Cloud Condensation Nuclei Comparisons from Surface and Aircraft Measurements in North Dakota

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Objective

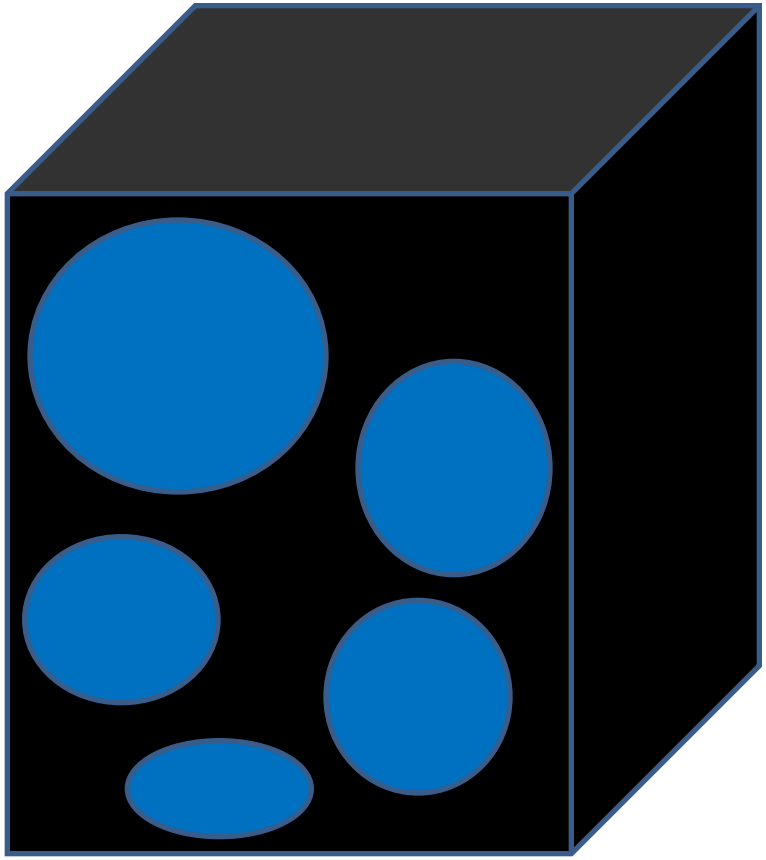
Determine if surface measurements could be used to estimate cloud base CCN concentrations.

- Current measurements are difficult and expensive due to use of aircraft
- Continuous measurements could be beneficial for any aerosol-cloud studies

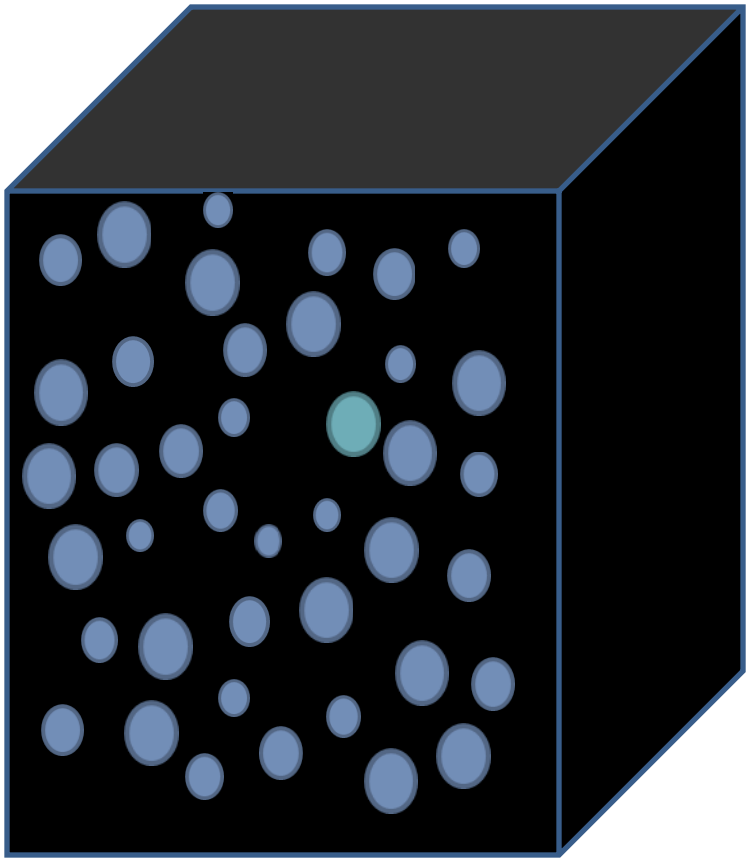
Cloud Condensation Nuclei (CCN)

- Aerosols are solid or liquid particular matter suspended in the atmosphere.
- Aerosols with the size and chemical composition to act as nuclei for the condensation of water vapor in a super saturated environment are cloud condensation nuclei.
- Cloud condensation nuclei have an ability to affect the precipitation formation ability of clouds.

Assume the same liquid water content



Low CCN Concentration
Larger Droplets



High CCN Concentration
Smaller Droplets

The low concentration indicates a larger individual CCN size allowing for collision coalescence. High CCN Concentration indicates a smaller individual size, inhibiting cloud droplet formation.

Field Projects

Polarimetric Cloud Analysis and Seeding Test (POLCAST) campaigns

- Hygroscopic cloud seeding
  - Project since 2006
  - Surface Measurements done 2010 and 2012 Campaign
  - High CCN Concentration
  - Seeding with Calcium Chloride

