"Reporting on climate change: A computational analysis of U.S. newspapers and sources of bias, 1997–2017"

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ABSTRACT

News organizations constitute key sites of science communication between experts and lay audiences, giving many individuals their basic worldview of complex topics like climate change. Previous researchers have studied climate change news coverage to assess accuracy in reporting and potential sources of bias. These studies typically rely on manually coding articles from a handful of prestigious outlets, not allowing comparisons with smaller newspapers or providing enough diversity to assess the influence of partisan orientation or localized climate vulnerability on content production. Making these comparisons, this study indicates that partisan orientation, scale of circulation, and vulnerability to climate change correlate with several topics present in U.S. newspaper coverage of climate change. After assembling a corpus of over 78,000 articles covering two decades from 52 U.S. newspapers that are diverse in terms of geography, partisan orientation, scale of circulation, and objectively measured climate risk, a coherent set of latent topics were identified via an automated content analysis of climate change news coverage. Topic model results indicate that while outlet bias does not appear to impact the prevalence of coverage for most topics surrounding climate change, differences were evident for some topics based on partisan orientation, scale, or vulnerability status, particularly those relating to climate change denial, impacts, mitigation, or resource use. Overall, this paper provides a comprehensive study of U.S. newspaper coverage of climate change and identifies specific topics where outlet bias constitutes an important contextual factor.

1. Introduction

Despite accumulating evidence and an overwhelming consensus among scientists regarding the broad characteristics of anthropogenic climate change, Americans remain politically polarized over questions of its cause, risk, scientific consensus, and other dynamics (McCright and Dunlap, 2011; Dunlap et al., 2016). In the background of American political polarization lies conservative accusations of "liberal bias" in mainstream media affecting the coverage of a broad range of issues, including environmental problems. This should not surprise anyone, as news media are sites of struggle to define and defend the assumptions underpinning social reality (Gamson et al., 1992). Given the importance of news, many social scientists have conducted content analyses of climate change media coverage in order to understand persistent themes and potential sources of bias across outlets (e.g., Boykoff and Boykoff, 2004; Feldman et al., 2017).

However, constrained by computing power and software accessibility, past researchers were practically limited in how diverse a news corpus they could select for content analysis. Understandably, this resulted in focusing data collection around nationally circulated "prestige press" (in the U.S., this typically includes newspapers such as the *Los Angeles Times, New York Times, Wall Street Journal*, and/or *Washington Post*). While such analyses provide

insight into elite media content, exclusively focusing on prestige press makes research vulnerable to a form of outlet bias (Moser, 2014) and may not provide a representative picture of newspaper coverage overall. Given the animus commonly expressed toward prestigious newspapers, as well as the geographic pattern underlying American political polarization, analyzing a broader set of newspapers would provide a more comprehensive picture than currently exists of the informational context surrounding climate change in the U.S. public. Fortunately, advances in computational techniques can automate content analysis and make use of "big text" data, allowing researchers to draw comparisons across longer timespans and more diverse outlets.

In this analysis, I explore an array of issues associated with climate change communicated by a diverse set of American newspapers, inspecting how topical focus varies by partisan orientation, scale of operation, and climate vulnerability. I accomplish this through a form of automated content analysis known as topic modeling, applied to over 78,000 articles spanning two decades from 52 U.S. newspapers discussing climate change (the largest such corpus assembled on U.S. climate change news to date). This large-scale analysis systematically reveals the influence of political leaning, scale of circulation, and measured climate risk on the prevalence of climate change news coverage. While conservative and liberal newspapers

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dedicate similar amounts of coverage to most topics associated with climate change, some topics expose partisan differences in attention. A similar trend emerges when comparing the topical focus of national newspapers with regional newspapers, or those located in areas with higher levels of objectively measured climate risk. Such patterns highlight the importance of acknowledging outlet bias in studies of climate change media coverage, opening the opportunity to expand research on agenda setting and outcomes in local and state climate politics.

2. Literature review

In their meta-analysis, Schäfer and Schlichting (2014) identified 133 studies analyzing media coverage of climate change. Overall, existing research heavily focuses on outlets located within the U.S. (e.g., Trumbo, 1996; Zehr, 2000; Antilla, 2005) or U.K. (e.g., Carvalho and Burgess, 2005; Boykoff and Mansfield, 2008; Painter and Gavin, 2016), though contributions also exist that focus on Australia (McKewon, 2012), Brazil (Dayrell, 2019), Canada (Young and Dugas, 2011; Ahchong and Dodds, 2012), Chile (Dotson et al., 2012), China (Yang, 2010), Finland (Lyytimäki, 2015), France (Brossard et al., 2004), Germany (Kaiser and Rhomberg, 2016), India (Billett, 2010; Ghosh and Boykoff, 2019; Das, 2020g; Keller et al., 2020), Italy (Mariotto and Venturini, 2017), Mexico (Pulver and Sainz-Santamaría, 2018), New Zealand (Chetty et al., 2015), Nigeria (Ukonu et al., 2012), Poland (Kundzewicz et al., 2019), Russia (Boussalis et al., 2016), South Korea (Yun et al., 2014), Sweden (Olausson, 2009), and others. While a sizeable but smaller set of studies have conducted cross-national research comparing news coverage of climate change across several countries (Boykoff and Roberts, 2007; Painter and Ashe, 2012; Schmidt et al., 2013; Broadbent et al. 2016; Engesser and Brüggemann, 2016; Brüggemann and Engesser, 2017), research overall remains overwhelmingly focused on western sources (Schäfer and Schlichting, 2014).

In terms of temporal reference, researchers in this area have analyzed newspaper coverage dating back to the 1980s (e.g., McComas and Shanahan, 1999) up to the present. The temporal range included in content analysis varies across studies, but typically includes articles covering at least several years and sometimes a couple decades. While researchers commonly focus exclusively on news reporting, many others have examined opinion pieces as an important section often promoting uncontested climate change skeptic perspectives (e.g., Antilla, 2005; Carvalho and Burgess, 2005; Painter, 2011; Painter and Ashe, 2012; Elsasser and Dunlap, 2013; Painter and Gavin, 2016). Studying Canadian newspapers, Young (2011) argued that letters to the editor are a particularly important space where climate change skeptic views are established and legitimized.

Many studies concern how news organizations translate the complexity of climate science to their lay audience. Some mark the advent of sustained climate change coverage in U.S. media around 1988, a year that included severe heat and drought as well as the famous testimony of Dr. James Hansen to the U.S. Senate regarding the greenhouse effect (Ungar, 1992; Revkin, 2018). As coverage waned in the 1990s, it was thought that climate change followed a typical issue-attention cycle outlined by Downs (1972) where the public inevitably turns attention away from environmental issues for stories perceived as more relevant or pressing (Trumbo, 1996; McComas and Shanahan, 1999; Brossard et al., 2004). Over the last decade, however, news coverage of climate change continues to increase, though this varies across national context (Schmidt et al., 2013). Many authors have identified themes of media coverage in terms of risk framing (Carvalho and Burgess, 2005), representation of scientific uncertainty or contention (Zehr, 2000; Antilla, 2005; Boykoff, 2007b; Olausson, 2009), the transition of climate change from a scientific to social issue (Jaspal and Nerlich, 2014), or a process of banalization that lends less attention over time to causes and more attention to superficial intersections with politics and business (Young and Dugas, 2011).

Perhaps the most well-known theme in the literature on newspaper coverage of climate change concerns accuracy in reporting, i.e. the extent to which news stories accurately convey the scientific consensus versus giving equal weight to climate change denial arguments whose status lie on the fringe of the science community. Boykoff and Boykoff (2004, 2007) argued that journalistic norms of balanced reporting unduly amplified skeptics' perspectives in news reporting, leading to systematic informational bias in U.S. newspaper coverage.

Many studies have since recognized that the balance-as-bias trend decreased over time and was not always present in all national contexts (e.g., Boykoff, 2007a; Young, 2011). Hiles and Hinnant (2014) interviewed experienced climate journalists to discuss adherence to "weight of evidence" norms (Dunwoody, 2005) that privilege the perspectives of scientific consensus over marginalized dissent. This trend toward deemphasizing marginal voices is supported by research from Merkley and Stecula, 2018 showing that the presence of contrarian and climate change skeptic voices slightly declined since the early 2000s in conservative print media and *Fox News* broadcasts (although this does not necessarily indicate the absence of climate change skeptic perspectives, and conservative media still include more skeptic voices than non-conservative media). Brüggemann and Engesser (2017) argued that newspapers increasingly report on climate change in line with scientific consensus, though the "warmers vs. deniers" frame still overshadows other relevant aspects. Schmid-Petri et al. (2017) found in a year of coverage of high-circulation U.S. newspapers that perspectives promoting outright denial of anthropogenic climate change were supplanted by resistance to regulation (which is among the core factors motivating free market-oriented think tanks to promote climate change denial in the U.S.; Bohr, 2016, Rea, 2019). Despite evidence suggesting that contemporary journalistic norms increasingly align news coverage of climate change with the scientific mainstream, uncontested climate change skeptic perspectives are still present in news outlets, at least among opinion writers (Painter and Ashe, 2012; Elsasser and Dunlap, 2013; Painter and Gavin, 2016).

Although several studies include newspapers with ideologically diverse editorial positions (e.g., Trumbo, 1996; Boykoff, 2007a; Broadbent et al. 2016), they typically do not make outlet bias as a reflection of ideological orientation the point of focus. There are exceptions, however. Carvalho and Burgess (2005), for example, observed that once the political, economic, and lifestyle changes required to address climate change became apparent (sometime around the late 1980s), newspapers began to divide over the question of responsibility for mitigation and continued framing climate change risk through associated ideological standpoints. Boykoff and Mansfield (2008) found a similar pattern among British tabloids, while Dotson et al., 2012 found that liberal newspapers in Chile published twice as many articles (that were twice as long) about climate change versus their conservative counterparts. Painter (2011), Painter and Ashe (2012), and Painter and Gavin (2016) indicated that climate change skeptic arguments are more prevalent in conservative newspapers but mostly contained within editorial rather than non-editorial news content. Comparing the *Wall Street Journal* with other nationally-circulated U.S. newspapers, Feldman et al., 2017 found it was more likely to emphasize negative economic over environmental impacts of climate change in their non-editorial news coverage.

