ALADIN Numerical Weather Prediction Project

NWP at the Hungarian Meteorological Service

Hungarian Meteorological Service

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY35T1
- Initial conditions: local analysis (atmospheric: 3dVar, surface: OI)
- Four production runs a day: 00 UTC (54h); 06 UTC (48h); 12 UTC (48h); 18 UTC (36h)
- Lateral Boundary conditions from the ECMWF/IFS global model

Assimilation settings

- 6 hour assimilation cycle
- Short cut-off analysis for the production runs
- Downscaled Ensemble background error covariances
- Digital filter initialisation
- LBC coupling at every 3 hours

Model geometry

- 8 km horizontal resolution (349*309 points)
- 49 vertical model levels
- Linear spectral truncation
- Lambert projection

Forecast settings

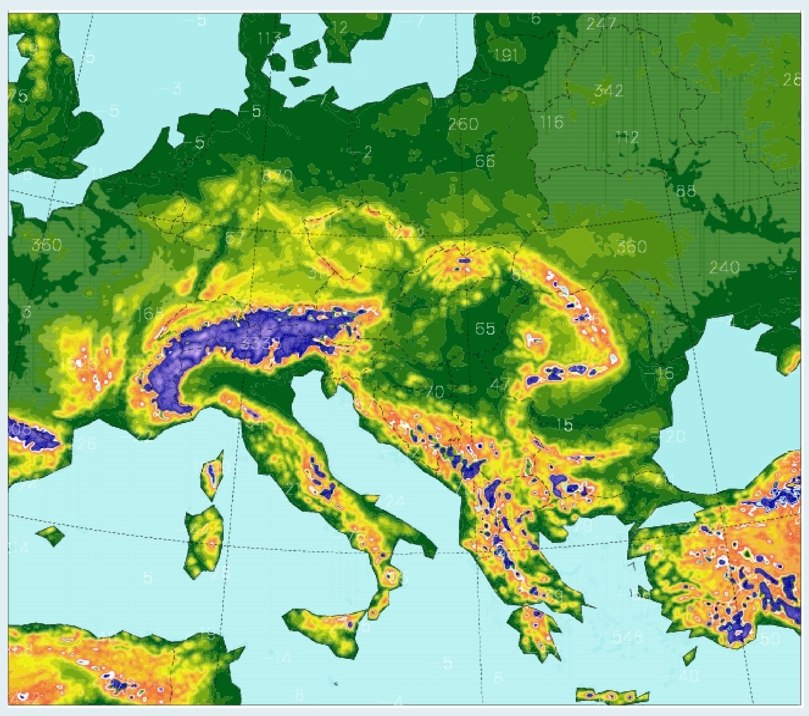
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

Operational suite / technical aspects

- Transfer ECMWF/IFS LBC files from ECMWF via RMDCN, ARPEGE LBC files (as backup) from Météo France (Toulouse) via Internet and ECMWF re-routing.
- Model integration on 32 processors
- 3D-VAR and Canari/OI on 48 processors
- Post-processing
- Continuous monitoring supported by a web based system

The computer system

- IBM iDATAPLEX Linux cluster
- CPU: 500 Intel Xeon processors (2,6 Ghz)
- 1.5 Tbyte internal memory
- Torque job scheduler



