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Simulation of the West African Monsoon using the MIT Regional Climate Model

Eun-Soon Im (1), Rebecca L. Gianotti (2), and Elfatih A. B. Eltahir (2)

(1) Singapore-MIT Alliance for Research and Technology, Center for Environmental Sensing and Modeling, Singapore, (2) Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Massachuss

We test the performance of the MIT Regional Climate Model (MRCM) in simulating the West African Monsoon. MRCM introduces several improvements over Regional Climate Model version 3 (RegCM3) including coupling of Integrated Biosphere Simulator (IBIS) land surface scheme, a new albedo assignment method, a new convective cloud and rainfall auto-conversion scheme, and a modified boundary layer height and cloud scheme. Using MRCM, we carried out a series of experiments implementing two different land surface schemes (IBIS and BATS) and three convection schemes (Grell with the Fritsch-Chappell closure, standard Emanuel, and modified Emanuel that includes the new convective cloud scheme). Our analysis primarily focused on comparing the precipitation characteristics, surface energy balance and large scale circulations against various observations. We document a significant sensitivity of the West African monsoon simulation to the choices of the land surface and convection schemes. In spite of several deficiencies, the simulation with the combination of IBIS and modified Emanuel schemes shows the best performance reflected in a marked improvement of precipitation in terms of spatial distribution and monsoon features. In particular, the coupling of IBIS leads to representations of the surface energy balance and partitioning that are consistent with observations. Therefore, the major components of the surface energy budget (including radiation fluxes) in the IBIS simulations are in better agreement with observation than those from our BATS simulation, or from previous similar studies (e.g Steiner et al., 2009), both qualitatively and quantitatively. The IBIS simulations also reasonably reproduce the dynamical structure of vertically stratified behavior of the atmospheric circulation with three major components: westerly monsoon flow, African Easterly Jet (AEJ), and Tropical Easterly Jet (TEJ). In addition, since the modified Emanuel scheme tends to reduce the precipitation amount, it improves the precipitation over regions suffering from systematic wet bias.