With a focus on nationally-circulated "prestige" press outlets such as the *New York Times* or *Washington Post* in the U.S. to supply data (e.g., Trumbo, 1996; Boykoff and Boykoff, 2004; Schmid-Petri et al., 2017), existing research often overlooks newspapers operating within regional media markets. Nationally-circulated newspapers have been analyzed for their climate change coverage at over triple the rate of their regional counterparts (Schäfer and Schlichting, 2014). This is understandable given practical limitations of how many articles can be manually coded by a team of researchers; within these constraints, selecting prestigious newspapers serves the conceptual goal of understanding elite discourse that in some way shapes agenda-setting in the political realm or impacts public opinion trends (Hilgartner and Bosk, 1988; Ungar, 1992; Carvalho and Burgess, 2005; Boykoff, 2007a; Boykoff and Boykoff, 2007; Zhao et al., 2016).

There are exceptions, however. Boykoff and Mansfield (2008) explored media coverage of climate change through the UK tabloid press more

typically consumed by working-class readers. In contrast to more prestigious outlets, Boykoff and Mansfield found more divergence from the scientific consensus on climate change among tabloids, without an increase in accurate coverage over the course of the study (2000–2006). Similarly, McKewon (2012) found more favorable coverage of a prominent climate change contrarian book among regional newspapers in Australia. Brown et al. (2011) studied regional newspapers in England, noting that such news coverage tends to "domesticate" global climate change by translating it into a locally-significant phenomenon. Liu et al. (2008) examined climate change coverage in the *Houston Chronicle*, whose findings were broadly consistent with those studying national newspapers at the time. Although Young and Dugas (2012) found differences in breadth and style of coverage across English- and French-language regional Canadian newspapers, researchers have generally avoided systematic comparisons of news coverage across regional and national or "prestige" newspapers.

Recent research has explored connections between objectively measured climate change vulnerability with communication about climate change. Boussalis et al. (2018) conducted a computational analysis of press releases from 82 U.S. cities, finding that vulnerability shaped the volume of communication about climate change. Boussalis et al. (2019) followed up this analysis with a topic model associating climate vulnerability with the discussion of adaptation, but not mitigation efforts. The relationship between climate change vulnerability and government communication is intuitive, and consistent with research from Bromley-Trujillo et al., 2019 finding that localized impacts (measured through temperature anomalies) were predictive of Democratic legislators sponsoring state-level bills (although Republican legislators did not respond to such impacts). Whether these trends observed among political actors extend to newspaper coverage are explored below. We should expect that climate vulnerability predicts the volume of climate change coverage, at least with some topics.

3. Data & methods

Data was collected from full-text articles available in 52 newspapers indexed across the LexisNexis, Newspaper Source Plus, and U.S. Newsstream databases. While the current study is limited to newspapers contained in these databases (although voluminous, they are not exhaustive), these newspapers are diverse in terms of geography, partisan orientation, and scale, and are mapped in Fig. 1. Text from figure captions are included in the data, but not text embedded in an image such as an infographic. Data regarding the inclusion of visual content in an article was not available.

Partisan orientation was measured by presidential endorsements from newspaper editorial boards since 1996 (+1 for Democratic candidate endorsements, −1 for Republican candidate endorsements, and 0 for no endorsement).[1] Scores of less than −2 on this scale were labeled "conservative" (16 newspapers, including the *Wall Street Journal* as a commonly recognized conservative editorial board despite their standard of not endorsing presidential candidates), scores of −2 to 2 were labeled "moderate" (18 newspapers), and scores greater than 2 were labeled "liberal" (18 newspapers). While we should not assume that news reporters share the political orientation of their editorial boards (nor that an editorial board's political preferences impact the accuracy of news reporting), this measure may serve as a proxy of the political orientation of the newspaper's core readers (Gentzkow and Shapiro, 2010). Newspaper scale was categorized as "national" (*Chicago Tribune, Los Angeles Times, New York Times, USA Today, Wall Street Journal,* and *Washington Post*), "large regional" (which included 23 newspapers with circulations greater than 100,000 in 2015), and "small regional" (24 newspapers).[2] Vulnerability was measured using data supplied by the ND-GAIN Urban Adaptation Assessment (2018) overall climate risk. Newspapers located in areas with an overall risk score at least

one standard deviation below the mean were categorized as "Low" (6 newspapers), those located in areas at least one standard deviation above the mean were categorized as "High" (12 newspapers), with all others categorized as "Medium" (34 newspapers). Alternative operational definitions of climate vulnerability were explored, comparing newspapers above versus below the mean overall climate risk score.

A Boolean search for "climate change" or "global warming" in these 52 newspapers from 1997 – 2017 returned 176,982 unique articles after removing duplicate entries.[3] Upon qualitative inspection, however, many articles did not focus on climate change and simply mention one of the keyword phrases a single time in passing. To restrict the corpus to newspaper articles primarily focused on climate change, articles were filtered by whether they made at least two mentions of the phrases "climate change," "global warming," or "greenhouse gas." This left 78,599 articles that were used for analysis.

Given the size of this corpus, topic modeling (a form of automated content analysis – see Mohr and Bogdanov, 2013 for an introductory overview) was used to simplify information and identify a minimal number of coherent and substantively meaningful topics surrounding newspaper coverage of climate change. Topic modeling uses a statistical approach to text analysis, identifying clusters of commonly co-occurring words within documents. These word clusters, referred to as "topics," represent latent associations between words across a corpus of documents, and are identified through latent Dirichlet allocation (Blei et al., 2003).

This process systematically infers k latent topic distributions across w words contained in i documents, yielding a proportional topic score for each document. The model results presented below provide a greater level of detail regarding topical attention to climate change than typically produced by traditional forms of content analysis.

Standard data preprocessing was completed before building a term-document matrix from which topic models were estimated, including reducing words to word stems, removing punctuation, numbers, and common stop words. Words that occurred fewer than 25 times or in more than 90% of all documents were also removed. Prior to running models, compound phrases (such as "climate change") were identified using the *textstat_collocations* function from the quanteda R package (Benoit et al., 2018). A dynamic topic model was estimated using the stm R package developed by Roberts et al., 2014a. Appendix A includes a plot of generality scores used to guide the selection of number of topics for the model; after inspecting several candidates, a model with 28 topics was selected for analysis. Topic labels were determined through an interpretation of associated word stems that were frequent and exclusive to each topic ("frex" scoring; Bischoff and Airoldi, 2012; Roberts et al., 2014b) as well as a qualitative inspection of the 25 most representative newspaper articles for each topic.

One approach to providing validation to topics comes in whether their temporal patterns conform to external events (Quinn, 2010; Grimmer and Stewart, 2013). Temporal patterns for each topic were inspected, revealing a correspondence with key events we would expect to find. For example, the Religion topic (top frex word stems: *pope, franci, cathol, christian, pope_franci*) spiked in prevalence during 2015, when Pope Francis released *Laudato Si'*, his encyclical that addressed climate change and other environmental problems. Likewise, the International Agreements topic (top frex word stems: *china, treati, india, agreement, beij*) spiked during the late 1990s, when newspaper coverage of climate change was dominated by the Kyoto Protocol and U.S. debate over participation (which focused on differential emissions standards across the U.S., China, and India). Another means of assessing external validity regards word and topic intrusion tests that compare human evaluations of machine output (Chang et al., 2009). These

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[1] https://noahveltman.com/endorsements/

[2] Circulation data was collected by Alliance for Audited Media, https://auditedmedia.com.

[3] Seven newspapers were only available from 1999-2017: *Arizona Republic, Billings Gazette, Cincinnati Enquirer, Clarion Ledger, Des Moines Register, Detroit Free Press, Louisville Courier-Journal.* Other newspapers had limited availability: *Las Vegas Review-Journal* (1997-2012), *New Hampshire Union Leader* (2010-2017), *The Tennessean* (2001-2017), but were included to expand geographic and partisan diversity.
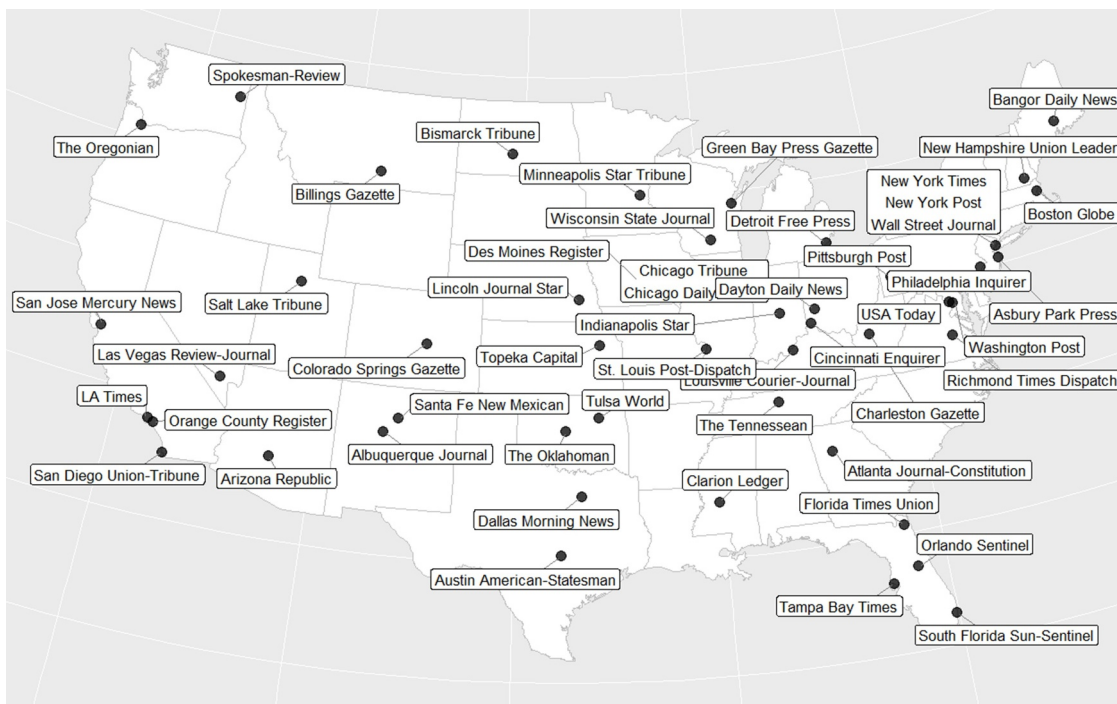
Fig. 1. Geography of newspapers included in analysis.

test results are presented in Appendix B, and indicate that most topics possess high external validity, with "Campaigns" and "Letters to the Editor" standing out as exceptions (neither of which are central to the analysis presented below).

