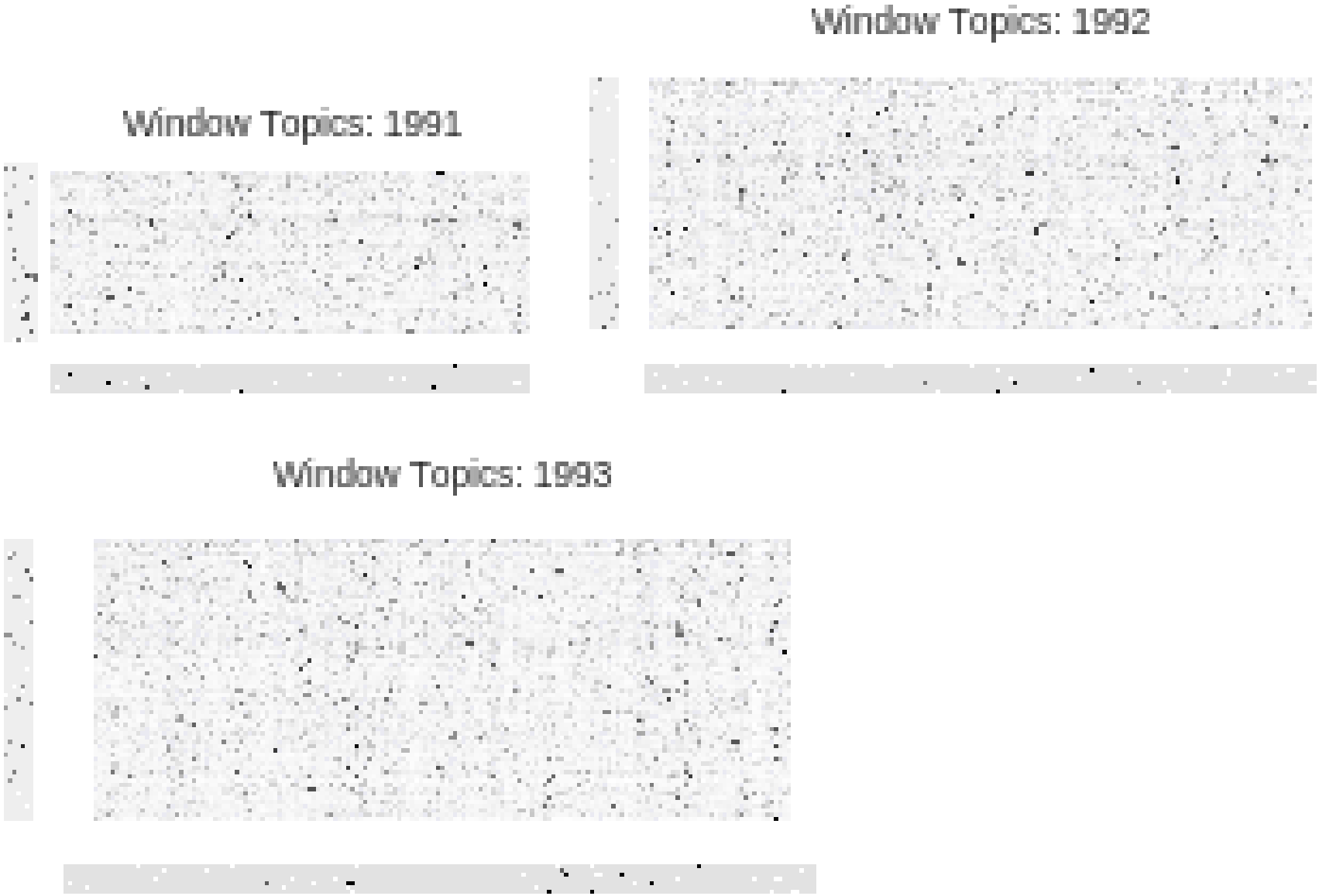
Where the size and variety of the literature we want to model has increased exponentially, we need an approach that allows for the emergence of new topics.

Dynamic NMF

Dynamic NMF



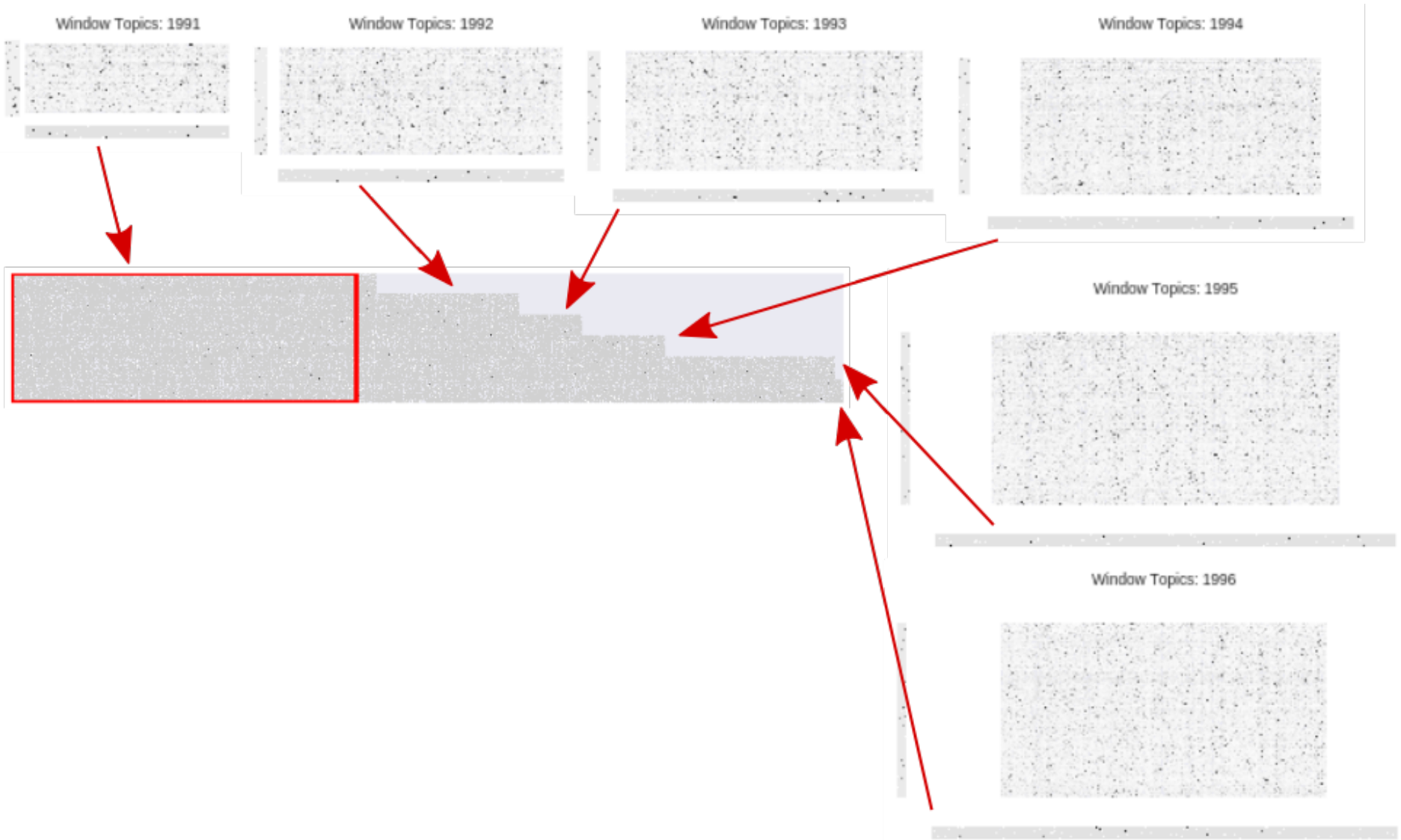
Dynamic NMF



Dynamic NMF


Window Topics: 1991
Window Topics: 1992
Window Topics: 1993
Window Topics: 1994
Window Topics: 1995
Window Topics: 1996

