Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

Data assimilation activities in RC LACE

EWGLAM meeting 2018

Antonín Bučánek on behalf of LACE DA colleagues

DHMZ SHMU ARSO METEO Slovenia OMSZ ZAMG ROMANIA ANM

Outline

LACE
nwp central europe

- LACE DA systems
- Surface assimilation activities
- The use of observations
  - RADAR observations
  - GNSS ZTD, Slant total delays
  - Aircraft derived data
  - Automatic weather station data (AWS)
- Hourly updated DA systems
- Jk used in AROME 2.5km
- Bufr data handling
- Outlook and future plans

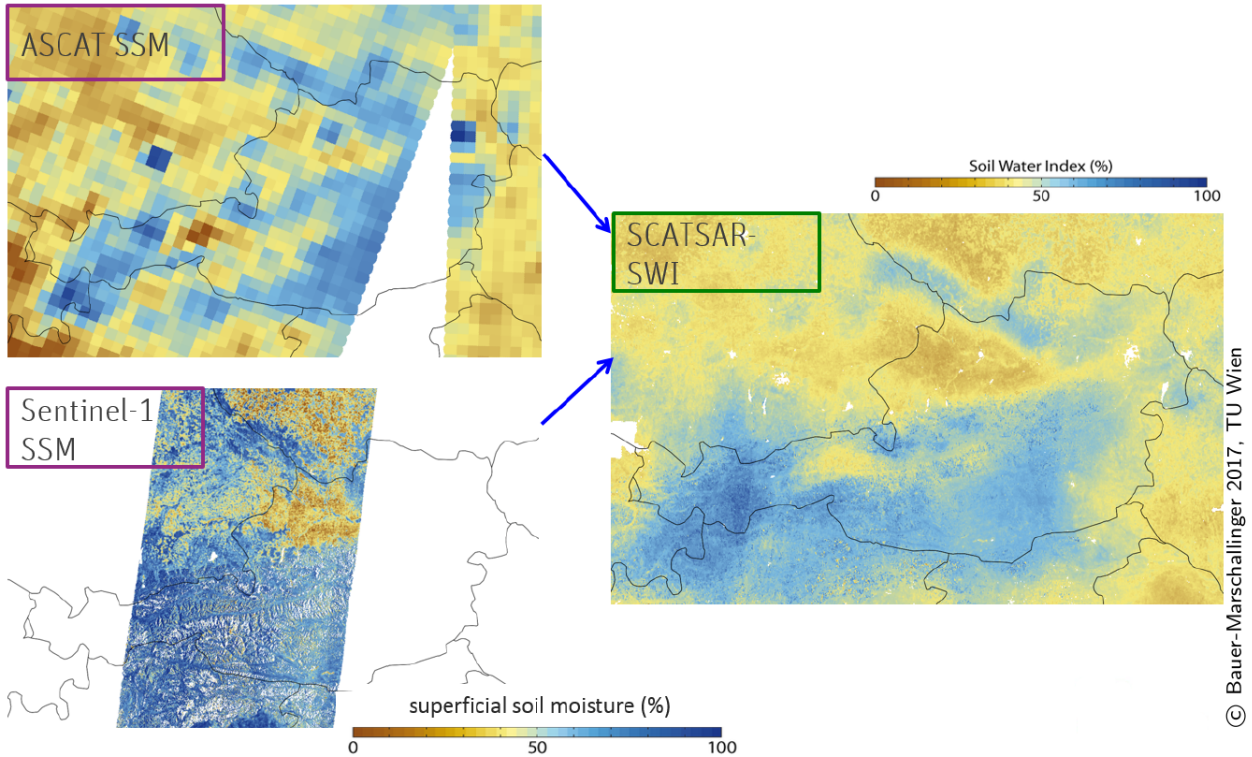
Developments of local DA systems

LACE
nwp central europe

- LACE countries operate 11 DA systems with large variety of configurations and observation sets
- All the systems run ALADIN models with AROME or ALARO physics on resolution ranging from 1.2km up to 9km
- Most of the LACE DA systems uses 3D-Var for upper-air assimilation (with 2 exceptions DF Blending, BlendVar)
- Regional cooperation is the most evident in the common observation pre-processing (OPLACE) activities supporting those operational DA systems. Beside observation from "global" sources national data are also exchanged.

