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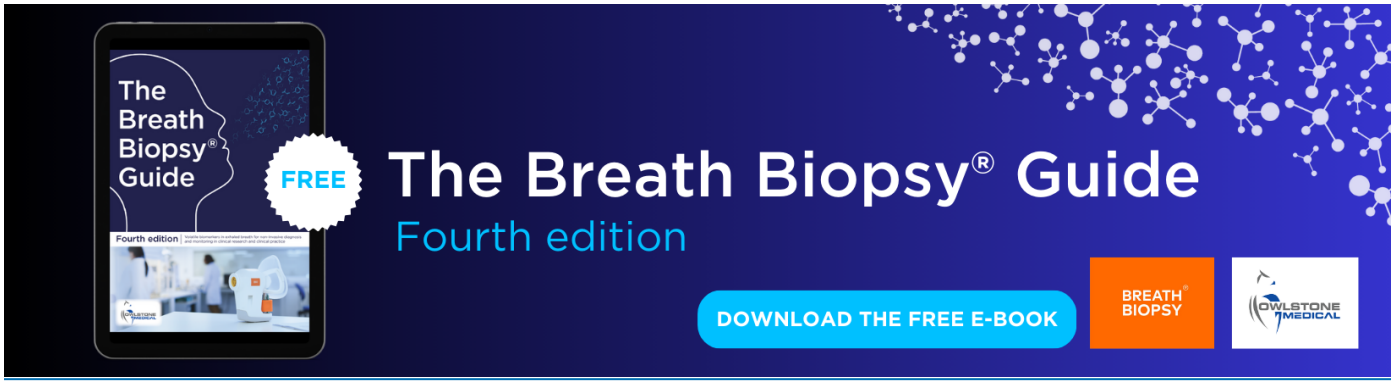

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# Public interest in climate change over the past decade and the effects of the 'climategate' media event

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**Abstract**

Despite overwhelming scientific consensus concerning anthropogenic climate change, many in the non-expert public perceive climate change as debated and contentious. There is concern that two recent high-profile media events—the hacking of the University of East Anglia emails and the Himalayan glacier melt rate presented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change—may have altered public opinion of climate change. While survey data is valuable for tracking public perception and opinion over time, including in response to climate-related media events, emerging methods that facilitate rapid assessment of spatial and temporal patterns in public interest and opinion could be exceptionally valuable for understanding and responding to these events' effects. We use a novel, freely-available dataset of worldwide web search term volumes to assess temporal patterns of interest in climate change over the past ten years, with a particular focus on looking at indicators of climate change skepticism around the high-profile media events. We find that both around the world and in the US, the public searches for the issue as 'global warming,' rather than 'climate change,' and that search volumes have been declining since a 2007 peak. We observe high, but transient spikes of search terms indicating skepticism around the two media events, but find no evidence of effects lasting more than a few months. Our results indicate that while such media events are visible in the short-term, they have little effect on salience of skeptical climate search terms on longer time-scales.

S Online supplementary data available from stacks.iop.org/ERL/9/054005/mmedia

Keywords: new media, focusing events, global warming, media coverage, science communication, search engines

## 1. Introduction

Scientific consensus that human emissions of greenhouse gases are the dominant driver of recently observed climate change has strengthened considerably over the past two decades. The 2013 Summary for Policymakers of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) finds that it is 'extremely likely' (>95% chance) that anthropogenic greenhouse gases are responsible for most of the recent warming of the Earth's surface (IPCC 2013). Studies quantifying the consensus among scientists also find strong agreement with statements in the IPCC, often at 95–98% agreement (Oreskes 2004, Anderegg *et al* 2010, Cook *et al* 2013). Despite the overwhelming consensus among experts, substantial segments of the public remain skeptical of climate change (i.e. are not in concordance with

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the scientific consensus regarding trends, attribution, and/or impacts; (Hobson and Niemeyer 2013)) and political polarization of opinions on climate change has increased over the past decade (Dunlap and McCright 2008, McCright and Dunlap 2011b; Whitmarsh 2011).

