

Airborne Measurements During the POLCAST Field Projects in North Dakota

**David Delene¹, Jeffrey Tilley²,
Cedric Grainger¹, Mariusz Starzec¹,
Gretchen Mullendore¹, and Darin Langerud³**

¹Department of Atmospheric Sciences, University of North Dakota

²Regional Weather Information Center, University of North Dakota

³North Dakota Atmospheric Resource Board, North Dakota State Water Commission

Motivation

- Evaluate hygroscopic seeding flares for use in the North Dakota Operation Weather Modification Program.
- To better understand the effects of hygroscopic cloud seeding at cloud base on convective clouds that occur in North Dakota.



13 July 2010 Flight (20:39:43 Z)



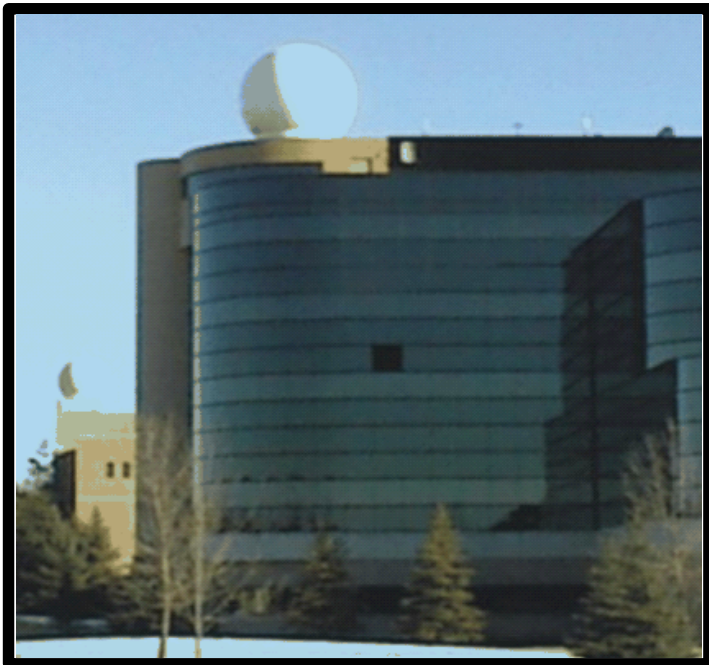
15 June 2010 Flight (21:23:17 Z)

Research Objectives

- Characterization of hygroscopic seeding effects in radar parametric fields stratified by aerosol and Cloud Condensation Nuclei (CCN) concentrations using statistical analysis of a randomized experiment.
- Determine if surface measurements can be used to estimate cloud base CCN concentrations.
- Evaluated the use of the Weather Research and Forecasting (WRF) model in predicting North Dakota convection.
- Understand how cloud micro-physical properties are related to CCN concentrations..

Field Projects

- The Polarimetric Cloud Analysis and Seeding Test (POLCAST 1,2 and 3) project conducted field measurements during the summer of 2006, 2008 and 2010.
- Polarimetric radar measurements were used to detect changes in large drops.
- Aircraft measurements were used to understand the processes linking aerosols and cloud micro-physics.



Clifford Hall with the NorthPOL radar dome.



View out the front of the Citation Research Aircraft on 15 July 2010 (20:17:24 Z).

Measurement Components

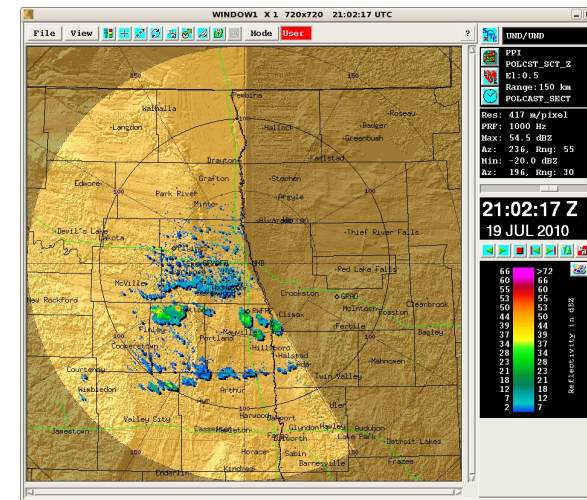
Polarimetric Radar

Seeding Aircraft

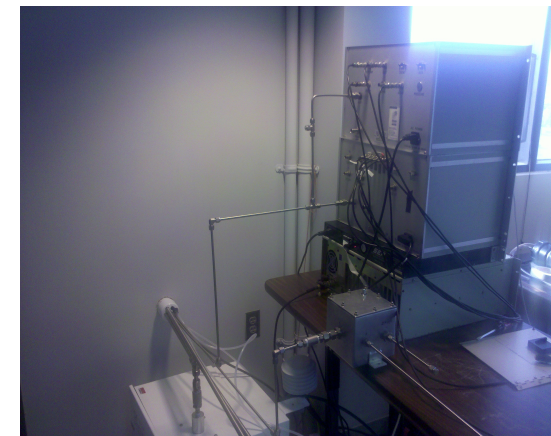
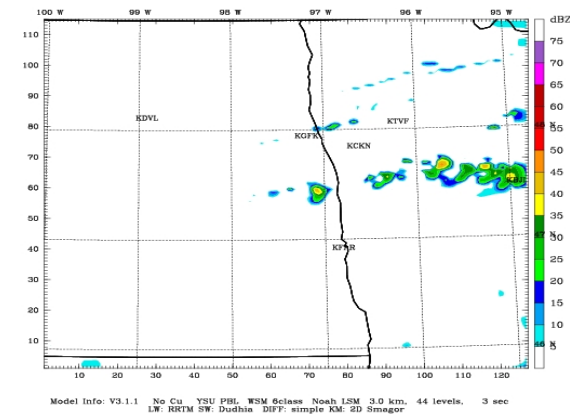
Model

Cloud-physics Aircraft

Surface Measurements



Dataset: d03 RIP: rip dbz Valid: 2300 UTC Mon 19 Jul 10 Init: 0000 UTC Mon 19 Jul 10
Fcast: 23.00 h at height = 2.00 km Reflectivity ()

