# Report on the LACE Data Assimilation Working Days 2011

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## Introduction

The 2nd LACE Data Assimilation Working Days were held in Budapest (June 14-16 2011) in order to follow the progress towards operational data assimilation in LACE, to point out blocking points and difficulties and also to do planning for the future. Participants from the HIRLAM community (Netherlands and Sweden) contributed to the working days by sharing their experiences with ALADIN/ ALARO/AROME and by discussing common goals within data assimilation. The program included progress presentations from each participating country, which was followed by some thematic presentations (on surface assimilation, revision of AMSU satellite channel use and radar preprocessing for assimilation) and by case studies. The last morning of the meeting was dedicated to planning and defining actions to progress in the forthcoming months.

## Progress in local installations

- In Austria (talk by Florian Meier and Xin Yan), surface (CANARI) assimilation was introduced operationally in the high resolution (5 km) ALARO runs. A new cycle (cy36t1) was implemented for both surface (CANARI) and atmospheric (3DVAR) assimilation. A couple of interesting developments were done to improve CANARI: a vertical correlation term was introduced to reduce the radius of influence observations in mountainous areas (slight positive impact), the orography rejection was revisited (relaxed) in order to keep snow observations over mountains (more realistic snow cover and T2m in mountains). Developments were also done on the atmospheric 3DVAR assimilation part: VarBC has been introduced and all available satellites from OPLACE were tested (NOAA, METOP: AMSU-A,B, HIRS, MSG:SEVIRI) (neutral to slight negative impact). The impact of different observing systems in the assimilation was diagnosed (by measuring the total energy growth in the forecasts due to each elements of the observing system), which showed an important impact of AMDAR, TEMP and AMSU-A measurements. A new B matrix was computed by downscaling the ARPEGE EnVar system with ALARO cy35t1 (slight positive impact). GPS Zenith Delay observations were used in the 3DVAR assimilation and their impact studied in detail (slight positive impact).
- In Croatia (talk by Antonio Stanesic and Tomislav Kovacic), the preprocessing was improved using uniquely BUFR data for satellites. Also the static satellite bias correction was replaced by VarBC (smaller bias) in 3DVAR. Soil Wetness Index diagnostics were run for June-July 2010 where the surface CANARI caused a humid bias at 2m (these diagnostics were then run by all LACE countries for June 2010 for comparison). The 2m scores are improved generally by assimilation, upper air scores show a positive impact on some periods but they can also degrade compared to dynamical adaptation. A good case (flood over Pula, 25.09.2010) was found which demonstrates the benefit of data assimilation.
- In Czech Republic (talk by Alena Trojáková and Patrik Bénácek) the assimilation suite was moved to cy36t1. The work continued with the implementation of conventional (element by element) and satellite observations to the 3DVAR system (surface CANARI is already operational). A couple of useful conclusions come from this work. The use of temperature measured by TEMPs causes a degradation in the geopotential forecast (not in the analysis),

which might come from imbalance between Pb (vorticity balanced geopotential) and temperature in the initial conditions. The impact of AMSU-A channels on the analysis and forecast was studied. There is a positive impact found but also degradations occur for certain forecast ranges and heights. A detailed study shows the contribution of a single AMSU-A pixel on the analysis increment of T and RH.

- Hungary (talk by Gergely Bölöni, Edit Adamcsek, Máté Mile and Roger Randriamampianina) runs the ALADIN/ALARO assimilation system based on cy35t1. The impact of surface (CANARI) and atmospheric (3DVAR) assimilation was studied separately for the period of June 2010. The objective scores (against observations) show that both CANARI and 3DVAR improves the forecasts, the latter being more dominant. Background error covariance matrices were computed via local Ensemble assimilation (with perturbed observations) and Ensemble Transform runs. Several diagnostics suggest that these techniques improve background error modeling, as well as objective scores are improved if using the newly defined and derived background error covariance matrices. First steps towards setting up an AROME assimilation system were done (computation of B matrix and validation of conf. 002, 131 in cy36t1).
- Netherlands (talk by Jan Barkmeijer) runs an AROME (2.5 km) assimilation system based on cy36h1.2 at ECMWF. The system uses conventional observations (SYNOP, TEMP, AMDAR) and high resolution aircraft measurements Mode-S. Based on observation monitoring and B matrix diagnostics the system behaves reasonably well, however some increased T2m bias occurs compared to the Hirlam model forecasts. An optimal nesting strategy is under investigation (coupling to Hirlam or to ECMWF/IFS). A couple of cases show a positive impact of assimilation with a more succesful initialization of convection. Plans include a 3h (or more freq.) assimilation cycle implemented locally at KNMI (800x800 point domain) incorporating more and more humidity observation such as GPS and radar.
- Romania (talk by Mirela Pietrisi) prepared a couple of case studies using CANARI and 3DVAR with conventional observations. These cases demonstrate a slight improvement of ALARO forecasts in T2m due to assimilation. Plans include the use of satellite data.
- Slovakia (talk by Michal Nestiak) runs surface CANAR with DFI blending in a test mode. A contribution to the OPALCE observation preprocessing system was made by the option of removing duplicated SYNOP reports. The presentation was held in oral, the presentation slides are to be distributed by Michal after the meeting.
- Slovenia (talk by Benedikt Strajnar and Jure Cedilnik) introduced surface (CANARI) and atmospheric (3DVAR) assimilation on the 30$^{th}$ March 2011 in its high resolution (4.4 km) ALARO runs, which is welcomed by local forecasters. Concerning the development of the system, a revision of satellite channel use was made and tested (no improvement due to this revision so far). Also the order of the surface and atmospheric assimilation was changed (first CANARI then 3DVAR instead of running them in parallel) (improvement in the 2m fields). Interesting tests with incremental DFI and by relaxing the normal DFI filtering were performed. These show that a normal DFI with less filtering brings balanced forecasts and keeping convective systems more realistic (compared to the incremental DFI or a strong DFI). The assimilation of LandSAF albedo was tested, with promising results to improve 2m field forecasts. Several cases were saved during operational forecasting by Benedikt, when assimilation had a slight positive impact compared to the dynamical adaptation. Plans to use Mode-S measurements in 3DVAR are at stake in Slovenia.
- Sweden (talk by Magnus Lindskog) and most of the HIRLAM countries run data assimilation using ALARO and AROME setups (3 of them runs only surface assimilation). The data included are conventional observations (SYNOP, TEMP, AMDAR, PILOT, DRIBU) but also AMSU-A data from NOAA18 and METOP. The Swedish setup is a 5.5km ALARO with the old soil scheme based on cy35, which will be upgraded by using SURFEX and cy36 during

