Vertical Profiles - A Comparison between German, Italian and Swiss Verification

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1 Introduction

The verification of vertical profiles is an important part of the operational verification of a limited area model. In addition to the separate verification of each operating centre, a lot can be learned about the influence of the differing model set-up by comparing the verification results of the different Local Model installations of each country. For the COSMO General Meeting of 2004, the German, Swiss and Italian responsibles for the upper-air verification contributed their results of summer 2004 to a common presentation.

The model set-ups involved are named as follows: The German operational Local Model set-up with 35 layers in the vertical, soil-moisture analysis and nudging for the initial conditions, GME boundary conditions, and the prognostic-tke surface-layer scheme is named LM. The Italian version running at Bologna, with 35 layers, nudging for the initial conditions, and GME boundary conditions and prognostic-tke surface-layer scheme is called LAMI. The Swiss set-up finally, with 45 layers, nudging for initial conditions, IFS for boundary conditions, and the old surface-layer scheme is referred to as the aLMo (Alpine Model).

While the differences in the model set-ups rend the comparison of the verification results interesting, there are also differences in the verification itself, which is to some extent detrimental to the direct comparison. The German upper-air verification use all available radiosonde stations over the model domain (Pflger 2004). The Swiss aLMo is verified at 30 selected sites evenly distributed over the model domain (Arpagaus 2004). The Italian verification, in contrast, uses a set of 7 stations in the Italian area (Emiliani et al. 2004). A similar verification with 6 stations south of the Alps is available for aLMo but not for the LM. Due to the different set of stations involved, the following figures will either contain overlay of LM and aLMo results for the whole model domain, or overlays of LAMI and aLMo results for the Italian part of the model domain. The humidity verification can only be compared between LM and aLMo both using use relative humidity, whereas LAMI on the other side verifies dewpoint temperature.

Another difference in the LAMI verification is the definitions of the seasons. The summer season is usually defined as the calendar months of June, July and August. The LAMI verification for summer 2004 originally included July, August and September. For the purpose of this paper however the LAMI verification only includes July and August.

2 Results

Fig. 1 shows the geopotential height verification for LM (black, green, and yellow) and aLMo (red, blue, magenta, and cyan). The aLMo bias shows a see-saw in the upper troposphere. This is probably an artifact stemming from a vertical interpolation error (Arpagaus 2002).

The standard pressure levels (markers in Fig. 1) however are not affected and give meaningful results. In the lower troposphere, the LM starts at the initial time with a positive bias of

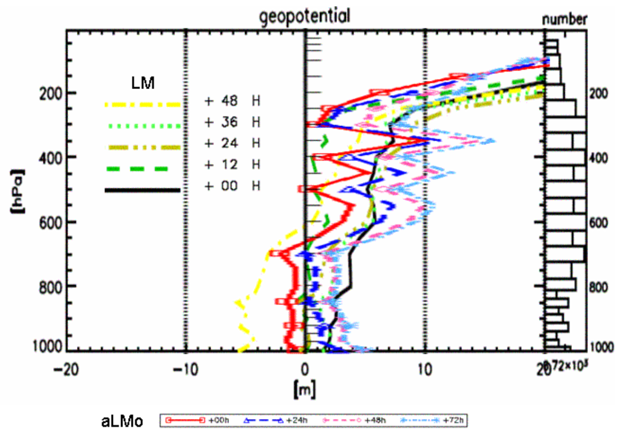

Figure 1: Bias of geopotential height for LM (black-green-yellow) and aLMo (red-blue-magenta-cyan) for summer 2004.

2 to 3 m, which is slowly reduced towards zero throughout the integration until 36 h, then jumps to -5 m at 48 h. The aLMo, in contrast, starts with a slightly negative bias of about -1 to -2 m, which increases gradually to +3 m.

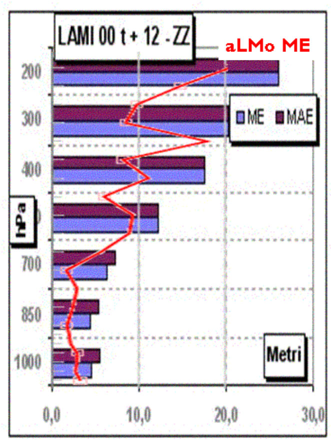

Figure 2: Bias of geopotential height for LAMI (blue bars) and aLMo (red line) for summer 2004 at forecast hour 12.

