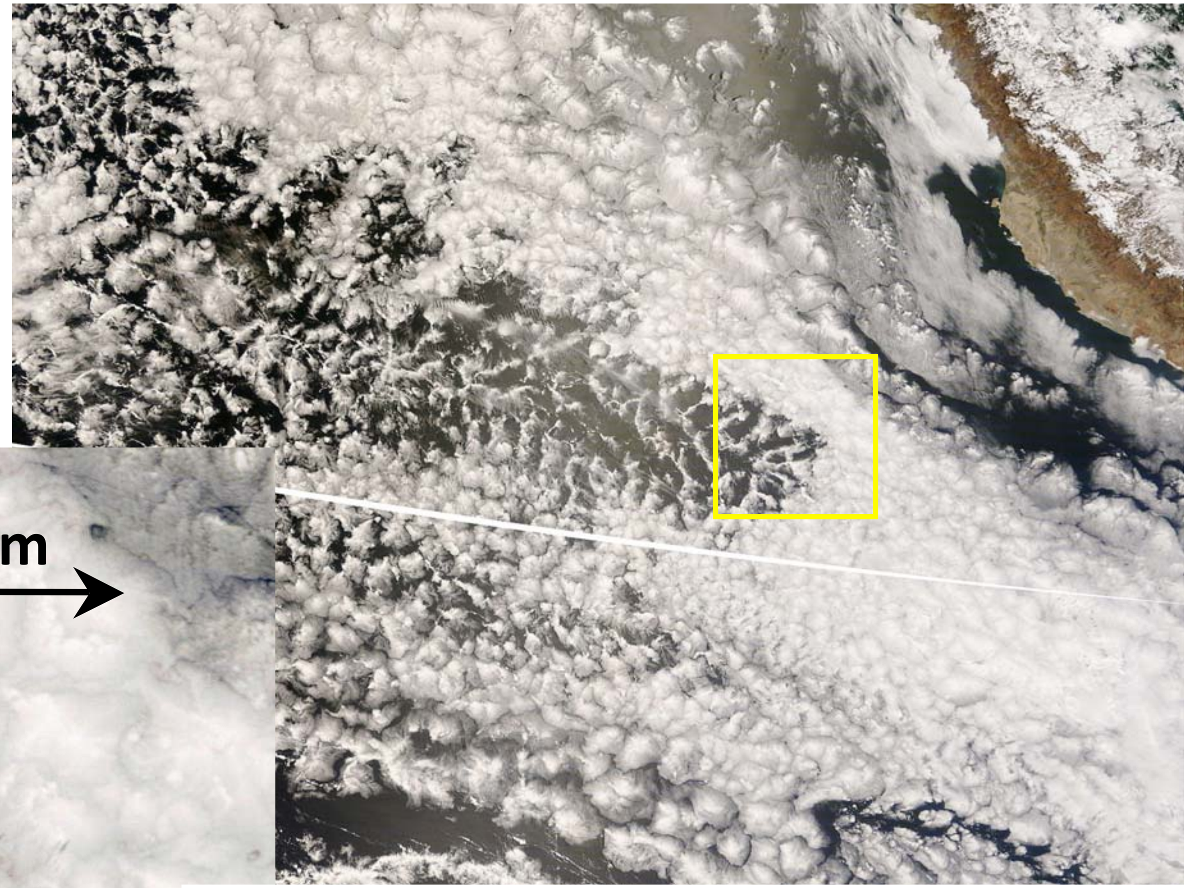
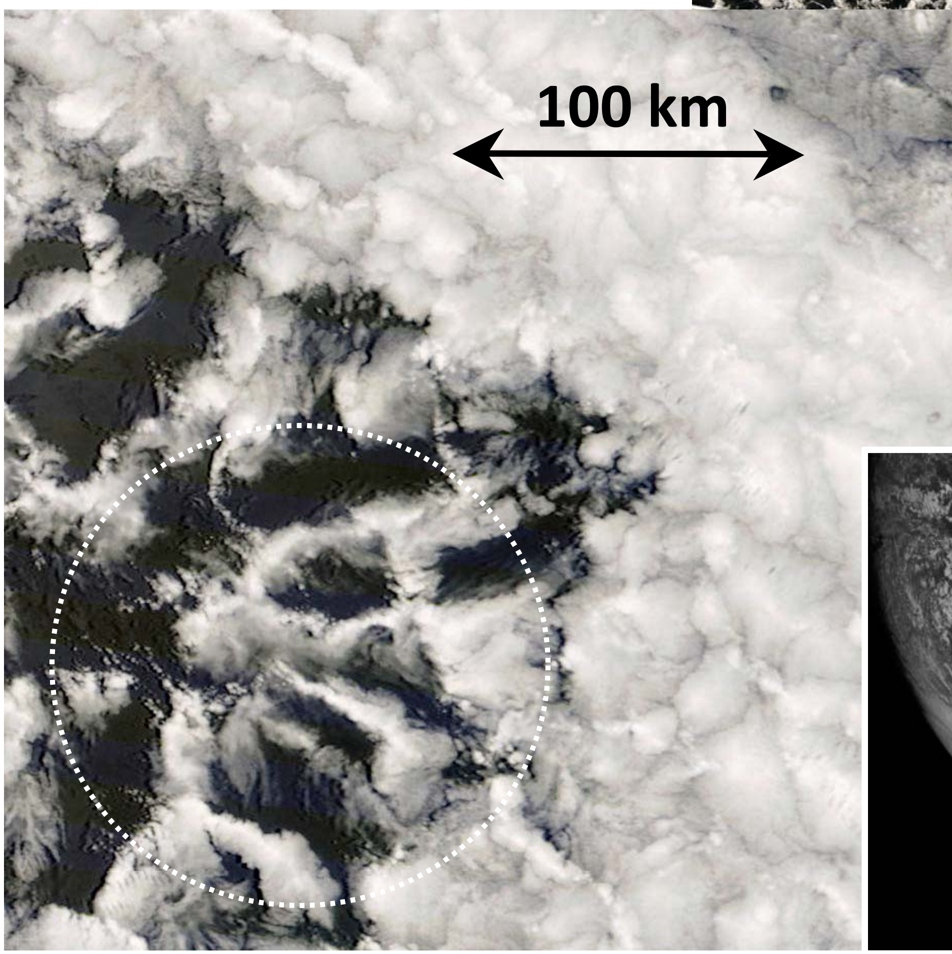
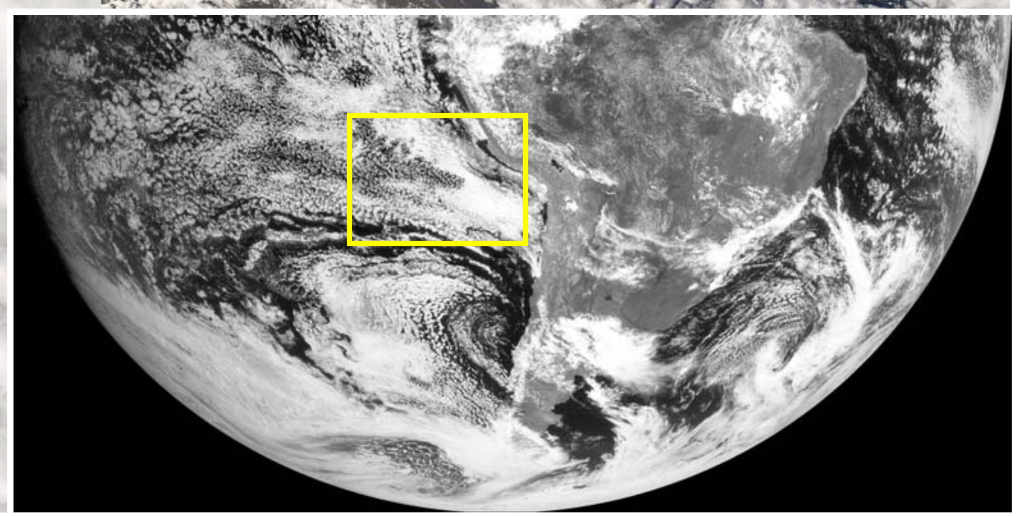
The 28th October (RF06) Case Study

