Report from LACE Data Assimilation Working Days (DAWD)

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Short progress summary: Main efforts were devoted to upgrades of model cycles, optimization of operational applications and/or enhancements of observation usage. The operational DA systems are using cy38t1 or higher almost at every LACE centres. There are new systems targeting nowcasting forecast ranges and related applications, namely AROME/Nowcasting in Vienna and ALARO nowcasting framework based on 3DVAR and OI of the screen parameters (VarCanPack) at CHMI. Regarding algorithmic developments the Latent Heat Nudging (LHN) method of assimilation of 2D rain rates was implemented in AROME following Jones and Macpherson (1997). The OPLACE system was extended by new aircraft observations (AMDAR humidity and high resolution Mode-S EHS data from KNMI) and to support radiance assimilation of new sensors the data from the cross-track scanning Advanced Technology Microwave Sounder (ATMS) were implemented. The observations distributed by OPLACE are more and more used by LACE members, especially newer ones like Slovenian Mode-S, HRW AMV and satellite radiances. Other observations not available on OPLACE e.g. GNSS ZTD were also studied at many LACE partners. Furthermore various settings, switches (LDIRCLSMOD, MESCAN, LSPRT) were under investigation to identify its proper use. More details about the topics can be read at different sections of the report.

Overview of operational DA systems (with highlighted recent upgrades) :

	AUSTRIA ALARO	AUSTRIA AROME	CROATIA ALARO	CZECH REP ALARO-1	HUNGARY ALARO	HUNGARY AROME	SLOVAKIA ALARO	SLOVENIA ALARO	ROMANIA ALARO
resolution	4.8L60	2.5L90	8L37	4.7L87	8L49	2.5L60	9L36	4.4L87	6.5L49
cycle	36t1 exp	40t1 38t1	35t1 38t1	38t1tr	38t1_bf3	38t1_bf3		38t1	38t1 40t1
LBC	IFS 3h	IFS 3h	IFS 3h	ARP 3h	IFS 3h	IFS 1h	ARP 3h	IFS	
method	OI	OI_main inline (modified correlation, snow	OI + 3DVAR	OI + BlendVAR (DF blending + 3DVAR)	OI + 3DVAR	3DVAR	OI + DF blending	OI + 3DVAR	OI + 3DVAR

		from MODIS + offline snow model) + 3DVAR	tests on 4.4km			tests on 4.5km			
cycling	6h	3h	6h	6h	6h	3h	6h	3h	6h
B	-	downscaled LAEF	NMClagg	downscaled ARP ENS				new down-scaled IFS ENS	
Special	additional snow melting			sigma_coef=0.67; REDNMC=1.7; IDFI in prod					

Austria (Florian Meier):

Operational AROME configuration **was upgraded to cy40t1 (except 3dvar), CANARI OI_MAIN inline with the MESCAN setting** and Constance lake temperature measurement interpolation was implemented. AROME nowcasting (hourly +12h forecast based on operational AROME guesses) is being tested on two resolutions (2.5L90 and 1.2L90), coupled by AROME-OPER and surface from ALARO or last AROME or cycled surface DA. Assimilated data as OPER + RADAR REF/DOW + MODE-S-Slovenia + AMDAR-humidity + OPLACE-national + Latent heat nudging (INCA). Future plans comprise a testing of the cloud initialization, further optimisation of radar DA+LHN, experiments with Mode-S EHS and surface EKF data assimilation.

Croatia (Antonio Stanesic):

Main efforts were dedicated to a set-up and evaluation of ALADIN-HR4 (ALADIN-HR4 has more clouds, T2m better bias during day, too warm during night; comparable RMSE, RH2m better bias during day, too dry during night; wind speed – bigger (positive) bias; smaller RMSE . Better results for T2m and wind speed during winter and better results if we look whole domain (HARMONIE verif))

Surface data assimilation was tested and **suspicious increments were found using LDIRCLSMOD=.T.**. The CANARI probably does not take into account fluxes when recomputing 2m diagnostics (similarly as in the first time step of model forecast).

