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Change of debris cover on glaciers of the Eastern Alps, Austria

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Debris cover on glaciers influences climate-glacier dynamics by controlling surface energy and mass balance of glaciers. In effect, glacier flow dynamics and glacier melt are strongly influenced by superficial debris. Debris input is a result of bedrock weathering and rockfall processes at the surrounding rockfaces, which are often affected by permafrost conditions. Changes in air temperatures, permafrost melt, as well as increased release of fresh rock faces due to melt down of glaciers in the accumulation zone can lead to increased rockfall activity and contribute to more debris input. Additionally, negative mass balances may lead to an enhanced melt-out of englacial debris in the ablation zone and consequently to an increase in debris cover. Thus, debris cover of glaciers can represent a signal of ongoing effects of climate change in mountain areas. In the European Alps a strong increase of mean air temperatures has been observed within the last 35 years, which led to corresponding negative mass balances and an acceleration of glacier melt rates throughout the region. Following this trend, debris cover of glaciers should have increased as well.

In order to test this hypothesis we assessed the temporal evolution of supraglacial debris cover on glaciers of the Eastern Alps, Austria. We mapped debris cover on 255 glaciers utilizing a ratio-based threshold classification method with Landsat data at three time steps between 1996 and 2015. Results were compared with manually mapped debris covers from orthophotos for accuracy assessment.

We found no general trend towards an increase in the total debris-covered area, but observed an increase in relative debris cover. More than 18 % of the glaciers exhibited a continued increase in debris-covered area within the period of observation, however many glaciers displayed varying changes of supraglacial debris. We relate this to an up-glacier rise in debris cover due to increasing debris input and a concurrent intense retreat of the debris-covered glacier front. Both processes seem to vary with time and have a high variability among individual glaciers. The investigated glaciers of the Eastern Alps are much smaller and are located at lower elevations compared to other studies on debris-covered glaciers in other mountain regions, like the Himalayas. In contrast to larger glaciers at higher elevations, negative mass balances do not lead to an increase in debris cover on the majority of glaciers in the Eastern Alps. Whereas, debris covers on many high altitude glaciers of the Himalayas often leads to a stagnation of the glacier terminus and subsequent debris cover area increase with time.