Supplemental Material for Request for VIIRS Cloud Properties Beta Maturity

DR # 7154
CCR # 1075
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VIIRS Cloud Properties Product Cal/Val Core Team

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- Northrop Grumman – E. Wong
- NASA/DPE – J. Feeley (JAM)
- Raytheon – K. Brueske
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- University Colorado St./CIRA – S. Miller, Dan Lindsey, Curtis Seeman, Y. Noh

Cloud Product Users

- U.S. Users
  - AFWA – Air Force Weather Agency
  - NOAA NWP (Stan Benjamin, Brad Ferrier)
  - FNMOC
  - NWS through JPSS PG
- User Community
  - Navigation, Transportation
  - Operational Weather Prediction
  - Climate Research through NOAA CLASS.
  - DOD

Beta EDR Maturity Definition

- Early release product.
- Minimally validated.
- May still contain significant errors.
- Versioning not established until a baseline is determined.
- Available to allow users to gain familiarity with data formats and parameters.
- Product is not appropriate as the basis for quantitative scientific publication studies and applications.

Goto: outline, p.2

Summary of Cloud Properties Product Requirements Based on JPSS L1RD Thresholds

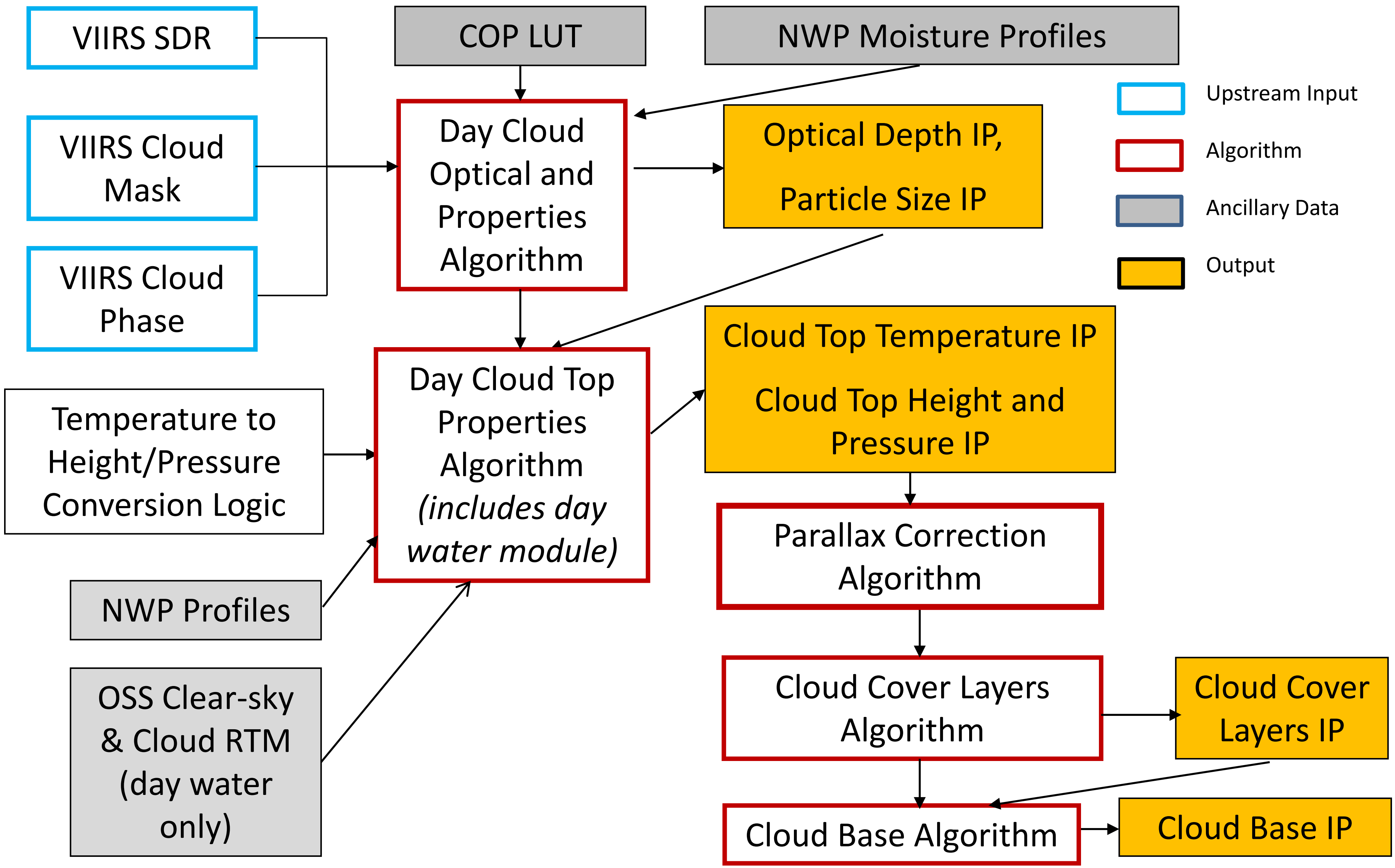
- Cloud Base Height
  - Measurement Uncertainty = 2 km
- Cloud Cover/Layers
  - Total Cloud Cover Uncertainty (not applicable to layers) 0.1 + 0.3*sin(sensor zenith Angle) of HCS Area
- Cloud Effective Particle Size
  - Precision & Accuracy: 22% for Water; 28% for Ice (or 1 µm whichever larger)
- Cloud Optical Thickness (τ)
  - Precision = 33%; Accuracy = 24% (or =1 τ , whichever larger for both Prec. & Acc.)
- Cloud Top Height
  - Precision = 1 km; Accuracy = 1 km (both increased to 2 km for thin clouds, i.e. $\tau < 1$)
- Cloud Top Pressure
  - Precision & Accuracy: 100 mb (0-3km); 75 mb (3-7 km); 50 mb (> 7km)
- Cloud Top Temperature
  - Precision & Accuracy = 3 K (both increased to 6 K for thin clouds, i.e. $\tau < 1$)

Summary of the VIIRS Cloud EDR

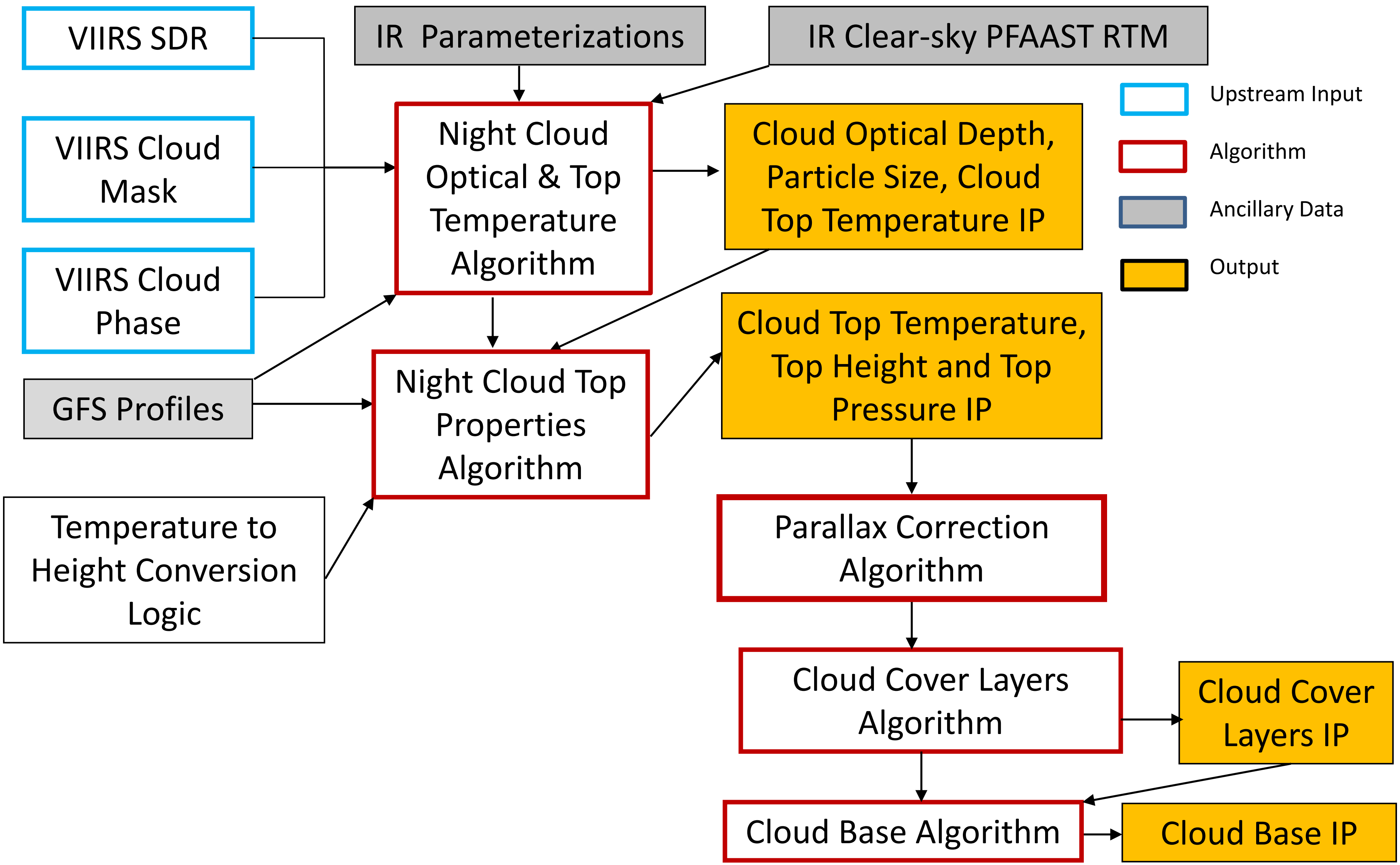
- VIIRS Cloud Products generated from 6 algorithms.
  - Daytime Cloud Optical Properties
  - Daytime and Night Cloud Top Properties
  - Perform Parallax Correction
  - Cloud Cover Layers
  - Cloud Base Height
- Products are
  - optical depth
  - effective particle size,
  - top-temperature,
  - top-pressure
  - top-height
  - cover by layer (up to 5 values)
  - base height
- Channels used (7 M-bands, M5,M8,M10,M12,M14,M15,M16)
- Important sensitivities
  - Surface albedo and emissivity
  - Clear-sky radiative transfer
  - Cloud mask and phase errors are hard to recover from

Goto: outline, p.2

VIIRS Daytime Cloud IP Flow



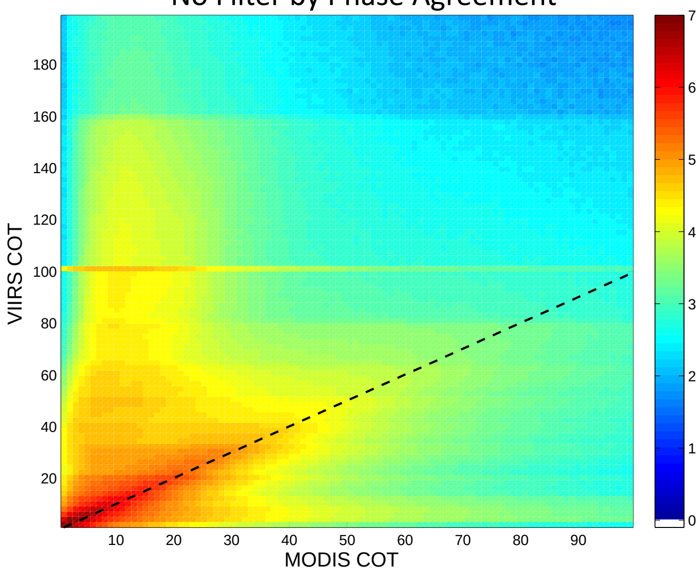
VIIRS Nighttime Cloud IP Flow



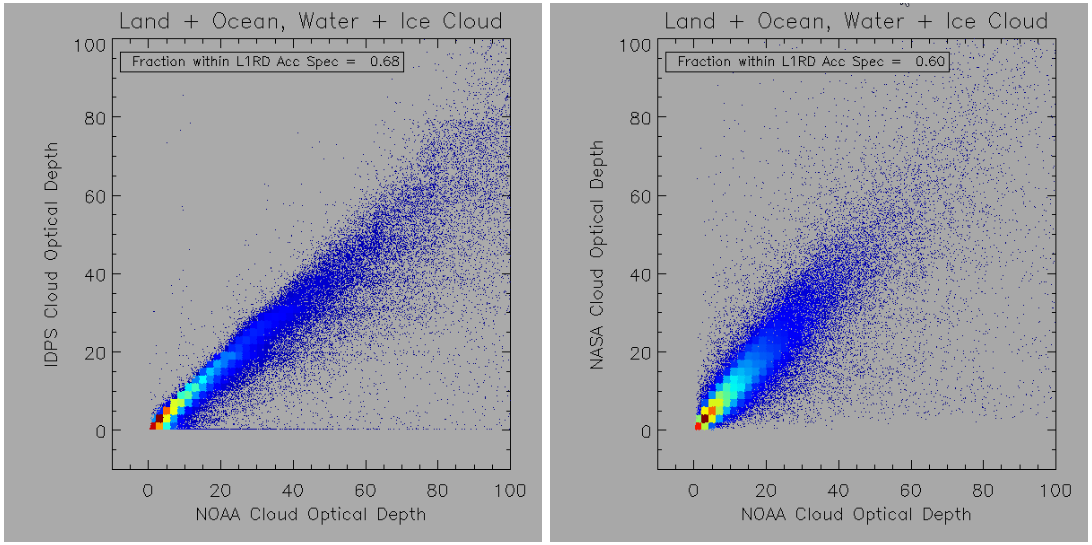
Methods to Compare IDPS to NOAA and NASA Products (Impact of Phase Filter)

- We conducted three types of analysis
  1. Colocated IDPS/VIIRS and NASA/MODIS over many days (left)
  2. IDPS/VIIRS and NOAA/VIIRS for one day where we excluded pixels with different phases (right image). Note we also include NOAA vs. NASA on MODIS for reference.
  3. CALIPSO/CALIOP comparison to IDPS CTP. (shown later)
- We feel #2 is a better judge of the algorithm in isolation and is the basis for our beta decision. #1 represents the impact of all components and will be looked at more in future validation decisions.

No Filter by Phase Agreement



Filtered by Phase Agreement



Atmosphere PEATE

SSEC

CIMSS

Comparison to NOAA VIIRS Products

- Data analyzed was from April 28, 2013 – two days after COP LUT update.
- **NOAA products generated from IDPS VCM data (mask and phase errors are excluded).**
- NOAA VIIRS data based on modifications of GOES-R AWG code.
- **QF flags ignored.**
- **No penalty for failed retrievals.**
- Granules mapped to globe at 0.1° resolution. Most nadir view taken in regions of orbital overlap.
- **Snow and ice covered areas ignored**.
- Same analysis applied to MODIS and NOAA algorithms applied to TERRA/MODIS data. Useful reference in gauging NOAA vs IDPS results.
- MODIS is C5 ATML2 (C6 is coming)
- L1RD accuracy specification made relative to NOAA, not an independent validation source.

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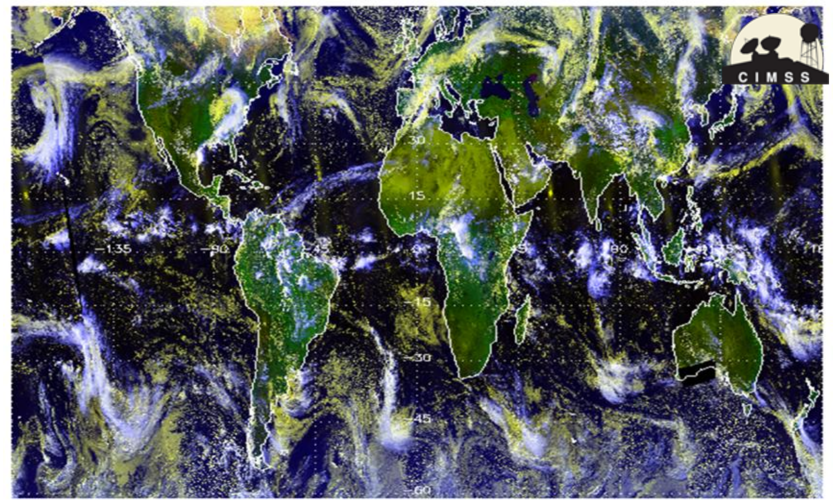
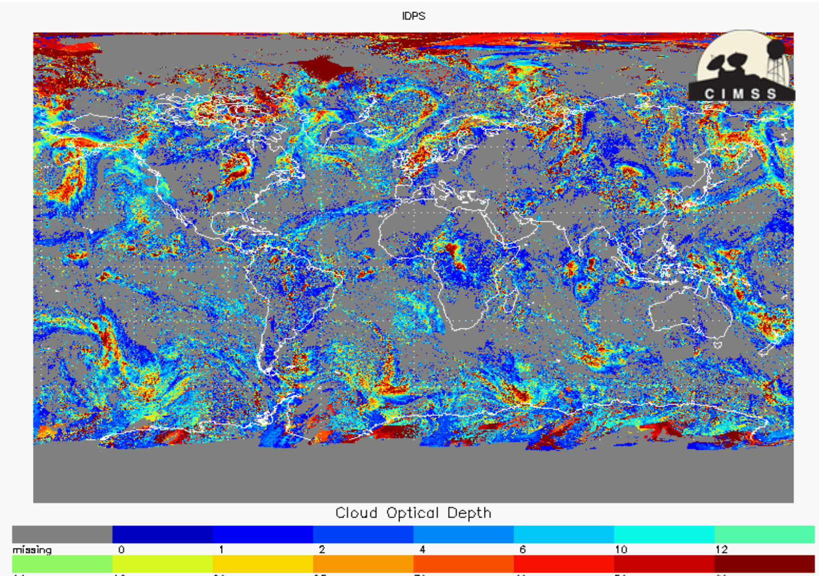


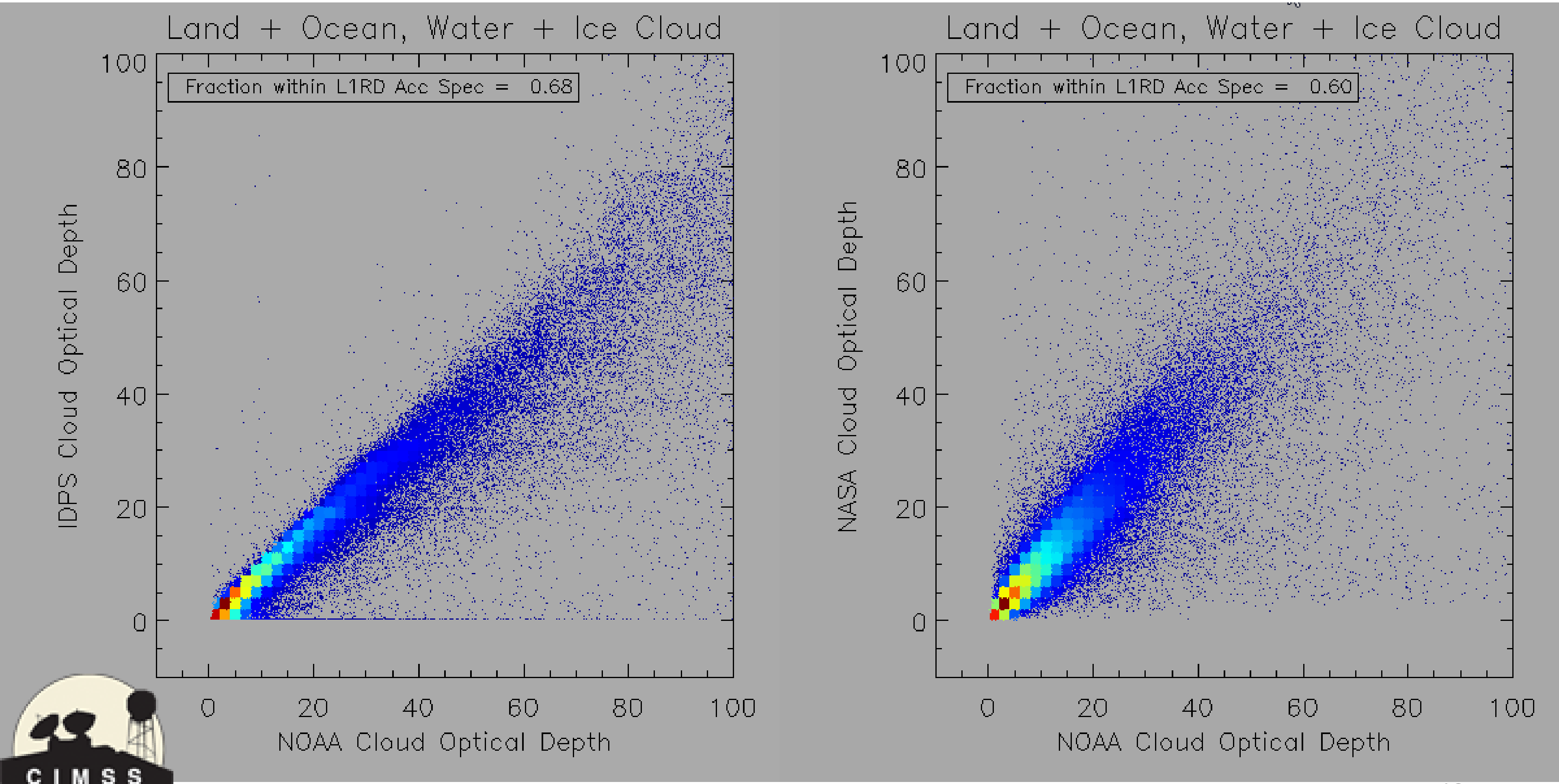
False Color Image
Red=0.63μm, Green = 0.86μm, Blue = 11μm (reversed)



