Numerical Weather Prediction activities at CHMI

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NWP system

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

- domain 1069x853 grid points, Δx~2.3km
- linear truncation E539x431
- 87 vertical levels, mean orography
- ICI scheme with 1 iteration, time step 90 s
- 3h coupling interval
- 00, 06, 12, 18 UTC forecast to +72h
- hourly analysis system VarCan Pack
- ALADIN cycle 46t1as_op1 (ALARO-1vB)

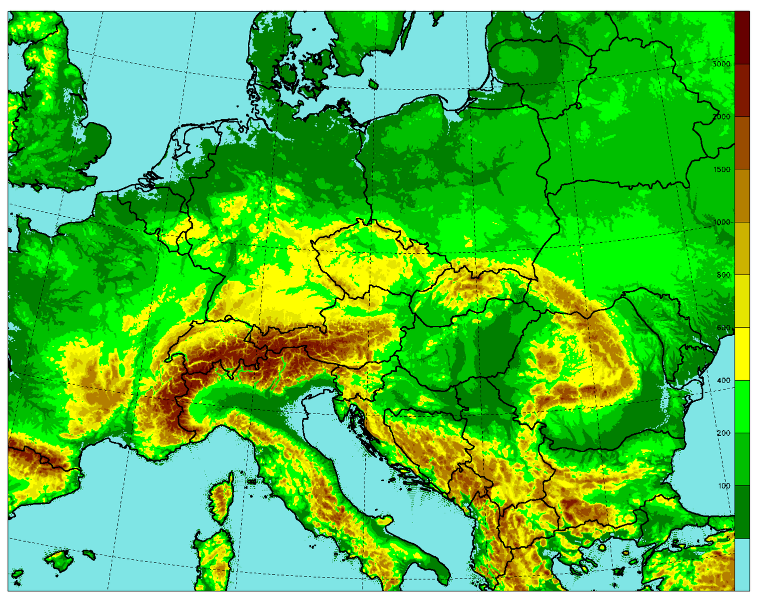

Fig. 1. *Orography of the domain.*

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 the 3DVAR analysis (Fischer et al., 2005)

- digital filtering at truncation E102x81; space consistent coupling
- no DFI in long cut-off 3h cycle; incremental DFI in short cut-off production analysis
- observations: SYNOP, TEMP, AMDAR, Mode-S, SEVIRI, WP, HR-AMV, ASCAT

HPC system

NEC SX Aurora TSUBASA

48 computing nodes with:

- one **AMD EPYC** 7402 CPU (24 cores, 512GB RAM) , and
- eight **NEC Vector Engines** 20B (8 cores, 48GB RAM each)
- total **1152 VH + 3072 VE cores**

Fig. 2. *NEC SX Aurora*

Radar reflectivity

with credits to S. Panežić & B. Strajnar

The size distribution of rain proposed by Abel and Boutle (2012) was implemented for radar reflectivity diagnostics and reflectivity observation operator, making it consistent with the size distribution used in the microphysics scheme. This distribution delivers smaller particles in the case of low mass fraction of rain and bigger in heavy rain than the formerly used Marshall-Palmer one. Thus, simulated reflectivities are lower in drizzle and light rain and higher in heavy precipitation.

