Working Area Data Assimilation

Progress Report

Prepared by:	Area Leader Máté Mile
Period:	2014 (from January to December)
Date:	02/03/2015

Progress summary

In this report, the LACE DA activities will be summarized which have been done between January and December, 2014. Coordinated LACE stays dedicated to RADAR Quality Control (QC) and to variational bias correction (VARBC) of GNSS Zenith Total Delay (ZTD) have been accomplished. Unfortunately the remaining two stays (Surface assimilation with EKF, Generation of LAM sigmaB maps) were postponed to 2015 which produced underspending in LACE DA budget. Because of this and difficulties with Romanian DA system, an additional stay was realized at the very end of 2014.

In the first part of the progress report, an overview on the developments of operational, pre-operational DA systems will be reported. In 2014 major part of the DA manpower have been booked for new cycle (CY38t1) implementation and validation issues. Regarding OPLACE activities, the national SYNOP data exchange progressed a lot and several maintenance problems have been already solved e.g. system capabilities for TAC to BUFR coding migration of SYNOP and BUFR reports. The detailed OPLACE activities are summarized in DM's report.

The bigger part of the report will give a summary on the research oriented actions. The pre-processing of LACE RADAR data samples has been progressed, but the conversion of quality indexes has to be further studied. Progression has been achieved in local RADAR DA studies based on new model cycle (CY38t1) and more accurate local reflectivity and radial wind observations. Already this year, the data assimilation of Mode-S MRAR observations became operational in Slovenia after extensive validation. Data Assimilation studies related to satellite radiance observations have been continued also focusing on advanced usage of polar-orbiting satellites. The work on variational bias correction of GNSS ZTD and the using of new 3D refractivity has been examined. The action to use Extended Kalman-Filter with conventional observations for surface assimilation purposes was started in 2014 but progressing slowly, hence the limited manpower and adjourned LACE stay. Last but not least the algorithm using grid-point sigmaB maps has been corrected and coordinated work is being devoted to sigmaB maps generated from limited-area ensemble.

Action/Subject/Deliverable: ***Towards operational implementation of full (upper air and surface) DA system***

Description and objectives: Operational assimilation suites were upgraded in Austria, Czech Republic, Hungary, Slovenia and Slovakia. Most of these changes related to new cycle implementation (CY38t1), increased vertical resolution and improvement on the representation of structure functions.

In Slovenia, Mode-S MRAR observations after successful studies have been introduced operationally in ALARO DA system. Vertical resolution (87 levels) was increased and a new B-matrix was computed over the period from 15 March to 1 May 2012 using ECMWF EnDA ensembles. The use of satellite radiance observations has been revised due to changes in vertical resolution and VARBC monitoring. The operationally applied 3 hourly RUC was also validated thanks to a flat-rate stay using data assimilation diagnostic tools (Degree of Freedom for Signal, Moist Total Energy Norm). The DFS validation reflects the high importance of AMDAR and Mode-S observations in the Slovenian DA system considering a 10 days long experiment. An example from the DFS results regarding the dependency of absolute DFS to the analysis network times can be seen on Figure 1 showing the biggest contribution by AIREP (including Mode-S MRAR).

