Media Representation of Extreme Event Attribution: A Case Study of the 2011–17 California Drought

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ABSTRACT

Extreme event attribution (EEA) is a relatively new branch of climate science combining weather observations and modeling to assess and quantify whether and to what extent anthropogenic climate change altered extreme weather events (such as heat waves, droughts, and floods). Such weather events are frequently depicted in the media, which enhances the potential of EEA coverage to serve as a tool to communicate on-the-ground climate impacts to the general public. However, few academic papers have systematically analyzed EEA's media representation. This paper helps to fill this literature gap through a comprehensive analysis of media coverage of the 2011–17 California drought, with specific attention to the types of attribution and uncertainty represented. Results from an analysis of five U.S. media outlets between 2014 and 2015 indicate that the connection between the drought and climate change was covered widely in both local and national news. However, legitimate differences in the methods underpinning the attribution studies performed by different researchers often resulted in a frame of scientific uncertainty or disagreement in the media coverage. While this case study shows substantial media interest in attribution science, it also raises important challenges for scientists and others communicating the results of multiple attribution studies via the media.

1. Introduction

For decades, climate change has posed a difficult problem in communication because its impacts are seen as distant in both space and time (Lorenzoni et al. 2007; Hulme 2009; Gifford 2011; Sacchi et al. 2016). Members of the public have long associated climate change impacts with future generations, faraway places, or other species; therefore, instead of engaging with the threat

of climate change, individuals tend to focus on what they view as more immediate dangers or concerns (Moser and Dilling 2004; Lorenzoni et al. 2007). This has made it difficult to attract and maintain public interest in the issue (Spence and Pidgeon 2010; Spence et al. 2012).

However, in recent years, developments in computer modeling have provided a new method for bringing climate change into the here and now (Hulme 2014). This is the method known as extreme event attribution (EEA), which compares the likelihood or severity of a given weather event in a world with or without anthropogenic greenhouse gas emissions (Allen 2003). In recent years, scientists and other organizations have joined forces to perform attribution studies more quickly, often while

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TABLE 1. Prominent attribution studies of the California drought published from 2014 to 2015, with general findings. These studies were collated via a combination of Google Scholar search for “California drought,” “climate change,” and “attribution” and a brief analysis of media articles and drought reports. “Human influence found” indicates that the drought was made either *more likely* or *more severe* as a result of anthropogenic greenhouse gas emissions. Asterisks indicate that the study was mentioned in the media corpus examined in this paper.

Author and Year	Journal or source	Result
AghaKouchak et al. (2014)	<i>Geophysical Research Letters</i>	Human influence found
Cheng et al. (2016)	<i>Journal of Climate</i>	No human influence found
Diffenbaugh et al. (2015)*	<i>Proceedings of the National Academy of Sciences</i>	Human influence found
Funk et al. (2014)*	<i>Bulletin of the American Meteorological Society</i>	No human influence found
Seager et al. (2014)*	NOAA report	No human influence found
Seager et al. (2015)	<i>Journal of Climate</i>	Human influence found
Shukla et al. (2015)	<i>Geophysical Research Letters</i>	Human influence found
Swain et al. (2014)*	<i>Bulletin of the American Meteorological Society</i>	Uncertain
Wang and Schubert (2014)*	<i>Bulletin of the American Meteorological Society</i>	No human influence found
Wang et al. (2014)	<i>Geophysical Research Letters</i>	Human influence found
Williams et al. (2015)*	<i>Geophysical Research Letters</i>	Human influence found

the extreme event is still in the news cycle (Cullen 2016; Hausteine et al. 2016).

EEA has the potential to help bridge the temporal and spatial gap of climate change, but while more and more studies are being performed in the natural sciences, it remains only occasionally studied in the social sciences (notable exceptions include Stott and Walton 2013; Hulme 2014; Sippel et al. 2015; Maibach et al. 2016; Lusk 2017). Although some have argued that communicating immediate, local impacts of climate change can produce longer-term engagement with the issue (Sippel et al. 2015; Jones et al. 2017; Halperin and Walton 2018), existing scholarship has not examined how EEA results are currently communicated to the public via the media, even as EEA coverage becomes more common in national and local outlets. Although a media study cannot indicate how members of the public receive and perceive information about EEA and climate change, it provides an important first step in understanding communication, by assessing how journalists represent and report the complexities of attribution science. Meanwhile, to date, few scholars have performed a systematic review of EEA coverage in the media (cf. Painter et al. 2020).

This paper helps to fill this literature gap by analyzing media representation of attribution in a particular case—that of the 2011–17 California drought. Some scientists estimated the 2011–17 event was California’s worst drought in over a millennium (Griffin and Anchukaitis 2014; Nagourney 2015). Moreover, in its most severe years (2014–15), the California drought was prominently depicted in the media; according to an analysis by Quesnel and Ajami (2017), the 2011–17 drought received “unprecedented media coverage” (see also Kam et al. 2019). This high amount of media coverage has also been linked to high public interest and drought awareness—Quesnel

and Ajami (2017) found that peaks in news coverage corresponded to peaks in the Google search frequencies for “California drought” (see also Gonzales and Ajami 2017).

Meanwhile, from the beginning, the drought was connected to climate change by various political actors (Henry 2015; McCarthy 2015). California Governor Brown told ABC News in April 2015: “With the weather that’s happening in California, climate change is not a hoax. We’re dealing with it, and it’s damn serious” (McCarthy 2015). In a statement given from California in early 2014, President Obama announced that “a changing climate means that weather-related disasters like droughts, wildfires, storms, floods are potentially going to be costlier and they’re going to be harsher....[S]cientific evidence shows that a changing climate is going to make [droughts] more intense” (Obama 2014).

