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Studying the Colima active volcano, Mexico 2009

Daniel and Stefan studied Earth Science at Oxford University. For their project they went to Mexico to work as field assistants with the Colima Volcanic Observatory making gas flux, infra-sound and temperature measurements.

Below is a written report by Stefan about his and Daniel's fieldwork research on Volcán de Colima.

Report on fieldwork and current research on Volcán de Colima, México, for the Lydia Press Memorial Fund – Stefan Lachowycz

Volcán de Colima – background

Volcán (or Fuego) de Colima, on the Jalisco-Colima state border in western México, is one of the most active volcanoes in North America, with a history of large eruptions & massive collapse events. Given its situation in a densely populated area, it has been designated a 'Decade Volcano', one of 16 worldwide identified by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) as being worthy of particular study given the threat they pose to human life. The volcano has been undergoing cycles of lava dome growth & destruction in large eruptions for nearly 20 years, with daily small explosions since 2003. Evidence from volcanic deposits around the volcano suggests that larger Plinian events (possibly up to the size of the 1991 Pinatubo eruption) occur approximately every 100 years; the last occurred in 1913. The Vulcanian eruptions in 2005, the most energetic events since 1913, generated pyroclastic flows and prompted the evacuation of some of the villages closest to the volcano. Concern about the threat posed by the volcano has grown amongst the public in recent months after the current lava dome became clearly visible from the city of Colima, 30km to the south – however, there is little indication that a new phase of explosive activity is imminent.

Fieldwork

Although fieldwork was hampered by an unusually cloudy rainy season, the primary objective of the fieldwork, to assess the potential of each of the volcano monitoring techniques used at Colima to produce data suitable for statistical analysis, was achieved. Two trips were made to the civil protection base at the summit of the extinct volcano Nevado de Colima to monitor its active sister volcano using a UV spectrometer (to monitor SO_2 flux) and a thermal imaging camera. Another two trips were made to near the summit of the volcano, one to repair infrasound equipment, and another to the summit itself to take detailed thermal images of the growing lava dome, which was also achieved in two flights in a light aircraft around the summit. Many day trips to the flanks of the volcano allowed other equipment to be repaired or installed, and measurements to be made of various other parameters, including spring water chemistry and diffuse gas flux. Although only the seismic data has the high time resolution necessary for identifying short-term variations using statistics, these other data collected will be useful to constrain physical models of how changes in the statistical data relate to volcanic processes.

Research & findings to date

Research since returning from México has been focussed on developing a new, informative volcano monitoring technique using seismic data that can be applied in real-time, and so potentially be useful for forecasting new phases of activity at Colima and similarly hazardous volcanoes. To date, research has been focussed on exploring the use of entropy estimation and detrended fluctuation analysis (DFA) to identify and/or classify volcano-seismic events in the signal from a seismometer located <2km from the summit of the volcano.

The entropy of this seismic signal has been shown to increase when a volcano-seismic event takes place, but, significantly, the amplitude of the entropy 'spike' is not directly dependent upon the amplitude of the signal. Therefore, this entropy estimation technique shows promise as a more accurate method of determining event rate than the commonly used real-time seismic amplitude measurement (RSAM). As the volcano-seismic event count is the key parameter in the failure forecast method of predicting eruptions, and the hazardous Vulcanian activity in 2005 was preceded by swarms of low-amplitude events (undetectable using RSAM), the results of the preliminary analysis of entropy estimation suggest that this may be a valuable technique for volcano monitoring.

Previous work applying DFA to seismic data from Teide volcano suggested that DFA is also useful for identifying seismic events, particularly when there is significant background noise – however, preliminary analysis applying the technique to Colima data suggests that this technique may not be applicable to other volcanoes. A different technique using DFA has been applied to limited data from Colima, the results of which suggest that this approach may be suitable to detect or possibly even broadly classify volcanic events in the seismic signal – future work will explore this further, and explore the application of additional statistical techniques, such as standard deviation and probabilistic analysis.