The ALADIN/HU model domain and orography

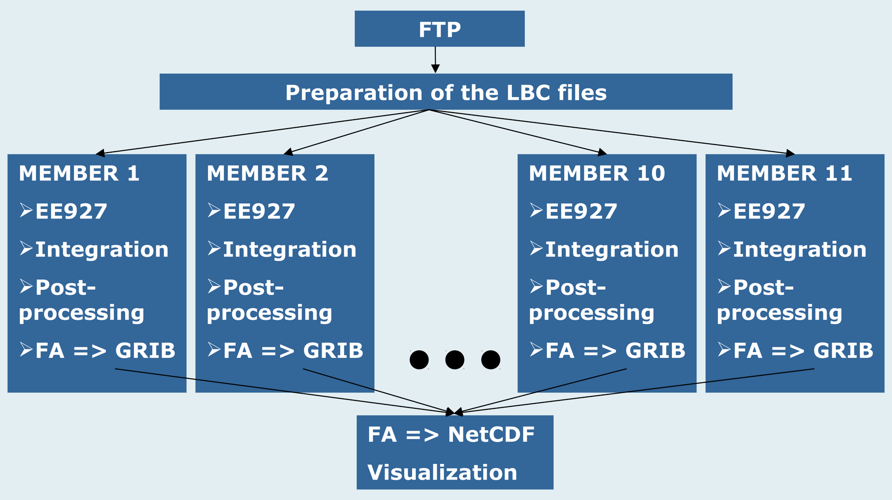
Observation usage

- Maintenance and use of the OPLACE system (Operational Preprocessing for LACE)
- SYNOP (T, Rh, Z)
- SHIP (T, Rh, Z, u, v)
- TEMP (T, u, v, q)
- ATOVS/AMSU-A (radiances from NOAA 16, 18) with 80 km thinning distance
- ATOVS/AMSU-B (radiances from NOAA 16, 17 and 18) with 80 km thinning distance
- METEOSAT-9/SEVIRI radiances (Water Vapor channels only)
- AMDAR (T, u, v) with 25 km thinning distance and 3 hour time-window,
- Variational Bias Correction for radiances
- AMV (GEOWIND) data (u, v)
- Wind Profiler data (u, v)
- Web-based observation monitoring system

Operational ALADIN ensemble system

The main characteristics of the operational short-range limited area ensemble prediction system of HMS is listed below.

- The system is based on the ALADIN limited area model and has 11 members.
- For the time being we perform a simple downscaling, no local perturbations are generated.
- The initial and lateral boundary conditions are provided by the global ARPEGE ensemble system (PEARP3.0).
- LBCs are coupled in every 6 hours
- The LAMEPS is running once a day, starting from the 18 UTC analysis, up to 60 hours.
- The horizontal resolution is 8 km, the number of vertical levels is 49 (hybrid coordinates).
- The forecast process starts every day from cron at 23:50 UTC and finishes around 03:00 UTC.



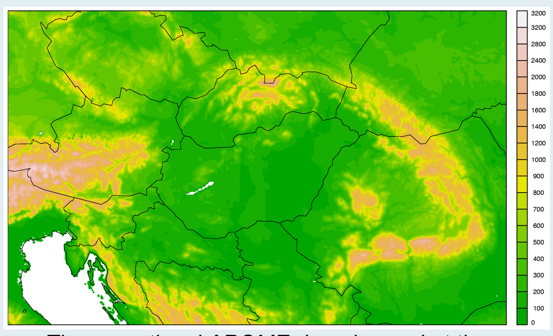
Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY35T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Four production runs a day: 00 UTC (48h); 06 UTC (36h); 12 UTC (48h); 18 UTC (36h)
- Initial conditions: from ALADIN/HU
- Lateral Boundary conditions from ALADIN/HU with 1h coupling frequency
- To calculate the screen level fields we use the SBL scheme over nature and sea

We are running the AROME model over Hungary on daily basis since November 2009 (since December 2010 operationally). The model performance is evaluated regularly by our NWP group and the forecasters group. Moreover it is compared with other available models (ALADIN, ECMWF).



The operational AROME domain used at the Hungarian Meteorological Service.

