# The North Dakota Polarimetric Cloud Analysis and Seeding Test (POLCAST) Research Project

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# POLCAST Overview

- Why provide funds to fly aircraft around developing storms?
  - Why conduct the POLCAST project?

- How to use aircraft platforms to conduct work?
  - Conducting the POLCAST research project?

- What is the result of burning all that fuel?
  - What did we learn from POLCAST?

# Need for Precipitation

- **90 % of North Dakota is used for farming and ranching that depends on sufficient precipitation (Farm Flavor 2017).**
- **The 2006 drought cost was approximately $425 million.**
- **North Dakota has the highest insurance dollar loss in the United States (Smith et al. 1997).**
    - Possible cost-effective method of mitigating the impact of drought is hygroscopic cloud seeding.

# Effectiveness of Hygroscopic Seeding

- **Hygroscopic cloud seeding in South Africa, Mexico City and Thailand had positive statistical results (Mather et al. 1997; Terblanche 2005).**
- **Convective clouds only transform approximately 10 percent of ingested water vapor into precipitation (Langhans et al. 2015).**
- **Scientific studies indicate that enhancement of water supplies may be possible by modifying the micro-structure of cumulus clouds using aerosols (Levin and Cotton 2008).**
    - It is important to determine if North Dakota is similarly to locations where hygroscopic seeding seems to work.

# Objective

**Research the use of hygroscopic seeding flares for use in the North Dakota weather modification program.**

- Characterization of hygroscopic seeding effects stratified by Cloud Condensation Nuclei (CCN) concentrations using statistical analysis of a randomized experiment.
- Sample environmental and cloud micro-physical properties of target clouds to enable evaluation of suitability of North Dakota for hygroscopic seeding..

**View from Seeding Aircraft on July 8, 2012**

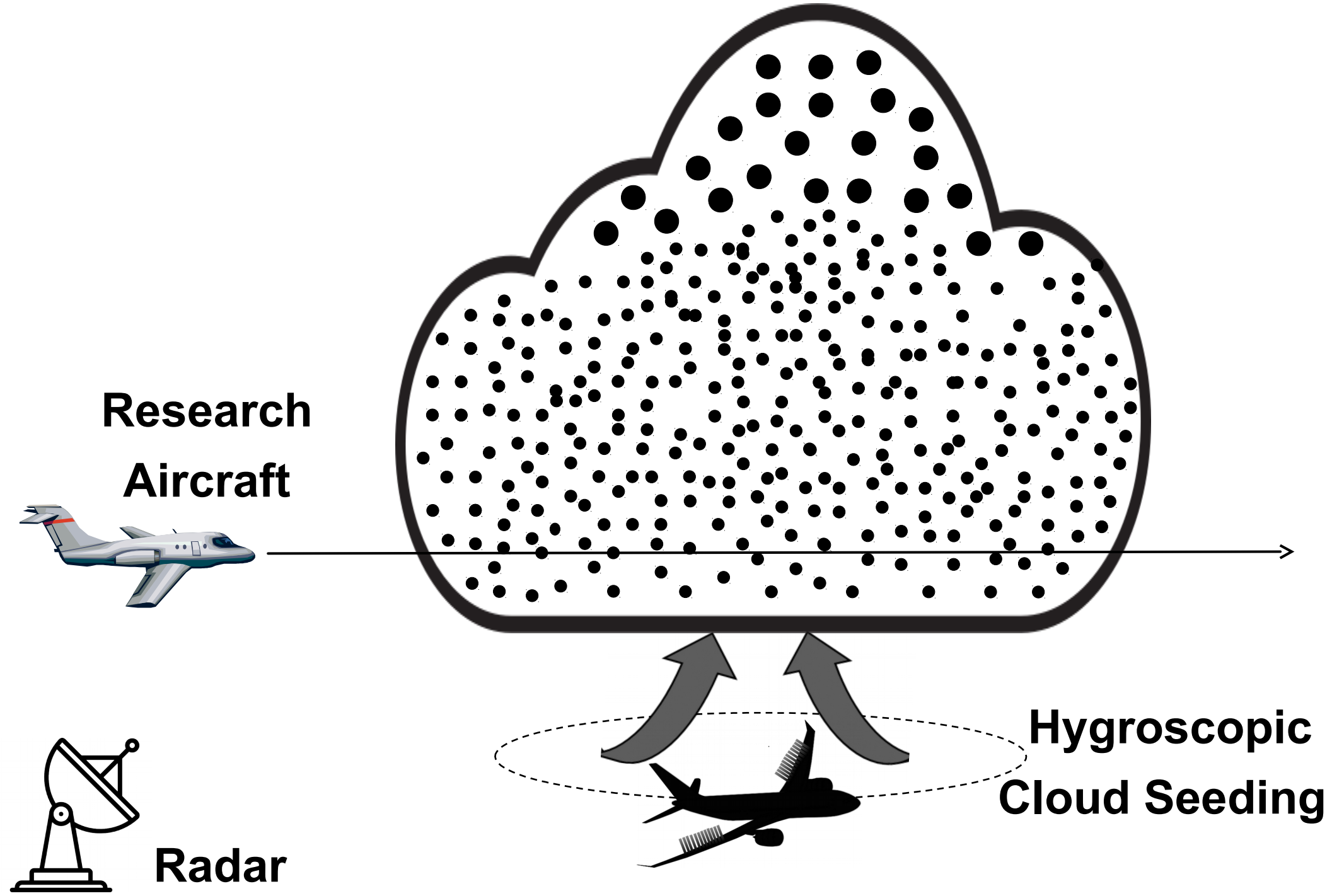
**View of Cumulus Cloud on July 12, 2012**

# Role Playing (Two Person Groups)

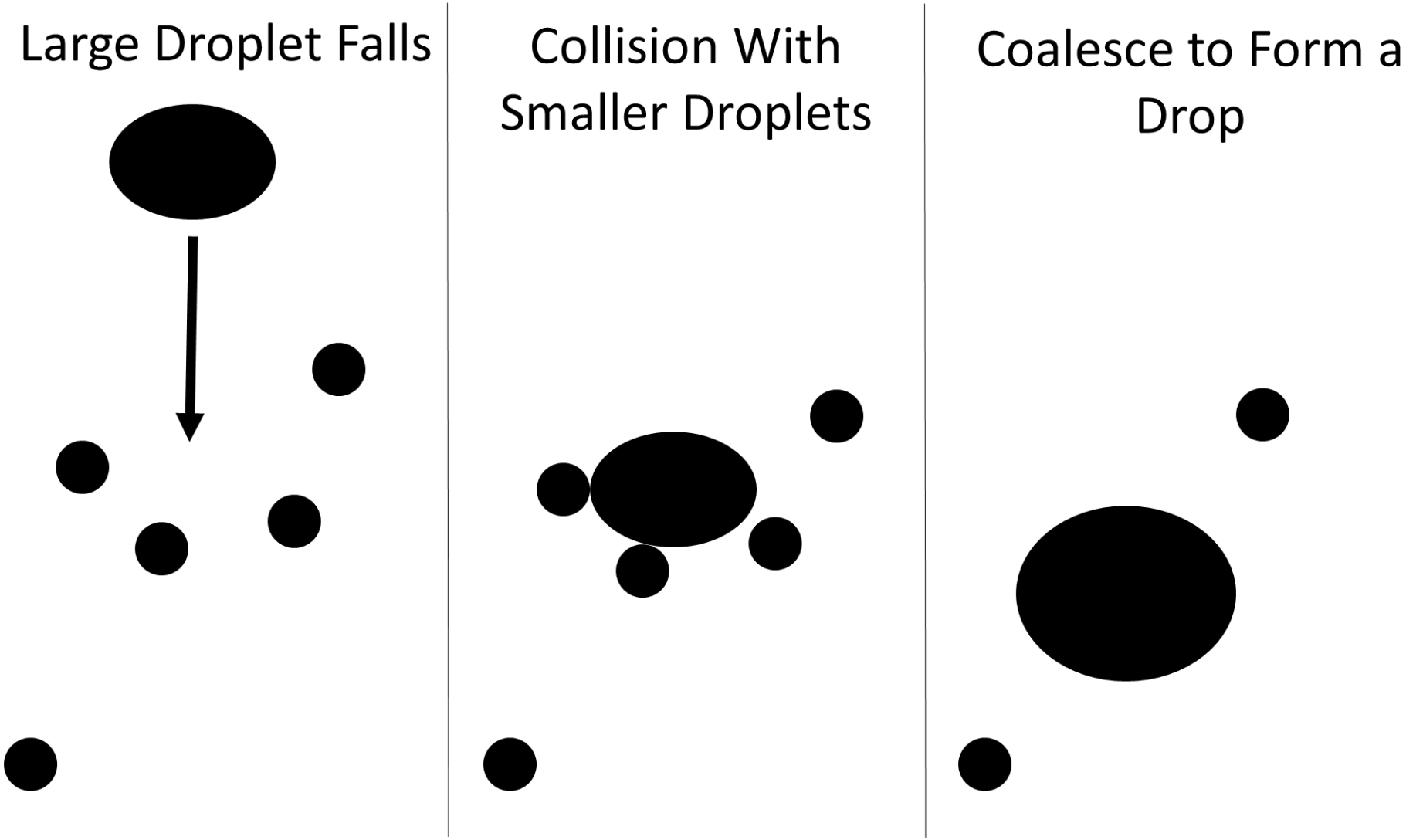
- **Person on the left should explain why they spent the summer in North Dakota flying an aircraft to research seeding with hygroscopic flares to person on right, a Grandparent.**

