ASIAN MONSOON RAINFALL CHARACTERISTICS OVER LAND BY TRMM SATELLITE AND SURFACE STATION DATA

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1. INTRODUCTION

There are several rainfall products available, especially from Tropical Rainfall Measurement Mission (TRMM), including Precipitation Radar (PR) or TRMM Microwave Imager (TMI). There are many manuscripts documenting the rainfall characteristics over Ocean (Adler et al., 2000, Short and Nakamura, 2000), but a few over land (Hirose and Nakamura, 2002). Precise rainfall measurement over land is crucial for water management, agriculture, weather forecast, disaster mitigation, which is fully related with our lives.

The main purpose of this paper is to document intercomparison among rainfall products over land and discuss the annual rainfall and seasonal change over Asian summer monsoon region.

2. DATA

The data we used are as follows.

1) TRMM 3G68 Version 5 data

- PR (2A25) and TMI (2A12) unconditional rain rate, total pixel number, rain pixel number and percentage of convective rain

0.5 deg x 0.5 deg
hourly

2) TRMM 3B43 data

Combined TRMM data with SSM/I, VIS/IR and rain gage data

1 deg x 1 deg
monthly

3) Global Precipitation Climatology Project(GPCP) data(Huffman et al., 1997)

1 deg x 1 deg
daily

4) Rain gauge data

- Global Historical Climatology Network(GHCN) http://www.ncdc.noaa.gov/(20590 stations)
- Monthly surface meteorological data of China (edited by CMA/NMC) (194 stations)
- Monthly rainfall data from India Meteorological Department (IMD) for 1871-1990 (306 stations)

3. RESULTS

3.1 ANNUAL RAINFALL

Fig. 1 shows the 5-year (1998-2002) averaged annual rainfall in 3B43 (top), masked TMI (middle) and PR (bottom). The masked TMI is referred as the TMI data with the same swath width as the PR. This is mainly due to removal of the difference in sampling error between PR and TMI. It is easily found that the rainfall maximum is found over the central Africa, maritime continent, Asian monsoon region and South America. The products look similar but if we plot the difference among the products we can see more detailed pattern. Fig. 2 shows the difference between 3B43 and TMI (top) and between 3B43-PR Rain (bottom). You may find the difference more clearly in Fig. 2. Fig. 2 shows that TMI is larger than 3B43 over the equatorial land region, but smaller over Asia. Comparing 3B43 with PR the difference is getting smaller and over South America 3B43 is larger. Also over arid area (Sahara, Saudi Arabia, Australia) PR is slightly larger than 3B43 and TMI is the smallest.

Is there any relationship between rain-type (convective, stratiform) and the difference among the products? Fig. 3 shows scatter plots between the percentage of convective rain (ordinate) and (a) TMI-PR and (b) 3B43-PR. In Fig. 3a, there is a maximum difference between TMI-PR when the convective rain is about 50-70%. This may be due to the overestimate of rainfall by TMI when the 85 GHz ice scattering signal is strong. However, Fig.3b shows a different characteristic. When the convective rain is not dominant, 3B43 is larger than PR, suggesting that PR is apt to miss stratiform rain, bacause PR cannot measure rainfall near the surface away from the sub satellite point. But when the convective rain is getting dominant (say, 60-80%) then PR is larger than 3B43. If we think PR is right then the reason is that 3B43 does not give us high spatial resolution rainfall map from IR estimation and over the mountainous area the observation points are sparse. But if we think 3B43 is right then the reason is that PR has a sampling problem. Both effects may mix up in Fig. 3.

3.2 Monsoon RAINFALL

So far we have checked annual rainfall. Next we would like to analyze the monsoon rainfall, especially Asian summer monsoon rainfall during June to August.

