clouds cause a reduction in natural cirrus, because they modify the water budget in the upper troposphere; however, this reduction in natural cirrus is relatively small (-7 mW m^{-2}).

Overall, and despite their short lifetime, contrails may have more radiative impact at any one time than all of the aviation-emitted carbon dioxide that has accumulated in the atmosphere since the beginning of commercial aviation. It is important to note, however, that the emitted carbon dioxide would continue to exert a warming influence for much longer than contrails, should all aircraft be grounded indefinitely. These results are intrinsically difficult to validate against observations, but the authors have performed a sensitivity study that shows their results are not significantly affected by the contrail spreading rate (±5 mW m^{-2}). This is a conservative estimate of the uncertainty and more work is needed to assess the robustness of the results.

These findings are important, because if the calculations of Burkhardt and Kärcher are correct, they provide a basis to develop mitigation strategies to reduce the impact of aviation on climate. For instance, it has been suggested that flight routes or flight altitudes could be planned and altered in real time to avoid parts of the atmosphere that are supersaturated with respect to ice[8,9]. Even though this would help to reduce both young and spreading contrails, such a strategy is likely to lead to an increase in fuel consumption. It would be important to make sure that, given the large difference in atmospheric lifetime of carbon dioxide and contrails, the associated carbon dioxide penalty does not offset in the longer term the gain obtained by avoiding contrail formation[10].

The results by Burkhardt and Kärcher might also justify the development of a novel engine concept that seeks to condense a fraction of the water vapour in aircraft emissions in a cooling unit before it leaves the engine[11]. The condensed water could be vented in the form of large ice crystals or droplets that would fall quickly through the atmosphere. Reducing the content of water vapour in the engine exhaust would make contrail formation less likely.

Alternatively, one could make use of the finding that spreading contrails suppress the formation of natural cirrus clouds. It may be possible to accelerate the deposition of ambient water vapour onto the contrail ice crystals either by modifying the aircraft wake dynamics or the aerosol and cloud microphysics in the exhaust plume. If the lifetime of the contrail cirrus can be reduced several-fold for the same suppression of natural cirrus, there could be a net climate-cooling effect from contrail formation.

Although the work of Burkhardt and Kärcher[3] offers some exciting pointers as to how the impacts of aviation on the climate system might be reduced, the uncertainties remain large. Given the urgency of the issue, it is important that research on the climate impacts of contrails and on how contrails could be mitigated through technological advances or operational changes in the aviation industry are pursued in parallel. ❐

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PSYCHOLOGY

Climate change hits home

Engaging the public with climate change has proved difficult, in part because they see the problem as remote. New evidence suggests that direct experience of one anticipated impact — flooding — increases people's concern and willingness to save energy.

Elke U. Weber

In the face of political obstacles to achieving domestic and international agreements on the reduction of greenhouse-gas emissions, policymakers are increasingly looking to individuals to voluntarily cut their energy use to curb emissions in the near term[1]. Unfortunately, most people living in western countries fail to install energy-saving technologies, even if doing so would save them money in the long run[2]. Furthermore, they show little motivation to change their lifestyles in ways that require personal sacrifice. Social scientists have attributed such reluctance to engage in energy-efficient behaviour at least in part to a lack of personal experience of the impacts of climate change[3]. Empirical evidence to support this hypothesis has, however, been scarce. Writing in *Nature Climate Change*, Spence and colleagues[4] provide welcome evidence that direct experience of adverse climate impacts increases people's concern about climate change, as well as their perceived ability to tackle it and their willingness to act.

In most western countries, people lack personal experience of climate change, which is considered to have direct impacts on people's lives only in far-away places or the distant future. This situation contrasts with that of climate scientists, whose work can take them to locations where the impacts of climate change are clear, and whose training may also make them less reliant on personal experience to appreciate the risks. It is plausible that these effects explain the discrepancy in views about the magnitude and severity of the risks associated with climate change between the general public and climate scientists[5] — the majority of whom see the risks as growing and believe that concerted action is needed to reduce them[6]. However, empirical evidence that personal experience of a risk motivates action to reduce it has been thin and inconclusive in the context of climate change.

