Beta/Provisional Maturity Science Review For NOAA-21 Cloud Optical and Microphysical Properties (COMP)

CIMSS COMP Team: Andi Walther, Jessica Gartzke-Maier, Mike Foster, William Straka

NOAA Cloud Science Team Lead: Mark Kulie

Presented by Andi Walther & Mark Kulie

Date: 11/29/2023

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.

COMP Products

- Cloud Optical and Microphysical Properties (COMP)
  - Cloud Optical Depth (COD) or Thickness (COT)
  - Cloud Top Particle Effective Radius (REF)
  - Cloud Water Path (CWP/LWP)

- Daytime COMP (DCOMP)
  - VIS/Near-IR

- Nighttime COMP (NCOMP)
  - IR channels only
  - Independent from DCOMP
  - No further development activities
  - Future plans: Transition to NCOMP derived from Enterprise Cloud Height Algorithm

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  - Cloud Top Particle Effective Radius
  - Cloud Water Path

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- Nighttime COMP (NCOMP)
  - IR channels only
  - Independent from DCOMP

- Nighttime Lunar COMP (NLCOMP)
  - VIS/Near-IR (lunar reflectance when available)
  - Related to DCOMP
  - Produced operationally, but no operational requirements yet
  - Consider this a non-operational product for this review!!!

Executive Summary

- Analysis:
  - Visual Inspection
  - AMSR2 product comparisons (DCOMP and NCOMP)
  - SNPP/N20/N21 comparisons (DCOMP)
  - MODIS comparisons (DCOMP)

- Issues: Missing/Incomplete data sets, various questions related to DCOMP data fields and quality flags

- **Recommendation: Beta/Provisional Maturity for both DCOMP and NCOMP** (effective March 30, 2023) algorithms, but various minor issues raised in this review should be addressed before the Validated Maturity review.

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

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NOAA-21 COMP Algorithm Cal/Val Team

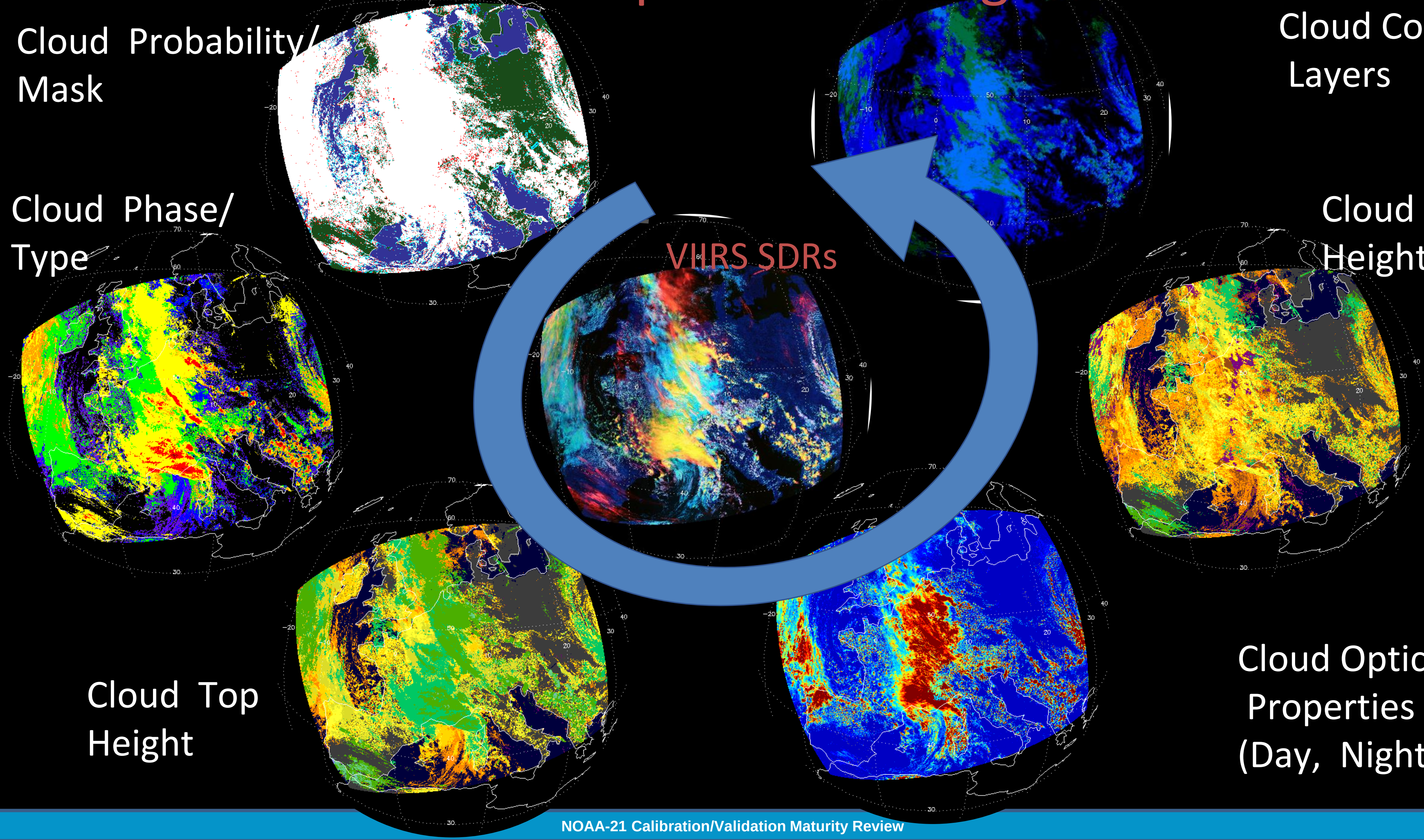
Algorithm Cal/Val Team Members

Name	Organization	Major Task
Andi Walther	UW-Madison/CIMSS	Lead, Algorithm development, validation
Mark Kulie	NOAA-NESDIS	Cloud Algorithm Working Group Lead
Mike Foster	UW-Madison/CIMSS	Supports implementation
William Straka	UW-Madison/CIMSS	Supports algorithm integration
Jessica Gartzke-Maier	UW-Madison/CIMSS	NCOMP cal/val
David Donahue	OSPO	Cloud Algorithm PAL
Shuang Qiu	OSPO	JPSS Product Area Lead

Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data
    - Reflectance M5, M11
  - Ancillary Data
    - Surface albedo
    - Atmospheric profile of water vapor (NWP)
    - Ozone (NWP)
  - LUTs / PCTs
    - Pre-calculated functions of Cloud reflectance, transmission, spherical albedo
  - Upstream algorithms
    - Cloud Mask
    - Cloud Phase
    - Cloud Top Pressure

NOAA Enterprise Cloud Algorithms



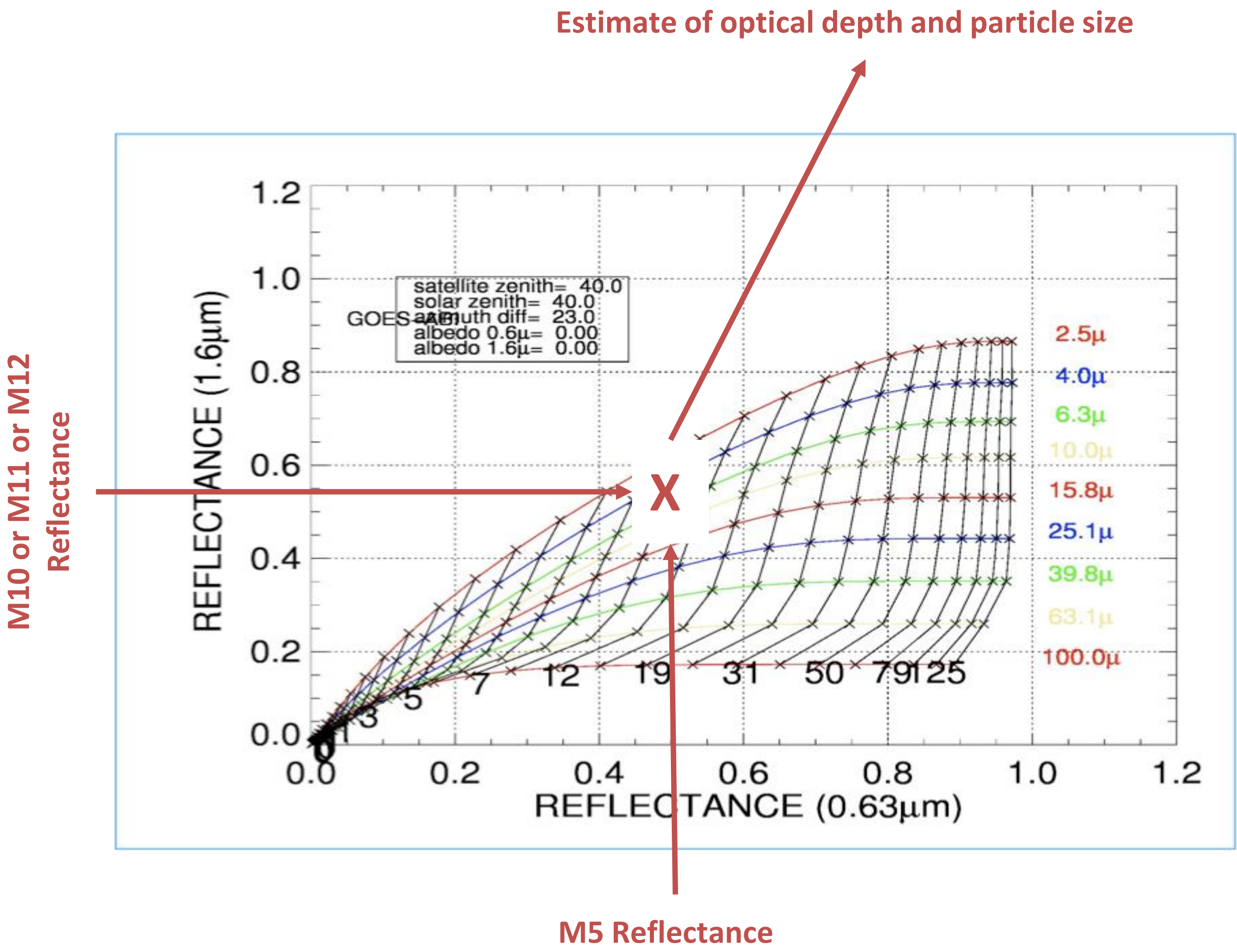
Cloud Optical and Microphysical Properties Overview