Media coverage can have a strong influence both on setting the topics that the public considers and on public opinion itself (Soroka 2003, Hahn *et al* 2009, Brulle *et al* 2012). A media focus on contrarian viewpoints can reinforce and increase interest in the public's skepticism of climate change (Boykoff 2011, Feldman *et al* 2012). Thus, recent, high-profile media events such as the release of emails hacked from the Climate Research Unit at the University of East Anglia (colloquially known as 'climategate') in November 2009 and the discovery of an error in projections of Himalayan glacier melt date in the IPCC Working Group II Fourth Assessment Report in January 2010, may have severely damaged public opinion of climate science (Cicerone 2010, Cogley *et al* 2010). Numerous subsequent inquiries cleared the scientists impugned in the email hacking and the IPCC acknowledged that the melt date was an error (Powell 2011). Nevertheless, media coverage of these two focusing events was quite intense and the long-term impact on opinion of climate change, although often alleged to be severe (Curry 2010), remains unclear (Maibach *et al* 2012).

A broad array of survey data has quantified public opinion, interest, and skepticism of anthropogenic climate change over time (Krosnick *et al* 2000, Nisbet and Myers 2007, Leiserowitz 2010, McCright and Dunlap 2011a, Whitmarsh 2011). Such polling data can provide powerful insight into trends in interest and opinion, as well as the mechanisms driving these trends. However, proper collection of polling data is complex, time-intensive and costly (Weisberg *et al* 1996). An emerging tool, exploiting the availability of data on patterns of worldwide search term volumes, has the potential to complement survey data by providing rapid, low-cost, and spatiotemporally explicit assessments of public interest and opinion of climate change and climate-related media events (Brossard and Scheufele 2013, Proulx *et al* 2013); however, it remains largely unexplored.

We draw upon this novel tool, specifically the freely available data on worldwide web search volumes provided by Google Trends, to examine temporal patterns in public interest in climate change and an indicator of skepticism of climate change, including the effects of these two media events. Google Trends is one of the few open sources of high resolution search query data and Google accounts for >80% of global search engine use (Net Market Share 2013). Increasingly utilized for applications in public health (Ginsberg *et al* 2009), political science (Koehler-Derrick 2013), and economics (Goel *et al* 2010), Google Trends is considered a robust and valid indicator for tracking interest, attention, and public opinion over time (Ortiz *et al* 2011, Reilly *et al* 2012, Zhu *et al* 2012, Mellon 2013b) and has previously been used to quantify trends in public interest in environmental key words (McCallum and Bury 2013, Proulx *et al* 2013). Importantly, Google Trends data have been validated for the term 'global warming' relative to independent longitudinal polling data (Mellon 2013a). Specifically, we ask: (1) What language does the public use when searching for information about climate change? (2) How has public attention to climate change varied over the last decade? (3) Are there lasting effects of media events such as climategate or the glacier error on indicators of public skepticism of climate change? Addressing these questions can improve the efficacy of climate change communication by providing insights into how media events and ongoing narratives are recognized and perceived by the public both in real time and in retrospect.

## 2. Methods

### 2.1. Approach

We queried specific search terms on Google Trends (www.google.com/trends) for all available data between 2004 and the present. Queries were first conducted worldwide, then repeated for the US alone and were primarily focused on English language terms. Data availability varied based on the interest in a search term at a given spatial and temporal scale. The output is returned in the form of a relative search interest, whereby the database computes the number of searches carried out for the specific search term in a given day, week, or month relative to the total number of searches over the specified time period (Choi and Varian 2012). Multiple search terms can be queried simultaneously and the relative search interests (hereafter: relative search volume) for all terms are provided relative to the term with the highest total number of searches, allowing comparison of relative interest among different terms. Specific search terms were queried without quote marks and therefore results include all searches irrespective of word order (e.g. 'global warming' includes 'global warming' and 'warming global'). Preliminary analyses confirmed that quotation marks result in negligible differences for the terms used. Search terms are also inclusive of other words (e.g. 'global warming' includes searches for 'global warming' and 'global warming hoax'); we correct for and note this possibility where necessary. Queries were exported as CSV files from Google Trends between 1–31 October 2013. Detailed explanations of the data query, normalization, and scaling methods are provided at: https://support.google.com/trends/.

