Working Area Data Assimilation

Progress Report

Prepared by:	Area Leader Antonín Bučánek
Period:	2024
Date:	24/02/2025

Progress summary

The report summarizes the RC LACE DA activities in 2024, with highlights on use of observations, mainly the radar, mode-s and gnss zdt data, implementation/refinement of hourly assimilation systems suitable for NWP-supported nowcasting and surface data assimilation.

The research and development on radar data assimilation has a goal to enhance the realism of modeled precipitation patterns in the initial hours of the NWP forecast. Two scientific stays on radar data assimilation were executed. Several proposals to mitigate the observed drying effect in Bayesian inversion for reflectivity were implemented and validated. At the same time, considerable steps were made to reach and provide a robust solution to radar dealiasing, a prerequisite to be able to use radar Doppler winds from networks that only provide measurements on a low Nyquist interval. Work on assimilation of satellite radiances received more attention after a long time, with activities linked to validation of all-sky approach for certain SEVIRI channels and by studying properties of data to be provided by the future MTG IRS sounder.

After successfully implementing SEKF to their deterministic AROME suite, OMSZ implemented this advanced technique, together with 3D-Var atmospheric assimilation, to the AROME-EPS system. Numerous activities were aimed at improving the surface assimilation, either through tuning of optimal interpolation or adding new observations through the SEKF (moisture, LAI).

Several members approached the implementation of hourly DA systems (RUC) and several aspects of frequent cycling were studied, from observation availability to spin-up and interaction with surface data assimilation.

Last but not least, the first steps were taken to familiarize with the new C++ layer of the ACCORD/ALADIN code, which was earlier successfully ported and used to reproduce the current 3D-Var assimilation. The first technical runs with ensemble variational (EnVar) assimilation are available, but this activity will require considerably larger person power input in the future.

Actions/Subjects/Deliverables

Subject: *Operational implementation of DA systems [COM3]*

Description and deliverables:

An overview of the current operational DA systems in RC LACE countries are presented in the following two tables (yellow colors indicate the system upgrades and additions made in 2024):

Table E1: Operational DA for NWP systems run by RC LACE countries.

DA	AUSTRIA AROME	CROATIA ALARO	CZECH REP. ALARO	HUNGARY ALARO	HUNGARY AROME	SLOVAKIA ALARO	SLOVENIA ALARO
Resol	2.5L90, 600 x 432	4.0L73 480 x 432	2.3L87-NH 1069 x 853	8L49 349x309	2.5L60 490x310	4.5L63 625x576	4.4L87 432 x 432
Cycle	43t2bf11+loc.	43t2bf10	46t1as_op1	cy40t1	cy43t2bf11 migration to cy46t1	cy46t1bf07	43t2bf10
LBC	IFS 1h (lagged)	IFS 1h (lagged)	ARP 3h	IFS 3h (lagged)	IFS 1h (lagged)	ARP 3h	IFS 1h/3h (lagged)
Method	OI_main MESCAN + 3d-Var	OI + 3D-Var + Jk	OI + BlendVar	OI + 3D-Var	SEKF + 3D-Var	BlendVar + OI	OI + 3D-Var
Cycling	3h	3h	3h	6h	3h	6h	3h
B matrix	EDA on C-LAEF	EDA	EDA	EDA	EDA	Downscaled AEARP	Downscaled ECMWF ENS
Initiali-zation	No (SCC)	No (SCC)	IDFI in pro-duction, SCC	DFI	No	No	No (SCC)
Obs.	Synop + AS, Amdar/MRAR /EHS-EU, AMV, Temp, ASCAT, Snow-grid/MODIS, snowmask, Ceilometer	Synop, Amdar/MRAR, AMV, Temp, Seviri, Radar RH (OPERA),	Synop + AS, Amdar/MRAR /EHS-EU, HRW, Profiler, Temp, ASCAT, Seviri	Synop + AS, Amdar, AMV, Temp, Seviri, AMSUA/MHS,	Synop + AS, GNSS ZTD, Amdar/MRAR, Temp, AMV+HRW,	Synop + AS TEMP HRW AMDAR + Mode-S	Synop + AS Amdar/MRAR/ EHS, AMV, Temp Seviri, AMSUA/MHS/ IASI, ASCAT/OSCAT, E-GVAP ZTD (passive)
Cut-off (prod / assim)	1:45h					2:35 / 7:45h	2:15 / 4:00h

Table E2: Operational DA for NWP-based nowcasting systems at hourly scale run by the RC LACE countries.

DA	AUSTRIA AROME RUC	CZECH REP. VarCanPack	SLOVENIA ALARO-RUC
Resol	1.2L90 900 x 576	2.3L87-NH 1069 x 853	1.3L87 589x589
Cycle	43t2bf11	46t1as_op1	cy43t2bf10
LBC	AROME-Aut 2.5km 1h	-	ECMWF 1h
Method	OI_main MESCAN + 3d-Var + LHN + FDDA +IAU	3DVAR + OI	3D-Var + OI
Cycling	1h	-	1h
B matrix	Static EDA + differences of the day	EDA	static DSC ENS
Initialization	IAU		No (SCC)
Obs	Synop + AS, Amdar (q)/MRAR/EHS national, EHS-EU, AMV/HRW, bufrTemp, Seviri, AMSUA/MHS/HIRS/ATMS/IASI (+ Metop-C), ASCAT, GNSS ZTD (Austria + EGVAP 1h VarBC), GPSRO (ROMSAF/OPLACE), Radar RH/Dow, INCA + AS at hig.freq., MODIS snowmask, windfarms, celiome-ters, Profiler, towers, NOAA20 JPSS ATMS, NOAA21 ATMS	Synop + AS, Amdar/MRAR/EHS-EU, HRW, Profiler, ASCAT, Seviri	SYNOP + AWS, AMDAR/ MRAR/ EHS, AMV, TEMP, SEVIRI, AMSU-A/MHS/IASI, ASCAT/OSCAT, radar reflectivity
Cutoff	0:27		0:35/1:10

Table E3: Operational ensemble systems in RC LACE countries that include the DA component.

DA	AUSTRIA C-LAEF	HUNGARY AROME-EPS	LACE A-LAEF
Resol.	2.5L90, 600 x 432	2.5L60, 490 x 310	4.8L73, 1250 x 750
Cycle	43t2bf11	cy43t2bf11	40t1
members	16+1	10+1	16+1
LBC	IFS-EPS	IFS ENS 1h (lagged)	IFS 6h (lagged)
Method	OI_main MESCAN + 3d-Var, pert. obs. + Jk	3D-Var + SEKF	DF blending + ESDA
Cycling	3h	3h	12h
B matrix	EDA on C-LAEF	Static EDA	-
Additional Initialization	No	No	No
Obs.	Synop + AS, Amdar, Geowind, Temp, ASCAT, Snowgrid/MODIS	SYNOP + AWS, GNSS ZTD, AMDAR/MRAR, TEMP, AMV+HRW	Synop + AS
Obs. cutoff		1:30	1:00

In **Austria**, a 1 km version of C-LAEF (CLAEF-1k) is continuously developed on ECMWF HPC. The system consists from 16 C-LAEF1k EDA members, 1 control member +1 EnVar member. CLAEF-1k is completely based on cy46t1 while the EnVar member is on cy48t3. Observations and other settings are mostly as in C-LAEF, GNSS-ZTDs data with revised whitelist and RADAR reflectivity data with Slovenian setting are used. For configuration e001 MF settings are used. Domain was extended southward and truncation changed to quadratic. Therefore new B- and V-Matrix was calculated.

New satellite observations NOAA21 ATMS and snow assimilation were added to AROME-RUC.

Offline fortran tool was built to convert grid point FA files back to spectral (needed as input for FESTAT and EnVar FG, while EnVar EPS requires GP-Files).

In the **Czech Republic**, data assimilation of SEVIRI was temporarily suspended due to VARBC performance issues after the Meteosat-10/Meteosat-11 mission swap in March 2023. SEVIRI data are back to operations after the cold start of VARBC with increased adaptivity. 3-h cycling is made operational from February 2024 after tuning of CANARI. Soil moisture increments depend on sun declination and they are averaged in time (LISSEW), relaxation to climatology is half of 6-h cycle, no relaxation of snow to climatology. E-suite with radar reflectivity assimilation is under development.

In **Croatia**, radar reflectivities from OPERA are successfully implemented to the operational chain from the end of 2023. The CANARI was tuned to avoid oscillation in T2m forecasts from different network times (summer), smoothing of soil moisture in time is applied by running average of last 3 analyses and to fix unrealistic soil moisture evolution during year.

In **Hungary**, OPLACE national Synops were added to AROME, new whitelist for GNSS ZTD improves results. An AROME RUC e-suite is running with hourly cycling at 1.3 km horizontal resolution and 90 vertical levels since December 2023. Migration of AROME to cy46t1bf7 is finished; it will be operational at the end of February 2025.

In **Slovakia**, The cy46t1 version was implemented at the end of year 2023. 1 km hourly RUC with 3D-Var is under construction and evaluation. 1-h and 6-h accumulations of precipitation along with 10-minute average intensity added to national data for OPLACE. Digital filter initialization and 87 levels added to 1km RUC configuration.

In **Slovenia**, modernization of scripts for operational runs (ecflow classes), significant increase of Slovenian automatic weather stations assimilated. SEVIRI data in netcdf format are assimilated. HOOF preprocessing improved, version 2 supported. Radar assimilation was migrated to Nimbus OPERA provision service.

In **Romania**, there are ongoing efforts to set up data assimilation cycling with CANARI with promising results.

In **Poland**, the activities towards the first assimilation suite are ongoing based on model cycle

43t2_bf10.

Contributors: All (approx. 1 PM per country, more in some institutes)

Subject: ***In-situ observations [DA1]***

Description and objectives:

Implementation of high-resolution ascent and decent radiosondes and wind profilers: optimize local pre-processing, extend observation operator, assess the quality and perform impact study. (DA1.1)

Local implementation of TEMP BUFR in SHMU & HungaroMet oper & nowcasting systems

During the ACCORD DA Working Days in Vienna (June 2024), the local implementation of TEMP BUFR was technically tested in CY46, as well as in SHMU (Slovakia) and HungaroMet (Hungary). The work on BUFR TEMP (CY43) by **Peter Strban(SK)** and **Maria Derkova (SK)** was further upgraded by **Michal Nestiak (SK)**, who implemented it in the operational NWP model (4.5 km ALARO-1) and also in RUC1 (1 km ALARO-1). In HungaroMet's operational environment (2.5 km AROME/HU CY43t2), the work was carried out by **David Lanz (HU)** and **Helga Toth (HU)**. Additionally, during the working week, the working environment was prepared for David Lanz, who will come to Bratislava on the RC LACE stay in the autumn. David will continue works on validation and verification of BUFR TEMP.

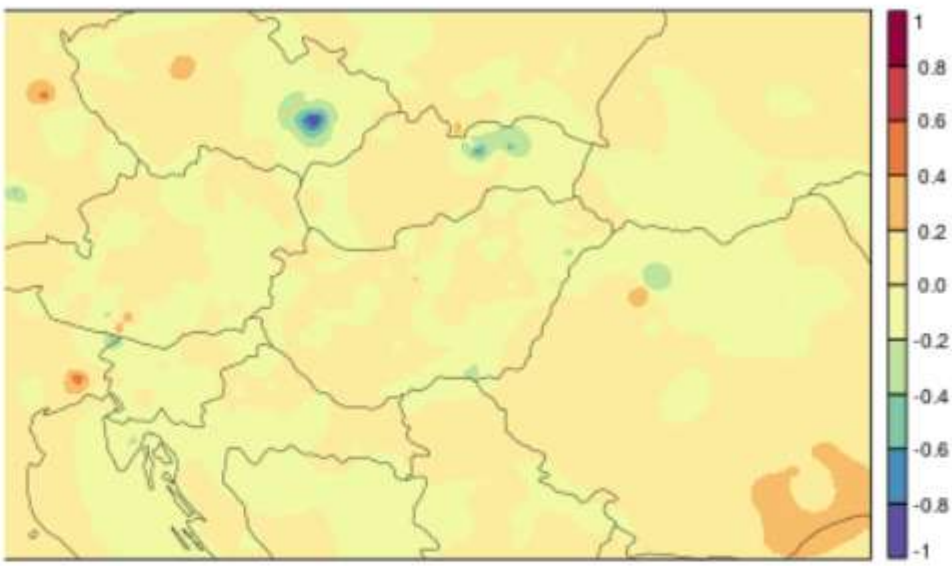

Figure 1.1.1: Difference of temperature at level 60 between EXP – REF experiment in AROME/HU cy43.

Experiments with BUFR TEMP data in ALARO/SK and AROME/HU

During a LACE stay at the Slovak Hydrometeorological Institute supervised by Mária Derková, **Dávid Lancz (HU;** 1.25 PM**)** examined the impact of using high resolution TEMP in BUFR format instead of the still widely used older OBSOUL format. BUFR format allows for two additional assimilation options compared to OBSOUL: 1) using of descending data from radiosondes with codetype 135 and 2) taking into account the trajectories of radiosondes. We tested only the first option since the trajectory computation requires too much computational memory and we had technical problems with it (see the Master Thesis of Peter Štrbáň).

Three experiments assimilating TEMP observations were set up for the period from 15 to 31 October 2024, performing 48-hour forecasts at 00, 06, 12 and 18 UTC. Experiment *OBSP* is using OBSOUL format, experiment *BRFP* is using BURF format without descending data, experiment *135P* is using BUFR format including descending data. Only stations providing both OBSOUL and BUFR TEMPs were used in experiments. All three experiments were compared with operational runs of ALARO SHMU. The results showed that neither the change from OBSOUL to BUFR TEMP, nor the data from the descending radiosonde had significant impact, bigger differences were obtained with the data from the descending radiosonde. Corresponding experiments were then repeated at the Hungarian Meteorological Service with the AROME model. These results led to similar conclusions. In Figs 1.1.2 and 1.1.3 some verification results are shown where there is a notable difference between the experiments.

The usage of BUFR TEMP does not have a negative effect on the forecasts and it allows us to utilize more measurements so we plan to replace the OBSOUL TEMP assimilation in our operational data assimilation. The impact of descending radiosondes in AROME/HU will be further evaluated for a period where radiosondes with parachute were emerged in Budapest.

