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Operational use of airborne laserscanning for glacier monitoring in Switzerland

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Glacier mass balance is widely accepted as a key parameter in hydrological and climate change research. Traditionally, the mass balance of a glacier is measured in-situ, at an annual or seasonal basis, using ablation stakes and snow pits and compared with decadal volume changes derived from photogrammetric analysis of aerial photographs. A major drawback in glacier photogrammetry is the lack of contrast in shady and snow covered (accumulation) areas. Since the 1990s, pilot studies have repeatedly shown that laserscanning has the potential to overcome these problems and can provide accurate elevation changes at an even higher spatial resolution.

In this study, we show the operational use of airborne laserscanning for the calibration of the glaciological mass balance measurements at Findelgletscher in the Valaisan Alps, Switzerland. So far, two flight campaigns were carried out in June/October 2005 and in October 2009. The area of interest covers 27 km^2 with a mean point density of more than two laser echoes per square meter. Besides the geometrical data, the Optech ALTM 3100 laserscanning system provides as well intensity data with 12bit resolution for every return. Using terrestrial survey data of roof tops, the positional and vertical accuracy of the corrected point cloud was estimated to be better than 50 cm and 15 cm, respectively. The point cloud was subsequently converted into a gridded digital surface model with one meter spatial resolution.

Preliminary results show that between 2005 and 2009 the ice thickness reduced over the entire Findelgletscher. In the region of the glacier tongue maximum thickness losses of 25 m to 30 m occurred. On average, the glacier, having an area of about 14 km^2, lost 3.4 m of ice. Assuming a density of 900 kg m^{-3}, this results in a mean annual mass balance of -0.8 m a^{-1} and indicates that the corresponding in-situ measurement might have a systematic positive bias.

Next steps in the project are detailed analyses of the uncertainties of both the volume changes as estimated by remote sensing and the in-situ mass balances. Furthermore, we aim at using calibrated laser intensity values for estimating the spectral albedo distribution on the glacier. A next flight campaign is planned for spring 2010 and shall provide high-resolution information on the spatial distribution of the winter accumulation.