### 2.2. Validation

To ensure that the specific search terms we used accurately reflected our questions, we adopted the approach developed by Mellon (2013b) for validating Google Trends data, whereby we ensured (1) that the search terms used were indicative of the issue of interest, (2) that the content returned by the search term was consistent with the issue of interest, and (3) that the search terms employed correlated to an existing measure of the issue of interest. For steps 1 and 2, we began with terms used in published studies (Mellon 2013b, Proulx *et al* 2013) and then ran many

permutations of search terms for each research question and selected the search term that both returned content consistent with the issue of interest (e.g. public interest in climate change, climategate, or an indicator of public skepticism of climate change) and had the highest relative search volume among the given permutations (see section 3). For step 3, we use the validation against longitudinal survey data provided by Mellon (2013b).

### 2.3. Temporal interest in climate change

To evaluate temporal trends in public interest of climate change, we examined the relative search volume of 'global warming' and 'climate change' searches from 1 January 2004 to present both globally and in the US. To quantify trends in relative search volume, we accounted for temporal autocorrelation by applying a seasonal trend decomposition procedure to monthly means of each time series in order to estimate the trend, the seasonal effect, and any remaining error contributing to the observed data (Cleveland *et al* 1990). Prior to applying the decomposition, data were log-transformed to account for changes in variance structure over time. We then summed the trend and random components determined by the decomposition procedure and performed ordinary least squares (OLS) regression. As the random component still possessed small, but at times significant autocorrelation, we also performed generalized least squares regression using maximum likelihood estimation and an explicit correlation structure based on either a first or second order ARMA model (Cowpertwait and Metcalfe 2009). The results were always qualitatively similar and we present only the OLS models.

### 2.4. Temporal interest in focusing events

To evaluate the length of the climategate media event, we calculated the half-life of searches for 'climategate' using data at a daily resolution (1 November–31 December 2009) by fitting a nonlinear regression with an exponential function (exponential decline) starting with the date of highest search interest. To evaluate whether persistent effects of climategate and/or the Himalayan glacier melt rate error were observed after the initial, transient interest spike, we calculated the mean relative search volume for 'global warming hoax,' which was determined to be a reasonable indicator of public skepticism (see section 3), for one year before (9 November 2008–9 November 2009) and one year after (7 March 2010–7 March 2011) the media events. We did this for both search volumes of 'global warming hoax' (GWhx), as well as normalization through the division of 'global warming hoax' by 'global warming' volumes (GWhx-n) to account for any potential of the negative trend in total public interest driving this difference. In normalizing by 'global warming' search volumes, we explicitly subtracted out the search volumes of global warming hoax (syntax: 'global warming'—'global warming hoax'). To account for temporal autocorrelation, we thinned the data by factors of 3–9. Because data were non-normal, we then performed non-parametric Wilcoxon signed rank tests on the relative search volumes during one year before and after the media events. While this method results in loss of data, it provides an exceptionally conservative test as to whether the relative search volume for global warming hoax in the period after the media events was higher than before the media event. Finally, to further evaluate patterns in relative search volumes of 'global warming hoax,' we determined the relationship between average search volumes at the level of the state within the US and the state-level Cook Partisan Voting Index, which is based on the extent of Republican (higher values) versus Democratic (lower values) voting in the 2008 and 2012 presidential elections (The Cook Political Report 2012).

## 3. Results

### 3.1. Search terms

While both search terms return content relevant to climate change, relative search volume for 'global warming' far exceeds that of 'climate change' both across the globe (figure 1(A)) and in the US alone (figure 1(B)), although this difference has narrowed over time. Ten-year global average volume was 32% (of the maximum weekly volume that occurred over the period) for 'global warming' and 12% for 'climate change,' but the most recent two year averages were 16% and 10%, respectively.

Relative search volume for 'climategate' demonstrated the strongest temporal concordance with the release of emails hacked from the Climate Research Unit at University of East Anglia, returned results relevant to the event, and had the highest relative search volume when compared to terms including 'global warming scandal,' 'global warming emails,' 'CRU emails,' and 'global warming conspiracy.' Directly related search terms included 'climategate emails,' 'climategate scandal,' 'climategate wiki,' 'climategate news,' and 'gore climategate.' The search term 'climate gate' demonstrated a smaller relative search volume; however, the temporal pattern of interest mirrored that of 'climategate.'

