

Working Area Data Assimilation

Progress Report

Prepared by:	Area Leader Antonín Bučánek
Period:	2018 (from January to September)
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Progress summary

In this report, the LACE DA activities are going to be summarized which have been done between January and September of 2018. Until mid September 5 LACE stays with a total duration of 4.25 months were realized supporting the activities of hourly DA systems and the use of radar based observations. As usual, large part of the DA work has been booked by the operational system upgrades and maintenance duties. These mainly local DA efforts are summarized in the first section of the LACE DA report.

Concerning research oriented actions, the use of high resolution observations and the application of high resolution DA systems for nowcasting purposes were in the main focus of the LACE members in 2018. The Mode-S aircraft observations have wider and wider network consisting Czech, Austrian, Slovenian and already KNMI distributed EHS observations in LACE. Regarding RADAR data assimilation, members started to make progress with the use of OPERA volume data, the new pre-processing tool was developed in Slovenia which help with homogenization of OPERA data from different radars. Now the main effort is in investigation of the quality of OPERA data and is processing trough BATOR-HDF5 reader. The assimilation of GNSS tropospheric delays (mostly ZTD) has been progressed also employing advanced bias correction scheme and further experiments with more observations resulted in operational use in Hungary, while other members still suffer with unsatisfactory results. The use of satellite observations was also investigated focusing on the specification of bias correction for limited-area challenges. Beside the observation usage, algorithmic developments (hourly analysis systems, EKF surface assimilation) will be shortly reported as well.

Action/Subject/Deliverable: *Towards operational implementationof full (upper air and surface) DA systems*

Description and objectives:

An overview of the current operational DA systems in LACE can be given by the following table (yellow colors indicate the latest system upgrades):



DA	AUSTRIA ALARO	AUSTRIA AROME	CROATIA ALARO	CZECH ALARO	HUNGARY ALARO	HUNGARY AROME	SLOVAKIA ALARO	SLOVENIA ALARO	ROMANIA ALARO
Resol.	4.8L60	2.5L90	8L37	4.7L87	8L49	2.5L60	4.5L63	4.4L87	6.5L49
Cycle	40t1	40t1	38t1	43t2_bf8	38t1_bf3	38t1_bf3	40t1	40t1	40t1
LBC	IFS 3h	IFS 1h	IFS 3h	ARP 3h	IFS 3h	IFS 1h	ARP 3h	IFS 3h	ARP 3h
Method	OI +dynadapt	OI_main+ <mark>Mescan</mark> + 3DVAR	OI + BlendVar	OI + 3DVAR	OI + 3DVAR	OI_main + 3DVAR	OI + DF Blending	OI + 3DVAR	OI + 3DVAR
Cycling	6h	3h	6h	6h	6h	3h	6h	3h	6h
B matrix	-	Down- scaled LAEF 11km	ALARO EDA	Down- scaled AEARP	ALARO EDA	AROME EDA		Down- scaled EC ENS	
Special	Additional snow melting	Snowgrid+ SAT snow init		sigmao_co ef=0.67 REDNMC= 1.7 IDFI in prod		GNSS ZTD			

In Austria, the operational ALARO (only OI-surface) and AROME (3DVAR+OI_MAIN) DA systems all cy40t1 export run mostly unchanged. The migration from MSG-10 to MSG-11 was done for GEOWIND and SEVIRI data according to the advice from LACE. HARMONIE-Observation monitoring was installed for AROME. A parallel AROME-ESUITE started this summer including assimilation of radar reflectivity from Austrian, German and Slovenian stations and MODE-S winds from Slovenia, KNMI and Austrian ATC, "Austrocontrol". Evaluation of this experiment is ongoing. Due to data policy only part of this data can be used in next operational version.

In the Czech Republic local effort was dedicated to validation of a new cycle CY43T2_bf8. BUFR data processing and message handling (BUFR SHIP, BUOY and TEMP data processing by BATOR) was improved. The higher density of TEMP observations with corrected time and position was investigated in 3DVAR and in verification by Duygu Ustuner. The stay report is in preparation, the preliminary results shows improved fit of the analysis to observations and very small positive impact for +6h forecast. Other CHMI DA activities are going to be reported in separate DA actions below.

In Slovakia local effort was dedicated to computation of EDA based B matrix for ALARO system and to investigation of bug in festat on cy40t1. The new 6-hour cycle of AROME 2L73 was technically implemented and validated. The development of EKF surface assimilation is ongoing. Other SHMU DA activities are reported in separate DA actions below.



