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Seepage: Climate change denial and its effect on the scientific community

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ABSTRACT

Vested interests and political agents have long opposed political or regulatory action in response to climate change by appealing to scientific uncertainty. Here we examine the effect of such contrarian talking points on the scientific community itself. We show that although scientists are trained in dealing with uncertainty, there are several psychological reasons why scientists may nevertheless be susceptible to uncertainty-based argumentation, even when scientists recognize those arguments as false and are actively rebutting them. Specifically, we show that prolonged stereotype threat, pluralistic ignorance, and a form of projection (the third-person effect) may cause scientists to take positions that they would be less likely to take in the absence of outspoken public opposition. We illustrate the consequences of seepage from public debate into the scientific process with a case study involving the interpretation of temperature trends from the last 15 years. We offer ways in which the scientific community can detect and avoid such inadvertent seepage.

1. Introduction

Opponents of the scientific consensus on climate change—defined here broadly as the agreement that (a) the Earth is warming and (b) most of that warming has been due to human greenhouse gas emissions (Anderegg et al., 2010; Doran and Zimmerman, 2009; Oreskes, 2004)—have often emphasized scientific uncertainty in order to forestall mitigative action (e.g., Kim, 2011; Freudenburg et al., 2008; Nisbet, 2009). Those arguments often exaggerate, for political or ideological reasons, the actual degree of uncertainty in the scientific community or imply that uncertainty justifies inaction (e.g., Hoggan and Littlemore, 2009; Jacques et al., 2008; McCright and Dunlap, 2003, 2010; Mooney, 2007; Oreskes and Conway, 2010; Stocking and Holstein, 2009). Appeals to uncertainty are so pervasive in political and lobbying circles that they have attracted scholarly attention under the name "Scientific Certainty Argumentation Methods", or "SCAM" for short (Freudenburg et al., 2008). SCAMs are widespread and arguably have postponed regulatory action on many environmental problems, including climate change (Freudenburg et al., 2008).

In this article, we argue that the appeal to uncertainty in public discourse, together with other contrarian talking points, has "seeped" back into the relevant scientific community. We suggest that in response to constant, and sometimes toxic, public challenges, scientists have over-emphasized scientific uncertainty, and have inadvertently allowed contrarian claims to affect how they themselves speak, and perhaps even think, about their own research. We show that even when scientists are *rebutting* contrarian talking points, they often do so within a framing and within a linguistic landscape created by denial, and often in a manner that reinforces the contrarian claim. This "seepage" has arguably contributed to a widespread tendency to understate the severity of the climate problem (e.g., Brysse et al., 2013; Freudenburg and Muselli, 2010).

We first review known reasons why such seepage may occur; we then present a case study to argue that it has occurred and that

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contrarian talking points have unduly influenced scientific discourse; and we then point to ways in which such seepage may be avoided in future.

2. The psychological allure of uncertainty

There are several known psychological factors that can explain why SCAMs can be an effective tool in public debate to delay policy action. Perhaps the most inhibiting type of uncertainty arises from conflicts or apparent disagreements among scientists. Smithson (1999) demonstrated that conflicting estimates from experts generate more severe doubts in participants' minds than agreed but imprecise estimates. Conflicting estimates also tend to decrease trust in the experts. Cabantous (2007) replicated these findings with a sample of insurers, who assigned higher premiums to risks for which the risk information was conflicting than to risks where that information was consensual but uncertain (see also Cabantous et al., 2011). Any appearance of expert disagreement in public debate is therefore likely to undermine people's perception of the underlying science, even if an issue is considered consensual within the scientific community.

Relatedly, people prefer to bet on known rather than unknown probabilities, even if the expected outcome is mathematically identical, a preference known as ambiguity aversion (Ellsberg, 1961; Fox and Tversky, 1995). In the context of climate change, political decisions inevitably involve options with uncertain outcomes. The "doing something about climate change" options appear laden with unknown probabilities ("what will happen to the economy?"), whereas the "business as usual" (BAU) option gives the appearance of being associated with a known outcome ("won't things just stay the same?"). Ambiguity aversion leads us to avoid taking action—we prefer to take a gamble on what we "know" (i.e., "life seems fine now") rather than on what we do not know ("the Earth might warm by 5 °C or it might warm only 1 °C").

Ambiguity aversion is amplified by two further processes: first, uncertainty breeds wishful thinking (Markowitz and Shariff, 2012), reinforcing the possibility that the Earth will warm by 1 °C rather than 5 °C. Second, people generally have a strong preference for the current state of affairs over change, a tendency known as the status quo bias (e.g., Eidelman and Crandall, 2012; Gal, 2006; Roca and Maule, 2009). The status quo bias arises from a pure preference for the current state of affairs (Samuelson and Zeckhauser, 1988) as well as a preference to do nothing (i.e., an "omission bias"; Ritov and Baron, 1992). This inertia, along with the well-documented tendency to discount future losses so they seem less pertinent than immediate costs (e.g., Hardisty and Weber, 2009), further mutes people's appetite for action. At a political level, the relative difficulty of "making something happen" over "leaving things as they are" was illustrated by McKay (2012), who showed that it takes 3.5 times as many lobbyists to make something happen in the U.S. Congress (positive lobbying) than to keep it from happening (negative lobbying).

In sum, uncertainty is effective as a strategy to delay action because it resonates with human tendencies towards preference for preservation of the status quo. Uncertainty arising out of perceived expert disagreement is particularly effective at generating public doubt about an issue.

3. From public inertia to the scientific landscape of reticence

Scientists might think that they are not susceptible to such common errors of reasoning, especially given that the scientific community has developed various regimes of dealing with uncertainty, including quantifying it (e.g., Henrion and Fischhoff, 1986) and providing guidelines for how best to communicate it (Budescu et al., 2011; Intergovernmental Panel on Climate Change, 2005). In contrast to this belief, evidence suggests that the public's asymmetrical response to uncertainty parallels a similar asymmetry within the scientific community. Risbey (2008) identified an asymmetry with which scientific warnings about climate change are evaluated within the science community: descriptions of impacts in serious terms are often dismissed as "value laden," whereas equally subjective language describing impacts as mild is not considered value laden but is accepted without challenge. Hansen (2007) made a similar point about general scientific "reticence"; that is, the undue downplaying of dangers when the reality is (or at least may be) more alarming.

At a coarse level of analysis, the results of undue conservatism and reticence were reflected in the fourth assessment report of the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2007), which has subsequently been shown to have been unduly conservative rather than adventurous. Freudenburg and Muselli (2010) showed that the vast majority of scientific findings that were reported in the media subsequent to the IPCC's 2007 report revealed the climate to change *faster* than predicted. The *Copenhagen Diagnosis*, by a group of leading climate scientists, came to a similar conclusion (Allison et al., 2009).

