German Aerospace Center

Ten megatons of ash and three megatons of sulphur dioxide – DLR publishes the results of its volcanic ash measurement flights

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One year ago, on 14 April 2010, the Icelandic volcano of Eyjafjallajökull erupted and effectively grounded large parts of the air transport sector across Europe. At this time, there was no defined limit for airborne concentrations of ash. Instead, there was just an international guideline stating that flying in regions with increased concentrations of airborne ash should be avoided since the risk of aircraft engines getting damaged by ash particles appeared to be far too great.

On 20 April 2010, barely one week after the eruption, the permitted limit was defined as two milligrams of ash per cubic metre, with substantiating documentation to back this up. The measurement flights flown by the Falcon 20E research aircraft operated by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) contributed greatly towards this outcome. The data collected has now been evaluated; the newly defined limit was never exceeded in the skies above Germany. Thanks to this new limit value and improved model-based forecasts, it will be possible to restrict or even completely avoid the need to impose airspace closures in the wake of any future volcanic eruption

An international team of researchers led by DLR performed the evaluation of the enormous dataset. The researchers also compared the data with other measurements and mathematical models. "We were able to correct the initial estimates of ash concentrations made on 19 April last year: on this date, ash concentrations in the skies above Germany and Holland were below 0.2 milligrams per cubic metre –well below the recently defined limit," explained Ulrich Schumann, Director of the DLR Institute of Atmospheric Physics. "If airspace closures are to be restricted or prevented in future, the ash cloud in the vicinity of the source volcano needs to be analysed quickly, and predictions need to be checked against comprehensive measurements. A combination of aircraft conducting measurement flights, satellites and ground-based remote measuring systems is needed to accomplish this. It is also important for the various measurements, models and flight planning systems to be interconnected in a European information system in the future, and for this to be made available online to the aviation sector."

Ash layers at altitudes of up to seven kilometres

On the flights conducted by the DLR research aircraft, scientists were able to gather samples of particulates and obtain various measurements, which they could then analyse back at the laboratory. This data was crucial for the evaluation of the measurements. The researchers were able to detect particles with sizes ranging from four nanometres to 800 micrometres in diameter. The bulk of the ash took the form of particulates measuring between 3 and 15 micrometres in diameter. "Overall, the volcano is estimated to have ejected close to ten megatons of ash and three megatons of sulphur dioxide," stated Schumann. "We were able to find ash layers at altitudes of up to seven kilometres. They ranged from a few hundred metres to three kilometres in thickness, and were between 100 and 300 kilometres wide." In many respects, the ash cloud closely resembled the dust clouds that form during Sahara sandstorms, which DLR has analysed several times in the past.

The Falcon completed a total of eight measurement flights. During its flights over Iceland on 1 and 2 May 2010, the ash concentrations in the centre of the cloud were roughly one milligram per cubic metre. On 19, 20 and 22 April and on 9 May, ash clouds above Germany and over the North Sea and the Baltic Sea exhibited concentrations of less than 0.2 milligrams per cubic

metre. On 17 and 18 May, clouds of ash across Holland and Germany had concentrations that may occasionally have exceeded 0.2 milligrams per cubic metre, but certainly never rose to as much as two milligrams per cubic metre.

Implications for air transport

A volcano erupts in Iceland roughly every five years. In the past, the eruptions of Eyjafjallajökull have frequently been followed, within a year, by the eruption of a much more dangerous volcano, Katla. There are also active volcanoes in southern Europe and on the Canary Islands. Other disasters such as forest fires or nuclear accidents could present similar threats to volcanic eruptions.

The results of the 'ash flights' will now be used internationally to test and improve forecasting models. In the light of these events, the exchange of information between all parties involved must improve substantially. The aviation industry is pressing for the right to take its own operational decisions about flights in the wake of future volcanic eruptions. To make this possible, the necessary risk analysis procedures and relevant information must be available. DLR can certainly make a contribution towards this process with its expert knowledge of the atmosphere and aviation, using its research aircraft, measuring instruments, satellite data and simulation tools. The results now being published by DLR researchers in the scientific journal 'Atmospheric Chemistry and Physics' constitute an important step towards this goal.

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Measurement flight of the Falcon over the Eyjafjallajökull volcano on 1 May 2010

On 1 May 2010, the Falcon took off at 13:00 CEST for another measurement flight over Iceland and its plume of volcanic ash. Despite light cloud cover, measurement conditions were almost perfect. The flight took the Falcon directly over the Eyjafjallajökull volcano. At a distance of approximately 200 kilometres from the volcano, the Falcon flew several times over the volcanic ash cloud at an altitude of six kilometres.

Credit: DLR (CC-BY 3.0).

Eyjafjallajökull volcanic ash cloud over Iceland on 1 May 2010

Although it is clearly weaker than it was shortly after start of the eruption, the volcano is still active and the volcanic ash is reaching altitudes of 5000 metres.

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