Diurnal Cycle of Convection, Clouds and Upper Troposphere Humidity

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ABSTRACT

Multi-scale Modeling Framework (MMF) is a new approach in which the conventional cloud parameterization in global climate models is substituted by the cloud resolving models, thus cloud related dynamical, physical and chemical processes can be represented on their native scale. Previous observational study (Tian et al, 2004) shows that there is a clear land-sea contrast in the diurnal phase relationship between upper tropospheric relative humidity (UTH), high clouds (CLD) and precipitation index (PI). Our study aims to make an assessment on the diurnal cycle of deep convections in the MMF based on this relationship. 3-hourly global data for July 1999 are collected both from MMF simulations and satellite observations (Tian et al, 2004). Brightness temperatures (at 6.7 and 11 micrometer) are simulated based on the MMF cloud microphysics, surface properties and the atmospheric vertical structures of temperature, humidity and ozone. PI, high clouds and UTH are retrieved from the brightness temperatures with the same algorithm in Tian et al. 2004. Monthly mean, diurnal composites and anomalies are constructed and compared to both the satellite data and the MMF model output. Three years continuous forcing data (Xie et al. 2004) from Atmospheric Radiation Measurement (ARM) Southern Great Plain (SGP) site are also analyzed and compared to the MMF output data on the nearest GCM grid point to the SGP site. In this poster, preliminary results and analysis are presented.

