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The volcanic ash plume near the Eyjafjallajökull in April/May 2010

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This paper describes the analysis of airborne measurements and model simulations of the volcanic ash plume close to Iceland's Eyjafjallajökull volcano in April/May 2010. In particular we quantify the plume properties for the period of 1 to 2 May, 2010, up to 450 km downstream the volcano. The measurements provide information on the plume width, upper height, mean depth, wind speed profile, attenuated Lidar backscatter profile, plume temperature, ash particle sizes, ash mass concentration, ash particle size distribution, humidity, O3, CO and SO2 mixing ratio, ash optical depth, volume flux, and mass flux. Here we report about analysis of the optical depth from the Lidar observations using the shadow method, and on comparisons of modeled and measured plume properties constraining the ash properties.

The measurements above and near the volcano, over Iceland and over the North Atlantic up to Scotland, have been performed with the research aircraft Falcon of the Deutsches Zentrum für Luft- und Raumfahrt (DLR). A total of 17 flights have been performed as described in Schumann et al. (2010; doi:10.5194/acpd-10-22131-2010). The Falcon instrumentation included a downward looking, scanning 2-μm-Wind-Lidar (aerosol backscattering and horizontal wind, 100 m vertical resolution), and several in-situ instruments. The particle instrumentation covered particle number and size from 5 nm to some tens of μm. Moreover, information on the particle sizes, composition, shape, refractive index and density properties are available from particles collected in situ with impactors and analyzed with scanning electron microscopy. The model simulations were performed with FLEXPART and HYSPLIT models.

At the volcano, the plume showed vigorous convection due to intermittent eruptions and buoyant convection. At a distance of about 10-20 km, the plume became less vigorous and the initially apparently well-mixed plume spread laterally because of directional wind shear and ambient stratification. With increasing distance from the volcano, the plume top altitude first ascended from 3.5-3.8 km (at the volcano location and up to 70 km downstream) to 5.1 km in about 200 km distance, and then varied between 4.5-4.9 km. Plume properties were measured by Lidar during flights above the plume perpendicular to the plume axis at several cross-sections. At about 200 km distance from the volcano, the plume was about 3-4 h old, 30-35 km wide, and reached up to 4.9 km altitude; it was 1.7 km deep on average, with mean wind speed of 14 m/s, and with plume top temperature of -20°C. The corresponding volume flux was 0.8+-0.4 km3/s. On 2 May, the plume was scanned from above by Lidar first at about 50 km and 160 km downwind the Volcano with plume top height of 3.9 km and. 4.2 km, and then again at about 450 km distance. At the latter stage, the plume was about 61 (56-65) km wide, 1.3-2 km deep, with plume top and bottom at 3.8 and 1.6 km altitude including two separated vertical structures The mean wind speed was about 11 m/s corresponding to a volume flux of 1 [U+F0B1] 0.5 km3/s. Based on the in-situ measurements in the top part of the plume and extrapolation over the plume cross-section with Lidar and model information, we estimate the ash mass flux. The particle sizes ranged up to about 50 μm and 30 μm at the two distances of 200 km resp. 450 km; the optical depth of the ash plume was below 1.5 and 1.2. The results allow constraining the mass concentration, and the mass flux in these plume cross-sections. From the ash/SO2 mass concentration ratio we also derive the SO2 mass flux strength in this plume.

The mass fluxes are smaller than what we expected from the initial quick look analysis. This has direct implications for the maximum concentration found downstream the volcano. The results are of interest for testing and calibration of ash dispersion models, and for estimates of the ash mass flux as a function of plume properties, e.g. for the purpose of volcanic ash advisories to aviation.