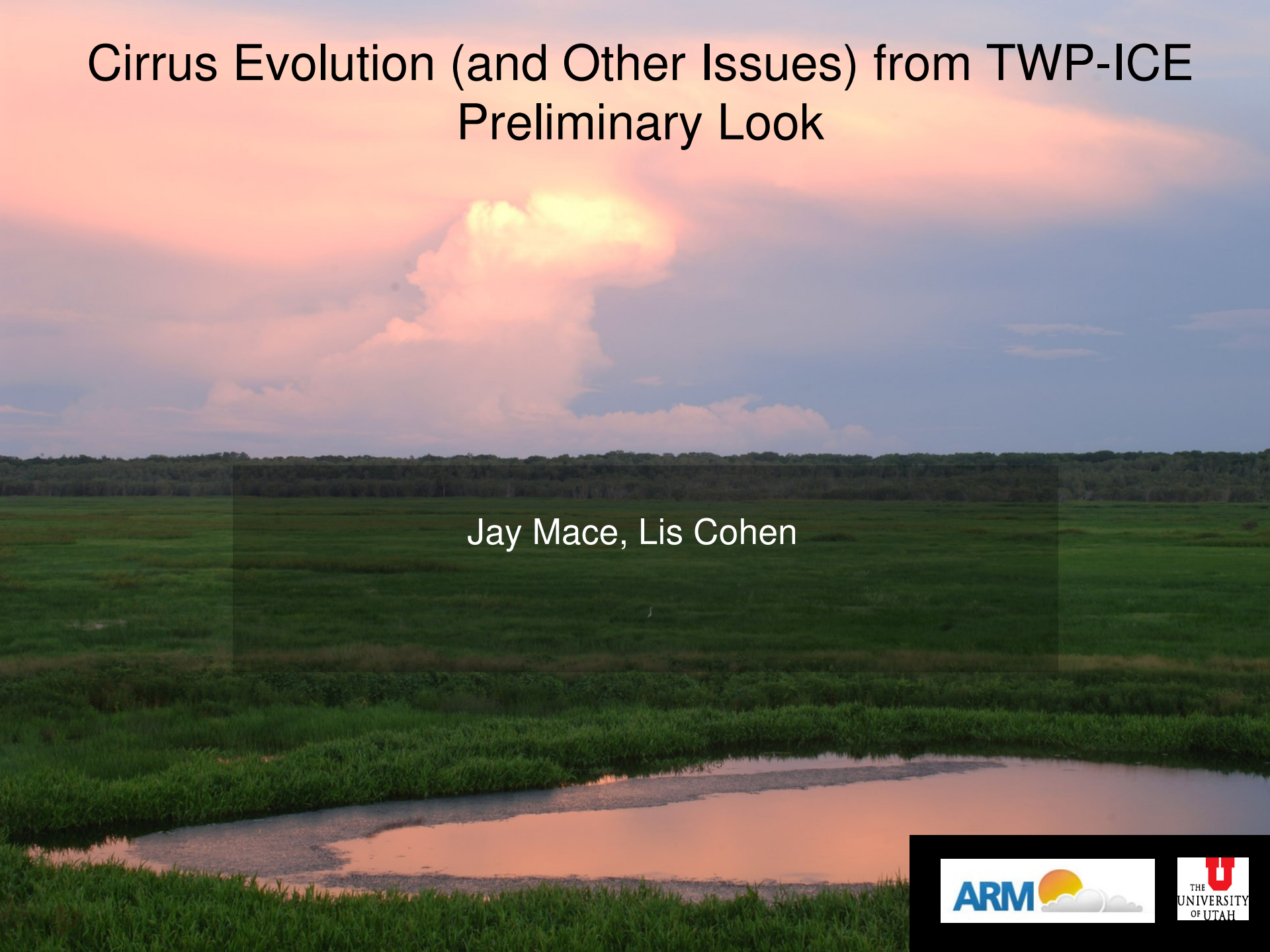
Cirrus Evolution (and Other Issues) from TWP-ICE Preliminary Look

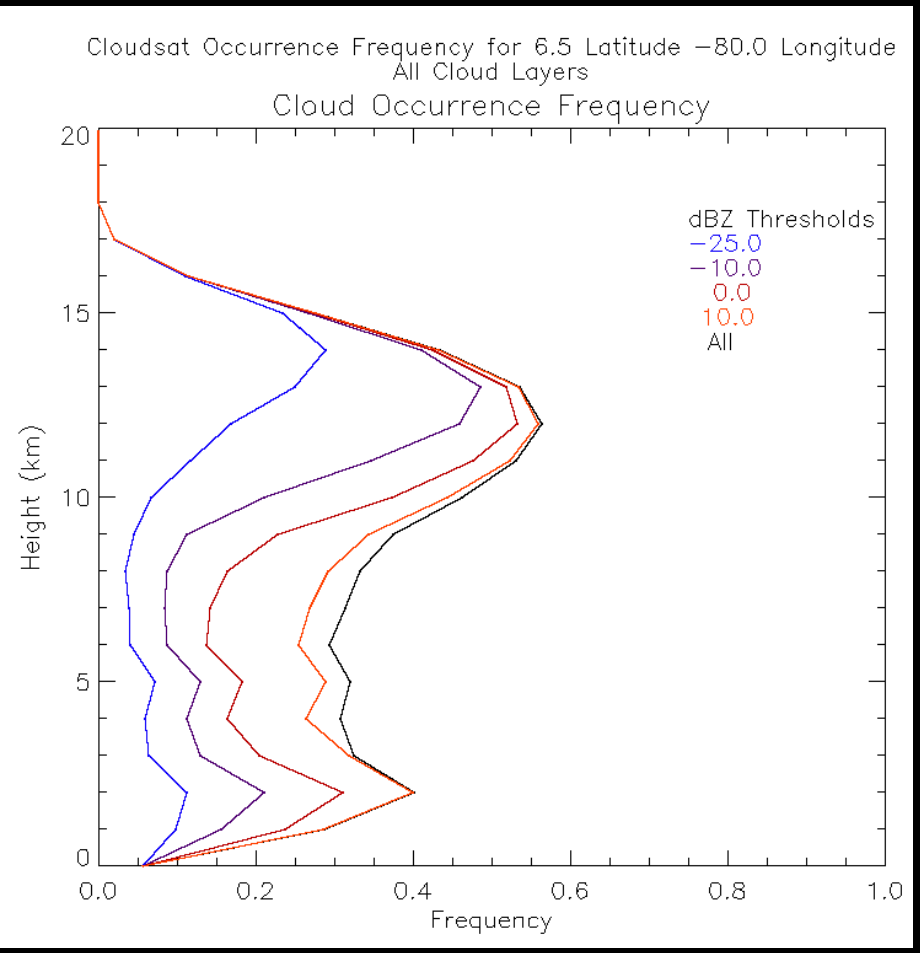


Jay Mace, Lis Cohen

ARM

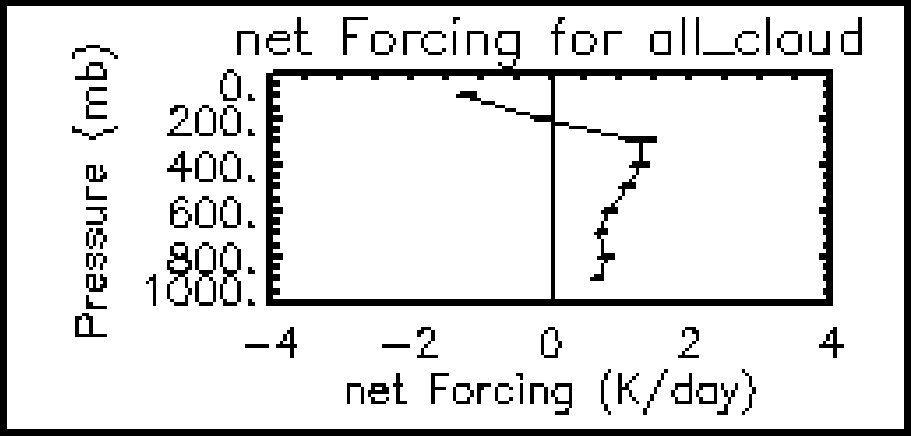
THE UNIVERSITY OF UTAH

Motivation: Large Cirrus Occurrence Freq Have a BIG Impact on Heating



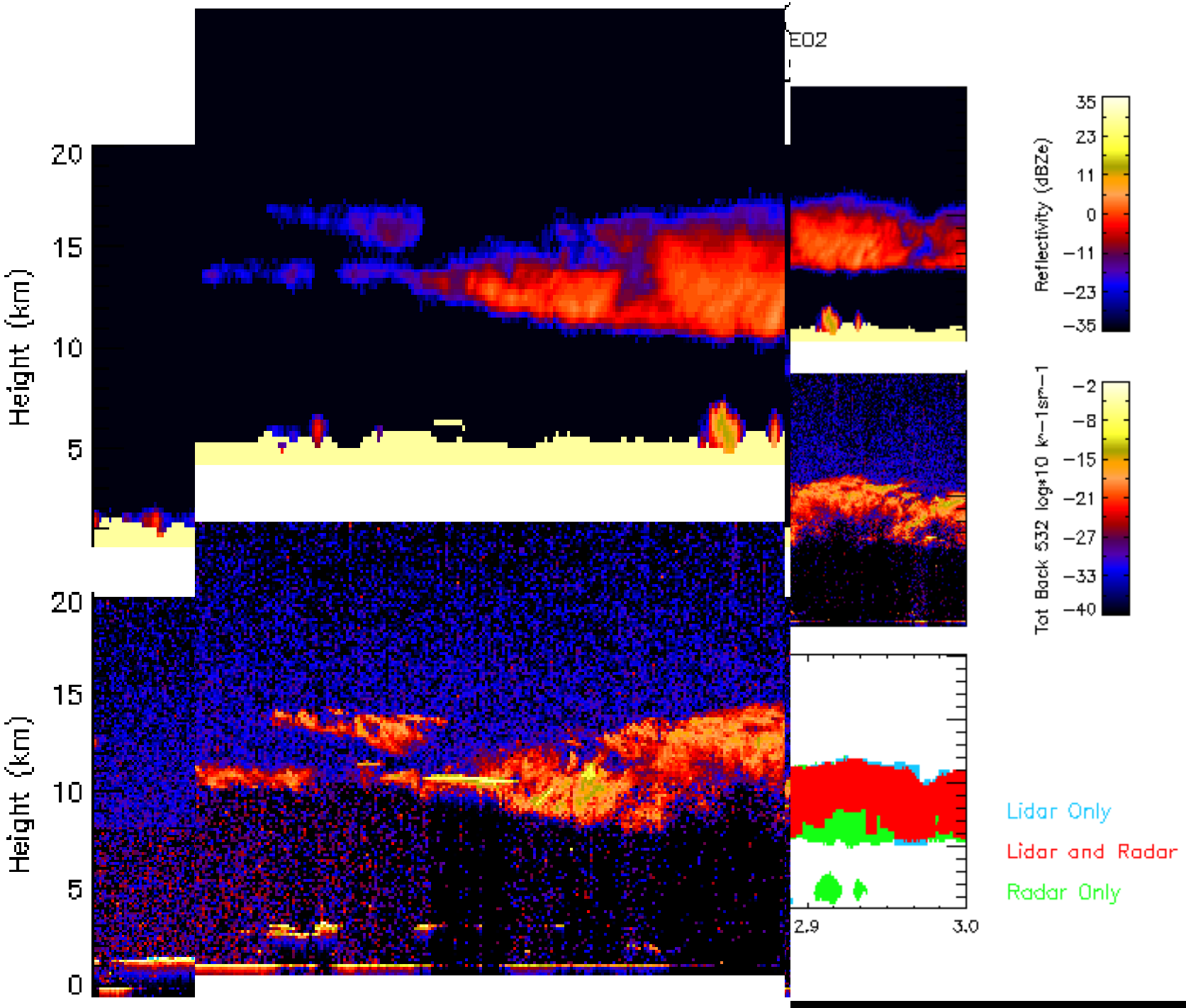
Combined Cloudsat-Calipso Cloud Freq.

