NWP at the Hungarian Meteorological Service

LACE nwp central europe

ALADIN Numerical Weather Prediction Project

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OMSZ Hungarian Meteorological Service

Operational ALADIN configuration

Main features of the operational ALADIN/HU model

- Model version: CY33T1
- 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
- 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

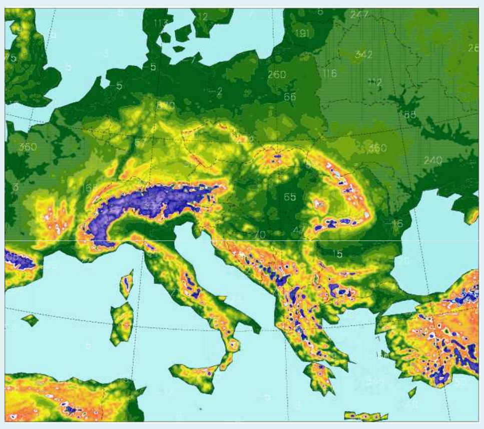
- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Output and post-processing every 15 minutes

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 32 processors
- Post-processing
- Continuous monitoring supported by a web based system

The computer system

- SGI Altix 3700
- CPU: 200 processors from which 92 are for NWP (1,5 Ghz)
- 304 Gbyte internal memory
- IBM TotalStorage 3584 Tape Library (capacity: ~ 30 Tbyte)
- PBSpro job scheduler
  (Migration to new IBM computer is ongoing)



The ALADIN/HU model domain and orography

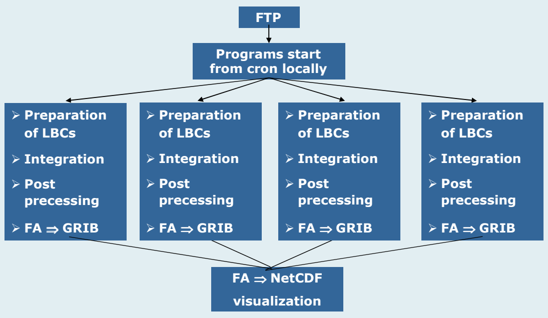
Observation usage

- SYNOP (T, Rh, Ps)
- SHIP (T, Rh, Ps, 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, together with a special filter (that allows only one profile in one thinning-box)
- Variational Bias Correction for radiances
- AMV (GEOWIND) data (u, v)
- Wind Profiler data (u, v)
- Web-based observation monitoring system

Operational ALADIN EPS 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 PEARP ensemble system (LBCs every 6 hours).
- The LAMEPS is running once a day, starting from the 18 UTC analysis, up to 60 hours.
- The horizontal resolution is 12 km, the number of vertical levels is 46 (hybrid coordinates).
- The forecast process starts every day at 23:00 UTC and finishes around 04:00 UTC.



Schematics of the LAMEPS system. Ensemble members are organized into 4 groups, each group running independently from the other groups until the preparation of the NetCDF files, which is done in one go for all members.

Pre-operational AROME configuration

Main features of the AROME/HU model

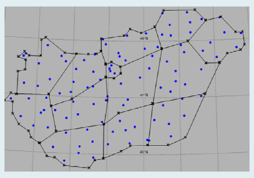
- Model version: CY33T1
- 2.5 km horizontal resolution (300*192 points)
- 60 vertical model levels
- Four production runs a day: 00 UTC (36h); 06 UTC (6h); 12 UTC (18h); 18 UTC (6h) (The 06 and 18 UTC forecasts are only used to cycle the hydrometeors.)
- Initial conditions: from ALADIN/HU (with PREP_REAL)
- 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 run the AROME model over Hungary on daily basis since November 2009. The model performance is evaluated regularly (subjectively and objectively) by our NWP group and the forecasters group. Moreover it is compared with other available models (ALADIN, ECMWF and the competing non-hydrostatic models).

