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

HUNGARIAN METEOROLOGICAL SERVICE

1. Summary of highlights

In 2006 there were some important changes in the computer system of the Hungarian Meteorological Service: a new SGI Altix 3700 mainframe computer and a new IBM archiving system was purchased and installed. The ALADIN mesoscale limited area model for ultra-short range and short range numerical weather prediction is now exploited on the SGI Altix linux platform with the introduction of four model integrations daily (with some extension of the integration lengths).

2. Equipment in use

SGI Altix 3700 server with 144 Itanium 2 processors (1,5 GHz processors), IBM p655 cluster server with 32 processors (1,7 GHz processors), IBM Regatta p690 server with 32 processors (1,3 GHz processors), SGI Origin 2000 machine with 16 processors (500 MHz processors), HP L3000 cluster server with 8 processors, HP RX7620 cluster server with 8 Itanium 2 processors, SGI Altix 350 server with 12 Itanium 2 processors; different workstations (HP, DEC, SUN, PC), EMC CLARiiON CX700 and FC4700 (backup) disk storage systems (13 Tbyte native capacity), IBM 3584 LTO3 Ultrium 3/60 Tape Library (around 30 Tbyte capacity), 18 Linux/Unix servers (used for: Message Switching System, FTP, mail server, and other special meteorological purposes), 10 Netware and Windows servers, as well as CISCO routers and switches.

3. Data and Products from GTS in use (daily statistics)

- SYNOP - 3900
- TEMP – 900
- METAR – 300
- GRID (EGRR) – 1000
- GRIB (EDZW) – 1300
- FAX (EDZW) – 250
- RADAR – 700
- Windprofiler - 500

4. Forecasting system

4.1 System run schedule and forecast ranges

The ALADIN ultra-short and short range forecasting model is executed on the Altix machine four times a day (at 00, 06, 12 and 18 UTC network times) providing 54h, 48h, 48h, 36h forecasts, respectively. The medium, extended and long range forecasts are provided on the basis of the ECMWF products. The data processing and visualisation are made on HP servers, workstations and also on linux PC-s.

4.2 Medium range forecasting system (4-10 days)

4.2.1 Data assimilation, objective analysis and initialization

4.2.1.1 In operation
Locally none (see ECMWF)

4.2.1.2 Research performed in this field
Locally none (see ECMWF)

4.2.2 Model

4.2.2.1 In operation
Locally none (see ECMWF)

4.2.2.2 Research performed in this field
Locally none (see ECMWF)

4.2.3 Operationally available Numerical Weather Prediction Products

Locally none (products are received through ECMWF dissemination channels).

4.2.4 Operational techniques for application of NWP products *(MOS, PPM, KF, Expert Systems, etc..)*

4.2.4.1 In operation
10 days forecasts of ECMWF deterministic model and ensemble prediction system are operationally used. Meteorological fields are displayed on workstations by the HAWK (Hungarian Advanced WorKstation) visualisation software. Automatic forecast generation is carried out based on the outputs of the ECMWF model until 10 days. The Model Output Statistics (MOS) procedure is operational for the 2m temperature and relative humidity and 10m wind forecasts of the ECMWF model (see also ALADIN/HU model). The products of the ensemble prediction system is clustered with a clustering algorithm targeted to the Carpathian Basin.

4.2.4.2 Research performed in this field
The improvement of the MOS-based statistical post-processing system was realised.

4.2.5 Ensemble Prediction System (EPS)

4.2.5.1 In operation
Locally none (see ECMWF)

4.2.5.2 Research performed in this field
Dynamical downscaling of the ECMWF EPS system with the help of the ALADIN limited area model was tested and some case studies investigated.

4.2.5.3 Operationally available EPS Products

Locally none (products are received through ECMWF dissemination channels)

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

4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation
The operational numerical weather prediction model ALADIN/HU is applied using three-dimensional variational data assimilation (3d-var) algorithm for the computation of initial fields for the numerical model. The main characteristics of the data assimilation system is as follows:

- Observations: SYNOP surface measurements (surface pressure), TEMP upper air soundings (temperature, wind, geopotential, specific humidity), AMDAR aircraft reports (temperature, wind), ATOVS satellite observations (AMSU-A, AMSU-B radiances).
- Assimilation cycle: 6 hours
- Analyses method: three-dimensional variational data assimilation
- Analysed variables: temperature, humidity, wind components, surface pressure
- First guess: ALADIN 6h forecasts
- Coverage: Continental Europe
- Horizontal resolution: 8 km
- Vertical resolution: 49 levels
- Initialisation: digital filter initialisation
- Boundary conditions: ARPEGE French global model

4.3.1.2 Research performed in this field

Continuous improvement of the operational data assimilation system as far as observation usage and background error modellisation are concerned.

