ACTRIS TNA Activity Report

Marine Aerosol Cloud Interactions, MaCloud, Inc.

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Introduction and motivation

New particle formation is the spontaneous creation of new nanometer-sized particles in the atmosphere. Observations spanning from megacities to isolated forests show that these events can occur frequently and extend for hundreds of square kilometers. While the impacts of these events are not well understood, they are often the dominant source of particles in the remote regions and could play a crucial role in the Earth's climate by regulating the number and activity of cloud condensation nuclei (CCN). This effect of aerosols on cloud properties is recognized in the Fourth IPCC Assessment Report as the largest single contributor to uncertainty in predicting climate change. Since cloud droplet activation normally occurs on particles of about 100 nm in diameter, the key to understanding the impact of new particle formation on climate lies in the ability to predict both the formation and growth rates of newly formed particles.

Scientific objectives

The current study is motivated by the need to understand the species and mechanisms by which new particles form and grow in a coastal environment. This will be accomplished by directly measuring the chemical composition of nanometer-sized particles at Mace Head Research Station in County Galway, Ireland using the Thermal Desorption Chemical Ionization Mass Spectrometer (TDCIMS) (Smith, Moore et al. 2004). If successful, these will be one of the most complete data sets on the composition of nanometer-sized marine aerosol.

Reason for choosing station

The site of the measurement campaign, Mace Head Research Station, is the most extensively studied marine site focusing on aerosol physico-chemical properties. Two primary types of marine-influenced events have been reported. The first is characterized by intense bursts of sub-20nm diameter particles, and is thought to be caused by iodine species emitted from seaweed at low tide (O'Dowd, Jimenez et al. 2002). These events are thought to occur onshore. The second is characterized by the appearance of 15 nm diameter particles at Mace Head, which subsequently grow slowly to diameters of ~50nm (O'Dowd, Monahan et al. 2010). These events are expected to occur offshore, and have been termed "open ocean nucleation events." Other studies at Mace Head have highlighted the importance of organic compounds in marine aerosol during periods of high biological activity (Facchini, Decesari et al. 2008).

Method and experimental set-up

The TDCIMS measurements were performed during 13 – 31 May 2011 (2.5 weeks). The instrument was located in the upper cottage at Mace Head, with a sampling inlet consisting of 10mm copper tubing protruding above the cottage. Sampling was performed at three different particle diameters: 15 nm, 20 nm, and 30 nm. The size was chosen to correspond to the peak in the nucleation mode of the size distribution. Samples were collected for 15-30 min, and both positive and negative ion mass

spectra were acquired to obtain the most complete representation of size-resolved aerosol composition. This resulted in a measurement frequency of approx. 1 hr. Standards for calibrating inlet sensitivity as well as mass spectrometer accuracy were applied throughout the study.

Preliminary results and conclusions

The measurement period was characterized by steady offshore winds and offshore "open ocean nucleation events" such as the one shown in Figure 1. Two events are actually shown in the plot: one from the previous day ends at ordinal date 140.2 (~5:00AM) with a peak at ~40 nm (black circle) and another that begins at ordinal date 140.3 (~7:00 AM) with a peak at ~20 nm. Figure 2 shows a TDCIMS-derived mass spectrum of the chemical composition of aerosol sampled during the period circled in Figure 1. This spectrum is typical of many obtained during the measurement period. As shown in Figure 2, chlorine-and sulfur-containing species dominate the ion abundance. Additionally, many smaller peaks that correspond to organic compounds were observed. During the observation period, onshore events were observed only during a few periods.

Outcome and future studies

A thorough analysis of the dataset is currently underway. Already it is clear that the dataset will provide many insights into the composition of aerosol produced during open ocean nucleation events. A publication is planned summarizing TDCIMS measurements of nanometer-sized marine aerosols from the campaign. This will be submitted on or before summer 2012. A future study that focuses on iodine-influence onshore formation events would nicely complement the current data set. Although no future plans have been made, the PI is interested in participating in such a study in the near future as schedules and funding permit.

