TRMM OBSERVATIONS OF THE PRECIPITATION AROUND THE HIMALAYAN REGION

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Abstract

The climatological features of the diurnal cycle of precipitation are investigated around the Himalayas by utilizing hourly, 0.05 deg. x 0.05 deg. gridded, precipitation data from the Tropical Rainfall Measuring Mission (TRMM) satellite for each meteorological season of the five-year period 1998-2002. The horizontal and vertical distribution of precipitation are investigated in the context of diurnal cycle. There is substantial seasonal and diurnal variation of precipitation over the southern slopes of the Himalayas. There is midnight-early morning peak of precipitation in the summer monsoon season. This peak migrates southward over the southern slopes of the Himalayas.

1. Introduction

It is generally said that atmospheric convection in the Himalayas and Tibetan Plateau plays an important role in sustaining the monsoon through the release of latent heat. Therefore, it is important to understand the variability of convective activities in this region. To the authors knowledge, precipitation regime has not been well studied around the Himalayas, where annual precipitation is as much as 300-400 cm over the southern slopes of the Nepal Himalayas (Shrestha 2000; Barros et al. 2000) and there appears strong variability over the diurnal cycle with nocturnal peak in rainfall during the summer monsoon season (Barros et al. 2003).

Ever since the launch of the Tropical Rainfall Measuring Mission (TRMM) in 1997, tremendous interest has arisen in the field of using these remotely sensed data to establish a global precipitation climatology. The non-synchronus orbit of TRMM has potential for documenting the diurnal cycle. The TRMM produces data from unique sensors like TRMM Microwave Imager (TMI) and Precipitation Radar (PR). TMI is a nine-channel passive microwave sensor desinged to provide quantitative rainfall information. The PR is capable of measuring the detailed, three-dimensional structure of precipitation with horizontal resolution of 4.3 km. The PR measurement has a very high accuracy, whether taken over land or ocean. More description of TRMM sensors can be found on Kummerow et al. 1998.

Here, we would like to demonstrate one of the remarkable precipitation characteristics observed by TRMM: the diurnal variation of rainfall. Areas of emphasis include: horizontal and vertical variation of the diurnal cycle of precipitation.

2. Data and Method

We mainly used PR products (e.g., PR2A25, PR2A23) to investigate precipitation distribution. The main data included are the attenuation-corrected radar reflectivity factor and near-surface rainfall rate. 'Near-surface rainfall rate' was accumulated and binned to hourly local times for the grid size of 0.05 deg. x

0.05 deg. for each meteorological season for the 5-year period 1998-2002. We adopted similar procedure for the radar reflectivity factor and storm height datasets. Additionally, we choose rainrate threshold of $<=5$ mm h^{-1}(120 mm day $^{-1}$) as light rain and >5 mm h^{-1} as moderate to heavy rain. This selection was based on the precipitation histogram tendency around the Himalayas. Refer to Bhatt and Nakamura, 2005 for more details.

3. Results and Discussion

3.1 Horizontal distribution

The spatial variability of storm height around the Himalayas is shown in Fig. 1a. It shows a difference of the peak (maximum) storm height between June-July-August (JJA) and March-April-May (MAM). Actual storm height used in our analysis is the top of the precipitation column above the ground level instead of mean sea level. There is an increase of peak storm height over the southern slopes of the Himalayas, and decrease over the northern Indian subcontinent and the Tibetan Plateau in the premonsoon season. These results suggest that there is significant difference among the storm height distribution over the Tibetan Plateau, northern Indian subcontinent and southern slopes of the Himalayas.

The storm height characteristics over the southern slopes of the Himalayas are unique. We next present area-averaged 3-hourly diurnal cycle of rainfall occurrence in three climatic divisions (refer Bhatt and Nakamura, 2005) over the Himalayas (Fig. 1b). These plots show normalized percentage of rainy grids in three climatic divisions of the Himalayas. An inspection of the diurnal cycle of precipitation reveals an afternoon maximum during the premonsoon season and midnight-early morning maximum during the summer monsoon season. Other noted features include: daytime peaks during September-October-November (SON) and December-January-February (DJF). As a unique feature, midnight-early morning southward progression of precipitation is noticed during JJA over the southern slopes of Himalayas.

