Signals of Doubt: Text-Mining Climate Skepticism

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Abstract

Although agreement among scientists on anthropogenic climate change is clear, national surveys show that the American public's perceptions on the science of climate change diverge significantly from the "consensus view." Explanations for this divergence range from the influence of local weather events to the health of the economy, while many place blame on the efforts of climate change deniers to sway public opinion away from mainstream climate science. This study examines the dynamics of climate change "contrarianism" in the American context by analyzing the content of major conservative think tanks on the issue from the mid 1990s to the present. Specifically, we rely on an unsupervised text classification algorithm to produce time series measures of climate skepticism. Our results highlight how even simple uses of recent advances in natural language processing provide insight into key questions in the literature on media coverage of the environment.

Keywords: climate change, skeptics, text classification, latent Dirichlet allocation

1 Introduction

Climate scientists resoundingly agree that the Earth is getting warmer and that the rise in average temperature is predominantly due to human activity. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) states that, "warming of the climate system is unequivocal", and that "it is extremely likely that human activities have exerted a substantial

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net warming influence on climate since 1750"(Solomon et al. 2007). Similar statements have been made by major scientific organizations. For example, in the United States, the National Academy of Sciences concurs, stating that, "there is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities" (National Research Council 2010). In their survey of a representative sample of Earth scientists, Doran and Zimmerman (2009) find that 96.2% of respondents who are active climate researchers agree that mean global temperatures relative to pre-1800s levels have risen, and 97.4% of the same group agree that human activity is a significant contributor to the changing average global temperature. The authors conclude by stating that, "it seems that the debate on the authenticity of global warming and the roles played by human activity is largely nonexistent among those who understand the nuances and scientific basis of long-term climate processes"(Doran and Zimmerman 2009, p. 23). Anderegg et al. (2010) find that among 1,372 active climate researchers, 97-98% agree with the main tenets of anthropogenic climate change as expressed in the IPCC Fourth Assessment Report. [1] In a recent survey of 11,944 academic articles on climate change over the period 1991-2011, Cook et al. (2013) find that among the studies that express an opinion on anthropogenic global warming, over 97% agree with the consensus view that increases in the average global temperature have been caused by human greenhouse gas emissions.

While a strong consensus among climate scientists regarding human-induced rising global temperatures appears to be a reality, perceptions among the American public on climate change diverge significantly from the "consensus view". In 2012, 41% of Americans believed that increases in the Earth's temperature are determined by "effects of natural changes in the environment that are not due to human activities", while 32% believed that scientists are "unsure" about whether global warming is occurring, and 42% held the view that the seriousness of global warming is "generally exaggerated" in the news (up from 30% in 2006) (Gallup News Service 2012). Americans also seem to be global leaders in opposing mainstream climate science. In 2010, a survey of 150 countries found that the United States had the largest share of respondents (47%) who primarily attribute rising global temperatures to natural causes (Ray and Pugliese 2011).

What explains this chasm in understanding of global warming between climate change experts and the general American public? This question has been explored extensively in the literature (e.g., Immerwahr 1999, Sterman and Sweeney 2002, Krosnick et al. 2006, Brody et al. 2008, Kellstedt et al. 2008, Borick and Rabe 2010). Explanations of the divergence between beliefs on climate change held by scientists with those of large segments of the U.S. population abound. Some have argued that short-term weather phenomena can have significant impacts on lay opinion on climate science if affected people believe that recent local temperatures are abnormally high Li et al. 2011, Egan 2012,

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[1]Specifically, that it is "very likely" that human-made greenhouse gas emissions have been responsible for "most" of the "unequivocal" warming of the average global temperature in the second half of the 20th century (Anderegg et al. 2010, p. 12107)

Krosnick et al. 2006. Others argue that the state of the economy influences public concern for climate change. As economic conditions, such as unemployment, worsen, studies have shown that the public tends to attribute a lower priority to climate change Guber 2003, Smith et al. 2011, Scruggs and Benegal 2012. Empirical evidence also suggests that information attribution and elite cues influence public opinion on global warming Guber (2013).

One prominent explanation–and the emphasis of the current study–is the influence of skeptical segments of the conservative movement on the public's understanding of climate science. In this paper, we apply automated text analytic methods to systematically understand what arguments climate change contrarians have put forth into the public sphere and how the prevalence of these arguments has evolved over time.

2 Understanding 21st Century Climate Change Contrarianism

This study focuses on the role of segments of the American conservative movement that have targeted climate science and environmental policy proposals which seek to address global warming. McCright and Dunlap (2000; 2003) argue that a concerted effort on the part of an ideologically conservative countermovement to climate science is largely responsible for the troubling levels of skepticism among the American public regarding the soundness of climate science and the need for policies, such as carbon emission reductions, to combat global warming.

McCright and Dunlap (2010) describe this conservative countermovement against climate science and policy as a network of conservative foundations, think-tanks, media outlets and public intellectuals that are heavily funded by conservative families and various corporations. The level of climate change denial varies within this network: in the extreme case, some continue to espouse the view that irregular warming is not occurring, while others concede the observed warming trend but deny any human cause. Some within the network agree that the warming is anthropogenic but strongly disagree with mitigation policies.

