Geophysical Research Abstracts
Vol. 21, EGU2019-12893, 2019
EGU General Assembly 2019

Aircraft-based single particle analysis of cloud residuals and aerosol particles in the summertime Arctic

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Arctic clouds play an important role in enhanced Arctic warming, commonly known as "Arctic amplification". To better understand Arctic cloud formation, it is required to know the sources and properties of aerosol particles acting as cloud condensation nuclei. Due to the low aerosol particle concentration in the Arctic, even small influences by long range transport from lower latitudes can significantly contribute to the Arctic particle population, adding to the inner-Arctic particle sources like the ocean surface microlayer.
Here we present aircraft-based single particle measurements of aerosol particles and cloud droplet residuals (CDR), conducted during the ACLOUD campaign in May/June 2017 in the Svalbard region. A Counterflow Virtual Impactor (CVI) inlet allowed sampling of cloud residuals and ambient aerosol particles. Using the single particle aerosol mass spectrometer "ALABAMA", particle size and chemical composition of single particles in the range of 0.2 – 2.5 μm were studied. Simultaneous measurements of trace gases such as CO, CO_2 and O_3 allowed for the identification of different air mass origins. In particular, we used CO and CO_2 to disentangle polluted and non-polluted air masses.
Observations in the boundary layer suggest a marine source for particles, such as sea spray aerosol and organic particulate matter, especially trimethylamine (TMA). In contrast, pollution plumes with increased fractions of metal-containing particles, accompanied by enhanced CO signals, were measured above the boundary layer up to 4 km altitude. More than 50% of the analysed particle spectra from cloud residuals show signatures of amines, not only TMA but also other amines like TEA (triethylamine). Since the ALABAMA analyses only particles larger than 200 nm, the data set refers only to a subset of all cloud residuals during ACLOUD. Statements on smaller cloud residuals cannot be made. However, the finding that a higher fraction of particles containing TEA is much higher in cloud residuals than in the out-of-cloud aerosol suggests that uptake from the gas phase leads to the high abundance of TEA in cloud residuals. This large abundance of amines in cloud residuals shows the importance of marine-biogenic influences on Arctic cloud processes. The dataset from these observations will further be combined with FLEXPART model simulations to identify source regions for the analysed particles.