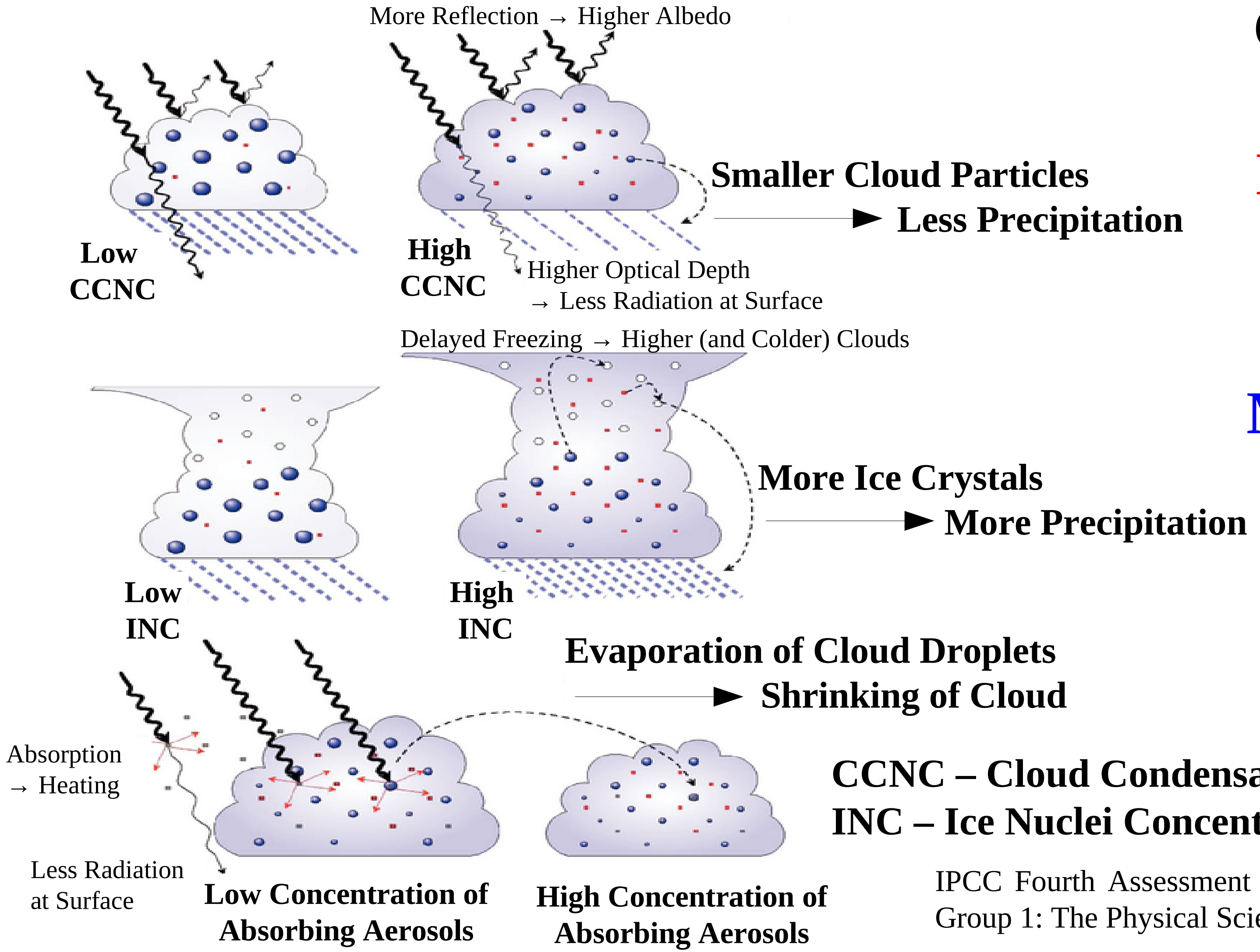
Aerosol Indirect Affect

Importance of Aerosols and Clouds



Cloud Albedo and Lifetime Effect

Less Precipitation

Glaciation Effect

More Precipitation

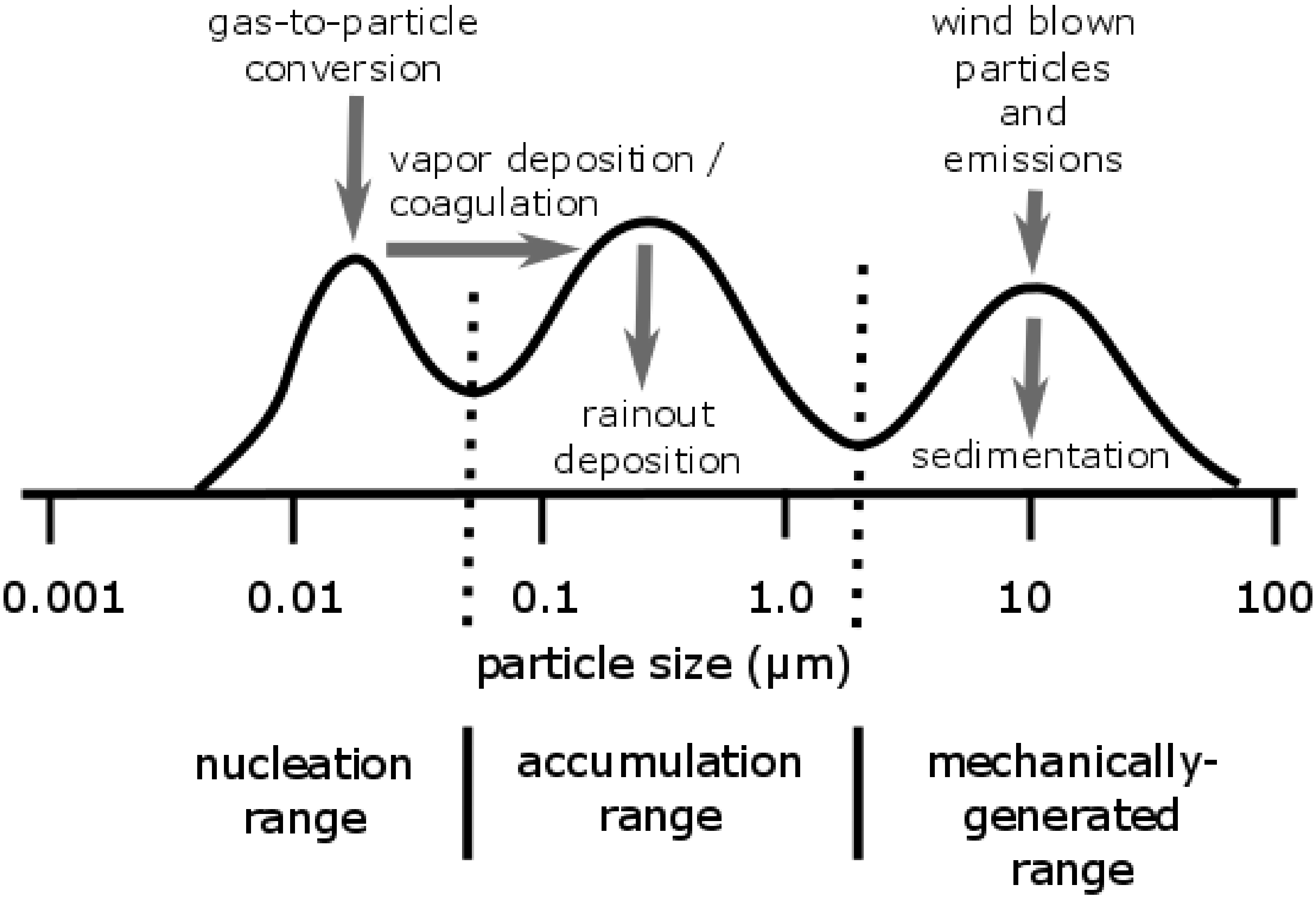
Semi-direct Effect

Less Precipitation

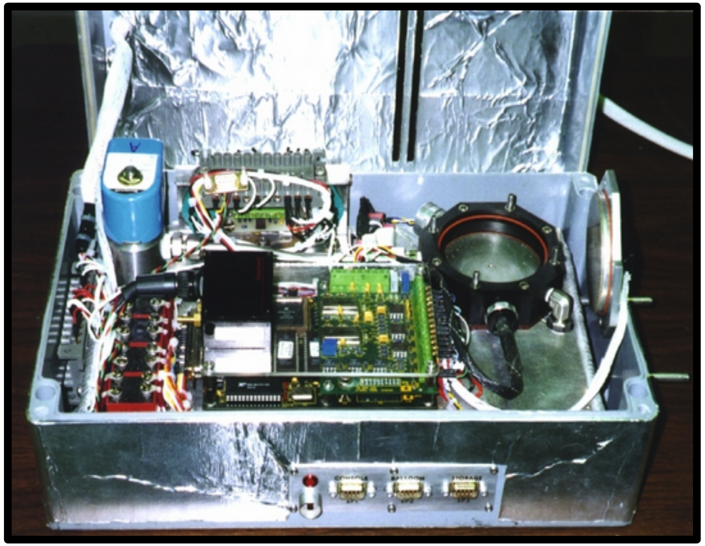
CCNC – Cloud Condensation Nuclei Concentration
INC – Ice Nuclei Concentration

