Regional Cooperation for Limited Area Modeling in Central Europe

LACE

nwp central europe

ALARO at high resolution - setup and results

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Specifications

- Horizontal Resolution: 4.7 km => 2.3 km
  - Preserving the domain size.
  - 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, with orography filtered at 3dx.
- Vertical resolution: kept at 87 levels.

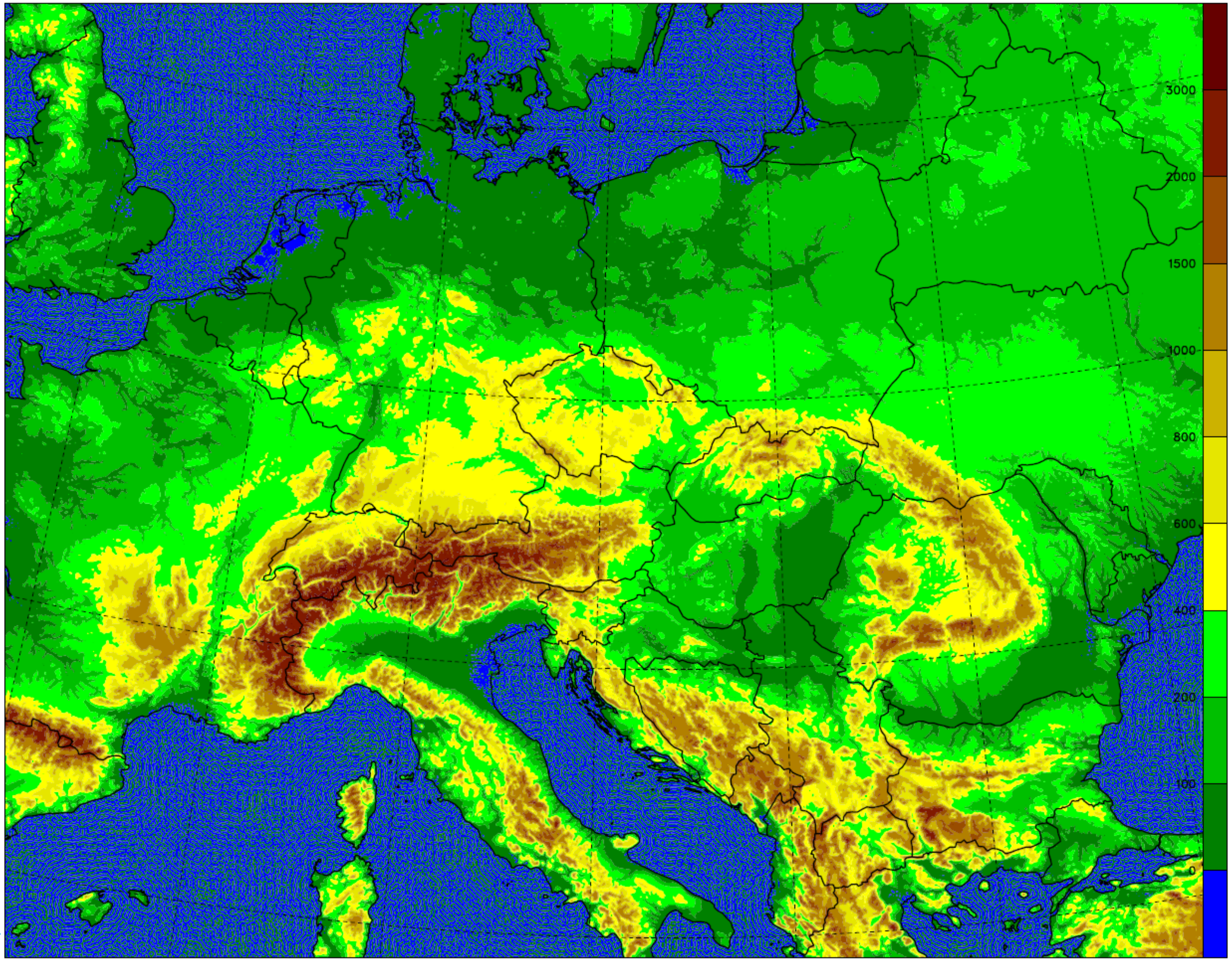
Climate files set-up

- 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?

Climate files setup - choices

- To get the new database for orography:
  - 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 JM)
- Question of what to do with other tunings – reduction factor FACZ0 and smoothing it – NLISSZ. (Francoise was recommending FACZ0=1., NLISSZ=1). Tests were done and we keep:
  - FACZ0=0.53 (this has the highest impact)
  - NLISSZ=3