Dynamic NMF


Window Topics: 1991
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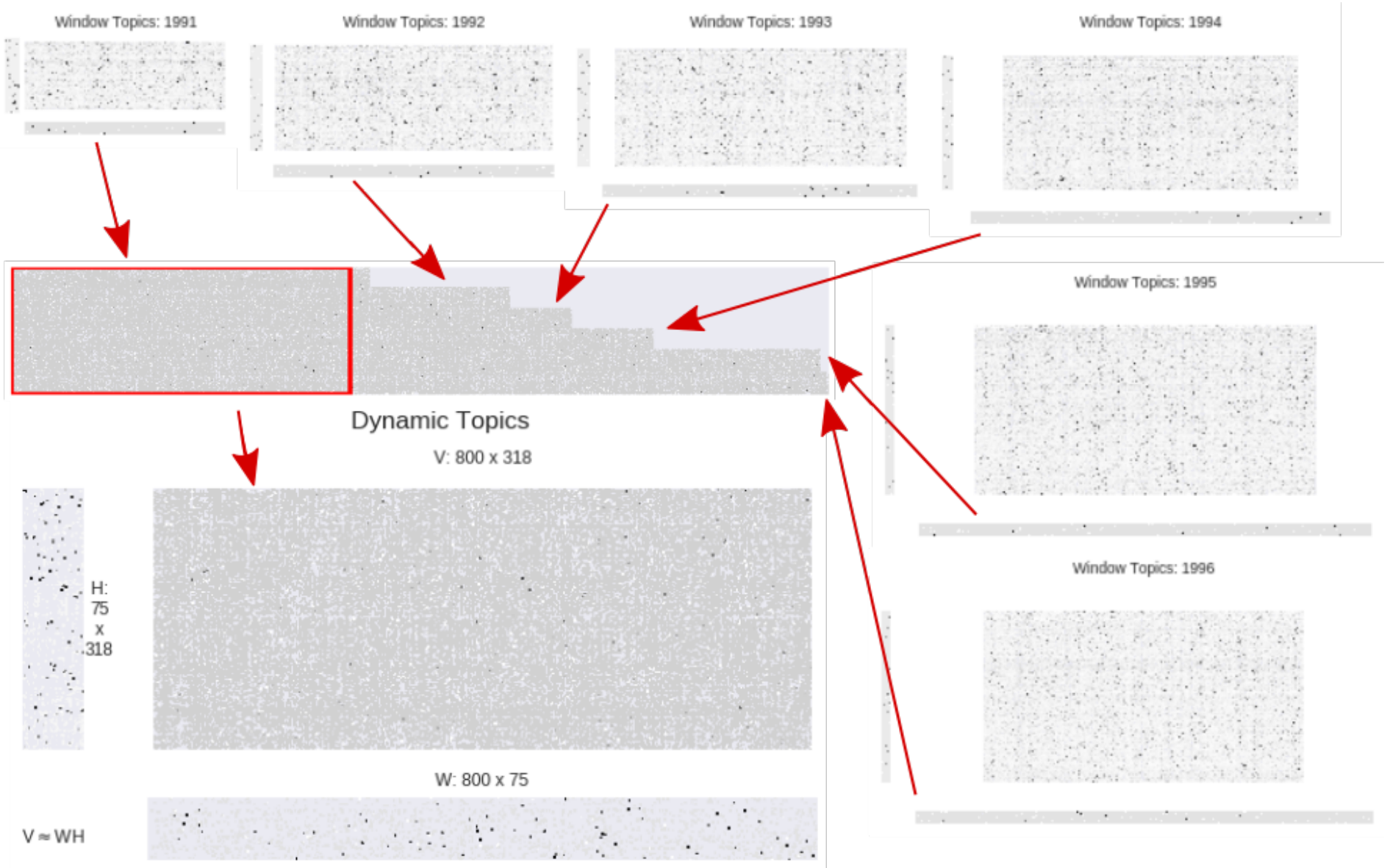
Window Topics: 1991
Window Topics: 1992
Window Topics: 1993
Window Topics: 1994
Window Topics: 1995
Window Topics: 1996
Dynamic Topics
V: 800 x 318
H: 75 x 318
W: 800 x 75
V ≈ WH

Dynamic NMF - application to climate change

- Choosing the number of window topics is non-trivial. Data-driven approaches are limited (see below), and human selection is time consuming.
- To facilitate the description of trends over the assessment periods of the IPCC, and to minimize the number of modelling decisions, I consider each IPCC assessment period as a time window.

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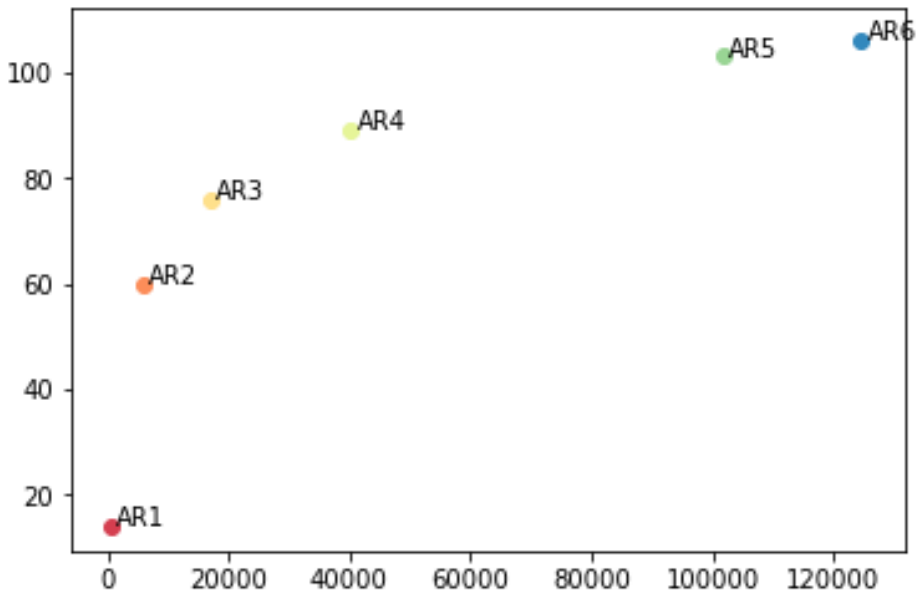
- Starting from a logarithmic relationship between the number of documents and the ideal topic number, I compare 5 runs with varying numbers of topics for each window



Dynamic NMF - number of topics

Human topic number criteria

- Intelligibility

Data-driven topic number criteria

- Reconstruction accuracy
- Predictive capacity

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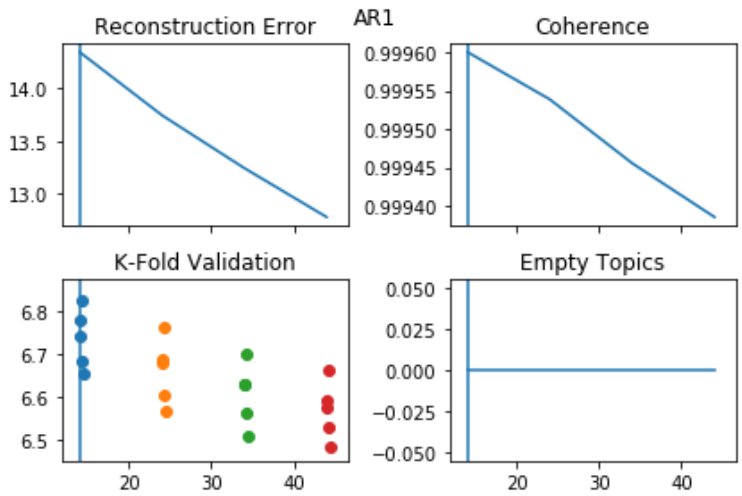

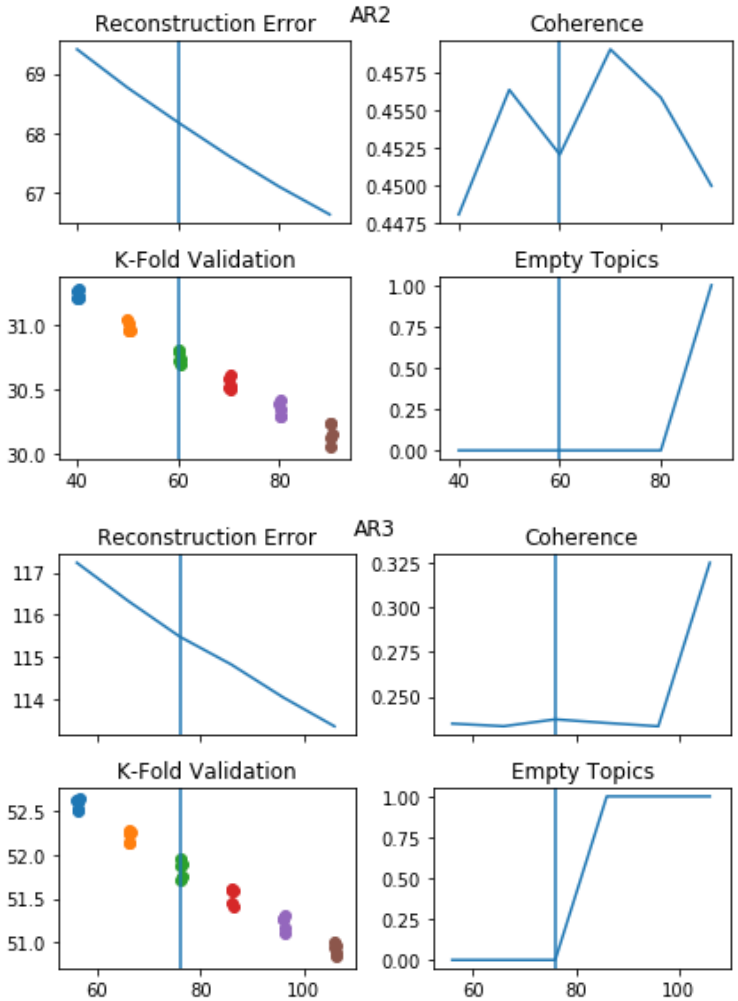

Results

Outline

Results

Outline

- Topography

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- Topography
- Structure

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- Development

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- Representation in past IPCC reports

