Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
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LACE operational applications ALADIN-LAEF and OPLACE

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Aire Limitée Adaptation dynamique Développement InterNational - Limited Area Ensemble Forecasting (ALADIN-LAEF)

- meso-scale ensemble system ALADIN-LAEF
- based on the limited area model ALADIN
- developed in frame of RC LACE cooperation,
- focusing on short range probabilistic forecast
- profiting from advanced multi-scale ALARO physics.
- provide forecast on daily basis for the national weather services of RC LACE partners
- applied to hydrology, energy industry and even in the nowcasting.

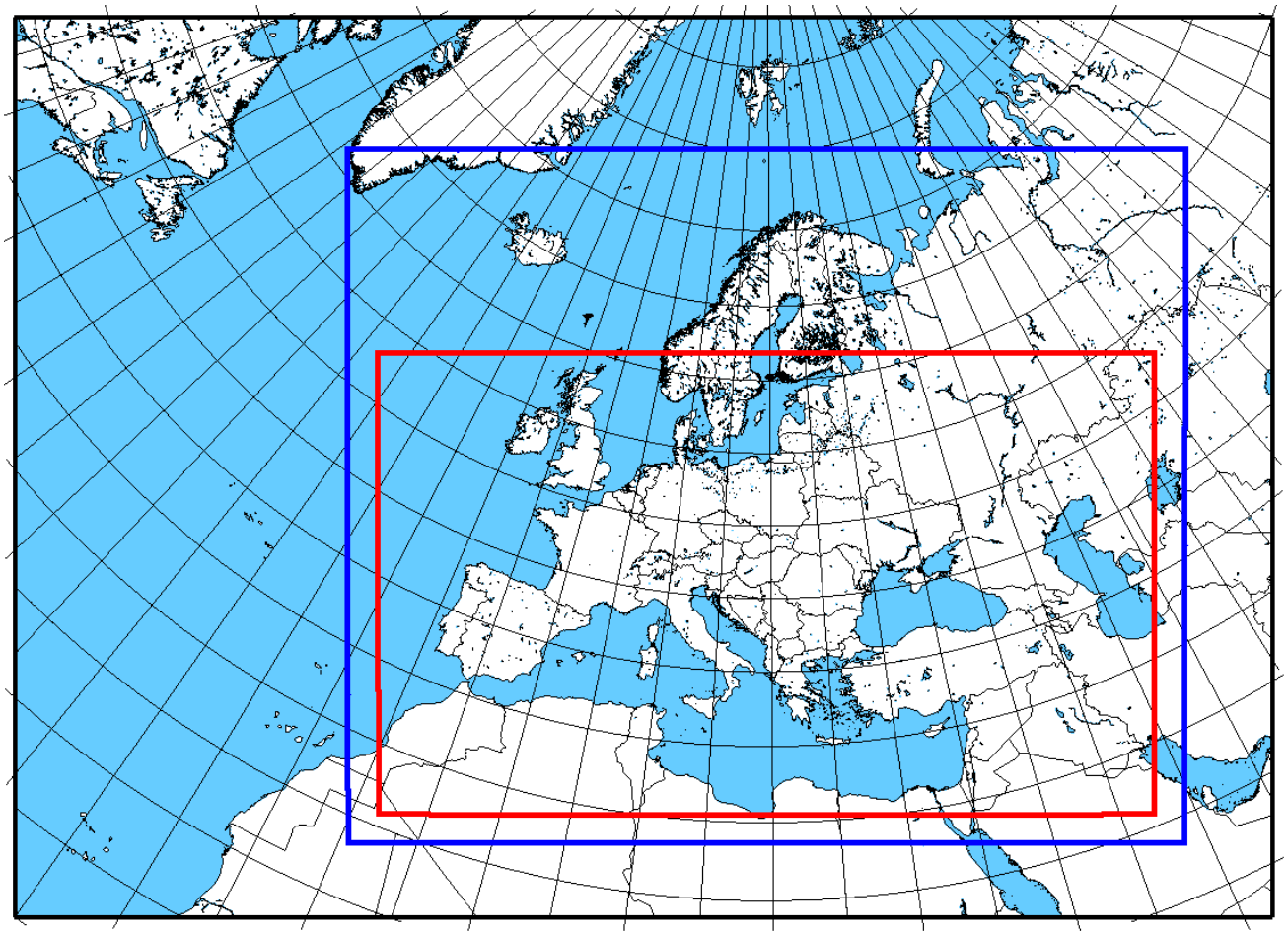
- operational in 2011, horizontal resolution of 18 km and 37 vertical levels, running in ECMWF.

- in 2013 the first substantial upgrade:

  - the increase of horizontal and vertical resolutions to 11 km and 45 vertical levels,
  - larger computational domain and
  - new ensemble of surface data assimilations involving perturbed screen-level conventional observations.

