

CLOUD PROPERTIES FROM MODIS AND CALIOP ...

Steve Ackerman, R. Holz, R Frey, S.
Platnick, A. Heidinger, and a bunch
of others....



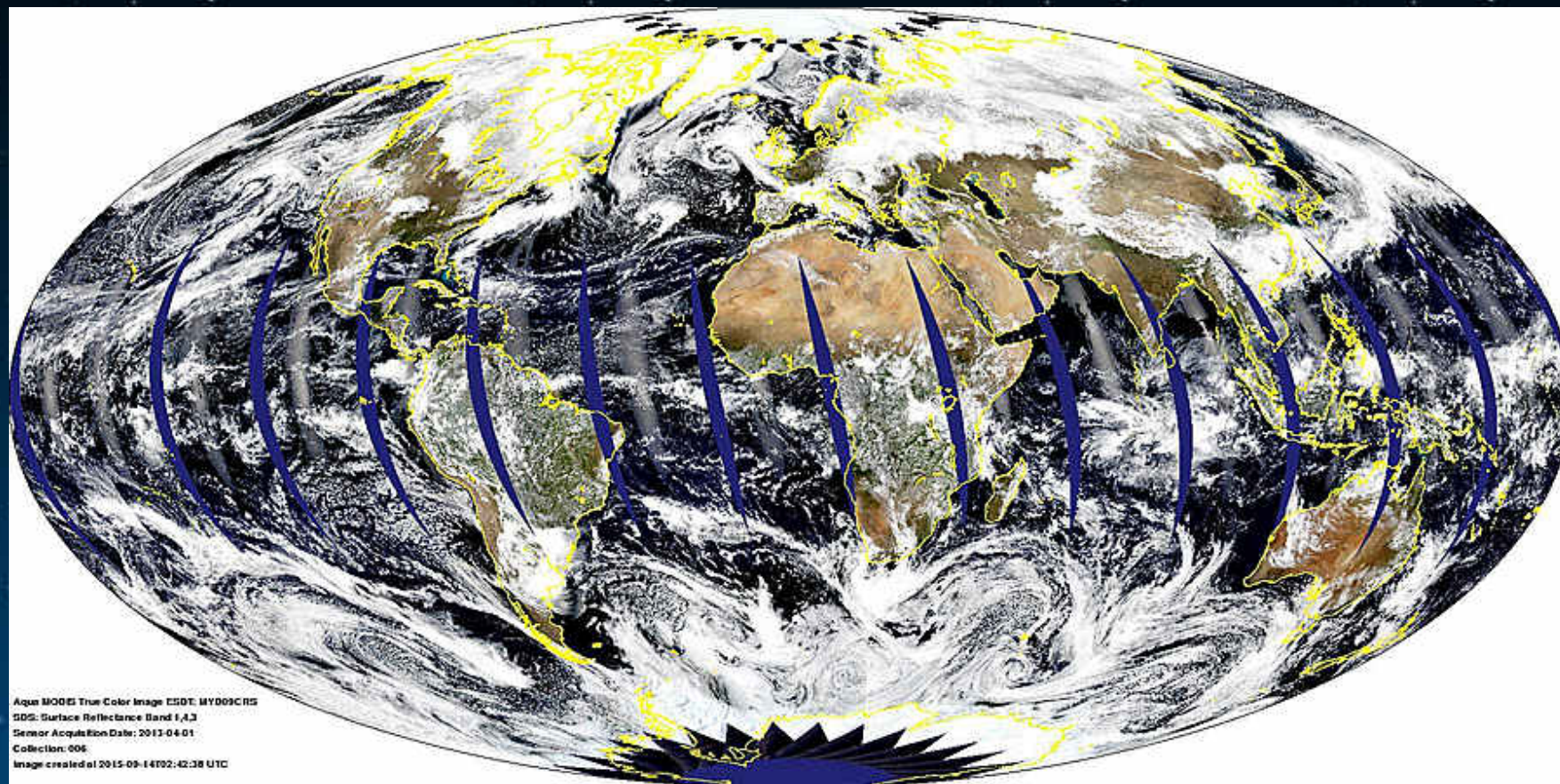
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Outline

- Using CALIOP to Validate MODIS
 - Cloud Detection,
 - Cloud Height Assignment,
 - Optical Properties
- Clouds and Surface
- Low level (<5 Km cloud tops) Marine Clouds

