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Interannual variability of rock glacier surface velocities and its relationship to climatic conditions on a decadal scale: Some insights from the European Alps

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Active, inactive and relict rock glaciers are widespread periglacial landforms in the European Alps as revealed by several inventories elaborated for Slovenia, Austria, Switzerland, Italy, and France. Rock glaciers indicate present or past permafrost conditions in mountain environments and hence have a high climatic or paleoclimatic relevance. The monitoring of surface velocities at active rock glaciers has a long tradition in the European Alps with first terrestrial photogrammetric surveys in the Swiss and Austrian Alps already in the 1920s. Since the 1990s velocity monitoring activities have been substantially expanded but also institutionalized. Today, several research groups carry out annual or even continuous monitoring of rock glacier creep at more than 30 rock glaciers in Austria, France, Italy, and Switzerland. In many cases such a kinematic monitoring is jointly accomplished with meteorological and ground temperature monitoring in order to better understand the rock glacier-climate relationships and the reaction of rock glacier behavior to climatic changes. In this contribution we present a synthesis of the main results from long-term monitoring of several rock glaciers in the European Alps with at least annually-repeated data. Similarities but also differences of the movement patterns at the different sites are discussed, while the spatio-temporal pattern of the surface displacement is looked at against the climate context. In general, rock glacier surface velocities in the European Alps have been rather low during the 1980s and 1990s and reached a first peak in 2003/04 followed by a drastic drop until c.2007/08. Since then rock glacier surface velocities increased again with new velocity records in 2015/16 superior to the first peak around 2003/04. These creep rate maxima coincide with the warmest permafrost temperatures ever measured in boreholes and are likely a result of the continuously warm conditions at the ground surface over the past seven years.