NWP at the Hungarian Meteorological Service

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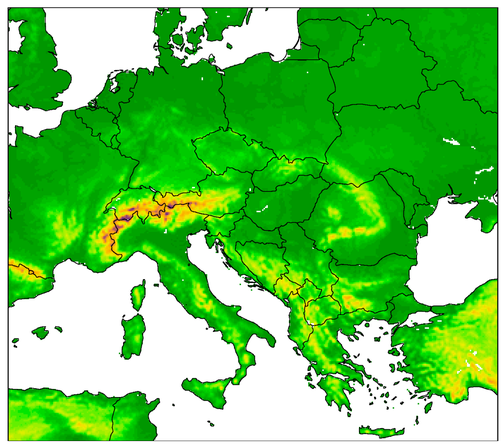
Operational configurations

ALADIN/HU

- Model version: CY40T1 (ALARO-v1b physics)
- 8 km horizontal resolution, 49 vertical levels
- 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 initialization
- 4 runs per a day:
  00 UTC (60h); 06 UTC (48h); 12 UTC (60h); 18 UTC (36h)
- 3 hourly lateral boundary conditions from ECMWF-HRES
- Hourly outputs

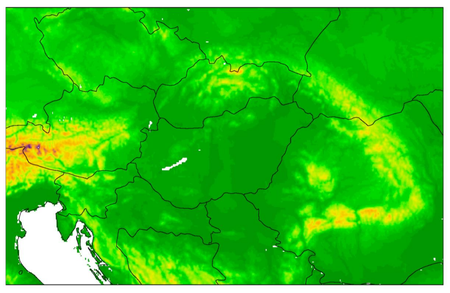


ALADIN/HU model domain

AROME/HU

- Model version: CY40T1
- 2.5 km horizontal resolution, 60 vertical levels
- Local data assimilation:
  - 3D-Var (upper air), OI-main (surface)
  - 3-hour assimilation cycle
  - Lake temperature initialized from measurements at Lake Balaton
  - Hydrometeors & snow cycled through assimilation cycle
- 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, q) • Slovenian Mode-S MRAR • GNSS ZTD



AROME/HU and AROME-EPS domain

Convection-permitting ensemble system

- 11 ensemble members using AROME
- Downscaling, no local perturbations
- Atmospheric initial conditions and hourly LBCs from 18 UTC ECMWF EPS, surface initial condition from 0 UTC AROME/HU
- One run per a day, from 0 UTC up to 48 hours
- Resolution, physics etc. as in AROME/HU
- Backup ALARO suite was stopped in July

Computer system

- HPE Apollo 6000 server
- 40 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, backup ARPEGE LBCs 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
- RC-LACE NHMSs exchange their dense national surface synoptic measurements and high-resolution aircraft Mode-S MRAR data in real time in OPLACE
- Data (see tables on the right) are available on the FTP server of OMSZ for LACE countries
- Also for non-LACE countries in framework of a special agreement

Observations available in OPLACE

Observations	Type/Sensor	Platform
Surface synoptic	SYNOP,SHIP,BUOY	
Aircraft	AMDAR,ACARS	
Upper-air sounding	TEMP,TEMP MOBIL	
Wind profiler	E-PROFILE	
Atm. Motion Vectors	GEOWIND,HRWIND	Meteosat 11
Satellite radiances	SEVIRI	Meteosat 11
	AMSU-A/B,MHS HIRS, IASI ATMS	NOAA 18/19 Metop A/B/C SNPP
Ocean/sea winds	ASCAT OSCAT	Metop A/B/C ScatSat-1

Observations	Obstype number	Type/Sensor	Data provider
Surface synoptic	1	SYNOP, AWS	Austria
			Croatia
			Czech Republic
			Hungary (internal data)
			Slovakia
			Slovenia
			Romania (via GTS)
			Poland
Aircraft	2	Mode-S MRAR	Slovenia
			Czech Republic
		Mode-S EHS	Netherlands (KNMI)
GNSS	1	ZTD	E-GVAP