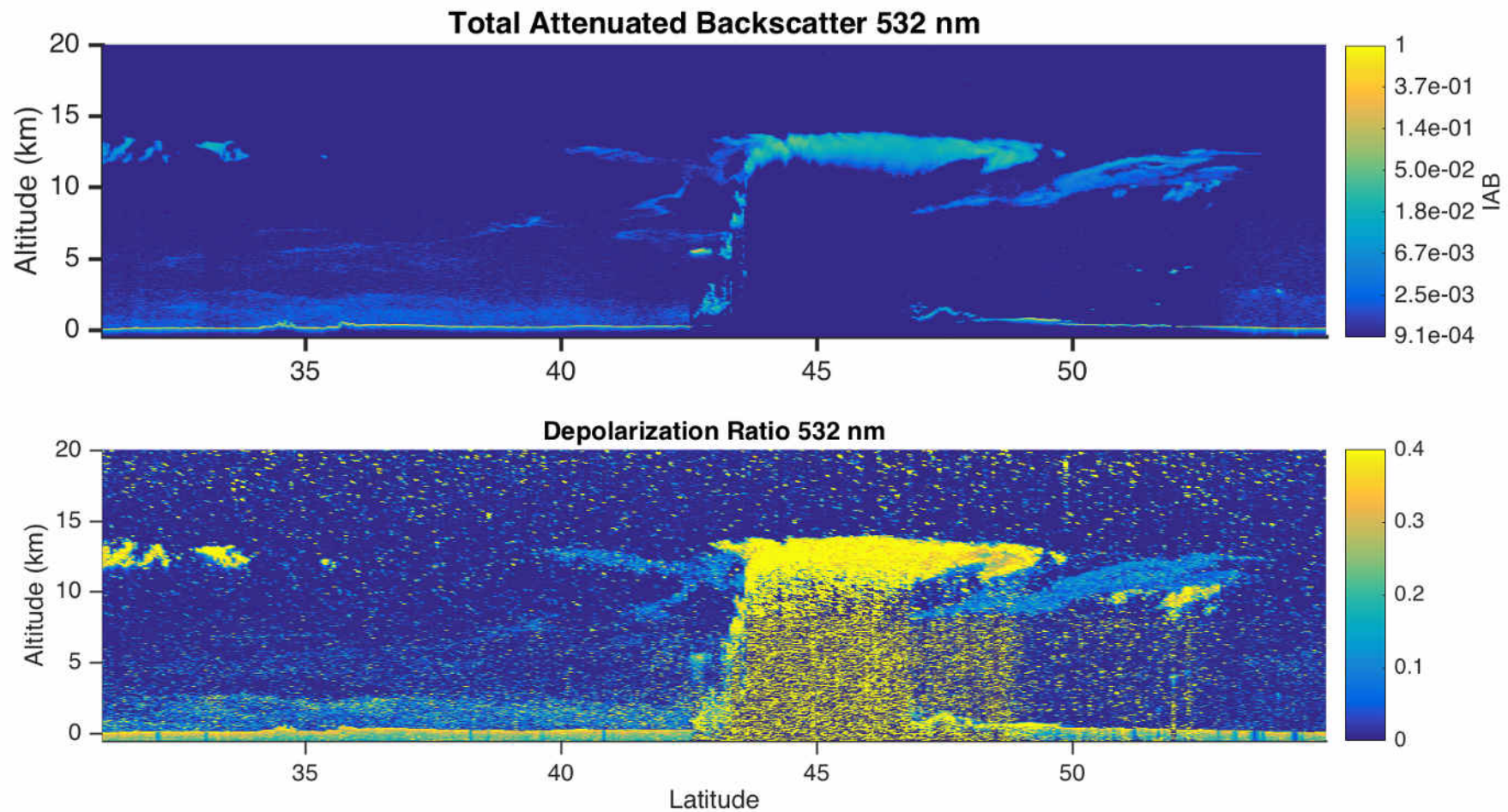


Horizontal Sampling of MODIS

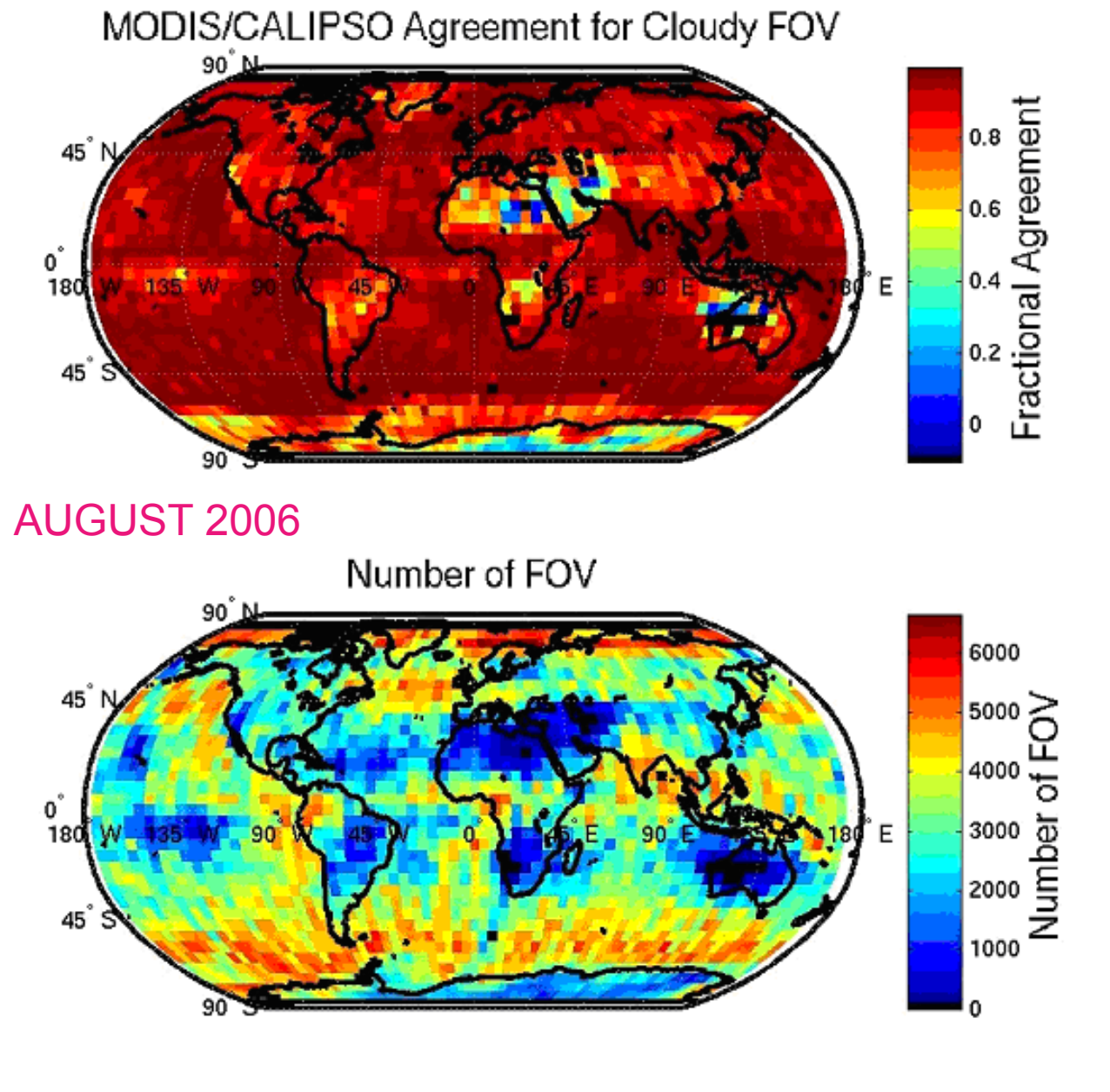


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Vertical sampling CALIOP



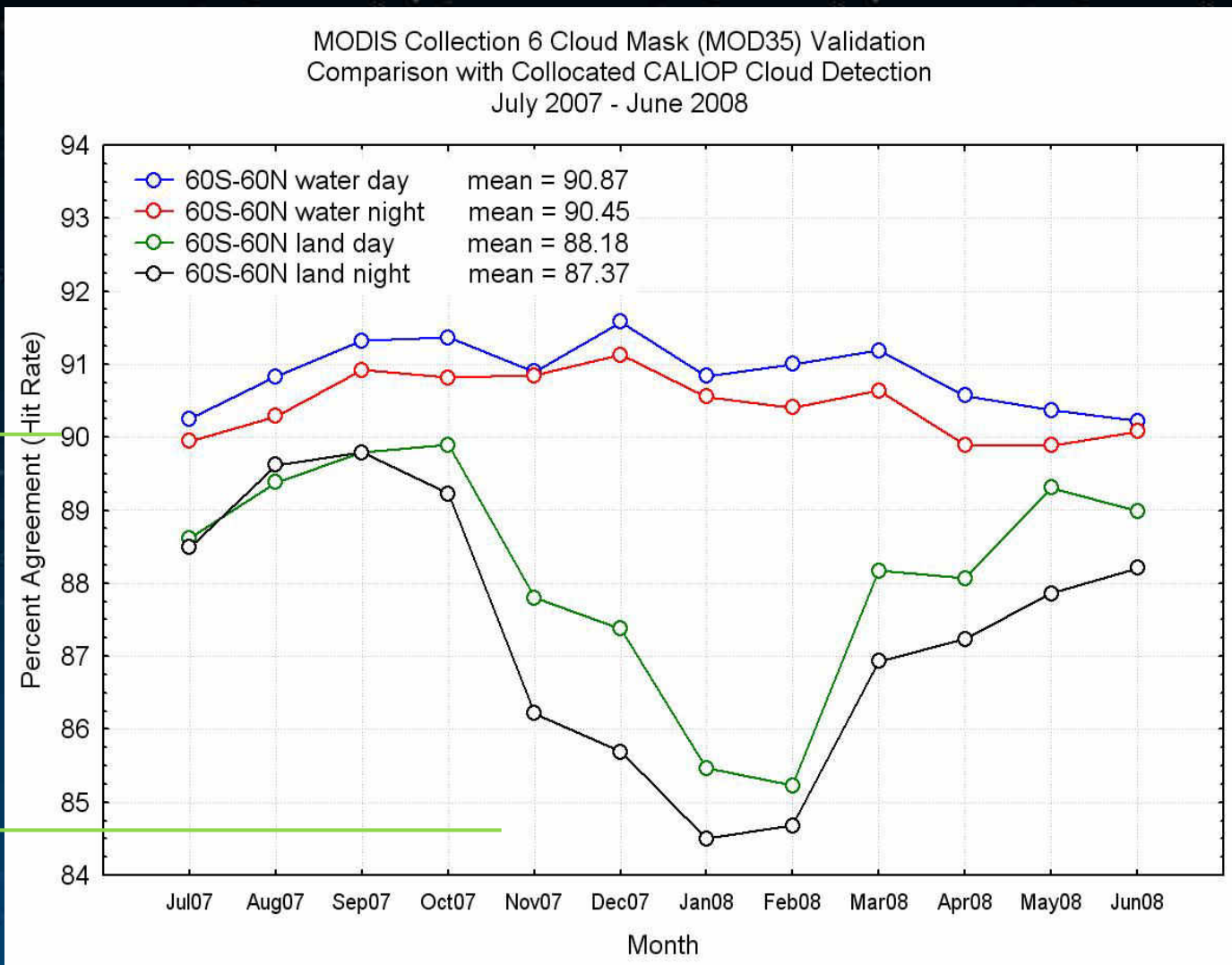
Validation of cloud and clear sky detection



Zonal Means July 2007 – June 2008

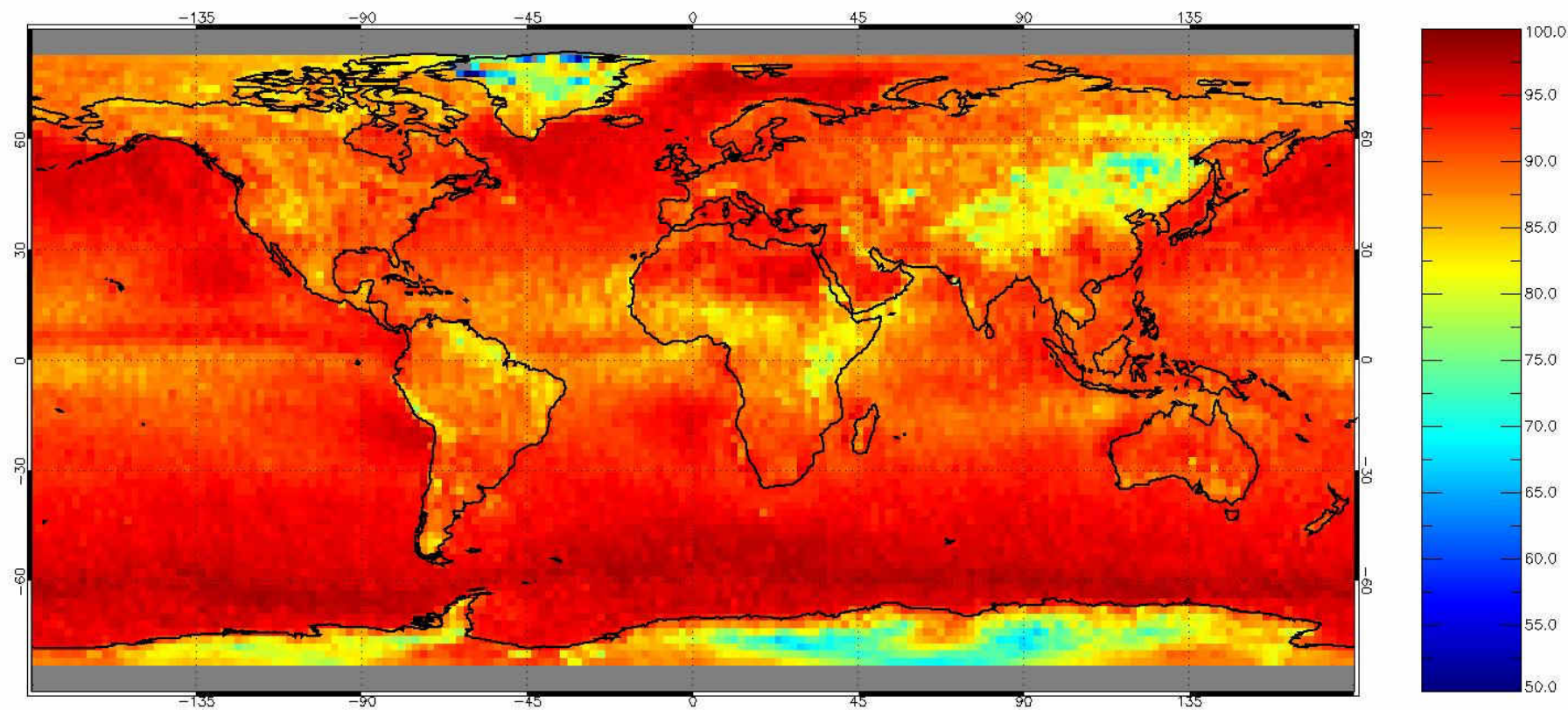
High agreement for
ocean scenes

Cold land night a
problem



Agreement 2007-2012

2007-2012 MYD35 C6 vs. CALIOP Day Hitrates (%)



Hit Rate (%): $(\text{\#agree clear pixels} + \text{\#agree cloudy pixels}) / \text{total pixels} * 100.0$

1-km MODIS cloud mask is compared to 1-km CALIOP data for JJA 2007-2012.

Map resolution is 2 degrees



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Validation, validation, validation...

One month, regional and Skill scores

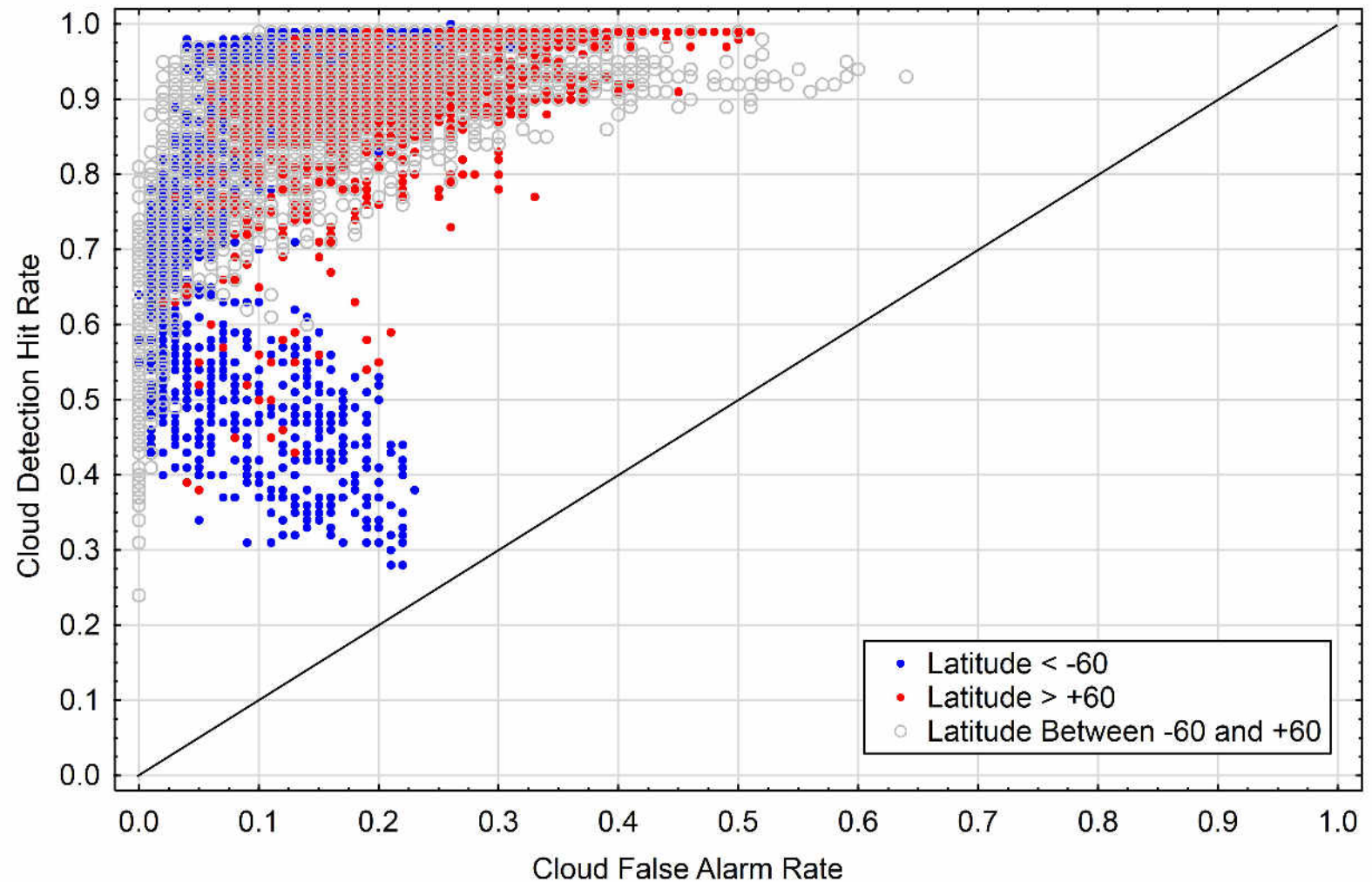
August 2014	MYD35 vs. CALIOP				MVCM Aqua vs. CALIOP				MVCM NPP vs. CALIOP (5 minute filter)			
Scene Type	HR Cloud	HR Clear	HR Comb	H-K SS	HR Cloud	HR Clear	HR Comb	H-K SS	HR Cloud	HR Clear	HR Comb	H-K SS
Global	88.6	86.6	88.0	75.2	89.0	83.6	87.3	72.6	89.0	80.7	86.4	69.7
60N-60S	91.7	88.3	90.6	78.0	92.9	84.9	90.2	77.8	91.1	84.3	88.8	75.3
Global Day	91.8	88.0	90.6	79.8	93.5	81.4	89.6	74.9	90.8	81.4	87.9	72.2
60S-60N Day	91.6	90.0	91.1	81.7	94.3	82.5	90.2	76.9	92.2	82.7	88.9	74.9
Global Night	85.5	85.3	85.4	70.8	84.6	85.8	85.0	70.4	87.2	80.1	84.9	67.3
60S-60N Night	91.8	86.3	90.1	78.1	91.6	85.8	90.3	79.1	90.0	85.9	88.7	75.9
Global Water	91.3	83.7	89.3	75.0	92.6	77.6	88.6	70.2	91.2	76.3	87.2	67.5
Global Water Day	94.1	84.5	91.4	78.6	96.5	74.4	90.2	70.9	93.0	74.9	88.0	67.9
60S-60N Water Day	93.7	86.8	91.6	80.5	96.9	75.5	90.2	72.4	94.7	76.1	89.0	70.8
Global Water Nt	88.5	82.8	87.1	71.3	88.7	81.5	86.9	70.2	89.5	77.8	86.5	67.2
60S-60N Water Nt	92.8	82.4	90.1	75.2	92.5	84.1	90.3	76.6	90.3	84.7	88.8	75.0
Global Land	81.1	90.4	85.2	71.5	78.5	91.9	84.3	70.4	82.9	86.7	84.5	69.7
Global Land Day	85.0	94.1	88.7	79.1	84.3	93.9	88.2	78.2	84.8	91.7	87.6	76.5
60S-60N Land Day	84.4	95.6	89.7	80.0	85.1	95.2	89.9	80.3	84.3	93.4	88.6	77.7
Global Land Nt	77.9	87.8	82.3	65.6	73.6	90.4	81.3	64.0	81.1	82.8	81.9	63.9
60S-60N Land Nt	88.0	91.8	89.9	79.8	87.6	92.6	90.1	80.2	88.5	88.1	88.3	76.6
Polar	81.8	82.1	81.9	63.8	80.5	80.1	80.4	60.6	84.6	70.3	80.7	54.9
Polar Day	92.2	80.4	89.4	72.5	91.8	76.9	88.3	68.7	87.9	75.9	85.3	63.9
Polar Nt	72.2	83.1	75.6	55.3	69.7	82.1	73.7	51.8	81.2	67.0	76.7	48.2
Arctic Day	91.9	79.8	88.9	71.7	91.5	76.3	87.8	67.8	88.0	75.1	85.1	63.1
Antarctic Night	68.2	84.7	73.6	52.9	65.1	83.6	71.2	48.7	78.6	67.7	75.0	46.3
Desert Day	70.1	99.0	90.8	69.1	71.4	98.6	90.8	70.0	67.8	97.0	89.0	64.9
Desert Nt	74.5	96.5	89.2	71.0	74.8	96.0	88.9	70.8	75.9	94.7	88.4	70.6