3.2 Vertical distribution

As anticipated from our earlier discussion on horizontal variability, the vertical profiles of radar reflectivity factor could show relatively similar geographical variability over the Himalayas. We selected radar reflectivity factor data above the terrain and gridded for 0.05 deg. x 0.05 deg. over three climatic divisions of the Himalayas. Figure 2 shows the climatological diurnal cycle of the radar reflectivity factor and its vertical distribution averaged over the 82.5E-85.0E longitudinal belt during JJA. The white dashed contours represent the vertical velocity from GAME reanalysis dataset, which provide some idea on the upward motion. We observe, daytime northward migration of precipitation denoted by 'A' and midnight-early morning southward one denoted by 'B'. At the extreme high elevations, daytime precipitation cells are enhanced as denoted by 'C'. There is trailing stratiform precipitation in this region. The brightband altitude appears approximately at 5.5 km MSL. There is relatively deep but small precipitation system in the foothills of the Himalayas at 3-6 LT. We also studied the climatological diurnal cycle of radar reflectivity factor for MAM over the same region. We found that vertical profiles depicted isolated deeper precipitation cells (not shown) than in the summer monsoon season with no brightband. Overall, the analysis of precipitation does confirm substantial diurnal and seasonal variability.

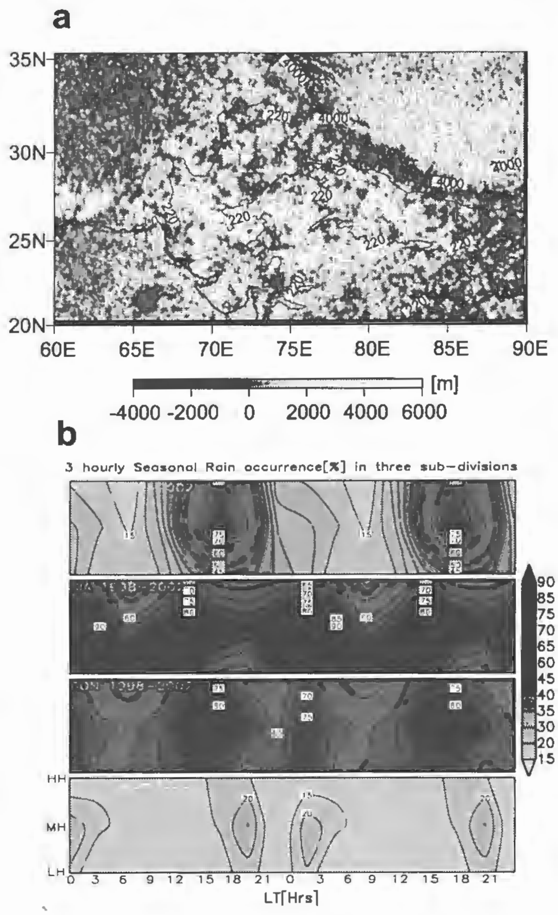

Figure 1: (a) Horizontal distribution of peak storm height difference between JJA and MAM. The topographic contours are also shown. (b) Areal representation of the seasonal variation of the diurnal cycle of rainfall occurrence in three climatic divisions over the Himalayas for eight time periods of a day. The LH, MH, HH in y-axis stand for the lower, middle and high Himalayas, respectively. See text for explanations.

4. Concluding Remarks

The climatological features of the diurnal cycle are investigated using high resolution PR data. An inspection of the diurnal cycle of precipitation appeared in PR observations reveals an afternoon maximum during the premonsoon season and midnight-early morning maximum during the summer monsoon season over the southern slopes of the Himalayas. Unlike the horizontal distribution of precipitation, the vertical distribution of precipitation shows almost similar geographical variability over the southern slopes of the Himalayas. The vertical profiles of the radar reflectivity factor reveals trailing stratiform precipitation regime over the southern slopes of the Himalayas in the summer monsoon season.