This movement is not a new phenomenon. Conservative activism against environmental policymaking emerged in parallel with the first steps toward environmental regulation during the late 1960s and early 1970s. The objective of these activists is tackling what many within the movement regard as anti-modernist scientific inquiries and policies—that is, science that seeks to evaluate the impacts and costs of modern industrialist production (Scnaiberg 1980, McCright and Dunlap 2010). The policy implications of this "impact science" is viewed as a threat to free-market capitalism by many conservative anti-environmentalists and, as such, it should be challenged in order to protect economic productivity and technological innovation.

Having gained significant political power with the arrival of Ronald Reagan to the White House, conservative activists pushed to weaken the authority of the

Environmental Protection Agency and the Department of the Interior, albeit unsuccessfully McCright and Dunlap (2010). Indeed, the push for curtailing environmental policies during the first Reagan administration was met with popular discontent Gillroy and Shapiro (1986). Nonetheless, attempts to dismantle the environmental regulatory architecture, prevent substantive environmental protection policy, and reduce support for environmental research picked up during the Republican-led Congress of the mid 1990s, continued through the presidency of George W. Bush, and have persisted to the present. McCright and Dunlap (2010) review how, to achieve these ends, anti-environmentalist activist groups have relied on tactics such as:

1. Obfuscating and undermining consensus scientific findings by promoting contrarian viewpoints and selectively focusing on studies which deviate from the consensus view, while choosing to ignore or misrepresent mainstream climate science (see McCright and Dunlap 2000; 2003; 2010, Mooney 2005, see).

2. Manipulating, altering, and suppressing climate science reports produced by government agencies. For example, the Bush Administration effectively excluded the comprehensive Clinton-era report *National Assessment of Potential Consequences of Climate Variability and Change* from all official climate-related documents (see Mooney 2007).

3. Targeting climate scientists in academia and government agencies with intimidation and threats of sanctions (see McCright and Dunlap 2000; 2003, Oreskes and Conway 2010).

The tactic most relevant to the current study, however, is the concerted effort by the conservative countermovement to sway public opinion on climate science and policy through the media and public events. Regarding the use of media, the effort has largely been effective in generating what has come to be known as the "dueling scientists scenario" McCright and Dunlap (2003), whereby, in an effort to uphold the journalistic norm of "objectivity," rigorous findings and unsubstantiated speculation are effectively equated and mixed together to produce a "confusing impression that scientists share no consensus of the probable magnitude, timing, and potential seriousness of the environmental and societal consequences of the documented and well-understood buildup of various greenhouse-enhancing gases in the atmosphere" Schneider (1993). In their seminal study on the role of "balanced reporting" on climate change in the American "prestige" print press, Boykoff and Boykoff (2004) argue that journalistic norms such as objectivity, fairness, accuracy, and balance serve as a source of "informational bias" regarding coverage of global warming. Indeed, when it comes to science reporting, these journalistic norms act as [surrogates] for validity checks" since "the typical journalist, even one trained as a science writer, has neither the time nor the expertise to check the validity of claims herself" Dunwoody and Peters (1992), Boykoff and Mansfield (2008). In effect, while providing a "balanced" view, many media outlets are really presenting a biased view of climate

science by offering grossly disproportionate levels of attention to climate change contrarians. [2]

3 Learning about Climate Skepticism: An Unsupervised Approach

What does it mean to be a climate skeptic? What topics shape the conversation of the conservative counter-movement on global warming? These questions were explored in detail in McCright and Dunlap (2000)'s seminal study on climate skepticism and the conservative movement's counter-claims. The authors content analyze documents related to global warming for 14 major conservative think tanks over the period 1990-1997. After searching each organizations website, they gained access to 224 publications—the vast majority of which were produced during 1996 and 1997—and spent the summer of 1998 coding the documents. Overall, the content analysis suggests that climate skepticism during this period centered on three major counter-claims (see McCright and Dunlap 2000, pg. 510, Table 3):

1. *The evidentiary basis of global warming is weak or wrong.* Arguments falling within this counter claim tended to focus on the uncertainties associated with published scientific findings—i.e., that it is "junk" science—and expressed doubts whether there was indeed a "scientific consensus" when it came to global warming.

2. *Global warming would be beneficial if it was to occur.* The main arguments under this claim focused on the benefits in terms of weather, health, and agriculture.

3. *Global warming policies would do more harm than good.* That is, the economic, security, and environmental costs are too high to justify action.

