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 43t2ag (ALARO-1vB)

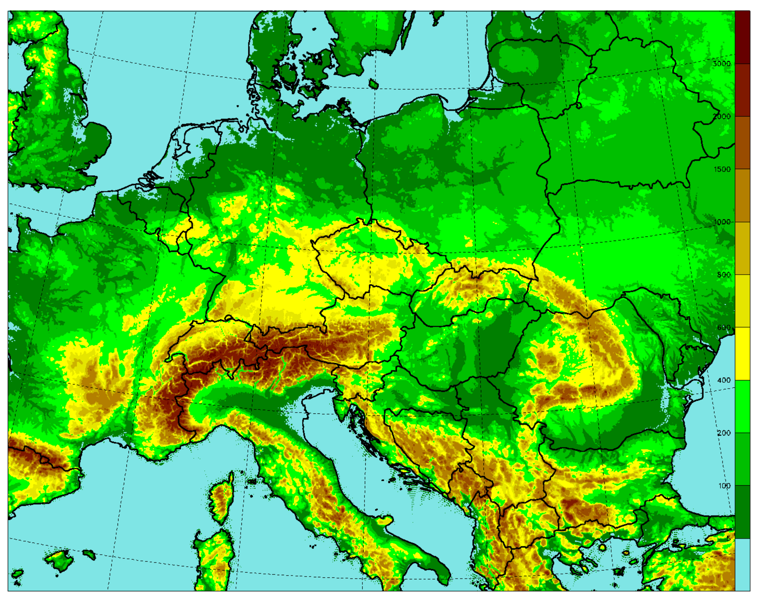

Figure 1: *Orography of the domain.*

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

NEC LX series HPC cluster
- 320 computing nodes with:
  - two **Intel Broadwell** CPU (12 cores, 64GB RAM)
- total **7680 computational cores**

new: **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**

ALARO climate simulations at CHMI

J. Mašek, R. Brožková

Within the PERUN project, CHMI is now running ALARO-1 in climate mode. Domain and resolution are the same as in CHMI operations (dx = 2.3km, 87L). The first set of simulations is performed without SURFEX, using ISBA scheme with 4 soil levels in order to capture diurnal and annual temperature cycles correctly.

Simulations cover historical period 1989-2014. Reanalysis and evaluation runs were coupled with ERA5, the former with assimilation of the surface observations and with upper air blending, the latter controlled only via lateral boundary conditions. Currently, historical simulation coupled with CNRM ESM2-1 GCM model is being finalized, to be followed by selected CMIP6 scenarios for period 2015-2100. In the second phase, runs with SURFEX and improved physics will follow.

Tools necessary for proper generation of coupling files were created. The main issue was to replace SST from ARPEGE file, contaminated along the coastlines due to SURFEX averaging of sea and land tiles, by the value from NEMO ocean model. The problem and its solution are demonstrated on Figure 2, depicting also LACE telecom domain with dx = 15.4km. Simple treatment of lake temperature was implemented before the FLAKE model can be used.

