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Assessing aerosol-cloud interactions linking ground-based and airborne observations

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Aerosol-cloud interactions should be studied at the cloud level; yet, aerosols (and particularly cloud condensation nuclei) are often measured at ground-based sites owing to high costs and demanding infrastructure associated with routine airborne observations. To reduce the uncertainty of the impact of aerosol particles on the climate, the European Integrated project on Aerosol Cloud Climate and Air Quality Interactions (EUCAARI) integrated multiple aircraft and ground stations to quantify the sources and sinks of regional aerosol and their physical and chemical transformations with respect to their cloud-forming potential. During EUCAARI, simultaneous observations of cloud condensation nuclei (CCN) and lidar aerosol extinction profiles provide a unique opportunity to quantify the vertical distribution of CCN and relate the in-situ measurements to remote sensing observations.

Comparisons between ground-based and airborne in-situ CCN observations indicate that CCN measurements on the ground often over-estimate the concentrations at levels where clouds form at a urban background site in the Netherlands. During the clean background conditions when the air masses originate from the North Sea and cloud bases are relatively low, the boundary layer is well mixed and CCN concentrations at the ground resemble those at cloud base. The difference between ground-based and airborne measurements is especially important at higher concentrations associated with local pollution, when boundary layer mixing timescales are greater than the timescales for transport. In addition, multiple layers of aerosols with different origins related to long-range transport, especially during a Sahara dust episode, further complicate the relationship between in-situ ground-based and airborne CCN measurements. Ground-based and airborne lidar observations detect multiple aerosol layers, provide insight into boundary layer mixing and are useful tools to investigate the relationships between ground-based and airborne measurements.