Working Area Data Assimilation

Work Plan

Prepared by:	Area Leader Benedikt Strajnar
Period:	2021
Date:	16/03/2021

Introduction and background

RC LACE data assimilation activities are focused on implementation and operationalization of data assimilation systems at the LACE centers, which provide users with short-range NWP and recently also NWP-based nowcasting. The local DA manpower is typically 1-2 FTE but a relatively large share of this manpower is spent usually technically demanding continuous upgrades, specific to each institution in terms of code compilation and maintenance, data flow and archiving, and extensive computations. The group works in strong cooperation with other ACCORD partners.

The RC LACE countries (except Romania and Poland) now run 8 operational DA system plus 2 NWP-based nowcasting suites. IMWG of Poland, the new RC LACE member, designs its first data assimilation system in collaboration with DA starters kit (DAsKIT) work group organized within the ALADIN consortium, but is expected to start contributing to the LACE DA area. The members have continuously enhanced the use of commonly available and national observations over the last years and now use a large variety of conventional and remote-sensed observations, including higher resolution datasets than those provided by GTS where available. The LACE DA work plan is trying to support and consolidate this efforts by encouraging exchange of information within the group as well as with other ACCORD partners. It encourages short-term portable developments and also targets commonly achievable mid-term and, less frequently, long-term research. For example, short-term developments related to the use of new observations and their pre-processing or diagnostic studies regarding data assimilation system performance are recognized as vital and well-shared activities in RC LACE. On the other hand the extensions to standard 3D-Var for upper-air or advanced approaches to surface data assimilation require longer-term research developments. The group tightly follows developments by Météo France on these topics, which is reasonable taking into account the group's limited manpower.

The planning of work common ACCORD consortium has become more unified and is now managed by the Rolling Work Plan (RWP) 2021. The structure of the current RC LACE DA plan for 2021 therefore highly follows areas of RWP and references to RWP items are clearly indicated.

Goal

The contribution of RC LACE focuses on optimization the current DA systems by enhancing observation use and design of suitable systems for nowcasting/convective scale NWP and observations suited for these systems. The members will be focused on implementation of new hourly updated systems that are currently under design or validation and further refinement or existing systems (Austria, Czech Republic).

Another direction of development will be towards utilization of an alternative soil analysis scheme to replace the currently used OI: the Simplified Extended Kalman Filter (SEKF) within the SURFEX land model will be further validated with AROME model and progressively explored also in combination with ALARO model physics. This also includes sensitivity studies with additional observations for

surface and soil, such as land surface temperature (LST), soil wetness index (SWI) and leaf area index (LAI).

Effective use of observations stays the top priority of LACE DA group. Most of the efforts in upper-air data assimilation would be invested to implementation of the radar data assimilation. Apart from impact studies with OPERA radar reflectivity we would like to focus also on radial winds, which still needs further algorithmic developments related to de-aliasing. Other observations to be considered are several types of GNSS-derived data, extensions in use of aircraft derived data (ADD) Mode-S EHS/MRAR and their quality control and bias correction, revising use of radiances, wind profilers, atmospheric motion vectors, as well as new data types such as GNSS slant delays and microwave link delays.

The design of assimilation capabilities under the OOPS code infrastructure currently lacks manpower within RC LACE. At least the AL will try to keep track of these activities in cooperation with MF, and the DA code training which is to be organized in Toulouse is expected to start to bring OOPS expertize within the RC LACE.

Main activities

Action/Subject/Deliverable: ***Operational implementation of DA suites [COM3]***

Description and objectives:

The action includes installation, technical and meteorological validation, specific validation based on user needs and operationalization of newer common model cycles. This item also covers design and implementation of operational suites, operational implementation of new observations (once tested and ready for operations), coordination and reporting within the consortium.

The main goal for 2021 is migration to latest export cycle cy43t2 at Members who have not migrated yet and operationalization of certain validated observation datasets.

