Progress Report on the Global Data Processing System for 2002

INDIA METEOROLOGICAL DEPARTMENT

NEW DELHI

1. Summary of Highlights

The major events during 2002 are:

(a) GTS data decoders of NCEP Washington are installed in Origin 200 computer system. Further work has been in progress to implement the decoder for operational model run.

(b) Experiments are carried out to examine the impact of MSMR (Multi frequency Scanning Microwave Radiometer) surface wind on the analysis and forecast of operational Limited Area Model. Some positive impacts are noticed in the analysis field.

(c) Experiments are in progress to study the impact of temperature and moisture profiles of HRPT on the Analysis and Forecast of Limited Area Model.

(d) Impact studies with METSAT CMV data on the analysis and forecast of Limited Area model are in progress.

2. Main Computer System

(a) CDC CYBER 2000U (Operating System NOS/VE)

(Used for processing incoming GTS data, plotting of various charts and research)

- One CPU with 256 MB memory; includes Vector processor.
- Maximum speed 26 MFlops (Vector) and 19 MFlops (Scalar).
- peripherals

- 4 tape units
- 16 GB disc storage
- 2 pen plotters
- 2 electrostatic plotters
- 3 laser printers (one color)

- 2 line printers
- 2 color copiers
- Optical disk subsystem

(b) Origin 200 (*Operating System – IRIX)*

(Used for operational runs of analysis and forecast models and research)

- 2 x R12000 CPU, 270 MHz Processor
- 2GB Memory
- 9GB System Disk, 64 bit RISC Processor
- 36 x 2 HDD
- Pentium – III based SGI 330 Visual Workstation

Software

- MIPS pro Fortran-77 Compiler 7.2.1 & MIPS pro Fortran-90 Compiler 7.3 & MIPS pro C++ Compiler 7.3
- Exceed

(c) *Two CDC 4680 (operating System EP/IX (UNIX))*

(Used as DEC geteway)

- 1 CPU 32 M bytes memory
- Disk: 1.0 G byte

(d) *Two VAX 11/730*

(Used for operational data processing and research and development)

- 1 CPU 4 M bytes memory
- Disk: 121, 456 MB

(e) *Graphics Workstation*

(Used for processing of satellite data and model output products)

- 4 CYBER 910-485 32MB memory workstation (Operating System: IRIX)

(f*) Internet Server*

Two SGI O2 machines are being used as Internet Servers in backup mode. The internal connection is through a 64 kbps dedicated radio link. The IMD web site was started in June 2000.

(g) Networks

- Ethernet (10 M bits/s)
- Connects the CYBER 2000U mainframe, Origin 200, two CD4680's, CYBER 910-485 workstations, electrostatic color plotter, calcomp pen plotters, laser plotters.
- Connects CYBER 2000U mainframe with VAX-3400 and RTH linux workstation (for online transfer of satellite imageries data and GTS data respectively), Dec Alpha (NCMRWF) for transfer of limited area model initial and boundary file.

3. Data and Products from GTS in use

Nearly all observational data from the GTS are used. GRID and GRIB data from WAFC Washington, Bracknell, ECMWF are received and processed. Approximate figures for 24 hours are:

SYNOP, SHIP	29,000 reports
TEMP/PILOT	1,900 reports
AIREP, AMDAR	7,200 reports
SATOB	37,000 reports
BUOY	900 reports

4. Data Input System

Fully automated system.

5. Quality Control System

Automated quality control of incoming data based on WMO criteria.

6. Monitoring of the Observing System

Surface observations and upper air observations are monitored as per WMO procedures.

7. Forecasting System

The operational forecasting system, known as Limited Area Forecast system (LAFS), is a complete system consisting of data decoding and quality control procedures handled by AMIGAS software, 3-D multivariate

optimum interpolation scheme for objective analysis and a multilayer primitive equation model run twice a day at 00UTC and 12UTC. First guess and boundary conditions for running the LAFS are obtained online from global forecast model being operated by the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi. The model is run upto 48 hr.

7.1 System Run Schedule

There are two operational runs of the Limited Area Model daily based on 00 and 12 UTC. NCMRWF global analysis and forecasts are used as initial fields and lateral boundary conditions for the model. The system run starts with a 4 hours cut off time after the main synoptic hours 00 and 12 UTC.