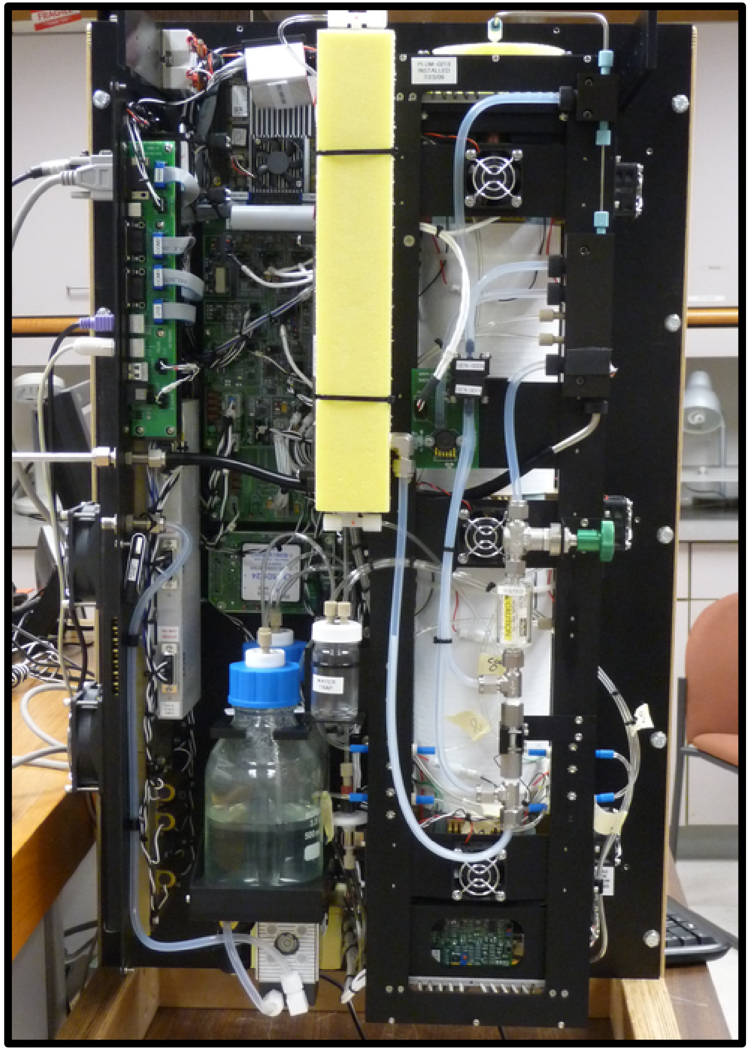
IPCC Fourth Assessment Report: Climate Change 2007: Working Group 1: The Physical Science Basis, Figure 7.20

Cloud Condensation Nuclei (CCN)



Aerosol and Cloud Condensation Nuclei (CCN)





Cloud Condensation Nuclei (CCN) Measurements

Location	CCN Concentration
Australian Cost	120 $\#/cm^{-3}$
North Atlantic Ocean	145-370 $\#/cm^{-3}$
High Planes, Montana	290 $\#/cm^{-3}$
Australia, Africa, USA	600 $\#/cm^{-3}$
High Planes, Montana	2000 $\#/cm^{-3}$
Buffalo, New York	3500 $\#/cm^{-3}$
Texas, USA	3000-5000 $\#/cm^{-3}$

Cloud Condensation Nuclei (CCN) concentrations at 1% Supersaturation measured at various locations.

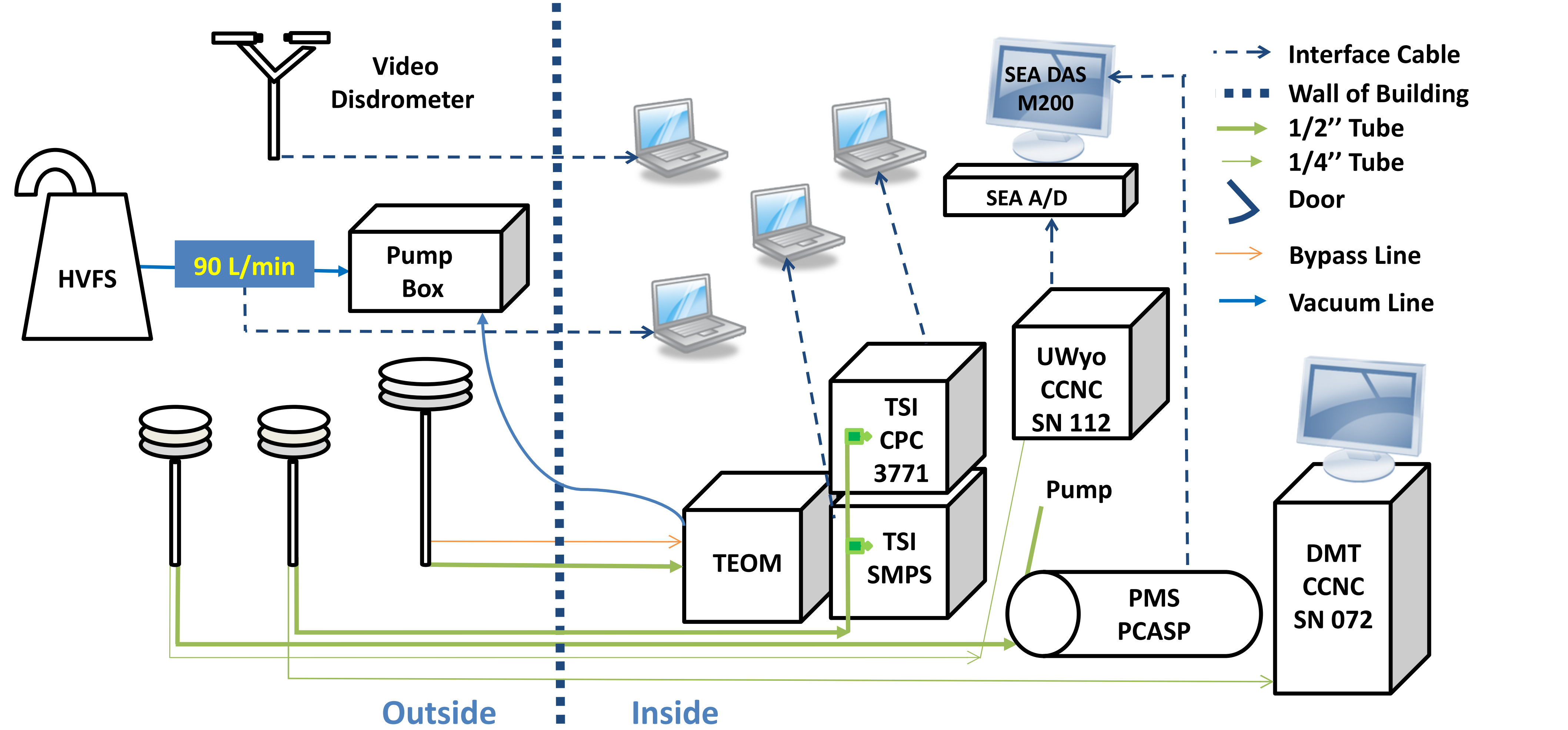
Source: Pruppacher, H. R., and J. D. Klett, Microphysics of Clouds and Precipitation, pp. 287-289, Kluwer Acad. Norwell, Mass., 1997.

UWyo CCN Counter Measurements

Location	**Time of Year**	**CCN Concentration**
Wyoming, USA	Winter	146 ± 20 $\#/cm^{-3}$
Wyoming, USA	Summer	445 ± 157 $\#/cm^{-3}$
New Zealand	Summer	964 ± 17 $\#/cm^{-3}$
Bamako, Mali	09/08/07	367 ± 247 $\#/cm^{-3}$

Cloud Condensation Nuclei (CCN) concentrations at 1% supersaturation measured by the University of Wyoming CCN counter in the lower troposphere at various locations.

Source: Delene, D. J. and T. Deshler, Vertical profiles of cloud condensation nuclei above Wyoming, Journal of Geophysical Research - Atmospheres , 106, 12579-12588, 2001.