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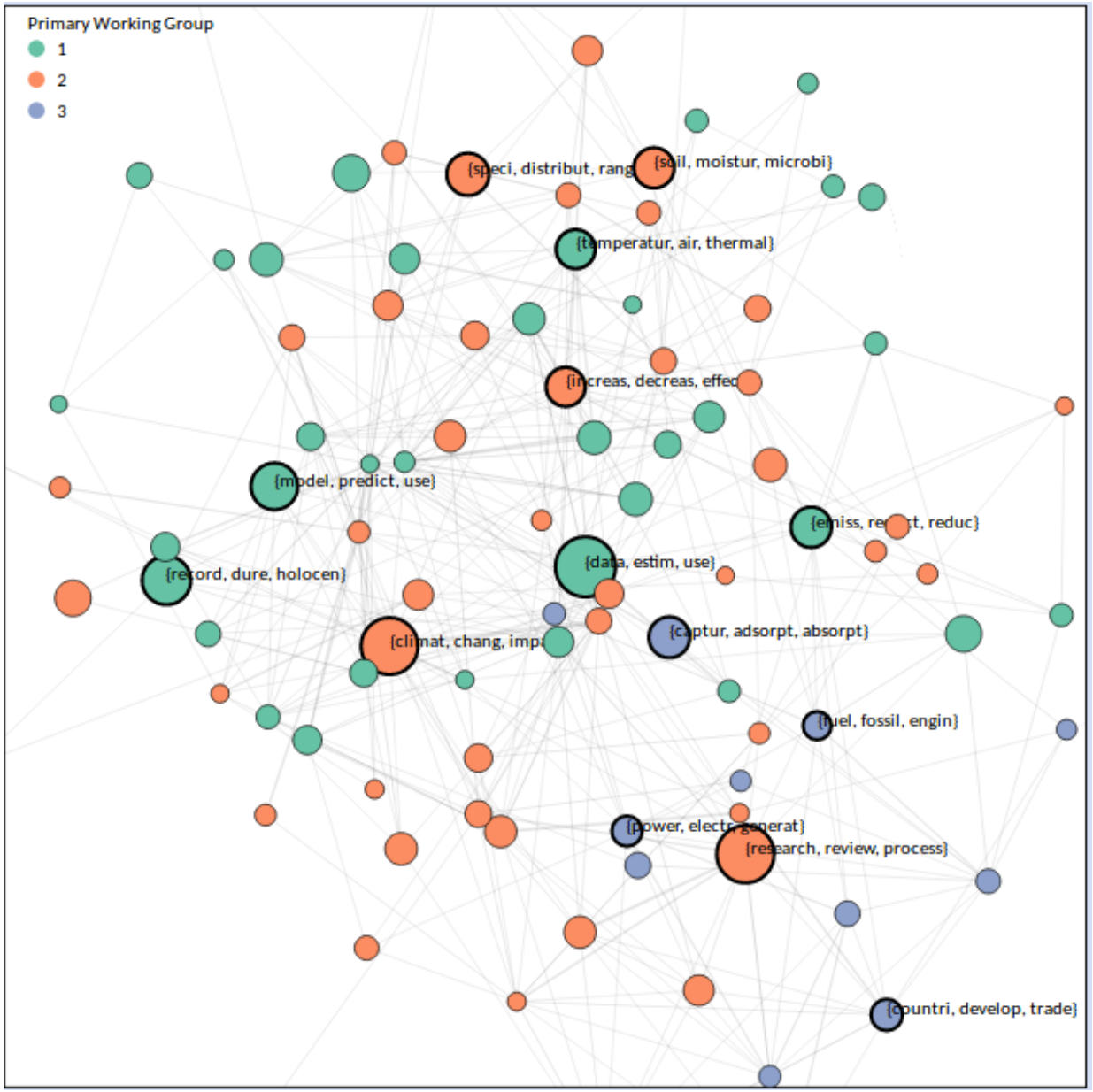
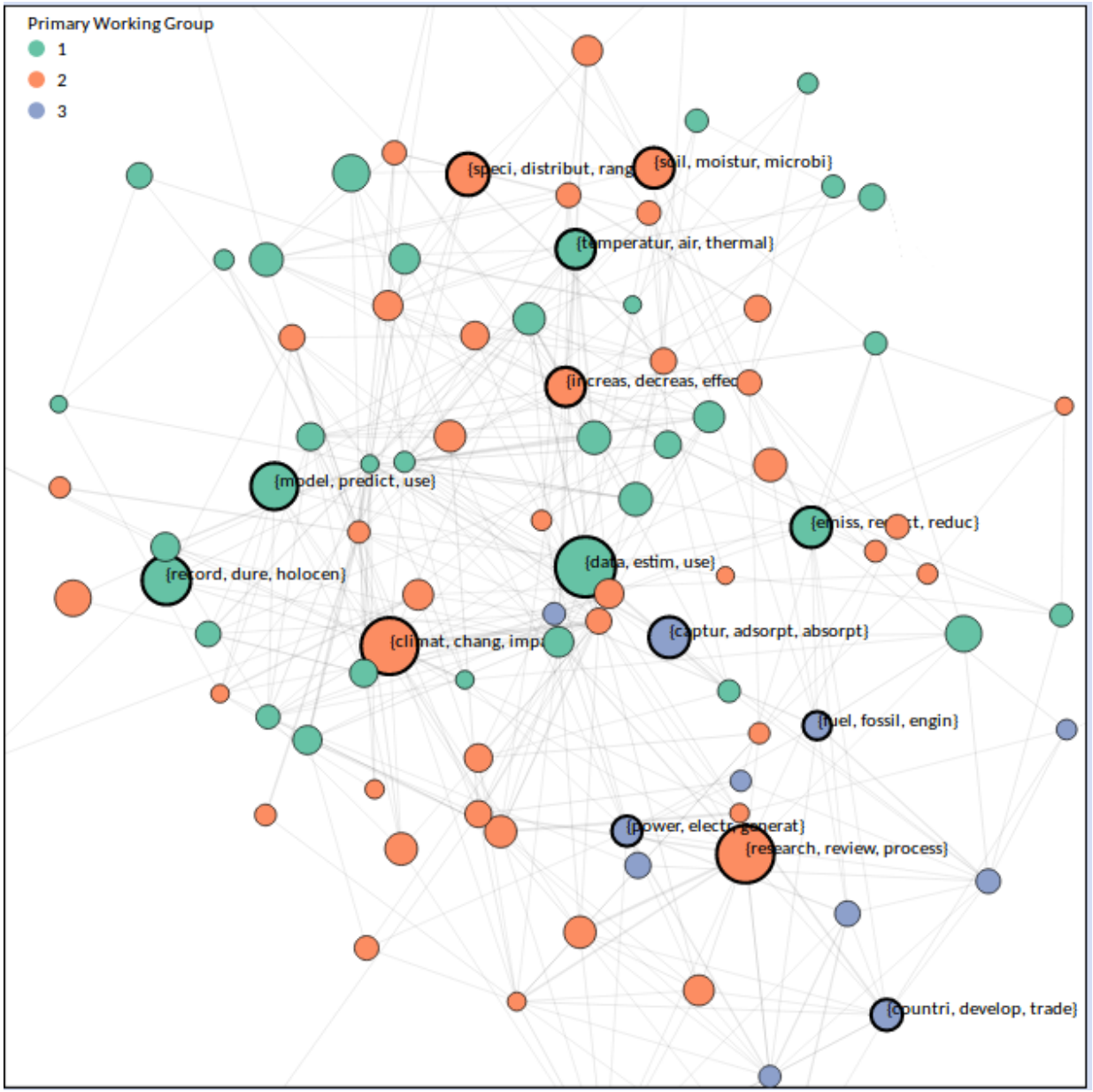
- AR6 outlook

Results - structure



- Topics describe comprehensible themes in climate change research

Results - structure



- Topics describe comprehensible themes in climate change research
- Matching topics to the IPCC working group from which the majority of the topics are referenced in, a structure is generated based on topic-document correlations

Results - Inter-working Group topics - WG 1 and 2

IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.16%	1	{rainfal, monsoon, rain}	0.50%	0.50%	0.00%
0.10%	2	{veget, ndvi, cover}	0.41%	0.59%	0.00%
0.16%	1	{snow, cover, winter}	0.59%	0.41%	0.00%
0.17%	2	{region, local, scale}	0.41%	0.59%	0.00%
0.16%	1	{coastal, mangrov, rise}	0.57%	0.42%	0.01%

