Regional Cooperation for Limited Area Modeling in Central Europe

LACE
nwp central europe

ALARO CMC at high resolution

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Introduction

- ALARO has been created as a concept of:
  - having handy multi-scale parameterizations for various applications in NWP and climate,
  - keeping consistency thanks to the governing equations, using a well defined flux-form interface to the dynamics with a guaranty of conservatism,
  - offering a modularity for innovations at the level of processes.
- The multi-scale aspect has been primarily addressed to the problem of the so-called grey zone of moist deep convection (dx between 7 km to 3 km roughly).
- However, little is known on the high resolution limit of this grey zone, and also how it is with other parameterizations, e.g. those coping with still unresolved orography etc.
- The capacity of ALARO with resolution going toward the high resolution limit has been tested in case-studies, e.g. the grey-zone experiment.
- More robustly one can however assess it in a full-fledged NWP setup.
- In this talk we present a build-up of the CHMI configuration of ALARO run operationally at 2,3 km.

Main Specifications of the new setup

- Horizontal Resolution: it moves from 4.7 km (fully in the grey-zone of moist deep convection) => 2.3 km (resolution, where it has been believed we do not need to parameterize moist deep convection any more)
  - Preserving the domain size to avoid a too small one.
  - Number of points: 540 x 432 => 1080 x 864; which is 4 times more points, i. e. 4 times more operations per model time-step;
  - Spectral resolution: 269 x 215 waves => 539 x 431 waves (so no cubic truncation tricks etc.), with orography filtered at 3dx.
- Vertical resolution: kept at 87 levels.

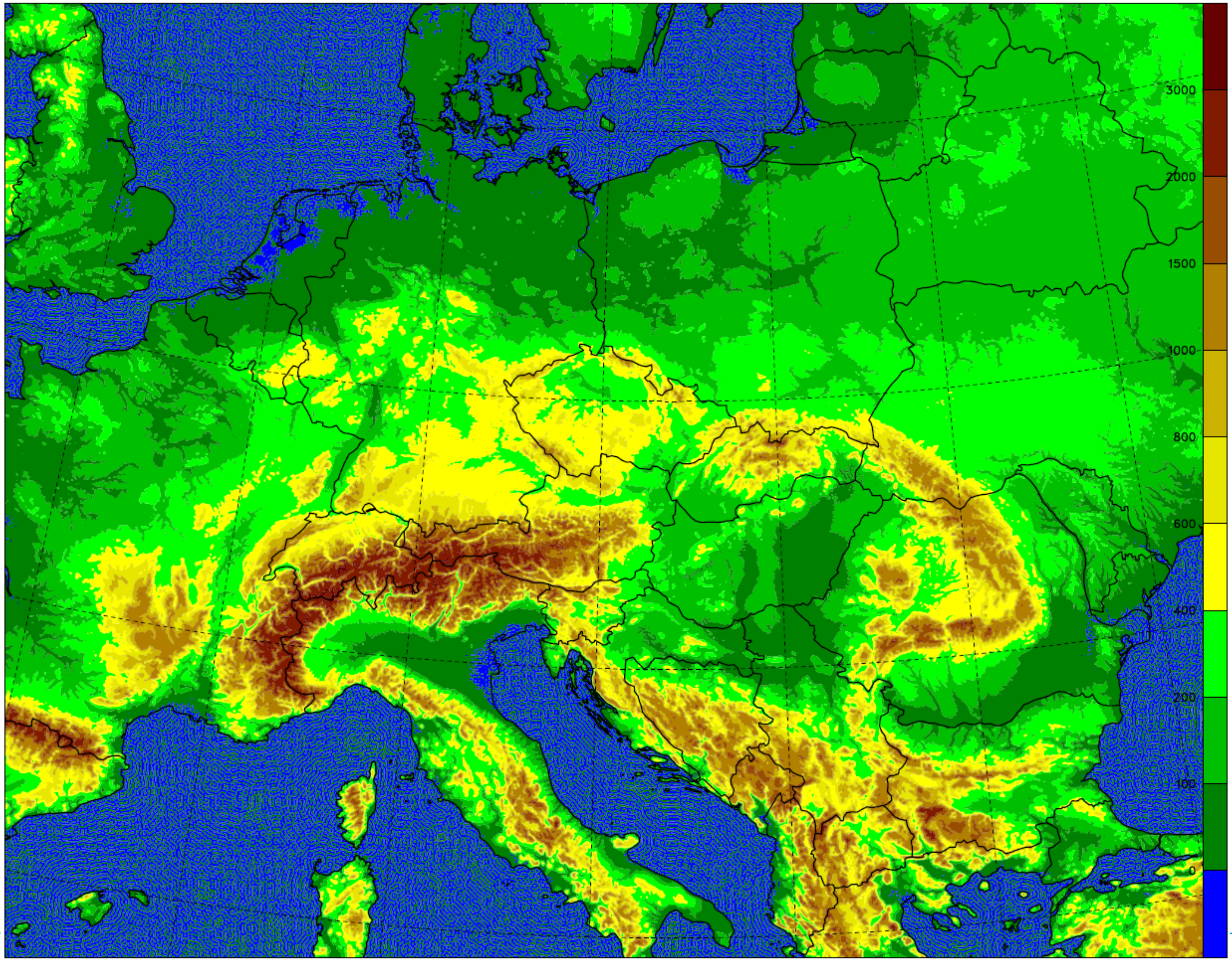
Climate files set-up

- Importance:
  - More precise orography, but:
    - Standard e923 procedure, adapted to ISBA, has on input the old database gtopo30, which for high resolutions gets inappropriate.
  - Sub-grid-scale roughness determination:
    - Roughness is always sub-grid-scale;
    - Problem of various types of surface, e.g. snow;
  - Effects of still unresolved orography
    - Do we need the „gravity wave drag“ parameterization or not, or if yes, retuned?
  - ALARO coupled with SURFEX ?
    - The problem of the “gravity wave drag” parameterization family remains unsolved due to the file handlings (different names, units ….).
    - The question of roughness determination remains still open … investigations are ongoing.

