LACE
nwp central europe

ALADIN Numerical Weather Prediction Project

NWP at the Hungarian Meteorological Service

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Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY38T1 (ALARO-0 baseline 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

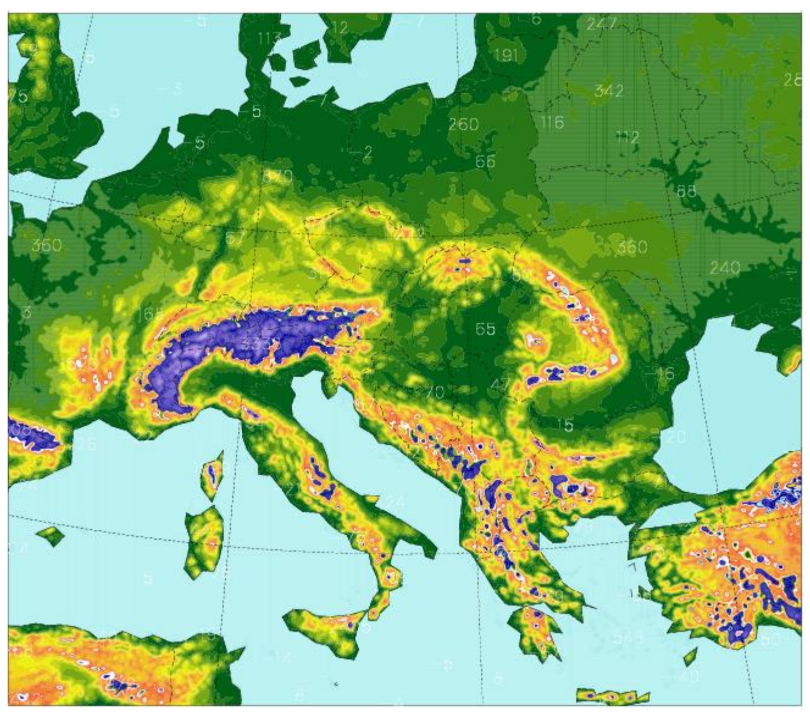
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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 32 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
- IBM FlashSystem 840
- Torque job scheduler



The ALADIN/HU model domain and orography

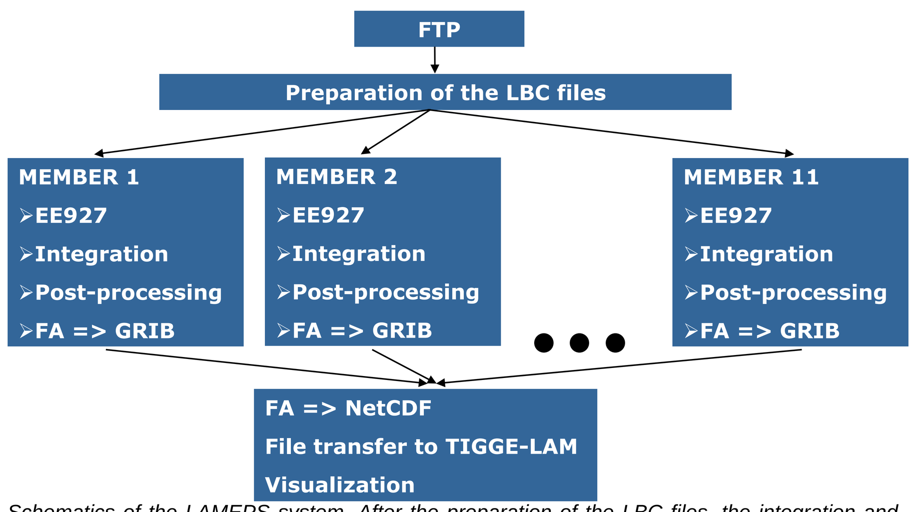
Observation usage

- 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 18) with 80 km thinning distance, passively NOAA 19, Metop A/B
- ATOVS/AMSU-B (radiances from NOAA 17 and 18) with 80 km thinning distance, passively NOAA 19, Metop A/B
- METEOSAT-10/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 integration of the single members is similar than in 'deterministic' ALADIN/HU case (see above): same resolution, same physics, etc.
- The forecast process starts every day from cron at 23:50 UTC and finishes around 02:00 UTC.