Domain how it looks like

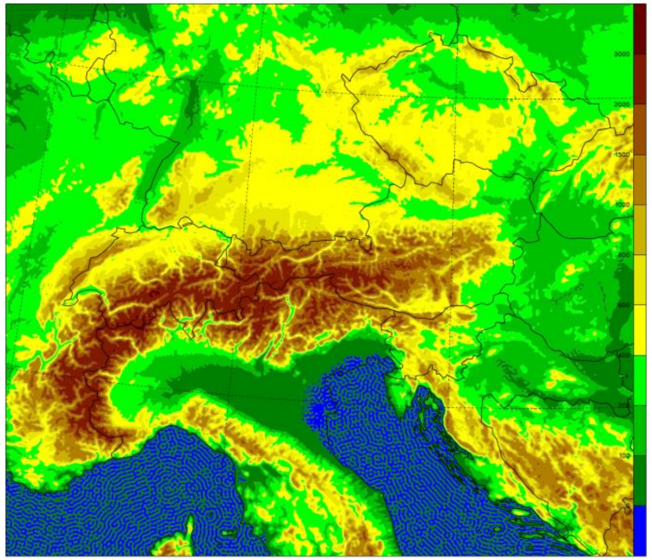


Blending truncation

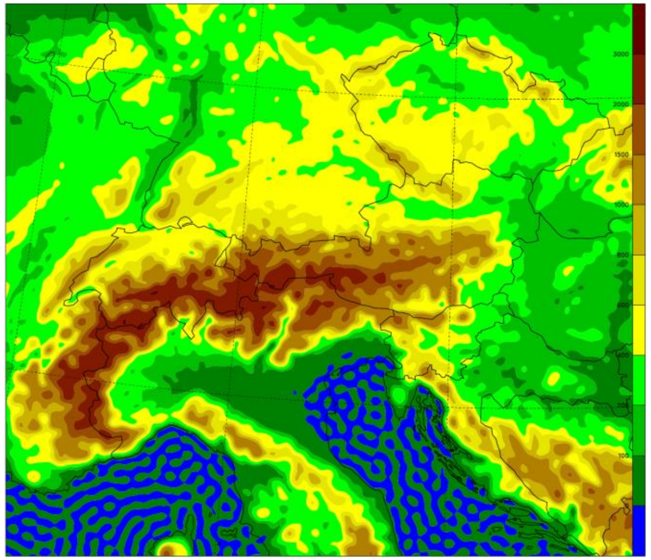
Standard cook book was applied. Resulting cut-off truncation is 102 x 81 waves

How orography looks like – zoom over the Alps

truncation 360x288 ; 3dx



truncation 102x81; ekvivalent of ARPEGE analysis



First runs and problems

- Dynamical adaptation from ARPEGE coupling files:
  - Beginning of the integration quite unstable, for time-steps which should be normally holding.
  - Necessity of running DFI on the INIT file with a reduced time-step; then OK.
  - Question: would it get better in the cycling?
  - Inspection of the AROME/France operational namelists for presence of any DFI and/or lancelot:
    - Discovery of the **LESCALE_U=.FALSE.** in LANCELOT; this is in the part of the vertical geometry changing (APACHE treatment of PBL layer).
    - This switch means that the PBL wind shape is not kept when changing the vertical geometry – orography and vertical levels; Likely it was producing wind field with high divergence values and consequent important time tendencies/oscillations of divergence.
  - Setting the switch **LESCALE_U=.FALSE.** in LANCELOT solved this problem.

First runs and problems

- Testing starts on the period of January 2017.
  - In the first half of the month we get strong North-West flow, snow showers, etc.
  - In the end of the month we get inversion type of weather over Central Europe.
- First upper air scores are not good;
  - We verify first HPE vs NH – also HPE does not perform well;
  - We still search the optimal setup of NH, like NSITER, time-step length, vs affordable cost. Obviously we have to look also to the horizontal diffusion tunings.
  - First discovery: at high resolution we must increase the number of iterations to search the origin point of S.-L. trajectory. Finally we shall set NITMP=4

Long search for the dynamics setup

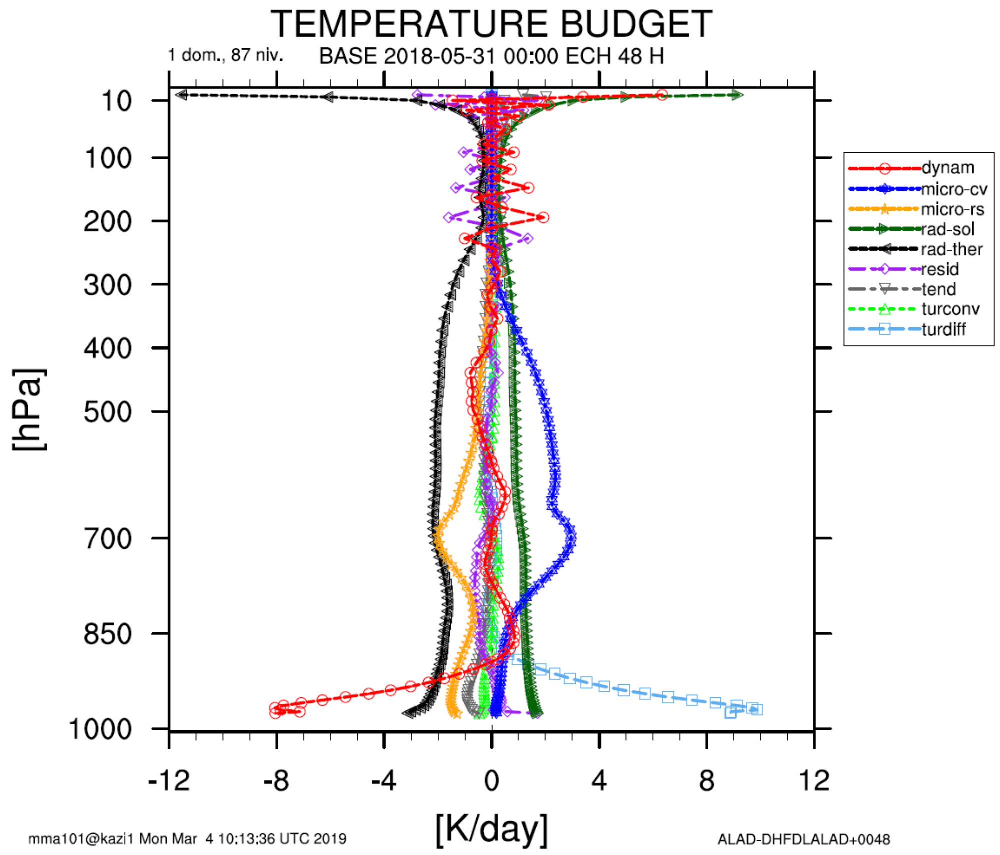
- In NH – we go back to finite differences
- Use of NSITER=2 looked promising, allowing for even 120s, but … the 4th January 2017 case was too severe: many Semi-Lag trajectory underground cases;
- Keeping NSITER=2 with shorter time-step would have been nice, but too expensive for the operational target.
- Finally, we stay with: NSITER=1, dt=90s.
- Tests for the best tuning of horizontal diffusion – we have mixture of the spectral and SLHD. We tried also AROME spectral diffusion but this yields worse scores.
- Comprehensive report and presentation of Petra

