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 +72/54h
- hourly analysis system VarCan Pack
- ALADIN cycle 46t1mp (ALARO-1vB)

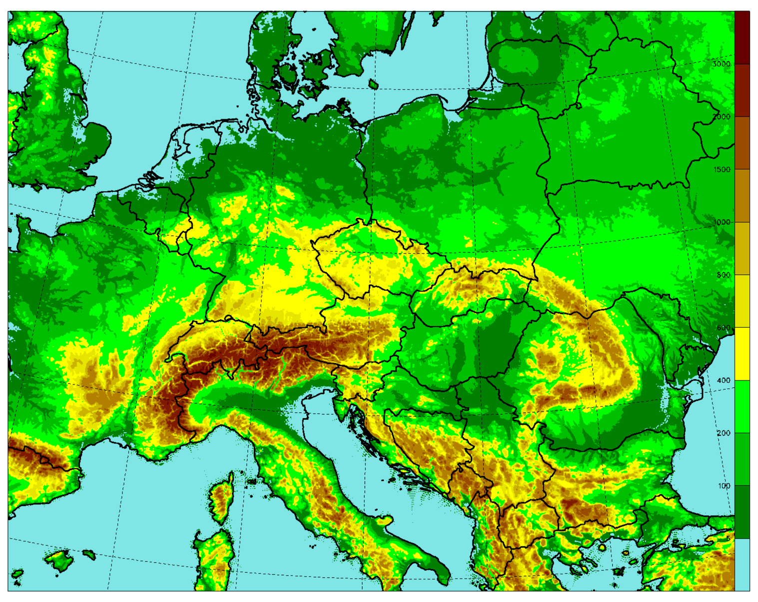

Fig. 1. *Orography of the domain.*

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 6h cycle; incremental DFI in short cut-off production analysis
- observations: SYNOP, TEMP, AMDAR, Mode-S, SEVIRI, WP, HR-AMV, ASCAT

HPC systems

Two HPC systems at CHMI:

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**

NEC LX series HPC cluster
- 320 computing nodes with:
  - **Intel Broadwell** CPU (2x12 cores, 64GB RAM)
- total **7680 computational cores**

Fig. 2. *NEC SX Aurora*

New convective diagnostics

A set of convective diagnostics was implemented in cooperation with the CHMI convection-specialized team and became operational in May 2023. Firstly, selected already available visualizations were revised, for example the visualization of CAPE was enhanced for CIN and moisture convergence (Figure 3) or alternatively for wind shear between the low level and a mid-tropospheric level (Figure 4), Secondly, new products, including storm relative helicity (Figure 5), updraft and downdraft track, and updraft helicity track (Figure 6) were added. These new products are useful for determining the type of convective storm, e.g. squall lines or supercells; eventually for predicting favorable environment for tornado development.

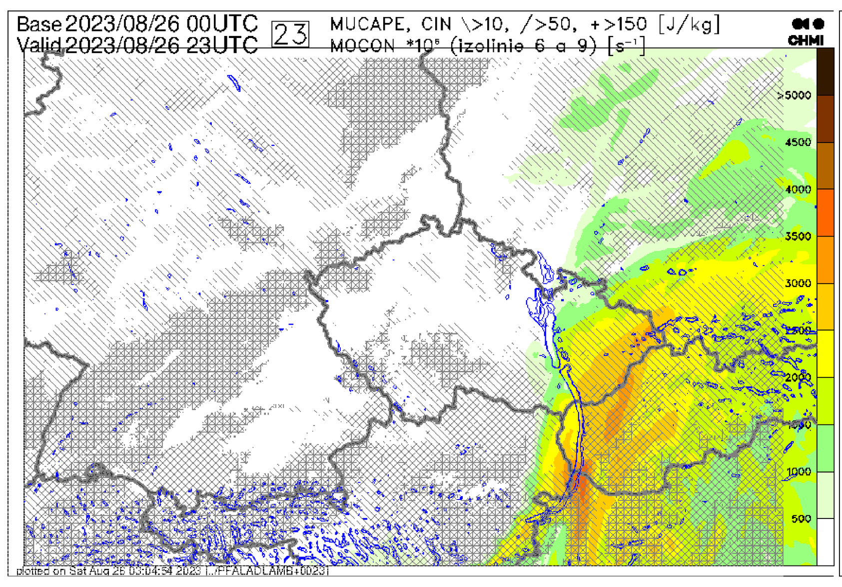

Fig. 3. *Combination of Most Unstable CAPE (colors), CIN (hatching) and moisture convergence near the ground (isoline) for 26 Aug 2023 00UTC +23h.*