As a general conclusion, our experience is that the AROME model gives the best temperature and cloudiness forecasts. Based on the SAL verification (not shown here) it also captures the size of the precipitation objects very well. However, it tends to overestimate precipitation maximum and wind gusts in strong convective cells (see also the SLHD tuning on right panel)

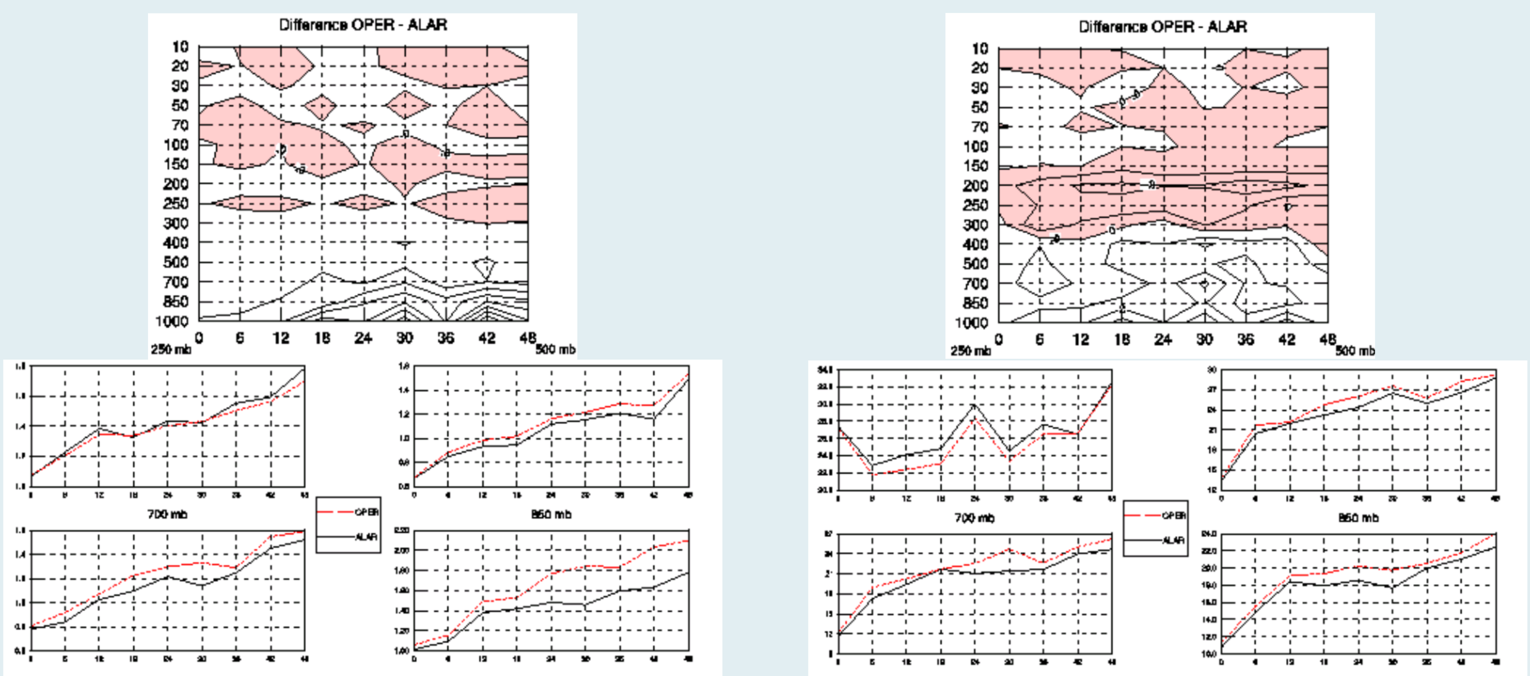
Operational usage of ALARO

ALARO physics had been tested for a long time at HMS before its operational introduction which was last autumn for the LAMEPS and this spring for the 'deterministic' system. The newest developments entering CY36T1 related to ALARO physics were backphased to our operational library CY35T1 based on the experiences of the Czech ALADIN team. The envelope orography was changed to mean orography to allow the application of the new gravity wave drag scheme.

