WRF Model Prediction of Bay of Bengal Cyclone Sidr

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Introduction

Early and accurate prediction of tropical cyclone track and intensity are crucial and challenging task for any operational meteorological agency since it involves use of state of art numerical models. This study investigates how well the operational WRF-ARW forecasts in movable nest condition represent the cyclone intensity and its evolution and also the impact of high resolution on the predicted intensity and rainfall.

During 8-10 November 2007, an upper air cyclonic circulation laid over southeast Bay of Bengal and adjoining area of south Andaman Sea. Under the influence of decreased vertical wind shear and more defined circulation a low pressure formed at 0300 UTC of 11 November over South-east Bay of Bengal & it neighborhood. It concentrated into a depression on same day and moving slightly northwestwards, it intensified into a deep depression and eventually intensified into cyclonic storm **Sidr** and lay centered at 0300 UTC of 12 November near latitude 10.5^0 N & 91.0^0 E, about 220 km southwest of Port Blair. The system moved as a severe cyclonic storm in northwestward direction till 00 UTC of 13th November and from 1200 UTC of 15 November the system re-curved and moved in a north-northeasterly direction.

Most of the models failed to predict the correct track of the system. In this experiment, initial conditions of 13 and 14 November 2007 were utilized and 78 hours forecasts were produced. The NCMRWF T254L64 global model captures the cyclone position and intensity very well in the initial conditions (fig.1). These initial conditions along with the predicted boundary conditions are used in this study. To study the effect of enhanced resolution a 9 Km moving nest is embedded into the main 27 Km domain. Initially a large static nest of 9Km resolution covering the entire Bay of Bengal was attempted. However, it was found to be computationally expensive. Hence a movable nest is constructed to cover a small region around the cyclone. The movable nest tracks the vortex once every 15 minutes to predict the changing position of the cyclone. The 27 Km mother domain provides the initial and lateral boundary conditions for the nested domain.

Results

It is seen in the 24 hr forecast plot that the SLP for 9 km domain 2 (fig. 2b) shows a lower pressure (higher intensification) as compared to the 27 km domain1 (fig. 2a). Low pressure area of 994 hPa is seen close to 90^oE and 10^oN in 27 km course domain (fig. 2a) whereas a low of 992 hPa is distinctly seen over the same are in the 9km domain (fig. 2b).

Figure 3a and 3b shows the evolution and intensification of the Sidr. For domain 2 the SLP continues to decrease until 63 hrs (forecasted) and becomes the lowest with value of 972 hPa and consequently the wind increases upto this forecasted hour and reaches a maximum of 41.3 ms^{-1}. Thereafter the cyclone starts to weaken with increasing SLP and decreasing wind speeds. For domain 1 the minimum value of SLP (977 hPa) and maximum value of wind speed (33.1 ms^{-1}) are comparatively lower as that of domain 2.

This shows stronger intensification of the cyclone in the movable 9km high resolution domain.

Figure 4a and 4b shows the 24 hour forecasted precipitation for domain 1 (27km) and domain 2 (9km) respectively. The 27 km course domain plot doesn't show a high of over 490 mm of rainfall that is clearly seen in the high resolution 9 km domain 2 near 90^{o}E and 15^{o}N. The maximum rainfall band which is seen in 27 km mother domain plot is ~370 mm which validates that using higher resolution study the intensification of the cyclone and its aspects are more clear and can be studied in a better way.

As we see using high resolution (9km) over the course domain (27km) enhances the features in the system. They are more explanatory and proper analysis of the system can be done using this higher resolution study. Since high resolution can't be applied over the entire domain as it computationally extensive and expensive, we opt for the 'moving nest' technique to get higher resolution just over the area of concern.

Concluding Remarks

The present experiment showed that the higher resolution WRF model forecast was able to capture the movement and intensity of tropical disturbance Sidr in a better way than the course resolution over Bay of Bengal region.