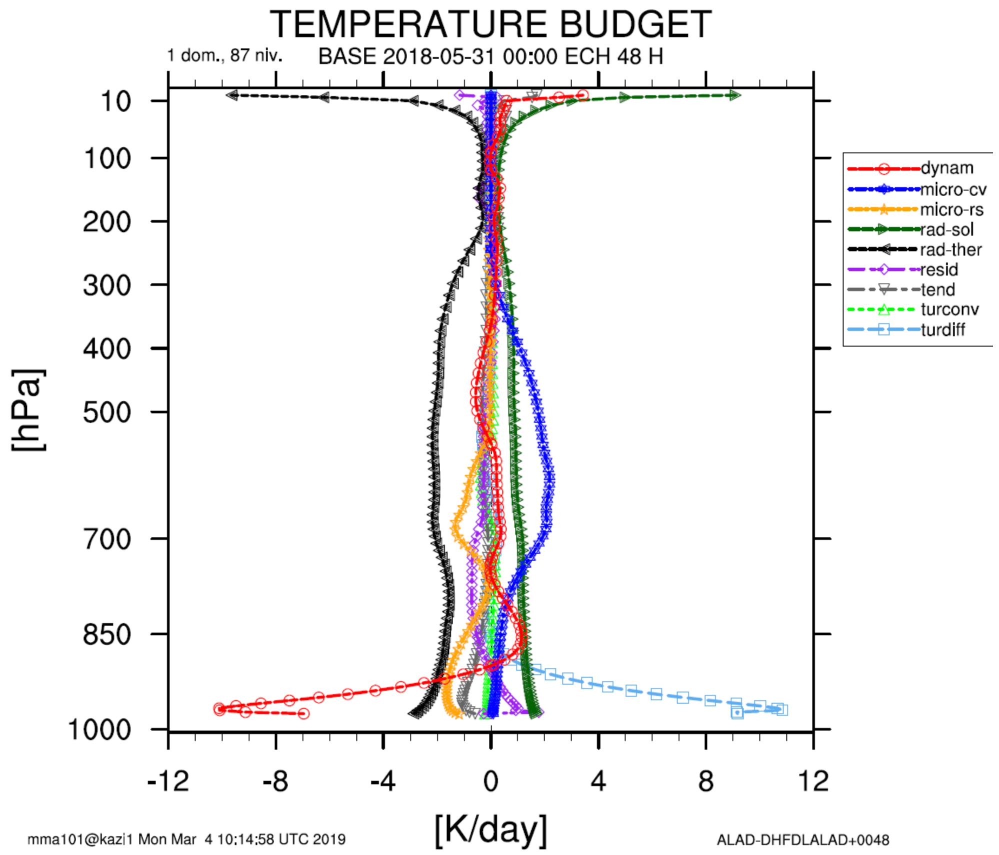
One unexpected DDH result (1)

- 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

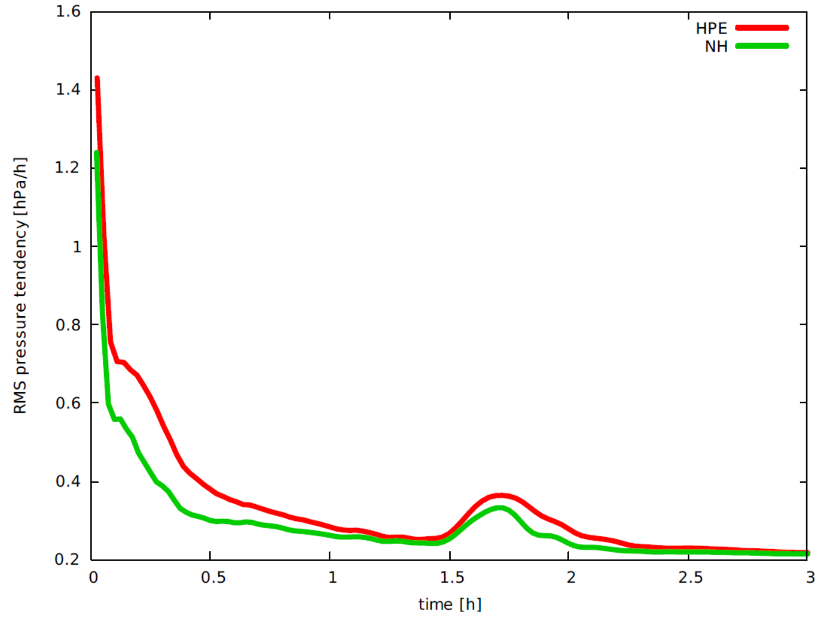




Going to the cycling …

- 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.



