ASSIMILATION OF QUIKSCAT DATA IN A MESOSCALE ATMOSPHERIC MODEL (MM5)

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ABSTRACT

Challenges relating to forecasting in the tropics differ from mid latitudes due to weak dynamical constraints, rapidly evolving mesoscale weather systems, important role of convection in tropics and sparseness of the conventional data network in the tropics especially over ocean areas. Regional model forecasts are quite useful for monitoring of weather for localized situations. MM5 is known as fifth generation NCAR/Penn State Mesoscale model (MM5), which is the non-hydrostatic version of the model originally developed by Anthes and Warner (1978). Radar systems such as space-borne scatterometers with extended coverage are able to provide accurate winds over the ocean surface and potentially contribute to improve the situation for tropical and extra tropical cyclone prediction. In this study, we will outline the results of a cyclone simulation case to demonstrate the impact of scatterometer derived sea surface winds in mesoscale model simulation. A new scatterometer Seawinds launched onboard QuikSCAT in June 1999, observes surface wind vectors over the ocean with the swath of 1800 km, which is more than three times wider than that of ERS Scatterometer. Hence, its large contribution to Numerical Weather Prediction (NWP) is expected. QuikSCAT derived winds have been used to diagnose the motion of the cyclone that formed over Bay of Bengal during the year 2001. For a cyclonic situation, data of few ships of opportunity and of some coastal or island stations are only available. For the assimilation of observed data into MM5, a few passes of QuikSCAT at different times are available. These additional data strengthen the initial data for assimilation. The initial field with the inclusion of scatterometer data was nearer to the actual position and the model is also capable of successful cyclone genesis and improvement in its track with the help of scatterometer data.

(Key words: Regional model, MM5, QuikSCAT, NCEP(AVN) data, Newtonian relaxation, FDDA, Meteosat Imageries, SSM/I)

1. INTRODUCTION

One of the main challenges remaining in the study of tropical cyclones is understanding and predicting their genesis, especially the development of organized cloud clusters (i.e., one or more mesoscale convective systems (MCSs)) into a warm core vortex. The difficulty in making progress in this area has reflected the genesis process involving three scales of motion (cloud, mesoscale, synoptic) and the need to observe each of these in detail, from upscale growth and intensification of a complex, dispersed system into a single, coherent vortex. On October 13, 2001 a low pressure system that ultimately intensified into a cyclonic storm was present in SW Bay of Bengal.

2. DATA AND METHODOLOGY

A single domain run (SDR) option at 30 km resolution is set over Indian region. The control run is performed with NCEP (AVN) data without assimilation of additional QuikSCAT data and the experimental run is performed with the assimilation of additional QuikSCAT data. The QSCAT data used for the assimilation is for 11-12 Oct and 15-16 Oct 2001 for two separate runs. The MM5 FDDA procedure is based on a ***Newtonian relaxation (nudging)*** procedure and readily allows assimilation of asynoptic data such as satwinds. Error characteristics for different data types assigned either objectively or subjectively and are incorporated into weightings for each observation type that have both horizontal and vertical structure. Hence, for example, near surface winds may only be assimilated in one layer, but may have broad horizontal influence on the analysis field. Two 60 hr model simulations are compared here: an "***FDDA run***" in which the MM5 forecast includes FDDA on 11 Oct for genesis case and 15 Oct for center and track prediction case and a "***non-FDDA run***" in which no satwinds are used. In both cases, NCEP (AVN) analysis and forecasts are used to provide initial and boundary conditions. Since the purpose of this study is to investigate the impact of satwinds on the MM5 forecast, 12 hr FDDA on the forecast was used for maximum impact. The period studied extends from 0000 UTC on 11 Oct 2001 to 1200 UTC on 13 Oct 2001 and from 0000 UTC on 15 Oct 2001 to 1200 UTC on 17 Oct 2001. The Meteosat imageries and SSMI data of the same period are used for model verification.

