NWP at the Hungarian Meteorological Service

LACE nwp central europe

ALADIN Numerical Weather Prediction Project

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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

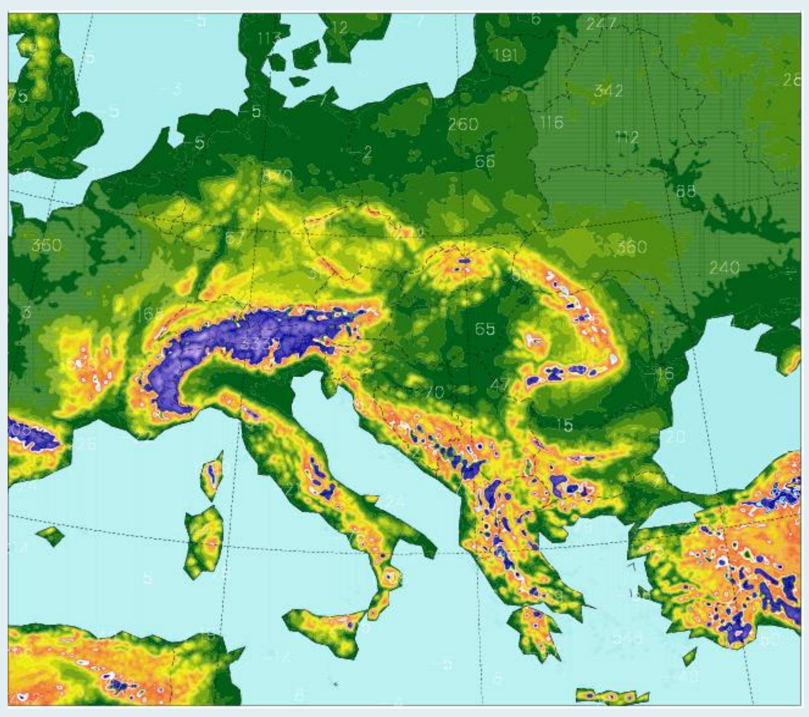
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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

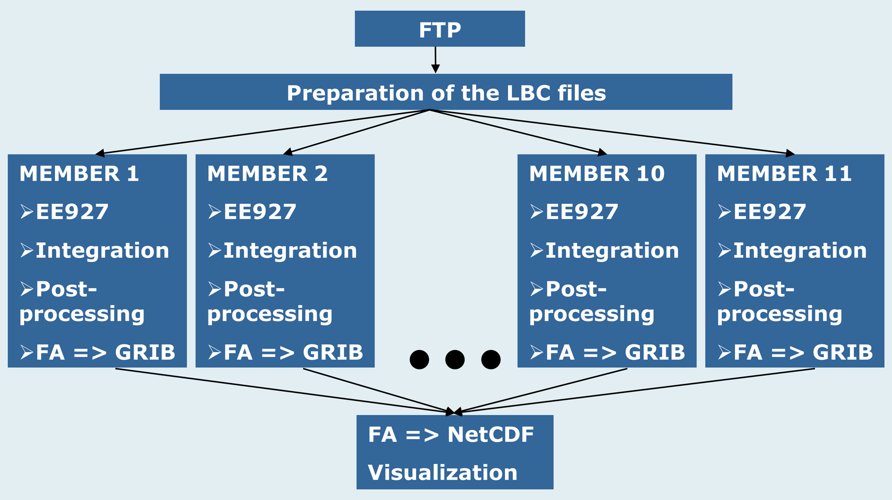
Observation usage

- 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.

