JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR *2016*

HUNGARIAN METEOROLOGICAL SERVICE, BUDAPEST

1. Summary of highlights

Both global (ECMWF, GFS) and limited area models (LAM: ALADIN, AROME, WRF) models are used in the forecasting practice. LAMs are run locally at the Hungarian Meteorological Service (OMSZ) on a IBM IDataPlex Linux cluster. ECMWF is used for medium range forecasts including its EPS component, ALADIN and AROME are used for short and very short range forecasts, including an EPS component of ALADIN and a research EPS component for AROME (without the capability of providing operational forecasts on a daily basis). A local 3DVAR data assimilation system is run operationally for both ALADIN and AROME. Radar data (radial wind and reflectivity) are experimentally assimilated in the AROME 3DVAR system. Besides data assimilation, local developments on the ALADIN and AROME model are done regarding physical parametrizations and ensemble prediction. The WRF model is used as a numerical weather prediction and a background data provider for the nowcasting system MEANDER. Observation and latent heat nudging methods are applied for data assimilation of surface data and radar reflectivity information. WRF uses both ECMWF and GFS analyses and forecast as first guess data.

2. Equipment in use

IBM iDataPlex Server with 280 Intel Xeon X5550 processors (4 core/proc), SGI Altix 3700 server with 200 Itanium2 processors (1,5 GHz processors), HP L3000 cluster server with 2x4 processors, HP RX7640 cluster server with 2x6 Itanium2 processors, SGI Altix 350 server with 16 Itanium2 processors; PC (Linux and Microsoft) workstations, EMC^2 CLARiiON CX4-480, CX-700 (backup) and IBM DS3400 disk storage systems (95 Tbyte native capacity), IBM FlashSystem 840 (2 Tbyte capacity), IBM 3584 LTO4 Ultrium 8/220 Tape Library (around 200 Tbyte capacity), 24 Linux/Unix servers (used for: Message Switching System, FTP, mail server, and other special meteorological purposes), 7 Windows servers, as well as CISCO routers and switches.

3. Data and Products from GTS in use

The daily statistics of bulletins:

- SYNOP (SM,SI,SN) - 4300
- SYNBUFR (ISM, ISI, ISM) - 8000
- TEMP (US,UK,UL,UE) – 1050
- TEMPBUFR (IUK, IUS) - 430
- METAR (SA) – 13500
- GRID (G) – 0
- GRIB (H) – 1036
- FAX (P,QGD) – 22
- PNG (PH,PT,PW,Q) - 782
- RADAR (PA) – 816
- Windprofiler (IUPD) – 11700
- AMDAR (IUAD, UD) - 3100

4. Forecasting system

4.1 System run schedule and forecast ranges

The ALADIN short range forecasting model is run on the IBM machine four times a day (at 00, 06, 12 and 18 UTC network times) providing 60h, 48h, 60h, 36h forecasts, respectively. Model runs are coupled with the ECMWF deterministic forecast with a 6h time lag, using Optimal Interpolation surface analysis and local 3D-VAR data assimilation for upper air. The AROME ultra-short range forecasting model receives its boundary conditions from the ECMWF model too, a 3 hourly 3DVAR data assimilation cycle provides its initial conditions for the upper air, and OI_main method is used for surface analysis. AROME runs are performed eight times a day (at 00, 03, 06, 09, 12, 15, 18 and 21 UTC network times), and is integrated for 48, 36, 48, 36, 48, 36, 48, 36 hours respectively. The 11 ALADIN LAMEPS members are computed using ECMWF's ENS initial and boundary conditions for 60 hours once a day at 18 UTC. The medium, extended and long range forecasts are provided on the basis of the ECMWF products.

