The chemical composition of the marine aerosol and its relation to hygroscopic properties over Atlantic Ocean

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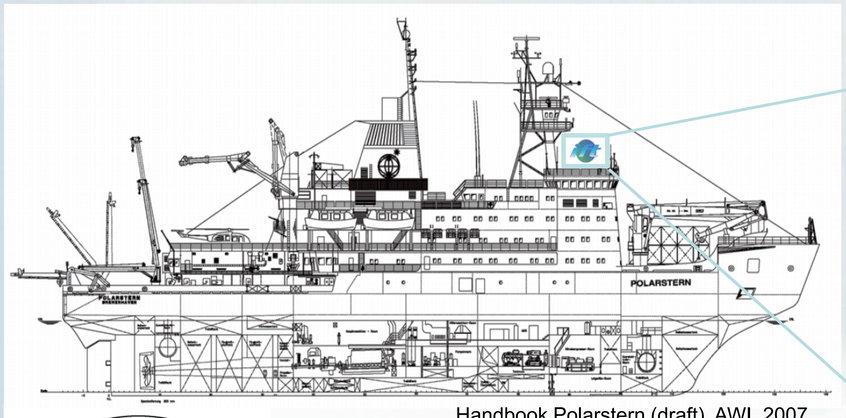
Introduction

Marine aerosol particles play an important role in global climate regulation and marine biogenic system. For a better understanding of their importance, physical and chemical properties of the marine aerosol were measured on board of the research vessel Polarstern. This study shows results of 1) spatial distribution of main chemical compositions along the cruise, and 2) the closure study utilizing the HTDMA and AMS data.



Handbook Polarstern (draft), AWI, 2007

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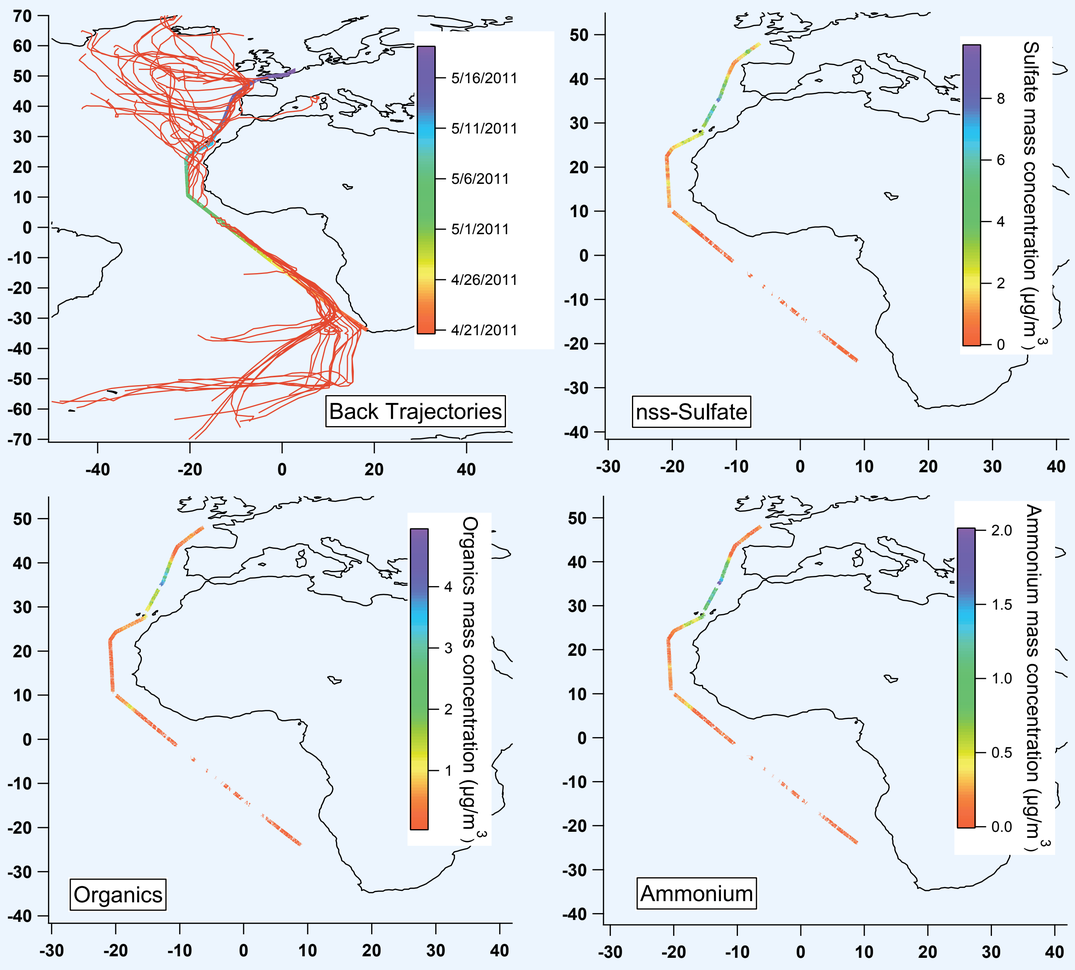
ANT-XXVII/4
Expedition: from Cape Town, South Africa to Bremerhaven, Germany
Duration: April 20, 2011- May 20, 2011
Total distance: 6633 nm

