Preliminary report on implementation of Hurricane Weather Research and Forecasting (HWRF) System at India Meteorological Department (IMD) for Tropical Cyclone Forecast for Indian Seas

Project: NOAA-MoES Tropical Cyclone Program

Background:

The Weather Research and Forecast (WRF) system for hurricane prediction (HWRF™) is operational at National Centre for Environmental Prediction (NCEP), USA since 2007, providing deterministic forecast guidance to the National Hurricane Center (NHC) for the Atlantic and North Eastern Pacific basins. This advanced hurricane prediction system was developed at Environmental Modelling Centre (EMC), NCEP to address the Nation's next generation hurricane forecast problems. The HWRF™ is a high resolution coupled air-sea-land prediction model with a movable nested grid and advanced physics for high resolution. This model is currently coupled to the Princeton Ocean Model (POM) in the Atlantic basin. The HWRF™ has the capability to address hurricane structure and rainfall forecast problems in addition to advancing wave and storm surge forecasts. Continued advancements in track and intensity prediction are important focus areas of this prediction system.

HWRF for Indian Seas:

Dr Vijay Kumar Tallapragada, Team Leader and Dr Zhan Zhang, Research Scientist, HWRF, EMC, NCEP, USA were on deputation to India Meteorological Department, New Delhi from 28 June to 01 July 2011 for technology transfer of HWRF model system and provide training on initial operating capability of HWRF model.

The basic version of the model HWRFV(3.2+) which was operational at EMC, NCEP was ported on IBM P-6/575 machine with nested domain of 27 km and 9 km horizontal resolution and 42 vertical levels with outer domain covering the area of 80^0x80^0 and inner domain 6^0x6^0 with centre of the system adjusted to the centre of the observed cyclonic storm. The outer domain covers most of the North Indian Ocean including the Arabian Sea and Bay of Bengal and the inner domain mainly covering the cyclonic vortex with moving along the movement of the system. The model has special features such as vortex initialization, coupled with Ocean model to take into account the changes in SST during the model integration, tracker

and diagnostic software to provide the graphic and text information on track and intensity prediction for real-time operational requirement.

A case study was undertaken to test the ability of the model for Indian Seas for Severe Cyclonic Storm 'JAL' formed during 4 to 7 November 2010 over the Bay of Bengal which crossed north Tamilnadu – south Andhra Pradesh coast, close to the north of Chennai near 13.30^0N and 80.30^0E around 1600 UTC of 07 November 2010 as a deep depression. The model was integrated for 5-days forecast with basic input from GFS spectral fields based on 4 November 18 UTC initial conditions using Gridpoint Statistical Interpolation (GSI) assimilation system. The 5 days forecast completed in 60 minutes using 3 nodes with 91 processors of IBM computer. The forecast track, Intensity/Vmax and mean sea level pressure (MSLP) of the NCEP operational run, HWRF test run made at NCEP and HWRF run made at IMD are given in Fig.1to Fig.3. Also the six hourly cycling of the HWRF model was tested to run the model in cycling mode. In this run only the atmospheric model (HWRF) was tested. The Ocean Model (POM-TC) and Ocean coupler requires the customization of Ocean Model for Indian Seas. In this regards, INCOIS, Hyderabad which is running the Ocean Models (POM)/Hybrid co-ordinate ocean model (HYCOM) is requested to help and support in porting the Ocean Model with Indian Ocean climatology and real time data of SST over Indian Seas.

In addition, a special run was also completed based on 00 UTC 01 July 2011 for Atlantic Tropical Storm "ARLENE' which made landfall near Cabo Rojo, Mexicio around 06 UTC of 1 July 2011. The forecast up to 5 days was generated using IMD GFS T574 spectral files to test the Ocean Model (POM-TC) and Ocean coupling software. This run was undertaken only to test and familiarization of POM-TC model and Coupler software, and to confirm working with the real-time GFS model forecasts generated by IMD.

Four Scientists from IMD's NWP division and two Research Students from IIT Delhi were provided with hands-on training in installing; configuring and running the operational HWRF model for Indian Seas.

