CLIMATE MODELLING

Accounting for the human factor

One of the greatest sources of uncertainty about future climate change is the path greenhouse gas emissions will take. Now research using a coupled model of human behaviour and climate finds that individual behaviour can significantly alter emissions trajectories and global temperature.

Jonathan M. Gilligan

Despite growing awareness that human behaviour is an important driver of emissions[1,2], virtually all global energy–climate models reduce behaviour to simple economic treatments. Indeed, anthropogenic climate change is perhaps the largest and most complex human–natural system, but while models of local and regional coupled human–natural systems routinely use complex treatments of human behaviour, which can include feedback cycles between changing behaviour and a changing environment[3,4], most integrated models of society and climate treat behaviour economically, as rational wealth or utility maximization[5]. In contrast, models of adaptation to climate change often explicitly consider complex behavioural responses to risk and uncertainty[6,7]. Writing in *Nature Climate Change*, Brian Beckage and colleagues[8] present the Climate–Social Model (CSM), a novel system-dynamics model that couples a psychological model of behavioural response to risk with a model of greenhouse gas emissions and climate change, and find that characteristics of individual decisions about energy use can raise or lower the global temperature in the year 2100 by as much as 1.5 °C relative to a baseline emissions trajectory.

In CSM (Fig. 1), personal actions drive emissions, which affect global temperatures. CSM represents human responses to climate change using the theory of planned behaviour, a psychological model that is widely used to describe environmental and health-related behaviour[1,2,9]. Personal emissions reduction is driven by a combination of perceived climate risk (here defined as proportional to the number of extreme heat events in recent years, which is consistent with research findings[10]), perceived self-efficacy (belief that taking action can affect the risks), perceived social norms (a sense of how much society expects a responsible person to reduce personal emissions), and perceived behavioural control (the sense of how easily and successfully one can reduce greenhouse gas emissions). Perceived risk combines with

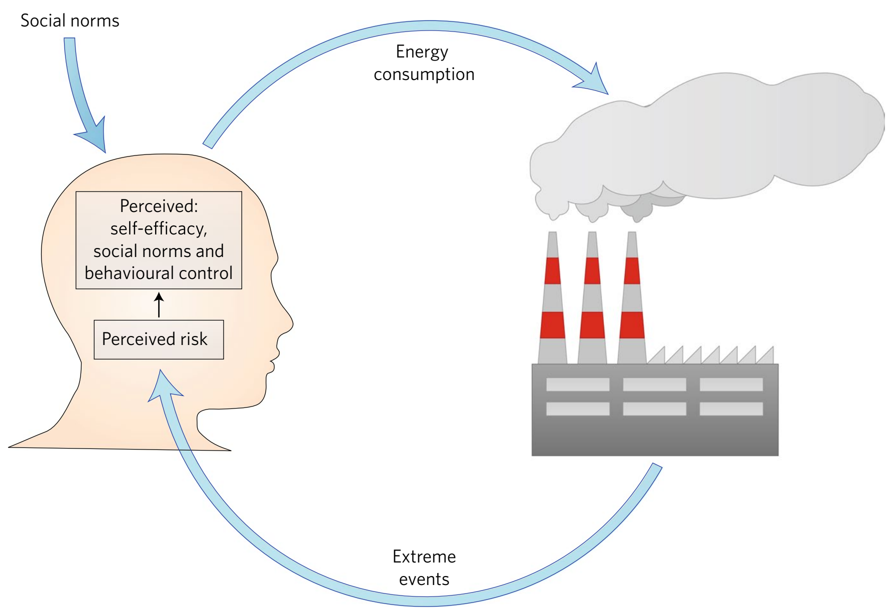

Fig. 1 | The coupled climate–social model (CSM) examines a feedback loop in which climate-related extreme events affect people's perceived risk, which then interacts with perceptions of societal expectations and personal capabilities to stimulate actions that reduce greenhouse gas emissions.

perceived self-efficacy to produce an attitude toward reducing greenhouse gas emissions; attitude, perceived social norms, and perceived behavioural control determine emissions reduction; attitude changes over time as the number of extreme heat events drives changes in perceived risk, but perceived social norms do not change.

Empirical data were not available to calibrate the behavioural model, so Beckage et al. sampled 766,656 combinations of parameters and functional forms to explore its dynamics and sensitivity to the different unknowns. They find that under the same policy conditions, different behavioural responses can change global temperatures by up to 1.5 °C relative to a baseline trajectory.

Several noteworthy details emerge from this analysis. First, even though perceived social norms do not change in response to changing climate and perceived self-efficacy modulates the effect of a changing climate on attitude, perceived social norms have the strongest effect on behaviour and perceived self-efficacy has very little effect. This suggests that if social norms are static, they add inertia to behaviour, slowing down its response as experience of extreme weather raises perceived risk; and that behaviour is shaped more by a sense of what others think than whether one believes that one's own actions can make a difference.

