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Trans-dimensional ambient noise tomography of the Klyuchevskoy Volcanic System, Kamchatka

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The Klyuchevskoy volcanic group (KVG) is a cluster of 13 closely spaced stratovolcanoes, situated at the northern end of the Kamchatka volcanic arc, where it intersects with the Aleutian Arc. Klyuchevskoy volcano at its centre is one of the most active in the world, erupting on average 1 cubic metre of rock per second over the last 10000 years. Many international flight routes cross the Kamchatka peninsula, where eruptions from volcanoes of this group occasionally fill the air with ash. Between August 2015 and July 2016 an international collaboration conducted the KISS experiment, a temporary network of 83 seismographs, to investigate what drives the unusually high volcanic activity here. Combined data from the temporary stations and a permanent monitoring network, are now available to investigate the volcanic and tectonic seismic sources, velocity structure, and magmatic processes within the volcanic group. Our seismic imaging aims to constrain the distribution of magma supply beneath these highly active volcanoes, and to determine whether the underlying magma reservoirs are fed by a single large interconnected volcanic complex.

Here we present results of the seismic velocity structure from ambient noise derived Rayleigh wave dispersion observations. Estimated Greens Functions are optimised by selectively stacking the daily noise correlation functions with high coherence, which are not contaminated by distant P-wave microseism sources. Seismic tremor during eruptive activities at Klyuchevskoy Volcano does not interfere at the frequencies of interest here. Group velocity measurements are manually picked using the frequency-time analysis, and phase velocities are measured using the zero-crossings of the cross correlations in the frequency domain. We have then employed a two-step transdimensional Markov-chain Monte Carlo (McMC) approach to perform seismic tomography. This method samples the probability distribution of the model space, and provides physical uncertainty information. The transdimensional methodology is designed to remove user related bias by dispensing with arbitrary user-selected regularisation parameters. The first step consists of the construction of 2 dimensional velocity maps from the observed dispersion curves where the McMC approach automatically adopts the spatial discretization to the density of available data. We then employ a transdimensional McMC inversion to infer the 1D shear velocity structure from the local dispersion curves to build a fully 3D shear velocity structure. Our results show excellent resolution of the structure of the volcano-clastic sediment filled river valleys and indicate the internal structure within the volcanic massive. This offers the possibility of constraining sediment volume fluxes from this rapidly growing volcanic complex and improve the image of the shallow volcanic system that is currently based on body wave tomography alone.