Macloud II

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Introduction and motivation

Phytoplankton is ubiquitious in the oceans and most species of phytoplankton excrete dimethylsulphide (DMS). DMS is oxidized in the atmosphere and a significant amount of the products will end up in aerosol particles. The role of the aerosol particles as cloud condensation nuclei lead to the suggestion of biologically emitted DMS being important for global climate [Charlson et al., 1987]. The publication Charlson et al. (1987) gave name to what has become known as the CLAW hypothesis. The hypothesis states that global warming will lead to increased emissions of DMS which will increase the concentration of cloud condensation nuclei (CCN). An increase of the concentration of CCN will lead to a larger concentration of cloud droplets that on average will turn smaller. When the average size of the droplets turn smaller the clouds will turn brighter and thus the clouds will more efficiently reflect the incoming sunlight and thus lead to a cooling of the climate. Thus the role of phytoplankton would be to stabilize climate.
The actual role of DMS on climate has been debated and later studies have pointed out that sea spray should not be neglected as a source of marine CCN [O'Dowd et al., 1997]. However the global emission of DMS is estimated to 13-37 Tg(S)/a and DMS is thus a main source of atmospheric sulphur [Kettle and Andreae, 2000]. A lot of questions about the actual role of DMS emissions on climate remain to be fully answered.

Scientific objectives

After the release of DMS to the marine atmosphere, it is rapidly oxidized to different sulphur containing compounds, where methanesulphonic acid (MSA) and SO_2 are among the most important. The only known source of MSA is from the oxidation of DMS. This makes it an important measure of the marine biogenic contribution to sulphur aerosols. The ratio between MSA and SO_2 is often calculated and used as a measure of how much sulphur that is released from natural versus anthropogenic sources. The purpose of the project is to measure the concentration of marine MSA in different aerosol particle size bins. In addition several other anions will be measured to facilitate the interpretation of the measurements.

Reason for choosing station

The Mace Head atmospheric research station is located close to the ocean on the Irish west coast. The site is ideally located to measure the prevailing (about 51% of the time) westerly-southwesterly air from the Atlantic [Jennings et al., 2003] and thus the airmasses often reflect the background remote marine conditions.
There are several continuous measurements of aerosol particle characteristics and meteorological parameters at the station, which is provided to optimize the planning of measurements and the interpretation of data. There is also an option to connect to a clean sector system so that the instrument only runs during clean background marine conditions. Furthermore the visit took place during the MACLOUD II campaign so that several intense measurements of special aerosol particle characteristics were carried out – which will provide additional data relevant for the interpretation of our results.

Method and experimental set up

An M110 MOUDI cascade impactor with ten rotating stages was used to collect particulate matter (PM) on impactor foils. The PM is size segregated into 10 size bins during collection and the instrument was operated with a flow rate of 30 L/min. The instrument was placed in a tower roughly 10 m above ground level at the Mace Head atmospheric research station. The distance to the shore line varied from roughly 80

m to 180 m depending on the tide. The samples were collected over two to three days to get enough mass for the analysis.
The collected foils were extracted in Millipore water in ultrasonic bath for one hour. The solutions were filtrated and analyzed with ion chromatography using a Metrohm suppressed chromatography system with a Metrosep A supp 5-250 anion column.

Preliminary results

From the ion chromatograms the concentrations of several anions have been calculated. The preliminary results from the first five samples of the concentration of MSA versus particle size are depicted in figure 1. There seem to be two modes present – one centered around a particle diameter of 300 nm and another mode closer to a particle diameter of 1 µm. For the 5 shown samples two of them are partly influenced by continental airmasses during the days May 7th to 10th and again during May 13th to 15th. However from studies of wind direction, back trajectories and aerosol particle properties the three other depicted samples are expected to reflect background marine North Atlantic airmasses. There are still three samples remaining to be analyzed and all three of them are expected to be entirely representative of the marine North Atlantic background – except for one of them being influenced by the volcanic eruption of Grimsvötn.

