Marine and Continental Upper Tropospheric Convective Cloud Characteristics as Observed during SEAC4RS

Melody Avery, Paul Lawson, John Yorks, Sarah Woods, Matthew McGill, Robert Holz, Anne Garnier, Charles Trepte, Mark Vaughan, Stuart A. Young, Qixu Mo, David Winker

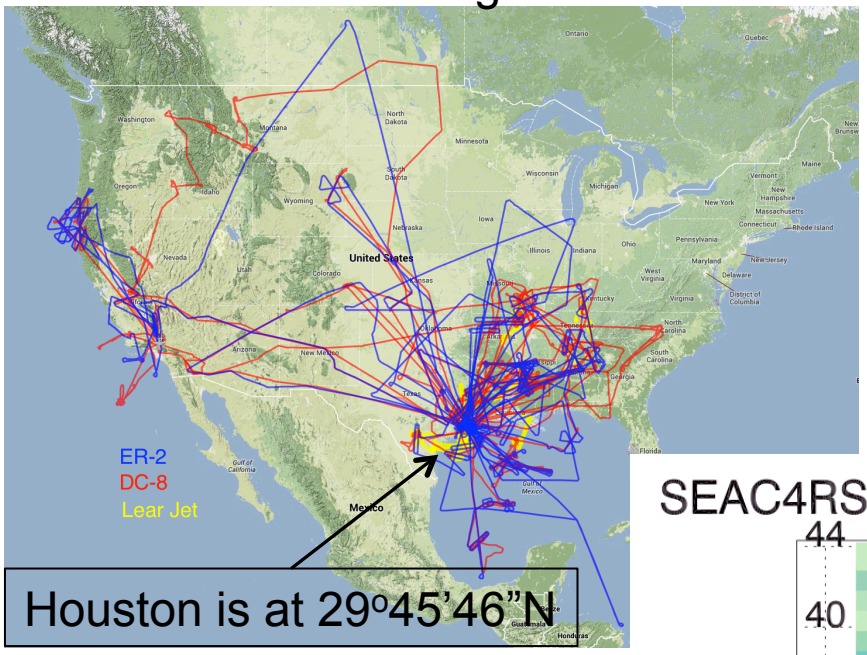
SEAC4RS Science Team Meeting, April 2015, Pasadena, CA

Research Objectives

* Provide an overview of high altitude Ci cloud distribution during SEAC4RS using CALIOP observations.
* Aircraft observations provide a way to “see” inside Ci cloud layers. Combine CPL with Learjet cloud probe observations for a fresh perspective.
* Relate temperature, lidar backscatter, depolarization and color ratio to crystal habits and size distributions.
* Linking the cloud microphysical properties to the remotely sensed optical cloud properties improves the lidar retrievals and potentially allows up-scaling of the microphysical measurements.

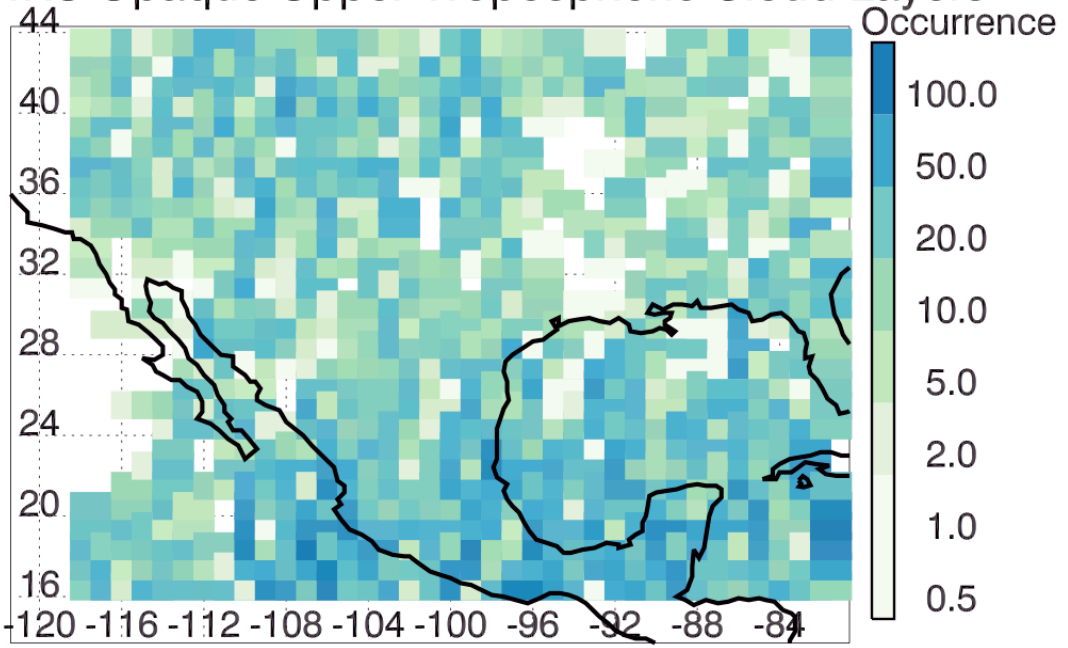
Upper Tropospheric Opaque Cloud Layers and Aircraft Sampling During SEAC4RS