Unlike many other weather events over the previous decade in the United States, the California drought also coincided with growth in attribution science. Multiple attribution studies on the drought were performed, largely between 2014 and 2015, when the drought was making headlines both nationally and abroad (see Table 1). The drought quickly became one of the most-studied events in EEA research to date, with groups of scientists from across the United States and the world contributing analyses (Pidcock et al. 2019).

The combination of complex EEA results, economic impacts, and extensive media coverage makes the California drought an exemplary case study for how media represent the complexities of EEA. In this paper we focus on both online and print forms of mainstream media. Although there have been changes in the media ecosystem over the past several decades, including the growth of social media and television coverage, mainstream media remain very important sources of public

information (Newman et al. 2019). We seek to answer four interconnected research questions through a detailed content analysis:

- 1) How often did mainstream media sources make the link between the California drought and climate change?
- 2) When the link was made, who was quoted and what were the different ways in which it was described?
- 3) To what extent did attribution coverage vary over time, and how did it relate to the release of the attribution studies?
- 4) To what extent did the media report the uncertainties and disagreements present in, or derived from, the multiple attribution studies?

2. Background

a. Climate change communication and the media

Some scholars have argued that communicating immediate, local impacts of climate change can produce longer-term engagement with the issue (Jones et al. 2017). This is in accordance with construal level theory (Trope and Liberman 2003, 2010), which postulates that temporal and spatial closeness to an issue allows individuals to assess risks more accurately and make more informed decisions (Trope and Liberman 2010). There are some signs that individuals are beginning to view climate change as more relevant to their lives. According to an opinion poll published in December 2019 by the Yale Program on Climate Change Communication, a majority (72%) of Americans believe that climate change is occurring and is largely human caused; meanwhile, almost half (45%) of Americans believe that climate change is affecting U.S. residents “right now,” up from 32% in March 2015 (Leiserowitz et al. 2019); A. Leiserowitz, the lead author of the poll report, has previously attributed at least some of this trend to an increase in extreme weather events that could be linked with climate change (Schwartz 2019).

Some empirical research supports this theory with respect to climate change and extreme weather events. Some scholars have argued that extreme events provide a communication opportunity, as experiencing an extreme weather event can increase climate change concern (Bergquist et al. 2019). Others have warned that temporal and spatial closeness can sometimes backfire (Reser et al. 2014; Brügger et al. 2015). For example, in a survey of the literature, Reser et al. (2014) found that the influence of weather on climate change beliefs is predicated on whether the event was attributed to climate change, and the role of uncertainty present. However, they argue that framing climate change through weather

can also serve to trivialize or normalize more severe global impacts (Reser et al. 2014).

A few researchers have examined whether linking climate change and extreme weather through EEA can prompt behavior change or make the issue seem more relevant for members of the public. For example, Halperin and Walton (2018) found in a survey that attribution statements about the 2011–17 California drought encouraged adaptation behaviors, but only in those who were already “concerned” about global climate change. In stakeholder meetings with television journalists, Stott and Walton (2013) found that journalists were enthusiastic about the prospect of EEA, since extreme weather events attracted public attention and interest. However, the media representatives also expressed “frustration with scientists’ inability to communicate the complexity of attribution science in a way that is accessible” (Stott and Walton 2013, p. 278). Moreover, “the issue of uncertainty within the science was also seen as problematic to report, as this is still seen by many as ‘not knowing’” (Stott and Walton 2013, p. 278).

EEA communication is part of a larger issue of how the public responds to scientific uncertainty in general. According to Painter (2016, p. 4), “the non-scientist often expects the scientist to know things, equating science with certainty.” If a scientist professes uncertainty about some aspects of complex systems, this is sometimes interpreted by the public as the scientist not knowing “*anything* about the subject” (Pollack 2003, p. 7). However, science is filled with “epistemic” uncertainties, or uncertainties inherent in model selection and limited data—which may be difficult for nonexperts to understand. Journalists play a crucial role in mediating these uncertainties and framing them for the public (Stecula and Merkley 2019).

There is evidence indicating that communicating uncertainty can decrease public engagement with environmental issues and even decrease proenvironmental behaviors. Morton et al. (2011) found that uncertainty about future negative climate impacts reduced participants’ willingness to engage in proenvironmental actions. Shuckburgh et al. (2012, p. 28) found that focus group participants were frustrated by the inclusion of uncertainty in news articles about climate change, finding them inconclusive and “lacking facts.” Moser (2016) has similarly argued that uncertainty can render individuals unable to appropriately manage climate change cognitively, thus diminishing engagement. Others have hypothesized that uncertainty presented on one aspect of climate science may affect trust in other aspects of climate science—a phenomenon known as “uncertainty transfer” (Spence et al. 2012).

For example, legitimate uncertainty over climate impacts or a particular aspect of climate science may lead to uncertainty over the causes of climate change (Spence et al. 2012). Thus, there is a possibility that uncertainty about EEA could lead to uncertainty about broader aspects of climate science in general.

