# An Experiment with WRF Model for Tropical Depression over Bay of Bengal and Arabian Sea – A Preliminary Study

Y.V. Rama Rao, Y. Sudhakar* and H.R. Hatwar
India Meteorological Department
Mausam Bhavan, Lodi Road,
New Delhi – 110003, INDIA
ramarao@imdmail.gov.in

* Hinditron Infosystems, New Delhi, India

**Abstract**
Prediction of track and intensity of tropical cyclones and associated heavy rainfall is one of the many challenging problems in meteorology, but very important for issuing timely warning for many agencies engaged in disaster preparedness and mitigation. With the advancement in observation technology, especially weather satellites and buoys, there is considerable improvement in the quantum of observational data around a tropical system such as cyclones/depressions. The availability of faster computing power, improved tropical cyclone models with better parameterization schemes, vortex initialization schemes, a large number of forecasting centers running specialized cyclone models, limited area models or utilizing other centers outputs/products for operational use. Several studies have been conducted for studying various aspects of cyclone using high resolution Pennsylvania State University (PSU)/ National Centre for Atmospheric Research (NCAR) non-hydrostatic mesoscale model (MM-5) (Dhudhia 1993).

Recently, an effort is made in India Meteorological Department (IMD) to run WRF (Version 2) on Cray XD1 AMD Opteron based super computer for tropical cyclone 30 September-3 October 2004 and monsoon depression of 2-5 October 2004. The model domain consists of $10^0$S to $45^0$N and $50^0$E to $115^0$E and 12 km horizontal resolution with 31 vertical sigma levels. Using the initial analysis and forecast fields for boundary from NCEP Global Final Analyses (FNL) at $1^0$x$1^0$ lat./long. resolution, 3-days forecasts are produced. The basic idea of this experiment is to test the WRF for tropical depression/cyclone forecast over the Indian region.

**Forecast Experiment:**
At the end of south-west monsoon season (June-September) a low pressure system formed over east central Arabian Sea on 29th September 2004. Moving north-northwesterly direction the system intensified into a depression and further into a cyclonic storm on 1st October. The system subsequently moved in a northerly direction and lay centred at 020300 UTC near lat 21.0 N/long. 66.5 E, subsequently it recurved north-eastwards and further intensified into a severe cyclonic storm at 020900 UTC. The system weakened rapidly into cyclonic storm on 3rd and subsequently into depression/low over the same region over the Sea. At the same time another low pressure area formed over south east Bay of Bengal on 30th September 2004. Moving in nort-westerly direction it concentrated into a depression on 2nd October. Subsequently moving north-west direction it crossed the south coastal Andhra Pradesh on 4th October and weakened into a low pressure system.

Under the influence of the Arabian Sea system, significant rainfall was observed over the northern parts of India on 3rd October and the Bay of Bengal system, heavy to very heavy rainfall occurred over coastal Andhra Pradesh particularly on 4th October and widespread rainfall over

south coastal Orissa (on 5th October) of peninsular India.

In the present experiment, using the initial conditions of 2nd and 3rd October 2004, 72 hours forecasts were produced. As outlined in the preceding paragraphs, a cyclonic storm is located over the Arabian Sea and another depression was over Bay of Bengal. The initial analysis based on 2nd October 2004 shows, both the systems captured as observed. In the model forecast of day-1 to day-3, the Arabian Sea systems movement and intensity was more realistic as observed. In day-1 forecast valid for 3rd October, the system intensified into cyclonic storm with sustained wind strength of 30-40 kts along northern sector of the system and in day-2 & day-3 forecast, the system shown weakening over the sea itself as observed. In case of Bay of Bengal system, the day-1 to Day-3 forecast shown the movement of the system northwest and crossing the south Andhra Pradesh coast on 4th October as observed. However, the model over estimated the intensity of the system which shown strengthening of the system into a cyclonic storm with intensity of 40-60 kts. In association with both the systems, the rainfall prediction by the model was more realistic. The heavy rainfall on 3rd October over northern parts of India and moderate to heavy rainfall on 4th & 5th October over east coast of peninsular India was well captured by the model.

**Concluding remarks**

The preliminary study shown, that the WRF model forecast was able to capture the movement and intensity of tropical disturbances over Indian Seas. The Arabian Sea system's movement and intensity was more realistic. However, the model over estimated the intensity in the case of Bay of Bengal system. The rainfall prediction by the model was able to capture the heavy rainfall areas as observed. 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 representations must be tested to develop an optimum combination suitable for Indian region. These aspects will be expected to be tested in the future program of model development.

