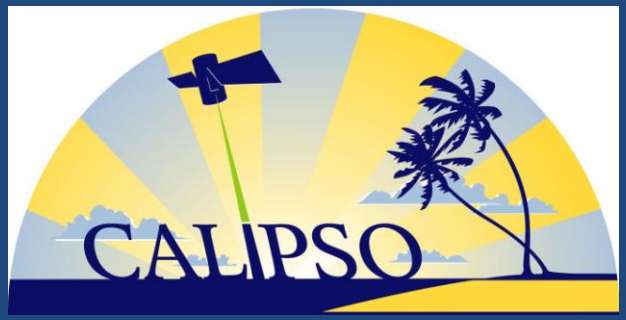
How much ice is there in the Tropical Transition Layer?

Observations from ATTREX 2014 From the Global Hawk and from Space



A Progress Report for the ATTREX 2014 Science Team Meeting
October 2014, Boulder, Colorado

“I get by with a little help from my friends…”

Presented by M. A. Avery
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Cloud Physics Lidar: M. McGill, D. Hlavka, J. Yorks
Hawkeye: R. P. Lawson, S. Woods, N. Krause, C. Roden, S. Lance, B. Gandrud
MMS: T. Bui
NOAA Total Water: T. Thornberry, A. W. Rollins, D. Fahey
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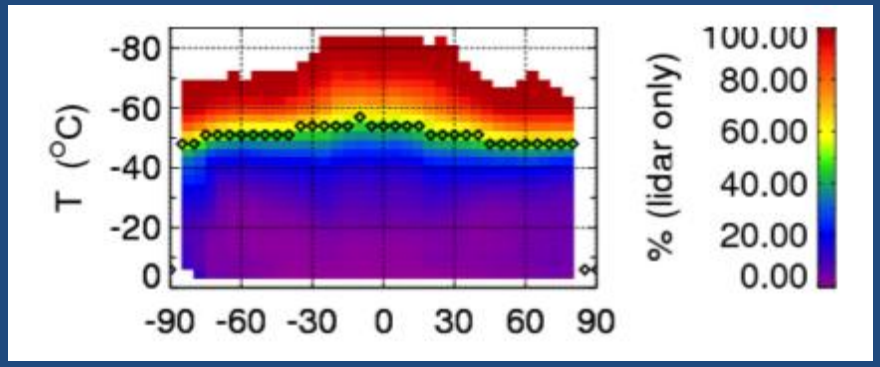
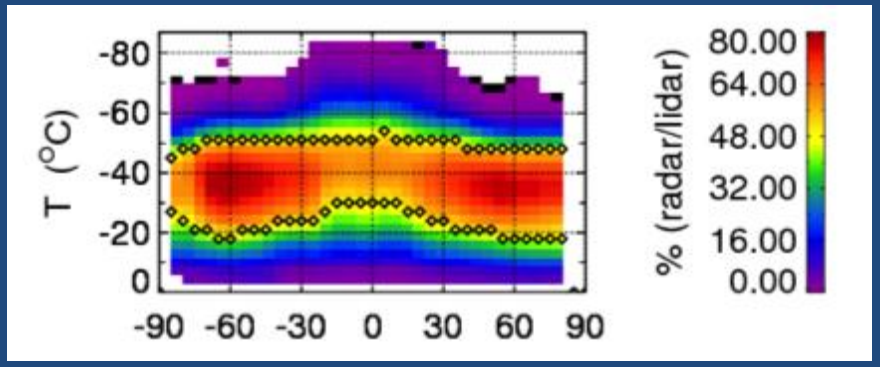
Why Measure Cloud Ice Water Content from Satellite Instruments?

Clouds are the largest source of uncertainty in climate models.

Fraction of clouds detected only by CALIOP



Fraction of clouds detected by both CALIOP and CPR



Heymsfield et al., JGR 2014

CALIPSO Instruments

The CALIPSO payload consists of three co-aligned nadir-viewing instruments:

- Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)
- Imaging Infrared Radiometer (IIR)
- Wide Field Camera (WFC)

New Version 4 Level1 improves 532 nm night, day/night agreement and 1064 calibrations.

CALIPSO Cloud Ice Products:

- CALIOP Ice Water Content (IWC)
- CALIOP Ice Water Path (IWP)
- CALIOP Extinction
- CALIOP Optical Depth (OD)
- CALIOP Depolarization
- IIR Ice Water Path (IWP)
- IIR Optical Depth (OD)
- IIR Effective Particle Size
- IIR Microphysical Parameter

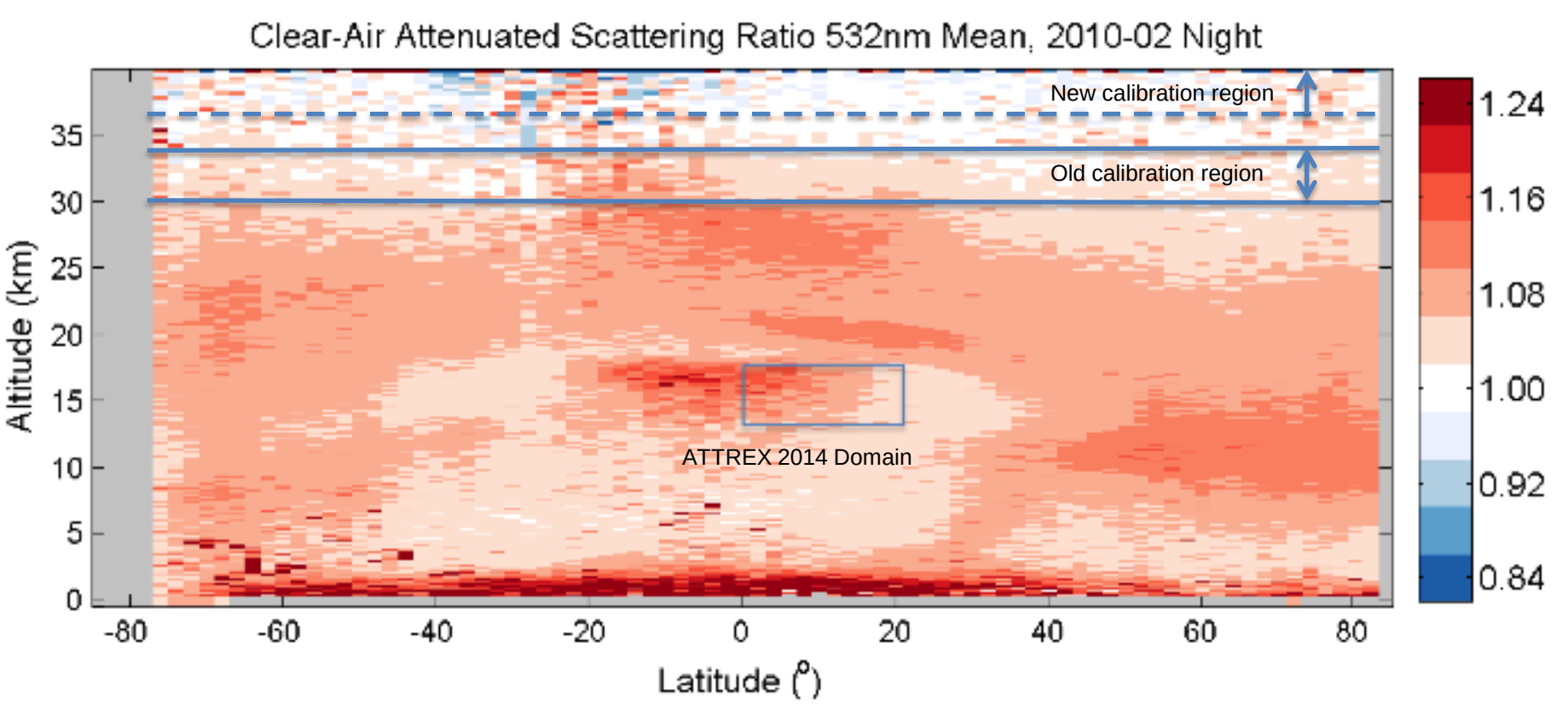
Objective:

Upscale bulk cloud properties derived from the microphysical data using CPL as a standard and CALIOP to provide regional statistics and trends of TTL sub-visible cirrus cloud extinctions and ice water content, over 8 years.