- **Person on the right, a business person working for cloud seeding company, should explain why the county should fund hygroscopic cloud seeding to person on the left, a County Commissioner.**

# Cloud Seeding Research



# Collision and Coalescence




https://youtu.be/AYg4Y3mZ8cg

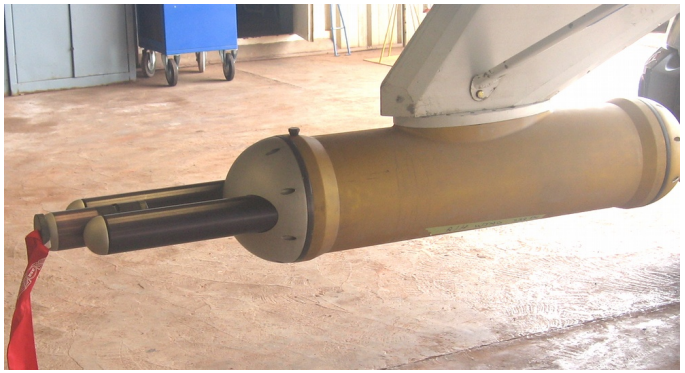
# UND NorthPol Radar

- C-band (5 cm wavelength) Doppler radar
- Dual-polarized Antenna Mounted Receiver
- 28 m Antenna Above Ground
- SIGMET IRIS and TITAN Analysis Software
- Operated Mostly in Full-Volume Mode during POLCAST3

