

LONG-TERM VARIABILITY IN THE OBSERVED OROGRAPHIC PRECIPITATION GRADIENTS IN ICELAND

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Abstract: Motivated by recent numerical results on large interannual variability of orographic enhancement of precipitation in Iceland, and forecasts of seasonal increase in the orographic enhancement of precipitation in the 21st century, long time series of precipitation observations are investigated. The observations do confirm a large interannual variability, but they also reveal periods of several years with either small or large orographic enhancement. The observations are partly in line with the climate predictions.

Keywords: *Orography, precipitation, gradient, trend, Iceland, variability*

1. INTRODUCTION

In complex terrain, precipitation gradients can be very large. Recent studies of precipitation in Iceland indicate that while annual precipitation away from mountains may be less than 1000 mm, precipitation in nearby mountains may be as much as 8000 mm, or even more (Rögnvaldsson et al., 2007 and ref. therein). Numerical simulations by Rögnvaldsson et al. (2007) did not only confirm the large precipitation gradient, but they also indicated a strong interannual variability in the ratio of precipitation in the lowlands to the precipitation in the mountains of Iceland. This variability was attributed to the variability in the frequency of wind directions, but orographic enhancement of precipitation can in some cases be very sensitive to the direction of the wind impinging the mountain. In a study of dynamic downscaling of precipitation in future climate (Rögnvaldsson and Ólafsson, 2005), an increase in the mean ratio of precipitation in the mountains to precipitation in the lowland was predicted for the 21st century. Such a pattern was particularly clear for winter precipitation in NE-Iceland, and in the autumn in S- and W-Iceland.

It is not a straightforward task to investigate precipitation in the mountains of Iceland. There are very few observations, and no long time series from mountains with heavy precipitation. In fact, observations from the mountains are mostly indirect (snow accumulation and run-off). Even if there were available direct observations of precipitation, such data would be of limited value because of large undercatchment of solid precipitation in strong winds.

In this study, precipitation observations from selected weather stations in Iceland are studied in order to shed some light on the temporal variability of the orographic enhancement of precipitation in Iceland. Precipitation observed away from the mountains is compared to precipitation observed at the foothills of the mountains where the orographic enhancement is important.

2. DATA

Figure 1 shows the location of the manned weather stations used for this study. There are four sets of stations, SW, N, NE and S. Each set contains one weather station where orographic enhancement of precipitation can be considered to be small and at least one station at the foothill of nearby mountains, on their upstream side during most precipitation events. The stations are Keflavíkurlflugvöllur and Stardalur (SW), Hraun and Sauðanesviti/Siglunes (N), Raufarhöfn and Dalatangi (E) and Stórhöfði, Skógar and Vatnsskarðshólar (S). All of these stations are operated by Veðurstofa Íslands (the Icelandic Meteorological Office).

3. RESULTS

Figure 2 shows the ratio of the difference between annual precipitation at the mountain station and the lowland station normalized with the annual precipitation at the lowland station. There is indeed a very large interannual variability in this ratio. There is also a clear variability on a longer time scale; there were periods

of several years in the late 40s, in the late 60s and around 1990 with relatively low orographic enhancement in the northeast (NE). In the south (S1 and S2), the orographic enhancement was high around 1970, low around 1980 and there is a relatively regular increase from 1980 to 2000, followed by a decrease. The increase in the orographic enhancement in the NE since 1990 is present in all seasons, but most clearly in the

