Meteorological measurements at Haut Glacier d'Arolla from 2001 - 2006, and mass balance estimation for this period using DEM's

R. Dadić, J.G. Corripio

Institute of Environmental Engineering , ETH Zürich, Switzerland
dadic@ifu.baug.ethz.ch

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Introduction

Our project aims to improve the detailed understanding of the processes of snow accumulation and ablation in Alpine environments, as well as their possible response to future climate scenarios. The main task is assessing water resources in snow covered and glaciated basins. Accurate estimation of water stored within the snow and ice cover of such basins requires knowledge of a distributed snow and ice mass balance throughout the year.

The test research site is the Haut Glacier d'Arolla in southwestern Switzerland, with the intention to use a highly instrumented site in the Alps for testing and implementation of process based mass and energy balance models, which could be applied in other mountain regions of the world. Here, we are presenting a continuous meteorological record at the Haut Glacier d'Arolla since 2001. The measurements include meteorological data from weather stations inside and outside the glacier. These meteorological data is employed to asses the observed change on the glacier, which is derived from continuous runoff and mass balance. The mass balance is evaluated through ablation/accumulation stakes, snow depth measurements and the comparison of two recent DEM's.

Methods

Figure 1: Map of the Haut Glacier d'Arolla with indicated locations of the automatic weather stations, ablation/accumulation stakes and the location, where the automatic camera, overviewing the glacier, is being located.

Instrumentation

- 2 permanent Automatic Weather Stations outside the glacier (temperature, humidity, SW radiation in/out, LW radiation in/out, wind speed/direction, precipitation, snow height)
- 1 permanent Automatic Weather Station on the glacier (temperature, humidity, SW radiation in/out, wind speed/direction, snow/ice surface temperature, snow height)
- 18 ablation/accumulation stakes on the glacier, since 2005
- Automatic camera overviewing the lower part of the glacier, since 2006

In spring, snow depth distribution and density on the glacier are also measured. These measurements show large variation over the glacier and do not necessary correlate with the altitude.

Temperature data

Stations outside the glacier

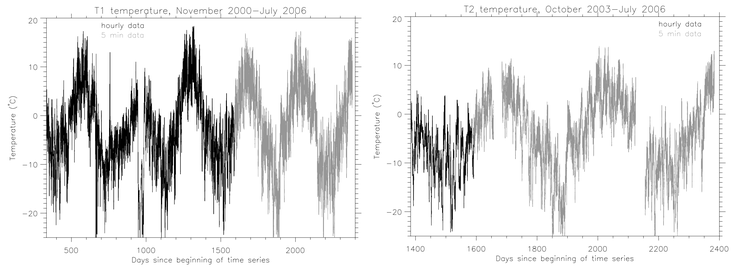

Figure 2: Air temperatures for T1(left) and T2 (right). Black line is an hourly record, grey line a 5-min record. The station T1 is recording since 2001, the station T2 since fall 2003. The temperatures are not corrected for the height of the station, which varies from 1 to 4 meters.

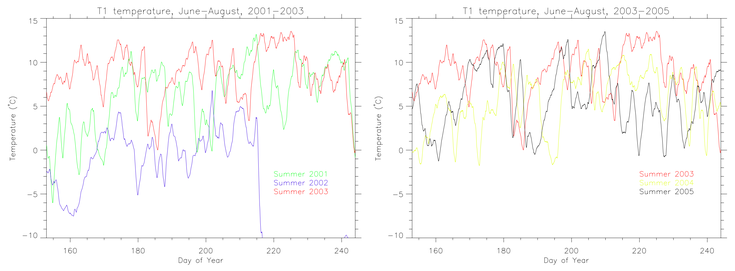

Figure 3: Summer temperatures for T1, 2001-2005. 2001-2003 is shown in the left figure, 2003-2005 in the right figure. Summer 2003 is shown in red through all plots.The temperatures are not corrected for the height of the station, which varies from 1 to 4 meters.

