Working Area Data Assimilation

Progress Report

Prepared by:	Area Leader Máté Mile
Period:	2017 (from January to September)
Date:	15/09/2017

Progress summary

In this report, the LACE DA activities are going to be summarized which have been done between January and September of 2017. Until mid September, 3 LACE stays with a total duration of 6 months were realized supporting the activities of hourly DA systems, the use of Mode-S observations and the validation of EKF surface assimilation (this one is originally postponed from 2016).

As usual, large part of the DA work has been booked by the operational system upgrades and maintenance duties. In the first half of 2017 the implementation and validation of cy40t1 was on the to-do list at many LACE countries. 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 2017. 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 using HDF5 reader and related pre-processing (prepopera.py) tool. The assimilation of GNSS tropospheric delays (mostly ZTD) has been progressed also employing advanced bias correction scheme and further experiments with more observations. 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 implementation of 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 REP ALARO	HUNGARY ALARO	HUNGARY AROME	SLOVAKIA ALARO	SLOVENIA ALARO	ROMANIA ALARO
resolu-tion	4.8L60	2.5L90 (tests on 1.2km)	8L37 (tests on 4.4km)	4.7L87	8L49	2.5L60	9L36 (tests on 4.5km,1km)	4.4L87	6.5L49 (tests with L60)
cycle	36t1 exp	40t1 (e-suite) 38t1	35t1 38t1	38t1	38t1_bf3	38t1_bf3		40t1	40t1
LBC	IFS 3h	IFS 3h	IFS 3h	ARP 3h	IFS 3h	IFS 1h	ARP 3h	IFS	ARP
method	OI	OI_main + 3DVAR	OI + 3DVAR	OI + BlendVAR (DF blending + 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	-	downscaled LAEF	NMC lagged vs ALADIN EDA	downscaled ARP ENS	ALARO EDA	AROME EDA		new down-scaled EC ENS	
Special	additional snow melting			sigmao_coef =0.67; REDNMC= 1.7; IDFI in prod					

In Czech Republic local efforts was dedicated to utilize GTS SYNOP and AMDAR BUFR data processing, BUFR message handling and BUFR reading in BATOR. The necessary BATOR modifications (of cy38t1 and cy40t1) were distributed to the ALADIN/LACE colleagues and sent also to Météo-France phasing team. In 2017 the use of Mode-S MRAR observations became operational in Prague. More accurate background error statistics computed uniquely for Czech BlendVar DA system has been also prepared and a related article was published in Tellus.

In Austria the operational AROME DA system is running in e-suite with cy40t1 and at the end of 2017 it becomes operational before new HPC

migration. In 2017, the cloud analysis/nudging procedure was also further tested, tuned. Other ZAMG DA activities are going to be reported in separate DA actions below.

In Slovakia there were no updates in the operational DA suites. The development of EKF surface assimilation and the use of GNSS ZTD observations were examined during the first half of 2017, but those topics are going to be reported in dedicated LACE actions below.

In Slovenia the cy40t1 became operational which brought significant improvement in ALARO forecast performance (mainly due to new ALARO physics developments). The two-way coupled ocean-atmosphere model and DA system have been also further studied investigating new case studies and different coupling settings.

Regarding Romanian local work, ALARO DA system based on cy40t1 was successfully implemented (by the utilization of ALARO DA testbed on beaufix) and a high impact precipitation case study was evaluated comparing ALARO forecasts with and without local data assimilation. This case showed promising results which can be seen on figure 1 below.