3. RESULTS AND DISCUSSION

Starting at 0000 UTC on 11 Oct 2001, a 60 hrs simulation was carried out with and without FDDA of Satwinds. Control run used data from the NCEP global aviation (AVN) model initialized at 00 UTC 11 Oct 2001. The AVN grids were available on a 0.75 $\times$ 0.75 degree latitude-longitude grid and were spatially interpolated to the model grid domain. Fig.1 shows the initial flow at 1000 hPa. From the figure the absence of convergent flow in Bay of Bengal is noted. In Fig.2 (24 hr forecast) a weak convergent flow has developed and this weak flow has been intensified into a strong cyclonic circulation (48 hr forecast). The model simulated low pressure system ***without FDDA*** is compared with model simulation ***with FDDA*** for 24 hr and 48 hr forecasts. The intensity and the position of the low pressure system is well simulated in the experimental run compared to the model simulation ***without FDDA***. Convergence patterns are stronger in the QuikSCAT assimilated simulation at the leading edge of the low pressure system. These simulated forecasts are also compared with observed fields (QuikSCAT) for 12 Oct and 13 Oct 2001 (Fig 3). In the case of simulation, the intensity of the low pressure area is weak and is seen to the north of its position in comparison to the analysed field. Fig.4 indicates the time series of model simulated minimum sea level pressure (MSLP) averaged over a box of latitude 15°-16°N and longitude 85°-86°E for 60 hr run for both control and experimental runs. The model is able to simulate the deepening of low pressure and agrees well with the actual observations.

Starting from 0000 UTC of 15 Oct 2001, a 60 hr simulation was carried out. The difference in 24 hr forecast of 850 hPa winds with and without FDDA of Satwinds is shown in Fig 5. From the figure, it is seen that at 0000 UTC on 16 Oct 2001, the cyclone has moved westward and is positioned near the east coast. Maximum Wind speeds of the order of 20-25 m/s are seen over the wall cloud region. Inclusion of satwinds vastly increased the description of the upper troposphere over the ocean without directly impacting the flow over land because of their availability over the ocean. Even at 60 hr, the differences in upper tropospheric flow are predominantly over ocean or in the vicinity of the storm. Fig 6 shows the comparison between the simulated track with and without satwinds and actual track as seen in the analysed field. The track of cyclone was well simulated by the experimental (with satwinds) forecast of the model. Inclusion of satwinds in this case has resulted in improvement in the track prediction.

4. CONCLUSIONS

The initial field with the inclusion of scatterometer data was nearer to the actual position. In the prediction experiment, it is seen that the inclusion of QuikSCAT data improved the prediction up to 48 hrs. Beyond 48 hrs, the forecasts are nearly identical suggesting that the forecast lateral boundary condition, which is same for both the experiments, has become an important influence over the limited area. The rainfall prediction of the model is monitored by superimposing the Meteosat imageries. The model is able to provide spatial distribution of mean rainfall. Model is also capable of successful cyclone genesis and improvement in its track with the help of scatterometer data. However, Vortex generation and track prediction has to be tested with many more cases to assess the reliability of the assimilation of QSCAT data.

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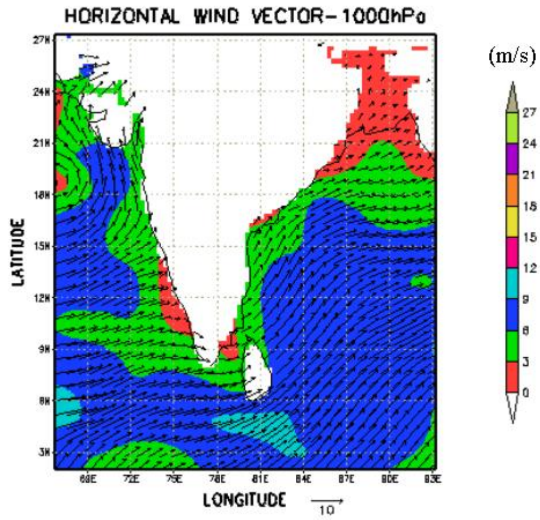
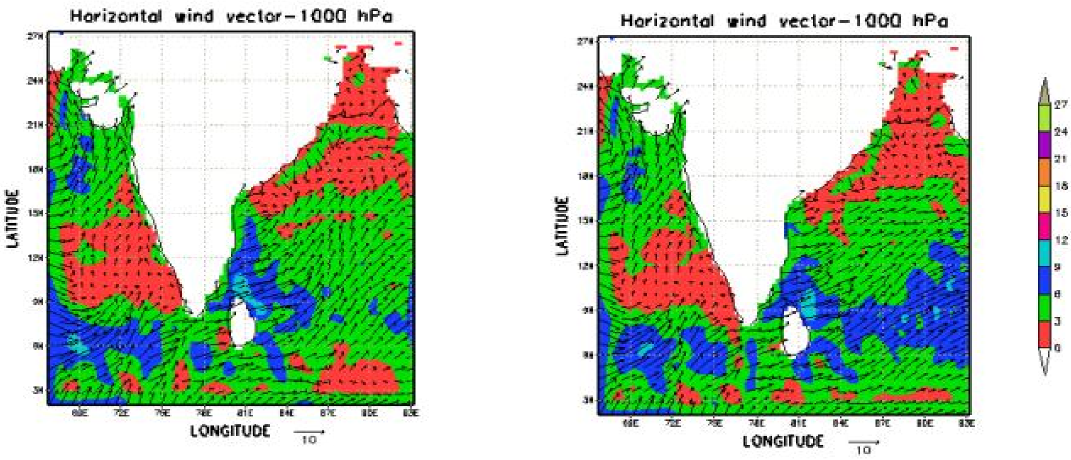


