Validated Stage 1 Science Maturity Review for VIIRS Cloud Top Height and Daytime Optical and Microphysical Products

Andrew Heidinger

September 3, 2014

Outline

- Algorithm Cal/Val Team Members

- Cloud Top Properties
  - Product Requirements
  - Evaluation of algorithm performance to specification requirements
    - Evaluation of the effect of required algorithm inputs
    - Quality flag analysis/validation
    - Error Budget
- Cloud Optical Properties
  - Product Requirements
  - Evaluation of algorithm performance to specification requirements
    - Evaluation of the effect of required algorithm inputs
    - Quality flag analysis/validation
    - Error Budget
- Documentation
- Identification of Processing Environment
- Users & User Feedback
- Conclusion
- Path Forward

VIIRS Cloud Cal/Val Team

Name	Organization	Major Task
Kurt F. Brueske*	IIS/Raytheon	Code testing support within IDPS
Janna Feeley*	Aerospace Inc	JAM
Andrew Heidinger	NOAA/STAR	Lead
Eric Wong*	NGAS	Algorithm Updates and Documentation Lead
Robert Holz	UW/SSEC	CALIPSO Validation and PEATE Liaison
Andi Walther	UW/CIMSS	Daytime COP Algorithm Support
Yue Li	UW/CIMSS	CTP Algorithm + ADL Support
Denis Botembakov	UW/CIMSS	Validation Data and Analysis Generation
Steve Miller	CSU/CIRA	Cloudsat Validation
Jay Mace	University Utah	ARM (surface) Validation Tools
Kwo-Sen Kuo	NASA/Goddard	Scattering Models for Daytime COP
Bryan Baum	UW/SSEC	Scattering Models for Daytime COP
Eva Borbas	UW/SSEC	Using CrIS for VIIRS cloud height validation
Curtis Seaman	CSU/CIRA	Cloud Base Height
Yoo-Jeong Noh	CSU/CIRA	Cloud Base Height
Min Oo	UW/SSEC	General Validation Support

Members in grey are no longer funded. * Members funded outside of cloud team budget

SNPP Validation Stages Maturity Definition

Validated Stage 1:

Using a limited set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 2:

Using a moderate set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 3:

Using a large set of samples representing global conditions over four seasons, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Cloud Provisional Recommendations

Guidance from the Review Board:

- All cloud products except Night COP for Water Clouds are provisional.
- The Cloud Team feels that remaining issues with Day COP are significant enough to prevent Validation Stage 1.
- The Review Board recommends assessment of CLAVR-x algorithms as the replacement algorithms. Freeze further NPOESS cloud property algorithm improvements.
  - Action to Andrew Heidinger to present to review panel within 30 days results based on CLAVR-x with similar rigor shown in this review.
  - CLAVR-x = clouds from AVHRR and beyond.
    - Beyond = VIIRS, ABI = Enterprise Algorithm
- CLAVR-x is in CSPP with user engagement .

Cloud Team followed all of these directives.

Evaluation of algorithm performance to specification requirements

Improvements since Provisional

- Cloud Team did stop work on open DR's for IDPS cloud algorithms (IR RTM and Surface Reflectance)
- Algorithm Improvements of the NDE are ongoing
  - CTP – cirrus heights near edges have been improved using a spatial filter to limit edges deviating from cloud centers
  - Cloud base height retrained with CloudSat
  - Day COP modified to work better over snow
  - Use of DNB in Cloud Mask and "Lunar" COP is maturing.

Evaluation of algorithm performance to specification requirements

- Cal/Val Activities for evaluating algorithm performance:
  - Cal/Val Activities are unchanged with move to NDE
  - Mask: CALIPSO, METAR and MODIS C6 comparisons
  - Type: CALIPSO
  - CTP: CALIPSO
  - Day COP: MODIS C6, ATMS
  - Night COP: ATMS
  - Cloud Base Height: CloudSat
  - Cloud Cover Layers: (CALIPSO)

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data
    - Mask: M1,M5,M7,M9-M16,I1,I5, (DNB)
    - Type: M5,M9,M10,M12,M14-M16
    - CTP/ACHA: M14-M16
    - Day COP: M5,M8,M10,M11,M12
    - Night: M12,M13,M15,M16
  - Ancillary Data
    - NWP: Profiles of Pressure, Temp, Height, wvmr, o3mr, tropopause height, surface temperature, surface pressure and surface elevation.
    - Surface: MODIS White-sky albedo (M5,M8,M9,M10). IR Emiss (M12-M16). UMD Surface Type, MODIS Land Mask, Hires Surface Elevation.
  - Upstream Algorithms: Mask/Phase
  - LUTs / PCTs
    - Mask: Naïve Bayesian Classifier Data
    - Type: No
    - CTP: No:
    - Day COP: Reflectance LUTS
    - Night COTP: Emissivity LUTS
- Evaluation of the effect of required algorithm inputs
  - Not Done.

Evaluation of the effect of required algorithm inputs

- Evaluation of the effect of required algorithm inputs
  - We have not explored robustness due to ancillary data drop outs or degradation.
  - Our algorithms have been designed to operate on many channel combinations. This have given us robustness in terms of missing channels.
    - Mask will perform as long as 11 μm is available.
    - Type will perform as long as 11 μm is available.
    - Height will perform as long as 11 μm is available but will also perform with only the 11 and 12 μm channels (8.5 μm is missing).
    - Day COP will perform if 0.65 μm is available and any of the following: 1.6, 2.2 or 3.75 μm.

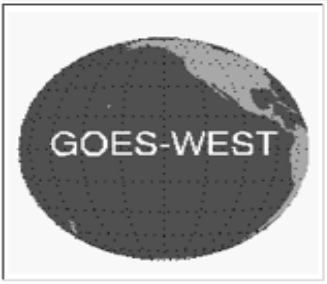
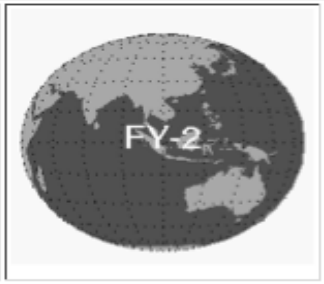
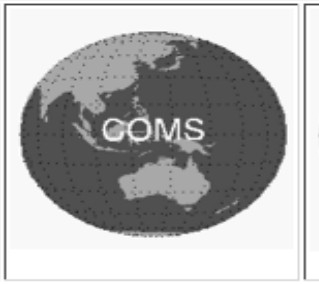
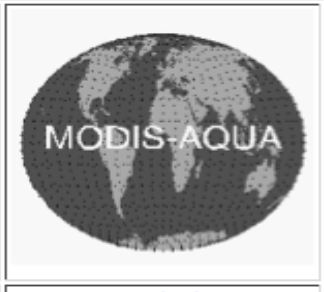
Description of Analysis

- NDE cloud algorithms have delivered to AIT and are being implemented in the SAPF.
- These algorithms run with the Clouds from AVHRR Extended (CLAVR-x) processing system with is run in OSPO (and will be replaced by the SAPF).
- CLAVR-x can not run
  - The Nighttime Cloud Optical Properties.
  - The NDE Cloud Type
- For this analysis, CLAVR-x read in the VCM and Cloud Type/Phase from the IDPS output.
  - NDE is funding a separate VIIRS Cloud Mask but that is not analyzed here.
  - NDE algorithms retrieve for probably-cloudy
- Pixels where the VCM (Mask/Phase) disagrees with our validation data are ignored.

What is CLAVR-x?

- CLAVR-x is the NESDIS Operational AVHRR and GOES Cloud Processing System.
- CLAVR-x runs the GOES-R AWG cloud algorithms implemented in NDE. Product list almost equivalent to IDPS cloud products.
- CLAVR-x is now part of the CSPP Direct Broadcast Package.
- CLAVR-x and the NDE algorithms also run on many other sensors (see below)

http://cimss.ssec.wisc.edu/clavr

Geostationary Data					
					
goes-west ftp	goes-east ftp	seviri ftp	not available	coms ftp	mtsat ftp
Polar Orbiting Data					
					
avhrr-gac ftp	avhrr-hrpt ftp	avhrr-lac ftp	modis ftp	viirs ftp	

Yue Li and Andrew Heidinger

CLOUD HEIGHT

Cloud Top Height Requirements

Table 5.3.7 - Cloud Top Height (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
CTH Applicable Conditions: 1. Requirements apply whenever detectable clouds are present.		
a. Horizontal Cell Size	7 km	1 km
b. Vertical Reporting Interval	Tops of up to four cloud layers (1)	Tops of all distinct cloud layers
c. Mapping Uncertainty, 3 Sigma	4 km	1 km
d. Measurement Precision		
1. COT $\geq$ 1 (2)	1.0 km	0.15 km
2. COT < 1 (2)	2.0 km	0.15 km
e. Measurement Accuracy		
1. COT $\geq$ 1 (2)	1.0 km	0.3 km
2. COT < 1 (2)	2.0 km	0.3 km
f. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	4 hrs.
		v2.4, 12/13/12

Notes:

1. The "average" cloud top height of all layers is also output, but there are no accuracy requirements of this output.
2. COT, expressed in units of "Tau", is also referred to as "Optical Thickness" or "Optical Depth". Optical Thickness is related to Transmittance "t" where $t = e^{-tau}$. Transmittance varies from 0 to 1, where OT = 1 is the point where all radiances pass through the cloud. For Tau = 1, the Transmittance is about 0.37 (37% of the radiances pass through the cloud).