4. Results

Fig. 2 presents the distribution of all articles in the corpus over time, making three periods of aggregate attention to climate change from U.S. newspapers apparent. First, from the beginning of the corpus until 2005, U.S. newspapers paid less attention to climate change, consistent with prior research (Feldman et al., 2017; Schmid-Petri et al., 2017). Second, a surge in attention occurred between 2007–2010, likely driven by the release of the Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC), former Vice President Al Gore's activity (releasing an award-winning documentary, sharing the Nobel Peace Prize with the IPCC), and the "Climategate" scandal (discussed further below). A third distinct period of attention occurred 2013–2017, during which the IPCC released its Fifth Assessment Report, the U.S. joined the Paris Agreement under President Obama, and the U.S. withdrew from the Paris Agreement under President Trump. These patterns are broadly consistent with those tracked by the Media and Climate Change Observatory Data Sets (Boykoff et al., 2019).

A plot demonstrating the prevalence of 28 topics, their labels, and the top ten frex-scored word stems is available in Appendix C. The most prevalent topic identified, International Agreements, discussed various international agreements and negotiations among nations to mitigate emissions. Articles focused on atmospheric levels of carbon dioxide and other greenhouse gases, typically tying their increase to fossil fuel combustion, drove the next most prevalent topic, Emissions & Pollution (top frex word stems: *carbon_dioxid, co2, emiss, carbon, fossil_fuel*). Notably, Climate Change Denial (top frex word stems: *scienc, conclus, ipcc, skeptic, scientif*) emerged as the third most prevalent topic in the corpus under this model. This topic covers both arguments made by climate change deniers against mainstream scientific conclusions as well as refutations of these claims. As discussed further below, this is a key topic to inspect regarding partisan bias. Absent from these results is "adaptation" as a distinct topic – confirming prior research that news reporting on climate change rarely covers adaptation (Boykoff and Roberts, 2007; Liu et al., 2008; Moser, 2014; Ford and King, 2015), as

well as the relative absence of climate models themselves (Akerlof et al., 2012).

4.1. Key events

Examining topical prevalence over time, we can detect several newsworthy events that drove climate-related attention in U.S. newspapers across two decades. These spikes in attention are revealed when visualizing the temporal prevalence of all 28 topics (Appendix D1 and D2). We can use these spikes in topic scores to strategically read relevant documents at specific points in time in the corpus and identify meaningful content. Several key events become apparent from doing this, starting with the Kyoto Protocol, which drove the International Agreements topic during the early part of the corpus. Perhaps no other event evident in this corpus garnered as much disproportionate attention within its time period as the story of American non-participation in the Kyoto Protocol.

Another notable event that saw a large spike in topic prevalence was cap-and-trade legislation covered across 2009–2010, driving the Legislation topic (top frex word stems: *legisl, bill, lawmak, amend, legislatur*). Most of this reflected federal attempts to pass cap-and-trade legislation that would limit greenhouse gas emissions. Representatives Henry Waxman of California and Edward Markey of Massachusetts proposed a cap-and-trade system through the American Clean Energy and Security Act of 2009, which passed the House of Representatives but was never brought to a vote in the Senate.

Around the same time (months after the Waxman-Markey bill was introduced), the Climate Change Denial topic spiked in prevalence. This corresponded with the infamous "Climategate scandal" wherein emails from climate scientists at the University of East Anglia were hacked and used to accuse them of data manipulation – charges the scientists were cleared of by multiple investigations (see Painter, 2011 for an overview). It is important to note that not all articles driving this topic necessarily carried an explicitly climate change denial outlook; several of the most representative articles contained refutations of such perspectives. Overall, the Climategate event and its fallout dominated U.S. newspaper coverage of climate change for several months after it occurred.

A less explicitly-political spike in newspaper coverage of climate change came with the Weather topic (top frex word stems: *weather,*
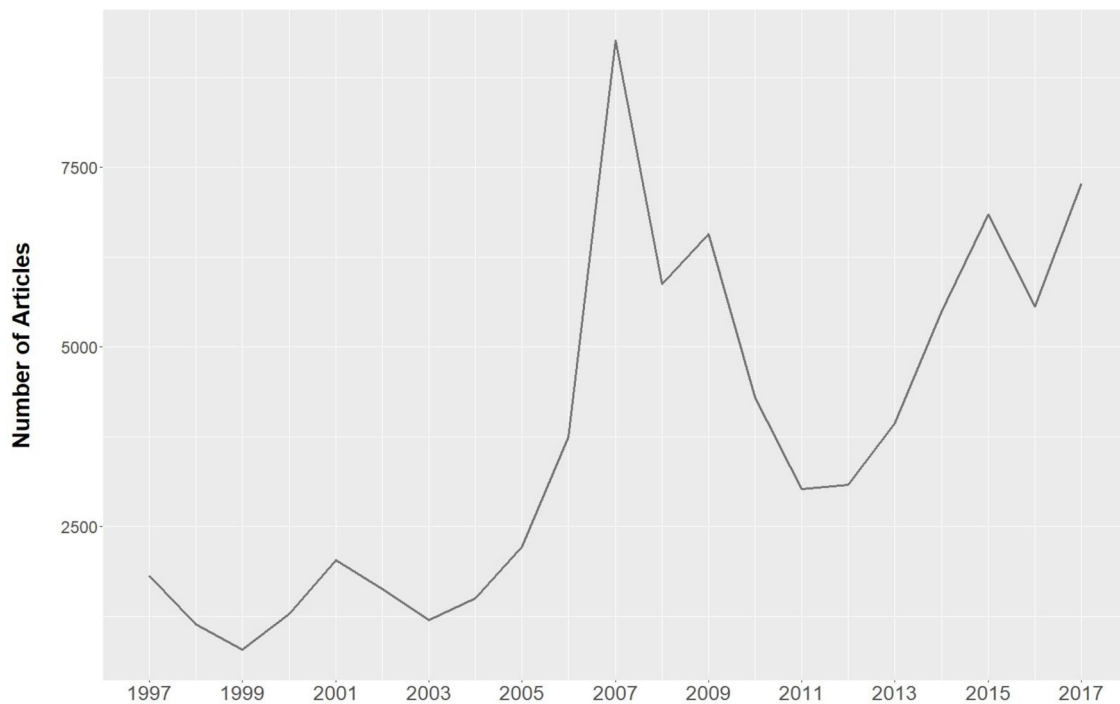
Fig. 2. Number of articles included in analysis per year.

temperatur, tornado, winter, forecast) during the summer of 2012. Numerous articles covered the record-setting heat wave that hit North America then, as well as destructive thunderstorms that left millions without electricity across the eastern U.S. The Weather topic spiked again at the end of the corpus in 2017, reflecting news coverage of Hurricane Irma. The relatively low prevalence of this topic around 2006, when Hurricane Katrina devastated New Orleans and surrounding areas, may seem conspicuous, but suggests that news coverage of Katrina may not have tied its occurrence or intensity to climate change. More recently, the Environmental Protection Agency (EPA) topic (top frex word stems: *epa, agenc, lawsuit, rule, court*) spiked during 2016, reflecting the legal battle over the Clean Power Plan under President Obama, in which the EPA would have overseen the regulation of carbon dioxide emissions from stationary power sources. The Clean Power Plan was challenged in court and the Supreme Court ordered the EPA to halt enforcement in 2016 by a 5–4 vote.

4.2. Partisan orientation & topical prevalence

When looking at topic prevalence over time, relatively few differences emerged based on partisan orientation, indicating that for most topics identified here, little partisan bias exists. Several exceptions exist, however, visualized in Fig. 3. Perhaps most notable is the partisan difference in attention to the Climate Change Denial topic. Although many articles contributing to this topic did not necessarily indict the professionalism of climate scientists, the larger trend remains that newspapers with conservative editorial boards provided much more coverage of the Climategate events than their moderate and liberal counterparts.

This difference in attention to events like Climategate and the topic of Climate Change Denial may not surprise familiar readers. Other examples of partisan differences in climate-related news coverage also exist. Perhaps the largest overall difference lies in attention paid to the Corporations topic (top frex word stems: *mr, ms, investor, exxon, compani*). Inspecting the content of representative articles revealed a range of topics surrounding corporate activity with implications for climate change, or how climate change may impact corporate stability and profits. Two spikes in conservative coverage of the Corporations topic occurred between 2002–2007 and again 2016–2017. Unsurprisingly, the business-oriented *Wall Street Journal* was a

major contributor to covering this topic. Articles about shareholder activism and pushes for socially responsible investment comprise much of the first period, while the more recent spike concerns controversies over whether oil companies such as ExxonMobil suppressed knowledge of anthropogenic climate change and the fallout in public opinion and possible legal challenges emanating from this.

Several other topics display partisan differences at certain points in time. Conservative newspapers devoted less coverage to the Arctic Region (top frex word stems: *polar_bear, bear, hunt, alaska, villag*) and Oceans & Sea Level (top frex word stems: *coral, reef, beach, coastal, florida*) topics than liberal newspapers from 2006 on. Representative Arctic Region articles discussed the implications of ice loss in the Arctic, such as impacts on Innuit communities and wildlife, the experience of tourism, and the possibility of new transit routes. The geography of newspapers producing the most representative articles in the Oceans & Sea Level topic concentrate near the coasts (e.g., the *Asbury Park Press, Boston Globe, Los Angeles Times, South Florida Sun-Sentinel*), which may help explain the relative under-coverage of this topic from conservative newspapers (whose geography is more inland; this is explored in terms of climate vulnerability in Section 4.4 below). Top articles in this topic discussed a wide range of issues such as marine life, coastline erosion, major storm events, and property values.

