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

## Portugal/Instituto de Meteorologia

### 1. Summary of highlights

During 2006, the main progress on the Portuguese Data-Processing and Forecasting System was the upgrade on the local version of the limited area model ALADIN, hereafter mentioned as ALADIN/Portugal: a new version and new geographical configuration on a new computer platform were implemented into operations. Some effort has also been put on the renewal of actual objective verification procedures. Besides, our observations pre-processing and model fields processing systems are now under the monitoring and scheduler package SMS/Xcdp(ECMWF). The TIDB2, our on-line data-base, is now being used in pre-operational mode archiving BUFR, GRIB and FA(ARPEGE) files; ECMWF expansion plug-ins have been implemented on a browser allowing a fast check for the archived BUFR and GRIB data. An historical archive of the operational model outputs has therefore started for ALADIN/Portugal. A huge effort has been also put on the migration of remaining meteorological applications from OpenVMS to DecAlpha/True 64 UNIX. At the same time, experiments have continued with the Live Linux distribution PaiPix/IM where the ALADIN model has been installed in parallel processing. PaiPix/IM is now full in use for NWP development. Finally, a new computer platform for NWP purposes has just been acquired.

### 2. Equipment in use

To handle GTS links:
1 cluster of 4 Micro VAX's (2x3400, 2x400) – dual system, with 5 Gbytes of mirrored disk space.

To handle GTS links plus GDPFS functions (ECMWF dissemination data) and the NWP activities:
1 cluster of 2 DecAlpha Servers 2000 4/275, with 128 Mbytes of memory (each) and 36 Gbytes of mirrored disk space.

To handle graphical applications:
1 DecAlpha XP1000 server, with 500 Mbytes of memory.

For future NWP activities:
IBM HPC 10xp575 (16 power 5+, 1.9 GHz, 32Gb RAM) ~1,024 Tflops

### 3. Data and Products from GTS in use

- SYNOP-39761 (OpenVMS/operational); SYNOP-50848 (UNIX/pre-operational)
- SHIP-4451
- EMP-3

Besides, the following NWP model products are available:

GRIB (ECMWF-different areas and resolutions)
GRIB (LPMG-ALADIN/Portugal, local area, 12,7km resolution)
GRIB (LEMD-HIRLAM/INM, local area, 16km resolution)

### 4. Forecasting system

Several components are included on the national forecasting system. Main components are: the atmospheric trajectory model based on ECMWF forecasts; the atmospheric limited area model ALADIN/Portugal; an open sea-wave model, hereafter called MAR3G; several fields derived from ECMWF and ALADIN/Portugal model forecasts; different meteorological applications as service providers.

## 4.1 System run schedule and forecast ranges

Pre-processing GTS data system runs in near-real-time basis.

Atmospheric trajectory model:

| | |
|---|---|
| 0130 | 12UTC ECMWF forecasts (up to H+48 time step) |

Mesoscale limited area atmospheric model – ALADIN/Portugal:

| | |
|---|---|
| 0244 | 00UTC ALADIN/Portugal (up to H+48 time step) |
| 1455 | 12UTC ALADIN/Portugal (up to H+48 time step) |

Open sea-wave model – MAR3G:

| | |
|---|---|
| 2300 | 12UTC MAR3G (up to H+120 time step) |

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

Derived products are operationally elaborated from ECMWF dissemination field forecasts.

### 4.2.1 Data assimilation, objective analysis and initialisation

None.

### 4.2.2 Model

None.

### 4.2.3 Operationally available Numerical Weather Prediction Products

None.

### 4.2.4 Operational techniques for application of NWP products

4.2.4.1 In operation

Several derived products are produced from ECMWF dissemination forecasts: pseudo-TEMP's up to H+24, Q vector divergence (using real wind), thermal front parameter, stability indexes (convective instability index, Jefferson index, total totals index), moisture convergence in the layer 1000-850hPa, temperature advection at 850hPa, vorticity advection at 500hPa, differential temperature advection in the layers 850-500hPa and 700-300hPa and differential vorticity advection in the layers 850-500hPa and 700-300hPa.

