Numerical Weather Prediction at Czech Hydrometerological Institute

40th EWGLAM & 25th SRNWP EUMETNET Meetings, 1 - 4 October 2018, Salzburg, Austria

NWP system

ALADIN/CHMI couples hydrostatic dynamics and the set of ALARO-1 physical parameterizations suited for modeling of atmospheric motions from planetary up to the meso-gamma scales:

- domain 529x421 grid points, Δx~4.7km
- linear truncation E269x215
- 87 vertical levels, mean orography
- time step 180 s
- 3h coupling interval
- 00, 06, 12/18 UTC forecast to +72/54h
- hourly analysis system VarCan Pack
- **ALADIN cycle 43t2_op2 (ALARO-1vB)**

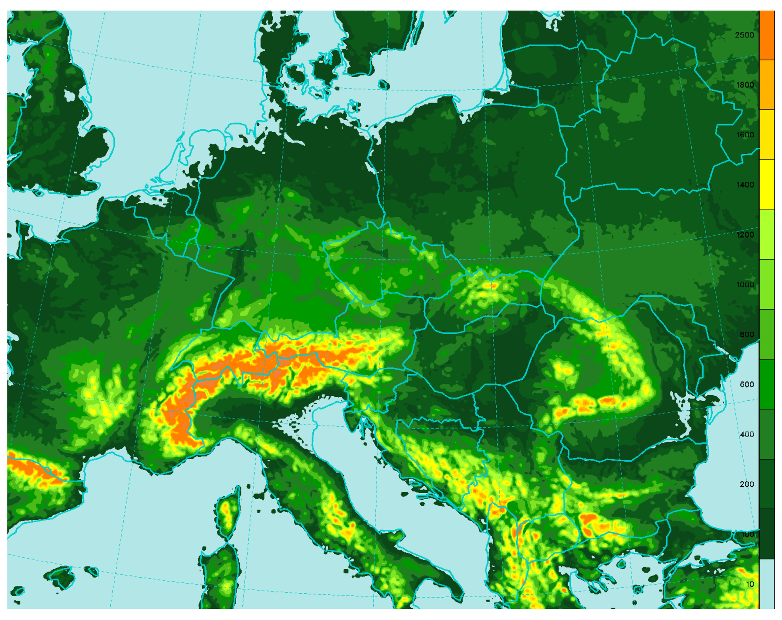

Figure 1: Orography of model domain

Data assimilation includes surface analysis based on an optimal interpolation (OI) and **BlendVar** analysis for upper air fields, which consists of the digital filter spectral blending (Brozkova et al., 2001) followed by 3DVAR analysis based on the incremental formulation originally introduced in the ARPEGE/IFS global assimilation (Courtier et al., 1994, doi: 10.1002/qj.49712051912).

- digital filtering at truncation E87x69; space consistent coupling
- no DFI in long cut-off 6h cycle; incremental DFI in short cut-off production analysis

New HPC system operational since January 2018

- **NEC LX series** HPC cluster
- 320 computing nodes connected through high-speed Mellanox EDR InfiniBand
- each node consists of two **Intel Broadwell** CPU (12 cores, 64GB RAM)
- **7680 computational cores** in total
- operating system is CentosOS 7.2 Linux OS
- more than 1 Petabyte of storage capacity based on Luster technology with bandwidth performance of more than 30 GB/s
- SLURM scheduler
- Intel Parallel Studio XE Cluster Edition

Improved treatment of surface roughness in the ISBA scheme

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In ARPEGE/ALADIN, the 2 layer ISBA surface scheme is available either directly, or via inline SURFEX. Direct use of ISBA is restricted to old physiography handled by configuration e923, while ISBA embedded in SURFEX benefits from new physiography (GMTED2010, ECOCLIMAP, etc.) and can be combined with more advanced treatment of snow, lakes, etc. It is therefore desirable to switch ALARO physics to SURFEX. In order to do that consistently, compatibility of the two ISBA implementations must be checked.

As the first step, SURFEX treatment of thermal roughness was tested in ALARO-1 using ISBA directly (Figure 1). Climate files had to be re-created via configuration e923 employing option LZ0THER=F (thermal roughness without the orographic component), using the recommended retuning of FACZ0 and NLISSZ (scaling factor and smoothing applied on the orographic roughness). However, enhanced orographic component of the dynamical roughness resulted in reduced 10m wind speed (yellow). After combining option LZ0THER=F with the original tuning of orographic roughness (light green), bias of 10m wind speed returned to its original level (red).