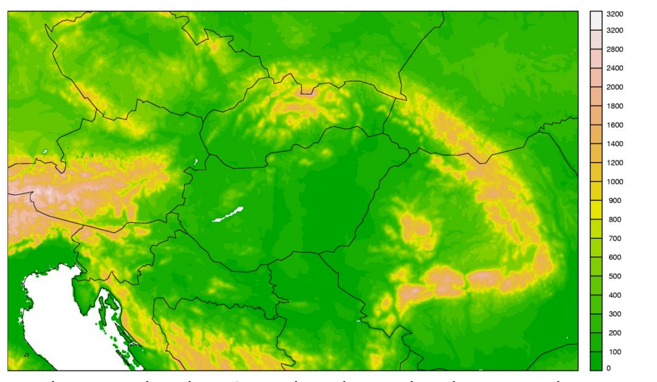


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

- Model version: CY38T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Eight production runs a day: 00 UTC (48h); 03 UTC (36h); 06 UTC (39h); 09 UTC (36h); 12 UTC (48h); UTC (36h); 18 UTC (39h); 21 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

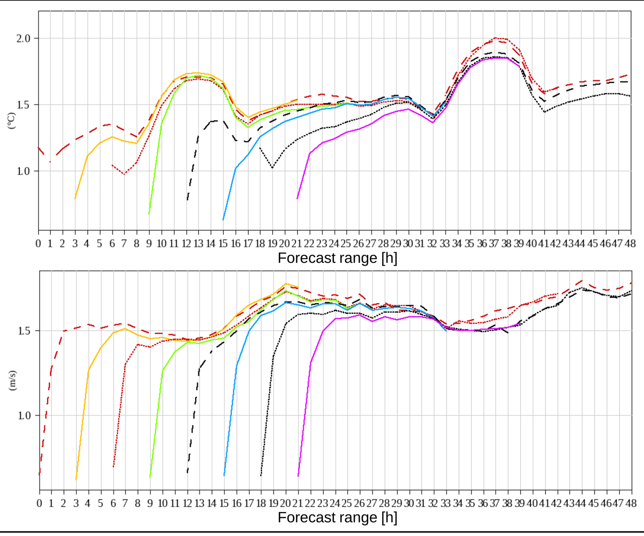


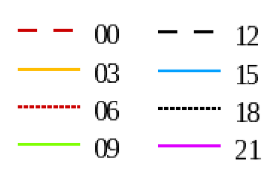
The operational AROME domain used at the Hungarian Meteorological Service.

Eight AROME forecats runs per day

Since 9th March 2016 AROME at the Hungarian Meteorological Service is run eight times per day, using analyses from the three hourly Rapid Update Cycle (RUC) of AROME. For the time being the runs starting at 03, 09, 15 and 21 UTC are run for +36h only, but this is planned to be extended in future. The main motivation for the introduction of the new forecast runs was that in situations with severe weather events the more frequently updated AROME products could help forecasters in issuing warnings.

Figures on the left show scores over Hungary during the pre-operational phase of the new AROME runs. It can be concluded that the new runs could give a benefit as compared to older runs only in the first 3-4 hours of the forecasts (especially for temperature), after this range the systematic errors of the model dominate. However, it is expected that after the operational introduction of the assimilation of remote sensing instruments (Radar, satellites, GNSS) this time range could be extended.





RMSE of 2 metre temperature (upper panel) and 10 metre wind speed (lower panel) for the eight AROME runs for the period 2016-01-25 – 2016-02-23.

ECMWF ENS-BCs in the LAMEPS of OMSZ

Our current LAMEPS has been described at Operational ALADIN configuration (top left box). It contains 11 members which are the dynamical downscaling of the first 11 members of the 18UTC French ARPEGE-EPS (PEARP). Model integrations run for 60 hours with the available 6-hours coupling frequency. While at the moment there is no local data assimilation and perturbation generation in our ensemble system we have already tested ensemble data assimilation (EDA) method producing initial conditions (ICs) with better quality and describing the initial uncertainties better. The results of such tests underlined that the quality of a data assimilation cycle can be negatively influenced if global information is available only once a day (only 18UTC run) with a relatively rare frequency (6-hours).