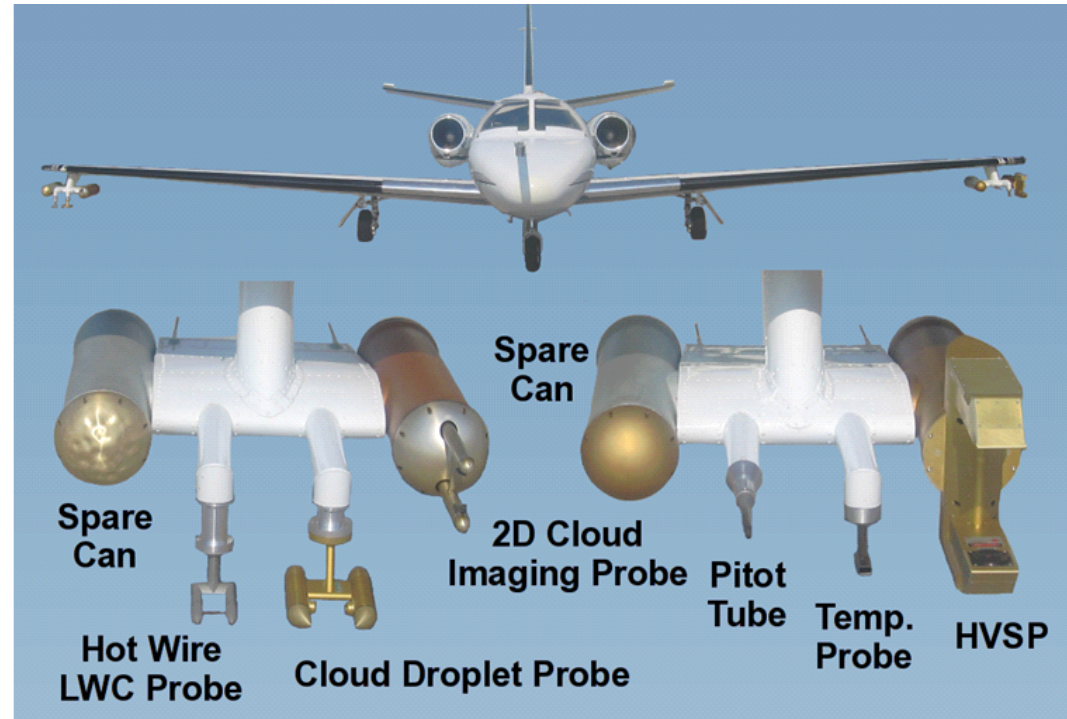


Instrumentation

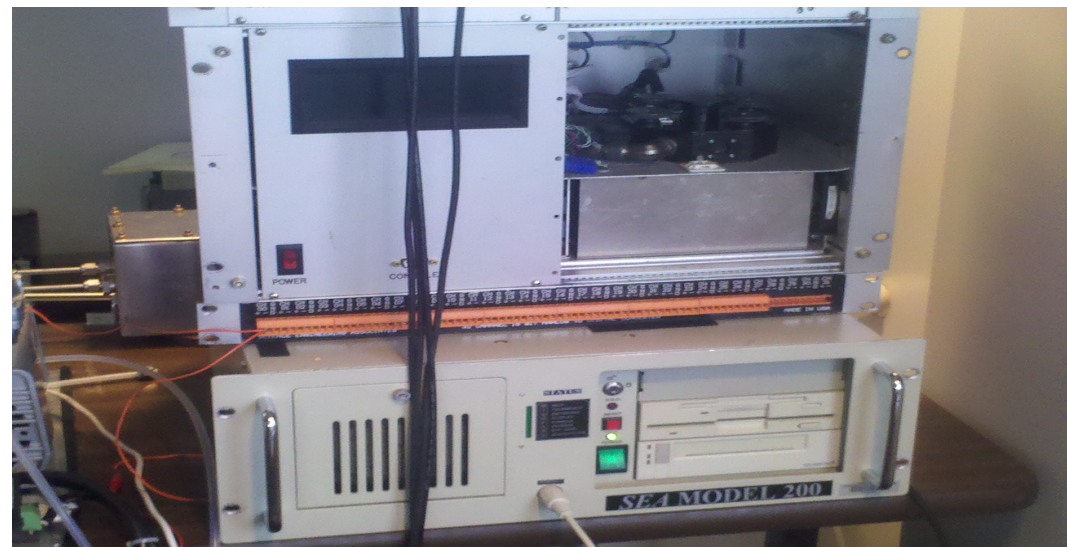
Seeding Aircraft



Cloud-physics Aircraft

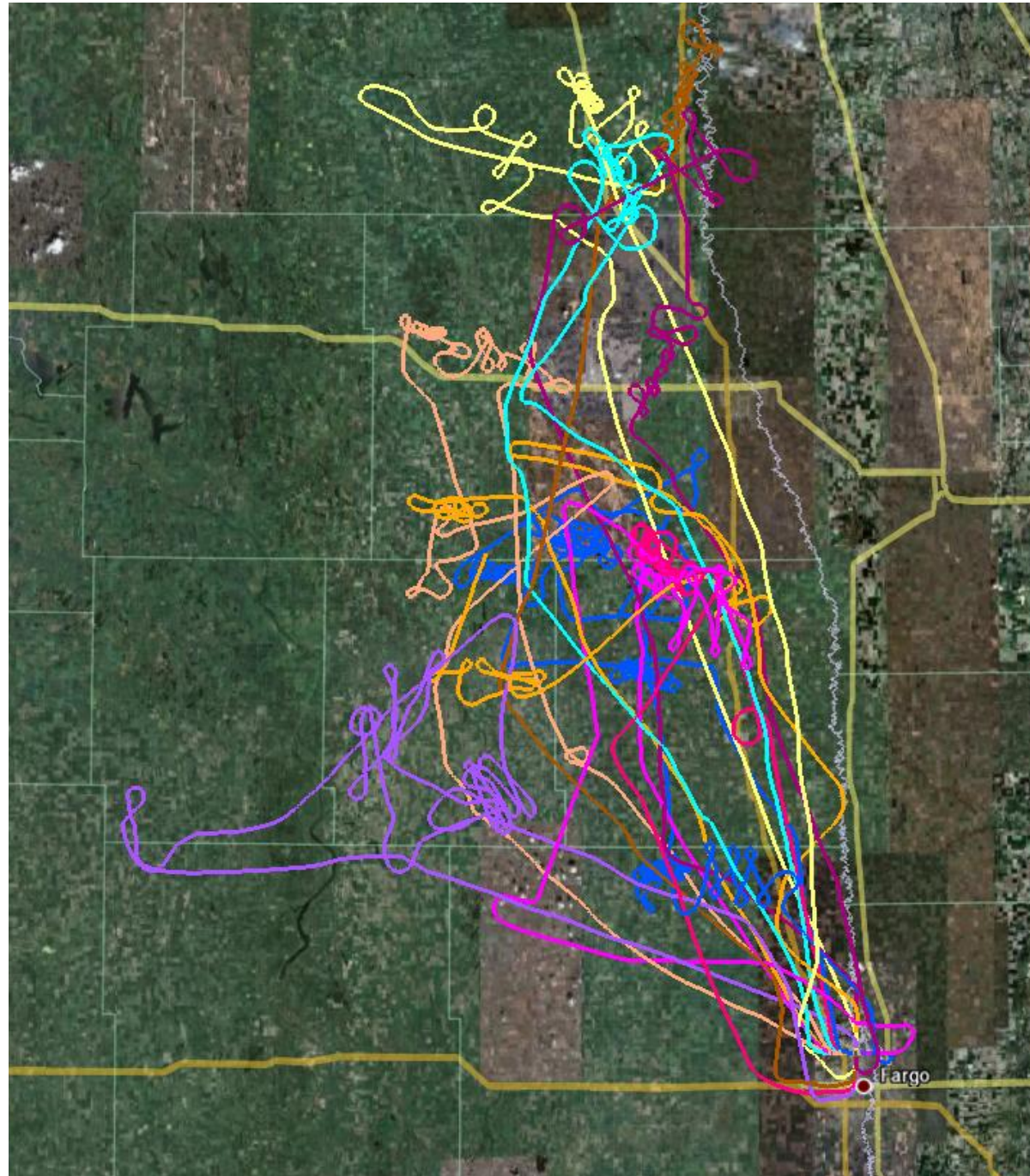


Surface Station

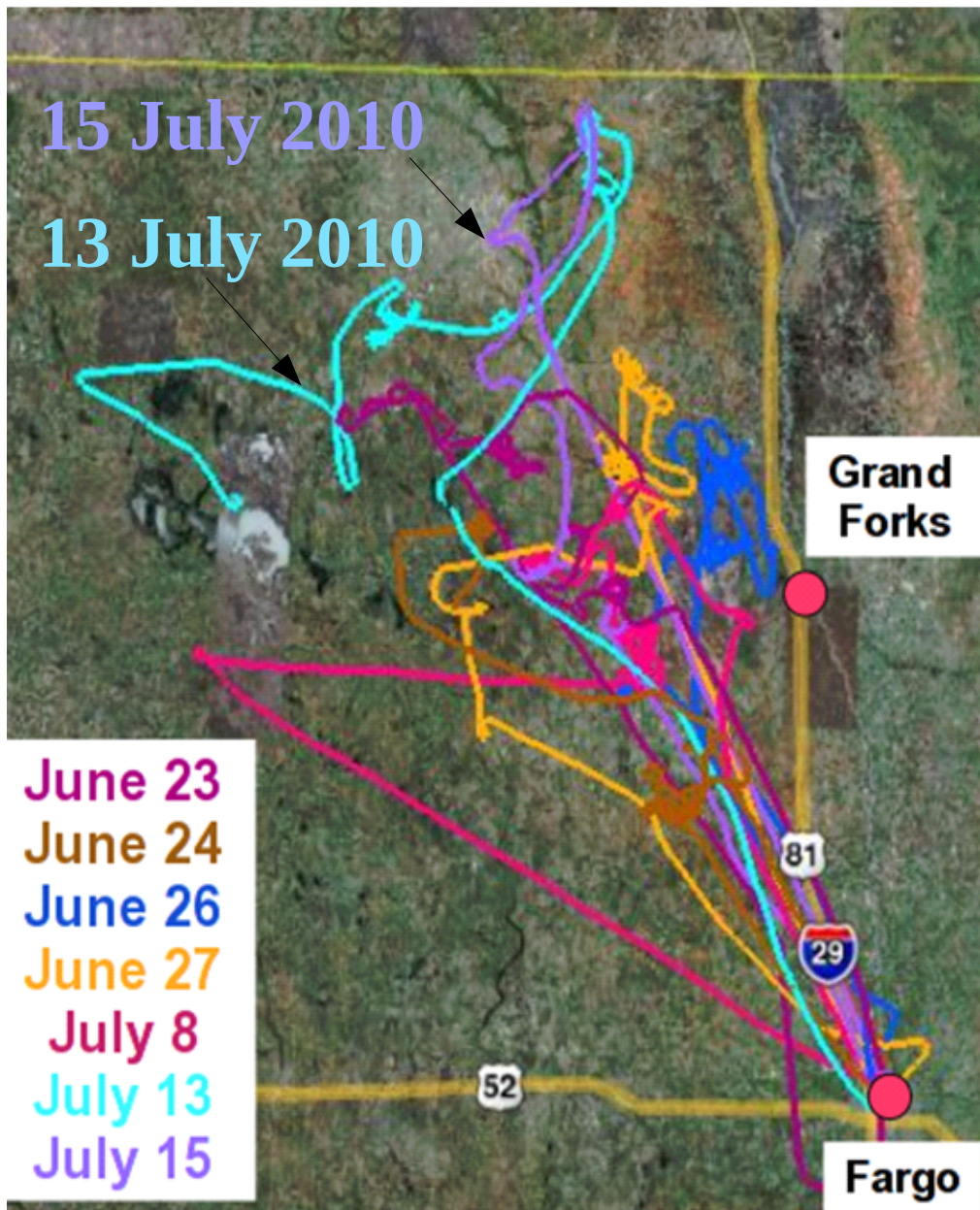


POLCAST2 Aircraft Flights

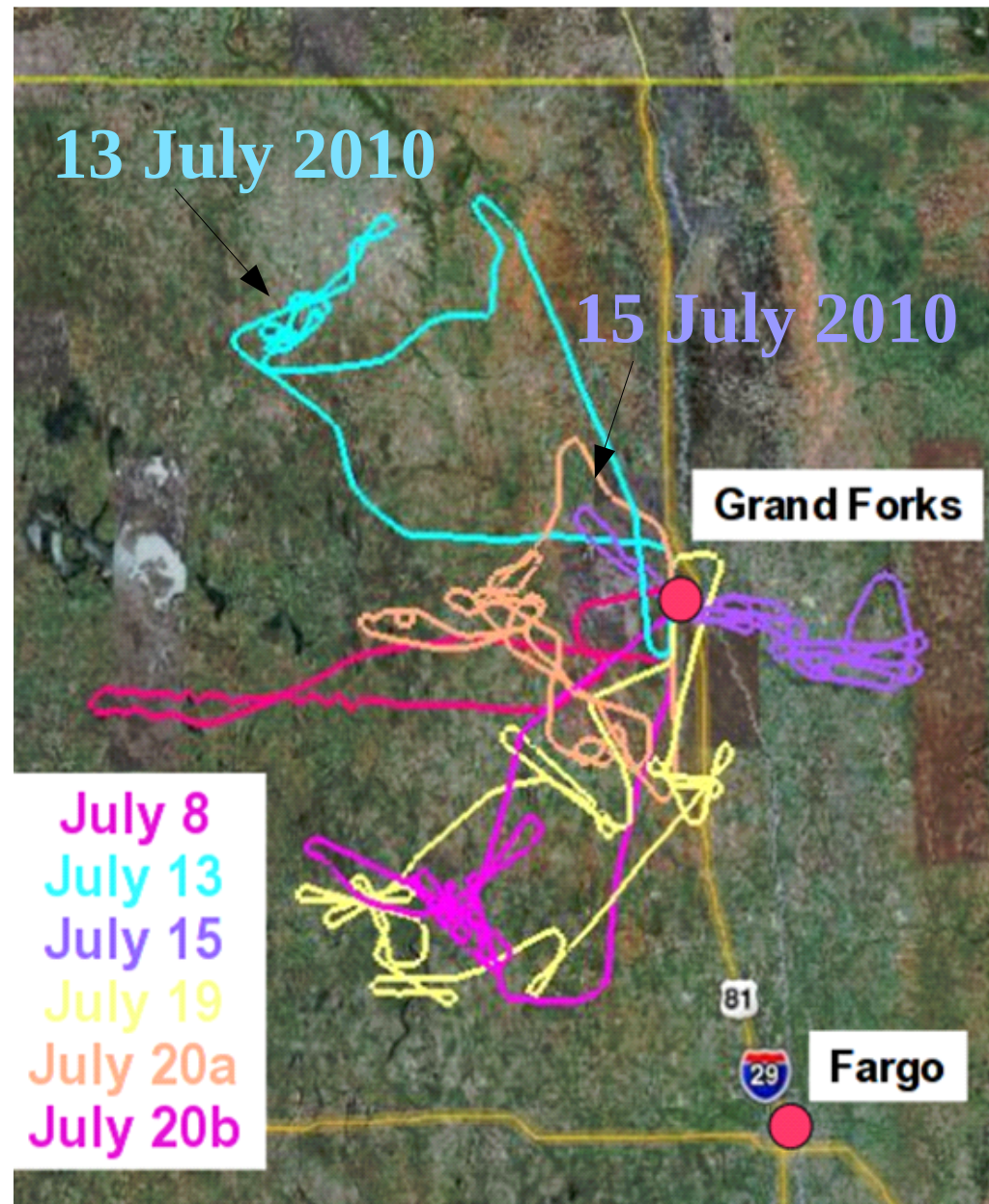
- Flights took off from Fargo, North Dakota.
- Targets with in coverage (100 km) of the UND radar.
- Targets with in North Dakota.
- Obtained 7 seed cases and 6 no seed cases.
- Aircraft measurements on all flights.



