

Impacts of surface wind and moisture data from microwave sensors in the analysis and prediction of weather in the Indian Ocean region

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सार – हिंद महासागर जैसे अपर्याप्त आँकड़ों वाले क्षेत्र के लिए सूक्ष्मतरंग सेंसरों से प्राप्त किए गए मौसम विज्ञानिक आँकड़ें अत्यंत उपयोगी हैं। मौसम के आँकड़ें उपलब्ध कराने वाले विभिन्न उपग्रहों में लगे सूक्ष्मतरंग सेंसरों से सतही पवन गति और सकल वर्षणीय जल अवयव (टी.पी.डब्ल्यू.सी.) का उपयोग करके राष्ट्रीय मध्यावधि मौसम पूर्वानुमान केन्द्र में समावेशीकरण प्रयोग किए गए। राष्ट्रीय मध्यावधि पूर्वानुमान केन्द्र में समावेशित किए गए इन आँकड़ों ने मानसून ऋतु के दौरान विश्लेषण और पूर्वानुमान को महत्वपूर्ण रूप से प्रभावित किया है। इन आँकड़ों से विश्लेषण का शुष्क बायस समाप्त हुआ और मानसून परिसंचरण की व्याख्या में सुधार हुआ। भारतीय दूर संवेदी उपग्रह आइ.आर.एस.–पी.4 से प्राप्त आँकड़ों का उपयोग करके अनेक प्रयोग किए गए हैं। उड़ीसा में महाचक्रवात का विश्लेषण करने में विभिन्न सूक्ष्मतरंग सेंसरों से प्राप्त आँकड़ों के उपयोग से अत्यंत सुधार हुआ है। माडुलन के लिए टी.पी. डब्ल्यू. सी. आँकड़ें महत्वपूर्ण प्राचल प्रतीत होते हैं। आँकड़ों को पुनः प्राप्त करने और उनके समावेशन की तकनीक पर उचित ध्यान दिया जाना चाहिए जिससे इस प्राचल को ठीक से प्रस्तुत किया जा सके।

ABSTRACT. Meteorological data from microwave sensors are very useful over the data sparse regions such as the Indian Ocean. Assimilation experiments have been carried out at NCMRWF using surface wind speeds and total precipitable water content (TPWC) from microwave sensors on-board various satellites providing meteorological data. These data when assimilated at NCMRWF have affected the analyses and forecast significantly during monsoon seasons. The dry bias of the analyses gets removed with these data and description of monsoon circulation improved. Several experiments have been carried out using data from the Indian remote sensing satellite IRS-P4. The analyses of Orissa super cyclone improved considerably when data from various microwave sensors were used. TPWC data seems to be very crucial parameter for modeling purpose. Due care must be taken in the retrieval and assimilation techniques so that this parameter is represented correctly.

Key words – Analysis, Surface wind, TPWC, Indian ocean, NCMRWF, Remote sensing.

1. Introduction

A better quality analysis of data (including all types of data available) is essential for understanding atmospheric processes in the tropics and it is also important for defining the initial conditions for a global atmospheric model used for weather prediction purposes. The conventional observations are very few and mostly over land, leaving behind vast amount of data sparse oceanic region. Thus it is very essential to make use of non-conventional remotely sensed data, mainly from various satellites. A lot of research work is going on to utilize both conventional and non-conventional data (e.g. from satellites) to obtain better analyses of weather systems. Assimilation of all types of data for specific humidity analysis is also more important as the humidity field is directly responsible for physical processes such as the convection, cloud and rainfall.

Satellite passive microwave imagers are increasingly important for monitoring the earth's climate. Advantages of passive microwave sensors are that unlike visible and infrared imagers, microwave sensors “see” through most clouds. They are therefore able to measure atmospheric and surface variables under a far wider range of weather conditions. Microwave radiometers are sensitive to the roughness of the ocean surface. Since ocean waves are created by the action of wind, this property allows microwave radiometers to be used to estimate the surface wind speed over the ocean. However, there are several disadvantages of passive microwave sensors, which include: microwave sensors have much poorer spatial resolution than visible or infrared imagers, because of the long wavelength of microwave radiation. Due to the above problem, it is not yet practical to place microwave imagers in geo-stationary orbit. Coverage of a given location by a single microwave imager is therefore limited to once or

twice a day, on an average. The best known of these sensors is the Special Sensor Microwave/Imager (SSM/I), of which several copies have been launched in polar sun-synchronous orbit since 1987. Three DMSP (Defence Meteorological Satellite Program) satellites, which carry onboard SSM/I, namely F13, F14 and F15 are presently operational. The SSM/I has 7 channels covering 4 frequencies (19.35, 22.235, 37.0, 85.5 GHz) at two polarizations (Vertical and Horizontal). Only one channel is available at 22.235 GHz in vertical polarization. Each of these channels is sensitive to both surface and atmospheric variables.

The radiometer onboard the Tropical Rainfall Measuring Mission (TRMM) satellite, known as the TRMM Microwave Imager (TMI) is well-calibrated, similar to SSM/I, and contains lower frequency channels required for sea surface temperature retrievals. TRMM satellite is on low altitude (350 km), low inclination, non-sun-synchronous platform. The entire data set includes sea surface temperatures (SST), surface wind speeds derived using two different radiometer channels, atmospheric water vapor, liquid cloud water and precipitation rates. TRMM is a joint program between NASA and the National Space Development Agency of Japan (NASDA). The data are available from December 1997 to the present. All images cover a global region extending from 40° S to 40° N at a pixel resolution of 0.25 deg (25 km). Unlike SSM/I on DMSP platforms, the TRMM satellite travels west to east in a semi-equatorial orbit. This produces data collected at changing local times for any given earth location between 40° S and 40° N. The DMSP platforms are in a near-polar, sun-synchronous orbit. Therefore, the SSM/I instruments collect data daily at the same local time.

