VALIDATION OF TRMM-TMI, PR RAINFALL USING DOPPLER WEATHER RADAR DATA OVER INDIA: SOME CASES STUDIES

R.M. Gairola*, Samir Pokhrel, A.K. Varma, Vijay K. Agarwal, M.S. Narayanan

Meteorology and Oceanography Group

Space Applications Centre (ISRO), Ahmedabad 380 015, India

G. Viswanathan and Lekshmi Vijayan

Radar Development Cell, ISRO HQ, Bengalore, India

Digant Sharma, Mohen Konwar and Sanjay Sharma

Dept. of Physics, Science College, Jotsana, Nagaland, India

1. INTRODUCTION

Several studies have been carried out in the past to intercompare satellite derived precipitation products among themselves and with surface observations. The Algorithms Intercomparison Projects (AIP) –1, -2 and –3, coordinated by World Climate Research Program (WCRP) (Arkin and Xie, 1984, Ebert et al., 1996) and Precipitation Intercomparison Projects (PIP) –1,-2 and –3, coordinated by NASA WetNet project (Dodge and Goodman, 1994, Barrett et al., 1994, , Smith et al., 1998), were the two major projects for this purpose. The focus of AIP and PIP projects was to validate the precipitation measurements from SSM/I. In 1997, Tropical Rainfall Measuring Mission (TRMM) satellite was launched jointly by NASA and NASDA to provide 4-dimensional distributions of precipitation and hence the latent heat in the tropical atmosphere (Simpson et al., 1996, and Kummerow et al., 2000). The TRMM carries a precipitation radar (PR), a passive TRMM microwave imager (TMI), cloud and earth's radiation energy system, and lightening imaging sensor. The precipitation measurements from PR and TMI are available to global users. Considerable efforts have been made in the development of methods for classification of tropical precipitation. The TRMM still continues to provide a unique opportunity to compare the space based radar and radiometric observations of rainfall with the newly upcoming validation sites in various parts of the tropical regions. Validation of TMI rain is separated into two categories.

Corresponding author address: R.M. Gairola MOG, Space Applications Centre (ISRO), Ahmedabad 380 015, INDIA.
e-mail: rmgairola@rediffmail.com

The first is the routine comparison of TMI rain with rain gauges and radar estimates. The second effort consists of field experiments around the globe to validate physically and, when necessary, to improve the assumptions in both space borne, and ground based instrument algorithms (Kummerow et al., 2000). Though the validation sites for TRMM are spread over different parts of the globe, there are however, gaps over the Indian region. The validation sites not only contribute to assess the quality of rainfall, but they are often used to fine-tune the retrieval algorithms. The non-availability of validation data over this region have impact in the retrieval of rain over this region, especially as the rainfall in this region is dominated by a different physical phenomenon, the orographic rain in western ghats, thunderstorm activities in certain areas and rains during south-west and north-east monsoons over all India.

We present here the results of a TRMM validation campaign launched during monsoon season for a two months period of October and November in 2003. We compared and analysed TRMM precipitation from TMI and PR, both quantitatively and qualitatively, in conjunction with the Doppler Weather Radar (DWR) data over India at Shriharikota at 13^o 66$'$ N and 80^o 23$'$ E location. The DWR is an indigenously developed S-Band radar which has been used first time for the validation of rainfall from TRMM sensors in India. The rain rate values of TMI are obtained from GSFC/NASA following the Goddard Profiling (GPROF) algorithm and PR rainfall from Iguchi et al. (2000). The DWR rain values have been derived using Z-R relationship developed during the campaign using disdrometer data at the site. The DWR values are available in the scan radius of 610 km with scan resolution of 300 meter. However a significant data within 200 km radius has been considered for validation exercises. A single scan of DWR covers 360^o azimuth directions at one elevation. In the present study 0.5^o elevation data of DWR are used to create the surface rainfall for the comparisons with the TRMM rainfall. The rain rates derived from PR and TMI shows good agreements with DWR rain and the details of the results would be presented in the conference. The objective of the present study is also to assess the strengths and weaknesses of the both space and ground based rainfall measurements to plan for the more advanced validations in India during Indo-French and US-Japan Megha-Tropiques and GPM missions respectively.

