# JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR 2013

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## 1. Summary of highlights

The high resolution ALADIN model switched to the improved parameterization of moist deep convection scheme, coping with the resolutions across the so-called grey zone. This version of the ALADIN model is also used in the Grey Zone Project proposed by JSC-CAS WGNE.

## 2. Equipment in use

The data processing centre is equipped with a vector computer NEC SX-9, two nodes with 16 processors and 1 TBytes shared memory each. There are two front-end servers NEC Express 5800/140Rf-4 and Global File System NEC gStorageFS with capacity of 100 Tbytes.

A Sun M8000 and 6900 servers for central database 2-node cluster (Oracle 10i and RAC and partitioning) are used (16 processors Sparc) including two mirrored Hitachi 9900 disk arrays which were installed in 2007 and reinstalled 2010.

Central cluster uses Solaris virtualization resource – zoning environment.

SAN 2/4/8 Mbps storage infrastructure is in operation in Prague.

The MSS at the RTH Prague consists of coupled SUN computers (Sun Fire V440 with RAID5 disk array) using the cluster technology. Software used for MSS is MovingWeather - producer IBL Software Engineering.

Backup activities are performed on the upgraded server Sun Fire V490 connected to the Qualstar TLS46120 tape library (software Legato).

Archiving activities are performed on the cluster of two Sun Fire V440 servers using disk capacity of SAN network attached disc arrays and Qualstar TLS 58264 with 8 S-AIT tape driwers. SamFS archiving software is used.

Central server Sun Fire V445 for system logs collecting was installed.

Virtualisation platform service was started in Prague. It use one Oracle Blade chassis with 7 blade Intel processor based servers. One Blade server is used for service purposes. It uses VMware virtualisation software. Six Blade servers use KVM virtual machine platform software. Virtual servers, running on this platform, are LDAP master server, CHMI Identity Management system, web servers. All virtual servers are based on Linux.

Old portal farm consisting of 8 portal and SRA servers (Sun Java Portal) and 3 application servers (Oracle Application server) and test portal infrastructure was put into the operation in May 2009.

Emergency air pollution dispersion model operations were also moved to new front-end servers of the HPC System. Each server is equipped by four Intel quad-core Xeon 7350 processors (2.93GHz) and 32GB of memory. They run under Linux SUSE operating system. The model development is now supported also by these front-end servers.

Branch offices use database services centralised in Prague now.

IBL Software product VisualWeather, Linux Server version was put in operation in headquarters and six branch offices in 2008.

## 3. Data and Products from GTS in use

* SYNOP-7000
* SHIP-1600
* TEMP-900
* TEMP SHIP-15
* PILOT-150
* AMDAR-4500
* WINDPROFILER-4000
* BUOY
* CLIMAT
* BUFR
* GRIB-9000
* T4-1200

## 4. Forecasting system

### 4.1 System run schedule and forecast ranges

Medium range forecasting system (4-10 days):

We do not run such a system ourselves. We use NWP products from ECMWF (EPS products included), from NOAA/NCEP, MetOffice UK, and DWD.

Short range forecasting system (0-72 hours):

We operate the high resolution ALADIN System, which we developed jointly with other fifteen NM(H)Ss of the ALADIN Consortium. The production forecast is run four times a day up to 54 hours, with output frequency of 1 hour. We produce objective analysis every hour for the needs of nowcasting.

Besides, we use the ALADIN EPS configuration called ALADIN/LAEF, namely for the precipitation forecast, which is the result of the RC LACE consortium of seven Central European NM(H)Ss. ALADIN/LAEF is run twice a day up to 72 hours.

Nowcasting and very short range forecasting system (0-12 hours):

We operate a set of nowcasting tools, targeted namely for flash floods, developed by us. We also use the INCA System developed jointly by a Central European consortium. Where convenient, ALADIN System products are used in the nowcasting system.