Second, perceived behavioural control interacts with perceived social norms to amplify behaviour changes: for high perceived behavioural control, emissions are lowest with high perceived social norms and highest with low perceived social norms. It may seem puzzling that making it easier to reduce emissions (increasing perceived behavioural control) leads to greater emissions when norms are weak. This may just be an artifact of the mathematical realization of the behavioural model, but one can also interpret it in human terms: if there is little social pressure to reduce emissions, little evidence of risk to date, and one thinks it will be easy to reduce emissions significantly in the future if risks increase, then it would be tempting to put off action. Furthermore, perceived social norms have an asymmetric effect on emissions: strengthening norms reduced emissions more than weakening norms raised them. This asymmetry may be the result of risk perception, which links increasing temperature to a growing intention to reduce emissions, regardless of perceived social norms, especially when perceived behavioural control is high.

These first results from CSM are largely consistent with previous work on behavioural approaches to reducing emissions, which finds that making it simpler and easier for people to take actions (increasing perceived behavioural control) and engaging social norms are likely to achieve greater behavioural change[11,12]. These results suggest rich opportunities for future research: it will be important for empirical studies to constrain and calibrate model parameters, and model sensitivity analyses can also guide empirical psychology. The theory of planned behaviour is not the last word in modelling human behaviour, and the structure of CSM allows substituting other behavioural models and using agent-based treatments to explore heterogeneity and emergent effects of interactions among individuals and groups[13]. In particular, the importance of static perceived social norms in this model suggests that future work ought to explore the response of social norms to changing climate and changing behaviour.

Beckage et al.[8] demonstrate that individual behaviour can have a large impact on global emissions and temperatures, and provide new evidence for the importance of incorporating non-economic aspects of behaviour into emissions models. Climate policy design and analysis will benefit from the richer understanding of coupled climate–behaviour dynamics this research can provide. ❐

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GLACIOLOGY

The health of Antarctic ice shelves

The thinning of floating ice shelves around Antarctica enhances upstream ice flow, contributing to sea-level rise. Ice-shelf thinning is now shown to influence glacial movement over much larger distances than previously thought.

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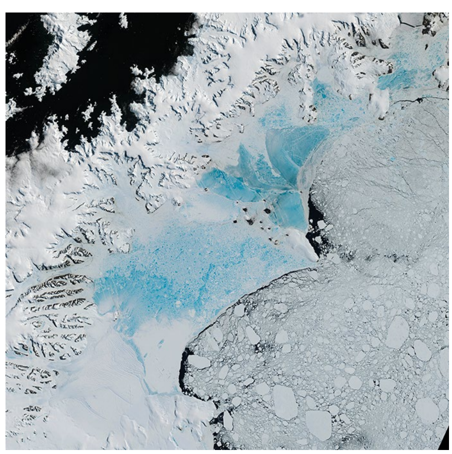
At the beginning of July 2017, a giant iceberg — ten times the size of Manhattan — detached from the Larsen C Ice Shelf on the eastern Antarctic Peninsula[1]. Given that Antarctica stores enough freshwater to raise global sea levels by 60 m (ref. 2), and that ice shelves control ice fluxes into the Southern Ocean, this spectacular event reinforces anxieties surrounding the future stability of Antarctica in the context of global warming: what impacts will the Larsen C calving, and other similar events, have on the mass balance of Antarctica? Now, writing in *Nature Climate Change*, Ronja Reese and colleagues[3] develop a model framework to quantify the current health of Antarctic ice shelves in light of idealized melt. This allows an estimation of the relative influence of each part of the ice shelf on the overall flow of the Antarctic Ice Sheet.

Floating ice shelves play an important mechanical role in controlling the



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movement of grounded tributary glaciers, providing a buttress — or barrier — that constrains ice flow into the ocean. If these ice shelves are weakened by a reduction in their size or thickness, upstream flow can be drastically accelerated. Following the disintegration of the Larsen B Ice Shelf in 2002, for example, the neighboring Hektoria, Green and Evans glaciers experienced a marked acceleration[4], increasing annual ice fluxes from 2.7 km^3 to 23.5 km^3. Today, more than a decade after the Larsen B collapse, these glaciers are still losing mass at an increased rate. Similar features were also observed following the collapse of the Larsen A and Wilkins Ice Shelves in January 1995 and March 1998 (ref. 5), respectively.

While the catastrophic disintegration of ice shelves clearly exemplifies the instantaneous loss of the buttress effect and associated acceleration of flow, ice-shelf strength is also altered by various processes related to a warming climate. For instance, at the ocean–ice interface, intense melt driven by the onshore flow of circumpolar deep water has modified