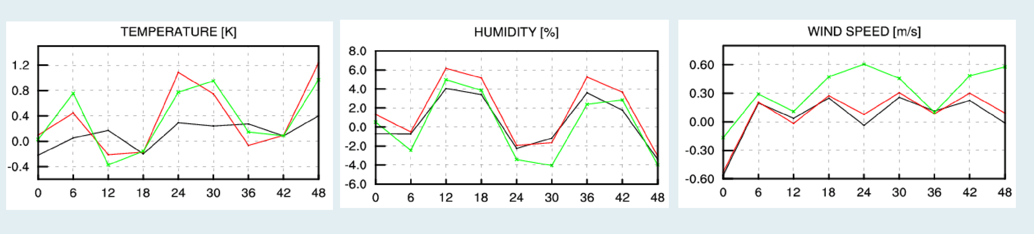
The first experiments with ALARO either with dynamical adaptation or with data assimilation gave very good results in high-atmosphere (see the comparison which was done for the following period: 07th December 2010 – 31st December 2010). Despite all the positive impact we had experienced on the pressure levels there were some obvious problems with the near-surface fields and the cloudiness which make us postpone the operational introduction while doing some further investigation.

The above mentioned investigation aimed two different topics:
• Modifications in screen level diagnostics: A Richardson-number dependent formulation was introduced for the calculation of a_h during the screen level diagnostics which had an impact on 2 meter temperature and relative humidity. For the better performance of the new formulation the surface heat capacity was increased which resulted some small changes in other fields.
• Modifications in Xu-Randall cloudiness parametrization related namelist settings. The main goal was to develop the model in such cases when the forecast of 100% cloudiness were failed.

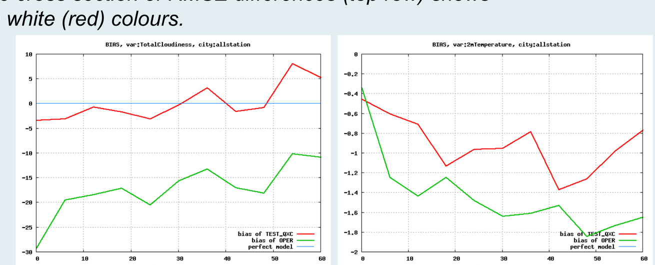
These changes helped to eliminate the most problematic cases we had found in ALARO experiments and they resulted slight improvements in comparison with our ex-operational (ALADIN based) system. After the operational introduction furthers investigation are planned.



Verification against TEMP data (RMSE) averaged over the whole model domain (Veral package). Left: temperature, Right: relative humidity. Black solid line: ALARO physics, Red dashed line: operational ALADIN/HU physics. The cross section of RMSE differences (top row) shows improvements (degradations) using ALARO physics in white (red) colours.



Verification against SYNOP data (BIAS) averaged over Hungary (Veral package). Left: temperature, Middle: relative humidity, Right: wind speed. Black solid line: ALARO physics with Geleyn scheme in screen level diagnostics, Red line: ALARO physics with new Ri-dependent scheme, Green line: operational ALADIN/HU physics. The examined period: 07th December 2010 – 31st December 2010 .

