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Frequent but Accurate: A Closer Look at Uncertainty and Opinion Divergence in Climate Change Print News

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ABSTRACT

The prevalence of uncertainty and opinion divergence frames in climate change news reporting has generated concerns about the misrepresentation of scientific consensus. We first develop reliable, valid, and more nuanced measures of often-conflated types of uncertainty and opinion divergence frames. Then we analyse the co-occurrence combinations of those distinct types of opinions, sources, and topics in mainstream climate change news stories between 2005 and 2015. Results indicate that while uncertainty and opinion divergence frames are indeed frequent, once clearly distinguished, they in general accurately reference non-scientist sources (e.g. government officials) and topics that do *not* have a scientific consensus (e.g. the severity of climate change effects).

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Climate change journalism frequently presents the knowledge or opinions of diverse sources about a wide variety of topics of climate change (Hulme, 2009). While often demonstrating support for climate change science and solutions, these opinion portrayals can often, instead, be framed as expressions of uncertainty, scepticism, disagreement, or controversy (Antilla, 2005; Zehr, 2000). This could misrepresent the scientific consensus on climate change and could hinder the alignment of public opinion with the scientific consensus. However, research in this area has overlooked crucial distinctions in the types of these uncertainty or opinion divergence frames, conflating them with the disparate sources and topics they reference. Failing to distinguish among these distinct frames, or to assess their co-occurrences, likely results in over-generalized and misleading conclusions about climate change reporting discourse and effects. Thus, we develop a conceptual framework that distinguishes the types of "opinion frames" (e.g. uncertainties, disagreement, controversy, scepticism) in climate change news stories, the sources portrayed as holding these opinions, and the disparate climate change topics about which the opinions are held. Then, we investigate and interpret the patterns of these distinct co-occurrences in climate change news articles from 2005 to 2015 through this more nuanced perspective.

1. Concerns about the framing of climate change discourse

1.1. Discursive frames in climate change reporting

Frames organize, highlight, and obscure different ways of presenting, emphasizing, weighting, defining, and interpreting aspects of a message (Nisbet, 2009b). At a general level, a frame organizes and bounds the topic, identifying what the issue is, or is seen as. Thus a frame can allow negative, neutral, or positive positions, agreements and disagreements, within the topic.

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The concept of framing has been portrayed and interpreted by scholars in myriad ways (Cacciatore, Scheufele, & Iyengar, 2016). Generally, it can take the form of *equivalence framing*—the use of one of multiple orientations of equivalent information, often resulting in different responses. This is best exemplified by the original research on the effects of gain/loss framing (e.g. Kahneman & Tversky, 1979; 1984). Although arguably diverging from the original conceptualization (Scheufele & Iyengar, 2014), much research also investigates *emphasis framing*—presenting select content elements of an issue, making them more salient and thereby affecting interpretations and responses (e.g. Entman, 1993). In both conceptualizations, though, " … frames are never neutral: they define an issue, identify causes, make moral judgements and shape proposed solutions" (O'Neill, Williams, Kurz, Wiersma, & Boykoff, 2015, p. 380). Prior research has identified diverse families of emphasis frames used in climate change discourse (Nisbet, 2009a), including frames of ethics (e.g. morality, blame, responsibility) and economics (e.g. costs, obstacles, opportunities). Of special relevance to this study is *valence* framing—emphasizing a topic's positive or negative aspects (e.g. Schuck & De Vreese, 2006). While this rudimentary dichotomy has limited utility due to its imprecision (i.e. there are many distinct kinds of positive or negative frames that should not be conflated), it can serve as an organizing tool to describe one aspect of frames.

Much of the extant science communication research—and the present study—focuses on frames that emphasize an entity's explicit or implied opinions about climate change. We will refer to these as *opinion frames*. Opinion frames can be positive or negative but are in contrast to factive discourse (e.g. Kuha, 2009), which states information without portraying it as being an opinion, held by some entity. Information presented via modern journalism is often characterized by opinion frames because journalists present much of the information in a given story as being the opinion(s) of their source(s), rather than as being fact or their own opinion.

It is important to clarify that not all opinion frames are valence frames (i.e. an expression of opinion can be neither positive nor negative), and not all valence frames are opinion frames (i.e. positivity and negativity can be conveyed via factive discourse). However, they often occur together (i.e. highlighting the positive or negative opinions held by actors/entities).This study primarily focuses on the nature and frequency of opinion frames of *uncertainty* (*deficient* or *technical*) and *opinion divergence* (*disagreement, controversy*, or *scepticism*).which tend to be either negative or neutral. Thus, we make careful distinctions between these and code positively valenced opinion frames as one general, separate category.

Opinion framing has been a frequent focus of the science and environmental communication literature. For example, much evidence indicates journalists' penchant for focusing on reporting diverse entities' opinions of *disagreement*, *controversy*, and *scepticism*—which we will collectively refer to as "opinion divergence"—to reflect their emphasis on competing or discrepant opinions. In the early 2000s, as much as 15% of print news articles mentioned *only* opinions of sources who are oppositional to the anthropogenic explanation for climate change, and around 40% of print news (and 69% of television news) portrayed *both* supporting and oppositional opinions (Boykoff, 2008; Boykoff & Boykoff, 2004; Dispensa & Brulle, 2003). Prior content analyses also concur that opinion frames of *uncertainty* are dominant in climate change news across multiple countries and publications (e.g. Antilla, 2005; Bailey, Giangola, & Boykoff, 2014; Kuha, 2009; Painter & Ashe, 2012; Zehr, 2000).

This prevalence of frames of opinion divergence and uncertainty has been widely attributed to the professional journalistic norm of "balance" (Boykoff, 2008; Boykoff & Boykoff, 2004), which guides reporters to afford relatively equal recognition to multiple sides of contentious issues (Bennett, 1996). In the case of climate change, this balanced coverage underrepresents the overwhelming scientific consensus and results in "intentionally biased coverage of global warming" (Boykoff & Boykoff, 2004, p. 134) or what Nisbet (2009b) calls false balance. Some scholars argue that this norm has decreased since the original wave of research (e.g. Boykoff, 2007; Hiles & Hinant, 2014), and recent analyses have reported that the existence or anthropogenesis of climate change is now disputed in 7–15% of climate change reporting (Takahashi, Huang, Fico, & Poulson, 2017;

Zhao, Rolfe-Redding, & Kotcher, 2016). However, U.S. news continues to emphasize uncertainty, controversy, conflict, and scepticism significantly more than non-U.S. news does (e.g. Painter & Ashe, 2012; Zamith, Pinto, & Villar, 2013).

Even if journalistic norms of balance are decreasing (in mainstream climate change news), some *opinion sources* are inherently associated with frames of uncertainty or opinion divergence (e.g. public opinion polls inherently portray opinion divergence). Similarly, the *opinion topic* itself can inherently elicit uncertainty or opinion divergence frames—for example, frames of uncertainty are almost unavoidable when describing emerging scientific developments, model projections, or the relative weight of different influences or priorities (e.g. science, economics, ethics, society). For these reasons, in combination with the fact that journalism discourse relies heavily on citing the (often valenced) opinions of their sources, these opinion frames of uncertainty and opinion divergence are likely to persist.

