Mechanical Engineering Doctoral Defense

Improving Climate Projections Through the Assessment of Model Uncertainty and Bias in the Global Water Cycle

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abstract

The implications of a changing climate have a profound impact on human life, society, and policy making. The need for accurate climate prediction becomes increasingly important as we better understand these implications. Currently, the most widely used climate prediction relies on the synthesis of climate model simulations organized by the Coupled Model Intercomparison Project (CMIP); these simulations are ensemble-averaged to construct projections for the 21st century climate. However, a significant degree of bias and variability in the model simulations for the 20th century climate is well-known at both global and regional scales. Based on this insight, the following study provides an alternative approach for constructing climate projections that incorporates knowledge of model bias. The approach is implemented on a global scale with an emphasis on semiarid regional studies for their particular vulnerability to water resource changes. The new scheme is tested on the former CMIP Phase 3 (CMIP3) and current Phase 5 (CMIP5) model archives. This investigation is accompanied by a detailed analysis of the dynamical processes and water budget to understand the behaviors and sources of model biases. Sensitivity studies of selected CMIP5 models are also performed with an atmospheric component model by testing the relationship between climate change forcings and model simulated response. The information derived from each study is used to determine the progressive quality of coupled climate models in simulating the global water cycle by rigorously investigating sources of model bias related to the moisture budget. As such, the conclusions of this project are highly relevant to model development and potentially may be used to further improve climate projections.

July 12, 2013; 10:00 AM; ERC 593