Monthly Mean Precipitation

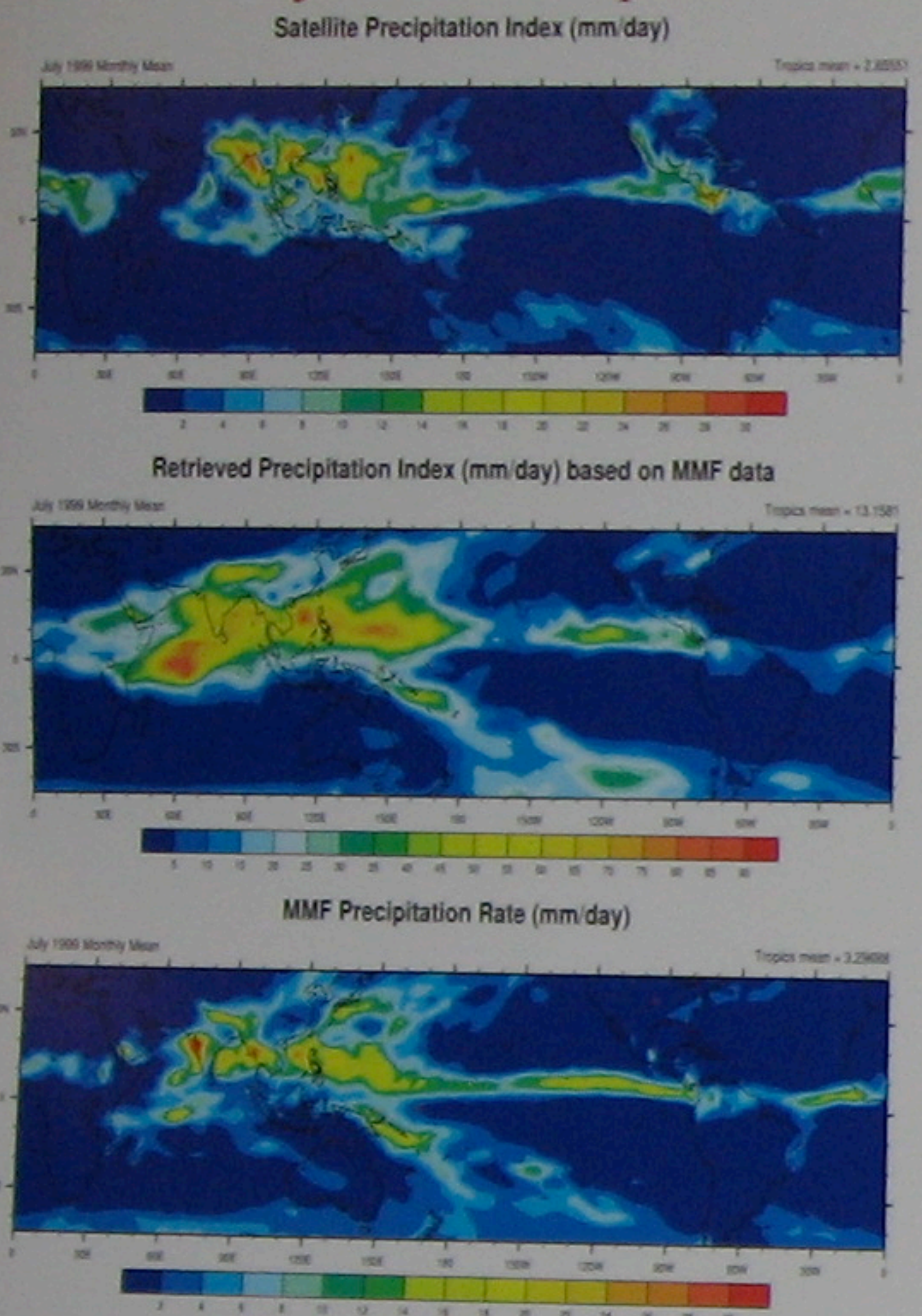

Figure 1: Monthly mean precipitation. Notice that in the middle panel, the retrieved PI is much higher than both the satellite data (upper) and the MMF model output (lower).

Precipitation Diurnal Cycle

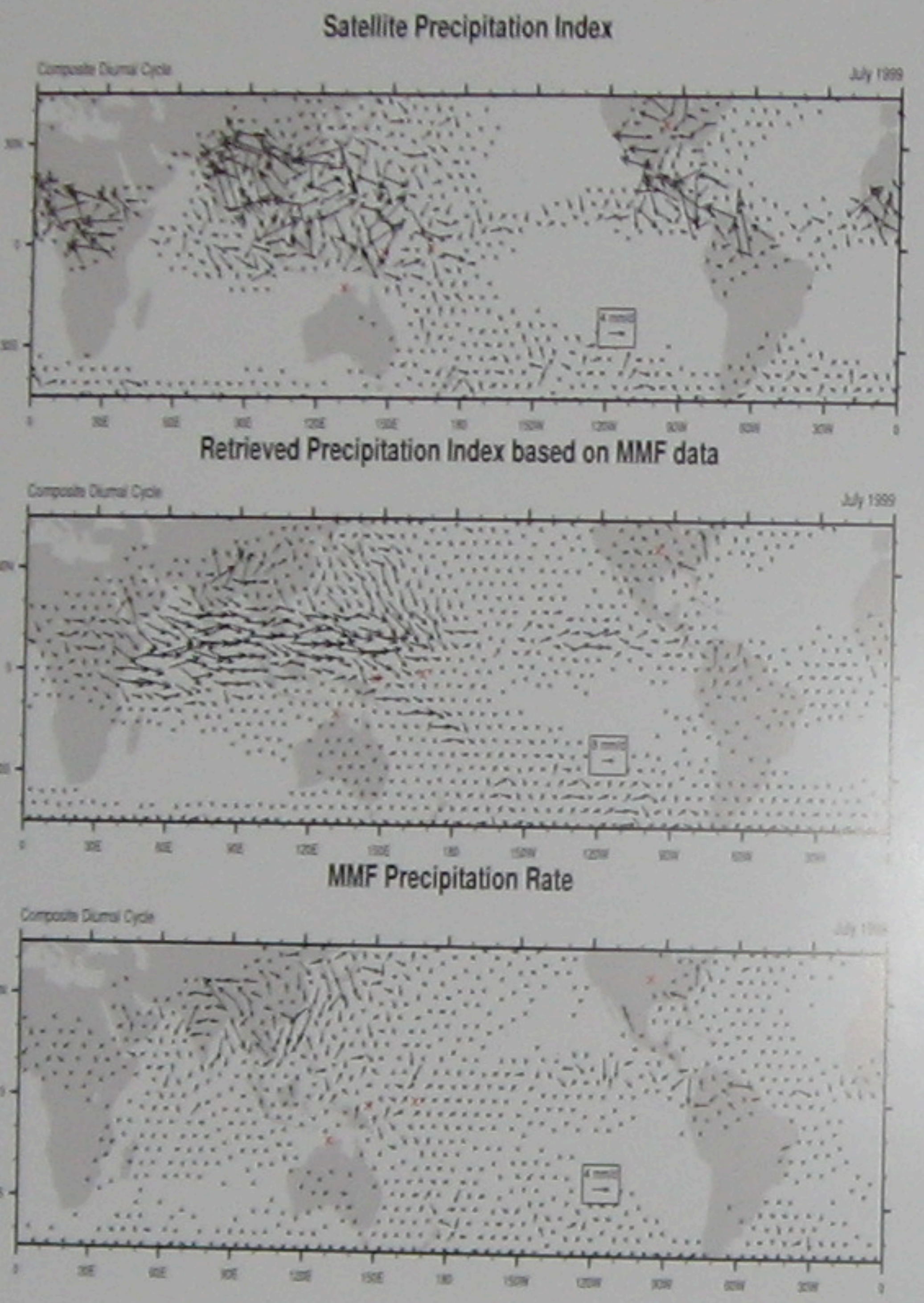

Fig 2:Diurnal amplitudes and phases of precipitation. The length of the arrow depicts the diurnal amplitude. The diurnal phase corresponds to the local time of maximum and can be determined from the orientation of the arrows with respect to a 24-hour clock. Arrow pointing upward indicate a peak at 0000 local standard time (LST midnight), downward indicate a peak at 1200 LST (noon), toward the right indicate a peak at 0600 LST (dawn), and toward the left indicate a peak at 1800 LST (sunset).