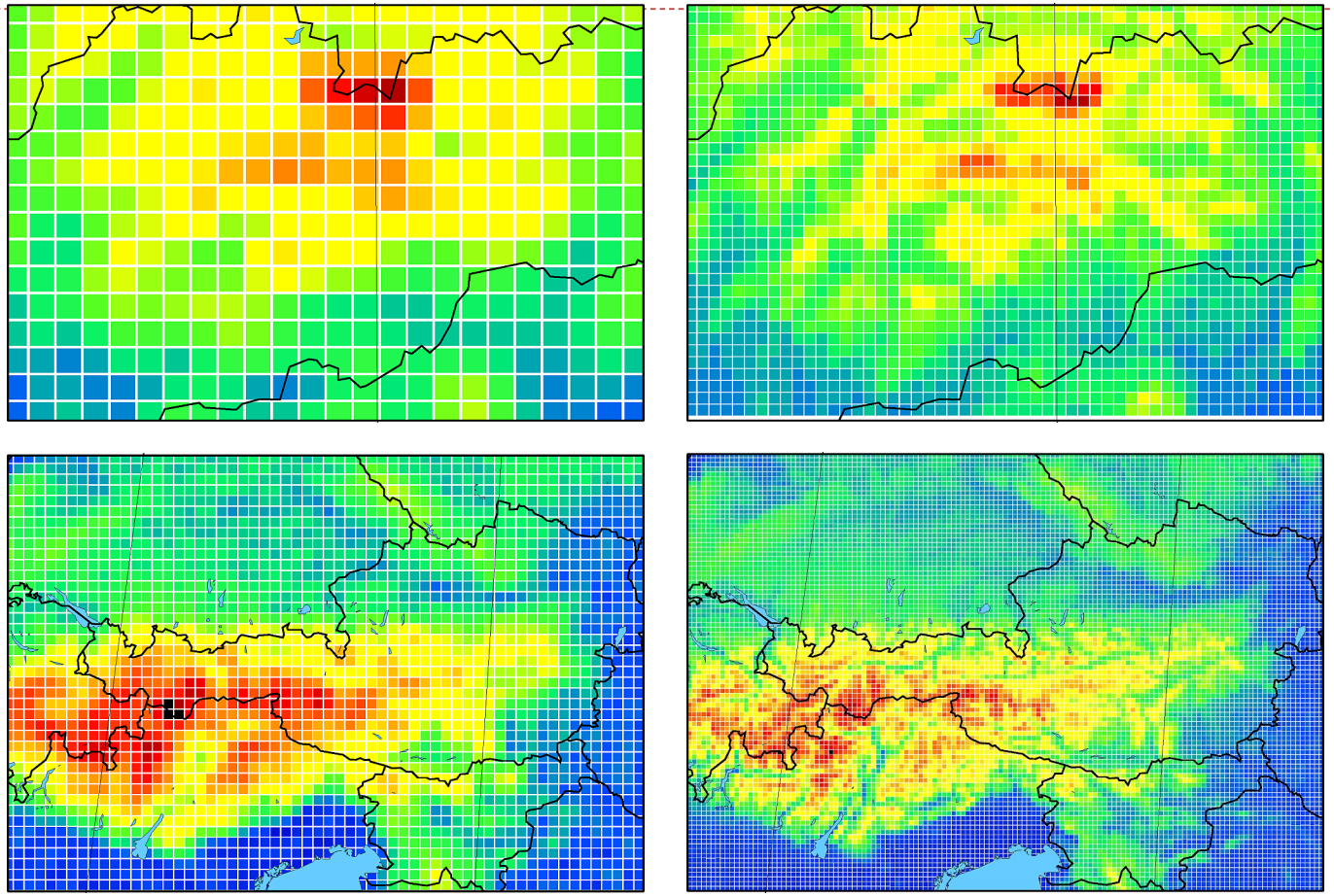
- now going towards 5 km / 60 levels and implementing several other upgrades.

Computational domains



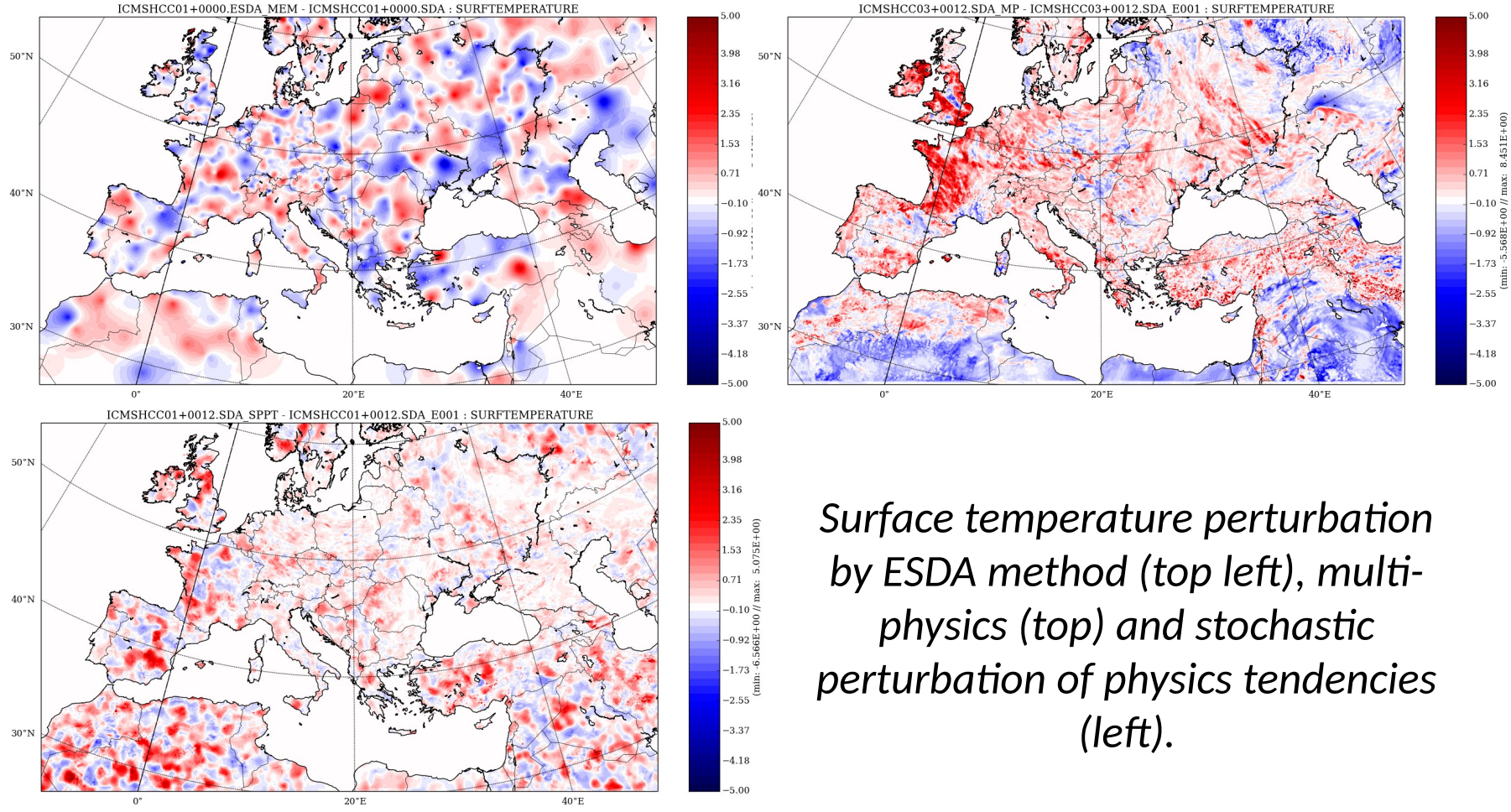
Current ALADIN-LAEF domain (blue) and upcoming domain after upgrade to 5 km horizontal resolution (red).