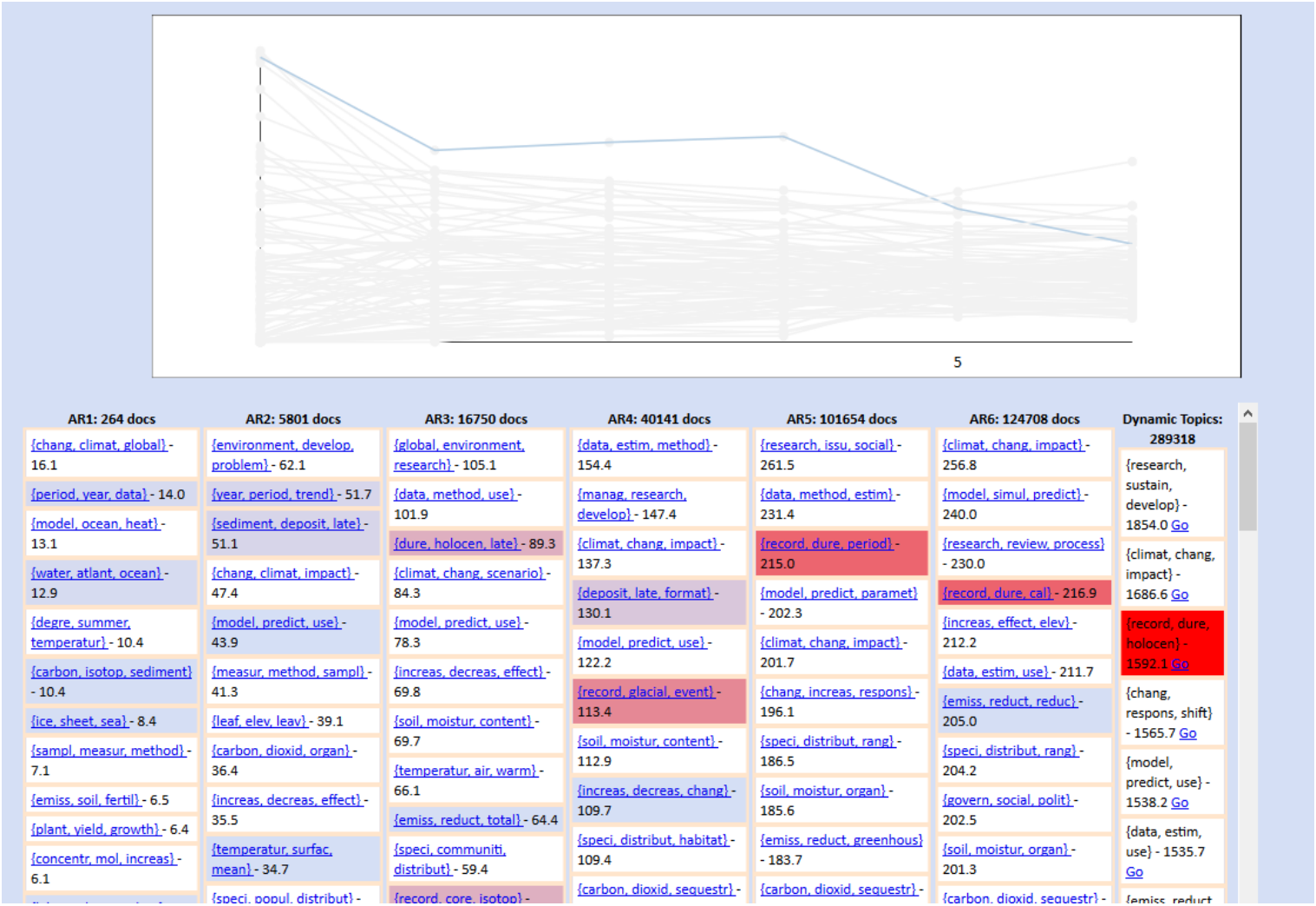
Results - Inter-working Group topics - WG 1 and 3

IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.09%	3	{gas, coal, greenhous}	0.30%	0.15%	0.56%
0.10%	3	{transport, vehicl, road}	0.24%	0.12%	0.64%
0.13%	1	{emiss, reduct, reduc}	0.45%	0.21%	0.34%
0.09%	1	{methan, oxid, methanotroph}	0.63%	0.16%	0.20%
0.13%	3	{ghg, greenhous, gas}	0.15%	0.09%	0.75%

Results - Inter-working Group topics - WG 2 and 3

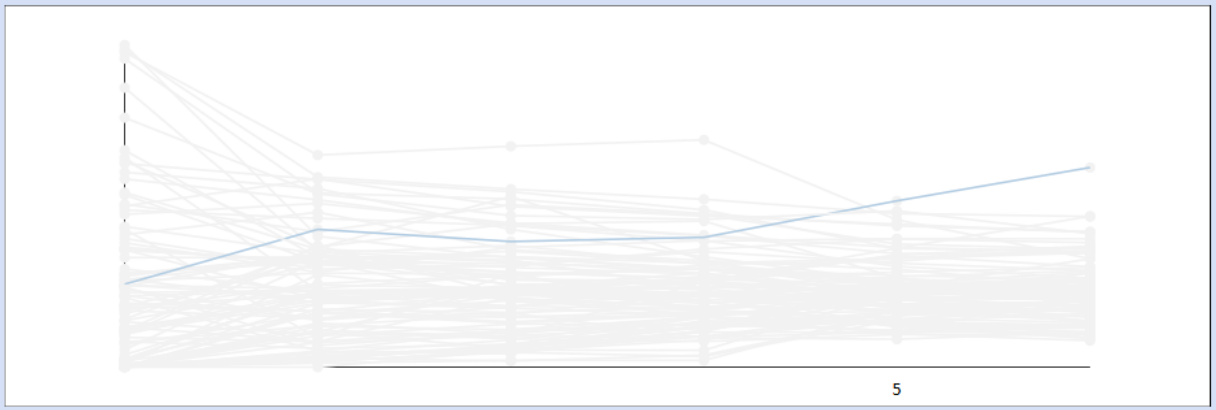
IPCC Coverage	Primary WG	Topic Title	WG 1	WG 2	WG 3
0.11%	2	{sustain, develop, resourc}	0.04%	0.51%	0.46%
0.08%	3	{build, construct, design}	0.03%	0.38%	0.59%
0.11%	2	{environment, impact, life}	0.06%	0.58%	0.36%
0.19%	3	{polici, tax, govern}	0.02%	0.32%	0.66%
0.16%	2	{urban, citi, plan}	0.07%	0.55%	0.38%

Results - Development



Basic climate science topics are not as prominent as they were previously

Results - Development



AR1: 264 docs	AR2: 5801 docs	AR3: 16750 docs	AR4: 40141 docs	AR5: 101654 docs	AR6: 124708 docs	Dynamic Topics: 289318
{chang, climat, global} - 16.1	{environment, develop, problem} - 62.1	{global, environment, research} - 105.1	{data, estim, method} - 154.4	{research, issu, social} - 261.5	{climat, chang, impact} - 256.8	{research, sustain, develop} - 1854.0 Go
{period, year, data} - 14.0	{year, period, trend} - 51.7	{data, method, use} - 101.9	{manag, research, develop} - 147.4	{data, method, estim} - 231.4	{model, simul, predict} - 240.0	{climat, chang, impact} - 1686.6 Go
{model, ocean, heat} - 13.1	{sediment, deposit, late} - 51.1	{dure, holocen, late} - 89.3	{climat, chang, impact} - 137.3	{record, dure, period} - 215.0	{research, review, process} - 230.0	{record, dure, holocen} - 1592.1 Go
{water, atlant, ocean} - 12.9	{chang, climat, impact} - 47.4	{climat, chang, scenario} - 84.3	{deposit, late, format} - 130.1	{model, predict, paramet} - 202.3	{record, dure, cal} - 216.9	{chang, respons, shift} - 1565.7 Go
{degre, summer, temperatur} - 10.4	{model, predict, use} - 43.9	{model, predict, use} - 78.3	{model, predict, use} - 122.2	{climat, chang, impact} - 201.7	{increas, effect, elev} - 212.2	{model, predict, use} - 1538.2 Go
{carbon, isotop, sediment} - 10.4	{measur, method, sampl} - 41.3	{increas, decreas, effect} - 69.8	{record, glacial, event} - 113.4	{chang, increas, respons} - 196.1	{data, estim, use} - 211.7	{data, estim, use} - 1535.7 Go
{ice, sheet, sea} - 8.4	{leaf, elev, leav} - 39.1	{soil, moistur, content} - 69.7	{soil, moistur, content} - 112.9	{speci, distribut, rang} - 186.5	{emiss, reduct, reduc} - 205.0	
{sampl, measur, method} - 7.1	{carbon, dioxid, organ} - 36.4	{temperatur, air, warm} - 66.1	{increas, decreas, chang} - 109.7	{soil, moistur, organ} - 185.6	{speci, distribut, rang} - 204.2	
{emiss, soil, fertil} - 6.5	{increas, decreas, effect} - 35.5	{emiss, reduct, total} - 64.4	{speci, distribut, habitat} - 109.4	{emiss, reduct, greenhous} - 183.7	{govern, social, polit} - 202.5	
{plant, yield, growth} - 6.4	{temperatur, surfac, mean} - 34.7	{speci, communiti, distribut} - 59.4			{soil, moistur, organ} - 201.3	
{concentr, mol, increas} - 6.1						

Sustainable development, and research agendas are more prominent

words
research
sustain
develop
review
issu
process
scienc
approach
challeng
paper
discuss
understand
need
social
knowledg
ecolog
new
scientif
address
provid
articl
focus
global
framework
recent
problem
inform
govern
integr

Terms across all window topics

Adjust threshold 0.1.
Filter terms by the product of the term-window topic score and the window topic-dynamic topic scores.