In Slovenia the use of observations in operational suite is significantly improved by high resolution AMVs, KNMI processed Mode-S EHS data, AMDAR humidity, radiance data – IASI and ASCAT winds. Research on the impact of SST information on forecast was continued. There is submitted paper to QJRMS about two-way real time coupling between ALADIN and POM. Other ARSO DA activities are reported in separate DA actions below.

Regarding Romanian local work, ALARO DA system based on cy40t1 is in preoperational state on 6.5km with conventional observations. There is effort to introduce also geostationary satellite data but for time being it is unsuccessful. The problems are connected to "warm start" of VarBC coefficients while the "cold start" technically works.

In Croatia, study of different approaches to B matrix sampling continues. The local effort was devoted to radar assimilation mainly. An overview of HDF5 files from different radars was prepared. A case study was performed using Croatian, Slovenian and Hungarian radars with promising results.

In Hungary, there is operationally implemented assimilation of GNSS ZTD data in AROME. The main preparation of this data type had been done by Mate Mile before he left. Operational implementation was finalized by Viktoria Homonnai and Mihaly Szucs. Mate Mester focused on radars data pre-processing, more details can be found in radar section below.

Efforts: 6.75 months (local work) Contributors: roughly 1 person per countries Documentation: national reports on LACE webpage Status: ONGOING

Action/Subject/Deliverable: Hourly updated DA systems (RUC, RAP, cycled and non-cycled hourly DA systems)

Description and objectives:

In 2018 sensitivity experiments with AROME-nowcasting-1.2km-system are performed and evaluated in Austria. The system was upgraded by 2-hourly cycling, which was found better than 1-hourly cycling due to reduced spin-up.

The background errors were also optimized by adaptation of scaling coefficient REDNMC. It was found that use of too high values of REDNMC, which are used at Meteo-France for non-cycled system (REDNMC=3), means strong degradation in cycled system. Optimization of assimilation window (-90min-+30min) had neutral impact.



There were observed problems in 1.2km 3D-Var Minimization in several cases due to NaN values in SYNOP-GOM-arrays. It is still under investigation.



Figure. Comparison of Harmonie-RADAR-BATOR vs MF-RADAR-BATOR at 20180706 07UTC+3h precipitation: INCA-analysis (top), AROME-HARMONIE-Bator (middle), AROME-MF-BATOR cy40t1 backphased (bottom), observations are the same radars from Slovenia, Austria, Germany (national exchange) and OPERA (CZ,SK, HR, Hu, CH, F total 44stations)



During LACE stays the objective verification of AROME/Nowcasting system continued in Vienna. The main focus was put on the comparison of precipitation fields of INCA and AROME nowcasting system by fraction skill scores. The goal of this evaluation was to determine the exact forecast-range where NWP can outperform Nowcasting products like INCA. The results shows that INCA outperforms AROME nowcasting system only in first two hours of forecasts. For larger accumulations of precipitations the AROME nowcasting outperforms INCA after first hour of forecast, more details can be found in Mirela Pietrisi's LACE stay report.

Efforts: 7 months Contributors: F. Meier (At), M. Pietrisi (Ro) Documentation: reports on LACE webpage Status: ONGOING

Action/Subject/Deliverable: Studies of background error statistics in 3DVAR

Description and objectives:

In Slovakia a new EDA base B matrix was computed and validated for ALARO system (4.5L63).

In Croatia a study comparing three different B matrix sampling approaches and their influence on forecast was created. The B matrices compared are derived using standard National Meteorological Center (NMC) and two ensemble data assimilation (EDA) methods, one with unperturbed LBCs (ENS) and one with perturbed LBCs (ENSLBC). Diagnostic comparison showed that ensemble techniques shifts correlations towards small scales. This is the most pronounced for ensemble with unperturbed LBCs. The use of the new ENSLBC based B matrix

reduces spinup in first hours of forecast. The verification shows modest improvement for experiment with the new ENSLBC based B matrix compared to NMC based B matrix, see figure.



Fig. 10 Normalized mean root-mean-square difference between ENSLBC and NMC experiment for a) mean sea level pressure, b) cloud cover during 24 hours of forecast computed over all surface observations inside the model domain (700 stations) for June 2017. Error bars show 95% confidence intervals from Student t-test (negative values mean that ENSLBC experiment is better; difference is significant if error bars do not cross zero line).



