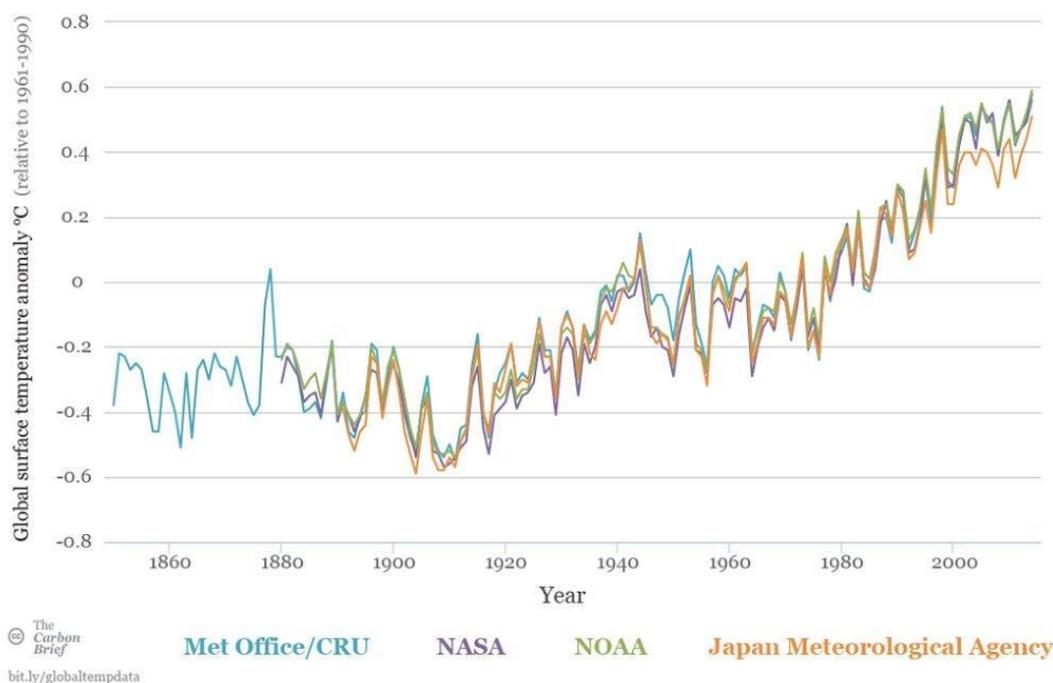


## IEAGHG Information Paper 2015-10; The Earth’s Getting Hotter and So Does the Scientific Debate

A recent study published in *Nature Climate Change*<sup>1</sup> suggests that the rate of climate change we're experiencing now is faster than at any time in the last millennium. The research team from the Joint Global Change Research Institute, Pacific Northwest National Laboratory, USA, have compared how temperature has varied in blocks of 40-year periods over millennia from. Their main conclusion is that the Earth is entering a new phase what they refer to as rapid temperature change. One implication of this work is that ‘we are already locked into fast-paced changes in the near future because of past emissions, which means we'll need to adapt to minimise the impacts of climate change, even if greenhouse gas emissions are cut substantially’.

By looking back at how the temperatures have changed over the past century, the researchers conclude that temperature rise of the Earth's surface has not been smooth. The peaks and troughs in the temperature data, they conclude, are in part caused by natural phenomena (volcanic eruptions and El Niño,) which have yearly impacts on the Earth's climate. The figure below (taken from a Carbon Brief blog on the study) shows average global surface temperatures for every year back to the 1850s. It shows that the temperature changes from decade to decade vary which they suggest is due to the impact of natural cycles on the climate.



**Figure 1. How the major global surface temperature datasets compare. Showing NASA GISTEMP (purple), JMA (orange), NOAA MLOST (green) and Met Office/CRU (blue). Credit: Rosamund Pearce, Carbon Brief**

<sup>1</sup> Smith, S. et al. (2015) Near-term acceleration in the rate of temperature change, *Nature Climate Change*, doi:10.1038/nclimate2552