Station on the glacier

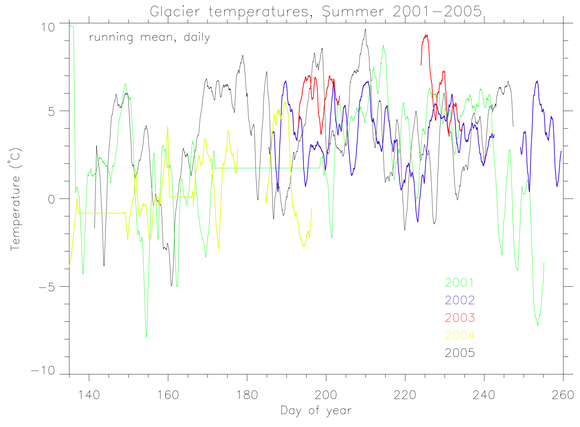

Figure 4: Air temperatures on the glacier. Until August 2005, the station was on a 2 m tripod, so no corrections need to be applied on this data. There is only a continuos record for the summer 2001, and from may 2005 on.

DEM

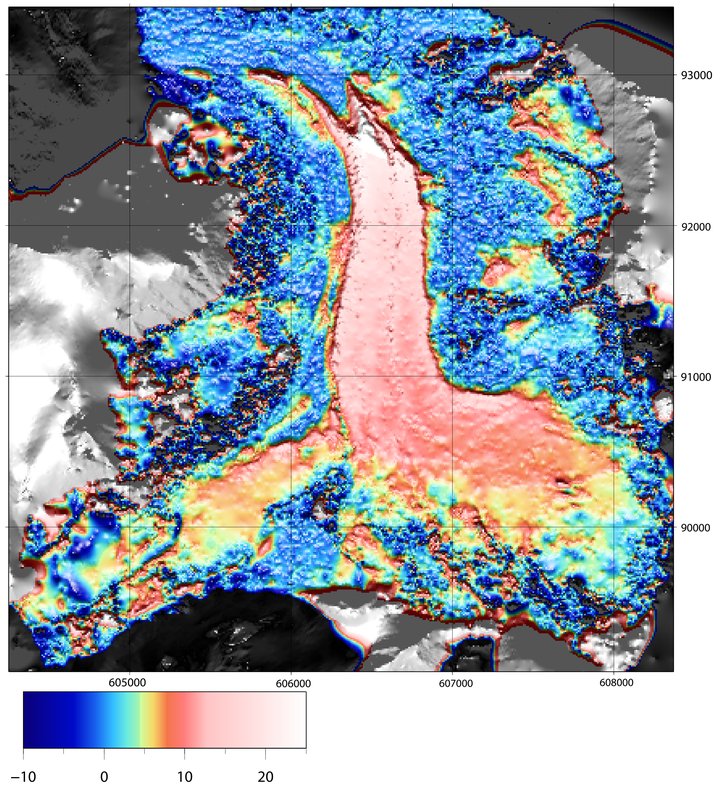

Figure 5: Difference between the DEM generated from aerial photographs 1999 and 2005. The 1999 DEM has a 10 m grid size. The 2005 DEM has a 15 m grid size, but is interpolated to the same grid size as 1999. This gives an uncertainty in elevation of about 1 m, which explains the noise in the non-glaciated area (largest uncertainty is in steep slopes). The borders of the 2005 DEM are not very accurate and therefore show large variations, but have no effect on the DEM over the glaciated area. The change in ice thickness for these 6 years is up to 20-25 on the tongue of the glacier.

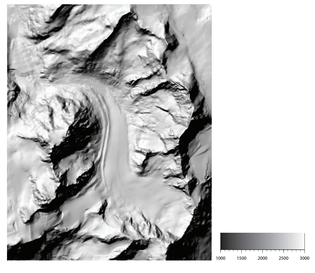

Figure 6: DEM from Arolla 1999, with 10 m grid size.

Acknowledgements

The authors are very grateful to T. Blunschi, H. Bösch, P. Burlando, M. Funk, M.G. Haas, H. Horgan, P. Jenni T. Keller, F. Pellicciotti, P. Perona, K. Schroff, C. Senn, R. Weber, T. Wyder and many more people who are still supporting us during fieldwork fieldwork. The project is carried out under the Swiss National Science Foundation Grant No. 200021105586.