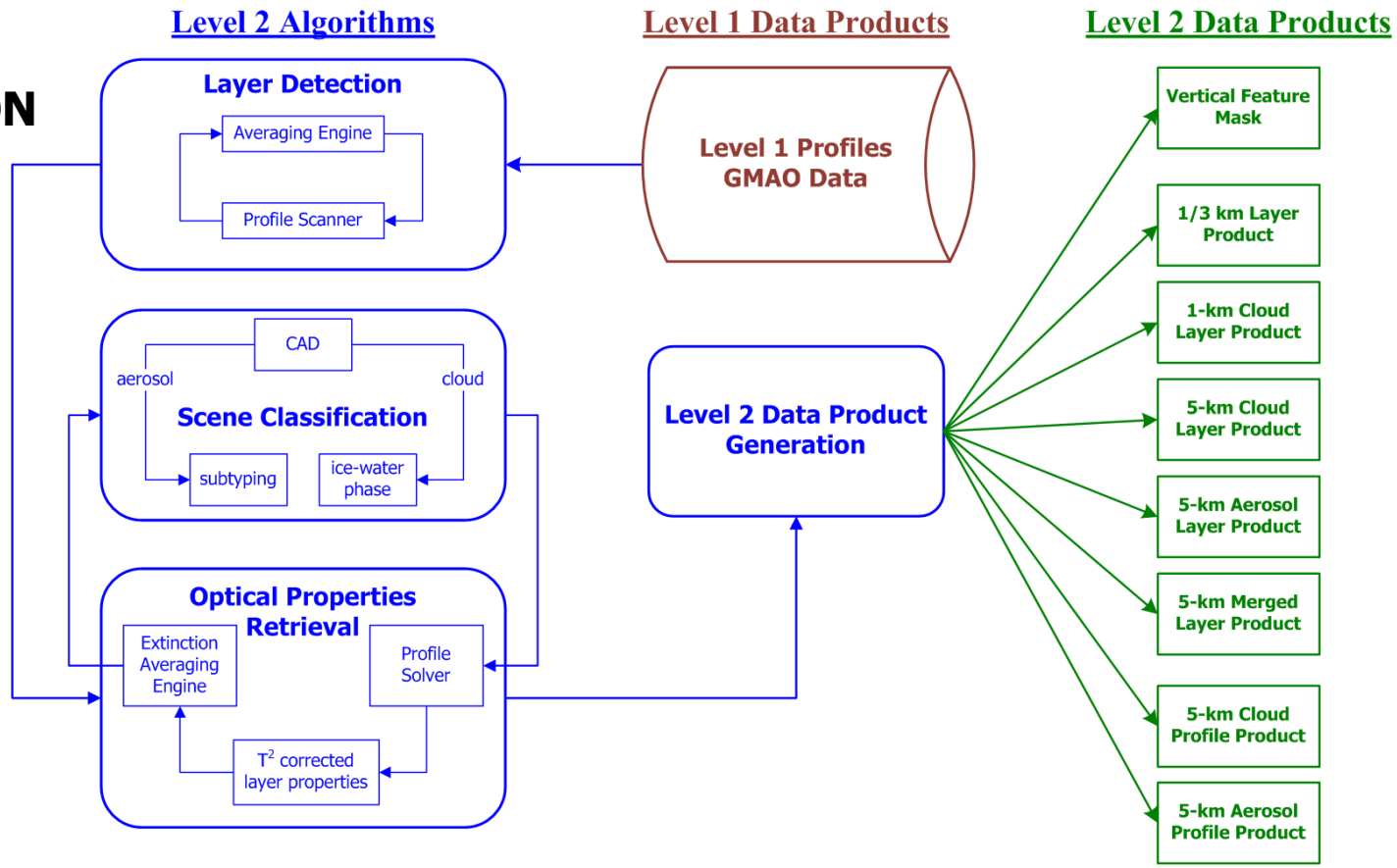
The Top 10 Improvements to the Version 4 Level 2 CALIPSO Lidar Data Products

Mark Vaughan, Anne Garnier, Jason Tackett, Stuart Young, Jay Kar, Melody Avery, Ali Omar, Zhaoyan Liu, Brian Getzewich, Kam-Pui Lee, Bill Hunt, Dave Winker, Jacques Pelon, Chip Trepte, Bob Holz, Travis Toth, Pat Lucker, Sharon Rodier, Jim Lambeth, Brian Magill, Rob Ryan, Josh Phillips, Shan Zeng, Xia Cai, Tim Murray, Ken Beaumont, Paula Detweiler

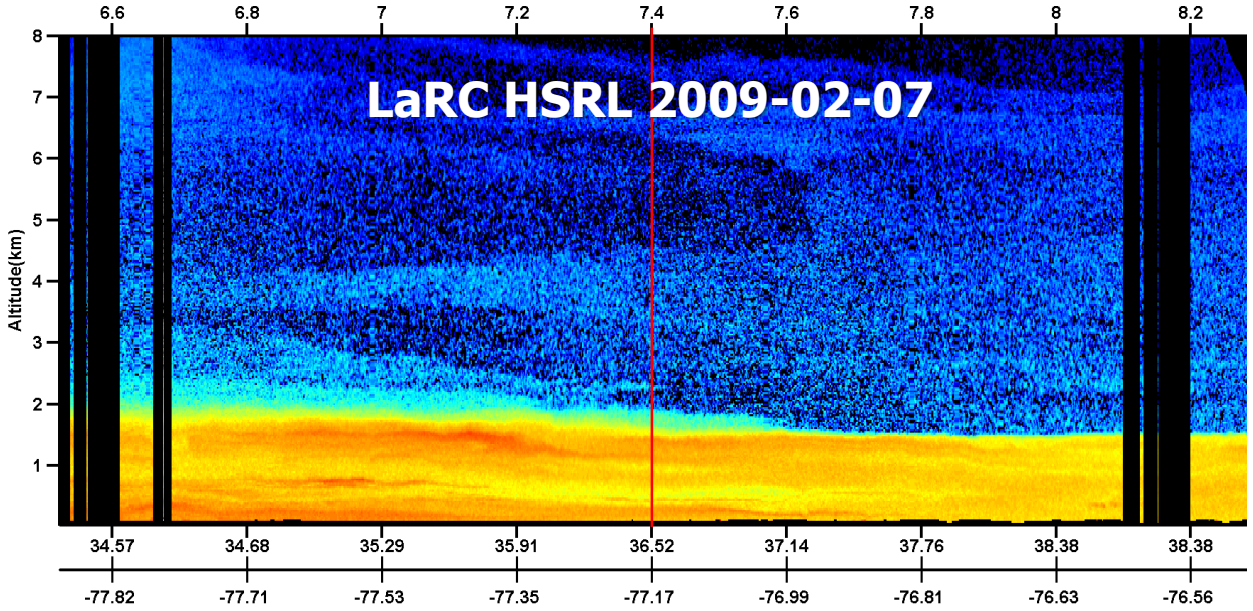
The Top 10 List

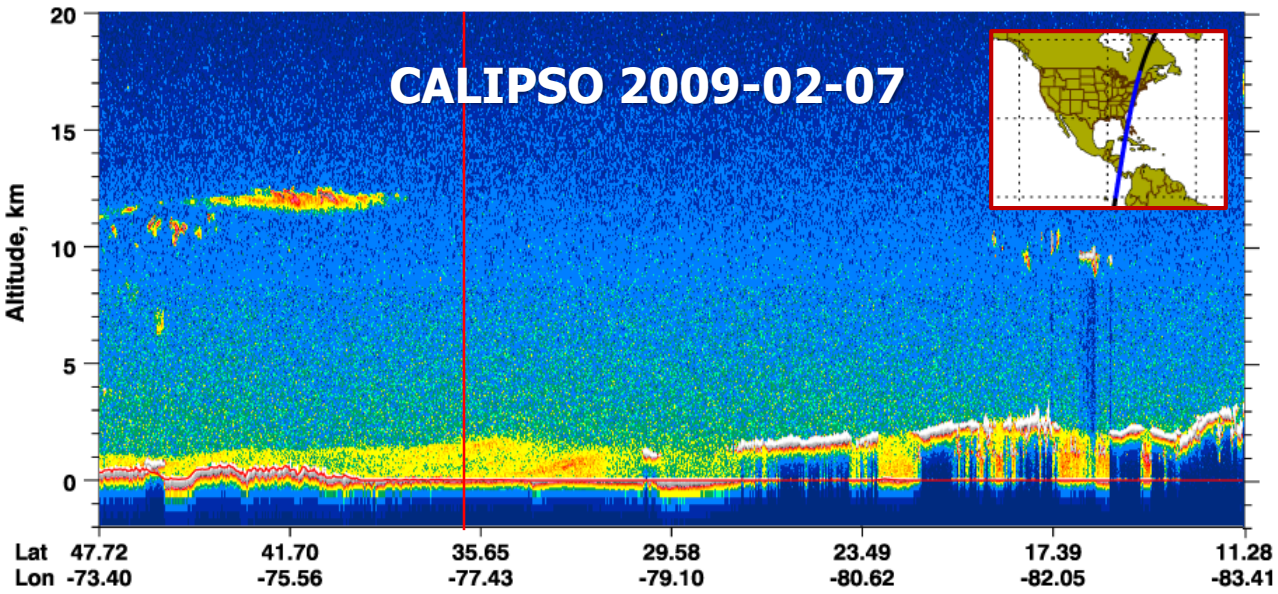
1. Calibration
2. Surface Detection
3. Cloud-Aerosol Discrimination
4. Stratospheric Aerosol Classification
5. Tropospheric Aerosol Classification
6. Ice-Water Content and Ice-Water Phase
7. Cirrus Multiple Scattering
8. Extinction Retrievals
9. A-Train Synergies
10. New Data Product(s)