Model topography



Model orography for current 11 km grid (left) and new 5 km resolution (right). Tatra mountains in northern part of Slovakia (first row) and Austrian Alps (second row).

Surface temperature perturbations

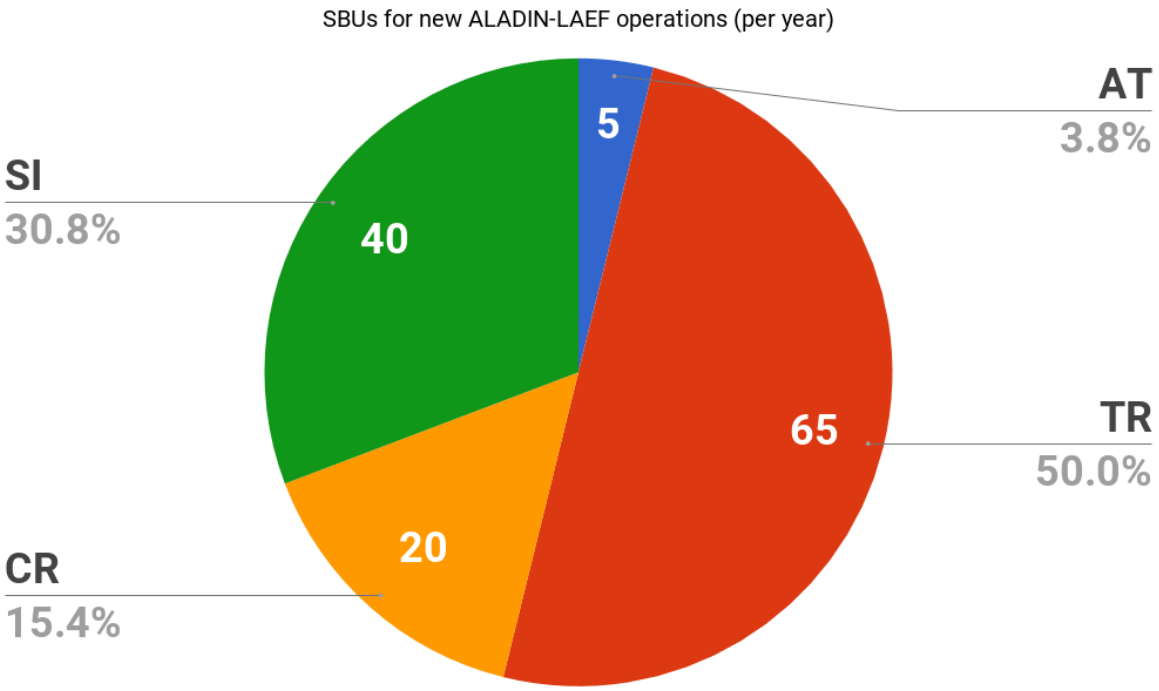


Surface temperature perturbation by ESDA method (top left), multi-physics (top) and stochastic perturbation of physics tendencies (left).

ALADIN-LAEF system specifications for current and new version

ALADIN-LAEF	current	new
Code version	cy36t1	cy40t1
Horizontal resolution	10,9 km	4,8 km
Vertical levels	45	60
Number of grid points	500x600	750x1250
Grid	quadratic	linear
Time step	450 s	180 s
Forecast length	72 h (00/12 UTC)	72 h (00/12 UTC)
Members	16+1	16+1
IC perturbation	ESDA [surface], breeding-blending [upper-air]	ESDA [surface], blending (Phase I) / ENS BlendVar (Phase II) [upper-air]
Model perturbation	ALARO-0 multi-physics	ALARO-1 multi-physics + surface SPPT
LBC perturbation	ECMWF ENS	ECMWF ENS
SBUs consumed per year	~10 mil	~120 mil

SBU costs division between Austria, Turkey, Slovenia and Croatia



The scripting system of new ALADIN-LAEF Phase I configuration

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ESDA

Slide 1

$$\Delta T_s = \Delta T_{2m} \qquad \Delta W_s = \alpha_s^T \Delta T_{2m} + \alpha_s^H \Delta H_{2m}$$

$$\Delta T_p = \frac{1}{2\pi} \Delta T_{2m} \qquad \Delta W_p = \alpha_p^T \Delta T_{2m} + \alpha_p^H \Delta H_{2m}$$