Climate files setup – choices of compromise

- To get the new database for orography and land-sea-mask:
  - Run the preparation of the so-called PGD file, using new GMTED2010, and insert it into the e923 procedure.
- Father, thermal roughness should not be anymore put together with the mechanical one:
  - LZ0THER=.FALSE. in e923 => in the model you put LZ0HSREL=.TRUE. (adapted code by J. Mašek)
- Question of what to do with other tunings – reduction factor FACZ0 and smoothing it – NLISSZ. (The recommendation was to set FACZ0=1., NLISSZ=1). Tests were done and we keep:
  - FACZ0=0.53 (this reduction has the highest impact)
  - NLISSZ=3

Domain how it looks like

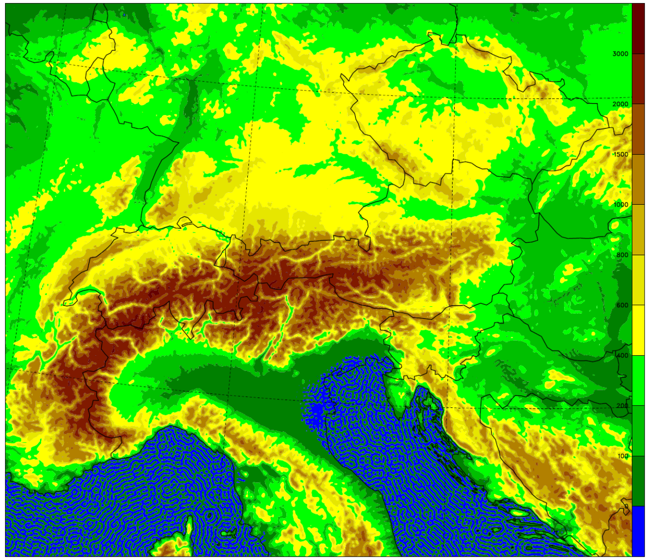


Blending truncation

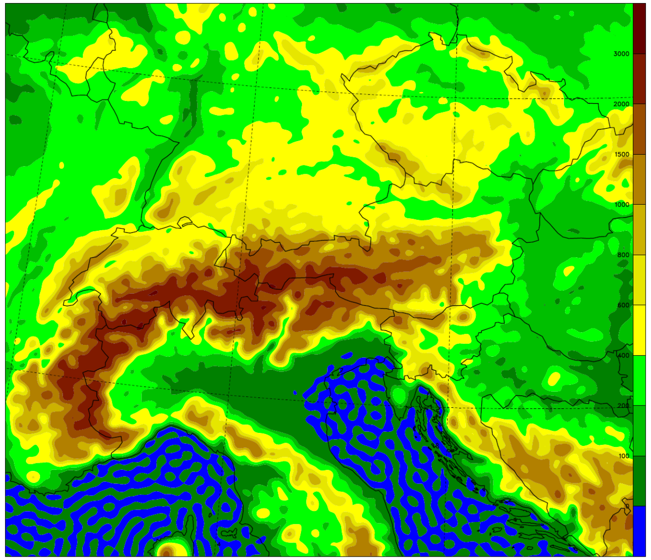
Standard cook book was applied. Resulting cut-off truncation is 102 x 81 waves

How orography looks like – zoom over the Alps

truncation 360x288 ; 3dx



truncation 102x81; ekvivalent of ARPEGE analysis



Search for the dynamics setup (1)

- In Non-Hydrostatic dynamics – we go back to finite differences for vertical discretization;
- Time discretization:
  - Use of NSITER=2 looked promising, allowing for even 120s, but … winter (January 2017) cases was too severe: many Semi-Lagrangian trajectory underground cases;
  - Keeping NSITER=2 with shorter time-step would have been nice, but too expensive for the operational target.
  - Finally, for the time scheme, we stay with: NSITER=1, dt=90s.

- Although in winter there is a very strong polar jet, we do not need any spectral nudging to ARPEGE (coupling model) nearby the model top. These strong Christmas jets may require our attention still, e.g. for the set-up of vertical levels.

Search for the dynamics setup (2)

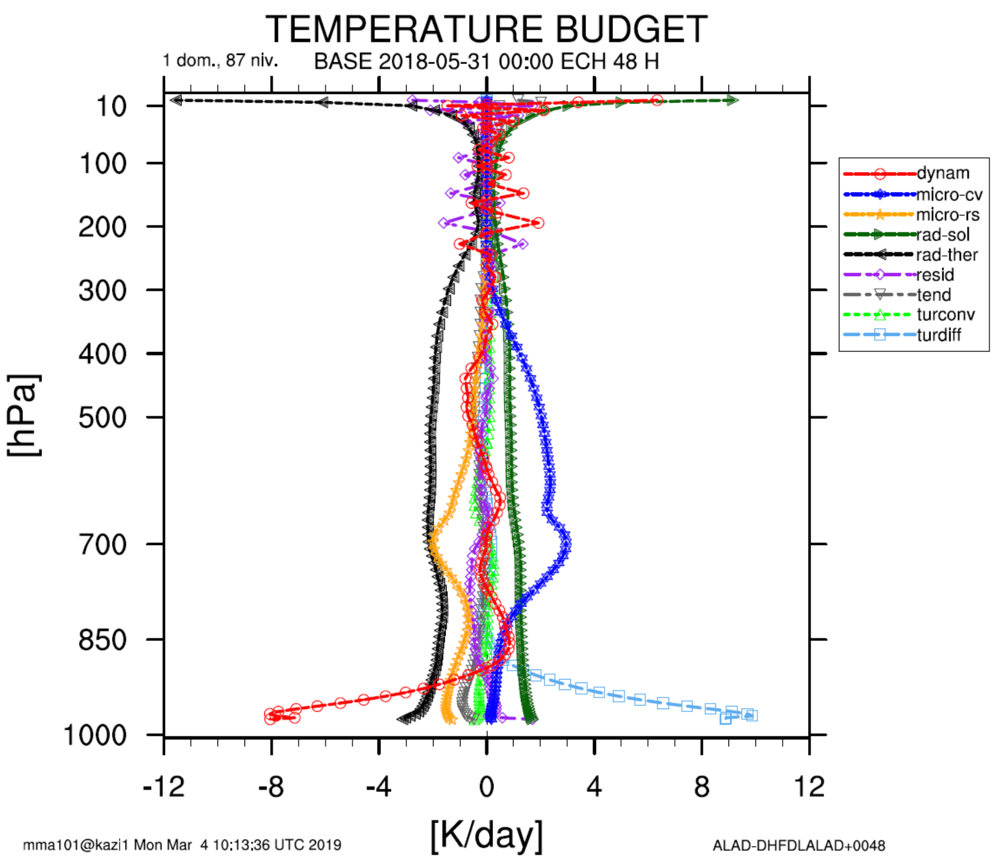
- Other two important issues:
- Search for ***semi-Lagrangian trajectories***;
  - In mountain areas the iterative computation has worse convergence in general;
  - At higher resolution with steeper orography we increased the number of iterations to NITMP=4
- Tests for the best tuning of ***horizontal diffusion*** – we have mixture of the spectral and SLHD.
  - We re-tuned mainly the spectral diffusion acting toward higher atmosphere;
  - We tried also AROME spectral diffusion but this choice yields worse scores.
- Comprehensive report on new dynamics set-up and more detailed presentation is done by Petra

