ALADIN Numerical Weather
Prediction Project

NWP at the Hungarian Meteorological Service

Hungarian
Meteorological
Service

Gergely Bölöni, László Kullmann, Máté Mile, Roger Randriamampianina, Roland Steib, Mihály Szűcs, András Csáki, Balázs Szintai

(boloni.g@met.hu)

Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY35T1 (ALARO physics)
- 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

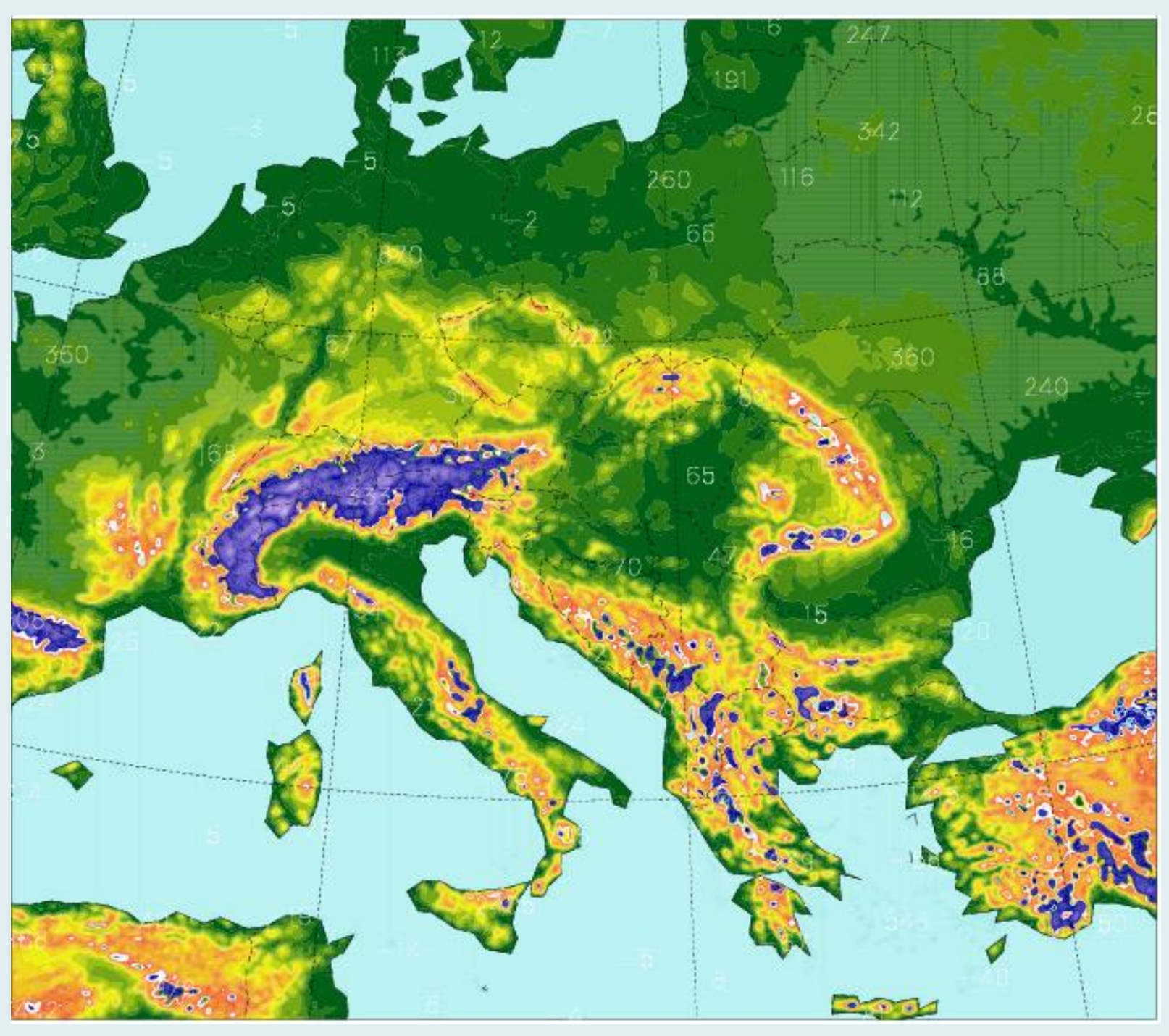
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

Operational suite / technical aspects

- Transfer ECMWF/IFS LBC files from ECMWF via Internet, 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