January 2003 CRF Profile

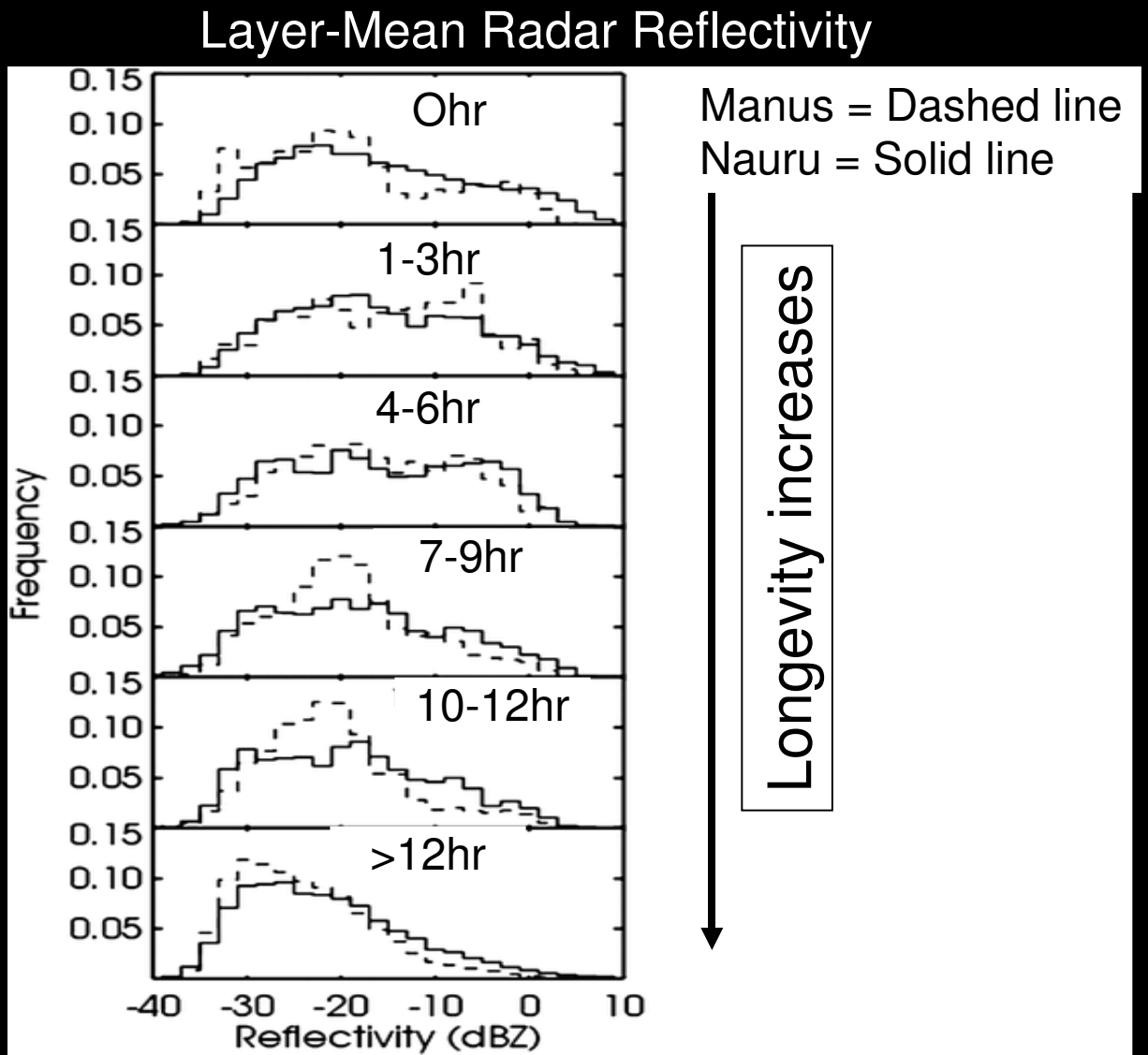


2003 CRE (W/m2)

	Solar	IR	Net
TOA	−79.8	86.2	6.4
ATM	12.1	71.8	83.9
SFC	−91.9	14.4	−77.5


EO2
Height (km)
20
15
10
5
0
Reflectivity (dBZe)
35
23
11
0
−11
−23
−35
Tot Back 532 log*10 k−1sr−1
−2
−8
−15
−21
−27
−33
−40
2.9
3.0
Lidar Only
Lidar and Radar
Radar Only

Why are cirrus properties evolving similarly in Manus and Nauru?



The frequency distributions of layer-mean radar reflectivity for different longevity are very similar at Manus and Nauru (Mace et. al 2006).

Persistent Cirrus (29 January)

Deep Landlocked Cyclone

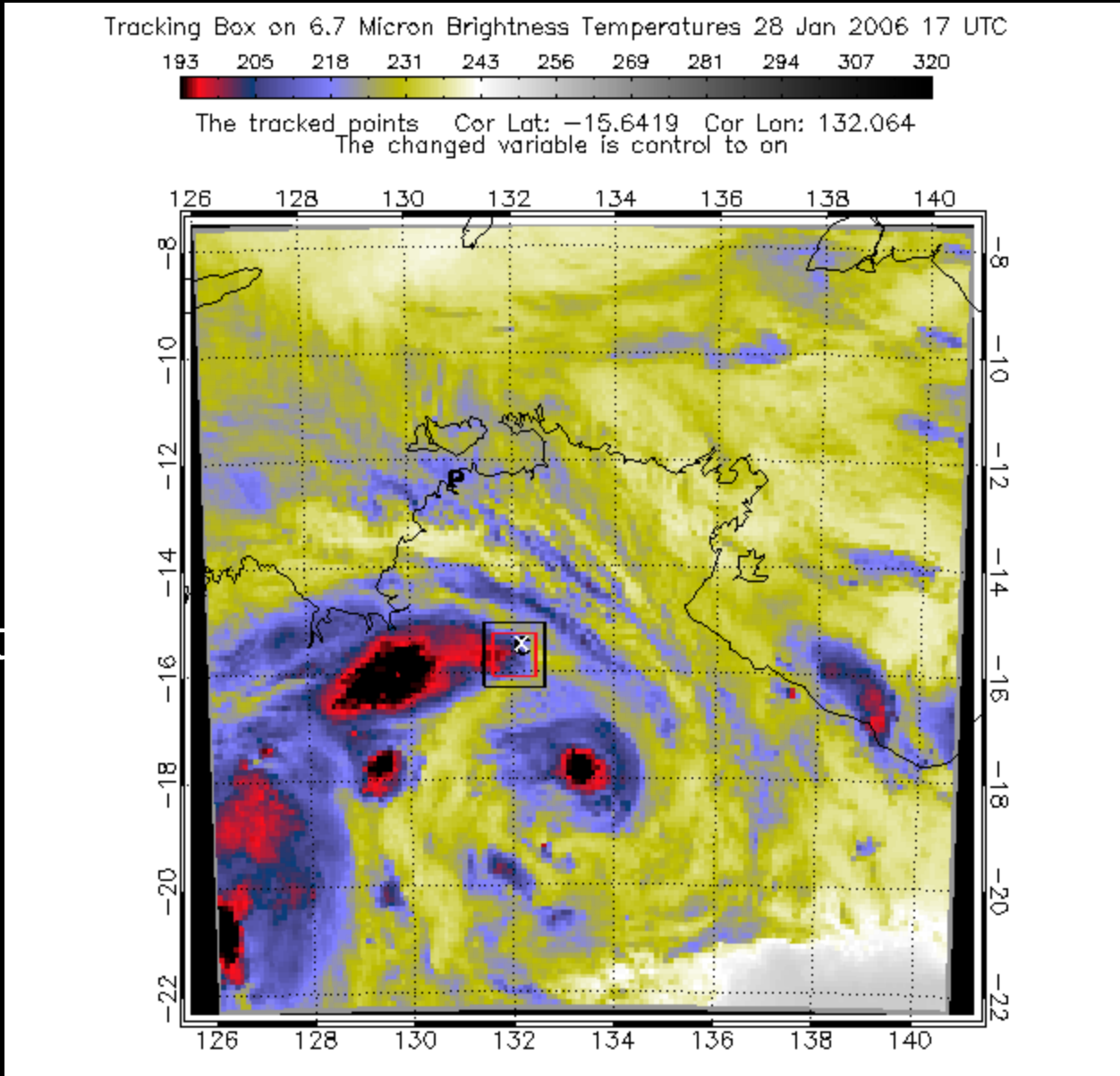
Track Path
(29 Jan case)

Start time: Airplane "P" intersects the Cirrus "C".

Next time: -1 hour

Watch the C (cirrus).

