P8.12 CONNECTION BETWEEN THE LOW-LEVEL AIRFLOW AND THE INCREASE OF PRECIPITATION WITH HEIGHT

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1. INTRODUCTION

Knowledge of the precipitation climate and possible evolution of the precipitation in the future is important for land use and the exploitation of the water. Estimating precipitation in complex terrain where a large part of the annual precipitation falls as snow in stong winds is problematic because of strong precipitation gradients and large observation errors. In some regions, such as in most of the mountain ranges in Iceland, there may not even be any observations available at all.

The Reykjanes peninsula in SW-Iceland is one of only few locations in Iceland where precipitation has been observed regularly for a number of years at high altitude and close to the coast. Reykjanes is the most densely populated part of Iceland and the water is a precious resource, not only for the population in their everyday life, but also for geothermal exploitation and for winter recreation. There is little aid from runoff observations, since there is basically no runoff on the surface of the earth. A large part of the winter precipitation falls in the form of snow and there are consequently large uncertainties in the precipitation observations.

Precipitation was observed in a dense network in the Reykjanes mountains during 6 weeks in the autumn of 2002 (de Vries and Ólafsson, 2003). These observations revealed a positive correlation between the speed of the incoming airflow and the increase of precipitation with height along the upstream slopes. The observations also showed that apparently similar weather events may lead to quite different precipitation patterns in the mountains.

The purpose of this study is firstly to establish a connection between the precipitation gradient in the mountains and the incoming airflow. Such a connection will help estimating the precipitation of the region during seasons with predominantly solid precipitation in the mountains and it will also be of guidance for the estimation of precipitation in other coastal mountain ranges of similar size. Secondly, the observed precipitation on the lowland and the connection between the precipitation gradient and the speed of the incoming airflow will be applied to construct a 50 years time series of precipitation in the mountains. This time series will be discussed in relation to extremes in the level of groundwater in the region.

2. PRECIPITATION OBSERVATIONS

Precipitation has been observed at an automatic weather station in the Reykjanes mountain range (Bláfjöll) since 1996 (Ágústsson, 2001). Here, the observed precipitation at Bláfjöll (station at 530 m.a.s.l) is compared to observed precipitation in the lowland at Keflavíkurflugvöllur (approximately 60 m.a.s.l.) where synoptic weather observations have been made every 3 hours for more than 50 years (Fig. 1). Apart from the time series, the dataset in this study includes only precipitation observed from 9-18 UTC during the summer season with winds at Keflavíkurflugvöllur from the sector between SE and SSW and temperature sufficiently high for the precipitation to be liquid in the mountains as well as on the lowland. The time series are constructed from all precipitation observations during all seasons, but only in flow from the sector between SE and SSW.

3. RESULTS

Figure 2 compares individual precipitation observations in the mountains and in the lowland. As expected, there is much more precipitation in the mountains in most cases, but there is not a very good correlation between the two stations. For 10 mm of rain in the lowland, the precipitation observed in the mountain is fairly evenly distrbuted between 5 and 55 mm. Precipitation intensity in the lowland alone is in other words a poor indicator of precipitation intensity in the mountains. With much more precipitation in the mountains than in the lowland, a larger proportion of the total precipitation must come during periods of intense rain. Figures 3 and 4 illustrate this difference between the lowland and the mountains. While days with precipitation 10 mm or less contribute to 70% of the total precipitation in the lowland, the corresponding proportion in the mountains is only 20%.

An investigation of the connection between factors of the incoming airflow and the precipitation gradient with height has revealed a clear and interesting connection between the wind speed and the precipitation gradient. This result is presented in Fig. 5, showing both the ratio of precipitation in the mountains to precipitation in the lowland and accumulated precipitation in the lowland as a function of wind speed in the lowland. The figure reveals that for wind speed 4 m/s or less, there is little difference between precipitation amount in the mountains and in the lowland, but only a little proportion of the total precipitation falls during such wind conditions. For increasing mean wind speeds, the precipitation ratio increases very rapidly and reaches 4 for 8 m/s. For wind speeds 8-16 m/s, the precipitation ratio remains close to constant and is even reduced for the wind interval of 12-15 m/s. At 18-19 m/s the ratio reaches up to 7, but that peak is based on a very limited number of observations, and so are the values for wind speeds above 19 m/s.

