RC LACE Data Assimilation
The hourly Rapid Update Cycle
Kick-off meeting

Venue: ZAMG Vienna, Austria
From 17th to 18th of March 2015.

Participants:

Jan Barkmeijer (KNMI)
Florian Meier (ZAMG)
Mate Mile (OMSZ)
Michal Nestiak (SMHU)
Benedikt Strajnar (ARSO)
Yong Wang (ZAMG)

remotely:

Pierre Brousseau (Meteo-France)
Claude Fischer (Meteo-France)
Yann Michel (Meteo-France)
Thibault Montmerle (Meteo-France)
Alena Trojakova (CHMI)

Introduction:

A Kick-off meeting has been organized in order to discuss future possibilites of an hourly updated data assimilation system and related challenges inside LACE. During the first day, preliminary results were shown and questions were also raised for the latter discussion. Beside LACE participants, one participant (Jan Barkmeijer) from HIRLAM and remotely Meteo-France colleagues have been joined to share their experiences about hourly RUC.

The schedule of the meeting was the following:

Tuesday afternoon (17th of March, 2015)

- Presentations:
  - Mate Mile – RUC Activities at Hungarian Met. Service
  - Benedikt Strajnar – Towards 1h-RUC: Perspectives in Slovenia
  - Michal Nestiak – SHMU – NWP models, nowcasting, RADAR assimilation
  - Jan Barkmeijer – HIRLAM implementations and ideas on RUC/RAP
  - Meteo-France teleconf. Session – Pierre Brousseau – AROME-France DA system
  - Alena Trojakova – Status and Plans at CHMI
  - Florian Meier – LACE RUC meeting – status in Austria

Wednesday morning (18th of March, 2015)

- Discussion:

- Highlights about preliminary results
- Discussion on questions and cooperation

Summary of the presentations:

- In Hungarian presentation, results have been shown from a study investigating added value of 3 hourly to 6 hour assimilation cycle. In more details the optimal observation cut-off time was discussed with special emphasis on the OPLACE pre-processing. It was mentioned that faster observation pre-processing is crucial for an hourly RUC.
- In Slovenia, ALARO 3h RUC is running operationally using high frequency Mode-S observations. Considering DFS results, AMDAR and Mode-S observations together have the largest influence on ALARO analyses. Preliminary tests with 1h RUC showed big importance of the observational loss where analysis from 1h RUC provided worse initial conditions (temperature profile) than analysis from 3h RUC in one particular case study.
- From Slovakia, the NWP and Nowcasting systems have been presented. Beside this, the technical aspects of such systems (i.e. storage and computer capacity) was highlighted which is worth taking into account during the design of future RUC system. Finally the status of RADAR assimilation was reported where QC (specifically for radial wind) still have to be solved, investigated.
- From HIRLAM countries, existing hourly updated assimilation systems have been introduced, namely the LAPS-Harmonie from Finland, the HIRLAM RUC at DMI and KNMI and also Harmonie 1h RUC at KNMI. Regarding the first one, it was mentioned that open source NOAA's LAPS system has been implemented into Harmonie (cy38h1.1) in order to use wide range of observations (including RADAR) and to get fast available forecasts. The LAPS-Harmonie provides better captured wind, cloud and precipitation fields at the beginning of the forecasts and better verification scores than 3h Harmonie RUC. Concerning hourly RUC at DMI, the assimilation consists a two-step 3DVAR-nudging procedure which is clearly improve the HIRLAM forecasts up to 6 hours. This nudging scheme is uniquely developed by DMI and efficiently digests specific 2D RADAR composites through the nudging of divergent term in continuity equation. Also HIRLAM model is running in an hourly RUC manner at KNMI which gives improvement on wind and temperature forecast compared to 3h RUC. The success of HIRLAM 1h RUC is due to the GNSS ZTD which improves precipitation objects, rainfall characteristics and due to the Cloud mask initialization using MSG. A Harmonie 1h RUC was also running at KNMI which is now under development regarding the proper use of RADAR and GNSS observations. Beside Harmonie 1h RUC, Harmonie 4DVAR is running and soon will be upgraded to hourly suite at KNMI.
- Meteo-France colleagues showed their latest results of AROME 3DVAR 1h assimilation cycle focusing on spin-up initialization, structure of the assimilation cycle and future plans. Spin-up noises were efficiently reduced by the use of new B matrix and space-consistent coupling, therefore additional initialization is unneeded. It was pointed out that the hourly cycled system is only using initialization (IAU) for long forecasts to reduce the effect of observation loss due to shorter cut-off. Better results have been obtained during summer period especially for convective cases. It was also mentioned that Meteo-France has short term goals with AROME 1h RUC and on longer term AROME 4D-EnVAR will be developed. AROME 4DVAR is also under development just for research purposes and to provide reference for future AROME 4D-EnVAR.
- In Czech Republic, the use of RUC approach is under evaluation in order to reduce time

representativity errors of polar satellite radiances proposed by Benacek. Preliminary results of spin-up initialization showed that IDFI and space-consistent coupling together are able to reduce noises during first hour of integration.

- Austrian AROME 3DVAR has already been tested in hourly updated assimilation cycle with special emphasis on initialization and RADAR data assimilation. Preliminary results showed minor differences between 1h and 3h RUC in precipitation case studies. It was mentioned that IDFI initialization has been studied and due to technical problems AROME 3DVAR without initialization was preliminary tested. Additionally latest results about RADAR data assimilation were presented using 1h RUC approach.

