Progress Report on the Global Data Processing System 2003

European Centre for Medium-Range Weather Forecasts

1. HIGHLIGHTS OF THE YEAR

14 January 2003: Cycle 25r4, a major upgrade of the model that included:

- Revised multi-incremental (T95/T159) 4D-Var algorithm, including a non-linear balance in the Jb, statistics from 4D-var ensembles, and revised Jc (more selective to gravity waves)
- GOES WV radiances, MODIS winds, more HIRS channels and SAR data are activated; SSM/I radiances directly assimilated
- Improved cloud-scheme numerics, revised cloud physics and convection scheme with new type and cloud top/base algorithms; checks all levels up to 700hPa for initiation of deep convection
- Rescaling of EPS initial perturbations to reflect new data assimilation error statistics.

24 February 2003: ECMWF publishes its version of the WMO/CBS Global Monthly Monitoring Report on http://www.ecmwf.int/products/forecasts/monitoring/mmr/ (public access)

4 March 2003: All operational forecast suites are switched to run on the new IBM clusters;

25 March 2003: ECMWF medium range operational forecasts (T511L60 deterministic and T255L40 EPS) are run twice per day (00 and 12UTC). The data assimilation cycle has remained unchanged.

31 March 2003: the Fujitsu computers are decommissioned. As a result and according to plan, the old version of the seasonal forecast suite (System 1) has been discontinued

29 April 2003: Cycle 26r1- a technical change introducing in operations the use of the Observation Data Base (ODB) for analysis input and feedback files (it has been used internally by the IFS since Cy22r3)

7 October 2003. New model version (Cy 26r3) is implemented that includes:

- A new formulation of the humidity analysis (modified background-error covariances, a corrected calculation of background errors for SSMI that uses the FASTEM emissivity model over the sea);
- New data streams (AIRS from Aqua, AMSU-B, AMSUA from Aqua, Japanese wind profilers, Meteosat-5,GOES-9and GOES-12 water-vapour clear-sky radiances, GOES-12 winds and MIPAS ozone-profile retrievals);
- Passive monitoring of ENVISAT data: SCIAMACHY,GOMOS, and MIPAS;

- A new linear radiation scheme in 4D-var, a new radiation sampling (HALO) and a new aerosol climatology in the full model;
- A relaxation of the convective mass-flux limiter for long time steps (used for the EPS and monthly forecasts);

2 December 2003: The ECMWF Council has appointed Mr. Dominique Marbouty as Director from 18 June 2004. He will succeed Dr. David Burridge, ECMWF Director since 1991.

22 December 2003: A co-operation agreement comes into force between Romania and ECMWF[1]

Note: All model changes since 1985 are described and updated in real time at:
http://www.ecmwf.int/products/data/operational_system/index.html

2. EQUIPMENT IN USE

The computer equipment in use at the end of 2003 summarised in Table 1 below:

Table 1: Computer equipment in use for operational activities (end of 2003)

Machine	Processors	Memory (GB)	Storage (TB)	Tape Drives
2 IBM Cluster 1600	1820	2500	12	
3 HP K580 machines	18	2.2	0.4	
5 IBM p660 nodes	26	40	20	73

3. QUALITY CONTROL SYSTEM

The observational data used in the operational analysis (cf para. 5 below) undergo a quality control in near real-time, after having been decoded. Each observation is subject to a number of tests:

(i) The parameter values are compared with gross limits for the parameter. Limits depend on latitude and, for surface parameters, also on the season of the year.

(ii) Redundancy of information between the parameter values allows some internal consistency checks to be performed.

(iii) Temporal consistency checks on observations from the same source are done for the position of moving platforms.

The tests have, in general, been extracted from the publication "Guide on the Global Data Processing System", WMO-N305 1982 Chapter 6 - "Quality Control Procedures".

[1] ECMWF Member States are: Belgium, Denmark, Germany, Spain, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Austria, Portugal, Switzerland, Finland, Sweden, Turkey, the United Kingdom. Co-operation agreements are now in force with with: Croatia, Czechia, Iceland, Hungary, Romania, Slovenia, Serbia-and-Montenegro

4. MONITORING OF THE OBSERVING SYSTEM

The operational monitoring of all data types continues to provide the basis for decisions on the operational use of the data. The quality of observations is monitored in non real-time, based on statistics of the departures between the data and the operational 3-15 hour forecasts and analyses. All data types used in the data assimilation system are monitored in that way.