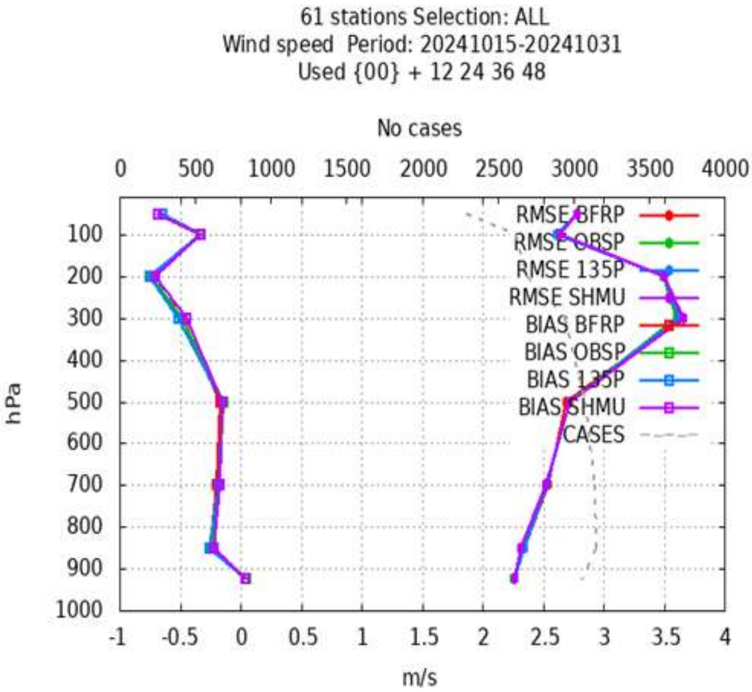

Figure 1.1.2: Vertical distribution of bias (lines with squares) and RMSE (lines with dots) of wind speed forecasts for ALARO experiments with OBSOUL TEMP (green), BUFR TEMP (red), BUFR TEMP with data from descending radiosondes (blue), operational ALARO (purple).

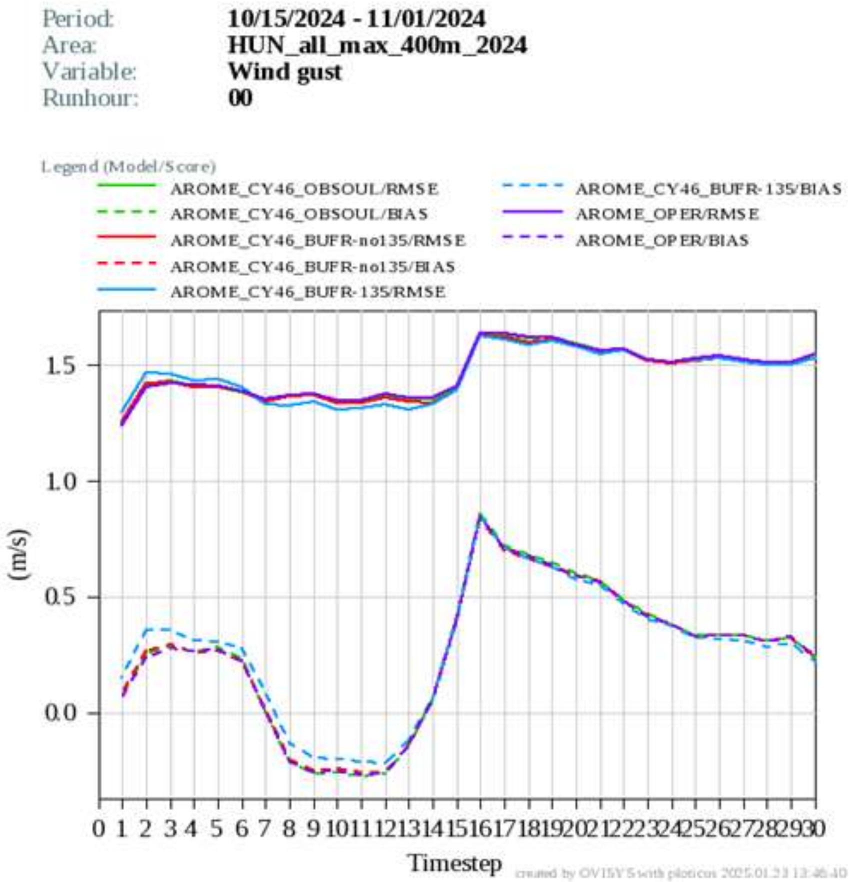

Figure 1.1.3: Bias and RMSE of wind gust forecasts in function of lead time for AROME experiments with OBSOUL TEMP (green), BUFR TEMP (red), BUFR TEMP with data from descending radiosondes (blue), operational AROME/HU (purple); all initialized at 0 UTC.

Reference:

Štrbáň P., 2021: Impact of the radiosonde drift in the data assimilation of the ALADIN/SHMU numerical weather prediction system. Master thesis, Univerzita Komenského, Bratislava.

Surface observations (Ps, T2m, Hu2m, V10m): Perform impact assessment of high-quality and high-resolution SYNOP DA (DA1.2)

Extension of AROME/HU data assimilation with OPLACE national SYNOP data:

A significant amount of extra SYNOP data is available from the surrounding countries of Hungary, due to RC LACE national data exchange. The goal is to add data from Romania, Slovakia, the Czech Republic, Austria, Croatia and Slovenia on top of SYNOP data from GTS in AROME/HU data assimilation system. **Lilla Duics-Korosecz** and **Helga Kolláthné Tóth (HU; 3.5 PM)** examined the impact of the additional SYNOP data and the modification in the model settings on the quality of the forecasts. 1-month experiments were prepared for May and November 2023. The reference run (OREF) represents the operational AROME/HU; in EXP1 the additional SYNOP data were assimilated with the same setting as in the reference run; in EXP2 during the CANARI optimal interpolation, we reduced the horizontal length scale for 2 meter temperature and relative humidity observations from the operationally used 80 km to 40 km, based on Bučánek (2020). Figure 1.2.1 shows the locations of the SYNOP observations for OREF and EXP1, the number of used SYNOP reports at 0 UTC on May 1

2023 was 499 and 1041, respectively.

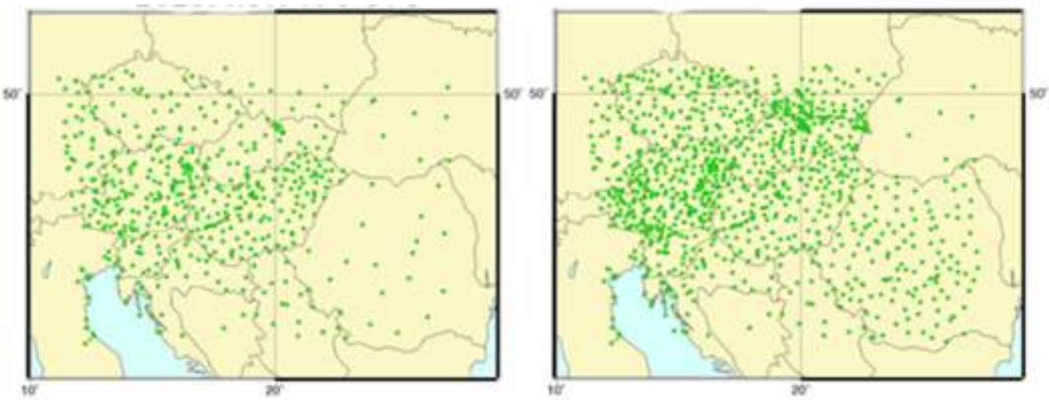

Fig. 1.2.1: SYNOP reports used by OREF (left) and EXP1 (right) at 0 UTC on May 1 2023.

The new observations slightly improved the analyses and forecasts. Figure 1.2.2 shows the EDS score of 3-hour afternoon precipitation for May 2023. The two experimental runs almost always outperformed the OREF, however, the two experimental runs differed little, and in most cases the second experimental run provided better predictions. The detailed results are published in a master thesis (Duics-Korosecz, 2024). We are planning the operational introduction after further tests.

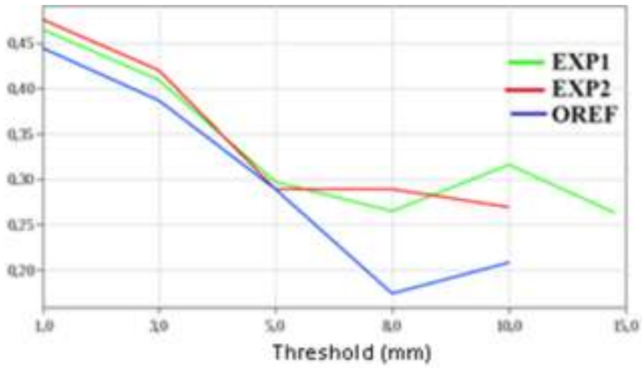

Fig. 1.2.2: EDS of 3-hour precipitation for between 15 and 18 UTC in May 2023.

References:

- Bučánek, A., 2020: Progress report of data assimilation: Assimilation of surface observations (SYNOP, national data, private observation networks) for upper-air and soil data assimilation.
- Duics-Korosecz L., 2024: Extension of AROME/HU data assimilation with additional SYNOP data (in Hungarian). Master Thesis, Eötvös Loránd University, Budapest.

Alina Dumitru (RO) continued the implementation process of surface data assimilation in Romania. New experiments using CANARI+DFI+Dynamical Adaptation with different setups for cy43t2bf10 were made. The experiments were completed taking into account the settings which have the biggest impact on analysis. As it was shown previously, a set of 4 experiments with different versions of ISBA polynomes were compared and the impact was visible. In order to increase the impact of surface data assimilation in addition to the different ISBA files, another parameter SMU0 (zenith solar angle taken into account) was modified from 0 to 7. In the following pictures the impact of these modifications can be observed:

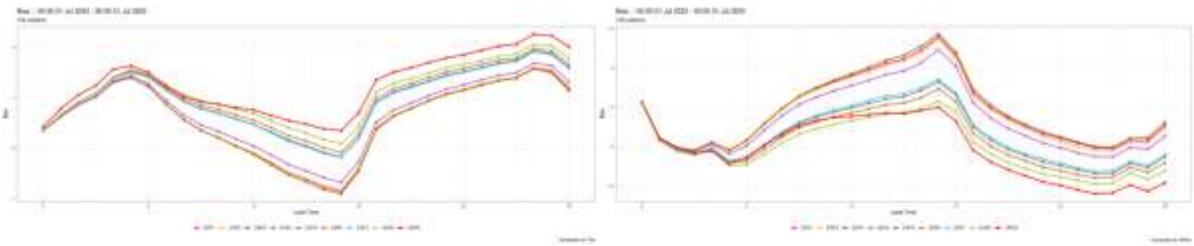

Figure 1.2.3: BIAS for 2m temperature (left) and 2m relative humidity (right) for July 2023, 00 UTC

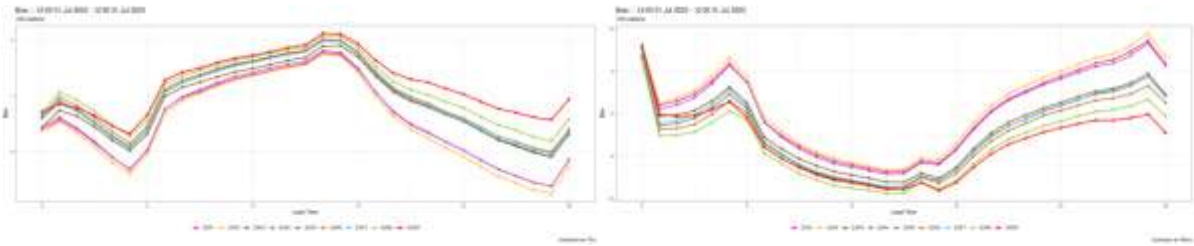

Figure 1.2.4: BIAS for 2m temperature (left) and 2m relative humidity (right) for July 2023, 12 UTC.

In order to implement operationally the setups of experiment EXP1 were chosen and the version of model was set to cy43t2bf11 from cy43t2bf10. The differences between the model versions were studied and no differences were notified.

High-resolution crowd-sourced surface observations (surface pressure, T2m, Q2m, V10m): further explore the potential of volunteered observations from crowd-sourced/private weather stations, cars, and smartphones (DA1.3).

No work reported.

Aircraft-based observations: assist implementation of Mode-S wind and temperature (EHS and MRAR); assess performance of fast observations from EMADDC. (DA1.4)

Experiments with EMADDC Mode-S EHS data in AROME/HU data assimilation

Viktória Homonnai and **Péter Elek (HU; 2 PM)** have started to extend the current assimilation of aircraft data in AROME/HU with Mode-S EHS to compensate the anticipated reduction of AMDAR data as well as the recent dramatic drop of national Mode-S MRAR data. Since August 2023, Mode-S EHS data from EMADDC have been available in OPLACE, both the regular (15-minutes window) and fast (5-minutes window) BUFR files. Experiments were carried out using the fast data in the AROME/HU model at 2.5 km resolution. In the first experimental run all available data were used. It was found that the number of iterations in the minimization process was too small, so it was increased from 60 to 200. Although the minimization now takes more time, it remains manageable. Unfortunately, the ALADIN obsmonitor program cannot handle such a large volume of data, so a pre-thinning Python program from Siebren de Haan was used for the initial experiment (AROME-EHS_exp1) with the following box-thinning settings: box_heights: 300,300,600,1000 m; box_width: 40 km. With fewer incoming data, the minimization process speeds up and usually finds the minimum after approximately 100 iteration steps.

Some studies indicated that the observation error should be increased. Therefore, in a second experiment (AROME-EHS_exp2), the SIGMAO_COEF was raised from 0.9 to 2.8. The experiments were carried out over a period of 14 days, from 27/11/2023, to 10/12/2023, with a 9-day spin-up period before. The observation monitor showed normal OMG and OMA statistics for the experiments.

The main difference from the operational run (represented by AROME-REF experiment) was that AMDAR data is only available below the level of 200 hPa, whereas Mode-S EHS data is available at higher levels. This is likely because AMDAR data comes only from commercial aircraft, whereas private jets, which can reach much greater heights, provide Mode-S EHS data. Contrary to our expectation, the verification results mainly showed neutral impacts. The most significant differences were observed in 2-metre relative humidity and mean sea level pressure (Fig. 1).

Assimilation of EHS is continued for a summer period. At the same time, we are working on implementing them into our hourly AROME-RUC e-suite. We expect higher impact in RUC considering that with its very short cut-off we lose much AMDAR data in comparison with the operational AROME/HU.