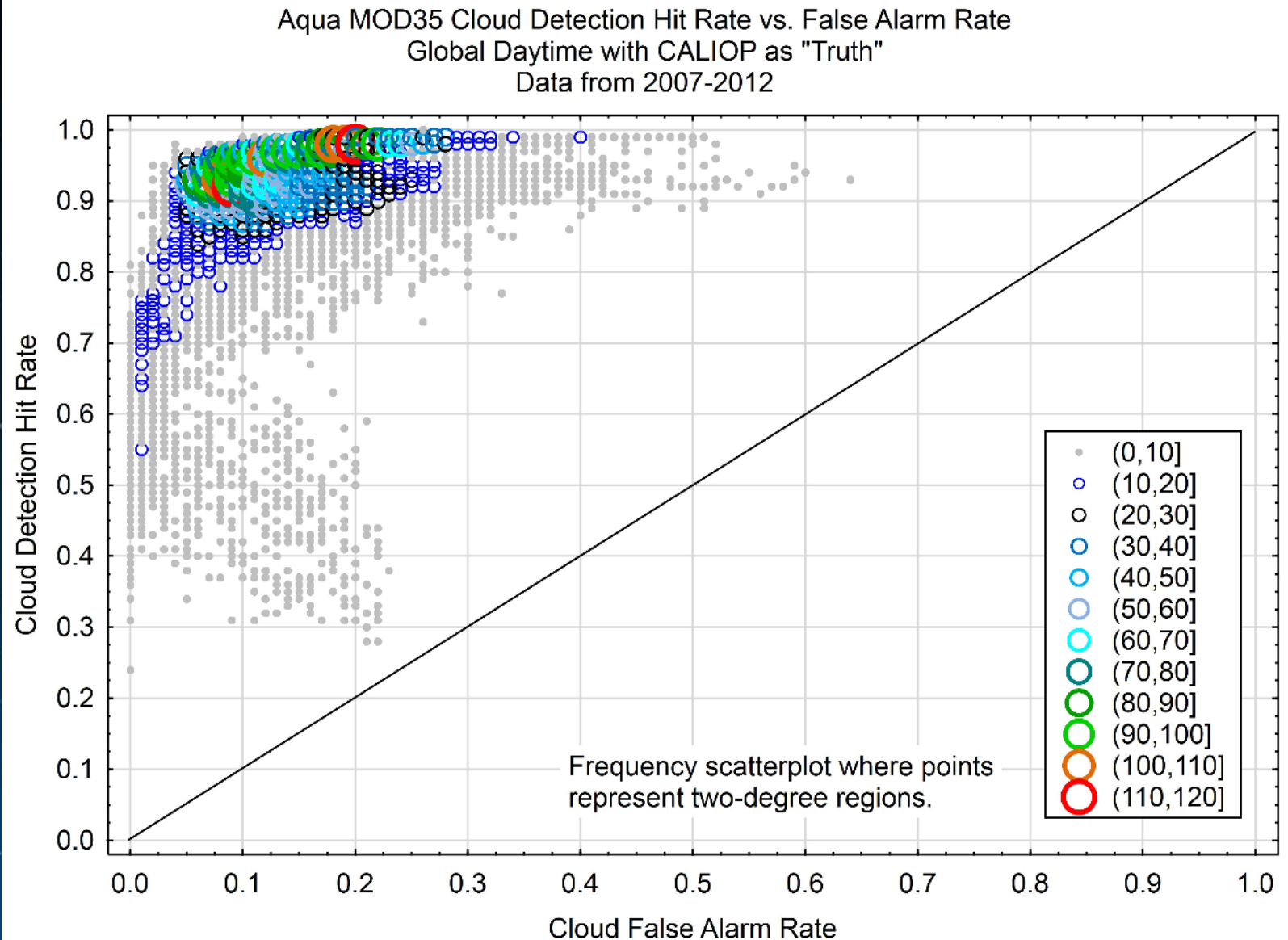
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Hit rate and false alarm... CLOUD

Aqua MOD35 Cloud Detection Hit Rate vs. False Alarm Rate
Global Daytime with CALIOP as "Truth"
Data from 2007-2012

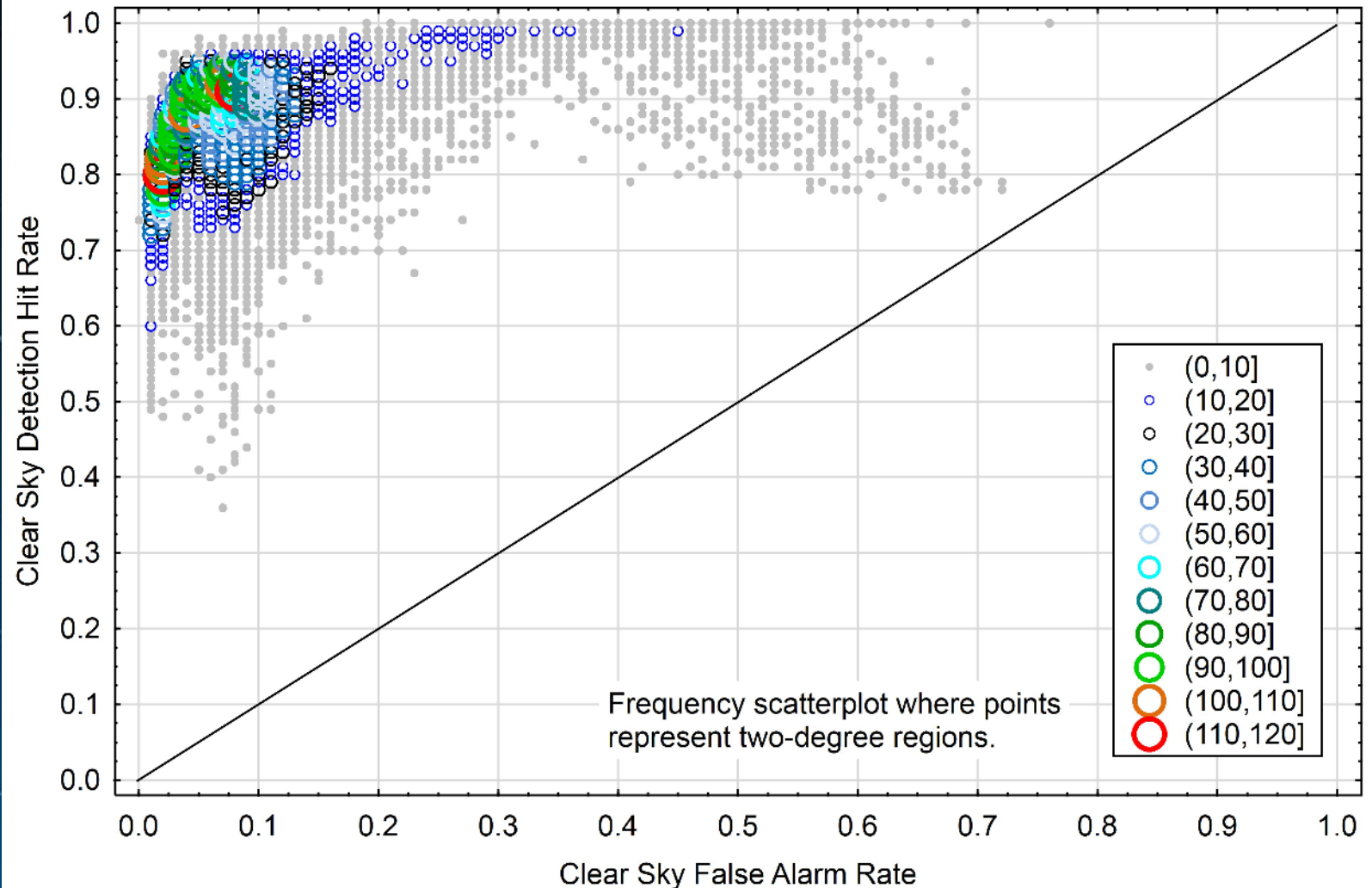


Hit rate and false alarm... CLOUD



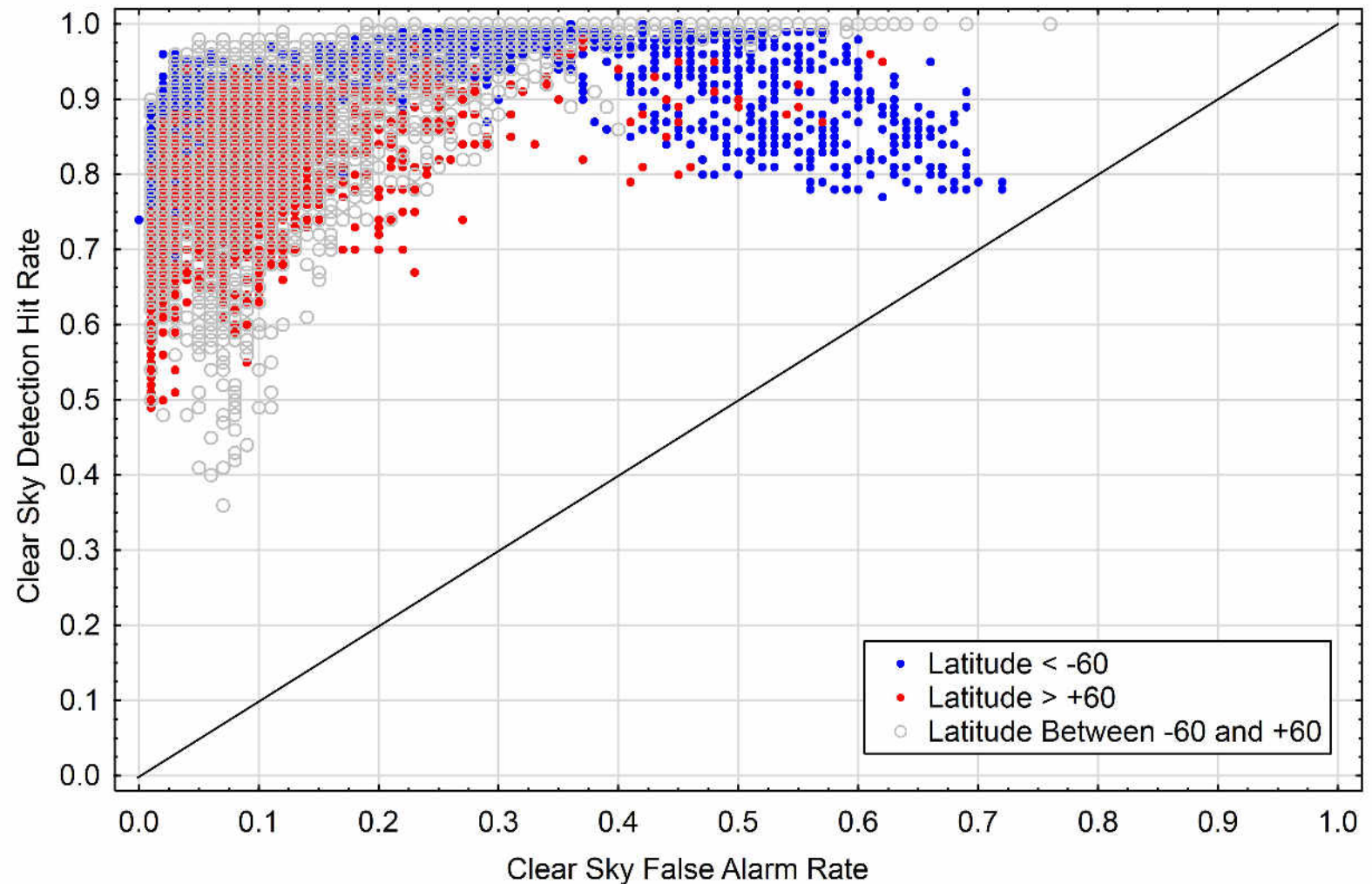
Hit rate and false alarm... CLEAR

Aqua MOD35 Clear Sky Detection Hit Rate vs. False Alarm Rate
Global Daytime with CALIOP as "Truth"
Data from 2007-2012