Cloud Top Pressure Requirements

Table 5.3.8 - Cloud Top Pressure (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
CTP Applicable Conditions: 1. Requirements apply whenever detectable clouds are present.		
a. Horizontal Cell Size	7 km	1 km
b. Vertical Reporting Interval	Tops of up to four layers	
c. Mapping Uncertainty, 3 Sigma	4 km	1 km
d. Measurement Precision, COT ≥ 1		
1. Surface to 3 km	100 mb	10 mb
2. 3 to 7 km	75 mb	7 mb
3. > 7 km	50 mb	5 mb
e. Measurement Accuracy, COT ≥ 1		
1. Surface to 3 km	100 mb	30 mb
2. 3 to 7 km	75 mb	22 mb
3. > 7 km	50 mb	15 mb
f. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	4 hrs.
		v2.2, 9/22/12
Notes: 1. Reserved		

Cloud Top Temperature Requirements

Table 5.3.9 - Cloud Top Temperature (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
CTT Applicable Conditions: 1. Requirements apply whenever detectable clouds are present.		
a. Horizontal Cell Size	7 km	1 km
b. Vertical Reporting Interval	Tops of up to four cloud layers	Tops of all distinct cloud layers
c. Mapping Uncertainty, 3 Sigma	4 km	1 km
d. Measurement Precision		0.5 K
1. Optical thickness ≥ 1	3 K	NS
2. Optical thickness < 1	6 K	NS
e. Measurement Accuracy		
1. Optical thickness ≥ 1	3 K	1.5 K
2. Optical thickness < 1	6 K	2 K
f. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	4 hrs.
		v2.5, 1/23/13
Notes: 1. Reserved		

Cloud Top Property Error Budget

- Based on CALIPSO/CALIOP co-locations with VIIRS.
- COT filter > 1 accomplished using CALIOP COT
- Data where VIIRS and CALIOP phase disagreed where thrown out (a loss of 17% of data)
- CTP based on MODIS Comparisons. No CTP in CALIOP product.

Attribute Analyzed	L1RD Threshold	Analysis/Validation Result (within specs)	Error Summary
CTT	3K when $\tau \geq 1$, 6K when $\tau < 1$	47.6% (accuracy) 37.8% (precision)	1.9K (bias) 8.3K (standard dev)
CTH	1km when $\tau \geq 1$, 2km when $\tau < 1$	73.2% (accuracy) 77.2% (precision)	-0.51km (bias) 1.24km (standard dev)
CTP	$\tau \geq 1$: 100mb for [0,3km], 75mb for [3,7km], 50mb for > 7km	82.9% (accuracy) 82.9% (accuracy)	-0.02hPa (bias) 68.8hPa (standard dev)

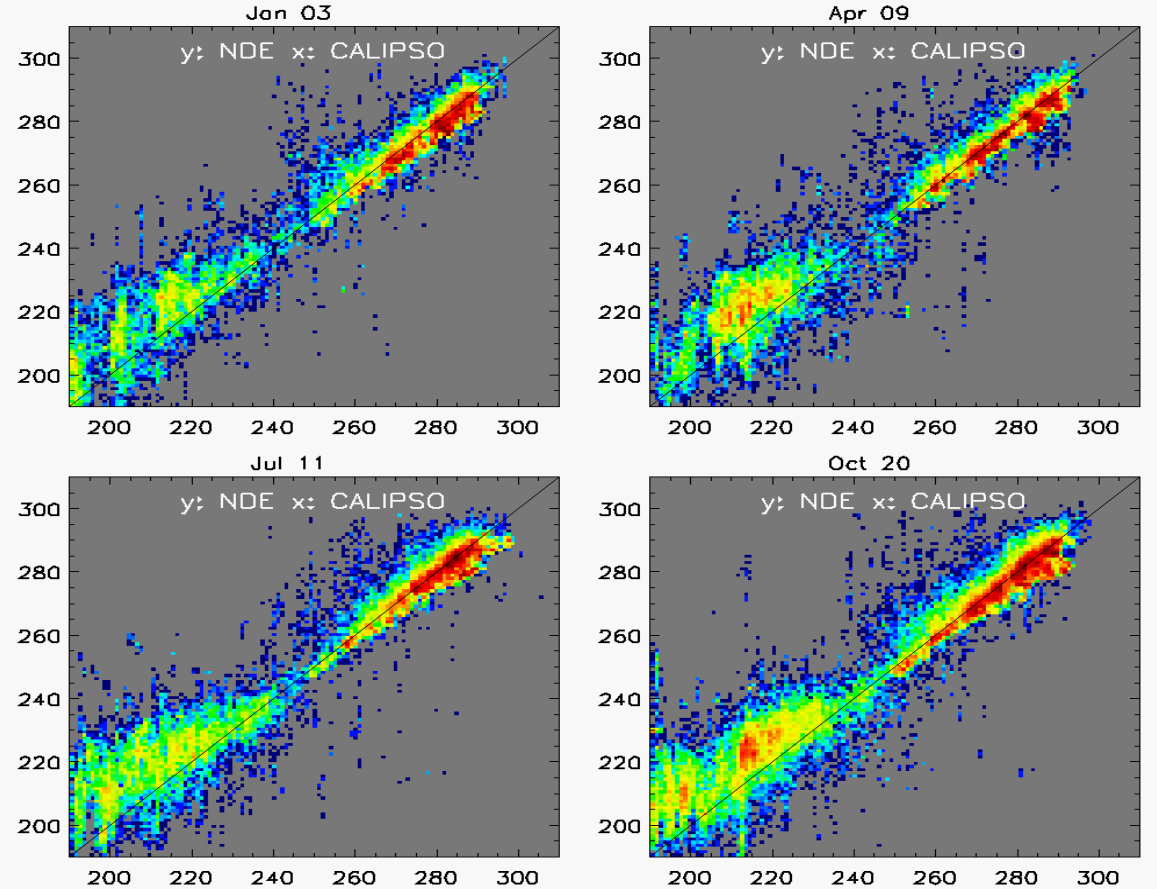
Limitations:

a. Analysis is based on single-layer data between 60°N and 60°S

b. Phase match excludes a large percentage of data

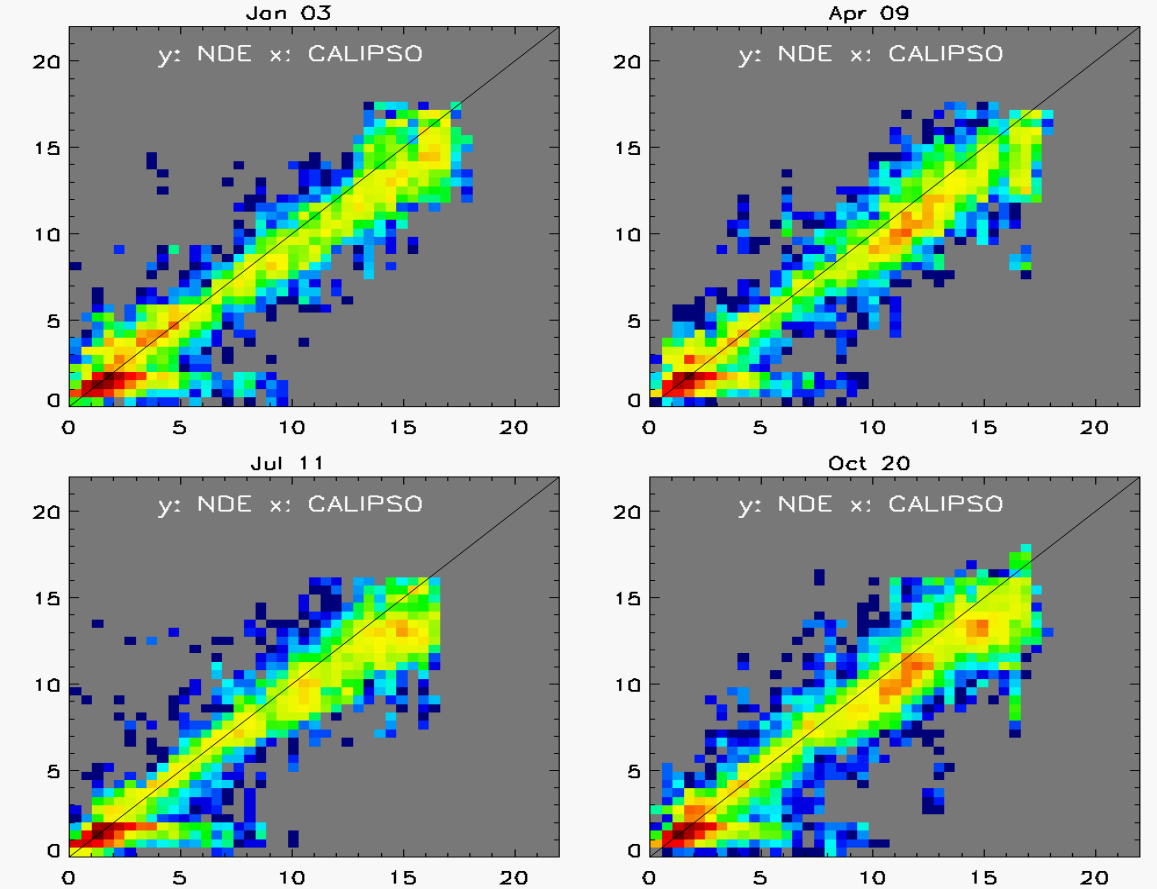
c. CTP is based on comparison with MODIS C6

