

# JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR 2006

## Pakistan Meteorological Department - Pakistan

### 1. Summary of highlights

A high resolution regional model (HRM) of Duetscher Wetterdienst (DWD), Germany has been installed in R & D Division of Pakistan Meteorological Department (PMD) Islamabad. PMD version of HRM is run on a horizontal grid resolution of 28km and hybrid vertical coordinates with 20 to 40 layers. The model includes radiation schemes, grid-scale precipitation schemes, mass flux convection schemes and seven-layer soil model including snow and interception storage. Latest version of HRM includes Multiple-layer soil model. The model is integrated in a domain of 60°E to 96°E and 10°N to 44°N for summer season and domain of 56E to 80E and 18N to 45N for winter season. The input data required for preparing initial and boundary conditions are drawn from GME datasets, downloaded through ftp from DWD server. The global model GME of DWD covers the globe with triangular grid of about 40km mesh size.

### 2. Equipment in use

PMD has acquired Grid Rack Computing System from HP. The total peak performance of the whole platform can reach 56 GHz in full configuration. The technical specifications of the system are as under.

#### **Hp Rack Mount Servers (9 Nodes)**

#### **Management Node (Nos 01)**

Hp Proliant DL380 G4 3.4GHZ double processors 2MB-HPM AP SERVER 4 Gb RAM  
72.8 Gb Hard Drive (ULTRA 320 SCSI) Nos. 02

#### **Compute Node (Nos 08)**

Hp Proliant DL380 G4 3.4GHZ dual processors 2MB-HPM AP SERVER  
4 Gb RAM  
72.8 Gb Hard Drive (ULTRA 320 SCSI)

#### **Operating System**

RedHat Enterprise Linux ES 4 Update 2  
Internet Connectivity Fiber Optic 512kb

In addition, Dell Proliant Servers 380 are put place for in real-time operation on July, 2005. Dell Systems are being used for domestic communication, namely, reception, processing and dissemination operations of domestic meteorological data.

### 3. Forecasting system

#### System run schedule and forecast ranges

The regional model HRM (Regional Assimilation and Prediction Enhanced System) run for forecasting 72 hours on 00uct on the new HP Grid Rack Computing System. It produces regional analyses for the eight synoptic hours 00, 03, 06, 09, 12, 15, 18 and 21 UTC. It takes about 31 minutes clock time for the purpose.

#### Medium range forecasting system (4-10 days)

Medium range forecast data is extracted from GFS output and is processed at 00 & 12 UTC data.

#### Research performed in this field

HRM output is being verified through post processing and comparison with actual data. There are two types of weather elements verified: continuous weather elements and categorical weather elements.

The following is a list of continuous elements verified and their units:

- Temperature\_2m(°C)
- Maximum Temperature\_2m (°C).
- Minimum Temperature\_2m (°C)
- Dew Point\_2m (°C)
- Mean Sea Level Pressure (hPa)
- Wind Speed\_10m (knots) and Wind Direction\_10m (degrees).

The following is a list of categorical elements verified and their units:

Precipitation: Precipitation forecasts at 24 hourly intervals are verified against 24 hour accumulations reported by available stations at 00 and 12 UTC. In order to determine the ability of the model to forecast different rain events (ex. heavy or light rain events), statistics and scores will be calculated individually for each one of the following categories:

$0.1 \leq \text{Precip} < 2.0 \text{ mm}$

$2.0 \text{ mm} \leq \text{Precip} < 10.0 \text{ mm}$

$\text{Precip} \geq 1.0 \text{ mm}$ .

$\text{Precip} \geq 10.0 \text{ mm}$ .

- **Low Level Clouds (LLC):** Just like the precipitation case, in order to determine the ability of the model to forecast different low cloud amounts (ex. few, broken, and overcast), statistics and scores are calculated for the following categories:
  - i.  $\text{LLC} < 3/8$
  - ii.  $3/8 \leq \text{LLC} < =7/8$

iii.  $LLC \geq 7/8$ .

- **Dew Point Depression (DPD):** This is defined as:  $DPD = T_{2m} - Td_{2m}$ .

DPD is taken as a measure of how well the model can forecast surface relative humidity.

Low DPD values would indicate high relative humidity. Therefore, the ability of the model to forecast fog can be implied from DPD verification statistics. The following categories used:

i.  $0 \leq DPD \leq 0.2$  C

ii.  $0.2 < DPD \leq 0.5$  C

iii.  $0.5 < DPD \leq 1$  C

## 4 Model Description

### In operation

The weather forecasting model in use is High-resolution Regional Model (HRM). Deutscher Wetterdienst (DWD) provided this comprehensive package to Pakistan Meteorological Department.