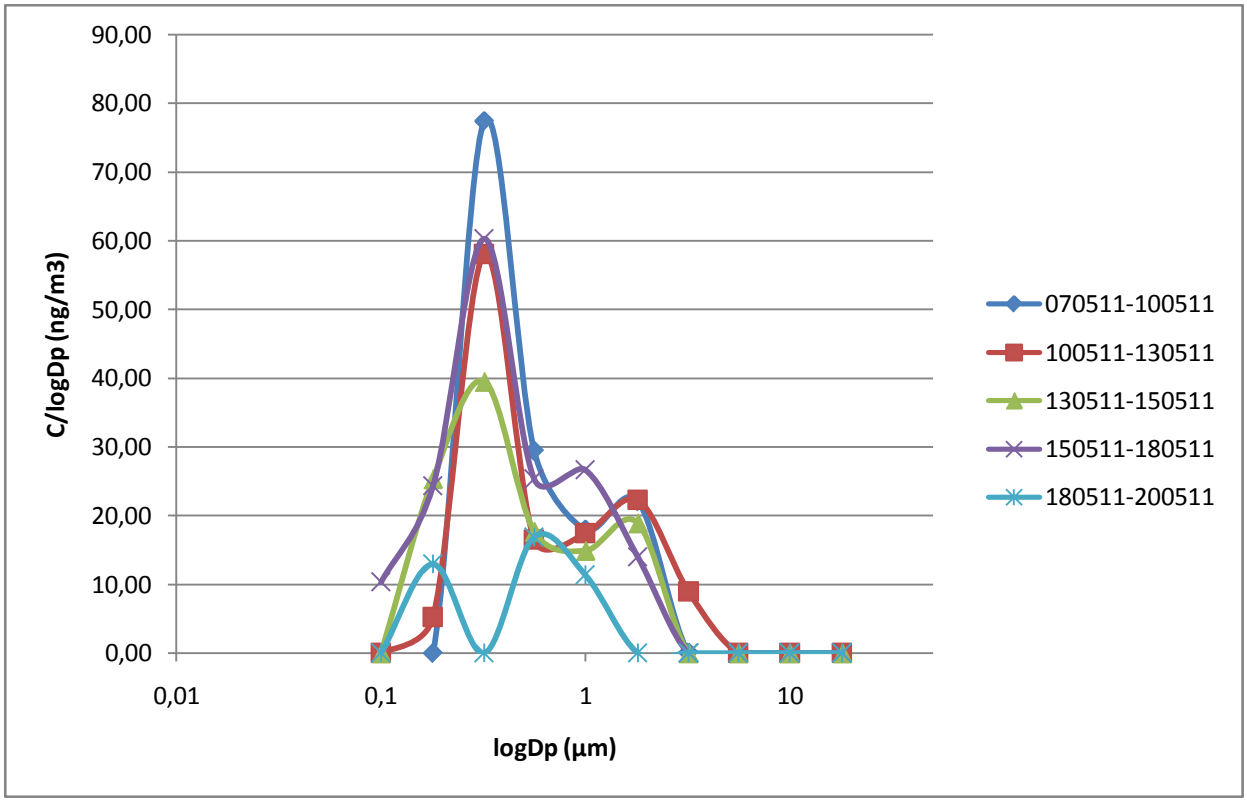

Figure 1. The concentration of methanesulphonate in the different particle size bins versus aerosol particle size. The concentration (C) is inferred from ion chromatograms.

Outcome and future studies

The size distributions of methanesulphonate in marine airmasses have been inferred and from the preliminary results there seem to be two modes present. The picture seems to be similar when the samples are partly influenced by continental airmasses.
The size distributions of other anions will also be inferred. Intercomparisons of the different anion concentrations may give information on whether the methanesulphonate is present in particles primarily consisting of sea salt or whether there will be separate modes dominated by sulphur containing compounds. During the campaign we encountered some days with very high winds speeds – so it will be investigated how wind speed has an effect on emission of DMS.
On May 24th the airmasses were influenced by the eruption of the Icelandic volcanoe Grimsvötn. Studies of backtrajectories and modeling performed by Volcanic Ash Advisory Centre in London confirmed that the

airmasses were influenced by the eruption. The Aerodyne aerosol mass spectrometer at Mace Head detected an elevated level of the SO_4^{2-}concentration for roughly 8 hours on May 24th along with an increase in particulate matter with particle diameters below 10 µm. The samples from this special event will be analyzed with a scanning electron microscope (SEM) to check whether ash particles are deposited on the foils. Furthermore the SEM studies may provide useful information about the morphology of the deposited particles in general.

References

Charlson, R. J., J. E. Lovelock, M. O. Andreae, S. G. Warren, Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate, Nature, 326, 655-661, 1987.

Jennings, S. G., C. Kleefeld, C. D. O'Dowd, C. Junker, T. G. Spain, P. O'Brien, A. F. Roddy, T. C. O'Connor, Mace Head atmospheric research station – characterization of aerosol radiative parameters, Boreal Env. Res., 8, 303-314, 2003.

Kettle, A. J., M. O. Andreae, Flux of dimethylsulfide from the oceans: A comparison of updated data sets and flux models, J. Geophys. Res., 105, D22, 26793-26808, 2000.

O'Dowd, C. D., M. H. Smith, I. E. Consterdine, J. A. Lowe, Marine aerosol, sea-salt, and the marine sulphur cycle: a short review, Atmos. Env., 31, 73-80, 1997.