ACCORD activities at ARSO

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Operational suite (ALADIN SI)

Model characteristics

- Code version cy43t2_bf10, ALARO-v1B physics,
- 4.4 km horizontal resolution, 87 vertical levels, 432×432 horizontal grid points,
- 180 s time step, hydrostatic,
- coupling with ECMWF (6h lag), 1h (assim. cycle) 3h(forecast),
- space-consistent LBC at initial time,
- production runs to 72 h (every 6 h), 4 runs to 36 h.

Data assimilation

- 3h 3D-Var for atmosphere, OI for soil,
- static downscaled ensemble B-matrix,
- observations (mostly from the OPLACE system): SYNOP, AMV, HR-AMV, TEMP, AMSU&MHS, SEVIRI, IASI, ASCAT, OSCAT, Mode-S MRAR SICZ, MUAC EHS, ZTD (passive).

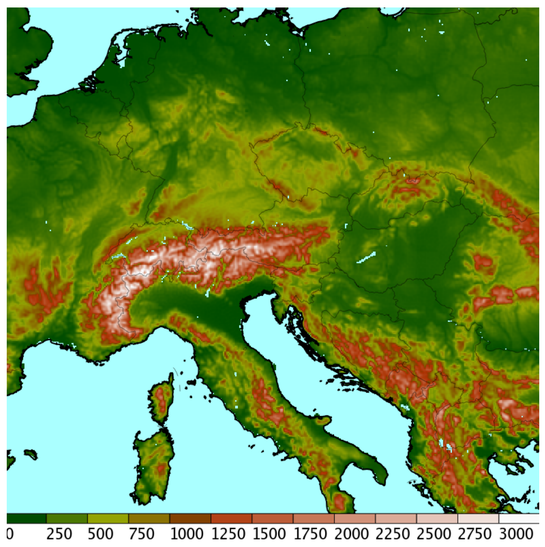

Figure 1: Operational ALARO 4.4 km

ALARO-RUC for nowcasting

Operational setup:

- Code version cy43t2_bf10, ALARO-v1B physics,
- 1.3 km horizontal resolution, 87 vertical levels, 600×600 horizontal grid points,
- domain centered in the North Adriatic Sea,
- 60s time step, non-hydrostatic,
- coupling with ECMWF (lag 6h to 12h), every hour,
- space-consistent LBC at initial time,
- cutoff times:
  - assimilation: 70 min after nominal time,
  - production: 35 min after nominal time,
- 36h forecasts every hour,
- upper-air DA: 1h 3D-Var, static ENS DSC B matrix,
- all observation as in 4km suite + radar reflectivity,
- output every 5 min, plots and movies available for subjective validation.

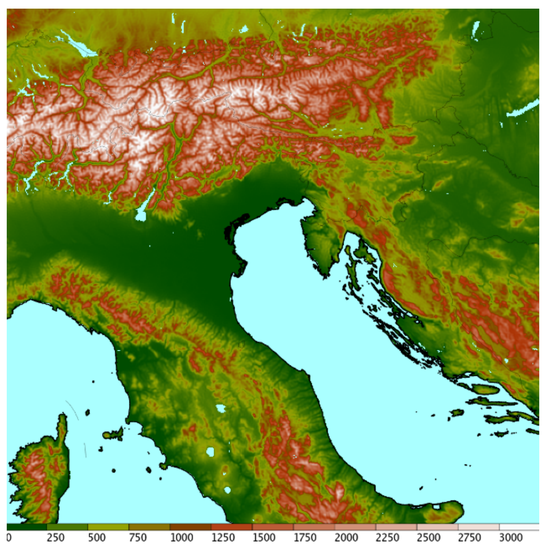

Figure 2: Operational 1.3 km 87L ALARO-RUC model domain.

