REGIONAL AND SEASONAL VARIABILITY IN PRECIPITATION SCENARIOS FOR ICELAND

Haraldur Ólafsson[1,2] and Ólafur Rögnvaldsson[2,3]

[1]University of Iceland, Reykjavík, Iceland
[2]Bergen School of Meteorology, Geophysical Insitute,
University of Bergen, Norway
[3]Institute for Meteorological Research, Reykjavík, Iceland

ABSTRACT

Dynamic downscalings of precipitation scenarios are explored. The simulations show only a moderate change in the mean annual precipitation in Iceland. However, there is a substantial precipitation increase predicted in S-Iceland and W-Iceland in the autumn and in NE-Iceland in the winter. The simulations show a maximum increase above sloping topography, leading to the conclusion that due to poor resolution of the topography, an increase in precipitation in the mountains may be much greater than simulated. This emphasises the need for high-resolution climate simulations.

INTRODUCTION

In order to assess plausible regional changes of precipitation in Iceland, dynamic downscaling of global atmospheric simulations from the Hadley center model (HadAM3H, Johns *et al.*, 2003) have been explored. The downscalings were carried out with the HIRHAM regional climate model (BjÃÿrge *et al.*, 2000) for a limited area (1) over the N-Atlantic and NW-Europe (Haugen and Iversen, 2005). They were an integrated part of the international PRUDENCE climate project (Christensen, 2004). The global model represents a coupled ocean-ice-atmosphere system with a horizontal resolution of T106 which corresponds roughly to 125 km.

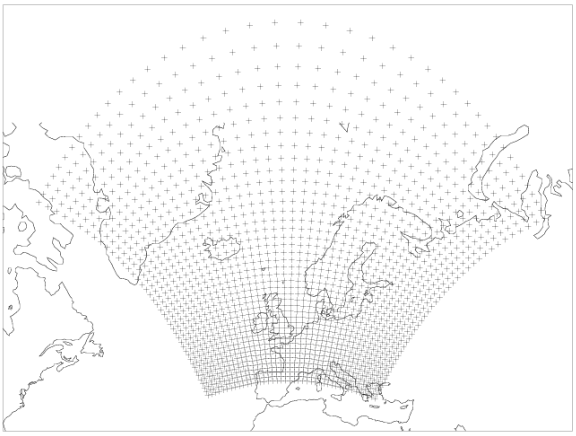


Figure 1: The simulation domain of the HIRHAM dynamic downscaling.

The HIRHAM downscaling was carried out in 19 vertical levels with a horizontal resolution of 55 km. Most weather systems approach Iceland from the south and the west. The outer boundaries of the simulation domain, southwest of Iceland, are only about 1200 km away and this may have an impact on the development of extratropical cyclones arriving from this direction. It is not clear how important this effect may be and should be investigated in connection with future simulations. Some numerical noise is found at the outermost gridpoints of the HIRHAM domain, but this noise fades out within 5 grid points or even less. Global simulations corresponding to two emission scenarios were downscaled, the IPCC SRES A2 and IPCC SRES B2 (Nakicenovic and Swart, 2000).

REGIONAL AND SEASONAL VARIABILITY OF PRECIPITATION

Figures 2 and 3 show the projected changes in the mean annual precipitation and the mean seasonal precipitation from the reference period (1961–1990) to