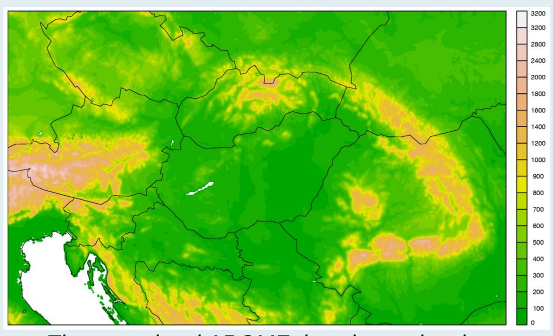


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

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 (39h); 12 UTC (48h); 18 UTC (39h)
- Initial conditions: 3DVAR (upper air), interpolated ALADIN surface analysis (see details in the block below)
- 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



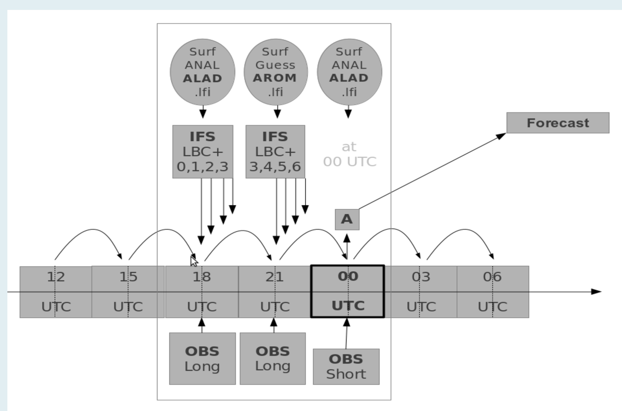
The operational AROME domain used at the Hungarian Meteorological Service.

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).

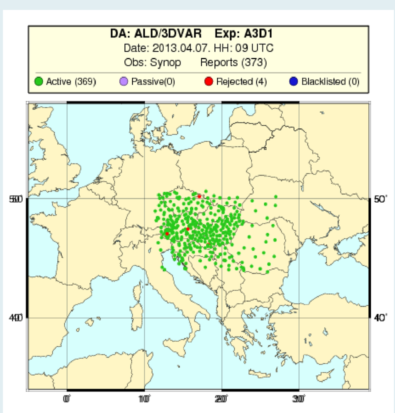
As a general conclusion, our experience is that the AROME model gives the best temperature and cloudiness forecasts. Based on the SAL verification (not shown here) it also captures the size of the precipitation objects very well. However, it tends to overestimate precipitation maximum and wind gusts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

Operational Data Assimilation for AROME

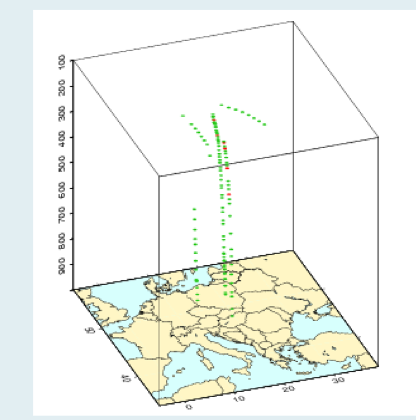
The implementation of an operational data assimilation system for our AROME suite at 2.5 km resolution was one of the main goals of the NWP team at the Hungarian Meteorological Service. The system presented below has been implemented operationally on the 27th March 2013 after a long validation process.



The operational 3DVAR AROME data assimilation cycle at the Hungarian Meteorological Service.



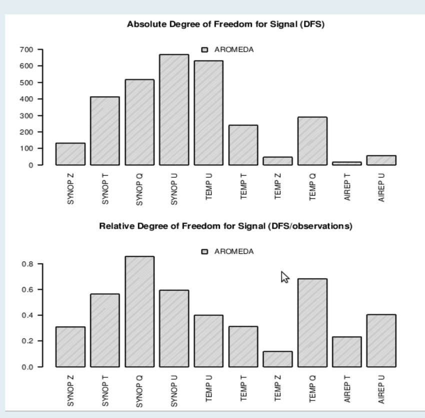
Assimilated surface observations in the operational 3DVAR on an arbitrarily chosen date



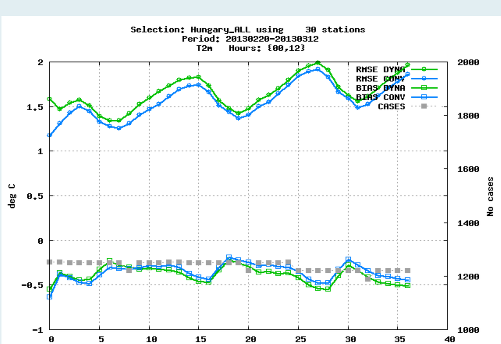
Assimilated aircraft (AMDAR) observations in the operational 3DVAR on an arbitrarily chosen date

The setup: The atmospheric analysis is obtained with the 3DVAR assimilation scheme and a 3 hourly assimilation cycle is used for the sake of using as much surface and aircraft observations as possible. The background error covariance matrix is sampled by downscaling a LAM Ensemble Data Assimilation (EDA) experiment performed in the ALADIN model (at 8 km resolution). The surface is updated at every 6 hours with by interpolated OI analysis of the ALADIN LAM (at 8 km resolution). No initialization is applied after the analysis.