Fig. 4 shows the summer rainfall in various products with station data (circle with color). Keep in mind that the station data over China comes from the Monthly surface meteorological data of China, covering the 5 year period, but over India, the data is "climatological" (1961-1990 mean). It is found that GPCP and 3B43 look similar in its magnitude and distribution and TMI and PR also look similar. With fner resolutions, TMI and PR show detailed distributions. For example, we can see a sharp rainfall belt along the foot hill of the Himalaya in TMI and PR. We may detect that the rainfall by GPCP or 3B43 over East India and Tibet is larger than that by TMI and PR.

Fig. 5 presents the seasonal change of 5-year mean (1998-2002) monthly rainfall over (a) East India and (b) South India. The black circle is the monthly rainfall of "climatological" 30-year mean station data by IMD. For Fig. 5a, it shows that both 3B43 and GPCP have a rainfall maximum in July, but the TRMM data (2A12 and 2A25) show a peak in May and IMD has a peak in June. Comparing 3B43 and GPCP with TRMM data, we found that during the summer monsoon period both TMI and PR is much lower rainfall amount than 3B43. In South India (Fig. 5b) the seasonal march of the IMD data, 3G43 and PR

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shows good agreement, however, TMI and GPCP data shows less rainfall than other data.

4. DISCUSSION

Rainfall estimation over land by microwave radiometer is harder than that over ocean. There are several reasons, one is come from the surface condition, another is weakness of rainfall estimation in the lower atmosphere during enhanced convective rain. For PR, we may get less chance of observation over mountainous area, thus the sampling error may increase over the area. Over land we also consider the effect of diurnal component of rainfall. Although we accumulated more than 6 year data, at each 0.5 deg x 0.5 deg box we get about 10 observations a month for PR, thus we still need more data to discuss the seasonal march of rainfall over land.

5. SUMMARY

We analyzed the monthly precipitation data, 3G68, 3B43, GPCP and several station data to see the annual rainfall and the seasonal march over land during the boreal summer in the Asian monsoon region.

The result shows that these datasets coincide well qualitatively, but quantitatively there are differences.

For annual rain, over Africa, there is a large difference between TMI and 3B43, greater than 3 mm/day (thus more than 1000 mm/yr). The difference between PR and 3B43 over Africa is less than 1 mm/day. Over South America and maritime continent the difference is large (> 2 mm/day) for TMI-3B43.

For seasonal change over Asian monsoon region, the change was examined with the climatological station data and found that the TRMM data are well correlated with the station data except for the boreal summer period. Both TMI and PR underestimate over the monsoon season. At this moment we do not identify the reason.

REFERENCES

Adler, R. F., G. J. Huffman, D. T. Bolvin, S. Curtis and E. J. Nelkin, 2000: Tropical rainfall distribution determined using TRMM Combined with other satellite and rain gauge information, *J. Appl. Meteor.*, 39, 2007-2023.

Hirose, M. and K. Nakamura, 2002: Spatial and seasonal variation of rain profiles over Asia observed by spaceborne precipitation radar, *J. of Climate*, 15, 23, 3443-3458.

Huffman, G. J. and Coauthors, 1997: The Global Precipitation Climatology Project(GPCP) comined precipitation dataset. *Bull. Amer. Meteor. Soc.*, 78, 5-20.

Short D. A. and K. Nakamura, 2000: TRMM radar observation of shallow precipitation over the tropical ocean, *J. Appl. Meteor.*, 39, 4107-4124.