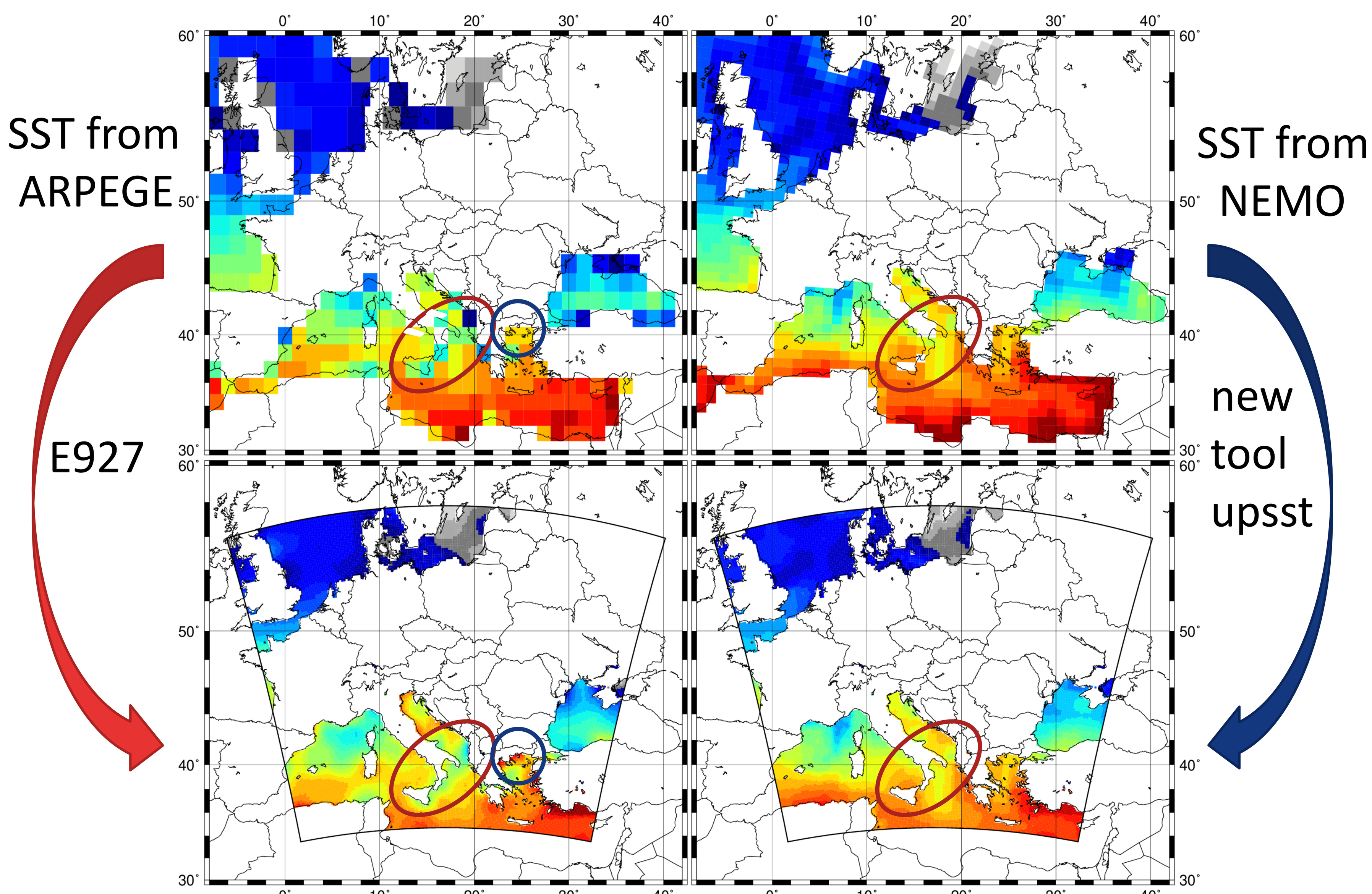

Figure 2: *SST from ARPEGE subject to SURFEX tiling (truncation T127, upper left); SST from NEMO ocean model (resolution ~1 degree, upper right); SST from ARPEGE after interpolation to LACE telecom domain by configuration E927 (lower left); SST from NEMO interpolated to LACE telecom domain by the new utility upsst, avoiding overshoots and contamination by tiling (lower right). Case shown is 01-Jan-2015 00z; contour interval is 0.5K.*

We are grateful to colleagues from Météo France and RMI for their technical help, and for advice how to design the climate simulations properly.

Major operational changes

15 Feb 2022 e-suite AKV	• e-suite of ALARO with prognostic graupel (see description below)
4 Jan 2022 e-suite AKU	• Mode-S EHS data from airspace of Belgium, Netherlands, Luxembourg and Germany (MUAC) are replaced by European EHS data with improved pre-processing (see description below)

Prognostic graupel in ALARO e-suite

D. Němec, R. Brožková

The ALARO microphysics became more complex by replacing simplified pseudo-prognostic graupel treatment by the fully prognostic one. Graupel is created by the Wegener-Bergeron-Findeisen kind of auto-conversion from cloud water droplets, and by rain freezing. The presence of the second solid state precipitating species naturally means smaller amount of snowflakes w.r.t. having prognostic snow only, see Figure 3. As a consequence, simulated reflectivity does not have so exaggerated maxima, caused by too much snow. A more realistic amount of graupel required retuning of precipitation type thresholds for small and big hail.