Proposed contributors, estimated efforts: approx. 1 pm per Member, **8 PM**

Action/Subject/Deliverable: ***Further development of 3D-Var [DA 1]***

Description and objectives:

This work package is devoted to additional scientific validation, tuning and optimization of the current 3D-Var based systems. This includes in particular the tuning of the background errors their correlation length scales, where more and more members are expected to apply the EDA rather than downscaled covariances. On observation side, possible improvements are expected from optimization of observation thinning and possible supeobbing. Initialization techniques are also to be investigated here to achieve optimal control of small-scale noise.

Specific tasks for 2021:

- Upgrade of BlendVar data assimilation cycle frequency from 6 h to 3 h, explore surface analysis setting/coupling within SURFEX. [DA 1.5]
- Recalculation of climatological B-matrix based on local ensemble data assimilation (EDA) and comparisons with static B. [DA 1.2]
- Evaluation of error statistics for the methods allowing to preserve results of host model analysis in a LAM domain Jk. [1.3]

Proposed contributors, estimated efforts: A. Trojáková (Cz) 2, A. Bučánek (Cz) 3, A. Stanešić (Cr) 1.5, S. Panežić (Cr) 1, M. Derkova (Sk) 3, V. Hommonai (Hu) 1, **12 PM**

Planned time frame: whole year

Planned deliverables: reports on LACE DA working days, ACCORD newsletter

Action/Subject/Deliverable: ***Use of existing observations – radar [DA 3.1]***

Radar reflectivity and radial wind observations remain the top priority observations in RC LACE. The area is quite well covered by radar sites and most of them are available through OPERA/OIFS data. This data set is complemented by national data or data from bilateral exchange. While the OPERA provides a large step towards homogeneous data format, there are still some exceptions in terms of data structure. Even more uncertainty comes around the quality control – locally controlled datasets often include more customized QCs while OPERA relies on a set of controls provided by BROPO package from Baltrad for reflectivity, and there is no special QC for Doppler winds. The radar assimilation is operationally used in Austria in their AROME-based systems. For ALARO, validation of radar reflectivity observation operator and generation of pseudo observations are ongoing in 2020. Validation of winds from sites with wind-optimized scans (high Nyquist velocity) has also started. To be able use Doppler wind from all radar station, the aliasing problem needs to be sufficiently solved first. A facility in the radar pre-processing software HOOF is foreseen to accomplish this, based on comparison and implementation of existing methods. Further validation and especially sensitivity and impact studies are foreseen, and this is hoped to lead to operational implementation in 2021. Concrete tasks on the radar action to be addressed:

- Validation of solutions for wind dealiasing and quality control in cooperation with the OPERA User group. The common homogenization tool (HOOF) will be extended with functionality for wind dealiasing. [DA 3.1]
- Impact studies with original and de-aliased OPERA Doppler wind data [DA 3.1]
- Impact studies with OPERA reflectivity observations (subject of RC LACE stay). [DA 3.1]
- Updates of the HOOF preprocessing tool, addition of functionality to create super-observations based on proposal from HIRLAM. [DA 3.1]

Proposed contributors, estimated efforts: F. Meier (At) 2, V. Švagelj (Si) 1, B. Strajnar (Si) 1, P. Smerkol (Si) 1, A.Trojáková (Cz) 1.5, A. Bučánek (Cz) 2.5, M. Szczech-Gajewska (Pl) 1, G. Stachura (Pl) 2, M.

