A Topography of Climate Change Research - Results

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1 Results

1.1 Literature growth

The literature on climate change has grown rapidly (Grieneisen and Zhang, 2011). The implications for the IPCC are discussed in (Minx et al., 2017). Since that study's publication, growth has continued (see SI figure x.)

Not only are more articles being published, the range of themes being discussed in the context of climate change (see for example recently zika and biochar, which were not to be found at all before ARs 6 and 5 respectively) has expanded.

	AR1	AR2	AR3	AR4	AR5	AR6
Years	1986-1989	1990-1994	1995-2000	2001-2006	2007-2013	2014-
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 1: Growth in climate change literature

Topic modelling helps us to map out the literature, and make sense of broad patterns in the distribution of documents and their words. In this way, we can answer questions about the growth of the climate change literature, and its representation in IPCC assessment reports. The answers to these questions can help inform IPCC processes, and understand how the IPCC functions.

1.2 Topic structure of literature maps to broad disciplinary categories

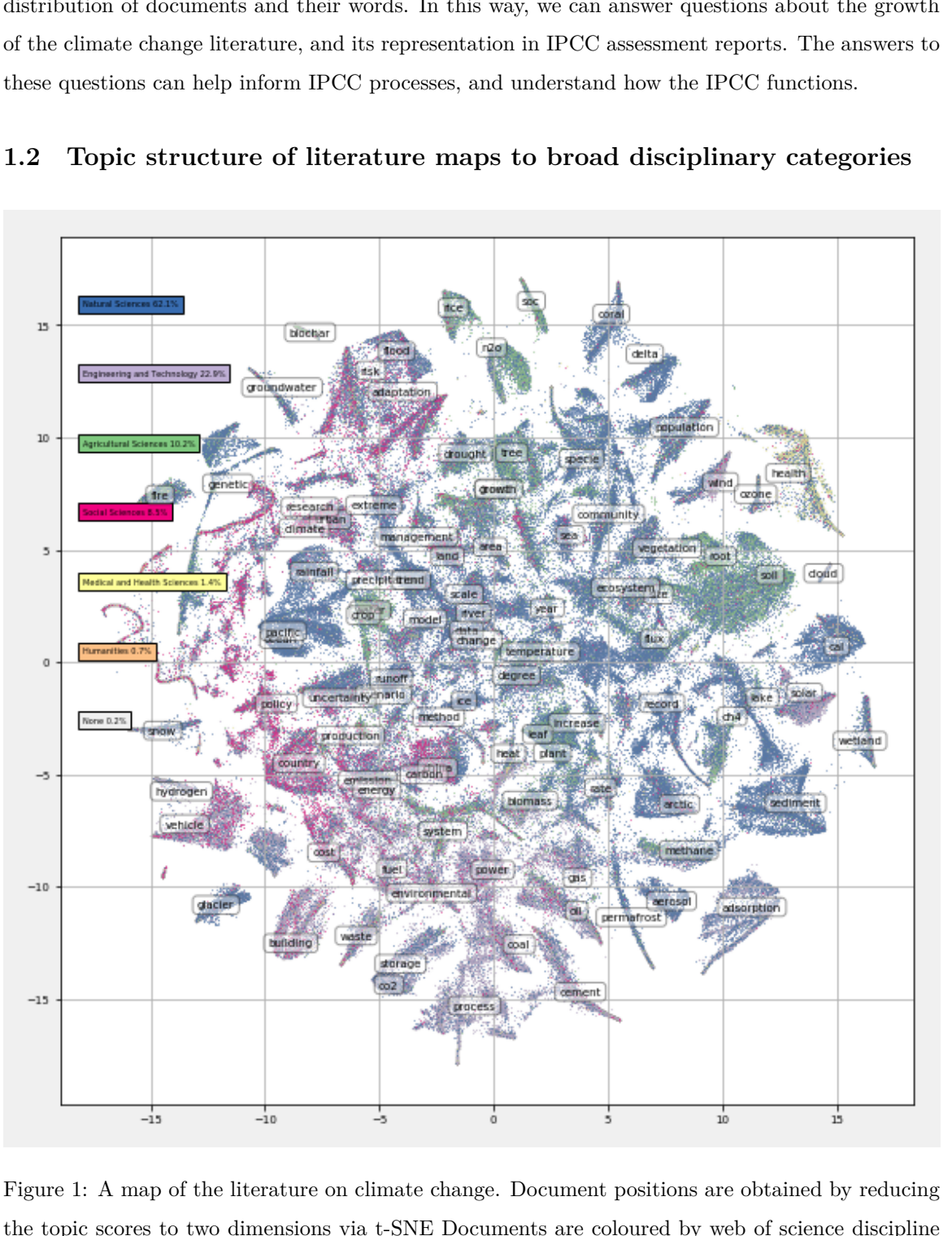

Figure 1: A map of the literature on climate change. Document positions are obtained by reducing the topic scores to two dimensions via t-SNE Documents are coloured by web of science discipline category. See SI table for topic composition of each grid square

- The thematic structure of the topics reflects journal disciplinary categories.
- Different disciplines clearly deal with different themes, although some topics are more interdisciplinary
- Topics in the south of the map (coal, oil, gas, cement, power) show a strong mix of social sciences and engineering

Show disciplinary entropy of topics in SI, give examples

1.3 Contrary to suggestions, the social sciences are over-represented in IPCC reports, while agricultural sciences and engineering are under-represented

(Bjurström and Polk, 2011) and (David G. Victor, 2015) point to an under-representation of social science literature within the IPCC, and a dominance of the natural sciences

