Volcanic Ash Cloud Observations with the DLR-Falcon over Europe during Air Space Closure

Ulrich Schummann, Bernadett Weinzierl, Oliver Reitebuch, Andreas Minikin, Hans Schlager, Stephan Rahm, Monika Scheibe, Michael Lichtenstern, Caroline Forster, DLR, IPA

+ many partners (IPA, FB, LaMP, TU Darmstadt, IfT Leipzig, LMU München, NILU, Uni. Iceland, DWD, VAAC, DFS, LBA, etc.)
19 April, 13:00 UTC - Mid-European airspace closed

DLR-Falcon started at 14:11 UTC

http://www.radarvirtuel.com/

taken from BBC: Iceland volcano in maps
Objectives: Operational & scientific

- Closure of airspace justified or exaggerated?
- Quality of forecasts?
- Comparable to Saharan dust?
- What do the lidar instruments see?
- How to convert particle number concentrations to mass concentration?

- Aviation conditions near Iceland
- Volcanic source (mass, particle sizes, chemistry)
- Chemical composition
- Volcanic dynamics
Falcon 20E D-CMET, DLR Oberpfaffenhofen, since 1976

**Aerosol & Trace Gas Inlet**
- Total & non-vol. aerosol, 3-λ Bap, particle comp. & shape (4 nm - 2.5 µm)
- CO (UV fluorescent.), O₃ (UV photom.), SO₂ (fluorescent.), H₂O (τ-point, Ly-α)

**Meteorological Measurements**

**DLR Falcon 20-E5**
- Max. altitude: 42.000 ft
- Max. endurance: 4 h

**FSSP-300 & 2-DC**
- (0.3 -800 µm)

**2-μm-Wind-lidar**
- (heterodyne)

**GPC (particle collector)**
- TU Darmstadt

**PCASP-100X**
- (dry accumulation mode concentration)

**Institut für Physik der Atmosphäre**

**Deutsches Zentrum für Luft- und Raumfahrt e.V.**

in der Helmholtz-Gemeinschaft
Nine DLR Falcon flights, April 19 - May 2: OP - Iceland

range-corrected backscatter signal @ 2 µm

OP – Keflavik: 2700 km

(perspective plots generated by Martin Wirth, DLR, IPA)
Vulcanic ash layer over Leipzig, April 19, 2010, 15:00 UTC
Lagrangian: Iceland - North Atlantic - Ireland - Scotland

(29/04/2010: 50 km distance, arriving in Iceland)
01/05/2010: (8-)200 km distance, 62.5 N, 16.5 W, 11:44 UTC, 1-5 km altitude
   (age < 3.7 h)
02/05/2010: 450 km distance, 15 W, 60 N, 15:00 UTC, May 2, 2010, age 7 h
04/05/2010: Mace Head, W, N, ? UTC, May 4, 2010, age about 60 h
05/05/2010: ARSF and FAAM (U Manchester), Scotland airborne, age about 80 h
Eyjafjallajökull volcano plume, 29 April, late afternoon time
Eyjafjallajökull volcano plume, May 1, noon time
Eyjafjallajökull volcano plume, May 1, noon time
Reykjavik/Keflavik: No plume traces, May 1, noon time
Institut für Physik der Atmosphäre

range-corrected backscatter signal @ 2 µm

plume sounded 1st time

Volcanic ash plume

Ci clouds

St Cu clouds

Eyjafjallajökull

7.4 km

60 km

Plume and Keflavik (Iceland) soundings, May 1
From Keflavik to Stornoway, May 2

Plume sounded and sampled, 2nd time

range-corrected backscatter signal @ 2 µm
North Atlantic (60° N): 15 minutes before flying into the plume
Comparison with Saharan dust (SAMUM-1, 2006, 17 flights)

Aerosol-optical depth (AOD, @532)

Munich
17.04. (plume age: 3 days): 0.8
19.04. (plume age: 5 days): 0.4

Leipzig
17.04. (plume age: 3 days): 1.0
19.04. (plume age: 5 days): 0.5

For comparison:
Sahara, SAMUM-1: 0.4 - 0.6
Conclusions (science & operations)

- Falcon measurements between April 19 and May 3, 2010: 2-µm-Lidar, in-situ aerosols, CO, O₃, SO₂, H₂O
- Particles sizes 10 nm - 30 µm age dependent (mainly silicate, ammonia sulfate, more Na, K than in Saharan dust)
- Mass loading (60 µg/m³, Leipzig, 5 days) comparable to Saharan dust (< 0.2 mg/m³)
- 200 km distance, 3-4 h age: 40 km wide, 2 km thick, 15 m/s, sharply edged, strong wet convective turbulence, well mixed?
- 450 km distance (same plume), 7 h age: at upper plume edge: 400-3400 µg/m³, no 2-DC probe particles, mass flux > 3000 kg/s, strong chemistry
- Lidar signal and FSSP-300 signal strongly dependent on refractive index, ash density, particle size spectrum 1-50 µm

- Mid-European airspace closure justified until Sat. April 17; then ageing of ash load
- Keflavik/Iceland free of ash as predicted on April 19 - May 2
- Quality of forecasts reliable enough for aviation
- Future: Combination of models + lidar + satellite + in-situ
- Improved linking between operations and academia
- Continue operations of the DLR Falcon as Emergency Aircraft