

Automated Immersion Mode Ice Spectroscopy

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BACKGROUND

Ice nucleating particles (INPs) suspended in the Earth's atmosphere influence cloud properties and can affect the overall precipitation efficiency and predictability of cloud systems worldwide. INPs induce freezing of cloud droplets at temperatures above their normal freezing-point (~-38 C), and at a relative humidity (RH) below the normal freezing RH of aqueous solution droplets at lower temperatures. These INP induced variabilities influence cloud lifetime, phase, as well as cloud optical and microphysical properties. Developing a relational model of INPs in global climate models has proven challenging as existing instrumentation systems either require too much air volume (in real-time flow instruments) or exhibit too much temperature variability (in off-line frozen assay based instruments). Thus, there is a real urgency to address this unmet need.

TECHNOLOGY DESCRIPTION

Researchers at the Scripps Institution of Oceanography (SIO) have developed an updated, high-throughput off-line assay-based system known as the Automated Ice Spectrometer (AIS) to meet this need. They have come up with a novel improvement on immersion mode ice spectroscopy instruments for INP concentrations at specific temperatures of a liquid sample. INP measurements of air samples are made by collecting particles on a filter (or via impinging particles into liquid) and transferring the particles to ultra-pure water. The liquid sample is then distributed in microliter aliquots into a clean 96-well disposable polypropylene sample tray. The sample trays are then inserted into a specially engineered and heat-transfer modeled aluminum block that provides precise, rapid and uniform cooling until the samples are frozen. The freezing point of each well is automatically monitored using a software-controlled, real-time computer vision system designed to leverage optical changes of water droplets to detect freezing events.

This automated system affords greater accuracy than existing human-read approaches, giving greater accuracy and throughput to the instrument. For the first time, heat transfer properties of the INP measurement technique are characterized using a finite-element analysis based heat transfer simulation to improve accuracy of INP freezing temperature measurement. The heat transfer simulation provides a tool to explain the sources of bias in temperature measurements in existing INP measurement techniques, and ultimately explain the observed discrepancies in measured INP freezing temperatures between different instruments. AIS measurements of the standard test dust illite NX are compared against 5 other immersion mode droplet assay techniques that use wet suspensions. The AIS and its characterization of heat transfer properties allows higher confidence in accuracy of freezing temperature measurement, higher throughput of sample analysis, and enables disentanglement of the effects of heat transfer rates on sample volumes from time dependence of ice nucleation.

APPLICATIONS

An automated, computer controlled instrument to study the ice nucleating properties of suspended aerosol particles.

ADVANTAGES

In order to increase sample throughput and improve accuracy of Ice Nucleating Particle (INP) freezing temperature measurement, the exemplary immersion mode AIS both increases sample cooling rates and monitors changes in optical properties of water

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OTHER INFORMATION

KEYWORDS

Automated, cloud formation, computer vision, freezing, supercooled, spectroscopy, ice nucleating particles

CATEGORIZED AS

- ▶ **Environment**
 - ▶ Sensing
- ▶ **Engineering**
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RELATED CASES

2017-073-0

droplets during freezing. This offers advantages over existing instrumentation that are currently available.

STATE OF DEVELOPMENT

A prototype system has been fully tested and been operational for 6 months after going through 2 prototype stages. Samples have been tested against other systems using a particulate standard (Illite NX).

INTELLECTUAL PROPERTY INFO

A provisional patent has been submitted and the technology is available for licensing.

RELATED MATERIALS

- ▶ [Charlotte M. Beall, M. Dale Stokes, Thomas C. Hill, Paul J. DeMott, Jesse T. DeWald, and Kimberly A. Prather. \(2017\). Automation and heat transfer characterization of immersion mode spectroscopy for analysis of ice nucleating particles. Atmospheric Measurement Techniques; Katlengurg-Lindau. Vol. 10, Iss.\(7\),2613-2626. - 07/21/2017](#)

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,557,810	02/11/2020	2017-073

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