NWP at the Hungarian Meteorological Service

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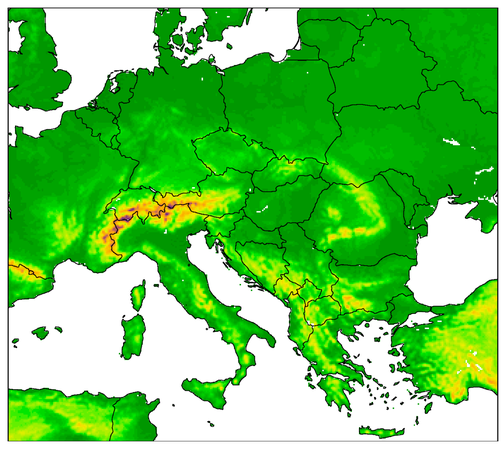
Operational configurations

ALADIN/HU

- Model version: CY40T1 (ALARO-v1b physics)
- Local data assimilation:
  - 3D-Var (upper air), optimal interpolation (surface)
  - 6-hour assimilation cycle
  - Short cut-off analysis for the production runs
  - Downscaled ensemble background error covariances
- Digital filter initialisation
- 4 runs per a day:
  00 UTC (60h); 06 UTC (48h); 12 UTC (60h); 18 UTC (36h)
- 3 hourly lateral boundary conditions (LBCs) from ECMWF-HRES
- Forecast settings:
  - Linear spectral truncation, 8 km horizontal grid resolution (Lambert projection), 49 vertical levels
  - Two-time level SISL advection scheme: 300 s time step
  - Hourly outputs

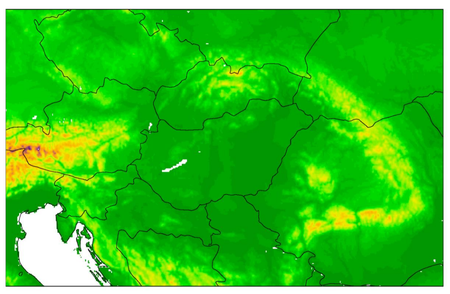


Operational ALADIN/HU model domain

AROME/HU

- Model version: CY40T1
- 2.5 km horizontal resolution (500 x 320 points), 60 vertical levels (preparatory work for 90 levels; see details on the right)
- Data assimilation:
  - 3D-Var (upper air), OI_main (surface)
  - 3-hour assimilation cycle
  - Lake temperature initialized from measurements at Lake Balaton
  - Hydrometeors & snow cycled trough data assimilation cycle
  - Experiments for hourly rapid update cycle (see on the right)
- Initialization: space-consistent coupling (no DFI)
- 8 runs per a day:
  00 UTC (48h); 03 UTC (36h); 06 UTC (48h); 09 UTC (36h);
  12 UTC (48h); 15 UTC (36h); 18 UTC (48h); 21 UTC (36h)
- LBCs from ECMWF-HRES with 1h coupling frequency
- SBL scheme over nature & sea to calculate the screen level fields
- Hourly outputs for forecasters, special outputs in every 15 minutes for commercial users & the hail prevention system

Assimilated observations	
ALADIN/HU	AROME/HU
• SYNOP (u, v, T, RH, z) • SYNOP-SHIP (u, v, T, RH, z) • TEMP (u, v, T, q) • AMDAR (u, v, T) • ATOVS (AMSU, MHS radiances) • MSG/GEOWIND (AMV) • MSG (SEVIRI radiances)	• SYNOP (u, v, T, RH, z) • TEMP (u, v, T, q) • AMDAR (u, v, T, humidity) • Slovenian Mode-S MRAR • GNSS ZTD



Operational AROME/HU domain

Limited area ensemble system

- 11 ensemble members using ALADIN
- Downscaling, no local perturbations
- Initial conditions and 3-hourly LBCs from ECMWF EPS
- One run per a day, from 18 UTC up to 60 hours
- Resolution, physics etc. as in ALADIN/HU
- Probabilistic products for energy suppliers to warn them on high-impact weather events
- Parallel suite: convection-permitting 11-member ensemble up to 48h with AROME at 2.5 km resolution (see details on the right)

