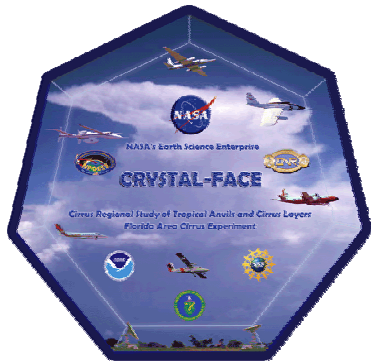


# *In Situ* Studies of Particles that form Atmospheric Ice

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Ice Initiation

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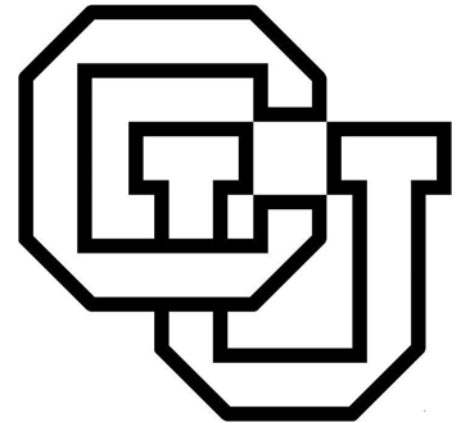
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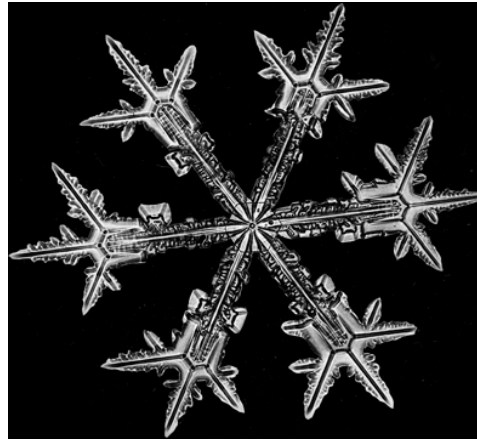
***Division of Atmospheric Sciences***