2011. Background error covariances for 3DVAR are computed by the downscaling of the IFS EDA system. Classical scores using ALARO are comparable with those of HIRLAM, which makes possible the operational implementation of ALARO possibly in the near future. To do this, the strong T2m bias of ALARO at winter time is to be removed. Experiments with 3h cycling and showed some potential for improvements in some case studies. An ALARO 5.5 km 4DVAR (with outer inner loops at 10 km resolution) is validated and compared to 3DVAR (5.5 km), which implies some improvements on wind and temperature at 500 hPa. Beside others, plans consist of research on 4DVAR, application of radar data assimilation as well as using AMSU-B data and improving the large scale mixing from global models. For surface assimilation the use of the EKF soil assimilation scheme is planned. A common target of Sweden and Norway is to run common operational ALARO (5 km, 1212x1360 points, 65 levels)/AROME (2.5 km, 1134x1120 points, 65-90 levels) models in 2014 on a common computer including data assimilation.

**General impact of assimilation systems**

A common finding of all participants is that 2m scores are improved by both surface (CANARI) and atmospheric (3DVAR) assimilation. Note that for some weather regimes (depending on the period of the experiments) 2m scores were found to be degraded due to assimilation but these periods are negligible to those bringing improvements. Classical scores for the upper air show slightly positive to neutral or even slightly negative impact of the surface (CANARI) and atmospheric (3DVAR) assimilation depending on the weather or the setup of observation use. These might come from imperfect analysis of very large scales by the LAM due to their limited size (large scales coming from the global model being probably more accurately analyzed), by insufficient blacklisting or by imbalances in the initial conditions. Selected case studies (Austria, Croatia, Hungary, Romania, Slovenia) showed that data assimilation improves the precipitation/cloud forecast mostly for the first few hours but also sometimes over 1 day. In many precipitation cases local assimilation (with the present setups) is not enough for improvement.

**Problems found and actions decided aiming for improvements**

1. Based on a common LACE study, the evolution of soil moisture (Soil Wetness Index: SWI) and 2m parameters due to assimilation were investigated. The 2m analysis and forecast induced by SWI changes (or the SWI changes induced by 2m analyses and forecasts) were not fully understood. Also 3DVAR and CANARI seems to act in the opposite direction (bias of opposite sign) as far as 2m increments are regarded. Also it was pointed out that CZ, HU and CRO does not have CANARI increments in the surface moisture (SURFRESERV.EAU), while AU has such.

   **To do:**

   - Alena sorts out what can cause the lack of surface moisture increments. She also sets up an experiment list to diagnose the relation of SWI and 2m forecasts and publishes it at the LACE forum.
   - Benedikt, Florian, Antonio, Alena and Gergely checks if the lack of SURFRESERV.EAU comes from different FA packing options (through namelist and increment comparisons)
   - Antonio or Alena gets into contact with Francoise Taillefer or Francois Bouyssel to sort out if Meteo France has or not SURFRESERV.EAU increments.
   - Antonio publishes his findings on the forum in a document related to CANARI runs for the July 2010 period.
   - HU runs experiments with SURFEX OI_main to compare with CANARI