Computer system and technical aspects

- HPE Apollo 6000 server (migration in April 2019)
- 72 Intel XeonE5-2698 (2.2 GHz, 20 cores) processors, 2 CPU/node
- 128 GB RAM/node
- Maui 3.3.1 job scheduler, Torque 6.1.2 queue manager
- Transfer of IFS LBCs from ECMWF via Internet, ARPEGE LBCs (as backup) from Météo France via Internet & ECMWF re-routing
- AROME data assimilation on 40, model integration on 160 processor cores
- Continuous supervision & monitoring in a combined SMS & web based system

Operational Preprocessing for LACE (OPLACE)

- Real-time pre-processing of observations for data assimilation
- General data handling (fetching, partition, uploading), quality control, format conversions, derived products, monitoring
- Hosted by OMSZ since 2009
- Currently provides surface synoptic data, upper-air sounding, wind profiler, aircraft observations, remote sensing data, such as radiances, atmospheric motion winds, and sea wind measurements
- RC-LACE NHMSs exchange their dense national surface synoptic measurements and high-resolution aircraft Mode-S MRAR data in real time in OPLACE
- Data are available on the FTP server of OMSZ for LACE countries
- Also for non-LACE countries in framework of a special agreement
- Further details in *Trojáková et al.* (2019)

Observation types, satellite sensors and data formats available in OPLACE

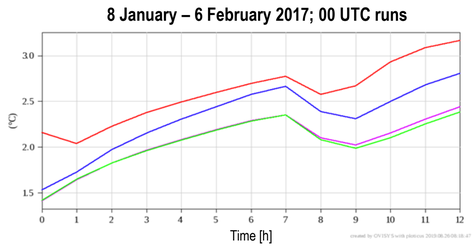
Observations	Type/Satellite sensor	Platform	Input format	Output format
Surface synoptic	SYNOP, SHIP, BUOY		ASCII, BUFR	OBSOUL
Aircraft	AMDAR, ACARS		BUFR	OBSOUL
Upper-air sounding	TEMP, TEMP MOBIL		ASCII, BUFR	OBSOUL
Wind profiler	E-PROFILE		BUFR	BUFR
Atmospheric motion vectors	GEOWIND, HRWIND	Meteosat 10/11	BUFR	BUFR
Satellite radiances	SEVIRI	Meteosat 10/11	HRIT	GRIB
	AMSU-A/B, MHS	NOAA 18/19	BUFR	BUFR
	HIRS, IASI	METOP-A/B		
	ATMS	SNPP		
Ocean/sea winds	ASCAT	Metop-A/B	BUFR	BUFR

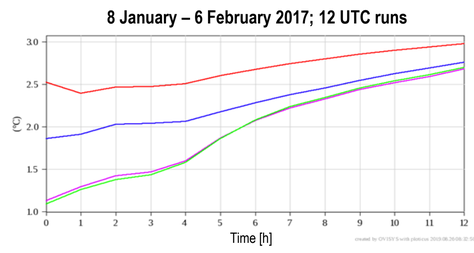
Reference:

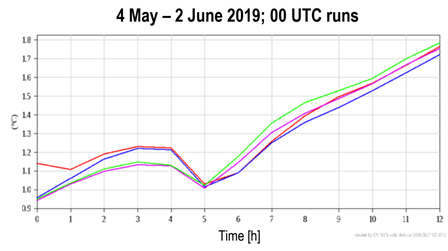
Trojáková, A., Mile, M., Tudor, M., 2019: Observation Preprocessing System for RC LACE (OPLACE), Adv. Sci. Res. 16, 223–228, https://doi.org/10.5194/asr-16-223-2019

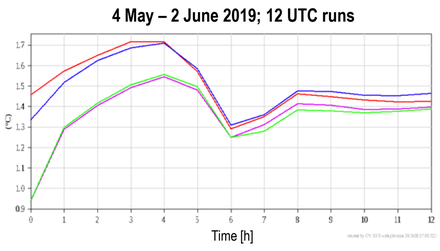
AROME 1 hourly rapid update cycle experiments

