



Unmanned aerial vehicle measurements of volcanic carbon dioxide fluxes

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Recent advances in unmanned aerial vehicle (UAV) technology are set to revolutionise the geosciences in the coming decades. These platforms are unique in their ability to rapidly provide high spatial resolution data over large areas, at a fraction of the cost of conventional manned aircraft surveys. UAVs also provide the further benefit of decoupling the observer from the monitoring environment, which is of particular advantage in hazardous settings such as on volcanoes. Here we report measurements of volcanic gases with a UAV: a manually operated radio controlled helicopter of 3 kg payload, which was deployed on La Fossa crater, Vulcano Island during April 2007. The plume was traversed from beneath with a vertically pointing ultraviolet spectrometer to determine the volcano's SO_2 flux, then by flying into the plume with an electrochemical sensor and infrared spectrometer assembly, the plume's CO_2/SO_2 ratio was measured. Multiplication of these data yielded a CO_2 flux of 170 Mg d^{-1} . Given the deeper exsolution of carbon dioxide from magma, and its lower solubility in hydrothermal systems, relative to SO_2 , the ability to remotely measure CO_2 fluxes is significant, and shows promise to provide more profound geochemical insights, than possible with SO_2 fluxes alone: the most ubiquitous current source of remotely sensed volcanic gas data.