P 9.35

Characteristics of acoustic and micro-seismic signals in steep bedrock permafrost on Matterhorn (CH)

Samuel Weber[1], Jérome Faillettaz[1], Matthias Meyer[2], Jan Beutel[2] & Andreas Vieli[1]

[1] Department of Geography, University of Zurich, Winterthurerstr. 190, CH-8057 Zurich (samuel.weber@geo.uzh.ch)
[2] Computer Engineering and Networks Laboratory, ETH Zurich, Gloriastr. 35, CH-8092 Zurich

Understanding processes and factors affecting rock slope stability are essential for detecting and assessing the stability of potentially hazardous slopes. Despite ever increasing range of possibilities for the instrumentation of steep rock slopes, our ability to detect precursor events remains limited. Analysis based on surface displacement measurements may successfully be complemented by passive monitoring of acoustic emission and micro-seismic activity, providing a potential integrated signal of a rock mass.

However, analyzing such signals raises significant challenges, since it depends on (i) the nature and positioning of sensors as well as (ii) the attenuation of signals in the rock mass under observation. To explore these properties in detail through a set of controlled experiments simulating surface detachment events, we installed an experimental setup in steep, fractured bedrock permafrost on Matterhorn (CH) acquiring acoustic and micro-seismic activity in the range 1-10^5 Hz (Figure 1).

The analysis of artificial forcing using a rebound hammer led to two major findings: First, a strong change in waveform characteristics during propagation was observed, disabling feature detection by cross-correlation. Second, significant signal amplification in the frequency band 33-67 Hz was observed (Figure 2). The origins of this phenomenon remains unclear, especially whether this frequency band of amplification is site or location dependent and is a general characteristic for fractured bedrock conditions. However, this latter effect leads to an enhanced detection in this particular frequency band, an observation that is strongly supported by evidence from artificial rock fall events and natural fracture displacement.

Furthermore our analysis of the two-years time series suggested that filtering raw data in such frequency band might be a first important step towards the constitution of an unbiased catalogue of micro-seismic events. Indeed, the energy rate of the triggered events in this frequency band is not sensitive to positive temperature values. However, anthropogenic noise, e.g. caused by mountaineer activity, is also detected in this frequency band and complicates statistical analysis. Further analysis is required to label and eventually distinguish anthropogenic activity from bedrock-internal activity.

