NOAA-20 VIIRS Nighttime (NCOMP) Provisional Maturity

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VIIRS NCOMP Team

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Executive Summary

- NDE NCOMP Cloud Optical Thickness (COT) and Cloud Particle Size (CPS) products were evaluated both visually and quantitatively with other products.
- Visual inspections reveal issues such as missing granules due to NDE processing, but those have been resolved.
- Comparison to CALIOP and AMSR2 retrievals demonstrate good product performance. All products that have direct validation sources meet accuracy requirements and are very close to meeting precision. Future data filtering should increase performance.
- For non-NDE product Liquid Water Path (LWP), AMSR2 comparisons show that accuracy requirements are mostly met and precision partially meets requirements.
- For non-NDE product Ice Water Path (IWP), CALIOP comparisons show that accuracy requirements are met and precision partially meets requirements.
- LWP and IWP results infer that COD and CPS are reasonable.
- Comparisons with SNPP NCOMP retrievals are consistent.
- **The cloud team recommends provisional maturity**

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages –
COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Requirement Check List – Cloud Optical Depth

JERD	Requirement	Meet Requirement (Y/N)?
	Applicable Conditions: 1. Requirements apply whenever detectable clouds are present	
JERD-2430	The algorithm shall produce a cloud optical depth product that has a horizontal cell size of 0.8 km	
JERD-2482	The algorithm shall produce a cloud optical depth product that has a mapping uncertainty (3 sigma) of 4 km	
JERD-2483	The algorithm shall produce a cloud optical depth product that has a measurement range of 0.3 – 64 (Day) and 0.3 – 8 (Night)	
JERD-2484	The algorithm shall produce a cloud optical depth product that has a measurement precision of greater of 30% or 3.0 Tau (Day) and greater of 30% or 0.8 Tau (Night)	
JERD-2485	The algorithm shall produce a cloud optical depth product that has a measurement accuracy of Liquid phase: 20% (Day), 30% (Night); Ice phase: 20% (Day), 30% (Night)	

Requirement Check List – Cloud Particle Size Distribution

JERD	Requirement	Meet Requirement (Y/N)?
	Applicable Conditions: 1. Requirements apply both day and night and whenever detectable clouds are present	
JERD-2431	The algorithm shall produce a cloud particle size distribution product that has a horizontal cell size of 0.8 km	
JERD-2486	The algorithm shall produce a cloud particle size distribution product that has a mapping uncertainty (3 sigma) of 4 km	
JERD-2487	The algorithm shall produce a cloud particle size distribution product that has a measurement range of 2 to 50 µm (day), 2 to 32 µm for water (night), and 2 to 50 µm for ice (night)	
JERD-2488	The algorithm shall produce a cloud particle size distribution product that has a measurement precision of greater of 4 µm or 25% for water and greater of 10 µm or 25% for ice	
JERD-2489	The algorithm shall produce a cloud particle size distribution product that has a measurement accuracy of Greater of 4 µm or 30% for water and 10 µm for ice	

Specifications for Cloud Top Products

- COD = Cloud Optical Depth
- CPS = Cloud Particle Size
- LWP = Liquid Water Path*
- IWP = Ice Water Path*

* Not an official NDE product

Product	Validation Source	Range	Accuracy	Precision
COD	CALIOP	1 - 5	30%	0.8 or 30%
CPS Water	Indirect	2 - 32µm	4µm or 30%	4µm or 25%
CPS Ice	Indirect	2 - 50µm	10µm	10 or 25%
*LWP**	*AMSR2*	*25 - 100 g/m^2*	*25 g/m^2 or 15%*	*25 g/m^2 or 40%*
*IWP**	*CALIPSO*	*25 - 175 g/m^2*	*25 g/m^2 or 30%*	*25 g/m^2 or 40%*

Outline

- NCOMP Description
- NCOMP Status in NDE
- Evaluation of NCOMP
- Provisional Maturity Conclusions
- Path Forward to Full Maturity
- Future Plans

NCOMP Channels

NCOMP uses these VIIRS channels:

- M12 (3.7µm)
- M15 (10.8µm)
- M16 (12µm)

		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan) Nadir	End of Scan
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58
	S/MWIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58
Emissive Bands		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58
	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789
		M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58

NCOMP

- NCOMP is the Nighttime Cloud Optical and Microphysical Properties algorithm.
- NCOMP was developed for GOES-AWG and works presently on VIIRS-SNPP and VIIRS-NOAA-20. It was based on NASA Langley's Solar-infrared Infrared Split-window Technique (SIST) that applied to nighttime data for GOES, GOES-ABI, Himawari-ABI, MSG-SEVIRI, AQUA-MODIS, Terra-MODIS, and other instruments.
- NCOMP is a FORTRAN 90/95 package which works with the identical code for both VIIRS and GOES.

- **NCOMP** uses the following **input**, in addition to the radiances from VIIRS three channels.
  - Cloud type
  - Cloud top temperature
  - Surface type, surface emissivities (all 3 channels)
  - Clear-sky IR RTM calculations
  - All-sky temperature, atmospheric profiles, and skin temperatures (NWP)
  - Cloud emittance parameterization coefficients (LUTs)

NCOMP retrieval

For semi-transparent clouds, ε_λ and T_{cld} can be estimated from simultaneous measurements at two different wavelengths, λ_1 and λ_2 (assuming a hydrometeor absorbs differently at λ_1 and λ_2).

If scattering is neglected then

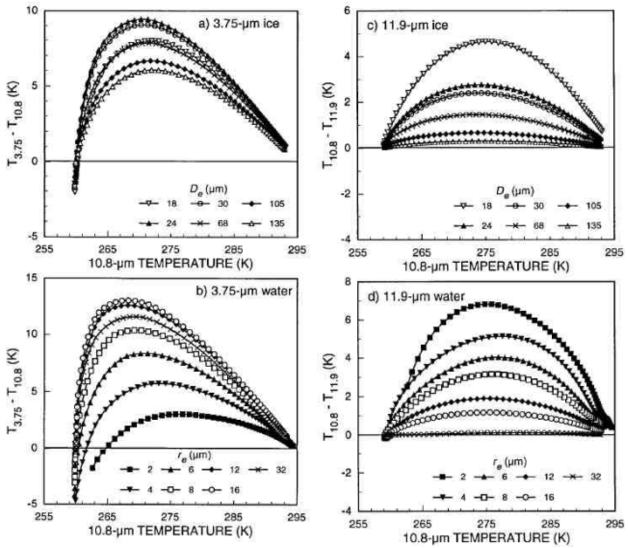
$$\varepsilon_\lambda = 1 - \exp(-\tau_{a\lambda} / \mu)$$

where $\tau_{a\lambda}$, absorption optical depth, is a function of effective particle size, r_e.

If ε_λ is known, then τ_λ can be determined from the equation above.

If T_{cld} is know from another source, e.g., VIIRS algorithms, then τ_λ and r_e can be estimated by using two or three different wavelengths.

This technique uses three wavelengths: VIIRS channels M12, M15 and M16.



Modeled BTDs using NCOMP Cloud Emittance Parameterizations for a particular cloud and VZA.

Effective Radius/Diameter	Phase
r_e = 2, 4, 6, 8, 12, 16 and 32 µm	water
D_e = 5.83, 18.15, 23.86, 30.36, 45.30, 67.60, 104.9, 123.0, and 134.9 µm	ice

Water and ice particle size models used in Cloud Emittance Parameterizations.

Evaluation Methodology

Unlike other cloud products, e.g., cloud height, cloud fraction, cloud phase, NCOMP products are radiative parameters. Thus, it is not possible to validate optical thickness and effective radius directly from in-situ observations without making assumptions about the scattering properties of cloud particles. Therefore bona fide independent validation sources do not exist.

Our Specific Evaluation Methodology applied here:

- Visual checks of product imagery
- Direct comparison with CALIPSO products for ice cloud COD.
- For ice clouds we also use LIDAR retrievals to validate cloud Ice Water Path. IWP is directly computed from COD and CPS. Validation of IWP is therefore an indirect validation of COD and CPS.
- Similarly, for liquid clouds we use passive microwave retrievals to validate Liquid Water Path. LWP is directly computed from COD and CPS. Validation of LWP is therefore an indirect validation of COD and CPS.

