Utilising the Potential of Large-N Seismology: Monitoring Water in the Critical Zone

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The deployment of low cost, lightweight, low power seismic nodes, or the use of fibre optic cables as distributed acoustic sensors have allowed seismologists to move from deployments of 10s of broadband seismometers over wide areas, to deployments of hundreds or thousands of sensors in much denser networks – so called large-N seismology. This has led to vast improvements in traditional seismological methods, lowering the magnitude of completeness of earthquake catalogues or improving the resolution of seismic images. These new advances in technology are also opening new applications for passive seismology, especially in the field of environmental seismology. In this talk I will introduce a new project that uses seismic nodes to study the critical zone, the so-called skin of our planet between the solid Earth and fluid atmosphere. In a collaboration with Stryde, the UK Centre for Hydrology and Ecology and Scotland's Rural College, we deployed 1600 seismic nodes with 5-10 m spacing in a farm in Dumfries, Scotland. Using seismic ambient noise coda wave interferometry, we can constrain small velocity changes with 10m spatial resolution and 30 minute temporal resolution at seismic frequencies sensitive to the top few metres of the Earth. These velocity changes show remarkable correlations with in-situ measurements of soil moisture, showing the potential for passive seismology to be a new way to monitor soil moisture that can fill the existing temporal and spatial sampling gap between point measurements and those based on satellite data. Further, we captured a significant period of flooding in the Dumfries area and show that the relationship between seismic velocity and soil moisture breaks down ~1 day before flooding occurs. We relate this to soil saturation occurring at depth before being observed at more shallow depths. This suggests it could offer a potential monitor for soil saturation at depth, valuable information when monitoring potential flood risk.

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