Tested ALARO-1 configurations using ISBA scheme directly	e923			e001
	LZ0THER	FACZ0	NLISSZ	LZ0HSREL
reference configuration	T	0.53	3	F
recommended e923 setting for LZ0THER=F decelerated 10m wind speed	F	1.00	1	T
revised e923 setting for LZ0THER=F bias of 10m wind back to original level	F	0.53	3	T
target configuration with fixed ISBA code reduced bias of 10m wind speed and T2m	F	0.53	3	T

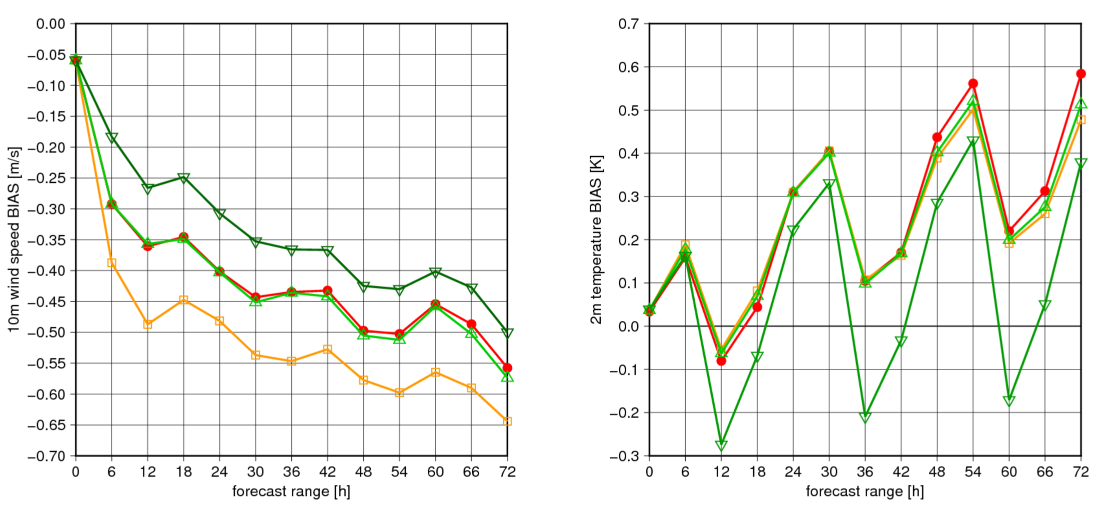


Figure 1: Bias of 10m wind speed (left) and 2m temperature (right) during period 14-19 January 2017 (ALARO-1 00UTC runs, dynamical adaptation).

Inspection of ISBA code outside SURFEX revealed several problems related to snow. The most serious one was a missing orographic component in dynamical roughness of snow, partially compensated by using separate snow fractions for computing average gridbox albedo and roughness. After applying the fixes and necessary retunings, bias reduction for both 2m temperature and 10m wind speed was achieved in winter (dark green). Impact on other scores and in summer is neutral.

The target configuration is planned for operational use at CHMI. The code inspection on SURFEX side will be more demanding and it is planned for later.

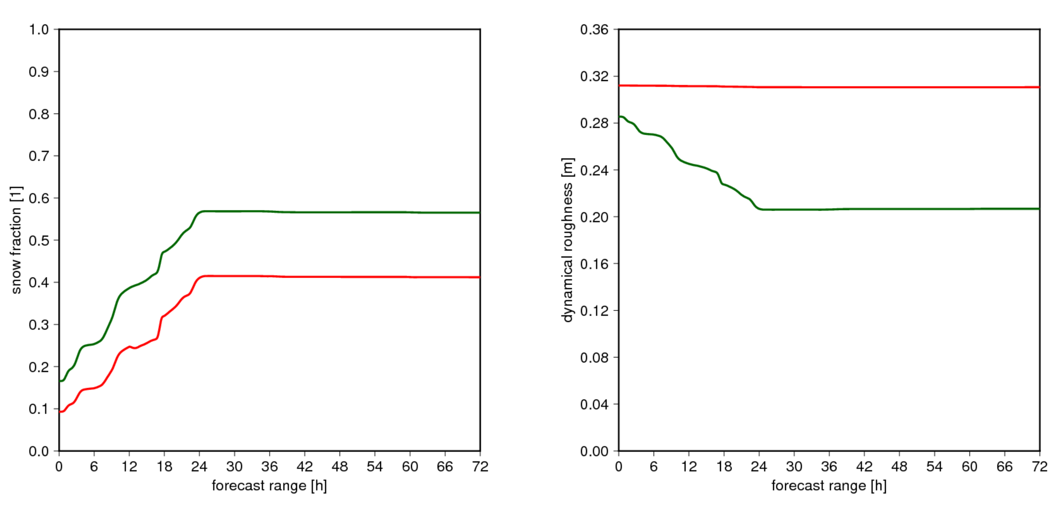


Figure 2: Point evolution of snow fraction (left) and effective dynamical roughness (right) in Prague (ALARO-1 runs from 16 January 2017 00UTC).