- Experiments using operational AROME configuration
- 30-minute cut-off time in 1 hourly RUC
- Model runs at 00, 06,12 and 18 UTC up to 12 hours
- Impact of 1, 3 and 6 hourly surface data assimilation frequencies
- Periods:
  - 8 January – 6 February 2017 (extremely cold)
  - 4 May – 2 June 2019 (extremely rainy)
- Assimilation cycle started 6 days before the forecast
- Spin-up time examination with ECHKEVO diagnostics: less than one hour model spin-up for both periods
- Conclusions:
  - AROME_1hourly performed better than AROME_3hourly for 2-metre temperature (graphs)
  - Higher accuracy with reduced surface assimilation frequency
  - Bigger difference between the performance of configurations in January comparing to May
  - No significant difference in precipitation between the configurations (table)









AROME_3hourly:
operational AROME settings

AROME_1hourly:
1 hourly 3D-Var & surface data

AROME_combo_1hourly_surf3:
1 hourly 3D-Var & 3 hourly surface data

AROME_combo_1hourly_surf6:
1 hourly 3D-Var & 6 hourly surface data

	00 UTC				06 UTC			
	5%	10%	20%	50%	5%	10%	20%	50%
AROME_3hourly	0,282	0,391	0,570	0,992	0,382	0,475	0,666	1,037
AROME_1hourly	0,276	0,365	0,506	1,075	0,297	0,454	0,666	1,026
AROME_combo_1hourly_surf3	0,274	0,373	0,578	1,117	0,325	0,492	0,652	1,051
AROME_combo_1hourly_surf6	0,261	0,410	0,570	1,128	0,369	0,484	0,655	1,016
	12 UTC				18 UTC			
	5%	10%	20%	50%	5%	10%	20%	50%
AROME-3hourly	0,366	0,447	0,665	1,096	0,357	0,534	0,684	1,157
AROME-1hourly	0,358	0,450	0,625	1,052	0,379	0,514	0,768	1,216
AROME-1hourly_surf3	0,307	0,424	0,648	1,094	0,369	0,484	0,643	1,159
AROME-1hourly_surf6	0,302	0,442	0,647	1,111	0,314	0,446	0,642	1,216

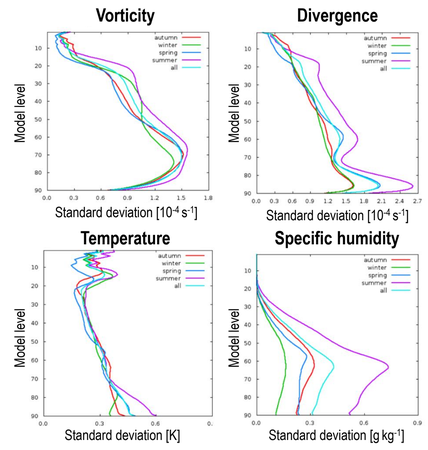
Graphs: 2-metre temperature RMSE [°C] for two periods

Table: SAL central statistics, radius covering a given percentage (5%, 10%, 20%,50%) of cases. Lower radius values indicate better performance on precipitation forecasts (highlighted in green)

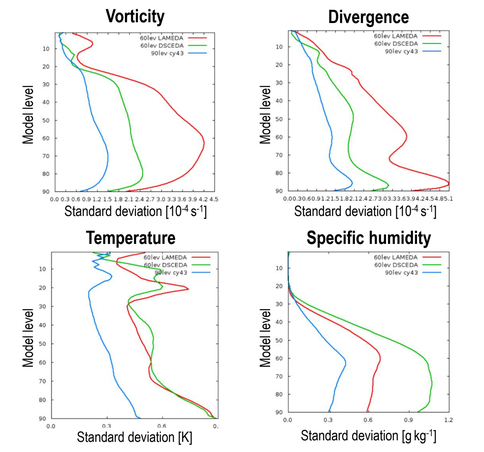
New background error covariance matrix for AROME

In wintertime we experienced some instabilities in our 60-level operational AROME due to the high model top. In the cases of model crash, AROME ran with 90 levels successfully. Our new HPC makes it possible to increase the number of vertical levels to 90 levels, however, we need to compute a new B-matrix for the data assimilation.