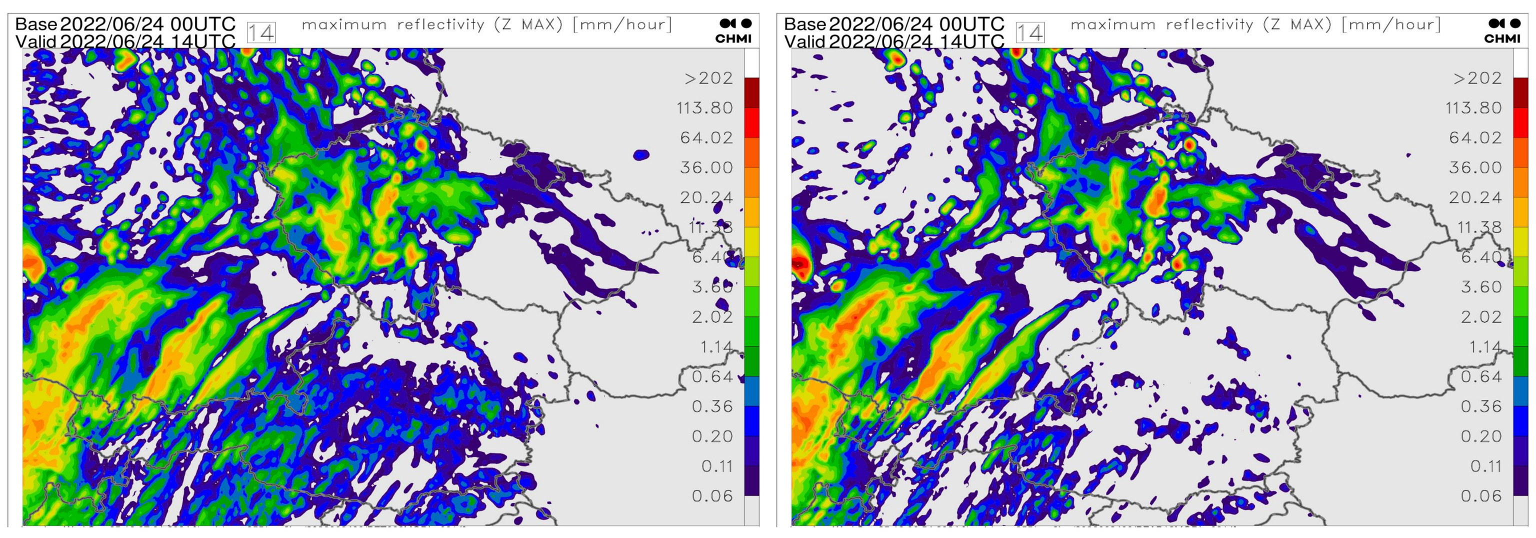

Fig. 3. *Simulated maximum reflectivity with default (Marshall-Palmer) distribution of rain (left) and Abel and Boutle distribution (right) for 24 Jun 2022 00UTC +14h.*

The data assimilation of radar reflectivity volumes from OPERA in ALARO CMC is currently being tested in the e-suite. The 1D+3D-Var assimilation method (Wattrelot et al., 2014) is employed, which indirectly assimilates radar reflectivity as humidity profiles. Initial experiments demonstrated a significant systematic drying caused by "non-rainy" observations (undetected). A promising approach to mitigate excessive drying is a combination of error inflation for observations created from undetected pixels and the threshold method. The threshold method assimilates reflectivity observations only when the observed or modelled reflectivity exceeds a threshold, which is 0 DBZ in our case. Further ingredients are the Abel Boutle rain size distribution used in the radar observation operator to be consistent with ALARO microphysics. There is also a new way of filtering reflectivity data before computing the minimum detectable reflectivity factor (MDRF) in BATOR. This avoids too low values in case of noisy data (e.g. DE, HU). One percentile of data is removed for each distance bin from the radar before computing the MDRF. This modifications should protect against too much drying by undetected observations.