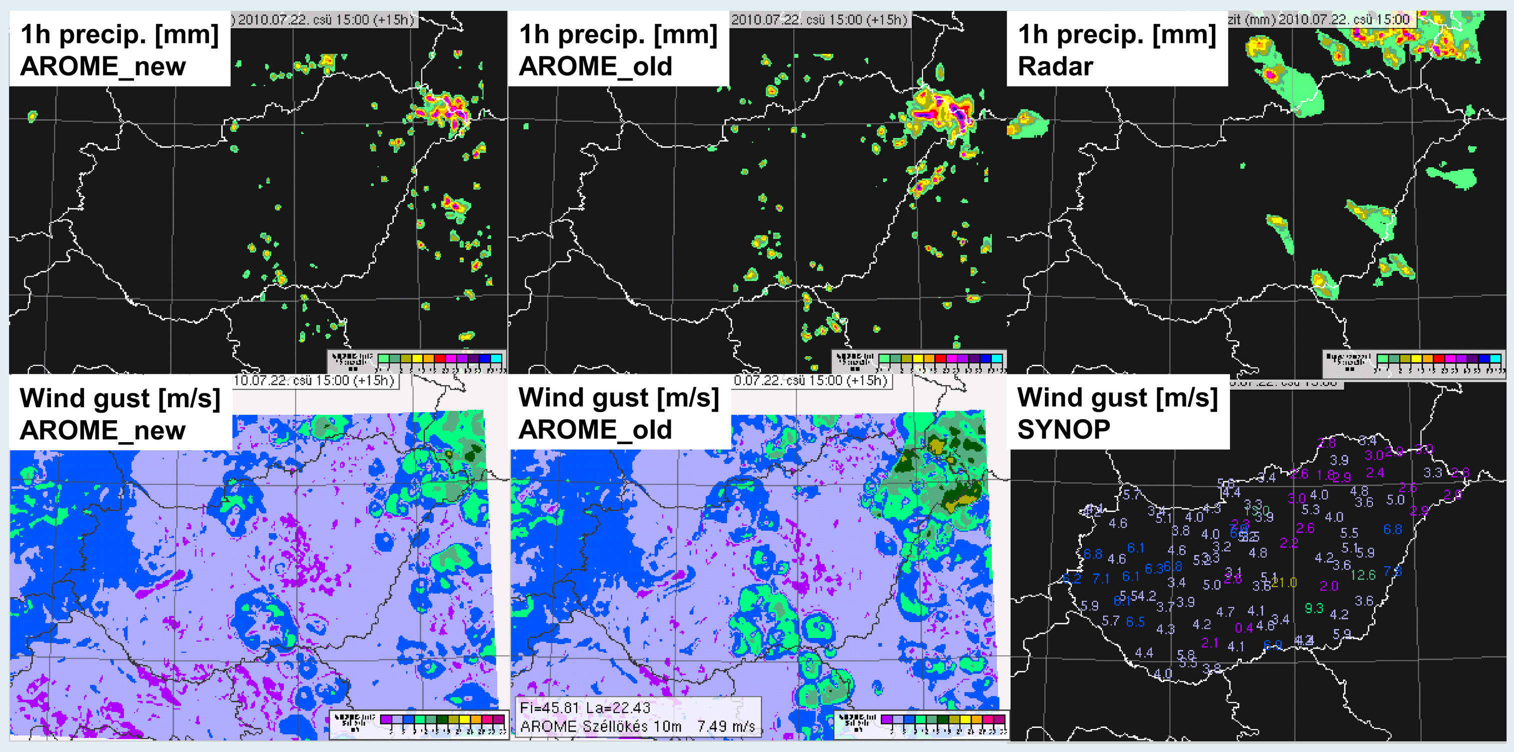


Verification against SYNOP data (BIAS) averaged over Hungary. Left: cloudiness, Right: temperature. Green solid line: ALARO physics with original cloudiness parametrization settings, Red line: ALARO with modified cloudiness parametrization settings. The examined period: 01th January 2012 – 21st January 2012.

Impact of horizontal diffusion in AROME

As the default configuration in AROME, the non-linear, flow dependent Semi-Lagrangian horizontal diffusion (SLHD) is applied to all (falling and non-falling) hydrometeors. However, experience shows that AROME tends to overestimate precipitation maximum and wind gusts in strong convective cells. It was assumed that changes in the horizontal diffusion scheme might have a beneficial impact on these problems. Following the work of Bengtsson et al. (2012), SLHD was applied to all dynamical fields (temperature, wind, water vapour), but not to falling hydrometeors („AROME_new" experiment). Additionally, the supporting spectral diffusion was switched off below 100 hPa. These new settings are operational at the Hungarian Meteorological Service since July 2011.

In the following, a case study for the 22nd July 2010 is presented. On this day the weather situation over Hungary was characterized by an anticyclone. In the early afternoon light to medium strength showers were observed over central Hungary which developed into heavy thunderstorms in the evening over the eastern part of the country. The application of the new SLHD settings reduces both the maximum precipitation and the wind gusts associated with convective cells.



Forecasted precipitation and wind gusts of the two AROME experiments and measurements for 22nd July 2010 at 15 UTC (+15 h forecasts).