Cloud Temperature Error Budget Supporting Material and Analysis



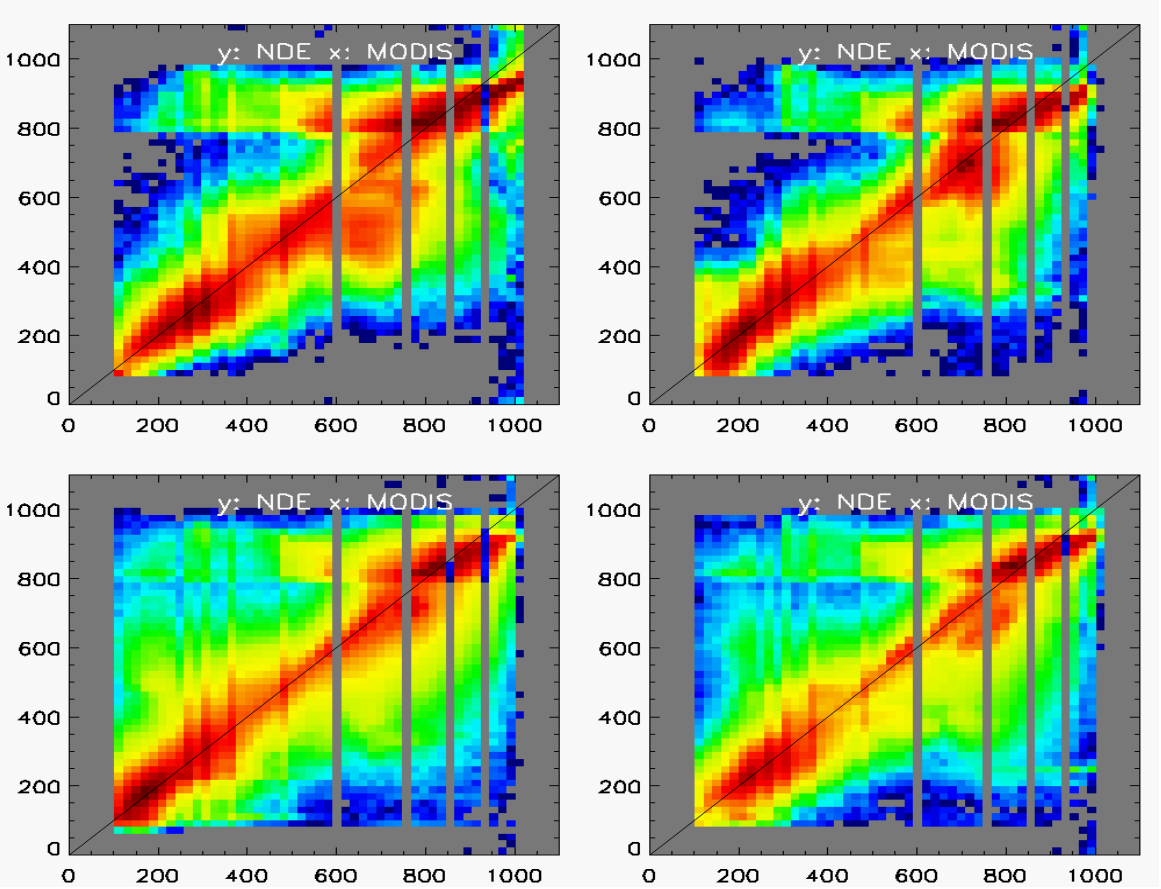
CTT – All Clouds							
Date	Bias(K)	StanDev(K)	RMSE(K)	Corr	Counts	Within Specs - Accuracy	Within Specs - Precision
01/03	1.0	7.5	7.6	0.98	39578	46.5%	40.1%
04/09	1.7	8.0	8.2	0.97	37664	48.9%	41.3%
07/11	2.1	8.4	8.7	0.97	49205	49.5%	38.3 %
10/20	2.4	8.7	9.0	0.97	66751	46.2 %	34.3%

Cloud Height Error Budget Supporting Material and Analysis



CTH – All Clouds							
Date	Bias(km)	StanDev(km)	RMSE(km)	Corr	Counts	Within Specs - Accuracy	Within Specs - Precision
01/03	-0.44	1.24	1.32	0.97	41586	73.4%	76.1%
04/09	-0.54	1.31	1.42	0.97	39888	70.8%	74.2 %
07/11	-0.53	1.20	1.31	0.98	49649	74.9%	78.6%
10/20	-0.53	1.22	1.33	0.98	68578	73.3%	77.9 %

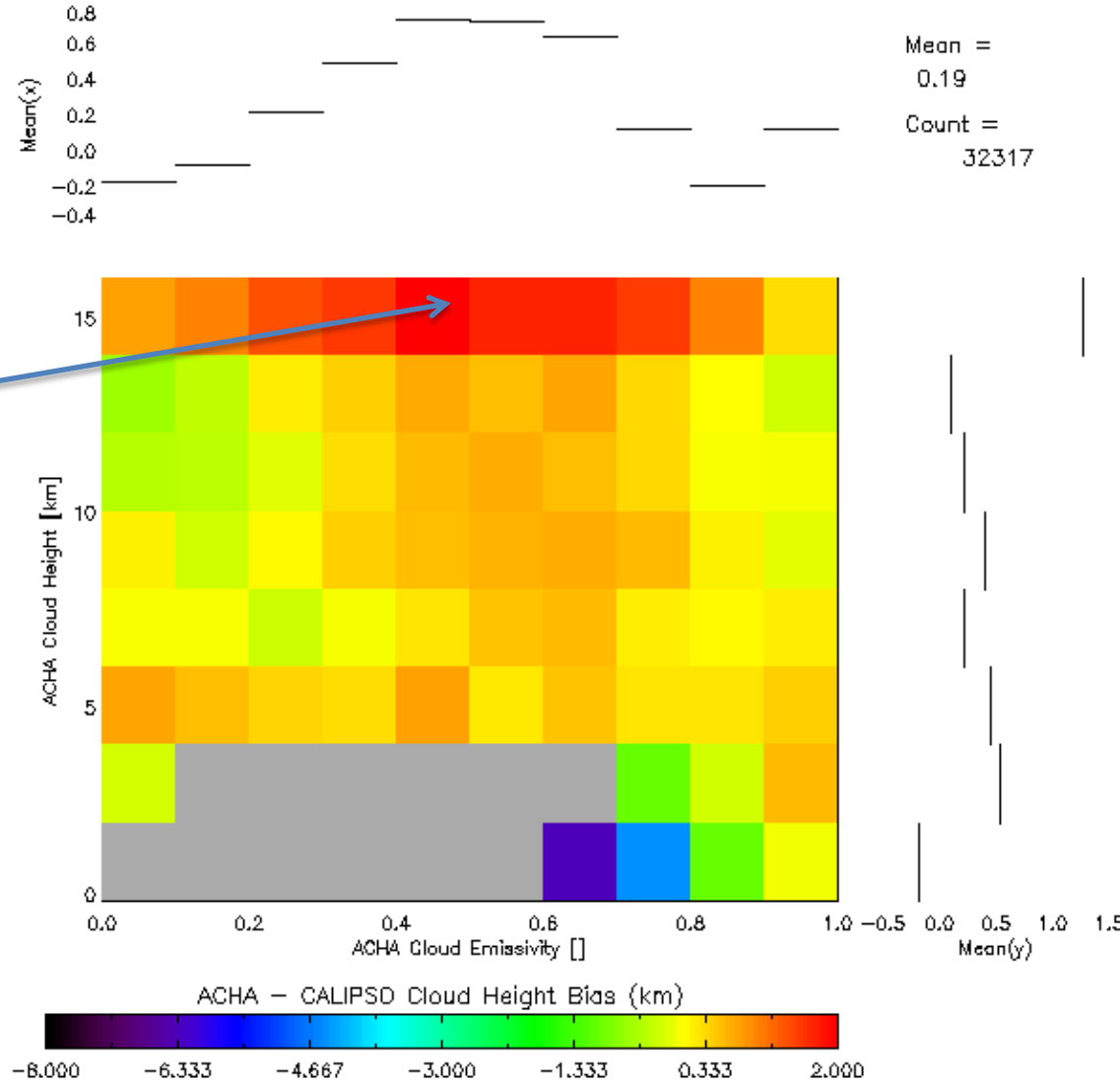
Cloud Pressure Error Budget Supporting Material and Analysis



CTP - All Clouds						
Date	Bias(hPa)	StanDev(hPa)	RMSE(hPa)	Corr	Within Specs - Accuracy	Within Specs - Precision
01/03	-5.4	88.4	88.6	0.95	77.9%	78.0%
04/09	1.8	69.9	70.0	0.97	81.6%	81.6%
07/11	4.7	65.6	65.8	0.98	83.7%	83.9%
10/20	-3.8	64.0	64.1	0.97	84.1%	84.3%

