

# OBSERVATIONS OF MARINE ATMOSPHERE FROM INDIAN OCEANSAT-1

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## *Abstract*

A Multichannel Scanning Microwave Radiometer (MSMR) has been in operation onboard the first Indian Oceansat, launched on May 26, 1999 by the Indian Polar Satellite Launch Vehicle (PSLV). This four frequency (6.6, 10.6, 18 and 21 GHz) dual-polarized instrument is operationally providing data of total precipitable water, cloud liquid water, sea surface temperature and sea surface winds over the global marine atmosphere once in two days. Some of the important research products include soil moisture, Antarctic snow cover and oceanic rainfall. MSMR is the first satellite instrument since SMMR of Nimbus-7 in 1987 with a 6.6 GHz channel capable of providing SST, soil moisture etc.

Extensive validation of the data have been carried out using data of special ship cruises, GTS data, contemporary satellite observations and model analysis. RMS errors of 1.5 K, 2 m/s and 0.3 gm/cm<sup>2</sup> for sea surface temperature, sea surface wind speed and total precipitable water, respectively have been obtained for the operational data products.

Studies related to large scale features, onset of monsoon etc have been carried out using these data. Using simultaneously the 8 channel data, direct estimation of latent heat flux have also been made. The data have been used in the NCMRWF global assimilation and thence sea state monitoring and prediction viz of waves, ocean circulation, MLD etc. Monthly composites of instantaneous rainfall data from 18 GHz have been able to bring out features related to movements of ITCZ and the monsoon depressions. Antarctic ice cover has been monitored using the year - round data. The change in areal extent of ice cover over a period of 8 years around Antarctica brought out by SMMR data have been corroborated with MSMR observations.

## 1. Introduction

Observations of temperature, humidity and winds at surface as well as at multiple levels in the earth's atmosphere are critically required for monitoring and predicting the weather and the ocean state. Meteorological and ocean state numerical models with provision of assimilating the meteorological and oceanographic parameters over the earth are used for this purpose. Such a large data-intensive task cannot be achieved without resorting to measurement by orbiting satellites. One of the successful space-borne sensors is passive microwave radiometer, which was first tested by the US Seasat satellite mission in 1978. Seasat demonstrated the capability of the microwave radiometer in measurements of water vapour, cloud water, sea surface temperature, sea surface wind speed and rain rate. The heritage of Seasat was successfully continued by Nimbus 7 SMMR upto 1987 and thereafter there was no international mission with a similar configuration. It was in May 1999, that the Indian Oceansat I (IRS P4) with onboard Multifrequency Scanning Microwave Radiometer (MSMR) and Ocean Colour Monitor was launched. The present paper gives a brief account of the satellite as well as its application potentials.

MSMR along with similar contemporary international missions like TRMM and SSMI has provided unprecedented data coverage in space and time for studies on marine atmosphere and global oceans' exchange processes. The experience gained through these studies will enable a better definition of MADRAS (Megha Tropiques) Science mission. In a way, Megha Tropiques is likely to provide some sort of continuity of data of MSMR.

## 2. Multifrequency Scanning Microwave Radiometer (MSMR)

The orbital parameters of the Oceansat-1 satellite (IRS P- 4) and the MSMR instrument specifications are given in Table 1. MSMR is basically a 4 frequency (6.6, 10.6, 18 and 21 GHz), dual-polarised microwave passive instrument with a 2-days repetivity to observe the global oceans, land and the atmosphere from an altitude of about 720 km. The parameters obtainable from this instrument are sea surface wind speed, columnar water vapour, sea surface temperature and the cloud liquid water content.

**Table 1 : Specifications of IRS-P4 and MSMR**

<b><i>Satellite</i></b>	
Altitude	720 km
Swath	1360 km
Repetivity	2 days
Orbit inclination	98°
<b><i>MSMR</i></b>	
Weight	65 kg
Frequency	6.6, 10.6, 18 , 21 GHz
Polarization	V & H
Spatial Resolution	40 to 120 km
Temperature Resolution	1 °K

Operational parameters derived from MSMR are described in Table 2 (Gohil et al, 2000). Several other parameters are also being retrieved on research mode from the brightness temperature measurements from MSMR. These parameters are Antarctic sea ice boundaries (Vyas et al, 2001), rainfall rate over oceans (Varma et al, 2000) and large area soil moisture (Thapliyal et al, 2000).