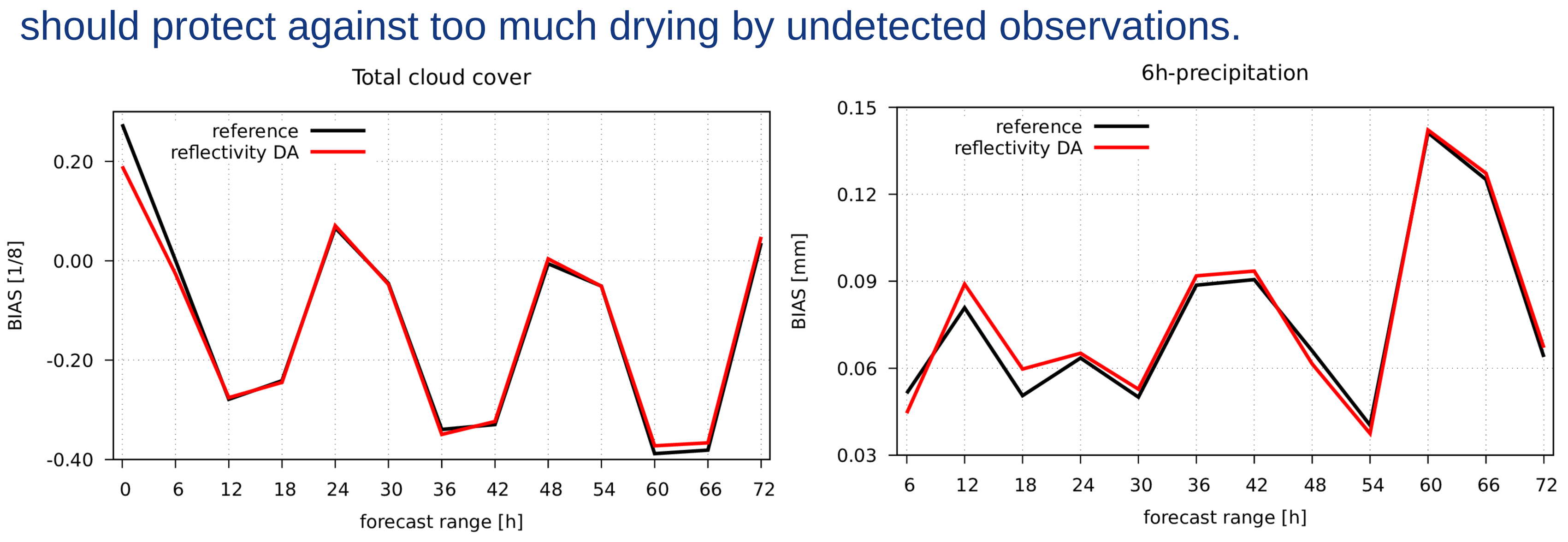

Fig. 4. *Bias of total cloudiness and 6h-precipitation for the period from 20-02-2024 to 22-03-2024. Black: reference, red: experiment with radar reflectivity data assimilation.*

Major operational changes

3 Sep 2024	SEVIRI water vapor channels reintroduced into data assimilation with updated VARBC
3 Oct 2024	Rain size distribution by Abel and Boutle (2012) implemented for simulated reflectivity diagnostics (see description in the left panel)
6 Jan 2025	18UTC production prolonged to +72h
19 Feb 2025	e-suite ALE data assimilation of OPERA radar reflectivity (see description in the left panel)

Testing turbulence mixing length based on TKE in TOUCANS

This new mixing length parameterization is under development by Hrastinski et al. 2025. It started from the BL89 proposal and it incorporates further developments and improvements. Tests were performed with the 3D model over four different periods in 2024: stratocumulus regime in March, deep convection in June, flood period in September and stable anticyclone in the end of December. New mixing length has a very good potential to improve model performances. There is still an issue of its interaction with deep moist convection because of moisture transport within the PBL and its impact on the closure. The DDH diagnostics shows insufficient moistening of the PBL which leads to less precipitation.