BLENDING

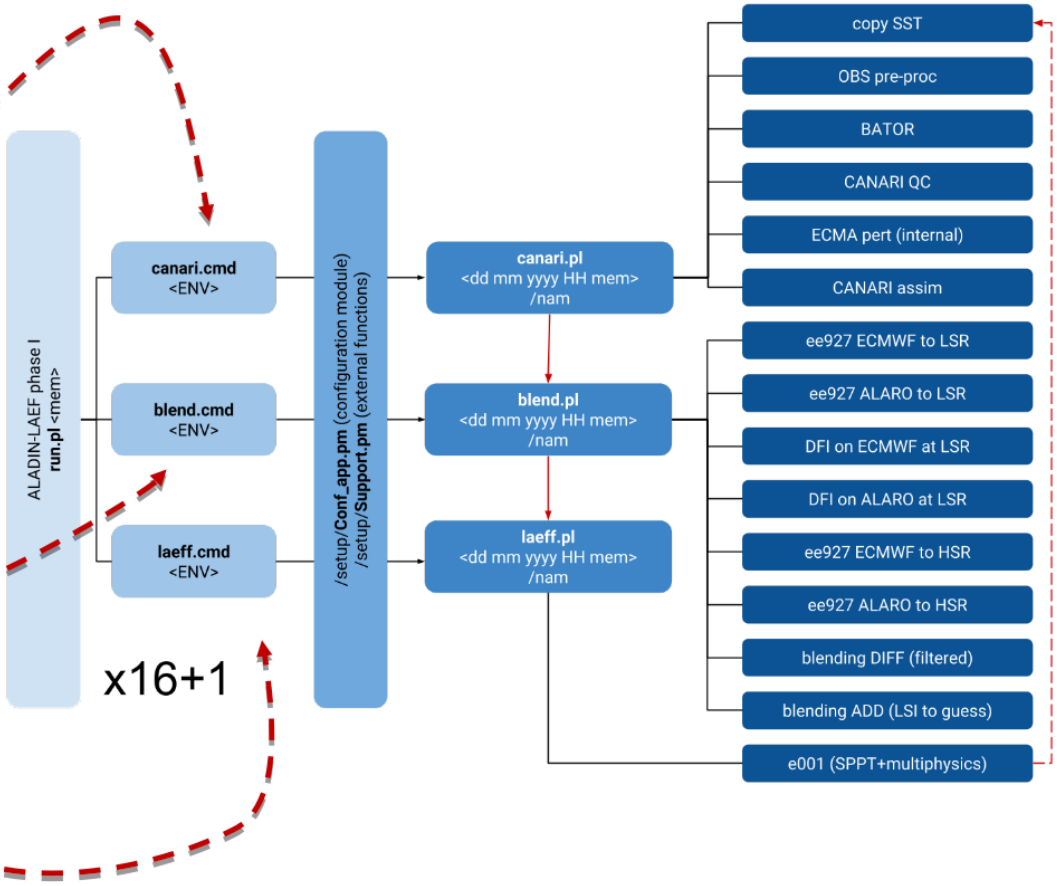
$$IC^n_{blend} = a^n_{breed} + \{ \overline{(a^n_{sv})_{trunc}} - \overline{(a^n_{breed})_{trunc}} \}$$

$$IC^n_{blend} = LS^n + a^n_{breed}$$

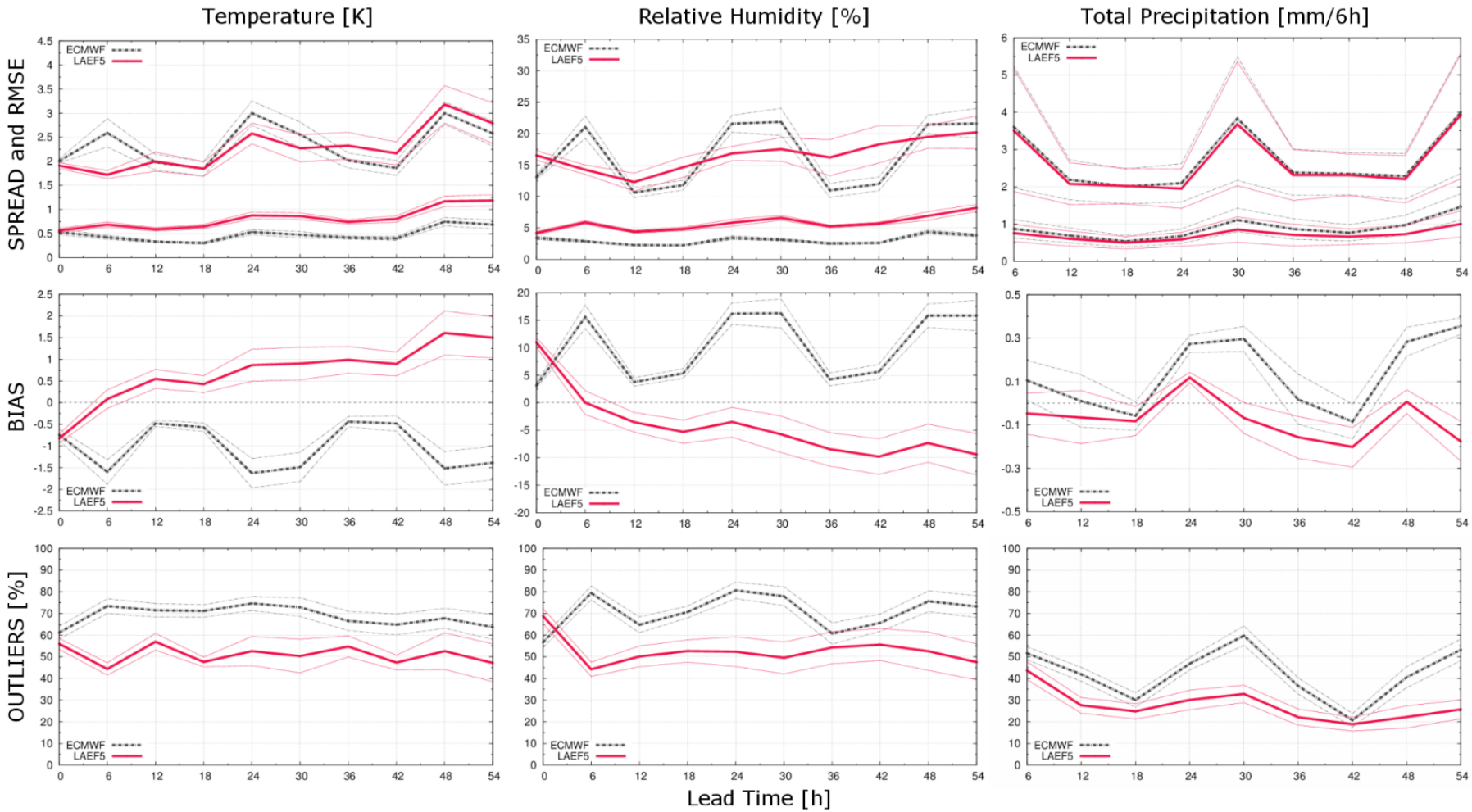
SPPT+MP

$$\frac{\partial e_j}{\partial t} = A(e_j, t) + P'(e_j, t)$$

$$P'_j(e_j, t) = (1 + r_j(\lambda, \varphi, t)_{D,T}) P_j(e_j, t)$$



ALADIN LAEF scores



Scores of screen level temperature, relative humidity and 6-hourly total precipitation versus forecast lead time, calculated against SYNOP observations for ECMWF ENS downscaling (black) and new ALADIN-LAEF Phase I (red). Thin lines denote 10% and 90% confidence intervals.