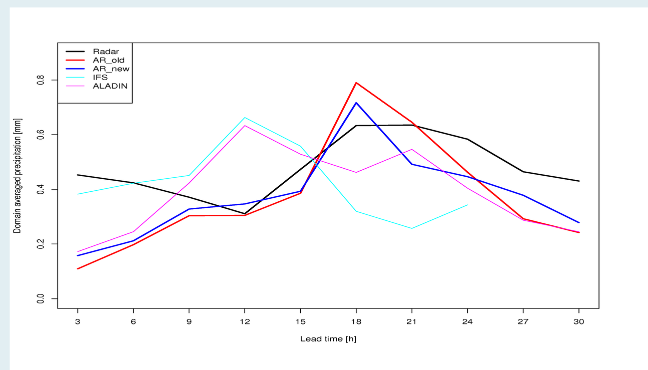
	Max. temperature		Precipitation		Wind speed		Wind gusts		Cloud cover	
Experiment	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE
AROME...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	Min. temperature		Precipitation		Wind speed		Wind gusts		Cloud cover	
Experiment	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE
AROME_new	1.1	1.7	-0.6	3.69	0.9	1.2	0.4	2.38	0.2	1.18
AROME_old	1	1.55	-0.5	3.69	0.9	1.21	1	2.54	0.4	1.15

Verification scores for the one-month period for daytime (from 06 to 18 UTC, upper panel) and night time (from 18 to 06 UTC, lower panel).

Next to the case studies a longer period, between 17th July 2010 and 17th August 2010, has also been investigated with objective scores (panels on the right). In this verification method model fields and observations were first upscaled to 13 larger regions covering Hungary. The SLHD modification slightly deteriorates temperature, has neutral impact on precipitation and wind speed, and significantly improves the wind gust forecasts.

An important characteristic in forecasting heavy precipitation events is the ability of the NWP model in forecasting the timing of convection. For the one-month period the simulated diurnal cycle of precipitation was compared to radar measurements. Models with a parameterized deep convection (ECMWF/IFS, ALADIN) initiate convection too early. The AROME model with resolved deep convection performs much better in this respect. The AROME run with default SLHD settings overestimates the precipitation peak in the late afternoon. The experiment with new SLHD settings corrects this overestimation, however, precipitation is now underestimated during the night.

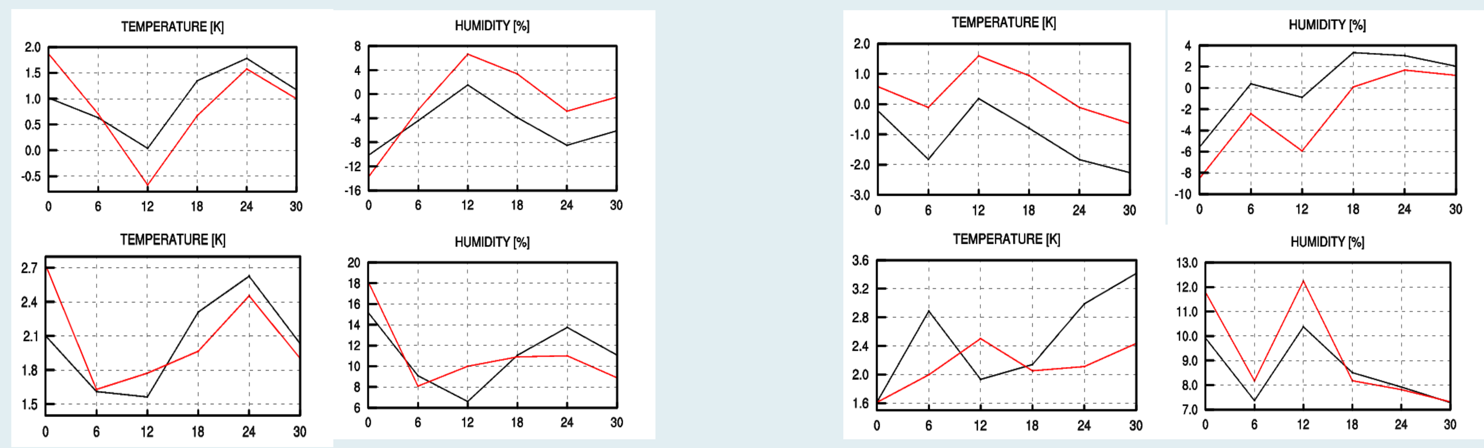


Observed and predicted diurnal cycle of precipitation for the one-month prediod (domain averaged precipitation).

