Geophysical Research Abstracts
Vol. 15, EGU2013-3995-1, 2013
EGU General Assembly 2013

Combination of LiDAR and GPR measurements to derive snow and ice dynamics at glacier surfaces

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Within one accumulation season, surface elevation changes on alpine glaciers can mainly be attributed to the seasonal snow cover. Additional factors influencing the snow surface are the densification of firn layers and ice flow. However, in complex alpine topography accurate modeling of all three processes in combination with the present state of a glacier is difficult and only sparse data for calibration and validation exist.
To analyse the spatial distribution of the snow cover, Airborne Laser Scanning (ALS) data were recorded for a large part (approx. 745 km^2) of the Ötztal AlpS (Tirol, Austria) before and at the end of the accumulation season 2010/2011. Likewise, a smaller subcatchment (approx. 36 km^2) of the upper Rofental valley was scanned in 2011/2012. Ground penetrating radar measurements in combination with snow depth probings were performed simultaneously to the spring ALS acquisitions to account for ALS offsets.
The deviations of these data sets indicate prevailing submergence due to firn compaction and ice dynamics in the accumulation zones of the glaciers as well as emergence at the very front of the glacier tongues. Magnitude and differences of the contributing processes can be analysed along the quasi-continuous GPR profiles. Additionally, crevasses can be used to account for ice dynamics. Under the assumption that shape and size of crevasses stay constant during one accumulation season, utilizing the positions of crevasses in fall from ALS data and locations of the same crevasses in spring from GPR, a sequence of horizontal velocities can be obtained.
Hence, the combination of ALS, conventional depth probings and GPR measurements seem applicable to derive vertical ice dynamics combined with firn compaction, horizontal ice flow velocities and actual snow depths along GPR transects for accumulation seasons.