METEOROLOGICAL AND HYDROLOGICAL MODELING OF AN EXTREME PRECIPITATION EVENT IN S–ICELAND

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Abstract: The atmospheric conditions and surface runoff during an event of extreme precipitation have been simulated using numerical weather and hydrological runoff models. The results are compared to the available observations, indicating that the simulations are quite successful in reproducing the event. In the atmospheric simulations, there are very large orographic gradients in precipitation, but no direct observations to verify these gradients. The increase in runoff provides however an indirect validation and the quality of the results are such that numerically simulated precipitation will be used in future hydrological studies in the region.

These studies are of great importance to improve flood prediction for the area and for the creation of design floods for various hydropower plants, reservoirs and diversion structures within the river basin.

Keywords *– Numerical simulations, hydrology, precipitation, flood prediction, Iceland, HEC-HMS, MM5*

1. INTRODUCTION

A short winter flood in S–Iceland in January 2002 has been simulated using numerical methods. Results were compared to observed precipitation and discharge data from within the Þjórsá–Tungnaá river basin shown in Fig. 1.

2. EXPERIMENTAL SETUP

The atmospheric conditions were simulated using the PSU/NCAR MM5 mesoscale model (Grell et al., 1995), forced with initial and boundary data from the European Centre for Medium range Weather Forecasts (ECMWF). 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 were carried out with 9 and 3 km horizontal resolution. The mother domain size being 109×85 points with 40 vertical levels and the 3 km, one-way nested, domain being 79×88 points. Data was written out every three hours. Further discussions about the model setup and the observational network in Iceland can be found in Rögnvaldsson et al. (2004).

Evolution of the snow pack was modeled by a one-dimensional energy and mass balanced model and surface runoff was simulated with the HEC-HMS model (Hydrologic Modeling System, 2000), using atmospheric parameters from the MM5 model as input.

2.1 Flood routing

The model domain of the runoff model for the Þjórsá–Tungnaá river basin includes 850 points in the weather and snow model, 105 overland flow sub basins, 370 km of river reaches (several hundred cross sections in open channels) . The runoff model further takes into account reservoirs and power stations and other hydraulic structures within the area.

2.2 Model calibration

The HEC-HMS model was calibrated for a short winter flood in January 2002. The flood lasted for approximately five days. The most important calibration parameters were the initial snow depth (water equivalent, see Fig. 1), percentage of ground surface that was covered with snow, the liquid water holding capacity of the snow and the infiltration to the ground.