The rainfall prediction by the model was able to capture the heavy rainfall areas in the higher resolution (9 km) study as compared to that in course resolution (27km). Since the physics representations will play crucial role in the model accuracy of the predicted intensity and precipitation distribution, many combinations of boundary layer, cumulus parameterizations, explicit moisture treatments, and ice microphysics representation must be tested to develop an optimum combination suitable for Indian region. These aspects would be tested in the future program of the model development.

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References

Dhudia, J., 1993, A non-hydrastaic version of the Penn State NCAR mesoscale model validation test and simulation of Atlantic cyclone and cold front, Mon. Wea. Rev, 121, 1493-1531.

Emanuel, K. A., 1988: The maximum intensity of hurricanes. J. Atmos. Sci., 45, 1143-1155.

Fiorino, M. J., and R. L. Elsberry, 1989: Some aspects of vortex structure related to tropical cyclone motion. J. Atmos. Sci., 46, 975-990.

Fovell, R. G., 2004: Adjoint of a parameterized moisture convection model. Meteor. Atmos. Phys., 86, 173-194.

Holland, G. J., 1983: Tropical cyclone motion: Environmental interaction plus a beta effect. J. Atmos. Sci., 40, 328-342.

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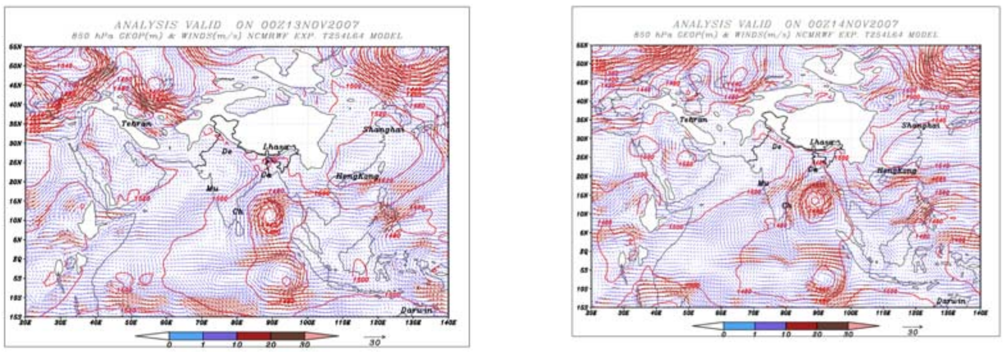

Fig. 1: <u>SIDR cyclone as seen in the global model T254L64 analysis on 13th & 14th Nov. 2007</u>

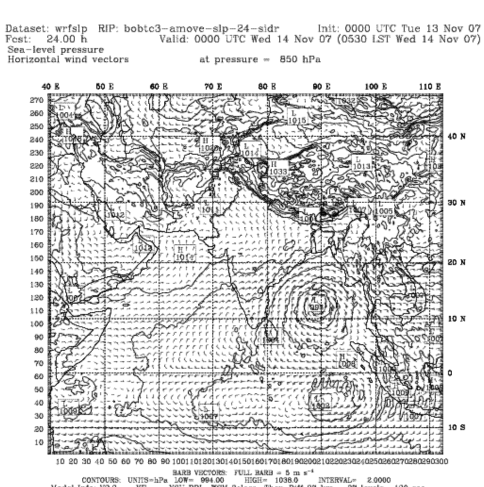

Fig. 2a

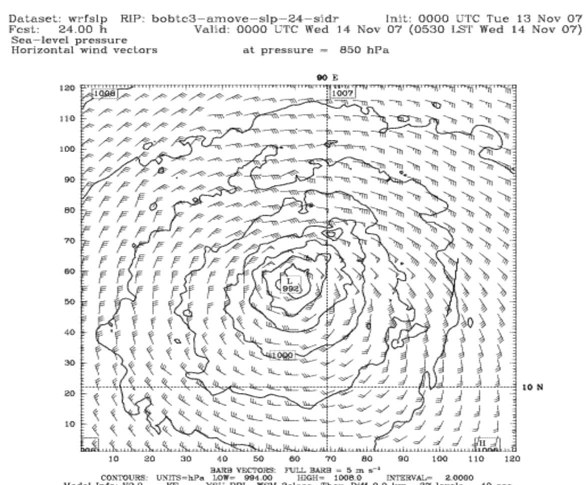

Fig. 2b

Fig. 2 a, b: <u>Sea Level Pressure and Wind Circulation at 850 hPa for 13th Nov. 2007 (24 hr. forecast) for domain-1, (27km) and domain-2, (9km)</u>

