P1.4 VALIDATION AND IMPROVEMENT OF MOIST PHYSICAL PROCESSES IN A GCM

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1. INTRODUCTION

The space-time variations of the vertical structure of the latent heating from precipitating clouds and a proper interaction between the cloud and planetary boundary layer (PBL) have a significant impact on tropical atmospheric general circulations. 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^o N ~ 30^o N) from the GEOS3 GCM of the NASA Global Modeling and Assimilation Office (GMAO) are compared to TRMM estimates for Feb 1998. The effort is to evaluate and improve the model's moist physical parameterizations.

2. BACKGROUND

The spatial distribution and the partition of the convective/stratiform (C/S) monthly mean precipitation rates simulated by the GEOS3 GCM, in general, are in good agreement with the TRMM estimates (Tao et al., 1998). However, the vertical structure of the heating/moistening profiles is rather different from that of TRMM's estimates (Not shown). 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(for example, Houze 1997).. However, in the GEOS3 GCM (referred as CONTROL), 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. In addition, for the coupling between the convective scheme and the planetary boundary layer (PBL), illustrated by Fig. 1, a constant forcing from convective scheme is applied evenly at each PBL layer, resulting in an overestimate of surface sensible and latent heat fluxes (Fig. 2).

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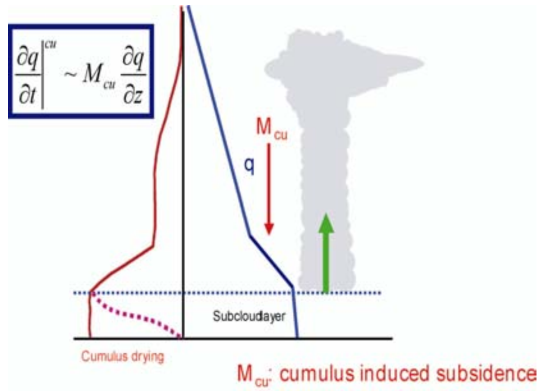

Figure 1. Illustration of the modification of the interaction between the convection and PBL schemes in the GEOS3 GCM.

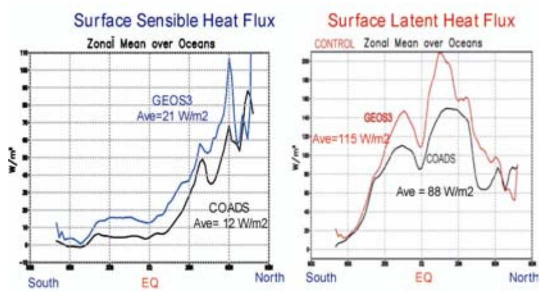

Figure 2. Zonally average of model simulated surface sensible (left) and latent (right) heat fluxes of the GEOS3 GCM.

3. MODEL REVISIONS AND RESULTS

Motivated by the model deficiencies mentioned in Section 2, 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 indicated as a dashed line in Fig. 1, 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 from monthly mean of 21 to 17 (W m^{-2}) compared to that of COADS of 14 (W m^{-2}) over oceans (Fig. 3).

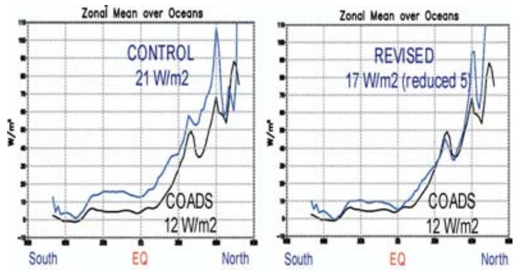

Figure 3 Monthly zonal mean surface sensible heat flux (W m^{-2}) of (left) simulated Control and (right) revised compared to COADS for Feb of 1998,respectively.

With the revised GEOS3 AGCM, the simulated precipitation and its partition between convective and stratiform shown in figure 6 are qualitatively more comparable to the TRMM's (Fig. 5) than that with the Control (Fig. 4)

The moist heating/moistening profiles and the partition between the convective and stratiform rain rates correspond reasonably well with those derived from the TRMM's estimates (Not shown).

4. CONCLUSION

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 proper coupling between the convection, PBL and large-scale condensation schemes in GCMs is crucial.

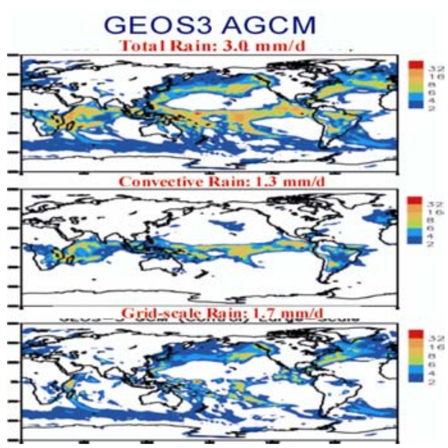

Figure 4 Monthly mean rainfall (mm day^{-1}) of (upper) total, (middle) convective and (lower) stratiform for Feb of 1998 simulated by the control version of the GEOS3 GCM, respectively.

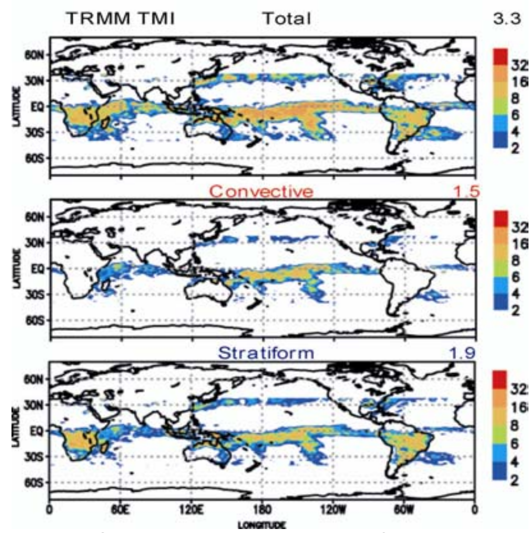

Figure 5 Same as in Fig. 4 but derived from TRMM TMI.

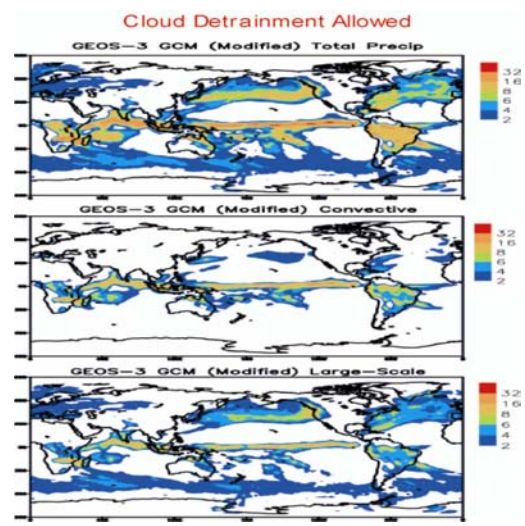

Fig. 6 Same as in Fig. 4 but for the revised version of the GEOS3 GCM.

REFERENCE

Houze, Robert A. 1997: Stratiform Precipitation in Regions of Convection: A Meteorological Paradox?. *Bulletin of the American Meteorological Society*: Vol. 78, No. 10, pp. 2179–2196.

Tao, W.-K., Lang, S., Olson, W. S., Meneghini, R., Yang, S., Simpson, J., Kummerow, C., Smith, E., Halverson, J. 2001: Retrieved Vertical Profiles of Latent Heat Release Using TRMM Rainfall Products for February 1998. *Journal of Applied Meteorology*: Vol. 40, No. 6, pp. 957–982.