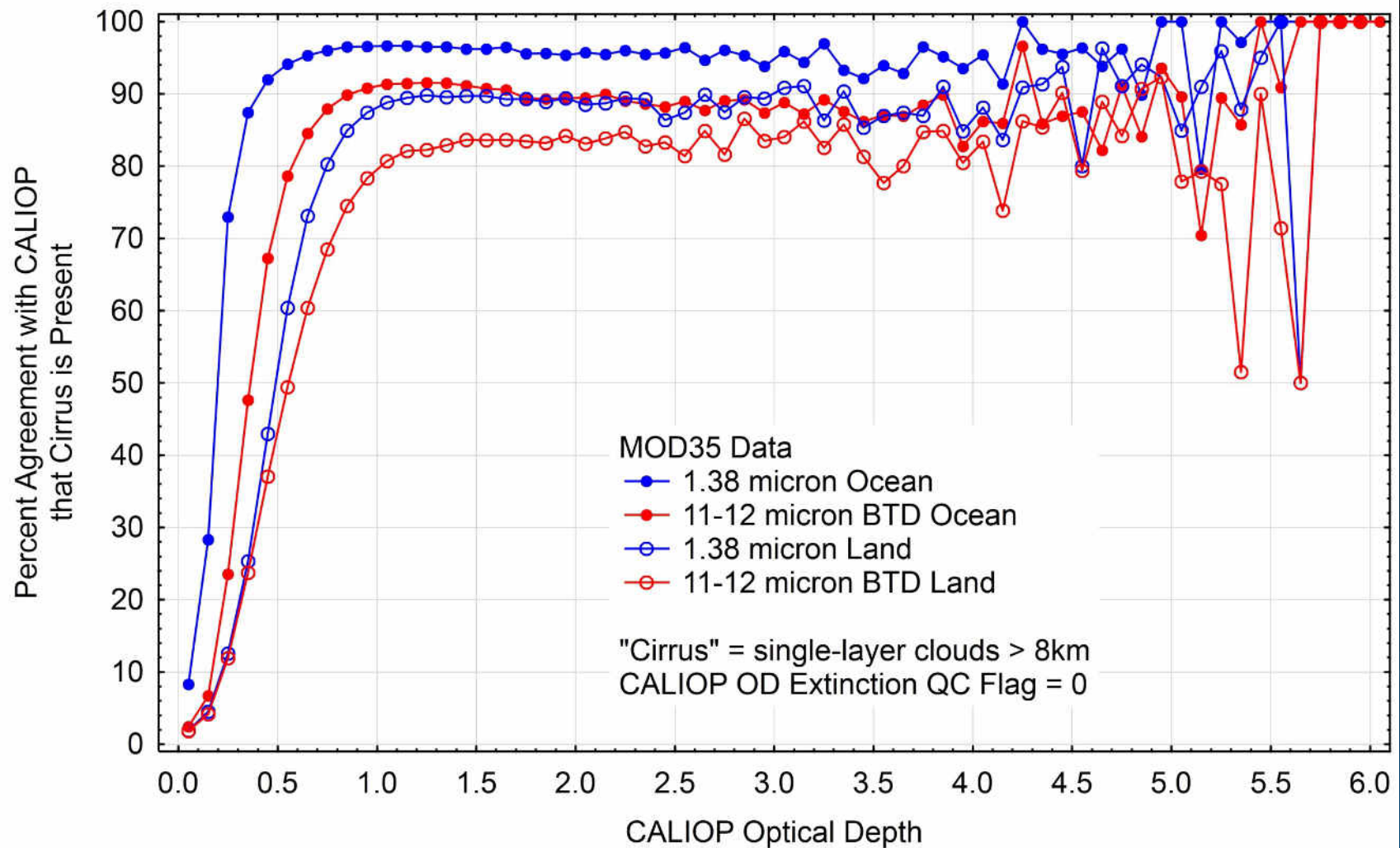


Hit rate and false alarm... CLEAR

Aqua MOD35 Clear Sky Detection Hit Rate vs. False Alarm Rate
Global Daytime with CALIOP as "Truth"
Data from 2007-2012



Percent Daytime Cirrus Detected by MODIS 1.38 and 11-12 micron Tests
 CALIOP Cirrus Detection is "Truth"
 Confidence of Cloud > 0.5
 13 June 2006 to 25 June 2013
 60S-60N Latitude



Cloud fraction as a function of scene

Cloud amounts at 1 km scale from CALIOP and MODIS Water/Land over South America

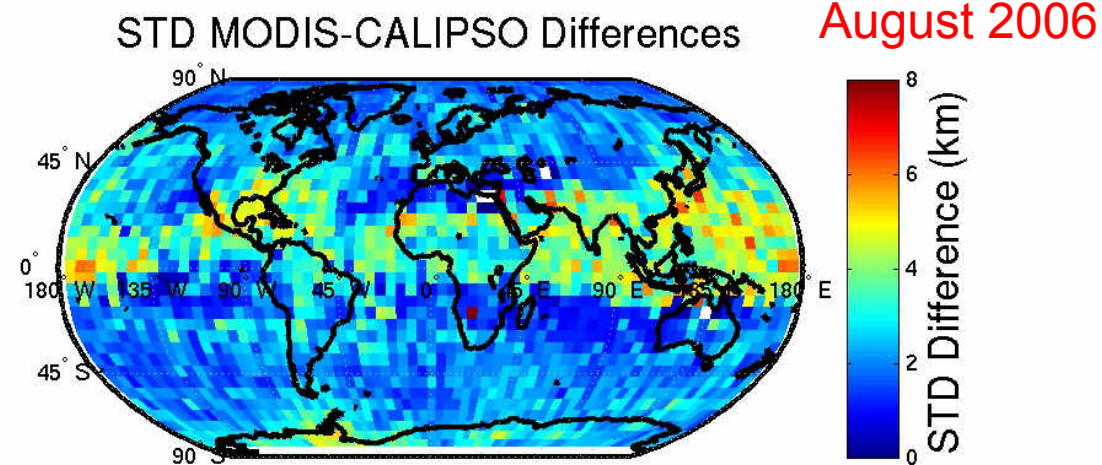
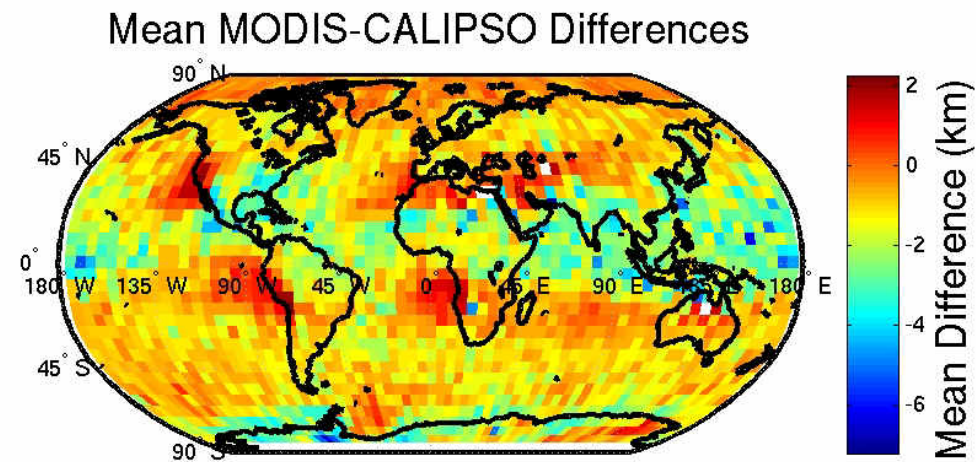
Instrument/ Scene	Day Mean Cloud Amounts (%)
CALIOP Water	26.6
CALIOP Land	34.2
MYD35 Water	24.2
MYD35 Land	34.9



Cloud Top Altitude



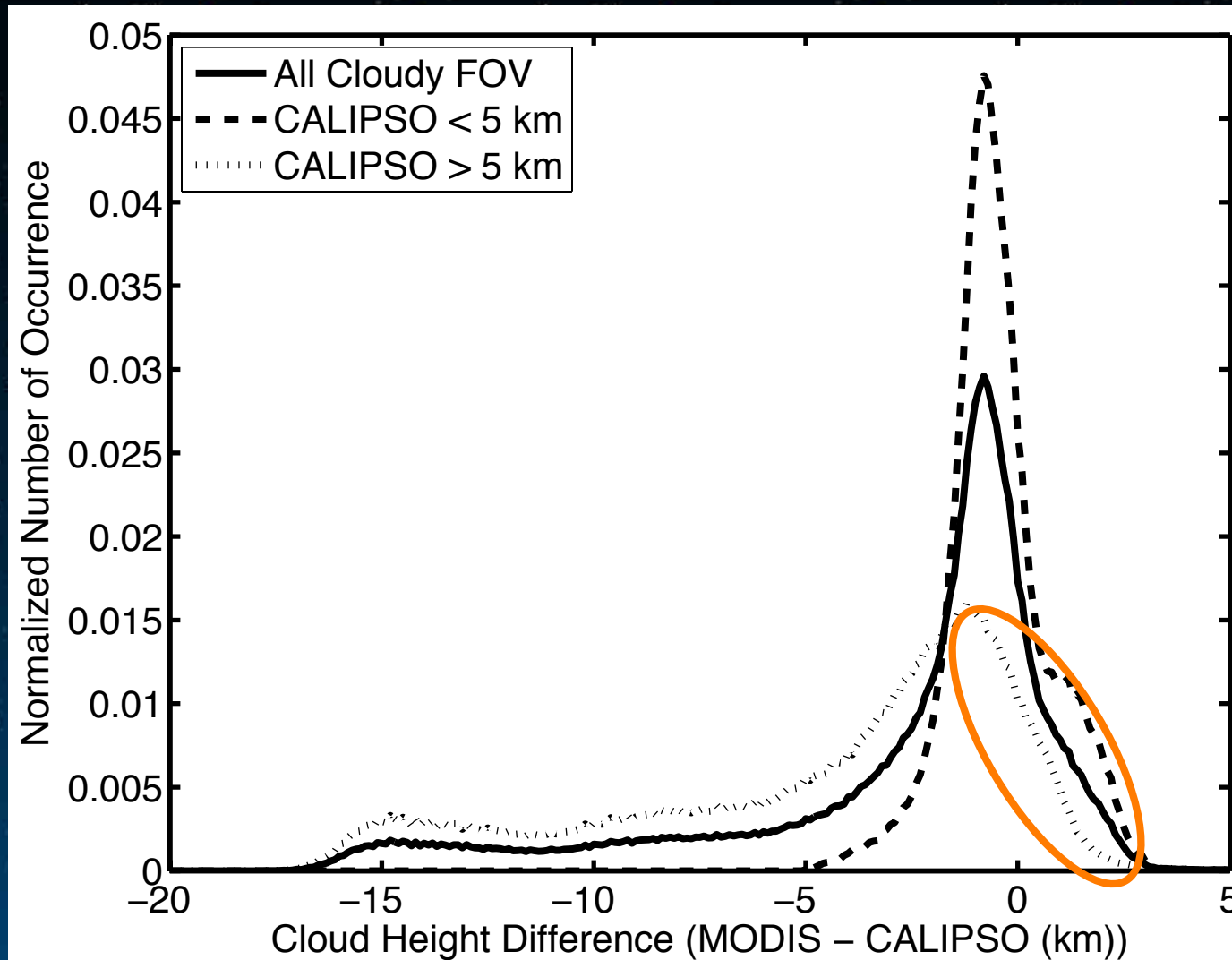
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The mean cloud top height differences (MODIS – CALIOP). The bottom image presents the standard deviation of the MODIS – CALIOP cloud height differences for each 5-degree region.



