Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

Recent data assimilation developments in LACE
EWGLAM meeting 2017.

Mate Mile on behalf of LACE DA colleagues

DHMZ SHMU ARSO METEO Slovenia OMSZ ZAMG ROMANIA ANM

Outline

- LACE DA systems and OPLACE
- Surface assimilation activities
- The use of observations
  - OPERA RADAR reflectivity
  - Radiance and bias correction
  - Aircraft derived data
- Outlook and future plans

LACE DA systems and OPLACE

- LACE countries operate more than 10 DA systems with large variety of configurations and observation sets.
- Regional cooperation is the most evident in the common observation pre-processing (OPLACE) activities supporting those operational DA systems.
  - Distributed observations types: SYNOP, SHIP, TEMP, AMDAR, AMV, WP, ATOVS, SEVIRI, IASI, ATMS
  - Regarding conventional observations, currently both TAC and BUFR databases are considered and converted in order to not lose any data. However, SYNOP and AMDAR BUFRs are also included in OPLACE.
  - On the top of AMDAR, Mode-S from KNMI(EHS) and from ARSO(MRAR) are available for OPLACE users.
  - National SYNOP observations are also exchanged within LACE members.

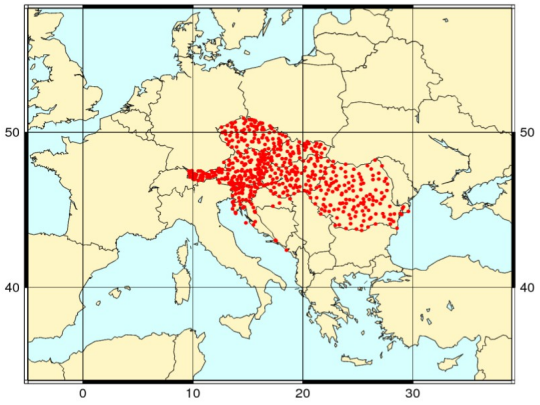


Figure: OPLACE national data exchange

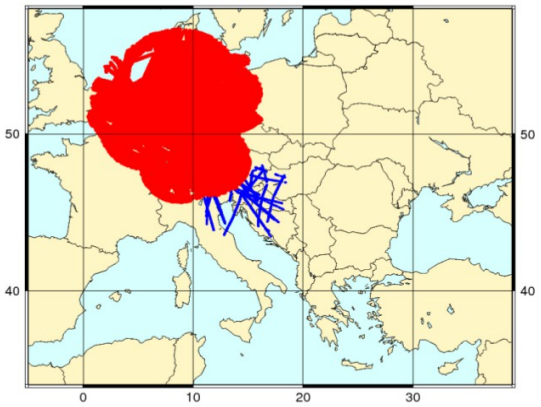


Figure: Distribution of Mode-S data in OPLACE

Surface data assimilation

- In most of the LACE DA systems OI is operationally employed.
- The Extended Kalman-Filter (EKF) approach is experimentally tested with **conventional observations**.
- EKF and SURFEX model in 1D-column setup were built to make detailed validation.
  - Avoid possible error sources which might come from gridded observation (surface spatialization tool)
  - Use in-situ observations from a Hungarian SYNOP station providing measured forcing and real soil observations
  - Reduce significantly the computation costs of these validation experiments

Surface data assimilation

- For special project purposes Extended Kalman-Filter (EKF) approach is also used with **non-conventional (satellite) observations**.
- LST assimilation experiments
  - Sentinel-3, MSG, MODIS
  - Technically working with latest SURFEX releases, validation is ongoing
- SWI assimilation experiments
  - SCARSAR-SWI (combination of ASCAT SSM and Sentinel-1 SSM)
  - ISBA diffusion scheme, assimilation SWI in 6 layers
  - AROME T2m scores improved over flatlands, neutral elsewhere