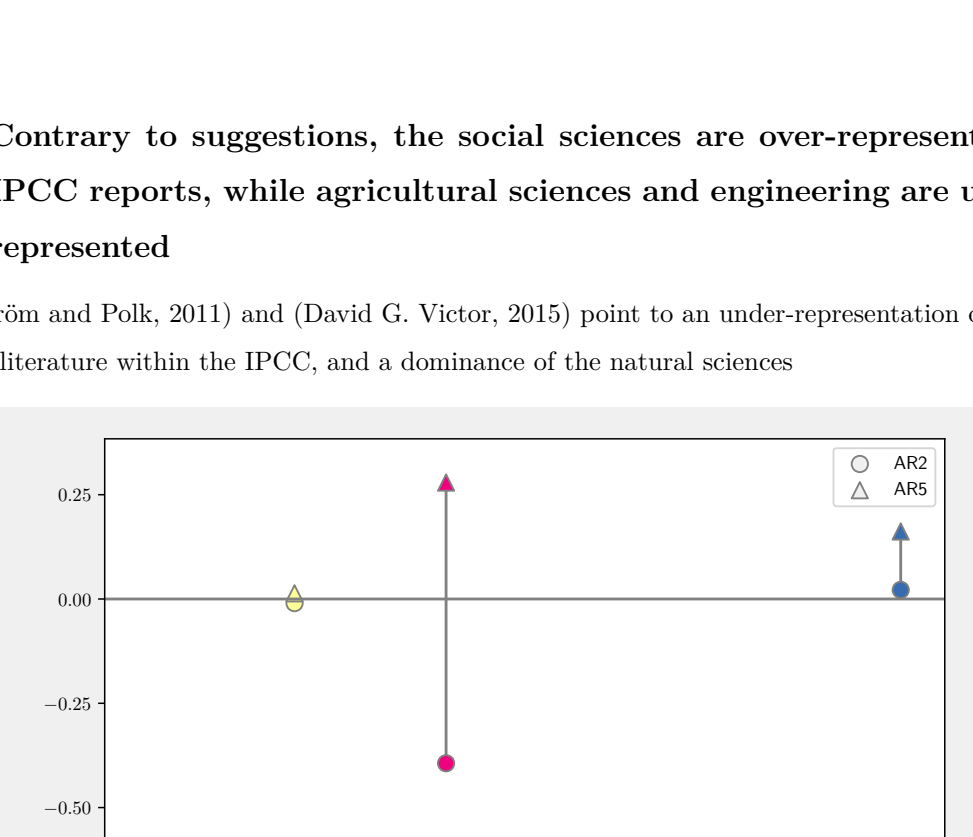

Figure 2: The representation within the IPCC of each discipline over time

- The natural sciences have always made up the greatest share of IPCC citations and documents about climate change
- The ratio of these two proportions tells us whether a certain discipline is over-represented or under-represented
- The natural are indeed slightly over-represented
- Although the Social sciences were under-represented in the past, by AR5, they were the most over-represented discipline

1.4 Solution oriented topics have seen rapid growth, which has not been matched by coverage in the IPCC

The topic model allows us to dig deeper into the content of the types of documents which are under-represented in the IPCC, as well as helping us understand how the thematic structure of the literature has developed.

