Development of a remote multi-sensor global monitoring system for active volcanoes

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The complexity of active volcanic systems produces a vast array of eruptive phenomena; some persistently active volcanoes display combinations of effusive activity such as passive degassing, lava flows, lava fountains and lava lakes, while others display more explosive strombolian and vulcanian characteristics. Satellite remote sensing techniques provide the opportunity to monitor activity without the requirement of costly ground-based instrumentation or monitoring networks. Two datasets commonly utilised for satellite-based volcano monitoring are sulphur dioxide (SO_2) measurements using ultraviolet (UV) wavelengths and thermal anomaly detection using thermal infrared (TIR) wavelengths, but there have been few efforts to combine these techniques. We focus on operational SO_2 measurements made by the Ozone Monitoring Instrument (OMI) on NASA's Aura satellite, and TIR MODVOLC data derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua platform. Both Aqua/MODIS and Aura/OMI are in NASA's A-Train satellite constellation, providing daily, near-coincident observations of SO_2 emissions and heat flux at active volcanoes facilitating coupled analysis of the information obtained from these datasets. Our goal is to develop a technique to classify and monitor volcanic activity autonomously using OMI, MODIS and (ultimately) other satellite datasets. In order to characterize the style of eruptive activity based on satellite observations alone, we will first compile a database of OMI and MODIS observations for periods of well-documented volcanic unrest, and analyze their temporal variability. Time-series analysis techniques including Fourier functions, power spectral density and wavelet analysis will be utilised to identify the presences of cyclical patterns in the OMI and MODIS data from the selected locations. Select volcanic targets will be assessed representing diverse locations and styles of activity in order to test the developed methodology. Kilauea (Hawaii) will be incorporated due to its well-established eruption record compiled by the Hawaii Volcano Observatory (HVO) providing an invaluable source of observations to validate the technique. Popocatepetl (Mexico) will be analysed to represent the complexities associated with the presence of both natural and anthropogenic sources of SO_2, testing the validity of the methodology when sources of SO_2 are not purely volcanic. The ultimate aim of this project is to develop a more robust multi-sensor satellite monitoring and alert system than currently exists.