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Assessment of future glacier extent by means of hypsographic and GIS-based modelling

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Due to the rapid wastage of Alpine glaciers observed during the past two decades, a complete deglacierization of entire mountain ranges is likely in a warmer future climate. As glaciers in the Alps are of a high economic value (hydro power, discharge, tourism), the assessment of adjusted glacier size and volume under changed climatic conditions is of major interest. However, there is yet no simple and robust scheme that can be applied to thousands of glaciers providing new individual glacier shapes and sizes according to a given change shift in ELA. The available methods can either not be applied automatically (manual rendering) or require input parameters that are not available for most glaciers (bed topography). Here we present a GIS-based approach that calculates changes in glacier area due to a given shift in ELA automatically from the hypsographic curve of a glacier utilizing digital glacier outlines and a DEM. The position of the steady-state ELA is approximated for all glaciers from a fixed accumulation area ratio of 0.6, as obtained from long-term Alpine mass balance measurements. Moreover, for all glaciers the same temperature sensitivity of the ELA is assumed and geometry changes due to glacier flow or curvature are neglected. While glaciers with their highest points below the shifted ELA disappear in our model, for all other glaciers their new size and the new elevation of their lowest point is calculated from the hypsographic curve. We applied this model to all glaciers in Switzerland, where digital outlines from about 3000 glacier entities are available from the year 1973 (nearly steady-state) using ELA shifts from +100 up to +600 m in 100 m steps. For a 200 m (400 m) upward shift of the ELA about 74% (91%) of all glaciers might get lost, formerly covering about 54% (80%) of the glacierized area and representing about 50% (78%) of the volume. Deleting the area below the respective new lowest glacier point within the GIS, allows impressive and automatically created visualizations of the changed landscape (perspective views with draped satellite imagery).