By contrast, liberal newspapers paid much less attention to the Energy Infrastructure (top frex word stems: *coal, indiana, pipelin, nuclear_power, reactor*) and Water Resources (top frex word stems: *dam, river, utah, lake, arizona*) topics compared with moderate and conservative newspapers. Articles representative of the Energy Infrastructure topic discussed initiatives carried out at specific power plants to address emissions (or announcing plant closures), particularly at coal plants. Unsurprisingly, the newspapers producing the most representative Water Resources content are geographically concentrated within the western U.S. (e.g., *Albuquerque Journal, Arizona Republic, Orange County Register, Spokesman-Review*), discussing issues such as drought and the impact of shrinking snowpack on rivers; this geographic concentration probably explains the increased prevalence of this topic among conservative versus liberal newspapers in the context of this corpus.

There were also partisan trends associated with the EPA and Weather topics introduced earlier. During the Bush administration, liberal newspapers covered the EPA topic more than conservative
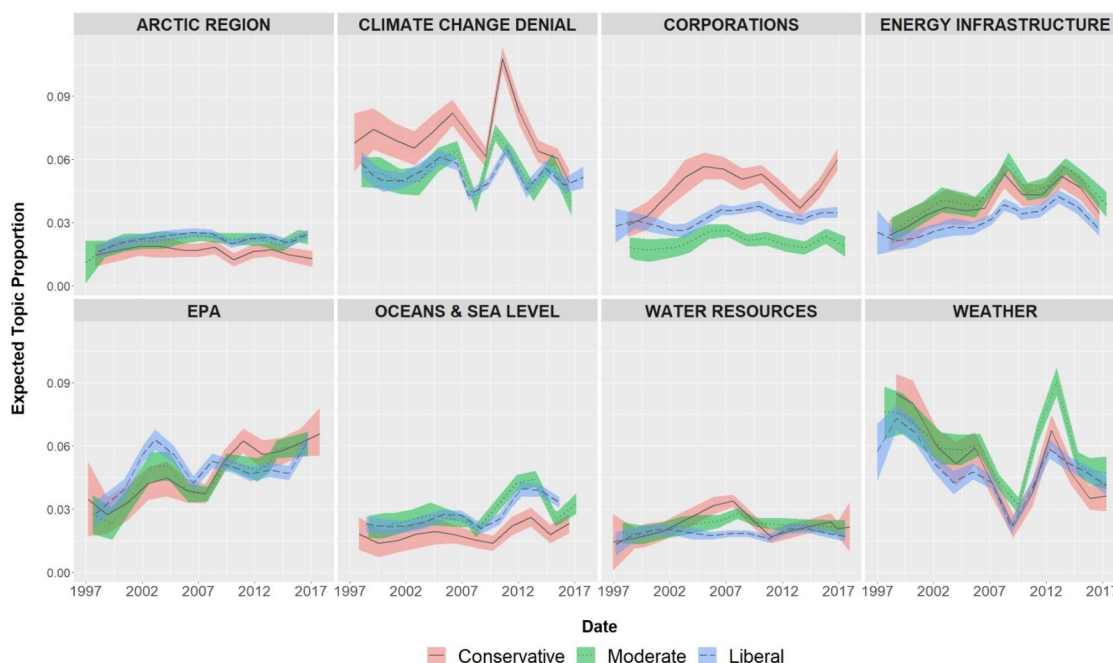
Fig. 3. Newspaper coverage of selected topics over time, by partisan orientation.

newspapers, while conservative newspapers covered the EPA topic more than liberal newspapers during the Obama administration. Moderate newspapers outpaced both conservative and liberal newspapers in their coverage of the Weather topic from 2010 – 2014 (the only topic and period where moderate newspapers stood out).

4.3. Scale & topical prevalence

Similar to partisan differences, very few systematic differences in topical attention emerged when comparing newspapers by scale of their circulation. Fig. 4 displays some exceptions. National newspapers focused more on the global context of greenhouse gases in the Emissions and Pollution topic, particularly from 2007–2017. National newspapers also devoted much more coverage to the International Agreements and Corporations topics throughout most of the period.

Regional papers instead gave relatively more attention to the Cities, Energy Infrastructure, and Weather topics. The Cities topic (top frex word stems: *mayor, citi, district, council, counti*) focused on city-specific climate impacts or efforts to address climate change mitigation. Representative examples range from an article discussing an EPA grant awarded to Salt Lake City to mitigate greenhouse gas emissions from vehicles, to a neighborhood initiative in Minneapolis aiming to help thousands of residents consume less energy and emit fewer emissions via energy efficiency programs Consistent with Brown et al. (2011), these patterns of regional papers giving more attention to these types of topics, combined with the relative over-coverage of weather events, suggest that regional papers "domesticate" their coverage of global climate change.

4.4. Vulnerability & topic prevalence

Given the overlap of political orientation and scale of circulation with geography, it is worthwhile to examine topic prevalence across estimated vulnerability to climate change. As with political orientation and scale, most topics display little difference in prevalence by vulnerability status, though some exceptions are visualized in Fig. 5. There we see newspapers located in areas of high vulnerability paying additional attention to several topics, many of which mirror patterns observed in Fig. 4.

Newspapers in high vulnerability cities gave more attention during certain time periods to the Corporations, Emissions & Pollution,

International Agreements, and Oceans & Sea Level topics. These newspapers paid more attention to corporate activity, tuned into GHG emissions as a driver of global warming (along with those of medium-vulnerability), and international efforts to address a global environmental problem. Unlike partisan orientation and scale of circulation, we see variation in the Oceans & Sea Level topic when looking at vulnerability status. As discussed earlier, this topic was driven by newspapers located near coasts, demonstrating those media organizations' response to localized impacts and concerns. Notably, the variation in attention to the topics presented in Fig. 5 (with the exception of Corporations) by vulnerability status takes off post-2007 when attention to climate change surges in the U.S. and several other countries.

Conversely, the Cities and Energy Infrastructure topics received relatively less attention from newspapers in high-vulnerability locations. The Cities topic offered surprising results along this comparison, with newspapers in low-vulnerability areas paying the most attention. Since the Cities topic focused on articles discussing localized mitigation efforts, this could be consistent with Boussalis et al., 2019 finding that higher levels of climate risk drove local government communication of adaptation but not mitigation; media outlets in low-vulnerability areas may even cover mitigation efforts to the extent that they are more controversial among local residents, though this model cannot confirm this. While we should read these results on the Cities topic with caution as there are few newspapers in this corpus operating in low-vulnerability locations, similar patterns were observed when categorizing climate vulnerability as above versus below the mean climate risk score.

5. Discussion

This analysis presented a systematic overview of outlet bias among 52 U.S. newspapers in their coverage of climate change spanning two decades and over 78,000 articles. Utilizing computational methods, I identified 28 themes found in U.S. newspaper coverage of climate change. These newspapers were diverse in terms of the partisan orientation of their editorial boards (conservative, moderate, liberal), scale (national, large regional, small regional), and locally measured climate risk. Across most topics, there was little variation in prevalence by partisanship, scale, or vulnerability over time. However, the partisan orientation of newspaper editorial boards does affect the prevalence of coverage for several topics and
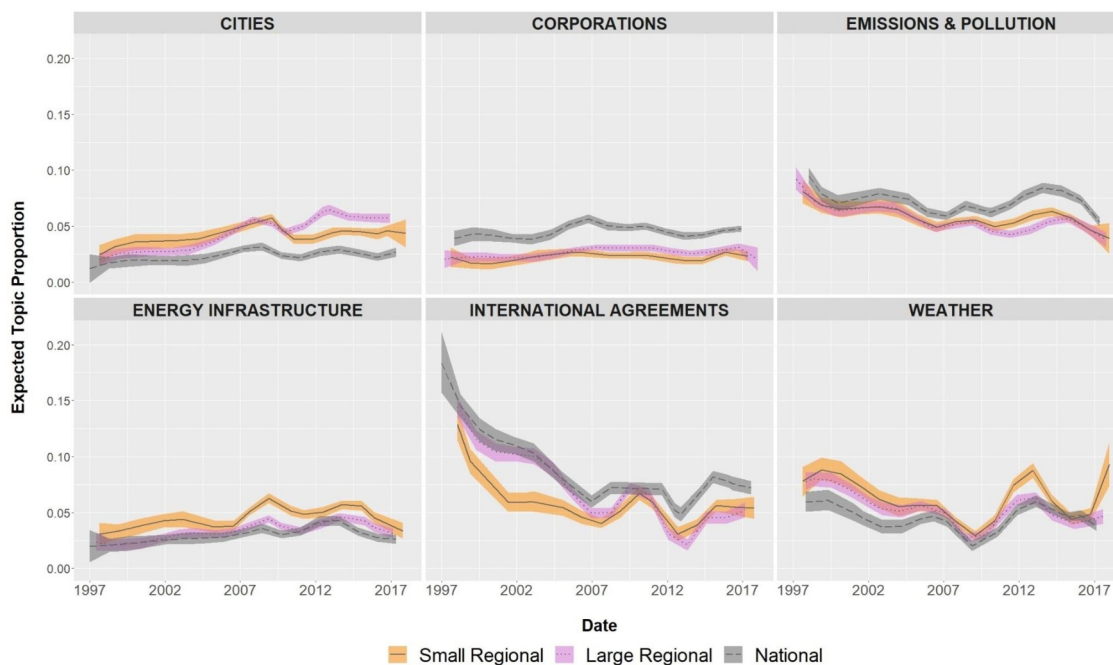
Fig. 4. Newspaper coverage of selected topics, by scale of circulation.

events. Conservative newspapers provided outsized attention to Climategate, corporate activity and regulation, and issues of resource extraction and use. Liberal newspapers meanwhile covered topics relating to climate change impacts at greater levels than their conservative counterparts. Looking at newspapers by scale, those with national circulations took on a more global perspective in their coverage of climate change (relating to negotiations between nation-states, activities and impacts on multinational corporations, or levels of greenhouse gas emissions) while regional papers provided more coverage of issues with localized context (local government action, actions affecting specific utilities, particular weather events). Newspapers also cover some topics in accordance with their objectively measured risk. Outlets located in areas vulnerable to climate change dedicated more coverage to impacts such as sea level rise, GHG emissions as a driver of climate change, and international efforts to address climate change.