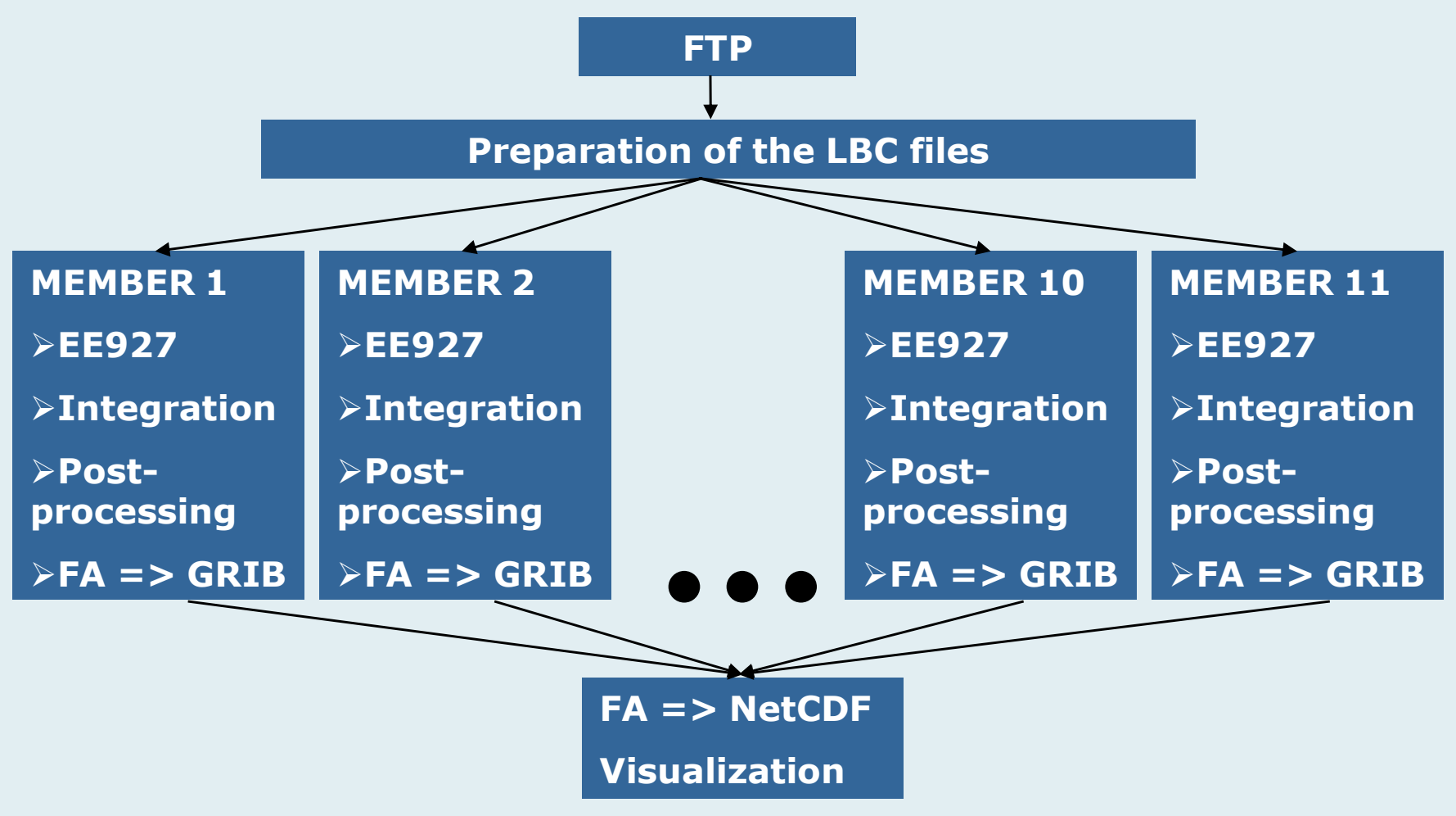
Observation usage

- 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.



FTP

Preparation of the LBC files

MEMBER 1	MEMBER 2	MEMBER 10	MEMBER 11
➢EE927	➢EE927	➢EE927	➢EE927
➢Integration	➢Integration	➢Integration	➢Integration
➢Post-processing	➢Post-processing	➢Post-processing	➢Post-processing
➢FA => GRIB	➢FA => GRIB	➢FA => GRIB	➢FA => GRIB

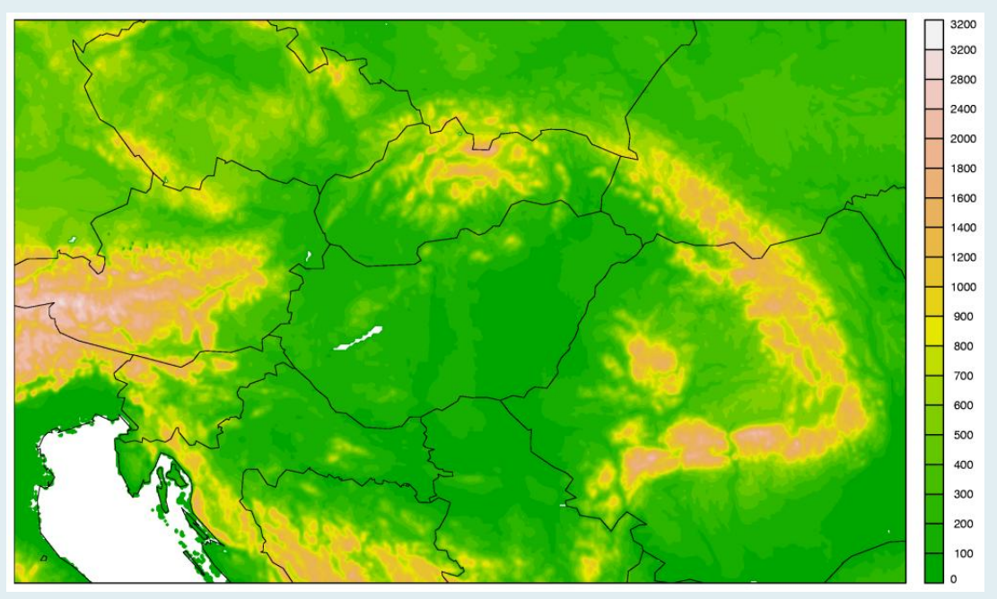
FA => NetCDF
Visualization

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: CY36T1
- 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: 3DVAR (upper air), interpolated ALADIN surface analysis
- 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



The operational AROME domain used at the Hungarian Meteorological Service.

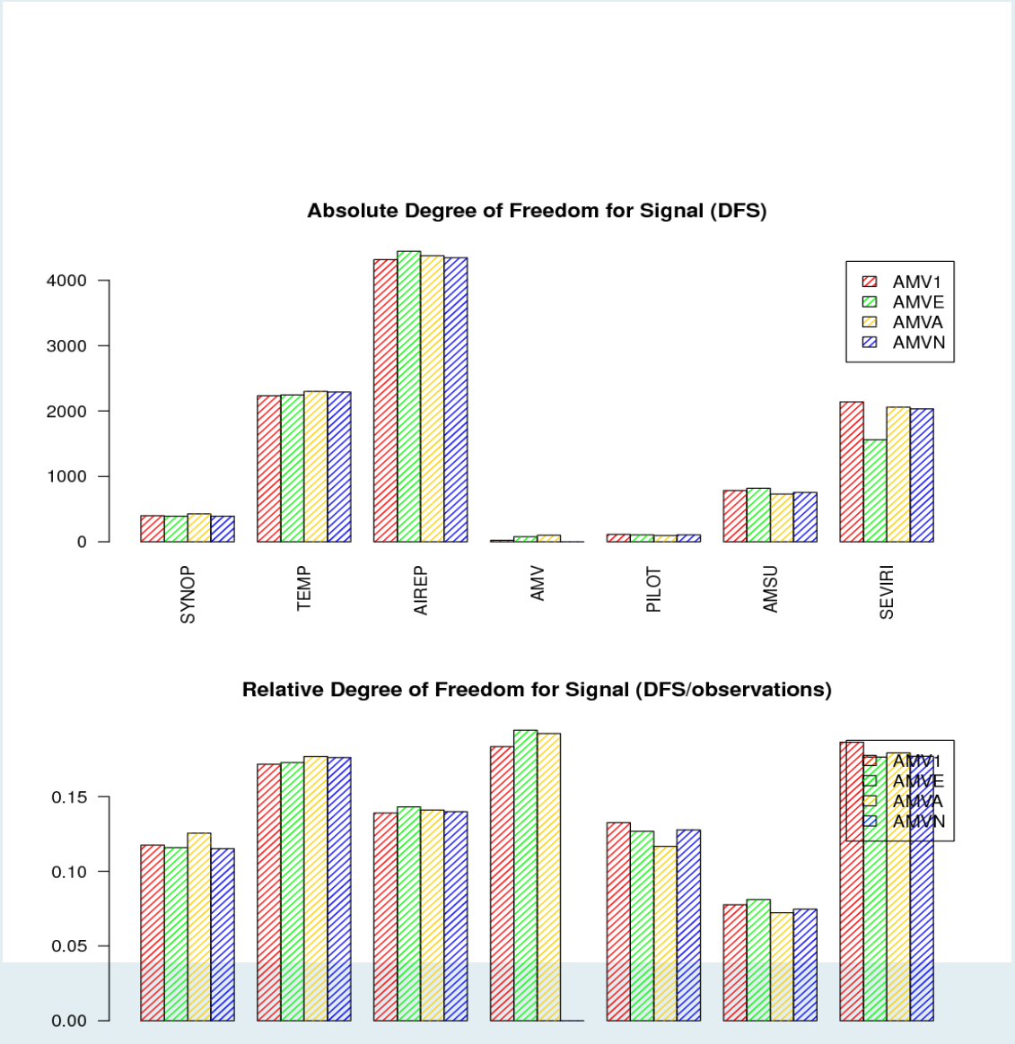
We are running the AROME model over Hungary on daily basis since November 2009 (since December 2010 operationally and since March 2013 with local 3DVAR data assimilation). The model performance is evaluated regularly by our NWP group and the forecasters group. Moreover it is compared with other available models (ALADIN, ECMWF).

