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-1 physics)
- Initial conditions: local analysis (atmospheric: 3dVar, surface: OI)
- Four production runs a day: 00 UTC (60h); 06 UTC (48h); 12 UTC (60h); 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

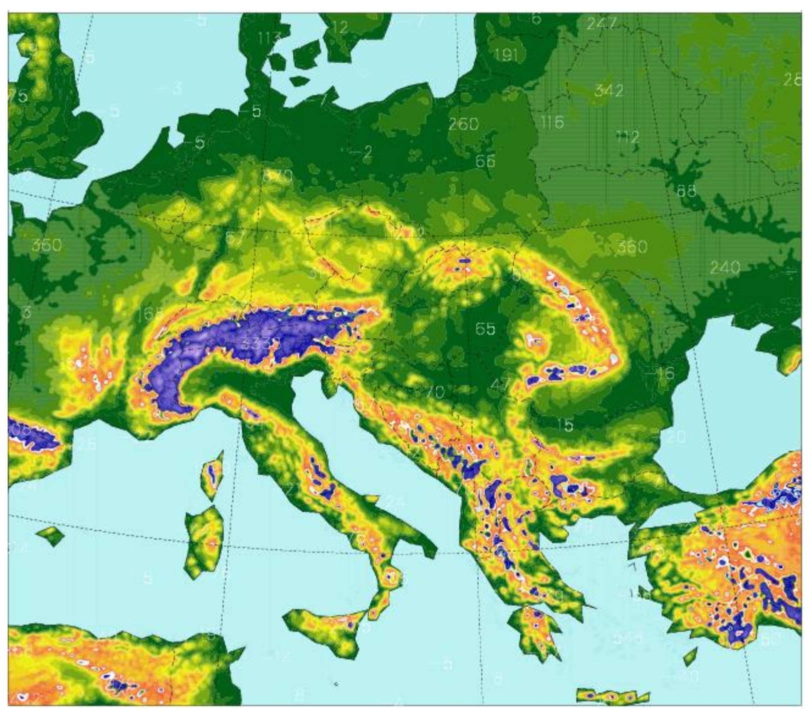
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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

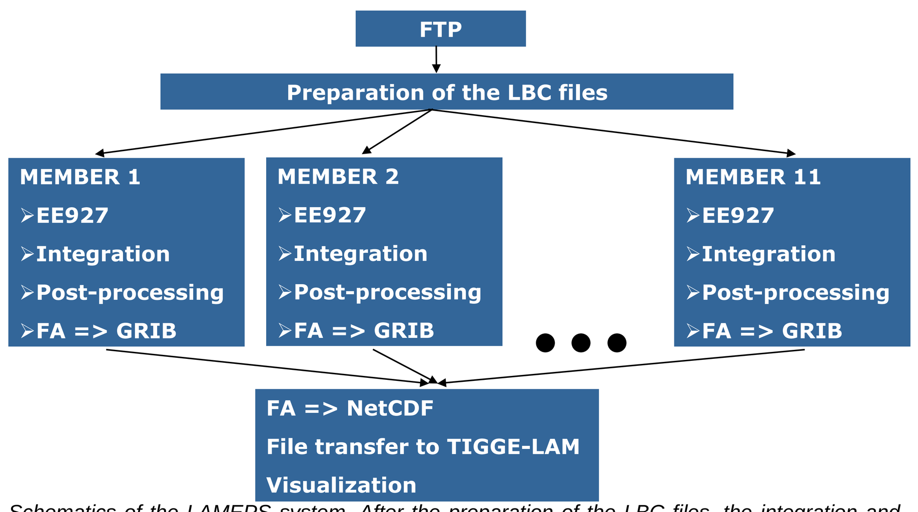
Observation usage

- 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, q) with 25 km thinning distance and 3 hour time-window
- Slovenian Mode-S data
- 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 ECMWF ENS system.
- LBCs are coupled in every 3 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 00:45 UTC and finishes around early morning.

