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Analysis of the Diurnal Cycle of Precipitation and its Relation to Cloud Radiative Forcing Using TRMM Products

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TRMM PROGRESS REPORT

Analysis of the diurnal cycle of precipitation and its relation to cloud radiative forcing using TRMM products

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SUMMARY: While awaiting the formal release of TRMM products later this summer, and in order to improve our understanding of the interactions between clouds, radiation, and the hydrological cycle simulated in the Colorado State University (CSU GCM), we focused our research on the analysis of the diurnal cycle of precipitation, top-of-the-atmosphere and surface radiation budgets, and cloudiness using 10-year long AMIP[1] simulations. Comparisons of the simulated diurnal cycle were made against the diurnal cycle of ERBE[2] radiation budget and ISCCP[3] cloud products. This report summarizes our major findings over the Amazon Basin.

1. First analysis using TRMM data

Figures 1 and 2 illustrate first comparisons that we started to undertake between components of the hydrologic cycle simulated with the CSU GCM and retrieved from TRMM data. Figure 1 shows the January ensemble average of the rainfall rate simulated by the model against the single January-averaged rate measured by the TRMM precipitation radar. Figure 2 shows the vertical distribution of the monthly-aver-

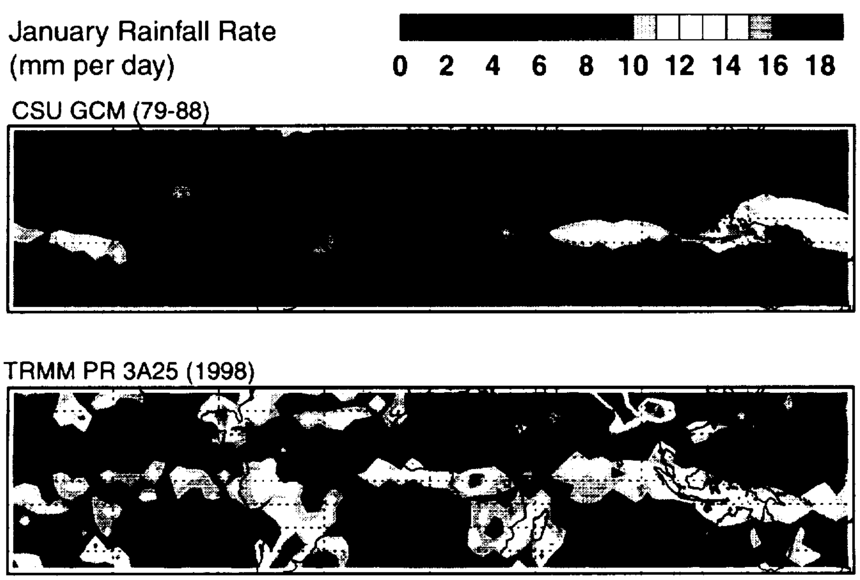

FIG. 1. Geographical distribution of the monthly-averaged rainfall rate simulated with the CSU GCM (top panel) and measured by the TRMM precipitation radar (bottom panel), for January. Units are millimeters per day.

1. AMIP: Atmospheric Model Intercomparison Project.
2. ERBE: Earth Radiation Budget Experiment.
3. ISCCP: International Satellite Cloud Climatology Project.

aged profiles of cloud water and cloud ice mixing ratios simulated with the CSU GCM against those retrieved from the TRMM Microwave Imager (TMI) for a single model grid-box located over the Amazon Basin. These results are of course preliminary. We plan to extend this type of analysis when recalibrated gridded data will become available later this summer.

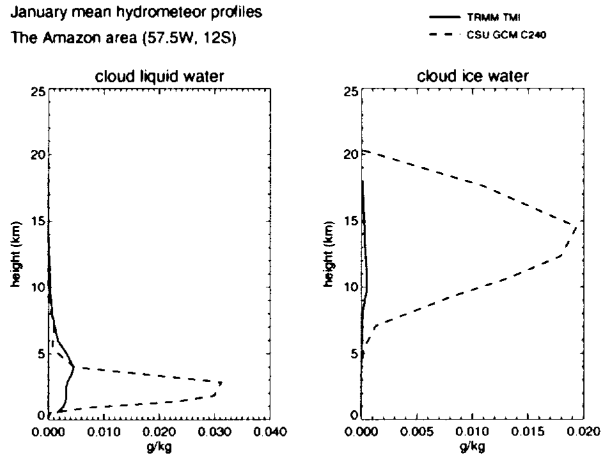

FIG. 2. Vertical distribution of the monthly-averaged cloud water (left panel) and cloud ice (right panel) mixing ratios simulated with the CSU GCM against TMI retrieved profiles, for January. The TMI profiles were obtained by spatially averaging pixel-level data over a model grid-box.