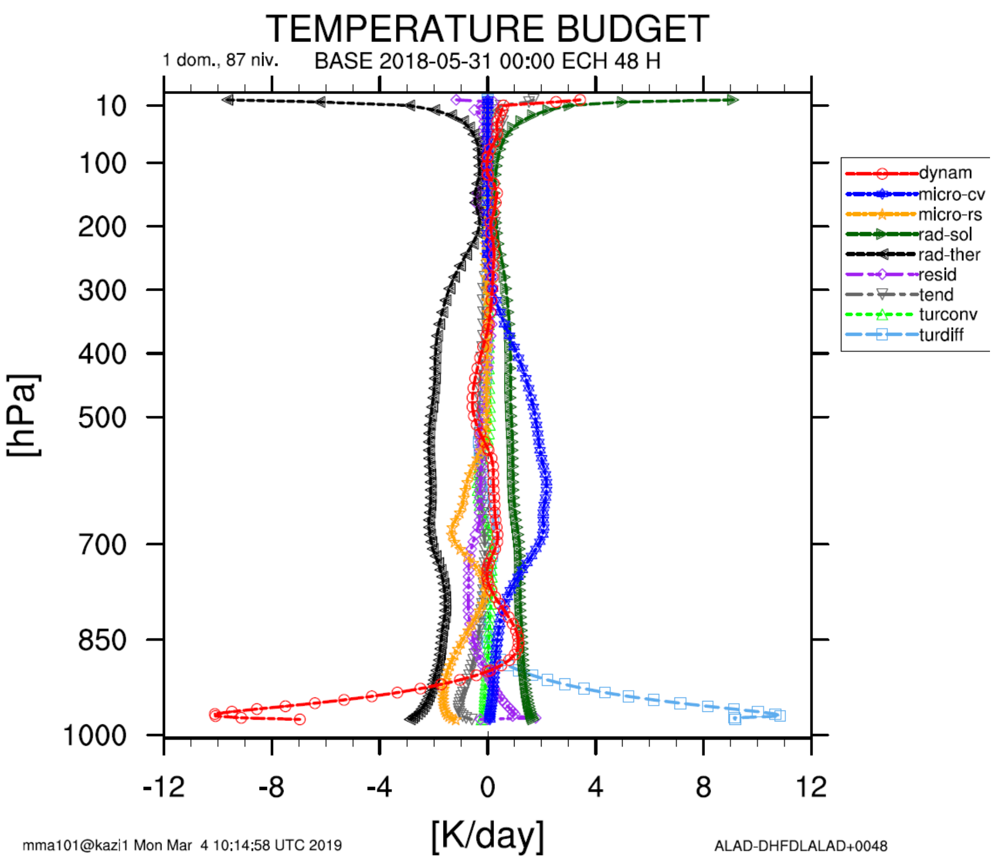
One unexpected DDH result (1)

- In ALARO we still use the “old” DDH (“flexdia” does not work for OpenMP parallelization);
- Results were changing for the enthalpy (temperature) budget with different number of nodes, MPI tasks etc …. empirically we found we have to set LSPLIT=.FALSE. in the MPI parallelization setup;
- Going from Vertical Finite Elements back to the Finite Differences vertical discretization due to NH, we got rid of a strangely looking mode in the enthalpy budget in the stratosphere. Origin has not been found yet; a suspicion is an excited Lorenz grid mode, which is not seen in the vertical integral of geopotential. We reported this finding to MF colleagues.