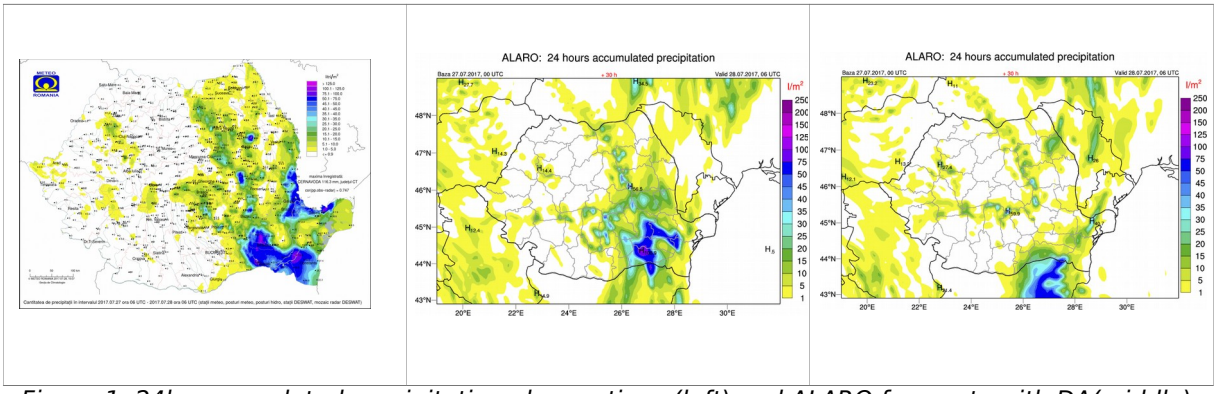


Figure 1. 24h accumulated precipitation observations (left) and ALARO forecasts with DA(middle) and without DA (right) for case study of 27th of July 2017.

In Croatia, a local ALADIN EDA was built with 6 ensemble members in order to compute new B matrix (ENS B) based on ensemble methodology. For the ensemble assimilation cycles, LBC were used from ECMWF EPS. This new ENS B was diagnosed and compared with background errors computed by NMC method and also compared with another ENS B using unperturbed LBC. The preliminary diagnostic results suggested the benefit of the new ENS B instead of NMC B. In addition the tunning of sigmao-sigmab relation was studied for the different B matrices applying Desroziers method.

In Hungary there were no upgrades in the operational data assimilation suites so far in 2017. The validation of cy40t1 for AROME OI_main was

time-demanding due to the SURFEX file format change (LFI to FA), inline OI_main and lake surface temperature initialization issues. Other more research oriented activities are going to be summarized in specific DA topics.

Efforts: 6 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 2017 the non-cycled hourly DA systems and its developments have been further examined. In Austria the production of AROME/Nowcasting system was further evaluated running the system for July 2016 and January 2017 employing 3DVAR radar assimilation (1D+3DVAR) and latent heat nudging. The so called IAU was also used in these tests. The higher resolution of AROME/Nowcasting (1.2km) is going to be studied after the migration of new HPC.

During LACE stays the objective verification of AROME/Nowcasting system has been performed in Vienna. The main focus was put on the precipitation field assessing the forecasts by the so called MET (Model Evaluation Tool) and its statistics. Also the goal of this evaluation is to determine the exact forecast-range where NWP can outperform Nowcasting products. The results and report of this investigation is under preparation, therefore more details are going to be reported later and will be read in Mirela Pietrisi's LACE stay report.

Efforts: 6 months

Contributors: F. Meier (At), A. Trojakova (Cz), P. Benacek (Cz), A. Bucanek (Cz), M. Pietrisi (Ro)

Documentation: reports on LACE webpage

Status: ONGOING

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

Description and objectives:

In 2017 beside the local developments of background error statistics (reported already under the first action of operational DA system) no common action happened. Just recently a document was sent to LACE DA colleagues about ideas, proposals for the generation of flow-dependent aspects of structure functions. During the upcoming LACE DA Working Days it is going to be further discussed and more details will be reported in the updated LACE progess report.

Efforts: 6 months

Contributors: B. Strajnar (Sl), M. Mile (Hu), A. Stanesic (Cr), T. Kovacic (Cr)

Documentation: reports on LACE webpage

Status: ONGOING

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

Description and objectives:

At ZAMG, sEKF soil moisture and soil temperature assimilation experiments have been carried out in 2017. For soil moisture the assimilation setup consisted SURFEX v8.0 and AROME cy40t1 model configuration (including ISBA diffusion scheme). Test runs and preliminary verification results (against SYNOP stations below 300m) showed significant improvement for T2M (see figure 2.) and RH2M short-range forecasts, but for verification against higher stations and for precipitation in general, there is no clear impact of the assimilation. The same sEKF assimilation setup was used also for soil temperature assimilation experiments where INCA gridded observations were applied. The results of this second study is under evaluation.