3. TIME SERIES

Although most of the precipitation falls in wind speeds close to 12 m/s, the annual mean wind speed during days with precipitation is only about 8 m/s (Fig. 6), but ranging from a little above 6 to nearly 9 m/s. Coincidently, this is the same range for which the ratio of precipitation in the mountains to precipitation in the lowland changes from 2 to 4. This invites us to construct an extended time series for precipitation in the mountains based on the observed precipitation in the lowland and the ratio of precipitation in the mountains to precipitation in the lowland as a function of wind speed. Such a time series is plotted in Fig. 7. There is of course a correlation between the two time series, but the relative amplitude of the oscillations is quite different. To give an example, there are similar peaks in 1972 and 1983 in the precipitation in the lowland. The 1972 maximum is associated with relatively stong winds, while the 1983 maximum has much less mean winds. Consequently, there is a much higher peak in the calculated 1972 mountain maximum than in the calculated 1983 mountain maximum.

4. DISCUSSION

The connection between the precipitation gradient or the ratio of precipitation in the mountains and in the lowland and the wind speed is the main result of this study. As the wind speed increases, so does the topographically forced ascendance over the upstream slopes of the mountain. The positive correlation between wind speed and the precipitation gradient with height is therefore not surprising. The strong increase in the precipitation ratio mountain/lowland for winds from 4 to 8 m/s may be associated with a regime change from blocked flow to flow over the mountains. The reduction in the precipitation ratio mountain/lowland for winds of 12-15 m/s may be associated with the precipitation maximum in the mountains being shifted in space, but this remains to be investigated. More observations are needed for investigation of the conditions under which the precipitation ratio mountain/lowland is extremely high.

There is no way to validate directly the calculated time series of the precipitation in the mountains, but some comparison can be made with groundwater data which is available for most of the period in question (Vatnamælingar Orkustofnunar). The absolute maxima at two locations (Heiðmörk and Kleifarvatn) close to the mountains were observed at the end of November and early December 1993. The absolute minima at the same locations are from November 1967 and May 1981. All these peaks correspond very well with the calculated time series for the mountains and they are more clearly distinguishable in the mountain time series than in the lowland observations (Fig. 7)

5. REFERENCES

Ágústsson, H., 2001: Samanburður á úrkomumælingum í Bláfjöllum og í Reykjavík. Tech. Rep., VI-TAS01015 (in Icelandic). 17 p. Available at the Icelandic Meteorological Office, Reykjavík, Iceland and at http://www.vedur.is/utgafa/greinargerdir/2001

Vatnamælingar Orkustofnunar (Hydrological Service of the National Energy Authorities): Observations of groundwater in SW-Iceland. Available on http://www.os.is/vatnam/maelinst.html

De Vries, M., and H. Ólafsson, 2003: Precipitation across a mesoscale mountain ridge – The Reykjanes Experiment (REX). Proc. Int. Conf. Alpine Meteorol. (ICAM), Brig, CH, May 2003. 4 p.

