The new Lokal-Modell LME of the German Weather Service

J.-P. Schulz

Deutscher Wetterdienst, Offenbach, Germany

1 Introduction

In order to fulfill new requirements of both external and internal customers, for instance in aviation, sea traffic or air pollution modelling, the German Weather Service (DWD) decided to expand the model domain of the operational limited area model, the Lokal-Modell (LM, Doms and Schättler 2002, Steppeler et al. 2003, Schulz 2005). The new version has successfully been introduced in the operational numerical weather prediction system of DWD on 28 September 2005.

2 The model LME

The former version covered basically Central Europe, including Germany and its neighbouring countries. The new version covers almost entire Europe and therefore got the name LM Europe (LME). The integration domain of LME is shown in Fig. 1.

The number of grid points per layer is enhanced from 325 $\times$ 325 to 665 $\times$ 657, while the mesh size is kept unchanged at 7 km $\times$ 7 km. The number of vertical layers is increased from 35 to 40. The additional layers are mainly located in the lower troposphere, the height of the lowest layer is reduced from 33 m to 10 m. This is in accordance with the new 40-km version of the driving global model GME which started operation at DWD in September 2004. The poles of the rotated LME coordinate system are different from the LM system. The LME system is rotated in a way that the equator is located within the center of the model domain. This has the advantage that the grid cells have a similar size and shape throughout the entire domain or, in other words, the divergence of the longitude rows is minimal. The main non-technical model change is the introduction of a new multi-layer soil model, the same that was incorporated into GME in 2004.

3 Results

The introduction of LME at DWD was done in several steps. First of all, two experiments were set up at ECMWF in 2004, namely LME and LM, running daily forecasts driven by GME. Here, the influence of the domain size or the distance between the boundaries and the region of interest, respectively, can be tested. It turns out that in most weather situations there is very little influence. But, there are sporadic cases where for example the development of a cyclone evolves significantly differently. The results of an objective verification show some advantage for LME forecasts for precipitation and gusts and some disadvantage for mean sea level pressure.

In January 2005 a full LME data assimilation cycle has been set up in an operational parallel suite at DWD. This parallel suite also includes two 78h-forecasts (00 and 12 UTC) per day. Hence, LME could be tested in operational mode against LM and GME during spring and summer 2005. All postprocessing procedures had to be adjusted. Preliminary verification showed similar results as the experiments at ECMWF.

