HIGH TIME RESOLUTION IN CHEMICAL CHARACTERISATION OF AIR MASSES BEFORE AND DURING THE PASSAGE THROUGH OROGRAPHIC CLOUDS DURING THE FEBUKO FIELD EXPERIMENT

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INTRODUCTION

In the joint project FEBUKO the microphysics and chemistry of different types of aerosols, the role of aerosol chemical composition for cloud formation as well as the chemical transformation in cloud processes have been investigated by means of ground-based cloud experiments at Mt. Schmücke in the Thuringian Forest (Germany). Low clouds covering the mountain top in October 2001 were used as a flow through reactor and the air masses were characterised in detail before, during and after the cloud passage. Although kind and behaviour of organic substances were of special interest, attention was given to the role of inorganic soluble material being main part of the cloud condensation nuclei.

METHODS

The contribution of the ETU group was focussed on different measurements at the valley station Goldlauter (windward, 590 m a.s.l.) and on top of Mt. Schmücke (937 m a.s.l.). Beside meteorological parameters, cloud base height and trace gas mixing ratios the partitioning of some water soluble inorganic compounds between the gas and aerosol phase was measured with high time resolution in the valley. The use of a denuder allows the collection of reactive trace gases with a separation from their particulate counterparts. \( \text{HNO}_3 \) and \( \text{HNO}_2 \) measurements were performed using a wet effluent diffusion denuder (WEDD) system coupled directly with an ion chromatography unit (Acker et al., 2001). The system was extended by a steam jet unit to determine aerosol components (nitrite, nitrate, chloride, sulfate) with a high time resolution. The airflow through the denuder / jet steam is 10 l min\(^{-1}\) and using 30 minutes sampling time concentrations of 0.010 \( \mu \text{g m}^{-3} \) of \( \text{HNO}_2 \), \( \text{NO}_2 \), \( \text{HNO}_3 \) and \( \text{NO}_3^- \) can be reliably recorded. Measurements of cloud physical parameters as well as sampling of cloud water were carried out on a measurement platform 20 m above ground at the Schmücke summit.

CONCLUSIONS

During the investigated cloud events (connected flow between the 2 field sites and clouds only at Mt. Schmücke) medium or low polluted air masses moved from the Goldlauter valley to the mountain top. On average concentrations of \( \text{SO}_2 \) (ETI 42S) below 1 ppb and of \( \text{NO}_2 \) (Ecophysics CLD 770 ppb/PLC 760) below 10 ppb were observed. A mean \( \text{HNO}_3 \) to \( \text{NO}_2 \) ratio of 0.015 was found, significantly higher than the contribution from direct emissions (on average 0.008) and an indication for an additional heterogeneous formation of \( \text{HNO}_3 \) from \( \text{NO}_2 \) on adsorbed water on ground and wet aerosol particles. The temporary development of the \( \text{HNO}_3 \) concentration was close linked with that of the aerosol nitrate and about one fourth of the measured \( \text{N}^{\text{III}} \) occurred in the aerosol phase (Fig. 3). The concentration of \( \text{HNO}_3 \) was very low because of nearly 100% relative humidity and the high solubility of this gas. Up to 30 times more \( \text{N}^{\text{V}} \) was found as inorganic nitrate in the aerosol phase (Fig. 1). The temporary profiles of Schmücke cloud water nitrate and sulfate were very well correlated to the temporary profiles of the Goldlauter
aerosol nitrate and sulfate, indicating connected flow conditions (Fig. 1 and 2). Beside heterogeneous nucleation also entrainment of particles and gases from the sub-cloud layer is assumed. Nitrate mostly was the dominant anion in the aerosol and also in the cloud water phase. Similar observations, i.e. replacement of sulfate by nitrate, were made during many field experiments at other sites, e.g. at Mt. Brocken (Acker et al., 2002). After the drastic decrease in emissions of sulphur dioxide and dust the importance of nitrogen oxides being atmospheric pollutants increased markedly. Nitric acid and nitrate are now often the main input for acidification of ecosystems in Europe and North America.

Figures 1-3. Distribution of reactive components between gas and aerosol phase at the valley station Goldlauter before the air masses reached Mt. Schmücke during different cloud events. There simultaneous cloud water was collected (Winkler single stage sampler) and analysed for the solute mass of these ions.

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REFERENCES