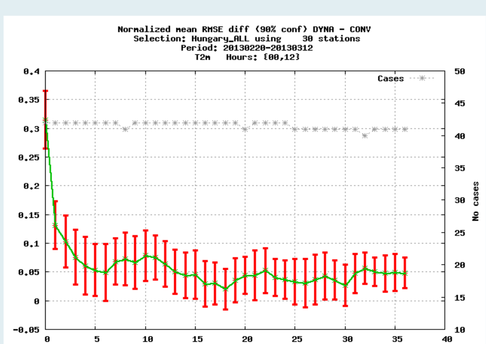
The observations used: For the time being only conventional observations (SYNOP: Z, T2m, RH2m, U10m, TEMP: Z, U, T, RH, AMDAR: T, U) are used in the operational assimilation system, which are summarized in the table below. A novelty compared to the ALADIN 3DVAR system is that the U10m observations are assimilated also over land, bringing a substantial improvement in the wind forecast. The importance of U10m observations is also proved by absolute DFS (Degrees of Freedom for Signal) diagnostics. The relative DFS diagnostics show a high importance of the humidity observations.



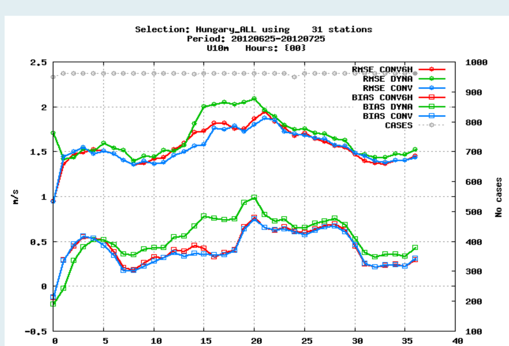
Degrees of Freedom for Signal computed for the conventional observations used in the operational setup



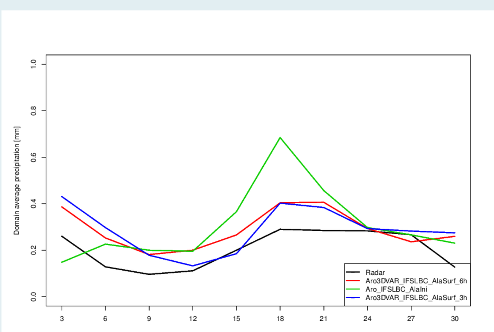
T2m RMSE and BIAS scores showing an improvement by the local 3DVAR assimilation (blue) over the dynamical downscaling (green)



T2m RMSE differences (Dynamical downscaling minus 3DVAR) showing a significant improvement by the local 3DVAR assimilation



U10m RMSE and BIAS scores showing an improvement by the local 3-hourly 3DVAR assimilation (blue) over the dynamical downscaling (green) and over the 6-hourly 3DVAR cycle (red)



Model and Radar domain average precipitation statistics showing an improvement by the local 3-hourly 3DVAR assimilation (blue) over the dynamical downscaling (green) and over the 6-hourly 3DVAR cycle (red)

Performance: The implementation of the 3-hourly 3DVAR data assimilation cycle led to the improvement of the operational AROME forecasts especially regarding the screen level parameters (T2m, U10m) and precipitation. The known overestimation of the convective precipitation during the afternoon has been reduced due to the data assimilation, however still not in the required extent.

Future plans: As indicated by the DFS diagnostics above, humidity observations are very important for feeding our AROME mesoscale initial conditions. For this reason the one of our high-priority plan is to implement an operational radar reflectivity (beside radial wind) and GPS ZTD assimilation. For the improvement of the background error covariance matrix, an AROME EDA sampling is foreseen.

