Impact of the GSI data assimilation on WRF-NMM forecast of tropical cyclones over North Indian Ocean.

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Abstract

With development of the high resolution numerical models having detailed physics and data assimilation, there has been great potential in weather forecasting, especially in short time scale to predict the intensity and track of the cyclones well in advance, inorder to reduce the destruction and loss caused by the cyclones upon landfall.

The main aim of the paper is to predict the track and intensity of the tropical cyclones over the North Indian Ocean using the WRF_NMM Version 3.0; with and without Gridpoint Statistical Interpolation (GSI) -Data Assimilation(DA) Scheme. In this study it is proposed to see the impact of GSI data assimilation scheme for cyclone cases in North Indian Ocean with WRF_NMM model. The WRF_NMMV3 will be integrated for a period of 48 hours using different initial conditions with and without GSI DA scheme. The impact of the GSI DA scheme and the way of utilising observations will represent the track and intensity forecasts.

It is expected that GSI DA scheme will improve the track and intensity of cyclone. Diagnostics about mean sea level pressure, wind and precipitation that are to be shown upto 72 hours forecast will be examined.

Keywords: Tropical cyclone, GSI scheme, track and intensity prediction.

1. Introduction

WRF_NMM Version 3.0 developed by NCEP/NOAA and the Gridpoint Statistical Interpolation (GSI) -Data Assimilation(DA) Scheme is used for studying the impact of observations over the tropical cyclone forecasts over North Indian Ocean, as the mesoscale models have the capacity to predict the intensity and track of the cyclones well in advance.

A preliminary study is done for one case SIDR, a very severe cyclonic storm that formed over Bay of Bengal sea in North Indian Ocean and that crossed the west coast of Bangladesh (11 -16 November 2008). The system initially formed as low pressure area over the southeast Bay of Bengal at 00UTC of 11 November, 2007 and then intensified into a Deep Depression on the same day at 200km south-southwest of the PortBlair. Further the system moved in Northwesterly direction and intensified into severe cyclonic storm at 03UTC of 12 November. The system moved in Northwesterly direction until 00UTC of 13 November and thereafter started move in Northerly direction till 12 UTC of 15 November with the same intensity of 90 knots. After 12 UTC of 15 November, the system attained the intensity of very severe cyclonic storm of 115 knots and started moving in North-Northeasterly direction. Then crossed the west coast of Bangladesh around 17UTC near 21.7^0N latitude and 89.8^0E longiturde with same intensity. Upon landfall, the system lost its intensity and weakened into cyclonic storm and afterwards it further weakened into depression at 03UTC and 06UTC of 16 November.

2. Objective

For the control experiment, WRF_NMMV3 is integrated for a period of 48 hours using different initial conditions of 12 - 16 November 2008. Another set of experiments are done with the same initial conditions and assimilation of observations with the GSI -DA system. Preliminary experiments are done to show the impact of the GSI Data Assimilation on

the WRF_NMMV3 generated track and intensity forecasts.

3. Initial & Boundary conditions

The initial conditions are obtained from NCEP, FNL data sets of 1degree x 1degree resolution for 12 November to 16 November 2008. The 6 hourly forecast files of the FNL data sets is used as the boundary conditions in all the integrations for different initial conditions. The GDAS Bufr data sets are used for assimilating the observations using the GSI DA scheme to improve the forecasting features. The corresponding intensity, track and other features from all the runs for different initial conditions are compared with the GSI DA scheme integrations and the observations.

4. Model Details

The WRF_NMMV3 model is basically designed with Non-Hydrostatic system of equations formulated on a rotated latitude-longitude, Arakawa E-grid and a vertical, pressure hybrid (sigma-P) coordinate on regional scale(Janjic et al. 2001, Janjic 2003a,b). Two domains with static nesting and two way interaction is used for the model setup. The outer domain is having horizontal resolution of 27 km with 330 x 430 points and inner domain is chosen to have resolution of 9 km with 250 x 510 points and having 51 levels in vertical with pressure at the top fixed to 10 hPa. In the present study the following physics options are used with above model setup.

Table 1.

Grid configuration	Two domains (two – way nesting)
Parent domain Inner domain	27 km resolution(40^0 -130^0 E lon and 15^0 S–45^0 N lat) 9 km resolution(55^0 -110^0 E lon and 0^0 – 27^0 N lat)
Model Vertical levels	51 (sigma-p)levels
Convective parameterization	Betts Miller Convection scheme (Janjic 2000)
Microphysics	Ferrier scheme (Ferrier et al. 2002)
Boundary layer	Mellor -Yamada-Janjic scheme (Janjic 1990, 1996a, 2002)
Surface layer	Janjic Similarity scheme (Janjic, 1996b, Chen et al. 1997)
Land surface model	Noah Land-Surface Model (Chen and Dudhia, 2001)
Long wave Radiation	GFDL (Schwarzkopf and Fels 1991)
Short wave Radiation	GFDL (Lacis-Hansen 1974)

5. Summary and Conclusions:

The forecast fields during 12hr, 24hr, 36hr and 48 hr forecast based on 12^{th} – 16^{th} November, 00UTC initial conditions are examined interms of Mean sea level pressure, 850 hPa wind and precipitation (figures are not shown). Similarly the corresponding forecasts from the Data Assimilation with GSI scheme are also analysed for 12 hr, 24 hr, 36hr and 48 hr forecast periods and are compared with the model forecasts.

Based on the forecast positions at 12 hr, 24hr, 36hr, 48 hr and the corresponding observed positions, the forecast track error in respect of WRF_NMM model and with GSI-DA will be compared and the average track errors at the time of landfall are found to be approximately 100km to 170 km.

The preliminary case study shows that WRF_NMMV3 is having reasonable prediction skill both in the prediction of the movement and the track of the system upto 48hr forecast period

and the prediction skill with GSI DA scheme should improve of the WRF_NMMV3 forecast.

Many more case studies are to be examined to arrive at some definite conclusions to know the impact of the data assimilation on the cyclone track and intensity forecasts.

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