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Semi-automated classification of mountain glacier types

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Glaciers are considered to be among the most effective erosive agents in geomorphology. Cirques, ridges, U-shaped valleys and other landforms that compose high mountain landscapes with current or past glacier presence are typical witnesses of glacial erosion. During postglacial and interglacial times, mid-latitude glaciers are restricted to the uppermost zones. They are typically classified according to their morphology as valley glaciers, cirque glaciers, plateau glaciers, hanging glaciers, and others. Glacier morphology is a function of topography, climate and lithology. Even though each glacier is unique due to highly variable boundary conditions, a classification of glaciers is based on its position in the landscape, size and form. Glacier morphology implies different characteristics of mass balance, ice flow, ice thickness, erosive force, sediment load, or glacier hydrology. Consequently, different glacier types represent different mechanisms and intensities in shaping of mountain landscapes. In times of glacial retreat due to increasing temperatures new surfaces are exposed during glacier melt. The morphology of these new land surfaces varies for different glacier types and is a function of the erosional and depositional legacy of the glacier. Furthermore, while glaciers shrink, glacier morphology and glacier type change with small cirque glaciers, debris covered glaciers, rock glaciers and ice-cored moraines being the end-members of mountain glaciation before complete ice disappearance.
Here we present an approach to semi-automatically classify glacier types based on their position within high mountain topography. The approach includes the definition of topographic rule sets for different mountain glacier types. We combine digital surface analysis techniques and automated landform classification with glacier distribution. Landform classification uses the Topographic Position Index (TPI) that is applied to medium scale digital elevation models. This classification delivers medium scale landforms like valleys, cirques and headwalls. We introduce a regional classification of glacier types that enables to track changes in glacier morphology, for example from valley glaciers to cirque glaciers, based on time series glacier inventory data. The approach is applied to two study sites, the Austrian Alps and the Mount Waddington area, Coast Mountain range, BC, Canada.