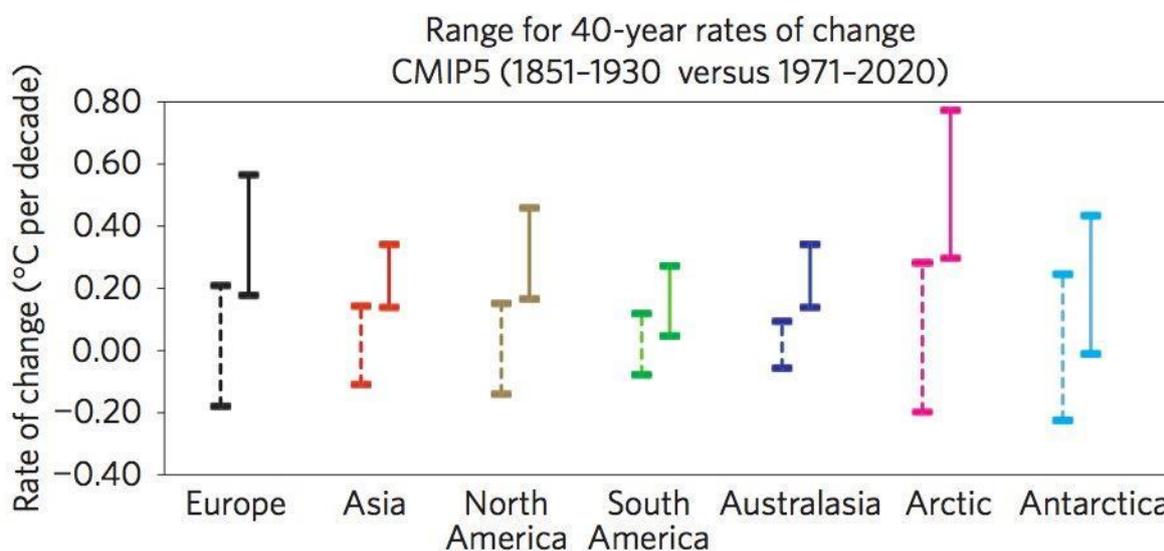


The graph also shows how much faster the temperature has increased in recent decades compared to any time over the last 1,000 years.

Through their analysis of past temperature records, they found that:

- In the 900 years before the 20th century, the 40-year periods didn't show warming of more than 0.1 degrees per decade;
- However in the second half of the 20th century, the speed of temperature changes increased. They found that in the Northern Hemisphere it was over 0.2 degrees per decade.

Using climate models, they also calculated the rates of decadal temperature changes for 1971-2020 and compared them to 1851-1930; i.e. a period before substantial human-caused warming occurred. Note: The projections were based on an Intergovernmental Panel on Climate Change (IPCC) CMIP5 RCP4.5 scenario<sup>2</sup>. The graph from the study, below (Figure 2), shows the results for each region of the world. The bars show the range in results from the climate models, with the solid lines showing 1971-2020 data and the dashed lines showing 1851-1930.



**Figure 2. Range of past (1851-1930, dashed lines) and near-future (1971-2020, solid lines) regional rates of surface temperature change per decade. Bars show the range of climate model results, based on emission scenario RCP4.5. Source: Smith et al. (2015)**

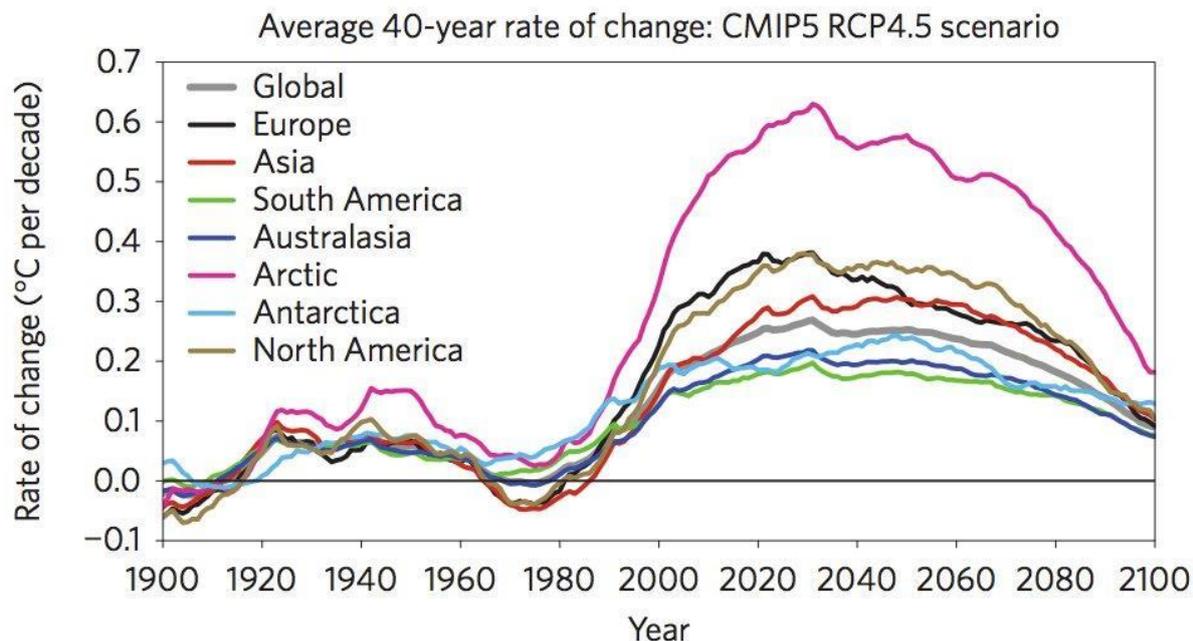
The rates of change are projected to increase for all regions, with the Arctic showing the highest rise of all continents. Temperatures in the Arctic are currently rising twice as fast as the global average. The reason for this the researchers claim is that as Arctic sea-ice diminishes, energy from the sun that would have been reflected away by sea-ice is instead absorbed by the ocean, a phenomenon scientists apparently call Arctic amplification<sup>3</sup>.