Surface Assimilation

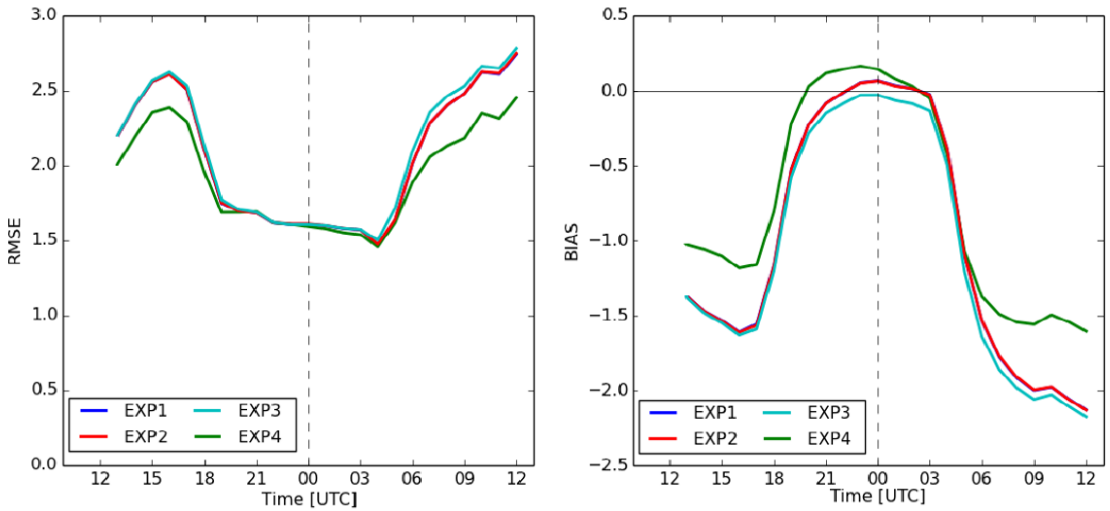
- In most of the LACE DA systems OI is operationally employed.
- For special project purposes Extended Kalman-Filter (EKF) approach is also used with satellite observations in offline SURFEX.
- Assimilation of SCARSAR-SWI (comb. MetOP ASCAT, Sentinel-1 SAR)
  - Copernicus product starting in autumn 2018
  - high spatial resolution = 1km, temporal resolution = 1day



Surface Assimilation II

LACE
nwp central europe

- ISBA diffusion scheme, assimilation SWI in 6 layers
- AROME T2m scores improved over flatlands, neutral elsewhere
- Red line reference, dark green SWI assim



- Test with spatially varying observation error – slight improvement
  - Error for each grid point estimated with Triple Collocation Analysis (Stoffelen 1998)
- Assimilation of Land Surface Temperature (LST) from combination of Sentinel-3 and MSG, MODIS
  - spatial resolution: 1 km / 4 km; temporal resolution: 6 days / 15 min
  - still issues to solve