In May 1999, India launched IRS-P4 (OCEANSAT-I) satellite with two payloads *i.e.* Multi-frequency Scanning Microwave Radiometer (MSMR) and an Ocean Color Monitor (OCM) to study both the biological and physical parameters of the oceans. The satellite is placed in a near circular, sun-synchronous orbit at an altitude of 720 km with the local time of equatorial crossing in the descending node at 1200 hr + 10 minutes. The orbit inclination is 98.28 and orbit period is 99.31 min. Distance between adjacent orbital traces is 1382 km and distance between successive ground traces is 2764 km. MSMR is configured as a 8 channel radiometer with both vertical and horizontal polarizations in 4 frequencies. The spatial resolution corresponding to the frequencies 6.6, 10.65, 18 and 21 GHz are 120, 80, 40 and 40 km respectively.

Several studies have been carried out to show the usefulness of microwave imager data on the weather

analysis and forecasts. This includes the validation of microwave radiometer geophysical parameters using meteorological model analysis (Eymard *et al.*, 1993), comparative studies (Varma *et al.*, 1998), rainfall, cloud liquid water, surface winds and precipitation related studies (Xiao *et al.*, 2000; Weng *et al.*, 1997; Ledvina and Pfaendtner, 1995; Chang and Holt, 1994) etc. Many operational centers are using these data sets in their operational assimilation system. It is well known that many atmospheric models exhibit dry bias [Ledvina and Pfaendtner, 1995 for the NASA model; Wu and Derber, 1994 for NCEP model; Phalippou and Ārad, 1996, Ārad and Saunders, 1999 for ECMWF model]. Assimilation of SSM/I total precipitable water content (TPWC) data using these models was shown to reduce these biases in short to medium-range forecasts. Deblonde (1999) has found positive impact of SSM/I TPWC data in the Canada Meteorological Centre's assimilation forecast system.

At National Centre for Medium Range Weather Forecasting (NCMRWF), India, a global data assimilation system at T80L18 (spectral, horizontal 80 waves in Triangular truncation with 18 vertical layers) resolution is run on operational basis every day. Continuous attempts are made to utilize more data (both conventional and non-conventional) to get better description of atmospheric conditions. Medium-range weather predictions are made routinely using the analyses as initial conditions for a global spectral model. At NCMRWF, suitable schemes have been developed to utilize the processed meteorological data from MSMR in the Global Data Assimilation System (GDAS), (Rizvi *et al.* 2002). The MSMR wind speed and TPWC, derived at 150 km and 75 km resolutions have been assimilated in the GDAS along with other global meteorological data received on operational basis at NCMRWF, (Rupa *et al.* 2002). A detailed study on the use of microwave sensors' data on the analysis and prediction of Orissa super cyclone has been carried out (Kar *et al.* 2002).

In this paper, impact of the TPWC and surface wind speed data from microwave sensors (both active and passive) on the NCMRWF GDAS & forecasting system has been discussed. These sensors are on board various satellites namely TMI on TRMM, SSM/I on DMSP and MSMR on IRS-P4. Experiments with TMI and MSMR data were carried out for the monsoon season of 2000 and similar experiments were carried out for monsoon 2001 using MSMR and SSM/I data. Impact of TMI, MSMR and SSM/I data on the analysis of Orissa super cyclone has been discussed here briefly to highlight the need of more satellite data over the Indian Ocean region. Section 2 of this report briefly describes the data assimilation and