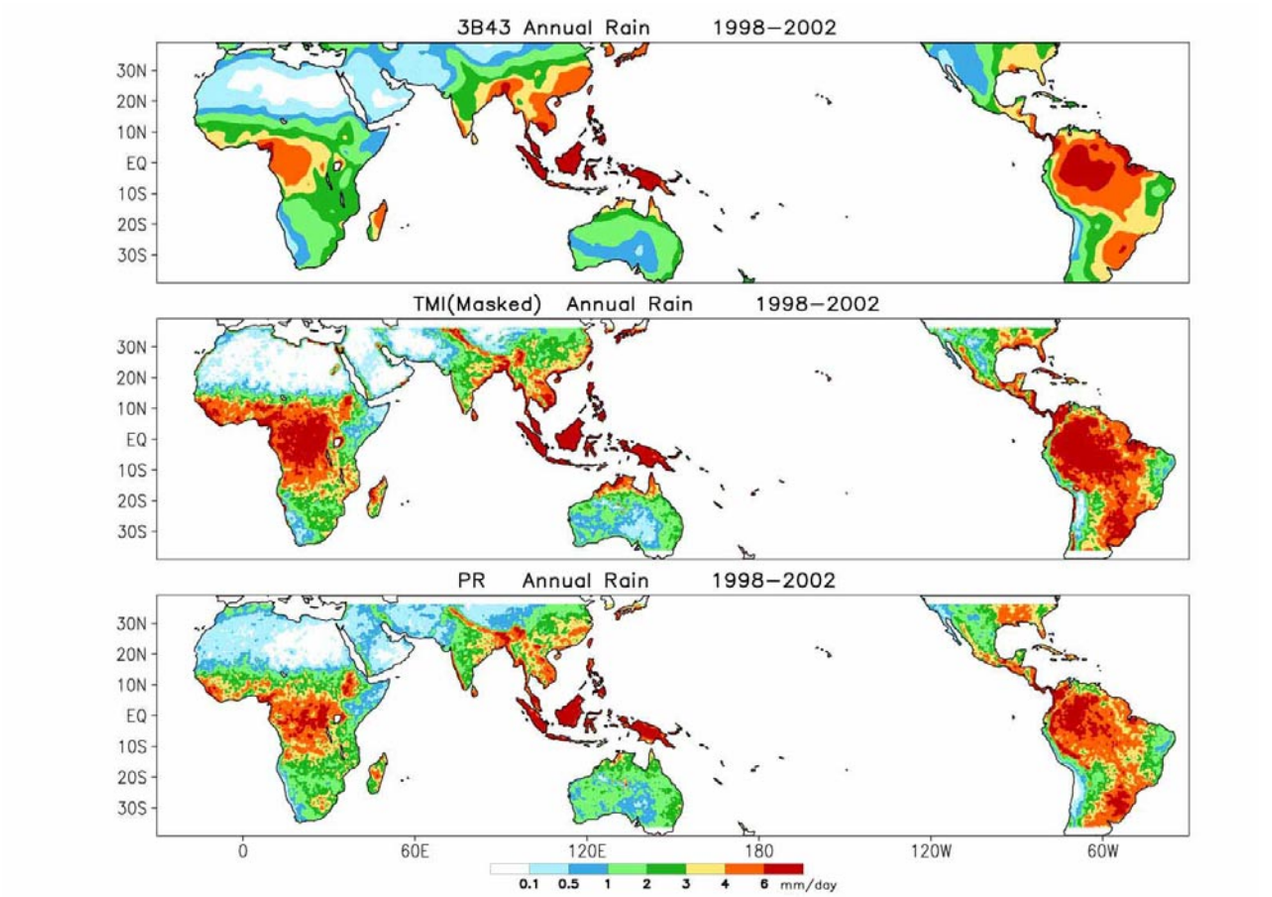

Fig. 1 Annual rainfall rate (mm/day) for 3B43(top), Masked TMI(middle) and PR 2A25 (bottom), averaged from 1998 to 2002)