WRF short range forecasting model runs four times a day (with 00, 06, 12, 18 UTC initial times) using ECMWF first guess and boundary conditions producing 48, 36, 48 and 48 h forecasts, respectively. WRF runs two times a day (with 00 and 12 UTC initial times) using GFS first guess and boundary conditions producing 48 h forecasts. There are special WRF runs (3-4 times a day, weather condition dependent) to provide first guess data for nowcasting system MEANDER.

MEANDER nowcasting system runs in every 10 minutes producing 3 hours linear forecast (nowcast).

The data processing and visualisation are performed using the in-house software HAWK3.

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 and GFS deterministic models and ensemble prediction system are operationally used. Meteorological fields are displayed on workstations by the HAWK3 visualisation software. Automatic forecast generation is carried out based on the outputs of the ECMWF model until 10 days. The products of the ensemble prediction system are clustered with a clustering algorithm targeted to the Carpathian Basin.

4.2.4.2 Research performed in this field
Potential improvements to the clustering method and potential for EPS calibration were investigated.

4.2.5 Ensemble Prediction System (EPS)

4.2.5.1 In operation
Locally none (see ECMWF and GFS)

4.2.5.2 Research performed in this field
EPS calibration using ECMWF's reforecast model climate data was investigated and calibration method has been operationally introduced.

4.2.5.3 Operationally available EPS Products

Individual members
Two-dimensional fields: mean sea level pressure, 10m wind speed and wind gusts, 2m temperature and relative humidity, convective and frontal precipitation (including snow), sunshine duration and solar radiation. Calibrated 2m temperature, precipitation and 10m wind speed are available for area of Hungary.

Three-dimensional fields: These fields are obtained on 5 pressure levels (on 1000, 925, 850, 700 and 500 hPa). The variables, covering all Europe are as follows: geopotential, temperature, wind field, relative humidity. In addition to standard pressure fields 91 model level fields are also available covering Carpathian-basin.

Wide range of locally developed products like EPS meteograms, EPS plumes probability of exceeding a given limit are available. Complementing standard ECMWF EPS products, local clustering is made, cluster means and representative members are provided. Ensemble vertical profiles based on full 91 model levels are also provided for the forecasters.

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 a 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 are as follows:

- Observations: SYNOP surface measurements (surface pressure, 2 metre temperature and relative humidity), TEMP upper air soundings (temperature, wind, geopotential, specific humidity), AMDAR aircraft reports (temperature, wind), ATOVS satellite observations (AMSU-A, AMSU-B, MHS radiances), MSG3/SATOB, MSG3/SEVIRI satellite observations.
- Assimilation cycle: 6 hours
- Analyses method: Optimal interpolation (CANARI) for the surface and three-dimensional variational data assimilation for upper air
- Analysed variables: soil temperature and moisture, temperature, humidity, wind components, surface pressure
- First guess: ALADIN 6h forecasts
- Initialisation: digital filter initialisation

An operational 3DVAR data assimilation system is also in place for the AROME model (at 2.5 km resolution with 60 vertical levels) for the region of the Carpathian-basin. The main characteristics of the data assimilation system are as follows:

- Observations: SYNOP surface measurements (surface pressure, 2 metre temperature and relative humidity), TEMP upper air soundings (temperature, wind, geopotential, specific humidity), AMDAR aircraft reports (temperature, wind)
- Assimilation cycle: 3 hours
- Analyses method: OI-main for the surface and three-dimensional variational data assimilation for upper air

- Analysed variables: soil temperature and moisture, temperature, humidity, wind components, surface pressure
- First guess: AROME 3h forecasts

Nudging techniques and tools for WRF applied for data assimilation of surface and upper air observations. Latent heat nudging techniques are used for radar reflectivity assimilation. Both methods serves WRF forecasts and nowcasting.

4.3.1.2 Research performed in this field

Continuous improvement of the operational data assimilation system in observation usage and background error modelling (ALADIN model). Development of the AROME data assimilation system will involve the use of satellite data (such as used in the ALADIN assimilation system but in higher resolution), of radar observations (radial wind and reflectivity) and of GNSS ZTD observations.