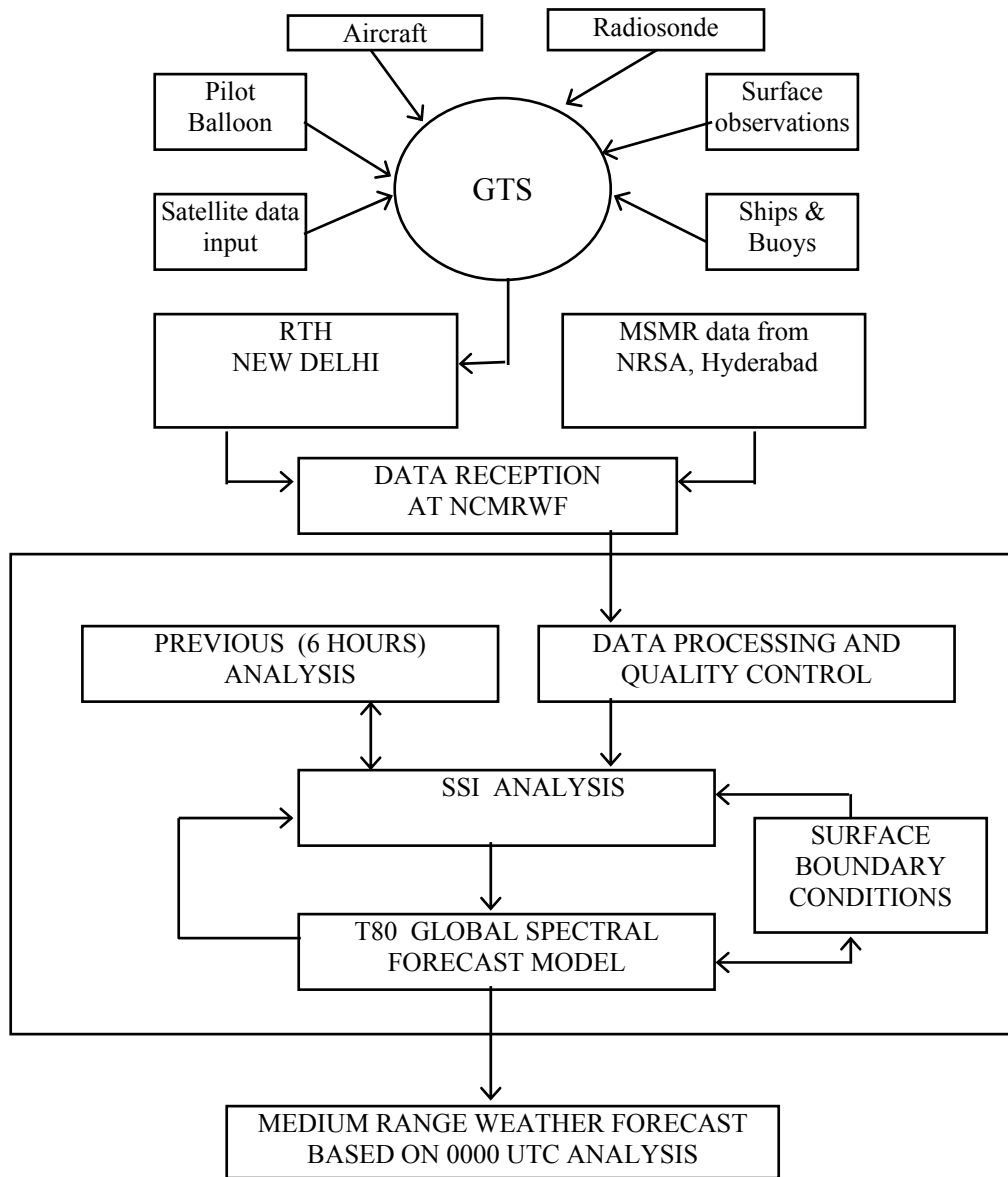


Fig. 1. Flow chart of NCMRWF analysis/forecast system

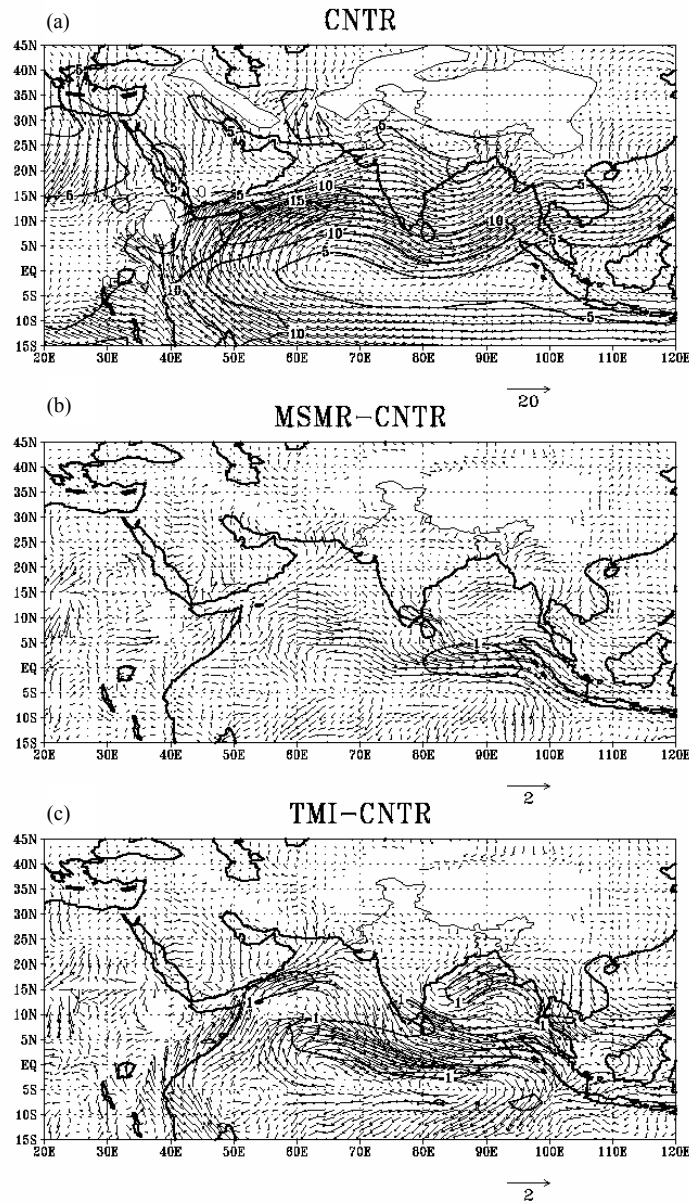
forecast system operational at NCMRWF. Results and discussions are presented in section 3. The present study is concluded in section 4.

2. The global assimilation-forecast system

The meteorological data from various observing platforms from all over the globe are received at Region Telecommunication Hub (RTH), New Delhi through Global Telecommunication System (GTS) and the same are made available to NCMRWF. These data are then passed through the operational comprehensive hydrostatic quality control procedure. The analysis scheme

operational at NCMRWF is mainly based on the concept of minimising a generalised cost function using the Spectral Statistical Interpolation (SSI) technique. This analysis scheme is an adapted version of the analysis scheme of the National Centres for Environmental Prediction (NCEP, formerly NMC) in USA described by Parrish and Derber (1992) and modified by Rizvi and Parrish (1995). First guess for the analysis cycle (four 6-hourly cycles in a day) is provided from a 6-hour forecast from a global spectral model with 80 waves in triangular truncation (T80) and 18 vertical levels in sigma coordinate (Kanamitsu, 1989). Medium range predictions are prepared by integrating the model for 7-days from 0000UTC