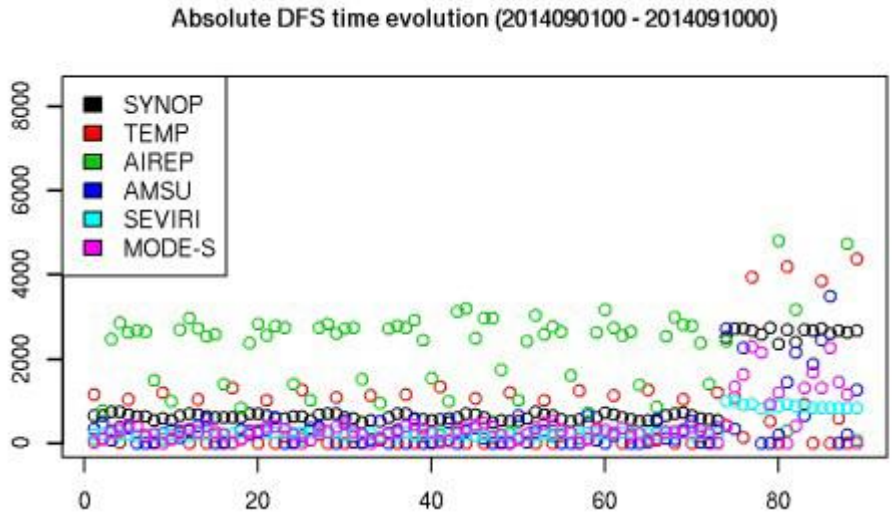

Figure 1. Absolute DFS time evolution for available observation parameters on Slovenian ALARO domain

In Czech Republic, the modified humidity treatment of the newer cycle (CY38t1) and snow analysis issues have been studied. After broad validation of the new cycle, CY38t1 became operational for surface assimilation. Furthermore pre-operational testing of BlendVar (3DVAR combined with DF blending) configuration was also started with the latest physics/forecast ALARO settings. Examining preliminary results on a given summer period of 2014, comparison against observations showed improvements on temperature, geopotential

and wind speed forecast scores on short ranges but on longer ranges degradations was also reported. According to the over-fitting to observations, background and observation errors were also tuned.

In Hungary, new background error statistics were calculated for AROME Hungary based on forecast differences of AROME EDA. In operational ALARO 3DVAR AMSU-A and MHS sensors from NOAA-19, METOP-A and METOP-B have been introduced as passive radiance observations. The validated CY38t1 became operational for AROME DA and pre-operational for ALARO DA.

In Austria, extended domain (covering all LACE countries except Romania) and increased vertical resolution of the AROME DA suite have been done (2.5km/90L cy36t1/cy37t1op1). Due to lower model top (about 20hPa), high peaking AMSU-A and HIRS channels were switched off, some predictors were modified. The replacement of snow water equivalent in AROME by values from the external "SNOWGRID" snow layer model was enabled. It is done differently in CY36t1 (by Offline OI_main) and in the next cycle CY38t1 (by Blendsur).

In Slovakia, new cycle (CY38t1) was introduced operationally for CANARI surface assimilation and upper-air blending.

Regarding Romanian DA system, a two weeks long stay was additionally organized in Budapest to maintain and upgrade the pre-operational ALARO OI+3DVAR system. During this work, CY38t1 on new IBM platform has been installed with all the necessary upgrades to be able to use satellite AMV and radiance observations correctly in the system.

Efforts: 6 months (local work)

Contributors: roughly 1 person per countries

Documentation: national reports on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: ***Assimilation of radiance observation (ATOVS, IASI, SEVIRI) in DA systems***

Description and objectives: Investigation of IASI radiance observations has been continued with ALADIN/CZ system. First half of this work focused on examining bias parameters with different variational bias correction setups. In conclusion bias parameters initialized from global ones (i.e. warmstart) and with tuned adaptivity (NBG parameter) are necessary to get accurate VARBC coefficients. The second study was to evaluate the impact of the time-delay of polar-orbiting satellites using 3DVAR only 4 times in a day. Polar satellites are crossing Central-Europe in sub-synoptic times which produce higher bias and even data rejection in a 6 hourly updated assimilation system (Figure 2 shows the data stream of different polar

satellites). As the outcome of this study, the reduction of assimilation window from 6 to 3 hours is recommended to avoid higher biases (and reject observations respectively) and to use valuable satellite data the usage of 3h RUC or 3D-FGAT is also suggested.