Diurnal Anomalies in Tropics

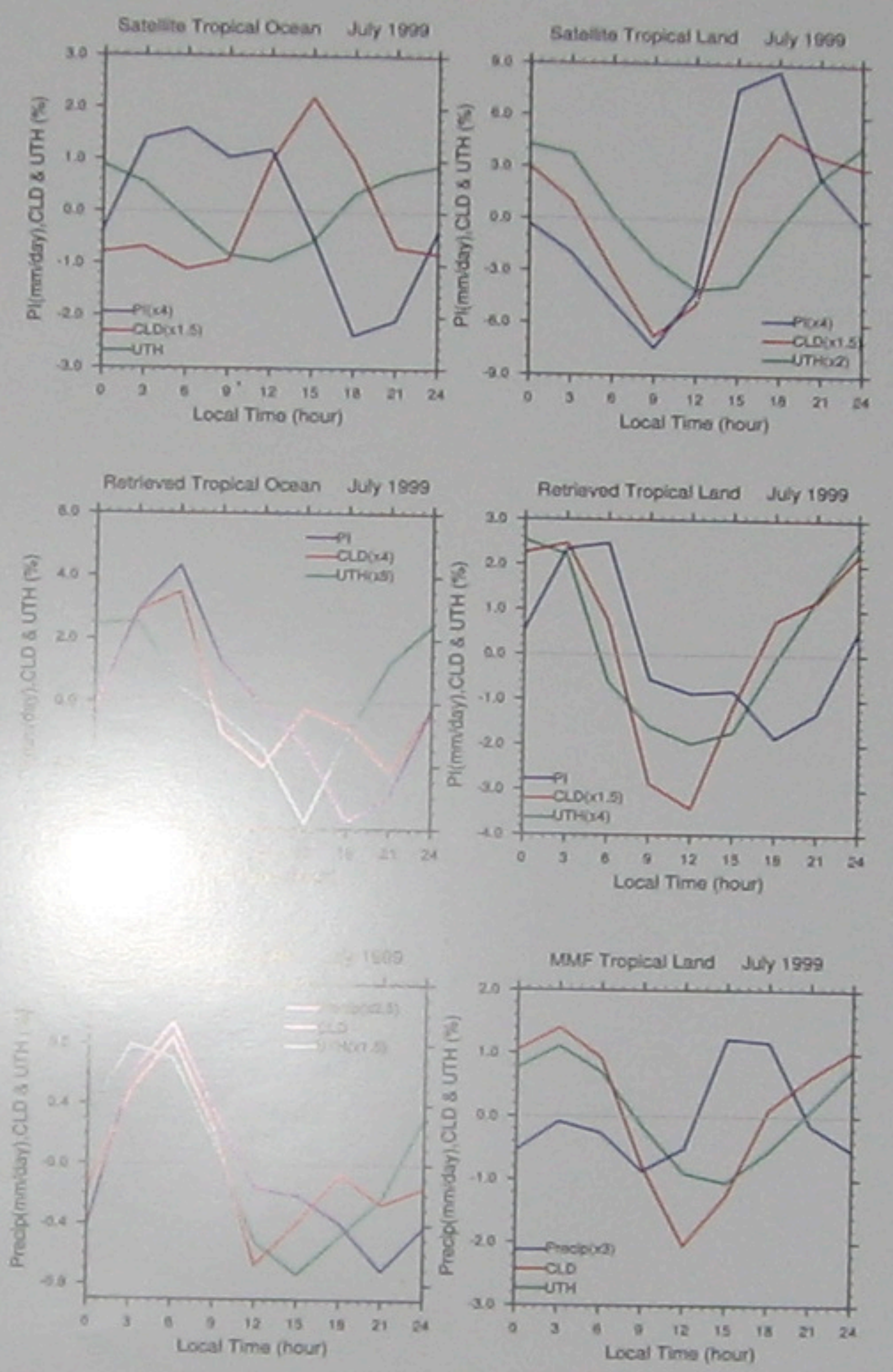

Fig 3: Diurnal anomalies in deep convection precipitation (PI), high cloud amount (CLD), and upper tropospheric relative humidity (UTH) for spacial weighted average over tropical ocean (left three) and tropical land (right three) regions.