Data Used in this Analysis

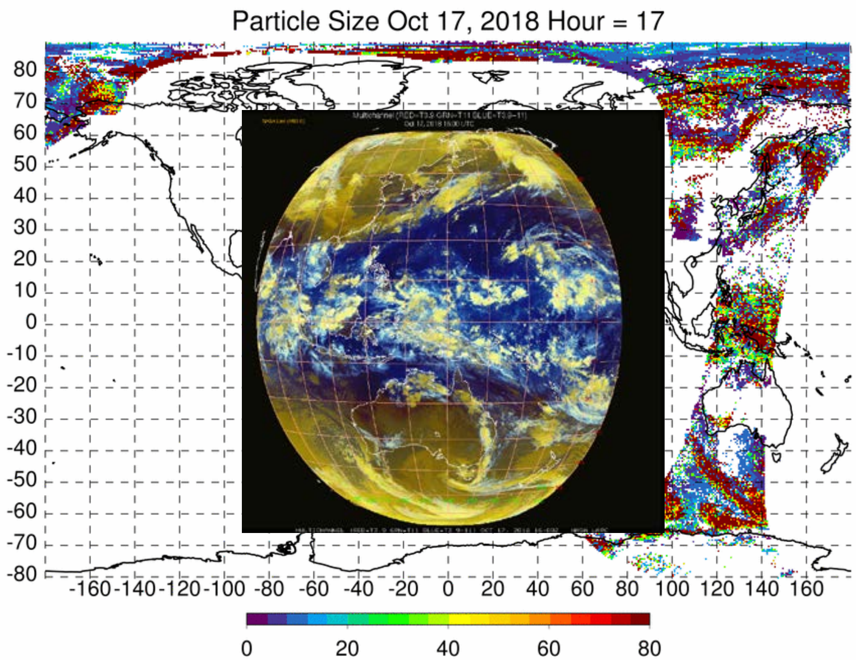
- NOAA-20: 40 days from September to December, 2018
- NOAA-20: 7 days from February, 2019
- SNPP: 7 days from February, 2019
- CALIOP/CALIPSO: 40 days from September to December, 2018
- AMSR2/GCOM-W: 40 days from September to December, 2018

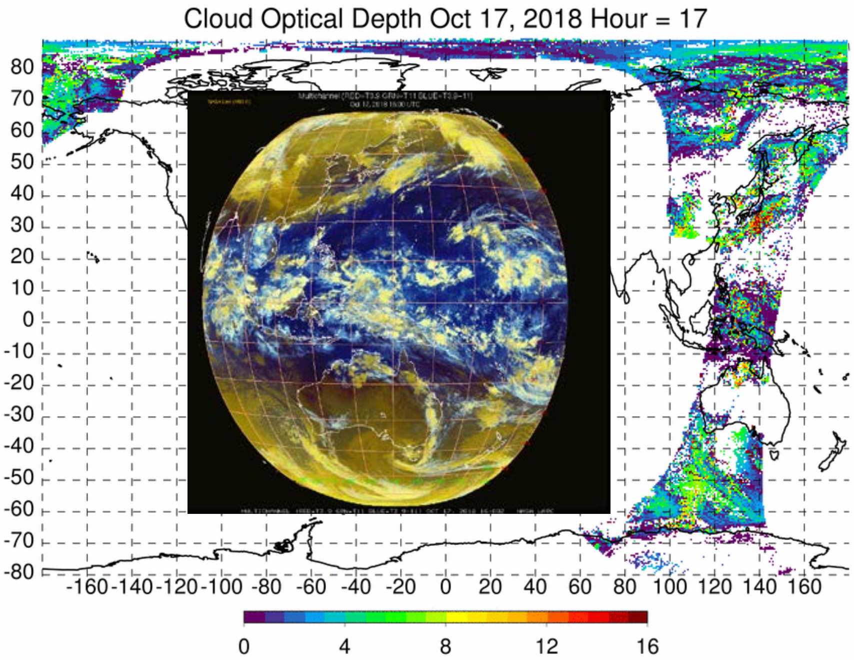
Visual checks of product imagery

Visual Checks

One Hour of NCOMP JPSS VIIRS Granules with Himawari-8 Imagery

Oct. 17, 2018 1700-1759 UTC



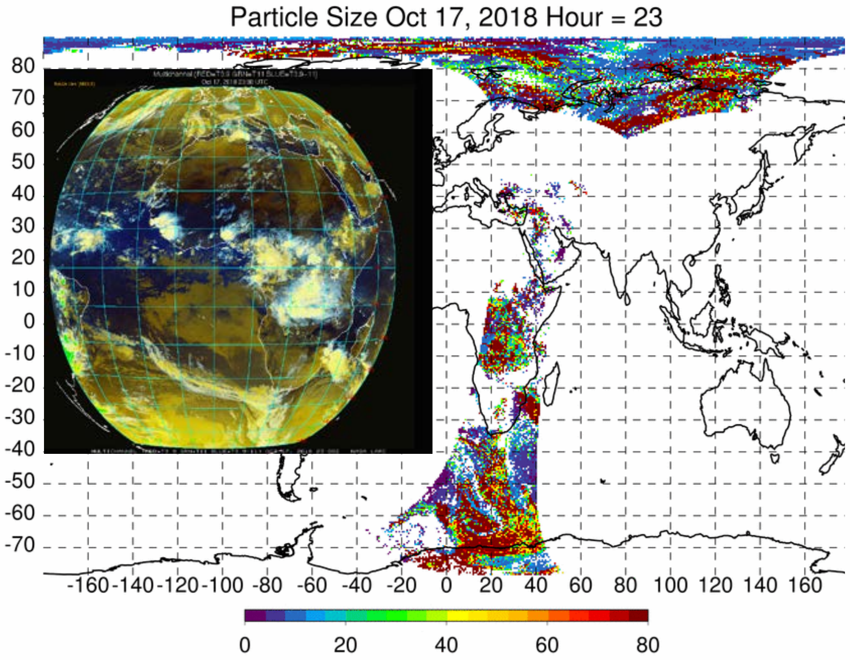


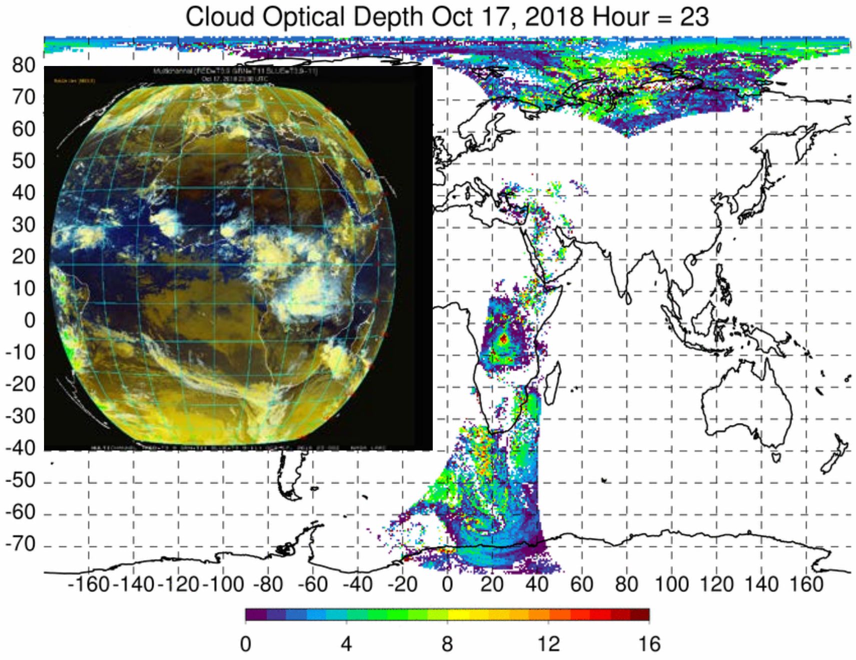
CPS and COD look reasonable off southern Australia, into the tropics, and northward

Visual Checks

One Hour of NCOMP JPSS VIIRS Granules with Meteosat-11 Imagery

Oct. 17, 2018 2300-2359 UTC



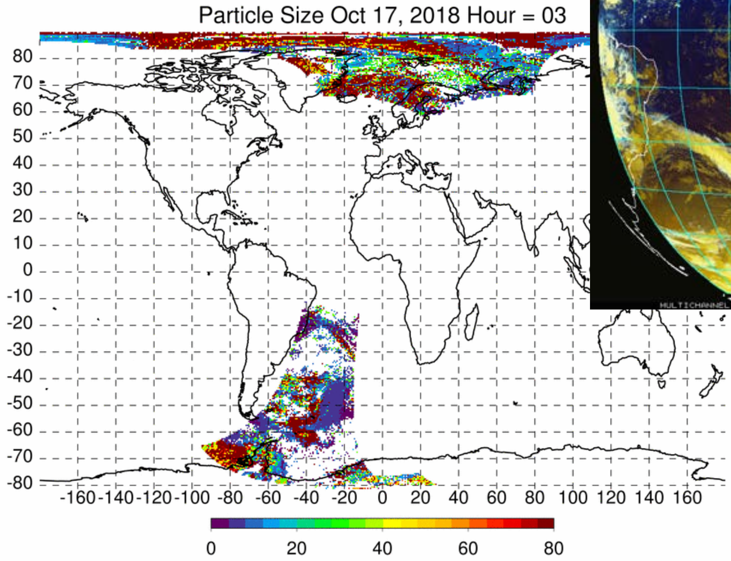


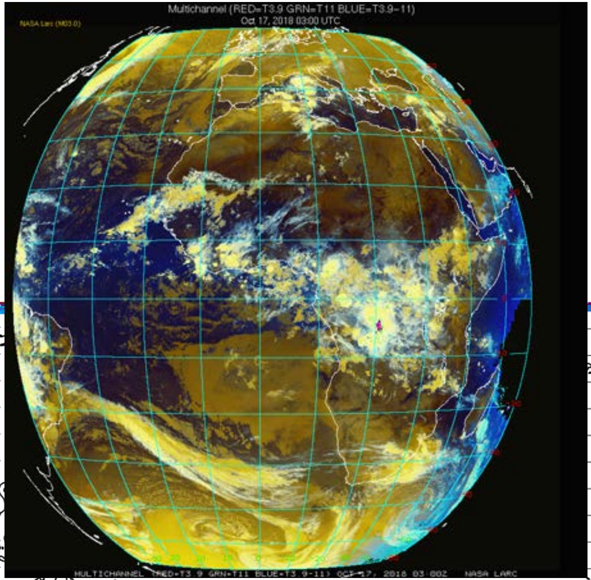
CPS and COD are consistent with RGB imagery south of Africa and into convective core over Zambia