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)

Data Assimilation Activities

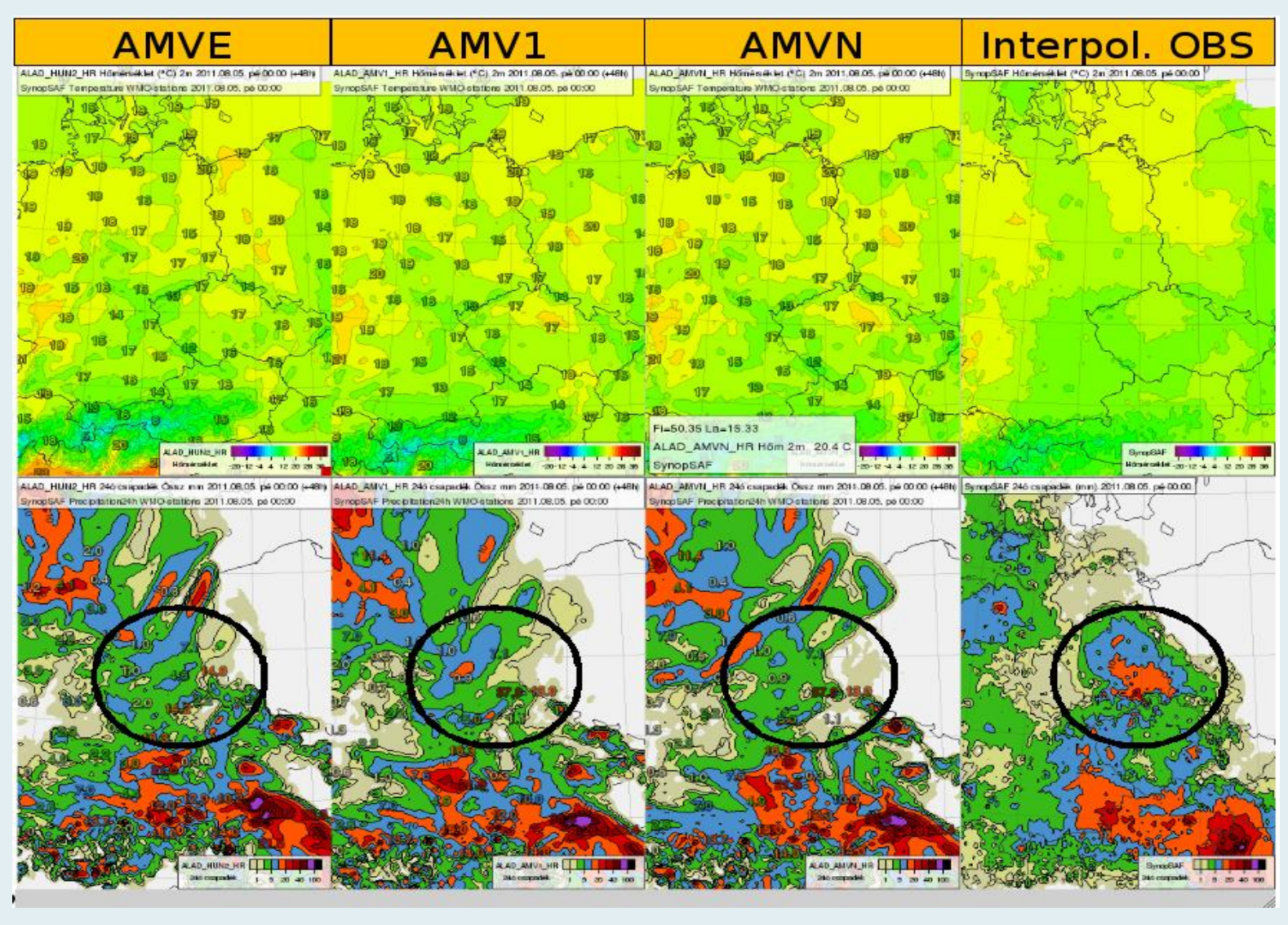
AROME
Since the 27th March 2013 a local 3DVAR data assimilation system has been introduced operationally for the AROME model. See the presentations of Máté Mile and Roger Randriamampianina.

ALADIN
The impact of the AMV data (both the –locally retrieved - HRW and of those received through the EUMETCast and used in the operational analysis system) was assessed trough data-denial experiments for the period between 15th of July till 20th of August 2011, accounting the first four days as warming the data assimilation system. Our aim was to evaluate the impact of the new HRW AMV (exp. AMV1) and to compare with the operational (exp. AMVE where GEOWIND included) assimilation sets. The impact of the AMV data on the analyses was evaluated through the computation of the Degrees of Freedom for Signals (DFS) of each observation in the system. The results of the DFS computation indicated a high relative importance of AMV data in the ALADIN Hungary limited-area model operational assimilation system (left figure below). The high importance of AMV data is also visible in different case studies, e.g. at 7th of August 2011 when a high precipitation event occured and the HRW AMV observations could improve the capture of the precipitation.



Absolute DFS on the top and Relative on the bottom.

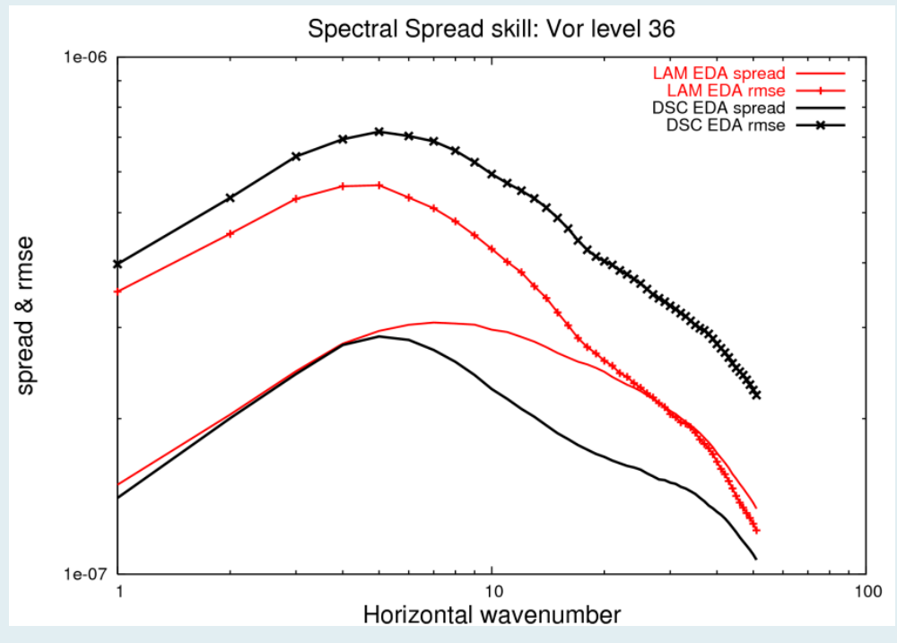
AMV1 – ALADIN with HRW AMV; AMVE – ALADIN with GEOWIND; AMVN – ALADIN without AMV and AMVA ALADIN with HRW and GEOWIND AMV



Case Study at 7th of August 2011.