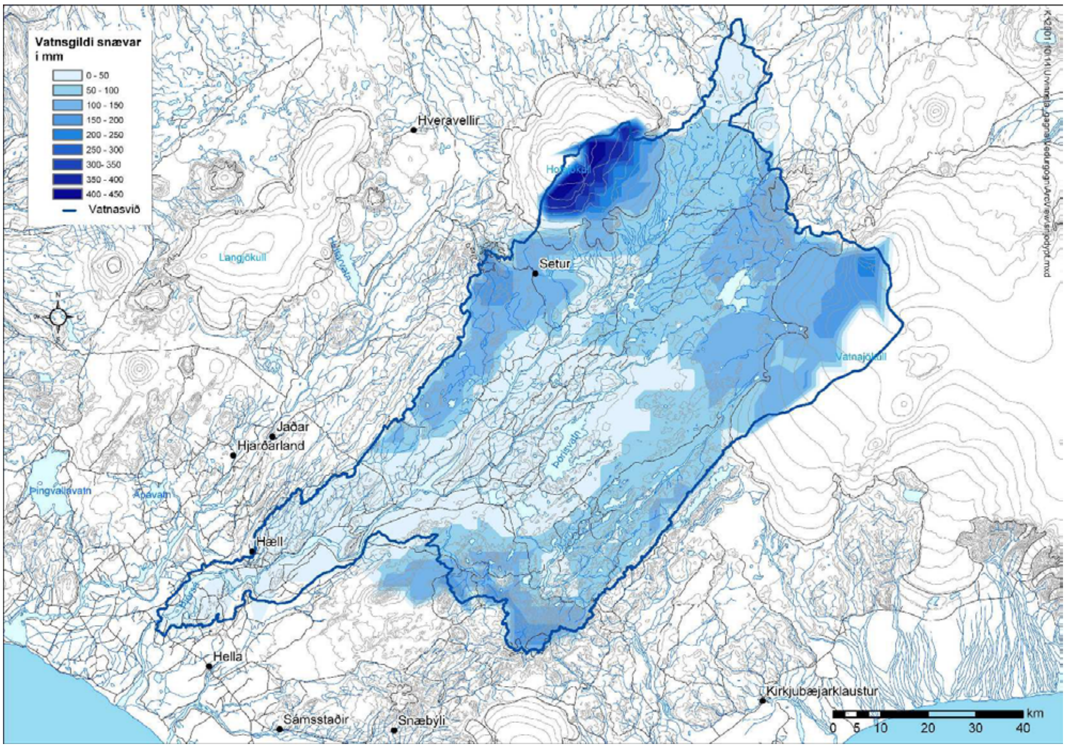


Figure 1. Initial snow cover, water equivalent in mm, for the Þjórsá–Tungnaá river basin.

4. COMPARISON WITH OBSERVATIONS

Fig. 2 shows comparison between computed and measured vapour pressure at automatic weather station Setur, shown in Fig. 1.

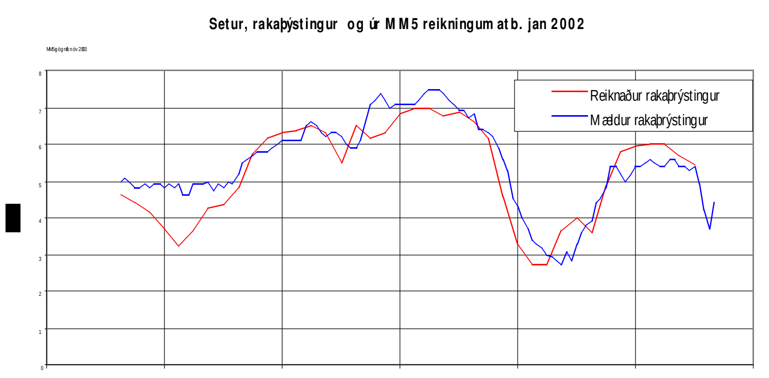


Figure 2. Vapour pressure [hPa] at station Setur. Blue lines indicate measured values and red simulated values.

The vapour pressure is quite well simulated and shows little signs of being biased. Fig. 3 shows comparison between computed and measured two meter temperature at the same station.

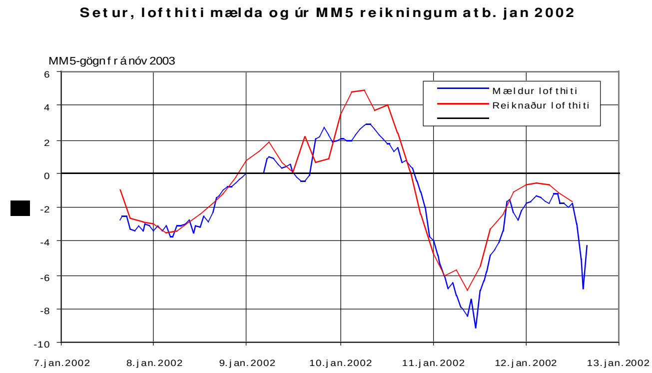


Figure 3. Two meter temperature [°C] at station Setur. Blue lines indicate measured values and red simulated values.

The temperature is well simulated, except the model is overestimating it by approximately 2°C on January 10. Fig. 4 shows the accumulated precipitation from the MM5 model between January 8 and 12.

