Locating flowing conduits in Karst using passive seismic deployments

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Karst is an important landscape in many locations incorporating many subterranean waterflow passages in the form of caves, conduits, and fractures. Although challenging, some karst structures can be imaged by active geophysical techniques however they generally cannot facilitate differentiation between flowing and non-flowing waterways. In this study, we aim to locate flowing conduits by passively capturing flow-induced seismic signals.

To gain a broad understanding of seismic source versus path effect in these complex structures and to help us design bespoke field experiments, we commence our study by undertaking 3D numerical simulation (using SPECFEM3D) for different cases of shallow and deep conduits. These choices are informed by known conduit geometries in Ireland (they have been dived). Spectral resonance, synthetic heat maps, and amplitude-based locations of synthetic data reveal interesting information regarding the conduit response.

Based on the results of these simulations, we designed the layout of a passive field experiment on karst on Pollnagran cave in County Roscommon, Ireland using 1Hz seismometers and 5 Hz Geophones. The karst deployment is also complemented by smaller experiments on surface rivers in order to help better understand observed signals. We also undertake an active hammer seismic survey at the site in order the build a model for future site-specific numerical simulations.

Consistent with numerical experiments, clear discrete frequencies associated with water flow are observed in the field data. A complex picture is emerging where the largest dived caves are not necessarily the flow structures with the largest seismic amplitudes.