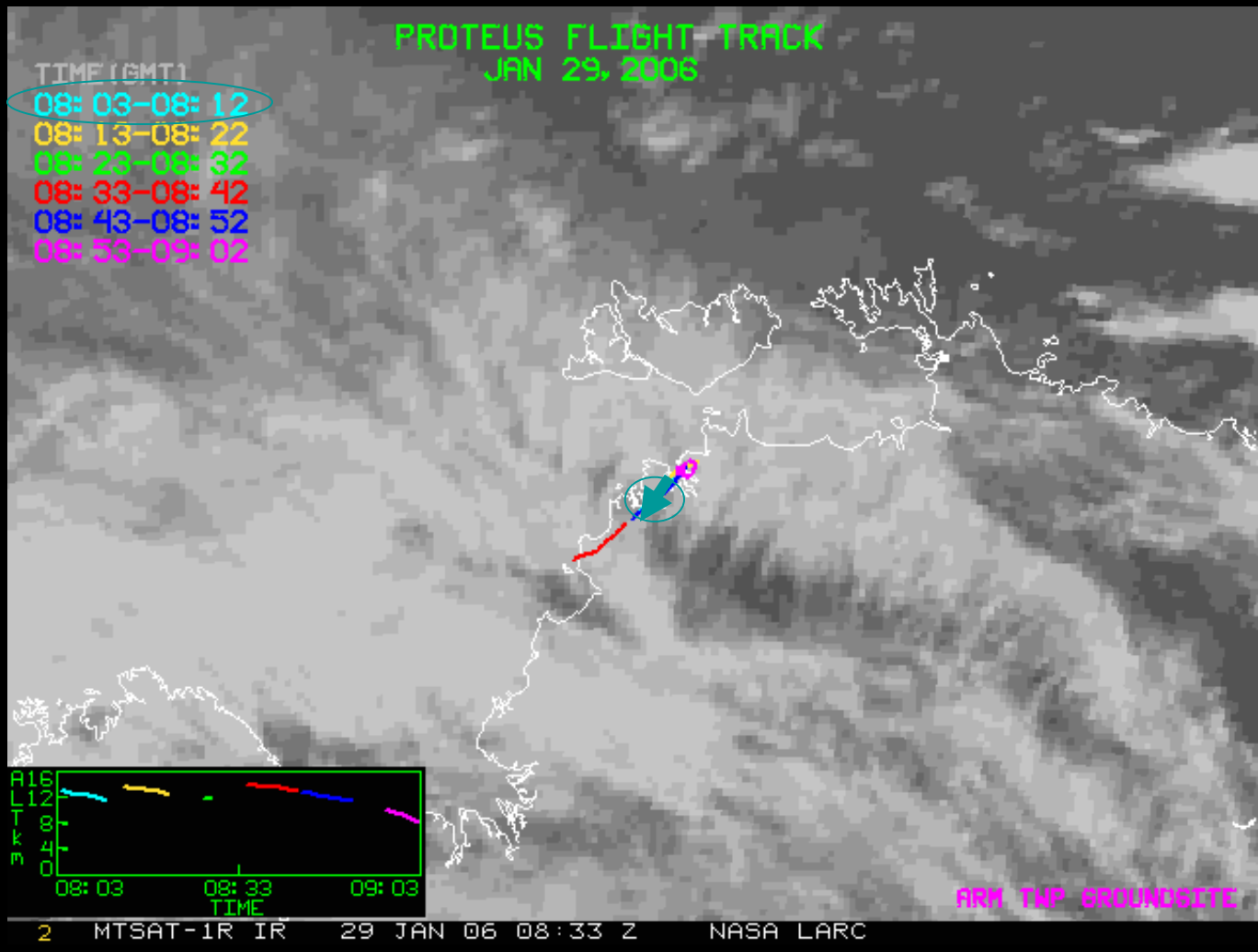
The airplane "P" flew through the cirrus that has evolved from convection 14 hours ago.

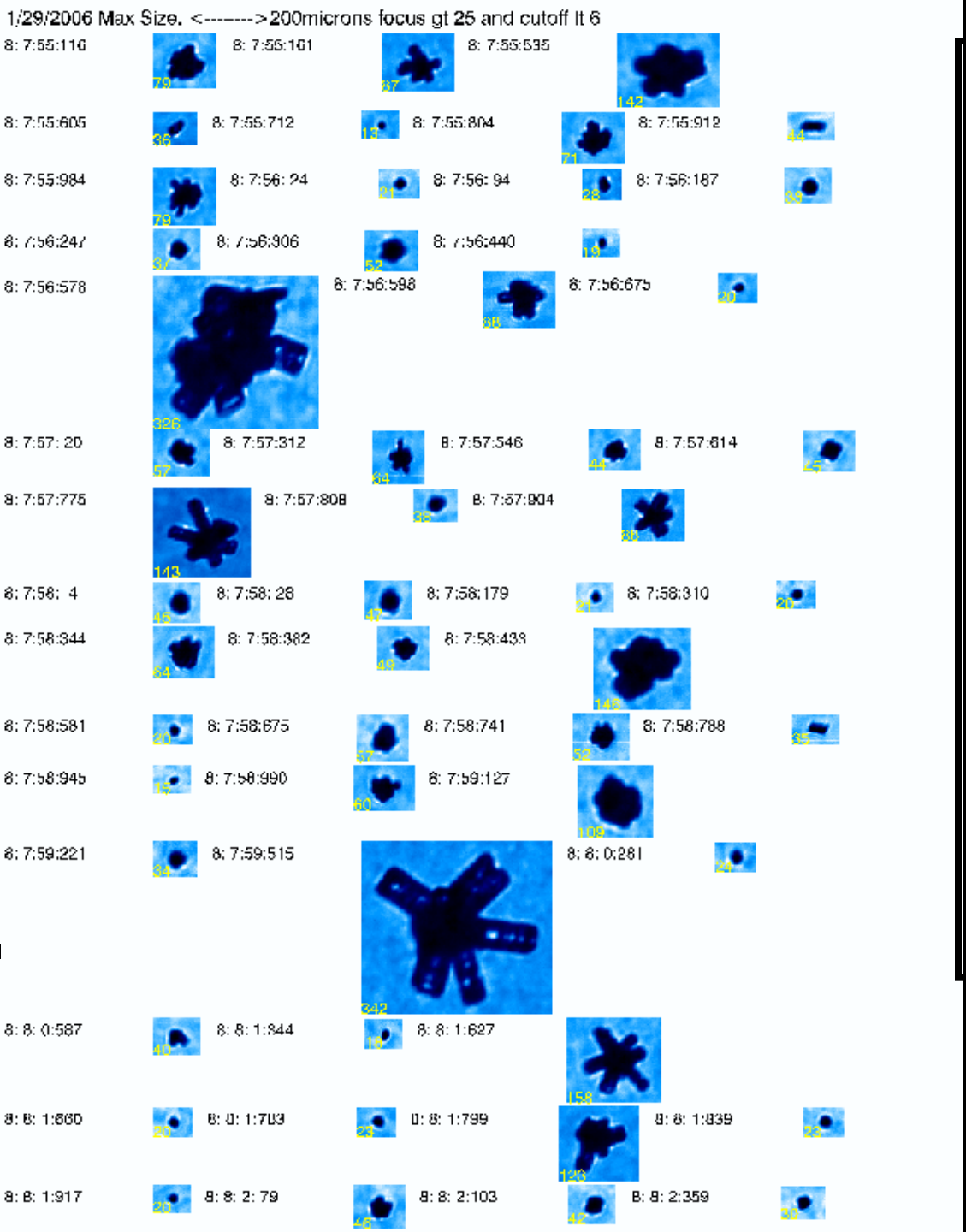


Cloud Spectrometer and Impactor (29 Jan case)

- Cloud Water Content from the CSI instrument = 21.22 mg/m^3

- Start time (hh:mm:ss):
  8:07:52 UTC
- End time:
  8:09:56 UTC





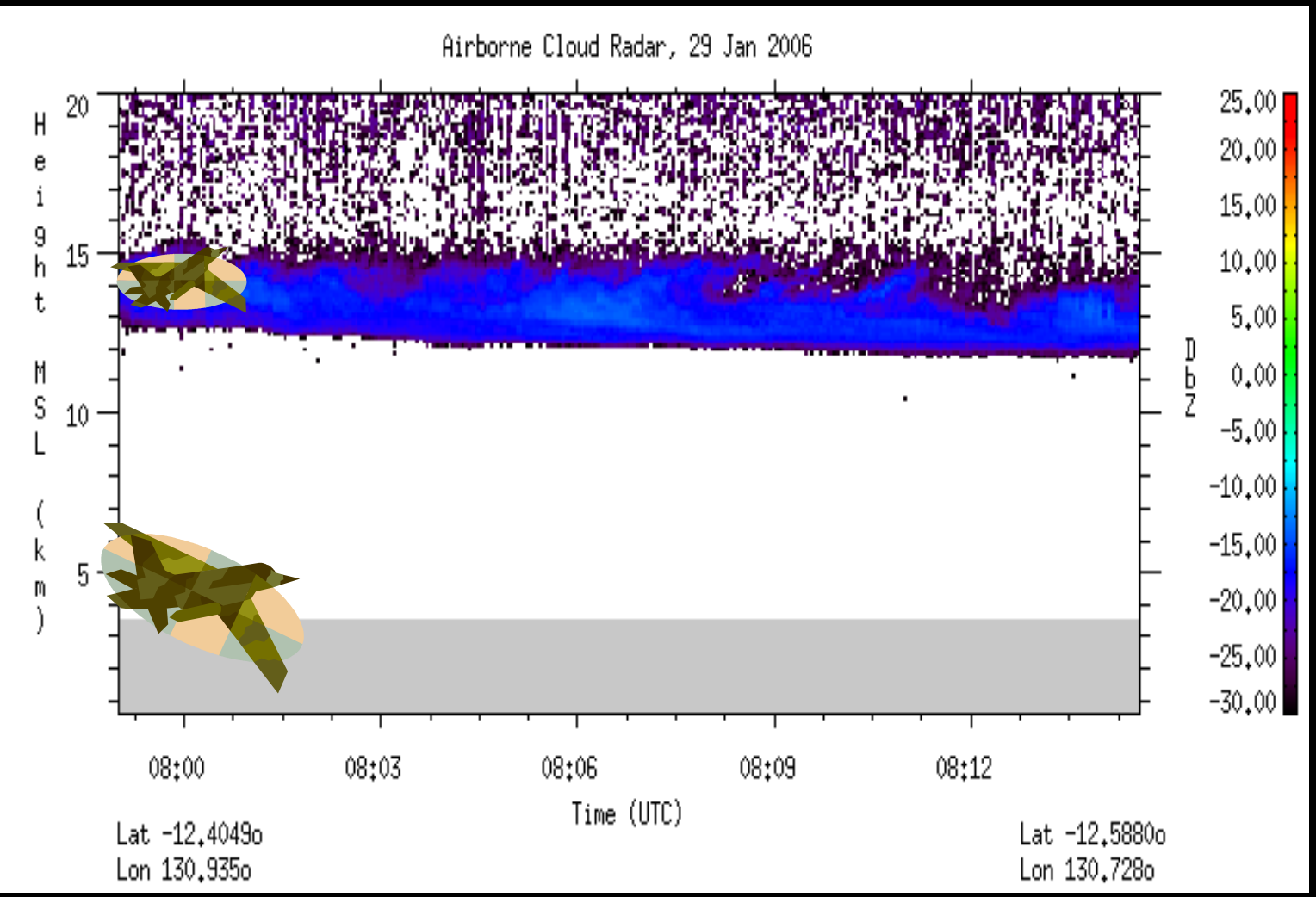
Cirrus Ice Crystals ↔ = 200 microns

One second of Cloud Particle Imager data while flying through the persistent cirrus.