Model system SEEMHEWS

One of the NWP models within the South-East European Multi-Hazard Early Warning Advisory System project:

- runs on ATOS machine at ECMWF,
- same model version and assimilation setup as in operational ALADIN-SI,
- 2.5 km horizontal resolution, 87 vertical levels, 1429×1141 horizontal grid points,
- 90 s time step, non-hydrostatic,
- coupling with ECMWF, 1h (assim. cycle) 3h (forecast),
- observations from OPLACE preprocessing system, additional regional observations available and tested.

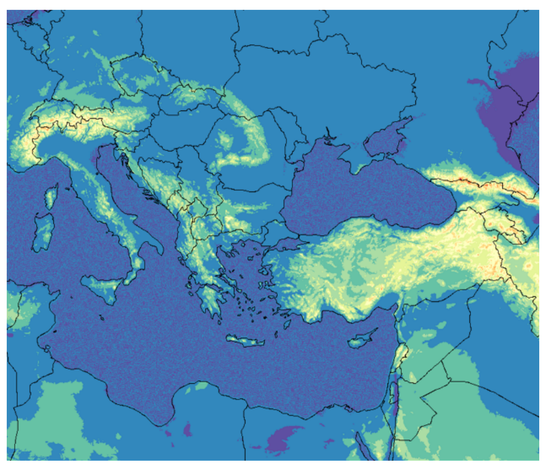

Figure 3: Model domain of SEEMHEWS 2.5 km/87L model domain, run daily at ECMWF HPC.

Migration of operational suite to test HPC

- Procurement of a new HPC and renovation of the computing center has been delayed to the end of 2025,
- 3 nodes presumably resembling the anticipated HPC were already obtained for testing purposes,
  - 2× AMD EPYC 9654 96-Core Processor and 750GB RAM per node,
  - CEPH file system, Infiniband network connection,
  - Debian GNU/Linux 12 (bookworm), SLURM queueing system,
- Failure of UPS and other issues on the old HPC prompted an inopportune migration of the operational 1.3km ALARO-RUC suite to the testing machine.

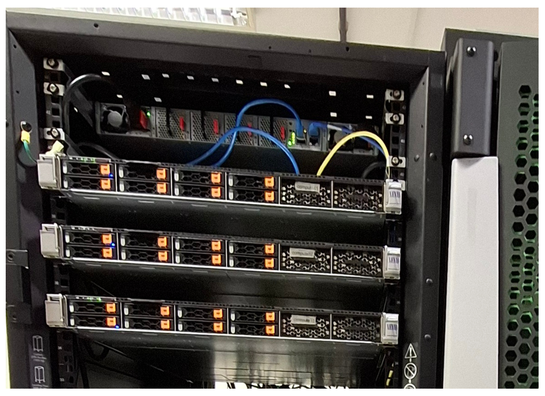

Figure 4: 3 new nodes procured in anticipation of new HPC.

Figure 5: Old HPC used for operations.

Issues on test machine:

- Current implementation does not meet requirement of under 1h computation for lead time +36h for ALARO-RUC,
- cy48t3 performance is greatly improved (15 % compared to cy43t2), however a segmentation fault is produced by all except certain values of OMP threads with hybrid MPI/openMP,
- Upgrade and homogenization of CEPH nodes resolved long lasting struggle with the file system.

EnVar in Claef1k ensemble system

Testing 3D-EnVar in Claef1k

- 3D-EnVar added as a control member for comparison with 3D-Var,
- winter 2025 results shows promising performance (cases, scores),
- increased cost (+3h forecast steps in assimilation cycle, minimization) and complexity (requires previous run members).

Perturbations for 3D-EnVar

- B-matrix sampled from a sufficiently large perturbation ensemble,
- limited ensemble size addressed via lagged runs andor host model members,
- sensitivity to perturbations computation methods.

