4-18-2016

Determination of an Open/Closed Vent Volcanic System

Matthew Von Lintig

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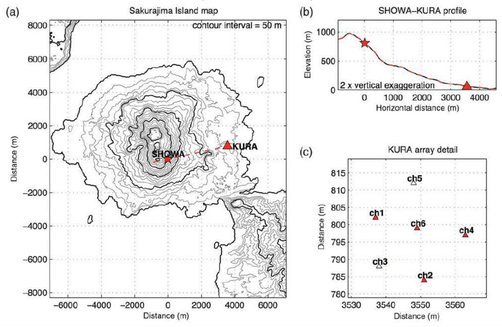
BOISE STATE UNIVERSITY

Author: Matthew R VonLintig
Advisor: Jeffrey B Johnson

Introduction

Monitoring volcanic activity through infrasound is a fast, cheap, non-invasive method of study. This figure *(left)* displays a volcanic eruption and the corresponding infrasound signal. This characteristic signal has a strong bipolar pulse which represents the explosion from the vent. The explosion is followed by a trailing “coda” as ejecta and gasses continue to erupt from the crater.

The study site is Sakurajima volcano located on Sakurajima Island, Japan. The active vent, Showa Crater, is located on the southeast slope of the cone. The area is prone to infrasonic noise from wind, ocean waves, and pressure systems.



(left) (a) Map view of the active volcanic vent, (b) profile showing vertical displacement, (c) blown up map view of array orientation. Receivers 1, 2, 4, and 6 were used. (Johnson & Miller, 2014)

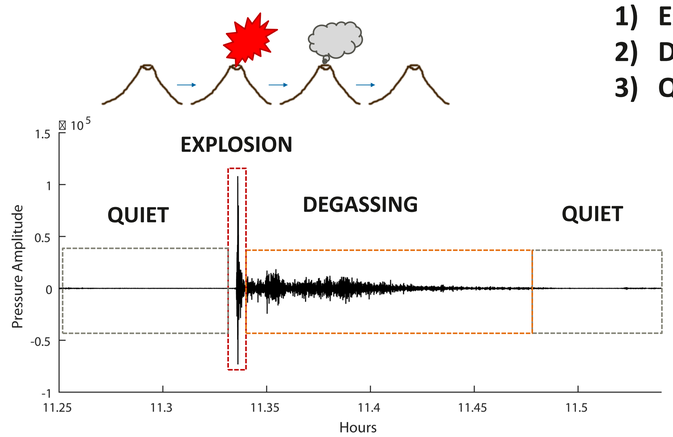
Abstract

Through the observation of infrasound signal, it is possible to determine the status of an open/closed vent volcanic system. In this study, twenty-four hour long infrasound signals from four receivers located ~3.5 km away from Showa Crater are utilized in characterizing the time distribution between eruption events at Sakurajima volcano in Japan. The application of filtering, stacking, correlation, and comparison of receivers highlights vent activity among other sources of infrasound. Presented are various methods and procedures used in determination of vent status. Simplification of this system to a binary signal of open or closed vent status allows for the probability distribution of interevent time durations to be modeled. Benefits of modelling the time distribution of hazardous events are to maintain safety among nearby communities and to further the communal understanding of the Earth as a system. In further application, these model parameters can be applied to probabilistic determination of impending eruption events as well as a reference for monitoring changes in the system.

The Main Idea

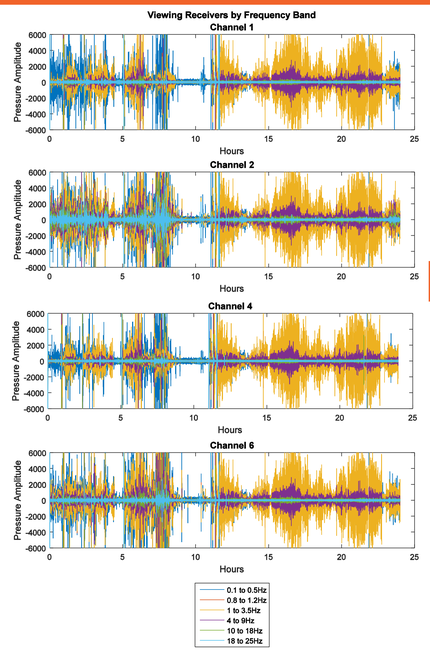
The objective of this study is to observe the infrasonic signal radiating from a volcanic vent in order to determine when the vent is open and when it is closed. Sakurajima Volcano displays complex behavior. In most cases, the behavior obeys a **three stage process:**