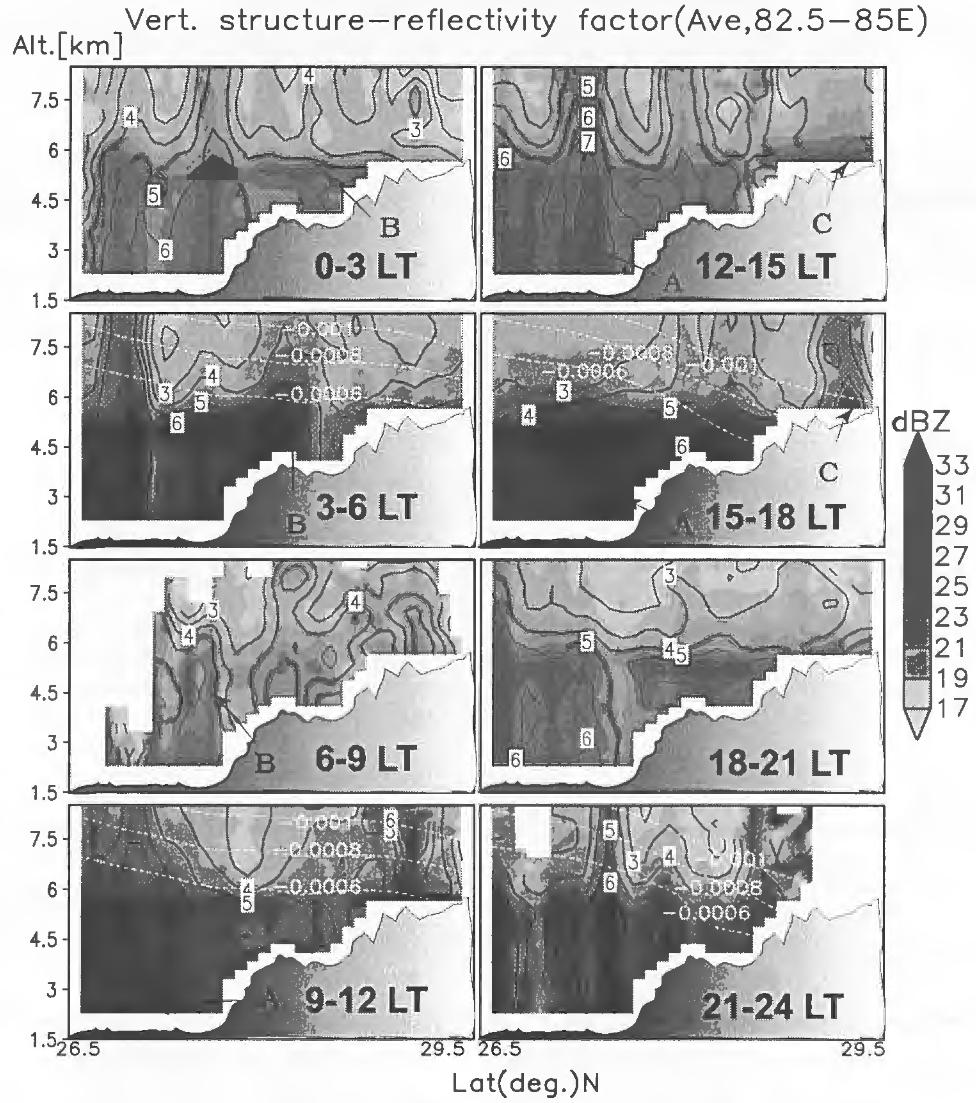

Figure 2: The diurnal variation of the vertical profiles of radar reflectivity factor averaged over 82.5°−85.0°E longitudinal belt from PR during JJA of 1998-2003. The solid contours represent standard deviation, label by label for each 250 km by 5 km segments from south to north. The white dashed contours represent climatological mean vertical velocity (m s^{-1}) averaged over 80°−85°E longitudinal belt from GAME reanalysis. For more explanations, refer to text.

References

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