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Some examples of modelling glacier mass balance and results from snow melt mitigation strategies in the Italian Alps

Ph.D. Thesis

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Indice

Abstract

In this PhD Thesis were reported the main results obtained analysing melting processes at the surface of some selected Alpine glaciers. In particular mitigation strategies to reduce snow and ice ablation at the surface of theDosdéGlacier (Lombardy Alps) and thePresena Glacier (Trentino) were analyzedto evaluate their effectiveness and applicability. Moreover some modeling approaches were applied to distribute ice and snow melting at the surface of the Dosdè debris free Glacier and the Venerocolo debris covered Glacier (Lombardy Alps) also to evaluate glacier meltwater discharge.

As regards the applied strategies to reduce ice and snow melting they were performed on two different glacier sites: the Presena Glacier, where skiing activates are performed from November to June without interruptions and only a short pause occurs during the hottest summer months, and the Dosdè Glacier, an Alpine glacier without strong human impacts where only trekking and mountaineering are performed. Then on the first site the preservation of winter snow is important to guarantee the possibility of performing skiing activities also in spring and early summer and several facilities (sly lifts and snow cats among the others) area available to perform and manage the mitigation strategies. Moreover snow cover presents peculiar features (density and strength different with respect to the natural conditions) due to the action of snow cats. Differently on the Dosdè glacier snow cover derived only by snowfalls and avalanches and it presents density and strength typical of a natural and untouched cold environment. No facilities area available to perform and manage the experiments. Then on this two different glacier sites the experiments we performed had different purposes: at the Dosdè Glacier we tested on natural snow the efficiency of artificial covers to preserve snow and ice. Then only a small glacier area was covered with a special material (Iceprotector500 ©) and some instruments were installed as well to measure albedo and energy balance at the glacier surface and at the surface of the artificial cover. Differently on the Presena Glacier the Autonomous Province of Trento asked for having an assessment of the effect of a wide artificial cover (up to 70,000 m^2) on the glacier mass balance as they initiated an actual program of mitigation of snow and ice ablation to change drastically the glacier mass balance and then to preserve the possibility to use the Presena Glacier as a tourist resource. On this glacier we evaluated not only the artificial cover efficiency in reducing ablation of compact snow but also we evaluated the impact of this method on the whole glacier seasonal variation. In addition on this glacier was also possible to test different artificial covers (varying their chemical compositions, their thickness and their weight per area unit) to evaluate the most convenient for such purposes.

As regards the modeling of ice and snow melting we followed different approaches. The main aim was to develop a simple method capable to describe the natural variability of glacier melt starting from simple data as air temperature and solar radiation which can be easily measured or evaluated. Other main input data are glacier melt rates measured on the field at least for short period.

In particular we applied an enhanced melt index obtained by considering both positive degree days and incoming solar radiation. Different attempts were performed by applying index calibration over short period (high accuracy but difficult to be applied on different years) and by calibrate the index on larger time frame (less accuracy but higher possibility of make the models running on different time windows).

To calculate the whole glacier mass balance we also described temporal and spatial variability of snow coverage. This issue is particularly difficult on the Italian Alps since poor data are available to describe snow depth and density at higher elevations. Also in this case our modeling approaches started from simple and largely available data (slope, aspect and elevation of each glacier pixel) and from some fundamental field data collected at the begging and at the end of the summer periods (snow depth and density evaluated trough snow pits). To improve our snow coverage modeling we also tested the use of a georadar to acquire a large sample of snow depth data coupling such information with snow density from snow pits.

Last but not least the glacier modeling approaches are based on robust series of climatic data. In fact as preliminary work we performed during the PhD was an analysis of all the available meteo data describing the climate settings of the study sites to evaluate their reliability. We check all the series (through statistical tests) thus obtaining a good record of data which constituted the main input of our glacier models and analysis. We also evaluated local lapse rates to be applied in our models. This part of the research was reported and explained in the Annex.