Some researchers have examined the role of uncertainty in media portrayals of climate science and potential climate impacts (e.g., Shuckburgh et al. 2012; Painter 2013, 2016). Some of this work has looked at the role of denialist groups, sometimes funded by fossil-fuel companies, in perpetuating climate change denial among a larger population (Oreskes 2012). But uncertainty around climate change in the media can go far beyond the simple quoting of denialist voices. In a detailed discourse analysis of U.K. media around climate change, Ereaut and Segnit (2006) argued that one of the metanarratives around climate change is a sense of general uncertainty. With so many conflicting messages and framing, they noted: “It seems likely that the overarching message for the lay public is that, in fact, nobody really knows” (Ereaut and Segnit 2006, p. 10). Similarly, Nisbet (2009) identified eight dominant frames of climate change media coverage, one of which was “scientific and technical uncertainty.”

Other researchers have used linguistic approaches to assess uncertainty descriptors in the media. Bailey et al. (2014, p. 200) examined “epistemic markers”—“words or expressions that communicate uncertainty”—in U.S. and Spanish news media, arguing that linguistic choices in climate change reporting might spread public uncertainty. Painter (2013) found many examples of uncertainty in research on media coverage of Intergovernmental Panel on Climate Change (IPCC) reports, including modal verbs such as “may,” “might,” or “could,” “dueling experts,” “uncertainty parameters,” and more. According to his analysis of six countries, uncertainty was the second most common frame in media coverage of the IPCC reports, second only to the frame of “disaster” (Painter 2013).

More recent research has suggested that the uncertainty frame is on the decline in climate change media coverage. Stecula and Merkley (2019) note that uncertainty frames were significantly lower in four major American newspapers between 2006 and 2014 than they were in either the period from 1988 to 1996 or from 1997 to 2005. They argue that little current coverage disputes the consensus view of the IPCC (Stecula and Merkley 2019). In particular, the norm of “false balance,” in which skeptical voices of climate change were contrasted with facts from climate scientists and experts, seems to have diminished in the past decade and a half (Boykoff and Boykoff 2007;

Schmid-Petri 2017). However, even if the media has moved away from depicting uncertainty about core aspects of climate science, there is still uncertainty about others: for example, the timing and severity of future impacts and the role of climate change in extreme weather events.

b. EEA studies of the California drought

The case of the 2011–17 California drought provides a useful starting point for exploring the role of uncertainty in EEA. The drought was a long-term event, unfolding over six years, and thus must be considered as distinct from short-term extreme events (such as heat waves or floods), which receive different forms of media and scientific attention (Ungar 1999; National Academies of Sciences, Engineering, and Medicine 2016). The long-term nature of the drought provides an extended look at how multiple EEA results are communicated over time by the media. During the key years of the drought there was no overall consensus on the influence of anthropogenic climate change. In 11 prominent studies conducted by the end of 2015, 6 found anthropogenic influence on the drought, 4 found no human influence, and 1 was uncertain (Table 1). The different results can be explained by a few different factors. First, researchers often asked different questions—while some were interested in whether the drought had become *more likely* as a result of climate change, others focused on whether it had become *more severe*. Furthermore, the southwest region of the United States is known to be a problematic area to understand in terms of climate dynamics, due to the complexity of the interactions between the tropical Pacific Ocean, the atmosphere, and in this case extratropical forcing from a high pressure system (Seager and Hoerling 2014).

The drought event itself was defined in a number of different ways and represented by different variables (Wilhite 2000). For example, Shukla et al. (2015) modeled the drought using winter snow water equivalent, soil moisture, runoff deficit and evapotranspiration, while Seager et al. (2015) only looked at precipitation. Cheng et al. (2016) used agricultural drought as their definition for the event, modeling precipitation, near-surface temperature, and soil moisture as the climate variables. Wang and Schubert (2014), on the other hand, defined the drought meteorologically, as the prevalence of dry weather patterns over California.

Moreover, the computer modeling process used by scientists can also deliver different results. Scientists will often use different datasets to run their models, and start the model runs with different initial conditions. Some models might therefore show wetter conditions over California, while others might show drier conditions.

For example, Shukla et al. (2015) used a hydrological model while Seager et al. (2015) compared seven atmospheric models.

Each of these approaches, ways of framing the research question and modeling techniques are scientifically robust and have undergone peer review. Therefore, the results of these studies can all be considered valid. In some cases, attribution scientists did agree—for example, in the latter half of the drought, a limited consensus did emerge around the role of extreme temperatures in exacerbating the drought, although the role of precipitation generally remained uncertain (see section 4). However, when multiple, seemingly contradictory attribution studies were released to the press, the communication of these differences often led to a framing of conflict and uncertainty between scientists.

3. Method

Five mainstream newspapers, three national and two regional, were chosen for analysis. At the national level, the *New York Times*, *USA Today*, and the *Wall Street Journal* were selected due to their wide readership and influence. At the regional level, the *Los Angeles Times* and the *San Francisco Chronicle* were chosen. These papers are representative of large urban areas in Southern and Northern California, respectively.

The period monitored was between 1 January 2014 and 31 December 2015. This period was chosen because of the number of EEA studies released (Table 1), and the fact that drought coverage peaked during this time.¹ A manual content analysis was performed on each article result, which included the Boolean search terms “California drought” and “climate change” or “California drought” and “global warming.” This resulted in 71 articles for coding across the five outlets. Two authors each coded all of the articles manually using a code book, and a coder reliability assessment was performed. Every disagreement between the manual coding results was resolved through in-person discussion and recoding between the two coders, as well as refinement of the code book when necessary. Articles from the *New York Times*, *USA Today*, and the *Los Angeles Times* were collated using the ProQuest Newsstream, the *Wall Street Journal* articles were collated through Factiva, and the *San Francisco Chronicle* articles were collated through the

newspaper’s online archive system.² Article collating systems were used for ease of analysis and exporting articles, but they do face some methodological limitations; different archiving systems can sometimes miss articles that would be found if manually collated, particularly in periods of abnormally high coverage (Roby et al. 2018). For example, Roby et al. (2018) found that the ProQuest Newsstream returned significantly fewer *New York Times* articles about the California drought during April 2015 than a comparable manual search.

