Annual WWW Technical Progress Report

On the Global Data Processing and Forecasting System 2004

INDIA

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1. Summary of Highlights

The major events during 2004 are:

(a) The Quasi-Lagrangian Model (QLM) for cyclone track prediction has been upgraded to extend forecast range from 36 hours to 72 hours.

(b) The latest version of IIT Delhi storm surge model covering entire east and west coast of India has been implemented. Another new storm surge model adapted from NIOT Chennai for the east coast of India has also been implemented on experimental mode.

(c) Various sensitivity studies related to Impact of non conventional data in the operational NWP model of IMD has been carried out.

(d) The computer system CYBER 2000U has been closed down and as a stop-gap arrangement a new computer system Altix –350 has been installed.

2. Main Computer System

(a) AIrix-350 (Operating System LINEX)
(Used for processing incoming GTS data, plotting of various charts and research)

Two CPU with 2 GB RAM, 1.4 GHz processor

(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*) 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.

(d) Networks

- Ethernet (10 M bits/s)
- Connects the Altix-350, Origin 200.
- Connects Altrix-350 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, 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 initial conditions. NCMRWF global forecasts are used as 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; 1^{o}x1^{o} 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*

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

Basic equation:	Primitive equations
Independent Variables:	x,y,σ,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 :	0.75^{o}X0.75^{o}
Vertical Resolution :	16 sigma levels.
Integration Domain :	139X107 grid points. (30^{0}S-50^{0}N, 25^{0}E-130^{0}E)
Time Step :	10 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 1^{0} 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 cloud 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

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 hourly upto 72h 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 00,850,700,500,400,300,250,200,150,100 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. IMD also uses computer based dynamical storm surge model developed by IIT Delhi and NIOT Chennai. The dynamical models are fully non-linear and is forced by wind stress and quadratic bottom friction following the method of numerical solution of the vertically integrated mass continuity and momentum equations

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

(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 2004 are given in

Table 1-3:

9. Plans for the future

(a) Upgradation of Computer system and implementation of Meso-scale (non-hydrostatic) model, Global Spectral model and Climate model.
(b) Development of meso scale analysis for the finer resolution forecast

(b) Upgradation and Implementation of decoders for GTS data.

(c) Implimentation of non-hydrostatic mesoscale model MM-5 using LAFS outputs model as initial and boundary values

TABLE 1

Geopotential heights (in gpm) 500 hPa

2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	27.7	24.4	25.2	25.7	26.6	26.3	26.7	26.9	27.4	22.3	20.4	20.9
Persistence error	25.4	30.1	26.0	26.6	23.5	20.2	19.1	19.3	22.6	24.9	26.0	29.0
F/C error (T+48)	34.7	31.7	30.6	35.6	31.9	30.9	32.1	32.0	31.8	28.5	26.3	27.6
Persistence error	36.1	43.8	38.2	38.4	33.3	29.2	26.8	27.7	30.1	36.3	34.8	39.0

TABLE 2

Vector Wind (in m/s) 850 hPa

2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	4.6	4.6	4.6	4.4	4.7	4.8	4.8	4.7	4.7	4.4	4.4	4.5
Persistence error	4.7	5.4	5.0	5.3	5.4	4.8	4.8	4.7	4.8	4.4	4.4	5.3
F/C error (T+48)	5.3	5.6	5.3	5.8	5.8	5.6	5.6	5.6	5.3	5.1	5.1	5.2
Persistence error	5.6	5.6	6.4	6.2	6.5	6.3	5.8	5.7	5.9	5.9	5.9	6.2

TABLE 3

Vector Wind (in m/s) 250 hPa

2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F/C error (T+24)	7.9	7.1	7.1	7.1	7.1	6.6	6.7	7.0	7.1	7.0	7.2	7.5
Persistence error	10.1	11.3	10.5	11.4	10.7	9.6	8.6	8.6	10.0	10.7	10.5	11.3
F/C error (T+48)	9.6	9.2	9.1	9.7	9.4	8.6	8.5	8.5	8.7	8.9	9.0	9.4
Persistence error	12.6	14.7	14.0	14.8	13.8	12.4	11.0	10.8	12.4	14.0	13.3	13.5