Cloud Optical Thickness (COT) is defined as the optical thickness of the atmosphere due to cloud droplets, per unit cross section, integrated over each and every distinguishable cloud layer, in a vertical column above a horizontal cell on the Earth's surface

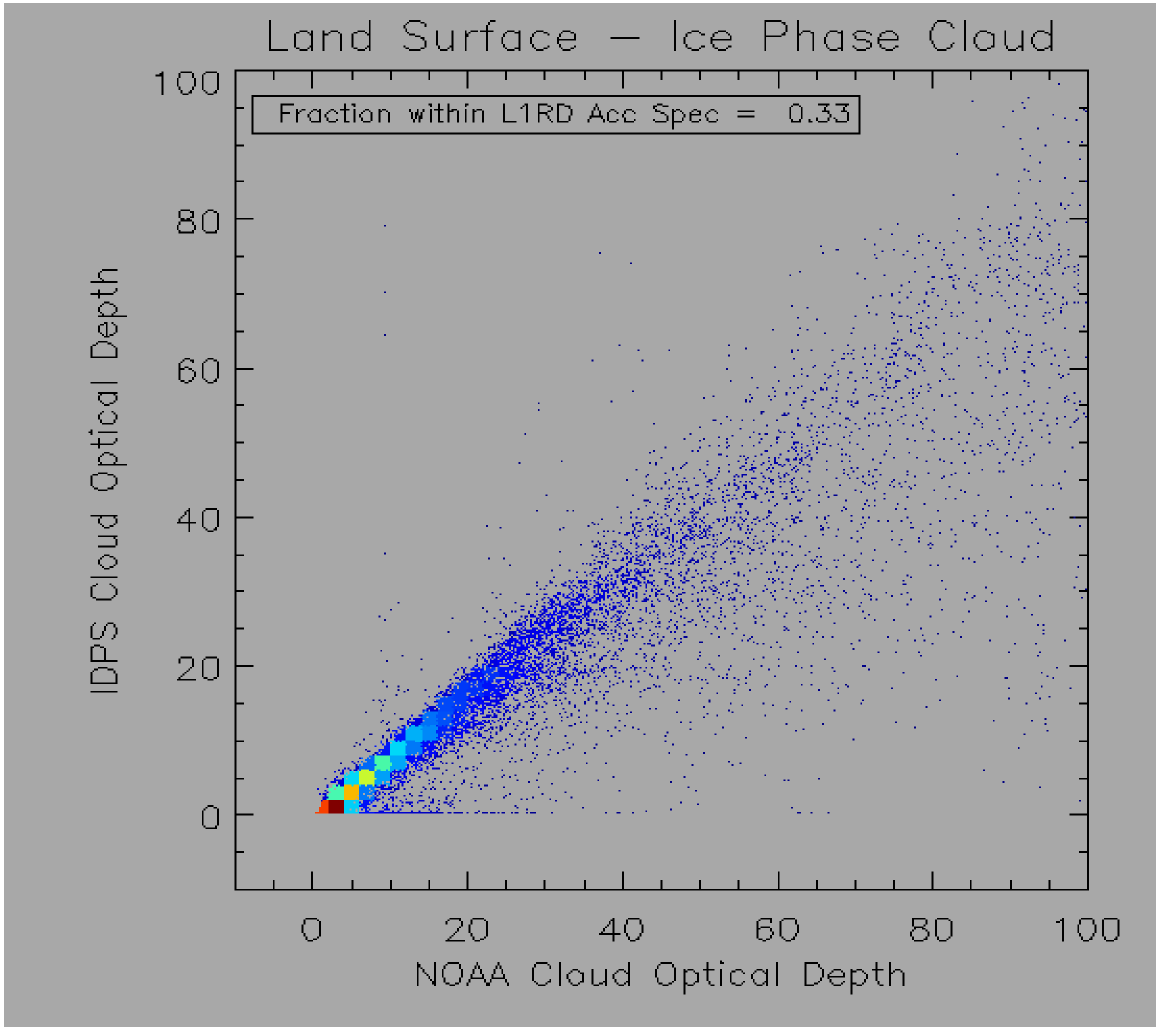
Optical Depth Comparison

- Plots show a scatterplot. Color represent density. Red is high, dark blue is low density.
- Good correlation of IDPS with NOAA. 68% of IDPS within L1RD spec relative to NOAA.
- Tighter but less symmetric scatter seen between IDPS and NOAA, than NOAA and NASA



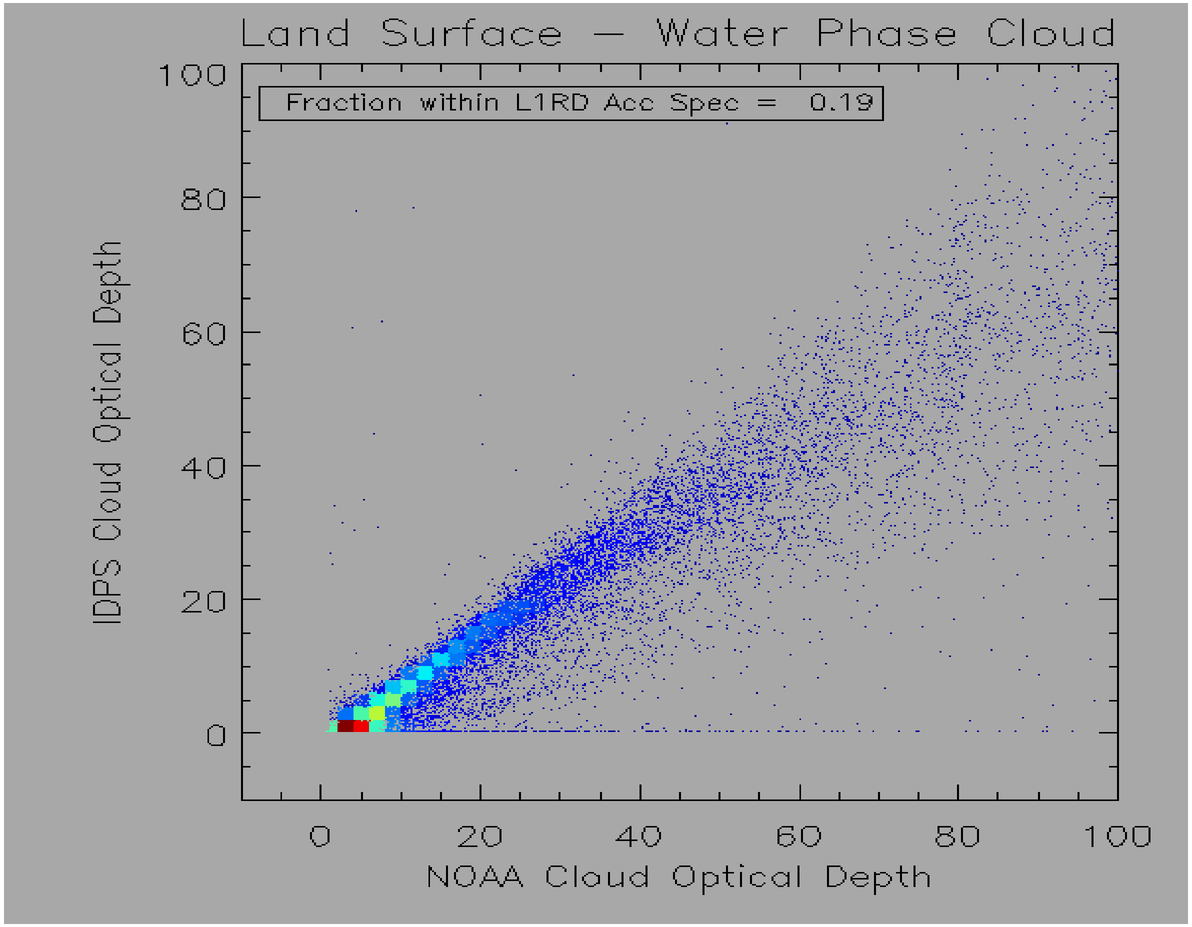
Comparison of VIIRS Day Ice COT with NOAA COT under Land background (by UW/CMISS)

- Good comparison with NOAA COT
- 33 % pixels of VIIRS day ice COT within L1RD accuracy requirement
- Scatter due to large variation of land surface albedos



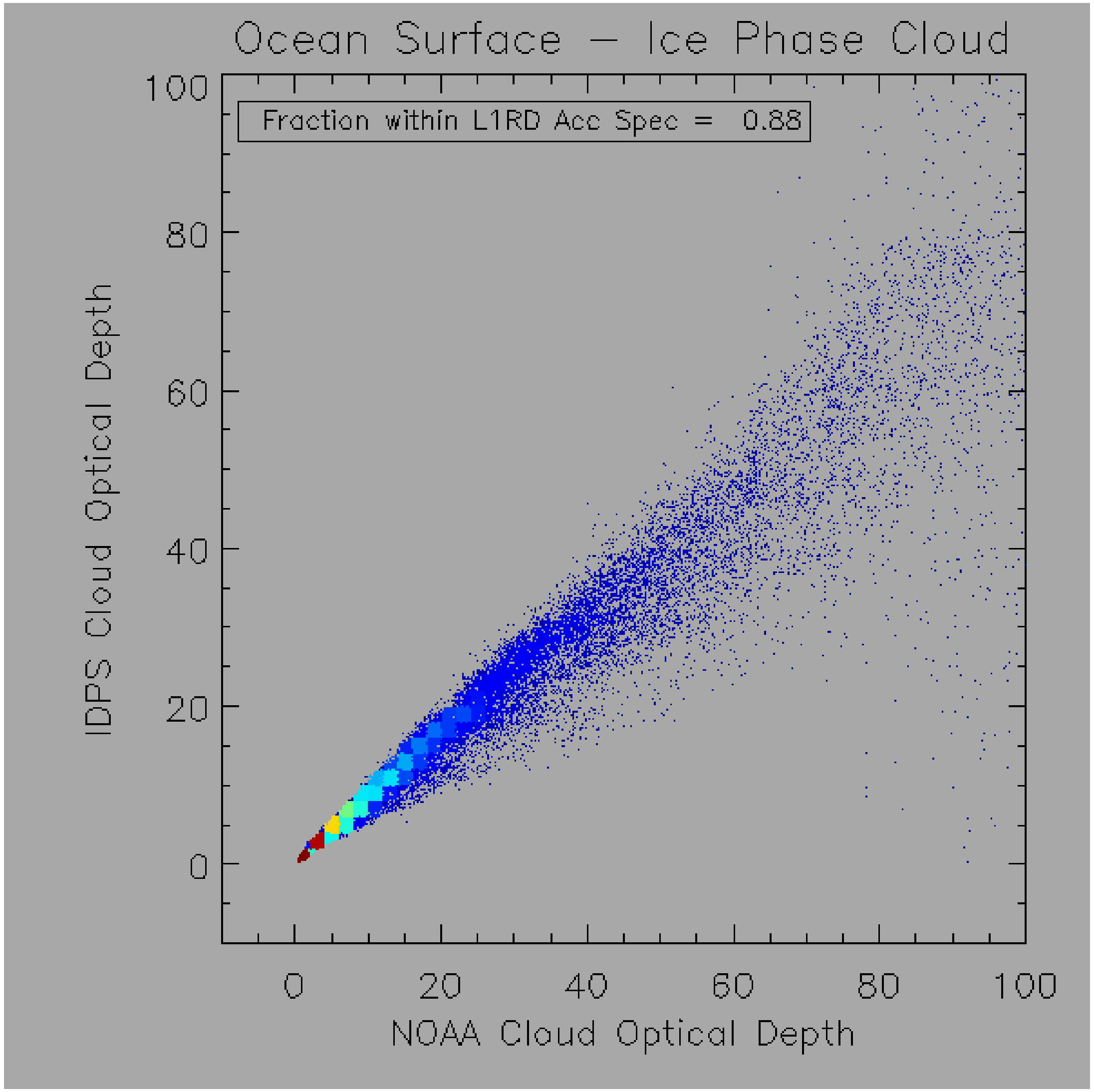
Comparison of VIIRS Day Water COT with NOAA COT under land background (by UW/CMISS)

- Reasonable good comparison with NOAA COT
- 19 % pixels of VIIRS Day Water COT within L1RD accuracy requirement
- Scatter due to large variation of land surface albedos



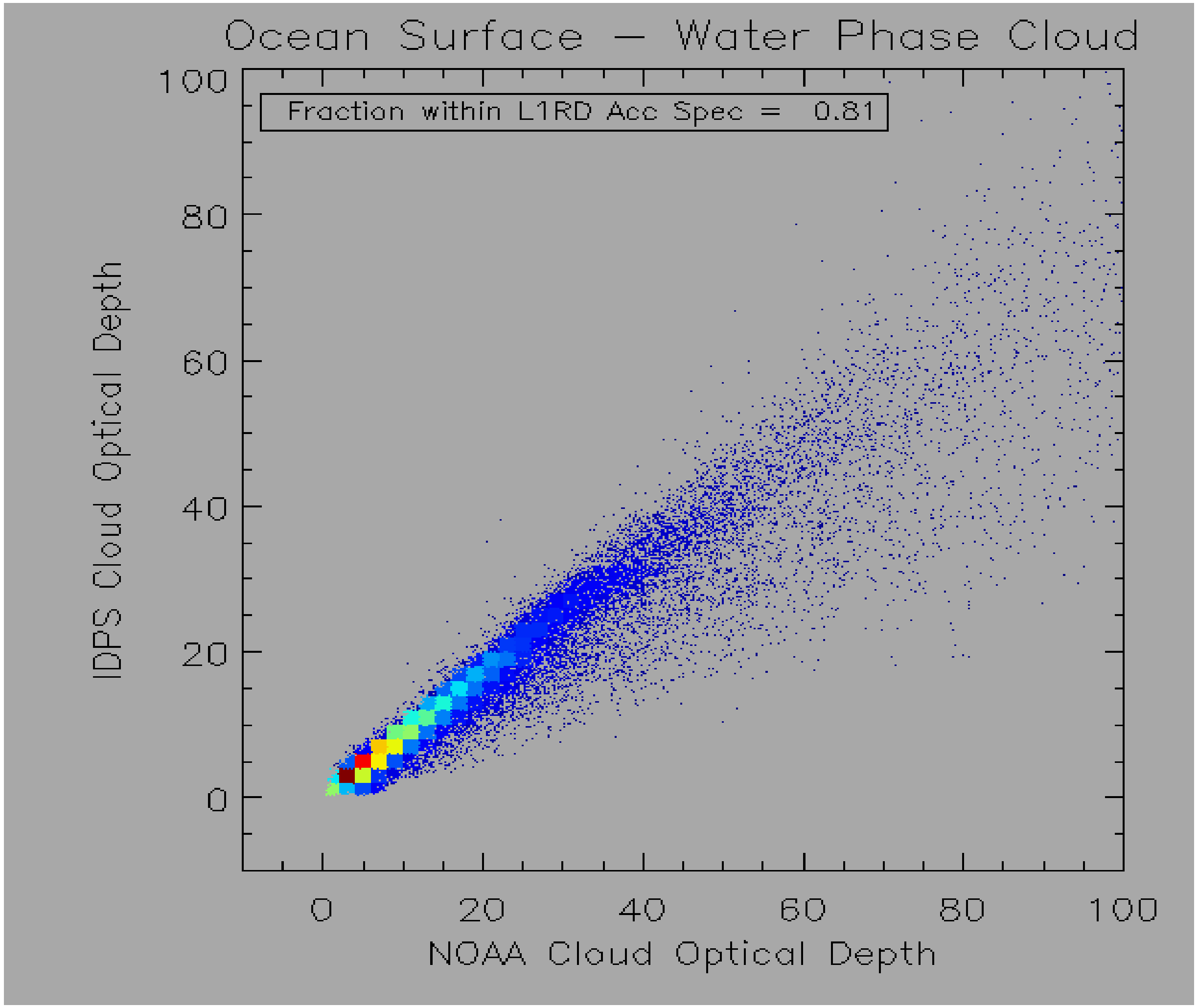
Comparison of VIIRS Day Ice COT with NOAA COT under ocean background (by UW/CMISS)

- Good comparison with NOAA COT
- 88 % pixels of VIIRS day ice COT within L1RD accuracy requirement
- Small scatter due to near constant ocean surface albedos

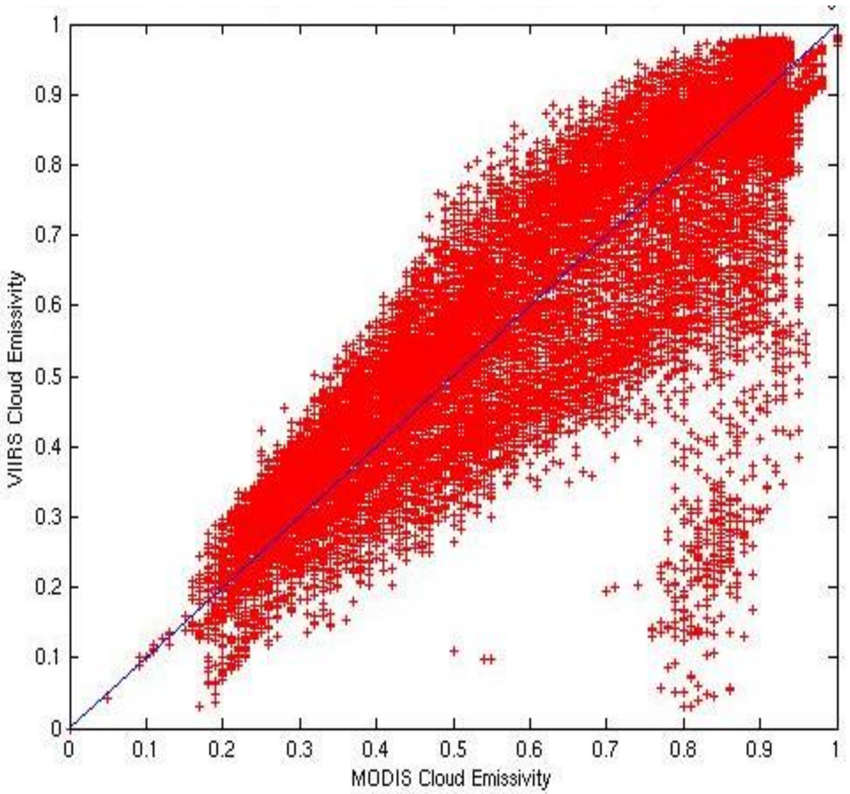


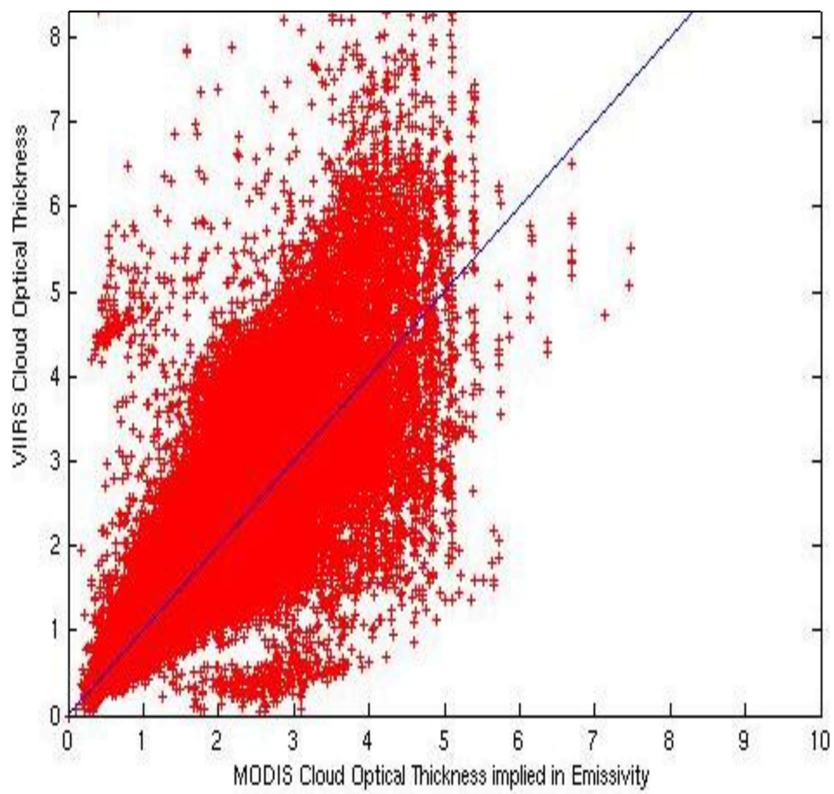
Comparison of VIIRS Day Water COT with NOAA COT under ocean background (by UW/CMISS)