POLCAST Flight Intervals

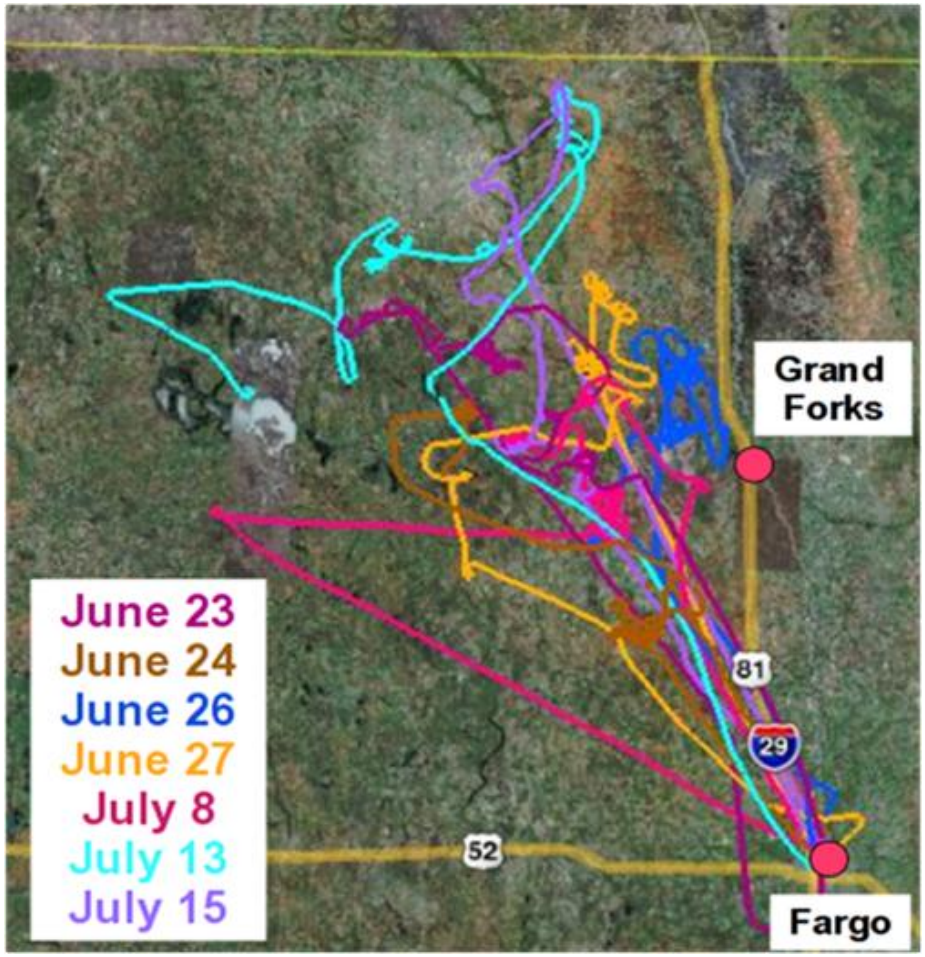


Figure 4: 2010 Cessna 340 Flight Paths

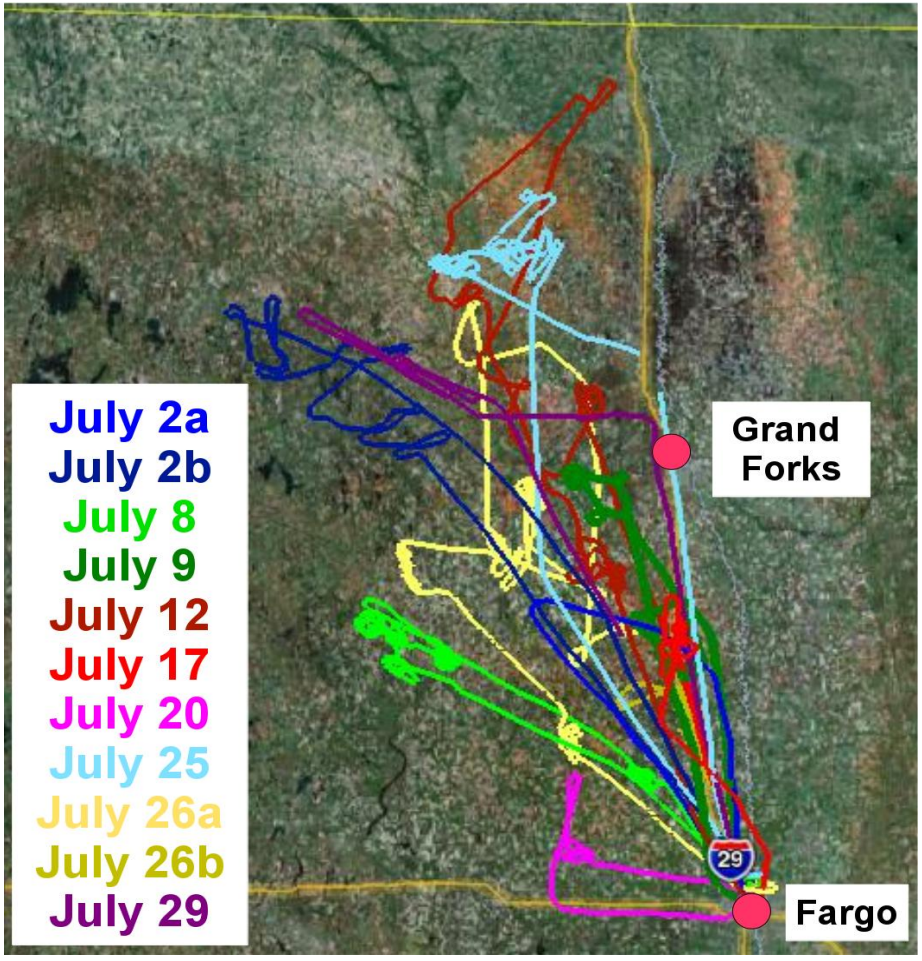


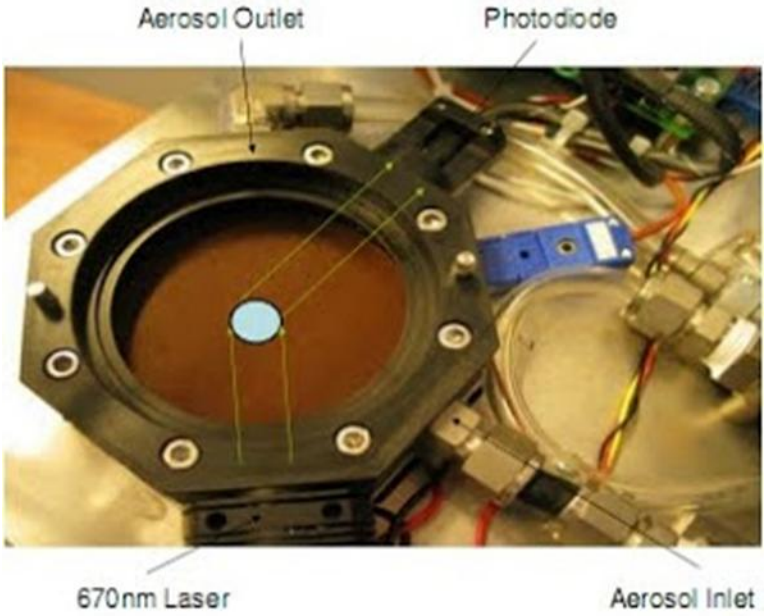
Figure 5: 2012 Cessna 340 Flight Paths

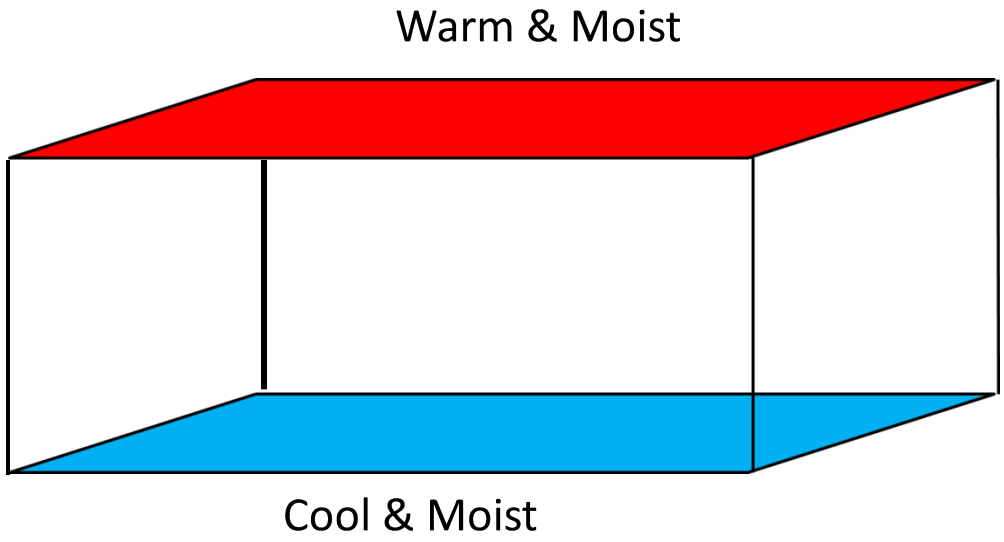
Instrumentation

- Two University of Wyoming Cloud Condensation Nuclei Counters

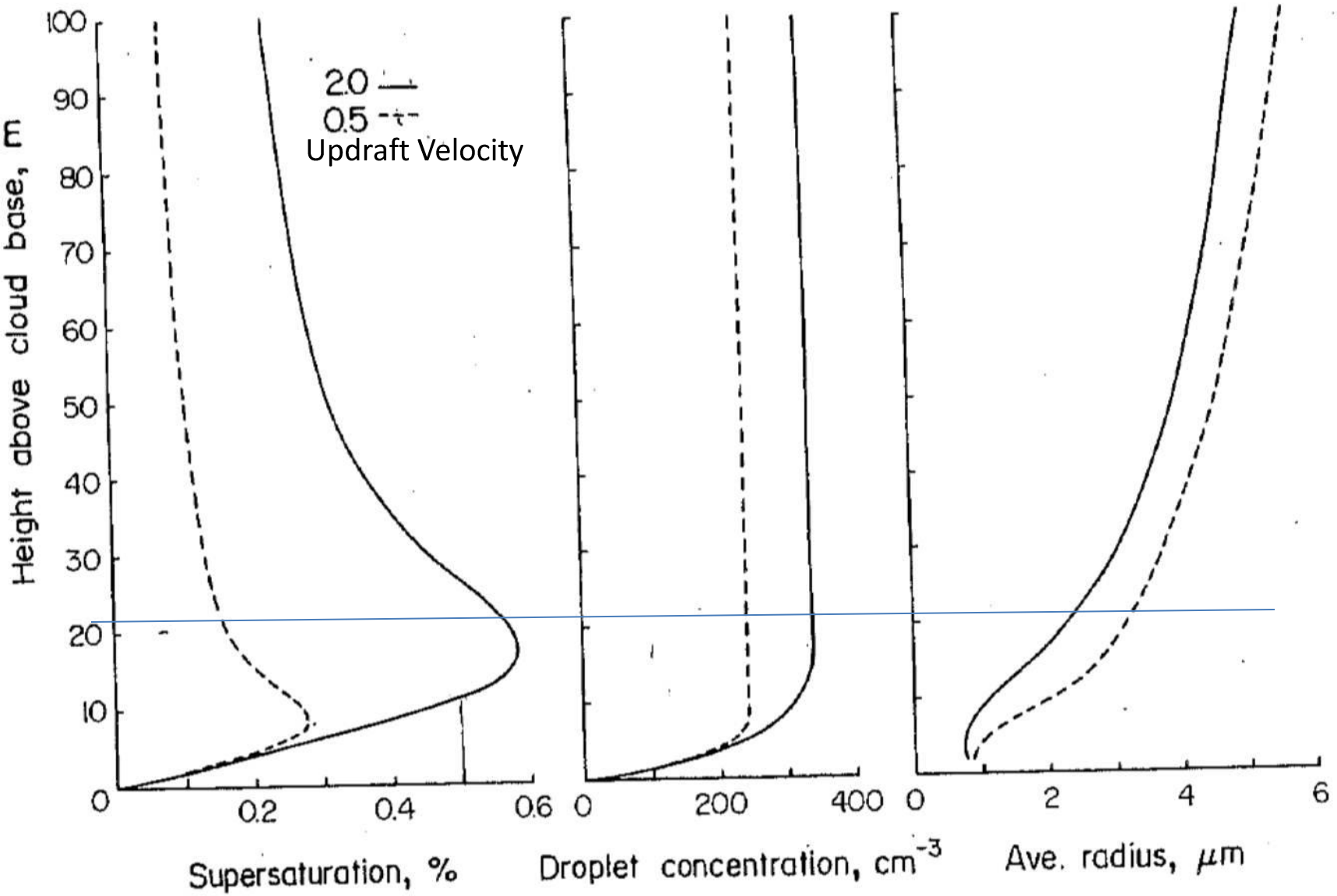
How does it work?

