



## Evolution and hydrological importance of debris-covered glaciers and ice-debris landforms

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Debris-covered glaciers and ice-debris landforms such as rock glaciers are common in many mountain areas of Earth, are important for the debris transport system and contain a significant amount of ice. The presence, amount and characteristics of debris can strongly alter ice melt and the evolution of glaciers and ice-debris landforms. However, debris cover and debris content exhibits strong spatial variations. To understand the evolution and physiognomies of ice-debris complexes it is important to consider both debris supply and transport as well as deposition, which are impacted by climatic conditions, topography and lithology. A holistic approach to the investigation of these coupled complex systems seems thus crucial.

In this talk we present findings from our work based on in-situ investigations (e.g. geophysical methods), multitemporal high resolution remotely sensed imagery (including historical aerial images, Corona KH 4 images and recent data) and modelling (including surface ablation, englacial debris transport and ice flow) conducted on selected debris-covered glaciers and ice debris landforms worldwide.

Results show that a significant amount of ice is buried beneath debris cover in glacier forefields, ice cored moraines and rock glaciers under permafrost conditions. The response of rock glaciers to climate change is heterogenous with overall increasing velocities and on average only slight surface elevation changes. Slight increases in surface elevation occur their termini while debris-covered glaciers show on average a clear signal of surface lowering and decreasing velocities. The heterogeneity of debris cover can to a large extend be explained by the different debris sources and the characteristics of the headwalls while englacial and supraglacial streams favour the evolution of rough surface topography on debris-covered glaciers with the presence of ice cliffs. The findings will be illustrated with specific examples from the Swiss Alps, the Himalaya and the Tien Shan.