Evaluation of a convection-resolving model simulation in mountainous terrain

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I. INTRODUCTION

In mid-latitude mountainous regions, convective precipitation is the dominant form of summer precpitation. Forecasting convective precipitation remains a challenge for current state-of-the-art numerical weather prediction (NWP) models. Especially in mountainous regions small scale local flow systems can determine the timing and location of convection. Only very recently, the spatial resolution of NWP models has been increased to an extent that they start to explicitly resolve the processes associated with deep convection. The objective of the present work is to evaluate the performance of a convection-resolving NWP model under convective conditions in mountainous terrain in Central Europe.

II. CASE STUDY: 12 JULY 2006

We use observations obtained within the PRINCE - Prediction, identification, and tracking of convective cells - field experiment (Corsmeier and Ziegler, 2006) to evaluate the model results. PRINCE was designed to observe deep convection in the northern part of the Black Forest. Available observations include precipitation radar measurements from Karlsruhe, radiosoundings from Brandmatt (on the western slope of the Black Forest), and mobile radiosoundings close to active convection within the study area. Continous measurements using cloud radar, aerosol and temperature lidar were conducted from Hornisgrinde (i.e. the highest elevation in the northern Black Forest, 1177 m asl).

Here, we focus on the situation on 12 July 2006. This day was characterized by weak synoptic forcing over Central Europe and the initiation of local convection along mountainous regions at about 11 UTC. CAPE and CIN values of the morning sounding (09 UTC) were about $1700\,\mathrm{J\,kg^{-1}}$ and $85\,\mathrm{J\,kg^{-1}}$, respectively, pointing to high convective potential. Horiontal winds were very weak suggesting the formation of local ordinary convective cells. Around local noon, several single convective cells formed in the study area close to the Murg Valley lasting about 3 hours. The total precipitation derived from the radar observations from Karlsruhe between 09 and 19 UTC is shown in Figure 1. Most precipitation in the area of interest can be found north of Freudenstadt in the Murg Valley with maximum values of more than

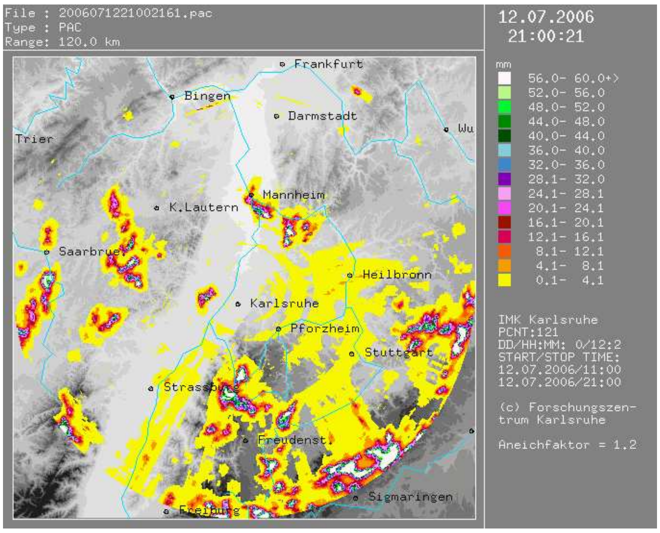

FIG. 1: Precipitation between 09 UTC and 19 UTC on 12 July 2006 derived from radar measurements from Karlsruhe.

$60\,\mathrm{mm\,(10\,hrs)^{-1}}$. More information on PRINCE and the measurements obtained on 12 July 2006 can be found in Groenemeijer et al. (2007).

III. MODEL DESCRIPTION

The model developed by the Consortium for Small-Scale Modelling (Steppeler at al. (2003), Schättler et al. (2005), formerly known as the Local Model, LM) is used in the present work. The non-hydrostatic COSMO-model is used for operational NWP at several European weather services, including the German Weather Service, DWD. It has recently been extended for convection-resolving simulations and is used for operational high-resolution short range forecasting at DWD since April 2007.