- It is a static thermal gradient diffusion chamber instrument.
- Wetted pads on top and bottom plate
- Top plate is at ambient temperature
- Bottom plate is cooled by a thermoelectric cooler
- The supersaturation is set to 1%, which is equivalent to 0.6% of the natural atmosphere.





Supersaturation at 0.6%

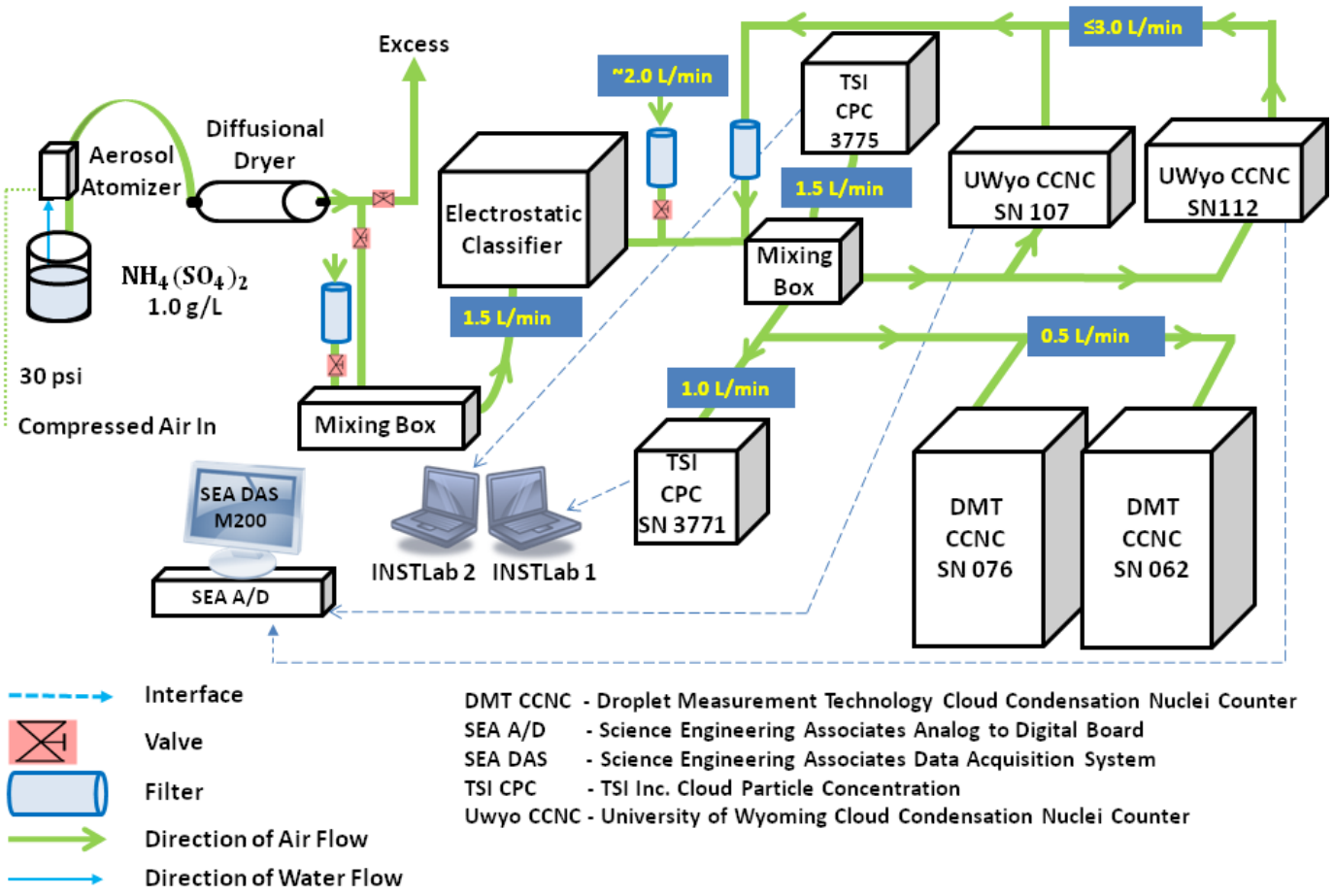


Reproduced from Fig. 7.3 of "A Short Course in Cloud Physics" 3rd. Edition by R.R. Rogers and M.K. Yau

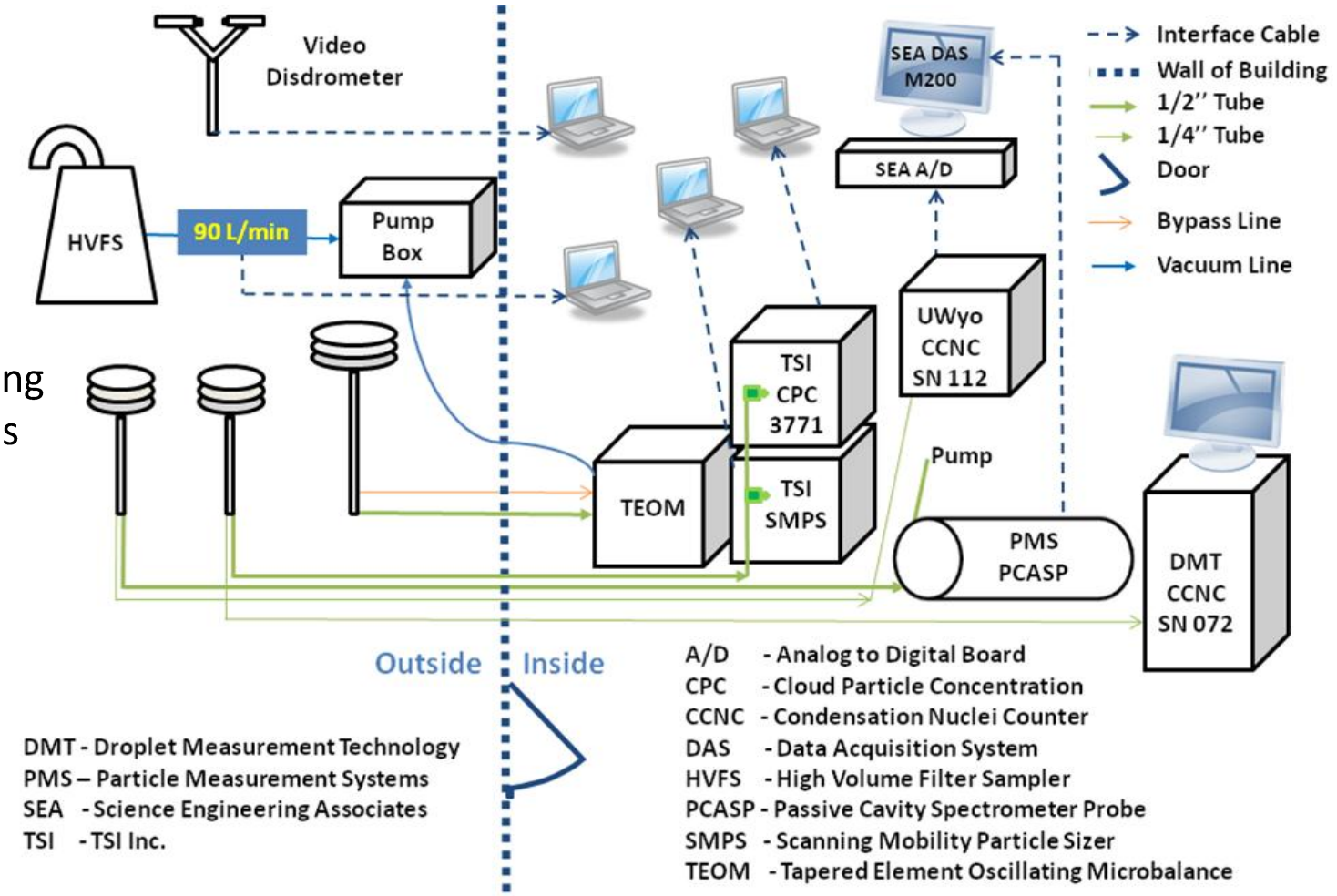
Calibration

- The calibration was conducted by comparing 100 nm ammonia sulfate particles between the Condensation Particle Counter (CPC) and the CCN counter.