Parameterizations

- Key ones:
  - Gravity wave drag: to keep or not, and if yes, how to tune it?
  - Roughness parameterization – work of Ján
  - Cloudiness scheme – attempt to go along the unification path: no conclusive yet, subject to the retuning.
- Slight retuning:
  - Updraft closure modulation in 3MT: RMULACVG= 5.5 (grey zone end at 1000m); downdraft effectivity coefficient is lowered GDDEVF=0.043

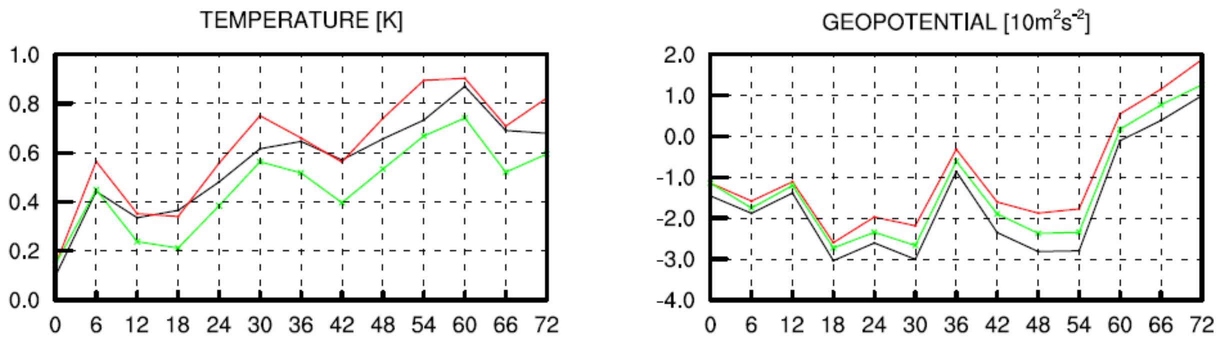
Unresolved mountain effects

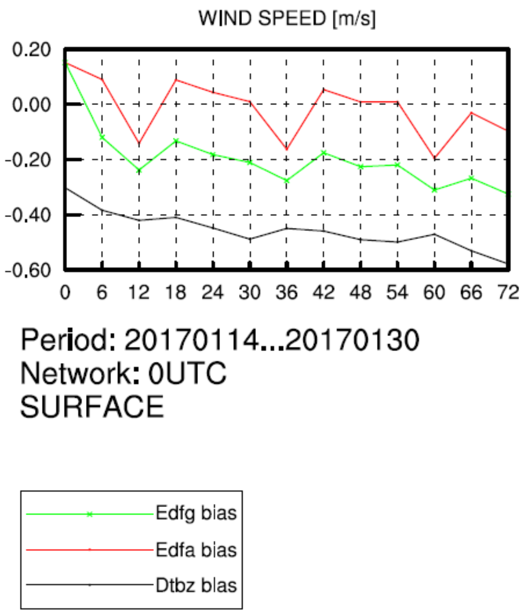
- Under the generic "gravity wave drag" scheme (switch LGWD), there are three parameterizations of unresolved orography effect (still bigger obstacles than just local ones to be seen as roughness by turbulence):
  - Gravity wave drag – acts in the opposite direction to low level wind; flow splits to 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.

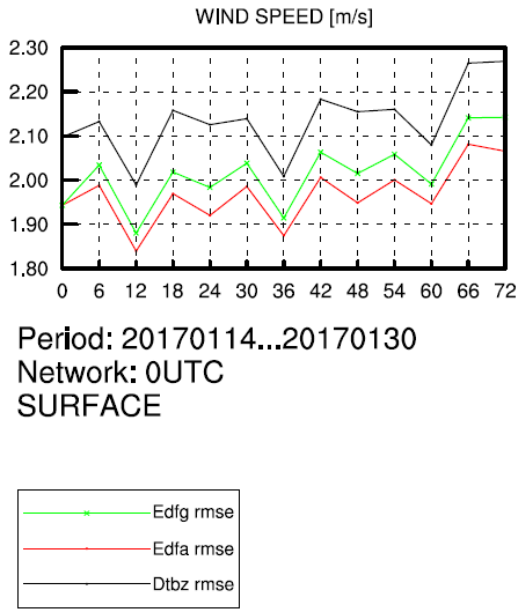
Gravity wave drag results (1)

- 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.