RADAR observations

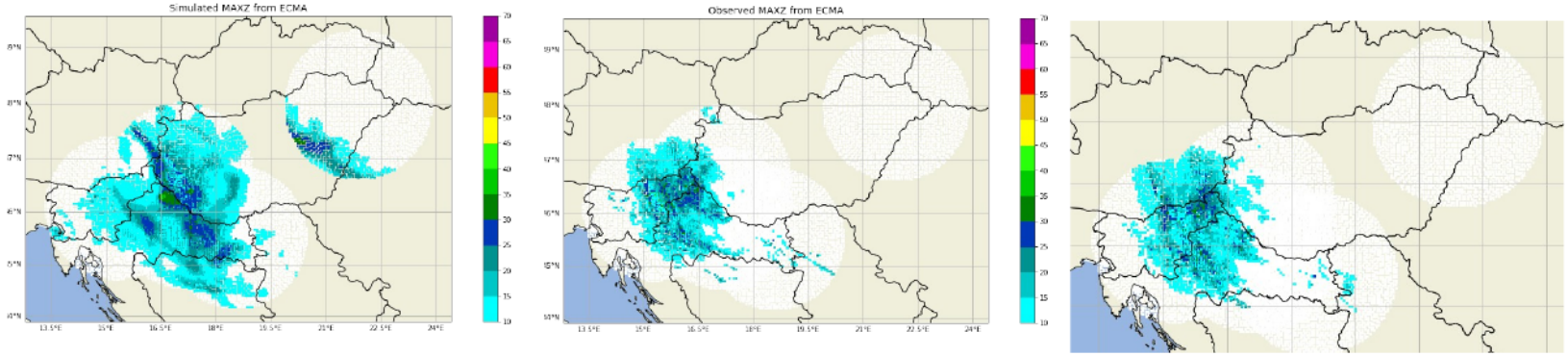
LACE nwp central europe

- New pre-processing tool for OPERA data written in python (see Slovenian poster)
  - splitting of 15 min merged OIFS files to separate measurements
  - rearranging the content according to specification in namelist
  - retaining only the desired variables (e.g. reflectivity and/or radial winds)
  - possibility to encode prescribed meta data separately for individual radars or for the whole data set
- Summary of ODIM HDF5 file content created for countries: be, cz, de, es, fr, hr, hu, pl, si, sk
  - The radar reflectivity is represented in uniform way by all countries.
  - All information needed for data assimilation is present
  - The exception is the minimum detectable energy. It is provided only by Croatia and Slovenia