One unexpected DDH result (2)

- Enthalpy budget; left: run with VFE; right: run with FD





Parameterizations

- Key ones:
  - Gravity wave drag: to keep or not, and if yes, how to tune it?
  - Roughness parameterization – work of Ján (presented last year);
  - Cloudiness as input for radiation – the “resolved” cloudiness is not unified yet with the thermodynamic adjustment. Necessity of retuning – scale awareness.
- Slight retuning:
  - Updraft closure modulation in 3MT: RMULACVG= 5.5 (grey zone limit pushed further to finer resolutions);
  - Downdraft effectivity coefficient is lowered GDDEVF=0.043

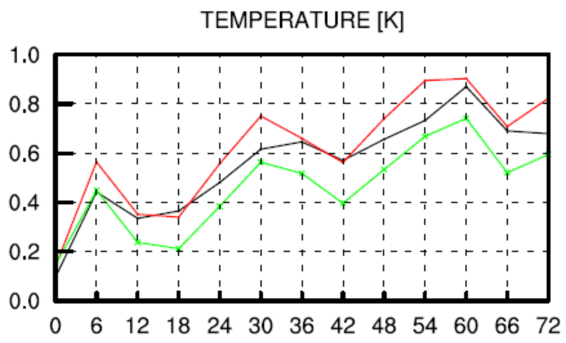
Unresolved mountain effects

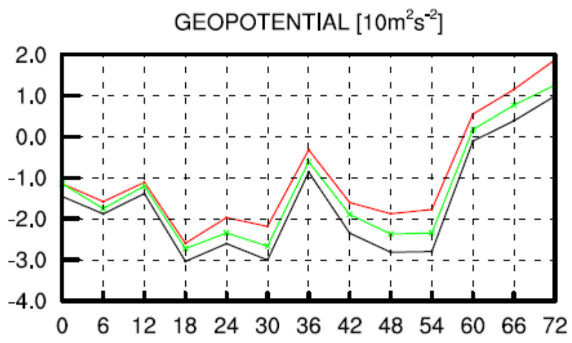
- Under the generic “gravity wave drag” scheme (switch LGWD), there are three parameterizations of unresolved orography effect (still bigger obstacles than just local ones to be seen as roughness by turbulence):
  - Gravity wave drag – acts in the opposite direction to low level wind; flow splits to parts going above and around mountain. Surface drag is enhanced and stratospheric deposition is done following Lindzen method;
  - Form drag – it also acts in the opposite direction to low level wind going around the mountain; deposition happens between surface and characteristic mountain height;
  - Lift – it acts in the orthogonal direction of geostrophic wind. Its effect should preserve potential vorticity of the flow perturbed by unresolved mountains.
- Physiography inputs: variance, direction and anisotropy of still sub-grid scale orography.
- Higher resolution – lower variance and the parameterizations should act less.
- Belief – below 5km resolution these can be switched off. However, practical results at 2.3km resolution do not completely support this.

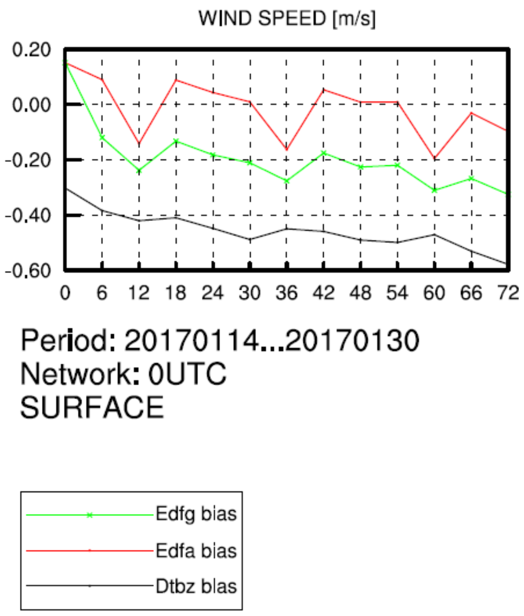
Gravity wave drag results

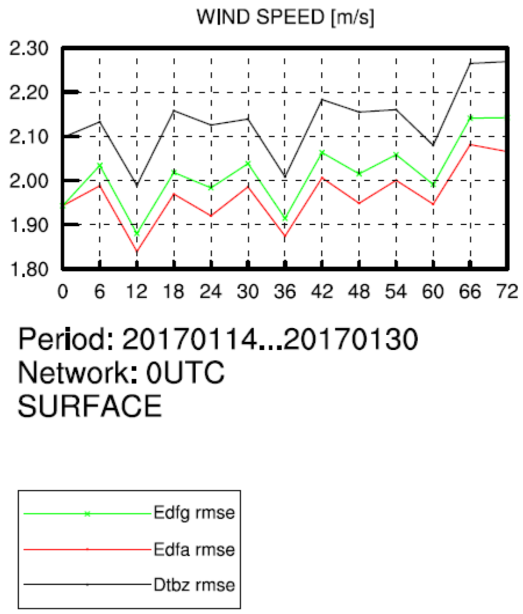
- When off: experiment DFA w.rt. TBZ (reference at 4.7km), surface gets warmer. Bias at PBL top (next slide) are OK but random error gets worse.
- When on: experiment DFG, it cools the surface and warms the PBL top.
- A compromise tuning had to be found.