- Good comparison with NOAA COT
- 81 % pixels of VIIRS day water COT within L1RD accuracy requirement
- Small scatter due to near constant ocean surface albedos



Comparison of Night Ice COT with MODIS Night COT Implied from Cloud Emmissivity Product (By NG)



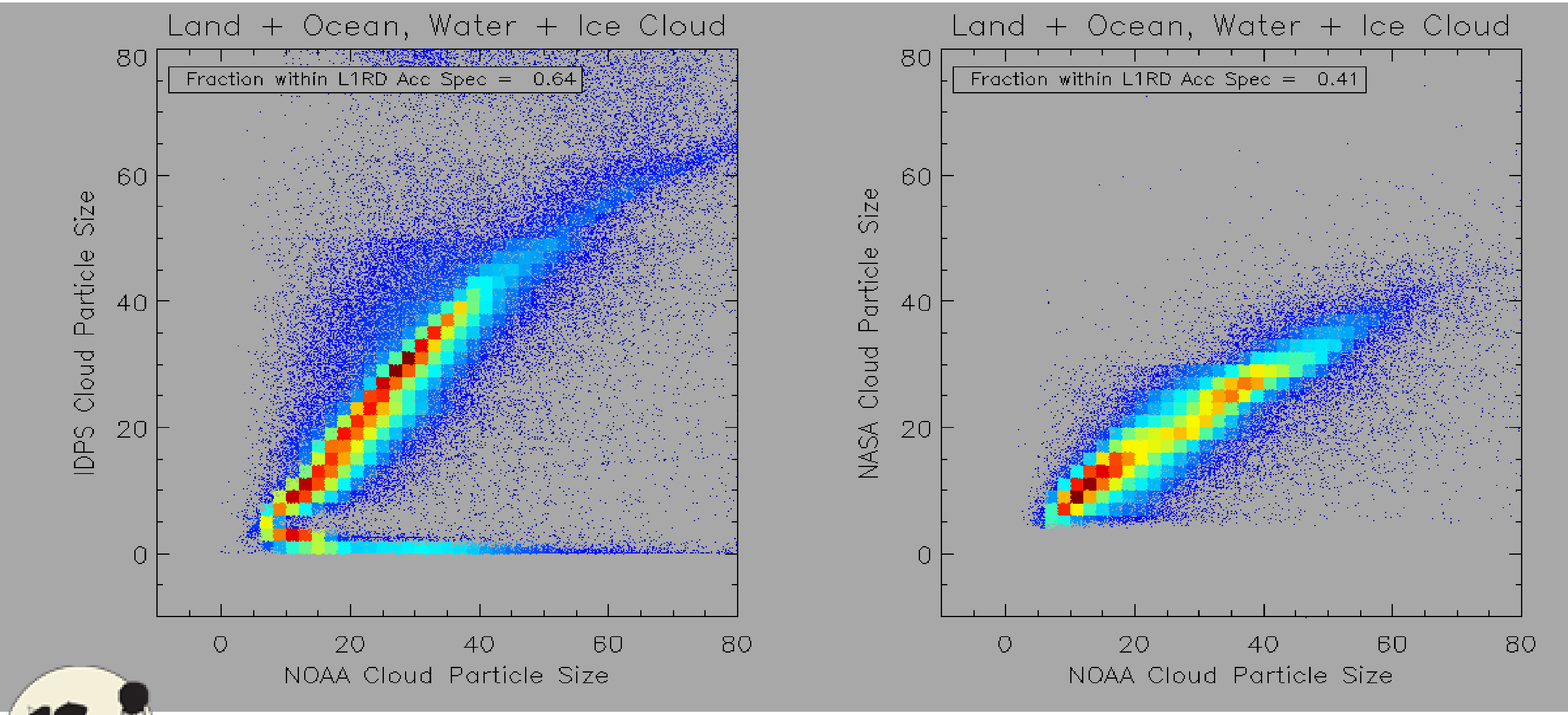


- VIIRS Night Ice cloud COT performance estimate:
  - Average Accuracy ~ 20%
  - Average Precision ~ 40%
- Night water cloud COT performs poorly due the 2 errors found in code: (1) sensor zenith angle not accounted for; (2) a factor used during algorithm testing not removed

Cloud Effective Particle Size (CEPS) is a representation of the cloud particle size distribution. The effective particle size or effective particle radius is defined as the 3rd moment of the drop size distribution to the 2nd moment, averaged over a layer of air within a cloud. For ensembles of irregular shaped particles such as ice crystals, the exact mathematical relationship between size distribution and effective radius is somewhat obscure, since a radius is not well defined.

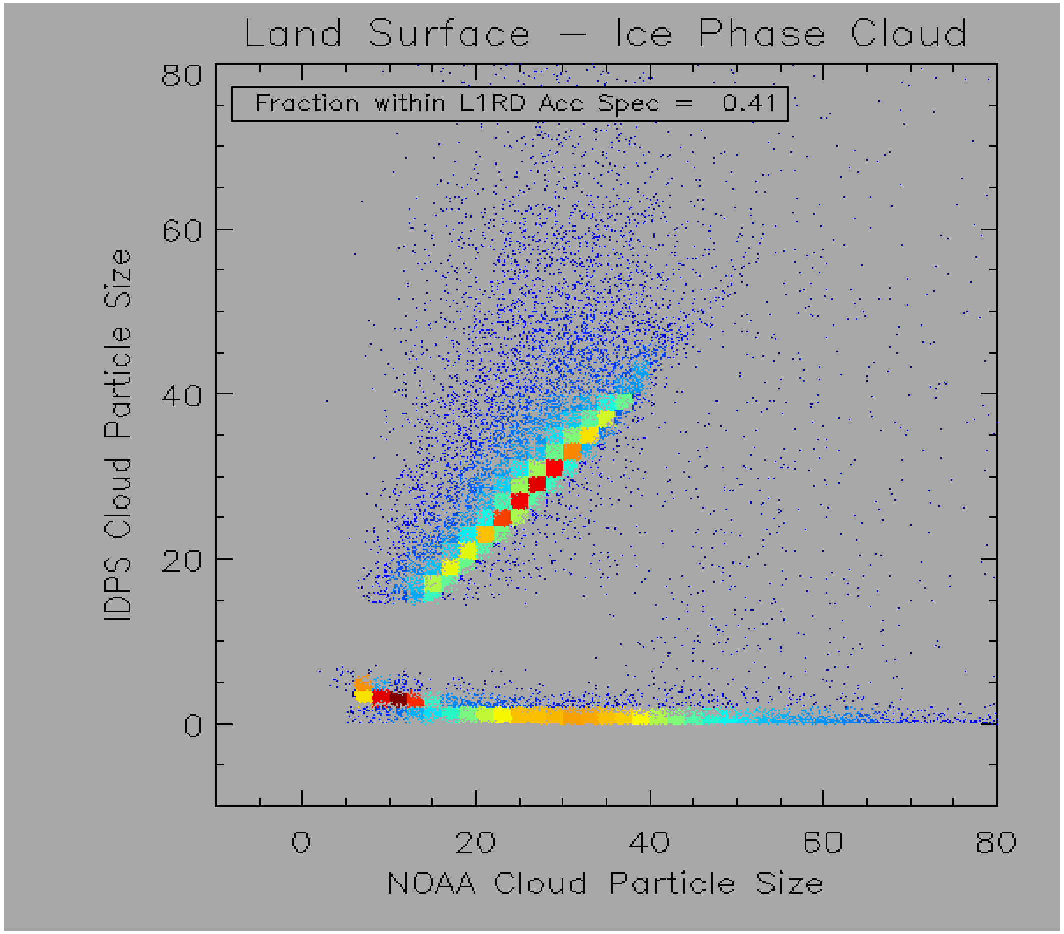
Cloud Effective Particle Size Comparison

- Good correlation of IDPS with NOAA. 64% of IDPS within L1RD spec relative to NOAA.
- Cluster of points with very small CEPS from IDPS is still a problem and is being investigated. These are failed IDPS retrievals over land (QF would catch this)
- Higher correlation of NOAA with NASA than IDPS and NOAA. C5 CEPS < C6 CEPS



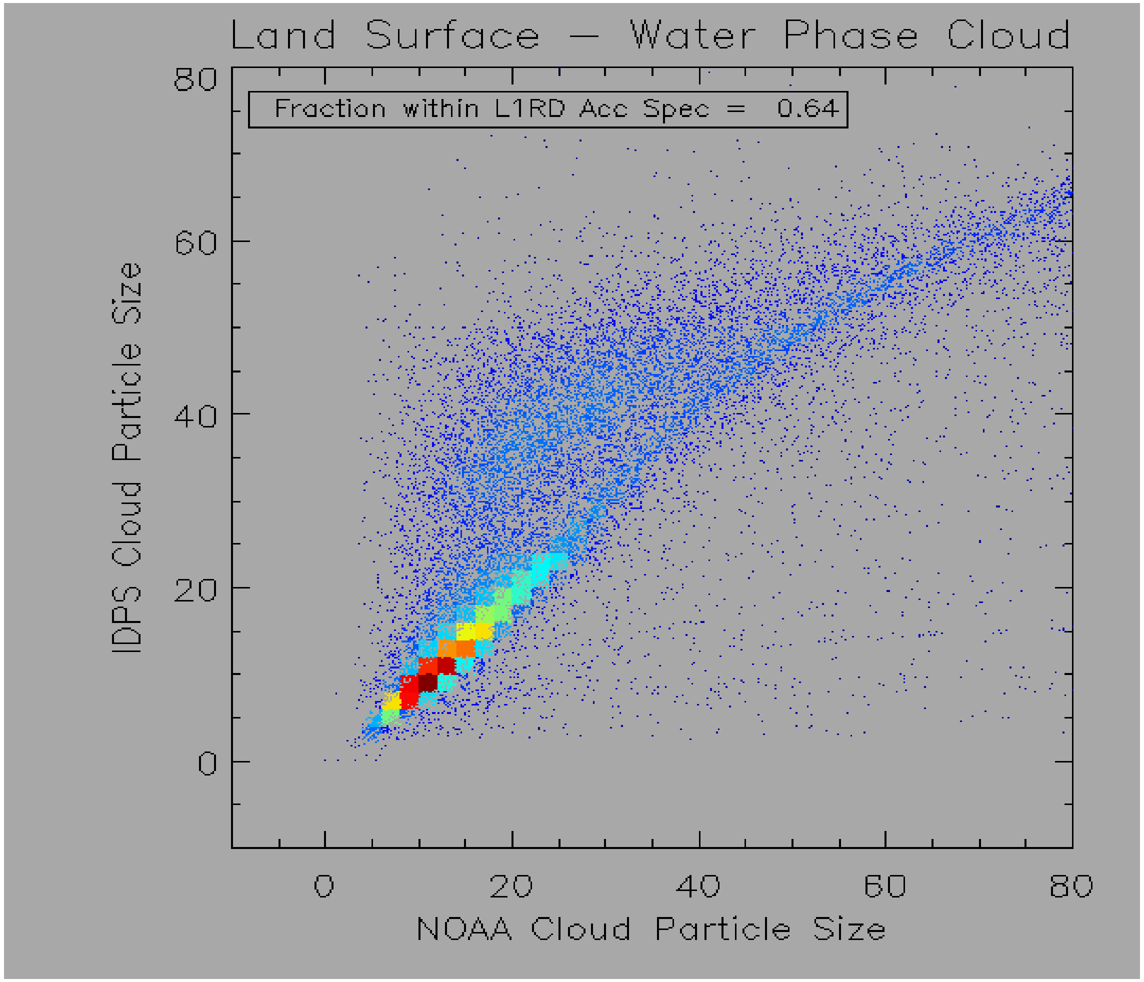
Comparison of VIIRS Day Ice CEPS with NOAA CEPS under Land background (by UW/CMISS)

- Reasonably good comparison with NOAA CEPS
- 41 % pixels of VIIRS day ice CEPS within L1RD accuracy requirement
- Scatter due to large variation of land surface albedos



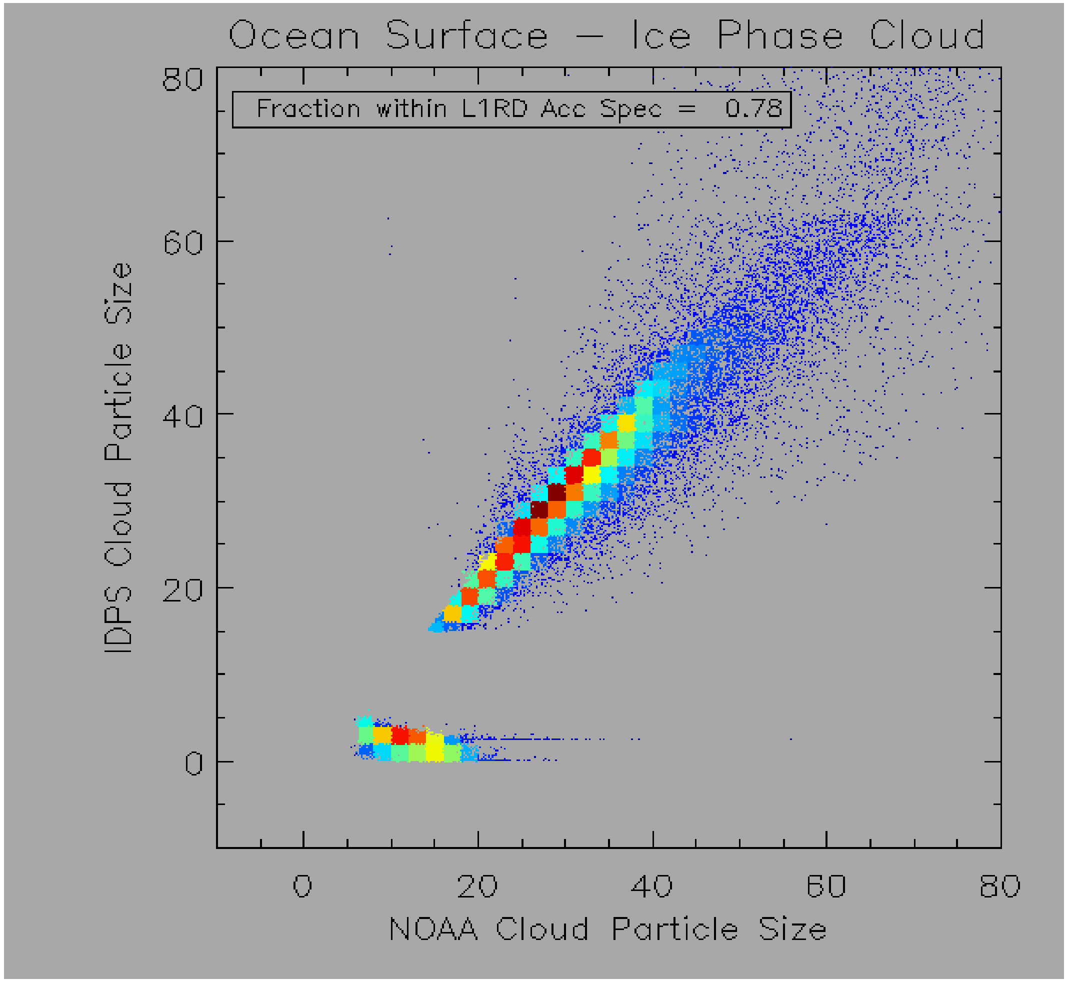
Comparison of VIIRS Day Water CEPS with NOAA CEPS under land background (by UW/CMISS)

- Reasonably good comparison with NOAA CEPS
- 64 % pixels of VIIRS day water CEPS within L1RD accuracy requirement
- Scatter due to large variation of land surface albedos



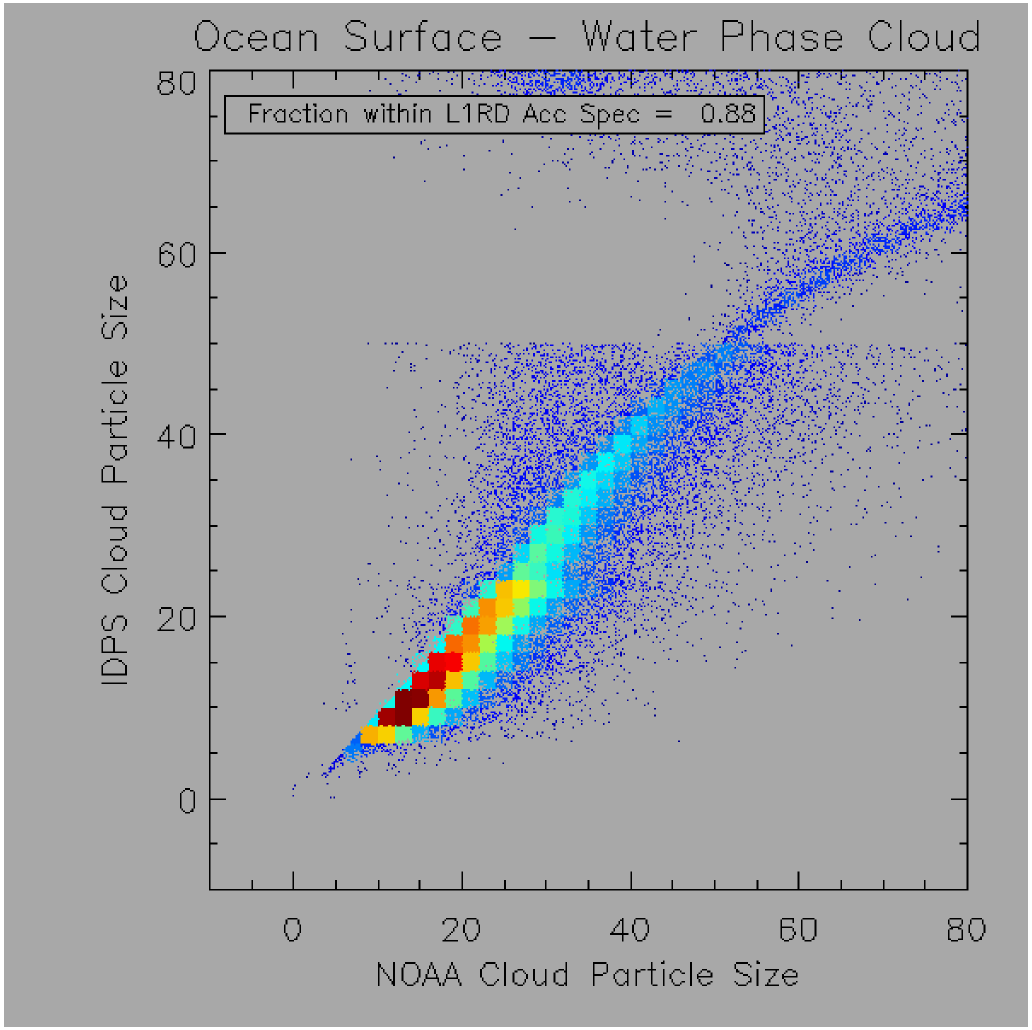
Comparison of VIIRS Day Ice CEPS with NOAA CEPS under ocean background (by UW/CMISS)

- Good comparison with NOAA CEPS
- 78 % pixels of VIIRS day ice CEPS within L1RD accuracy requirement
- Smaller scatter due to near constant ocean surface albedos



Comparison of VIIRS Day Water CEPS with NOAA CEPS under ocean background (by UW/CMISS)

- Good comparison with NOAA CEPS
- 88 % pixels of VIIRS day water CEPS within L1RD accuracy requirement
- Smaller scatter due to near constant ocean surface albedo



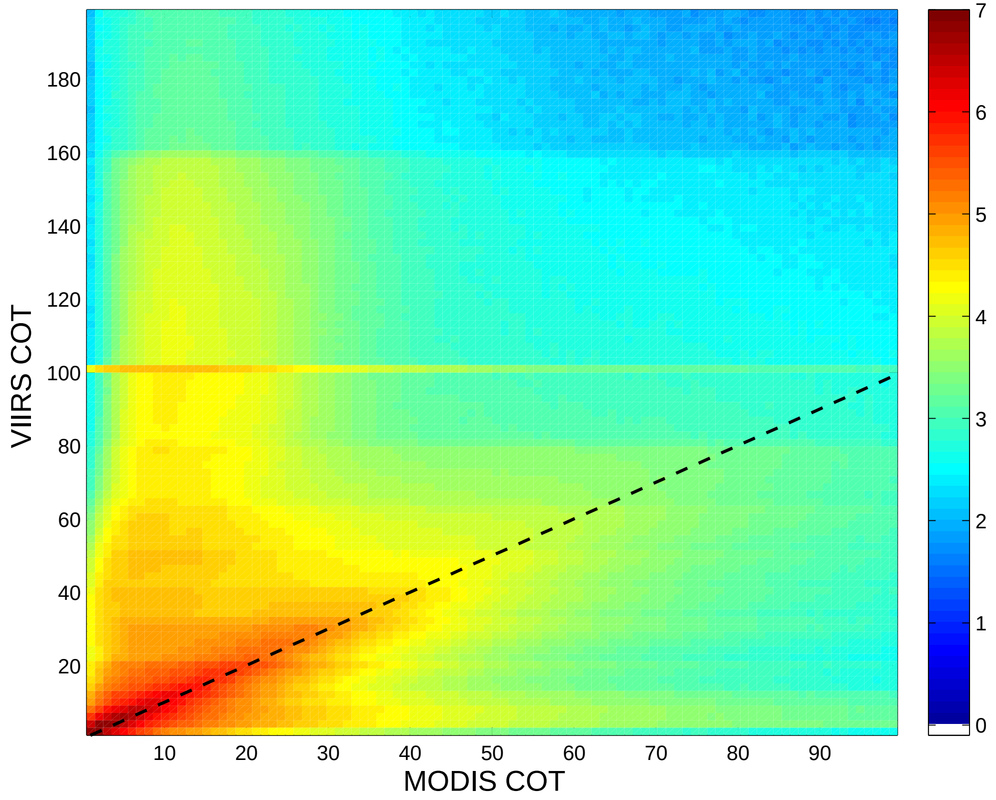
Direct Comparison to NASA MODIS Products

- The UW NPP Atmospheric PEATE has developed tools to co-locate VIIRS and MODIS.
- These comparisons as shown do not stratify by phase and therefore show a “true” comparison.
- These comparisons include errors in phase assignment.
- As a consequence, the agreement is much less than that seen in the previous NOAA vs IDPS analysis but same features are evident.
- Full presentation includes stratification by Cloud Top Temp.

