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Exploring energy delivery to coastal rock cliffs

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This study uses microseismic ground motion as a proxy for energy delivery to a rock coastal cliff to examine the contributions of three key forcing mechanisms: waves, tides and storms. The energy delivered to hard rock cliffs from waves, tides and storms is acknowledged as a key control of cliff erosion, due to the influence on the effectiveness of mechanical and hydraulic processes. The direct impact and variability of wave energy and its influence on rock cliffs however is poorly constrained. Questions remain around the relative impact that waves, tides and storms have on energy delivery to the coast and the relative significance of marine to sub-aerial weathering processes in controlling cliff failure is unknown.

This paper presents the findings of a two year dataset collected from a 10 instrument 3D seismometer array, combined with an intensive program of monitoring of marine and aerial conditions at the cliff section. The study site on the coast of northeast England, consists of numerous strata of Jurassic mudstones, sandstones and shales. The high tidal range and exposure to frequent stormy conditions results in wide day-to-day variations in environmental conditions.

The instrument array enables examination of exact marine and weather conditions at the cliff and cliff motion responses to these both in terms of the distribution across the cliff face and propagation back through the cliff material. The data is explored using spectral and wavelet analysis to examine the sensitivity of rocky cliff ground motion to wave characteristics such as height and period, tidal characteristics including heights and durations of inundation, and wind and rainfall events. The results show unexpected energy delivery patterns throughout the tidal cycle and a detailed insight into relationships between environmental conditions and cliff behaviour.