Analysis 850hPa Winds(m/s) JJAS 2000

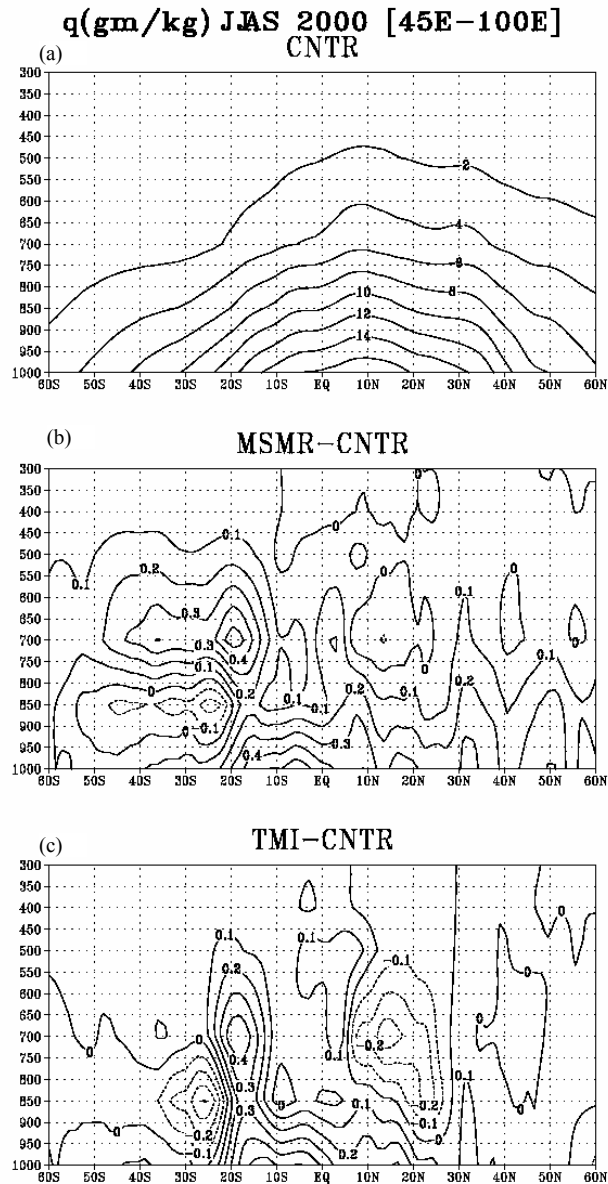


Figs. 2(a-c). (a) Mean JJAS-2000 CNTR analysis of winds (m/s) at 850 hPa, (b) Difference of wind analysis with MSMR data from CNTR and (c) Difference of wind analysis with TMI data from CNTR

of each day at the NCMRWF. The schematic diagram showing different components of NCMRWF analysis/forecast system is given in Fig. 1.

The MSMR wind speed and TPWC, derived at 75 km resolution have been assimilated in the NCMRWF GDAS along with other global meteorological data received on

operational basis *via* Regional Telecommunication Hub (RTH), New Delhi at NCMRWF. MSMR data has been used for our study for both the monsoon season *i.e.*, June, July, August and September (JJAS) of 2000 and 2001. SSM/I and TMI data at 25 km resolution were downloaded from www.ssmi.com and have been assimilated for JJAS of 2000 and 2001 respectively. It



Figs.3 (a-c). (a) Latitude-pressure cross-section of mean JJAS analyzed specific humidity (CNTR) averaged over 45°E-100°E, (b) Latitude-pressure cross-section of the difference between MSMR and CNTR analyzed specific humidity and (c) same as (b) but difference between MSMR and CNTR analysis

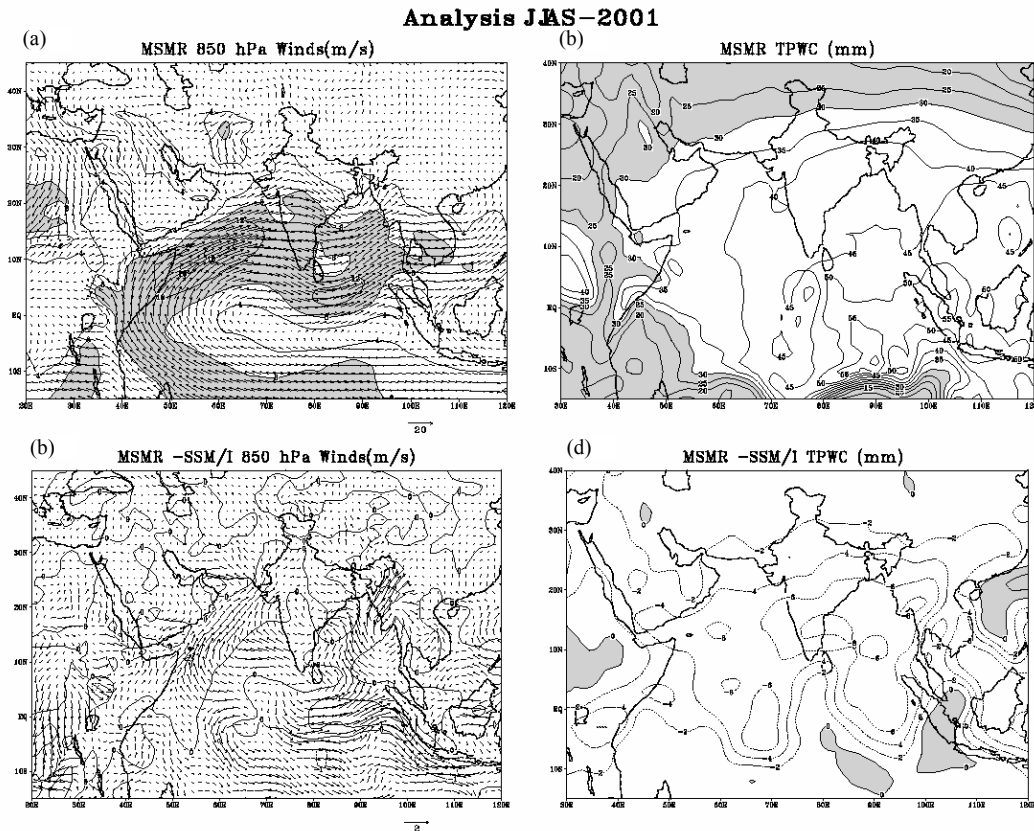
may be mentioned here that SSM/I data were interpolated to 75 km resolution before assimilation, but the TMI data were assimilated at their original resolution.

