Proof of Concept: Cloud Condensation Nucleus Counter for Unmanned Aircraft Systems

Dr. David J. Delene

Department of Atmospheric Sciences University of North Dakota

Objectives

- Development of a prototype miniaturized Cloud Condensation Nucleus (CCN) counter for Unmanned Aircraft Systems (UAS).
- Evaluation of markets for a follow on proposal.



View of Rain from Aircraft on July 8, 2012

View of Rain on July 12, 2012

Cloud Condensation Nuclei (CCN)

Particles that water vapor condenses upon to

form liquid cloud droplets.

Droplet Measurement —— Technology's (DMT) Counter

University of Wyoming (UWyo) Counter





North Dakota, Cloud Base, Summer 2012



Statistical distributions near cloud base of 30 s 1 % supersaturation (counter's theoretical value) Cloud Condensation Nuclei (CCN) concentrations adjusted to standard temperature and pressure obtained during the 2012 North Dakota project. The solid circle is the mean value, the horizontal line is the 50th percentile, the top of the box is the 75th percentile, the bottom is the 25th percentile, and the top and bottom of the whiskers are the 95th and 5th percentiles, respectively.

Proposed Technology





Laboratory Evaluation of Prototype Counter



Uwyo CCNC - University of Wyoming Cloud Condensation Nuclei Counter

Direction of Water Flow

Direction of Air Flow

Technology Advancement Piezo Film Sensor

- Allows Detection of Individual Droplets
- Enables Multiple Supersaturation Measurements in One Instrument
- State-of-the-Art Electronics and Software
 - Small, Robust and Simple Instrument



Summary of Potential Markets

- Research Applications
 - Laboratory, surface, aircraft, and UAS
- Weather Modification Operations
 - North Dakota and Around the World
- Environmental Monitoring
 - Measurements at surface stations, on commercial aircraft and from UAS platforms
- Advanced Electronic Manufacturing
 - Particle monitoring in clean rooms.
- Indoor Air Quality Monitoring
 - Monitor the quality of air inside buildings.



Research Applications

- One commercially available cloud condensation nuclei (CCN) counter.
 - Available since 2002
 - Sold over 100 Units, Mostly Labs
 - Price is Approximately \$70,000
- A smaller, less expensive, instrument that is capable of multiple supersaturation measurements would be able to compete effectively in this existing market.
 - There is interest from University's Center for Unmanned Aircraft Systems in flight testing.



Weather Modification Operations

- Operational weather modification programs are starting to routinely conduct hygroscopic cloud seeding.
 - The Texas program uses hygroscopic seeding.
 - North Dakota is researching hygroscopic seeding.
 - China has more than 50 cloud seeding aircraft.
- Cloud condensation nuclei measurements are key for an efficient hygroscopic cloud seeding operation.



Countries conducting weather modification projects. (Courtesy of Timm Uhlmann)

Environmental Monitoring

- Cloud condensation nuclei (CCN) measurements are critical to understanding precipitation development and climate change.
 - CCN can not be measured by satellites; hence, surface and airborne measurements are required.
 - Europe has started measuring particles from commercial aircraft.
- A CCN counter is the only method for monitoring this important parameter.

Environmental monitoring site in Fargo, North Dakota



Advanced Electronic Manufacturing

- Advanced electronics are manufactured in clean rooms that require very low particle concentrations.
 - Condensation particle counters (CPC) are currently used to continuously monitor particle concentrations in clean rooms.
 - CPC sell for \$15,000-\$30,000.
- A cloud condensation nucleus counter operated at a high supersaturation is able to detect very low particle concentrations.



Image from www.cleanroombuilders.com

Indoor Air Quality

- The Environmental Protection Agency (EPA) has concerns about the human health impacts of particles in buildings.
 - High concentrations of particles that penetrate into the lung is one of the most important air quality issues in the United States.
 - Particle concentrations in building is very important since people spend most of their time indoors.
- A cloud condensation nucleus (CCN) counter could be use to monitor the air quality in buildings.



Conclusion

- The Piezo film sensor cloud condensation nucleus counter is new technology that originated at the University of North Dakota.
- The implementation of an advanced Piezo film sensor is a significant technological advancement.
- The technology has application in research, weather modification, environmental monitoring, electronic manufacturing and indoor air quality.
- There is interest in commercialization of the counter by a North Dakota based company and interest in licensing the technology by a Colorado based company.

Questions, Comments and Discussion

11/1