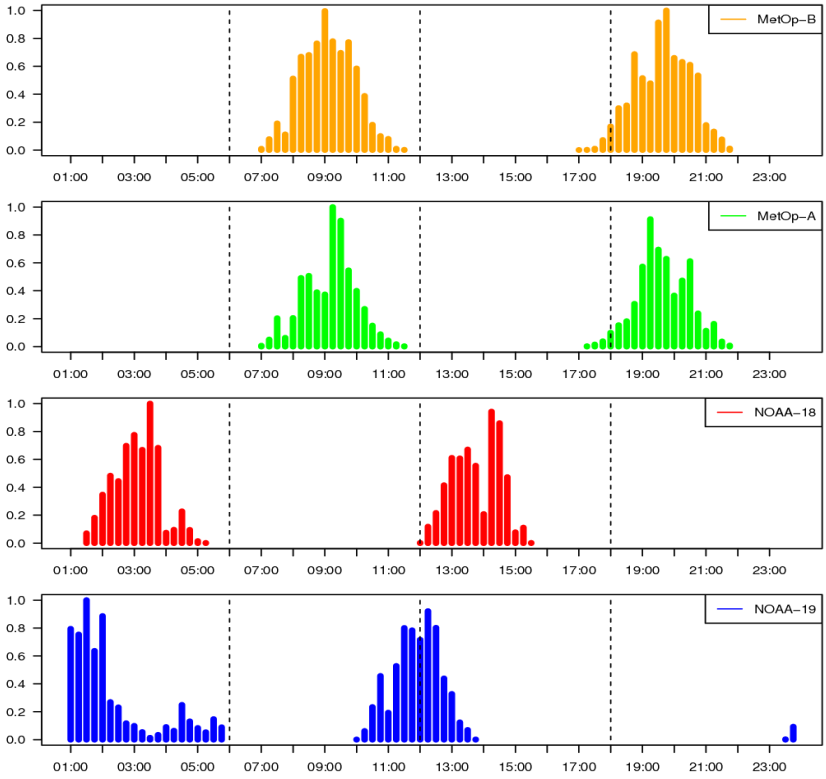

Figure 2. Satellite crossing times over ALADIN/CZ domain

In the Slovenian DA system due to VARBC monitoring over seven months, the observation minus analysis statistics have been studied. Thanks to this investigation, several issues were identified and tackled like the decommissioning of NOAA-16, increased amplitude of AMSU radiances during September of 2014 and implementation of new satellite channels. Therefore NOAA-16 was no more used, channel 13 from NOAA-18, NOAA-19, METOP-A, METOP-B and channels (4-5-6) from MSG SEVIRI have been switched on. AMSU-A VARBC coefficients of 09 and 21UTC network time have been tuned (for channel 7 to 12 and not for channel 5-6) taking into account VARBCs from 18UTC to avoid oscillation in the statistics. For AMSU-B, initialization of VARBC coefficients to zero has been found to optimal.

Efforts: 6 months

Contributors: P. Benacek (Cz), B. Strajnar (Sl), Z. Sassi (Tun)

Documentation: reports on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: ***Investigation of spatially varying flow-dependent background error variance***

Description and objectives: As the continuation of last year activity, the algorithm using grid-point sigmaB maps has been validated and corrected. In 2014 after the validation, the necessary code developments had been revised for generation of sigmaB maps from limited-area ensemble information. Minimum modifications are needed in routines SUJBVARENS, SUJBCOVNOISE, SUJBCOVSIGNAL, FLTBGCALC for reading of ensemble members and writing errgrib (sigmaB map) files. Beside scientific work, coordination issues have been discussed to bring closer the LACE Predictability and DA people for the purpose of this action. At the last quarter of 2014 there was no more progression (mainly because of the failed cooperation) and stay was postponed to 2015.

Efforts: 2 months

Contributors: A. Bucanek (Cz)

Documentation: report on LACE webpage

Status: ONGOING

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

Description and objectives: This action gathers the local RADAR assimilation activities and a coordinated task to prepare and pre-process RADAR data samples uniformly inside LACE for data assimilation purposes.

Regarding LACE RADAR data collection, difficulties have been found related to different data content using same OPERA HDF5 format. At the beginning of 2014 additional problems have been stated concerning conversion of quality indexes. In the first half of 2014 these corrections are being tackled and INCA2 Quality Control was further studied.