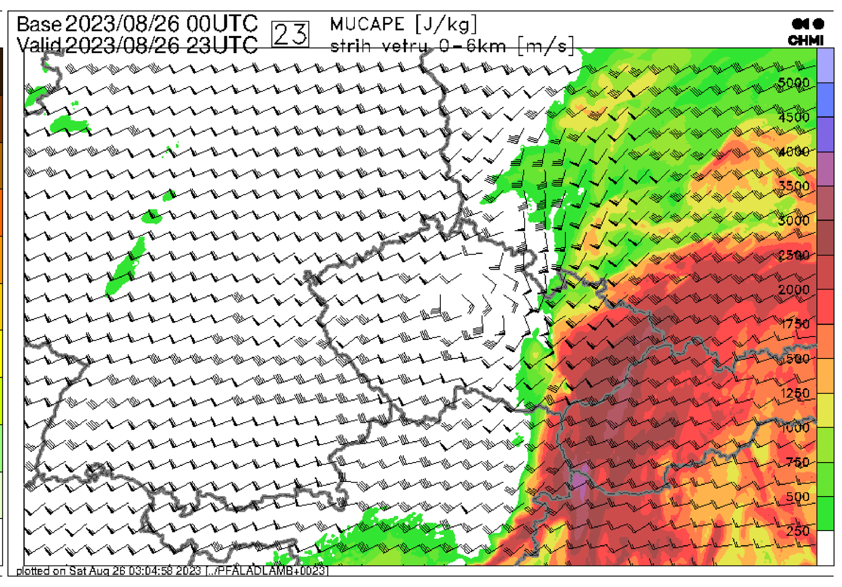

Fig. 4. *Combination of Most Unstable CAPE (colors) and wind shear (wind arrows) between the near surface and 6km for 26 Aug 2023 00UTC +23h.*

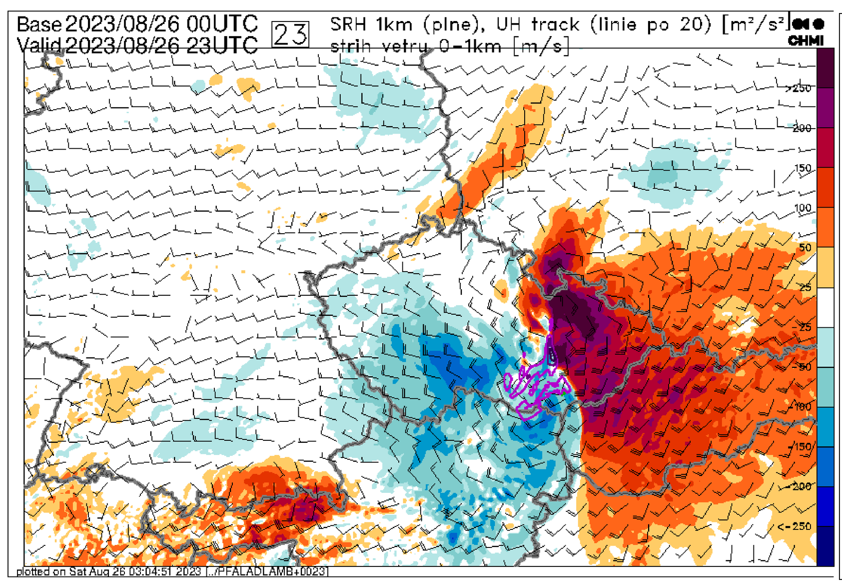

Fig. 5. *Combination of Storm Relative Helicity (colors), Updraft Helicity track (isoline) and wind shear (wind arrows) between the near surface and 1km.*

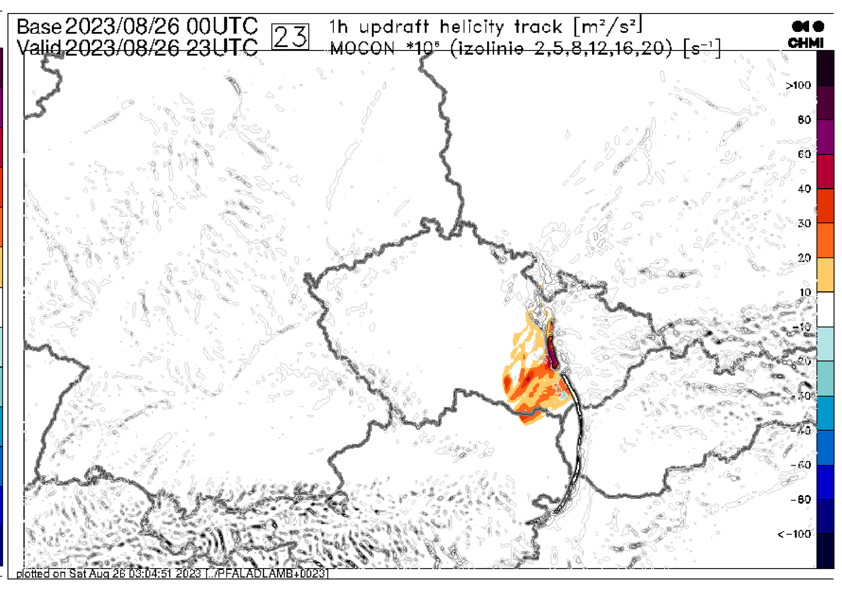

Fig. 6. *Combination of Updraft Helicity track (colors) and moisture convergence (isoline) for 26 Aug 2023 00UTC + 23h.*