Dr. S. Gopalakrishnan, NOAA/AOML, Hurricane Research Division, Miami, FL and Dr. Tallapragada, EMC delivered IMS lecture on 01 July 2011 on Research and Operational aspect of HWRF model at USA.

Future Plans for Transition to Operations:

1. Vortex initialization for Bay of Bengal and Arabian Sea Cyclones requires creation of a model generated synthetic composite vortex as first guess using IMD best track data sets. IMD will run the HWRF model for several cyclonic storms over the Indian Seas and generate this composite vortex for use in individual model runs. This is a pre-requisite to the retrospective testing described in (2) below.

2. Testing of the atmospheric HWRF model for the last 5 years Cyclonic Storm formed over Arabian Sea and Bay of Bengal for 6 to 8 cases with cycling of 6 hourly forecast runs for each case with total 70 to 80 runs. Evaluation of model performance will include estimation of track and intensity errors in comparison to official IMD forecast errors. EMC, NCEP, USA will provide necessary initial and boundary GFS spectral fields for the above runs. IMD will identify these cases and share the information with NCEP.

3. The installed version of HWRF modeling system in IMD, only the atmospheric model was tested for Indian region. The Ocean Model (POM-TC) and Ocean coupler requires the customization of Ocean Model for Indian Seas. For that purpose, as suggested by the Dr Ravichandran, INCOIS during the video conference with Dr. Vijay Kumar and IMD, MoES scientists at IMD on 5 July 2011, the MOM-4 model code at IMD computer centre will be ported by INCOIS for initial testing of Ocean model to couple with HWRF and subsequently IMD will help INCOIS in porting HWRF at INCOIS Computer centre for coupling the atmospheric model to a wave model. IMD will work with INCOIS to identify the ocean model component for the Indian Seas and will develop the infrastructure to run the coupled modeling system. EMC will also provide software and instructions to eventually couple the atmospheric model to a wave model. The assimilation of different data sets in the Indian Ocean are assimilated by INCOIS in the MOM, and the coupled HWRF-MOM system for the Indian Ocean will be tested for track and intensity forecast skill.

4. A joint report (Indo-US) to be prepared based on the above runs by the end of August 2011 and experimental operational forecasts up to 5 days are generated during the September-December 2011 cyclone season with 4 runs (00, 06, 12 18 UTC) per day

during the cyclone situations from depression stage to landfall/dissipation of the system.