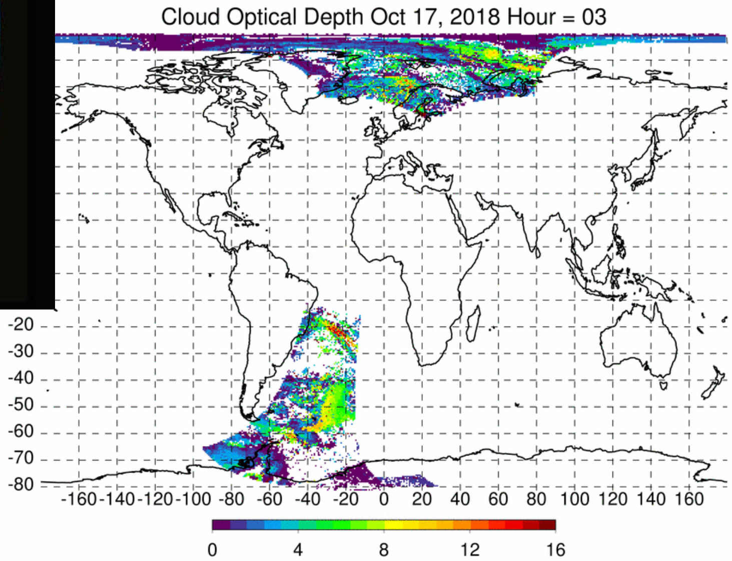
Visual Checks

One hour of NCOMP JPSS VIIRS granules with GOES-16 Imagery

Oct. 17, 2018 0300-0400 UTC



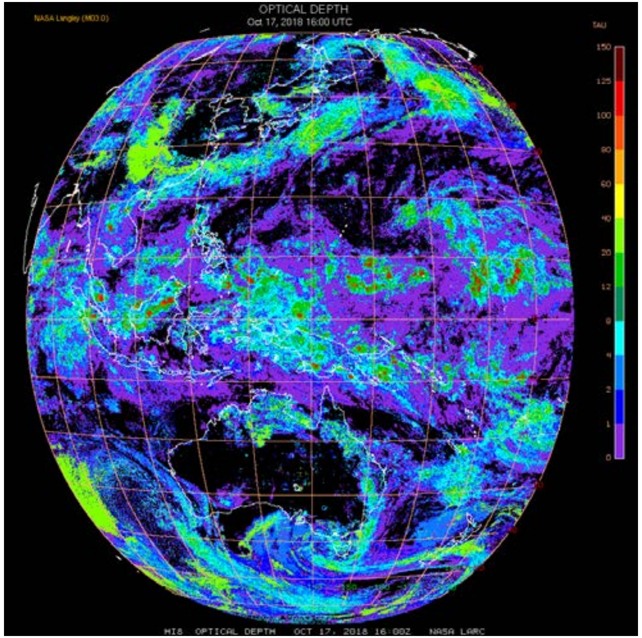


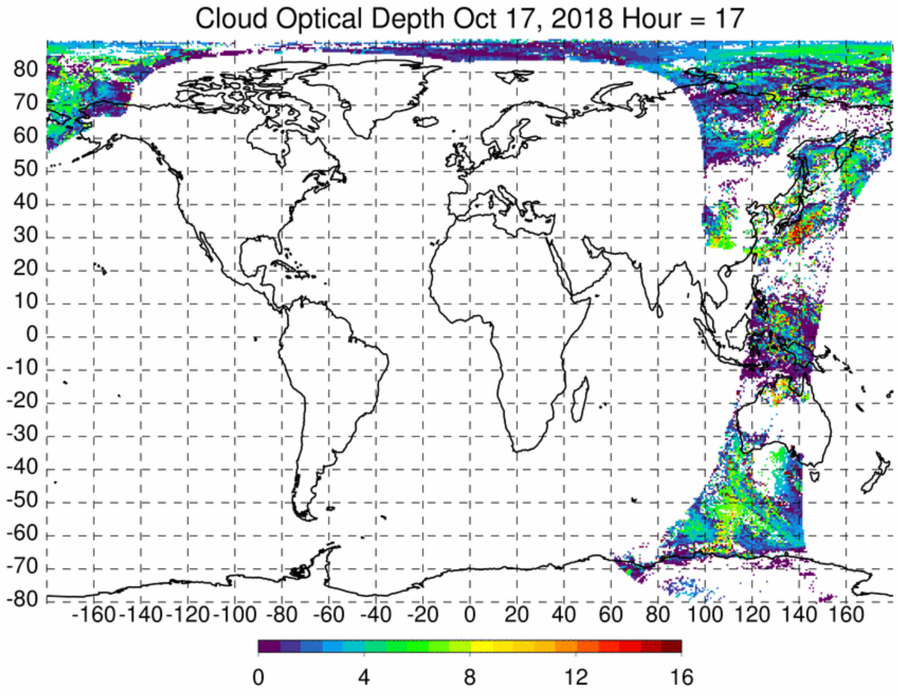


CPS and COD are consistent with RGB imagery off coast of Argentina

One Hour of JPSS VIIRS Granules with Himawari-8 SIST Products from NASA Langley

Cloud Optical Depth Oct. 17, 2018 1700-1759 UTC





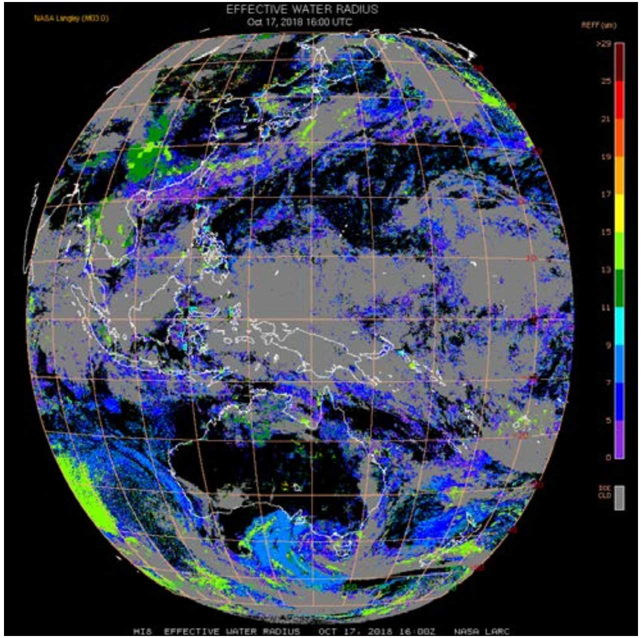
NCOMP COD is similar to SIST COD despite algorithm differences (note different color scales)

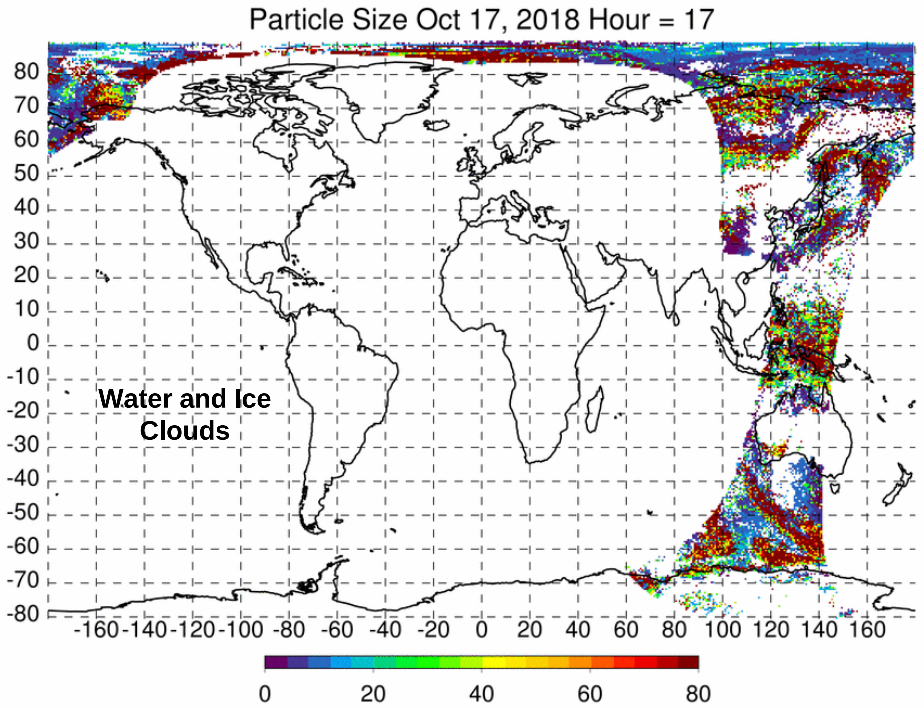
Visual Checks

One Hour of JPSS VIIRS Granules with Himawari-8 SIST Products from NASA Langley

Cloud Particle Size Oct. 17, 2018 1700-1759 UTC

Water Clouds Only





NCOMP CPS for water clouds is similar to SIST CPS despite algorithm differences (differing color scales)

Conclusions from Visual Comparisons

Issue	Comment
COD and CPS appear reasonable.	Impact of inputs that may not be exact, not evaluated here.
Visual comparisons in polar regions remain difficult to accomplish.	Can compare to CERES SIST products from VIIRS when they are available.
CPS appears to be to high in some ice clouds.	Future updates to NCOMP will include new ice cloud emittance parameterizations.