These analyses have been echoed by several meta-analyses of ecological data: for example, many terrestrial organisms are moving to higher latitudes and higher elevations at greater speeds than previously assumed (Chen et al., 2011), and empirical observations of the risk of extinction are often outpacing predictions (Maclean and Wilson, 2011). Likewise, Brysse et al. (2013) provided detailed evidence of systematic under-predictions of key attributes of global warming by scientists, including Arctic ice depletion and the possible disintegration of the West Antarctic ice sheet. Brysse et al. (2013) referred to this tendency as "erring on the side of least drama." The authors attribute this tendency to the internal norms of scientific research, which, valorizing dispassion and restraint, lead scientists to tend to downplay dramatic, alarming, or upsetting results.

This broad background of reticence and under-prediction provides the departure point for our present investigation, which has two principal aims: the first aim is to survey the known psychological mechanisms by which scientists might be affected by contrarian public discourse. There is considerable scholarly agreement that any research related to climate change is subject to organized denial (e.g., Hoggan and Littlemore, 2009; Jacques et al., 2008; McCright and Dunlap, 2003, 2010; Mooney, 2007; Oreskes and Conway, 2010; Stocking and Holstein, 2009), and there is strong evidence that this denial has affected public discourse (Boykoff and Boykoff, 2004; Boykoff, 2013), with attendant distortions of the public's perception of the prevailing opinions in society (Leviston et al., 2013) and among scientists (Ding et al., 2011; Lewandowsky et al., 2013). Given that science operates in a societal context, there are strong a priori grounds to assume that relentless denial may find some degree of reflection in the scientific community. We refer to this potential phenomenon as "seepage"—defined as the infiltration and influence of what are essentially non-scientific claims into scientific work and discourse. Our second aim is to present specific instances of such seepage on scientific thinking. We focus on one suggestive case and argue that it has been to the public's detriment because of the reinforcement and amplification of the prevailing tendency of scientists towards reticence and erring on the side of least drama.

4. The social processes underlying seepage

In theory, scientists evaluate evidence by the internal norms of their expert communities. How citizens feel about matters such as evolution or climate change should, ideally, be irrelevant to how scientists judge the evidence regarding those matters. Given this, how could scientific work be subject to seepage?

Although the expertise of climatologists provides an ample reservoir for the refutation of overt falsehoods—such as the long-debunked "zombie arguments" that are levelled at climate science (Weart, 2011)—the complex and nuanced nature of climate science, the prominent role of uncertainty, and its inter-disciplinary aspects, offer the door to more subtle routes of influence. Many scholars have argued that it is impossible to present or discuss the science without some kind of context or frame (e.g., Spence and Pidgeon, 2010), and that all science reflects, at least to some degree, the values of the scientists who develop it (Ezrahi, 1990; Holton, 1973).

Frames are rhetorical and communicative structures that select and highlight certain aspects of a perceived reality over others in order to promote one particular viewpoint (Dirikx and Gelders, 2010). Because frames are rarely made explicit—for example, few people know that the use of the term "climate change" rather than "global warming" was advocated by Republican strategist Frank Luntz because its connotation was less frightening (Lakoff, 2010; Mooney, 2005)—they shape in a "hidden" manner the way in which people conceptualize and discuss an issue (de Boer et al., 2010).

Nevertheless, scientists strive to work in a manner that emphasizes factual information and de-emphasizes value judgements. Moreover, climate scientists might argue that their values predispose them to be concerned about climate change—and that this would insulate them from the effect of contrarian discourse. Still, scientists live in a world in which contrarian claims in the media and other public arenas abound. Scientists are exposed to those claims and framings just like everyone else. But unlike others, they may feel the need to respond to these claims. This may occur informally, as when friends, neighbours, or family members ask questions motivated by claims they may have encountered in the media or on the internet, or formally, when scientists speak to journalists or appear in public venues. These encounters may involve what we could call "honest" skeptical questions, such as "How do we know global warming isn't caused by the sun?" or "What about volcanoes?" or "What about the 'pause' in warming"—that is to say, questions that are honestly motivated, but are already framed in contrarian terms, because that is how people have heard of them. In attempting to answer "honest" questions, climate scientists may inadvertently accept the biasing terms in which those questions are framed. For example, short-term fluctuations in global surface air temperatures that give rise to the contrarian claim that "global warming has stopped" (Carter, 2006) may attract undue attention when scientists seek to explain such fluctuations by at least tacitly accepting them as a to-be-explained global-warming "signal" rather than as statistically insignificant noise superimposed on the long-term signal (Risbey, 2015).

In addition, scientists are not immune to hostility or pressure from the public and politicians. For example, Farnsworth and Lichter (2012) conducted a survey of nearly 500 climate experts that offered some insight into the results of such extra-scientific pressures. Farnsworth and Lichter (2012) found that "... perceived pressure to alter one's views had an independent effect on assessments of global warming. Scientists who said they had been pressured to downplay the results of global warming in public rated the likely effects of global warming as slightly less severe than did other scientists" (pp. 98–99). Although this result was confined to a small (5%) subset of their sample, in the present context it serves to highlight the possibility that climate scientists are not immune to external pressures.

5. The cognitive processes underlying seepage

There are a number of well-understood cognitive processes that can give rise to seepage. Here we focus on three such processes that we consider to be particularly relevant. First, the barrage of public criticisms and vitriol levelled against the climate science community is likely to have threatened their self-image: the large literature on *stereotype threat* points to numerous adverse consequences of such exposure, including several that may affect scientific practice. Second, the literature on *pluralistic ignorance* suggests that scientists may underestimate the support for their own opinions, increasing the likelihood that those opinions may be abandoned or softened. Third, there is ample evidence that people are affected by persuasive messages, including those that they explicitly dismiss. This phenomenon is known as the *third-person effect* and it implies that scientists may be inadvertently susceptible to arguments they explicitly know to be false.

We next review the relevant evidence for these processes. (The Appendix briefly presents some known ways in which those factors may be counteracted or resisted.)

5.1. Stereotype threat

The scientific enterprise is guided by norms or principles. Perhaps the most well known and influential analysis of the norms of science was articulated by sociologist Merton (1942), who argued that the results of research should be the common property of the scientific community ("communism"); that knowledge should transcend racial, class, national, or political barriers ("universalism"); that scientists conduct research for the benefit of the scientific enterprise rather than for personal gain ("disinterestedness"); and that scientific claims must be exposed to critical scrutiny before being accepted ("organized skepticism"). Empirical evidence shows that those norms continue to be broadly internalized by the scientific community (Macfarlane and Cheng, 2008). Whether or not Merton's description is precisely correct for any given community of experts, adherence to scholarly norms is clearly important to the self-perception and identity of researchers and scholars. What are the consequences of accusations that those norms have been violated? What are the effects of the virtual public inquisition to which climate science has been subjected (Powell, 2011), and which frequently stigmatizes scientists as "money grabbing", self-interested, or as being mere "pseudo-scientists" in public fora (Koteyko et al., 2013)?