Methods:

- Evaluate CALIOP and IIR Version 4 during the ATTREX 2014 spatial and temporal domain.
- Relate CALIOP and CPL 532 nm IAB, extinction, layer thickness, depolarization, 1064/532 color ratio.
- Use the geometric approximation: Extinction Coefficient = 2 x Projected Area to relate SPEC probe area distributions to CPL extinction coefficients.
- Apply the Heyms 2014 ext/Deff/IWC parameterization to CPL extinctions, compare with NOAA total water.

CALIOP Version 4 – Much Improved Calibration



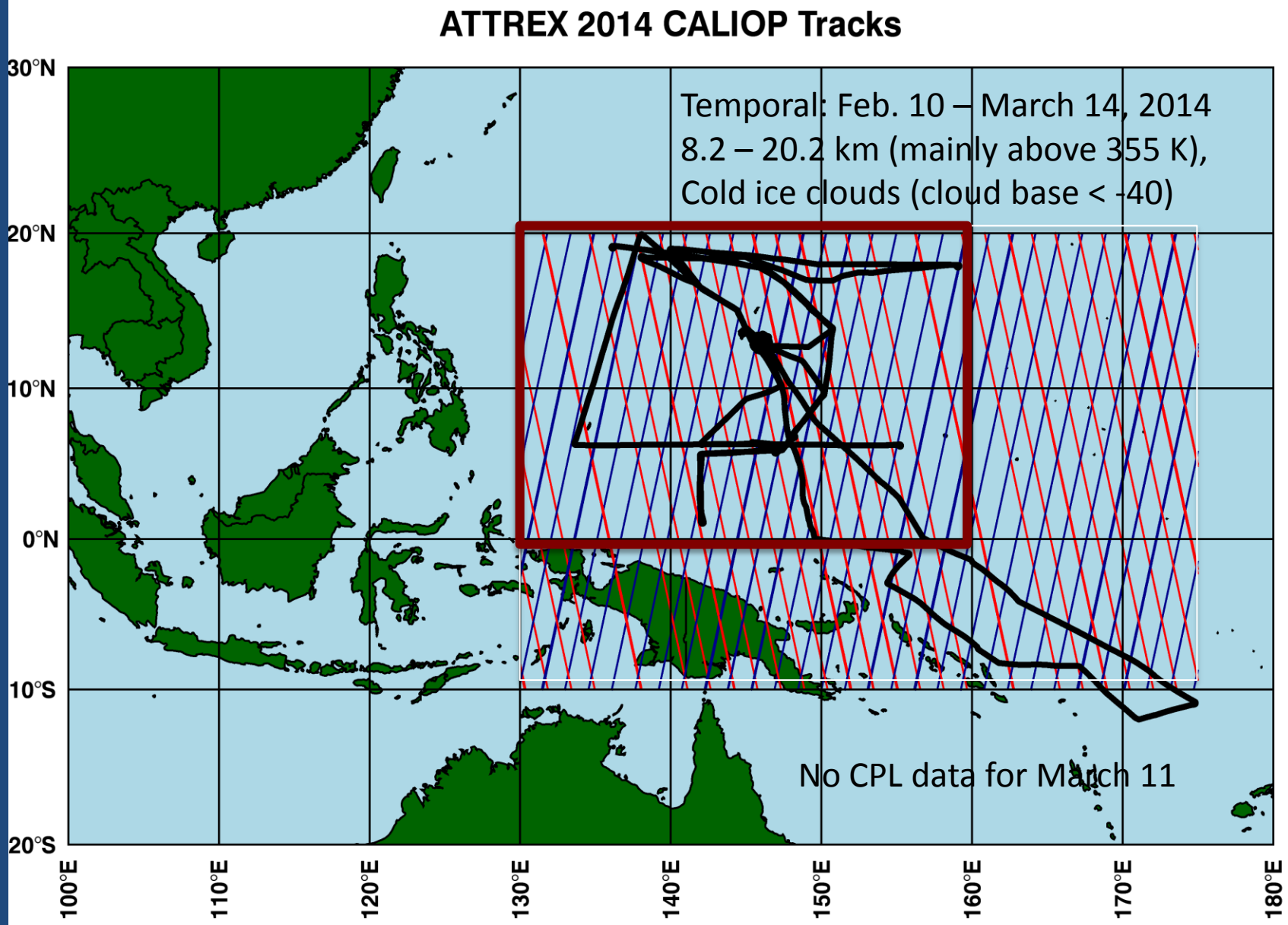
CALIOP 532 nm Nighttime channel clear air scattering ratios show that Version 3 calibration region is not really “clear air” for molecular normalization.

In the Tropics, CALIOP sees volcanic aerosols and ice particles with N too small to detect as layers.