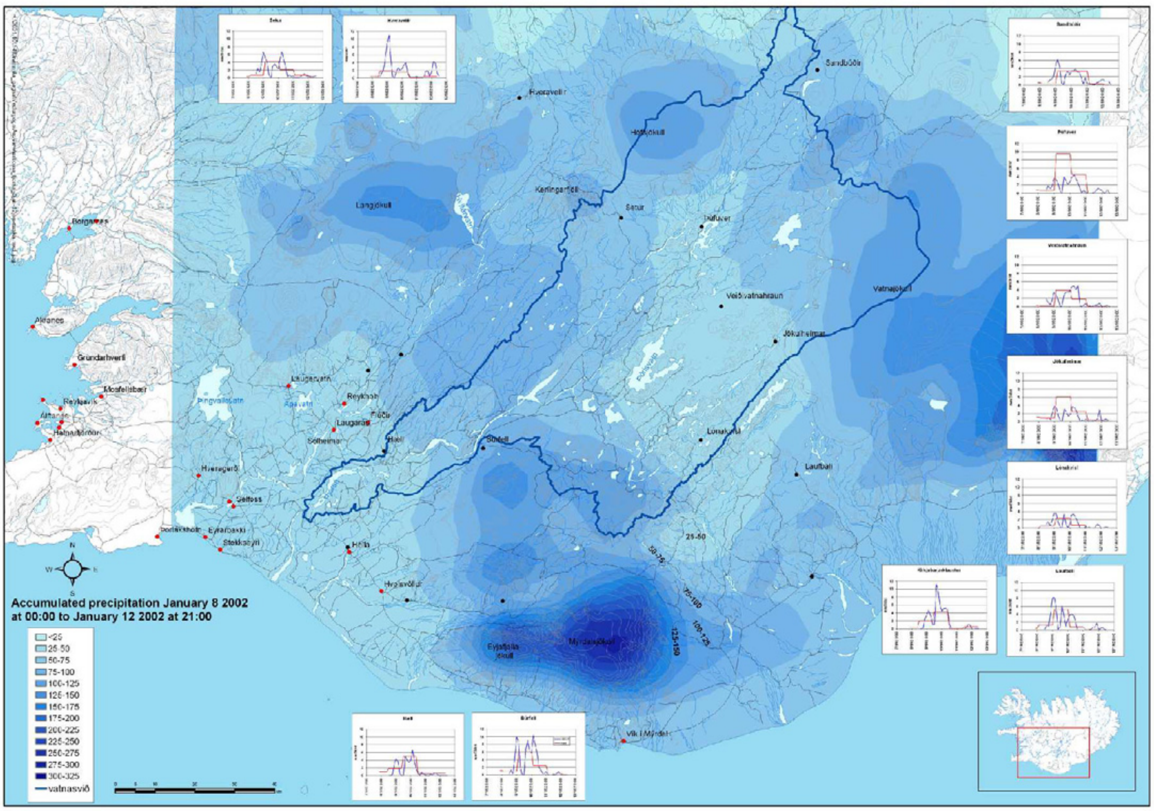
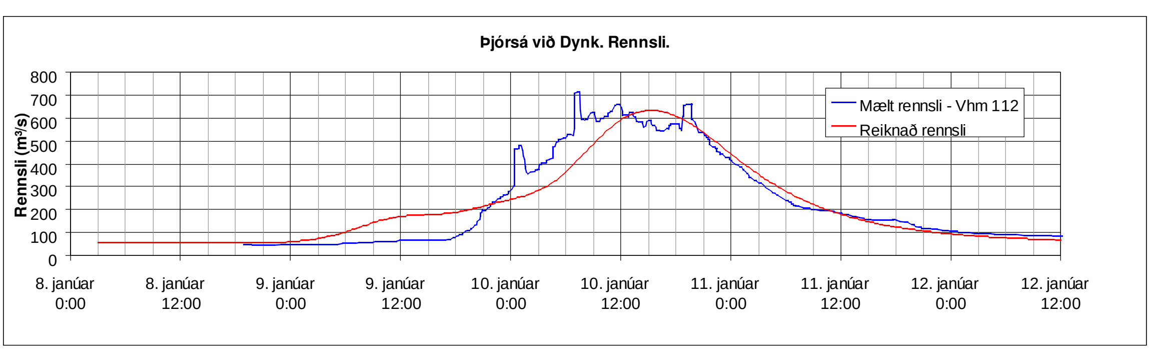


Figure 4. Accumulated precipitation [mm] between January 8 and 12, simulated by MM5.

The simulations show a realistic precipitation pattern with strong orographic gradients over the Eyjafjalla- and Mýrdaldsjökull glaciers. The heaviest precipitation within the river basin is to the north and northeast, as well as over the southern part. The central area is fairly well sheltered by the surrounding highlands.