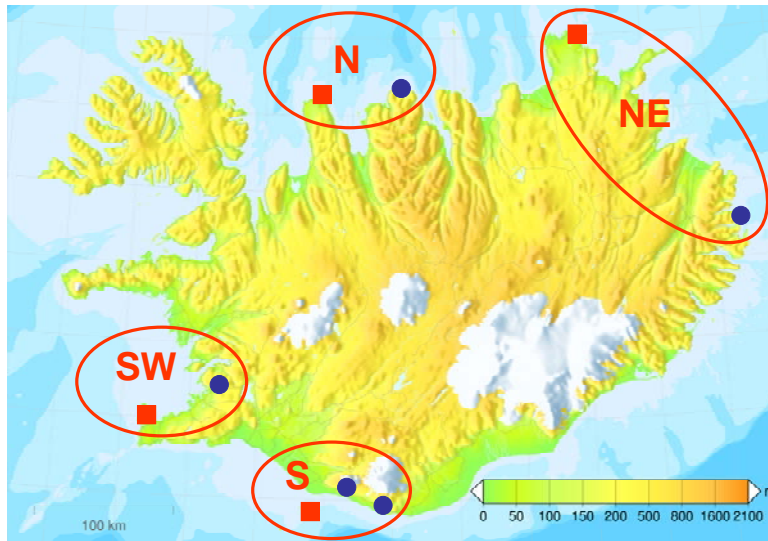


Figure 1: Location of the weather stations used for this study and four sets. Boxes indicate the stations away from the mountains, while circles show the location of the stations at the foothill of the mountains

autumn (fig.3 SON). The 1980 low values and the subsequent rise in the south are present in all seasons, and so is the decrease after the year 2000. The orographic enhancement is higher in the summer than in the winter in sets N and NE, it is quite similar in all seasons in set S, but higher in the winter than in the summer in set SW.

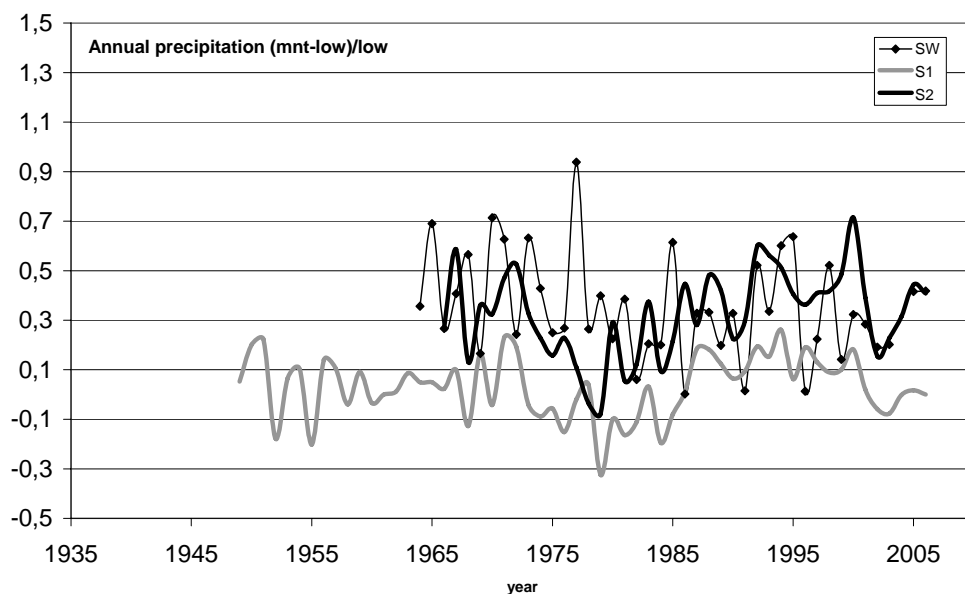


Figure 2(a): Difference between precipitation at the mountain station and the lowland station, divided by the annual precipitation at the lowland station. Stations in the two regions in the south (fig.1).