Major operational changes

19 Apr 2023 Implementation of the new model release - cy46t1mp

15 May 2023 New convective diagnostics (see description in the left panel)

Deep soil analysis oscillations

Analysis of deep soil reservoir in CANARI is too active in warm part of the year (SMU0=0. in CANARI namelist) when increments are not dependent on sun zenith angle or sun declination. This is more pronounced in 3h cycling frequency where we observe oscillations of soil water reservoir, this in turn modifies evaporation from soil and via the latent heat flux it influences T2M, then we observe T2M forecast jumpiness from one model run to the next.

Recommended setting for ARPEGE and AROME is to make this activity dependent on the sun zenith angle μ0 (SMU0=7. in CANARI namelist). This setting makes increments of deep soil reservoir small/zero at small sun elevations/night. Oscillations are then stabilized over spring/summer period. However, we get another problems. In winter the analysis is almost inactive at our latitudes, and the soil gets too wet, with cold T2M bias. In summer, the analysis is active during the day time, mainly 12 UTC, and the prevailing effect is drying, bringing also warm T2M bias.

Another proposal is based on the annual cycle of sun declination, where we need to suppress the analysis activity during spring and summer when diurnal amplitudes of screen level parameters are big. A function with a minima at summer solstice and maxima at winter solstice is used to modulate deep soil reservoir analysis increments. With positive effect on diurnal amplitude of oscillations.

To make the daily cycle of the reservoir even smaller the possibility to average the increments of deep soil reservoir in Canari is used ("LISSEW"). The code with LISSEW was commented out (CY43t2_bf11) so debugging was necessary. Canari is then averaging the last 4 analysis increments to overcome diurnal variation of 6h cycle, which makes the amplitude smaller but with a shifted phase for 3h cycling. To overcome this issue the 8 analysis increments are used in averaging. There is almost no oscillation of deep soil moisture with positive effect on jumpiness of forecasts. But a consequence is cold bias in afternoon maximal temperature which need to be tackled.