The content analysis took both quantitative and qualitative forms. Each article was first coded for quantitative analysis on 1) whether the article linked climate change and the California drought, 2) the type of attribution link made, and 3) how prominent attribution was as a topic in the article (all articles were coded with attribution as a “major topic,” “minor topic,” or “brief mention”: a “major topic” article was defined as one in which more than one-third of the paragraphs discussed attribution, a minor topic as one in which less than one-third of the paragraphs discussed attribution, and a brief mention as one to two sentences on attribution). Then, each article was coded for 4) whether the attribution link was supported by one of more scientific studies, 5) what types of actors were quoted making attribution links, and 6) whether disagreement or uncertainty was depicted. All of the articles were also assessed qualitatively for how they depicted any uncertainty relating to attribution.

Sentences, phrases, or other wording in the articles that connected climate change with the California drought—hereinafter called “attribution links”—were divided into five categories. The first three categories were derived from the expected results of the EEA studies: 1) the drought could have been made *more likely* by climate change, 2) the drought could have been made *more severe* as a result of climate change, or 3) the drought was found to be mostly attributable to *natural causes* (Table 2). EEA studies can also discover that an extreme weather event was made *less likely* or *less severe* due to climate change. However, these types of attribution links did not appear in the sample. To these was added 4) *long-term* and 5) *other*. “Long-term” statements did not directly claim that climate change caused the drought, but that climate change could contribute to making future, similar droughts more likely or more severe. These long-term claims are not typically considered to be forms of attribution,

¹ A ProQuest Newsstream search of 48 prominent U.S. newspapers for the keywords “California drought” resulted in 10 597 articles in 2014 and 13 103 articles in 2015, as compared with 2241 in 2013 and a decrease to 5315 in 2016.

² The *San Francisco Chronicle* archiving system does not distinguish between strict Boolean search strings (e.g., “California drought”) and inclusive search strings (e.g., “California” and “drought”). This fact likely contributed to the higher number of articles from the *San Francisco Chronicle* than from the other newspapers.

TABLE 2. Examples of attribution types. The italics were added to emphasize the attribution type.

More likely	“‘It’s very likely that observed global warming <i>has increased the probability of that atmospheric condition</i> by at least a factor of three,’ Diffenbaugh said.”— <i>San Francisco Chronicle</i> (Alexander 2014a)
More severe	“Global warming caused by human emissions <i>has most likely intensified the drought</i> in California by 15 to 20 percent, scientists said on Thursday.”— <i>New York Times</i> (Gillis 2015)
Natural causes	“Scientists who have analyzed California’s extreme drought have concluded that it is a result <i>of natural climate variability</i> over the past three years and that climate change caused by humans has played little role.”— <i>New York Times</i> (Fountain 2014)
Long-term	“Projections for global warming mean <i>that 2014 could become a typical year in the decades ahead</i> . The Scripps Institution forecast that Sierra snowpack may shrink by 80 percent this century.”— <i>San Francisco Chronicle</i> (Palmer 2014)
Other	“‘Everybody can do something to help out,’ Gannon said, referring to climate change, which <i>some studies suggest has contributed to the past three bone-dry years</i> .”— <i>San Francisco Chronicle</i> (Alexander 2014b)

since they do not draw a direct connection between climate change and the particular extreme event. However, they were included in this study because they provide key insight into the different ways that weather and climate change are connected in public discourse via traditional media. Moreover, for many members of the public, there may not be a clear distinction between such long-term claims and more technical attribution claims. “Other” indicated phrasing in an article that connected the drought to climate change generally but did not specify likelihood, severity, or long term (Table 2). If there were multiple types of attribution claims in the same article, each type was coded. Additionally, each article was coded by a single author for the types of actors quoting making attribution statements. Quoted actors were categorized as “scientists,” “politicians/policy makers,” or “citizens.”

The articles were qualitatively assessed by a single author for the type of uncertainty or disagreement represented. Each article coded for uncertainty was examined and interpreted thematically. Most articles that incorporated uncertainty did so either through language indicating a “lack of consensus” or “expansion of the problem domain” (see Table 3; Zehr 2000; Painter 2013). Articles depicting a lack of consensus utilized language of “debate” or “disagreement” between scientists and often presented differing attribution results. Articles with the “expansion of the problem domain” framing either noted that attribution research had not been completed, or that the data and method for attribution was currently inadequate (Table 3).

4. Results

a. Volume of attribution coverage

Seventy-one articles were identified with the terms California drought and climate change or California drought and global warming in the five outlets between 2014 and 2015. Of these, 47 articles (approximately 66%) included an attribution link (Fig. 1). Articles with an attribution link were distributed according to the weight of

attribution as a topic within the piece: brief mention, minor topic, or major topic. Most of the articles fell into the major topic or brief mention categories (Fig. 1).

Articles containing attribution links did not appear evenly across the news outlets. Figure 2 shows all the articles in the sample distributed according to news outlet, with and without attribution links. The *Los Angeles Times* had 9 articles during this time period that featured some form of attribution link, the *New York Times* had 12, the *San Francisco Chronicle* had 25, and *USA Today* had only 1 (Fig. 2). The *Wall Street Journal* only had one result for the search terms, and that article did not contain an attribution link. Note that the regional newspapers had more results for the search terms but they also had a smaller proportion of articles including attribution statements (as compared with, e.g., the *New York Times*). This may be because regional California newspapers had both more overall coverage of the drought and more coverage concerned with local impacts, rather than global or national issues such as climate change.