Calibration

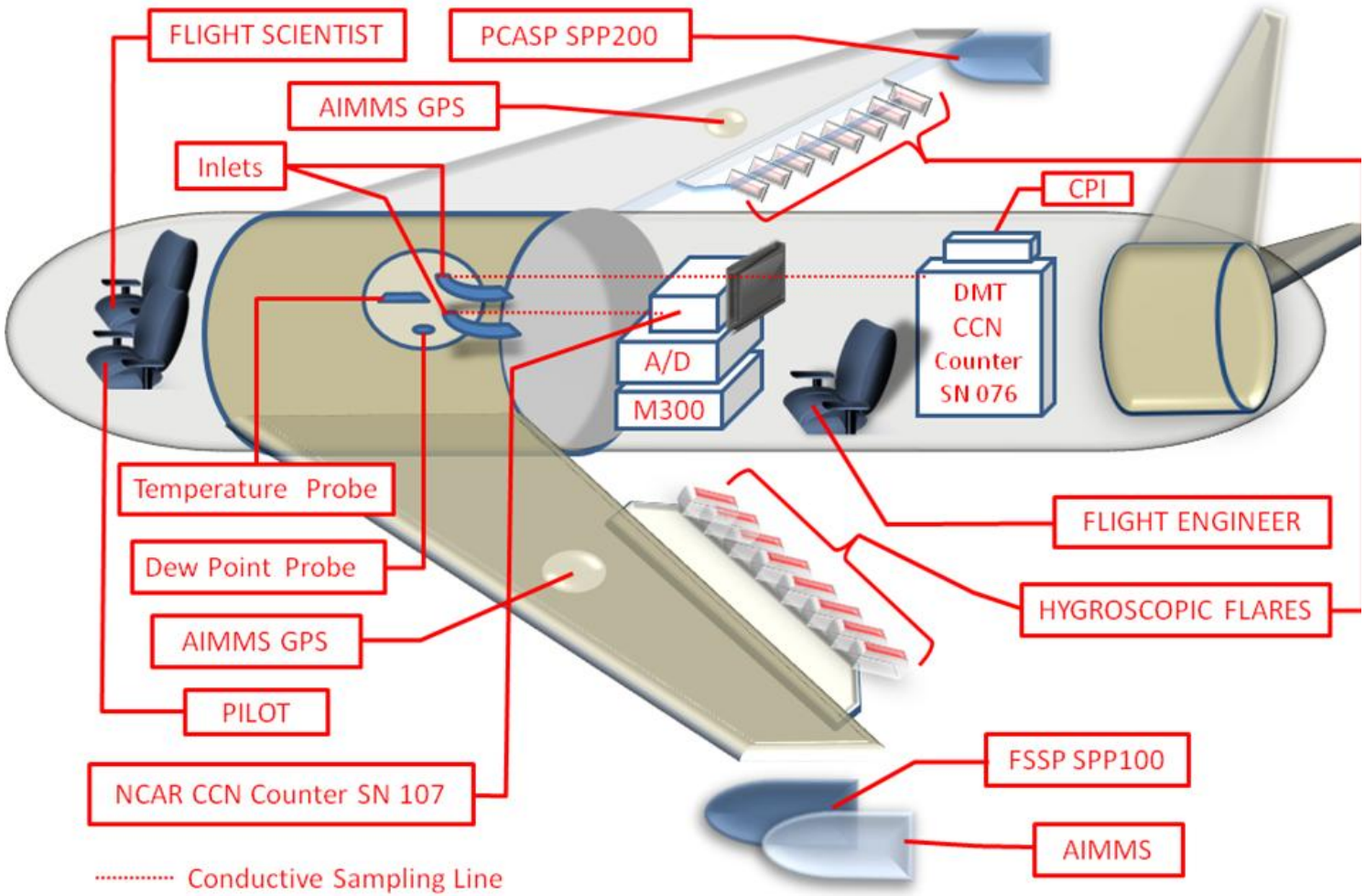


Deployment of Counters



2012 POLCAST 4 Surface Instrument Configuration

Deployment of Counters

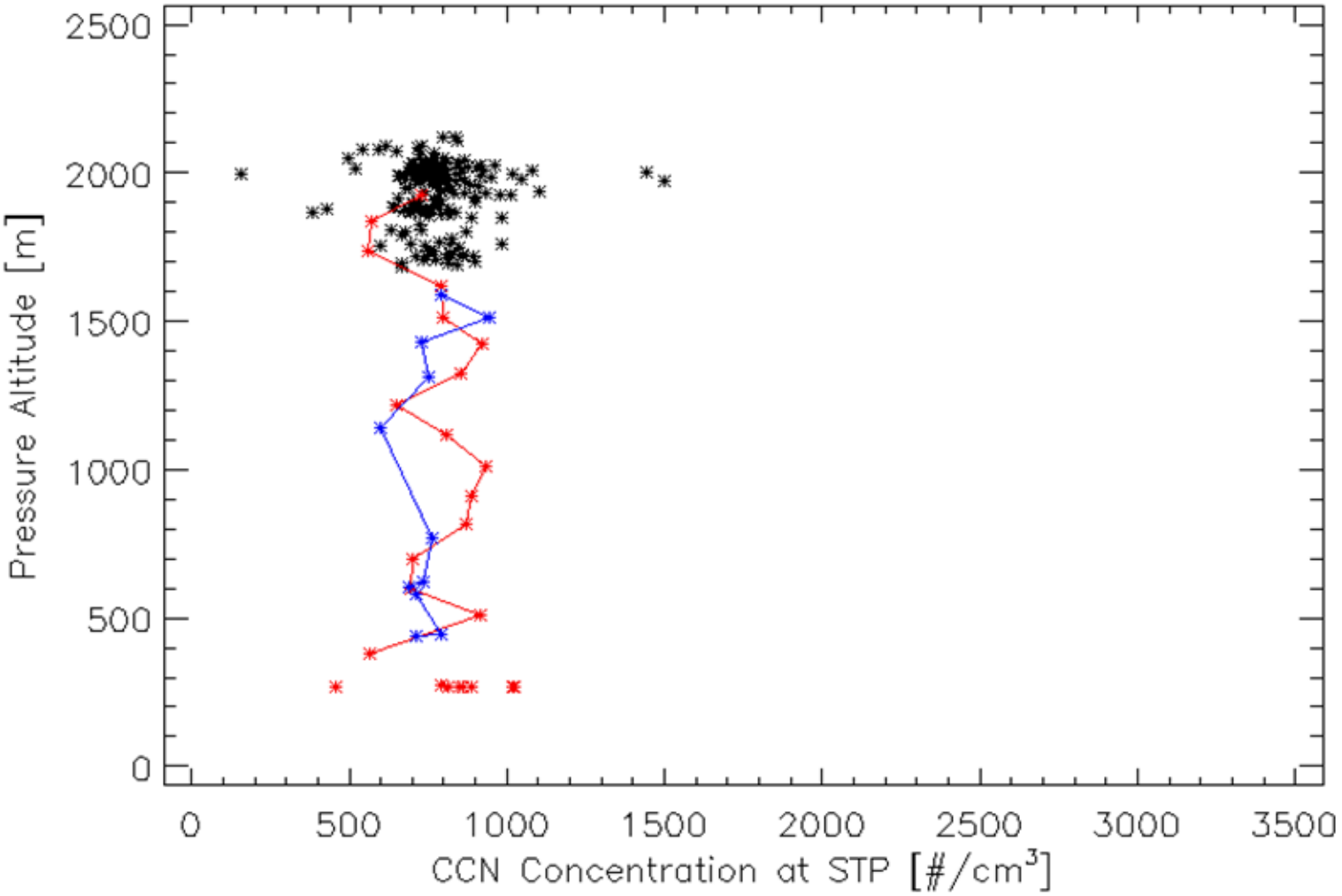


Methodology

- Used the ADPAA[1] open source software to process data
- Quality assurance on the 2010 but not 2012 data
- Majority of analysis was done using CPLOT

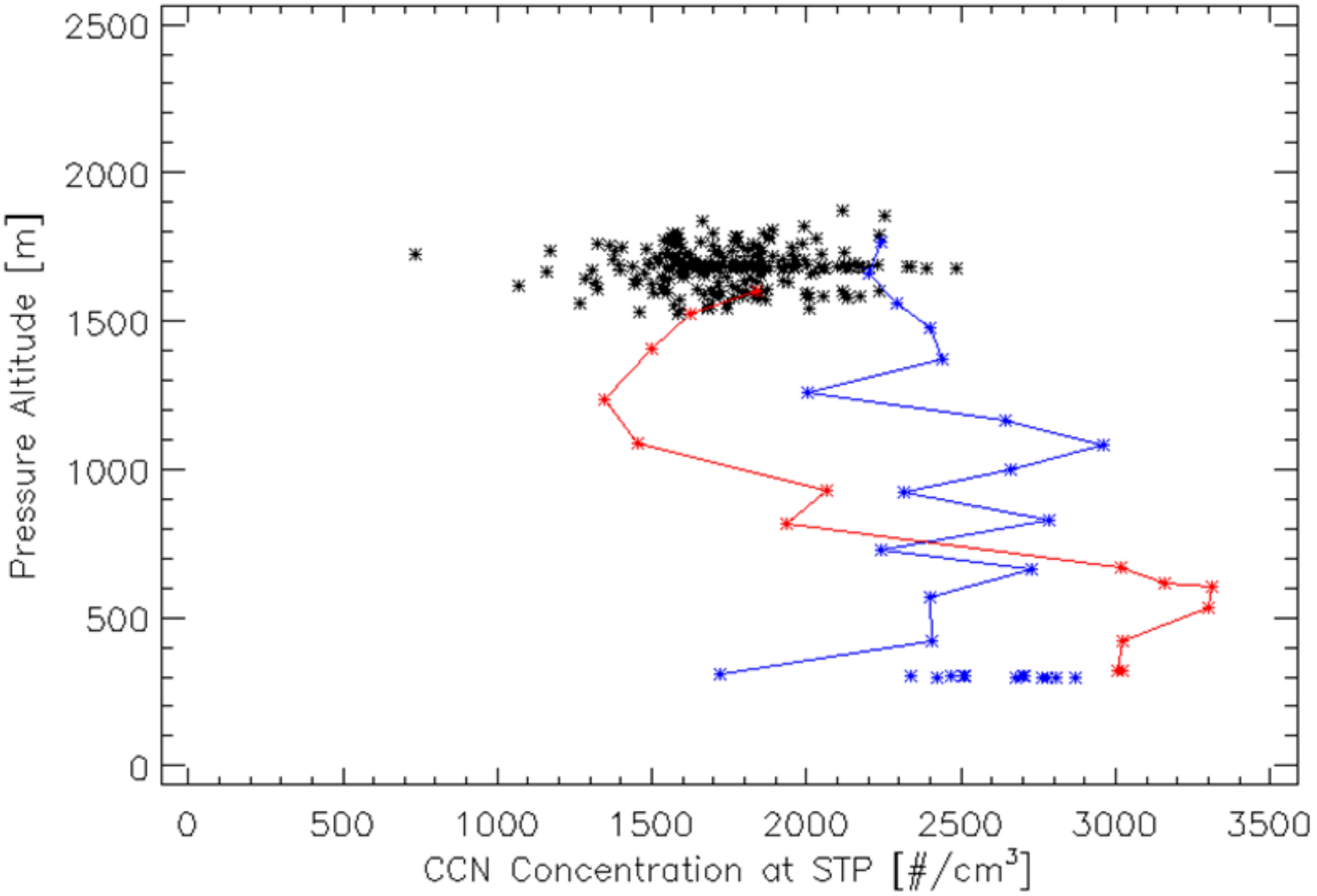
[1]Delene, D. J., Airborne Data Processing and Analysis Software Package, Earth Science Informatics, 4(1), 29-44, 2011, URL: http://dx.doi.org/10.1007/s12145-010-0061-4, DOI: 10.1007/s12145-010-0061-4.