Concerning local RADAR assimilation efforts, major progress accomplished in Austria to correct Austrian local RADAR reflectivity and radial wind observations (by now real-time available RADAR data from Austrocontrol) and validate assimilation configurations respectively (CONRAD-BATOR-SCREENING-MINIM). More precisely, de-aliasing of Austrian RADAR data has been tackled making local implementation of the method proposed by He et al, 2012. To convert HDF5 to MF BUFR, CONRAD-RC package is being used for the 4 Austrian RADAR data. In the absence of the complete quality control, blacklisting of lowest elevations (<1,5°) was applied. In conclusion the results of various impact studies showed improvement and degradation also which underline the importance of more precise QC.

For summer period of 2012 (same period as LACE RADAR data collection - May & June of 2012) AROME 3DVAR was tested with new cycle (CY38t1) and improved local RADAR data in Hungary. Hungarian QC was employed by RADAR software and local developments which basically contains RLAN filter, RaySmooth, Clear-sky echo removal and Velocity Filter

procedures. In order to convert RADAR data to MF BUFR a locally developed HunBUFR tool is being used. Thanks to the data corrections and new cycle (CY38t1, bugfixes) the spin-up problem in surface variables (reported last year) has been solved and good signal was obtained in forecast verification scores compared to operational configuration (Figure 3. shows preliminary verification scores).

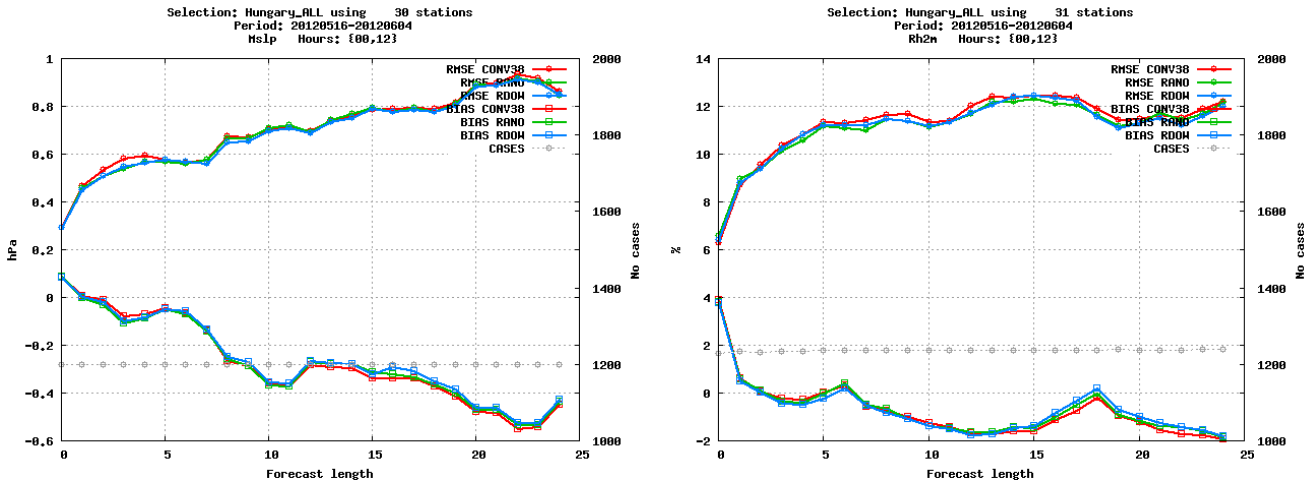

Figure 3. RMSE and BIAS scores for MSLP(left) and 2m Relative Humidity(right). Red curves – AROME CONV: Operational configuration, Green curves – AROME RANO: AROME CONV+ RADAR reflectivity and radial wind, Blue curves – AROME RDOW: AROME CONV + RADAR radial wind

At the end of 2014 another impact study has been carried out to verify the impact of RADAR data assimilation on different period (from 1st to 23rd of August 2014). Similar results (compared to above mentioned study) have been obtained where RADAR assimilation did not change surface scores significantly (however sometimes improvement, sometimes degradation can be seen), but better precipitation skill scores were gained. An example from the verification results are plotted on Figure 4.

