Assimilation of Radar Data in the Mesoscale NWP-Model of DWD

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The Lokal-Modell (LM) of DWD is a non-hydrostatic meso-scale model for short-range numerical weather prediction (NWP). Operationally, its initial state is generated by an assimilation scheme based on the nudging technique. Using non-gridded conventional observations, the focus is on the analysis of meso-alpha-scale structures.

In view of the development of a very high-resolution version of LM (so called LMK) dedicated to very short-range NWP of severe weather, high-resolution precipitation data derived from radar networks are introduced in the assimilation. The aim of this approach is to assimilate observed meso-gamma-scale structures and adjust the moist processes in order to improve the quantitative precipitation forecasting (QPF). Radar data, currently used for the assimilation, is a composite based on the precipitation scans of the 16 German radars (spatial mesh: ~ 1 km x 1 km, time resolution 5 min).

Using the Latent Heat Nudging (LHN) technique, the thermodynamic quantities of the atmospheric model are adjusted in such a way that the modelled precipitation rates resemble the observed precipitation rates. This adjustment scheme works locally, because it is based on the assumption that in a vertical column, the integrated release of latent heat is proportional to the precipitation rate at the ground. Based on the quotient of observed over modelled precipitation rate a temperature increment is calculated in such a way that heating will take place at grid points where modelled precipitation is below the observed one. The LHN approach implemented in LMK is based on the algorithm described in Jones and Macpherson (1997). Their algorithm has been operationally and successfully used at the UK MetOffice since April 1996 (Macpherson, 2001).

Current schemes for gridscale precipitation often assume a column equilibrium for sedimenting constituents (Gassmann, 2002). That is, sedimentation can be considered to be a fast process compared to the characteristic time of cloud development. In the model's framework precipitation is falling to the bottom model level within one single time step. Below, this scheme will be referred to as "diagnostic". When increasing the model's spatial resolution, the assumption of column equilibrium for the precipitating constituents becomes more and more unrealistic. 3D advection and interactions between the different kinds of hydrometeors have to be considered within a "prognostic" precipitation scheme.

Figure 1 compares hourly precipitation amounts for the 9th of June 2004 8-9 UTC derived from radar measurement (b) with different assimilation runs. Figure 1a shows a control run without LHN, the lower panels show two runs with LHN. In fig. 1c a simulation with a diagnostic precipitation scheme is presented and in fig. 1d a simulation with prognostic precipitation. The results from this case study show that precipitation patterns are introduced in the analysis (data assimilation mode) in good agreement, both in position and amplitude, with those observed by radar if the model calculates the precipitation diagnostically. Particularly during the assimilation, the performance of LHN becomes worse if a prognostic treatment of precipitation is deployed. The major challenge seems to be the lagged model feedback on the LHN increment, which is caused by the fact, that precipitation, simulated by a prognostic scheme, needs some time to reach the ground. Therefore the LHN algorithm does not notice if precipitation has been increased or reduced so far, which mainly leads to a strong overestimation of precipitation.

The features of the prognostic precipitation scheme have a tremendous effect on the LHN algorithm. The algorithm assumes a strong correlation between the integral of the latent heat release within a vertical column and the precipitation rate at the bottom of the same column. Such a correlation is found for model runs with a diagnostic precipitation scheme and is shown in fig. 2a. Since we have used a prognostic precipitation scheme the basic assumption is no longer valid within one vertical column. Figure 2b gives the impression that the precipitation pattern is slightly shifted upstream of the pattern of vertical integrated latent heat rate. Thus one has to adopt the former LHN algorithm on the new specifications due to the prognostic precipitation scheme. Work is underway to find out how this can be achieved.