1.2. Why climate change news framing matters

Communicating about climate change through frames of uncertainty or opinion divergence (instead of factive discourse or positive opinions) is likely to reinforce the already widespread uncertainty about, or lack of belief in, climate change rather than remedy it. Dixon and Clarke (2012) report that "balanced" portrayals of science result in uncertainty, mediated by perceived disagreement in the scientific community. Similarly, perceived uncertainty about the imminence and costs of environmental conservation dilemmas hinders people from collective action, instead promoting self-interest (Hine & Gifford, 1996). "Balanced" coverage could also fuel the dissent of those who directly oppose climate science, by providing an opportunity for motivated reasoning (Kunda, 1990; Taber & Lodge, 2006). Using these principles as a persuasion tactic, conservative lobbyists, think tanks, and others have strategically motivated a wide implementation of uncertainty frames in climate change discourse (Boykoff, 2013; Nisbet, 2009a; Oreskes & Conway, 2010), resulting in effects as significant as the defeat of major pro-environmental policies and the rejection of the Kyoto Protocol (Jacques, Dunlap, & Freeman, 2008; McCright & Dunlap, 2003). In sum, uncertainty and opinion divergence framing research has been a cornerstone of science and environmental communication research over the last decade and has raised much concern. However, closer investigation reveals much uncertainty within this research.

2. The need for clear and detailed distinctions

Most of the analyses of opinion framing in climate change reporting cited above analysed framing by tallying the articles in the sample that contained one or more instances of an opinion frame (e.g. "uncertainty" or "controversy"). However, this analysis does not distinguish disparate meanings created by the existence of—or associations among—distinct opinion *types*, *sources*, and *topics*. Making such distinctions is crucial for an accurate understanding and evaluation of climate change news reporting and its effects.

2.1. Distinguishing types of opinion framing: uncertainty and opinion divergence

The following sections explicate the important distinctions between two distinct types of uncertainty, among three types of opinion divergence, and between uncertainty and opinion divergence (see Table 1 for examples), emphasizing the negative implications of *not* making such distinctions when analysing framing in climate change news.

2.1.1. Types of uncertainty

2.1.1.1. Deficient uncertainty. This common type of uncertainty refers to a lack of knowledge about a topic either because no one has studied it, because the evidence or measurement is not yet conclusive

Table 1. Exemplars of distinct types of opinions: uncertainties, opinion divergences, positive.

Opinion type	Example sentence about climate change	Source	Topic(s)	Publication	Date published
Uncertainty					
Deficient	"'While a changing climate is likely to lead to a change in patterns of diversity, we don't have the data yet to know what this response might look like,' said Derek P. Tittensor, marine ecologist."	Scientist	Severity of effects	WSJ	07/29/10
Technical	"Over the next century, many scientists expect sea levels to rise between 7 and 24 inches as climate change melts polar ice."	Scientist	Severity of effects	WP	10/28/2009
Opinion Divergence					
Disagreement	"(Cap-and-trade) legislation narrowly passed the House in June, but it faces a tougher time in the Senate."	Gov. official	Policy/law	WP	10/18/2009
Controversy	"The new research is an attempt to resolve a scientific controversy that erupted several years ago about exactly how fast West Antarctica is warming."	Scientist	Severity of effects	NYT	12/24/2012
Scepticism	" … with some senators challenging the notion that the earth is warming."	Gov. official	Existence	NYT	02/04/2010
Positive	"Scientists have said burning fossil fuels helps to contribute to global warming, causing sea levels to rise."	Scientist	Causes, severity of effects	WSJ	10/30/2014

Note: NYT = *New York Times*, WP = *Washington Post*, WSJ = *Wall Street Journal*.

or sufficient, because the knowledge in question cannot (perhaps ever) be obtained, or because of new developments or broadening of the problem domain (Zehr, 2000).

2.1.1.2. Technical uncertainty. This type refers to when the lack of knowledge is specified or quantified as a result of scientific study—for example, as indicated by the confidence intervals around the lower and upper bounds of projected sea level rise for a given time period. An opinion characterized by technical uncertainty is (in)formed by the acquisition of knowledge and is (relatively) objective and measurable. Friedman, Dunwoody, and Rogers (1999, p. xii) posit, "Perhaps the most common outcome of the scientific process is not facts, but uncertainty."

2.1.1.3. Implications. If framing analyses do not distinguish between these types of uncertainty, they cannot accurately evaluate whether the prevalence of uncertainty frames over-emphasizes deficient uncertainty, or, instead, accurately reflects the relevant technical uncertainty. For example, a journalist reporting that technical uncertainty exists about the effect of climate change on sea level rise (for example, estimates of the likely rate and amount of sea level rise) would *not* be misrepresenting climate science. However, if it were portrayed as deficient uncertainty (for example, "scientists are uncertain about how much rise will occur and how soon it will happen"), then it *would* be a misrepresentation because they have provided carefully quantified probability distributions of the amount and rate of sea level rise.

Currently, these disparate uses are not typically distinguished in the research on framing in climate change reporting. For example, Kuha (2009), Painter and Ashe (2012), Shehata and Hopmann (2012), and Zhao et al. (2016) report the frequency of uncertainty portrayals, but do not distinguish between technical and deficient uncertainty. Nisbet (2009a) and Zehr (2000) use the terms "scientific uncertainty" and "technical uncertainty," and both describe them as frequent in climate change communication, but do not differentiate these from deficient uncertainty.

2.1.2. Types of opinion divergence

We propose three types of opinion divergence, varying across five characteristics (Table 2)—*number of sources* (one, two, or more), *reference targets* (individual, group, idea), *duration of the opinion divergence* (brief or prolonged), *depth of detail* (low, high, or any), and *breadth* (low, medium, high). Each of these characteristics, and especially in combination, influences the nature and thus

Table 2. Five characteristics of three types of opinion divergence.

				Topic	
Divergence type	# Sources	Reference targets	Duration	Detail	Breadth
Disagreement	≥2	Individual vs. individual	Brief	High	Low
Controversy	≥2	Group vs. group	Prolonged	Low	Med/Low
Scepticism	≥1	Individual/group vs. idea/source	Prolonged	Any/All	High

implications of the opinion divergence. We do not assert that these characteristics are the only way to differentiate these frames; others could reasonably argue for dividing the types of opinion divergence into more, or different, constructs. For example, Rahmstorf (2005) distinguished several types of climate change sceptics: trend (denying climate change), attribution (deny human causes), and impact (deny negative consequences). For this preliminary foray into a deeper level of analytical nuance, we simply use the set of concepts that appear most frequently in the literature (disagreement, controversy, and scepticism) while making clear distinctions between them.

2.1.2.1. Disagreement. Disagreement is similar to Cobb and Elder's (1983, p. 82) "public issue," that is, "a conflict between two or more identifiable groups over procedural or substantive matters relating to the distribution of positions or resources." For our study, disagreement is defined as mutual opposition between an identifiable number individual, focused on a brief point in time, and about a clearly specified topic—often regarding the intricacies of an issue, rather than its fundamental tenets. Corbett and Durfee (2004) similarly operationalized this concept as multiple scientists with competing views about a specific finding of science. For example, a portrayal of two scientists arguing about the appropriateness of a modelling technique for estimating sea level rise would be disagreement.

2.1.2.2. Controversy. This opinion divergence type involves larger groups over a prolonged time, typically about a clearly specified topic but regarding the fundamental tenets or assumptions of the issue. An example would be a portrayal of the ongoing opposition between conservatives and liberals (generally) about the fundamental assumptions of climate science (existence, causes, etc.). Controversy can be considered similar to disagreement in that they both are portrayals of mutual opposition. However, disagreement would be a portrayal of transient disputes over minor, technical details, while controversy would be a portrayal of an enduring divide in beliefs about fundamental precepts. We contend that disagreement and controversy, as defined here, represent significantly different meanings. However, the extant analyses typically treat or code disagreement and controversy as the same (e.g. Antilla, 2005; Brossard, Shanahan, & McComas, 2004; Dispensa & Brulle, 2003; McComas & Shanahan, 1999; Zhao et al., 2016).