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 run 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 ALARO-0 physical parameterization package is used (radiation, microphysics, deep convection, boundary layer turbulence)

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 60, 48, 60, 36 hours, respectively;
- 360*320 points in horizontal and 49 vertical model levels,
- Approximately 8 km of horizontal resolution;
- Coupling to the ECMWF IFS global model at every 3 hours;
- Post-processed products every hour on 32 pressure and 9 height levels, high resolution (5km horizontal, 10 m vertical up to 500 m) dynamical adaptation of wind every 15 min.

The main characteristics of the operational **AROME** model are the following:

- Non-hydrostatic primitive equations;
- physics based on MesoNH
- 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;
- Domain covering the Carpathian Basin;
- Integration eight times a day (at 00, 03, 06, 09, 12, 15, 18 and 21 UTC network times for 48, 36, 48, 36, 48, 36, 48, 36 hours, respectively;
- 500*320 points in horizontal and 60 vertical model levels,

- Approximately 2.5 km of horizontal resolution;
- Coupling to the ECMWF model at every hour;
- Post-processed products every hour on 32 pressure and 12 height levels.

The operational WRF model is the version 3.6.1. of the Weather Research and Forecasting Model. The description of dynamics and parametrizations of the model can be found on page www.wrf-model.org.
In operative practice the following set is applied:

- Non-hydrostatic primitive equations
- Hybrid vertical coordinates.
- The partial differential equations are solved using semi-implicit time stepping followed by the 3rd-order Runge-Kutta finite difference method. Adaptive time step can be considered.
- NOAH Multiple Parametrization soil/surface scheme, Milbrandt-Yau time split, 2-moment microphysics scheme including 7 classes of hydrometeors (explicit hail calculation), local or nonlocal boundary layer schemes (YSU, Bougeault-Lacarrere) depending on actual weather conditions
- High order numerical diffusion scheme to avoid numerical instabilities.
- Boundary conditions are provided from hourly ECMWF/GFS data.
- Domain approximately: between 52° - 43° of latitude and 15° - 24° of longitude.
- The horizontal grid resolution is 2,5 km, the number of vertical levels is 37 between the surface and 50 hPa.
- Post-processed products are provided in the WRF core during the integration in order to reduce calculation cost. After the model run the results are immediately available every hour on 19 pressure and 8 vertical levels.

WRF model (WRF-BETA) has special settings for providing background data for nowcasting. This model has higher horizontal resolution (1.2x1.2 km) and using latent heat suppressing technique heavy convection – which is an undesirable noise for nowcasting first guess data – is switched off. WRF-BETA gets first guess from operational WRF data.

4.3.2.2 Research performed in this field

The model developments focus on the improvement of the AROME model. These cover the study of horizontal diffusion for convective cases, the development of various schemes for winter inversion cases and the improvement of the turbulence scheme for very high resolutions (dx <= 1 km).

4.3.3 Operationally available NWP products

Two-dimensional fields

- mean sea level and surface pressure,
- surface temperature
- convective (ALADIN) and frontal precipitation, including snow and graupel (AROME)
- cloudiness, including low, medium, high level and convective (ALADIN) clouds
- snow-water equivalent, snow depth (AROME)
- 10m wind and wind gust
- 2m temperature, 2m dew point temperature and 2m 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
- planetary boundary layer height (AROME)
- stability indices (K, SSI, etc.)