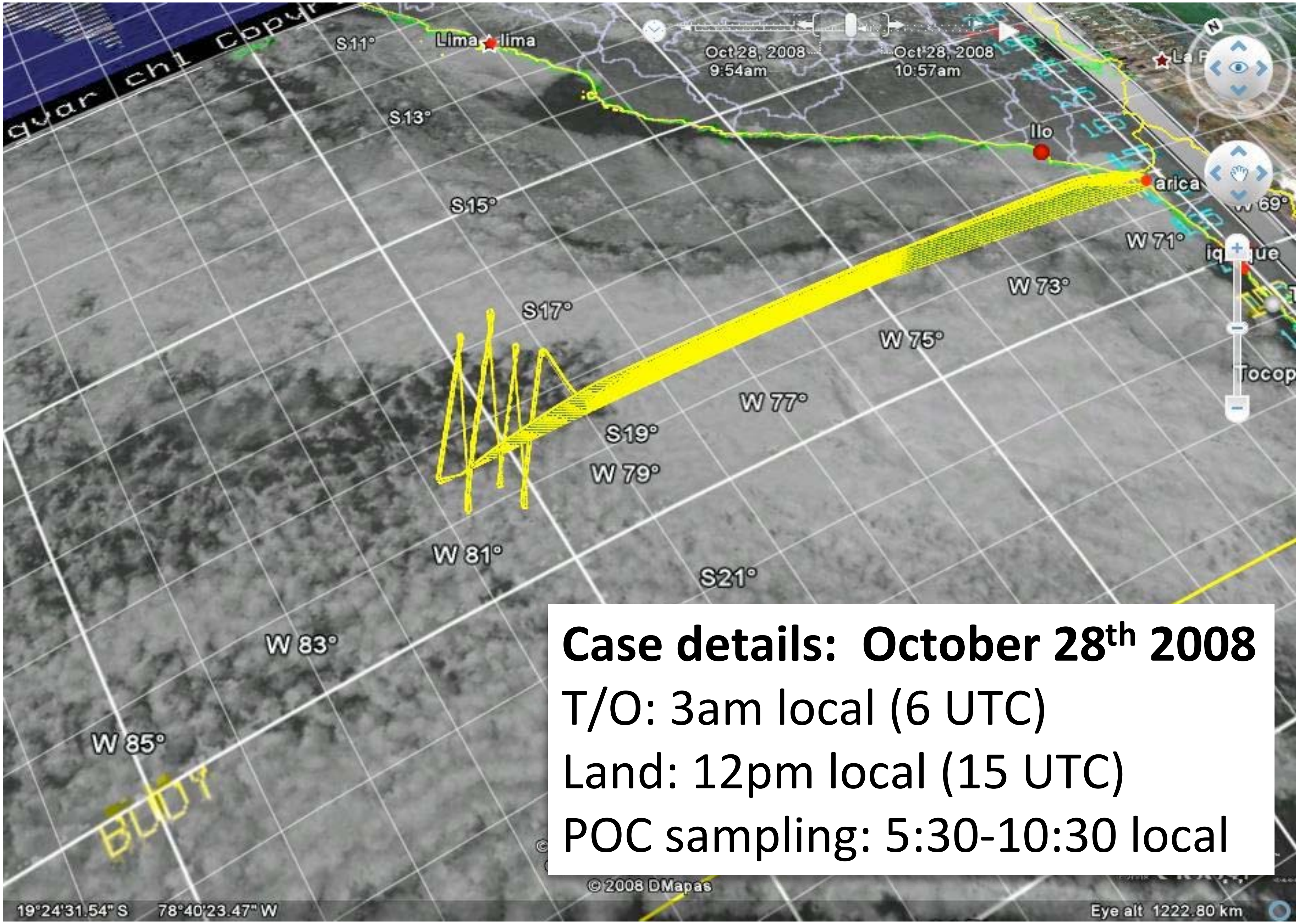
Robert Wood, University of Washington
Dave Leon, Chris Bretherton, Tony Clarke, Paquita Zuidema

October 27/28th 2008
POC Lagrangian -
BAe-146 & NSF C-130









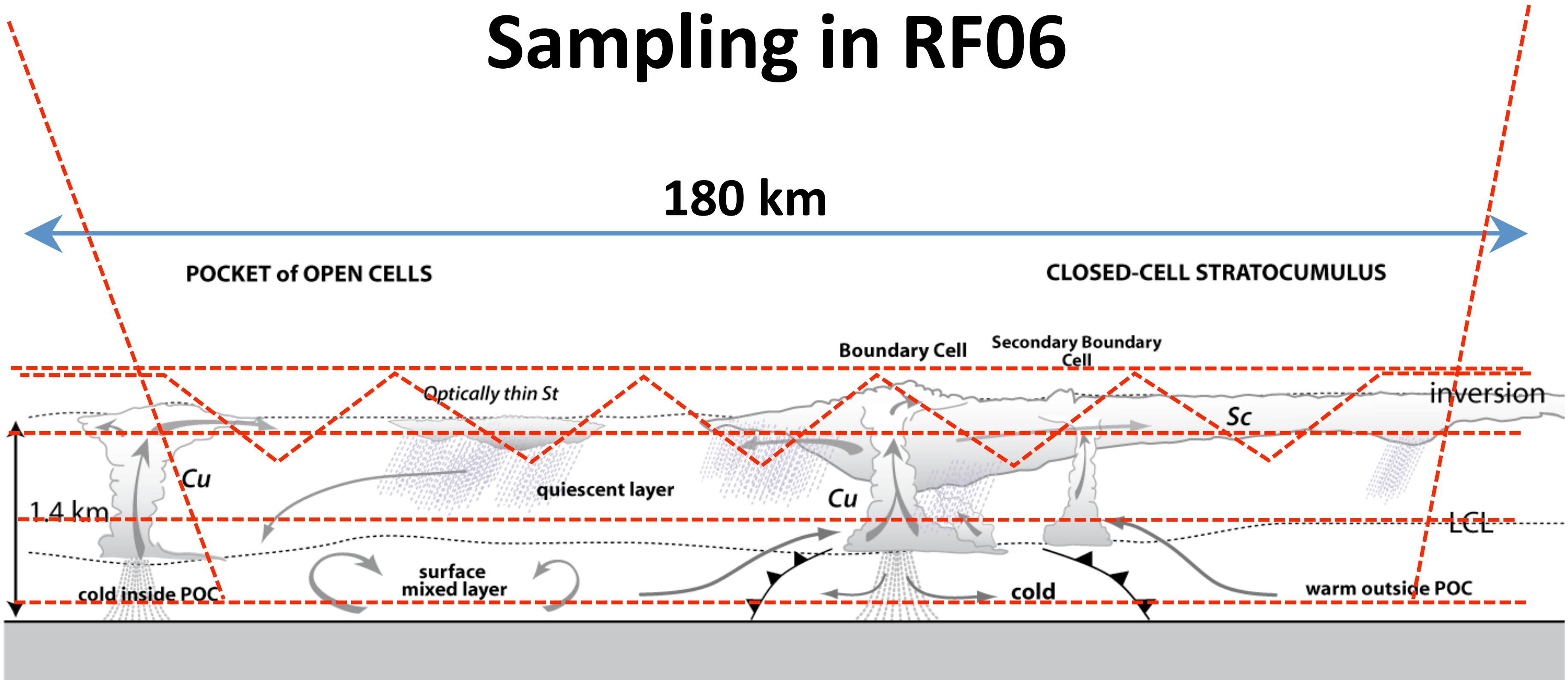
Case details: October 28th 2008

T/O: 3am local (6 UTC)

Land: 12pm local (15 UTC)