Results are published in a monthly Global Data Monitoring Report, which is publicly available on ECMWF web site together with other data monitoring informations (see item "Monitoring of the observing system." in the "Forecast" page at www.ecmwf.int.) Paper copies can be provided on request. Feedback is also provided directly to data producers.
The Centre has continued to fulfil its rôle of lead centre for radiosonde and pilot data monitoring as requested by WMO, including co-ordination and liaison with other lead centres, and setting up the list of reference stations used for the exchange of verification scores for NWP products

5. FORECASTING SYSTEM - DECEMBER 2003

Model:

Smallest half-wavelength resolved:
40 km (triangular spectral truncation 511)

Vertical grid: 60 hybrid levels (top pressure: 10 Pa)

Time-step: 15 minutes

Numerical scheme:
Semi-Lagrangian, semi- implicit time-stepping formulation.

Number of grid points in model:
20,911,680 upper-air, 1,394,112 in land surface and sub- surface layers. The grid for computation of physical processes is a reduced, linear Gaussian grid, on which single- level parameters are available. The grid spacing is close to 40km.

Variables at each grid point (recalculated at each time-step):
Wind, temperature, humidity, cloud fraction and water/ ice content, ozone content (also pressure at surface grid-points)

Physics:
orography (terrain height and sub-grid-scale), drainage, precipitation, temperature, ground humidity, snow-fall, snow-cover & snow melt, radiation (incoming short-wave and out-going long-wave), friction (at surface and in free atmosphere), sub-grid-scale orographic drag - gravity waves and blocking

Data Assimilation:

Analysis: **Mass & wind** (four-dimensional variational multi- variate analysis on 60 model levels)

Humidity (four-dimensional variational analysis on model levels up to 250 hPa)
Surface parameters (sea surface temperature from NCEP Washington analysis, sea ice from SSM/I satellite data), soil water content, snow depth, and screen level temperature and humidity

Data used: **Global satellite data** (SATOB/AMV, (A)TOVS, AIRS, Quikscat, SSM/I, SBUV, GOME, Meteosat and GOES WV radiances and wind products, MODIS wind products), **Global free-atmosphere data** (AIREP, AMDAR, TEMP, PILOT, TEMP/DROP, Profilers from networks in the USA, Europe and Japan), **Oceanic data** (SYNOP/SHIP, PILOT/SHIP, TEMP/SHIP, DRIBU), **Land data** (SYNOP). Data checking and validation is applied to each parameter used. Thinning procedures are applied when observations are redundant at the model scale.

Ensemble Prediction System: same model as used for data assimilation and deterministic forecast, except for :

Initial perturbations generated from singular vectors at T42 resolution. 10-days forecasts are perturbed through random perturbations of the physical tendencies (stochastic physics).

50 ensemble members at T_L255 resolution (linear grid), 40 levels, time step=45 minutes

Dissemination of analyses and forecasts to Member States:

via the RMDCN wide area network (mainly 64,000 bits per second) connecting the ECMWF system with the computer systems in the meteorological services of the 18 Member States and seven co-operating States

dissemination requirements updated (and repeat transmissions requested) by individual Member States

Dissemination to non-Member States:

via the Global Telecommunications System, network (50 to 64,000 bits per second) operated under the World Weather Watch of the World Meteorological Organization, connecting the meteorological services of all countries of the world. The horizontal resolution is 5 x 5 degrees (dissemination in code GRID) and 2.5 x 2.5 degrees (dissemination in code GRIB).

Dissemination to the African Centre of Meteorological Applications for Development (ACMAD):

via METEOSAT MDD *Specific products for the African region*

Dissemination to EUMETSAT:

A range of ECMWF products are sent daily to the Meteorological Product Extraction Facility at EUMETSAT to aid in retrieving cloud motion winds from METEOSAT. The ECMWF products

are used for calculation of sea surface temperature and to assign cloud top heights to pressure levels.

Dissemination to the European Space Agency:

A range of ECMWF products are sent daily to ESA to aid in processing data from the ERS satellites.

Management of the operational suite

The processes forming the operational suite and the research experiments are managed and controlled by a Supervisor - Monitor - Scheduler (SMS) system. Many suites can be controlled under one SMS; alternatively, several versions of SMS may run simultaneously.

Data archives and services

Demand for data from the Centre's archives of grid products, provided for research by ECMWF data services, continued to grow. Available data and services for external users are described at the following address: http://www.ecmwf.int/products/data/

6. VERIFICATION OF PROGNOSTIC PRODUCTS IN 2003

Average of the monthly WMO/CBS standard scores for **2003** are summarised in Table 2 and Table 3 below; the evolution of scores over the last 8 years is also shown in graphical format in Figure 1.