VIIRS-MODIS Collocation

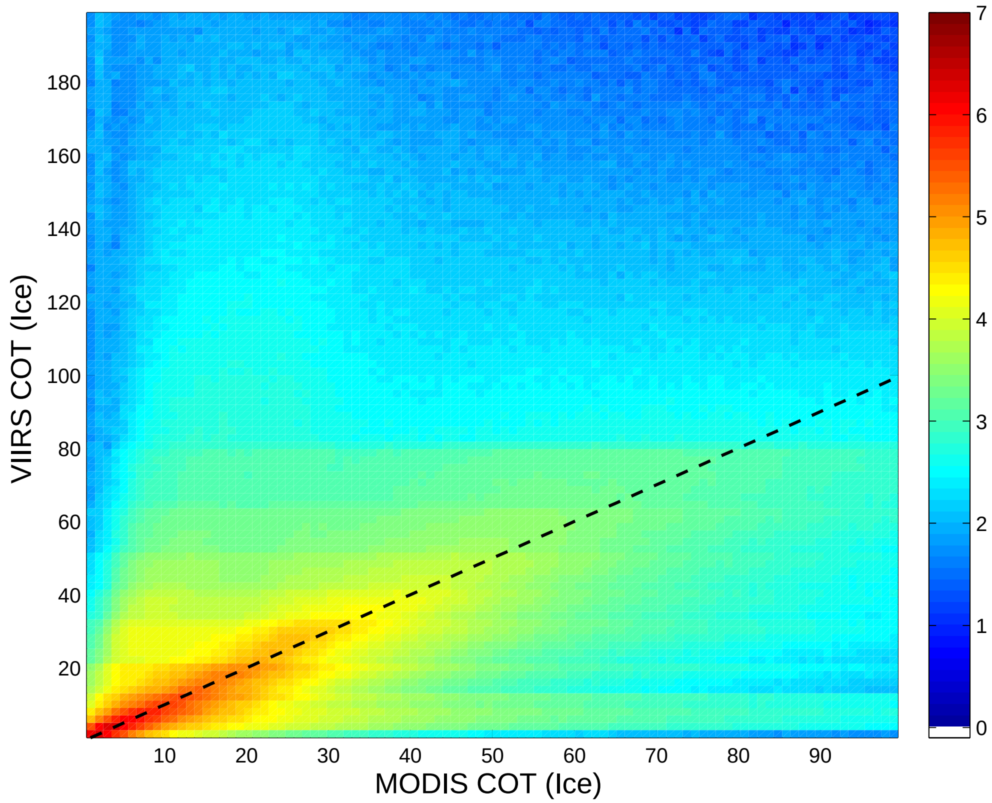
- The Co-located VIIRS-MODIS matchups Cloud Optical Thickness and Effective Particle Size over Land and Ocean
- MODIS (C005.1 1km) and VIIRS (IP) IVCOP are matchup in 5 minutes temporal resolution
- 3 Cloud Top Temperature threshold (<233.16, >253.16 and >273.16) are used to define cloud phase
- Julian days: 120,122,123,125,128,130,131 and 133 of 2013

VIIRS-MODIS COT comparison



- Number of sample= 234 mills
- Both Ice and water cloud
- Color bar shows number density in log scale (example: 3 =1,000)

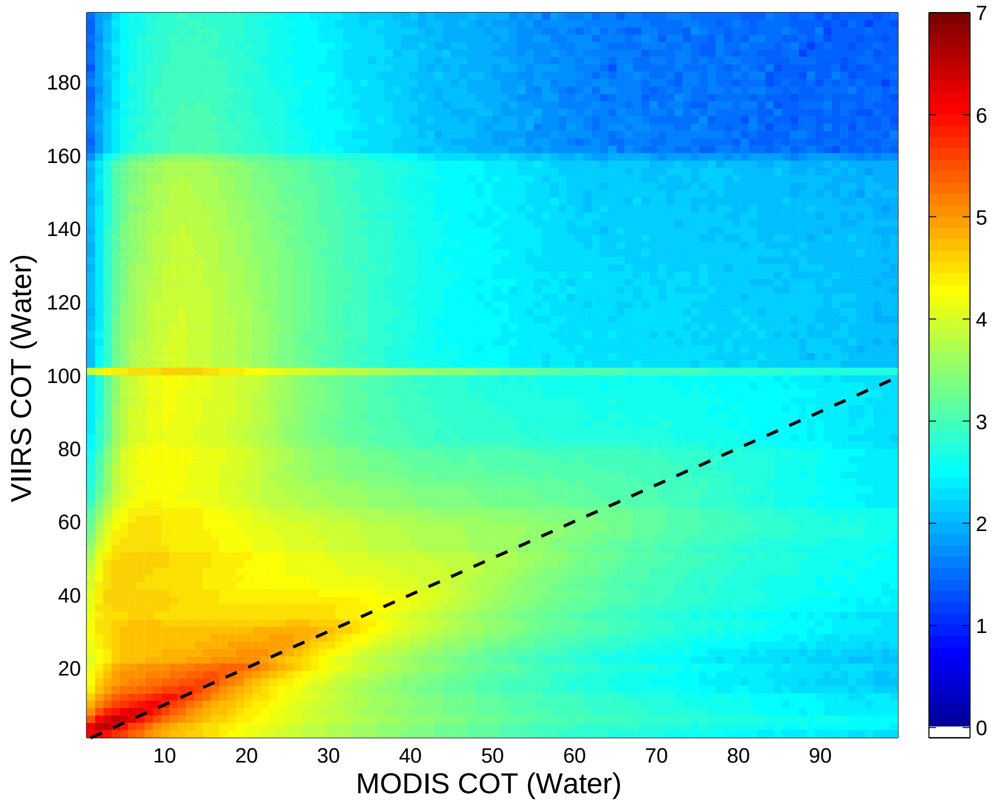
VIIRS-MODIS COT comparison



- Number of sample= 56 mills
- Phase = Ice
- CTT< 233.16
- Mean bias=1.94
- STD=45.78
- CORRCOEF=0.422
- Uncertainty=45.85

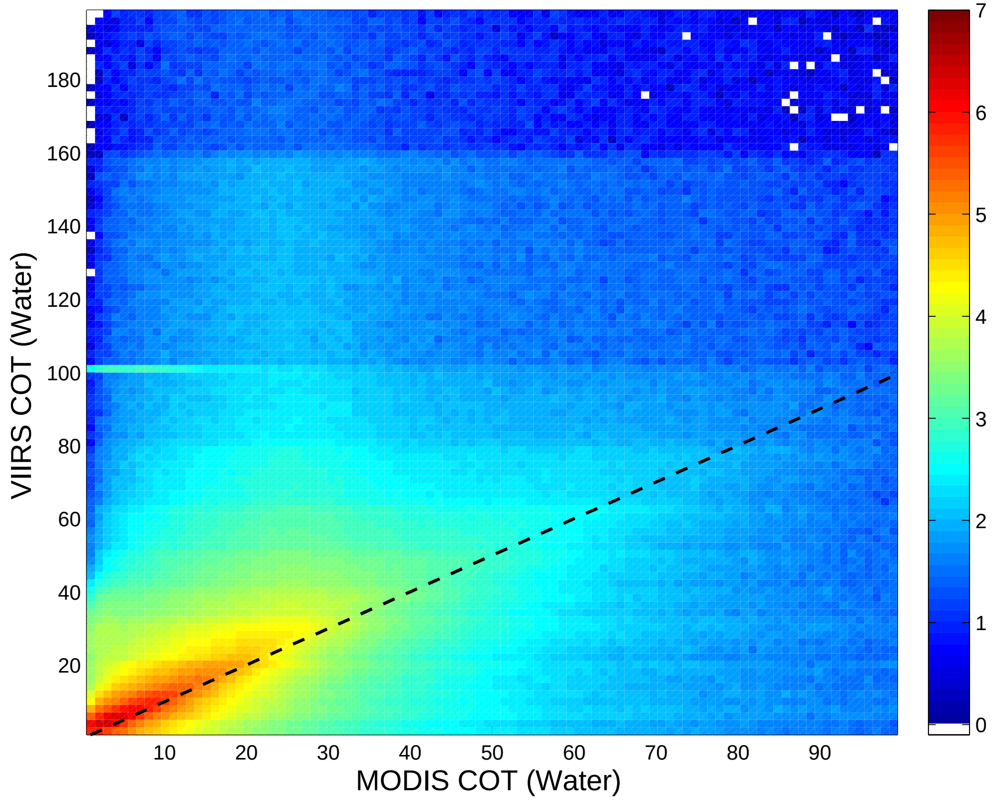
Mean bias= mean of (VIIRS COT – MODIS COT)
Uncertainty = root mean square error (or mean bias)

VIIRS-MODIS COT comparison



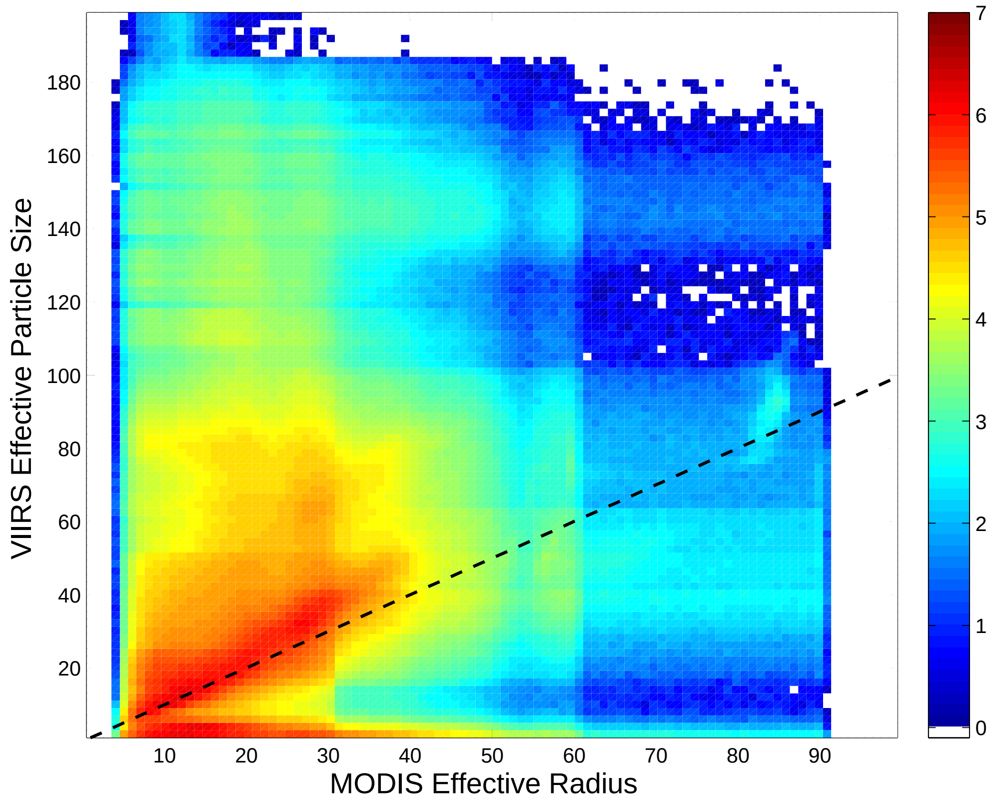
- Number of sample= 113 mills
- Phase = Ice/water
- CTT> 253.16
- Mean bias=20.34
- STD=89.89
- CORRCOEF=0.312
- Uncertainty=93.08

VIIRS-MODIS COT comparison



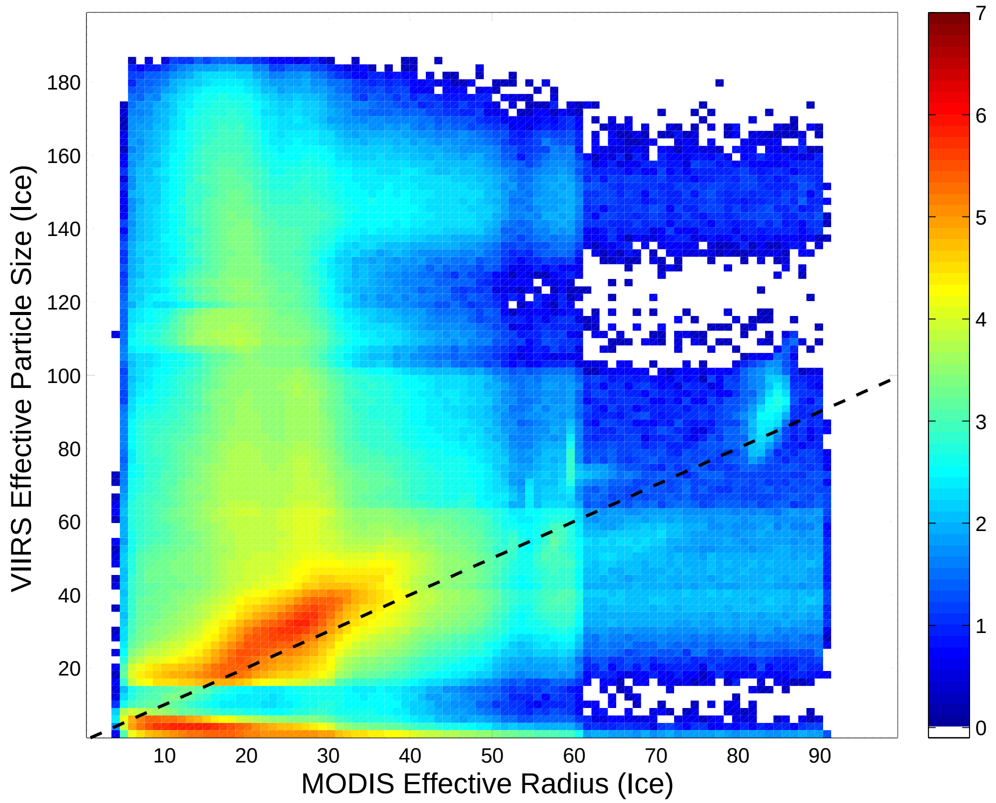
- Number of sample= 44 mills
- Phase = water
- CTT> 273.16
- Mean bias=3.20
- STD=28.66
- CORRCOEF=0.48
- Uncertainty=28.87

VIIRS-MODIS EPS comparison



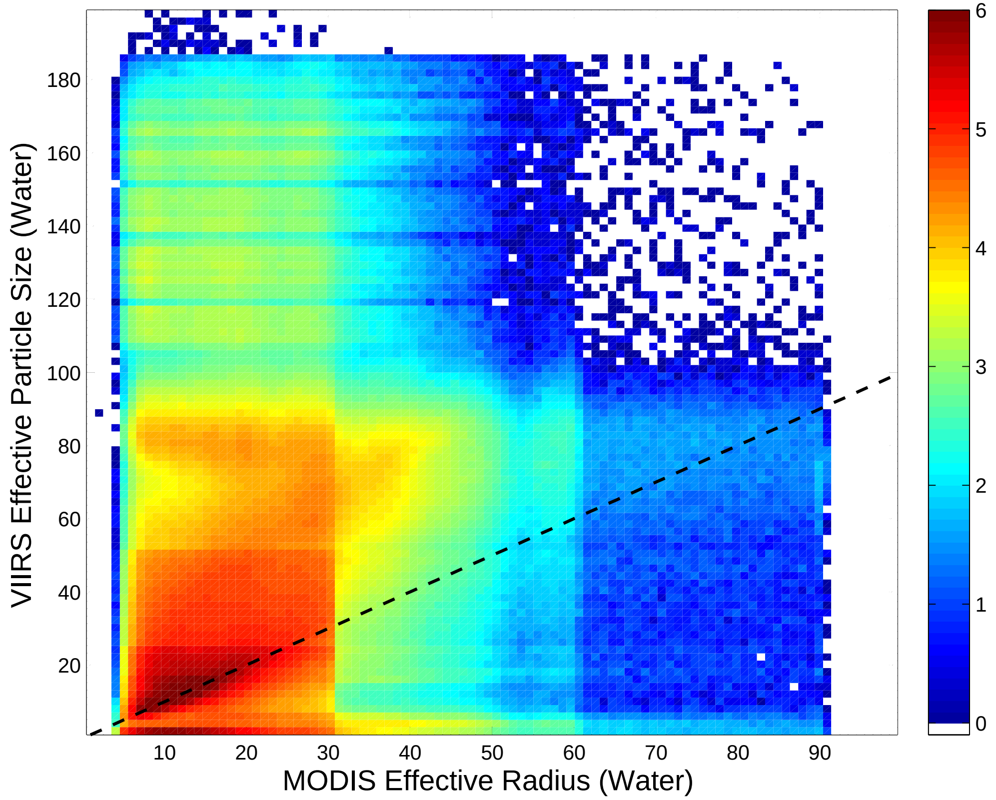
- Number of sample= 213 mills
- Both Ice and water cloud
- Color bar shows number density in log scale (example: 3 =1,000)