For the stations south of the Alps (Fig. 2 and 3), the aLMo shows a slight increase of the bias from the initial time (Fig. 2) to 48 h forecast (Fig. 3), like for the whole model domain.

LAMI, with a bias decreasing with increasing forecast range, behaves as LM did for the whole domain, although with a larger value (-10 m at 48 h) of the bias. The reason of this mass deficit in LM and LAMI in the 48 h forecast is unknown. The fact that aLMo showed the same behavior in summer 2002 and 2003 hints to the GME boundary conditions as possible reason.

The temperature profiles of LM and aLMo behave in a comparable manner, except that the aLMo bias is shifted to slightly lower values (Fig. 4). The negative bias peak in the boundary layer is at 975 hPa for the LM, but at 925 hPa for aLMo. This could be caused by the choice of verification sites. For the region south of the Alps (Fig. 5), aLMo shows a bias similar to the one for the whole domain. LAMI shows a bias profile with a positive

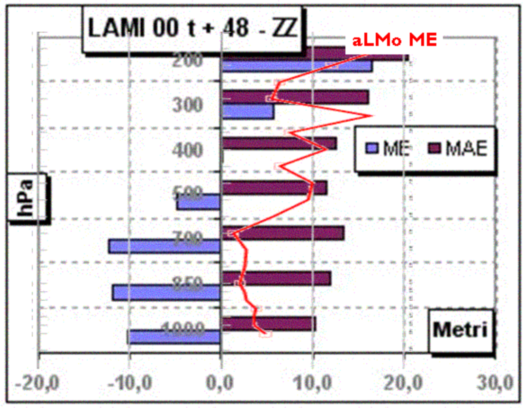

Figure 3: Bias of geopotential height for LAMI (blue bars) and aLMo (red line) for summer 2004 at forecast hour 48.

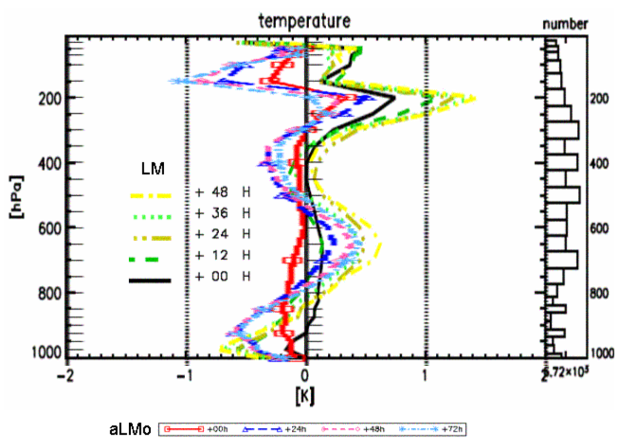

Figure 4: Temperature bias for LM (black-green-yellow) and aLMo (red-blue-magenta-cyan) for summer 2004.

peak at 400 hPa, a feature present neither in LM nor in aLMo.

The relative humidity bias is nearly equal for LM and aLMo (Fig. 6). As mentioned above, the LAMI verification does not use relative humidity but dewpoint temperature and cannot be compared to the LM and aLMo verifications. The positive peak of the aLMo bias at 1000 hPa at the initial time (red line in Fig. 6) could be the result of using the old turbulence scheme without prognostic tke.

The wind speed bias for LM and aLMo is largest (around -1 m/s) below and above the tropopause region (Fig. 7). It is also large between 800 hPa and 500 hPa in all models. The amount of the bias differs: In the whole domain at 48 h, it is -0.75 m/s for the LM and -0.5 m/s for aLMo. Remarkable is the different sign of the bias in the boundary layer: while the LM bias is negative, the aLMo has a positive bias below 900 hPa. No such difference is found in the wind direction (not shown). South of the Alps (Fig. 8), the wind speed bias is -1.5 m/s for LAMI and -1 m/s aLMo.