POC sampling: 5:30-10:30 local

Sampling in RF06



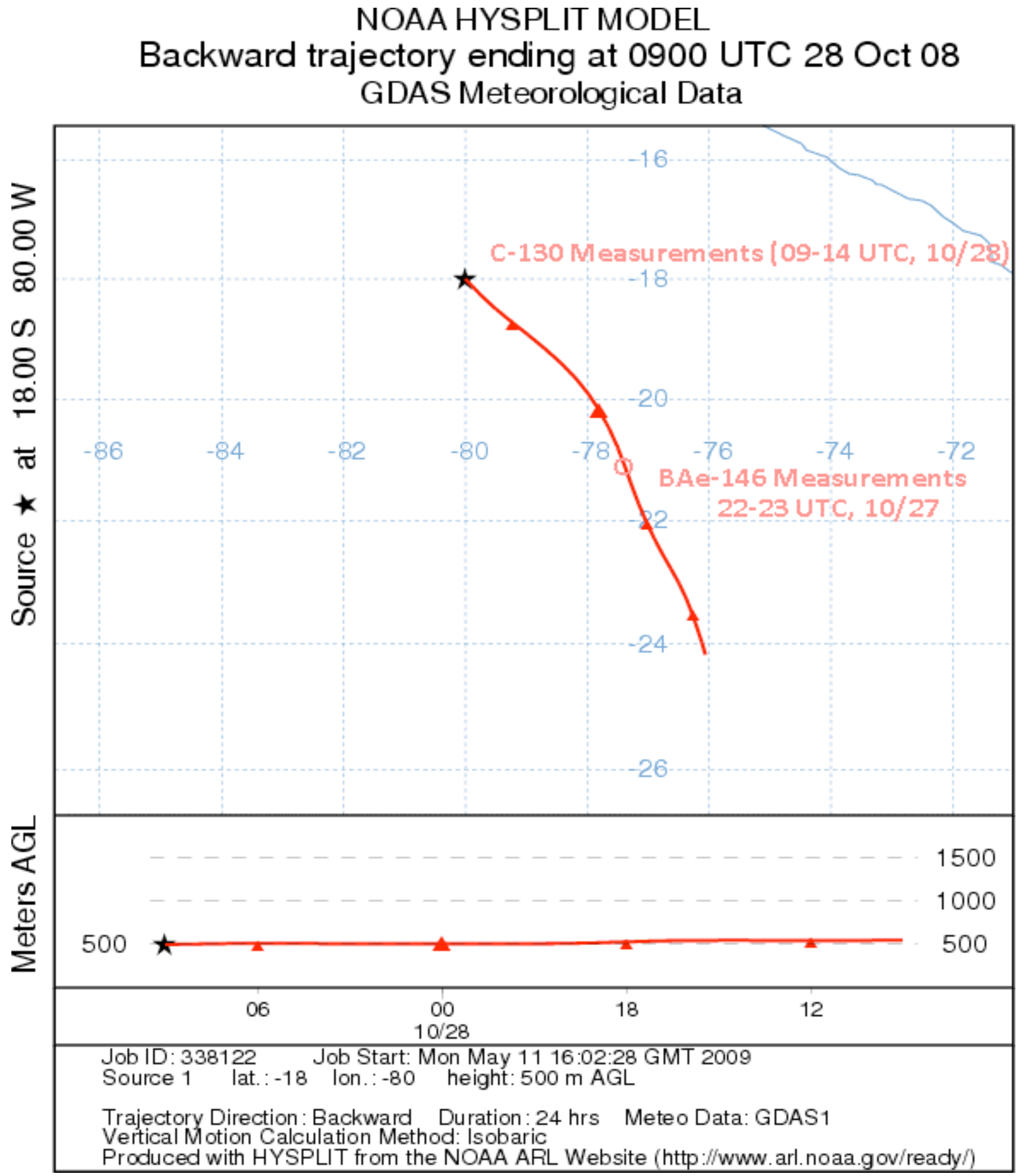
Straight and level runs [~180 km]

Above cloud leg (AC)	1580 m
Cloud layer legs (AC)	1080 & 1160 m
Cloud base/mid MBL leg (CB)	600 m
Sfc. layer/subcloud legs (SC)	145 & 145 m

Sawtooths and profiles

Sawtooth through inversion
Profile in overcast
Profile in POC
Additional profile segments

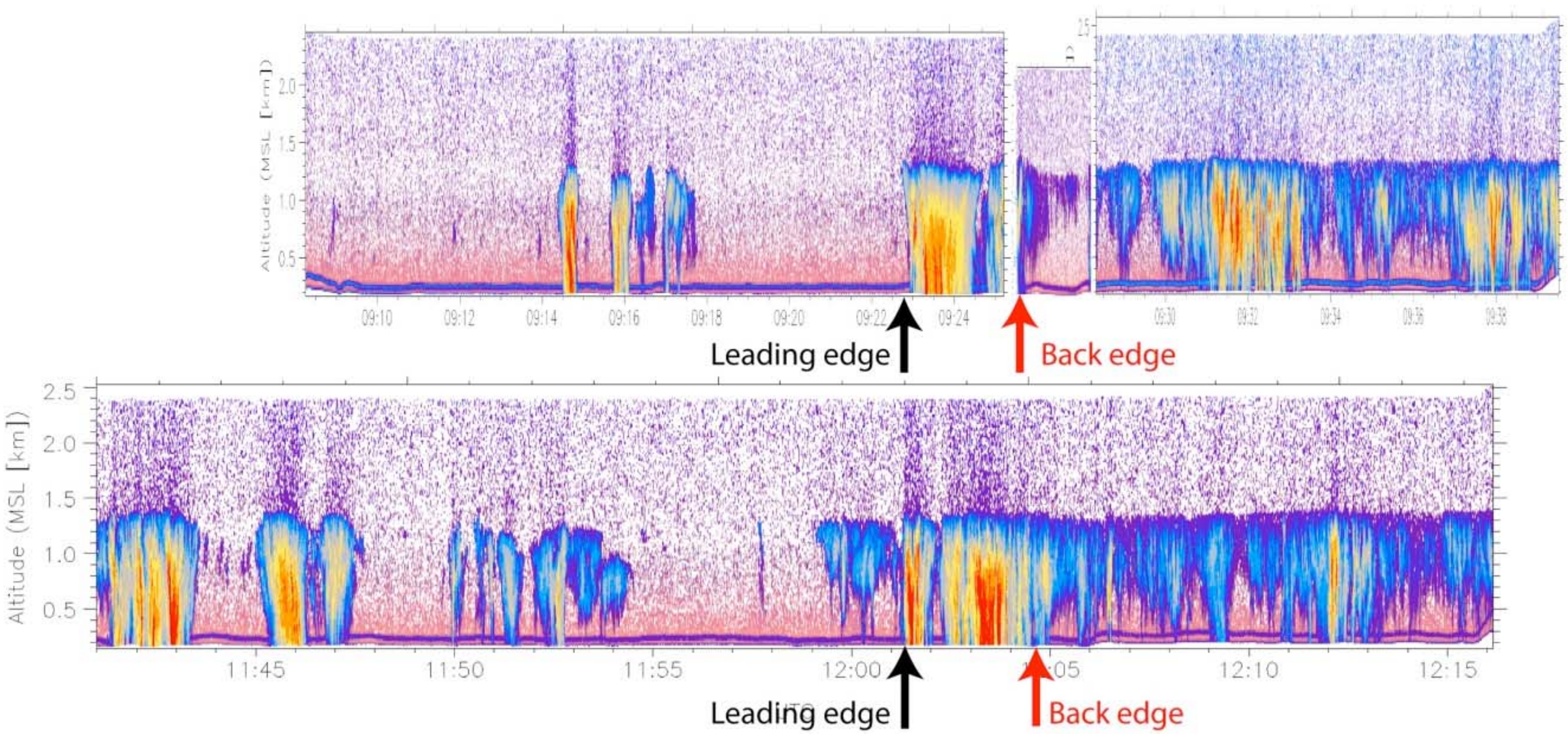
Cosampling of same POC 12 hours earlier by BAe-146



Boundary cell(s) – a persistent feature in RF06

WYOMING CLOUD RADAR from subcloud runs (SC1, top; SC2, bottom) during VOCALS RF06

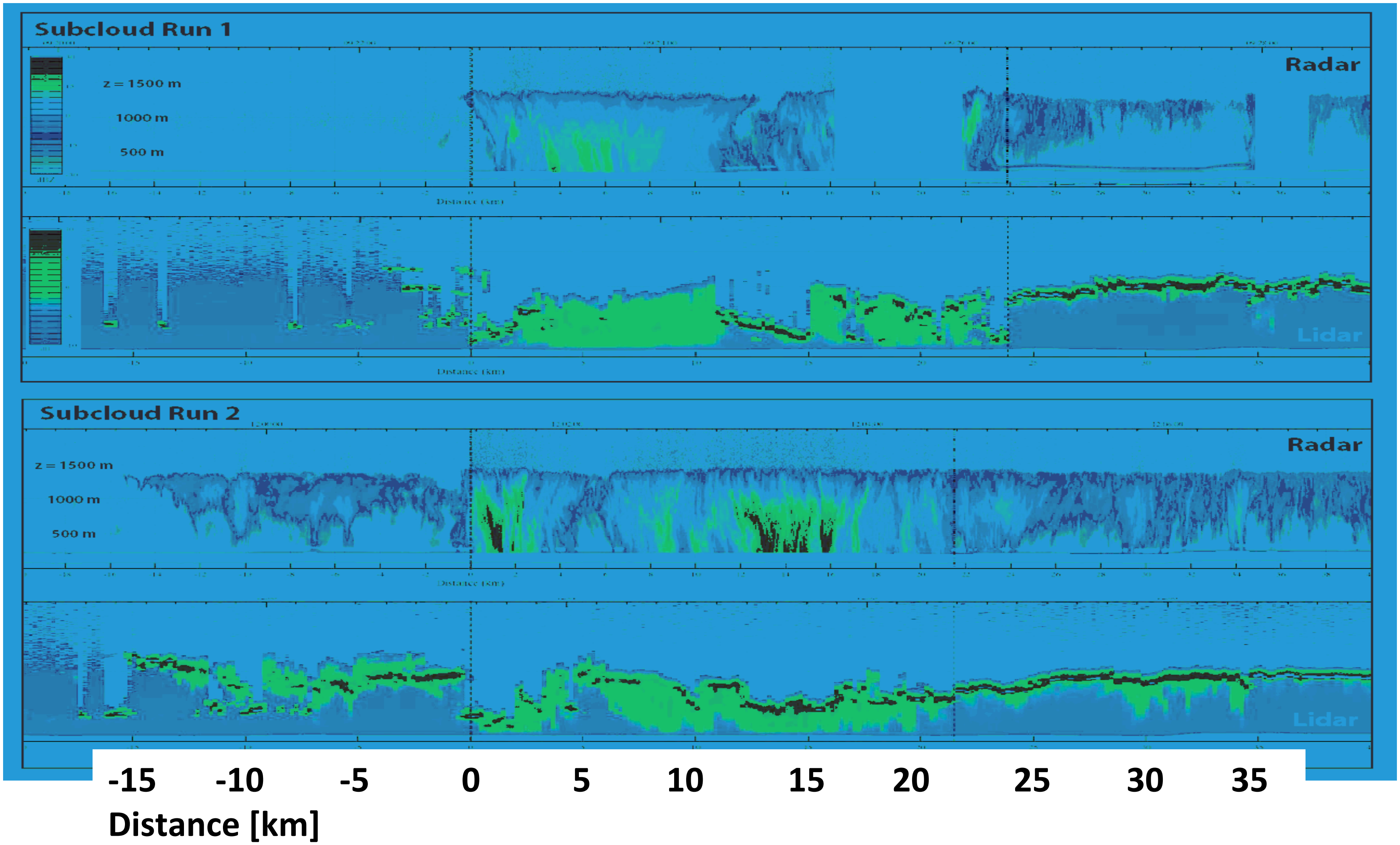
Note that the reflectivity values are not to scale and differ between panels