3. Results and discussion

3.1. Monsoon-2000 with MSMR and TMI data

During the monsoon season of 2000, the operational analysis system at NCMRWF was not using any data from

MSMR, or SSMI or TMI. However, several other experiments were conducted during 1999 and 2000 to evaluate the impacts of surface wind speed data and TPWC data from these microwave sensors. The studies carried out more or less indicated that the NCMRWF analyses of moisture have too less values and are generally dry compared to most analyses done at other leading Centres. Utilization of TPWC data from various microwave sensors helped remove the dry nature of the analyses. In this section, we describe the analyses



Figs. 4(a-d) (a) Mean JJAS-2001 analysis of winds (m/s) at 850 hPa obtained using MSMR data, (b) Difference of wind analysis with MSMR data from SSM/I, (c) Mean JJAS-2001 analysis of TPWC and (d) Difference of TPWC analysis with MSMR data from SSM/I

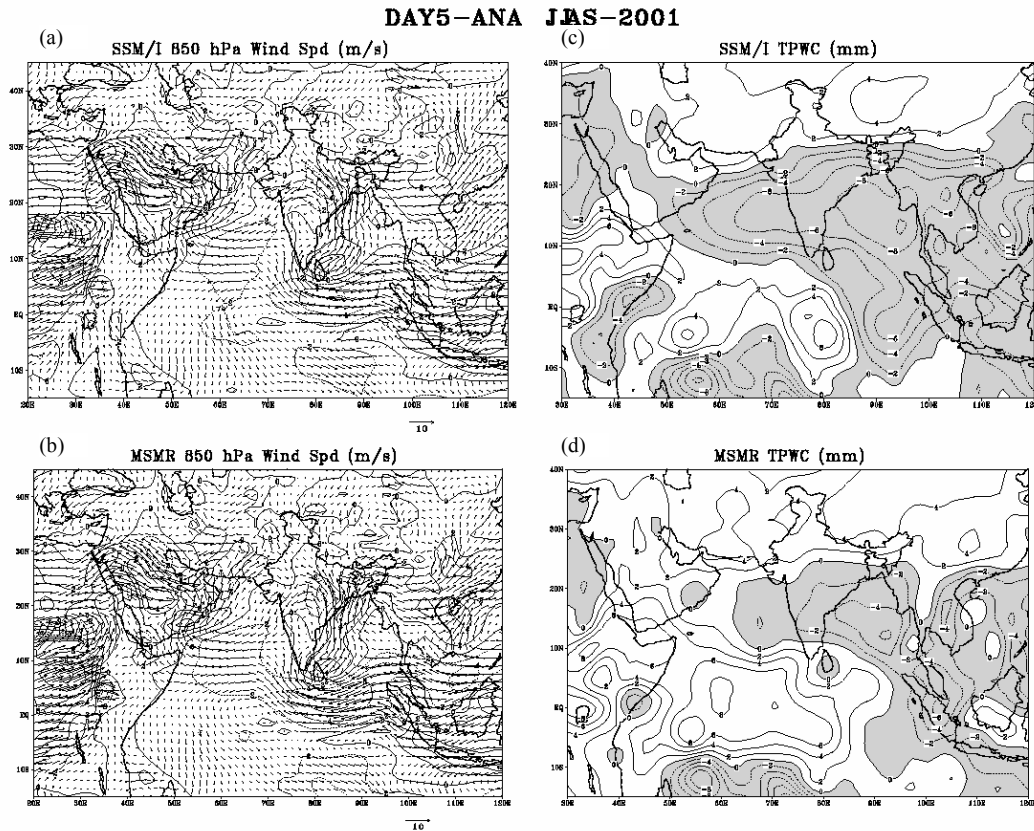
obtained using MSMR and TMI TPWC and surface wind speed data on the monsoon circulation during JJAS-2000 and compare them against the operational analyses.

Fig. 2(a) shows the mean seasonal (JJAS) operational analyses of winds at 850 hPa over the Indian region. Main feature to note in this figure is the cross-equatorial flow, the Somali jet and the monsoon trough. The NCMRWF analysis system has been able to represent the lower level circulation reasonably well during Northern Hemisphere summer. Over the Indian Ocean, cross-equatorial flow corresponding to monsoon winds are also well analyzed. The strength of the monsoon winds over India, the position and intensity of the monsoon trough during this season are also correctly represented by the analysis system.

Figs. 2(b&c) show the mean JJAS analyses wind difference at 850 hPa between experiments with MSMR and TMI data respectively from the operational run (CNTR); *i.e.* MSMR-CNTR and TMI-CNTR over the Indian region. In both the experimental analyses, the

model has tried to increase the strength of south-westerlies over the north Arabian Sea and Bay of Bengal. Strengthening is seen to be more with TMI data than the MSMR data. Cross-equatorial flow is also stronger in the TMI run than the CNTR or MSMR runs. Maximum difference in the winds can be noticed in the equatorial Indian Ocean when additional satellite data are used. Over the Indian land, no large difference in the wind field is noticed. It is seen that impact of the MSMR and TMI data in the analyses of tropical winds is quite significant in the NCMRWF assimilation system.

The impact of TPWC data from MSMR and TMI is such that it increases the moisture content over the entire tropical oceans. Fig. 3(a) shows the zonal mean (between 45° E and 100° E) of JJAS mean specific humidity at pressure level. It is seen as expected that the moisture content in the Northern Hemisphere is more than the Southern Hemisphere over the Indian longitudes. With the addition of additional TPWC data from MSMR and TMI, the moisture level has further increased in this region as seen from Figs. 3(b&c) where difference of specific



Figs. 5(a-d) Difference of mean Day-5 forecasts from the mean verifying analyses (systematic errors) for JJAS 2001 (a) 850 hPa winds with SSM/I, (b) 850 hPa winds with MSMR, (c) TPWC with SSM/I and (d) TPWC with MSMR experiments