Projections for the rest of the century show average rates of temperature change per decade could reach around 0.4 degrees in Europe and North America, and 0.6 degrees in the Arctic.

<sup>2</sup> [http://cmip-pcmdi.llnl.gov/cmip5/guide\\_to\\_cmip5.html](http://cmip-pcmdi.llnl.gov/cmip5/guide_to_cmip5.html)

<sup>3</sup> [http://en.wikipedia.org/wiki/Polar\\_amplification](http://en.wikipedia.org/wiki/Polar_amplification)

The inherent warning is that as these results are from a scenario of limited greenhouse gas emissions, the rates could get even higher.



**Figure 3. Average rates of regional surface temperature change per decade for the 21st century. Based on emission scenario RCP4.5.** Source: Smith et al. (2015)

The researchers feel that the results show the Earth's climate is moving to a new regime where the rate of temperature change is dominated by rising greenhouse gas emissions. The lead author suggests the study highlights the need for humans to adapt, but he says the impacts of an extended period of increasing rates of temperature change are unclear:

*"[The need to adapt] is really the bottom line of our study. I don't believe we know the answer at this point. There are increasing efforts around the world to adapt to climate change. But we also need to better understand which impacts are likely to become important over the next few decades, and then determine how we can best react."*

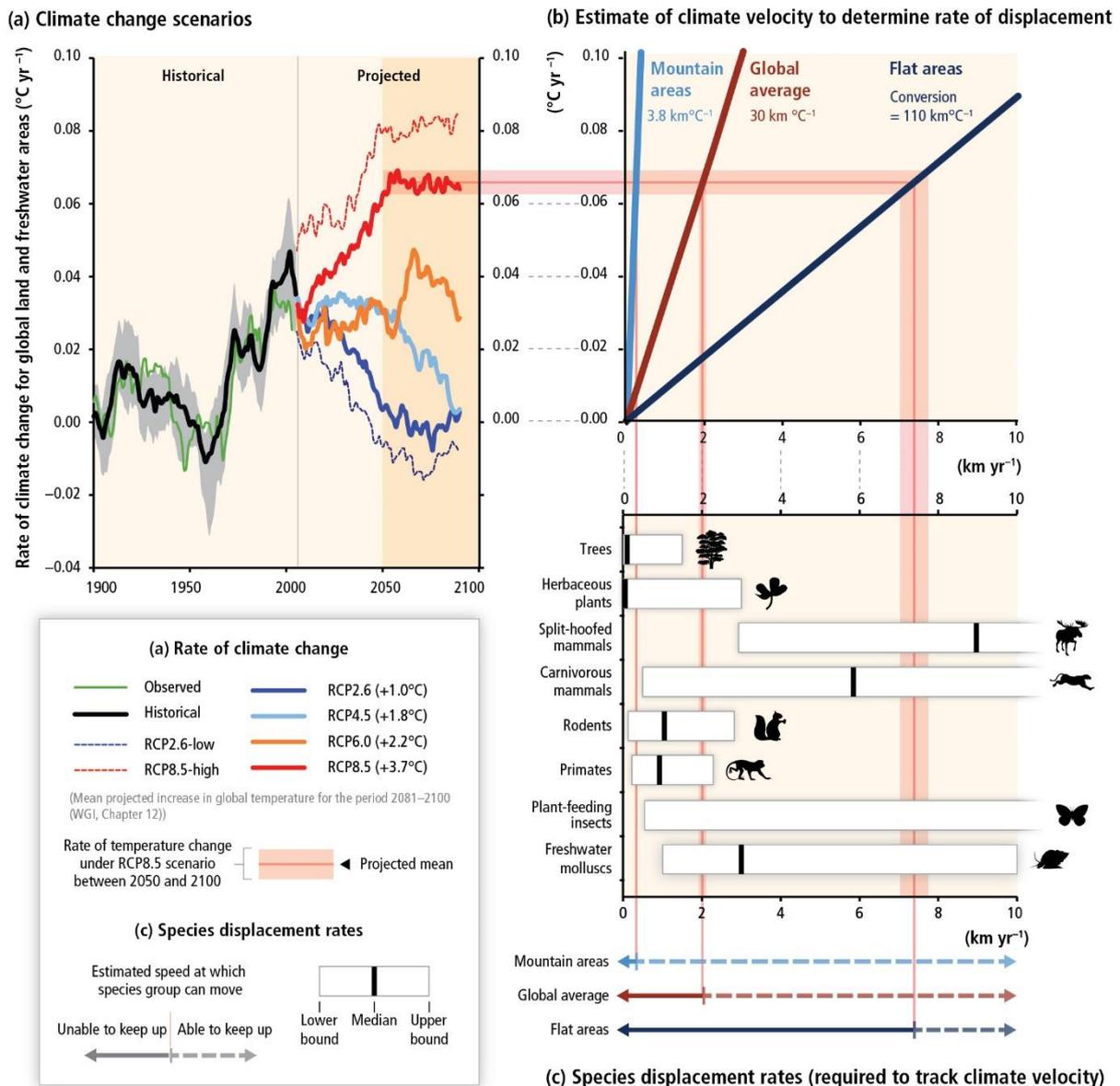
