Testing physiographic and climatic controls on glacier retreat

Daphné Freudiger, Kerstin Stahl, and Markus Weiler

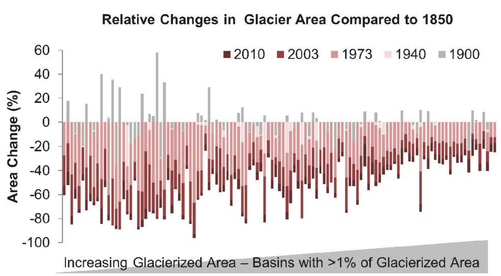
This poster participates in OSP Outstanding Student Poster Contest

Motivation

Glacier melt provides an important part of the summer discharge of many European rivers. The understanding of the processes behind the glacier mass losses and glacier retreats observed during the last century is therefore relevant for a sustainable management of the water resources and reliable models for the prediction of future changes.

An overall retreat of all glaciers in the glacierized sub-basins of the Swiss Alps was observed from 1850 to 2010 with some variations in the sub-periods. However, **the relative changes in glacier area compared to 1850 differed for every sub-basin and some glaciers decreased much faster than others.** This raises the question:

What are the potential controls on glacier retreat?



Hypothesis and Objectives

H1: The relative changes in glacier area compared to 1850 differ regionally.

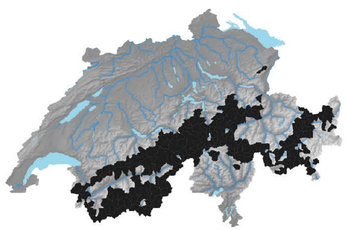
H2: Theses differences can be related to several physiographic and climatic controls.

The aim of this study was to empirically investigate the controls of glacier retreat and to identify regional differences for all glacierized sub-basins of the Swiss Alps for the time period 1850 to 2010.

Data and Methods

- **313 glacierized sub-basins** with an average area of 40 km^2.

Study Area



The glacier area of Siegfried maps for the years **1900** and **1940** were compared with satellites and bedrocks derived glacier areas for the years **1850, 1973, 2003, 2010.**

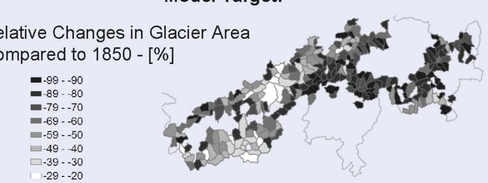
The number of glacier bodies changing with time, a glacier area was defined as the total area within the sub-basin.

The physiographic model predictors were derived from the digital elevation model DHM25 of Switzerland. The Climatic predictors were calculated from the interpolated gridded Datasets for Temperature and Precipitation RhiresD v1.0 and TabsD v1.2 (Products of MeteoSwiss).

The effects of the potential controls on glacier retreat were assessed by fitting a **General Linear Model (GLM).** The predictors were tested for correlation and only statistically significant ($p<0.05$) predictors were selected.

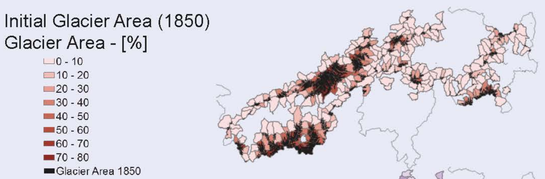
Model Target:

Relative Changes in Glacier Area Compared to 1850 - [%]

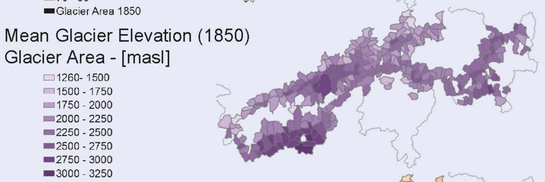


Model Predictors:

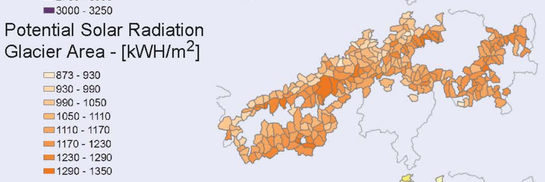
Initial Glacier Area (1850)
Glacier Area - [%]