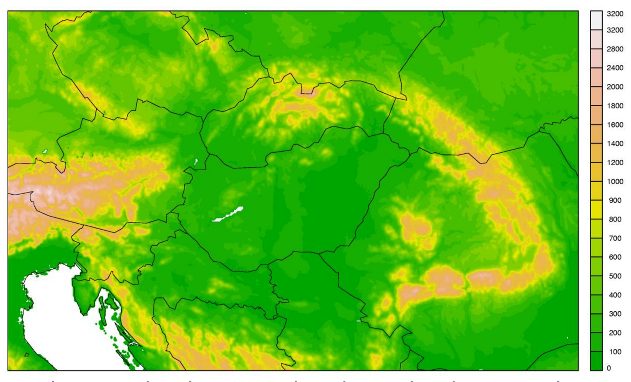


Schematics of the LAMEPS system. After the preparation of the LBC files, the integration and the post-processing are running in parallel for all the members. The preparation of the NetCDF files is done in one go for all members.

Operational AROME configuration

Main features of the AROME/HU model

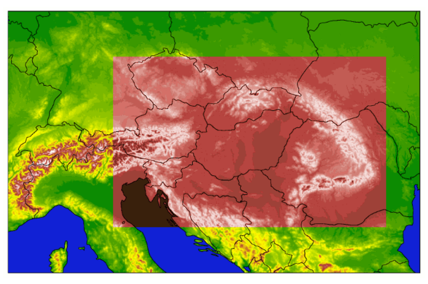
- Model version: CY38T1
- 2.5 km horizontal resolution (500*320 points)
- 60 vertical model levels
- Eight production runs a day: 00 UTC (48h); 03 UTC (36h); 06 UTC (48h); 09 UTC (36h); 12 UTC (48h); UTC (36h); 18 UTC (48h); 21 UTC (36h)
- Initial conditions: 3DVAR (upper air), OI_main (surface)
- Lateral Boundary conditions from ECMWF/IFS with 1h coupling frequency
- To calculate the screen level fields we use the SBL scheme over nature and sea



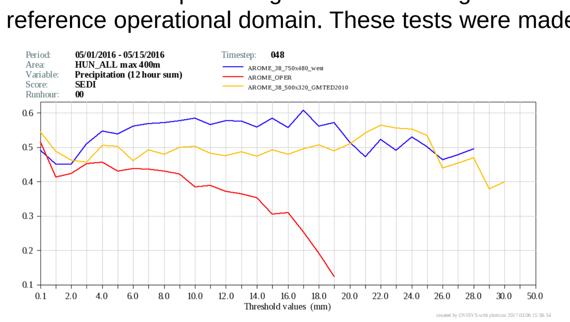
The operational AROME domain used at the Hungarian Meteorological Service.

Testing of new domain for AROME – impact of size and topography data

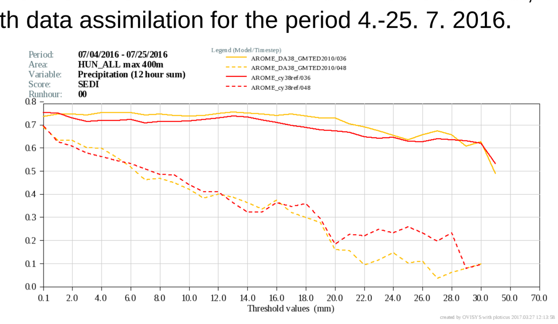
The new AROME domain tested at HMS is bigger (750x480 instead of 500x320), its center is moved toward west and a new topographical data was used for its preparation (GMTED2010 instead of the GTOPO30). It is hoped to better handle the precipitation forecast as it could capture bigger meteorological objects. The operational sized domain from the GMTED2010 was also tested (domain2).
The first tests were made without data assimilation for the period 1.-15. 5. 2016 and the new domain was compared to the operational and the domain2. The results showed that both the new domain and the domain2 were promising. As the advantages of the new domain didn't befit the additional numerical cost, in the following tests the domain2 was compared to the reference operational domain. These tests were made with data assimilation for the period 4.-25. 7. 2016.



