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Modeling glacier beds in the Austrian Alps: How many lakes will form in future?

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Glacial retreat exposes landscapes with relief characteristics greatly differing from the former ice covered surfaces. If glacial retreat exposes natural basins capable of forming proglacial lakes, then the downstream hydrologic and geomorphic systems in such catchments will be significantly altered due to discharge modifications, sediment trapping, decoupling effects and long term sediment storage (e.g. Geilhausen et al. 2013). Further implications are related to hydropower management, tourism and natural hazards. Consequently, sound knowledge of present day glacier beds ("proglacial zones of tomorrow") and in particular the total number, locations and characteristics of overdeepenings are of importance. For Austria, however, this important information about significant future changes of high alpine regions is yet missing. An interdisciplinary research project is currently in preparation to close this gap. This paper presents results of a pilot study.

We used a novel GIS-based approach (GlabTop, cf. Linsbauer et al. 2012) to compute approximate glacier beds in the Austrian Alps. GlabTop ('Glacier bed Topography') is based on an empirical relation between average basal shear stress and elevation range of individual glaciers and makes use of digital elevation models (DEM), glacier outlines and branch lines (i.e. a set of lines covering all important glacier branches). DEMs and glacier outlines were derived from the Austrian glacier inventory (1998) and branch lines were manually digitized. The inventory includes 911 glaciers of which 876 (96%) were considered and 35 were excluded due to size restrictions (< 0.01 km^2) or insufficient DEM coverage.

We found 165 overdeepenings (> 0.01 km^2) with the potential of forming proglacial lakes when glacier retreat reveals the bed. The total area and volume of all overdeepenings is approx. 10 km^2 and 236 Mio m^3 respectively and 33 lakes will be larger than 1 km^3. A total glacier volume of 16 ± 5 km^3 with an average ice thickness of 36 ± 11 m was calculated for 1998. Comparisons with geophysical surveys (13 GPR profiles) revealed that ice thickness is mostly within the $\pm$ 30 % model uncertainty range and locations of potential future lakes are robust. Future work will focus on further model validation and optimization.

References:
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