With this study, we gain insight into the systematic differences in climate change newspaper coverage by partisanship, scale, and climate risk. This research confirms trends found in Carvalho and Burgess (2005), Boykoff and Mansfield (2008), Dotson et al., 2012, and Painter and Ashe (2012) that political leaning influences how or the extent to which a newspaper covers climate change. These partisan differences in the prevalence of coverage are relevant in the American political context, where the merging of party loyalty and social identity increasingly shape political culture (Cramer, 2016; Mason, 2018; Barber and Pope, 2019), and conservative voters may dismiss climate change science via negative cues from Democrats rather than affirmatively taking cues from Republicans (who are cited less often in conservative media than Democrats in relation to climate change; Merkley and Stecula, 2018).

Including a diverse array of local and national newspapers provides researchers new opportunity to explore patterns of climate change media coverage. To the extent that climate change policy in the U.S. emanates from local and state governments rather than the federal government, more
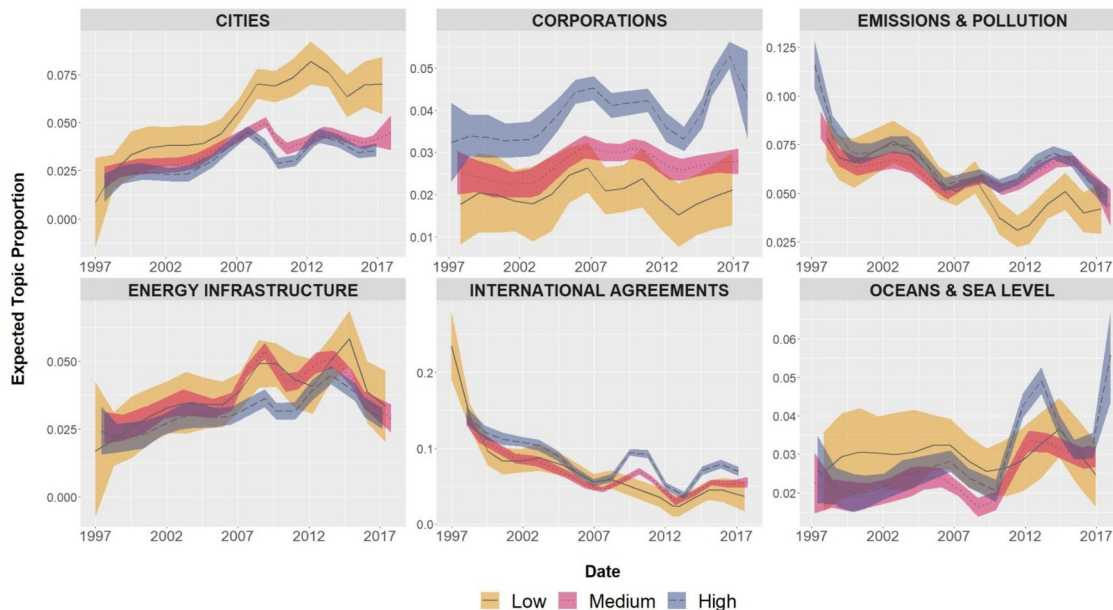

Fig. 5. Newspaper coverage of selected topics, by climate vulnerability status (with floating y-axis).

research could explore the agenda setting function of local media against other factors, similar to what Carmichael and Brulle (2017) accomplished in their study of public opinion on climate change. Across many states, Tan and Weaver, 2009 observed a moderately strong relationship between local news coverage and state-level policy agendas. Given the increasing evidence of climate change impacts, we should expect the topical attention of regional newspapers to reflect localized concerns going forward (Brown et al., 2011). This should encourage climate change media researchers to consider outlet sources as important metadata steering attention in regional politics. To the extent that local concerns focus on impacts, researchers working with corpora comprised of diverse outlets should also incorporate risk measurements into their models.

Acknowledging how outlet bias potentially confounds the relationship between newspaper coverage and various political outcomes provides an opportunity to add to the extensive body of research on agenda setting (McCombs and Shaw, 1972), focused on the processes that heighten the issue salience of climate change among readers. Elaborations on this perspective indicate that independent of qualitative content, quantity of coverage of environmental and technology issues can shape levels of fear and risk aversion among the public (Mazur and Lee, 1993). This perspective assumes a fairly uniform coverage of topics across subnational geographic and ideological variation. While that was the case for most topics identified in this analysis, there were several exceptions. Future research could utilize the systematic measurements of coverage offered by topic models to assess how topics that differ in prevalence by type of source affect political outcomes, and whether localized climate vulnerability constitutes an important component of the agenda setting process. Pursuing this type of question for local and state climate politics could synthesize strands of research initiated by Tan and Weaver, 2009 and Bromley-Trujillo et al., 2019.

Of course, there are limitations to the current study. Most of all, newspapers have peaked in their media prominence. This study cannot comment on whether different trends in climate change coverage would be observed among new media or television broadcasts in comparison with traditional newspapers. While social media still plays a relatively modest role in informing Americans about science news (Pew Research Center 2017), we should expect the influence of different mediums to change in the future. Moreover, there may be legitimate concerns about the reliability of digitized newspaper databases, particularly nearer the beginning of the corpus when such archiving practices were new.

The systematic differences described above only apply to topical prevalence but say nothing systematically of the sentiment conveyed. Similarly, this analysis does not assess how accurately newspapers reported scientific research on climate change, the relative balance of established experts versus figures primarily associated with the climate change denial network (Boykoff, 2013), or for example the deference provided to an industry's views on a given topic (see Dispensa and Brulle, 2003). Nor does it systematically analyze how different news outlets frame climate-related issues in their news content (e.g., Trumbo, 1996; Bowe et al., 2014; Broadbent et al. 2016), or the importance they convey about their climate change coverage via placement on front pages of print copies or prominent placement on a website. All of these points (medium, sentiment, accuracy, prominence, or framing of coverage), combined with diverse data, could serve as the focus of future research studies aiming to expand the literature on media representation of climate change. Moving beyond a focus on traditional newspaper text, researchers could further explore other fields that expose people to climate change information such as digital news platforms that now rival legacy media brands (Painter et al., 2016), online video (León et al., 2018), news images (León and Erviti, 2015; Duan et al., 2017), or comedy (Anderson and Becker, 2018).

Future researchers could also apply supervised computational techniques to focus attention on specific topics to complement the exploratory, unsupervised results of this study. For example, training models to identify and estimate the prevalence of climate change adaptation media coverage (otherwise overshadowed in the results presented here) could test whether the trend observed by Boussalis et al. (2019) – that local climate change

vulnerability shapes the discussion of adaptation but not mitigation among U.S. city government press releases – also applies to newspaper coverage. Similarly, it is important to classify the sentiment contained within certain types of media coverage, for example testing whether newspapers located in low-vulnerability areas provide more coverage of local mitigation (as appears to be the case in this analysis) because such actions garner more controversy in those cities.

Another important area for future research lies in comparing results of computational studies across national contexts, in order to gain general knowledge on the drivers of climate change media coverage. Along these lines, researchers should endeavor to build large corpora with diverse outlets in terms of political orientation, scale, subnational geography (to account for local climate change vulnerability), and other relevant metadata. The increasing accessibility of computational methods makes this goal achievable. Few examples exist at present that apply computational methods to large corpora, with some exceptions. Comparing political leaning and ownership structure, Boussalis et al., 2016 found that left-leaning Russian newspapers owned by journalists provided more coverage of climate change versus those owned by energy interests, with national economic conditions exerting the greatest influence of overall coverage. Compared with U.S. outlets, though, Russian newspapers provide much less coverage of climate change. Keller et al. (2020) estimated a topic model of two large Indian newspapers across a corresponding time period as the current study, revealing both commonalities and differences. Newspapers in both India and the U.S. dedicated more attention to international efforts to address climate change than any other topic, with several other topics (forests, sea level, wildlife) displaying approximately similar proportions. The differences in coverage probably reflect the contrasting political and economic context of climate change across the two countries, however. While Indian newspapers focused more on agricultural impacts as well as activist and educational campaigns, American newspapers dedicated a lot of coverage to climate change denial, EPA regulatory politics, and the impacts on large corporations.

Studying sources of bias affecting the news coverage of climate change can help contextualize the political polarization that exists in the American public despite accumulating scientific evidence regarding the role of human activity in driving recent warming. The results presented here are consistent with research suggesting that key events drive the narrative surrounding climate change (e.g., Boykoff, 2007a). Ungar (1992) noted the necessity of environmental problems to converge with dramatic events in order to receive attention from the mass media. The clearest differences were seen in how conservative newspapers provided additional space for the Climategate scandal versus outlets with liberal or moderate editorial boards. Despite investigative conclusions that no malfeasance occurred among the scientists involved in the Climategate scandal, the fallout resulted in decreased belief in global warming among U.S. television meteorologists (Maibach et al., 2011) and a loss of public trust in climate scientists, especially among politically conservative individuals (Leiserowitz et al., 2012). With the analysis provided here, we now have a systematic understanding of what types of newspapers drove U.S. coverage of Climategate, as well as several other topics related to climate change.

