EGU2020-20833, updated on 17 Oct 2021
https://doi.org/10.5194/egusphere-egu2020-20833
EGU General Assembly 2020

Tracking surface and subterranean water flow using continuous seismic tremor

Haleh Karbala Ali[1], Chris Bean[1], David Craig[1], Ka Lok Li[1], Gareth O'Brien[2], Caoimhe Hickey[3], and Billy O'Keeffe[4]

[1]Geophysics Section, School of Cosmic Physics, Dublin Institute for Advanced Studies, Dublin, Ireland
[2]Tullow Oil Company, Dublin, Ireland
[3]Geological Survey Ireland, Dublin, Ireland
[4]Transport Infrastructure Ireland, Dublin, Ireland

Water is a critical resource that can range from being either available in short supply or excess, causing floods. In many locations the majority of this supply is underground. In some geological terrains such as karst these underground systems transport water primarily through crack or conduit flow. Determining the subsurface locations of the dominant flowing structures and their flow rates in such karst systems is a significant challenge. The details of these complex flow networks can, for example, have a first-order control on water supply, surface floods and the locations of seasonal lakes. Current geophysical methods focus on active geophysical imaging of karst structures but usually fail in determining if such structures are flowing. In this work, we take a different approach locating flowing conduits in Irish karst via a multi-method analysis of ground vibrations from temporary deployments of passive seismic sensors. We start by testing the methodology on surface rivers.

Hydrological processes including turbulent water flow and sediment transport create ground vibrations that can be detected on seismic stations. In the initial test, we deployed two small aperture arrays of 4 and 6 three-component (3C) short-period seismometers and a short linear array beside a river with a typical flow rate of 25 m3/second. We see clear spectral peaks associated with water flow at frequencies of 10 to 40 Hz. We locate the sources for these frequency bands using both conventional beamforming array analysis and an Amplitude Source Location Method (ASLM). Before ASLM, we constrain the velocity based on array analysis. Both methodologies perform well in determining the known locations of rapid flow in the river. We then move to a test karst location where the subsurface pathways of large conduits are known through cave dives. We deploy 3C short period seismometers for a few hours. Again we see clear peaks in the seismic spectra which, using ASLM and Frequency-Dependent Polarization Analysis (FDPA), located close to the known conduits. In the station close to a known conduit, we see sustained very high-frequency signals which are in agreement with numerical simulation of crack dominated flow for secondary short narrow cracks. This work is the prelude to a larger seismic nodal deployment that will take place in the winter/spring of 2020 in the same location. Initial results from that experiment will also be presented.