5. Final report will be prepared at the end of the Cyclone Season 2011 by the end of December 2011.

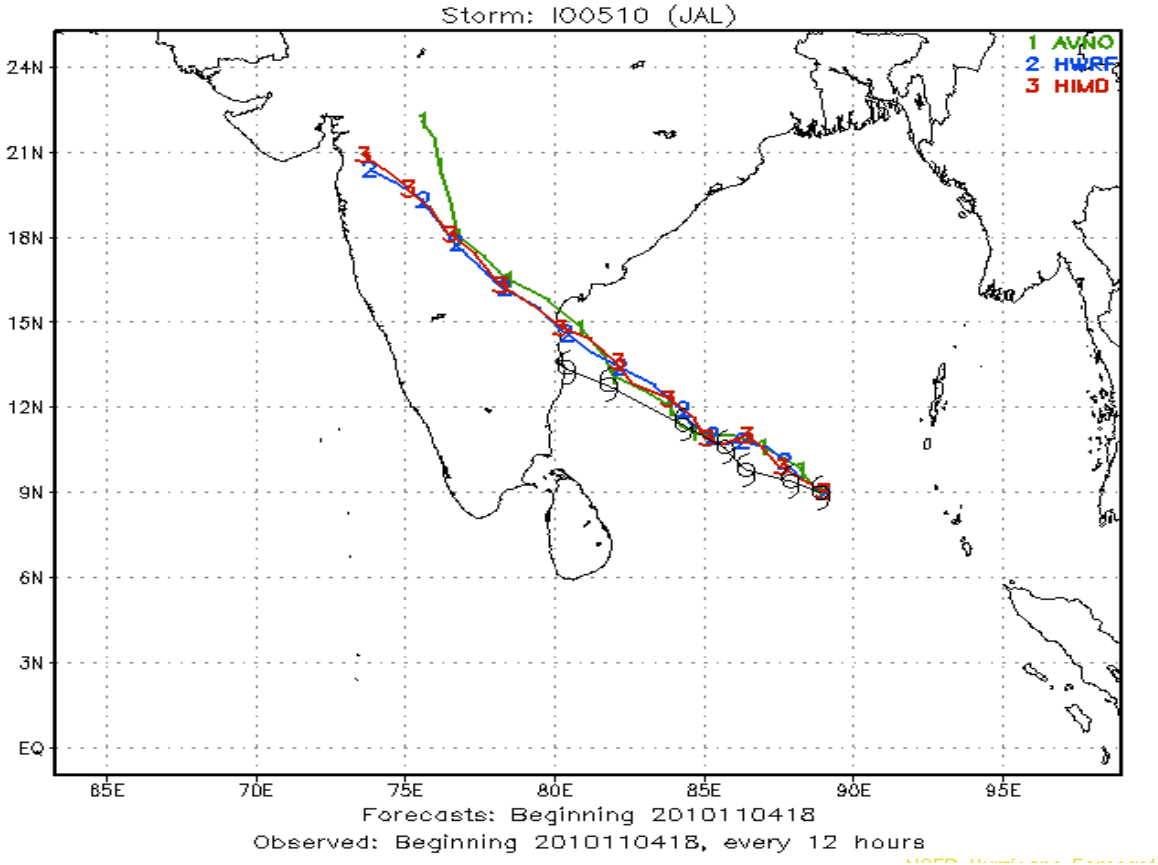

Fig.1: Track forecast upto 120 hours for TC 'JAL' based on 18 UTC of 04 Nov. 2010. 1. Based on NCEP GFS forecast 2. NCEP HWRF run at USA 3. IMD HWRF run at IMD. The observed track plotted with black line with TC symbol.