Author statement

I declare that I am the sole author of this research, responsible for all prose and formal analysis.
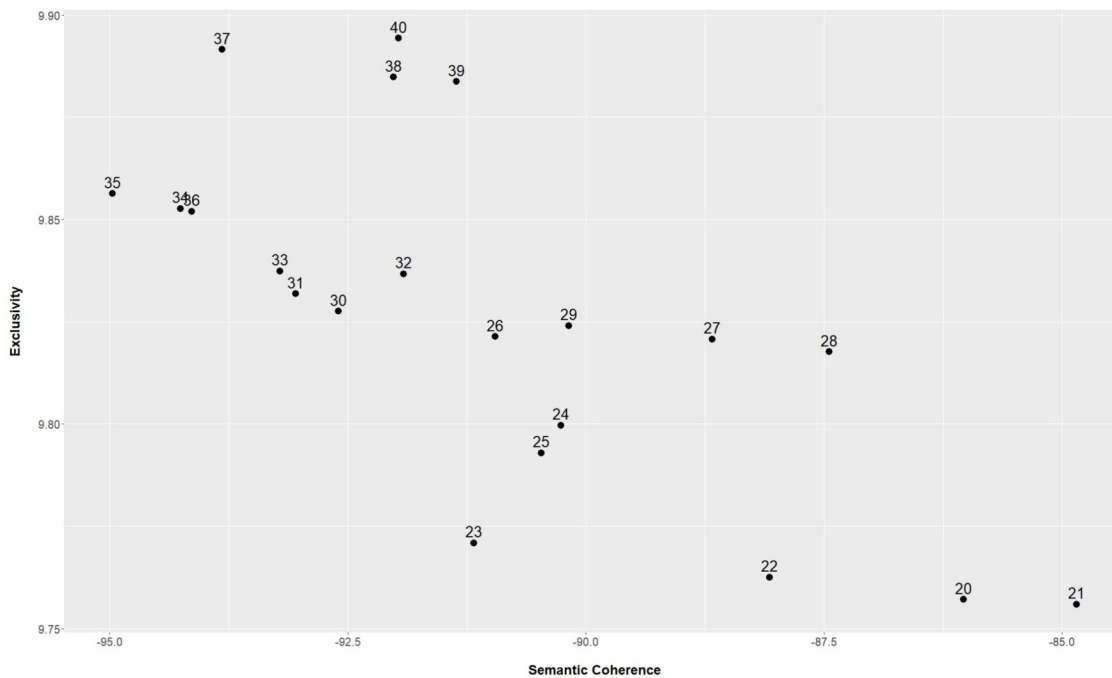
Declaration of Competing Interest

None.

Acknowledgments

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2020.102038.

Appendix A – Generality scores representing topic exclusivity and semantic coherence of models estimated by *k* topics
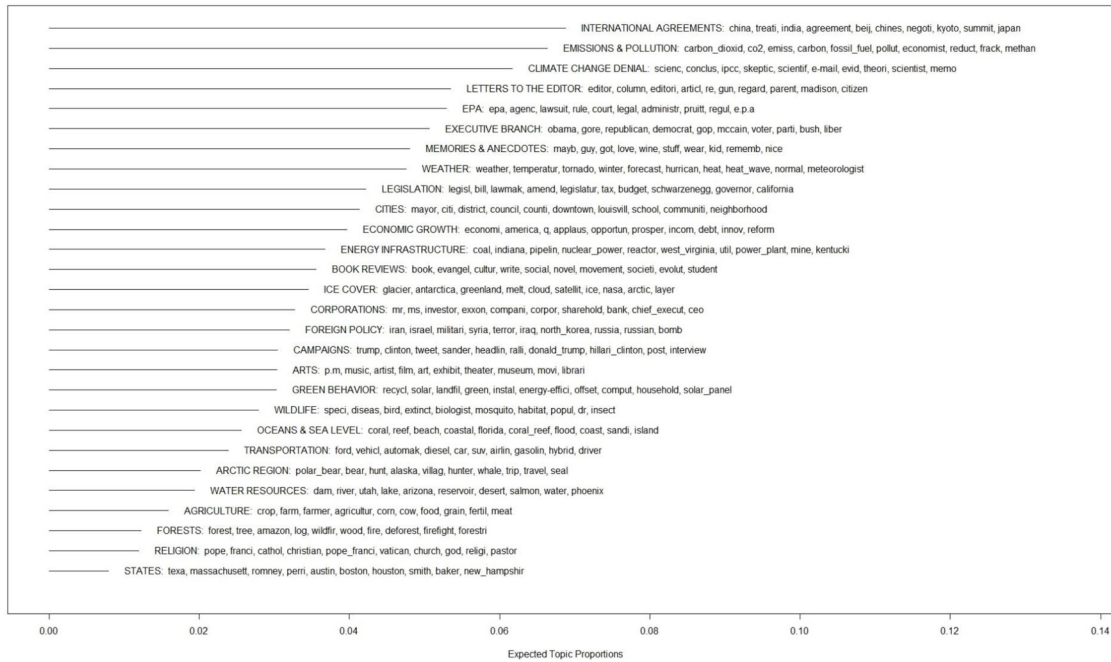

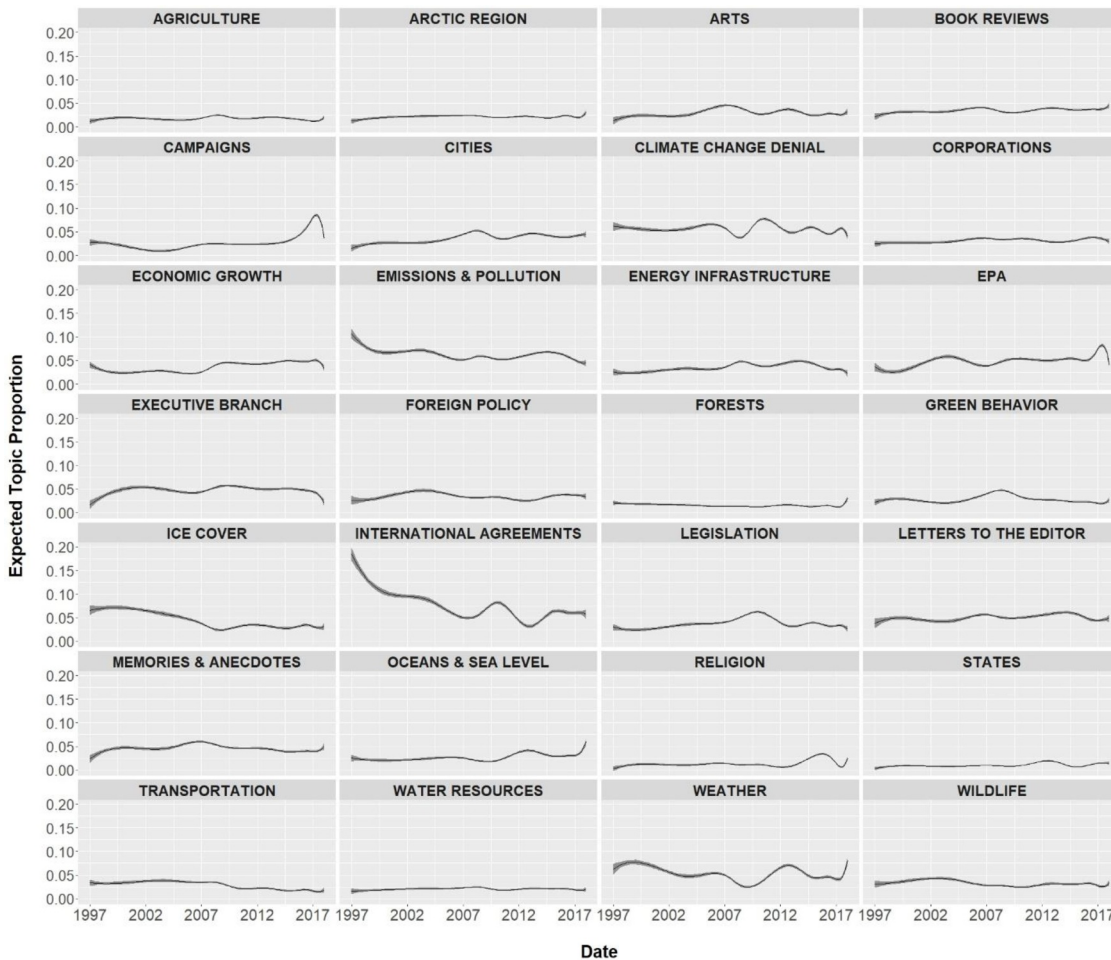**Appendix B – Results from external validation tests**

Topic	Word Intrusion	Topic Intrusion
Agriculture	100%	100%
Arctic region	83%	100%
Arts	75%	100%
Book reviews	92%	100%
Campaigns	58%	88%
Cities	83%	100%
Climate change denial	83%	100%
Corporations	100%	100%
Economic growth	83%	100%
Emissions & pollution	100%	100%
Energy infrastructure	75%	100%
EPA	92%	100%
Executive branch	100%	75%
Foreign policy	100%	88%
Forests	100%	100%
Green behavior	100%	100%
Ice cover	100%	100%
International agreements	100%	100%
Legislation	100%	100%
Letters to the editor	50%	88%
Memories & anecdotes	83%	100%
Oceans & sea level	100%	100%
Religion	100%	100%
States	92%	100%
Transportation	100%	88%
Water resources	83%	100%
Weather	100%	100%
Wildlife	100%	88%