As a general conclusion, our experience is that the AROME model gives the best temperature and windgust forecast. It improves significantly the low level cloudiness as well. However regarding the precipitation forecast it doesn't give much improvement with respect to ALADIN. We have noticed too many and too intensive convection in some of the cases, which problem is going to be addressed in the near future (see below).

The objective evaluation is based on domain averaged score calculation. The verification domain is divided into 13 subdomains. Over each subdomain the average of the observations and the model field is compared. Two forecast periods are taken into account: daytime (06-18 UTC) and nighttime (18-30 UTC).

		Temp BIAS	Temp RMSE	Wspeed BIAS	Wspeed RMSE	Wgust BIAS	Wgust RMSE	Cloud BIAS	Cloud RMSE	ETS >2mm	POD >2mm	FAR >2mm
daytime	AROME	**0.03**	**1.51**	0.54	0.96	1.51	**1.21**	**2.68**	0.75	0.42	0.75	0.35
	ALADIN	-1.16	1.92	**0.24**	0.86	-1.20	2.53	2.11	0.90	0.41	0.66	**0.33**
	ECMWF	-0.42	1.66	0.70	**0.71**	**0.41**	2.11	-0.12	**0.70**	**0.45**	**0.79**	0.36
nighttime	AROME	**0.73**	1.41	0.92	**1.20**	0.70	2.36	**0.31**	1.15	0.31	0.47	0.30
	ALADIN	1.59	2.08	0.88	1.25	**0.02**	2.50	0.33	1.18	0.28	0.42	0.30
	ECMWF	1.42	**1.24**	1.02	1.31	0.37	**2.33**	-0.38	**1.13**	**0.43**	**0.64**	**0.29**



Verification domain.

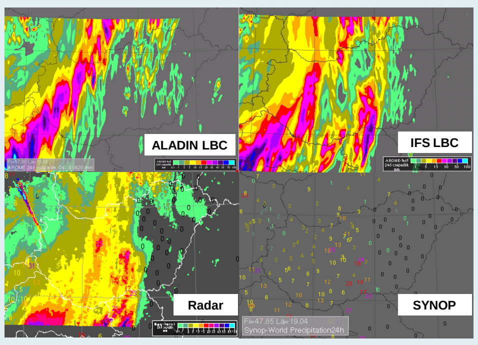
Verification of AROME based on the domain averaged objective scores. Comparison with other models. Period: May-August, 2010.

AROME runs with direct ECMWF/IFS coupling

At the Hungarian Meteorological Service the impact of the choice of the driving model on the performance of AROME was investigated on several case studies with a focus on precipitation forecasts. AROME was either coupled to ALADIN as it is done in the pre-operational suite (further referred to as the "al-bc" run), or lateral boundary conditions directly from the IFS model of ECMWF were used ("ec-bc" run). Due to the large differences between the surface schemes of ALADIN and IFS the surface initial conditions were always taken from ALADIN. For the AROME runs no additional data assimilation was performed, initial conditions were interpolated from the driving model. The coupling frequency was always three hours. In the experiments the model version CY33T1 was applied. The experimental model domain was larger than the pre-operational AROME domain and covered the whole Carpathian Basin. In the following, two case studies are presented and the AROME precipitation forecasts are evaluated with Radar and SYNOP measurements.

30th July 2010

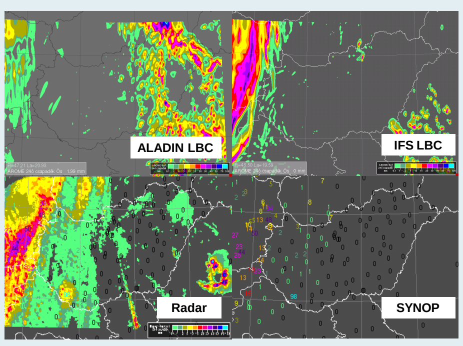
On this day the weather situation over the Carpathian Basin was characterized by a frontal system approaching from west, causing large daily precipitation sums. The IFS model was successful in forecasting the location and intensity of this precipitation, while the ALADIN model gave the location too far to the west (not shown). The two AROME runs show the same characteristics as the driving models. The "al-bc" run simulates large amounts of precipitation to the west of the country, and gives no precipitation to the south. The "ec-bc" run was more successful in predicting both the location and the intensity of this precipitation event.



