Simulating aerosol-cloud-radiation-climate interactions using online-coupled WRF-CAM5 over East Asia

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Introduction

Accurate simulations of aerosol-cloud-radiation-climate feedbacks require robust parameterizations in regional and global climate models. The Weather Research and Forecasting Model with Chemistry version 3.4.1 (WRF/Chem v3.4.1) with physics packages from the Community Atmosphere Model version 5 (CAM5) (WRF-CAM5) is a new regional climate model to assess the robustness of CAM5 physics package for high-resolution climate modeling. This study presents recent model development, multi-year application, and evaluation over nested domains in East Asia.

Model Development and Evaluation

To enhance the model's capability in reproducing aerosol interactions with various types of clouds, WRF-CAM5 is further improved by NCSU and collaborators and applied over triple-nested domains in East Asia at horizontal resolutions of 36-, 12-, and 4-km for six years (i.e., 2001, 2005, 2006, 2008, 2010, and 2011). The model accounts for the aerosol indirect effects on cumulus and ice cloud formation and offers two aerosol activation parameterizations and five heterogeneous ice nucleation parameterizations. The evaluation of baseline results against datasets from surface networks and satellites show an overall good performance for major meteorological variables, column abundances and surface concentrations of chemical species, and vertical profile of CCN but larger biases for some surface concentrations and cloud variables. Compared with the default Abdul-Razzack Ghan aerosol activation parameterization, simulations with the Fountoukis and Nenes series parameterization produce > 100% higher cloud droplet number concentrations and are more skillful in simulating cloud, radiation, and precipitation. Asian dust shows large impacts on cloud and chemical predictions, and aerosols show large impacts on Asian moosoon formation. Additional sensitivity simulations indicate the dominancy of the aerosol indirect effects in aerosol-cloud-radiation-climate interactions. The scientific/policy implications of the results will be discussed along with recommendations for future model improvement aiming at reducing the uncertainties in the current models' estimate for aerosol indirect effects.