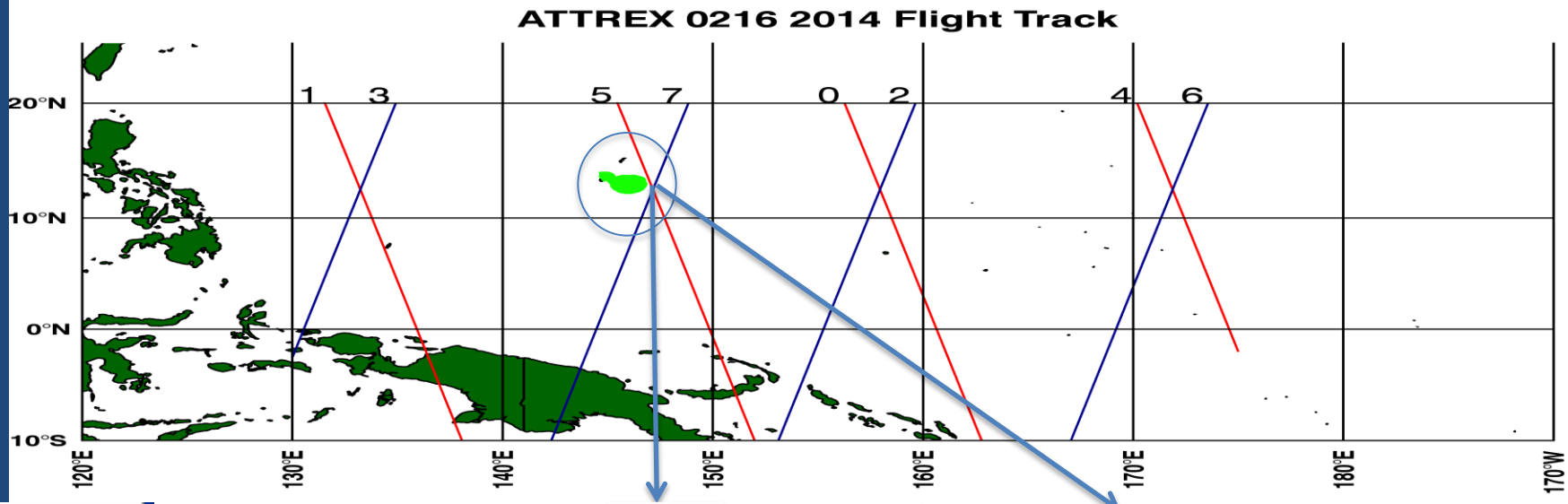
Status, October 2014

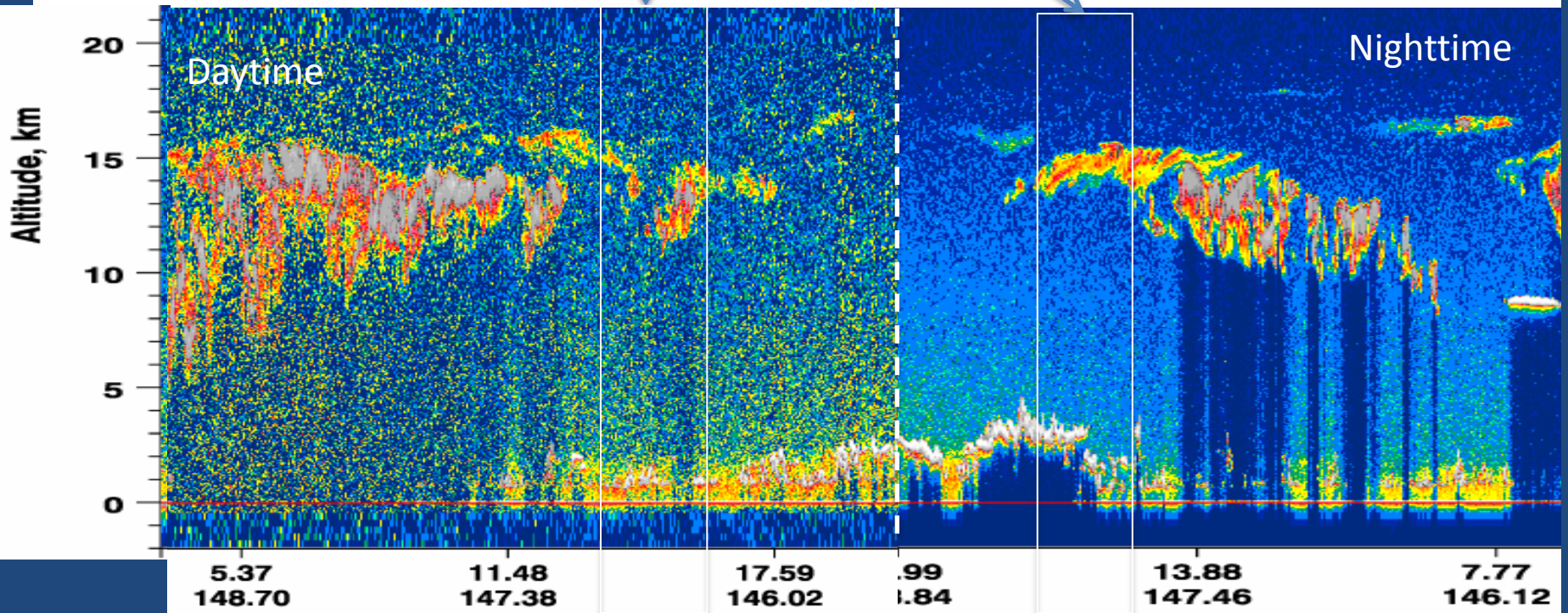
- CALIOP Version 4 Level 1 has been created through August 2014
- CALIOP Version 4 Level 1 is currently available from June, 2006 – December 2012
- January 2013 – August 2014 is anticipated to be released in a few weeks
- IIR data Version 3 is available
- CPL data is available
- SPEC data is available, but FCDP and 2DS needs to be thoughtfully combined
- NOAA ice water content just recently became available