**Table 2 : Geophysical Parameters from MSMR**

Parameters	Channels	Grids (km)	Range	Accuracy
Total Water Vapour	21 + 18, 10	50	0.2 to 7.5 g/cm <sup>2</sup>	0.3 g/cm <sup>2</sup>
Sea Surface Wind	10 + 6, 18, 21	75	2-2.4 m/s	1.5 m/s
Sea Surface Temperature	6 + 10, 18, 21	150	273 -303 ° K	1.5° K
Cloud Liquid Water	21 + 18, 10	50	0-80 mg/cm <sup>2</sup>	-

Though MSMR radiometer systems are similar to SMMR, MSMR data are being processed over much larger swath (~1360 km). This necessitated special numerical approaches beyond 45° scan angles, which are affected by 'singularities' in the computation of polarized radiation. Besides, with the satellite inclination of 98° and incidence angle of 49° of MSMR, one is able to observe very close to the poles. In fact, MSMR is able to provide unique microwave radiation data in those polar regions, which are missed by SSM/I data (and earlier by SMMR) over land / ice surfaces, that constitute less understood research problems.

### 3. Validation

The MSMR geophysical products have been validated (Ali et al, 2000; Varma et al, 2000) using three different approaches : insitu, intersatellite and model analysed fields. Each have their own merit (and limitations), considering the spatial and temporal resolutions, decorrelation lengths and the interconsistency of different atmospheric parameters from the modelling point of view. The RMSE of some of these comparisons are summarised in Table-3. Validation with further data is in progress.

**Table 3 : SUMMARY OF COMPARISON (RMSE)**

SOURCE	SST (°K)	WS (m/s)	WV (g/cm <sup>2</sup> )
Insitu	1.3	1.8	0.4
NCMRWF	-	2.0	0.6
NCEP	0.9	2.1	0.6
SSMI	-	2.4	0.5
TMI	1.5	2.0	0.4

#### **4. MSMR Applications Programme**

An extensive MSMR Utilisation Programme was evolved in early phases of the Project in close collaboration with a large number of national research and operational organisations. The programme addresses three major application areas: (i) Atmospheric Prediction in different scales, (ii) Sea State Monitoring and Predictions (iii) Monitoring of Antarctic Sea Ice. Figure 1 shows the overall plan of MSMR Utilisation Programme (Gopalan et al, 2000).

Results of a few representative applications are described in the following: Figure 2 (a, b) show the moisture field (total water vapour content) and wind field (surface winds) as observed by MSMR on typical monsoon days. This information is being routinely processed by India Meteorological Department in close collaboration with Space Applications Centre (ISRO) for monitoring the onset and progress of Monsoon. The time series analysis of wind speed data clearly brings out the series of monsoon surges and alongwith water vapour data indicate the regions of moisture convergence, with potentiality of heavy rainfalls. National Centre for Medium Range Weather Forecasts (NCMRWF), Delhi assimilate MSMR derived moisture and wind data for making atmospheric prediction in medium range.

MSMR derived Sea surface temperature surface winds and integrated water vapour fields were zonally averaged for characterisation of large scale features. MSMR could capture the large scale oceanographic and meteorological features like east-west gradient in the Pacific ocean SST, large temperature gradients towards the north western pacific associated with Kuroshio current, cooler temperatures over Peru coast due to upwelling, high amount of TWV over the ITCZ etc (Sharma et al, 2000). The latitudinal distribution of zonally averaged SST and TWV show large values in the tropical region with a small low in SST near the equator influenced by the equatorial upwelling. Similar results were obtained by Njoku and Swanson (1983) using 90 day (11<sup>th</sup> July to 10 Oct 1978) averaged seasat SMMR observation.