4.2.4.2 Research performed in this field

None.

### 4.2.5 Ensemble Prediction System (EPS)

None.

## 4.3 Short-range forecasting system (0-72 hrs)

The kernel of the national short-range weather forecasting system is the atmospheric mesoscale limited area model, ALADIN/Portugal. Besides, derived products are created in operational mode for forecasting purposes.

### 4.3.1 Data assimilation, objective analysis and initialisation

4.3.1.1 In operation

ALADIN/Portugal does not have its own assimilation system; it runs on a dynamical adaptation mode in which initial and boundary conditions are provided by the global mode ARPEGE (via Météo-France).

4.3.1.2 Research performed in this field

Some effort has been put to settle up CANARI, the multivariate optimal interpolation objective analysis system available from the ALADIN code, for weather forecasting support and nowcasting purposes. However, non-reliable results have been found near the Peninsula coast and are being investigated.

### 4.3.2 Model

4.3.2.1 In operation

ALADIN/Portugal is a spectral limited area model and the operational version runs in hydrostatic mode with the digital filter initialisation option; the temporal discretization is the two-time level semi-Lagrangiam scheme with 600s of time step. The integration domain covers the Iberian Peninsula and part of the neighbouring Atlantic Ocean and has 108 x 108 point size with 31 vertical levels and 12.7 km horizontal resolution; the coupling frequency is 6h.

This model is integrated twice a day-00UTC and 12UTC-up to H+48 and post-processing is applied every 1 hour with conversion of all required fields done into GRIB (projection used Lat/lon) for further handling, visualisation and archiving.

4.3.2.2 Research performed in this field

Main future efforts will be devoted to the enlargement of the integration area, to the increase of horizontal resolution, the increase of coupling frequency and number of vertical levels.

### 4.3.3 Operationally available NWP products

Surface parameters: surface pressure, mean sea level pressure, two metre temperature, soil temperature, soil wetness, deep soil temperature, deep soil wetness, snow depth, height geopotential, land sea mask, ten metre u wind component, ten metre v wind component, two metre relative humidity, two metre maximum temperature, two metre minimum temperature, total cloud cover, convective cloud cover, convective precipitation, convective snow-fall, large scale precipitation, large scale snow-fall.

Standard pressure level parameters: geopotential, temperature, u wind component, v wind component, relative humidity, absolute vortivity, potential temperature, pseudo-wet-bulb potential temperature.

### 4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

Isentropic Potential Vorticity is a derived product locally produced. Besides, pseudo-TEMP's up to H+24, Q vector divergence (using real wind), thermal front parameter, stability indexes convective instability index, Jefferson index, total totals index), moisture convergence in the layer 1000-850hPa, temperature advection at 850hPa, vorticity advection at 500hPa differential temperature advection in the layers 850-500hPa and 700-300hPa and differential vorticity advection in the layers 850-500hPa and 700-300hPa.

4.3.4.2 Research performed in this field

ALADIN wind and temperature dynamical adaptation is being validated on the Iberian territory of Portugal. We have also undergoing an evaluation of the bias reduction of a linear Kalman filter approach on the air temperature and humidity forecasts. So far, this approach was taken over a group of 24 weather stations on the steps H+24 (12UTC run) and H+36 (00UTC run). The overall results point to a bias reduction of 1ºC on the temperature and 5% on the relative humidity.

### 4.3.5 Ensemble Prediction System

4.3.5.1 In operation

None.

#### 4.3.5.2 Research performed in this field

Several ALADIN/Portugal fields are being disseminated to integrate the PEPS probabilistic products.

#### 4.3.5.3 Operationally available EPS Products

None.