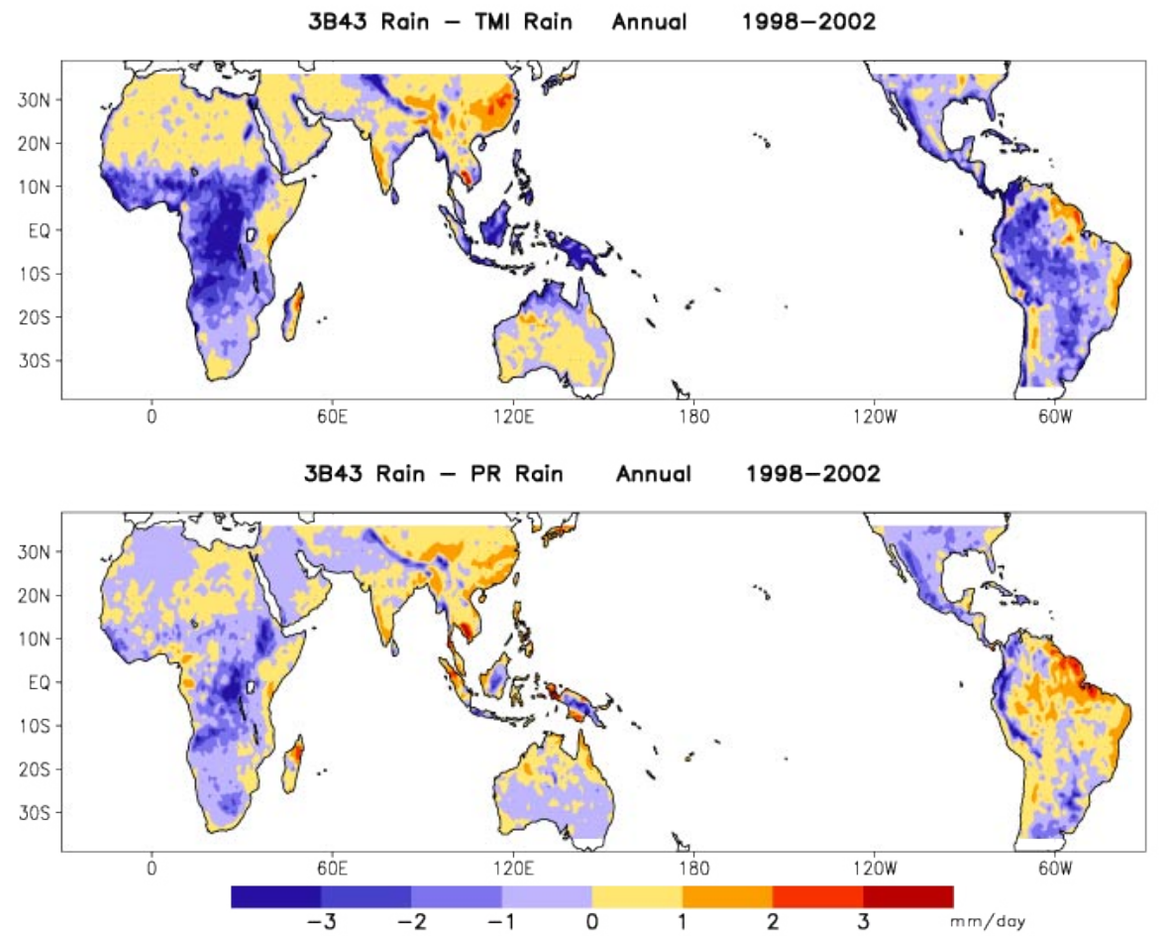

Fig. 2 Same as in Fig. 1, except for the difference of 3B43-TMI(top) and 3B43-PR(bottom). The unit is mm/day.