The movement of ITCZ in different seasons are monitored. Retrieval of instantaneous rainfall directly from brightness temperatures have yielded a correlation of 0.8 with TMI derived rainfall over global oceans. Similar attempts to compute instantaneous latent heat flux over oceans have been found to improve the accuracy significantly. (Singh et al 2001) MSMR brightness temperatures also reveal distinct signatures of ice covered sea and open water in the Antarctica. This is useful in monitoring the seasonal variations in the areal extent of ice covers in the polar continent (Vyas et al, 2001; Dash et al, 2001).

Microwave radiometers of the MSMR type has opened up several new research areas. One such area is estimation of 'Large Area-Averaged Soil Moisture' and its use in seasonal (or longer scale) atmospheric predictions (Thapliyal et al, 2000). Soil moisture like sea surface temperature, represents boundary conditions, memory of atmospheric variabilities of longer time scales and thus enhancing the atmospheric predictability of longer time scales. The lowest frequency (6.6 GHz) brightness temperature, by virtue of emissivity dependence on soil wetness, is shown to be a reasonable good indicator of soil moisture in the top layer in its footprint. Soil types, soil roughness, soil cover, etc are other factors which need to be accounted for in developing a full-fledged model for estimation of soil moisture.

MSMR data assimilation exercise in Global Data Assimilation System in GCM has opened up new applications in the country viz. Ocean State Forecast. Analysed and Forecast Winds are utilized in Ocean Wave and Oceanic Mixed Layer Models to generate Wave and MLD forecasts (Basu et al, 2001; Gopalan et al, 2001). The forecast parameters are presently undergoing evaluation.

## 5. Conclusion

The MSMR onboard IRS-P4 satellite is routinely providing for a last two years the total atmospheric water vapour, sea surface wind speed, sea surface temperature and cloud liquid water over global oceans once in two days. These data are being used for many meteorological applications. Validation from 3 different approaches has shown the data of good quality and reliability. Large scale features of all the observed parameters and their inter linkages have been well brought out by the data. The research parameters viz. Rainfall rate, sea ice extent and soil moisture have also shown good promise.

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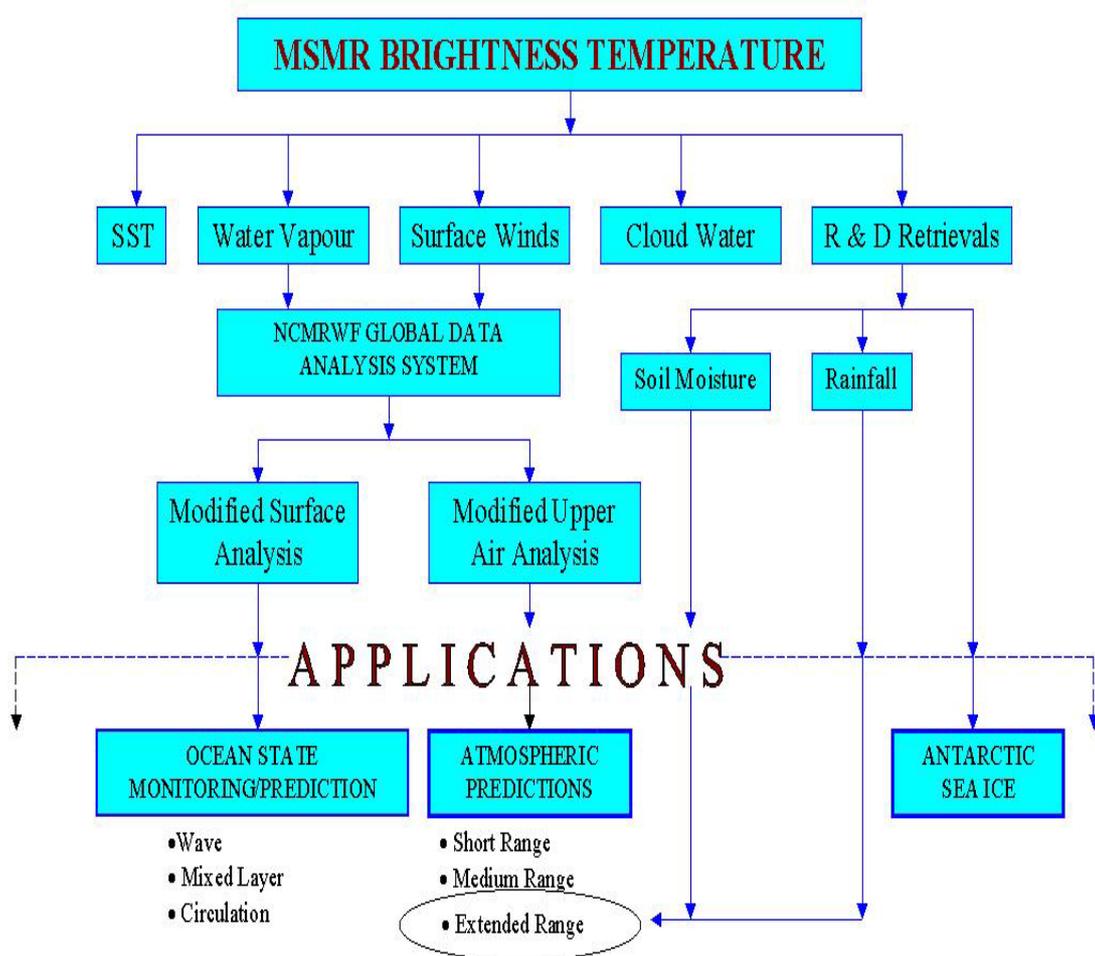


