Numerical Weather Prediction at Czech Hydrometerological Institute

Joint 28th ALADIN Workshop & HIRLAM All Staff Meeting 2018, 16 - 20 April 2018, Toulouse, France

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 38t1tr_op7 (ALARO-1vB)**

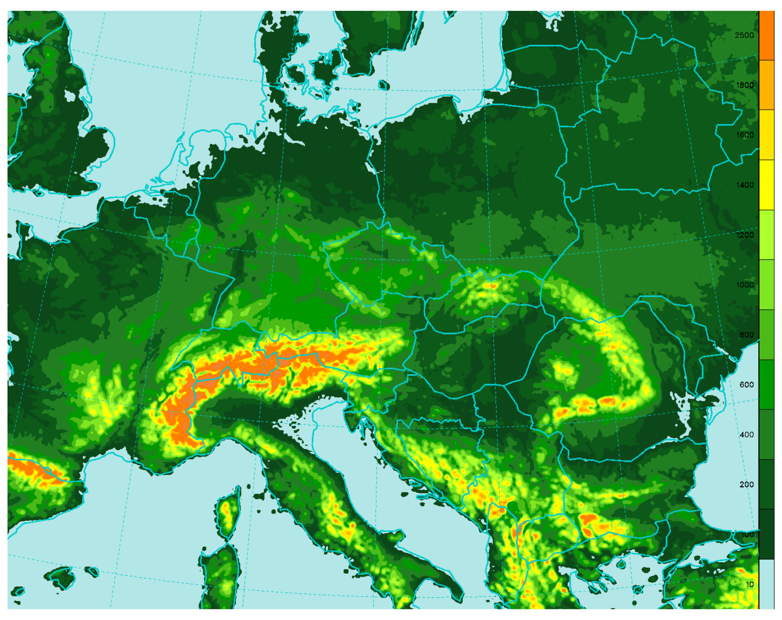


Figure 1: Orography of model domain

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

Major operational changes

20 Jun 2017 - implementation of local Mode-S MRAR data assimilation
- optimization of aircraft data assimilation
9 Jan 2018 - operational switch to the new HPC system

The high resolution aircraft **Mode-S MRAR** observations available in the airspace of the Czech Republic are implemented.

- observations obtained from air traffic surveillance systems (Mode-S radars) (Strajnar 2012, doi:10.1029/2012JD018315)
- quality of Mode-S MRAR data is similar to AMDAR
- positive impact was found in the nowcasting context and in the first hours of NWP forecast

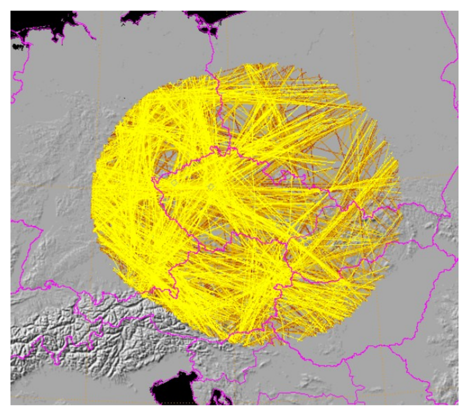


Figure 1: Geographical coverage.

Further overall **optimization of aircraft (MRAR & AMDAR) data assimilation** included:

- reduction of horizontal thinning distance from 50km to 25km
- increase of the vertical thinning to 15hPa
- inflation of observation errors by coefficient 2.8

The optimization brings slight positive impact in the first hours of forecast, see Figure 2:

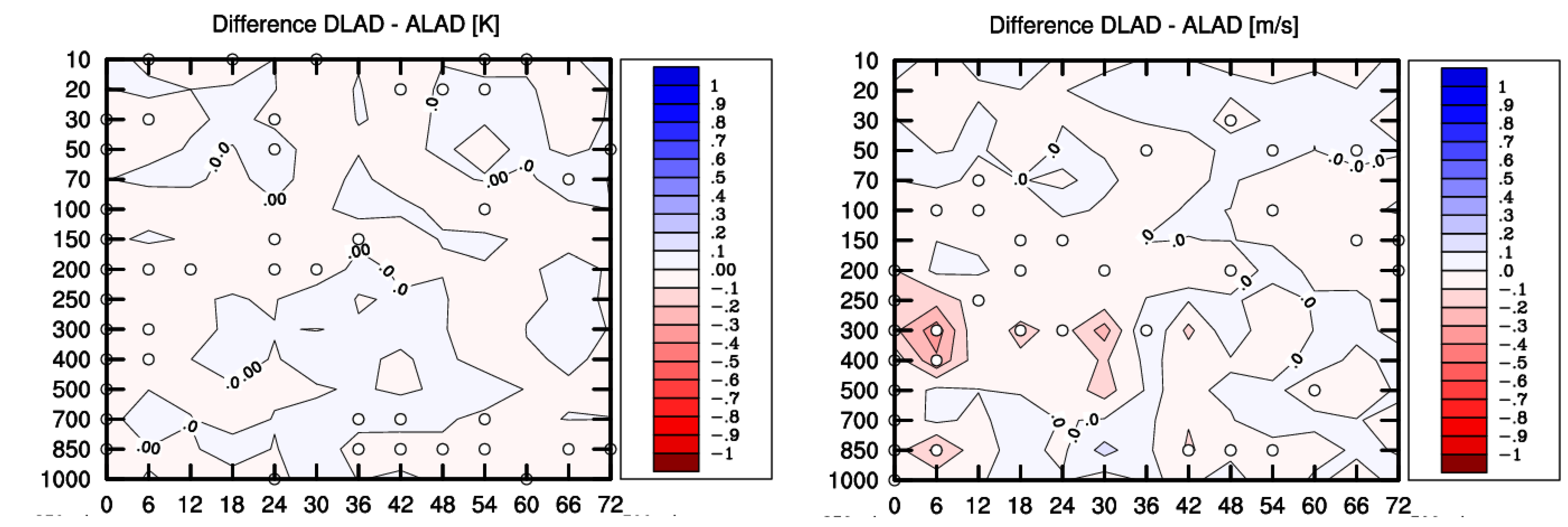


Figure 2: **RMSE differences of temperature** (left) and **wind speed** (right) for period of 11 May – 20 Jun 2017 12UTC. Red areas denote better performance of optimized aircraft data assimilation with respect to operational runs. The white circles point that RMSE difference is better/worse with significance 95% two-side confidence interval.

Improved treatment of surface roughness in the ISBA scheme

Radmila Brožková, Martin Dian, Ján Mašek

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

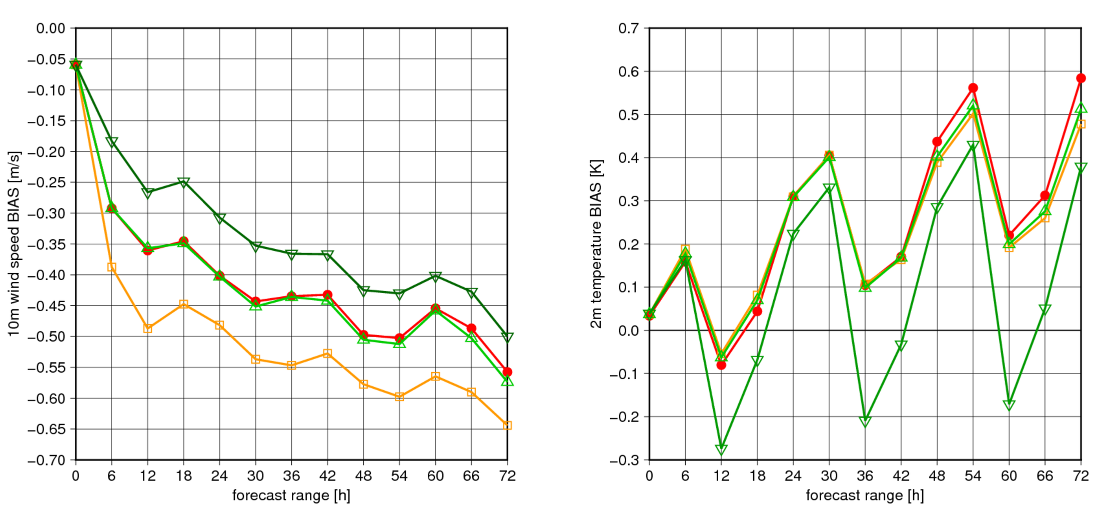


Figure 1: Bias of 10m wind speed (left) and 2m temperature (right) during period 14-19 January 2017 (ALARO-1 00UTC runs, dynamical adaptation).

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.