Conclusions and summary

The ALADIN-LAEF system runs operationally on HPCF at ECMWF twice a day with the integration starting at 00 and 12 UTC going up to 72 hours.

The ensemble consists of 1 unperturbed control run and 16 perturbed members involving:

- initial condition (IC) uncertainty,
- model error simulation and
- coupling to perturbed lateral boundary conditions rendered by ECMWF ENS.

Published papers

Bellus, M., Y. Wang, F. Meier, 2016: Perturbing surface initial conditions in a regional ensemble prediction system. Mon. Wea. Rev. 144: 3377-3390.

Wang, Y., M. Bellus, C. Wittmann, M. Steinheimer, F. Weidle, A. Kann, S. Ivatek-Šahdan, W. Tian, X. Ma, S. Tascu, and E. Bazile, 2011: The Central European limited-area ensemble forecasting system: ALADIN-LAEF. Quart. J. Roy. Meteor. Soc., 137, 483–502.

Wang, Y., M. Bellus, J. Geleyn, X. Ma, W. Tian, and F. Weidle, 2014: A new method for generating initial perturbations in regional ensemble prediction system: blending. Mon. Wea. Rev. 142: 2043-2059.

Wang, Y., A. Kann, M. Bellus, J. Pailleux, and C. Wittmann, 2010: A strategy for perturbing surface initial conditions in LAMEPS. Atmos. Sci. Lett., 11, 108–113.

Wang, Y., M. Bellus, G. Smet, F. Weidle, 2010b: Use of ECMWF EPS for ALADIN-LAEF. ECMWF Newsletter, 126, Winter 2010/2011, 18-22.

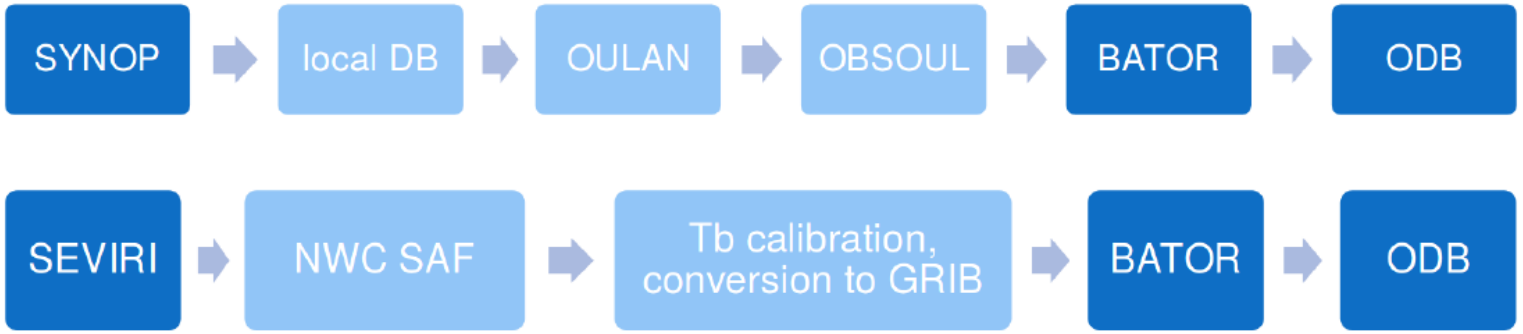
Derkova, M., M. Bellus, 2007: Various applications of the blending by digital filter technique in the ALADIN numerical weather prediction system, Meteorologicky casopis, 10, 27–36.

Wang, Y., M. Bellus, A. Ehrlich, M. Mile, N. Pristov, P. Smolikova, O. Spaniel, A. Trojakova, R. Brozkova, J. Cedilnik, D. Klaric, T. Kovacic, J. Masek, F. Meier, B. Szintai, S. Tascu, J. Vivoda, C. Wastl, Ch. Wittmann, 2017: 27 years of Regional Co-operation for Limited Area Modelling in Central Europe (RC LACE). Bulletin of the Am. Met. Soc., Vol. 99 Issue 7, 1415-1432.

What is OPLACE

A common observation preprocessing system (OPLACE).
- processed and quality checked meteorological observations in an appropriate format for data assimilation in NWP models.
- NMSs exchange their dense national surface synoptic measurements and high-resolution aircraft data in real-time.

OPLACE ensures stable and reliable bases for operational NMS purposes.