How DCOMP Works

- Standard approach (Nakajima & King)
- Retrieves Cloud particle size (effective radius) and Cloud optical depth using two channels in VIS and NIR.
    - Does a separate retrieval for each VIS and NIR combination.
    - NIR = 2.24 mm (M11) is the default for operations.
- Retrieves cloud water path assuming vertically homogeneity:

$$LWP = \frac{2}{3}\tau\ R_e\ \rho \quad (*0.83)$$

- Different Look-up-tables for ice and water. We cooperate with the MODIS Science Team on selecting them.



DCOMP accounts for atmospheric gaseous absorption and scattering and spectral surface reflectance. Separate logic over snow and ice.

Nighttime Cloud Optical Properties (NCOMP) Product Overview

- 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 for the 11, 12 and 13µm)
  - –Clear-sky IR RTM calculations
  - –All-sky temperature, atmospheric profiles, and skin temperatures (NWP)
  - –Cloud emittance parameterization coefficients (LUTs)

Requirement Check List – VIIRS Cloud optical properties

DPS	Requirement	Performance
DPS-473	The Cloud Optical Depth product shall provide cloud optical depth, globally, day and night, whenever detectable clouds are present, at the refresh rates of the instrument.	
DPS-477	The Cloud Optical Depth product shall provide cloud optical depth with a measurement precision of the greater of 30% or 3 optical depths in daytime; and the greater of 30% or 0.8 optical depths at night.	
DPS-478	The Cloud Optical Depth product shall provide cloud optical depth with a measurement accuracy of 20% in daytime and 30% at night.	
DPS-465	The Cloud Particle Size Distribution product shall provide the cloud effective particle size, at cloud tops, globally, day and night, whenever detectable clouds are present, at the refresh rates of the instrument.	
DPS-468	The Cloud Particle Size Distribution product shall provide cloud effective particle size over a range from 2 to 50 microns for ice and water in daytime and for ice at night; and 2 to 32 microns for water at night.	
DPS-469	The Cloud Particle Size Distribution product shall provide cloud effective particle size with a measurement precision of: the greater of 25% or 4 micron for water; greater of 25% or 10 micron for ice.	

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Product Requirements and Observed Validation DCOMP

Attribute	Threshold	Observed/validated
Geographic coverage	global	global
Vertical Coverage	n/a	n/a
Vertical Cell Size	n/a	n/a
Horizontal Cell Size	0.8 km	n/a
Mapping Uncertainty	4 km	n/a
Measurement Range	COD : 0.3 – 64 (Day) CPS : 2 to 50 µm (day)	n/a
Measurement Accuracy	COD : greater of 30% or 3.0τ (Day) CPS : Greater of 4 µm or 30% for (liquid) and 10 µm for ice	Yes#
Measurement Precision	COD : Liquid phase 20% (Day) Ice phase: 20% (Day) CPS: Liquid phase : greater of 4 µm or 25% Ice phase : greater of 10 µm or 25% for ice	No#, but results deemed reasonable based on somewhat limited validation dataset and uncertainties driven by spatiotemporal matching with validation datasets.

#Similar results were obtained during NOAA-20 and S-NPP DCOMP Provisional and Validated Maturity Reviews. See backup slides for further details.

Product Requirements and Observed Validation NCOMP

Attribute	Threshold	Observed/validated
Geographic coverage	global	global
Vertical Coverage	n/a	n/a
Vertical Cell Size	n/a	n/a
Horizontal Cell Size	0.8 km	n/a
Mapping Uncertainty	4 km	n/a
Measurement Range	COD : 0.0 – 16 (Day) LWP: 0mm -	n/a
Measurement Accuracy	COD : greater of 30% or 8.0τ LWP: 25 mm or 15%	Yes#
Measurement Precision	COD : 8 or 30% LWP: 25 mm or 15%	No#, but results deemed reasonable based on somewhat limited validation dataset and uncertainties driven by spatiotemporal matching with validation datasets.

#Similar results were obtained during NOAA-20 and S-NPP NCOMP Provisional and Validated Maturity Reviews. See backup slides for further details.

Daytime Cloud Optical Properties (DCOMP) Processing Environment and Algorithms

- DCOMP is the Daytime Cloud Optical and Microphysical Properties algorithm of the NOAA-AWG retrieval scheme PATMOS-x.
- Currently being processed within SAPF at NCCF
- Developed for GOES-AWG and works presently on VIIRS-SNPP and VIIRS-NOAA-20, MODIS, GOES, SEVIRI, MSAT, GOES-ABI and others.
- FORTRAN 90/95 package which works with the identical code for all sensors and software environments (e.g. CLAVR-x, GEOCAT, FRAMEWORK).
- Uses pre-computed cloud parameters stored in LUTs. (NCDF4 format)
- Uses the reflective information from the 0.64, 1.6, 2.2 and 3.9µm
- Operational version: v3r2 (no science code updates since 2018 other than to add new satellite support. The interface to the SAPF added DNB support in 2022)
- For VIIRS, DCOMP also processes visible optical properties during moonlit conditions, which is used by the cloud base algorithm. There are no requirements for nighttime visible cloud optical properties (NLCOMP).

Processing Environment and Algorithms

- NCOMP is the Nighttime Cloud Optical and Microphysical Properties algorithm.
- NCOMP was developed at *NASA* Langley Research Center
- Algorithm developers were Pat Minnis and Pat Heck.
  - Both algorithm developers have retires and this algorithm is in maintenance mode
  - Future work is underway to replace NCOMP with COD/REF from ACHA
  - There are no known downstream users of NCOMP.
- Operational version: v3r2 (no updates since 2018 other than to add new satellite support)

DCOMP: File design issues discovered

The following issues were discovered during this NOAA-21 review:

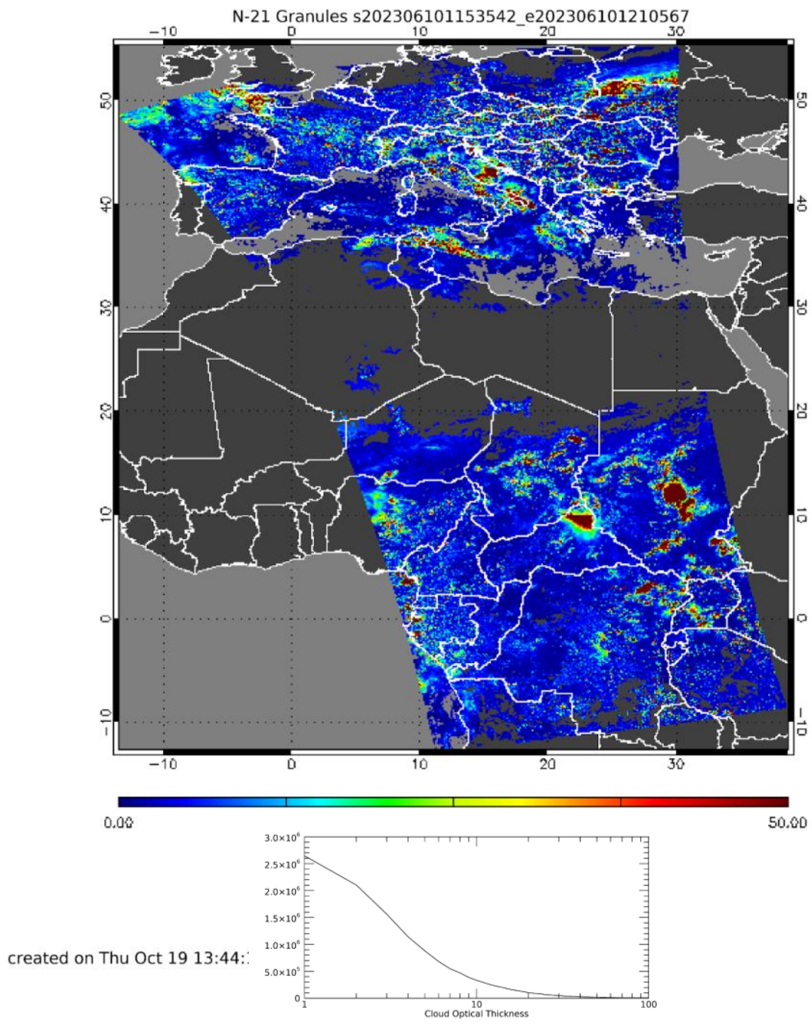
- DCOMP issues with nighttime granules:
  - Including NLCOMP retrievals in DCOMP files can be confusing and is not adequately documented
  - Include an easy-to-understand filter for DCOMP versus NLCOMP retrievals
  - Investigate COD retrieval values in NLCOMP retrievals
- Some global attributes show potentially wrong values.
- Some quality flags have the wrong data type (e.g. byte versus integer).
- The Cloud Water Content field is not sorted according to water and ice phase and is identical for both values. Each pixel should only be either ice or liquid water.
- This issue affects all VIIRS DCOMP products (S-NPP, NOAA-20, and NOAA-21) that are generated by the current version of the software
- See backup slides (slides 51-58) for further details about each of these issues and refer to ASSISTT slides for code analysis of these issues.

Validation Results - Visual Inspection

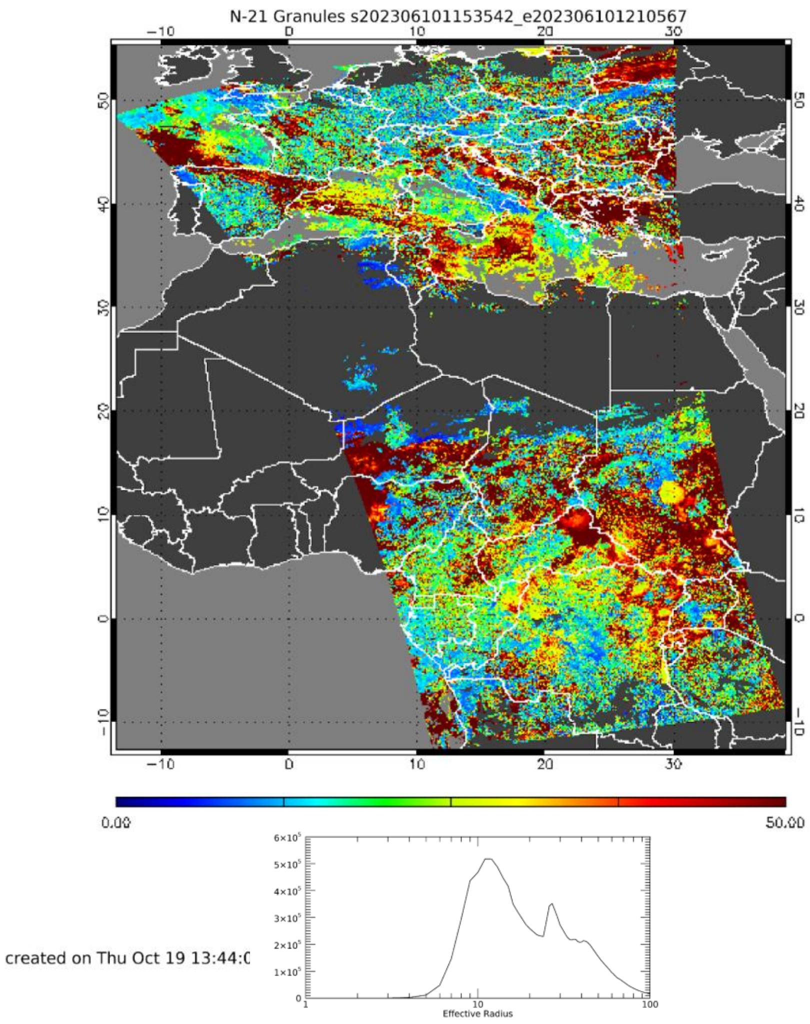
- Comprehensive visual inspections were performed on DCOMP and NCOMP products
- No major issues were identified
- Visual inspection examples are shown in the following slides

