The behavior of two climate models that include a PDF-based parameterization

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Abstract

We report the implementation of a parameterization of subgrid probability density functions (PDFs) into two climate models, NCAR's CAM5 and GFDL's AM3. The parameterization is called "Cloud Layers Unified By Binormals" or "CLUBB". It prognoses several subgrid higher-order moments of velocity, moisture, and temperature. It then uses these moments to construct a PDF of subgrid variability on the assumption that the PDF shape is a multivariate double Gaussian. The PDFs varies with space and evolves in time according to meteorological conditions. In the initial implementation of CLUBB in CAM5 and AM3, the deep convective parameterizations in CAM5 and AM3 have been left active, but CLUBB replaces the default stratiform cloud (macrophysics), shallow cumulus cloud, and boundary layer turbulence parameterizations.

In early global simulations, AM3-CLUBB and CAM-CLUBB are almost competitive with their default counterparts, AM3 and CAM5. In both models, the inclusion of CLUBB degrades the simulation of cirrus clouds over the western Pacific warm pool. However, AM3-CLUBB improves upon the near-coastal marine stratocumulus in AM3, and CAM-CLUBB produces a more gradual and hence improved transition of stratocumulus to cumulus clouds as compared to CAM5.

One difficulty that challenges all four models is that they fail to include the (non-zero) correlation of cloud water and rain water. This omission would be expected to diminish the rate of accretion of cloud droplets by rain drops and hence the simulated rain formation rate, ceteris paribus. Work is proceeding in order to include the correlation of cloud water and rain water into global simulations with CLUBB.