Data Coverage during ATTREX 2014

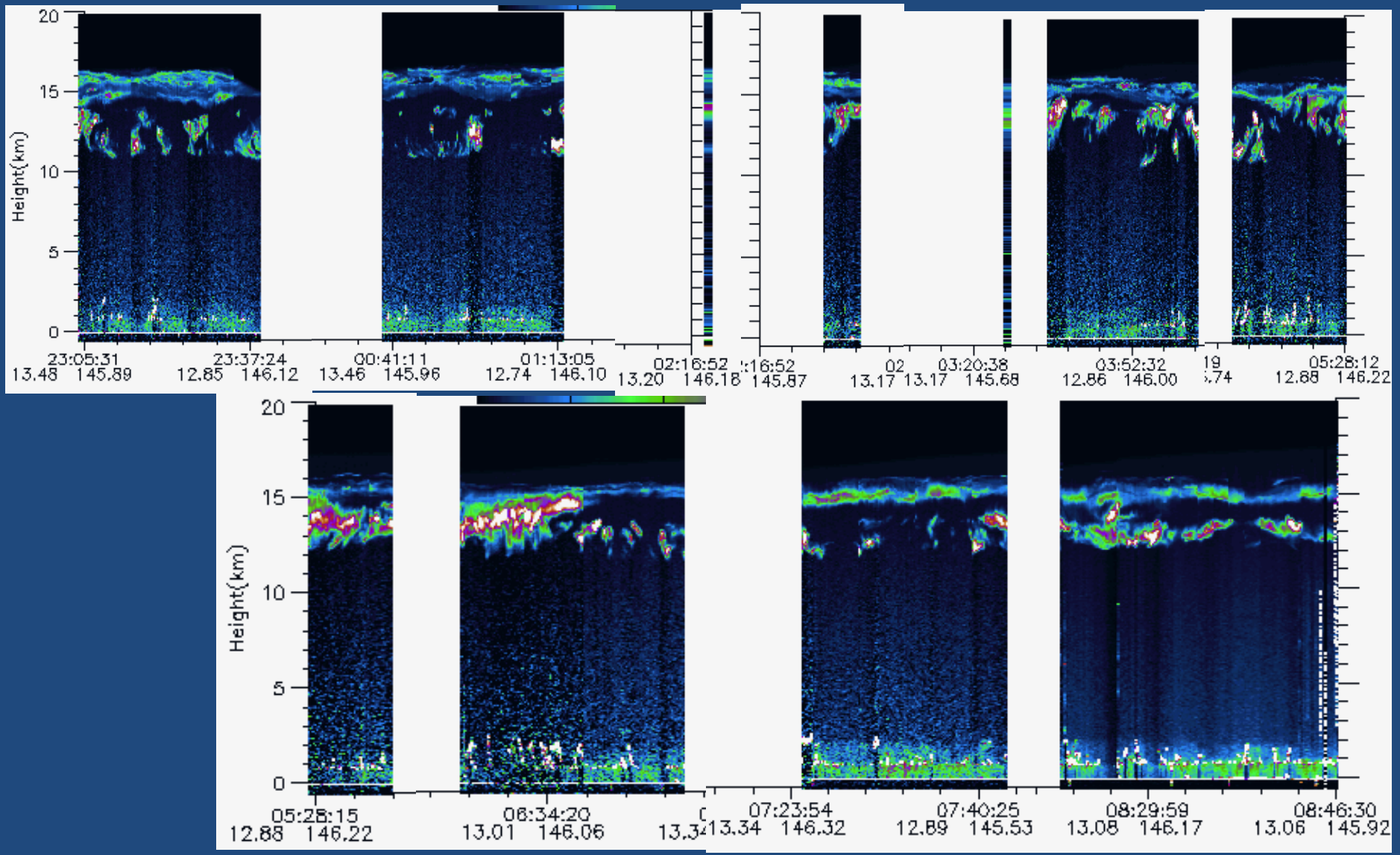


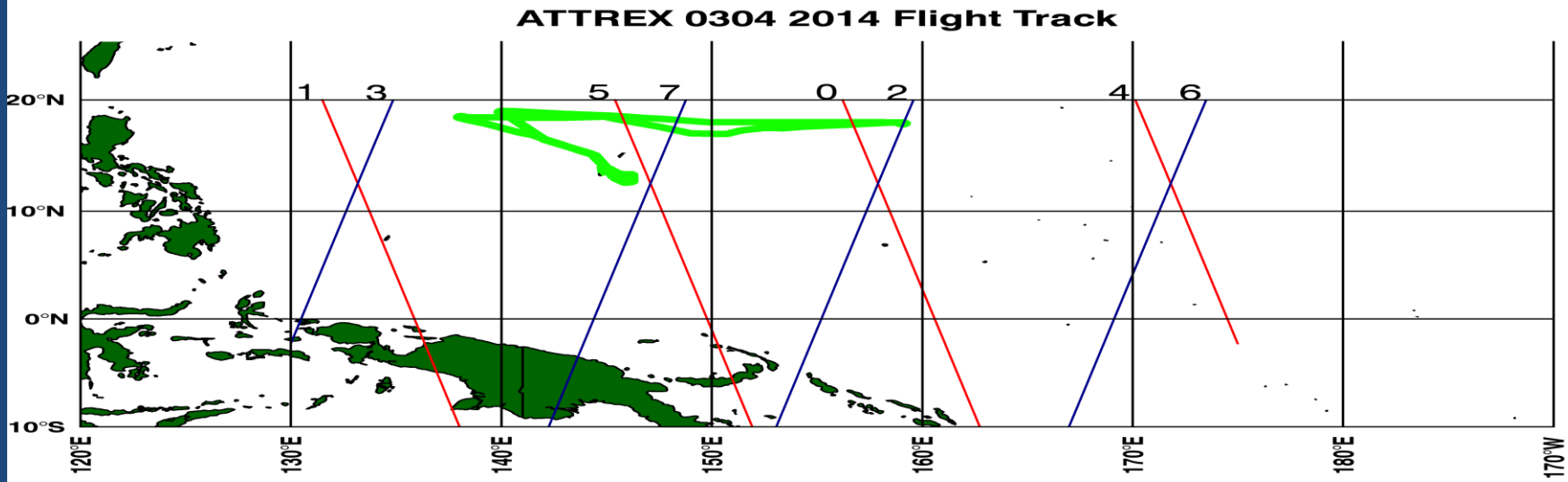
ATTREX Guam “go nowhere” Flight

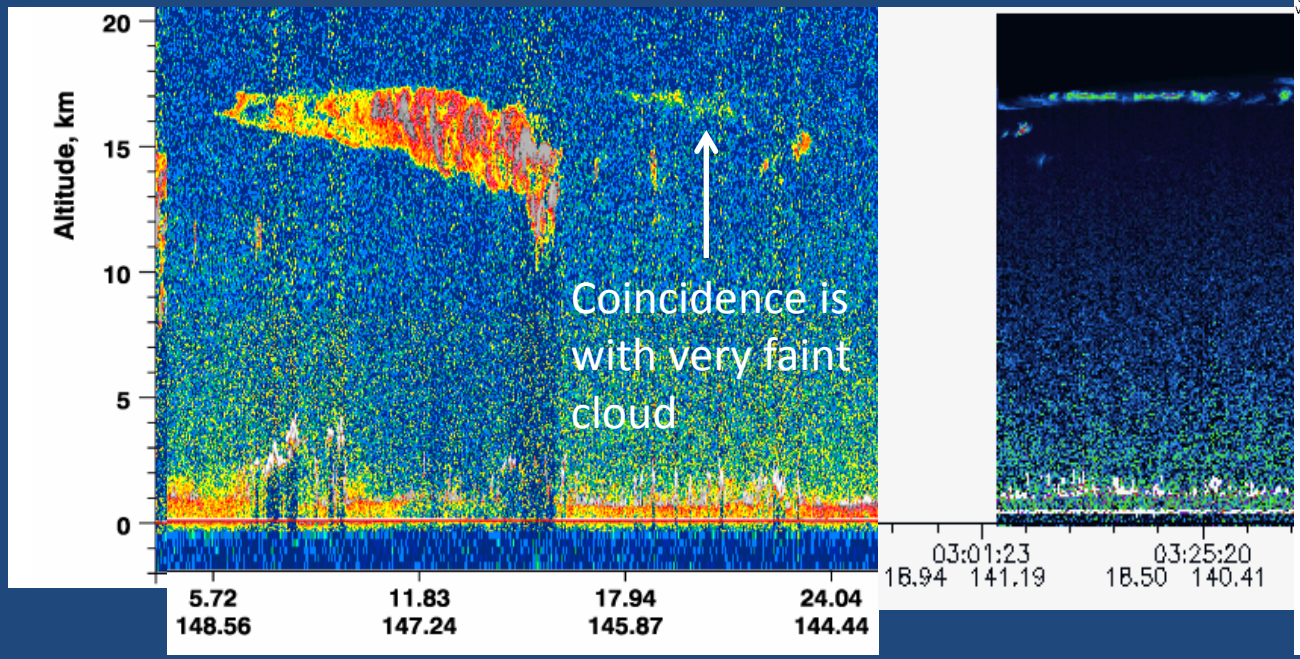


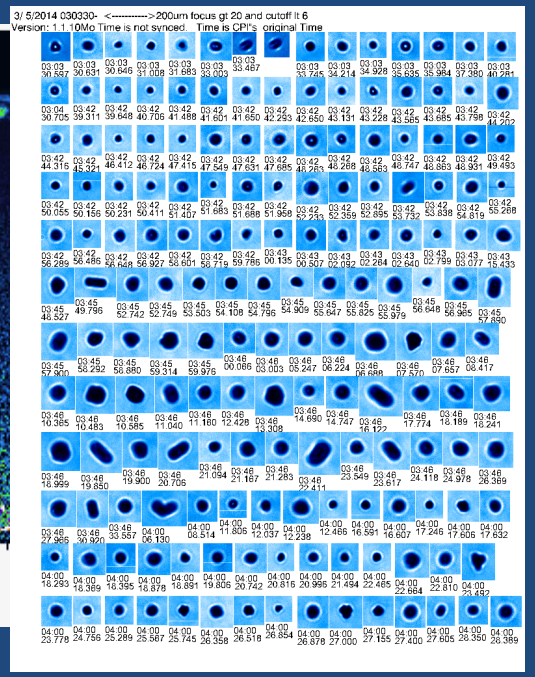


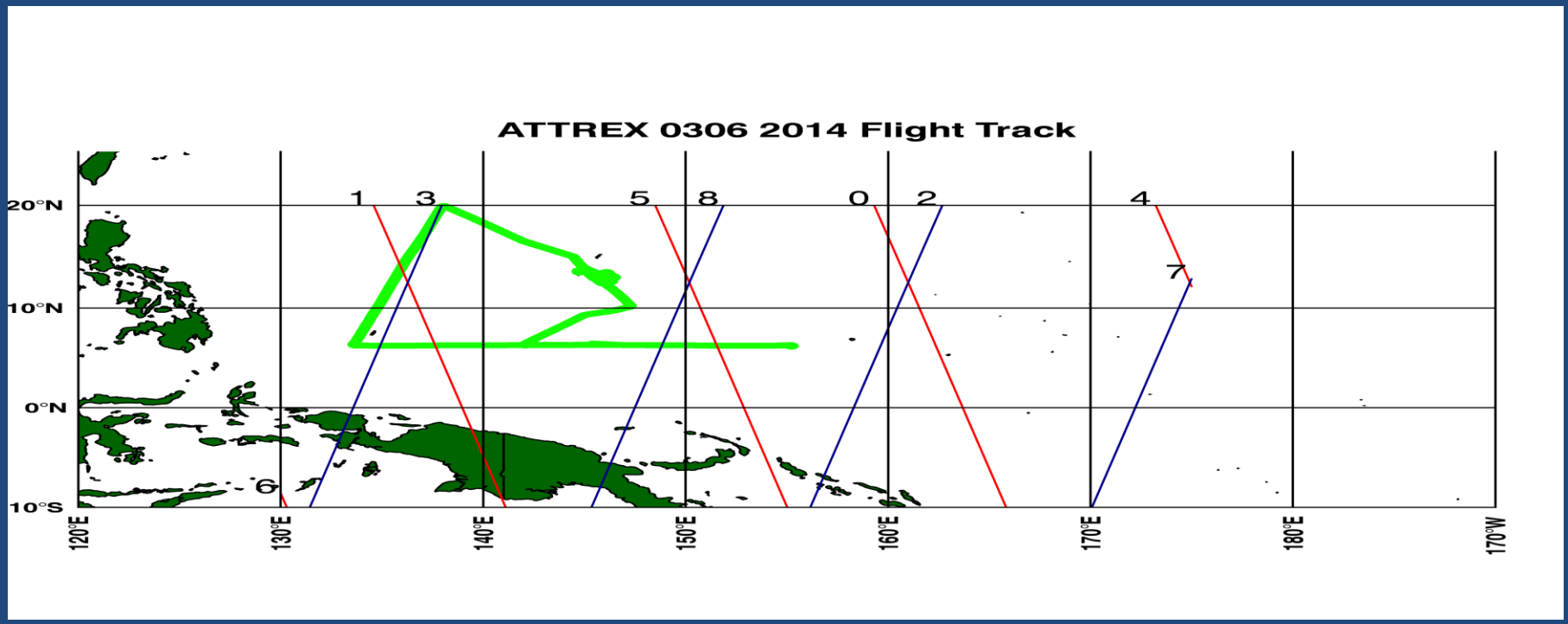
Cloud Physics Lidar Composite, Feb 16-17