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

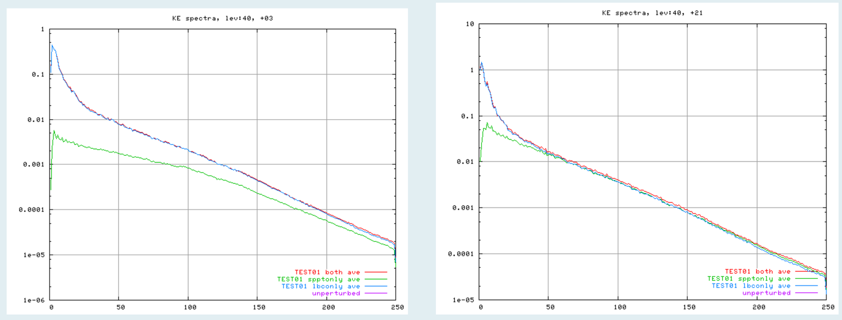
Hungarian Meteorological Service is a participant of an ECMWF special project called 'Continental winter weather prediction with the AROME ensemble prediction system'. Our long-term goal in this project is to develop a high-resolution EPS which can correctly estimate the uncertainty of the forecasts 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.

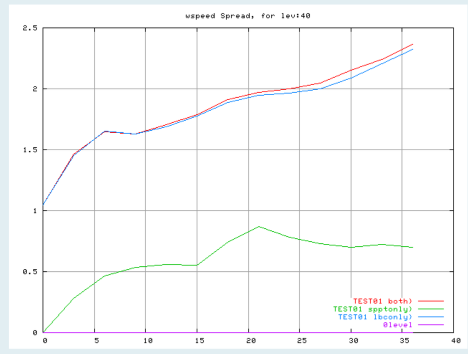


Kinetic energy spectra of the perturbations for the three various test versions at +3hours (left side) and at +21hours (right side)

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.

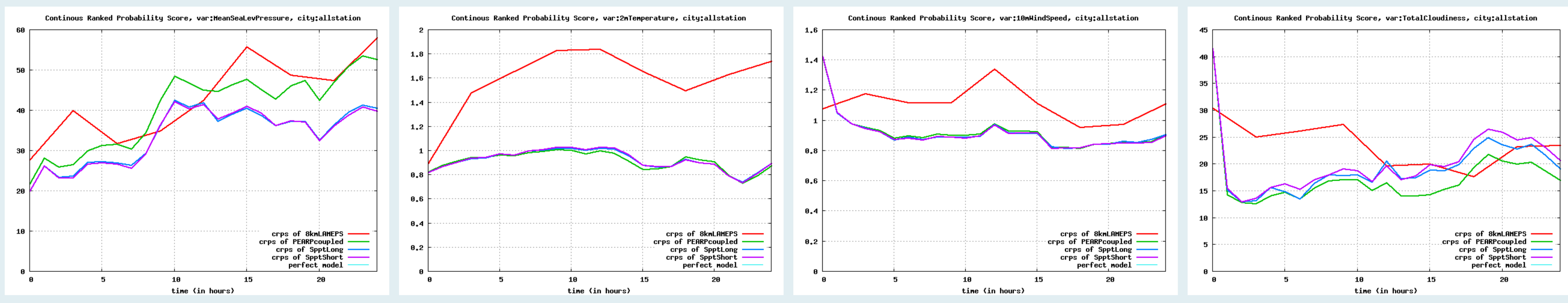
All experimental system contained 11 members and model integrations were started at 00UTC and run for +24 hours.