V4 Calibration Validation Using LaRC HSRL

Poster: Getzewich et al., "Updates to the Version 4 CALIOP Level 1 Algorithm"

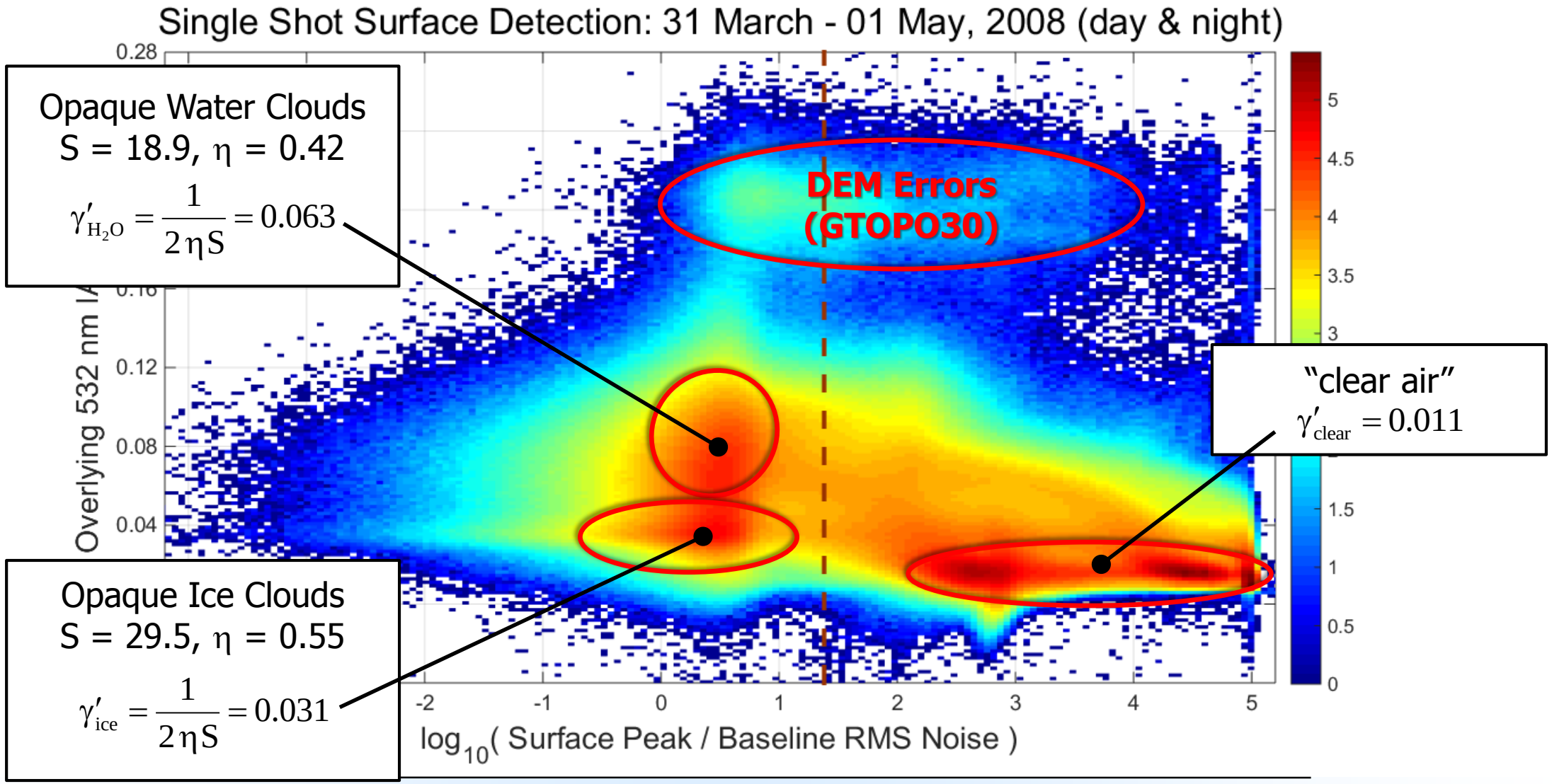




2006 – 2014 118 Flights	Daytime Bias		Nighttime Bias	
	Version 3	Version 4	Version 3	Version 4
Mean (HSRL-CALIOP)	2.0%	-0.2%	2.2%	0.2%
Standard Deviation	3.5%	3.9%	2.2%	2.4%

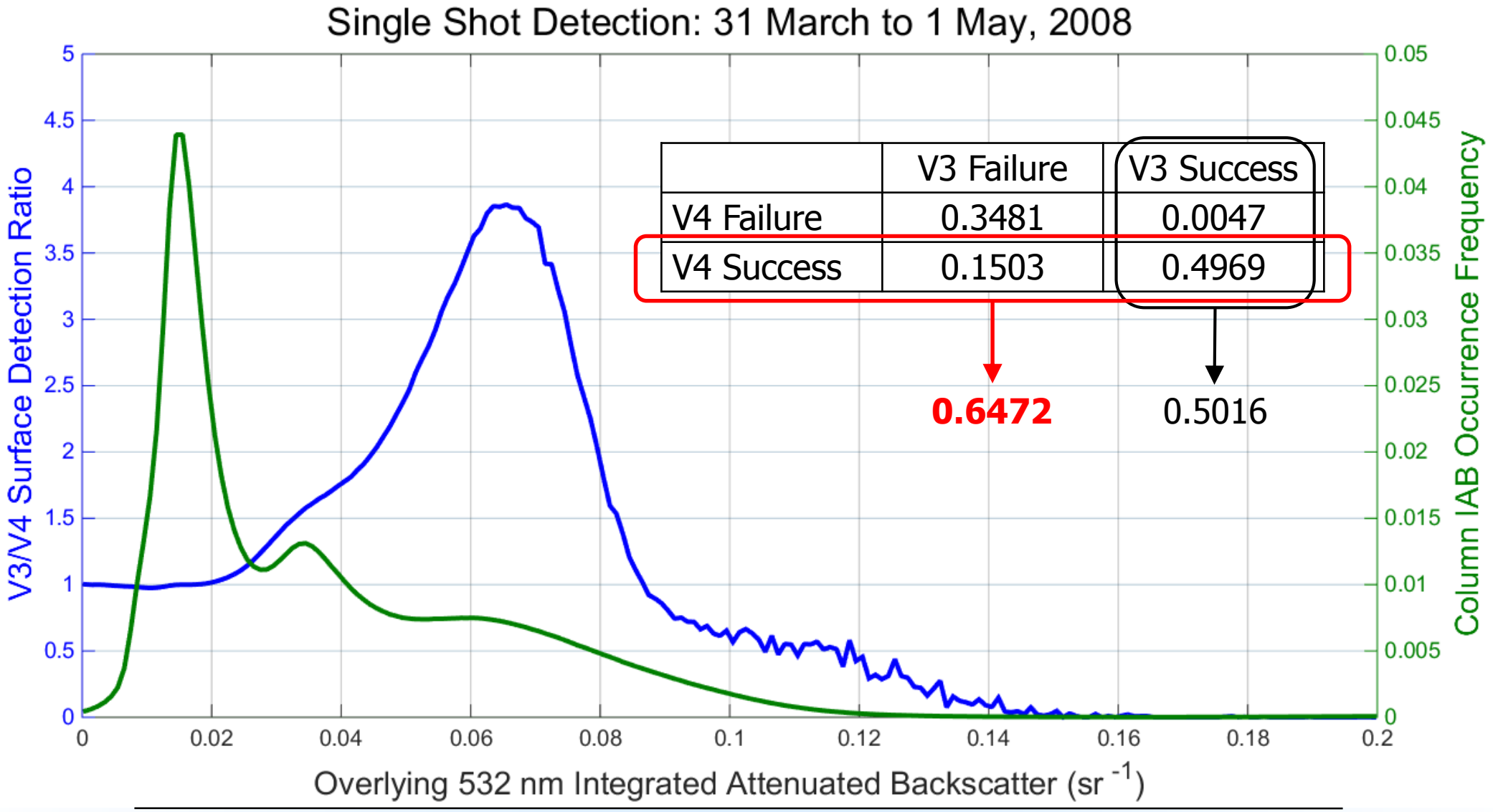
Surface Detection

Poster: Vaughan et al., "Improvements to the CALIOP Surface Detection Algorithm"



