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Analysis of spatiotemporal volume changes of glaciers: An Example from Goldbergkees and Kleinfleisskees in Goldberggruppe (Hohe Tauern)

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The aim of this study is to develop and validate digital elevation models to quantify changes in volume and ice-thickness for two small adjacent glaciers Goldbergkees (1.4 km^2) and Kleinfleißkees (0.9km^2) in Hohe Tauern, Austrian Alps. The investigation period stretches from 1909 to 2009.
Digital elevation models (DEMs) from airborne laser scanning (2009) and aerial photography (1992 and 1998) were ready for use. The work also included the digitalization, registration and interpolation of contour maps for the years 1909, 1930, 1953 and 1979.
One of our main objective was to evaluate the suitability of several common interpolation routines to construct DEMs for glaciological applications. Therefore Spline-Interpolation, Kriging, Triangulated Irregular Network (TIN) and the ANUDEM-Algorithm (v4.6.3) were quantitatively validated. For this purpose we focused on the Root Mean Square Errors (RMSEz) of the vertical coordinate (Z). The RMSEz of the various interpolated DEMs were calculated with respect to D-GPS measured spot elevations obtained for the 1998 photogrammetric DEM. Visualization methods including hillshading, slope maps and elevation contours were used to assess the representation of topography in each DEM.
Elevation differences on barren terrain (assumed to be stable) were analysed for potential biases, e.g. not perfectly aligned pixels of each DEM. Correction was applied by co-registering them using linear regression. Ultimately a significant glacier change signal could be distinguished from multi-temporal DEMs.
The study allows us to estimate the evolution of glacier volume over a period of 100 years. A bedrock DEM from 2003 enables the estimation of absolute glacier volumes for the given years. To estimate the robustness of glacier volume changes in the area, some of the resulting glacier volume changes are compared to those derived by cartometric methods in earlier years.