1) The new domain with the operative domain inside (red field)



2) Verification of 12 hour precipitation after 48 hours over Hungary (SEDI index – best value is 1): new domain (blue), operative domain (red), operative domain from GMTED2010 – domain2 (orange)



3) Verification of 12 hour precipitation after 36 (solid line) and 48 (dashed line) hours over Hungary (SEDI index – best value is 1): operative domain from GMTED2010 – domain2 (orange), operative domain (red)

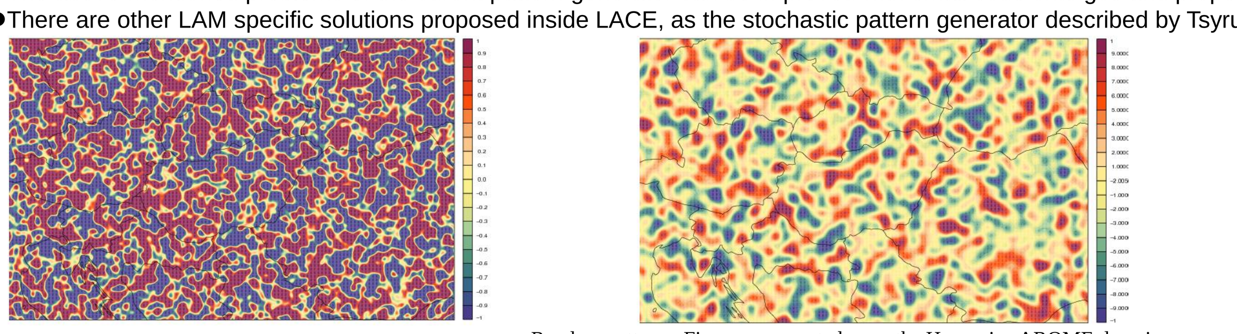
Stochastically Perturbed Parameterized Tendencies - SPPT

The basic concept of SPPT is quite simple: We multiply the parameterized tendencies with ***(1+r)*** where ***r*** is a random number from a Gaussian distribution with 0 mean. The technical challenges can be divided into two parts:
- The generation of the random number fields which takes place in spectral space.
- The application of random numbers in gridpoint space. This is basically the way how we use perturbations.

Hereafter, there are two issues from both parts. They can be called as open questions in the current SPPT implementation in AROME/ALADIN.

Random pattern generation

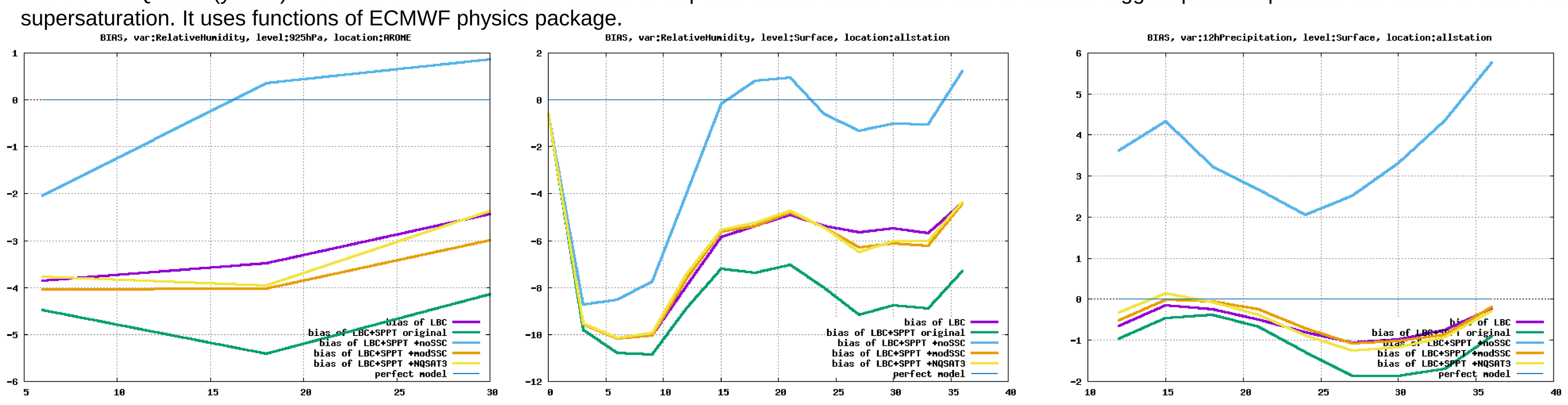
Obviously, it is important not to use independent random numbers in neighbour columns and in following timesteps. The current spectral pattern generator of SPPT is an extension of a global application which creates "smooth" fileds in space and time.
- This pattern generator does not work on a perfect way with the default settings because it has too large spread and too small horizontal correlation. (see left figure)
- The above-mentioned problems of the curent pattern generator can be improved with small code changes and proper namelist settings (see middle figure)
- There are other LAM specific solutions proposed inside LACE, as the stochastic pattern generator described by Tsyrulnikov and Gayfulin (see right figure)