Validation of Cloud Optical Depth with CALIOP

CALIOP: Data and Methodology

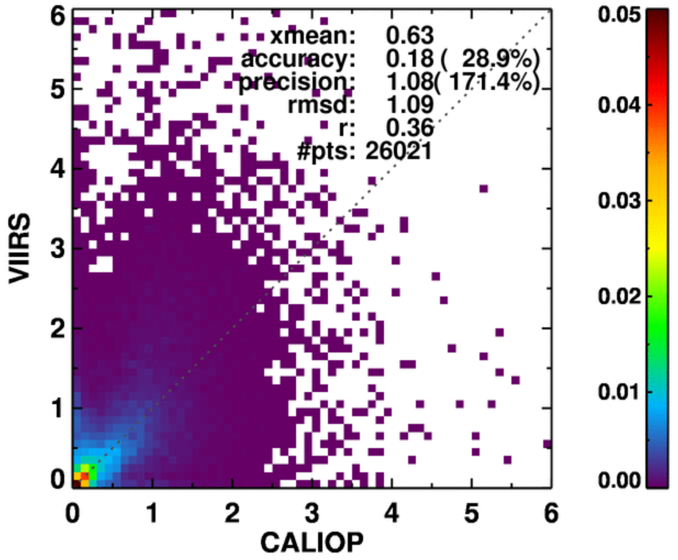
- Lidar retrievals from CALIOP are used for 40 days of NCOMP data from 2018.
- CALIOP is on the CALIPSO satellite in the A-Train.
- Thin ice clouds provide good validation opportunities, although CALIOP's strength is very thin clouds, These very optically thin clouds (COD < 1.0) are outside of NCOMP's retrieval range.
- CALIOP Version 3.4 retrievals were used. Version 4 was not yet available when these comparisons were done.
- Several filters were used to best match the two sources:
    - Scan time difference ≤ 10 minutes
    - Ice clouds only
    - CALIOP Cloud Feature Horizontal Extent employed, depending on filtering
    - CALIOP Constrained and/or Unconstrained retrievals, depending on filtering

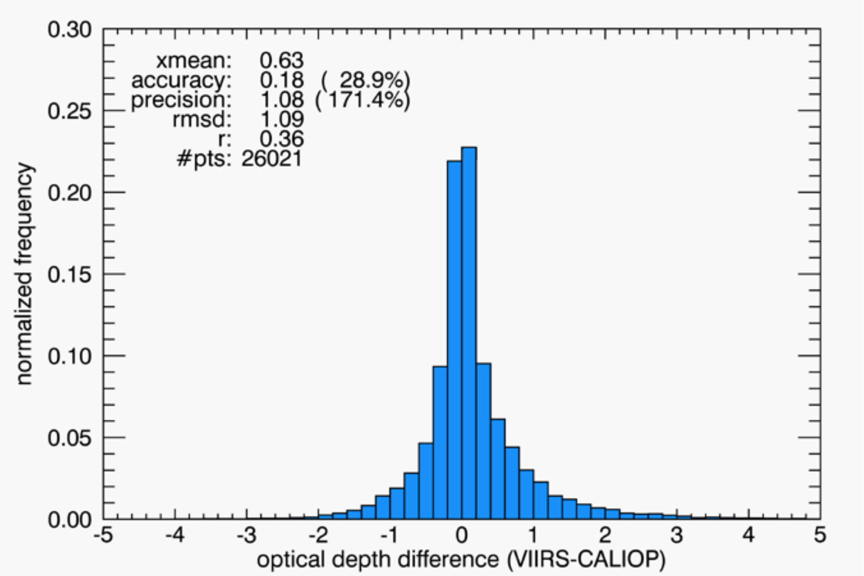
CALIOP Comparison

NCOMP COD Compared to CALIOP COD for Ice Clouds

VIIRS: 40 Days of Granules

CALIOP: Constrained + Unconstrained





Measurement Accuracy	30%
Measurement Precision	Greater of 8.0 or 30%

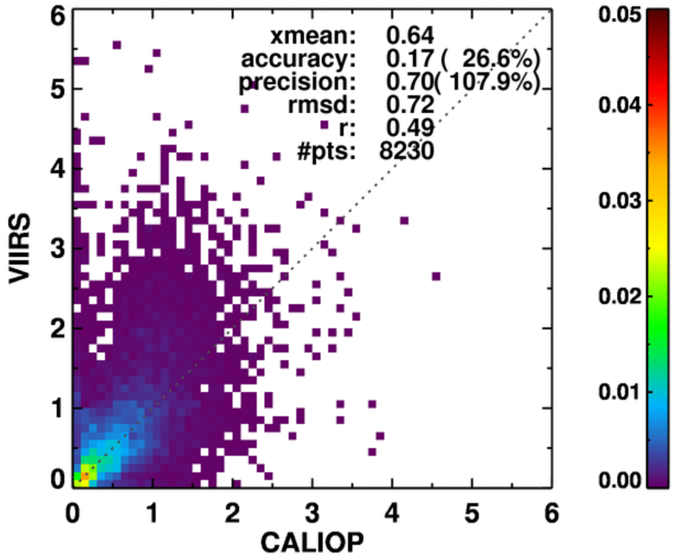
NCOMP COD accuracy is good, but scatter is large so precision specification is not met.

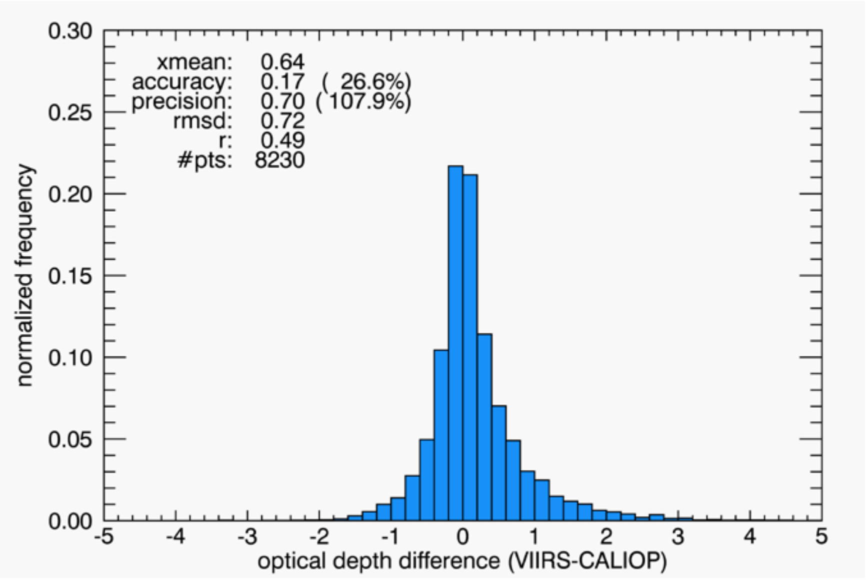
Most points outside NCOMP COD range of 1.0 ≤ COD ≤ 5.0

NCOMP COD Compared to CALIOP COD for Ice Clouds

VIIRS: 40 Days of Granules

CALIOP: Constrained + Unconstrained, 25km horizontal feature





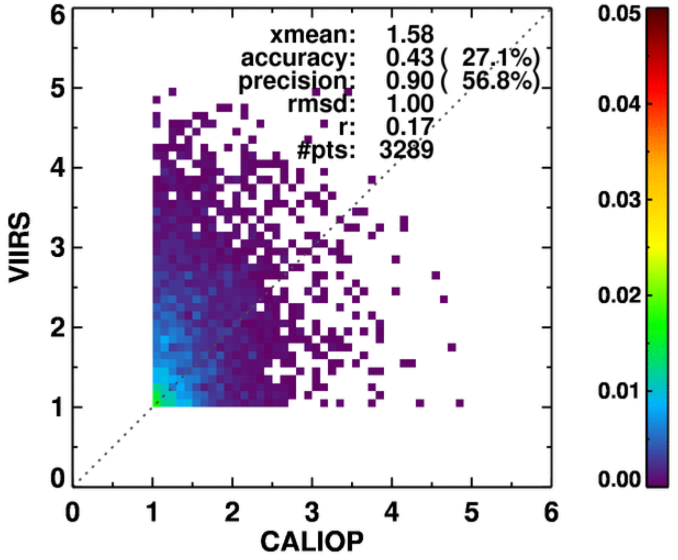
Measurement Accuracy	30%
Measurement Precision	Greater of 8.0 or 30%