*Science*

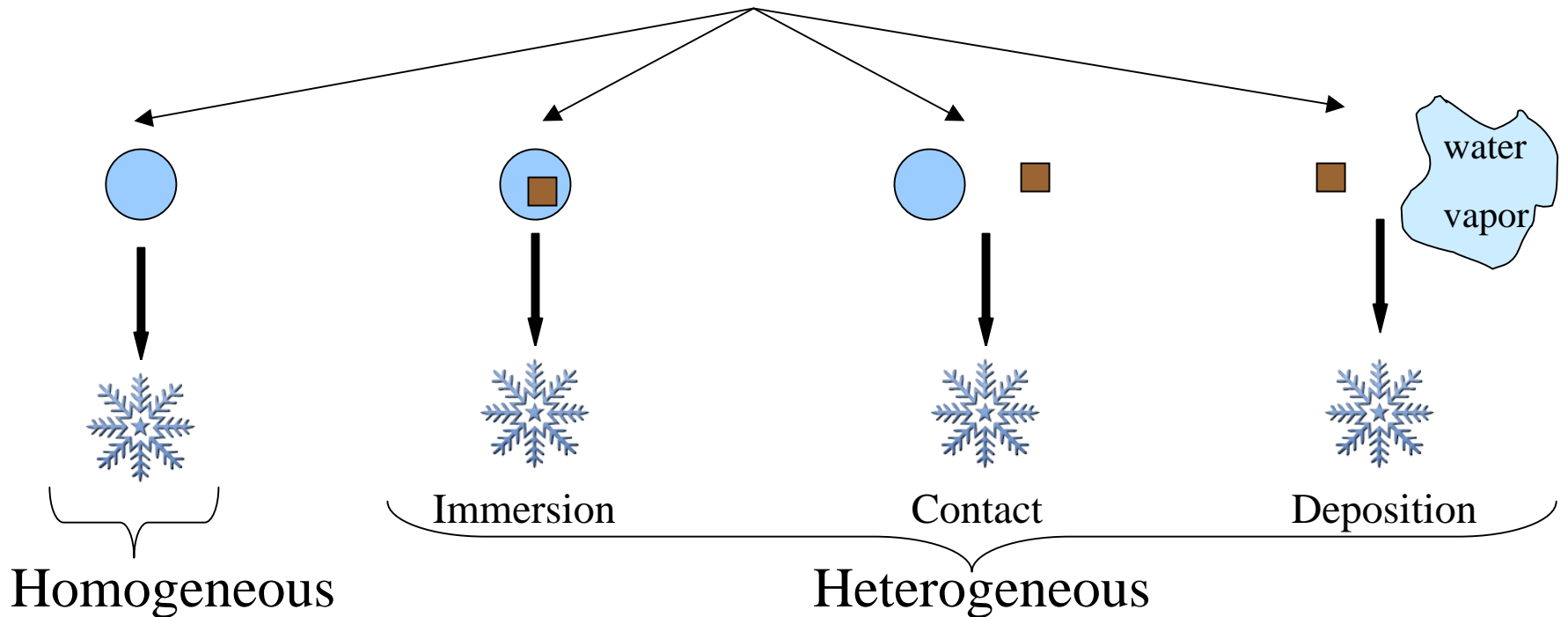
*Environment*

*Solutions*

# We Know Atmospheric Ice Formation is Important...



## But How Does it Occur?



# Ice Forming Particles - Two Methods



## **COLLECTION: Find Some Ice**

Parungo et al., J. Rech. Atmos., X, 1976

Twohy and Gandrud, GRL, 25, 1998

Sheridan and Mussleman, Atmos. Environ., 19, 1985

**Benefit:** Analyzed material is from atmospheric ice

**Problem 1:** What was scavenged after ice formed (gas, particles)?

**Problem 2:** EM; Volatile components are lost

**Problem 3:** Sample collection, prep and analysis

## **GROWTH: Make Some Ice**

Chen et al., GRL, 25, 1998

Rogers et al., JGR, 106, 2001

**Benefit:** Precludes scavenging events

**Problem 1:** MUST sample relevant particles

**Problem 2:** EM; Volatile components are lost

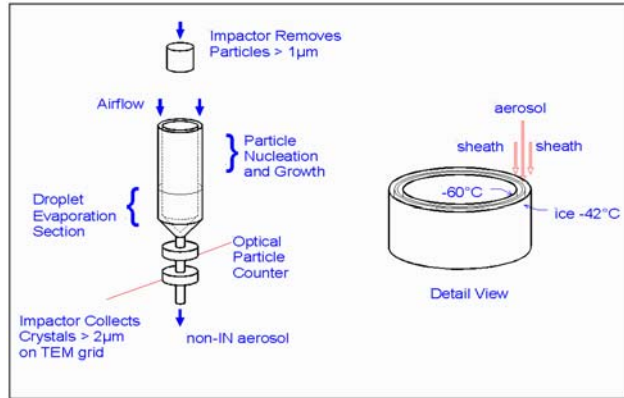
**Problem 3:** Sample collection, prep and analysis

Is it possible to determine the chemical composition of ice-forming aerosols *in situ* and without artifacts (loss or addition of material)?

# Experiment # 1 : Make Some Ice

(Remote Mountaintop)

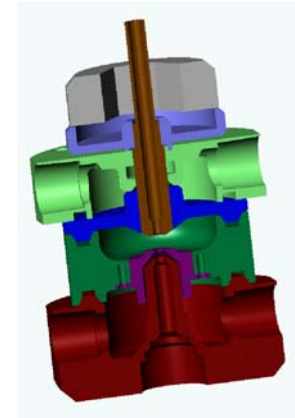
CFDC



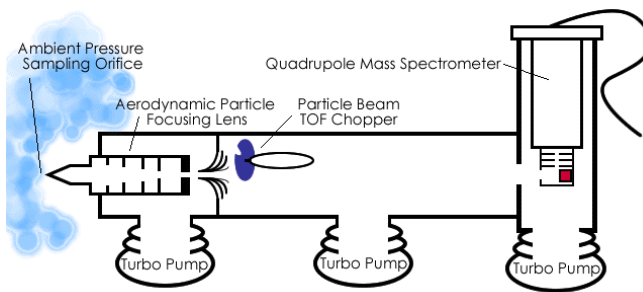
Ice Formation



LCVI

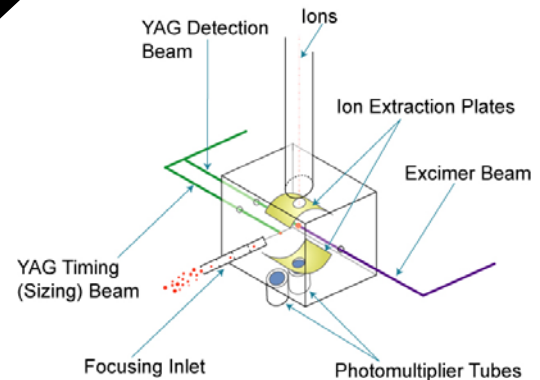
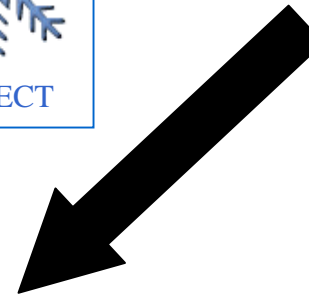