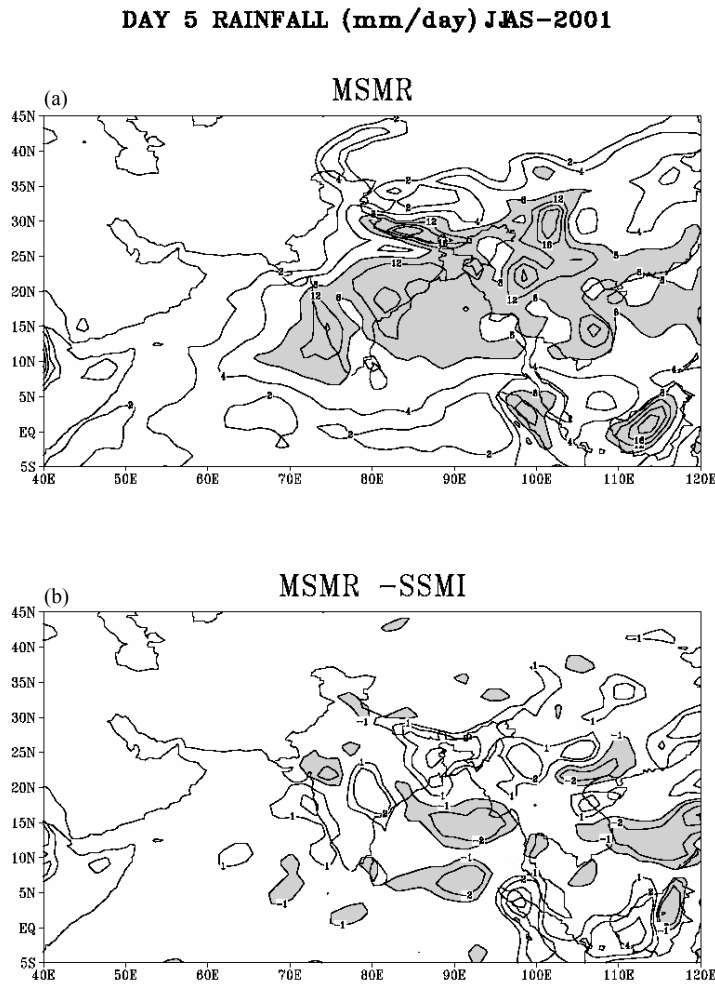
humidity MSMR-CNTR and TMI-CNTR are shown. It is interesting to note that because of MSMR data, moisture increase is more over the region of equator to 10° S, whereas TMI has increased the moisture more over the region 10° S to 20° S. Some reduction in moisture is seen in both experiments at 20° S - 30° S. Over the Indian land area, at higher level (around 700 hPa), TMI data has caused a reduction of moisture.

3.2. Monsoon-2001 with MSMR and SSM/I data

From January 2001, operational analyses at NCMRWF started to include surface wind speed data and TPWC from SSM/I. Therefore, during the monsoon season of 2001, we have the operational analyses with SSM/I data. It was interesting to see the role of MSMR data on the monsoon of 2001 and compare the performance of data from Indian satellite against the SSM/I. Therefore, parallel assimilation experiments were made using the MSMR TPWC and surface winds and

dropping the SSM/I data, to look at the impact of data from these microwave sensors over the Indian Ocean. Our earlier experience during assimilation of MSMR data of 1999 and 2000 was that MSMR data makes the analyses too moist compared to the CNTR analyses, which was too dry (Rizvi *et al.*, 2002). In order to remove this bias in the analyses, the observation error of the MSMR TPWC data was increased further and a set of assimilation experiment was carried out without this modification. In this section, we discuss the results for the monsoon season of 2001 obtained using SSM/I data and MSMR data (with modified observation error characteristics).

Fig. 4(a) shows the mean JJAS analyzed winds at 850 hPa over the Indian region. This plot is obtained using MSMR data. In Fig. 4(b), we have shown the difference of winds at the same level between the analyses of MSMR and SSM/I. It is noticed that south-westerlies over the Arabian Sea reaching Gujarat coast are stronger in the

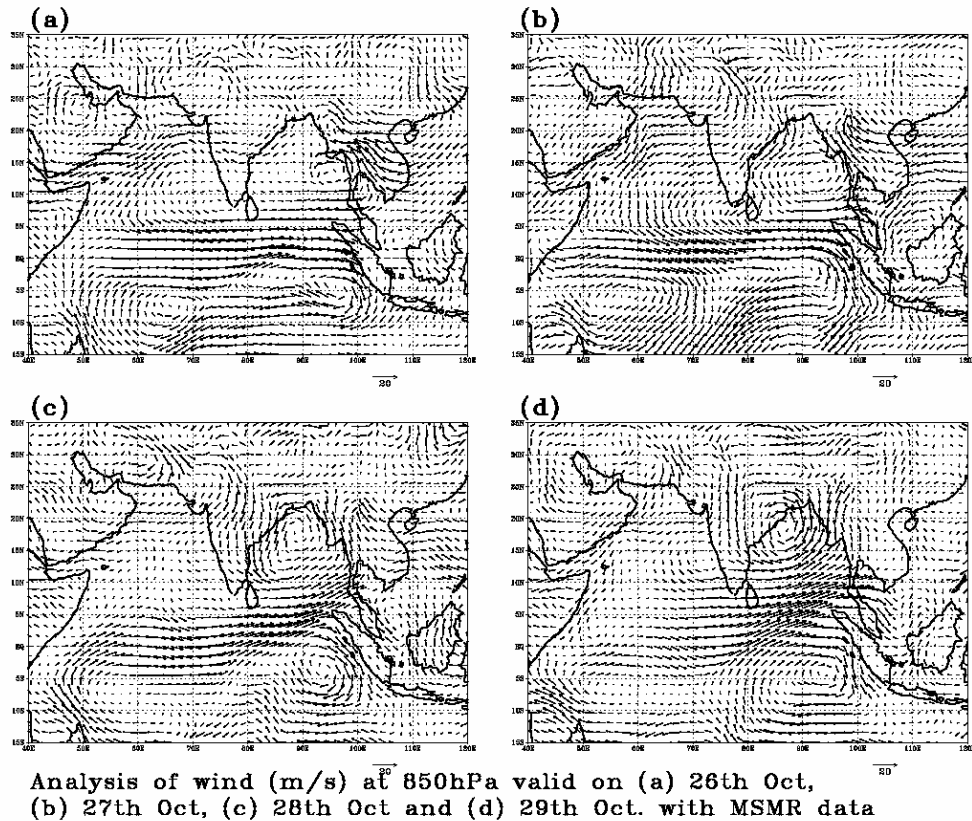


Figs. 6 (a&b). (a) Mean JJAS Day-5 forecast rainfall (mm/day) obtained from MSMR experiments and (b) Difference of JJAS mean Day-5 forecast rainfall from MSMR and SSM/I experiments

MSMR experiment. However, the easterlies in the Indian Ocean south of equator are weaker in this experiment compared to SSM/I run. In Fig. 4(c), analyzed TPWC is shown for MSMR experiment and Fig. 4(d) shows the difference of TPWC between MSMR and SSM/I experiments. Maximum TPWC over the Indian region is seen to be around 60 mm at 90° E and 10° S. Over the Indian land, the TPWC values range from 30mm to 45 mm. It is seen that the moisture content in the analysis with SSM/I data is about 4 to 6 mm more than that obtained using MSMR data.