2. PREPARATION OF DATA

TMI and PR Data:

The rain rate values (mm/hr) are provided in the data set from NASA-GSFC following the GPRO algorithm (2A12 products) by NASA following the Bayesian inversion scheme (Kummerow et. Al. 1996). The rain values are available across scan (swath) along the direction of the satellite in a uniform resolution of about 10 km with geo-location and time-tag information. In this study we have used the TMI values as provided. The surface rainfall from PR are obtained from the 2A25 products from profiling algorithm by Iguchi et al (2000). The 2A12 and 2A25 datasets are then assigned to a common format of the spatial allocation.

DWR Data:

A great deal of effort was made to make DWR data compatible after due calibrations, for inter comparison with other products. At scan elevation of 0.5^{o}, the surface clutter contaminates the data in the area near the centre of the radar. A clutter removal procedure was developed though the removal of this surface clutter causes loss of some data also. The higher elevation data cannot be used for areas farther away form the center, as in these case they provide observations at higher altitude levels; often above the base of the clouds. Assuming that cloud base is above 1 km, it is safe to use 0.5^{o} elevation scan data for up to 200 km from the centre of the radar.

In order to have a meaningful comparison, it was necessary to geo-locate each bin of the radar observation and then average them over the same area as that of TMI and PR observation grid. The geo-location, was done by assigning latitude-longitude to each bin and then averaging it over the TMI and PR resolution. Assigning latitude-longitude is carried out using SHAR latitude-longitude as reference coordinate and then using plane trigonometry to assign coordinates (latitude-longitude) of each bin.