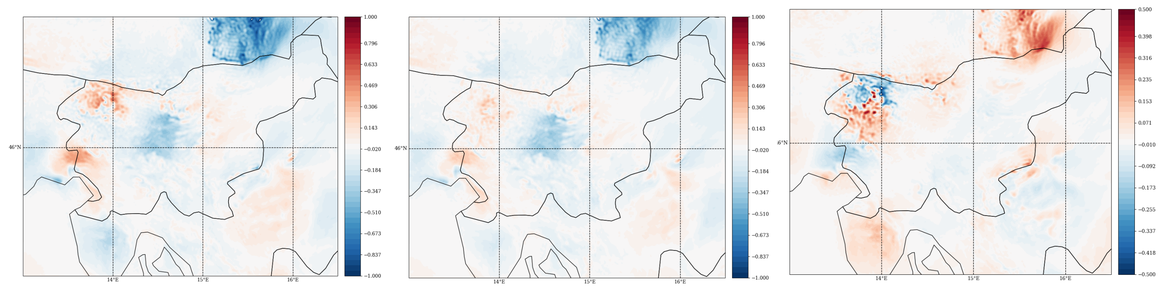

Figure 6: L88 temperature analysis increment using perturbed forecasts from previous (16) and second-last (16) analysis times. Left: single ensemble, middle: separate normalization per run, right: difference between methods.

TOMs scheme stability

- In TOUCANS, Third-Order Moments (TOMs) contributions to heat and moisture fluxes can be included,
- TOMs provide non-local effects:

$$\overline{w\theta} = \underbrace{-K'' \frac{\partial \Theta}{\partial z}}_{\text{local}} + \underbrace{A_1^{\theta} \frac{\partial \overline{w^3}}{\partial z} + A_2^{\theta} \frac{\partial \overline{w\theta^2}}{\partial z} + A_3^{\theta} \frac{\partial \overline{w^2\theta}}{\partial z}}_{\text{non-local}}$$

  - turbulent transport can be maintained even in no-gradient conditions,
  - counter-gradient fluxes that can penetrate stable layers.
- TOMs code numerically unstable - corrected in 2024 by adding a term related to the time derivative of flux and limiting TKE values from below,
- solver matrix is now positive definite for all time steps and levels ($d_{min}(j,t) > 0$),
- preliminary results show that TOMS fluxes on average add about 0.5% to the whole flux, but with systematic change of about 50 J/m^2 for a dry convective situation after 15h of forecast,
- for some cases, code is still not completely stable - investigation of this will be done in 2025.

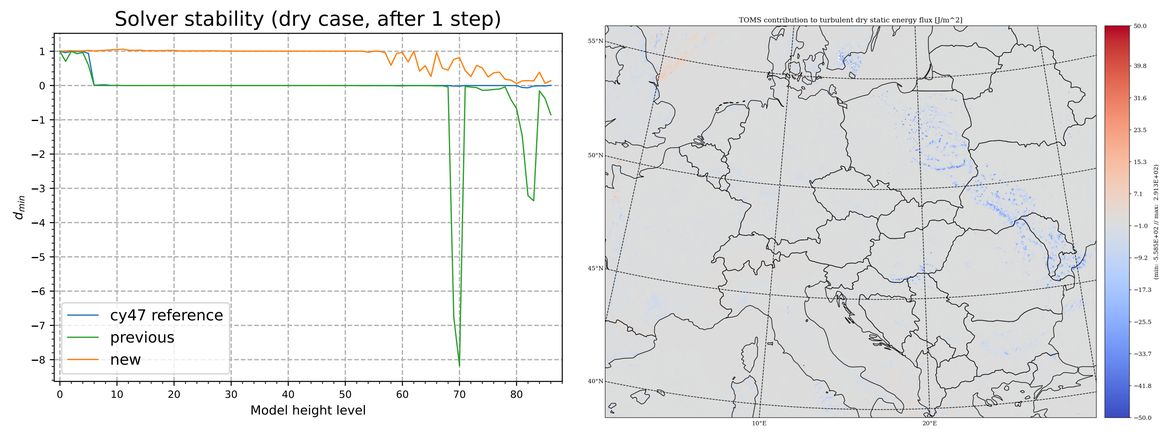

Figure 7: Left: Solver stability (dry case, after 1 step). Right: TOMs contributions to turbulent dry static energy flux.