Efforts: 4.75 months Contributors: M. Derkova(Sk), A. Stanesic (Cr) Documentation: reports on LACE webpage Status: ONGOING

Action/Subject/Deliverable: *Surface Assimilation using Extended Kalman-Filter*

Description and objectives:

At ZAMG, tests with local observation errors for soil moisture data assimilation with sEKF in SURFEX 8.1 were performed. So far, the results shows small not significant improvements compared to the static observation error but tests are ongoing to improve the error estimation of the satellite data with triple collocation. Assimilation of T2m with sEKF in SURFEX 8.1 is technically working, but no validation took place so far.

At SHMU, sensitivity analysis of 2-L and 3-L ISBA force restore scheme for soil volumetric water content has been started using the offline SURFEX and 1-column setup. A new method is proposed to allow efficient computation of EKF Jacobian matrices H and M in 1-column runs. It may be especially useful for higher dimensional control space like in diffusion scheme. The new method is used for investigation of the nonlinear behavior of coupled ISBA-CANOPY (ISBA-DIAG) scheme that is acting as observation operator in EKF analysis of soil moisture. More detail will be available later in Viktor Tarjani's detailed LACE report on webpage.

Efforts: 3 months

Contributors: S. Schneider (At), J. Vural (At), H. Toth (Hu), V. Tarjani (Sk) Documentation: reports on LACE webpage Status: ONGOING

Action/Subject/Deliverable: *Object (OOPS) and LACE's contributions Oriented code refactoring*

Description and objectives:

In the first half of 2018, no new action has been made in terms of LACE's contribution in OOPS refactoring.

Efforts: 0 months

Contributors: M. Mile (Hu)

Documentation: reports on LACE webpage



Status: ONGOING

Action/Subject/Deliverable: Assimilation of radiance observations (ATOVS, IASI, SEVIRI) in DA systems

Description and objectives:

The radiance observations from NOAA and METOP satellites are already in operational use at many LACE centre's DA systems. However, its use and more accurate assimilation requires further examination.

Patrik Benacek (CZ) is proposing a new configuration of VarBC suitable for LAM. The new configuration is compared with other VarBC approaches and evaluated by an impact study. An article related to the new configuration of VarBC is close for submission.



Figure. A response of different LAM-cycling VarBC approaches on the artificial instrument bias 0.1 K is evaluated for the AMSU-A channel 6 on NOAA-19. The following approaches are compared: CAM50 based on Cameron and Bell (2016), NBG2000 based on Lindskog et al. (2012), NEW50 is the newly designed approach and CONTROL is a reference without the artificial bias. A quality of the model-first guess is evaluated based on relative RMS (left) and BIAS (right) scores of OMG after 15-day spin-up period using the 3-hour analysis cycle. There is evident that the new VarBC configuration is able to adjust the bias correction to instrument bias changes on a shorter time-scale than other methods.



Efforts: 6 months Contributors: P. Benacek (Cz) Documentation: reports on LACE webpage Status: ONGOING

Action/Subject/Deliverable: Implementation of RADAR reflectivity and radial wind

Description and objectives:

In 2018, LACE members strengthen the collaboration on radar data assimilation. The plan is to first focus on use OPERA volume data and afterward on radial winds. The strong collaboration allowed us as LACE to give user feedback to OPERA about our experience with those data. We reported several problems and inconsistencies in the data sets and also lack of updates of documentation. The feed back document could be found in RCLACE forum in section "Data Assimilation/OPERA users group". There was two hangout meeting this year related to effective distribution of work on radars initiated by Slovenian colleagues.

This year was planned to have 5 radar DA related stays and 4 of them are already passed. One of the stays was devoted to pre-processing of radar data which started development of a new LACE pre-processing tool for OPERA data instead of know preopera tool from HIRLAM countries which was found as insufficient. Slovenian colleagues continued the effort that resulted in a new python pre-processing tool, which is available to all LACE members. The other stays are related to OPERA data quality and processing of radar data in BATOR. As a preliminary result of OPERA data quality it could be shown one of conclusions of Alena Trojakova report: "We can't fully relay on the OPERA QIs and a special attention to the data quality is necessary when assimilating OPERA radar reflectivity." Report from the stay on BATOR processing of radar data will be available later, so no conclusions so far. The BATOR-HDF5 reader was back-phased from cy43t1 to cy40t1 by Alena Trojakova to make it available to the all LACE members.