Table 2: Annual scores against Analyses

VERIFICATION AGAINST ANALYSIS in **2003** (*2002*)							
		24 hr		72hr		120hr	
North. Hemisphere	500-hPa height RMS (m)	**8.0**	*8.7*	**24.4**	*26.2*	**48.2**	*50.8*
	Wind RMSVE 250 hPa (ms^{-1})	**4.1**	*4.5*	**8.7**	*9.4*	**13.8**	*14.5*
South. Hemisphere	500-hPa height RMS (m)	**9.0**	*10.3*	**28.5**	*32.2*	**55.8**	*61.5*
	Wind RMSVE 250 hPa (ms-1)	**3.8**	*4.4*	**8.9**	*9.9*	**14.4**	*15.6*
Tropics	Wind RMSVE 850 hPa (ms^{-1})	**1.9**	*2.2*	**2.9**	*3.3*	**3.6**	*3.9*
	Wind RMSVE 250 hPa (ms^{-1})	**3.6**	*4*	**6.3**	*6.8*	**7.9**	*8.5*

Table 3: Annual scores against Radiosondes measurements

VERIFICATION AGAINST RADIOSONDES in **2003** *(2002)*							
		24 hr		72hr		120hr	
North America	500-hPa height RMS (m)	**10.9**	*12.0*	**25.3**	*28.9*	**46.9**	*51.2*
	Wind 850 hPa (ms^{-1})	**4.1**	*4.3*	**5.5**	*5.9*	**7.5**	*8.0*
	Wind 250 hPa (ms^{-1})	**6.1**	*6.5*	**10.1**	*10.9*	**15.1**	*15.9*
Europe	500-hPa height RMS (m)	**11.0**	*11.2*	**25.2**	*27.8*	**51.7**	*55.8*
	Wind 850 hPa (ms^{-1})	**3.8**	*3.9*	**5.1**	*5.5*	**7.3**	*7.7*
	Wind 250 hPa (ms^{-1})	**5.4**	*5.8*	**9.6**	*10.6*	**15.9**	*17.2*
Asia	500-hPa height RMS (m)	**12.3**	*12.9*	**21.9**	*24.2*	**37.1**	*41.8*
	Wind 850 hPa (ms^{-1})	**4.0**	*4.1*	**5.2**	*5.5*	**6.8**	*7.1*
	Wind 250 hPa (ms^{-1})	**5.7**	*6.1*	**9.1**	*9.9*	**12.5**	*13.7*
Australia/NZ	500-hPa height RMS (m)	**10.1**	*10.8*	**17.9**	*20.2*	**32.6**	*37.0*
	Wind 850 hPa (ms^{-1})	**3.9**	*4.0*	**4.8**	*5.0*	**6.2**	*6.3*
	Wind 250 hPa (ms^{-1})	**5.7**	*6.1*	**8.3**	*9.0*	**11.9**	*12.9*
Tropics	Wind 850 hPa (ms^{-1})	**3.8**	*3.9*	**4.3**	*4.4*	**4.8**	*5.0*
	Wind 250 hPa (ms^{-1})	**5.4**	*5.7*	**7.2**	*7.5*	**8.5**	*9.1*
North Hemisphere	500-hPa height RMS (m)	**12.0**	*12.5*	**26.5**	*29.0*	**51.2**	*54.7*
	Wind 850 hPa (ms^{-1})	**4.0**	*4.1*	**5.4**	*5.7*	**7.5**	*7.8*
	Wind 250 hPa (ms^{-1})	**5.6**	*6.0*	**9.6**	*10.4*	**14.8**	*15.8*
South Hemisphere	500-hPa height RMS (m)	**12.2**	*13.1*	**24.1**	*27.1*	**45.1**	*49.8*
	Wind 850 hPa (ms-1)	**4.2**	*4.4*	**5.3**	*5.6*	**7.0**	*7.3*
	Wind 250 hPa (ms^{-1})	**6.0**	*6.4*	**9.1**	*9.9*	**13.5**	*14.7*

Following recent recommendations from CBS, a preliminary set of annual verifications statistics for the Ensemble Prediction System follows in Table 4 below:

Table 4: Annual scores against analyses of the Ensemble Prediction System

EPS VERIFICATION AGAINST ANALYSES (2003)					
			72 hr	120hr	192hr
North Hemisphere	500-hPa height	Ensemble Mean RMSE (m)	26.0	46.4	69.5
		Ratio Ensemble Spread vs Ensemble Mean Error (%)	97.6	85.3	81.6
	850-hPa Temperature	Ensemble Mean RMSE (K)	1.69	2.44	3.31
		Ratio Ensemble Spread vs Ensemble Mean Error (%)	84.0	84.0	84.6
South Hemisphere	500-hPa height	Ensemble Mean RMSE (m)	30.6	53.7	80.1
		Ratio Ensemble Spread vs Ensemble Mean Error (%)	100.9	90.6	87.4
	850-hPa Temperature	Ensemble Mean RMSE (K)	1.63	2.33	3.08
		Ratio Ensemble Spread vs Ensemble Mean Error (%)	93.3	92.7	93.2

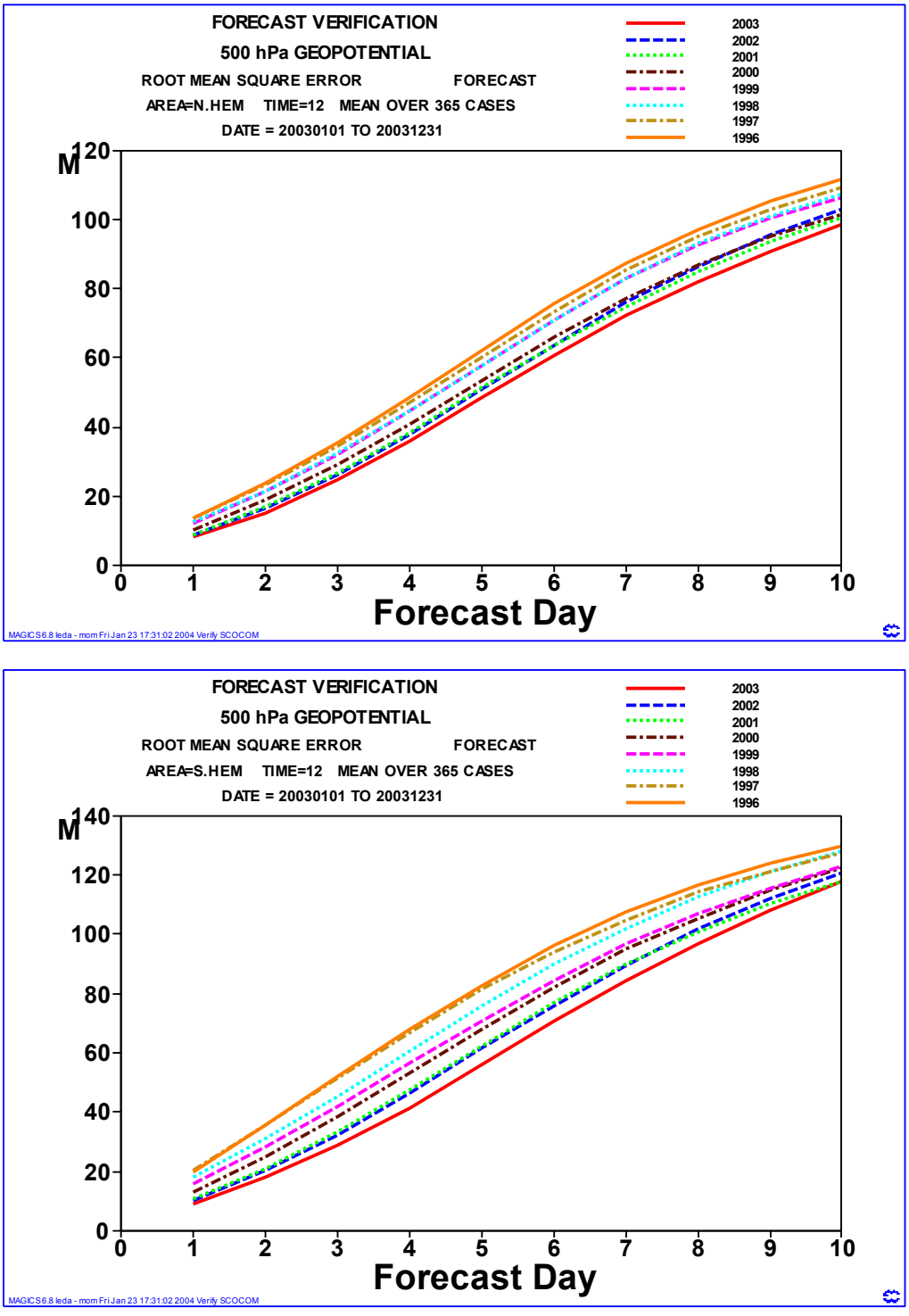

Figure 1: Z500 RMSE over N. Hem. (upper) and S.Hem. (lower) extratropics over the last 8 years.