Major operational changes

9 Jan 2018 - operational switch to the new HPC system

10 Jun 2018 - extended data assimilation of high-resolution aircraft observations by Mode-S EHS & modified computation of the shallow convection (see description below)

21 Aug 2018 - implementation of the new model release - cy43t2

Data assimilation of aircraft observations (AMDAR and local Mode-S MRAR from the Czech Republic) was extended by high resolution aircraft **Mode-S EHS** observations from KNMI covering airspace of Germany, Belgium and the Netherlands.

- observations obtained from air traffic surveillance systems (Mode-S radars) (de Haan, 2011, doi:10.1029/2010JD015264)
- quality assessment w.r.t NWP showed Mode-S EHS data to be comparable with AMDAR observations:
  - good BIAS and STD for wind
  - good BIAS, but higher STD for temperature

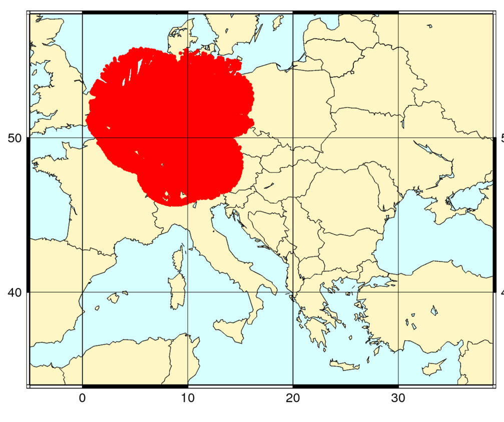
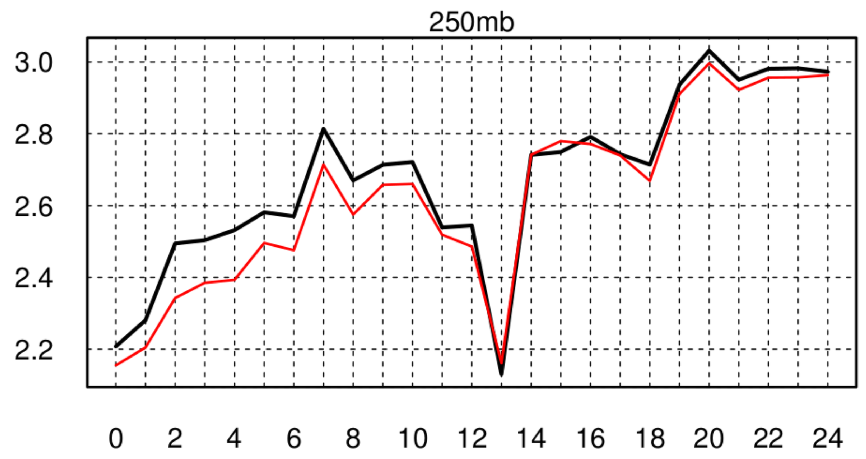


Figure 1: Geographical coverage of Mode-S EHS from KNMI.



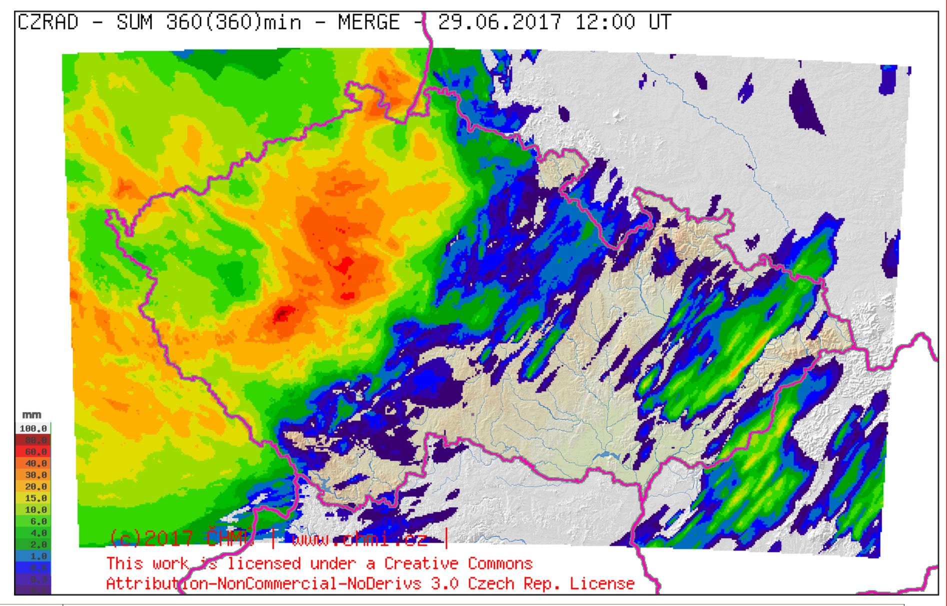
Positive impact was found up to the first (<10h) hours of forecast (reduction of RMSE and BIAS of upper level wind and temperature).