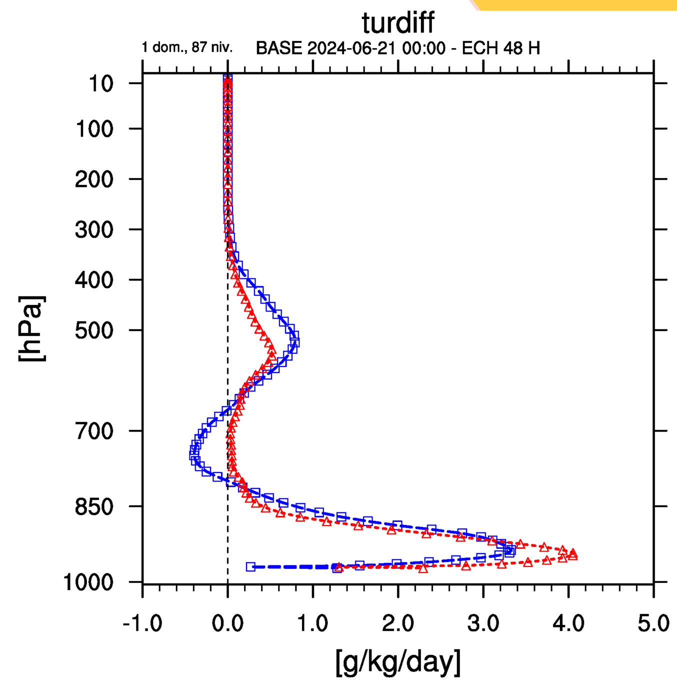

Fig. 5. *Tendency of water vapour by turbulence transport: 48h forecast for 21 Jun 2024.The reference and new mixing length experiment.*

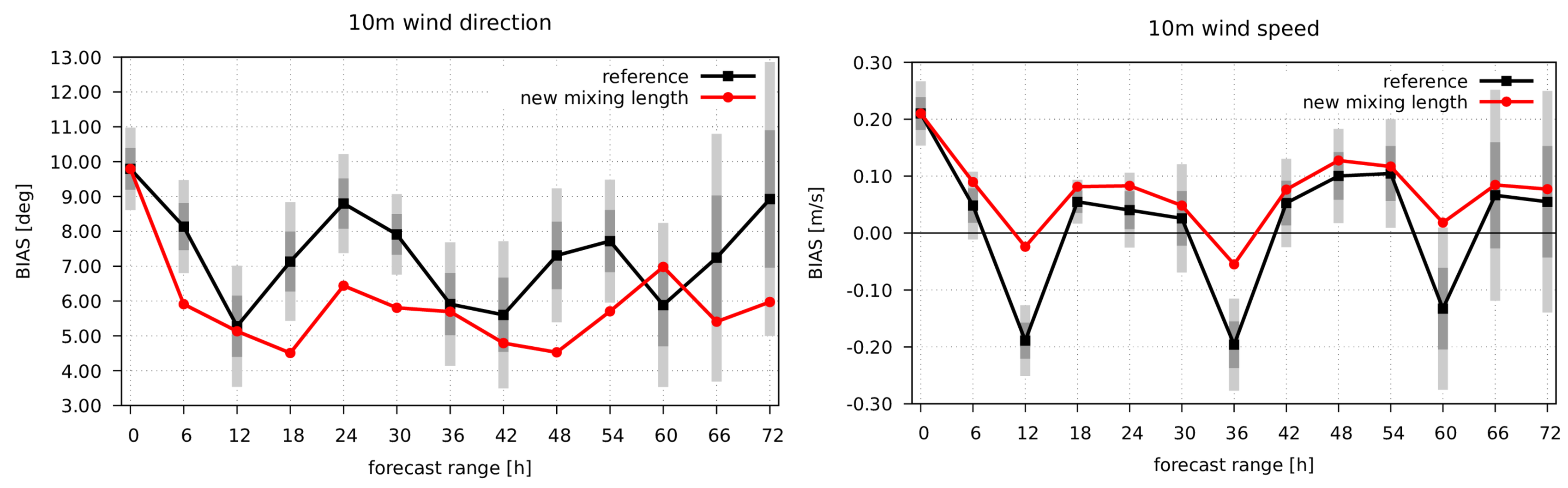

Fig. 6. *Bias of wind direction and speed at 10m for the period from 03-03-2024 to 10-03-2024. Black: reference, red: experiment with new mixing length. For the reference, the dark and light bars show ±σ (~68%) and ±2σ (~95%) confidence intervals respectively.*

Validation of TEB configuration

with credits to P. Sekula, P. Samuelsson & S. Schneider

Work on ALARO with SURFEX has progressed nicely, most of desired options can now be used in a forecast mode. Candidate NWP configuration involves 3L ISBA force-restore scheme, 3 nature patches, D95 snow scheme, and TEB scheme. Since the TEB scheme offers several options, we tested its ability to capture urban heat island (UHI) of Prague, using 7 sunny days with observed maximum 2m temperature above 30 deg C. Temperature difference between the city center and the rural point 20km to the south-west was evaluated. The figure demonstrates that while old ISBA scheme was not able to simulate UHI effect at all, SURFEX with TEB captures roughly one half of it. The best configuration with ECOCLIMAP II dataset involves building energy model (BEM), garden option, and retuned building properties (doubled thermal conductivity and heat capacity; roof and wall albedos reduced by 20%).