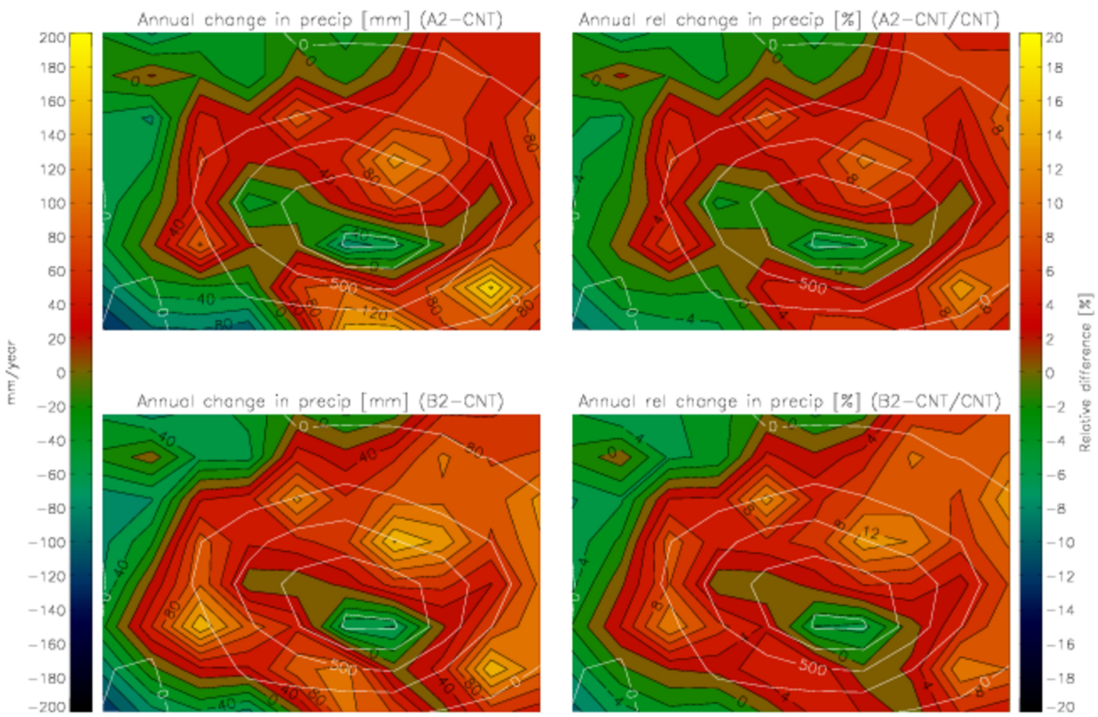
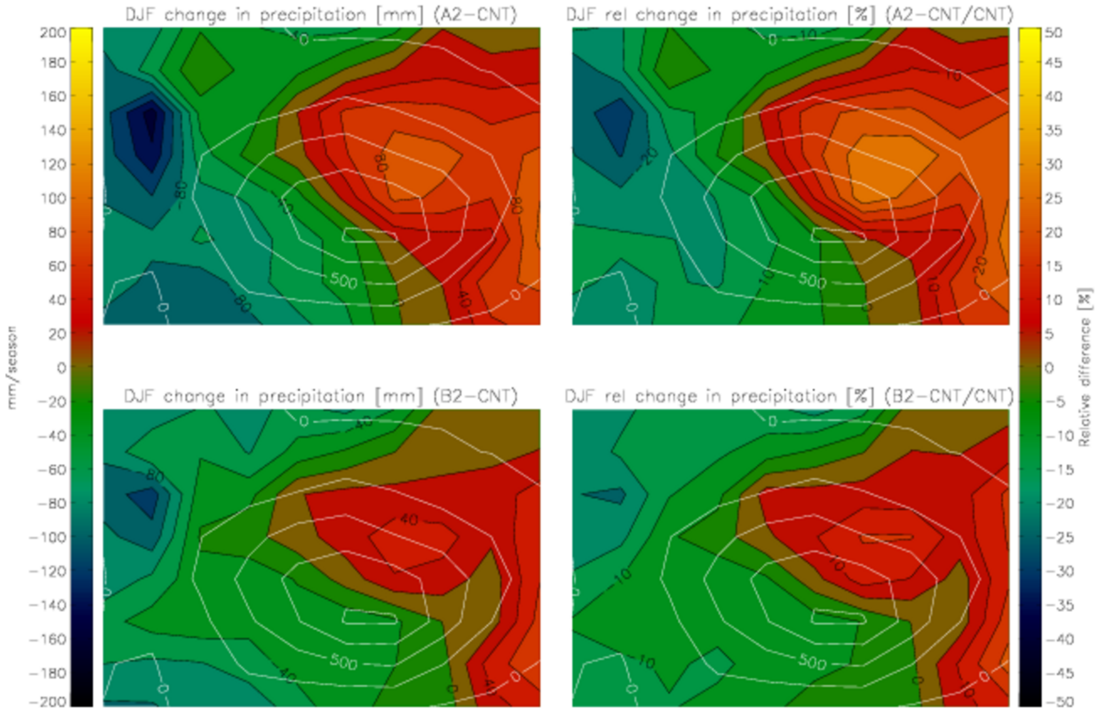