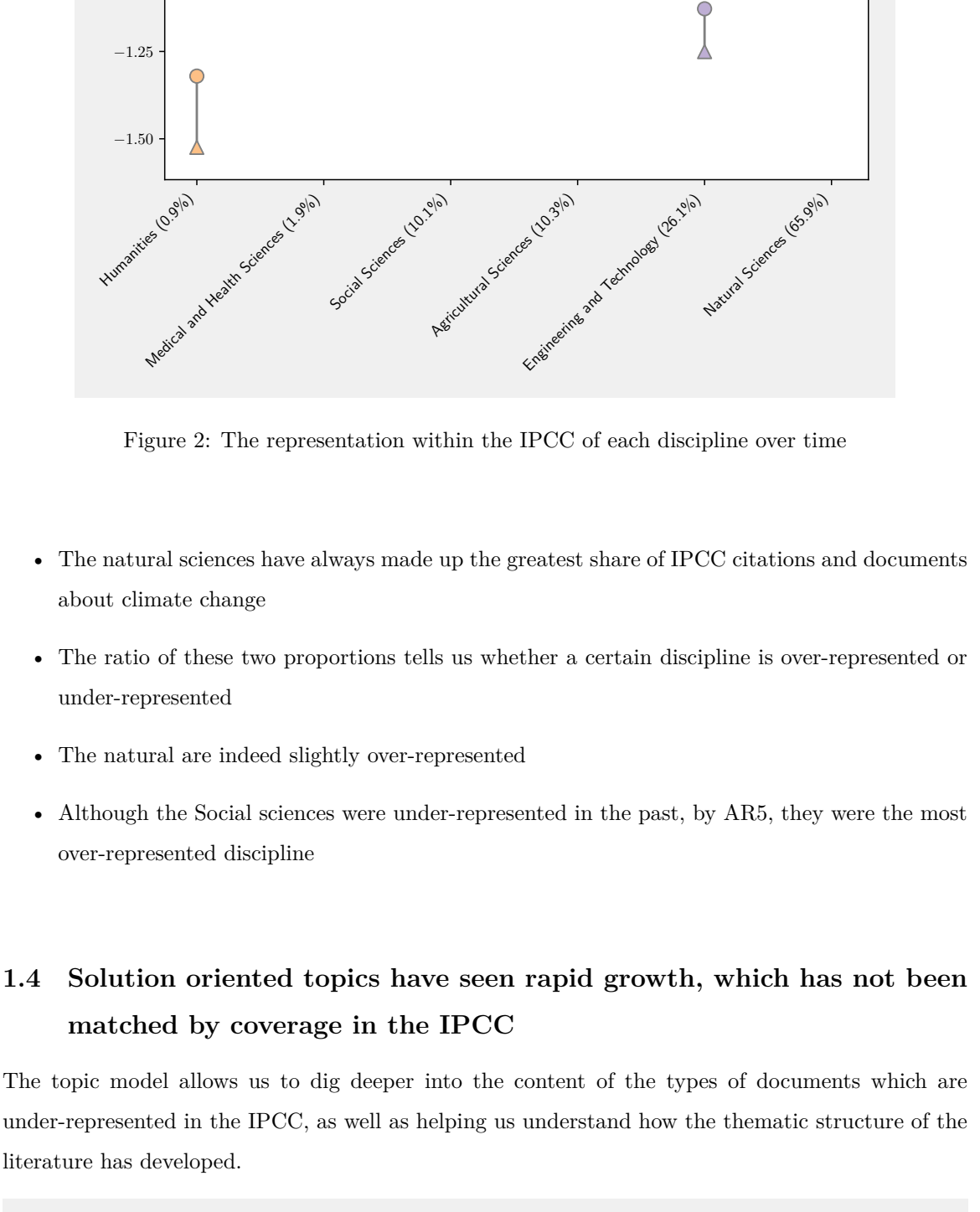

Figure 3: A map of the literature on climate change. Document positions are obtained by reducing the topic scores to two dimensions via t-SNE Documents are coloured by working group citations. In each assessment period, the largest cluster of documents relating to each of the 10 fastest growing topics is outlined.

- 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)
- A number of different patterns of growth are visible. Adsorption was a fast growing topic in AR5, but had few IPCC citations, while risk and adaptation were fast growing, with many WGII citations

