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Annual Progress Report to NASA for

USE OF TRMM DATA TO TEST AN IMPROVED PARAMETERIZATION OF STRATIFORM PRECIPITATION

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ANNUAL REPORT

1. FLYING THE TRMM SATELLITE IN A GCM

By incorporating the TRMM satellite orbital information into the most recent geodesic version of the Colorado State University General Circulation Model (CSU GCM), we are able to fly a satellite in the GCM, and sample the simulated atmosphere in the same way as the TRMM sensors sample the real atmosphere. The TRMM sampling statistics of precipitation and radiative fluxes at annual, intra-seasonal, monthly-mean and composited diurnal time scales are evaluated by comparing the satellite-sampled against fully-sampled simulated atmospheres. This information provides a valuable guidance for efficient usage of TRMM data and future satellite mission plannings.

We have also evaluated the effects of TRMM sampling errors on the inferred tropical-mean hydrologic cycle and radiative fluxes. We have found that there are strong spurious oscillations associated with the TRMM orbital geometry, with periods of 23 days and 3-4 months, in tropical-mean daily and monthly precipitation. Caution must therefore be used when applying TRMM observations of tropical-mean precipitation to interpret climate variations at intraseasonal and interannual scales.

A manuscript (Lin et al. 2001) has been submitted to JGR.

2. USE OF TRMM DATA TO EVALUATE A CONVECTION PARAMETERIZATION

The CSU GCM uses a prognostic kinetic energy (CKE) to relax the quasi-equilibrium closure of the Arakawa-Schubert cumulus parameterization. A parameter, α, is used to relate the CKE to the cumulus mass flux. This parameter is expected to vary with cloud depth, mean shear, and the level of convective activity, but up to now a single constant value for all cloud types has been used. By comparing climate simulations run with the CSU CGM against TRMM, ERBE, and ISCCP, we found that this approach cannot yield realistic simulations of both the diurnal cycle and the monthly mean climate states (Lin et al. 2000).

A physically-based parameterization has been developed to incorporate cloud depth, mean shear, and the vigor of convection. We have tested it in a single-column model and a full GCM. Preliminary results indicate that the new scheme gives improved simulations over the tropical summer continents. We are now combining 2-D and 3-D cloud resolving model simulations to estimate the statistical features of these effects over different climate regimes and try to incorporate these correlations into the CSU GCM.

One or two papers on this work will be prepared.

3. CONVECTIVE AND STRATIFORM PRECIPITATION IN TRMM AND IN A GENERAL CIRCULATION MODEL

Our recent results focus on the ability of the parameterizations of convection and large-scale cloud microphysics developed for CSU GCM, to simulate the partitioning between the convective and large-scale precipitation observed in TRMM.

On a monthly time scale, and for a spatial averaging of 5° in latitude by 5° in longitude, TRMM precipitation radar (PR) data show that 1) convective and large-scale precipitation always coexist; and 2) their ratio to the total precipitation is about 0.5. As an example, Fig. 1 shows a scatter diagram of the convective versus stratiform precipitation measured by the TRMM PR for the combined January 98, January 99, and January 00.

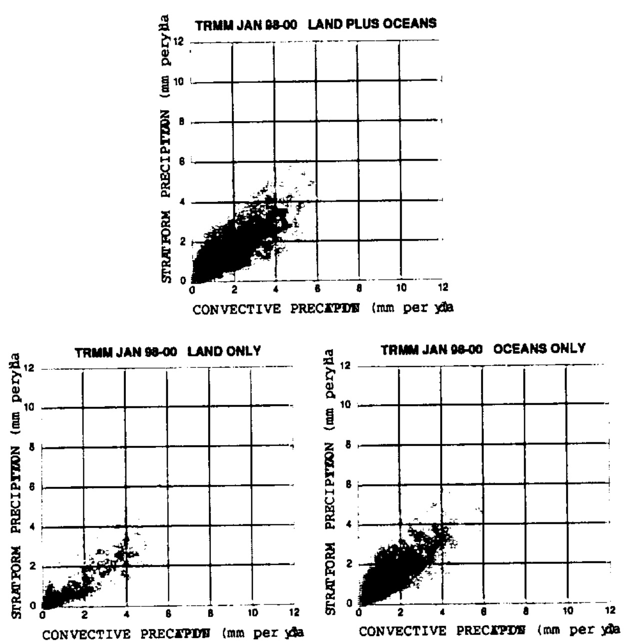

FIGURE 1: Scatter diagram of convective versus stratiform precipitation observed by the TRMM PR, for January.