External validation was assessed via "word intrusion" and "topic intrusion" tests (Chang et al., 2009; Keller et al. *forthcoming*). For word intrusion, twelve reviewers were presented with five of the most probable words associated with each topic, as well as a randomly selected sixth word that was *not* among the 500 most probable words for the topic. For topic intrusion, eight reviewers read an article and were presented with the topic it scored very highly on as well as two topics on which it scored very low. Reported percentages in the above columns indicate amount of agreement correctly identifying intruding words or topics.
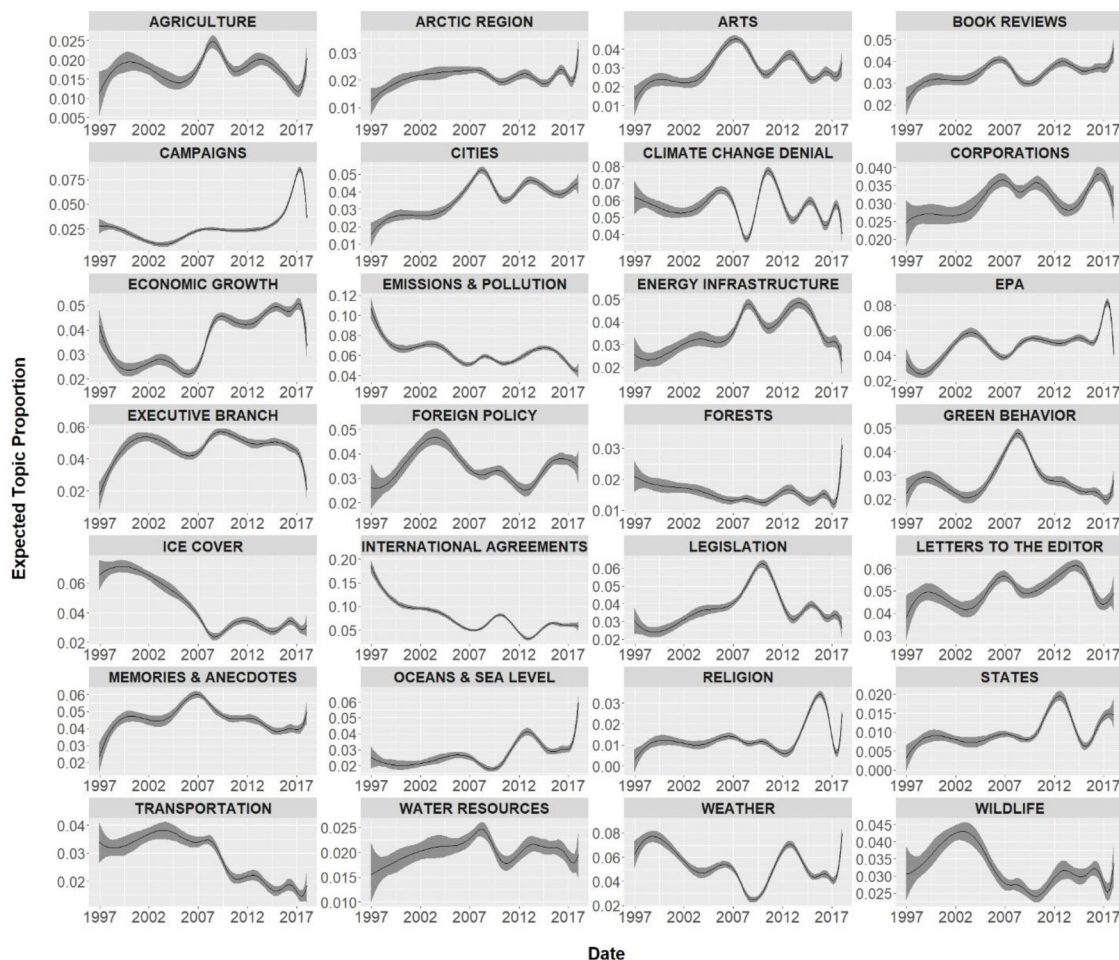
Appendix C – Topic prevalence, topic labels, and top 10 frequent and exclusive (FREX) word stems

Appendix D1 – 28 topics over time, with fixed *y*-axis

Appendix D2 – 28 topics over time, with floating *y*-axis

References

Ahchong, K., Dodds, R., 2012. Anthropogenic climate change coverage in two Canadian newspapers, the Toronto star and the Globe and Mail, from 1988 to 2007. Environ. Sci. Policy 15 (1), 48–59.

Akerlof, K., Rowan, K.E., Fitzgerald, D., Cedeno, A.Y., 2012. Communication of climate projections in US media amid politicization of model science. Nat. Clim. Change 2, 648–654.

Anderson, A.A., Becker, A.B., 2018. Not Just Funny After All: Sarcasm as a Catalyst for Public Engagement With Climate Change. Science Communication 40 (4), 524–540.

Antilla, L., 2005. Climate of scepticism: US newspaper coverage of the science of climate change. Global Environ. Change 15, 338–352.

Barber, M., Pope, J.C., 2019. "Does party trump ideology? Disentangling party and ideology in America.". Am. Politi. Sci. Rev. 113 (1), 38–54.

Benoit, K., Watanabe, K., Wang, H., Nulty, P., Obeng, A., Müller, S., Matsuo, A., 2018. Quanteda: an R package for the quantitative analysis of textual data. J. Open Source Softw. 3 (30), 774.

Billett, S., 2010. Dividing climate change: global warming in the Indian mass media. Clim. Change 99 (1–2), 1–16.

Bischof, J., Airoldi, E., 2012. Summarizing topical content with word frequency and exclusivity. In: Langford, John, Pineau, Joelle (Eds.), Proceedings of the 29th International Conference On Machine Learning (ICML-12). Omnipress, New York, NY, pp. 201–208.

Blei, D.M., Ng, A.Y., Jordan, M.I., 2003. Latent dirichlet allocation. J. Mach. Learn. Res. 3, 993–1022.

Bohr, J., 2016. The 'Climatism' cartel: why climate change deniers oppose market-based mitigation policy. Env. Polit. 25 (5), 812–830.

Boussalis, C., Coan, T.G., Holman, M.R., 2018. Climate change communication from cities in the USA. Clim. Change 149 (2), 173–187.

Boussalis, C., Coan, T.G., Holman, M.R., 2019. Communicating climate mitigation and adaptation efforts in American cities. Climate 7 (3), 45.

Boussalis, C., Coan, T.G., Poberezhskaya, M., 2016. Measuring and modeling Russian newspaper coverage of climate change. Global Environ. Change 41, 99–110.

Bowe, B.J., Oshita, T., Terracina-Hartman, C., Chao, W.-C., 2014. Framing of climate

change in newspaper coverage of the East Anglia e-mail scandal. Public Understand. Sci. 23 (2), 157–169.

Boykoff, M.T., 2007a. Flogging a dead norm? Newspaper coverage of anthropogenic climate change in the United States and United Kingdom from 2003 to 2006. Area 39 (2), 470–481.

Boykoff, M.T., 2007b. From convergence to contention: United States mass media representations of anthropogenic climate change science. Trans. Inst. Br. Geogr. 32 (4), 477–489.

Boykoff, M.T., 2013. Public enemy no. 1? Understanding media representations of outlier views on climate change. Am. Behav. Sci. 57 (6), 796–817.

Boykoff, M.T., Boykoff, J.M., 2004. Balance as bias: global warming and the US prestige press. Global Environ. Change 14, 125–136.

Boykoff, M.T., Boykoff, J.M., 2007. Climate change and journalistic norms: A case-study of US mass-media coverage. Geoforum 38 (6), 1190–1204.

Boykoff, M., Daly, M., McAllister, L., McNatt, M., Nacu-Schmidt, A., Oonk, D., Pearman, O., 2019. United States newspaper coverage of climate change or global warming, 2000-2019 – June 2019. Media Climate Change Obs. Data Sets 191.

Boykoff, M.T., Mansfield, M., 2008. 'Ye olde hot aire'*: reporting on human contributions to climate change in the UK tabloid press. Environ. Res. Lett. 3 (2), 024002.

Boykoff, M.T., Roberts, J.T., 2007. Media coverage of climate change: current trends, strengths, weaknesses. Human Development Report 2007/8. United Nations Development Programme.

Broadbent, J., et al., 2016. Conflicting climate change frames in a global field of media discourse. Socius 2, 1–17.

Bromley-Trujillo, R., Holman, M., Sandoval, A., 2019. Hot Districts, Cool Legislation: Evaluating Agenda Setting in Climate Change Bill Sponsorship in US States. State Politics & Policy Quarterly 19 (3), 375–395.

Brossard, D., Shanahan, J., McComas, K., 2004. Are issue-cycles culturally constructed? A comparison of French and American coverage of global climate change. Mass. Commun. Soc. 7 (3), 359–377.

Brown, T., Budd, L., Bell, M., Rendell, H., 2011. The local impact of global climate change: reporting on landscape transformation and threatened identity in the English regional newspaper press. Public Understand. Sci. 20 (5), 658–673.

Brüggemann, M., Engesser, S., 2017. Beyond false balance: how interpretive journalism shapes media coverage of climate change. Global Environ. Change 42, 58–67.

Carmichael, J.T., Brulle, R.J., 2017. Elite cues, media coverage, and public concern: an integrated path analysis of public opinion on climate change, 2001-2013. Env. Polit. 26 (2), 232–252.

Carvalho, A., Burgess, J., 2005. Cultural circuits of climate change in U.K. broadsheet newspapers, 1985-2003. Risk Anal. 25 (6), 1457–1469.

Chang, J., Gerrish, S., Wang, C., Boyd-Graber, J.L., Blei, D.M., 2009. Reading tea leaves: how humans interpret topic models. Adv. Neural. Inf. Process. Syst. 288–296.

Chetty, K., Devadas, V., Fleming, J.S., 2015. The framing of climate change in New Zealand newspapers from June 2009 to June 2010. J. R. Soc. N. Z. 45 (1), 1–20.

Cramer, K.J., 2016. The Politics of Resentment: Rural Consciousness in Wisconsin and the Rise of Scott Walker. University of Chicago Press.

Das, J., 2020Das, Forthcoming. The struggle for climate justice: three Indian news media coverage of climate change. Environ. Commun. 14 (1), 126–140.

Dayrell, C., 2019. Discourses around climate change in Brazilian newspapers: 2003-2013. Discourse Commun. 13 (2), 149–171.

Dispensa, J.M., Brulle, R.J., 2003. Media's social construction of environmental issues: focus on global warming – A comparative study. Int. J. Sociol. Soc. Policy 23 (10), 74–105.

Dotson, D.M., Jacobson, S.K., Kaid, L.L., Carlton, J.S., 2012. Media coverage of climate change in Chile: a content analysis of conservative and liberal newspapers. Environ. Commun. 6 (1), 64–81.

Downs, A., 1972. Up and down with ecology – the 'issue-attention cycle.'. Public Int. 28, 38–50.

Duan, R., Zwickle, A., Takahashi, B., 2017. A construal-level perspective of climate change images in US newspapers. Clim. Change 142, 345–360.

Dunlap, R.E., McCright, A.M., Yarosh, J.H., 2016. The political divide on climate change: partisan polarization widens in the US. Environment 58 (5), 4–23.

