Validation of MM5 model over Indian region during Monsoon 2004

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Abstract:

Performance of the MM5-model, which has been running in real time at NCMRWF since Jan.'2002, in predicting different features of Indian Monsoon during June – September 2004, is discussed in this paper. In general, model has shown ability to predict dry and wet spells during the season. However, the predicted rainfall is comparatively higher than the observed rainfall. Model error in predicting track of the monsoon system is 1-4º lat/long in 24hr. prediction, which goes up to 7º in 72 hr. prediction. MM5-3DVAR has been tested over Indian region during monsoon 2004. MM5-3DVAR system is able to bring out mesoscale features in the analysis, which has resulted in improvement of subsequent forecasts. Some results of 3DAVR run are also presented.

Introduction:

National Centre for Medium Range Weather Forecasting (NCMRWF) was established by Government of India in 1988 to provide medium range weather forecast to the farming community of the country. Monsoon is economic lifeline of India and providing accurate weather forecast during monsoon season is one of the challenging tasks. NCMRWF is providing medium range weather forecast using an adapted version of NCEP's T80/L18 global model. Forecasting using MM5 model at NCMRWF in experimental mode began in 2002. Though in general, MM5-model has shown its capability to capture heavy rainfall epochs during monsoon but it has a tendency to predict less rain over Indian Land mass and more rain over adjoining seas. Verification of MM5-model forecasts during monsoon 2004 has been carried out and the results are presented in following sections. It was felt that mesoscale data assimilation system is very much required for improving the forecast skill of the mesoscale models. MM5-3DVAR analysis scheme has been tested in six-hourly cyclic mode over Indian region during July 2004. Initial results of these run are very encouraging and some of them are discussed here.

Model and data assimilation system:

The MM5 model is a 5th generation PSU/NCAR Mesoscale Model (limited area), non-hydrostatic, terrain-following sigma coordinate, designed to simulate or predict mesoscale & regional scale atmospheric circulation (Dudhia et al, 2002). The MM5-modeling system adapted for mesoscale weather forecasting at NCMRWF (Das, 2002) has triple-nested domains at 90, 30 and 10 km resolutions (Fig.1) with 23 vertical levels. The model is run using the Grell scheme (Grell et al., 1994) for cumulus parameterization and, a non local closure scheme for the boundary layer

parameterization. Explicit treatment of cloud water, rain water, snow and ice has been performed using the simple ice scheme of Dudhia (1996). Cloud radiation interaction is allowed between explicit cloud and clear air (IFRAD=2). The initial and lateral boundary conditions are obtained from the operational global T80 model of NCMRWF.

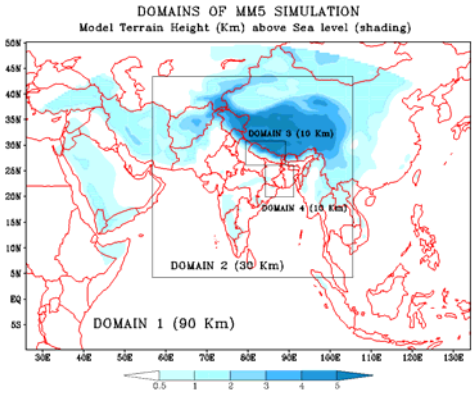

Fig 1. Triple nested domain

Three-dimensional observations over the Indian region are mainly centered around the main synoptic hours (0000, 0600, 1200, 1800 UTC) of observation. Keeping this in mind, MM5-3DVAR (Barker et al. 2004) assimilation system is designed as a cyclic 6-hrly intermittent assimilation scheme, where analysis is performed four times a day i.e. at 0000, 0600, 1200, 1800 UTC. Global data received through GTS are ingested in the system at the analysis time with ±3 hours time window.

Forecast verification during Monsoon 2004: Results and Discussion

Verification of MM5 forecasts over Domain-2 is carried out for Monsoon (JJAS), 2004. Upper level predicted winds and geopotential heights at 850, 500 and 200 hPa are compared against verifying analysis (interpolated T80). Precipitation forecast is verified against real time daily precipitation analysis of Climate Prediction Centre(CPC), NOAA.

Wind verification shows that RMSE of zonal wind (u-component) at 850 hPa in day-1 forecast is 2-4 m/s over Indian land mass, however there are some pockets of high RMSE(8m/s) over north-east hilly regions. Verification of same for day-3 forecast has shown RMSE upto 4m/s over Indian land mass. High RMSE(10m/s) is seen over Arabian Sea near the Lower level jet region. This is associated to model tendency to intensify the lower level jet in subsequent forecast. Similarly, the model has tendency to intensify the upper level tropical easterly jet and the same is seen as a zone of high RMSE (10-12 m/s) over this region at 200 hPa level in day-3 forecast verification. Meridional component of wind (v) has shown noticeable RMSE(>4m/s) over head-Bay region associated to formation and deepening of monsoon trough over that region.

Fig-2 depicts RMSE of predicted geopotential height(z) at 850 hPa level over Indian domain (5ºN-40ºN / 65º-100ºE).