1) **Explosion**
2) **Degassing**
3) **Quiescence**



Procedures

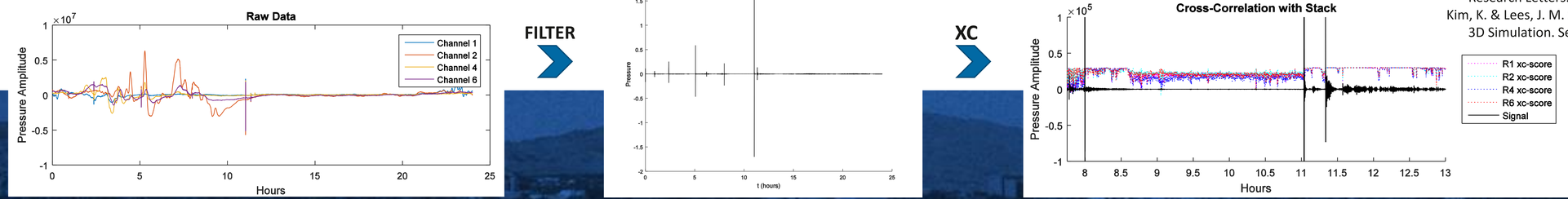
Filtering



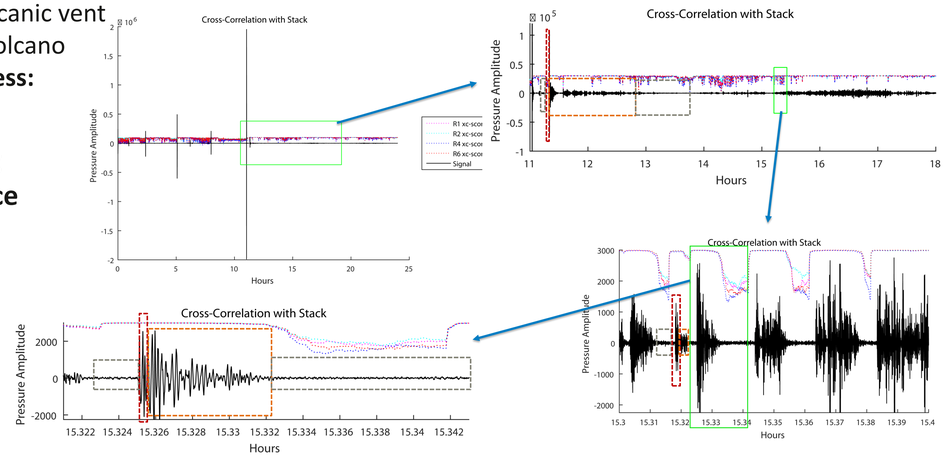
(left) Each receiver signal has been subject to **6 band-pass filters: .1-.5 Hz, .8-1.2 Hz, 1-3.5 Hz, 4-9 Hz, 10-18 Hz, and 18-25 Hz**. These frequency bands separate volcano events from noise. Volcanic eruptions are most prominent around .5-10 Hz (Fee *et al.,* 2014). Separating events by frequency spectrum allows for first robust noise and false event identification .

Cross Correlation

(below) Cross-correlation is used to assess how well each receiver signal matches up. Here is where we can differentiate from noise contaminating events that bear the same frequency as the vent activity. Calculating expected phase delay from the vent to each receiver ensures high XC scores correspond to vent activity. The four receiver signals were filtered and averaged together into a single “stack.” Then each receiver was cross-correlated with the stack. *(XC scores factored for scale)*



Results

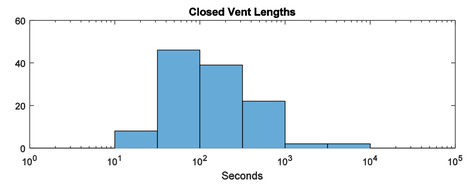


(above) Results from the data show fractal event patterns. Statistical analysis of interevent times and event magnitudes suggests chaotic behavior. This is expected for a complex, nonlinear system such as volcanism. The implications of this result include the inability to accurately predict specific event time and size, however, the probability based on event history may be described.

Conclusion

The quantitative determination of vent activity (open/closed status) leads into the important implication of estimating the probability of eruption. What has been described is a sequence of steps that can be put to use towards any volcanic system. These steps are essential in any analysis regarding the time distribution of events.

(below) The estimated probability of eruption measured immediately after an event is described by a histogram.



Further Research:

- Categorize event frequency by amplitude
- Compare new data to observe changes

References

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