COMMENTARY

Overshoot, adapt and recover

We will probably overshoot our current climate targets, so policies of adaptation and recovery need much more attention, say **Martin Parry**, **Jason Lowe** and **Clair Hanson**.

If policy-makers are to reach international agreement on greenhouse-gas emissions at the United Nations Framework Convention on Climate Change conference in Copenhagen in December, they need to be optimistic that their decisions could have swift and overwhelmingly positive effects on climate change. The reality is less certain, but no less urgent.

Even the most restrictive emissions policies proposed to date leave a sizeable chance that significant climate change will occur over the next several decades, probably surpassing the 2 °C warming target adopted by the European Union and held by many as a dangerous limit beyond which we should not pass[1]. We must therefore complement a strong emissions policy with a plan to adapt to major environmental, social and economic changes in the lengthy period during which we will overshoot safe levels of climate change. This will require much more investment in adaptation than is currently planned.

The stringent greenhouse-gas-reduction policies posed at the G8 summit in 2007, for example, assume a reduction of around 50% in emissions by 2050. The storyline we develop here assumes that everyone agrees to this target at the Copenhagen talks in December and that policy is implemented immediately, thus ensuring the start of a downturn in global emissions — currently increasing at about 3% per year — by 2015 (Fig. 1). Implementing the policy would mean continual 3% year-on-year emissions reductions that could, after several centuries, lead to greenhouse gas concentration of about 350 parts per million (p.p.m.) of carbon dioxide equivalents. A new and useful approach for quantifying long-term emission targets is presented in two new pieces of work published in this issue (pages 1158 and 1163).

We have simulated the outcomes of this 3%-per-year reduction strategy with a simple Earth system model[2] and have plotted them on a table of projected effects that we constructed, with other Intergovernmental Panel on Climate Change Working Group II authors, for the IPCC 2007 assessment[3] (Fig. 2). Our storyline — immediate implementation, achieving peak emissions in 2015 and 3% global emissions cuts annually thereafter — leaves an even chance of exceeding 2 °C of warming. Temperatures would probably peak around 2065 just above a 2 °C rise, but with about a 20% chance of exceeding a 2.5 °C rise. If the same rate of year-on-year emissions reductions was maintained over the next century, temperatures would slowly recover to about 1 °C of warming by 2300. This would be a considerable challenge, however, because it would require substantial reductions in fossil fuel use and deforestation and, in the long term, major and much more difficult reductions of emissions from agriculture.

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With the same 3%-per-year long-term emissions reductions but a slower start, peak temperatures would rise substantially and the overshoot would extend. For example, delaying mitigative action by ten years and so reversing emissions trends by 2025 would raise peak median temperature by about 2.5 °C; delaying by a further ten years (a 2035 downturn) would mean a rise of about 3 °C, with much longer recovery.

The damage from these levels of warming could be substantial, placing billions more people at risk of water shortage and millions more at risk of coastal flooding. To avoid such damage will require massive investment in adaptation, such as improving water supply and storage, and protecting low-lying settlements from rising seas. But how much adaptation should we plan for?

It will be very expensive to protect against warming at the upper end of the uncertainty range. We therefore will need to make a judgement about what damage is worth avoiding completely and what we will have to bear. Looking at the median projected warming for different peak emissions dates, with ranges of uncertainty of climate response (shown by horizontal bars in Fig. 2), one can predict that damages to the right of the median should probably be avoided by mitigation, while those to the left would probably need to be borne or be adapted to.

If we make some simple assumptions about the amount of risk we wish to cover, we can identify how much we need to adapt. For example, we might assume that small amounts of adaptation would cover at least 10% of the risk of harm; moderate amounts might cover half; and much larger amounts could cover 90%.