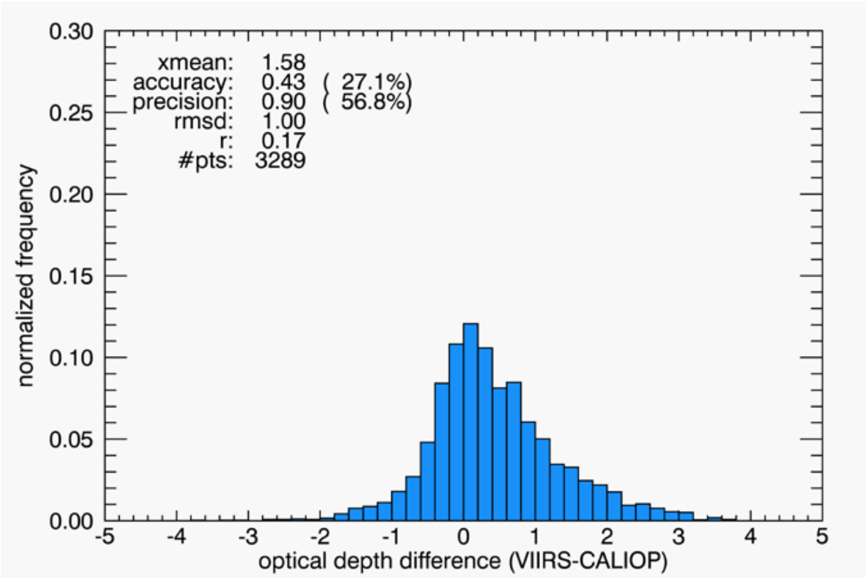
NCOMP COD remains accurate, scatter improves, precision specification improves

NCOMP COD Compared to CALIOP COD for Ice Clouds

VIIRS: 40 Days of Granules

CALIOP: Constrained + Unconstrained, 25km horizontal feature





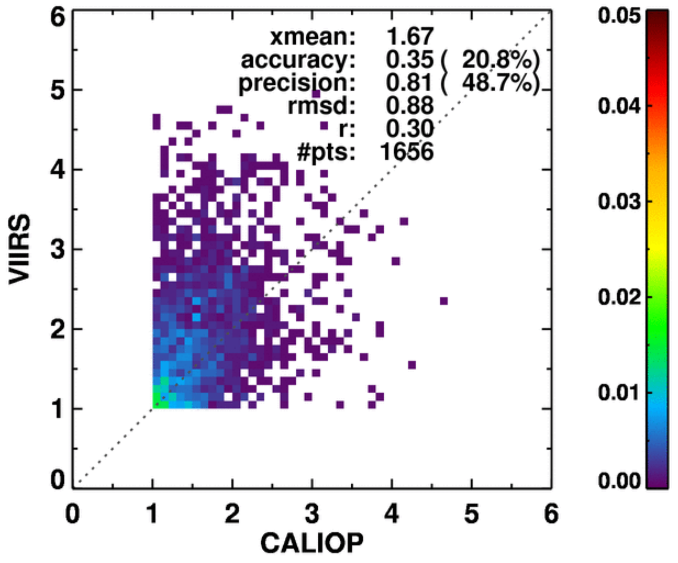
Measurement Accuracy	30%
Measurement Precision	Greater of 8.0 or 30%

NCOMP COD remains accurate, scatter improves for these higher COD clouds, precision specification improves

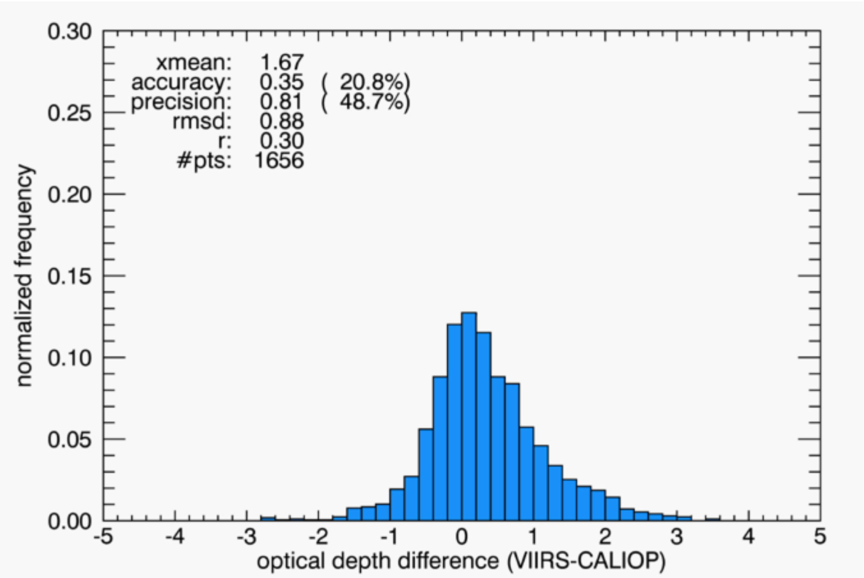
CALIOP Comparison

NCOMP COD Compared to CALIOP COD for Ice Clouds

VIIRS: 40 Days of Granules



CALIOP: Constrained Only, no horizontal feature filter



Measurement Accuracy	30%
Measurement Precision	Greater of 8.0 or 30%

NCOMP COD remains accurate, scatter improves despite relaxation of CALIOP horizontal cloud feature filter. Precision = 0.81

Conclusions from CALIOP Comparison

- NCOMP NDE NOAA-20 performs well compared to CALIOP retrievals of COD and easily meets target specification for accuracy.
- NCOMP NDE NOAA-20 COD meets target specifications for precision in that 0.81 << 8.0.NCOMP.
- NDE NOAA-20 COD is close to meeting the maximum % precision in that 48.7% is relatively close to the 30% requirement, but the results are highly impacted by filtering decisions and CALIOP's strength being the thinnest clouds.
- Further filtering should enables meeting all precision specifications, but the number of points drops substantially, even for 40 days of VIIRS data.
- Note that some twilight data (sza < 90 degrees) was inadvertently included. Future validation will properly screen that out, so performance will improve.

Validation of Liquid Water Path with ASMR2

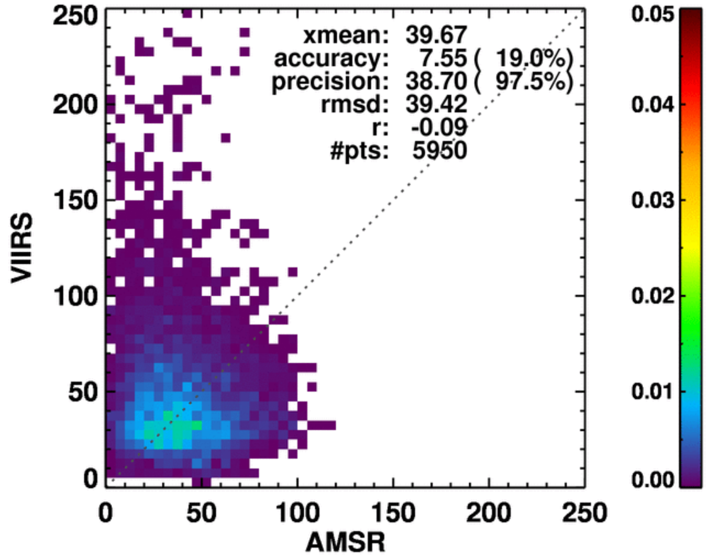
AMSR2: Data and Methodology

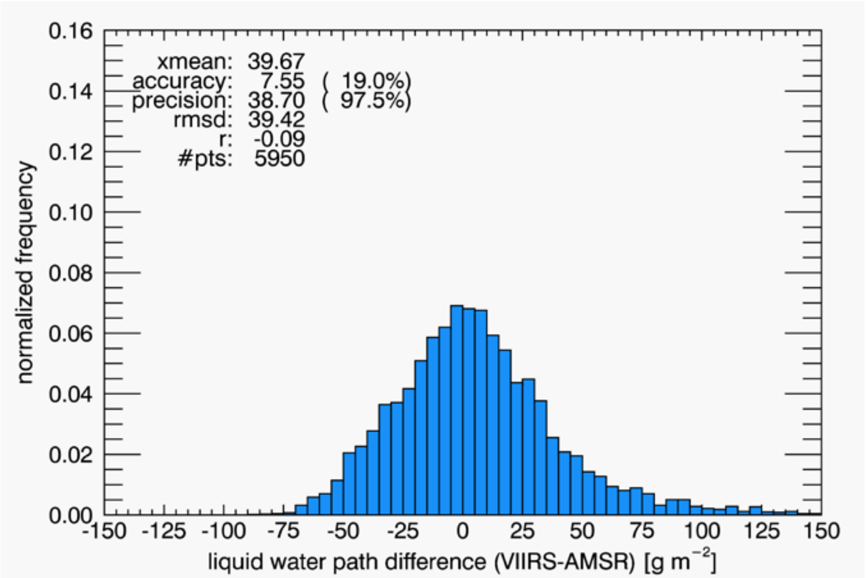
- Microwave satellite based sensors offer the only really independent satellite-based validation source.
- AMSR2 is aboard the GCOM-W satellite.
- NDE Liquid Water Path is computed by a simple equation from NDE products CPS and COD, therefore a validation of LWP is also an assessment of both NCOMP products.
- Validation is limited due to coarse spatial resolution and because AMSR2 usage is primarily for large COD clouds, the comparisons are not the best case scenario.
- We apply several filter criteria:
    - Scan time difference ≤ 10 minutes
    - We exclude all AMSR2 pixels with rain flag
    - AMSR2 Cloud Horizontal Extent employed, depending on filtering
    - AMSR2 Clear or Cloudy retrievals, depending on filtering
    - Coincident CALIOP requirement: no CALIOP ice clouds in AMSR2 footprint

