Geophysical Research Abstracts
Vol. 19, EGU2017-8295, 2017
EGU General Assembly 2017

Volcanic plumes fast detection: a methodological proposal for an integrated approach

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The behaviour of erupting volcanoes ranges from the quiet, steady effusion of lava to highly explosive eruptions. Therefore volcanic eruptions may present a direct threat to the safety of aircraft in flight and major operational difficulties at aerodromes and in airspaces located downwind the resulting volcanic ash cloud, in particular when eruptions are of high intensity and/or prolonged. Since volcanic ash clouds and gases are not displayed on either airborne or ATC radar and are extremely difficult to identify at night, pilots must rely on reports from air traffic controllers and from other pilots to determine the location of an ash cloud or gases. As a result, there is a clear need to develop extra tools enabling the timely on-board sensing of volcanic plumes for the sake of safety purposes.

Large scale eruptions may eject many cubic kilometres of glass particles and pulverized rock (volcanic ash) as well as corrosive/hazardous gases high into the atmosphere, potentially over a wide area for timescales ranging from hours to weeks or even months. Volcanic ash consists mostly of sharp-edged, hard glass particles and pulverized rock. It is very abrasive and, being largely composed of siliceous materials, has a melting temperature below the operating temperature of modern turbine engines at cruise thrust. A volcanic plume in fact contains a complex mixture of water vapour, sulphur dioxide (producing sulphuric acid as a result of gas-to particle conversions reaction catalysed by iron in cloud droplets), chlorine and other halogens, and trace elements which are highly reactive and may interact with the mineral particles to produce corrosive effects hazardous to both airframes and human health.

Remotely piloted aircraft system (RPAS) or Unmanned aerial vehicles (UAV) are slowly becoming efficient platforms - with dedicated miniaturized sensors that can be used in scientific/commercial remote sensing applications – and are of fundamental support to the planning, running and control of the territory in which public safety is or may be at risk, and with reference to all those subjects that require a continuous cyclical process of observation, evaluation and interpretation.

At the same time, a better knowledge of the chemical properties of volcanic emissions is a must for the future expansion foreseen in the next coming years in air transportation, for the health hazards that a volcanic ash cloud poses around the world and for a better understanding of the reduction already observed in GPS/GNSS satellite signals anytime a volcanic cloud covers the sky (thus obscuring the signal used by the navigation systems of modern aircraft), with associated safety risks.

In this paper we propose a multitasking experimental approach based on the integrated use of remote sensing, aerosol sampling and chemical speciation together with the use of drones/tethered balloons equipped with aerosol sensors aimed at providing all the information which have been collected partially so far. The study will also collect information about the 3D distribution of all the aerosol properties described before with the aim of determining and helping the vertical resolution of data from remote sensing.