Derived cloud top altitude comparison



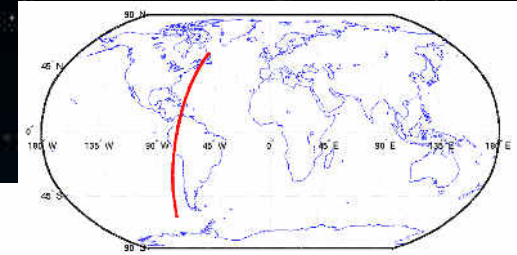
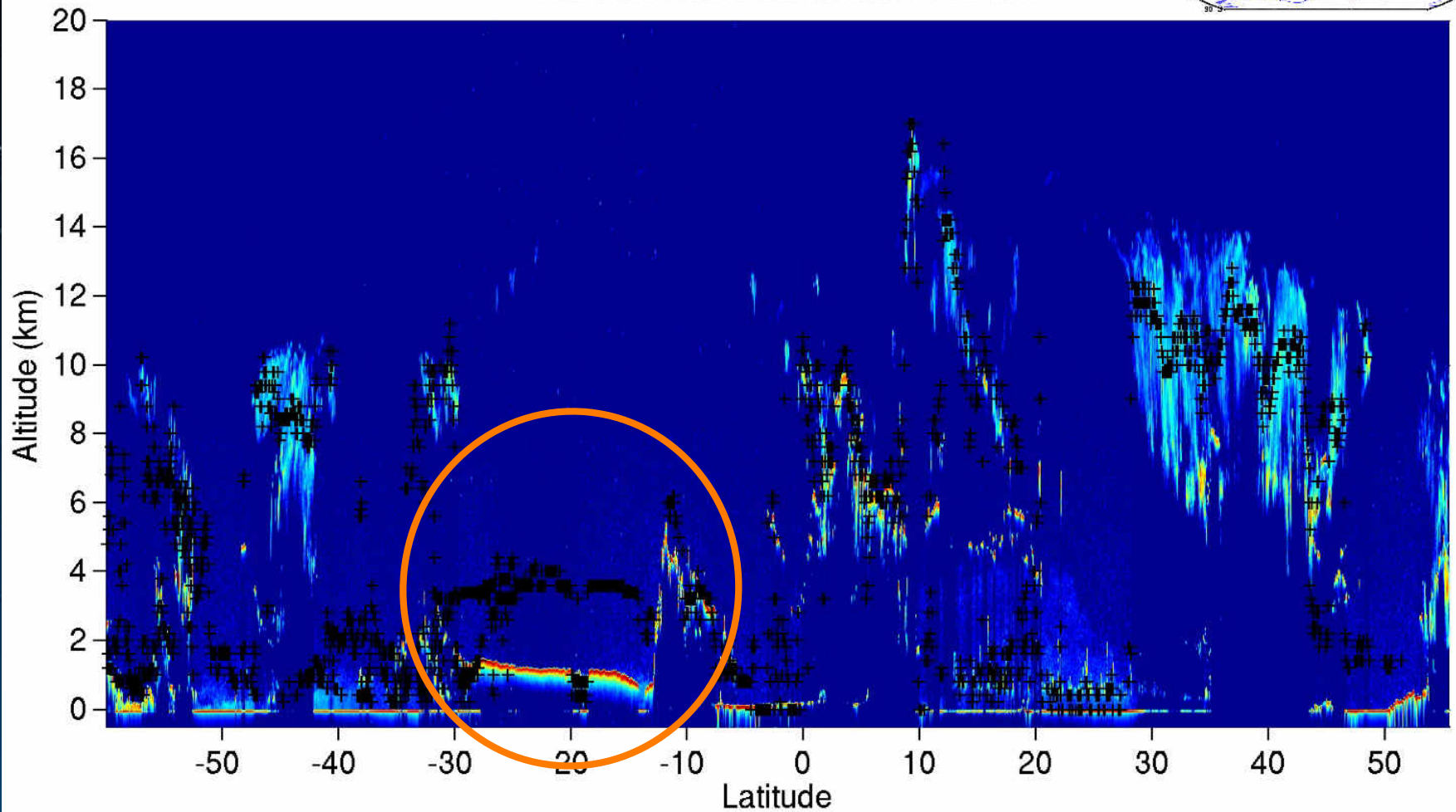
As expected, for thin clouds, the MODIS (IR passive approach) is sensitive to a layer below the physical cloud top.



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CALIPSO/MODIS Comparison

Total Attenuated Backscatter 532 nm



Comparison is helping to understand performance of MODIS CO2
Slicing derived cloud altitudes. Black points are MODIS cloud heights.



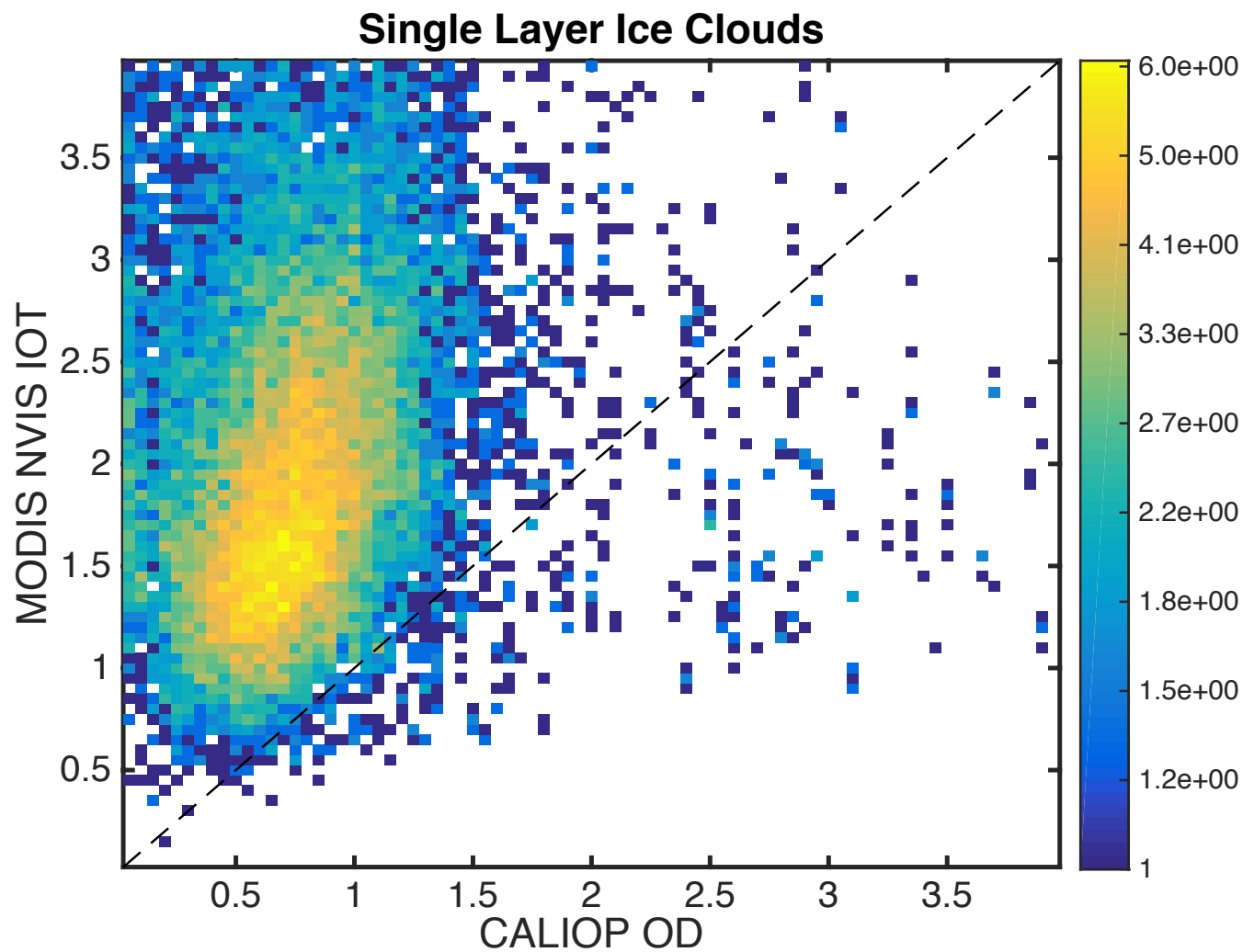
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Cloud Optical Depth