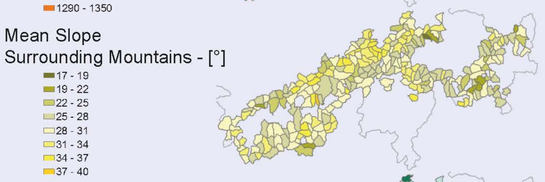
Mean Glacier Elevation (1850)
Glacier Area - [masl]



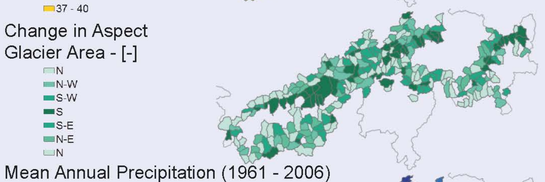
Potential Solar Radiation
Glacier Area - [kWH/m^2]



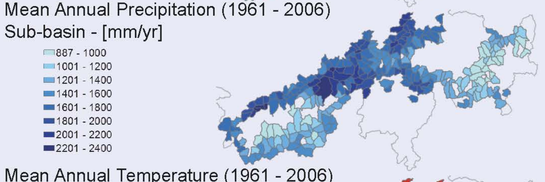
Mean Slope
Surrounding Mountains - [°]



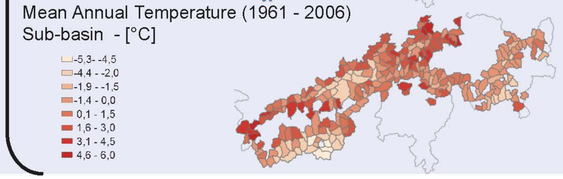
Change in Aspect
Glacier Area - [-]



Mean Annual Precipitation (1961 - 2006)
Sub-basin - [mm/yr]

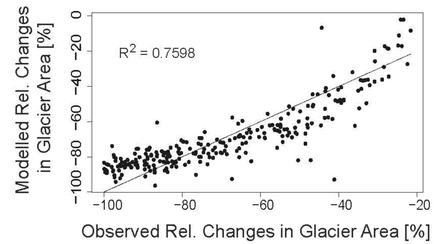


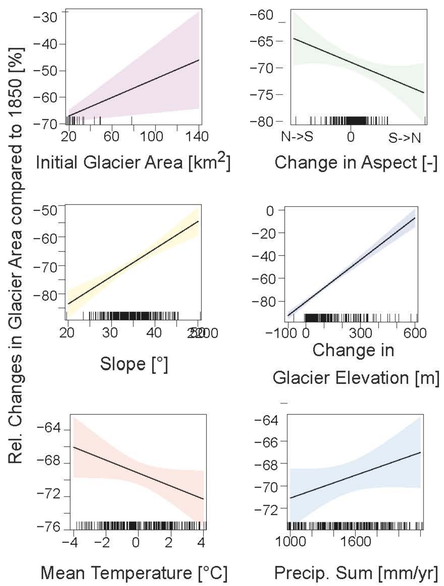
Mean Annual Temperature (1961 - 2006)
Sub-basin - [°C]



Results

The fitted model explains **more than 75% of the observed variance** of the relative change in the glacier area.





The initial glacier area alone explains only a small proportion of the observed variance.

Lower slopes of the surrounding mountains, higher mean annual Temperatures, and higher annual Precipitation sums led to higher relative changes in glacier area

The more the aspect of the glacier area changed from S to N, the higher was the relative changes in glacier area.

Potential solar radiation was not significant.

Conclusion and Outlooks

H1 ✓: Regional differences in the relative changes in glacier area could be observed for the time period 1850 - 2010.

H2 ✓: These differences were related to several physiographic and climatic controls, and the model was able to explain more than 75% of tthe observed variance.

The important role of the physiographic controls in the model prediction indicates that snow redistribution may play an important role for the glacier mass balances and needs to be considered appropriately in hydrological models. The derived predictors will be further analysed and the observed patterns will be compared to modelling studies.

Chair of Hydrology, Albert-Ludwigs-University of Freiburg
daphne.freudiger@hydrology.uni-freiburg.de

Acknowledgments: The authors would like to thank Swisstopo, Frank Paul, Matthias Huss, and Max Maisch for glacier data, and Meteoswiss for the meteorological datasets. A special thanks to Damaris De who manually digitalized the Siegfried maps.