Random patterns. Figures are created over the Hungarian AROME domain

Supersaturation check

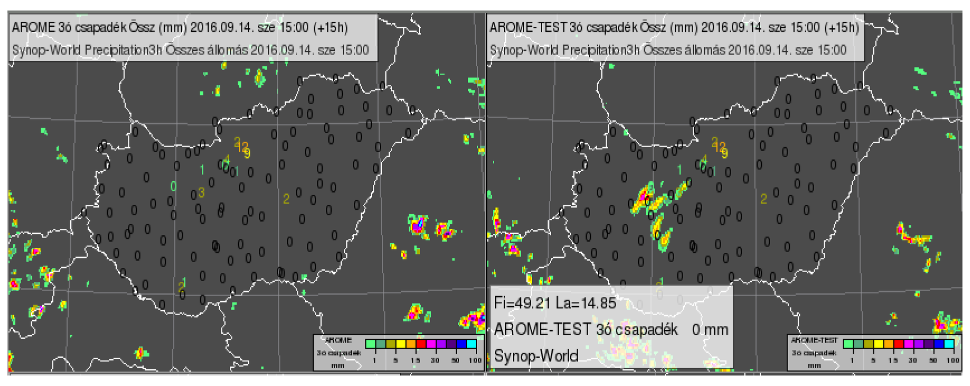
After the perturbation of the tendencies there is a "supersaturation check" which controls if the perturbations cause supersaturation or not. This additional check is quite important and it affects the humidity and precipitation BIAS. Figures show BIAS information of the following test configurations in AROME-EPS framework:
- LBC (purple) – reference, SPPT is not activated;
- SPPT original (green) – default supersaturation check, it cuts immediately all the perturbations to 0 which cause supersaturation;
- SPPT + noSSC(blue) – supersaturation check is switched-off;
- SPPT + modSSC (orange) – an own version of supersaturation check which tries iteratively to find smaller perturbations if the original one causes supersaturation;
- SPPT + NQSAT3 (yellow) – a more advanced built-in version of supersaturation check which tries to find the biggest possible perturbation which does not cause supersaturation. It uses functions of ECMWF physics package.



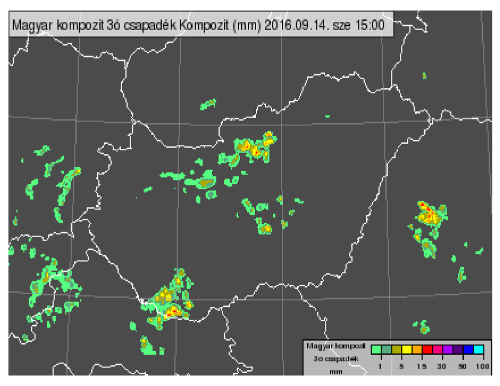
BIAS of the above-described AROME-EPS configurations calculated from 10 runs which were focusing on convective events of 2015.
Verification was made against radiosonde observations of the Hungarian AROME domain and SYNOP observations of Hungary.

Operational OI_main surface assimilation in AROME model

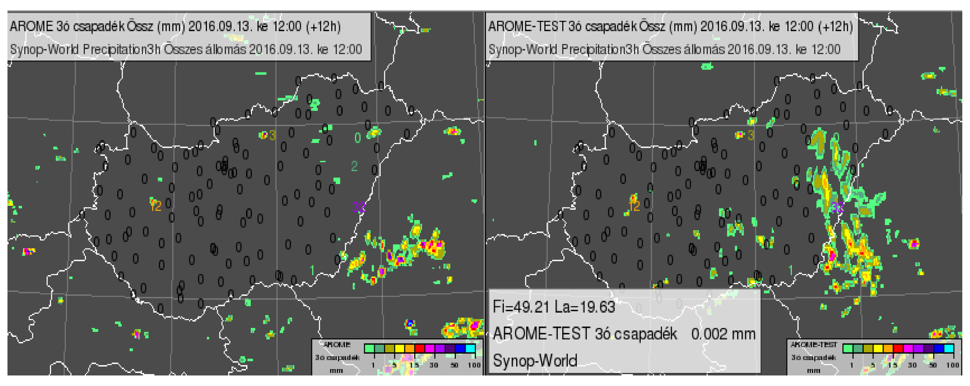
After extensive validation, the OI_main based surface assimilation has been introduced operationally in AROME DA system of Hungary. Previously the downscaled surface analysis of ALARO/Hungary model (CANARI at 8km) was used which provided relatively good surface initial conditions and comparable surface skill than AROME with CANARI-OI_main. Therefore the operational implementation of OI_main was decided to make operational AROME system independent from ALARO and get more consistent physics parametrization. Few of the case studies and forecast verifications are highlighted below where OI_main performed better than downscaled ALARO surface analyses in AROME.