Inertial Separation



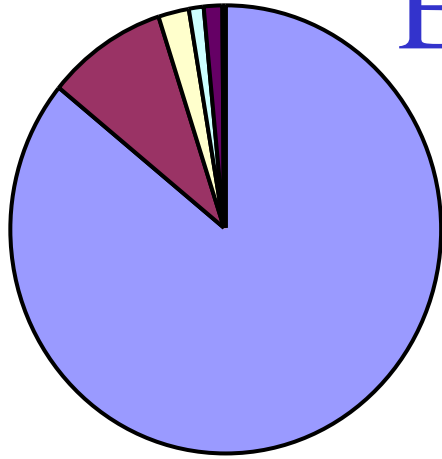
AMS

Mass  
Spec

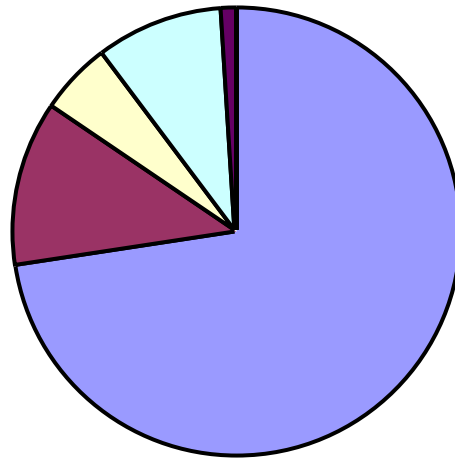
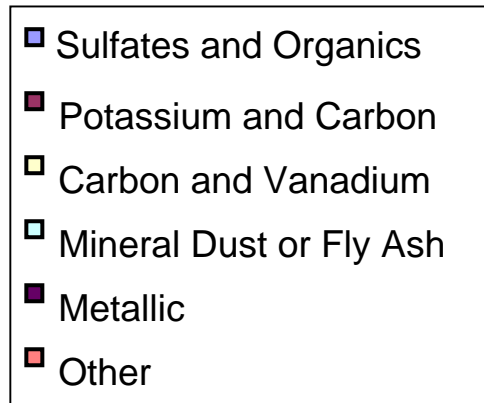


PALMS

# Experiment # 1 : Results

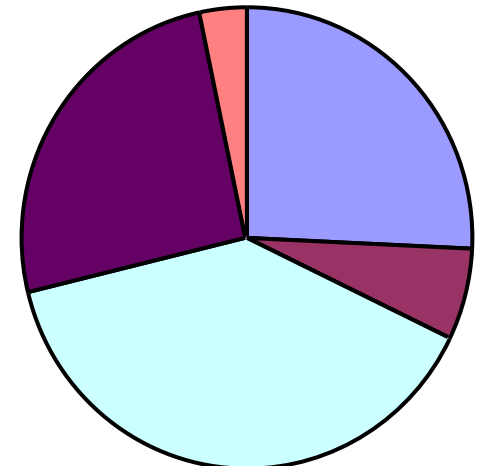


The **background aerosol** (no freezing) was predominantly sulfate/organics with some biomass burning. Minimal refractory particles.



Under **homogeneous** freezing conditions, at which point sulfates freeze, composition resembled the background aerosol...

Under **heterogeneous** conditions (highest temperature and lowest saturation) refractory particles dominate.