2.1.2.3. Scepticism. While extensive research has identified scepticism as distinct from other contrarian opinions about climate change (Pew, 2015; Poortinga, Spence, Whitmarsh, Capstick, & Pidgeon, 2011; Roser-Renouf et al., 2014), it has not been distinguished with similar nuance in analyses of news framing. Unlike the scientific perspective of scepticism (questioning but open to evidence; e.g. Dunlap, 2013; O'Neill & Boykoff, 2010), we use the lay meaning. Here, scepticism is defined as prolonged opposition or fundamental questioning by one entity toward a certain set of arguments, information, or a certain source or point of view—with few bounds on topic specificity. For example, portrayals of someone disapproving of the mainstream media's coverage of climate change, or being opposed to climate change legislation, would both be instances of scepticism. Unlike controversy and disagreement, scepticism is unidirectional, rather than involving mutual opposition.

2.1.2.4. Implications. If framing analyses do not distinguish between types of opinion divergence frames, they risk conflating disparate and crucial meanings. For example, a journalist might report

that two scientists disagree about the effects that a specific, proposed piece of climate legislation might have on emission levels (disagreement). This is fundamentally different than reporting that there is a long-standing rift in the scientific community about whether governments should enact legislation to reduce emissions (controversy). More extreme still, a scepticism frame would portray a (group of) scientist(s) as opposed to climate legislation, in general and on principle. Certainly, the former type of opinion divergence is likely to be both frequent and accurate, while the latter two would likely be misrepresentations of scientific opinion. Yet, the framing analyses that code the frequencies of some type of denier/oppositional opinion in climate change news do not make these distinctions between types (e.g. Brossard et al., 2004; Dispensa & Brulle, 2003; McComas & Shanahan, 1999; Takahashi et al., 2017; Zhao et al., 2016).

2.1.3. Distinguishing uncertainty and opinion divergence

This norm of broad, rough categorization in the literature has been noted by Boykoff (2013), and some studies even conflate uncertainty and opinion divergence. For example, Zehr (2000) and Kuha (2009) treat uncertainty and controversy as interchangeable. Takahashi et al. (2017) code opinions about climate change as either "supporter" or "denier." Antilla (2005) reports the prevalence of frames of scepticism, uncertainty, or controversy as a whole, but does not distinguish between them or differentiate the types within each. An implication of such minimal distinction is difficulty in determining whether reporters are indeed under-representing the scientific consensus, or are simply representing the nuanced opinion divergences that do exist across the many diverse climate change sources and topics.

2.2. Distinguishing opinion sources

The entities, or "sources," to which an opinion is attributed are diverse (Hulme, 2009; Trumbo, 1996), and contribute contextual information that is necessary for accurate interpretation and evaluation (Boykoff, 2007; Takahashi et al., 2017). For example, portraying deficient uncertainty or opinion divergence about the existence of climate change *among scientists* would be a gross misrepresentation (IPCC, 2007). However, it would be wholly accurate if the source referenced was, instead, the public (Pew, 2015; Poortinga et al., 2011; Roser-Renouf et al., 2014). Differences in the source that is referenced by an opinion frame significantly influence the fundamental meaning of the frame. A review of extant research on uncertainty and opinion divergence frames in climate change indicates the primary general source categories include *scientists* (including experts if they are conducting independent research, i.e. not representing a particular stakeholder), elected and appointed *government officials* (e.g. the President, members of Congress), *government agencies* (e.g. EPA), *non-governmental organizations and groups* (including corporations and lobbying groups), the *public* (including opinion polls), and the *media* (including pundits, and opinions of individual reporters) (see Brossard et al., 2004; Hulme, 2009; Liu, Vedlitz, & Alston, 2008; Takahashi et al., 2017; Takahashi & Meisner, 2013; Zamith et al., 2013).

2.3. Distinguishing opinion topics

The *topics* referenced by an uncertainty or opinion divergence frame also provide contextual information that is crucial for interpretation and evaluation of climate change reporting (Boykoff, 2013). For example, it might be specious "balance" to emphasize uncertainty and opinion divergences about the existence and anthropogenic nature of climate change. However, it would not be specious if the topic was, instead, a discussion of the optimal legislation or technology solutions (on which there is no scientific consensus). A review of relevant research indicated that the subtopics of climate change can be reasonably categorized as its *existence, causes, imminence of effects, severity of effects, policy/legislation remedies,* and *technology/science remedies* (Billett, 2010; Liu et al., 2008; Takahashi & Meisner, 2013).

2.3. Co-occurrence across types, sources, and topics of climate change opinion framing

Topics and frames can co-occur, representing the "totality of a particular frame" (Olausson, 2009, p. 424), with each combination representing or generating different meanings and implications (Liu et al., 2008). However, few studies of journalism in the U.S. consider this level of nuance in opinion framing. Trumbo (1996) reported that newspaper quotes of scientists tend to be "emphasizing problems and causes, while politicians and special interests tend to be … emphasizing judgments and remedies" (p. 269). Zehr's (2000) early analysis showed that uncertainty frames often co-occurred with arguments that policy decisions were yet premature. Recently, Takahashi et al. (2017) found that climate change news coverage in the Great Lakes region used "denier" sources when discussing controversy, who were usually non-scientists. Each of these examples considers the co-occurrence of, at most, two dimensions (e.g. frame type and source), leaving the third dimension (e.g. topic) unconsidered.

3. Research questions

While the extant literature suggests that opinion frames (including uncertainty or opinion divergence, as well as positive frames) and factive discourse are each frequent in mainstream climate change news, the observed frequencies vary significantly across studies, likely due to considerable variations in operationalization and sampling. Thus, we cannot offer hypotheses, but instead ask:

> RQ1: How frequent are uses of the types of uncertainty and opinion divergence frames, sources, and topics in climate change print news?

The three-way co-occurrence of type, source, and topic is essential for identifying the true meaning of each instance and of the emerging patterns overall, because each unique combination has its own implications for meaning, interpretations, effects, and even for its accuracy. Thus, we ask:

> RQ2: How do opinion frame types, sources, and topics co-occur in climate change print news?

Opinion frames and their sources and topics relating to climate change are not static, as the news reflects changes in information, policy, people, and events. Thus, we ask:

> RQ3: How do the frequencies and co-occurrences of uncertainty and opinion divergence frames, sources, and topics change over time in climate change print news?

4. Methodology

4.1. Sample

We sought articles about global warming or climate change in three major newspapers with moderate political stances: *The New York Times*, *The Washington Post*, and *The Wall Street Journal*. The use of similar "prestige press" or "legacy media" is common in the extant literature, often justified by the argument that these newspapers are the best standard barometer of American news coverage, due to their perceived credibility and reach. Certainly, one could (rightly) argue that (qualitatively dissimilar) news content from fringe sources and alternative platforms is becoming increasingly influential and far-reaching, via the structures and affordances of social and digital media (e.g. Bennett & Iyengar, 2008). However, using a sample that is dissimilar (however new and interesting) from the dominant paradigm of prior research would decrease our ability to draw valid comparisons between our results and those of the existing literature. Thus, we save the investigation of social, digital, local, and fringe media sources for future research.

Initially, we searched the Lexis-Nexus database for all news articles in *The New York Times* and *The Washington Post*, and the Factiva database for all news articles in *The Wall Street Journal*, during 2009–2015, using the terms, "global warming" or "climate change," excluding items denoted as

editorials and blogs. From this initial set of 12,096 articles, we selected every 10th article, resulting in a sample of 1210 articles. We then removed 142 articles that were over 2000 words long, mostly essays and magazine-style pieces, resulting in 1068 standard news articles (NYT = 463; WP = 358; WSJ = 247). Later, we conducted the same search for 2005–2008, resulting in 8619 articles. Selecting every 10th article created an initial set of 863, from which 76 long entries were removed, resulting in 787 articles (NYT = 304; WP = 335; WSJ = 148). The total analysis sample from 2005 to 2015 was 1855 news articles.

The starting point of the sampling frame (2005) was selected in order to gather a substantial dataset that would partially overlap with the sampling frame used by many of the foundational content analyses (noted in the review) that catalyzed and popularized the current scholarly opinion about the nature of uncertainty frames. The periods 2005–2008 (*T*1) and 2009–2015 (*T*2) also span diverse cultural and political climates relevant to climate change, such as quite different climate change policies in the Bush and the Obama administrations, and the emergence and widespread coverage of the 2007 IPCC report, etc.