We can observe that EEA was prominently represented in the coverage of the California drought from 2014 to 2015. Three of the five outlets published multiple articles during the 2-year period that quoted or made attribution claims. We did not attempt to perform a comprehensive analysis estimating the proportion of overall drought coverage that included attribution statements, but a simple assessment of their coverage is instructive (Table 4). For example, the *Los Angeles Times* published 71 articles between 2014 and 2015 that contained the search phrase California drought, and of these, 16 mentioned climate change or global warming (approximately 23%). Nine of those 16 included an attribution statement (approximately 13% of the total articles that mentioned the California drought; see Table 4).³

³ The large set of articles containing the search term “California drought” was not coded to verify that they were entirely focused on the drought itself. Further research would be needed to produce a more rigorous understanding of the proportion of coverage that included attribution or climate change mentions.

TABLE 3. Examples of uncertainty types. The italics were added to emphasize the uncertainty type.

Lack of consensus	<p>“Whether climate change—whatever its cause—has played a role in the California drought <i>is a matter of debate</i>”—<i>Los Angeles Times</i> (Boxall 2015)</p> <p>“Some scientists have argued that the ocean and atmospheric factors that produced the ridge have become somewhat more likely because of climate change, <i>but others have disputed that, and the matter remains unresolved.</i>”—<i>New York Times</i> (Gillis 2015)</p>
Expansion of problem domain	<p>“Scientists such as Hoerling and Ault say <i>they don’t have the tools to tease out how much of this specific drought might be attributable to climate change</i>”—<i>USA Today</i> (Rice 2014)</p> <p>“Scientists have not yet linked the California drought directly to climate change. Thomas Karl, head of the National Oceanic and Atmospheric Administration’s National Climatic Data Center, said Tuesday in announcing the latest study. ‘I’m sure there’s a way, but we haven’t done it yet,’ he said.”—<i>San Francisco Chronicle</i> (Lochhead 2015).</p>

b. Representation of attribution

A variety of different types of attribution links appeared in the sample. The most common type of link was the long-term type, in which an actor (or the article author), mentioned that climate change would make droughts more likely or intense *in the future*, without making a direct link to the current drought (Fig. 3). However, all of the coded types of attribution were prevalent in the sample, including “more likely,” “more severe,” “natural causes,” and “other” (Fig. 3). Almost half of the articles (23 of 47) had multiple types of attribution link in the same article—for example, a journalist might include a long-term statement about droughts in general, but also note that this particular drought was due to natural causes.

Articles that only had a brief mention of attribution in one or two sentences (21 of 47) primarily included long-term statements. These articles often covered the drought issue generally but included a cursory mention

of climate change and a single attribution link, sometimes as a quote from a politician or other actor. Some examples are below.

This year, [Senator] Feinstein said, she wanted to take a longer view that incorporates climate change and the likelihood that California’s droughts will become harsher and more frequent.—*San Francisco Chronicle* (Lochhead 2015)

“With all the climate change, we are looking at continuing drought,” said [Cupertino Mayor] Mr. Sinks, sitting in his City Hall office on yet another hot and dry afternoon. “I believe we are heading for a more arid climate here. We have to act as if it’s really going to happen. This may be the new normal.”—*New York Times* (Nagourney 2015)

At other times, a cursory statement would cite general studies or would express a view held by “scientists” in general:

State climatologists say the warming pattern [leading to decrease in snowpack and drought] could be tied to an El

FIG. 1. Proportion and number of articles containing the terms “California drought” and “climate change” or “global warming” that included an attribution link.

FIG. 2. Number of articles from 2014 to 2015 by news outlet, with or without attribution links.

Niño condition in the equatorial Pacific. . . . Some scientists say climate change could be a factor.—*Wall Street Journal* (Carlton 2015)

“Everybody can do something to help out,” Gannon said, referring to climate change, which some studies suggest has contributed to the past three bone-dry years. “This is what I’ve done.”—*San Francisco Chronicle* (Alexander 2014a)

Overall, these articles with attribution as a brief mention included an attribution statement as background information and did not generally quote attribution scientists or cover specific studies.

The second primary type of coverage occurred in articles in which attribution was a major or minor topic (19 of 47 articles). Featuring headlines like “Global Warming? Not Always” (Hoerling 2014), “Study: Global Warming Has Made California’s Drought Worse” (Fagan and Sernoffsky 2015), and “Warming, Drought Link Uncertain” (Boxall 2014), these articles almost always featured multiple types of attribution links and almost always depicted disagreement or uncertainty (22 of 26 articles, or about 85%). These major or minor topic articles often featured many different climate experts with varying perspectives on the drought—some arguing it was due to natural variability, others noting that it had been made worse by climate change, and some claiming it had been made more likely by climate

change. For example, the *New York Times*’ J. Gillis reported a host of divergent claims in a February 2014 article, soon after the drought began making national news, quoting some scientists arguing that the drought had been made more likely by climate change, and others arguing that it was too early to say (Gillis 2014a).