POLCAST3 Aircraft Flights

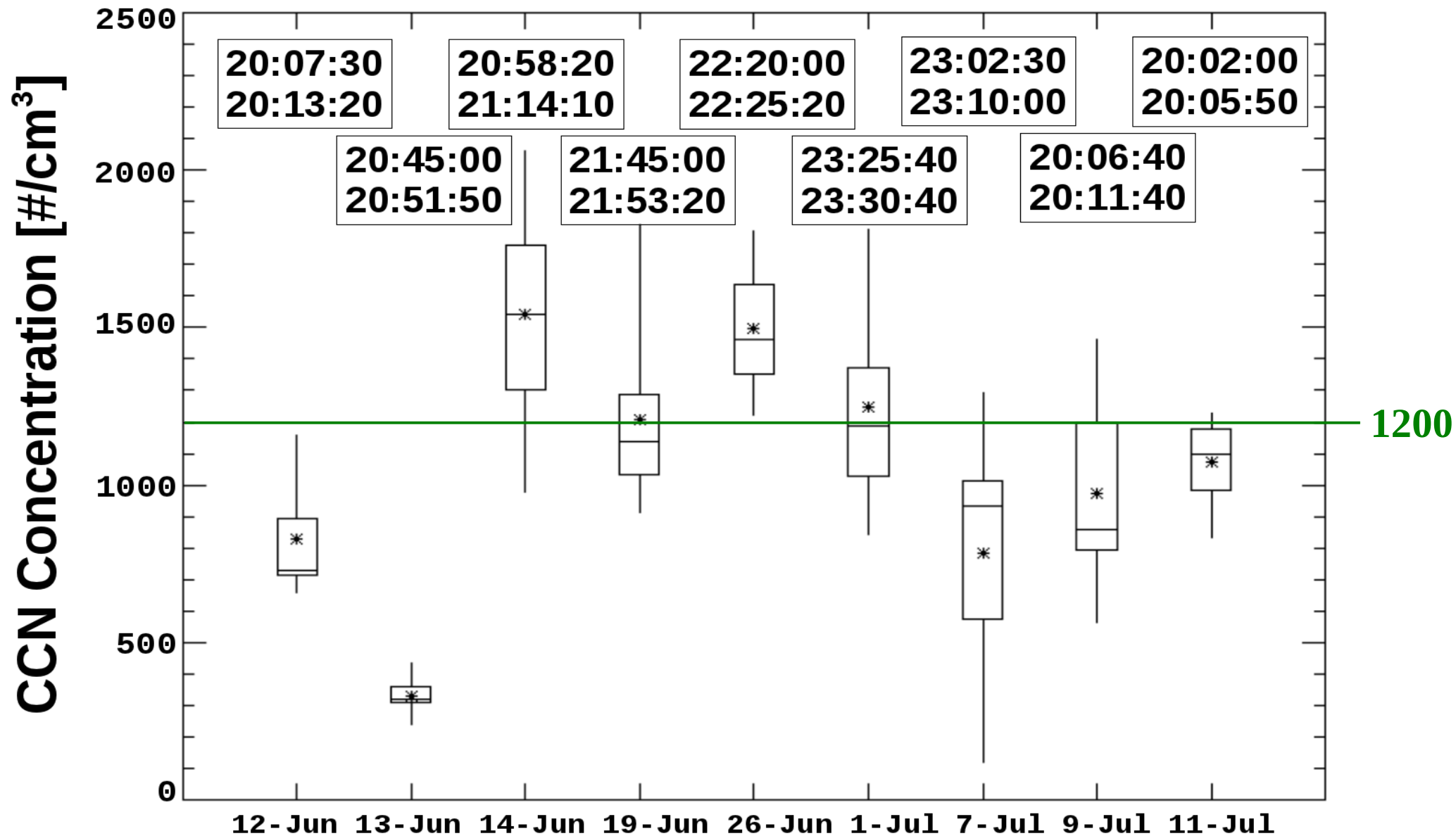


Seeding Aircraft



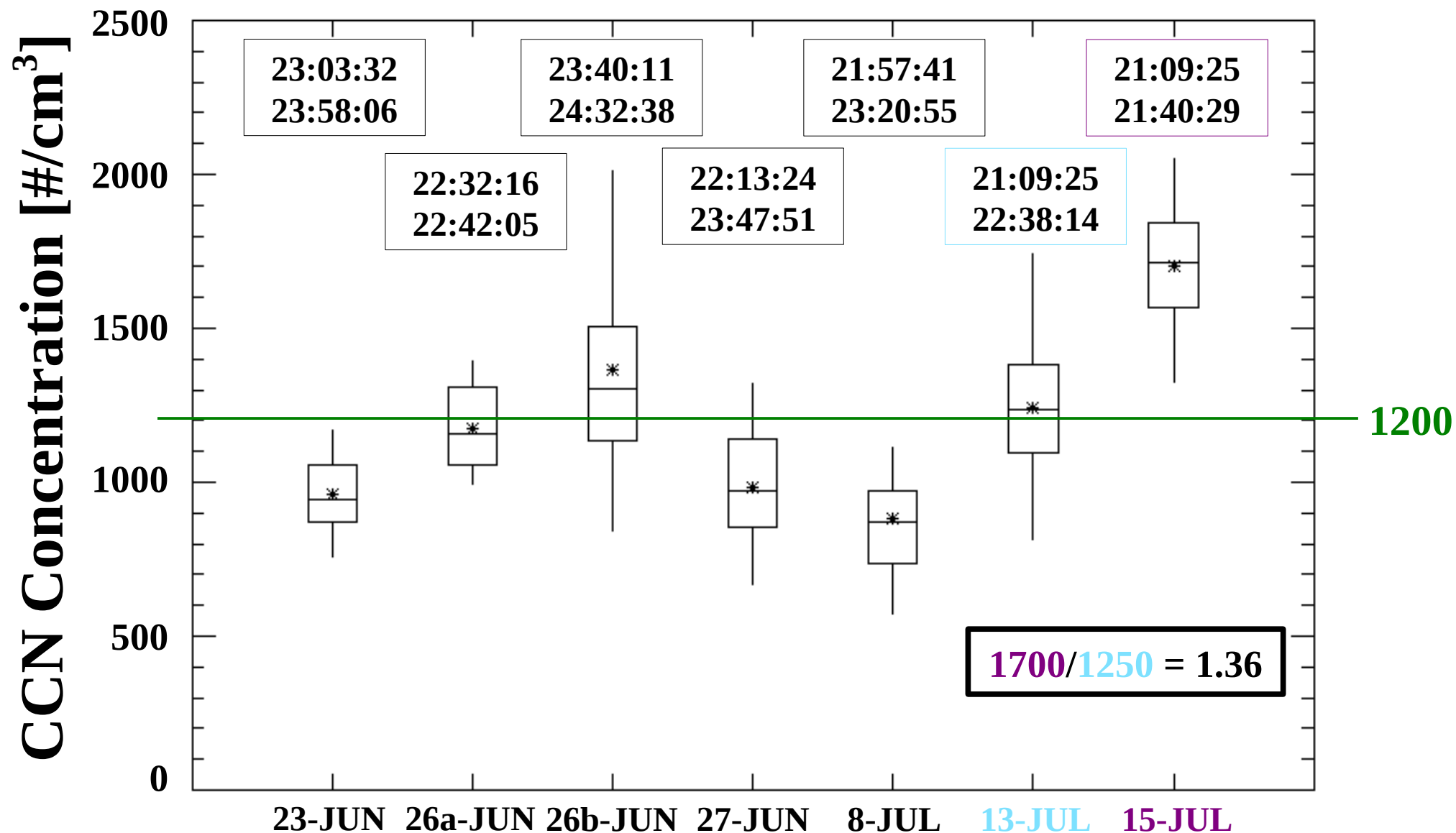
Cloud-physics Aircraft

Cloud Base: 2008

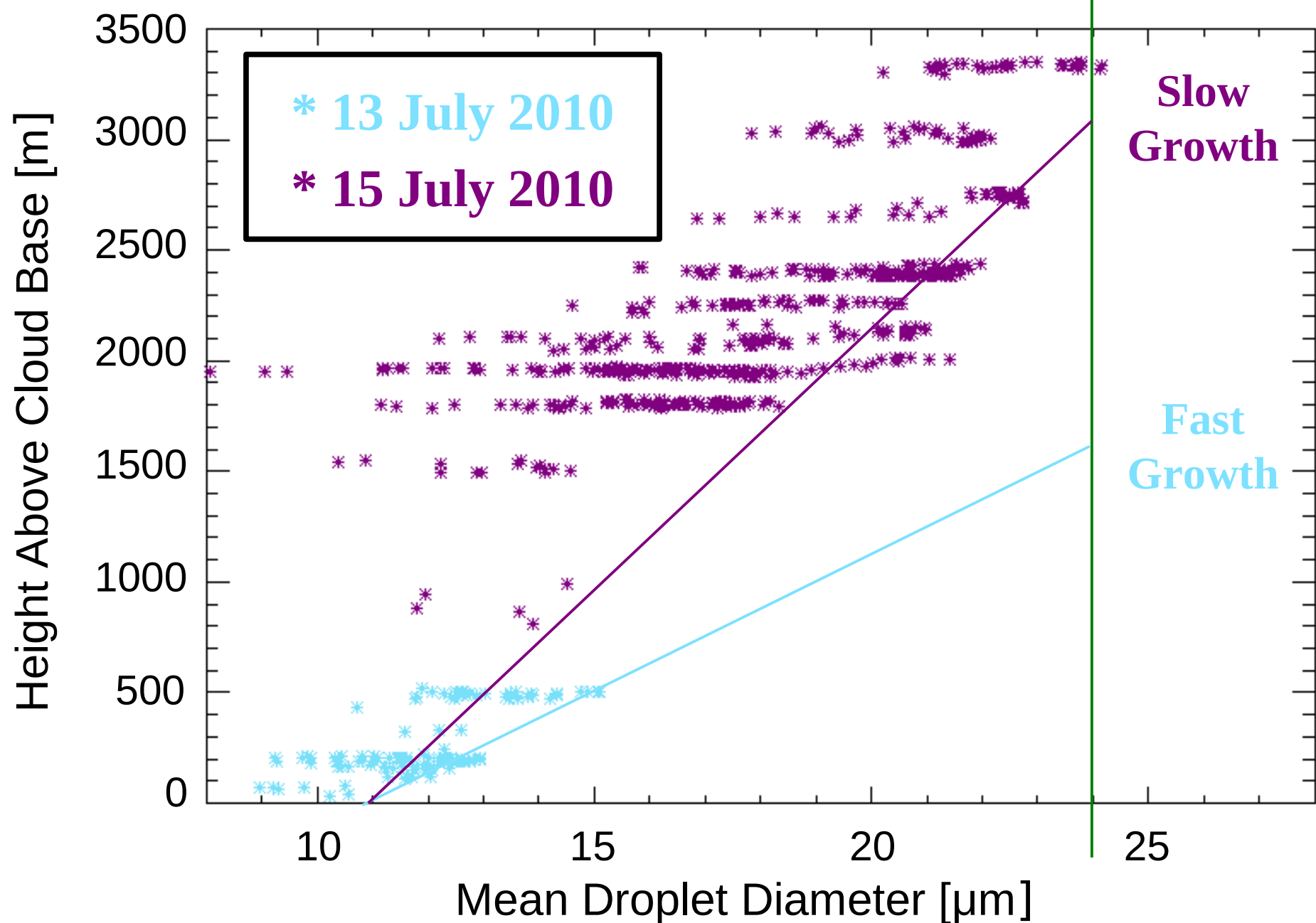


Statistical distributions near cloud base of 30 s 1 % supersaturation (Uwyo CCNC theoretical value) Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure during the 2008 POLCAST2 field project. The solid circle is the mean value, the horizontal line is the 50th percentile, the 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.