4.2. Coding

Using Matthes (2009) terminology, we began with a deductive approach using *a priori* media frame codes and operationalizations, adapted those inductively and iteratively, used manual coding, and did not derive more general frames through data reduction such as cluster analysis. For this analysis, coders identified which, if any, opinion types (uncertainty and opinion divergence) were present in an article. The coders also identified which *source(s)* and *topics(s)* accompanied the coded instances of the opinion types. These data were used to conduct article-level analyses, and individual frame instances, as explained below.

Manifest coding of each article included a *case number*, the *newspaper*, *publication date*, and *headline*. *Latent coding* was applied in the following order of operations, with binary (0/1) coding to indicate which—of all possible attributes—were present. Each article was evaluated in full, sentence by sentence. If no portions of the article were relevant, we coded the article as not relevant (=0) and moved to the next article. If relevant content was found (=1), coders also recorded whether any portions contained an *opinion frame*. If it did not (=0), we coded the *source* and *topic* that were the main subject of the article and moved on to the next article. If any portion of the article did contain an opinion frame (=1), we coded which *opinion types* (*positive,* two *uncertainty* types, three *opinion divergence* types) were absent (=0) or present (=1) in the article, and then coded the *source* and the *topic* referenced by the first instance of each different opinion type that occurred in the article (each absent = 0; present = 1).

4.2.1. Relevance

Relevant articles were a news report or feature story which also specifically referenced either the broad issue of climate change, or global warming, climate science, climate scientists, climate change policy/law or technology/science remedies. *Not relevant* articles that escaped the original search filter often included op-eds, obituaries, or other types that did not refer to the issue of climate change, climate science, or climate scientists specifically. For example, if an article's only mention of climate change was "Steven Chu, former advisor to President Obama on climate change, has accepted a position as a board member of a Canadian energy company," this article would be coded as *not relevant* and would be eliminated from all analyses.

4.2.2. Opinion frame

A relevant article may or may not also have an *opinion frame* of some type. As noted above, this is in contrast to stories that only use factive discourse—such as simply noting that, say, a conference was held, without portraying a certain entity as advocating or promoting a position or opinion on one or more climate change topics. In particular, for this analysis, an article with an opinion frame simply

means that it portrays an entity as holding at least one of the six types of opinions about a climate change topic: uncertainty (*deficient uncertainty*, *technical uncertainty)*, or opinion divergence (*disagreement*, *controversy*, scepticism*),* or *positive* (that is, supportive).

Positive opinion is a broad category that covered all explicitly and implicitly supportive opinions and actions by an entity associated with one of the seven climate change topics (below), as in the "supporter" half of Takahashi et al.'s coding structure (2017). While future analyses could subdivide positive opinions into more nuanced types, the focus of the current study is only on heightening the specification of the types of uncertainties and opinion divergences.

The six opinion types can either be explicitly stated (e.g. "Senator James Inhofe said 'I am strongly opposed to the idea that human activity causes climate change'") or implied from action (e.g. "a heated debate over the new cap-and-trade bill is currently raging in Congress"). After our iterative codebook revisions and training, the coded full sample contained no instances of a relevant opinion that did not clearly fit into one of these six opinion types. For more than 95% of the articles, fewer than three different types of opinions appeared per article.

If an article was relevant *and* had an opinion frame of some type, the *first occurring instance* of each different type of opinion (up to the six different opinion types) was coded, along with the one or more sources and one or more topics that they referred to. This method was chosen because simply recording a list of which opinion types, sources, and topics occurred in an article would conflate disparate meanings in the same way as prior research, as it would not track which types occurred with which sources and topics in particular. However, due to the quantity of content, it is impractical to report "sentence-level data"; that is, reporting a code for each single sentence of each article in the sample. Thus, to maintain the article-level structure of the data while still maintaining the distinctions between the multiple individual opinion frames that can occur, and co-occur, in an article, we coded only the first instance of each—if any—of the six possible *opinion types* that occurred in the article. These first occurrences were usually the most substantive occurrence in the article. Furthermore, repeated occurrences of an opinion type within an article tended to also repeat the same source and topic. To summarize, the data describing any given article's opinion frame content consists of the first (if any) occurrence of *deficient uncertainty*, the first (if any) occurrence of *scepticism*, etc., and the respective sources and topics they referred to.

Coders were instructed that an instance of an opinion frame type need not always fill all five criteria. For example, if a coder read that a proposed bill "faces a tougher time in the Senate" (example given for Disagreement; Table 1) it may indeed reasonable to interpret the time span as neither clearly brief (as such quarrels could be indefinite) nor clearly long-standing (as the surrounding content referenced a specific dispute that happened at one time over one piece of legislation). However, what gave our coders great confidence is that the other four criteria very clearly indicated "disagreement" instead of any other type. Thus, while any one dimension may be—and sometimes was—either "on the fence" or simply unspecified, our coders were able to repeatedly demonstrate strong reliability using the preponderance of the evidence.[1]

4.2.3. Source

Sources included *scientists* (including non-academic and non-governmental "experts" if they are conducting independent, scientific research, i.e. not representing a particular stakeholder), elected and appointed *government officials* (President Obama, "Chinese officials"), *government agencies* (e.g. EPA), *non-governmental organizations and groups* (e.g. corporations, lobbyists), the *public* (including polls), the *media* (including pundits, and opinions of individual reporters), and *other*.

4.2.4. Topic

Topics included the *existence* of global warming or climate change, its *causes*, the *imminence of effects*, the *severity of effects*, *policy/legislation remedies*, *technology/science remedies*, and *other*. However, all instances of "other" were about the broad topic of climate change so were labelled as *general issues*.

4.2.5. Example

As an example of the full coding process, a *New York Times* article published on 5 March 2013 ("Cabinet Picks Could Take On Climate Policy") was coded as *relevant* because there was at least one instance of a portrayal of implicit or explicit opinion(s) about some climate change topic(s). Specifically, this article portrayed a *positive* opinion, the first instance of which was by a *government official* about *policy/law*, and the article also portrayed *disagreement,* the first instance of which was between *government officials* and an *organization/group* about *policy/law*.

4.3. Reliability

The reliability process was extensive and iterative. First, we developed the codebook based on the literature review, the above theorizing about uncertainty and opinion divergence, and the main sources and topics identified in the literature. Then all four members of the research team discussed the codebook sentence by sentence, pointing out any ambiguities, and developing familiarity with the codes. Next we read, independently coded, and collectively discussed 24 of the most complex and lengthy articles that represented the full range of opinion types, sources, and topics, using this process to iteratively identify necessary revisions to the codebook. Then we similarly discussed and coded 50 short excerpts, selected for complexity and range of opinion types, sources, and topics, and made final codebook revisions.

We established inter-coder reliability among the team's three coders through four separate reliability tests. We used I_r, which measures reliability for nominal categories for two judges, correcting for chance and for the number of categories available for coding (Hayes & Krippendorff, 2007; Perreault & Leigh, 1989) (see note to Table 3). All reliabilities were computed pairwise among the three coders in order to clearly identify the source of any coding discrepancies. These four tests involved diverse (including relevant/non-relevant, all uncertainty types, opinion divergence types, sources, and topics) brief excerpts selected from a representative sample of articles in the dataset ($n = 100$, $n = 100$, $n = 50$, $n = 50$). The excerpt passages were selected by one of the authors, who read random articles from across the whole sampling frame and extracted excerpts that would illustrate diverse co-occurrences of frame types, sources, and topics, according to the operational definitions. The composition of these sets was also engineered to include many non-relevant sections, and relevant sections without opinion frames, similar to the natural occurring proportions in the sample. The choice to use excerpts was made because it closely represents the coders' process of analysis. Specifically, to generate the codings for each article, coders progressed through each article sentence by sentence, continuously indicating the presence or absence of uncertainty and opinion divergence frames, and sources and topics, in an article according to the operationalizations.

