NCAR-ACD Particle profile measurements for detecting nucleation-sized particles aloft.

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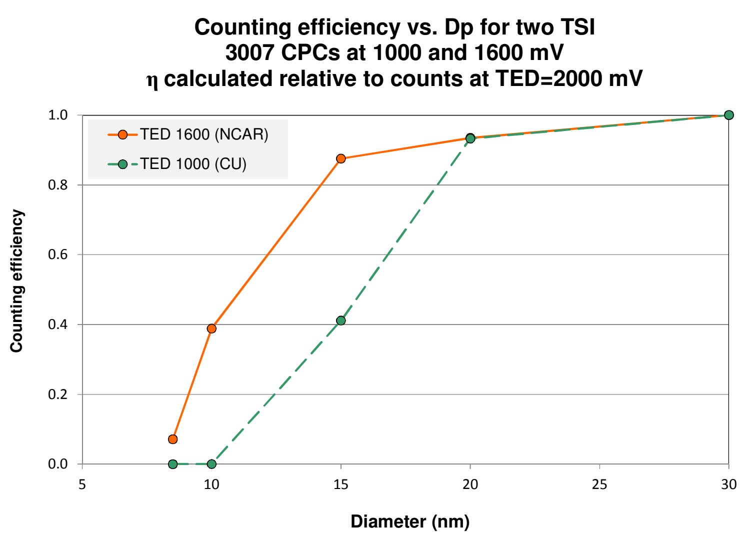
Instrument Description and Background:

NCAR-ACD will operate two hand-held condensation particle counters (CPC) on the PISA profiling instrument carriage at the Boulder Atmospheric Observatory (BAO). The CPC allows detection of sub 100 nm particles by exposing the particle-containing sample air stream to a warm saturated alcohol vapor. The air stream is then cooled using a thermal electric device (TED) causing the alcohol to condense onto the particles, which causes them to grow in size. Once particles grow to ~100 nm, they can be detected using an optical particle counter. The voltage applied to the TED directly affects the temperature difference between the saturated and condenser regions within the CPC, which thus determines the particle sizes that can be detected. Figure 1 below shows the experimentally-determined counting efficiency of two of these CPCs for diameters between 8.5 and 30 nm when operated at either 1600 or 1000 mV TED voltages.

Figure 1: Counting efficiency of two hand-held TSI model 3007 CPCs determined from mono-dispersed ammonium sulfate particles.



When new particle formation events are observed, it is often unclear whether the event has happened locally, or either some distance upstream of the measurement site or aloft. By operating the two counters at different TED voltages, one can infer the difference in the particles as a proxy for small (Aitken mode) particles. Because measurements occur at 1 Hz, this can be observed as a profile. This information along with concurrent measurements can provide insights into atmospheric structure and conditions that cause new particle formation. This approach has been applied by NCAR using a tethered blimp in Oklahoma at the Southern Great Plains DOE Atmospheric Radiation Measurement (DOE ARM) site and was useful for showing that newly formed particles can occur aloft prior to observations at the ground surface.

To ensure that this approach is valid, it is important to verify that the two CPCs that are used agree at the same TED voltages. Figure 2 shows the performance of two of these same units (TSI model 3007). The two traces show the particle concentrations in number per cm^3 as the TED voltage was varied from 1000 to 1999 mV. The measurements of the two counters are indistinguishable at all TED voltages from 1000 mV to 1600V. The last dashed rectangle (from ~61900 s to 63500 s) indicates the conditions in which the TED voltage of one CPC (red trace) was set to 1000 mV, while the other (blue trace) was set to 1600 mV. During this time period, higher particle concentrations are measured using the latter CPC, and the difference is proportional to the number of particles between ~8 and 20 nm as indicated by the counting efficiency curves shown in Figure 1. Without *a priori* knowledge of the ambient particle size distribution, the true difference in particle number cannot be quantitatively determined. But by observing trends in the difference between these two measurements with concurrent ground-based measurements, this technique is able to determine levels in the atmosphere where small particles are first observed, whether or not they are homogenously distributed vertically, and how the profile changes with time.

Figure 2: Particle number concentrations measured by two hand-held TSI 3007 CPCs operated at varying TED voltages.