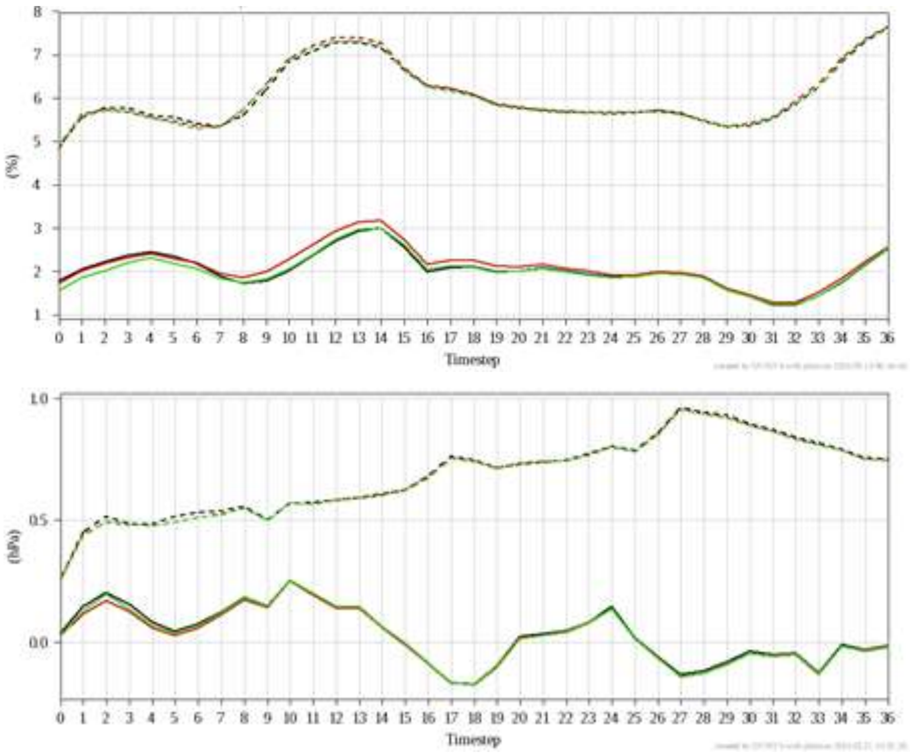

Figure 1.4.1: Bias (solid) and RMSE (dashed) of 2 meter relative humidity (top) and mean sea level pressure (bottom) forecasts in the function of lead time for AROME-REF (black), AROME-EHS_exp1 (red) and AROME-EHS_exp2 (green) experiments (all initialized at 0 UTC) in the winter period.

Elek Péter (**HU**; 3 PM) continued with a 2.5 km resolution summer experiment for June 2024 with 1-week spin up. In this run we used the pre-thinning parameters of box_heights: 300,300,600,1000 m; box_width: 40 km and SIGMA_COEF=2.8. Based on the verification measures, the impact of assimilation of EHS data is negligible both for surface and upper-air variables. We set up the assimilation of EHS data in AROME-RUC at 1.3 km resolution and hourly assimilation with a 30-minute cut-off time for the same summer period. The first results show some impact in high level winds (over 300 hPa; Figure 1.4.2) and in precipitation, though the improvement is not clear.

To investigate the impact of the Mode-S EHS data we implemented the tool to calculate the DFS (Degree of Freedom Signal). This measure makes it possible to compare the impact of different data or data types. Based on the DFS calculation we can conclude that the overall impact of the Mode-S EHS data could be big because the calculated DFS is relatively big compared to other data but that's expected because we have a lot of data points. On the other hand a single AIREP-U data has a bigger impact on the assimilation result if we exclude the Mode-S EHS data (which can be caused by increased SIGMA_COEF).

We are going to investigate the error correlations and find an optimal thinning, also we are exploring different thinning methods based on Vivien Pourret's (Meteo France) work.

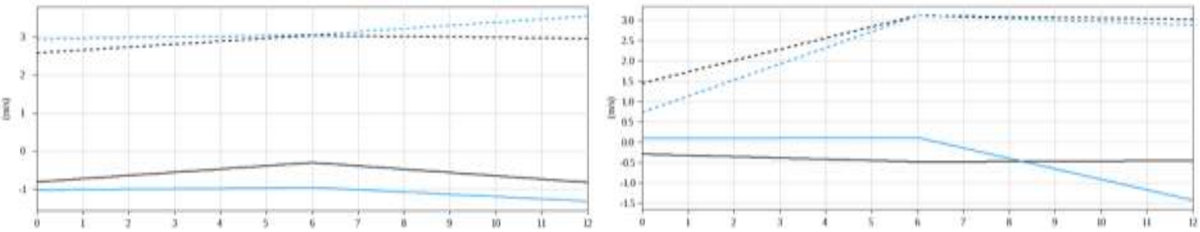

Figure 1.4.2: Bias (solid) and RMSE (dashed) of wind speed forecasts at 100 hPa (left) and 300 hPa (right) in the function of lead time (h) for AROME experiments with (black) and without (blue), assimilation of Mode-S EHS data (all initialized at 0 UTC).

Total efforts: 15 months

Contributors: H. Toth (HU) 0.5, V. Homonnai (HU) 1.75, L. Duics-Korosecz (HU) 3.25, P. Elek (HU) 4.25, A. Dumitru (RO) 3.75, D. Lancz (HU) 1.25, M. Derkova (SK) 0.25

Documentation: /

Status: ONGOING

Subject: ***Use of ground-based remote sensing [DA 2]***

Description of tasks:

Implementation of reflectivity data assimilation (OPERA data) based on common preprocessing HOOF and benefiting from recent recommendations on tuning of Bayesian inversion (DA 2.1)

All lace members who have experience with radar assimilation were focusing on validation of new production line of OPERA radar data (NIMBUS). The new production line is operational since June 2024. Beside validation of NIMBUS production line works continued on testing and improving reflectivity assimilation. See details:

Parallel DA cycle with the data from the OPERA NIMBUS production line was set up by **Suzana Panežić (HR)** and was run from 7th December 2023 - 4th January 2024. Preprocessing was performed with HOOF v2 and during the selected period no issues were observed with data availability and timeliness. The overall performance of the DA cycle using NIMBUS data was comparable to the operational HR40 using MF OIFS data.

Michal Nestiak (SK) participated in an RC LACE stay in Prague in February 2024. The objective of the stay was to compare two OPERA radar data production lines, OIFS (MF) and NIMBUS (Geosphere), in collaboration with **Antonín Bučánek (CZ)** and **Alena Trojakova (CZ)**, see the stay report. It was found that for some radars (CH,UK), there are discrepancies between nodata and undetect metadata values and the data themselves. More noise was also observed in the data for some radars compared OIFS. All was reported back to OPERA in coordination with ACCORD.

Michal Nestiak (SK) developed a Python program for the automatic control and comparison of these two datasets. The comparison of data is based on the structural similarity index (Qi), which more effectively characterises differences between two arrays by penalising structural discrepancies in the fields rather than isolated single-point values. Michal Nestiak also continues this work in the ACCORD DA Working Days in Dublin. The results were presented at the OPERA User Forum and also in Dublin. Results from DA WD and Prague were included in the final "ACCORD feedback on NIMBUS radar data" to OPERA.

Figure 2.1.1: Difference between NIMBUS and OIFS from 2024-01-18 20:50 elev 0.00 mf.satfilter (Qi=0.748)

Antonín Bučánek (CZ) continued efforts towards the operational implementation of radar reflectivity assimilation at CHMI, significant time was devoted to optimization of screening for the NEC Aurora vector machine. Due to performance issues of BATOR we moved it to the scalar part of the machine. A promising setup seems to be a combination of inflation of errors for observations created from undetected pixels and the threshold method. The threshold method assimilates reflectivity observation only when observed or modelled reflectivity is larger than a threshold, in our case 0 DBZ.

Florian Meier (AT) switched radar pre-processing to Nimbus. Further, the modifications to avoid drying effects when assimilating RADAR reflectivities by Bučánek and Panežić (LACE stay report) were phased into local cy46t1 and cy48t3 versions and applied to C-LAEF1k esuite.

Antonín Bučánek (CZ) optimized screening for NEC vector machine SX-Aurora Tsubasa, running time of screening with radar reflectivity observations dropped from ~12minutes to ~2minutes. Unfortunately the modifications are not yet in the common code repository.

Michal Nestiak (SK) participated in the RC LACE stay in Prague in November 2024. The aim was to transfer and validate radar modset provided by CHMI (local cycle cy46t1as) to Slovakia. After resolving technical problems with compilation the CHMI results were reproduced (in collaboration with Antonín Bučánek (CZ)). The second objective was to test the key LRADAR_SIGMA3CHECK=T. The idea of the key is to use only model profiles in surrounding of observation whose average distance (1/N*sum[(O-m)^2] over all elevation of model profile) is less than 3*xsigma. The idea would work if model reflectivity would be close enough to observation. The model is able to produce minimal values of reflectivity around -300 DBZ while observations are usually not less than -40 DBZ. This result in not enough observations “surviving” the Bayesian inversion in vicinity to the radar, see Figure 2.1.2. The use of the LRADAR_SIGMA3CHECK=T is not recommended. The stay report is in preparation.

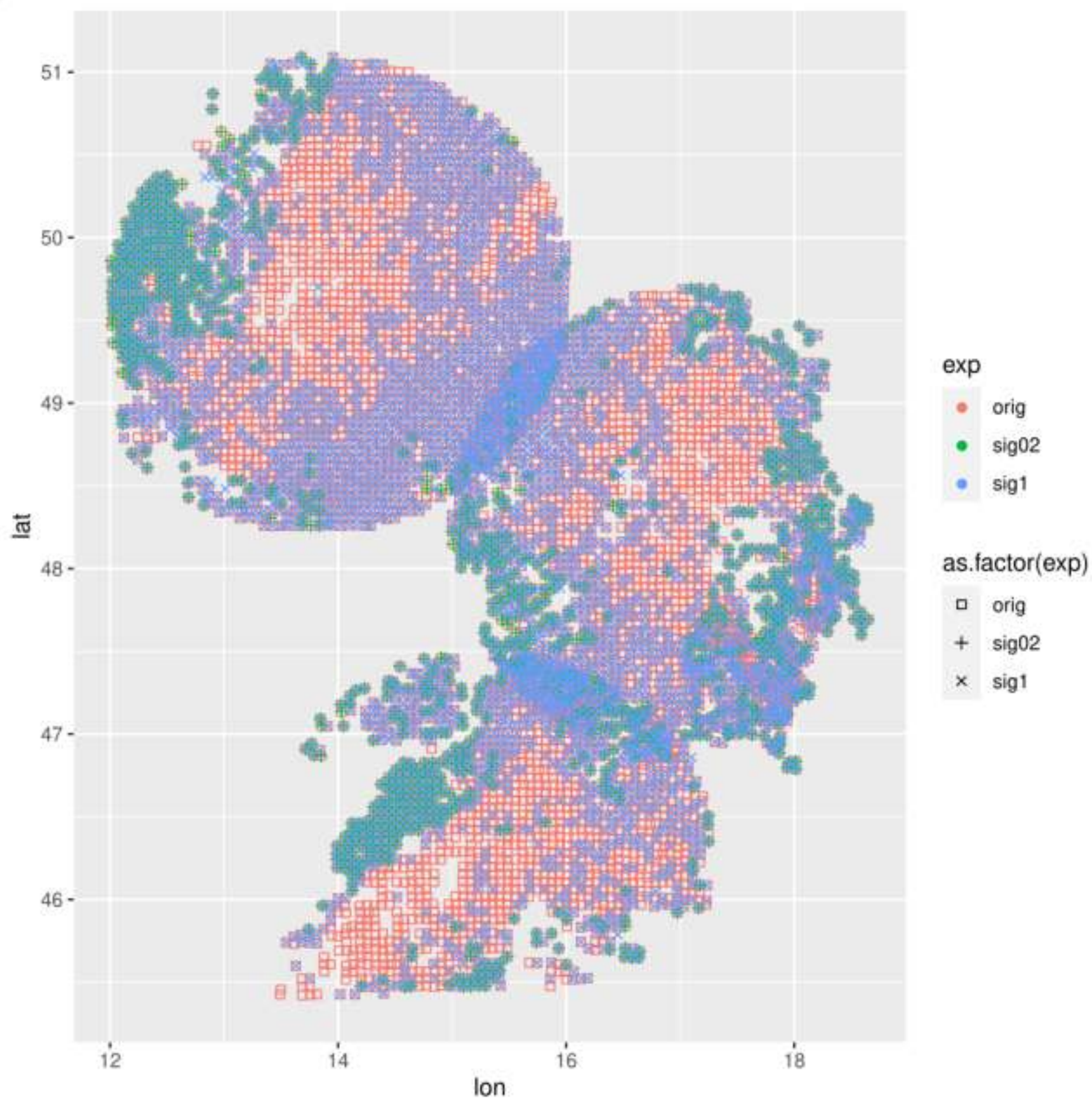

Figure 2.1.2: Position of observations for which the Bayesian inversion was successful (radars czbrd, skjav, hubud on 12.9.2024 6UTC). Red squares denote original setting (xsigma=0.2 and LRADAR_SIGMA3CHECK=F), Green plus signs denote LRADAR_SIGMA3CHECK=T and Blue x signs denote setting xsigma=1 and LRADAR_SIGMA3CHECK=T.

Antonín Bučánek (CZ) was testing a new way of filtering reflectivity data before computation of minimum detectable reflectivity factor (MDRF) in Bator. MDFR is used to specify value for undetected observations. Since DBZ can be noisy for some radars (e.g. DE, HU) one percentile of data is cut out for each distance bin from radar before computation of MDRF. Blue line on Figure 2.1.3 represents all possible values of undetected observations in original setting, red line represents new values of undetected observations (DEDRS, elevation 0.5, 7.12.2024 00utc). This modification should protect against excessive drying by undetected observations in analysis. Impact on scores is neutral to slightly positive (1month period, June 2022, RMSE), see Figure 2.1.4.

