SOCIOLOGY

Impacts on climate change views

Climate researchers and educators must recognize legitimate disagreements about the risks of climate change, and should support informed dialogue about value-laden choices.

Paul C. Stern

The risks posed by climate change have been a subject of public policy debate in many countries. In some (most notably the United States), even the existence of an anthropogenic element in climate change remains controversial, despite increasing scientific consensus. Consequently, citizens' acceptance or rejection of consensus science on climate change has become a topic of interest among social scientists. A 2012 paper by Daniel Kahan and colleagues in *Nature Climate Change*[1] offered relevant insights and received considerable attention among climate scientists.

The authors found evidence from US survey data for two propositions: that the degree of perceived risk from climate change was not associated with measures of general scientific knowledge and numeracy, and that it was strongly associated with differences in a measure of respondents' world-views. People with 'egalitarian, communitarian' world-views, who favour greater collective attention to individual needs, perceived higher levels of risk from climate change than people with 'hierarchical, individualistic' world-views — people who, in the words of the authors, "give authority to conspicuous social rankings" and eschew "collective interference with the decisions of individuals possessing such authority". Furthermore, the difference by world-view was greater among respondents scoring high on science literacy and numeracy.

These concepts of world-view came from what social scientists call the cultural theory of risk[2]. This theory, first formulated in the wake of the 1970s rise of the environmental movement, posits that risk perceptions are more reflective of perceivers' world-views, defined as a cultural phenomenon, than of actual risk. It has been widely critiqued as an effort to discredit the movement's concerns as fundamentally subjective rather than rational[3,4].

The main findings presented in the paper were not surprising to social scientists working in this area. The insight that perceptions of environmental risks do not derive simply from scientific knowledge was well established in research on risk perception[5], though it might have surprised climate scientists who believed that better education would necessarily result in widespread acceptance of IPCC conclusions regarding the risks. Kahan *et al.*[1] helped draw attention in the climate research community to some important questions at the interface of science and action: if science education does not lead to acceptance of consensus climate science and increased concern with reducing climate risks, what would? And why do some scientifically knowledgeable people fail to accept the scientific consensus?

The conclusion that risk perceptions are linked to fairly stable attributes of the perceiver confirmed past studies. Climate change risk perceptions were known to be related to multiple individual-level factors (including general pro-environmentalism, political orientation and gender), and perceptions were more polarized among the better educated and knowledgeable[6]. Research grounded in psychological theories of fundamental human values[7] had shown that individuals holding altruistic values develop beliefs that are more supportive of environmental protection than individuals whose values prioritize self-enhancement, and that value measures sometimes explain beliefs about environmental risks better than the world-view measures from cultural theory[8].

Studies such as that of Kahan *et al.*[1], which seek explanations through individual-level analysis, are important for revealing the significance of values to risk perceptions, but can leave the mistaken impression that these relationships are universal and grounded only in stable personal characteristics. International comparisons suggest otherwise. Rejection of consensus climate science and polarization of opinions are cultural in a way cultural theory did not anticipate: they are peculiar to the US and a few other Anglophone countries. US conservatives stand out from publics in other countries in their rejection of consensus climate science[9]. The differences follow the left–right political cleavage in US politics, the world-views measured by Kahan *et al.*[1], and the opposition between altruistic and self-enhancement values.

But there is more involved than only these cleavages. Polarization on climate change risks is strongest in countries where a contrarian social movement funded by fossil fuel and related interests has been most active in raising doubts about the scientific consensus[10–13]. Polarization seems to depend not only on individuals' stable values or world-views, but also on organized influence attempts, which have proved most effective with receptive subpopulations holding particular political and social values. In the US, where these influence attempts are strongest, polarization has increased over time, affecting mainly political conservatives[6]. It is worth noting that many contrarian arguments generate mistrust of mainstream climate scientists[10], a strategy that past research suggests affects risk perceptions[14].

The stream of social science research on climate risk perceptions, including that of Kahan *et al.*[1], forces recognition that climate 'facts' are not all that matter in judging risks. Values also matter. Climate change and efforts to reduce its risks affect different people and the things they value in different ways that change over time and are not entirely predictable. Climate choices involve trade-offs between different objectives and time horizons, also evoking values.