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:

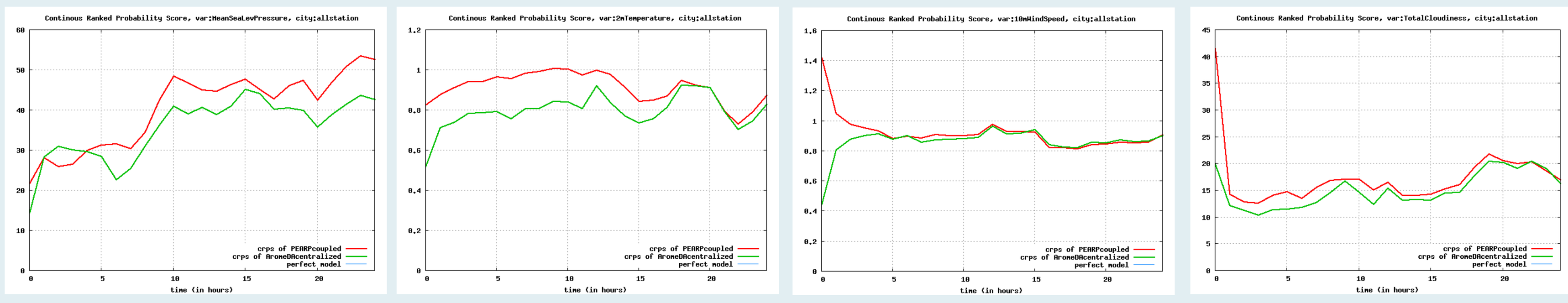
1. Comparison of AROME-EPS and operational 8kmLAMEPS:
- AROME-EPS is in almost all scores clearly better for almost the whole forecast period.
- Cloud is an exception because in the second part of the forecast period AROME-EPS and 8kmLAMEPS have similar performance.
- In some aspects the first 3-hour 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 skillful and feasible way if an AROME EDA system is not available.

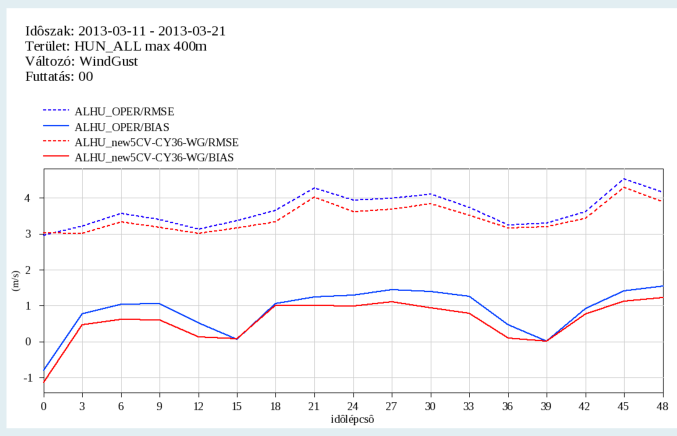


The time evolution of the CRPS of the experimental PEARPcoupled (red) and AromeDAcentralized (green) configurations. The parameters from left to right: mean sea level pressure, 2meter temperature, 10meter wind speed, total cloudiness.

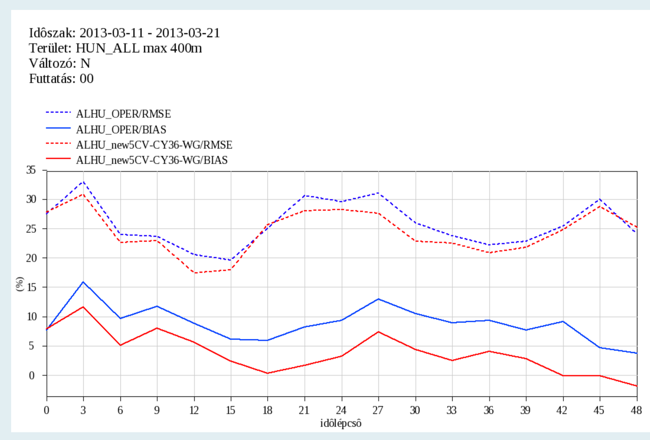
We plan further work in the framework of this ECMWF's special project. The downscaling of the experimental high-resolution ECMWF EPS is going to be an important test in the near future. Interesting winter situations are also in the focus and detailed case studies are needed to deeper understand the behave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

Operational upgrade of ALARO

A new version of the ALARO physics based on CY36T1 (ALARO-0 baseline) was introduced operationally in September 2013 both in the deterministic and EPS ALADIN systems at 8 km resolution. The evaluation of this new physics package (developed by LACE) was based on parallel suites over more then a one month period. Verification scores against observations have been computed and feedbacks were obtained from the duty forecasters. The upper air performance remained similar to the previous model version (CY35T1, ALARO-0) but there has been an improvement found in the forecasts of 10m wind, cloudiness and precipitation in terms of scores. The feedbacks from the forecasters supported the findings from the scores: cloudiness and precipitation patterns have been found more structured and realistic in the new model version.