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[2]The empirical record suggests that the American media do, in fact, allow for disproportionate levels of attention to contrarian viewpoints. Regarding print media, Boykoff and Boykoff (2004) estimate that for 1988-2002, about 53% of "prestige" newspaper coverage of global warming was "balanced"—that is, it provided "roughly equal" attention to the view that human activity is primarily responsible for global warming and also the opposing contrarian position that any warming is due to natural causes. In a similar vein, McCright and Dunlap (2003) found that, over the period 1994-1997, a handful of climate change contrarians were cited in the nation's most popular newspapers just as often as the leading climate scientists. In a comparative context, and perhaps unsurprisingly, studies have found that the United States "prestige" print press appears to be a global leader in hosting skeptical viewpoints about climate change. Dispensa and Brulle (2003), Brossard et al. (2004) show how, during the period of study, top American newspapers were much more likely to emphasize uncertainty in climate science findings relative to selected foreign newspapers. More recently, Painter and Ashe (2012) content analyze articles from major newspapers from the United States, United Kingdom, Brazil, China, France, and India for early 2007 and November 2009 - February 2010. The authors find that, relative to these other countries, American newspaper coverage is much more likely to voice uncontested skeptical views on climate change.

This paper builds upon the early work of McCright and Dunlap (2000) by employing a simple probabilistic model to "learn" the topics discussed by climate skeptics. What motivated our choice to rely on automated text analysis, as opposed to human coding of contrarian documents? One significant reason was reducing data collection cost. As discussed in Grimmer and Stewart (2013), human-coding methods can be very costly in terms of time and resources. As the size of the corpus intended to be coded increases, so does the cost, since each text needs to be read by a human coder. When working with very large corpora, as is the case in the current study, the cost can become prohibitive. A second motivation to utilize an automated text analytic method was that following McCright and Dunlap (2000), there has been no update to the systematic classification of contrarian arguments against climate science and policy. As will be discussed below, by utilizing an automated classification method, we are able to identify a range of new and unique topics that have sprouted among deniers since the late 1990s.

3.1 Building a Contrarian Corpus

To build a corpus of "contrarian texts," we scrapped the websites of 15 well-known conservative think tanks and organizations for information related to climate change. Our choice of organizations, to a large extent, mirrors that of McCright and Dunlap (2000). Table 1 displays the names of the organizations and think-tanks which we study along with the number of documents that are included in the corpus from each website. The total number of documents included in the corpus are 13,114. To retrieve the contrarian documents, we downloaded the HTML code of pages which were either classified by the respective organization as dealing with climate change or from within-site search results for the terms "climate change" or "global warming". Next, documents that contained the term "climate change" or "global warming" were retained from the larger set of retrieved documents. Documents in PDF format and audiovisual materials were a minority of the overall set of documents and were excluded in the current analysis.[3] Relevant text was extracted from the HTML source code using a set of regular expressions. The resulting text was then tokenized and filtered (i.e. stop words and punctuation were removed, tokens were stemmed using a the common Porter Stemmer).

3.2 Finding Topics

This section utilizes the well-known latent Dirichlet allocation (LDA) model originally proposed in Blei et al. (2003). LDA is a simple hierarchical Bayesian model which starts with the assumption that each word in a text is exchangeable, that a text in a corpus is a combination of a specific number of topics (T_k), and each specific topic is represented as a distribution of words (w) in a fixed

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[3]We are currently in the process of cleaning PDF reports. These documents (primarily "Policy Reports") will be added to the corpus shortly

Organization Name	Number of Documents
American Enterprise Institute (AEI)	642
Cato Institute (CEI)	301
Competitive Enterprise Institute (CEI)	937
Fraser Institute	63
Global Warming Policy Foundation	7,892
Heartland Institute	272
Heritage Foundation	220
Hoover Institution	24
International Climate and Environmental Change Assessment Project (ICECAP)	1,784
George C. Marshall Institute	139
National Center for Policy Analysis (NCPA)	43
National Center for Public Policy Research (NCPPR)	386
Pacific Institute	226
Reason Foundation	159
Total	13,114

Table 1: The number of documents currently in the corpus for 15 well-known conservative think tanks and organizations for information related to climate change.

vocabulary. The generative structure that produces each document in a corpus is represented as random mixtures of latent topics and their associated distributions of words. Specifically, the LDA assumes that documents are generated from the following probabilistic process:

1. Each of the k topics are drawn from a topic distribution by

$$\theta \sim Dirichlet(\alpha)$$

2. The term distribution β for each topic is represented by

$$\beta \sim Dirichlet(\eta)$$

3. For each of the N words w_n:

   Randomly sample a topic $z_n \sim Multinomial(\theta)$.

   Choose a word w_n from $p(w_n|z_n, \beta)$.

While this process provides a simple representation of the data generating process for corpus of texts, the model has been shown to preform well in a wide range of areas, from population biology to information retrieval(see Blei 2012, for an overview).