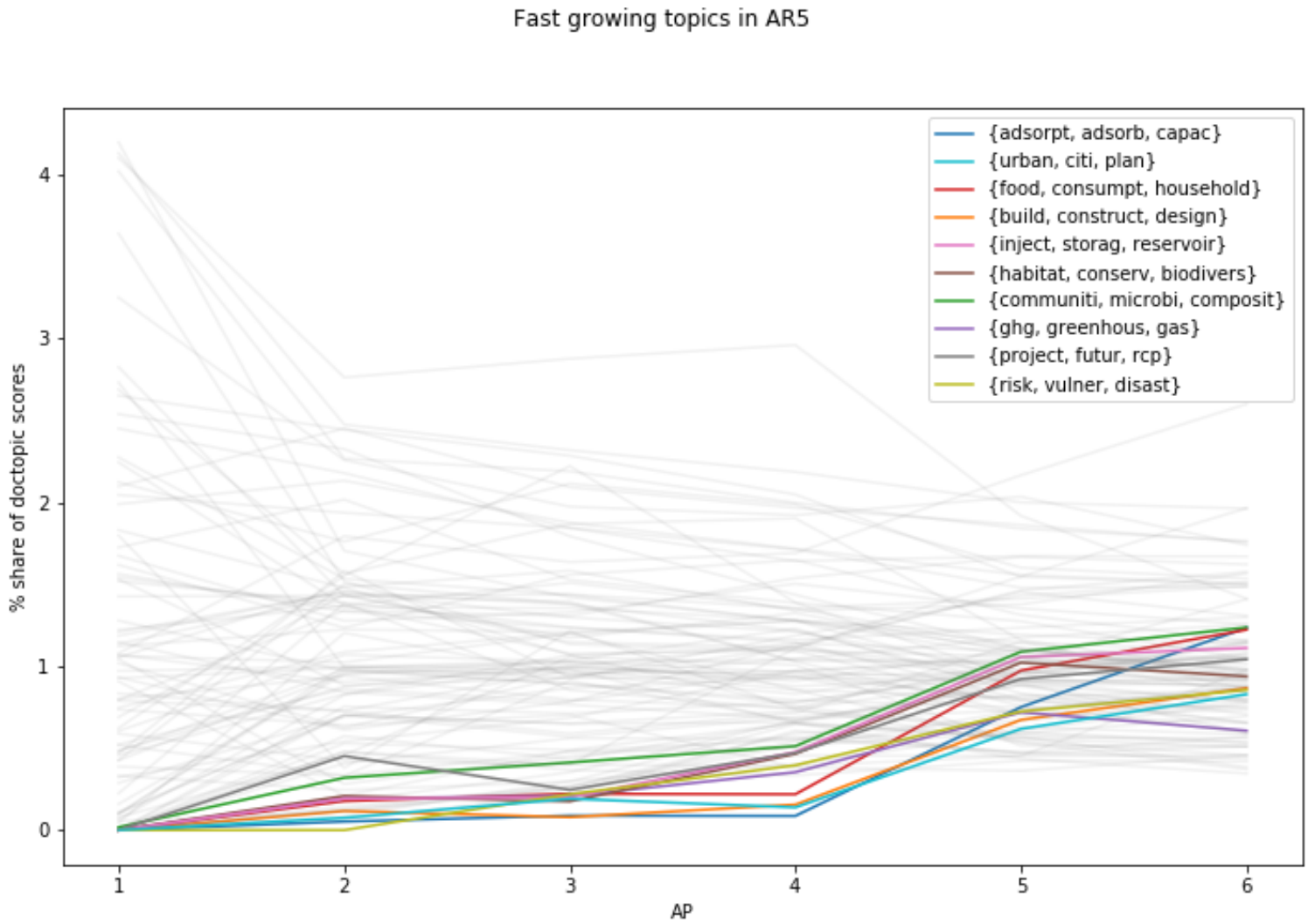
2	environment	develop	problem	research	polici	issu	intern	need	system	global
3	global	environment	research	issu	problem	impact	develop	manag	paper	human
4	manag	research	develop	sustain	issu	approach	process	need	understand	scienc
5	research	issu	social	sustain	scienc	challeng	paper	govern	articl	develop
6	research	sustain	review	process	approach	develop	knowledg	challeng	scienc	discuss

Terms in window topics where the primary dynamic topic is this one

View	0.42	2	{environment, develop, problem}	environment	develop	problem	research	polici	issu	intern	need	system	global
View	0.74	3	{global, environment, research}	global	environment	research	issu	problem	impact	develop	manag	paper	human
View	1.33	4	{manag, research, develop}	manag	research	develop	sustain	issu	approach	process	need	understand	scienc
View	2.24	5	{research, issu, social}	research	issu	social	sustain	scienc	challeng	paper	govern	articl	develop
View	2.61	6	{research, review, process}	research	review	process	approach	develop	knowledg	challeng	scienc	discuss	understand
View	1.3	6	{sustain, develop, econom}	sustain	develop	econom	resourc	social	tourism	environment	goal	framework	challeng
View	0.61	6	{govern, social, polit}	govern	social	polit	public	articl	local	action	institut	particip	engag

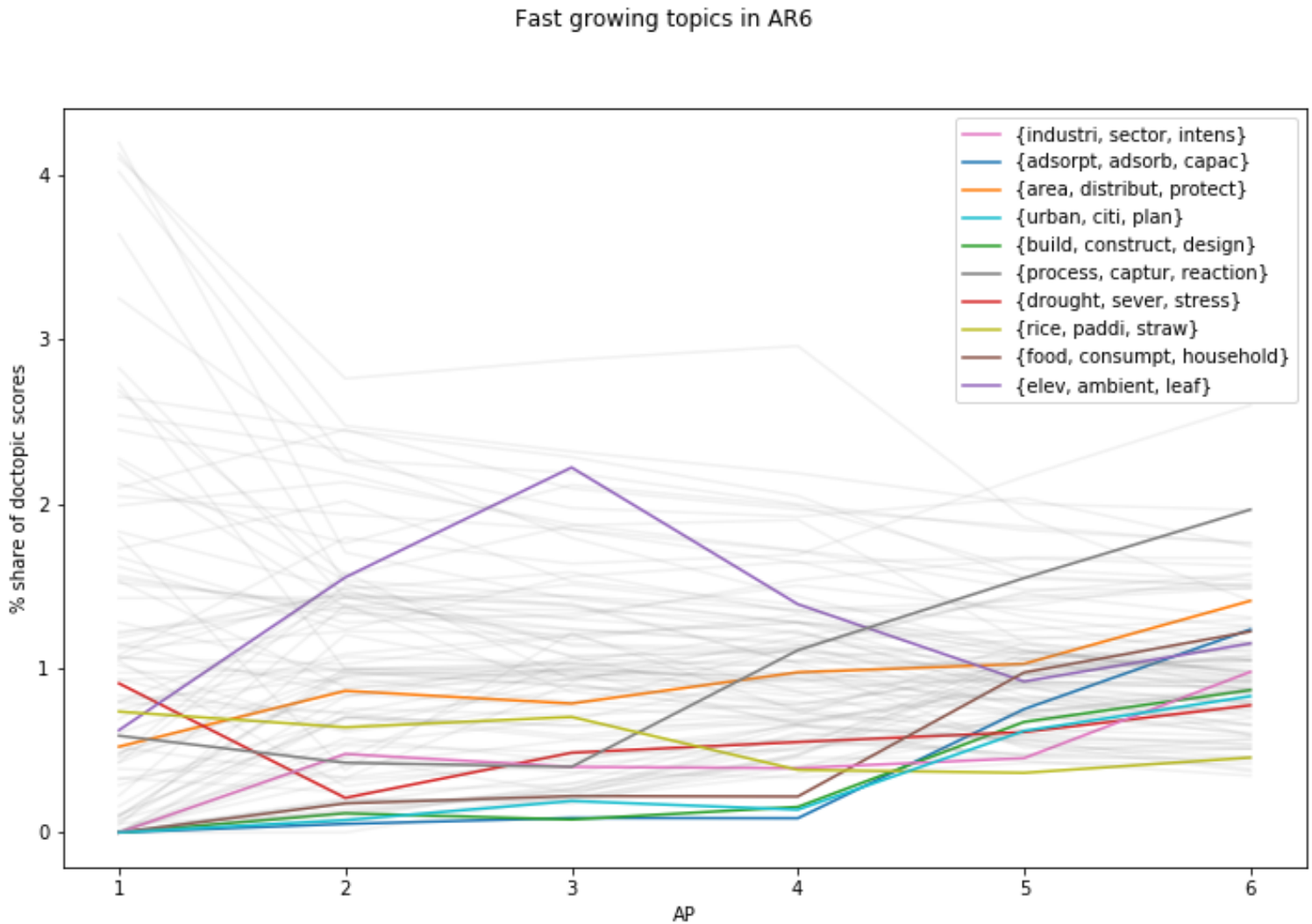
PY	Title	Topic Score
2011	Structuring sustainability science	0.1131
2016	Developing a quantitative index system for assessing sustainable forestry management in Heilongjiang Province, China: a case study	0.1008
2007	The implications of complexity for integrated resources management	0.0983
2001	Africa and global climate change: critical issues and suggestions for further research and integrated assessment modeling	0.0950
2017	Sustainability	0.0865
2006	An integrated framework for science-based arid land management	0.0843
2017	A methodological approach for the design of sustainability initiatives: in pursuit of sustainable transition in China	0.0829