Preprocessing steps

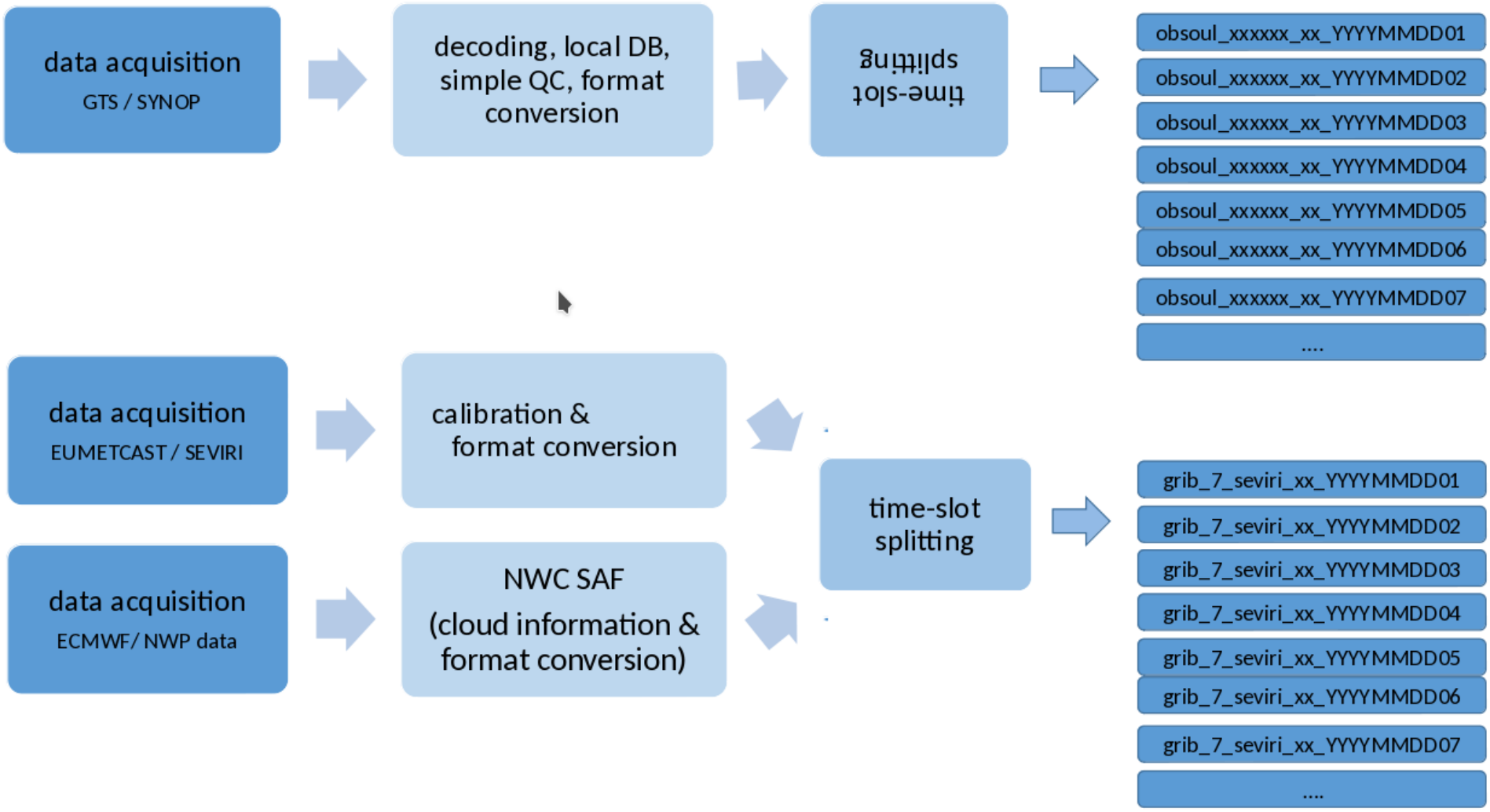


Illustration of observation preprocessing steps for synoptic data and SEVIRI radiances.

Observation types

Observations	Type/Sensor	Platform	Format
Surface synoptic	SYNOP, SHIP, BUOY		ASCII, BUFR
Aircraft	AMDAR, ACARS		BUFR
Upper-air sounding	TEMP, TEMP MOBIL		ASCII, BUFR
Wind profiler	EUROPROFILE		BUFR
Atmospheric motion vectors	GEOWIND, HRWIND	Meteosat 10/11	BUFR
Satellite radiances	SEVIRI AMSU-A/B, MHS, HIRS, IASI	Meteosat 10/11 NOAA 15/18/19 Metop-A/B,	GRIB BUFR
Ocean/sea winds	ASCAT	Metop-A/B	BUFR

Overview of observations types, sensors and data formats available in OPLACE.

OPLACE – national data

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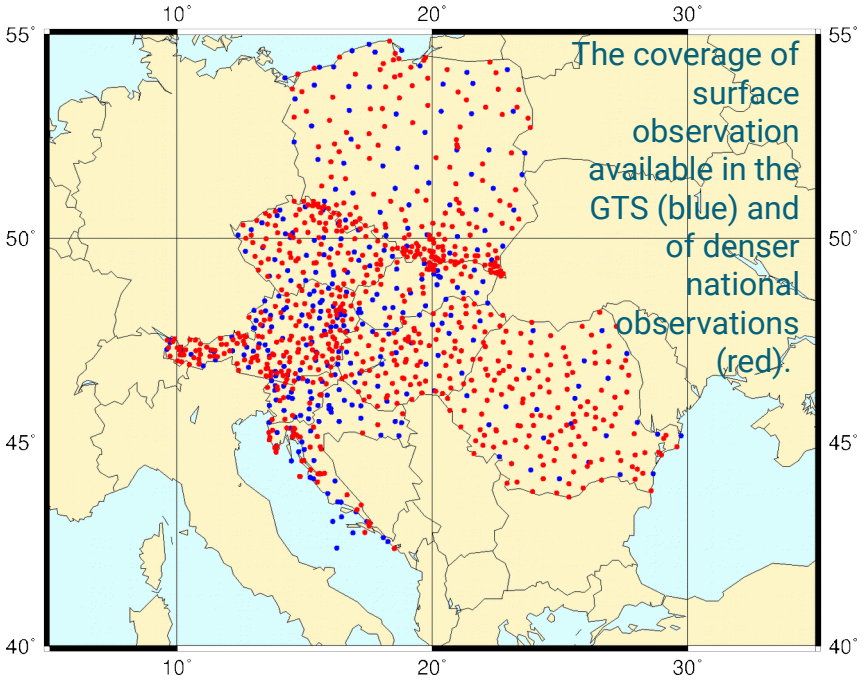
OPLACE national data exchange and access

• high resolution surface synoptic data exchange

• **OPLACE access for non-LACE countries**

- currently two non-LACE users (Tunisia, Poland)

Number of national stations		Update WRT 2017
Austria	169	-0/+0
Croatia	21	-0/+0
Czech Republic	60	-30/+0
Hungary	93	-2/+3
Romania	134	-0/+0
Slovakia	47	-0/+1
Slovenia	17	-0/+0
Poland	186	-0/+186
Total:	727	



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OPLACE - developments

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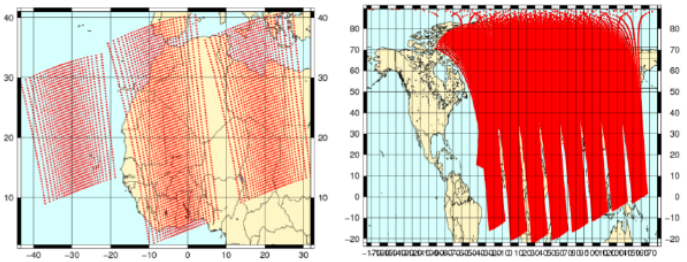
- **ATOVS data handling corrections for Metop-A**
  - lack of data fixed in February 2018



