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Airborne laser scanning based quantification of dead-ice melting in recently deglaciated terrain

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Dead-ice is explained as stagnant glacial ice, not influenced by glacier flow anymore. Whenever glaciers have negative mass balances and an accumulation of debris-cover on the surface, dead-ice may form. Although, there are numerous conceptual process-sediment-landform models for the melt-out of dead-ice bodies and areas of dead-ice environments at glacier margins are easily accessible, just a few quantitative studies of dead-ice melting have been carried out so far. Processes and rates of dead-ice melting are commonly believed to be controlled by climate and debris-cover properties, but there is still a lack of knowledge about this fact. This study has a focus on the quantification of process induced volumetric changes caused by dead-ice melting.
The research for this project was conducted at Hintereisferner (Ötztal Alps, Austria), Gepatschferner (Ötztal Alps, Austria) and Schrankar (Stubai Alps, Austria), areas for which a good data basis of ALS (Airborne Laser Scanning) measurements is available.
'Hintereisferner' can be characterized as a typical high alpine environment in mid-latitudes, which ranges between approximately 2250 m and 3740 m a.s.l.. The Hintereisferner region has been investigated intensively since many decades. Two dead ice bodies at the orographic right side and one at the orographic left side of the Hintereisferner glacier terminus (approx. at 2500 m to 2550 m a.s.l.) were identified. Since 2001, ALS measurements have been carried out regularly at Hintereisferner resulting in a unique data record of 21 ALS flight campaigns, allowing long-term explorations of the two dead-ice areas.
The second study area of 'Gepatschferner' in the Kaunertal ranges between 2060 m and 3520 m a.s.l. and is the second largest glacier of Austria. Near the glacier tongue at the orographic right side a significant dead ice body has formed. The ALS data used for quantification include a period of time of 4 years (2006 – 2010).
'Schrankar' is located in the Western Stubai Alps in a north to south aligned valley, with 12 rockglaciers of different activities between elevations of 2400 m and 2800 m a.s.l.. Beside the rockglaciers, a big dead ice body (approx. at 2800 m to 2850 m a.s.l.) next to the terminus of the southern Schrankarferner was identified. For the quantification of dead-ice melting, ALS data was used from 2006 – 2009. Additionally, a time series of digital elevation models (DEM) derived from aerial images of different periods (1953 -2003) were integrated in the analysis.
In recent years, high-accuracy DEMs from ALS altimetry are emerging as an additional data source to existing field measurements. We present inter annual and annual trends of topographic changes caused by dead-ice melting. These trends are determined from multitemporal DEM differencing. The DEMs are generated from aerial images and ALS data. First results on the three dead-ice bodies of Hintereisferner show significant changes (-0.48 m and -2.24 m respectively per year). The derived melt rates are discussed, summarized and assessed in relation to climate parameters, like mean annual air temperature, mean summer air temperature, mean annual precipitation, mean summer precipitation, and annual sum of positive degree days.