Here, we are using a similar model setup as is used at DWD for NWP. The horizontal grid spacing is 0.025° (≈2.8 km), the lowest vertical layer of the 50 terrain-following layers is located 10 m above the local topography. No parameterization of deep convection is employed. The solution of the dynamical equations is based on the Runge-Kutta Scheme using a timestep of 30 sec. Microphysical processes were calculated using the recently developed Graupel-Scheme. For the initial and the

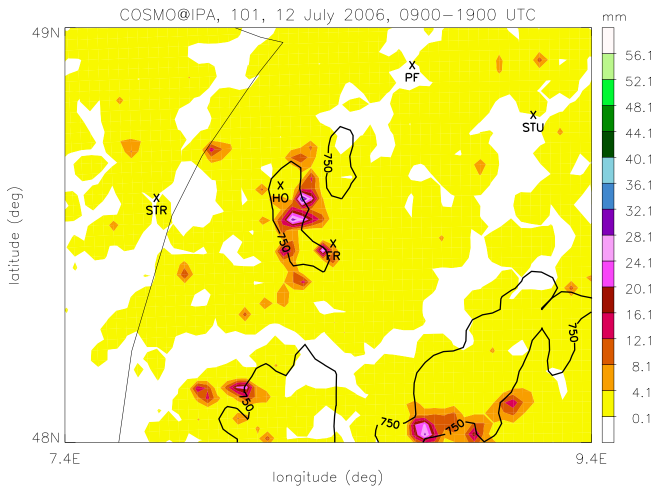

FIG. 2: Simulated precipitation between 09 UTC and 19 UTC on 12 July 2006. FR: Location of Freudenstadt, HO: Location of Hornisgrinde

boundary conditions hourly data from the operational COSMO-LME analysis from DWD at a horizontal resolution of 0.0625° are used.

IV. EVALUATION OF MODEL RESULTS

A first evaluation of the model simulations with the available observations is presented. Here, we focus on radar observations obtained by the Karlsruhe-radar. A more comprehensive model evaluation using radiosoundings and lidar measurements will be presented at the conference.

Figure 2 shows the simulated precipitation between 09 UTC and 19 UTC. Significant precipitation is predicted in the area of interest with a maximum of 32 mm within 10 hours. The simulated precipitation occurs mainly in Murg Valley north of Freudenstadt (marked FR in Figure 2). This distribution can be compared to the radar observations presented in Figure 1. Note that the spatial domain of the measurements extends further north than shown in Figure 2 from the model simulation. While the location of the precipitation maximum inside the Murg Valley is well captured by the model, the amount of surface precipitation compared to the radar measurements is underestimated. The correct prediction of the location of the convective cells suggest that the processes that lead to the initiation of the convection were well represented in this model simulation. A more detailed model evaluation with additional measurements (e.g., radiosoundings, wind and aerosol lidar) will provide further information on the processes leading to convection, in the model simulations and in reality.

V. CONCLUSIONS AND OUTLOOK

We compare convection-resolving model simulations conducted with the COSMO-Model, an operational NWP model, with dedicated field observations during a convective situation in Central Europe. On 12 July 2006 weak synoptic forcing lead to the initiation of local convective cells over orographically-structured terrain in Central Europe including the Black Forest. Field observations obtained within the PRINCE experiment give insights into the pre-convective environment and the initiation of convection. The evaluation of the model simulation shows that the general meteorological situation and the formation of convective precipitation is well captured by the model. The location of the convective inside the Murg Valley can be reproduced by the model simulation, while the amount of precipitation compared to radar observations is underestimated. The timing of the precipitation (not shown here) is significantly delayed in the model simulations.

Further studies, to be presented at the conference, will focus on a more in-depth model evaluation of the initiation of convection compared to available observations obtained within PRINCE.

VI. ACKNOWLEDGMENTS

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