Three-dimensional fields

These fields are obtained on 9 height levels in the planetary boundary layer:

20, 100, 300, 500, 600, 750, 900, 1250, 1500 meters for ALADIN and
20, 50, 100, 250, 300, 500, 600, 750, 900, 1000, 1250, 1500 meters for AROME

and on 32 pressure levels:

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 for ALADIN and AROME

The 3D variables are as follows:

- pressure (only on height levels and only for ALADIN)
- temperature
- wind field
- relative humidity
- pseudo-potential temperature (only on pressure levels for AROME)
- cloud water and ice (AROME)
- rain, snow, graupel (AROME)
- geopotential (only on pressure levels),
- vertical velocity (only on pressure levels),
- divergence (only on pressure levels),
- potential temperature (only on pressure levels),
- potential vorticity (only on pressure levels)
- absolute vorticity (only on pressure levels)

Products available from WRF model (next to the ones mentioned above):

2D variables:
precipitation type (6 categories)
fraction of frozen precipitation
visibility

3D variables:
radar reflectivity (on pressure levels)

Pressure levels:
1000, 975, 950, 925, 900, 875, 850, 825, 800, 750, 700, 650, 600, 550, 500, 400, 300, 200, 150 hPa
Planetary boundary layer levels:
10, 20, 30, 50, 100, 150, 300, 600 m

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

Automated product (image, text, code) generation.

4.3.4.2 Research performed in this field

None

4.3.5 Ensemble Prediction System

4.3.5.1 In operation

The operational numerical weather prediction model ALADIN/HU is used in the LAMEPS, with the following main characteristics:

- Domain and resolution are identical to the deterministic ALADIN:
    - Domain is covering continental Europe
    - Approximately 8 km of horizontal resolution
    - 360*320 points in horizontal

    - 49 vertical levels
- 11 members
- Coupling in every 3 hours to the first 11 members of the 18UTC run of ECMWF's ENS
- Integration is started at 18 UTC for 60 hours
- ALARO-0 physics is used as in deterministic ALADIN

4.3.5.2 Research performed in this field

- Research about initial condition perturbations:
    - Perturbation generation with perturbed observation in an ensemble data assimilation cycle (EDA method);
    - Model error representation with stochastically perturbed parameterized tendencies (SPPT method)
- Experiments with an AROME EPS at 2.5 km resolution. This involves the representation initial uncertainties (downscaling of the PEARP or ECMWF's ENS Singular Vector + Ensemble Data Assimilation) and the model errors (SPPT: Stochastically Perturbed Parametrization Tendencies)

4.3.5.3 Operationally available EPS Products

- Individual members can be visualized for the next parameters:

Near surface fields: mean sea level pressure, 2m temperature and relative humidity, convective and frontal precipitation (including snow), 10m wind speed and wind gust, cloudiness (total, convective and three levels)
Pressure level fields: These fields are obtained on 8 pressure levels (on 1000, 925, 850, 700, 500, 300, 200, 100 hPa). The variables are as follows: geopotential, temperature, wind field, relative humidity.

- EPS mean values for the same parameters than at individual members
- Probabilities with different thresholds for the following parameters: 2 meter temperature, precipitation, wind speed, wind gust.
- Plume diagrams for the bigger Hungarian cities with the following parameters: 2 meter temperature, 10 meter wind speed, precipitation, 850hPa temperature, 500hPa geopotential

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

4.4.1 Nowcasting system (MEANDER-WRF 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. The system has two main parts: a non linear dynamical and a linear extrapolation part.

The non linear segment is based on the WRF model. The first segment of the WRF model runs on a domain that covers the Carpathian basin and produces +36 hours forecast every six hours. This segment (named WRF-ALPHA) uses ECMWF data for boundary conditions. The second segments of the WRF model (WRF-BETA) runs in every hour and uses nudging technique of the model. The 3D nudging procedure applies hourly surface observations and radar reflectivity and WRF-ALPHA data as first guess. The length of the nudging term is 2 hours. The WRF-BETA provides 3 hours forecast with 15 minutes time resolution for the linear nowcasting segment.