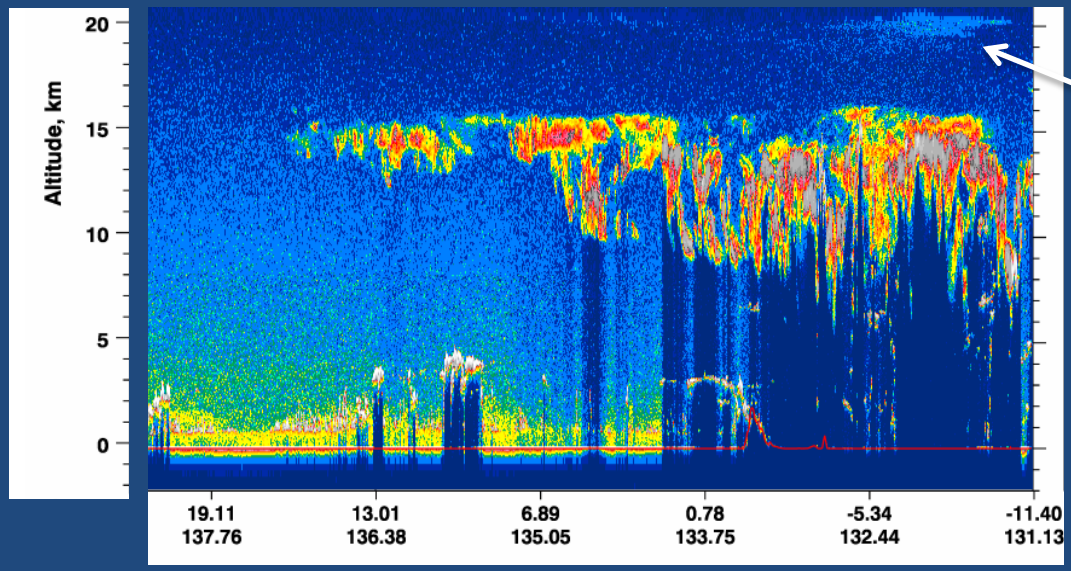



ATTREX 0304 2014 Flight Track
1
3
5
7
0
2
4
6
20°N
10°N
0°N
10°S
120°E
130°E
140°E
150°E
160°E
170°E
180°E
170°W

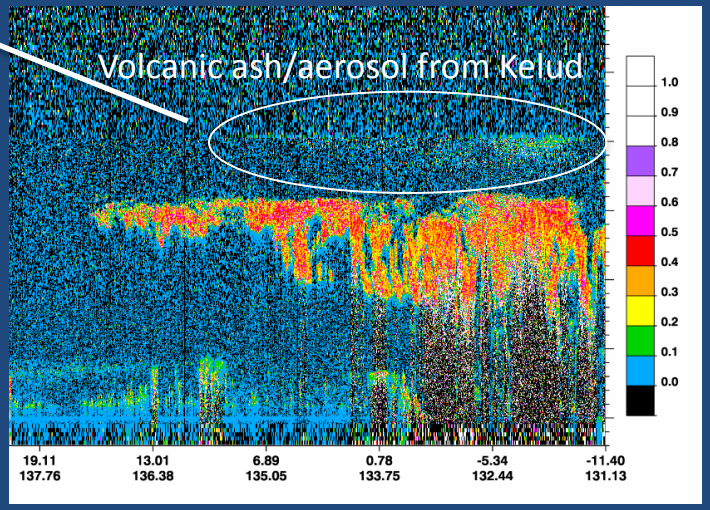

Altitude, km
20
15
10
5
0
Coincidence is with very faint cloud
5.72
148.56
11.83
147.24
17.94
145.87
24.04
144.44
03:01:23
18.94 141.19
03:25:20
18.50 140.41


