7. Klaus STADLBACHER : "Systematic qualitative evaluation of high-resolution non-hydrostatic model"

Generalities

During the last months experiments with ALADIN Cycle 25 on different domains at high resolution were performed. On the one hand it has been tried to have a look at the influence of the use of a smoothed orography on the forecasted fields (for details see the last Newsletter), while on the other hand the focus has been put on identifying the advantages of the non-hydrostatic (NH) dynamics compared to the hydrostatic (HYD) one.

Details 1

Based on the previous promising results concerning the use of a smoother orography for improving the forecasted precipitation fields at high resolution domains, one question should be answered : How much relevant meteorological information is destroyed when the original orography (which has the same spectral truncation as the meteorological fields) is replaced by a smoother one, that represents a worse description of the shape of the real surface ? A general answer won’t be given here, cause this would probably require the calculation of standard verification scores, but nevertheless some hint can be found in the pictures 0 to 3. The domain is located in mountainous central Austria, the resolution is 2.5 km, the model was run with hydrostatic dynamics and coupled to the LACE model, and the shown case is taken from MAP-IOP 5. Figures 0a shows the "normal" orography (applying the Jerczinsky cost function), while in figure 0b the orography after smoothing with the additional spectral cost function is displayed. Figures 1a and 1b show the 24-hour forecast of the precipitation field using the orographies from Figs 0a and 0b, respectively. 6-hours accumulated precipitation amounts are displayed. It is evident, that the precipitation field in Fig. 1b (smoother orography) does not include that many and that extreme peaks like in Fig. 1a and using the smoothed orography generally gives a much more realistic precipitation field, that doesn’t include that "chaotic" orographically caused patterns, although the significant high amounts are not totally lost. In comparison to the mentioned positive impact on the precipitation field, Figs 2a-b as well as 3a-b show the 10m wind forecast and the 2m temperature forecast respectively, for the same time. Besides other parameters these two should be considered as very sensitive to the orography description in the model. The shape of the orography influences the wind field, while the height of the mountain itself has an additional impact on the 2m temperature. For the wind just very slight differences can be seen, but in general both fields look nearly identical. For the temperatures all basic structures, like e.g. the warmer Inn, Saalach and Salzach valley are kept (Fig. 3b), but smoothing the orography logically causes a smoother 2m temperature field, which doesn’t show that much small-scale variances as the original one (Fig. 3a).

The use of a smoother orography seems to make a lot of sense with high-resolution model runs, because of the remarkable positive impact on the strongly orographically affected forecasted precipitation fields and the fact that other near surface fields are not that much influenced to spoil the forecasts in a dramatic way. For this reason all further experiments on domains with high mountains are performed with a smoothed orography to make results more comparable to observations.