RADAR observations II

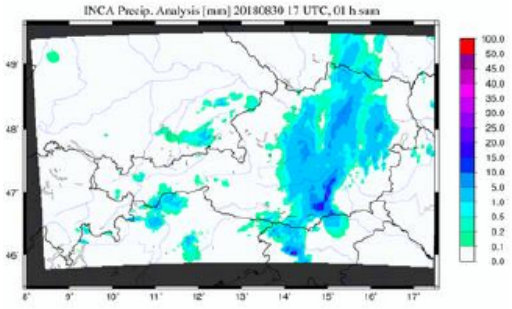
- **Case study 8th Nov 2017**

Guess simul. refl. **observed refl.** **fc+3h**

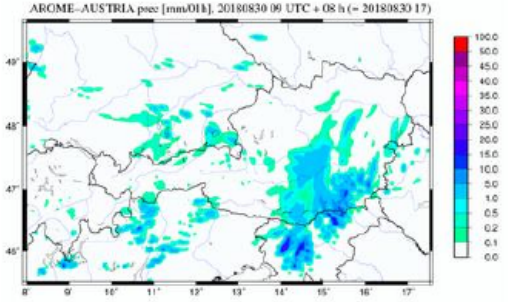


- **Radar reflectivity in parallel suite in Austria (radar AT, DE, SI)**

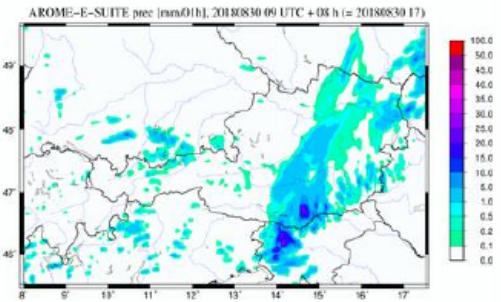
INCA analysis



AROME OPER

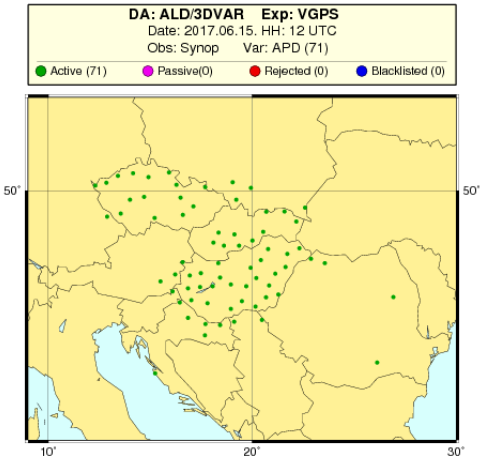


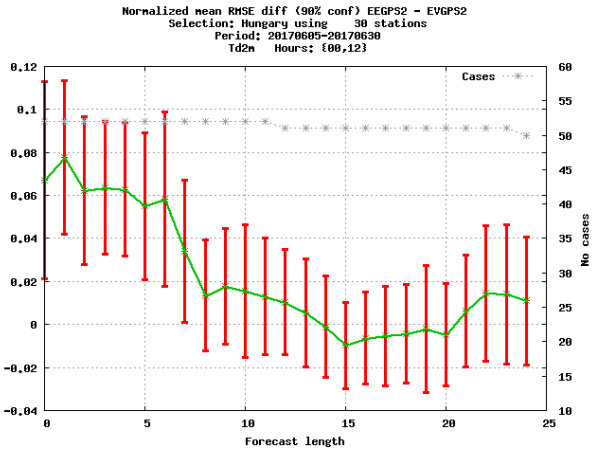
AROME ESUITE



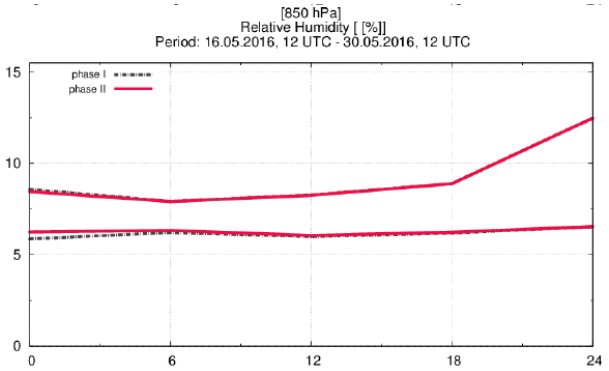
Assimilation of GNSS-ZTD

- In Hungary, Operational implementation of GNSS ZTD, VarBC for each station
  - GNSS-ZTD – improvement in summer, neutral impact in winter





- GNSS ZTD were tested in ALADIN – LAEF 3D-Var assimilation with slight positive impact on RMSE and SPREAD
- Slant total delays
  - computed from N, E gradients of ZTD
  - Spatial resolution is 25x25 km in horizontal and 1 km in altitude



Aircraft derived data

- **Aircraft observations (AMDAR, ACARS and Mode-S) are important components of LACE's DA systems.**
- **The quality of Mode-S EHS observations from KNMI (airspace of Germany, Belgium and the Netherlands) was checked and is comparable to AMDAR – no need for pre-selection**
- **Operational in the Czech Rep., Slovenia and in ESUITE in Austria**

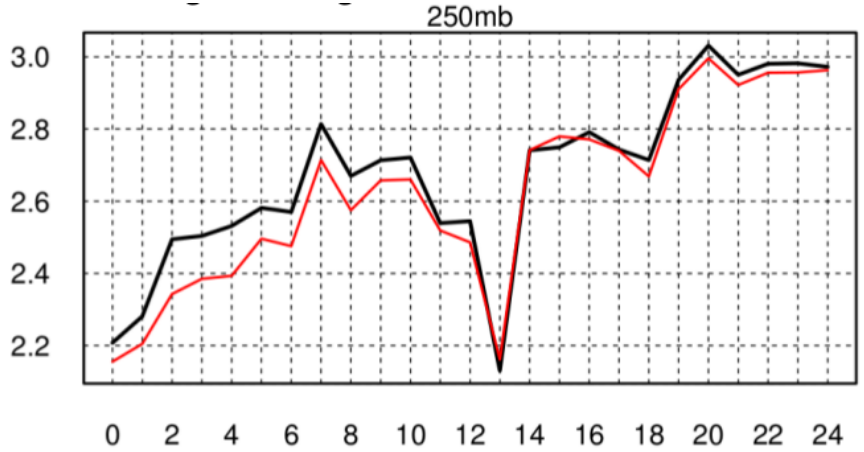
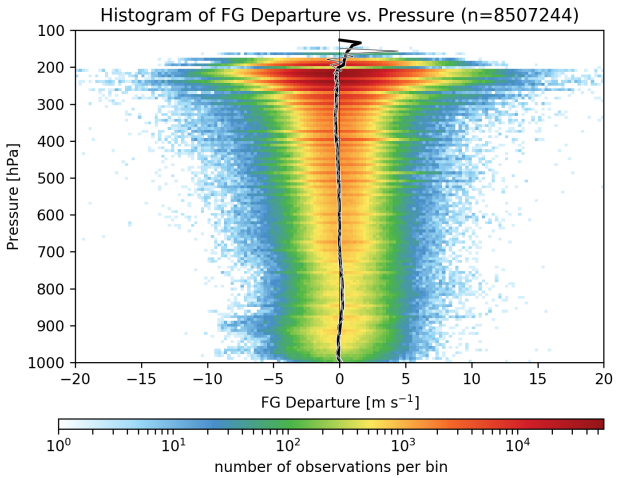