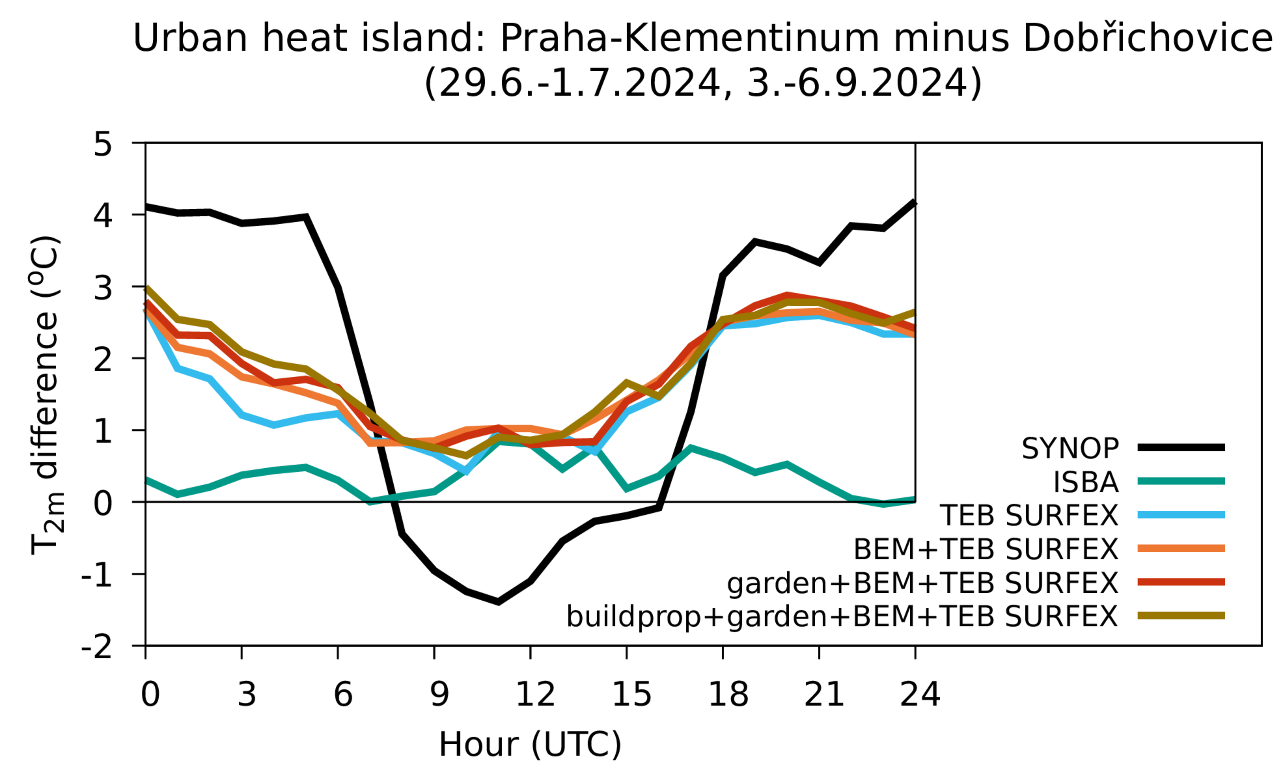

Fig. 7. *Diurnal evolution of T2m difference between stations Praha-Klementinum and Dobřichovice: black - SYNOP observations; green - old ISBA; blue - SURFEX with TEB; orange - SURFEX with TEB and BEM; red - SURFEX with TEB, BEM and garden; brown - SURFEX with TEB, BEM, garden and retuned building properties.*