Fig. 1 Analysis - 00 UTC 11 Oct 01



A Without FDDA

B With FDDA

Fig. 2 24 hr Forecast 00 UTC 12 Oct 01

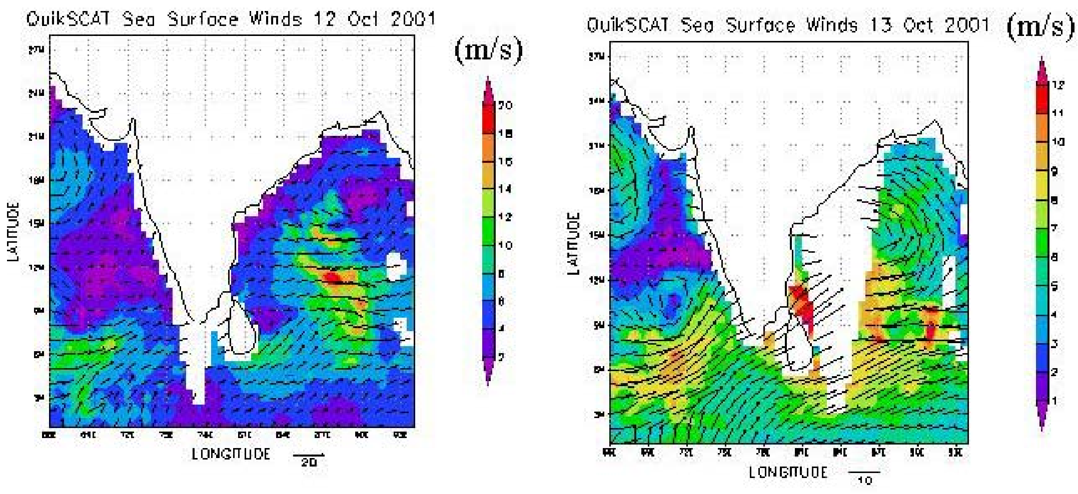


Fig. 3 Analysis of QSCAT winds

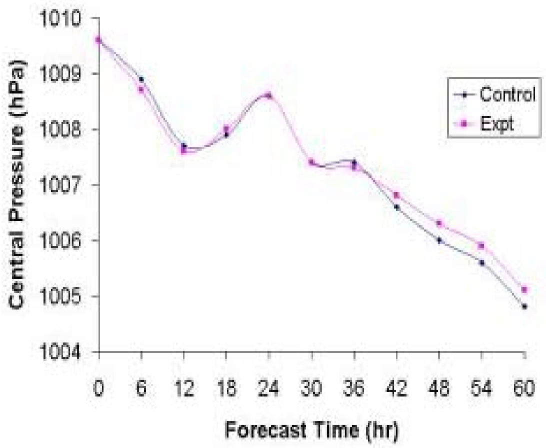