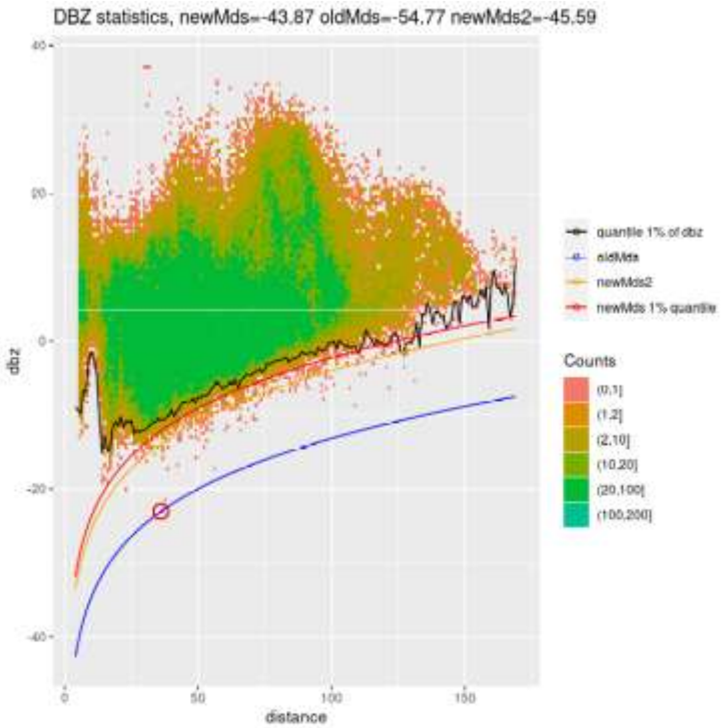

Figure 2.1.3: DBZ values on elevation 0.5˚ of radar DEDRS on 7.12.2024 00utc.

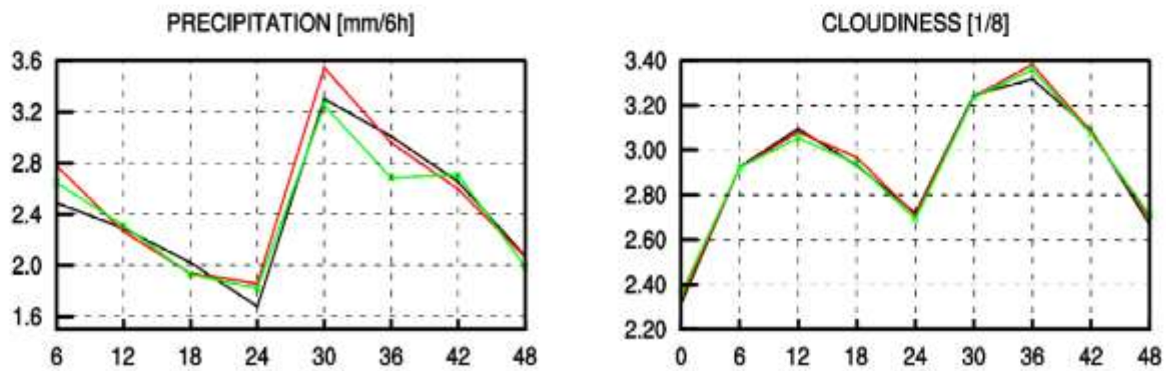

Figure 2.1.4: RMSE scores for precipitation and cloudiness over June 2022 against Synop observations. Black line indicates operational model setting without radars, red line indicates radar assimilation with old MDRF computation. Green line indicates radar assimilation with New MDRF computation algorithm.

Setting up radar reflectivity experiment in AROME/HU data assimilation

Following the operational release of the new OPERA production line, called NIMBUS, new radar data became available to users from the beginning of November 2024. Hence, **Laura Magyar (HU**; 3.5 PM) has started collecting 15-minute radar products (00-minute files per every hour) from 30 radar stations in our domain. Figure 2.1.5 shows these stations by their ODIM code.

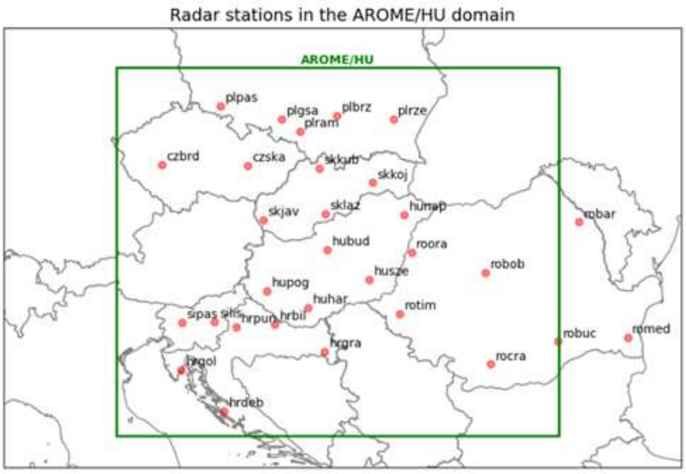

Figure 2.1.5: Radar stations selected for the radar experiment in AROME/HU. The stations are indicated by their ODIM code and the approximate AROME/HU domain is marked by the green rectangle.

We set up a radar experiment with the 2.5 km resolution AROME/HU (cy43t2) model by including reflectivity data in the assimilation. Since radar HDF5 files vary in structure and content for each country, a homogenization process must take place before filtering (BATOR). This is done by a dedicated preprocessing tool called HOOF written in Python. In our experiment, we implemented HOOF version 2. HOOF only keeps the data at those elevation angles where all the required parameters are present which includes corresponding corrected and uncorrected reflectivity factors (DBZH – TH pairs) and all the quality flags. Table shows which quality flags are contained by radar files per country. Fortunately, HOOF2 enables the selective writing of the required QC flags in its configuration file thus providing a solution for the issue of incomplete quality flags. However, the handling of the new quality flag (eu.opera.odc.hac) has not yet been resolved. We have encountered a different problem with Czech radar data: homogenization of these files results in error due to the missing required /dataset/how groups. In the following, we are going to continue the investigation of HDF5 homogenization issues in addition to transferring our radar experiment to cycle 46.

Table 2.1.1: Quality flags per country. Green and red shadings indicate if the QC flag is or is not present in the HDF5 files, respectively. ROPO: fi.fmi.ropo.detector.classification, BLOCK: se.smhi.detector.beamblockage, SAT: fr.mf.satfilter, TOTAL: pl.imgw.quality.qi_total, NEW: eu.opera.odc.hac

Quality flags per country					
	ROPO	BLOCK	SAT	TOTAL	NEW
Czechia	No	Yes	No	Yes	No
Croatia	Yes	Yes	Yes	Yes	Yes
Hungary	No	Yes	No	Yes	Yes
Poland	No	No	No	Yes	No
Romania	Yes	Yes	Yes	Yes	Yes
Slovenia	Yes	Yes	Yes	Yes	No
Slovakia	No	Yes	No	Yes	Yes

Impact studies with original and de-aliased OPERA Doppler wind data. (DA 2.1)

The work on the OPERA radial wind data assimilation in ALARO has been resumed by **Martin Petrovič (SK)** within an RC LACE stay in cooperation with local host **Alena Trojáková (CZ)**. Data from the NIMBUS system were analysed, with a focus on the radial wind (VRAD) and Nyquist velocity (NI) parameters. A colour-coded map (Fig.2.1.6) was used to visualise the distribution of NI values across different countries, highlighting areas with sufficient and insufficient coverage.

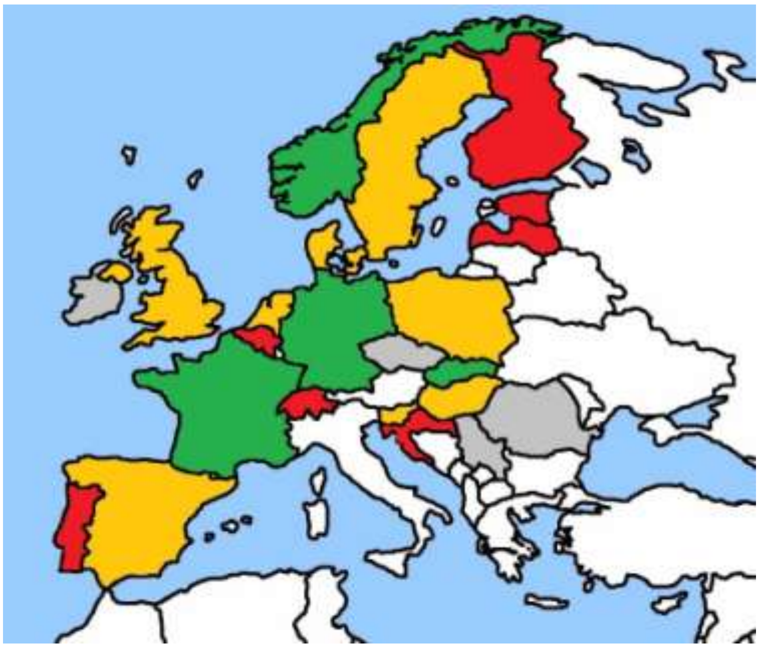

Figure 2.1.6: Colour code map of selected European countries based on the condition of the Nyquist velocity value. Green represents countries with NI values above 30 m/s, red for values below 30 m/s, yellow for both, and grey for missing NI data or datasets.

We analysed radar data pre-processing (HOOF) and filtering (BATOR) that removes unwanted artefacts and noise. A passive experiment with radar observations was conducted to assess the quality of radial wind data with respect to the NWP model. First, we examined the difference between the total number of observations and the subset of active Doppler wind observations. Second, we computed observation-minus-forecast (OMG) differences. The OMG histograms revealed that most radars exhibited a normal (Gaussian) distribution of departures, except for one Danish radar at Virring, which showed a bimodal distribution. Finally, we applied a transformed histogram for enhanced visual analysis and to determine an appropriate rejection limit. A detailed report is on LACE webpage.

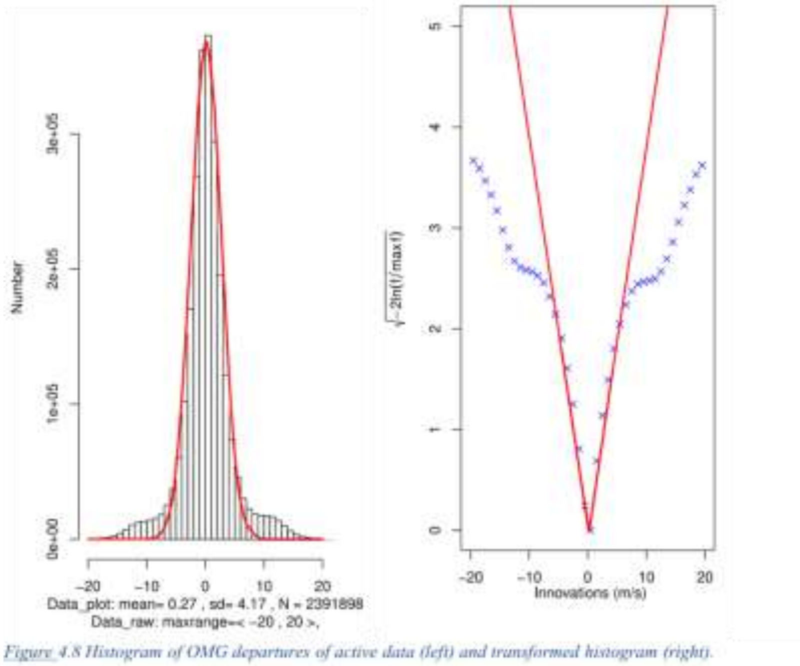

Figure 2.1.7: Histogram of OMG departures of active data (left) and transformed histogram (right).

Florian Meier (AT) found a small issue in BATOR DOW assimilation (cy43t2/cy46t1). The Nyquist speed NI of the OPERA file header section ("how") instead of individual elevations is read and checked against a minimum limit from the HDF5 namelist. That was changed for better adapted blacklisting in AROME-RUC of Doppler winds. More OPERA radars ("fraja", "frale") and one additional Austrian radar were added to the pre-processing to possibly use them later in C-LAEF1k.

Peter Smerkol, Vito Švagelj and Benedikt Strajnar (SI) refined the torus mapping algorithm in the HOOF software as part of the peer-review process. The algorithm currently correctly dealiases more than 90% of radial winds, which results in reasonable quality for data assimilation after the additional QC step of DA (rejection of observations where first guess departure exceeds 20 m/s). For Slovenian datasets with NI=8 m/s, dealiasing ensures that around 5% of useful data (representing high winds) from outside the NI interval are mapped into observations that fit into the QC interval and are retained for assimilation. Dealiasing is also beneficial for moderate NI measurements (German dataset).

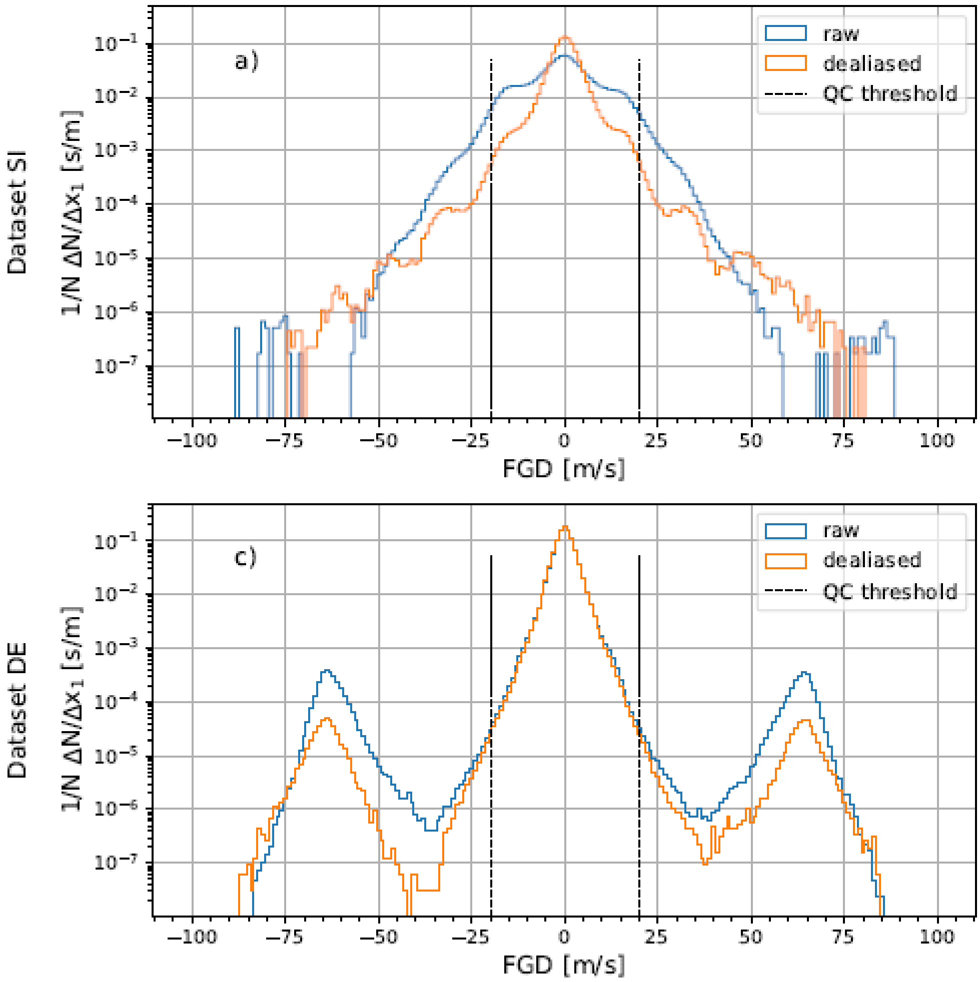

Figure 2.1.8: First guess departure distribution of radial winds over one year. The comparison is between raw and de-aliased datasets for SI (upper panel) and DE (lower panel). The side peaks in all distributions represent aliased measurements and should be diminished in favor of the main peak. The vertical dashed line represents QC interval in DA.