Such accusations and vitriol can have adverse consequences on scientists' performance and opinions via a process known as stereotype threat. Stereotype threat refers to the feelings of anxiety that arise when a person is reminded of an adverse stereotype against a group to which they belong (Steele and Aronson, 1995). The consequences of such stereotype threat can be quite dramatic: for example, if African-American students are informed that a test they are about to take is intended to yield "... an accurate measure of your ability..." Steele and Aronson (1995, p. 803), their test performance is considerably lower than that of African–American participants in a control group who were told to try hard on the same test "even though we are not evaluating your ability ...." (p. 803). The mere mention of an ability test is sufficient to depress performance in a group stereotyped to be lower in academic achievement—in actual fact, performance of African–Americans in the control group was identical to that of Caucasians.

In the present context it is particularly relevant that the effects of stereotype threat are not limited to groups that are stereotyped as performing lower than others. Aronson et al. (1999) showed that among Caucasian males who were selected on the basis of their high math-proficiency ($\geq$610 on SAT), performance on math problems suffered considerably when participants were briefly reminded that "Asian students outperform Caucasian students in mathematical domains" before taking the test. Performance in the stereotype-threat condition was 30% lower than in a control condition that did not receive a stereotype threat, notwithstanding the fact that participants in both conditions were selected on the basis of their high math proficiency.

Stereotype threat can have long-term and lasting effects, when people disidentify from a formerly valued identity. In a longitudinal naturalistic study involving a panel of 1,420 high-achieving students intent on pursuing a PhD and a scientific career, Woodcock et al. (2012) found that chronic stereotype threat (as revealed by repeated surveys) led to disidentification among Hispanic students, and a declining interest in pursuit of a scientific career years later.

In addition to causing possible performance decrements and disidentification from the scientific community, exposure to negative and often aggressive criticism can trigger a number of compensatory responses. Those compensatory processes can span the range from seeking support from one's peers to the opposite—viz. distancing oneself from the peer group and devaluing its importance (Shapiro and Neuberg, 2007). Another known compensatory response to stereotype threat involves the attempt to disidentify from one's own group and engage in counterstereotypic behaviour; for example, African–American subjects become less likely to endorse their true preferences for rap music or basketball under conditions of stereotype threat (Steele and Aronson, 1995).

Applying the process of stereotype threat to climate scientists, consider that, among other things, contrarians (and even some non-contrarian scientific critics) have routinely attempted to stereotype scientists as "alarmists." A predicted response would be for scientists to strive not to appear alarmist by downplaying the actual degree of threat, a pattern that has demonstrably occurred (Brysse et al., 2013; Freudenburg and Muselli, 2010). Similarly, a predicted response to allegations that the science is highly uncertain would be for scientists to exaggerate their concern with uncertainty: we find this supported in the fact that the 2013 annual Fall Meeting of the American Geophysical Union hosted 128 sessions over 5 days that contained the theme "uncertainty" (http://fallmeeting.agu.org/2013/files/2013/11/2013-FMPB_Web_new.pdf), as compared, for example, to only 13 sessions on carbon capture and storage, even though both were highlighted themes for the meeting. Likewise, the IPCC's Fourth Assessment Report (2007) used the word "uncertain" or its derivatives more than 1200 times in the report of Working Group 1 alone—equivalent to around 1.2 times per printed page. By contrast, the word "know" and its derivatives (e.g., "knowledge" or "known") occurred only 256 times.

Another response would be for scientists to "bend over backwards" to appear to be open to contrarian claims, for example by giving unwarranted attention and credence to internet-based arguments or by inviting contrarians to conferences or public events. This accommodation would be a predicted response to contrarian allegations that an "elite" of "corrupt" and "arrogant" climate scientists is "censoring" contrarian voices through "pal review" and is creating a "hoax" (Inhofe, 2012). In this case, an agreement to take contrarian arguments seriously and to debate them would constitute counter-stereotypic behaviour. It would also be compatible with scientists' tendency to solve puzzles, and to engage in dialogue with opposing arguments.

5.2. Pluralistic ignorance and false consensus effect

Studies have repeatedly shown that the vast majority of climate scientists—around 97%—endorse the basic conclusion that the globe is warming from greenhouse gas emissions (Anderegg et al., 2010; Cook et al., 2013; Doran and Zimmerman, 2009; Oreskes, 2004). Yet this high level of consensus fails to be perceived by the public at large (Ding et al., 2011; Dunlap and McCright, 2008; Lewandowsky et al., 2013). This is not surprising, given the prevalence of contrarian challenges, but what is surprising, at least at first glance, is that climate scientists may also *under*-estimate the consensus among their colleagues on a number of important questions (http://results.visionprize.com/). For example, although most of the scientists surveyed deemed it likely or very likely that global sea level rise would outpace even the most extreme IPCC projections for the end of the century, they did not expect their peers to share that opinion. The scientists instead presumed that the modal position of their colleagues was indeterminate; that is, that they would deem it as likely that sea level rise would follow IPCC projections as it would be to exceed them.

On further reflection, however, this misperception of peer-opinion may not be altogether surprising given that scientists are trained to think in uncommon ways, and are accustomed to possessing views (particularly in their niches of specialization) that may differ—in some respect—from those of their colleagues, let alone from the public at large. Moreover, to obtain funding and publish research, scientists must articulate original positions that, by definition, are at least somewhat different from their colleagues' views. It turns out that this perception (or reality) of holding a "minority" view can render scientists vulnerable to a phenomenon known as pluralistic ignorance, which in turn can have consequences for the conduct of science.

In general, people tend to over-estimate the prevalence of their own opinions (Holmes, 1968). For example, in a classic 1970s study, students who proclaimed support for women's rights believed their position was shared by the majority of their peers in much the same way that students who did not support "women's lib" also thought that the majority was in their corner (Ross et al., 1977). However, distortions of this general tendency can arise when a minority opinion is given disproportionate prominence in public debate and by the media, in which case the *actual* majority of people may think that their opinion is in the minority. This mistaken perception is known as pluralistic ignorance (Shamir and Shamir, 1997; Todorov and Mandisodza, 2004). A recent example involves the American public's perceptions of their own opinions regarding U.S. foreign policy in the aftermath of the terrorist attacks of 9/11: although only a minority of people (around 25%) thought that the proper policy response was for the U.S. to work unilaterally to combat terrorism, rather than in concert with other nations, the people who held this minority view thought that around half the public endorsed their unilateral approach (Todorov and Mandisodza, 2004). Conversely, the overwhelming majority of Americans (around 75%) who preferred a multilateral approach to foreign policy thought that their view was only shared by half the population.

Because people's attitudes are affected by what they perceive to be the prevailing social norm, pluralistic ignorance can have far-reaching implications. In the study by Todorov and Mandisodza (2004), people who incorrectly perceived the unilateral view to be the majority's preference were far more likely to support an invasion of Iraq than respondents who correctly perceived the unilateral view to be in the minority. There is fairly widespread evidence that the extent to which people over-estimate the prevalence of their opinion predicts their intention to engage in attitude-consonant behaviours: for example, the likelihood that someone might smoke marijuana increases with the extent to which the person over-estimates peer-support for the legalization of drugs (Bauman and Geher, 2003). Similarly, there is evidence that people shift their attitudes or behaviours over time in the direction of what they perceive to be the prevailing majority opinion (even if it is not; Botvin et al., 1992; Prentice and Miller, 1993). Thus, a public discourse that asserts that the IPCC has exaggerated the threat of climate change may cause scientists who disagree to think that their views are in the minority, and they may therefore feel inhibited from speaking out in public.