July 9, 2012 (Typical POLCAST Profile)



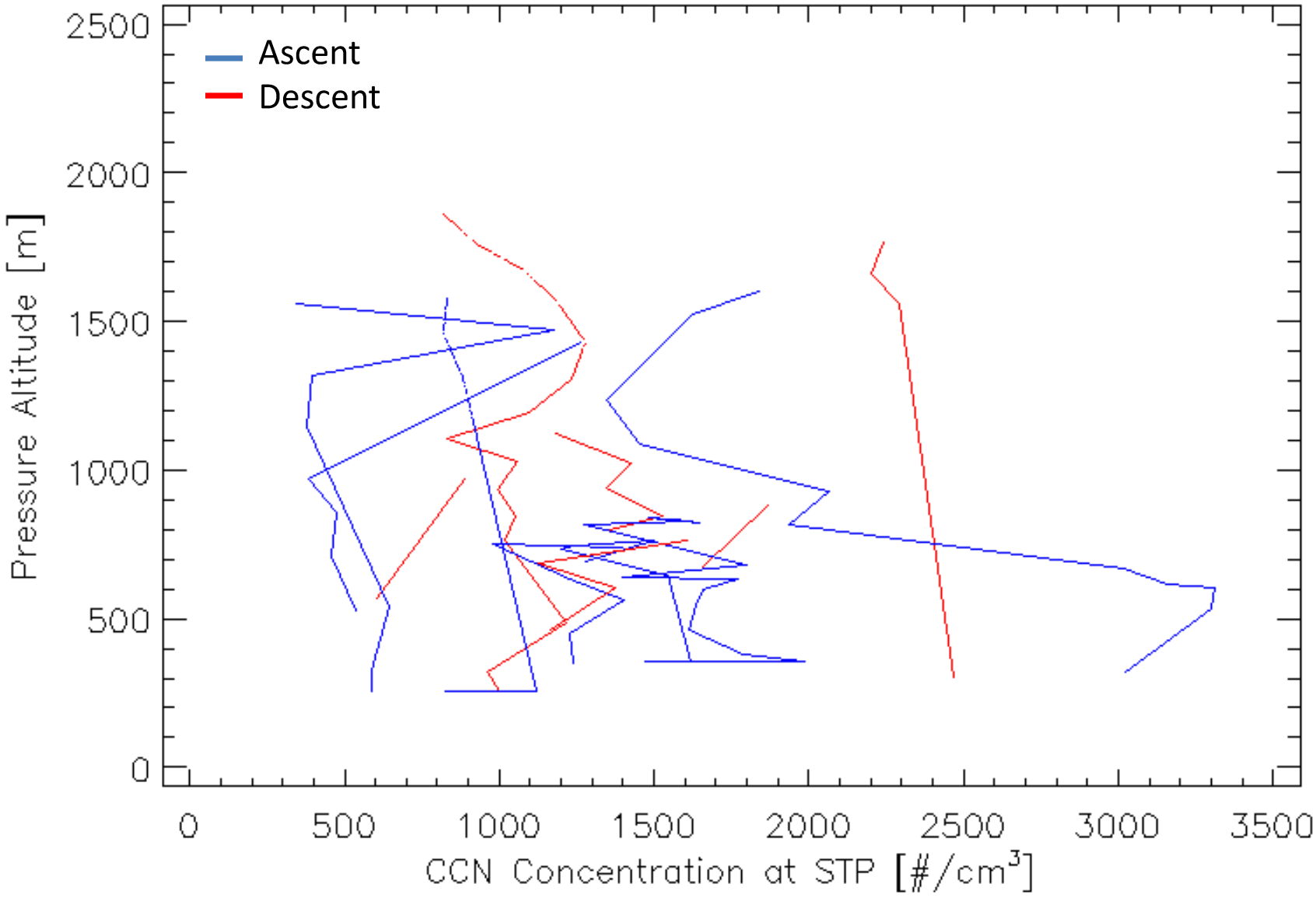
CCN concentrations during July 9, 2012 POLCAST flight. Red line is ascent, blue line is descent, and black dots are cloud base.

July 15, 2010 Atypical POLCAST Profile

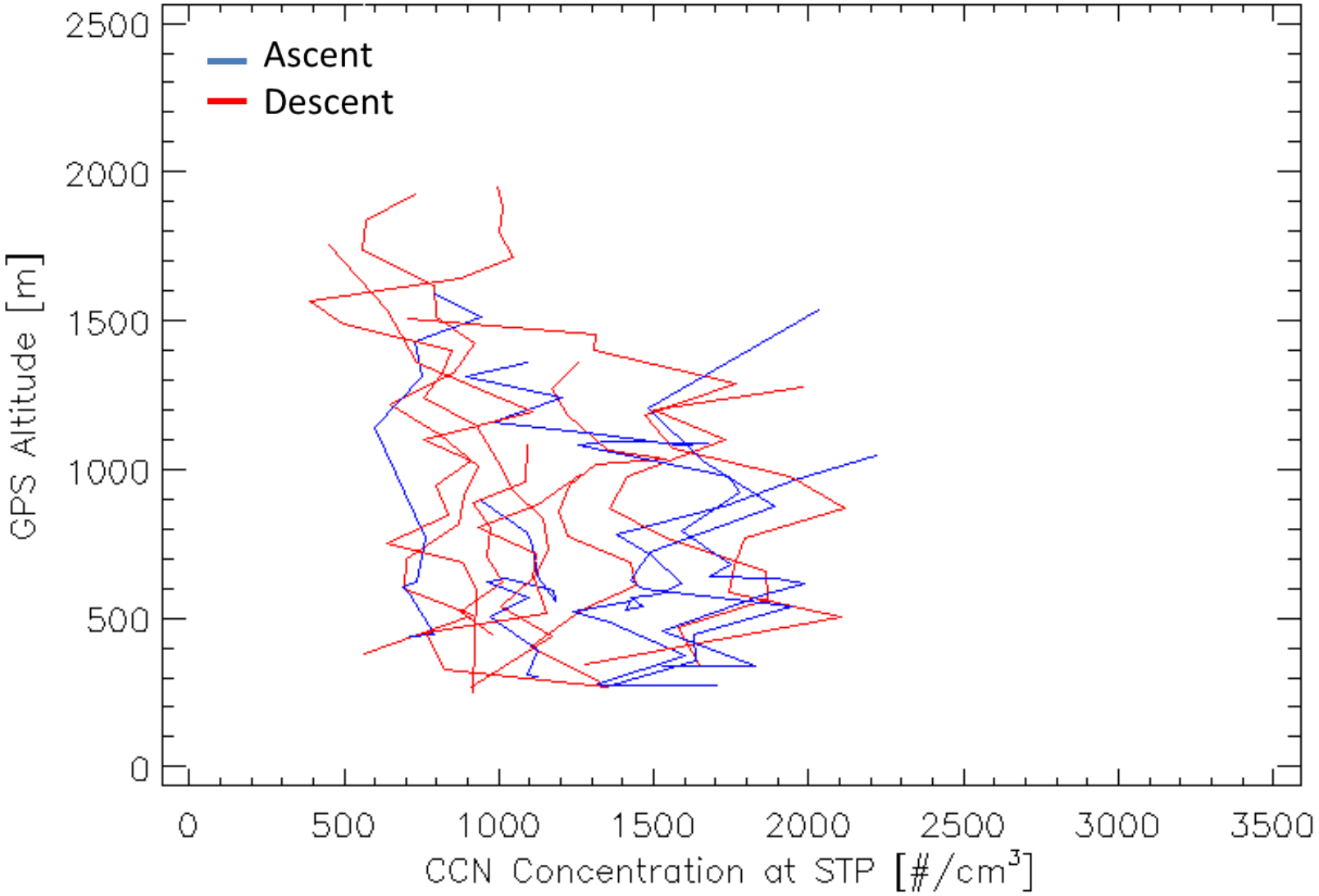


CCN concentrations during July, 15 2010 POLCAST flight. Red line is ascent, blue line is descent, and black dots are cloud base.