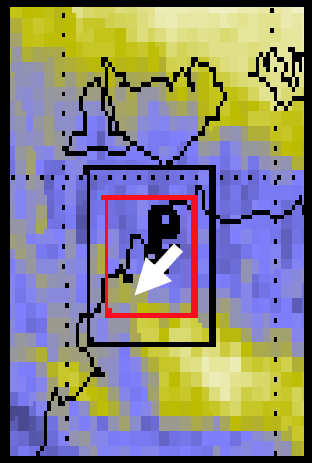
Notice the small spheroids and the bullet rosettes.

Airborne Cloud Radar on Twin Otter Aircraft

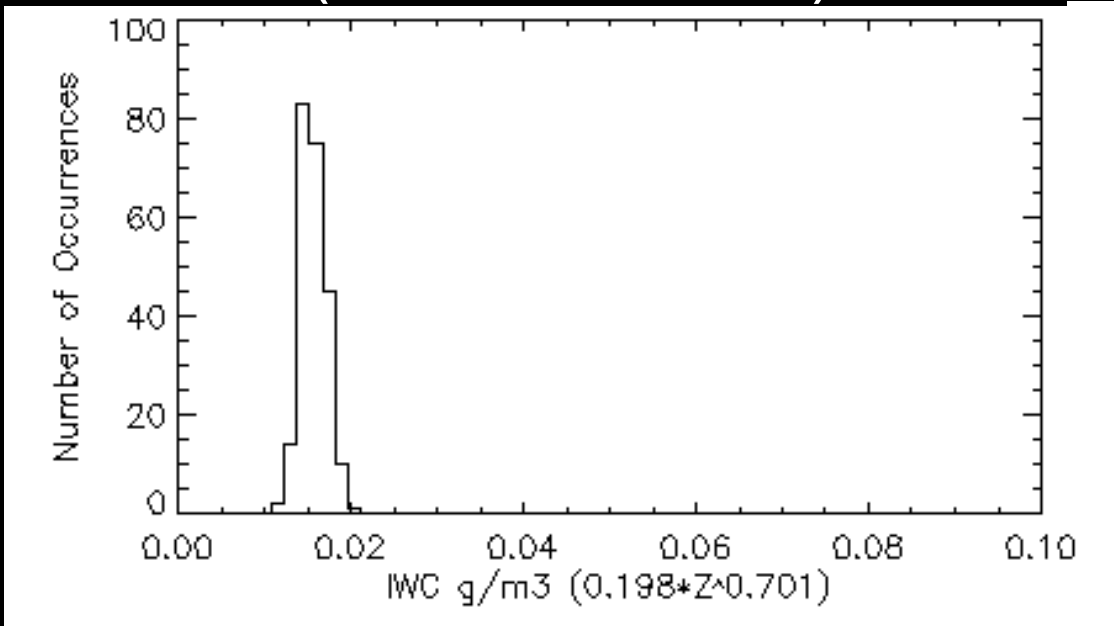
Purpose: To determine Ice Water Content from Z (Liu, Illingworth, 2000)
(29 Jan case)



Satellite Image and Flight Track



Ice Water Content From Radar Z
(29 Jan Case)



- Mean IWC = 13.4 mg/m^3
- Standard Dev. IWC: 1.6 mg/m^3
- Data Fraction: 1.0
- Proteus Altitude: 13.0 km

Radar Data provided courtesy Steve Denardo and Richard Austin
Analysis by Jay Mace

Dissipating Anvil
(10 February)

Hector

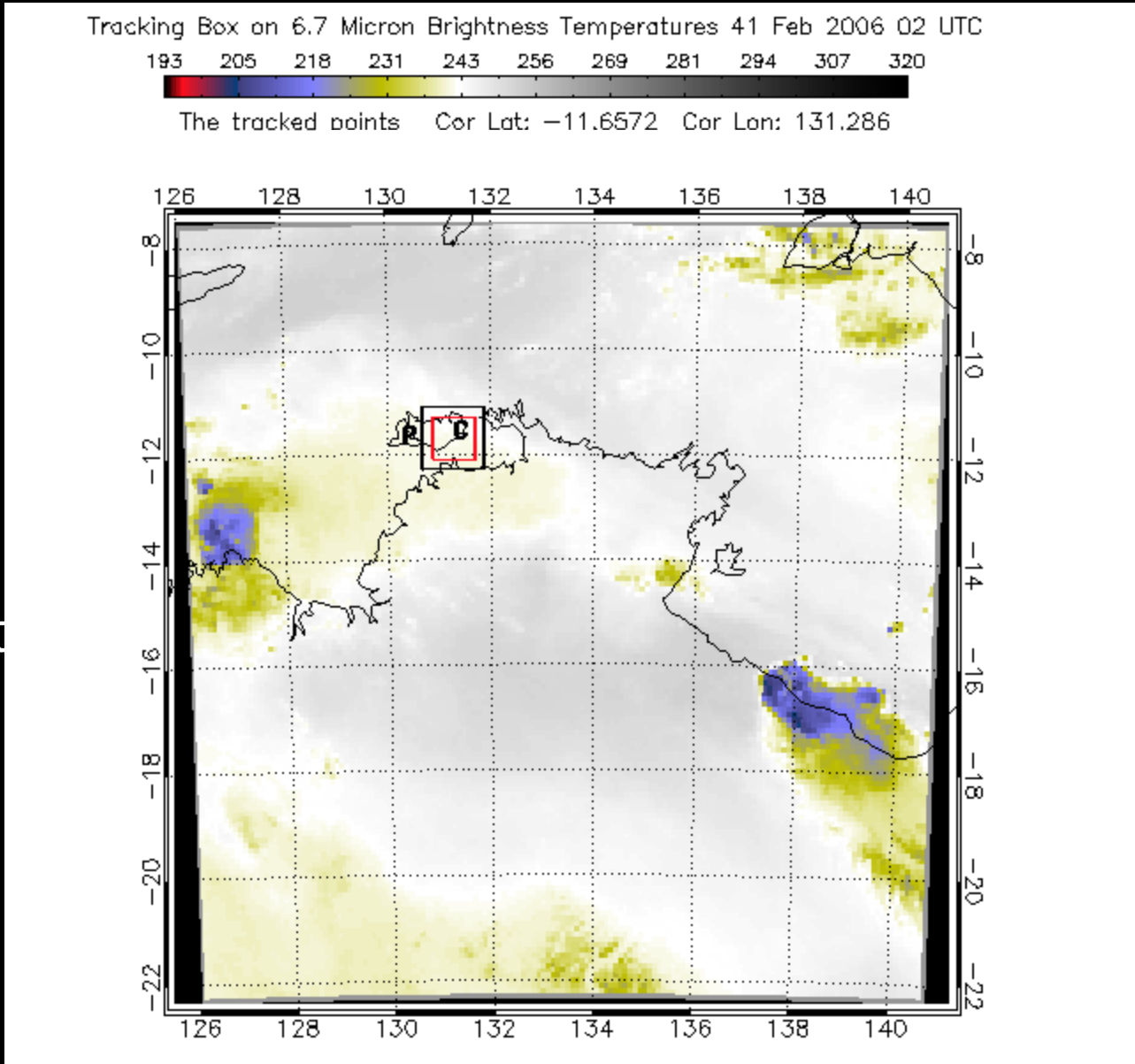
Track Path (10 Feb case)

Start time: Airplane "P" intersects the Cirrus "C".

Next time: -1 hour

Watch the C (cirrus).

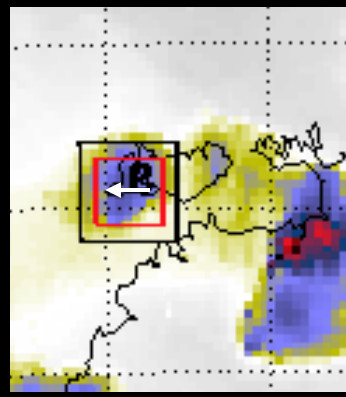
The airplane "P" flew through the cirrus that has evolved from convection 3 hours ago.