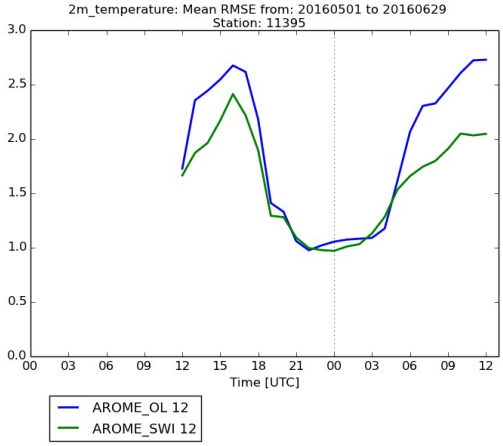


Figure 2.RMSE verification against Austrian SYNOP station 11395 for AROME 2m temperature forecast. Blue curve shows AROME reference without SWI assimilation, green curve indicates AROME with SWI assimilation.

Another EKF surface assimilation activity employing conventional observations was examined in 2017 as well. In the frame of a LACE stay at OMSZ, the validation of EKF method was investigated by 1D-column experiments. This established 1D EKF testbed helped to make separation of possible errors sources e.g. CANARI gridded observations, observation operator and to focus on EKF methodology. Furthermore the use of in-situ tower and soil observations from a Hungarian SYNOP station (Debrecen-Kismacs) gave the possibilities to create direct forcing and input observations (not using 2m SYNOPs and CANARI) for the simplified validation process. Additionally the physiography data (HWSD database and cover types from ECOCLIMAP) had to be generated to the given location and also several source code changes (in varassim.F90) had to be developed. More technical information is available in Viktor Tarjani's detailed LACE report on webpage.

Efforts: 9 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 Oriented code refactoring (OOPS) and LACE's contributions***

Description and objectives:

In the first half of 2017, no new action has been made in terms of LACE's contribution in OOPS refactoring. At the second half of 2017 the cy43t1 is foreseen to be tested in the context of OOPS and related test harnesses.

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.

A new approach of the VarBC stiffness parameters was studied (VarBC-new) based on a variance-bias trade-off of an observation bias. This method harmonizes a bias correction specifically across analysis times and satellite channels considering daily-mean contributions of a NWP model bias. The VarBC-new method was examined in terms of a VarBC initialization in the limited-area model (LAM) Aladin-CZ. Different initialization methods were compared, namely global-restart (global-RS), warmstart (VarBC-warm), coldstart (VarBC-cold), coldstart proposed by Lindskog et al. (2012) (VarBC-cold-ML) and the VarBC-new method. These approaches were evaluated in terms of a length of a spin-up period and a quality of satellite bias correction. To sum up, all the initialization methods provided robust prediction of the observation bias in the LAM. While the VarBC-cold method required extensive spin-up period (3-4 months) to provide a meaningful bias correction especially for low-peaking AMSU-A channels, the VarBC-cold-ML method reduced the spin-up period for these particular channels up to 1-2 months. However, both coldstart methods were not capable to gain better quality of the air-mass and scan-angle bias correction compared to the methods based on the global bias parameters i.e. global-RS, VarBC-warm and VarBC-new. (see figure 3 below) The global-RS method was shown as a good option for the bias correction in LAMs considering no spin-up period that is required for the initialization. However, this approach should be used provided that the detected observation bias and VarBC schemes are consistent between the global and LAMs. In Aladin-CZ, these assumptions were violated for low-peaking AMSU-A channels resulted in significantly worse bias correction quality. In this case, it was recommended to use the developed VarBC-new method (prior to VarBC-warm) reducing significantly the variation of the observation bias prediction for MHS channels due to the NWP model bias.

Efforts: 6 months

Contributors: P. Benacek (Cz)