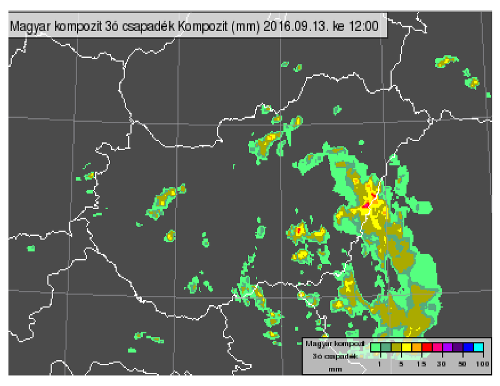
AROME 3h acc. precipitation forecasts at 15UTC, 14th of September 2016 started from 00UTC analyses. AROME with downscaled surface analysis on the left, AROME with OI_main on the right and SYNOPs with coloured numbers.



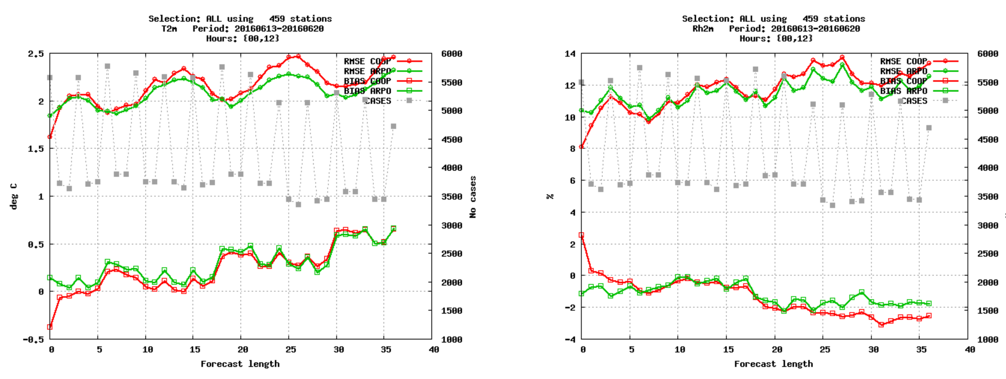
RADAR 3 hours composite for 15UTC, 14th of September, 2016.



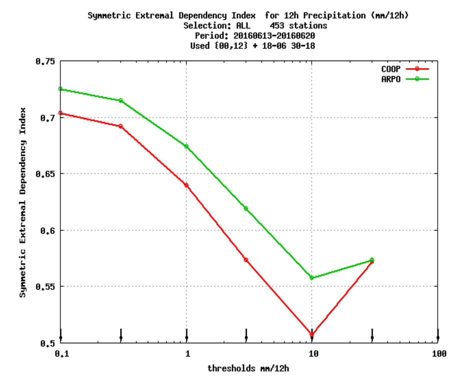
AROME 3h acc. precipitation forecasts at 12UTC, 13th of September 2016 started from 00UTC analyses. AROME with downscaled surface analysis on the left, AROME with OI_main on the right and SYNOPs with coloured numbers.



RADAR 3 hours composite for 12UTC, 13th of September, 2016.