Diurnal Cycle in ARM-SGP Site

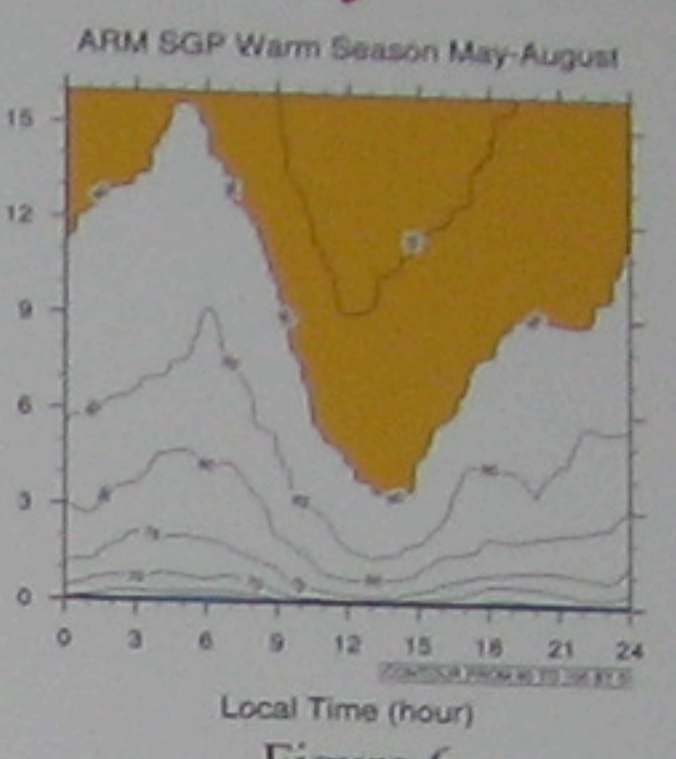

Figure 6.

3-year ARM SGP continuous forcing data for warm season are analyzed (366 days). Figure 6 shows the cumulative probability for cases (among 366 days) with precipitation rate under a specific level at a specific LST. Area above 90 percent is shaded. A primary peak is before dawn (0300 LST) and a secondary peak is in the late afternoon (1800 LST). Based on the precipitation rate magnitude and peak time, diurnal composites of precipitation (Fig.7) and cloud fraction (Fig.8) are constructed among three categories: weak (second row), daytime (third row) and nighttime (last row) precipitating cases. Shaded area in Fig. 7 shows the specific studied time period. The preceding and following diurnal cycles are also shown.