3/ 5/2014 030330- <----------> 200um focus gt 20 and cutoff lt 6
Version: 1.1.10Mo Time is not synced. Time is CPI's original Time

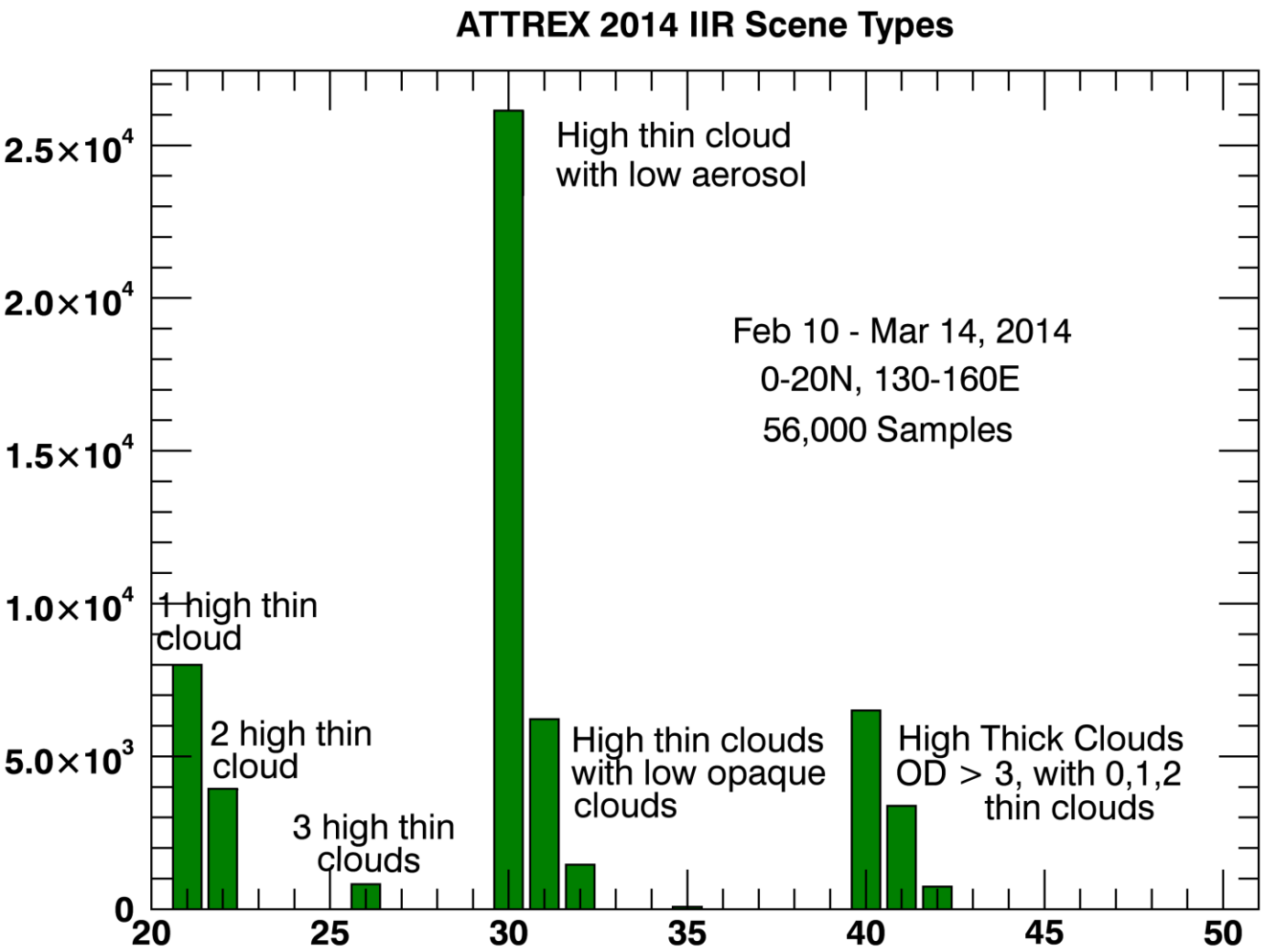




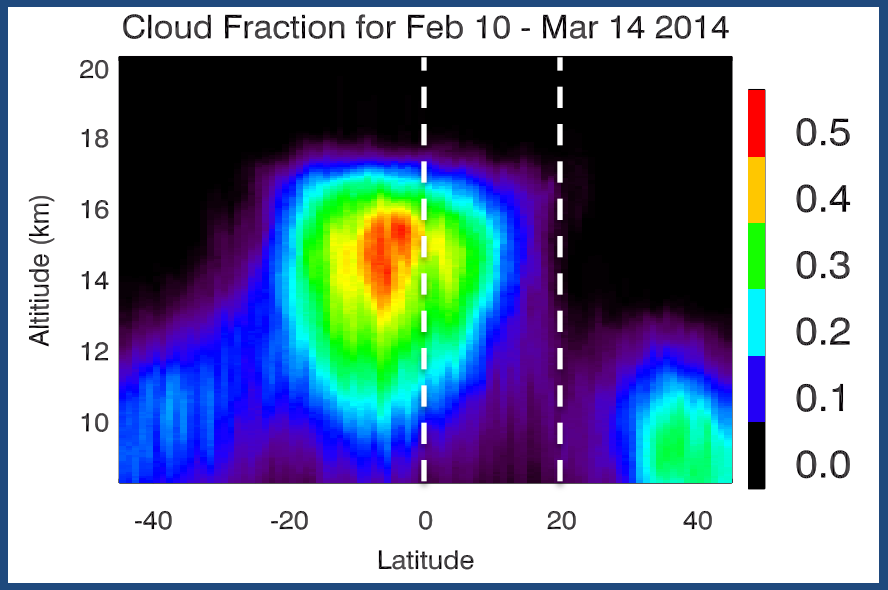
Depolarization

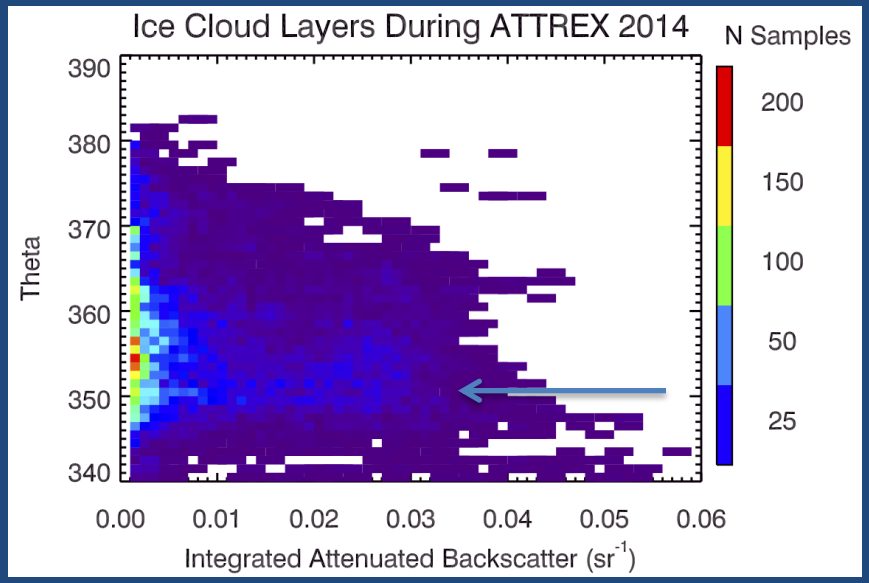


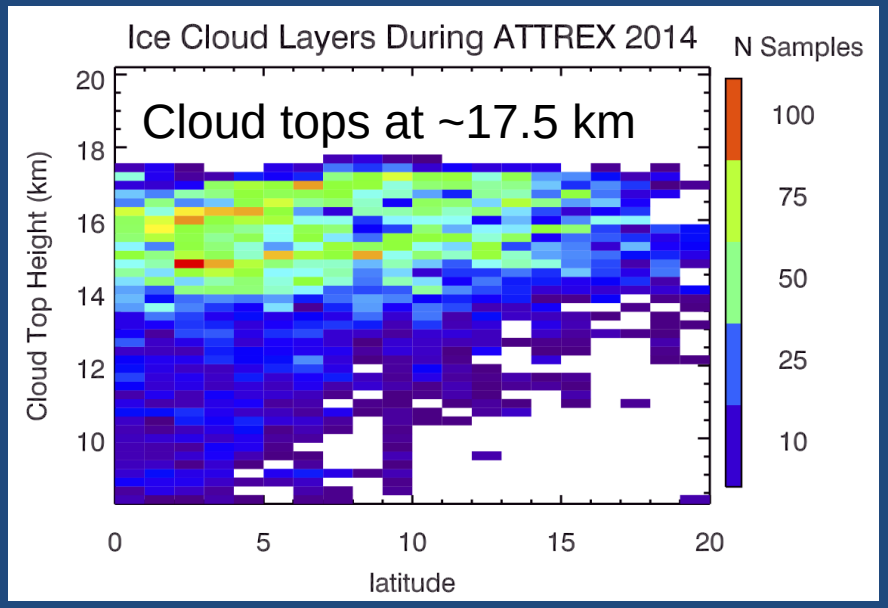
CALIOP/IIR Scene Type Classification

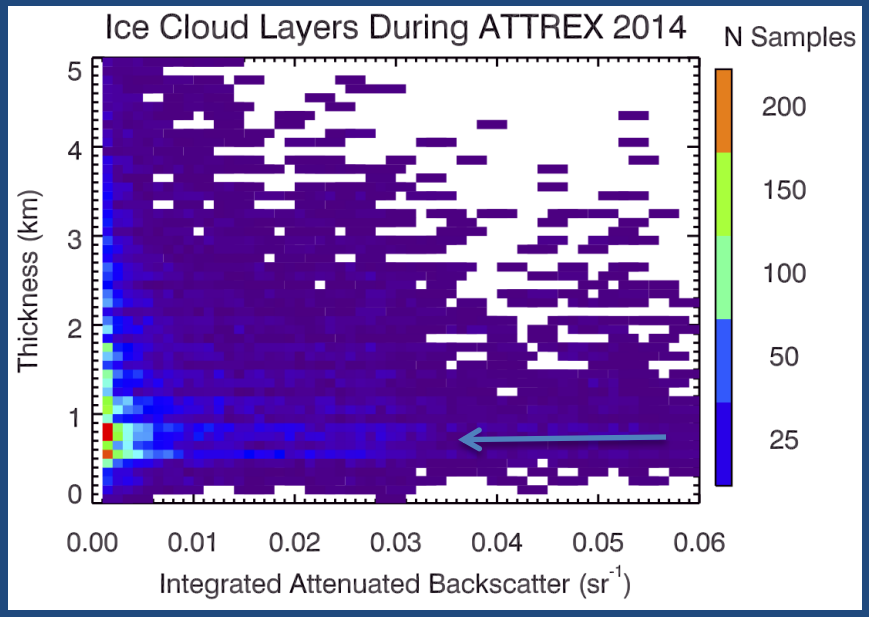


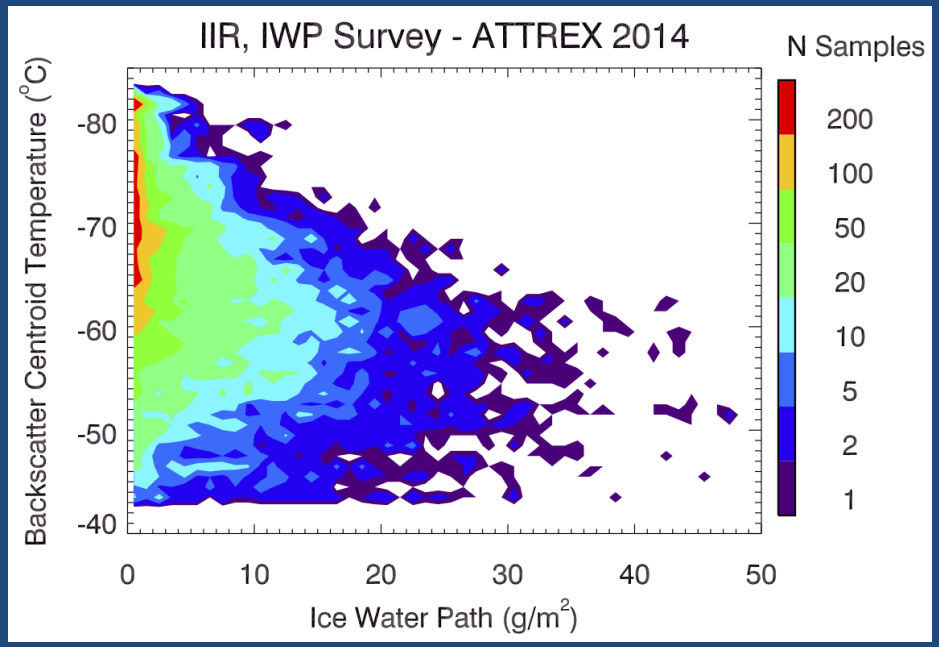
CALIOP Overview: Feb 10 – Mar 14, 2014





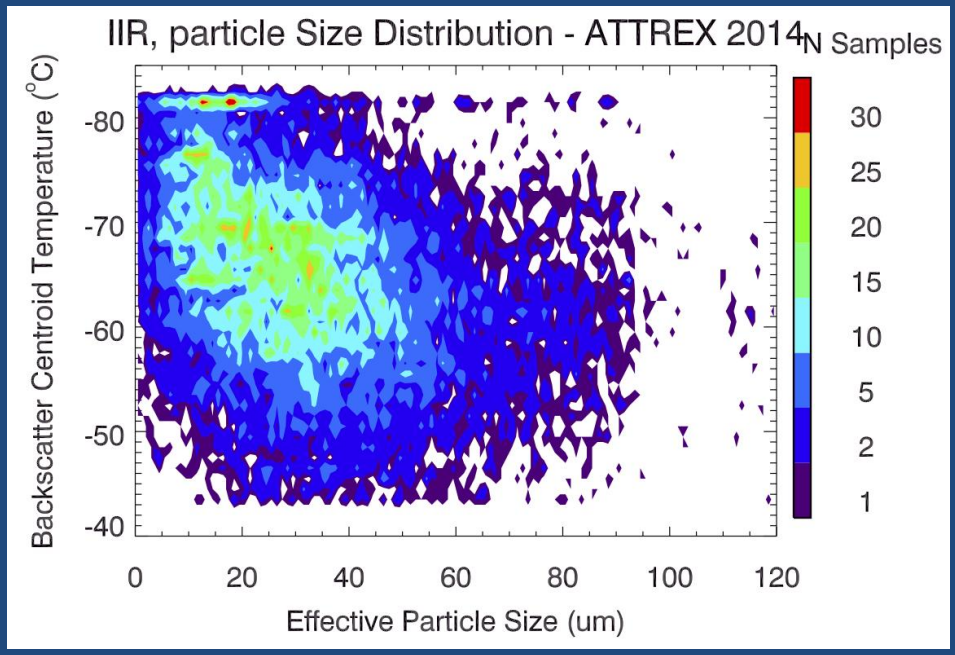




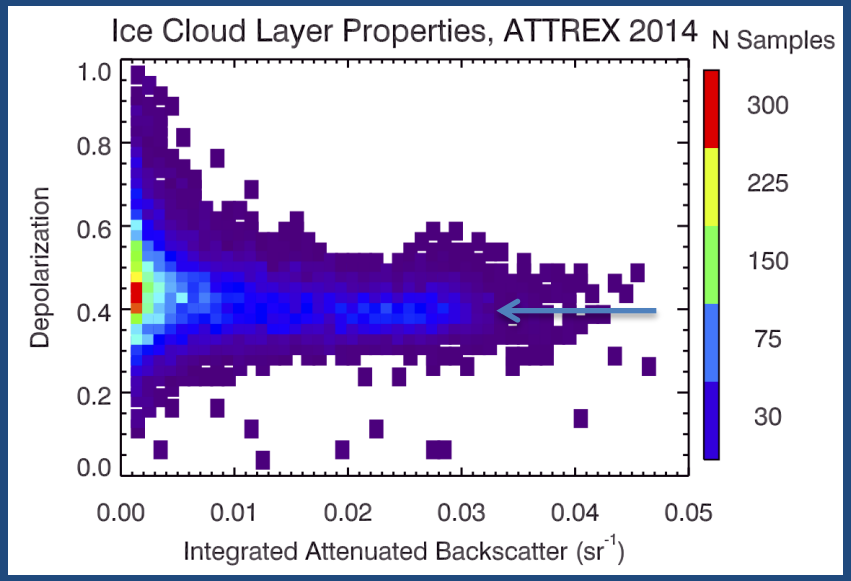


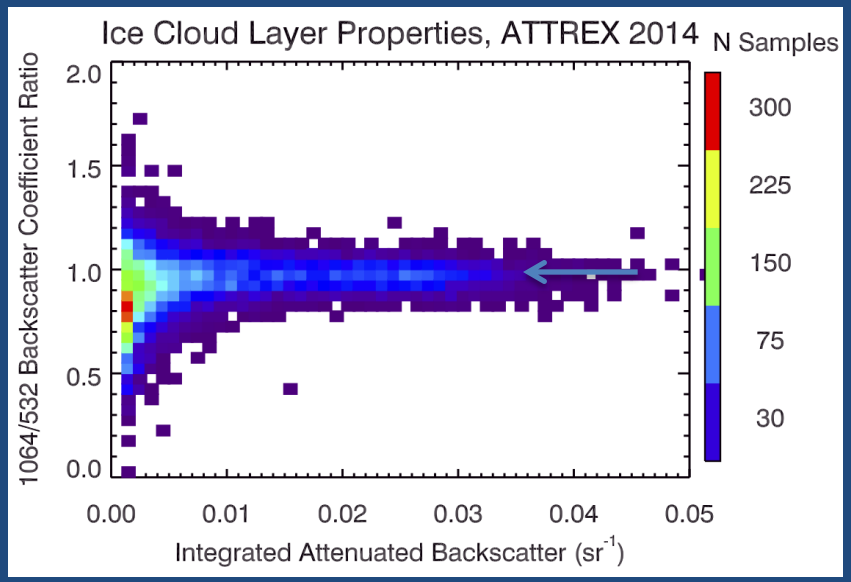
IIR Effective Size and IWP

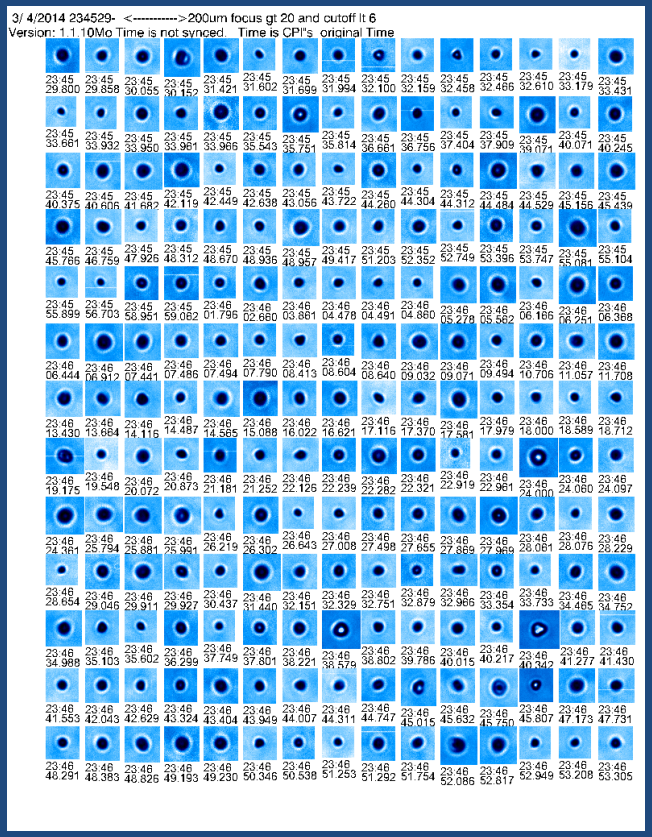