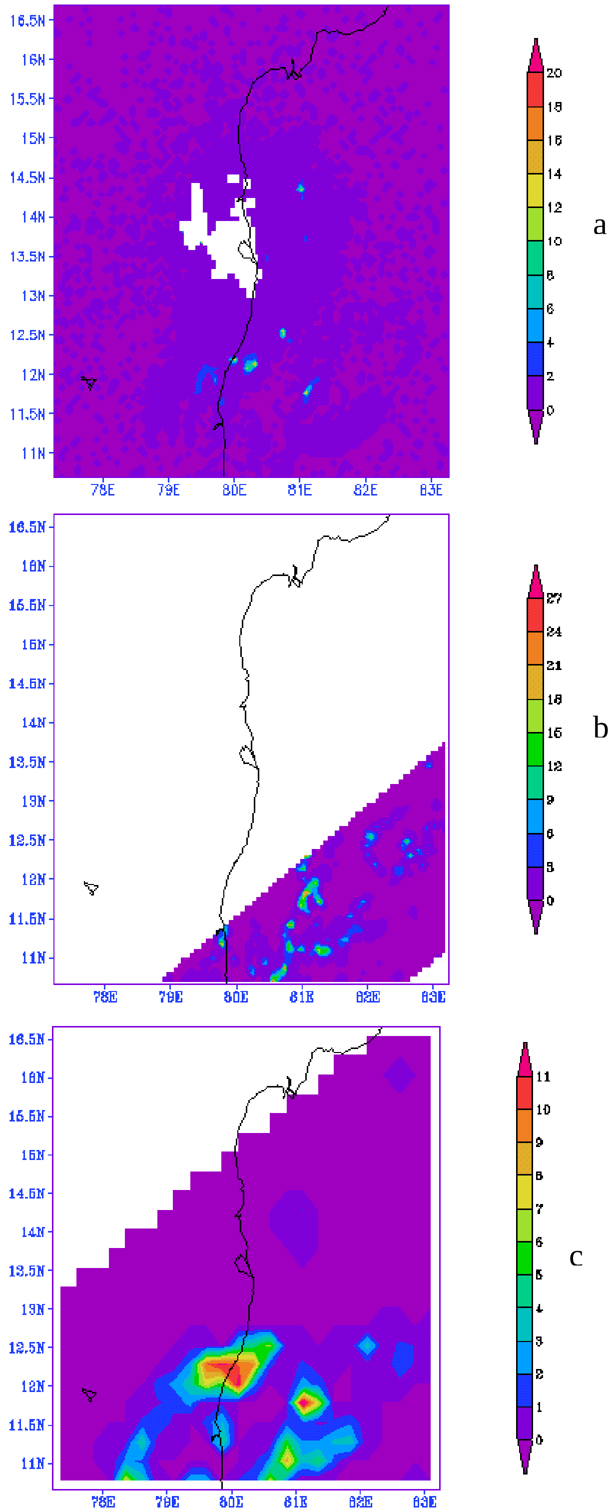

Fig. 1 The rainfall rates at SHAR from (a) DWR-SHAR, (b) TRMM-PR and (c) TRMM-TMI on 6 Nov. 2003.

3. ANALYSIS AND RESULTS:

The PR and DWR data are first averaged in 0.05^o X 0.05^o latitude-longitude grid and TMI was averaged in 0.25^o X 0.25^o grid. Fig. 1 (a-c) show the TMI, PR and DWR gridded rain values for November 6, 2003, respectively. The time difference of three observations was less than 10 min. With the given time difference, the DWR, TMI and PR values are seen to be in good qualitative agreement. There are however, some indications of slight over estimation of rain rate by PR compared to the TMI, the DWR shows better comparisons with both TMI and PR in the present case. We analysed some more possible rain events during the campaign period, however only one case study is shown here for the brevity. The details of the all other events would be presented in detail in the conference.

Thus the present study deals with the rainfall validation of TRMM radar and radiometric rainfall over an Indian validation site having ground based DWR and rain gauges over land. Qualitative and quantitative assessment of the horizontal and vertical distribution of rainfall from TMI and PR is assessed in comparison with the Surface Rainfall Intensity from DWR site at SHAR first time. These data as well as the measurements to be made by Megha-Tropiques and GPM missions and by other upcoming validation sites in India would be a new source of valuable climatological records to help in knowing more about the climate regimes and climate variability thereof. This study serves the purpose of understanding more towards the intricacies of comparison of satellite and DWR rain for validation.

Acknowledgement

Authors are thankful to India Meteorological Department for DWR data operations, and GSFC-NASA for providing TRMM data. Authors are also thankful to Director, Space Applications Centre, Ahmedabad for encouragements.

References

Arkin, P. A., and Xie, P., 1984, The Global Precipitation Climatology Project: First Algorithm Intercomparison Project, *Bulletin of American Meteorological Society*, **75**, 401-419.

Barrett, E.C., Dodge, J., Goodman, H.M., Janowiak, J., Kidd, C., and Smith, E.A., 1994, The First WetNet Precipitation Intercomparison Project (PIP-1), *Remote Sensing Reviews*, **11**, 49-60.

Dodge, J.C., and Goodman, H.M., 1994, The WetNet Project, *Remote Sensing Reviews*, **11**, 5-21.

Ebert E.E., 1996, Results of 3rd Algorithm Intercomparison Project (AIP-3) of Global Precipitation Climatology Project (GPCP). *BMRC* Res. Rep. No. **55**, 199 pp.

Iguch T., Kozu T., Meneghini R., Awaka J., and Okamoto K., 2000, Rain-Profiling algorithm for the TRMM Precipitation Rdara, *J. Appl. Met*., **39**, 2038-2052.

Kummerow et al., 2000, The Status of the Tropical rainfall Measuring Mission (TRMM) after Two Years in Orbit, *J. Appl. Meteor.*, **39** (12), 1965-1982.

Simpsion J., C. Kummerow, W.-K. Tao and R.F. Adler, 1996, “On the Tropical Rainfall Measuring Mission”, *Met. Atmos. Phys*., **60**, 19-36.

Smith et al., 1998Results of WetNet PIP-2 Project, *J. Atmos. Sci.*, **55** (9), 1484-1536.

Simpsion J., C. Kummerow, W.-K. Tao and R.F. Adler, 1996, “On the Tropical Rainfall Measuring Mission”, *Met. Atmos. Phys*., **60**, 19-36.