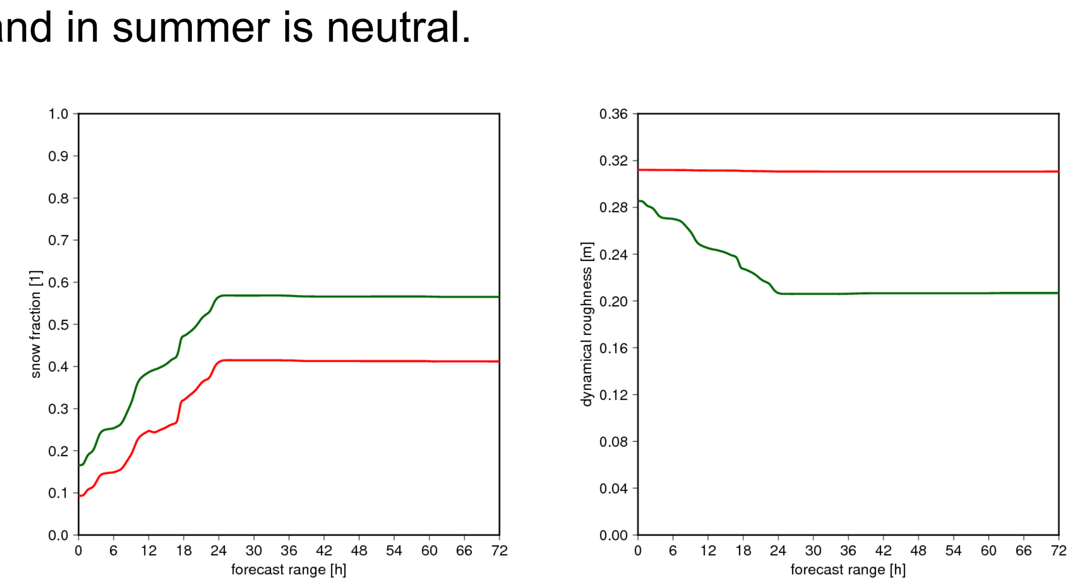


Figure 2: Point evolution of snow fraction (left) and effective dynamical roughness (right) in Prague (ALARO-1 runs from 16 January 2017 00UTC).

Data assimilation of Mode-S EHS aircraft observations

Benedikt Strajnar, Patrik Benáček, Alena Trojáková

High resolution aircraft Mode-S EHS observations from KNMI covering airspace of Germany, Belgium and the Netherlands are being investigated.

Quality assessment w.r.t. NWP showed EHS data to be comparable to AMDAR:

- good BIAS and STD for wind
- good BIAS, but a higher STD for temperature
- no need for quality pre-selection

Preliminary impact on NWP forecast :

- reduction of RMSE and BIAS of upper level wind and temperature in the first (<10h) hours of forecast

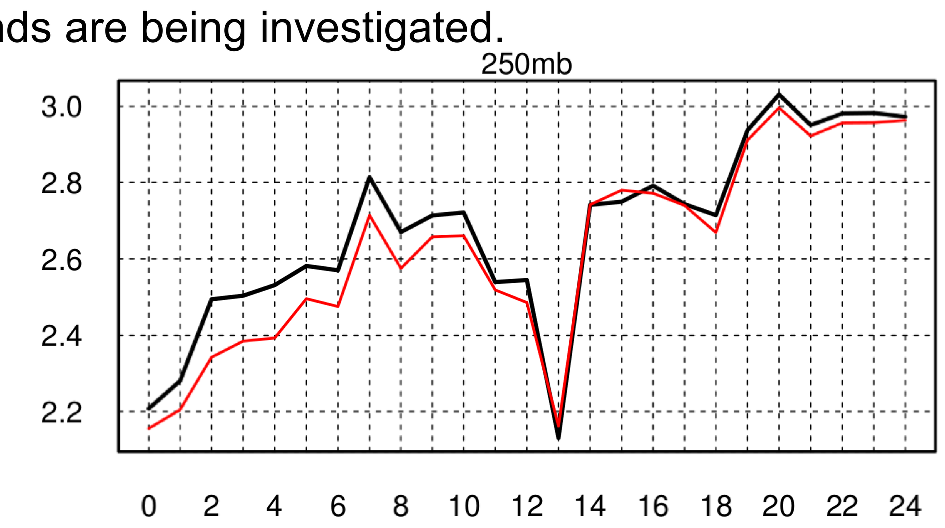


Figure 1: Time evolution of **RMSE for wind speed at 250hPa** verified against aircraft observations for period of 11 Jan – 9 Feb 2017 12UTC. **Reference** and Mode-S EHS experiment.

