On-line testing of the importance of nitrate as CCN-component

H.M. ten Brink, P. Jongejan, R. Otjes, G. Kos
Netherlands Energy Research Foundation (ECN), P.O. Box 1, 1755 ZG Petten, The Netherlands

Keywords: Nitrate, Cloud Chamber, CCN

A start was made to study the importance of nitrate as component of the cloud condensation nuclei (CCN). This investigation is performed in our large flow-through cloud chamber.

The chamber is strategically located at the coast of the North-Sea, where arctic air from the North contains low concentrations of CCN that acts as background air for Europe. From other directions polluted air arrives with often very high concentrations of submicron nitrate.

A decade ago, Khlystov [1998] found a first indication of the importance of nitrate as CCN-agent. He made manual measurements on the composition of the aerosol in the size-range in which the maximum number of CCN resides. This was done in the same cloud chamber as used in the present study.

In the mean time we developed an instrument for size-classified sampling and automated analysis of the aerosol in the same size-classes as a cascade-impactor. This instrument, the MARGA-sizer, is a more sensitive version of the instrument described earlier [ten Brink et al., 2007]. The MARGA-sizer is used in combination with instrumentation determining the size and number of aerosols.

In order for the reader to appreciate the experiments we briefly summarise the set-up. The cloud-chamber is run at a supersaturation that is representative for that in marine stratocumulus in our region. This is at a typical supersaturation of 0.1%.

The number of CCN is derived by difference. This means that the particles in the ingoing and outgoing air are measured; this is done with two identical SMPS-systems. The difference in the number of particles before and after the cloud-chamber is the number of CCN. In addition, and as direct check, an FSSP-100 measures the number (and size) of droplets formed.

The residual particles behind the cloud-chamber are separated from the cloud droplets via a cyclone. Because of the large sample flow, the air cannot be easily dried with a drier. Instead aerosol-free pressurised air is added to the sample stream. This results in a relatively high RH (85-90%).

At the given relatively high humidity the aerosol is larger than at the entrance. This applies for the aerosol as measured with the MARGA-sizer. However, in the two SMPS systems the sizes should be similar, because the RH is governed by that in the sheath air in the DMA that is obtained from the room.

There is only one MARGA-sizer. It alternatingly measures the aerosol before and after the chamber. The efficiency of transmission of inactivated ammonium nitrate through the cloud-chamber was tested with the instrument. The reason is that ammonium nitrate is semi-volatile and might possibly be lost in its way through the chamber. For the test the cloud chamber was run at saturation conditions without actual cloud formation. There was negligible loss of ammonium nitrate.

We gathered a host of data and are currently evaluating these. As an example we show results from a period in which the concentrations of nitrate and sulphate alternated, but cloud droplet numbers as generated in the cloud chamber were quite stable. The measurements show that most of the CCN are in the size-range of 100 to 200 nm (in diameter).

The concentration of the two major hygroscopic components of the CCN is given in figure 1. It shows that there are periods in which the composition is dominated by nitrate. Further analysis of the data is in progress.

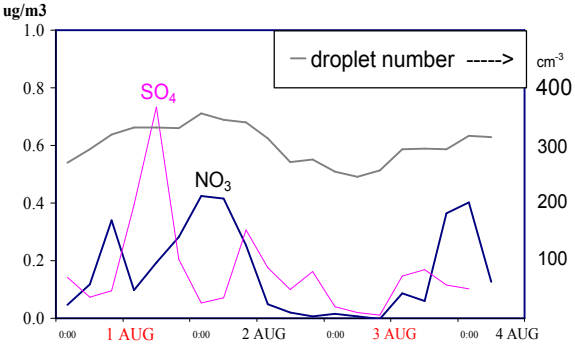

Figure 1: Concentration of nitrate and sulphate in the CCN size-range. Also the number of cloud droplets are shown, formed in the ECN cloud-chamber during the indicated period in August 2007.

The study is financed by the national Bsik-KvR program and the ministry of VROM.

Khlystov A. (1998). Cloud forming properties of ambient aerosol in the Netherlands. PhD Thesis, Wageningen University

ten Brink, H., Otjes, R., Jongejan, P., Slanina, J. (2007). Atmos. Environ., 41, 2768–2779.