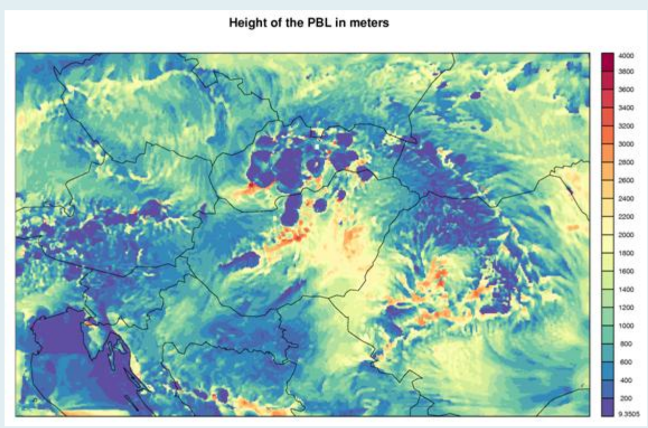
10m wind speed RMSE and BIAS scores showing an improvement by the new model version (red) over the old one (blue)



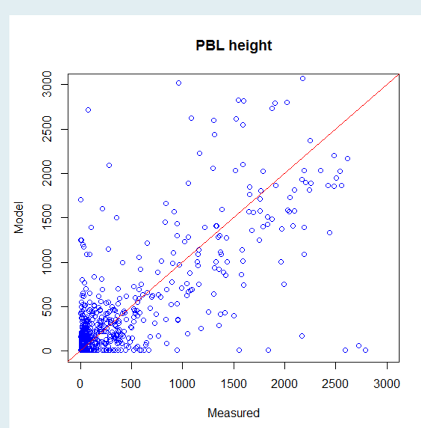
Cloudiness RMSE and BIAS scores showing an improvement by the new model version (red) over the old one (blue)

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

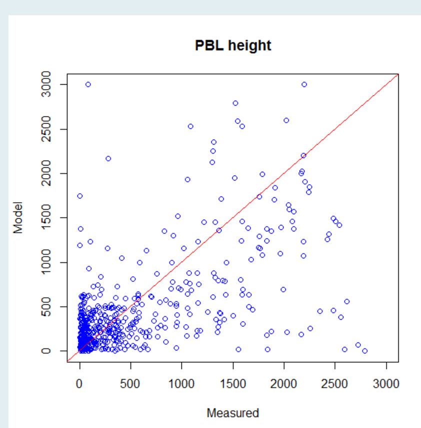
The height of the planetary boundary layer (PBL) is a very important input parameter for dispersion and chemistry transport models, thus there is a high need to estimate it with NWP models. In this experiment two options for the PBL height were compared: one is is calculated from the moment flux (MF) 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 entire model domain (2011-06-05)



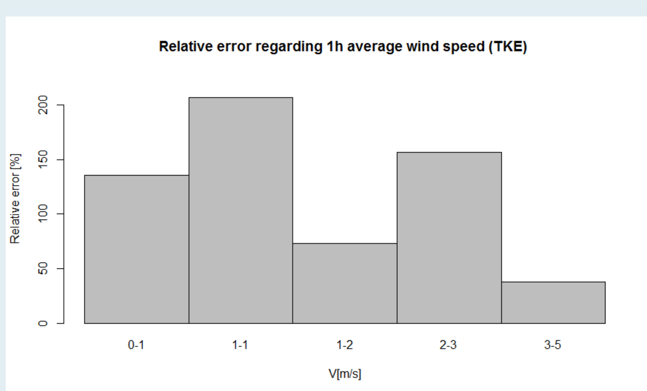
Scatter plot of the TKE PBL height,



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 is 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 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 meteorological 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.