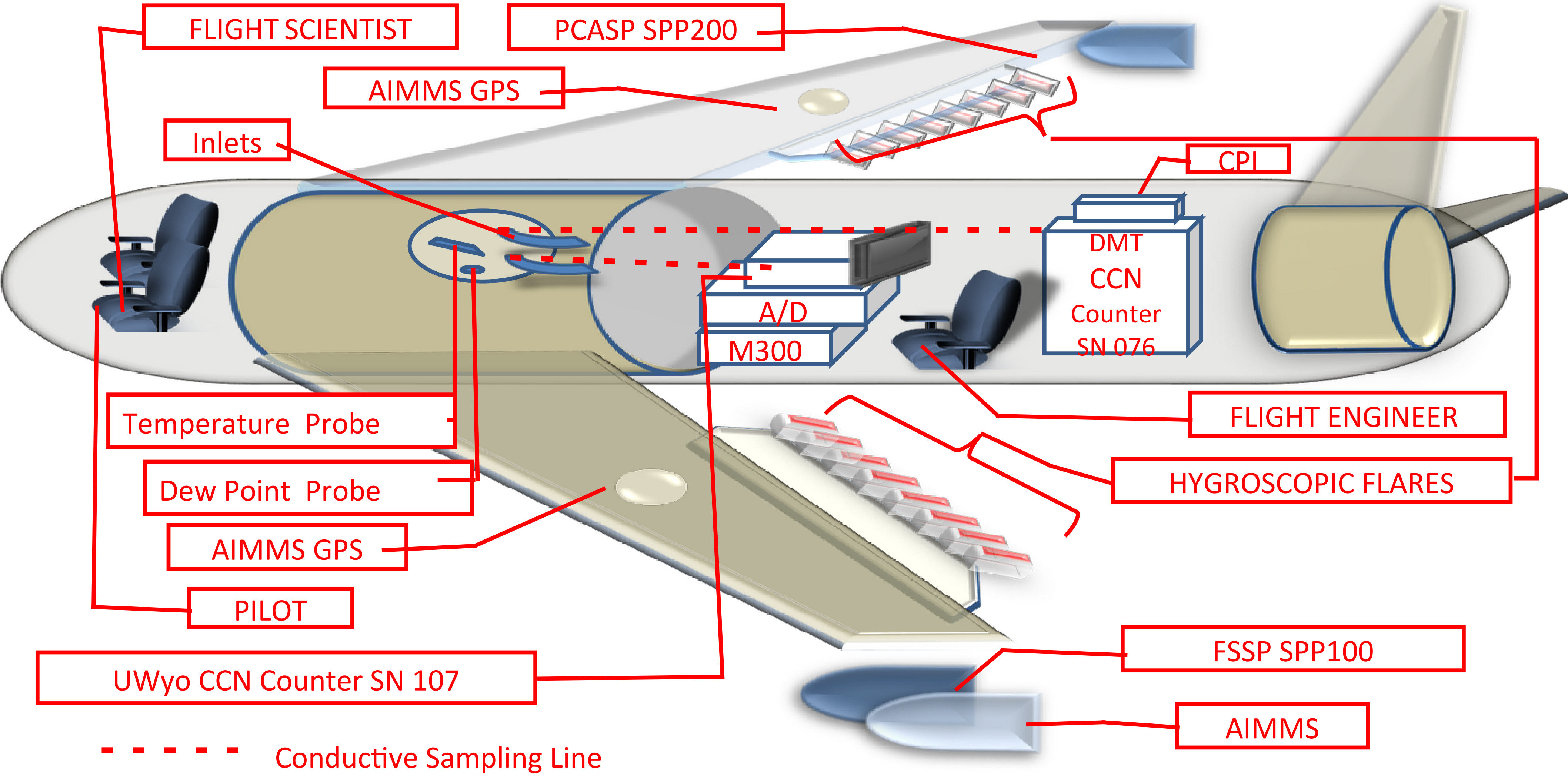


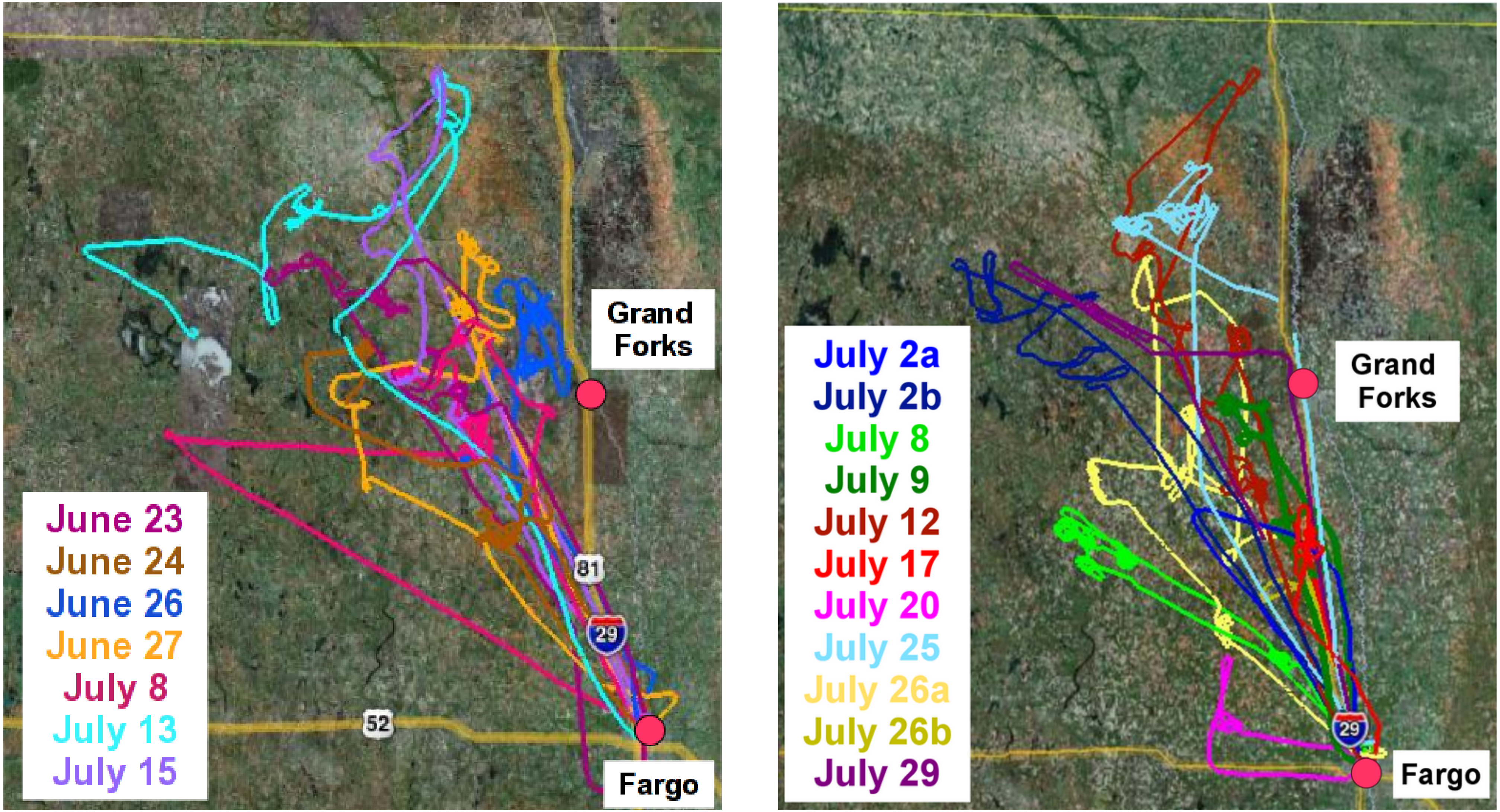
HVFS - High Volume Filter Sampler
PCASP - Passive Cavity Spectrometer Probe
SMPS - Scanning Mobility Particle Sizer
TEOM - Tapered Element Oscillating Microbalance

A/D - Analog to Digital Board
CPC - Cloud Particle Concentration
CCNC - Condensation Nuclei Counter
DAS - Data Acquisition System

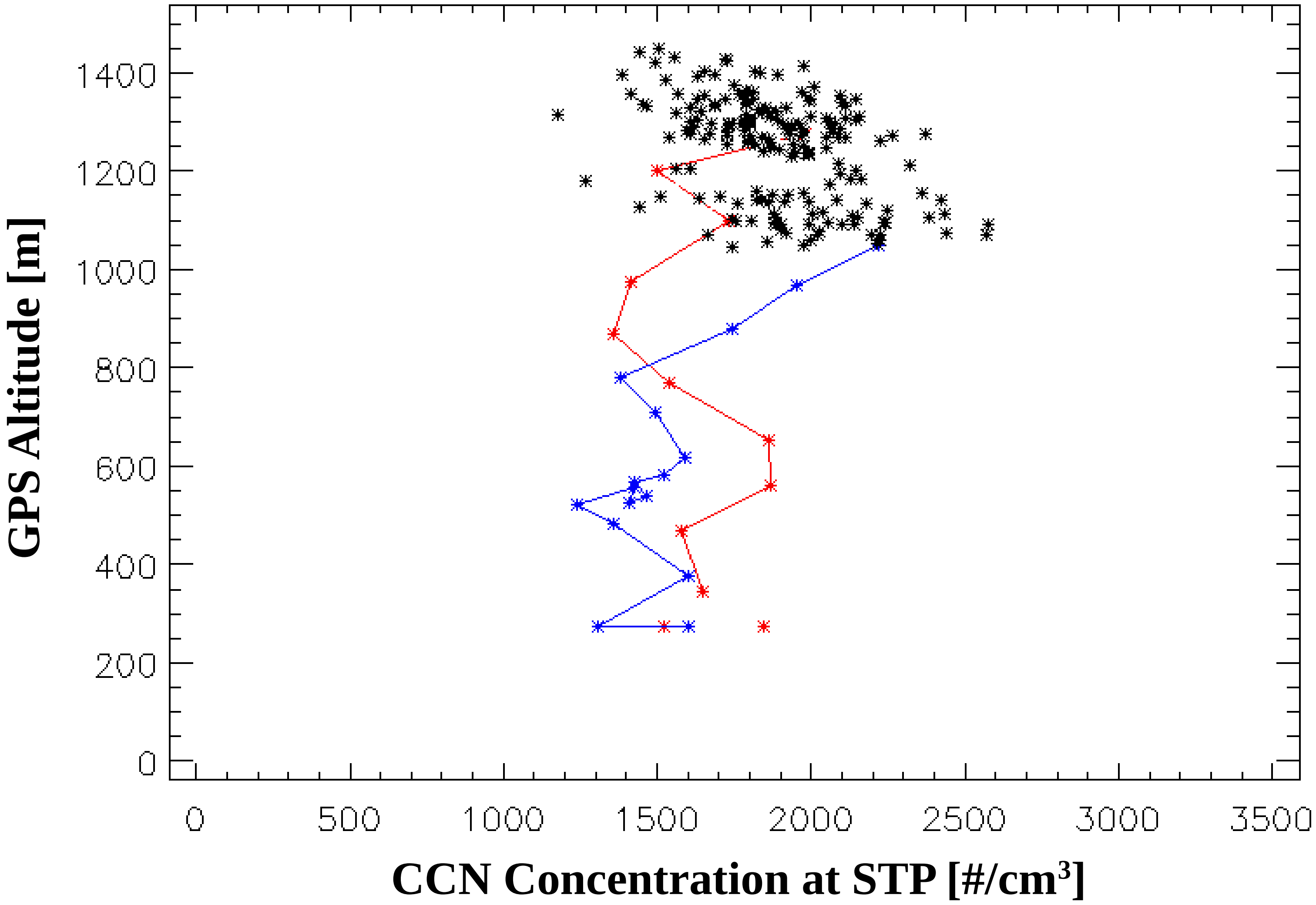
DMT - Droplet Measurement Technology
PMS – Particle Measurement Systems
SEA - Science Engineering Associates
TSI - TSI Inc.

POLCAST4 CESSNA340 N98585 INSTRUMENT CONFIGURATION





Flight paths during the 2010 POLCAST3 (left) and 2012 POLCAST 4 (right) projects.



