Working Area Data Assimilation

Work Plan

Prepared by:	Area Leader Benedikt Strajnar
Period:	2023
Date:	20/09/2022

Introduction and background

Within a broader collaboration in the framework of the ACCORD consortium, the 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 NWP-based nowcasting. The DA person-power is typically 1-1.5 FTE per Member but a relatively large share of it is usually spent on technically demanding continuous upgrades, specific to each institution in terms of code compilation and maintenance, data flow and archiving, and extensive HPC computations.

Currently, 6 RC LACE countries are operationally running 7 DA systems to initialize their short-range weather forecasts plus 3 NWP-based nowcasting suites and 2 ensemble systems applying the DA. Poland and Romania have not yet reached operational DA but both plan to implement it in the near future.

The RC LACE members have continuously enhanced the use of commonly available and national observations and now assimilate 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 these efforts by encouraging exchange of information within the group as well as with other ACCORD partners.

The reporting and planning of work in the common ACCORD consortium is increasingly unified and is now managed through the Rolling Work Plan (RWP) 2023. The structure of the current RC LACE DA plan for 2023 is therefore highly aligned with the RWP.

Goal

The contribution of RC LACE focuses on optimizing 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 more numerous hourly updated systems that are currently under design or validation (Hungary, Slovakia) and further refinement of existing systems (Austria, Slovenia, Czech Republic) and progressive migration to flow-dependent algorithms such as **ensemble-variational (EnVar)** algorithms as enabled by the OOPS assimilation codes. First technical tests of this algorithm were already made in 2022 and initial experience was shared during the ACCORD WDs in June 2022.

Another direction of algorithmic development will be towards utilization of an alternative soil analysis scheme to operationally 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 (provided that validation of coupling with SURFEX will be completed). This also includes sensitivity studies with additional observations for surface and soil, such as leaf area index (LAI), soil wetness index (SWI) and the land surface temperature (LST).

Effective use of observations remains the top priority of the LACE DA group. Most of the efforts in upper-air data assimilation would be invested in implementation of the radar data assimilation. One of the outstanding goals in 2023 is to **widespread use of radar reflectivity and radial winds** provided by OPERA, together with own solutions for aliased wind, in order to achieve the breakthrough on this topic and spread operational applications with enhanced success of the convective scale forecast. GNSS-derived data are another example of important observations with already much investment but relatively few operational applications. Other data such as wind profilers, atmospheric motion vectors, as well as new data types such as GNSS slant delays and microwave link delays will also be developed.

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. Operationalization of cy43 is still needed in Croatia. This item also covers design and implementation of operational suites, operational implementation of new observations (once tested and ready for operations), re-computation of background error covariances, coordination and reporting within the consortium.

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 and their correlation length scales, where more and more members are expected to apply the EDA rather than downscaled covariances. On the observation side, possible improvements are expected from optimization of observation thinning. Initialization techniques are also to be investigated here to achieve optimal control of small-scale noise.

Specific tasks for 2023, linked to evolutions of 3D-Var based operational suites:

- Cycling strategy for RUC [DA 1.2]

- Refinements of the B-matrix representation. [DA 1.3]

- Maintenance and evolution of current DA suites, including RUC. [DA 1.7]

- Implementation of BlendVar and increase of its data assimilation cycle frequency from 6 h to 3 h. [DA 1.7]

Proposed contributors, estimated efforts: M. Derkova (SK) 0.5, B. Strajnar (SI) 1, A. Stanešić (CR) 1, A. Trojáková (CZ) 1, A. Bučánek (CZ) 3, N. Awan (AT) 6, A. Varkonyi (HU) 2, D. Lancz (HU) 4, **18.5 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 among 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, which has been upgraded recently in Croatia. This data set can be complemented by national data or data from bilateral exchange. The radar data assimilation is operationally used in Austria and Slovenia (RUC systems, wind and/or reflectivity). The reflectivity DA (Bayesian inversion technique) is dependent on the radar site characteristics while the radar obs. operator depends on the use of microphysical parametrization and used quantities. The reflectivity assimilation in ALARO is thus related also with implementation of prognostic graupel. The dealiasing algorithm is available for wind and its validation is ongoing and has been promising. Further validation and especially sensitivity and impact studies are foreseen, and this is hoped to lead to more operational implementations.

