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Real-time in situ measurements of volcanic plume physico-chemical properties using Controlled METeorological balloons

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While the climatic effects of volcanogenic sulphate aerosol in the stratosphere are well characterised, the nature and global impact of sustained tropospheric volcanic degassing is less well understood. In situ measurement of volcanic emissions can be used to understand plume processes (e.g., microphysics and chemistry), and used to validate and improve remote sensing techniques. New developments in sensor and communication technologies have led to the production of miniaturized lightweight unmanned atmospheric measurement platforms. Controlled METeorological (CMET) balloons collect real-time observations of atmospheric physico-chemical properties at altitudes of up to 5 km for hours or even days at a time. Standard measurements include pressure ($\pm$ 10 mb), aspirated temperature ($\pm$ 0.3 C), relative humidity ($\pm$ 5 %) and location (GPS position $\pm$ 5 m horizontal, $\pm$ 50 m vertical).

Balloon platform-based measurements of volcanic plume properties were made for the first time using CMET balloons equipped with miniature electrochemical sensors during the eruption of Halema'uma'u crater (Kilauea) in Hawai'i in 2008. In addition, multiple measurement platforms were simultaneously deployed that included (1) ground-based remote measurements (mini-DOAS and UV camera); (2) satellite-based sensors (MODIS and OMI); and (3) in situ sampling at the emission source using ground-based electrochemical sensor instrumentation.

During the 25 July 2008 flight, a single CMET balloon remained in the plume and collected data for several hours. Ratios of [H_2O] and [SO_2] correlate in proximal regions of the plume, though were found to anti-correlate further downwind. Correlation is explained through co-emission of SO_2 and H_2O at source, as has been frequently previously observed e.g. by FTIR. Anti-correlation of [H_2O] and [SO_2] ratios has not previously been reported and may reflect dehydration of the aged plume through condensation of water vapour on volcanogenic sulphate aerosol. The sulphate aerosol was likely a mixture produced from high temperature processes in and near the vent and low temperature processes during transport downwind.