AMV1 – ALADIN with HRW AMV; AMVE – ALADIN with GEOWIND; AMVN – ALADIN without AMV and Interpolated observations

For the simulation of background errors the Ensemble Data Assimilation technique has been applied in the Hungarian version of the ALADIN model. This consist of running an ensemble (5 members) of LAM assimilation cycles implied by random perturbation of input observations. This error simulation technique was compared with the (presently operational) downscaling of a global EDA system in terms of spectral diagnostics and in terms of assimilation and forecast experiments. The figure on the right shows the spread-skill relationship in spectral space for the LAM EDA (red) and the downscaled EDA (DSC EDA) experiments (black). Note that the RMSE was computed against 3DVAR-VARPACK diagnostic analyses, that is to gridded fields being close to the observations. It is sensible that the LAM EDA experiment improves the spread-skill relationship especially at the small scales (by both reducing the RMSE and increasing the spread).



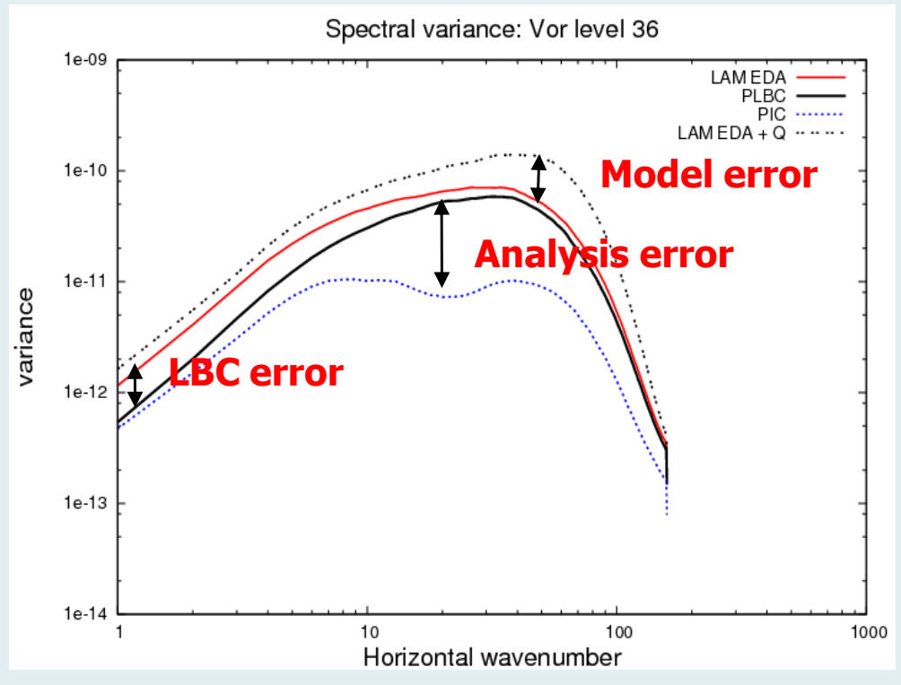
Using the combination of the LAM EDA error simulation technique and the multi-physics approach the contribution of analysis, LBC and model errors to the full background error have been studied.

$$\varepsilon_b = \mathbf{M}\boldsymbol{\varepsilon}_a + \varepsilon_M$$

LBC error **Analysis error** **Model error**

The separation of background error components has been achieved by running LAM EDA:
- assessment of pure LBC errors: „perfect” model and initial conditions (only LBCs are perturbed)
- assessment of pure analysis errors: „perfect” model and LBCs (only the analysis is perturbed)
- assassment of model (physics) errors: using ALARO physics in the control member while perturbed members use „old ALADIN” physics.

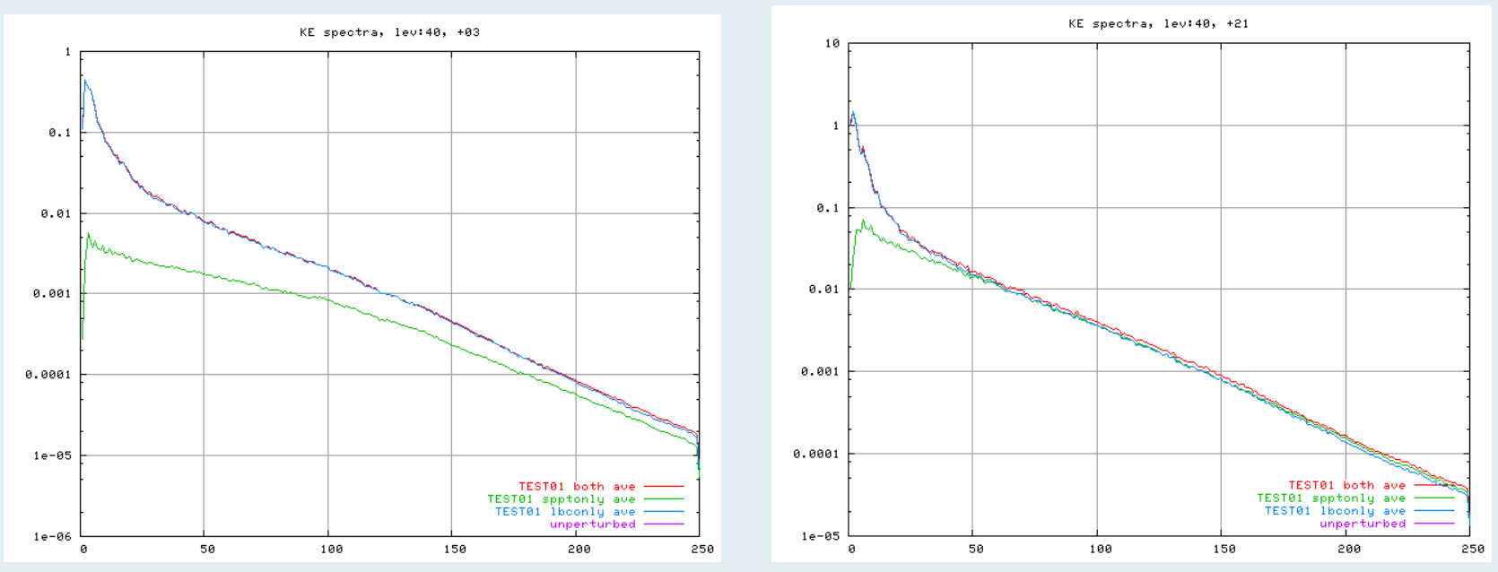
Results: model (physics) errors are the most important on the smallest scales, analysis errors have a large contribution over intermediate scales, LBC errors have some contribution at large scales