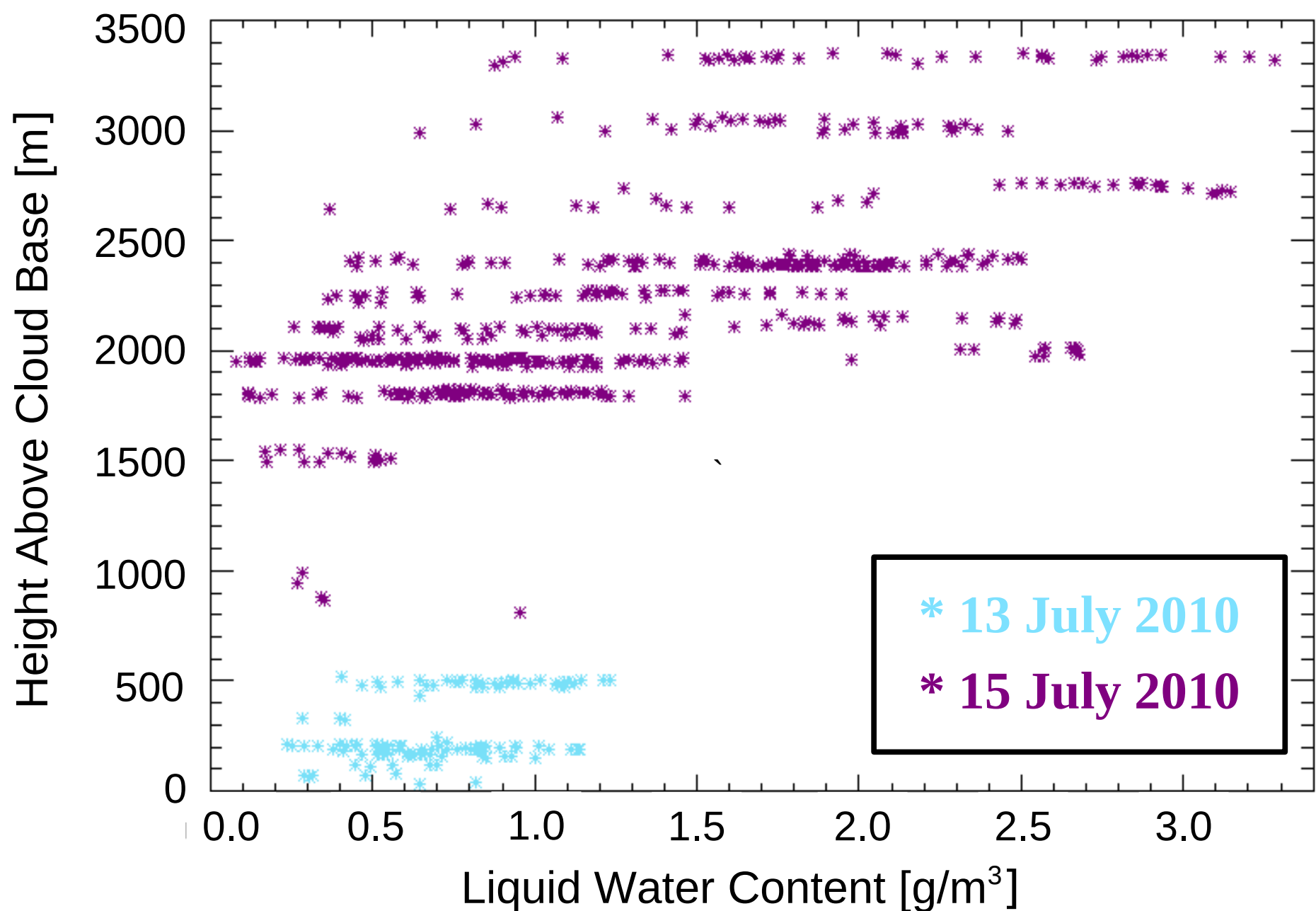
Cloud Base: 2010



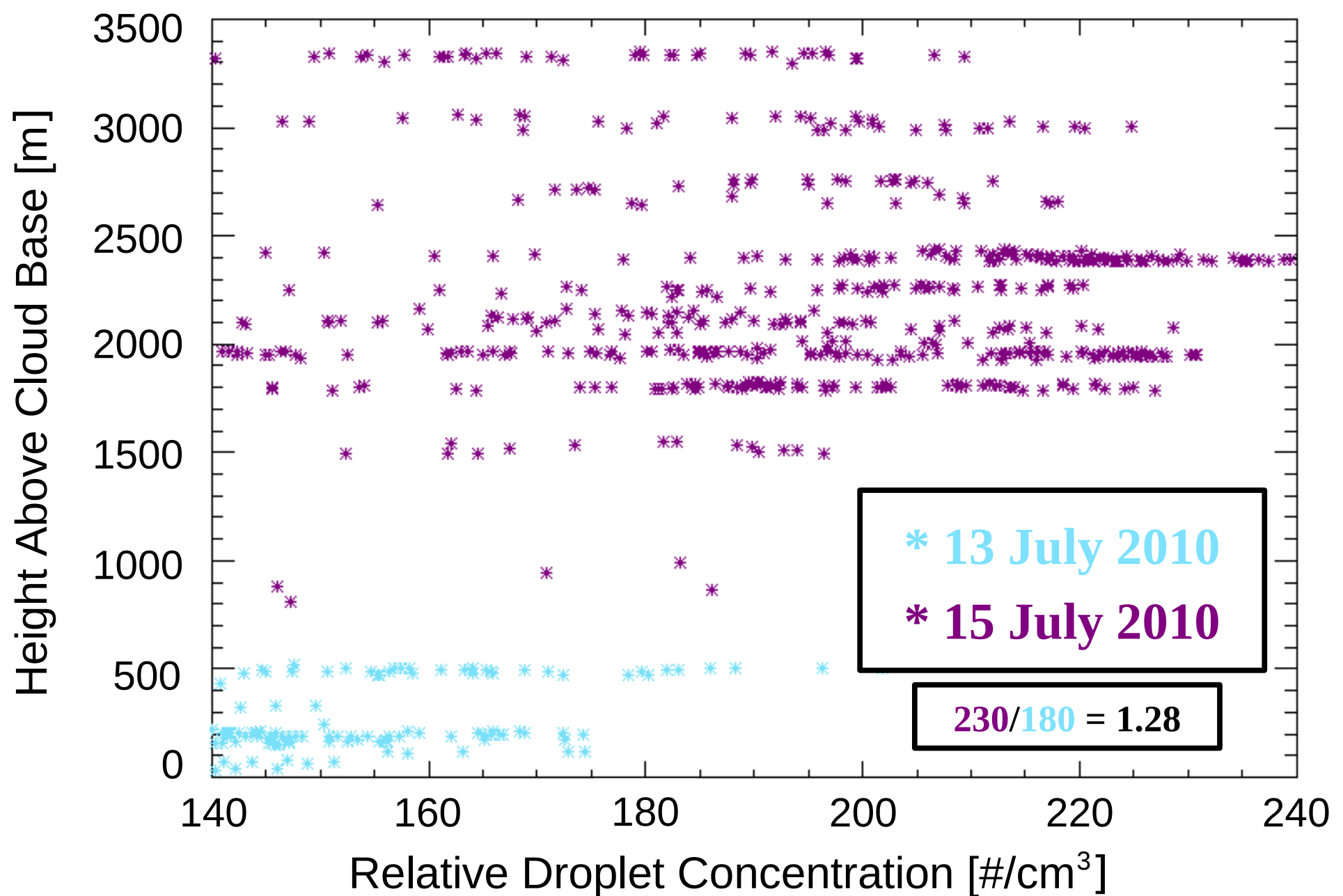
Statistical distributions near cloud base of 30 s 1 % supersaturation (Uwyo CCNC theoretical value) Cloud Condensation Nuclei (CCN) adjusted to standard temperature and pressure during the 2010 POLCAST3 field project. The solid circle is the mean value, the horizontal line is the 50th percentile, the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



The Cloud Droplet Probe (CDP) mean droplet diameter versus the height above cloud base (1,900 m) for aircraft flights during POLCAST3 near Grand Forks, North Dakota. Only measurements with Cloud Droplet Probe concentrations about 140 cm^{-3} are presented.