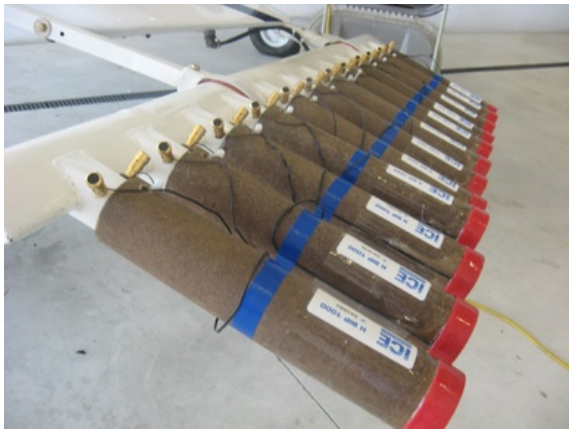
# Cessna 340 Equipment

## CCN Counter


## FSSP

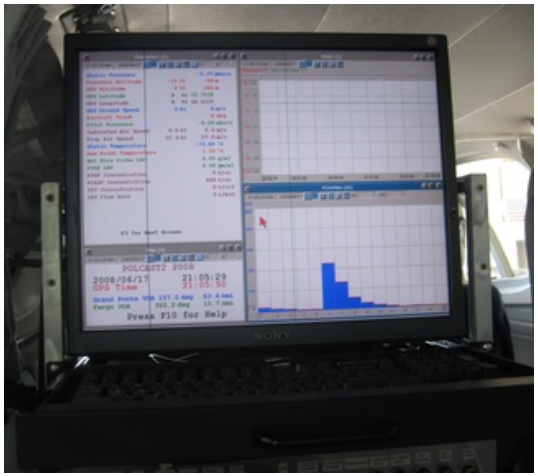


## Flare Rack



## PCASP

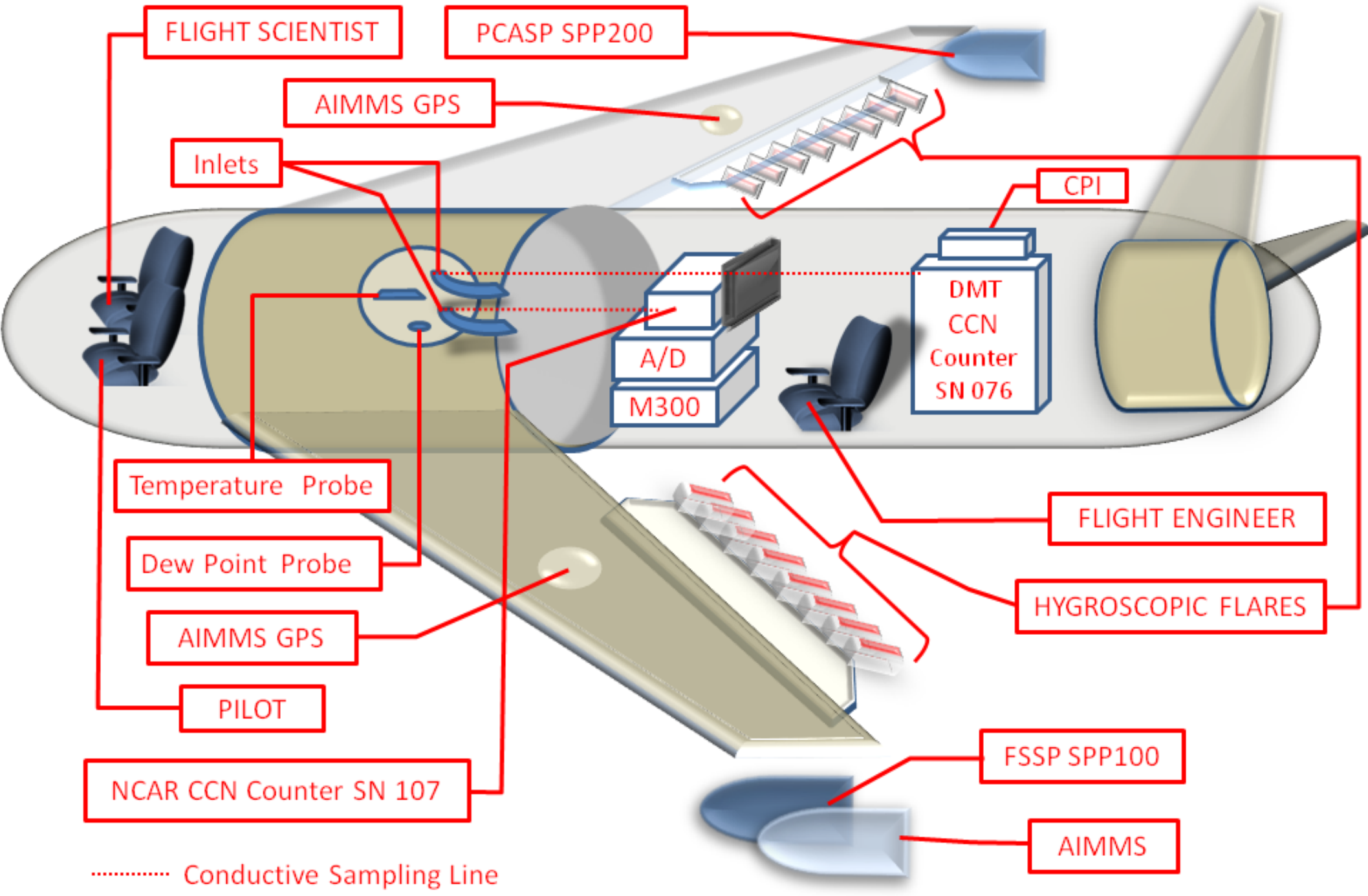
## M300 Display



## Temperature and Hot Wire Probe

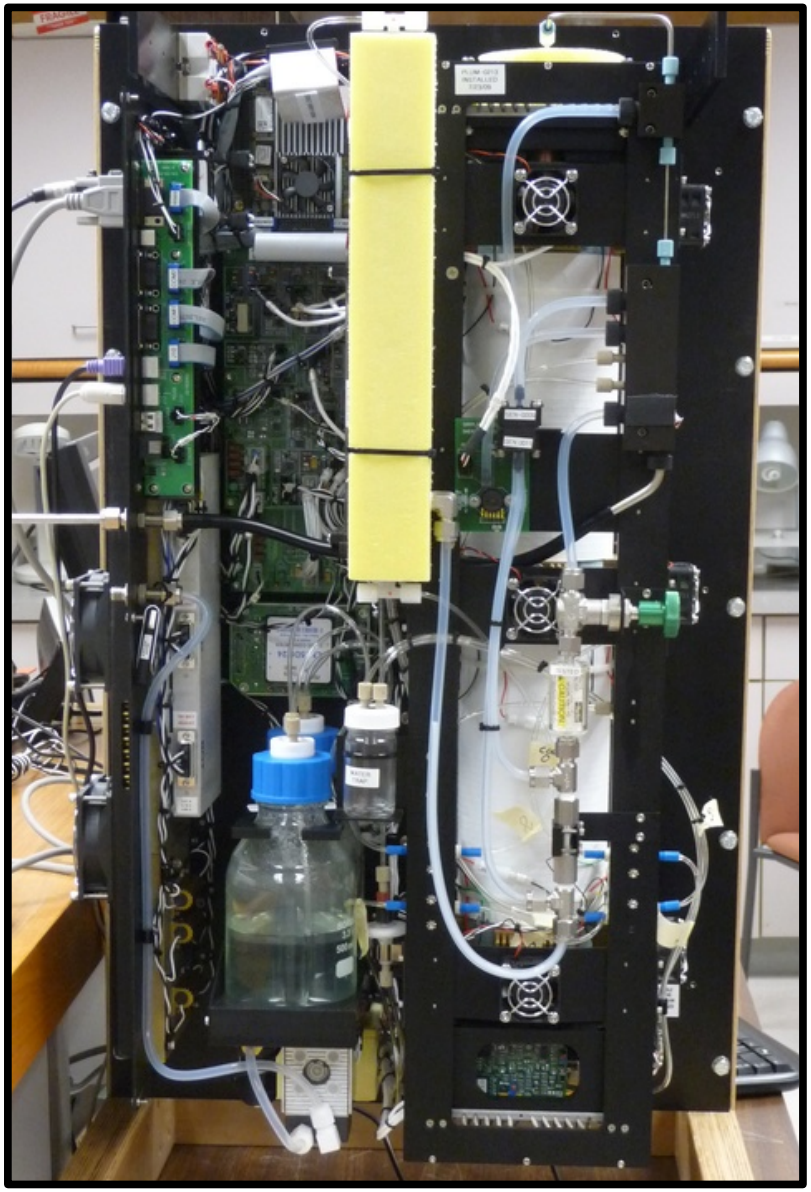
## Dew Point Temperature Sensor Head

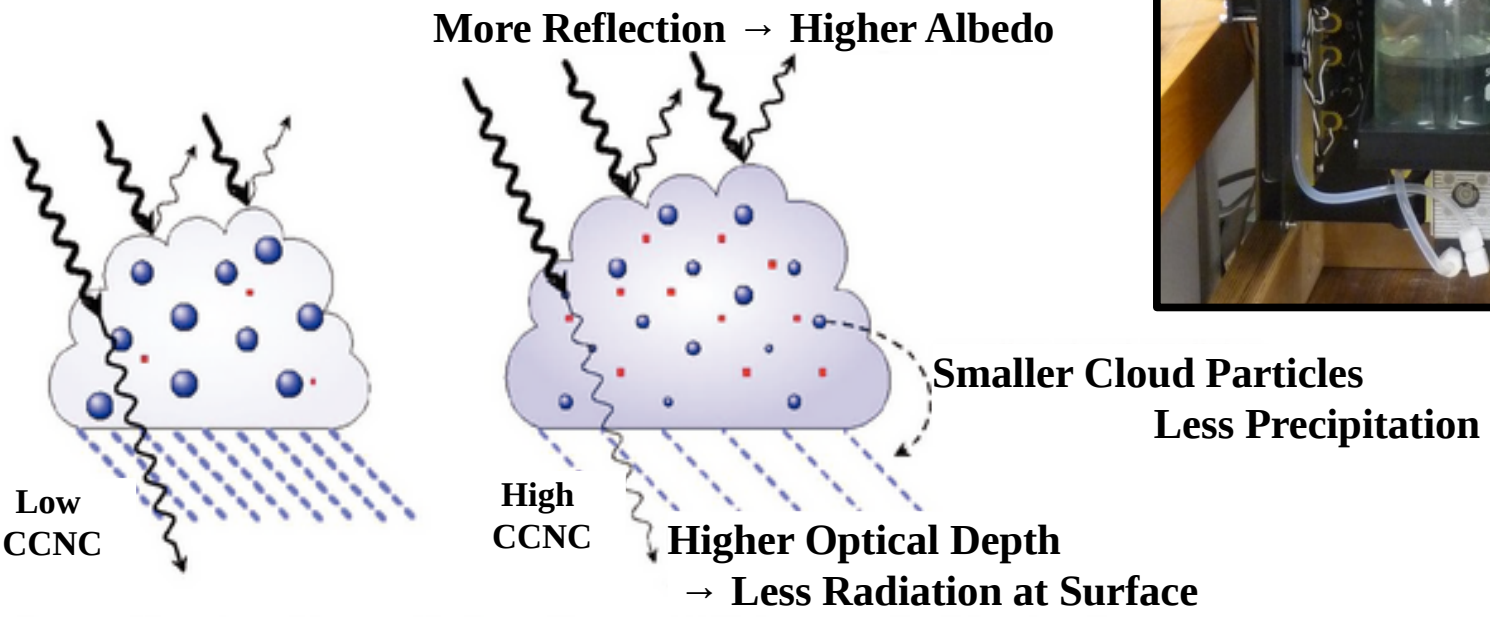
# POLCAST4 CESSNA340 N98585 INSTRUMENT CONFIGURATION



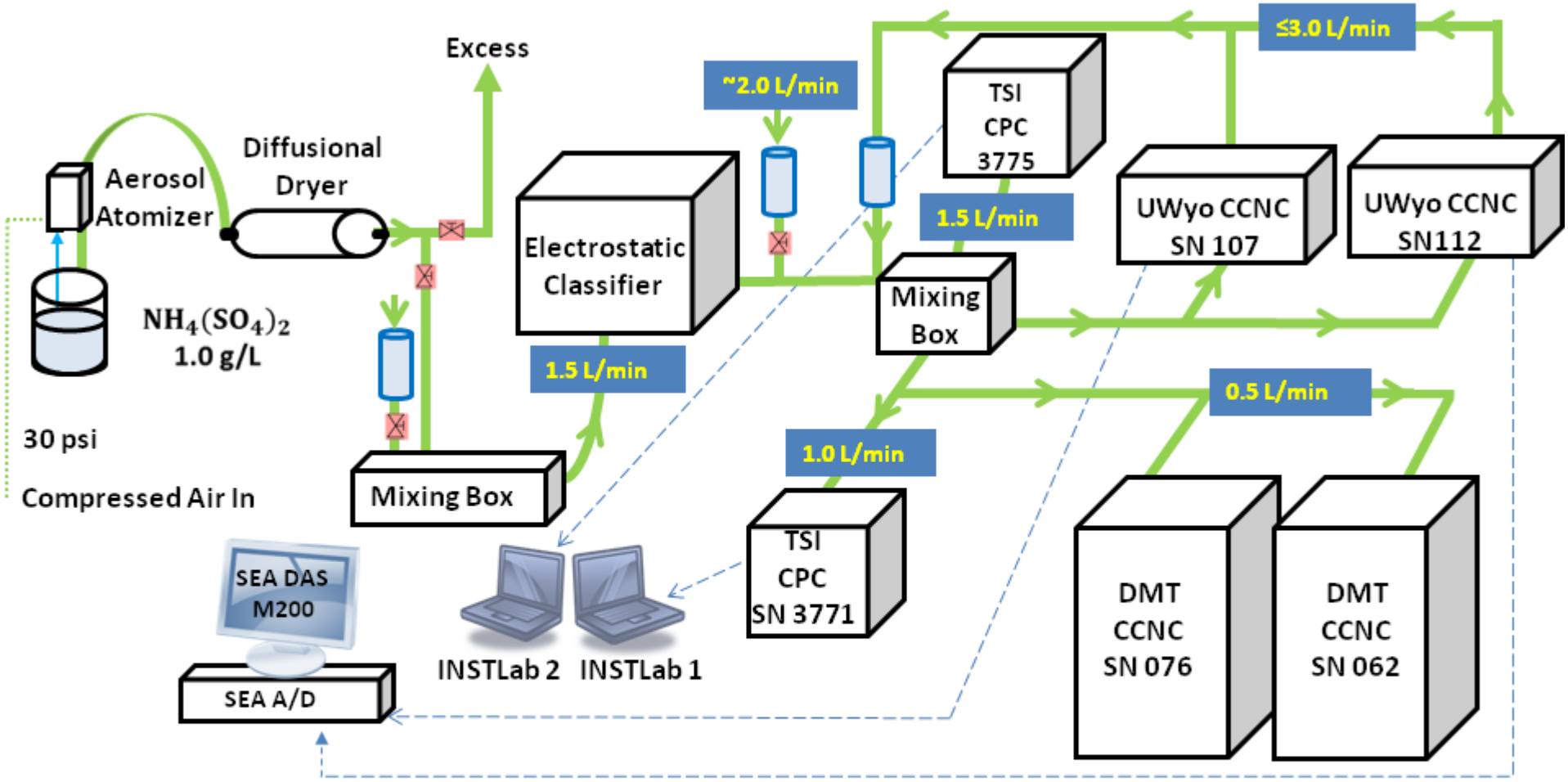
# Aerosol Importance

- Scatter and Absorb Radiation
- Media for Chemical Reactions
- Serve as Cloud Condensation Nuclei CCN)