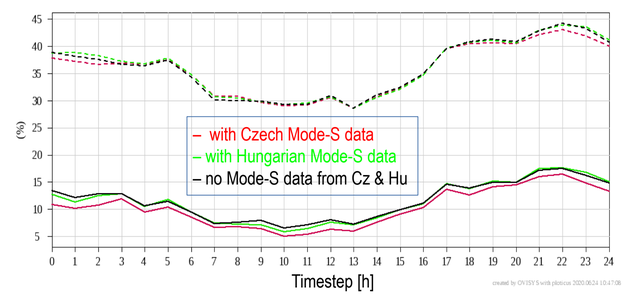
Reference:
Trojáková, A., Mile, M., Tudor, M., 2019: Observation Preprocessing System for RC LACE (OPLACE), Adv. Sci. Res. 16, 223–228, https://doi.org/10.5194/asr-16-223-2019

Impact study for assimilation of Mode-S data

Two experiments were carried out using Mode-S MRAR data from Czech Republic and Hungary. First, only the impact of inclusion of the new data in the assimilation cycle was investigated. The study covered the period from 1 to 19 December 2019.

The Czech Mode-S data were taken from the OPLACE server. The pointwise verification shows a slight improvement for most variables. We plan to extend the analysis with a summer period from 2020.

Cloudiness bias (–) & RMSE (- -) [%] over Hungary in 0 UTC runs of AROME/HU

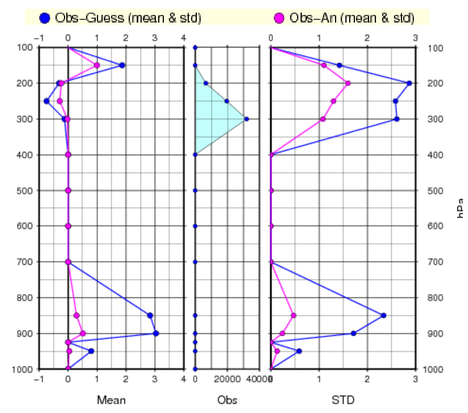


The Hungarian Mode-S data were provided by the Hungarian air traffic controller (HungaroControl) for test purpose. Our preliminary results show, that the accuracy of the AROME/HU forecasts were slightly affected by the raw MRAR dataset. We will extend the test experiments with the Hungarian data to 9 March 2020 and tune the whitelist settings.

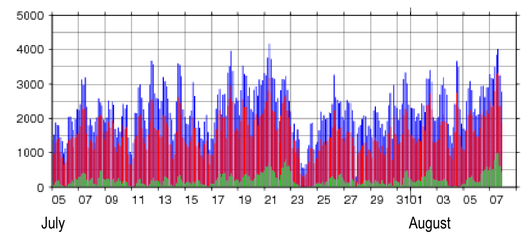
Impact study for assimilation of EUMETSAT AMV & NWCSAF HRW data

Geowind and hrwind data was assimilated from 5 July to 7 August 2019 (when lots of severe convective storms occurred over Hungary). The used AMVs were generated form IR, VIS and WV channels. For thinning and blacklisting we applied the ALADIN/HU settings.

Vertical distribution of active observations



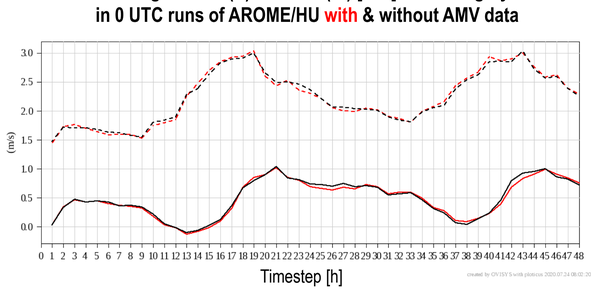
Number of total, rejected & active AMV observations over the AROME/HU domain



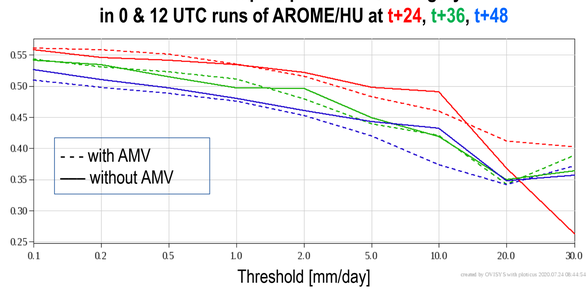
A huge number of observations were blacklisted: data with QI below 85 %, all data over 700 hPa from visible channels, data between 350 and 800 hPa. Active wind vectors were located between 300 and 250 hPa and a few measurements were between 1000 and 850 hPa.