He goes onto to say that tackling climate change is not just about a long-term two degree target, but rapid temperature rise in the near future highlights the need for both mitigation and adaptation.

The report, as summarised in the Carbon Brief (see <http://www.carbonbrief.org/blog/2015/03/earth-entering-new-era-of-rapid-temperature-change-study-warns/>), has been the subject of some comments on social media – mostly supportive. One of the IPCC AR5 authors (Dr Richard Betts, UK Met Office) has commented on the study in a separate online post entitled “Hiatus delays unprecedented warming rates” (see: [www.climate-lab-book.ac.uk/](http://www.climate-lab-book.ac.uk/)).

Whilst generally in agreement with the key conclusions of the study. Dr Betts goes on to say that:

*‘Smith et al rightly point out that the rate of change is a critical factor in climate change impacts, especially if the change is so fast that it cannot be adapted to. We discussed this in the IPCC Working Group 2 report<sup>4</sup>’* (please see overleaf):

<sup>4</sup> <http://ipcc-wg2.gov/AR5/>



**Figure 4. (a) 20-year rates of global warming from observations and CMIP5 simulations. (b) Corresponding ‘climate velocities’, quantifying the shift of local temperature states across the landscape as the global climate warms. (c) Displacement rates of groups of species – comparison with climate velocity gives an indication of whether species can adapt to warming by tracking the movement of preferred temperature states across the landscape. For further details see IPCC AR5 WG2 Chapter 4, ‘Terrestrial and Inland Water Systems’ – this is Figure 4-5 from that chapter.**