3.2.1   Inferring Topic Structure

The next step is to infer the underlying structure (i.e., topics) from based on the model described above. We rely on the sparse Gibbs sampler described in Yao et al. (2009).[4] After a good deal of experimentation regarding model's hyperparameters, we found that the efficient hyperparameter optimization routine utilized in Wallach et al. (2009a) provided the most easily interpretable set of topics.[5]

LDA requires one to specify the number of topics *a priori*. This presents an obvious challenge, as researchers generally do not have strong prior information about the number of topics in a corpus. While a range of methods have been introduced in the literature to estimate the "optimal" number of topics based on the held-out likelihood (see Wallach et al. 2009b, for an overview), there remains considerable debate on the utility of data-driven approaches for generating interpretable topics. For instance, using a large number of human subjects, Chang et al. (2009) present evidence suggesting models which preform better in terms of held-out likelihood, may actually infer less meaningful topics. The results suggest the need to carefully examine the interpretability of the latent space when employing topic models and provide caution against blindly choosing the model that minimizes held-out likelihood.

In this study, we take balanced approach between "optimal" data-driven methods and a qualitative assessment of the interpretability of the latent space. First, in terms of data-driven methods, we rely on 10-fold cross-validation and examine changes in "perplexity" over a coarse grid of topic numbers (Blei et al. 2003).[6] Here, we looked primarily for major changes (i.e. reductions) in the estimated perplexity when moving across the coarse grid. This analysis suggests considerable changes in the estimated perplexity when moving from, say, 20 to 100 topics, but only minor gains thereafter. Moreover, our analysis generally conforms to the findings in Chang et al. (2009): simply minimizing the model's perplexity with respect to the number of topics—as is often suggested in the topic modeling literature (Wallach et al. 2009b)—led to a considerable number of topics that were quite difficult to interpret. Based on this assessment, we chose to estimate the LDA assuming a 100 topic model.

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[4]Our choice to rely on the sparse Gibbs sampler was driven primary by concerns over efficiency and computational convenience. Note that little changes when using other commonly employed sampling algorithms such as the variational expectation maximization approach discussed in Blei et al. (2003) or the (also quite efficient) collapsed Gibbs sampler discussed in Griffiths and Steyvers (2004).

[5]We optimize both the α and β hyperparameter in the results provided below. It is important to note, however, that the topics described below display a good deal of stability across a wide range of specifications.

[6]The intuition associated with minimizing perplexity is that if the model is accurately inferring the structure of the corpus, it should also be able to accurately infer the structure of held-out data from the same corpus. Perplexity thus measures how confused (or "perplexed") the model is when seeing new data.

3.2.2 Topic Interpretation

Table 2 provides a list of the estimated topics, a descriptive label, and a list of the 5 most probable keywords for each topic. The validity of the assigned topic labels was assessed by small sample ($n = 10$) of articles assigned (with a high proportion) to each topic (Quinn et al. 2010). After removing 16 "junk" topics (AlSumait et al. 2009), the final list included 84 topics representing a range of issues related to global warming, from skepticism associated with climate science to energy policy.[7]

Table 2: Topics in the Climate Skepticism Corpus

	Topic Name	Topic Family	Import-*ance	Keys
1	International Agreements	International Agreements	0.036	climat, countri, develop, copenhagen, nation
2	Climate Trends (Long-Term)	Climate Trends	0.032	warm, temperatur, global, climat, year
3	Energy Consumption	Economic Impacts	0.030	energi, bill, price, cost, per
4	Shale Gas (Hydraulic Fracturing)	Unconventional Energy	0.026	shale, frack, drill, water, well
5	Government Investment Renewable (UK)	Renewable Energy	0.022	govern, plan, new, invest, project
6	Shale Gas (Energy Independence)	Unconventional Energy	0.022	price, natur, shale, energi, product
7	Global Cooling	Climate Trends	0.021	winter, cold, snow, record, temperatur
8	Sea Level Rise	Climate Impacts	0.019	ice, sea, level, rise, arctic
9	General Policy Keywords	Environmental Policy	0.019	polici, more, problem, govern, need
10	Energy Policy (UK)	Energy Policy	0.018	energi, govern, minist, green, britain
11	Renewable Energy (General)	Renewable Energy	0.017	energi, renew, fuel, technolog, fossil
12	IPCC (Peer-Review)	Scientific Integrity	0.017	ipcc, report, review, panel, author
13	Solar Energy	Renewable Energy	0.017	solar, subsidi, energi, panel, industri
14	Climategate	Scientific Integrity	0.017	email, cru, climateg, jone, univers
15	Consensus Myth	Scientific Uncertainty	0.016	scienc, scientist, scientif, climat, consensu
16	Cap and Trade	Energy Policy	0.015	tax, carbon, trade, emiss, cap
17	US Debate of Kyoto	International Agreements	0.014	kyoto, treati, protocol, emiss, nation
18	Clean Air Act	Environmental Policy	0.014	epa, regul, air, act, greenhous
19	Wind (UK)	Renewable Energy	0.013	wind, turbin, farm, energi, plan
20	Anthropogenic Causes	Human Forces	0.013	global, warm, climat, scientist, caus
21	California AB32	Energy Policy	0.012	california, cap, bill, state, energi
22	Obama	US Politics	0.012	obama, presid, democrat, republican, elect
23	Ice Age	Climate Trends	0.011	ice, period, year, temperatur, climat
24	Temperature Data	Skepticism (Data)	0.010	data, temperatur, station, record, adjust
25	Climate Trends (Short-Term)	Climate Trends	0.010	temperatur, year, global, warm, decad
26	Biofuel	Renewable Energy	0.010	food, ethanol, biofuel, crop, product
27	Solar Forcing	Natural Forces	0.010	solar, sun, cycl, activ, earth
28	US Legislature	US Politics	0.010	senat, bill, hous, vote, energi
29	Wind	Renewable Energy	0.010	power, wind, electr, gener, renew
30	Climate Activism (Alarmists)	Scientific Integrity	0.010	global, warm, hansen, climat, nasa
31	Clouds	Natural Forces	0.010	atmospher, climat, effect, greenhous, cloud