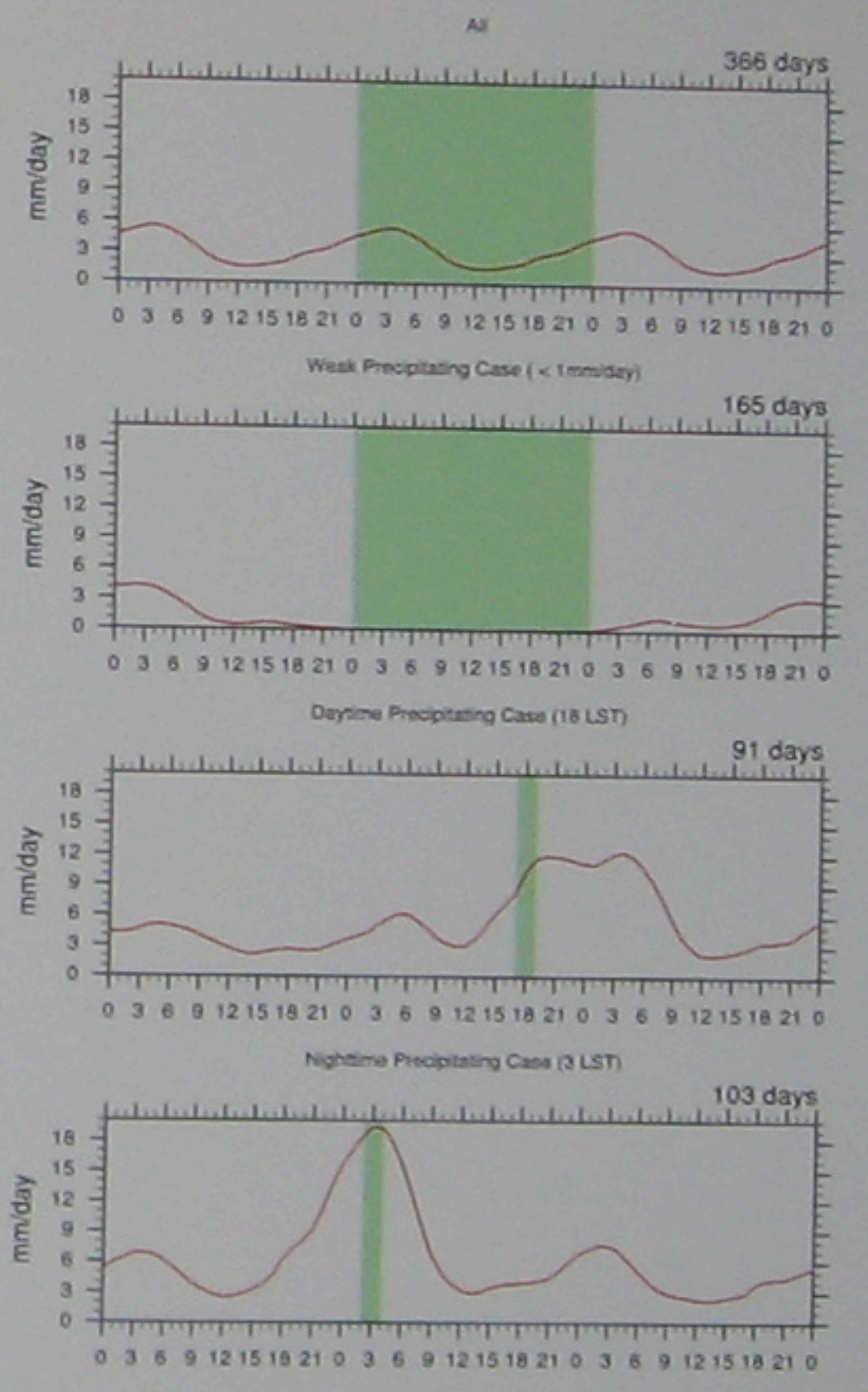

Figure 7.

