A Miniaturized, Lower Cost Static Diffusion Chamber for Cloud Condensation Nuclei Measurements

GAVIN R. McMEEKING1, J. Alex Huffman2, Markus D. Petters3, and Donald Huffman4
1Handix Scientific LLC, Boulder, CO, USA; 2Department of Chemistry and Biochemistry, University of Denver, Denver, CO, USA; 3Department of Marine, Earth, and Atmospheric Sciences, NCSU, Raleigh, NC, USA; 4Tucson, AZ, USA

MOTIVATION and BACKGROUND

- Cloud condensation nuclei (CCN) have important impacts on precipitation, cloud microphysics and climate, but anthropogenic influence remains uncertain.
- Emerging platforms such as tethered and free balloons, unmanned aerial vehicles and ground-based measurement networks are providing new opportunities for measuring atmospheric properties.
- The research community lacks a compact, lightweight, low-power and accurate instrument for measuring CCN, despite its importance.
- Static thermal gradient diffusion chambers (STGDCs) are an established accurate instrument for measuring CCN, despite their importance.

Static thermal gradient diffusion chambers (STGDCs) are an established accurate instrument for measuring CCN, despite their importance. They are capable of measuring a wide range of CCN concentrations, but they are large and require significant energy. Emerging platforms such as tethered and free balloons, unmanned aerial vehicles and ground-based measurement networks are providing new opportunities for measuring atmospheric properties. One limitation to improving understanding is limited measurement opportunities for measuring atmospheric properties.

INITIAL DEVELOPMENTS

- We used a simple droplet growth model to simulate the measurement chamber and inform design decisions. The model will also be used to evaluate laboratory data once it becomes available.

- We thank Ezra Levin and Paul DeMott for their assistance with the CCN project. We also thank Tim Gordon for his advice on design of the CCN measurement chamber. Matt Freer contributed to aspects of the image processing and analysis software.

- Laboratory evaluation of measurement chambers will begin by the end of June and will involve size-selected measurements of ammonium sulfate.
- Comparisons with the DMT CCN-100 instrument are planned for July/September.
- Environmental testing and calibration stability will be evaluated for July/September.

REMAINING PHASE I WORK

INSTRUMENT SIMULATIONS

- We used a simple droplet growth model to simulate the measurement chamber and inform design decisions. It will also be used to evaluate laboratory data once it becomes available.

- Figure 4a. (left) Theoretical super-saturation profile for an approximately 3.5 degree temperature difference between top and bottom plates. (right) Droplet trajectories predicted for a random distribution of particles seeded into the measurement chamber. Particles that do not activate remain suspended, while activated droplets grow and fall to the lower plate. Trajectories for particles originating below 4 mm are not shown for clarity.

INSTRUMENT SIMULATIONS

- We used a simple droplet growth model to simulate the measurement chamber and inform design decisions. It will also be used to evaluate laboratory data once it becomes available.

- Figure 4a. (left) Theoretical super-saturation profile for an approximately 3.5 degree temperature difference between top and bottom plates. (right) Droplet trajectories predicted for a random distribution of particles seeded into the measurement chamber. Particles that do not activate remain suspended, while activated droplets grow and fall to the lower plate. Trajectories for particles originating below 4 mm are not shown for clarity.

REFERENCES


ACKNOWLEDGMENTS

Microfluidic INP development: DOE SBIR Phase II (DE-SC0018474)

We thank Ezra Levin and Paul DeMott for their assistance with the CCN project. We also thank Tim Gordon for his advice on design of the CCN measurement chamber. Matt Freer contributed to aspects of the image processing and analysis software.

Figure 1. Basic schematic showing key components of a static thermal gradient diffusion chamber (STGDC). Sample aerosol are introduced between two moist plates with a known temperature gradient, which leads to a supersaturated region between them. CCN activate into large droplets that can be detected by a digital camera located perpendicular to the illumination laser beam.

Figure 2. (top) Number of activated particles located within a 2 mm viewing region as a function of time and peak chamber supersaturation. At low supersaturations, INP are the windows for the illumination laser (left) and window for viewing droplets by the digital camera (off-screen, right). The chamber measures approximately 2 inches in diameter by 1 inch high.

Figure 3. Screen capture showing activated droplets in an early version of the CCN measurement chamber with glass walls.

Figure 4. Photograph showing newly developed electronics for operating the CCN chamber, including temperature measurement and control. The board is designed for easy integration with a Raspberry Pi single-board computer.

Figure 5. Photograph showing newly developed electronics for operating the CCN chamber, including temperature measurement and control. The board is designed for easy integration with a Raspberry Pi single-board computer.