People who over-estimate the prevalence of their attitudes are also more resistant to changing their opinions than people whose perceptions are better calibrated. This was starkly illustrated by Leviston et al. (2013), who polled Australians' attitudes to climate change in two consecutive years (2010 and 2011). Although only a very small proportion of individuals (at most 7.2% across the two surveys) denied that the climate was changing, those individuals thought that nearly half the population shared their minority views—an over-estimate in the order of 40% or more. The more those individuals over-estimated the prevalence of their opinion on the first occasion, the more likely they were to cling to their beliefs when they were surveyed a second time a year later. By contrast, people who held the modal opinion—viz. that the climate was changing due to greenhouse gas emissions—*under*-estimated the actual prevalence of their opinion by up to 10% on both occasions. Moreover, even people who held the modal opinion vastly over-estimated (by up to 23%) popular support for the denialist position.

In summary, it is known that an opinion or attitude that is perceived to be prevalent—irrespective of its actual prevalence—serves as a social norm that promulgates attitude-congruent behaviours, serves as an attractor for growing conformity, and imbues people who hold that opinion with resilience towards attitudinal change.

The evidence that scientists under-estimate the level of concern about key climate issues among their colleagues must therefore give reason for concern. Any under-estimation of consensus among scientists renders them more vulnerable to potential attitude change than they need to be. This vulnerability might be amplified by the further possibility that scientists—like other members of the public (Leviston et al., 2013)—over-estimate the proportion of people who deny that the climate is changing.

We suspect that many scientists might believe that, as scientists, they would not be vulnerable to the effects of perceived consensus, stereotype threat, and pluralistic ignorance just reviewed. However, we counsel against adopting this belief too strongly because, as we show next, another cognitive factor that might enable seepage is the mistaken belief in one's own immunity to persuasive messages.

5.3. Third-person effect

A robust and extensive body of research shows that people generally believe that social manipulations and persuasive communications exert a stronger effect on others than on themselves. This belief is referred to as the third-person effect (for a review, see Perloff, 1993). In most experiments, people read a passage and then estimate the effects that passage is thought to have on the attitude of others as well as on themselves. In the vast majority of cases, people's estimates of the effect on others is greater than their estimates of the effect on themselves. One exception to this pattern involves messages that are judged to be socially desirable (e.g., texts encouraging "safer-sex" practices; Duck et al., 1999). We do not consider those cases of a "reverse third-person effect" here because we doubt that the scientific community would find it desirable to be responsive to the persuasive messages of persons who operate outside the realm of peer review.

When people's actual shifts in attitudes are compared to their predictions, it turns out that people tend to be more affected by persuasive messages than they expect. Two studies are particularly relevant in this context: Douglas and Sutton (2004) presented participants with a persuasive text that purported to show that CO_2 is not a pollutant but the basis of all life and that the effects of climate change would be benign. (For a discussion of how this specific argument was actually used by the fossil fuel industry, see Oreskes, 2010.) Upon reading the passage, participants provided four judgments about opinions relating to climate change: their own current opinions (after reading the persuasive passage; *current self*), their opinions before they had read the passage (*retrospective self*), and the presumed opinions of their peers before (*retrospective other*) and after (*current other*) they read the same passage. People's *self* ratings differed less between *current* and *retrospective* than did their ratings for *other*; this difference represents the standard third-person effect. However, people's *current self* opinions differed from those provided by control participants who received no persuasive message to the same extent as the *current other* differed from *retrospective other*. That is, people's attitude shifted to the same extent that they presumed others to be persuaded, and that shift was far greater than they admitted.

One might argue—and hope—that climate scientists, unlike the undergraduate participants in the study by Douglas and Sutton (2004), would be impervious to fallacious claims about the beneficial effects of increased CO_2. However, another, similar study, which employed a nearly identical design, showed that people are affected even by conspiracy theories (e.g., that Princess Diana was killed by the British Secret Service) that they explicitly dismiss (Douglas and Sutton, 2008). The finding that participants are affected by messages that they explicitly dismissed (i.e., gave low endorsement ratings), suggests that the scientific community may be susceptible to contrarian argumentation even when they know them to be false.

6. Seepage observed: a case study

We argue that seepage has indeed occurred. We postulate two criteria to identify seepage: first, it must be shown that the scientific community has adopted assumptions or language from discourse that originated outside the scientific community or from a small set of dissenting scientific voices. Second, it must be shown that those assumptions depart from those commonly held by the community. That is, at the very least it must be shown that in other circumstances or at a different time the scientific community did not accept the reasoning offered now. This criterion would be fulfilled if scientists are doing and saying things now that are at odds with what they were doing and saying before, but *without* any methodological or empirical argument to justify that change.

Using these criteria, we present evidence of seepage within the current discussion in the scientific literature surrounding the alleged "hiatus" or "pause" in global warming during the past decade or more. We argue that this discussion is taking place within a rhetorical frame that was created by contrarian voices outside the scientific literature and that some of the current discussion is at odds with previously accepted scientific reasoning.

6.1. "Global warming has stopped"

The notion that global warming has stopped or stalled has been a long-standing contrarian claim (e.g., Carter, 2006). In an analysis that is largely consonant with our views, Boykoff (2014) showed in detail how the media and other public actors created a frame for the discussion of climate change that focused on the allegation that global warming—measured by global mean surface temperature (GMST)—had "stalled", "stopped", "paused", "plateaued", or entered a "hiatus."

Although those terms have different meanings—for example, "stopped" implies a complete cessation of warming whereas "stalled" or "paused" can describe a temporary stoppage in an overall pattern of warming that might be presumed to be expected to resume—they have been used nearly interchangeably by contrarians. All those terms carry two important linguistic implications. The first implication is that the period in question somehow differs notably from other similar periods in the past—in other words, that the "pause" or "hiatus" is more than a routine short-term fluctuation or deviation from a long-term trend. The second implication is that the physical processes governing global warming have ceased to operate or are somehow operating differently, that scientists have failed to adequately understand the climate system, or that the climate problem is less significant than previously supposed.