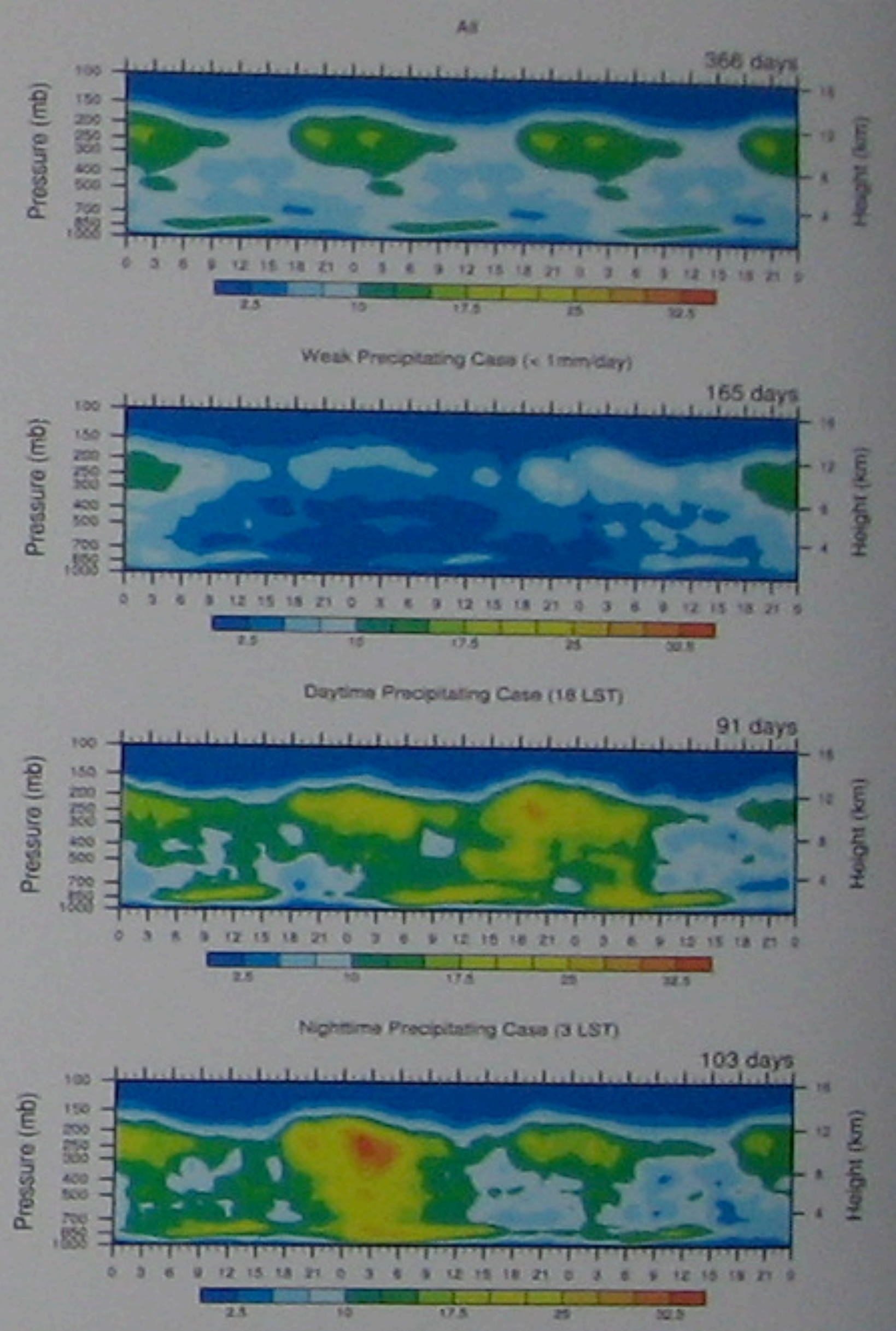

Figure 8.

Brightness Temperature Analysis

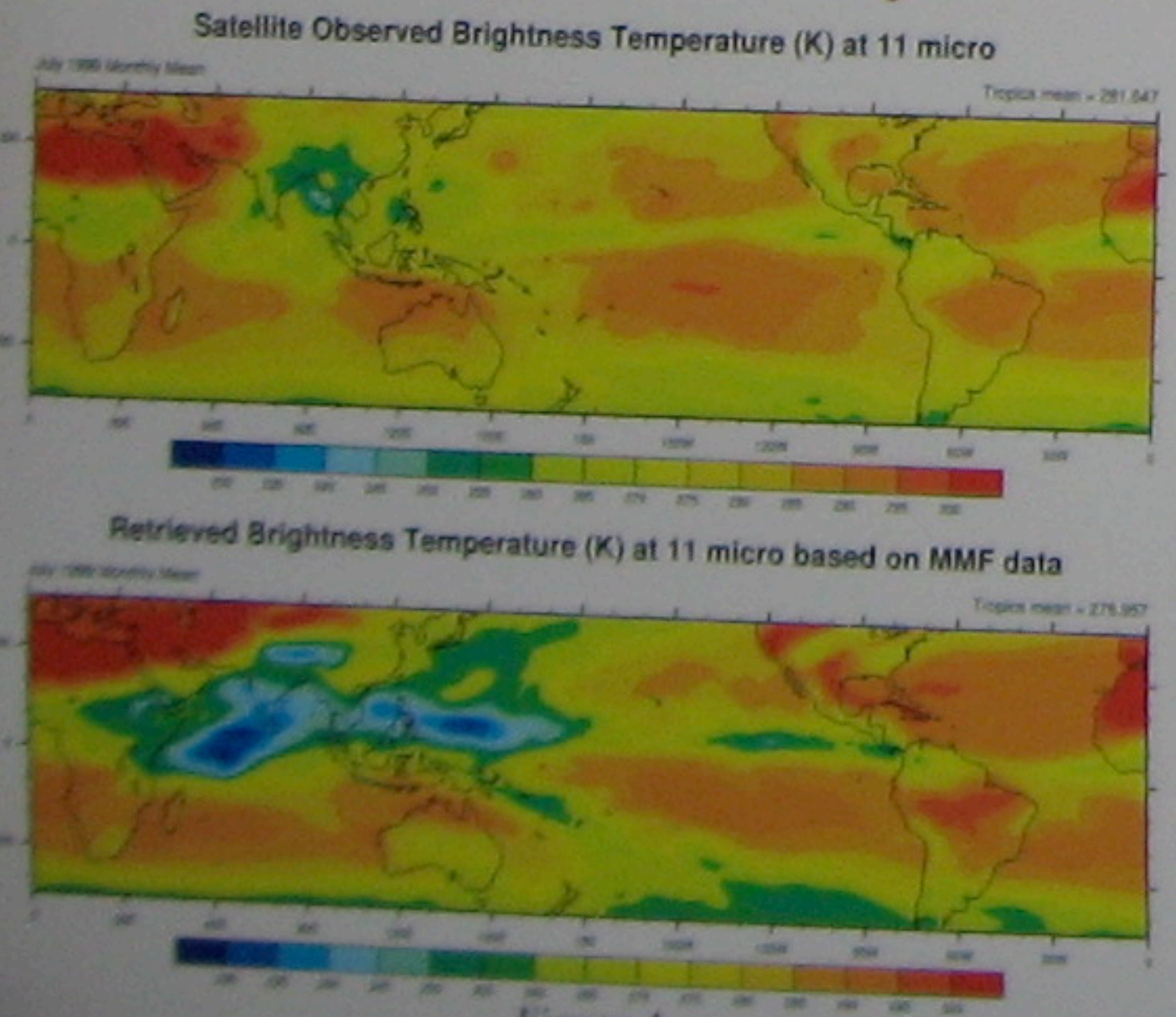

Figure 4.