2. Diurnal cycle analysis

We plan to use TRMM gridded orbit data to reconstruct the diurnal cycle of precipitation on a seasonal scale, as data become available. Figure 3 shows the regional distribution of the first harmonic of the diurnal cycle of precipitation simulated with the CSU GCM over the Amazon Basin in January. The phase and amplitude of the diurnal cycle are highly variable across the whole basin. The amplitude of the diurnal cycle is the strongest in the center of the continent with a maximum in precipitation around 17:00 LST. One

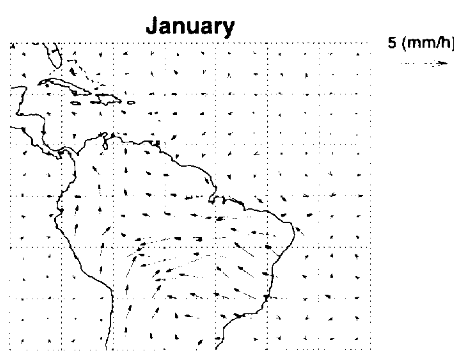

FIG. 3. Phase and amplitude of the first harmonic of the diurnal cycle of precipitation simulated with the CSU GCM over the Amazon Basin, for January. Arrows pointing upward indicate maxima at local midnight, those pointing downward indicate maxima at local noon.

of the TRMM science objective was to understand the difference in the diurnal cycle of precipitation between land and oceans, and help validate the diurnal cycle of precipitation simulated with general circulation models (GCMs). Besides monthly-averaged data, this product is sorely needed for GCM related climate research.

In order to improve our understanding of the interactions between clouds, radiation, and the hydrologic cycle in the CSU GCM, we computed the diurnal cycle of the short and long wave components of the top-of-the-atmosphere radiation budget, and cloudiness. Figures 4 and 5 illustrate the kind of analysis that we conducted using ERBE radiation budget and ISCCP cloud products. As seen in both figures, there are signicant differences between the simulated and satellite-derived top-of-the-atmosphere outgoing long-wave radiation (OLR) and upper-tropospheric cloudiness. The OLR simulated with the CSU GCM is over-estimated relative to the ERBE data over a major part of the Amazon Basin. Comparison against ISCCP-D1 data reveal that the amplitude of the diurnal cycle of simulated cloudiness is too small and out of phase relative to that obtained from the satellite retrieval.

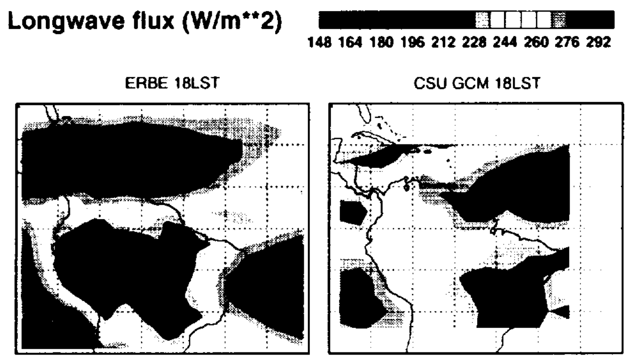

FIG. 4. Regional distribution of the monthly-averaged top-of-the atmosphere outgoing longwave radiation at 18:00 LST, in January. The left panel is from ERBE S9 data and the right panel is from the CSU GCM.

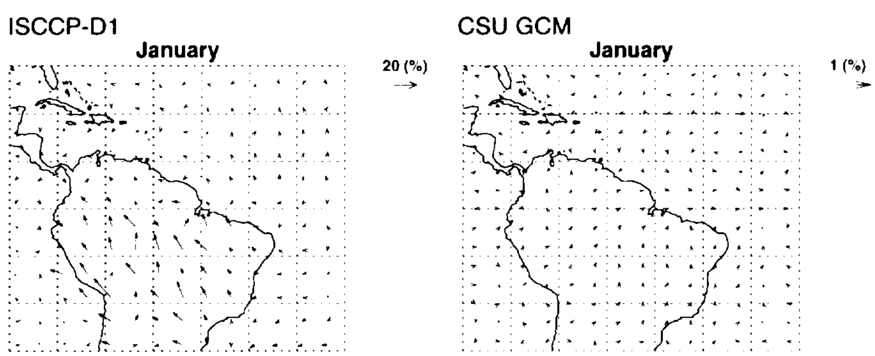

FIG. 5. Phase and amplitude of the first harmonic of the diurnal cycle of high-level clouds obtained from ISCCP-D1 data (left panel) and simulated with the CSU GCM (right panel).

CONCLUSION: The results presented are snapshots of systematic comparisons made between components of the hydrological cycle, radiation budget, and cloudiness simulated with the CSU GCM against a variety of satellite data, including preliminary data from TRMM. Now that TRMM products are becoming available, we will focus our efforts on the use of TRMM products to understand strength and weaknesses of the hydrologic cycle simulated with the CSU GCM.