By plotting each topic's newness and IPCC representation, we can dig down into the types of topics which are over or under represented

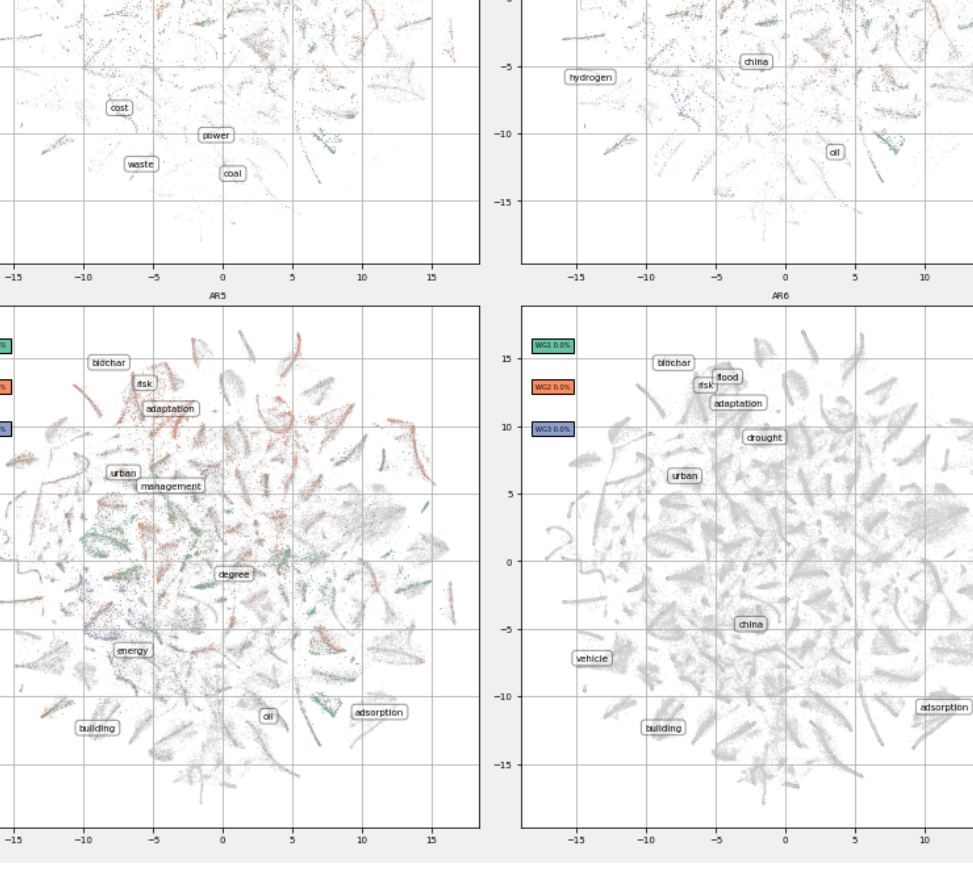

Figure 4: The IPCC representation and age of the topics. Representation shows the log of the share of topic documents in IPCC citations divided by the share of topic documents among all documents. Assessment period occurence shows the assessment period in which the mean topic document was published