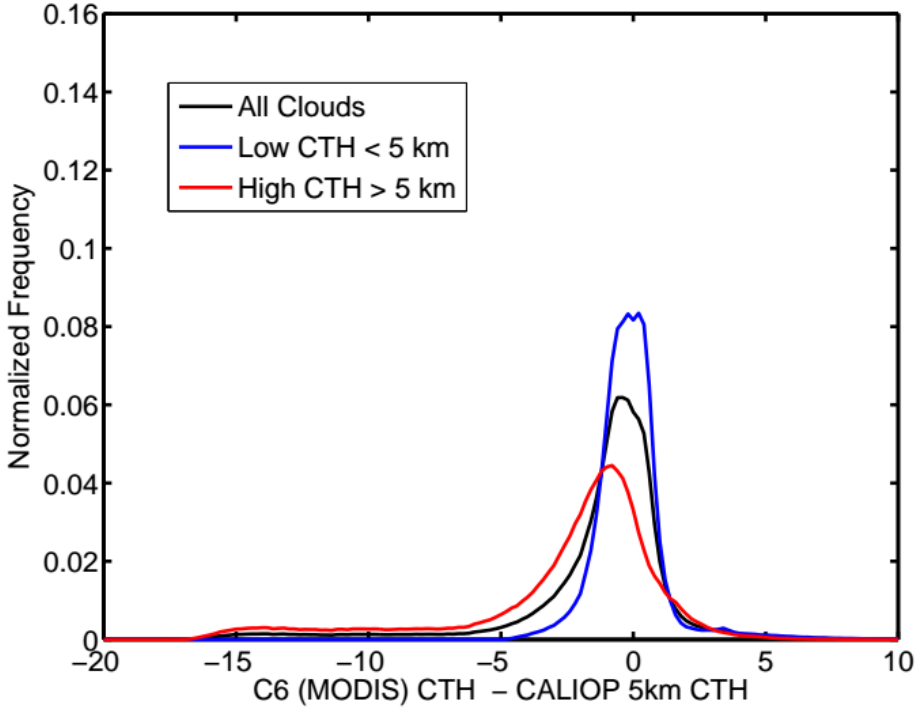
Cloud Height Error Budget Supporting Material and Analysis

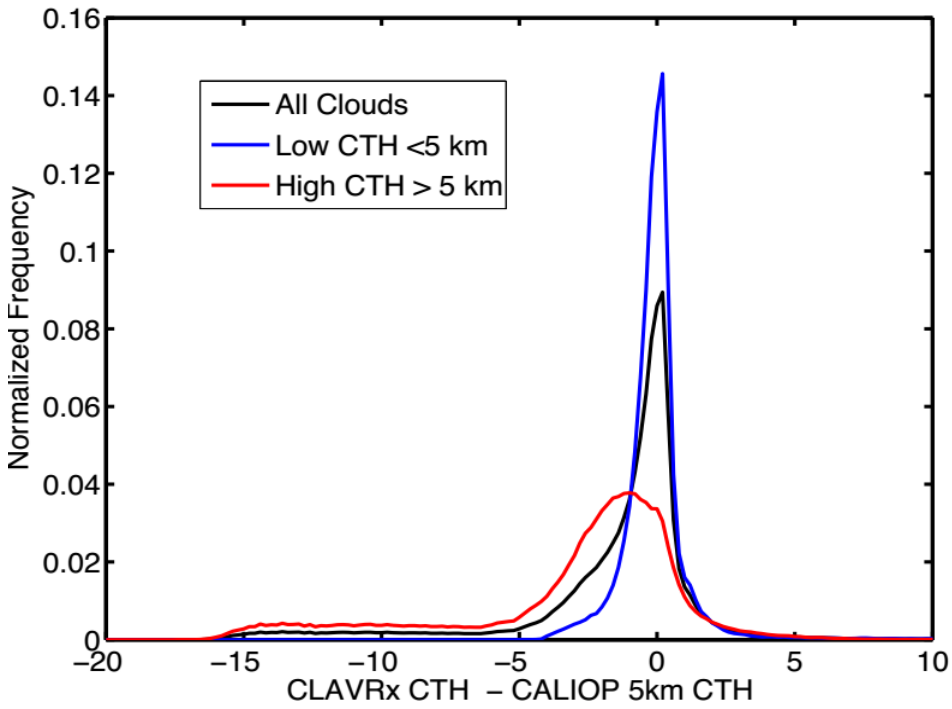
- Plotting CTH bias as a function of retrieved height (y-axis) and retrieved emissivity (x-axis).
- This illustrates a known problem – over estimation of height for thin and very high cirrus clouds.
- The solution is the microphysical model which is the most difficult thing to nail down and is an active area of research.
- Similar to k-ratio DR's on IDPS algorithms.
- VIIRS is sensitive to this because of no h2o or co2.



CTPH: NDE-VIIRS vs C6-MODIS

- Images below show the same analysis plotted differently for C6 MODIS and CLAVR-vs CALIPSO cloud height . NDE is run in CLAVR-x run and CLAVR-x appears on axis.
- MODAWG = MODIS + NOAA AWG = Processing system proposed for NPP Proposal lead by Steve Platnick. MODAWG heights are CLAVR-x.
- **CLAVR-x on VIIRS is similar to but not identical with C6 MODIS**.





January 2014 Day + Night

CTP/ACHA Quality flag analysis/validation

- Meta Data Definition (per pixel)
  1. Cloud Height Attempted (0 = no / 1 = yes)
  2. Bias Correction Employed (0 = no / 1 = yes)
  3. Ice Cloud Retrieval (0 = no / 1 = yes)
  4. Local Radiatve Center Processing Used (0 = no / 1 = yes)
  5. Multi-layer Retrieval (0 = no / 1 = yes)
  6. Lower Cloud Interpolation Used (0 = no / 1 = yes)
  7. Boundary Layer Inversion Assumed (0 = no / 1 = yes)
  8. NWP Profile Inversion Assumed (0 = no / 1 = yes)

- Quality Flag Definition (per pixel)
  1. Processed (0 = no / 1 = yes)
  2. Valid Tc Retrieval (0 = yes, 1 = no)
  3. Valid ec Retrieval (0 = yes, 1 = no)
  4. Valid beta Retrieval (0 = yes, 1 = no)
  5. degraded Tc Retrieval (0 = no, 1 = yes)
  6. degraded ec Retrieval (0 = no, 1 = yes)
  7. degraded beta Retrieval (0 = no, 1 = yes)

- Analysis/validation
  - Verified manually

Cloud Top Property Summary

- Within specs percentages are higher for CTH and CTP than CTT, due to conversion relationship from height to temperature
- NDE shows a negative cloud height bias for ice clouds, common to passive sensor
- Water clouds CTH bias is possibly related to temperature inversion, and less reliable CALIPSO data at lower levels?
- Large bias and variations of nighttime CTP is likely due to poor MODIS performance at night, and MODIS C6 CTP is pending validation too
- ACHA COD performs well for values less than 1.5
- ACHA COD validation is only applicable to ice clouds

Andi Walther, CIMSS

DAYTIME CLOUD OPTICAL PROPERTIES

Cloud Optical Depth Requirements

Table 5.3.6 - Cloud Optical Thickness (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
COT Applicable Conditions: 1. Requirements apply whenever detectable clouds are present.		
a. Horizontal Cell Size	7 km	NS
b. Vertical Reporting Interval	Up to four cloud layers	4 layers
c. Mapping Uncertainty, 3 Sigma	4 km	1 km
d. Measurement Precision	Greater of 33 % or 1 Tau	2 %
e. Measurement Accuracy	Greater of 24% or 1 Tau	5 %
f. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	3 hrs.
		v2.5, 1/23/13
Notes: 1. Reserved		

Cloud Effective Particle Size Requirements

Table 5.3.3 - Cloud Effective Particle Size Parameter (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
CEPS Applicable Conditions: 1. Requirements apply both day and night and whenever detectable clouds are present.		
a. Horizontal Cell Size	7 km	1 km
b. Vertical Reporting Interval	Up to 4 cloud layers	0.3 km
c. Mapping Uncertainty, 3 Sigma	4 km	1 km
d. Measurement Range	0 to 50 μm	NS
e. Measurement Precision	Greater of 22% or 1 μm for water; Greater of 28% or 1 μm for ice	2 %
f. Measurement Accuracy	Greater of 22% or 1 μm for water; Greater of 28% or 1 μm for ice	5%
g. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	4 hrs.
		v2.2, 9/22/12
Notes: 1. Reserved		

Day Cloud Optical Properties Error Budget Supporting Material and Analysis

Challenge: Cloud optical parameters, in particular optical depth, are difficult to validate. Validation sources are rare. Most evaluation sources use similar retrieval approaches, and are therefore not independent.

Strategies:

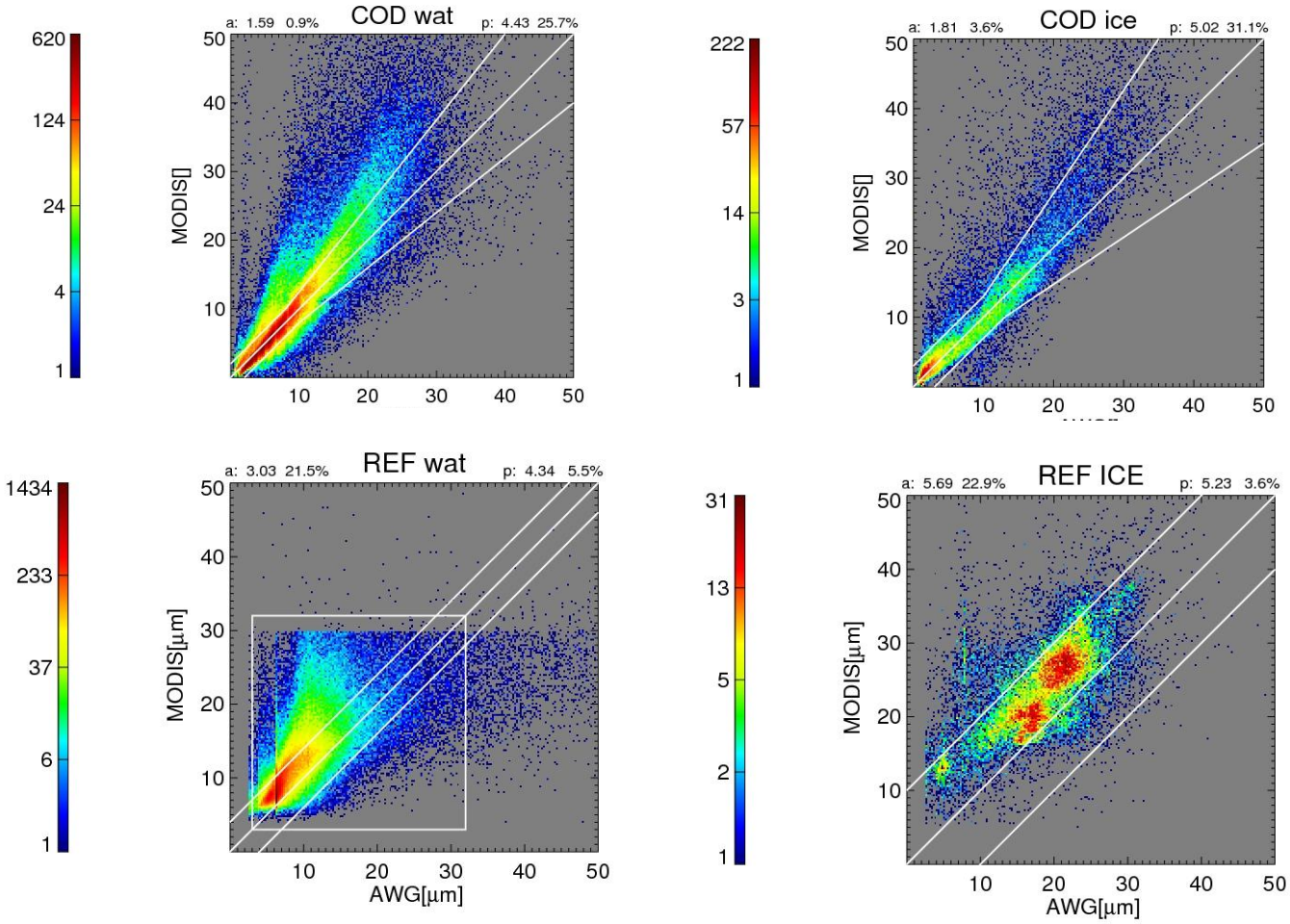
- Sanity checks by inter-comparisons with existing retrievals
- Direct comparison with MODIS products.
- Use of passive microwave retrievals to validate liquid water path.
- A-TRAIN measurements can help to identify aerosol layers and multi-layer clouds.

Day Cloud Optical Properties Error Budget

- Errors computed relative to MODIS C6 COD and CEPS.
- VIIRS results are colocated AQUA/MODIS over 10 days.

Attribute Analyzed	L1RD Threshold	Analysis/Validation Result	Error Summary
COD Accuracy	Greater of 24% or 1	A: 2.9% P: 26% ; 92.1% inside accuracy specs	✔
CEPS Water Accuracy	Greater of 22% or 1um	A: 21.5% P: 5.6%; 77.4% inside accuracy specs	✔
CEPS Ice Accuracy	Greater of 28% or 1um	A: 22.9% P: 3.6%; 69.3 % in accuracy specs	✔

Day Cloud Optical Properties Error Budget Supporting Material and Analysis



Comparison of DCOMP to MODIS-AQUA products for 10 full days. White lines depict requirement limits.

Day Cloud Optical Properties Error Budget Supporting Material and Analysis

Microwave sensors offer a further validation source
Validation is limited due to coarse spatial resolution and to only liquid phase sensitivity
We apply several filter criteria:

- 90% of DCOMP pixels must be covered by liquid clouds
- MW is insensitive to thin clouds. We exclude clouds thinner than COD = 5.
- We exclude all MW pixels with rain flag.

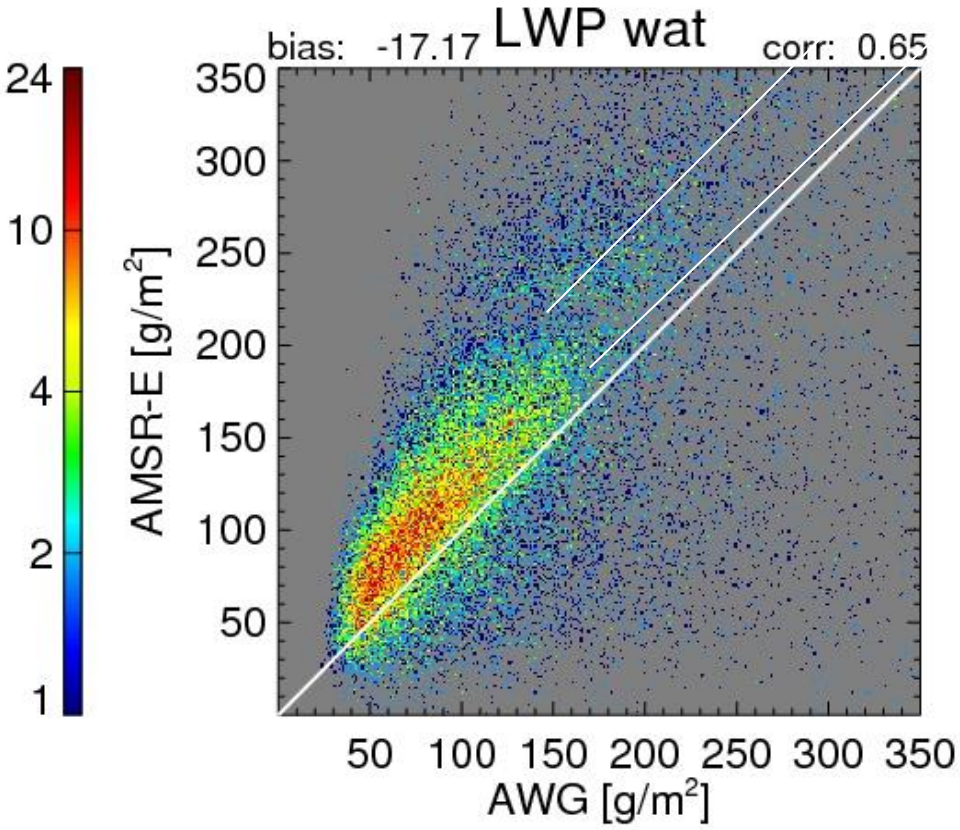


Image shows that 90 percent of pixels are within the 50 g/m2 spec.

Day Cloud Optical Properties Error Budget Supporting Material and Analysis

- We demonstrated that DCOMP is consistent over the sensors:

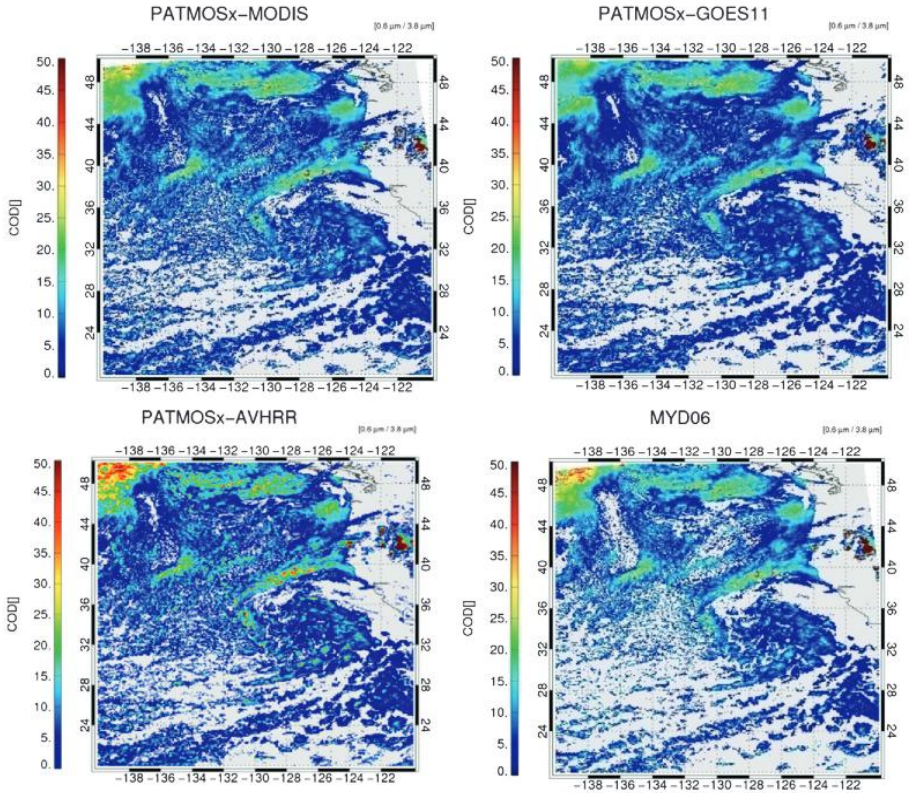


FIG. 5. Cloud optical thickness for PATMOS-x run on MODIS *Aqua*, on *GOES-11*, and on AVHRR on *NOAA-18*, and the MYD06 data collection for an example scene around 2200 UTC on yearday 218 of 2006.