The timing and stringency of emissions reduction will also influence the scale of potential damage, which would affect how much adaptation is needed: slower and lower reductions would lead to larger effects. Thus, if we wished to adapt to 90% of the risk implied by delaying mitigative action until 2035, we should be planning to adapt to at least 4 °C of warming. Given the severity of the mitigation challenge that we have described, this seems at present to be a wise precaution.

What would be the cost of such adaptation?

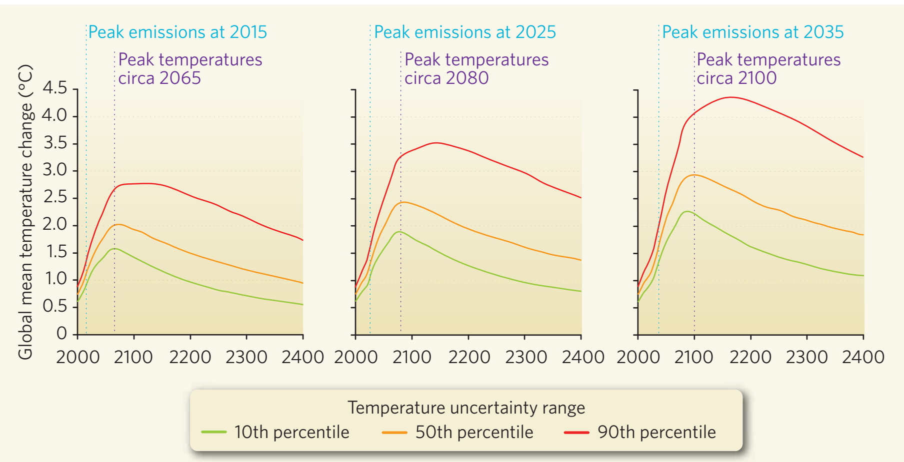

Figure 1 | **Temperature scenarios.** Global average surface temperature scenarios for peak emissions at three different dates (2015, 2025 and 2035) with 3%-per-year reductions in greenhouse-gas emissions