Furthermore, MESCAN setting (background error correlation function for T2m and RH2m dependant on difference in height and land-sea between two locations) and an effect of fluxes (cloud, precipitation and wind) on surface/soil increments

was tested. A **3dvar issue** (NaN in minimization => no about, but no performed analysis!) was pointed, but no solution has been found yet.

Validation of ALADIN-HR4 will continue in the future together with an implementation of new observation types (GPS). Background errors sampling and diagnostic will be further investigated and work on radar DA will be revitalized.

Czech Republic (Antonin Bucanek):

Data assimilation of **Mode-S MRAR** data available in the airspace of the Czech Republic was investigated. Mode-S MRAR observation are of a good quality and ready for data assimilation just after the basic data selection based on statistics of differences with respect to NWP model. For Mode-S EHS larger errors were observed and there is a potential for further improvement of the data quality using more advanced preprocessing. Mode-S data seems very interesting and potentially very helpful for NWP and nowcasting applications.

Main efforts were devoted to an **operational implementation of VarCan Pack** (hourly non-cycled analysis system) replacing the operational diagnostic analyses (Diag Pack) based on CANARI. The VarCan Pack consists of 3D-Var for the upper-air and CANARI for the screen level. The 3D-Var setting is exactly the same as in the OPER and CANARI performs analysis of T2m, Rh2m, 10m wind and MSLP with a very close setting to the former Diag Pack. The 2m and 10m fields are read from guess and not re-diagnosed (LDIRCLSMOD=TRUE). Observation cut-off is 18min and assimilated observations are OPER (SYNOP, TEMP, AMDAR, AMV, SEVIRI) + Mode-S MRAR from the Czech Republic . **The fullpos was extended by wind gust and MOCON diagnostics** to be computed from analyses.

The verification package (VERAL) was upgraded to cy38t1tr, **LDIRCLSMOD option was extended for 10 wind**, thus all screen level parameters are read from guess (T2m, Rh2m, 10m wind) . This modset for cy38 is available upon request and a phasing to an export is being discussed with Meteo France. Furthermore, the formula using the saturation against water is applied (similar to one WMO recommend for radiosonde humidity measurement) via LNEGE=F.

A misbehaving of observation operator for 10m wind (too large increments in points where the last model level is below 10m) was pointed, but not fixed yet. This issue can be overcome by using LDIRCLSMOD=T.

The LSPRT=T switch (important mainly during model integration for a precise computation of pressure gradient term also in presence of cloud and falling precipitation species) **seems to be bugged for ALADIN/ALARO analysis configurations (using spectral humidity) and it is suggested to set LSPRT=F in the 3DVAR. Furthermore, LSPRT=.F. should be used in femars** (computation of forecast differences for B matrix to compute covariances of temperature and not virtual temperature!). **For AROME Pierre Brousseau recommends to use LSPRT=.T. and do not read the hydrometeors (NREQUIN=0 in NAMGFL) in the minimization!**

Hungary (Mate Mile)*:*

There were only minor changes in operational systems since last year. However many issues were reported about the ALARO DA system and the use of radiance observations. First of all the relatively rare crash in screening in routine **rttov_calcbt_basic.F90** was still observed only for MHS radiances of NOAA-18 satellite. Furthermore an issue with radiance observations and **VARBC** was reported when major overestimation of precipitation was obtained in ALARO. The VARBC parameters and the channel selection have to be revised in the future. Regarding the CANARI surface assimilation system of ALARO/Hungary the **missing surface fluxes** (reported previous years by CHMI and SMHU colleagues) in first guess were checked. Considering these fluxes in first guesses slight positive impact can be gained in ALARO DA system.

The validation of cy40t1 is not completed due to an abort in screening with error message **"invalid surface pressure"** in RTTOV. More investigation on this issue is planned at the end of 2016.

In AROME DA system the **OI_main surface assimilation** was further tested and a parallel suite was launched to observe the performance of AROME+OI_main on a longer period. However the AROME+OI_main is not fully outperforming the AROME+downscaled ALARO OI system, it was recommended to implement operationally due to technical reasons and better consistency of AROME surface and PBL parametrization.

