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The new Swiss Glacier Inventory SGI2016: a detailed cartographic representation of Swiss glacier extent and supraglacial debris-cover

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With increasing anthropogenic greenhouse gas emissions and corresponding global warming, glaciers in Switzerland are shrinking rapidly as in many mountain ranges on Earth. Repeated glacier inventories are a key task to monitor such glacier changes and provide detailed information on the extent of glaciation, and important parameters such as area, elevation range, slope, aspect etc. for a given point or a period in time. Here we present the new Swiss Glacier Inventory (SGI2016) that has been acquired based on high-resolution aerial imagery and digital elevation models in cooperation with the Federal Office of Topography (swisstopo) and Glacier Monitoring in Switzerland (GLAMOS), bringing together topological and glaciological knowhow. We define the process, workflow and required glaciological adaptations to compile a highly accurate glacier inventory based on the digital Swiss topographic landscape model (swissTLM^{3D}).

The SGI2016 provides glacier outlines (areas), supraglacial debris cover, ice divides and location points of all glaciers in Switzerland referring to the years 2013-2018, whereas most of the glacier outlines have been mapped based on aerial images acquired between 2015-2017 (75% in number and 87% in area), with the centre year 2016. The SGI2016 maps 1400 individual glacier entities with a total glacier surface area of 961 km^2 (whereof 11% / 104 km^2 are debris-covered) and constitutes the so far most detailed cartographic representation of glacier extent in Switzerland. Analysing the dependencies between topographic parameters and debris-cover fraction on the basis of individual glaciers reveals that short glaciers with a moderate mean slope and glaciers with a low median elevation tend to have high debris fractions. A change assessment between the SGI1973 and SGI2016 based on individual glacier entities affirms the largest relative area changes for small glaciers and for low-elevation glaciers, whereas the largest glaciers show small relative area changes, though large absolute changes. The analysis further indicates a tendency for glaciers with a high share of supraglacial debris to show larger relative area changes.

Despite of an observed strong glacier volume loss between 2010 and 2016, the total glacier surface area of the SGI2016 is somewhat larger than reported in the last Swiss glacier inventory SGI2010. Even though both inventories were created based on swisstopo aerial photographs, the additional data, tools, resources and methodologies used by the professional cartographers digitizing glacier outlines in 3D for the SGI2016, are able to explain the counter-intuitive difference between SGI2010 and SGI2016. A direct comparison of these two datasets is thus not meaningful, but an experiment where a representative glacier sample of the SGI2010 was re-assessed based on the approaches of the SGI2016 led to an upscaled total glacier surface area of 1010 km^2 for the Swiss Alps around 2010. This indicates an area loss of 49 km^2 between the two last Swiss glacier inventories. As swisstopo data products are and will be regularly updated, the SGI2016 is the first step towards a consistent and accurate data product of repeated glacier inventories in six-year time intervals that promises a high comparability for individual glaciers and glacier samples.