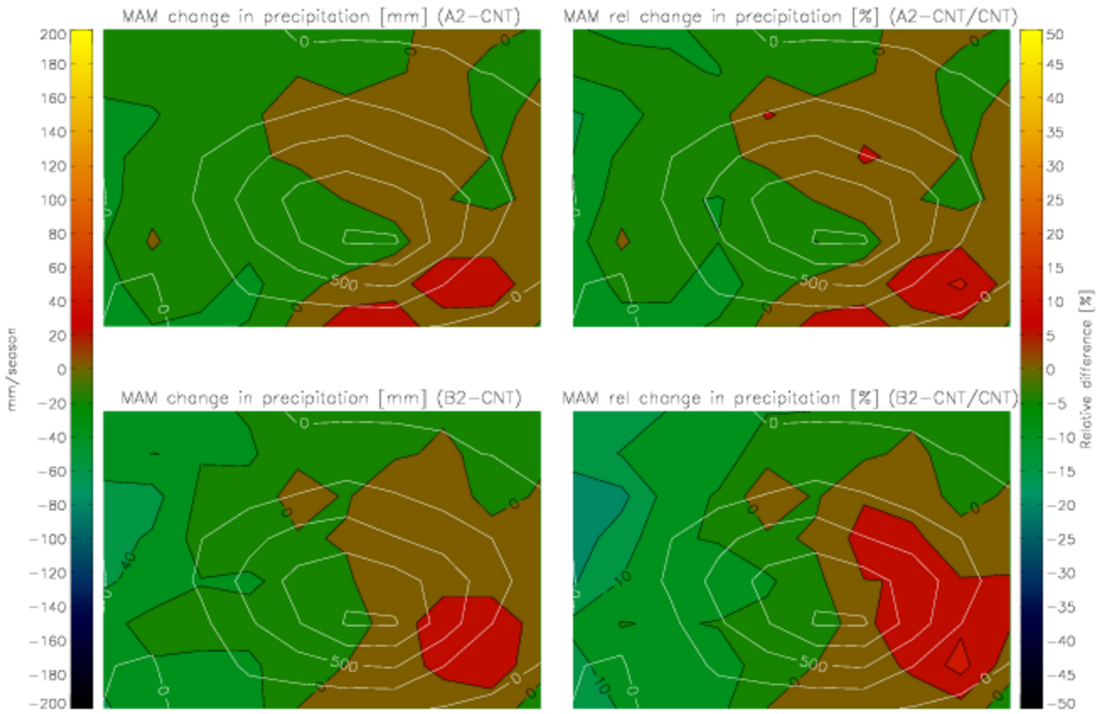