AMSR2 Comparison

<u>Filters</u>

- NCOMP COD restricted to 1 – 5
- LWP for both > 0
- Allow AMSR2 DQF to be “clear”





Measurement Accuracy	Greater of 25g/m^2 or 15%
Measurement Precision	Greater of 25g/m^2 or 40%

Accuracy spec is met, but scatter is large – not unexpected given AMSR2 COD sensitivity limitation

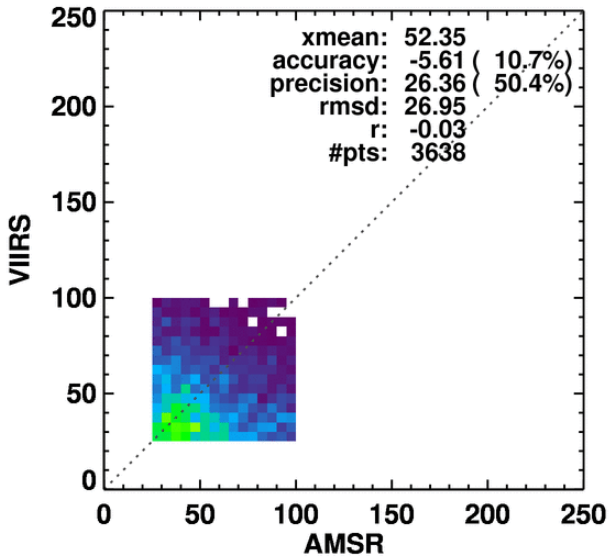
AMSR2 Comparison

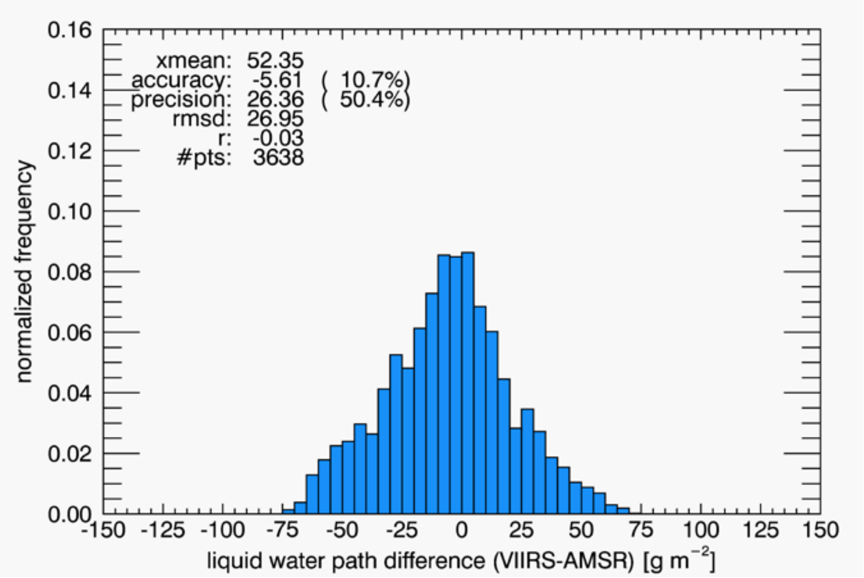
<u>Filters</u>

- NCOMP COD restricted to 1 – 5
- LWP for both > 0

<u>Additional Filters</u>

- IWP limited to NCOMP range
- Allow AMSR2 DQF to be Cloudy or Clear





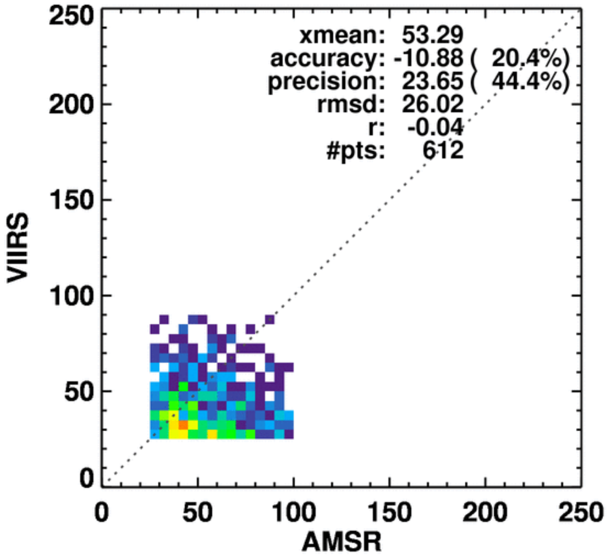
Measurement Accuracy	Greater of 25g/m^2 or 15%
Measurement Precision	Greater of 25g/m^2 or 40%

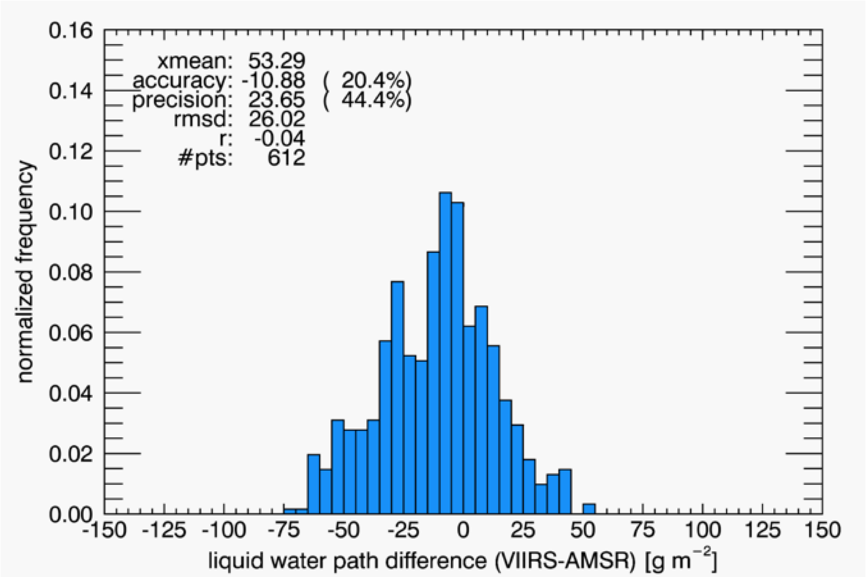
Accuracy has not changed appreciably, but scatter is reduced

AMSR2 Comparison

<u>One Additional Filter</u>

- IWP limited to NCOMP range
- Restrict AMSR2 to Horizontal Cloud Feature > 15km





Measurement Accuracy	Greater of 25g/m^2 or 15%
Measurement Precision	Greater of 25g/m^2 or 40%

Precision improves and met, but number of points greatly reduced.

Conclusions from AMSR2 Comparison

- NCOMP NDE NOAA-20 performs well when compared to AMSR2 observations of LWP if data is carefully filtered.
- Results imply that LWP (a non-NDE product) can be used to infer that NCOMP COD and CPS are not unreasonable since direct comparisons of those quantities are not possible.
- Since microwave observations are not well-regarded for low COD clouds, the comparison is mostly qualitative.
- Note again that some twilight data (sza < 90 degrees) was inadvertently included. Future validation will properly screen that out, so performance will improve.