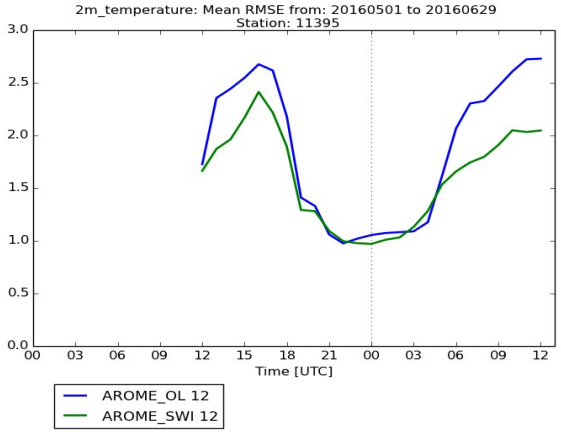
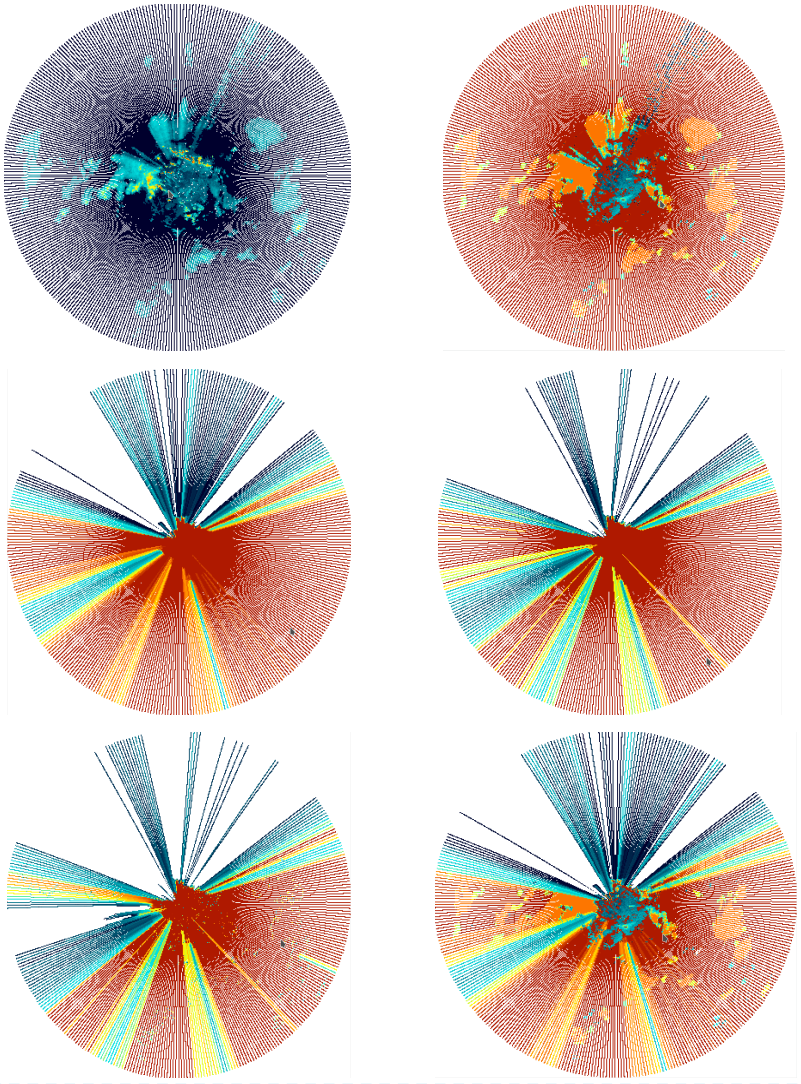


Figure: *RMSE verification against Austrian SYNOP station 11395 for AROME 2m temperature forecast. Blue curve shows AROME reference without SWI assimilation, green curve indicates AROME with SWI assimilation.*

Progress with the use of OPERA data

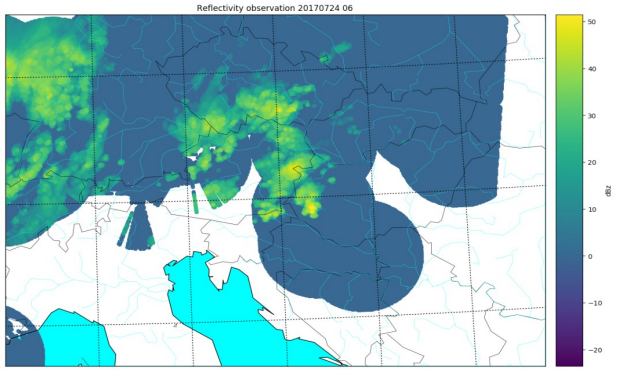
- For a Slovenian RADAR, the local QC modules (developed from INCA2) were compared with OPERA QC for reflectivity.
- Both quality control procedures have similar QIs
  - Attenuation (QI1-BROPO - INCA2)
  - Beam blockage
  - Laplace test (only in INCA2)
  - Satellite cross-check (QI2 - NWCSAF)
  - WLAN filter
  - Common QI (minimum - sum)
- The OPERA quality check was found to be skillful, but further elements can be considered (Laplace, climate, etc) or locally applied.
- To be studied for DOW as well.