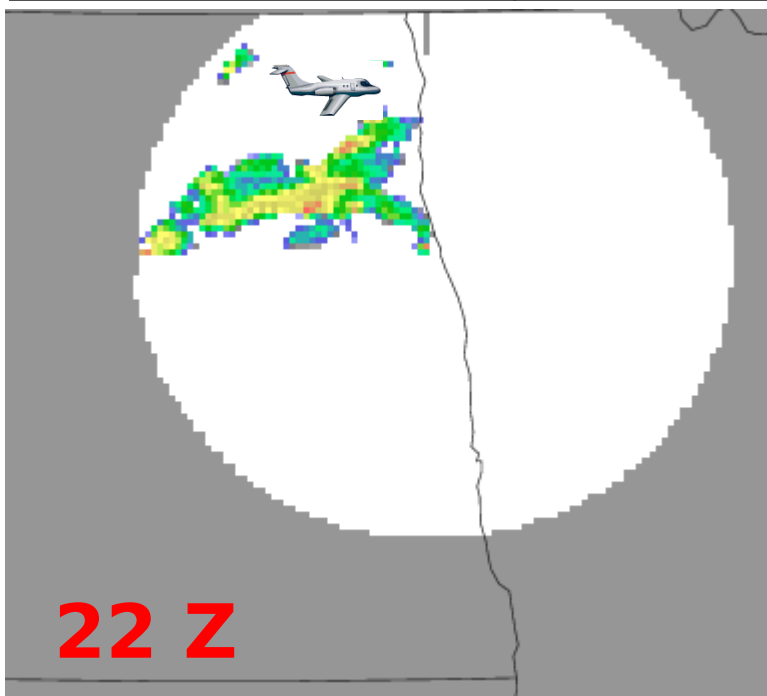
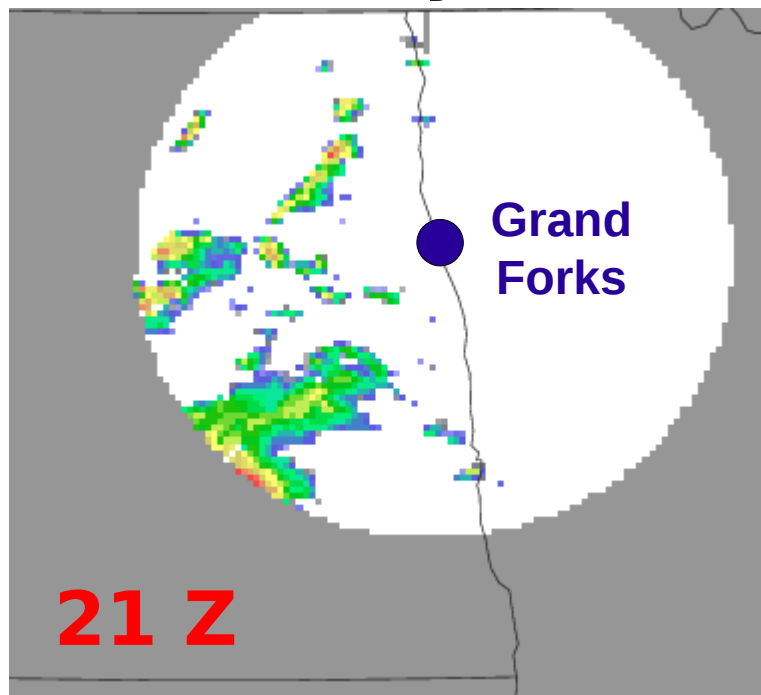
The King Probe Liquid Water Content versus the height above cloud base (1,900 m) for aircraft flights during POLCAST3 near Grand Forks, North Dakota. Only measurements with Cloud Droplet Probe concentrations about 140 cm^{-3} are presented.



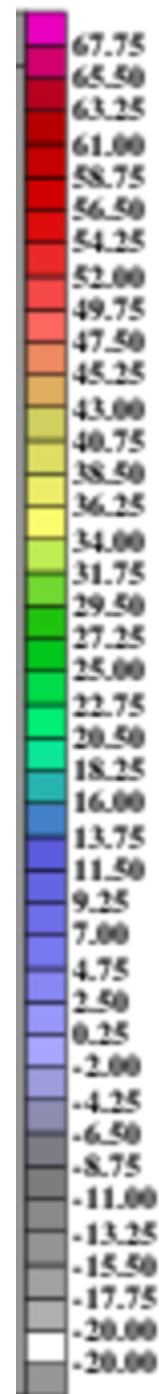
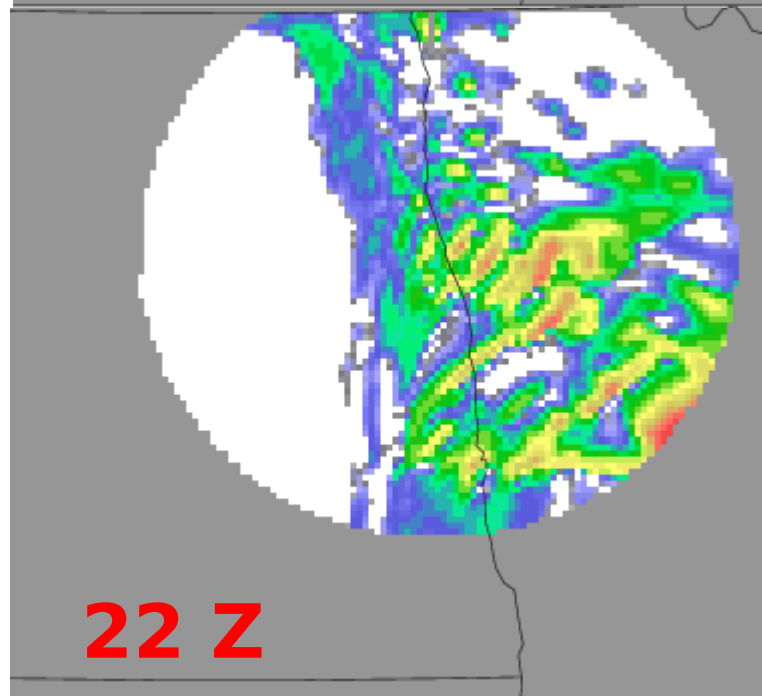
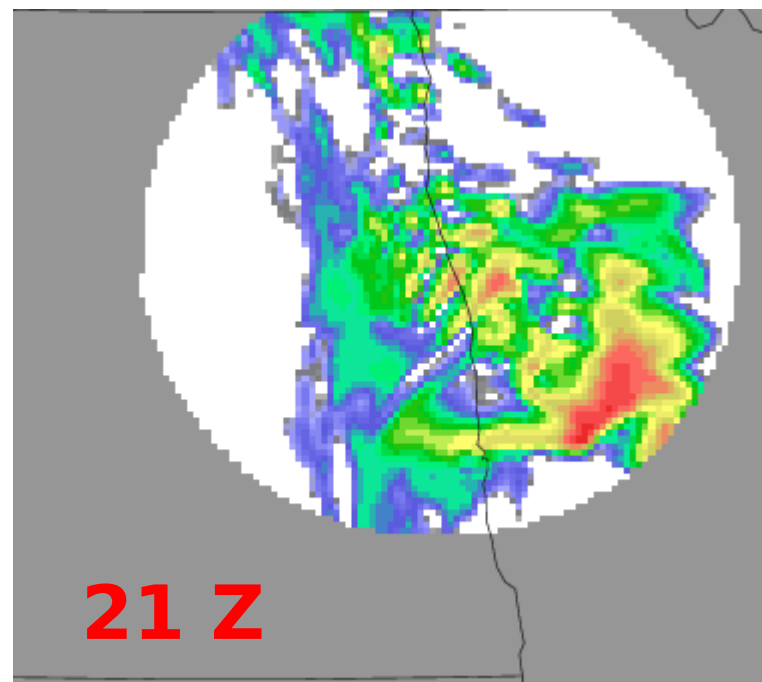
The droplet concentration (DMT Cloud Droplet Probe) versus the height above cloud base (1,900 m) for aircraft flights during POLCAST3 near Grand Forks, North Dakota.