Nestiak (Sk) 3, J. Vivoda (Sk) 1, K. Čatlošová (Sk) 4, A. Dumitru (Ro) 1, A. Stanešić (Cr) 1, S. Panežić (Cr) 1 **23 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page, non t-code software

Action/Subject/Deliverable: ***Use of existing observations - other observations [DA 3]***

This action includes validation and progressive operational implementation of several observation types that have become available over the last years and are (most of them) distributed to Members via the OPLACE preprocessing system. For LACE this includes radar observations as top priority (see above) and other observations such as various surface observations, aircraft-derived data (ADD) including Mode-S EHS/MRAR, GNSS ZTD, various atmospheric motion vectors (AMV) and radiances from polar-orbiting satellites. Tasks to be accomplished in 2021:

- Validation and impact assessment of newly available Mode-S EHS (EMADDC, local data sets) and MRAR observations (Sk, Si, Hu, Cz). [DA 3.2]
- Refining the application of Mode-S observations in DA systems with increased assimilation cycle frequency, including application of variational bias correction (Var-BC) procedures (subject of a RC LACE stay). [DA 3.2]
- Evaluation and impact assessment of E-GVAP ZTD (possibly during a RC LACE stay). [DA 3.3]
- Use of mobile GNSS sensors on Austrian trains in cooperation with Technical university of Vienna. [DA 3.3]
- Optimization of the use of existing AMV observations, including high resolution winds (NWC/GEO-HRW), optimization of blacklisting and performing impact studies. [DA 3.5]
- Sensitivity studies with individual polar-orbiting sensors, with emphasis on new sensors such as ATMS and IASI, which will be included on board the next generation geostationary satellites (MTG). Eventually feasibility study with GNSS-RO. [DA 3.6]
- Implementation and test of high-resolution radiosondes in BUFR. [DA 3.8]
- Enhanced QC for dense surface observations base on A-LAEF. [DA 3.9]
- Assimilation of Sodar observations. [DA 3.10]

Proposed contributors, estimated efforts: B. Strajnar (Si) 0.75, F. Meier (At) 1, F. Weidle (At) 3, V. Hommonai (Hu) 0.5, Z. Kocsis (Hu) 0.5, A. Trojáková (Cz) 1.5, A. Bučánek (Cz) 2.5, M.Derkova (Sk) 1, M. Nestiak (Sk) 4, M. Imrišek (Sk) 4, K. Čatlošová (Sk) 8, J. Cedilnik 2, **21.75 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page, non t-code software

Action/Subject/Deliverable: ***Use of new observations types [DA 4]***

This action contains research and development activities related to exploitation of new, not yet routinely available observation data sources. Given the current observation structure in high resolution LAMs run by RC LACE members, the priority is on moisture and wind observations. Examples of this are GNSS-derived products apart from ZTD, aircraft humidity observations and delays in telecommunication links due to rain and use of advances satellite techniques. Research on these items include data provision, preprocessing and quality control in order to ensure reliable data sets of sufficient quality. In RC LACE, the following items are planned for 2021:

- Finalization of the implementation of slant tropospheric delays (STD) in the common model cycles (in cooperation with HIRLAM). [DA 4.2]
- Explore the potential of volunteered observations from crowdsourced, private weather stations. Use these measurements for NWP case studies to show their potential. [DA 4.4]
- Refinement of the preprocessing to efficiently separate dry and wet attenuation, which should lead to a reliable relationship between attenuation and rain rate. [DA 4.10]
- Test of assimilation of mobile phone links (from Austrian mobile phone provider) via the INCA-LHN in AROME-RUC. [DA 4.10]

Proposed contributors, estimated efforts: P. Scheffknecht (At) 4, B. Strajnar (Si) 1.5, P. Smerkol (Si) 2, M. Imrišek (Sk) 2, M. Nestiak (Sk) 2, F. Meier (At) 0.5, **12 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page, t-code contributions

Action/Subject/Deliverable: ***Development of assimilation setups suited for nowcasting [DA 5]***

Frequently updated assimilation approach ensures to employ more observations with reduced representativeness error in time. Hourly analyses can be carried out by fully cycled (RUC) and non-cycled data assimilation systems or combination of both. The observational datasets are constrained by fast delivery. In 2021, the following experimental (pre)operational RUC setups are planned:

- Validation of existing observations (those from DA 3) in RUC and preparation of high resolution observational dataset suitable for nowcasting: the focus is on data with fast delivery and locally available data which can enhance the widely available datasets. [DA 5.1]
- Design/improvement of existing and new RUC prototypes based on 3D-Var (Austria, Hungary, Slovenia, Slovakia). [DA 5.2]
- Explore possibility to initialize/modify the hydrometeors values in AROME-RUC by radar-derived rain type in AROME-RUC. [DA 5.3]

Proposed contributors, estimated efforts: F. Meier (At) 2.5, P. Scheffknecht (At), B. Strajnar (Si) 1.5, V. Hommonai (Hu) 3, G. Tóth (Hu) 3, A.Trojáková (Cz) 0.5, A. Bučánek (Cz) 0.5, M. Nestiak (Sk) 3, M. Dian (Sk) 1, K. Szanyi (Hu) 5, **20 PM**

Action/Subject/Deliverable: ***Participation in OOPS development [DA 6]***

The general goal of this action in (as defined in the RWP2021) is to enable the object-oriented C++ layer for control of the LAM data assimilation (and forecast model) applications. The computational code remains in FORTRAN, based on the IFS/Arpège/LAM shared codes, but has to be adapted (re-factored) towards an OO coding. LACE has not been deeply involved to this action so far, so the main goal is to reach a certain level of familiarization, so that we can reproduce the basic assimilation tools (3D-Var, OI) with the OOPS-ified code (available from cycle 46t1). The ultimate target is be to be ready to switch any NWP system to OOPS binaries after ECMWF and MF have done so (presumably 2023). The following concrete task which helps with familiarization is planned:

- Run and compare 3D-Var minimization run using OOPS and non-OOPS binary with similar setting, initially at MF's computing platform. Port the relevant cy46t1 code and reproduce the experiment locally.

Proposed contributors, estimated efforts: B. Strajnar (Si), **1 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

Action/Subject/Deliverable: ***Observation pre-processing and diagnostic tools [DA 7]***

The work package includes mainly the maintenance and evolution of the OPLACE preprocessing service which provides majority of observations for RC LACE DA systems (see also LACE DM plan). Additional this work package includes implementation and extension of diagnostics tools such as ObsTool (determination of observation error and thinning distance), DFS (weight of observations in the analyses), ObsMon (observation monitoring), moist total energy norm (weight of relative observation impact on forecast) and adjoint forecast sensitivity to observation (FSOI). All of them except FSOI are used within RC LACE but some of the tools would need an update (scripts, executables and support for new obs. types).

Tasks:

- Feasibility study to implement/use FSOI. [DA 7.2]
- Maintenance and development of observation preprocessing system OPLACE (details in Data Manager plan) [DA 7.5]

- Installation and customization of the Obsmon observation monitoring package. [DA 7.2]

Proposed contributors, estimated efforts: F. Meier (At) 0.5, S. Panezić (Cr) 0.5, **1 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

Action/Subject/Deliverable: ***Basic data assimilation setup (DAsKIT) [DA 8]***

Description and objectives:

DAsKIT currently defines a basic set of DA infrastructure to ease developments of the DA from consortium members with no prior experience. Poland, which is still part of DAsKIT, plans to consider the following tasks:

- Follow the DAsKIT implementation plan which includes a gradual implementation of OI for the surface analysis and 3D-Var (with static B) for the upper-air analysis for the ALARO-based system. [DA 8.1]

Proposed contributors, estimated efforts: M. Szczech-Gajewska (Pl) 2, Gabriel Stachura (Pl) 1, **3 PM**

Planned time frame: whole year

Planned deliverables: reports on DAsKIT working days, ALADIN/HIRLAM newsletters

Action/Subject/Deliverable: ***Algorithms for surface assimilation [SU 1]***

Description and objectives:

The Simplified Extended Kalman Filter (SEKF) framework in SURFEX land model allows for assimilation of conventional and non-conventional observations to generate surface analysis in a more flow-dependent way. In this LACE action both AROME and ALARO models are considered to be utilized within SEKF. In 2021 the following actions are foreseen:

- Experiments with SEKF and SYNOP observations in AROME cy43t2 using ISBA force-restore and ISBA-DIF surface scheme (Austria, Hungary) [SU 1.1]

Proposed contributors, estimated efforts: S. Schneider (At), H. Tóth (Hu) 3, V. Tarjani (Sk) 2, M. Ličar (Si) 3, **8 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

Action/Subject/Deliverable: ***Use of observations in surface assimilation [SU 2]***

Description and objectives:

One of the main advantages offered by the Extended Kalman Filter (EKF) approach to surface and soil data assimilation is to be able to successfully assimilate non-conventional observations, such as land surface temperature (LST), leaf-area index (LAI), different surface/soil properties such as albedo and snow water equivalent. This action is devoted to make benefit from rapidly evolving satellite soil observation methods. The following tasks are planned for 2021:

- Assimilation of Sentinel-2 based LAI within SEKF in AROME/SURFEX, impact experiments [SU 2.8.2]
- Application of daily-updated LAI in AROME/HU [SU 2.8.2]
- Evaluation of LSA LST in SEKF [SU 2.9.1]

Proposed contributors, estimated efforts: S. Schneider (At) 6, B. Szintai (Hu) 1, M. Ličar (Si) **7 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

Summary of resources

Subject	Estimated manpower (PM)	From LACE	Other (HIRLAM, ALADIN)
Operational implementation of DA suites [COM3]	8	8	-
Further development of 3D-Var [DA 1]	12	12	-
Use of existing observations [DA 3.1] – radar	23	23	-
Use of existing observations [DA 3] – other data types	21.75	21.75	
Use of new observations types [DA 4]	12	12	-
Development of assimilation setups suited for nowcasting [DA 5]	20	20	-
Observation pre-processing and diagnostic tools [DA 7]	1	1	-
Basic data assimilation setup (DAsKIT) [DA 8]	3	3	-
Algorithms for surface assimilation [SU 1]	8	8	-
Use of observations in surface assimilation [SU 2]	7	7	-

Total	**115.75**	**115.75**	**-**

Meetings, events and list of RC LACE stays

AL travels:

1) 1st ACCORD ASW, 12-16 April 2021, online event.
2) 43th EWGLAM meeting and 28th SRNWP workshop 2021, online event.
3) Spring and autumn LSC meetings and RC LACE management meeting
4) 8 participants at DA Working Days/ DAsKIT 2021
5) DA code training week, Toulouse, delayed from 2020, TBD
6) Participation of AL to one of the HIRLAM/ACCORD DA working weeks (if organized as physical meeting), online participations to other DA working days.

LACE stays:

1) S. Panezić (Radar DA) – Prague (5w)
2) K. Čatlošová (VarBC for Mode-S) – Prague (5w)
3) P. Scheffknecht (assimilation of microwave links) – Ljubljana (4w)
4) G. Toth (RUC, initialization) – Vienna (4w)

Additional open proposals:

- Hosts: ZAMG (GNSS assimilation), OMSZ (SEKF soil assimilation)

Execution will highly depend on Covid-19 conditions and restrictions.

LACE DA video meetings:

AL organizes an internal radar action videoconference in January 2021 and another one after the first radar stays/before summer. Other internal web meetings will be organized as needed.

Problems and opportunities

- Part of the planned activities (stays, DA code training) might be finally cancelled or delayed due to Covid-19 conditions.

- Considerable manpower spent on maintenance & evolution of systems (on the longer term, implementation of DA in OOPS is expected to ease maintenance).
- Too little focus on algorithms compared to observation developments. After radar is implemented, majority of the assigned manpower should to be directed to DA algorithms (such as EnVar in OOPS for instance or algorithms suited for NWP-based nowcasting).
- Many new (inexperienced but not overloaded) staff members in some countries.