Modeling aerosol water uptake in the Arctic and its direct effect on climate

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Introduction

Water uptake or hygroscopicity is one of the most fundamental properties of atmospheric aerosols. Aerosol particles containing soluble materials can grow in size by absorbing water in ambient atmosphere. Hygroscopic growth depends on the dry size of the particle, its chemical composition and the relative humidity in the ambient air (Fitzgerald, 1975; Pilinis et al., 1995). One of the typical problems in aerosol studies is the lack of measurements of aerosol size distributions and optical properties in ambient conditions. In this study we try to bridge the gap between measurements performed under dry conditions and aerosol properties in the humid atmosphere. To do this we utilize a hygroscopic model which calculates the hygroscopic growth of aerosol particles at Mt Zeppelin station, Ny Ålesund, Svalbard during 2008.

Methods

A hygroscopic growth model was built on the κ-Köhler theory (Petters and Kreidenweis, 2007). The monthly chemical composition of the aerosol particles is represented by observations of inorganic ions obtained from the Norwegian Institute for Air Research (NILU) and filter sample analysis for the organic and elemental carbon (OC/EC) concentration (Silvergren et al., unpublished manuscript). The assumed components are: soluble and insoluble organics, sulfate, sea salt and soot. Internally mixed aerosol particles with homogenous chemical composition are assumed. After using the hygroscopic model, the radiative properties and radiative influence of the aerosols on the Arctic environment are studied using a Mie scattering model (Wiscombe, 1979) and a radiative transfer model (Richiazzi et al., 1998). A scheme of the models and inputs is shown in Fig 1.

Conclusions

The evaluation of the hygroscopic model calculations with HTDMA measurements from September 2007- August 2008 (Silvergren et al., unpublished manuscript) and the Mie scattering model calculations with humid nephelometer measurements during a 90 days campaign at Zeppelin station (Zieger et al., 2010) show a good agreement.

Sensitivity tests show that the model calculations are more sensitive to relative humidity and particle's size than its chemical composition. The hygroscopic growth of aerosol particles in ambient atmosphere increases the annual mean scattering coefficient by about a factor of 5 compared with calculations on completely dry aerosols. Hygroscopic growth should therefore be considered in all comparisons between in situ measurements, satellite products and model predictions of aerosol optical thickness. Our results also indicate that the RH profiles and variation are key parameters needed for correct predictions of aerosol optical properties.

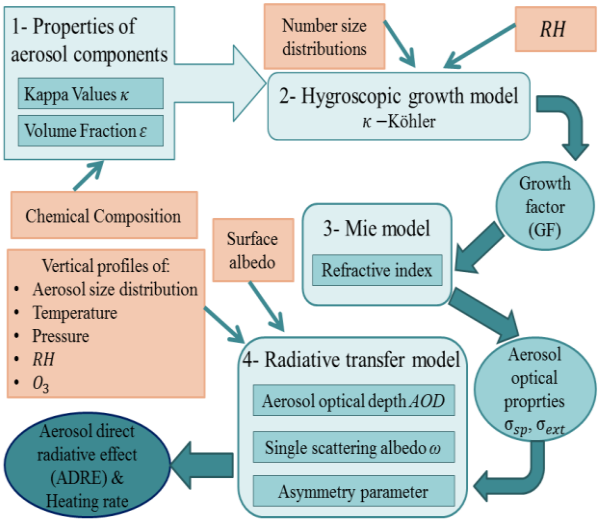

Figure 1. Scheme of the models and inputs, starting from defining the individual components of the aerosol particles and ending to calculate the aerosol direct radiative effect (ADRE) and heating rate profiles.

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