In the previous years we have produced several tests with ECMWF's ENS-BCs in our LAMEPS. These tests were motivated mainly by the following reasons:

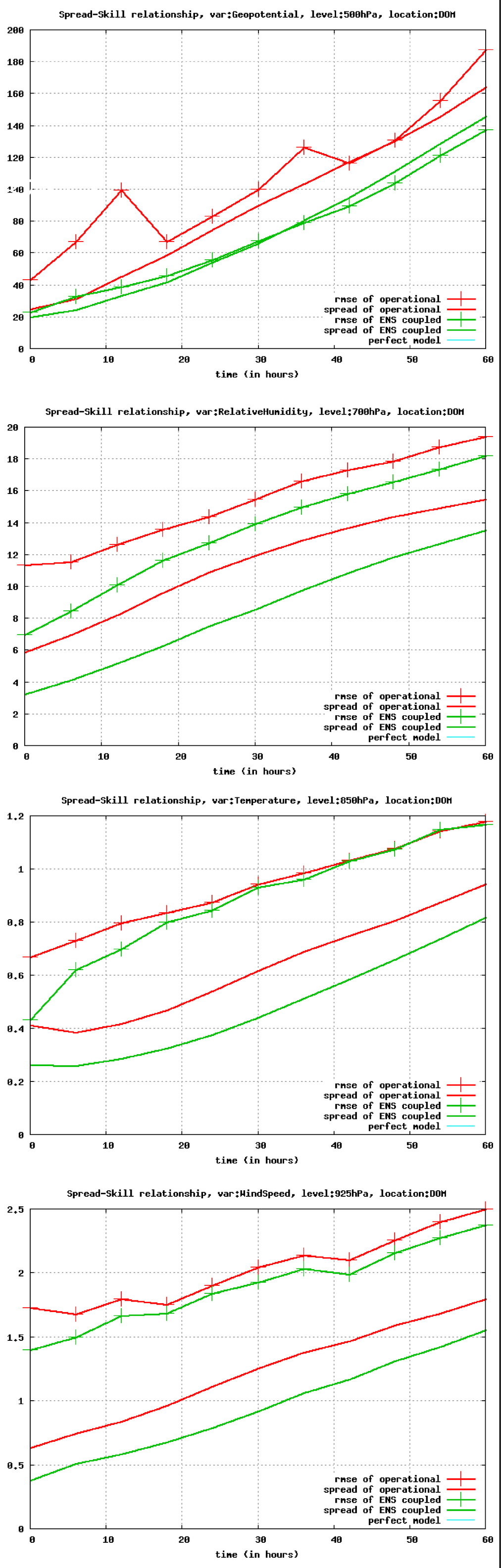
- Earlier studies showed possible improvement with the change of BC strategy;
- There is a need to stay consistent with our "deterministic" systems which is coupled to ECMWF's HRES model runs;
- Because of the above-mentioned reasons there is a need for more frequent BC production (more runs, more LBCs per run), which can be particularly important in an EDA system.

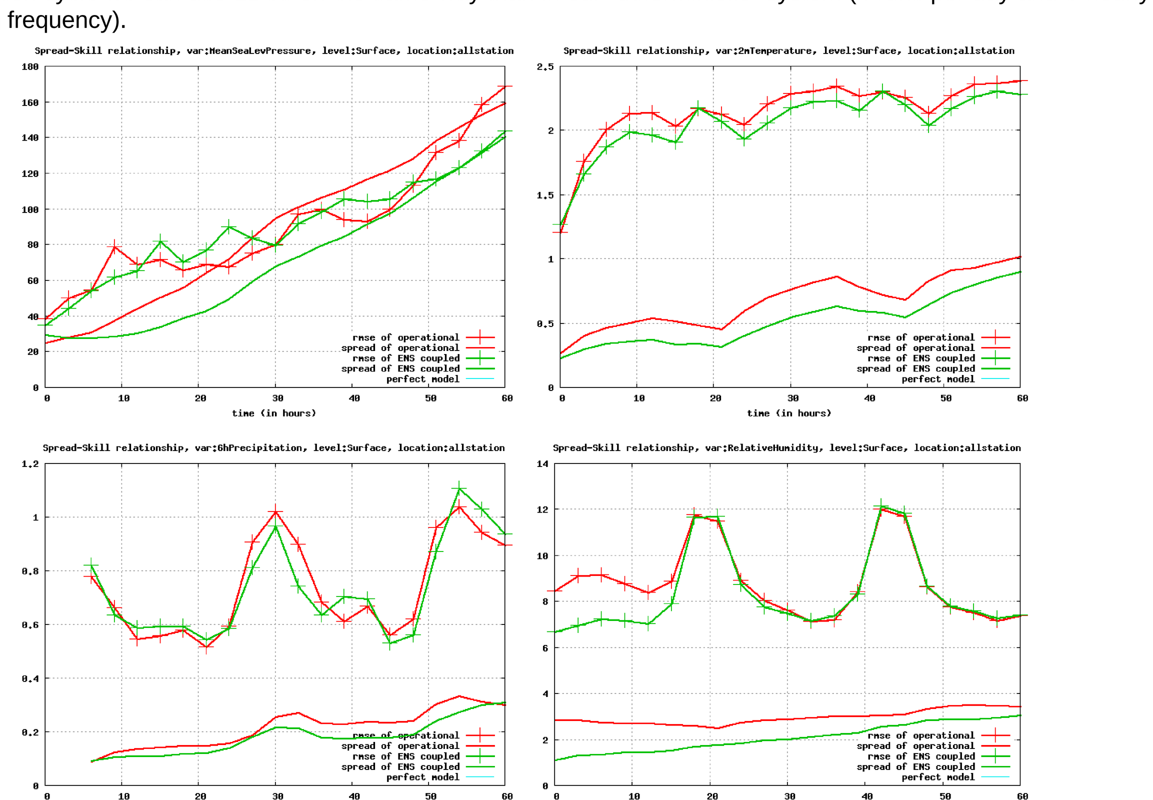
After the extension of Optional BC project (July, 2015) ENS-BCs became available for us and we reached the possibility to carry out a longer test period:

- Which goes from 11th of December 2015 to 31st of January 2016;
- In this first configuration (similar to out operational configuration) runs start at 18UTC and they are the dynamical downscaling of the ECMWF's ENS members;
- There is no assimilation in the system. Surface fields have to be changed from ARPEGE runs, but surface perturbations of ENS BCs can be added to them.

Generally we can say that the application of ENS BCs improves the quality of the single members and decreases the root mean square error of the ensemble mean. At the same time they slightly decrease the spread of the system as well (see figures on the right side of the box).

Hopefully in the future ENS-BCs can also support our EDA related efforts. For the maintenance of the data assimilation cycle we can use LBCs on the same way than in our "deterministic" system (4 runs per day and 3-hourly coupling frequency).



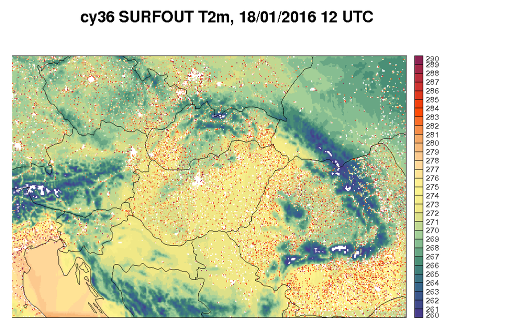


Comparison of rms error of ensemble mean and the spread of the ensemble members. Red line belongs to our operational LAMEPS while green line belongs to ENS coupled test LAMEPS. The names of variables are marked on the separated figures. On left side there are near-surface scores and on the right edge there are upper-air plots.

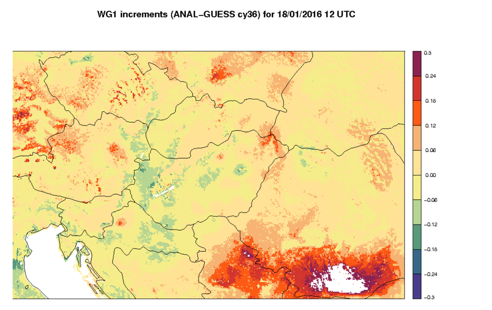
EKF Surface Assimilation in AROME model

Extended Kalman Filter (EKF) surface assimilation study was continued at OMSZ during the RC LACE stay in Budapest by Viktor Tarjanyi. The validation was originally started with offline SURFEX version 6.0 and AROME cy36t1. Conventional gridded observations (T2m and Rh2m – created by CANARI) are tested to analyze TG1, TG2 and WG1, WG2 parameters. Issues have been found with SURFEX offline runs with enabled town energy balance scheme (TEB) because unrealistic high 2 m temperature values were detected over town tiles. Initial surface conditions were first checked showing no indication of mentioned issue. However issue immediately appeared in the first offline SURFEX step and then remaining present in all subsequent steps. It was found that problem can be eliminated by enabling TOWN2ROCK switch in offline SURFEX, however this was only used for validation purposes.