In Slovakia, Cooperation and technical help were given on investigation OPERA OIFS quality during LACE stay in Bratislava. The back-phased BATOR43T1 was tested locally at SHMU. Investigation of BATOR input/out for RCLACE radars is ongoing after LACE stay in Budapest.

In Austria, also the back-phased version of BATOR was tested in a case study against HARMONIE-HDF5-BATOR. This needeed updates of locally used pre-processor PREOPERA.



The tests of new LACE pre-processor were carried in comparison with PREOPERA. It was found that PREOPERA is rather slow compared to new LACE pre-processor due to additional interpolation/superobbing/vertical thinning.

The Obs operator for reflectivity (cy40t1) was compared to recent changes in cy43t1: A quality check was modified and MF changed number of profiles and search radius from 100km/81 to 200km/225. The latter requires significantly more memory in screening. Due to the fact that the operator cannot inject observed echos into the model, in case nothing is simulated within the search radius, the saturation of profiles with high observed reflectivity firstly tested during the stay at MF in 2015 was reconsidered.

In Croatia, An overview of ODIM HDF5 files from radars within Croatian ALARO NWP model domain was made. The report will be available in RCLACE web page. During the work on this overview some tools where developed. They help searching through ODIM HDF5 format and to do different kinds of file content listings.

A case study on 8th November 2017 was analyzed. For this case only data from Croatian, Hungarian and Slovenian radars were used. Radar data assimilation helped to remove wrongly forecasted rain in reference operational run.

In Slovenia, OPERA OIFS data set was found to be highly diverse in terms of data organization and meta data, so the main effort was devoted to homogenization software (pre-processor). The new pre-processor has modular functionalities:

- splitting of 15 min merged OIFS files to separate measurements
- rearranging the content according to specification in namelist
- retaining only the desired variables (e.g. reflectivity and/or radial winds)
- possibility to encode prescribed meta data separately for individual radars or for the whole data set

The tool called RH.py was used and preliminarly debugged on Bator cy43. Further validation is needed. A complementary Python tool was developed to be able to browse through all metadata and its values in a sample of radar files. It enables checking all the possible values for a given parameter and verify default values in Bator.

In hungary, Mate Mester was participating on development of the new preprocessor and was collaborating and giving technical help to the LACE stay for BATOR processing. The collaboration continues after the stay.

Efforts: 15 months



Contributors: F. Meier (At), B. Strajnar (SI), P. Smerkol (SI), A. Stanesic (Cr), T. Kovacic (Cr), A. Trojakova (Cz), M. Mester (Hu), M. Nestiak (Sk)

Documentation: reports on LACE webpage **Status:** ONGOING

Action/Subject/Deliverable: Assimilation of (ZTD, STD, refractivity index, gradient, etc) GNSS path delays

Description and objectives:

The usage of GNSS observations is in focus for most of the LACE members. Operational implementation of GNSS ZDT was done in Hungary this year. In Slovakia the whitelist of stations based on long term first guess and analysis departures was prepared and validated.

In Slovenia, GPS observations from Slovenia and its close surroundings are available operationally from Geodetic Institute of Slovenia. In the previous years several experiments were carried out in order to select stations of reasonable quality. However, the current results of long term evaluation are still unsatisfactory. While the upper-air impact on humidity is neutral to slightly positive we observe significant degradation of surface fields over Slovenia. This has to be understood and currently prevents the data from the operational usage.

Efforts: 2.25 months

Contributors: M. Mile (Hu), V. Homonnai (Hu), B. Strajnar (SI), M. Imrisek (Sk)

Documentation: reports on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: *Assimilation of Mode-S observations*

Description and objectives:

The use of Mode-S observations (both MRAR and EHS) have a fast growing network and increasing importance in LACE and in the mesoscale DA systems.

In Slovakia, there is ongoing negotiation with Slovak Air Traffic service to provide local Mode-S data for a diploma thesis for Katarina Catlosova (newcommer). Katarina is now getting theoretical preparation and is familiarizing with processing of raw Mode-S data.