Cloud Base Temperature 5.1 °C

Cloud Base 0.6 % Ambient Supersaturation and STP

25 Percentile – 1740 [#/cm³]

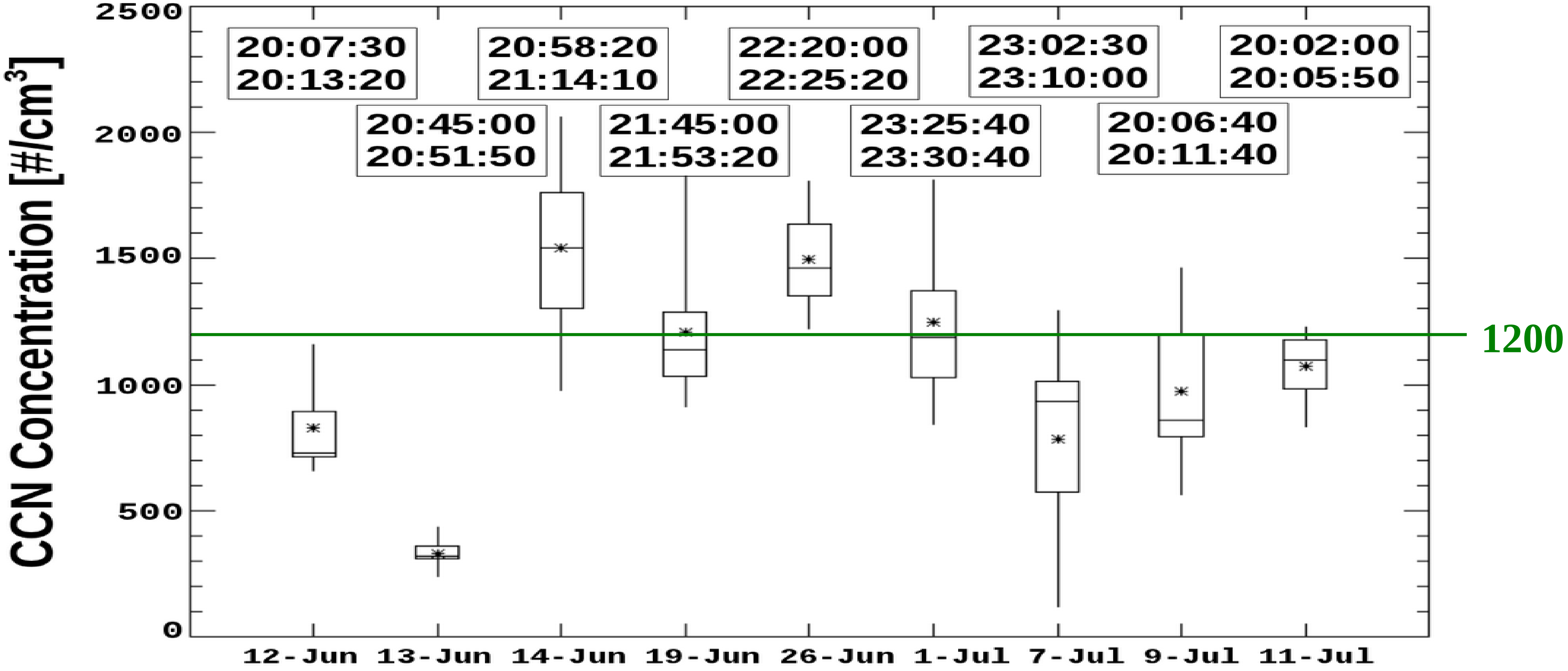
50 Percentile – 1880 [#/cm³]

75 Percentile – 2050 [#/cm³]

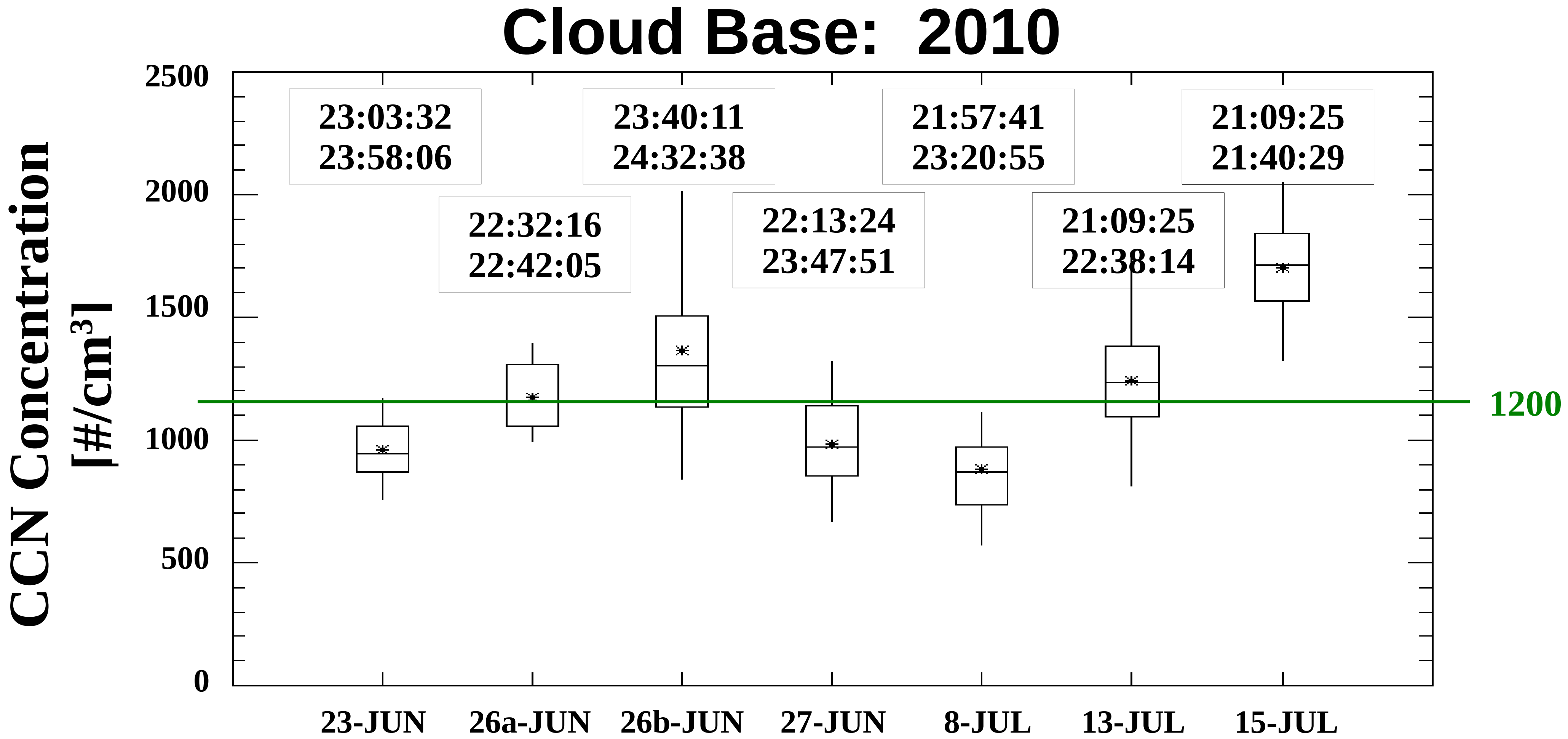
Surface Temperature 14 °C

University of Wyoming cloud condensation nuclei (CCN) counter measurements (0.6 % ambient supersaturation) adjusted to standard pressure and temperature (STP) on aircraft ascent (red, 17:40:00-17:45:00 UTC), during July 8 2012 cloud base sampling (black stars, 18:04:00-19:36:10) and during descent (blue, 19:36:20-19:56:40).