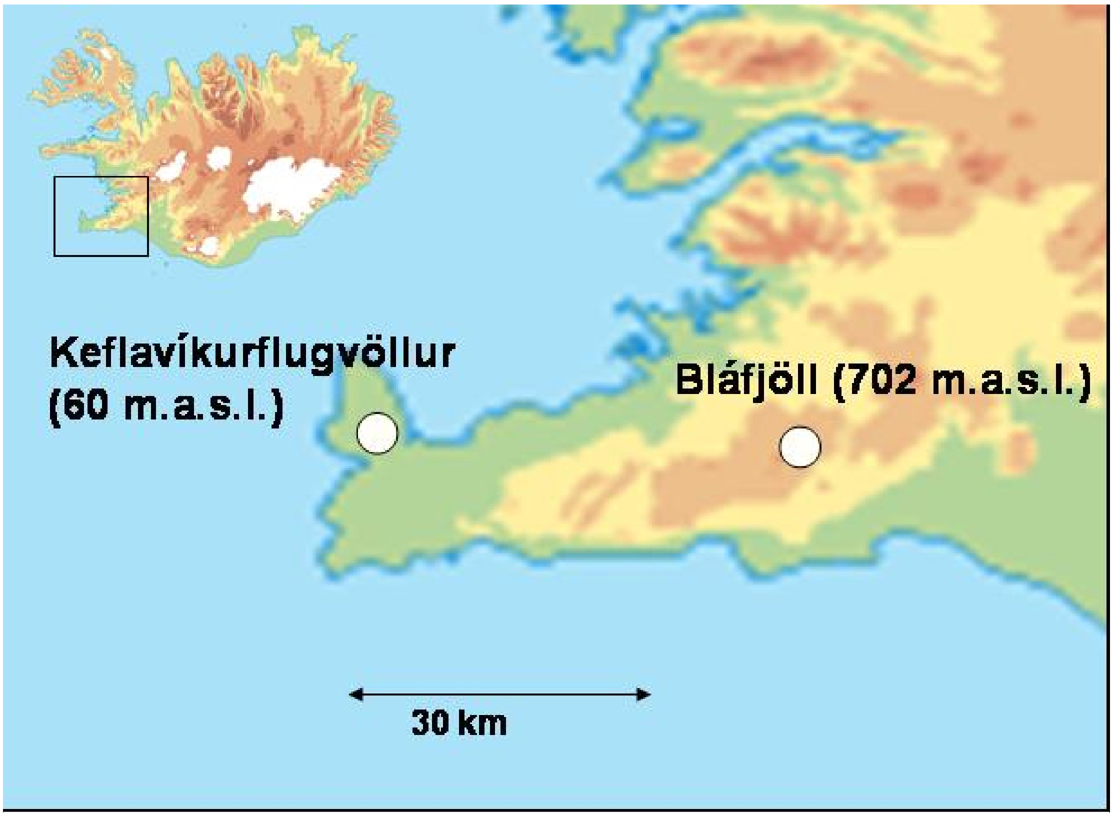

Figure 1. The location of the precipitation observation sites in the Reykjanes peninsula, SW-Iceland. The mountain top is at 702 m.a.s.l., but the raingauge is located to the west of the mountain top at 530 m.a.s.l.

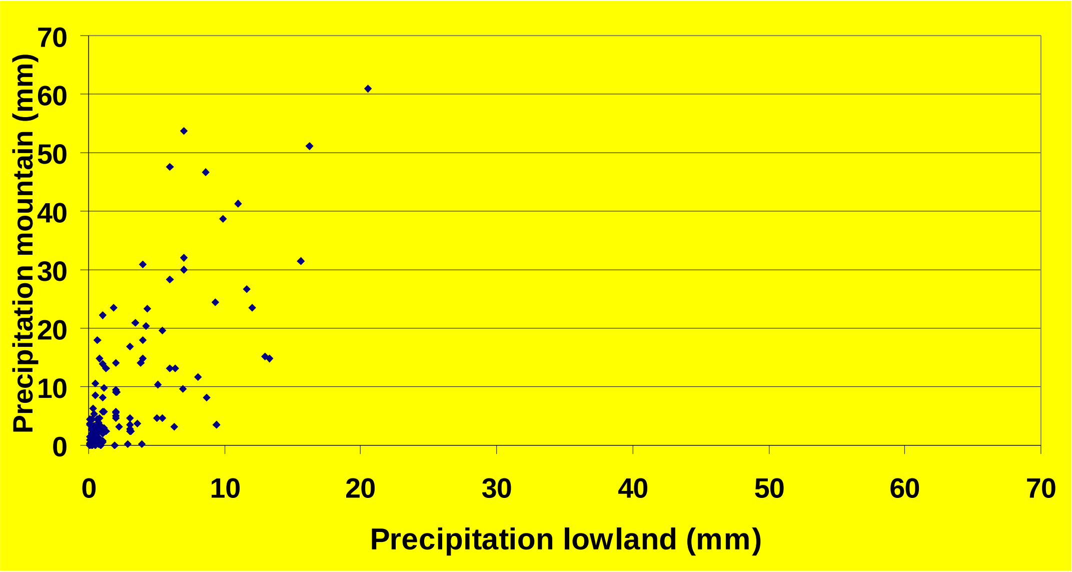

Figure 2. Precipitation at Bláfjöll (mountain) and Keflavíkurflugvöllur (lowland).