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32	Nuclear Power	Conventional Energy	0.010	nuclear, power, reactor, plant, japan
33	Government Funding Research	US Politics	0.010	fund, million, govern, billion, program
34	Aviation Emissions (Asian Retaliation to EU)	Environmental Policy	0.010	trade, airlin, european, china, aviat
35	Oil Production	Conventional Energy	0.010	oil, drill, barrel, product, pipelin
36	Carbon Reduction's Impact on Industry	Economic Impact	0.010	industri, cost, energi, manufactur, busi
37	Energy Policy (EU)	Energy Policy	0.009	european, europ, commiss, target, franc
38	Climate (General Discussion)	Buzz Words	0.009	climat, chang, impact, scienc, polici
39	Email Discussions	Scientific Integrity	0.009	public, inform, report, document, issu
40	Extreme Weather (General)	Extreme Weather	0.009	weather, extrem, event, climat, flood
41	Coal	Conventional Energy	0.009	coal, power, plant, electr, fire
42	Public Opinion	Society	0.009	percent, poll, survey, american, warm
43	Wind (Hurricane)	Extreme Weather	0.009	hurrican, storm, tornado, global, tropic
44	JUNK	JUNK	0.008	offic, global, warm, polici, prefix
45	Australian Carbon Tax	Energy Policy	0.008	australia, australian, govern, carbon, canada
46	It's Cold Outside	Weather	0.008	offic, met, forecast, winter, weather
47	Hockey Stick	Scientific Integrity	0.008	mann, hockey, stick, data, univers
48	UK Coverage of Climate	Society	0.008	bbc, sceptic, societi, climat, royal
49	Cost-Benefits of Emissions Reduction	Economic Impact	0.008	cost, percent, per, billion, econom
50	German Renewable Policy	Renewable Energy	0.007	germani, german, energi, merkel, green
51	Shale Gas (Mediterranean)	Unconventional Energy	0.007	shale, reserv, resourc, energi, cubic
52	Carbon Emissions (General)	Energy Policy	0.006	carbon, emiss, dioxid, greenhous, reduc
53	Coral Reefs	Climate Impacts	0.006	ocean, coral, more, reef, read
54	Electric Cars	Energy Policy	0.006	car, electr, vehicl, batteri, hybrid
55	Environmental Activists	Society	0.006	environment, group, green, campaign, environmentalist
56	Security (Asia)	International Relations	0.006	china, state, secur, unit, nation
57	Climate Models	Skepticism (Models)	0.006	model, climat, predict, forecast, comput
58	Ocean Temperature	Climate Impacts	0.006	ocean, temperatur, surfac, heat, climat
59	Ideological Debates	Society	0.006	book, polit, social, peopl, liber
60	Economic Growth	Development	0.006	econom, technolog, growth, develop, market
61	Carbon Taxes	Energy Policy	0.006	govern, peopl, american, tax, more
62	Pollution (Air)	Environmental Policy	0.006	environment, pollut, air, environ, qualiti
63	Green Jobs	US Politics	0.006	job, green, creat, economi, econom
64	Peer-Review (General)	Scientific Integrity	0.005	paper, research, studi, publish, review
65	Government Investment Green Tech	Renewable Energy	0.005	compani, busi, bank, invest, corpor
66	International Health	Health	0.005	health, malaria, diseas, death, risk
67	Polar Bears	Climate Impacts	0.005	bear, polar, arctic, popul, ice
68	Japan Methane Hydrate	Unconventional Energy	0.005	methan, hydrat, earth, water, japan
69	Fuel Standards	Energy Policy	0.005	fuel, car, vehicl, standard, effici
70	Melting Glaciers	Climate Impacts	0.004	glacier, melt, himalayan, india, indian
71	Religion and Environment	Society	0.004	human, earth, world, natur, environment
72	Al Gore	Al Gore	0.004	gore, truth, film, inconveni, nobel
73	Deforestation	Human Forces	0.004	forest, speci, tree, extinct, wood
74	Adaptation	Adaptation	0.004	ghg, polici, climat, control, chang
75	Less Developed Countries	Development	0.004	world, countri, develop, global, africa
76	Heartland Institute Incident	Heartland Institute Incident	0.004	fraud, document, investig, gleick, polic
77	Water (Drought/Flood)	Extreme Weather	0.004	water, drought, flood, precipit, rainfal
78	Environmental Law	Law	0.003	court, law, state, case, legal
79	Energy Security (Europe)	Energy Security	0.003	russia, russian, poland, gazprom, europ
80	Volcanic Activity	Natural Forces	0.002	ozon, earth, erupt, volcan, year

