

## COMBINED USE OF MICROWAVE AND IR DATA FOR THE STUDY OF INDIAN MONSOON RAINFALL–2009

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**KEYWORDS:** Rainfall, Monsoon, Microwave, Infrared, Automatic Weather Station.

### ABSTRACT:

In the present study, an attempt has been made to analyze the rainfall during the onset and progress phase of the Indian summer monsoon of 2009 starting from the onset period to August using IMSRA technique developed in-house. Contrary to IR, microwave rain rates are based on measurements that sense precipitation in clouds and do not rely on cloud top temperature. IMSRA technique is the combination of the IR and microwave measurements. Geostationary satellites provide broad coverage and frequent refresh measurements but microwave measurements are accurate and sparse. The assessment of rainfall estimate has been carried out by intercomparison with TRMM-3B42 and validation using the ground based data. These studies are taken up to enhance the capability of rainfall retrievals in near future from both INSAT-3D and Megha-Tropiques, IR and MW imagers respectively.

### 1. INTRODUCTION

The temporal and spatial distribution of rainfall and their variability over the country is very crucial because Indian economy is highly dependent on agriculture. It is said that Indian budget is a monsoon gamble. An early or delayed onset followed by the intensity and distribution of monsoon rainfall are very crucial for the total annual agricultural yield. So, it is very important to study the onset, progress and distribution of monsoon rainfall over the country.

Southwest monsoon is generated by the large thermal gradient between the heated Indian landmass and the surrounding ocean with relatively colder temperature. Any disturbances such as low pressure, cyclones that forms over the monsoon region can significantly influence the advancement and performance of the monsoon system.

Over India and adjoining oceans rain information is available through ground based radar and dense network of rain gauges. The meteorological satellites provide the rapid temporal update over the globe. For the retrieval of rain from IR data various algorithms have been developed. Major algorithms are GOES Precipitation Index (GPI) (Arkin et al. 1979) and Modified GOES Precipitation Index (MGPI) (Mishra et al. 2009). These algorithms are used for larger spatial and temporal scales. A complete overview of the early work and physical premises of VIS and IR techniques is provided by Barrett and Martin (1981). But, precipitation from IR measurements is based on indirect methods which do not represent the true interpretations mostly due to cloud types like Cirrus.

At passive microwave frequencies precipitation particles are the main source of attenuation of upwelling radiation. Thus, microwave techniques are more direct than those based on VIS/IR radiation. But, the biggest disadvantage is the poor spatial and temporal resolution. The first due to diffraction which limits the ground resolution for a given satellite microwave antenna and the latter due to the fact that MW sensors are consequently only (0.25°x0.25°). IMSRA algorithm uses a proper cloud classification scheme (Roca et al.2002) followed by Kalpana-1 IR and TRMM-PR microwave data for the retrieval of rainfall. This technique gives better performance than GPI and MGPI techniques (Mishra et al., 2009). In the present study, we have analyzed the rainfall from the monsoon onset to August 2009 using this technique. The validation with ISRO-AWS data has also been carried out for these months

### 2. DATA USED

#### 2.1 Kalpana-1 Data

Kalpana-1 satellite is dedicated meteorological geostationary satellite launched by GSLV and operating since 24th Sept 2002. This geostationary satellite carries onboard a Very High Resolution Radiometer (VHRR) along with other instruments. This sensor operates in three wavelengths band namely VIS, TIR, WV. In WV and TIR, spatial resolution is 8 Km where as in VIS band spatial resolution is 2 Km.

- Thermal IR band-TIR: 10.5µm-12.5µm
- Visible band- VIS: 0.55µm-0.75µm
- Water vapour band-WV: 5.7µm-7.1µm
- In the present study we used the IR and WV data.

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### 2.2 Automatic Weather Station (AWS) Rain Guage Data

The Indian Space Research Organization (ISRO) designed AWS is as a very compact, modular, rugged, powerful and low-cost system and housed in a portable, self contained package. Among many other sensors it has a Tipping bucket rain gauge with a magnet and reed switch with unlimited rain measuring capacity with accuracy of less than 1 mm. AWS transmits its hourly meteorological data in burst of 68 millisecond duration (at a data rate of 4.8 kbps). At present there are about 300 AWS are operationally working all over India. INSAT Data Collection Platform is used for data acquisition. For the validation of the present algorithm the rain gauge data during June 2009 to August 2009 are used.

### 2.3 TRMM-3B42 Data

The Tropical Rainfall Measuring Mission (TRMM) is a joint US-Japan Satellite Mission to monitor tropical and subtropical precipitation and to estimate its associated latent heating. It was launched in the late November 1997 in to circular orbit approximately 350 km altitude (now raised to 420 km) and 35° inclination from the equatorial plane.