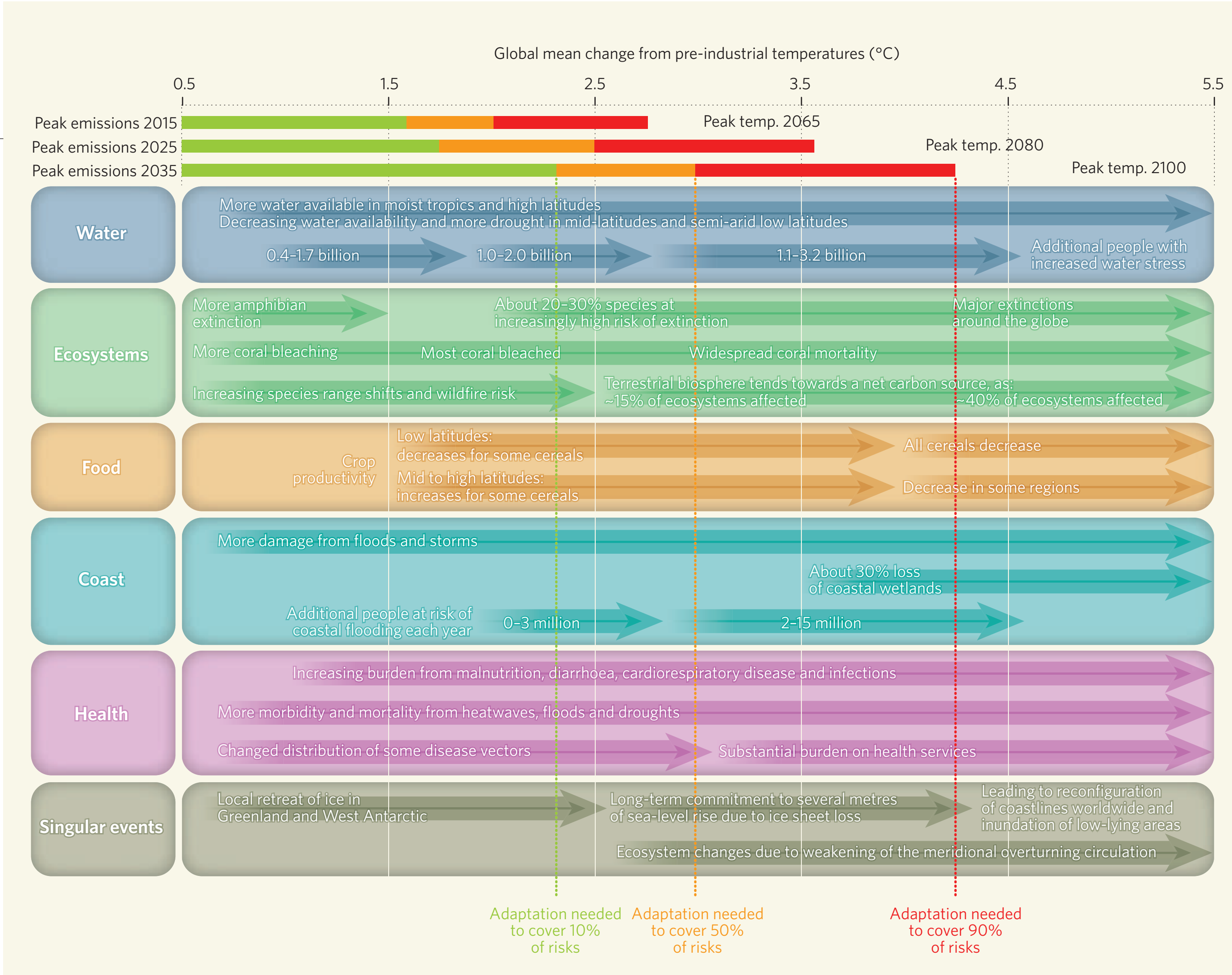

Figure 2 | Expected effects on a range of global sectors for different global mean temperature increases from preindustrial levels. Plotting peak temperatures from the three scenarios explained in Fig. 1 shows the range of projected damaging effects and the adaptation needs for 10%, 50% and 90% coverage of impact risk, and examples of these effects for a range of global sectors (source, ref. 4).

Change (UNFCCC) has estimated that between US$50 billion and US$170 billion per year (in current values) will be needed by the year 2030 (ref. 4). This is only a twentieth of current spending on development of new infrastructure globally and a tenth the expected cost of emissions reduction[5]. Such a low figure for the cost of adaptation might lead one to doubt whether climate change poses much of a challenge. The ultimate cost will probably be several times the UNFCCC estimate, however, and much more than this if emissions reduction is delayed or if we wish to protect against high-end uncertainty[3].

Additionally, much adaptation may not be physically possible or economically worthwhile. One estimate is that this impracticable adaptation would amount to two-thirds of all damages — about $1 trillion per year in 2030 (ref. 6), or ten times the UNFCCC estimate for total adaptation funding. This includes damages to irreplaceable biological systems such as coral reefs or the costs of continuing to irrigate for farming in drying regions.

long recovery process, from peak temperatures this century to roughly 1 °C of warming far in the future, may be far from linear. Sea levels, for example, may continue to rise for some decades after land areas have begun to cool; and there is also the possibility that extended melting in the Arctic would reduce albedo and increase methane release, pushing the warming peak higher and further into the future[7].

The window of opportunity for beginning effective long-term action on climate change is extraordinarily narrow. Urgent and major emissions reductions are essential to avoid the most severe effects. Yet even the most prompt and stringent action still risks overshooting a target of 2 °C, and it will require centuries to achieve a roughly stable climate with tolerably low amounts of warming. The consequent demands on adaptation will be enormous, many times those currently envisaged. We should therefore give policies of adaptation much more urgent attention. ■

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See also Editorial, page 1077, and www.nature.com/climatecrunch

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