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

#### 4.2.1 Data assimilation, objective analysis and initialization

4.2.1.1 In operation

4.2.1.2 Research performed in this field

#### 4.2.2 Model

4.2.2.1 In operation

4.2.2.2 Research performed in this field

#### 4.2.3 Operationally available Numerical Weather Prediction Products

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

4.2.4.1 In operation

4.2.4.2 Research performed in this field

#### 4.2.5 Ensemble Prediction System (EPS)

4.2.5.1 In operation

 *(Describe also: time range, number of members and number of models used: their resolution, number of levels, main physics used,* *perturbation of physics, post-processing: calculation of indices, clustering)*

4.2.5.2 Research performed in this field

#### 4.2.5.3 Operationally available EPS Products

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

#### 4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation

 *(Indicate boundary conditions used)*

For upper air model variables the so-called blending technique is used: the high resolution guess is blended with the 4DVAR analysis of the global model ARPEGE of Météo-France, which also yields lateral boundary conditions. Surface analysis is performed using the optimum interpolation algorithm to analyse screen level variables. Analysis increments are then translated into soil variables’ increments. The assimilation cycle is run with 6h update. Besides, every hour an analysis is computed for purposes of nowcasting. For initialization, a weak incremental digital filter is used.

4.3.1.2 Research performed in this field

Research is performed on topics which are important for a high-resolution limited area model. It is a proper choice of background error structure functions on the one hand, and selection of high resolution representative observations on the other hand. An operational application is now under preparation, using the combination of blending and 3DVAR. Future research will be focused on the use of MODE-S data and low peaking cloudy radiances, and on the problem of flow dependent background error structure functions.

#### 4.3.2 Model

4.3.2.1 In operation

The ALADIN model is a primary tool of short-range weather forecasting at the CHMI. It is a spectral limited-area model with horizontal resolution of 4.7 km (elliptical truncation 269×215 waves, linear collocation grid of 540×432 points) and 87 hybrid-type vertical levels.

Dynamics - hydrostatic primitive equations, two-time-level semi-implicit semi-Lagrangian scheme; spectral discretization in horizontal, vertical finite element discretization in vertical;

Horizontal diffusion – local selective semi-Lagragian interpolator based scheme;

Physics - the so-called ALARO-0 version of physics parameterization is used.

Radiation scheme: broad band, net exchange rate algorithm;

Moist deep convection: 3MT (Multi-scale, Modular, Microphysics and Transport) prognostic scheme with memory;

Microphysics: one momentum Kessler type, statistical sedimentation, geometry of cloudiness and falling precipitations; joint use for stratiform and convective precipitations;

Turbulence and shallow convection: pseudo-prognostic turbulent kinetic energy scheme.

Gravity wave drag is still used at the operational resolution.

Surface: ISBA (Interaction Soil Biosphere Atmosphere) scheme is used.

4.3.2.2 Research performed in this field

Regarding the dynamical core, the non-hydrostatic kernel, foreseen for horizontal resolutions below 3km is being completed by the vertical finite element vertical discretization option;

Interaction of the horizontal diffusion parameterization with the model physics and problems of the multi-scale setup of the diffusion/dissipation scheme are under study;

Important original development of the radiation scheme has been completed in 2013, having in core the refitting of the gaseous transmission functions and new design of the intermittent algorithm. New original scheme is foreseen for high resolution models, allowing the interaction with cloudiness at every model time-step.

Another big important development is focused on turbulence and shallow convection, where new modular parameterization scheme was designed to incorporate latest theoretical advancements in this field.

#### 4.3.3 Operationally available NWP products

The raw and post-processed data outputs are produced every hour of the forecast on both the original Lambert-projection integration area (a 4.7 km mesh) and the transformed domains regular in the geographic coordinates with various resolutions. All standard variables are processed to pressure levels, PV levels, isentropic levels, height levels, screen level, completed by a set of specialised customised outputs (such as height of boundary layer, ventilation index, various computations of CAPE, CIN, moisture convergence, surface fluxes, etc).