Results - Development



Fast growing topics in AR5 were on urban systems, negative emissions, buildings, consumption, biodiversity and risks

Results - Development



Negative emissions topics continue to grow,

Results - topic representation in IPCC reports

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

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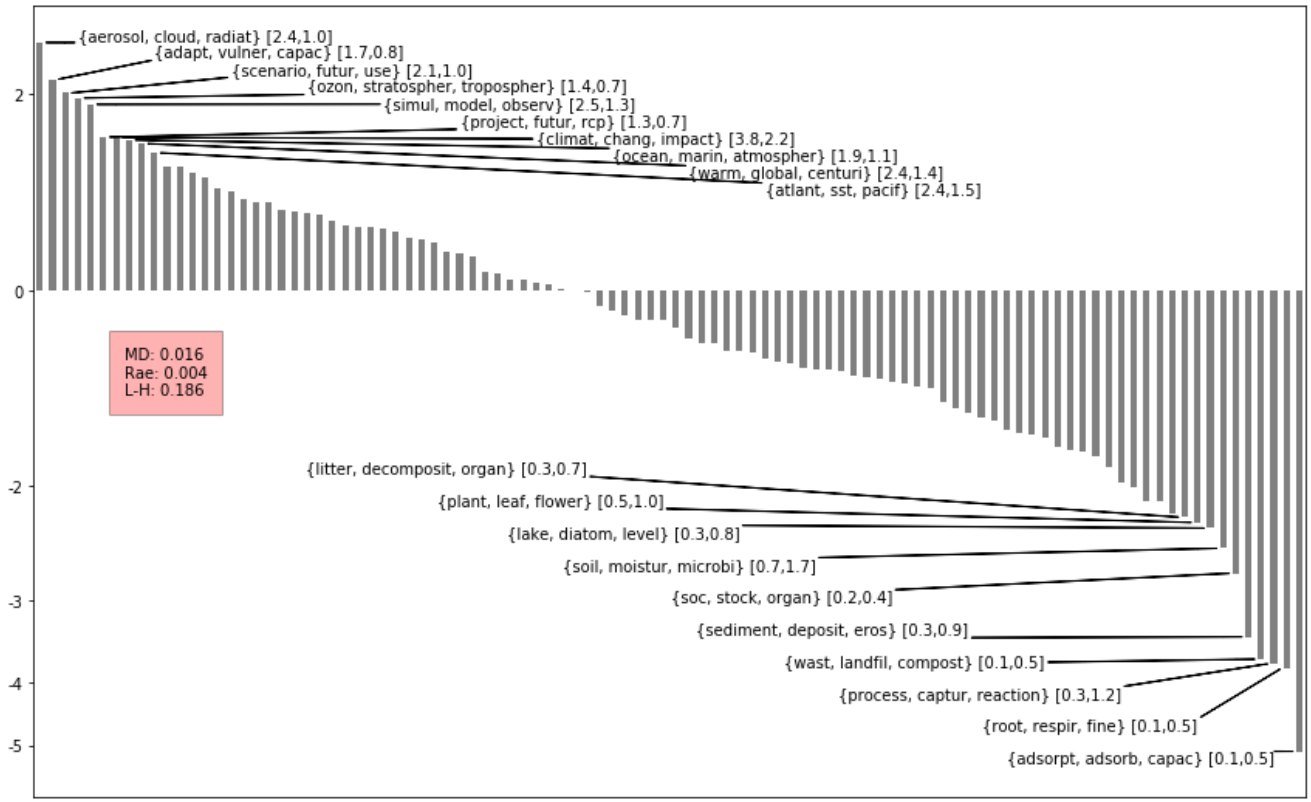
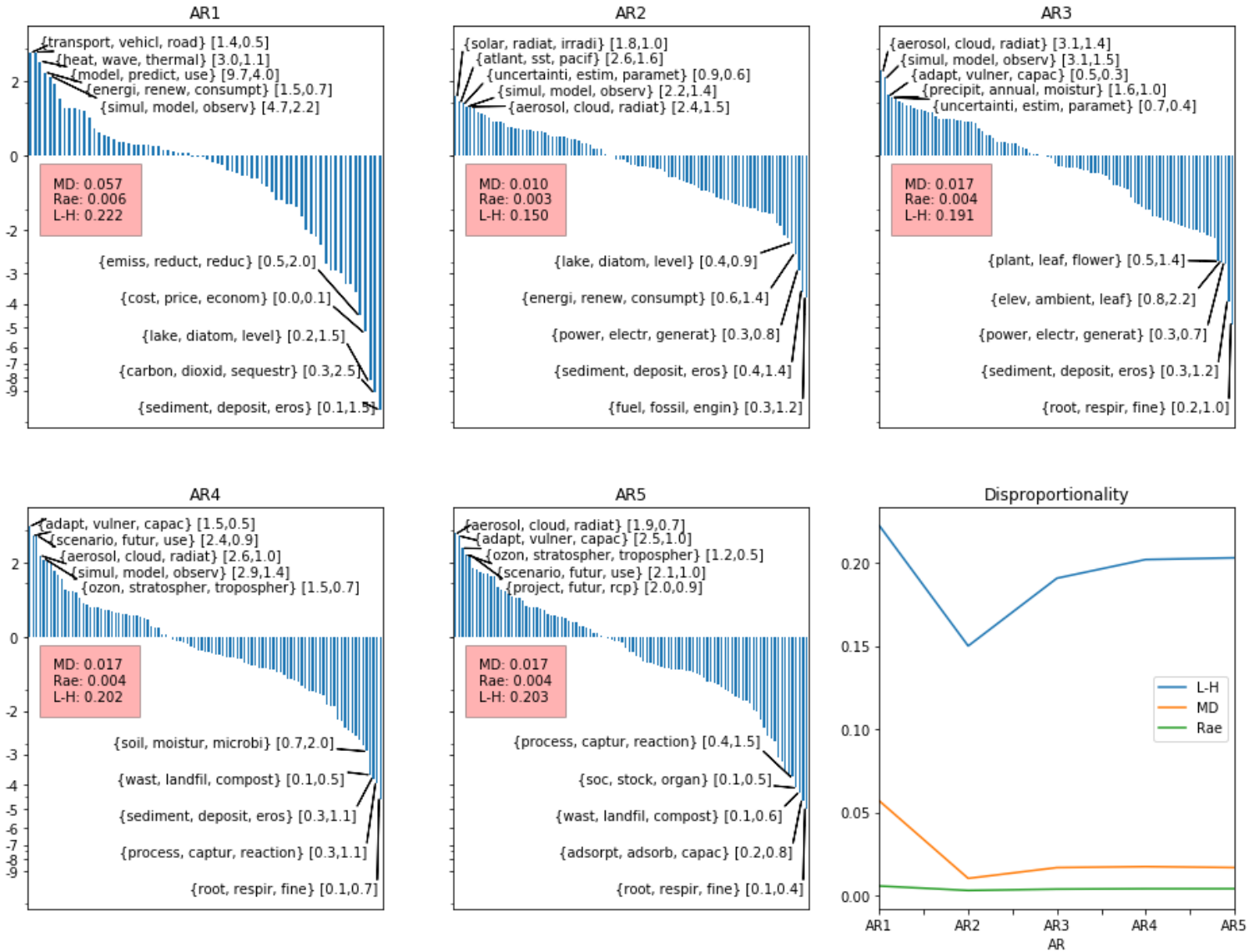
- This and other measures come from literature on the proportionality of electoral systems (e.g Karpov, 2008)