Documentation: reports on LACE webpage

Status: ONGOING

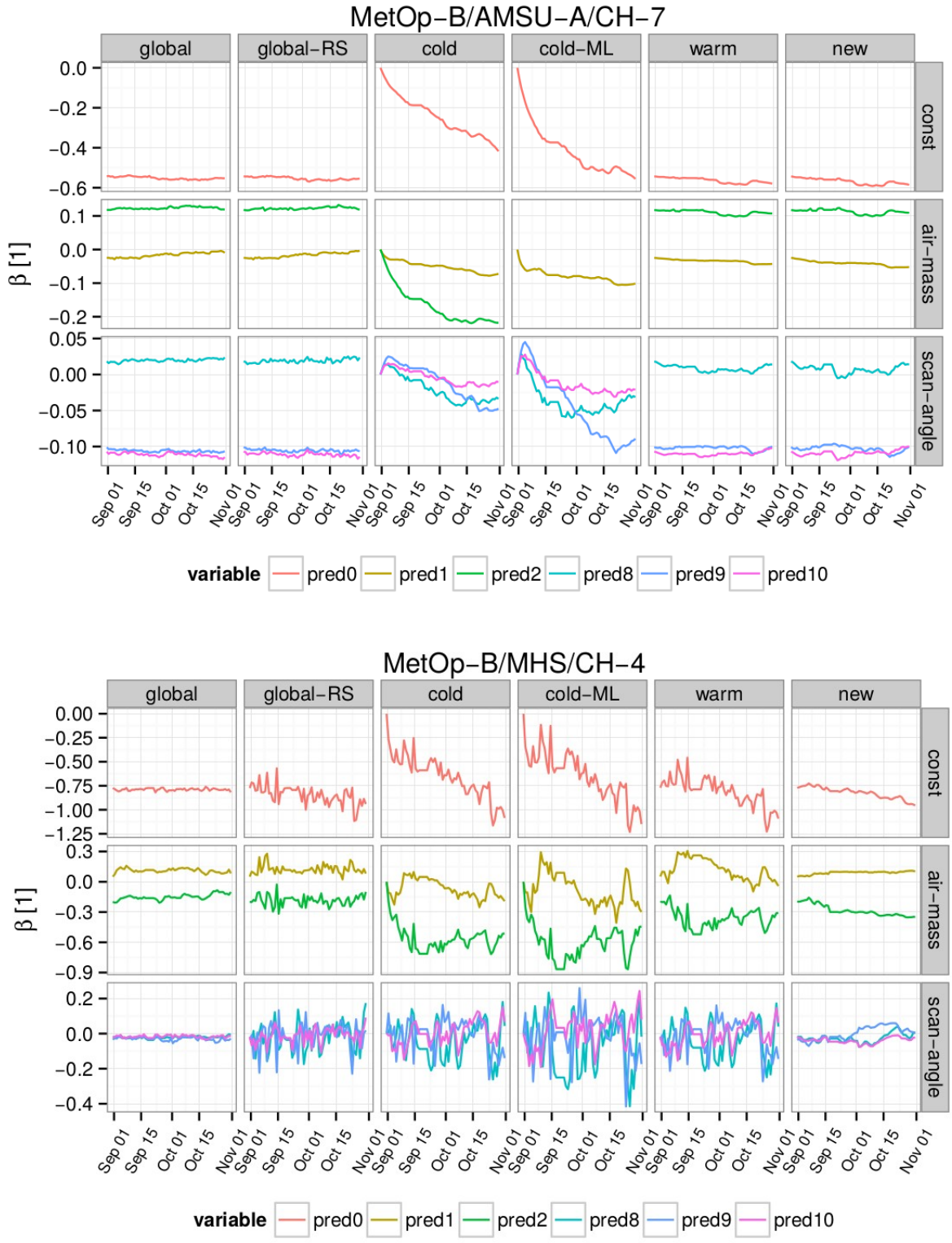


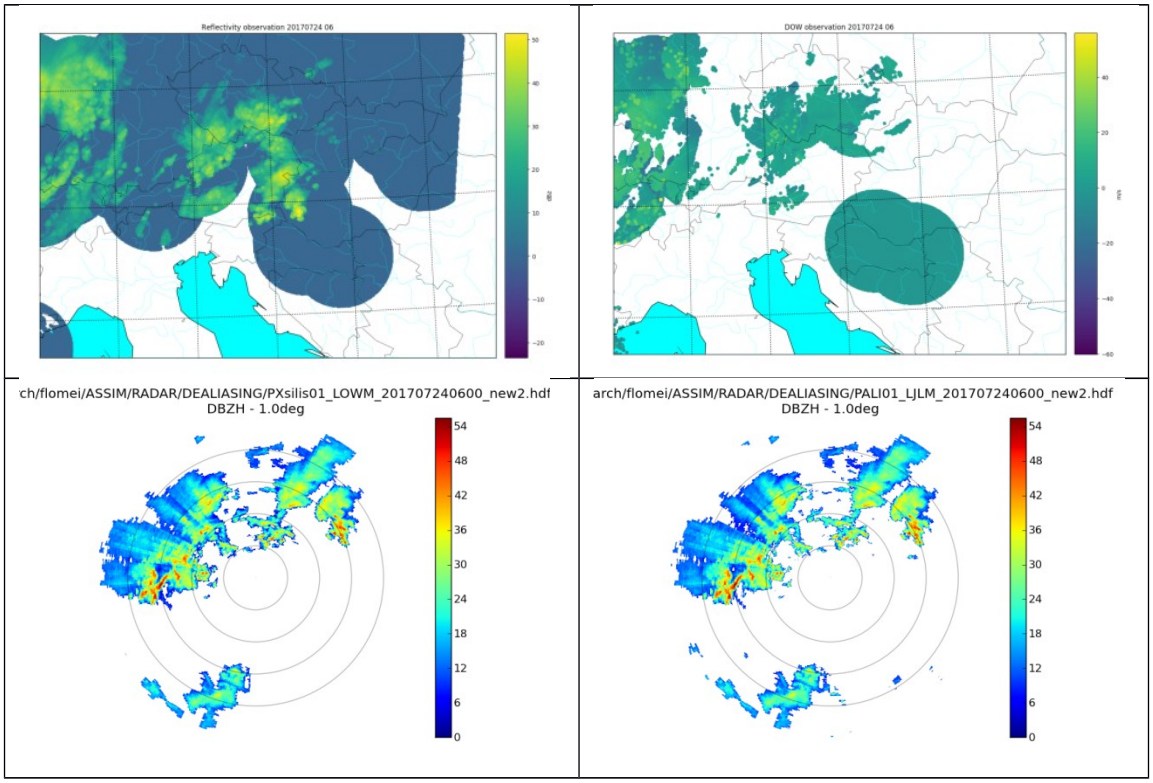
Figure 3. Time-evolution of bias parameters associated with constant (top), air-mass (middle) and scan-angle (bottom) predictors that are detected for the ARPEGE (global), global-restart (global-RS), default coldstart (cold), coldstart proposed by Lindskog et al. 2012 (cold-ML), default warmstart(warm) and warmstart with the new formulation of stiffness parmameter (new). The bias parameters are monitored for the AMSU-A channel 7 (top) and MHS channel 4 (bottom) on MetOp-B from Sep to Oct 2015..

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

Description and objectives:

In 2017 more and more LACE members started the experimental use of RADAR observations, especially using OPERA volume data and related pre-processing (prepopera.py) tool developed by HIRLAM colleagues. Beside that a common strenghten cooperation and proposal for the LACE Council is under discussion.

In Austria major progess was achieved with the use of RADAR data in OPERA HDF5 format. The HDF5-reader in Bator was modified and the pre-processing tool (prepopera.py) was also adapted to the different RADARs, therefore all available OPERA data in Austrian AROME domain became usable for data assimilation. A case study has been also performed with the use of 40 RADAR sites (see figure 4 below). Additionally a tuning of the Latent Heat Nudging (LHN) for AROME/Nowcasting test period was investigated. A slight modification of the nudging function following Stephan's 2008 approach was implemented in the source code accordingly.