Figure 2: Change in annual precipitation in Iceland according to the HIRHAM A2 and B2 downscaling of HadAm3 GCM simulations. The left panels show changes in mm and right hand panels show relative changes (difference of the mean precipitation in the periods 2071–2100 and 1961–1990 relative to the mean precipitation of 1961–1990). The top panels show scenario A2 and the bottom panels scenario B2. White contours indicate the model topography of Iceland with 250 m intervals.

2071–2100 as simulated with the HIRHAM model. The changes in the mean

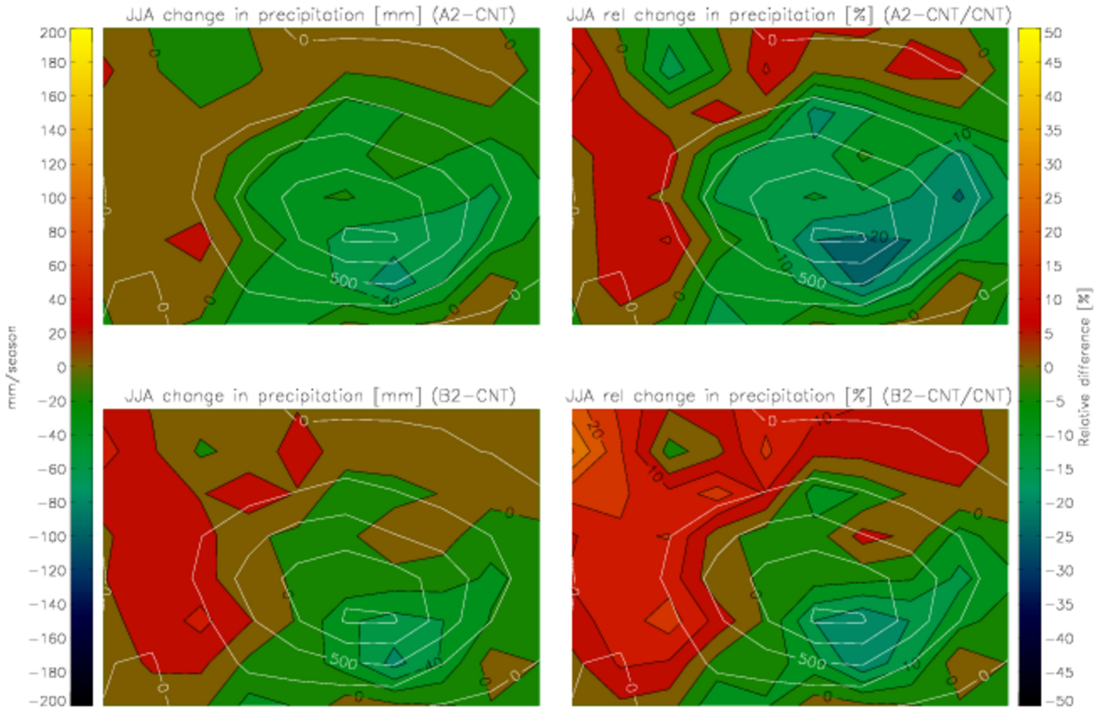


(a) DJF change in precipitation

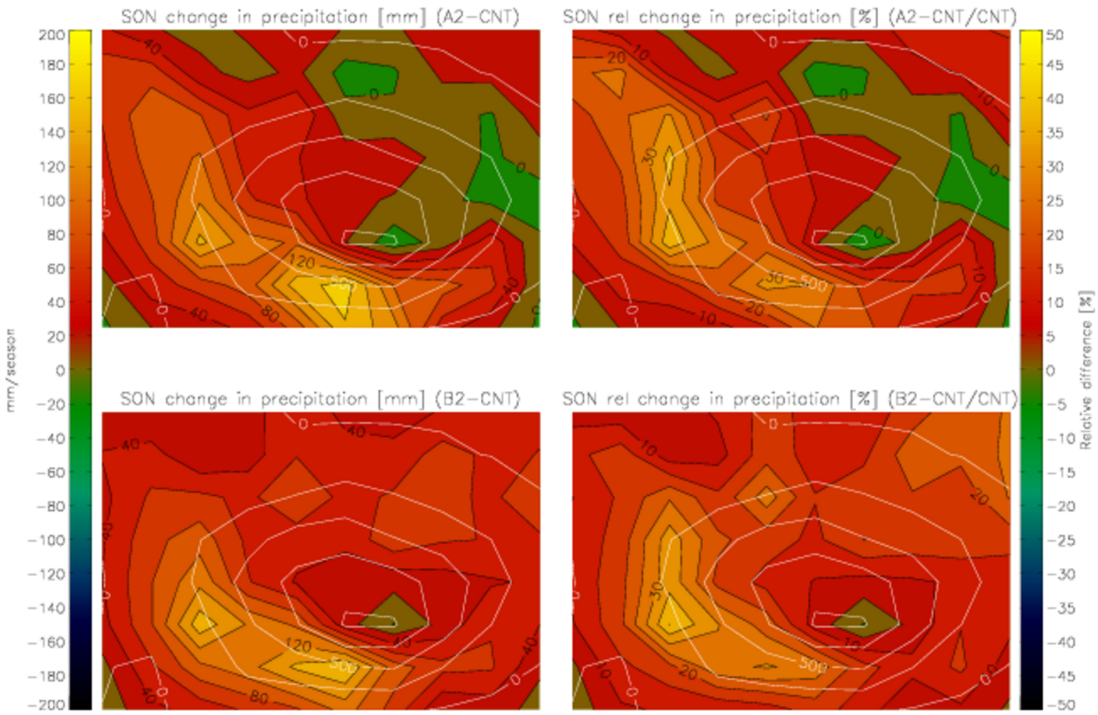


(b) MAM change in precipitation

Figure 3: Same as 2, but for individual seasons (DJF, MAM, JJA and SON.



(c) JJA change in precipitation



(d) SON change in precipitation

Figure 3: Cont.

annual precipitation are quite moderate. In most coastal regions there is an increase of 0–10%, but in the central highlands there is a small decrease. In general, the predicted patterns of precipitation change are similar in both scenarios, A2 and B2. While there is only quite a moderate increase in mean annual precipitation, there is a relatively large change in the mean precipitation in individual seasons (cf. 3). The autumn is expected to be considerably wetter in S-Iceland and W-Iceland, while the projections for N-Iceland and E-Iceland are more ambiguous. The spring becomes slightly drier everywhere and the winter is expected to be drier in SW-Iceland and much wetter in NE-Iceland. The summer predictions are rather noisy. As for most other aspects of projected changes in precipitation, it is unclear to what degree these local and seasonal changes are due to "natural" fluctuations in the climate simulations or to what extent they represent a true deterministic signal caused by greenhouse warming.

THE SLOPE SIGNAL

There is a clear slope-signal in the predicted precipitation change, particularly in the autumn precipitation increase in the south and in the winter precipitation increase in the NE. The maximum precipitation increase coincides with