SEAC4RS Aircraft Flight Tracks



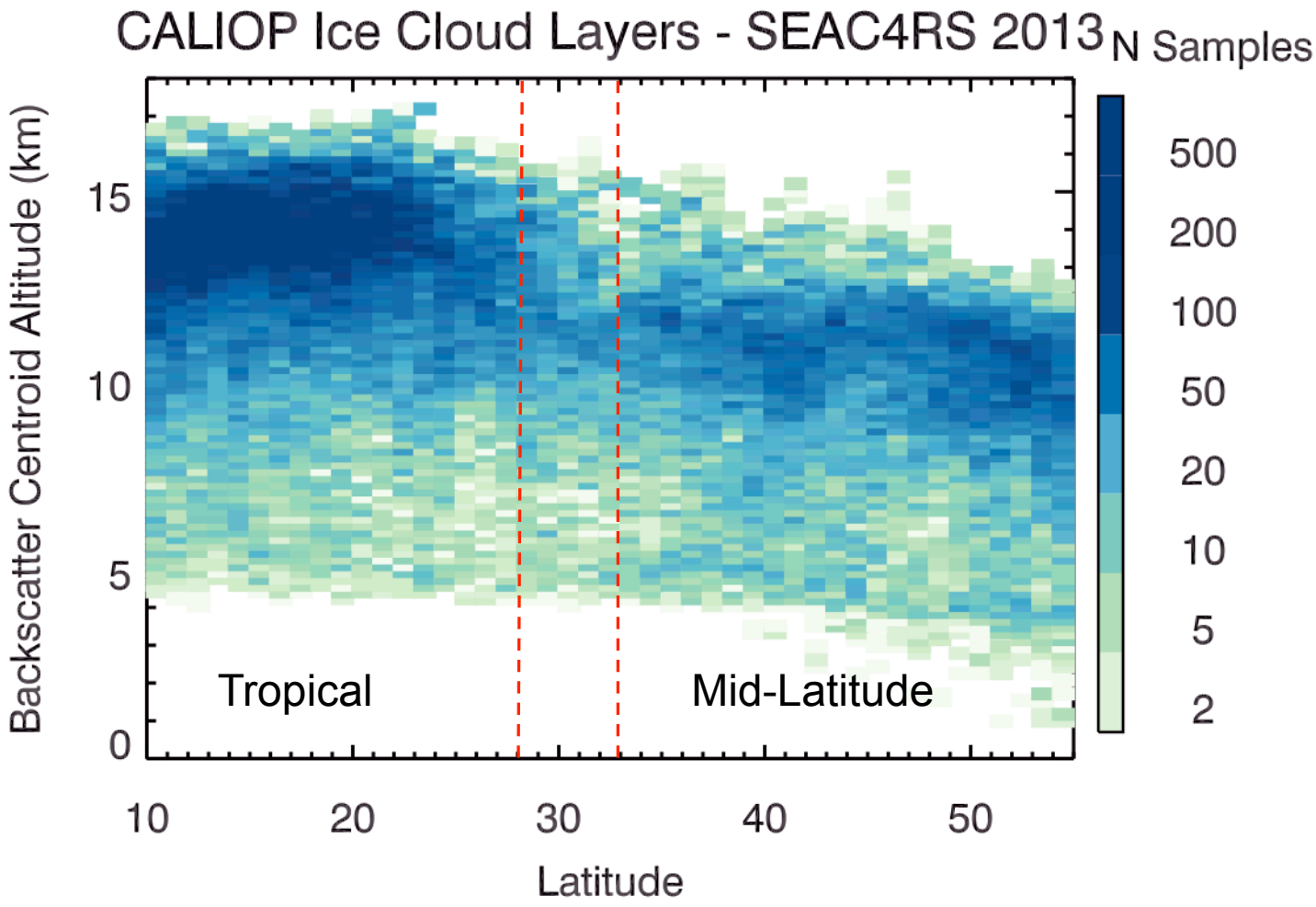
Much of the aircraft sampling during SEAC4RS was Subtropical, in the Gulf of Mexico and SE US.

SEAC4RS Opaque Upper Tropospheric Cloud Layers



A map of CALIOP opaque cloud layers (convection) during the SEAC4RS field campaign shows relatively few convective systems in this region.

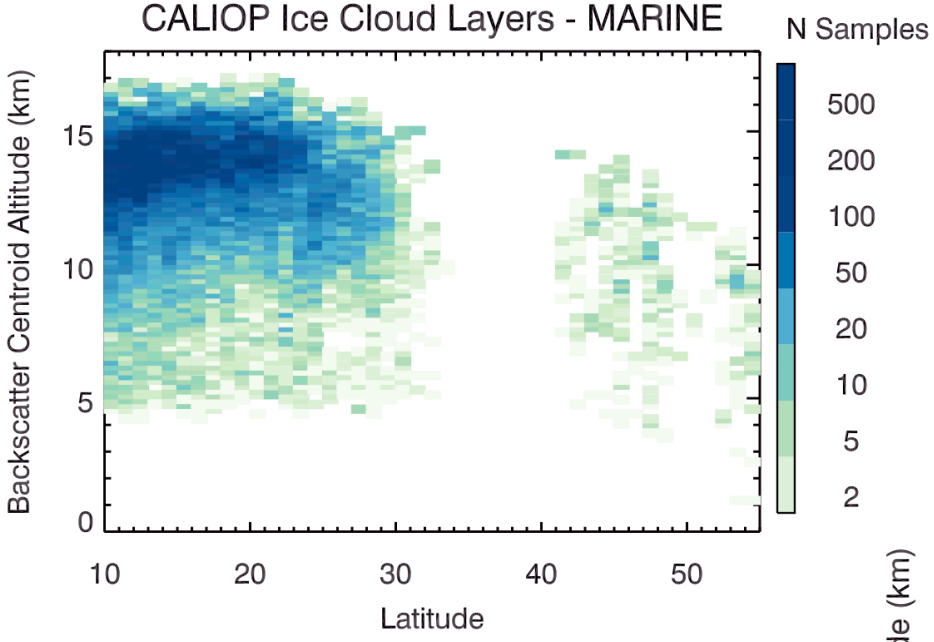
Overview: Vertical Distribution of Clouds by Latitude



South of ~28N is more Tropical, North of ~33N is Mid-Latitude
28N-33N Subtropical transition region (tropopause break)

Vertical Distribution of Upper Tropospheric Layers – Marine vs Continental

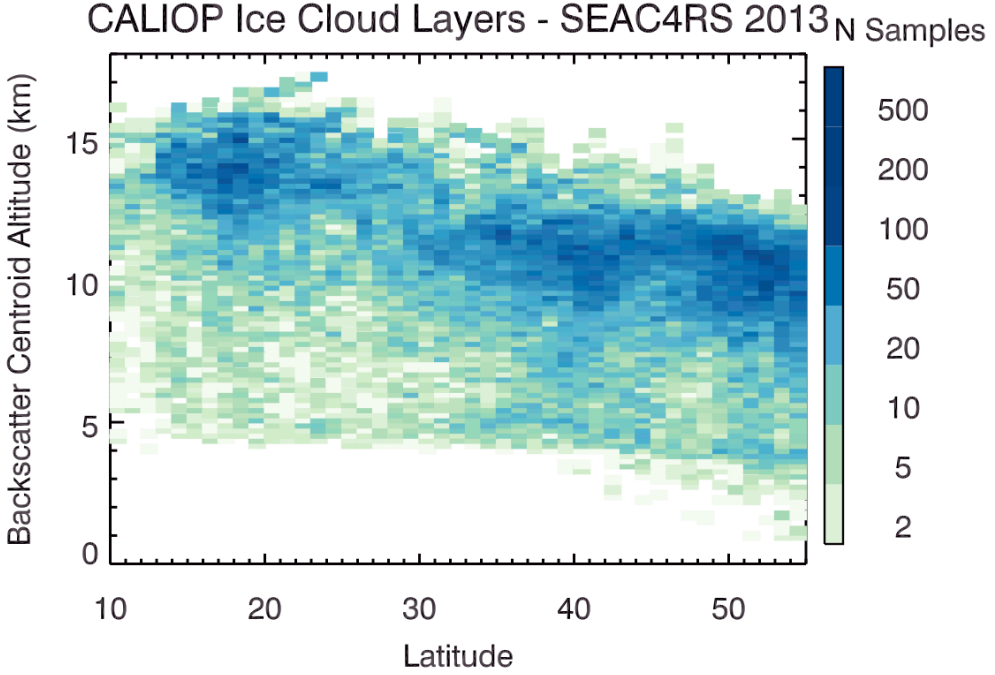
MARINE



During SEAC4RS the marine clouds observed were mainly Tropical…

…and clouds over land were mainly Mid-Latitude.