6.1.1. The scientific literature and the "pause"

This contrarian linguistic frame has found growing traction in the peer-reviewed literature, culminating with two 2014 special issues/sections of *Nature* journals devoted to the "pause" or "hiatus" (*Nature Climate Change*, March 2014, No. 149; and *Nature Geoscience*, February 2014, No. 157), and with the IPCC adopting the term "hiatus" in its Fifth Assessment Report (Stocker et al., 2013). The number of scientific papers devoted to this alleged "hiatus" is large and growing rapidly (e.g., Allan et al., 2014; Balmaseda et al., 2013; Bao and Ren, 2014; Brown et al., 2014; Cazenave et al., 2014; Chen and Tung, 2014; Clement and DiNezio, 2014; Crowley et al., 2014; de Boisséson et al., 2014; Desbruyères et al., 2014; Dong and Zhou, 2014; Drijfhout et al., 2014; Easterling and Wehner, 2009; England et al., 2014; Estrada et al., 2013; Fyfe et al., 2013; Fyfe and Gillett, 2014; Goddard, 2014; Guemas et al., 2013; Haywood et al., 2014; Hawkins et al., 2014; Held, 2013; Huber and Knutti, 2014; Hunt, 2011; Kamae et al., 2014; Kaufmann et al., 2011; Kosaka and Xie, 2013; Laepple and Huybers, 2014; Lean and Rind, 2009; Lin et al., 2014; Lorentzen, 2014; Lovejoy, 2014; Lu et al., 2014; Macias et al., 2014; Maher et al., 2014; McGregor et al., 2014; Meehl et al., 2011, 2013b, 2014; Meehl and Teng, 2014; Palmer and Smith, 2014; Ridley et al., 2014; Risbey et al., 2014; Santer et al., 2011, 2014; Schmidt et al., 2014; Seneviratne et al., 2014; Sillmann et al., 2014; Smith, 2013; Solomon et al., 2010, 2011; Tollefson, 2014; Trenberth, 2009; Trenberth and Fasullo, 2013; Trenberth et al., 2014; Triacca et al., 2014; Tung and Zhou, 2013; Watanabe et al., 2013, 2014; Wayman, 2013). We do not claim that this list of articles is exhaustive; however, we are confident that the selection is not arbitrary or "cherry-picked". After all, the IPCC represents the thoroughly vetted consensus view of the scientific community, and its treatment of the "hiatus" as a phenomenon worthy of explanation confirms that its existence has entered the mainstream scientific discourse—a proposition supported by two special collections of articles in *Nature* journals.

There is considerable heterogeneity among authors of the extent to which they have adopted the "pause" frame. To illustrate, on the one hand Seneviratne et al. (2014) call the term "pause" ill-chosen and misleading, and they go on to conclude that ". . . not only is there no pause in the evolution of the warmest daily extremes over land but . . . they have continued unabated over the observational record" (p. 2). Similarly, Risbey et al. (2014) and Santer et al. (2014) refer to the pause or hiatus in quotation marks (i.e., scare quotes), thereby implying scepticism or disagreement with the phrase. On the other hand, England et al. (2014) stated that "global average surface air temperature has remained more or less steady since 2001" (p. 222), and they use the term hiatus (without quotation marks) 28 times in their article. Similarly, Ludescher et al. (2014) couched their paper on improved predictability of El Niño in terms of a "hiatus," notwithstanding the fact that they also suggested that 2015 may set a new record for GMST. Lin et al. (2014) likewise refer to the "hiatus" repeatedly (3 times in the abstract alone) while nevertheless explaining that the "supertyphoon" Haiyan in 2013 was fuelled by abnormally high ocean temperatures in the western Pacific. Indeed, the papers by Seneviratne et al. (2014) and Lin et al. (2014) at least tacitly express some apparent surprise at the rapid increase of temperature extremes and the emergence of "supertyphoons", respectively, as if those events should not be expected against the backdrop of a "pause."

This analysis suggests that our first criterion for seepage has been met; namely, that mainstream scientific discourse has inherited, and is now extensively using, a framing that was demonstrably created by contrarians (Boykoff, 2014).

Is there also evidence of a departure from standard scientific practice? Our argument is nuanced and deserves to be unpacked carefully, but we argue that far from representing merely a linguistic import, the "pause" meme has affected scientific practice. We make two points: first, the "pause" is not a pause but a fluctuation that is no more unusual than previous fluctuations and can be seen as a "pause" only by violation of statistical conventions. Second, the scientific response to this most recent fluctuation differs significantly from the (lack of) scientific response to previous fluctuations that were greater in magnitude but of different sign—that is, previous episodes of accelerated warming above the long-term trend.

6.1.2. Standard scientific practice and the "pause"

It is part of the basic climatological canon that short-term trends are indicative of climate "noise" induced by a range of natural variations in the system. Periods of 15 years have long been regarded as too short to indicate meaningful trends. For example, Santer et al. (2011) showed that periods of at least 17 years are required to identify a human influence on climate trends. Of course, natural fluctuations and short-term trends may be of intrinsic scientific interest, and examining the reasons underlying such fluctuations, by itself, cannot be construed to constitute seepage. Formal decadal predictions are a relatively new area of research, and there has been considerable interest in the processes that set variability in temperature on that time scale (e.g., Meehl et al., 2013a).

However, we argue that acceptance of the "pause" constitutes a departure from standard scientific practice and is indicative of seepage. Fig. 1 shows global temperature anomalies for the period of modern global warming (1970–2013) using three global data sets. The data set of Cowtan and Way (2013) filled known coverage gaps in the HadCRUT4 data set by spatial interpolation and use of satellite data. This arguably improved data set has found support in other, related research (Dodd et al., 2014; Simmons and Poli, 2014). Our conclusions generalize across data sets, but unless otherwise noted all analyses reported from here on use the data of Cowtan and Way (2013).

Claims about a "pause" typically invoke a period commencing in 1998; the top panel of the figure shows that that year saw particularly high temperatures owing to an extreme El Niño event. When this single outlying year is omitted (as illustrated in the bottom panel), the purported pause in warming is no longer apparent. Statistically, what one observes is a decrease in the rate of warming—a slowdown, if you will—but this slowdown is at most modest: during the last 15 years (1999–2013) the linear trend is .13 °C/decade, compared to the trend for the overall period (1970–2013) which is .18 °C/decade. It is only when 1998 is arbitrarily used as the starting point to define the "pause" that the recent rate of global warming has been appreciably lower (.10 °C/decade) than the long-term trend. The top panel in Fig. 2 shows this reduced trend (in red) against the 95% confidence envelope of the long-term trend.

Thus, arguments about a "hiatus" or "pause" can only be sustained by ignoring the fact that the most recent trend is statistically nearly identical to that of other decades unless a single particular year is used as a starting point—in other words, only by cherry-picking. The use of a single "cherry-picked" outlying year to establish the presence of a "pause"—without *a priori* definition of