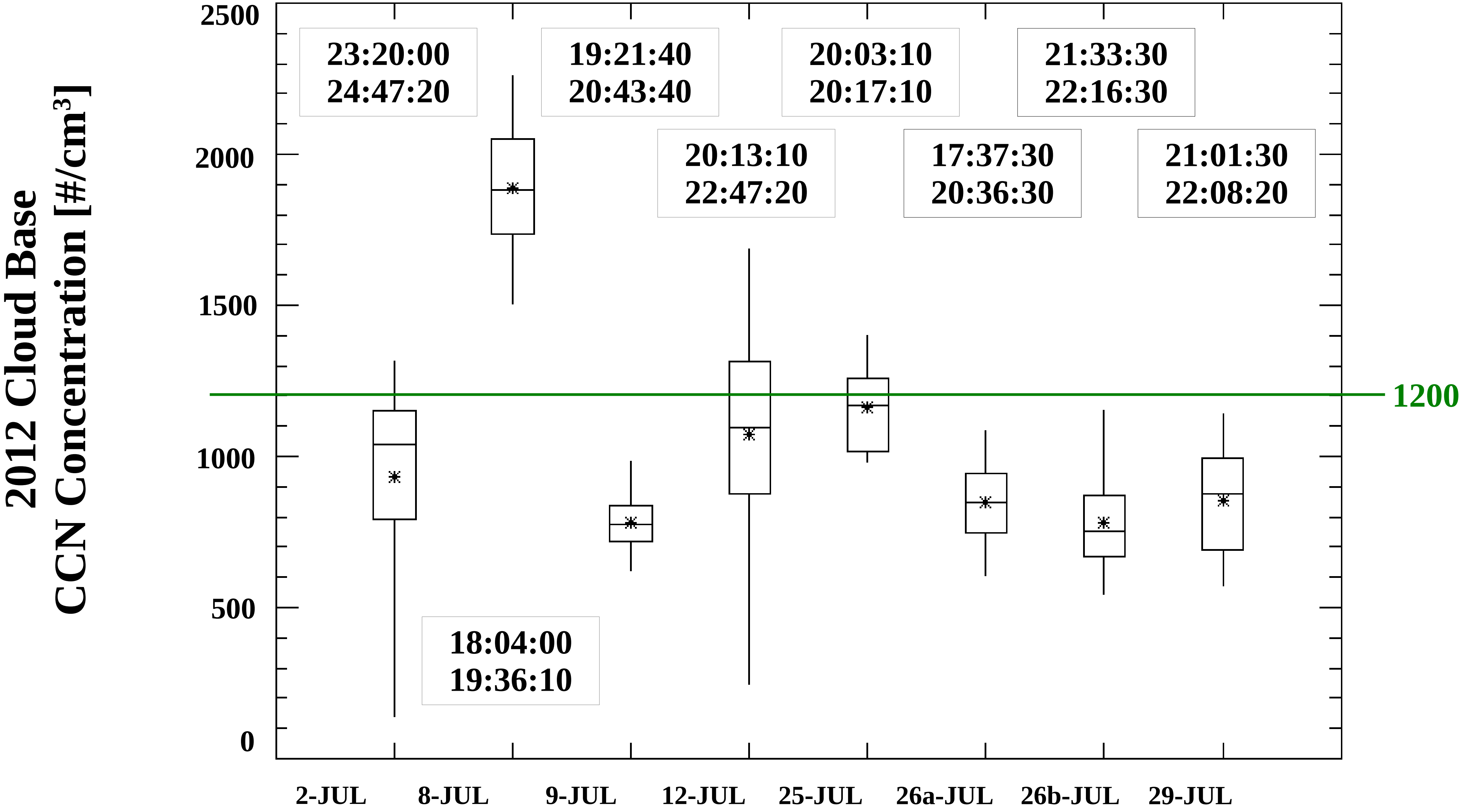
Cloud Base: 2008

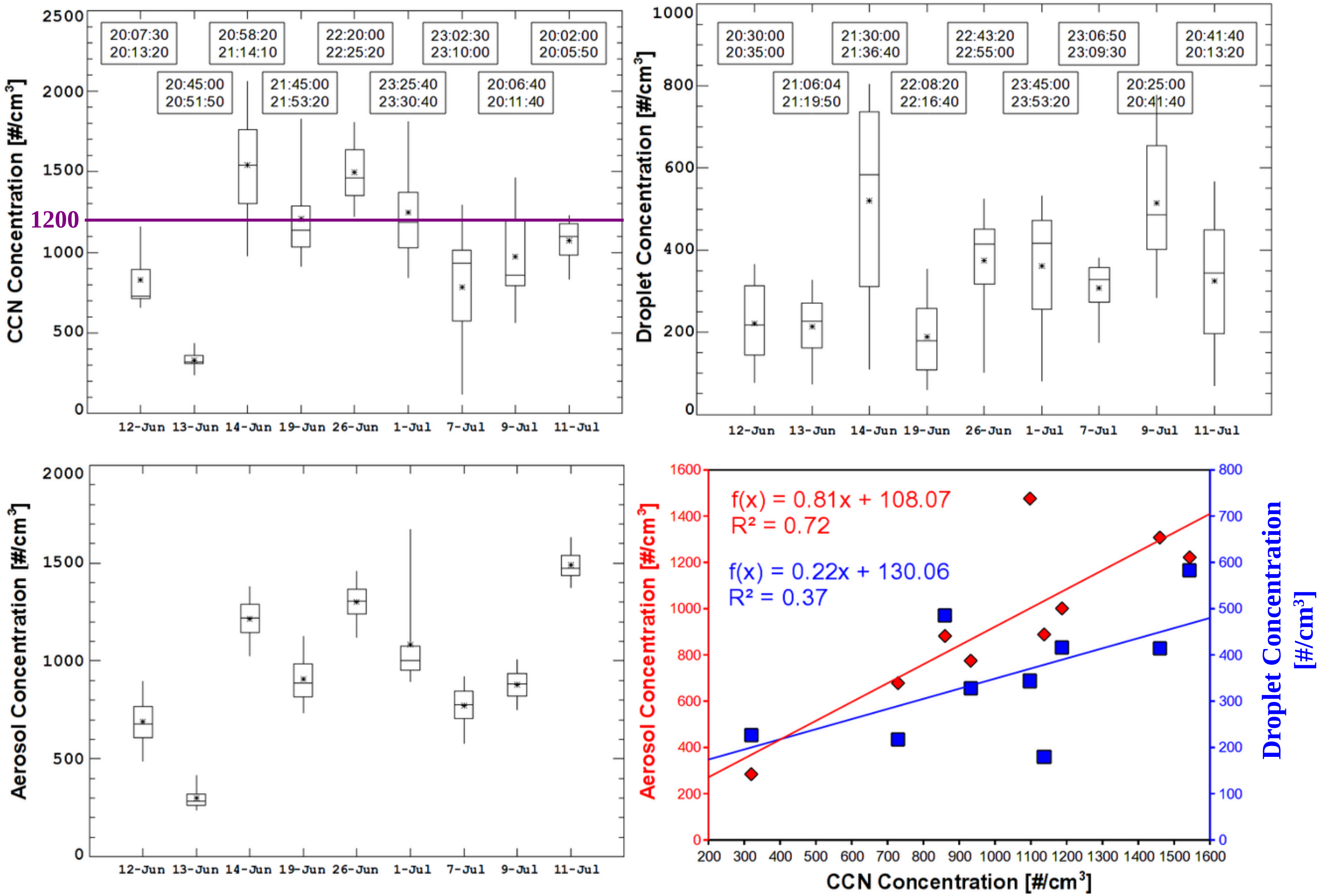


Statistical distributions near cloud base of 30 s 1 % supersaturation (UWyo CCNC theoretical value) Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure during the 2008 POLCAST2 field project. The solid circle is the mean value, the horizontal line is the 50th percentile, the top of the box is the 75th percentile, the bottom is the 25th percentile, and the top and bottom of the whiskers are the 95th and 5th percentiles, respectively.



Statistical distributions near cloud base of 30 s 1 % supersaturation (Uwyo CCNC theoretical value), Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure during the 2010 POLCAST3 field project. The solid circle is the mean value, the horizontal line is the 50th percentile, the top of the box is the 75th percentile, the bottom is the 25th percentile, and the top and bottom of the whiskers are the 95th and 5th percentiles, respectively.

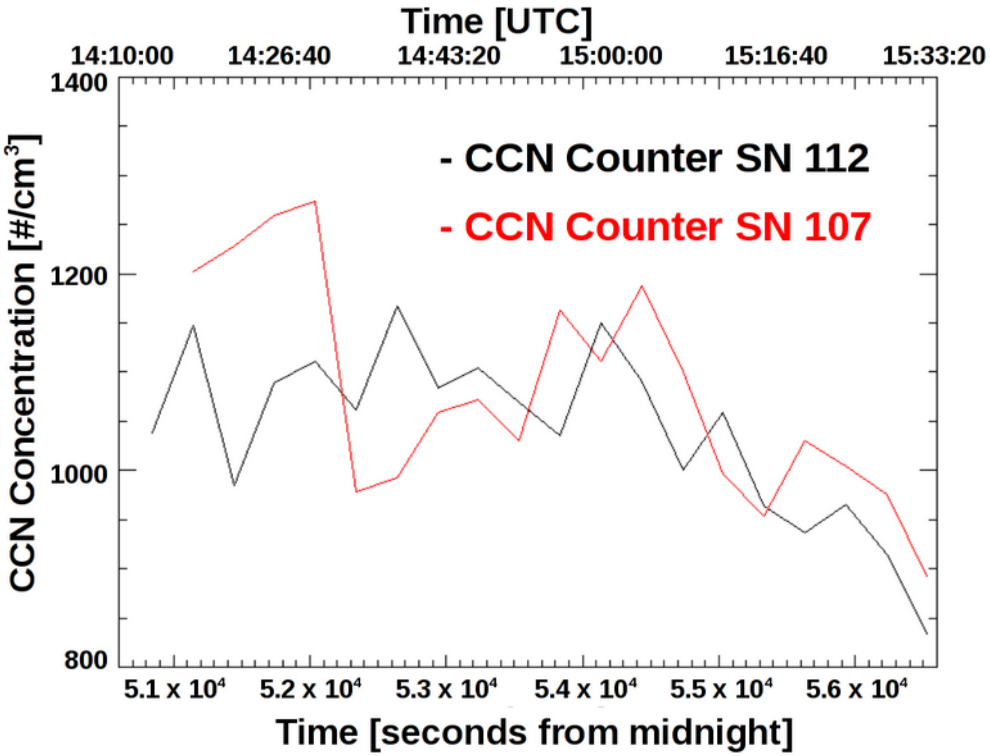

2012 Cloud Base
CCN Concentration [#/cm^3]
2500
2000
1500
1000
500
0
23:20:00
24:47:20
19:21:40
20:43:40
20:03:10
20:17:10
21:33:30
22:16:30
20:13:10
22:47:20
17:37:30
20:36:30
21:01:30
22:08:20
18:04:00
19:36:10
1200
2-JUL
8-JUL
9-JUL
12-JUL
25-JUL
26a-JUL
26b-JUL
29-JUL



