Scientists 'read' the ash from the Icelandic volcano two years after its eruption

May 11 2012

In May 2010, the ash cloud from the Icelandic volcano Eyjafjallajökull reached the Iberian Peninsula and brought airports to a halt all over Europe. At the time, scientists followed its paths using satellites, laser detectors, sun photometers and other instruments. Two years later they have now presented the results and models that will help to prevent the consequences of such natural phenomena.

The eruption of the Eyjafjallajökull in the south of Iceland began on the 20 March, 2010. On the 14 April it began to emit a cloud of ash that moved towards Northern and Central Europe, resulting in the closure of airspace. Hundreds of planes and millions of passengers were grounded.

After a period of calm, volcanic activity intensified once again on the 3 May. This time the winds transported the aerosols (a mixture of particles and gas) towards Spain and Portugal where some airports had to close between the 6 and 12 May. This was also a busy time for scientists who took advantage of the situation to monitor the phenomenon. Their work has now been published in the *Atmospheric Environment* journal.

"The huge economic impact of this event shows the need to describe with precision how a volcanic plume spreads through the atmosphere. It also highlighted the importance of characterising in detail its particles composition and establishing its concentration limits to ensure safe air navigation," explains Arantxa Revuelta, researcher at the Spanish Research Centre for Energy, Environment and Technology (CIEMAT).

The team identified the volcanic ash cloud as it passed over Madrid thanks to LIDAR (Light Detection and Ranging), the most effective system for assessing aerosol concentration at a height. The CIEMAT station is one of 27 belonging to the European network EARLINET (European Aerosol Research Lidar Network) that use this instrument. Its members have also published a publicly accessible article on the matter in the *Atmospheric Chemistry and Physics* journal.

Using LIDAR technology, scientists direct a laser beam towards the sky, like a saber in Star Wars. The signal reflected back from particles provides information on their physical and chemical properties. A maximum aerosol value of 77 micrograms/m3 was estimated, which as a concentration is below the risk value established for air navigation (2 miligrams/m^3).

Furthermore, the levels of particles rich in sulphates shot up even though they were fine particles (with a minimum diameter of 1 micra). This meant that they were much smaller than those particles over 20 micra found in countries in Central Europe.

These thicker particles are generally considered to be 'ash' and can really damage aircraft motors. The fine matter, like that detected over the Iberian Peninsula, is similar to that commonly found in urban and industrial areas. It is subject to study more for its damaging health effects rather than its impact on air navigation.

NASA's network of sun photometers

It is important to track the evolution of all the particles in order to provide information to managers responsible for this kind of crisis. Working in this field were members of NASA's AERONET (AErosol RObotic NETwork) network, which is made up by the different tracking stations in Spain and Portugal (integrated into RIMA) equipped with automatic sun photometers. These instruments focus towards the sun and collect data each hour on the aerosol optical thickness and their distribution by size in the atmospheric column.

The combined use of sun photometers and LIDAR technology boosts data collection. For example, the station in Granada and Évora revealed that the volcanic ash cloud circulated between 3 km and 6 km above the ground.

"Instruments like LIDAR are more powerful on an analytical level but their spatial and weather coverage is low. This means that sun photometers come in very useful in identifying volcanic aerosols when no other measures are available," outlines the researcher Carlos Toledano from the University of Valladolid and member of the AERONET-RIMA network.

From their stations it was confirmed that "there is great variation between the size and characteristics of the volcanic aerosol particles over successive periods." This was also verified by members of another European Network, EMEP (European Monitoring and Evaluation Program), which traces atmospheric pollution and is managed in Spain by the National Meteorological Agency. This group confirmed an increase in aerosols and their sulphate concentrations over the Iberian Peninsula and recorded the presence of sulphur dioxide from the Icelandic volcano.

Models and Predictions

The large part of observations of Eyjafjallajökull's eruption, which were taken from aeroplanes, satellites or from earth, helped scientists validate their prediction and particle dispersion models.

"During the management of the crisis it became evident that there are still no precise models that provide real time data for delimiting an affected airspace, for example," admits Toledano. Nevertheless, his team put the FLEXPART model to test using empirical data. From the Norwegian Institute for Air Research (NILU), it managed to calculate the arrival of volcanic ash in certain situations.

The powerful equipment available at the Barcelona Supercomputing Center (BSC-CNS) was used on this occasion to validate a model which had been developed at the centre: the Fall3d. As one of the authors Arnau Folch states, "the model can be applied to the dispersion of any type of particle. But, in practice, it has been especially designed for particles of volcanic origin, like ash."

Volcanologists and metereologists use this model to re-enact past events and, above all, to make predictions. More specifically it predicts the amount of aerosols in the ground and their concentration in the air. It is therefore of "special interest" to civil aviation. The final objective is to make this type of prediction so as to be prepared during the next volcanic eruption.

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Provided by Spanish Foundation for Science and Technology (FECYT)