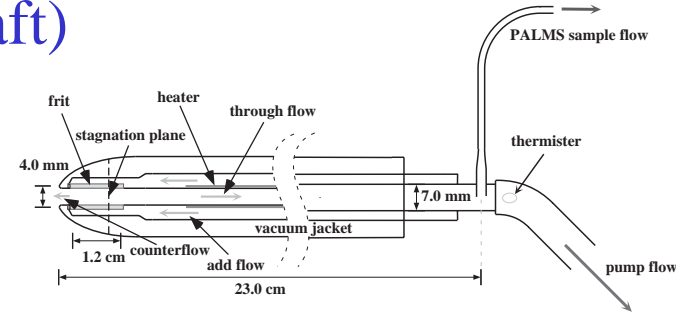
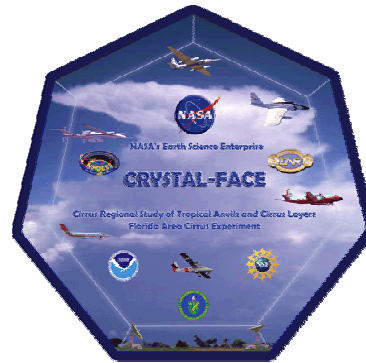


# Experiment # 2 : Find Some Ice

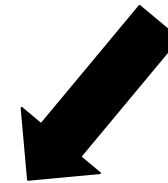
(High Altitude Aircraft)



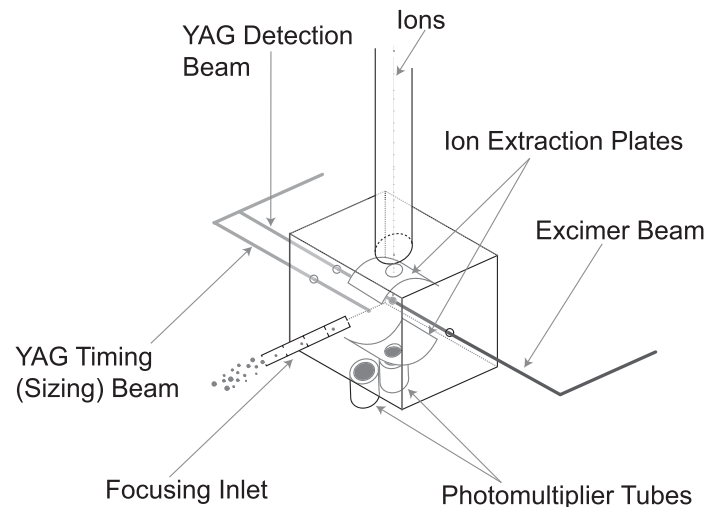
Ice Cloud (Cirrus)



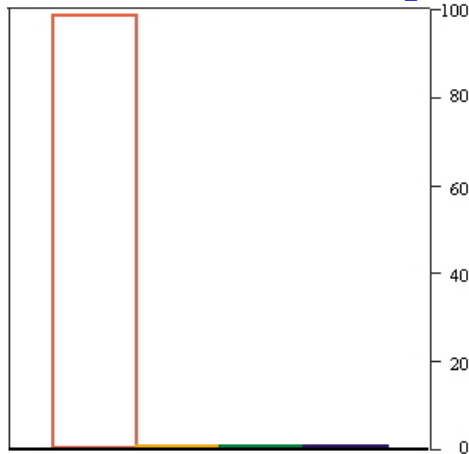
Inertial Separation



PALMS

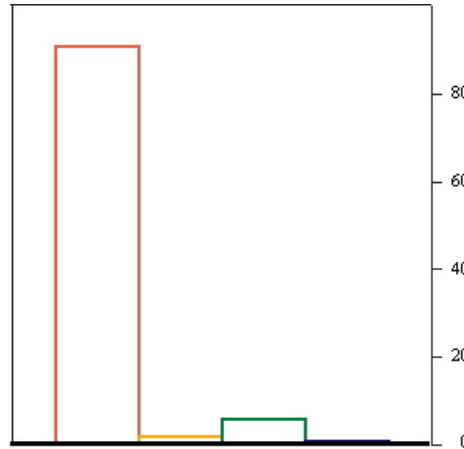


# Experiment # 2 : Results



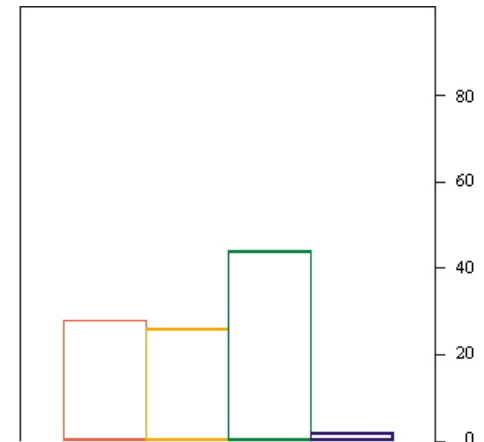
**Background aerosol** was dominated by sulfate/organics.