CONTINENTAL

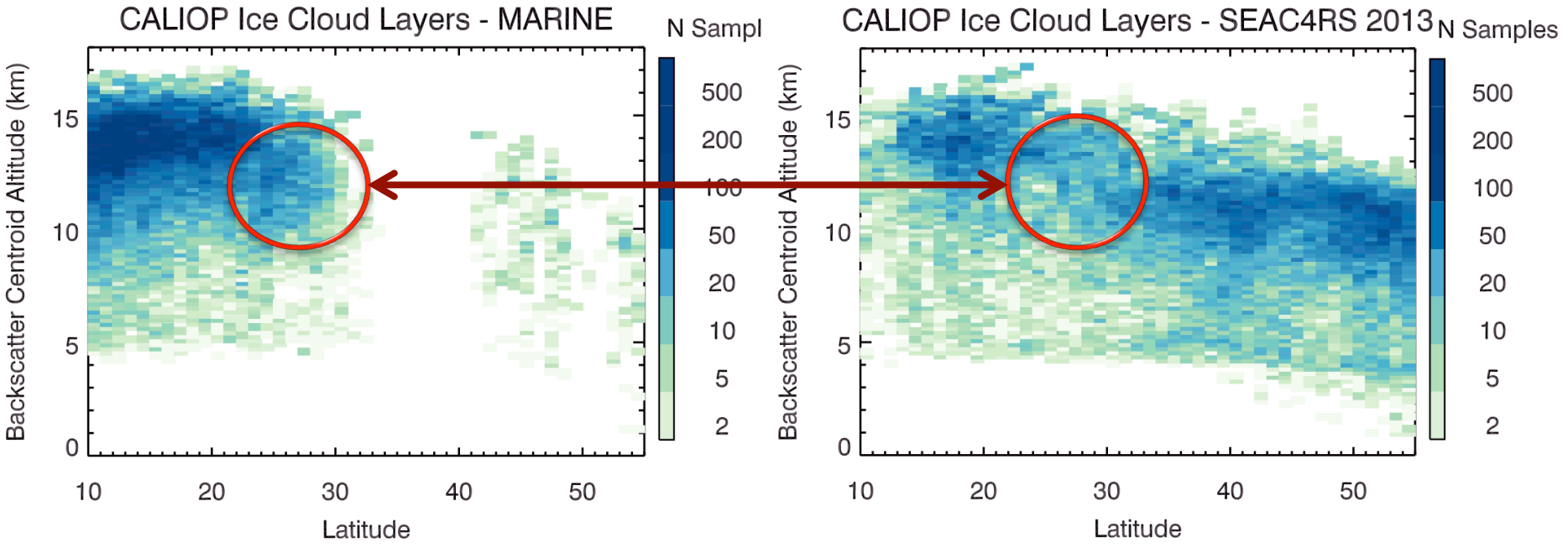


Examine Case Studies using SEAC4RS Aircraft Data

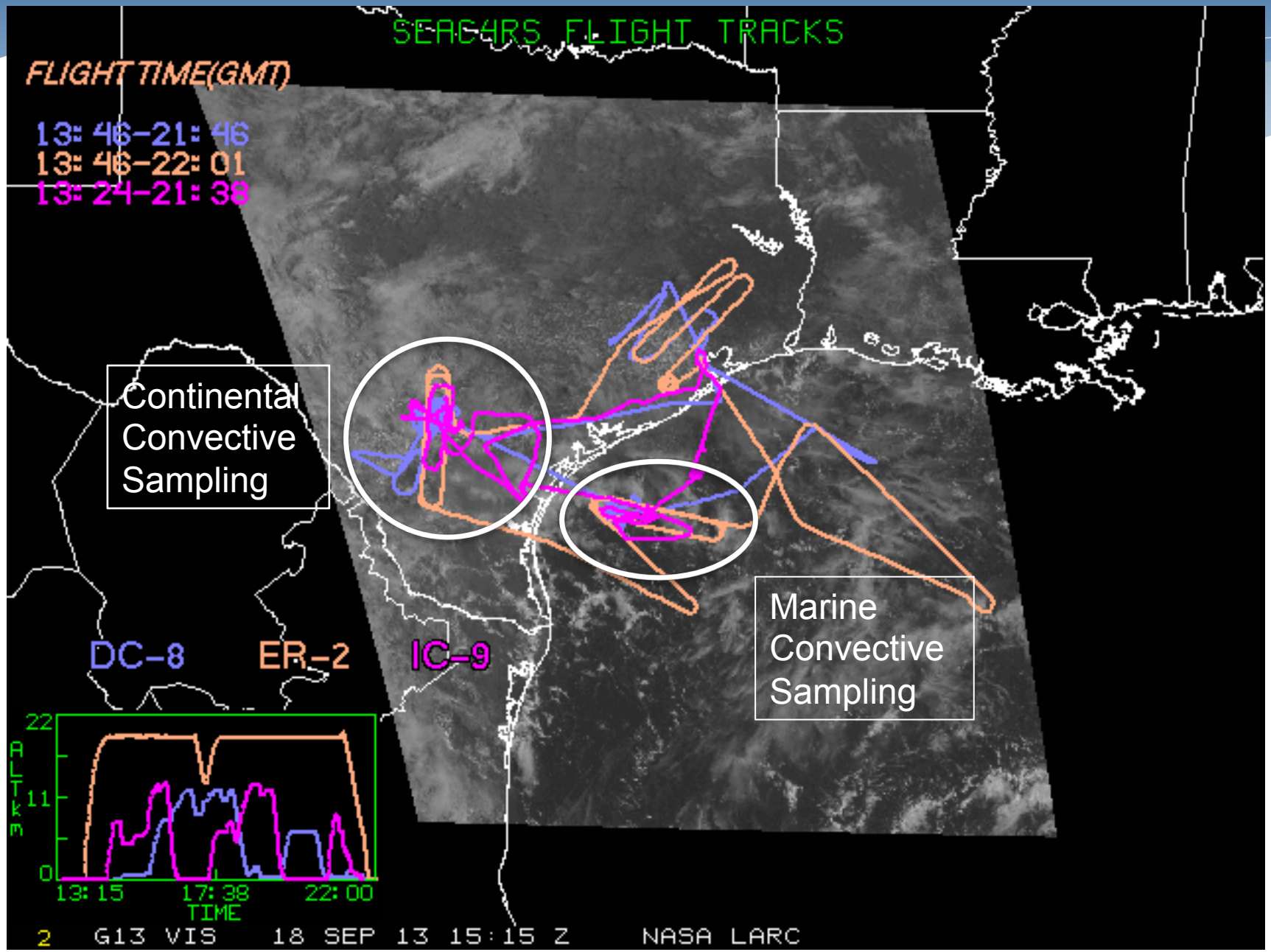
Look at September 18, 2013 - SEAC4RS ER-2 and Learjet coordinated flights.

