Geophysical Research Abstracts
Vol. 17, EGU2015-11294, 2015
EGU General Assembly 2015

Using climate model experiments to explore difference between degrees of global warming: lessons from a study of African precipitation

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A 2°C increase in global mean temperature (ΔTg) has been widely adopted as a benchmark for dangerous climate change, and is currently being reviewed under the United Nations Framework Convention on Climate Change. However, there has been relatively little research into the implications of 2°C, or any other degree of global warming, for regional climate. This lack of research is particularly pressing in the case of vulnerable regions, including many in Africa. In recognition of this research gap, we conducted an in depth study of changes in African temperature and precipitation associated with 1°C, 1.5°C, 2°C, 3°C, 4°C, and beyond, using output from almost 400 climate model experiments: simulations from international modelling centres (CMIP3 and CMIP5), two perturbed physics ensembles, and a group of five regional models.

The implications of global warming are different depending on which models are consulted, but each model consistently shows that temperature and precipitation anomalies are enhanced progressively with global warming. At 1°C, there is little significant change, but from 1.5°C or 2°C anomalies develop which grow in magnitude and spatial extent with global temperature, for example drying over Angola, and wetting in East Africa. The main difference between ΔTg intervals is in the magnitude and spatial extent of change. There do not appear to be rapid accelerations in the rate of change or trend reversals. This is not only true for lower levels of anthropogenic forcing, but also at higher degrees of warming up to 6°C.

This finding has potential implications for policy. Given that larger changes in climate are likely to generate greater challenges for society, it suggests that global temperature should be limited to the lowest level possible. It does not imply that 2°C, or any other ΔTg increment, should be a preferred target from the perspective of regional climate. However, it is important to consider whether the approximately linear relationship between global warming and local climate change implied by the model experiments is reliable. It may be that the models are unable simulate feedbacks in the earth system which might lead to nonlinear change, due to their resolution and complexity. Analysis of earth system models run in long experiments with high levels of greenhouse gas forcing does reveal some nonlinear change. Further research might be needed to test the rate of change in global climate models before their results are used to infer difference between 1.5°C, 2°C, and other degrees of warming.