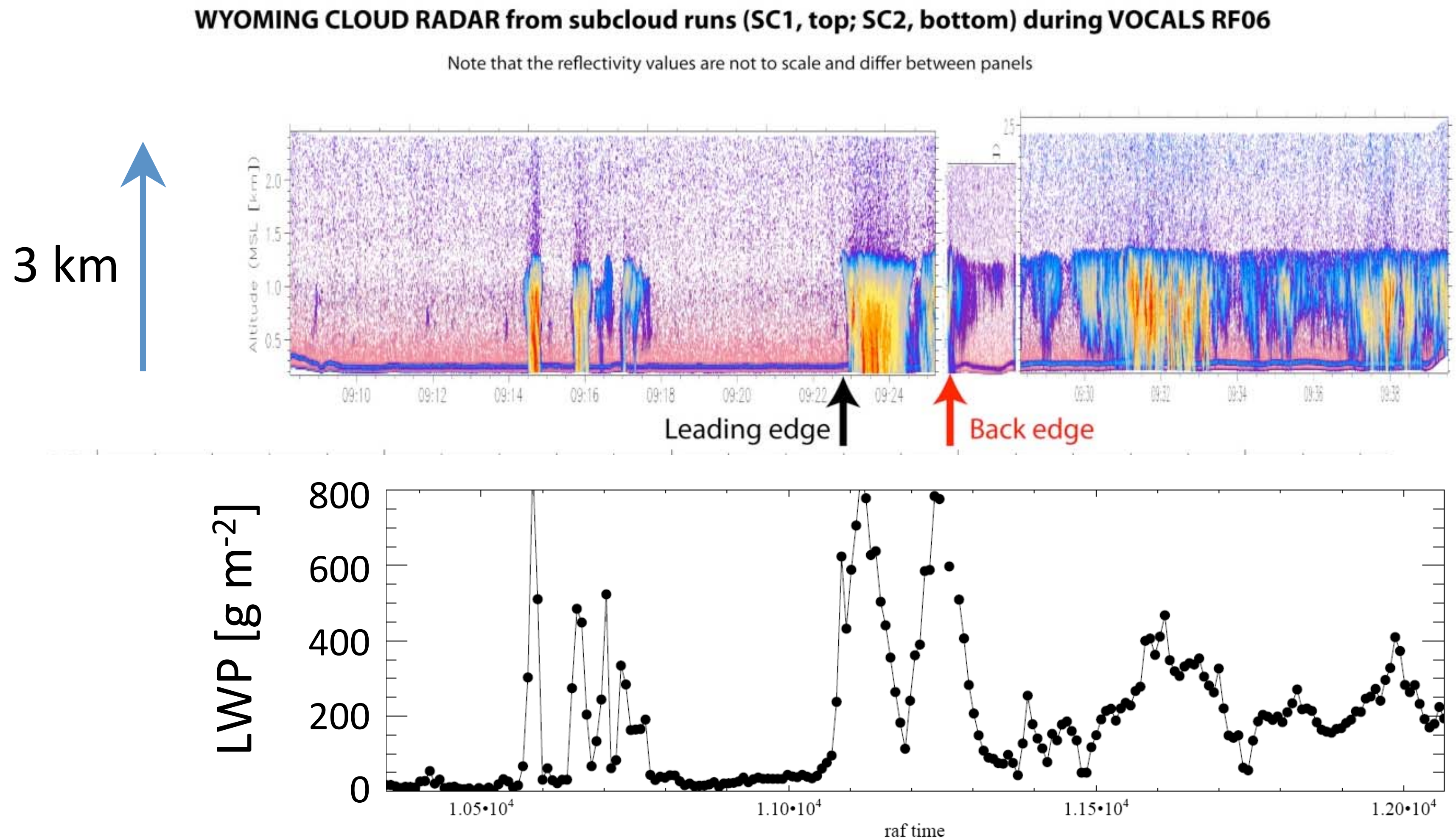
Strongly precipitating cell present in all passes.....