After each of these reliability tests, the three coders and the principal researcher met to review the codings, discuss each discrepancy, and reword operationalizations as necessary. Reliabilities were excellent throughout (average I_r for each variable across all reliability tests was .98–.99; Table 3). The three coders then coded the first 750 articles (70.2%) of the 2009–2015 sample. To test for coding drift, the three coders then re-evaluated reliability on a fifth set of selected excerpts ($n = 50$), showing excellent reliability (Table 3). Then the 3 coders completed the remaining 318 articles (29.8%) of the 2009–2015 sample.

At this point, the authors decided to collect and include the 2005–2008 sub-sample in the analysis. Two of the three original coders were used for this extended sample. To re-check for coder drift, they read and coded 50 more excerpts from the full range of articles, finding the same excellent reliability. Then those two coders coded the 787 articles from 2005 to 2008.

5. Results

Analyses are conducted at two levels. The data are organized as individual *instances* of the possible frame types from each article, which allows for analysis of co-occurrence among frame type,

Table 3. Summary coding reliabilities.

	Reliability round						
	2009–2015						2005–2008
	1	2	3	4	5	5*	6
N	100	100	50	50	50	50	50
Code	M	M	M	M	M	M	M
Opinion frame	.74	.65	.78	.93	.99	.97	.94
Opinion type							
Uncertainty							
Deficient	.99	.88	.91	.97	1.00	.80	1.00
Technical	1.00	.99	1.00	1.00	1.00	.75	1.00
Opinion divergence							
Disagreement	.97	.96	.97	.99	.99	−.00	.99
Controversy	.98	.93	.96	.98	1.00	.71	.98
Scepticism	.98	.99	.99	1.00	1.00	.83	.99
Source							
Scientists	.99	.99	.99	.99	1.00	.95	1.00
Govt. officials	.92	1.00	1.00	.99	1.00	.90	.97
Govt. agencies	.97	.99	.99	1.00	1.00	.78	.98
Orgs/groups	.98	.98	.98	.99	1.00	.66	.99
Public	.99	.97	.98	.98	.99	.83	.99
Media	1.00	1.00	1.00	1.00	1.00	n	1.00
Topic							
Existence	.98	.98	.99	1.00	1.00	.86	1.00
Cause	.98	.99	.99	.99	.99	.89	.99
Imminence	.99	1.00	1.00	1.00	1.00	1.0	1.00
Severity	.96	.96	.98	.98	.99	1.0	1.00
Policy/law	.91	.98	.98	.99	1.00	.83	.97
Tech/science	.97	.97	.98	.99	1.00	.94	1.00
General issue	.97	.97	.97	.98	.99	.96	1.00

Note: Values are mean I_r reliabilities (Perreault & Leigh, 1989) over the five opinion types of uncertainty and opinion divergence (for simplicity, we do not include the results aggregated over the positive opinion frame, though those are all equally higher or higher). Rounds 1–5 are across three pairwise coders, for the 2009–2015 articles. Round 6 is across two coders, for the 2005–2008 articles.

5*: For a rough comparison to I_r, this column presents Krippendorff Alpha reliabilities (SPSS macro V3) for this last coding set using all three coders. These show satisfactory to high reliabilities, except for several instances, illustrating why we prefer I_r to KAlpha. Because KAlpha is based on disagreements (Hayes & Krippendorff, p. 82), in some cases it seems to report lowreliabilities when there are just a few 1s and even just one disagreement. For example, consider the overall reliability of disagreement, −.00. One coder indicated 3 present and 47 absent, while the other 2 coders both reported 50 absent. Some would argue that as the existence of the code is rare, even slight disagreement means poor reliability. But that interpretation would mean if we switched the 0s and 1s that would not be a problem. Also, when there is no variation, KAlpha reports an ERROR, with no reliability value (here, indicated by "*n*"). But, in fact, for this test sample, there were no instances, so the three coders each reported all 0s, which means perfect agreement. The 1.0 reliabilities for imminence and severity result from all three coders coding one specific instance of each.

source, and topic. These (up to six possible) frame instances from each article are also aggregated at the *article* level, which includes the count for each variable summed across the article's instances.

5.1. Descriptives and cross-tabulations

Table 4 shows the frequency and percentages of the manifest and latent coding for articles for *all relevant* articles, *all relevant articles with no opinion framing (factive language only)*, and *all relevant articles with opinion framing (uncertainties, opinion divergences, or positive)*.

5.1.1. RQ1: overall percentages for relevant articles

Nearly two-thirds of the 1855 sampled articles (62.7%, $N = 1164$) were relevant (column 1) (that is, had any type of frame: uncertainty, opinion divergence, positive). The many non-relevant articles were editorials, blogs, and book reviews. Informing RQ1, 7.1% of all articles contained *deficient uncertainty* and 4.0% *technical uncertainty*. 11.2% portrayed *disagreement*, 10.6% *controversy*, and

Table 4. Descriptive statistics for relevant articles.

Variable *N*	1. Articles 1164 (from 1855 articles), 62.7%	2. Opinion frame = 0 (factive only) 198 (from 1164 relevant articles), 17.0%	3. Opinion frame = 1 965 (from 1164 relevant articles), 82.8%
Publication			
NYT	39.8%	36.4%	40.4%
WP	40.3	46.0	39.2
WSJ	19.9	17.7	20.4
Opinion frame			
No	17.0%	100.0%	0.0%
Yes (1 or more)	83.0	0.0	100.0
Opinion type			
Positive	71.2%	0%	85.9%
Uncertainty			
Deficient uncertainty	7.1	0.0	8.6
Technical uncertainty	4.0	0.0	4.9
Opinion divergence			
Disagreement	11.2	0.0	13.5
Controversy	10.6	0.0	12.7
Scepticism	15.4	0.0	18.5
≥1 use of an uncertainty or opinion divergence	35.7%	0.0%	43.0%
Sources			
Scientists	12.7%	13.1%	24.6%
Gov. officials	52.0	46.0	53.3
Gov. agencies	6.1	3.0	6.7
Orgs/groups	19.2	10.1	23.0
Public	12.5	10.1	13.1
Media	5.0	13.6	3.2
Other	3.6	8.1	2.6
Topics			
Existence	5.7%	1.0%	6.6%
Causes	12.8	9.6	13.5
Imminence	1.6	0.0	2.0
Severity	25.3	18.2	26.6
Policy/law	27.0	23.7	39.8
Tech/science	15.7	10.1	16.9
General issue	19.4	41.4	26.9

Note: Cell values are percentages of column *N* articles that have one or more cases of the variables. The sum of percentages in opinion types, sources, and topics, respectively, is greater than 100 because articles could have multiple opinion types, and opinion types could have multiple sources and topics.

15.4% *scepticism*. Sources primarily included *government officials* (52.0% of articles), followed by *organizations/groups* (19.2%), *scientists* (12.7%), *the public* (12.5%), and small percentages of the others. Common topics were *policy/law* (27.0% of articles), *severity of effects* (25.3%), and *general issue* (19.4%).

5.1.2. RQ3: differences in frequencies across time

We also considered how the relative coverage of climate change opinion frames changed between the earlier and later time periods, or, more generally, over time. Table 5 shows that for relevant articles with at least one opinion frame, the mean number of articles including *positive opinion*, *deficient uncertainty*, *technical uncertainty*, *scientists*, *organizations/groups*, the *public*, and *causes* was significantly higher from 2005 to 2008 than from 2009 to 2015. However, coverage increased for *government officials* and the *existence* of climate change. Because dichotomizing the time periods creates measurement error, we also looked at correlations between each variable and the article's publication date. As publication dates moved from 2005 to 2015, articles included significantly less *positive opinion*, *deficient uncertainty*, *scientists* and the *public,* and *severity of effects* as topics, but significantly more *disagreement* and *policy/law*.