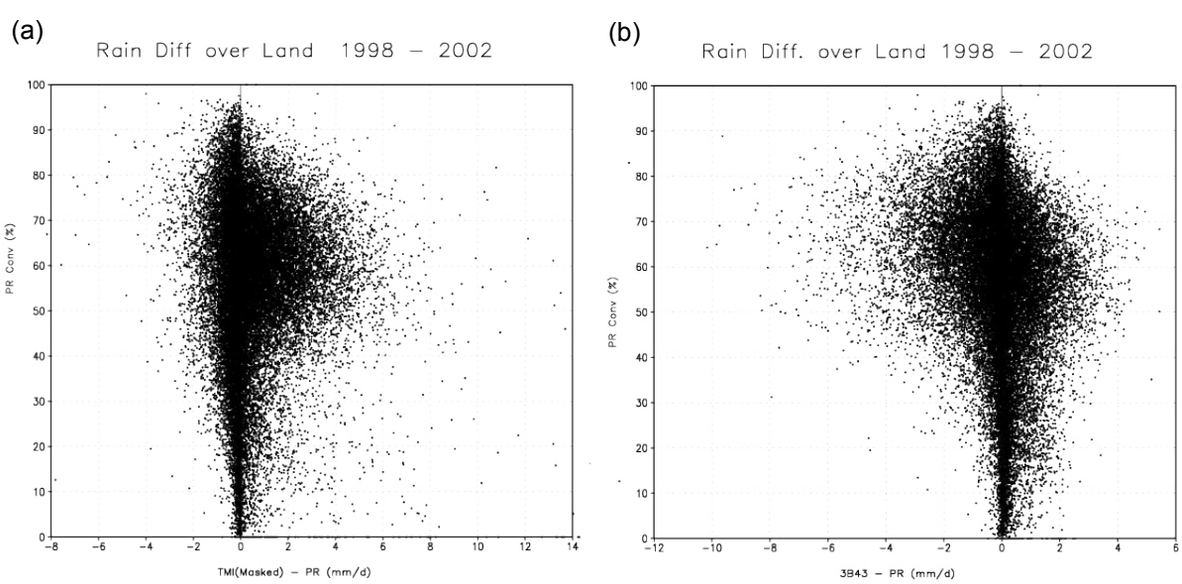

Fig. 3 Dependency of rain type with the difference of (a) TMI-PR and (b) 3B43-PR. The ordinate is the convective rain percentage from PR. The unit of the abscissa is mm/day.

