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Contribution of statistical modeling to the understanding of the mass balance of a small arctic glacier

Sophie SCHIAVONE1, Eric BERNARD1, Florian TOLLE1, Jean-Michel FRIEDT2, Madeleine GRISELIN1, Daniel JOLY1

1. Introduction

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

Operating a statistical model is a new approach in our work that enables us to combine most of the available data on the studied glacier. It helps having a synoptic point of view on annual and interannual cause of the variability of the Austre Lovén mass balance.

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

2. Objectives

The work described here aims at better understanding how contrasted climatic and snow conditions in recent years do constrain, sometimes unexpectedly, mass balance dynamics.

Objectives are (i) to identify factors and combination of factors affecting annual mass balance and (ii) to reveal trends over time and space.

4. Data & method

● Data preparation

A rich measurement network (a) : - 20 temperature sensors (snowpack monitoring) - 42 drilling points (snowpack monitoring) - precipitation extrapolation from the Ny Alesund station (alitudinal gradient applied, Bernard, 2011).

In a different way as usually done, we used the Kemp REGR technique (1983) to reconstruct temperatures (c).

\[ T_{reconst} = \sum_{i=1}^{n} W_i (T_{stn} + T_{skn}(t)) \]

(c) REGR : the weighting functional values WR are proportional to the squares of the between station correlation

From punctual information to a 10k points grid (20x20m) for a better spatialization of phenomena. A geostatistical interpolation (krigage) were done using the LISDQS software (prototype developped in ThéMA lab.).

● Data preparation

A tool : explanatory modelling (d) :

Exploratory Data Analysis
Variable & method selection
Evaluation & model selection
Validation
Model use & report

(d) Steps in the statistical modeling process

Variable to explain : mass balance

Explicative variables : - cumulative thawing degree-days (base 0°C and 5°C) - liquid precipitations (winter / summer) - snow accumulation

Modeling method : multiple linear regression

Best models were selected each year using the Akaike’s Information Criterion (AIC) and the field knowledge. Each model was then validated according to a residual analysis. Fitting a statistical model is a long iterative process.

6. Discussion and future work

The explanatory model and geomatic treatments are designed to help understand mass balance behavior at a local scale over the Austre Lovén. It is an original approach integrating lots of different measured variables. Fitted models seem pretty good at explaining the reasons of mass balance variability even though it is weaker for extrem years. Preliminary results show that the glacier’s organization is well represented by the model with a front which register the strongest changes whereas cirques are more preserved. The most important variables enhanced each year are coherent. Future work will focus on defining this for each pixel of the glacier.