We concluded mostly neutral impact of AMV data on forecasts of near-surface temperature, humidity, wind, surface pressure. A slight positive effect is seen for wind gust. In case of precipitation, a positive impact is detected in days with very small or very large amount.

Wind gust bias (–) & RMSE (- -) [m/s] over Hungary in 0 UTC runs of AROME/HU with & without AMV data



SEDI for 24h precipitation over Hungary in 0 & 12 UTC runs of AROME/HU at t+24, t+36, t+48



Surface assimilation experiments with SEKF

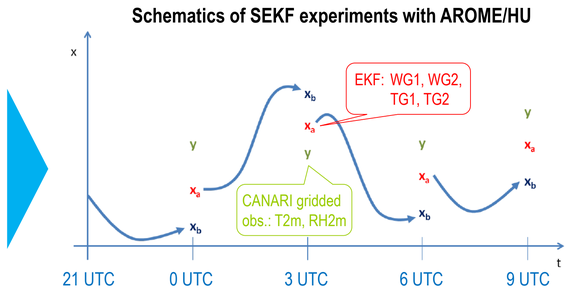
Simplified Extended Kalman Filter (SEKF) surface data assimilation method was validated and tested over Hungary with AROME cy40t1 and SURFEX 7.3.

Experimental set-up:

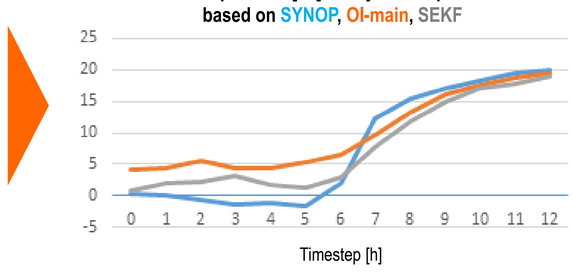
- Date: 0 UTC on 8 April 2020;
- Observations: 2m temperature and relative humidity;
- Control variables: soil temperature and soil moisture;
- 3-hourly assimilation cycle two weeks before to get appropriate first guess for the experiment;
- Forcings to offline SURFEX run from AROME inline forecasts at 9 m.

This permanent anticyclonic period was slightly warm and unusually dry with almost no precipitation in Hungary. The diurnal temperature cycle was overestimated by the operational AROME/HU using OI-MAIN, resulting in an inaccurate 2m temperature analysis. The analysis was improved by SEKF which affected the forecast, too.

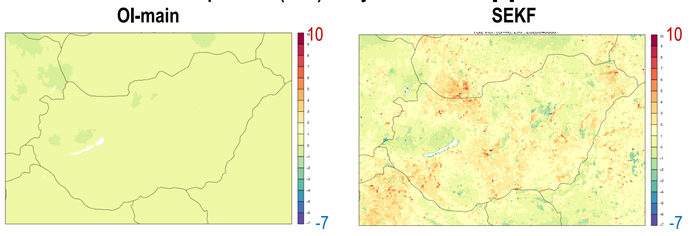
Schematics of SEKF experiments with AROME/HU



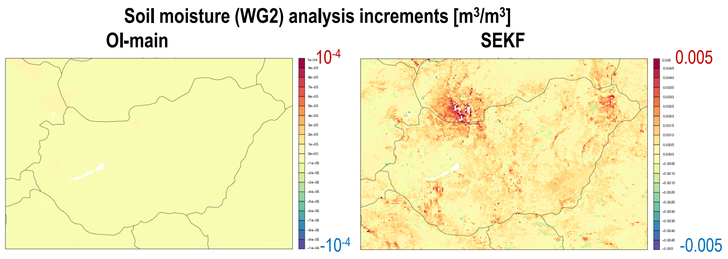
2m temperature [°C] in Baja on 8 April 2020 based on SYNOP, OI-main, SEKF



Soil temperature (TG2) analysis increments [K]



Soil moisture (WG2) analysis increments [m³/m³]