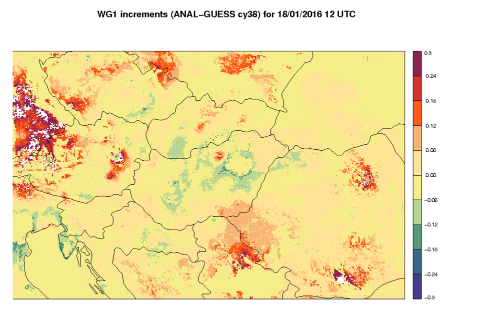
In order to overcome the above mentioned TEB issue, it was decided to check newer offline SURFEX release and to use newer common cycle instead of debugging an old version of SURFEX. Therefore offline SURFEX 7.2 was installed and tested with AROME (cy38t1). After necessary namelists have been upgraded for 927 and 001 configurations of cy38t1, preliminary tests indicated that mentioned issues have not been presented with offline SURFEX 7.2. Validation of the gridded observation procedure (CANARI) and the EKF analysis has been started as well. In the near future analysis increments of EKF method will be compared with those of OI_MAIN method.



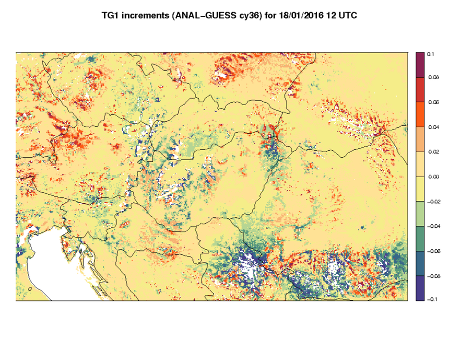
T2m analysis at 18/01/2016 12 UTC with AROME cy36t1 and SURFEX v6.0



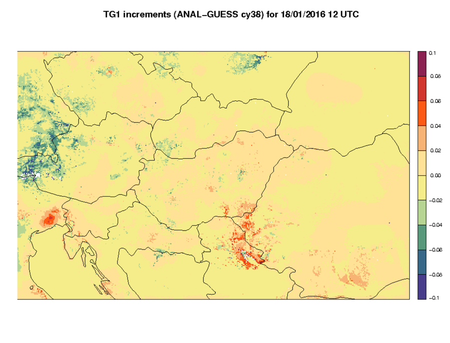
WG1 increments at 18/01/2016 12 UTC with AROME cy36t1 and SURFEX v6.0