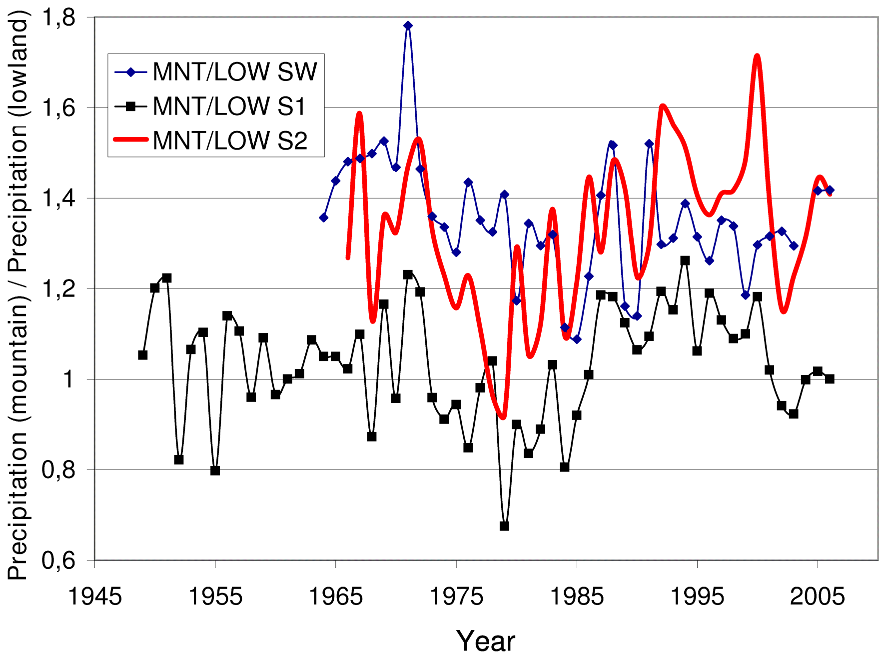


Figure 4: Ratio of observed precipitation at locations where there is significant orographic enhancement of precipitation (mountain) to precipitation observed in the same region, but farther away from the mountains (lowland). The weather stations are Stardalur and Keflavíkurflugvöllur (SW), Vatnsskarðshólar and Stórhöfði (S1) and Skógar and Stórhöfði (S2). The figure is redrawn from Ólafsson and Arason (2007).

the maximum slope of the topography, indicating that the orographic enhancement of precipitation will increase. The complexity of the connection on climatic time-scales between precipitation in the mountains and in the lowlands may in other words be greater than previously considered. If this is correct, time-series of precipitation that are created by assuming linear connection between precipitation in the mountains and precipitation in nearby lowlands must be revised. If mountains are poorly resolved, which is almost always the case, the use of the delta method (future scenario minus control simulation) for estimating precipitation change in the mountains becomes questionable. The orographic signal raises the question on how the ratio of precipitation in mountains to lowland precipitation looks like in the past. Figure 4 shows that there is indeed not only interannual, but also substantial interdecadal variability in this ratio. This needs to be investigated further and connected to elements of the meso- and synoptic scale airflow.

CONCLUSIONS

Apart from quantitative results on precipitation in different regions and in different seasons in Iceland, a key conclusion of this study is that a strong slope signal in the projected precipitation changes calls for high-resolution simulations of future scenarios. The resolution should be sufficient to reproduce the topography. Optimal resolution for climate studies can therefore be expected to be dependent upon the steepness of the mountains.

Acknowledgement

The authors would like to thank J. E. Haugen and T. Iversen for providing the HIRHAM data. This study was supported by the CE and VO projects.

REFERENCES

Bjørge, D., J. E. Haugen and T. E. Nordeng (2000) Future climate in Norway. Dynamical downscaling experiments within the RegClim project. *Res. Rep. 103*, Norw. Meteorol. Inst. Oslo, Norway.

Christensen, J. H. (2004) PRUDENCE (Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects) Final report (http://prudence.dmi.dk).

Haugen, J. E. and T. Iversen (2005) Response in daily precipitation and wind speed extremes form HIRHAM downscaling of SRES B2 scenarios. In *RegClim Tech. Rep. 8.* Norw. Met. Inst., Oslo, Norway.

Johns, T. C., J. M. Gregory, W. J .Igram, C. E . Johnson, A. Jones, J. A. Lowe,

J. F. B. Mitchell, D. L. Roberts, D. M .H. Sexton, D. S. Stevenson, S. F. B. Tett and M . J. Woodageet (2003) Antropogenic climate change for 1860 to 2100 simulated with the HadCM3 model under updated emission scenarios. *Clim. Dyn.*, 20, 583–612.

Nakicenovic, N. and R. Swart (eds) (2000) *Emission Scenarios. A Special Report of Working Group III of the IPCC*. Cambridge Univ. Press UK, 570 pp.

Ólafsson, H. and T. Arason (2007) Observed trends in the orographic precipitation gradient. *Proc. Int. Conf. Alpine Meteorol. (ICAM)*, June 2007, Chambery, France, 4 p.