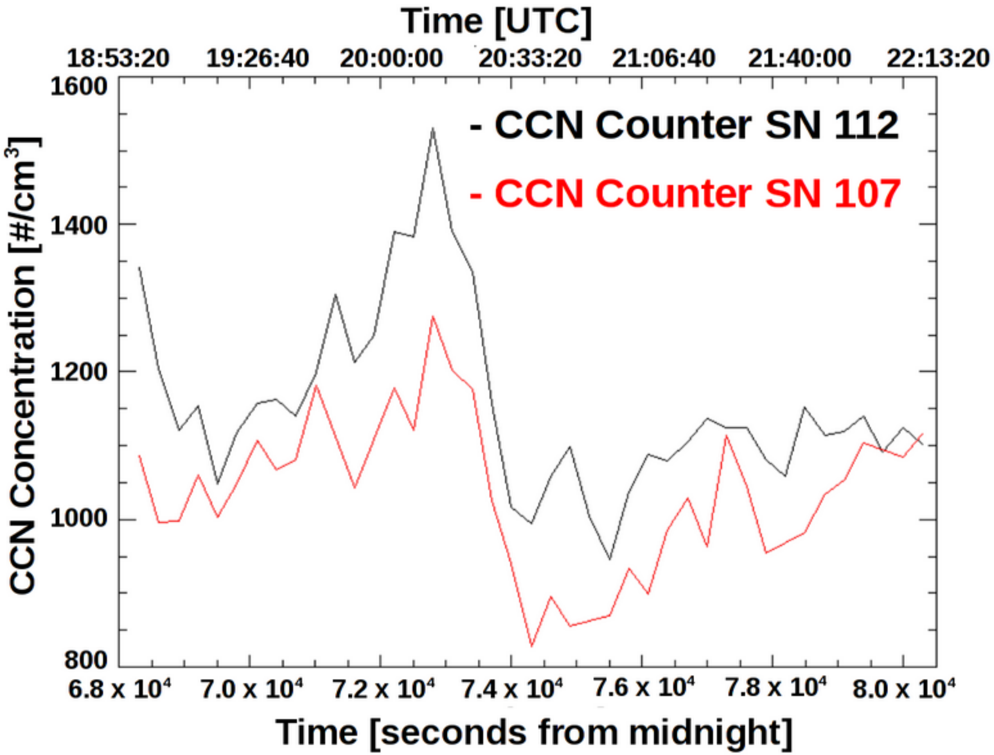
20:07:30
20:13:20
20:45:00
20:51:50
20:58:20
21:14:10
21:45:00
21:53:20
22:20:00
22:25:20
23:25:40
23:30:40
23:02:30
23:10:00
20:06:40
20:11:40
20:02:00
20:05:50
1200
CCN Concentration [#/cm³]
0
500
1000
1500
2000
2500
12-Jun 13-Jun 14-Jun 19-Jun 26-Jun 1-Jul 7-Jul 9-Jul 11-Jul
20:30:00
20:35:00
21:06:04
21:19:50
21:30:00
21:36:40
22:08:20
22:16:40
22:43:20
22:55:00
23:45:00
23:53:20
23:06:50
23:09:30
20:25:00
20:41:40
20:41:40
20:13:20
Droplet Concentration [#/cm³]
0
200
400
600
800
1000
12-Jun 13-Jun 14-Jun 19-Jun 26-Jun 1-Jul 7-Jul 9-Jul 11-Jul
Aerosol Concentration [#/cm³]
0
500
1000
1500
2000
12-Jun 13-Jun 14-Jun 19-Jun 26-Jun 1-Jul 7-Jul 9-Jul 11-Jul
f(x) = 0.81x + 108.07
R² = 0.72
f(x) = 0.22x + 130.06
R² = 0.37
Aerosol Concentration [#/cm³]
0
200
400
600
800
1000
1200
1400
1600
Droplet Concentration [#/cm³]
0
100
200
300
400
500
600
700
800
200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600
CCN Concentration [#/cm³]

Lab CCN Comparison

October 14, 2010

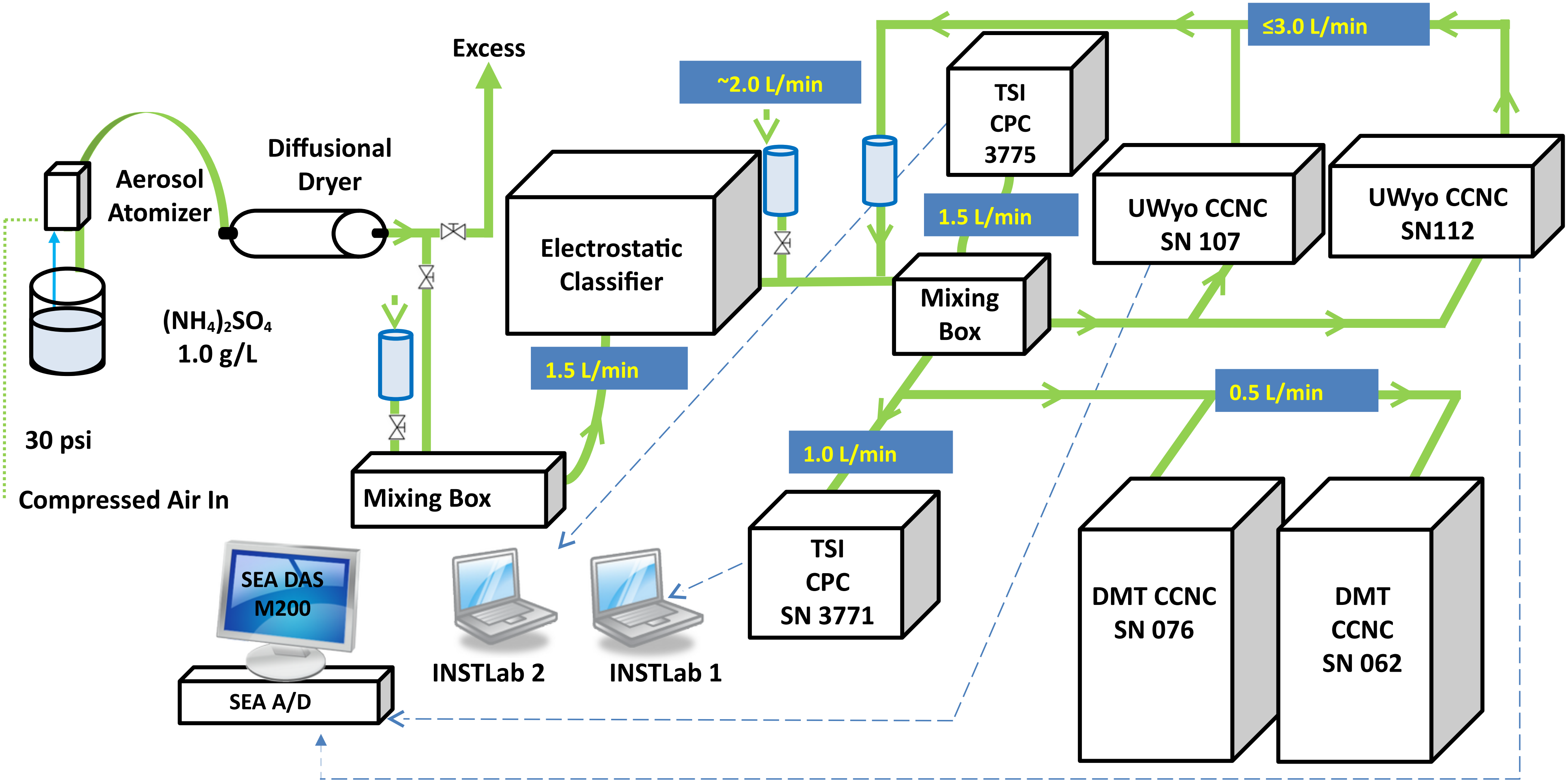


October 7, 2010



Comparison between Cloud Condensation Nuclei (CCN) counters used during POLCAST3.

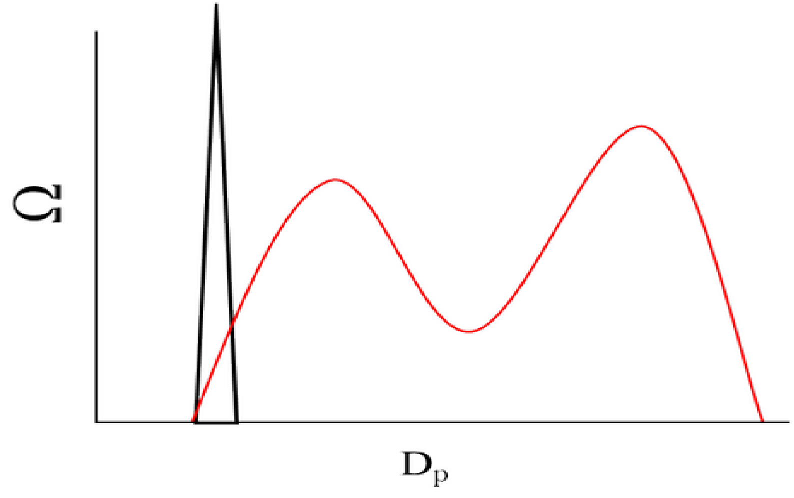
Cloud Condensation Nuclei Performance Check