Forecasted and diagnostic fields are provided in GRIB format and netCDF format. Number of special products for downstream hydrological and environmental applications is provided, as well as customized data forms for various end users and publishers (TV broadcast, on-line media servers, and smart phones’ applications).

#### 4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

*(MOS, PPM, KF, Expert Systems, etc..)*

4.3.4.2 Research performed in this field

#### 4.3.5 Ensemble Prediction System

4.3.5.1 In operation

 *(Describe also: time range, number of members and number of models used: their domain, resolution, number of levels, main physics used, for post-processing: calculation of indices, clustering)*

C.f. RC LACE ALADIN/LAEF System.

4.3.5.2 Research performed in this field

Calibration of the precipitation EPS forecast of ALADIN/LAEF.

#### 4.3.5.3 Operationally available EPS Products

Namely precipitation and screen temperature.

**4.4 Nowcasting and Very Short-range Forecasting Systems (0-12 hrs)**

**4.4.1 Nowcasting system**

4.4.1.1 In operation

*(Note: please also complete the CBS/PWS questionnaire on Nowcasting Systems and Services, 2013)*

COTREC – areal radar echo extrapolation up to 180 minutes.

CELLTRACK – convective cells are approximated by radar reflectivity cores. CELLTRACK tracks and extrapolates reflectivity cores up to 90 minutes.

INCA – temperature, wind and precipitation analyses available to the public. Precipitation extrapolation and combination with NWP is computed up to 6 hours with 10 minute time step. Temperature and wind forecast computed with 1 hour time step up to 12 hours.

JSWarnView – gives warning to the observers if precipiation, hail probability or lightning activity is higher than given threshold.

JSMeteoView – displays primarily radar data and also other data sources (satellite,lightning, station data), GIS features

HydroView – precipitation analyses and forecasts for defined catchments, gives warnings for individual catchments if precipitation sums are higher than given threshold.

FFG – Flash Flood Guidance – publicly available application. Issues warnings to the users based on crossing soil saturation and precipitation thresholds

4.4.1.2 Research performed in this field

NWC SAF – Satellite Application Facility on Support Nowcasting and Very Short Term Forecasting software package produces several kind of products – Cloud Products, Precipitation Products, Clear Air Products, Winds, Conceptual Model and Conception Products. Software runs automatically, its output isn’t currently used operationaly.

Two hydrological models are used for flash flood nowcasting in Brno regional office. Model HYDROG (also used in routine within the Flood Forecasting Service) and fuzzy logic based model. Both models are implemented for testing operation (HYDROG on 20 catchments and fuzzy model on 219 catchments). Final forecast is derived from a set of discharge forecasts based on various precipitation nowcasting input data.

CELLCOTREC – combination of CELLTRACK and COTREC extrapolation field

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

4.4.2.1 In operation

4.4.2.2 Research performed in this field

### 4.5 Specialized numerical predictions

[Specialized NP on sea waves, storm surge, sea ice, marine pollution transport and weathering, tropical cyclones, air pollution transport and dispersion, solar ultraviolet (UV) radiation, air quality forecasting, smoke, sand and dust, etc.]

MEDIA model: radioactive air pollutant dispersion model developed by Météo-France, is operated on an area covering the Czech Republic and surroundings using the meteorological fields forecast by ALADIN.

For information on a possible transport of air pollution from a more remote source, a simple trajectory model TRAJEK using the ECMWF deterministic forecast wind data is operated.

River catchment models AQUALOG and HYDROG, using real time observations and/or ALADIN precipitation and temperature forecast are run operationally to provide hydrological flood forecast.

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

4.5.1.1 In operation

4.5.1.2 Research performed in this field

Optimal interface between atmospheric and river catchment models;

Implementation of the chemistry model CAMx coupled with the ALADIN atmospheric model.