.....use to define leading and back edge

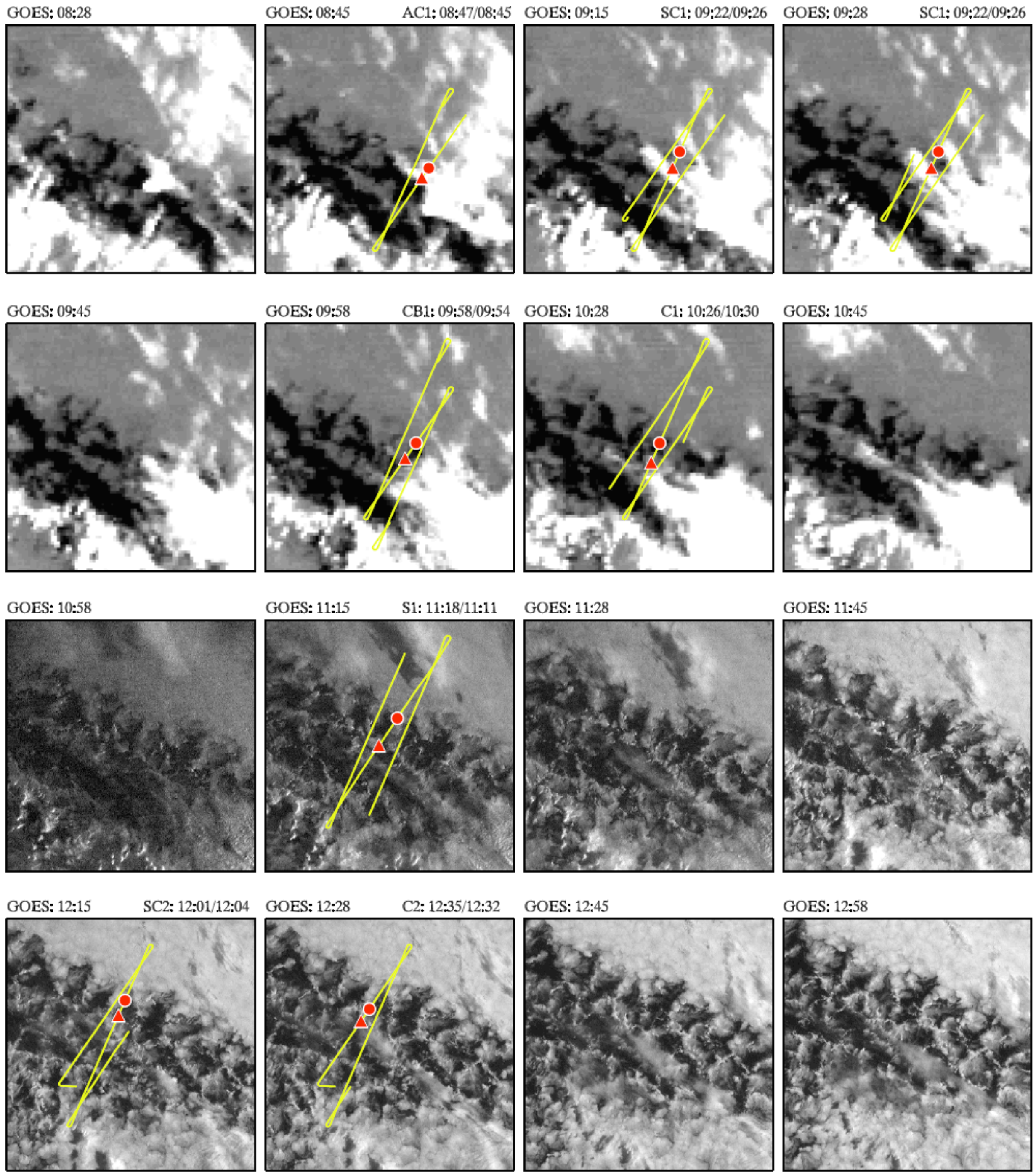
Boundary cell during RF06

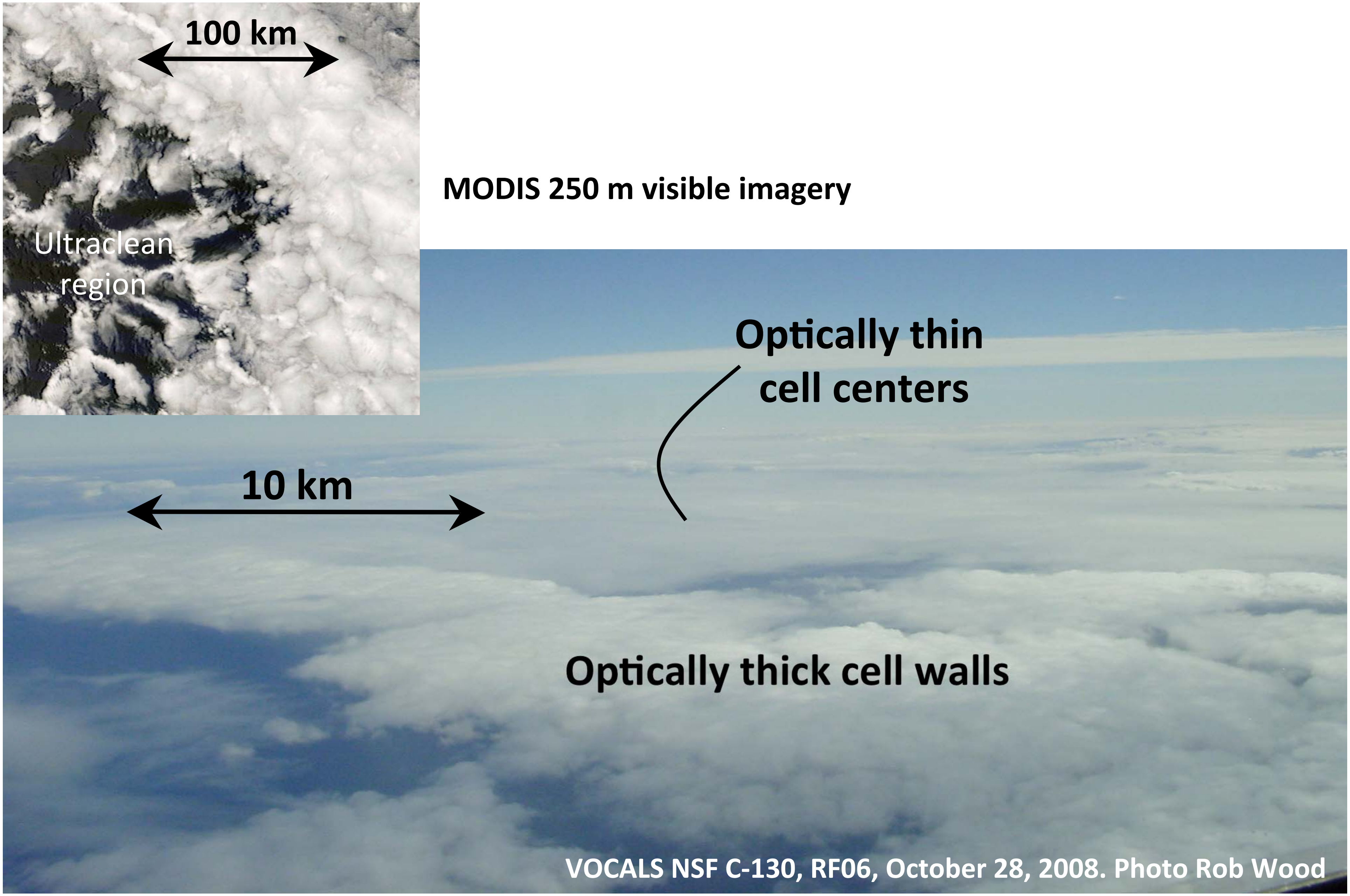


Boundary cell(s) – drizzle and liqui

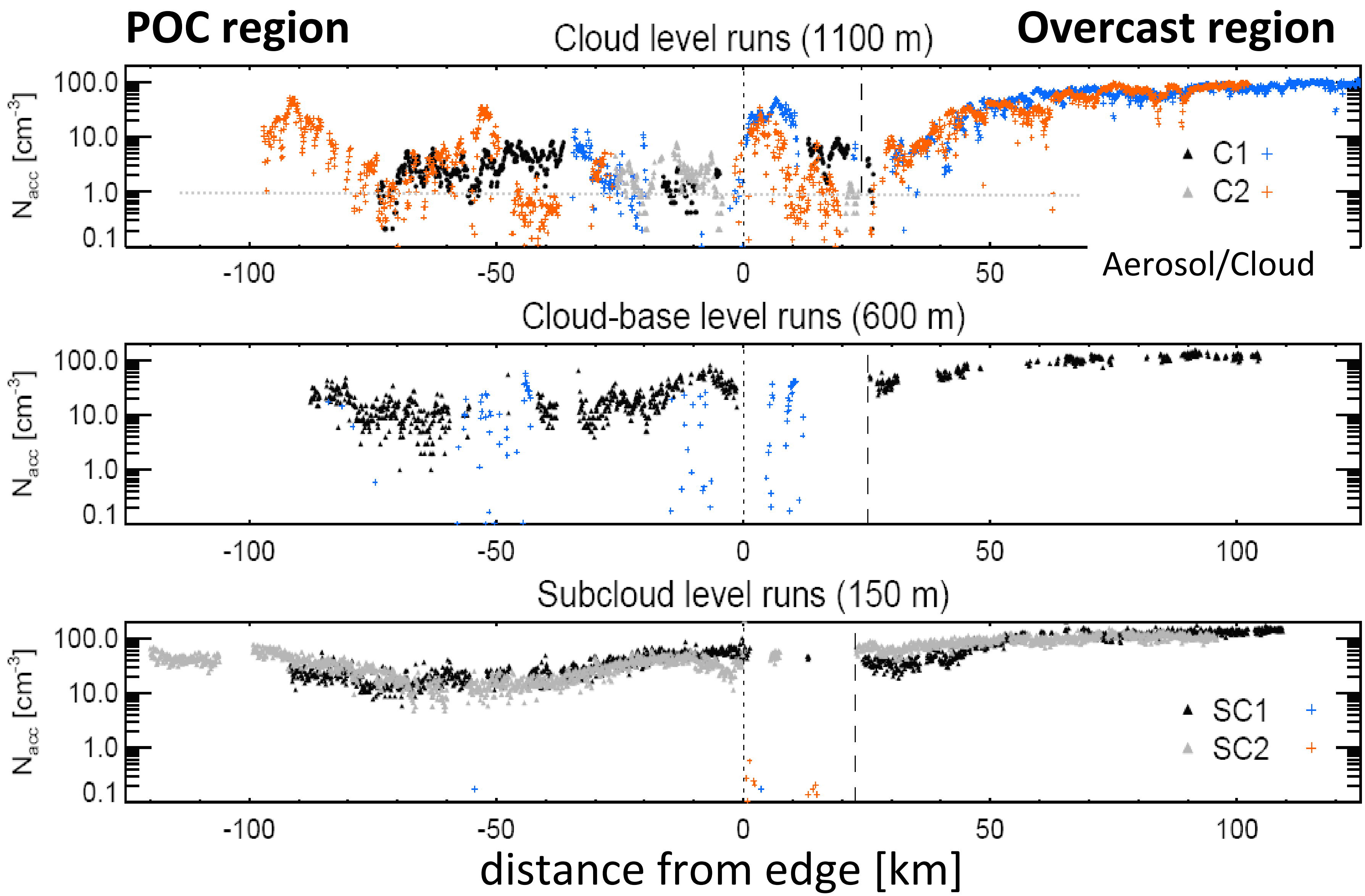


High liquid water path associated with precipitating cells

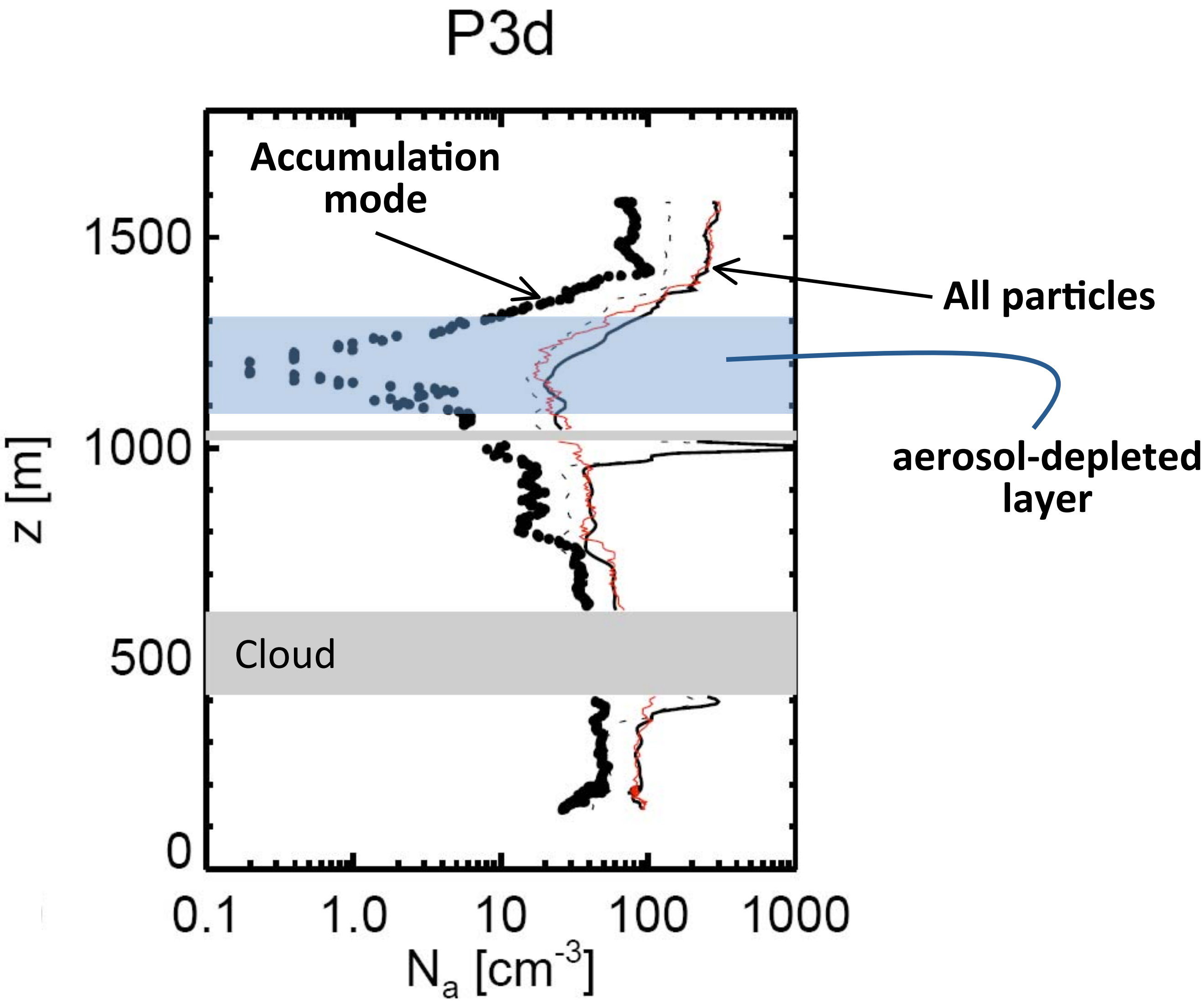

GOES: 08:28
GOES: 08:45
AC1: 08:47/08:45
GOES: 09:15
SC1: 09:22/09:26
GOES: 09:28
SC1: 09:22/09:26
GOES: 09:45
GOES: 09:58
CB1: 09:58/09:54