Bias of temperature and geopotential at surface



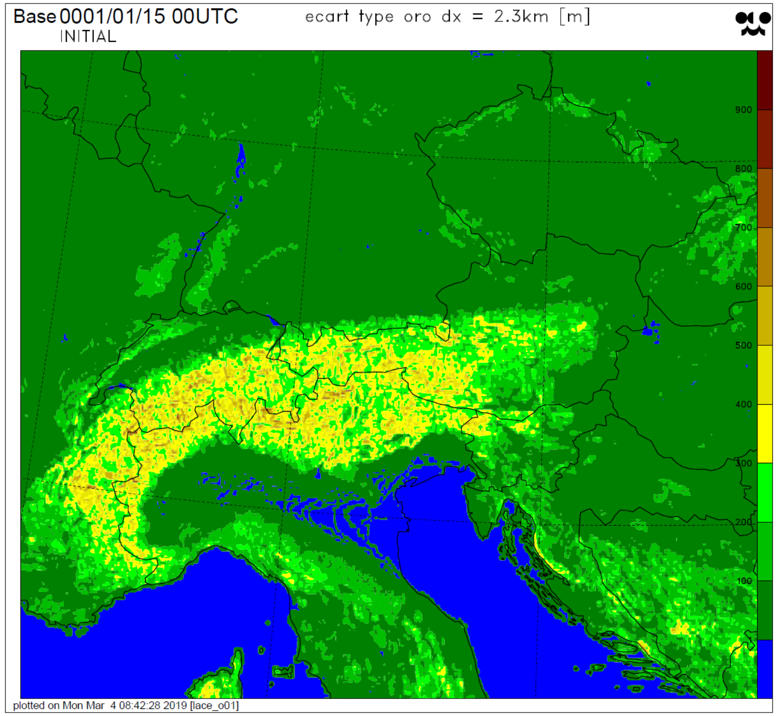


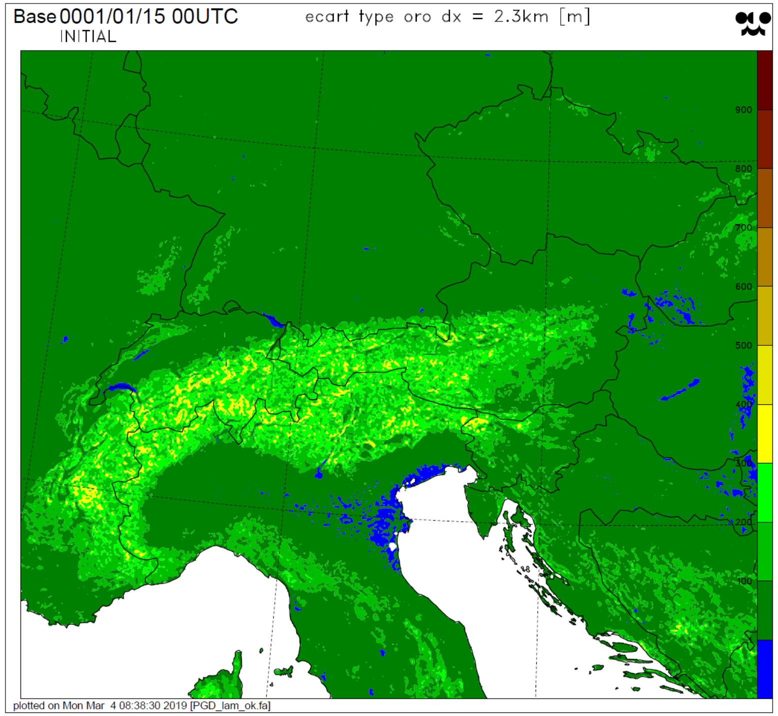




Gravity wave drag – still to do

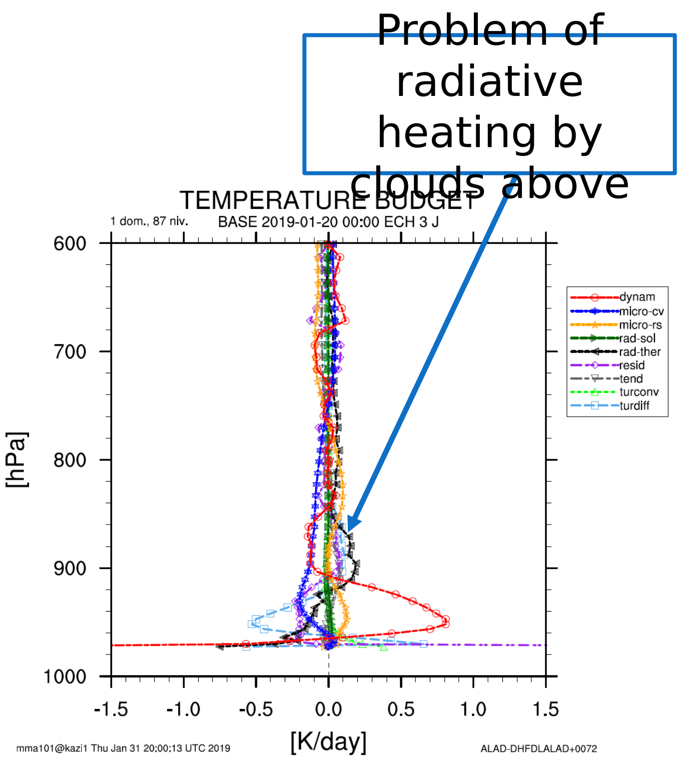
- Current procedure e923 is not adapted yet on its input to give variance, anisotropy and direction of unresolved orography from a better database.
- The required fields could be taken from the PGD result after verification.
- Example of orography variance is given below; left – result from gtopo30; right – result from gmted2010 by PGD (over sea values are 10E+20! ….SURFEX way to set unused points)





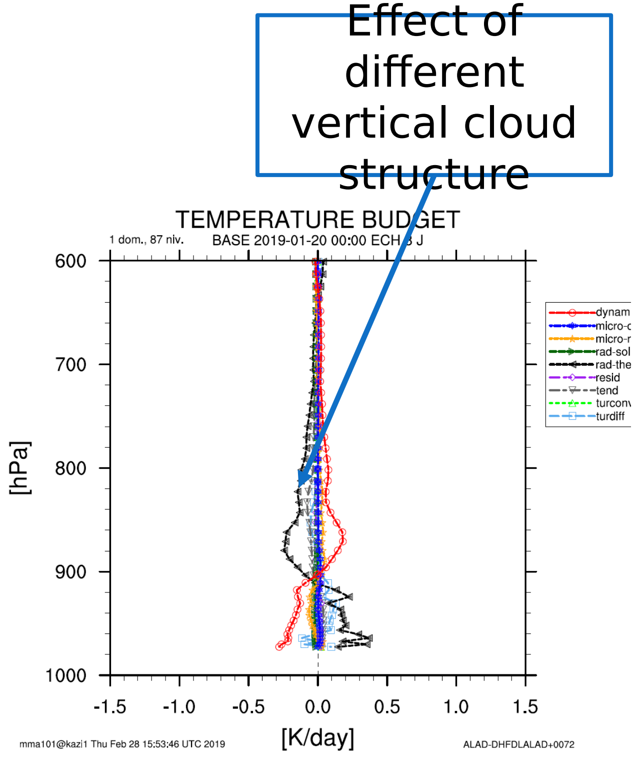
Cloudiness for radiation

- Lack of cloudiness in winter – even less at high resolution in the first tests, especially in day time;
- Adding more cloudiness – yes, but in the way to get the radiative answer correct.



