

Ice nuclei measurements on the UND Citation - methods, problems and solutions

David C. Rogers¹ Paul J. DeMott² Tony Prenni³ Cindy Twohy³ Mike Poellot⁴ Sarah Brooks²

¹NCAR/ATD
²Colorado State University
³Oregon State University
⁴University of North Dakota
<http://atd.ucar.edu/~drogers>



Research Goals

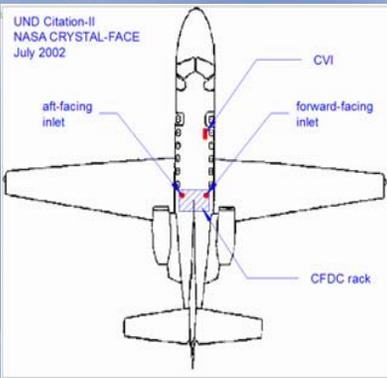
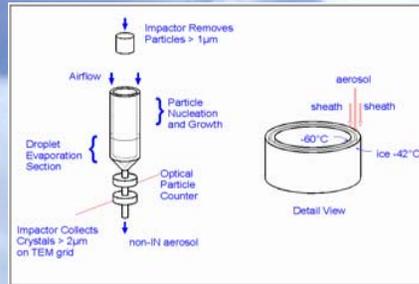
- Characterize ice nucleating activity of ambient aerosol particles + microphysical processes that lead to the formation of cirrus cloud ice crystals
- Derive ice nucleation functional descriptions for modeling:
 $Concentration = f(T, SS, spatial\ distribution, sources)$

Methods

- in-situ aerosol sampling with CSU ice nucleus chamber in UND Citation
- air source options:
sample inlet or CVI (cloud particle residues)

CSU Ice Nucleus Chamber

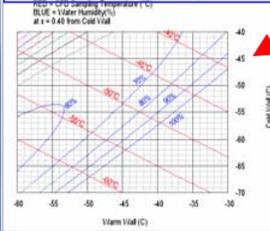
- CFDC (continuous flow diffusion chamber)
- ice-coated concentric cylinders at different temperatures
- cascaded two-stage refrigeration compressor system



Ice nucleus chamber – tight fit in cabin



Sampling TEMPERATURE and HUMIDITY determined by wall temperatures

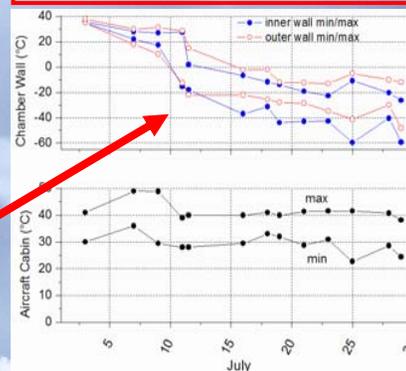


For example, -40C warm wall & -55C cold wall give sampling conditions -49C 90%RH

Problems & Solutions

<p>excess heat in aircraft cabin</p> <ul style="list-style-type: none"> → inadequate heat sink for CFDC refrigeration system → overpressure refrig gas (300 psi) → shutdown 	<ul style="list-style-type: none"> • precool chamber before flight • increase cabin air ventilation <ul style="list-style-type: none"> • add two fans @ 300 cfm each • add ducts to direct airflow ↔ CFDC rack • send all air conditioning to rear of cabin • adjust refrigerant quantities <ul style="list-style-type: none"> – too much Freon → system shutdown from overpressure – too little → insufficient heat transfer
<p>high water vapor in sample air</p> <p><i>plugging of air exhaust piping</i> <i>CVI enhances water vapor content 30x</i></p>	<ul style="list-style-type: none"> • remove vapor from sample stream with diffusion dryers to pass particles • use desiccant cartridges on exhaust
<p>particle activation changes & particle losses in tubing</p>	<ul style="list-style-type: none"> • heat exchange preconditioner • minimize piping lengths • estimate loss corrections from lab tests

Excess heat in cabin limited CFDC operation in first half of project



Summary

Unexpected problems were overcome
 Useful measurements of ice nuclei July 18-29

Future Work

- New & Improved CFDC ??
- Explore options for measuring ice nuclei
- Air flow and particle trajectory modeling
- Air inlet sampling efficiency
 - Nucleation, growth & transport of droplets and ice crystals inside chamber
- Avoid hot cabin problems
- Heat sink outside aircraft ?

Air sample inlet and exhaust



Air flow modeling studies