Table 5. Mean differences for uncertainty, opinion divergence, source, and topic, across 2005–2015, and correlation with publication date, for relevant articles with an opinion frame.

Variable	M (*T*1, *T*2)	s.e.m. (*T*1, *T*2)	*T*-ratio	*df*	Correlation with publication date
Opinion type					
Positive	.90, .83	.015, .016	3.0**	962.2	−.12***
Uncertainty					
Deficient	.11, .07	.015, .011	2.4*	795.9	−.11***
Technical	.07, .03	.012, .008	2.4*	737.3	.00
Opinion divergence					
Disagreement	.14, .13	.017, .014	.5	963.0	.08**
Controversy	.15, .11	.017, .014	1.7	894.8	.00
Scepticism	.20, .17	.020, .016	1.4	878.6	−.03
Source					
Scientists	.29, .21	.022, .018	2.9**	858.5	−.10***
Gov. officials	.48, .58	.024, .021	−3.0**	905.9	.03
Gov. agencies	.06, .07	.012, .011	−.68	963.0	.04
Orgs/groups	.25, .18	.021, .017	2.6**	854.1	−.05
Public	.16, .11	.018, .013	2.3*	831.4	−.09**
Media	.04, .03	.010, .007	1.2	806.4	.01
Topic					
Existence	.05, .08	.011, .012	−1.6*	960.6	.01
Causes	.16, .11	.018, .014	2.2*	836.8	.03
Imminence	.02, .02	.006, .006	−.64	963.0	−.03
Severity	.26, .27	.021, .019	−.32	963.0	−.13***
Policy/law	.40, .40	.024, .021	−.15	963.0	.07*
Tech/science	.19, .15	.019, .015	1.7	864.1	−.05
General issue	.28, .26	.022, .019	.51	963.0	.01

Note: Values are based on the number of articles that have one or more cases of the variables. Independent samples *t*-test; $N = 965$ (425, 540); appropriate significant test and *df* used based on Levene's test. Spearman rho correlations, two-tailed significance test. Later publication date is a higher value; so negative values means decline over time.
*$p < .05$; **$p < .01$; ***$p < .001$.

5.2. Co-Occurrences of source and topics within opinion frame instances

5.2.1. RQ2: correlations among opinion frame instances, sources and topics

Using all instances of an opinion frame, Table 6 presents Spearman *rho* correlations among opinion frame types, sources, and topics. Significant positive correlations indicate a propensity for characteristics to occur in the same frame instance, while significant negative correlations indicate a propensity to not occur together.

Some of the notable correlations include the following. *Scientists* as sources are positively significantly associated with *deficient* and (more strongly) with *technical uncertainty*, and negatively or non-significantly with the three kinds of *opinion divergence*. They are negatively associated with the other sources, while positively associated with topics of *existence, causes, imminence,* and most strongly associated with *severity of effects*, but negatively with *policy/law* or *technology/science topics*. This means that opinion types referencing scientists usually reference scientists only (rather than comparing or contrasting the opinions of scientists with those of another type of source), are likely to associate them with the scientific aspects of climate change rather than the political and technological solutions, and tend to portray scientists as having uncertainty rather than being involved in a disagreement, controversy, or scepticism. In addition to scientists, *technical uncertainty* is positively correlated with *imminence* and *severity of effects* and negatively correlated with *government officials* and *policy/law*.

Conversely, government officials are positively associated with *policy/law, disagreement,* and *controversy,* and negatively associated with *positive opinion* and *severity of effects* and both types of uncertainty. In addition to government officials, *disagreement* and *controversy* are significantly positively associated policy/law, while significantly negatively associated with the severity of effects. Their respective associations with topics of *existence* and *causes* are non-significant. The *public* is significantly positively associated with the topic of *general issue*, but significantly negatively with policy/law.

Table 6. Correlations among sources and topics, for relevant cases with an opinion frame.

	Opinion type						Source						Topic					
	Pos	Def	Tec	Dis	Cont	Skep	Scientist	Gov. off	Gov. agen	Org/ groups	Public	Media	Exist	Causes	Imm	Sev	Policy/ law	Tech/ Sci
Opinion type																		
Positive	–																	
Uncertainty																		
Deficient	−.26***	–																
Technical	−.22***	−.05	–															
Opinion divergence																		
Disagreement	−.37***	−.08**	−.06*	–														
Controversy	−.36***	−.08**	−.06*	−.10**	–													
Scepticism	−.45***	−.09**	−.07**	−.12**	−.12**	–												
Source																		
Scientists	−.03	.09**	.32**	−07**	.01	−.14**	–											
Gov. officials	−.07*	−.11**	−.17**	.15**	.12**	.03	−.46**	–										
Gov. agencies	.01	−.05	−.04	.06*	.08**	−.07**	−.11**	−.09**	–									
Orgs/groups	−.04	.01	−.08**	.05	.00	.05	−.21**	−.31**	−.09**	–								
Public	−.03	−.01	−.06*	−.01	.02	.06*	−.16**	−.28**	−.07*	−.10**	–							
Media	−.01	.04	−.03	.02	−.05	.04	−.07**	−.15**	−.04	−.04	−.05	–						
Topic																		
Existence	−.07**	−.01	−.03	−.04	−.04	.14**	.06*	−.02	−.06*	−.06*	.08**	−.02	–					
Causes	−.02	.06*	−.01	−.05	−.02	.04	.17**	−.14**	−.04	−.01	.02	.01	.19**	–				
Imminence	.02	.02	.11**	−.04	−.02	−.05	.11**	−.09**	−.03	−.02	.02	−.02	.07**	.01	–			
Severity	.09***	.07*	.22**	−.09**	−.10**	−.11**	.53**	−.37**	−.02	−.11**	−.09**	.05*	−.04	−.02	.05	–		
Policy/law	−.13***	−.07**	−.12**	.19**	.10**	.07**	−.36**	.45**	.10**	−.01	−.17**	−.07**	−.17**	−.23**	−.07**	−.40**	–	
Tech/science	.11***	.00	−.01	−.04	−.07*	−.06*	−.09**	−.05*	.03	.15**	.02	−.02	−.09**	−.09**	−.03	−.19**	−.13**	–
General issue	.08**	−.05	−.09***	−.08**	.05	.00	−.17***	.02	−.06*	.01	.22***	.04	−.11***	−.15***	−.06 *	−.24***	−.36***	−.16***
	Pos	Def	Sci	Dis	Cont	Skep	Scientist	Gov. off	Gov. agen	Org/ groups	Public	Media	Exist	Causes	Imm	Sev	Policy/ law	Tech/ sci

Note: Each opinion type will necessarily be negatively correlated with the others because, at the case level, an instance of one type of opinion is, necessarily, not one of the others.
*$p < .05$; **$p < .01$; $N = 1421$. Two-tailed significance level, Spearman *rho* correlations.

5.2.2. RQ3: co-occurrences among sources and topics within each opinion frame instance

Table 7 presents the co-occurrences of all three variables (opinion types, sources, and topics). For example, of the 139 instances of *disagreement*, 7.2% were by *government agencies* about *policy/law*. We focus our summary on the co-occurrence cells with the highest percentages and/or the ones most relevant to the purpose of the study: the source and topic co-occurrences in uncertainty and opinion divergence.

For *all relevant articles with a deficient uncertainty frame*, the most frequent co-occurrences were between scientists and severity of effects (26.6%), and government officials and policy/law (15.6%). In only five instances scientists were portrayed as having deficient uncertainty about the causes of climate change, and in only one instance about its existence.