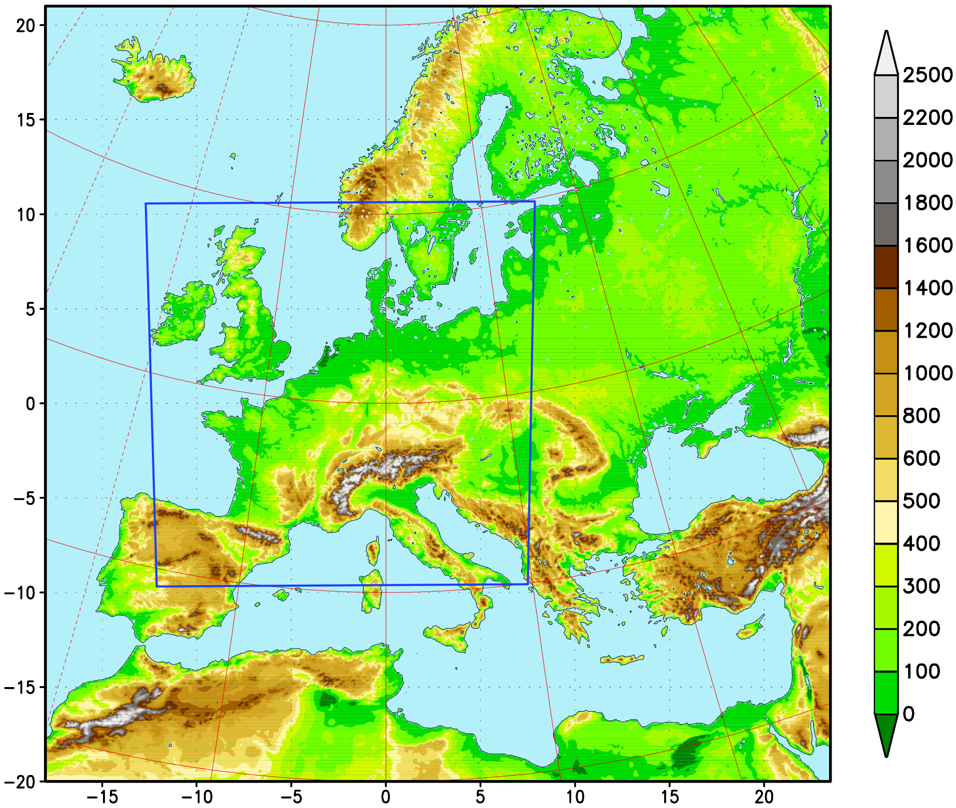

Figure 1: Model domain of LME. Topographical height (m) for land fractions > 50% (for the operationally used filtered orography). The frame in the figure depicts the integration domain of the former LM.

More detailed comparison revealed that the evaporation over sea in LME is up to 30% higher than in GME. Furthermore, precipitation in LME tends to show a systematic positive trend during the forecasts, even on a monthly mean basis, while precipitation in observations and also in GME is balanced. This behaviour indicates that evaporation over sea in LME is likely to be overestimated. Some sensitivity tests were carried out at DWD and a parameter tuning led to a LME version with reduced evaporation over sea. Preliminary verification of this version showed some improvement in the simulated moisture budget and also the mean sea level pressure.

A quantity of particular importance is the simlated soil moisture. First of all, it is a component of the new multi-layer soil model of LME and therefore needs to be monitored with great care. This has certainly been done already during the development of the model, but due to the very long memory of the soil with respect to e. g. temperature and soil moisture content, it is hard to run it long enough to ensure reasonable initial states for all its variables. Secondly, it is affected by the variational soil moisture analysis (SMA) scheme. This external analysis scheme is part of the data assimilation scheme of LME and is run once per day, at 00 UTC. It adjusts the soil moisture in an indirect way by minimizing the model bias of the near-surface air temperature. It has been switched on in LME in mid May 2005.

Figure 2 shows the simulated soil moisture of the third layer of the multi-layer soil model of LME compared to in-situ measurements from January to November 2005. Generally, the simulated soil moisture resembles the observations very well during most of the annual cycle of 2005, in particular during the first half of the year. After about day 205 LME becomes a bit drier than the observation, but the curves tend to converge again later in the year. But

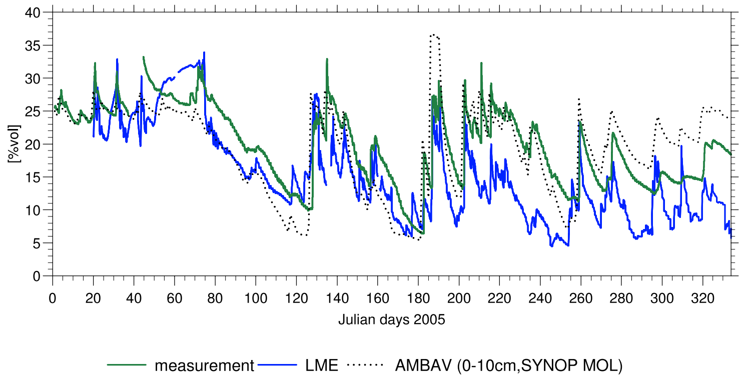

Figure 2: Soil moisture simulated by LME from January to November 2005 compared to measurements at the site Falkenberg (Meteorological Observatory Lindenberg, DWD). Shown is the soil moisture of the third layer (depth: 3–9 cm) of the new multi-layer soil model and a corresponding measurement. The third curve depicts results of AMBAV, which is a land surface scheme used at DWD for agricultural applications. It is more complex than the LME land surface scheme. For this study, it has been run off-line, forced by atmospheric conditions from the Meteorological Observatory Lindenberg which is close to the soil moisture measurement site. This figure was provided by G. Vogel, DWD.

during the entire period the tendencies of soil moisture variations are very similar between model and observation which is a good sign for the soil model performance. A likely reason for the difference between model and observation is that there was too little precipitation in the model at the beginning of the second half of the year. A hint for this is that the second model, AMBAV, run off-line with atmospheric forcing is much better able to follow the observed soil moisture evolution during this period.

4 Conclusions

In order to fulfill the requirements of several customers the German Weather Service (DWD) decided to expand the model domain of its operational limited area model, the Lokal-Modell (LM). The new LME, covering almost entire Europe, has successfully been introduced in the operational numerical weather prediction system of DWD on 28 September 2005. Current verification results look reasonable, further subjective and objective verification is carried out.

References

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