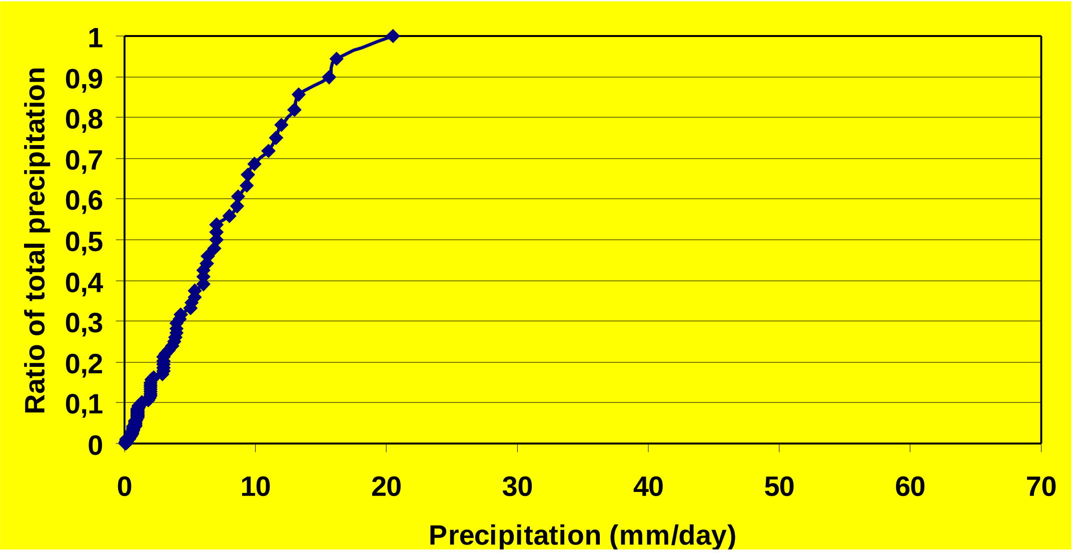

Figure 3. Accumulated precipitation as a function of precipitation intensity in the lowland (Keflavíkurflugvöllur).