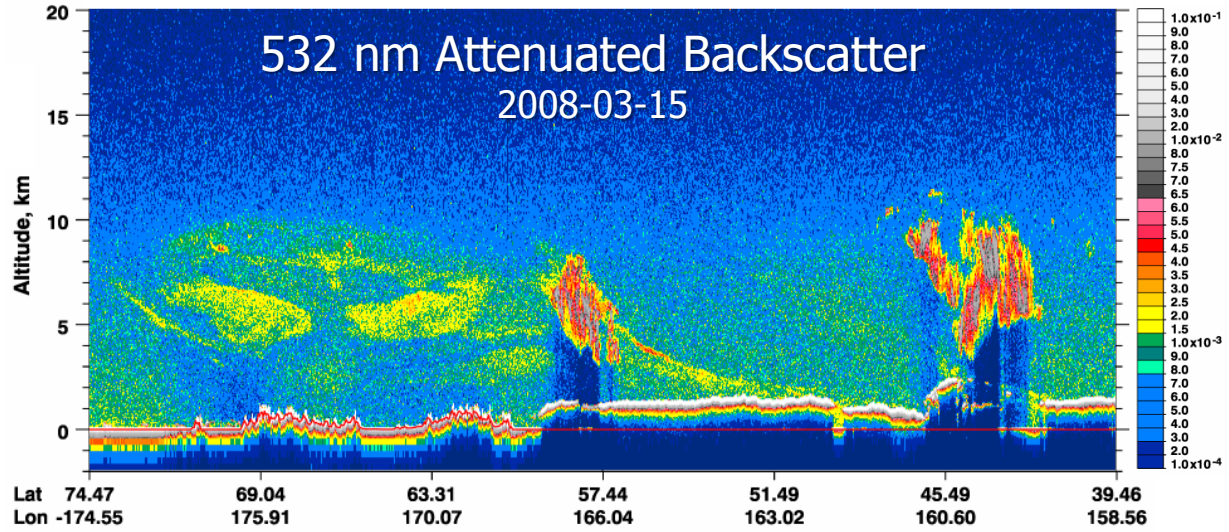
Surface Detection

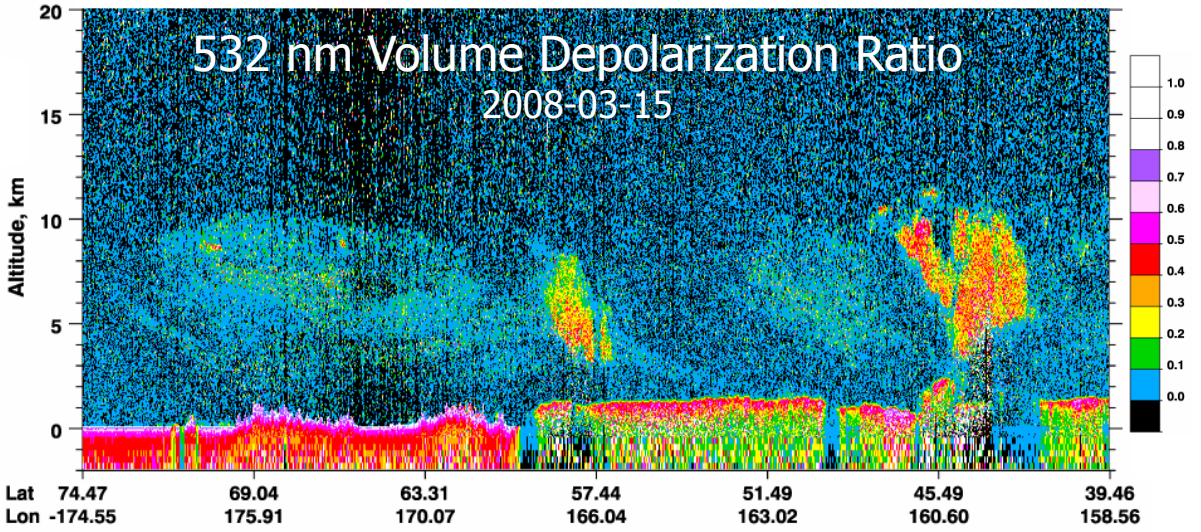
Poster: Vaughan et al., "Improvements to the CALIOP Surface Detection Algorithm"

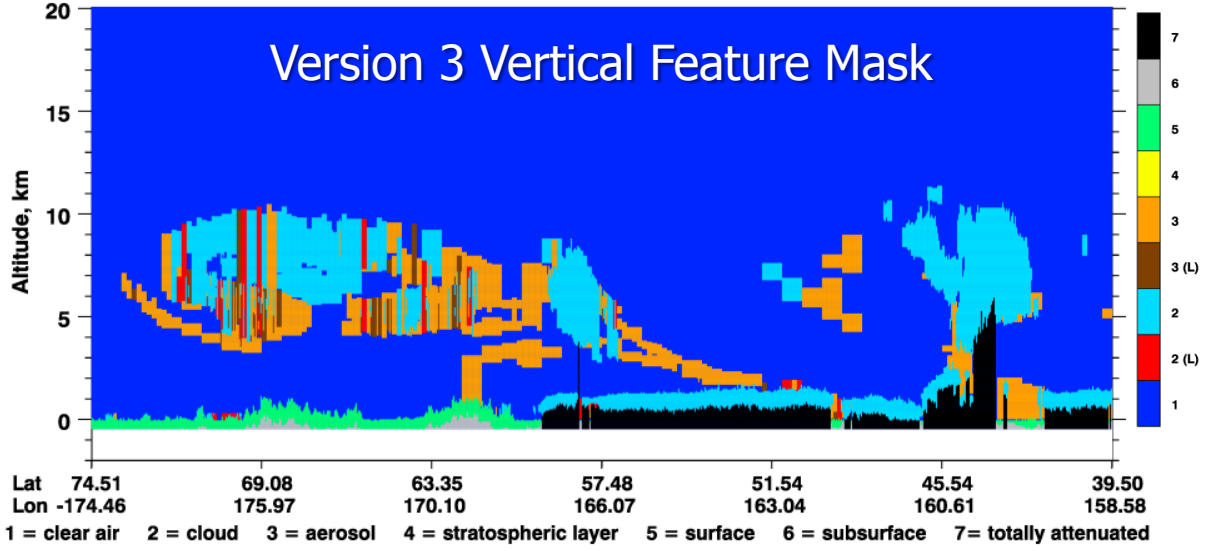


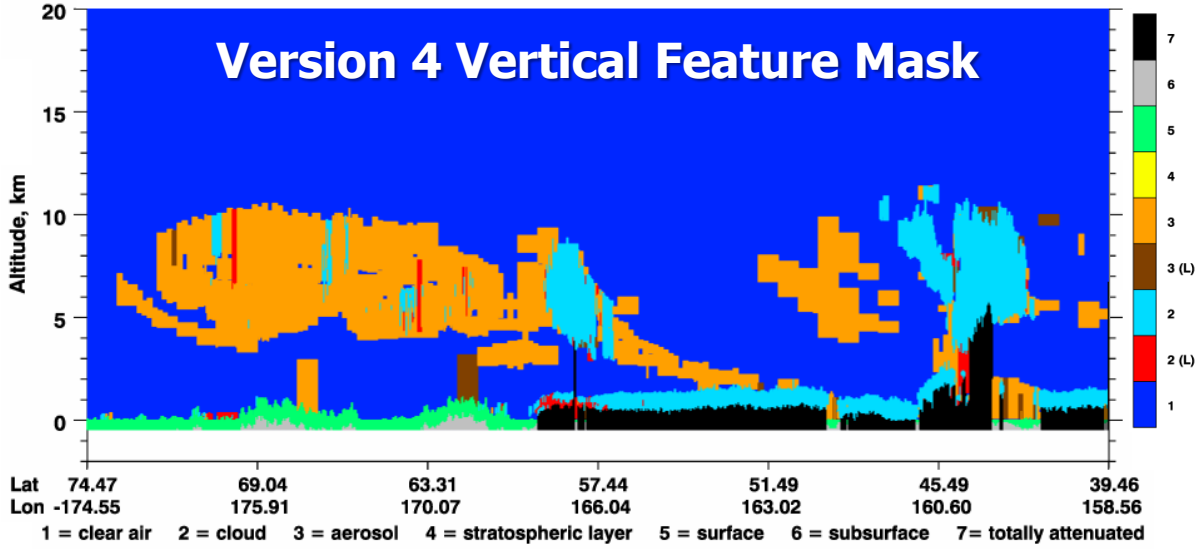
Cloud-Aerosol Discrimination

Poster: Kar et al., "Cloud Aerosol Discrimination (CAD) Updates in CALIOP Version 4"





