Geophysical Research Abstracts
Vol. 21, EGU2019-12752, 2019
EGU General Assembly 2019

Time-domain multi-array analysis of volcano-related seismicity around Fogo and Brava, Cape Verde

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The Cape Verde archipelago originates from a mantle plume beneath an almost stationary tectonic plate. Fogo and Brava are located in the south-western part of the archipelago, about 18 km apart from each other and belong to the younger islands of the Cape Verde. Only Fogo experienced historic eruptions at intervals of about 20-25 years, with the last eruption from November 2014 to February 2015. It is known from several previous studies that most of the seismic activity occurs in the vicinity of Brava. Based on these findings, a possible link of the plumbing system of Fogo to a magmatic source near Brava was proposed.

Here, we aim to investigate the magmatic system of Fogo and to characterize the seismic activity of the region in greater detail. As the majority of the events are located offshore, we employ multi-array techniques to study the seismic activity. Furthermore, as many volcano-related seismic signals lack a clear onset of phases, array methods may be better suited for their localization. In January 2017 we installed three seismic arrays on the islands - two on Fogo and one on Brava. Each array consisted of 3 broad-band and 7 short-period stations distributed over a circular shaped area with an aperture of approximately 700 m. The arrays were complemented by seven single short-period stations, five on Fogo and two on Brava. The complete network of 37 stations was in operation until January 2018. To locate earthquakes, we perform the array analysis in the time-domain. While computationally more expensive than traditional f-k analysis, the time-domain approach allows for more flexibility regarding the selection of relevant time windows to calculate the beam energy. Traces are first shifted and then cut to select suitable time windows for the energy stack as function of horizontal slowness.

For a single array, epicentral distances can be estimated from arrival-time differences between S- and P-waves, by assuming a suitable velocity structure. However, with two or more arrays, earthquake epicenters can be obtained directly from the intersecting beams. In addition, using S-P arrival-time differences, depth estimates are also possible. As the three intersecting beams, generally, lead to three different solutions, we determine the epicenter by combining individual probability functions for the arrays. These are derived from the energy stack and its variation as function of slowness (backazimuth) close to the maximum. The technique can be applied to earthquakes as well as to volcanic signals lacking a clear onset of P- and S-phases, e.g. hybrid events. We test our approach by comparison with results from a classical earthquake localization applied to events located between Fogo and Brava and using the 7 single stations of the network.