Indeed, many of the articles in the sample, particularly major topic or minor topic articles (29 of the 47 articles with attribution links) included quotes from scientists or other actors linking the drought and climate change. Overwhelmingly, the articles quoted at least one scientist (25 of 29, or 86%), while a few articles quoted politicians or citizens (Fig. 4). Citizens and politicians tended to make long-term links connecting the drought and climate change, or links that fell into the other category (Table 2). Scientists, however, were quoted making a great variety of attribution links, ranging from long-term links to natural causes and severity. This aligns with the fact that many scientists interviewed were reporting on their own studies, which came to varied conclusions on climate change’s effect on the drought.

c. Coverage over time

The second year of severe drought, 2015, featured more articles with attribution statements than 2014, likely because of the increasing number of studies performed on the event (Fig. 5). Four attribution studies were prominently cited in the article corpus—the report of the *Bulletin of the American Meteorological Society* (BAMS; Stott et al. 2014), a report of the National Oceanic and Atmospheric Administration (NOAA) by Seager et al. (2014), a study by Diffenbaugh et al. (2015), and a study by Williams et al. (2015) (see Table 1). The BAMS report featured three studies by different authors on the drought (Funk et al. 2014; Swain et al. 2014; Wang and Schubert 2014), but it was almost always cited holistically in the journalistic coverage.

The timeline (Fig. 5) indicates that the release of EEA studies was a strong driver of coverage. Most of the key studies resulted in a spike in coverage, in particular the BAMS report in September 2014 and the Williams

TABLE 4. Percentage of articles with the search term “California drought” that included an attribution link, by news outlet.

News outlet	“California drought”	Drought and “climate change” or “global warming”	Attribution	Percentage of total articles including attribution
<i>Los Angeles Times</i>	71	16	9	13%
<i>New York Times</i>	25	14	12	48%
<i>San Francisco Chronicle</i>	314 ^a	38	25	8%
<i>USA Today</i>	6	2	1	17%
<i>Wall Street Journal</i>	24	1	0	0%

^a See text footnote 2.

FIG. 3. Attribution link by type. Note that the number of links exceeds the number of articles containing attribution, because many articles had multiple types of attribution in a single article.

paper in August 2015. Both of these releases were notable: the *BAMS* report was the first EEA assessment of the California drought, while the Williams paper was the first to attempt to directly quantify the effect of climate change on the drought. This shows that, at least in the California drought case, some of the attribution research was covered by national and regional media sources. However, not all of the prominent attribution studies of the drought between 2014 and 2015 were mentioned in the media (see Table 1). This is likely due to a combination of factors, including patterns in the news cycle, how well the various studies were publicized, and journalists' familiarity with particular researchers.

d. Uncertainty

Overall, uncertainty or disagreement was prominent in the sample, appearing in roughly half (24 of 47) of the articles with attribution statements, and primarily in articles with attribution as a major topic. Qualitative analysis revealed that most of the uncertainty in the articles took the form of a "lack of consensus" framing (see Table 3). This framing occurred either through 1) differing results from scientific studies or 2) from differing opinions offered by various climate scientists and meteorologists. (The latter is often referred to as the dueling experts frame; see Painter 2016.) For example, the *Los Angeles Times* reported that the studies in the *BAMS* report had come to divergent results:

One of three studies examining the California drought in 2013 found that the kind of high-pressure systems that blocked winter storms last year have increased with global warming. But another study concluded that a long-term rise in sea surface temperatures in the western Pacific did not contribute substantially to drought.—*Los Angeles Times* (Boxall 2014)

FIG. 4. Actors quoted making attribution links. Note that the number of articles with a given actor type exceeds the number of articles overall, because some article had multiple types of actors quoted in the same piece.

The *BAMS* report provoked a great deal of this kind of uncertainty coverage, since three papers were released simultaneously that appeared to contradict one another; K. Alexander, reporting in the *San Francisco Chronicle*, also noted a lack of consensus:

Climate researchers at Stanford University have previously reported that the high-pressure system . . . is more likely to occur in the presence of man-made greenhouse gases. The report is one of many that has sought to link human-caused climate change to the California drought. To date, though, there's little consensus on a connection.—*San Francisco Chronicle* (Alexander 2015)

At other times, quotes or statements from different scientists were presented together to depict a lack of consensus. For example:

"The drought is consistent with what can happen with natural variability," said the study's lead author, Richard Seager . . . But some scientists, including Michael E. Mann, a climate scientist at Pennsylvania State University, said the report had understated the impact of warming.—*New York Times* (Fountain 2014)

These two types of lack of consensus were often intertwined as well: many articles featured both dueling experts and differing results from studies.

Some journalists did provide detail on why this lack of consensus existed, explicating the different variables examined by different scientists. For example, a *San Francisco Chronicle* article articulated the difference between studies that focused on a lack of rainfall (e.g.,

FIG. 5. Timeline of news articles with attribution links ($n = 47$). Articles citing key studies are color coded. If an article mentioned multiple key studies, it was coded by the study that was most prominently featured.

those examining the high pressure system in the Pacific), and those that looked at warming temperatures exacerbating the drought (Alexander 2015). Another piece for the *New York Times* also attempted to settle the confusion between the question of whether the drought had become more likely or more severe (Fountain 2015). However, few articles went into depth on the methodological differences between studies; as we shall see in the discussion section, journalists faced constraints that made such detailed reporting difficult or less prioritized.

Uncertainty was also depicted through “expansion of the problem domain” (see Table 3). In these articles, scientists were quoted saying that attribution had not been performed yet, that they did not have adequate tools or data to perform attribution, or that further research was needed to uncover the role of climate change. For example, an Associated Press piece reprinted in the *San Francisco Chronicle* noted that “It is too early to point directly at the near-record California drought as another sign of global warming, but it fits the pattern, [climate scientists] Yohe and Wuebbles said” (Associated Press 2014). A *New York Times* article reported that University of Oxford Professor M. Allen “noted in an interview that attributing extreme events to human emissions was still contentious and difficult, so any answers given today must be regarded as provisional” (Gillis 2014b).