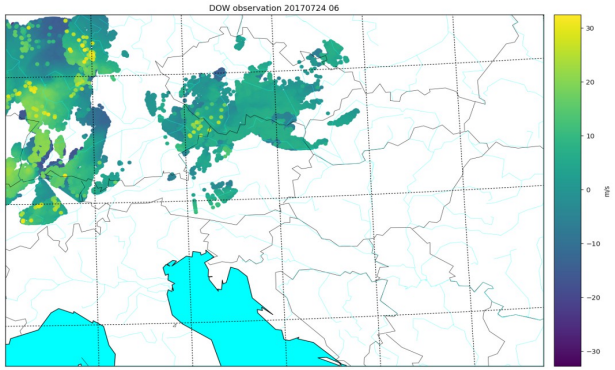
OPERA QIs *(bropo, beam, all)* ***INCA2 QIs*** *(att, beam, all)*

Progress with the use of OPERA data

- OPERA volume data from OIFS server was collected for Austrian AROME domain (34 stations: 1-Be, 9-De, 9-Fr, 2-Cz, 4-Pl, 2-Sk, 2-Hu, 2-Sl, 2-Hr, 1-Rs).
- The HDF5 reader in observation pre-processing and related prepopera.py tool (developed by HIRLAM) were adapted in order to handle OPERA data and additionally for local RADARs as well.
- Beside reflectivity, DOW observations have been also used which requires accurate de-aliasing (locally applied).



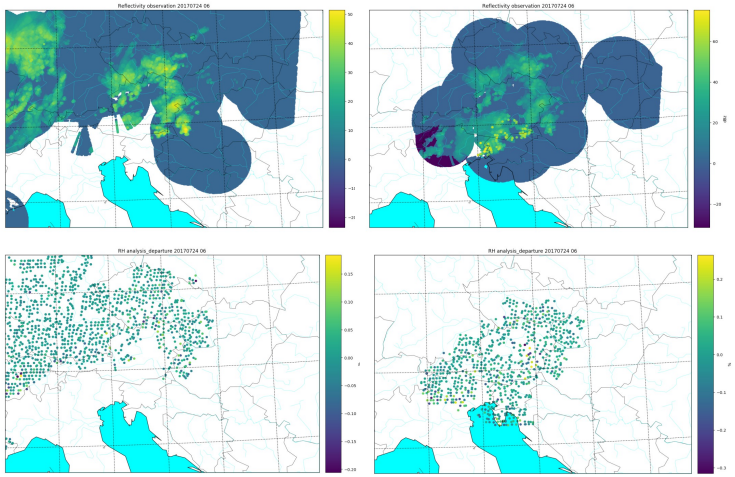
OPERA reflectivity at 1.5° (24th of July, 2017, 06UTC)



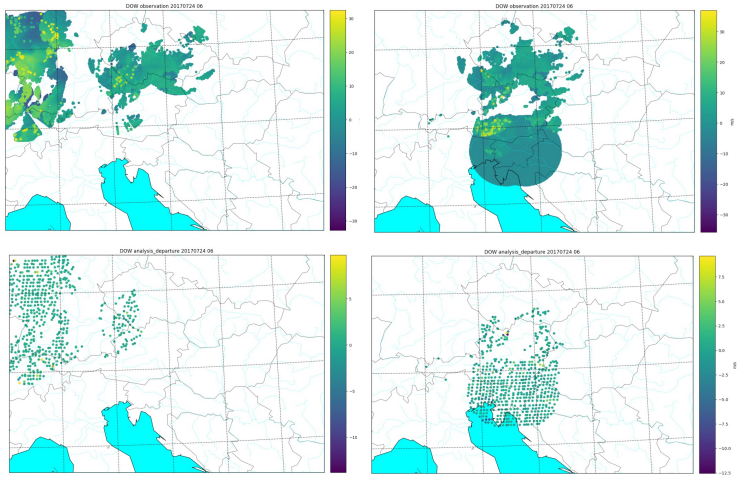
OPERA radial wind at 1.5° (24th of July, 2017, 06UTC)

