Forecasting of severe weather with the convection-resolving model COSMO-LMK

A. Seifert, M. Baldauf, J. Förstner, T. Hanisch, C. Schraff, K. Stephan
Deutscher Wetterdienst, Kaiserleistr. 42, D-63067 Offenbach, Germany
(Dated: May 15, 2007)

Since April 2007 the operational NWP system of the Deutscher Wetterdienst (German Weather Service, DWD) has been extended to the convection-resolving scale by the introduction of the 2.8 km grid-spacing limited-area model COSMO-LMK. The computational domains of the three models GME, COSMO-LME and COSMO-LMK are shown in Fig. 1. The new high-resolution model COSMO-LMK aims towards the explicit forecasting of severe weather phenomena on the meso-gamma scale, for example severe weather events related to deep moist convection or interactions of the flow with topography like strong orographic precipitation or downslope windstorms.

One of the most interesting features of a meso-gamma model is that it no longer needs a parameterization of deep convection. Instead, COSMO-LMK resolves at least the coarse modes of deep convection explicitly. Compared to models using parameterized convection, like COSMO-LME, the convection-resolving model leads to a more realistic simulation of the diurnal cycle of clouds and precipitation. This can also be seen in the average stratification of the model atmosphere during summertime: while the 7 km model has a too stable stratification, due to a too rapid convective overturning, the convection-resolving COSMO-LMK shows a slightly too high potential instability probably due to an underestimation of convective activity.

To represent the smaller scales of convection the shallow convection part of the Tiedtke cumulus parameterization is used. This parameterization contributes significantly to the vertical transport of moisture from the boundary layer to a height of about 3-4 km and therefore avoids the overestimation of low cloud coverage.

A meso-gamma model has special requirements concerning data assimilation. At this scale high resolution, rapidly updated observations are needed, which can in principle be delivered by radar data with a horizontal resolution of roughly 1 km. Currently only the two-dimensional precipitation scans are assimilated by the latent heat nudging (LHN) approach. One basic assumption of the LHN is that the latent heat release in a vertical column is proportional to the surface precipitation rate. Unfortunately, this basic assumption is in contradiction to the use of a prognostic precipitation scheme. This problem can to some extent be resolved by several refinements of the conventional LHN scheme, including an undelayed reference precipitation defined by a vertical integral of the precipitation flux.

We will present several case studies, for example the case of 5 Nov 2006 when severe downslope winds occurred at the Erzgebirge. This event was well simulated by COSMO-LMK, but not by the 7 km grid-spacing COSMO-LME. In general, the prediction of mountain waves benefits a lot from higher resolution, which is especially interesting for aviation forecasts.

Examples of severe deep convection are shown where COSMO-LMK has an increased prediction skill, for example when severe convection is forced by frontal systems. Another interesting case is the tornado event of 1 Oct 06 near Quirla, Germany when the pre-operational COSMO-LMK was at least able to predict a well developed supercell in the area. But there are also examples where COSMO-LMK has problems to initiate convection properly, most likely due to a too stable atmospheric boundary layer.

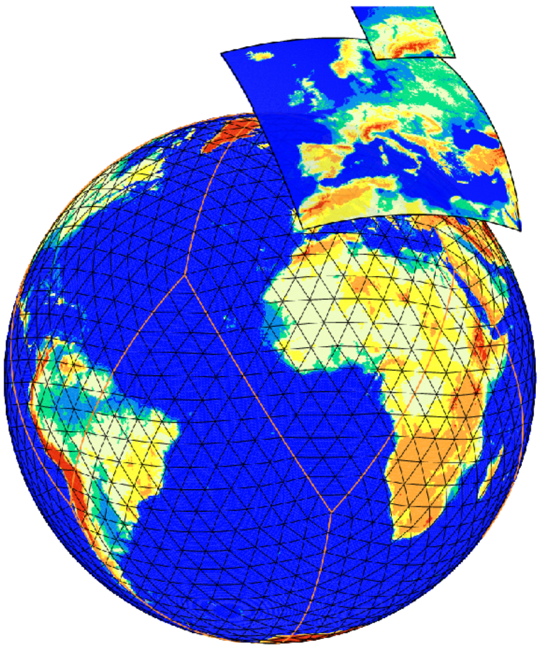

FIG. 1: Computational domains of the operational NWP models at DWD: The global model GME with about 40 km resolution, the meso-beta model COSMO-LME covering Europe and the meso-gamma model COSMO-LMK which covers Germany.