VIIRS-MODIS EPS comparison



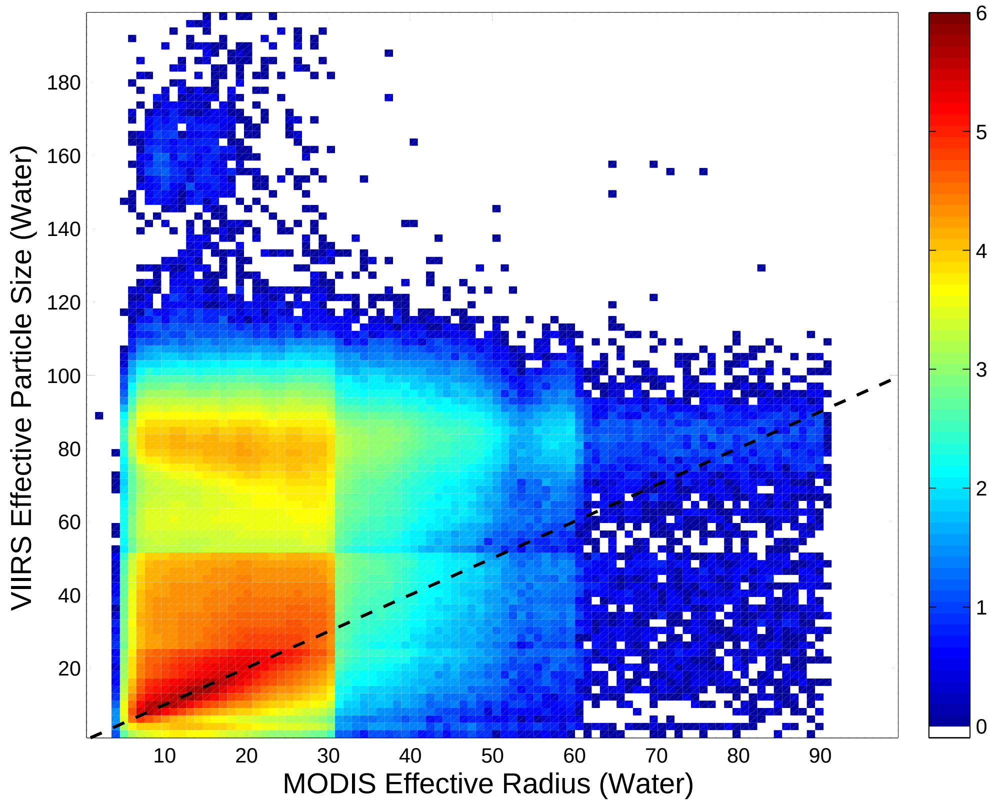
- Number of sample= 52 mills
- Phase = Ice
- CTT< 233.16
- Mean bias=4.99
- STD=20.91
- CORRCOEF=0.389
- Uncertainty=21.42

VIIRS-MODIS EPS comparison



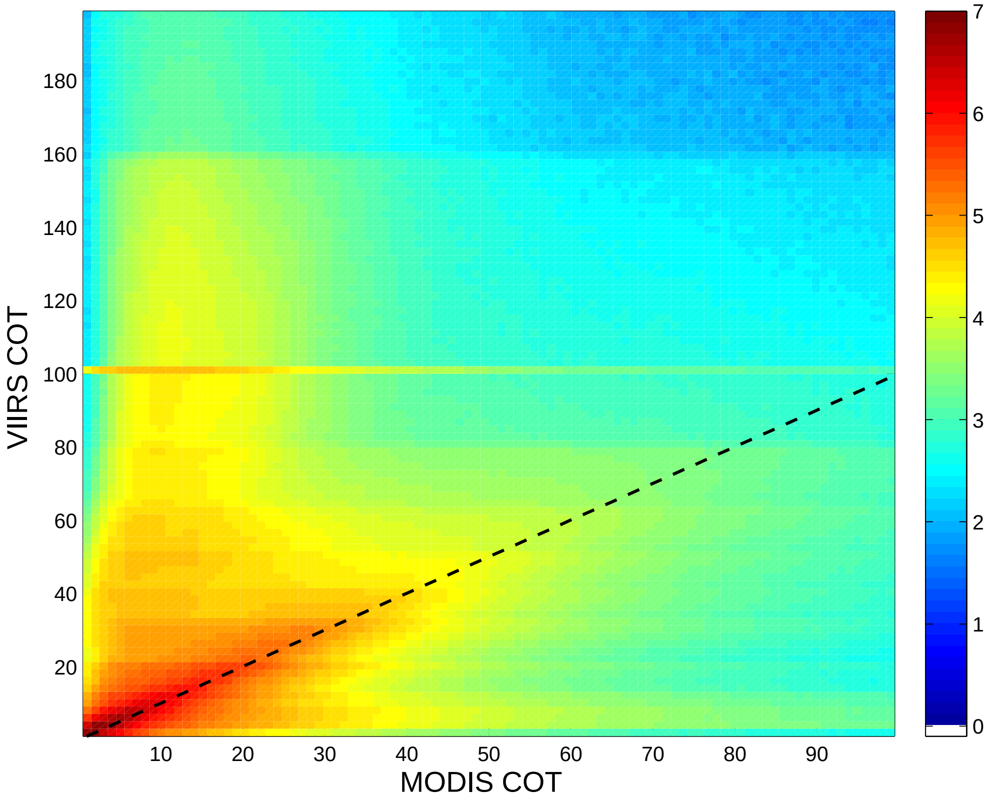
- Number of sample= 101 mills
- Phase = Ice/water
- CTT> 253.16
- Mean bias=8.16
- STD=27.73
- CORRCOEF=0.295
- Uncertainty=29.12

VIIRS-MODIS EPS comparison



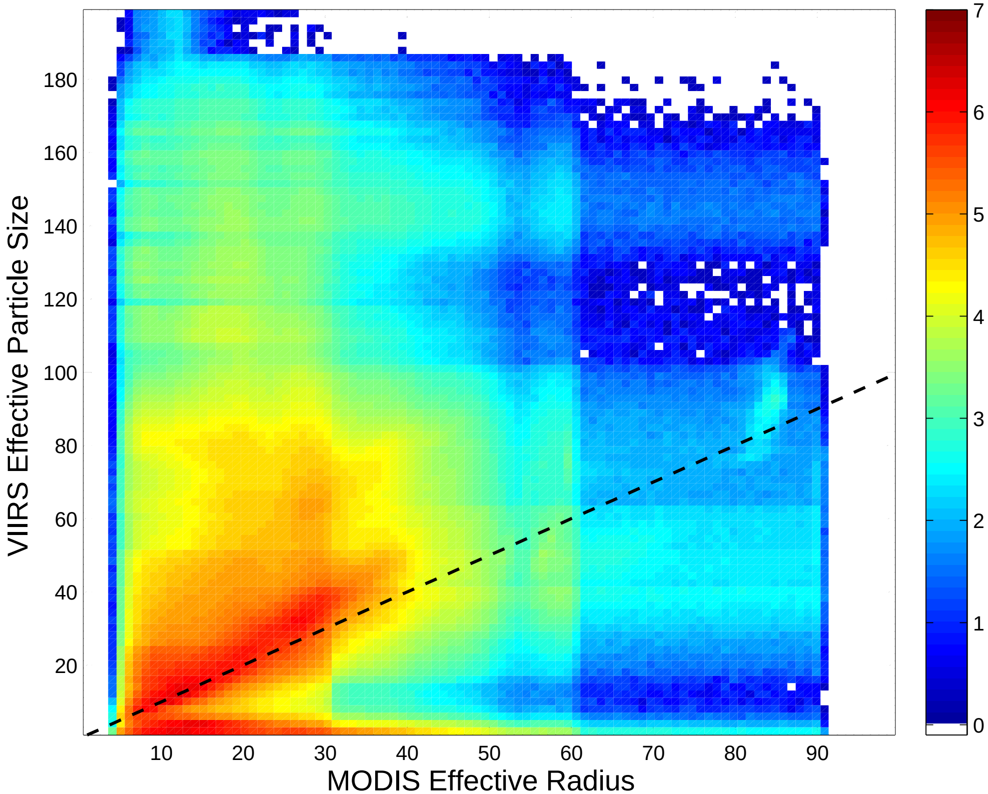
- Number of sample= 37 mills
- Phase = Water
- CTT> 273.16
- Mean bias=8.94
- STD=32.51
- CORRCOEF=0.197
- Uncertainty=33.83

VIIRS-MODIS COT comparison



- Number of sample= 234 million
- Both Ice and water cloud
- Color bar shows number density in log scale (example: 3 =1,000)

VIIRS-MODIS EPS comparison



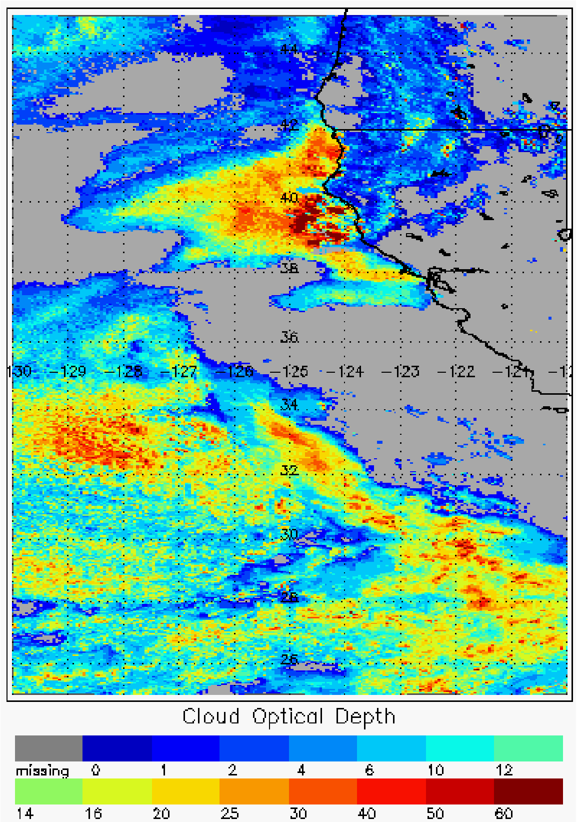
- Number of sample= 213 million
- Both Ice and water cloud
- Color bar shows number density in log scale (example: 3 =1,000)

Atmosphere PEATE

Qualitative Assessment of VIIRS Nighttime COP based on comparisons with GOES results over Marine Stratus (known dirunal cycle)

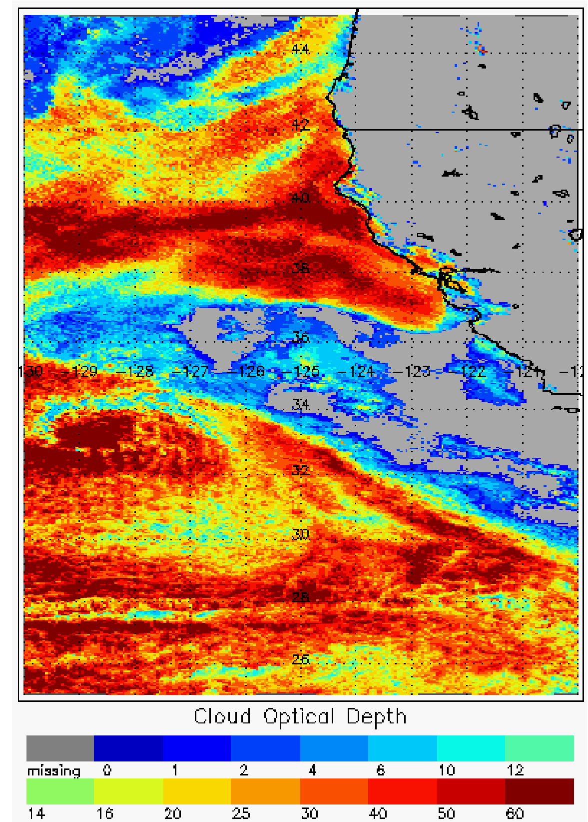
- The images below show the GOES-R AWG Daytime Cloud Optical Properties (DCOMP) applied to GOES-15. The data is cloud optical depth which is related to the mass of the cloud.
- Image on the left is at 6:00 PM local (Evening), image on the right is at 9AM local (Morning) on April 26, 2013.
- Image in the middle is at 2 AM local (Night), where there is no sunlight and no DCOMP results from GOES (*this is the gap*).
- Stratus clouds tend to grow through the night in both coverage and mass.

GOES-15 Evening



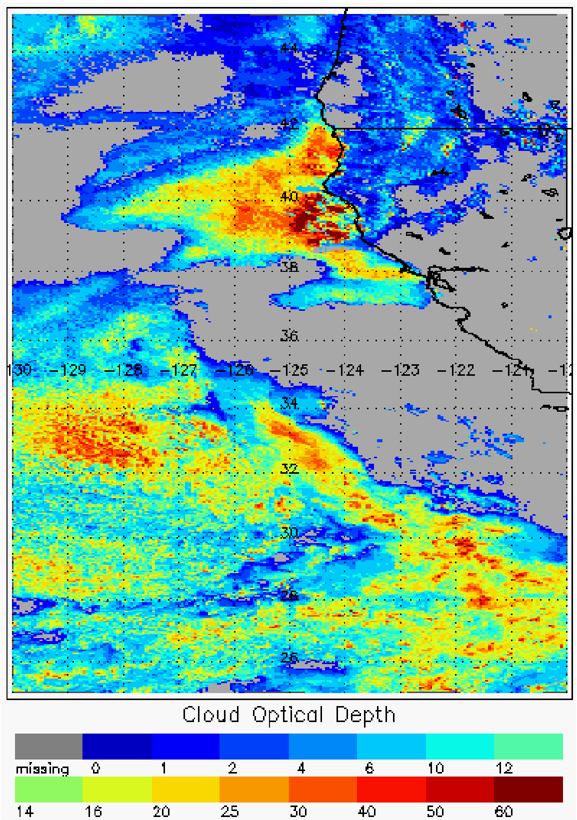
GOES-15 Night

GOES-15 Morning

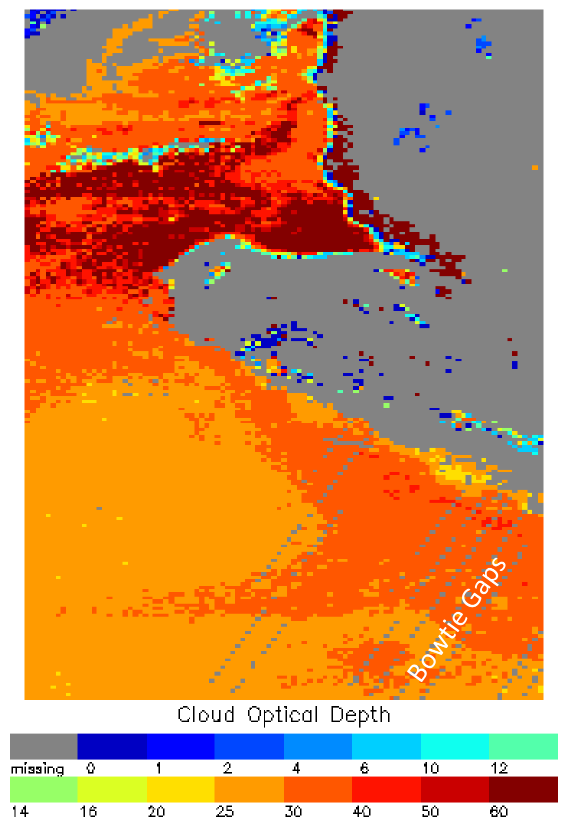


- The left and right are the same GOES data shown previously
- VIIRS IR channels do provide information to allow for a retrieval and the center image shows the cloud optical depth from the official IDPS product from VIIRS at 2:00 am local.
- IR retrievals struggle to retrieve optical depths above 4 with skill and the lack of thermal contrast with low clouds also poses problems for IR retrievals.
- The IR VIIRS cloud optical depths do not seem to be consistent with the GOES results and the expected diurnal behavior of the stratus clouds.

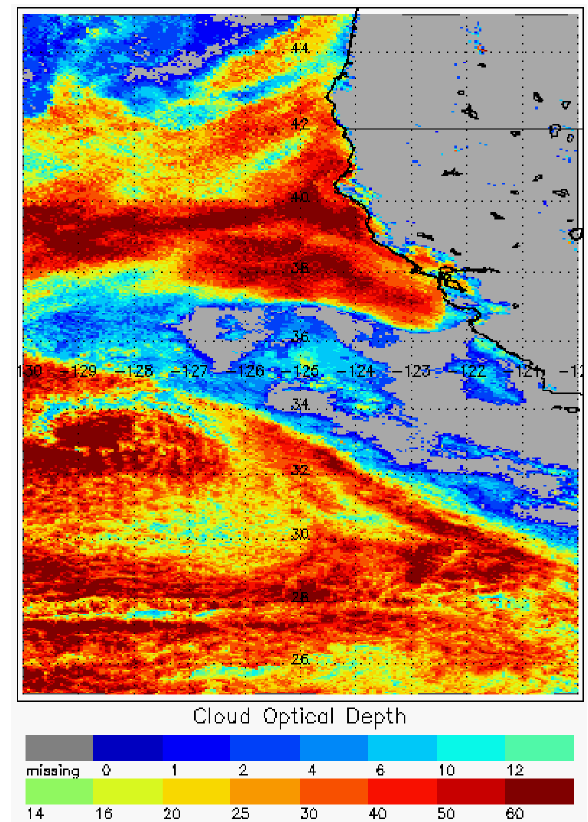
GOES-15 Evening



IDPS VIIRS IR Night



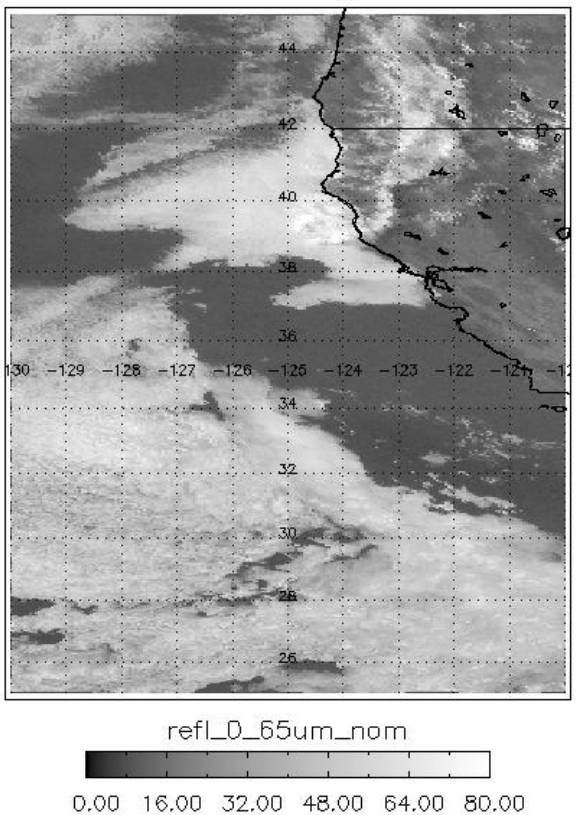
GOES-15 Morning



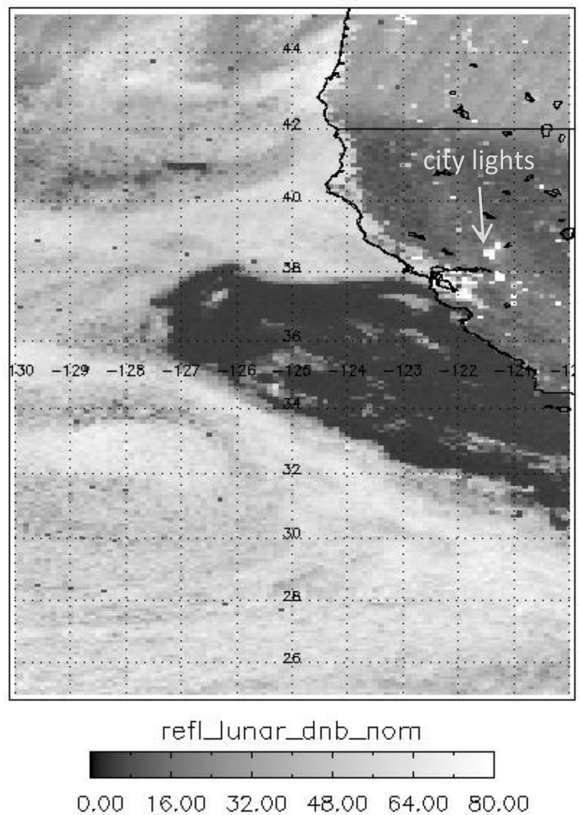
Comparison to Experimental NOAA VIIRS DNB Retrievals

- The VIIRS DNB offers daytime like capabilities when sufficient moon-light is present.
- The images below show the GOES 6 pm (left), GOES 9 am (right) and VIIRS-DNB (center) visible reflectance images. Note the presence of city lights in the VIIRS DNB.
- Cloud detection and phasing is also being modified to exploit the DNB.