- Sulfates, K<sup>+</sup>, Organics, NO<sup>+</sup>
- Sea Salt
- Mineral Dust or Fly Ash
- Other



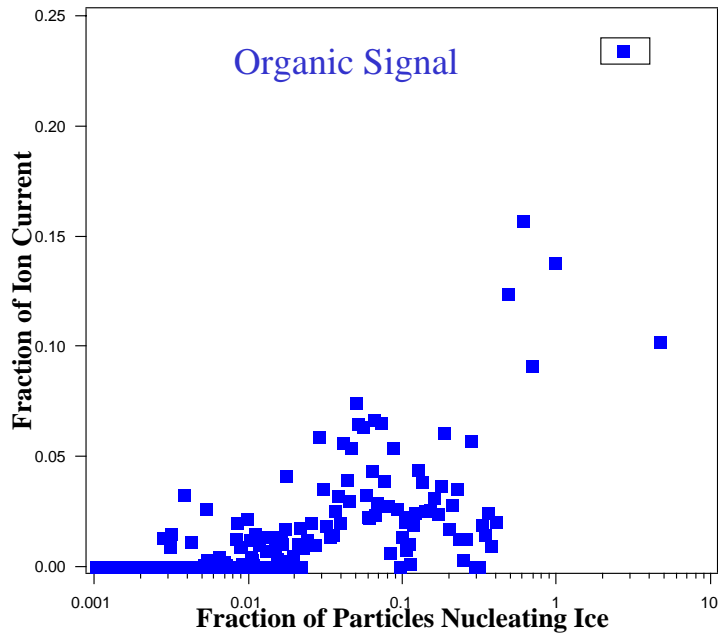
Some clouds (07/09/02) appear to have frozen **homogenously...**

... whereas others contain **mineral dust and sea salt.**



# Other Results of Interest...

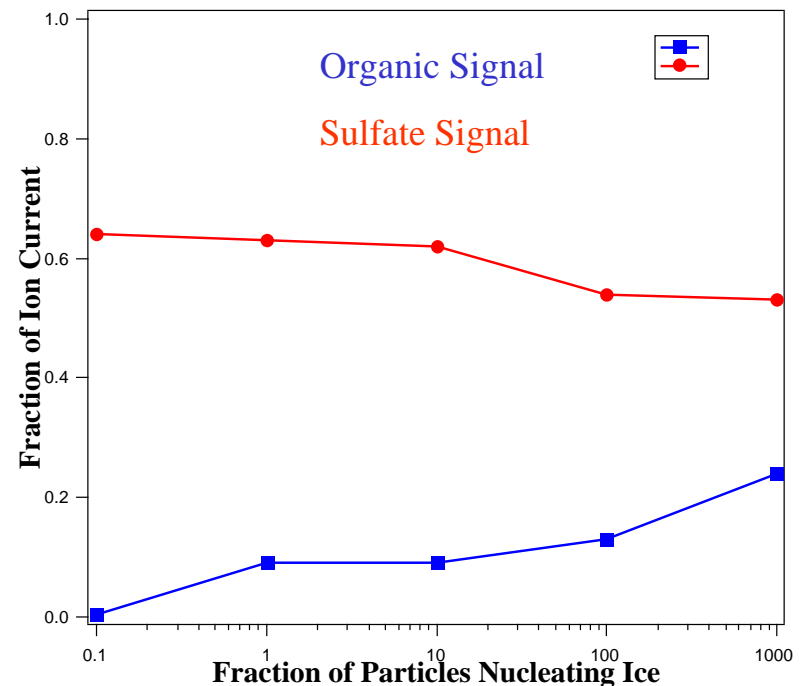
## CRYSTAL-FACE



... shows organics do not partition equally to the frozen and unfrozen phases.

Using mass spec to observe individual components not discernable with EM ....

## INSPECT



# Important Conclusions...

- Both **heterogeneous** and **homogeneous** ice formation are atmospherically **relevant**.
- **Heterogeneous nuclei** originate from a **small subset** of atmospheric particles and most often exhibit minimal volatile material.
  - The **boundary layer** and lower troposphere play an important role in **anvil cirrus formation** (sea salt and mineral dust).
- **Organic components** may **affect ice formation**.