Figure 1: Time evolution of **RMSE for wind speed at 250hPa** verified against aircraft observations for period of 11 Jan – 9 Feb 2017 12UTC. **Reference** and Mode-S EHS experiment.

Aircraft derived data II

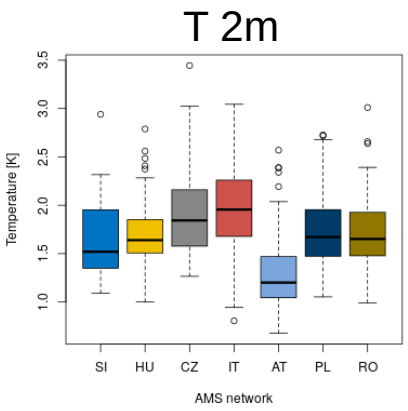
- In Austria new national EHS data delivered by national ATC “Austrocontrol”
- Much higher data density at cruise flight levels compared to KNMI EHS
- Low bias, major step compared to early version of dataset
- Used in AROME ESUITE

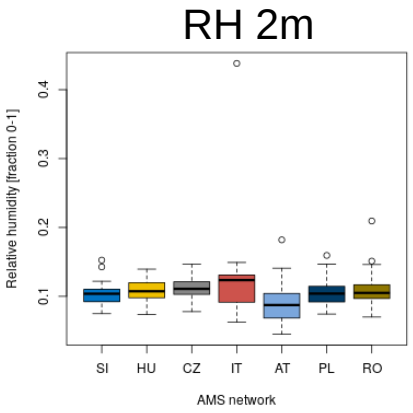


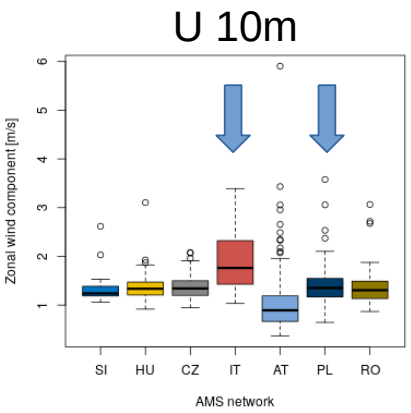
Monitoring of AWS data

- 1 month monitoring of all OPLACE AWS + Italian stations. Blacklisting needed?

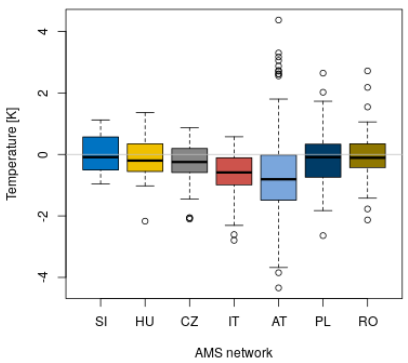
OMG Std.