Test of super observation functionality in HOOF for radar reflectivity (or alternatively radial wind). (DA 2.1)

No work reported.

Further elaborate the assimilation of GNSS ZTD observations and conduct impact studies, focusing on data from regional providers, assist quality improvement of solutions from these centers (DA 2.2)

At the end of 2023 an e-suite of AROME Rapid Update Cycle (AROME-RUC) was launched with 1-hour assimilation frequency using 3D-Var and Simplified Extended Kalman Filter over the AROME/HU domain at 1.3 km horizontal resolution and 90 levels. In January 2024, an issue was fixed in PREGPSSOL, since the program is originally hardcoded with 3-hourly cycling, the 1-hourly cycling should be added. A cold start of VARBC was made, the spinup of the assimilation cycle took about 2 weeks, at the end of the month almost all GNSS ZTD data was assimilated by **Helga Kolláthné Tóth (HU; 1 PM)**. The whitelist was the same as for AROME/HU at 2.5 km resolution.

Both AROME/HU and AROME-RUC overestimated the 2 meter relative humidity for winter. The error of fine resolution run was even larger than that of the coarser one. The overestimation subsided in spring, and turned into an underestimation (Fig. 2.2.1 for analysis). The value of VSIGQSAT for AROME-RUC was changed to the same value as for AROME/HU (VSIGQSAT=0.02) from 15 April 2024.

Besides, a new whitelist was generated for AROME-RUC. The BMEG, GF1R, ASI, WUEL and GOP1 networks were included and 1-hourly cycling was also taken into account. At the end, 192 points were selected (recently 122 ones are used operationally). Forecasts with the new whitelist showed positive impact for 2 meter temperature and relative humidity for 1–15 May 2024 (Fig. 2.2.2). The test will continue with inclusion of additional data from a new network provider, BMEL.

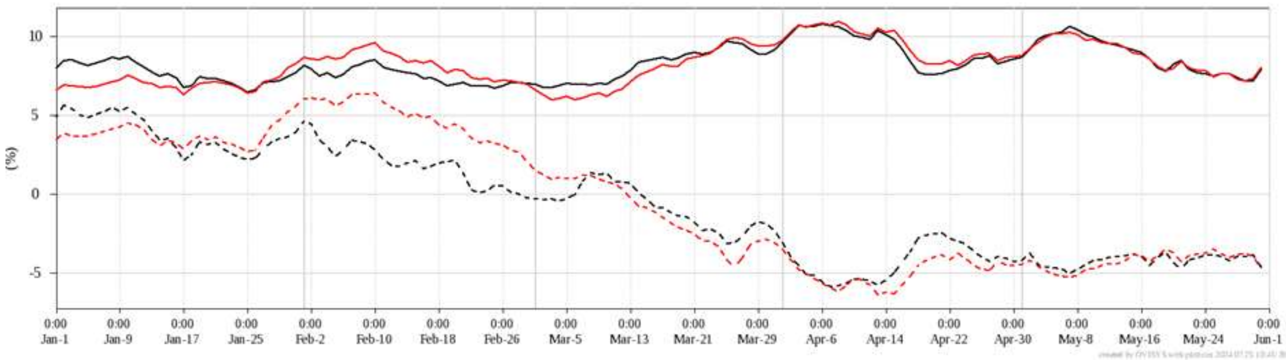

Figure 2.2.1: RMSE (solid) and bias (dashed) of 2 meter relative humidity analyses for 1–31/5/2024 (only 0 UTC runs). Black: AROME/HU, red: AROME-RUC.

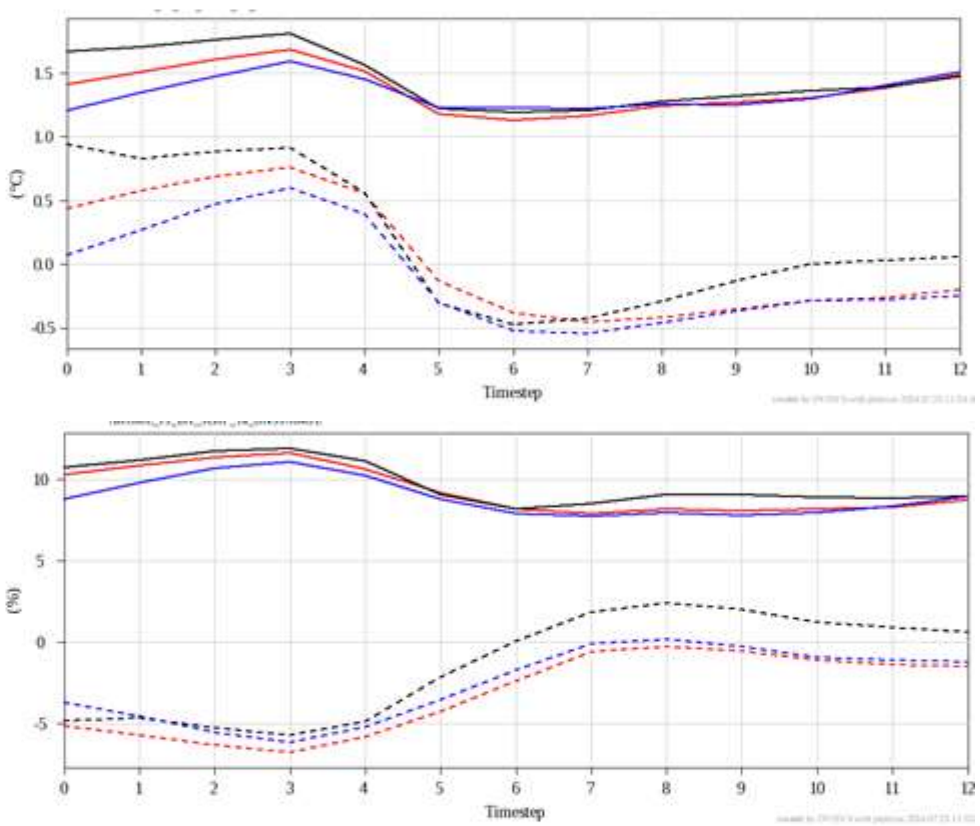

Figure 2.2.2: RMSE (solid) and bias (dashed) of 2 meter temperature (top) and relative humidity (bottom) forecasts for 1–14/5/2024 (only 0 UTC runs). Black: AROME/HU, red: AROME-RUC with the original whitelist, blue: AROME-RUC with new whitelist.

Florian Weidle (AT) produced a whitelist for GNSS-ZTD data for CLAEF-1K EPS esuite by installing and applying the standard whitelist generation tool using departures of a passive assimilation period GNSS ZTD. Also the whitelist for AROME-RUC in AT was revised.

Florian Meier (AT) found a bug (allocation of already allocated arrays) in varbc_setup.F90 in cy46t1 which caused crashes of VARBC for GNSS ZTD in C-LAEF1k (AROME) system. Further we successfully tested NDREMOVE and LCLEANTABLE switches in NAMVARBC to get rid of corrupted old VARBC entries without restarting VARBC of C-LAEF1k. GNSS-ZTD is active in C-LAEF1k esuite now.

GNSS slant delay impact studies with 3D-Var (DA 2.2)

Martin Imrišek (SK) was debuging Slant total delay contribution (IAU repository (CY49T1)).

Florian Meier (AT) assimilated one season (January-July 2023) Sentinel-1 radar delays of ASC146 into AROME 2.5km using STD operator (cy43t2) of de Haan and Imrisek. First the relative delay observation file was converted to obsoul format, simulated values from the first satellite overpass were added to the relative delays to create observations for the second overpass. The domain averaged departure was subtracted as bias correction and thinning applied. Due to the large time gap between two overpasses the experiment was not cycled but initialised with the operational configuration and compared to the reference without Sentinel-1 assimilation. Scores are mostly neutral. However, some improvement was found for 2m humidity bias and in single cases slightly improvement of precipitation patterns.

For one case an EDA experiment was conducted randomly perturbing the Sentinel-1 observations.

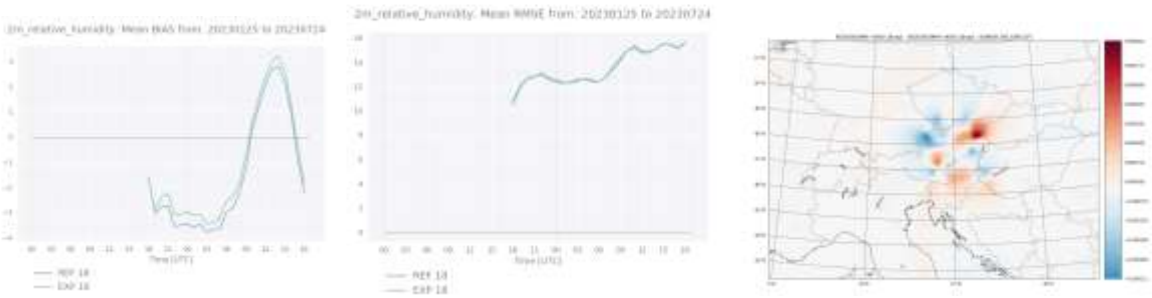

Figure 2.2.3: 2m RH bias (left) and RMSE (middle) of one Season Sentinel 1 ASC146 delay assimilation into AROME 2.5km (validation against Austrian surface stations). analysis increment (Q L90) due to Sentinel 1 assimilation 30th June 2023 18 UTC.

Attenuation in telecom. microwave links due to rain/cloud: refine the processing to efficiently separate dry and wet attenuation. Study suitable observation operators to assimilate retrieved rain rates (cloud ingestion, standalone physics package from P. Lopez, etc.) (DA 2.3)

No work reported.

Total efforts: 26 months

Contributors: H. Toth (HU) 1, F. Weidle (AT) 0.5, F. Meier (AT) 1.25, S. Panežić (HR) 0.5, M. Nestiak (SK) 2.25, A. Bučánek (CZ) 5.75, A. Trojakova (CZ) 1.75, M. Petrovič (SK) 1. P. Smerkol (SI) 0.5, M. Imrišek (SK) 8, L. Magyar (HU) 3.5

Documentation: /

Status: ONGOING

Subject: ***Satellite-based remote sensing observations [DA 3]***

First steps towards using visible information from MSG with RTTOV visible operator and implementation of assimilation interface. Provide good description of albedo to screening and minimization. (DA 3.2)

Adhithiyan Neduncheran (AT) is working on all sky assimilation of IR and VIS channels of MSG SEVIRI within OOPS (cy48t1) ENVAR. Code modifications were done to activate all_sky within RTTOV for IR. With support from MF it was found that simulated all_sky radiances are stored within a separated column of ODB after screening, but so far not passed to the minimization. Control variable extensions to hydrometeors in EnVar were successfully tested following MF advice. After OPLACE provided a netcdf test file of SEVIRI containing VIS channels those were successfully passed through BATOR into ODB. However, due to coefficient files for VIS the combined use of VIS and IR requires a re-consideration of channel numbers. Currently the simulation of VIS channel with RTTOV in cy48t1 is in progress. Necessary coefficient files were generated, but this also requires modifications of FG check and interface code->RTTOV. It was also found that parts of emphasis VIS operator in RTTOV available in cy49r version did not make it to T cycle 49T1 yet. In next year it is planned to test VIS operator also with MTG satellite data (imager instrument).

All-sky assimilation of MSG SEVIRI water vapor channels has been tested further with an introduction of observation error model that takes into account the cloud amount coming from the model and observation, thereby assigning an observation error dynamically for better assimilation practices. This approach has been earlier used/tested by Okamoto et al. 2013. An ACCORD scientific research stay report of **Adhithiyan Neduncheran (AT)** at Meteo France in autumn 2024 is available. Work on visible channel assimilation is in progress, after fixing the RTTOV-MFASIS related issues.

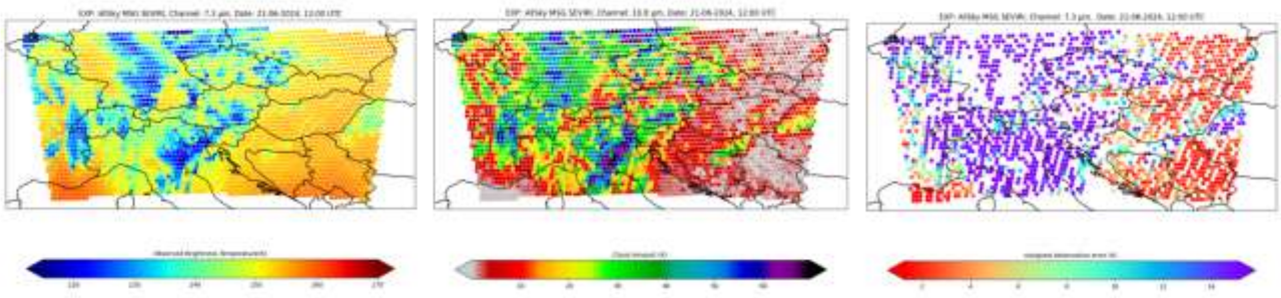

Figure 3.2.1: Observed brightness temperature (K) from WV073 (left), Calculated cloud amount (middle), Assigned observation error (K) for various active observations (right)

Implement new or revised all sky assimilation strategy for IASI as preparation to use similar data from MTG IRS. (DA 3.2)

Suzana Panežić (HR) is working on the technical implementation of an all-sky approach in LAM, following Kozo Okamoto's approach. In-front research is to be done using IASI radiance data and should be extended to MTG-IRS data when data becomes available. First step towards the goal was to set up the environment for further research. A local branch of C-LAEF was created and modified so that IASI data was assimilated in clear-sky mode. In collaboration with Adhithiyan Neduncheran (AT), code modifications for all-sky assimilation of IASI data were tested.

