ACTRIS TNA Activity Report

Marine Aerosol Cloud Interactions, MaCloud Inc. 2.3

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Introduction and motivation

Oceans, covering about 70 % of the earth surface, are an important source of both primary and secondary aerosols, which further affect formation and properties of marine clouds. Recent advances in understanding the production processes of marine aerosols are encouraging (e.g. O'Dowd, C. D. and de Leeuw, G., 2007). Yet, a more quantitative knowledge is required in order to adequately present the climatic effects of marine aerosols in global scale models. This project aims to build on recent advances in marine aerosol formation processes and marine aerosol-cloud interactions.

Scientific objectives

In addition to coastal iodine-driven nucleation and growth events (e.g. O'Dowd et al., 2002), it has been recently established that open ocean particle production and growth is quite frequent over the NE Atlantic and appears to be driven by organics (O'Dowd et al., 2010). This project aims to better characterize these coastal and open ocean events. Further, aerosol mass spectrometry has revealed unique marine aerosol organic characteristics with effective cloud nucleating properties despite low growth factors (Ovadnevaite et al., 2011). The project will aim to characterize the growth factor and CCN activity of varying enrichments of sea-spray aerosol. Extensive measurements of aerosol physical and chemical properties, both in gas and solid phase, will be used simultaneously for aerosol characterization. In particular, LaMP measurements contribute to a better quantification of volatile and CCN properties of marine aerosols by using VTDMA and CCN measurements in parallel and coupled. The 2011 May campaign characterises the high biological activity period on aerosol-cloud interactions and can be compared to the previous winter 2010 low biological activity period. In case of open ocean nucleation, the volatility and hygroscopic properties of the newly formed aerosol will complete the information obtained from the TD-CIMS operated by the Helsinki group.

Reason for choosing station

The station is one of the rare sites where fresh marine aerosols, without major anthropogenic influences, can be studied. It is frequently gathering air masses directly from the East Atlantic and has served as a research site for several marine aerosol studies in the past. The station infrastructure is excellent, and the measurements profit of the diverse permanent on-site instrumentation as well as the supportive campaign measurements.

Method and experimental set-up

LaMP provided measurements of aerosol size resolved CCN properties at 2 different supersaturations, as well as aerosol volatilization at temperatures between 100 and 150 degrees.

Size-resolved CCN-activation properties of particles were measured for the first 2 weeks of the campaign using a mini-CCN chamber at two supersaturations. Both marine and continental air masses were prevailing during this time and the obtained data will allow making comparisons of the CCN activation properties at different air mass types. Results will be compared with those of the other groups to obtain a wider range of supersaturations as well as to ensure the congruence and quality of the data.

Particle volatile properties at 100 degrees (occasionally also 150 degrees) as a function of size were measured for the whole campaign using self-built LaMP VHTDMA system (Villani et al., 2008). Dry and volatile scans were performed, one by one, for sizes 50, 75, 110 and 165 nm in diameter. This data will be complementary for aerosol chemical composition, hygroscopic and CCN activation measurements to better understand the effect of changes in chemical composition for the particle climate effects during aerosol processing as well as to examine the particle mixing state.

For the last two weeks of the campaign, the V-TDMA instrumentation was modified and coupled with the CCN chamber with an ambitious goal to measure the change in CCN activation properties after volatilisation of the particles. This was done in order to offer supplementary, novel data for other measurements. Bubbling experiments with artificial sea salt and sea water were also done for obtaining a reference for atmospheric results to facilitate the interpretation. The data will be used to answer the question whether the volatile, presumably organic, fraction of the marine aerosol suppresses cloud activation. In my knowledge, these types of measurements have not been obtained previously. Coupled with aerosol chemical composition, size distributions, hygroscopic properties and air mass origin, the results can be used to quantify the volatile properties and activation potential of primary and secondary marine organic aerosol.

Preliminary results and conclusions

Particle volatile properties showed interesting variations with both time and size. In particular, in marine air masses, bimodal volatilized distribution, indicative of external mixture, was often observed. In this case, a non-volatile sea-salt mode coexisted with a moderately volatile mode likely composed of sulphate particles enriched with varying fraction of organics. Particle volatility generally increased with size and average "growth" factors varied around 0.85 and 0.95 (Fig. 1).