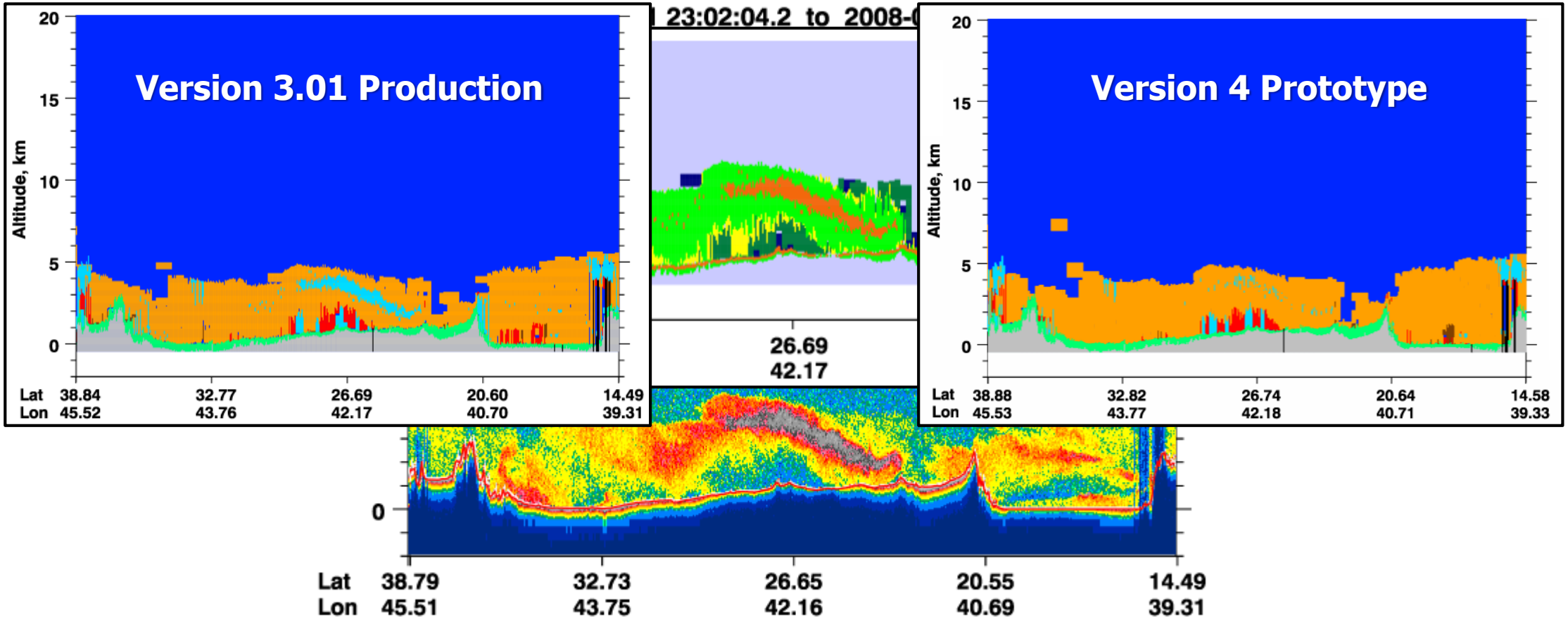




Cloud-Aerosol Discrimination

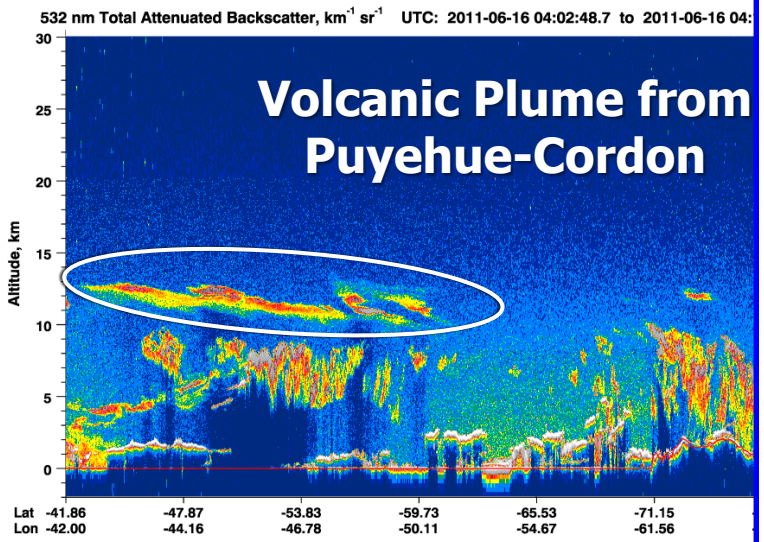
Poster: Kar et al., "Cloud Aerosol Discrimination (CAD) Updates in CALIOP Version 4"