WG1 increments at 18/01/2016 12 UTC with AROME cy38t1 and SURFEX v7.2



TG1 increments at 18/01/2016 12 UTC with AROME cy36t1 and SURFEX v6.0

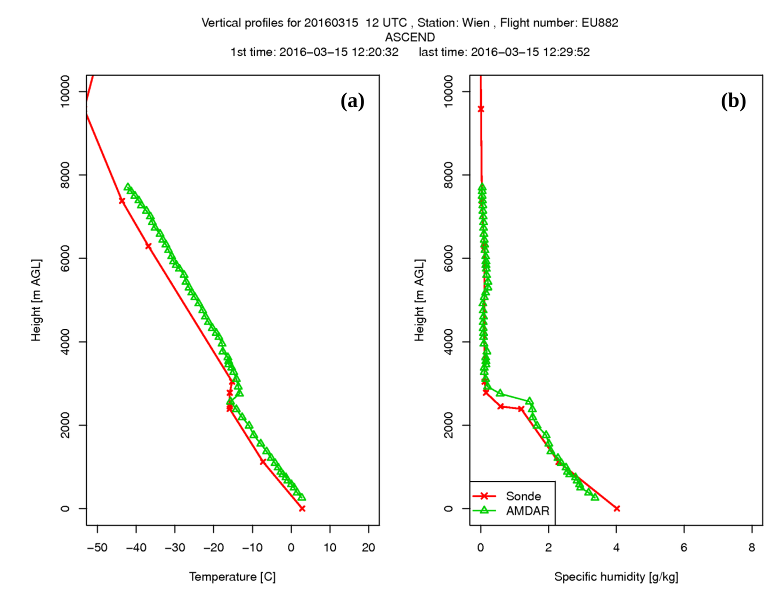


TG1 increments at 18/01/2016 12 UTC with AROME cy38t1 and SURFEX v7.2

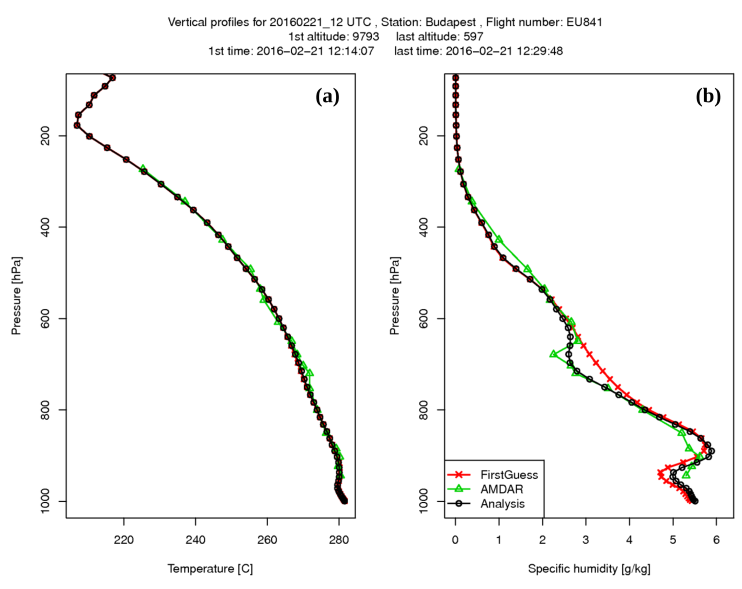
Preliminary results of using AMDAR humidity in the AROME data assimilation system

Direct temperature and wind measurements from aircraft are important data in our operational AROME data assimilation system because we use only conventional observations. Recently humidity data are also available in more and more AMDAR reports not only in the USA but also in Europe. These data are especially useful when the aircraft is in descending or ascending phase so it observes vertical characteristics of the troposphere more frequently than radiosondes. The sensor measures mixing ratio of water vapor which can be converted to specific humidity for the assimilation.

As a first step radiosonde and aircraft humidity data were compared when both observation types were available. Visual check of vertical profiles indicates a good agreement between the two measurements so in the next step only single specific humidity profile from AMDAR report was assimilated. On the vertical profile of the first guess and the analysis it can be seen well that after the analysis humidity profile is closer to the observations.



Vertical profile of a) temperature and b) specific humidity from TEMP (red) and AMDAR (green) over Wien at 12UTC on 15th March 2016



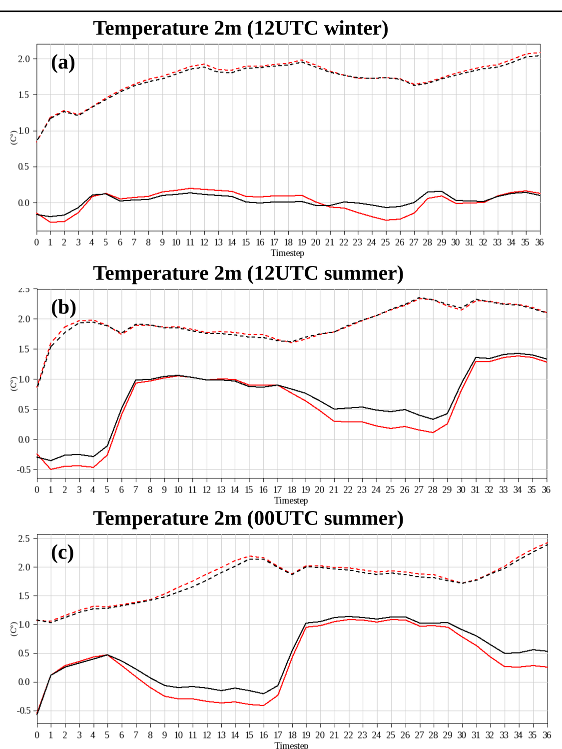
Vertical profile of a) temperature and b) specific humidity from AMDAR (green) and model background (red) and analysis (black) over Budapest at 12UTC on 21st February 2016

