MM5 3D-Var Data Assimilation and Forecast System over Indian Subcontinent - Results from Recent Experiments

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Abstract

NCMRWF was using MM5 model version 3.4 since Jan 2002, which has been recently upgraded to version 3.6. Offline experiments have been conducted using 3-DVAR assimilation system to study a case of western disturbance over the western Himalayas. Additional surface observations from 25 observatories densely located in the Himalayan region are also used in the 3D-VAR assimilation. Results of the experiment have shown definite improvement in wind as well as precipitation forecasts.

1. Introduction

A non-hydrostatic version (v3.4) of the Pen State/NCAR mesoscale model, with a triple-nested domains at 90, 30 and 10 km resolutions, was installed and adapted for real time mesoscale weather forecasting at National Center for Medium Range Weather Forecasting (NCMRWF) since 2002. The initial and lateral boundary conditions (every 12hrs.) required for model run are provided by global data assimilation and forecast system at T80/L18 resolution, operational at NCMRWF. Recently, 3D-var assimilation system (NCAR) compatible with MM5 model has been experimentally tested at NCMRWF. It is expected that the forecast skill will improve with 3D-Var assimilation.

Two consecutive episodes of heavy precipitation along with intense hail occurred over North Indian region, associated with the passage of two western disturbances in quick succession in the month of April 2004. Though, the operational implementation MM5 with out data assimilation was able to predict the passage of the system, rainfall forecast was not very accurate for all the days. Experiments have been carried out using 3D-Var assimilation to simulate these heavy rainfall cases. Apart form the conventional data used in global data assimilation system, the surface observations from special observatories (Fig. 1) over Himalayan region are also assimilated to study the cases.

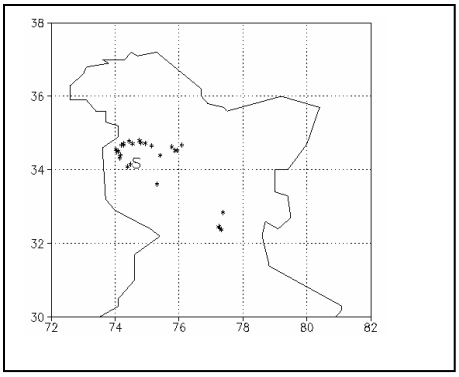

Fig 1. Geographical location of surface stations in Himalyan region

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 model has been adapted for real time mesoscale weather forecasting at NCMRWF (Das, 2002). It is run on triple-nested domains at 90, 30 and 10 km resolutions (Fig.2) with 23 vertical levels. Recently and updated version of the model (3.6) has been installed.

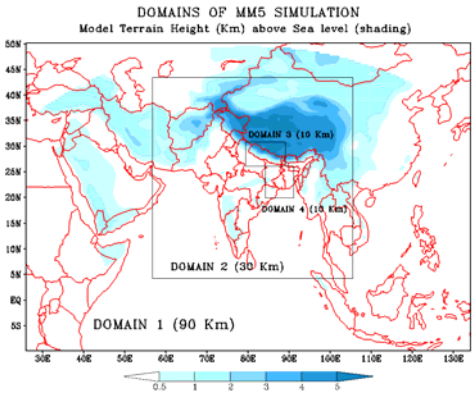

Fig 2. Triple nested domain

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. This run is taken as control run (CRTL).

3D-VAR data assimilation system compatible with MM5 (Barker et al.,) has been used for off line experiments. Background error have been computed over Indian region based on NCEP technique using 30 days forecast made over the Indian region with same configuration and nesting. Experiments have been carried out by applying 3-DVAR over the outer domain only. Observations assimilated are SYNOP, SHIP, BUOY, AMDAR, SATOB and SATEM (NOAA 15&16) in experiment-1 (EXP1). The special surface observations over Himalayan Region discussed in above section are assimilated in experiment-2 (EXP2).

Results

On 23rd a deep westerly trough was seen at 500hPa level (Fig. 3) over north-west India associated with heavy precipitation over this region. In the lower level (850 hPa) a broad cyclonic circulation is also seen in the global analysis.

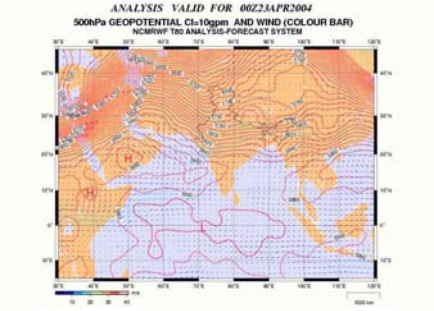

Fig 3. Global analysis(T80) at 500 hPa level on 0000 UTC 23rd April 2004 showing westerly trough over North west India.

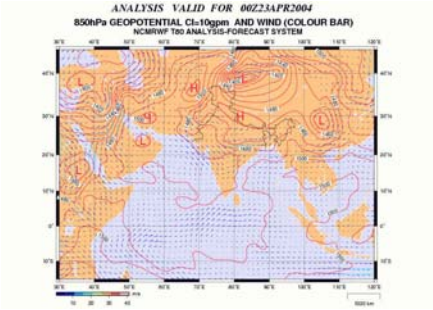

Fig 4. Global analysis (T80) at 850 hPa level on 0000 UTC 23rd April 2004 showing westerly trough over North west India. Precipitation forecast over Domain-1 for CTRL and EXP1 runs are shown in Fig-5.

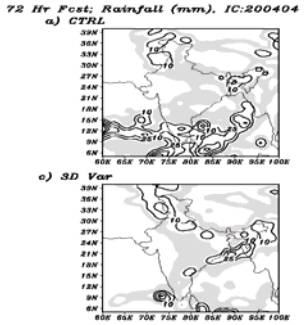

Fig 5. 72 hr. precipitation forecast IC :20 April 2004 (Domain-1)

The 72hr. prediction of this trough from MM5 model for CRTL, EXP1 are shown in Fig 6.

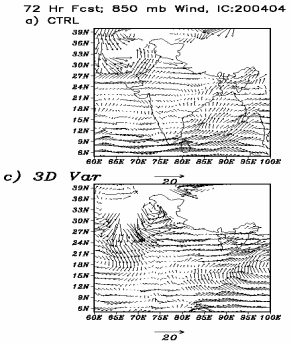

Fig 6. 72 hr. wind forecast 850 hPa IC :20 April 2004 (Domain-1)

The results from EXP-2 are not shown for brevity.

Conclusions

Experiments with 3D-Var assimilation scheme have shown lot of improvements over the control run as expected. Assimilation of extra observation also showed some improvement in precipitation forecast.

References

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