13 July 2010 Radar Returns [dBZ]

Observation



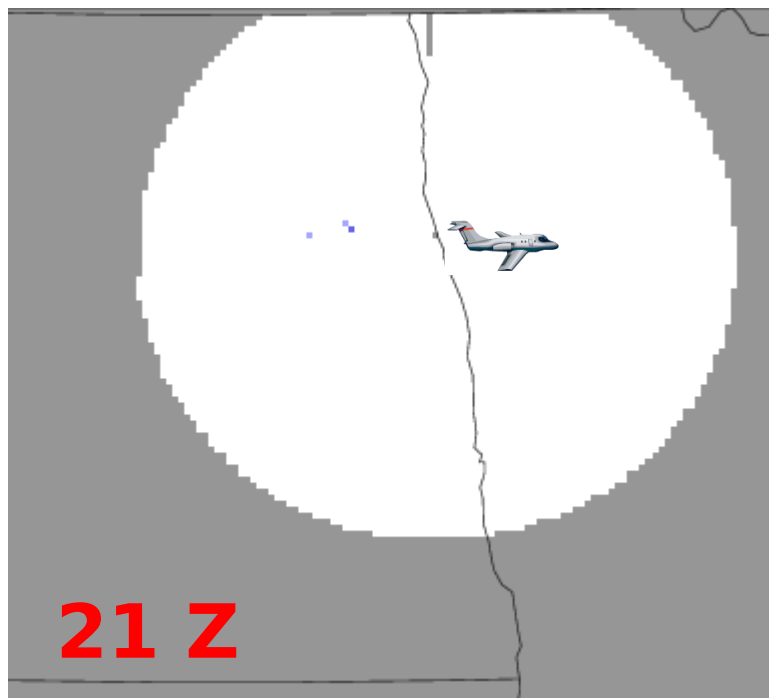
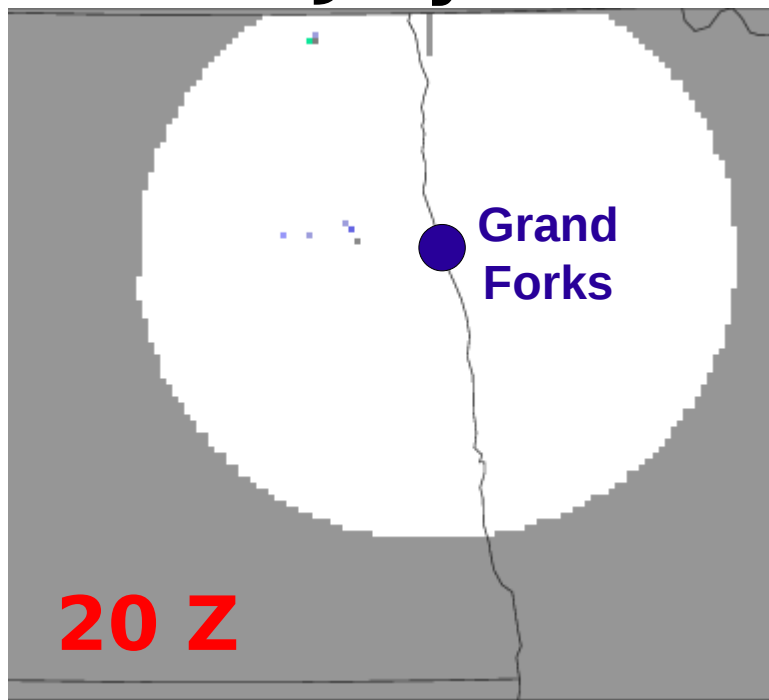
WRF 0 Z Forecast



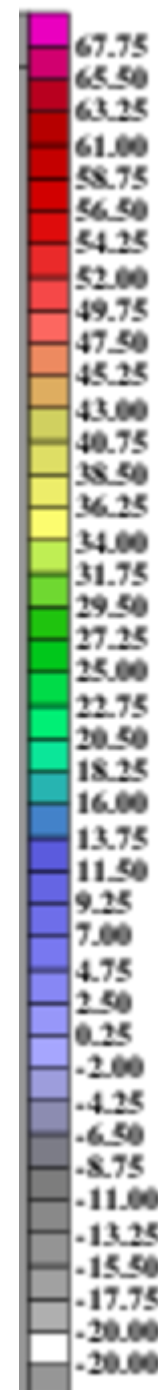
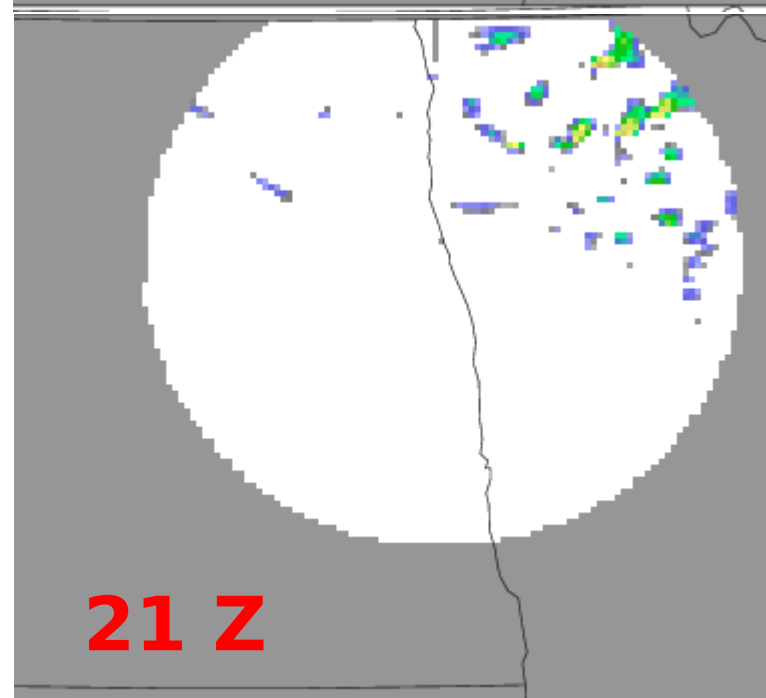
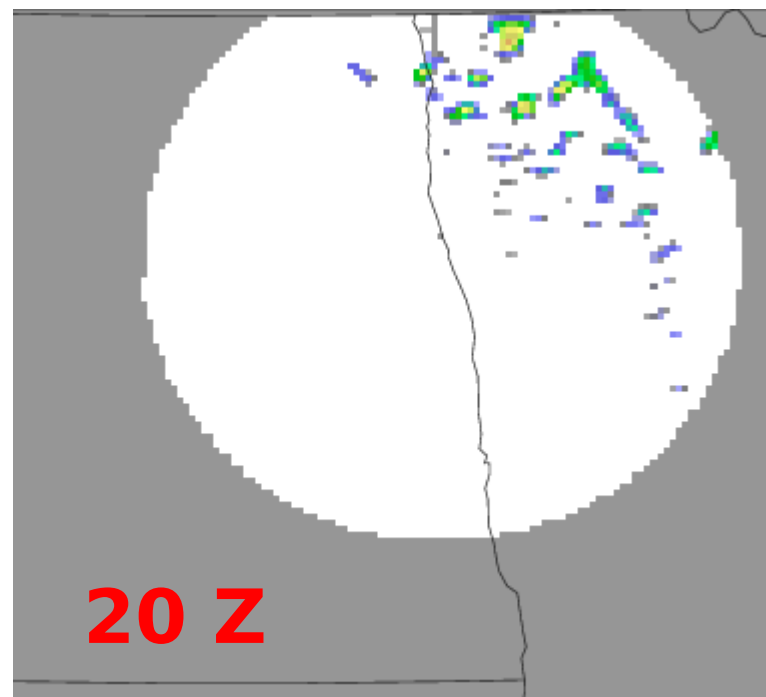
Model Info: V3.1.1 No CU YSU PBL WSM 6class Noah LSW 3.0 km, 44 levels, 3 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smaga

