

Impact of ATOVS data in a mesoscale assimilation-forecast system over the Indian region

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Abstract

One of the major problems of numerical weather prediction over Indian region is the scarcity of data over the neighboring oceanic region where tropical systems, which affect Indian subcontinent, are formed. So ATOVS temperature and humidity profiles are very important data over this region. MM5 forecast system is being used at National Centre for Medium Range Weather Forecasting (NCMRWF), India for the meso-scale forecast over Indian region. Recently a regional assimilation system from NCAR, USA (MM5-3DVAR) is implemented at NCMRWF to provide high resolution initial condition for MM5 model. ATOVS data is included in the assimilations system. An impact study was carried out for 10day period in July 2004, when few tropical systems were formed over Bay of Bengal. Our results show that utilisation of ATOVS data improves the mass and wind balance in the MM5 forecast. ATOVS data also helped to improve the track prediction of the tropical system formed over Bay of Bengal during the period of our study.

Introduction

Indian sub-continent is surrounded by data sparse oceanic regions. The formation and intensification of most of the tropical weather system, which affect Indian region, occurs over these oceanic areas. Since initial conditions are crucial for the numerical forecast, preparation of realistic initial condition by an assimilation scheme requires high density, high quality data.

Temperature and moisture profile data from polar orbiting satellite is one of the valuable data set over oceanic regions, which has already proved its beneficial impact on

NWP analysis and forecast. The vertical profiles of temperature and humidity from TIROS Operational Vertical Sounder (TOVS) system, on board NOAA series of satellite were available to scientific community since 1979. Currently, NESDIS processed global ATOVS (advanced TOVS) temperature and moisture profile data from NOAA 15 & 16 at 120 Km resolution in BUFR code is available to users. Atmospheric temperature and moisture profiles, in both clear and cloudy atmospheres are being retrieved from ATOVS radiance measurements by NESDIS, using the International ATOVS Processing Package (Li. et. al. 2000). This data set mainly contains atmospheric temperature for 40 levels (1000-10 hPa), mixing ratio for 15 levels (1000–300 hPa), ozone amount, cloud amount and total precipitable water content etc.

MM5 model (Grell et. al., 1995) is being used at National Centre for Medium Range Weather Forecasting (NCMRWF), India for the meso-scale forecast over Indian region since 2002. Recently MM5-3DVAR regional assimilation system (Barker et. al. 2003 & 2004) from NCAR, USA is implemented at NCMRWF to provide high resolution initial condition for MM5 model. The MM5 model is being run at NCMRWF as nested at 90, 30 and 10 km resolution (fig.1).

