

Inorganic cloud chemistry and its relation to the valley sites particle chemistry during HCCT

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GOALS AND METHODS

Introduction

Clouds are effective chemical reactors in the troposphere. Liquid phase processes in cloud droplets can be investigated in laboratory experiments but not all influences can be simulated.

During the six week campaign nine cloud events with a connected flow between the three sampling sites in the Thuringian Forest (Germany) have been selected for further investigations. The region is optimally suited for the investigation of the influences of a cloud passage on the tropospheric aerosol with the dominant wind direction Southwest and the height differences between the valley sites in Goldlauter (605m) and Gehlberg (732m) to the mountain site Schmücke (937m).

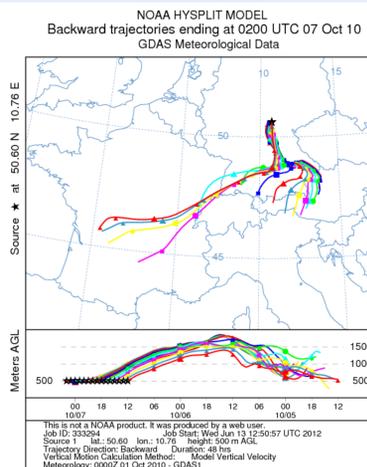
Experimental approach

At the valley sites PM₁₀ and PM₁ HV samplers (DHA-80, Digital) and a five-stage low pressure impactor (LP180/0.05, Hauke) were applied to collect PM for chemical analyses. At the mountain site a set of four bulk and two size-segregating cloud water collectors were operated on top of the tower (Fig. 1).

In this study the PM samples and cloud water samples were investigated for water soluble ions, H₂O₂, formaldehyde, OC and EC by ion chromatography (ICS3000, Dionex) and a thermographic method (Cmat5500, Ströhlein).



Fig. 1. Cloud water measurement tower during HCCT 2010 with collectors mounted at the sides to SW on top of the tower. Series of backward trajectories during full cloud event FCE 13.3.



RESULTS

- Aerosol concentration of all major compounds decreased from upwind to downwind site in different amounts during the cloud events (Fig. 2 and 6).
- Cloud water concentration of ammonium and nitrate was in several cloud events higher than the PM concentration at the upwind site in Goldlauter (Fig. 2).
- Very low concentrations of S(IV) were found in cloud water samples (20-70 ng/m³, Fig. 3).
- The pH of all samples was found between 3.3 and 5.6. (Fig. 4). Lowest values were observed in smallest droplets.
- In size fractionated droplets the equivalent air concentration of all ionic species decreased with increasing droplet diameter (Fig. 5), depending on cloud water loading.
- The variability of cloud water concentrations of major ions is given in Fig. 7.
- Nitrate is the most important ionic species during the whole campaign.

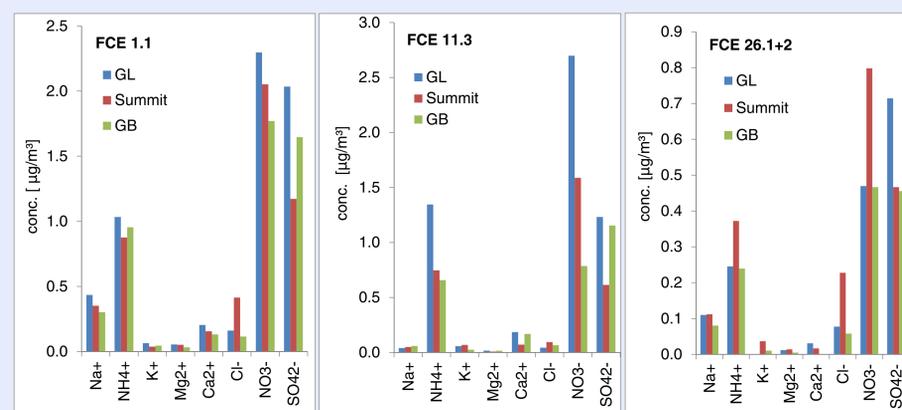


Fig. 2. Concentration of water soluble ions in PM₁₀ filter samples and bulk cloud water (examples from three major cloud events)