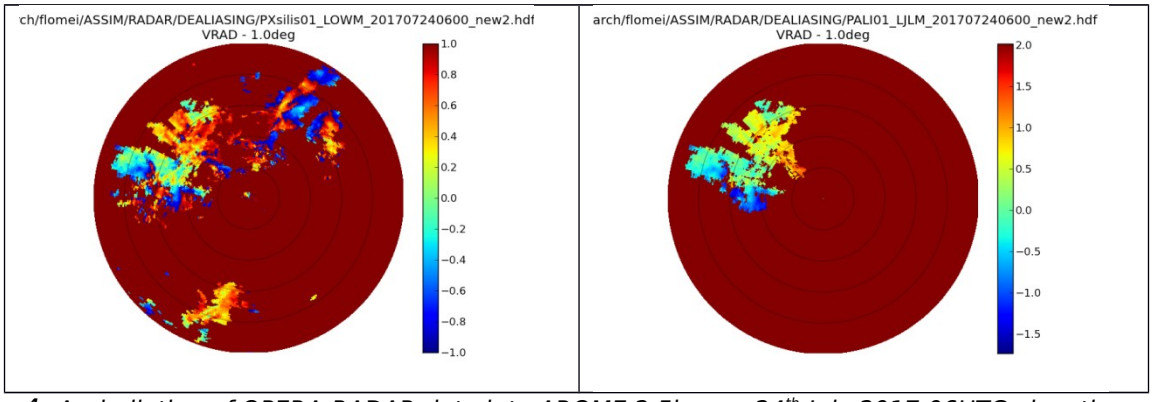


Figure 4. Assimilation of OPERA-RADAR data into AROME 2.5km on 24th July 2017 06UTC elevation 1.5°: top left reflectivity observations in Screening, top right Doppler wind observations in Screening. 32 OPERA radars from Belgium 1, France 8, Germany 9, Poland 4, CZ 2, SK 2, HU 2, SL 2, HR 2 and 4 Austrian radars (Austrocontrol) and 1 Italian (bilateral exchange) *Middle: reflectivity observation 1° elevation from Ljubljana RADAR (left OPERA, right bilateral exchange + Austrian QC). Bottom: same for Doppler wind (bilateral data after de-aliasing).*

In Slovenia the first RADAR data assimilation experiments have been started reading observations in OPERA HDF5 format and employing OPERA pre-processing (prepopera.py) tool. Also the RADAR quality control was studied comparing the INCA and OPERA QC procedure for the Slovenian reflectivity data (see an example in figure 5. below).

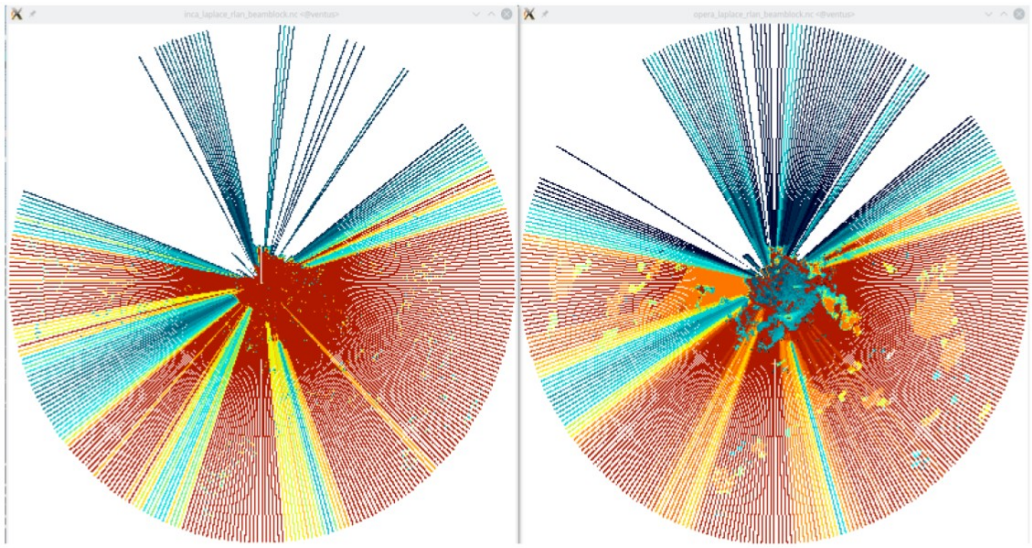


Figure 5. A comparison of total quality indices from INCA (left) and for OPERA QC (right) for one case study.

In Croatia, the RADAR data assimilation studies have been restarted with ALARO model on 4km resolution. Similarly to ARSO and ZAMG, the OPERA HDF5 format (and HDF5 reader in Bator) in combination of prepopera.py tool were considered and applied. Hourly RADAR observations from OPERA data hub were collected and the first results are under evaluation.

Efforts: 5.5 months

Contributors: F. Meier (At), B. Strajnar (Sl), A. Stanesic (Cr), T. Kovacic (Cr)

Documentation: report on LACE webpage

Status: ONGOING

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

Description and objectives:

In Slovenia, new data assimilation experiments with the use of GNSS ZTD were carried out working with the observations of Geodetic Institute of Slovenia. However, the pre-selection of trusted GNSS sites was extensively studied, but the impact of GNSS ZTD is still not satisfactory in ALARO analyses and forecasts. Further investigation is needed in order to understand the deficiencies.

