Seeing inside flood embankments: combining electrical and seismic imaging.

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Flood embankments (levees or dykes) are used worldwide to protect homes, industry and farmland from flooding caused by extreme weather events and tidal surges. Their role is becoming increasingly important for two key reasons: climate change is causing larger and more frequent floods, and the number of people living on floodplains is increasing globally. Both these factors necessitate that flood defences are well maintained to minimise failure during flood events, and reduce disruption, damage, and even loss of life.

There are more than 10,000 km of flood embankments in UK alone, so condition monitoring must be rapid. Current monitoring relies on qualitative walkover surveys every 6-12 months, but this can only detect the surface features that form in response to subsurface processes or characteristics. If we could detect subsurface properties and deterioration features directly it would enable us to identify areas at risk significantly earlier, minimising both risk and mitigation costs. Two complementary geophysical methods stand out: Electrical Resistivity Tomography (ERT) and Multi Channel Analysis of Surface Waves (MASW). These are sensitive to different hydro-mechanical properties of the materials that make up flood embankments and their foundations. ERT is sensitive to moisture content, clay content and porosity, whereas MASW is sensitive to elastic properties controlled by material strength, density, porosity and saturation.

In this work we combine co-located ERT and MASW surveys with time-lapse airborne lidar on three contrasting embankments on the River Thames, River South Tyne, and the Humber Estuary. Each site was selected based on known anomalies or the availability of existing geotechnical information to ground truth the geophysical measurements. The three embankments represent a range of different soil types, ages and varying foundation materials, making an ideal suite of targets to test the different geophysical methods.
In total c. 1 km of embankment was surveyed. Preliminary analysis shows good spatial agreement between units imaged by the ERT and those identified in the borehole data for each site. Areas of greatest settlement identified using time-lapse lidar also correlate with low resistivity anomalies indicating areas of soft clay and peat. Further data analysis will incorporate the MASW results and use clustering to quantitatively divide the subsurface into units with similar electrical and seismic properties. Geotechnical properties will then be attributed to each of the clusters, allowing more accurate fragility analysis of the embankment during flood conditions to be conducted.