Validation results (I) – Visual Inspection - Pass

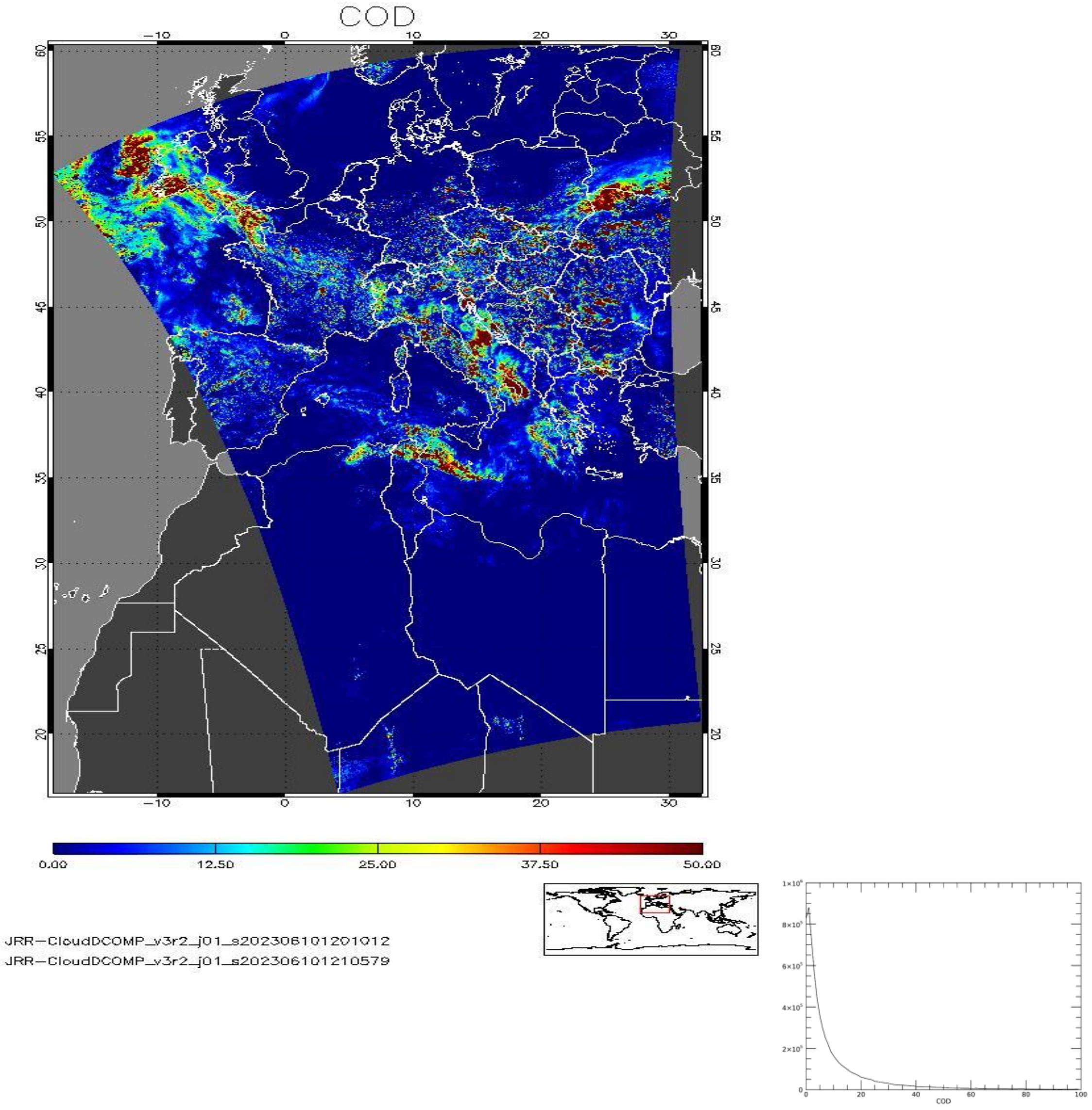
Cloud Optical Thickness

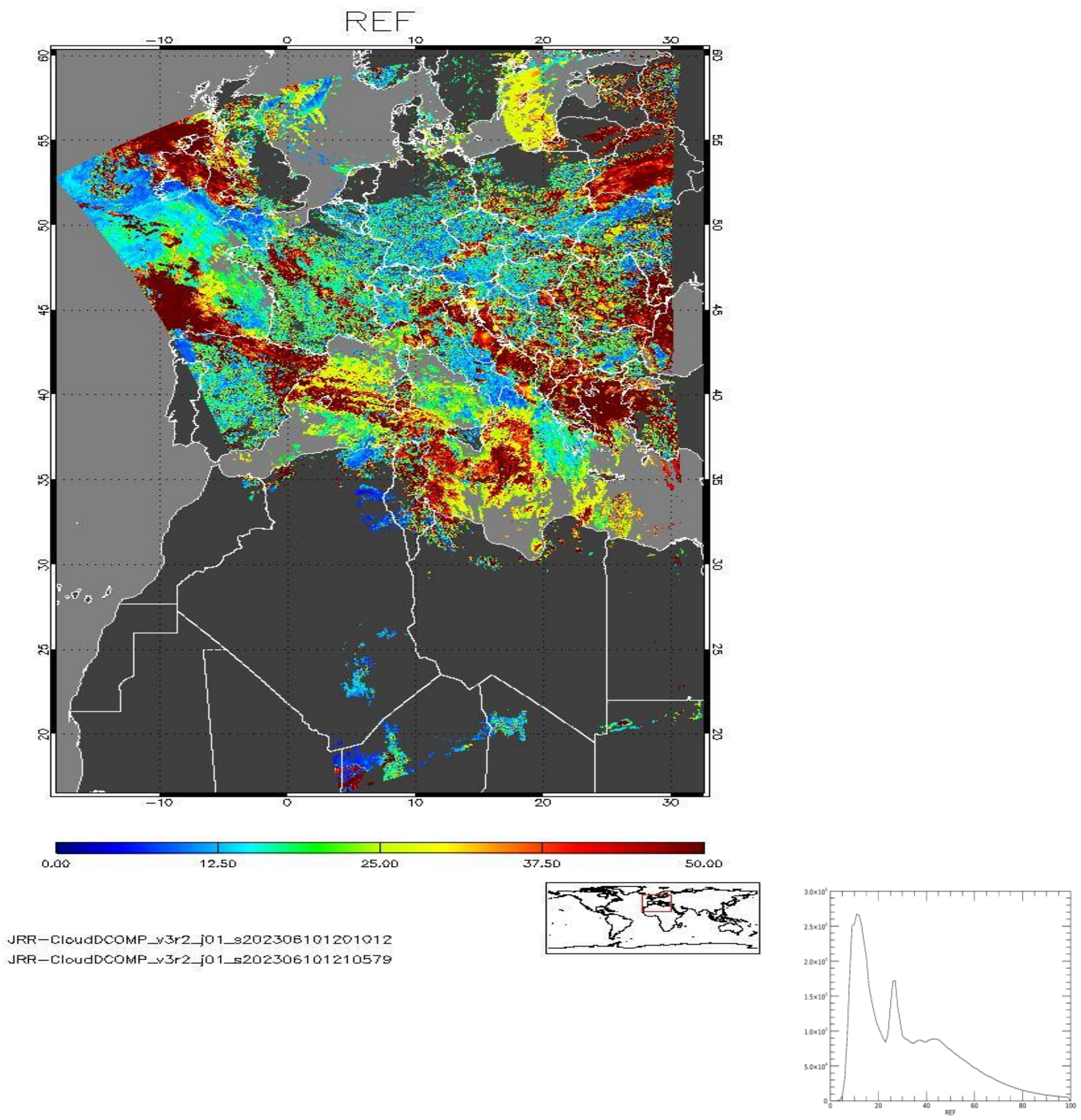


Effective Radius



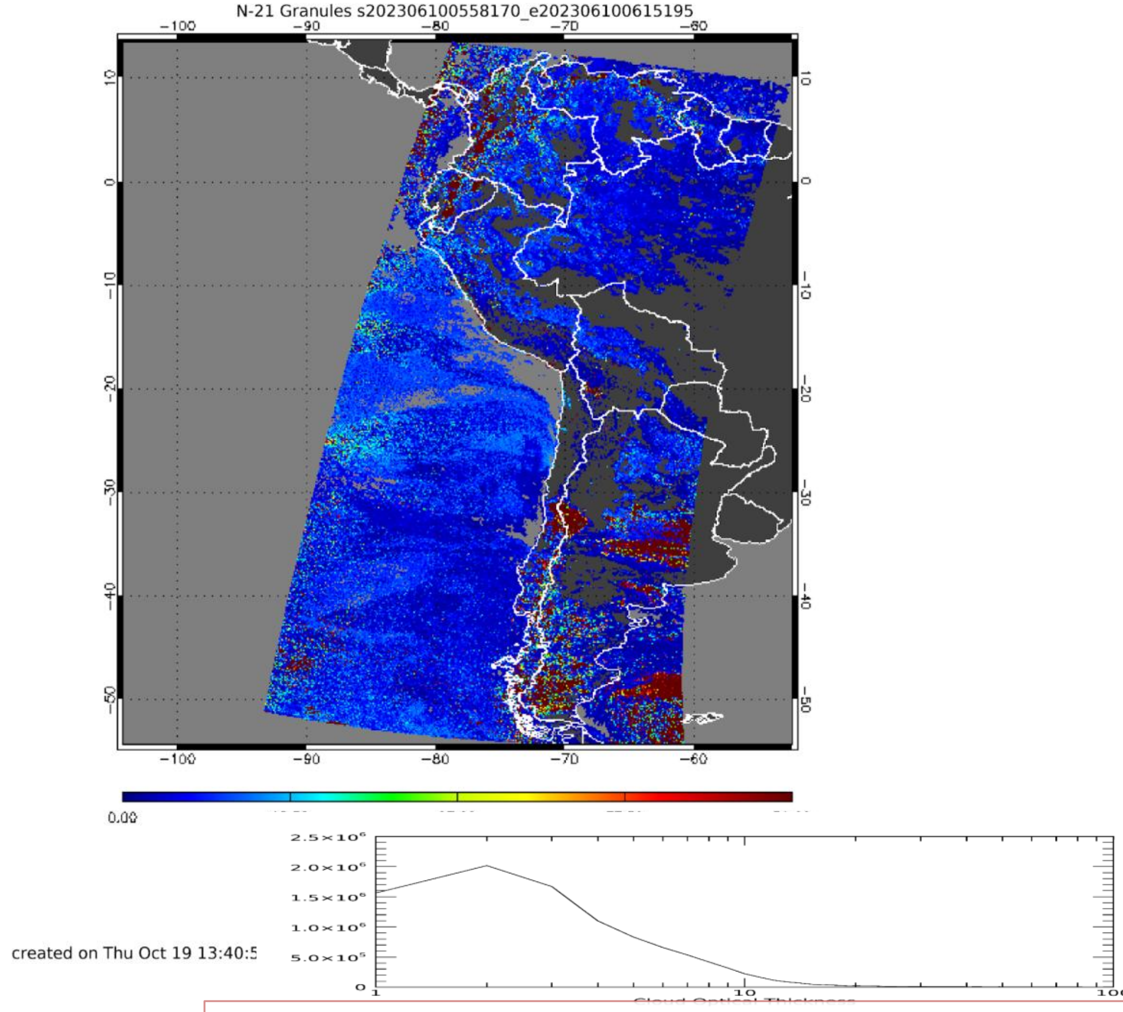
NOAA-20 visual inspection



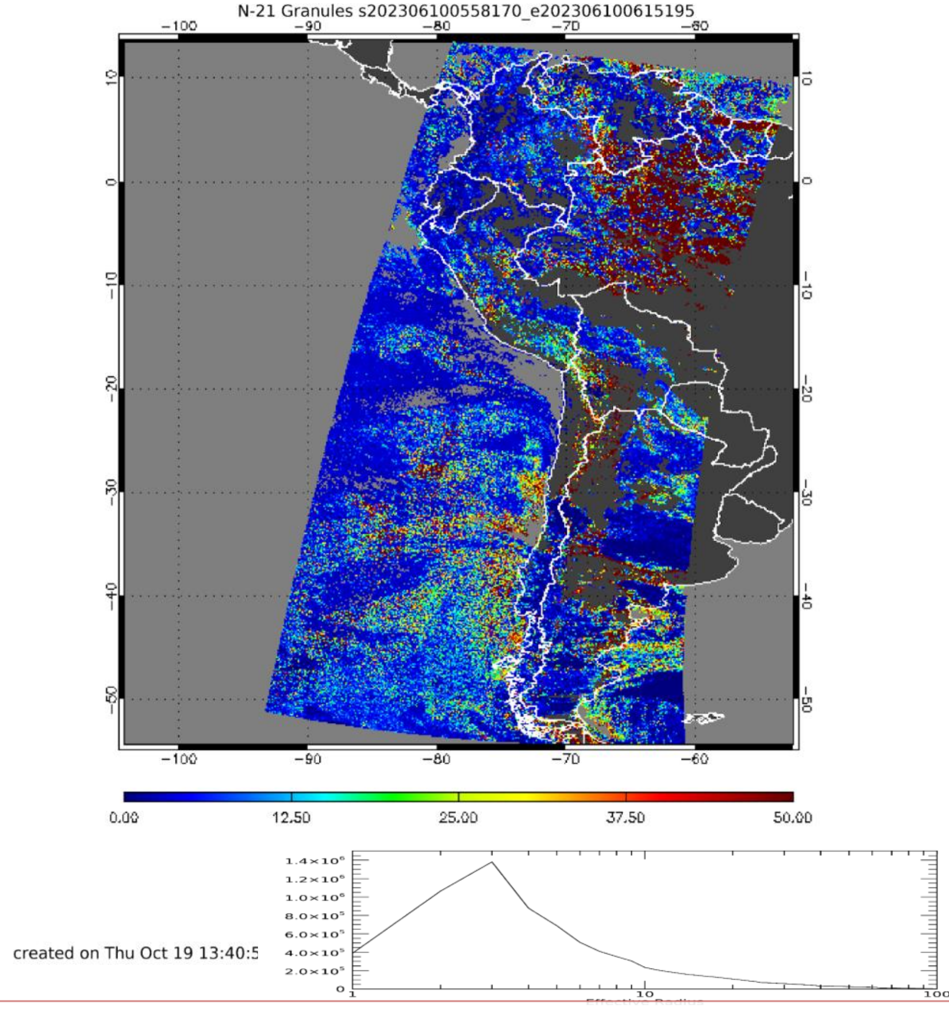


Validation results (II) – Visual Inspection (NLCOMP) - Pass

Cloud Optical Thickness

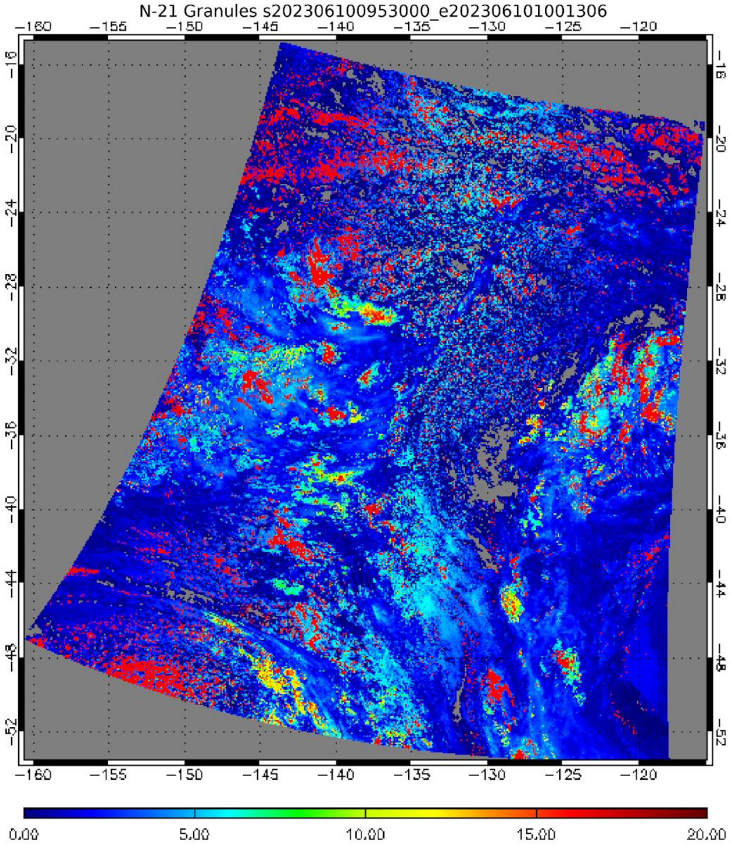


Effective Radius