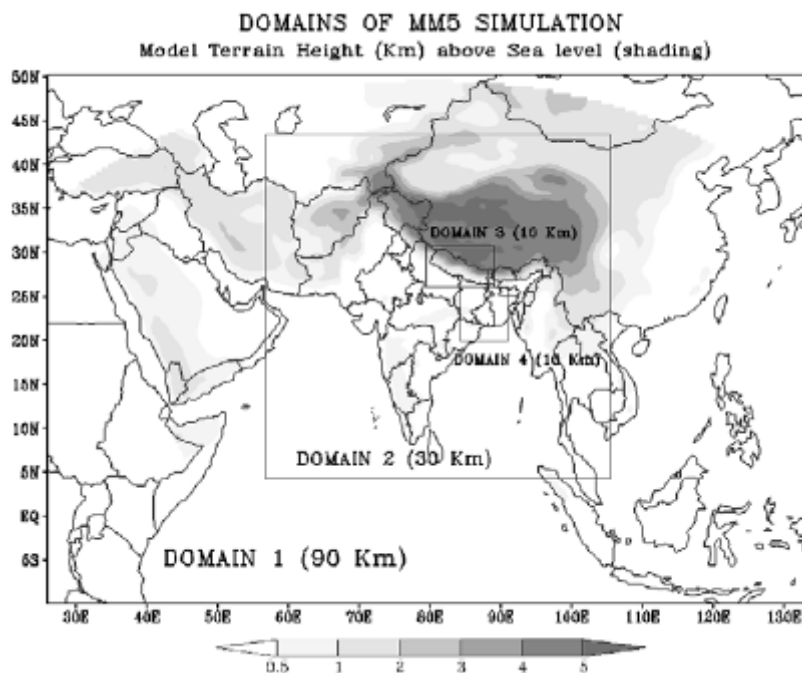


Fig.1 Domains of MM5 forecast (NCMRWF) over Indian region

MM5-3DVAR (Version 1.2) had provision for assimilating only TOVS thickness data. Assimilation of ATOVS temperature and moisture profile required the development of suitable modules. Separate modules have been developed for inclusion of ATOVS moisture and temperature data. In this study, data assimilation is carried out in cyclic mode (6 hr intermittent) for a period 21 to 31, July 2004 during which ATOVS temperature and humidity profiles are also used in addition to the conventional data.

Results & Discussion

During July 21-31, 2004 two cyclonic circulations extended up to mid-troposphere formed over head Bay-of Bengal region in quick succession resulting copious rainfall in the east coast of India. First system was formed at 24th July over oceanic region ($87^{\circ}\text{E}/17.5^{\circ}\text{N}$) moved northwestward and cross the coast on 00 UTC 25th. Next system formed on 27th over the ocean and intensified as monsoon depression and moved northwesterly direction, crossed east coast of India near Orissa, and persisted as a low-pressure system centered at $81^{\circ}\text{E}/23^{\circ}\text{N}$ over land up to 00UTC of 31st July.

In this present experiment ATOVS temperature and moisture data at standard atmospheric levels over oceanic region for cloud free retrievals are assimilated in cycling mode for the period 21 to 31, July 2004 along with other conventional GTS data set. In the control (CTRL) analysis, all conventional GTS data were used whereas in the ATOVS analysis, ATOVS data is also included in addition to the GTS data.

Fig.2 depicts the CTRL (GTS data) and ATOVS (GTS+ATOVS data) analyses at 850hPa of 00 UTC of 27, 28 and 29 July 2004. Analyzed position of the cyclonic circulation near the east coast of India, in wind field, are not much different in both the runs, but in ATOVS run, in formative stage(i.e. 00UTC 27 July 2004), the system is weaker compared to CTRL . But, in the later stage i.e. on 00UTC of 28 and 29 winds are stronger in ATOVS. The system is also analysed more intense in geopotential height field of ATOVS compared to CTRL analysis on all these days. However, in all the three days in ATOVS analysis, the centre of circulation in wind field coincide the centre of low in height field, whereas in CTRL analysis there are disagreement in both the centers, mainly in the formative stage.

