CES Nordic Project on Climate and Energy Systems

Climate and Energy Systems: 2007–2010
The Hydropower–Snow and Ice group

http://www.vedur.is/ces

Changes in glacial runoff are one of the most important consequences of ongoing and future climate change in Iceland, Greenland and some glacierised watersheds in Scandinavia. Such changes have a strong impact on the hydropower industry as discharge volumes, seasonal variations and extreme discharge conditions change. The rapid retreat of glaciers also has other implications; for example changes in fluvial erosion from currently glaciated areas, changes in the courses of glacial rivers, which may affect roads and other infrastructures, and changes that affect travellers in highland areas and the tourist industry.

During historical times, glaciers and ice caps in Nordic countries have retreated and advanced in response to climate changes that are believed to have been much smaller than the greenhouse-induced climate changes that are expected during the next decades to century. The "Hydropower, snow and ice" work group of CES will analyse the effects of future climate change on glaciers and ice caps in Nordic countries and their implications for the hydrology of glacial rivers.

Glaciers are important for hydropower in the Nordic countries

Greenland

Hydropower potential is primarily from partly glacierised basins. A recent report, "Energiplan 2020", has evaluated various possible future energy sources for Greenland and concluded that hydropower is the only sensible solution on a large scale.

Iceland

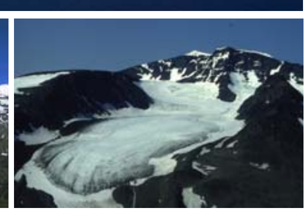
Operational plans of hydropower plants and decisions for new installations are being adjusted with recent and future climate change in mind.

Norway

An important part of hydropower is from partly glacierised basins. There is large interest in the effect of future climate change on the operational environment of existing plants.

Sweden

Interest in glacier changes is primarily for scientific reasons. Swedish glaciologists work with colleagues in other Nordic countries on projects related to glacier runoff changes.



Photographs

Múlajökull, Breiðamerkurjökull, Iceland; Paakitsoq, Greenland; Briksdalsbreen, Storbreen, Norway; Storglaciären, Sweden; Photographs, IMO, GEUS, NVE, University of Uppsala.

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Main tasks

- Meteorological downscaling and mass balance modelling of a glacierised watershed in Greenland
- Mass balance and dynamic modelling of glaciers in Iceland and Norway
- Precipitation downscaling in Iceland and Scandinavia
- Coupled glacial runoff – dynamic glacier modelling in Iceland and Norway
- Model development

An example from Iceland

Future climate change is likely to have pronounced effects on glaciers, glacial rivers and hydro-resources of Iceland. Icelandic glaciers store a total of 3600 km^3 of ice and are retreating and thinning rapidly at present.

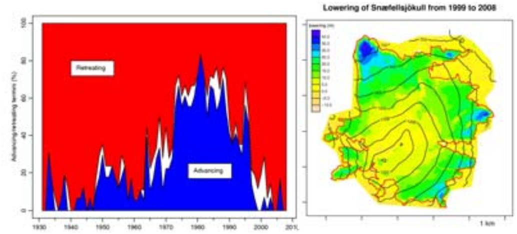

Figure 1: Left: Percentage of advancing and retreating termini of non-surging glaciers in Iceland from 1931 to 2008. Over most of the time period shown, the figure is based on measurements at 11 to 19 locations (somewhat fewer termini in the years 1931 and 1932). Right: Lowering of the Snæfellsjökull ice cap (area 12.5 km^2 in 2000) from 1999 to 2008.

The downwasting of the glaciers is projected to intensify during the coming decades, leading to their almost complete disappearance in the next 150–200 years. The response of the main ice caps of Iceland, Langjökull, Hofsjökull and Vatnajökull to climate warming was simulated with a coupled mass-balance/-dynamical model as a part of the CES project. A mean warming of 2.5–3°C between 1961–1990 and 2071–2100 was assumed with the greatest warming in the spring and fall. Precipitation changes are comparatively small, with up to 10–20% average increase in the fall between these periods but little change in other seasons. The simulations are started from 1990.

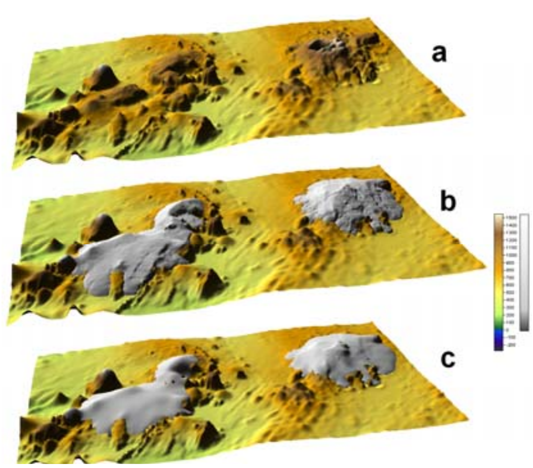

Figure 2: a) Measured bedrock of Langjökull and Hofsjökull ice caps. b) Measured 1997 and 1999 ice surfaces of Langjökull and Hofsjökull, respectively. c) Steady-state glacier geometries after a few hundred year spin-up with constant mass balance forcing.

The simulated rate of retreat is similar for Hofsjökull and Vatnajökull, but much faster for the lower and thinner Langjökull (Figure 3). Langjökull loses 35% of its initial volume during 50 model years while S-Vatnajökull and Hofsjökull lose 25% of their volume (Figure 4). Langjökull is predicted to disappear after 150 model years and only the highest peaks of Hofsjökull and Vatnajökull survive more than 200 years.

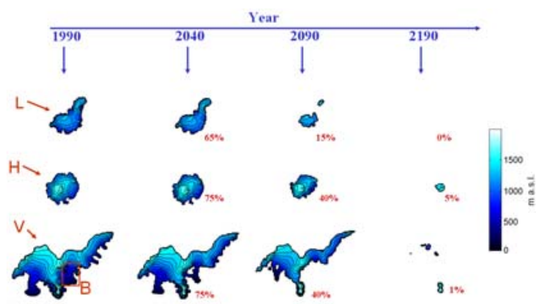

Figure 3: Simulated response of Langjökull (L), Hofsjökull (H) and southern Vatnajökull (V) to climate change. The inset numbers are projected volumes relative to the initial stable ice geometries shown for the year 1990. Note that the figure shows only the southern part of the Vatnajökull ice cap, south of the main east–west ice divide.

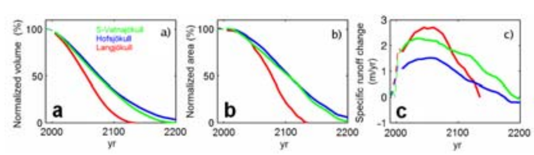

Figure 4: Volume and area reduction, normalised to present day values and area-averaged runoff change. The runoff is always from the present day ice-covered areas and consists of both glacier melting and precipitation. The enhanced glacier melting is the dominant contribution to the runoff change to begin with.

Subglacial water courses and outlet locations of many glacial rivers are likely to change due to the thinning of ice caps and the retreat of glacier margins. River runoff is projected to increase by 25% between 1961–1900 and 2071–2100, mainly due to increased melting of glaciers. Runoff seasonality and flood characteristics are projected to change such that there will in general be more autumn and winter runoff, and spring floods will be earlier and most likely smaller in amplitude. A substantial temporary increase in hydropower potential is projected for more than 100 years. The changes in runoff, discharge seasonality and water courses imply modifications in design assumptions and changes in the operating environment of hydropower plants and other hydrological infrastructure such as bridges and roads.

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