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Imaging of surface wave phase velocities from array phase observations

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While temporary deployments some 10 years ago were largely based on short-period seismometers, the availability of broadband instruments in instrument pools increased strongly in recent years and as such modern temporary deployments for passive seismological recordings often consist to a large extent, if not exclusively, of broadband instruments. This opens for new analysis approaches as the broadband seismic wavefield is obtained at a relatively high spatial sampling relative to the wavelength.

In an attempt to infer surface wave phase velocity anomalies beneath Southern Norway based on data from a temporary network of 41 broadband instruments, we present a new approach to overcome the limitations of two-station phase measurements (on the great circle with the source) and instead exploit the two-dimensional nature of the wavefield by taking into account phase measurements at all stations of the array from a single event. This is based on the assumption that the wavefield is at least piecewise linear within the study region. By triangulation of the network region and linear estimation of the phase gradient in each triangle we get without further a priori assumptions a coarse image of the phase velocity variations within our network. The image can be significantly refined for a single event recording by stacking multiple images based on arbitrary subsets of the available data.

Phase velocity anomalies measured from single event recordings can be biased and blurred by non-plane arriving wavefield, reflections and diffractions of heterogeneities. Therefore, by averaging over velocity fields from different events with varying backazimuths, artefacts are reduced and the recovered image significantly improved. Another way to improve the recovered structures is to take into account the spatial variation of the amplitude field. However, while the phase between two neighboring stations may be (at least close to) linear, the amplitude may not, hence estimation of the second spatial derivative of the amplitude field inheres a higher uncertainty.

In our contribution we will present the methodological aspects of our approach, as developed by analysis of synthetic data to illustrate the power and limitations of the method, and will apply it to real data from Southern Norway.