7.2 Data assimilation, objective analysis and initialization

The main characteristics of the OI scheme are given below:

Analysis method :	3-dimensional multivariate optimum interpolation.
Horizontal and vertical :	Flexible; 1ox1o lat/lon. and 12 sigma levels grid resolution
Analysis variables:	Geopotential, u and v components of wind, specific humidity.
Data input :	Synop, Ship, Temp, Pilot, Satem, Satob, Aireps, Amdar, Buoy
Bogus data :	Tropical Cyclone bogus data during tropical cyclone situations.
First guess :	Global 24 hours forecast from T 80 global model run by NCMRWF.

7.3 Forecast models

(a*)* ***Limited Area Model*** (Based on Dept. of Meteorology, Florida State University, USA)

The following are the outlines of the Limited Area Model :-

Basic equation :	Primitive equations
Independent Variables :	x,y,ó,t
Time Dependent variables :	lnp -log of surface pressure u,v -wind components T - temperature q - specific humidity z - geopotential
Numerical Integration :	Horizontal- finite difference, staggered Arakawa c scheme vertical-centered difference for all variables except humidity, which is handled by an upstream differencing scheme. Semi-lagrangian semi implicit time integration scheme.
Horizontal Resolution :	0.75oX0.75o
Vertical Resolution :	16 sigma levels.
Integration Domain :	139X107 grid points. (300S-500N, 250E-1300E)
Time Step :	15 minutes.
Initialization :	Dynamic normal mode initialization.
Orography :	Envelop orography.
Horizontal Diffusion:	Fourth order horizontal diffusion.
Vertical Diffusion :	Vertical distribution fluxes using diffusive formulation where exchange coefficients are function of Richardson number.
Planetary Boundary :	Surface fluxes by means of similarity theory.
Sea Surface :	Daily SST analysis at 10 resolution (From NCEP data server).
Earth Surface :	Ground temperature is computed over land with the help of the surface energy equation.
Radiation :	Longwave and shortwave radiative fluxes based on a band mode, parameterisation of low and high clouds based on threshold relative

	humidity for radiative transfer calculations.
Convection scheme :	Kuo-type cumulus parameterisation; Shallow convection, Dry convection adjustment.
Atmosphere Moisture :	Large scale condensation.
Boundaries :	Boundary condition from NCMRWF global forecasts.

***(b) Quasi-Lagrangian Model* (Based on NCEP, USA for cyclone track prediction)**

Data input :	SYNOP, PILOT, SATOB, AIREP, AMDAR, DRIBU, BUOY
First guess :	Global 12/24 hr F/C from T80 model of NCMRWF
Objective analysis:	3-D multivariate optimum interpolation
Variables :	Geopotential (Z), Temperature (T), Zonal (u) & Meridional (v) components of wind, specific humidity (q)
Boundary conditions:	Global model T80 forecasts, NCMRWF, New Delhi
Resolution :	40 km ; 16 Sigma Levels
Integration :	Variable – centered on the initial position of the cyclone
Domain :	40°x 40° (Approx.)
Input Fields :	Z, T, u, v, RH
Output Fields :	12, 24h & 36h forecast track, surface pressure Z, T, u, v, q at 10 Pressure levels; rainfall and fields of derived parameters such as Vorticity, Divergence, Vertical velocity.

7.4 Numerical Weather Prediction Products

The products of LAFS available operationally are :

Mean sea level pressure, geopotential, temperature and wind, relative humidity at 1000,850,700,500,400,300,250,200,150,100 hPa levels; accumulated precipitation for 24 hrs and 48 hrs. Some of the derived products like vorticity, divergence, Stream function, Velocity potential, Vertical velocity, Moisture flux divergence, Wind shear are also taken.

7.5 Storm Surge Modelling

For the operational storm surge prediction India Meteorological Department (IMD) has been using nomograms developed by IMD. The nomograms are based on the numerical solution to the hydrodynamical equation s governing motion of the sea. The nomograms are prepared relating peak surge with various parameters such as pressure drop, radius of maximum winds, vector motion of the cyclone and offshore bathymetry. The performance of these techniques as seen operationally over the years has been reasonably good.

IMD also uses PC based storm surge model developed by IIT Delhi . The model is fully non-linear and is forced by wind stress and quadratic bottom friction following the method of numerical solution to the vertically integrated mass continuity and momentum equations. The method uses a conditionally stable semi-implicit finite difference scheme with staggered grid for numerical solution of the model equation. The bottom stress is computed from the depth-integrated current using conditional quadratic equation. The bathymetry of the model is derived from Naval Hydrographic charts applying cubic spline technique.

