Diurnal Cycle of Deep Convection

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ABSTRACT

Multi-scale Modeling Framework (MMF) is a new approach in which the conventional cloud parameterization in global climate models (GCM) is substituted by the cloud resolving models (CRM), thus cloud related dynamics, physics and chemical processes could be represented on their native scales. In this study, we aim to develop an evaluation strategy for MMF, especially on the diurnal cycle of deep convections. 3-hourly global data for July, 1999 are collected from MMF simulations. Two analyses are shown. In tropics, we compare deep convection precipitation (PI), high cloud (CLD) and upper troposphere humidity (UTH) with the satellite observations. PI, CLD and UTH are retrieved from brightness temperatures (6.7 and 11 micro), which are simulated based on MMF data with the same algorithms in *Tian et al, 2004*. Direct outputs of precipitation rate, CLD and calculated UTH from MMF are also shown in the comparison. At ARM SGP site, 3-year hourly continuous forcing data (*Xie et al. 2004*) are adopted for diurnal cycle analysis during warm season, May to August. Based on the magnitude and the diurnal peak time of precipitation rate, we construct diurnal composites for three categories: weak, daytime and nocturnal precipitating cases. We also showed the comparison between ARM continuous forcing data and the MMF result averaged on 5 GCM grid points closest to the SGP site.

Monthly Mean

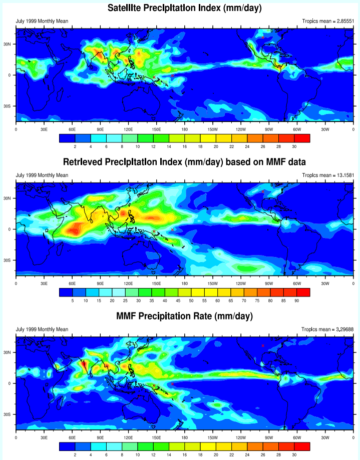

Fig.1: July 1999 monthly mean precipitation rate. Satellite observation (upper); retrieved PI based on MMF data (middle); MMF output (lower). Notice that the color scale in the middle panel is different from the other two.

Diurnal Cycle

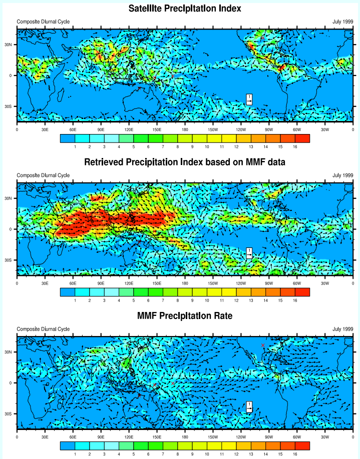

Fig.2: July 1999 mean precipitation diurnal cycle. Diurnal amplitude is in color contour. Diurnal phase corresponds to the local time of maximum. Arrow upward indicates a peak at 0000 (midnight); right for 0600; downward for 1200 (noon); left for 1800.

Diurnal Anomalies

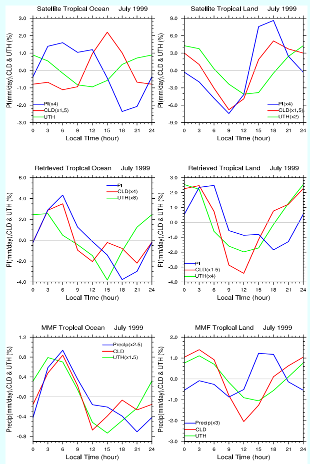

Fig.3: Diurnal anomaly composites over tropical ocean (left three) and land (right three) for precipitation (PI), high cloud (CLD) and upper troposphere humidity (UTH). Notice the scaling in the legends is different.

Brightness Temperature

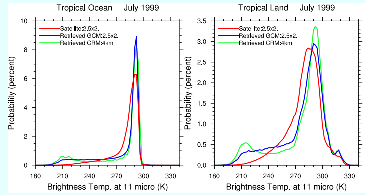

Fig.4: Probability density function for July 1999 brightness temperature at 11 micro (TB11). Observation is in red; retrieved TB11 are shown in different scales: GCM (in blue) and CRM (in green).

The overestimation of monthly mean (Fig.1), diurnal cycle amplitude (Fig.2), and the biased phase (Fig.3) in the retrieved precipitation is related to the underestimation of the brightness temperature (Fig.4). This suggests that although MMF is able to produce reasonable precipitation rate, its cloud fields may be biased in either cloud top (too high) or the area of deep convection clouds (too large).

ARM-SGP Continuous Forcing

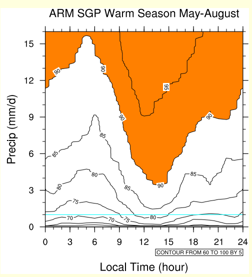

Fig.5: Cumulative probability for cases under a specific level of precipitation rate in all the available cases at a specific local time. Area above 90 percent is shaded in orange. Light blue line is the limit to distinguish deep convections and weak precipitating cases. Notice a primary peak is before dawn and a secondary peak is in late afternoon.

Precipitation

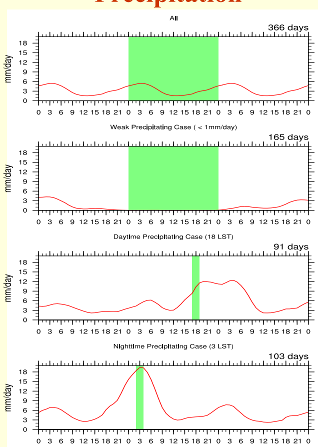

Fig.6: Diurnal cycle of precipitation for different cases. Green shaded area shows the specific studied time period. The preceding and following diurnal cycles are also shown for pre- and post-case condition analysis.

Cloud Fraction

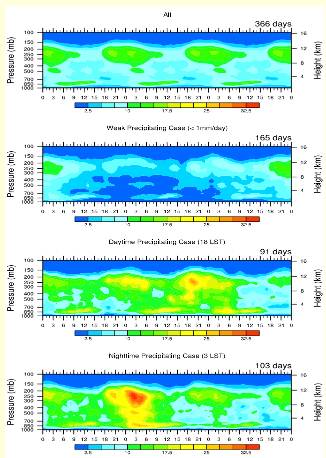

Fig.7: Diurnal cycle of cloud fraction at different vertical levels for different cases. The preceding and following diurnal cycles are also shown.

Comparison with MMF

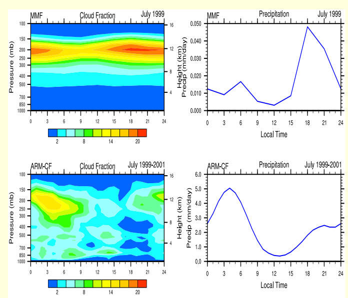

Fig.8: Diurnal cycle composites in July at ARM SGP site for cloud fraction (left two) and precipitation rate (right two) based on MMF output data (upper two) and ARM SGP continuous forcing data (lower two). Notice the different Y-Axis scale in the precipitation rate.

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