Progress with the use of OPERA data

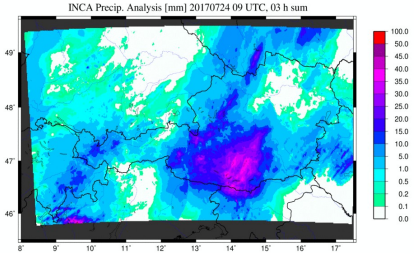
- Case study 24th of July, 2017.



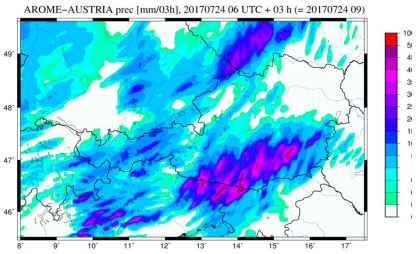
OPERA reflectivity at elevation 1.5°(above left) and 2.5°(above right) and in ODB (below)



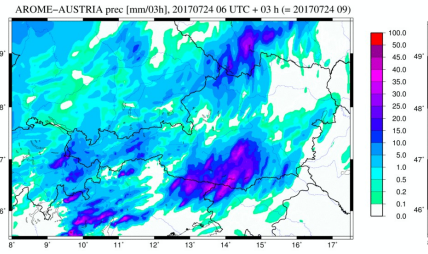
OPERA radial wind at elevation 1.5°(above left) and 2.5° (above right) and in ODB (below)