Relative search volume for the term 'Himalayan glaciers' demonstrated the strongest temporal concordance with the discovery of an error in the Himalayan glacier melt date in the IPCC Working Group II Fourth Assessment Report, returned results relevant to the event, and had the highest relative search volume when compared to terms including 'glaciergate,' 'glaciers growing,' 'IPCC glaciers' and 'Himalayan IPCC.' Although the search term 'Himalayan glaciers' could imply interest in a number of different topics, the highest relative search volume in the immediate period surrounding the discovery of the error far exceeds the interest at any other time between 2004 and present.

Finally, the term 'global warming hoax' demonstrated the strongest temporal concordance with the two events, returned content broadly relevant to climate change skepticism, and had the highest relative search volume when compared to terms including 'global warming myth,' 'global

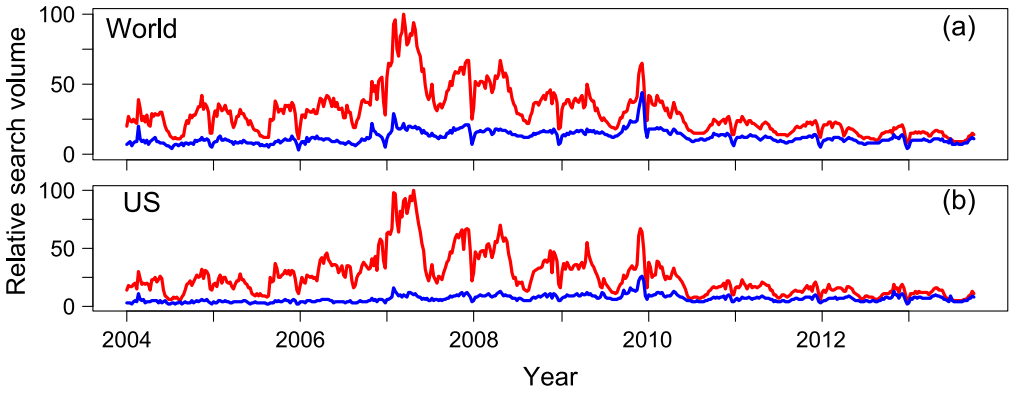


**Figure 1.** Relative interest in the search terms 'global warming' as indicated by the red line and 'climate change' as indicated by the blue line for (a) the world and (b) the US alone.

warming fake,' 'global warming debate,' 'global warming conspiracy,' and 'global warming alarmism.' While not a direct or perfect metric of climate change skepticism *per se* (Poortinga *et al* 2011, Hobson and Niemeyer 2013), the temporal patterns of interest in 'global warming hoax' relative these media events, the content returned by the search term, and the linguistic connotations of the search term (widely recognized as a framing presented in the communities and discourse of climate change skepticism; (Hoffman 2011, Hobson and Niemeyer 2013, Lewandowsky *et al* 2013)), indicates that it was nonetheless a reasonable indicator of skepticism.

### 3.2. Temporal interest in climate change

Public attention to global warming, as measured by relativized search volumes, has been declining since 2007 both globally and in the US (figure 1). We observe a long-term decline in search volumes both globally and in the US since January 2007 ($r^2 > 0.92$, $p < 0.001$; figure S1). Current global relative search volumes (January 2012–September 2013: 16%) are significantly lower than historic volumes (January 2004–September 2005: 24%), even considering growth in internet usage ($p = 0.006$). This 2007–2013 decline also occurs for the search term 'climate change' ($r^2 > 0.28$, $p < 0.001$) and is not compensated for by use of more specific search terms (table S1). For the decomposed trends in 'climate change,' the increase in relative search volume coinciding with the period around the focusing events resulted in outlying values; however, there was still a significant negative relationship both around the world and in the US alone. Furthermore, declines in 'global warming' and 'climate change' search terms also occur in Mandarin ('全球变暖' and '氣候變化') and Spanish ('El calentamiento global' and 'El cambio climático'), the second and third most common languages on the internet after English. We observed similar patterns of post-2007 decline, and higher volume for 'global warming,' indicating our primary findings are robust across other top languages (data not shown), although assessment of Mandarin is complicated by censorship issues in mainland China.