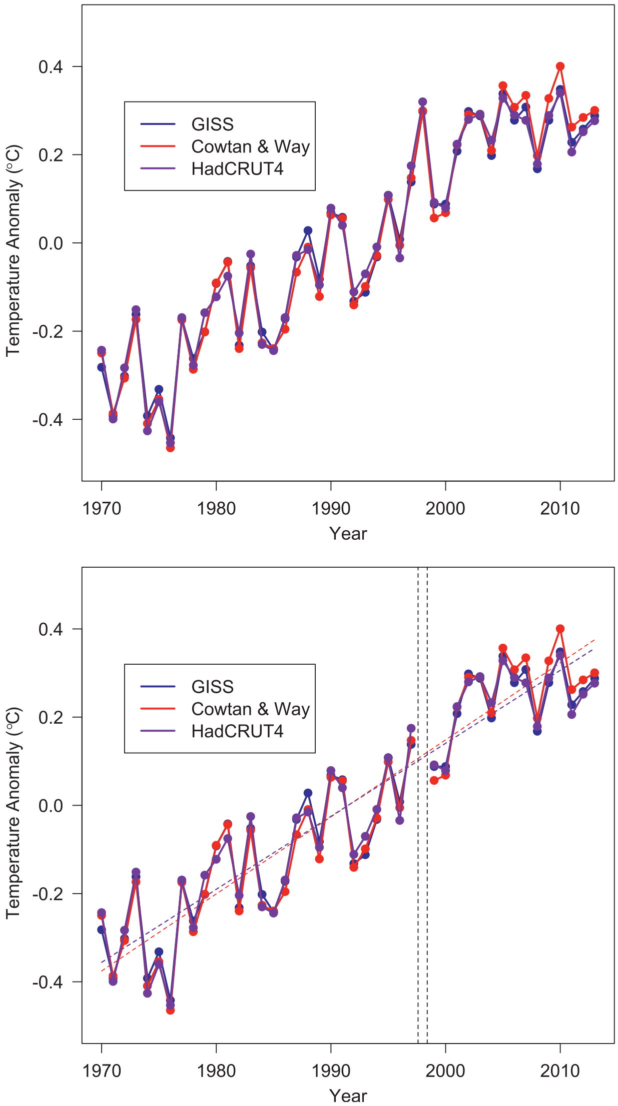

Fig. 1. Global mean surface temperature (GMST) anomalies from three data sets. GISS, NASA Gisstemp; HadCRUT4, UK Met Office; Cowtan & Way, Cowtan and Way (2013). To align the three data sets, which use slightly different climatological baselines, all anomalies here are computed for the period considered to encompass modern global warming (1970–2013); see (Foster and Rahmstorf, 2011). The top panel shows the complete record from 1970 to 2013 inclusive; the bottom panel omits observations for 1998 (indicated by vertical dashed lines) and adds best-fitting regression lines estimated from the entire time series (1970–2013), *including* 1998.

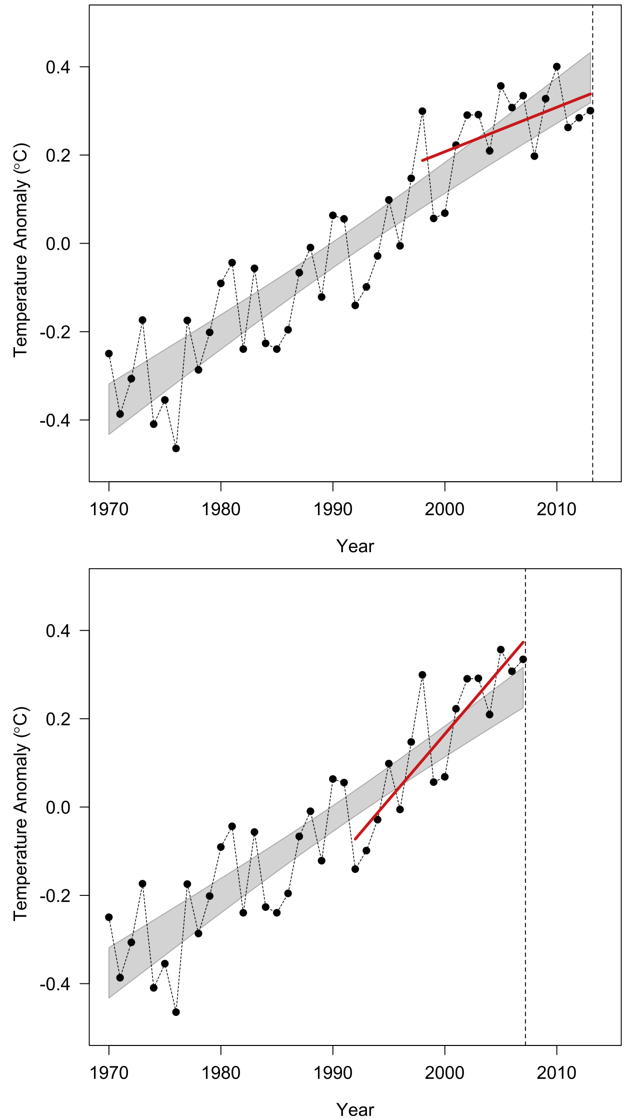

Fig. 2. Global mean surface temperature (GMST) anomalies for the data from Cowtan and Way (2013). Both panels show the data (filled plotting symbols) and the 95% confidence envelope for the linear trend estimate based on the entire period of modern global warming (1970–2013). The top panel additionally shows the trend line for the 16 years from 1998 to 2013, and the bottom panel shows the trend for the 16 years from 1992 to 2007. The bottom panel shows data only to 2007, the year that is considered to be the "present" for this demonstration. See text for details. (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)

what time period is necessary and sufficient to observe a "pause"—does not conform to conventional statistical practice and is testament to the degree to which the climate mainstream has embraced the "pause" meme for extra-scientific reasons.

To illustrate, Smith (2013) suggested that "it is now clear that the rate of warming has slowed substantially over the past 15 years or so (Fig. 1) and the observations are very much at the lower end of model simulations" (p. 618). Notably, the figure that accompanies the above statement shows that present temperatures are well within the 95% envelope of model projections, and that the most recent excursion of the data outside that envelope occurred around 1945, when temperatures were *higher* than expected by the models. The phrase "very much at the lower end of model simulations" is thus not readily reconciled with the data to which it refers.

Likewise, the IPCC AR5 report devotes considerable space and analysis to the "hiatus," defined as the reduced GMST trend during 1998–2012. (The IPCC does not explain why 1998 is used as a starting point and seemingly takes it for granted, notwithstanding its clear outlying status.) The German government criticized the usage of the term "hiatus" and provided the following comment (identified as being of "high priority") on the IPCC's relevant Summary for Policy Makers: "In addition, the underlying report and the TS label the recent reduction in surface warming as 'hiatus'. The web site http://thesaurus.com gives as definition of this expression 'pause, interruption', http://www.merriam-webster.com gives '1a: a break in or as if in a material object, 2a: an interruption in time or continuity; break; especially: a period when something (as a programme or activity) is suspended or interrupted.' All these definitions do not appropriately describe the recent temperature evolution as there is not a pause or interruption, but a decrease in the warming trend, and the first decade of this century has been the warmest since preindustrial times, see Figure SPM1. (a), lower figure. Hence, the expression 'hiatus' is strongly misleading and should not be used throughout the report" (http://www.climatechange2013.org/images/report/WGIAR5_FGD_FinalDraftSPMComments.pdf). The German delegation's suggestion was not adopted by the chapter authors. In summary, we suggest that there is sufficient evidence to consider the current discussion of a "pause" to reflect seepage: scientists have at least tacitly changed their interpretation of the data such that what once was considered to be variability has now become a "pause" or a "hiatus." Although the control experiment can never be conducted, we suggest that in the absence of concerted contrarian attempts to highlight the "pause"—which commenced at least as early as 2006, merely 8 years after the outlying El Niño event of 1998 (Carter, 2006)—the scientific community would not have given short-term variability the undue attention it has now received, used misleading language to describe it, and confused a change in the rate of warming with a cessation in warming.