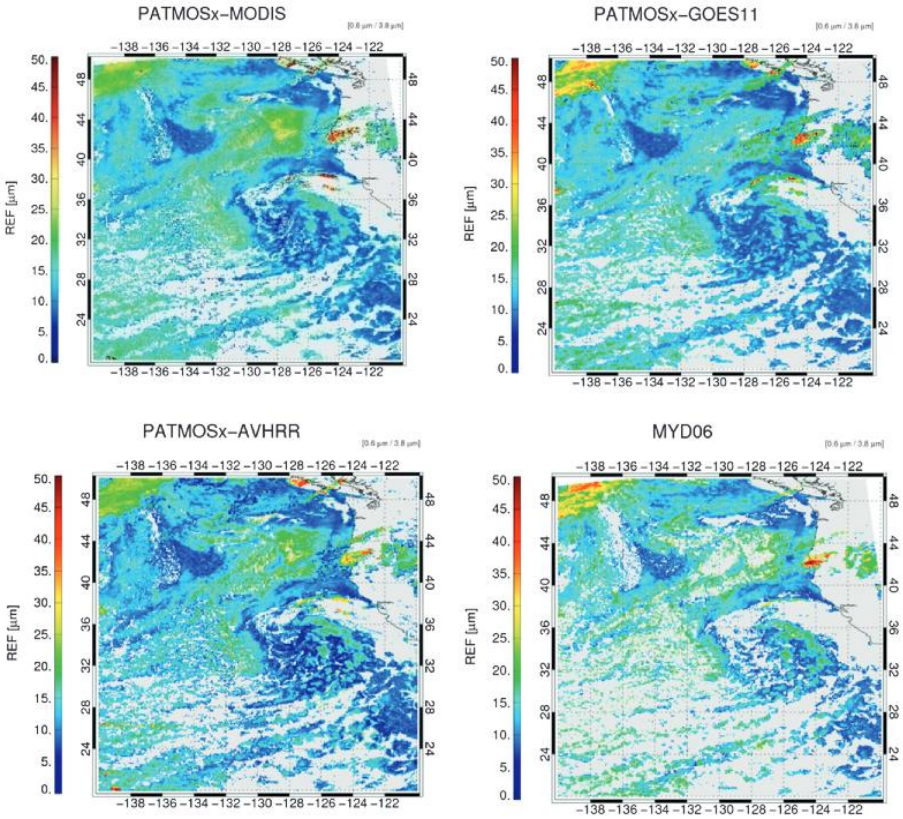
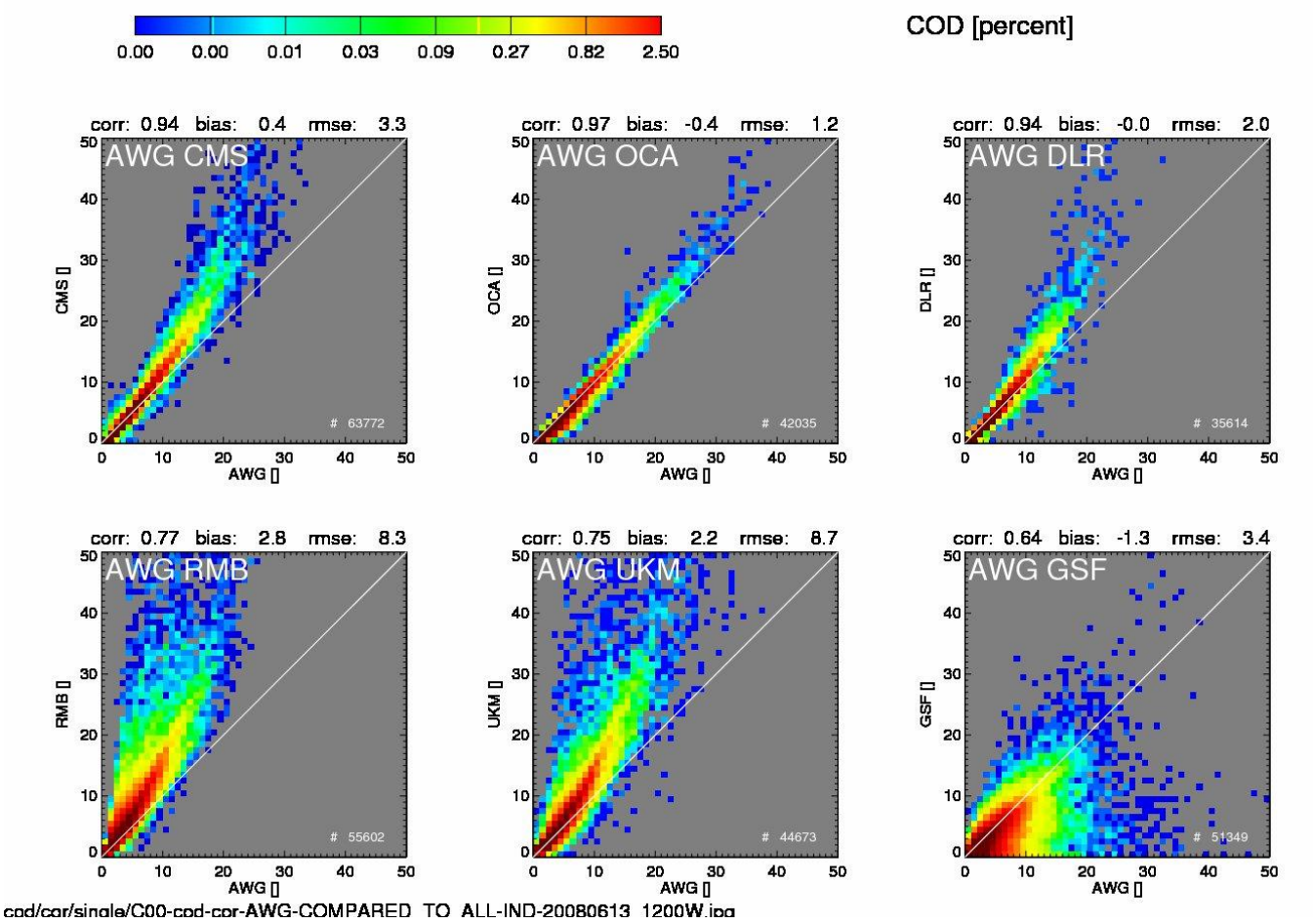


FIG. 6. As in Fig. 5, but for effective radius.

→ Validation efforts of DCOMP can be made for any sensor.

Day Cloud Optical Properties Error Budget Supporting Material and Analysis

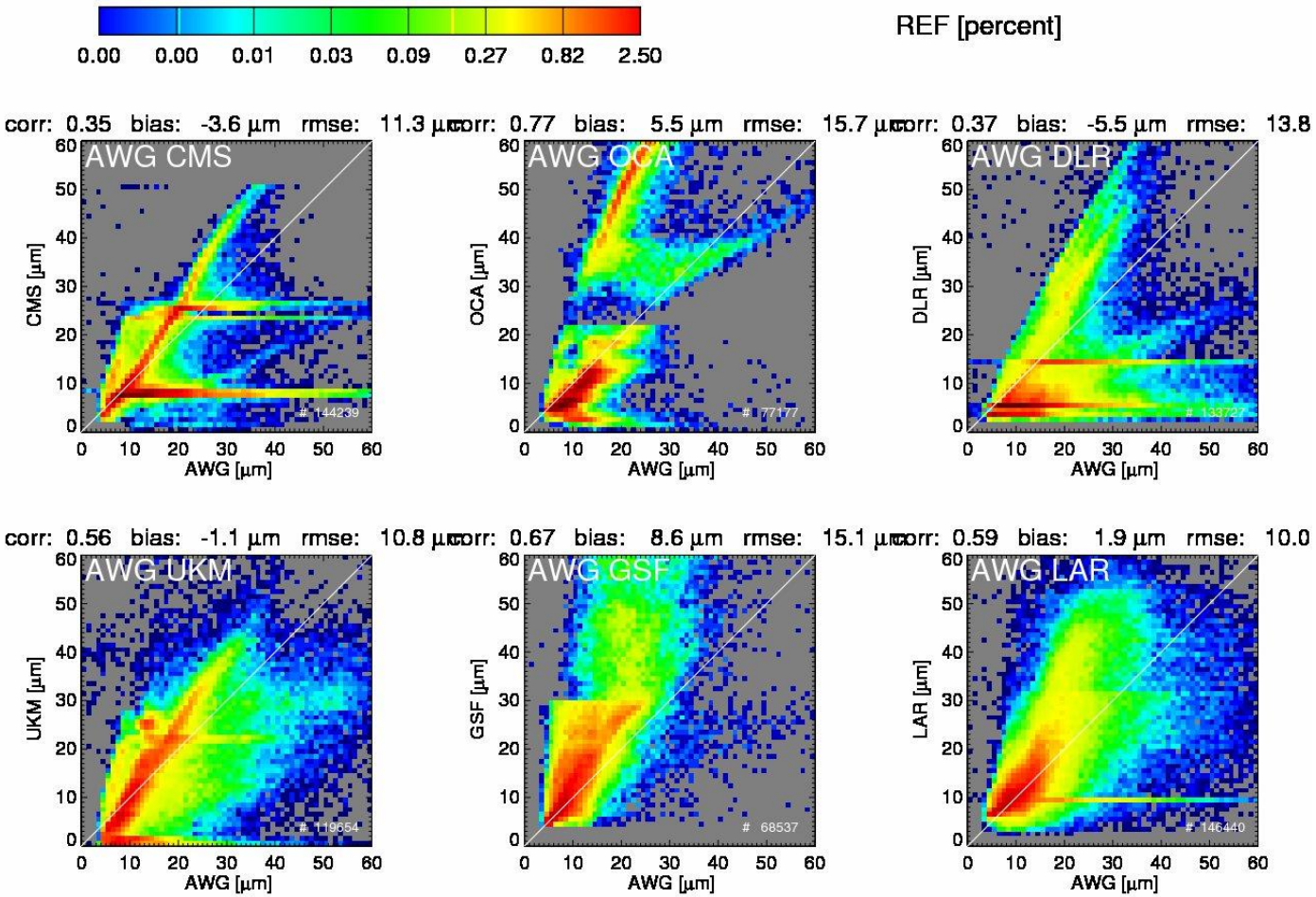
- COD-Inter comparison during CREW workshop



DCOMP was continuously tested in the Cloud Retrieval Evaluation Workshop (CREW) series. All leading cloud retrieval developer are part of CREW. Image shows comparison of DCOMP (on x-axis') to KNMI, EUMETSAT, DLR, Belgium Met office, UK Met Office and Goddard/NASA retrievals.