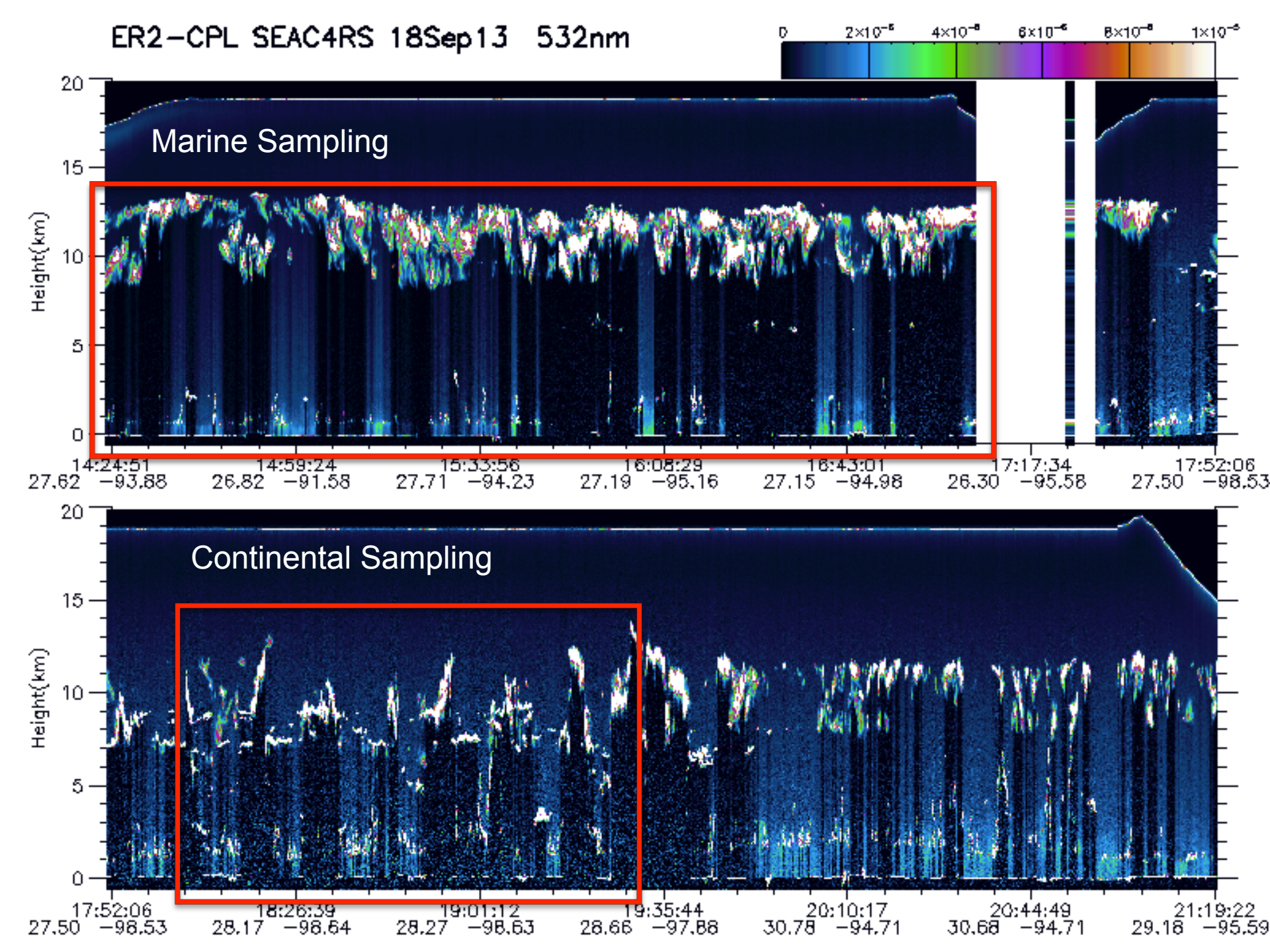
MARINE

CONTINENTAL

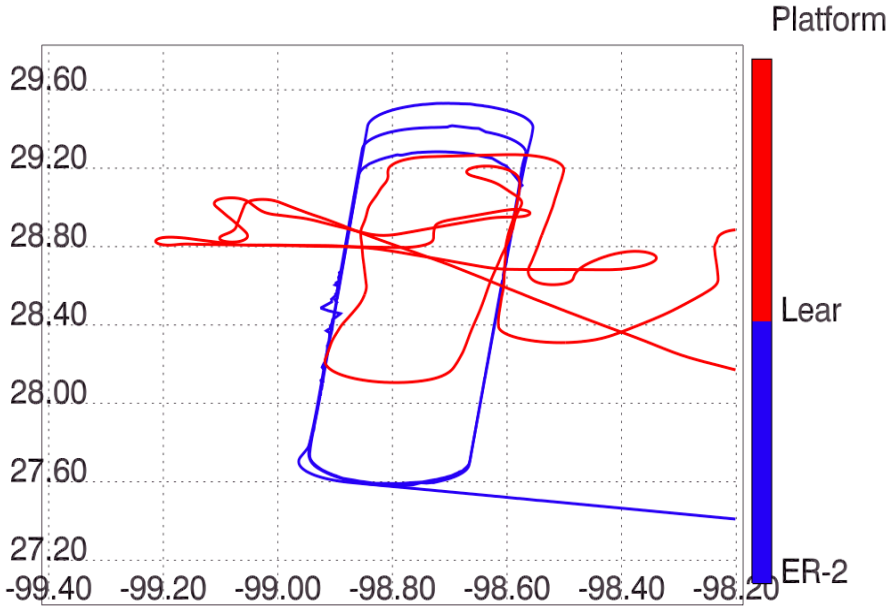


Objective:
Compare sampled marine and continental convective clouds.

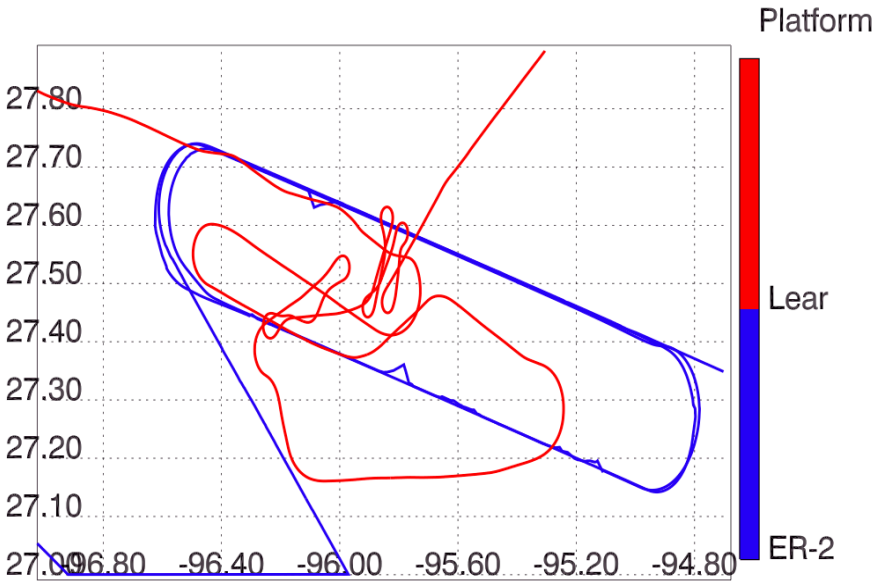

SEAC4RS FLIGHT TRACKS
FLIGHT TIME(GMT)
13:46-21:46
13:46-22:01
13:24-21:38
Continental Convective Sampling
Marine Convective Sampling
DC-8
ER-2
IC-9
22
11
0
ALT km
13:15
17:38
22:00
TIME
2 G13 VIS 18 SEP 13 15:15 Z NASA LARC