The model was run for 7 days to examine the impact of these data on model forecasts. Fig. 5 shows the difference between the Day-5 forecasts and the verifying analyses. These plots are for the mean of all the day-5 forecasts and analyses for entire JJAS period. Therefore,

any difference seen in the figures are statistically significant. As expected, the nature of difference between SSM/I runs and MSMR runs are very similar. However, easterly wind errors over the equatorial Indian Ocean in the MSMR run are larger than the SSM/I run as seen in Figs. 5(a&b). It is interesting to note the TPWC differences between analyses and forecasts as shown in Figs. 5(c&d). By day-5 forecast, the model has removed most of the moisture in the analyses provided by MSMR and SSM/I data over the Indian region. Since the moisture available in the SSM/I runs are more than MSMR, the model has removed more moisture 8-10 mm TPWC over the Bay of Bengal compared to 6 mm difference seen in MSMR runs. Difference over the Indian land area for SSM/I is about 2-6 mm compared to about 2 mm in MSMR run. Increase in the TPWC values over the eastern Indian Ocean is seen in the forecasts for both these two



Figs. 7(a-d). Analyses of winds at 850 hPa using MSMR data valid on (a) 26 , (b) 27 , (c) 28 and (d) 29 October 1999

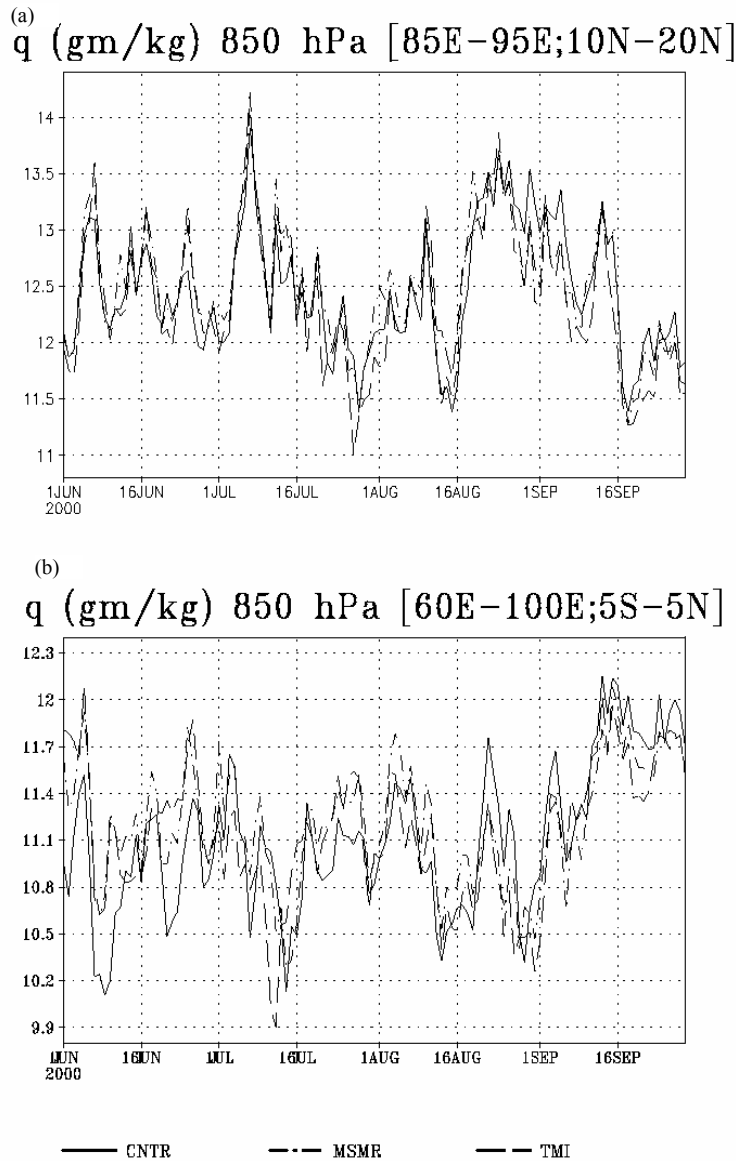
runs. However, in MSMR case, this increase is larger than the SSM/I run, and it may be related to the larger easterly wind errors in MSMR case.

The seasonal rainfall distribution from all the Day-5 forecasts during JJAS-2001 from MSMR run is shown in Fig. 6(a). The model has done a reasonable job in predicting rainfall maxima over Western Ghats and north-eastern India. However, with MSMR data, the model predicts more rain over east coast (*i.e.*, over Orissa and Andhra Pradesh). This deficiency is somewhat reduced by the utilization of SSM/I data, as shown in Fig. 6(b). Over the Bay of Bengal, the MSMR run produces less rainfall than the SSM/I run, because, as discussed earlier, the SSM/I run has too much TPWC available over this region.