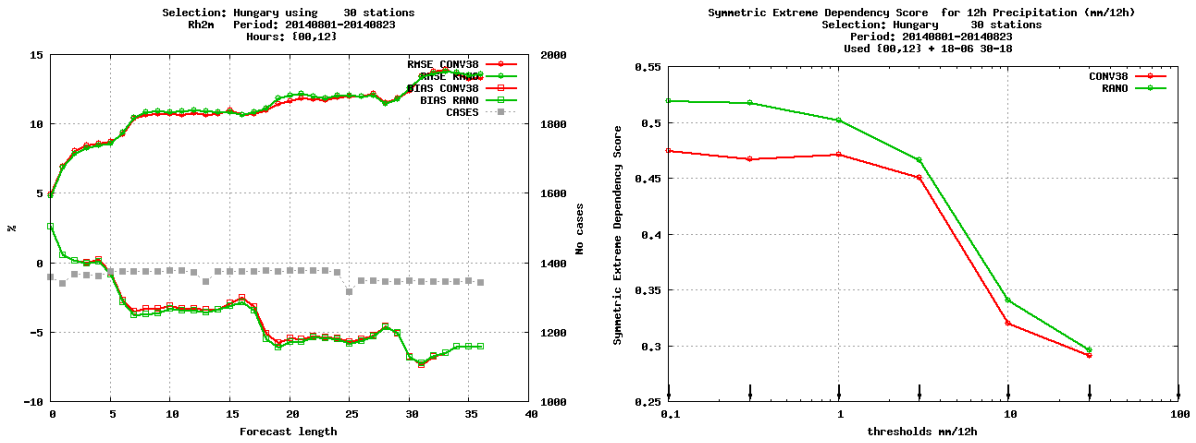

Figure 4. RMSE and BIAS scores for 2m Relative Humidity(left) and SEDS for 12h precipitation (right). Red curves – AROME CONV: Operational configuration, Green curves – AROME RANO: AROME CONV + RADAR reflectivity and radial wind.

Efforts: 9 months (1 month LACE stay for M. Nestiak (Sk))

Contributors: R. Steib (Hu), F. Meier (At), M. Mile (Hu), M. Nestiak (Sk)

Documentation: report on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: Implementation of ground-based GPS data assimilation

Description and objectives: The EUMETNET Water Vapour Programme (E-GVAP) has a fast growing network. In 2014, so called SGOB Network has been introduced to the E-GVAP Network bringing 35 new ground-based GNSS receiver stations around Hungary. Using this network an assimilation study of GNSS ZTD has been investigated with 67-68 selected (whitelist selection procedure) ground-based stations inside AROME Hungary domain. These stations provided reliable and good quality of ZTD observations and good data coverage over AROME domain. In conclusion the impact of assimilated ZTD has been showed promising results especially on humidity forecasts. It is worth mentioning that impact on analysis calculated by Degree of Freedom for Signal (DFS) showed important relative contribution of the ZTD observations to AROME analysis (Figure 5. the example of DFS).

