HIGH-RESOLUTION SIMULATIONS OF PRECIPITATION DURING
THE REYKJANES EXPERIMENT (REX)

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1. INTRODUCTION

During the Reykjanes EXperiment (REX), (de Vries and Ólafsson, 2003) precipitation was observed in a dense network across a 20 km wide and 700 m high mountain ridge in SW-Iceland (Figure 1). Here, we

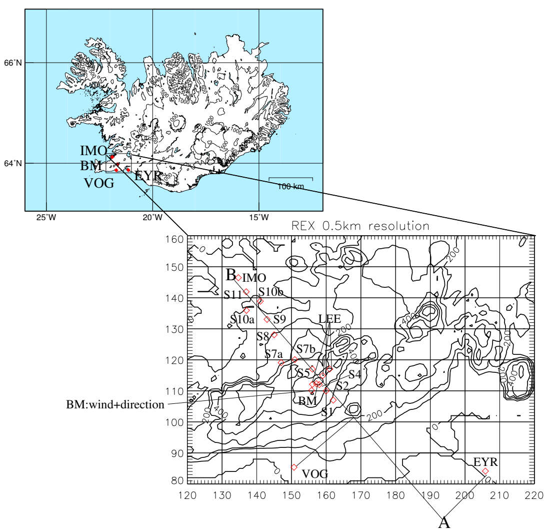

Figure 1: *Overview of the location of precipitation observations during the Reykjanes EXperiment.*

will focus on precipitation simulated numerically during Observation Period 5 (OP5) of REX, 3–7 October 2002.

2. EXPERIMENTAL SETUP

The evolution of the atmosphere is simulated with the PSU/NCAR MM5 model (Wang et al., 2001). In this study, the turbulent boundary layer is parameterized according to Hong and Pan (1996) and cloud physics and precipitation processes according to Grell et al. (1995) and Thompson et al. (2004), respectively. The simulations are carried out with horizontal resolution of 2, 4 and 8 km with initial and boundary conditions from both the European Centre for Medium-Range Weather Forecasts (ECMWF) and National Centers for Environmental Prediction (NCEP). The 2 and 4 km runs were initialized by one way nesting of data from the coarse, 8 km resolution run. The 8 km mother domain size is 123×95 points with 23 vertical levels but the higher resolution runs has 40 vertical levels.

3. MODEL RESULTS

3.1. Observation period 5

Figure 2 shows the accumulated precipitation as simulated with 2 km horizontal resolution, using ECMWF data, during OP5.

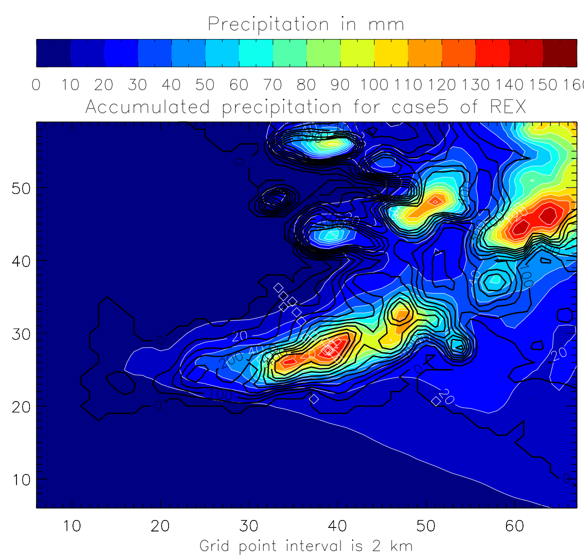

Figure 2: *Accumulated precipitation during REX OP5, 3–7 October 2002, as simulated with the MM5 model with 2 km horizontal resolution and boundary conditions from the ECMWF.*

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The orographic nature of the precipitation pattern is evident, as the precipitation isolines coincide largely with the topography. The simulated precipitation is typically about 20–30 mm at the south coast, while in the mountains the simulated precipitation is 5–6 times greater.

