Water soluble ions in bulk cloud water and droplet size fractionated samples during HCCT 2010

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Introduction and Motivation

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. The experimental site Schmücke in Thuringia is a place where cloud experiments took place already a decade ago during FEBUKO (Atmospheric Environment, 39, Issues 23-24, 2005). 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).

Trace gases, radicals, particulate matter interact in orographic hill cap cloud. The physico-chemial processing of the aerosol can be investigated under connected flow conditions between the three experimental sites.

Different cloud water collector types have been applied to supply suitable amounts of cloud water in different droplet sizes for chemical analyses.

Water soluble ionic species were analysed in all samples for comparison with the aerosol collected at the valley sites.

Fig. 1: *UBA site Schmücke with a 20 m-tower for cloud water sampling and meteorological measurements (937m above sea level)*

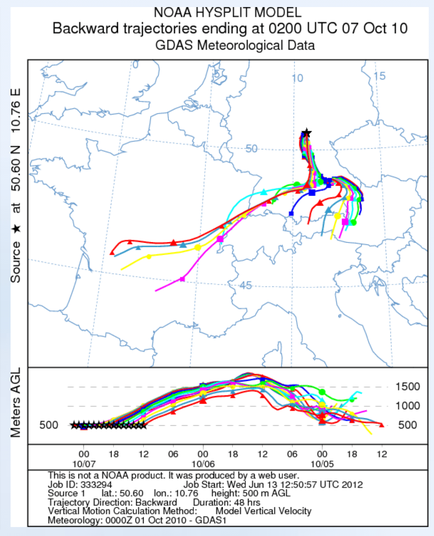
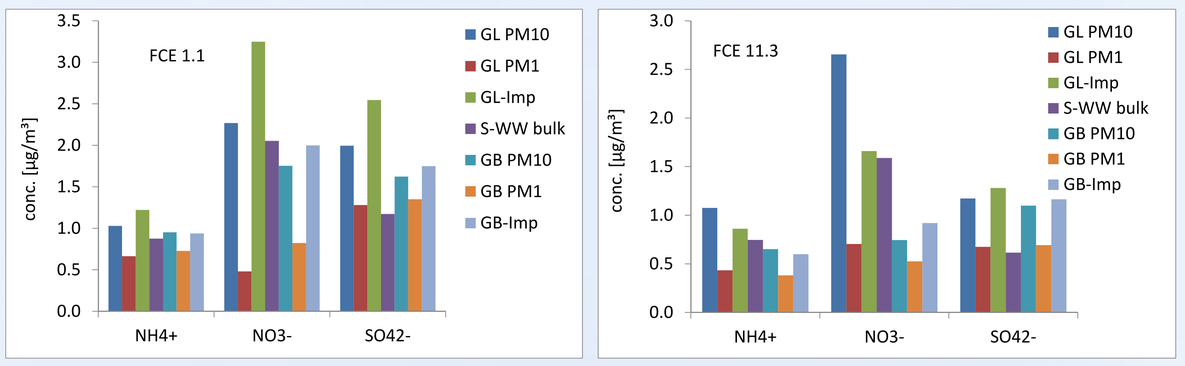


Fig. 2*: Series of back trajectories calculated once per hour during the cloud event 13.3*

Experiment and Sampling

During HCCT 2010 (September and October) at the UBA-site Schmücke (937 m above sea level, Thuringia) on top of a 20m tower (Fig. 1) cloud water collection took place. Four identical bulk samplers were applied, a three-stage with cut-off diameters of 22, 16, and 4 µm and a five-stage sampler (Raja et al., 2008) with cut-offs of 30, 25, 15, 10 and 4 µm constructed at CSU, Fort Collins (Moore et al.,2004). Depending on the cloud water content and the sampling velocity the sampling times of the samplers were one to five hours.



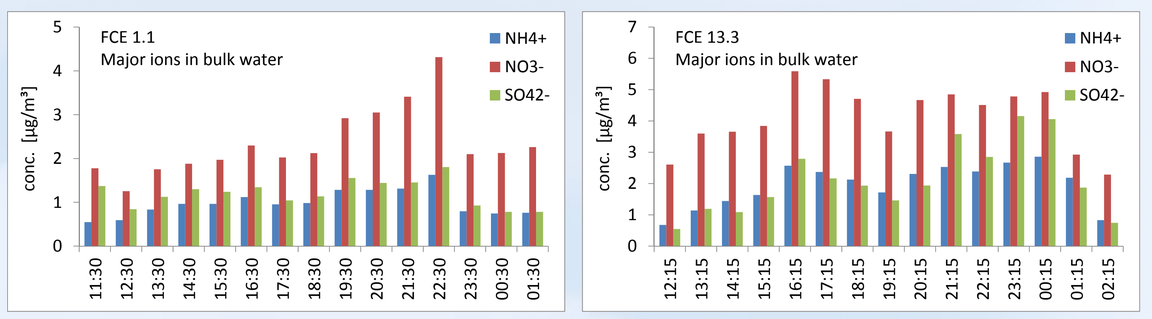
Comparison of all particle samples from the valley sites to cloud water samples from the bulk sampler for two major cloud events.

Results

Between 13 Sep and 25 Oct 2010 twelve cloud events have been investigated. Additionally, cloud water was collected during four cloud-only-events. After the recalculation of all meteorological parameters samples from six good and four suitable events were analysed.

Here we present the results of selected longer cloud events, cloud water ionic constituents were compared to the ionic species in PM samples at the valley sites. The pH of all samples was found between3.3 and 5.6. In size fractionated droplets the pH is normally increasing with droplet diameter.