15 July 2010 Radar Returns [dBZ]

Observation

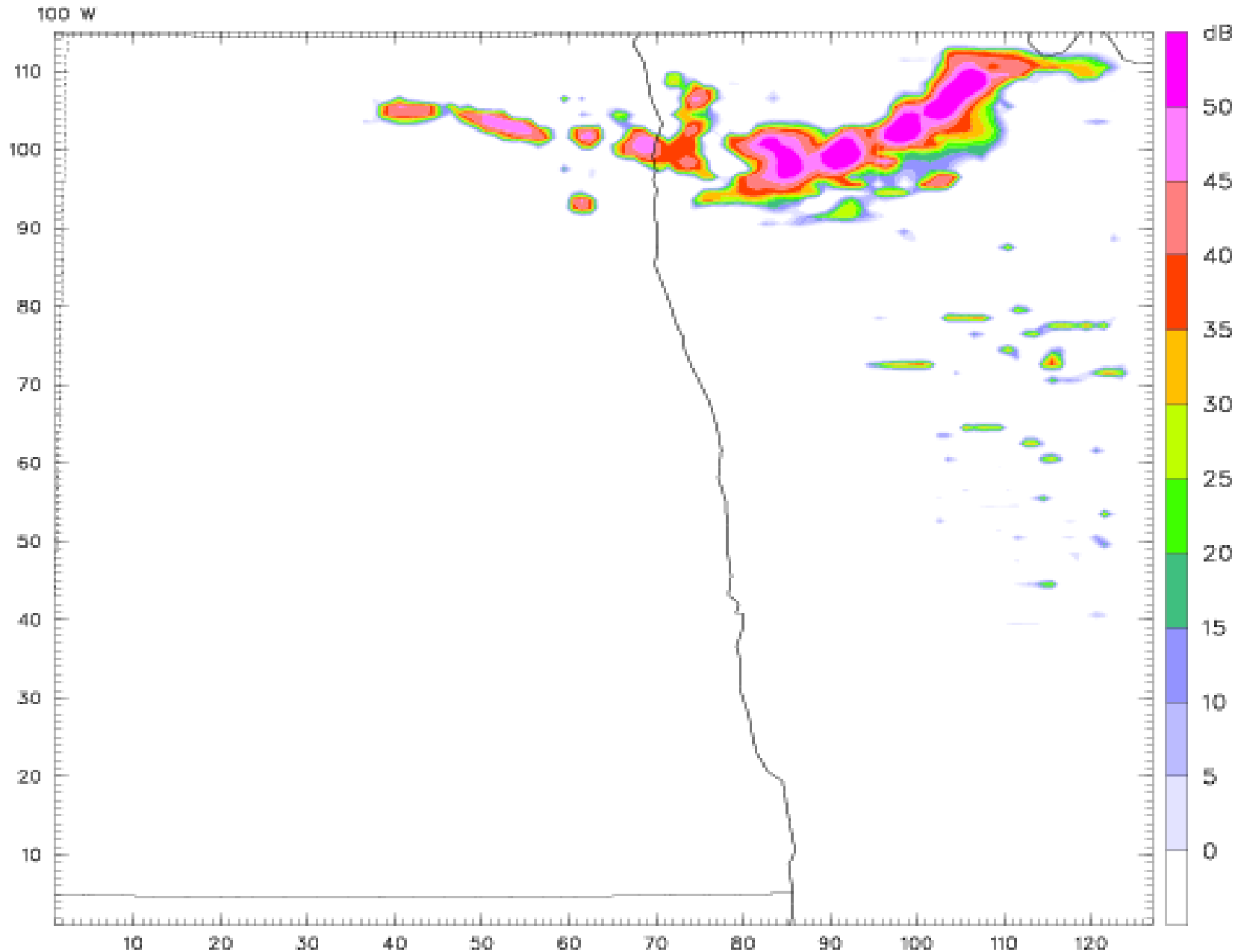


WRF 0 Z Forecast



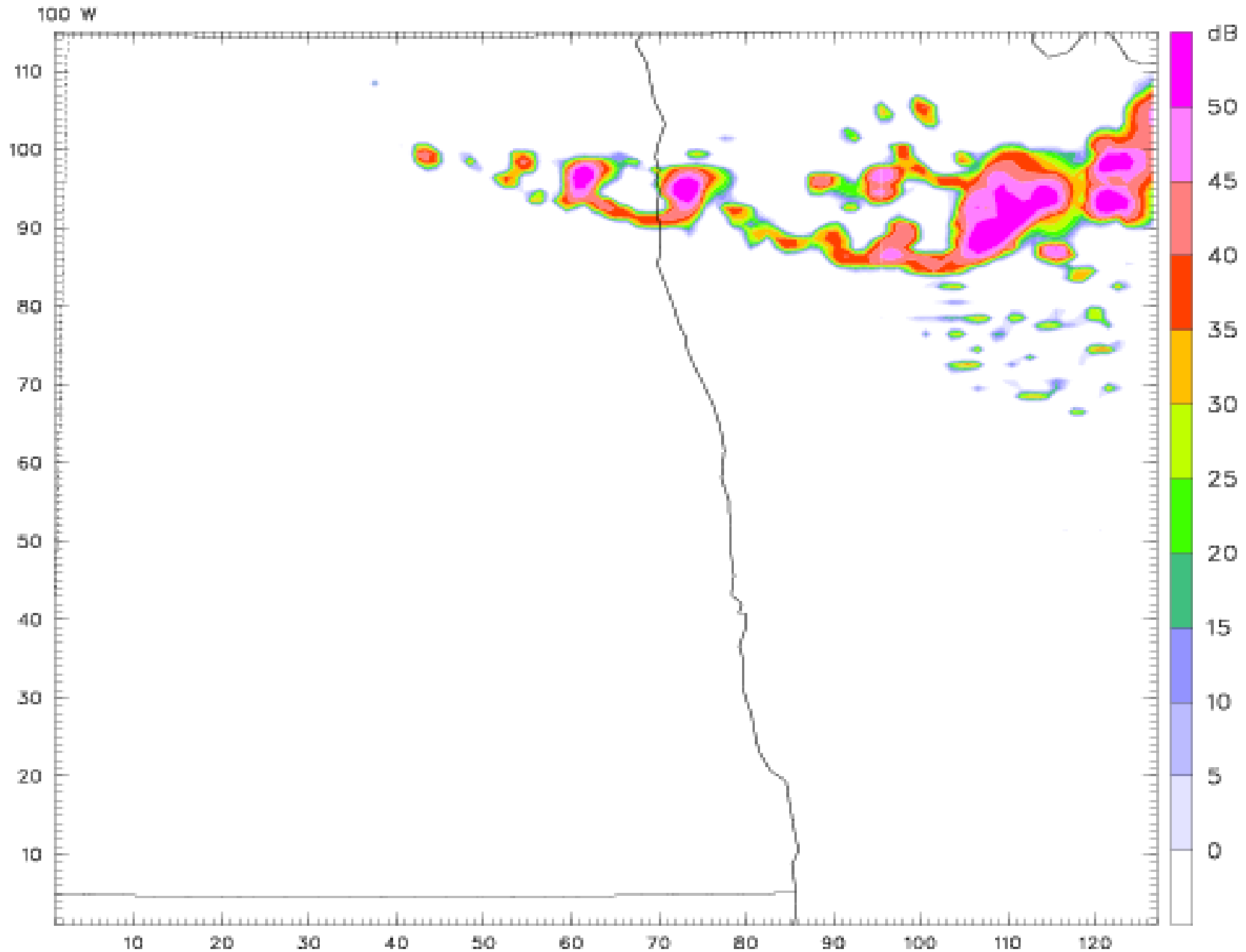
Model Info: V3.1.1 No CU YSU PBL WSM 6class Noah LSW 3.0 km, 44 levels, 3 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smaga

15 July 20 Z WRF: Double Moment



**Model Info: V3.2.1 No CU YSU PBL WSM 6class Noah LSW 3.0 km, 44 levels, 3 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smaga**

15 July 21 Z WRF: Double Moment



**Model Info: V3.2.1 No CU YSU PBL WSM 6class Noah LSW 3.0 km, 44 levels, 3 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smaga**

Conclusions

- 1200 $\text{\#}/\text{cm}^3$ Cloud base Cloud Condensation Nuclei (CCN) concentration represents a good division between high and low aerosol days for both POLCAST2 and POLCAST3.
- The cloud properties are different on the 13 and 15 of July 2010, with concentrations of CCN and droplets being approximately 30% higher on July 15.
- WRF trends to over develop precipitation. While predicted by WRF, no precipitation developed on 15 July 2010.
- We are trying to use the WRF modeling to help understand the radar observations using the CCN and cloud micro-physics observations.