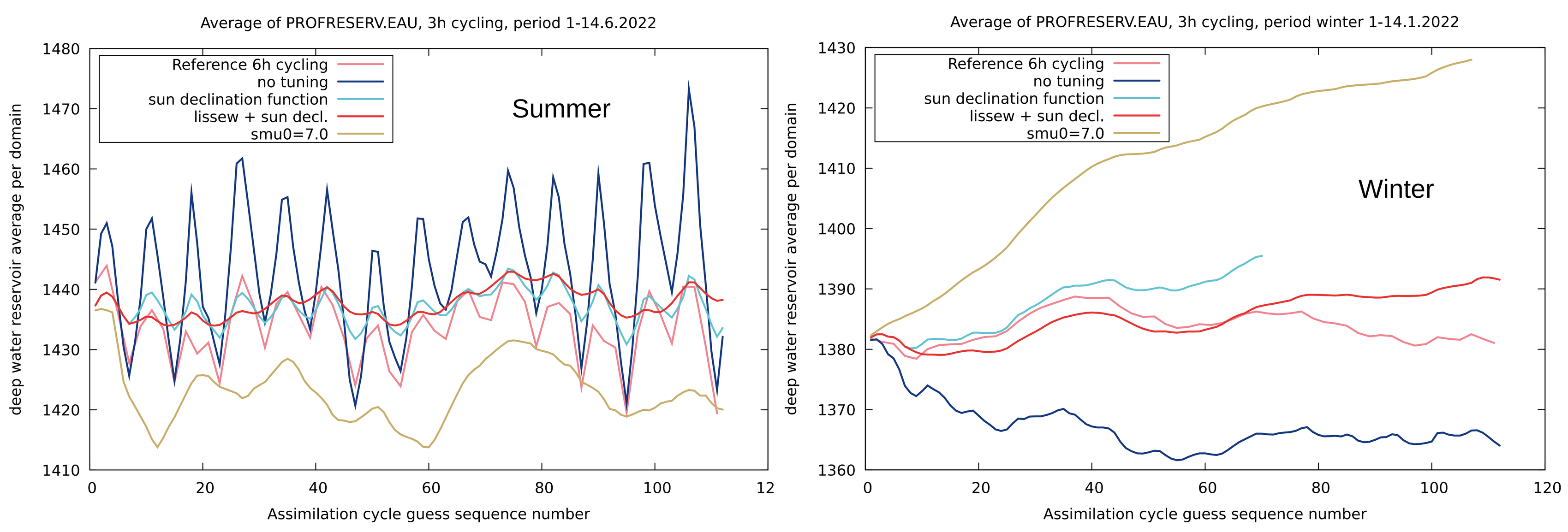

Fig. 7. *Domain average of deep water reservoir in 3h assimilation cycle, left summer, right winter period.* ***Dark blue*** *line is 3h cycling with the same setup as 6h cycle,* ***light blue line*** *represents 3h cycling with sun declination function only,* ***pink line*** *is reference 6h cycle,* ***red line*** *is 3h cycling with sun declination function and deep soil analysis increments averaging,* ***burly wood*** *color is 3h cycle with recommended setting for AROME (smu0=7.).*

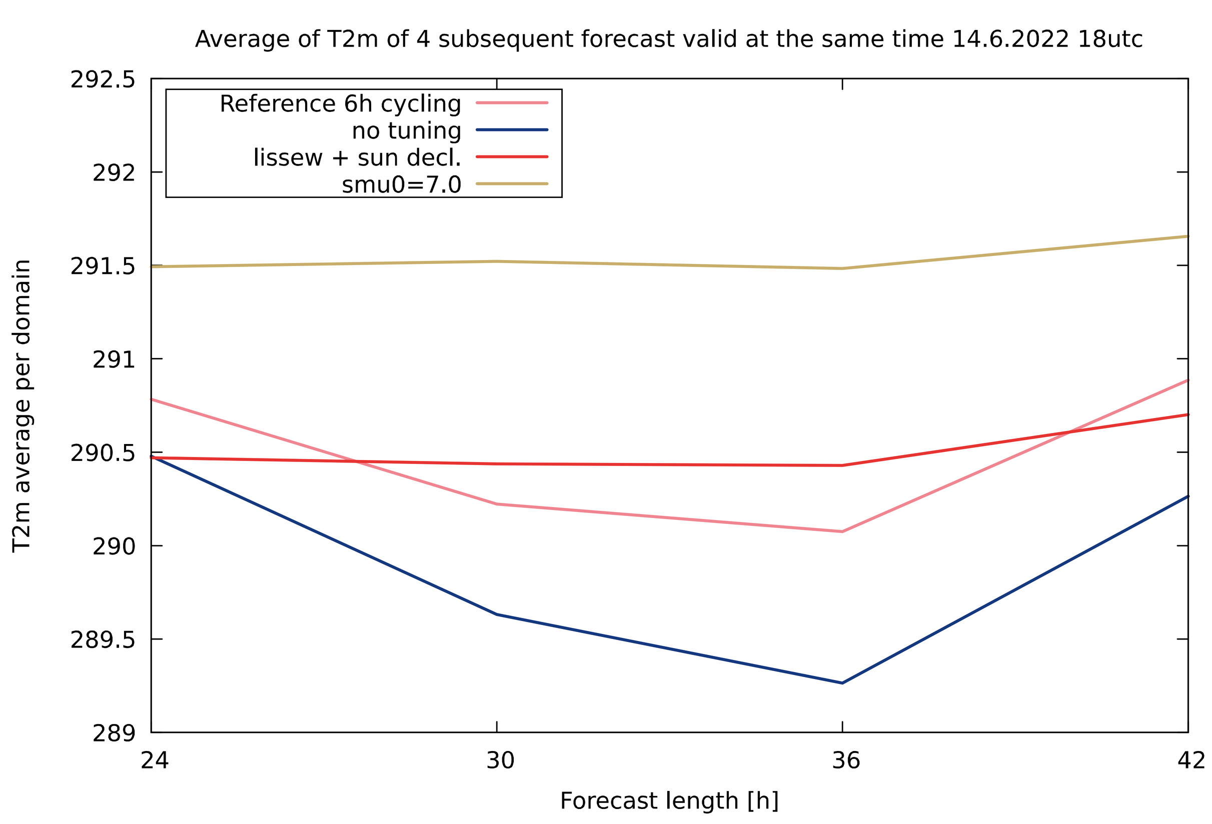

Fig. 8. *Domain average of 2m temperature forecasts valid at the same time, looking at the afternoon maxima (18UTC) at summer. As can be seen both recommended setting and the sun declination function + deep soil increments averaging do not have jumpiness of 4 subsequent forecast. While reference 6h cycle and not tuned 3h cycle change the forecast average quite significantly from one run to the other.*

The recommended setting has warm bias compared to reference which is with agreement with lower values in deep soil reservoir. Not tuned 3h cycle has cold bias from forecast starting at 6utc (+36h) where is maxima in deep soil reservoir analysis.