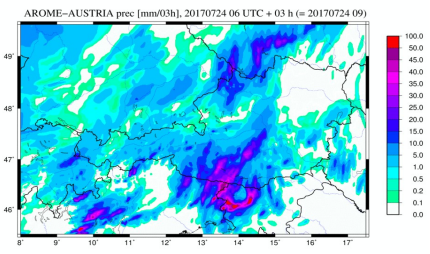
INCA precipitation analysis



AROME 2.5km no RADAR



AROME 2.5km with only OPERA



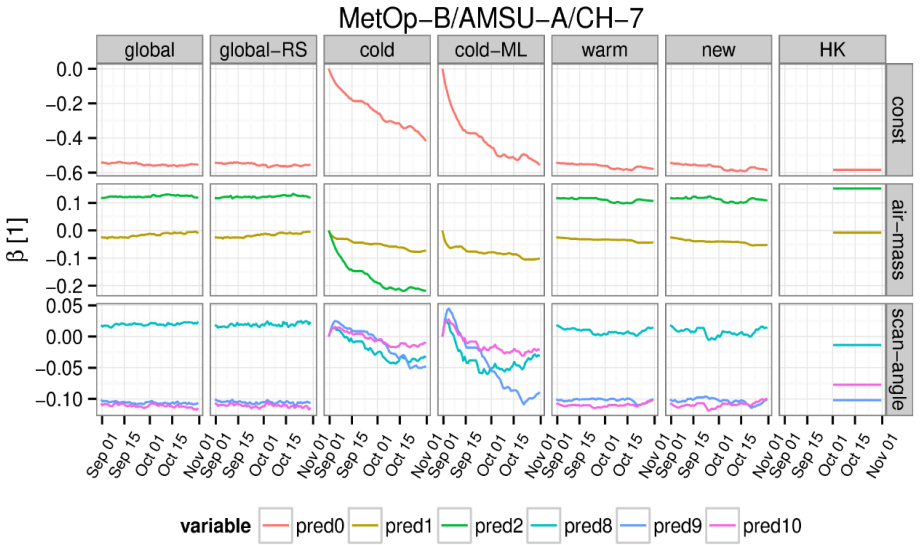
AROME 2.5km with all RADAR

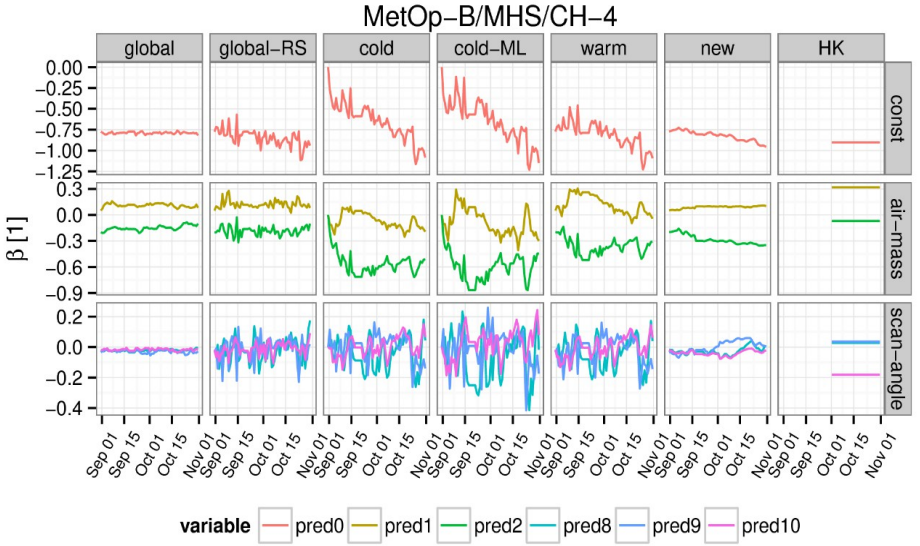
Radiance observations and bias correction

- The bias correction is essential for radiance data assimilation and related methods originally developed for global models need special consideration and revision in case of its limited-area application.
- For the use of polar-orbiting satellites the following aspects have been investigated aiming more accurate variational bias correction of a LAM DA system:
  - Observations sampling issues due to the limited-area domain
  - Bias parameter initialization and predictor selection
  - Evolution of bias parameters in the assimilation cycle
- Detecting reasonable satellite bias in LAMs has two choices:
  - Data collection over a long-time (offline methods)
  - Cycling bias information in time (VarBC method)

Radiance observations and bias correction

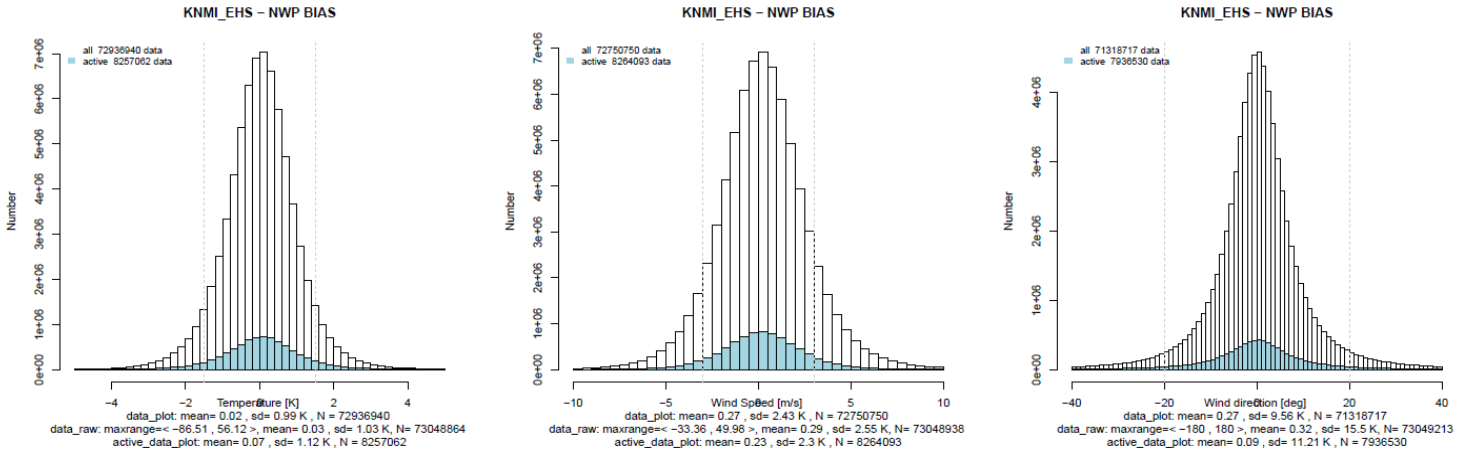
- Comparison of the performance of different bias initialization methods.
  - Global (global) and Global restart (global-RS)
  - Coldstart (cold) and Coldstart according to M. Lindskog et. al. (2012) (cold-ML)
  - Warmstart (warm) and Warmstart with tuned adaptivity parameter (new)
  - Harris and Kelly (HK)
- The adaptivity of VARBC scheme (N_{bg} set to 5000) is appropriate for global models.
- A more flexible and optimal N_{bg} have been determined for each satellite instrument and channel in LAM combined with warmstart in order to improve bias correction.





