3-D ACOUSTIC MULTIPOLE INVERSION AT YASUR VOLCANO, VANUATU

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Acoustic waveform inversion shows promise for improved eruption characterization that may inform volcano monitoring. Well-constrained acoustic waveform inversion can provide robust estimates of erupted volume and mass flux, increasing our ability to monitor volcanic emissions (potentially in real-time). Previous studies have generally assumed a simple acoustic source (monopole) that radiates pressure waves equally in all directions. More complex source reconstructions can be estimated using a combination of monopole sources. However, to date, volcano infrasound source mechanisms have not been well constrained in three dimensions due to infrasound sensors only being deployed on Earth's surface, and the assumption of no vertical directionality (dipole) has been made (e.g. Kim et al., 2012).

In this study we deployed a high-density seismo-acoustic network around Yasur Volcano, Vanuatu, including multiple acoustic sensors along a tethered balloon that was moved every 15-60 minutes (Figure 1). Yasur has frequent strombolian eruptions every 1-4 minutes from any one of three active vents within a 400 m diameter crater. Our experiment captured numerous explosions from each vent at 38 tether locations covering ~200° in azimuth and a take-off range of ~50° (Jolly et al., 2017). Additionally, FLIR, FTIR, and a variety of visual imagery were collected during the deployment to aid in the seismo-acoustic interpretations. The third dimension (vertical) of pressure sensor coverage allows us to begin to determine the vertical directionality of the acoustic source.

Our analysis employs Finite-Difference Time-Domain (FDTD) modeling to obtain the full 3-D Green's functions for each propagation path. This method, following Kim et al. (2015), takes into account realistic topographic scattering based on a high-resolution digital elevation model created using structure-from-motion techniques. We then invert for the source location and multipole source-time function using a grid-search approach. We perform this inversion for 40 events from each vent (A and C) to examine the source characteristics of the vents, including an infrasound-derived volume flow rate as a function of time. These volume flow rates are then compared to those derived independently from geochemical techniques.

We find that the simple (monopole) source mechanism is a good approximation for the explosions at Yasur Volcano, but a small directionality (dipole) component remains when topography is accounted for using numerical Green's functions. Furthermore, neglecting effects of topographic scattering leads to overestimation of both the monopole and dipole strengths (i.e. overestimating erupted mass), therefore topography must be constrained when performing acoustic source inversion. The addition of infrasound sensors on a tethered aerostat allows for a broadened view of the infrasonic source radiation pattern in three dimensions with an unprecedented view of the vertical dipole component.

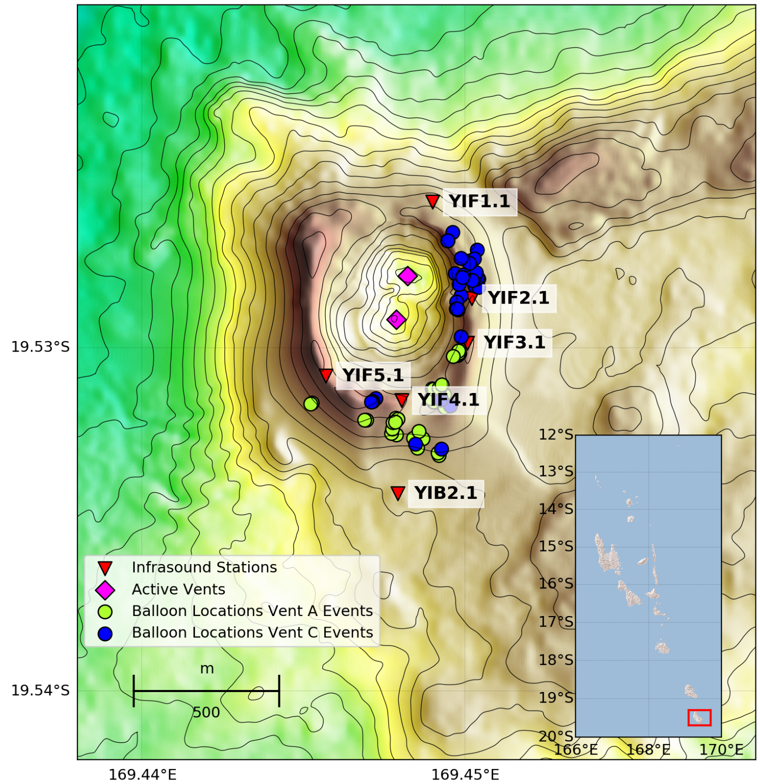

Figure 1: Yasur Volcano location map and sensor deployment. Infrasound sensors used in this study are shown by inverted red triangles and the two active vents are indicated by pink diamonds. The green and blue circles denote the balloon location for each of the 80 events used for the acoustic source inversion for Vent A and Vent C, respectively.

References:

Jolly, A.D., Matoza, R.S., Fee, D., Kennedy, B.M., Iezzi, A.M., Fitzgerald, R.H., Austin, A.C., Johnson, R., 2017. Capturing the Acoustic Radiation Pattern of Strombolian Eruptions using Infrasound Sensors Aboard a Tethered Aerostat, Yasur Volcano, Vanuatu. Geophys. Res. Lett. 44, 9672–9680. https://doi.org/10.1002/2017GL074971

Kim, K., Fee, D., Yokoo, A., Lees, J.M., 2015. Acoustic source inversion to estimate volume flux from volcanic explosions. Geophys. Res. Lett. 42, 5243–5249. https://doi.org/10.1002/2015GL064466

Kim, K., Lees, J.M., Ruiz, M., 2012. Acoustic multipole source model for volcanic explosions and inversion for source parameters. Geophys. J. Int. 191, 1192–1204. https://doi.org/10.1111/j.1365-246X.2012.05696.x