# CCN Counter Lab Calibration Setup




Interface

Valve

Filter

Direction of Air Flow

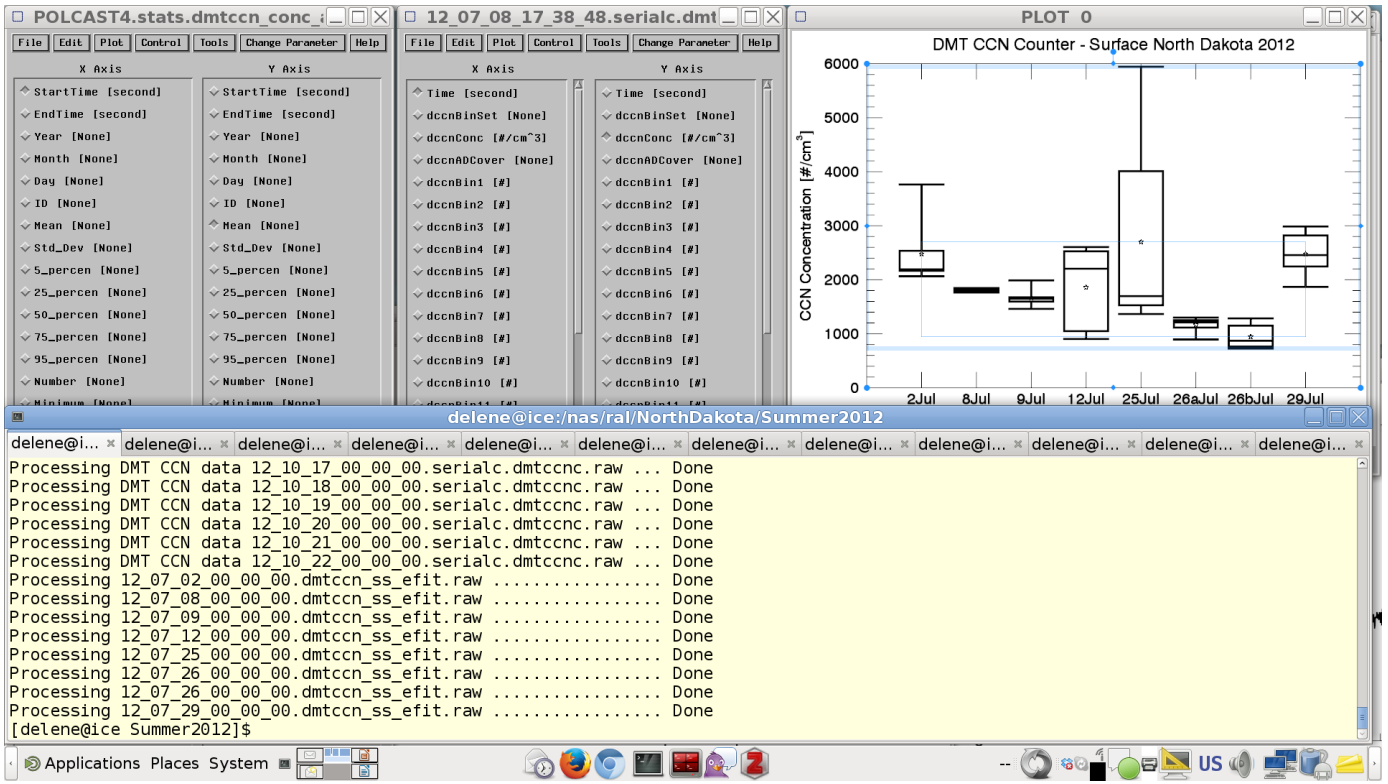
Direction of Water Flow

DMT CCNC - Droplet Measurement Technology Cloud Condensation Nuclei Counter
SEA A/D - Science Engineering Associates Analog to Digital Board
SEA DAS - Science Engineering Associates Data Acquisition System
TSI CPC - TSI Inc. Cloud Particle Concentration
Uwyo CCNC - University of Wyoming Cloud Condensation Nuclei Counter

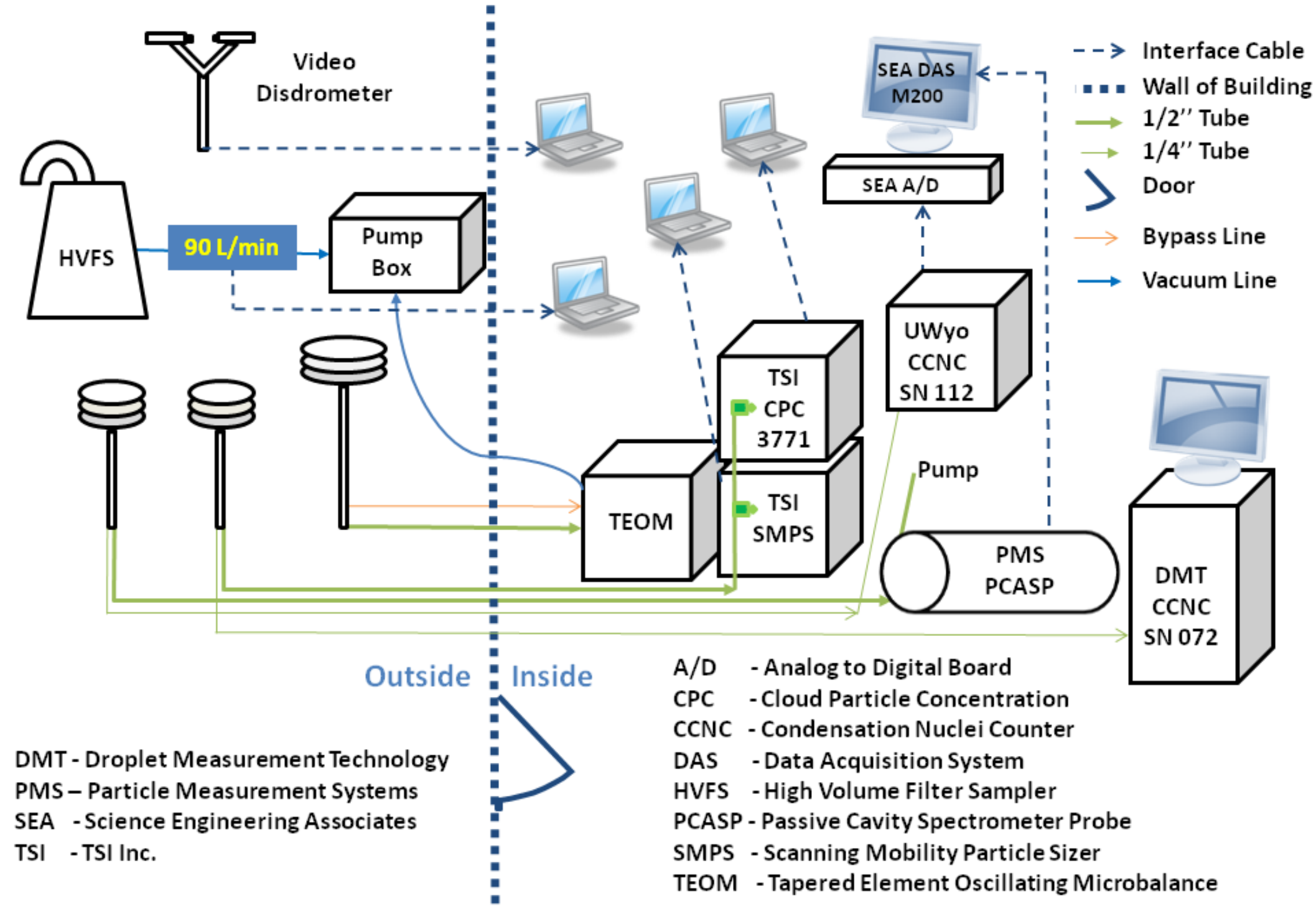
# Software

## Airborne Data Processing and Analysis (ADPAA)

- Open-source software
- Quality control and assurance checks
- Contains a compilation of scripts that can be used on a variety of airborne instruments by different users
- Allows for direct comparison of data sets



# POLCAST4 Surface Measurements: Clifford Hall 601




DMT - Droplet Measurement Technology
PMS – Particle Measurement Systems
SEA - Science Engineering Associates
TSI - TSI Inc.