ER2-CPL SEAC4RS 18Sep13 532nm
0
2×10⁻⁶
4×10⁻⁶
6×10⁻⁶
8×10⁻⁶
1×10⁻⁵
Marine Sampling
Height(km)
20
15
10
5
0
14:24:51
27.62 −93.88
14:59:24
26.82 −91.58
15:33:56
27.71 −94.23
16:08:29
27.19 −95.16
16:43:01
27.15 −94.98
17:17:34
26.30 −95.58
17:52:06
27.50 −98.53
Continental Sampling
Height(km)
20
15
10
5
0
17:52:06
27.50 −98.53
18:26:39
28.17 −98.64
19:01:12
28.27 −98.63
19:35:44
28.66 −97.88
20:10:17
30.78 −94.71
20:44:49
30.68 −94.71
21:19:22
29.18 −95.59

Close-Up of Convective Cirrus Sampling on Sept. 18

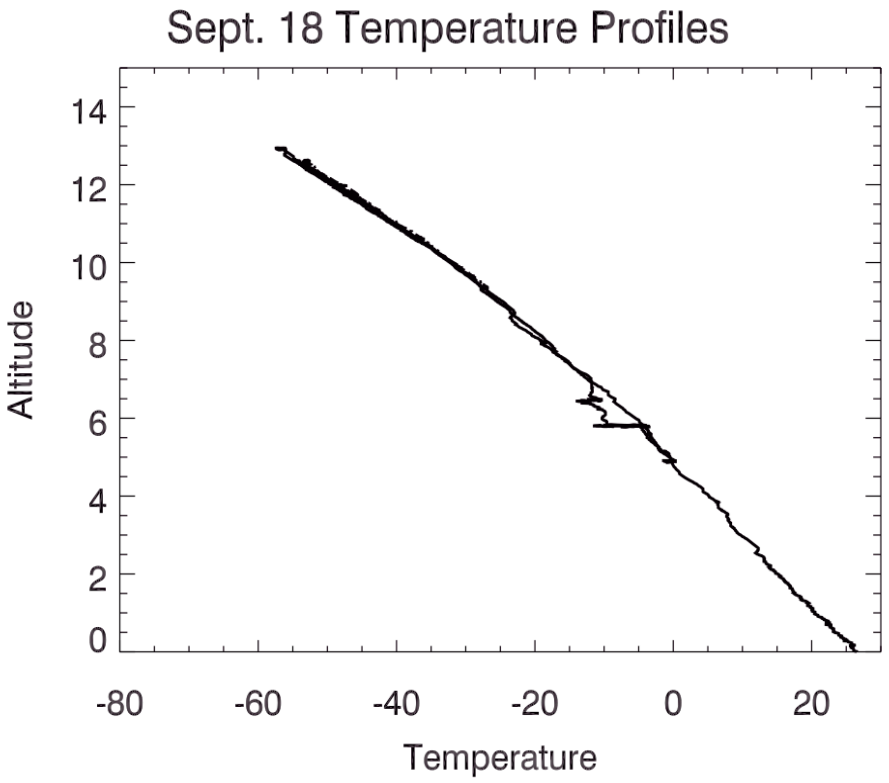


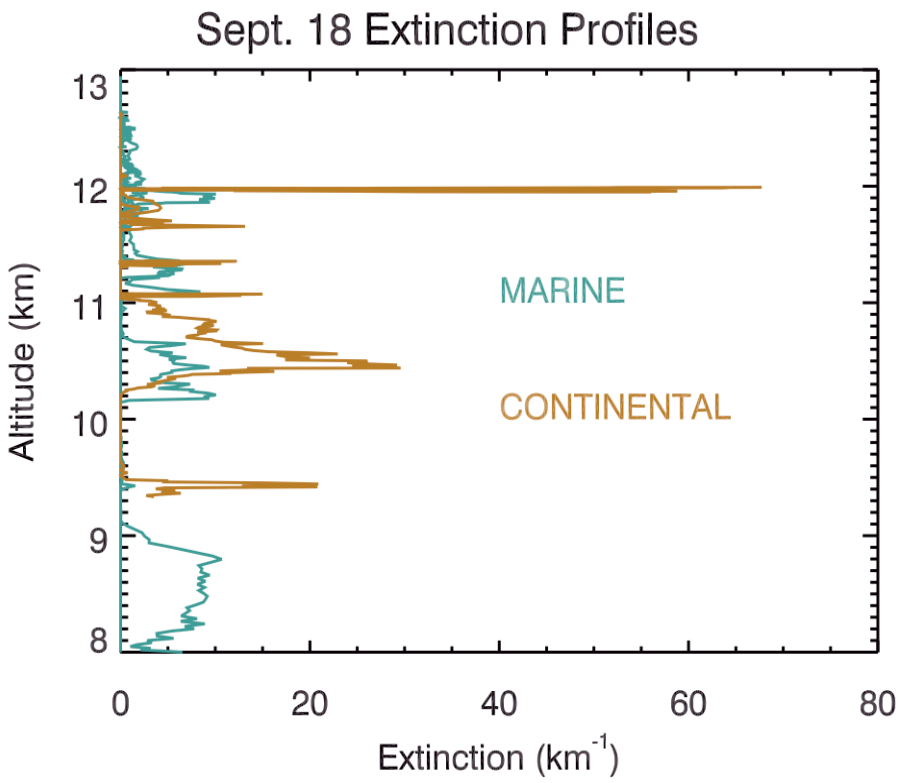
Over Texas



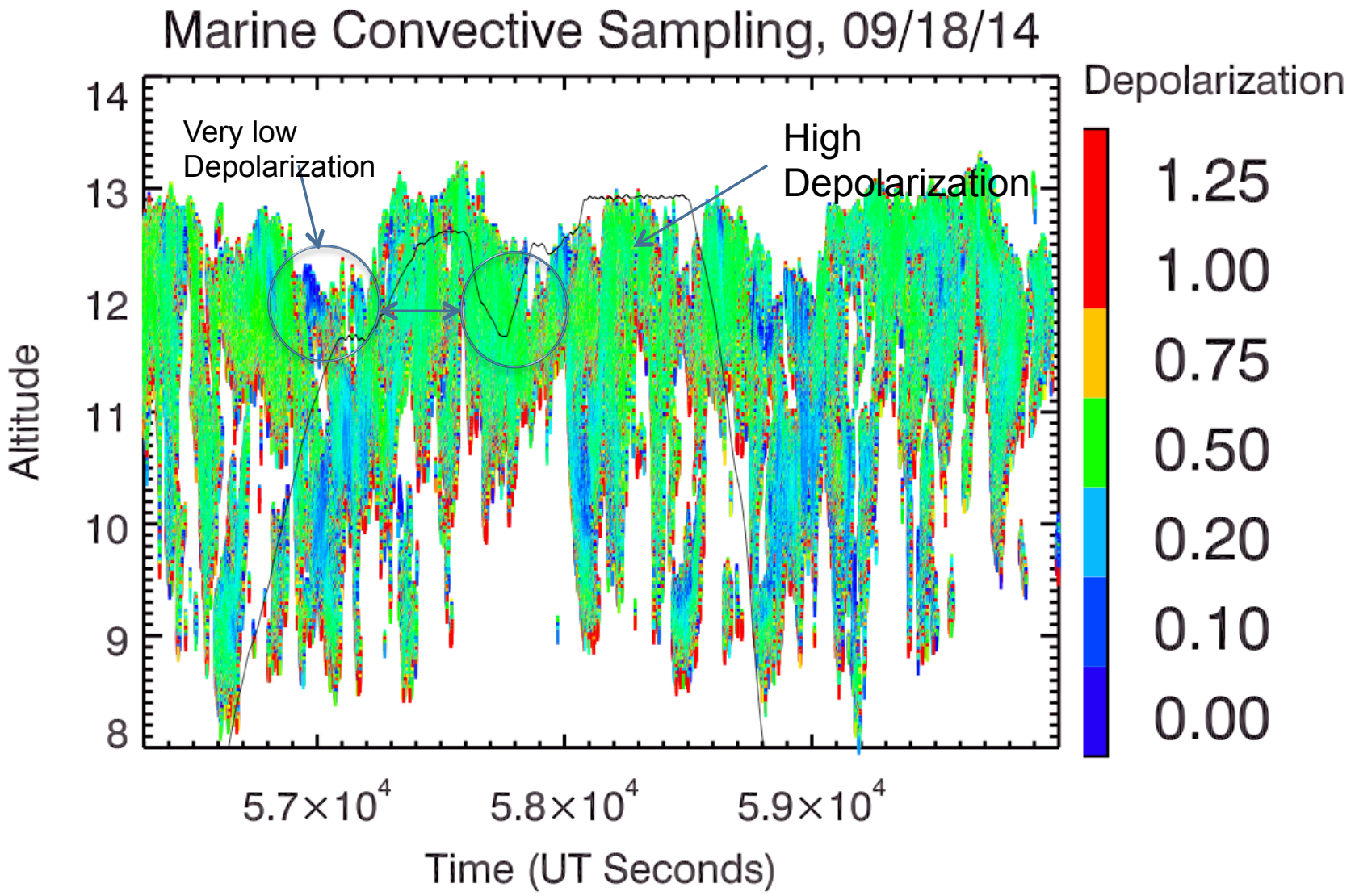
Over the Gulf of Mexico

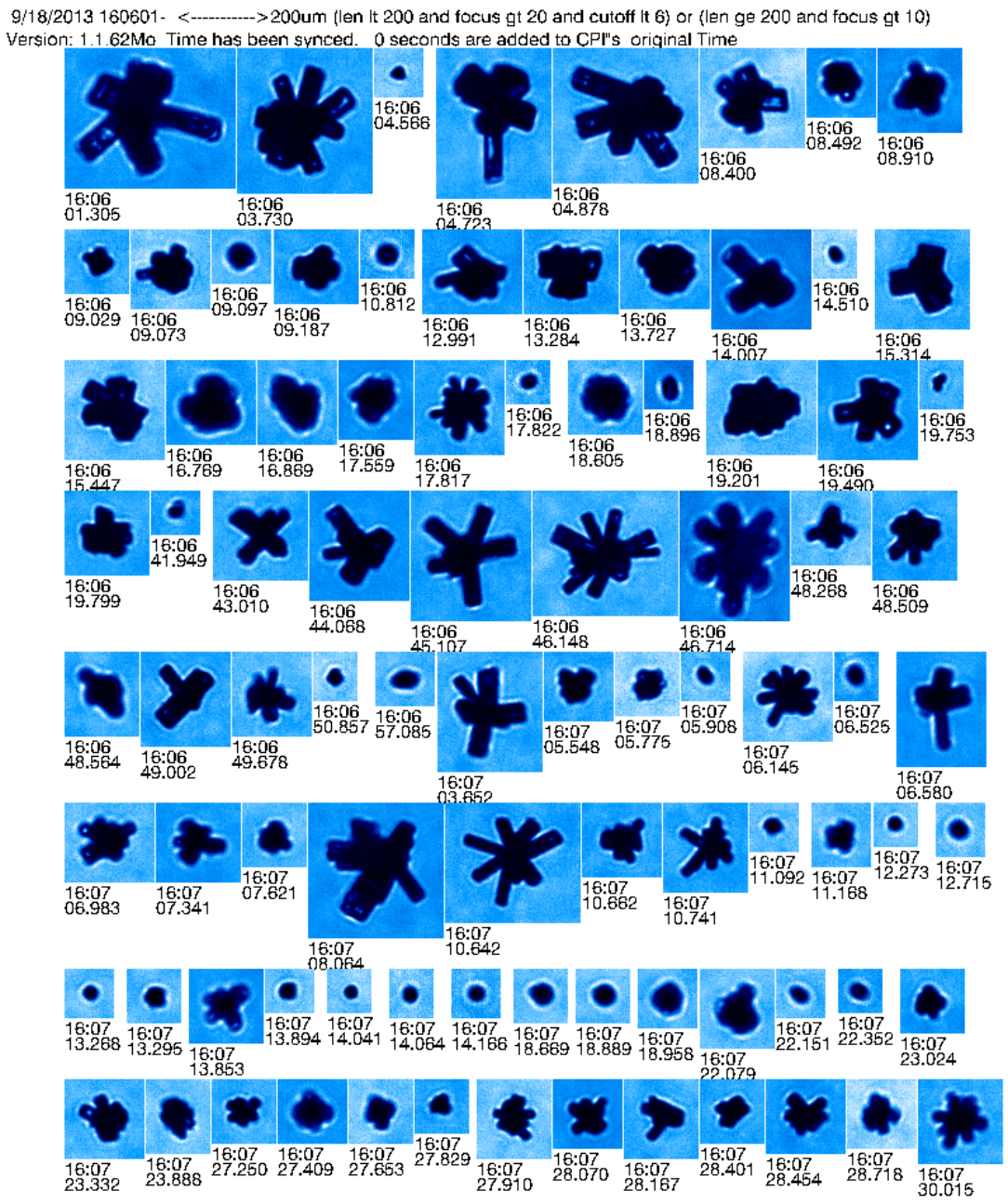
September 18 Learjet Profiles





CPL 1064 Depolarization





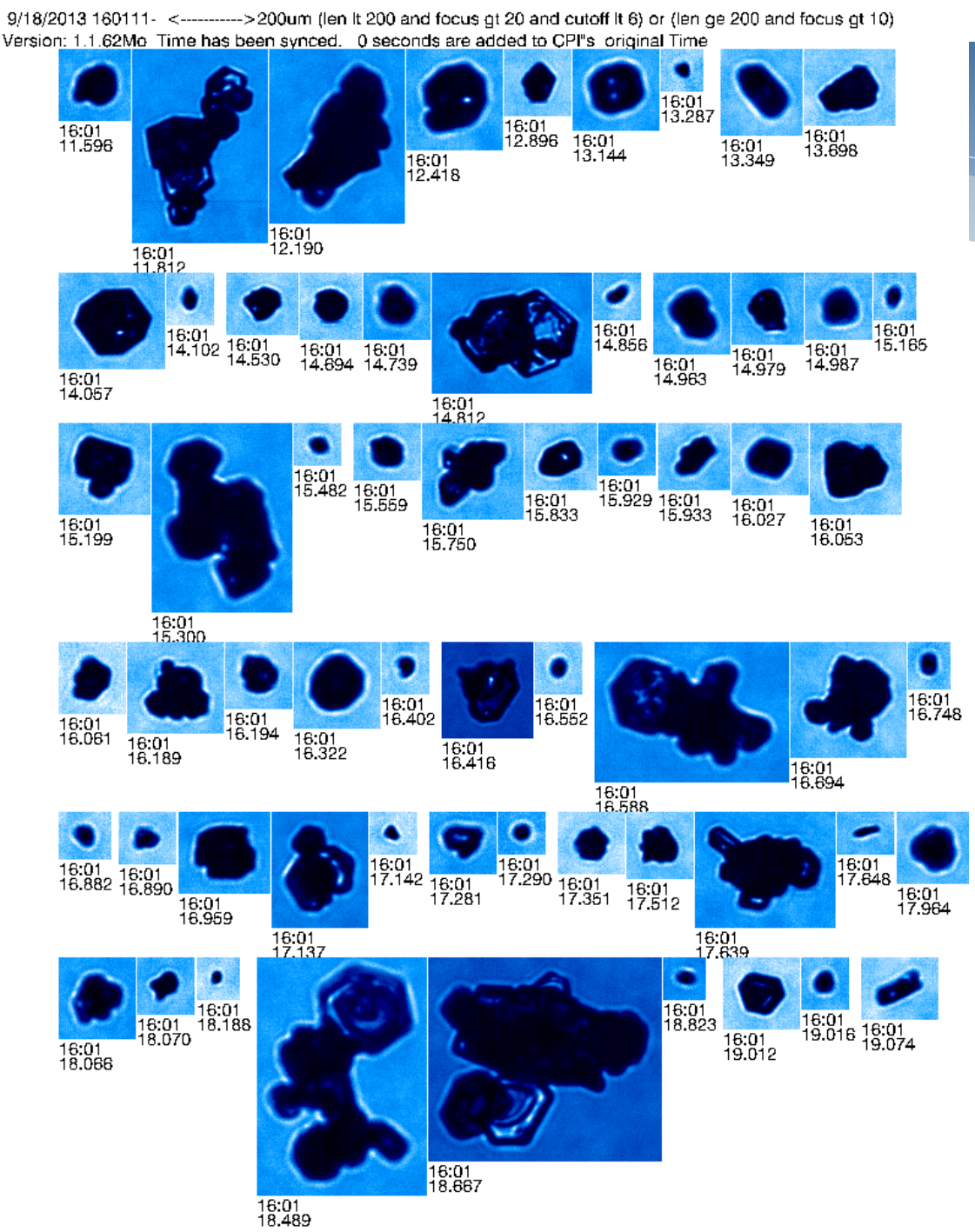
Example Images from Highest Altitudes at 16:06 – 16:07

Altitude > 12.45 km