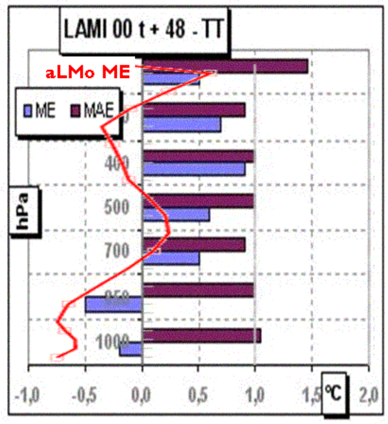

Figure 5: Temperature bias for LAMI (blue bars) and aLMo (red line) for summer 2004 at forecast hour 48.

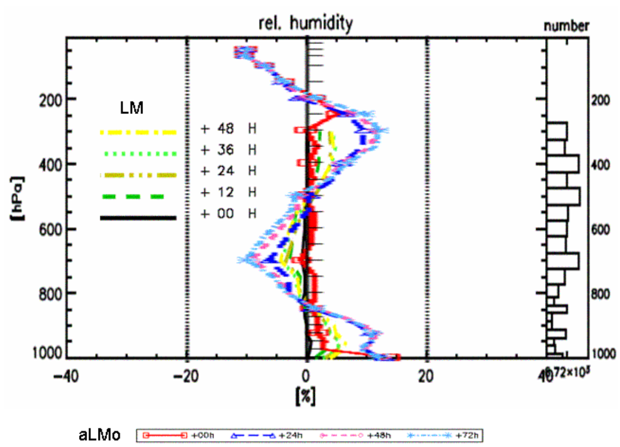

Figure 6: Relative humidity bias for LM (black-green-yellow) and aLMo (red-blue-magenta-cyan) for summer 2004.

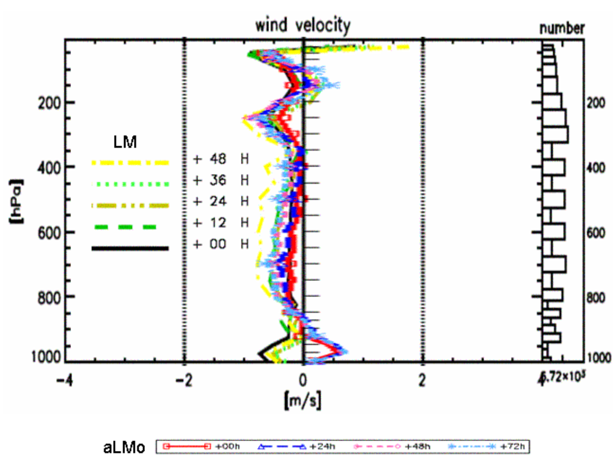

Figure 7: Wind velocity bias for LM (black-green-yellow) and aLMo (red-blue-magenta-cyan) for summer 2004.

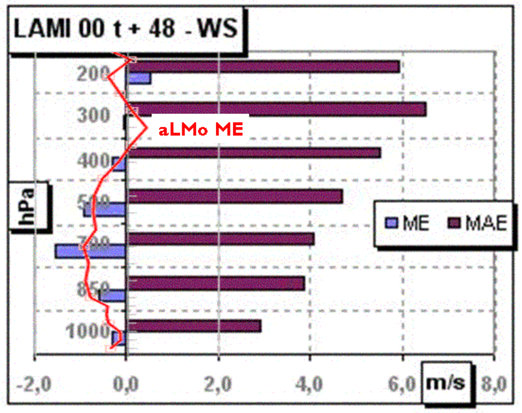

Figure 8: Wind velocity bias for LAMI (blue bars) and aLMo (red line) for summer 2004 at forecast hour 48.

3 Conclusion

The two model set-ups LM and LAMI both show a similar drop-off of the near-surface geopotential at the 48 h forecast range, and are driven by the same boundary conditions. The other common features of LM and LAMI that distinguishes them from aLMo are the tke surface-layer scheme and the number of vertical levels. These are however unlikely candidates to explain the difference in the pressure bias. They might however be causing differences in temperature and humidity near the ground. The verification results of these parameters are less consistent. With the existing differences in verification, it is difficult to decide whether and what differences in the model set-up cause different model behavior. For a more in-depth comparison, it would be helpful if the participating operating centers could agree on a common set of sounding stations, a common definition of seasons and some additional common statistical measures other than the bias. As an alternative, the model forecast could be exchanged and each country could not only verify its own, but also the other models. This would avoid the danger of still having unrecognized differences in the model verification that could mislead the interpretation.

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