Left – detected problem of too much cloudiness in mid levels.
Right – corrected cloudiness profile.

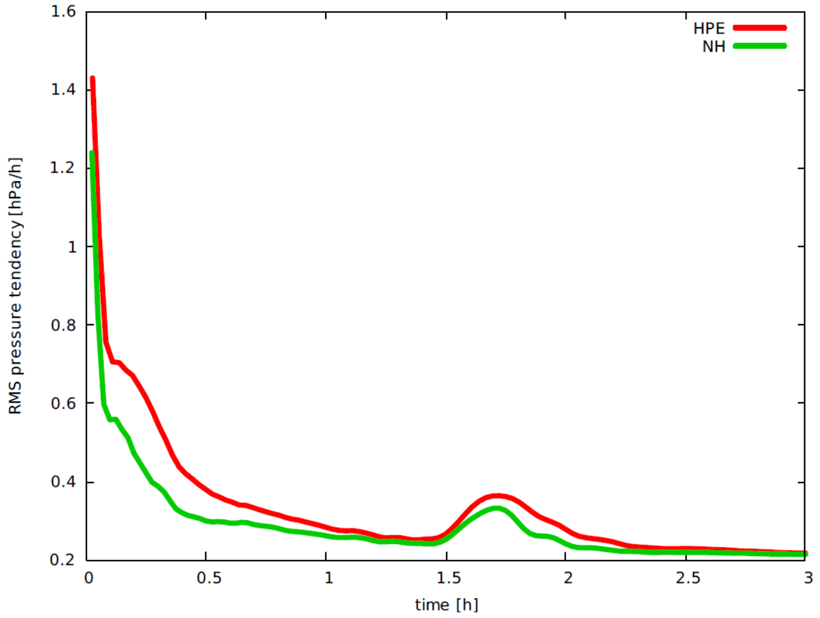
Final tunings for 2.3km:
LQXRTGH=.F. (no asymptotic modulation of RH), HUCREDRA=0.33 (mimicking dx dependency of HUC), QSSC=800. (more sub-inversion clouds), RPHI0=600. (less radiative cooling clouds).



Going to the cycling …

- Spin-up check;
  - Quite smoother in NH case;

- Should we use NH or HPE (cheaper) in the low resolution digital filtering (blending) jobs?
  - Keeping NH leads to better results.



Data assimilation

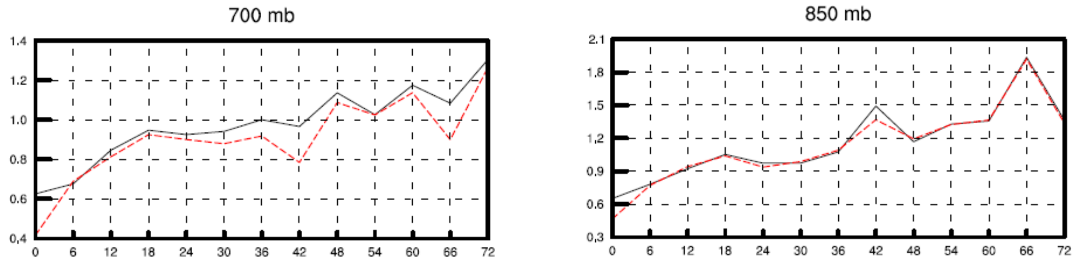
- Surface analysis – CANARI setup is without change;
- BlendVAR – first runs including 3DVAR have shown deterioration of humidity scores in the altitude – 250 hPa; cause – new B matrix, or better say the period for which the B matrix statistics were taken.

  - Retuning of the relevant satellite channel sigma_o
  - Retuning of the REDNMC (now 0.5)

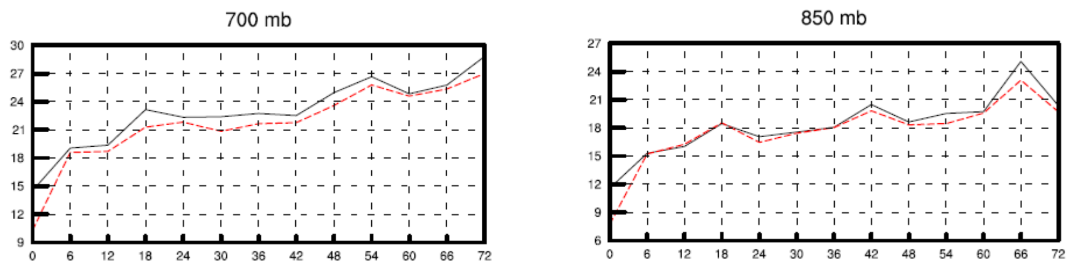
- Later it is planned to re-compute the B matrix and to refine the tunings.
- Other things like speed of convergence etc. did not show anything specific due to the resolution change.