4.3.2 Model

4.3.2.1 In operation

The operational ALADIN/HU limited area NWP model is a version of the ALADIN model for the region over continental Europe. The main characteristics of the ALADIN model are as follows:

- Hydrostatic primitive equations;
- The equations are solved using the spectral method having elliptical truncation of bi-Fourier series;
- Hybrid vertical co-ordinates;
- Two-time level semi-lagrangian advection scheme;
- Semi-implicit time-stepping;
- Davies-Kallberg coupling (relaxation) scheme;
- The physical parametrization package (simple radiation scheme, Bougeault deep convection scheme etc.) is rather the same than it is for the ARPEGE French global model.

The main characteristics of the ALADIN/HU application are the following:

- Domain covering continental Europe;
- Integration four times a day (at 00, 06, 12 and 18 UTC) for 54, 48, 48, 36 hours, respectively;
- 360*320 points in horizontal and 49 vertical model levels,
- Approximately 8 km of horizontal resolution;
- Coupling by the ARPEGE global model every 3 hours;
- Post-processed products every hour for the first 36 hours and 3 hourly afterwards on 32 pressure and 9 height levels.

4.3.2.2 Research performed in this field

The main area of research is non-hydrostatic modelling with the adaptation, validation and further improvements of the AROME model.

4.3.3 Operationally available NWP products

Two-dimensional fields: mean sea level pressure, surface temperature, convective and frontal precipitation (including snow), total cloudiness (including low, medium and high level clouds), surface pressure, snow thickness, 10m wind, 2m temperature and relative humidity, 2m minimum and maximum temperature, pressure and temperature of the ICAO jet, surface pressure tendency, total precipitable water, short wave radiation arriving to the surface.

Three-dimensional fields: These fields are obtained on 9 height levels (on 20, 100, 300, 500, 600, 750, 900, 1250, 1500 metres) in the planetary boundary layer and on 32 pressure levels (on 1000, 990, 980, 970, 960, 950, 940, 925, 900, 880, 860, 850, 840, 820, 800, 780, 760, 740, 720, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100 hPa). The variables are as follows: geopotential (only on pressure levels), pressure (only on height levels), temperature, wind field, relative humidity, pseudo-potential temperature, vertical velocity (only on pressure levels), divergence (only on pressure levels), potential temperature (only on pressure levels), potential vorticity (only on pressure levels) and absolute vorticity (only on pressure levels).

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

Automated forecast generation based on the outputs of the ALADIN models giving 48 hors forecasts. Model Output Statistics (MOS) statistical adaptation algorithm is operationally running

for improving the 2m temperature, 10 wind and 2m relative humidity forecasts of the ALADIN/HU model.

4.3.4.2 Research performed in this field
The improvements of the MOS-based statistical post-processing system were realised.

4.3.5 Ensemble Prediction System

4.3.5.1 In operation
None

4.3.5.2 Research performed in this field
Intensive research and development work is ongoing about limited area ensemble systems based on the ALADIN model. The dynamical downscaling of the ARPEGE PEARP system and the ECMWF EPS system was tested with the use of the ALADIN limited area model. For the ARPEGE EPS system the sensitivity of global singular vector computations is assessed with respect to its target domain and time.

4.3.5.3 Operationally available EPS Products

None

4.4 Nowcasting and Very Short-range Forecasting Systems (0-18 hrs)

4.4.1 Nowcasting system (MEANDER-MM5 system)

The nowcasting system of the Hungarian Meteorological Service (MEANDER) was developed as a tool for recognizing and predicting severe weather phenomena in objective way. MEANDER uses the following real time information: synoptic surface measures, EUMETSAT-MSG satellite data, radar reflectivity and wind data. MEANDER system makes an objective analysis every hour for a domain which covers Hungary. The horizontal resolution of the nowcasting domain is 1.7 km. Applied analysis techniques are Cressman-type analysis and MM5 nudging methods. First guess data available from the limited area model MM5. Using dynamically based methods MEANDER system calculates atmospheric replacement vectors to describe motion of precipitating (radar observed) weather systems like thunderstorms or stratiform cloudiness. Real time measured radar echoes are moved by these motion vectors making ultra short range precipitation forecast. Phase of precipitation (snow, rain, freezing rain) or possible hail sizes of thunderstorms are calculated by vertical cloud physic models. The linearly forecasted (MEANDER made) weather parameters are smoothed to MM5 calculated fields in 3 hours forecast time. The nowcasting system issues weather warnings for all regions of Hungary.