Bias of temperature and geopotential at surface

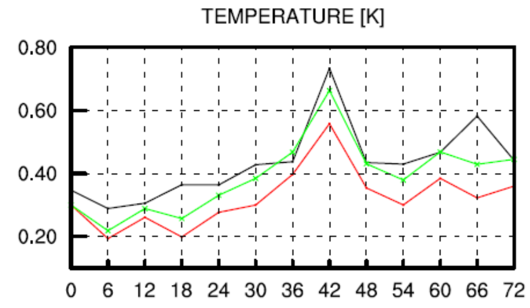


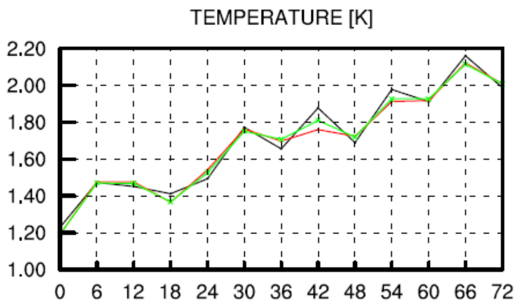


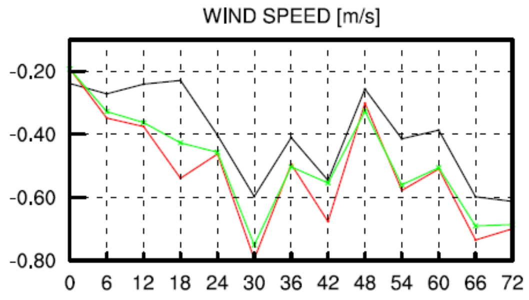


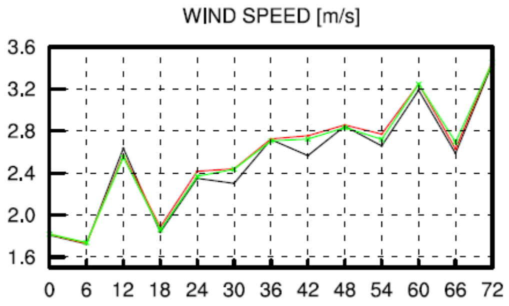
Gravity wave drag results - continuation

- 850 hPa – absence of drag leads to a bit worse wind scores in winter – we cannot win everywhere.





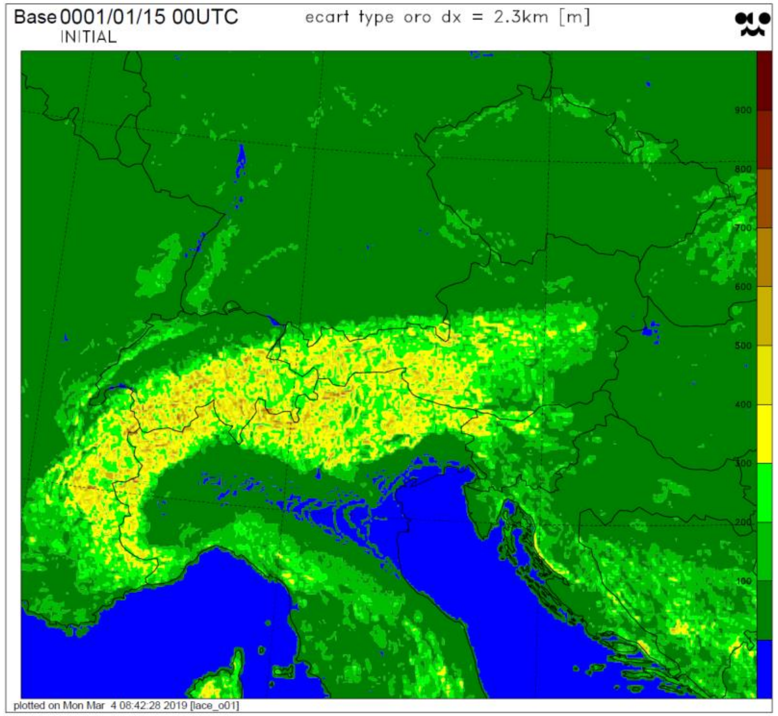


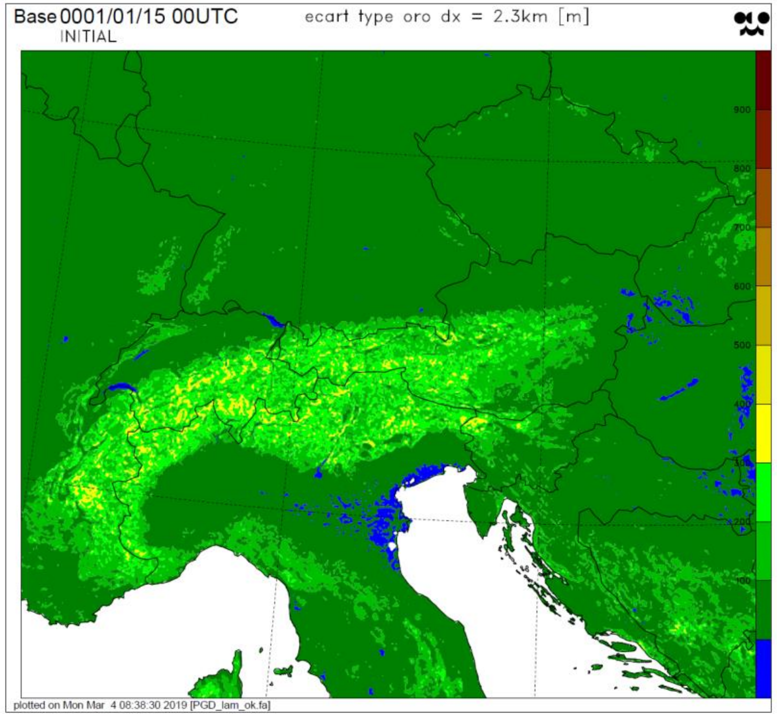


- A compromise tuning found:
  - LGWD and LGLT (lift) are .TRUE.
  - Form drag is reduced: GWDSE=0.005 (0.02 before); inspired by ARPEGE;
  - Lift coefficient is reduced: GWDLT=0.5 (1. before)