### 3.3. Temporal interest in focusing events

We found short, transient spikes in relative search volumes for 'climategate' and 'Himalayan glaciers' following each focusing event (figures 2(A), (C)). These spikes were short-lived. The observed half-life of 'climategate' was six days and returned to 10% of the maximum search volume within 22 days ($r^2 = 0.96$, $p < 0.0001$; figure S2). Immediately following the breaking of the story, the countries with the highest relative search volume for 'climategate' were Australia, Canada and the United States, while the cities were Toronto and London. Long-term patterns indicate that Washington, DC is the city with the highest relative search volume for climategate. Similar, high-resolution data for 'Himalayan glaciers' was unavailable.

We then used the search term 'global warming hoax' to provide additional context to the climategate and glacier melt rate events. Sufficient and sustained search volumes for 'global warming hoax' did not appear until September 2005. Global, English-language search patterns reveal the highest relative search volumes in the USA, Canada, and Australia. When normalized by overall searches of 'global warming' to account for declining search volumes, the mean volume for 'global warming hoax' was lower during the year following these events (23% relative search volume) than the year preceding them (28%) ($p = 0.15$), which was also true for non-normalized search volumes ($p = 0.03$) (figures 2(B),(D); table S1). During the peak of the events, relative search volumes for 'climategate' and 'global warming hoax' were substantial, but still lower than that of 'global warming' (42% and 14%, respectively; figure 2(E)). The results indicate that, if anything, the period after the events was likely to be significantly lower than the period before. Finally, the long-term average relative search volume for 'global warming hoax' significantly increased as a function of increasing preference for the Republican Party as measured by the Cook Political Index (OLS regression, $r^2 = 0.14$, $p = 0.03$; figure 3).

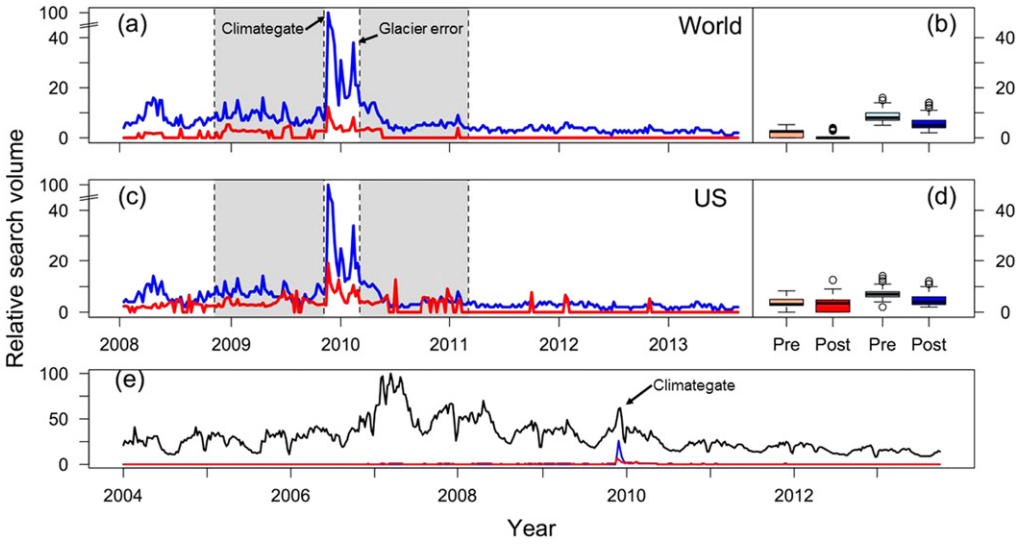


**Figure 2.** Relative search volume of the search term 'global warming hoax' as indicated by the blue line and 'global warming hoax' as a percent of the total searches for the term 'global warming' as indicated by the red line for (a) the world and (c) the US alone. Accompanying boxplots ((b), (d)) indicate means for one year before and one year after the period encompassing the two events (15 November 2009 to 15 March 2010) for searches of 'global warming hoax' and 'global warming hoax' as a percent of the total searches for the term 'global warming.' Relative search volume of the search term (e) 'global warming' in black, 'global warming hoax' in blue, and 'climategate' in red. Arrows indicate event timing.