Examination of SPPT scheme and different coupling strategies in AROME-EPS

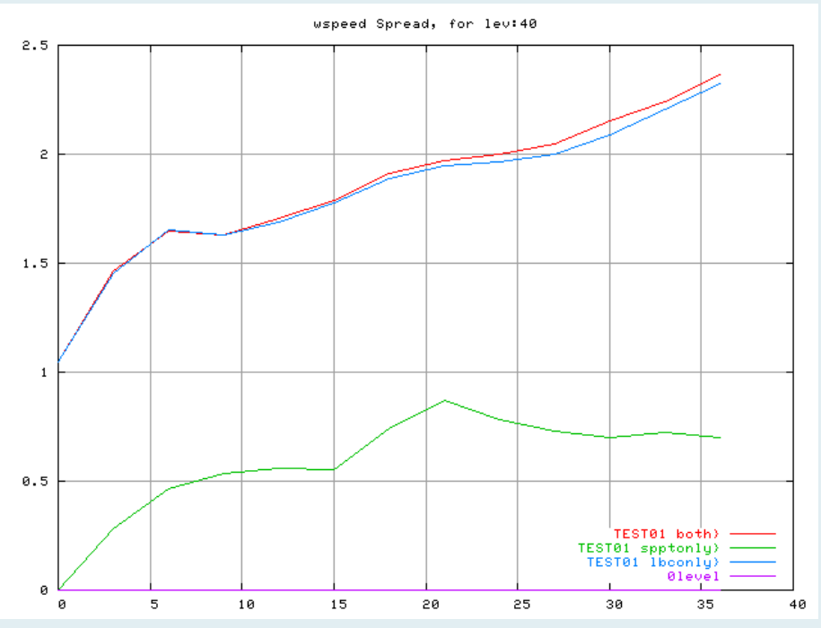
Hungarian Meteorological Service is a participant of an ECMWF special project called ‘Continental winter weather prediction with the AROME ensemble prediction system’. Our long-term goal in this project is to develop a high-resolution EPS which can correctly estimate the uncertainty of the forecasts especially in such weather situations which are frequently problematic for forecasters in Hungary. Low clouds and fog are typically from these weather types in the Carpathian Basin but heavy snowfall and strong wind events are also in the focus of our interest.

The first technical tests aimed to implement a „French” AROME-EPS configuration to the Hungarian domain (identical with the operational one) and to couple it to ARPEGE EPS (PEARP). LAM version of Stochastically Perturbed Physics Tendencies (SPPT) scheme was introduced to the AROME which was used through the model integration. Three tests were compared at the first sensitivity studies, each of them contained 11 ensemble members. Integrations run for +36 hours:
-’lbconly’: Each member was a simple downscaling of a PEARP member with the same number. No SPPT was activated.
-’spptonly’: Each member was coupled to the PEARP control member and SPPT was activated to perturb the tendencies.
-’both’: Each member was coupled to a various PEARP member and SPPT was also activated.



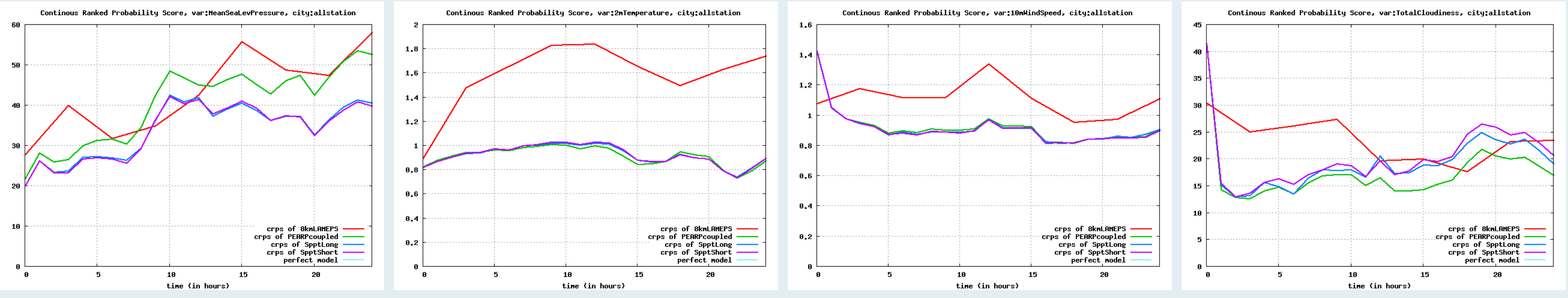
Kinetic energy spectra of the perturbations for the three various test versions at +3hours (left side) and at +21hours (right side)

After the above-described preliminar results a longer test-period was defined and used for additional tests. This period went from 26th of December 2011 to 8th of January 2012 which is a winter period when ECMWF EPS BCs are also available for tests and it is planned to do that in the near future. On such a two-week long period the aim of examinations was to compare the operational Hungarian LAMEPS (which has 8km horizontal resolution and uses ALARO physics) with the following AROME-EPS configurations:
- ‘PEARPcoupled’: Each member was a simple downscaling of a PEARP member with the same number. No SPPT was activated.
- ‘SpptLong’: Each member was a simple downscaling of a PEARP member with the same number. SPPT was activated with a longer horizontal correlation length scale.
- ‘SpptShort’: The same than the previous one but with a shorter horizontal correlation length scale.
All experimental system contained 11 members and model integrations were started at 00UTC and run for +24 hours.



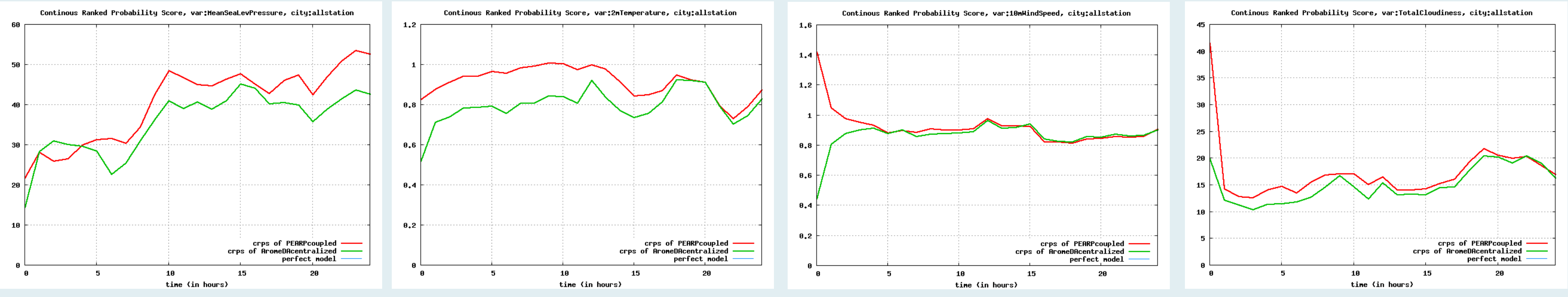
The time evolution of the spread of the 40th level wind speed for the three various test EPS.

The conclusion can be summarized in three main points:
1. Comparison of AROME-EPS and operational 8kmLAMEPS:
- AROME-EPS is in almost all scores clearly better for almost the whole forecast period.
- Cloud is an exception because in the second part of the forecast period AROME-EPS and 8kmLAMEPS have similar performance.
- In some aspects the first 3-hour period is problematic to AROME-EPS (it is especially true in the case of cloudiness). It gave an obvious motivation to the following test, where perturbations were centralized around initial conditions coming from a local AROME data assimilation system and where hydrometeor initialization was also introduced to the system.
2. Comparison of simple downscaling with the SPPT tuned versions:
- SPPT makes a clear improvement in mean sea level pressure scores (decreasing positive BIAS).
- SPPT makes a clear degradation in cloud scores (decreasing negative BIAS and CRPS; RMSE increasing more than the SPREAD).
- SPPT makes just really slight differences in the performance of other variables.
3. Comparison of the two different SPPT tuned tests:
- There is no real big differences between ‘SpptLong’ and ‘SpptShort’. The system does not look too sensitive to the correlation lengths scale.