AROME Data Assimilation Activities

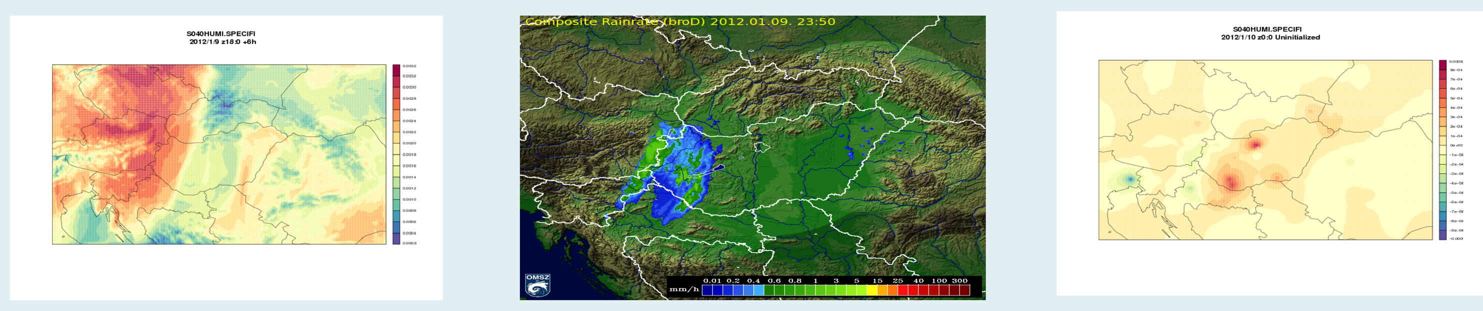
Several Data Assimilation(DA) activities, studies were investigated at HMS with AROME model to estimate and improve mesoscale information. Our aim is that the recent operational double nested AROME forecasts should be changed in the future to a system which directly coupled by ECMWF with a full DA suite. To start building this DA system surface assimilation OI_main scheme, computation of AROME background error statistics, estimating efficiency of RADAR observations and constructing DA cycle settings were tested.

The experiments of OI_main surface assimilation were run to a winter and two summer period with model cy35t1 and OI_main offline version (SURFEX v6.0). For this surface assimilation tests we still have been using the double nested AROME system, because we wanted to check the skill of the method for the summer periods when stronger 2m temperature bias observed in the operational AROME forecasts. The results of the experiments were compared with the operational scores (3h coupling) with Veral verification.



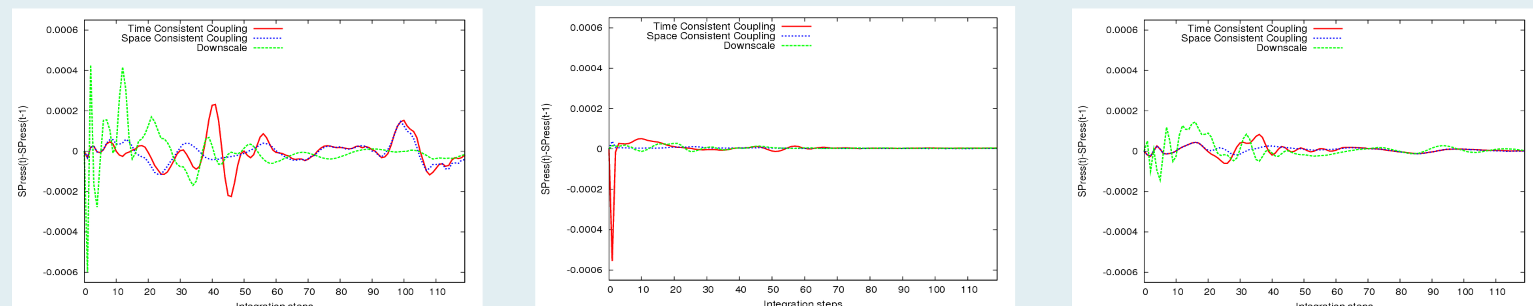
Verification against SYNOP data averaged over the whole model domain (Veral package). Black solid line: AROME/HU+OIMAIN, Red dashed line: operational AROME/HU. Left Block: 2011 Summer Period Right Block: 2010 Winter Period; Top row: BIAS, Bottom row: RMSE