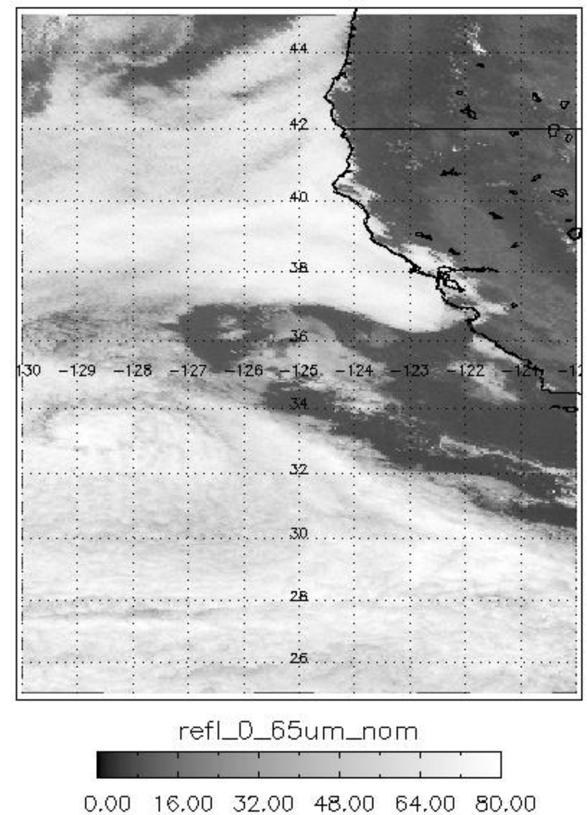
GOES-15 Evening



VIIRS DNB Night



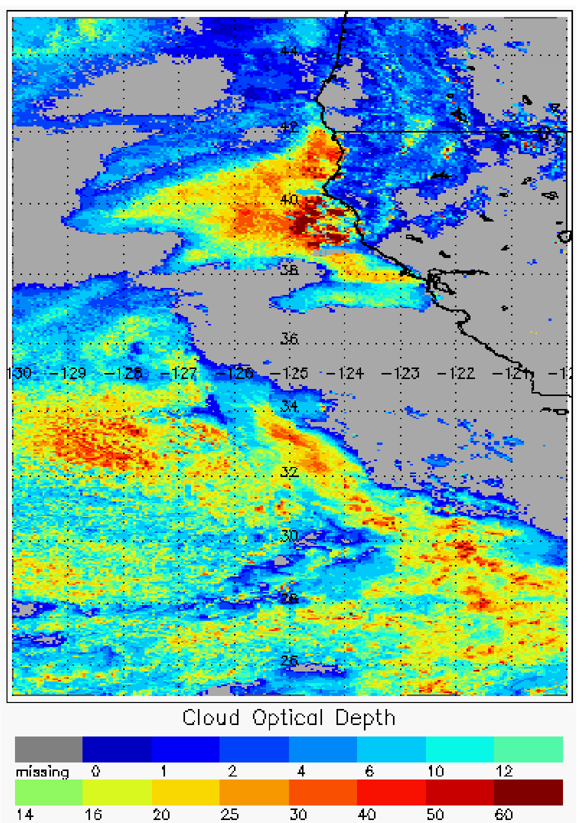
GOES-15 Morning



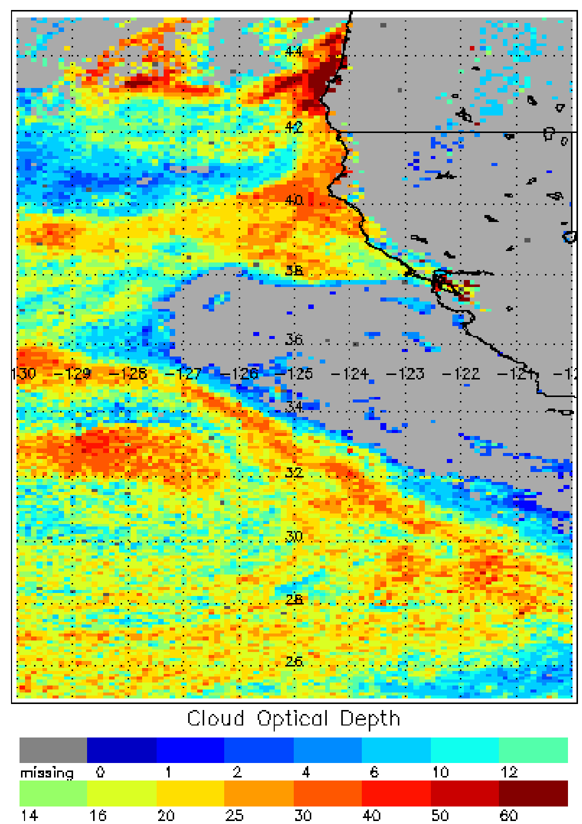
Comparison to Experimental NOAA VIIRS DNB Retrievals

- We have developed the **Nighttime Lunar Cloud Optical Properties (NLCOMP)** to derive cloud properties at night and these properties include cloud optical depth (center image).
- Note, the consistency from the NLCOMP results with the GOES results is much greater than with the IR-only IDPS results. Nighttime COP bug fixes will help improve these comparisons (TBD).
- Our sensitivity studies shows similar day-time performance for optical depth and similar day-time performance for particle size for many cloud types. There is a null-point where scattering and transmission effects reduce the sensitivity to particle size for certain clouds.

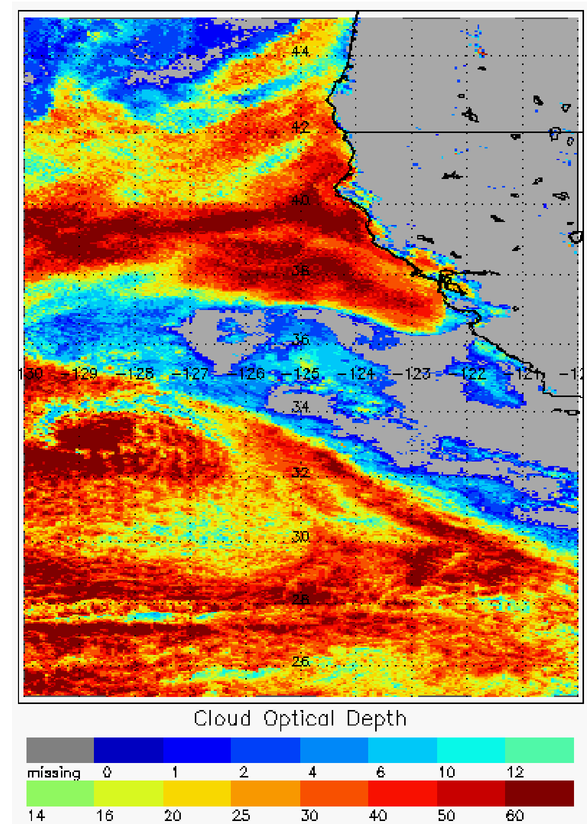
GOES-15 Evening



VIIRS DNB Night



GOES-15 Morning



Plans and Issues with Cloud Optical Properties – including Cloud Optical thickness and Cloud Effective Particles Size

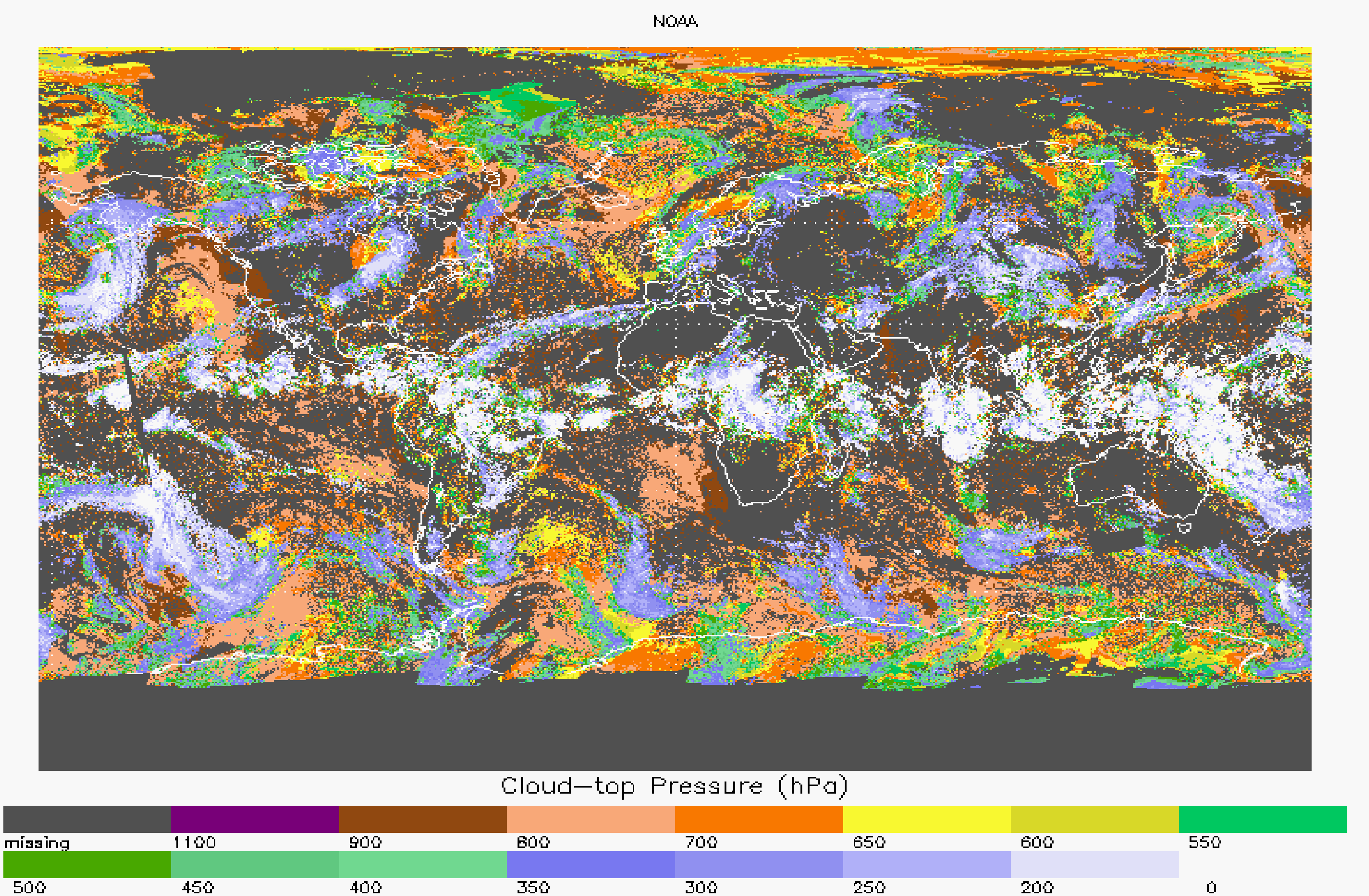
1. Need to reduce errors for Night COP – improve on the parameterization equations used in the IR method.
2. Need to correct 2 algorithmic errors found in the Night Water COP algorithm – inconsistent to ATBD, they must be fixed
3. Need to reduce CTH bias by reducing errors in CTT retrieval performed in COP – improve on the parameterization equation characterizing the extinction coefficient ratio of 2 IR bands

Conclusions: Cloud Optical Properties

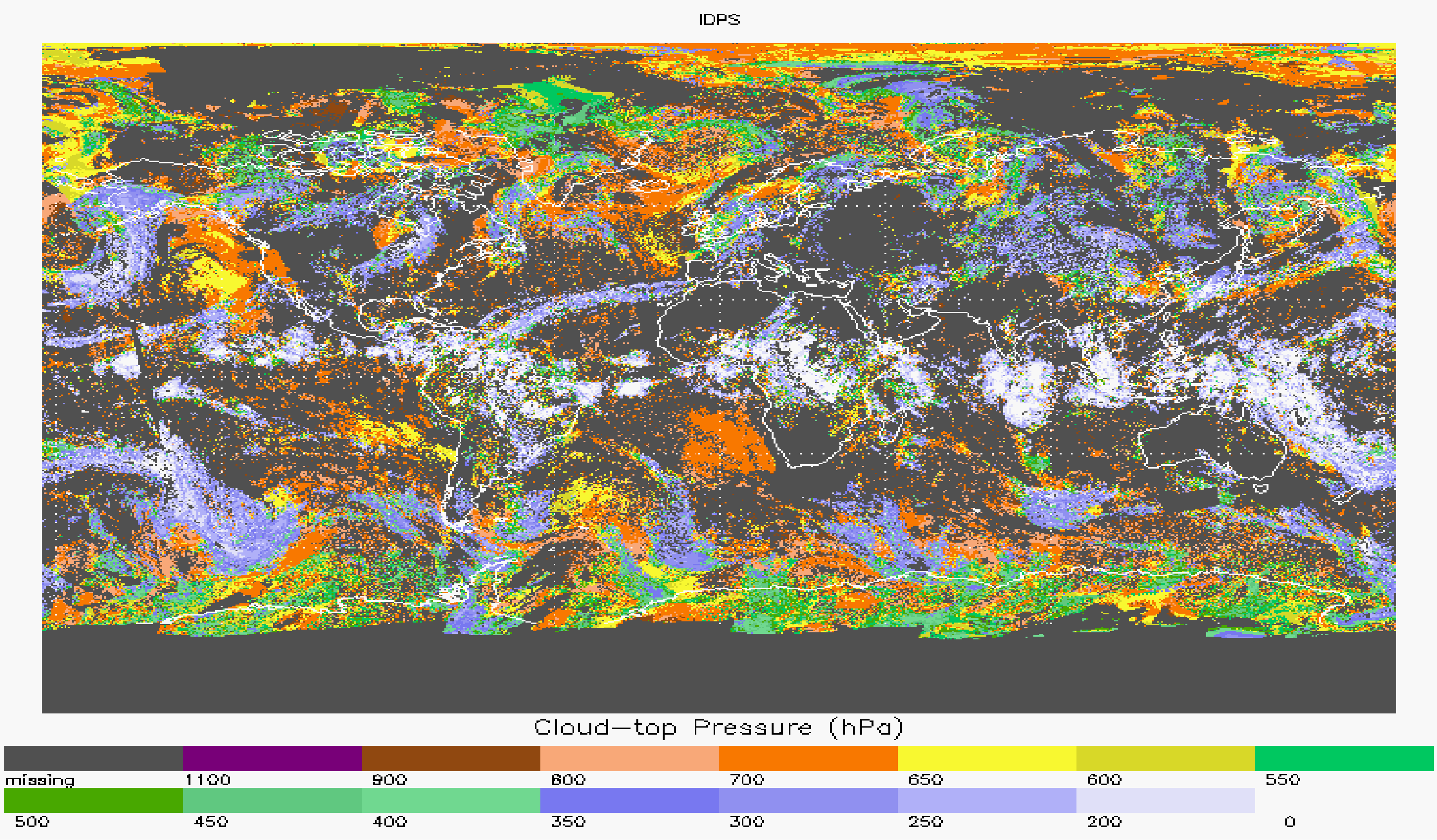
- The **VIIRS Cloud Optical Properties EDRs** (including COT and CEPS EDR) have met the Beta Maturity stage based on the definitions and the evidence shown
  - It meets or exceeds the definition of Beta in most cases
  - The product performance for day conditions is close to meeting requirements at this time.
  - The product performance for night conditions is not meeting requirements at this time pending issues to be resolved
- Issues have been uncovered during validation of the VIIRS Cloud Optical properties Product and solutions will be evaluated.
  - Identified problems are related to the night COP algorithms
  - Revised k-ratio parameterization equation is needed to remove bias in CTH, a product derived from CTT calculated in COP algorithm

Cloud Top Pressure (CTP) is defined for each cloud-covered Earth location as the set of atmospheric pressures at the tops of the cloud layers overlying the location

Global Cloud Top Pressure From NOAA GOES-R Cloud Product

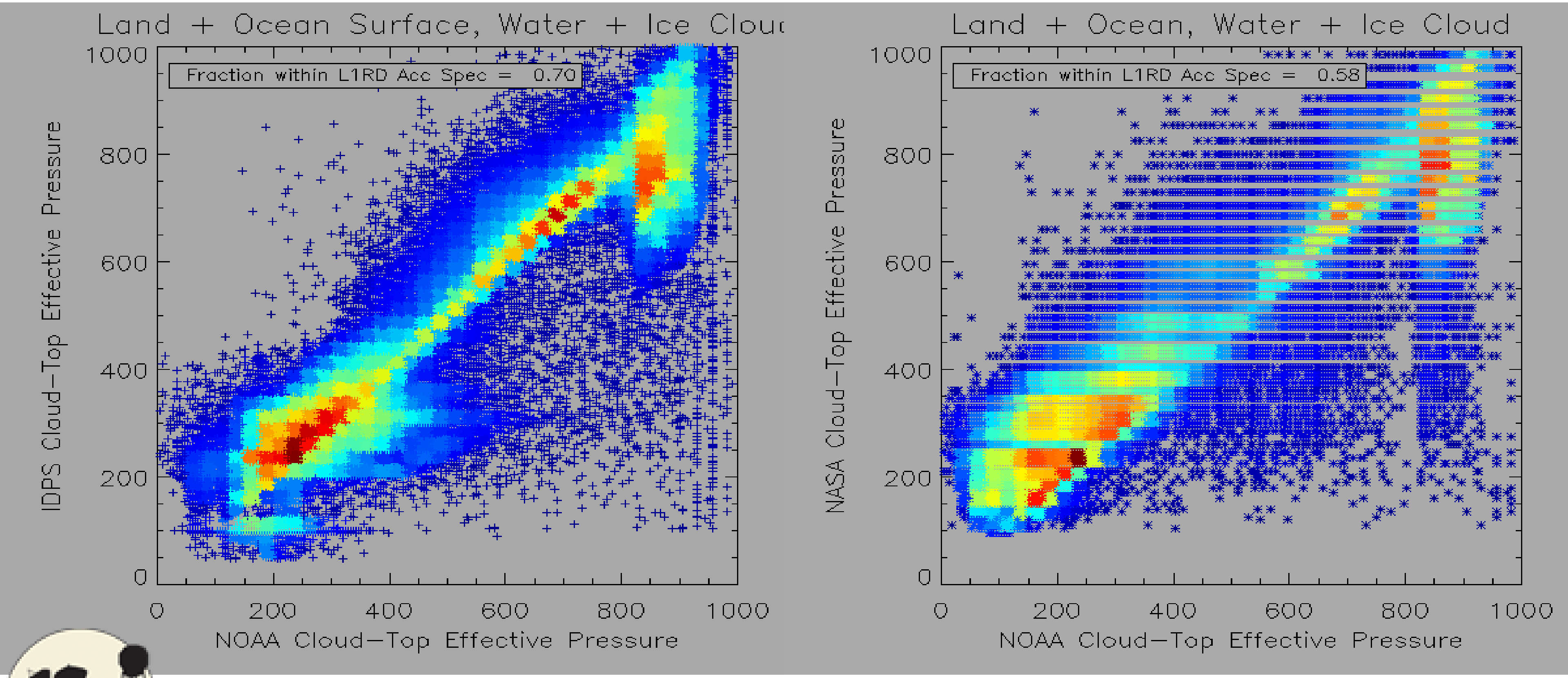


Global Cloud Top Pressure From NPP VIIRS Cloud Product



Cloud Top Pressure Comparison

- Good correlation of IDPS with NOAA. 64% of IDPS within L1RD spec relative to NOAA.
- IDPS shows a cluster of Tropopause solutions that is being investigated.
- Both IDPS and NASA show lower pressures for marine clouds than NOAA. NOAA implemented marine stratus fix, NASA and IDPS will do this.
- NASA is likely much better than NOAA which uses VIIRS channels from MODIS (no CO_2)



Cloud Top Height (CTH) is defined for each cloud-covered Earth location as the set of heights above sea level of the tops of the cloud layers overlying the location

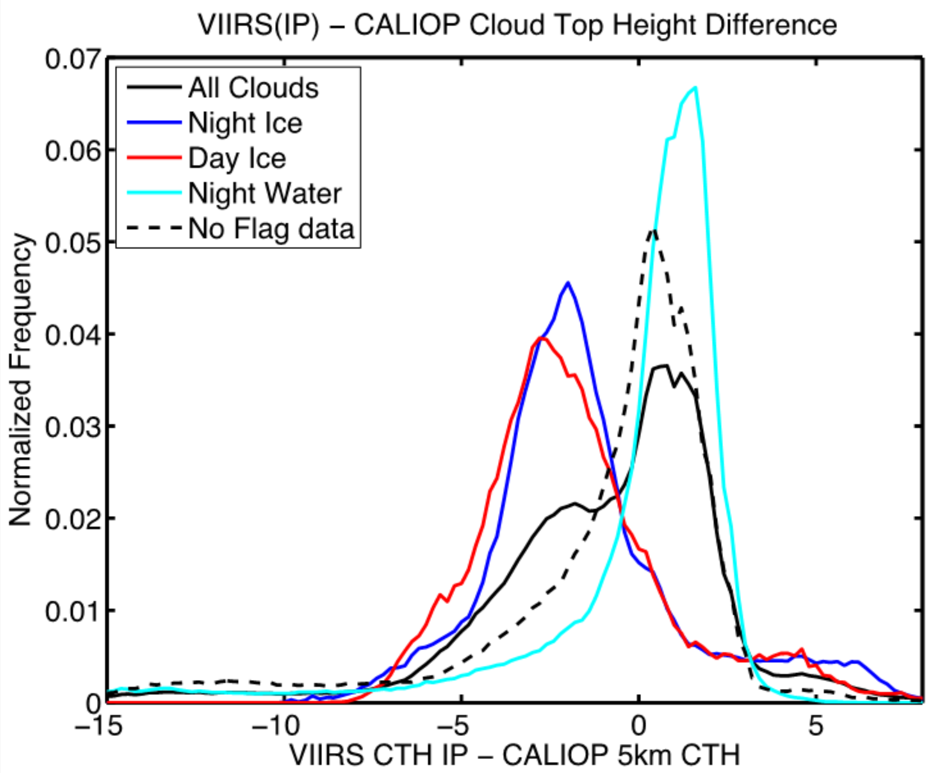
Global Cloud Top Height Evaluation of VIIRS with CALIOP CTH product

- The global distribution of CTH differences between CALIOP and VIIRS IP retrievals is presented.