The time evolution of the CRPS of the operational 8kmLAMEPS (red) and the experimental PEARPcoupled (green), SpptLong (blue), SpptShort (purple) configurations. The parameters from left to right: mean sea level pressure, 2meter temperature, 10meter wind speed, total cloudiness.

The above-mentioned results motivated an additional development, which used the Hungarian AROME data assimilation system (operational since end of March this year). In an experimental setup AROME DA was coupled to PEARP control between 12th of December 2011 and 8th of January 2012. Perturbations which were downscaled from PEARP could be added to ICs generated in the data assimilation system. In this way the whole system contained the downscaled PEARP perturbations centralized around initial conditions from AROME data assimilation system.
The results showed the clear benefit of this configuration. Some technical tuning is still needed but it is believed that such a coupling strategy can be a skilful and feasible way if an AROME EDA system is not available.

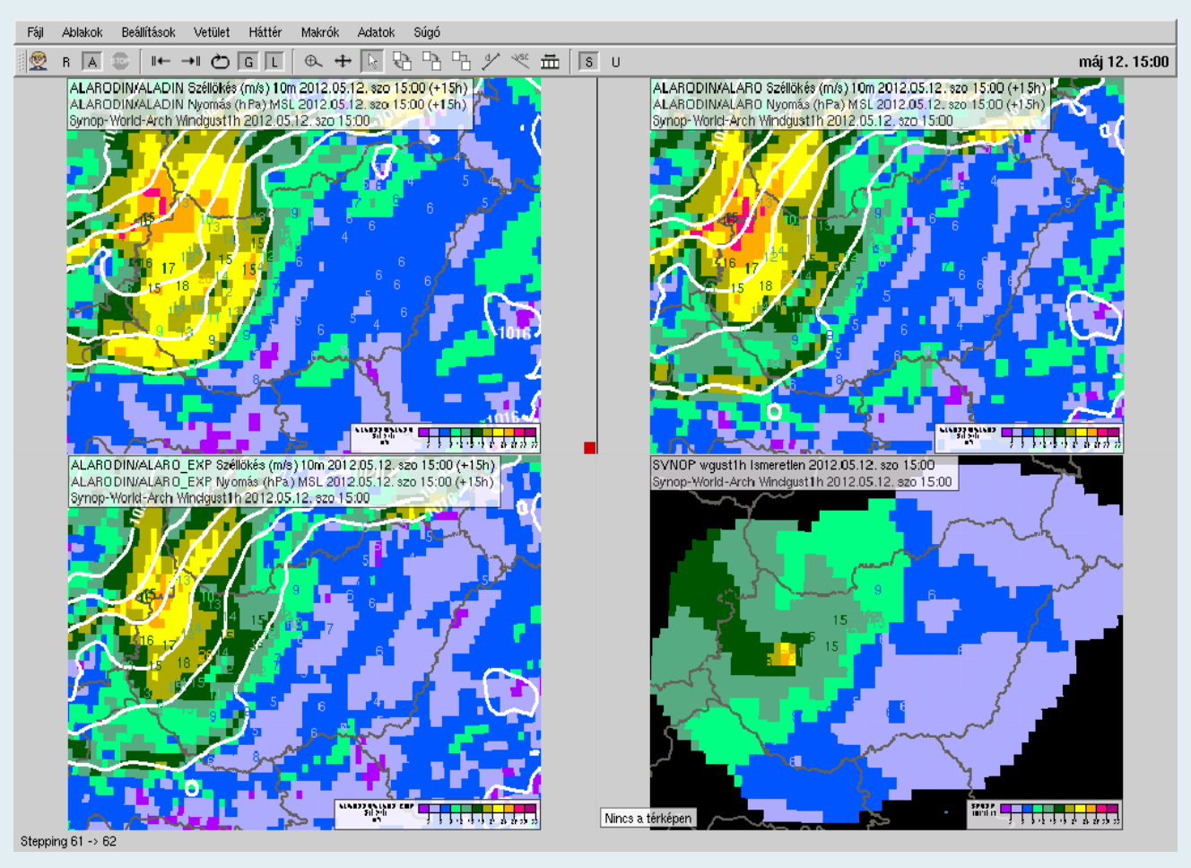


The time evolution of the CRPS of the experimental PEARPcoupled (red) and AromeDAcentralized (green) configurations. The parameters from left to right: mean sea level pressure, 2meter temperature, 10meter wind speed, total cloudiness.

We plan further work in the framework of this ECMWF’s special project. The downscaling of the experimental high-resolution ECMWF EPS is going to be an important test in the near future. Interesting winter situations are also in the focus and detailed case studies are needed to deeper understand the behave of the high-resolution EPS and the impact of SPPT scheme with different settings.

Wind gust settings in ALARO

ALARO physics was introduced in November, 2011 in LAMEPS and in March, 2012 in the so called deterministic system (both of them runs at 8km resolution). After some months of operational application, forecasters summarized their experiences and underlined the wind gust overestimation as a main problem after the physics upgrade. The overestimation was especially strong in post-frontal situations. It was decided to manage the problem simply through namelist settings modification. The so called FACRAF variable was decreased from 15 to 12 which moderated the wind gusts by 10-25% (depending on the weather situation).



