One of the difficult problems in volcano seismology is finding earthquakes in a large data stream and transforming these numbers into a measure of the level of seismicity at the volcano. As part of an NSF-sponsored REU internship, we have developed automated code that detects seismic events and records characteristics of each. This is an expanded version of what is currently being done by hand—earthquakes are counted daily at around twenty volcanoes in the Aleutian arc. These numbers are useful because they provide a means of comparing seismic activity over time and over several eruptions. The information we record about each event can be used to get an idea of the type of earthquake occurring and to distinguish between volcanic events and unwanted signals such as regional earthquakes, noise, and calibration pulses.

### Processing the Data

Read in the data and apply a bandpass filter to accept only frequencies between 1 and 10 Hz. 

At each time, take an average of the amplitude for the last 0.8 second, the short term average, and the last 7 seconds. The long term average smooths the long term average(Lta) and short term average(Sta) with a Hanning filter, an average with Gaussian weighting with width .45 second.

Obtain the amplitude of the signal by applying a Hilbert transform to create an envelope of the wave.

### Detecting Events

Trigger when the ratio increases above 2.5—start of the event.

Recorded start time is at the point of inflection closest in time to the trigger.

Record downturn when ratio decreases below 1.5.

### Waveform Attributes

For each event the computer records a number of characteristics, including:

- Maximum amplitude
- Impulsiveness: peak value of Sta:Lta ratio
- Duration
- Dominant frequency: calculated by counting the number of zero crossings during the event

This data is used to see the types of events occurring at the volcano.

It also has the potential to differentiate between volcanic seismic events and unwanted events including noise, calibration pulses, and regional earthquakes.

Examples of the algorithm applied to a variety of events. (Top) A “long period” event. The detection algorithm captures the salient features of this event. It is an eruptive burst, barely rising above the noise and has a dominant frequency of 2.2 Hz. 

(Middle) A “volcano-tectonic” earthquake with high impulsiveness and high dominant frequency. 

(Bottom) A long duration event lasting 15 s with intermediate frequency and impulsiveness values.

### Applications

With the data collected for each event, the number of counts per hour can be calculated along with statistics showing the types of events that occurred. We show data from Mount Veniaminof during a small eruption in January to February 2005 as a demonstration of the capabilities of the programs.