- The results from VIIRS retrievals indicate a significant negative CTH bias for ice clouds.

•The mean and standard deviation of biases relative to CALIOP separated by retrieval type. Negative values occur when VIIRS underestimates CALIOP.

•3 months of VIIRS/CALIOP matchups



	COT < 1.0	COT >1.0
Accuracy (mean km) % in spec	12 %	63 %
Precision (STD) (km) % in spec	43 %	49 %

SSEC Atmosphere PEATE

VIIRS Cloud Top Height Performance Estimate based on CALIPSO Lidar Measurements

The mean and standard deviation of biases relative to CALIOP separated by retrieval type. Negative values occur when VIIRS underestimates CALIOP.

	All Retrievals	Night Ice	Day Ice	Night Water	Day water
Mean (km)	-0.9	-1.5	-1.8	-1.8	-1.1
STD (km)	3.4	2.9	2.7	3.3	3.7

	COT < 1.0	COT >1.0
Accuracy (mean km) % in spec	12 %	63 %
Precision (STD) (km) % in spec	43 %	49 %

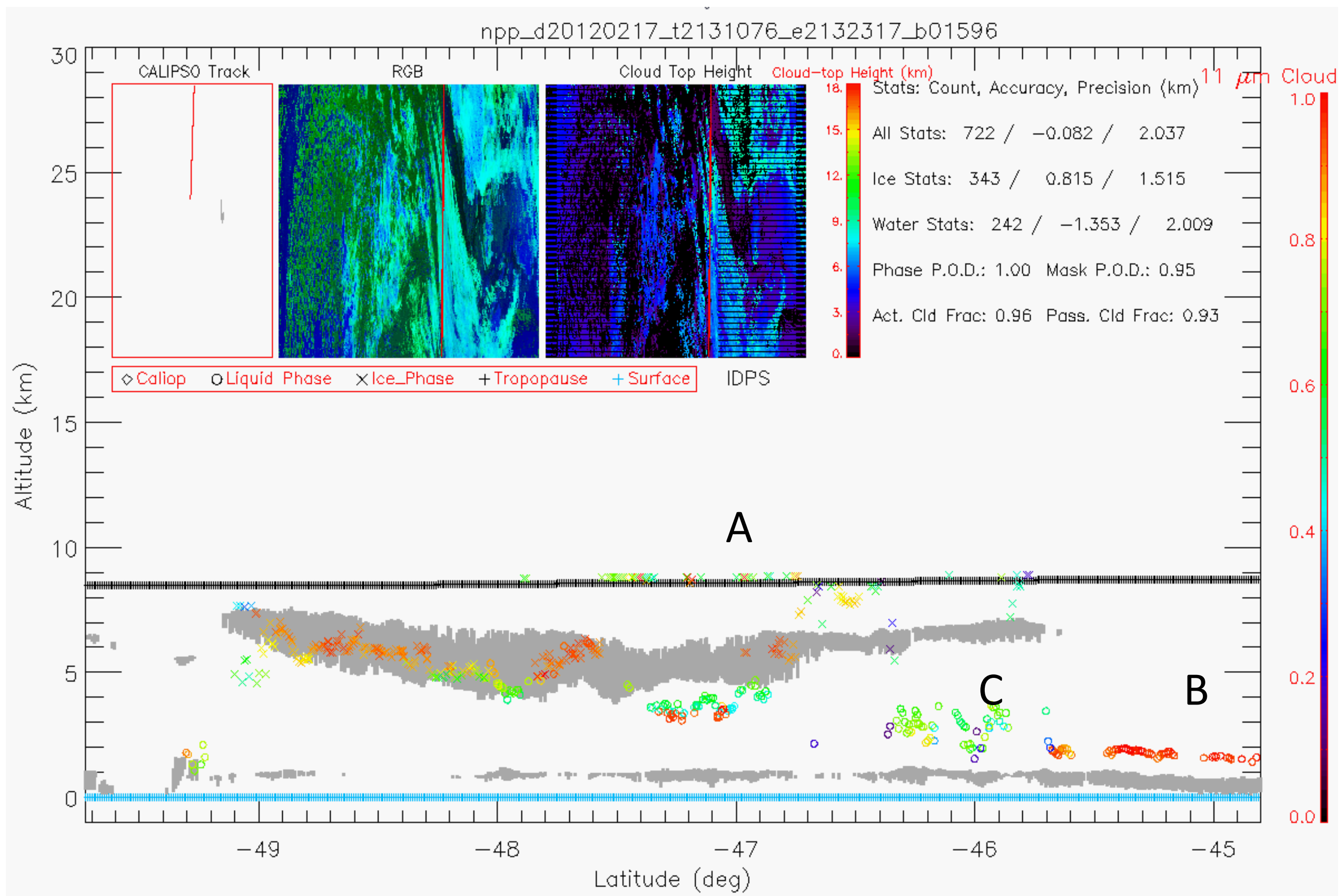
Comparison of VIIRS CTH with CALIOP CTH for One Granule

Detailed comparisons on a granule basis indicate some performance issues that likely account for these differences.

- IDPS gives clouds placed at the Tropopause. (A) – DR to be submitted
- IDPS overestimates heights in low-level marine clouds. (B) – fixed per DR 4740
- IDPS also does not account for multilayer scenarios. (C).

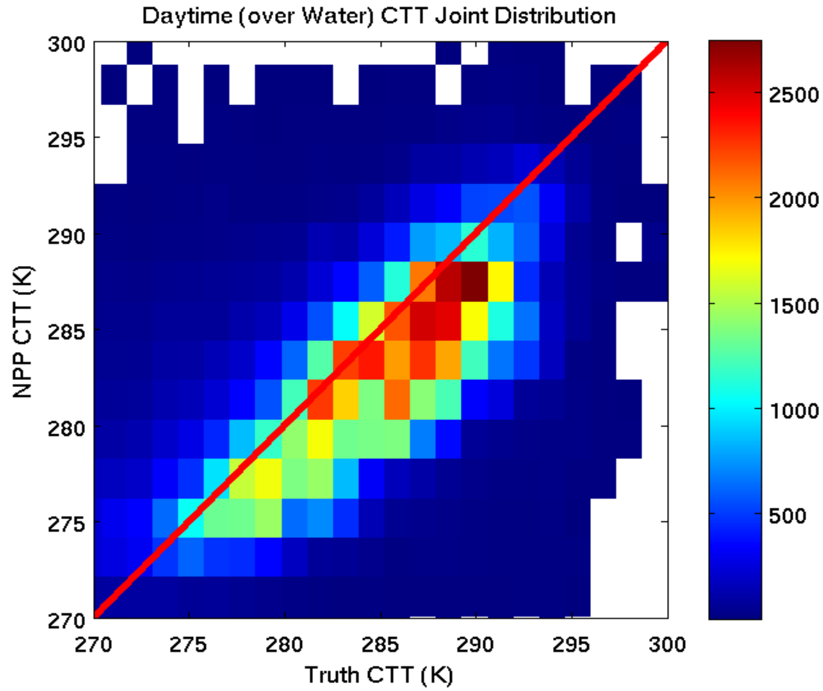
These issues are common issues to these type of algorithms.

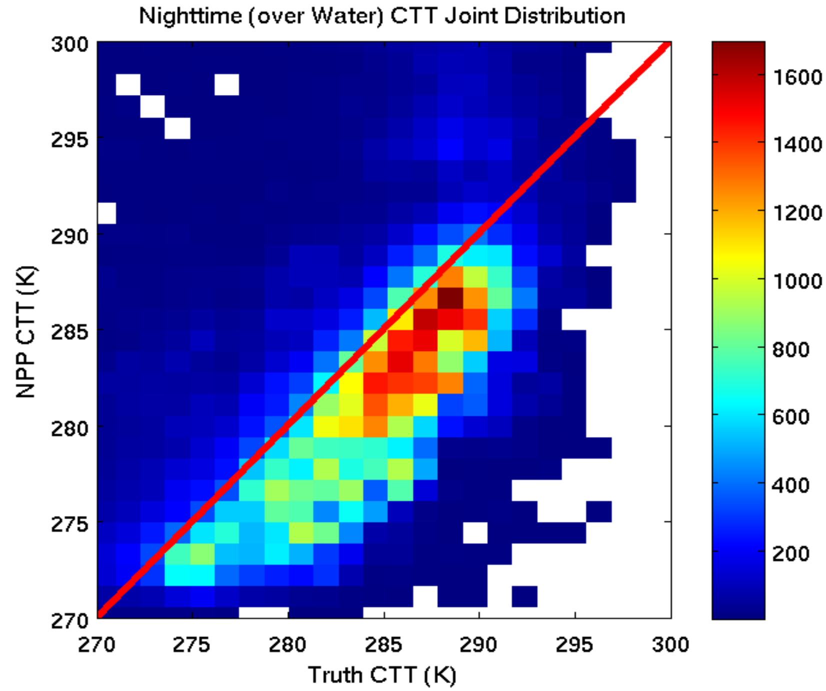
CALIPSO/CALIOP Matchup with IDPS VIIRS CTP IP



Cloud Top Temperature (CTT) is defined for each cloud-covered Earth location as the set of atmospheric temperatures at the tops of the cloud layers overlying the location

Global Cloud Top Temperature Evaluation of VIIRS with CALIOP CTT product





- •NPP CTT shows a negative bias indicating CTH being overpredicted
- DR 4740 (Marine Layer cloud Update) to be Operationalized for MX 7.0 will reduce or eliminate this CTT cold bias

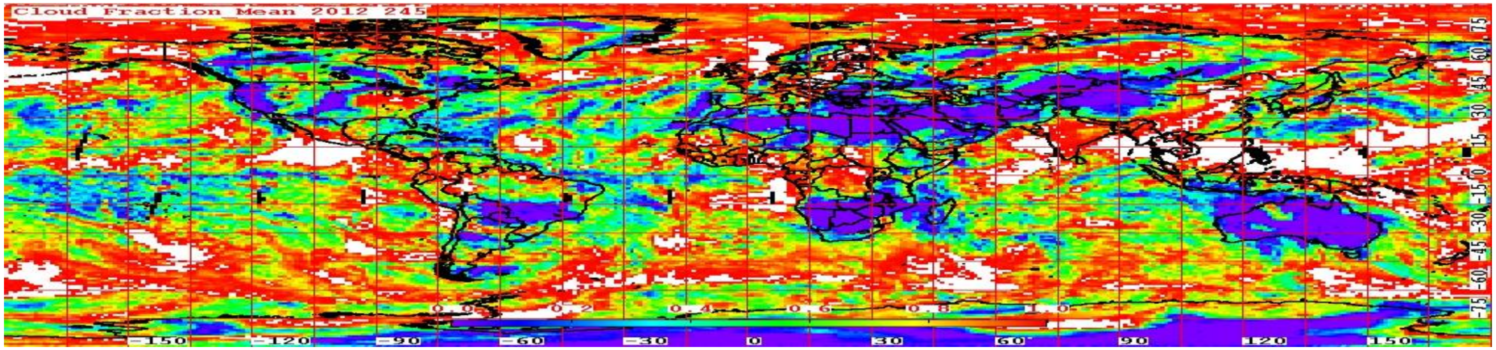
Conclusions: Cloud Top Parameters

- The VIIRS Cloud Top Parameters (which contain CTH, CTP and CTT EDR) have met the beta maturity stage based on the definitions and the evidence shown
  - They meet or exceed the definition of beta in most cases
  - There is a negative bias in the ice cloud CTH however, it should meet requirement when problems are fixed (see below)
- Issues have been uncovered during validation of the VIIRS Cloud Optical properties Product and solutions will be evaluated.
  - Identified problems are related to the COP algorithms where CTT is calculated
  - Revised k-ratio parameterization equation is needed to remove negative bias in CTH which also affecting CTT and CTP performance

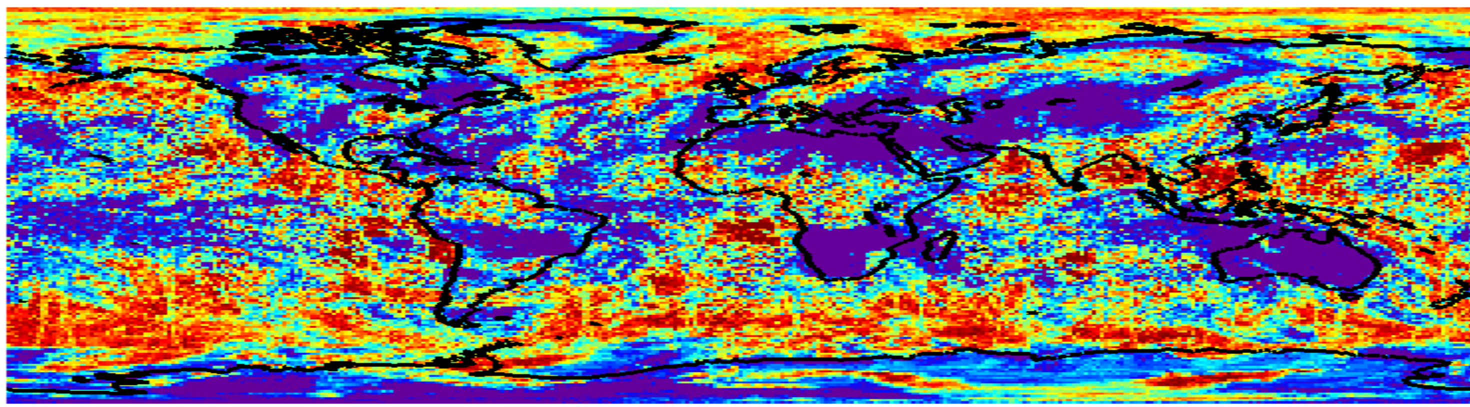
Cloud Cover (CCL) is defined as the fraction of a given area of the Earth's horizontal surface that is masked by the vertical projection of clouds

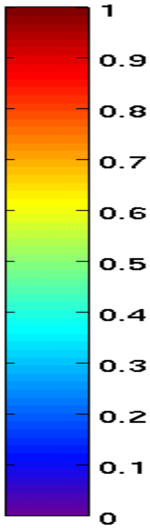
Comparison of NPP Global Cloud Cover with MODIS Product

MODIS Cloud Cover



NPP Cloud Cover





NPP Cloud Cover is qualitatively similar to MODIS

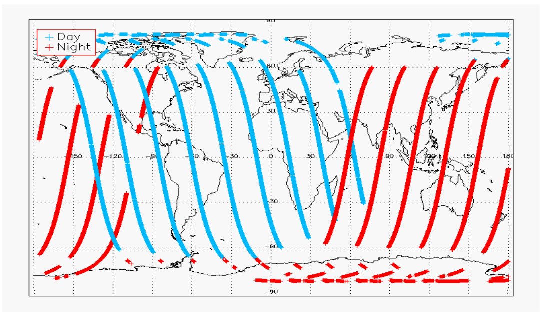
Performance of VIIRS Cloud Cover EDR derived from VIIRS Cloud Mask Probability of Cloud Detection

•Cloud Cover is defined as the faction of a given area, i.e. the Horizontal Cell Area, covered by the vertical projection of clouds
•VIIRS CCL algorithm calculates Cloud Cover based directly on VCM “confidently cloudy” pixels.
•Therefore the error or uncertainty of Cloud Cover must be equal to error (s) in detecting clouds (or 1- Probability of Cloud Detection)
•There are 2 sources of cloud detection errors: False Alarm; (2) Leakage
•Uncertainty of Cloud Cover = False alarm + Leakage

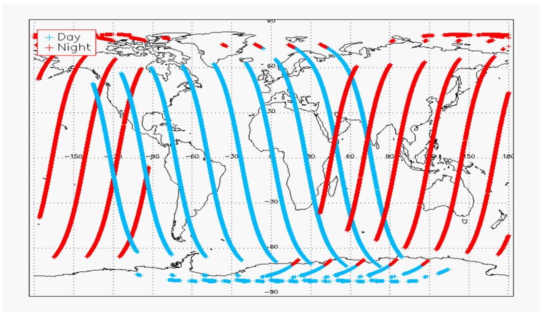
Product Quality – Global/All Clouds (From VIIRS Cloud Mask Provisional Status TIM, February 2013, VCM Cal/Val Team)

90N – 90S, Ocean/Land, Day/Night, No Snow/Snow/Ice

CALIOP - VIIRS Matchup Pixels, 05/10/2012



CALIOP - VIIRS Matchup Pixels, 11/10/2012

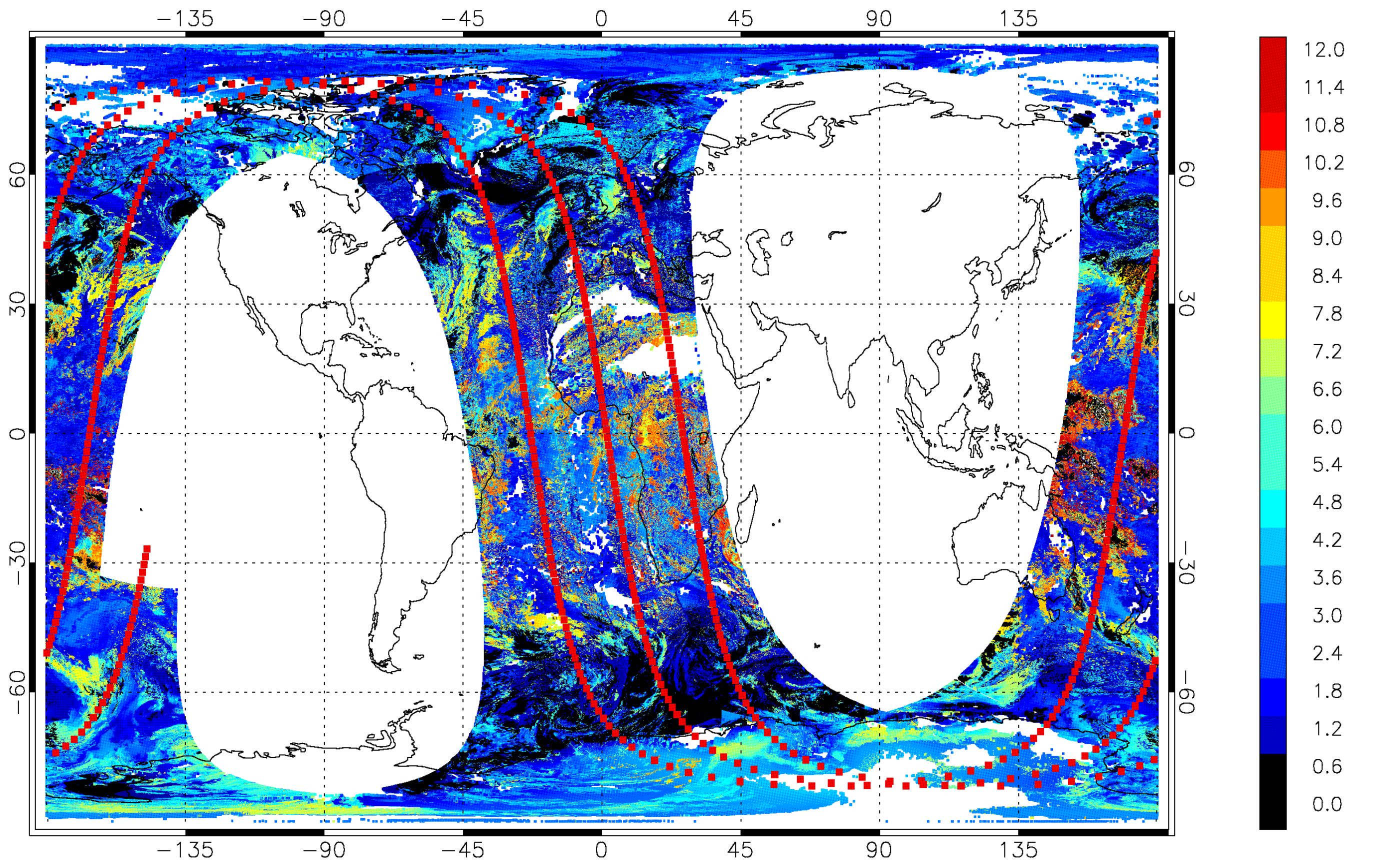


VIIRS Cloud Mask	Sample Size	Cloud fraction				Probability of		
		Active	Passive	Pr. Clear	Pr. Cloudy	Detection	False D.	Leakage
5/10/2012	257266	0.661	0.567	0.080	0.032	0.857	0.024	0.119
11/10/2012	304681	0.732	0.654	0.068	0.029	0.881	0.021	0.099