Fowler and Randall (2001) describe in great details the parameterization of convection developed for the CSU GCM, and the design of two sensitivity experiments later referred to as DETSNOW and FALLIN. In DETSNOW, snow forming in convective updrafts by conversion of cloud ice to snow is detrained at the tops of the clouds. The direct effect of detraining convective snow at the tops of convective clouds is to reduce convective precipitation and to increase large-scale precipitation. In FALLIN, convective snow falls at the base the convective updrafts, increasing convective precipitation and and decreasing large-scale precipitation. In Fowler and Randall (2001), emphasis is given on the two-way interaction between the parameterization of convection and large-scale cloud microphysics.

As shown in Figs. 2 and 3, DETSNOW and FALLIN cannot simulate the observed partitioning between convective and large-scale precipitations.

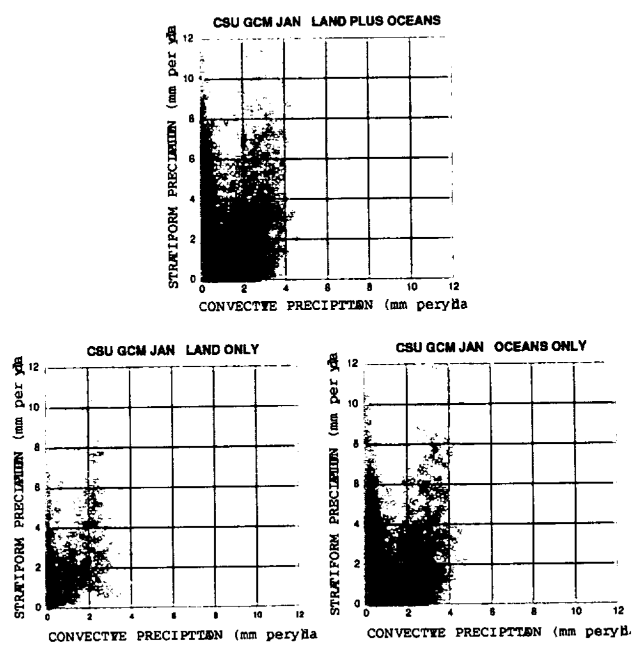

FIGURE 2: Scatter diagram of convective versus large-scale precipitation simulated by DETSNOW, for January.

Both figures show that there are a large number of grid-points for which convective precipitation occurs without large-scale precipitation, or vice versa, there are a large number of grid-points for which large-scale precipitation develops without convective precipitation, over both land and oceans. Neither DETSNOW and FALLIN reproduce satisfactorily the slope between convective and large-scale precipitations observed by the TRMM PR. In the tropics, DETSNOW yields too much large-scale precipitation while FALLIN yields too much convective precipitation.

In summary, this report illustrates how TRMM data are being used to understand deficiencies in our parameterizations of convective and stratiform clouds. A better understanding of precipitation processes in convective updrafts is needed.

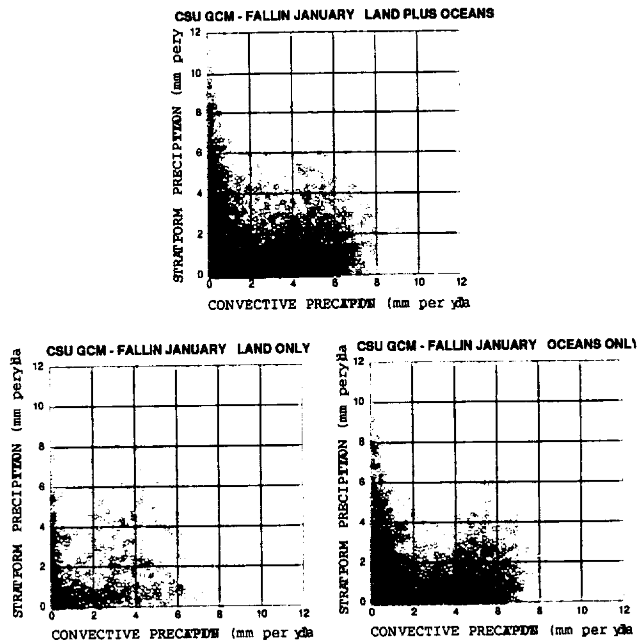

FIGURE 3: Scatter diagram of convective versus large-scale precipitation simulated by FALLIN, for January.

REFERENCES

Fowler, L.D., and D.A. Randall, 2001: Interactions between cloud microphysics and cumulus convection in a general circulation model. *Submitted to J. Atmos. Sci.*

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