4.4.1.1 In operation

(1) MEANDER system makes objective analysis and linear forecast of basic parameters every hour. Radar and satellite data are used to update precipitation in every 15 minutes. Using replacement vectors these updated fields allow issuing weather warnings by 15 minutes especially for severe convective events. MEANDER system can calculate “present weather” for all grid points.

The high resolution, non-hydrostatic MM5 model runs in every six hours, using nudging technique for data assimilation producing 18 hours forecast. MM5 model supports background data for MEANDER system and the very short range forecast for 18 hours ahead.

(2) See short range above (ALADIN/HU)

4.4.1.2 Research performed in this field

(1) Research activity is focusing to severe convective phenomena like supercells and torrential rain and flash flood cases. The nowcasting system is planned to recognize and warning for squall lines,

supercells or MCC. The main issue is to connect radar based linear forecast with non-hydrostatic numerical forecast.

(2) See short range above (ALADIN/HU)

4.4.2 Models for Very Short-range Forecasting Systems

MM5 and in the near future WRF models are applied for making 18 hours weather forecast. MM5 model is used for reanalysing and investigating extreme weather events, too. MM5 model used ECMWF analysis and forecast for initial and boundary conditions. The non-hydrostatic model has 2.5 km horizontal resolution and detailed cloud physics, allowing non-parameterized convective model runs. Weather observations are assimilated by four dimensional data assimilation methods (based on grid nudging technique) which is a part of the MM5 system.

4.4.2.1 In operation

(1) The operation model run based on ECMWF objective analysis at 00 and 12 UTC model runs and +6 hours ECMWF forecast and upper level and surface observation at 06 and 18 UTC model runs.

(2) See short range above (ALADIN/HU)

4.4.2.2 Research performed in this field

(1) MM5 model is applied for nowcasting and very short range forecast. Experiments are going on to include radar reflectivity information for thunderstorms forecast. The main issues are

- connecting nowcasting and NWP products (see 4.4.1.2)
- using nowcasting data for model input
- making detailed numerical case studies to understand features of severe weather in the Carpathian basin

(2) See short range above (ALADIN/HU)

4.5 Specialized numerical predictions

The outputs of the numerical weather prediction models used at the Hungarian Meteorological Service are intensively used for wide-range of applications like trajectory and dispersion modelling and hydrological modelling.

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

4.5.1.1 In operation
None

4.5.1.2 Research performed in this field
None

4.5.2 Specific Models

4.5.2.1 In operation
None

4.5.2.2 Research performed in this field
None

4.5.3 Specific products operationally available

None

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

4.6.1 Models

4.6.1.1 In operation

The products received from ECMWF are used in the operational regime.

4.6.1.2 Research performed in this field

None

4.6.2 Operationally available NWP model and EPS ERF products

None

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

4.7.1 In operation

The products received from ECMWF are used in the operational regime.

4.7.2 Research performed in this field

None

4.7.2 Operationally available EPS LRF products

None

5. Verification of prognostic products

5.1

ECMWF and ALADIN/HU products are verified and compared operationally computing simple statistical measures (bias and RMSE) using all the SYNOP and TEMP observations inside the domain of the ALADIN/HU domain. The automatically generated forecasts are also verified and compared to the forecasts issued by the forecasters. A new and comprehensive verification system (OVISYS: Objective VerIfication SYStem) was introduced operationally.

5.2 Research performed in this field

Some research was carried out as far as the precipitation verification was concerned.

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

6.1 Development of the GDPFS

6.1.1 Major changes in the Operational DPFS, which are expected in the next year

There are no major changes planned in the data processing system apart from the enhancement of the data archiving system (regarding its speed and capacity). The operational ALADIN/HU modelling system is planned to be improved with some small enhancements in the next year.

6.1.2 Major changes in the Operational DPFS, which are envisaged within the next 4 years

The data processing upgrades cannot be planned for the longer range (due to budgetary reasons), however as far as numerical weather prediction is concerned it is planned to use the AROME non-hydrostatic model for ultra-short range weather forecasting. Beside that the introduction of the short range limited area ensemble prediction system is planned to be realised.

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

6.2.1 Planned Research Activities in NWP

- Further enhancement of the three-dimensional variational (3D-VAR) data assimilation scheme for the ALADIN model: new observations (MSG SEVIRI data, ATOVS: HIRS data), improvements in the background error modelling.

- Development of a limited area ensemble prediction system based on the ALADIN model: computation of mesoscale local perturbations for the model based on the singular vector approach.

- Further development, validation and operational introduction of the next generation ALADIN model (called AROME).

6.2.2 Planned Research Activities in Nowcasting
See above (planned introduction of the WRF model, application of radar reflectivity in numerical model, flash flood and supercell nowcast)

6.2.3 Planned Research Activities in Long-range Forecasting
None

7. References

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