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

- Lack of cloudiness in winter – even less at high resolution, especially in day time.
- Adding more cloudiness – yes, but when done by a general tuning parameter, it increases already warm bias of T2m.
- First measure:
  - Compensation tuning of vegetation thermal inertia, making it lower and thus increasing the diurnal cycle amplitude, and adding a bit of snow fraction:
  - RCTVEG(3)=1.4E-05 (low vegetation), RCTVEG(4)=1.1E-05 (high vegetation), WCRIN=4. for snow fraction.
- Second measure:
  - It turned out necessary to re-assess the radiative cloudiness computation. See the presentation on cloud scheme.
  - 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).

Data assimilation

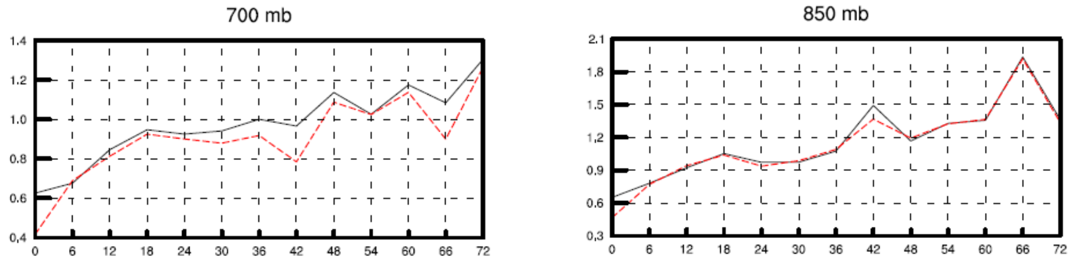
- Surface analysis – CANARI setup is without change;
- BlendVAR – first runs including 3DVAR have shown deterioration of humidity scores in the altitude – 250 hPa; cause – new B matrix, or better say the period for which the B matrix statistics were taken.

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

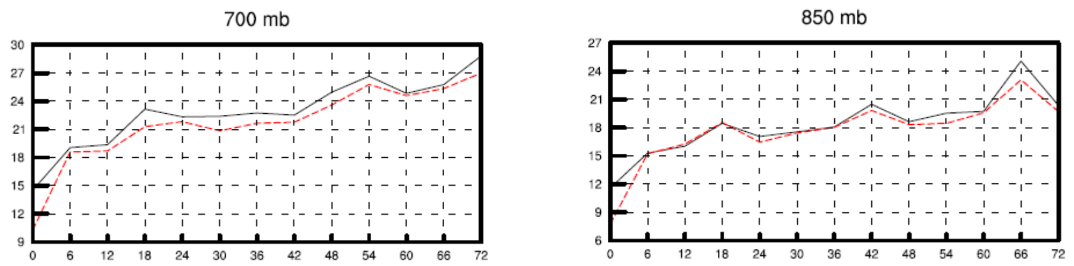
- Later it is planned to re-compute the B matrix and to refine the tunings.
- Other things like speed of convergence etc. did not show anything specific due to the resolution change.

Summer cases and scores

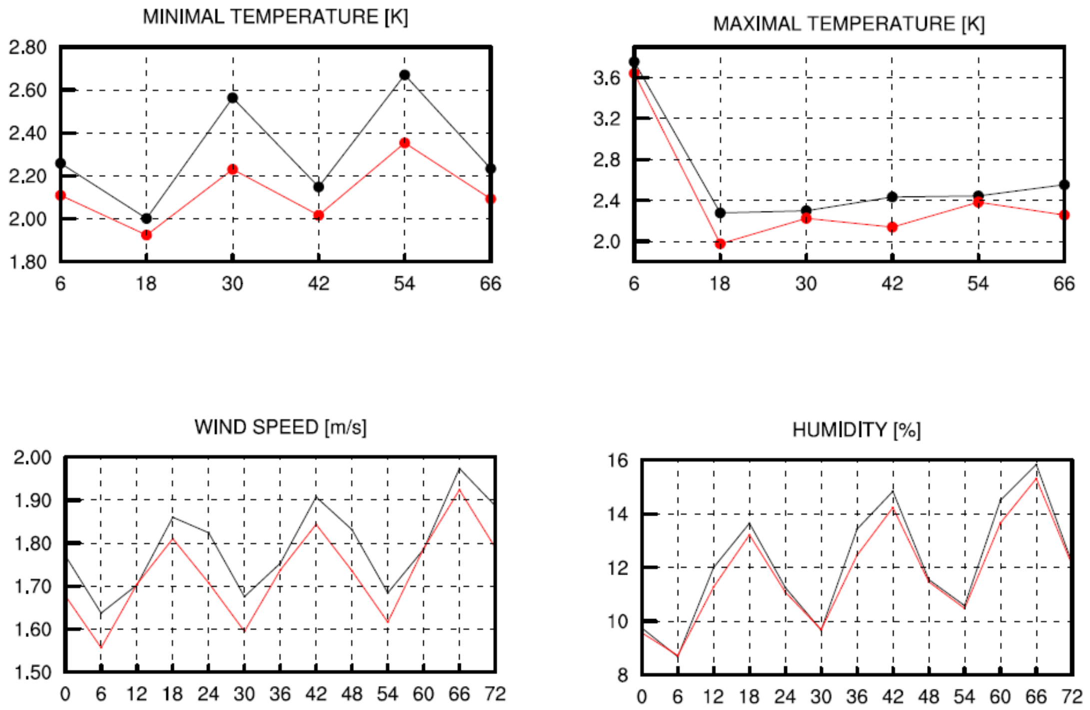
- Testing period was the second half of May 2018, from 14/05 to 31/05