3.3. The case of Orissa super cyclone

The super cyclone in October 1999 was the most intense tropical cyclone in the history of Orissa, the coastal state in India for the last 114 years. This state was battered for more than two days by strong winds and

intense rain. It also produced huge storm surge and catastrophic floods. It crossed Orissa coast of India between 0430 and 0630 UTC of 29 October. NCMRWF had on 24 October predicted the possibility of the storm approaching the coast of Orissa, but in subsequent forecasts, the storm was seen to have weakened. A major problem in the prediction of cyclonic storms over the Indian Ocean is that this area is mostly data sparse and the initial conditions for the model predictions are not well defined. If the location and intensity of the storm in the analysis does not match the observed location and intensity, the best model will also fail to predict the course of the storm in the prediction. In order to examine if the additional data from microwave sensors would provide a better analyses, several assimilation experiments were conducted using SSM/I, MSMR and TMI data along with operationally obtained GTS data for the period 20-31, October 1999. Results of these experiments are described in detail in Kar *et al.* (2002). In this paper, we have shown the wind analyses of the Orissa cyclone for 26-29 October obtained with MSMR data at 850 hPa (Fig. 7). It is seen that the cyclone is well analyzed by the NCMRWF GDAS



Figs. 8(a&b). Time series of areal mean specific humidity at 850 hPa for JJAS 2001 (a) 85° E - 95° E, 10° N - 20° N and (b) 60° E - 100° E, 5° S - 5° N

system when the MSMR data (TPWC and surface wind speed) are included. The position of the system is very close to the observed position (track of the cyclone not shown), but the intensity of the system is under-estimated. Similar analyses are produced when the assimilation experiments were conducted using TMI and SSM/I data. However, the analyses with the TMI data were the best. It may be noted here that the best forecasts of the Orissa cyclone were obtained using TMI data and METEOSAT winds.

3.4. Discussion

Microwave sensors are able to provide some data over the vast Indian Ocean, which is void with conventional meteorological data. At NCMRWF, suitable analysis packages have been developed to utilize this data, assimilate them and use for medium range weather forecasting. The experiments described in this paper were necessary to evaluate the data from these microwave sensors (namely MSMR, TMI and SSM/I) when they are

assimilated in to the NCMRWF GDAS system. It is seen that during the monsoon season, the role of surface wind speeds and TPWC from these sensors are quite important. The dry nature of the NCMRWF analyses is reduced, and the analyses become more realistic. There are differences among the analyses obtained from these experiments, which are quite significant as these are seen in the seasonal mean. Out of all the parameters provided by these sensors, TPWC is a crucial parameter and our examination of results show maximum impact is obtained from this field only. As the moisture data is responsible for all the physical processes in the data assimilation procedure, these additional moisture data is expected to affect the convection process in the model. As the TMI or MSMR or SSM/I analyses are more moist compared to CNTR, the experimental humidity field acts as an additional source of heating in the global tropics. The tropical circulation is mostly driven by the diabatic heating and therefore, the difference in circulation pattern between CNTR and experimental analyses is worth examining.

Over the Indian Ocean region, TPWC exhibits considerable intra-seasonal variability. These variations in the TPWC were found related to the equatorial eastward propagating convection anomalies in the equatorial Indian Ocean and to the intraseasonal variability of the Indian monsoon over the Bay of Bengal. In order to see if the additional TPWC data from TMI or MSMR has thrown any light in to the variability of TPWC in these two regions, area averaged specific humidity at 850 hPa over the equatorial Indian Ocean (60° E - 100° E, 5° S - 5° N) and the Bay of Bengal (85° E - 95° E, 10° N - 20° N) has been examined. Fig.8(a) shows the intraseasonal variability of this field over the Bay of Bengal and Fig. 6 (a) shows the same for equatorial Indian Ocean. For both panels, analyzed specific humidity with both TMI and MSMR experiments are shown along with CNTR analysis for JJAS 2000. It is seen that, with both the microwave sensor data sets, we are able to obtain the same phase of moisture variability over the Bay of Bengal. It is also seen that, analyses without TPWC data either from these two satellites, we obtain the phase of moisture variability right (figure not shown). The north Bay of Bengal, especially is surrounded by Radiosonde stations and data from these land observations help providing a better moisture analyses over this region. Therefore, the three analyses are not very different from each other. However, over the equatorial Indian Ocean region, they are sometimes very different. There are large differences in the magnitude of moisture among the analyses, and occasionally the phase also is not the same. It is also seen that the difference of wind speed among these experiments are quite large and may be more than the observation errors (figure not shown).

The satellite data used in this study have their own observation error and biases. All the validation studies carried out prior to the release of data show that they compare well with Radiosonde data or with observation from ships. Indian Ocean is mostly data void region. There are few island stations and validation conclusions using a few conventional observations may not correctly represent the actual quality of satellite data over this region. Uncertainty in the initial conditions also weakens the confidence in the predictions from a global model. The spread of data among the experiments suggest that an uncertain quantity, namely specific humidity, entering the physical processes of the model (used for preparing the guess field for data assimilation) and affecting the wind field in turn and affecting medium range weather forecasts too. It is also noted that any additional moisture added to the analysis are removed during model integration by about 5-7 days making the forecasts dry again. This study also shows that the modifications made to observation error during assimilation of MSMR data in JJAS-2001 was not very much necessary, as except, that the MSMR analyses was little drier than the SSM/I analyses, the impact was similar as seen in 1999 or 2000 analyses.

4. Conclusion

Meteorological data from microwave sensors are very useful over the data sparse regions such as the Indian Ocean. Assimilation experiments have been carried out at NCMRWF using surface wind speeds and TPWC from various satellites providing meteorological data from microwave sensors on-board (*i.e.* TMI, SSM/I and MSMR). Assimilation experiments have been carried out using TMI and MSMR data for the monsoon season of 2000 and the results have been compared against the operational analyses, in which no such data were used. For 2001, additional experiments were carried out using MSMR data and results were compared against the operational analyses with SSM/I data. These data when assimilated at NCMRWF have affected the analyses and forecast significantly during monsoon seasons. The dry bias of the analyses gets removed with these data. Large impact in the wind field is also noticed especially over the oceanic region. Therefore, the monsoon circulation gets affected. Assimilation and forecast experiments were also carried out using these data for the Orissa super cyclone. The analyses of this cyclone improved considerably when these data were used. TPWC data seems to be very crucial parameter for modeling purpose. Over the Indian Ocean, both wind speed data and moisture data from these satellites differ considerably. Any uncertainty in initial conditions will be reflected in the quality of weather forecasts generated using these data. Therefore, due care must be taken in the retrieval and assimilation techniques so that this parameter is represented correctly.

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