Title: Nucleation of Water Droplets and Ice Particles in the Earth's Atmosphere

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Abstract: Phase changes are important for the remove of water from the Earth's atmosphere. Cloud condensation nuclei (CCN) serve as the nucleation sites for the condensation of water vapor that results in the formation of cloud droplets. Ice nuclei (IN) convert water vapor or liquid droplets into ice particles. CCN and IN influence cloud formation and precipitation development. Precipitation is an important removal process for atmospheric particles, including pollution particles less than 2.5 μm ($PM_{2.5}$) and soot particles from incomplete combustion. Hence, understanding precipitation development and removal of particles requires accurate measurements of CCN and IN properties. Commercially supported CCN instrument have been available for 15 year; while IN instrument are just becoming commercially available. Making accurate CCN measurements requires accurate calibrations using a consistent methodology, but more detailed calibration conditions are necessary when taking aircraft measurements. Furthermore, the calibration uncertainties are required to compare measurements from different field projects. Recent laboratory evaluation of the Droplet Measurement Technologies (DMT) CCN Counter shows uncertainties in the calibration of the DMT CCN counter exist in the flow rate and supersaturation values primarily. The concentration depends on the accuracy of the flow rate calibration, which does not have a large (4.3 %) uncertainty. The supersaturation depends on chamber pressure, temperature, and flow rate. The supersaturation calibration is a complex process since the chamber's supersaturation must be inferred from a temperature difference measurement. Additionally, calibration uncertainties can result from the Köhler theory assumptions, fitting methods utilized, the influence of multiply-charged particles, and the temperature differences used by the calibration method. The supersaturation calibration uncertainty is 2.3, 3.1, and 4.4 % for calibrations at 700, 840, and 980 hPa respectively. However, the supersaturation calibrations done at UND is 42-45 % lower than supersaturation calibrations done at DMT approximately 1 year previously. Performance checks confirmed that all major leaks developed during shipping were fixed before conducting the supersaturation calibrations. Multiply-charged particles passing through the Electrostatic Classifier may have influenced DMT's activation curves, which is likely part of the supersaturation calibration difference. Furthermore, the fitting method used to calculate the activation size and the limited calibration points are likely significant sources of error in DMT's supersaturation calibration. While the DMT CCN counter's calibration uncertainties are relatively small, there is major difference between the UND and DMT calibration. The insights gained from the careful calibration of the DMT CCN counter indicate that calibration of scientific instruments using complex methodology is not trivial. However, to further our understanding of important atmospheric processes, such as the nucleation of water and ice, requires accurate measurements, which depends on accurate calibration. Ensuring measurements of sufficient accuracy to support our scientific conclusion, requires careful work by scientists.