Radiosonde observations valid at 02UTC were allowed to enter AROME 03UTC analysis and found to be positive on analysis and forecasts for a certain period. Therefore the extension of TEMP assimilation window was recommended to use more observations in 3DVAR 3 hourly RUC systems.

The **assimilation of GNSS ZTD observations** was also continued in Hungary in AROME 3DVAR. After the revision of ZTD station selection and the extension of VARBC predictors for surface observations like ZTD, positive impact was found versus the operational AROME system.

Last but not least the prototype of OOPS LAM 3DVAR (OOVAR) and new HOP driver were further tested. However there are still issues with the **OOPS configurations**, it was identified as an important action which will be continued in the future as well.

Slovakia (Michal Nestiak):

Evaluations of a new domain (4.5L63, OI+DF blending) continued. A significant progress was achieved in a technical implementation of ALADIN and AROME assimilation configurations! Next year the background error computation is planned, work on radar data assimilation will be revitalized and surface data assimilation using SURFEX will be studied.

Slovenia (Benedikt Strajnar):

The background errors were recomputed to account for physics changes (ALARO-0 → ALARO-1vA) for period of March 2016 (712 samples) using downscaled ECMWF EDA (at ECMWF). The new standard deviations showed mostly increased errors, except for low-levels temperature and humidity, somewhat sharper vertical correlations and a less coupling between humidity and temperature.

A positive impact was detected assimilating ZTD from E-GVAP and SIGNAL networks previously using white list approach and static and variational bias correction (VARBC). The individual impact of SIGNAL stations was tested this year. Elliptic vs geometric height issue was highlighted and an importance of stations pre-selection for VARBC performance was mentioned.

The two-way ocean atmosphere coupling of ALADIN and POM over Adriatic is investigated with promising results.

OPLACE progress report (Alena Trojakova)

The OPLACE system reliability and testing environment has been improved. The OPLACE was extended by AMDAR humidity observations and to support radiance assimilation of new sensors the data from the cross-track scanning Advanced Technology Microwave Sounder (ATMS) were implemented. Regarding non-LACE countries access to the OPLACE, a negotiation with Tunisia was finalized and the access to OPLACE essential data was granted.

The internal data exchange within LACE (OPLACE-national) is working well. The regular overview of exchanged surface synoptic data was prepared. A negotiation with KNMI was finalized and Mode-S Enhanced Surveillance (EHS) aircraft temperature and wind observation has extended available high resolution aircraft data in the OPLACE since August 2016.

A simple scripts for the 3DVAR testing was updated for cy40t1 at Meteo France HPC. There has been a very limited progress of the Continuous Observation Processing Environment (COPE) project and testing of the COPE framework is planned for the near future.

HIRLAM upper-air DA - progress and plan *(Roger Randriamampianina)*

The HIRLAM upper-air activities were summarized in three main groups (Operational systems, highlights of progress in UA-DA and DA plans). Regarding **operational systems**, the most common configurations are the 3 hourly cycled 3DVAR using most of the conventional and radiance observations (from NOAA and METOP satellites), furthermore few of them using scatterometer, GNSS, AMV and RADAR reflectivity observations as well. The VARBC approach is also employed for radiance and GNSS ZTD observations. Regarding the **recent DA progress**, the initialization and the balance operator of 3DVAR were highlighted as the most problematic part of the recent DA configurations. Beside system optimization, HIRLAM countries put many efforts to establish hourly RUC and nowcasting like (rapid fresh) DA systems and making developments of 4DVAR, LETKF for its future applications. Regarding the use of observations RADAR, Mode-S, GNSS, AMVs and ASCAT products are the most commonly studied ones in

the consortia. The AMV impact study was shown in details where Geowind, HRW and polar AMVs were tested in AROME 3DVAR. The first results of the validation and the use of GNSS slant delay were also reported which study consist detailed validation of the slant GNSS delay observation operator with benchmark dataset. Concerning the **future of DA in HIRLAM** it is planned to use wide range of algorithms at the different members, like LETKF, 4DVAR, EDA, hourly 3DVAR and later to build Hybrid DA and EnVAR systems as well. Furthermore to make tests with new approaches as "forth and backwards nudging scheme" or IAU. At the end, **everyone was encouraged to participate in HIRLAM meetings, especially HIRLAM videomeetings in the future to increase collaboration inside DA community**.