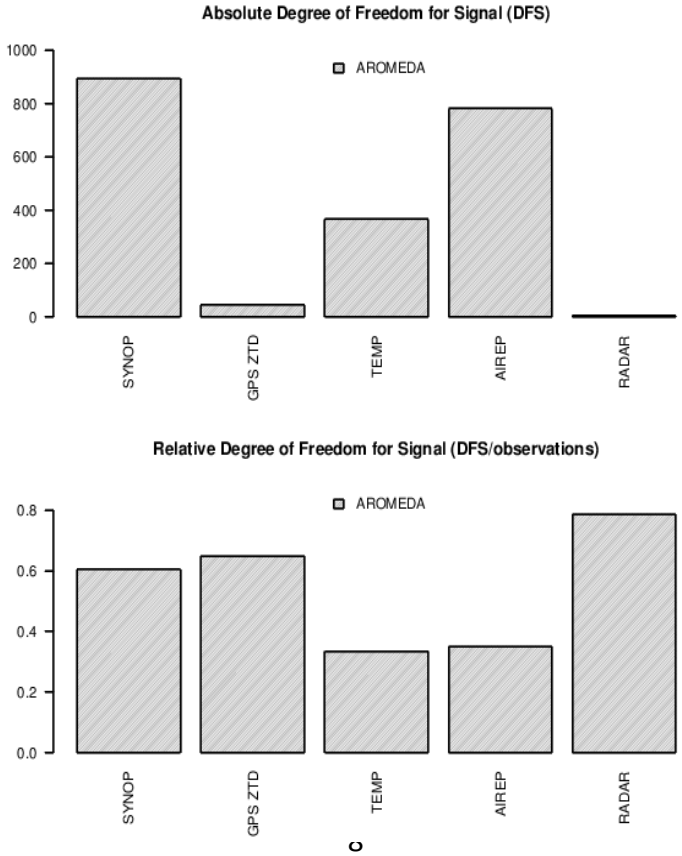

Figure 5. DFS calculated on analysis 12UTC 3rd of January 2014 for SYNOP, AIREP, TEMP, RADAR and GPS ZTD observations. Absolute DFS can be seen on the top and the relatively DFS is on the bottom.

The above mentioned assimilation study was made with static bias correction calculating representative bias over a 15 days long learning period. Another aim of this action is to examine the variational bias correction method for ZTD which method has a trial version available in new cycle (CY38t1). The validation was started and a technically working package has been obtained.

Also an additional activity using 3D refractivity in data assimilation has been started with Meteo-France cooperation. The forward observation operator and TL/AD operator have been developed but further work is needed in BATOR and SCREENING to build necessary changes for a new observation type.

Efforts: 8 months (1 month LACE stay for X. Yan (At))

Contributors: X. Yan (At), M. Mile (Hu)

Documentation: report on LACE webpage

Status: ONGOING

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

Description and objectives: The surface assimilation using EKF with conventional observations is being investigated after the trial version of the method kindly provided by Belgian colleagues has been installed in Hungary. Changes had to be made to generate atmospheric forcing for AROME and running offline SURFEX, hence trial version was made with ALARO model. On the other hand the generation of gridded observation has been used with the same (Belgian) settings (i.e. using the same observation weights, sigmaO-s).

Beside of the above mentioned EKF activity, work on snow analysis with use of satellite SAF products has been restarted. Procedures to interpolate observations (in hdf5 format) to model grid using R software were implemented. Observation monitoring (obs-minus-guess) has been performed over a winter period (2012/2013).

Efforts: 2 months

Contributors: H. Toth (Hu), J. Cedilnik (Sl)

Documentation: report on LACE webpage

Status: ONGOING

Action/Subject/Deliverable: Assimilation of Mode-S data

Description and objectives: The Mode-S MRAR high frequency aircraft derived data are being routinely collected in Slovenian airport and have been operationally introduced in Slovenian ALARO 3DVAR system in June 2014. The raw Mode-S data has to be carefully pre-processed and controlled before assimilation therefore temporal smoothing and preliminary data selection are needed. The controlled Mode-S data is coded into OBSOUL format and error characteristics are assumed to be the same as AMDAR observations. The impact of Mode-S observations shows good results especially on nowcasting ranges and in wintertime inversions (Figure 6. shows improved temperature profile analysis in a winter case study).

In 2014, regular data provision of Mode-S observations started between CHMI and Czech Air Traffic Control (ATC).

