Decoupling the volcano infrasound source from the crater acoustic response

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Volcano infrasound is an important component of multi-disciplinary volcano geophysics and has proven utility for tracking eruptive activity and quantifying eruption dynamics. Unfortunately, a major limitation in our interpretation of volcano infrasound is that it is critically affected by the morphology of the volcanic crater, which can transform potentially simple source-time functions occurring within the crater into a signal that is substantially more complex. If infrasound waveforms are to be used to recover important physical parameters about an eruption source, then a robust understanding of the acoustic response of the crater is required. In many cases, and especially for large deep craters, the acoustic response function acts as a severe filter. For example, at Cotopaxi Volcano (Ecuador) infrasound 'tornillos' with an impulsive onset and peaked spectra at 0.2 Hz decaying for more than 90 s are part of the source response due to the crater's steep-walled, deep crater.

We analyze broadband infrasound data from open-vent volcanoes with a wide variety of crater geometries and jointly calculate their crater acoustic response using 1-D (axisymmetric) and 3-D morphologies derived from structure-from-motion digital terrain models. We analyze both explosion and lava lake infrasound from Villarrica (Chile), Stromboli (Italy), and Nyiragongo (Democratic Republic of the Congo) to demonstrate a broad spectrum of volcano infrasound, whose attributes are heavily influenced by crater shape. We demonstrate how some differences between simulations and recorded explosion are influenced by source-time functions, which may range from brief and impulsive to complicated or extended in time. Numerical modeling shows that each volcanic crater has a unique impulse response and that deconvolving this acoustic response is vital for estimating important eruption parameters including the size of volcanic explosions.