RADAR assimilation in AROME/Nowcasting *(Florian Meier)*

The Austrian RADAR data assimilation activities were presented by Florian in a separate presentation. During this presentation different activities were highlighted. First of all, experiments with reduced thinning distance, modified SIGMAO_COEF, saturated pseudo humidity profile, increased search radius of Bayesian method and replacement of hydrometeor blending with profile supersaturation have been done in the frame of **a Meteo-France stay**. To shortly conclude, AROME-PI used in the studies with RADAR data assimilation provides good precipitation forecasts, but underestimates the maximum precipitation and overestimates the area of light rains. After that in the presentation, the structure of AROME/Nowcasting system at ZAMG was detailed. The RADAR data pre-processing was changed to be able to **read HDF5** instead of MF BUFR. In this case additional pre-thinning is needed to avoid memory issues, but this approach already provided better and simplified configuration (compared to CONRAD and MF BUFR) for RADAR assimilation. A **new LHN nudging** method was also implemented and tested with 2D INCA precipitation analyses. The method provides slight improvement in AROME precipitation forecasts, but further tuning is required for better performance. Last but not least, comparative case studies with **AROME 2.5km and AROME 1.2km** have been carried out which showed promising results of the higher resolution configuration.

VARBC study using cycled and global coefficients in ALARO/Slovenia *(Benedikt Strajnar)*

VARBC issues were identified last year (highly variable BC and divergences of predictors). An idea was tested to use global VARBC coefficients without updates in LAM model and to compare with cycled LAM VARBCs. ATOVS observations were used from NOAA-18, NOAA-19 and METOP-A,B satellites during a period in September, October 2015. The evolution of VARBC coefficients showed similar behaviours for most of the channels, except NOAA-19 MHS radiances.

The use of AMDAR q and Slovenian Mode-S in AROME/Hungary *(Viktoria Homonnai)*

The new AMDAR humidity and Slovenian Mode-S MRAR (available through OPLACE) observations were investigated in AROME/Hungary data assimilation

system. The impact of Mode-S MRAR observations was verified over a winter period and for a summer case study. In the heavy precipitation case study slight improvement has been obtained and during the winter period mostly neutral impact was found. In another impact study the new (also available via OPLACE) AMDAR humidity observations were tested in AROME 3DVAR as well. For the time being only limited number of aircraft are equipped with humidity sensors in Europe, therefore particular case studies were chosen to verify vertical profiles of AROME analyses with and without AMDAR measurements.

Spatial thinning and observation errors: assimilation of Mode-S and radiance observations *(Patrik Benacek)*

The characteristics of aircraft and radiance observation errors have been investigated in ALARO/CHMI data assimilation system. Due to the assumption of zero error correlations, either data thinning, error inflation or both should be applied. Regarding optimal data thinning estimation, data pairs of OMG, OMA were gathered and error correlations were calculated by Desroziers diagnostic as a function of separation distance. Due to the results of this study and the recommendation of Liu and Rabier (2003), the optimal distances of Mode-S MRAR are determined as 25-35km horizontally and around 20hPa vertically. Beside thinning distance, the optimal error inflation was also studied and obtained with a value of 2.0 verifying ALARO/CHMI forecast performance. These new settings had positive impact on short-range forecasts by its better description of Mode-S MRAR observation errors. Similar investigation was carried out for radiance observations of NOAA and METOP satellites. Regarding the optimal settings of error characteristics it was pointed out that observation and background error should be tuned together which will be in the focus of future studies.