Day Cloud Optical Properties Error Budget Supporting Material and Analysis

- EPS- Intercomparison during CREW workshop



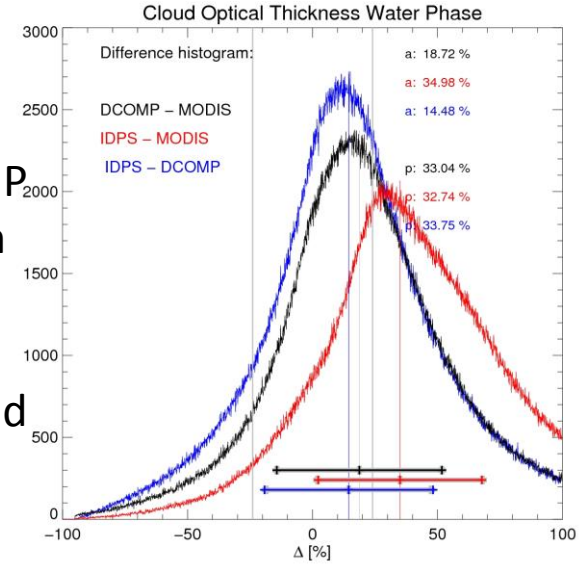
DCOMP was continuously tested over the last 6 years in the Cloud Retrieval Evaluation Workshop (CREW) series. All leading cloud retrieval developers are part of CREW.

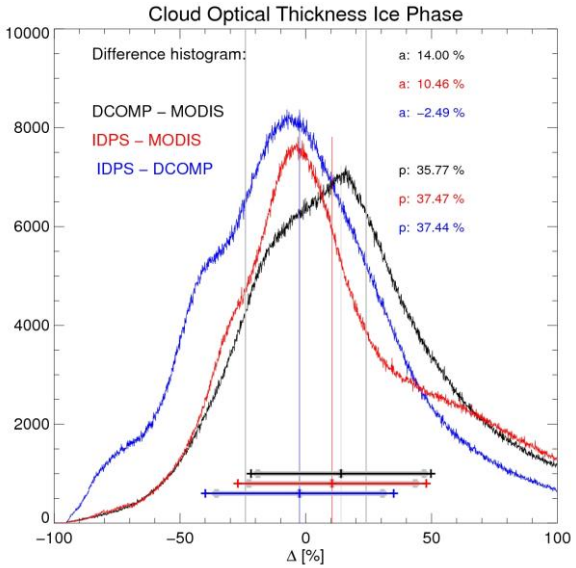
Image shows comparison of DCOMP/EPS (on x-axis') to KNMI, EUMETSAT, DLR, UK Met Office. Langley/NASA and Goddard/NASA retrievals.

DCOMP COMPARISON WITH IDPS

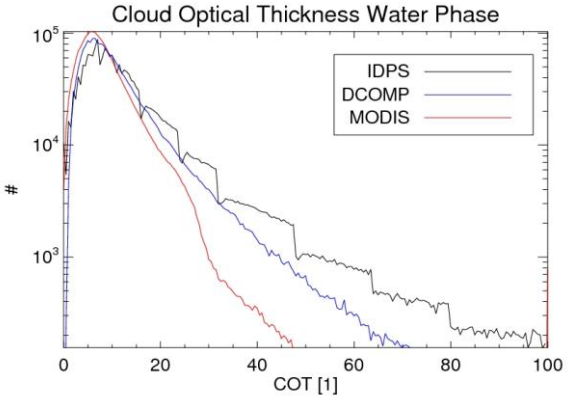
Day Cloud Optical Properties Error Budget Supporting Material and Analysis

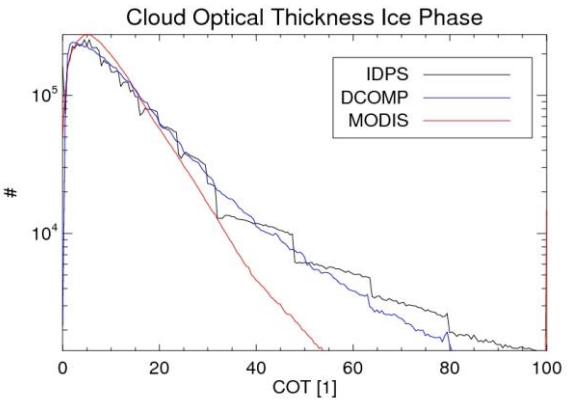
Images show difference histograms of pixel by pixel comparison between DCOMP on VIIRS, MODIS and IDPS on VIIRS retrievals for COD for water and ice.
Matching criteria are 5km and 10 minutes.





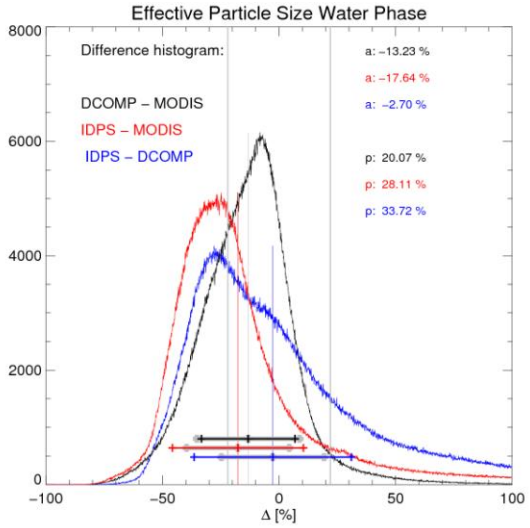
Imperfect matching complicates evaluation.
Histograms of results over same region and time can support analysis.
Images show Frequency of occurrence for COD water and ice phase for DCOMP, MODIS and IDPS.

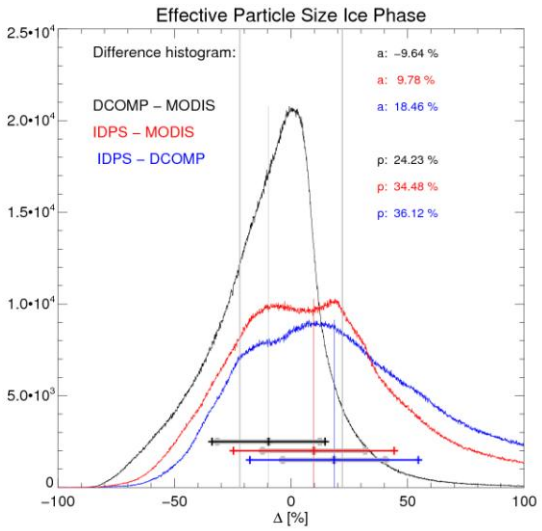




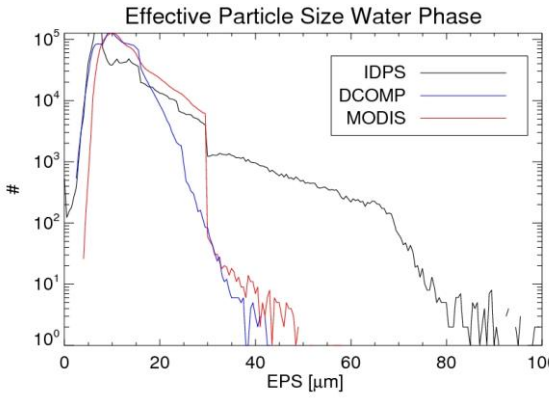
Day Cloud Optical Properties Error Budget Supporting Material and Analysis

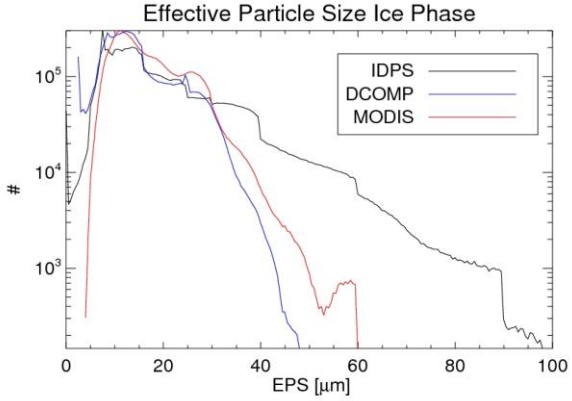
Images show difference histograms of pixel by pixel comparison between DCOMP, MODIS and IDPS retrievals for EPS for water and ice. Matching criteria are 5km and 10 minutes.





Imperfect matching complicates evaluation. Histograms of results over same region and time may support analysis. Images show Frequency of occurrence for EPS water and ice phase for DCOMP, MODIS and IDPS.





Day COP/DCOMP Quality flag analysis/validation

DCOMP Quality Flag per pixel:

QF1	Bit	F_i	Description	When to apply
DCOMP_PRCS_FLAG	0	1	0 - not processed 1- processed	
DCOMP_QF_COD_VALID	1	2	0 –Valid retrieval 1- not valid	If Q1/B0 EQ ‘1’
DCOMP_QF_REF_VALID	2	4	0 –Valid retrieval 1- not valid	If Q1/B0 EQ ‘1’
DCOMP_QF_COD_DEGRADED[1]	3	8	0 –no 1- degraded	If Q1/B0 EQ ‘1’
DCOMP_QF_REF_DEGRADED[2]	4	16	0 –no 1- degraded	If Q1/B0 EQ ‘1’
DCOMP_QF_CONVERGENCY	5	32	0 – convergent 1 - not	If Q1/B0 EQ ‘1’
DCOMP_QF_GLINT	6	64	0 – no glint 1- glint	If Q1/B0 EQ ‘1’

[1]Reasons for COD degradation are set in DCOMP_INFO flag. Possible reasons for COD are snow, sea-ice, twilight and thick cloud saturation.
[2]Reasons for REF degradation are set in DCOMP_INFO flag. Possible reasons for REF degradation are snow, sea-ice, twilight.