The HRM package consists of the following parts

- Topographical data sets for any region of the world at mesh sizes between 30 and 5 km; these data are prepared at the DWD on request.
- An interface program, called *gme2hrm*, which interpolates analysis and forecast data of the global model GME of the DWD to any HRM grid. The interpolated data serve as initial and lateral boundary data for HRM forecasts. Another transformation program, called *hmx2hmy*, allows interpolating HRM data to another (usually higher resolution) HRM grid.
- Several postprocessing programs which read the GRIB1 code forecast fields of the HRM and provide interfaces to the public domain graphic packages GrADS and VIS5D.
- A scheduler based on Korn shell scripts for setting up an operational HRM suite based on analysis and forecast data of the GME which are distributed by the DWD via the internet.

The domain of the model in Pakistan varies seasonally. It is from 60oE to 96oE and 10oN to 44oN for summer season and from 56E to 80E and 18N to 45N for winter season. The horizontal resolution of the model varies from 28km to 7km. For the time being it is run on 28km resolution. The vertical resolution of HRM is based on a hybrid coordinate system with 20 to 40 hybrid vertical layers. It is being run to generate forecast for 72 hours. HRM is a hydrostatic model. A short overview is given below

### **Physical parameterizations of HRM**

- $\delta$ -two stream radiation scheme (Ritter and Geleyn, 1992) including long- and shortwave fluxes in the atmosphere and at the surface; full cloud - radiation feedback; diagnostic derivation of partial cloud cover (rel. hum. and convection)
- Grid-scale precipitation scheme including parameterized cloud microphysics (Doms and Schättler, 2003)
- Mass flux convection scheme (Tiedtke, 1989) differentiating between deep, shallow and mid-level convection
- Level-2 scheme (Mellor and Yamada, 1974) of vertical diffusion in the atmosphere, similarity theory (Louis, 1979) at the surface
- Seven-layer soil model including snow and interception storage (Heise and Schrodin, 2002)

## Numerics of HRM

- Regular or rotated latitude/longitude grid
- Mesh sizes between 0.25° and 0.05° (~ 28 to 6 km)
- Arakawa C-grid, second order centered differencing
- Hybrid vertical coordinate, 20 to 40 layers (Simmons and Burridge, 1981)
- Split semi-implicit time stepping (Burridge, 1975);  $\Delta t = 150s$  at  $\Delta = 0.25^\circ$
- Helmholtz equation solved by a direct method (FFT and Gauss solver)
- Lateral boundary formulation due to Davies (1976)
- Radiative upper boundary condition as an option (Herzog, 1995)
- Linear fourth-order horizontal diffusion, slope correction for temperature
- Adiabatic implicit nonlinear normal mode initialization (INMI, Temperton, 1991) or diabatic digital filter initialization (DFI, Lynch, 1997)

## Prognostic variables

- Surface pressure ps
- Temperature T
- Water vapour qv
- Cloud water qc
- Cloud ice qi
- Ozone (optional) o3
- Horizontal wind u, v
- Several surface/soil parameters

## Diagnostic variables

- Vertical velocity  $\omega$
- Geopotential  $\phi$
- Cloud cover clc
- Diffusion coefficients tkvm/h

## Operationally available Numerical Weather Prediction Products

Output of HRM is regularly updated on website for end users and can be accessed from following web link.

[http://www.pakmet.com.pk/rnd/rnd\\_files/nwp.htm](http://www.pakmet.com.pk/rnd/rnd_files/nwp.htm)

## 5. Plans for the future (*next 4 years*)

- Establishment of Specialized Medium Range Forecasting Centre
- Establishment of Tropical Cyclone Early Warning Centre
- Establishment of Flood Warning Centre for NWFP province-Pakistan
- Establishment of five more Doppler radars at different locations of country to enrich existing network of seven radars.

## 6. Planned research Activities in NWP, Nowcasting and Long-range Forecasting

Research Activities in NWP

- Development of a new spectral dynamical core for HRM
- Development of the cumulus parameterization scheme of HRM
- Development of a parameterization of shallow cumulus convection
- Development of a new land surface scheme

- Improvement of a radiation scheme for HRM

## **7. References**

[http://www.pakmet.com.pk/rnd/rnd\\_files/nwp.htm](http://www.pakmet.com.pk/rnd/rnd_files/nwp.htm)

[http://www.pakmet.com.pk/rnd/rnd\\_files/hrm.htm](http://www.pakmet.com.pk/rnd/rnd_files/hrm.htm)

[http://www.pakmet.com.pk/rnd/rnd\\_files/Page553.htm](http://www.pakmet.com.pk/rnd/rnd_files/Page553.htm)