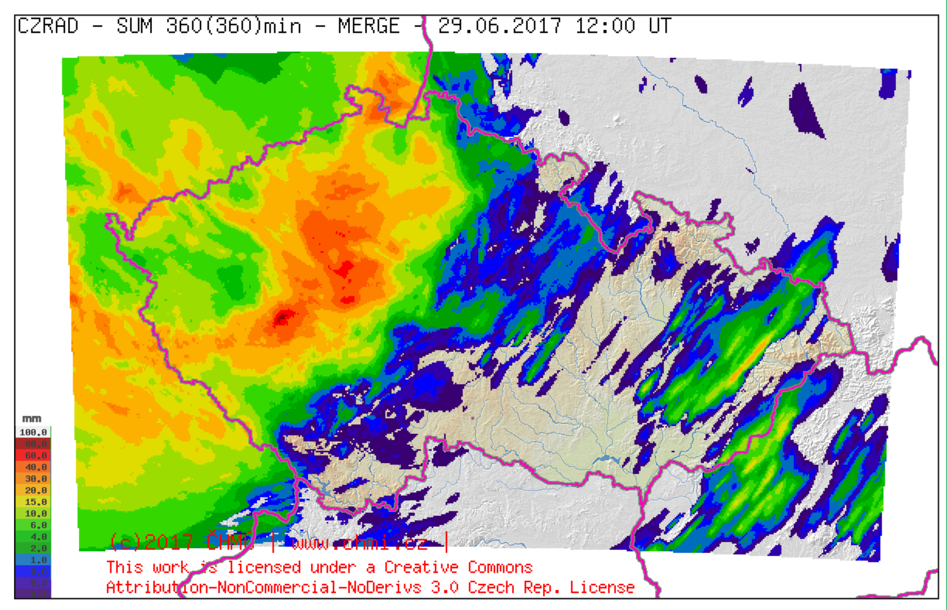
Further improvements of moist buoyancy term in TOUCANS

Radmila Brožková

The intensity of turbulent transport is highly influenced by phase changes of water, causing changes of density and energy 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.



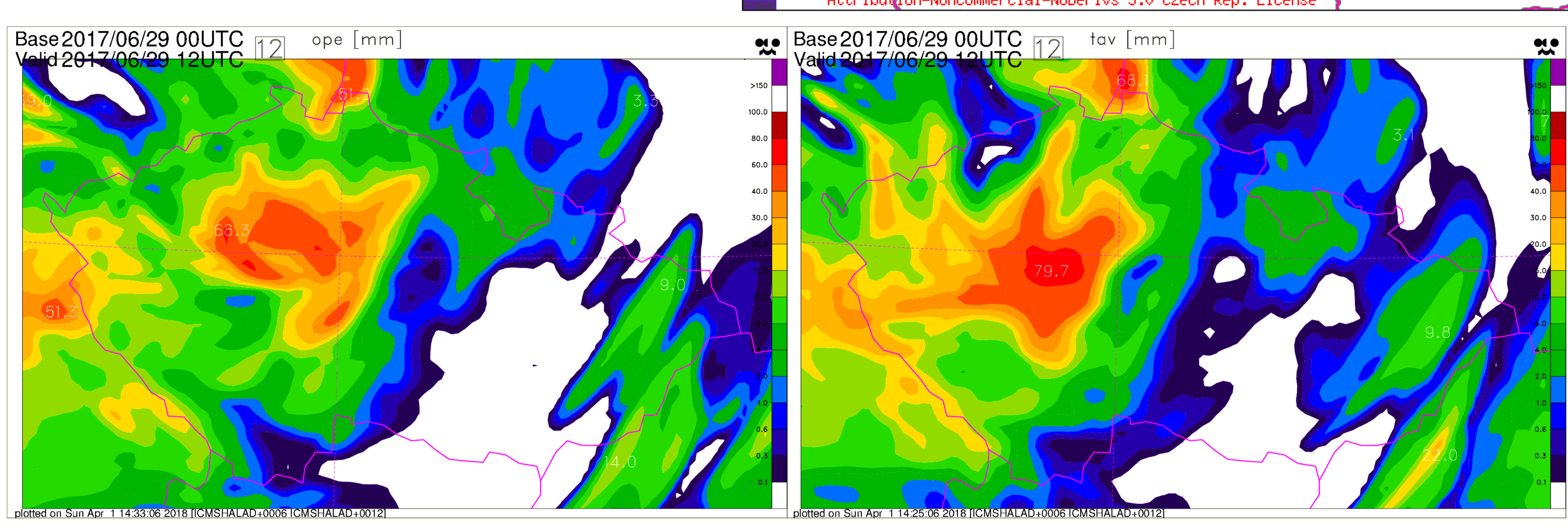


Figure 1: 6h precipitation forecast for 29 June 2017 00UTC for lead time of +12h for reference (left), the new scheme (right) and observations – radar and rain gauges based quantitative precipitation estimate (top).