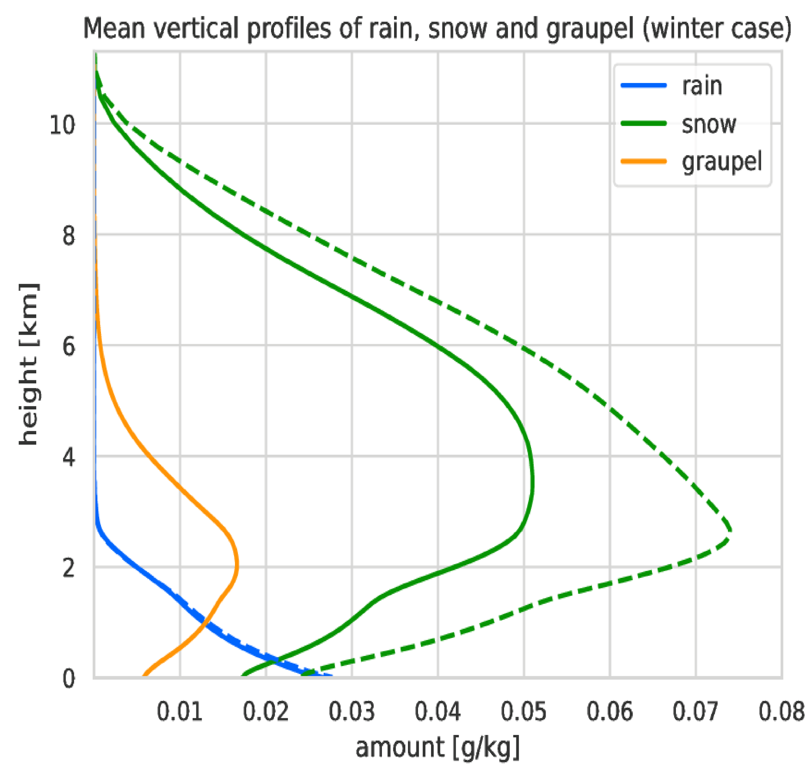

Figure 3: *The mean vertical profile of falling hydrometeors for ALARO without prognostic graupel (dashed lines) and with prognostic graupel (solid lines)*

Another impact is due to the different fall speeds of the snow and graupel, having feed-back on temperature and moisture through sublimation. In the very first prognostic graupel version the fall speed of graupel was equal to rain. This choice was revised, resulting in a new proposal that was implemented. The fall speed relation has the form of

$$w(\Re) = 0.46 \left[\frac{\Re}{\rho^{7/3}}\right]^{1/7}$$

This relation ensures similar graupel fall speeds as in the ICE3 scheme.