Figure 2: 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.

The **computation of moist buoyancy term in TOUCANS** was improved. The intensity of turbulent transport is highly influenced by phase changes of water, causing fluctuations of density due to latent heat release/consumption. Recently the so-called mass flux based computation was introduced in ALARO-1, leading to a direct estimation of moist Brunt Vaisala Frequency and of the related moist buoyancy term instead of using a modified moist Richardson number.

Here we further improve the scheme to compute buoyancy in the general case of partly saturated atmosphere. Namely we alleviate thresholds previously deciding on aborting the shallow cloud and we also introduce a proper handling of negative buoyancy.

Improved scheme enhances the lift of water from near surface layers higher up by the turbulent transport. Redistribution of water improves upper air scores of the model both in winter and summer. It also helps to get more realistic precipitation forecast, as shown on the extreme rainfall case from 29 Jun 2017 computed over Central Europe.



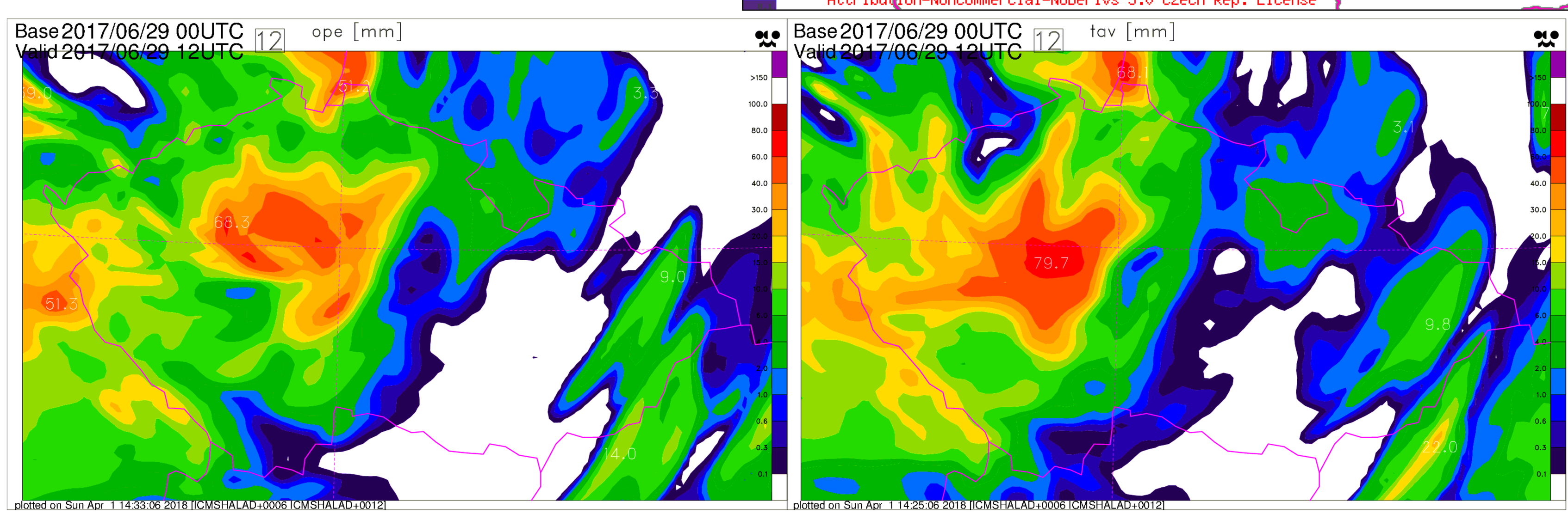


Figure 3: 6h precipitation forecast for 29 June 2017 00UTC for lead time of +12h for reference (left), the new scheme (right) and observations – radar and rain gauges based quantitative precipitation estimate (top).