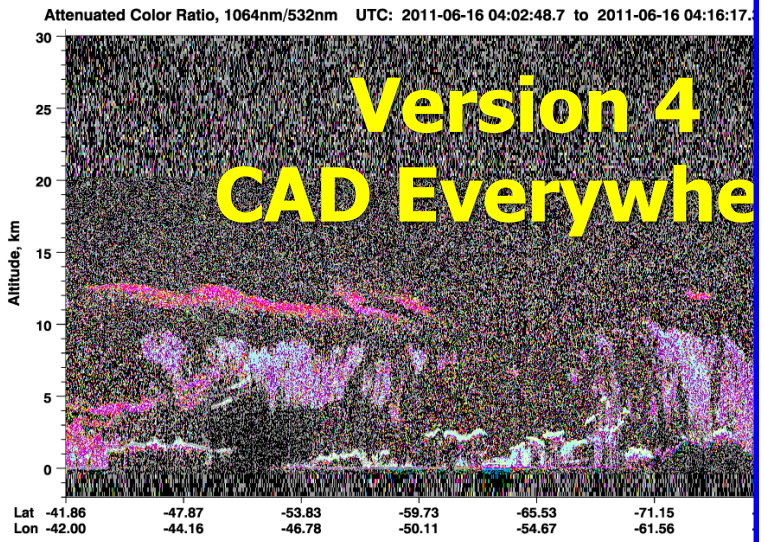
CAD at Single Shot Resolution

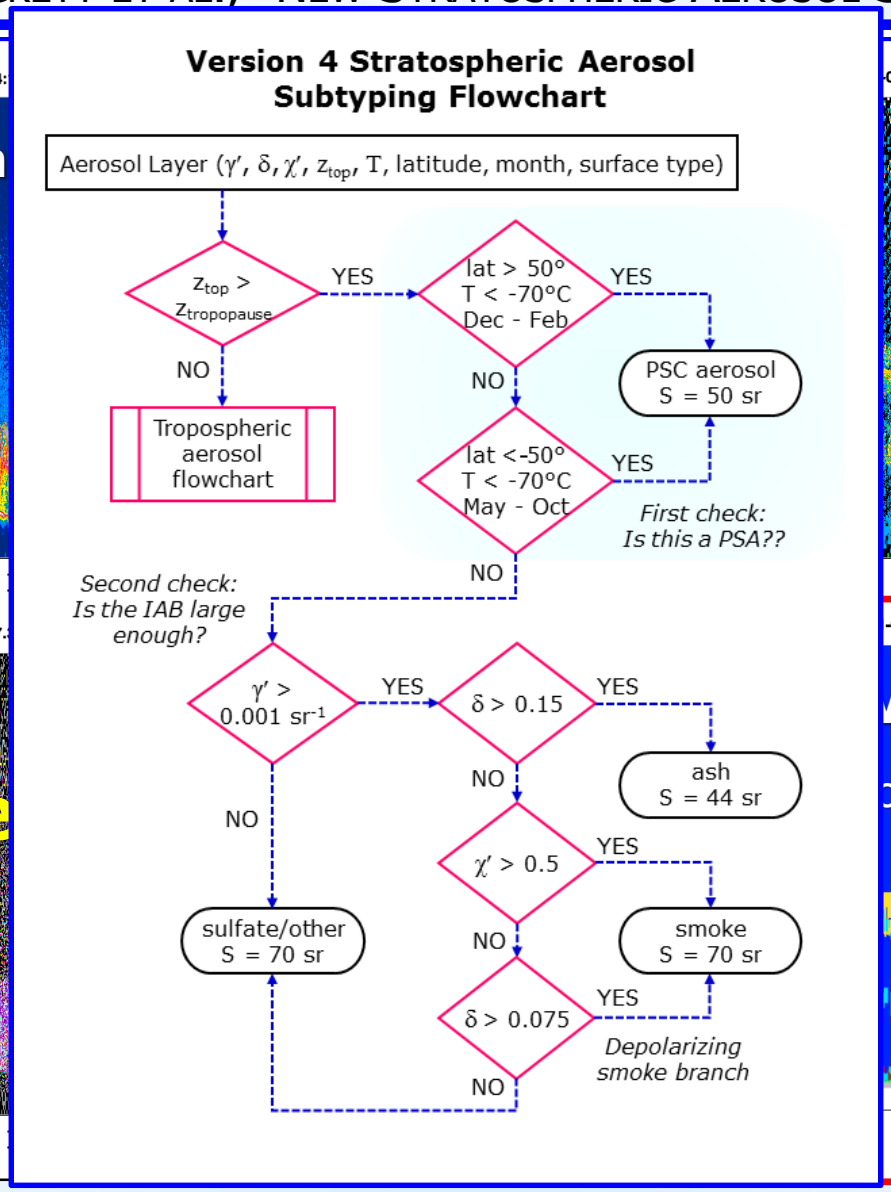


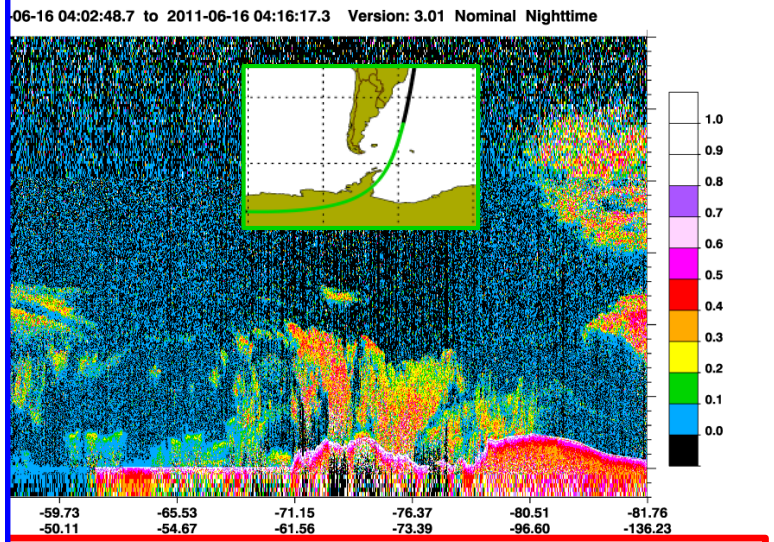
STRATOSPHERIC AEROSOL CLASSIFICATION

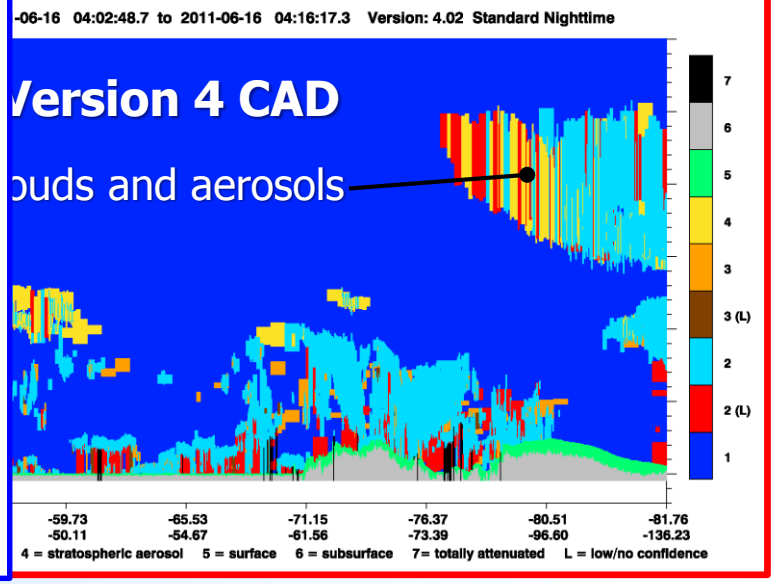
POSTER: TACKETT ET AL., "NEW STRATOSPHERIC AEROSOL SUBTYPES IN CALIOP VERSION 4"







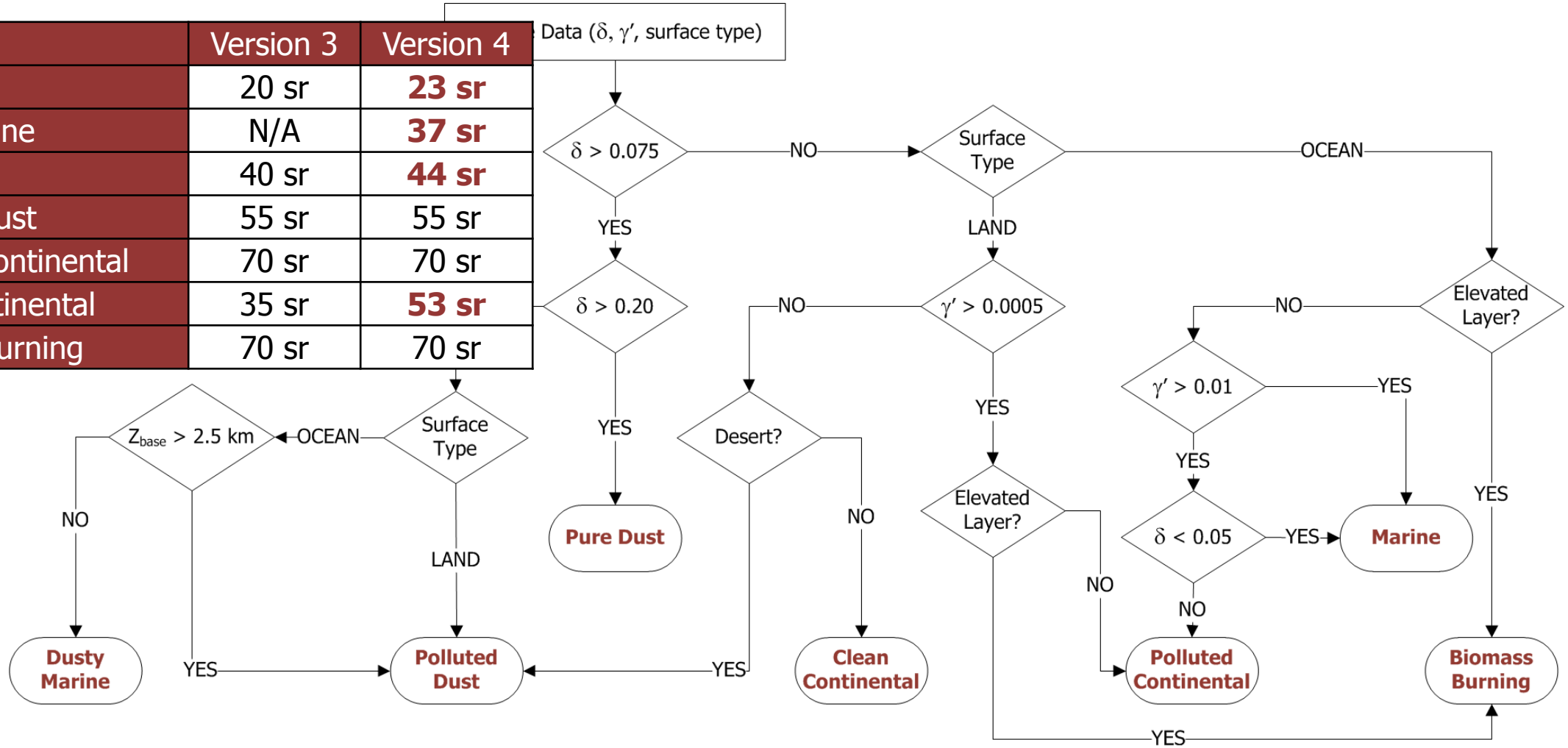




TROPOSPHERIC AEROSOL CLASSIFICATION

POSTER: OMAR ET AL., "AEROSOL SUBTYPING AND LIDAR RATIO SELECTION FOR CALIOP VERSION 4"

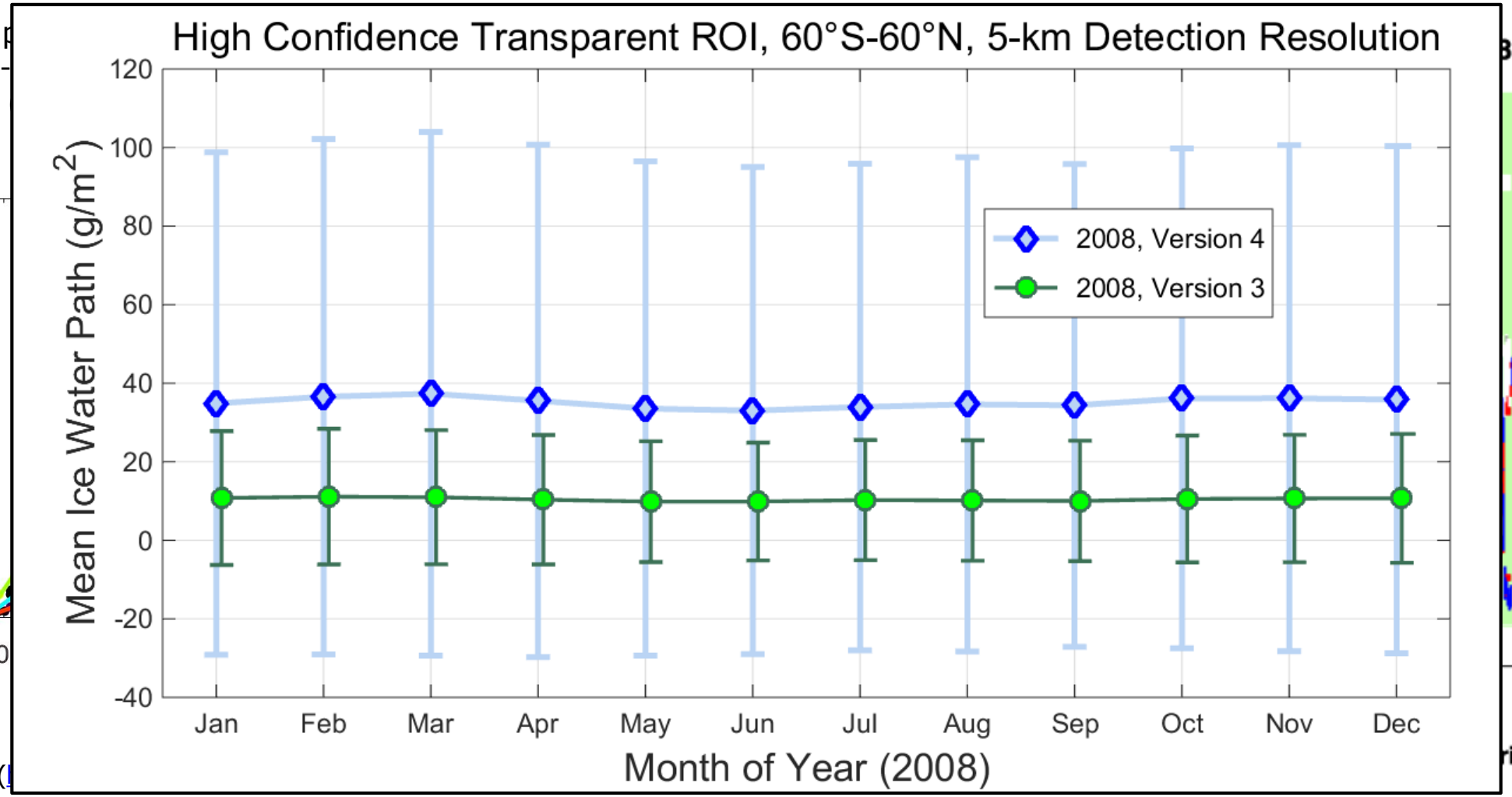
	Version 3	Version 4
Marine	20 sr	**23 sr**
Dusty Marine	N/A	**37 sr**
Pure Dust	40 sr	**44 sr**
Polluted Dust	55 sr	55 sr
Polluted Continental	70 sr	70 sr
Clean Continental	35 sr	**53 sr**
Biomass Burning	70 sr	70 sr