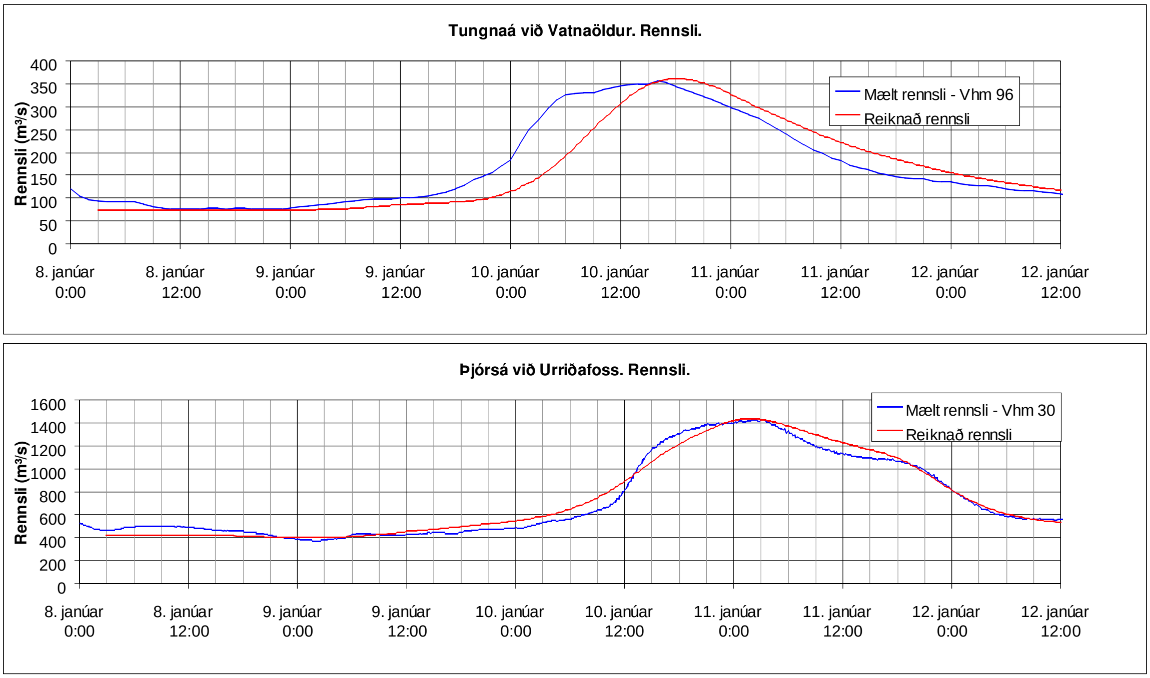


Figure 5. Measured (blue) and computed (red) discharge [m^3/s] at gauging stations Dynkur in Þjórsá river (top), Vatnaöldur in Tungnaá (middle) and Urriðafoss in Þjórsá (bottom).

Fig. 5 shows comparison between observed and computed discharge at three gauging stations in Þjórsá and Tungnaá rivers. Observed discharge is in general in fairly good agreement with simulated one. The 6–8 hour time delay between measured and computed discharge at Vatnaöldur gauging station can be explained by a local delay in computed precipitation in that part of the river basin as compared to measured precipitation at automatic weather stations in the area. Otherwise, the timing of the flood is very good. The magnitude and duration of the flooding events is very well simulated at all three stations.

5. CONCLUSIONS

We conclude that the HEC-HMS runoff model, calibrated with meteorological data from simulations made by the MM5 model, shows results that are in good agreement with observed discharge in the Þjórsá–Tungnaá river basin.

These studies are of great importance to improve flood prediction for the area and for estimating design floods for various hydropower plants, reservoirs and diversion structures within the river basin.

REFERENCES

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1995: A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5). NCAR/TN-398+STR. National Center for Atmospheric Research, Boulder, CO, 107 pp.

Hong, S. Y. and H. L. Pan, 1996: Nonlocal boundary layer vertical diffusion in a medium-range forecast model. *Mon. Weather Rev.,* **124**, 2322–2339.

Hydrologic Modeling System (**HEC-HMS**) – Technical Reference Manual, 2000. Hydrologic Engineering Center., U.S. Army Corp of Engineers, Davis, Calif.

Rögnvaldsson, Ó, P. Crochet, and H. Ólafsson, 2004: Mapping of precipitation in Iceland using numerical simulations and statistical modeling. *Meteorol. Z.*, **13**, No. 3, 209–219.

Thompson, G., R. M. Rasmussen, and K. Manning, 2004: Explicit forecasts of winter precipitation using an improved bulk microphysics scheme. Part I: Description and sensitivity analysis. *Mon. Weather Rev.*, **132**, 519–542.