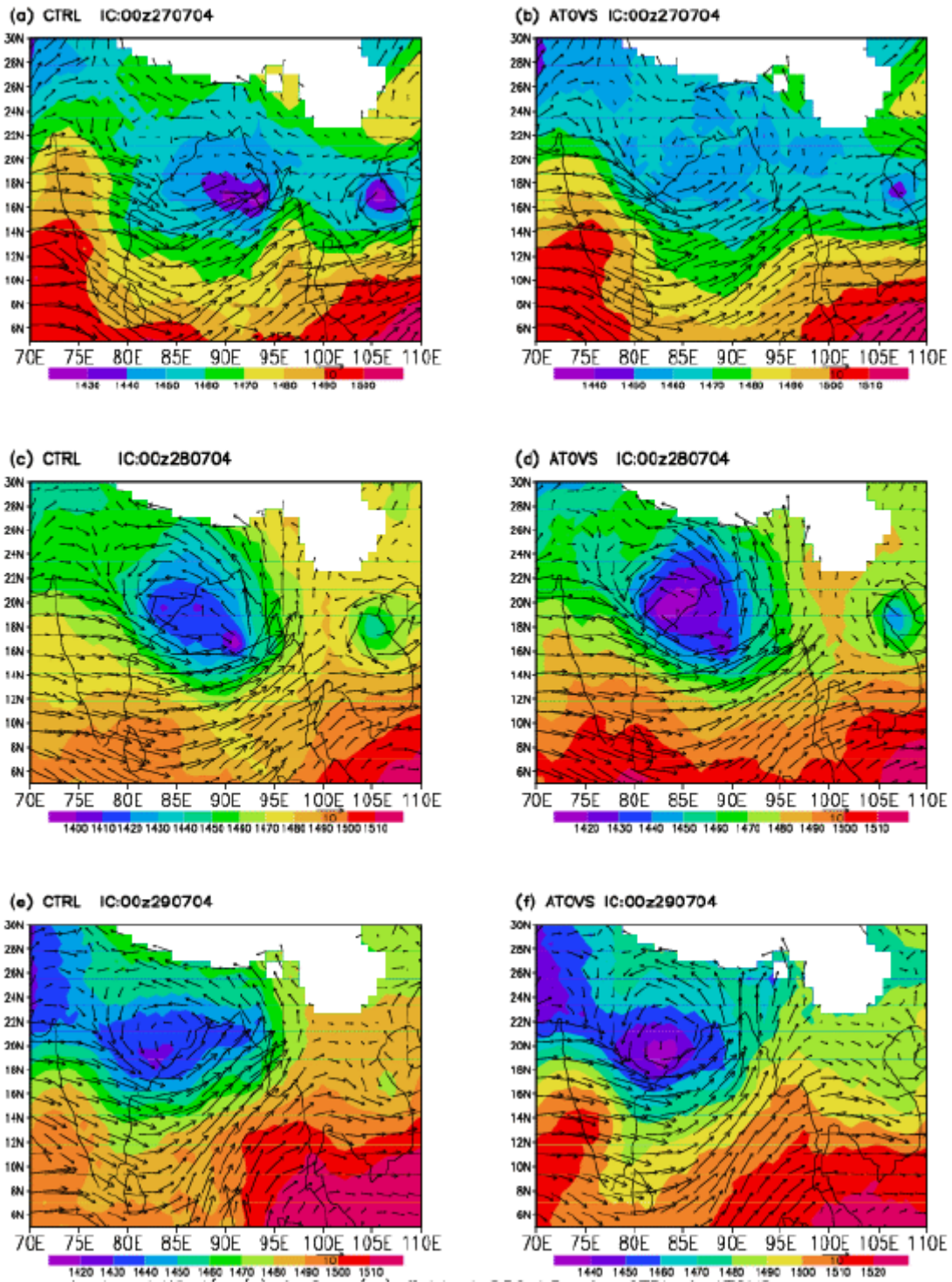


Fig.2 850hPa Geopotential height & Wind for CTRL and ATOVS analysis of 00 UTC of 27 to 29 July 2004