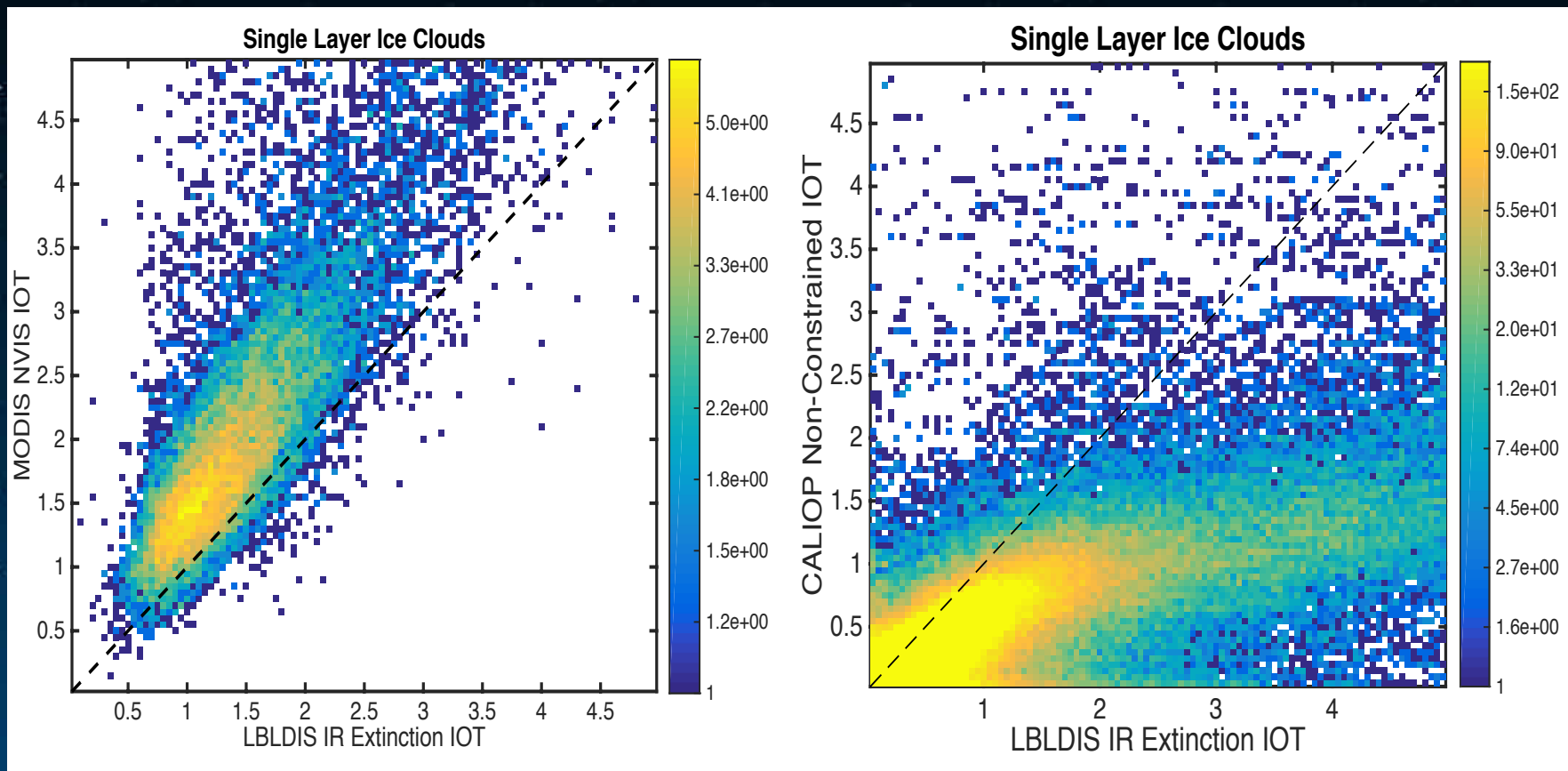


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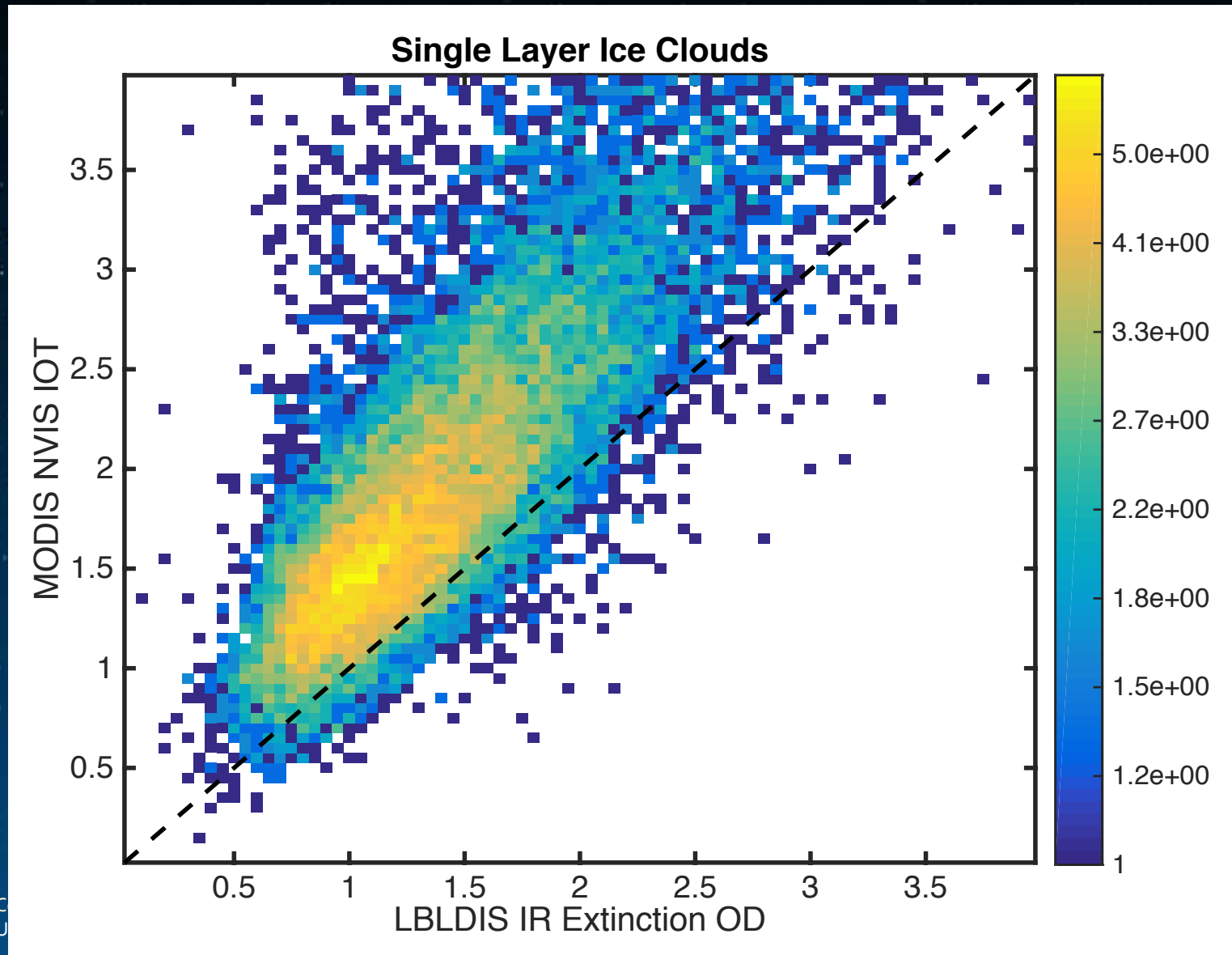
Cirrus Optical Depth



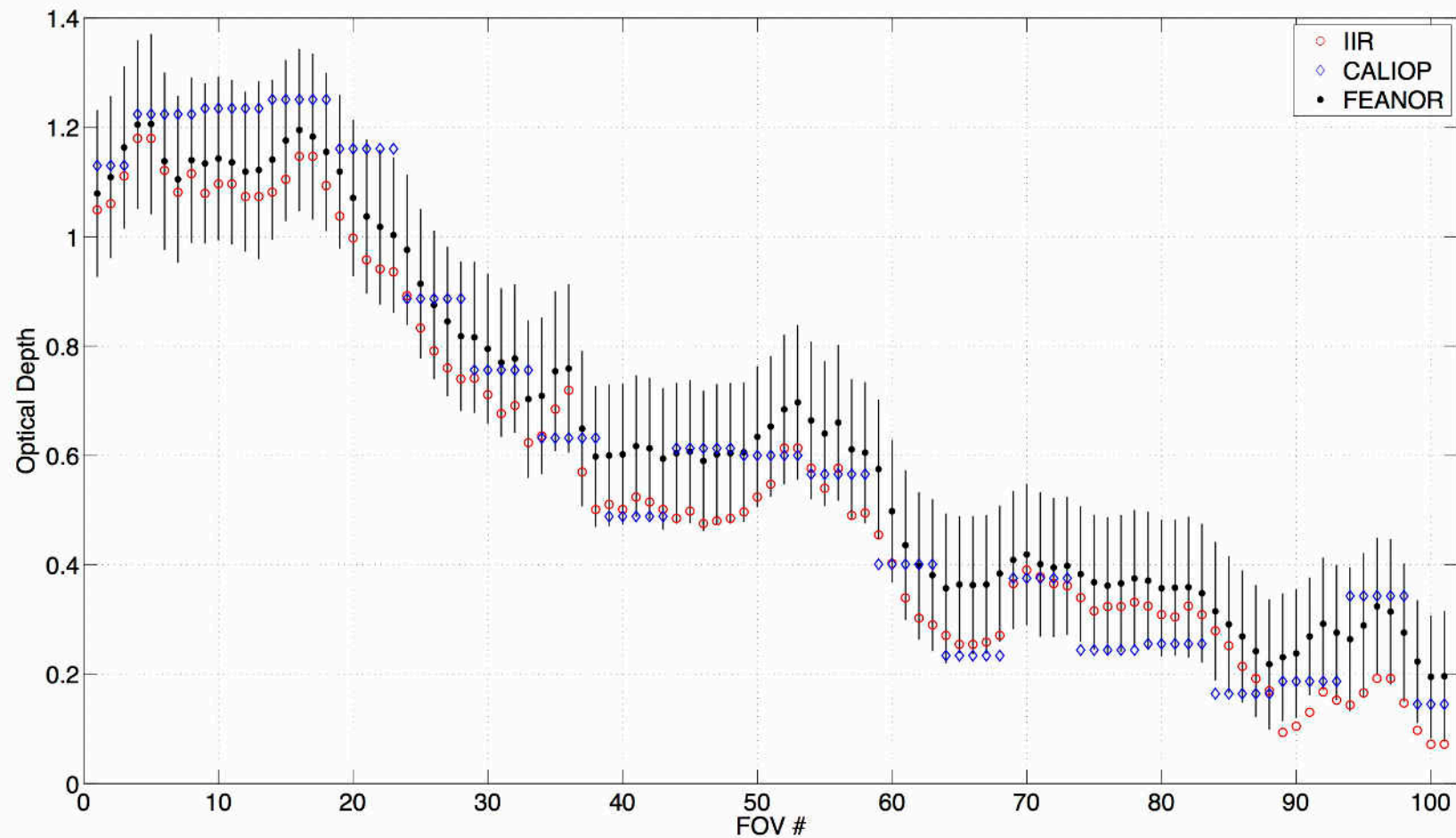
Cirrus Optical Depth: MODIS C5, CALIOP and IR



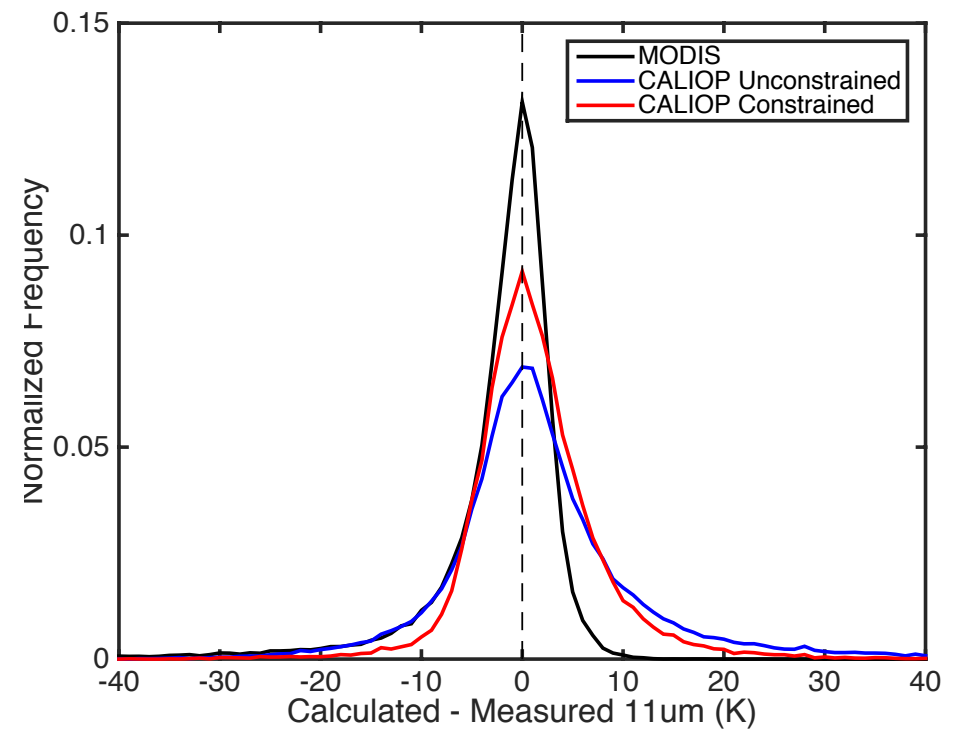
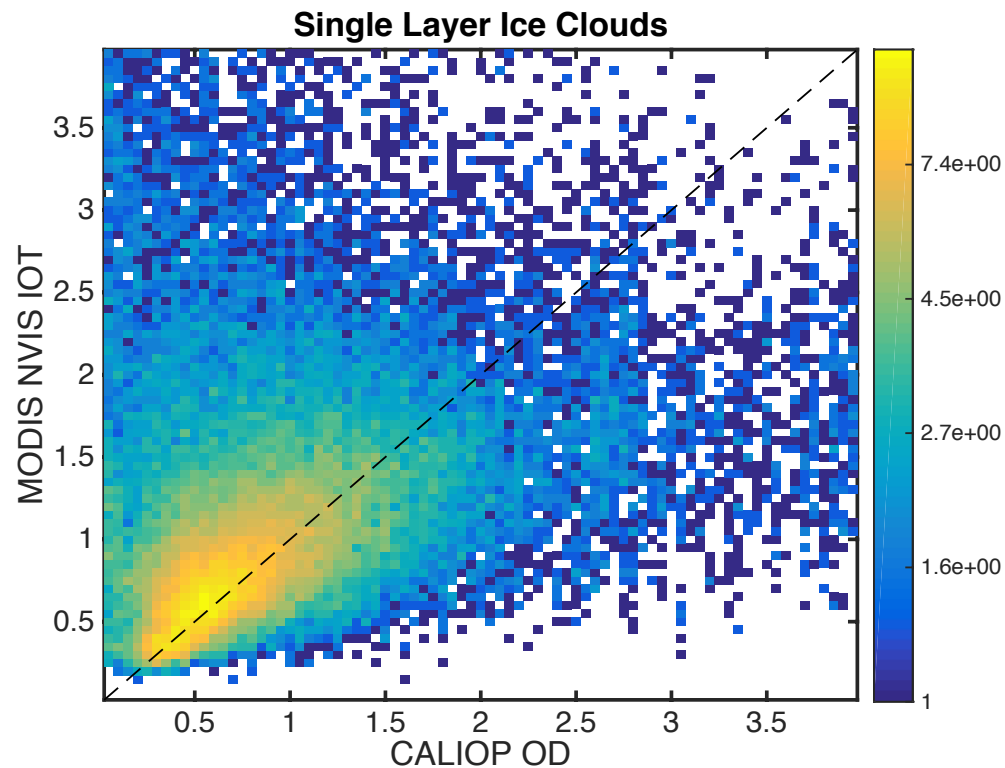
Cirrus Optical Depth



