SEASONAL VARIABILITY AND PERSISTENCE IN TEMPERATURE 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

More than 150 years of temperature observations and dynamic downscalings of temperature scenarios for Iceland are explored. The simulations show greatest warming in spring and autumn, but less warming in mid-winter and mid-summer. An important reduction is projected in the number of summer days with potential of subzero temperatures, while freezing may hamper the extension of the growing season into the autumn. Temperature observations in the past and the control simulation indicate high probability of a cold summer if the preceding winter was cold. Such a connection can neither be detected in past warm periods nor in future scenarios.

INTRODUCTION

Changes and opportunities in land use in a future climate in Iceland depend mainly on temperature. Here, important aspects of plausible regional changes of temperature in Iceland are explored in dynamic downscalings of global atmospheric simulations from the Hadley centre model (HadAM3H, Johns *et al.*, 2003). The downscalings were carried out with the HIRHAM regional climate model (Bjørge *et al.*, 2000) for a limited area (Fig. 1) over the N-Atlantic and NW-Europe (Haugen and Iversen, 2005).

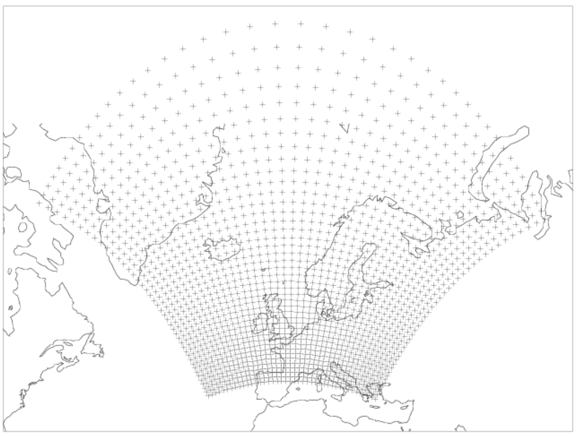


Figure 1: The simulation domain of the HIRHAM dynamic downscaling.

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 to roughly 125 km. The HIRHAM downscaling was carried out in 19 vertical levels with a horizontal resolution of 55 km. Some further discussions of the HIRHAM simulations and the simulated domain are elsewhere in these proceedings (Ólafsson and Rögnvaldsson: Regional and seasonal variability in precipitation scenarios for Iceland). Global simulations based on two emission scenarios were downscaled, the IPCC SRES A2 and IPCC SRES B2 (Nakicenovic and Swart, 2000).

SEASONAL VARIABILITY OF MEAN TEMPERATURE CHANGE

Figure 2 shows the annual cycle of temperature in Iceland in the control simulation and the two scenarios. The values are from an inland gridpoint

