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Locating sources of volcanic explosions and study of the structure at Yasur volcano, Vanuatu

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Yasur volcano is a small scoria cone, located on Tanna Island, in southern Vanuatu. The cone is composed of 3 vents: two vents (A and B) in the southern crater and one vent (C) in the northern crater. The volcano is going through a permanent strombolian activity, characterized by explosions of gas bubbles and small ash plumes. The activity generates thousands of seismic signals per day, mostly explosion quakes and LP events. From January 2008 to February 2009, seismic activity has been recorded by 12 seismic antennas each composed of 7 short-period sensors: a 3 components seismometer surrounded by six vertical sensors. Distances between the central seismometer and the others sensors was 20m or 40m. In May 2008, 10 broadband stations have been installed to complete the seismic network. In this work, we present both source locations and a structural study of the volcano. To locate sources of seismic events, a seismic antenna technique is used. For each signal, the slowness vectors (which contain back-azimuth and apparent slowness) are estimated on a sliding window by inversion of the time delays calculated between the sensors using the cross-spectral method. Combining back-azimuth calculated for each antenna, sources are located by using a probabilistic approach. This method enabled to locate events belonging to several families of similar explosion quakes allowing to assign each family to the activity of one of the vents. The results show periods during which the activity shifts from northern to southern part of the crater.
To improve our knowledge of the volcanic structure and therefore allow the use of other location techniques such as moment-tensor inversion, we applied remote sensing techniques and array methods in order to determine a 3D seismic velocity model of the volcano. First a Digital Elevation Model with a 5 to 10 meters resolution was built from a stereoscopic couple of satellite images (with 2.5 meters resolution) georeferenced with GPS points measured during the experiment. Then velocity models have been estimated below each antenna and for the whole array. Two methods have been used for this purpose: SPatial AutoCorrelation (SPAC) and high-resolution frequency wavenumber. These techniques enabled to determine the velocity structures below each antenna down 200m below the surface. To complete these models, the same methods are used on data recorded by the broadband stations, which allowed to estimate seismic velocities for greater depths. The different velocity models and the DEM are finally combined to recompose the P and S waves 3D velocity structures at the scale of the volcano.