#### 4.5.2 Specific Models (as appropriate related to 4.5)

4.5.2.1 In operation

MEDIA – radioactive pollution;

TRAJEK – pollution trajectory;

AQUALOG, HYDROG – river catchment models

4.5.2.2 Research performed in this field

#### 4.5.3 Specific products operationally available

#### 4.5.4 Operational techniques for application of specialized numerical prediction products *(MOS, PPM, KF, Expert Systems, etc..)* (as appropriate related to 4.5)

4.5.4.1 In operation

“[brief description of automated (formalized) procedures in use for interpretation of specialized NP output]”

4.5.4.2 Research performed in this field

#### 4.5.5 Probabilistic predictions (where applicable)

4.5.5.1 In operation

“[Number of runs, initial state perturbation method etc.]” *(Describe also: time range, number of members and number of models used: their resolution, main physics used etc.)*

Probabilistic hydrological forecast based on ALADIN/LAEF.

4.5.5.2 Research performed in this field

#### 4.5.5.3 Operationally available probabilistic prediction products

“[brief description of variables which are outputs from probabilistic prediction techniques]”

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

#### 4.6.1 Models

4.6.1.1 In operation

4.6.1.2 Research performed in this field

#### 4.6.2 Operationally available NWP model and EPS ERF products

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

4.7.1 In operation

4.7.2 Research performed in this field

#### 4.7.2 Operationally available EPS LRF products

## 5. Verification of prognostic products

5.1

Verification of the ALADIN forecast is made operationally with respect to ground SYNOP measurements and radio-sounding measurements in the area of Central Europe. Conventional scores such as bias, root mean square error and standard deviation are computed for geopotential, temperature, wind and relative humidity (for upper air levels) and for temperature (also minimum and maximum), mean sea level pressure, wind, humidity, cloudiness, precipitation (6h) at screen level. Recent scores, they long term series, as well as their annual and trimestral gliding means are produced.

Besides, there are more elaborated verification tools for assessing quality of the quantified precipitation forecast, such as frequency bias, equitable thread score, fraction skill scores etc.

5.2 Research performed in this field

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

### 6.1 Development of the GDPFS

**6.1.1**

Implementation of the new algorithm of data assimilation;

Implementation of new turbulence, shallow convection and radiation scheme;

Prolongation of ALADIN forecast range up to 72 hours.

**6.1.2**

Switch to higher resolution of 2km, non-hydrostatic kernel, implementation of new data types in the data assimilation, implementation of new surface scheme.

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

“[Summary of planned research and development efforts in NWP, Nowcasting, LRF and Specialized Numerical Predictions for the next 4 years]”

**6.2.1** Planned Research Activities in NWP

Data assimilation:

- flow dependent structure functions for high resolution limited area models – search of computationally affordable algorithms;

- optimal selection of satellite channels, variational bias correction of satellite data, use of MODE-S data;

Model:

- non-hydrostatic dynamics – vertical finite elements, strong orographic forcing, interface to physics;

- microphysics – introduction of aerosols;

- cloud scheme – unification for radiation, microphysics, shallow and deep convection schemes, introduction of more memory;

- turbulence and shallow convection – moist turbulence, mixing length;

- radiation – enhancements to climate modelling use of the new scheme.

**6.2.2** Planned Research Activities in Nowcasting

Further development of the flash-flood warning system;

High frequency analysis.

**6.2.3** Planned Research Activities in Long-range Forecasting

**6.2.4** Planned Research Activities in Specialized Numerical Predictions

Optimal interface between atmospheric and river catchment models;

Implementation of the chemistry model CAMx coupled with the ALADIN atmospheric model.

Development of very high resolution air pollution modelling tools adapted to major cities and industrial plants.

## 7. References

 *(Indicate related Internet Web sites also)*

[www.chmi,cz](http://www.chmi,cz); [www.cnrm.meteo.fr/aladin](http://www.cnrm.meteo.fr/aladin); [www.rclace.eu](http://www.rclace.eu)