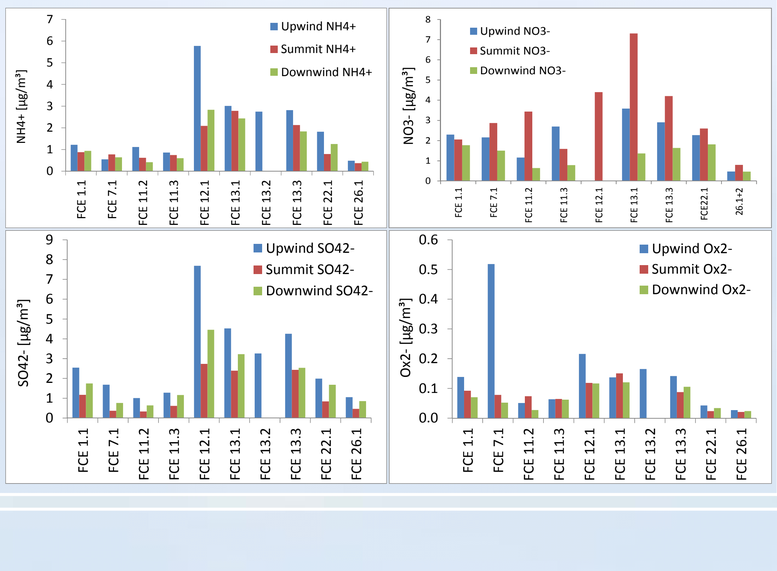
Ions and total S(IV) were given in their temporal variability during the cloud events.

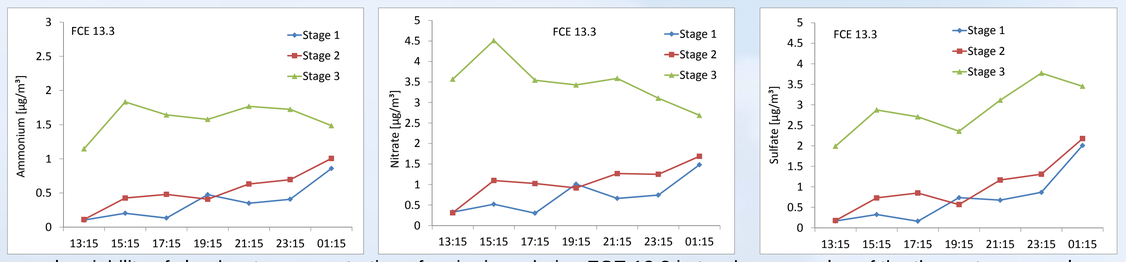


For all major events the concentrations of main ions and oxalate are give in the diagrams.

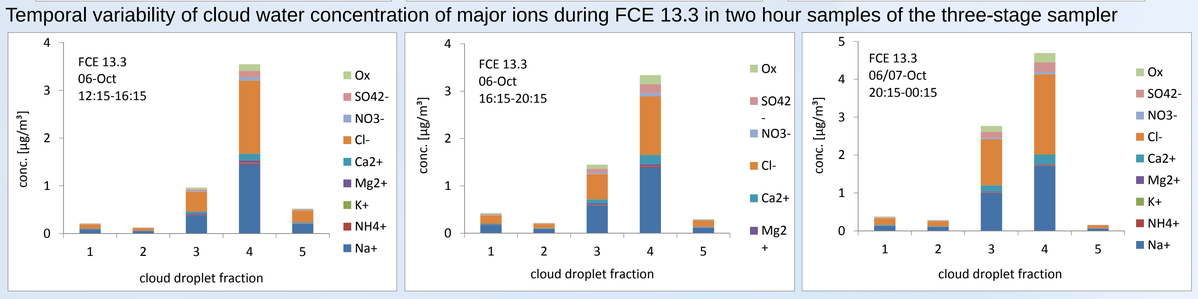
The cloud water concentration of sulfate is lower than the concentration in particles at both valley sites.

The nitrate concentration in cloud water is observed during three events higher than the upwind PM concentration.





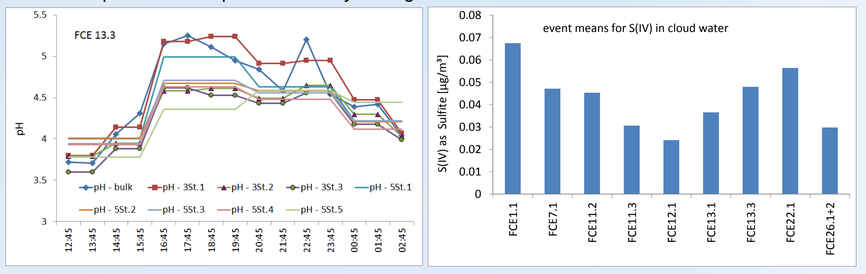
Temporal variability of cloud water concentration of major ions during FCE 13.3 in two hour samples of the three-stage sampler



Size distribution of ionic constituents in cloud droplets and temporal variability during FCE 13.3

pH variability during FCE 13.3 in all cloud water samples (bulk and in drop size fractions).

Mean sulfite values during all cloud events.



Conclusions

- Ionic constituents of particles and cloud water samples were found with decreasing concentrations in transport direction in most cloud events.
- pH values in size segregated droplets are highly variable within events with lowest values in smallest droplets typically.
- Major ionic constituents were found with increasing concentration to smaller droplets.
- Highest concentration of ionic species were found in air masses coming from Southwest Europe (FCE 13.1 and FCE 13.3).
- Sulfur (IV) was found in cloud water samples as sulfite and HMSA in low concentrations: 20-120 ng/m^3.

References

K.F. Moore et al., Atmospheric Environment 38 (2004), 1389-1402.

S. Raja et al., Atmospheric Environment 42 (2008), 2048-2061.

Acknowledgement

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