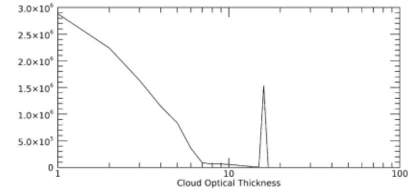


Validation results (III) – Visual Inspection NCOMP - Pass

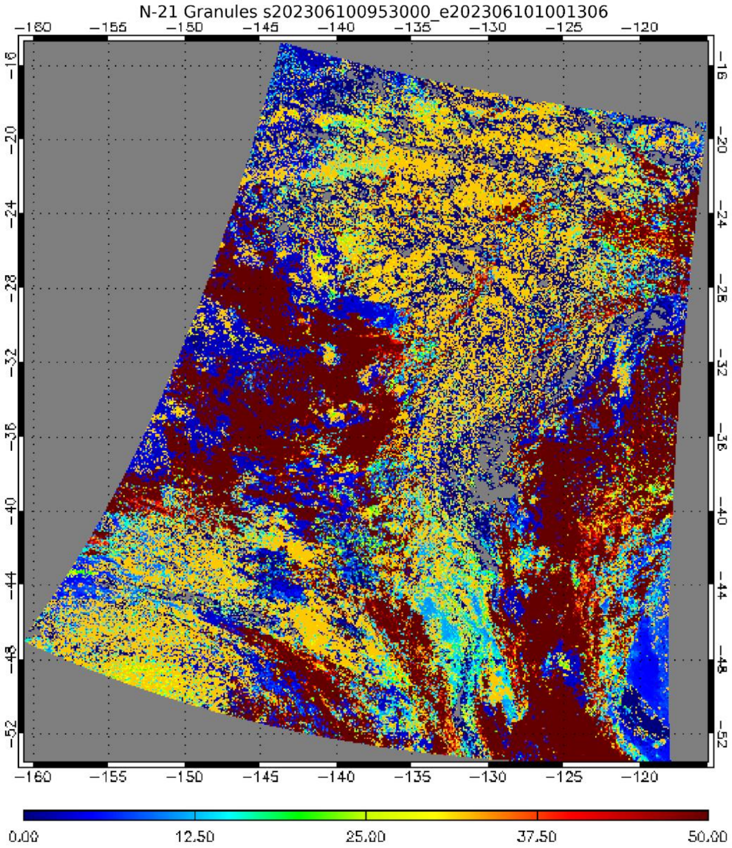
Cloud Optical Thickness



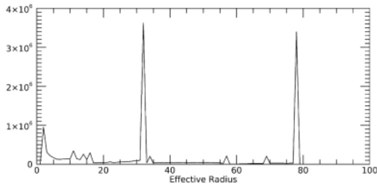
created on Mon Oct 23 01:43:39 2023



Effective Radius



created on Mon Oct 23 01:43:35 2023



Validation results (III) – AMSR-2

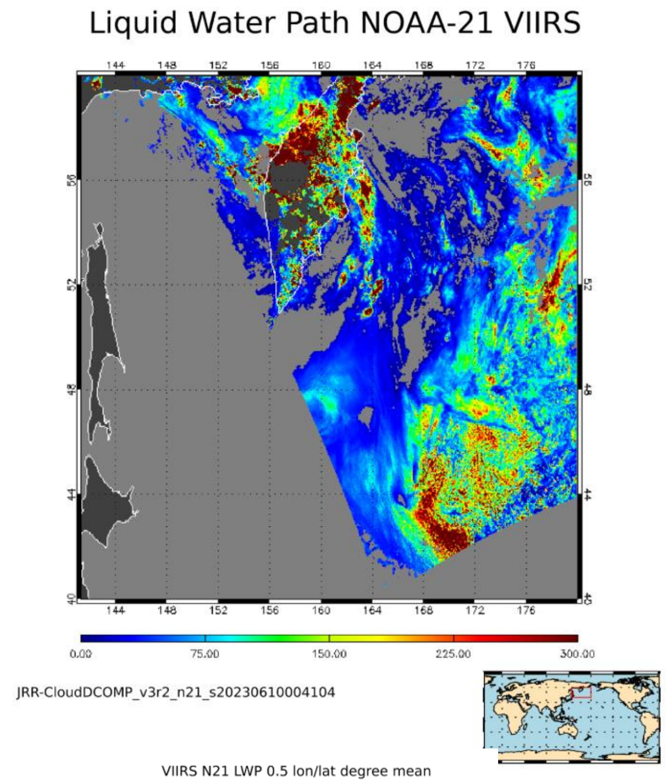
Comparison to Microwave-based AMSR-2 Cloud Liquid Water Path

