Towards mechanical modeling of rock glaciers from modal analysis of passive seismic data

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Among mountainous landforms, rock glaciers are mostly abundant in periglacial areas, as tongue-shaped heterogeneous bodies. By measuring physical properties sensitive to useful hydro-mechanical parameters of the medium, a wide range of geophysical methods provides interesting tools to characterize and monitor rock glaciers at large scale (1). However, the need of high resolution temporal monitoring reduces the choice of such methods.

Passive seismic monitoring systems have the potential to overcome these difficulties, as recently shown on the Gugla rock glacier (2). Indeed, seismological networks provide continuous recordings of both seismic ambient noise and microseismicity. From spectral analysis, we track resonance frequencies and modal parameters that are directly linked to elastic properties of the system, which evolve according to its rigidity and its density (3,4). Here, we propose to evaluate the potential of this methodology on two rock glaciers (Laurichard and Gugla) located in the Alps, at elevations where climatic forcing influences their internal structures and consequently their dynamics.

For both sites, we succeed in tracking and monitoring resonance frequencies of vibrating modes during several years. These frequencies show seasonal variations, indicating a freeze-thawing effect on elastic properties of the structure.

Assuming vibrating systems, we perform 2D mechanical modeling of rock glaciers, which fits well the recorded resonant frequencies. By modeling the increase of rigidity due to freezing in wintertime, seasonal variations are also mimicked. Differences between observed and modeled values, together with the variability of the results over sites, are discussed.

We finally compare the results of modal analysis with those from Ground Penetrating Radar surveys, in order to converge on a consistent view of these rock glaciers and their freeze-thawing cycles.

References