Validation of Ice Water Path with CALIOP

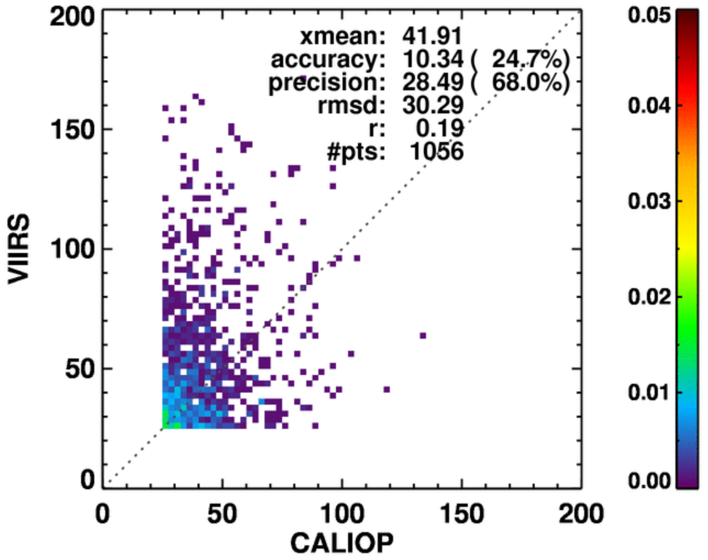
CALIOP - Data and Methodology

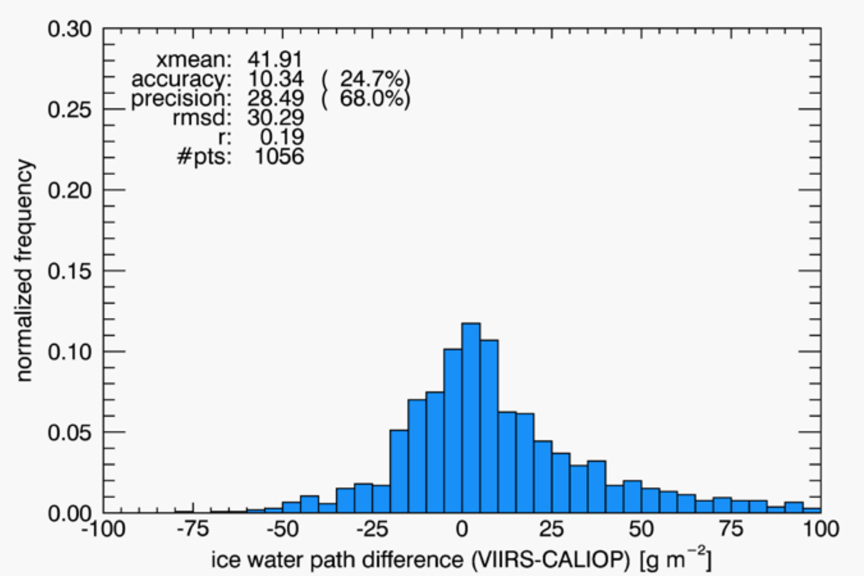
- Lidar retrievals from CALIOP are used for all 40 days of NCOMP data from 2018.
- CALIOP is on the CALIPSO satellite in the A-Train.
- Thin ice clouds provide good validation opportunities, although CALIOP's strength is very thin clouds, These very optically thin clouds (COD < 1.0) are outside of NCOMP's retrieval range.
- CALIOP Version 3.4 retrievals were used. Version 4 was not yet available when these comparisons were done.
- CALIOP IWP retrievals also involve parameterizations, so comparisons should be qualitative
- Several filters were used to best match the two sources:
    - Scan time difference ≤ 10 minutes
    - Ice clouds only
    - CALIOP Cloud Feature Horizontal Extent employed, depending on filtering
    - CALIOP Constrained and/or Unconstrained retrievals, depending on filtering

NCOMP IWP Compared to CALIOP IWP

VIIRS: 40 Days of Granules

CALIOP: Constrained, no horizontal feature used





Measurement Accuracy	Greater of 25 g/m^2 or 30%
Measurement Precision	Greater of 25 g/m^2 or 40%

NCOMP IWP meets accuracy specifications and precision specifications are close to being met. As with COD, CALIOP excels at thin ice clouds, so comparisons are difficult.

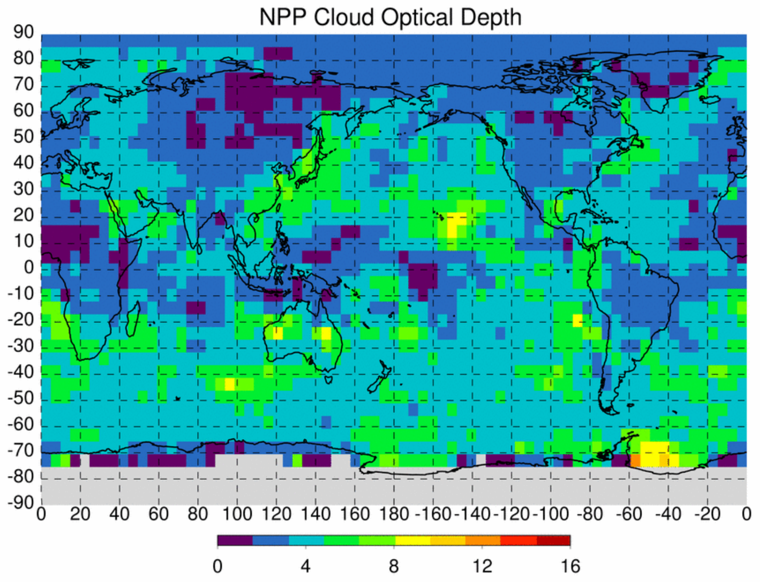
Comparisons with SNPP NCOMP

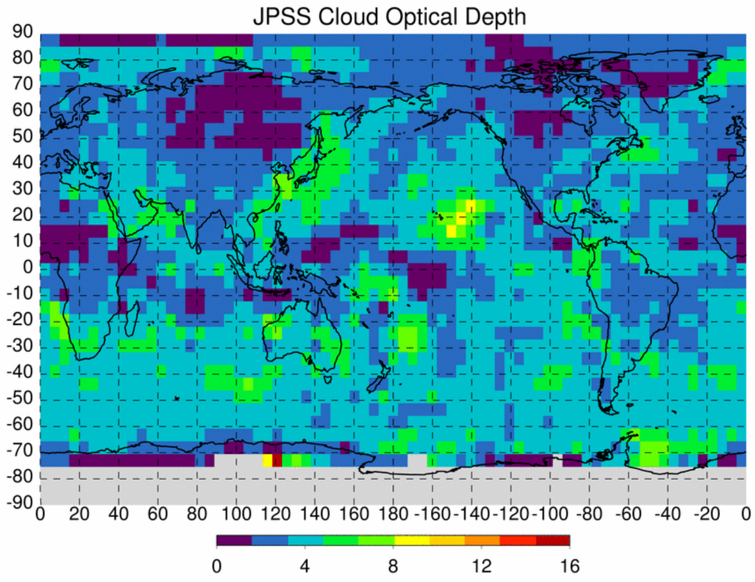
SNPP - Data and Methodology

- NCOMP retrievals from JPSS and SNPP from one week of February, 2019.
- Mean COD and CPS were computed for both instruments by placing all granules on a 5-degree by 5-degree latitude-longitude grid.
- Differences of observation time between JPSS and SNPP, as well as missing granules from either satellite, were not taken into consideration, so the comparisons are not expected to be exact, but should be similar.
- The V1R2 products have a known issue with PDA that caused missing granules throughout both JPSS and SNPP products.

SNPP Comparison

Mean NCOMP COD for 1 Week of February 2019

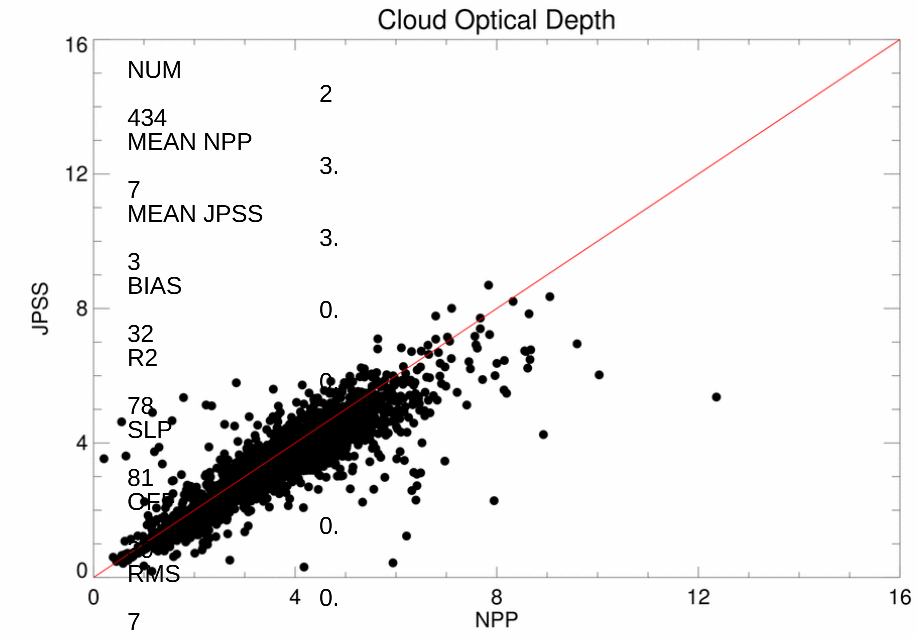




COD values and features across the globe look very similar.

SNPP Comparison

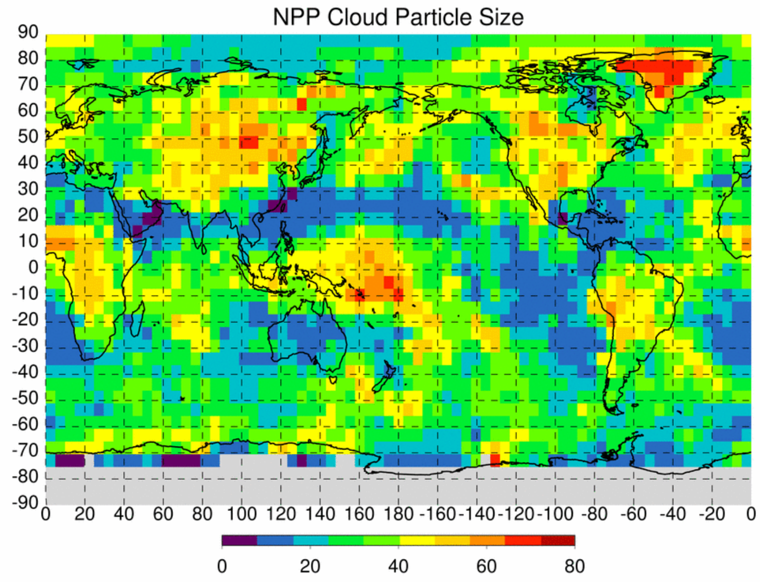
NCOMP COD from NPP and SNPP for 1 Week of February 2019

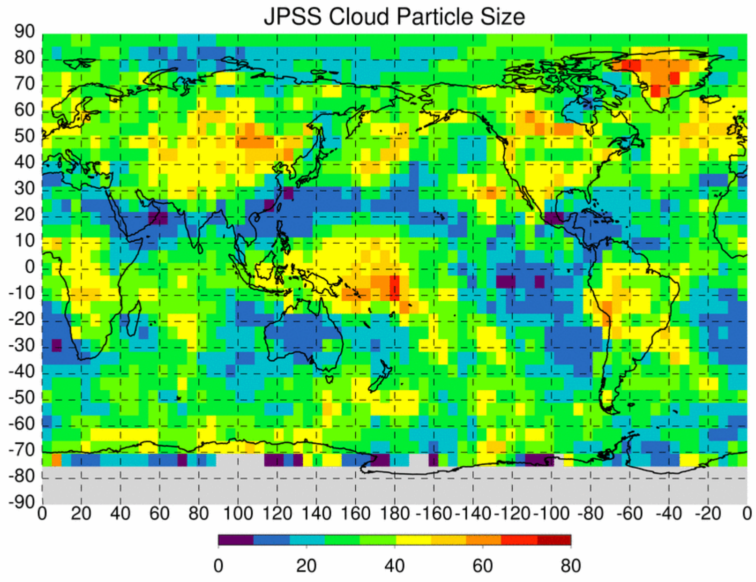


COD has a fair amount of expected scatter due to sampling differences. The bias is likely due to calibration for one or both of the instruments.