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81	Disaster Insurance	Extreme Weather	0.002	disast, insur, risk, flood, peopl
82	White House	US Politics	0.002	administr, bush, presid, white, hous
83	IPCC (Uncertainty)	Scientific Uncertainty	0.001	scenario, uncertainti, ipcc, sensit, estim
84	Development Goals	Development	0.001	popul, lomborg, year, age, ehrlich

Caption: This table provides the results of the 84 topic LDA, as descried above *We measure "importance" as the proportion of documents in which the topic has the highest posterior probability. We recognize that , clearly, this is an extremely rough measure of importance.

When looking across Table 2, we see many of the usual suspects discussed in previous studies but also some new topics. The topics produced by the model are generally consistent with those presented in McCright and Dunlap (2000), with a number of topics speaking directly to McCright and Dunlap (2000)'s "Counter-Claim One" (on the evidentiary basis for climate change) and "Counter-Claim" (questioning the utility of climate policies). Table 3 provides an overview of the specific themes outlined in McCright and Dunlap (2000, , pg. 510, Table 3), along with the topics most closely aligned with a given theme.

Skeptical voices related to the validity of mainstream climate science are common within the corpus. The notion that human activity, specifically the emission of greenhouse gases into the atmosphere, is leading to a rise in global temperatures (topic 20) has been labelled as the "man-made global warming scare" that is being pushed by "scare-mongers".[8] Appeals to long-term natural cycles in temperature (topic 2) are common support for arguments against anthropogenic global warming, such as the Roman and Medieval Warm Periods. Documents also focus on alternate climate forcing inputs such as solar (topic 27), clouds (topic 31), and volcanoes (topic 80) as more plausible explanatory factors for climate fluctuations than greenhouse gas emissions. The very existence of a true scientific consensus on anthropogenic warming (topic 15) continues to be denied and has been called "manufactured"[9] and "premature".[10] The predictive power of climate change models (topic 57) that are referenced in the IPCC assessments is often questioned. The validity and reliability of empirical data used in climate change studies (topic 24) to demonstrate global warming impacts are also cast into doubt. Further, the integrity of climate scientists is also frequently questioned, especially in relation to the peer-review process of the IPCC (topic 12) and the 2009 "climategate" email leakage incident (topic 14), Impacts of climate change on animals such as polar bears (topic 67) and coral (topic 53) are routinely downplayed; as are environmental impacts such as sea level rise (topic 8) and melting glaciers (topic 70).

The results of the LDA model also demonstrate the breadth of topics discussed in documents referencing climate change with important issue linkages

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[8]http://icecap.us/index.php/go/new-and-cool/does_it_really_take_much_imagination_to_project_what_the_scare_mongers_will/

[9]http://judithcurry.com/2012/10/28/climate-change-no-consensus-on-consensus/

[10]http://www.hoover.org/publications/defining-ideas/article/138101

across both the domestic and international political economy. For instance, much critical discussion surrounds international mitigation policies (topics 1 and 17), which are typically refuted based upon expected detrimental economic impacts such as rising energy prices (topic 3) and reduced economic growth (topic 60). Renewable energy technologies such as solar (topic 13), wind (topic 19), and biofuels (topic 26) are almost always presented as wasteful and counter-productive. Unconventional sources of energy such as shale gas (topics 4, 6, and 51) and methane hydrates (topic 68), on the other hand, are discussed in positive terms, typically in relation to energy independence and technological innovation.

Climate change deniers also do not seem to hesitate when singling out specific individuals as either disingenuous or misguided. Al Gore (topic 72) is a favorite target, especially in relation to his environmental activism and campaigning. Much of the focus has been on Gore's documentary film *An Inconvenient Truth*, which has been characterized as, "a colorfully illustrated lawyer's brief for global warming alarmism and energy rationing"[11] and that screenings of the film in schools amounts to "indoctrination". Gore has also been labeled a hypocrite for, among other things, the "prodigious personal use of electricity at his Nashville mansion"[12] and has often been denigrated for accepting the Nobel Peace Prize for his environmental activism. Individual scientists have also been targeted. For example, Michael Mann's infamous "hockey stick graph" (topic 47), which depicted rapid growth of post-Industrial Revolution global temperature, drew heavy fire from climate change skeptics, and his research agenda has been branded as "the biggest taxpayer-financed gravy train for science and academia in decades."[13]

3.2.3 Meta Topics and Topic "Families"

Even a cursory glance at Table 2 demonstrates a number of common themes across topics. As such, in addition to assigning each topic a more detailed label, we also coded each topic into a more general "topic family." These decisions were again guided by reading a small sample of articles. Based on this coding, the contrarian corpus is dominated by topics related to skepticism over climate science, discussions of energy policy (conventional, unconventional, and renewable), and domestic and international policy concerns (including specific climate agreements and domestic climate policies). As a further check on whether topics with similar labels are semantically similar, Figure 1 presents the results from a hierarchical agglomerative clustering (HAC) of the 84 topics (Quinn et al. 2010). As shown in the figure, the analysis suggests a number of distinct themes. For instance, topics related to energy and policy, as climate trends and the consequences climate change tend to cluster together in the figure.