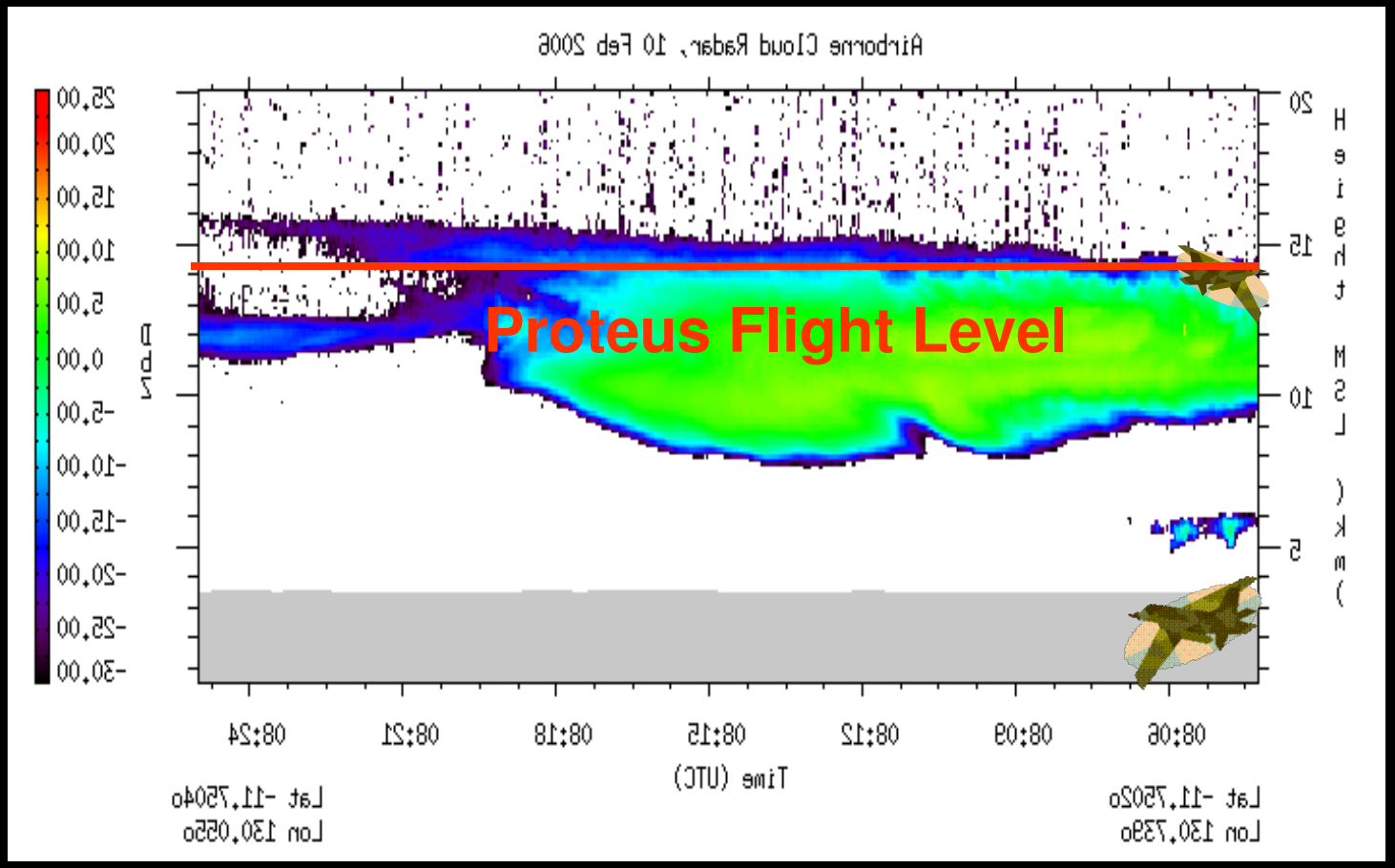


Airborne Cloud Radar on Twin Otter Aircraft

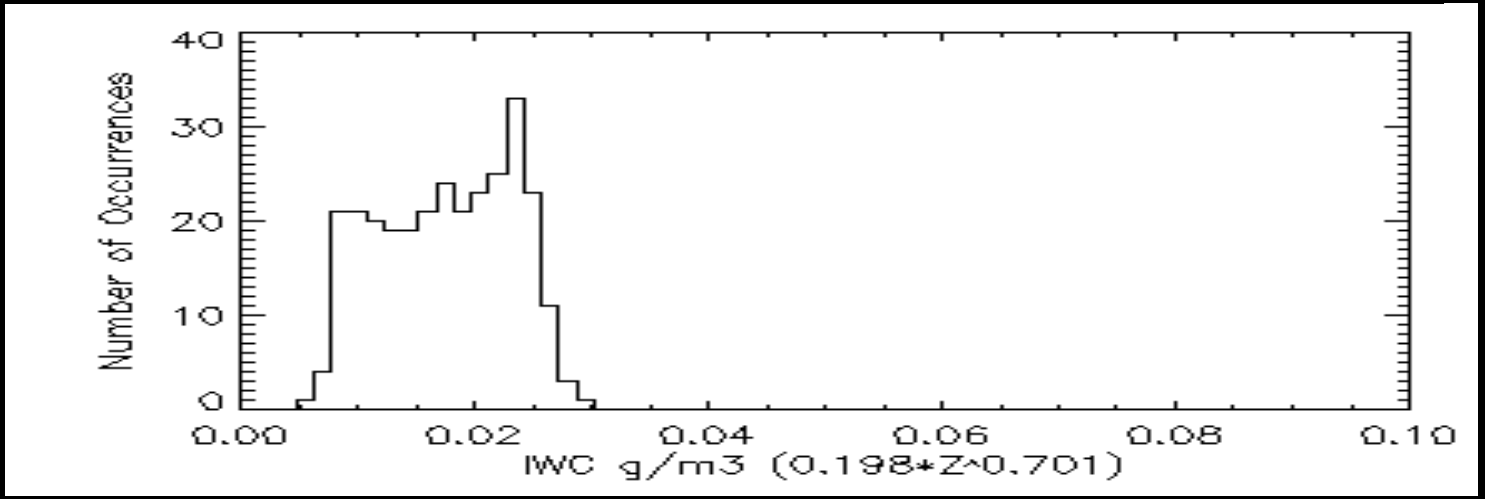
Purpose: To determine Ice Water Content from Z (Liu, Illingworth, 2000)
(10 Feb Case)

Satellite Image
and Flight Track





Ice Water Content Analysis from Radar Z (10 Feb Case)

