2 °C or not 2 °C? That is the climate question

Targets to limit the global temperature rise won't prevent climate disruption. Tim Lenton says that policy-makers should focus on regional impacts.

As a scientist who works on climate change, I am not comfortable with recommending policy. Colleagues frown on it, and peer review of scientific papers slams anything that could be construed as policy prescription. Yet climate science is under scrutiny in multiple arenas, and climate scientists have been encouraged to engage more openly in societal debate.

I don't want to write policies, but I do want to ensure that global efforts to tackle the climate problem are consistent with the latest science, and that all useful policy avenues remain open. Ongoing negotiations for a new climate treaty aim to establish a target to limit the global temperature rise to 2 °C above the average temperature before the industrial revolution. But that is not enough.

The target is linked to the United Nations Framework Convention on Climate Change (UNFCCC), which aims to "prevent dangerous anthropogenic interference with the climate system". But that noble objective is nearly 20 years old and is framed too narrowly, in terms of the "stabilization of greenhouse gas concentrations in the atmosphere". Long-term goals to limit temperature or concentrations have so far failed to produce effective short-term action, because they do not have the urgency to compel governments to put aside their own short-term interests.

Global average warming is not the only kind of climate change that is dangerous, and long-lived greenhouse gases are not the only cause of dangerous climate change. Target setters need to take into account all the factors that threaten to tip elements of Earth's climate system into a different state, causing events such as irreversible loss of major ice sheets, reorganizations of oceanic or atmospheric circulation patterns and abrupt shifts in critical ecosystems.

Such 'large-scale discontinuities' are arguably the biggest cause for climate concern. And studies show that some could occur before global warming reaches 2 °C, whereas others cannot be meaningfully linked to global temperature.

Disruption of the south- or east-Asian monsoons would constitute dangerous climate change, as would a repeat of historic droughts in the Sahel region of Africa or a widespread dieback of the Amazon rainforest. These phenomena are not directly dependent on global average temperature, but on localized warming that alters temperature gradients between regions. In turn, these gradients are influenced by uneven distribution of anthropogenic aerosols in the atmosphere.

Equally, an abrupt shift in the regions in which dense masses of water form in the North Atlantic could dangerously amplify sea-level rises along the northeastern seaboard of the United States. But the point at which that will occur depends on

the speed of climate change more than its magnitude.

Even when a threshold can be directly related to temperature, as with the melting of ice sheets, it is actually the net energy input that is important. The rapid warming of the Arctic in recent years is attributable less to increasing carbon dioxide levels than to reductions in emissions of sulphate aerosols (which have a cooling effect), and to increases in levels of warming agents, including black-carbon aerosols and the shorter-lived greenhouse gases methane and tropospheric ozone.

Ultimately, crucial climate events are driven by changes in energy fluxes. However, the one metric that unites them, radiative forcing, is missing from most discussions of dangerous climate change. Radiative forcing measures the change in the net imbalance of energy that enters and leaves the lower atmosphere; it is a better guide to danger than

greenhouse-gas concentrations or global warming. It takes into account almost all anthropogenic activities that affect our climate, including emissions of methane, ozone-producing gases and hydrofluorocarbons, and changes in land use and aerosol levels.

I suggest that the UNFCCC be extended. The climate problem, and the political targets presented as a solution, should be aimed at restricting anthropogenic radiative forcing to limit the rate and gradients of climate change, before limiting its eventual magnitude.

How would this help? A given level of radiative forcing is reached long before the resulting global temperature change is fully realized, which brings urgency to the policy process. The 2 °C target would translate into a radiative forcing of about 2.5 Watts per square metre (W m^{-2}), but

to protect major ice sheets, we might need a tougher global target of 1.5 W m^{-2} . We will still need a binding target to limit long-term global warming. And because CO_2 levels remain the most severe threat in the long term, a separate target could tackle cumulative carbon emissions. But while we wait for governments to reach an agreement on CO_2 , we can get to work on shorter-lived radiative-forcing agents.

The beauty of this approach is that it opens separate policy avenues for different radiative-forcing agents, and regional treaties to control those with regional effects. For example, hydrofluorocarbons emissions could be tackled under a modification of the 1987 Montreal Protocol, which aimed to halt ozone depletion. And emissions of black-carbon aerosols and ozone-producing gases could be regulated under national policies to limit air pollution. This would both break the political impasse on CO_2 and help to protect vulnerable elements of the Earth system. ■

Tim Lenton is professor of Earth system science in the College of Life and Environmental Sciences, University of Exeter, UK.
e-mail: t.m.lenton@exeter.ac.uk

**GLOBAL
AVERAGE
WARMING
IS NOT THE ONLY KIND
OF CLIMATE CHANGE
THAT IS
DANGEROUS.**

➔ **NATURE.COM**
Discuss this article
online at:
go.nature.com/1yurph