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

Within working group III, those topics which have more citations from the social sciences are better represented (SI figure x.) These are general topics about policy options, and international politics. Those topics which are not well represented are on specific solutions, such as vehicles, buildings, and negative emissions.

While there may be a need for more social science knowledge in IPCC assessments, this analysis makes it clear that this is rather a task for social scientists to produce more knowledge, than for the IPCC to reflect it better.

Further, given Policymakers' demands for more solution-oriented knowledge, the IPCC may do well to make efforts to cover more of the literature on individual solutions.

It may be argued that the technical solution-oriented knowledge is not yet in a proper form for synthesis by the IPCC. Although this is not an argument made for WGII (where the relationship between social science percentage and IPCC coverage for topics is not found), it would then be a task for the social sciences to produce research on solution oriented topics: increasing, for example, the less than 5% of the research on biochar that is published by social scientists.

2 SI

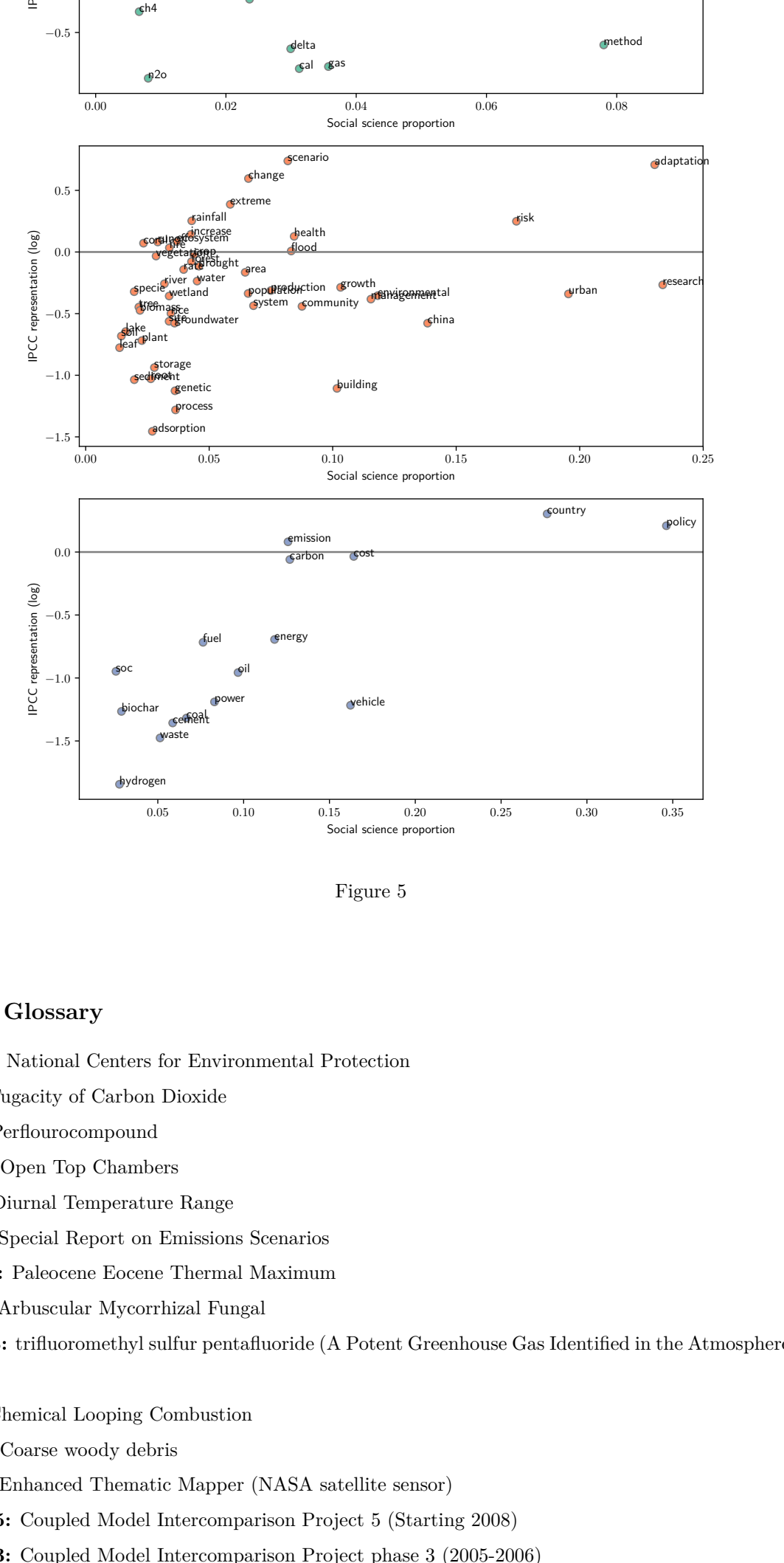

Figure 5

2.1 Glossary

ncep: National Centers for Environmental Protection
fco: Fugacity of Carbon Dioxide
pfc: Perflourocompound
otcs: Open Top Chambers
dtr: Diurnal Temperature Range
sres: Special Report on Emissions Scenarios
petm: Paleocene Eocene Thermal Maximum
amf: Arbuscular Mycorrhizal Fungal
sf5cf3: trifluoromethyl sulfur pentafluoride (A Potent Greenhouse Gas Identified in the Atmosphere, 2000)
clc: Chemical Looping Combustion
cwd: Coarse woody debris
etm: Enhanced Thematic Mapper (NASA satellite sensor)
cmip5: Coupled Model Intercomparison Project 5 (Starting 2008)
cmip3: Coupled Model Intercomparison Project phase 3 (2005-2006)
mofs: metal-organic frameworks (for CO2 storage)
sdm: statistical-dynamical model
mmms: Mixed Matrix Membranes (for CO2 capture)
cop21: 21 Conference of Parties (Paris 2015)
c3n4: Carbon nitride (a synthetic nanomaterial used for hydrogen production)
sdg: Sustainable Development Goals
indc: Intended Nationally Determined Contributions