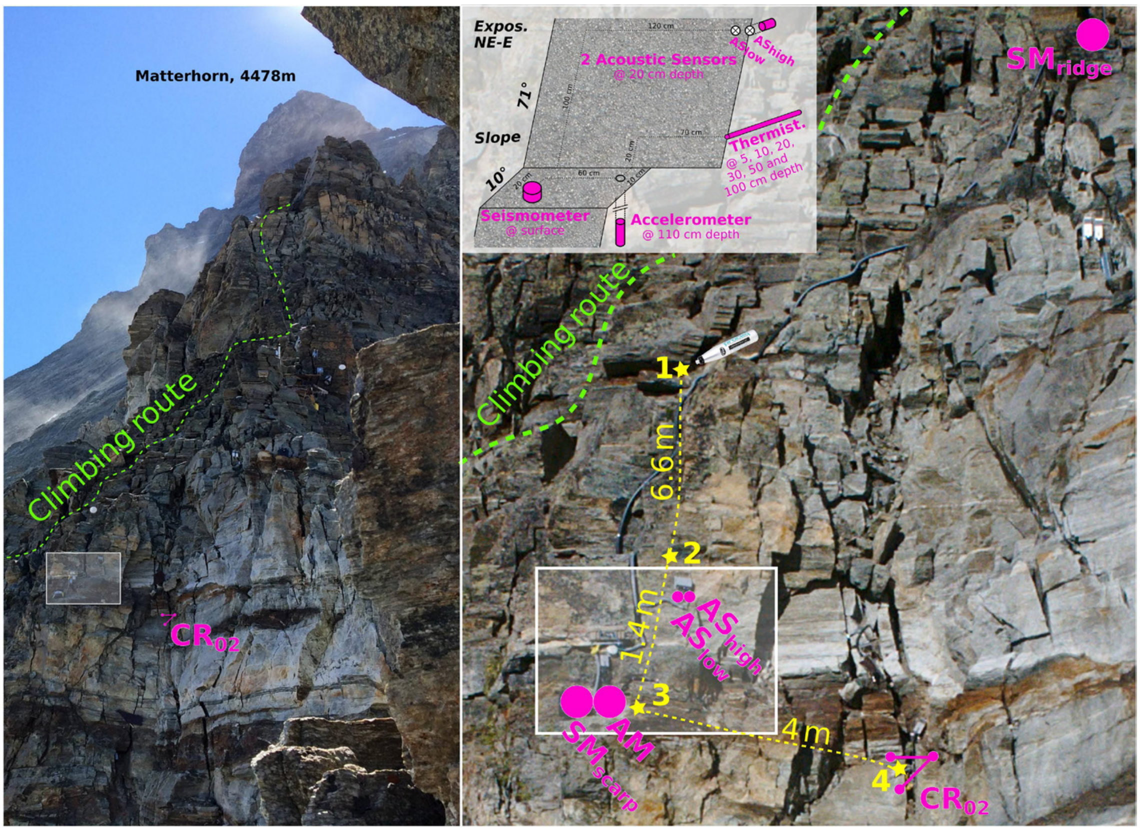

Figure 1. Detailed view on the Hörnligrat field site on the North-East ridge of the Matterhorn in the Swiss Alps with an average slope >60°C. Instrumentation setup for measuring acoustic (AS = acoustic sensor), micro-seismic (SM = seismometer; AM = accelerometer) and fracture kinematics (CR = crackmeter with displacement directions) are indicated in pink. A schematic zoom-in of the AE/MS instrumentation in the scarp is shown in the top white box. The yellow stars show the locations of the artificial events generated by the rebound hammer method.

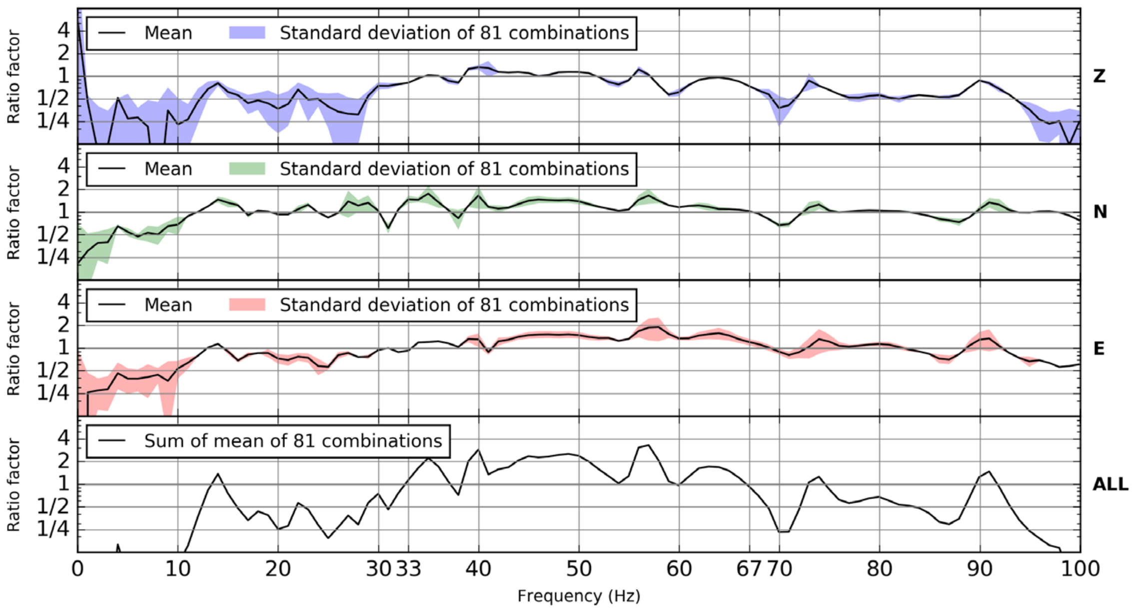

Figure 2. Filter spectrum between Location 3 and Location 4 indicating mean and standard deviation of 81 combinations. Amplification in the middle part of the frequency range (33-67 Hz).