Experiments in very high resolution

Ab initio simulations in highly variable terrain – World Cup ski jumping finals event in Planica. A 200m orography domain double nested in 500m/global DT simulated the wind conditions surprisingly well on a very challenging day capturing the morning down slope wind and with noticeable vertical mixing during the day (Figure 9 left column). Further verification with high resolution data is pending.

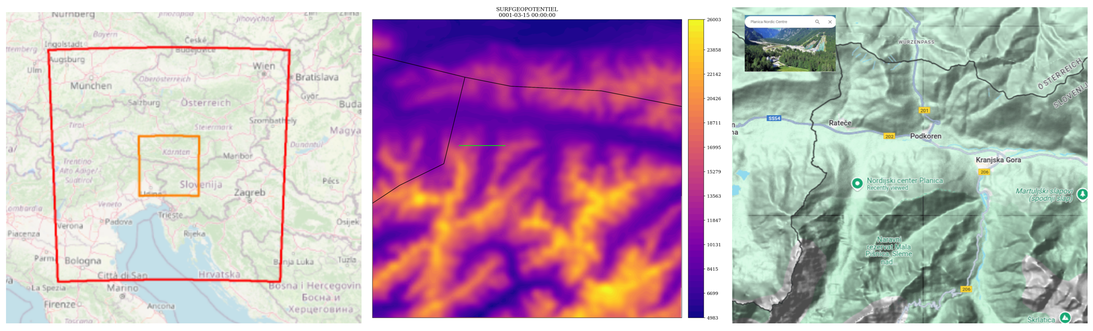

Figure 8: Domains used for experiment: 500m and 200m resolution domains (left), zoom in 200m orography over the region of interest with line along cross section in Figure 9 (center), high resolution topography image (right).

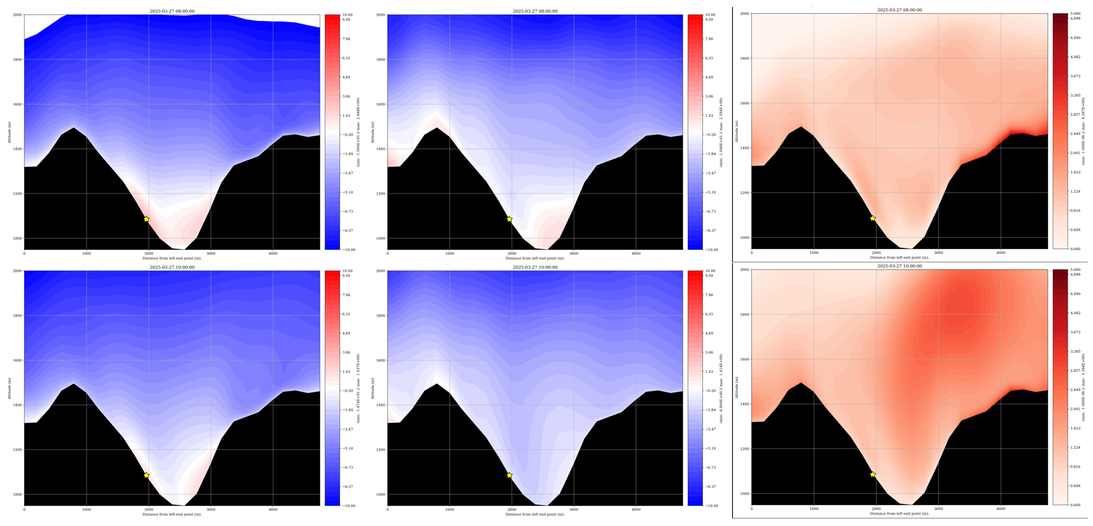

Figure 9: U (left), v (center) components of wind and TKE (right) for a vertical cross-section (Fig. 8, center) along the ski jump. Valid at 09 local time (top row) and at 11 (bottom). Location of ski flying hill depicted by yellow dot.