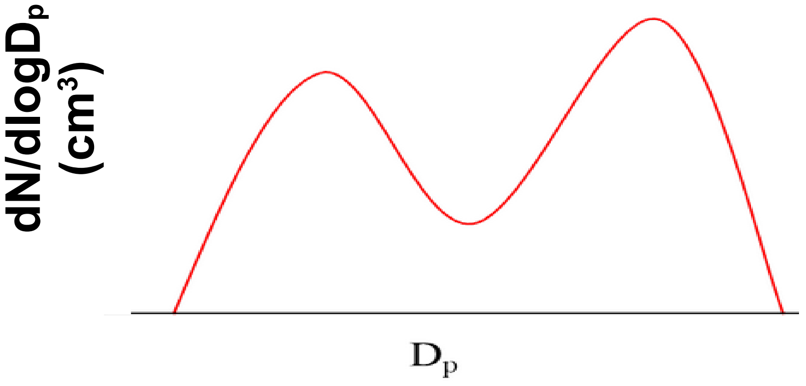


Differential Mobility Analyzer

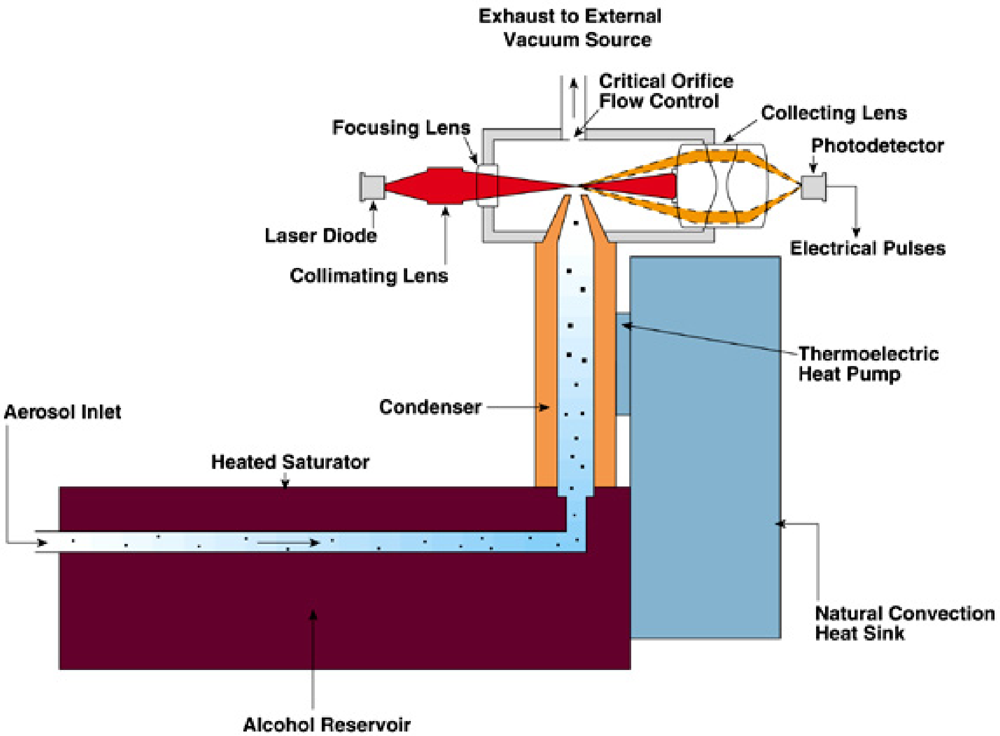
Polydisperse
Aerosol In

Monodisperse
Aerosol Out



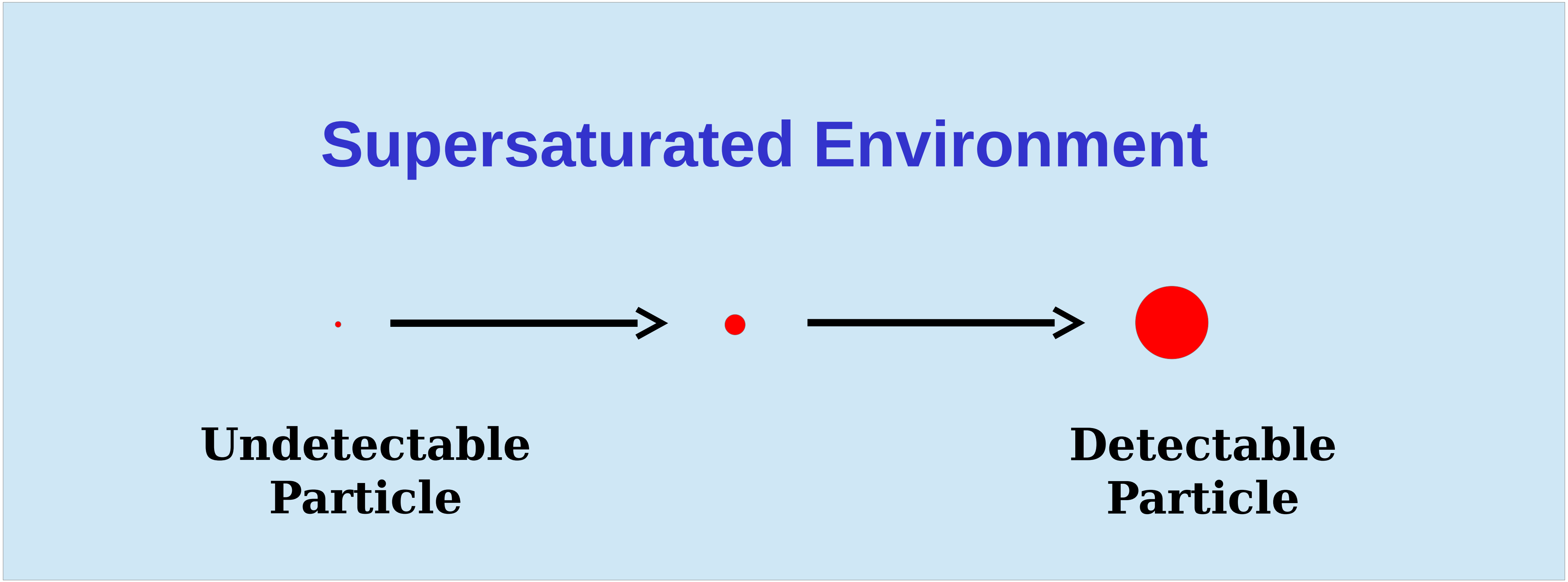


Condensation Nucleus Counter



Alcohol vapor condenses onto particles which create particles large enough to be detected by an optical particle counter. Upon entering the instrument, the air sample passes through a saturation block where alcohol evaporates saturating the flow. The air sample next enters a condenser tube which cools the air sample. Cooling of the air sample creates a supersaturated environment and the alcohol condenses onto particles, regardless of particle composition.

Grow Small Aerosols to Detectable Size



Software for Processing of Supersaturation Laboratory Data

<u>CCN Counter Processing Routines</u>

- **process_day_dmtccnc**
- **http://adpaa.sourceforge.net/wiki**

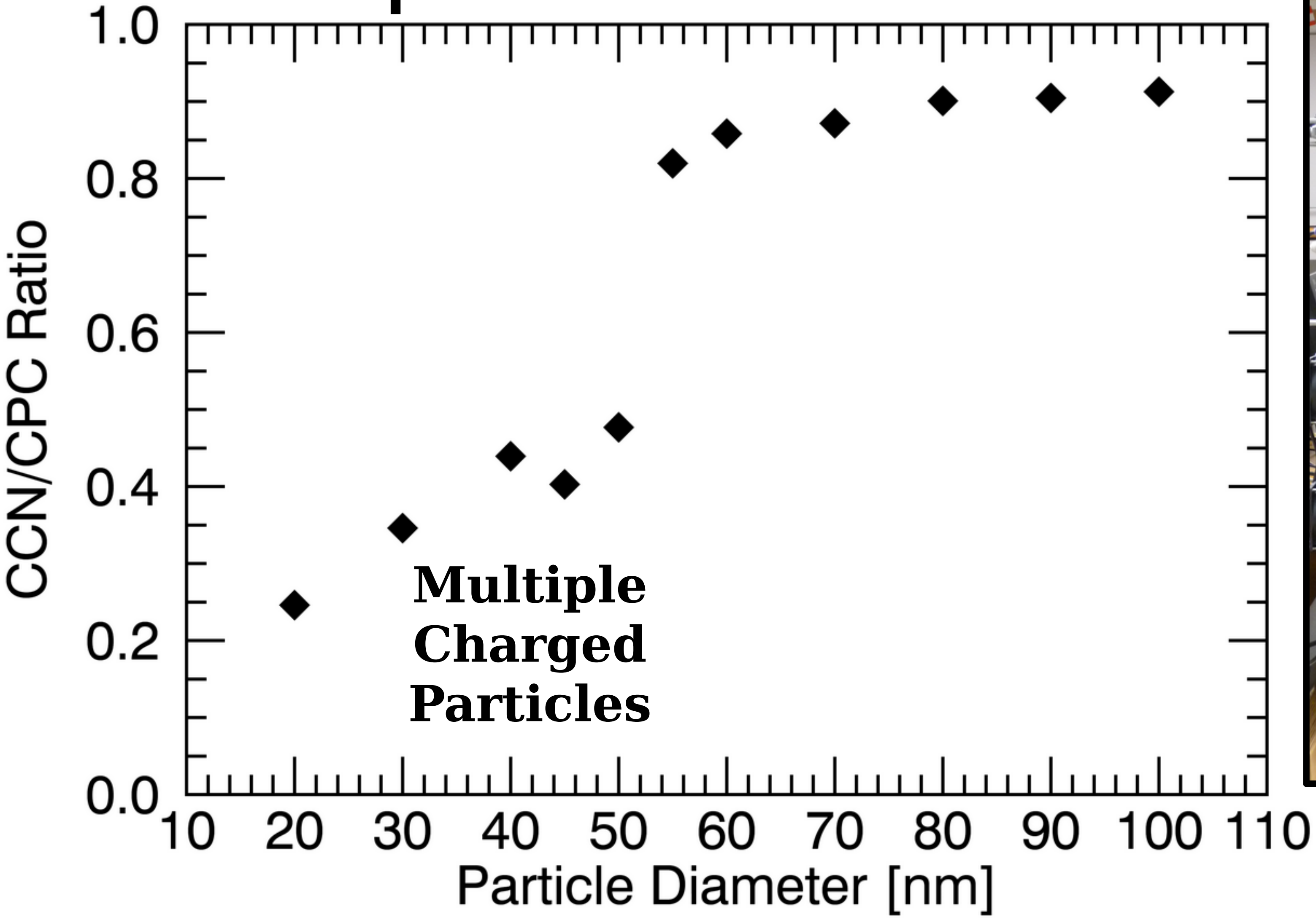
<u>CPC Processing</u>

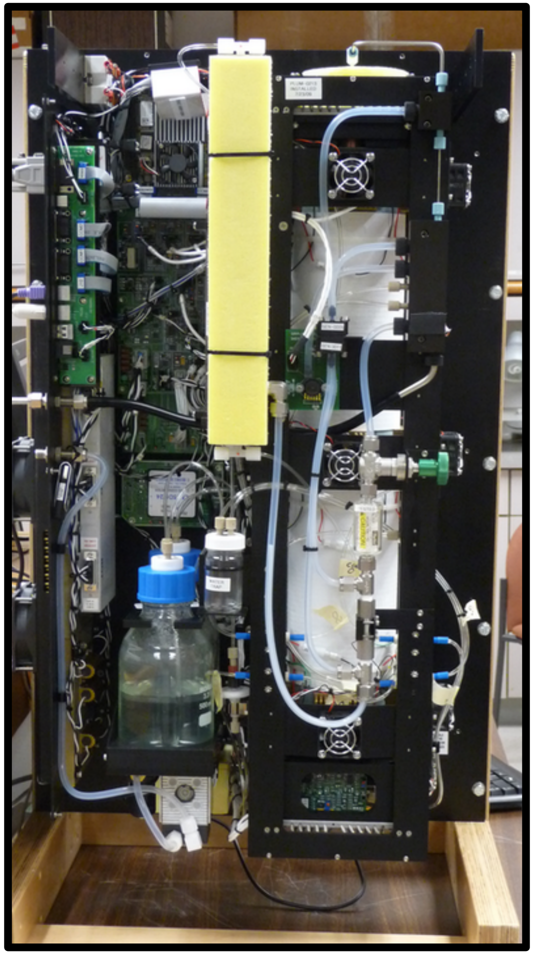
- **convert_cpc3771tonasa**
  - **Input File is CPC3772_161006.txt**

