First Results on Verification of LMK Test Runs Basing on SYNOP Data

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1 Introduction

Within DWD's *Aktionsprogramm 2003* a main focus is on the development, the implementation, and the evaluation of a high–resolution model system for the very short forecast range of 3 to 24 hours basing on the non–hydrostatic regional model LM. The mesh size of this model system, which is called *Lokal Modell Kürzestfrist* (LMK), will be about 2 to 3 kilometers horizontally and 50 model layers in vertical direction. This numerical resolution in space and time allows a direct calculation of phenomena of the meso–γ–scale as larger convective cells and enables DWD a more precise forecast of strong thunderstorms, and hence an earlier warning of the authorities, the customers, and the population potentially affected by severe weather.

Considering mainly January and two summer months in the year 2004 different LMK test series have been performed with respect to numerical aspects, boundary values and relaxation methods, introduction of prognostic graupel calculation, as well as data assimilation. Accompanying the LMK test series a standard verification of the results following Nurmi (2003) is done permanently basing on hourly SYNOP data. Due to the progress in instrumentation and measuring methods concerning area distributed data about cloud coverage and precipitation rates, new possibilities for verification of weather forecast results arise. In the following an overview will be given about present verification results of the LMK as well as on future plans.

2 Model configuration

The model domain used for the LMK test runs extends about 10.5 degrees in longitudinal and 11.5 degrees in latitudinal direction with the center of the model domain near Offenbach/Main at 10 degrees E and 50 degrees N (see Fig. 1). The horizontal grid length used is 2.8 km and the number of grid points count 421 in longitudinal and 461 in latitudinal direction. In vertical direction the model domain is divided into 50 layers with a height of the lowest model half layer of about 44 m and the lowest main level about 22 m above ground. Initialization and hourly boundary values are taken from the operational LM runs.

In the following two tables (Table 1 and Table 2) the different LMK test suites performed for January 2004 and July-September 2004 and their different configurations are listed. The first experiment 673 represents a LM run done with the usual features of the operational LM in January 2004 except the differences in spatial and temporal resolution. The basic features for the summer test suites are similar to those mentioned for experiment 683 except the use of an explicitly formulated cosine function for the lateral boundary relaxation.

Table 1: Different LMK test suites and their configurations. Part 1.

experiment	time integration scheme, time step	horizontal advection scheme	calculation of precipitation	thermodynamics	relaxation at lateral boundaries
673	leapfrog $\Delta t = 16$ s	centered 2. order	diagnostic	advection of $T = T_0 + T*$	*tanh* function, implicit, as to LM
683	TVD–RK 3. order $\Delta t = 30$ s	upwind 5. order	prognostic	advection of $T = T_0 + T*$	*tanh* function, as in LM, precipitation diagnostic
687	TVD–RK 3. order $\Delta t = 30$ s	upwind 5. order	prognostic	advection of $T* = T - T_0$	*cos* function, explicit, precipitation diagnostic
688	TVD–RK 3. order $\Delta t = 30$ s	upwind 5. order	prognostic	advection of $T* = T - T_0$	*cos* function, explicit, precipitation diagnostic, relaxation of q_v, q_c, and q_i

Table 2: Different LMK test suites and their configurations. Part 2.

experiment	shallow convection parametr.	lateral boundary values for pressure	precip. scheme, nr.of classes	data assimilation	advection of q_x
689	no	interpolation	5 classes	no	Euler–forward
696	yes	vertical integration	5 classes	no	Euler–forward
698	yes	vertical integration	including graupel 6 classes	no	Euler–forward
701	yes	vertical integration	5 classes	yes	Euler–forward
709	yes	vertical integration	including graupel 6 classes	yes	Semi–Lagrange
713	yes	vertical integration	including graupel 6 classes	yes	Bott–2–Scheme

3 Results on the Verification Using SYNOP Data

The temporal development of the True Skill Statistics (TSS) graphs shown in Fig. 2 to Fig. 4 has been calculated using hourly SYNOP data from stations situated within the LMK – and hence in the LM – model domain. For the LM the assignment of the SYNOP stations to the model grid has been done via the nearest grid point approach. In the case of the LMK the same approach has been used, but additionally the surrounding 8 LMK grid points have been taken for an arithmetic averaging of the model results on a grid size comparable to the operational LM.