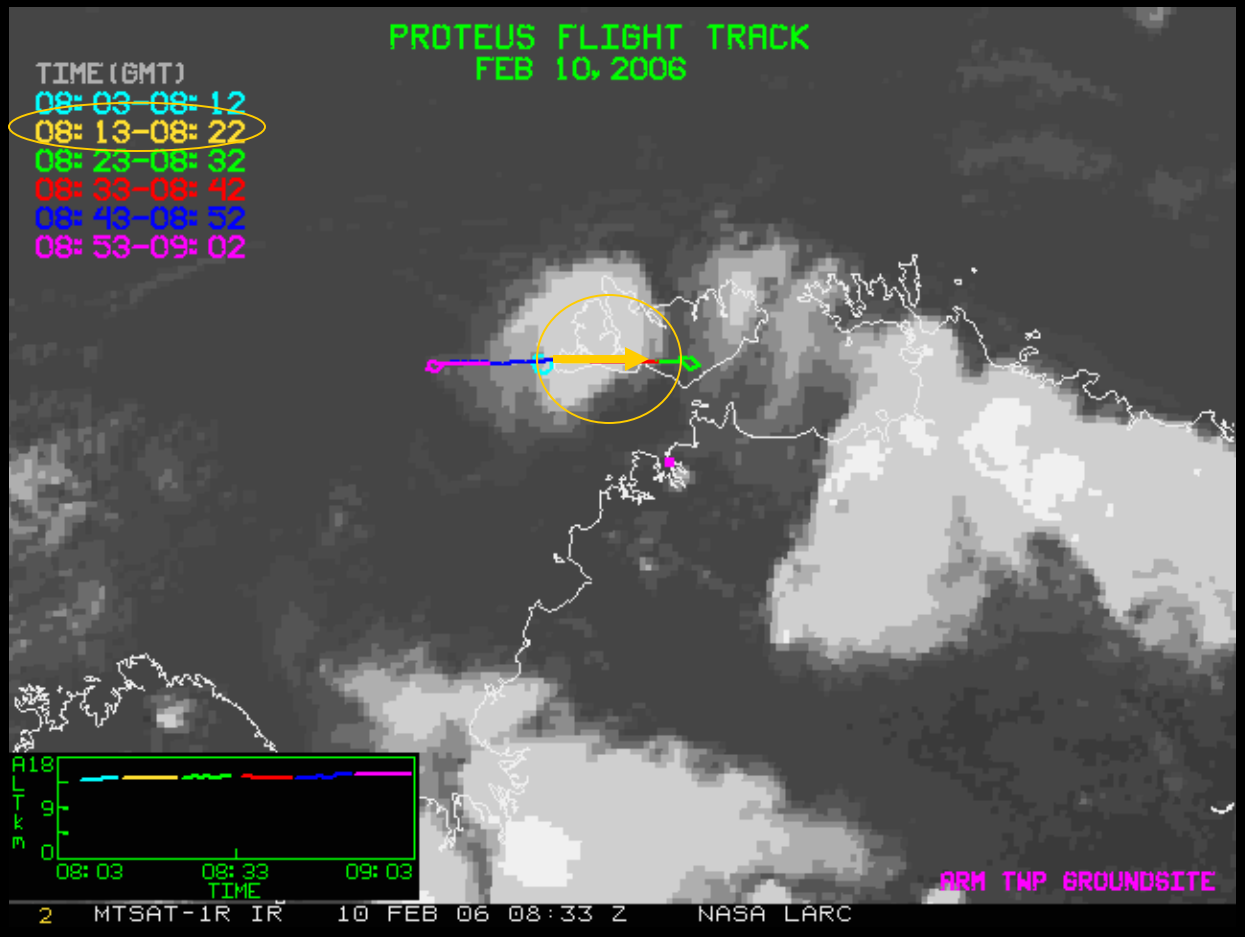


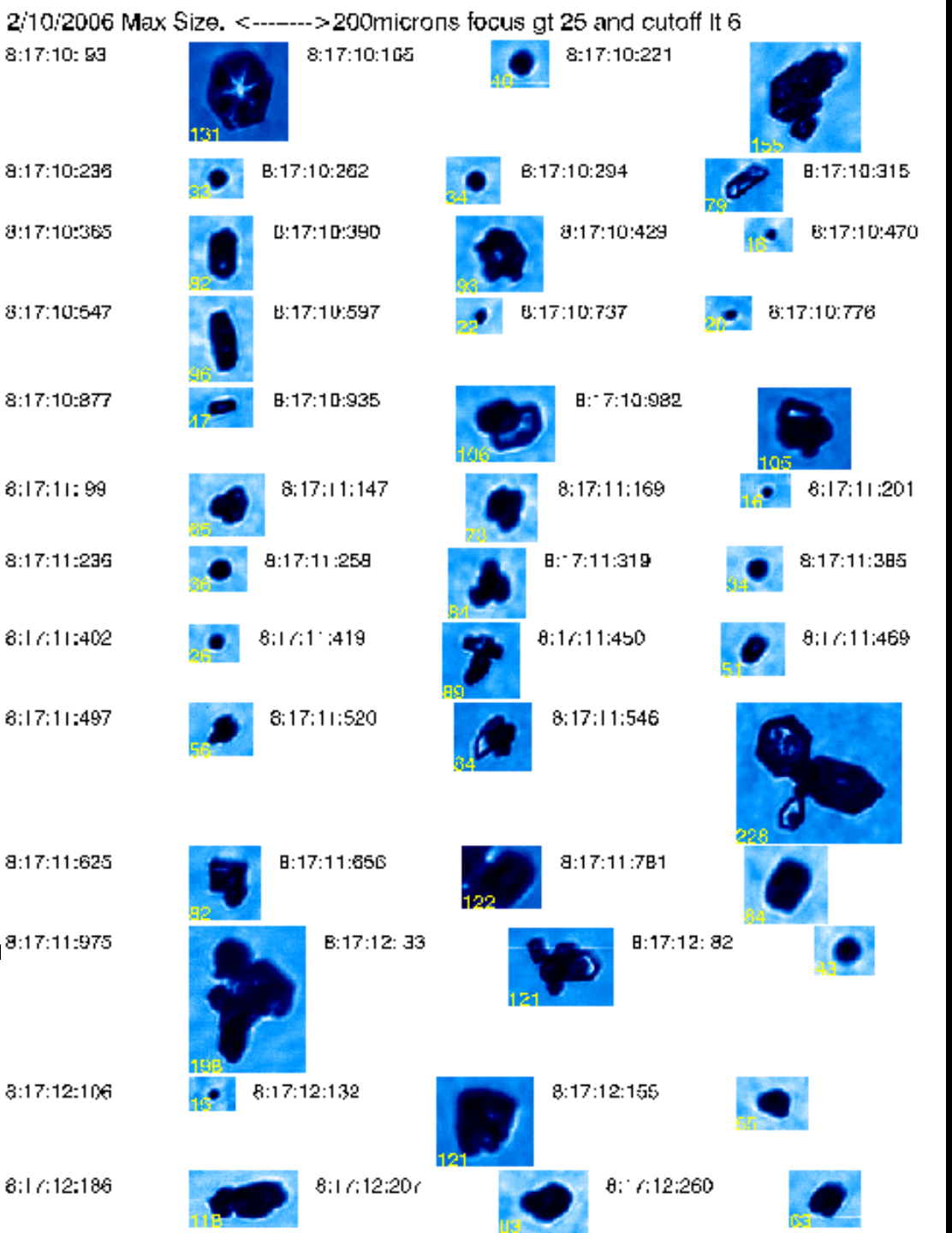
- Mean IWC = 15.4 mg/m^3
- Standard Dev. IWC: 5.6 mg/m^3
- Data Fraction: 1.0
- Proteus Altitude: 14.8 km

Radar Data provided courtesy Steve Denardo and Richard Austin
Analysis by Jay Mace

Cloud Spectrometer and Impactor (CSI) (10 Feb Case)

- Cloud Water Content from the CSI instrument = 2.38 mg/m^3
- Start time (hh:mm:ss): 8:17:10 UTC
- End time: 8:19:48 UTC





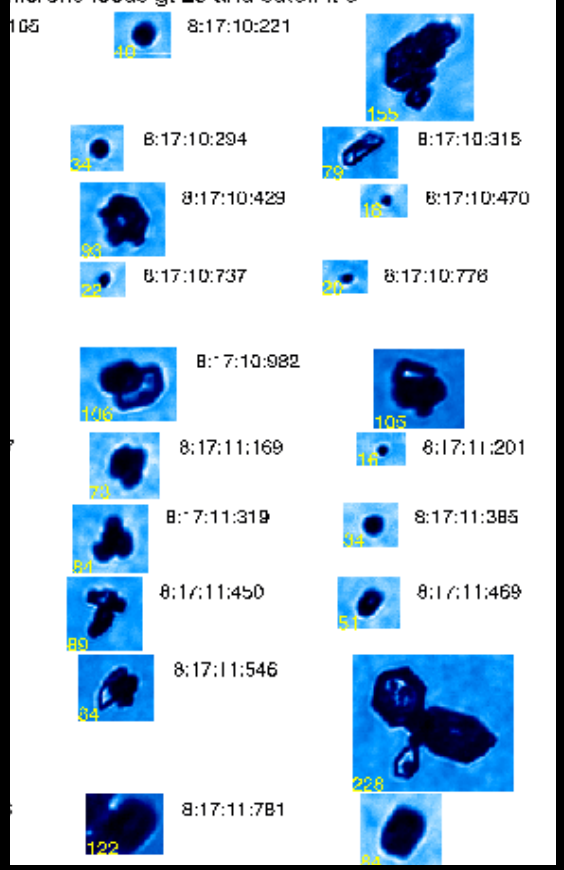
Cirrus Ice Crystals

↔ = 200 microns

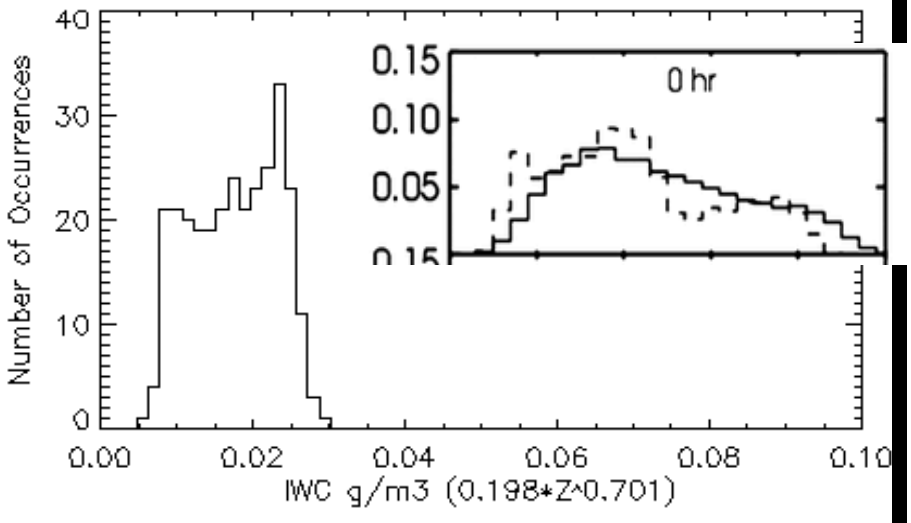
Two seconds of Cloud Particle Imager data while flying through the decaying cirrus anvil.

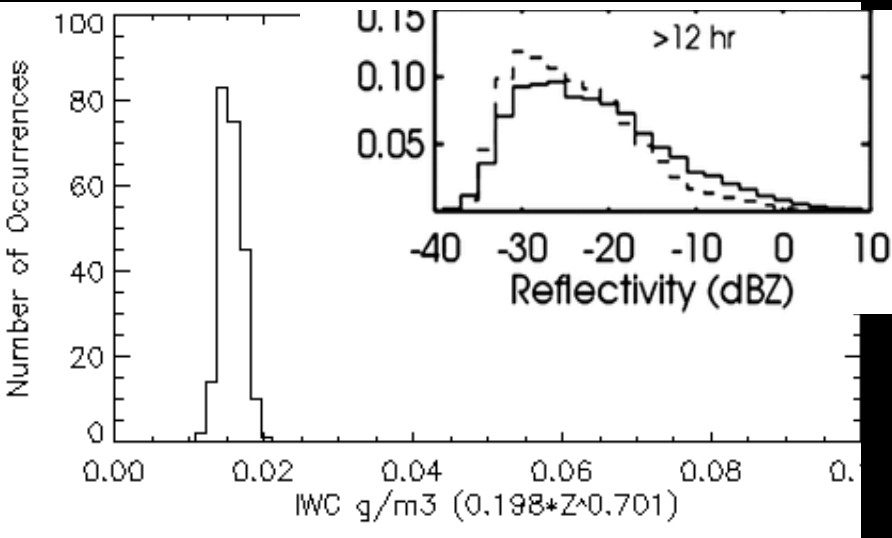
Notice the few plate like crystals and many irregular spheres.

Fresh Anvil



Aged Cirrus





TC4 Questions

- Anvils to Cirrus? What is the mechanism that drives the transition?
  - Radiative Heating?
  - Dynamics?
  - Ambient Water vapor?
- Can we document this transition?

Credits:

- Airborne Cloud Radar Data courtesy Richard Austin and Steve Dinardo.
- Satellite data courtesy Pat Minnis.
- This study is based on techniques introduced by Brian Soden.

Thank you!

Outline

- Goals
- Dissipating Anvil
- Persistent Cirrus
- Methodology
  - Tracking using Satellite Data
  - Flights
    - Radar Reflectivity
    - Cloud Particle Imager (CPI)
    - Cloud Spectrometer and Impactor (CSI)
- Future Work

