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On the visibility of airborne volcanic ash and other aerosols from the pilot's perspective in flight

B. Weinzierl (1), D. Sauer (2), A. Minikin (1), O. Reitebuch (1), F. Dahlkötter (1), B. Mayer (2), C. Emde (2), I. Tegen (3), J. Gasteiger (2), A. Petzold (1), A. Veira (1), U. Kueppers (4), and U. Schumann ()

(1) DLR, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, 82234 Oberpfaffenhofen, Germany (bernadett.weinzierl@dlr.de), (2) Ludwig-Maximilians-Universität München, Meteorologisches Institut, Theresienstraße 37, 80333 München, Germany, (3) Leibniz Institute for Tropospheric Research (IfT), Physics Department, Permoserstraße 15, 04318 Leipzig, Germany, (4) Ludwig-Maximilians-Universität München, Geo- und Umweltwissenschaften, Theresienstr. 41, 80333 München, Germany

In April 2010, the volcanic ash cloud from the Eyjafjalla volcano in Iceland strongly impacted aviation in Europe: more than 100 000 flights were cancelled affecting more than 10 million passengers. Several incidents in the past have shown that volcanic ash may have severe consequences on aviation. Therefore, one operational problem is whether a pilot has the means to avoid flying through potentially dangerous volcanic ash just by visual observation of the sky out of the cockpit of an aircraft.

The goal of our study is to assess whether it is possible from the pilot's perspective in flight to detect the presence of volcanic ash and to distinguish between volcanic ash and other aerosols just by sight. In our presentation, we focus the comparison with other aerosols on aerosol types impacting aviation. Besides volcanic ash, dust storms are known to be avoided by aircraft.

We approach the question on the visibility of volcanic ash and other aerosol layers in flight starting from the inspection of photographs taken during the Eyjafjalla volcanic ash research flights with the DLR Falcon in April/May 2010 and mass concentrations measured during those flights. Furthermore we use airborne data from the Saharan Mineral Dust Experiments (SAMUM) in 2006 and 2008. We complement this analysis with idealized radiative transfer simulations with libRadtran for a variety of selected viewing geometries.

Both aerosol types, Saharan mineral dust and volcanic ash, show an enhanced coarse mode (> 1 μm) aerosol concentration, but volcanic ash aerosol additionally contains a significant number of Aitken mode particles (< 150 nm), which are not present in mineral dust. Volcanic ash is slightly more absorbing than mineral dust, and the spectral behaviour of the refractive index is slightly different. According to our simulations, these differences are not detectable just by human eye.

The consequences of our study for aircraft operation are the following: under clear sky conditions volcanic ash is visible already at concentrations far below what is currently considered as dangerous for an aircraft engine (2 mg m-3). However, the presence of a grayish-brown layer in the atmosphere does not unambiguously indicate the presence of volcanic ash. An uninformed observer is unlikely to recognize an aged volcanic ash layer in his field of view without further information. The presence of clouds would make it even more complicated to visually detect volcanic ash. Clouds can either directly block the direct sight to the ash layer or reduce the contrast if present in the background.