Sometimes articles emphasized scientific uncertainty about one aspect of the science, but consensus on another aspect. The *San Francisco Chronicle* wrote that in the BAMS report overall, “Scientists said

they could not conclusively tie global warming to California’s lack of rainfall” (Alexander 2014b). However, the article concluded, “Most researchers agree, however, that California’s warming temperatures will worsen the state’s drought, as heat steps up evaporation” (Alexander 2014b). This framing—that scientists disagreed about whether the drought had become more *likely* but agreed that it had become more *severe*—was used by many articles in the sample, particularly after Williams et al. (2015) published a paper on drought severity. The *New York Times* reported that “while there is still debate about whether climate change has caused the lack of rain, there is less controversy about the role of warming temperatures” (Fountain 2015). This latter point emerged as a form of loose consensus during 2015, as more news coverage emphasized that, while climate change’s effect on precipitation remained uncertain, the warming temperatures had likely caused the drought to become more severe.

5. Discussion

a. Complex results present both journalistic and scientific challenges

The drought case study demonstrates that media coverage of attribution comes in many forms. Journalists reported that California droughts might become more frequent and intense in the future, and also reported more direct links that drew on EEA science. This indicates that extreme weather events are beginning to be substantively linked with climate change in the media,

shifting climate change from a problem exclusively distant in “space and time.”

At the same time, despite the volume of coverage, the multiplicity of EEA studies performed on the California drought and their sometimes divergent results present a possible conundrum for science communication (see Table 1). Unlike previous forms of climate change uncertainty in the media such as “balance as bias” (Boykoff and Boykoff 2004), uncertainty over EEA results is a legitimate scientific debate—not all scientists agreed on whether, or how, the California drought was linked to climate change. As we have seen, this was due to differences in the research questions utilized (whether the drought was made more likely or more severe by climate change), drought definitions (precipitation deficit, drought severity index, or a combination of precipitation and high temperatures), time scales examined, and climate models used. In some cases, two EEA studies, which examined different variables for drought, were positioned in newspaper articles as dueling experts, even though the researchers were fundamentally asking different questions.

These issues have occurred before in EEA communication. In the aftermath of the Russian heat wave of 2010, two studies appeared to report contradictory EEA results. Dole et al. (2011) claimed the heat wave was “mainly natural in origin,” while Rahmstorf and Coumou (2011) argued that it was made more likely due to anthropogenic climate change. Later research demonstrated that the two studies were actually asking different questions—Dole et al. (2011) focused on the severity of the event, while Rahmstorf and Coumou (2011) focused on its likelihood (Otto et al. 2012). To a lay audience, however, the Russian heat wave appeared to be a prime example of scientific uncertainty and disagreement (Jha 2012).

These findings are complemented by other qualitative research on the drought that shows constraints faced by journalists. In interviews with journalists at both national and regional papers, Osaka and Bellamy (2020) found that for many of them the California drought was a particularly difficult example of EEA reporting, because of the need to express nuanced scientific information in an easy-to-understand manner. Meanwhile, scientists interviewed agreed that the nuances of EEA were difficult to communicate and expressed frustration that the complexities of their research were sometimes represented through a lens of disagreement (Osaka and Bellamy 2020).

b. Implications of uncertainty framing

EEA of events like the California drought creates a difficult problem. In this case, while the reporting of

EEA results was largely accurate to the science, the repeated framing of uncertainty could have deleterious implications for perception of attribution science and even climate science more generally. Uncertainty in EEA reporting could cause readers to question the overall consensus on climate change through the aforementioned “uncertainty transfer” (Spence et al. 2012). Nonscientists may be unable to distinguish between the currently developing field of EEA and climate science more generally. It could also cause public disengagement with the issue, as a framing of disagreement might reinforce a perception in the public that “nobody really knows” whether there is a connection between extreme weather and climate change (e.g., Ereaut and Segnit 2006, p. 7). As Morton et al. note, “from the public’s perspective . . . uncertainty compromises the perception of scientific authority” (Morton et al. 2011, p. 103).

It is important to note, however, that the California drought was unique among EEA events—both for the number of studies performed on it and for its substantial press coverage. Most extreme events are researched in one EEA study, if any, and thus are not subject to the same repeated assessments that the California drought was (Pidcock et al. 2019). Because the drought stretched over a six-year period, multiple studies could be released and still garner press coverage. This compounded the issues of uncertainty and potential disagreement, as all the studies utilized slightly different time scales and methods. Other extreme events have not had the same levels of uncertainty in the media; for example, Painter et al. (2020) found that uncertainty was not a dominant framing in media coverage of the 2015 Andhra Pradesh heat wave or Chennai flooding—shorter-term events with more limited scientific assessment.

c. Possibilities to reduce uncertainty framings

There are ways that researchers have attempted to ameliorate uncertainty in EEA reportage. An increasing number of attribution researchers are beginning to collaborate in order to release studies in tandem under a unified message, particularly for high-profile events. In the case of Hurricane Harvey in 2017, two groups of researchers coordinated the release of EEA studies to coincide with the annual meeting of the American Geophysical Union (Risser and Wehner 2017; van Oldenborgh et al. 2017). The researchers used similar approaches and came to similar conclusions—that the hurricane had been made more severe as a result of climate change (Fountain 2017). The World Weather Attribution program coordinated at the University of Oxford, which was one of the groups that assessed the case of Hurricane Harvey, typically triangulates EEA via three different methods and then summarizes the

results for communication to the public (WWA 2019). An emergent system operational climate service for EEA in Europe is being explored through the European Prototype Demonstrator for the Harmonisation and Evaluation of Methodologies for Attribution of Extreme Weather Events (EUPHEME) project as part of the Copernicus Climate Change Service (C3S). This attribution service composed of researchers and stakeholders similarly uses multiple methods to assess and synthesize EEA results (EUPHEME 2019).