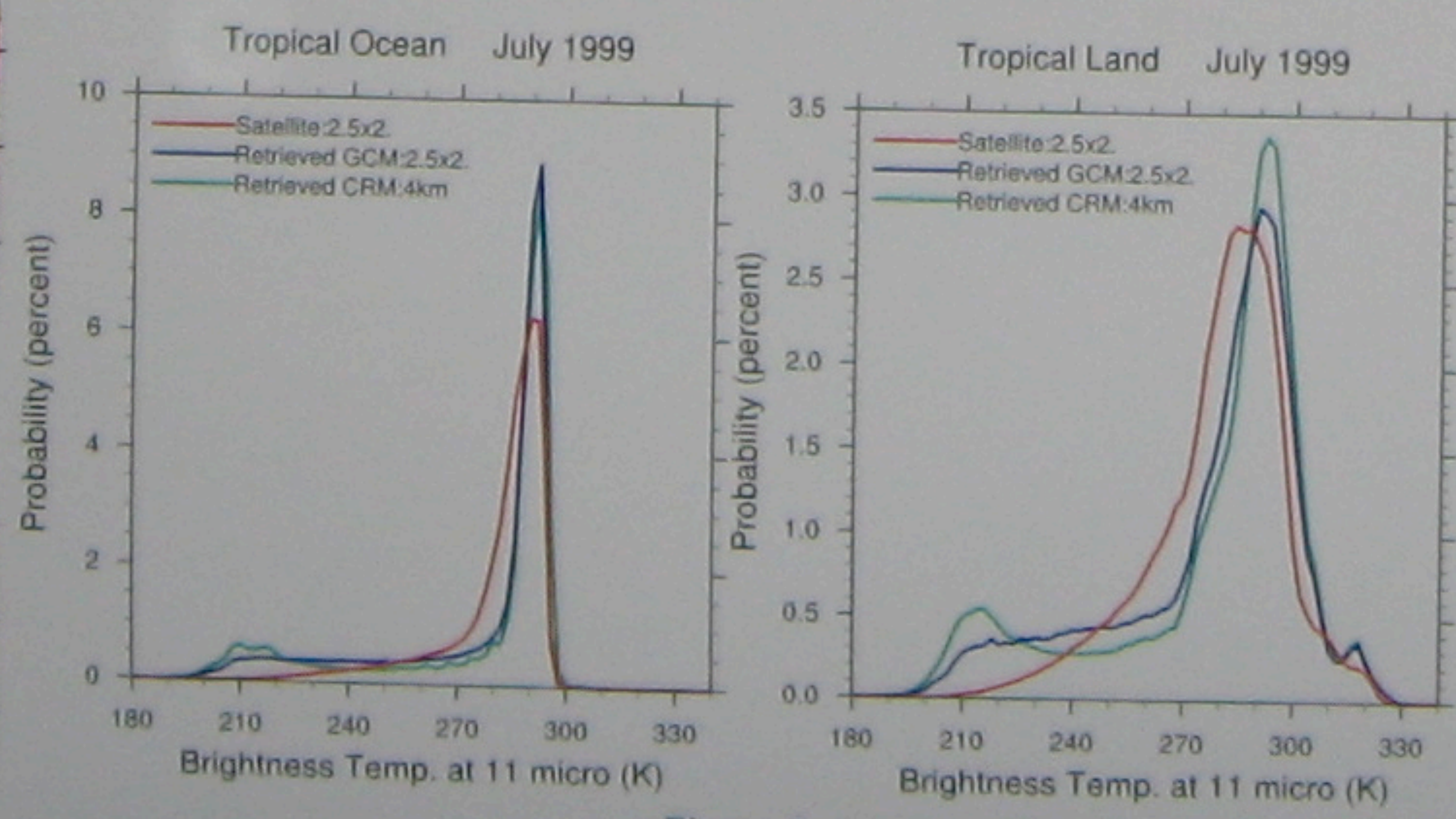

Figure 5.

Figure 4 shows the monthly mean brightness temperature at 11 micro (TB11) from satellite (upper) and the retrieval based on MMF data (lower).