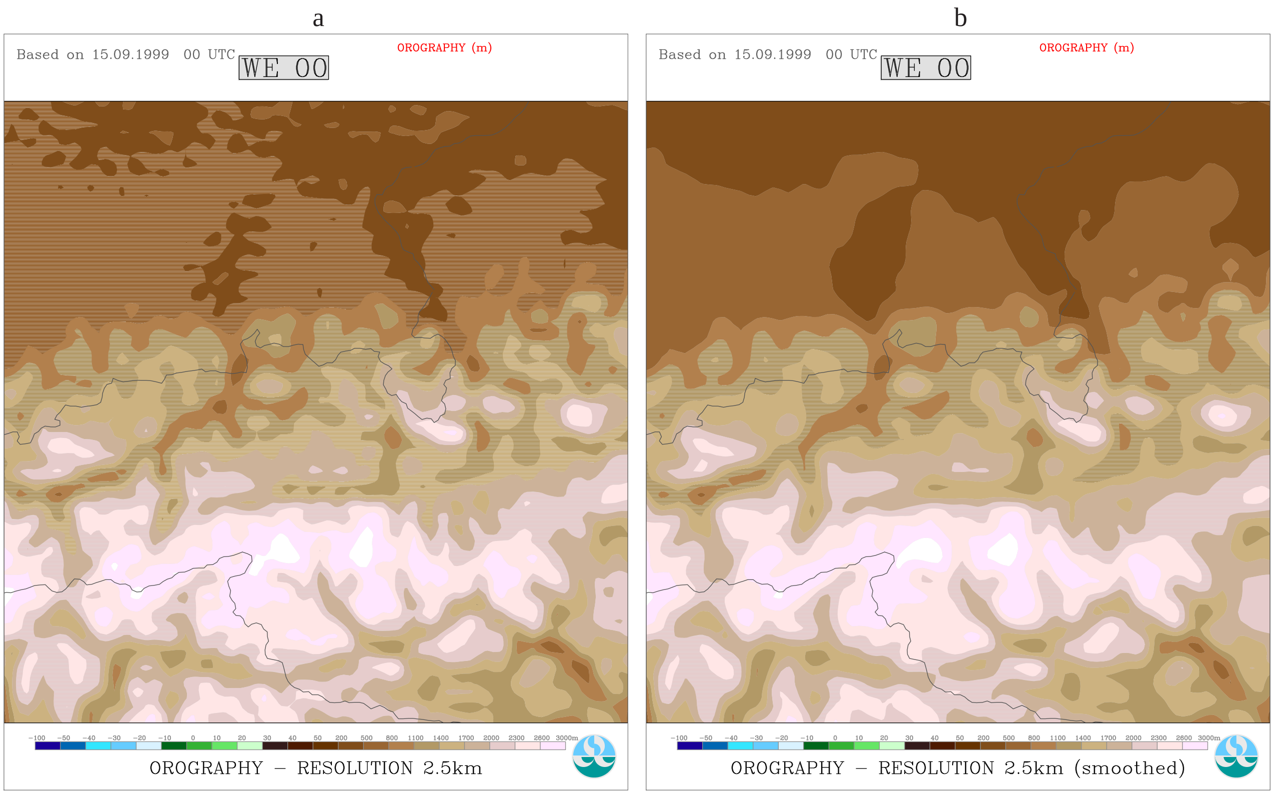

Figure 0 : Model orography : a) "standard", b) "smoothed"

