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The melody of a failing peak – seismic constraints on rock damaging and stick-slip motion at the Hochvogel (DE/AT Alps)

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Large rock slope failures play a pivotal role in long-term landscape evolution and are a major concern in land use planning and hazard aspects. While the failure phase and the time immediately prior to failure are increasingly well studied, the nature of the preparation phase remains enigmatic. This knowledge gap is to a large degree related to challenges in collecting appropriate data in such high mountain terrain. Classic monitoring techniques provide detailed data but mostly of point character and only reflecting the surface expression of processes within the rock mass. Thus, the integral behaviour of a peak, at the surface and at depth remains elusive.

Here, we present results from a continuous multi-sensor seismic analysis of the Hochvogel summit, a 2592 m high Alpine peak, which is deemed to fail in the near future, as a 5 m wide and 40 m long crack is progressively opening and mobilising up to 260,000 cubic metres of rock. The seismic network consisted of up to seven sensors, installed during July--October 2018 (with 43 days of data loss). We develop and discuss proxy time series indicative of cyclic and progressive changes of the summit.

Modal analysis, horizontal-to-vertical spectral ratio data and end-member modelling analysis reveal diurnal cycles of increasing and decreasing coupling stiffness of the fragmented rock volume, due to thermal forcing. Relative seismic wave velocity changes mimic this pattern but also reveal the release of stress within the rock mass. At longer time scales, there is a superimposed pattern of stress evolution, which increases for five to seven days and suddenly drops within a few days, also expressed in an increased emission of short seismic pulses indicative of rock cracking. Our data provide essential first order information on an early stage of a large-scale slope instability, which evolves towards a catastrophic failure.