OI_main questions and problems *(Maria Monteiro)*

In Portugal, a surface assimilation system based on OI_main was built for AROME/IPMA. The WMO BUFR SYNOP observations were locally pre-processed by the help of LACE DM (Alena) and MF colleagues. The OI_main configuration from cy38t1 export was preliminary tested and produced mainly worse scores for 2m temperature and humidity forecasts than dynamical adaptation. Surprisingly the 10m wind scores were improved. After the presentation some of the error sources were identified which would be the next step to verify and a know-how exchange was agreed between LACE and IPMA.

EKF-assimilation in Surfex7.3/Surfex8.0 at ZAMG *(Stefan Schneider)*

At ZAMG in the frame of special projects surface assimilation activities have been launched to study the use of satellite products by Extended Kalman Filter (EKF) approach. The current project targets the assimilation of Sentinel-1 and ASCAT soil moisture products in AROME using cy40t1 and SURFEX 7.3/8.0 releases. The technical implementation of EKF is rather complex where e.g. surface history files of cy40t1 have to be converted to LFI for SODA and then converted back to surface FA. The soil moisture satellite product is a combination of Sentinel-1 and ASCAT to a 1km horizontal grid available once in a day. With the new SODA

release, new control variables and observation types are going to be available for users. As a second aim of ZAMG i.e. a second special project will be soon started where Sentinel-3 LST observations are going to be assimilated via EKF system. This new surface assimilation activity should be well coordinated among ALADIN-HIRLAM-LACE partners in order to avoid duplicated work.

Surface assimilation with EKF and conventional observations (Helga Toth)

Common LACE activity to assimilate conventional observations with EKF was presented as well. The recent progress was made about the validation of EKF analysis and its increments in 2016. Through single observation experiment the generation of gridded observations and the structure of EKF increments were discussed where relatively large differences were observed in comparison with OI_main analyses. Furthermore, through a preliminary case study, the impact on AROME forecast showed good skill of AROME forecast initialized from EKF analysis. For the future the validation of EKF method should be completed with more tests and the optimization work for operational implementation should be also assessed.

Surface data assimilation activities in the HIRLAM consortium (Magnus Lindskog)

The last presentation summarized the HIRLAM surface data assimilation activities which are mostly based on HARMONIE-AROME with cy38 (soon cy40) and SURFEX 7.2 (soon 7.3) configurations. For nature tile there are basically 3 approaches to generate surface analysis (**OI, EKF, EnKF**) which are used for different purposes. The EKF method is used with ASCAT soil moisture satellite product on a Central-European domain. Also there are activities to create **snow, SST and sea ice analyses** in HARMONIE-AROME model for different domains. For lakes the Flake parametrization package and Global Lake Data Base are used in a study lead by FMI. Regarding future, it is planned to divide SURFEX nature tile into two patches for better vegetation description and to replace current force-restore scheme with the multilayer diffusion scheme. Furthermore it is planned to evaluate MESCAN and surface EnKF further and for example to apply data assimilation for lake points and sea ice areas in HIRLAM models.

Meteo-France teleconf session (Claude Fischer, Jean-Francois Mahfouf)

During the teleconference session with Meteo-France colleagues the following topics were discussed.

The **key LSPRT** should be FALSE in ALARO data assimilation including B matrix computation as well. However, in AROME only for minimization it should be TRUE and NREQIN should equal to zero in order to not read hydrometeors.

The **FEMARS** and the missing fix of grid-point humidity were discussed where Meteo-France colleagues recommended to test new python tool (EpyGram) for this purpose. It was mentioned that FEMARS will be obsolete soon and also

ECMWF is not using this tool. Meteo-France kindly invited beta testers of this new tool which is based on cy43t1 common cycle.

Regarding the **Mode-S subtype in ODB**, Meteo-France colleagues recommended to contact with ODB and "Mode-S" colleagues at Toulouse (Dominique Puech and Ludovic Auger). It was not decided yet, but the subtype 145 and 146 were mentioned to be potentially good choice for Mode-S type of aircraft observations (144 is used currently for AMDAR). (However these subtypes are already occupied in ECMWF odb which should be further discussed!)