	ipcc_share	share	representation	primary_wg	title	year_av
0	0.001476	0.005231	0.282130	3	{biochar, application, amendment}	4.750000
1	0.003186	0.008295	0.384082	3	{oil, biodiesel, palm}	4.695652
2	0.002360	0.007757	0.304271	3	{power, generation, electricity}	4.659091
3	0.006647	0.013308	0.499460	3	{energy, consumption, demand}	4.651163
4	0.011804	0.009582	1.231926	3	{policy, tax, sector}	4.651163
5	0.002172	0.007335	0.296183	3	{vehicle, electric, transport}	4.634146
6	0.001146	0.007246	0.158202	3	{hydrogen, catalyst, cell}	4.632653
7	0.002137	0.005510	0.387745	3	{soc, stock, soil}	4.630435
8	0.002861	0.011114	0.257421	3	{cement, material, concrete}	4.627907
9	0.010778	0.011162	0.965569	3	{cost, price, technology}	4.600000
10	0.016243	0.012001	1.353438	3	{country, develop, international}	4.595745
11	0.001480	0.005529	0.267688	3	{coal, combustion, technology}	4.588235
12	0.001508	0.006596	0.228565	3	{waste, landfill, treatment}	4.586957
13	0.003876	0.007937	0.488317	3	{fuel, fossil, engine}	4.560000
14	0.018589	0.017141	1.084467	3	{emission, ghg, reduction}	4.551020
15	0.010033	0.010648	0.942243	3	{carbon, low, sink}	4.530612
16	0.019166	0.009443	2.029604	2	{adaptation, vulnerability, farmer}	4.783784
17	0.004838	0.006800	0.711486	2	{urban, city, urbanization}	4.764706
18	0.002535	0.007666	0.330639	2	{building, design, construction}	4.717949
19	0.014287	0.011136	1.282994	2	{risk, disaster, vulnerability}	4.700000
20	0.001672	0.007167	0.233350	2	{adsorption, capacity, adsorbent}	4.675676
21	0.006691	0.011923	0.561208	2	{china, province, chinese}	4.675000
22	0.003102	0.009564	0.324295	2	{genetic, diversity, gene}	4.674419
23	0.003612	0.009224	0.391591	2	{storage, reservoir, injection}	4.659574
24	0.005945	0.005535	1.074085	2	{coral, reef, bleaching}	4.653061
25	0.007807	0.011444	0.682218	2	{management, resource, conservation}	4.651163
26	0.007568	0.010597	0.714164	2	{population, size, habitat}	4.645833
27	0.009763	0.008601	1.135212	2	{health, disease, human}	4.644444
28	0.020933	0.027325	0.766059	2	{research, social, issue}	4.644444
29	0.009519	0.013136	0.724671	2	{specie, distribution, habitat}	4.638298
30	0.003110	0.011201	0.277666	2	{process, membrane, solvent}	4.636364
31	0.005697	0.008857	0.643292	2	{community, microbial, composition}	4.627907
32	0.009337	0.013307	0.701647	2	{environmental, impact, life}	4.627907
33	0.005229	0.005866	0.891301	2	{drought, stress, index}	4.609756
34	0.005803	0.005757	1.007890	2	{flood, flooding, damage}	4.604651
35	0.010915	0.014922	0.731477	2	{production, food, farm}	4.600000
36	0.003627	0.006461	0.561418	2	{groundwater, recharge, aquifer}	4.600000
37	0.020661	0.009868	2.093696	2	{scenario, future, project}	4.595745
38	0.007511	0.011614	0.646723	2	{system, performance, design}	4.586957
39	0.006552	0.008477	0.772935	2	{river, basin, flow}	4.571429
40	0.004917	0.004751	1.034883	2	{fire, burn, wildfire}	4.568627
41	0.013464	0.015880	0.847837	2	{area, region, distribution}	4.565217
42	0.015998	0.010870	1.471793	2	{extreme, event, weather}	4.565217
43	0.012221	0.011233	1.087930	2	{ecosystem, terrestrial, net}	4.562500
44	0.008284	0.008467	0.978463	2	{crop, yield, wheat}	4.558140
45	0.006225	0.005740	1.084623	2	{runoff, catchment, hydrological}	4.551020
46	0.004990	0.007132	0.699621	2	{wetland, marsh, habitat}	4.520833
47	0.008846	0.006869	1.287774	2	{rainfall, monsoon, rain}	4.520000
48	0.010155	0.012861	0.789619	2	{water, resource, irrigation}	4.510638
49	0.005098	0.008187	0.622666	2	{biomass, aboveground, bioenergy}	4.480000