Test of cloud inhomogeneity factor in AROME cy38 over Hungary

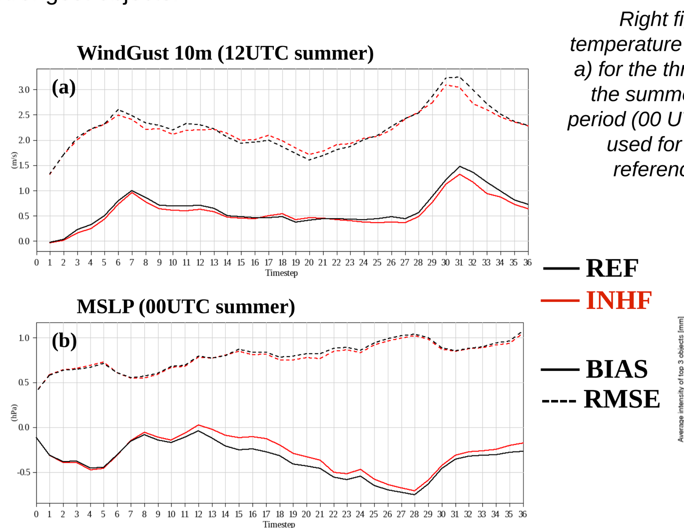
In the original SW and LW radiation scheme a cloud inhomogeneity factor was introduced to take into account the subgrid cloud variablility because of the coarse resolution. But in AROME deep convection is treated explicitly, the cloud structure is more resolved, so this factor may be unnecessary. For this reason this factor was set to 1 from the default value 0.7.

The impacts of the modification were studied on two longer time periods. One of them is a three-weeks summer period from 1st August 2014 to 23rd August 2014, the other one is a winter period from 27th December 2014 to 18th January 2015. In each periods 36 hours forecasts from 00 and 12 UTC were prepared with data assimilation cycle.

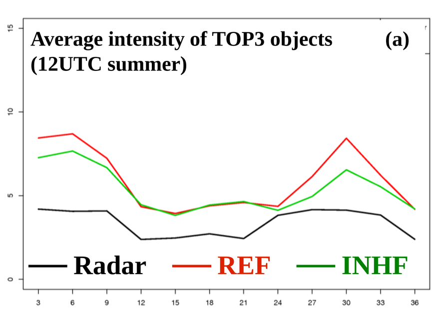
Usually the impact of the modification seems bigger in summer than in winter. For the most variables the effect is usually neutral, the biggest impact can be seen in the 2m-temperature scores (unfortunately it is rather negative) Windgust and MSLP scores show a little improvement. For precipitation SAL verification was carried out. Results show positive impact of the modification, especially in the intensity of the three strongest objects.

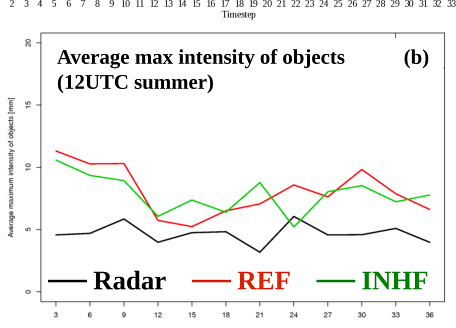


Right figure: BIAS (solid) and RMSE (dashed) temperature verification scores as a function of lead time a) for the three-weeks winter period (12UTC runs) b) for the summer period (12 UTC runs) c) for the summer period (00 UTC runs) SYNOP stations below 400 m were used for the calculations. Black lines indicate the reference and red lines are the experiment with increased inhomogeinity factor.



BIAS (solid) and RMSE (dashed) verification scores as a function of lead time for the summer periods a) wind gust at 10 m level (12UTC runs) and b) mean sea level pressure (00UTC runs). SYNOP stations below 400 m were used for the calculations. Black lines indicate the reference and red lines are the experiment with increased inhomogeinity factor.





SAL verification scores as a function of lead time for the summer periods and 12 UTC runs: a) the average intensity of the three most intensive objects and b) the average maximum intensity of the objects. Black lines indicate the radar observations, red and green lines are the reference and experiment with increased inhomogeinity factor, respectively.

Development of shallow convection parameterization in AROME at very fine resolution

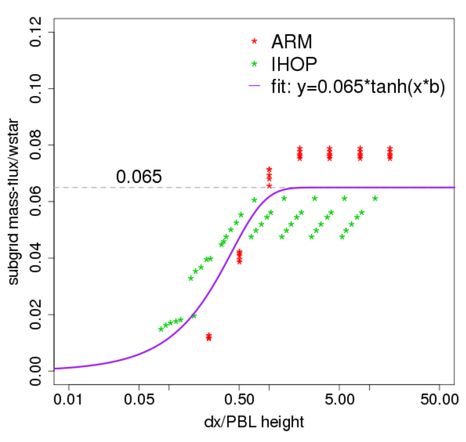
In this research at the Hungarian Meteorological Service (HMS) the focus is on the shallow convection grey zone in the AROME model at very fine resolution. At low horizontal resolution (dx > ~1 km) the effect of shallow convection eddies are parameterized, because the dynamics can not treat them. By contrast at very high resolution (dx < ~100 m – large eddy simulation (LES)) the parameterization of these eddies is not needed, they are fully handled by the dynamics. In the intermediate resolutions the eddies are only partly treated by the dynamics so they still have to be parameterized, but in a new way, dependent on the resolution.