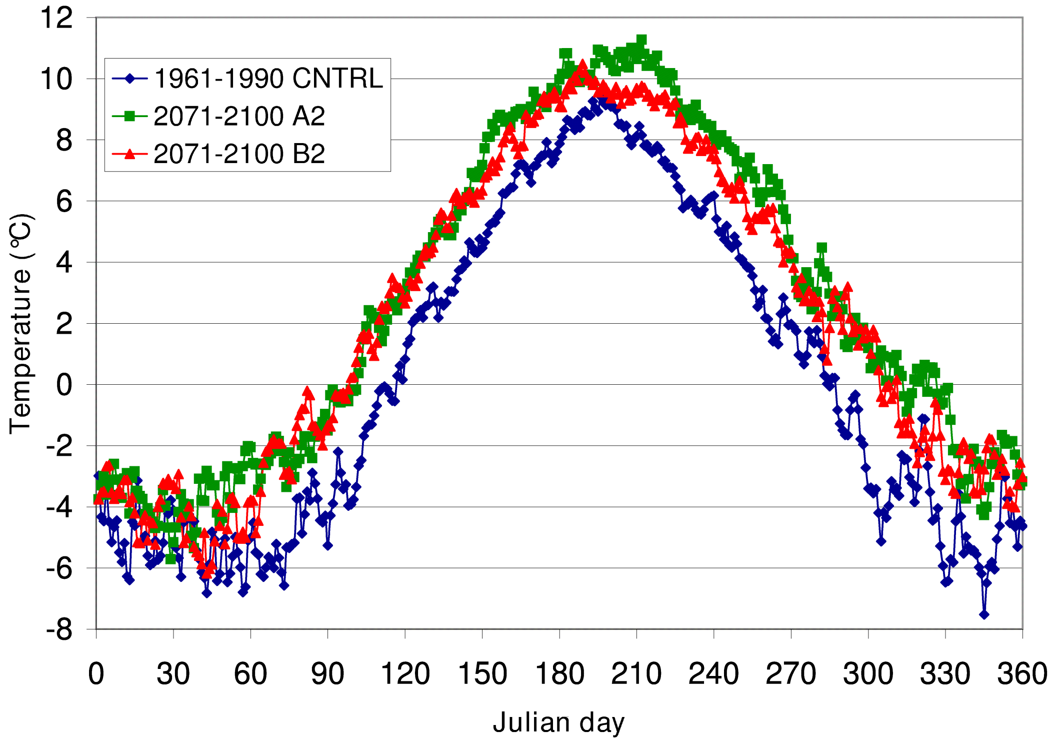


Figure 2: Temperature [°C] at an inland gridpoint in SW-Iceland in HIRHAM downscalings of HadAM3 GCM. Control (blue, 1961–1990) and scenarios A2 (green) and B2 (red) for 2071–2100.

in SW-Iceland, representing the character of the predicted temperature change elsewhere in Iceland. The greatest warming is in late winter/spring and in the autumn, while in mid-summer and in mid-winter, the changes are relatively small. The lack of warming in mid-winter can be expected to relate to a relative reduction in the northward heat flux generated by extratropical cyclones moving NE between Iceland and Greenland. Such cyclones are connected to the temperature gradient between E-Canada and the warm airmasses over the N-Atlantic east of N-America. A considerable warming is predicted over Canada, leading to weakening of the horizontal temperature gradient and a degradation of the conditions for cyclones that would otherwise generate a northward heat transport towards Iceland. Figure 3 shows the observed mean temperature change for individual months of the year (mean temperature 1987–2006 minus mean

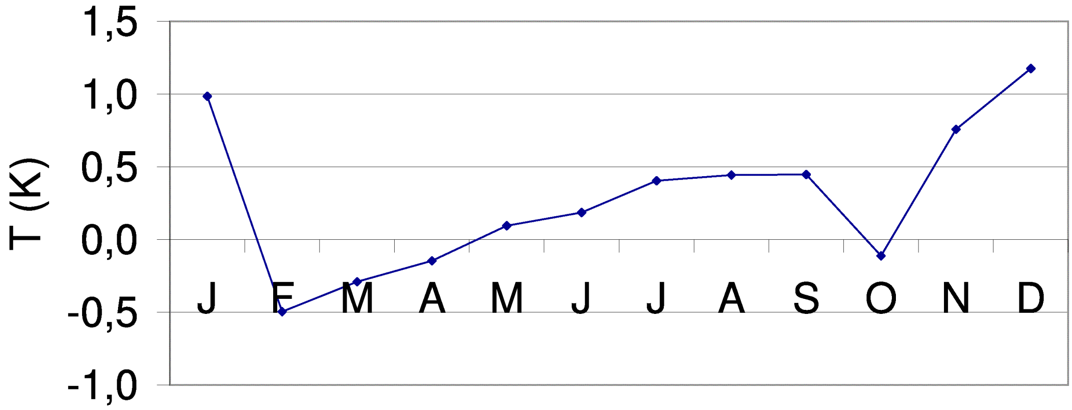
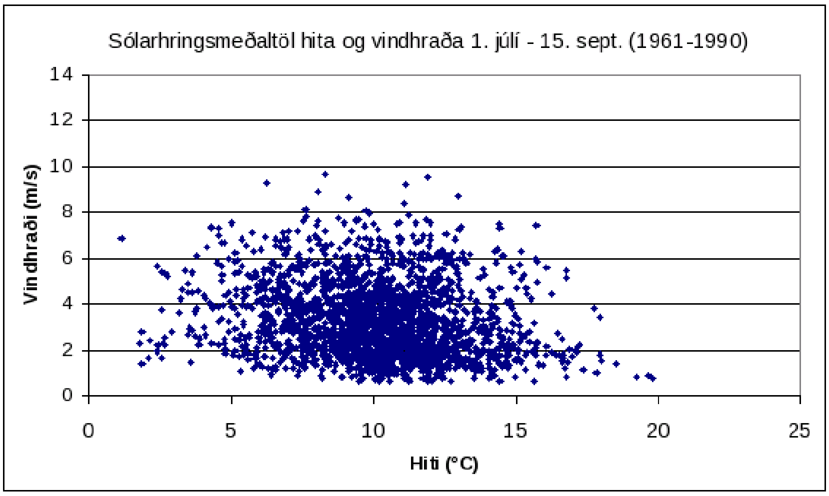


Figure 3: Observed changes in temperature in SW-Iceland, mean temperature 1987–2006 minus mean temperature 1947–1986).