2. Based on results of CZ, the assimilation of temperature (from radiosonds) implies a degradation of the geopotential forecast after 6 hours, although the geopotential anylsis gets closer to the observations and the temperature forecast is improved throughout the 2 days forecast. After discussion, 3 possible causes were pointed out by the participants: a) the balance between temperature and Pb (vorticity balanced geopotential) is not correct, b) the balance between humidity and temperature/Pb is not correct (humidity might comes into play through the R gas constant when computing the hydrostatic equation to compute geopotential), c) the large scale analysis coming from ARPEGE might be degraded due to the local 3DVAR, which is applied after the blending step.
   **To do:**
   - Alena and Gergely runs experiments where Pb and temperature are artificially decoupled from each other in 3DVAR to see, whether this balance is the guilty for the degradation in geopotential. Similarly experiments with univariate q can be run to see how much humidity coupling can be guilty.
   - Gergely prepares single observation experiment scenarios to see the impact of temperature observations on geopotential (and other variables). Alena prepares visualization scripts in Rfa that can be quickly run on the results and provides similar plots for all countries. All LACE countries run the single obs experiments and provides the figures.
   - Alena tries to run a 3DVAR experiment on a period exactly during the period of B matrix sampling, to see if the possible imbalances come from the seasonal sensitivity of statistics or not.
   - Alena runs a VarBlend experiment (instead of BlendVar) where first the 3DVAR analysis is done (based on a 6h forecast guess) and then it is blended to the ARPEGE analysis. If this experiment relaxes the degradation in geopotential forecast (compared to BlendVar), then it means that the degradation might come from the wrong analysis of very large scales by the LAM 3DVAR (which is corrected afterwards by blending in the VarBlend case).

3. It was pointed out by Alena Trojáková that there is a bug in the computation of RH in the SCREENING/3DVAR/CANARI and posibly OULAN (OPLACE) codes, which should be understood through correspondence with Meteo France colleague (information from Patric Moll posted on the Forum).
   **To do:**
   - Alena posts the information she got from Patric Moll on the LACE forum

4. There are not many humidity observations in our local assimilation systems (TEMP q, AMSU-B, SEVIRI). To improve this situation, CRO (in ALARO) and HU (in AROME) starts radar assimilation in 2011. AU and HU starts GPS assimilation in 2011 and 2012 respectively.

5. Based on the experience of Jan Barkmeijer, there are artificial negative specific humidity values in the analysis fields in AROME
   **Action:**
   - HU and AU tries to reproduce this problem in their local AROME assimilation systems

**Highlight topics**

During the planning several “highlight topics” were pointed out and discussed more in detail. These were discussed more in detail.

1. Radar assimilation: CRO and HU is interested in radar assimilation in 2011, AU plans to get

involved in 2012. We agreed to use the CONRAD tool to feed BATOR with local radar data. Tomislav prepared a reader plugin template in C++, which should be filled up with ther reading of local radar data by each LACE member.

**To do:**

- Tomislav collects information on the local formats in LACE and he publishes it on the forum. This probably helps to minimize the work in writing reader plugins for these data.
- All LACE countries tries CONRAD to feed BATOR with its raw radar data

2. GPS assimilation: AU and HU and SI is interested in using this data type in 2011/2012. The AU tests were done with ascii input but the use of BUFR data is recommended for the future.

   **To do:**

   - Alena/Gergely asks Meteo-France whether a BUFR reading for GPS is already implemented in BATOR and if yes, where the bias correction is applied.
   - Gergely asks for the policy of EGVAP whether these data can be redistributed on OPLACE for all LACE countries
   - All LACE countries look after local GPS networks and reports its findings on the forum

3. Surface assimilation: besides CANARI or OI_main LACE members intend to use the assimilation of LandSAF albedo deeloped by Jure Cedilnik and JF-Mahfouf.

   **To do:**

   - Jure posts a manual to the forum about the analysis scheme to be used for LandSAF albedo assimilation
   - Gergely includes LandSAF data to OPLACE

4. OPLACE upgrade with new data types: a couple of new observation types are needed by LACE members in the future. A priority order to proceed was set up as follows:
   - METOP/IASI data (after a reasonable channel selection)
   - National SYNOP data (including snow)
   - LandSAF albedo
   - GPS EGVAP (if legal)
   - ASCAT (soil moisture, ocean wind)
   - radar (long term plan)

**Long term planning (thinking)**

A discussion on long term planning also took place at the meeting. Participants pointed out that:

- a coordination on radar assimilation is to be done for the next 5 years with the goal of exchanging radar data needed for data assimilation (via OPLACE or bilateral agreements)
- a more frequent assimilation cycling is needed on the long term to make possible higher frequency short range forecast updates
- initial perturbations via ensemble data assimilation are to be included to the LACE EPS systems (LAEF and LAMEPS/HU)
- LACE is interested in LAM 4DVAR only for the 10 km scale (e.g. use it in the control run of LACE EPS systems) so we should keep ourselves updated about 4DVAR developments in the HIRLAM community and also contribute with smaller development tasks (as far as capacity is available)
- LACE is interested in the AAA implementation of the hybrid assimilation scheme coded in HIRLAM already