The current shallow convection parameterization in AROME is based on the Eddy Diffusion Mass Flux (EDMF) scheme, where the thermals are represented with a mass-flux value. This value is initialized at the surface and then integrated upwards.

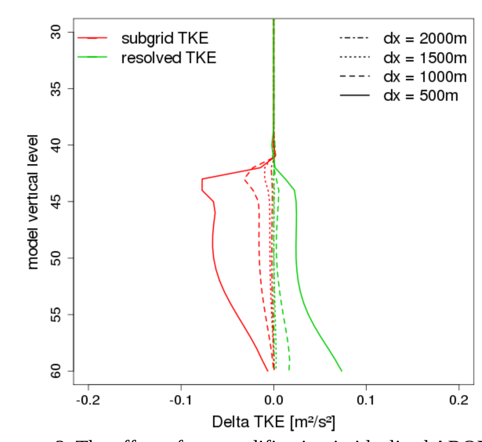
In our new parameterization the initialization is dependent on the dimensionless horizontal resolution. This dependency is derived from LES runs (figure 1.) of the IHOP and ARM cases made with the MesoNH (Honnert et al. (2011)). The normalization can be done optionally by the planetary boundary layer height (LUPBLH=T) or by the upward mixing length (LUPBLH=F).

At first it was tested on idealised AROME runs (figure 2.) and the modification moves the results in the desired direction. The verification was done on a 15-day-long real case period (figure 3. and 4.) at dx = 1 km horizontal resolution. The operational resolution of AROME at HMS is 2.5 km and the 1 km AROME shown in figures 3. and 4. is only a test. Compared to this, the modification produces little change, but this is still a result without tuning.

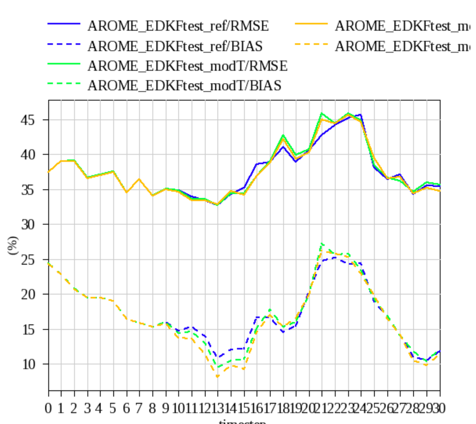
HONNERT, R., V. MASSON and F. COUVREUX, 2011: A Diagnostic for Evaluating the Representation of Turbulence in Atmospheric Models at the Kilometric Scale. J. Atmos. Sci., **68**, 3112-3131



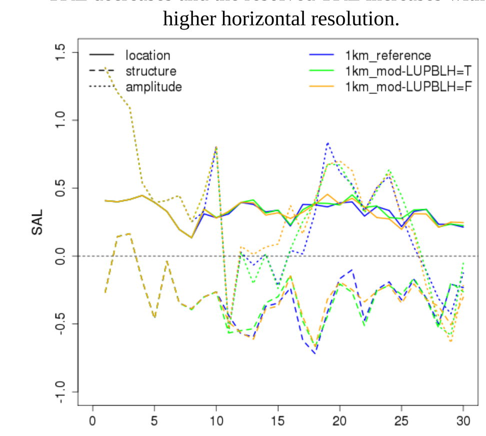
1. Normalized subgrid mass-flux (wstar is the vertical velocity scale) at the surface as a function of the normalized horizontal resolution (PBL is the planetary boundary layer - ~1 km height) according to LES experiments (IHOP, ARM)



2. The effect of our modification in idealised AROME experiments: difference between the mean turbulent kinetic energy (TKE) profiles (the simulation with modification minus the simulation without modification). The subgrid TKE decreases and the resolved TKE increases with the higher horizontal resolution.



3. Verification of the cloudiness - RMSE and BIAS, blue: reference 1km AROME, green: mod. AROME LUPBLH=T, orange: mod. AROME LUPBLH=F



4. SAL (structure amplitude location) verification of precipitation, blue: reference 1km AROME, green: mod. AROME LUPBLH=T, orange: mod. AROME LUPBLH=F