Influence of Topography and Non-Linear Acoustic Propagation on Infrasonic Jet Noise at Sakurajima Volcano, Japan

Sean Maher, Robin S. Matoza, Kent Gee, David Fee, and Akihiko Yokoo

We are investigating the influence of propagation effects at local distances (< 15 km) on the ability to recover the pressure-time history of volcano-infrasound (<20 Hz) sources. Diffraction around topographic barriers can create time delays, reduce overall sound pressure levels, and introduce ground-reflected phases, while nonlinear acoustic propagation of high-amplitude volcanic signals may transfer energy away from the peak frequency of the source. To constrain the influences of topographic diffraction and nonlinear propagation on volcano-acoustic signals, we characterize and model the waveforms and spectra of infrasound signals associated with Vulcanian eruptions at Sakurajima Volcano, Japan, over an 8-day period in July 2013. Observed signal power spectral densities vary by orders of magnitude across an azimuthally-distributed infrasound network with vent-receiver distances of 2.4 to 6.2 km. Application of a quadspectral density nonlinearity indicator shows that energy is transferred away from the 0.4 Hz peak. We perform modeling with a 2-D finite-difference time-domain code [de Groot-Hedlin, 2016] that incorporates rigid topography and nonlinear wave propagation at amplitudes above a 1% threshold of ambient pressure. Preliminary results using 1-meter resolution Sakurajima elevation profiles indicate that nonlinear propagation effects are significant for expected source amplitudes (820 Pa above ambient), and that topographic diffraction reduces overall sound pressure at the network stations. We hypothesize that sustained infrasonic eruption tremor at Sakurajima represents a volcanic form of jet noise that may be distorted by non-linear propagation effects and topographic scattering. This work has implications for infrasound-based estimation of physical eruptive parameters, which to date has been performed assuming linear acoustic propagation.

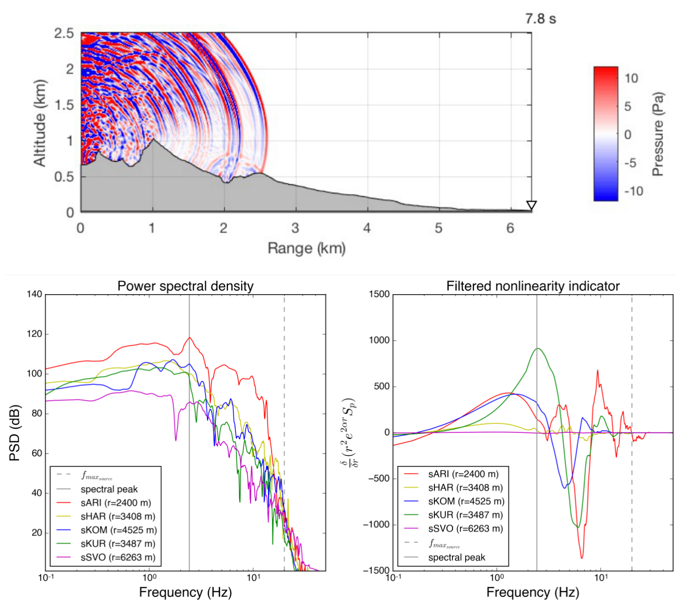

Figure 1. Wavefield visualization (top), power spectral density curves (bottom left) and quadspectral density nonlinearity indicator results (bottom right) for synthetic pressure data produced by nonlinear finite-difference time-domain modelling

References

de Groot-Hedlin, C. D. (2016). Long-range propagation of nonlinear infrasound waves through an absorbing atmosphere. The Journal of the Acoustical Society of America, 139(4), 1565-1577.