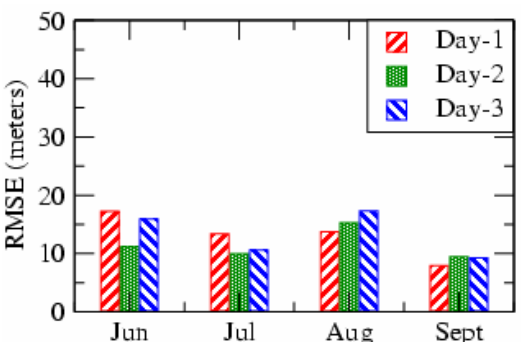

Fig.2: RMSE of predicted geopotential height(z) at 850 hPa

As seen in the plot, RMSE of Day-1 forecast is more than that of Day-2 and Day-3 for initial monsoon months, i.e. June & July 2004. RMSE is lowest for all days in September 2004. Geographical distribution of height RMSE at 850 hPa level for June 2004 has shown high RMSE (20m) along foothills of Himalaya and over Western Ghat region. Model error in predicting track of the monsoon system is 1-4º lat/long in 24hr. prediction, which goes up to 7º in 72 hr. prediction.

Predicted all India (5ºN-35ºN / 65ºE-100ºE) total rainfall has been compared with that of observed rainfall in Fig 3.

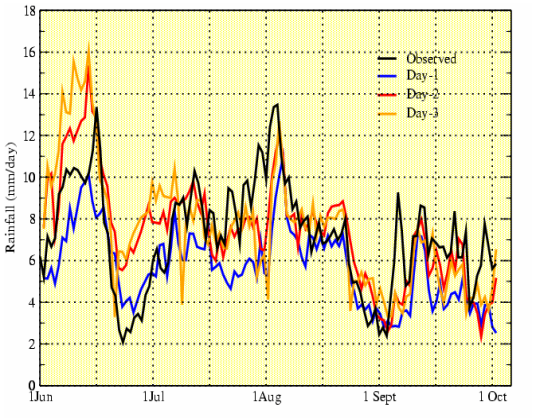

Fig 3. Predicted daily all India total rainfall along with observed rainfall(1st June -30th Sept 2004)

Model is able to capture the wet and dry spells of monsoon well up to 3-days in advance, though there is some difference in the daily predicted and observed rainfall amount. In the beginning of the season, rainfall is under predicted in Day-1 forecast, and over predicted in Day-2 and Day-3 forecast. The difference in predicted and observed rainfall amount decreases with the advancement of the season.

Results of MM5-3DVAR :

MM5 model (CTRL) has been run with initial condition generated by MM5-3DVAR analysis system for a 10 days period (20th –30th July 2004). In general, interpolated global(IGLB) T80-analysis fields are quiet smooth compared to CTRL. Meso-scale features are more prominent in CTRL analysis compared to IGLB. Fig 4(a) and (b) depict the analysed wind and height at 850 hPa level for 00UTC 24th July 2004.

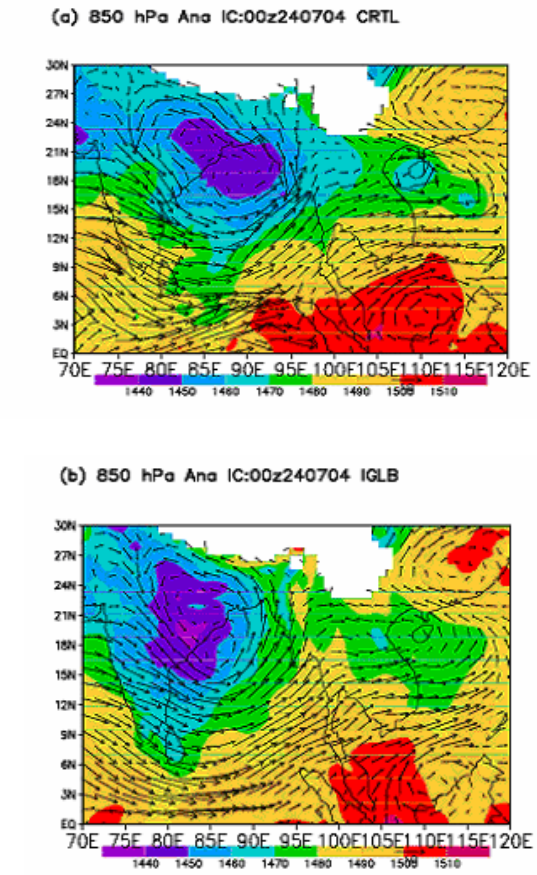

Fig 4: Analysed wind and height at 850 hPa level for 00UTC 24th July 2004.
(a)CTRL, (b) IGLB

Orientation of monsoon trough over Indian landmass in CRTL analysis at 850 -hPa, is north-east south-west,

with two embedded cyclonic circulations which is also supported by observation. Whereas, in IGLB the trough is north-south oriented and there is only one broad cyclonic circulation. MM5-3DVAR analysis system has been also able to bring out mesoscale features improvement in the subsequent track prediction of the system.

Future Plan :

NCMRWF is planning to install WRF assimilation-forecast system for Indian region in near future.

Acknowledgement:

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Reference:

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