The TSS graphs for all precipitation rates shown in Fig. 2 show two groups of lines: the first group is represented by the LM routine run (black line) and LMK experiment 673 (red line), whereas the other lines form a second group with different characteristics. In

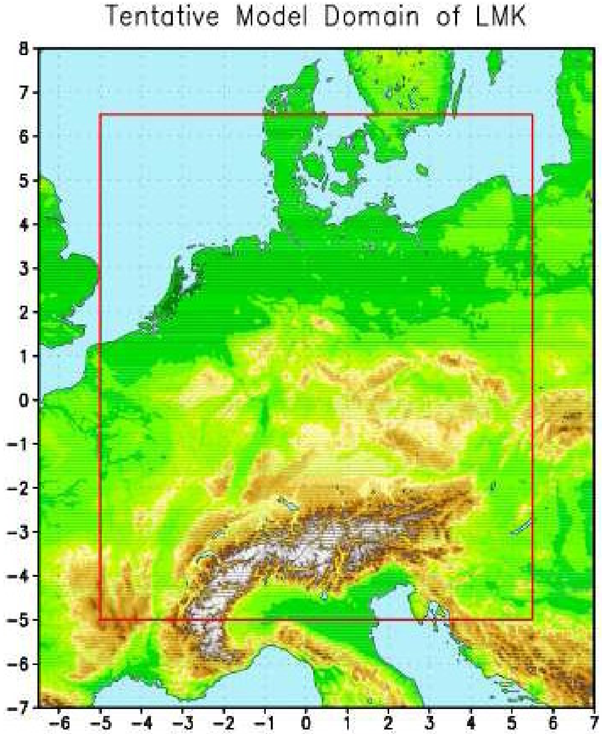

Figure 1: Integration area of the LMK model, topographical height [m].

the operational LM run as well as in LMK experiment 673 the precipitation is calculated diagnostically, whereas precipitation is computed via a prognostic equation in the other LM experiments shown. The TSS values for the diagnostic precipitation calculation are rather constant during the considered simulation time. In the prognostic case a strong spin–up effect can be seen in the TSS graphs during the first 2 to 6 hours of simulation. During daytime the TSS increases considerably to higher values than in the model runs with a diagnostic precipitation computation. This effect can be seen mostly remarkable in the first figure valid for precipitation rates > 0.1 mm/h.

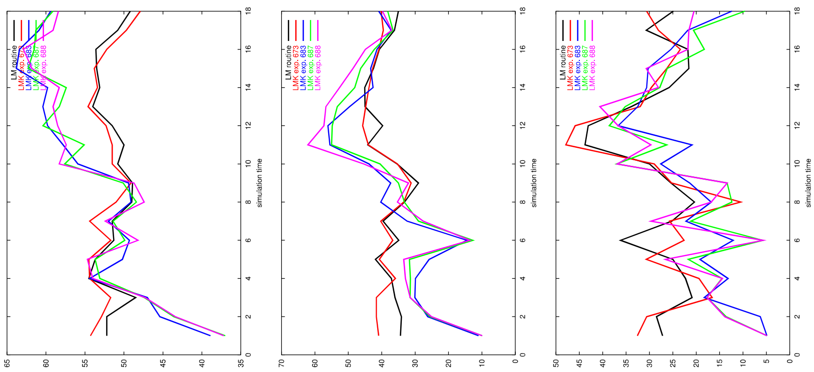

Figure 2: True Skill Statistics (TSS) for precipitation rates > 0.1 mm/h (top left), > 2 mm/h (top right) and > 10 mm/h (bottom). LM routine and different LMK test runs for January 2004, simulation start: 00 UTC.

Generally, the TSS for the July runs show much lower values as in the January simulations for the operational LM run as well as for all different LMK test runs (Fig. 3). The spin–up effect mentioned in the context of Fig. 2 can be seen again, but is significantly reduced in the

LMK test cases performed using data assimilation (LMK experiments 709 and 713). The precipitation calculated during these experiments results in much higher TSS values during the mainly convection governed afternoon hours considering medium and high precipitation rates. The TSS values decrease in all cases strongly during nighttime.

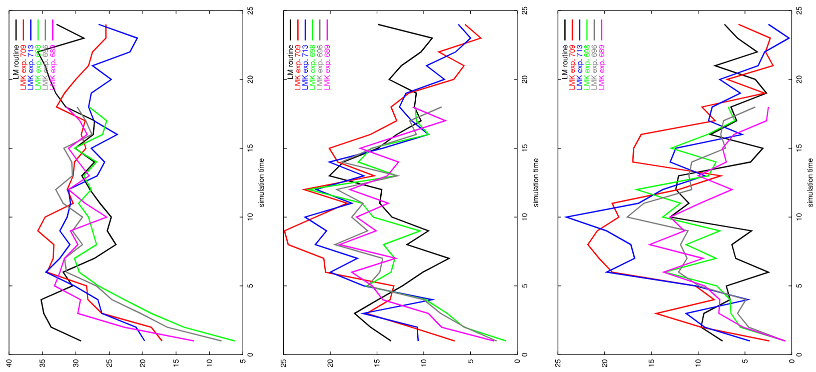

Figure 3: True Skill Statistics (TSS) for precipitation rates > 0.1 mm/h (top left), > 2 mm/h (top right) and > 10 mm/h (bottom). LM routine and different LMK test runs for July 2004, simulation start: 12 UTC.

