Flying despite volcanic ash – DLR develops satellite-supported prediction process

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To support the safety of air transport and improve the air traffic system's response times in the critical event of a volcanic eruption, the identification of ash-free airspace is essential. At the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), a satellite-supported procedure has been developed that rapidly determines the distribution of ash in the air and generates detailed images of areas with both heavy and light ash loads.

"The eruption of the Icelandic volcanoes Eyjafjallajökull in 2010 and Grimsvötn in 2011 demonstrated the vulnerability of the air traffic system in the event of volcanic eruptions and exposed gaps in the observation systems for volcanic ash," says Markus Rapp, director of the DLR Institute of Atmospheric Physics. "Because of this, we decided to develop a process to precisely track ash clouds using satellites that are already in space." In April 2010, large areas of the airspace over Europe had to be shut down as there were no threshold values available for tolerable concentrations of ash at the beginning of the crisis, and the actual concentration of ash in the air was not fully understood. At the time, approximately 100,000 flights were cancelled.

Observing the ash with Meteosat

When Eyjafjallajökull erupted, a threshold value of two to four milligrams of ash per cubic metre was determined during the course of the crisis as the maximum volcanic ash concentration permitted for aircraft to fly through the airspace above central Europe and Great Britain. But how can airspace with an ash mass concentration below these threshold values be identified? This is the question that DLR researchers are addressing. By 2015, they want to be capable of using satellites already in space to measure the ash cloud from a volcanic eruption in a timely and precise manner, and predict its movement during the following hours. "Satellite data is the most important source of information for making large-scale assessments of how an ash cloud is spreading," explains Rapp. Scientists at the DLR Institute of Atmospheric Physics have been working on the evaluation of Meteosat data for detecting volcanic ash since 2012, under Project VOLCATS (VOLCanic Ash impact on the air Transport System). "In doing so, we have detected important infrared signatures for volcanic ash in the airspace and integrated these into the data evaluation," continues Rapp. To achieve this, repeated comparison measurements were carried out by the DLR Falcon research aircraft in the vicinity of volcanoes and in mineral dust clouds, which the researchers used as test scenarios..

Ready for first deployment

A prototype of the new procedure for satellite-based volcanic ash detection (VADUGS - Volcanic Ash Detection Utilizing Geostationary Satellites) is ready for its first deployment in the event of an ash cloud resulting from the Bardarbunga volcano eruption. Not only will it provide significantly more accurate information about where the ash cloud is spreading to and in what concentration, but this information will also be kept fully updated. Every 15 minutes, the second generation Meteosat satellites operated by EUMETSAT will be providing data for an updated view of the situation.

Under the TeFiS project (Technology for Flight Management in Large Structures), which is sponsored by the the German Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie; BMWi), the DLR scientists are continuing to develop VADUGS in close cooperation with the German Weather Service (Deutscher Wetterdienst; DWD), Lufthansa and the German Air Traffic Control service (Deutsche Flugsicherung; DFS). The process is now being adapted to the specific requirements of routine operation by the German Weather Service. The involvement of German airline Lufthansa ensures that the requirements of the air travel industry will be taken into consideration in future developments and that the results will be supplied ready to use for pilots and flight planners.

Next goal – short-term predictions

In parallel with this, DLR atmospheric researchers are working on accurately predicting how the volcanic ash clouds that have been detected will spread within the next hour. "To do this, we are using an algorithm that is already being used successfully for short-term weather predictions," explains Rapp. "This involves looking at current wind patterns in detail and using them to make a significantly more precise prediction than is possible with conventional numerical weather forecasts."

Despite all the progress achieved with the evaluation of satellite data, the ability to measure volcanic ash from space has its limitations. For example, a thick cloud deck above the layer of volcanic ash prevents a clear pattern of the volcanic ash from appearing in the data. And to detect the altitude distribution of a volcanic ash cloud, the scientists also need measurement data from research aircraft, such as the DLR Falcon, and ground stations maintained by the German Weather Service.

DLR is combining its research work on the effects of volcanic ash on air traffic in the VOLCanic Ash impact on the air Transport System VolcATS project. This project includes a satellite-supported process that quickly determines and predicts the distribution of ash in the air and contributes to flexible air traffic management so that ash-free and hence safe regions for commercial aviation can be approved. In addition, the still inadequately understood effects of volcanic ash on aircraft engines are being investigated, and an ash warning system for commercial airliners is being designed. Participants include the DLR Institutes of Atmospheric Physics, Flight Guidance, Materials Research, Propulsion Technology, Flight Systems and Air Transportation Systems, together with DLR Flight Experiments.

During the Eyjafjallajökull eruption in 2010 the airspace over Germany was able to be re-opened on the basis of measurement flights performed by the DLR Falcon. The Falcon is the only research aircraft in Europe that is legally able to fly at high altitudes and over long distances in volcanic ash clouds.