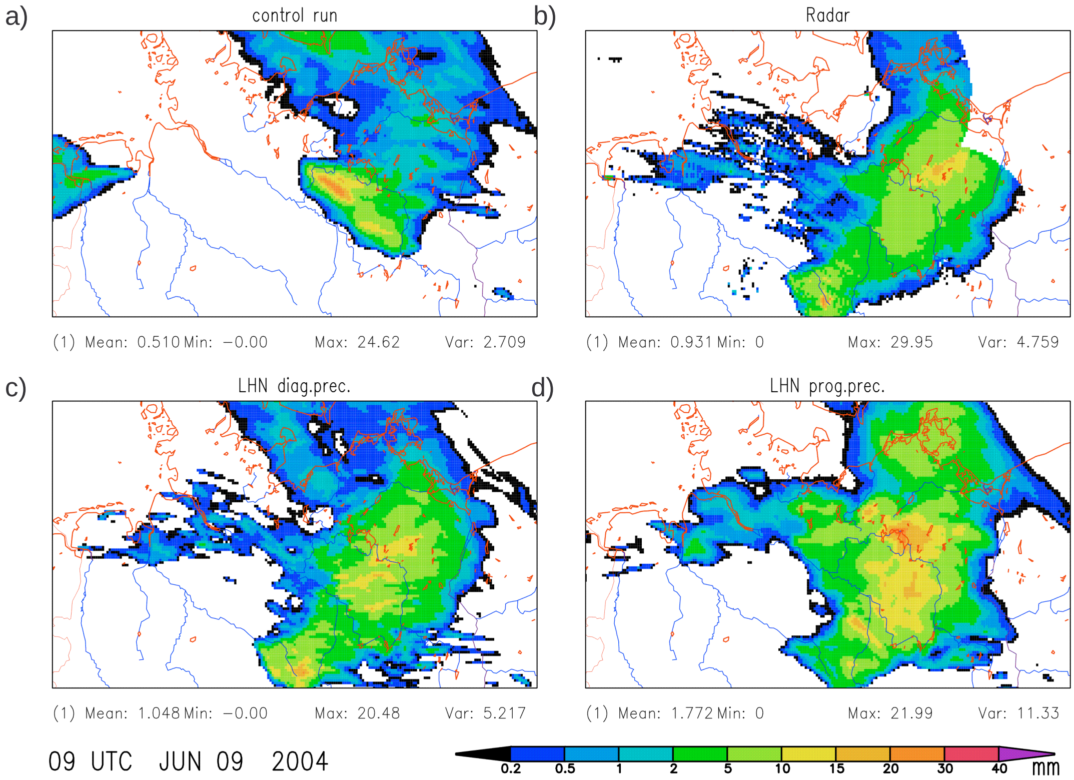

Figure 1: hourly precipitation sums for 9th June 2004 08-09 UTC, control run (assimilation mode) (a), Radar observation (b), LHN run with diagnostic precipitation (assimilation mode) (c) and LHN run with prognostic precipitation (assimilation mode) (d).

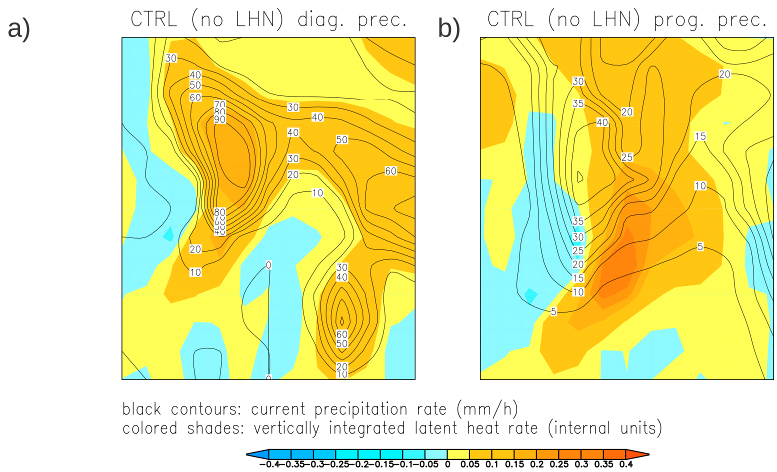

Figure 2: horizontal patterns of current precipitation rate and vertically integrated latent heat rate for a simulation with diagnostic precipitation (a) and with prognostic precipitation (b).

References

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