Besides the LMK experiments described above, an additional LMK test run using latent heat nudging during the first 3 hours of simulation has been performed for the time period from 07 to 19 July 2004. For all considered precipitation rate classes the TSS resulting from the latent heat nudging shows a very strong increase during these nudging period (Fig. 4). The TSS values decrease after switching off the latent heat nudging for several hours until the typical TSS valued of non–nudged LMK experiments is approached. After 6 to 9 simulation hours the effect of the latent heat nudging seems to be very small and the TSS is rather similar to unnudged LMK runs.

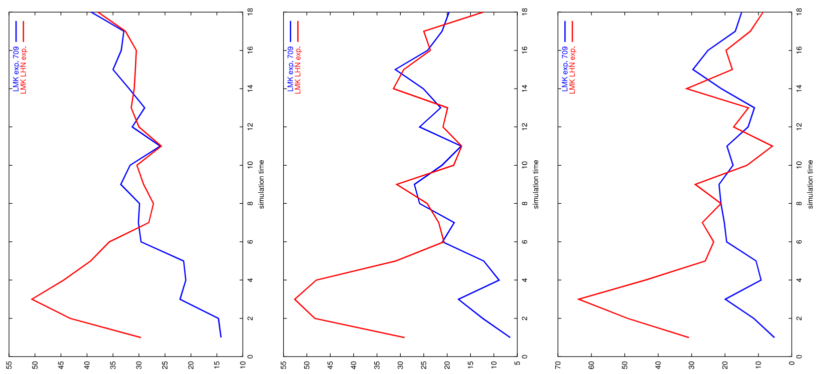

Figure 4: True Skill Statistics (TSS) for precipitation rates > 0.1 mm/h (top left), > 2 mm/h (top right) and > 10 mm/h (bottom). LMK experiment 709 and LMK experiment using latent heat nudging for 07th to 19th July 2004, simulation start: 12 UTC.

4 Future Plans

The verification of LMK test suites will be continued during the further development of LMK. The main focus of the verification will be on precipitation, but extends to other prognostic and diagnostic variables computed by LMK, e.g. temperature, pressure, cloudiness, wind vector and gusts etc. To allow a deeper investigation of the processes interacting in the model the development of a tool for a simple conditional verification of LMK results is ongoing. The conditional verification will include dependencies of two or more model variables, but no temporal or time–delayed interaction of variables. Results of the LMK model are used to calculate synthetic RADAR images for the RADAR sites of Germany according to the RADAR Simulation Model (RSM) of Haase (1998). Preliminary results of the application of the RSM on LMK output can be seen in Fig. 5: Entering the considered domain from the southwestern corner a simulated squall line crosses the domain of the RADAR site Hannover to northeastern direction within several hours. These synthetic RADAR images calculated from model results together with measured RADAR pictures will be taken for verification of precipitation patterns using pattern recognition methods as e.g. described by Ebert and McBride (2000).

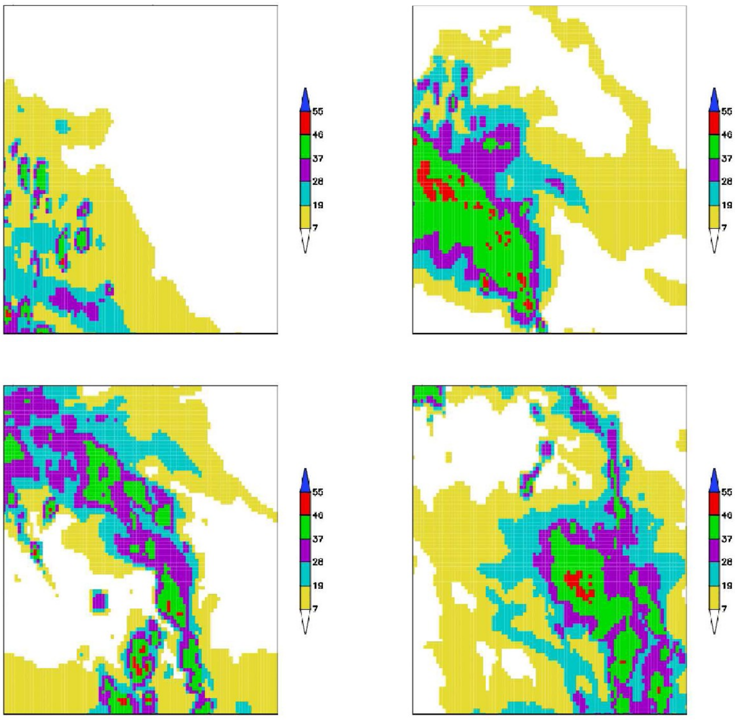

Figure 5: Results of the RADAR Simulation Model (RSM) for the LMK experiment 698 for 12th August 2004, simulation start: 12 UTC. Results after 4 h (top left), 6 h (top right), 8 h (bottom left), and 10 h (bottom right) of simulation time.

References

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Haase, G., 1998: Simulation von Radarmessungen mit Daten des Lokalmodells. Diploma Thesis, Meteorological Institute, University of Bonn, Germany, 84 pp.

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