Technical uncertainty was almost exclusively attributed to scientists, who co-occurred predominantly with reference to the severity of effects (63.8%) and technology/science (10.6%). In exactly five instances, scientists were portrayed as having technical uncertainty about the existence or causes of climate change.

Disagreement involving government officials about policy/law, specifically, accounted for 56.8% ($N = 79$) of all disagreements in the sample. Organizations and groups were portrayed as having frequent disagreements concerning policy/law (19), as well. Scientists, however, were associated with disagreement relatively infrequently—less than a third as often as government officials.

Controversy was attributed at least once to every source except the media themselves, and occurred overwhelmingly with government officials ($N = 61$; 48.1%)—followed by organizations (13; 10.3%)—concerning policy/law remedies. In several instances, scientists were portrayed as being part of a controversy about the existence ($N = 2$), causes (9), imminence of effects (1), severity of effects (7), policy/law aspects (5), or technology/science aspects (1) of climate change.

It is important to differentiate whether the disagreement or controversy involving scientists is *between* scientists and other parties (e.g. contrasting scientific opinion with that of government officials) or *amongst* scientists (e.g. portraying discord within the scientific community). Upon reviewing the 16 disagreements involving scientists, seven were *amongst* themselves. Two of those were about the existence or causes of climate change. Of the 25 instances of controversy involving scientists, it was *amongst* scientists in 12. Of these, six instances were in regards to the existence or causes of climate change.

Scepticism was most commonly attributed to government officials about policy/law remedies (26.9%) and general issues (10.8%) and organizations and groups concerning policy/law (12.4%). Scepticism was rarely associated with scientists.

5.2.3. RQ3: co-occurrences of sources and topics within each opinion frame instance, across time

Table 7 also reports the percentages of each co-occurrence separately for the two time periods, but for scientists only. For example, of the 90 overall occurrences of *deficient uncertainty*, 5.6% were by *scientists* and about *causes*. But we see that 8% of the 50 that occurred in *T*1, while this co-occurrence was only present in 2.5% of the 40 *deficient uncertainty* instances in *T*2.

In 25 individual co-occurrence combinations, the percentage of the yes-yes co-occurrences decreased, at least slightly, from *T*1 to *T*2. The largest declines were regarding the causes of climate change (positive and both uncertainties). The only notable increase was in disagreement about policy/law.

6. Discussion

6.1. Main conclusions and implications

The current study investigates the relative frequency and co-occurrence patterns of distinct opinion frame types, sources, and topics in a systematic sample of mainstream climate change news reporting

Table 7. Percent co-occurrences (only yes-yes) of sources and topics within each opinion type, for relevant cases.

		For each source, % of type by topic						
Type	Source	Exist	Cause	Imm	Sev	Pol/law	Tech/sci	GenIss
Positive (*N* = 833)	Scientists	1.9***	5.1***	1.0**	15.5***	.6***	1.6***	1.1***
	T1 (381)	1.8*	6.8***	1.0**	16.3***	.8***	2.1**	1.0***
	T2 (450)	2.0**	3.6***	.9*	15.1***	.4***	1.1**	1.1***
	Gov. officials	1.3	1.9***	.4	3.7***	27.0***	7.3	11.5
	Gov. agencies	.0	.5	.0	1.1	2.8**	1.3	.5*
	Orgs/groups	.2	1.6	.1	2.2**	2.9***	5.2***	3.8
	Public	.6	1.1	.2	1.2**	.6***	1.4	4.8***
	Media	.0	.2	.0	.7	.4	.1	.8
Deficient uncertainty	Scientists	1.1	5.6	.0	26.6***	1.1***	2.2	2.2
(*N* = 90)	*T1* (50)	2.0	8.0	.0	28.0***	2.0**	4.0	4.0
	T2 (40)	.0	2.5	.0	22.5***	.0**	.0	.0
	Gov. officials	2.2	7.8	.0	2.2***	15.6***	1.1	3.3
	Gov. agencies	.0	.0	.0	1.1	.0	.0	.0
	Orgs/groups	.0	3.3	1.1	2.2*	7.8	4.4	2.2
	Public	1.1	.0	1.1	.0*	1.1	6.7	3.3**
	Media	.0	.0	.0	2.2	1.1	1.1	.0
Technical uncertainty	Scientists	4.3	10.6	8.5	63.8	6.4*	10.6	.0
(*N* = 47)	*T1* (30)	3.3	16.7	6.7	63.3	6.7**	13.3	.0
	T2 (17)	5.9	.0	11.8	64.7	5.9	5.9	.0
	Gov. officials	.0	.0	.0	2.1	.0	.0	.0
	Gov. agencies	4.3	.0	.0	.0	.0	.0	.0
	Orgs/groups	.0	.0	.0	.0	2.1***	.0	.0
	Public	.0	.0	.0	.0	.0	.0	.0
	Media	.0	.0	.0	.0	.0	.0	.0
Disagreement (*N* =	Scientists	2.2***	3.6***	.0	5.0***	1.4***	.0	1.4
139)	*T1* (60)	3.3**	3.3*	.0	8.3***	3.3***	.0	1.7
	T2 (79)	1.3	3.8***	.0	2.5*	8.9***	.0	1.3
	Gov. officials	2.9	4.3	.0	2.9***	56.8***	4.3	5.8
	Gov. agencies	.0	.0	.0	.7	7.2	.7	.7
	Orgs/groups	.0	2.2	.0	2.2	13.7	2.9	2.2
	Public	.0	.0	.0	1.4	3.6*	2.9***	2.2
	Media	.0	.7	.0	.7	.0	.0	2.3***
Controversy (*N* =	Scientists	3.2***	6.3***	.8	6.3***	4.0***	.6	6.3
126)	*T1* (63)	3.2*	6.3**	.0	6.3**	6.3***	1.6	9.5
	T2 (63)	3.2*	6.3***	1.6*	6.3**	1.6**	.0	3.2
	Gov. officials	.8**	1.6***	.0	2.4***	48.4***	4.0	15.1
	Gov. agencies	.0	.0	.0	1.6	7.9	.8	1.6
	Orgs/groups	.8	.0	.0	.0	10.3	3.2**	2.4
	Public+	2.4***	1.6	.0	.6	1.6***	.0	6.3**
	Media	.0	.0	.0	.0	.0	.0	.0
Scepticism (*N* = 186)	Scientists	.0	1.1	.0	2.7***	2.2	1.6	1.6
	T1 (88)	.0	1.1	.0	4.5**	4.5	1.1	2.3
	T2 (98)	.0	1.0	.0	1.0	.0	2.0	1.0
	Gov. officials	9.7	8.1	.0	3.2	26.9	3.8	10.8
	Gov. agencies	.0	.0	.0	.5	.5	.0	.0
	Orgs/groups	1.1	2.7	.0	1.6	12.4*	.5	4.3
	Public	3.2	3.8	.0	1.6	3.2**	1.6	5.9*
	Media	.5	.5	.0	1.6***	.5	3.2	.0
Type	Source	Exist	Cause	Imm	Sev	Pol/law	Tec/sci	GenIss

Note: Cell values are the percent of cases that exhibit, for the specific opinion type, the presence of both the source and the topic (yes/yes). Significant overall Chi-square values only indicate an overall significant association in the 2 × 2 no/yes by no/yes cross-tabulation. For example, consider, for *positive* opinion type, the cross-tabulation of the topic *cause* with the source *scientists*. The table above reports the percentage of the yes/yes cell, and the χ^2 ratio significance, in bold.

*$p < .05$; **$p < .01$; ***$p < .001$, asymptotic significance test, 2-sided.

