

# Hiatus in context

The recent slow-down in the rate of warming, averaged over the surface of the entire planet, has incited much discussion. As climate scientists are tracking down the causes, we must not forget that average surface temperatures are only one indicator of climate change.

Global mean warming at the Earth's surface has been slow over the past 15 years or so, but climate change, in the broader sense, has not. Since the late 1990s, summer sea ice extent in the Arctic has marched relentlessly from one record retreat to the next<sup>1</sup>, extremely hot periods over land have become ever more common<sup>2</sup> and global mean sea level has continued to rise steadily<sup>3</sup>. Although the slow-down requires further attention, it does not seriously challenge current understanding of the mechanics of climate change: the evolution of global mean surface temperatures as well as the difference between climate model projections and observations are unusual, but not inexplicable, as argued in two Commentary articles in this issue (on pages 158 and 160, and as part of a web focus<sup>4</sup> to be published on 3 March).

Climate scientists never seriously doubted that the heat captured in the Earth's atmosphere by the continuously increasing concentrations of human-made greenhouse gases is accumulating somewhere in the Earth system, most likely in the ocean. Tracing that heat in detail has proved difficult, however, not least because deep ocean temperatures are fiendishly difficult to chart. Slow surface warming on global average initially received relatively little attention from scientists: a broad reference to decadal variability and possible ocean warming seemed to be a sufficient explanation. After a decade and a half of slow warming, however, there is now a broad call outside the scientific community, as well as within, for a more detailed investigation.

An evaluation of the warming slow-down, and its absence in climate model simulations, was duly included by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report of the Physical Basis of Climate Change (see Box 9.2 in ref. 5). The report states that warming hiatus periods of 10 to 15 years can simply result from internal variability in the coupled system of ocean and atmosphere, which is not expected to be captured in climate models. More interestingly, according to the assessment, 15-year trends in global mean surface temperature over most periods in the near future will show a steeper warming than the trend from 1998 to 2012 (unless there is a

powerful volcanic eruption), based on the length of simulated hiatus periods under conditions of unabated greenhouse gas emissions and expectations of future aerosol emissions and solar activity. In hindsight, this prediction for an imminent end of the period of slow warming seems surprisingly confident, considering the low predictability of internal variability.

With the help of climate models, the slowing of global average surface warming has since been traced back to cooling in the equatorial Pacific<sup>6</sup>, which in turn has been linked to an intensification of the Pacific trade winds<sup>7</sup>. The ultimate causes for the change in wind strength and Pacific surface temperatures, however, are still unknown. All three types of potential candidate mechanisms could be involved<sup>7</sup>: natural internal variability, such as the Pacific Decadal Oscillation (a long-term oscillation in sea surface temperatures); external influences, such as human-made aerosols, solar variability or volcanic eruptions; or global warming itself, for example in the Indian Ocean. The breadth of possible types of mechanisms makes foresight difficult. Internal variability will probably result in a swing back to faster warming in due course, and human-made aerosols and the solar activity are also likely to return to levels that would end the hiatus. However, Indian Ocean warming — or any other global warming feedback — is expected to continue, which could prolong the slow-warming period. If the latter influence is significant, this effect needs to be quantified.

But Pacific surface cooling by stronger trade winds is not the whole story. For example, the decline in ozone-depleting substances following the establishment of the Montreal Protocol as well as lower atmospheric methane levels have also been identified as influences on average surface temperatures over the past decade or two<sup>8</sup>. And, as noted on page 185 of this issue,

observations suggest that volcanic eruptions over the twenty-first century could have also played a role.

There is clearly much to learn about the interplay of various factors that have collectively caused the remarkable slow-down in global average surface warming. At the same time, it is important to keep in mind that this particular indicator of climate change — useful as it may be as an abstract, integrated measure — has little direct impact on human lives<sup>9</sup>. And when it comes to assessing the impact of climate change on terrestrial ecosystems, regional, seasonal and diurnal variability are key, as discussed in a Review article on page 173.

The average rate of warming at the Earth's surface is only one piece in the climate change puzzle. We ought to do what we can to obtain insights into the mechanisms that orchestrate its ups and downs on the decadal scale. However, in the course of this pursuit we must not lose sight of the more complicated expressions of climate change — for example, on continental or smaller spatial scales, in variables other than surface temperature, and in terms of extremes around the average. These changes are less easy to summarize, but they have the potential to affect life on the planet much more severely. □

## References

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