The linear nowcasting segment is the MEANDER system which runs every 15 minutes and produces nowcasting and warnings for the next 3 hours. The MEANDER system applies actual surface observations, radar and satellite data and WRF-BETA outputs. The MEANDER makes its own objective analysis every 15 minutes and the basic parameters (like wind, temperature, humidity, etc) are smoothed in such a way that at the beginning of the 3 hours period the analysis and at the end the WRF-BETA calculated forecast are considered. In this way instead of extrapolation, the interpolation is applied for the basic parameters. 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 nowcasting system issues weather warnings for all regions of Hungary.

4.4.1.1 In operation

(1) MEANDER system: The present version of MEANDER has been in operative usage since July of 2010. The system issues objective analysis and 3 hours forecast in every 15th minutes. Using predicted (nowcasted) parameters MEANDER systems provides special warnings for wind gusts (70 km/h- 90 km/h), hail storms, torrential precipitations and flash floods.

(2) See very short range above (AROME)

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 forecast.. The nowcasting system is planned to recognize and warn for squall lines, supercells or MCC. The main issue is to connect radar based linear forecast with non-hydrostatic numerical forecast.

4.4.2 Models for Very Short-range Forecasting Systems

Outputs of ECMWF deterministic model support first guess and boundary conditions for local models WRF-ALPHA. WRF-ALPHA non-hydrostatic model produces 36 hours forecast (4 times a day). WRF-BETA non-hydrostatic model uses outputs of WRF-ALPHA model and produces 6 hours forecast (in every hour) for the nowcasting system. The WRF-BETA assimilates radar reflectivity and surface observation using nudging method. The linear prediction system MEANDER provides 3 hours nowcasting in every 10 minutes using WRF-BETA outputs, radar, satellite and surface observations.

4.4.2.1 In operation

(1) See 4.4.2. above.

(2) See very short range above (AROME)

4.4.2.2 Research performed in this field

(1) Research activity is focusing to forecast severe convective phenomena like supercells and torrential rain and flash flood cases. The linear nowcasting system is planned to recognize and warn for squall lines, supercells or MCC. The main issue is to approach the linear forecast (based on advection) to non-hydrostatic numerical forecast.

(2) See very short range above (AROME)

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, air quality, dispersion modelling and wind power estimation.

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
Development of an input emission database for the CHIMERE chemistry-transport model for the area of Budapest based on yearly emission reporting and traffic count data.

4.5.2 Specific Models

4.5.2.1 In operation
FLEXTRA 4.0 trajectory model, FLEXPART 8.0 Lagrangian particle dispersion modell, CHIMERE chemistry-transport model for 24-48 air quality forecasts over Budapest, AERMOD regulatory model for case studies

4.5.2.2 Research performed in this field
Developing the CHIMERE model for air quality forecasts over Hungary

4.5.3 Specific products operationally available

Concentration and deposition fields

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

Research on the calibration of seasonal forecasts.

4.7.2 Operationally available EPS LRF products

None

5. Verification of prognostic products

ALADIN/HU, ALADIN-EPS, AROME/HU, ECMWF, GFS-HR3, FOCUS and WRF products (from 00 UTC runs except ALADIN-EPS where the 18 UTC runs of the previous day are in use) are verified and compared operationally computing simple statistical measures (BIAS and RMSE) using all of the SYNOP observations in Hungary under 400 m above sea level and all of the TEMP observations inside the domain of the AROME/HU via the comprehensive verification system (OVISYS: Objective Verification Interactive SYStem). The automatically generated forecasts are also verified and compared to the forecasts issued by the forecasters. Comprehensive verification made at OMSZ is annually available on ECMWF web: https://www.ecmwf.int/en/about/who-we-are/governance/tac

