



Short and long term mass balance of Sforzellina Glacier (Central Italian Alps) by GPS and DTM methods

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Mass balance measurements are typically performed by means of classical field glaciological methods (stakes drilled into the surface of the glacier). New technologies are now investigated to obtain the same kind of result with less investment in term of fewer operators in the field for less time. Photogrammetry in particular cases and remote sensing can give a help but may still need support of direct observations of operators in the field. GPS measurements in RTK modality can be an interesting new approach for mass balance calculation. A GPS master station installed close by the ice body can broadcast real time corrections to teams of operators with rover GPS receivers walking on the surface of the glacier. The collected points can be then imported in appropriate software for the restitution of Digital Terrain Models (DTM). In summers 2003 and 2004 Sforzellina Glacier mass balance was investigated by means of GPS measurements. A GPS base station was installed on a high quality benchmark close to the glacier snout, and RTK surveys in continuous cinematic mode were performed to collect as many as possible data about the morphology of the surface of the glacier. All field data have been integrated in the office software and imported in the software for the restitution of the DTM models. By a comparison of the 3D models obtained it has been possible to make volumes variation comparison and to quantify the mass balance. By Ground Penetrating Radar (GPR) measurements performed in 1999 on the same glacier, it was also possible to quantify the whole ice mass of the glacier ($8 \times 10^6 \text{ m}^3$ of ice). This data can help in understanding the survival time of this glacier, quantified in few decades. Between the years 2003 and 2004 the Sforzellina Glacier lost $944,000 \text{ m}^3$ of ice ($859,040 \text{ m}^3 \text{ w.e.}$) corresponding to a mean thickness reduction of 3.6 m (3.2 m w.e.). In order to understand longer term variations of the glacier in term of mass changes, the map Carta Tecnica Regionale (CTR) 1:10000 of Regione

Lombardia was digitized. With the obtained data a DTM was realized representing the surface of the glacier of 1983. The volume value obtained by this model was compared with the model of 2004 surveys. According to this kind of analysis results the glacier lost in thickness in 21 years an average value of about 25 m, also visible from profiles comparison of some common sections obtained by the different 3D models. It must be underlined that the cumulated field mass balance data 1987-2003 give a thickness reduction of about 18 m of ice.

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