Dunwoody, S., 2005. Weight-of-evidence reporting: what is it? Why use it? NiemanReports 54 (4), 89–91.

Elsasser, S.W., Dunlap, R.E., 2013. Leading voices in the denier choir: conservative columnists' dismissal of global warming and denigration of climate science. Am. Behav. Sci. 57 (6), 754–776.

Engesser, S., Brüggemann, M., 2016. Mapping the minds of the mediators: the cognitive frames of climate journalists from five countries. Public Understand. Sci. 25 (7), 825–841.

Feldman, L., Hart, P.S., Milosevic, T., 2017. Polarizing news? Representations of threat and efficacy in leading US newspapers' coverage of climate change. Public Understand. Sci. 26 (4), 481–497.

Ford, J.D., King, D., 2015. Coverage and framing of climate change adaptation in the media: a review of influential North American newspapers during 1993-2013. Environ. Sci. Policy 48, 137–146.

Gamson, W.A., Croteau, D., Hoynes, W., Sasson, T., 1992. Media images and the social construction of reality. Annu. Rev. Soc. 18, 373–393.

Gentzkow, M., Shapiro, J.M., 2010. What drives media slant? Evidence from U.S. daily newspapers. Econometrica 78 (1), 35–71.

Ghosh, A., Boykoff, M., 2019. Framing sustainability and climate change: interrogating discourses in vernacular and English-Language media in Sundarbans, India. Geoform 99, 142–153.

Grimmer, J., Stewart, B.M., 2013. Text as data: the promise and pitfalls of automatic content analysis methods for political texts. Polit. Anal. 21 (3), 267–297.

Hiles, S.S., Hinnant, A., 2014. Climate change in the newsroom: journalists' evolving standards of objectivity when covering global warming. Sci. Commun. 36 (4), 428–453.

Hilgartner, S., Bosk, C.L., 1988. The rise and fall of social problems: a public arenas model. Am. J. Soc. 94 (1), 53–78.

Jaspal, R., Nerlich, B., 2014. When climate science became climate politics: British media representations of climate change in 1988. Public Underst. Sci. 23 (2), 122–141.

Kaiser, J., Rhomberg, M., 2016. Questioning the doubt: climate skepticism in German newspaper reporting on COP17. Environ. Commun. 10 (5), 556–574.

Keller, T.R., Hase, V., Thaker, J., Mahl, D., Schäfer, M.S., 2020. News media coverage of climate change in India 1997-2016: using automated content analysis to assess themes and topics. Environ. Commun. 14 (2), 219–235.

Kundzewicz, Z.W., Painter, J., Kundzewicz, W.J., 2019. Climate change in the media: Poland's exceptionalism. Environ. Commun. 13 (3), 366–380.

Leiserowitz, A.A., Maibach, E.W., Roser-Renouf, C., Smith, N., Dawson, E., 2012. Climategate, public opinion, and the loss of trust. Am. Behav. Sci. 57 (6), 818–837.

León, B., Erviti, M., 2015. Science in pictures: visual representation of climate change in Spain's television news. Public Underst. Sci. 24 (2), 183–199.

León, B., Boykoff, M., Huda, J., Rodrigo, C., 2018. Framing in climate change videos. Communicating Science and Technology Through Online Video. Routledge, New York, pp. 107–119.

Liu, X., Vedlitz, A., Alston, L., 2008. Regional news portrayals of global warming and climate change. Environ. Sci. Policy 11, 379–393.

Lyytimäki, J., 2015. Prospects for environmental communication based on 25 years of newspaper coverage of climate change and eutrophication in Finland. Appl. Environ. Edu. Commun. 14 (4), 246–255.

Maibach, E., Witte, J., Wilson, K., 2011. "'Climategate' undermined belief in global warming among many American TV meteorologists.". Bull. Am. Meteorol. Soc. 92 (1), 31–37.

Mariotto, F.P., Venturini, C., 2017. 2014, The 'year without summer' in Italy: news media coverage and implications for the climate change debate. Environ. Dev. Sustain. 19, 1367–1380.

Mason, L., 2018. Uncivil Agreement: How Politics Became Our Identity. University of Chicago Press, Chicago.

Mazur, A., Lee, J., 1993. Sounding the global alarm: environmental issues in the US national news. Soc. Stud. Sci. 23 (4), 681–720.

McComas, K., Shanahan, J., 1999. Telling stories about global climate change: measuring the impact of narratives on issue cycles. Commun. Res. 26 (1), 30–57.

McCombs, M.E., Shaw, D.L., 1972. The agenda-setting function of mass media. Public Opin. Q. 36 (2), 176–187.

McCright, A.M., Dunlap, R.E., 2011. The politicization of climate change and polarization in the American public's views of global warming, 2001-2010. Soc. Q 52, 155–194.

McKewon, E., 2012. Duelling realities: conspiracy theories vs climate science in regional newspaper coverage of Ian Plimer's book, Heaven and Earth. Rural Soc. 21 (2), 99–115.

Merkley, E., Stecula, D.A., 2018. Party elites or manufactured doubt? The informational context of climate change polarization. Sci. Commun. 40 (2), 258–274.

Mohr, J.W., Bogdanov, P., 2013. Introduction—Topic models: what they are and why they matter. Poetics 41, 545–569.

Moser, S.C., 2014. Communicating adaptation to climate change: the art and science of public engagement when climate change comes home. Wires Clim. Change 5, 337–358.

ND-GAIN. Urban Adaptation Assessment Technical Document. 2018. Available at https://gain.nd.edu/assets/293226/uaa_technical_document.pdf (accessed on November 19, 2019).

Olausson, U., 2009. Global warming – global responsibility? Media frames of collective action and scientific certainty. Public Underst. Sci. 18 (4), 421–436.

Painter, J., 2011. Poles Apart: The International Reporting of Climate Scepticism. Reuters Institute for the Study of Journalism, Oxford.

Painter, J., Ashe, T., 2012. Cross-national comparison of the presence of climate scepticism in the print media in six countries, 2007-10. Environ. Res. Lett. 7 (4), 044005.

Painter, J., Erviti, M.C., Fletcher, R., Howarth, C., Kristiansen, S., Bienvenido, L., Oukrat, A., Russell, A., Schäfer, M.S., 2016. Something Old, Something New: Digital Media and the Coverage of Climate Change. Reuters Institute for the Study of Journalism, Oxford.

Painter, J., Gavin, N., 2016. Climate skepticism in British newspapers, 2007-2011. Environ. Commun. 10 (4), 432–452.

Pew Research Center, 2017. Science News and Information Today. Pew Research Center, Washington, D.C. http://www.journalism.org/2017/09/20/science-news-and-information-today.

Pulver, S., Sainz-Santamaría, J., 2018. Characterizing the climate issue context in Mexico: reporting on climate change in Mexican newspapers, 1996-2009. Clim. Dev. 10 (6), 538–551.

Quinn, K., 2010. How to analyze political attention with minimal assumptions and costs. Am. J. Pol. Sci. 54 (1), 209–228.

Rea, C.M., 2019. Regulatory thickening and the politics of market-oriented environmental policy. Env. Polit. 28 (7), 1167–1191.

Revkin, A., 2018. Climate change first became news 30 years ago. Why haven't we fixed it? Nat. Geogr. Mag. https://www.nationalgeographic.com/magazine/2018/07/embark-essay-climate-change-pollution-revkin/.

Roberts, M.E., Stewart, B.M., Tingley, D., 2014a. Stm: an r package for the structural topic model. R package 1.0.12.

Roberts, M.E., Stewart, B.M., Tingley, D., Lucas, C., Leder-Luis, J., Gadarian, S.K., Albertson, B., Rand, D.G., 2014b. Structural topic models for open-ended survey responses. Am. J. Pol. Sci. 58 (4), 1064–1082.

Schäfer, M.S., Schlichting, I., 2014. Media representations of climate change: a meta-analysis of the research field. Environ. Commun. 8 (2), 142–160.

Schmid-Petri, H., Adam, S., Schmucki, I., Häussler, T., 2017. A changing climate of skepticism: the factors shaping climate change coverage in the US press. Public Underst. Sci. 26 (4), 498–513.

Schmidt, A., Ivanova, A., Schäfer, M.S., 2013. Media attention for climate change around the world: a comparative analysis of newspaper coverage in 27 countries. Global Environ. Change 23 (5), 1233–1248.

Tan, Y., Weaver, D.H., 2009. Local Media, Public Opinion, and State Legislative Policies: Agenda Setting at the State Level. International Journal of Press/Politics 14 (4), 454–476.

Trumbo, C., 1996. Constructing climate change: claims and frames in US news coverage of an environmental issue. Public Underst. Sci. 5, 269–283.

Ukonu, M.O., Akpan, C.S., Anorue, L.I., 2012. Nigerian newspaper coverage of climate change, 2009-2010. New Media Mass Commun. 5, 22–37.

Ungar, S., 1992. The rise and (relative) decline of global warming as a social problem. Sociol. Q. 33 (4), 483–501.

Yang, G., 2010. Brokering environment and health in China: issue entrepreneurs of the public sphere. J. Contemp. China 19 (63), 101–118.

Young, N., 2011. Working the fringes: the role of letters to the editor in advancing non-standard media narratives about climate change. Public Underst. Sci. 22 (4), 443–459.

Young, N., Dugas, E., 2011. Representations of climate change in Canadian national print media: the banalization of global warming. Canad. Rev. Sociol. 48 (1), 1–22.

Young, N., Dugas, E., 2012. Comparing climate change coverage in Canadian English- and French-Language print media: environmental values, media cultures, and the narration of global warming. Canad. J. Sociol. 37 (1), 25–54.

Yun, S.-J., Ku, D., Park, N.-B., Han, J., 2014. Framing climate change as an economic opportunity in South Korean newspapers. Dev. Soc. 43 (2), 219–238.

Zehr, S.C., 2000. Public representations of scientific uncertainty about global climate change. Public Underst. Sci. 9, 85–103.

Zhao, X., Rolfe-Redding, J., Kotcher, J., 2016. Partisan differences in the relationship between newspaper coverage and concern over global warming. Public Underst. Sci. 25 (5), 543–559.