Discussion:

- *What is the purpose of 1h RUC in LACE?*
  First of all the goals were determined i.e. forecasts from such system would be basically used for automatic warning forecasts and nowcasting purposes covering short- and very short-ranges. Primarily the wind, wind gust, precipitation, convection (convective initiation) should be improved, well forecasted by the system based on 1h RUC and perhaps temperature (around 0 celsius) as well. Low level cloudiness, fog and visibility might be additionally considered as high-priority parameters.

- *What is the added value of 1h RUC taking into account such systems outside LACE?*
  A well designed 1h RUC is able to outperform 3h RUC, but the following issues become critical in the success:

  - Sufficient observation constraint in every analyses and fast observation pre-processing are mandatory, otherwise 1h RUC will fail
  - Control of noise accumulation with or without initialization is needed
  - The use of structure functions which more representative on smaller scales is also crucial.

- *Which DA algorithm should be used on short and longer term developments?*
  The use of LAPS system is not certain in LACE. Variational DA approach remains the basis of upper-air assimilation on short term, but on longer term LACE should join to one of the headline DA research to get knowledge on flow-dependency aspects and more advanced algorithms with affordable computational cost. Improvement on cloud forecast can be reached efficiently by MSG cloud initialization developed by HIRLAM which is already available in common code. In conclusion for short-term, LACE should focus on 3DVAR establishing an hourly updated prototype for next 2-3 years and later on or beside it other algorithm can be considered as well.

- *What kind of observations should we use in an hourly updated system?*
  The most important observation types are the conventional ones (SYNOP, TEMP, AIREP), Mode-S, RADAR reflectivity-radial wind and GNSS ZTD. The extended use of Mode-S observations is desirable including EHS and MRAR, however, data policy and implementation to OPLACE has to be clarified. Furthermore Meteosat satellite radiances and AMVs are good candidates for RUC as well. It means also that actions related to those observations should be investigated with higher priority in the future.

- *Do we have enough observations for 1h RUC?*
  This question should be investigated at first taking into account OPLACE and other (local) observation sources examining differently for each variables.

- *How long cut-off should we use for hourly cycling*
  At KNMI +/- 10 minutes are applied, however, this might be rather strict and effects too big observation loss in a LACE system. Primarily +/- 30 minutes seems a good approximation and meets with the expected delay of the forecasts started from RUC analyses. Furthermore to improve availability of the observations, the time schedule of OPLACE system might be revised as well. Recently it is running in every hour at 5 and 35 minutes which might be increased or modified in order to get observations more in advance. On longer term COPE project is also worth considering, however, it is far from its operational usage.

- *Do we need initialization and if yes, which method?*
  In theory the first guess, integration at initial time with space-consistent coupling and the analysis due to B matrix is balanced, therefore initialization is not needed. In practice the need of initialization should be investigated and should be used if noises are still existing.

- *Should we treat hydrometeors differently in 1h RUC than 3h or 6h?*
  Currently there is no better approach than cycling hydrometeors from first guesses, but it would be important to study the impact of this in special cases (e.g. heavy rainfalls, fog and low cloud situations)

- *What is optimal for initial coupling and how this should meet with initialization?*
  Most probably space-consistent coupling is efficient for hourly RUC as well, but using it with hourly LBC coupling frequency effects underrepresentation of large-scale constraints in assimilation cycle. In a future 1h RUC this should be investigated taking into account sub-hourly LBC coupling in the assimilation cycle and perhaps double nested RUC systems.

- *How we should construct the B matrix in an hourly RUC?*
  For climatological structure functions of 1h RUC, 3h forecast differences should be used, hence in 1h forecasts, energy and variance spectra on small scales are rather weak. But it is essential to construct B matrix from EDA system (with all available observations) which are more representative on small scales instead of the use of downscaled EDA. However LACE countries are usually cannot afford to run mesoscale EDA, cooperation on this area should be sought. It was also mentioned that the multivariate link between control variables should be studied when humidity is only corrected through cross-covariances. Due to Slovenian studies the mulitvariate link has been found more accurate during winter period, but it showed much more sensitivity during summertime.

- *Do we need higher frequency than 1h for LBC coupling in the assimilation cycle or not?*
  It was stated that sub-hourly coupling is worth investigating in 1h RUC, but probably there are some technical difficulties in common code as well. The double nested RUC system can be also considered as an alternative soluiton.

Conclusion:

- In LACE the above underlined actions and related works are going to be tackled with higher priority in short-term, but other mainly longer-term issues are going to be rediscussed after first results.
- Cooperation with HIRLAM and Meteo-France colleagues are very much appreciated.
- During discussion participants agreed on that the use of Mode-S, RADAR and GNSS observations and future development of flow-dependency can be the areas of future cooperation.

Rough estimate of planned work on the use of observations to be considered for cooperations:
(Contact persons and manpowers in 2015)

- ZAMG: Florian Meier (for 6 months) and 2 newcomers are willing to work on RADAR QC and data assimilation. Xin Yan is also working on GNSS data assimilation in 2015.
- SMHU: Michal Nestiak (for 6 months) is willing to continue the RADAR QC and data assimilation work.
- OMSZ: Mate Mile (for 3 or 4 months) is working on OPLACE – observation set, GNSS ZTD and RADAR data assimilation
- ARSO: Benedikt Strajnar (for 6-8 months) is working on Mode-S and going to work on GNSS ZTD assimilation.
- CHMI: Alena Trojakova is working with OPLACE development and Mode-S data assimilation.