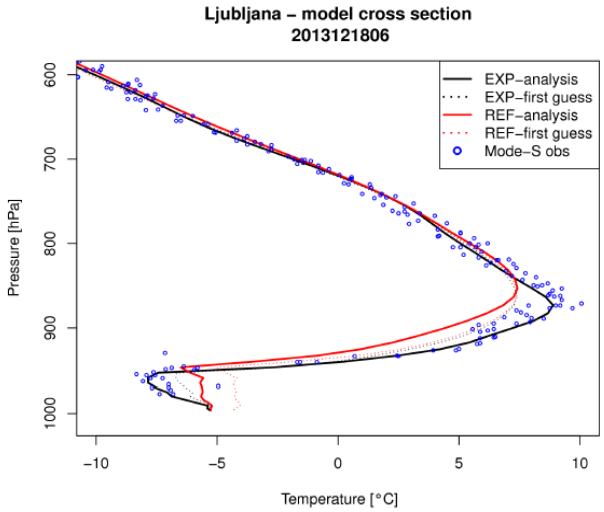

Figure 6. Impact of Mode-S MRAR on vertical temperature profile analysis. EXP is an experiment with Mode-S observations, which are also shown as blue circles. Full lines are analysis profiles and dotted lines are first-guess for the same analysis

Efforts: 3 months

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

Documentation: report on LACE webpage

Status: (local work) COMPLETED

Action/Subject/Deliverable: Assimilation of Meteosat HRW AMVs

Description and objectives: The new AMV observation so called High Resolution Winds (HRW) derived from NWCSAF package was introduced to OPLACE and the data content was already evaluated in 2014. The retrieval algorithm of HRW is able to provide more observations with better quality (higher Quality indexes) and without using NWP background compared to EUMETCast GEOWIND. The number of AMVs can be seen on Figure 7 where the use of HRW even above 90% Quality index gives more observations in higher atmosphere than the use of GEOWIND above 70%.

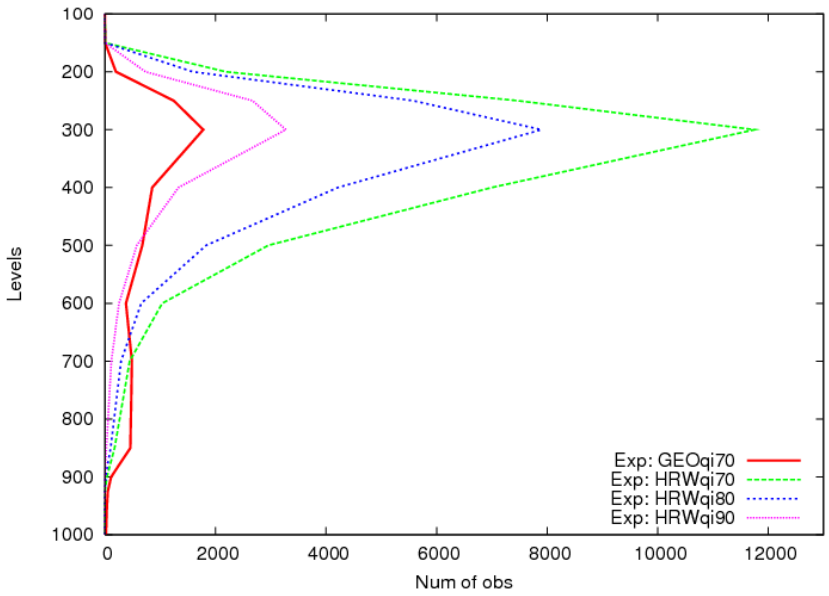

Figure 7. The number of AMV observations calculated over 10 days with 8 analyses per a day. GEOqi70(red) – the number of GEOWIND AMVs above 70% Qis, HRWqi70(green) – the number of HRW AMVs above 70% Qis, HRWqi80(blue) – the number of HRW AMVs above 80% Qis, HRWqi90(pink) – the number of HRW AMVs above 90% Qis

Efforts: 1.5 months

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

Documentation: report on LACE webpage

Status: ONGOING

List of actions, deliverables including status

Subject: Towards operational implementation of full (upper air and surface) DA system

Deliverables: operational implementation

Status: ONGOING, (project COMPLETED)

Subject: Assimilation of radiance observations (ATOVS, IASI, SEVIRI) in DA systems

Deliverables: report on LACE webpage

Status: ONGOING

Subject: Investigation of spatially varying flow-dependent background error variance