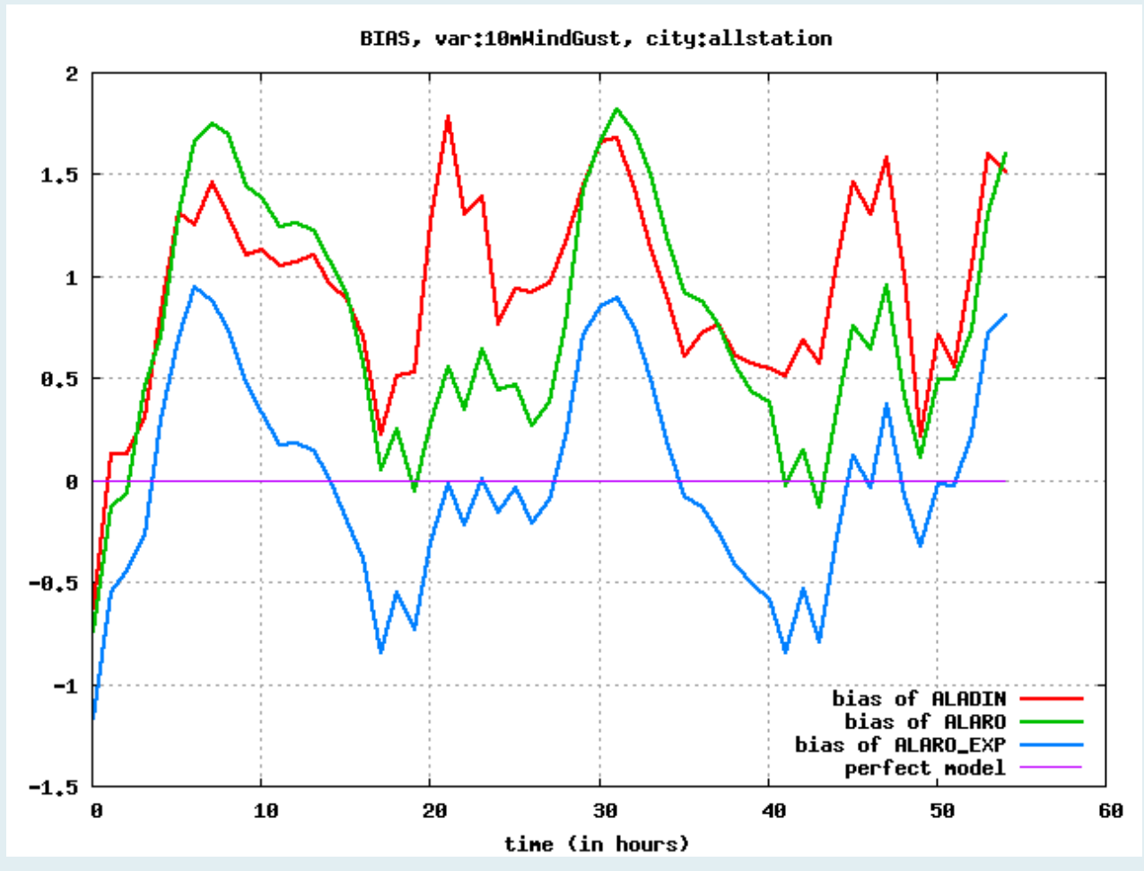
ALARODIN/ALADIN Széllökés (m/s) 10m 2012.05.12. szo 15:00 (+15h)
ALARODIN/ALADIN Nyomás (hPa) MSL 2012.05.12. szo 15:00 (+15h)
Synop-World-Arch Windgust1h 2012.05.12. szo 15:00

ALARODIN/ALARO Széllökés (m/s) 10m 2012.05.12. szo 15:00 (+15h)
ALARODIN/ALARO Nyomás (hPa) MSL 2012.05.12. szo 15:00 (+15h)
Synop-World-Arch Windgust1h 2012.05.12. szo 15:00

ALARODIN/ALARO_EXP Széllökés (m/s) 10m 2012.05.12. szo 15:00 (+15h)
ALARODIN/ALARO_EXP Nyomás (hPa) MSL 2012.05.12. szo 15:00 (+15h)
Synop-World-Arch Windgust1h 2012.05.12. szo 15:00

SYNOP vgust1h Ismeretlen 2012.05.12. szo 15:00
Synop-World-Arch Windgust1h 2012.05.12. szo 15:00

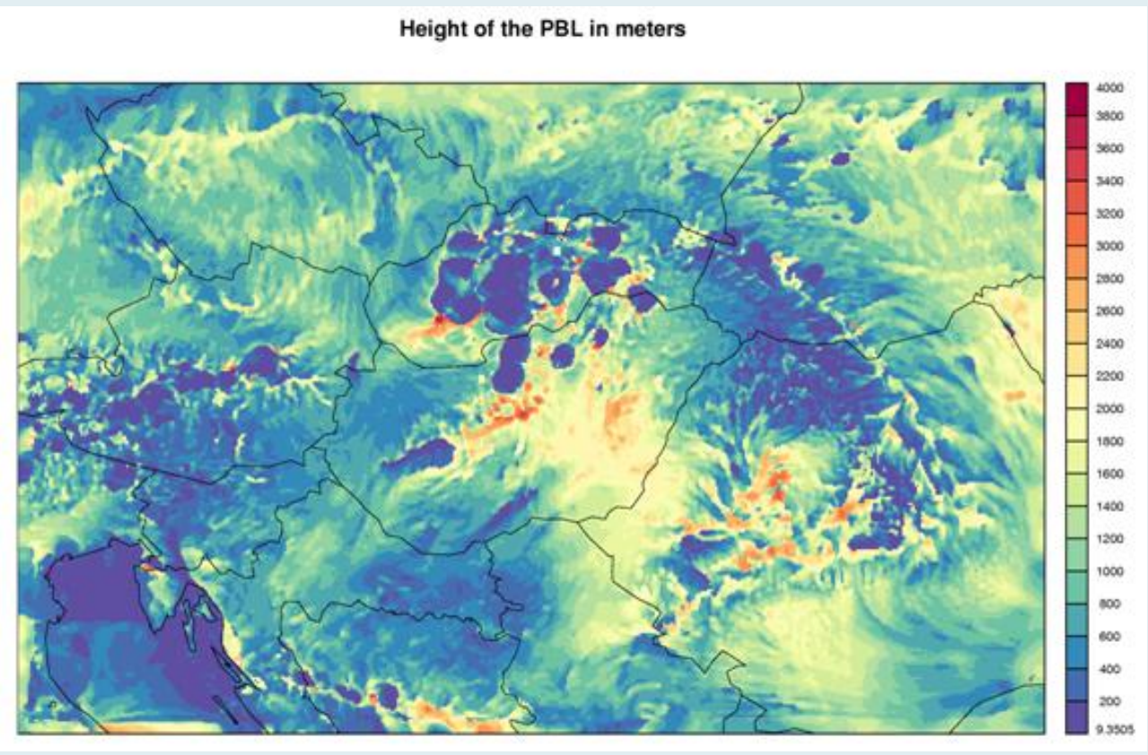
Strong wind gust values behind a massive cold front on 12th of May 2012. Old ALADIN settings (top left), original ALARO settings with FACRAF=10 (top right), new ALARO settings with FACRAF=12 (bottom left) and observations (bottom right)



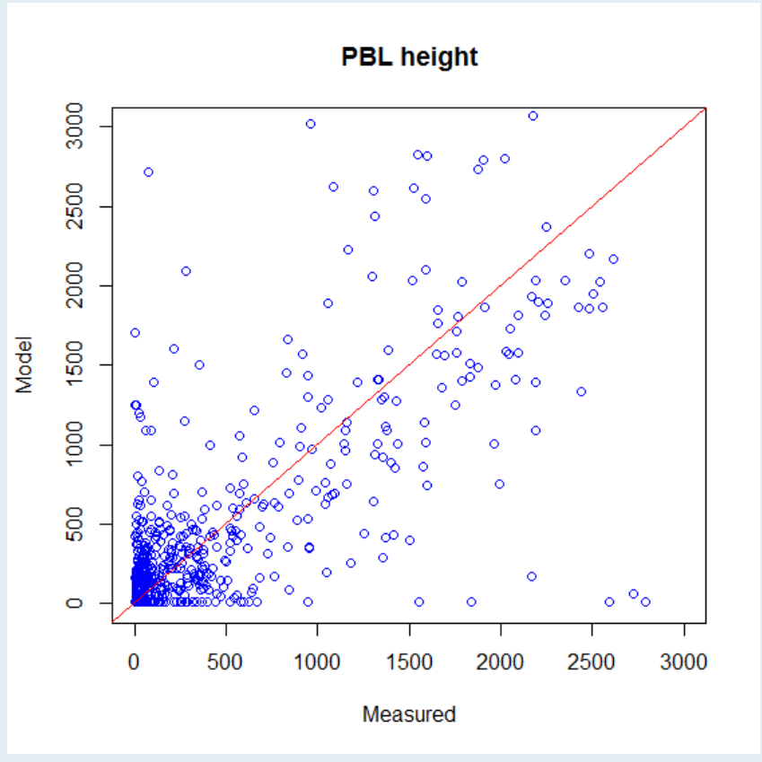
BIAS values based on a one month (June, 2012) verification. Old ALADIN settings (red), original ALARO settings with FACRAF=15 (green), new ALARO settings with FACRAF=12 (blues)

