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Vertical ice flow velocity and basal melt as important contributors to volume change on Alpine glaciers

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Very accurate airborne laser scanning (ALS) elevation data was used to calculate the annual volume changes for Hintereisferner and Kesselwandferner in Ötztal Alps, Austria for 2001/2002–2008/2009. The comparison of the altitude of 51 recently GPS surveyed ground control points showed that the accuracy of the ALS DEMs is better than 0.3 m. The geodetic mass balance was calculated from the volume change using detailed maps of the firn cover and applying corrections for the seasonal snow cover. The maximum snow height at the time of the elevation data flight was 0.5 m averaged over the glacier surface. The volume change data was compared to in situ mass balance data for the total area and at the stakes. For the total period of 8 years, the difference between the geodetic and the direct mass balance is 2.398 m w.e. on Hintereisferner and 1.380 m w.e. on Kesselwandferner, corresponding to about two times the mean annual mass balance. The vertical ice flow velocity was measured to reach the same order of magnitude as the mass balance at KWF. This is an indicator that volume change data does not allow the calculation of ablation or accumulation rates without detailed measurements or modeling of the vertical ice flow velocity. Therefore, only direct mass balance data allow process studies or investigation of the climatic controls of the resulting mass changes.
At Mittelbergferner, the glacier surface near the terminus showed subsidence rates much higher than the ablation rates. This subsidence rate can be explained by basal melt caused by subglacial streams. Detailed measurements were carried on on Hintereisferner to confirm the significant contribution of basal melt to the total mass balance.