- At very cold temperatures, the IIR (window channels) sees a very small effective particle size and corresponding small IWP
- Effective particle size decreases with temperature, as expected
- Best retrievals will occur where there are single-layer clouds with a well-defined measured background radiance.



Cloud Particle Properties







Hawkeye CPI shows that most small particles in colder Ci are irregular spheres (> 80%, Woods et al. AMS poster), yet CALIOP shows depolarization of 40-50%, as much or more than for larger ice crystals.

Summary

- CALIPSO lidar and IIR provide a unique regional view of UT/LS clouds.
- Most cloud layers observed with bases above 8 km are optically thin, have geometrical thickness between 0.5 – 1 km, and effective particle sizes between 10-40 μm.
- Highest cloud tops are observed at ~17.5 km during ATTREX 2014.
- In the coldest clouds the small particles are mainly irregular spheres but nevertheless depolarize 532 nm light 40-50%.
- Version 4 Level 1 CALIOP data products are currently available for June 2006 through 2012.
  - Accurate calibration of attenuated backscatter measurements at 532 and 1064 nm; better agreement between day and night.
  - Improved cloud extinction retrievals using transmission method.
  - More thin cloud layers detected, especially at night.
  - More accurate cloud ice water content parameterization.

Many thanks to our sponsors at NASA and CNES