Results - topic representation in IPCC reports

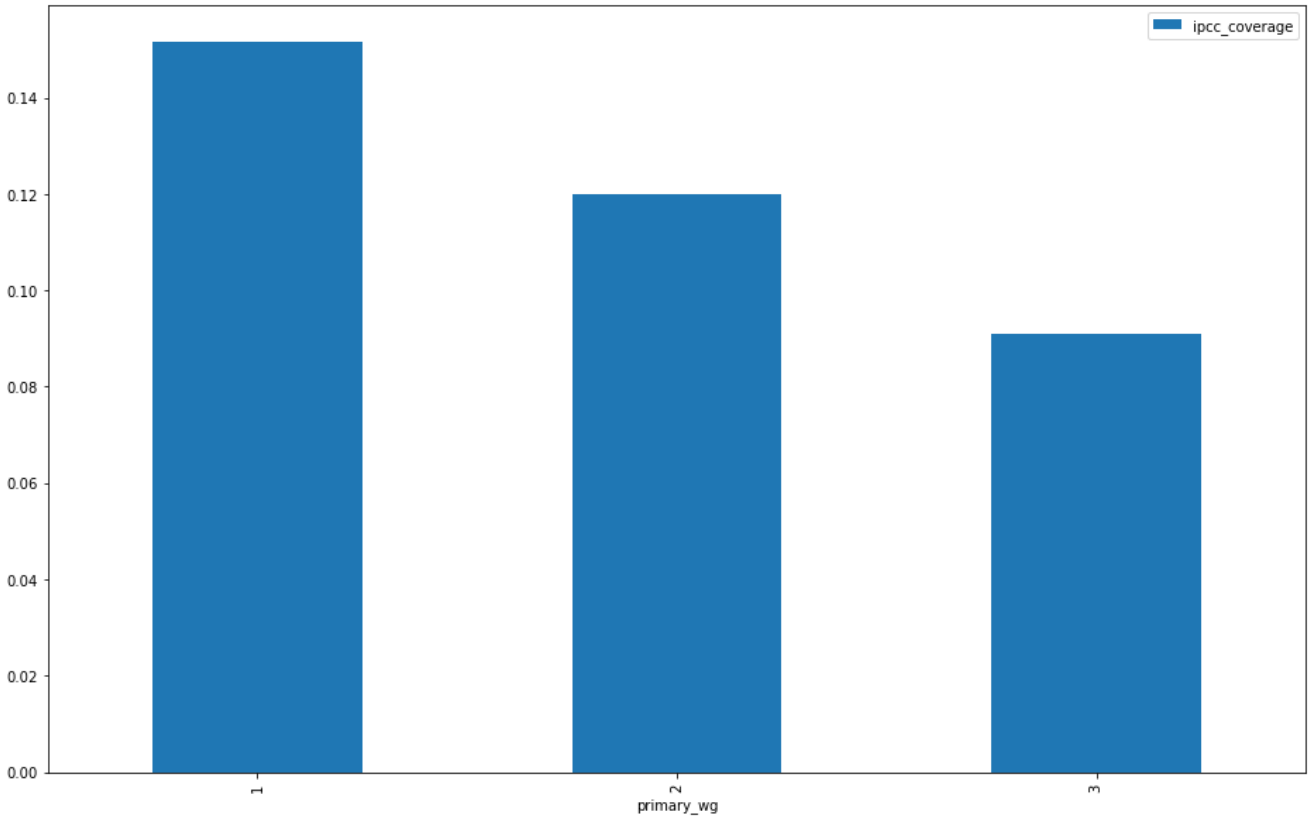


- The physical science aspects of climate change, as well topics on impacts, adaptation and scenarios are well covered by the IPCC
- Topics on specific technological solutions (particularly NETs), as well as soils and plants are less well represented

Results - topic representation in IPCC reports



Results - topic representation in IPCC reports



- On average, topics that are primarily referenced by working group I report have a higher proportion of constituent documents matching IPCC references

Results - AR6 outlook

- Outlines for the sixth assessment report have already been published

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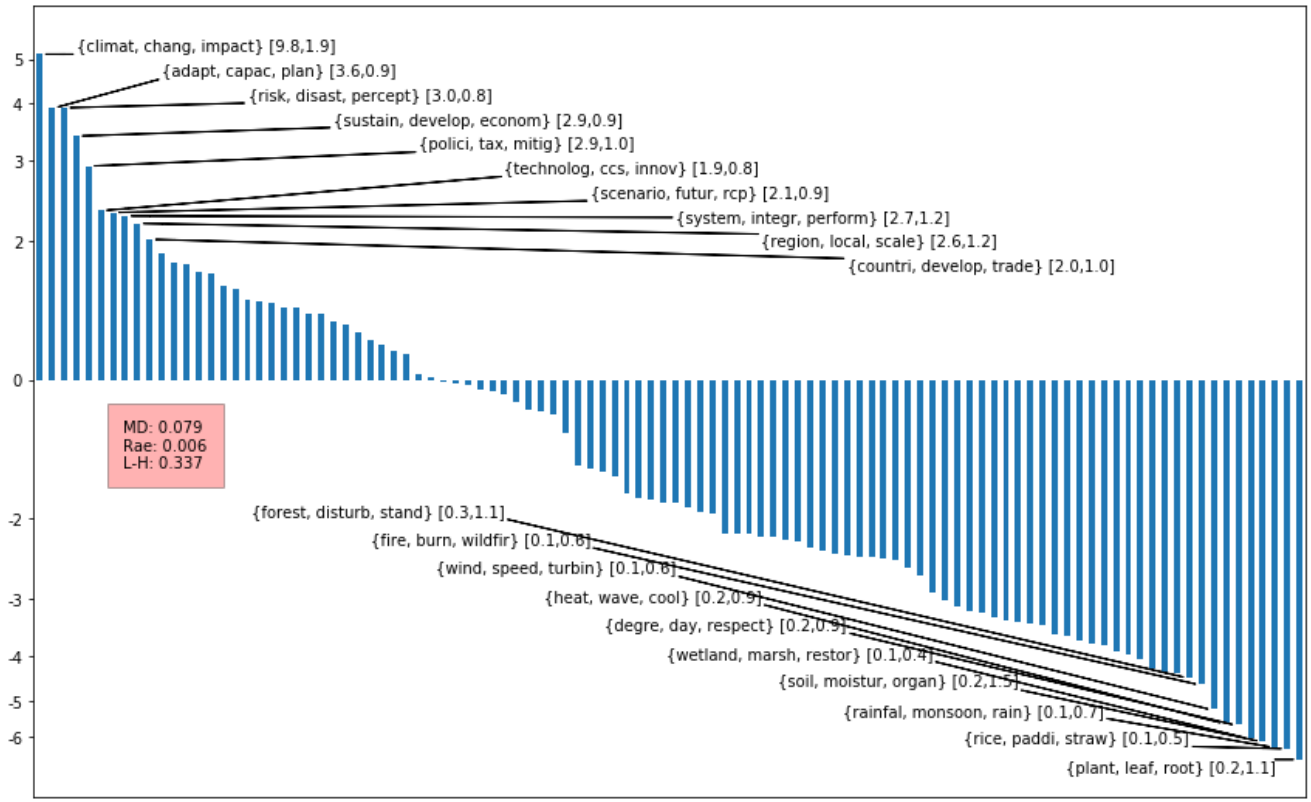
- These scores were summed and were compared to the corpus in general in the same way as with past reports

Results - topic representation in IPCC reports



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Robustness

Most work focuses on the measuring the sensitivity of the reconstruction error to different framings and parameters of the model. What we are more interested in is checking if the key messages are sound.

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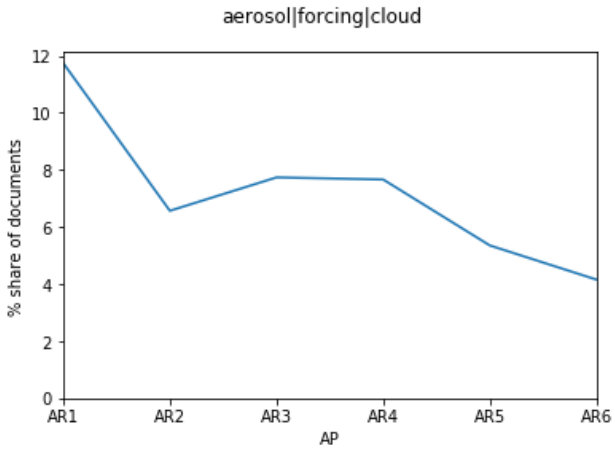

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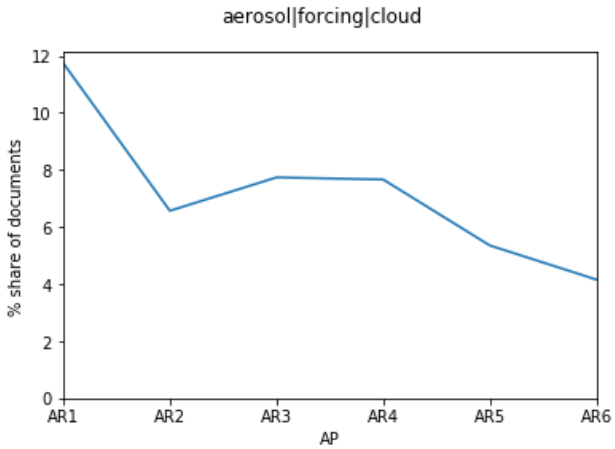