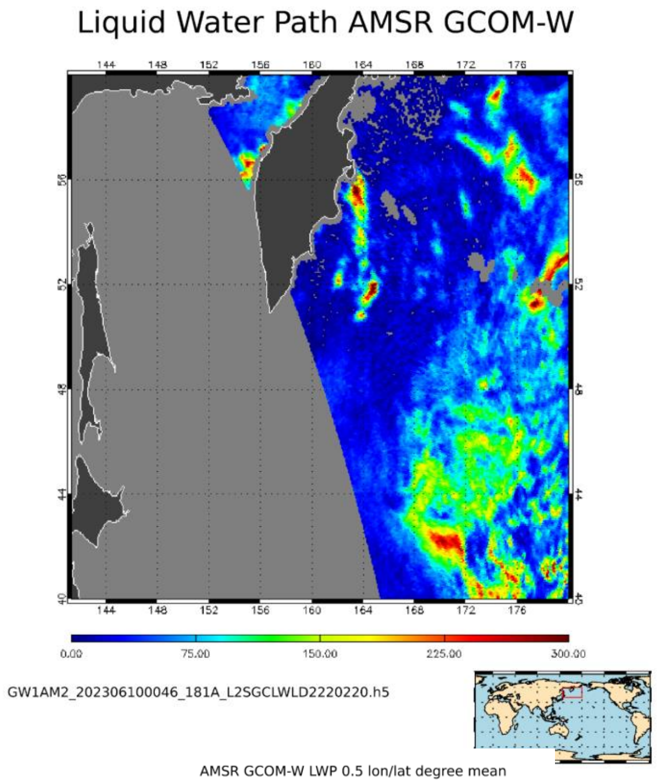
+AMSR-2 is an independent validation source

- Assumptions needed to compute LWP from COD/CPS
- Analysis is limited to water clouds over the ocean
- Different spatial resolution
- Microwave measurements are impacted by rain, ice clouds, and land surface
- AMSR-2 data have non-zero values for every pixel.

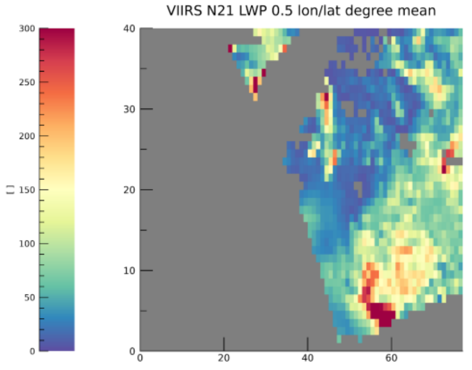
AMSR-2 flies onboard the GCOM-W polar-orbiting satellite with similar overpass times

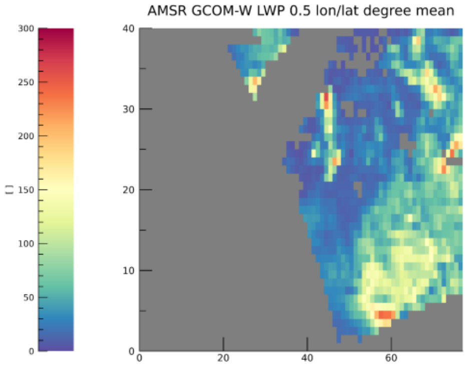
AMSR2 on GCOM-W vs. DCOMP

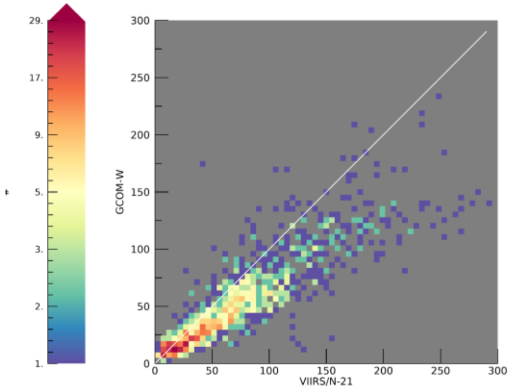




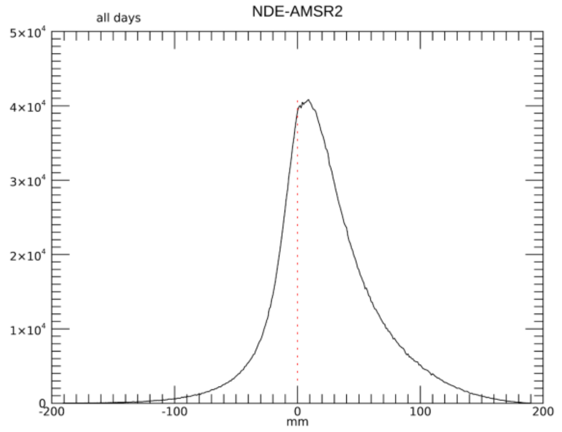
- Collect all liquid phase pixels in a 0.5 x 0.5 degree box.
- Use average for both datasets for these 0.5 degree boxes