Summer cases and scores

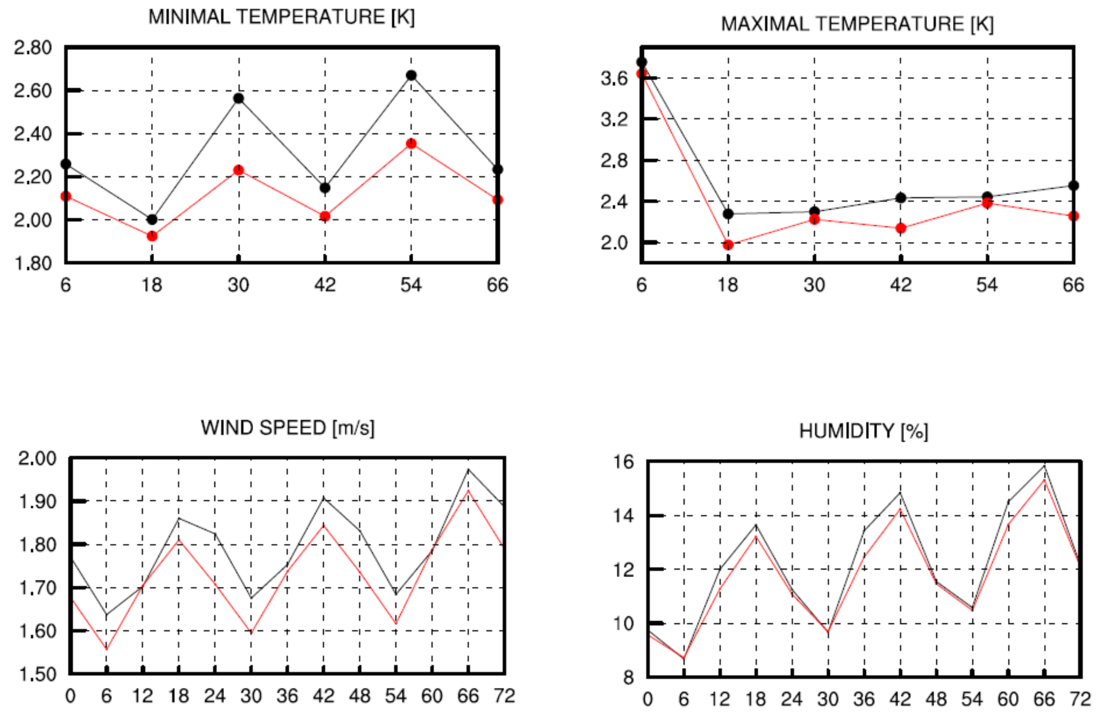
- Testing period was the second half of May 2018, from 14/05 to 31/05



Temperature RMSE

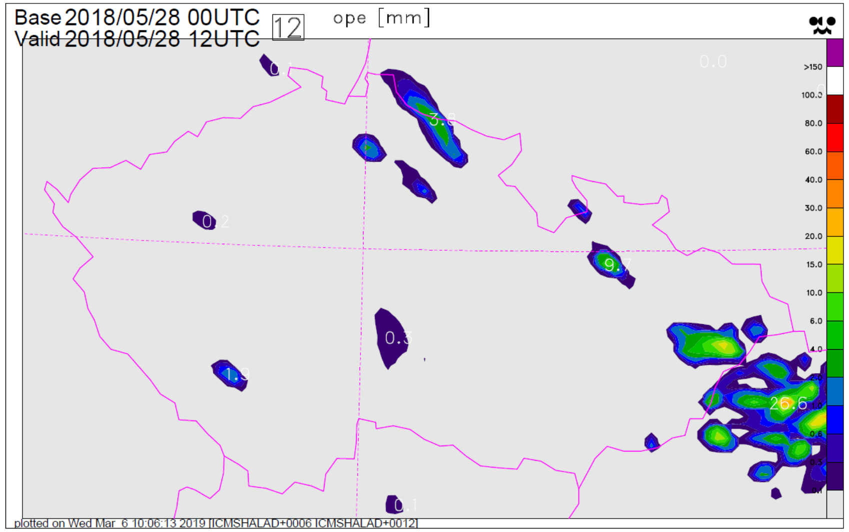


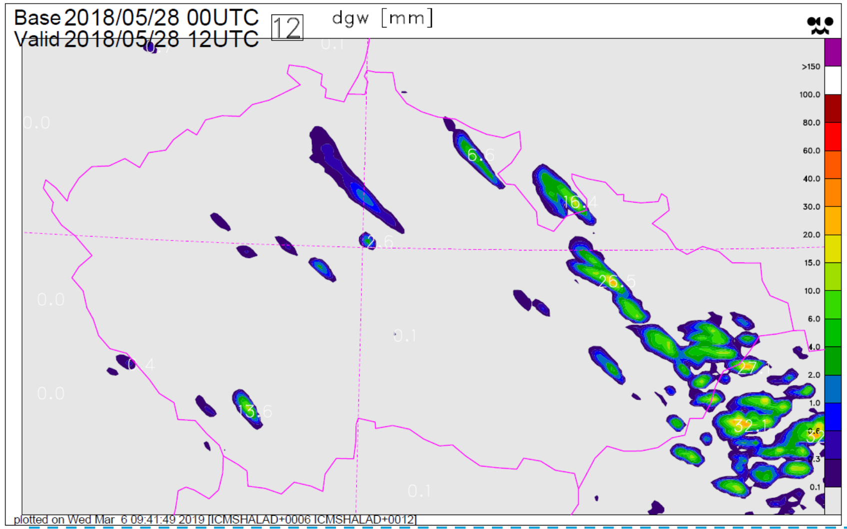
Relative humidity RMSE



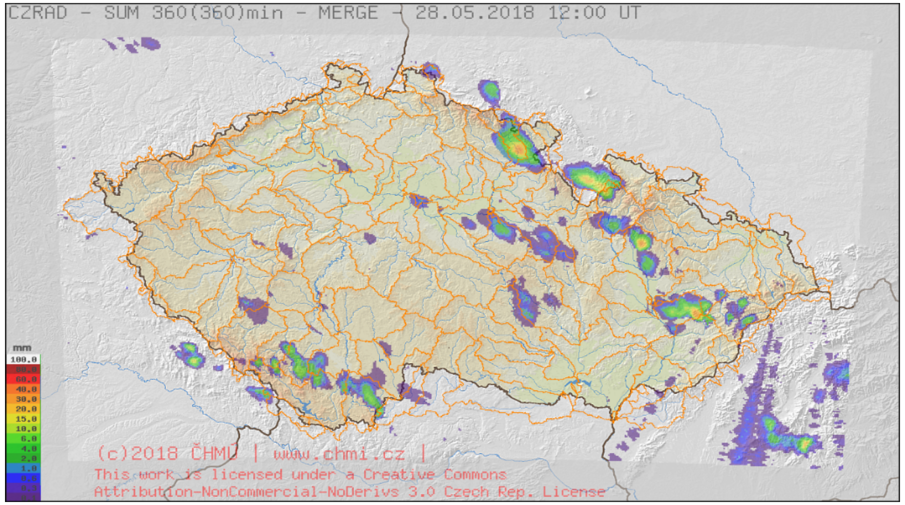
Surface RMSE scores

Summer cases and scores (2)