- Main goal: to use ensemble data assimilation (EDA) technique to compute background error statistics
- A first guess of B-matrix is needed → first an ensemble run with dynamical adaptation (spinup B-matrix):
  - Period: four 2-week periods from each season from April 2018 → possibility for seasonal B-matrix
  - Forecasts: 4 members at 00 UTC and 12 UTC
- Conclusion: the biggest difference between the seasons in the standard deviation for summer humidity → big impact also on the overall B-matrix



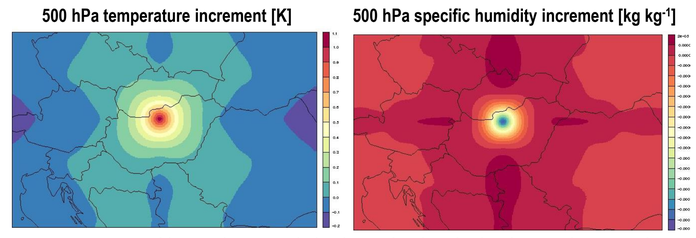
Seasonal and joint vertical profiles of standard deviation



Vertical profiles of standard deviation in the previously computed downscaled B-matrix, EDA B-matrix using 60 levels, the downscaled B-matrix using 90 levels. (Because of the different number of the vertical levels, 60 levels were multiplied by 1.5 to plot the statistics on the same graph.)

New vs. previous B-matrix (using 90 and 60 levels, respectively)

- First a spinup B-matrix with dynamical adaptation, then EDA experiment → statistics from both experiments
- Important difference: previously statistics computed from 6-hour forecast, now only 3-hour forecast differences were used (because of the 3-hourly operational data assimilation)

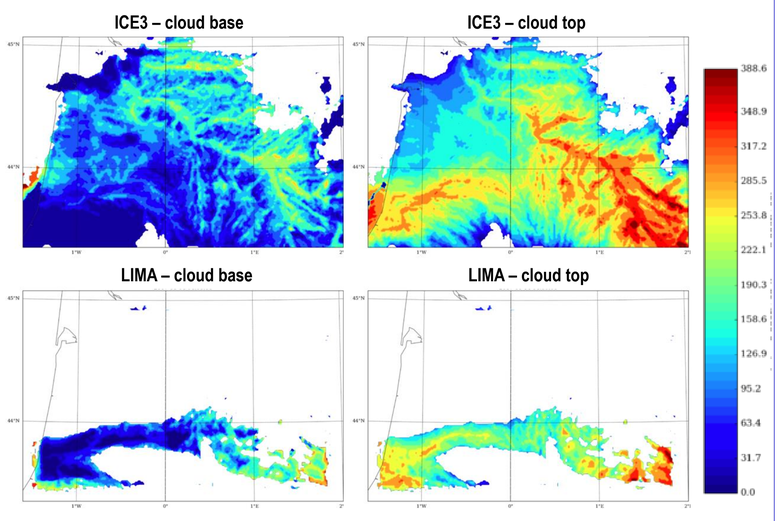


Homogeneous and isotropic B-matrix is shown by the single observation experiment

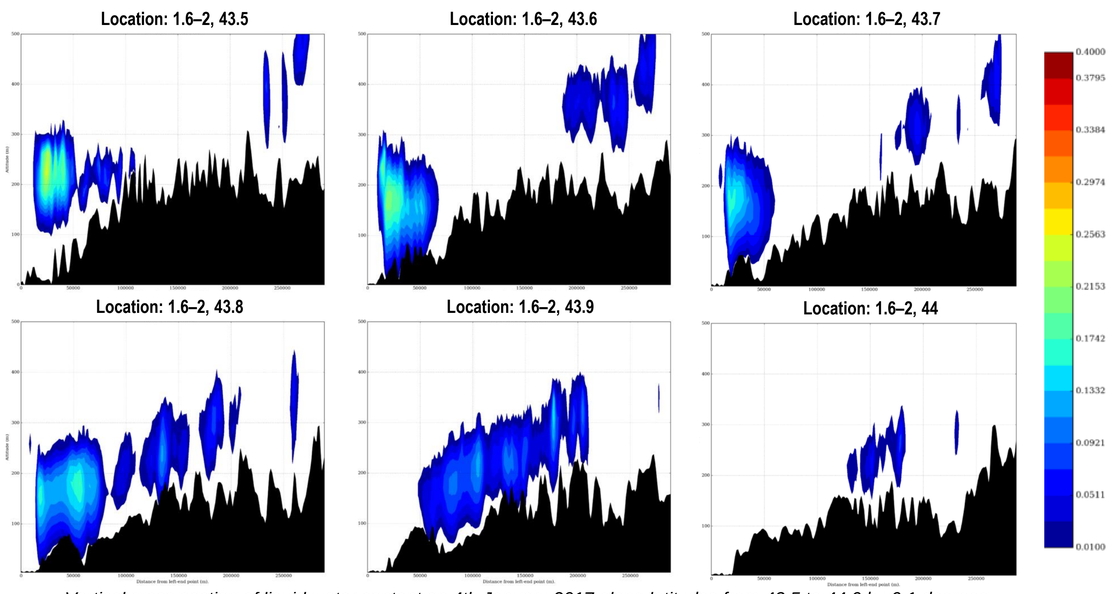
Sensitivity tests in fog cases with LIMA microphysical scheme