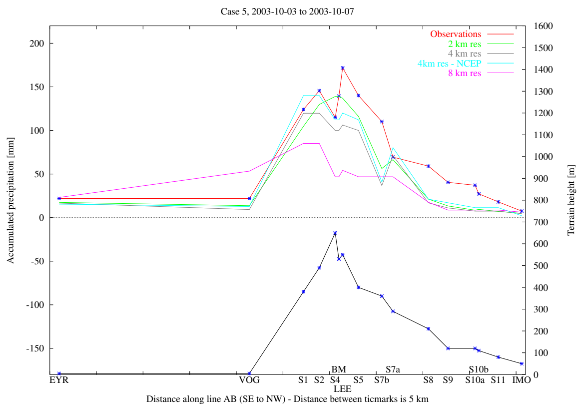

Figure 3: *Observed and simulated precipitation during REX OP5. The simulations are forced with either boundaries from the ECMWF or NCEP and they have horizontal resolution of either 8, 4 or 2 km. The lower panel shows the height of the topography for cross section AB (SE to NW) shown in Figure 1.*

Figure 3 compares observed precipitation and precipitation simulated with different horizontal resolutions and with different lateral boundary conditions. The precipitation on the upstream slope is slightly underestimated by the model, and so is the simulated precipitation close to the mountain top.

Over the downstream slopes the model produces on the other hand only half of the observed values. The simulation with 8 km horizontal resolution gives a smaller maximum value than the simulations with greater horizontal resolution, but the area of increased precipitation extends further upstream of the mountains. This corresponds to the topography being smoother in the 8 km simulation than in the 4 km and 2 km simulations. The simulation with the NCEP analysis at the boundaries produces more precipitation in the mountains than the simulation forced with data from the ECMWF. A comparison of these two simulations and the upper air observations from Keflavík (WMO 4018) reveal a relatively dry layer close to 850 hPa in the simulation with boundary data from the ECMWF. No such layer is present in neither the observations nor in the simulation with boundary data from NCEP (Figure 4 (a)–(c)).