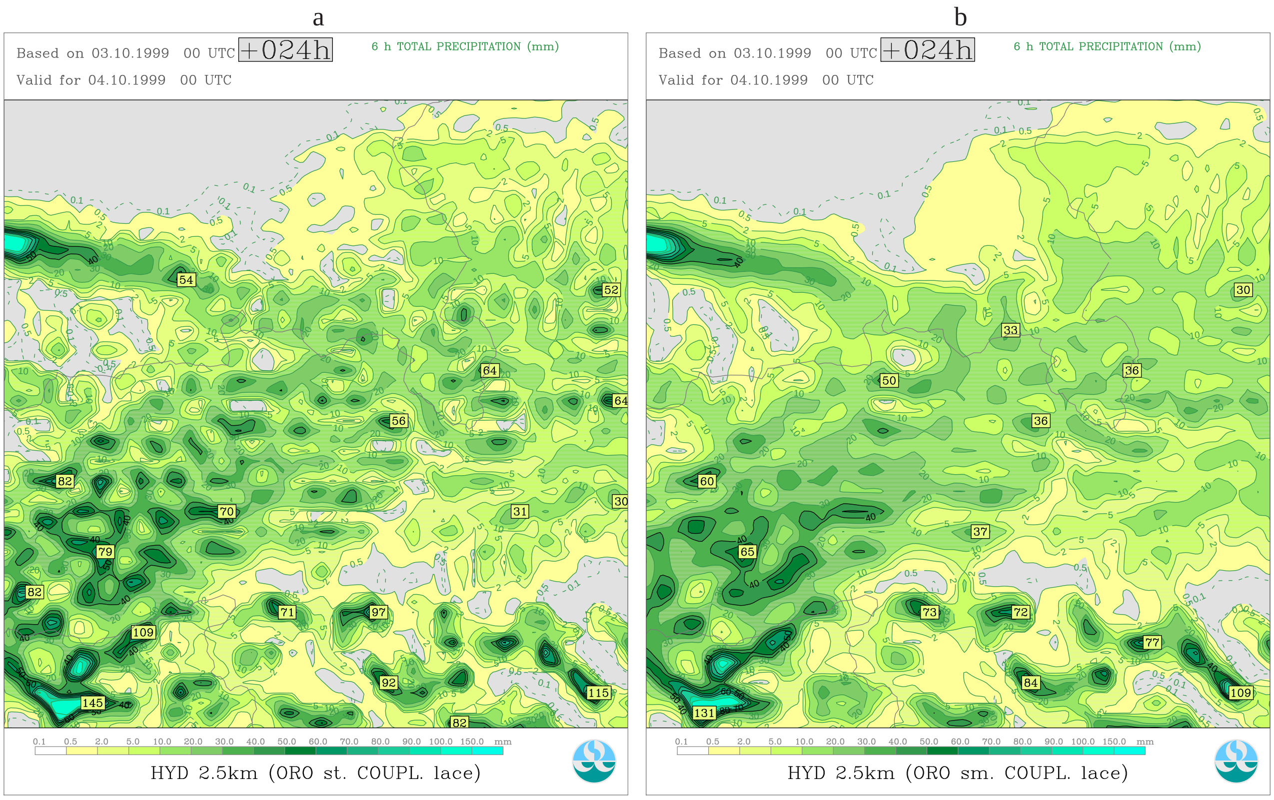

Figure 1 : 24h forecast of precipitation (6h accumulated) : a) "standard" orography, b) "smoothed" orography