## 4.4 Nowcasting and Very Short-range Forecasting Systems (0-6 hrs)

### 4.4.1 Nowcasting system

#### 4.4.1.1 In operation

RGB images from MSG channels for specific nowcasting purposes (fog and low clouds, strong convection, dust, fires and air masses).

SAF Nowcasting v1.2 products for MSG images (already operational: Cloud Mask, Cloud Type, Cloud Top Temperature and Height, Convective Rainfall Rate, Precipitating Clouds, Rapid Development Thunderstorms).

Radar system with base products (Surface Rainfall Intensity, Rainfall Accumulation in 1h and 3h, Maximum Return of Reflectivity, Echo Tops, Vertically Integrated Liquid Water Content, Vertical Wind Profile, horizontal wind) and severe weather warning products automatically running in the background (hail, heavy precipitation, severe cells and cell tracking).

For diagnose and for very-short range forecast purposes, the subjective recognition of several conceptual model signatures using radar imagery, in accordance to local climatology is recommend.

#### 4.4.1.2 Research performed in this field

Use of vertical wind profile data in numerical weather forecasting model assimilation processes. Installation of a visualizing system that combines different kinds of data (e.g. Satellite with NWP).

### 4.4.2 Models for Very Short-range Forecasting Systems

None.

## 4.5 Specialized numerical predictions

As specialized products we can mention: the 2D air trajectory model and the sea-wave model described bellow.

### 4.5.1 Assimilation of specific data, analysis and initialisation (where applicable)

None.

### 4.5.2 Specific Models

#### 4.5.2.1 In operation

2D trajectory model, used operationally for weather forecast support and in nuclear emergencies to follow the trajectory of radioactive plumes (in cooperation with the Environment Institute).

Sea-wave model, MAR3G, used to forecast the sea conditions. MAR3G is a third generation wind-wave model that solves the transport using a Mercators projection (propagation in lat-lon grid) with a grid mesh 1º latitude per 1º longitude, and source and sink terms based on a physical approach to wave growth induced by wind, non-linear wave-wave interaction and dissipation by white capping. MAR3G also includes a parameterisation for the effect of the wind variability on the Miles mechanism for wave generation that improves the model performance. For each point of the model, a spectral grid of 24 directions and 25 frequencies is calculated; and consequently, are calculated wave parameters, such as significant wave height, mean wave direction and mean period. The model is integrated once a day up to H+120, with a 6h time step. Top transform waves from the open seas to near-shore is used a ray model, that reproduces the effects of shelter by the shore, refraction, shoaling and dissipation by bottom friction. This model, constrained by the bathymetry, computes 25 ray fans (one for each of the frequencies of MAR3G) using 360 rays spaced by 1º at the origin. The parameters obtained by Ray model are: significant wave height, wind sea height, swell height. Maximum height most probably in 6 hours, power density, mean period, peak period, peak period unidirectional, power equivalent period, spectral width peak direction, mean direction, wind sea direction, swell direction and power direction.

4.5.2.2 Research performed in this field

None.

#### 4.5.3 Specific products operationally available

The Fire Weather Index (WI) is used to support the forecast fires prevention and fighting activities.

### 4.6 Extended range forecasts (ERF) *(10 days to 30 days)*

None.

### 4.7 Long range forecasts (LRF) *(30 days up to two years)*

None.

## 5. Verification of prognostic products

### 5.1 Annual verification summary

ALADIN/Portugal forecasts are objectively verified on a regular basis. When possible, a comparative analysis is done using ECMWF forecasts. In general the verification scores for surface and upper-level parameters are computed following standard recommendations. Upper level parameters, namely, geopotential, temperature, specific humidity and wind direction and accumulated precipitation in 6h and 24h are treated as categorical parameters and several statistics (Hit Rate, POD, FAR for instance) are computed based on categorical tables.

MAR3G is also objectively verified. In particular, a validation of model parameters is made, in order to evaluate the model's performance. Several statistical parameters, such as mean error (ME), mean absolute error (MAE) and root square error (RMSE), are calculated for significant wave height, peak period and mean wave direction.

