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Transdimensional Love-wave tomography of the British Isles

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In the last decade, ambient-noise interferometry has been revolutionising the way seismologists study the Earth by allowing them to record seismograms from earthquakes that did not occur in reality. This technique uses cross-correlation of long records of seismic noise to turn seismometers into 'virtual' earthquakes, whose signals are recorded by real seismic stations. These interferometric signals can then be treated as normal seismograms and used to produce seismic velocity maps of the Earth's subsurface using a variety of tomography methods.

Because seismic stations can be installed virtually anywhere on the Earth's surface at any desired time, the use of seismic interefrometry may be particularly beneficial where the area of interest is seismically quiescent and could not therefore be imaged using traditional teleseismic or local-earthquake methods. However, in many cases the distribution of seismic networks and even of stations within a network is also far from uniform, with station density being generally higher in areas of higher seismic activity or population and lower in scarcely populated or seismically quiescent regions. As a consequence, resolution may also vary across the region of interest, being better in areas that are covered by dense networks (i.e. traversed by a larger number of raypaths) and decreasing in areas that have a lower station coverage. While most tomography methods use fixed inversion grids and regularization parameters, and can be strongly influenced by the choice of the initial model and by the non-uniform distribution of information over the Earth's surface, a number of inversion techniques employ irregular parametrizations in order to adapt the model to the spatial distribution of information. Among these methods, the transdimensional reversible-jump Markov chain Monte Carlo (rj-MCMC) tomography method uses dynamic model parametrization with Voronoi cells, Markov chain Monte Carlo and the reversible-jump algorithm to invert traveltime data over a large number of randomly-generated velocity models and obtain a final model by averaging over the accepted samples. The use of rj-MCMC ensures that the proposed models sample all model space and are not influenced by the initial velocity model, while the Markov chain dynamically adapts to non-uniform data distribution without requiring the use of any regularization parameters.

Within this study, we used the transdimensional rj-MCMC algorithm to produce the first Love-wave velocity maps of the British Isles from ambient-noise interferometry with a fully non-linear approach. Thanks to the use of this innovative tomography technique, we were able to correctly integrate datasets of different spatial scales and overcome the irregularity of information distribution over our area of interest. At all periods we considered, the velocity structures identified in the models agreed with the known surface geology of the British Isles.