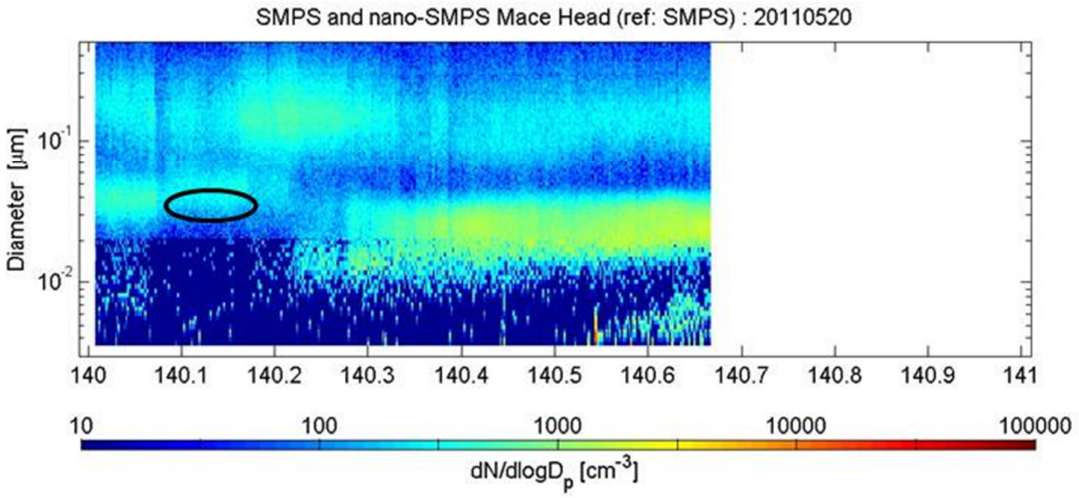

Figure 1. Particle size distribution evolution on 20 May 2011, showing the tail end of an open ocean nucleation event (circled) as well as the start of a new open ocean event starting at 7:00 (corresponding to 140.3 on the abscissa).

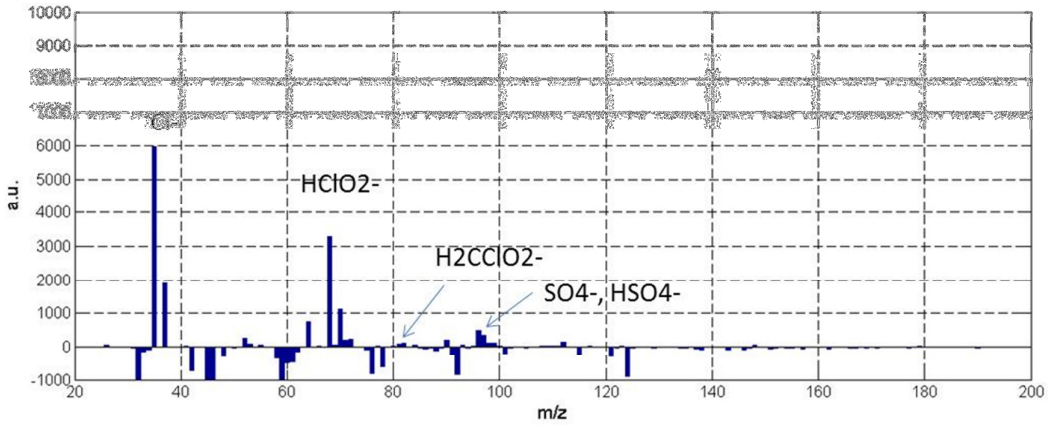

Figure 2. TDCIMS-derived background-subtracted negative ion mass spectrum of the composition of 30 nm diameter particles collected during the period circled in Figure 1. Positive-going peaks correspond to ions detected in the sampled aerosol. The identities of the major ions are shown.

References

Facchini, M. C., S. Decesari, et al. (2008). "Important Source of Marine Secondary Organic Aerosol from Biogenic Amines." Environmental Science & Technology **42**(24): 9116-9121.

O'Dowd, C., C. Monahan, et al. (2010). "On the occurrence of open ocean particle production and growth events." Geophysical Research Letters **37**.

O'Dowd, C. D., J. L. Jimenez, et al. (2002). "Marine aerosol formation from biogenic iodine emissions." Nature **417**(6889): 632-636.

Smith, J. N., K. F. Moore, et al. (2004). "Atmospheric measurements of sub-20 nm diameter particle chemical composition by thermal desorption chemical ionization mass spectrometry." Aerosol Science and Technology **38**(2): 100-110.