Figure 1 : Applications of MSMR data

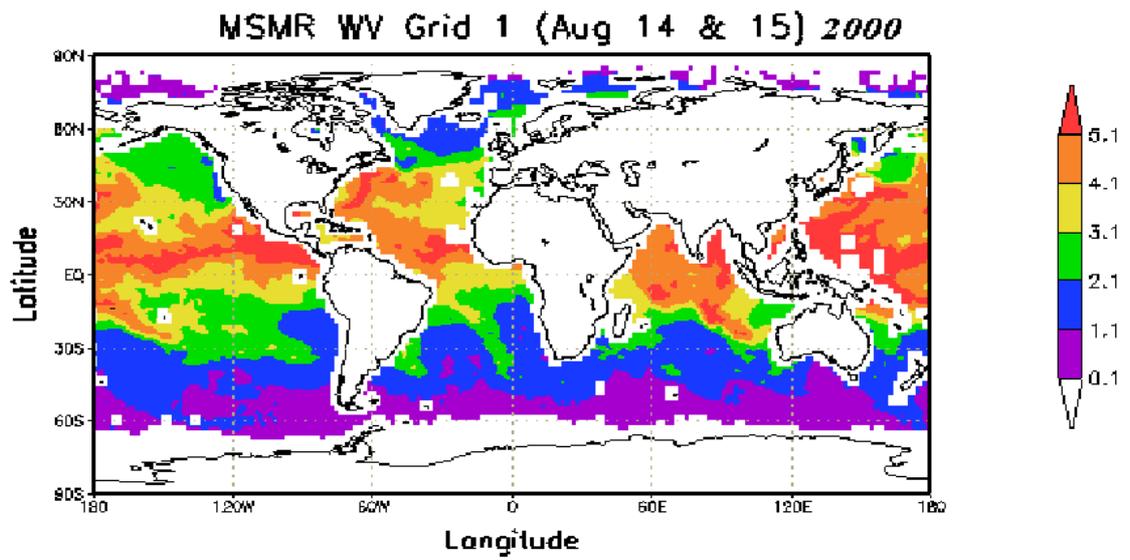