-54 °C

Altitude with High CPL Depolarization (~0.5)

Rosettes, Irregulars

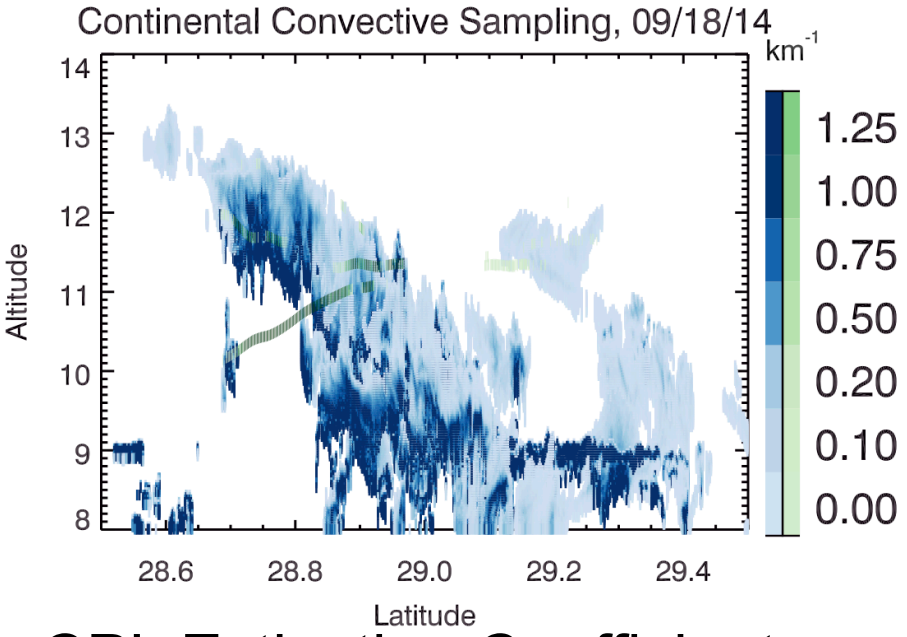


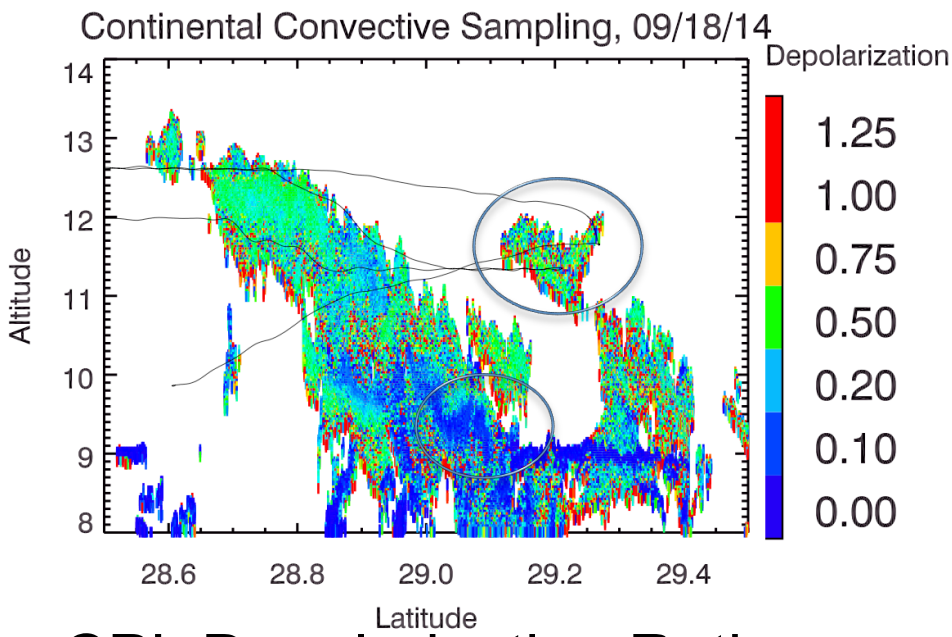
Example Images from Highest Learjet Extinctions at 16:01:20-40
12 km
-48 °C

During Learjet High Altitude “Dip”

Plates, Plate Assemblages, Irregulars

Continental CPL Extinction Coefficients and Depolarization Ratios





CPL Extinction Coefficients (blue)
Learjet 2D-S Extinctions (green)