IR Cloud Optical Depth Comparison



Cirrus Optical Depth



Improvements made for Collection 6



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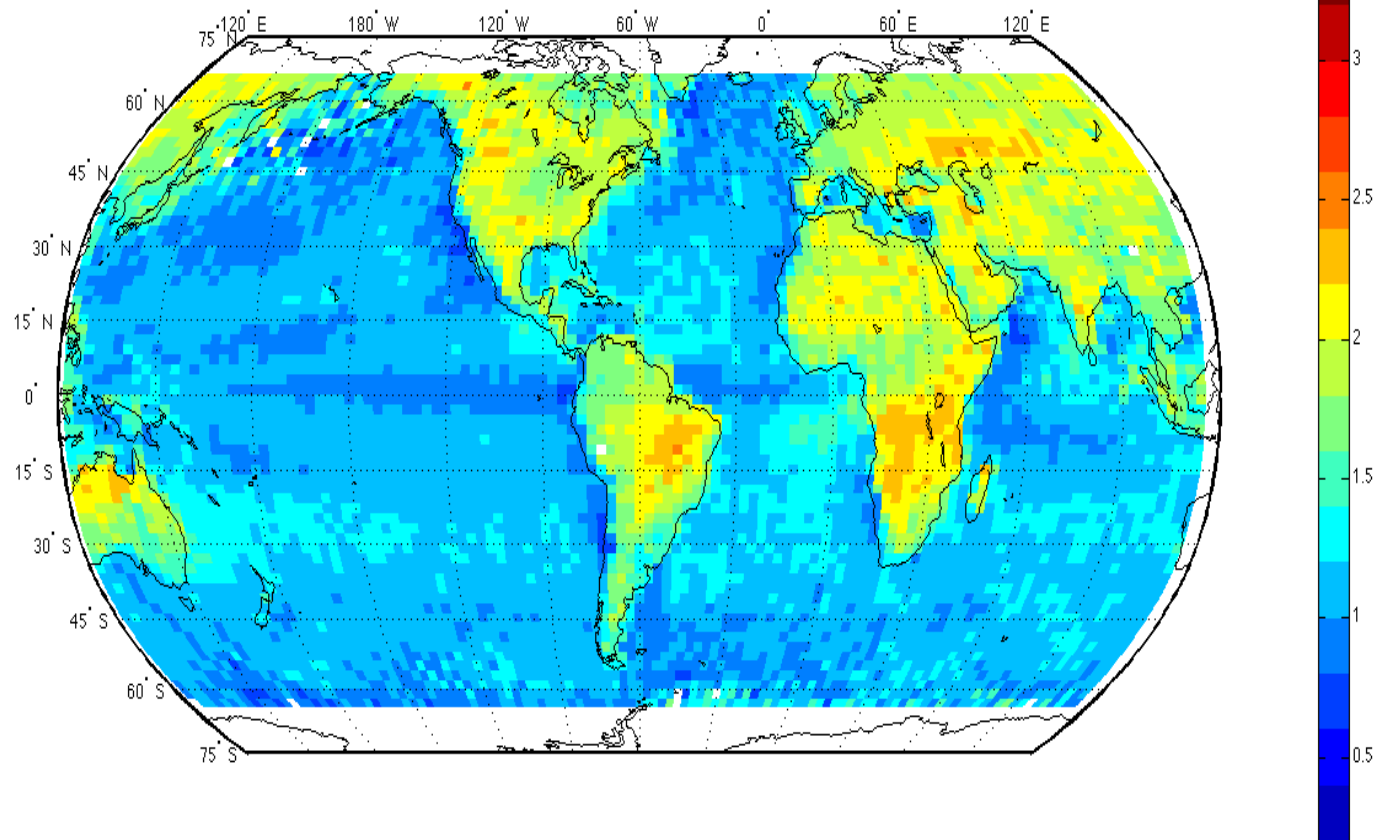
Clouds In the Boundary Layer



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“Boundary Layer” Heights

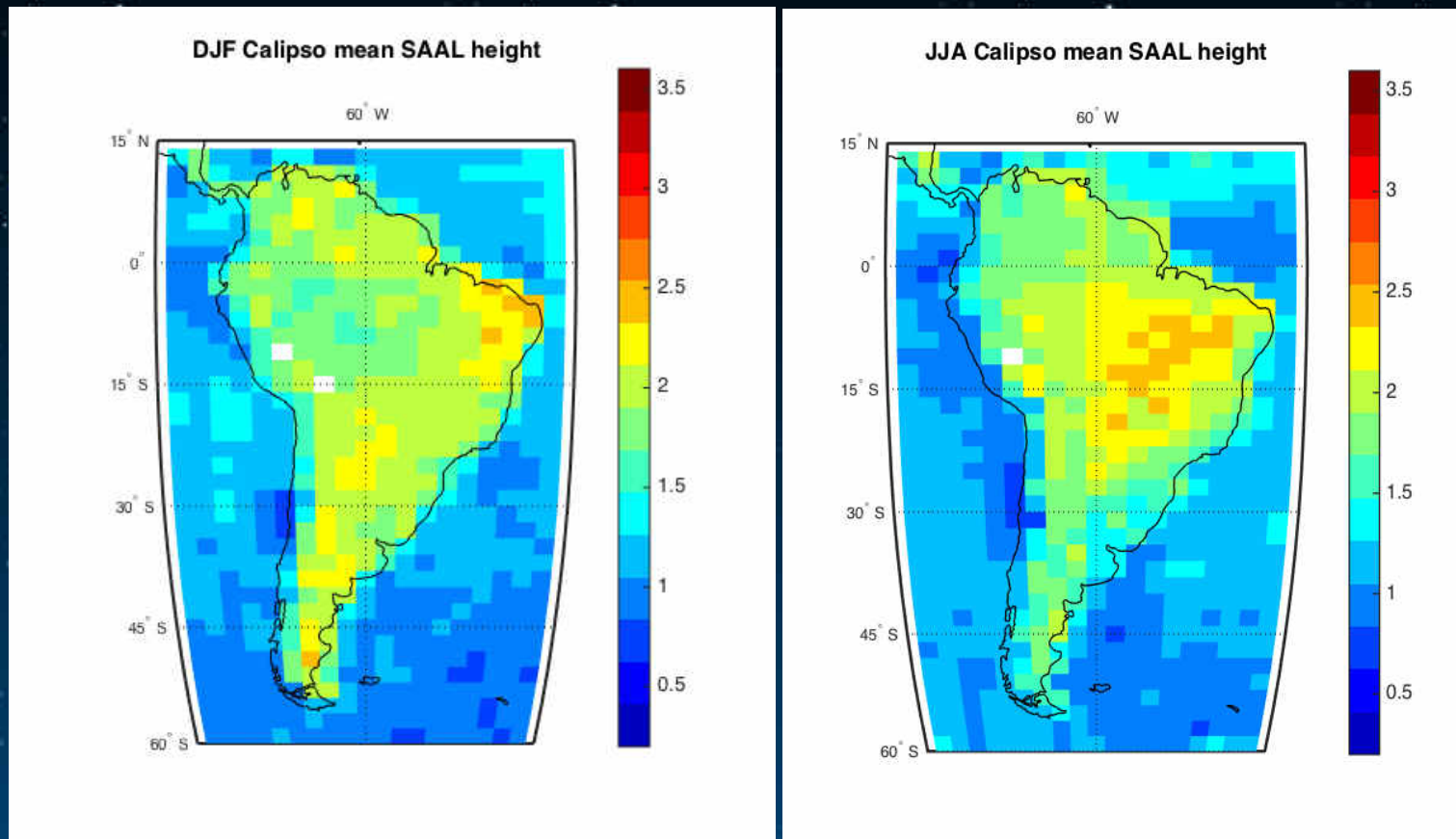
JJA CALIPSO ‘PBL’ HEIGHT



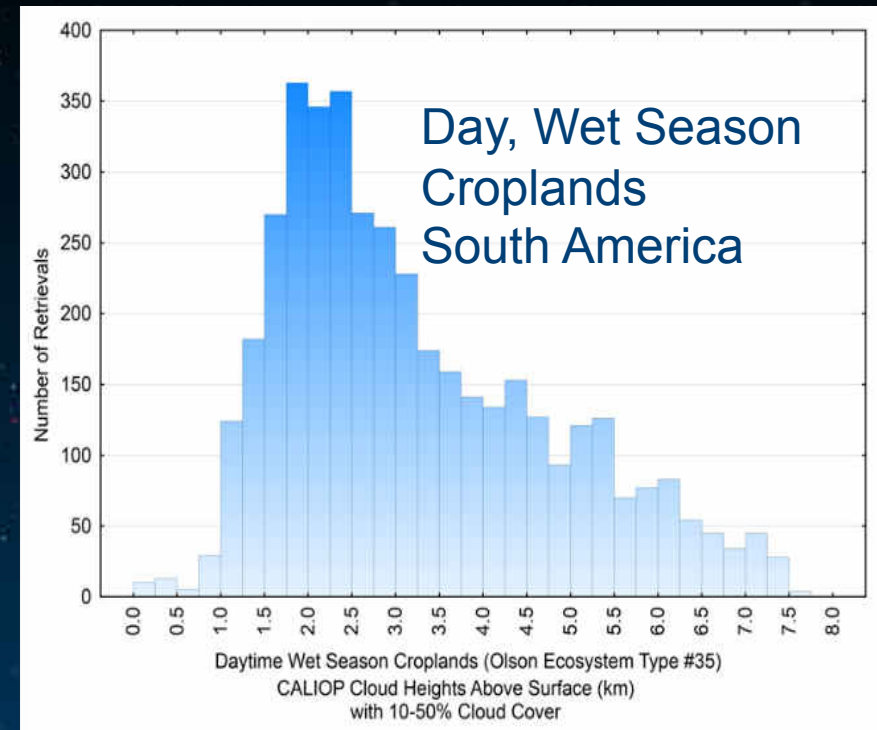
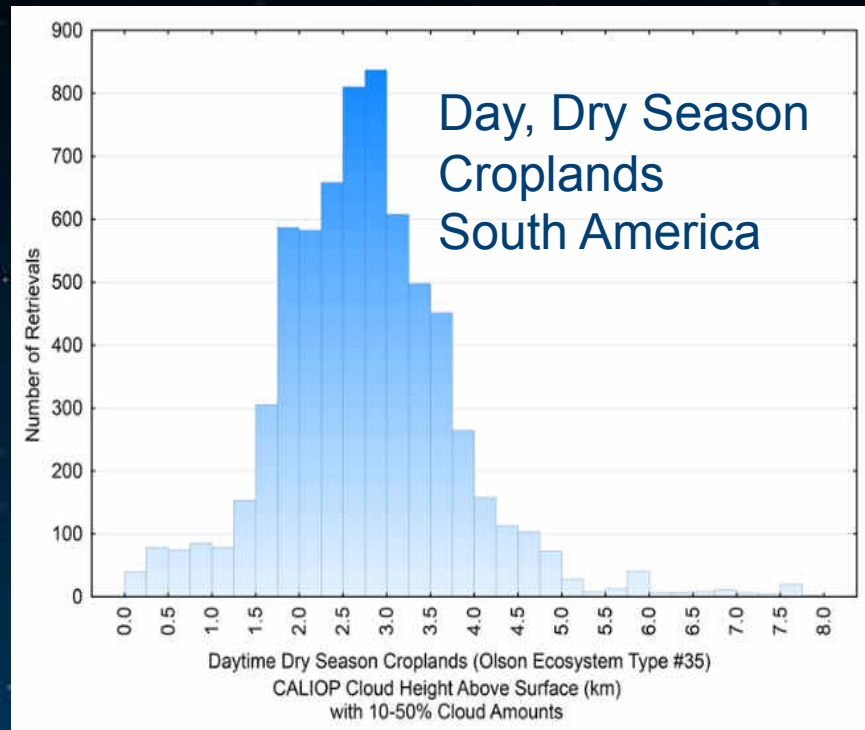
“Boundary Layer Height”

DJF

JJA



Cloud Top variations



A histogram analysis of CALIOP derived cloud top altitude in km above the surface, for cloud tops less than 8 km over South America for ecosystems classified as Croplands for the dry season (left) and the wet season (right) during daytime.



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Cloud microphysics...