Main inlet

Digitel filter sampler
24h filter sampling for chemical composition

- **High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS)**
  Size - resolved chemical composition
- **Aerodynamic Particle Sizer (APS)**
  Number size distribution (D_p> 500nm)
- **Scanning Mobility Particle Sizer (SMPS)**
  Number size distribution (D_p: 10-800nm)
- **Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA)**
  Hygroscopic growth factors at different RH
- **Differential Mobility Analyzer-Cloud Condensation Nuclei Counter (DMA-CCNc)**
  Particle activation
- **Integrating Nephelometer + Multi Angle Absorption Photometer(MAAP)**
  Light scattering and absorption

Back trajectories and spatial distribution of sulfate, organics and ammonium



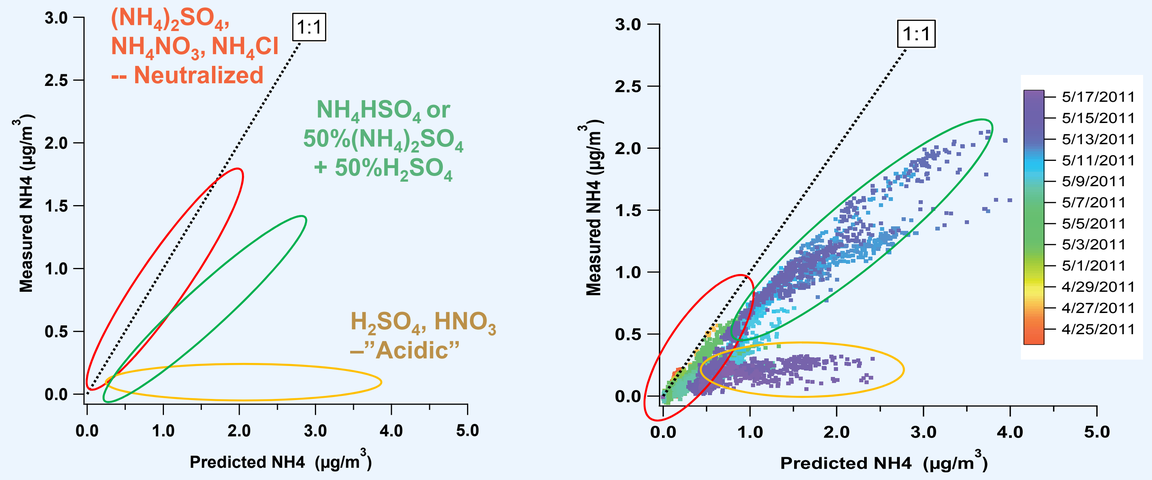
Three main compositions non-sea-salt (nss) sulfate, organics, and ammonium show very low concentrations (< µg m^{-3}) in most part of cruise, but higher concentration when the ship was closed to Europe and North Africa continents, indicating the possible influence from land. Gaps correspond to period with/of ship exhaust contamination and have been deleted.

Aerosol acidity estimation

Assume that 1) particles are completely neutralized, 2) ammonium is only present in the form of NH_4NO_3, $(NH_4)_2SO_4$, and NH_4Cl,

$$\Pr edicted[Ammonium] = 18 \times (2 \times \frac{[Sulfate]}{96} + \frac{[Nitrate]}{62} + \frac{[Chloride]}{35.5})$$

The relation between predicted and measured ammonium showed that aerosol measured during the cruise is neither pure acidic, nor pure neutralized, indicating influence from different air mass.



Closure method

The hygroscopic growth factor (HGF) for 200 nm particles measured by the HTDMA was directly compared with the estimated one based on the Zdanovskii-Stokes-Robinson (ZSR) method and the AMS and MAAP mass concentration. Predicted GF is calculated as below:

$$HGF = (\sum_i \varepsilon_i HGF_i^3)^{1/3}$$

ε_i are volume fraction of composition i in the mixture under the assumption of no change in the volume after compounds are mixed.

	$(NH_4)_2SO_4$	NH_4NO_3	NH_4HSO_4	H_2SO_4	Organics	soot
Density (g·cm^{-3})	1.77	1.72	1.78	1.83	1.4	1.77
HGF ($D_{p\text{-}dry}$=200nm)	1.72	1.82	1.8	2.06	1.19	1

Closure study

The predicted hygroscopic growth factor (HGF) based on AMS chemical composition could generally fit well with measured GF on 200 nm. But GF was overestimated when nss-sulfate took big portion.

Summary

During the cruise ANT XXVII/4, the chemical concentration of non-refractory submicrometer aerosol was very low. The higher concentration showed only when the ship was closed to European and African continents indicated potential continental influences. The closure study with ZSR method showed good fitting between predicted and measured HGFs in general. More detailed classification of chemical compositions need to be done to reduce the uncertainties of closure study.

Acknowledgement

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