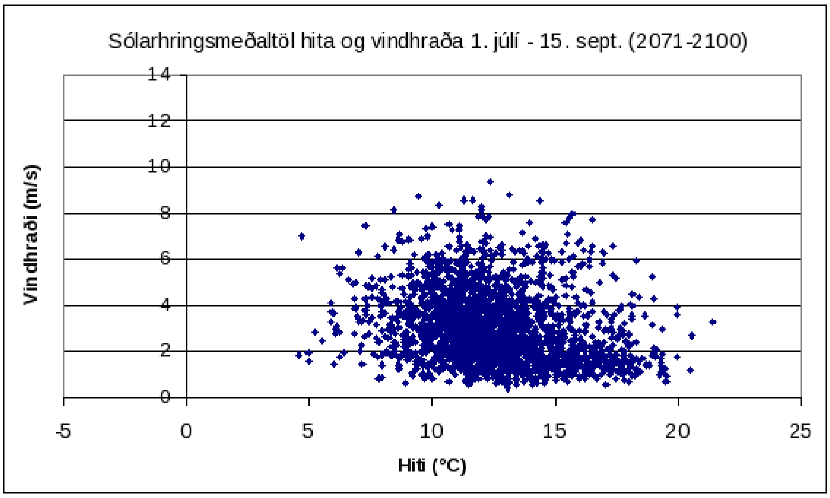
temperature 1947–1986). The character of this change is different from the future scenario; there a considerable mid-winter (DJ) warming, but much less warming or even cooling late winter and in the spring.

COLD SUMMER SPELLS

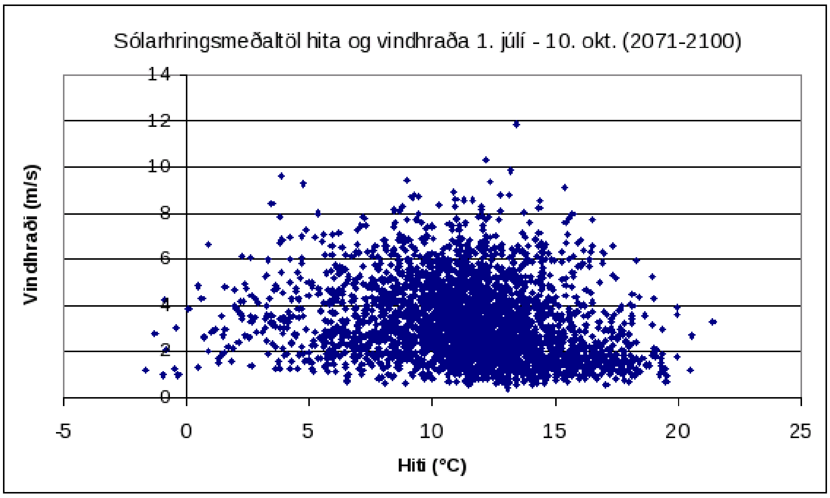
If the mean temperature was the only temperature criteria determining the length of the growing season, the temperature curves indicate that this period could be extended about 3 weeks in spring and autumn. However, other elements are also important. Damage to vegetation due to cold spells in summer is a problem in current climate and it is of interest to assess the change in frequency of such spells. Figure 4 shows values of mean daily wind speed and mean daily temperatures. The dots in the lower left corner of the graphs indicate days with favourable conditions for low level inversions and possible freezing at the ground. Comparing the control simulation and scenario A2 reveals a substantial change in the frequency of such events. In fact, the simulation of a



(a) 1 Jul to 15 Sep (1961–1990)



(b) 1 Jul to 15 Sep (2071–2100)



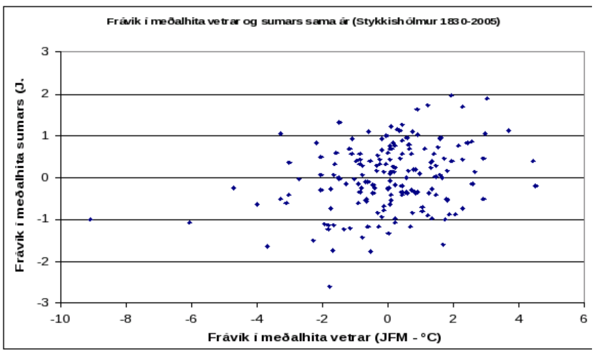
(c) 1 Jul to 10 Oct (2071–2100)

Figure 4: Plots of daily mean wind speed and daily mean temperature at an inland gridpoint in SW-Iceland; (a) in the control simulation 1 Jul to 15 Sep; (b) in a climate projection (A2) for 1 Jul to 15 Sep 2071–2100; (c) is the same as (b), but for the period 1 Jul to 10 Oct.