24 hour precipitation sums for 06 UTC on 31st July 2010. Upper left: AROME run with ALADIN LBCs; upper right: AROME run with ECMWF/IFS LBCs; lower left: Radar; lower right: SYNOP measurements.

14th August 2010

This case was determined by a weakening anticyclone, which caused hot summer weather in Hungary. Until the late evening hours no precipitation was observed in the country. This was well forecasted by IFS, however, ALADIN simulated middle strength showers over Eastern Hungary the whole afternoon (not shown). Again, the AROME runs were strongly influenced by the driving model. The "ec-bc" run gave practically no precipitation over the country, while the "al-bc" run developed a strong chain of thunderstorm over the eastern part.



24 hour precipitation sums for 06 UTC on 15st August 2010. Upper left: AROME run with ALADIN LBCs; upper right: AROME run with ECMWF/IFS LBCs; lower left: Radar; lower right: SYNOP measurements.

Conclusions

Based on the case studies analyzed at HMS for summer 2010 it can be concluded that the precipitation forecasts of AROME are strongly influenced by the lateral boundary conditions even if the experimental domain was relatively large. For the cases investigated, the AROME runs using LBCs from IFS gave better precipitation forecasts.

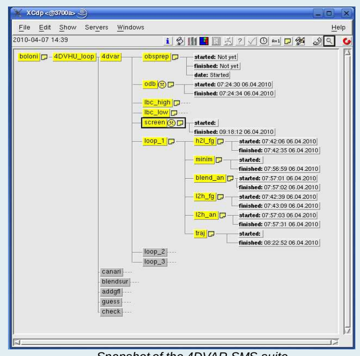
ALADIN 4DVAR prototype at HMS

A prototype 4DVAR system of the ALADIN model has been set up first in France and then in Sweden, which was adapted to the Slovenian and Hungarian computer platform in late autumn 2009. Our starting point was the Slovenian SMS environment used for their 3DVAR system, which was then completed with the additional elements needed for 4DVAR:

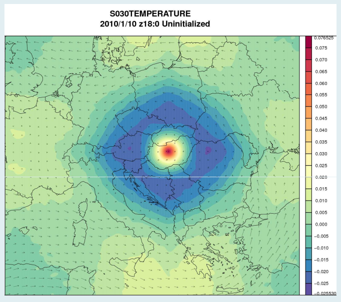
- Grouping of the observations in time-slots (1 hour slots from –0:30 min to +0:30 min) within the assimilation window
- 4D screening: this enables the computation of obs-model differences for each time-slot according to a 4D model trajectory as well as the quality control of observations
- Interpolation of the 4D model trajectory to a low resolution model geometry (to enable a cheaper 4D minimization)
- 4D variational minimization: this step provides the analysis increment by combining the 4D model trajectory with the observations available in the assimilation window (it includes a 6h TL/AD model integrations about 15 times)
- Interpolation of the low resolution analysis and low resolution (truncated) first guess to high resolution
- Trajectory run: it updates the observational departures on high resolution with respect to the new model state updated by the previous minimization. This step also provides an updated non-linear trajectory that can be used as reference for a new linearization (in the TL model and its AD).
- Surface blending: after the low resolution minimization, surface and soil fields are copied from the first guess (rather than using the surface fields provided by the simplified TL/AD runs)
- Outer loops: the steps above (from „4D screening" till „Surface blending") are organized into a loop, which is usually called „outer loop". This enables the a multiple linearization around the updated trajectories.