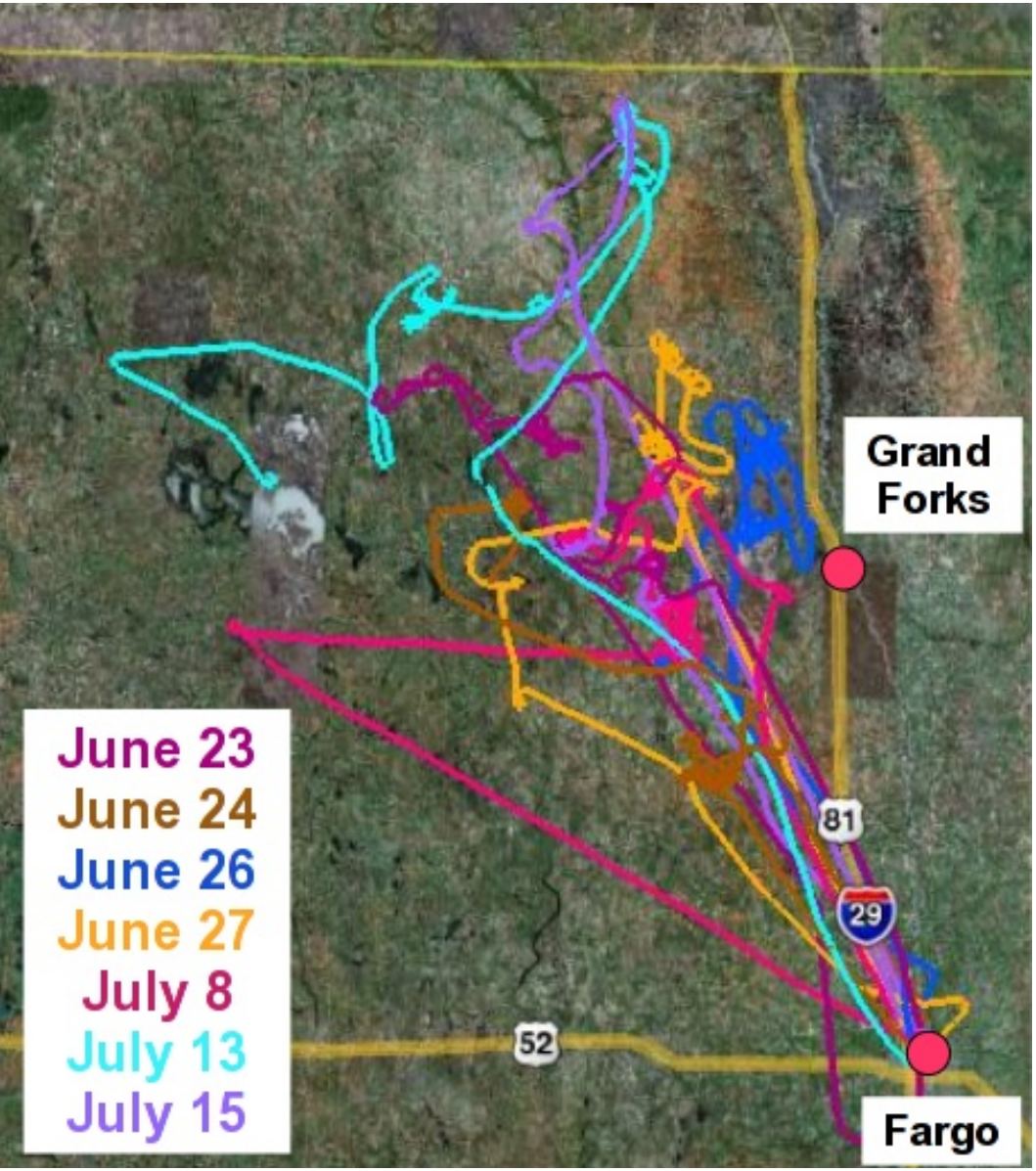
A/D - Analog to Digital Board
CPC - Cloud Particle Concentration
CCNC - Condensation Nuclei Counter
DAS - Data Acquisition System
HVFS - High Volume Filter Sampler
PCASP - Passive Cavity Spectrometer Probe
SMPS - Scanning Mobility Particle Sizer
TEOM - Tapered Element Oscillating Microbalance

# Questions

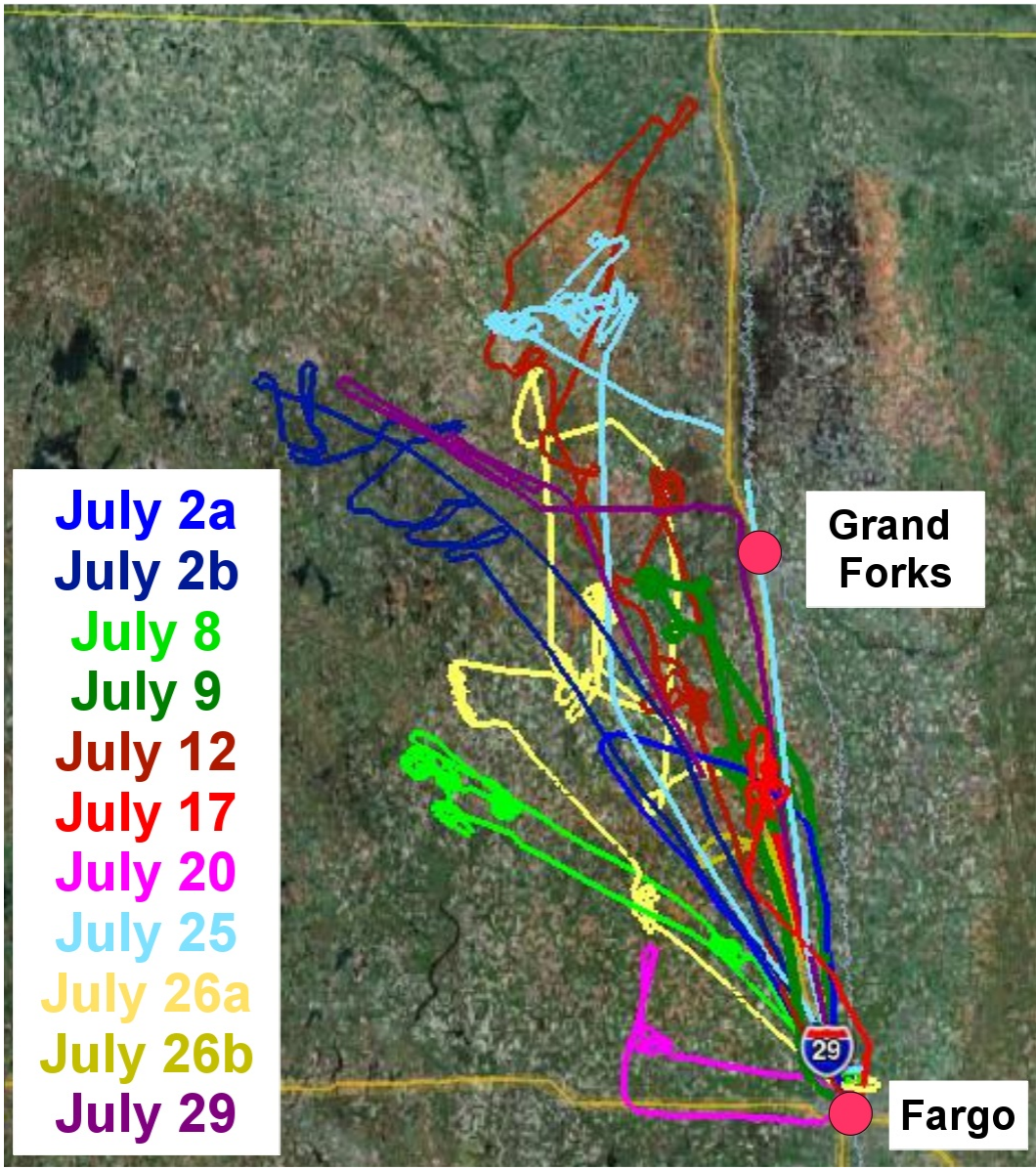
- 1.) Where do aircraft fly for hygroscopic seeding?
  a.) Just below cloud top.
  b.) Just above cloud top.
  c.) Just below cloud base.
  d.) Just above cloud base.
- 2.) Hygroscopic seeding particles should differ from naturally occurring aerosols by having?
  a.) Higher concentration of larger diameter particles.
  b.) Higher concentration of smaller diameter particles.
  c.) Lower concentration of larger diameter particles.
  d.) Lower concentration of smaller diameter particles.
- 3.) How do larger cloud droplets affect the coalescence process?
  a.) Decreases the size of cloud droplets.
  b.) Decreases production of rain.
  c.) Increases the production of rain.
  d.) Increases concentration of cloud droplets.