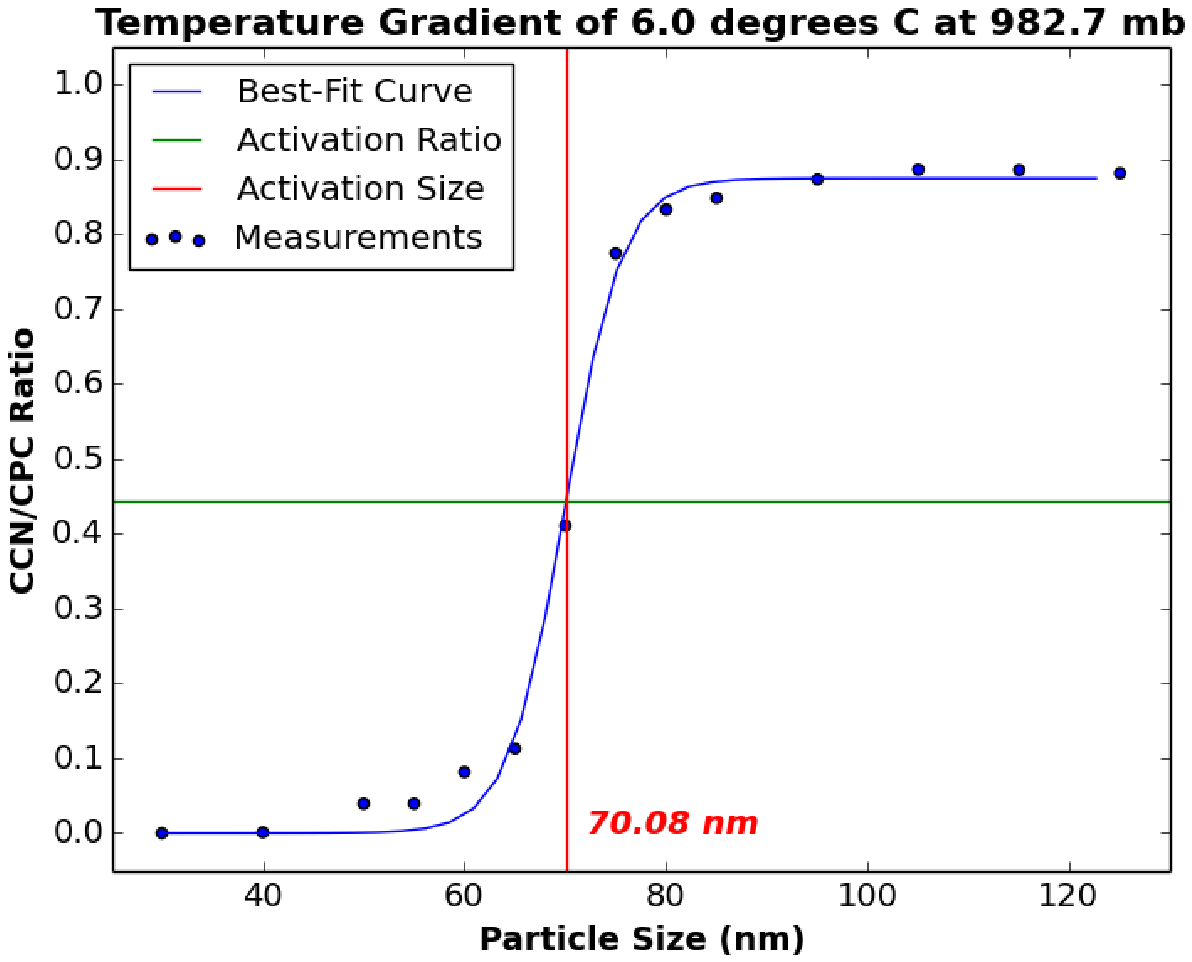
<u>Create Ratio Files</u>

- **CCNCactivationsize.py**
  - **Creates the ratio file.**

Supersaturation at 10 ^{0}C

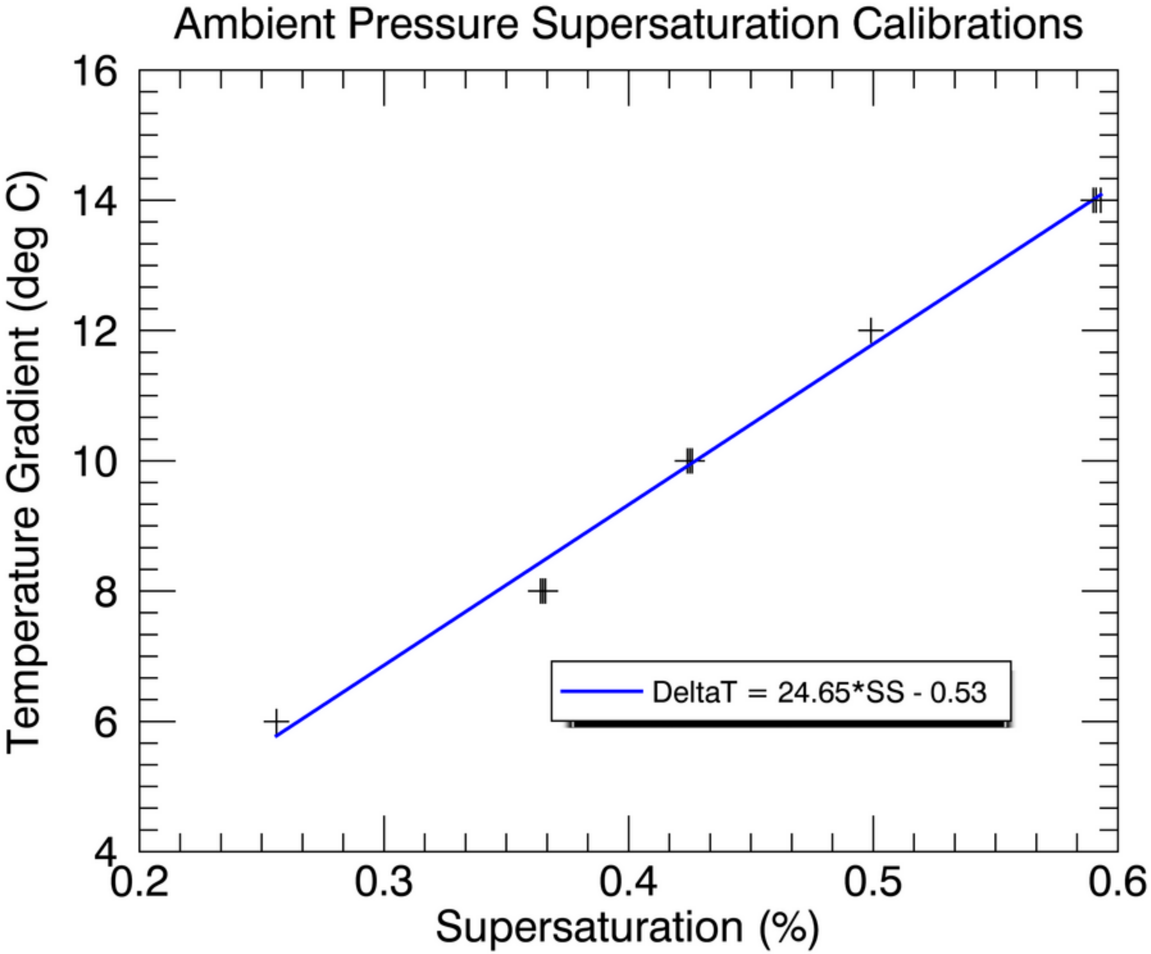






Activation size of 70.08 nm results in a calculated supersaturation of 0.256%

- **The activation curve is made using a sigmoidal curve fitting routine to fit the data**
- **The same processing script determines the activation size based on the size at which the activation curve crosses the activated ratio**
  - Normalization of ratio data to 1.0 does not significantly impact activation size calculation (< 0.5 %)
- **Using kappa-Köhler theory, the critical supersaturation is calclulated**
- **Critical supersaturation is calculated at 5 different instrument temperature gradients (6, 8, 10, 12, and 14 K).**
- **Process is repeated three times at each of three pressures: 700, 840, and 980 mb**



- **Calculated supersaturation is plotted with its corresponding temperature gradient and fitted linearly**
- **The fit equation coefficients are used as the instrument's calibration coefficients**

- **The uncertainty in supersaturation is determined using the relative deviation of three supersaturation calibrations for each temperature gradient.**
  - 0.1-0.3 % uncertainty
- **The overall supersaturation calibration uncertainty is calculated from the relative error of the three calibrations at a given pressure**
  - 2.3, 3.1, and 4.4 % uncertainty for 980, 840, and 700 mb calibrations respectively

Conclusions

Cloud Condensation Nuclei are a very important but difficult measurement.

Image taken from the Cessna 340 on July 8, 2012 during POLCAST4 file project.