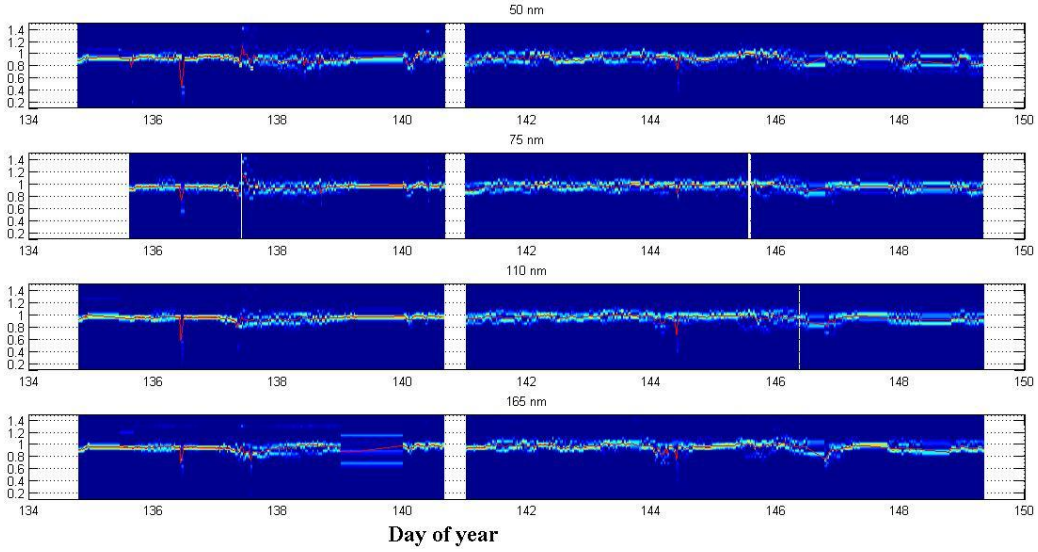

Figure 1. Time series of volatilized fractions for different sizes.

It also appeared that there is a correlation between particle volatility and CCN activation (Fig. 2). However, a detailed time-series analysis with supplementary data is needed to confirm the effect of different types of organics, of which a part may not be volatile at measured 100 degrees.

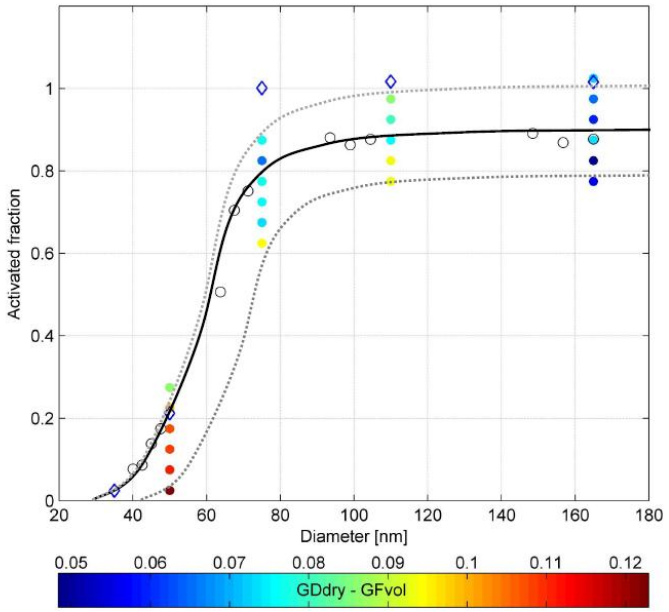

Figure 2. Preliminary (uncorrected for losses etc.) averaged particle activated fraction as a function of size for volatilized (100 ^{o}C) aerosol (open black circles), for dry aerosol (filled circles) and for ammonium sulfate (blue diamonds) using CCNc temperature difference of 6 ^{o}C. Colour scale indicates the change of the volatilized fraction between dry and volatilized measurement.

Outcome and future studies

The results offer important auxiliary information, when the effects of different types of organics for particle cloud activation and cloud microphysical properties are studied. They also provide direct evidence of the effects of aerosol volatile fraction on particle cloud activation. As a first step, quality assurance will be completed by comparisons with measurements of groups from UK, Ireland and Finland. Analysis of air mass origin together with particle chemistry will be used to separate between aerosols of different origin and organic enrichment. Periods with indications of influences from primary marine organics as well as the periods of open ocean particle formation will be studied separately to conclude on the volatile properties of marine primary organics, after which the cloud activation properties of different aerosol types will be studied. Finally, the impact of these activated aerosols on cloud optical and microphysical properties will be studied.

References

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