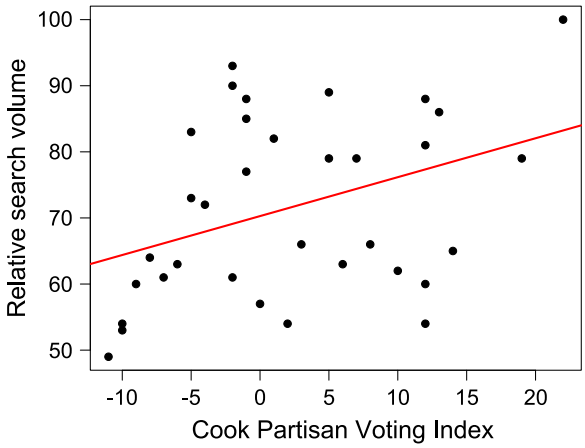


**Figure 3.** Relative interest in the search term 'global warming hoax' among 34 different states in the US for which there was sufficient data, represented as a function of the Cook Partisan Voting Index, which is based on the extent of Republican (higher values) versus Democratic (lower values) voting in the 2008 and 2012 presidential elections (The Cook Political Report 2012).

## 4. Discussion

### *4.1. Temporal patterns in climate change interest and focusing events*

Drawing upon an extensive global dataset of search term volumes from 2004–2013, we find that the public primarily conceives of and thinks about climate change in terms of 'global warming' rather than 'climate change,' but this difference is falling. This could indicate the effectiveness of a concerted effort to focus communication on the more technically-accurate term of 'climate change' (Schuldt *et al* 2011, Villar and Krosnick 2011), or that declines in searches for 'global warming' were more rapid than declines in 'climate change.' The search term 'global warming' is broadly inclusive, has much higher relative usage than other climate-related search terms, and shows temporal concordance with other search terms (e.g. 'climate change' and 'greenhouse gases'). It is notable that, as with other scientific key words, 'global warming' exhibits strong intra-annual periodicity with low values over the Northern hemisphere summer and during a few weeks around winter holidays, which suggests it is likely due to school calendars rather than weather seasonality (McCallum and Bury 2013). Our results have particular implications for climate change communication efforts and message framing. For instance, web-based, climate education resources are likely to receive more visits by explicitly considering the terms for which the public is searching (i.e. search engine optimization) rather than considering the terms most apparent to the scientific community.

Search volumes for 'global warming' and 'climate change,' serving as a proxy for general interest, have declined since a peak in 2007 across the top three languages on the internet. A substantial increase in 'global warming' search volume began in August 2006, coincident with the rising popularity of the documentary 'An Inconvenient Truth' by Al Gore and the start of the school year in the US, and continued through April 2007 following the release of the IPCC Fourth Assessment Report (figure 1). Interestingly, Hurricane Katrina and Hurricane Sandy do not appear as major events in US search volumes of climate terms, despite hurricanes receiving considerable media attention in this context (Sherman-Morris *et al* 2011). We find no evidence that these declines are compensated for by an increase in relative search volumes for more specific search terms (table 1). Moreover, there is no strong evidence of a bias in internet use based on

**Table 1.** Relative search volume (% of maximum weekly value of the highest volume term mean ± standard deviation) of search terms for the globe, averaged over 1 January 2004–21 October 2013.

| Search term | Relative search volume (2004–2013) | Relative search volume (2004–2007) | Relative search volume (2010–2013) |
|---|---|---|---|
| Global warming | 29.7 ± 16.3 | 36.1 ± 18.9 | 18.8 ± 6.84 |
| Climate change | 12.01 ± 4.54 | 10.9 ± 4.35 | 11.0 ± 2.82 |
| Greenhouse gases | 1.52 ± 0.57 | 1.67 ± 0.61 | 1.28 ± 0.48 |
| Sea level rise | 0.45 ± 0.5 | 0.44 ± 0.51 | 0.39 ± 0.5 |
| Ocean acidification | 0 ± 0 | 0 ± 0 | 0 ± 0 |
| Carbon sequestration | 0.24 ± 0.43 | 0.42 ± 0.5 | 0.01 ± 0.1 |

gender, education, family income or age, although individuals ⩽18 or ⩾65 years of age are less likely to use the web (National Science Board 2012). Thus, declining trends in searches of 'global warming' are unlikely to be driven by changing demographics of internet users, but instead reflect declining search interest. Our results are in concordance with research on newspaper coverage of climate change or global warming indicating a similar pattern of decline since 2007 (Boykoff and Mansfield 2010). The observed decline in public attention revealed may pose a problem for motivation to enact climate policy.

