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Relationships between Aerosol Properties and Characteristics of Supercooled Clouds on the Atlantic Ocean using Ship-borne Lidar

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For the first time ship-borne lidar measurements have been used to relate measured aerosol properties and the microphysical structure of supercooled clouds. The formation of droplets and ice crystals in clouds requires aerosol particles which act as nuclei for the hydrometeor formation. More concretely, the number and physical properties of ice nucleating particles controls the glaciation of supercooled clouds in a temperature range between 0°C and roughly -40°C where ice can only be formed heterogeneously [1]. By using remote sensing techniques and radiosonde measurements relationships between the cloud top temperature and the thermodynamic cloud phase can be derived [2]. However, there are no studies including directly measured aerosol properties under real atmospheric conditions as it is hard to obtain aerosol properties and cloud microphysical properties at the same time from measurements only. Therefore, existing studies relate aerosol properties derived from models as a proxy to microphysical cloud properties [3, 4]. Results of these studies indicate a dependence of aerosol load and aerosol type on the cloud phase.

By using measurements only and not relying on models this study takes a step forward in relating aerosol and heterogeneous ice formation. It presents case studies of the microphysical structure of supercooled clouds including the measured aerosol properties in the surrounding of these clouds for the first time. The applied lidar technique as well as improved methods enable the determination of both, aerosol properties and cloud properties. The dataset is based on observations of the lidar PollyXT_Oceanet conducted on board of the research vessel Polarstern during the cruise PS116 from Bremerhaven to Cape Town from 10 Nov 2018 to 11 Dec 2018. PollyXT provides backscatter coefficient, extinction coefficient, extinction-to-backscatter ratio (lidar ratio), and depolarization ratio profiles at 355nm and 532nm as well as the backscatter coefficient at 1064nm of aerosols and cloud hydrometeors up to an optical depth of 3. By using backscatter coefficient profiles cloud base and cloud top heights are obtained. Radiosonde data is used in order to determine the cloud top temperature. The thermodynamic cloud phase is obtained from the depolarization ratio. Aerosol properties are determined from backscatter coefficients, extinction coefficients, and the lidar ratio [5]. Furthermore, ice nucleating particle relevant number concentration profiles are calculated as presented in Mamouri and Ansmann (2016) [6].

It is expected to find differences in the efficiency of glaciation of clouds for different regions during the cruise PS116. Sulphates, Saharan dust, organics, black carbon, and sea salt are prevailing aerosol types in different regions, also occurring in varying concentrations. Case studies as well as statistics showing the relationship between aerosol properties and the thermodynamic phase of clouds are presented.

References [1-6] see in pdf above