2010


Ascent
Descent
Pressure Altitude [m]
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500
CCN Concentration at STP [#/cm^3]

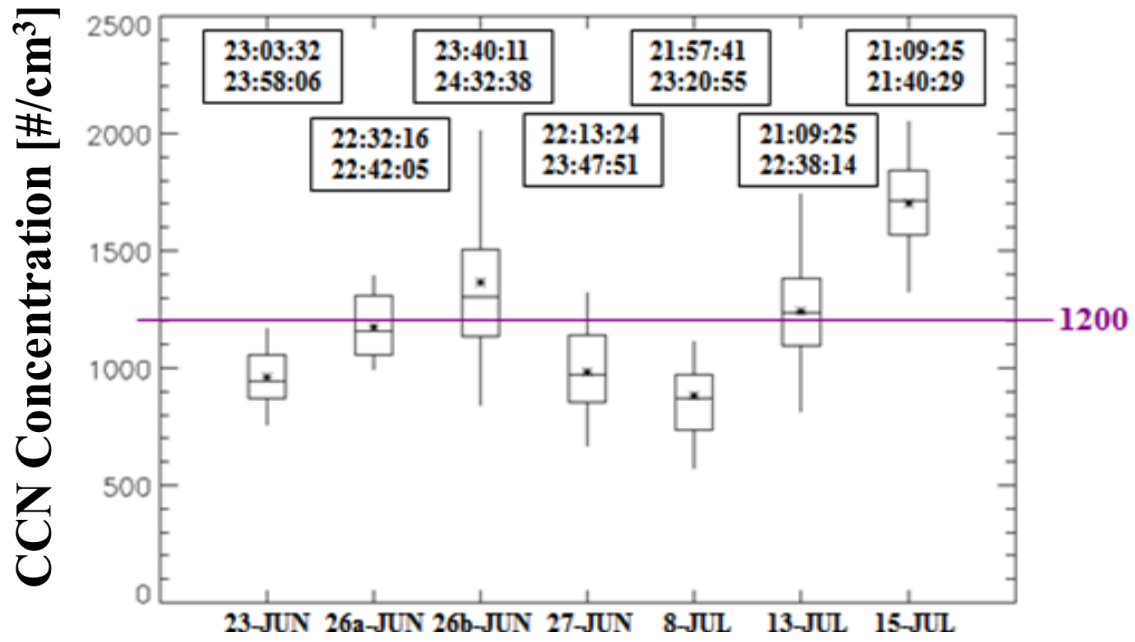
2012



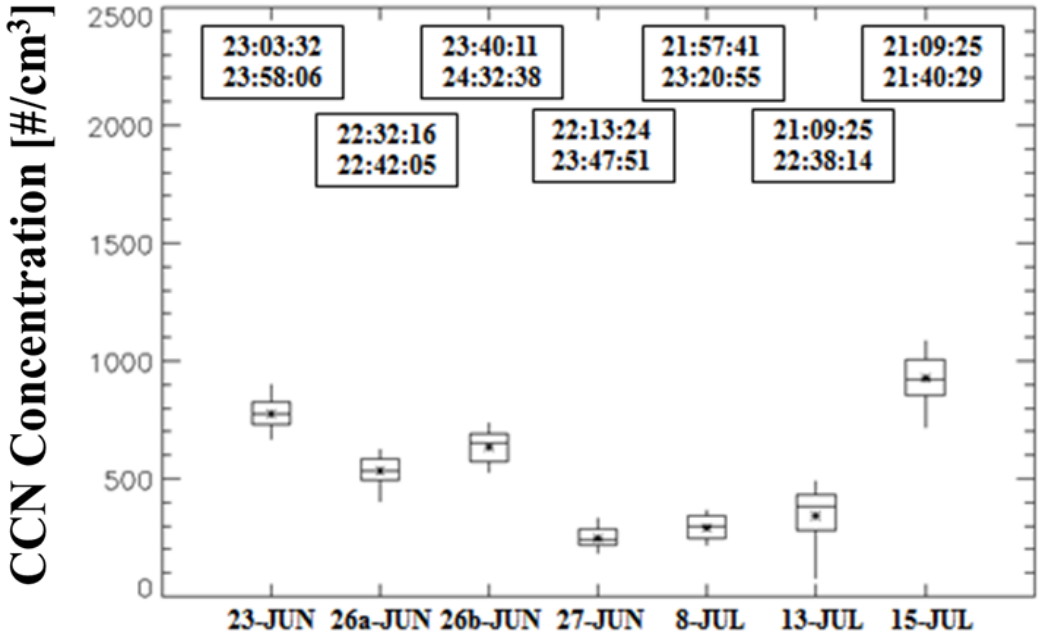
Above is the ascent (red lines) and descent (blue lines) CCN data for the 2012 POLCAST flights.