'Global warming hoax,' the search term used to indicate the potential for skepticism, accurately detected the spike in attention around the two focusing media events and despite considerable, short-term spikes of interest, we find no evidence for long-term effects on search volumes of terms indicating skepticism. Thus, climategate and the glacier melt rate events had little to no long-term effect on salience of skeptical terms, although this does not provide insight into changes in opinion that might have occurred. At the same time, relative search volumes for 'global warming hoax' also revealed underlying social and spatial patterns in climate science skepticism. Relative search volumes were highest in countries with the most active climate change denial movements (Dunlap and Jacques 2013), as well as in conservative-leaning US states. Political leaning is often strongly indicative of trust in climate science in the United States (Dunlap and McCright 2008, Kahan *et al* 2012). Longitudinal polling data quantifying the trust in climate scientists further corroborate our findings, with a detectable, short-term impact of climategate, but primarily within the conservative sector of society already predisposed to skepticism (Maibach *et al* 2012, Leiserowitz *et al* 2013) and with little or no long-term change (Krosnick and MacInnis in review).

### *4.2. Search engine data for rapid assessment of public interest in climate events*

The worldwide web has now become the predominant means by which people search for scientific information in the US and usage is growing rapidly around the world (Horrigan 2006). The percent of people in the US using the worldwide web as their primary information source for specific scientific issues has increased from ~52% to ~58% between 2004 and 2010 (National Science Board 2012). Search engine queries are widely considered to be a metric of individual or population level of interest, motivation, or curiosity in a topic, as expressed through the act of seeking information (Guo *et al* 2010, Baram-Tsabari and Segev 2013, Brossard and Scheufele 2013, Mellon 2013a). For instance, searches for 'global warming' correlate strongly with news coverage around the world (Baram-Tsabari and Segev 2013) and more critically, have a significant temporal relationship with survey data in the UK (Mellon 2013b). Relative search volume does not serve as a measure of belief, as both proponents and opponents of an issue can search for information. However, an individual's existing viewpoint on a scientific issue can significantly influence the type, framing, and linguistic choices in search terms of information they seek (Xenos *et al* 2011).

Google Trends can provide a meaningful and quantitative metric of public interest, while avoiding some of the biases and pitfalls of more traditional methods (Koehler-Derrick 2013, Mellon 2013b). However, recent criticisms of Google search methods to examine flu patterns highlight that algorithm transparency and careful validation with traditional data need to be better presented and utilized when using search volume data (Lazer *et al* 2014). As in public health efforts to monitor flu and disease spread, analyses with Google Trends could enable near real-time monitoring of key climate change communication efforts (Ginsberg *et al* 2009). For example, we found much lower interest and also a dampened peak in interest in the September 2013 release of the IPCC Fifth Assessment Report Working Group I Summary for Policymakers compared to the Fourth Assessment Report (figure S3). Analyses such as these can provide valuable quantitative, timely, and low-cost feedback for climate change communication efforts, serving a crucial function in the rapidly evolving new media landscape (Brossard and Scheufele 2013).

### *4.3. Conclusions*

We document here a strong decline in public attention to climate change since 2007. We find a detectable signal of media events such as climategate, but their effect seems to be minimal beyond the news cycle and skeptical search terms' salience quickly reverted to lower levels than before the events, although further polling data will be necessary to quantify any long-term effects on public trust in climate

scientists. These findings comport closely with a rich history of multidisciplinary scholarship on media effects and highlight the challenge of engaging the non-expert public on slow-moving issues such as climate change through media coverage of unique events. Tools such as Google Trends can be of great value in guiding the language, location and timing of climate change communication and education efforts.

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