Temperature RMSE

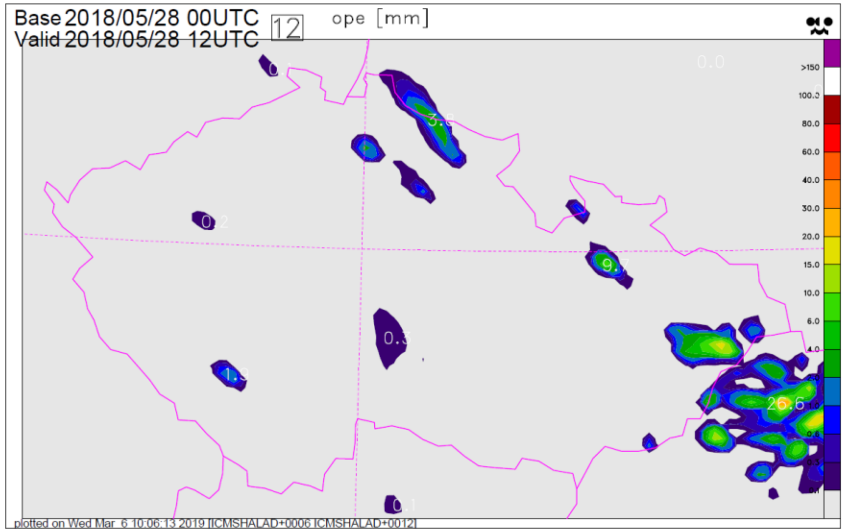


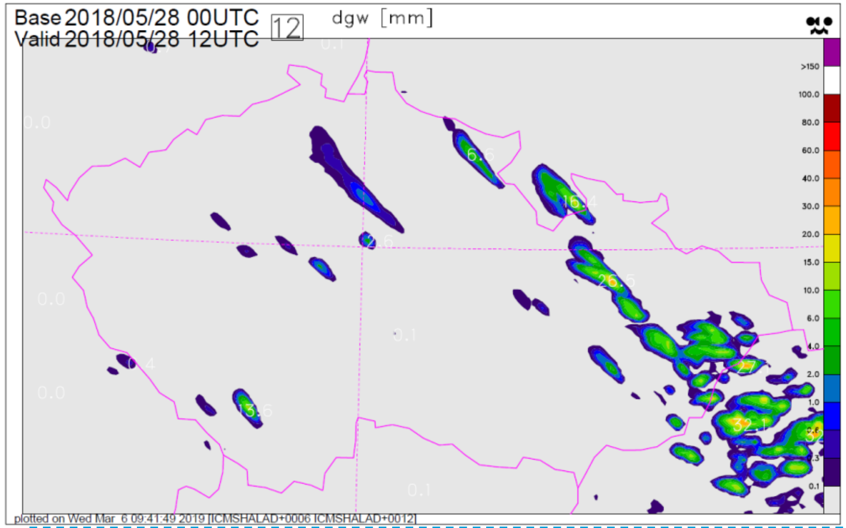
Relative humidity RMSE



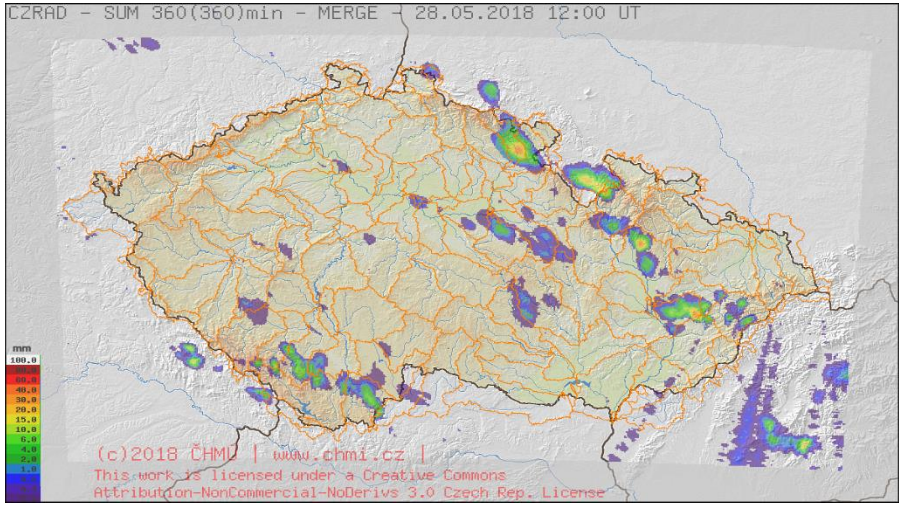
Surface RMSE scores

Summer cases and scores (2)