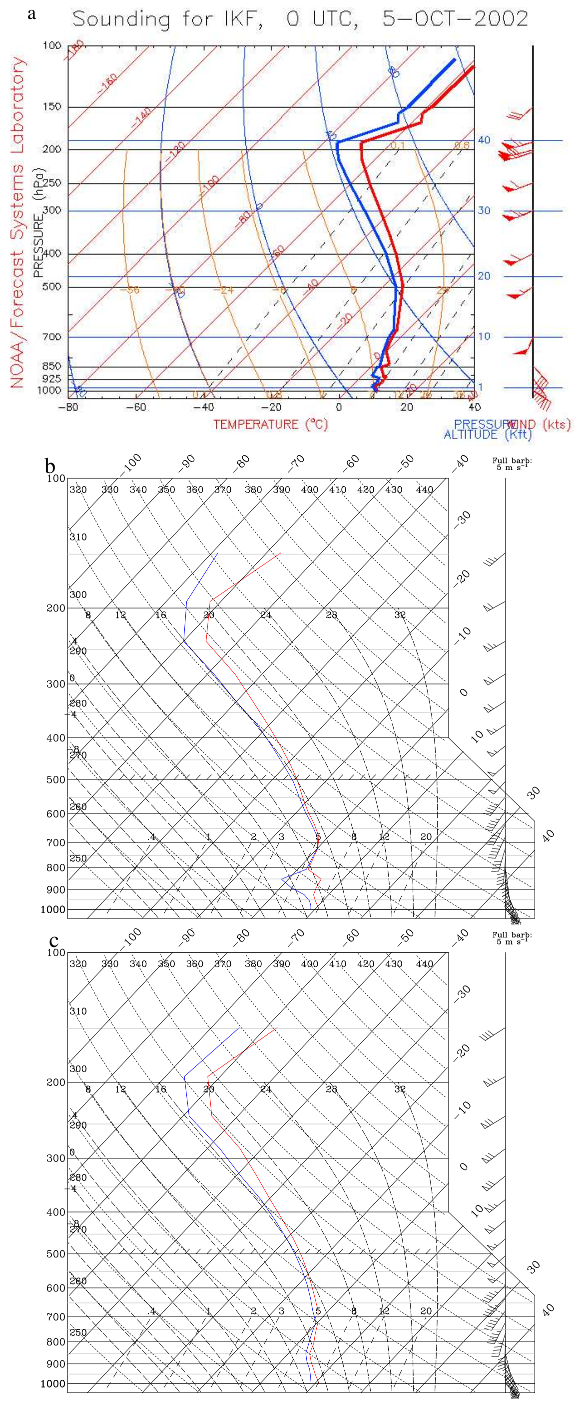

Figure 4: *The vertical profile of the atmosphere above Keflavík (WMO 4018) on 5 October 2002 at 00 UTC, (a) observed, (b) simulated with boundaries from the ECMWF, (c) simulated with boundaries from NCEP.*

3.2. Other observation periods

The downslope dryness in the simulated precipitaiton is apparent for all of the OP's and not only OP5.

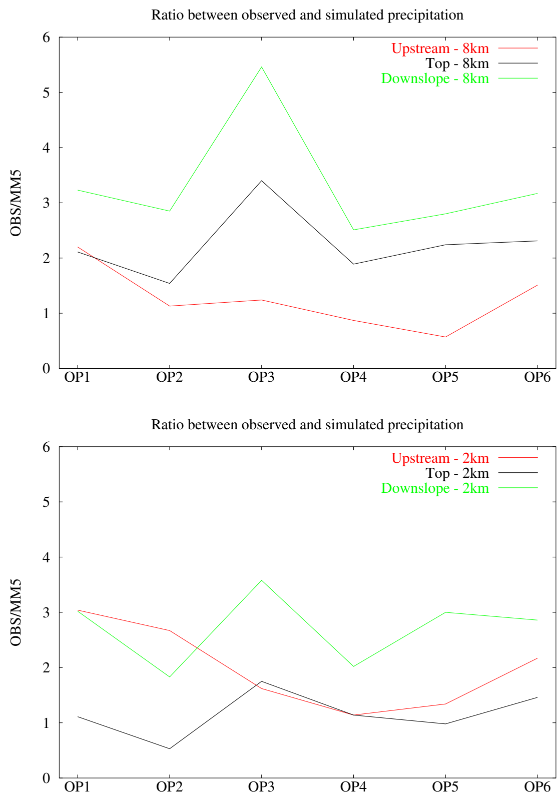

Figure 5: *The ratio between observed and simulated precipitation for all six observational periods. At 8 km horizontal resolution (upper) and 2 km resolution (lower).*

Figure 5 shows this clearly. Here, "upstream" is defined as the mean of points EYR and VOG in Figure 3. Further, "top" and "downslope" are defined as the mean of points S2, BM and S4 and points S10a, S10b, S11 and IMO, respectively, shown in Figure 3. It is also worth noticing that the upstream flow seems to become overly dry as the horizontal resolution is increased. This is presumably due to the lack of moisture in the impinging flow. The absolute error (in mm) is greater in the mountains than in the lowlands upstream. The relative error (Obs/MM5) tends to be lower in the mountains than in the lowlands.

4. DISCUSSIONS AND SUMMARY

The numerical model MM5 is able to reproduce the precipitation observed in REX OP5 quite realistically close to the crest of the mountain range, but underesitmates the precipitation over the lee slopes. As expected, a simulation with horizontal resolution of 8 km gives a different precipitation pattern with a lower maximum value than simulations with higher horizontal resolution and more detailed topography. However, the spatially averaged accumulated precipitation across the entire mountain range is similar at all resolutions.

A relatively dry layer close to 850 hPa is erroneously represented in the ECMWF analysis during OP5 and appears to contribute to the underestimation of precipitation at the crest of the mountain range.

Why the downslope precipitation is apparently grossly underestimated in the MM5 simulations for all OP's, independent of horizontal resolution, remains an open question and requires further study. One possible venue of thought would be to investigate the sensitivity of the microphysics scheme used for changes in the droplet spectra.

5. ACKNOWLEDGEMENTS

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