The TRMM-3B42 is a standard TRMM data product which is a merged rain product derived using Geostationary IR data and Microwave observation. The data from TRMM satellite are archived and distributed by the National Aeronautics and Space Administration (NASA) Goddard Space Flight Centre (GSFC). For the intercomparison of the present technique the TRMM-3B42 data is downloaded from <http://disc2.nascom.nasa.gov/Giovanni/tovas/> for the same period as that of the Kalpana-1 data mentioned above.

### 3. METHODOLOGY

INSAT Multispectral Rainfall Algorithm (IMSRA) is developed by collocating Kalpana-1 IR and WV brightness temperature with TRMM-PR rainfall in 0.25 ° x0.25 ° grids (Mishra et al., 2009) followed by the proper cloud classification (Roca et al., 2002). The collocated data set gives the regression curve by which rain rate was estimated by Mishra et al as

$$R=8.613098*\exp(-(Tb-197.97)/15.7061) \tag{1}$$

Where R= rain rate in mm/h and Tb= Cloud top brightness temperature in Kelvin.

For calculating the daily rain; three hourly rain is calculated using eqn-1. Then these three hourly rains are cumulatively added to get the daily rain.

The flow chart of the algorithm is shown in figure 1.

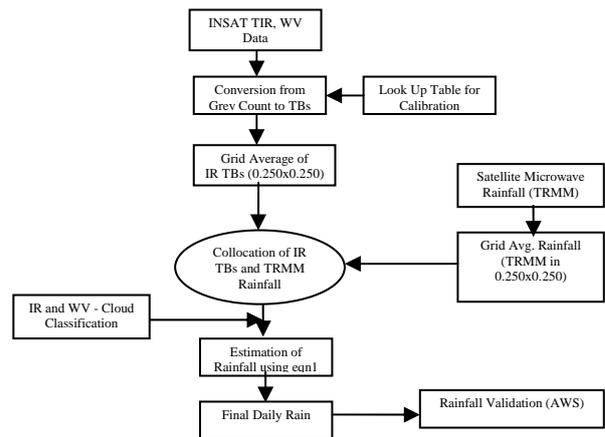


Figure. 1 Flow Chart of IMSRA Technique.

### 4. RESULTS AND DISCUSSIONS

As stated earlier TIR and WV measurements from Kalpana-1 and MW measurements from TRMM have been used for the rainfall estimation. The performance of the algorithm is validated qualitatively with TRMM-3B42 data, which is an independent data source. The algorithm is validated quantitatively with AWS data. Out of the complete phenology of monsoon-2009 to date, only some of the results are discussed for brevity. The first case is shown in figure 2 on the onset date (23<sup>rd</sup> May 2009) by the present technique and TRMM-3B42 which shows better agreement with each-other. The fair evidences of monsoon onset on Kerala coast are seen from both IMSRA and TRMM-3B42.

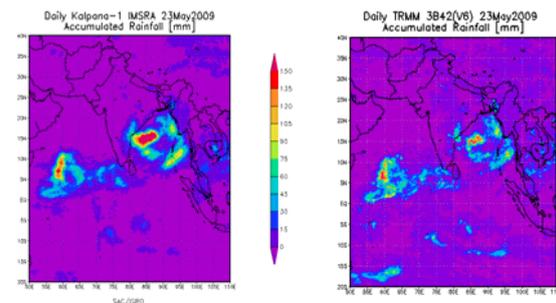


Figure. 2 Daily Rainfall Using Present Technique and TRMM-3B42 on 23rd May 2009.

The second case study was carried out for 25<sup>th</sup> May 2009 to examine the performance of this technique in cyclonic case. The daily rainfall using the present technique and from TRMM-3B42 on 25<sup>th</sup> May 2009 is shown in fig.3. This is the case of Aila cyclone in Bay of Bengal. The intercomparison between these two rainfall show that in cyclonic cases the present technique overestimates than TRMM-3B42.

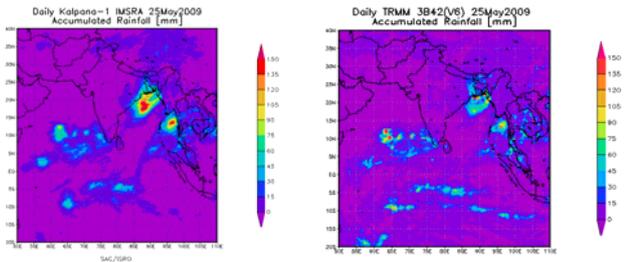


Figure. 3 Daily Rainfall Using Present Technique and TRMM-3B42 on 25th May 2009.