POLCAST Team

North Dakota Atmospheric Resource Board

Darin Langerud
Dan Brothers



Dr. Paul Kucera
NCAR



Dennis Afseth, Kelly Bosch
Hans Ahlness, Jody Fischer

**ICE Crystal
Engineering LLC.**

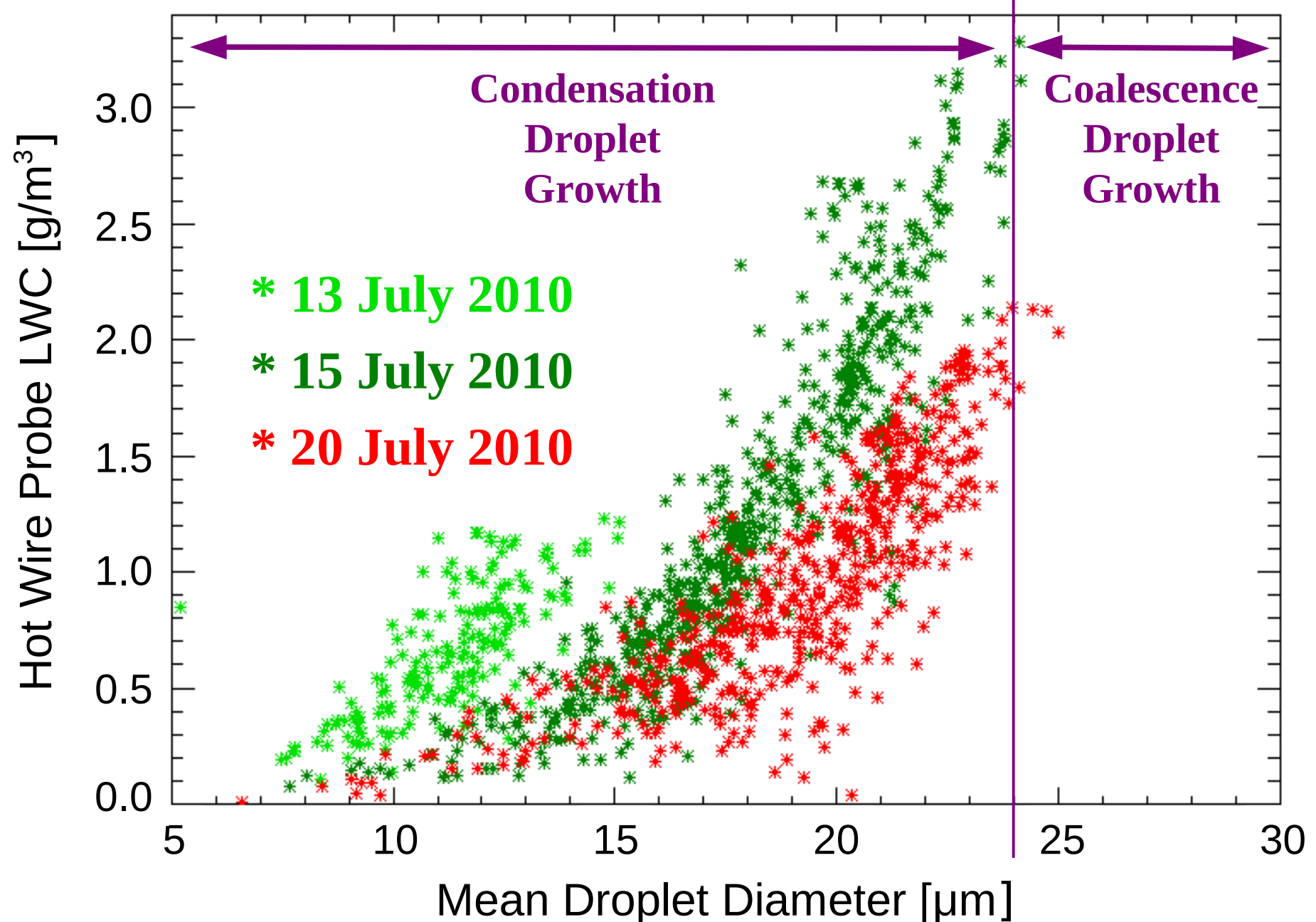


Dr. David Delene (Scientist)
Dr. Tony Grainger (Scientist)
Dr. Gretchen Mullendore (Scientist)
Chris Theisen (Radar Software)
Pavel Kirlov (Radar Hardware)
Aaron Ness (Aircraft Tech.)
Wayne Schindler (Pilot)
David Keith (Graduate Student)
Chris Kruse (Undergraduate)
Miranda Hilgers (Undergraduate)
Emily Danielson (Undergraduate)
Korey Southerland (Undergraduate)
Mariusz Starzec (Undergraduate)
Nicole Bart (Undergraduate)

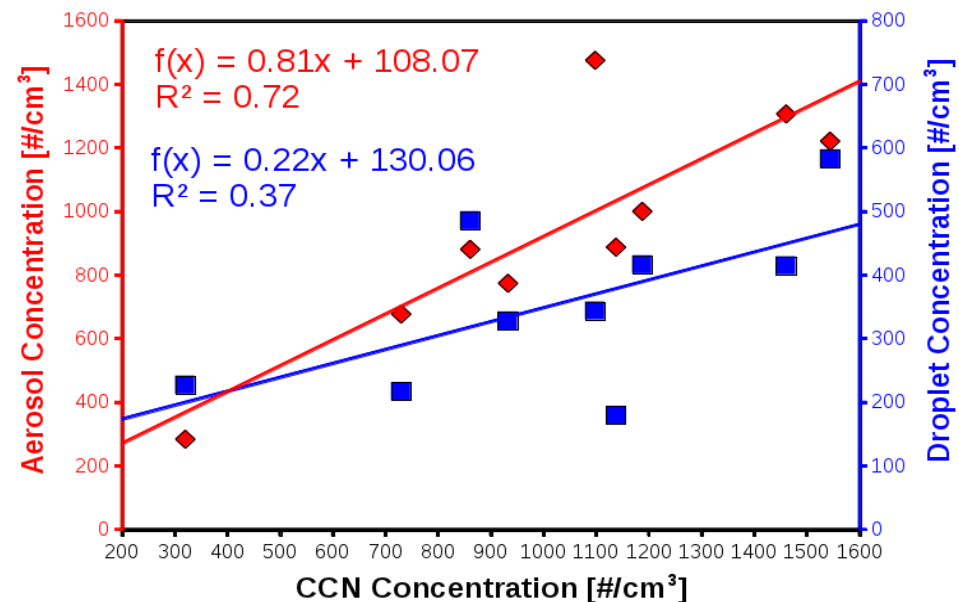
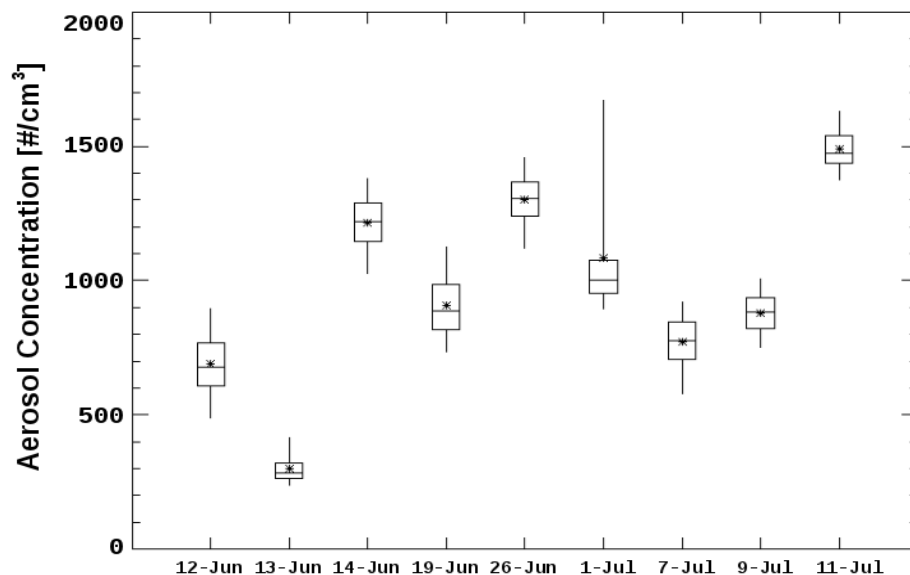
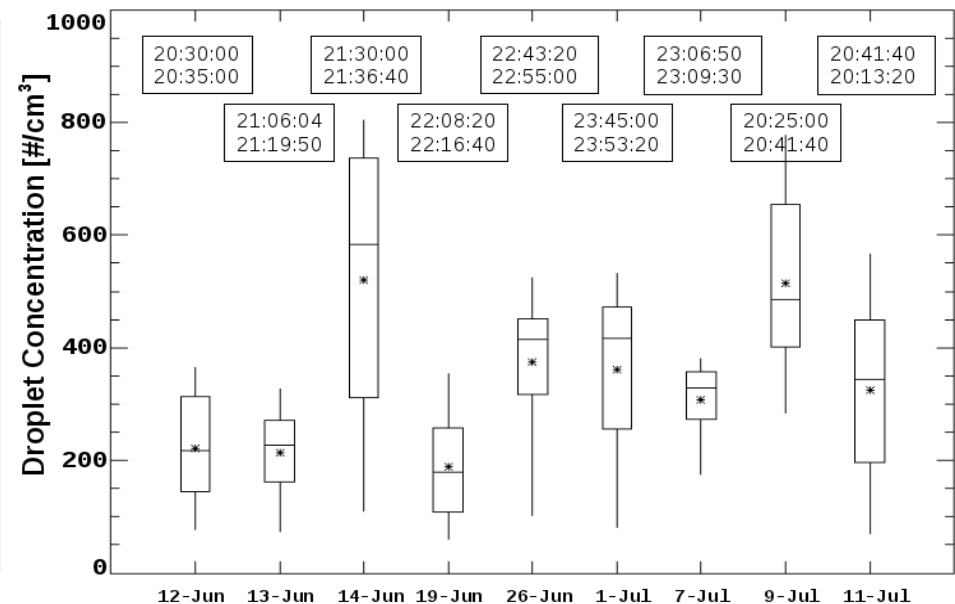
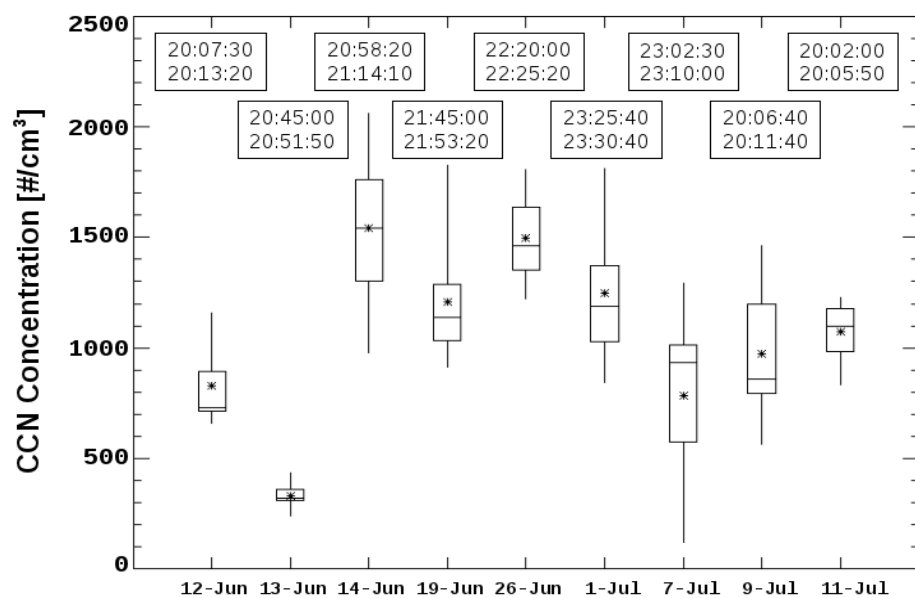
Questions

An aerial photograph of a rural landscape. The foreground and middle ground consist of various agricultural fields in shades of green and yellow. In the distance, a small cluster of buildings is visible. A massive, dark, and ominous storm cloud hangs low over the horizon, with a bright, white light source visible within its base, suggesting an approaching storm or sunset. The sky is filled with lighter, wispy clouds above the main storm cloud.

**For more information:
<http://aerosol.atmos.und.edu>**



The Cloud Droplet Probe (CDP) mean droplet diameter versus the King Probe Hot Wire Probe Liquid Water Content (LWC) for aircraft flights during POLCAST3 near Grand Forks, North Dakota. Only measurements with CDP concentrations about 140 cm^{-3} are presented.



Statistical distributions near cloud base of the 30 s Cloud Condensation Nuclei (CCN), 1 Hz cloud droplet and 1 Hz Passive Cavity Aerosol Spectrometer Probe (PCASP) aerosol measurements for flights during the 2008 POLCAST2 field project. All concentrations are adjusted to standard temperature and pressure conditions. 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.