### 5.2 Research performed in this field

New objective verification tools for daily Limited Area Models consistency verification based on 10-day statistics as well as long time series of model parameters skill scores are daily plotted and some development effort will be put in order to find a nice model performance monitoring method.

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

### 6.1 Development of the GDPFS

#### 6.1.1 Major changes un the operational DPFS which are expected in the next year

To finish the migration of the GDPFS systems from VAX/OpenVMS to UNIX, to implement full system under SMS/Xcdp (ECMWF) and to start the implementation of the system under a PC dual system having the Live Linux PaiPix/IM distribution are the major achievements expected for the next year. Besides a CVS system should be implemented. Hardware monitoring should be done under Nagios. Finally, the implementation of new features on our NWP data base, TIDB2 with the inclusion of plug-in's to FA files will allow the dissemination of historical initial and boundary conditions to shorter scale models than ALADIN/Portugal. PaiPix/IM is expected to be used as NWP instrument at the Portuguese Universities.

#### 6.1.2 Major Changes in the operational DPFS which are envisaged within the next 4 years

To find the proper solution for the NWP historical archive using our actual TIDB2 database will be one of the major targets for future developments. The availability of national/regional data coming from different observational and local model sources into our NWP database will be a natural achievement of our data processing centre. The migration of WMO Traditional Alphanumeric Code Forms to WMO Table Driven Code Forms will require the involvement of many resources. Quality control assessment of observations in near-real-time and climate modes is a demand, as well as the re-organization of the national archive. Finally, a data monitoring system should be implemented.

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

On the short term priority will be given to the redesign of our local version of the ALADIN model over the Iberian territory in order to take advantage of the new computer resources: the enlargement of the territory, the increase in horizontal resolution, the increase of the vertical levels, increase of coupling frequency will be some of the most immediate goals. Besides a deep investment will be put on the upgrade of verification tools in order to better understand the weaknesses of local operational model compared with other available models, in different meteorological situations. On the short term some effort must be also put on the implementation and exploitation of probabilistic forecast products. On the long term more interaction is expected with the Portuguese University, through an expect access agreement to our centre operational and development environments. Research aims should be the prediction of extreme events. Quality control assessment of numerical products as well as of national observations and the appropriate exploitation of probabilistic products will be a long time concern for the Portuguese centre. A closer involvement on the ALADIN International Project will be a constant concern.

To continue the adaptation and implementation of SWAN model (Simulating Waves Near-shore) to better represent waves in shallow waters near South Coast of Portugal Mainland, using an input wind provided by ALADIN/Portugal and directional spectra from MAR3G and ECMWF models as boundary conditions will be other branch of our NWP work.

To better represent the abnormal rise in water level caused by wind and pressure forces associated with an atmospheric disturbance in Portuguese coast, it will allow the continuation of the project for the implementation of a Storm Surge model.

Although in an early stage, the results obtained with the Kalman Filter approach will justify further research. Plans exists to continue the evaluation of this approach to the ALADIN forecasts and to extend it to ECMWF forecasts as well as to increase the number of steps in use. Some time will be dedicated to the development of the filter itself. The final goal will be the operational implementation of the Kalman Filter.

## 7. References

Horányi, A. I. Ihász, and G. Radnóti, 1996. ARPEGE/ALADIN: *A numerical prediction model for Central-Europe with the participation of the Hungarian Meteorological Service.* Idöjárás, 100, 277-300.

Komen, G.J., Cavaleri, L., Donelan, M., Hasselmann, K., Hasselman, S., Janssen, P. A. E. M., 1994: *Dynamics and Modelling of Ocean Waves*, Cambridge University Press, 532p.

Oliveira-Pires, H., 1993: *Numerical Modelling of Wind Generated Waves*, PhD Thesis, IST, Lisbon, 222p.