Figure 5 shows the probability density function for retrieved TB11 on land (right) and ocean (left) compared to observations.

The overestimation of both monthly mean value (Fig 1.) and diurnal amplitude (Fig 2.) and biased phase on land (Fig 3.) in the retrieved PI fields are related to the underestimation of the retrieved TB11 fields (Fig.4 &5) based on MMF data. This suggests that MMF cloud fields may be biased in either the cloud top height (too high) or the area of deep convection hot towers (too large).

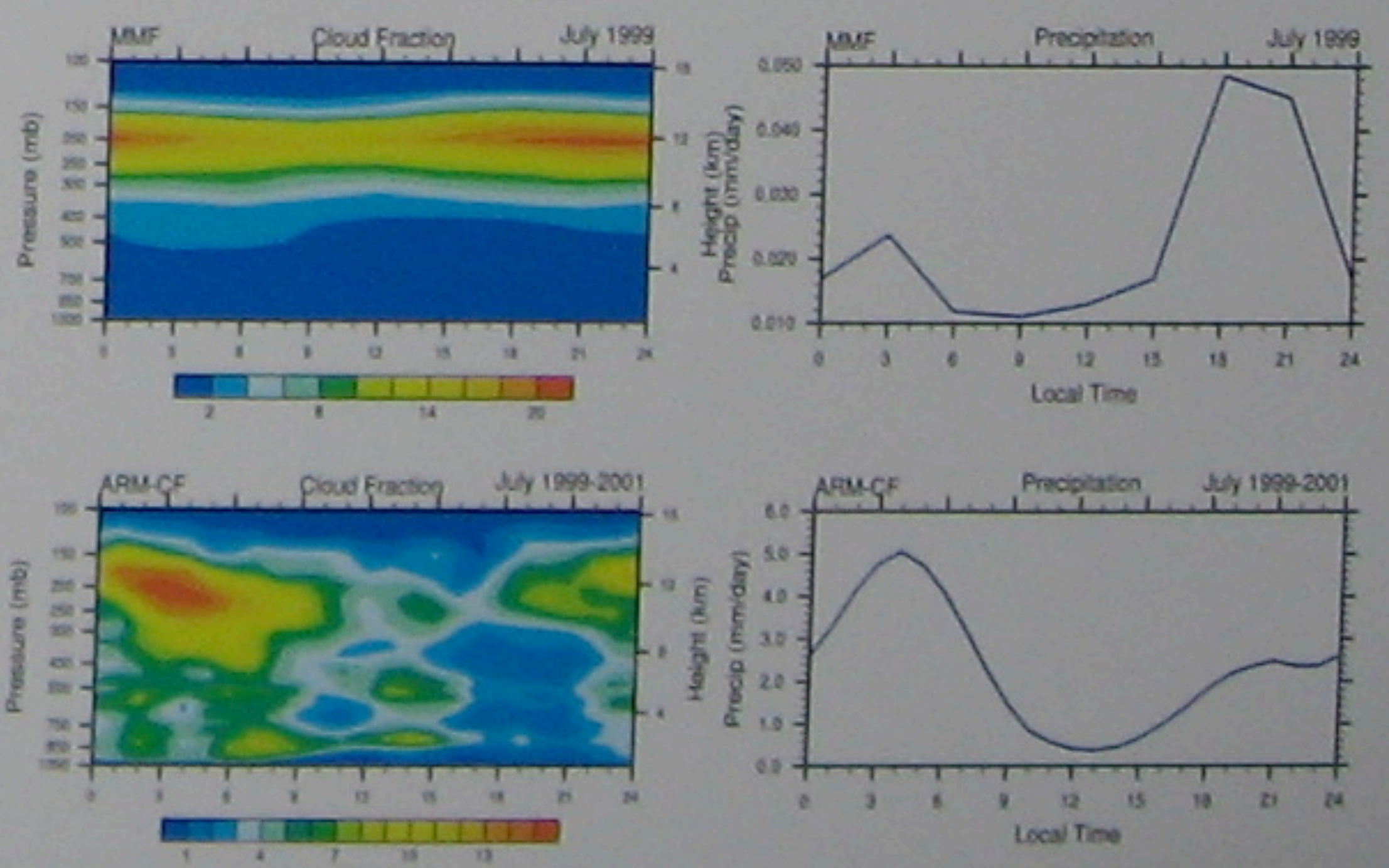

Figure 9: Diurnal composites in July at the ARM SGP site for cloud fraction (left two) and precipitation rate (right two) based on MMF output data (upper two) and ARM SGP continuous forcing data (lower two).

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