The Hungarian prototype was run on the operational domain (see the details on the top-left panel) and was completed with a low resolution geometry for the inner loop minimizations (~16km resolutions). Mostly single observation experiments were studied for validation. On the figures below the increments of one temperature observation above Budapest (at around 1000 hPa) are plotted. Full observation tests were also run afterwards in order to check the consumption of 4DVAR. Some conclusions from the validation experiments follow below:

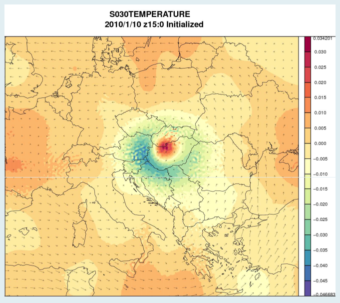
- In comparison with 3DVAR an increased anisotropy of 4DVAR analysis increments can be found as well as differences in the magnitude of the increments
- The CPU consumption is drastically higher in case of 4DVAR compared to 3DVAR (~20-30 times more in single observation experiments)
- In single observation 4DVAR experiments the problem of biperiodic increments seems to be even more annoying than in 3DVAR. Namely, when one plots the time propagation of the increment within the assimilation window, the fake increments on the borders have an important contribution to the overall picture



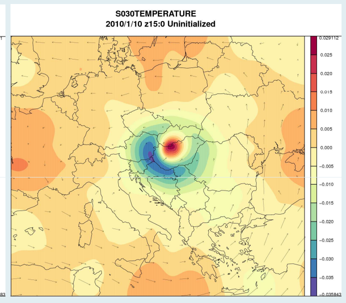
Snapshot of the 4DVAR SMS suite



3DVAR temperature analysis increment on model level 30 (~ 700 hPa) due to a temperature observation at ~1000 hPa



4DVAR temperature analysis increment (high resolution) on model level 30 (~ 700 hPa) due to a temperature observation at ~1000 hPa



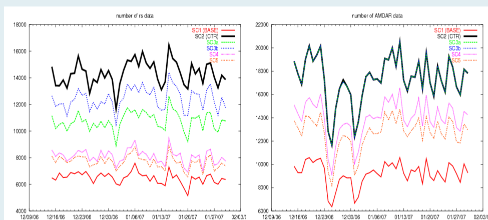
4DVAR temperature analysis increment (low resolution) on model level 30 (~ 700 hPa) due to a temperature observation at ~1000 hPa

EUCOS Upper Air Network Redesign

Observing System Experiments have been performed for the evaluation of thinned European radiosonde and AMDAR scenarios. The main objective of the study was to provide input for the definition of a European-wide network of ground-based upper-air observing systems with special emphasis on regional aspects. The former space-terrestrial EUCOS study indicated that the radiosonde and aircraft vertical profiles play important role with respect to the satellite observations for regional numerical weather prediction. This study concentrated on the possible refinement of the upper-air measurement network (radiosonde and aircraft data) regarding their optimal spatial and temporal distribution. Six different observation scenarios were specified, starting from the full operational data usage (control scenario) and ending with a baseline scenario, which is characterised by radical decrease of the number of radiosonde and aircraft profiles. The intermediate scenarios are focusing on the different thinning distances for the radiosonde and aircraft data with step-by-step degradation of their quantity. The scenarios are defined as follows:

Control scenario (scenario Sc2): Full operational observation coverage.
Scenario Sc3a: The radiosonde network is slightly reduced with a 100 km thinning distance, all aircraft data and the full remaining part of the observation network.
Scenario Sc3b: Like Sc3a, but no thinning is performed for the 00 UTC radiosonde profiles.
Scenario Sc4: Like Sc3a but 250 km thinning distance for radiosondes and aircraft data.
Scenario Sc5: Like Sc4, but 500 km thinning distance.
Baseline scenario (Scenario Sc1): GUAN radiosonde network, flight level aircraft data, aircraft profiles of less than 3 hourly visited airports and full remaining part of the observation network.