a b

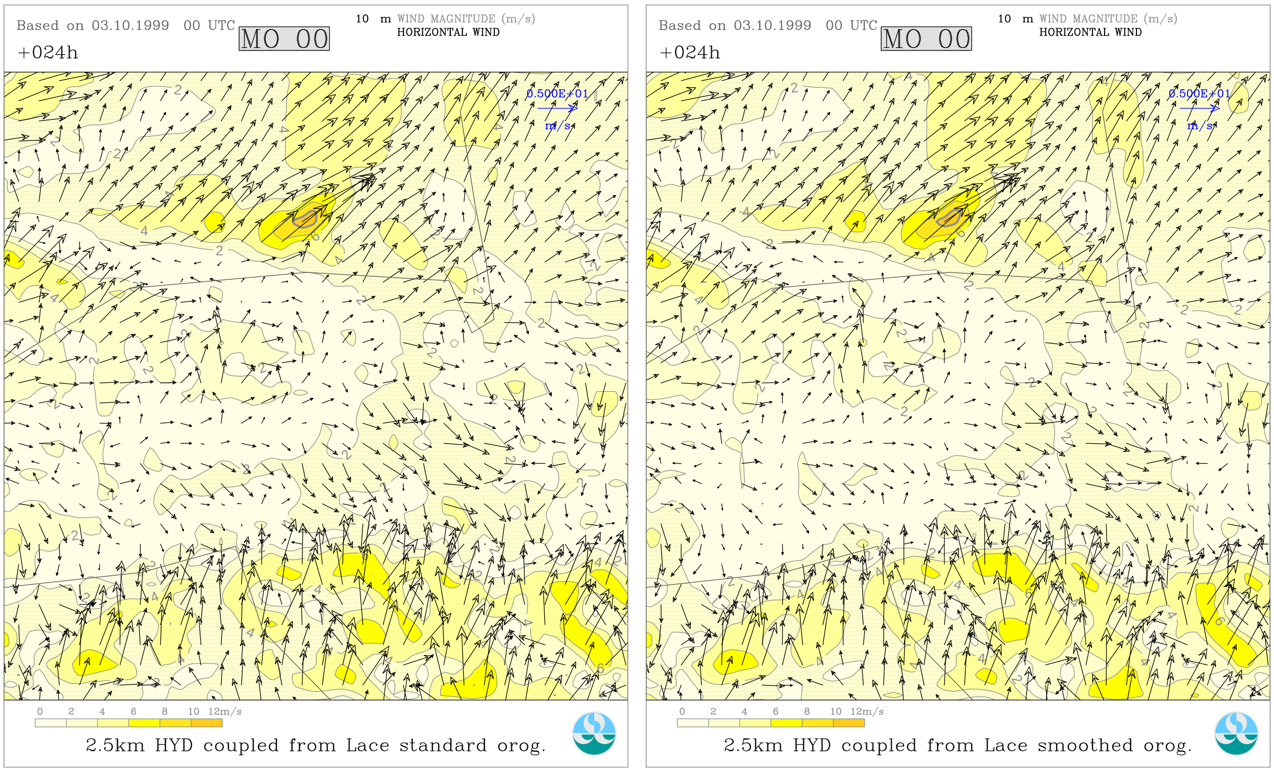

Figure 2 : 24h forecast of 10m horizontal wind : a) "standard" orography, b) "smoothed" orography

