Snow drills : snowpack investigations at local scale

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Contribution to the analysis of the Austre Lovénbreen hydro-glaciological dynamics

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1. Introduction

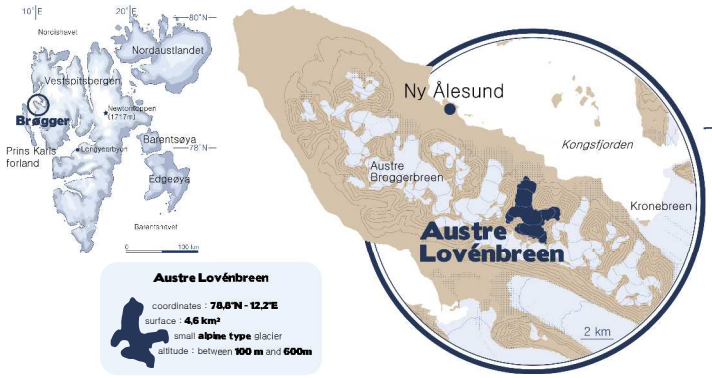
Glaciological dynamics are directly impacted by climate change, especially in the Arctic. Arctic glaciers are reliable indicators of these ongoing changes. In that context, snowpack has a crucial role which is interesting to study for a better understanding of the interacting processes in the hydrosystem.

Today, most of the studies on Arctic glaciers snowpack are performed using global scale datasets (satellite images, airbone data...). However, monitoring at local scale is necessary to analyze, understand and validate artic glaciers dynamics.

Snow drills are a valuable approach for snowpack monitoring and water content evaluation. It produces more accurate results than remote sensing methods and is easier to implement than snow profiles.

2. Objectives

The main objective of snow drills in the Austre Lovénbreen is to understand the link between snow cover processes and glaciological dynamics. These results should also be linked with liquid water runoff. Investigating the snow cover throughout the years, combined with other monitoring setup (temperature recordings, cameras, GPR...), allows to figure out which factors drive the snow cover properties and then the glacier mass balance.

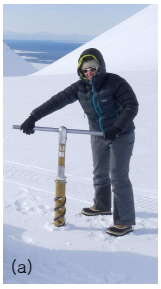


3. Study site

Austre Lovénbreen is a small polythermal glacier typical from the Brøgger peninsula. Geomorphological reasons led to the historical choice of the site (research here by J. Corbel and his team in the 60s). It is the only drainage basin of the area where all runoffs are not braided but forced by a limestone rockband which allows a precise monitoring at the outflow.

The Austre Lovénbreen has been systematically instrumented and monitored since 2007 thanks to a succession of research programs (Sensor-Flows, Cryo-Sensors and PRISM)

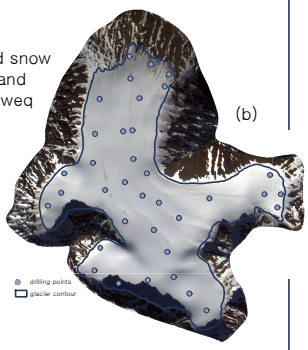
4. Drilling method & data processing


(a)

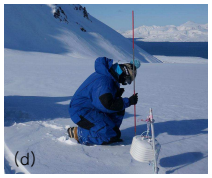
- **Drill PICO (Polar Ice Coring Office)** (a)

Drills are made through the entire snowpack until the firn layer is reached. The campaign is made before the melting season (end of april) to minimize the risk of liquid water in the snowpack. There are 36 sampling points homogeneously distributed on the glacier (b).

In situ weighing of the extracted snow columns is then processed (c) and density and water equivalence (weq mm) are calculated.




(c)


(d)

Height of the snowpack is validated using an avalanche probe (d). Several measurements are made all around the sample point to assess the quality of the measure and avoid mistakes (crevasse, hole, bédière, etc...)

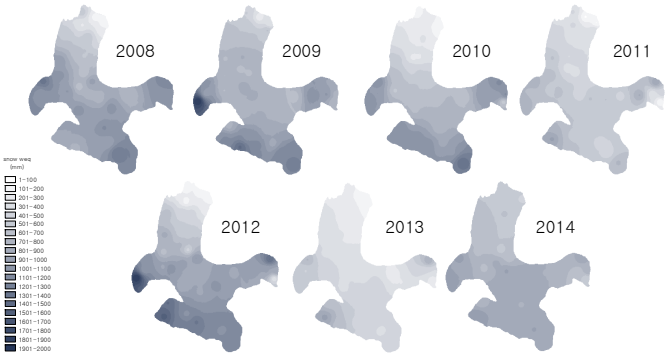
- **From isolated measures to spatial generalization :**

The representation of geographical data is then done using a Geographic Information System (GIS).

According to measurements, the snowpack is characterized by its height and water-equivalence. This data is spatialized using Interpolation by Inverse Distance Weighting (IDW) which has been tested and validated during field campaigns.

5. Results

Geomatic processing allows to highlight factors impacting nival dynamics and to spatialize snow properties (height, snow water-equivalence,etc). (e)



(e) *snow water-equivalence (mm) interpolated using IDW from snow drills data 2008-2014*

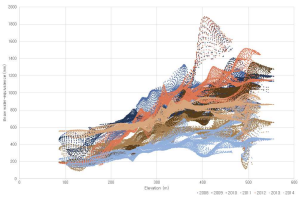
Austre Lovénbreen has shown an important spatio-temporal variability in water-equivalence of the snowpack since 2008. 2011 and 2013 displayed a remarkably shallow snowcover contrary to 2012.

The spatial variability is more or less noticeable from one year to another. The snow weq standard deviation is a good indicator of these variations (as in 2014 where it was low).

The left bank of the glacier tongue behave differently than the other side where rates are lower.

Most of the variability in snowcover is observed in altitude. (f)

Cirques seem to host an important amount of water supply especially western ones even during bad years.



(f) *Interannual variability of snow water-equivalence regarding the elevation*

6. Discussion and future work

The snow drills method and geomatic treatments are designed to help understand snowpack behavior at a local scale. Runoffs and glacier dynamics (mass balance, etc...) depend greatly on annual snowpack conditions. Austre Lovénbreen snowpack shows important discrepancies throughout time and space. After trying to measure snowpack with Ground Penetrating Radar (GPR), snow drills appear to be the best way to have a precise and yearly reproducible measure of snowcover properties.
It seems to be important to link the impact of nivologic dynamics to glaciological ones through new or changing processes like avalanches, rain or snow events.

References : BERNARD E., TOLLE F., FRIEDT J.M., MARLIN Ch. et GRISELIN M., 2013 : How short warm events disrupt snowcover dynamics : Example of a polar basin – Spitsberg 79°N, *Proceedings of ISSW (International Snow Science Workshop)*, Grenoble, France, pp. 1226-1231, 6p
BERNARD E, FRIEDT J.M., TOLLE F., GRISELIN M., LAFFLY D, et MARLIN Ch., 2013 : Seasonal snow and ice dynamics monitoring using ground based high resolution photography (Austre Lovénbreen, Svalbard, 79°N). *ISPRS Journal of Photogrammetry and Remote Sensing*, n°75, pp. 92-100