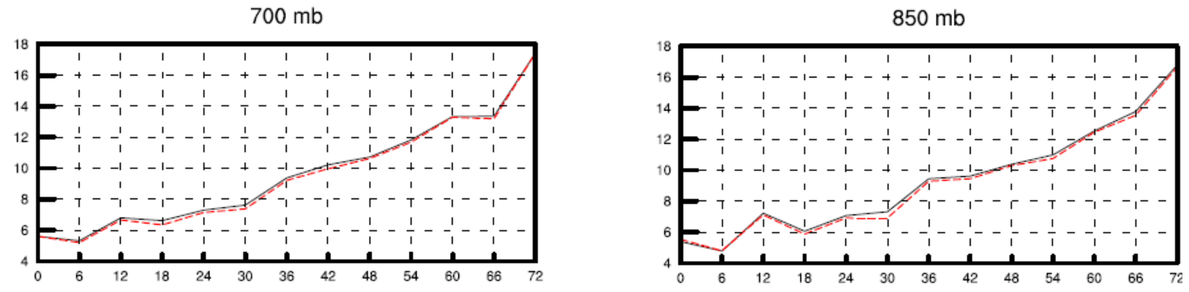


- 6h sum precipitation forecast at 4.7km (upper picture) and 2.3km (below) for 28/05/2018 at 12h UTC.
- It is a difficult case to capture the convection onset and location. High resolution run is clearly better.

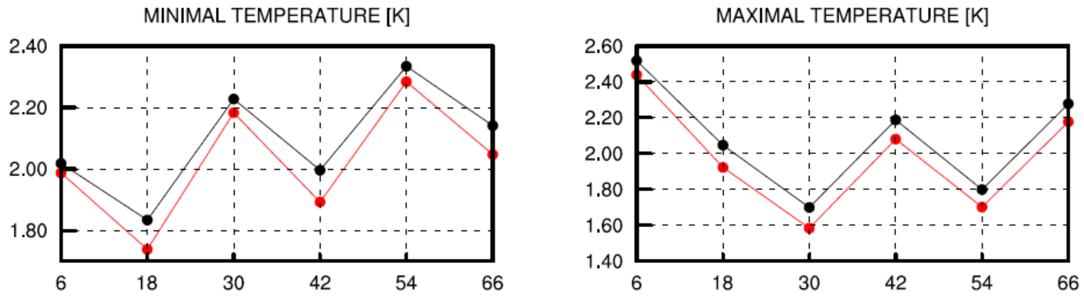


Winter scores

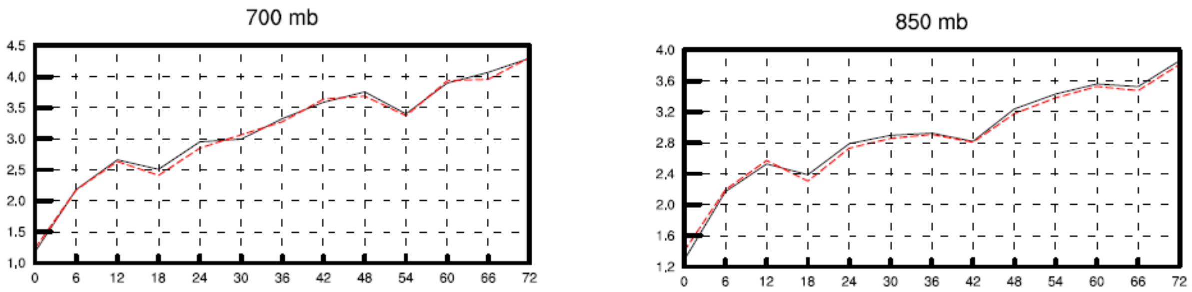
- Testing period was from 10 January to 21 February 2019



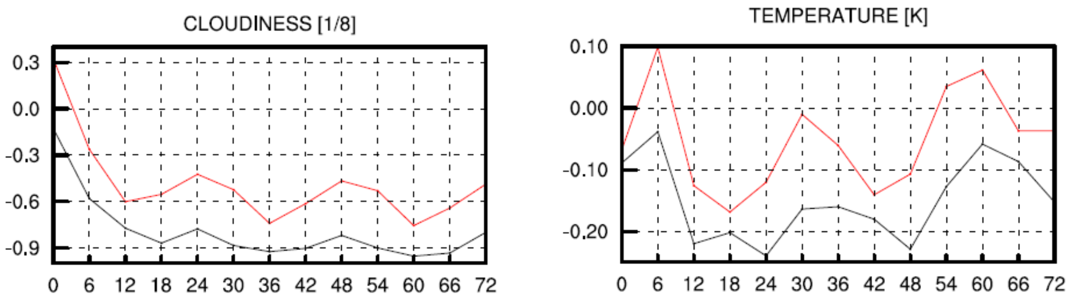
Geopotential RMSE



Surface RMSE scores



Wind speed RMSE



Surface BIAS scores

Conclusions and outlook

- When going to higher resolution, the majority of work was about the physiographic data and their impact on the forecast;
  - Orography;
  - Sub-grid-scale orography characteristics – gravity wave drag, form drag and mountain lift parameterizations: what a pity that the e923 procedure is not adapted to work with GMTED2010 database, at least for this!
  - Roughness lengths computations are affected as well by the orographic input.
- Switching to the NH dynamics needed an adequate attention;
- More in depth tuning was required where multi-scale treatment have been too short, e.g. the cloud scheme for radiation;
- Next important step is the work on ALARO with SURFEX.