SNPP Comparison

Mean NCOMP CPS for 1 Week of February 2019

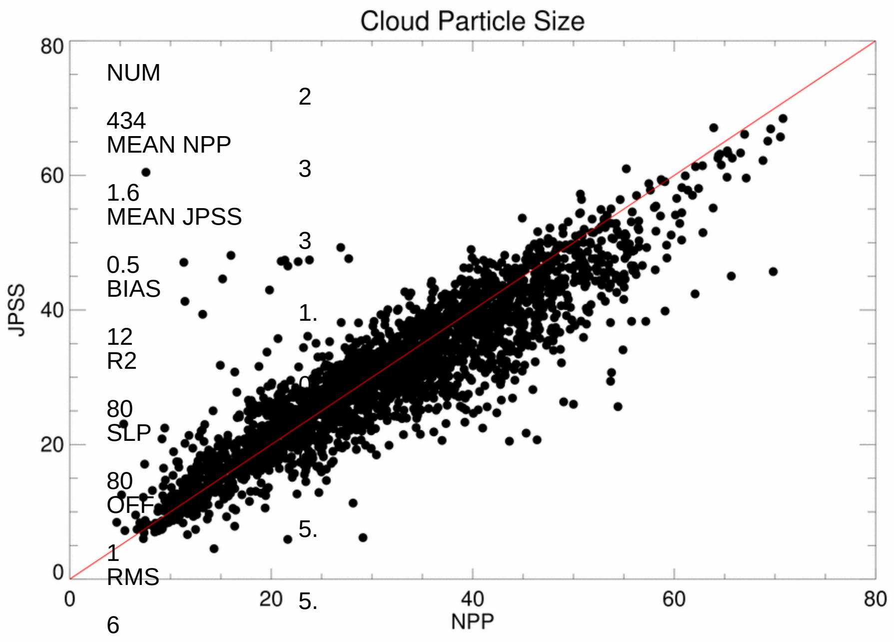




CPS values and features across the globe also look very similar.

SNPP Comparison

NCOMP CPS from NPP and SNPP for 1 Week of February 2019



CPS also has a fair amount of expected scatter. The small bias is also likely due to calibration for one or both of the instruments.

Conclusions from SNPP Comparison

- This one-week data set shows that SNPP and JPSS NCOMP COD and CPS are very similar.
- Time sampling differences explain the scatter and correlations, as well as missing granules from both instruments.
- The biases appear to be a result of calibration differences, but we will also verify that the cloud emittance parameterizations used in NCOMP are appropriate for both SNPP and NCOMP.
- Generally, JPSS NOMP results are consistent with SNPP results.

Validation- Summary

Product	Validation Source	Accuracy	Specs	Precision	Specs
COD Water	Indirect AMSR2	N/A	30%	N/A	0.8 or 30%
COD Ice	CALIOP	20.8%	30%	0.81 or 48.7%	0.8 or 30%
CPS Water	Indirect AMSR2	N/A	4µm or 30%	N/A	4µm or 25%
CPS Ice	Indirect CALIOP	N/A	10µm	N/A	10µm or 25%
LWP	AMSR2	10.9 g/m^2 or 20.4%	25 g/m^2 or 15%	23.7 g/m^2 or 44.4%	25 g/m^2 or 40%
IWP	CALIOP	10.3 g/m^2 or 24.7%	25 g/m^2 or 30%	28.5 g/m^2 or 68%	25 g/m^2 or 40%

Provisional Maturity Conclusions

- Accuracy specs are met for ice cloud COD and precision specs are mostly met. For non-NDE products LWP and IWP, the same can be said.
- The only independent validation source of LWP is AMSR2 and it has met requirement specifications for other NCOMP applications NCOMP. LWP is computed from NCOMP COD and CPS, so a successful validation of LWP implies NCOMP COD and CPS for water clouds are reasonable.
- Similarly for IWP, CALIOP is the IWP validation source and has met all requirement specifications for other applications. IWP is computed from NCOMP COD and CPS, so a successful validation of IWP implies NCOMP COD and CPS for ice clouds are reasonable.
- JPSS COD and CPS are consistent with NPP results.
- We expect an improvement if we collect more validation days so that more spatial and temporal filtering can be done without impacting statistical significance. Removing twilight granules will also improve performance.
- **The Cloud Team recommends Provisional Maturity at this time.**

Requirement Check List – Cloud Optical Depth

JERD	Requirement	Meet Requirement (Y/N)?
	Applicable Conditions: 1. Requirements apply whenever detectable clouds are present	
JERD-2430	The algorithm shall produce a cloud optical depth product that has a horizontal cell size of 0.8 km	Y
JERD-2482	The algorithm shall produce a cloud optical depth product that has a mapping uncertainty (3 sigma) of 4 km	Y
JERD-2483	The algorithm shall produce a cloud optical depth product that has a measurement range of 0.3 – 64 (Day) and 0.3 – 8 (Night)	Y (Night)
JERD-2484	The algorithm shall produce a cloud optical depth product that has a measurement precision of greater of 30% or 3.0 Tau (Day) and greater of 30% or 0.8 Tau (Night)	Y (NIght) Inferred for water
JERD-2485	The algorithm shall produce a cloud optical depth product that has a measurement accuracy of Liquid phase: 20% (Day), 30% (Night); Ice phase: 20% (Day), 30% (Night)	Y (NIght) Inferred for water

Requirement Check List – Cloud Particle Size Distribution

JERD	Requirement	Meet Requirement (Y/N)?
	Applicable Conditions: 1. Requirements apply both day and night and whenever detectable clouds are present	
JERD-2431	The algorithm shall produce a cloud particle size distribution product that has a horizontal cell size of 0.8 km	Y
JERD-2486	The algorithm shall produce a cloud particle size distribution product that has a mapping uncertainty (3 sigma) of 4 km	Y
JERD-2487	The algorithm shall produce a cloud particle size distribution product that has a measurement range of 2 to 50 µm (day), 2 to 32 µm for water (night), and 2 to 50 µm for ice (night)	Y (night)
JERD-2488	The algorithm shall produce a cloud particle size distribution product that has a measurement precision of greater of 4 µm or 25% for water and greater of 10 µm or 25% for ice	Inferred
JERD-2489	The algorithm shall produce a cloud particle size distribution product that has a measurement accuracy of Greater of 4 µm or 30% for water and 10 µm for ice	Inferred

Pathway to Full Validation

Pathway to Full Maturity

- We expect to apply the same activities to be conducted for Full Maturity:
  - We continue to gather an archive of golden days where we save SDRs and EDRs ongoing from September 2018. This collection is ongoing.
  - We will apply different levels of data filtering to prove precision specs.
  - We will evaluate the cloud emittance parameterizations to very their appropriateness.
  - We hope to continue to engage the teams and continue application-specific analysis.

Risks for Full Validation

Currently outstanding issues, unless fixed by handover, may prevent declaration of Full Validation Maturity:

- **NDE processing issues (Low)**
  - Missing granules in NDE processing
    - Only existed in v1r2 and previous DAP deliveries. Currently resolved.
- **Precision (Low)**
  - Data filter for provisional was loose to include as much matched data as possible. Additional filtering of both NCOMP and the validation source on temporal, spatial and other qualities will improve precision results.
- **Evaluation of high CPS in some ice clouds (Low)**
  - CPS occasionally appear to be too high. Will explore this by comparisons with the only other nighttime CPS product available – NASA Langley's SIST, when available from the CERES team.

Near Future Plans for NCOMP

- Analyze and mitigate any CPS retrieval high bias for ice clouds by evaluating the retrieval scheme and implementing any corrections. Comparisons with SIST will be used diagnostically.

- A planned update to the IWP formulation should improve CALIOP comparisons. Similarly, new definitions of CPS for ice clouds will be implemented in NCOMP and are expected to also improve the IWP comparisons.

- An extension of NCOMP's COD range for ice will be implemented in the algorithm. This will allow more robust comparisons with CALIOP IWP, which should increase specification performance and user applications.

Far Future Plans for NCOMP

- Use new two-habit ice crystal models to compute improved cloud emittance parameterization.
- Explore improving neural net approach for the extension of COD to apply to water clouds also. This would greatly expand and improve the ability to validate with AMSR2 thereby increasing inferred validation of water cloud COD and CPS.

Backup slides