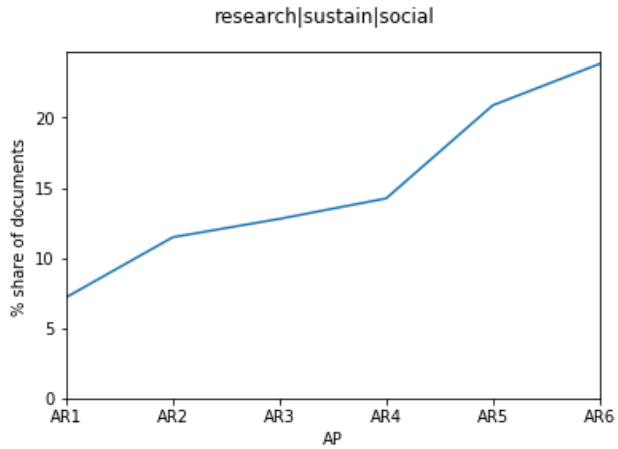

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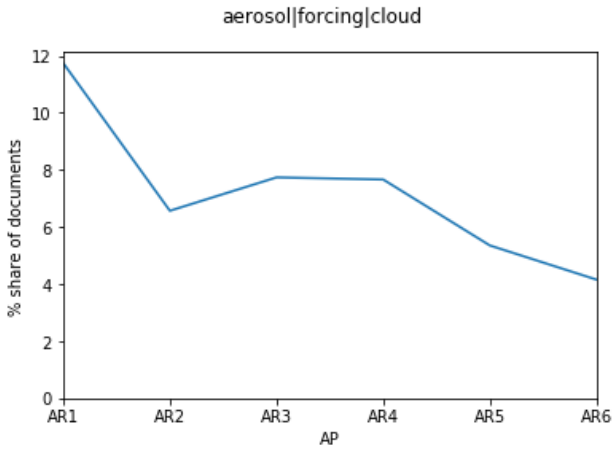

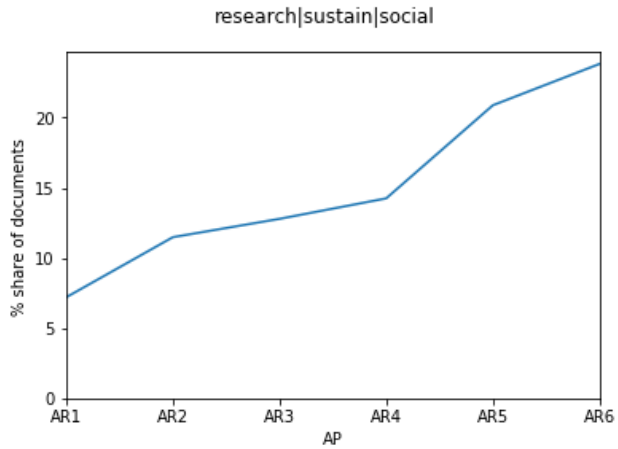

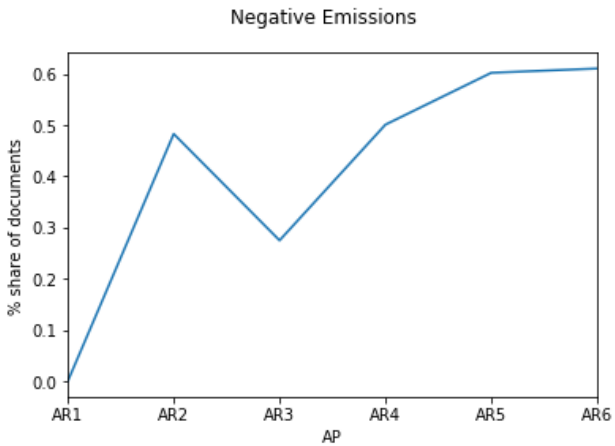

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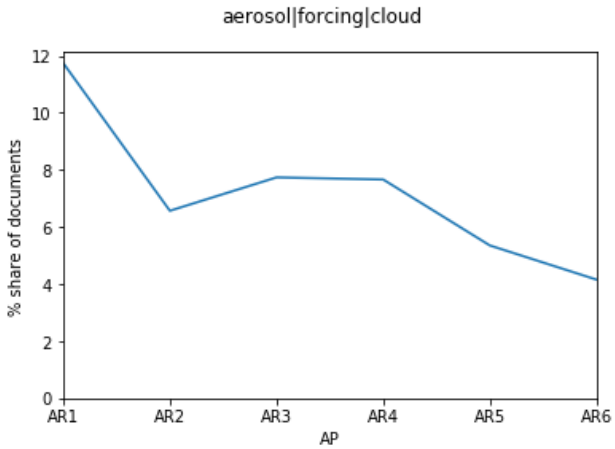

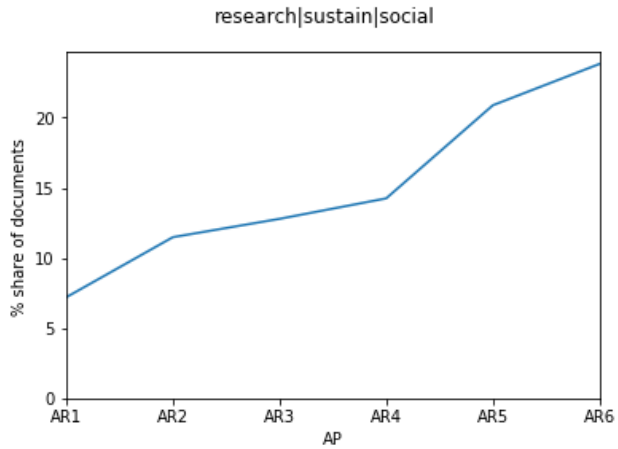

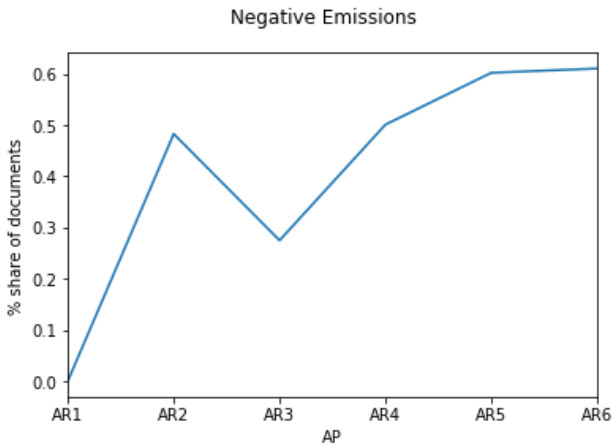

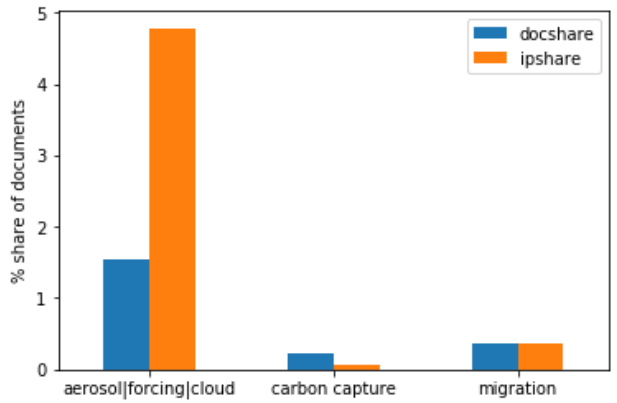

Conclusions

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- Endogenously discovered topics map and 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 specific, fast growing topics such those on negative emissions
- Some quantitative evidence is found to support policy makers' dissatisfaction with a lack of 'solution orientation' in IPCC reports (Kowarsch et al., 2017)

Discussion

- A perfectly representative relationship between the literature and IPCC reports is not necessarily desirable

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- A perfectly representative relationship between the literature and IPCC reports is not necessarily desirable
- The IPCC are best placed to decide which aspects of the literature to emphasise
- A topography of the literature helps to address issues of emphasis from a point of understanding, and to make decisions clear and transparent
- More generally, maps like this present exciting opportunities to aid the process of literature selection, and to understand the science policy process

A Topography of Climate Change Research

Figure: Portrait of map-makers, Gerard Mercator and Jodocus Hondius (Jodocus Hondius) source: `https://commons.wikimedia.org/wiki/File:Hondius_Portrait_of_map-makers.jpg`

Bibliography

Blei, D. M. and Lafferty, J. D. (2006). Dynamic Topic Models. *International Conference on Machine Learning*, pages 113–120.

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

Greene, D. and Cross, J. P. (2016). Exploring the Political Agenda of the European Parliament Using a Dynamic Topic Modeling Approach. pages 1–47.

Haunschild, R., Bornmann, L., and Marx, W. (2016). Climate Change Research in View of Bibliometrics. *PLoS ONE*, 11(7):1–19.

Karpov, A. (2008). Measurement of disproportionality in proportional representation systems. *Mathematical and Computer Modelling*, 48(9-10):1421–1438.

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*.