Contribution ID: **131** Type: **Presentation**

A study of deep neural networks for Newtonian noise subtraction

Wednesday, 24 May 2023 16:36 (15 minutes)

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The Euregio Meuse-Rhine border region of Belgium, Germany and the Netherlands has been identified as a candidate site for hosting Einstein Telescope. Newtonian coupling of ground vibrations to the core optics of the detectors may limit the sensitivity of Einstein Telescope at frequencies below about 10 Hz. The contribution of Newtonian noise is site specific and depends on the ambient seismic field which in turn depends on the site's geology and the distribution of surface and underground seismic-noise sources. We have investigated the application of machine learning in combination with the deployment of seismic sensor networks to predict seismic displacement noise at specific locations on the surface and underground. Moreover we have modeled a deep neural network that allows to subtract Newtonian noise from the strain data measured by Einstein Telescope. The seismic-field model is based on a complete solution of the elastodynamic wave equations for a horizontally-layered soil structure. The geology features soft-soil layers on hard-rock and was shown to be effective in attenuating Newtonian noise from surface waves below the required sensitivity. In addition our model includes a random background of body waves with all possible angles of incidence. We show that a deep neural network is effective in predicting Newtonian noise, whereas an Wiener filter approach is effective when surface boundary conditions dominate the Newtonian-noise contributions.

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Session Classification: Site characterization

Track Classification: Infrastructures: Site characterization