5.1 Annual verification summary

TYPE	TS	SCORES	PARAMETERS	AGAINST

Time-T x: time; y: score (moving average: 1 month)	12, 24	RMSE, BIAS	T2m RHU2, N, Wind10Sp, WindGust, MSLP	SYNOP
Time-T x: time; y: score (moving average: 1 month)	18	RMSE, BIAS	TMax12h	SYNOP
Time-T x: time; y: score (moving average: 1 month)	30	RMSE, BIAS	TMax24h, TMin12h, TMin24h	SYNOP
Time-TS x: imestep; y: score	0 – 48/60 (every 3 hours)	RMSE, BIAS	T2m, TMax3h, TMin3h, RHU2, N, Wind10Sp, WindGust, MSLP	SYNOP
Time-TS x: timestep; y: score	0 – 48/60 (every 12 hours)	RMSE, BIAS	H500, RHU700, T850	TEMP
Threshold x: threshold; y: score	30 (24 hour cumulated precipitation between 06-06 UTC)	Frequency BIAS, POD, FAR, PSS, EDS, SEDS, EDI, SEDI	R (Precip24h)	SYNOP

5.2 Research performed in this field
SEDS, EDI, SEDI for rare binary events; SAL (for precipitation and also for cloud cover); Performance (Roebber-Wilson) diagram; Taylor-diagram; EPS verification in OVISYS (Rank Histogram, Brier Score, etc.)

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

6.1 Development of the GDPFS

6.1.1 Major changes expected within the next year
The high resolution (2.5 km) NWP model AROME is run operationally in spin up mode since 2010 for a domain covering the Carpathian-basin. A data assimilation system (3DVAR for the upper air and OI for the surface) has been implemented operationally in March 2013. Radar data assimilation experiments are ongoing and we expect an operational implementation by the end of 2016. Next to radar data, assimilation of high resolution satellite winds (HRW) and GNSS Zenith Total Delay are also in progress and we expect an operational implementation by the end of 2016. Physical parameterizations of the AROME model are due to be developed for a better prediction of low cloud and convective situations. The lower resolution (dx=8km) ALADIN operational EPS system is to be extended with an ensemble data assimilation component, and PEARP ensemble LBCs are planned to be replaced with ECMWF ensemble LBCs.

6.1.2 Major changes expected within the next 4 years
The above three directions for development will remain. Sensitivity studies with AROME on 1 km resolution are ongoing as well as research on very high resolution EPS using a small size (5-10 members) AROME ensemble system.

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

6.2.1 Planned Research Activities in NWP
The following research activities are planned concerning the AROME model: i) radar, GNSS, and high resolution satellite assimilation; ii) improvements on the cloud physics and turbulence (convection and low stratus situations); iii) very high resolution small size (5-10 members) EPS with the AROME model accounting for the uncertainties in the initial conditions and in physical parameterizations.

6.2.2 Planned Research Activities in Nowcasting
Some efforts have been made for object oriented severe weather nowcasting using high performance radar data (dual polarization and Doppler wind). Special objective analysis is planned to develop for describing mezo-beta scale weather phenomena.

6.2.3 Planned Research Activities in Long-range Forecasting
None

6.2.4 Planned Research Activities in Specialized Numerical Predictions
None

7. Consortium

7.1 System and/or model
OMSZ is a member of the ALADIN and LACE consortia, which develops the ALADIN, ALARO and AROME models (these 3 models own the same dynamical core and similar data assimilation systems but differ a lot in physical parameterizations and are aimed for different spatial scales).

7.1.1 In operations
At OMSZ the ALARO and AROME models are used in operations (see section 4.3)

7.1.2 Research performed in this field
See section 6.1.1.

7.2 System run schedule and forecast ranges
See section 4.3.2.

7.3 List of countries participating in the Consortium
Algeria, Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Hungary, Morocco, Poland, Portugal, Romania, Slovakia, Slovenia, Tunisia, Turkey

7.4 Data assimilation, objective analysis and initialization
Both the ALADIN/ALARO and AROME models use local data assimilation systems (the latter is under development), namely an upper air 3DVAR and an OI surface assimilation scheme (see section 4.3.1 for more details).

7.5 Operationally available NWP products
See section 4.3.3.

7.6 Verification of prognostic products
See section 5.

7.7 Plans for the future
See section 6.

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