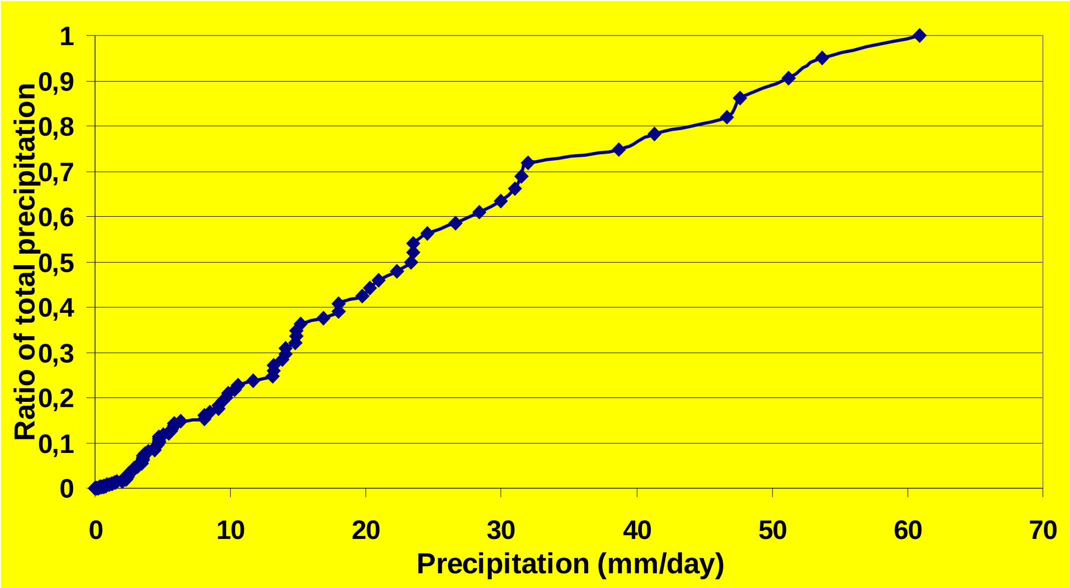

Figure 4. Accumulated precipitation as a function of precipitation intensity in the mountains (Bláfjöll).

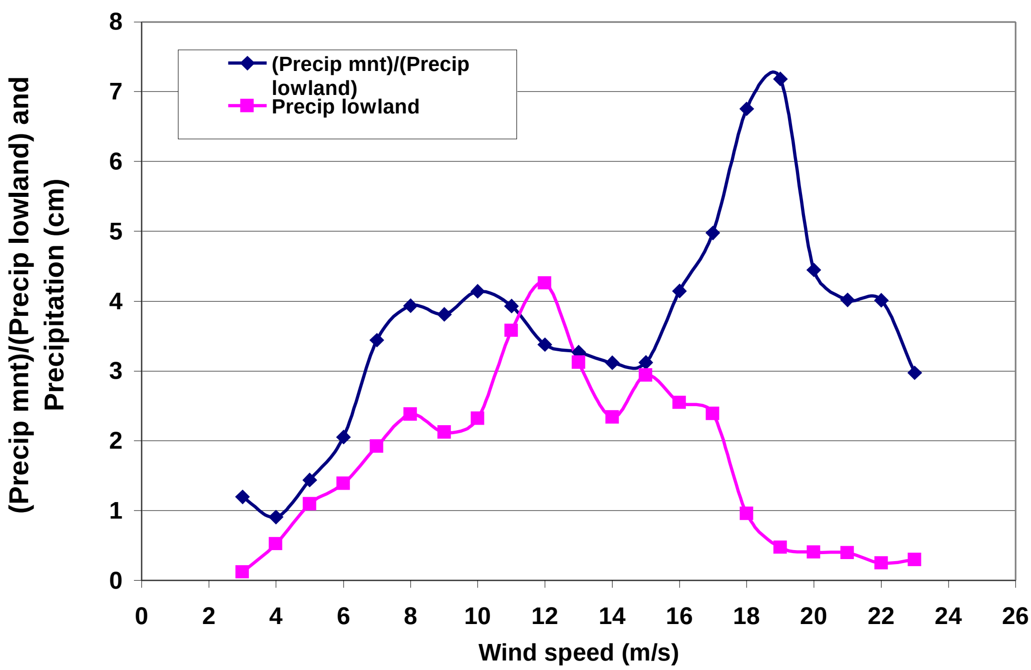

Figure 5. Accumulated precipitation in the lowland (Keflavíkurflugvöllur) and ratio of precipitation in the mountains (Bláfjöll) to precipitation in the lowland as a function of wind speed in the lowland. The precipitation ratio is smoothed by a running mean of intervals of 3 m/s.

