Mechanical Engineering Master's Defense

Assessments of global model simulations of present and future climate

School for Engineering of Matter, Transport and Energy

Sujay Kulkarni

Advisor: Dr. Huei-Ping Huang

abstract

Climate change has been one of the major issues of global economic and social concerns in the past decade. To quantitatively predict global climate change, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations have organized a multi-national effort to use global atmosphere-ocean models to project anthropogenically induced climate changes in the 21st century. The computer simulations performed with those models and archived by the Coupled Model Intercomparison Project – Phase 5 (CMIP5) form the most comprehensive quantitative basis for the prediction of global environmental changes on decadal-to-centennial time scales. While the CMIP5 archives have been widely used for policy making, the inherent biases in the models have not been systematically examined. The main objective of this study is to validate the CMIP5 simulations of the 20th century climate with observations to quantify the biases and uncertainties in state-of-the-art climate models. Specifically, this work focuses on three major features in the atmosphere: the jet streams over the North Pacific and Atlantic Oceans and the low level jet (LLJ) stream over central North America which affect the weather in the United States, and the near-surface wind field over North America which is relevant to energy applications. The errors in the model simulations of those features are systematically quantified and the uncertainties in future predictions are assessed for stakeholders to use in climate applications. Additional atmospheric model simulations are performed to determine the sources of the errors in climate models. The results reject a popular idea that the errors in the sea surface temperature due to an inaccurate ocean circulation contributes to the errors in major atmospheric jet streams.

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