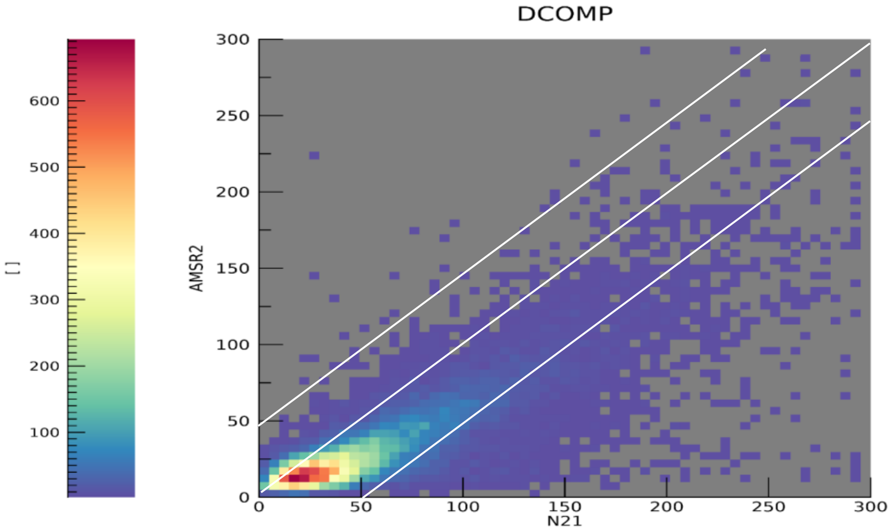






Validation results (III) – AMSR2. DCOMP



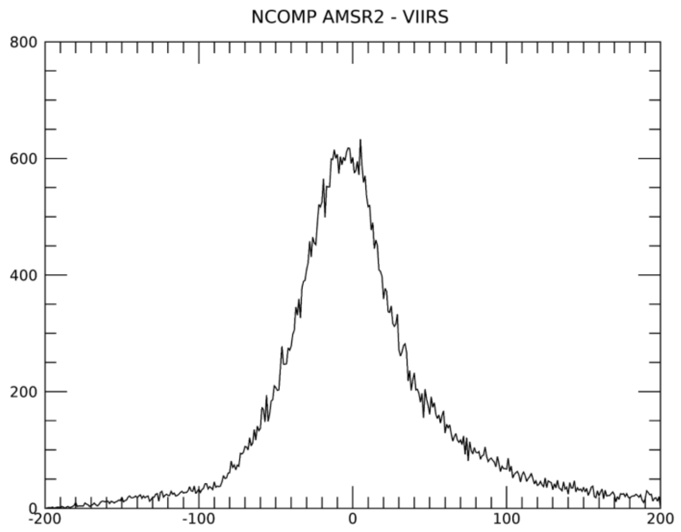


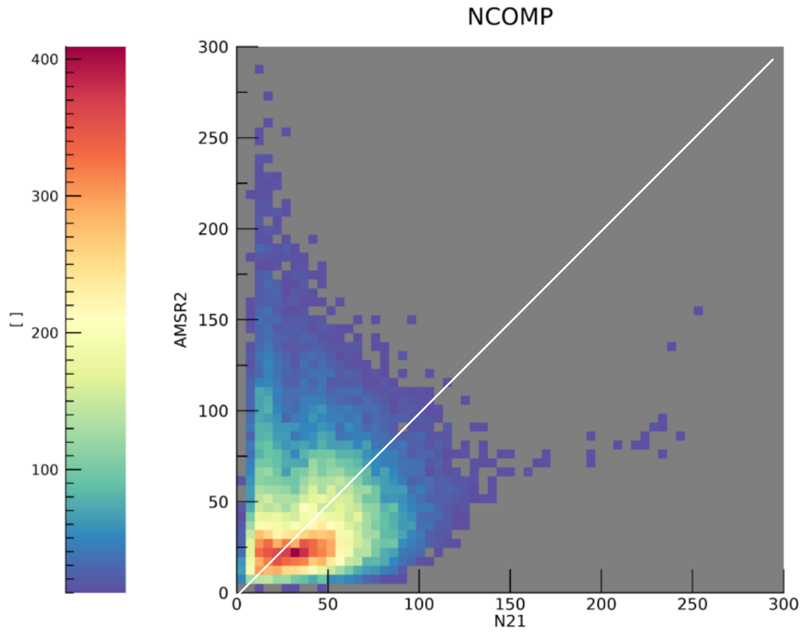
- All observed days (three) are in the same range of comparison results. ***Accuracy and precision requirements are met for all days and for the whole period.***

- The NCCF NOAA-21 VIIRS retrieval systematically overestimates high liquid water path values.

- Possible reasons for comparison discrepancies are filtering techniques, the too high CPS for water clouds as seen in the MODIS comparisons, and the COT overestimation in saturated clouds for which DCOMP has limited to no information skill.

Validation results (IV) – AMSR2 versus NCOMP LWP

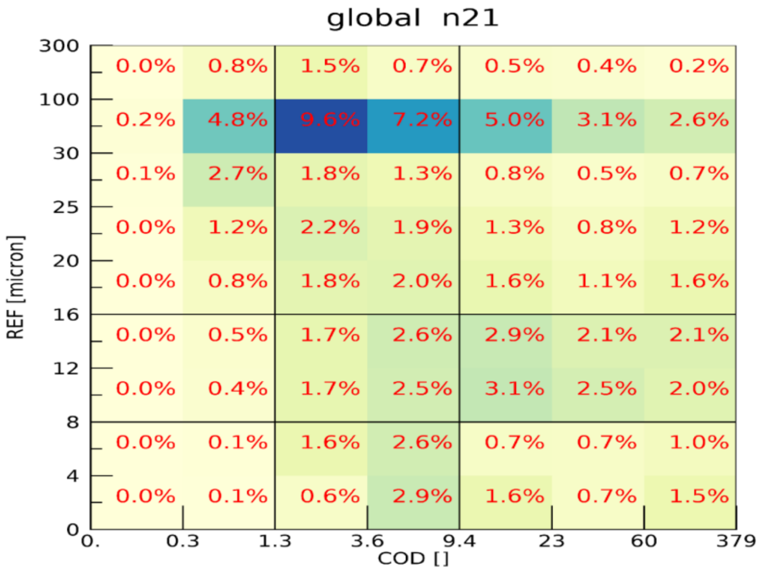




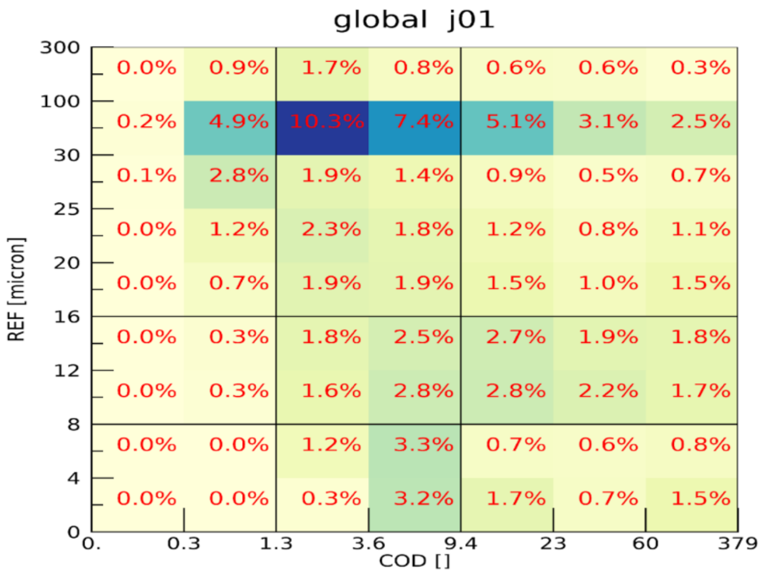
Bias: 8.9mm, precision: 60mm

NCOMP has a significantly lower value range than DCOMP for all VIIRS instruments since NCOMP's valid COD threshold is 12 due to limited information provided by IR-only channels.

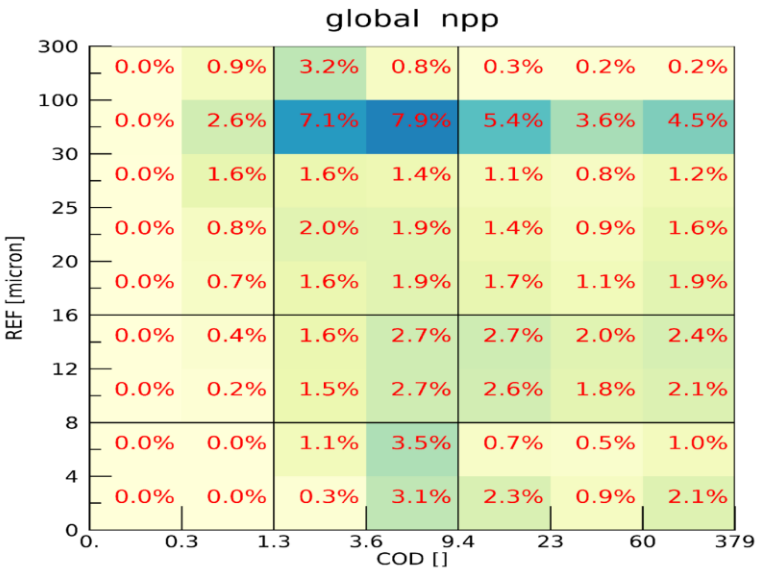
Validation results (V) –monitoring of NOAA-21, NOAA-20, and S-NPP



cloud fraction: 0.61860

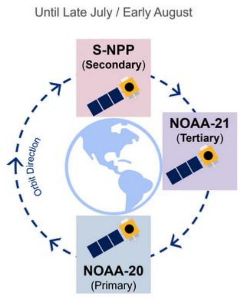


:loud fraction: 0.63180



cloud fraction: 0.62125

- The JPSS satellites fly at different crossing times. Since clouds have a diurnal cycle, we don't expect exact histograms of cloud products.
- **NOAA-21 and NOAA-20 comparisons are excellent**
- The impact of the 5% larger reflectance values in SNPP M5 versus NOAA-20/NOAA-21 M5 is evident in the thickest clouds, but comparison are reasonable given this complication.