All-sky code modification was extended to C-LAEF EnVar member within the OOPS (cy48t3) framework. In collaboration with **Benedikt Strajnar (SI),** observation error modeling for IASI was implemented. As such, observation error depends on the average cloud effect. Additional QC to reject data with large average cloud effect was implemented. Stay report is available online.

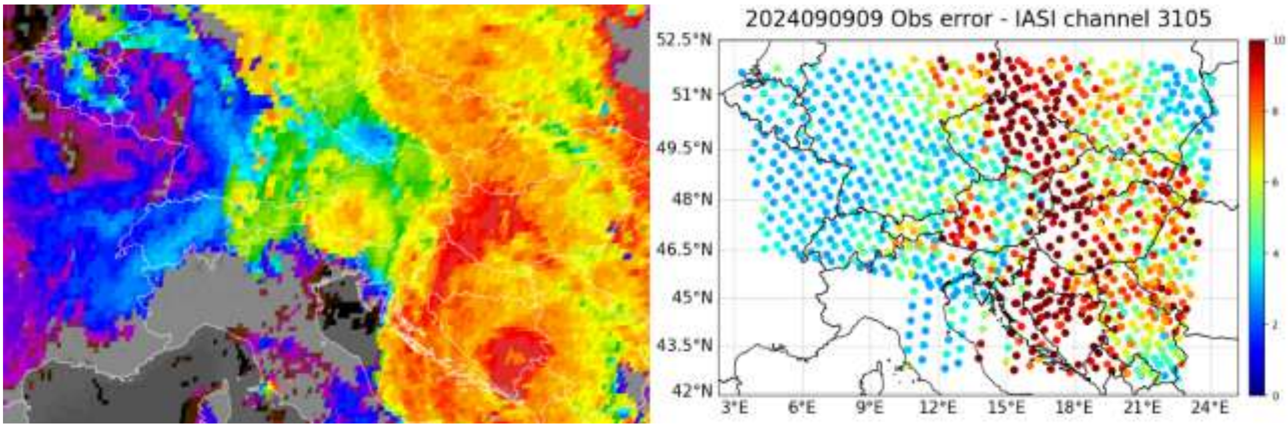

Figure3.2.2: Case 09.09.2024. at 09 UTC: Variate observation error values depending on the averaged cloud effect; IASI channel 3105.

Total efforts: 12 month

Contributors: F. Meier (AT) 0.75, A. Neduncheran (AT) 6.5, S. Panežić (HR) 3.75, M. Derkova (SK) 0.25, B. Strajnar (SI) 0.75

Documentation: /

Status: ONGOING

Subject: ***Observation pre-processing, quality control, bias correction and representation error [DA4]***

Local installation and test of new obsmonitor tool (DA 4.2)

There was a presentation about the HIRLAM obsmon program developed by Paulo Medeiros (SHMI), which created the opportunity for installing this program on our machine. We also needed the backend part, which creates the SQLite3 database. Benedikt Strajnar provided this modification pack, which was also installed parallel to the frontend by **Viktória Homonnai (HU)**. During testing, some issues with ECMA were revealed, which required some modifications. The graphical interface opens in a web browser, so when using a remote server, port forwarding could be very useful for improving speed and performance. In summary, this version of Obsmon provides a lot of interactive possibilities, but there are no statistical tables which are very useful in our current system. Therefore, we do not plan to replace our ALADIN Obsmon with this version.

A simple environment for the purpose of evaluating the functionality of OBSCONVERT and BATOR has been established on the Belenos HPC system, specifically on cy48t (**Alena Trojáková, CZ**) and Atos ECMWF (**Benedikt Strajnar, SI**). The initial comparative analysis of BATOR and OBSCONVERT was undertaken utilising ATOVS and radar data.

Regular upgrades of the HOOF preprocessing tool. (DA 4.2)

Retuned torus mapping, see DA2.1.

Tuning of observations and background and representation error, revise thinning, QC and VarBC settings. (DA 4.5)

No work reported.

Information on OPLACE maintenance work and developments is provided in the DM's report.

Total efforts: 4.25 month

Contributors: V. Homonnai (HU) 1.5, B. Strajnar (SI) 2.5, A. Trojakova (CZ) 0.25

Documentation: /

Status: ONGOING

Subject: *Variational assimilation systems [DA5]*

Develop, validate and consolidate full assimilation cycles using OOPS binaries (DA 5.1)

Martin Imrišek (SK) made technical installation of OOPS system on CY48T3 (export) in Slovakia following Benedikt Strajnar's document "The OOPS system for data assimilation - a short user introduction". Only technical run and first plots were produced, see Fig. 5.1.1.

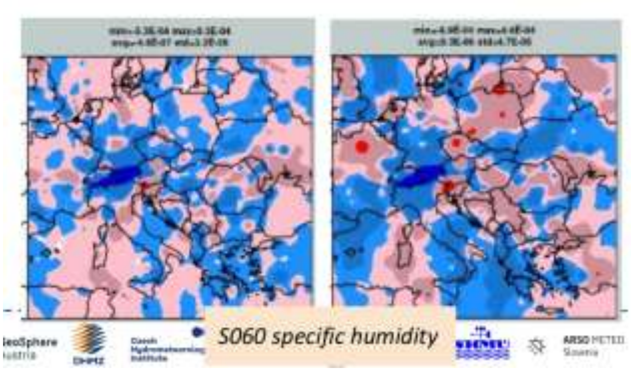

Figure 5.1.1: Comparison of increments from MASTERODB CY46t1bf07 (left) and OOVAR (right) executables.

Maintenance, setting up and evolution of current DA suites (3D-Var, BlendVar), exchange of scientific achievements between ACCORD partners. (DA 5.6)

SEVIRI data assimilation was withdrawn from operational setup in CHMI (CZ) after the exchange of Meteosat-10 and Meteosat-11 in March 2023 due to significant bias (~1K) with unusually large diurnal variations. Several VARBC warmup strategies were tested, finally a cold start with increased adaptivity was considered to update VARBC for Meteosat-10 (**Alena Trojakova (CZ)**).

Poland is continuing preparatory works for 3D-Var assimilation setup.

Total efforts: 7.75 months

Contributors: Alena Trojakova (CZ) 0.5, Martin Imrišek (SK) 1, M. Szczech (PL) 6.25

Documentation: /

Status: ONGOING

Subject: *EnVar, EDA and variants [DA6]*

Explore the use of global ensemble in LAM 3D/4D EnVar (DA 6.9)

Benedikt Strajnar (SI) and **Florian Meier (AT)** explored different ways of providing ensemble information to EnVar in the 16 member Claef-1k system prototype. A 50-member C-LAEF1k ensemble was set up for 16th April 2024 0 UTC cold front case and several experiment were carried-out, using perturbation from: 16 LAM members, 16 + 16 LAM ensemble from second-last run, mixed perturbations, global perturbations, and 50 LAM members as a reference (but operationally not feasible). The main finding was that the flow-dependency was well-captured with EnVar and that combining LAM and global perturbation produces potentially unrealistic covariances over large areas as well as spurious ripples in the analysis fields and was considered non-desirable.

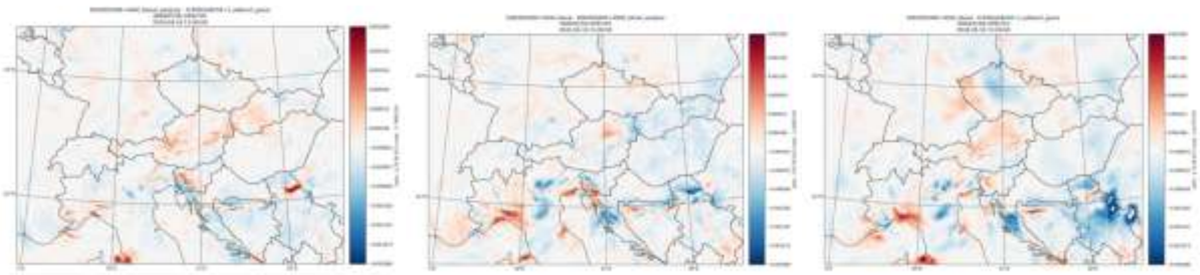

Figure 6.9.1: Near-surface humidity increments of EnVar with 50 LAM members, 50 global members and mixed LAM/global (16+32) members. Note the large negative covariances over Serbia in the mixed setup.

Florian Meier (AT) coded a fortran tool under utilities in cy46t1 based on blendsur code and spectral transformation library to convert grid point fields in FA file to spectral representation which is needed in 3DEnVar first guess and FESTAT (while EDA is in GP space for ENVar). Truncation limit has to be provided via namelist. The tool was tested on ATOS for 1km and 2.5km domain and runs on a single node about two minutes to convert all AROME fields U, V, T, PS, orography and NH fields to spectral space.

Florian Meier (AT) calculated a new B- and V-Matrix for the C-LAEF1k EDA using first downscaled and then EDA differences provided from Slovenian reruns (summer 2024) and near real time (autumn 2024) differences using FESTAT cy48t3 with FA input on ATOS.

Florian Meier (AT) and **Benedikt Strajnar (SI)** set up the EnVar member (cy48t3 export with small add-ons) within C-LAEF1k it uses 16(+3h) + 16(+6h) C-LAEF1k EDA members with the same set of observations as the other 3D-Var based C-LAEF1k members. A cold start option and 4D-EnVar option for tests was added to the scripting. A modification to be able to subtract ensemble mean separately for +3h and +6h forecast when computation EnVar perturbation was also implemented, but not yet included into routine runs.

Total efforts: 5.25 months

Contributors: F. Meier (AT) 4, B. Strajnar (SI) 1.25

Documentation: /

Status: ONGOING

Subject: *Initialization methods and nowcasting [DA7]*

No work reported.

Subject: *Diagnostic methods, optimization of assimilation cycling [DA8]*

No work reported.

Subject: ***AI/ML methods for data assimilation [DA9]***

Marko Rus (SI) and **Benedikt Strajnar (SI)** started a project to test AI-based replacement for Bayesian inversion to assimilate radar reflectivity. A large dataset was prepared for the year 2023, comprising radar observation columns from OPERA, model first guesses of relative humidity and reflectivity and several metadata for all the analysis times, in the measurement points and their near surroundings. A goal is to train a neural network to construct good pseudo-observed relative humidity profiles (as input to variational assimilation), using model columns with good match in reflectivity as training targets.

Marko Rus (SI) with help by **Benedikt Strajnar (SI)** continued a feasibility study of AI-based replacement for Bayesian inversion to assimilate radar reflectivity. A large dataset was prepared for the year 2023, comprising radar observation columns from OPERA, model first guesses of relative humidity and reflectivity and several metadata for all the analysis times, in the measurement points and their near surroundings. A neural network was set up to construct good pseudo-observed relative humidity profiles (as input to variational assimilation), using model columns from the training period where the match between reflectivity and model-simulated reflectivity was good. During the inference step, the method takes up to three consecutive OPERA radar files and produces a humidity field as a netcdf file (leftmost panel in Figure). The continuation remains unclear due after the main author has left ARSO.

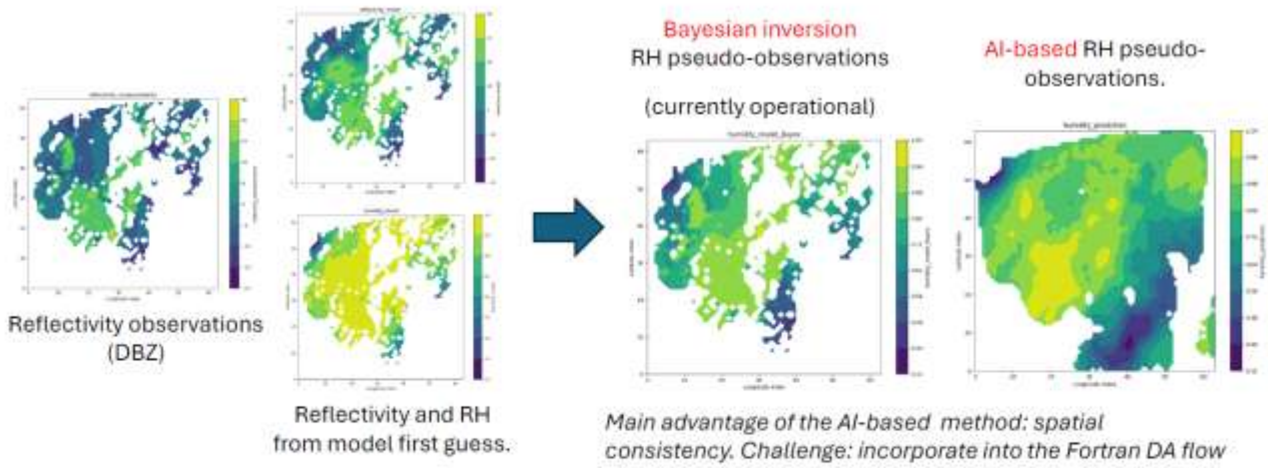

Figure 9.1: Construction of pseudo-RH observations for assimilation from radar reflectivity (and model first guess) by a ML method. The right side is a comparison between the standard procedure and ML/AI method for a given vertical (pressure) level.

Total efforts: 3.25 months

Contributors: M. Rus (SI) 1.5, B. Strajnar (SI) 1.75

Documentation: /

Status: ONGOING

Subject: ***Surface assimilation [SU1]***

Development of SYNOP-based snow analysis in CANARI. (SU1.1.4)

First technical tests to run SYNOP based snow analysis in CANARI for ALARO with ISBA scheme started. Snow analysis is only coded for SURFEX (cy46t1) and had to be enabled for ISBA scheme. An error in the CANARI analysis flags (datum_anflag.*@body) has been identified and fixed on the basis of the Météo France operational branch (NFLCAN replaced by individual codes NCUT2M, NCUH2M, NCUSN, ...). A study on the quality control of snow measurements is underway and a flexible rejection limit for snow QC over mountains (LAOROFLEXREJSN, kindly provided by Florian Meier) is being investigated by **Jáchym Ševčík, Alena Trojáková (CZ)**

Jáchym Ševčík and Alena Trojáková (CZ) continued the testing of snow analysis for ALARO CSC with the ISBA scheme. Case studies were performed to see the sensitivity to tuning parameters (horizontal and vertical length scales, observation and background errors). Additional local observations from Switzerland and Austria were collected to improve data coverage over the Alps.