- **new EUMETSAT prime spacecraft Meteosat-11 (MSG-4) since 20 February 2018**
  - parallel data provision from Meteosat-10/11 till 6 March 2018
  - information and guidelines provided on the RC LACE Forum

    http://www.rclace.eu/forum/viewtopic.php?f=37&t=130&start=140#p1959
- **coastal winds observations over the oceans from Advanced SCATterometer (ASCAT)**
  - new observations (12.5km resolution) implemented in 26 March 2018
  - validated in collaboration with Benedikt Strajnar
- **corrections for TEMP data processing**
  - workaround to avoid BATOR crash due to too many levels
  - adaptation to merge as much BUFR & ASCII as possible

OPLACE

Operational

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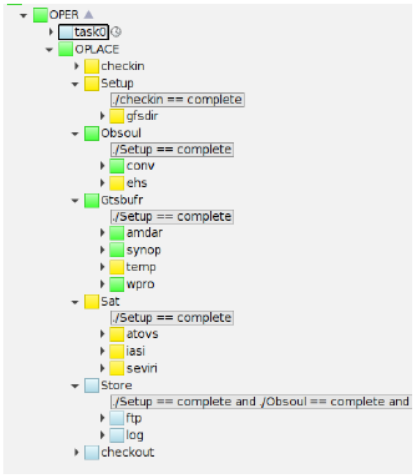
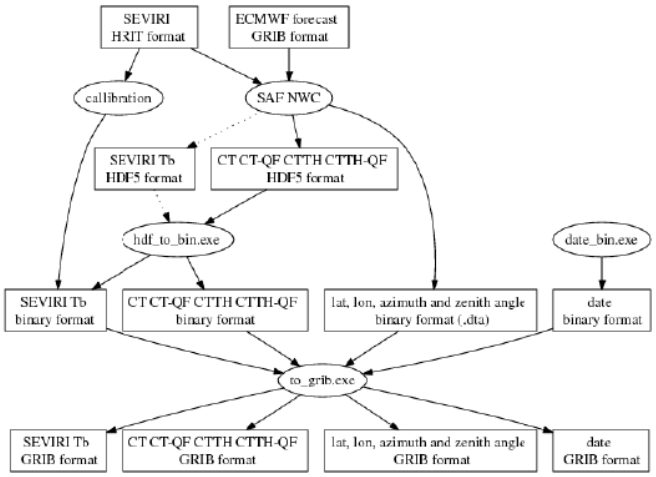
- **redesign of the OPLACE scripts**
  - more and more data is processed
  - complexity of the system is growing
  - aim is to improve the operations
    - - parallelization using ecFlow scheduler
    - - more robust to avoid data issues
    - - easier monitoring & supervision





- **technical upgrade for SEVIRI**
  - GRIB format to be replaced by netCDF
  - more simple product generation (using python, javac)
  - easier porting & more flexible for testing new NWC SAF versions
  - courtesy of CMS Lanion

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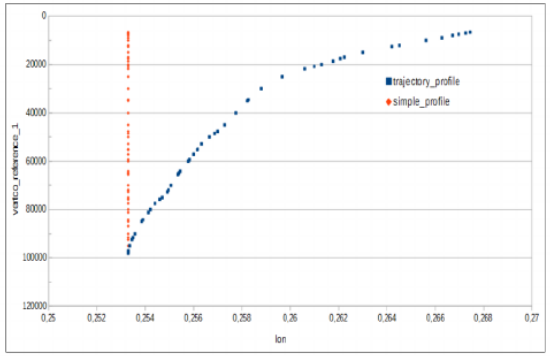
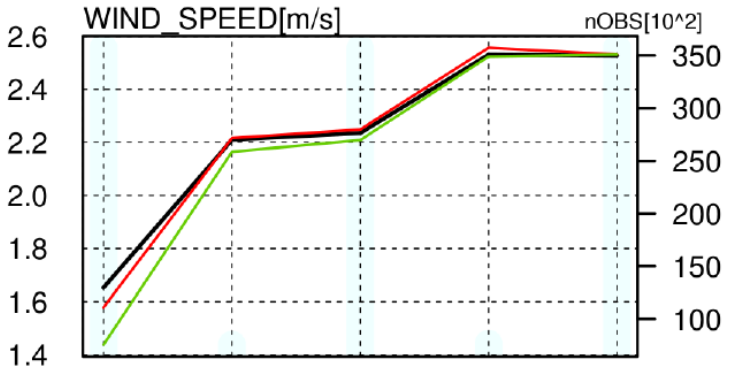
- **TAC2BUFR migration**
  - first prototype of BUFR SYNOP & AMDAR data processing in OPLACE test suite
  - further testing & the redesign is needed before operational implementation to avoid delays in OPLACE data provision

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





- **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

OPLACE - ModeS

OPLACE national data exchange and access

• high resolution aircraft data exchange from modern air surveillance systems
- Mode-S MRAR from ARSO/Slovenia
- Mode-S EHS from KNMI/Netherlands
- stable and reliable data provision

• extension by Mode-S MRAR from the Czech Republic - ongoing

• Mode-S EHS from Slovenia and the Czech Republic - ongoing

• negotiation with KNMI about processing our data started (B. Strajnar)

• All Members explore availability of Mode-S data.

