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Glacial lakes in Austria – current trends and future development

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Glacier melt is one of the most striking consequences of temperature rise in the 20th and 21st centuries in the European Alps. The space released by the disappearing ice is frequently filled by new glacial lakes. Glacial lakes have substantial environmental and socio-economic impact on high mountain systems including water resource management, sediment delivery, natural hazards, energy production, or tourism. Their development modifies the composition and appearance of high mountain landscapes. Recent developments in combining ice thickness models with high resolution glacier surface data allow producing models of the future, ice-free bedrock topography below current glaciers. The analysis of these potential glacier beds reveals glacially overdeepened bedrock depressions that represent potential locations for future lakes. Knowledge on the location, number and extent of future lakes can be used to assess potential impacts on high mountain geo-ecosystems and upland-lowland interactions. This information is critical to appraise threads and potentials provided by the new lakes for ecosystems and society.

In order to predict the formation of glacial lakes within the formerly ice-covered terrain in the Austrian Alps, we applied different ice thickness models (HF-model, Glabtop2) using high resolution terrain data and mapped glacier outlines. Ice thickness data was compared with glacier thickness data from geophysical surveying and model parameters were adjusted for optimization. We ran the models on three different glacier extents provided by the Austrian Glacier Inventories (1969, 1997, 2006). Ice thickness modelling of past glacier extents enable a comparison of modelled lakes with existing lakes. Potential future lake positions and sizes were validated using geophysical data on bedrock topography.

In Austria, more than 260 new lakes have formed in glacier forefields since the Little Ice Age covering an area of 2.9 km^2, while more than 600 km^2 of terrain has been released by glacier melt. Their formation dynamics show an increase in number and size of new glacial lakes since the 1980s and are consistent with the observed trend of rising temperatures. This trend is assumed to continue in the near future until glacier retreat reached steep headwalls. Both models predict about 200 depressions underneath the existing glaciers in Austria. They produce depressions at similar locations, but size and number of depressions vary between the two approaches. Glabtop2 tends to produce larger objects and more depressions at similar locations in all three model runs compared to the HF-model. A total area of subglacial depressions of 8.7 km^2 and 12.2 km^2 modelled by the HF-model and Glabtop2, respectively, most probably overestimates the number of potential new lakes with respect to the remaining glacier area. A poor match between predicted and existing lakes is observed for model runs using previous glacier extents. This reveals the complex dynamics of lake formation and lake evolution in glacier forefields resulting from the legacy of glacier erosion and sedimentation patterns. We finally discuss the current trends and potential future formation of glacial lakes in the Austrian Alps in relation to climate change, geomorphological, hydrological and socio-economic impact.