High CPL Extinctions at 8.5 – 9.5 km

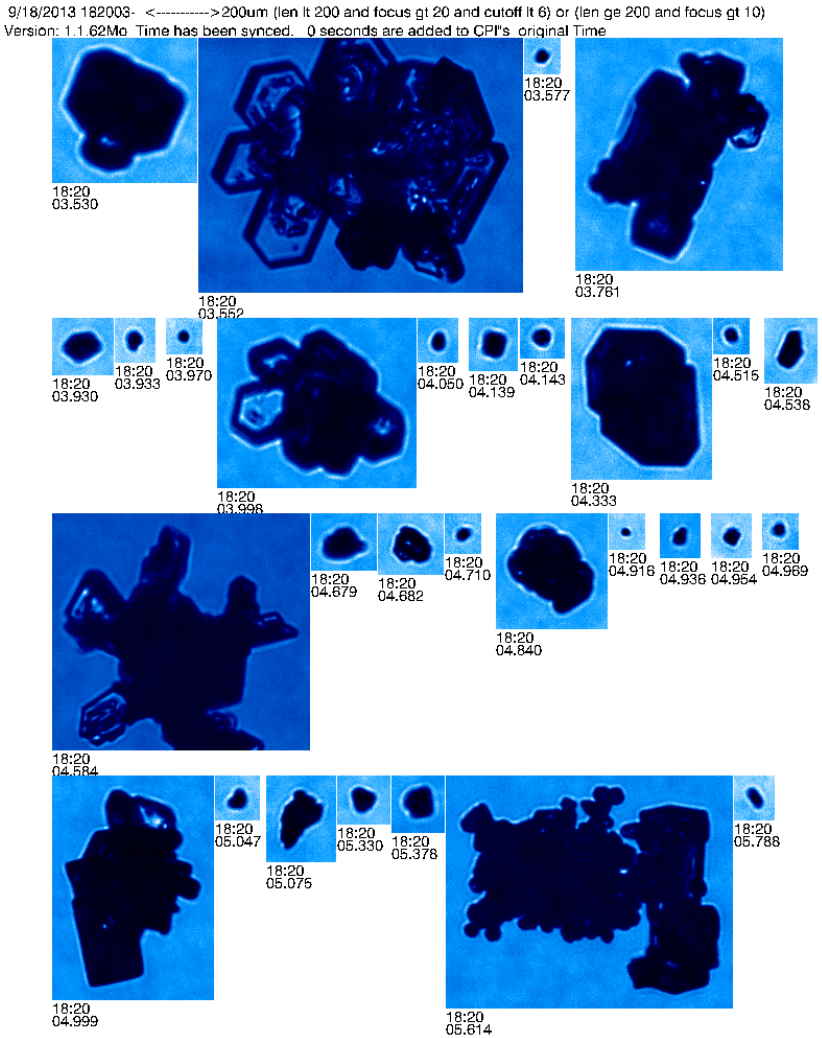
CPL Depolarization Ratios

Learjet track (black)

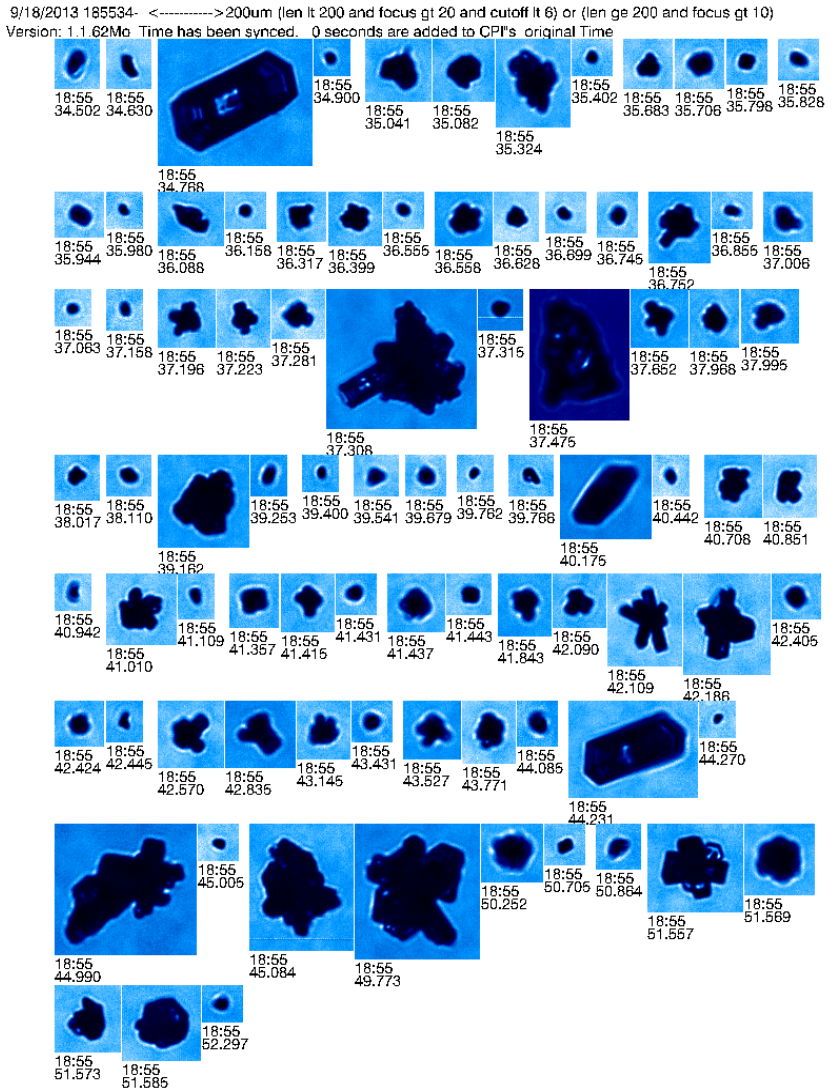
Very low depolarization ratios at 8.5 – 9.5 km

Learjet CPI Images from 9 and 11 km

CPI Images from 9.3 km, -26.7 ºC



CPI Images from 11.4 km, -43.2 ºC



Sept. 18 CASE Study Summary

- CPL Extinction and Depolarization are mainly anti-correlated in both marine and continental convection.
- The CPL 1064 nm depolarization shows areas of very low depolarization at 12 km – these are not water or horizontally-oriented plates.
- Learjet and ER-2 were not sampling along the same racetrack in a very heterogeneous system, so the evidence is circumstantial, but…
- In these Subtropical conditions it appears that cloud areas with very low depolarization (and high extinction) correspond to plates and plate assemblages, whereas high depolarization corresponds to rosettes.

Summary

* Much SEAC4RS aircraft cloud sampling was Subtropical.

* Subtropical marine and continental convective cirrus look similar.
  * Tropical and Mid-Latitude convective cirrus DO look very different;
    see the talk by Paul Lawson tomorrow.

* Cloud particle habit and linear depolarization appear to be correlated.

  At -40 - -55 ^{o}C:
  * High extinction and low (0.1-0.2) depolarization correlates with crystal shapes that are plate-like, or plate assemblages (but not oriented).
  * Moderate - high depolarization (0.4-0.5) correlates with rosettes.
  * For more information about the impact on combined lidar and IR retrievals, see the talk by Bob Holz tomorrow.

* Follow-on: More extensive habit/size distribution and optical property comparisons by combining aircraft field missions: SEAC4RS, SPARTICUS, TC^{4}, ATTREX, MACPEX and DC^{3}.