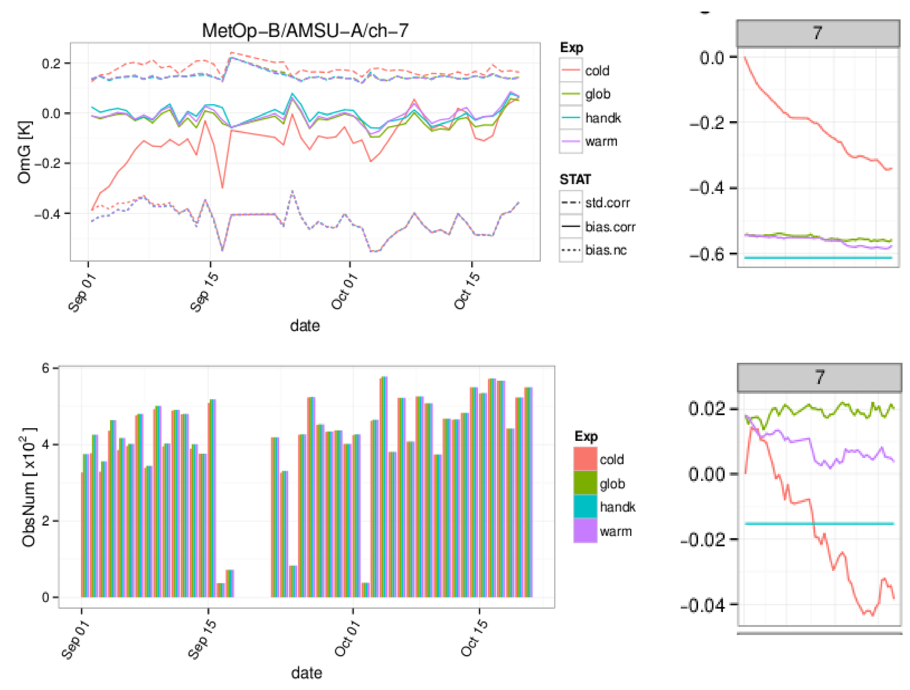
RMSE-BIAS verification for T2m and RH2m forecasts of AROME downscaled (red) and of AROME OI_main (green).



SEDI verification for precipitation forecasts of AROME downscaled (red) and of AROME OI_main (green).

Comparison of different VARBC initialization methods

Two VARBC initialization methods (coldstart and warmstart) in comparison with two different references (the use of global VARBCs and so called Harris and Kelly method) were studied in order to determine which approach can provide more reliable bias correction for LAM DA. In this study radiance sensors from METOP and NOAA satellites have been taken into account. As an example OMG statistics of AMSU-A channel 7 from Metop-B satellite can be seen on the figure below. Some of the main conclusions are also highlighted, but more details can be read in related LACE report on LACE DA website.



AMSU-A channel 7 OMG bias (corrected and non-corrected), OMG standard deviation on the left and the evolution of predictor 0 (top) and predictor 8 (bottom) on the right.

The conclusions about AMSU-A sensor are the followings.

1) Coldstart

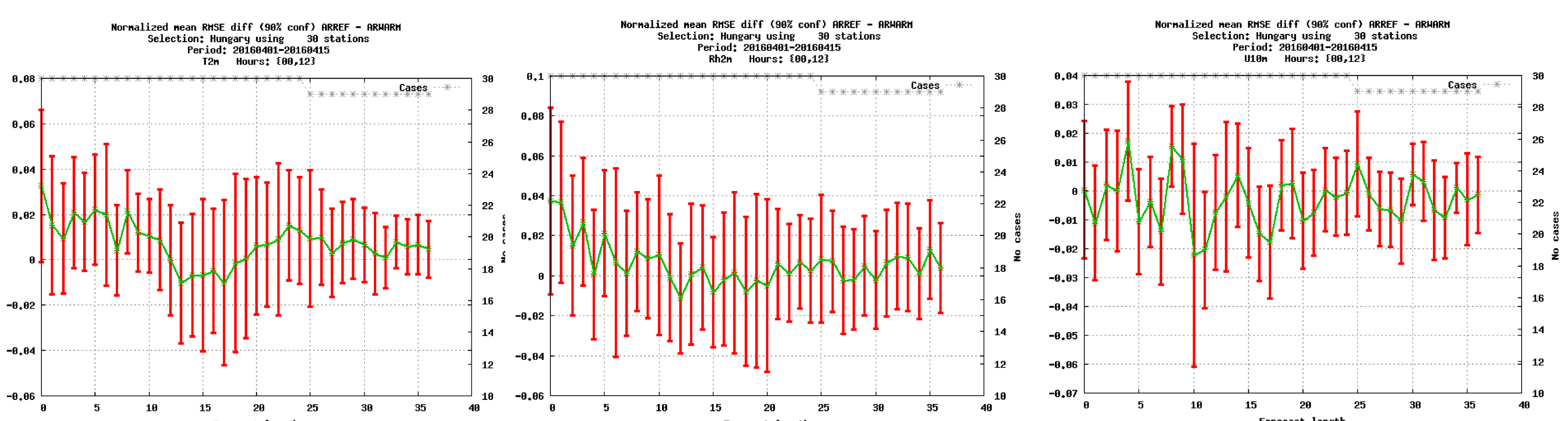
- This approach provides stronger predictor collinearity issues and it is not able to produce reasonable spin-up bias information in case of small observation sample (e.g. AMSU-A ch5 and ch7)
- Some of the bias estimation is not appropriate with respect of global coefficients (e.g underestimation of limb-correction predictors AMSU-A ch8 and ch10)
- The observed STDV of corrected OMG departures is sometimes larger than with the other approaches.

