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Developing an aviation warning system for Icelandic Volcanic Eruptions

The problem

Volcanic eruptions, such as that experienced in April 2010, when Iceland's Eyjafjallajökull volcano erupted, can lead to large-scale airspace restrictions across Europe, resulting in significant financial loss across the airline industry and the global economy. Aircraft are at risk if they fly through volcanic ash both from abrasion of the aircraft surfaces, but also from potentially catastrophic engine failure[1]. The cost to the UK airline industry as a result of the 2010 Eyjafjallajökull volcano has been estimated at £375m[2]. The global economy lost an estimated £1.3-2.2bn during the airspace shutdown. Therefore, forecasting and monitoring of volcanic ash clouds is paramount both for increasing human safety and for reducing the negative impacts on the global economy.

The science

Subsequent to the Eyjafjallajökull eruption, there have been important developments in increasing the resilience of UK airspace to future volcanic eruptions, including specific surface-based and aircraft-based capabilities. Three of these developments are presented here. Firstly, the Civil Aviation Authority (CAA) has funded the development, maintenance and operation of the Met Office Civil Contingency Aircraft (MOCCA[3]). Instrumentation on MOCCA makes in-situ and remotely sensed volcanic ash measurements, enabling detailed monitoring of ash plumes, and validation of numerical models of the dispersion of volcanic ash to aid in determining the influence of volcanic ash on certain flight paths. Secondly, the Department for Transport (DfT) commissioned the Met Office to establish a series of 10 monitoring sites using lidar and sun-photometers. Surface based lidars emit pulsed laser light vertically upwards into the atmosphere where they are scattered by volcanic ash particles back to the surface, and detected by a lidar receiver on the ground. Sun-photometers measure the reduction of direct sunlight at the surface caused by volcanic ash and other atmospheric aerosols. Combining both sensors together enables accurate assessment of the concentration of atmospheric volcanic ash above the sensors and its distribution for the wide geographical footprint of the ten sites across the UK. The system will provide both direct information on volcanic ash distributions and essential independent validation data for volcanic ash forecasts from future eruptions. Thirdly, the "Zeus" electrostatic sensor tested on the FAAM aircraft[4] during the Eyjafjallajökull eruption has been developed. Zeus measures the build-up of electrostatic charge which is transferred from particles in the atmosphere to the surface of an aircraft, particularly on non-conductive aircraft windows, and can act as an indicator of volcanic ash concentration[5,6,7].

Image 1: Eruption of Eyjafjallajökull. Ash is clearly visible. (Source: Journal of Geophysical Research Special Issue

The application to policy and practice

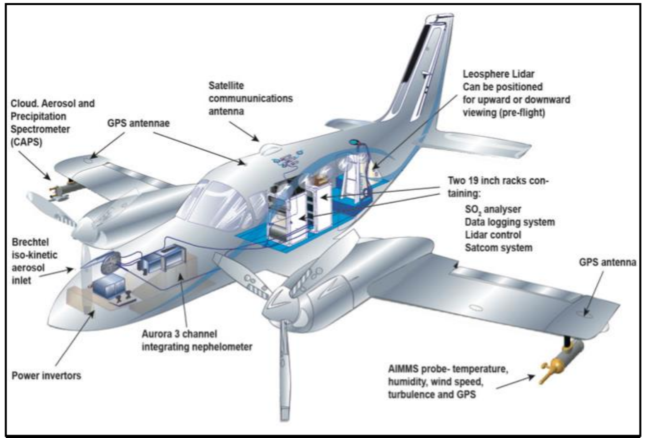

Image 2: Schematic of the MOCCA aircraft (Source: Met Office)

In conjunction with the Met Office and the National Centre for Atmospheric Science (NCAS), the Zeus sensor is in the process of being tested on commercial aircraft including twin-propeller aircraft flying on UK national routes and also on a large Boeing 747 aircraft flying on international routes. These test flights have enabled characterisation of the Zeus performance on airframes used by the UK, European and national civil aviation fleets. The invention is protected by several national, European and international patent applications. Several airlines and aircraft manufacturers are interested in installing the Zeus technology to increase their operational resilience to future volcanic eruptions. The MOCCA is on 24-7 operational standby should a volcanic eruption threaten UK airspace, and has successfully been deployed to detect emissions (mainly of sulphur dioxide and resulting sulphuric acid particles) from the 2014 eruption of Bardabunga. The lidar and sun-photometer network is in the process of being rolled out across the UK, and initial tests have shown the methodology is effective at detecting the presence of airborne atmospheric particles. Results from these three systems will allow the CAA and DfT to monitor and assess future volcanic eruptions and increase the UKs resilience to volcanic ash.

Did it/will it make a difference?

The forecast products produced by the Volcanic Ash Advisory Centre will inform the CAA of the geographical distribution and extent of volcanic ash. This technology will provide data that can test the accuracy of these forecasting products. This will aid CAA and aviation industry in decision making during future eruptions, helping to keep air-space closures to a minimum. This will lead to financial benefits both directly for the airline industry and indirectly for companies globally which are unable to manage their activities during long periods of airspace disruption. Given that the average return period for Icelandic volcanic eruptions is around once every five years, we will not have long to wait before the systems described above are called on to demonstrate increased resilience to Icelandic volcanic eruptions.

References

1. Guffanti, M., et al. (2010), Encounters of aircraft with volcanic ash clouds; A compilation of known incidents, 1953–2009, Data Ser. 545, U.S. Geol. Surv., Reston, Va. (Available at http://pubs.usgs.gov/ds/545.).
2.http://www.visitbritain.org/Images/Volcano%20Economic%20Impact%20Study%20-%20Oxford%20Economics_tcm29-15226.pdf
3. http://www.metoffice.gov.uk/publicsector/emergencies/civil_contingency_aircraft, accessed 18th December 2014
4. www.faam.ac.uk, accessed 18th December 2014
5. Turnbull, K., et al. (2012), A case study of observations of volcanic ash from the Eyjafjallajökull eruption. Part 1: in situ airborne observations, *J Geophys. Res*., Vol. 117, D00U12,doi:10.1029/2011JD016688.
6. Johnson, B et al. (2012), In situ observations of volcanic ash clouds from the FAAM aircraft during the eruption of Eyjafjallajökull in 2010*,* J. Geophys. Res.*,* 117*, D00U24, doi:*10.1029/2011JD016760*.*
7. Marenco, F., et al. (2011), Airborne lidar observations of the 2010 Eyjafjallajökull volcanic ash plume, *J. Geophys. Res.*, 116, D00U05, doi:10.1029/2011JD016396.

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