		Source: Scientist		Total
		No	Yes	
Topic: Cause	No	72.6%	16.8%	743
	Yes	5.5%	**5.1%**	788
Total		649	182	831

χ^2 (1) = 38.4, ***p* < .001**

between 2005 and 2015. Our results are not necessarily in competition with the theoretical justifications invoked by the extant literature. Specifically, this study, like others before it, supports the theory that the norms of journalism and the controversial nature of politicized science naturally beget portrayals of dissent. If we had, instead, simply tallied the frequency with which news articles portray any kind of uncertainty or opinion divergence about a climate change topic, we would have concluded that *over 35%* (415; Table 3) of the relevant articles in our sample included at least one instance of such discourse.

But our application of more nuanced measures indicates the vast majority of the uncertainty, controversy, disagreement, and scepticism frames in climate change journalism are *not* from scientists and are *not* in reference to topics on which there is scientific consensus. Rather, such instances usually reference non-scientist sources (primarily government officials) and topics that do not have an established scientific consensus (primarily climate change legislation or the severity of effects). When uncertainty *is* portrayed about the existence or causes of climate change, it is most commonly technical uncertainty, rather than deficient uncertainty. For example, Table 6 indicates that when scientists are commonly associated with uncertainty, the topics are the severity of effects and technology/science remedies, respectively. Thus, *the uncertainties and opinion divergences that do exist are overwhelmingly about topics on which there is not established scientific consensus* (policy/law remedies, severity of effects, etc.). Although many uncertainties and opinion divergences are indeed frequently portrayed, our results indicate that the classical, oft-maligned portrayal of specious turmoil that misrepresents the scientific consensus has been very infrequent between 2005 and 2015 in mainstream print journalism, though with some changes over that time period.

Our analyses of change over time are preliminary and rudimentary, but they may suggest an evolution of journalism discourse, such that while uncertainty overall decreases slightly, the uncertainty involving scientists is increasingly technical rather than deficient. Specifically, portrayals of scientists involved in deficient uncertainty has markedly *decreased* for all topics, while the portrayals of technical uncertainty have either *increased* or remained level for all topics except the causes of climate change and its tech/science remedies.

6.2. Limitations

First, our central conclusion about the prevailing accuracy of climate change journalism concerning opinion framing may *not* be the case in U.S. fringe media, regional media, or other platforms (e.g. broadcast, social media), and in other countries' newspapers (e.g. Boykoff & Yulsman, 2013; Painter & Ashe, 2012; Sharman, 2014; Takahashi et al., 2017; Zamith et al., 2013). Due to the limited inferences that can be drawn from this (or any) one analysis, future research should investigate a broader range of news sources with similar measures and methods. Second, we did not compare results across the three newspapers because (a) that question is outside the goals of this study and (b) comparisons of individual co-occurrence cells between individual publications would be underpowered. Thus, we simply treat these three sources as, together, a representative of mainstream American print journalism. Comparisons within legacy media would be valuable questions for future research.

Third, because we coded only the first instance of each opinion type in each article, it is possible that later instances were systematically and significantly different. However, it was not common for the uncertainties and opinion divergence types to appear multiple times in an article, and when they did, it was most often a repeated instance of the same type, source, and topic combination as the first instance. Thus, we do not expect that coding for every instance would significantly change the story that our results tell. Fourth, the structure of the reliability tests does not provide direct (only indirect) evidence that coders would identify the same instance of opinion frames as being the "first" occurrence of its type in an article. Of course, similar limitations are commonplace in content analyses. For our study, this limitation is mitigated by the reassurance that reliability was excellent on a sentence

by sentence level, which necessarily implies reliability for the resulting article data which is simply the sum of those codings.

Fifth, the exploratory over-time analysis does not provide a nuanced analysis of the change of the co-occurrence composition of all variables. For example, although the frequency of occurrence of controversy was not significantly correlated with publication date, it could be that there were massive shifts in the source and topics of that controversy over time. While we delve into this level of nuance with the *T*1 and *T*2 comparison for scientist sources, future research is needed to investigate these nuanced changes.

Sixth, we note that even if journalists *are* accurately portraying opinion divergence, as being, for example, between scientists and politicians, or among politicians and agencies, and not as being amongst scientists, they are *still* focusing the public eye on the opinion divergence or uncertainty (of some kind) instead of on the scientific consensus, which—regardless of accuracy—may have undesirable effects. Indeed, the original work on "balance" did not claim that factual errors were prevalent (Boykoff & Boykoff, 2004).

Similarly, it may not even matter to the average news reader that these distinctions are usually accurately navigated by reporters. Due to a range of processing biases, from selective perception to motivated reasoning and the rising influence of partisan media, audiences might, for example, perceive a story as portraying deficient uncertainty by scientists about the existence of climate change *even if* the journalist clearly reported technical uncertainty by a government official about the severity of effects. The diverse, extensive, and growing body of research in motivated reasoning/scepticism and cultural cognition (Kahan, Jenkins-Smith, & Braman, 2011; Taber & Lodge, 2006) would suggest that the accuracy of journalism is likely less important than psychological processing biases in explaining responses to climate change coverage.

7. Conclusion

The prevalence of uncertainty and opinion divergence framing in mainstream newspaper stories about climate change is incontrovertible. However, applying a deeper level of nuance than the prior literature, this study paints a much-revised portrait of the instances of uncertainty and opinion divergence framing in climate change journalism. Specifically, these frames occur *infrequently* about topics on which there is scientific consensus and usually do not involve scientists. Rather, the vast majority of uses of uncertainties and opinion divergences reference the other diverse actors and topics that exist in newsworthy topics related to climate change.

Note

1. The full codebook is available from the authors. However, to clarify the distinctions among the core types of opinion divergence – disagreement, controversy, and skepticism – we provide key portions of the operationalizations used for identifying the types in Table 2. An example of each appears in Table 1, and a general example of overall coding appears in section 4.2.5.

   Opinion divergence: expressions of divergence or difference in opinions between sources or other entities. There are five characteristics of opinion divergence that we will use to differentiate them.

   First, the number of sources, which refers to the number of distinct entities that are referenced as having the opinion divergence. Second, the nature of the sources themselves—distinct individuals (named or anonymous), groups (formal, such as "EPA," and informal, such as "conservatives"), or even ideas (environmentalism) or information sources ("the media"). Third, the duration of the opinion divergence, which refers to how long the divergence has lasted or is expected to last. This can range from very brief (less than a few months or, if not specified — when reconciliation is foreseeable within a few months) to prolonged (often, opinion divergence is indefinite and reconciliation is unforeseeable). Disagreement does not have to be going on at the time of the article. It can refer to a disagreement that was in the past and has since been resolved (very common, since resolution may be a characteristic of many disagreements). Controversy does not have to be going on at the time of the article. It can refer to an extended, over-time controversy that has ended. (e.g. "Throughout the 1990s … ").

   Fourth, the detail of the opinion divergence, which refers to the degree to which the divergence is about the intricate details of an issue. Thus, more detail signifies that the opinion divergence is not about the fundamental

assumptions or tenets of an issue, but rather is about the more particular details. Conversely, less detail signifies that an opinion divergence is about the fundamental assumptions. Fifth, the breadth of the opinion divergence, which refers to the degree to which the topic of divergence is broad or even unspecified. Thus, wide breadth signifies that the opinion divergence is not clearly bounded in one particular facet of a general topic, and may be applicable to multiple facets simultaneously. Conversely, narrow breadth signifies that the opinion divergence is clearly specified to a particular aspect or subtopic of the broader issue.

Note: Detail and breadth are not identical characteristics, although they are related. A topic of opinion divergence could be at a low detail (about fundamental assumptions) and wide breadth (not focused on one facet). An example of this would a debate of anthropogenic cause vs. natural variation. Conversely, a topic of opinion could be low detail but narrow breadth (about very specific elements of an issue). An example of this would be a debate about whether current measurement methods are capable of determining anthropogenesis. Note: as always, keep in mind that these criteria are guidelines that steer your best judgment, while also using the training examples and considering the possibility of anomalies that may satisfy most but not all of the criteria for this opinion type.

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