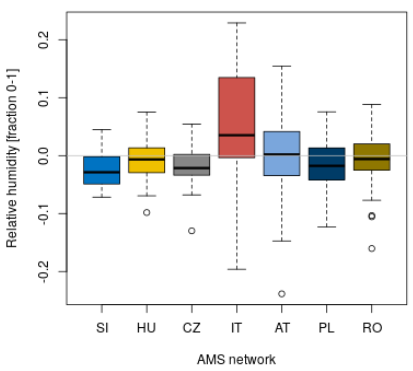


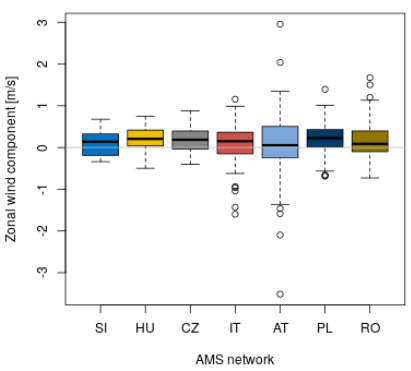




OMG Bias

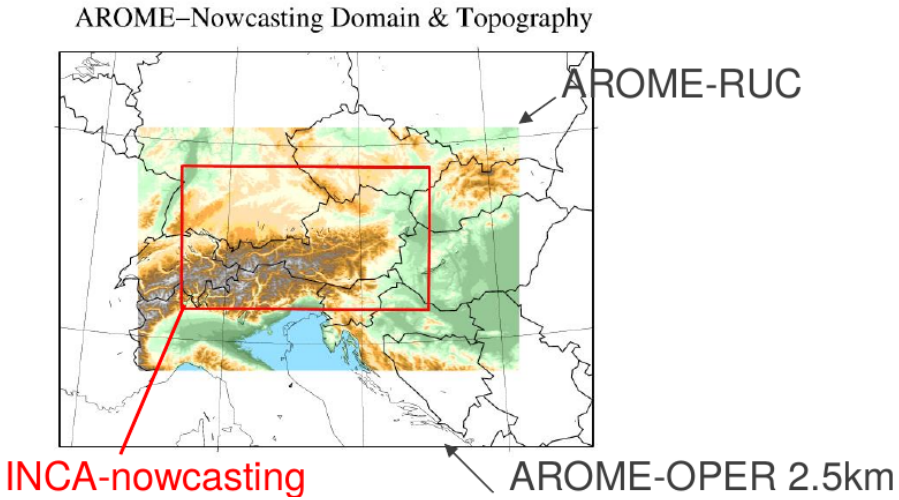






Hourly updated DA systems

- New high resolution rapid update cycle in Austria
- AROME 1.2L90, every hour +12H, 2x 2h cycle
- additional observations (radar reflectivity, Doppler winds, MODE-S aircraft, national SYNOP, AMDAR-Q, national GNSS ZTD)
- additional initialisation: latent heat nudging +35min (Stephan 2008), FDDA nudging (Liu et al. 2006) +30min (optional), (cloud analysis), IAU (Brousseau)



