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Analyzing earthquakes and hybrid events on Fogo and Brava, Cape Verde, with multiple arrays

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Fogo and Brava are part of the south-western chain of the Cape Verde archipelago, which is believed to originate from a mantle plume. The two islands are located about 18 km apart from each other. Only Fogo experienced historic eruptions at intervals of about 20 years, with the last eruption from November 2014 to February 2015. In contrast to Fogo, Brava shows a high seismic activity. In our study we focus on the characterization of the seismicity in the region. We employ multi-array techniques to study the seismic activity, as many events are located offshore. Additionally, arrays are well suited for the analysis of volcano-related seismic signals without clear onset of phases. From January 2017 to January 2018 we operated a network of three seismic arrays (two on Fogo, one on Brava) and seven single short-period stations (five on Fogo, two on Brava). The arrays consist of 4 broad-band and 6 short-period stations each and are shaped circularly with an aperture of approximately 700 m. We apply a time-domain array analysis to locate seismic events. This approach is computationally more expensive than a traditional f-k analysis, but allows for a higher flexibility in the selection of relevant time windows to calculate the beam energy. For the analysis in the time-domain, traces are first shifted and then cut to suitable time windows to determine the energy stack as a 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, epicenters can be obtained directly from the intersecting beams. The technique is applied to earthquakes as well as to hybrid events. During 2017 the seismicity is clearly dominated by volcano-tectonic earthquakes, mainly originating beneath and around Brava. Additionally we observe hybrid events on Fogo, which are characterized by a transition from high (20-40 Hz) to low (1-10 Hz) frequencies. The events lack clear phases, although they often exhibit a relatively sharp onset. These features provide ideal conditions for the application of the multi-array analysis. The hybrid events originate in the Chã das Caldeiras region, a collapse scar surrounding the present-day Fogo volcano, and are likely related to rock-fall events.