Determining the height of the planetary boundary layer with the AROME model

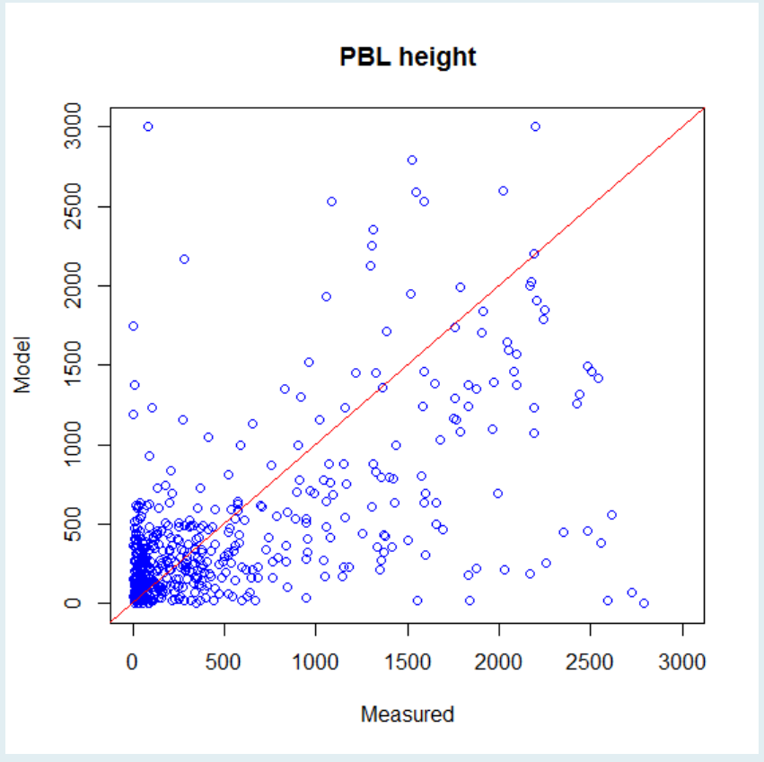
The height of the planetary boundary layer (PBL) is a very important input parameter for dispersion and chemistry transport models, thus there is a high need to estimate it with NWP models. In this experiment two options for the PBL height were compared: one is calculated from the moment flux (MF) profile, the other is determined from the turbulent kinetic energy (TKE) profile (this one is in the official code since CY36). The error of this parameter also plays a crucial role, that is why PBL height forecasts of the AROME model were verified with PBL height observations calculated from radiosonds.



The PBL height from the turbulent kinetic energy, visualized of the entrie model domain (2011-06-05)



Scatter plot of the TKE PBL height,

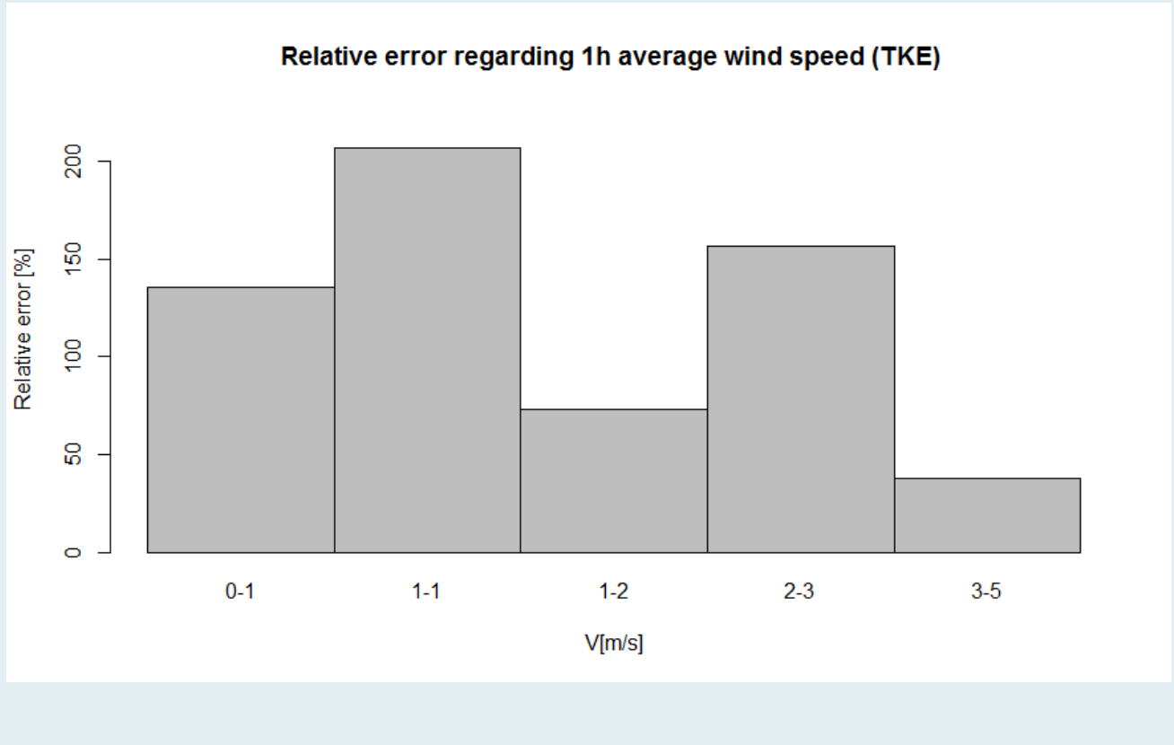


Scatter plot of the MF PBL height

	Correlation	Abs.rel.error [%]
Jan 00UTC	0,24 to 0,26	237 to 161
Jan 12UTC	0,55 to 0,59	101 to 48
Jun 00UTC	0,68 to 0,68	276 to 235
Jun 12UTC	0,09 to 0,35	284 to 36

The improvement of the correlation and the absolute value of the relative error by separating the worst 5% (Budapest, 2011)

The mean absolute value of the relative error is relatively high (296%), but the median is only 67%, which shows that few huge error deteriorate the values. The main source of errors are the misplacing and time lag of the heavy rain situations. If we select out these big error cases (the worst 5%), the error significantly decreases, the correlation increases.



There were also examinations taken, which meteorogical variables effect the most the relative errors. Here the influence of the 1hour average wind speed is shown. These examinations help to separate the situations which are difficult to simulate with AROME.

Acknowledgement: This poster presents results of ECMWF’s special project called ‘Continental winter weather prediction with the AROME ensemble prediction system’. We are especially thankful to Francois Bouttier, the leader of this project.