Ice-Water Content and Ice-Water Phase

Poster: Avery et al., "Changes to CALIOP Cloud Ice and Water Phase Discrimination"

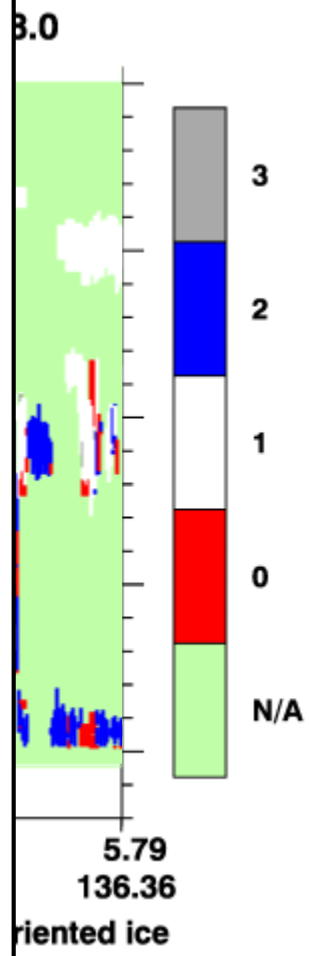
Ice Water Content



Heymsfield et al., 2014 IWC (mg/m^3)

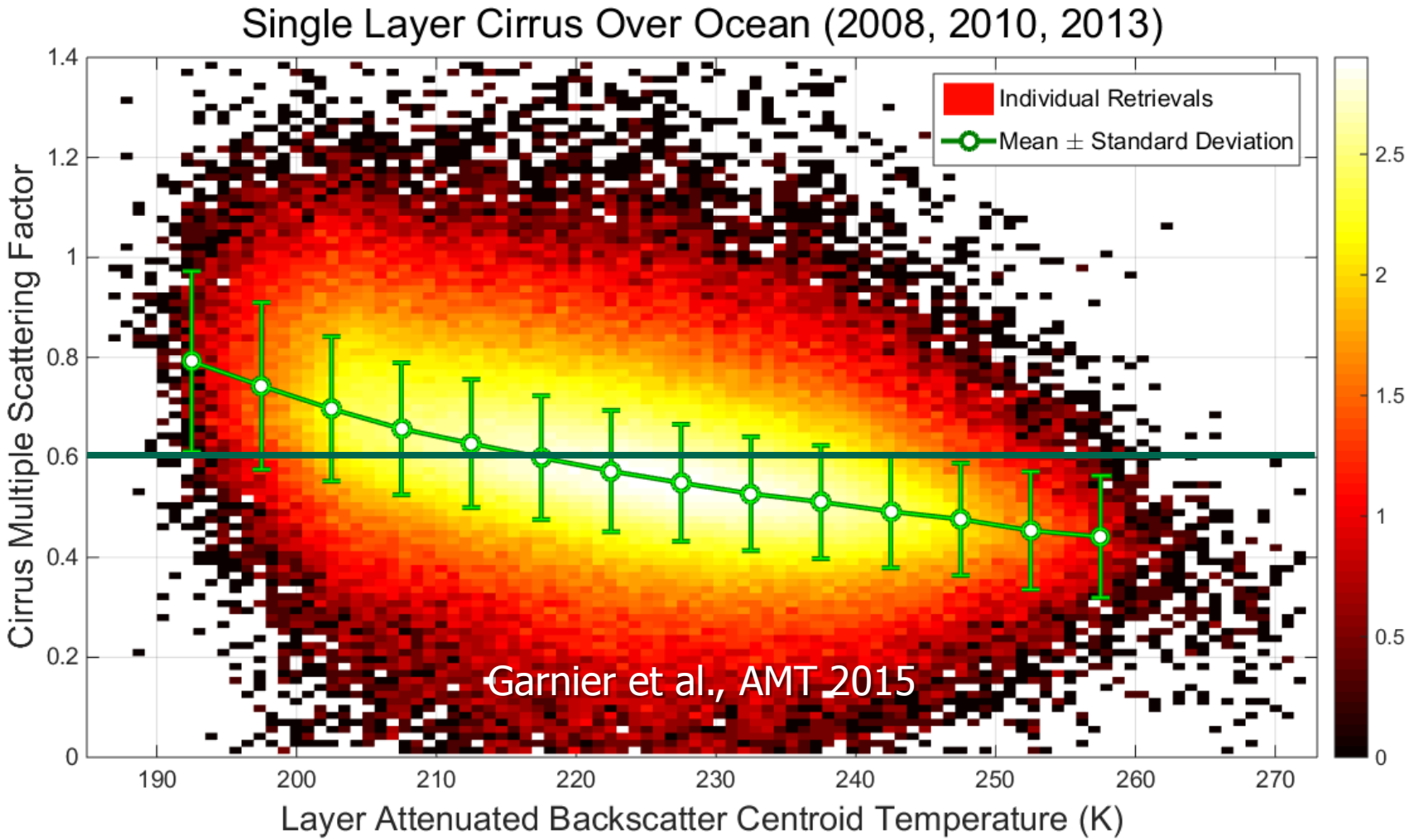
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

Ice Water Phase



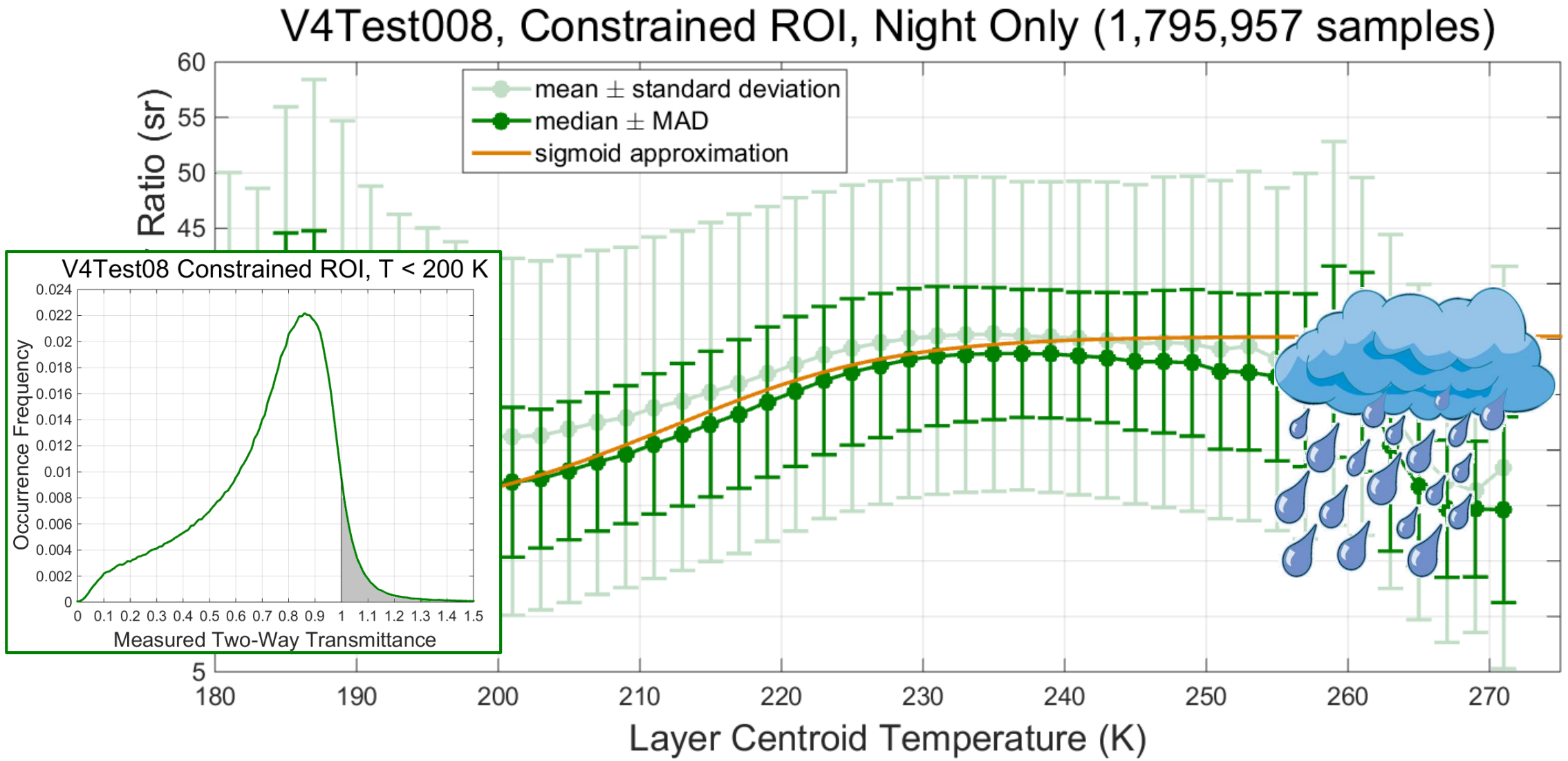
CIRRUS MULTIPLE SCATTERING

POSTER: GARNIER ET AL., "CIRRUS LIDAR RATIOS AND MULTIPLE SCATTERING FACTORS IN CALIOP VERSION 4"



