Remotely Operated Cloud Condensation Nucleus Spectrometer for RPA Applications

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LONG-TERM GOALS

The long term goal is to examine the nature and various roles of cloud condensation nuclei (CCN) in the atmosphere. The primary scientific interest is the role of CCN in climatically important atmospheric processes. Other potential interests include the impact of aircraft and spacecraft on the upper atmosphere.

OBJECTIVES

The first objective is to build a CCN spectrometer for use on remotely piloted aircraft to measure CCN spectra (CCN concentration as a function of critical supersaturation). The next objective is to use this novel instrument in the 2nd Aerosol Characterization Experiment (ACE-2) field campaign onboard the CIRPAS Pelican aircraft to further our understanding of the relationship between CCN and climate.

APPROACH

Previous CCN instruments are unsuitable for remotely piloted aircraft studies, either because the rate of data acquisition is very low (order of tens of minutes per spectrum) or their weight and power requirements are prohibitive. Through careful design, we aim to construct a high frequency and high resolution CCN spectrometer with large supersaturation and concentration measurement ranges which also satisfies the constraints of remotely piloted aircraft instrumentation, i.e. robustness, automated operation, and low power, weight and volume requirements.

Using the Pelican platform, data was acquired during the ACE-2 campaign. Of greatest interest are the cloudy column flights where the Pelican made measurements below a stratiform cloud while other

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aircraft flew in-cloud (Meteo-France Merlin) and above cloud (DLR Dornier). The Pelican measurements permit an attempt at local closure between size and chemical composition measurements and CCN data, while the multi-platform approach examines relationship between below-cloud CCN and climatically important cloud properties (droplet number distribution, effective radius, liquid water content, and cloud albedo).

WORK COMPLETED

The CCN spectrometer has been constructed. It was implemented during the ACE-2 campaign and data was collected for most of the Pelican flights (TF08 to TF23). The main problem experienced was that the calibration curve did not appear to remain constant during the duration of the experiment, varying even within a single flight, a problem that was only identified after the end of the campaign. We are unable to correct the ACE-2 data for this problem and as a result the CCN spectra have very large associated error bars to the extent that they would at best be of extremely limited use. It was decided that instead of spectra, a good data set for a single supersaturation (0.2%) will be generated from the ACE-2 data. In-flight intercomparison data with the CCN instruments onboard the Merlin and the MRF C-130 at this supersaturation show good agreement and thus we have confidence in this data set. We are currently in the process of analyzing the data to examine the relationship between below-cloud CCN concentrations and cloud properties as measured by the Merlin. We have greatly improved our understanding of the behavior of the CCN spectrometer and feel we understand the causes of the problems experienced during ACE-2. Therefore, we are currently also implementing design changes to the spectrometer in order to greatly improve its performance, focusing particularly on robustness and resolution, for future projects.

RESULTS

The use of the CCN spectrometer during ACE-2 taught us a great deal relating to the capabilities and performance of this instrument. The instrument worked well as a single 0.2% supersaturation instrument during ACE-2 but did not work well as a CCN spectra measuring device for reasons we have learned from lab experiments conducted after ACE-2. Using this knowledge, the instrument will be modified to produce a significantly improved version. The ACE-2 data are still being analyzed so all scientific results are pending.

IMPACT/APPLICATIONS

If the new version of the instrument performs as expected, reliable and reproducible CCN spectra will be measured. Such data would be extremely useful in understanding the connection between CCN and cloud formation and properties, and ultimately how perturbations in atmospheric CCN might affect climate.

TRANSITIONS

We are in the process of re-designing some components of the CCN performance. Specifically, changes to the optical particle sizing are expected to improve resolution and increase stability.

RELATED PROJECTS

Measuring the atmospheric aerosol size distribution using a combination of the Caltech ACAD (Automated Classified Aerosol Detector) and optical probes (PCASP and FSSP) onboard the Pelican are important in furthering our knowledge of the nature of CCN by allowing a local-closure calculation to be performed.

PUBLICATIONS

None yet.

PATENTS

A patent has been submitted for the CCN spectrometer.

IN-HOUSE/OUT-OF-HOUSE RATIOS

All work was done at Caltech with the exception of some machining.