Day COP/DCOMP Quality flag analysis/validation

DCOMP Meta information per pixel:

QF1	Bit	F_i	Description	When to apply
DCOMP_INFO_LAND_SEA	0	1	0 –Land 1- Ocean	
DCOMP_INFO_DAY_NIGHT	1	2	0 –Day 1-Night	
DCOMP_INFO_TWILIGHT	2	4	0- no 1- solar angle between 65 and 82	
DCOMP_INFO_SNOW	3	8	0 – no snow 1 -snow	
DCOMP_INFO_SEA_ICE	4	16	0 – no sea ice 1- sea ice	
DCOMP_INFO_PHASE	5	32	0- water 1- ice	If Q1/B0 EQ ‘1’
DCOMP_INFO_THICK_CLOUD[1]	6	64	0 – not 1 – yes	If Q1/B0 EQ ‘1’
DCOMP_INFO_THIN_CLOUD[2]	7	128	0-not 1-yes	If Q1/B0 EQ ‘1’

[1] Thick cloud retrieval set COD to upper bound (160). The COD Quality is degraded. REF quality is good.

[2]Thin cloud retrieval set REF to a-priori value. The REF retrieval output is not valid. COD quality is good.

Documentation

- The following documents will be updated and provided to the EDR Review Board before AERB approval:
  - Current or updated ATBD
  - README file for CLASS
  - Product User's Guide
  - Other documentation as required by SPSRB for NDE

* Note, there is no OAD equivalent for an NDE project. The delivery of the OAD is therefore unknown.

Identification of Processing Environment

- All algorithms shown here have been delivered to and implemented in the STAR Algorithm Processing Framework (SAPF).
- Algorithm Version = First Delivery to SAPF (number unknown).
- Version of LUTs : First Delivery to SAPF
- Version of PCTs: Not Applicable
- Description of environment used to achieve validated stage 1
  - All results shown here were generated with CLAVR-x version 5.4
  - CLAVR-x runs within CSPP (VIIRS, MODIS and AVHRR)
  - CLAVR-x runs in OSPO though only on AVHRR and GOES
  - CLAVR-x does not run the Night Cloud Optical Properties
  - CLAVR-x does not run the NDE Cloud Phase/Type Algorithm.
  - The official IDPS VCM including Cloud Phase were used in this analysis. CLAVR-x has the ability to read those in before generated downstream cloud products.

Users & User Feedback

- User Feedback
  - NDE Algorithms Released in CSPP.
  - Most feedback and interaction has been with training users on the product definitions and use of quality flags.
  - Taiwan Weather Service has given most feedback.
  - EUMETSAT has been served IDPS CTH since January – no feedback yet.
  - Bill Ward expressed interest Cloud Cover Layers over Hawaii.
- Downstream product list
  - Polar Winds (CTH used in height assignment)
  - In NDE, Fog and Icing use DCOMP and ACHA output.
  - Precipitation is considering use of DCOMP products. (Risk Reduction)
- Reports from downstream product teams on the dependencies and impacts
  - None received for IDPS or NDE algorithms yet.

Conclusion

- Cal/Val results summary:
  - Team recommends algorithm validated stage 1 maturity for
    - Cloud Top Parameters (ACHA)
      - Cloud Top Height
      - Cloud Top Temperature
      - Cloud Top Pressure
    - Daytime Cloud Optical Properties (DCOMP)
      - Cloud Optical Depth
      - Cloud Particle Size

Path Forward

- Planned further improvements
  - daytime cloud optical properties
    - Performance over snow surfaces
    - Optimal use of 1.6, 2.2 and 3.75 mm for improved cloud effective radius.
    - Explore integration of lunar algorithm to extend day time performance (JPSS-RR)
    - Explore elevating lwp and iwp as products as they are in GOES-R.
  - cloud height
    - optimize cloud height for AWV support
    - Improve use of cloud type and other information for multilayer performance.
    - Explore elevating IR optical depth and particle size as products as they are for GOES-R.
- Planned Cal/Val activities / milestones
  - Validate Nighttime COP when available from NDE SAPF
  - Launch our CALIPSO and MODIS near-real time monitoring site.
  - Draft reports on impacts of cloud type and cloud mask errors on cloud product performance.

EXTRA MATERIAL

ACHA Cloud Optical Properties Error Budget

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvement of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	L1RD Threshold (Precision/Accuracy)	Analysis/Validation Result	Error Summary
ACHA COD	Greater of 33% or 1 Greater of 24% or 1	90.2% (accuracy) 91.7% (precision)	0.20 (bias) 0.57 (standard

ACHA COD Statistics (NDE vs CALIPSO)

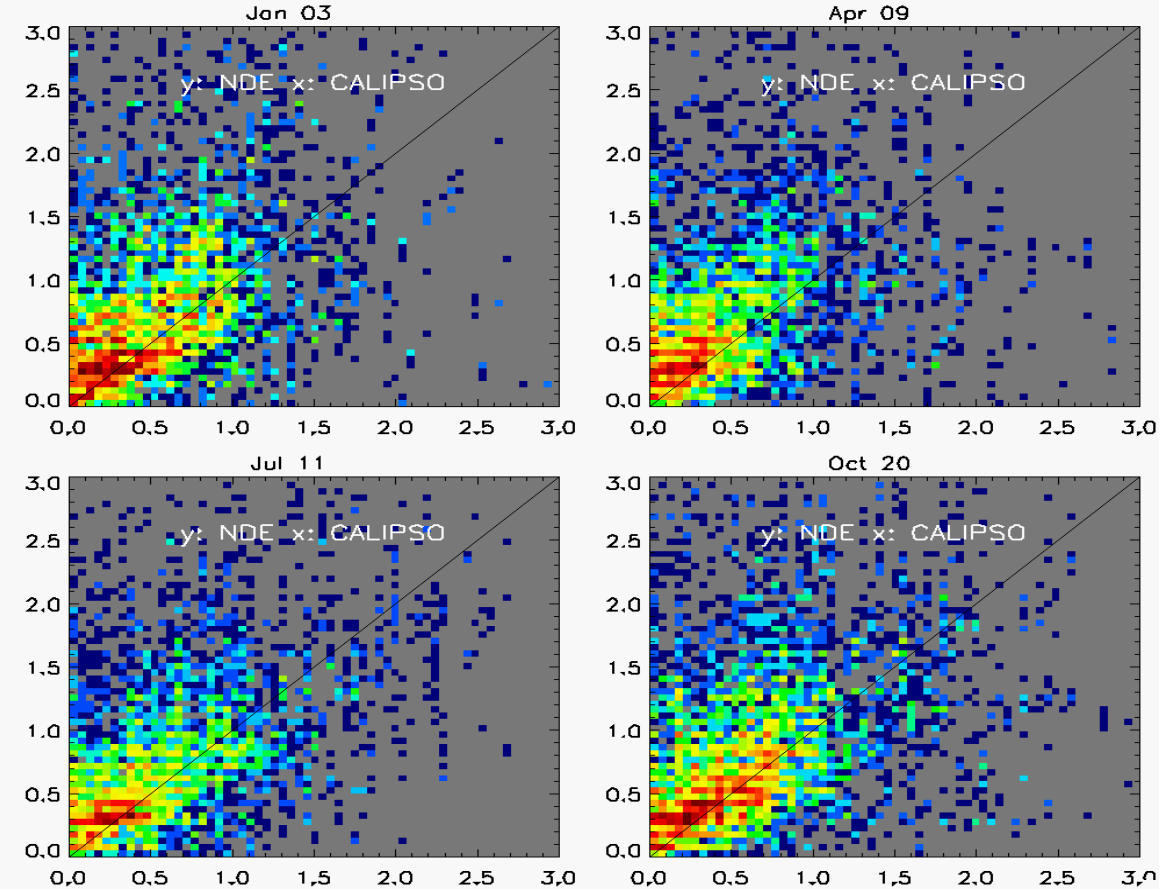
Type	Bias	StanDev	RMSE	Corr	Counts	Within Specs - Accuracy	Within Specs - Precision
All clouds	0.20	0.57	0.61	0.43	21210	90.2%	91.7%
Water	1.81	0.66	1.93	0.13	88	9.1%	90.7%
Ice	0.20	0.56	0.59	0.44	21122	90.5%	92.0%
Daytime	0.28	0.59	0.65	0.35	10142	88.1%	90.7%
Nighttime	0.13	0.54	0.56	0.52	11068	92.1%	92.6%

Limitations:

a. Analysis is based on data between 60°N and 60°S

b. Only COD values between 0 and 3 are included

ACHA Cloud Optical Properties Error Budget Supporting Material and Analysis



IR COD – Ice Clouds							
Date	Bias	StanDev	RMSE	Corr	Counts	Within Specs - Accuracy	Within Specs - Precision
01/03	0.22	0.58	0.62	0.40	4929	89.8%	91.2%
04/09	0.22	0.55	0.59	0.41	4946	91.4%	92.7%
07/11	0.16	0.52	0.54	0.51	4947	92.1%	92.9%
10/20	0.19	0.58	0.61	0.43	6300	89.1%	91.1%