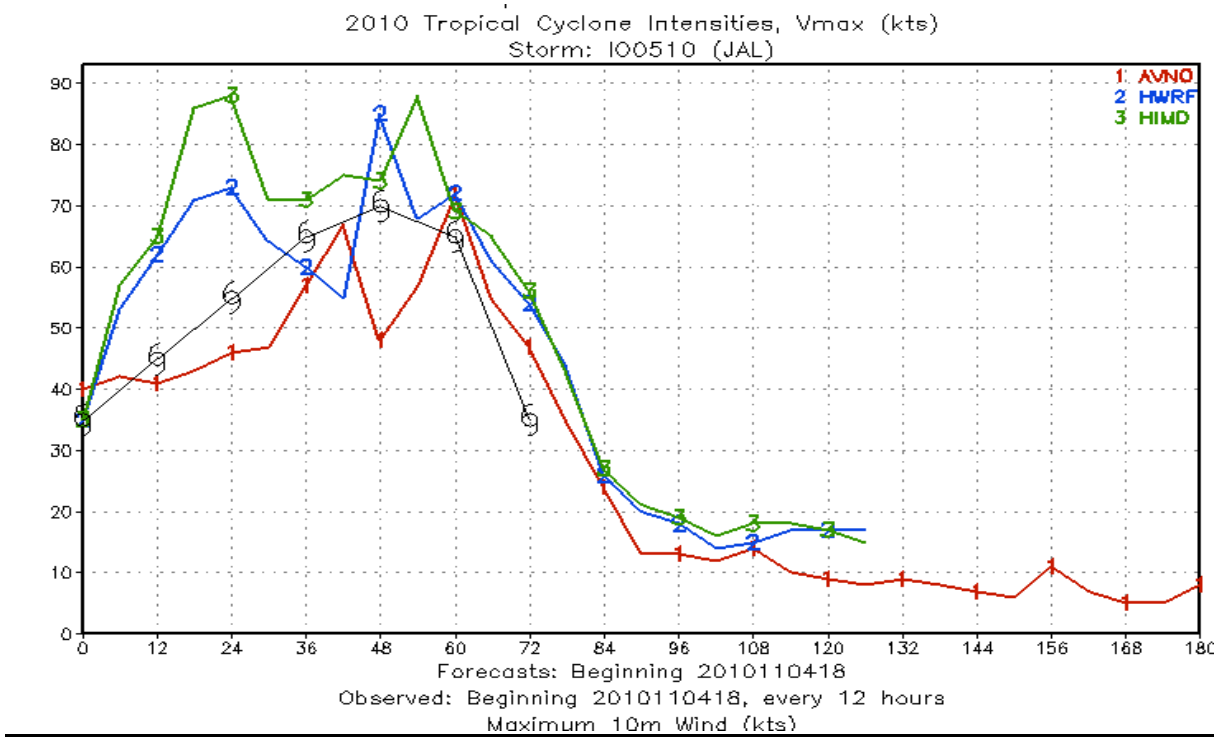

Fig.2: Intensity/VMAX (Kts) forecast upto 120 hours for TC 'JAL' based on 18 UTC of 04 Nov. 2010. 1. Based on NCEP GFS forecast 2. NCEP HWRF run at USA 3. IMD HWRF run at IMD. The observed track plotted with black line with TC symbol.

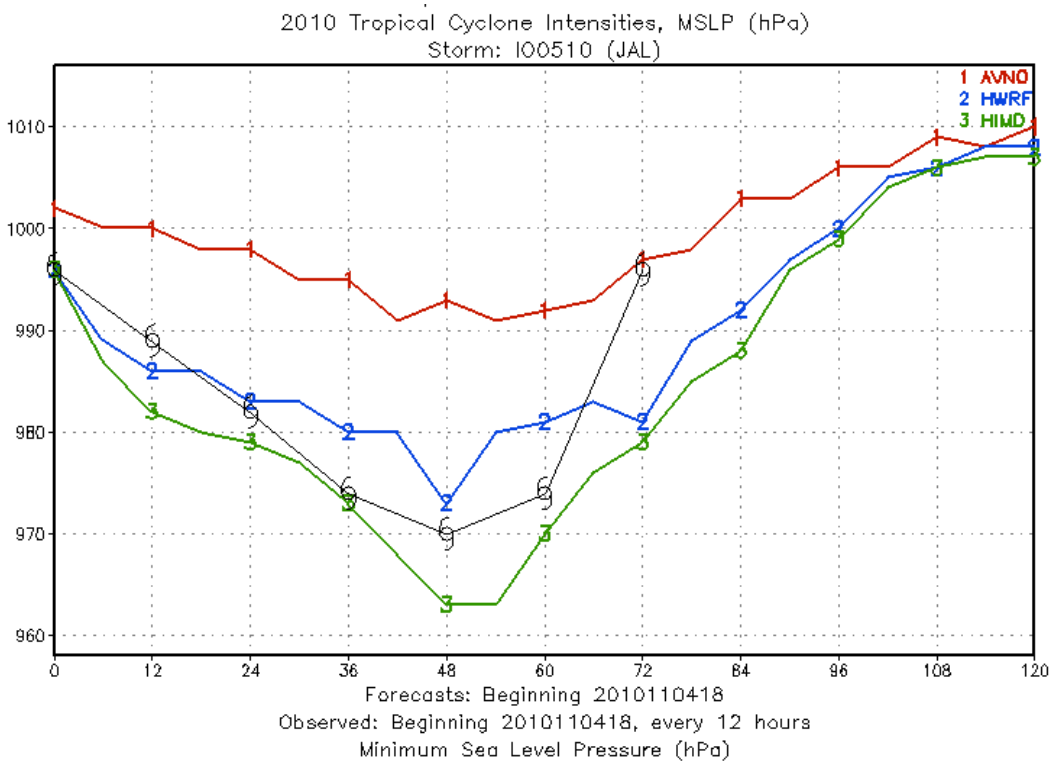

Fig.3: Mean Sea Level Pressure (hPa) forecast upto 120 hours for TC 'JAL' based on 18 UTC of 04 Nov. 2010. 1. Based on NCEP GFS forecast 2. NCEP HWRF run at USA 3. IMD HWRF run at IMD. The observed track plotted with black line with TC symbol.

List of Participants:

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