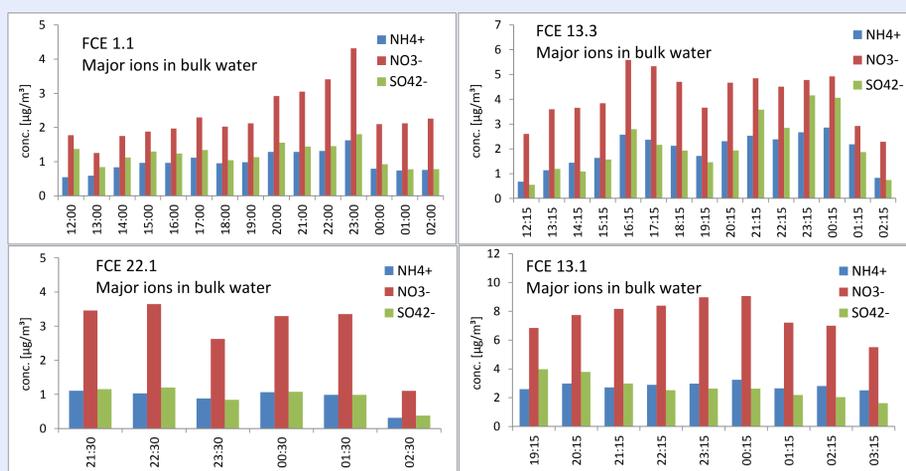


Fig. 7. Major ions in bulk cloud water samples – temporal variability during the longer cloud events

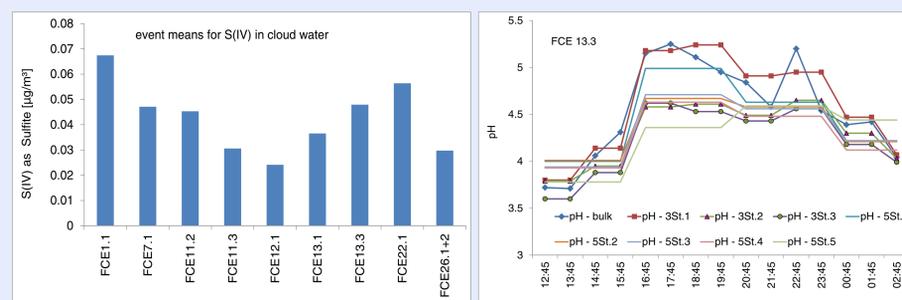


Fig. 3. Content of S(IV) in bulk cloud water samples

Fig. 4. pH in all cloud water samples of FCE 13.3

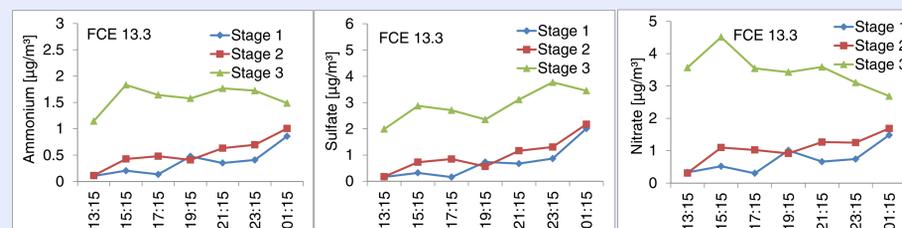


Fig. 5. Temporal variability of cloud water concentration of major ions in two-hour samples from the three-stage collector during FCE 13.3

SUMMARY

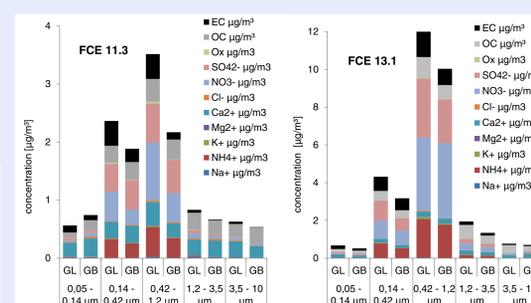
Particle and cloud water concentrations of inorganic species and OM were measured to identify sources and pathways. Between valley sites a decrease of concentrations was observed depending on dilution and deposition losses. Elevated cloud water concentration in comparison to valley PM concentrations of chloride, nitrate and sodium may be influenced by entrainment of sea salt particles. Nitrate concentrations are often highest in cloud water samples in comparison to particles collected at valley sites.

Cloud water constitution was variable within a single cloud event.

Long range transported constituents from the South during FCE 13.1 and FCE 13.3 delivered highest PM concentration during the campaign.

Other FCE were mainly influenced by marine air masses from the North Sea.

Fig. 6. Size-segregated particle constitution (ionic species, OC and EC) at the valley sites during FCE 11.3 and 13.1 – with the exception of smallest fraction in FCE 11.3 a decrease was observed for all components.



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