The use of aircraft-derived data

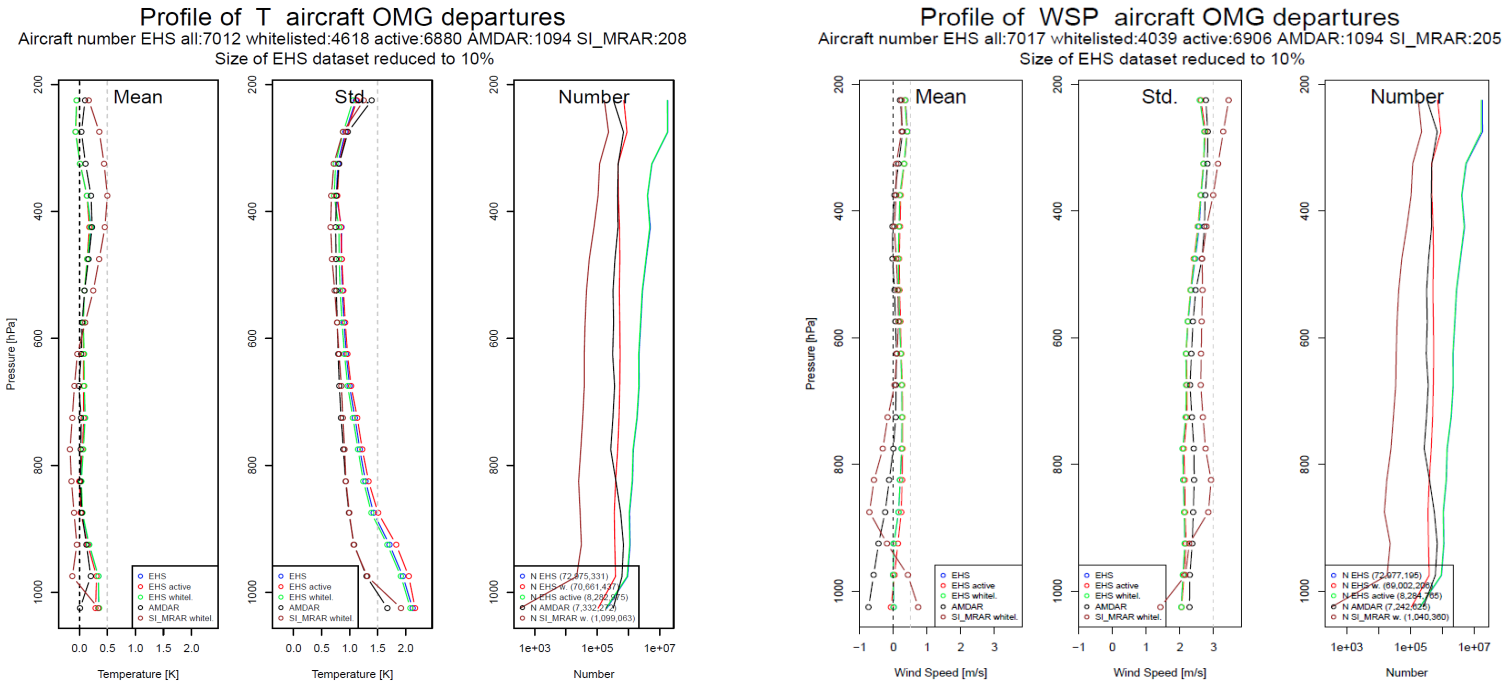
- Aircraft observations (AMDAR, ACARS and Mode-S) are important components of LACE's DA systems.
- The number of observations is gradually increased in the OPLACE (lately AMDAR q, Mode-S from KNMI).
- During last year the Mode-S EHS observations were extensively studied.
- Data quality based on standard deviation and bias of complete OMG data set was checked.