a b

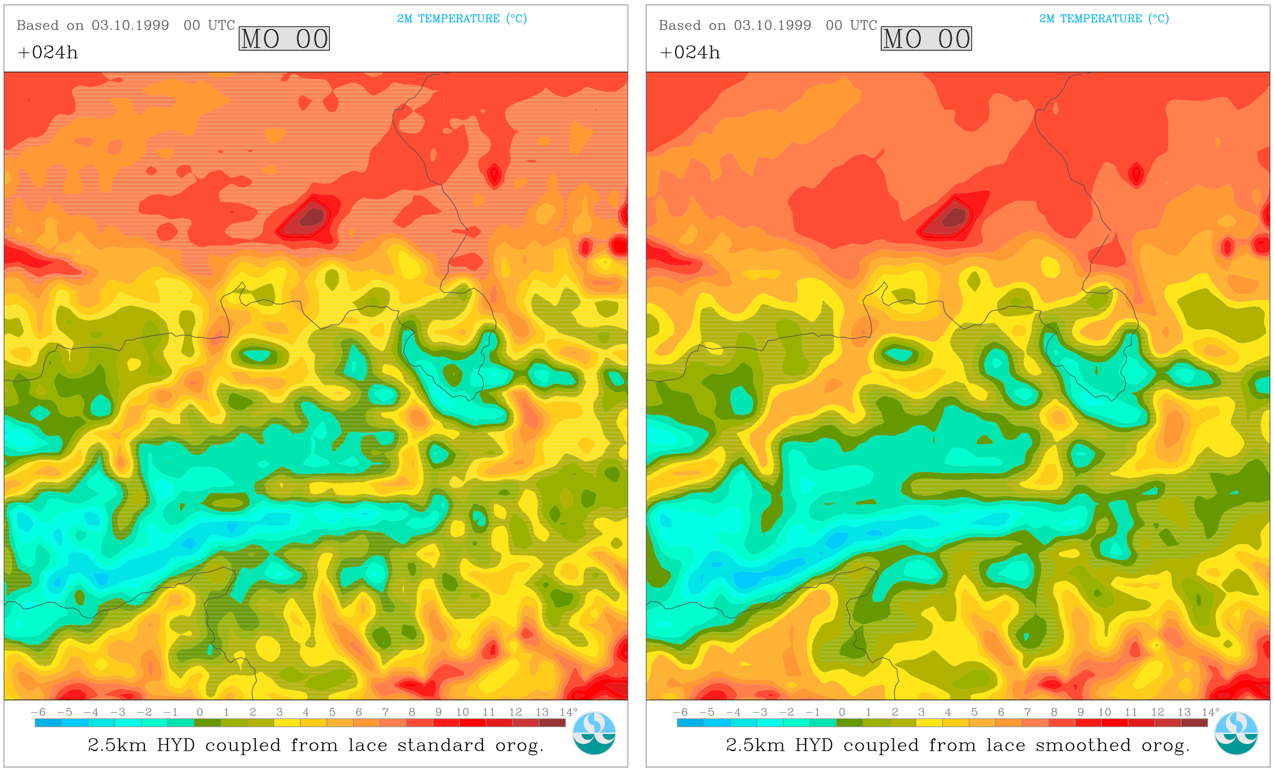

Figure 3 : 24h forecast of 2m temperature : a) "standard" orography, b) "smoothed" orography

Details 2

The most recent NH developments, that were introduced into Cycle 25, led to some reconsiderations about the impact of the non-hydrostatic dynamics at different resolutions. In the previous cycles the forecasted fields at 5 km resolution seemed to be nearly independent on the dynamics used, which could be seen in very similar forecasted fields (e.g. vertical velocity and precipitation, which should clearly reveal the differences, if they are present). In Figs 4a-b, precipitation forecasts at 5 km resolution are shown. Figure 4a shows the field for the hydrostatic run, while in Fig. 4b the non-hydrostatic dynamics is used. The most evident difference can be found in the maximum peak in the South-West of the displayed domain. While the hydrostatic run produces a huge maximum (above 80mm/6h) this peak is missing in the non-hydrostatic forecast, which is much closer to the observations, that did not measure such high amounts in this region (see Fig. 4c). The other parts don’t show those big differences. So in this case the impact of the non-hydrostatic dynamics can even be seen at 5 km resolution and additionally it pushes the model in the right direction in damping the unrealistic high peaks of precipitation.

Additionally the above-mentioned fact leads directly to the conclusion, that the results at a higher resolution, which are obtained with coupling to the 5 km model, are much more influenced by the dynamics used in the coupling model than seemed to be the case before.

Figures 5a and 5b show a comparison of precipitation forecasts at 2.5 km with non-hydrostatic dynamics. In Fig. 5a the model was coupled with the 5 km hydrostatic run, while in Fig. 5b the non-hydrostatic 5 km run was used for coupling. In both cases the maximum peak appears, but in the pure non-hydrostatic chain most of the peak amounts are significantly less than in the other case. Here the non-hydrostatism allows to reduce the vertical velocities to more realistic values, than is the case for the hydrostatic one.

The facts mentioned before might also be considered as important to answer the question about the nesting chain, namely to find the right resolution to go from hydrostatic to non-hydrostatic dynamics. It might give a strong hint that the resolution jump should not be too big, in order not to loose possible advantages that might be gained in using an intermediate resolution with non-hydrostatic dynamics. Figure 6 shows the NH run at 2.5 km, when the model is directly coupled to the LACE model. This last figure should also be compared with Fig. 1b which shows the hydrostatic run for the same coupling files. Differences can be seen in the number and magnitude of the peaks (higher in the NH case !) as well as in the general shape of the field, which shows a precipitation free area in the east of the domain, that is missing in the hydrostatic case.

Try of a summary

Since cycle 25 the differences in the forecasted fields between NH and HYD dynamics have become more evident than before. This is not just true for the 2.5 km runs, but also at 5 km significant differences occur. The usage of a smoothed orography seems a proper way to get (partly) rid of strange-looking precipitation fields without doing big harm to the other meteorological quantities. It is very likely that the non-hydrostatic dynamics at high resolution do the required job, although a pure systematic evaluation should be used additionally to prove it. The fact, that the non-hydrostatism may start to act noticeable already at 5 km and therefore indirectly influences the answer to the question of the coupling model for the 2.5 km runs, might lead to the conclusion, that a pure non-hydrostatic nesting chain below resolutions of 10 km would really be the best way.