The third case study was carried out for 27th May 2009 after the cyclone. Both the methods show the small break condition in monsoon due to cyclone sweeping away the moisture content. The daily rainfall using the present technique and from TRMM-3B42 on 27th May 2009 is shown in figure 4.

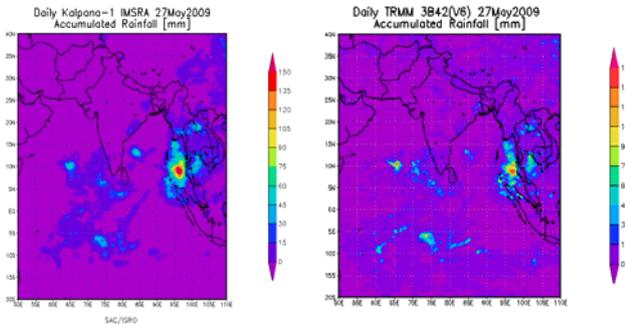


Figure. 4 Daily Rainfall Using Present Technique and TRMM-3B42 on 27th May 2009

These case studies show that the present technique gives better agreement with TRMM-3B42 qualitatively. Using this technique, we have estimated monthly rainfall for June, July and August 2009 which is shown in figure 5.

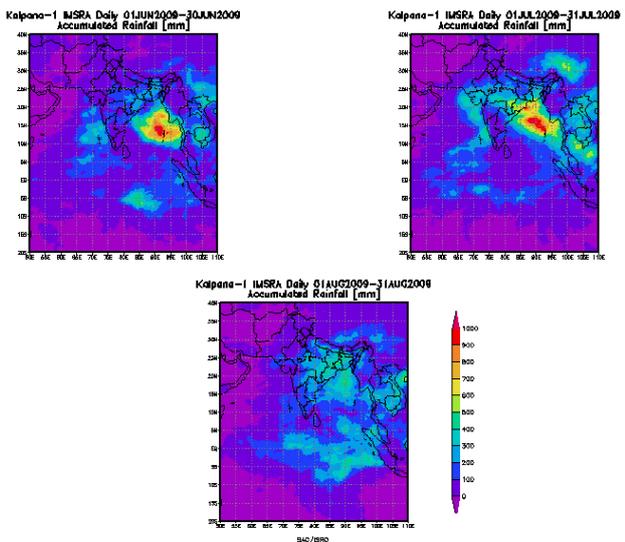
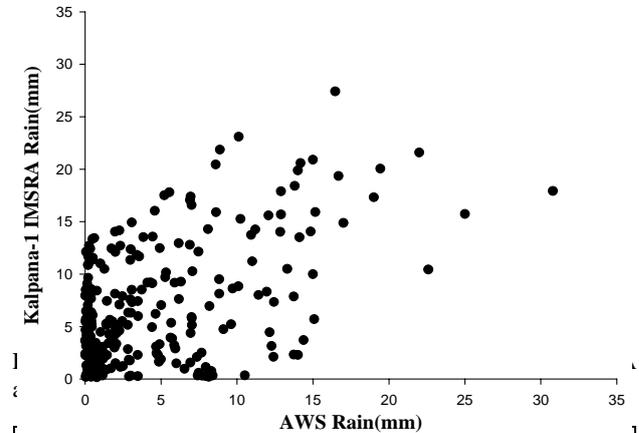


Figure. 5 Monthly Rainfall Using Present Technique for June, July and August 2009.

These three months accumulated daily rainfall using the present technique is validated with ISRO-AWS data. The scatter plot between the daily rainfall using the present technique and AWS is shown in figure 6 and the statistical comparison is shown in table 1.



No. of data points	257
Correlation coefficients	0.52
Root Mean Square Error (mm)	5.88
Bias (mm)	2.89

Table 1: Comparison of Daily Rainfall from AWS and from the Present Technique

## CONCLUSION

This paper describes the performance of the present rainfall estimation technique (IMSRA) based on both microwave and IR observations during this monsoon year (June 2009 to Sep 2009). The results show that IMSRA technique qualitatively very well matches with TRMM-3B42 merged product. Its comparison with AWS data shows a 52 percentage correlation. The accumulated daily rainfall shows that the monsoon was very weak for the month august. It is well captured by the rain estimated using this technique. Some issues like regional biases have to be resolved for accurate rain estimates and also orographic effects to be considered to make this algorithm more robust and reliable for operational use.

## ACKNOWLEDGEMENTS

We thank Director, Space Applications centre for the encouragements for the research work carried out in present study. The Kalpana-1 data and AWS data provided by MOSDAC is acknowledged with thanks. The TRMM-3B42 data from NASA/GSFC used in the study is thankfully acknowledged.

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