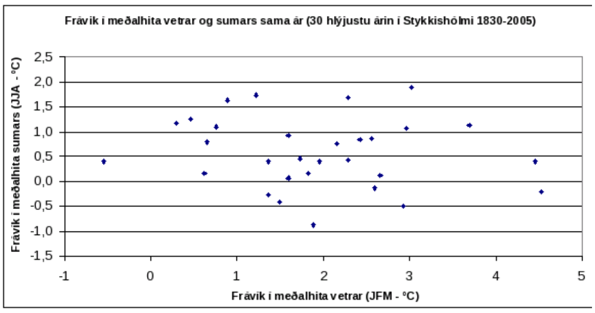
a future climate does not have any event within a surface cold-spell parameter space (in the lower left corner of the scatterograms) where there is one event a year in the control simulation. This is a big predicted change. Testing the idea whether it is possible to extend the growing period into the autumn one may look at a similar scatterogram, extending 25 days further into the autumn (10 October, Fig. 4c). Here, there are many more days with low temperatures and low wind speed than in the control simulation, indicating that the growing season can indeed not be expected to extend into the autumn as far as the changes in mean temperature may indicate. Other aspects such as sunlight and windstorms may also play an important role for certain species, limiting as well the usefulness of a possible temperature increase in the autumn.

SEASONAL PERSISTENCE

A cold winter may lead to late thawing of the soil. Under such conditions, the start of the growing season is delayed and it is particularly important to get a favourable summer. Otherwise, there may be no harvest in the autumn. Figure 5 shows the connection between mean winter temperature and the mean temperature of the following summer in the Stykkishólmur (W-Iceland) temperature series (Hanna *et al.*, 2004). Although there is a large overall scatter, the figure



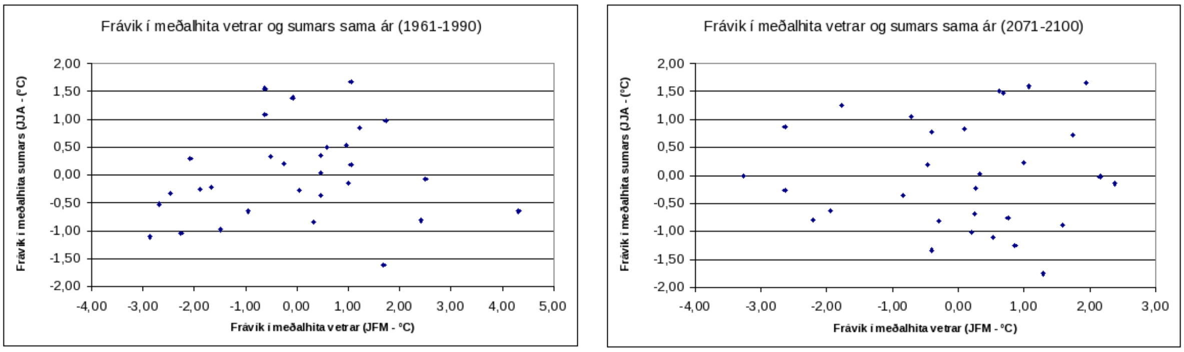
(a)



(b)

Figure 5: Deviation (a) of mean winter and mean summer temperatures of the same year from the 1830–2006 mean temperatures in Stykkishólmur (W-Iceland); (b) same as (a), but only for the 30 warmest years.

shows that out of ten of the coldest winters, only one was followed by a summer with temperatures above average. However, looking only at the warmest 30 years in the same dataset, there is no similar connection. A cold winter is in other words not more likely to be followed by a cold summer than by a warm summer. The control simulation shows a connection between cold winters and cold summers (cf. Fig. 6a) with 8 out of 10 of the coldest winters being followed



(a) **(b)**

Figure 6: Same as Fig. 5, but from the control simulation (1961–1990) and the A2 scenario for 2071–2100.

by a cold summer. The 2071–2100 scenario shows on the other hand no such connection (cf. Fig. 6b).

SUMMARY

Dynamic downscalings of simulations of future climate have been explored (HIRHAM/HadAM SRES A2 and B2). A warming of 2-3řC is predicted for Iceland in the 21st century. The warming is greatest in late winter/spring and in the autumn, but less in mid-winter and mid-summer. Calm winds and low temperatures are considered to be indicative of subzero temperatures at the ground in the summer. The simulations indicate a very large reduction in such cases in a future climate. Another important factor for agriculture is the persistence of cold weather from winter into the summer. Such a connection is found in cold periods in past climate and in a control simulation of current climate, but not in the future climate simulations and not during warm periods of past climate.

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.
Hanna, E, T. Jónsson and J.E. Box (2004) An analysis of the Icelandic climate since the nineteenth century. *International Journal of Climatology*, 24, 1193–1210.
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.