Mass spectrometric analysis of cloud droplet residuals in different orographic clouds

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We conducted in-situ mass spectrometric analysis of cloud droplet residuals from orographic clouds on several mountain research sites: On the central German mountain Schmücke (10°46'15"E, 50°39'19"N, 937 m a.s.l.) during the project HCCT, 2010, on the Puerto Rican mountain Pico del Este (65°45'33"W, 18°16'07"N, 1039 m a.s.l.) during the project PRADACS, 2011, and on the German alpine mountain Zugspitze (10°59'11" E, 47°25'16"N, 2650 m a.s.l.), during the project ACRIDICON-Zugspitze, 2012. Cloud droplets with diameters larger than 5 µm were sampled by a counterflow virtual impactor (CVI, Mertes et al., 2005) that evaporates the cloud water after sampling, and the submicrometer residual particles were analyzed by means of a compact time-of-flight aerosol mass spectrometer (C-ToF-AMS, Drewnick et al., 2005) that included also a light scattering module for single particle analysis. Additional measurements included size distribution and number concentration of the cloud droplets and the residual particles, cloud liquid water content (LWC), as well as interstitial and out-of-cloud aerosol particle composition, number and size.

The measurement sites represent different cloud regimes: Continental European orographic clouds (on a low mountain range during HCCT and on a high alpine mountain during ACRIDICON) and Caribbean trade wind orographic clouds (PRADACS). The different geographical locations are reflected in the composition of the background aerosol particles as well as in the composition of the cloud residuals: While the marine aerosol measured at Puerto Rico is dominated by sulfate (Fig. 1a), the continental aerosol at the Central German mountain Schmücke (Fig. 1b) is dominated by organics, as well as at the high mountain station at the Zugspitze (Fig. 1c), the latter being rather unexpected.

Interestingly, the cloud residual analysis show similar features in both cases: the fractions of nitrate and organics are enhanced in the cloud residuals compared to the out-of-cloud aerosol, and also a significant amount of chloride is detected in the cloud residuals, but not in the out-of-cloud aerosol.

The enhanced nitrate fraction is most likely due to uptake of gas-phase nitric acid by the cloud droplets. The enhanced chloride content can be explained by cloud processing of sea salt (NaCl) particles by reaction with H_2SO_4 and NH_3 to NH_4Cl which can be detected by the AMS. Interestingly this feature is not only observed in the marine aerosol at Puerto Rico but also at the high continental mountain site Zugspitze. At the lower continental site Schmücke the chloride and nitrate enhancements are much smaller.

This presentation will also discuss the single particle analysis that gives insight into the mixing state of the aerosol particles and cloud droplet residuals.

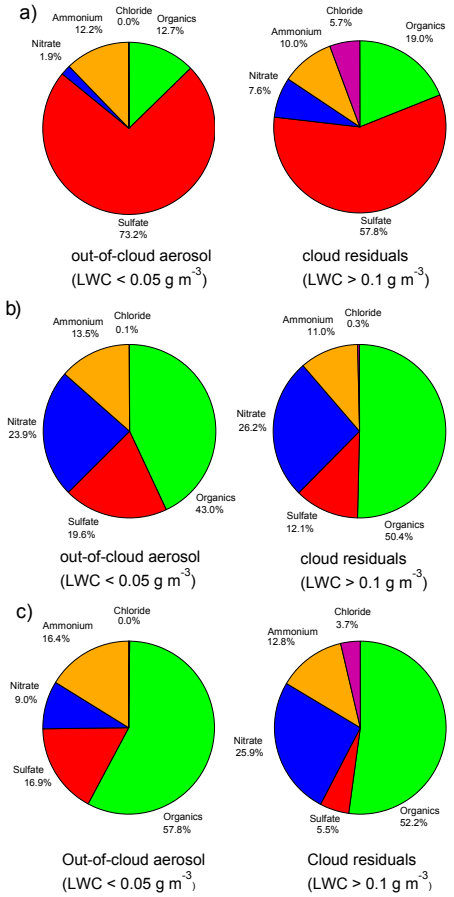

Figure 1. Average composition of aerosol particles measured out of clouds (left) and of cloud residuals (right) during: a) PRACDAS (Pico del Este, Puerto Rico); b) HCCT (Schmücke, Germany); c) ACRIDICON (Zugspitze, Germany).

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