**Acknowledgement**

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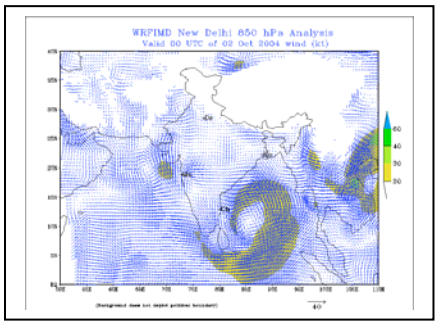
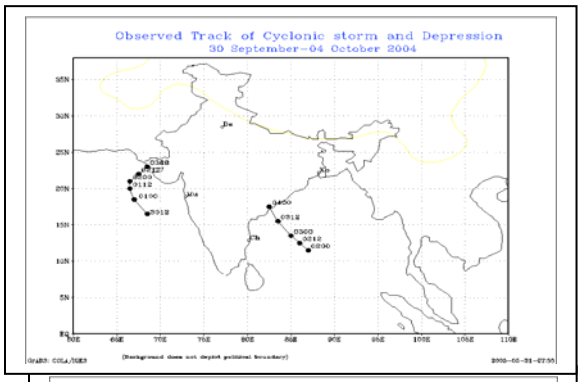
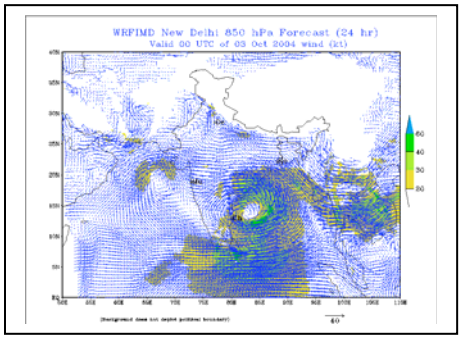
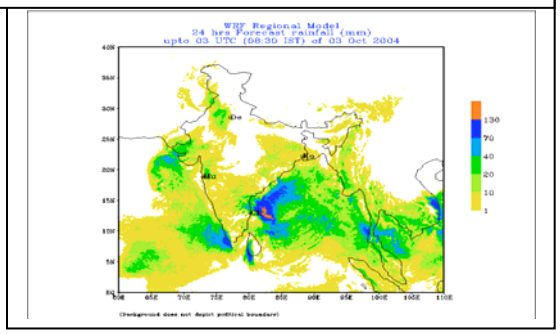
**Reference:**

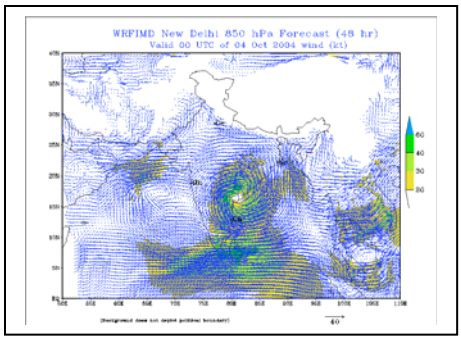
Dhudia, J., 1993, A non-hydrostatic version of the Penn State NCAR mesoscale model validation, test and simulation of Atlantic cyclone and cold front, Mon. Wea. Rev, 121, 1493-1531.

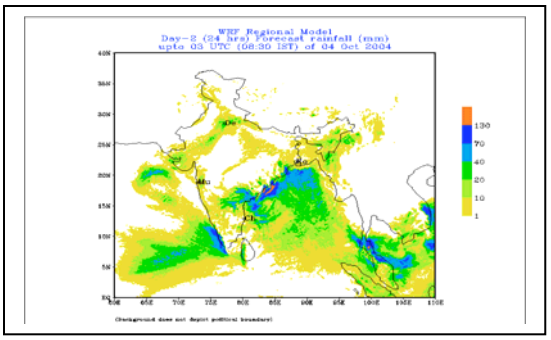

WRFIMD New Delhi 850 hPa Analysis
Valid 00 UTC of 02 Oct 2004 wind (kt)

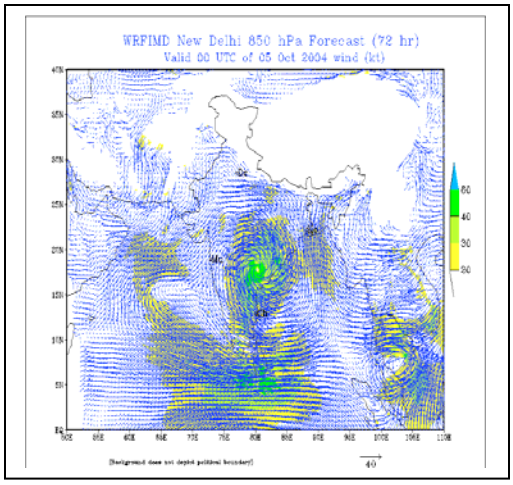

Observed Track of Cyclonic storm and Depression
30 September-04 October 2004

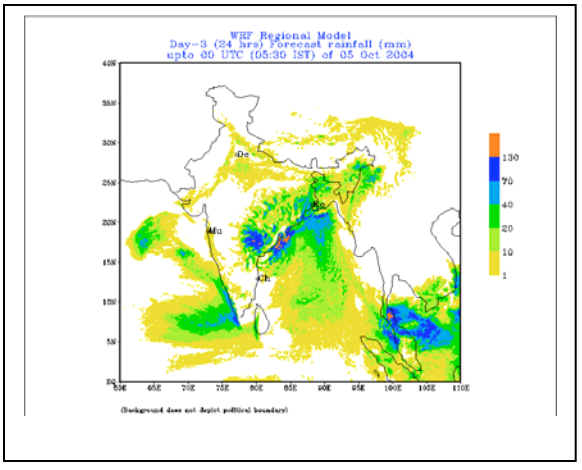

WRFIMD New Delhi 850 hPa Forecast (24 hr)
Valid 00 UTC of 03 Oct 2004 wind (kt)


WRF Regional Model
24 hrs Forecast rainfall (mm)
upto 03 UTC (08:30 IST) of 03 Oct 2004


WRFIMD New Delhi 850 hPa Forecast (48 hr)
Valid 00 UTC of 04 Oct 2004 wind (kt)


WRF Regional Model
Day-2 (24 hrs) Forecast rainfall (mm)
upto 03 UTC (08:30 IST) of 04 Oct 2004


WRFIMD New Delhi 850 hPa Forecast (72 hr)
Valid 00 UTC of 05 Oct 2004 wind (kt)


WRF Regional Model
Day-3 (24 hrs) Forecast rainfall (mm)
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