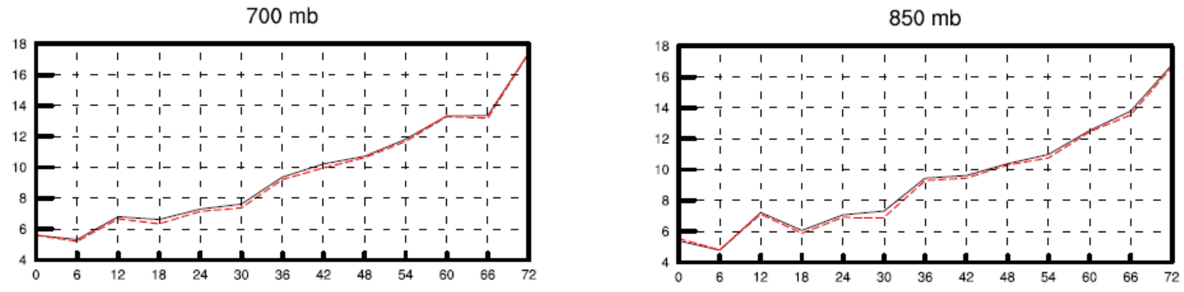


- 6h sum precipitation forecast at 4.7km (upper picture) and 2.3km (below) for 28/05/2018 at 12h UTC.
- It is a difficult case to capture the convection onset and location. High resolution run is clearly better.

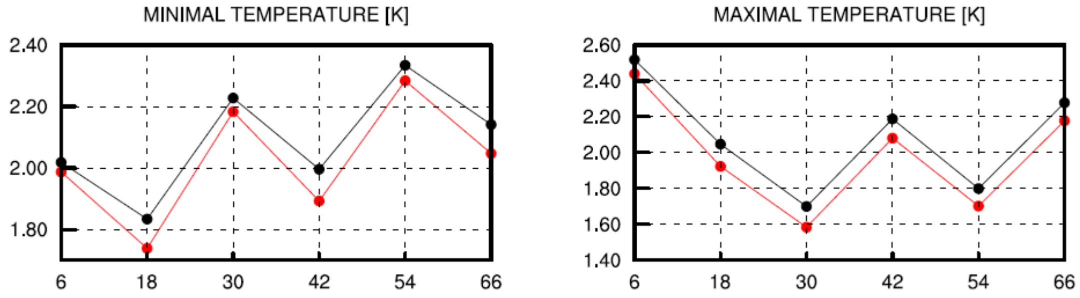


Winter scores

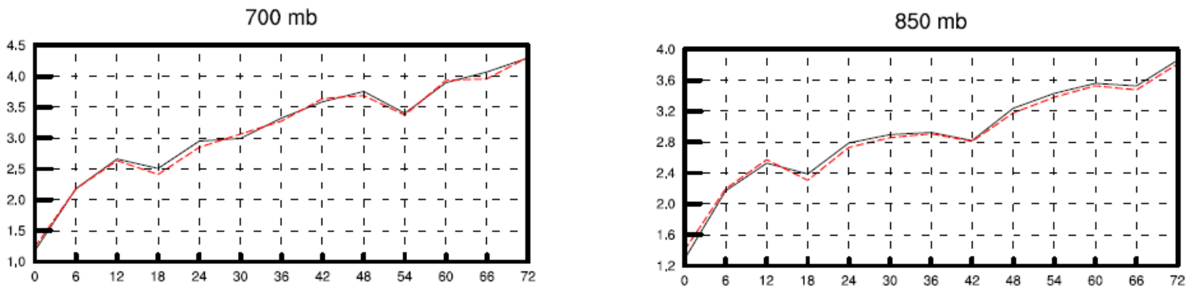
- Testing period was from 10 January to 21 February 2019



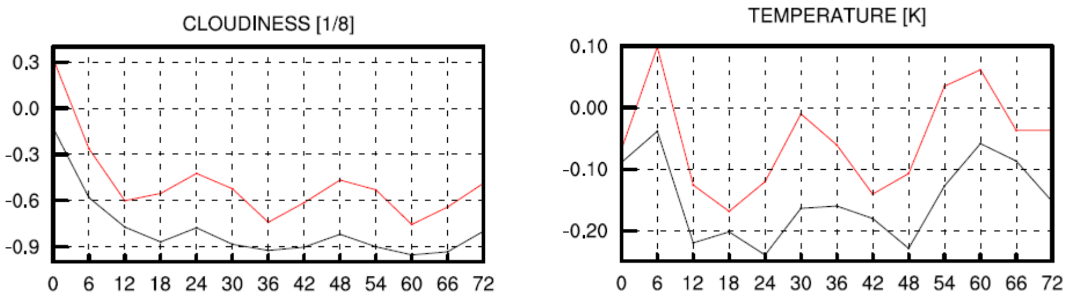
Geopotential RMSE



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.