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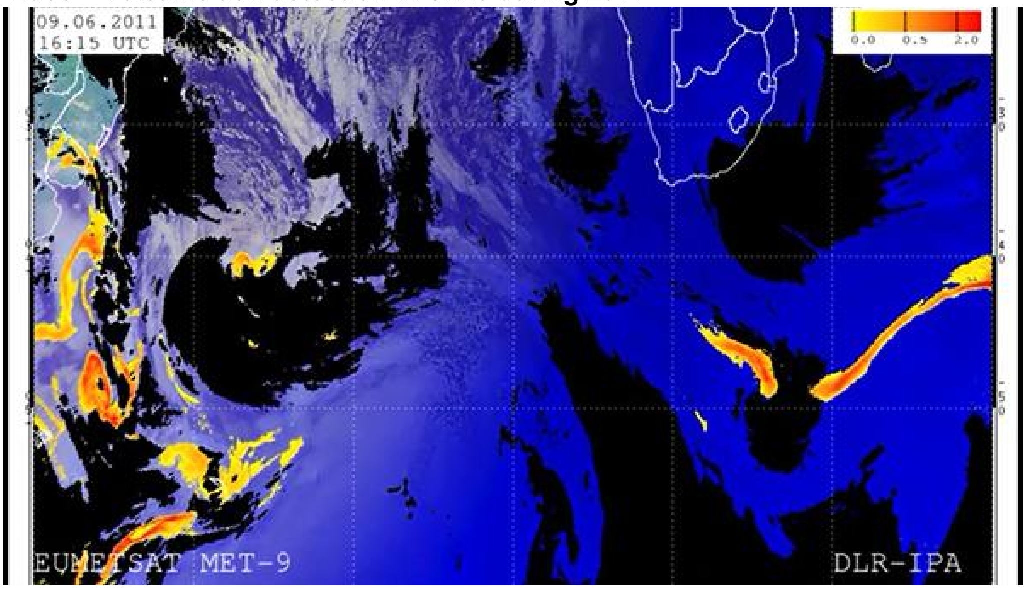
Recent image of of the Bardarbunga volcano on Iceland

The picture was acquired on 16 September 2014.

Credit: Icelandic Meteorological Office (IMO)/Freysteinn Sigmundsson.

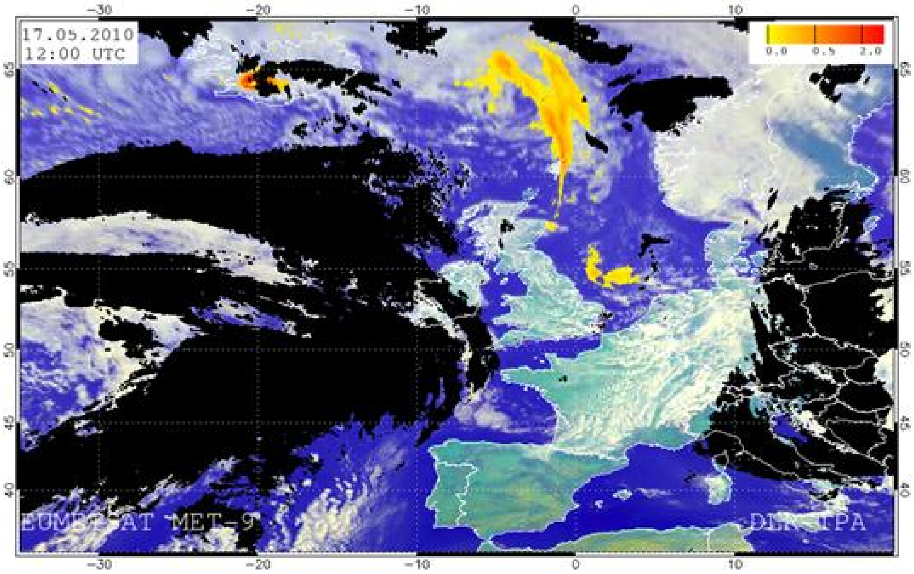
Video – Volcanic ash detection in Chile during 2011



Column concentration of volcanic ash in grams per square metre, derived using VADUGS, applied to the eruption of the volcano Puyehue in Chile in June 2011. The scene illustrates both the temporal masking of volcanic ash by high-lying cloud (colored black), but also the potential for using the high temporal resolution of MSG-SEVIRI for nowcasting.

Credit: DLR (CC-BY 3.0).

VADUGS-derived column concentration of volcanic ash from the Eyjafjallajökull volcano in 2010



VADUGS-derived column concentration of volcanic ash in grams per square metre for a situation during the eruption of the Icelandic volcano Eyjafjallajökull on 17 May 2010 at 12:00 UTC. The processing is based on MSG-SEVIRI data.

Credit: EUMETSAT.

Ash cloud from the Eyjafjallajökull volcano in 2010

The Eyjafjallajökull volcano in Iceland emitted large quantities of ash and sulphur dioxide into the atmosphere during its eruptions in March and April 2010. This photograph was acquired on 1 May 2010 during a measurement flight by the DLR Falcon research aircraft.

Credit: DLR (CC-BY 3.0).

DLR research aircraft Falcon

The Falcon is the only research aircraft in Europe that is legally able to fly at high altitudes and over long distances in volcanic ash clouds.

Credit: DLR (CC-BY 3.0).

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