CIRRUS LIDAR RATIO RETRIEVALS

POSTER: GARNIER ET AL., "CIRRUS LIDAR RATIOS AND MULTIPLE SCATTERING FACTORS IN CALIOP VERSION 4"



CIRRUS LIDAR RATIO RETRIEVALS

POSTER: GARNIER ET AL., "CIRRUS LIDAR RATIOS AND MULTIPLE SCATTERING FACTORS IN CALIOP VERSION 4"

V3 2008 Night			
cloud type	constrained solutions	total samples	constrained fraction
unknown	672	1265336	**0.05 %**
ROI	659449	7640625	**8.63 %**
water	31854	6155917	**0.52 %**
HOI	51455	1460019	**3.52 %**

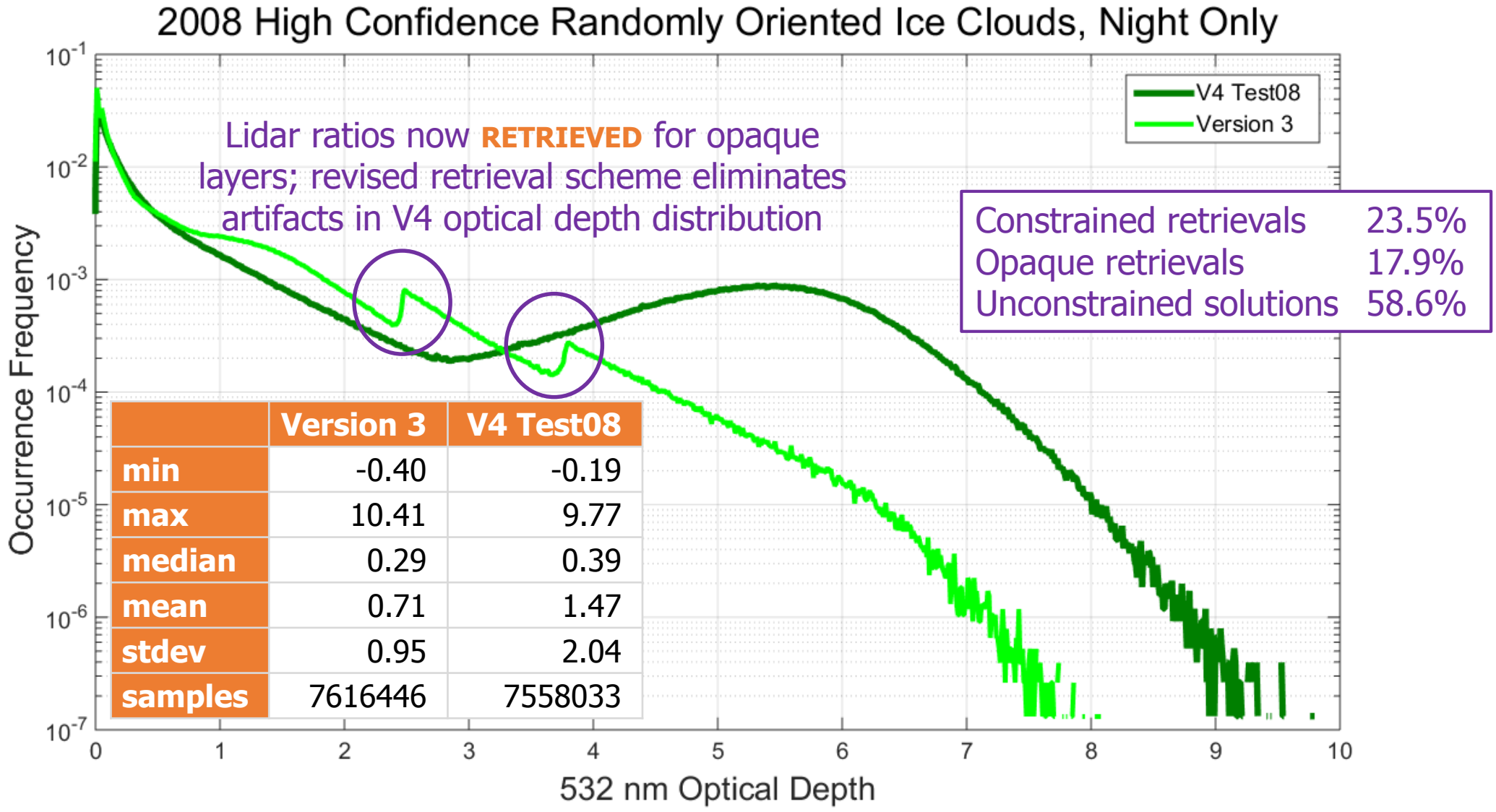
V4 2008 Night			
cloud type	constrained solutions	total samples	constrained fraction
unknown	60729	2050089	**2.96 %**
ROI	1795117	7642958	**23.49 %**
water	72724	6243186	**1.16 %**
HOI	10915	725420	**1.50 %**

V3 2008 Day			
cloud type	constrained solutions	total samples	constrained fraction
unknown	52	1422951	**0.00 %**
ROI	43921	7953237	**0.55 %**
water	2293	7145668	**0.03 %**
HOI	5053	1161500	**0.44 %**

V4 2008 Day			
cloud type	constrained solutions	total samples	constrained fraction
unknown	60063	2160802	**2.78 %**
ROI	1418617	7808434	**18.17 %**
water	153502	6989054	**2.20 %**
HOI	15796	494730	**3.19 %**

Extinction Retrievals

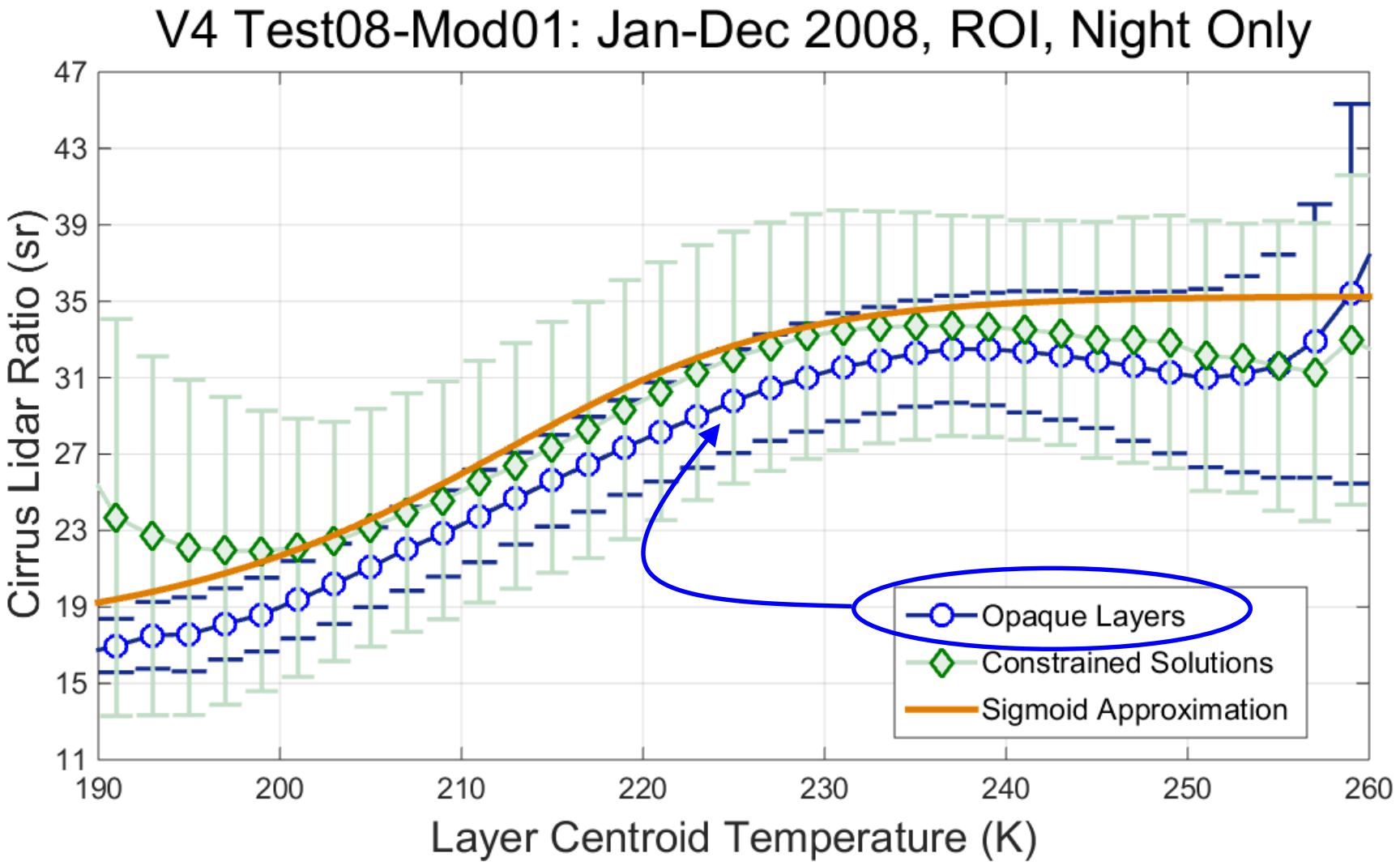
Poster: Young et al., "V4 Algorithms for Retrieving Optical Properties of Opaque Ice Clouds"