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MODIS, CALIOP and CloudSat together

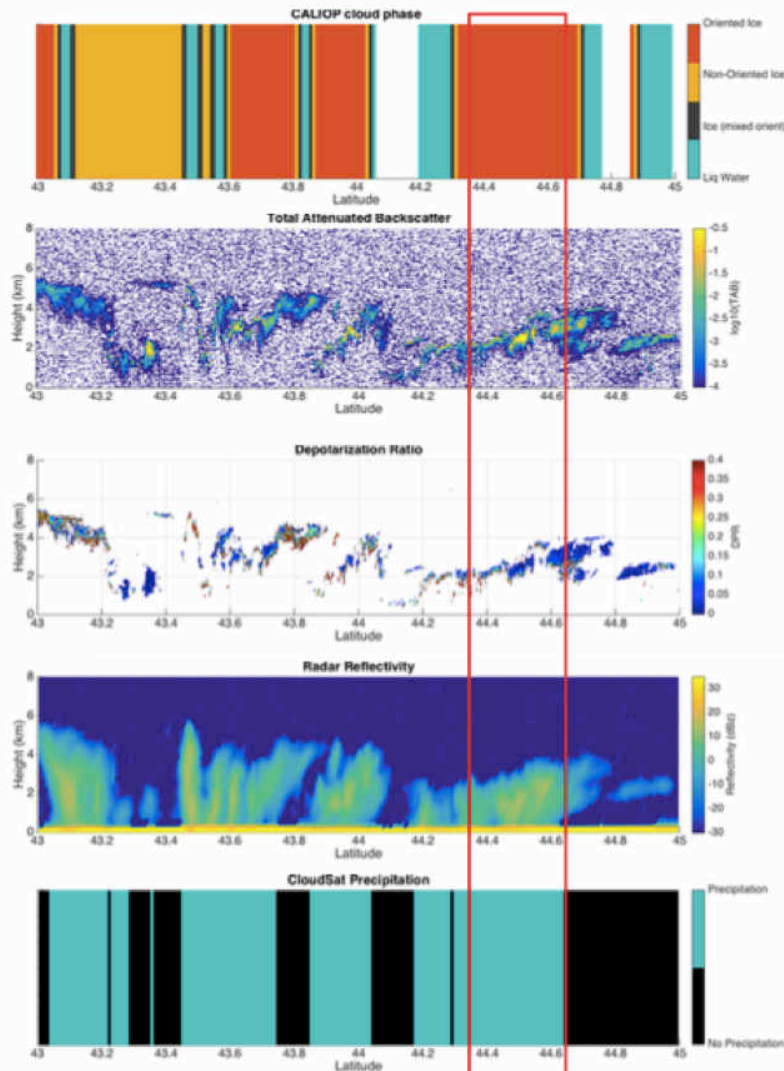


Figure 4.3: A case study above the North Pacific for February 21, 2007 at 21:30:55 UTC, data shown span 43° N to 45° N. Panels from top to bottom are: CALIOP cloud phase and ice orientation for Layer 1, CALIOP profile of total attenuated backscatter γ , CALIOP profile of depolarization ratio δ ,

CALIOP Cloud Phase

CALIOP Backscatter

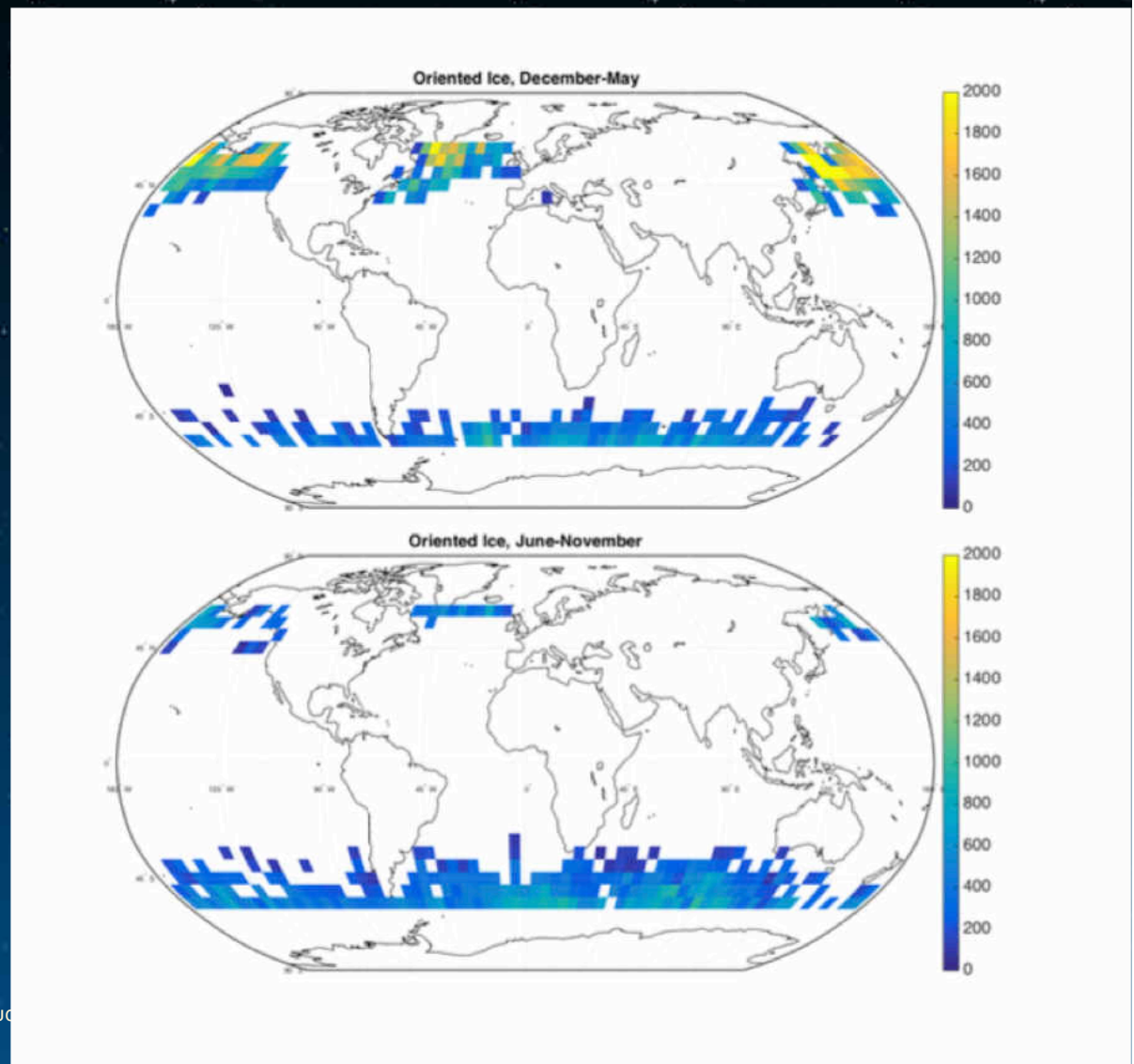
CALIOP Depolarization

CloudSat radar reflectivity

CloudSat precipitation flag

Occurrence of CALIOP oriented Ice Crystals

One year, ocean areas and cloud top below 5 km



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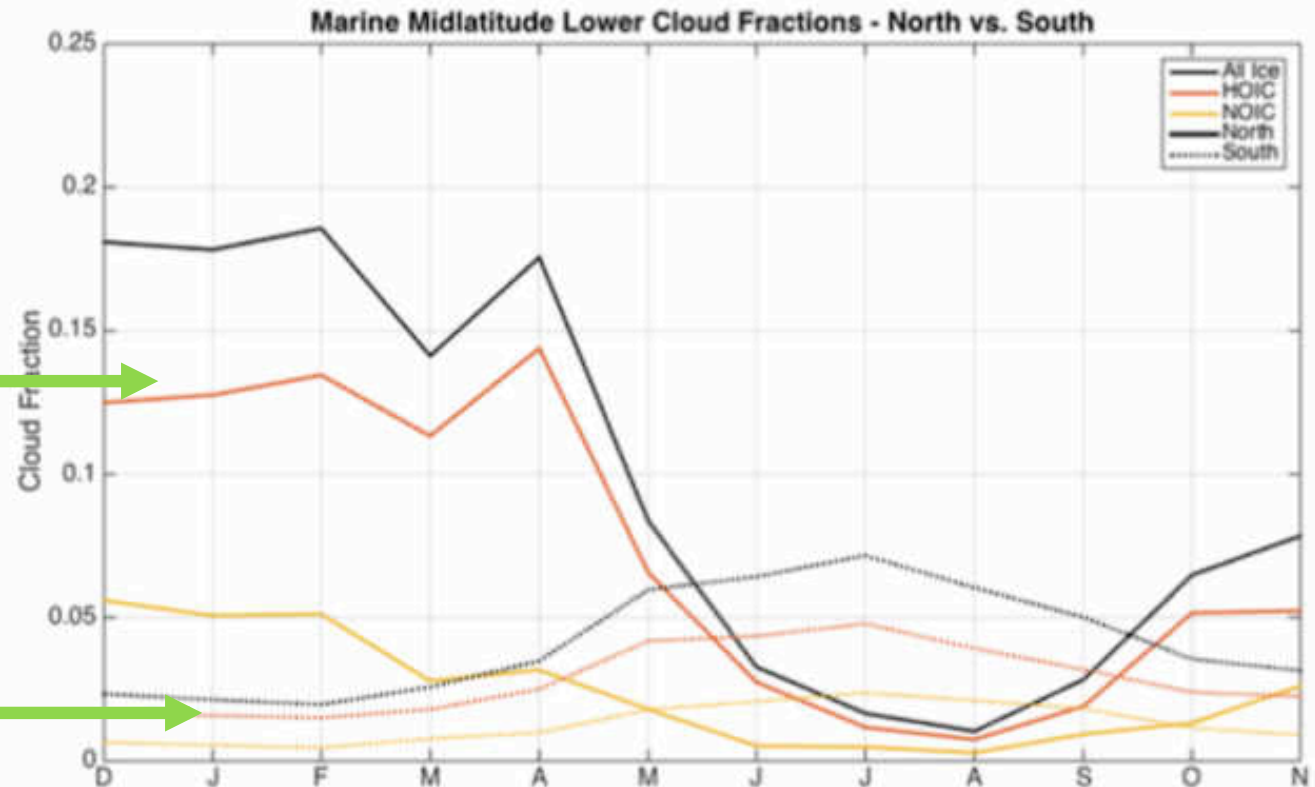
Seasonal Distribution HOIC

One year,
ocean areas
and cloud top
below 5 km

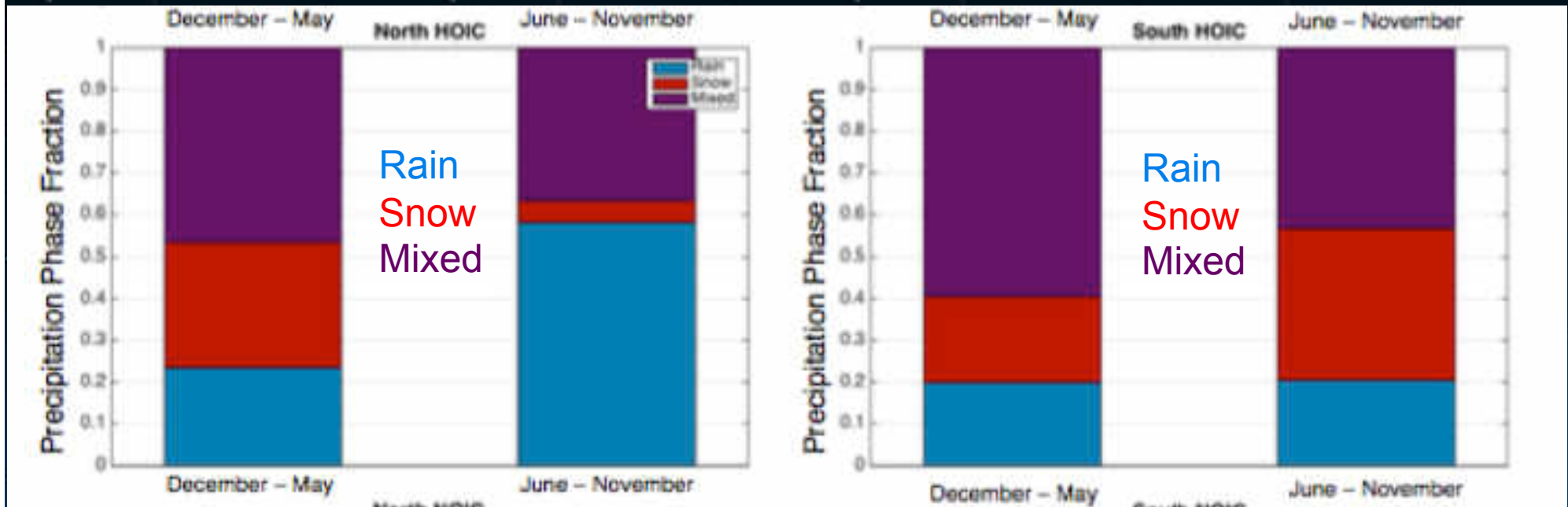
N.H. Orientated



S.H. Orientated



HOIC and CloudSat Precipitation



Atlantic

Pacific



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What have we learned, and are learning...

- The average fractional agreement for MODIS IFOVs with CALIOP is on the order of 90%.
 - Reference to other cloud detection methods)
 - Passive approach problematic for polar night.
- MODIS CO₂ cloud height biases of cirrus are lower than CALIOP altitudes by ~ 2.5 km, consistent with expectations for comparison with lidar.
- MODIS cloud height biases for marine stratus.
- MODIS and CALIOP optical depths are consistent with each other and IR approaches.
- Cloud properties coupled to surface types.
- A unique 1-year data set for horizontally oriented ice crystals...



Thank you – its fun working with
these data



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