- Cloud Cover Uncertainty is given by the 2 sources of error in cloud detection
- Based on VCM Provisional stated performance, Cloud Cover Uncertainty = 0.143

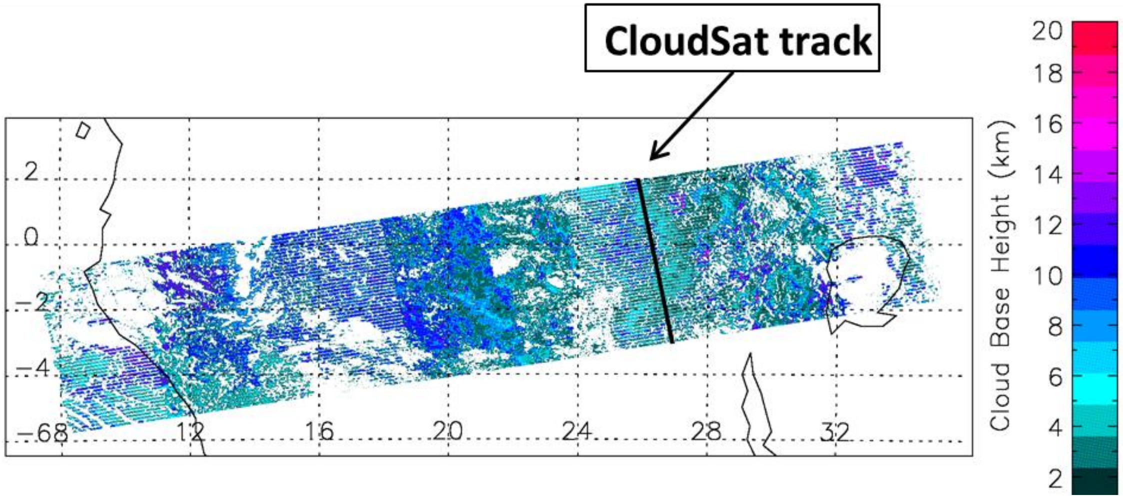
Cloud Base Height (CBH) is defined as the height above sea level where cloud bases occur

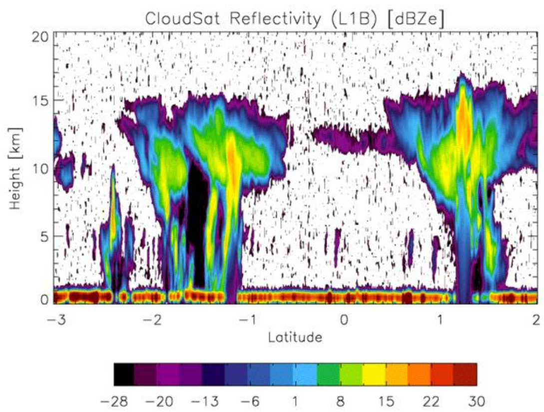
Cloud Base Height Evaluation with CloudSat (By Univ. Colorado State, CIRA)

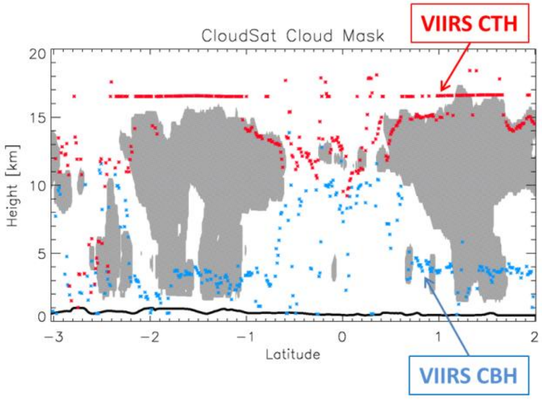


Example VIIRS/CloudSat matchup period from 17 February 2012 between 11:19 and 15:47 UTC. The CloudSat track is plotted as the dotted red line, and the VIIRS Cloud Base Height IDPS data (in km AGL) are plotted underneath.

Comparison of VIIRS Cloud Base Height with CloudSat Cloud Base height Product (By Univ. Colorado State, CIRA) - continued

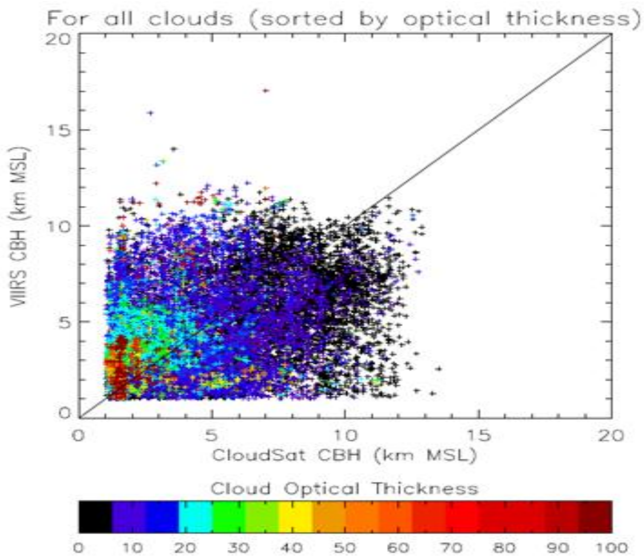


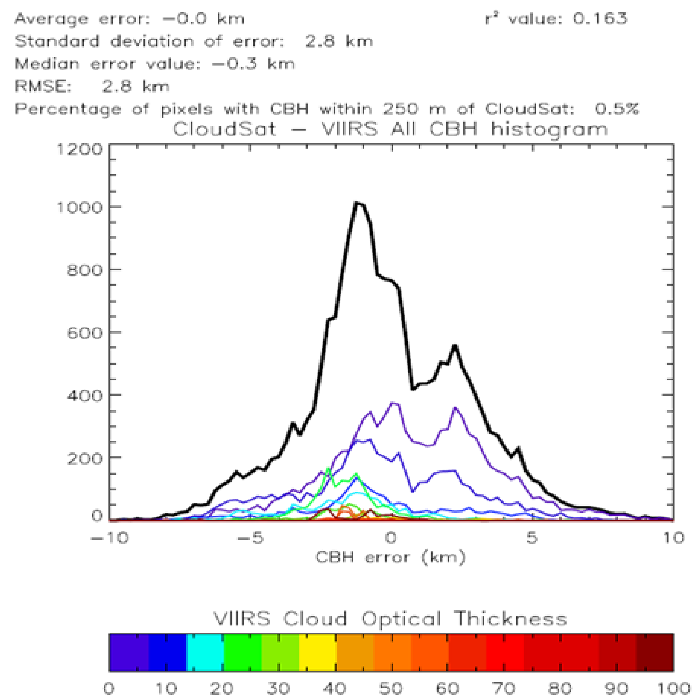




- Sample comparison of VIIRS cloud top and base heights with CloudSat cloud mask from 11:59:16 UTC to 12:00:40 UTC on 17 February 2012
- CloudSat reflectivity with VIIRS CBH IP (blue asterisks) overlaid
- In general, VIIRS CBH tend to over-predict the base height for low clouds, however, under-predicts the base for high clouds

Comparison of VIIRS Cloud Base Height with CloudSat Cloud Base height Product

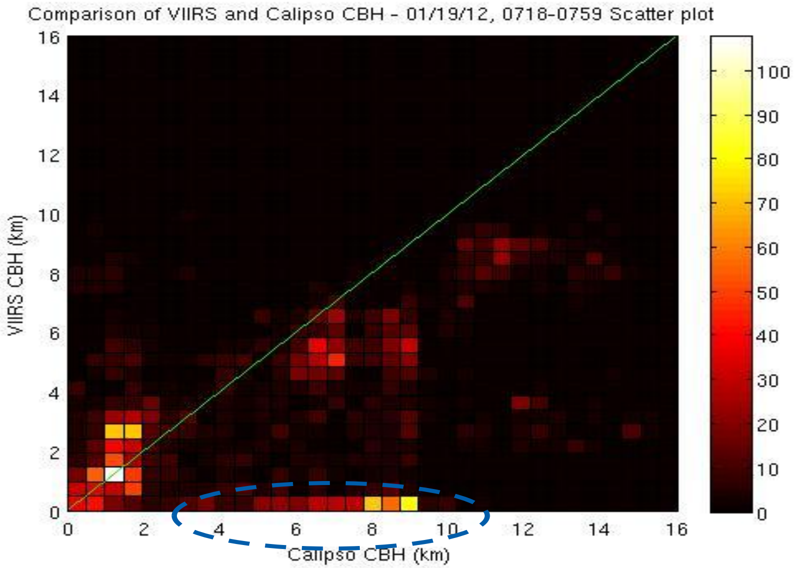




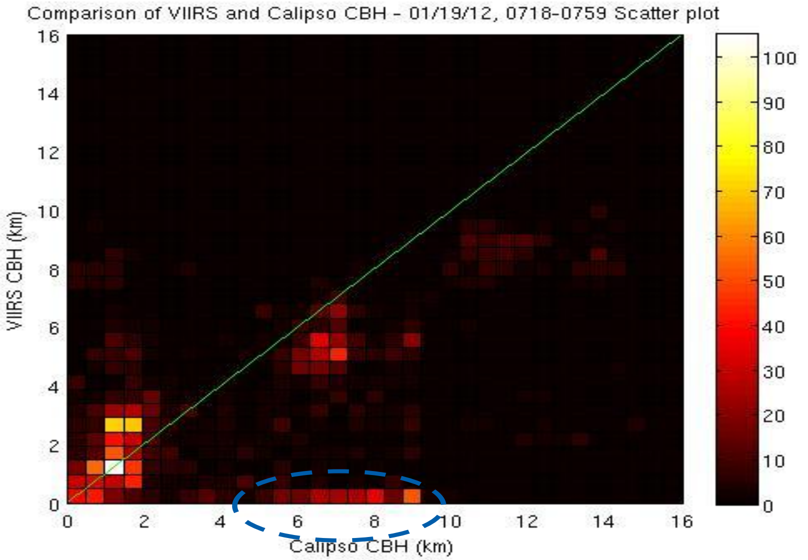
- The left figure presents scatter Plots of CBH for all valid CloudSat and VIIRS retrievals from September 2012. Points are color-coded according to the cloud optical thickness (see color scale). Note the large spread away from the diagonal line.
- The colored histograms represent errors for clouds in various optical thickness bins (see color scale). The thick black curve represents the histogram for all clouds.
- VIIRS CBH overall Performance Estimate: Uncertainty = 2.8 km

Comparison of VIIRS Cloud Base Height with CALIPSO Cloud Base Height Product (by NG)

All clouds detected by Calipso



All single layer clouds detected by Calipso



- VIIRS CBH compared against CALIPSO lidar for all clouds (left) and single-layer clouds (right).
- Notable features include VIIRS CBH overestimate of low cloud bases, underestimation of high cloud bases,
- Significant number of missed detections which may be related to VIIRS Cloud Mask performance.

Plans and Issues with Cloud Base Height Products

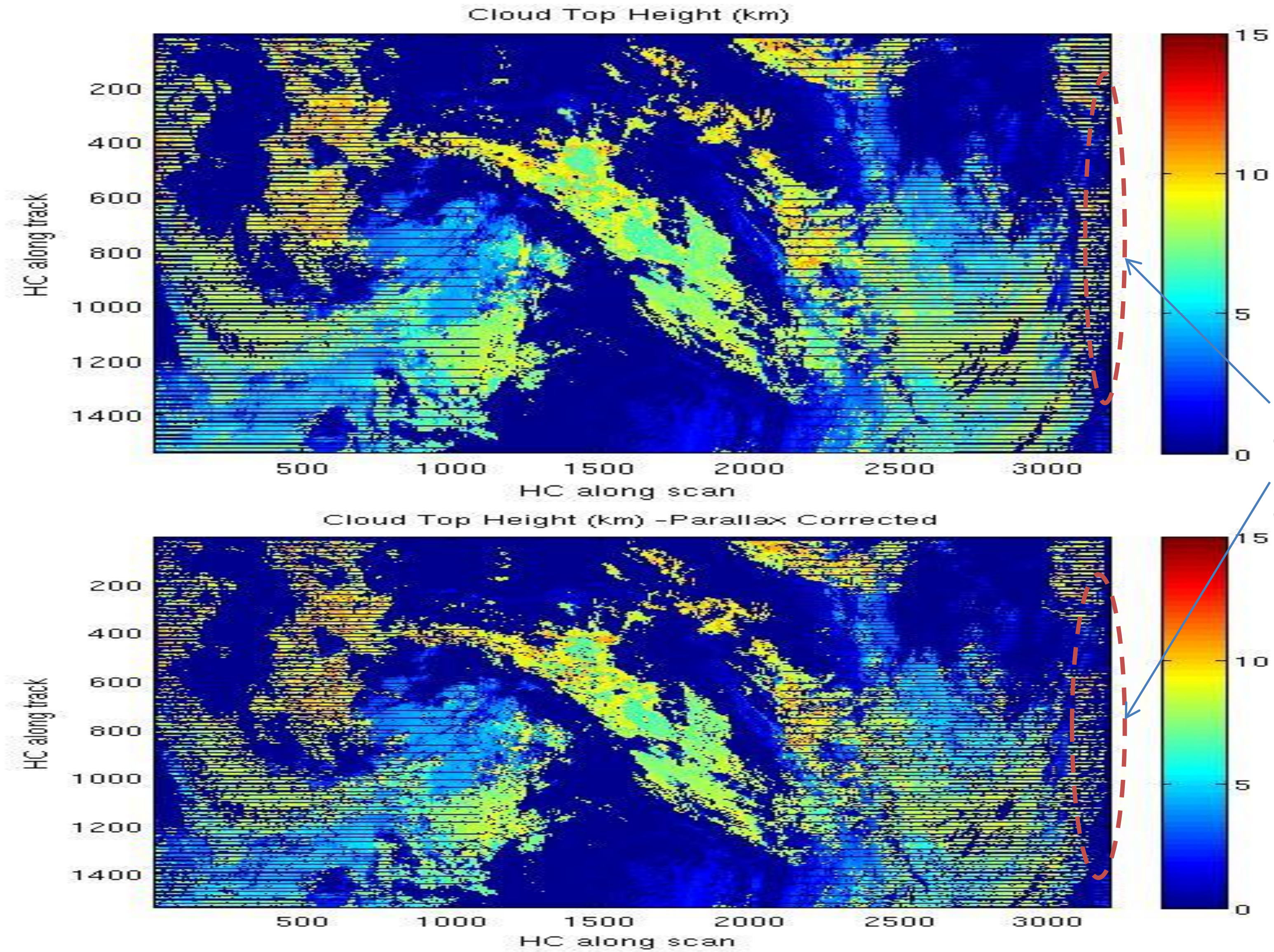
Issues identified: In general CBH algorithm over-predicts the base height of low clouds, however, under-predicts the base height of high clouds

Conclusions: Cloud Base Height Product

- The VIIRS cloud base height Products have met the beta maturity stage based on the definitions and the evidence shown
  - They meet the definition of Beta in cases studied
- Issues related to the products are the over-prediction of low cloud base and under-prediction of high cloud base – the problem is most likely caused by the error in the constant Cloud Liquid Water Contents of the 4 water cloud types. The level of error will be assessed and an error reduction approach will be developed

Validation of Perform Parallax Correction Algorithm

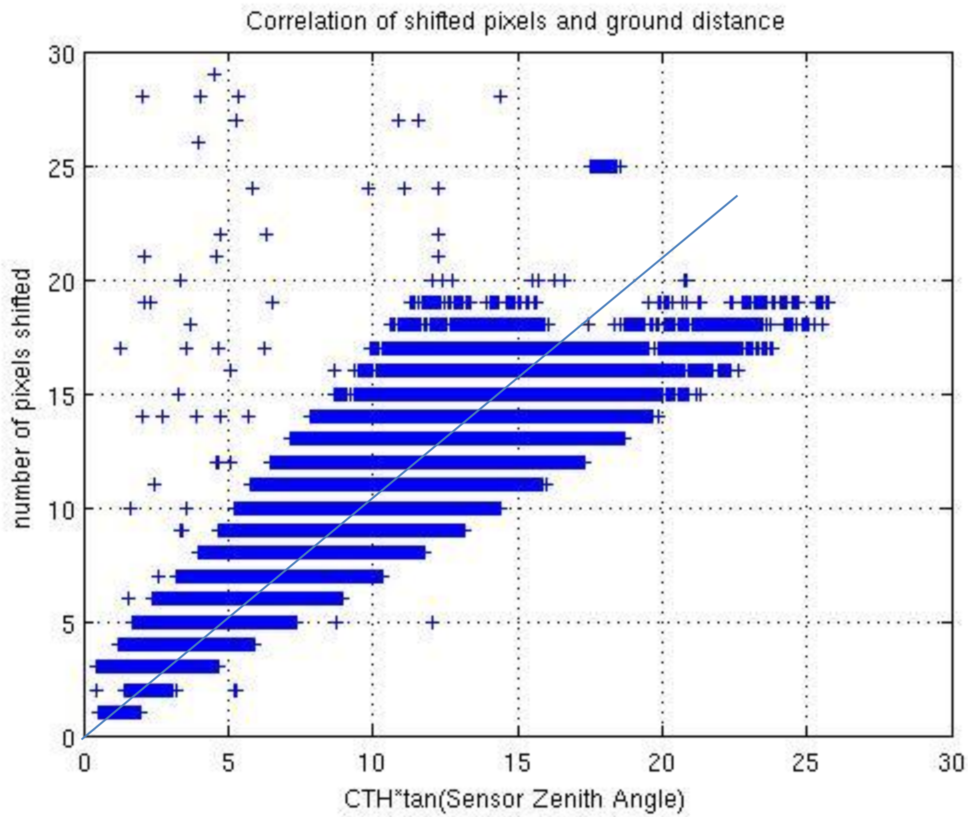
Comparison of CTH and Parallax corrected CTH IP – 2 granules from 09/01/2012, ~ 16:00



Cloud Shifted due to parallax correction

Comparison of PPC cloud IP products

- The expected linear relationship appears to hold
- Off diagonal points are from Edge-of-scan region where curvature effect is expected to be large



Future Plans and Issues

- We have gotten these changes into IDPS
  - A day COP LUT derived from the NOAA GOES-R AWG COP LUT (implemented April 26, 2013).
  - A code fix to implement NOAA marine stratus temperature to height/pressure conversion. (not implemented yet).
- We plan to implement these fixes
  - Nighttime COP bugs identified by NGAS.
  - MODIS (latitude dependent) marine stratus T to Z,P conversion
  - Nighttime COP ice cloud scattering (k-ratio) parameterization based on latest theory.
  - CBH modification of LWC/IWC values used for the various cloud types
  - Modification of quality flags.
- Future Work
  - Several issues remain without identified causes.
  - Nighttime COP and cloud base continued work

Conclusions

- VIIRS Cloud EDRs have made significant improvement over the past year.
  - Adoption of new COP NOAA-based LUTS has mitigated many artifacts.

- VIIRS Cloud EDRs have met the beta stage based on the definitions and the evidence shown
  - We are confident all products *except Nighttime COP and cloud base* meet or exceed beta.
  - Nighttime COP bugs have been identified and we expect full beta compliance once implemented.
  - Nighttime COP is not a common product (not available from MODIS) and we think the community has less expectations for nighttime COP than daytime COP.
  - Cloud base performance is also expected to improve. The specifications are low therefore we urge beta approval for this product.
  - For these reasons, we support beta for all cloud products.

Extra Material