Deliverables: report on LACE webpage

Status: ONGOING

Subject: Implementation of RADAR reflectivity and radial wind

Deliverables: report on LACE webpage

Status: ONGOING

Subject: Implementation of ground-based GPS data assimilation

Deliverables: report on LACE webpage

Status: ONGOING

Subject: Surface assimilation using Extended Kalman-Filter

Deliverables: report on LACE webpage

Status: ONGOING

Subject: Mode-S data assimilation

Deliverables: no

Status: (local work) COMPLETED

Subject: Assimilation of HRW AMVs

Deliverables: no

Status: ONGOING

Documents and publications

List of reports:

Patrik Benacek: Assimilation window in 3DVAR

Zied Sassi: RUC validation report

Mirela Pietrisi: RC-LACE stay report

List of presentations:

Mate Mile: "Assimilation of GPS ZTD in mesoscale AROME model at Hungary", COST ES1206 Workshop, 26-28 February 2014, Munchen, Germany

Mate Mile and Michal Nestiak: "LACE Radar DA and INCA2 QC", HIRLAM Working Days on RADAR Data Assimilation, (video-conf.) 17 March 2014

Mate Mile: "Data Assimilation activities in RC LACE countries", Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting, 7-11 April 2014, Bucharest, Romania

Benedikt Strajnar: "Collection and Assimilation of Mode-S MRAR aircraft observations in Slovenia", Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting, 7-11 April 2014, Bucharest, Romania

Florian Meier: "Recent development of data assimilation in AROME Austria", Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting, 7-11 April 2014, Bucharest, Romania

Mate Mile: "Recent Developments within LACE Data Assimilation Activities", 36th EWGLAM and 21st SRNWP meeting, 29/09 – 03/10 2014, Offenbach, Germany

National posters at Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting, 7-11 April 2014, Bucharest, Romania: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia, Romania, Available online: http://www.cnrm.meteo.fr/aladin/spip.php?article166&lang=en

National posters at 36th EWGLAM and 21st SRNWP meeting, 29/09 – 03/10 2014, Offenbach, Germany: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia, Romania, Available online: http://srnwp.met.hu/

List of articles:

Benedikt Strajnar: Collection and Assimilation of Mode-S MRAR observations in Slovenia. ALADIN-HIRLAM Newsletter no. 3. July 2014.

Activities of management, coordination and communication

1) Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting 2014, 7-11/04/2014, Bucharest, Romania (participation of Mate Mile)

2) 36th EWGLAM and 21st SRNWP Meeting 2014, 29th of Sept. – 3rd of Oct. 2014., Offenbach, Germany (participation of Mate Mile)

LACE supported stays – 2.0 months in 2014

1) Michal Nestiak (SHMI) – 1.0 month in Budapest (OMSZ), 12th of May – 06th of June 2014

2) Xin Yan (ZAMG) – 0.5 month in Toulouse (MF) and 0.5 month in Budapest (OMSZ), July and August(from 1st to 14th) 2014

3) Mirela Pietrisi (MeteoRomania) – 0.5 month in Budapest (OMSZ), 23rd of Nov. – 5th of Dec. 2014.

Summary of resources/means

Subject/Action/ Deliverable	**Resource**		**LACE stays**	
	planned	**realized**	**planned**	**realized**
Full DA system	5	6	0	0.5
Radiance Assimilation	6	6	0	0
SigmaB maps	4	2	1	0
RADAR Assimilation	9	9	1	1
GPS Assimilation	3	8	1	1
EKF Assimilation	3	2	1	0
Mode-S	2	3	0	0
HRW AMV	0	1.5	0	0
Total	**32**	**37.5**	**4**	**2.5**

Problems and opportunities

The main problems in 2014 were:

- The bigger part of the LACE DA resources have been loaded by the validation of new cycle (CY38t1) and maintenance issues of operational systems.
- The lack of communication and cooperation sometimes delayed the activities and produced duplicated work.
- There were problems with OPLACE operation because of the OMSZ IT infrastructure and AMDAR migration issues which had to be maintained.

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. This might be solved by more accurate and wide-spread remote connection facilities.
- the long term planning to determine priorities and to prepare long term aims and actions.