Collaboration, however, is not a panacea for EEA reportage. The Seager et al. (2014) report on the drought was the result of multistakeholder and institutional collaboration. Meanwhile, in events such as the California drought, where multiple reputable (although divergent) studies were carried out, the emphasis should not be on creating one uniform attribution statement. This might lead to a focus on spurious “certainty” to the detriment of a more detailed picture of the state of the science. Another possibility is greater training for both journalists and scientists in how to effectively communicate the nuances of EEA in a manner that does not result in the dueling experts frame. Journalists may need to clarify the difference between studies investigating likelihood and severity of events; meanwhile, scientists may need to be more explicit when interacting with journalists about the methodological differences between studies and how multiple studies can be scientifically robust even with divergent results. More research is needed around how other extreme events have been covered in the media with respect to EEA, and when and how uncertainty can be avoided or communicated in a more effective and understandable manner.

6. Conclusions

This paper investigated the attribution of the 2011–17 California drought to climate change, according to four interconnected research questions. Results showed, first, that attribution of the California drought to climate change received a high level of mainstream media attention in the 2014–15 period among three newspapers: the *San Francisco Chronicle*, *New York Times*, and *Los Angeles Times*. It received much less attention in the *Wall Street Journal* and *USA Today*.

Two primary types of attribution links were represented in the sample: first, attribution links that provided context in an article focusing generally on the politics or impacts of the California drought, and second, more varied types of attribution links in articles that focused primarily on EEA and the drought. Attribution links included claims that the drought was made more likely

or more intense due to climate change; that it was not influenced by climate change at all; or that similar droughts would become more common or more intense in the future. Articles with attribution as a “brief mention” were primarily of this latter “long-term” type. Many articles with attribution as a major or minor topic included multiple types of attribution links in the same piece.

An analysis of the timeline of media articles indicates that EEA studies were a strong driver of coverage. Four key studies were covered substantively in the sample: the *BAMS* report (Stott et al. 2014), Seager et al. (2014), Diffenbaugh et al. (2015), and Williams et al. (2015). The release of each of these studies resulted in a spike in attribution coverage. However, these studies were covered extensively while other attribution studies were not mentioned in the article corpus (Table 1). Further research could include qualitative interviewing of journalists to understand why some studies are covered and others are not.

Uncertainty was represented prominently in the coverage in two forms. Most common was a “lack of consensus” frame, in which multiple EEA studies were compared and differing opinions of scientists were presented. Other articles also presented a frame of “expansion of the problem domain,” in which actors argued that further research or more developed tools were needed to connect the drought with climate change. Articles with attribution as a major or minor topic were much more likely to depict uncertainty than articles that only mentioned attribution in passing. Twenty-two of 26 articles with attribution as a major or minor topic (about 85%) included disagreement or uncertainty. In some articles, journalists established both a consensus view (that climate change had made the drought more intense) and a contested view (that climate change had made the drought more likely). This reflects how the scientific narrative evolved over the two years of the drought as scientists grew more certain about the role of increasing temperatures but remained uncertain about the role of climate change in the precipitation deficit.

The current depiction of uncertainty when multiple attribution studies are performed on the same event could cause problems for communication to the public. Research has shown that uncertainty in climate change news coverage can be an obstacle to prosocial or pro-environmental behaviors and that it can reduce public engagement in the issue of climate change. As mentioned above, it also could cause “uncertainty transfer,” in which uncertainty on EEA spills over into uncertainty on the issue of climate change more generally. More research is needed into how these effects could potentially be mitigated through either greater scientific collaboration or journalistic training.

This study had some limitations, including the relatively small sample size of articles ($n = 71$) and the limited sampling from the *Wall Street Journal* and *USA Today*. It remains to be seen whether these papers might cover other instances of EEA, or whether the omission of coverage is part of a wider pattern for these publications. It is also important to note that the California drought was a special case due to the volume of EEA studies and the drawn-out media coverage over three to four years. Future media studies on EEA should examine coverage of other types of events, such as heat waves, floods, or hurricanes—and in particular, events where only one or two EEA studies were performed. Such research would provide a better understanding of when and how uncertainty about EEA is communicated.

In addition, more scholarship is needed on the public understanding of attribution statement types, particularly the distinction between an extreme event becoming “more likely” as a result of climate change or “more intense.” While statements such as “the drought was *not* caused by climate change, and rather by natural causes” are likely to be clear to the public, it may be more difficult for laypeople to grasp the distinction between modeling that assesses severity and modeling that assesses likelihood of a given event.

Last, members of the public interpret information through personal values and sociocultural belief systems. Focus groups and stakeholder workshops would be useful in assessing how news media reports on EEA are interpreted by groups with various interests and political beliefs, as well as to determine whether there is indeed a form of “uncertainty transfer” in EEA reportage. As the field of EEA grows and is more frequently covered in the media, such research will be crucial for informing journalists, scientists, and policy makers alike as to how to be accurate and effective in their communication of complex science.

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