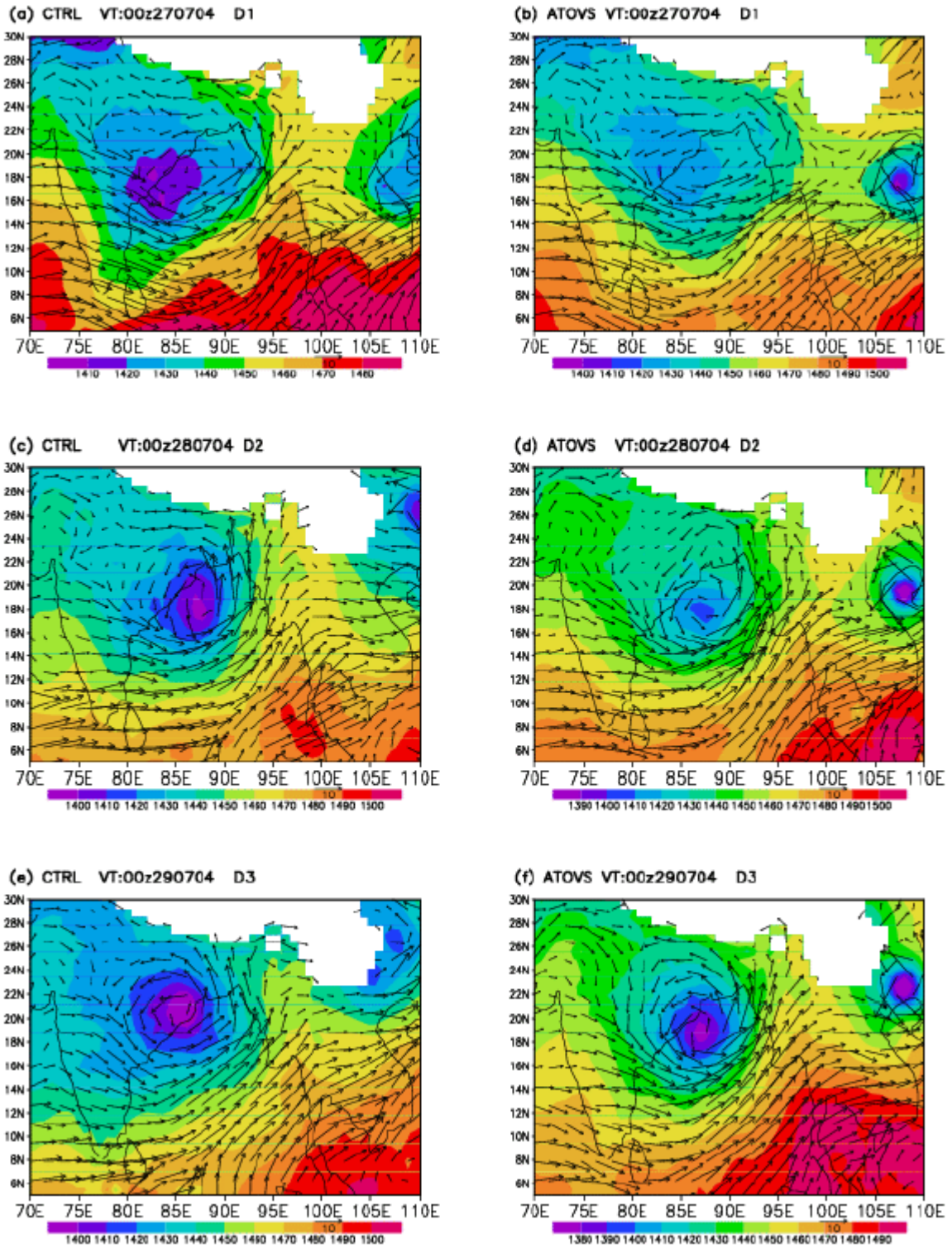


Fig.3 850hPa Geopotential height & Wind for CTRL and ATOVS forecast for 24(D1), 48(D2) and 72(D3) hrs forecast based on of 00 UTC of 26 July 2004

Fig.3 depicts 24, 48 and 72 hr. forecast of wind and geopotential height fields by MM5 model based on 00UTC of 26 July 2004 analysis of CTRL and ATOVS. Both the runs could predict the genesis of the system; however the movement of the system in ATOVS is slower than that of CTRL run. Our results also show that the position of the system in the ATOVS forecast (upto 48 hrs) is more closed to the observed position of the system, compared to CTRL forecast.

Summary

Utilisation of ATOVS data in the MM5-3DVAR assimilation system has shown better track prediction of the tropical system up to 48hrs (by MM5 forecast). Mismatch between circulation center in wind and height field in CTRL analyses is reduced considerably with utilization of ATOVS data during the period of our study.

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