In Slovakia, new action was started to use also locally produced GNSS ZTD observations in an experimental AROME framework. The first studies utilized default configurations of the whitelist generation procedure and the static bias correction scheme. The results are under interpretation.

In Hungary, more GNSS ZTD observations were tested from EUMETNET E-GVAP networks (SGO1-Hungarian, GOP1-Czech, WUEL-Polish inside AROME 3DVAR domain, see figure 6.) and new whitelist was generated accordingly. Beside the use of more observations, the variational bias correction procedure was further examined for GNSS ZTD. All together 4 predictors (0-constant, 1-1000-300hPa thickness, 3-skin temperature, 4-TCW) were used and therefore VARBC routines of surface observations were extended. However, the functionality of VARBC worked correctly for active assimilation (cold start initialization), the GNSS passive assimilation with VARBC was not able to update bias coefficients which has to be further studied. An additional issue has been identified about the 3DVAR minimization which is occasionally produced poor convergence when GNSS ZTD is switched on. The latest results and issues are under investigation.

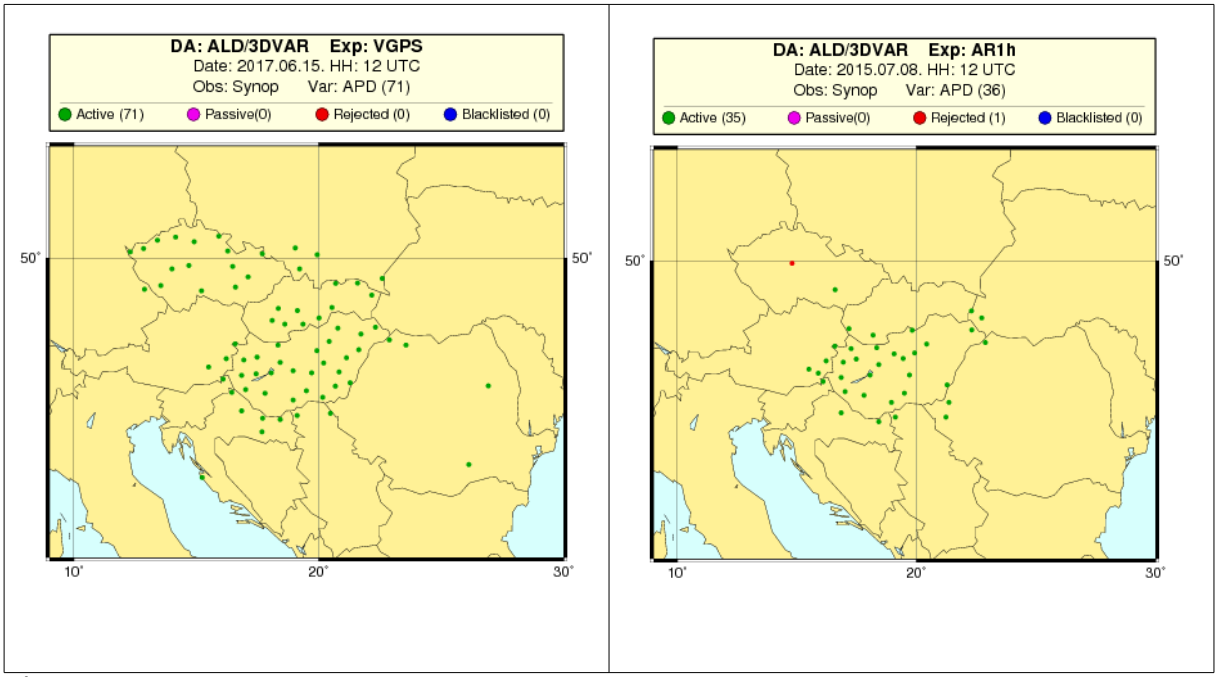


Figure 6. Observation monitoring of active GNSS ZTD stations from two different experiments. One is about the use of 3 E-GVAP networks (left figure) and another is using only observations from Hungarian (SGO1) network (right figure).

In Austria, the GNSS ZTD and recently Radio Occultation (RO) observations were examined in 2017. The data assimilation activity about the use of ZTD from national and E-GVAP networks was restarted. In the frame of a scientific project, an experimental RO dataset was also studied to check the observation operator and the related setting in AROME 3DVAR.