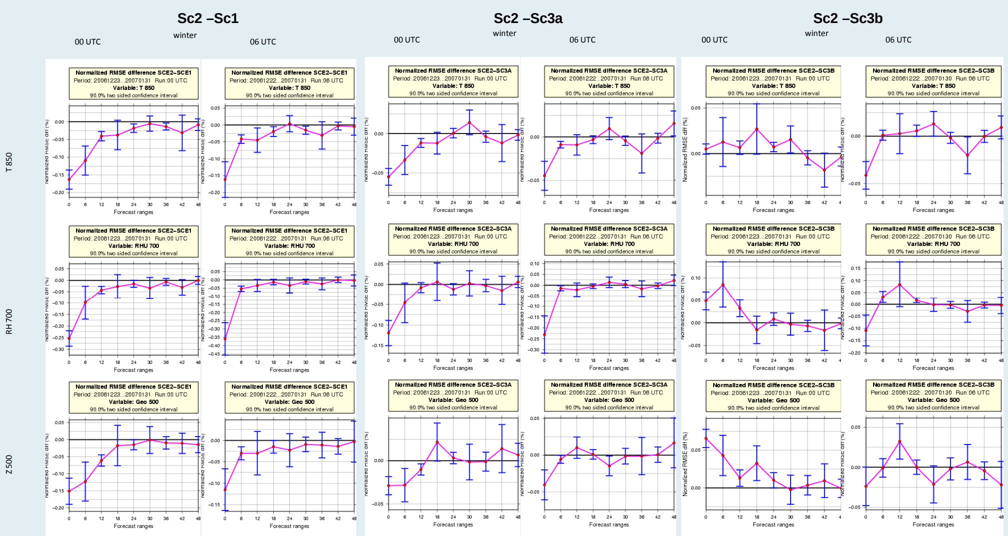
The difference between the radiosonde and aircraft observation usage can be seen on the figures below, where the amount of active data is displayed for each scenario (for the winter period). It can be seen that the control scenario is using more than double (rather 2,5 times more) amount of radiosonde and roughly double aircraft data with respect to the baseline scenario (these are the two extreme scenarios) and the intermediate scenarios are situated between these two extremes.



Number of daily observations (temperature, wind, geopotential and humidity for radiosondes and temperature and wind for aircrafts) assimilated into the ALADIN/HU model by the six winter scenarios for radiosondes and for aircraft easurements.

Experimental design:
- ALADIN/HU model (cy30)
- Experiment period: two 6-week periods (winter 2006/2007 and summer 2007)
- Analysis: 6 hourly (as operational)
- Forecast: 2 runs daily (00 UTC and 06 UTC)

Verification
- against observations (SYNOP and TEMP)
- winter and summer period: 00 and 06 UTC runs separately
- significance tests of RMSE differences were performed
- all the scenarios were compared to the control scenario (Sc2).



Normalized RMS error differences over Europe for winter for the parameters: 850 hPa temperature, 700 hPa relative humidity and 500 hPa geopotential height. The runs were started from the 00 UTC or 06 UTC initial time. Vertical bars represent significance on 90 percent confidence level. Left: comparison of the Control (Sc2) and baseline (Sc1) scenarios, Middle: comparison of the Control (Sc2) and Sc3a, Right: comparison between the Control (Sc2) and Sc3b

Conclusions

- The most sensitive variables to the thinning of radiosonde and AMDAR data are Temperature 850 hPa and Relative Humidity 700 hPa
- 00 UTC forecasts are more impacted than 06 UTC runs
- The thinning of radiosonde data has more influence in winter
- Scenario 4 and 5 show an important degradation compared to Scenario 2 (Control run)
- As regards scenario 3a and 3b, the degradation is rather small (compared to the Control)
- The degradation is the smallest for Scenario 3b (there is even some improvement compared to the Control) where the 00 UTC radiosondes are kept unthinned. Therefore, according to our results Scenario 3b is the one and only acceptable solution for a possible future upper air network redesign.