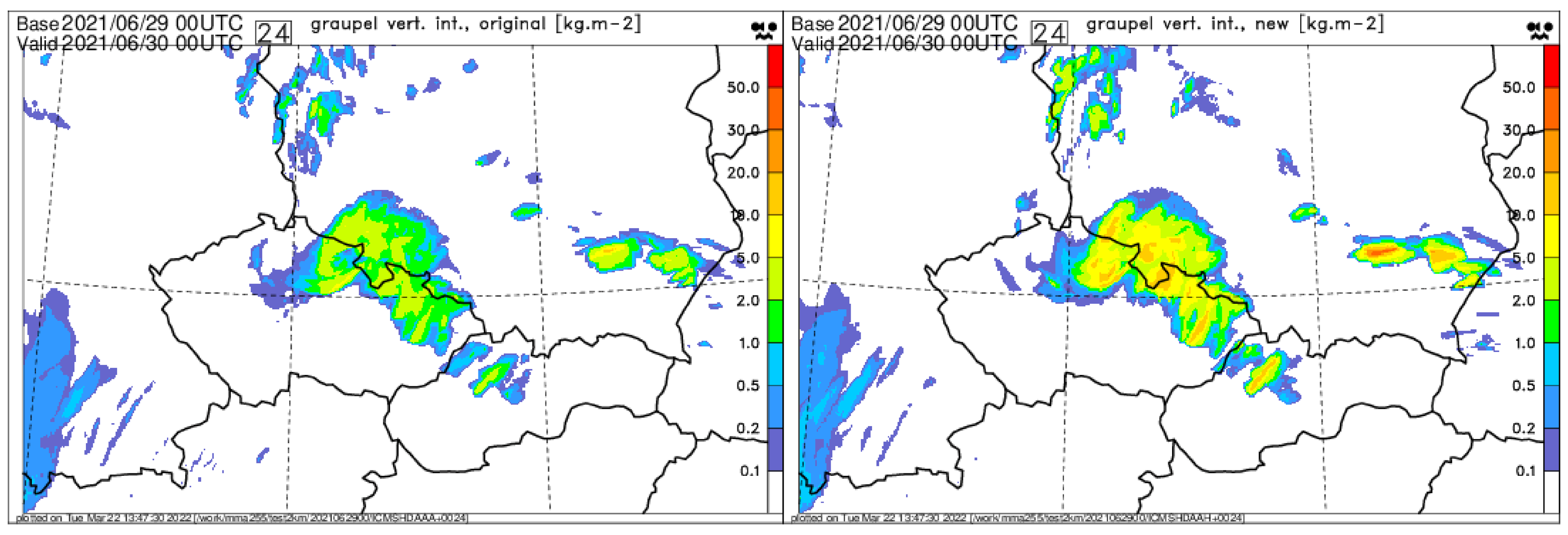

Figure 4: *A new fall speed relation for graupel was implemented. As the graupel fall speed is now significantly lowered, the vertical integral of graupel in convective storms case of 30-Jun-2021 is higher (right) than the original one (left).*

Prognostic graupel enabled a rather straightforward implementation of a lightning density simulation.

Mode-S EHS e-suite

A. Trojáková

The operational processing system for Mode-S data (EMADDC) prepared several improvements during 2021, such as the new heading correction method based on the entire area, new temperature and true airspeed correction methods following De Haan et al. 2021.

The evaluation at CHMI showed that EHS data coverage has been considerably improved and as of now it covers almost all Europe, see Figure 5. The OMG statistics of both wind and temperature STD improved mainly below 500hPa level. Considering a very large amount of Mode-S data (time frequency of EHS data is several seconds) the operational assimilation window of BlendVar was shortened from 3h to 1h (+/-30mins around analysis time).

The e-suite provided mostly neutral scores with respect to SYNOP and TEMP data except of small improvements of geopotential and temperature BIAS around 250hPa level up to +12h forecast.

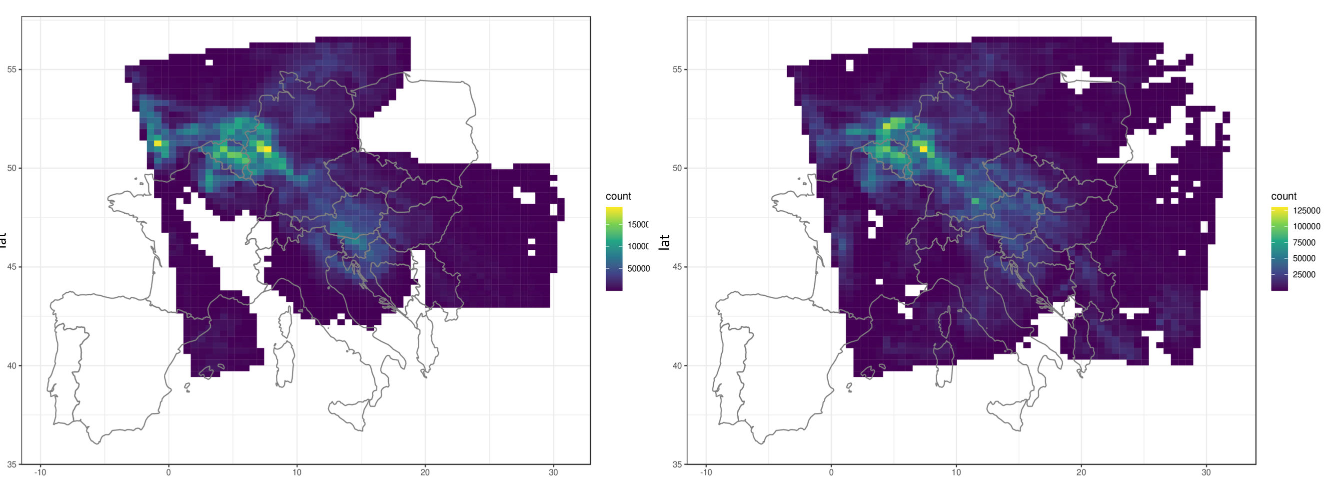

Figure 5: *Geographical distribution and counts of Mode-S EHS data for period of 9-17 Oct 2021 provided by EMADDC version 2.1 (left) and version 2.2 (right).*