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Imaging seismovolcanic tremor sources distribution with seismic network-based methods reveals fluid pressure pathways within Klyuchevskoy Volcanic Group magmatic system

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The Klyuchevskoy Volcanic Group (KVG) located in Kamchatka, Russia is one of the World's most active clusters of subduction volcanoes. In order to investigate its structure and very intense seismovolcanic activity, an international collaboration designed the KISS experiment operating a dense temporary seismic network between August 2015 and July 2016. During this period, the main volcano of KVG – Kyuchevskoy entered into eruption in the spring 2016. The preparation and eruptive periods have been characterized by a large number of volcanic earthquakes and tremors.

We applied in this study three cross-correlations network-based methods to detect and locate seismovolcanic tremor sources. From these three methods we extract simple 1D functions: spectral width (averaging in the 0.5-5 Hz frequency band the width of the network covariance matrix eigenvalue distribution), network response function (performing the 3D back-projection of the inter-station cross-correlations) and correlation coefficient function (averaging correlation coefficient functions computed at single station that characterize the stability in time of the single-station intercomponent cross□correlation function). The simultaneous application of these network features allowed us to classify the wavefield recorded by the dense seismic network. We then computed inter-station cross-correlations extracted from the first eigenvector filtered covariance matrix and generate time series of 3D spatial likelihood functions. Using output of our classification approach, we stack over time these 3D spatial likelihood functions for time windows containing tremor and we finally obtain a 3D Density Likelihood function imaging the seismovolcanic tremor sources distribution within KVG.

The addition of the temporary seismic stations from the KISS network greatly increased our detection and location resolution and thus allowed us to refine our knowledge about seismovolcanic tremor at KVG. Our results highlight a large distribution of tremor sources connecting different volcanoes and different depth levels. Most of tremor sources are located below the Klyuchevskoy volcano in a narrow zone vertically extended from the surface to the crust-mantle boundary and exhibit a highly intermittent behavior characterized by burst of activities and rapid upward and downward migrations between deep and shallow locations. Several tremor sources are also located along a SW-NE structure extending from Tolbachik to Klyuchevskoy volcanoes. We thus image the near-vertical quasi-open main conduit connecting the deep magmatic reservoir to Klyuchevskoy volcano in which very rapid pressure transfers might occur as well as a possible secondary conduit that links the marginal part of the deep reservoir to the Tolbachik volcanic system in which the system overpressure may be sometimes evacuated.