CCN Comparison at Cloud Base and Surface

2010 Cloud Base CCN Concentrations

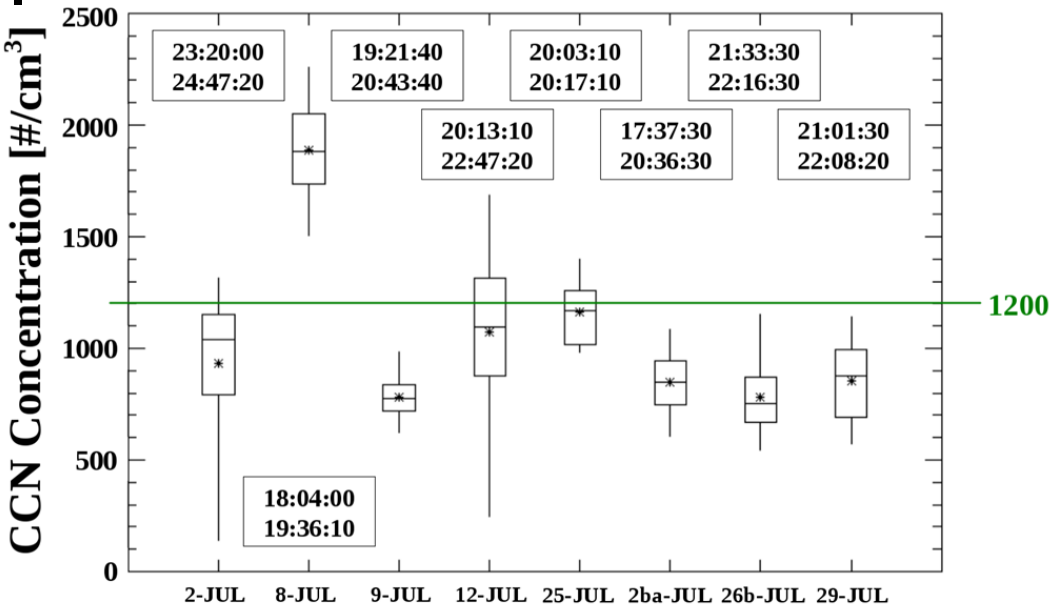


2010 Surface CCN Concentrations

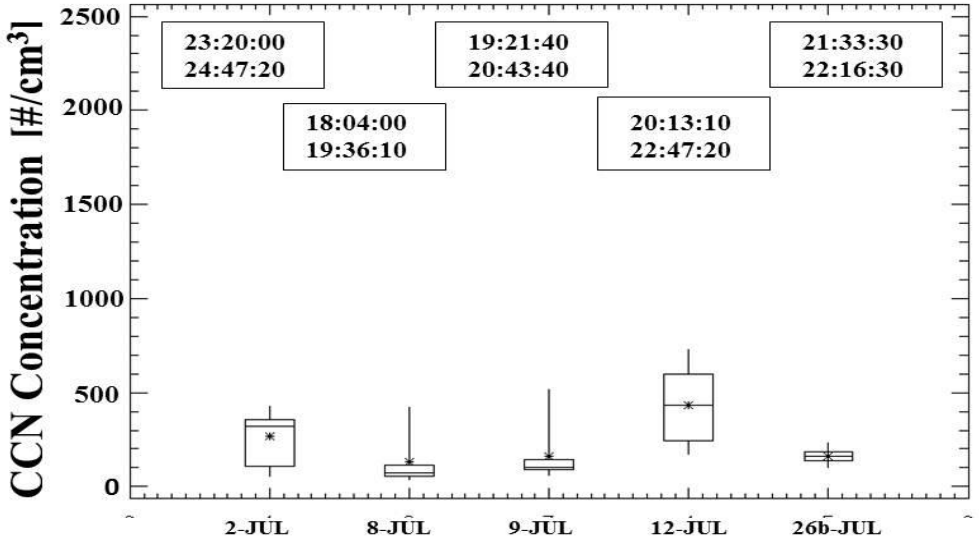


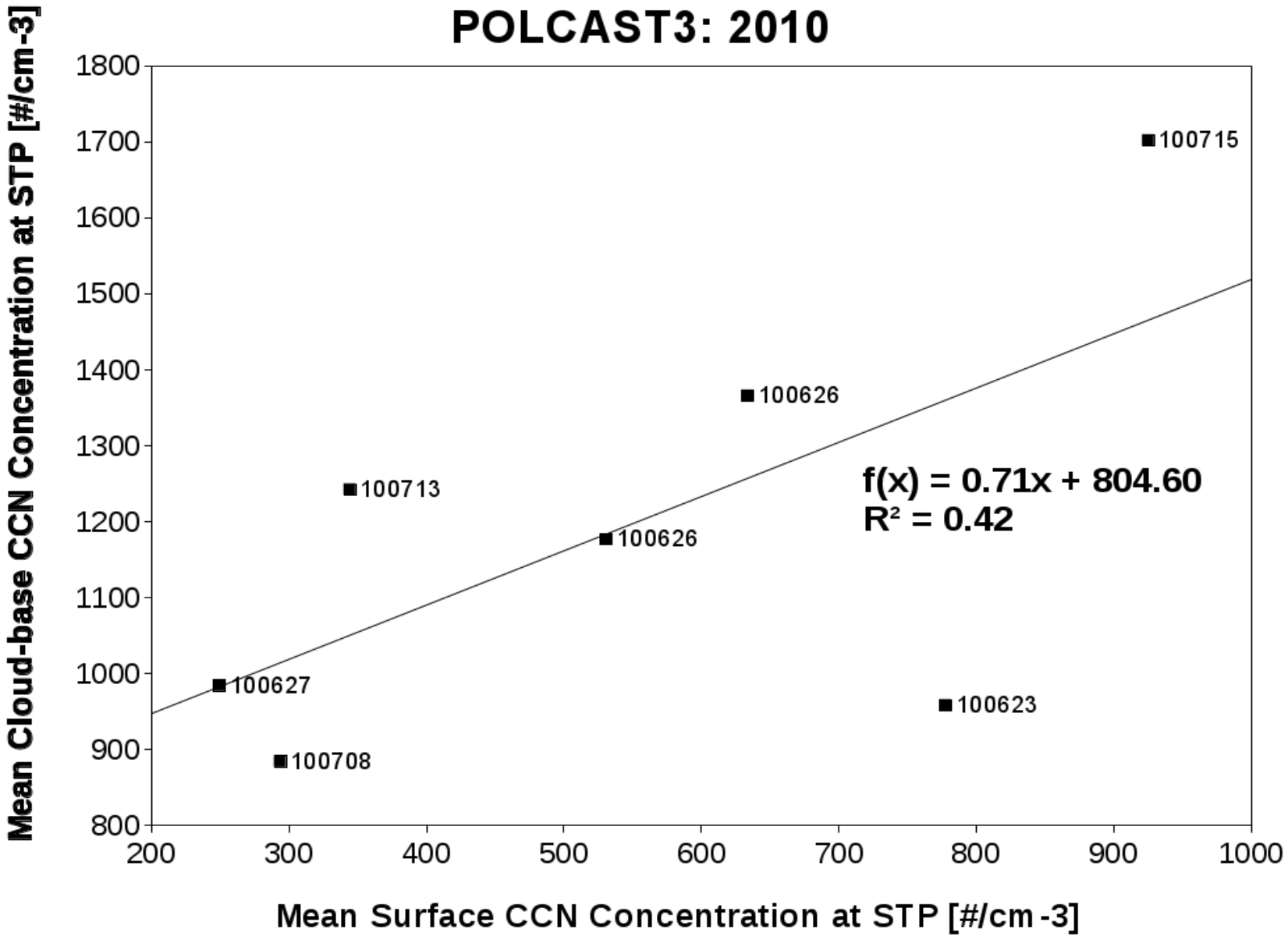
CCN Comparison at Cloud Base and Surface

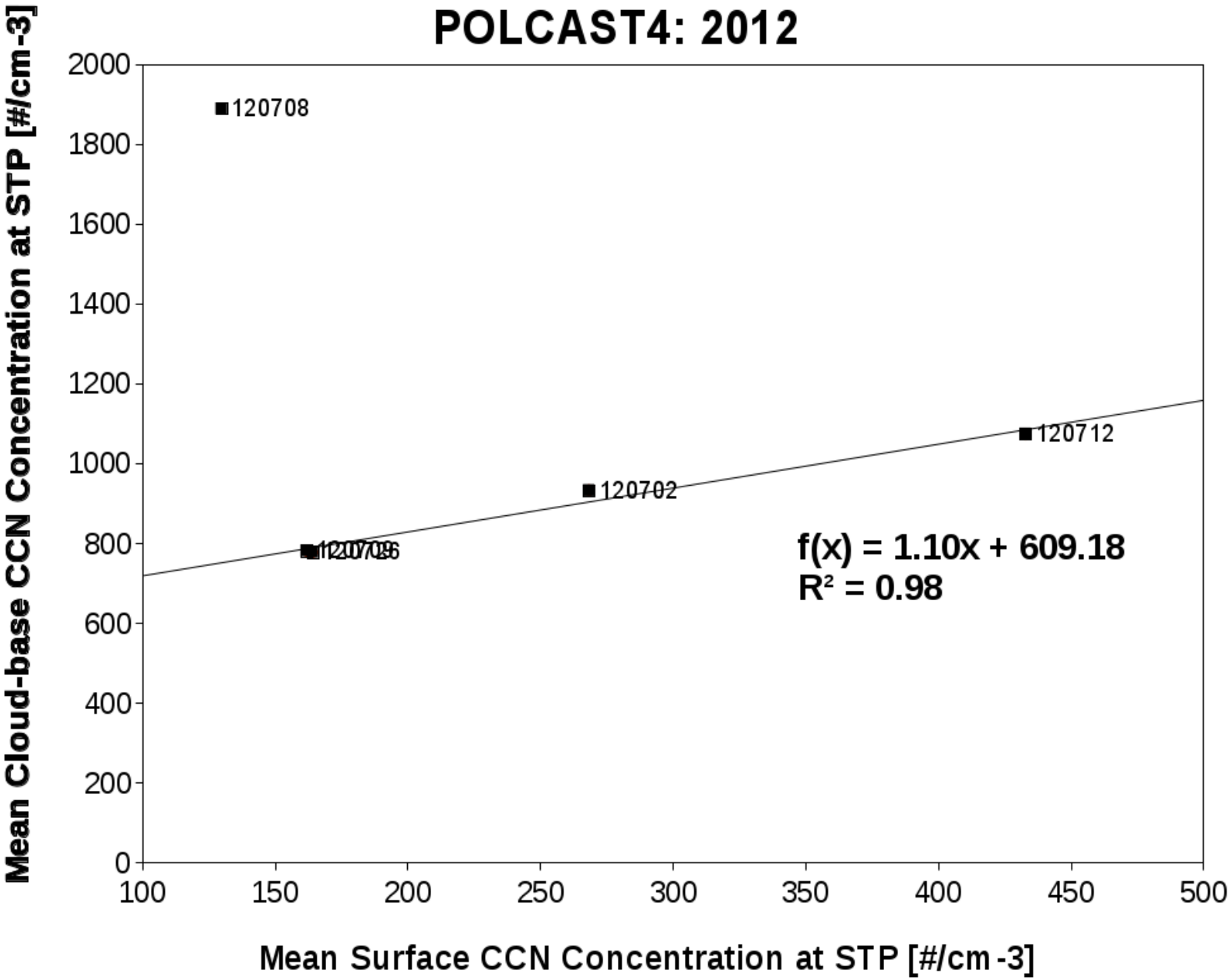
2012 Cloud Base
CCN Concentrations



2012 Surface
CCN Concentrations



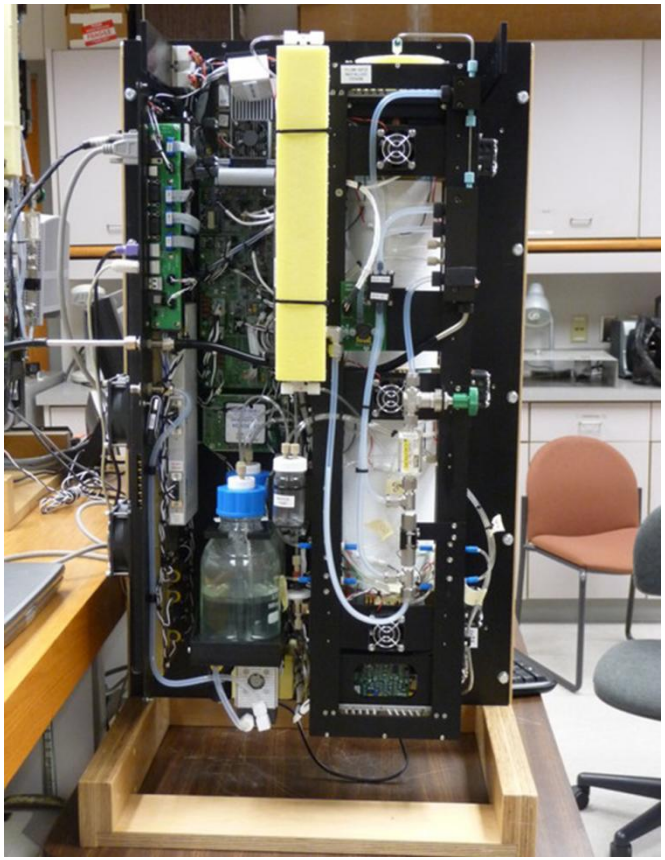

POLCAST3: 2010
Mean Cloud-base CCN Concentration at STP [#/cm-3]
Mean Surface CCN Concentration at STP [#/cm-3]
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
200
300
400
500
600
700
800
900
1000
100715
100626
100713
100626
100627
100623
100708
f(x) = 0.71x + 804.60
R² = 0.42