LIMA (Liquid Ice Multiple Aerosols) scheme is a two-moment microphysical scheme and was developed in MESO-NH to improve modelling of the complex aerosol–cloud interactions. Its implementation in AROME is under testing.

- First test at 1250 m horizontal resolution & 90 levels
- Area: Garonne valley
- Fog case: 4 January 2017
- Some modifications of LIMA with the radiation scheme using the number concentrations from the LIMA scheme
- Based on the Kunkel scheme, cloud base and cloud top was calculated from LWC values (results from the runs with ICE3 and LIMA in figures on the right)
- LIMA underestimates the cloud amount, especially in the northern part of the domain



Cloud base and cloud top fields on 4th January 2017 from ICE3 and LIMA runs

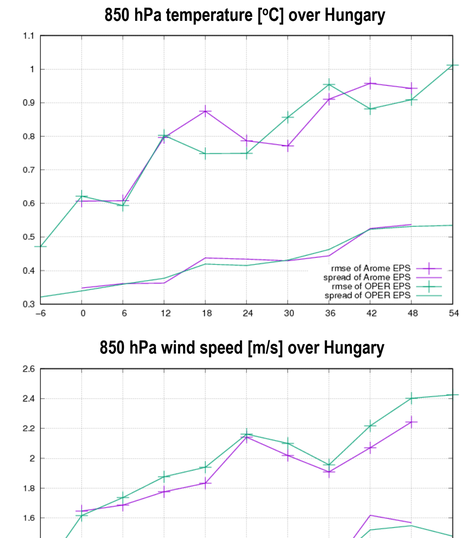


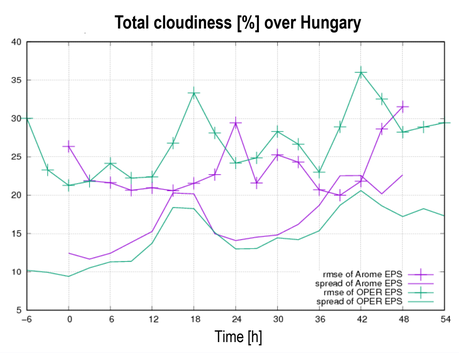
Vertical cross section of liquid water content on 4th January 2017 along latitudes from 43.5 to 44.0 by 0.1 degrees

New AROME ensemble suite

To satisfy forecasters' request for a better resolution ensemble, we developed a convection-permitting limited area ensemble system based on AROME running on our new HPC.

- Main characteristics:
  - 11-member forecast coupled 3 hourly to 18 UTC ECMWF ENS
  - 2.5 km horizontal resolution and 60 vertical levels over the AROME domain (see in the box about operational configurations)
  - Time range: from 00 UTC up to 48 hours
  - No data assimilation, upper air fields from LBC, initialization of hydrometeors and surface analysis from „deterministic" AROME
- Test version available for forecasters since May 2019
- Comparison of AROME and ALARO EPS for 28 May – 19 June 2019 (partly dry and warm period, but heavy precipitation induced by convection in a part of Hungary most days); first conclusions:
  - While forecasts of geopotential, wind and cloud parameters clearly improve in AROME ensemble, results for humidity, temperature and precipitation have varying performance (see figures)
- Plans:
  - to examine single ensemble members through verification & case studies
  - to develop new ensemble products (e.g., LAMEPS meteogram) in HAWK visualization system
  - to study the effect of EDA on AROME ensemble forecast through experiments with rising perturbation strength





Figures: spread (–) & RMSE (+) for AROME & ALARO EPS

Verification reference:

ECMWF analysis for upper air parameters (right panels),

surface observations of Hungarian stations for cloudiness (left)