GOES: 10:28
C1: 10:26/10:30
GOES: 10:45
GOES: 10:58
GOES: 11:15
S1: 11:18/11:11
GOES: 11:28
GOES: 11:45
GOES: 12:15
SC2: 12:01/12:04
GOES: 12:28
C2: 12:35/12:32
GOES: 12:45
GOES: 12:58


100 km
Ultraclean region
MODIS 250 m visible imagery
Optically thin cell centers
10 km
Optically thick cell walls
VOCALS NSF C-130, RF06, October 28, 2008. Photo Rob Wood

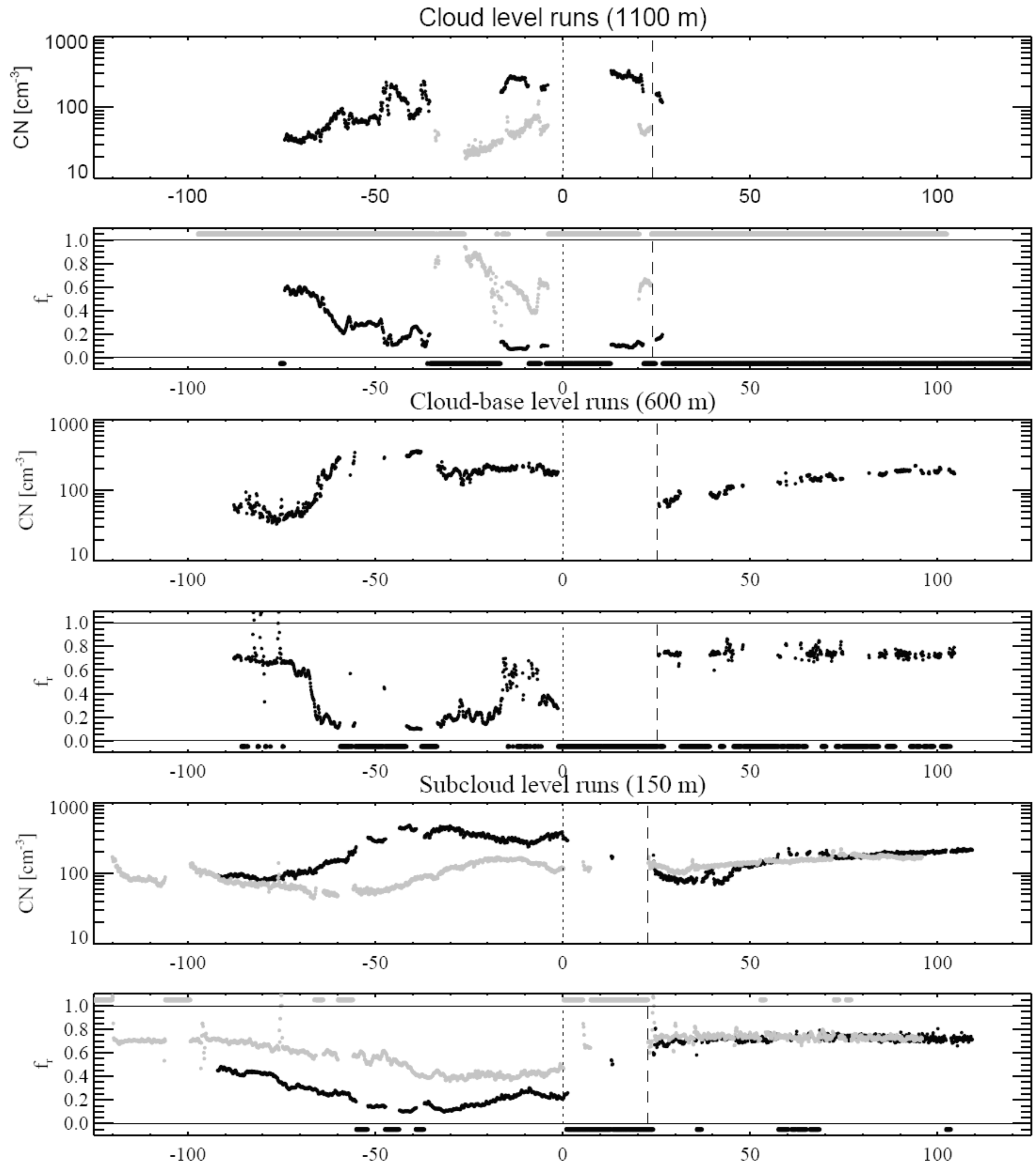
Cloud droplet and accumulation model aerosol concentrations