2) Warmstart

- It gives plausible bias correction with the default VARBC settings for AMSU-A lower peaking channels.
- Warmstart (and also coldstart) for AMSU-A higher peaking channels shows too adaptive evolution of bias parameters. The fluctuation of VARBC coefficients in time could be explained by a combination of a larger observation sample and a higher FG error.

Assimilation of radiance observations in AROME 3DVAR

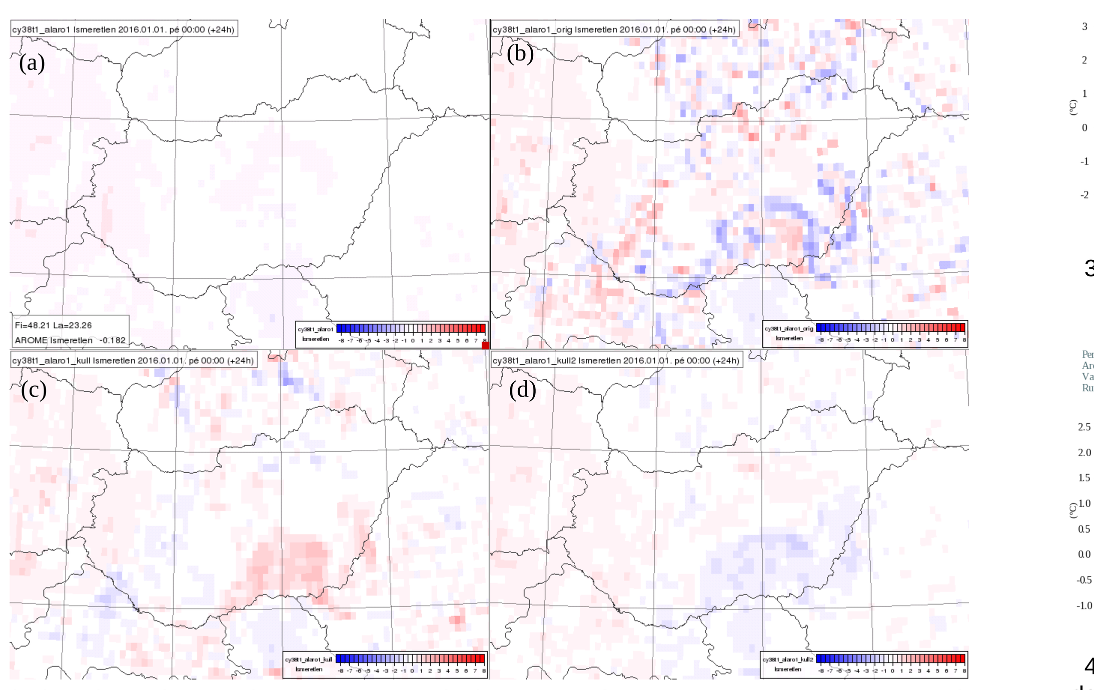
After the comparison of different VARBC initialization methods the forecast impact was also verified. Due to coldstart initialization has been found suboptimal for LAM DA in previous study, this approach has been excluded from the forecast impact investigation. Compared to the reference AROME configuration which employs only conventional observations, AROME 3DVAR with radiance observations from Metop, NOAA and MSG satellites using warmstart VARBC initialization provided mainly neutral impact on forecasts. Some of the verification scores about surface parameters are plotted below.



