Validation and improvement of moist physical processes in a GCM

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ABSTRACT

The space-time variations of the vertical structure of the latent heating from precipitating clouds have a significant impact on tropical atmospheric general circulations. Thus, it is important for general circulation models (GCMs) to properly simulate the moist physical processes associated with precipitation. The global tropical precipitation fields and latent heating profiles (-30° N ~ 30° N) from the GEOS3 GCM of the NASA Global Modeling and Assimilation Office (GMAO) are compared to TRMM estimates for Feb 1998 and July 2000. The effort is to evaluate and improve the model moist physical parameterizations.

The spatial distribution and the partition of the convective/stratiform (C/S) monthly mean precipitation rates simulated by the GCM, in general, are in good agreement with the TRMM estimates. However, the vertical structure of the heating/moistening profiles is rather different from that of TRMM estimates. From the observations it is believed that the stratiform latent heating is mainly contributed by the coupling between the convective core and anvil stratiform saturation processes through the cloud top detrained cloud properties. However, in the GEOS3 GCM, all the convective cloud liquid is collected at the cloud top with a portion of them re-evaporated as it falls resulting in convective heating/moistening and precipitation. In such a way, the convective rain re-evaporation offsets some of cumulus updraft induced heating/drying. For the coupling between the convective scheme and the planetary boundary layer (PBL), a constant forcing from convective scheme is applied evenly at each PBL layer, resulting in an overestimate of surface sensible and latent heat fluxes.

Motivated by the model deficiencies mentioned above, the model has been revised as follows: 1) the coupling between the convective scheme and the PBL is assumed to be a linear forcing profile with zero value at the surface, 2) some portion of cloud top liquid is detrained and treated as anvil rain and re-evaporated as it falls, and 3) the amount of stratiform rain is the sum of the anvil rain and that from large-scale condensation/evaporation processes. With the revised model moist physics, the overestimate of sensible heat flux is reduced over oceans and land. The moist heating/moistening profiles and the partition between the convective and stratiform rain rates correspond reasonably well with those derived from the TRMM estimates. The results emphasize that the heating/moistening profiles and the large-scale rain rates are very sensitive to the amount of cloud-top detrainment of cloud liquid, and that a direct coupling between the convective scheme and large-scale condensation in GCMs is crucial.

We will present some of the results of the model sensitivity tests at the meeting.

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