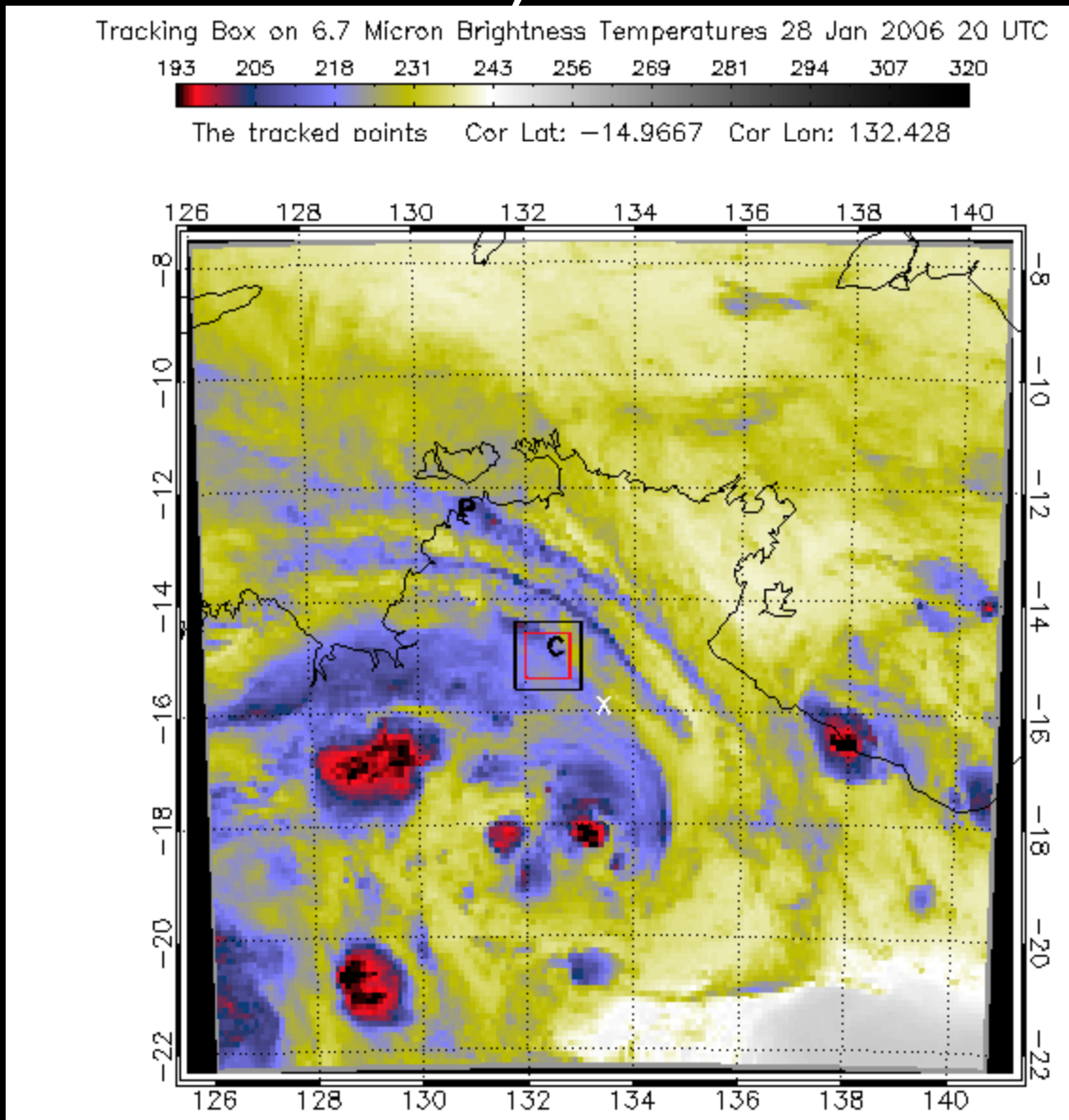
Track Path (29 Jan case)

Start time: Airplane “P” intersects the Cirrus “C”.

Next time: -1 hour

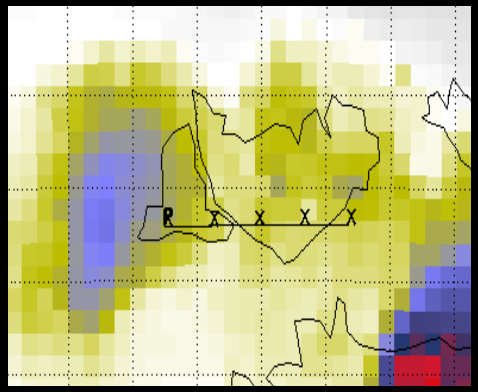
Watch the C (cirrus).

The airplane “P” flew through the cirrus that has evolved from convection 3 hours ago.

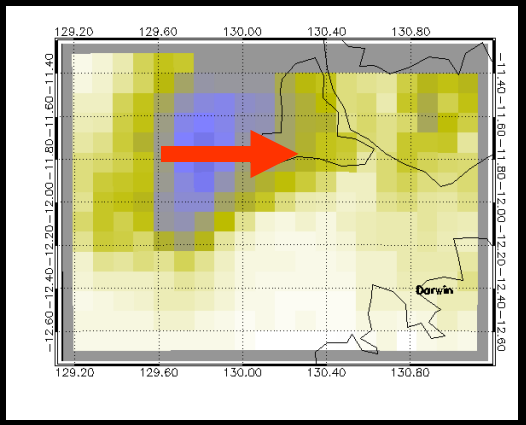


Data Sources for Cloud Information

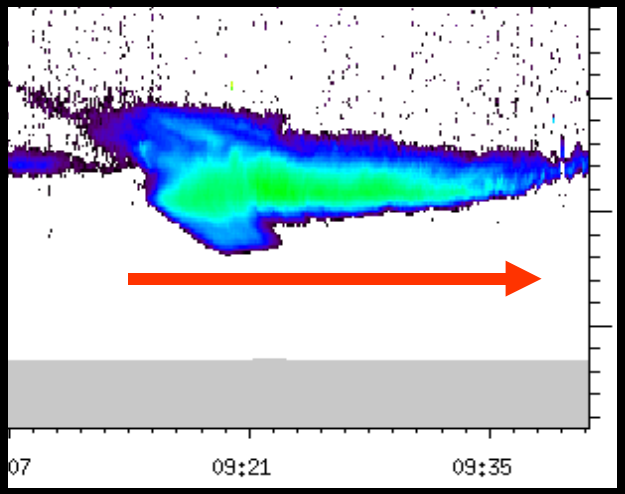
Satellite Tracking



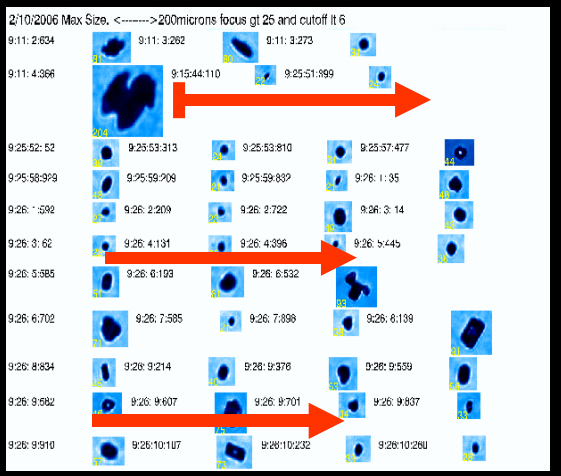
Aircraft Flight Path on Satellite Image



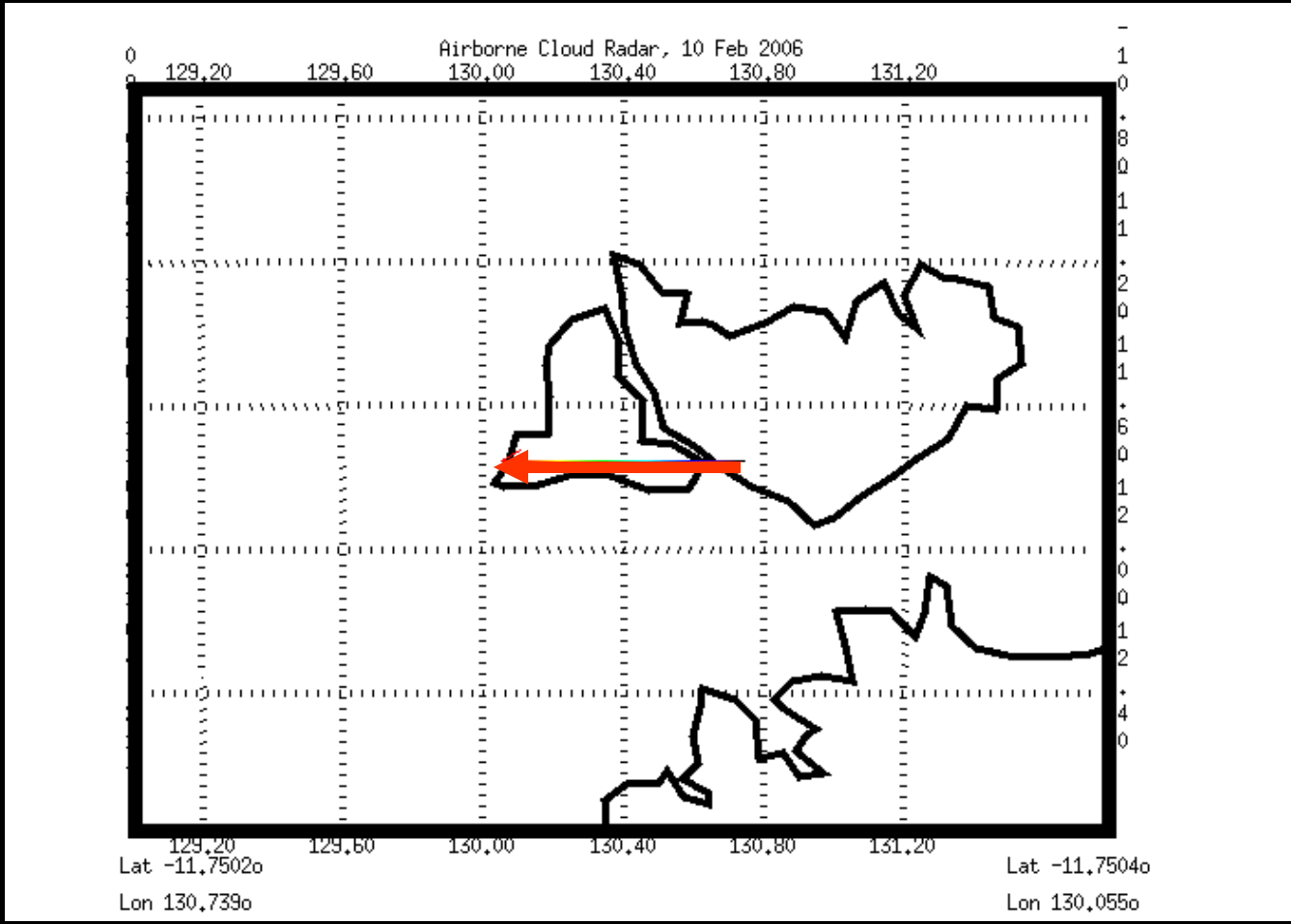
Airborne Cloud Radar



Cloud Particle Imager



Twin Otter Flight Path 10 February



UAV CSI Files

- CSI (Cloud Spectrometer and Impactor) probe flown in the ARM-UAV TWP-ICE campaign. The files contain the condensed water content (CWC) measured by the probe.