Florian Meier (AT) also continued to work on OI snow assimilation (AROME): The modification of first guess with external snowgrid model over the alps was adapted from 100% to only partly exchange to avoid too much impact of erroneous external data. Snow assim is activated in CLAEF-1k esuite from November 2024 in the same setting as in AROME-RUC. Some quality checks, adaptation of FG check and modification of background correlation function (LMESCANSN) were tested, to avoid rejection of mountain stations, the entering of wrong measurements (snow at 30°C) and spurious increments in the Alps. The latter needs further testing. **Nauman Kurshid (AT)** improved the snow monitoring tool at Geosphere.

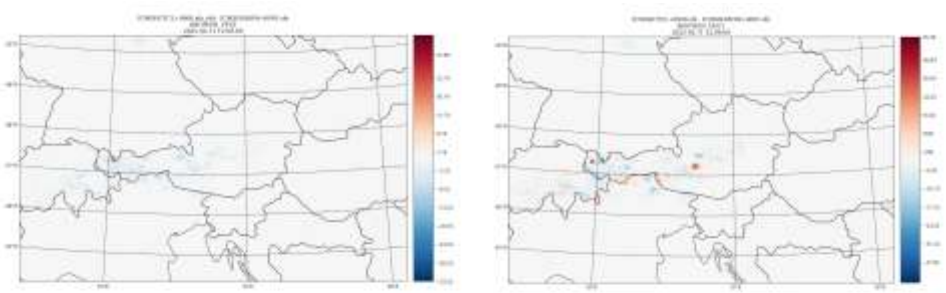

Fig. 1.1.4.1: Snow increments from CANARI snow assimilation using the current setting (left) and MESCAN like correlation function with linear decrease with altitude down to 0. (not 0.5 like in T2m/RH2m). RTCORSN(2)=0.002; REF_A_SN 12km->18km.

SYNOP snow depth assimilation in AROME/HU

Assimilation of SYNOP in-situ snow depth observations has been tested in AROME cy46t1 by **Helga Kolláthné Tóth (HU**; 0.5 PM). In some Central European country (in Hungary, Austria, Croatia, Serbia), snow depth is measured only at 06 UTC, or (in Slovakia, Czech Republic, Slovenia) at 06 and 18 UTC, but in some other countries (in Romania, Germany) it is available at 00, 06, 12 and 18 UTC. Until December the observations were included in the database of the Hungarian Meteorological Service only after human control, even 3-4 hours after the nominal measurement time which does not make it possible for operational use. After some adjustment, the uncontrolled snow depth data now immediately enter the database, and will be added to OPLACE operationally soon.

In the experiment, the 1-layer (D95) snow scheme was used with three prognostic variables: snow-water equivalent, snow density and snow albedo. Some important settings were prescribed in

CANARI namelist:

- LAESNM = T (active snow assimilation)
- REF_S_SN = 5 kg/m^2 (background error standard deviation)
- ECTERO(1,1,92,1) = 4 kg/m^2 (observation error standard deviation)

The snow depth measurements are converted into snow-water equivalent using the snow density in CANARI OI-MAIN, and then the snow-water equivalent is updated during the assimilation process. Experiment was launched for a snowfall case at 6 UTC on 22 November 2024 (with spin up from 18 November). Figure shows that the snow depth calculated from assimilation of the snow-water equivalent at 6 UTC on 22 November corresponded better with the observations than in the reference run in which the initial snow depth is taken from the 3-hour forecasts of the previous run.

The work will continue with different settings in CANARI OI-MAIN and we plan to test the bugfix of Florian Meier to set up a height-dependent rejection limit for observations with high deviations between station and model orography.

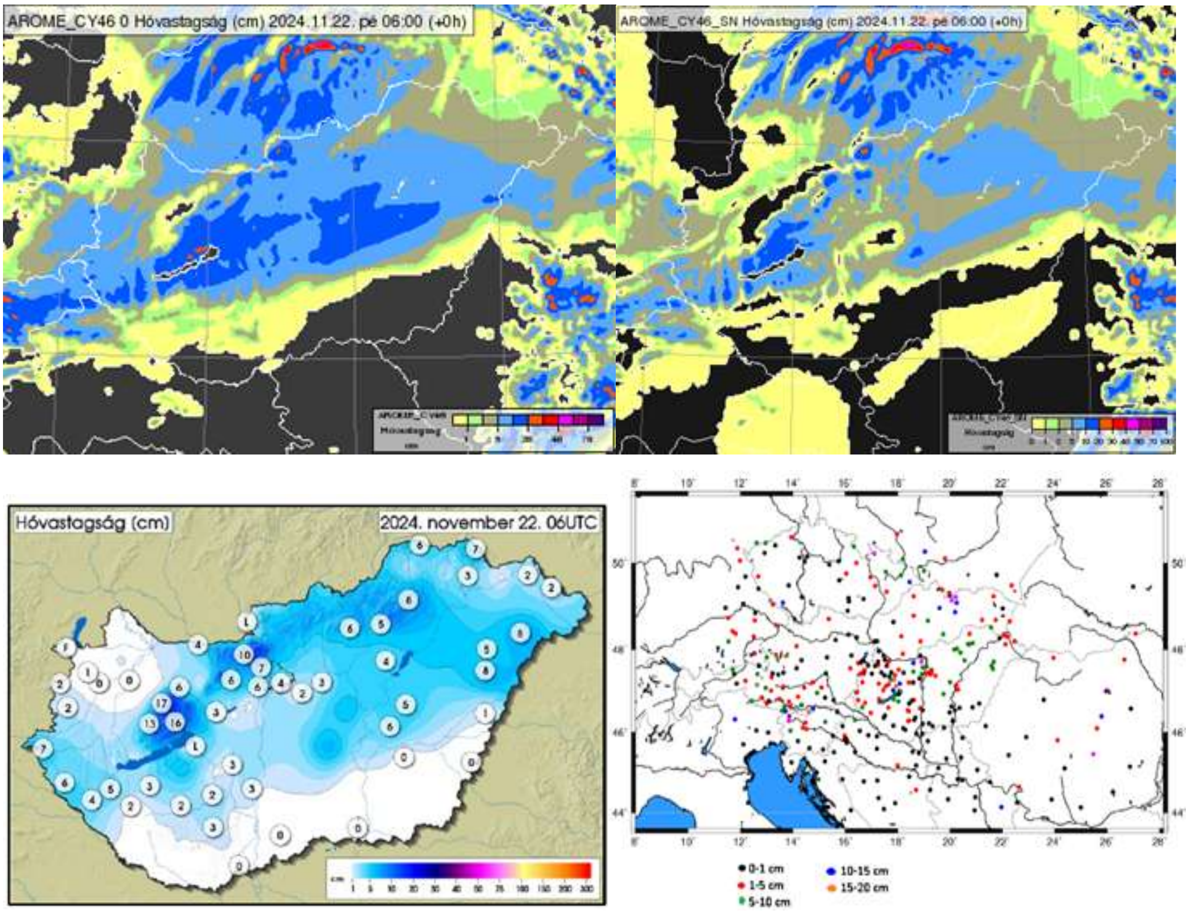

Figure1.1.4.2: Snow depth analyses in AROME without (top left) and with (top right) assimilation of snow water equivalent, Hungarian SYNOP observations (bottom left) and observations in CANARI OI-MAIN (bottom right) at 6 UTC on 22 November 2024.

Tuning of soil water content initialization in OI/CANARI. (SU1.1.11)

Antonín Bučánek (CZ), during preparation of a parallel suite with 3h cycling, it was found that turning off relaxation to climatology has a detrimental effect on the 2m temperature bias during autumn. To overcome this bias, the relaxation to the climatology was turned on again, but with half the coefficients of the 6-h cycle (RCLIMCA=0.0225). Relaxation towards snow stayed switched off. This produces a more realistic snow amount as can be seen on Figure 4. The new 3-hour cycling strategy was launched to operations in February 2024.

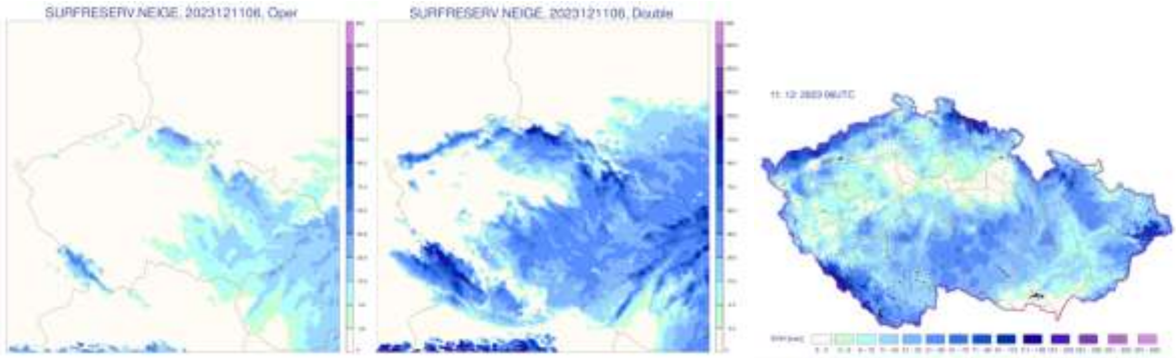

Figure 1.1.11.1: The snow water equivalent improved (11.12.2023). Left figure snow relaxed to climatology, Middle figure relaxation switched off, Right figure observed snow water equivalent.

Florian Meier (AT) found strangely low temperatures in the deep soil layer in CLAEF-1k over the Alpine mountains in the control run. This was related to the wrong snow cover. It was surprising that assimilation could not correct the soil temperature, even though T2m was high and soil temperature increments are not affected by snow cover in our CANARI setting. Two reasons were detected: 1) even though TG2 values were unrealistically low (about -25°C), the 2 m values were rather close to observations and therefore the OIMAIN increments were small. 2) In MESCAN vertical correlation decreases rapidly (linearly within the 250 m height difference and then stays at 0.5). In complex terrain most of the stations are located in valleys while peaks are not observed well. Also the height difference between tops and valleys are rather big. This combined with MESCAN vertical structure functions leads to very small soil increments which cannot correct wrong TG2.

Therefore the hardcoded values ZCORT2/ZCORH2 in catrma.F90/cacova.F90 were increased by a factor of 2. In that case the increments spread a bit further.

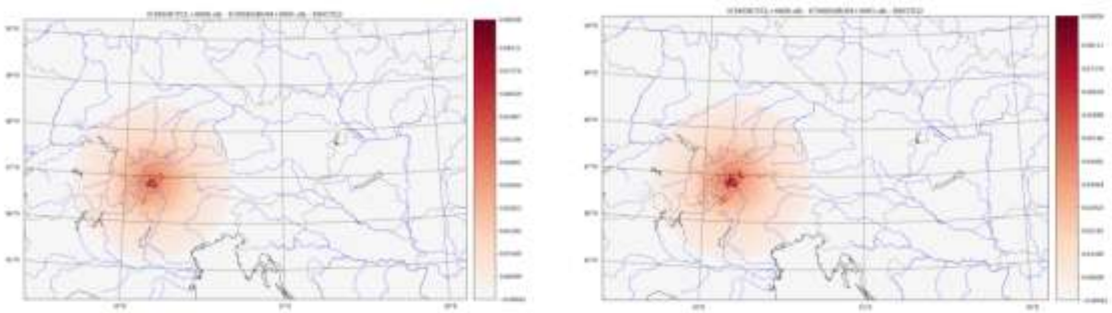

Figure 1.1.11.2: OIMAIN TG2 single observation experiment increment using one Tyrolean mountain station with standard ZCORT2/ZCORH2 (left) and modified (right).

A LACE stay was conducted at ARSO by **Anamarija Zajec (HR)** with **Matjaž Ličar (SI)** as the supervisor. The goal of the stay was to perform a full assimilation cycle in ALARO with SURFEX, which includes 3DVAR upper air assimilation, as well as assimilation of soil temperature and moisture in SURFEX-ISBA using CANARI/OI_MAIN. An experiment for a period of 7 days was prepared on the basis of the operational RUC model with a 1 hour assimilation window and 1km domain centred around Slovenia. The experimental setup differed from the operational one only in the use of SURFEX, to allow for a meaningful evaluation of results. Initial conditions were also obtained from the operational suite, with the exception of SURFEX files, which were produced via an EE927 run from ELSCF boundary files for cycle initialization, which was then cycled in subsequent runs.

Both the operational model and the experiment use version cy43t2, where the experiment includes the local SURFEX modset developed at CHMI (CZ). Most of the prior ALARO with SURFEX development at ARSO was performed with this version, so it was chosen for the experiment, despite technical issues.

The issue with the erroneous SST field in the SURFEX file produced by CANARI was mentioned in previous reports. There are further issues with other fields in CANARI output, which cause a segmentation fault at the integration step. This error is not directly reproducible and occurs after a different number of integration steps for different cases. After some examination of CANARI output it is not clear which field(s) could produce such an error. Integration with initial SURFEX files produced via an EE927 run however completes without error. This error was mitigated by producing an EE927 SURFEX file as a template, and then overwriting the fields contained in this file with CANARI output.

By comparison with the operational suite, the experiment shows a degradation of results. It is also worth mentioning, that during the same runs, the TG1 field in SURFEX files, and the SURFTEMP field in upper air ICMSH files show a substantial difference (Figure 1).

A single forecast case was also performed for a lead time of 36 hours. This was then validated against synop stations using the HAARP tool. We again see a degradation of results, with a colder bias of the experiment compared to the operational model with a bigger spread (Figure 2).