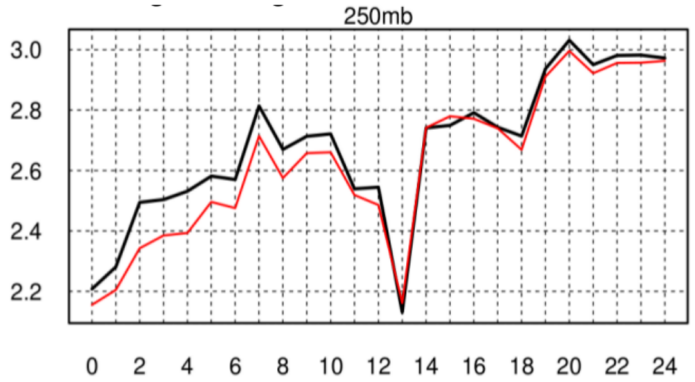
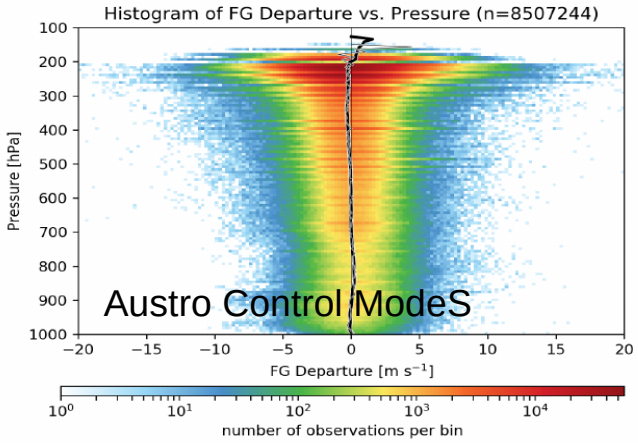
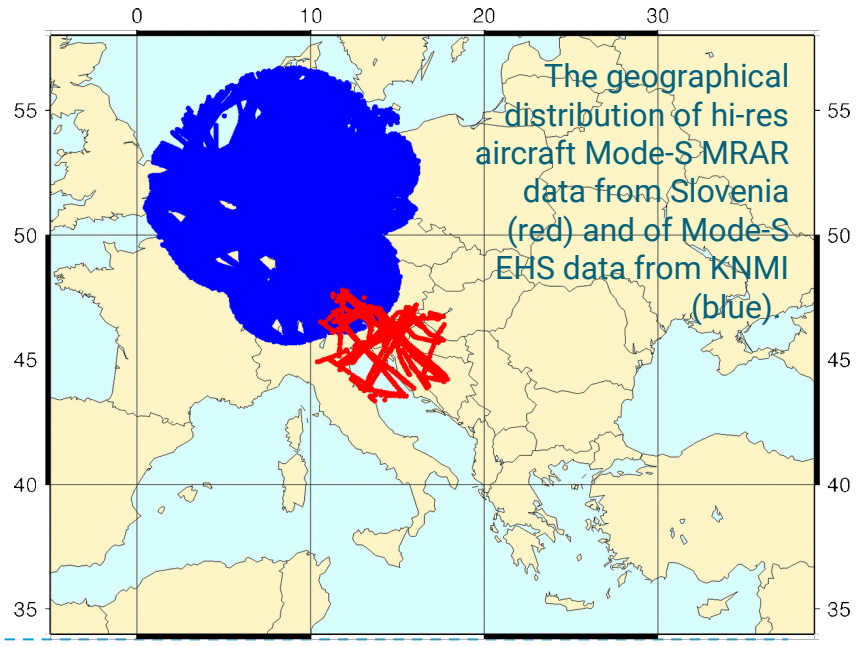


Figure 1: Time evolution of **RMSE for wind speed at 250hPa** verified against aircraft observations for period of 11 Jan – 9 Feb 2017 12UTC. **Reference** and Mode-S EHS experiment.





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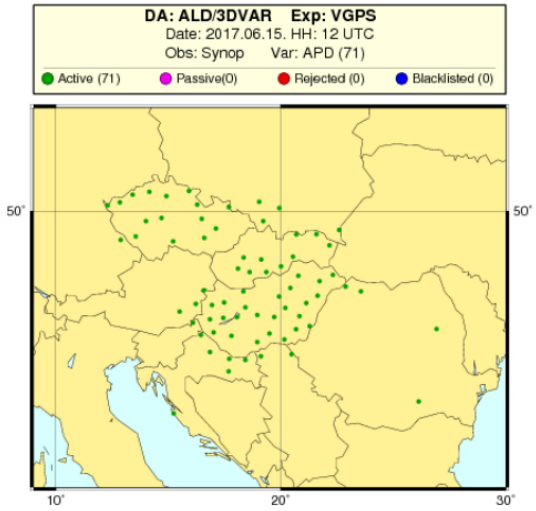
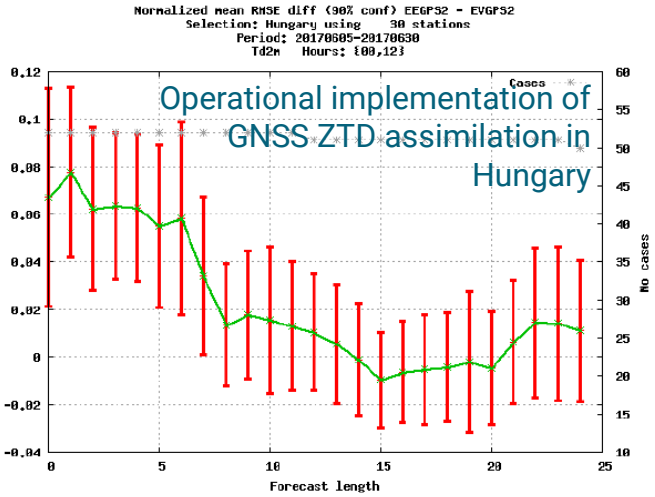
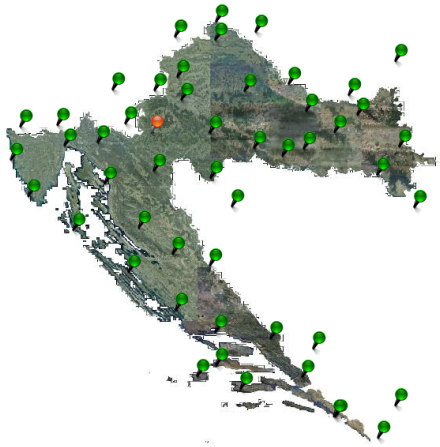
GNSS data





Operational implementation of GNSS ZTD assimilation in Hungary



- **Priorities for 2019:**
  - **scripts redesign to improve OPLACE operations**
  - **TAC2BUFR migration**
  - **review wind profiler processing**
  - **explore an extension by GNSS**
  - **any other observations ???**
  - **observation monitoring**