Meteorological inputs for the model are pressure drop, radius of maximum winds, forecast landfall, speed and vector motion of the storm. At present six versions of the model are available for Indian coasts depending on the resolution and coastal segments. The model are Coarser Grid model for the entire east coast and west coast; Location specific refined model for Andhra coast, Orissa coast West Bengal coast, Tamil Nadu coast and Gujrat coast. The resolution of coarser grid is 18-40 km in the east west (width 300 km) and 35.5 km in the north south direction. The refined model has the resolution of 2-15 km in the east west and 32.5 km in the north south direction. The time step of the model is 3 minutes. The coastal boundaries are taken as vertical side walls across which the normal transport vanishes. The normal current across the open sea boundaries is prescribed by a radiation type of boundary condition. It is assumed that the motion in the sea area is generated from initial state of rest.

The entire east coast storm surge model has been installed at IMD, New Delhi. The validation of this model was also carried out. The validation exercise shows performance of the model is reasonably good.

7.6. Internet Products (www.imd.ernet.in)

These are essentially charts in gif format, satellite pictures and textual bulletins.

(a) Satellite pictures derived from METSAT satellite in subregional, regional, full disc visible and IR picture.

(b) Daily weather bulletins and forecasts (texts) for all regions and special weather warnings such as Tropical Cyclones, heavy rainfall etc., if any.

(c) Limited Area Model analysis and 24 hours forecast charts, Tropical Cyclone track prediction by Quasi-Lagrangian Model .

(d) RSMC forecast wind and temperature charts for aviation .

7.7 Data archives

All decoded surface,upper air data and grid point data of ECMWF and NMC as received from GTS are being archived. Grid point data of LAFS are also being archived.

8 Verification of Forecast Products

Verification against analysis :- Verification of limited area forecasts are done by computing mean square errors against current analysis. Verification statistics for 2002 are given in Table 1-3:

9. Plans for the future

(a) Upgradation of Computer system and implementation of Global and Regional Spectral Models.

(b) Development of rainfall analysis scheme from the use of METSAT derived precipitation estimates land-rainfall observation. Implementation of Physical Initialization scheme in the Regional Spectral Model u this rainfall analysis as input.

(c) Development of meso scale analysis for the finer resolution forecast

(d) Implementation of NCEP decoder for GTS data.

(e) Assimilation of NOAA humidity, temperature profiles and METSAT CMV data in the LAM anal procedure.

(f) Further development work for extending QLM forecast from 36 to 72 hours and increase horizo resolution of the model from 40 to 20 km.

(g) Further development work for extending the domain of finer resolution storm surge model for the entire coast of India

TABLE 1

Geopotential heights (in gpm) 500 hPa

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	20.8	24.9	26.0	19.5	24.5	24.9	26.8	26.3	23.2	24.8	21.1	22.1
Persistence error	27.6	29.2	32.0	26.0	21.8	20.5	18.1	19.5	20.5	24.8	24.4	27.6
F/C error (T+48)	29.3	27.6	26.7	24.6	29.6	29.6	31.4	30.4	27.9	29.8	26.0	28.6
Persistence error	39.1	40.3	45.6	37.8	31.1	29.8	25.8	27.2	29.1	35.0	35.0	39.5

TABLE 2

Vector Wind (in m/s) 850 hPa

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	4.4	4.3	4.3	4.5	4.4	4.5	4.6	4.7	4.2	4.4	4.3	4.2
Persistence error	4.9	5.0	5.5	5.2	5.0	4.9	4.7	4.9	4.6	5.0	4.9	4.8
F/C error (T+48)	5.2	5.1	5.3	5.2	5.3	5.4	5.6	5.6	5.0	5.1	4.9	4.9
Persistence error	6.0	6.0	6.8	6.6	6.2	6.3	5.9	6.2	5.9	6.0	6.1	5.8

TABLE 3

Vector Wind (in m/s) 250 hPa

2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	7.1	7.3	6.8	6.9	7.2	7.0	7.0	6.9	6.3	7.0	6.7	7.2
Persistence error	11.2	11.1	11.9	11.2	10.4	10.0	8.9	8.8	8.9	10.4	10.4	11.1
F/C error (T+48)	9.1	8.9	8.7	8.9	9.2	8.7	8.7	8.9	8.2	8.9	8.5	9.3
Persistence error	14.4	14.2	15.7	14.2	13.2	13.0	11.1	11.4	11.6	13.0	13.1	13.6