For lake surface temperature initialization, Meteo-France suggested to try OSTIA and EUMETNET global lake database as input.

The problems identified with thinning distance calculations is under investigation at Meteo-France. It is mostly problematic when shorter or very short thinning distances are applied. Colleagues should keep in mind this issue during future studies.

The current status of **MF's OOPS activites** was summarized as well. In cy43t1 the HOP is fully recoded and new GOM structure is also implemented. For this cycle release HOP, HTL, HAD toy models are also tested at Meteo-France. At ECMWF the final phase of GOM refactoring is done in cy43r1 and GMV, GFL refactoring is going to be done in cy44. The refactoring of VARBC is still an open issue. At Meteo-France, the ARPEGE 4DVAR and AROME 4DVAR based on cy43t? is under validation and the related OOPS package is also available (cy43_op? _oops) on MF's computer by Etienne Arbogast.

Discussion

The common discussion touched the following topics after the Working Days presentations.

The new **MESCAN settings** of OI were tested by many LACE countries and found to be promising for future application.

The **VARBC settings** of LAM DA system have to be carefully studied. However, it is difficult to draw exact guidelines for its settings, the warmstart initialization was preferred and higher NBG parameter for less adaptivity in case of small amount of radiance observations.

The **surface assimilation based on Extended Kalman-Filter** method was discussed further. The coordination of common cycles and SURFEX releases is very important to not develop new features in old and obsolete releases. However, it is very difficult to track SURFEX developments in advance which will be implemented in common cycles. Therefore the coordination should go beyond the LACE level and have to be in contact with HIRLAM and Meteo-France colleagues as well. For its future evolution a LACE forum topic will be opened.

The option so called **LDIRCLSMOD** and its modifications will be shared via LACE forum topic as well.

Planning

For next year planning the preliminary LACE DA plan was discussed with the LACE colleagues.

The most interesting DA action for 2017 was the study of compute **daily B matrix** from global and/or LAM EDA systems. Many LACE partners (Slovenia, Croatia and Hungary) showed interest to participate in this action. Due to the big amount of computation costs, an ECMWF special project proposal was recommended. In order to get detailed and more exact picture about this action, a detailed design of this system should provide and further discussed internally. LACE DA AL will prepare the first draft version of the proposal and then share with the colleagues for discussion.

The plan of **EKF surface assimilation** activities was updated by a LACE stay proposal from ZAMG to develop LST assimilation during 2-3 weeks stay in Vienna supervised by Stefan Schneider.

For the **hourly RUC** action it was suggested to investigate 30min coupling frequency retrieved from Meteo-France, from ARPEGE and to verify its impact on DA and forecasting systems.

For the next year it is clear that less efforts will remain for **radiance data assimilation**, but new observations will be provided via OPLACE.

In 2017 the **common RADAR data assimilation** should be continued, however there was no agreement which proposal of the preliminary plan should follow (i.e. collect and study data from OPERA or collect a sample of QC-ed local data from LACE remote sensing colleagues). Both options have pros and cons which will be rediscussed later at the end of 2016 and at the beginning of 2017.

TODO-s

During the discussion section the following topics were identified to further work:

– LACE forum topic about the future of EKF and SURFEX developments

- LACE forum topic for EpyGram developments

- Share LDIRCLSMOD changes in LACE forum as well

- Detailed plan of the action computing daily background error statistics

– Detailed plan for RADAR data exchange in LACE

- A data sample of GNSS ZTD was kindly asked by SHMU colleagues

– All Members are encouraged to test OOPS prototypes available at HMS

– Upgrade OPLACE with the following discussed elements:

      – Implement new radiance observations (SSMIS, CrIS)

– Implement new wind observations (ASCAT, multi-Metop AMV)

– extend observation monitoring for new observations and bias corr

AOB/Miscellaneous

Most probably the next LACE DAWD will be held in Slovenia on the same week as LSC.