Figure: 2a

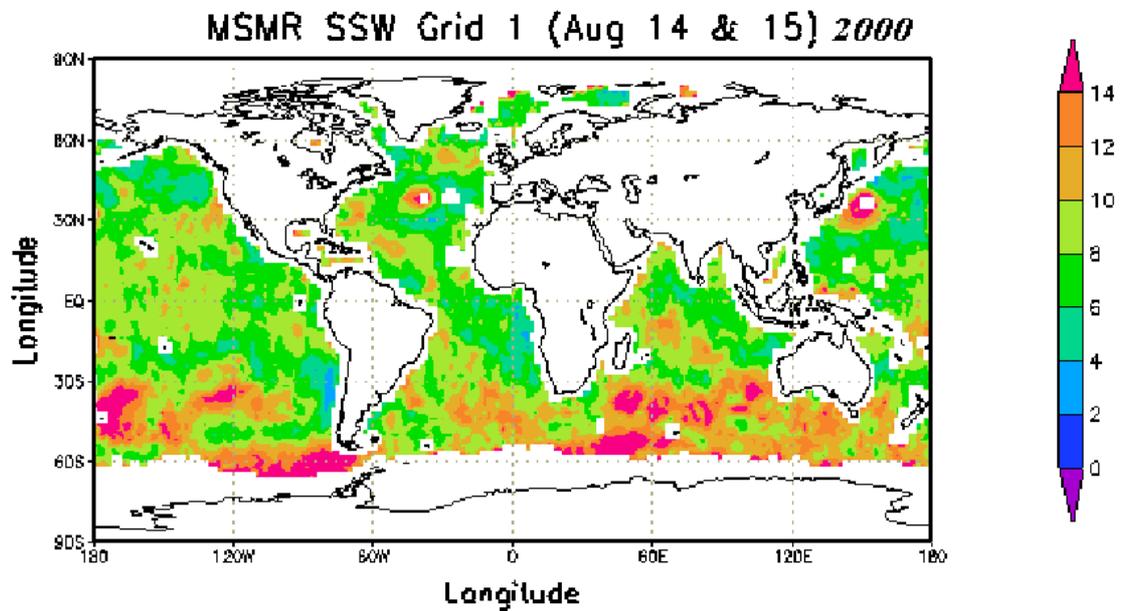


Figure: 2b

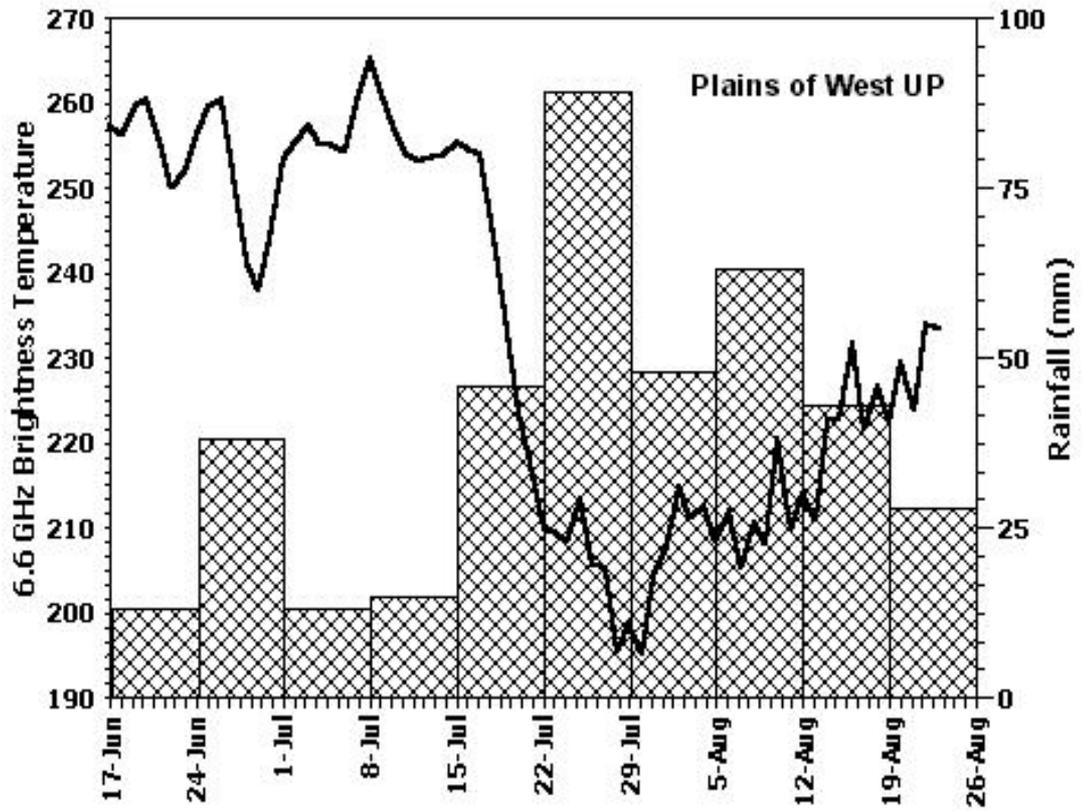