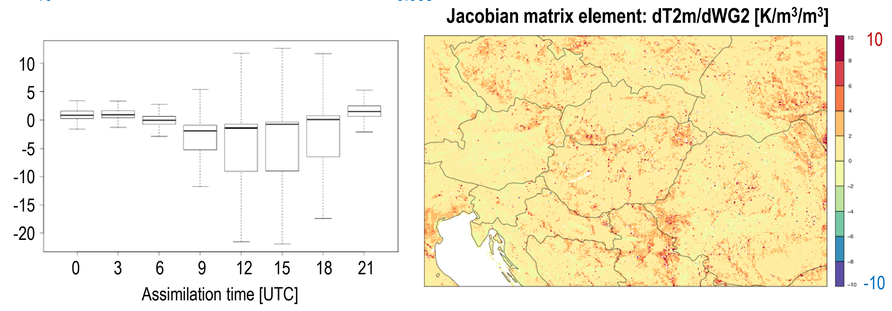


Increments of the control variables are studied to understand the background of the improvement. We concluded that SEKF produced much larger analysis increments for soil moisture and soil temperature (in both layers) than OI-main.

Examining the elements of the Jacobian matrix, the sensitivity of T2m to changes in soil moisture was much higher (especially during daylights) than expected.

We will repeat the case study with cy43t2_bf11 (and SURFEX 8.0). We continue to explore the sensitivity of the screen-level observations to the control variable perturbations.

Jacobian matrix element: dT2m/dWG2 [K/m³/m³]



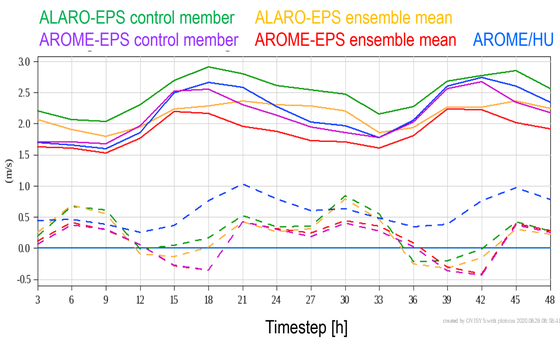
Operational convection-permitting AROME ensemble forecasts

AROME-EPS is operational since February 2020. Results of AROME-EPS and ALARO-EPS were compared for the period between June 2019 and January 2020.

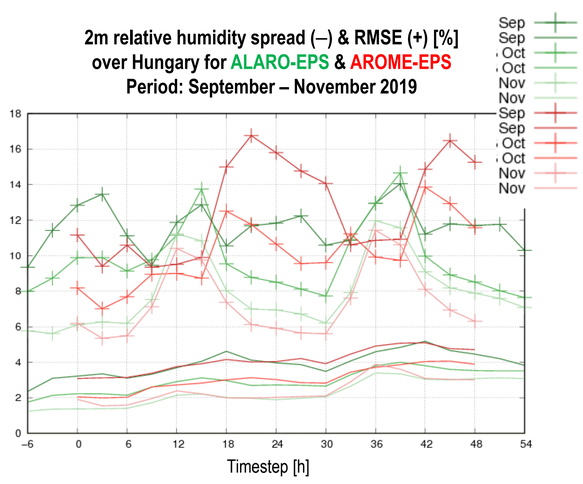
The ensemble mean of AROME-EPS was better for wind gust in all seasons than ALARO-EPS, it outperformed even AROME/HU forecasts in summer (figure on the right). AROME-EPS resulted in lower RMSE for 2m temperature, relative humidity (bottom figures for autumn and winter), total cloud cover in the daytime hours, but higher during the night.

We will continue with ensemble verification using HARP and some object oriented verification for precipitation. Experiments are ongoing to introduce local data assimilation and study the effect of ensemble data assimilation with rising perturbation strength.

Wind gust bias (- -) & RMSE (–) [m/s] over Hungary Period: summer 2019



2m relative humidity spread (–) & RMSE (+) [%] over Hungary for ALARO-EPS & AROME-EPS Period: September – November 2019



2m relative humidity spread (–) & RMSE (+) [%] over Hungary for ALARO-EPS & AROME-EPS Period: December 2019 – February 2020