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Quantifying the Lack of Consistency between Climate Model Projections and Observations of the Evolution of the Earth's Average Surface Temperature since the Mid-20th Century

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INTRODUCTION

Recent climate change literature has been dominated by studies which show that the equilibrium climate sensitivity is better constrained than the latest estimates from the Intergovernmental Panel on Climate Change (IPCC) and the U.S. National Climate Assessment (NCA) and that the best estimate of the climate sensitivity is considerably lower than the climate model ensemble average. From the recent literature, the central estimate of the equilibrium climate sensitivity is ~2°C, while the climate model average is ~3.2°C, or an equilibrium climate sensitivity that is some 40% lower than the model average.

To the extent that the recent literature produces a more accurate estimate of the equilibrium climate sensitivity than does the climate model average, it means that the projections of future climate change given by both the IPCC and NCA are, by default, some 40% too large (too rapid) and the associated (and described) impacts are gross overestimates.

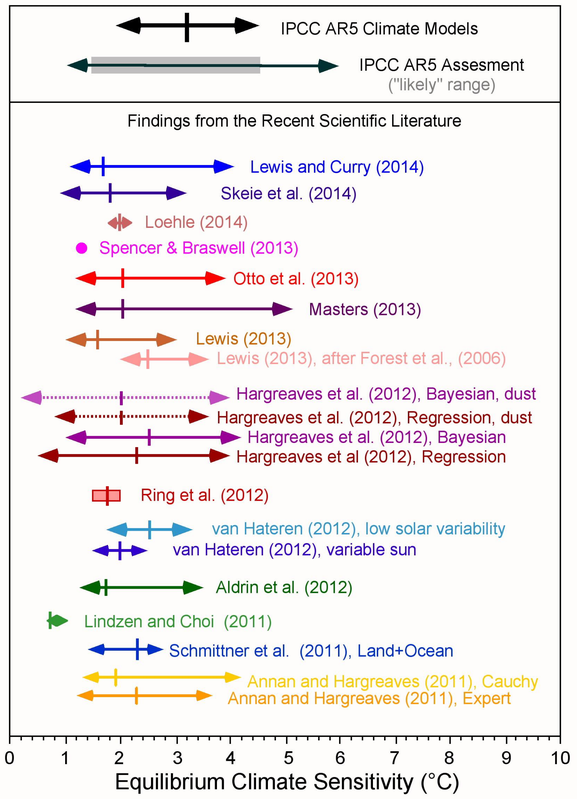
A quantitative test of climate model performance can be made by comparing the range of model projections against observations of the evolution of the global average surface temperature since the mid-20th century. Here, we perform such a comparison on a collection of 108 model runs comprising the ensemble used in the IPCC's 5th Scientific Assessment and find that the observed global average temperature evolution for trend lengths (with a few exceptions) since 1980 is less than 97.5% of the model distribution, meaning that the observed trends are significantly different from the average trend simulated by climate models. For periods approaching 40 years in length, the observed trend lies outside of (below) the range that includes 95% of all climate model simulations.

CONCLUSIONS

We conclude that at the global scale, this suite of climate models has failed. Treating them as mathematical hypotheses, which they are, means that it is the duty of scientists to, unfortunately, reject their predictions in lieu of those with a lower climate sensitivity.

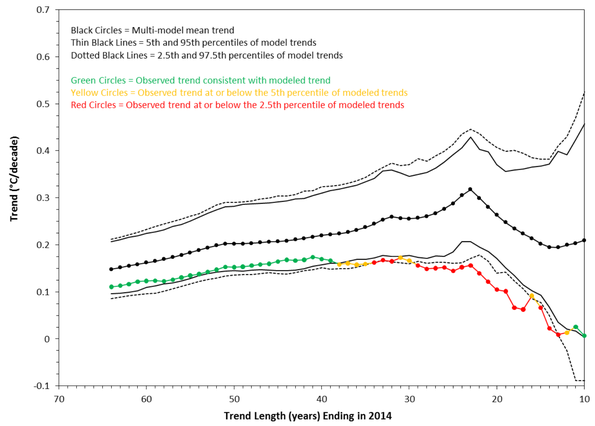
It is impossible to present reliable future projections from a collection of climate models which generally cannot simulate observed change. As a consequence, we recommend that unless/until the collection of climate models can be demonstrated to accurately capture observed characteristics of known climate changes, policymakers should avoid basing any decisions upon projections made from them. Further, those policies which have already be established using projections from these climate models should be revisited. Assessments which suffer from the inclusion of unreliable climate model projections include those produced by the IPCC and the U.S. Global Climate Change Research Program (including their most recent National Climate Assessment). Policies which are based upon such assessments include those established by the U.S. Environmental Protection Agency pertaining to the regulation of greenhouse gas emissions under the Clean Air Act.

EQUILIBRIUM CLIMATE SENSITIVITY

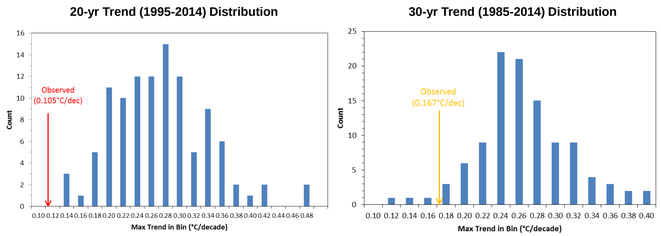


Climate sensitivity estimates from new research beginning in 2011 (colored), compared with the assessed range given in the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report* (AR5) and the collection of climate models used in the IPCC AR5. The "likely" (greater than a 66% likelihood of occurrence) range in the IPCC Assessment is indicated by the gray bar. The arrows indicate the 5 to 95 percent confidence bounds for each estimate along with the best estimate (median of each probability density function; or the mean of multiple estimates; colored vertical line). Ring et al. (2012) present four estimates of the climate sensitivity and the red box encompasses those estimates. The right-hand side of the IPCC AR5 range is actually the 90% upper bound (the IPCC does not actually state the value for the upper 95 percent confidence bound of their estimate). Spencer and Braswell (2013) produce a single ECS value best-matched to ocean heat content observations and internal radiative forcing. The mean climate sensitivity (3.2°C) of the climate models used in the IPCC AR5 60% greater than the mean of recent estimates (2.0°C).

MODELS VS. OBSERVATIONS



The annual average global surface temperatures from 108 individual CMIP5 climate model runs forced with historical (+ RCP45 since 2006) forcings were obtained from the KNMI Climate Explorer website. Linear trends were computed through the global temperatures from each run, ending in 2014 and beginning each year from 1951 through 2005. The trends for each period (ranging in length from 10 to 64 years) were averaged across all model runs (black dots). The range containing 90 percent (thin black lines), and 95 percent (dotted black lines) of trends from the 108 model runs is indicated. The observed linear trends for the same periods were calculated from the annual average global surface temperature record compiled by the U.K. Hadley Center (HadCRUT4) (colored dots) (the value for 2014 was the 10-mon, January through October, average). Observed trend values which were less than or equal to the 2.5th percentile of the model trend distribution were colored red; observed trend values which were between the 2.5th and the 5th percentile of the model trend distribution were colored yellow; and observed trend values greater than the 5th percentile of the model trend distribution were colored green.



Distribution of 20-yr temperature trends (left) and 30-yr temperature trends (right) from 108 climate model runs during the period ending in 2014 (blue bars). The observed 20-yr temperature trend (left) and 30-yr temperature trend (right) over the same intervals are indicated by the arrows colored to match the designations described in the previous figure.

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