Assimilation of RADAR reflectivity and wind has also been tested with Hungarian RADAR observations through case studies. A case 10th January 2012 was a frontal precipitation event which not so much captured by the model. The precipitation band in the AROME model was in a little delay at the initial times and AROME 3DVAR tested to improve the humidity fields. The reflectivity of RADAR measurement could help to localize the humidity in this case when the analysis increment gave positive impact to the eastern region of the frontal zone (figure below). The conventional observations (SYNOP;TEMP; AMDAR; AMV) were also assimilated in this experiment.



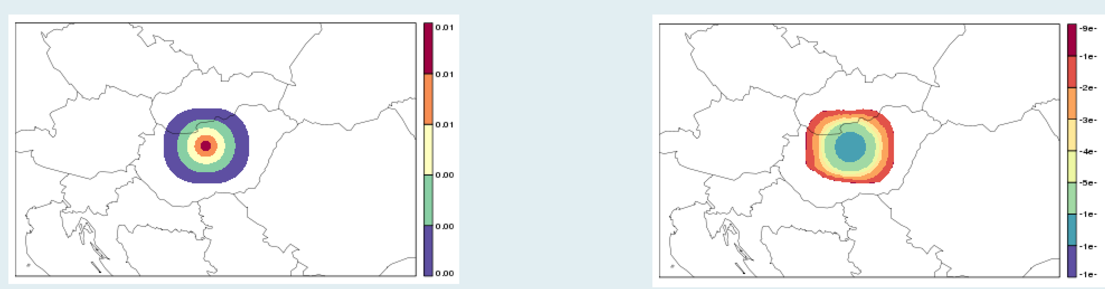
AROME RADAR assimilation case study 10th January 2012: Left figure - AROME First guess humidity field. MiddleFigure – Composite RADAR image. Right Figure: AROME RADAR analysis – guess

The operational AROME-Hungary is running without any initialization procedure and we made a test to verify the spurious noises which possibly appear at the very beginning of the integration. Two type of initial coupling and the operational downscaling were compared. At first the time consistent coupling was investigated where the imbalances between the analysis and zeroth LBC caused strong waves starting from the boundaries and closing towards the center. The test of the dynamical downscaling have produced spurious waves evolving from the orography. The space consistent coupling initially means that the analysis is used as the zeroth LBC as well and in that case the noises are decreased adequately at the borders and the orography as well.



AROME surface pressure tendency at different domain gridpoints: Green line – Dynamical Downscaling; Red line – Time Consistent Coupling; Blue Line – Space Consistent Coupling. Left figure -Mountain Gridpoint MiddleFigure – Boundary Gridpoint Right Figure: Gridpoint at the domain center

Hungarian AROME background error statistics were computed from downscaled ALADIN LAM Ensemble Data Assimilation approach. To make sure of statistics and balance a single observations experiment was created. In humidity increments(right figure below) a small anisotrophy structure is visible which perhaps in connection with the orography. A temperature observation was assimilated around 500hPa and model cycle 36t1 was used.



AROME Single Observation Experiment: 3DVAR analysis – First Guess. Left Figure: Temperature at model level 22; Right Figure: Humidity at model level 22.

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