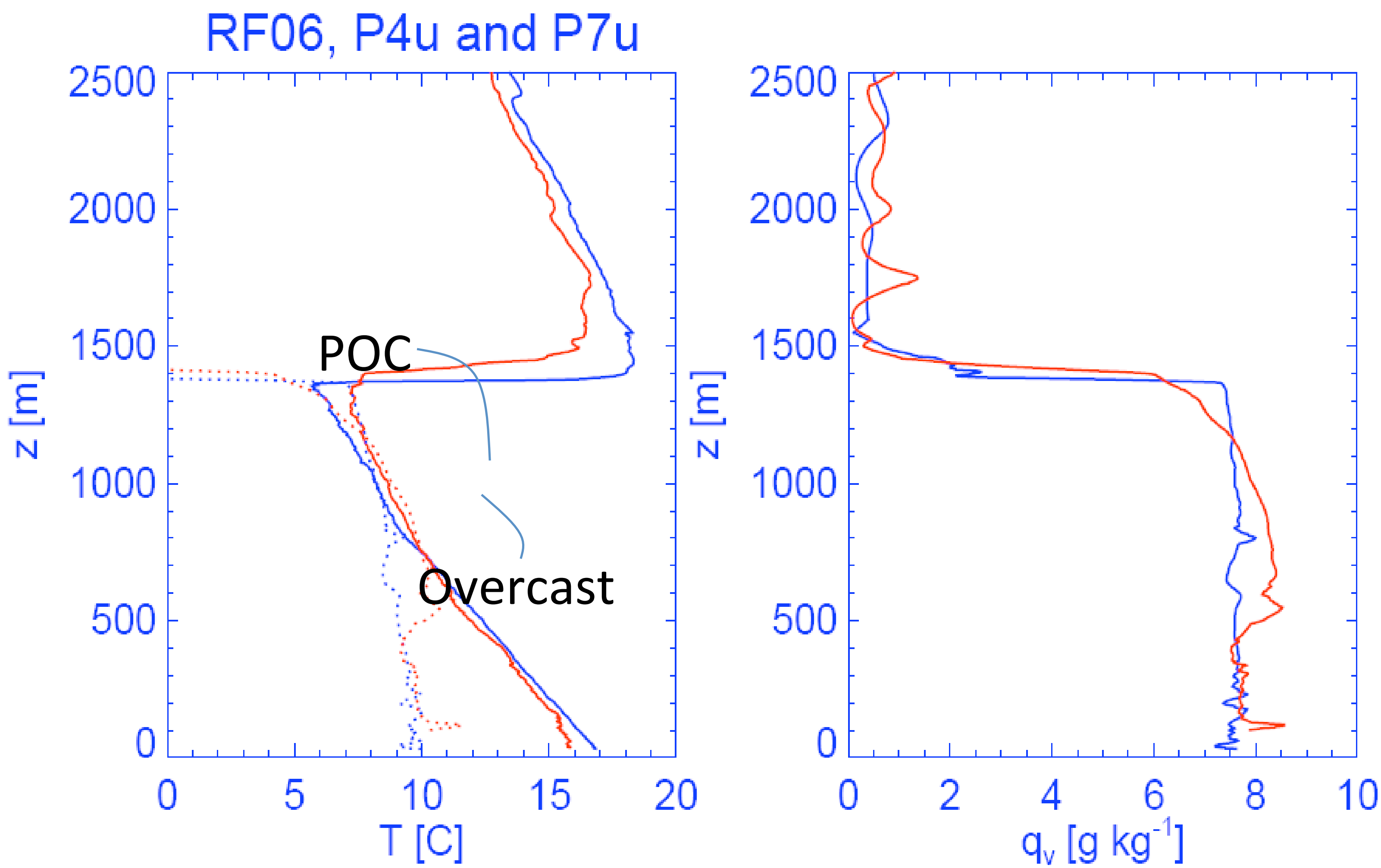
Aerosol-depleted layer



- Better graphic?
- Evidence for new particle formation in recent past



Profiles of temperature and water vapor



Conceptual model of POC edge

Extremely clean
[CN = 20-50 cm^{-3}, CCN = 5-20 cm^{-3}]

Moderately polluted
[CN = 500-1000 cm^{-3}, CCN = 100 cm^{-3}]

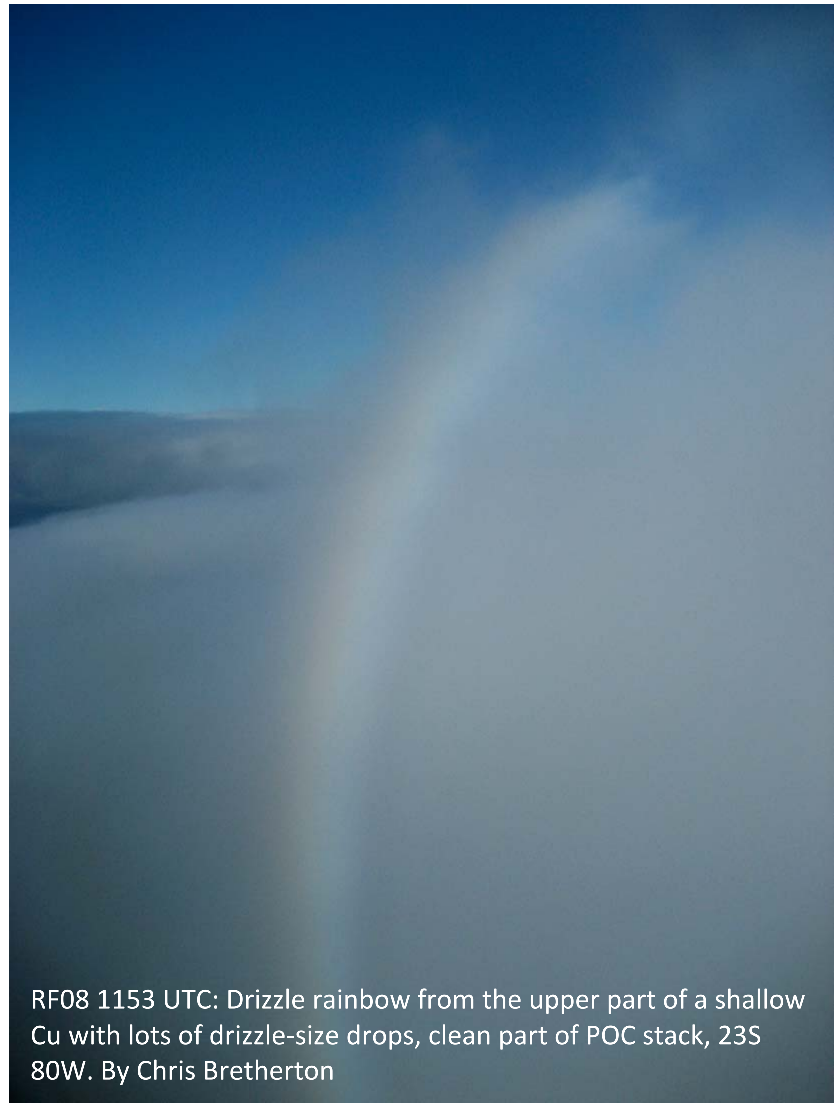
Summary

- POC-overcast boundary comprehensively sampled with C-130 (and BAe-146, 12 hrs earlier)
- **Both POC and overcast strongly drizzling**. More intermittent but strong within POC.
- Marked differences in meteorology and microphysics inside and outside POC (POC surface air temps cooler, upper layers warmer, more decoupled)
- Very strongly drizzling **boundary cell** observed (cloudbase precip rates ~10 mm day^{-1}). Possible squall line analogue?
- Quiescent layer of POC environment **astoundingly depleted in CCN** – drizzle scavenging important
- Optically thin drizzling clouds with most liquid in drizzle mode