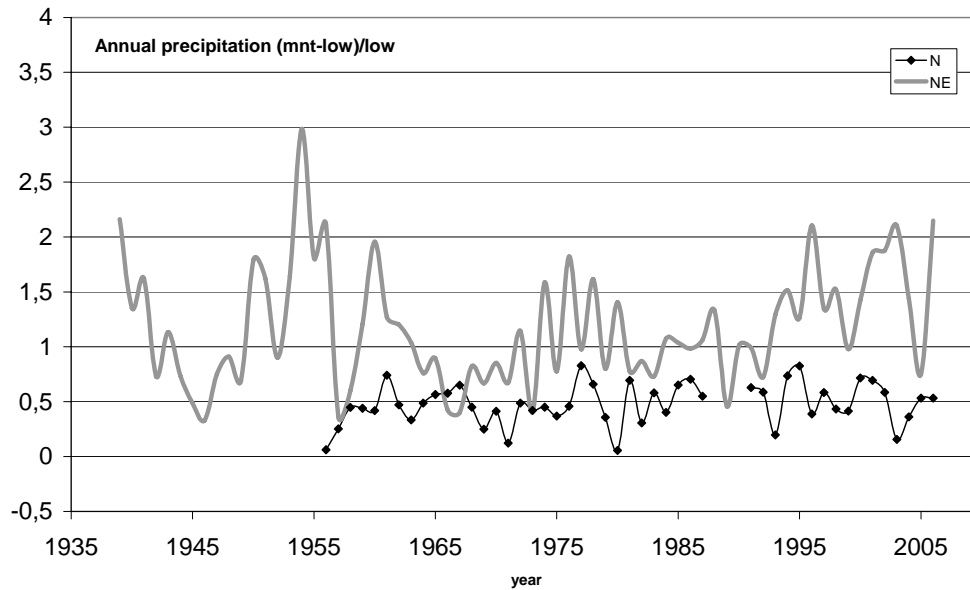
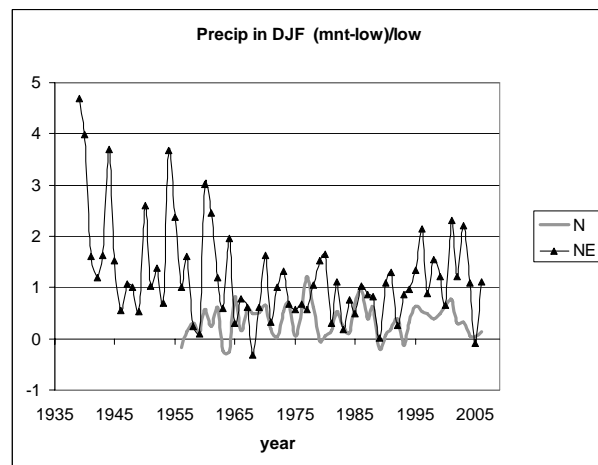
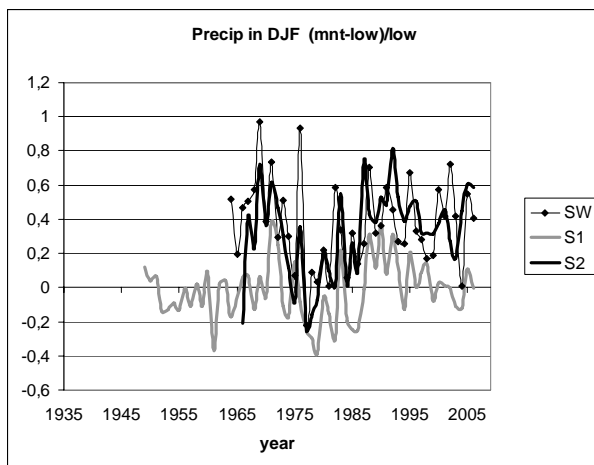


Figure 2(b): Difference between precipitation at the mountain station and the lowland station, divided by the annual precipitation at the lowland station. Stations in the two regions in the north (fig.1).

3. DISCUSSION

The results presented here confirm the large interannual variability in the orographic enhancement of precipitation indicated by Rögnvaldsson et al. (2007). However, in the present study, the maximum enhancement in the north is in the summer and not in the winter. This is presumably related to the location of the stations being upstream of the mountains. In the strong winter winds, the true orographic enhancement is presumably greater than in the summer, but the mountain precipitation maximum is further downstream than in the summer. Relatively weak winds in the summer give less advection of the precipitation and they also favour upstream blockings. Both contribute to shifting the precipitation maximum upstream. The set from the NE gives an increase in orographic precipitation from 1990 to 2006 which corresponds to the forecasted climate change (Rögnvaldsson and Ólafsson, 2005). However, unlike the climate forecast, there is somewhat stronger signal in the autumn (SON) than in the winter (DJF). Contrarily to the climate prediction for the 21st century, the observations show a moderate reduction in the orographic enhancement of autumn precipitation in the south (S) in the last 15 years.

The large observed variability observed in the orographic enhancement of precipitation needs to be related to elements of the atmospheric flow such as temperature and winds for conceptual understanding of the precipitation climate in the mountains and interpretation of future climate predictions.



