Raman and electron microscopy of aerosol particles released above Australian salt lakes

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Introduction

Western Australia was originally covered by natural eucalyptus forests, but land-use has changed considerably after large scale deforestation. Thus the ground-water level rose and brought dissolved salts and minerals to the surface. Nowadays a great plenty of salt lakes with pH levels reaching from 2.5 to 7.1 cover the land, which is in use for wheat farming and livestock. Missing rain periods cause dryness, which reason can be seen in the formation of ultrafine particles from salt lakes, which increase the cloud condensation nuclei and prevent therefore rainfall (Junkermann, ACP, 2009).

Several field campaigns have been conducted between 2006 and 2013 where new particle formation has been observed and correlated to the salt lakes. To identify the formed particles directly with the chemistry of and above the salt lakes, a 1.5 m³ Teflon® chamber was brought above the lake in 2012 and 2013 (figure 1).

Released particles from three different salt lakes (figure 2) were collected on alumina foils inside the Teflon chamber using a Sioutas impactor. While the ultra-fine fraction of the released particles is missing, aged aggregates of the original particles could be collected using the impactor.

A Horiba LabRam 800HR Raman microscopy was used for vibrational mapping of an area of about 100 µm x 100 µm of the foils at a resolution of about 1 µm. The same area was analyzed using a Quanta FEI 200 electron microscope. Besides the high-resolution image, the elemental composition could be investigated using energy-dispersive X-ray spectroscopy. This approach provided both molecular information and elemental composition at a high lateral resolution, allowing a detailed study of the deposited particles.

Sites, samples and methods

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Hyperspectral imaging

Both optical images and the related chemical images were combined and a chemometric investigation of the combined images was done using the software package Imagelab (Epin Software Labs).

Cluster analysis could be performed for the Raman and the EDX images.

Discussion & Conclusion

A detailed interpretation of the hyperspectral images unravels the complex composition of the aerosol, released above Australian salt lakes. SEM-EDX and Raman images (figure 3) indicate sodium chloride, sulfates (mainly CaSO₄) and organics as the main components. Especially the coating of inorganic seed particles with organics (degradation products of eucalyptus) is visible.

A more detailed picture is given by the cluster analysis (figure 4) of the Raman image, where different Raman active components can be distinguished. The different species are mainly related to oxidized organic compounds. Green and blue sub-clusters exhibit a strong correlation between sulfates and organics.

The combination of Raman imaging and electron microscopy in combination with electron-dispersive X-ray spectroscopy gains access to a deepened understanding of aerosol formation and interaction of different contributing compounds.