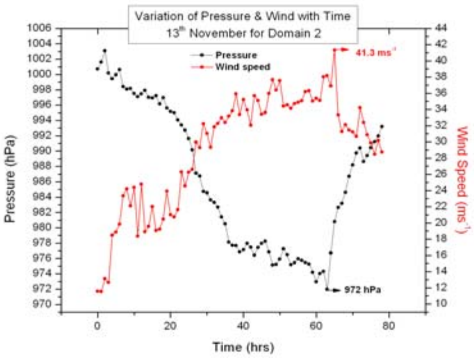

Fig. 3a

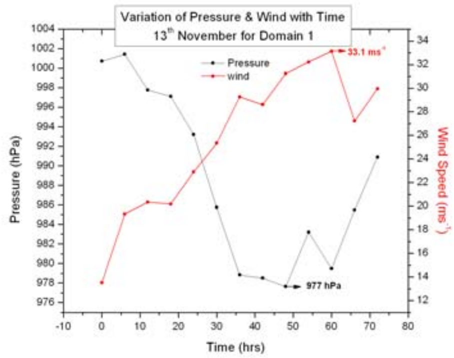

Fig. 3b

Fig. 3 a, b: **<u>Sea Level Pressure and Wind Speed time series for 13th November 2007 for domain-2 (9km) and domain-1 (27km)</u>**

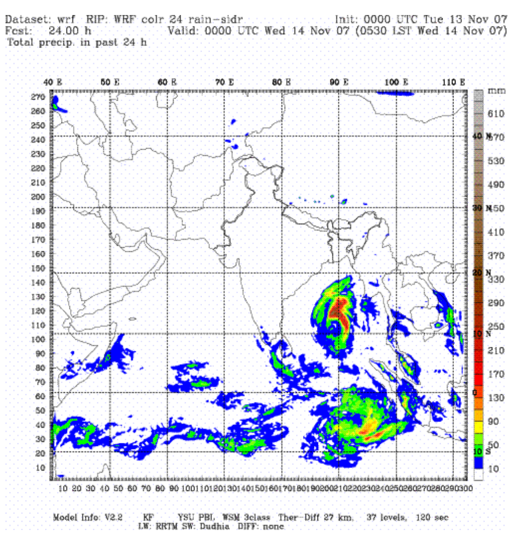

Fig. 4a

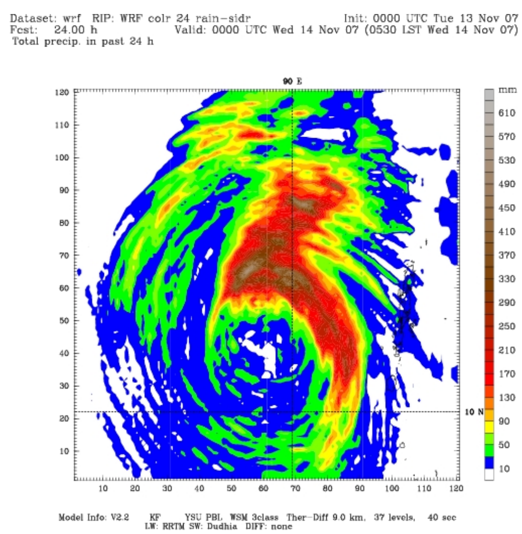

Fig. 4b

Fig. 4 a, b: **<u>24 hr. forecasted rainfall distribution for domain-1 (27km) and domain-2 (9km)</u>**