



Comparison of the responses of two temperate Alpine valley glaciers to climate change at the decadal scale

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Glacier advance and recession are considered as key indicators of climate change by the Intergovernmental Panel on Climate Change. Understanding the relationship between climatic variations and glacial responses is crucial. Here, we use archival photogrammetric methods to generate high resolution and precise Digital Elevation Models (DEMs) of two Alpine valley glaciers that have shown a contrasting response to recent climatic variability. Digital photogrammetry is well-established for glacier monitoring, mass balance determination and computation of the volumes of ice mass change. Reconstructions of the recent history of glaciers have been performed through and since the Little Ice Age and also more recently in relation to recent global warming. This study uses aerial imagery available from the early 1960s. Archival digital photogrammetry is applied to reconstruct the decadal scale glacial history of the Haut Glacier d'Arolla and the Glacier de Tsijiore Nouve in south western Switzerland. The data generated are used to explore the linkages between glacier changes and climate forcing. While both of the glaciers were subject to exactly the same climatic settings (they are only a few km apart), the responses to climatic variability have been markedly different. The data show continual recession of the Haut Glacier d'Arolla since 1967, associated with long-term climatic amelioration but only a weak response to shorter-term climatic deterioration. Glacier surface velocity estimates obtained using surface particle tracking showed that, unlike for most Swiss glaciers during the late 1970s and early 1980s, ice mass flux from the accumulation zone was too low to compensate for the effects of glacier thinning. Associated with glacier response time, that means that whilst there may have been a reduction in the ablation rate during the colder period, the flux did still not exceed the ablation rate, and hence snout advance was prevented. By contrast, the Tsijiore Nouve Glacier snout advanced between 1959 and 1977 before receding, a response related to the catchment geometry which allowed much more rapid flux of accumulated ice until the glacier tongue.