Geophysical Research Abstracts
Vol. 20, EGU2018-17190, 2018
EGU General Assembly 2018

Rock-glacier dams in High-Asia

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Rock glaciers are especially abundant in the periglacial zone of semiarid mountain belts. Here, they store large amounts of ice and might be important water reservoirs aside from glaciers, lakes, and rivers. Yet whether and how rock glaciers interact with watercourses in mountain valleys remains largely unresolved. In the present study, we examine the potential for rock glaciers to block or disrupt river channels, using a newly compiled inventory of more than 2000 intact rock glaciers that we mapped from remotely sensed imagery in the Karakoram, the Tien Shan, and the Altai mountains. In total, our inventory covers an area of 30,000 km^2, which we subdivided into 48 segments of 25x25 km^2. Within these subregions, we determined rock glacier density, as well as the area lying upstream of rock glaciers that impact the drainage network. We find that between 5% and 14% of the mapped rock glaciers partly buried, blocked, diverted or constricted at least 95 km of mountain rivers in High Asia, completely disrupting or partly disturbing the sediment delivery from up to 20% and 46% of a segment, respectively.

To discern those rock glaciers disrupting mountain rivers from those with no obvious impacts, we use a Bayesian robust logistic regression with multiple topographic (SRTM derived) and climatic variables (WorldClim). We identify elevation and potential incoming solar radiation (PISR), together with the size of feeder basins, as dominant predictors, so that lower-lying and larger rock glaciers from larger basins are more likely to disrupt river channels. Given that elevation and PISR are key inputs for modelling the regional distribution of mountain permafrost from the positions of rock-glacier toes, we infer that river-blocking rock glaciers may be diagnostic of non-equilibrated permafrost. Eliminating the strong correlation between these two and several other topographic and climatic variables with principal component analysis adds low temperature variability and low dry-season precipitation to the controls that characterise rock glaciers impacting on rivers, while accounting for size effects. Clarifying whether rapidly advancing rock glaciers can physically impound rivers, or fortify existing dams instead, deserves future field investigation. We conclude that rock-glacier dams are conspicuous features that may share a polygenetic history and encourage more research on the geomorphic coupling between permafrost lobes, river channels and the sediment cascade.