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Imaging shallow structures in Dublin city using seismic interferometry of seismic waves generated by train traffic

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Although train-induced vibrations are mainly regarded as a source of unwanted noise for classical seismological applications, these vibrations act as powerful sources for seismic imaging using seismic interferometry. Most of the seismic interferometry studies to date have concentrated on using the ambient seismic field generated by natural processes but the appropriate use of train-induced vibrations could result in higher resolution images.

In this study, we present results of seismic interferometry applied on 3 days of railroad traffic data recorded by an array of 3-component seismographs along a railway in Dublin, Ireland. Train-generated waves show a significantly higher frequency range than those recovered from typical ambient noise interferometry. Analysing the recorded signal, we have been able to distinguish between different train types (e.g. cargo vs. passenger trains) and train lengths (3-4, 5-6, 7-9, and/or 10-11 wagons).

For seismic interferometry, a Common Mid-Point – Cross-Correlation (CMP-CC) stack approach has been used to directly image the structures beneath the array. This approach produces a reflection image with interfaces consistent with nearby borehole data at ~450-500 m and ~1350-1400 m depth.

In addition to this reflection image, our results document a strong relation between the ambient source location (trains in this case) and the retrieved seismic reflection image. Since we have train location GPS data, we extracted 2-s time windows for when the train is 1500 m, 1000 m, and 500 m away from the first sensor and we applied the CMP-CC procedure to produce reflection images. As expected, the reflection images are sensitive to the location of the ambient noise source.

Numerical forward modelling of seismic wavefields for various source-receiver configurations also documents a strong correlation between the source location and the retrieved reflection image.

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