PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC SCIENCE BRIEF: OVERESTIMATED GLOBAL WARMING OVER THE PAST 20 YEARS

In a recent paper in the journal *Nature Climate Change*, Fyfe et al. find that the observed global warming over the past 20 years is significantly less than in climate model simulations. The authors also find that the same models successfully simulate the rate of warming over the 1900-2012 period.

Over long time scales, global climate models successfully simulate changes in a variety of climate variables, including the global mean surface temperature since 1900. However, over shorter time scales the match between models and observations may be weaker. A number of factors can influence this, such as internal climate variability and features of the climate system that are not well-represented in the models. Also, in order to simulate past climates, climate models require inputs in the form of historical greenhouse gas concentrations, the amount of aerosols present in the atmosphere from volcanic activity and industry, and changes in solar radiation over time. Uncertainty in these inputs can cause differences between climate simulations and observations.

Fyfe and colleagues (2013) compare climate model simulations and observational data in order to determine if model simulations are consistent with observations of global mean temperature over the period of 1993-2012. They find that the observed rate of warming, 0.14 °C per decade, is significantly less than the 0.30 °C per decade trend that is seen in climate model simulations, as can be seen in Figures 1 and 2. The difference between observations and model output is greater over the shorter period of 1998-2012, for which the observed trend of 0.05 °C per decade contrasts with a simulated trend of 0.21 °C per decade. Further statistical testing supports the finding that the models do not simulate the observed rate of global warming over either of these periods. However, the authors note that, for the long-term (1900-2012) trends, the model simulations and observations are very similar, as can be seen from the horizontal line and shaded band in Figure 2.

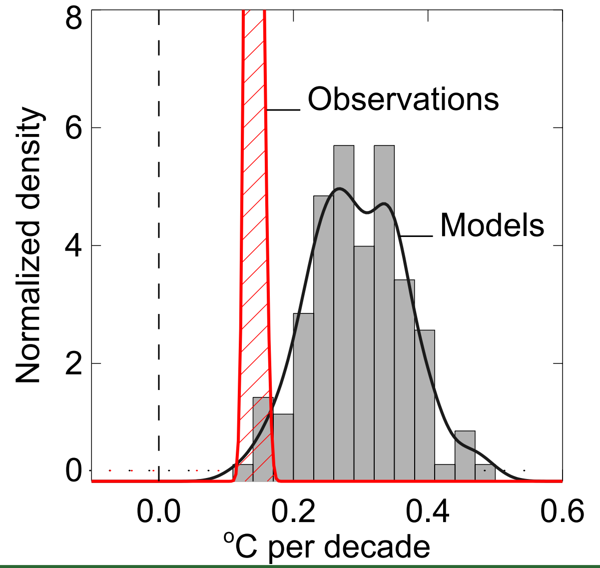

Figure 1: Global mean surface temperature trends, modified from Fyfe et al. (2013).
The figure above shows the distribution of rates of warming for both observations and climate model simulations. The x axis indicates the size of the trend in units of °C per decade and the y-axis indicates the relative frequency with which the trend occurs. The narrow width of the red curve indicates that there is only a small uncertainty in the observed trend, due to uncertainties in global temperature observations. In contrast, the width of the black curve or the spread of the black bars indicates that there are substantial differences in trends simulated by different models. Differences between models, and between observations and models, are to be expected for a number of reasons.

The authors examine several possible causes for the differences between observations and model simulations over the 15- and 20-year periods. El Niño[1] and large volcanic eruptions are explored as possible explanations, but the authors find that neither can account for the difference. Another climate variation, the Atlantic Multidecadal Oscillation[2], is also explored and, while the

1. The El Niño Southern Oscillation is a climate pattern with global effects that results from periodic variations in the sea surface temperature across the equatorial Pacific Ocean. El Niño is usually described with three phases: cool, warm and neutral.
2. The Atlantic Multidecadal Oscillation is a climate pattern associated with the sea surface temperature of the North Atlantic Ocean. The Atlantic Meridional Oscillation effects the global climate, especially in the Northern Hemisphere.

authors cannot rule out its involvement, they point out that it has not driven cooling over the period of 1993-2012. The presence of aerosols in the stratosphere from small tropical volcanic eruptions has not been taken into account in the model simulations and the authors note that these eruptions may have resulted in a cooling of 0.07 °C per decade, which would bring the model simulations and observations into closer agreement. Other potential sources of error include a decrease in stratospheric water vapour, which is not realistically represented in the models, errors in the aerosol forcing in the troposphere, errors in the solar forcing used, the possibility of overly high climate sensitivity on average in the models or internal climate variability that the authors have not considered.

Understanding the cause of the discrepancy between recent observed and simulated warming waits upon further research into simulated internal climate variability and forcings, and how these compare with observations over the periods examined in this paper.

Methodology

For this study, Fyfe et al. use HadCRUT4[3] observational data and 117 model simulations from 37 different global climate models participating in the fifth phase of the Coupled Model Intercomparison Project[4]. The authors first compare the rates of global surface warming in observational data and model simulation output over the periods of 1993-2012 and 1998-2012. The authors then use a carefully constructed statistical test to determine if the observed and model trends are equal, assuming either that (1) the models are exchangeable with each other or (2) the models are exchangeable with each other and observations. They ultimately reject the null hypothesis (that the observed and model mean trends are equal) at the 10% level.

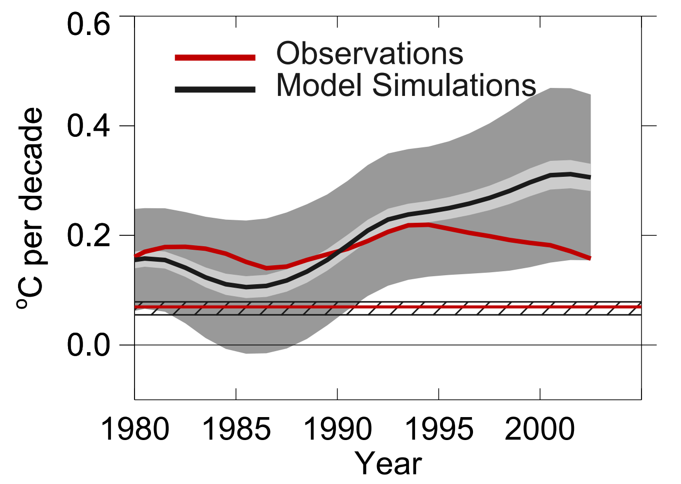

Figure 2: Global mean surface temperature trends, modified from Fyfe et al. (2013).
Above are the 20-year running surface temperature trend and the 1900-2012 surface temperature trend. Black curves are the 20-year running averages of the ensemble of model simulations, dark grey shading shows the 2.5-97.5 % ranges of simulated estimates and light grey shading shows 95 % uncertainty ranges on ensemble means. The red curve shows the corresponding 20-year running average of observations. Black cross-hatching in the lower section of the graph shows the 95 % uncertainty range of the simulated 1900-2012 model mean trend and the lower red line indicates the corresponding observed 1900-2012 global mean surface temperature trend.

Fyfe, J.C., N.P. Gillett and F.W. Zwiers, 2013: Overestimated global warming over the past 20 years. *Nature Climate Change*, **3**, 767-769, doi:10.1038/nclimate1972 .

3. For more on the HadCRUT4 gridded land-surface and sea-surface data set, see here: http://www.metoffice.gov.uk/hadobs/hadcrut4/
4. For more on the fifth phase of the Coupled Model Intercomparison Project, see here: http://cmip-pcmdi.llnl.gov/cmip5/

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