Our conclusion does not imply that research aimed at addressing the causes underlying short-term fluctuations in the warming trend is invalid or unnecessary. On the contrary, it is a legitimate and fruitful area of research, and we are certain it was not done because climate scientists intended to accept a contrarian frame—rather, if any values other than scientific curiosity drove their research, it was more likely to have been a desire to rebut contrarian talking points than a willingness to accept them. Whether that research constitutes seepage depends on whether it ignores, adopts, or rejects the framing of those fluctuations as a "hiatus" in climate change. Research that ignores or rejects that framing could not be seen to be subject to the cognitive processes underlying seepage and is not seepage. On the other hand, research that explains fluctuations by uncritically adopting the language of "pauses" and a "hiatus" likely fits the definition of seepage.

6.2. *The seepage that did* not *occur: "Global warming has accelerated"*

To place the flurry of research activity arising from the most recent fluctuation in global warming into a broader context, it is informative to consider previous fluctuations from the long-term trend. The bottom panel of Fig. 2 shows the trend for the 16 years leading up to 2007: this short-term trend (.30 °C/decade) departs from the long-term trend (.18 °C/decade for 1970–2013) by a considerably larger margin than the negative deviation experienced during the last 16 years (1998–2013; .10 °C/decade).

For statistical confirmation, we computed all possible 15-year trends for the period 1970–2013 (i.e., 1970–1984, 1971–1985, etc.) and converted the short-term trends of interest into z-scores. The z of the most recent period (i.e., the "pause") relative to all others is −.89, −1.52, and −1.36, respectively, for Cowtan and Way (2013), HadCRUT4, and GISS. By contrast, the 15-year periods of most rapid warming have z-scores of 2.22, 1.87, and 2.09, respectively. In other words, across all data sets, the recent change in the rate of warming constitutes a notably *smaller* deviation from the overall trend than were previous periods of accelerated warming.

It follows that if an observer had applied the same logic to the data in 2006 or 2007 that gave rise to the "pause" in 2013—namely, drawing conclusions based on the preceding 15 or 16 years—then the literature in the years after 2007 should have been replete with articles seeking to reconcile the accelerated warming with climate models and basic climatological parameters. To our knowledge, this did not occur. We are not aware of two special issues of *Nature* journals that were devoted to the spectre of "out-of-control catastrophic warming" based on the 15 (or 16) years leading up to 2007. Likewise, the positive fluctuation from the long-term trend leading up to 2007 was not used to re-assess (transient) climate sensitivity, in contrast to endeavours that have used the current departure from the long-term trend for that purpose (e.g., Lewis, 2013; Lewis and Curry, 2014; Otto et al., 2013; Stott et al., 2013).

No contrarians drew attention to the anomalously large positive temperature trend, because there are no significant contrarian groups misrepresenting the science from the side of exaggeration. This asymmetry of response—a strong response to a contrarian exploitation of a period of slower-than-average rate of increase in temperature but no attention to a period of faster-than-average rate—supports our interpretation of the impacts of contrarian pressure on the impartiality of scientific work.

6.3. *The full circle of seepage*

In summary, it is apparent that the scientific community has in the past resisted the allure of larger short-term fluctuations that fell above the long-term trend, whereas it recently embraced a more modest excursion below the long-term trend as something special that required explanation. Moreover, in so doing, the community—including the IPCC—adopted the phraseology of a "pause" or "hiatus" with its heavily laden linguistic implications.

The danger of accepting such misleading terminology becomes particularly clear when scientists attempt to interpret the implications of research findings for policy action. A conspicuous example has been offered by Victor and Kennel (2014), who argued recently in *Nature* that the world should "ditch the 2 °C warming goal," and focus instead on a set of more diverse measures of climate change and its impacts. Their reasoning rests in large part on the alleged "pause." For example, Victor and Kennel (2014) state that there is a "troubling pause," that "average global surface temperature [have] stalled since 1998", and that "the planet's average temperature has barely risen in the past 16 years." To address these presumed problems Victor and Kennel (2014) offer the radical policy prescription of abandoning a widely accepted and almost universally understood policy.

Whether or not their proposal has merit for other reasons remains to be seen; what is important here is that their prescription has taken the path of seepage full circle: from contrarian meme to an erosion of scientific practice to a recommendation to abandon a long-standing policy goal that, in the view of at least some scientists, was itself set for political reasons and was more lenient than the science would suggest (e.g., Hansen et al., 2013).

6.4. *Expert cognition and the "pause"*

We listed several psychological factors at the outset that may render scientists vulnerable to constant contrarian opposition. We then suggested that scientists departed from long-established practice in their field while responding to the "pause" in global warming. At first glance, this claim may seem adventurous: how can a community of experts with decades of relevant expertise, who successfully resisted rewriting of the canon when global temperature rises exceeded the long-term trend in the past, cast aside long-standing practice when seeking to explain a "pause"?

Upon closer inspection, however, our claim may not appear quite so adventurous: for example, Kelemen et al. (2013) showed that even "... physical scientists from top-ranked American universities" (p. 1074) displayed increased acceptance of unwarranted teleological explanations—e.g., that leaves on plants exist in order to provide shade, as purported by Aristotle—when put under time pressure. Teleological explanations for inanimate natural phenomena are conventionally rejected by contemporary scientists, based on their quasi-religious tacit appeal to design and animism. The fact that scientists fail to reject such explanations when put under cognitive pressure demonstrates the capacity of scientists to be influenced by relatively subtle stressors. Although time pressure differs considerably from the social pressures that confront climate scientists, the results of Kelemen et al. (2013) should at least alert us to the possibility that scientific reasoning may be altered by exogenous pressures.

Turning to the specifics of the "pause", there is a relevant body of evidence in cognitive science which shows that people's knowledge is "partitioned" into modules that appear to be independent of each other and that are accessed on the basis of contextual cues (e.g., Kalish et al., 2004; Lewandowsky et al., 2002, 2006; Sewell and Lewandowsky, 2011; Yang and Lewandowsky, 2003, 2004). Because access to knowledge is specific to the context in which it is queried, people may respond in one context by completely ignoring knowledge they demonstrably possess in a different context (Yang and Lewandowsky, 2004). This context-specificity can arise even though the context cue is normatively irrelevant (i.e., it does not stand in any predictive relationship with the correct outcome), and it may lead to surprisingly contradictory responses to problems that, normatively, require the same response. Lewandowsky and Kirsner (2000) showed that this context specificity, and propensity for contradiction, even holds among experts.

It follows that there is nothing cognitively surprising about a situation in which climate scientists may teach their students in the classroom that 15-year trends are of insufficient duration to be climatologically relevant, while the same experts simultaneously conduct research that uses a 15-year "pause" to redefine basic climatological parameters (cf. Otto et al., 2013). All it may take is the creation of a pervasive linguistic and social context by contrarians, and scientists may feel bound to respond to challenges within that context—even if outside the context, their responses would be recognized to be at odds with prevailing practice. There is direct evidence that people's choices are determined by which of a person's multiple social identities is made salient at the time of a decision (LeBoeuf et al., 2010), and people's expressed preferences may be in conflict between contexts.