POLCAST4: 2012
Mean Cloud-base CCN Concentration at STP [#/cm-3]
Mean Surface CCN Concentration at STP [#/cm-3]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
100
150
200
250
300
350
400
450
500
120708
120702
120712
f(x) = 1.10x + 609.18
R² = 0.98

Conclusions

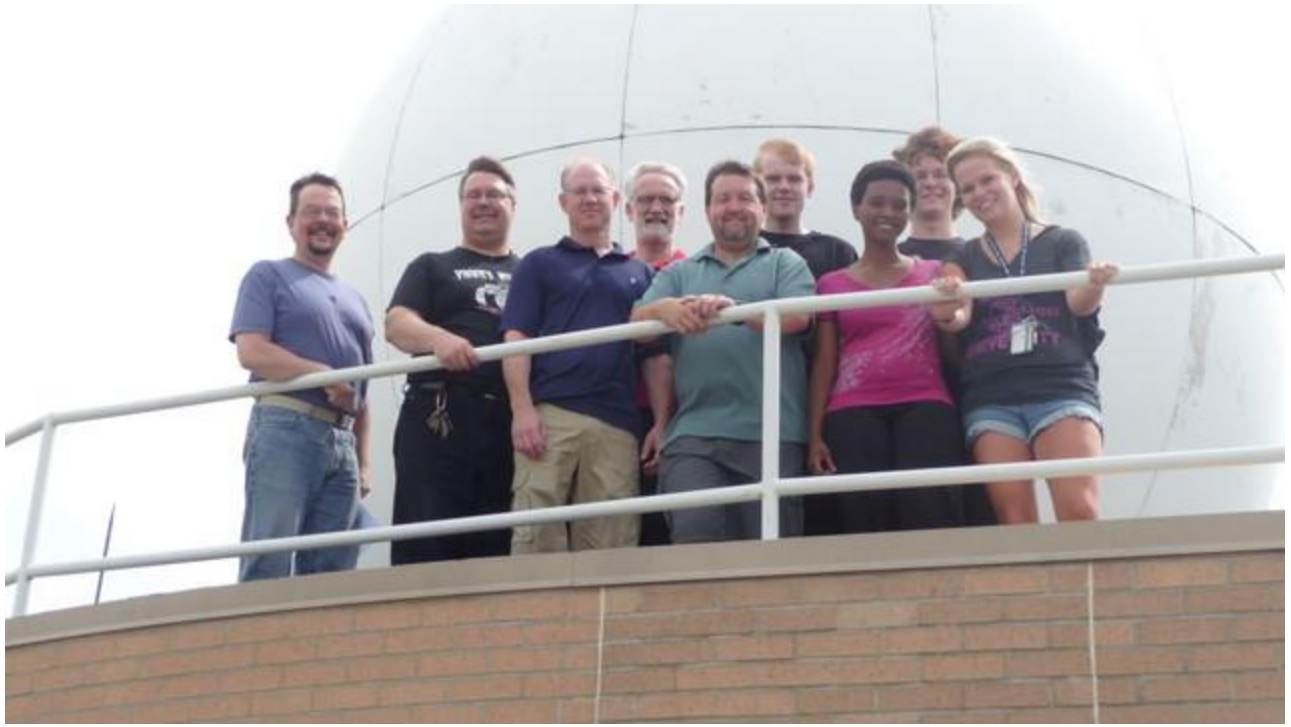
- Great CCN concentration variability from day to day
- Overall average in Grand Forks is (1200 #/cm^3, higher then other continental locations.
- Aircraft profile show a well mixed CCN concentration layer between the surface and cloud base. This indicates that typically surface measurement can be used to infer cloud base properties.
- Surface Measurements do not exactly correlate with cloud base measurements, due to a problem with the surface CCN counter.

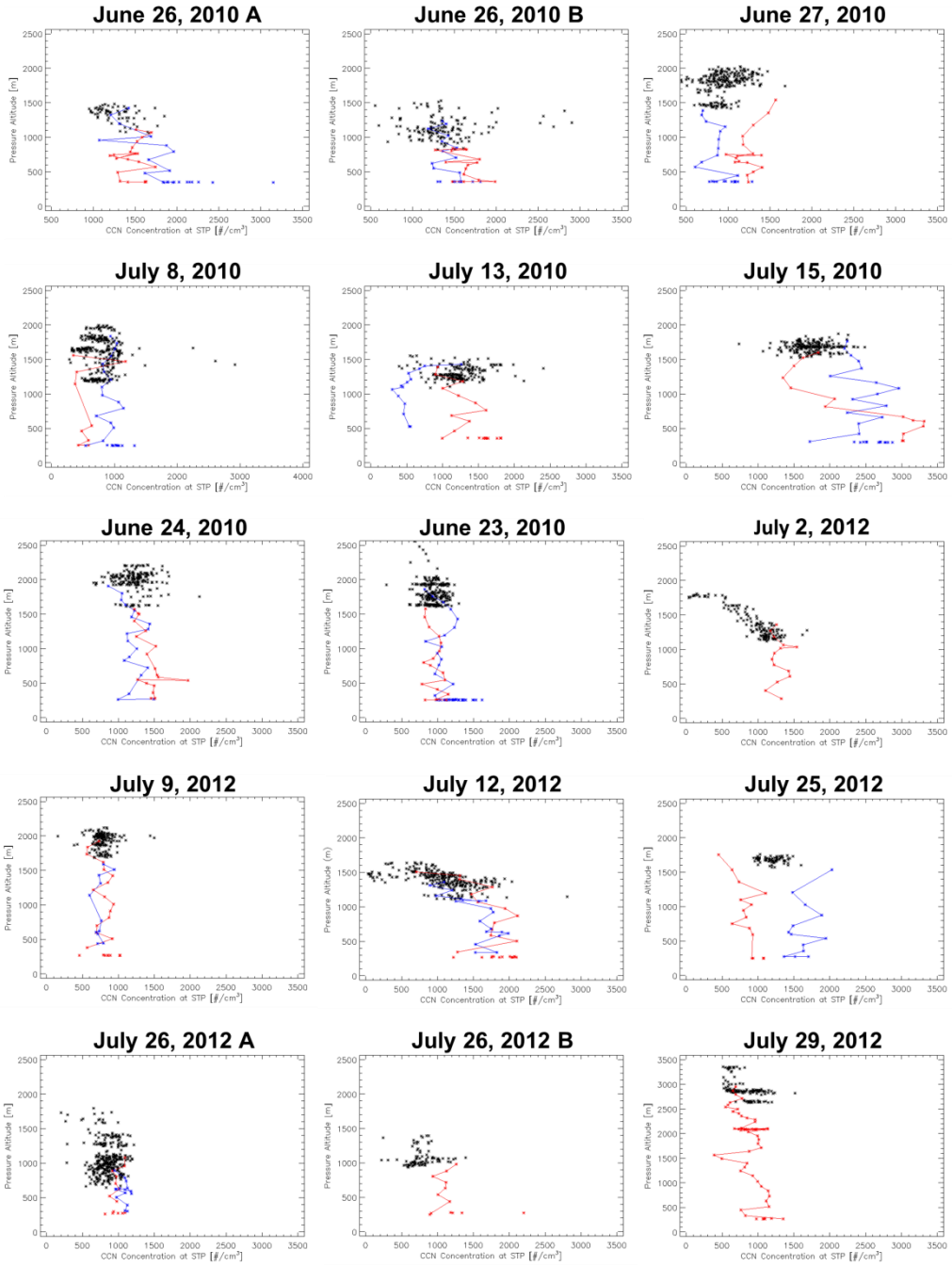
Future Work



- Droplet Measurement Technology CCN Counter
- Surface and Cloud Base Measurements
- Data taken during the 2012 POLCAST Campaign
- Currently processing data

Questions?




June 26, 2010 A
June 26, 2010 B
June 27, 2010
July 8, 2010
July 13, 2010
July 15, 2010
June 24, 2010
June 23, 2010
July 2, 2012
July 9, 2012
July 12, 2012
July 25, 2012
July 26, 2012 A
July 26, 2012 B
July 29, 2012
Pressure Altitude [m]
CCN Concentration at STP [#/cm³]