	Version 3	V4 Test08
min	-0.40	-0.19
max	10.41	9.77
median	0.29	0.39
mean	0.71	1.47
stdev	0.95	2.04
samples	7616446	7558033

CIRRUS LIDAR RATIO RETRIEVALS

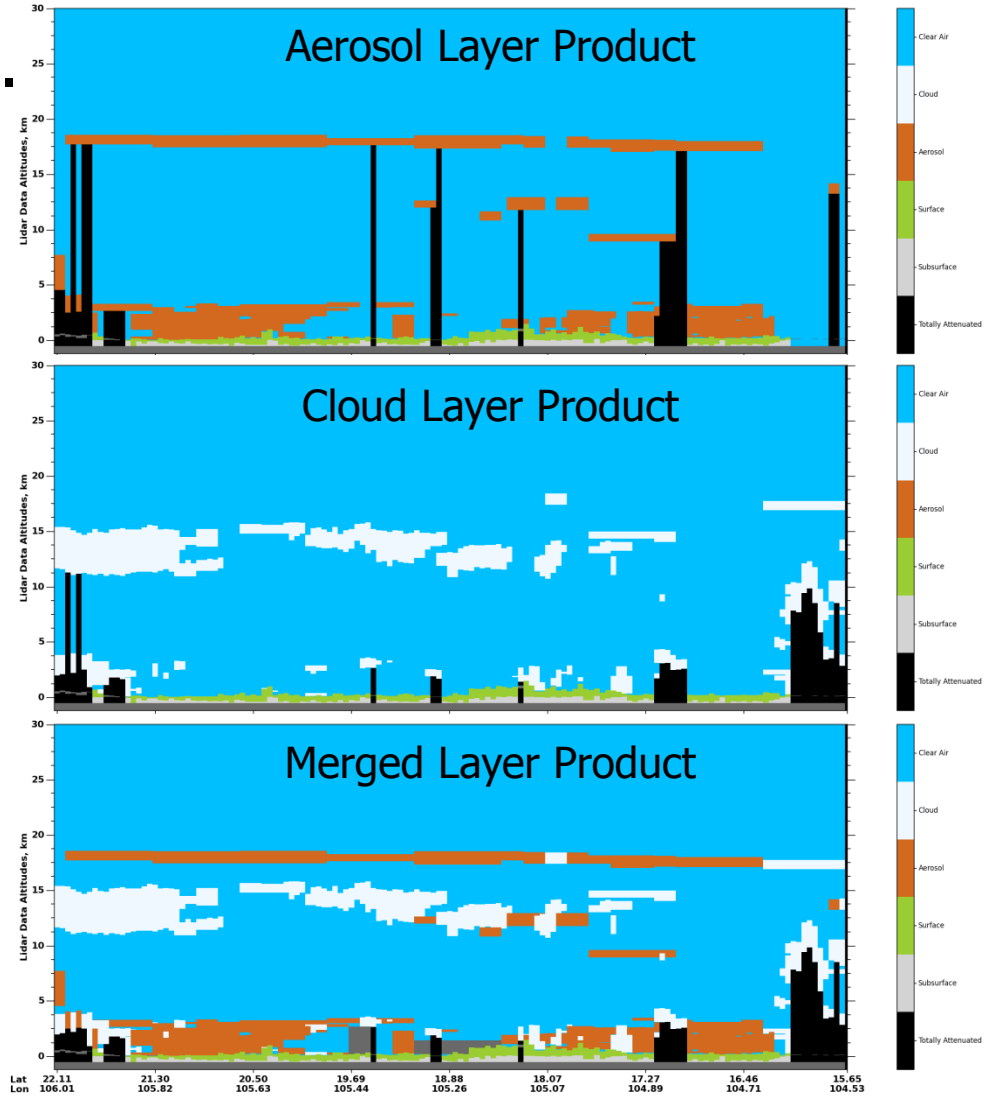
POSTER: YOUNG ET AL., "V4 ALGORITHMS FOR RETRIEVING OPTICAL PROPERTIES OF OPAQUE ICE CLOUDS"



New Data Products

Poster: Ryan et al., "CALIPSO's New 5km Merged Layer Product for V4 Level 2 Data Products"

- Expanded reporting of surface characteristics; e.g.
  - Color ratio
  - Depolarization ratio
  - Integrated backscatter
- 1/3-km layer detection results in 5-km layer products
- Lidar ratio uncertainties in 5-km layer products
- Layer centroid temperatures in all layer products
- Layer attenuated scattering ratio statistics in all layer products
- 5-km merged cloud and aerosol layer product



Holz et al., ACPD 2015:

Resolving ice cloud optical thickness biases between CALIOP and MODIS using infrared retrievals

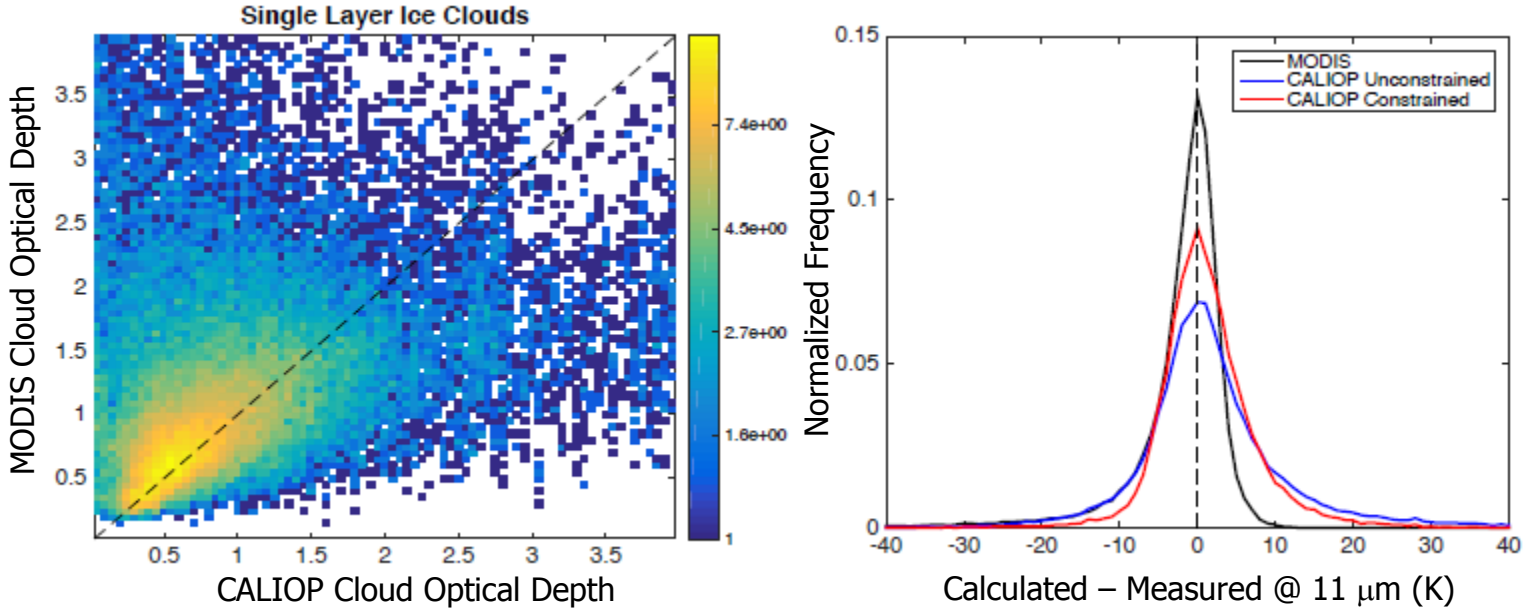


Figure 10. The CALIOP unconstrained IOT but processed using a modified lidar ratio of 32 is compared to the new single habit ice scattering LUT used in the updated MODIS C6 IOT retrievals in the left (a) panel. Notice the improved bias relative to the MODIS C5 and V3 CALIOP retrievals presented in Fig. 1. The radiative closure analysis using the updated retrievals is presented in the right (b) panel. The modifications have greatly improved agreement with the measured MODIS 11 μm channel compared to MODIS C5 and the current V3 CALIOP retrievals presented in Fig. 2.

In Case There Are Questions...

MATHEMATICS OF TOTALLY ATTENUATING LAYERS
VERSION 3

Platt's Equation: $\gamma' = \frac{1 - T^{2\eta}}{2\eta S} \Rightarrow \tau = -\left(\frac{1}{2\eta}\right)\ln\left(1 - 2\eta S\gamma'\right)$

to solve, must choose S so that $(1 - 2\eta S\gamma')$ is positive

for totally attenuating layers, $T^{2\eta} = 0$, so $\gamma' = \frac{1}{2\eta S}$ and thus $S = \frac{1}{2\eta\gamma'}$

when the CALIPSO extinction algorithm encounters a totally attenuating layer for which the estimated value of S is too large, it successively reduces the value of S in increments of 5% until a solution is achieved. so…

$$\tau = -\left(\frac{1}{2\eta}\right)\ln\left(1 - 2\eta\left(0.95\left(\frac{1}{2\eta\gamma'}\right)\right)\gamma'\right) = -\left(\frac{1}{2\eta}\right)\ln\left(0.05\right)$$

for cirrus clouds, $\eta = 0.6$, so that $-\left(\frac{1}{2\times 0.6}\right)\ln\left(0.05\right) = \mathbf{2.496}$

First presented at the CALIPSO Science Team Meeting, March 11-13 2008