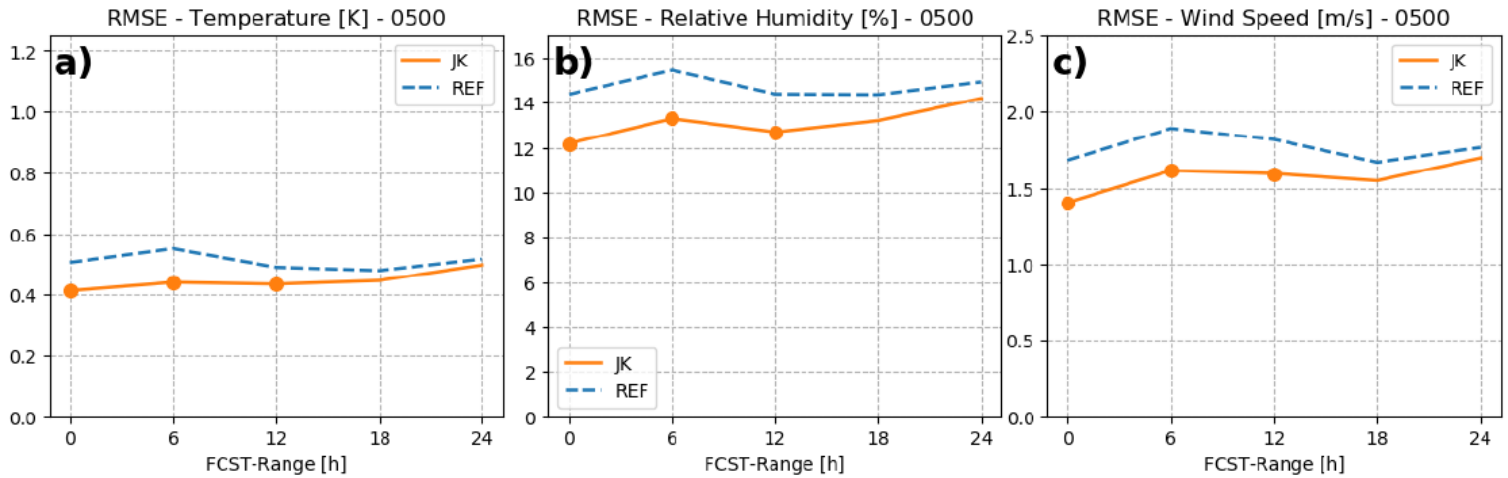
3D-Var with Jk term in AROME EPS

LACE
nwp central europe

- **Motivation:**
  - **Include large scales from global model directly to LAM by 3D-Var**
- **3D-Var cost function with Jk (Guidard and Fischer, 2008)**

$$J(\mathbf{x}) = J_b + J_o + \underbrace{\frac{1}{2}(\mathbf{x}-\mathbf{x}_{ls})^T\mathbf{V}^{-1}(\mathbf{x}-\mathbf{x}_{ls})}_{J_k} = J_b + J_o + J_k \qquad (1)$$

- **AROME 2.5L90 coupled to ECMWF EPS 18L91**
- **V matrix univariate formulation**
- **Jk term truncated on 135 km (Wave number 8)**

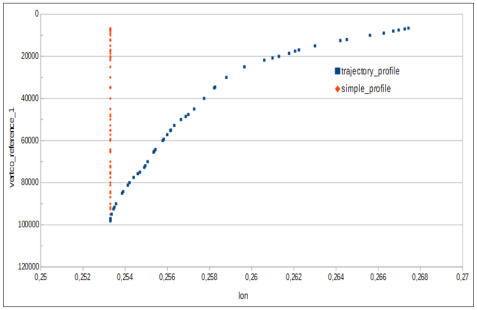


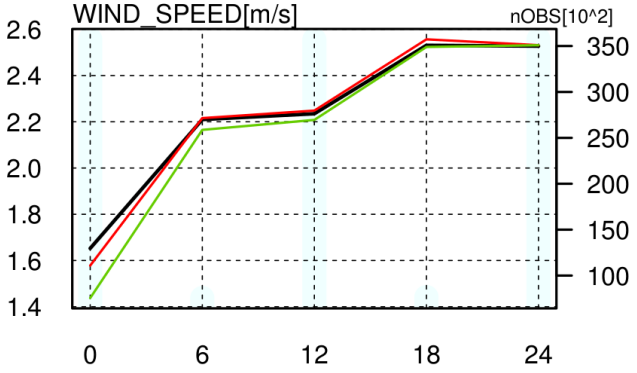
- **Submitted article to QJRMS**

BUFR data handling

- **BUFR SHIP&BUOY handling**
  - pre-processing of the data
  - evaluation of BATOR handling of SHIP&BUOY in collaboration with M. Monteiro
  - for more details see Monteiro (2018)

- **BUFR TEMP handling**
  - BATOR CY41/CY43 offers the use of updated time & trajectory information
  - tested in collaboration with A. Satouri, see Satouri (2017)





RMSE at 200hPa

- **impact on 3DVAR analysis and forecast**
  - tested in collaboration with D. Ustuner
  - improved fit to observations at analysis
  - very small positive impact for +6h of wind above 400hPa

Outlook and future plans

LACE
nwp central europe

- Ongoing
  - Radar reflectivity
  - GNSS Slant Delays
  - Mode-S
  - The use of EKF for surface operational assimilation
  - Jk for Croatian system
- GNSS Radio Occultation
- Hourly updated 3D-Var DA systems for nowcasting purposes
- LAM EDA system for generation of flow dependent bg. errors
- Optimisation of DA systems for new high resolution domains

End

LACE
nwp central europe

Thank you for your attention !

DHMZ ARSO METEO Slovenia OMSZ ZAMG ROMANIA ANM