2 cm sea level rise – Holland, you better get ready!

Can Svalbard be used as an indicator for the largest ice sheets?

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Introduction: Why Glaciers?

Svalbard is a highly glaciated archipelago situated in the high arctic at the northernmost edge of the North Atlantic drift and is therefore thought to be very sensitive to climatic changes. Over 60 % of the archipelago consist of ice caps and glaciers. The estimated total volume of the glaciers of Svalbard would rise the sea level by only 2 cm[1]. Nevertheless Arctic's smaller ice masses are expected to show a more rapid response to climate changes than the largest future contributors to sea level rise, Antarctica and Greenland[2]. Therefore, glaciers on Svalbard could function as an early indicator for how the larger ice sheets will react to the warming climate in the future.

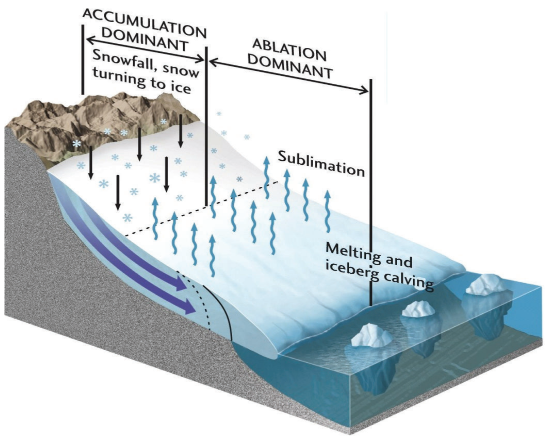


Fig 1: Schematic view of different zones of a glacier (taken from Fort Hays State University Webpage http://hays.outcrop.org/GSCI100/lecture42s.html as on July 11th, 2012[3]).

What should we know about glaciers?

A glacier is a perennial mass of ice and snow in motion[4]. Changes in the total mass of glaciers are measured in mass balance and depend upon summer mean temperatures for melting (ablation) and winter precipitation in the form of snow (accumulation).

mass balance = accumulation – ablation

Mass balance can be estimated by field measurements of accumulation and ablation, or satellite/airborne altimetry using laser or radar[5]. Stable glaciers have an annual mass balance of zero.

What factors can change the mass loss?

Calving and surging are two important processes for glaciers on Svalbard. Here calving accounts for about 16 % of the yearly mass loss[2] and almost 90 % of all glaciers in Svalbard have been observed to surge[6].

Warmer air temperatures will affect calving by increasing the melting on top of the glacier, while warmer ocean currents can melt the ice front from beneath. These processes lead to thinning of the ice which increases the calving.

Surging means that the glacier accelerates quickly over a short period of time, followed by a long period of very slow movement called the quiescent phase which can last for 30 – 500 years[7]. During a surge the mass is transported down and in the quiescent phase the mass is accumulating again.

Fig 2: Glacier front showing calving (taken from IPY lecture 2012, Prof. Doug Benn[8])

How can Arctic glaciers be affected?

Temperature trends and variability is found to be much larger in Arctic regions compared to the global average. This phenomenon, called "Polar amplification", has been known since the 1980s. Main drivers are increasing sea ice loss, the ice-albedo feedback and advection of heat from lower latitudes in both ocean and atmosphere [9].

Due to retreating sea ice there is enhanced evaporation over open water areas, resulting in increased moisture content in the lower Arctic troposphere which might lead to increased precipitation rates in adjacent regions.

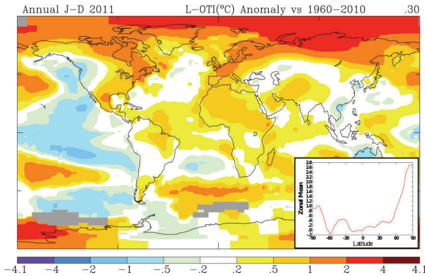


Fig. 3: Annual mean surface air temperature anomaly in 2011 compared to base period 1960-2010. The inset shows zonal mean surface air temperature anomaly for the same setting (created from http://data.giss.nasa.gov/gistemp as on July, 10th 2012[10]).

What has been observed?

By 2003, only about 0.5 % of the glacier area of Svalbard had been studied regarding surface mass balance[2]. Studies have shown that the total mass balance of Svalbard is receding by 4.5 ± 1 km³ per year[2]. However, there are significant differences in glacier mass balance change between the Western and Eastern parts of the archipelago (see Fig. 4).

West side:

Glaciers situated in Western Svalbard show consistent signs of thinning over the past decades[11]. While summer air temperatures have been observed to be rising since the 1960s, no clear long-term trend in winter precipitation in the Western parts of Svalbard could be detected. Therefore, there is increased summer melting, but no additional accumulation during winter.

Slightly different thinning signs most likely reflect local climatic conditions.

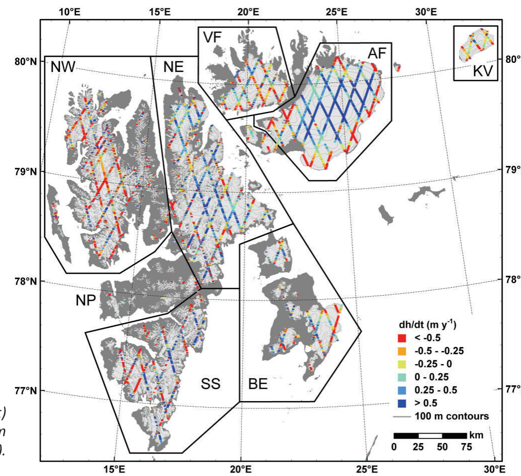
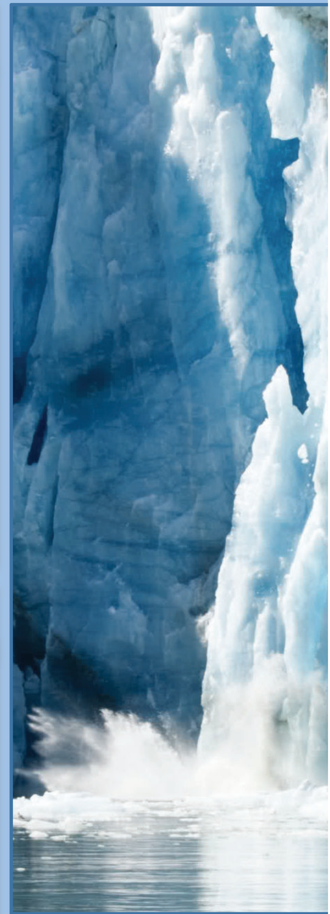


Fig. 4: Glacier elevation change rates (dh/dt) averaged over the 2003-2008 period (taken from Moholdt, 2010[12]).

East side:

The Northeast (Austfonna, AF) does not follow the general thinning trend as observed in the West of Svalbard. The inner part of the ice cap is actually **increasing its surface mass balance**[12]. There are two theories that could explain this:

1. Due to sea ice retreat in the Barents Sea, Austfonna receives increased precipitation which leads to thickening of the accumulation areas. Mass loss in ablation areas through melting and calving is increasing in response to Arctic temperature increase[13].
2. Austfonna has been surging in the past. Currently it might be going through a quiescent phase of accumulation[12].



Conclusion

Several glacial phenomena on Svalbard are not fully understood, therefore it is important to keep up the research since Svalbard´s glaciers are more sensitive to warming and could be used as an early indicator for larger ice sheets.

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