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[11]http://cei.org/studies-other-studies/al-gores-science-fiction-skeptics-guide-inconvenient-truth

[12]http://www.foxnews.com/story/2008/06/19/junk-science-al-gore-epic-hypocrisy/

[13]http://icecap.us/index.php/go/political-climate/hockey_stick_creator_michael_mann_seeks_courts_help_to_ensure_no_inquiry_no/

Description	Topics
The evidentiary basis for global warming is weak or wrong.	
1. The scientific evidence for global warming is highly uncertain	20, 24, 57
2. Mainstream climate research is "junk" science	46, 47, 83
3. The IPCC intentionally altered its reports to create a "scientific" consensus" on global warming	12, 15
4. Global warming is merely a myth or a scare tactic.	42, 55
5. Global warming is merely a political tool.	22, 72
Global warming policies would do more harm than good.	
1. Proposed policies would harm the economy.	3, 36, 49, 69
2. Proposed action would weaken national security.	56, 6
3. Proposed action would threaten sovereignty	17
4. Proposed action would actually harm the environment	–

Table 3: Counterclaim 1 and 3 from McCright and Dunlap (2000), as well as examples of topics in Table 2 that are consistent with each theme. We found few instances of McCright and Dunlap (2000)'s Counterclaim 2 (i.e. that a warmer climate would actually be beneficial.)
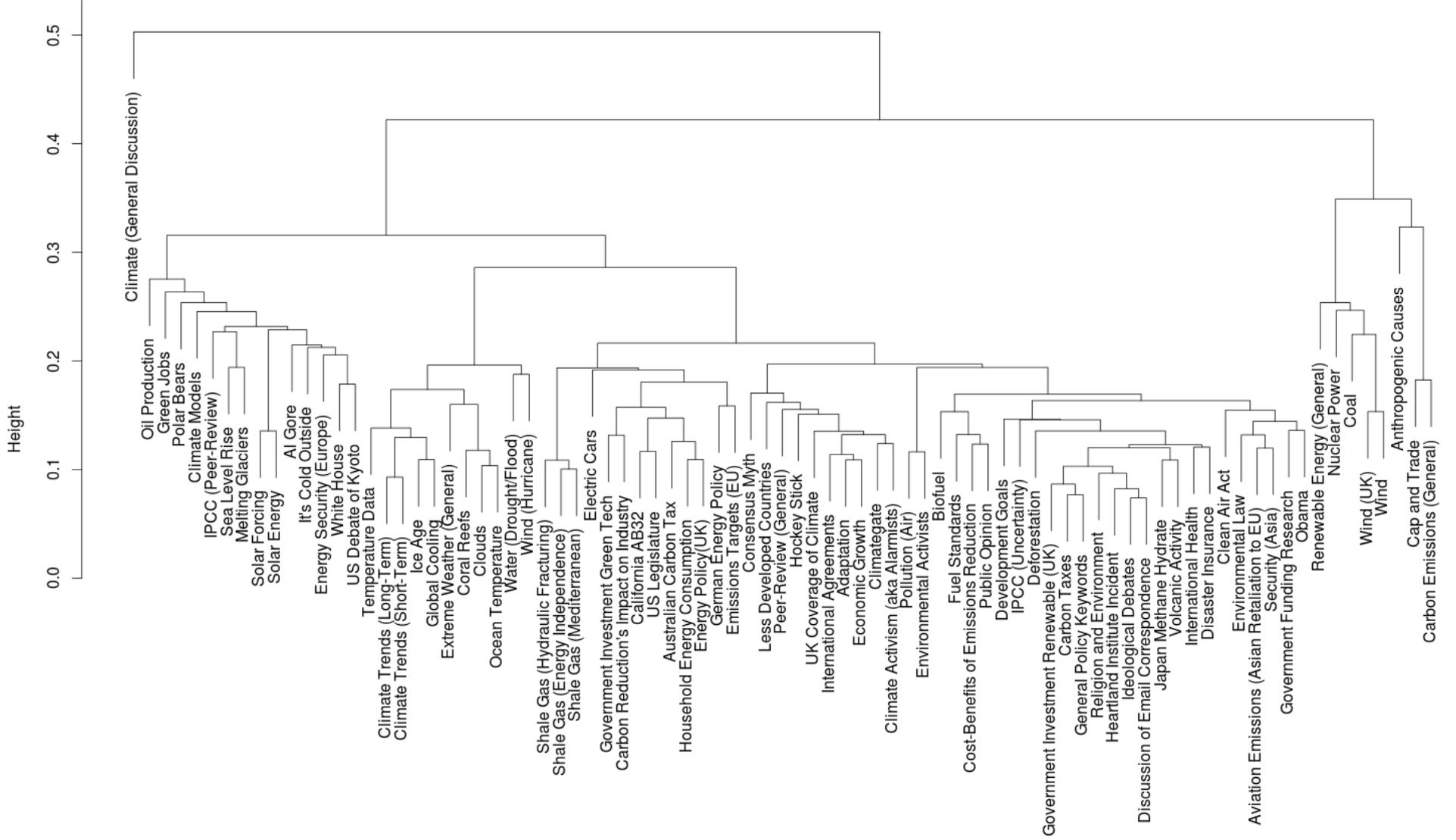
Figure 1: HAC results