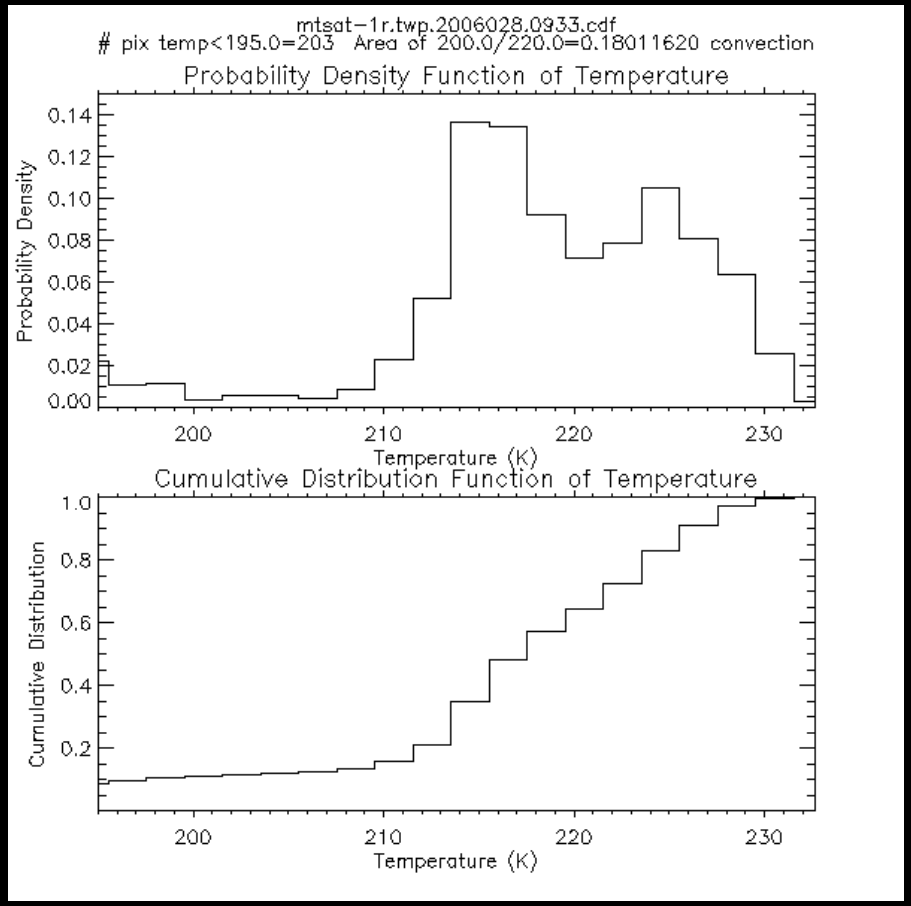
  Instruments:
  The CSI probe has a counter-flow virtual impactor (CVI) which incorporates a tunable diode laser (TDL) to detect condensed water vapor from 0.001 to 5 g/m3.

  Usage The data in these files are useful for determining the condensed water content along the aircraft's flight path.

ARM UAV CPI Image Files

- **Instrument:** The CPI was developed by the Stratton Park Engineering Research Company (SPEC Inc.). The CPI provides high-resolution (2.3 micrometers) two-dimensional images of ice crystals as particles pass through a sample volume. The CPI uses a particle detection system that consists of two continuous wave laser diodes, the intersection of which forms the sample volume of the instrument. When a particle passes through the sample volume, a 60-W imaging laser is pulsed and the image of the particle is cast on the charge-coupled device (CCD) of a digital camera, giving the high-resolution images included here. The images have been generated by CPIview software developed by SPEC Inc. with the ice paritle acceptance criteria of the focus greater than 25% and cutoff less than 6%.

What defines convection?

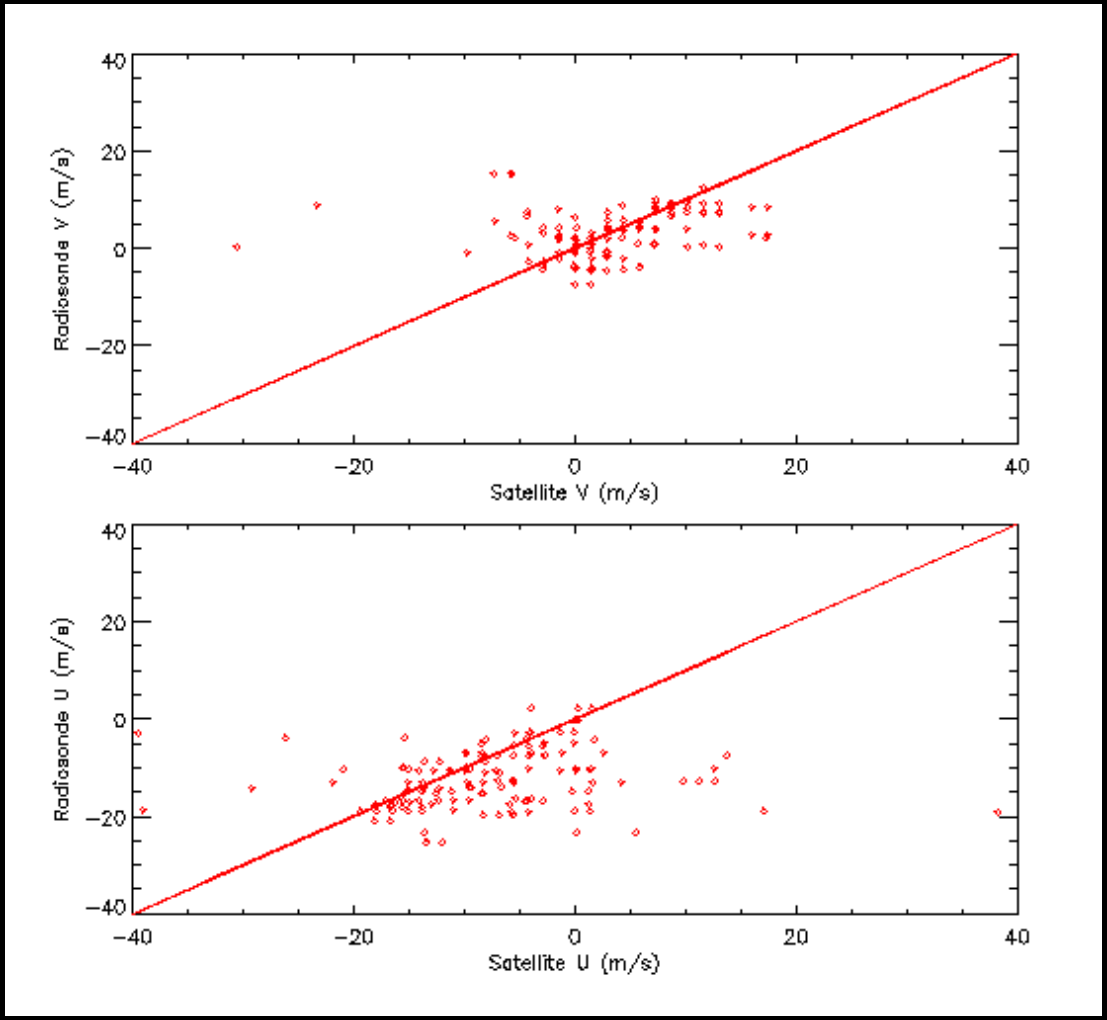


- FILL THIS IN

Min Deng, 2006

CPI data from Jan 29 case

What are the challenges?



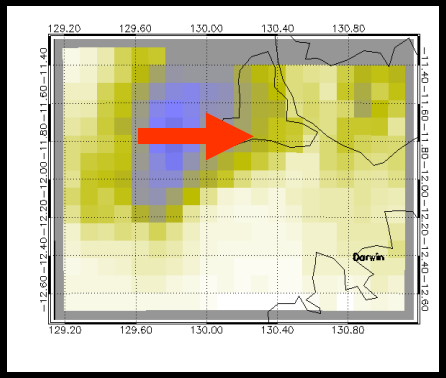
Wind sheer and new convection are challenges in the tracking validation.

Why study in Darwin, Australia?

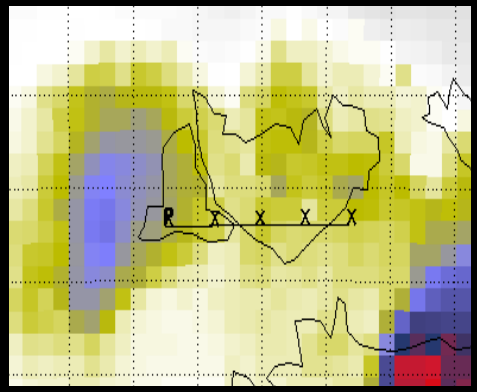
- The Australian monsoon, is traditionally strong in Darwin during January and February. The monsoon convection generates cirrus clouds.
- The ARM twp site is located in Darwin, Australia.

Method for Cloud Evolution Study

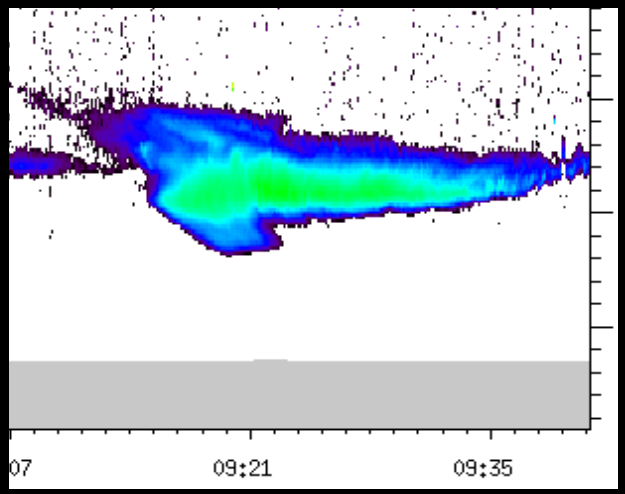
1. Flight Coincidences



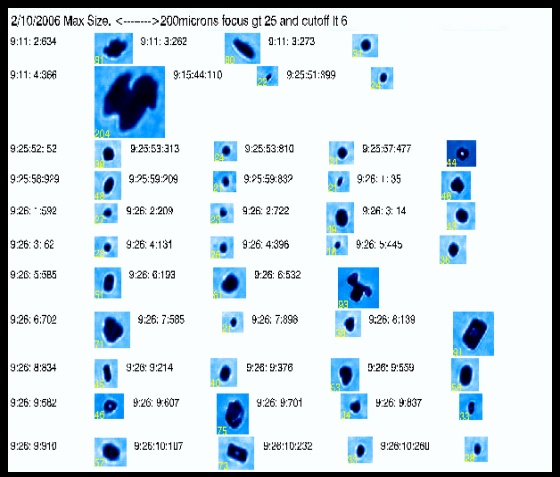
2. Time since convection



3. Twin Otter Flight Data (IWC)



4. Proteus Flight Data (CSI, CPI)



How do we track using water vapor imagery?

1. Define a cloud area (red box) around a center point at the initial time (t=0).
2. For the previous time, (t=-1), define a cloud area for every point within a search area (black box).
3. Choose the “best point” from the previous time.