In the Czech Rep., High resolution aircraft Mode-S EHS observations from KNMI covering airspace of Germany, Belgium and the Netherlands were investigated. Quality assessment with respect to NWP showed KNMI EHS data to be comparable to AMDAR, they have good BIAS for wind and temperature. STDE is



also good for wind while higher for temperature. There is no need for quality preselection. Preliminary results of impact on NWP forecasts show reduction of RMSE and BIAS of upper level wind and temperature in the first 10 hours of forecast.



Figure 1: Time evolution of **RMSE for wind speed at 250hPa** verified against aircraft observations for period of 11 Jan – 9 Feb 2017 12UTC. **Reference** and Mode-S EHS experiment.

In Austria new national EHS data were delivered for tests by national ATC "Austrocontrol". The latest activities on Mode-S at ZAMG were focused on the new data quality assessment.



Figure M2. 2-D histogram for wind data, showing FG-departure (x-axis) and pressure (y-axis) for all observations not rejected by SCREENING from 1 to 20 August 2018 from the AROME ESUITE. The left panel shows data for the u component and the right side shows data for the v component. The temperature was not assimilated. The thin (thick) black lines show the average FG departure for each height bin (running mean over 7 bins for the thick line) to visualize any bias in the data.

Figure M2 shows the distribution of FG-departure vs. altitude. It is immediately apparent that the ATC data has a much higher data density at cruise flight levels,



contrary to EHS data from KNMI (not shown), which has a more homogeneous distribution in height. The first guess departures are larger in the upper troposphere, the reason for this is not yet known. The bias is low at all altitudes except for the highest levels, where data is scarce. Overall, this is a major step forward compared to early versions of the data set.

Significant improvement of the ATC data quality (less outliers, better convergence of 3D-Var) allowed their use in the AROME ESUITE along side MODE-S winds from Slovenia and KNMI.

Efforts: 8.5 months

Contributors: M. Nestiak (Sk), K. Catlosova (Sk), B. Strajnar (Sl), A. Trojakova (Cz), P. Scheffknecht (At)

Documentation: reports on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: Assimilation of Meteosat HRW AMVs

Description and objectives:

In 2018, there was only limited time devoted to HRW AMVs in Slovenia. The HRW AMVs were added to operation suite after testing period which showed neutral impact on scores.

Efforts: 0.25 month Contributors: B. Strajnar (SI) Documentation: Status: ONGOING

Documents and publications

List of reports:

- Alena Trojáková, 2018/03: Radar data pre-processing
- Maria Monteiro, 2018/03: <u>CPDA1.3 implementation and validation of</u>
 <u>BATOR: SHIP&BUOY</u>
- Máté Mester, 2018/03: Towards homogenization of OPERA radar data
- Alena Trojáková, 2018/05: Evaluation of OPERA data quality for NWP DA purposes



RC LACE DA at Joint 28th ALADIN Workshop & HIRLAM All Staff Meeting 2018, 16-20/04/2018, Toulouse, France

List of presentations:

Benedikt STRAJNAR: Impact of Mode-S EHS observations in ALADIN

Posters:

- Imrisek Martin : Data assimilation activities at SHMU
- Kovacic Tomislav : Radar data assimilation in Croatia

National posters: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia, Romania.

Activities of management, coordination and communication

- 1) LACE Data Assimilation Working Days (DAWD) 2018, 19-21 September, Bucharest, Romania
- 2) 2nd hangout meeting on LACE radar DA stays in 2018, 21 June, initiated by Benedikt Strajnar



Summary of resources

Action (PM)	Resource		LACE stays			
	Planned	Realized	Planned	Realized		
Local DA system	-	6.75	-	-		
Hourly RUC	12	7	4	2		
Bmatrix	5	4.75	0	0		
Surface EKF	6	3 (SK not reported)	1	0		
Radiance obs	8	6	0	0		
RADAR obs	12	15	3	2.25		
GNSS obs	6	2.25	0	0		
Mode-S obs	8	8.5	0	0		
AMV obs	5	0.25	0	0		
Total	62	47	8	4.25		

Problems and opportunities

The main problems in 2018 were:

- A lot of work still booked by validation, maintenance and technical issues inside LACE DA activities.
- No time left for OOPS related developments which makes the future

Opportunities for more effective future work are:

- to increase the level of cooperation inside and outside LACE and support cooperation with other areas (e.g. DA & EPS common activities) as well.
- to make strategical decision about LACE's contributions in OOPS.
- a common state-of-art videoconference system should be used by all LACE members in agreement with ALADIN-HIRLAM community as well to avoid difficulties in communication