Concrete tasks on the radar action to be addressed:

- Impact studies with original and de-aliased OPERA Doppler wind data [DA 3.1]

- Impact studies with OPERA reflectivity observations using Bayesian inversion, fine tuning of data/profile selection, thinning and application of superobbing. Further Investigation of the drying effect. [DA 3.1]

- Regular updates of the HOOF preprocessing tool. [DA 3.1]

- Test radar-base initialization of hydrometeors. [DA 3.1]

Proposed contributors, estimated efforts: A. Bučánek (CZ) 3, A.Trojáková (CZ) 1.5, B. Strajnar (SI) 2, P. Smerkol (SI) 1, K. Szanyi (HU) 5, A. Stanešić (CR) 1, S. Panežić (CR) 3, M. Nestiak (SK) **16.5 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 2023:

- Refining the application of ABO observations in DA systems with increased assimilation cycle frequency, change of data source, whitelisting. [DA 3.2]

4

- Evaluation and impact assessment of E-GVAP ZTD. [DA 3.3]

- Use of mobile GNSS sensors on Austrian trains in cooperation with Technical university of Vienna. [DA 3.3]

- Test feasibility and impact of InSAR slant delay assimilation from Sentinel-1. [DA 3.3]

- Further impact study with additional AMV observations. [DA 3.5]
- Implementation and test of high-resolution radiosondes (from OPLACE) in BUFR. Use of descending radiosondes. [DA 3.8]

- Assimilation of SODAR/RASS observations - assessment of quality, finding or developing a suitable obs. operator for wind/temperature information. [DA 3.7]

Proposed contributors, estimated efforts: J. Cedilnik (SI) 2, H. Tóth (HU) 0.25, Z. Kocsis (HU) 0.25, A. Stanešić (CR) 2, S, F. Weidle (AT) 1 , F. Meier (AT) 3, A. Varkonyi (HU) 3, A. Dumitru (RO) 1, M. Nestiak (SK) , M. Imrišek (SK) **12.5 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 advanced 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 2023:

- Finalization of the implementation of slant tropospheric delays (STD) in the common model cycles (in cooperation with HIRLAM). Impact study in 3D-Var. [DA 4.2]

- Assimilation of microlink rain rates using direct RH estimate or obs. operator from P. Lopez or latent heat nudging. [DA 4.8]
- Test of MSG visible assimilation operator with RTTOV and implementation of assimilation interface. [DA 4.1]

Proposed contributors, estimated efforts: P. Scheffknecht (AT) 3 , M. Imrišek (SK) , M. Nestiak (SK), F. Meier (AT) 3 **6 PM**

Planned time frame: whole year

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

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

The general goal of this action in (as defined in the RWP2023) is to enable the object-oriented C++ layer for control of the LAM data assimilation (and forecast model) applications. Recently, LACE has been partly involved by porting and comparing the existing MASTERODB version of 3D-Var minimization with the OOPS-based one (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 tasks are planned:

- Contribute to preparation of a prototype of full-scale OOPS-based 3D-Var and EnVar systems. [DA 6.4]

Proposed contributors, estimated efforts: B. Strajnar (SI) 2, F. Meier (AT) 3, **5 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:

- Optimization and customization of the Obsmon observation monitoring package. Application of DFS and MTEN. [DA 7.2]
- Maintenance and development of observation preprocessing system OPLACE (details with manpower in Data Manager plan) [DA 7.5]

Proposed contributors, estimated efforts: A. Stanešić (CR) 1, B. Strajnar (SI) 1, N. Kastelec 1, **3 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

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

Description and objectives:

The algorithms for surface DA now include a simpler OI (CANARI, OI-MAIN) or a more advanced Simplified Extended Kalman Filter (SEKF) which allows for assimilation of conventional and non-conventional observations to generate surface analysis in a more flow-dependent way. SEKF is operational in Hungary and more members plan to investigate it in the future. For the ALARO system, a remaining part is coupling of the model with SURFEX land model and implementation of OI. In 2023 the following actions are foreseen:

- Implementation, experiments, design of parallel suites and operationalization with OI and SEKF and SYNOP observations in AROME/SURFEX, application to high resolution. [SU 1.1, SU1.11]
- Consider, develop and evaluate SEKF for explicit snow scheme as implemented in SURFEX/SODA. [SU 1.1.2]
- Develop an offline analysis environment based on full physics in SURFEX forced by a near-real-time analysis which provides an initial state for SURFEX variables in a new cycle. [SU 1.10, DEODE]
- Tuning of soil fields initialization in OI/CANARI. [SU 1.11]

Proposed contributors, estimated efforts: B. Szintai (HU) 1, M. Ličar (SI) 3, S. Schneider (SI) 3, R. Brožková (CZ) 1, J. Mašek (CZ) 1, **9 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 2023:

- Assimilation of daily updated LAI (Sentinel-based) within SEKF in AROME/SURFEX, impact experiments [SU 2.8.1]

- Assimilation of satellite moisture information (SWI) within SEKF in AROME/SURFEX, impact experiments [SU 2.2]

- Assimilation of radiation/temperature products for use in surface data assimilation. [SU2.5]

- Assimilation of remote-sensed snow extent products. [SU 7.2]

Proposed contributors, estimated efforts: H. Tóth(HU) 4, B. Szintai(HU) 5, S. Oswald(AT) 1.5, P. Schmederer(AT) 2, S. Schneider(AT) 3, M. Ličar(SI) 2 **17,5 PM**

Planned time frame: whole year

Planned deliverables: report on LACE web page

Summary of resources

Subject	Estimated manpower (PM)	DEODE (PM)	Other (HIRLAM, ALADIN)
Operational implementation of DA suites [COM3]	8		-
Further development of 3D-Var [DA 1]	18.5		
Use of existing observations [DA 3.1] – radar	16.5		-
Use of existing observations [DA 3] – other data types	9.5		
Use of new observations types [DA 4]	6		-
Participation in OOPS development [DA 6]	5	1	
Observation pre-processing and diagnostic tools [DA 7]	3	2	-
Algorithms for surface assimilation [SU 1]	9	5	-
Use of observations in surface assimilation [SU 2]	17.5		-
Total	**93**	**8**	**-**

Meetings, events and list of RC LACE stays

AL travels (or online attendance):

1) 4th ACCORD ASW, 27-31 March 2023.
2) Working week for ACCORD DA research/support teams, 2 physical meetings, 2 online.
3) 45th EWGLAM meeting and 30th SRNWP workshop 2023.
4) EUMETSAT Core NWP meetings, online.
5) OPERA NWP user group meeting, online.
6) Spring and autumn LSC meetings and RC LACE management meetings.

LACE stays:

1) Radar DA stay (further sensitivity studies with radar reflectivity DA) – CHMI Prague (>3 w)

2) K. Szanyi (Reflectivity data assimilation incl. test of superobservations) – ARSO Ljubljana (4w)

3) A. Bučanek (Radar DA) – DHMZ Zagreb (4w)

4) M. Ličar (Remote-sensed satellite observations - SWI in SEKF) – OMZS Budapest (4w)

Problems and opportunities

- Part of the planned activities might still finally be impacted, cancelled or delayed due to Covid-19 or other travel conditions.
- Considerable manpower spent on maintenance & evolution of systems (on the longer term, implementation of DA in OOPS is expected to ease maintenance).
- Progressively, more manpower should to be directed to DA algorithms (such as EnVar in OOPS for instance or algorithms suited for NWP-based nowcasting).
- No manpower for certain observation types, e.g. radiance assimilation.
- Interference with DEODE (skilled people will be involved there even if newcomers are employed).
- Opportunity: Increased manpower with DEODE.