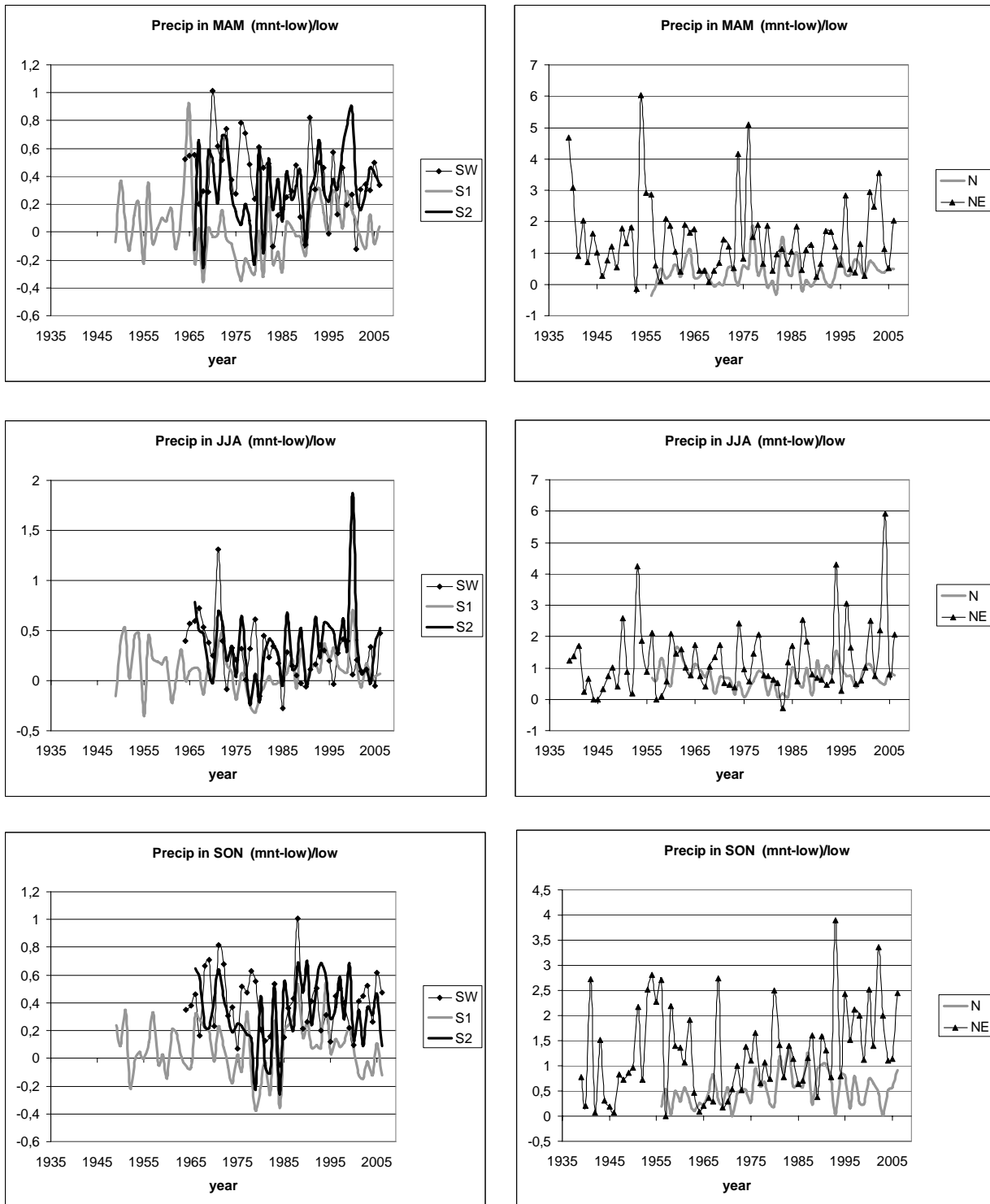


Figure 3: Time series as in fig. 2, but for individual seasons.

Acknowledgements: This work has been carried out in relation with the RÁV and CE projects.

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