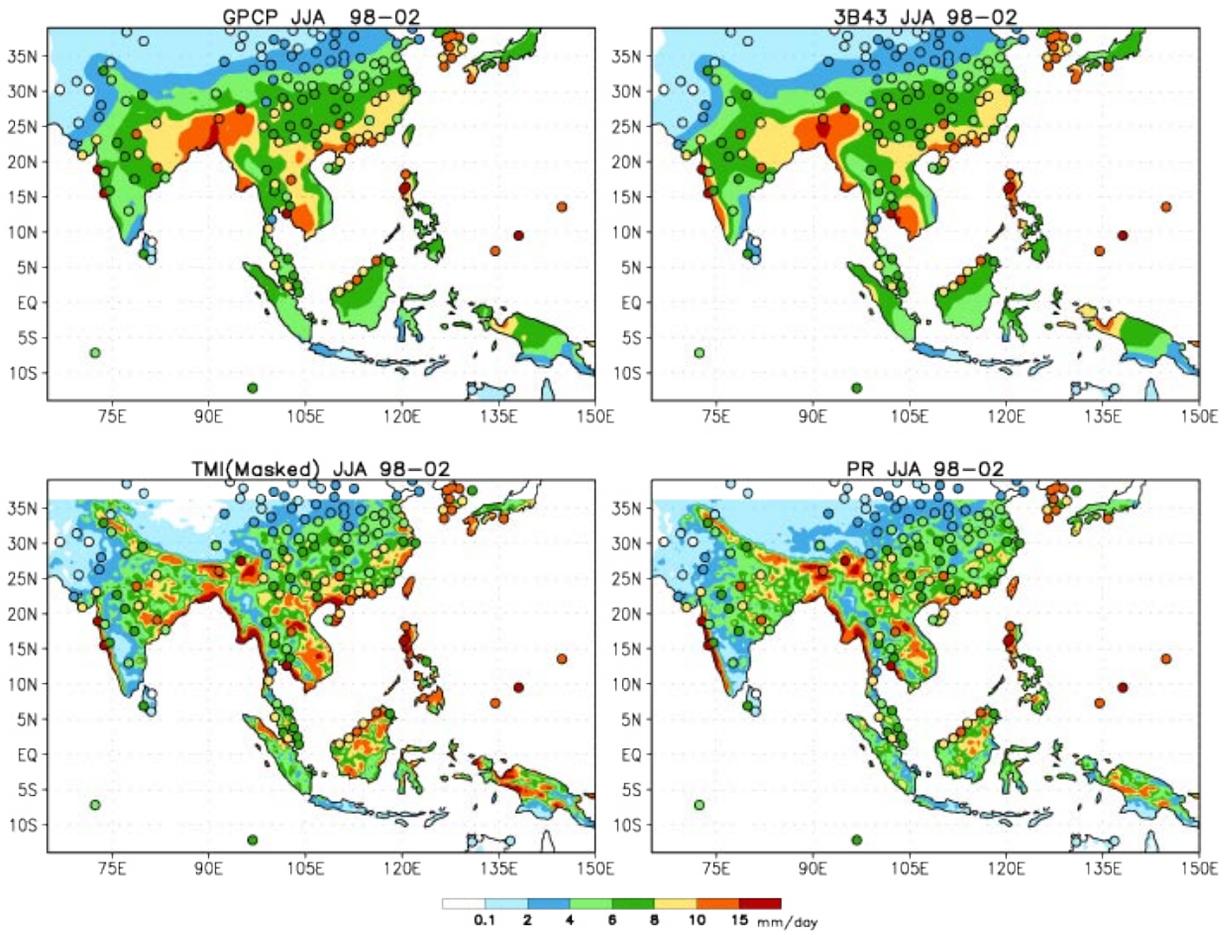

Fig. 4 5 year mean Asian monsoon summer rainfall (June - August) for GPCP(top-left), 3B43(top-right), Masked TMI(bottom-left) and PR(bottom-right) The unit is mm/day. The station data with open circle are drawn, too.

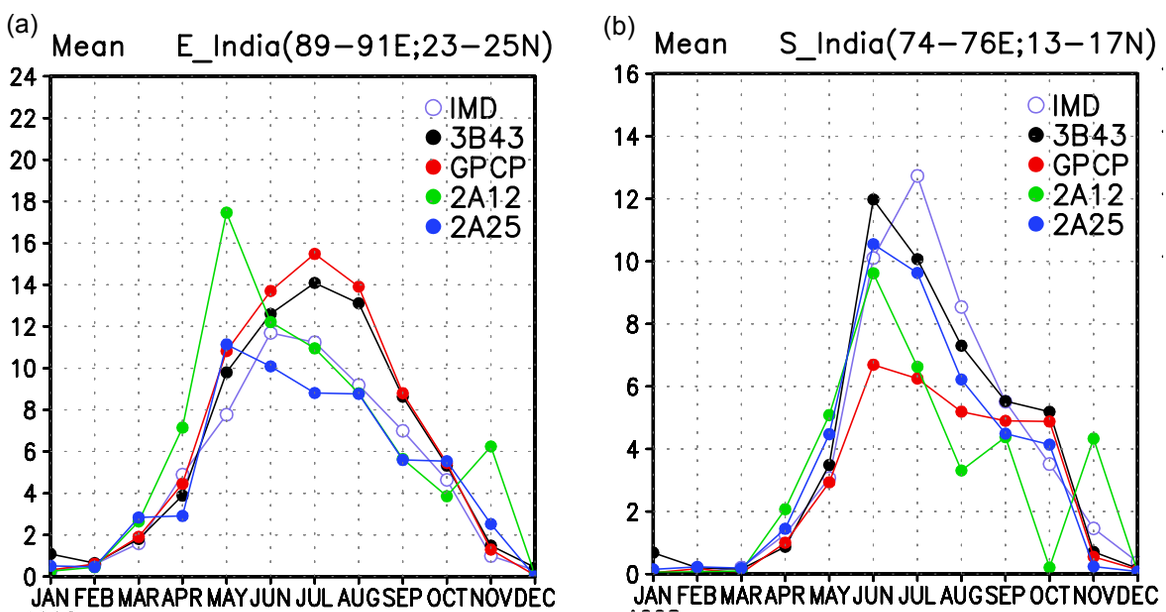

Fig. 5 Seasonal change of rainfall over (a) East India and (b) South India for various rainfall products. "IMD" shows the 30-year climatological monthly mean rainfall (1961-1990) from the India Meteorological Department.