Data quality estimated on a set of OMG departures over 10 months

The use of aircraft-derived data

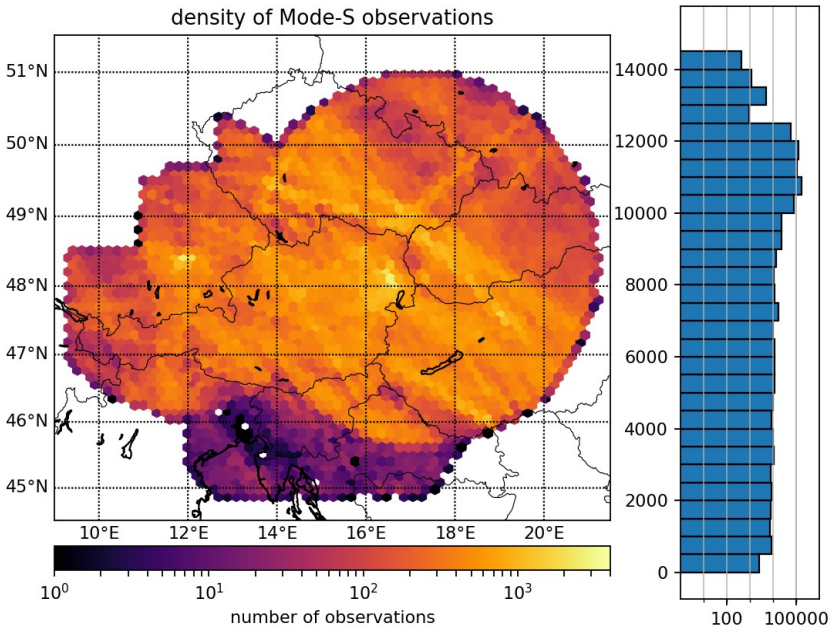
- Data quality based on profiles of OMG in comparison with AMDAR and Slovenian Mode-S MRAR was also investigated.
- Mode-S EHS (provided by KNMI) has high quality and it is true for indirect temperature observations as well.



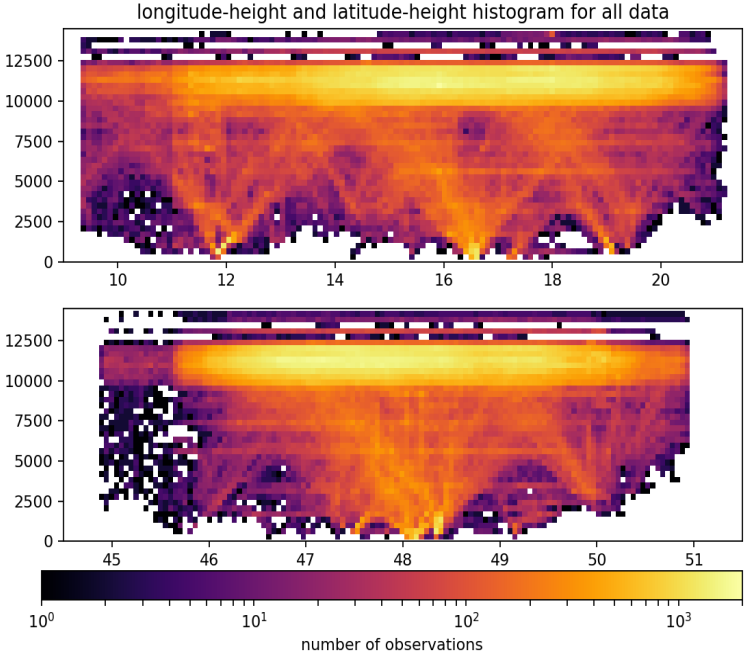
Profiles of OMG departures for temperature and wind speed

The use of aircraft-derived data

- Another study has been started with Austrian Mode-S EHS data.
- The aim is to perform high resolution AROME simulations and data assimilation specifically for a small domain over Vienna airport.



Horizontal distribution of Mode-S EHS and number of observations



Vertical distribution of Mode-S EHS

Outlook and future plans

- Finish TAC2TDCF migration
- Hourly updated 3D-Var DA systems with RADAR and Mode-S observations
- The use of EKF for surface operational assimilation (based on a stable and maintainable version)
- Advanced use of EDA information (cooperation with LACE Predictability group, LAEF EDA, LACE EDA)
- Continue the work with GNSS products
- Coupled ocean and atmospheric DA system

Thank You for your attention!
Questions?