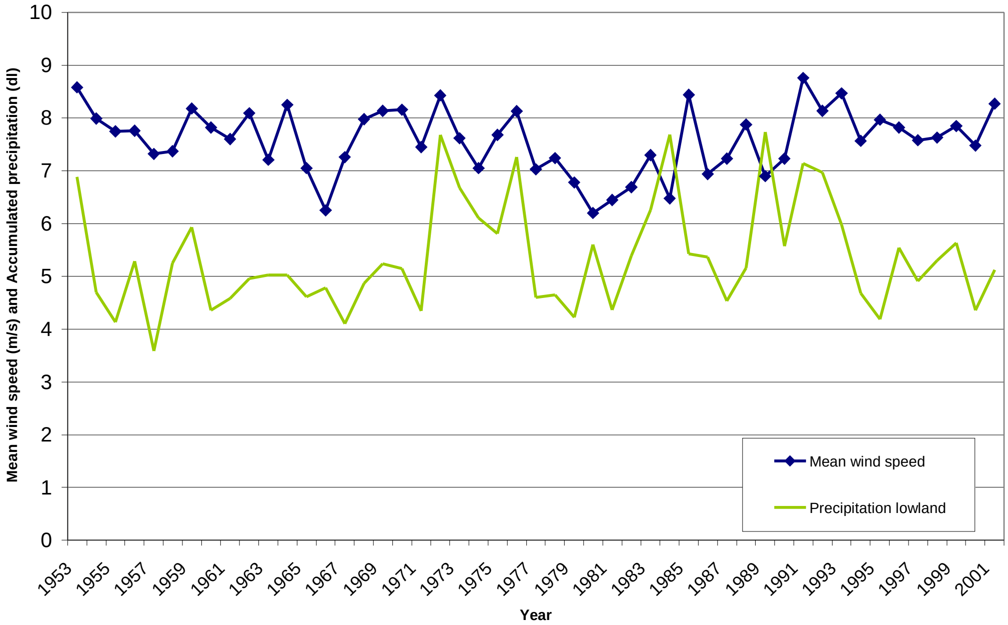

Figure 6. Mean annual precipitation and mean annual wind speed during days with precipitation in the lowland (Keflavíkurflugvöllur) Only days with southerly flow are considered.

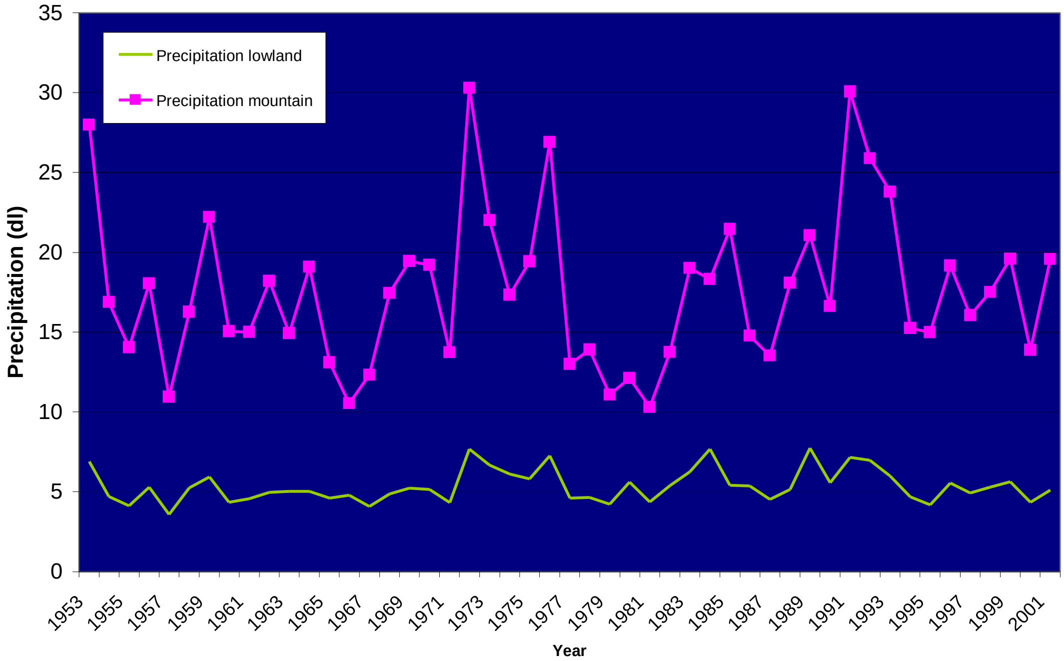

Figure 7. Mean annual observed precipitation in the lowland (Keflavíkurflugvöllur) and mean annual calculated precipitation in the mountains (Bláfjöll). Only days with southerly flow are considered.