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Using glacier inventory data to determine the sea-level contribution of glaciers

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Glaciers are widely considered as the best natural climate indicators. While this is certainly the case for glacier changes (length, volume), it also applies to glaciers itself as they can only exist within a certain range of climate conditions. A key parameter for the climatic classification of glaciers is their equilibrium line altitude (ELA) when referring to a balanced mass budget (ELA0). The ELA0 can be approximated by the mean or median elevation that is readily available for individual glaciers from inventories. Using well-established relations between temperature and precipitation at the ELA0, precipitation can be derived from mean elevations. Annual precipitation sums are indicative of the climatic regime and can be used to infer mass balance gradients. Once these are known, mass loss by melt can be approximated for each glacier under balanced conditions. By shifting the ELA0 upwards, the ablation region is increased and in combination with the mass balance gradient the additional glacier melt can be calculated for each glacier.

In this contribution we applied the above methods to all glaciers in the Swiss Alps using glacier outlines from the mid 1970s and a digital elevation model (DEM) from the mid 1980s as an input. The mass balance gradients derived from annual precipitation are within the range of known values (measured and modeled). The modelled ablation under balanced conditions is rather similar to the observed precipitation amounts over glaciers (considering measurement uncertainties). For a one degree temperature increase, specific mass loss increases by about 0.65 m / yr (the mass balance sensitivity) which gives a total mass loss of about 1 Gt / year over a glacier area of 1000 sqkm and for a temperature increase of 1.5 degrees. These values are in good agreement with the observed annual mass changes of glaciers in the Alps over the past two decades, thus confirming the observed temperature increase in the mid 1980s.