7. Construing uncertainty

Seepage can only occur when there is perceived uncertainty. If the public is certain that the earth is round, the flat-earth society can say whatever they like without making any impact on public opinion. In the case of climate change, however, the public continues to find it difficult to resist the allure of uncertainty, and political arguments continue to rely on Scientific Certainty Argumentation Methods (SCAMs). Given that uncertainty is an inevitable part of any scientific endeavour, and given that the particularly large uncertainties associated with climate change provide ample opportunity for seepage to occur and perpetuate SCAMs, how should scientists respond?

The tacit logic underlying SCAMs is that scientific uncertainty about climate science implies uncertainty about whether something should be done in response to it. This connection between scientific uncertainty and policy uncertainty is intuitively powerful and often taken for granted in public discourse. It is, however, incorrect. We have shown earlier (Lewandowsky et al., 2014a,b) that if scientific uncertainty about the evolution of the climate system is greater than thought, this virtually always implies that the potential adverse consequences are also greater. For example, the statistical properties of extreme values mandate that increasing uncertainty about the extent of future sea level rise requires increasingly greater protective measures if the risk of inundation is to be kept constant (Hunter, 2012). It follows that any appeal to scientific uncertainty should compel a stronger, rather than weaker, concern about unabated warming than in the absence of uncertainty (Lewandowsky et al., 2014a,b).

This actual implication of scientific uncertainty—namely, that greater scientific uncertainty implies greater *certainty* about the need for a policy response—is counterintuitive but undermines the reasoning of SCAMs. We therefore suggest that scientific uncertainty presents an opportunity for scientists to reframe SCAMs in a scientifically more appropriate manner. As noted by Jasanoff (2007), "the great mystery of modernity is that we think of certainty as an attainable state" (p. 33). Certainty may not be attainable, but uncertainty provides a certain impetus for action, and that recognition may be an important element in imbuing the scientific community with resilience to SCAMs and, by implication, seepage.

8. Conclusion

The conflation of public and professional debate is characteristic of scientific controversies in which non-experts have become engaged in scientific debates for political, social, or other reasons. This conflation is an indicator of the failure of scientists to maintain a clear demarcation between intra-scientific and extra-scientific considerations, a failure of what sociologist Thomas Gieryn (1983) has described as "boundary work"—the successful articulation and protection of the boundaries of the scientific domain. Many recent "scientific" controversies in which the scientific facts are disputed not by fellow experts, but by lay people, may be understood as a failure of boundary work.

Boundary work failures reflect the inability of scientists to persuade the lay public of the correctness of scientific conclusions—such as the safety of vaccinations or the age of the Earth—but they do not generally reveal evidence of scientists altering their own views of the matter in response to non-expert resistance. Historian Milena Wazeck (2013) has described how "lay experts"—men with some kind or degree of scientific training but generally not in physics—together with a few disgruntled physicists in the early 20th century challenged the theory of relativity, managing to maintain an on-going public debate long after the theory was broadly accepted by experts. Their opposition was rooted in ontological considerations, as they feared the implications of relativity for the role of the human observer in science, and/or because the theory marginalized them in the scientific world. Mainstream physicists may have been bothered by popular rejection and misconception, but they did not let it influence the course of their research. Similarly, AIDS researchers have explicitly sought to delegitimize denial and have undertaken strong efforts to defend the boundary between science and pseudoscientific challenges (e.g., Nattrass, 2011).

In climate science, we see a similar phenomenon of non-experts challenging an established body of evidence that has converged on the conclusion that global warming is unequivocal and in all likelihood due to human industrial and agricultural activity. But in this case we see scientists not only responding to these contrarian claims, but publishing a significant number of papers in peer-reviewed journals to try to explain them. In effect, scientists came to doubt their own conclusions, and felt compelled to do more work to further strengthen them, even if this meant discarding previously accepted standards of statistical practice. This, we suggest, is evidence of seepage: that non-epistemological considerations have seeped into—and thereby altered—scientific research and debate. Confidence, like prematurity and credibility, are value judgments, but it seems reasonable to conclude that the pressures of climate contrarians has contributed, at least to some degree, to undermining the confidence of the scientific community in their own theory, data, and models, all of which permit—and indeed expect—changes in the rate of warming over any arbitrarily chosen period.

Scientists have a unique and crucial role in public policy: to communicate clearly and accurately what we know about technical issues relevant to social and political decision-making. Ideally, this means neither overstating nor understating the evidence for any particular claim. While scientists cannot be expected to achieve a perfect match between what we know and what we communicate, we can do more to ensure that we do not inadvertently allow contrarian, skeptical, and denialist claims to seep into our thinking, leading us to overstate uncertainty, under-communicate knowledge, or add credence to erroneous claims by spending undue amounts of time responding to them, much less "explaining" phenomena that do not even exist.

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Appendix A. Responding to seepage

A.1. Stereotype threat

Research has identified various intervention strategies to reduce or eliminate the effects of stereotype threat.

Deemphasizing threatened group identity. Performance can be enhanced by blurring boundaries between groups (e.g., if women list the similarities between men and women before taking a maths test, their performance disadvantage under stereotype threat is reduced or eliminated; Rosenthal and Crisp, 2006). An analogue might be for climate scientists to consider the fact that they use the same scientific method as any other scientist—and that scientists are by and large the most trusted segment of society.

Self-affirmation. Self-affirmation involves people to think about aspects of themselves that they value or believe are important aspects of their esteem, usually by recalling a situation in which they felt good about themselves because they relied on their core values. There is evidence that self-affirmation eliminates or reduces the performance detriment that usually results from stereotype threat (Martens et al., 2006). Self-affirmation can have surprisingly lasting consequences: in one study, writing about their most important values twice at the beginning of a 15-week college course in physics reduced the gender gap considerably and elevated the modal grade of women from C to B (Miyake et al., 2010). In the scientific arena, affirmation can again invoke the fact that scientists enjoy considerable trust in the population at large.

Awareness of stereotype threat. Finally, mere awareness of the effects of stereotype threat may serve to eliminate its effects on performance. Johns et al. (2005) showed that when women are put under stereotype threat, their performance is unimpaired if the threat manipulation is accompanied by an explanation that any anxiety they may experience "could be the result of these negative stereotypes that are widely known in society and have nothing to do with your actual ability" (p. 176).

A.2. Pluralistic ignorance

When people are informed about the actual prevalence of behaviours, they no longer conform to the behaviour that they had (mistakenly) perceived to be the majority's behaviour (Schroeder and Prentice, 1998). So it is crucial for scientists to know what their colleagues are thinking (e.g., http://results.visionprize.com/).

A.3. Third-person effect

Attempts to eliminate the third-person effect (TPE) have often been unsuccessful. A recent exception is the work by Tal-Or and Tsfati (2007), who showed that the TPE is at least partially "substitutable" by other self-preserving mechanisms.

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