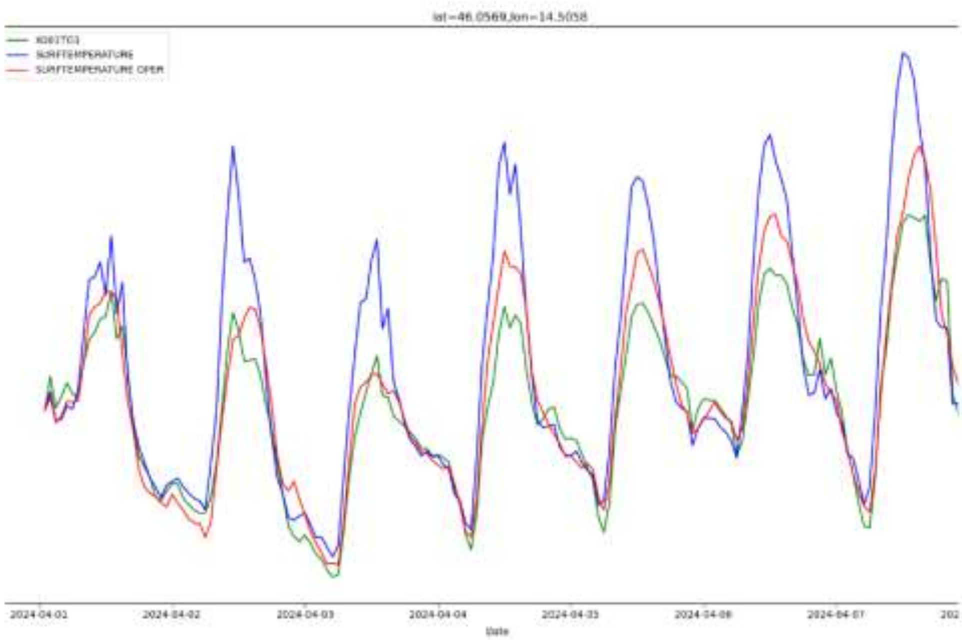

Figure 1.1.11.3: Surface temperature analysis for one location. Green: Experiment X001TG1 from .sfx file. Blue: Experiment SURFTEMP from UA file. Red: Operational RUC SURFTEMP.

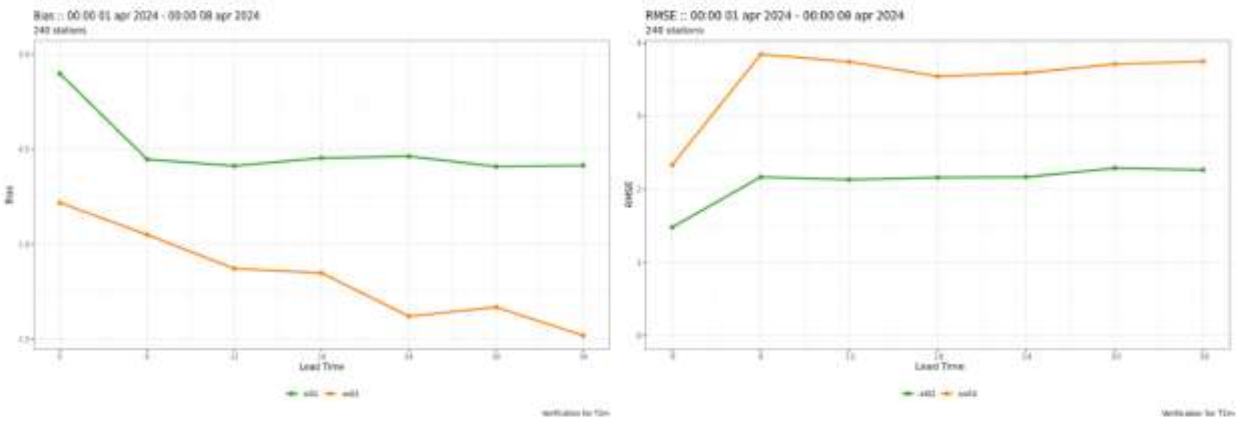

Figure 1.1.11.4: HARP forecast verification of T2m using synop observations (single case). Green: Operational RUC. Orange: SFX Experiment.

Assimilation of satellite moisture information (SWI) within SEKF in AROME/SURFEX, impact experiments (SU1.3.4)

The assimilation of ASCAT H08 Level-2 Soil Moisture product has been continuing. These superficial soil moisture measurements are expressed in percentage, valid for the European region, at a horizontal resolution of 1 km. The data assimilation runs were performed with AROME cy43t2, with 2.5 km horizontal resolution and 60 vertical levels by Helga Kolláthné Tóth (HU; 3 PM). The test period lasted from 1 to 31 May 2023 with a 1-week spin-up. We used 3-hourly assimilation in the upper air, and SEKF of soil moisture WG1 and WG2 in the surface. We tested different values for observation and model errors in the surface assimilation to check the sensitivity of the system. The enhanced model error resulted in a huge overestimation of nighttime temperature, no bias in daytime and a big negative bias of dew point (not shown). With the increased observation error we obtained a lower overestimation of night temperature and a larger underestimation of day temperature, however almost no dewpoint bias.

In the following experiments, soil temperature was also added to the control variables (Table). In ASCAT-ONLY experiment only the ASCAT SM observations are assimilated and the control variables are the soil moistures for the superficial and root-zone layers. In ASCAT+SYNOP_1SODA both soil moisture and temperature were control variables for two layers. ASCAT+SYNOP_2SODA contains two surface data assimilation runs: 2 meter temperature and relative humidity SYNOP data are first assimilated in SODA1 step (using the same observation and model errors as in the operational AROME/HU), which provides first guess for SODA2 step; ASCAT SM is assimilated in SODA2 step using the same observation and model errors as in ASCAT+SYNOP_1SODA.

Using a single SODA step, almost no added value is coming from assimilating SYNOP data (Fig. 1 for 2 meter temperature and dewpoint) with respect to the run only with ASCAT data. At the same time, only minor difference is between REF and ASCAT+SYNOP_2SODA experiments, that represents a small impact of ASCAT SM assimilation compared to the SYNOP data. In the continuation the extension of the CDF matching period to 2018–2023 will be tested.

Table 1.3.4.1: Main characteristics of the experiments.

Experiments	**REF (“OPER”)**	**ASCAT-ONLY**	**ASCAT+SYNOP_1SODA**	**ASCAT+SYNOP_2SODA**
Observations	SYNOP T2M, HU2M	ASCAT SM	ASCAT SM, SYNOP T2M, HU2M	ASCAT SM, SYNOP T2M, HU2M
Control variables	WG1, WG2, TG1, TG2	WG1, WG2	WG1, WG2, TG1, TG2	WG1, WG2, TG1, TG2,
Observation errors	1K, 7%	0.05 m3/m3	ASCAT: 0.05 m3/m3, T2M: 1K, HU2M: 7%	SODA1: T2M: 1K, HU2M: 7% SODA2: ASCAT: 0.05 m3/m3

Model errors	0.1 m3/m3, 0.15 m3/m3, 2K, 2K	0.01 m3/m3 , 0.01 m3/m3	0.01 m3/m3 (WG1/WG2) 0.2 K (TG1/TG2)	SODA1: 0.1/0.15 m3/m3 (WG1/WG2), 2 K (TG1/TG2) SODA2: 0.01 m3/m3 (WG1/WG2), 0.2 K (TG1/TG2)
Analyses (UTC)	00, 03, 06, 09, 12, 15, 18, 21	09, 18, 21	00, 03, 06, 09, 12, 15, 18, 21	00, 03, 06, 09, 12, 15, 18, 21
Forecast	00 UTC + 24h	00 UTC + 24h	00 UTC + 24h	00 UTC + 24h

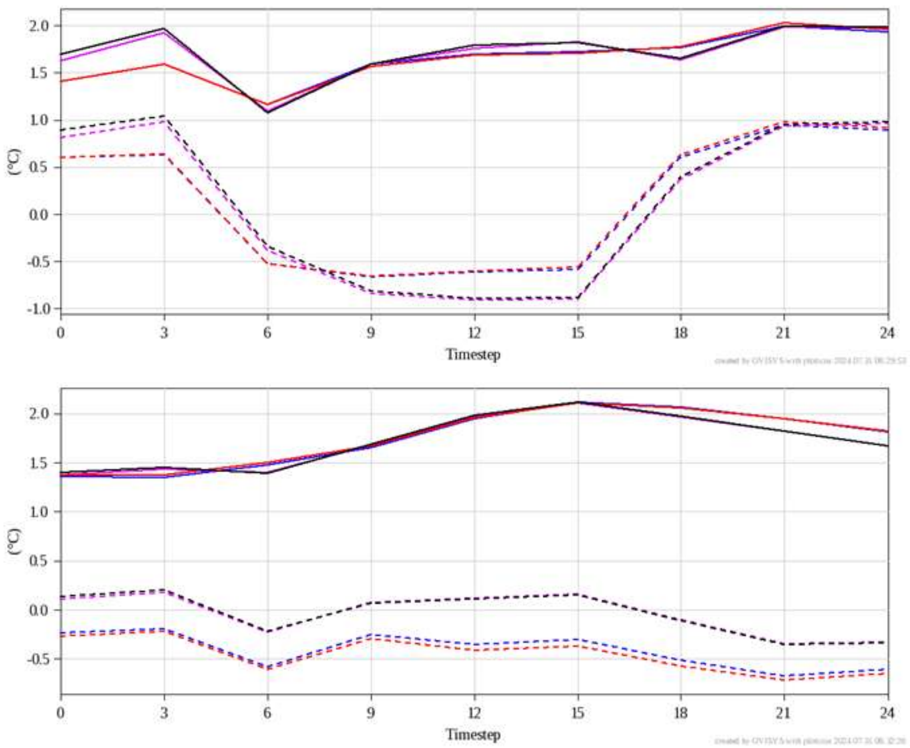

Figure 1.3.4.1: RMSE (solid) and bias (dashed) of 2-meter temperature (top) and dewpoint (bottom) for 1–31/5/2023 (only 0 UTC runs). Blue: REF, black: ASCAT-ONLY, pink: ASCAT+SYNOP_1SODA, red: ASCAT+SYNOP_2SODA.

Polly Schmederer (AT) 1.5PM got Sentinel-1A/B SWI data pre-processed by Technical University of Vienna for the whole year 2021. Assimilation experiment within SODA-SEKF was conducted allowing initalisation of 7 soil moisture layers in SURFEX. The experiment runs on C-LAEF 2.5km domain. Due to migration to new HPC at Geosphere the experiment is not yet finished, but results can be expected in the next reporting period.

Total efforts: 17.2 months

Contributors: V. Tarjani (SK) 1.25, A. Dumitru (RO) 1, M. Szczech (PL) (reported in DA5 4pm), M. Ličar (SI) 1, H. Tóth (HU) 4.7, Balázs Szintai (HU) 1.25, A. Trojakova (CZ) 2.5, J. Sevcik (CZ) 3, M. Derkova (SK) 0.5, F. Meier (AT) 0.5, P. Schmederer (AT) 1.5

Documentation: /

Status: ONGOING

Documents and publications

Publications:

Stay reports:

- ☐ M. Nestiak (SHMU): Testing of radar data from new OPERA NIMBUS production line, 22. 1. – 2. 2. 2024, Prague.
- ☐ M. Petrovič (SHMU): Data assimilation and validation of radar radial winds observations, 22. 4. – 17. 5. 2024, Prague.
- ☐ A. Zajec (DHMZ): Implementation and validation of OI analysis in a coupled ALARO/SURFEX system, 29. 4. – 24. 5. 2024, Ljubljana.
- ☐ S. Panežić (DHMZ): Data assimilation of all-sky radiance observations from MTG IRS, 17. – 28. 6. 2024 in Vienna, 2. – 13. 9. 2024 in Ljubljana
- ☐ A. Neduncheran (GeoSphere): Implementation of error model for cloud-affected Infrared observations from Meteosat-10 SEVIRI in AROME-Austria in AllSky assimilation, 21. 10. – 8. 11. 2024, Toulouse (Meteo France)

RC LACE DA at 3rd ACCORD All Staff Workshop 2023, 27 March – 31 March 2023, Tallin

List of presentations:

- ☐ BUČÁNEK Antonín: Data assimilation activities in RC LACE
- ☐ NEDUNCHERAN Adhithiyan: Assessing impact of SEVIRI water vapour channels in All-Sky conditions in AROME

National posters: Austria, Croatia, Czech Republic, Hungary, Poland, Slovakia, Romania

Activities of management, coordination and communication

1) Attendance to 4th All Staff Workshop, 15-19 April 2024, Norrköping
2) Attendance to ACCORD DAWW1: Met Éireann, Dublin, 11 - 15 March 2024

3) Attendance to 8th WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction and Earth System Prediction, Norrköping, 27-30 May 2024
4) Attendance to EUMETSAT Core NWP meeting, online. 3.9.2024
5) Attendance to OPERA NWP user group meeting, online. 8.2.2024
6) Attendance to TaskTeams meetings for new Accord Strategy document, online.
7) Attendance to Accord DAWW preparation meetings, online.
8) Informal LACE DA meetings (2nd Wednesday every two months), online.
9) ACCORD DA RD topical meetings, online.
10) LSC meetings.
11) Organization of LACE DAWD online 4-5.9.2024
12) Attendance to 46th EWGLAM and 31st SRNWP meetings, September 30 — October 3 2024, Prague

Summary of resources

Action (PM)	**Resource**		**LACE stays (months)**	
	Planned	**Realized**	**Planned**	**Realized**
Operational implementation of DA suites [COM3]	8	9.50		
In-situ observations [DA1]	12	15.00	1.0	1.00
Use of ground-based remote sensing [DA2]	20	26.00	1.5	2.25
Satellite-based remote sensing observations [DA3]	11	12.00	1.0 +1acd	2.00
Observation pre-processing, quality control, bias correction and representation error [DA4]	3	4.25		
Variational assimilation systems [DA5]	8	7.75		
EnVar, EDA and variants [DA6]	6	5.25		
Initialization methods and nowcasting [DA7]	1	0.00		
Diagnostic methods, optimization of assimilation cycling [DA8]	3	1.00		
AI/ML methods for data assimilation [DA9]	?	3.25		
Surface assimilation [SU1]	25	17.20	2.0	1.0
Total	**97**	**101.20**	6.5	6.25

Problems and opportunities

The main problems in 2024 are/remain:

- Distribute operational applications: local validation, maintenance and technical issues bring duplications of work that cannot be avoided.
- We are working on the different DA setups (cycle, method, resolution, physics) so individual results and setups are rarely directly applicable at other Members.

Opportunities for more effective future work are:

- Collaboration within the ACCORD consortium has generally improved due to numerous possibilities:
    - ACCORD Wiki – Working days mini subpages
    - RD on algorithms and observations related Slack communication exchange.
    - More coordination with MF accomplished (e.g. common topical reporting).
- On the other hand we keep LACE internal communication, mainly to discuss implementation results. The first feedback was positive.
- To try to unify the local developments, e.g. to try to achieve approximately the same level of development in majority of member countries.
- To actively participate in discussions and knowledge exchange regarding EUMETNET observations such as E-ABO, E-GVAP and OPERA.