Geophysical Research Abstracts
Vol. 19, EGU2017-7134, 2017
EGU General Assembly 2017

VolcLab: A balloon-borne instrument package to measure ash, gas, electrical, and turbulence properties of volcanic plumes

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Release of volcanic ash into the atmosphere poses a significant hazard to air traffic. Exposure to appreciable concentrations ($\geq$4 mg m-3) of ash can result in engine shutdown, air data system loss, and airframe damage, with sustained lower concentrations potentially causing other long-term detrimental effects [1]. Disruption to flights also has a societal impact. For example, the closure of European airspace following the 2010 eruption of Eyjafjallajökull resulted in global airline industry losses of order £100 million daily and disruption to 10 million passengers. Accurate and effective measurement of the mass of ash in a volcanic plume along with in situ characterisation of other plume properties such as charge, turbulence, and SO_2 concentration can be used in combination with plume dispersion modelling, remote sensing, and more sophisticated flight ban thresholds to mitigate the impact of future events.

VolcLab is a disposable instrument package that may be attached to a standard commercial radiosonde, for rapid emergency deployment on a weather balloon platform. The payload includes a newly developed gravimetric sensor using the oscillating microbalance principle to measure mass directly without assumptions about particles' optical properties. The package also includes an SO_2 gas detector, an optical sensor to detect ash and cloud backscatter from an LED source [2], a charge sensor to characterise electrical properties of the plume [3], and an accelerometer to measure in-plume turbulence [4]. VolcLab uses the established PANDORA interface [5], to provide data exchange and power from the radiosonde. In addition to the VolcLab measurements, the radiosonde provides standard meteorological data of temperature, pressure, and relative humidity, and GPS location.

There are several benefits of using this instrument suite in this design and of using this method of deployment. Firstly, this is an all-in-one device requiring minimal expertise on the part of the end user; it is essentially plug-and-play with commercial radiosondes enabling seamless integration with standard technology. It is cheap and disposable, having been designed with software at the heart of device operation, which controls basic electronic components. The single package allows several plume properties to be measured and transmitted simultaneously in real time. These systems can be deployed rapidly as part of a wider network of launches allowing spatially referenced datasets to be integrated with remotely sensed data. These measurements provide in situ plume characteristics for airspace risk management planning as well as providing valuable scientific information on plume dynamics.

References

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