High-resolution ALARO-NH experiments at 2.3km

Experimental **ALARO-NH** suite is under development for future operational use:

- domain 1069x853 grid points, Δx~2.325km
- linear truncation E539x431
- 87 vertical levels, mean orography
- ICI scheme with 1 iteration, time step 90 s (Benard, 2003, doi:10.1175/1520-0493(2003)131)

Moist deep convection scheme 3MT is still used at higher resolution. It's activity is reduced as shown on the lowered sub-grid (convective) condensation rate w.r.t. the 4.7km case (Figure 1).

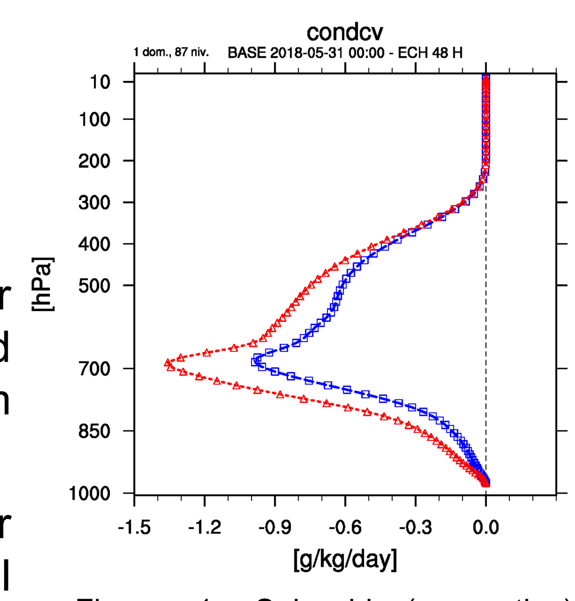


Figure 1: Sub-grid (convective) condensation rate. Reference experiment on 4.7km (red) and the test experiment on 2.3km (blue).

The first evaluation experiments employ only upper air digital filter spectral blending with ARPEGE global model and surface analysis for both the reference on 4.7km and the experimental suite at 2.3km. Scores are improved in general as shown on some examples:

- 6h precipitation sum bias gets reduced (Figure 2).
- RMSE of screen level temperature and surface geopotential are improved due to the higher resolution.

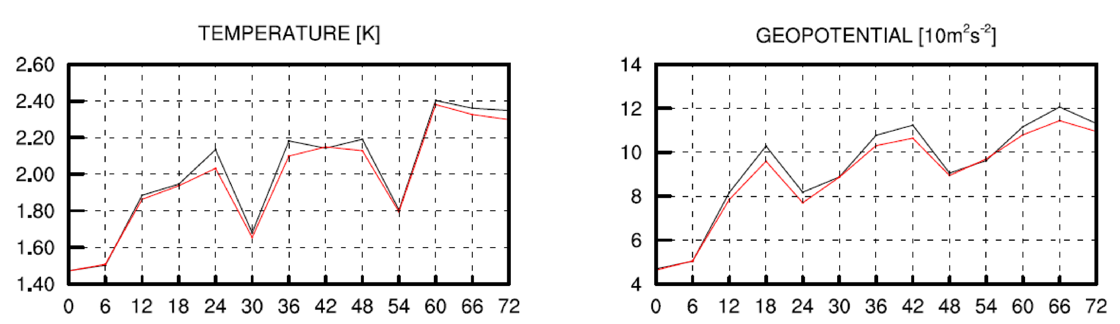


Figure 3: Time evolution of **RMSE for T2m and surface geopotential** for period of 23 – 31 May 2018. **Reference** (4.7km) and test experiment (2.3km).

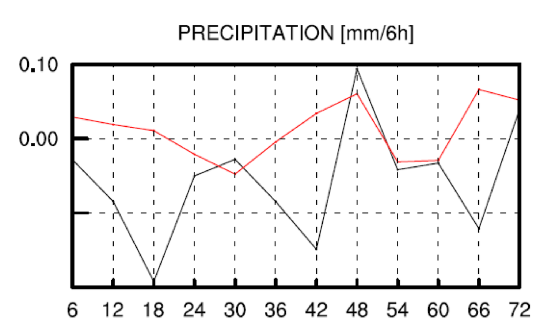


Figure 2: Time evolution of **6h precipitation BIAS** for period of 23 – 31 May 2018. **Reference** experiment (4.7km) and test experiment (2.3km).