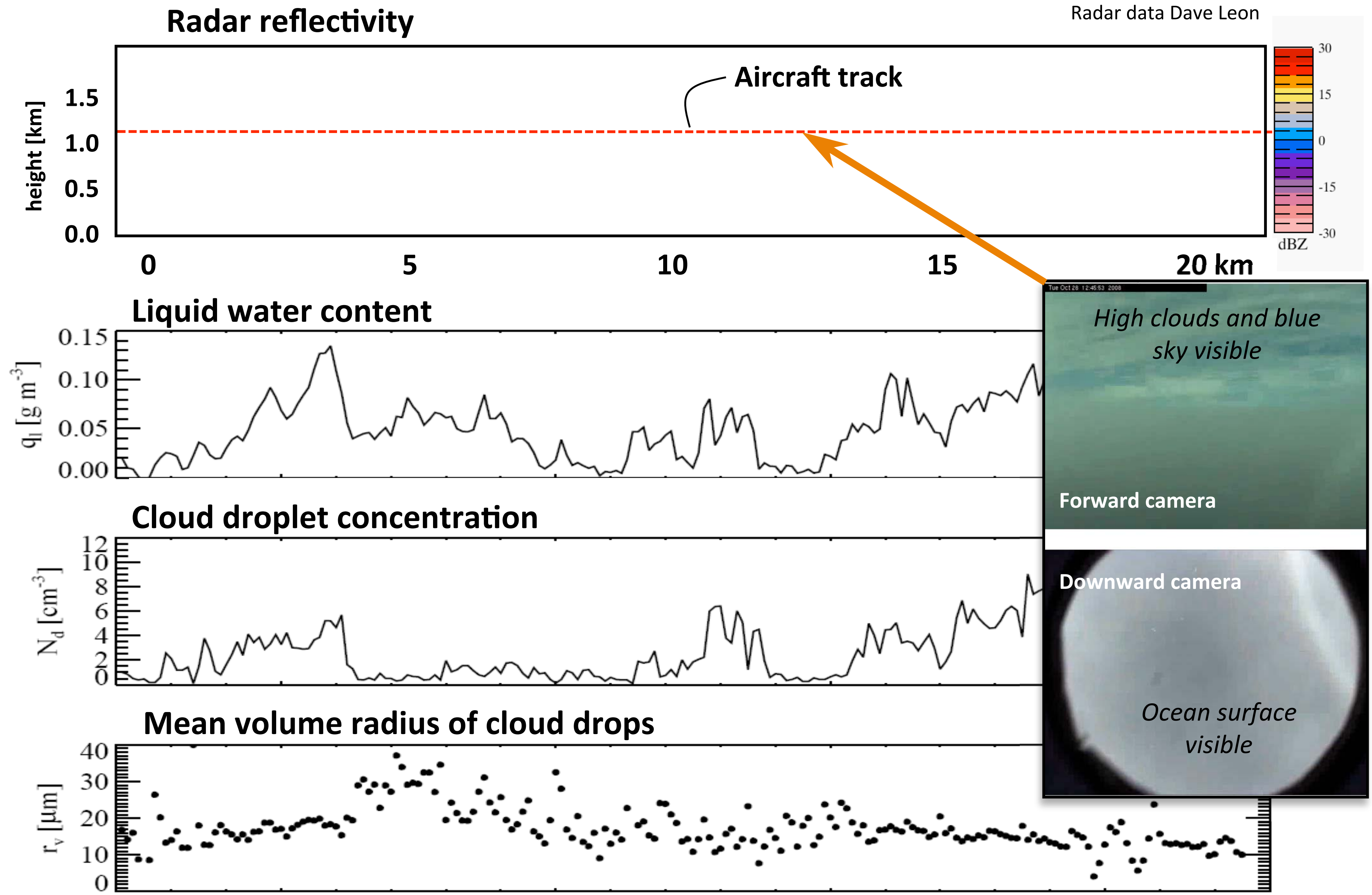
Too clean for clouds? VOCALS probes the anatomy of ultraclean marine low cloud layers and their sensitivity to pollution

RF07 1124 UTC: Over broken clouds and very thin Stratus clouds at south end of POC region, by Tony Clarke

RF07 1148: Optically thin drizzling cloud at end of S1 run near center of POC 4/4, by Tony Clarke



RF08 1153 UTC: Drizzle rainbow from the upper part of a shallow Cu with lots of drizzle-size drops, clean part of POC stack, 23S 80W. By Chris Bretherton

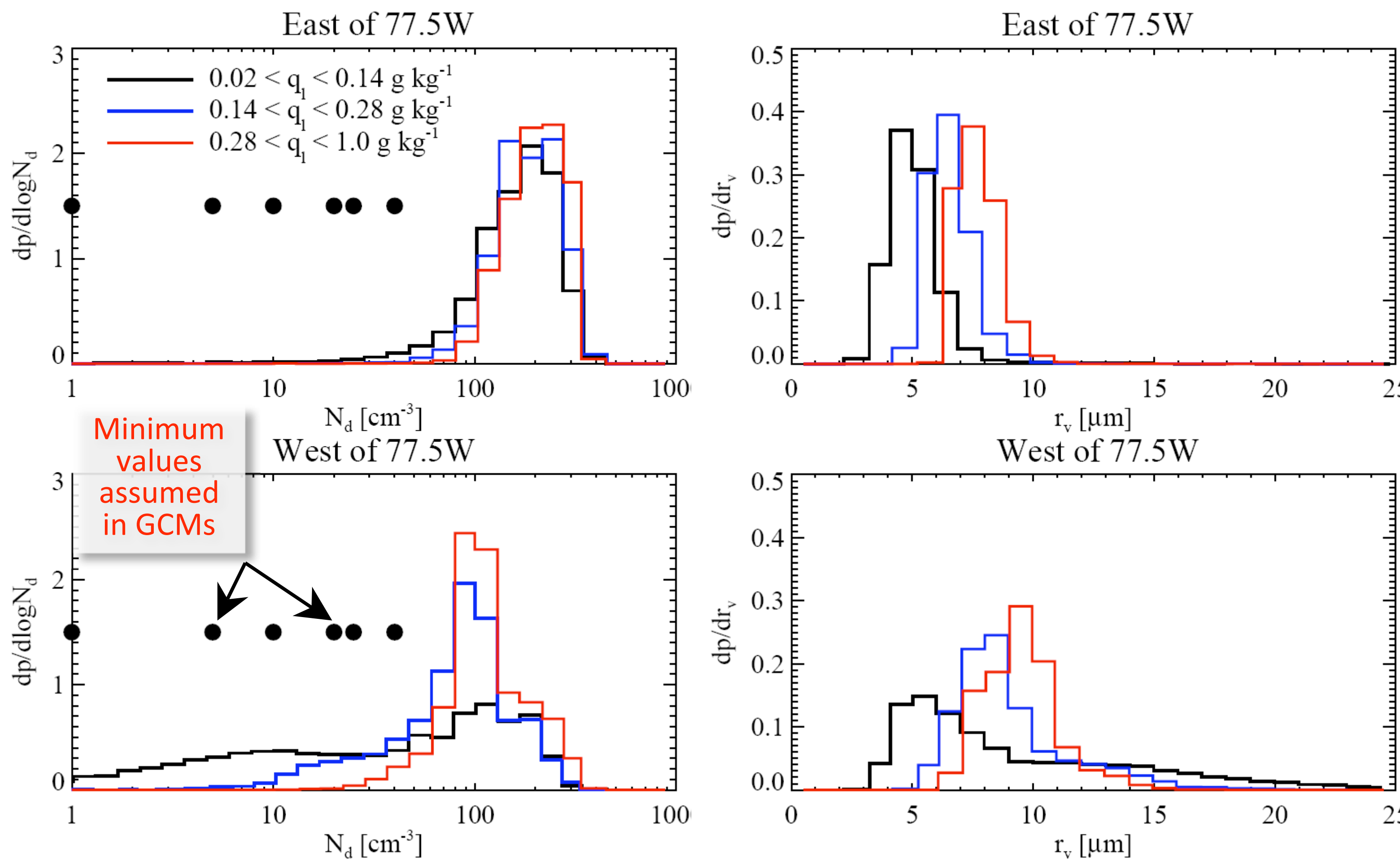


Radar reflectivity
Radar data Dave Leon
Aircraft track
height [km]
1.5
1.0
0.5
0.0
0
5
10
15
20 km
30
15
0
-15
-30
dBZ
Liquid water content
q_l [g m^{-3}]
0.15
0.10
0.05
0.00
Cloud droplet concentration
N_d [cm^{-3}]
12
10
8
6
4
2
0
Mean volume radius of cloud drops
r_v [μm]
40
30
20
10
0
High clouds and blue sky visible
Forward camera
Downward camera
Ocean surface visible

Distributions, for all VOCALS flights, of cloud droplet concentration (left) and droplet volume radius (right) for low (black), intermediate (blue) and high (red) liquid water content (q_L), for coastal regions east of 77.5°W (top) and remote regions west of 77.5°W.

Results show that in coastal regions east of 77.5°W cloud droplet growth is as expected from quasi-adiabatic growth, with droplet concentration approximately independent of liquid water content, and with droplet size increasing with q_L.

However, in remote regions, there is a population of extremely low cloud droplet concentration. These clouds are primarily found in clouds with low liquid water content. Interestingly, it is these low liquid water clouds that have the largest cloud drop sizes. This behavior is quite different from the behavior seen in the coastal clouds.



Optically thin drizzling clouds important for aerosol scavenging

- Extremely low CCN concentrations are observed in clear regions at the level where the optically thin drizzling clouds are present
- Optically-thin drizzling cloud layers appear to be horizontally extensive within regions of open cells, and not necessarily connected with strongly precipitating cell walls.
- Hypothesize that scavenging of aerosols in the upper boundary layer that results in the *aerosol-depleted layer* is primarily a result of precipitation and sedimentation in optically thin drizzling clouds rather than in the strongly drizzling but intermittent cell walls