Fig. 4 Minimum MSLP during Cyclogenesis

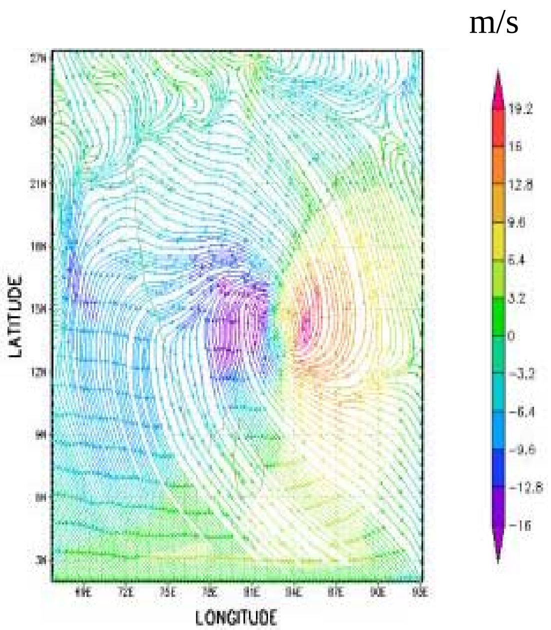


Fig. 5 Difference in horizontal wind vector-850 hPa on 16-Oct-2001

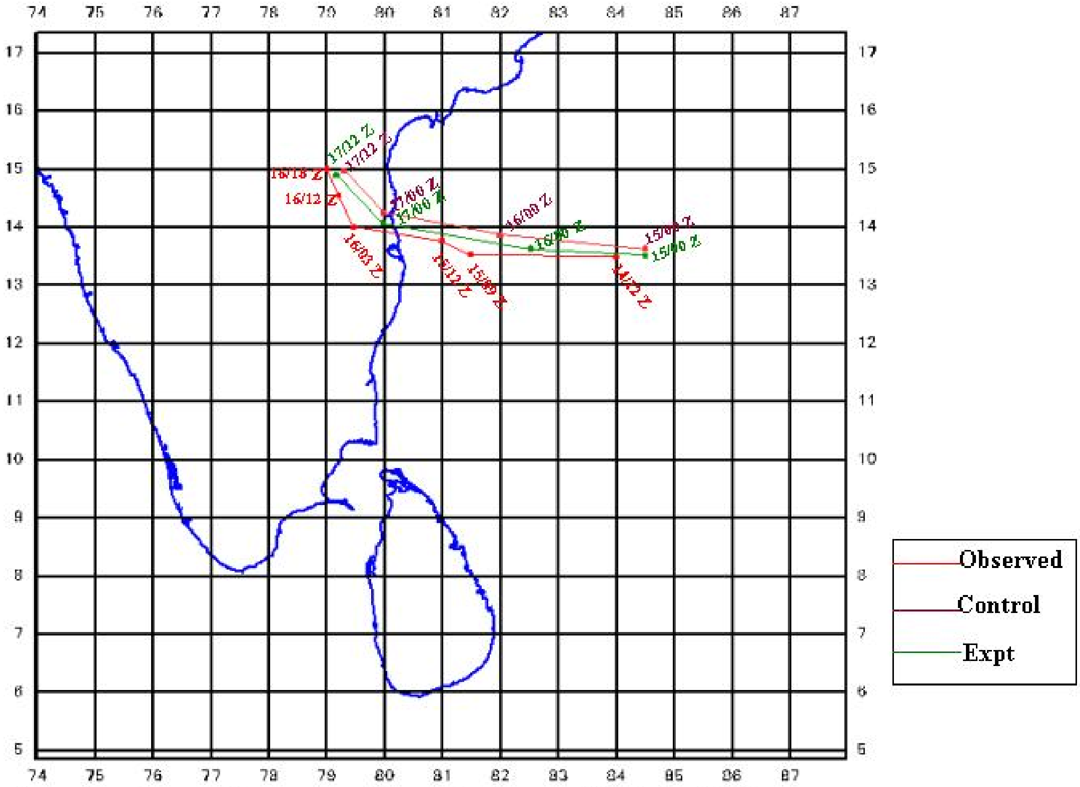


Fig 6 Comparison of tracks of Cyclone 15-17 Oct 2001