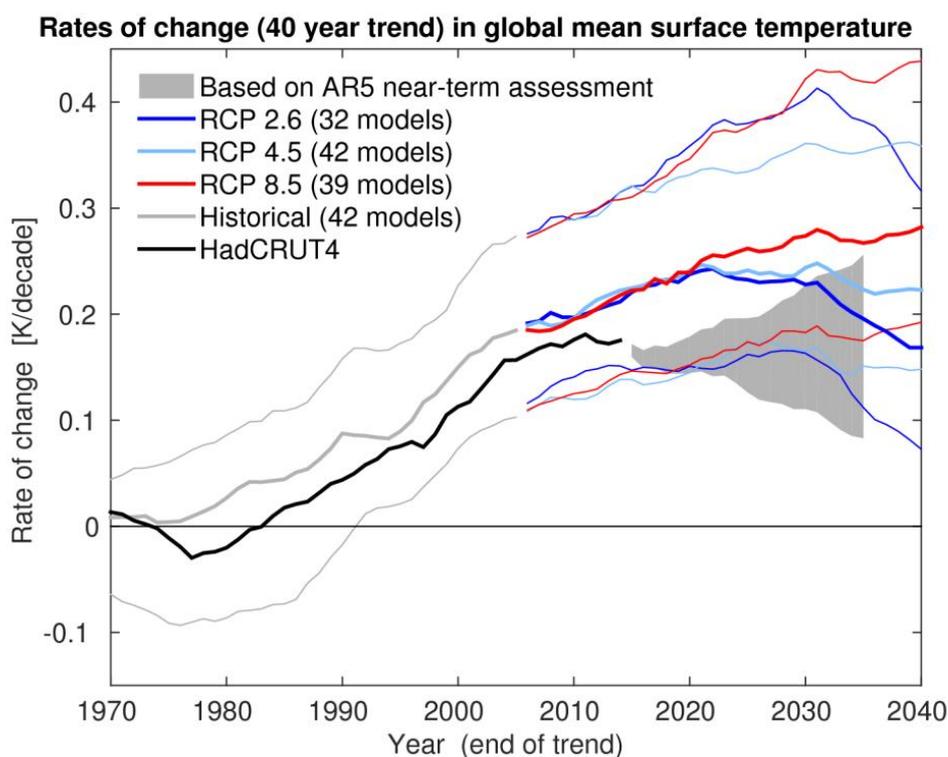
*‘Smith et al note that the projected rates of warming are faster than those seen in reconstructions over recent centuries, and discuss the implications of uncertainties in transient climate response and aerosol forcing – it’s an interesting and useful analysis. However, much of the media coverage of this paper focussed on a somewhat surprising statement in the abstract:*

*The rate of global-mean temperature increase in the CMIP5 archive over 40-year periods increases to  $0.25 \pm 0.05 \text{ }^{\circ}\text{C/decade}$  by 2020.*

*This is surprising because global mean warming has proceeded more slowly over the last decade and a half or so – the so-called warming slowdown or ‘hiatus’. After a warming rate of around 0.26 °C/decade in 1984-1998, the rate slowed to about 0.04 °C/decade in 1998-2012 (IPCC WG1 Chapter 9 Box 9.2)<sup>5</sup>.*

The question Dr Betts raises is: Will warming really accelerate again enough to give a 40-year warming rate of 0.25 °C/decade by 2020? He goes on to say that:

*‘The authors do acknowledge the observed recent slowdown. However they do not factor this into the projected 40-year warming rate by 2020. He suggests one way to account for recent observations is to use the constrained near-term projections presented in IPCC AR5 WG1 Chapter 11 (Figure 5). This figure took the range of warming rates from CMIP5 and applied these to a more recent baseline. This acknowledges that while the projected warming rates may be realistic, the warming in coming decades is now starting from a lower point than in the projections.’*



**Figure 5. 40-year warming rates for the HadCRUT4 observations (black), CMIP5 projections for RCP8.5 (red) RCP4.5 (light blue) and RCP2.6 (dark blue), and for the observations plus the IPCC’s ‘assessed likely range’ (grey plume).**

Dr Betts then suggests that using this in combination with the observed global mean temperature allows one to estimate the 40-year warming out to 2035 taking the hiatus into account. Doing this, and assuming of course that the IPCC’s ‘assessed likely range’ is realistic, he suggests we find that the 40-year warming rate is actually expected to reduce a little over the next 5 years or so. The 40-year rate peaked at about 0.18 °C/decade in 2011 and then drops off a little by 2015. This is due to a few cold years in the 1970s dropping out of the 40-year period. The 40-year rate is then projected to be

<sup>5</sup> <http://www.climatechange2013.org/>



between 0.14 and 0.18 °C/decade by 2020. By this method, Smith's central estimate of 0.25 °C/decade looks unlikely to be reached by 2020.

Betts concludes by saying that:

*'The wider point made by Smith et al still stands – there is a clear risk of rates of climate change exceeding those in recent centuries, especially if greenhouse gas emissions continue to increase. Recent 40-year warming has already been unusual in the context of the last millennium, but possibly not completely unprecedented. However, our brief analysis here suggests that the recent hiatus may have put off the time at which 40-year warming exceeds that seen in the last millennium. Nevertheless, this may still happen within the next two decades.'*

The note by Betts has itself been the subject of a number of comments, and an active discussion between climate scientists.

**John Gale**  
**20/03/2015**