Figure : 3

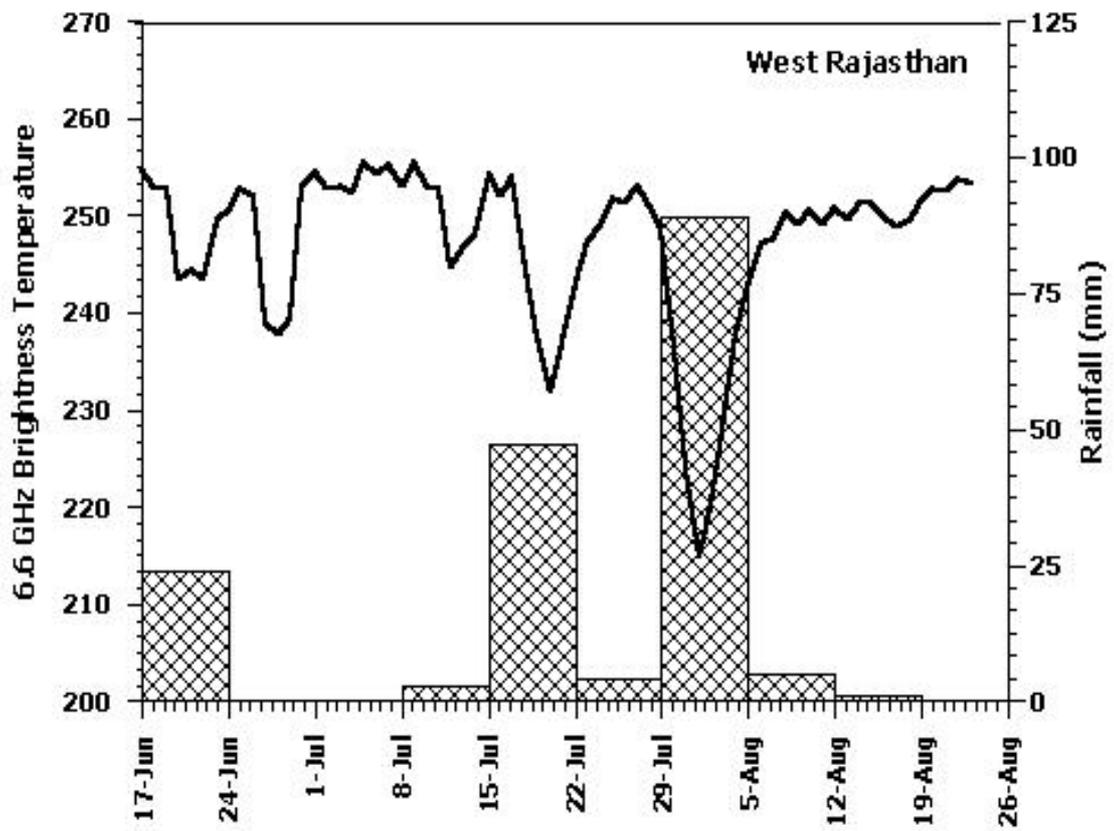


Figure : 4