Efforts: 5 months

Contributors: M. Mile (Hu), B. Strajnar (Sl), F. Meier (At), M. Imrisek (Sk)

Documentation: report 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 Austria, the Mode-S EHS data from AustroControl (ATC) in KNMI ASCII format was received by ZAMG. Then the KNMI ASCII format was converted

into OBSOUL ASCII and the first data assimilation experiments are currently ongoing.

In Czech Republic, the Mode-S MRAR observations have been introduced operationally in ALARO DA system in 2017. Furthermore the evaluation of the quality and impact of Mode-S EHS observations was also examined and a related LACE stay was accomplished just a month ago in Prague (in August 2017). The report from Benedikt Strajnar (Sl) and the assessment of the results are under preparation.

Efforts: 7 months

Contributors: B. Strajnar (Sl), A. Trojakova (Cz), P. Benacek (Cz), A. Bucanek (Cz)

Documentation: report on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: Assimilation of Meteosat HRW AMVs

Description and objectives:

In 2017, there were no significant progress on this subject, however, in Slovenian operational data assimilation system the adaptation of cy40t1 has been made to be able to read HRW observations as well (together with Geowind AMV).

Efforts: 0.5 month

Contributors: F. Meier (At), M. Mile (Hu), B. Strajnar (Sl)

Documentation:

Status: ONGOING

Documents and publications

List of reports:

- Florian Meier, Stefan Schneider, Phillip Scheffknecht, Florian Weidle, Jasmin Vural, Christoph Wittmann: DA activities at ZAMG in 2017
- Viktor Tarjani: Validation of EKF surface assimilation scheme (LACE stay report)
- Mirela Pietrisi: Comparison of NWP based nowcasting (AROME) with classical system (LACE stay report from 2016)
- Benedikt Strajnar: Overview of ALADIN data assimilation activities at Slovenian Environment Agency (ARSO)

List of presentations:

Mate Mile: “The latest data assimilation activities in LACE countries”, Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting, 3-7 April 2017, Helsinki, Finland

Antonin Bucanek: “Appropriate Bmatrix for BlendVar”, Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting, 3-7 April 2017, Helsinki, Finland

Florian Meier: “Tests on cloud initialization with AROME over Austria and Germany”, Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting, 3-7 April 2017, Helsinki, Finland

National posters at Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting, 3-7 April 2017, Helsinki, Finland: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia, Romania, Available online: http://www.umr-cnrm.fr/aladin/spip.php?article304&lang=en

Activities of management, coordination and communication

1) Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting 2017, 3-7/04/2017, Helsinki, Finland (participation of Mate Mile)

LACE supported stays – 20 weeks in 2017

1) Mirela Pietrisi (MeteoRomania) – 8 weeks in Vienna (ZAMG), June-July. 2017.

2) Viktor Tarjani (SHMU) – 5 weeks in Budapest (OMSZ), 16th of Jan. - 17th of Feb. 2017. (postponed from 2016)

3) Benedikt Strajnar (ARSO) – 3 weeks in Prague (CHMI), 21st of Aug. - 8th of Sept. 2017.

Summary of resources/means

Action	**Resource**		**LACE stays**	
	Planned	**Realized**	**Planned**	**Realized**
Local DA system	-	6	-	-
Hourly RUC	8	6	4	2
Bmatrix	3	6	0	0
OOPS	2	0	0	0
Surface EKF	6	9	1	(1)
Radiance obs	8	6	0	0
RADAR obs	8	5.5	0	0
GNSS obs	6	5	0	0
Mode-S obs	8	7	0.75	0.75
AMV obs	5	0.5	0	0
Total	**54**	**51**	**5.75**	**3.75**

Problems and opportunities

The main problems in 2017 were:

- A lot of work still booked by validation, maintenance and technical issues inside LACE DA activities.
- The communication channels are also not effective and to be improved in the future.
- No time left for OOPS related developments which makes the future cycle validations more and more difficult.

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 consider common scripting and validation systems to reduce technical part of the DA works.
- To make strategical decision about LACE's contributions in OOPS.
- to apply common international projects which supports the research oriented activities
- 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
- to make long term planning and to determine priorities for long term aims and actions.