4 Model Validation (Preliminary)

While the topics produced in Table 2 are largely consistent with the literature's understanding of climate skepticism, Grimmer and Stewart (2013) make a forceful case for the need to carefully validate text-analytic models. This section provides a first step toward achieving that objective.

4.1 Accuracy in a Small Random Sample of Contrarian Documents

Our first initial check on validity relies on a content analysis of a small ($n = 100$), random sample of documents from the contrarian corpus. The goal was to determine whether the topics that the model assigned for a document were similar to those that would be assigned by a human coder. To achieve this objective, we had a research assistant (blind to the study's objectives) code the "dominant" topic for each of the 100 documents. While the 84 topics in Table 2 provide a granular look of the issues discussed in the contrarian corpus, the coder was instructed to code at the more abstract "topic family" level. This decision was made for both practical and substantive reasons. Substantively, the literature on the contrarian counter movement and hypotheses associated with the dynamics of skepticism overtime tend to be specified at this more general level of analysis. Thus, our concern lies more in whether the model correctly classifies documents into these broader themes.

Table 4 provides descriptive statistics for the results. As demonstrated in the table, the accuracy score varies considerably across the topic families. For instance, while the model only accurately classified roughly half of articles for "Energy Policy," it did appreciably better for more specific aspects of energy such as "Renewable Energy" (6/6) and "Unconventional Energy" (7/7). While these results should obviously be interpreted with caution, they do at least suggest that data generated from the LDA may provide insight into important facets of the energy debate.

The results in Table 4 also suggest that the places were the model had difficulties. In particular, the model had difficulties sorting out the differences between "Scientific Uncertainty" and various aspects of skepticism over climate science (i.e., "Skepticism (Data)" and "Skepticism (Models)"). These topics are highly related (both substantively and semantically) and thus it not all that surprising that these areas posed challenges for the LDA.

5 Conclusion

While the debate on the determinants of public opinion on climate change continues, most would agree that climate skepticism, as expressed by conservative think-tanks and organizations, has at the least some discernible impact on public perceptions of climate change science and policy–questions still remain as to

Topic Family	N (Documents)	Accuracy
Al Gore	4	0.500
Climate Change Impacts	3	0.667
Climate Trends	2	0.500
Conventional Energy	2	0.500
Development	3	0.333
Economic Impact	6	0.833
Energy Policy	24	0.500
Extreme Weather	2	1.000
Human Forces	2	0.000
International Agreements	4	1.000
International Relations	1	0.000
Natural Forces	3	1.000
Other	3	0.000
Renewable Energy	6	1.000
Scientific Integrity	6	0.833
Scientific Uncertainty	4	0.000
Skepticism (Data)	2	0.500
Skepticism (Models)	4	0.000
Society	7	0.714
Unconventional Energy	7	1.000
US politics	3	0.667
Weather	1	0.000

Table 4: Accuracy in a small random sample of documents.

how large of an impact and what type of contrarian argument has the greatest impact. A significant limitation in the literature is a lack of a valid time series of climate change contrarianism which can be used for hypothesis testing.[14] By employing automated text analytic approached to the study of contrarianism, we are able to generate data series for other understudied regions such as Europe, which has yet to be studied systematically regarding the impact of skepticism in the media on public attitudes towards climate science and policy.

Another advantage of using text-mining methods to the study of climate change skepticism is that we are more able to update our knowledge of contrarian arguments due to the significant reduction of required time and resources. (McCright and Dunlap 2010, p. 114), for example, recognize that there are certain limits to our understanding of current contrarian discourse due to a lack of updated systematic knowledge. We believe that text-mining offers the opportunity to maintain a more current picture of the discourse across multiple platforms (i.e., social media, blogs, broadcast and print media) Further, we are able to significantly increase the number of documents employed in the learning process from a few hundred as done in previous studies to thousands. Again, using OCR and other text processing methods, text-mining methods can be applied to all kinds of contrarian publications, such as books, and are not limited to internet materials.

In future work, we plan to apply the results from the current study as well as supervised and unsupervised classification methods to study contrarianism in US print and television outlets; with the overarching objective being to study how topics have evolved over time, platforms and outlets.

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[14]For example, Scruggs and Benegal (2012) operationalize contrarianism as frequency of *New York Times* articles with skeptical references. We believe that, while this measure approximates contrarianism, a more valid measure is possible.

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