# Aircraft Flight Tracks

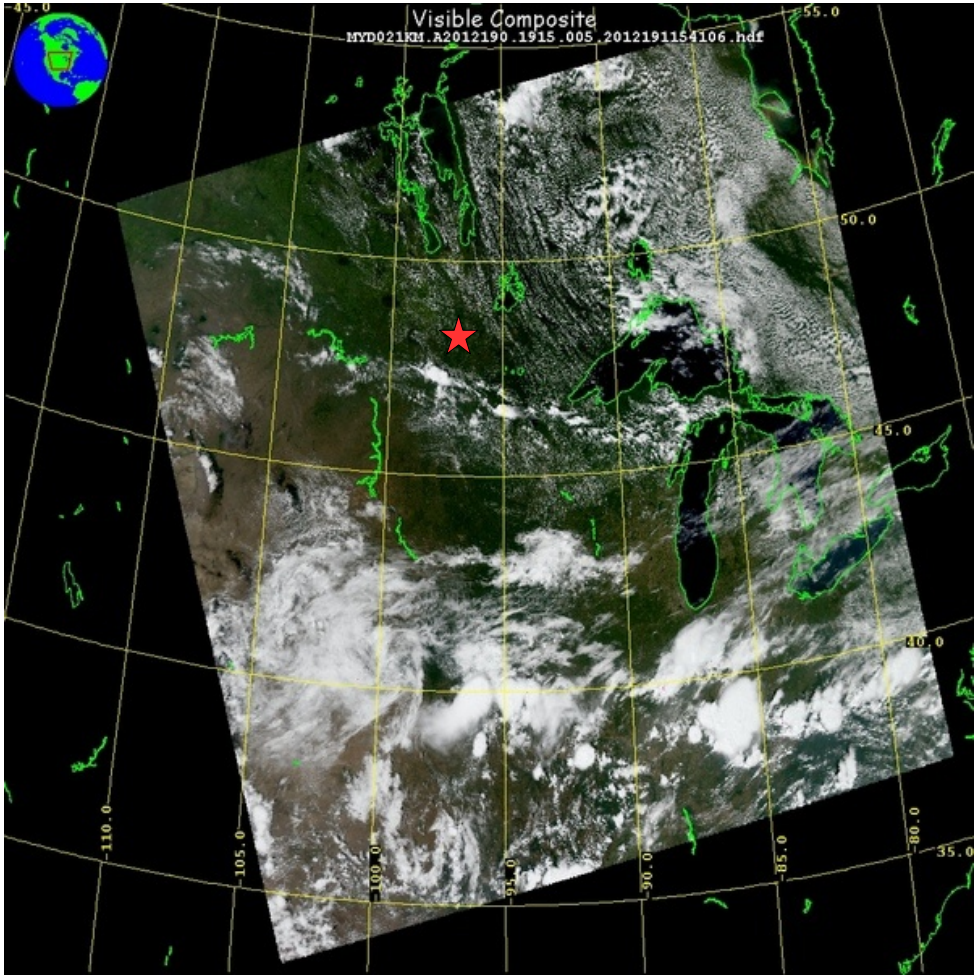
## 2010 POLCAST3



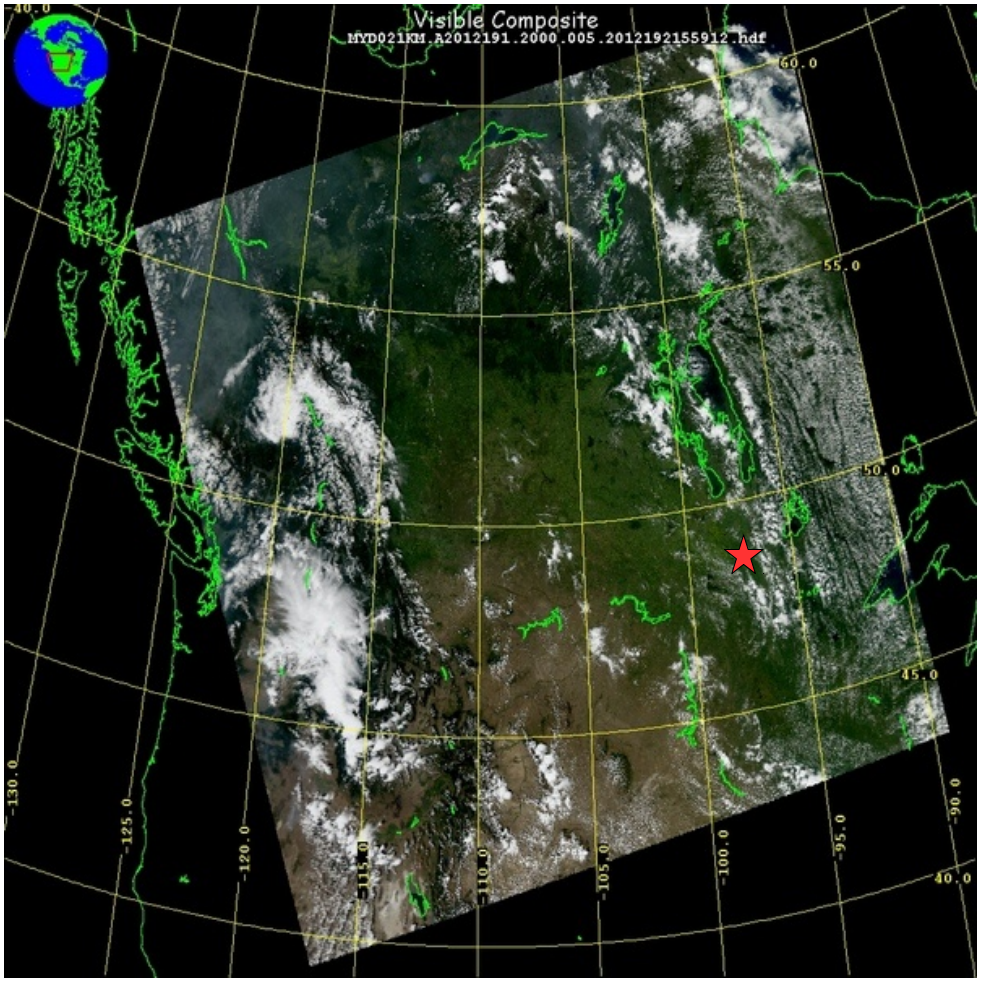

## 2012 POLCAST4



# MODIS Visible Images



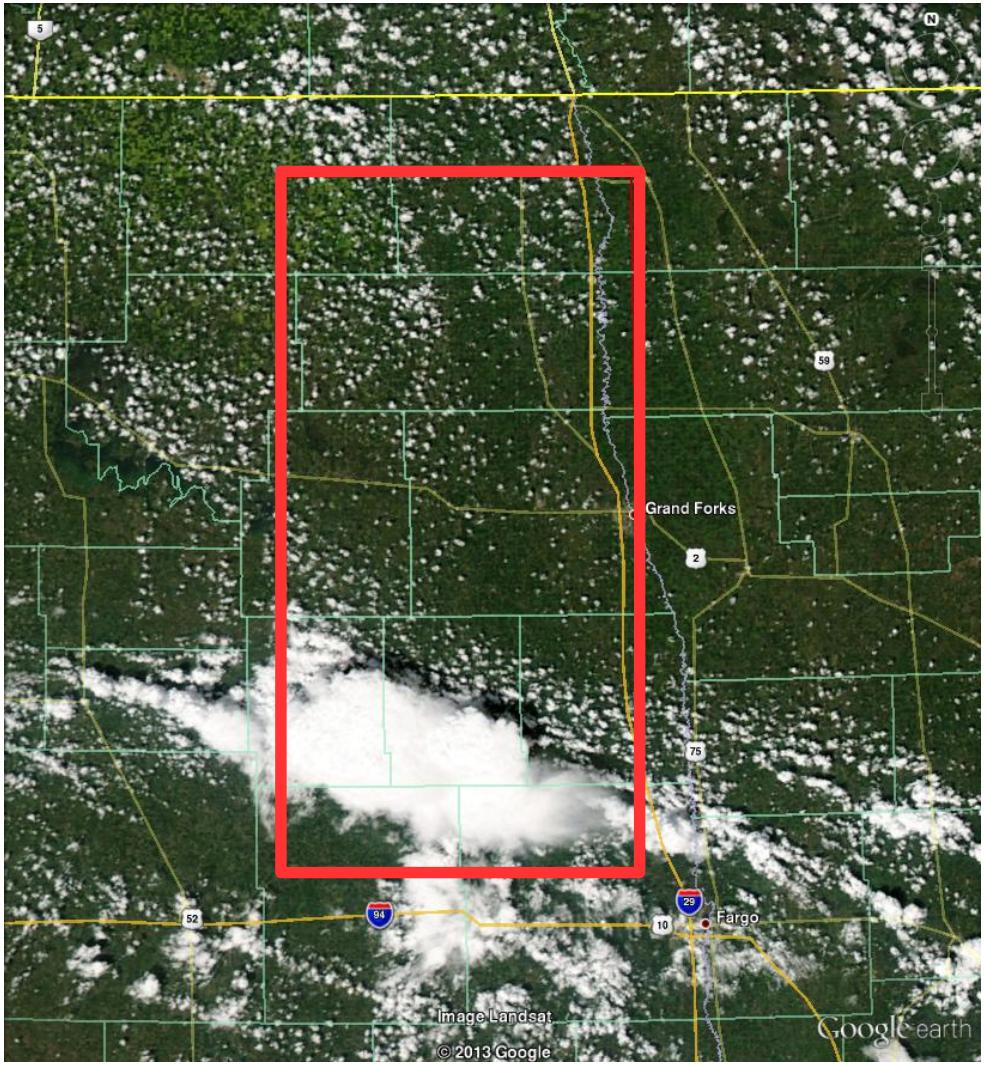

July 8, 2012



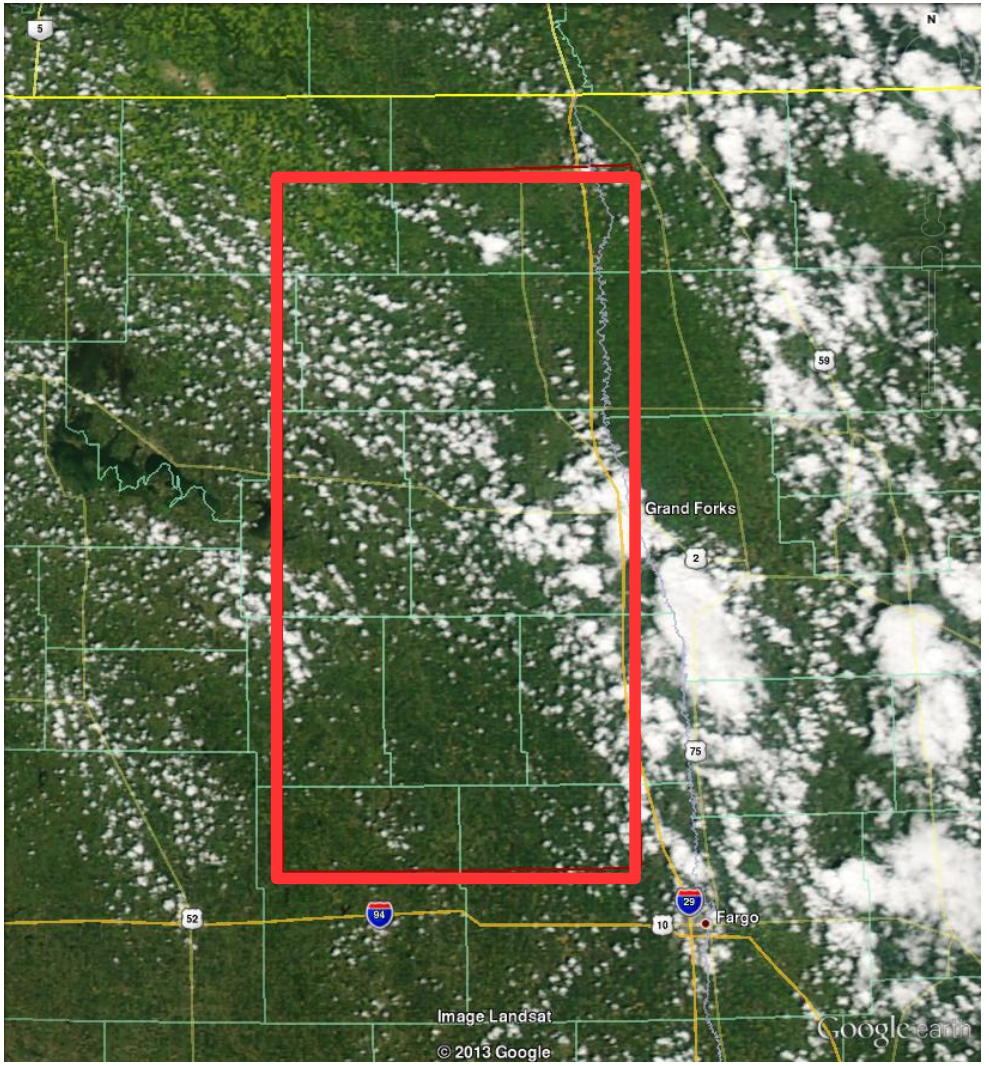

July 9, 2012

★ Grand Forks, North Dakota

# North Dakota Project Area

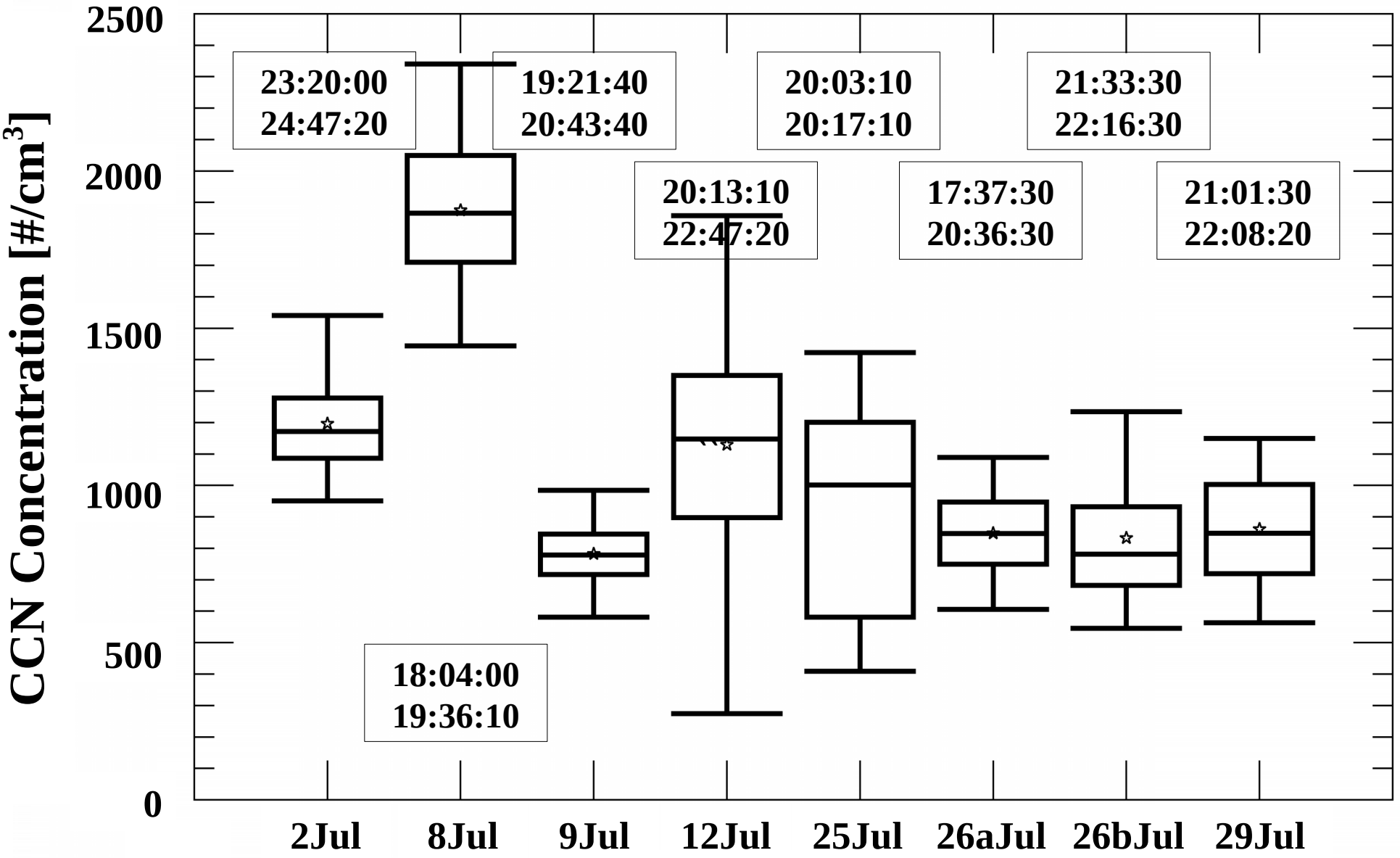



**July 8, 2012**



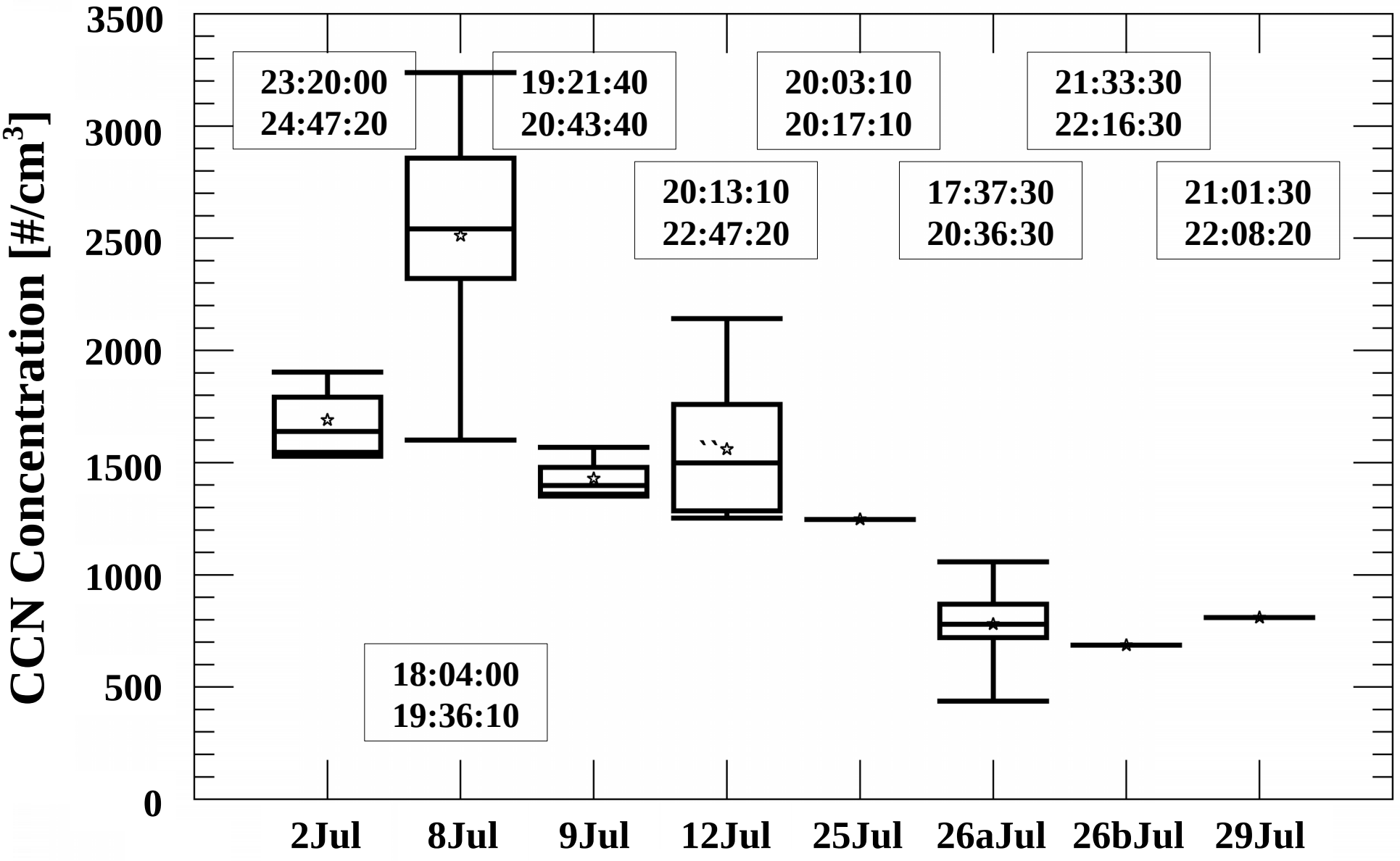

**July 9, 2012**

# UWyo Cloud Base – North Dakota 2012




Statistical distributions near cloud base of 30 s, 0.6 % ambient supersaturation Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure. Measurements are using the University of Wyoming (Uwyo) CCN counter. Star symbols are means, horizontal line is the 50th percentile, top of the box is the 75th percentile, bottom of the box is the 25th percentile, and the top and bottom of the whiskers are the 95th and 5th percentiles, respectively.

# DMT Cloud Base – North Dakota 2012




Statistical distributions near cloud base of 30 s, 0.6 % ambient supersaturation Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure. Measurements are using the Droplet Measurement Technology (DMT) CCN counter. Star symbols are means, horizontal line is the 50th percentile, top of the box is the 75th percentile, bottom of the box is the 25th percentile, and top and bottom of the whiskers are the 95th and 5th percentiles, respectively.

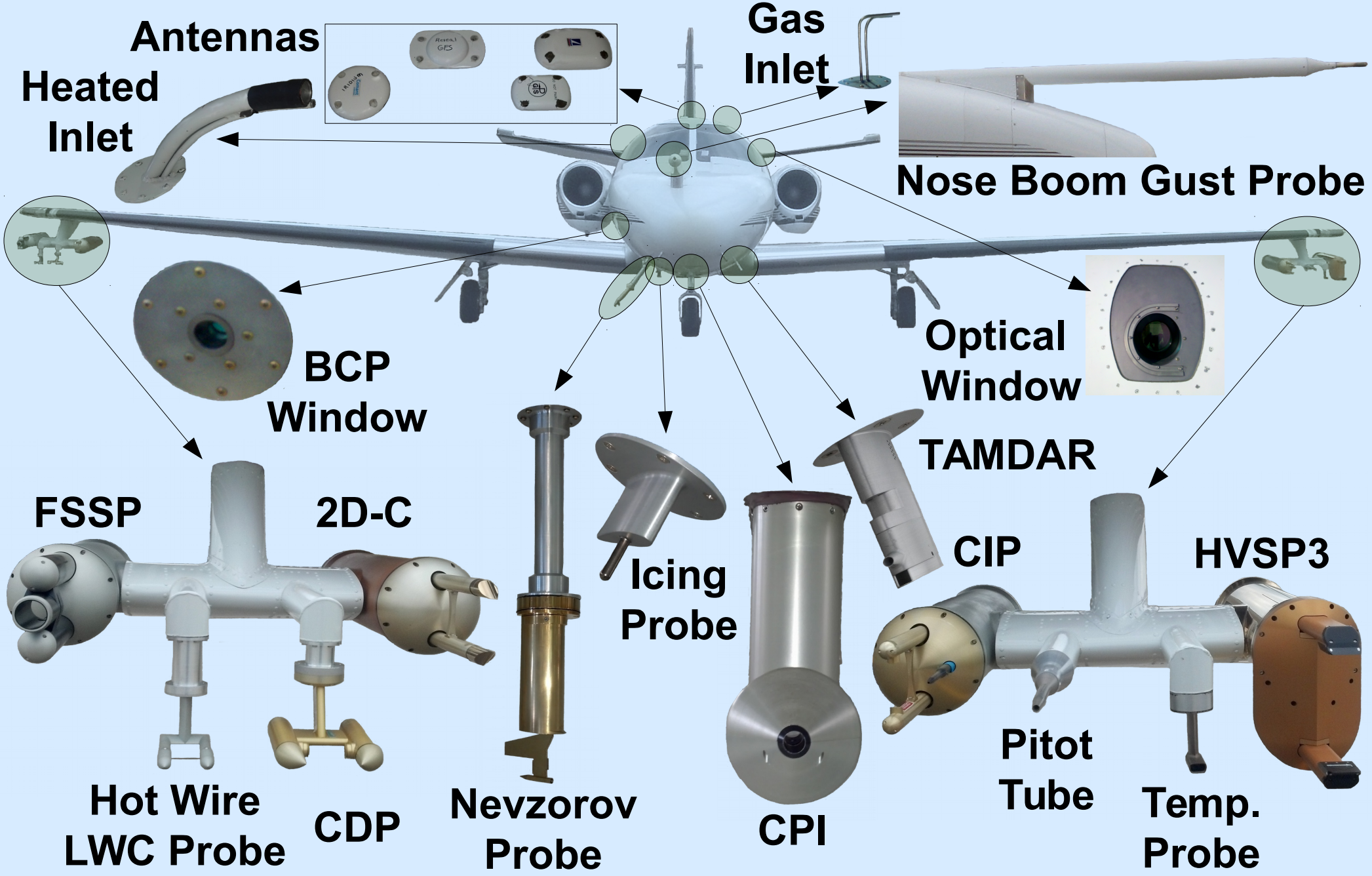
# Conclusions

- Field project conducting in 2006, 2008, 2010 and 2012.
- Aerosol, Cloud Condensation Nuclei and cloud base temperature measurements indicate that the environment is feasible for hygroscropic seeding.
- North Dakota environment is suitable for hygroscopic seeding (Delene 2016).

# Future Work

- Analysis of randomized seeding cases.

# Questions


Antennas
Heated Inlet
Gas Inlet
Nose Boom Gust Probe
BCP Window
Optical Window
TAMDAR
FSSP
2D-C
Icing Probe
CIP
HVSP3
Hot Wire LWC Probe
CDP
Nevzorov Probe
CPI
Pitot Tube
Temp. Probe

# References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