50	0.007313	0.012833	0.569862	2	{site, elevation, high}	4.471698
51	0.007674	0.008303	0.924322	2	{forest, stand, tropical}	4.470588
52	0.004958	0.007752	0.639595	2	{tree, ring, stand}	4.470588
53	0.026598	0.014656	1.814824	2	{change, climatic, response}	4.452830
54	0.004392	0.009012	0.487355	2	{plant, seed, stress}	4.450980
55	0.010987	0.012667	0.867345	2	{rate, litter, decomposition}	4.442308
56	0.009974	0.013288	0.750552	2	{growth, economic, relationship}	4.437500
57	0.009435	0.018665	0.505501	2	{soil, moisture, microbial}	4.433962
58	0.022989	0.019927	1.153663	2	{increase, concentration, effect}	4.431373
59	0.004003	0.007631	0.524600	2	{lake, level, diatom}	4.425926
60	0.008672	0.008962	0.967600	2	{vegetation, ndvi, index}	4.423077
61	0.003778	0.010649	0.354791	2	{sediment, erosion, core}	4.418182
62	0.003259	0.005365	0.607542	2	{rice, paddy, field}	4.413043
63	0.001751	0.004899	0.357442	2	{root, fine, litter}	4.327273
64	0.003527	0.007666	0.460028	2	{leaf, photosynthesis, photosynthetic}	4.232143
65	0.009283	0.016805	0.552391	1	{method, use, approach}	4.613636
66	0.027283	0.012961	2.105020	1	{uncertainty, estimate, projection}	4.591837
67	0.015975	0.009220	1.732693	1	{trend, station, significant}	4.580000
68	0.008020	0.007699	1.041678	1	{wind, speed, turbine}	4.571429
69	0.028312	0.023966	1.181354	1	{scale, spatial, variability}	4.571429
70	0.005978	0.007061	0.846558	1	{heat, wave, stress}	4.568182
71	0.011383	0.014051	0.810092	1	{data, use, satellite}	4.510204
72	0.013545	0.009377	1.444487	1	{land, cover, agricultural}	4.510204
73	0.017351	0.014745	1.176686	1	{degree, day, latitude}	4.500000
74	0.030144	0.013012	2.316559	1	{climate, future, global}	4.490566
75	0.017550	0.008862	1.980422	1	{arctic, warm, tundra}	4.481481
76	0.030064	0.017317	1.736093	1	{model, simulation, simulate}	4.480000
77	0.003953	0.008421	0.469484	1	{gas, natural, hydrate}	4.480000
78	0.015667	0.009617	1.629061	1	{precipitation, annual, moisture}	4.480000
79	0.016265	0.009344	1.740611	1	{sea, level, rise}	4.471698
80	0.018413	0.012939	1.423031	1	{temperature, warm, air}	4.470588
81	0.011250	0.009070	1.240376	1	{permafrost, thaw, layer}	4.460000
82	0.016362	0.013899	1.177200	1	{year, season, period}	4.454545
83	0.006649	0.004792	1.387340	1	{glacier, mass, balance}	4.444444
84	0.009897	0.007431	1.331933	1	{snow, cover, winter}	4.444444
85	0.002615	0.005658	0.462152	1	{cal, pollen, holocene}	4.440678
86	0.008515	0.007036	1.210228	1	{solar, radiation, irradiance}	4.423077
87	0.025430	0.011594	2.193472	1	{pacific, sst, enso}	4.410714
88	0.003498	0.006519	0.536520	1	{delta, isotope, value}	4.406780
89	0.018381	0.005610	3.276517	1	{aerosol, forcing, radiative}	4.362069
90	0.020180	0.011032	1.829170	1	{ozone, air, stratospheric}	4.357143
91	0.010142	0.013020	0.778990	1	{co2, mol, concentration}	4.346154
92	0.011092	0.011639	0.953008	1	{record, glacial, late}	4.338710
93	0.010530	0.010335	1.018868	1	{flux, measurement, surface}	4.327869
94	0.014068	0.005863	2.399568	1	{cloud, feedback, radiative}	4.315789
95	0.002732	0.006355	0.429918	1	{n2o, denitrification, emission}	4.313725
96	0.012937	0.005966	2.168370	1	{ice, sheet, sea}	4.285714
97	0.024596	0.009525	2.582329	1	{ocean, surface, deep}	4.278689
98	0.006208	0.007005	0.886203	1	{methane, oxidation, source}	4.267857
99	0.004046	0.005705	0.709267	1	{ch4, oxidation, emission}	4.265306

Table 2: Topics and their representation

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