Spence and co-workers[4] surveyed a representative sample of the UK population to assess their perceptions and beliefs about climate change, as well as their willingness to conserve energy. Intense rainstorms have caused a number of severe floods in the UK over the past decade or so, and about a

Flood water in the Ironbridge Gorge, UK. The question of whether personal experience of events that are perceived to be caused by global warming has an effect on how people think and behave in relation to climate change is important in terms of understanding how to motivate people to act. Spence and colleagues[4] provide convincing empirical evidence for such a link, showing that personal experience of flooding in the UK over recent years has changed individuals' perceptions of climate change and motivated them to reduce their emissions.

fifth of the people the authors surveyed had recently experienced flooding. Given that the link between increasing global temperatures and the likelihood of such rainstorms is now commonly made in the media, the authors assumed that respondents would tend to see flooding as evidence for climate change.

Using a sophisticated statistical method that aims to identify the factors that transmit or 'mediate' the effect of one variable on another, they were able to document what effect personal experience of flooding had on perceptions and beliefs about climate change, as well as the effect that these perceptions and beliefs in turn had on residents' intentions regarding energy use.

Several of the results are surprising and important. One might expect concern about climate change to go up in response to a recent experience of severe flooding, if indeed this experience is connected to climate change. One might also expect uncertainty about whether climate change is really happening to go down. Both of these reactions were observed. What is less obvious is that residents who had experienced flooding also felt more confident that their behaviour could have an effect on climate change, which in turn translated into greater preparedness to conserve energy, through efforts such as turning down the thermostat and not using 'standby' on electrical appliances.

Another noteworthy result is that residents' willingness to reduce their energy use was not related to their certainty (or uncertainty) about the existence of climate change; at least not above and beyond differences in their overall concern about climate change. This finding has ramifications for influencing and understanding the public's response to media coverage of the issue. Uncertainty about the existence of climate change — or at least about whether it is man-made and hence controllable — is one of the main arguments made by climate change sceptics against spending money to reduce emissions. Thus it is interesting that, for members of the British public, their motivation to reduce energy use does not seem to be related to their certainty that climate change is happening. Rather, it appears to be strongly influenced by whether they think their behaviour will be effective. This result supports recent calls to communicate the need for action to tackle climate change as a risk-management option, rather than a self-evident response to a predictable future[7].

Spence and co-workers' use of a sample that is representative of the UK population as a whole and their assessment of 'mediating' perceptions and beliefs lend credence to their results. Previous failure to find a connection between personal experience of flooding and attitudes towards climate change[8] may have been the result of surveying a small, idiosyncratic sample. Like any single study, however, the results have their limitations.

They are based on the difference in behaviour observed in two samples of residents, those who experienced flooding and those who did not, surveyed at the same point in time. Thus, the causal role of personal experience in changing perceptions and motivations must be assumed — as opposed to being shown directly, which would require following the perceptions and motivations of the same individuals over periods that include exposure to flooding. They are also based on respondents' own claims about their intentions, which may not reflect their actual behaviour. Future investigations should assess the effect that personal experience of adverse climate events have on actual — as opposed to intended — energy use.

Following the failed climate change negotiations in Copenhagen, the prospects for sufficient public concern about climate change and political will to reduce carbon emissions have seemed dim. However, recent events in Tunisia, Egypt and other countries have shown, albeit in a very different context, that increases in the perceived effectiveness of individual and collective action can change attitudes and behaviours quickly and dramatically; in this case the willingness of ordinary citizens to rise up against autocratic rulers. The results reported by Spence and colleagues provide a glimmer of hope that similar 'tipping point' dynamics might exist in the domain of climate change, a prospect that is strengthened by recent evidence that further links flooding to climate change[9,10]. ❐

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Published online: 20 March 2011