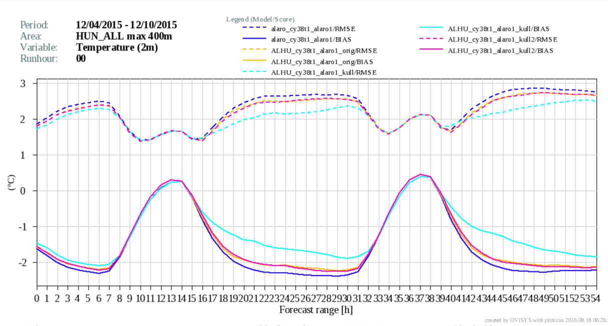
RMSE differences between ARREF: AROME reference (i.e. no satellite observations) and ARWARM: AROME warmstart radiance assimilation for Temperature 2m, Relative Humidity 2m and Wind 10m forecast parameters. The spin-up period of warmstart was started at 10th of March 2016 and active assimilation and forecast verification were started at 1st of April, 2016.

New 2 m diagnostics in ALARO parametrization

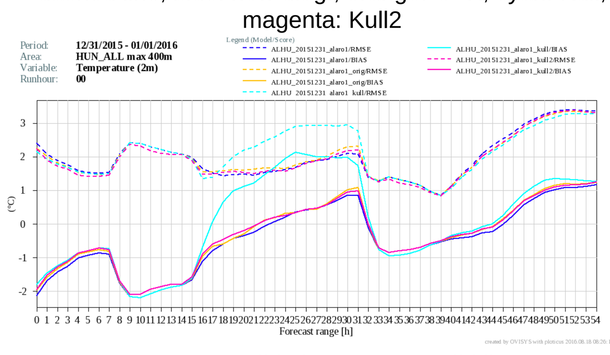
A new 2 m diagnostics was tested and then implemented into the operational ALADIN model at HMS. The new method was developed during a LACE stay by Martin Dian and Ján Mašek. The previous parametrization was a combination of Geleyn's and Kullmann's solution which caused oscillation in the 2 m temperature on calm days at night with clear sky. The new diagnostics sorted out this problem.
During the tests various methods were compared: the Kullmann solution (Kull), the upgraded Kullman solution (Kull2), the Geleyn + Kullmann solution (G+K) and the new one. The validations were made via a winter and a summer period and a cold winter night case study.
The vegetation thermal coefficient (RCTVEG) of the surface was changed some years ago. This change was revisited and found to be no longer needed.
The new solution have a tuning parameter: ACLS_HS, for what the 1, 3 and 5 values were tried. For winter the ACLS_HS=5 was the best while for summer the ACLS_HS=1 showed to be better. Into the operational ALADIN was then set to ACLS_HS=3 as a middle way.



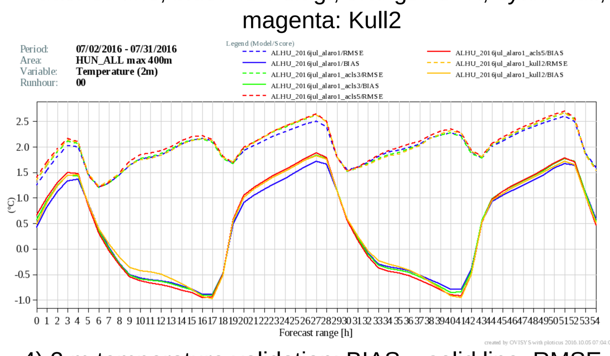
1) The 1 hour change of 2 m temperature in the ALADIN forecast on 01. 01. 2016 00 UTC (+ 24h). according to the ALADIN. Type of 2 m diagnostics: (a) new diagnostics, (b) Geleyn + Kullmann, (c) Kullmann, (d) upgraded Kullmann



2) 2 m temperature validation: BIAS – solid line, RMSE – dashed line; blue: new diag., orange: G+K, cyan: Kull, magenta: Kull2



3) 2 m temperature validation: BIAS – solid line, RMSE – dashed line; blue: new diag., orange: G+K, cyan: Kull, magenta: Kull2



4) 2 m temperature validation: BIAS – solid line, RMSE – dashed line; blue: new diag. ACLS_HS=1, green: new diag. ACLS_HS=3, red: new diag. ACLS_HS=5, orange: Kull2