To inform such choices, science needs to produce more than just physical facts — it should also attend to the social effects of climate choices, including inaction. Climate education needs to recognize that knowledge is evolving and that some uncertainty is inevitable. In addition to facts, it might offer mental models that embody these complexities and encourage dialogue across different points of view. One potentially useful analogy that has been suggested is coping with progressive medical conditions such as hypertension or atherosclerosis, for which there may be multiple defensible responses, each with associated risks, and room for informed disagreement[15]. Science can promote better-informed choices, but not straightforward answers. ❐

Paul C. Stern is at the National Academies of Sciences, Engineering, and Medicine, Fifth Street NW,

Washington, DC 20001, USA, and is also affiliated with the Norwegian University of Science and Technology, and the Social and Environmental Research Institute.
e-mail: pstern@nas.edu

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EXTREME EVENTS

The art of attribution

A high-impact weather event that occurred at the end of a decade of weather extremes led to the emergence of extreme event attribution science. The challenge is now to move on to assessing the actual risks, rather than simply attributing meteorological variables to climate change.

Friederike E. L. Otto

The first ten years of this century are no longer referred to as the decade of extreme weather events[1], given the spate of extremes that have occurred in the past four years (Fig. 1). 2015 and 2014 were each, at the time, the hottest year on record by a large margin[2]. Furthermore, 2016 started with record-breaking superlatives: the hottest January with the biggest increase over the previous record and the largest warming anomaly for any single month since records began[2]. However, Coumou and Rahmstorf's Review[1] in *Nature Climate Change* of the strong evidence linking many weather records broken since the beginning of the century to human influence on the climate is by no means old news. Some of the events they described have since become paradigmatic, studied over and over again. Most remarkably, this publication, together with a few other landmark studies, marked the beginning of a whole new branch of climate science, and facts that then passed almost unnoticed are now subject to fierce debate.

The detection and attribution of long-term trends in observed records (mainly temperature) has been routinely carried out at least since the second IPCC report in 1995. But attributing individual extreme events was deemed impossible until later, when the theoretical possibility was first described[3] and then applied to show that the likelihood of the European heatwave of 2003 was at least doubled due to human influence[4]. However, it took another paradigmatic event, the Russian heatwave of 2010, to push the scientific community to start scrutinizing the methodologies of analysis as well as the events themselves,

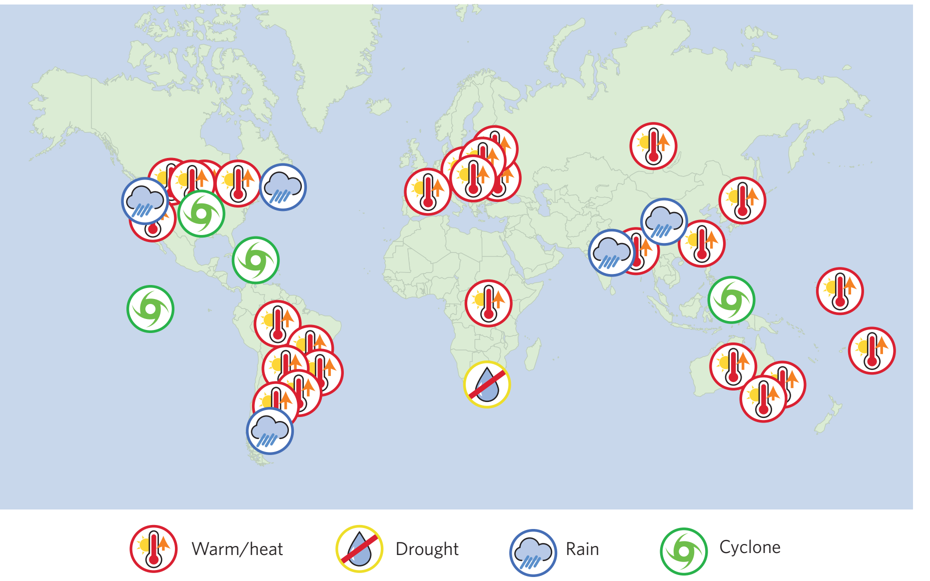

Figure 1 | Record-breaking extreme events, 2012–2015. The map shows record-breaking extreme weather and climate-related events listed in ref. 2, updating Fig. 1 in ref. 1. Information about the exact temporal and spatial extent of each event can be found in Supplementary Table 1.

and to realize the importance of defining events and framing the exact question that any study attempts to answer. It is not that obvious from a meteorological perspective why the 2010 Russian heatwave in particular is so famous, as there have since been many other extreme events around the globe that had impacts at least as high. It was, however, the first extreme weather event analysed in two extreme event attribution studies with apparently contradictory results. One study analysed the magnitude of the event and found no significant anthropogenic signal[5], whereas another found that such a heatwave was five times more probable compared with pre-industrial times due to anthropogenic climate change[6]. Soon after, these views were reconciled when it was shown that these are two complementary aspects of an event[7] and not mutually exclusive[1]. Coumou and Rahmstorf[1] used this example, as well as the ostensibly large number of meteorological records being broken around the same time, to review the state of scientific knowledge in this field. They highlighted that heatwaves are no surprise in a warming world, and