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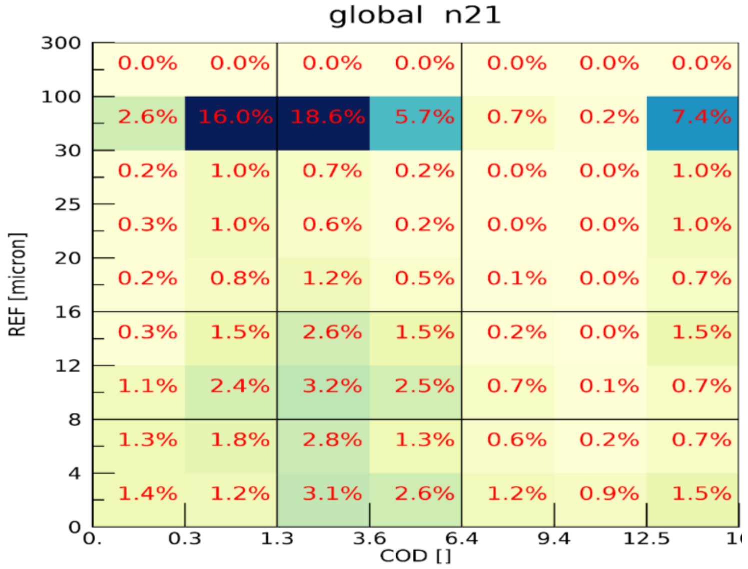
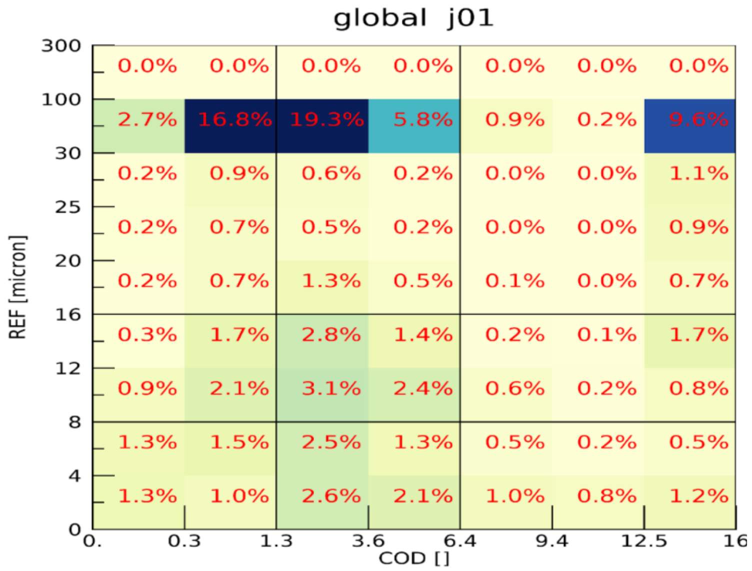
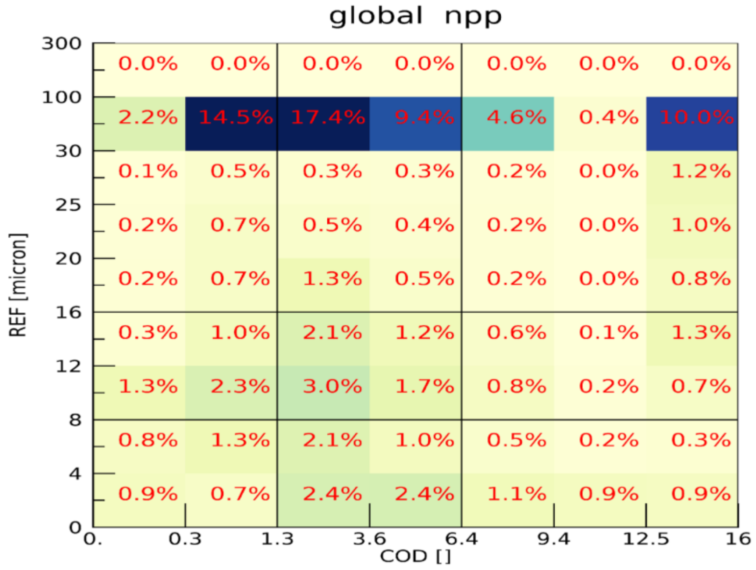


cloud fraction: 0.66915

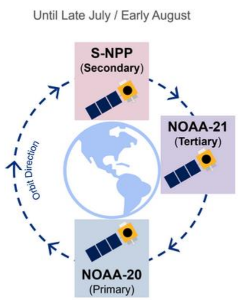


cloud fraction: 0.66629



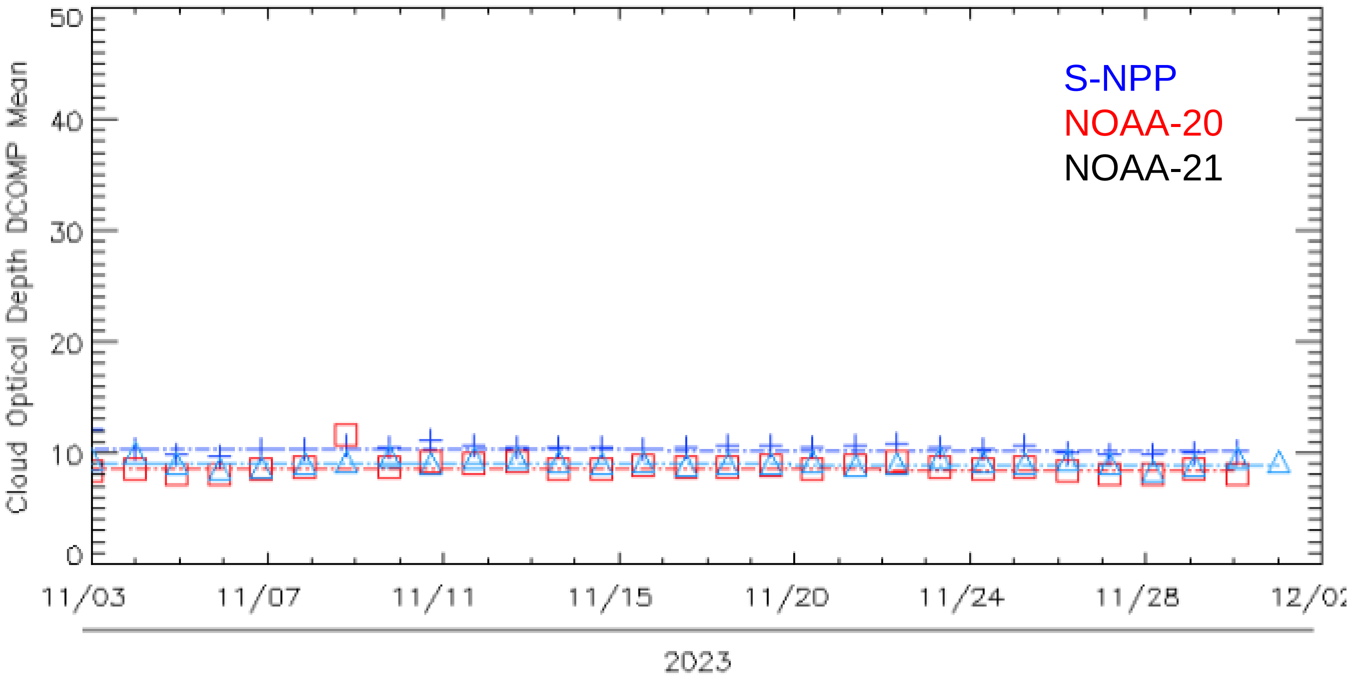
cloud fraction: 0.65974

- The JPSS satellites fly at different crossing times. Since clouds have a diurnal cycle, we don’t expect exact histograms of cloud products.
- **NOAA-21, NOAA-20, and S-NPP comparisons are excellent**



NOAA-21, NOAA-20, and S-NPP Long Term Monitoring Validation

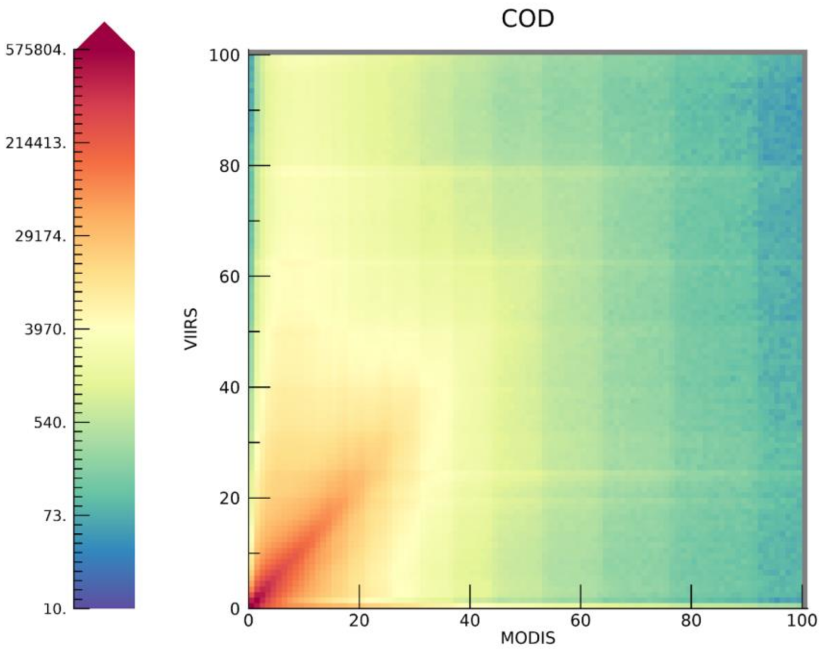
Long Term Monitoring#: Cloud Optical Depth (Ascending Orbits)

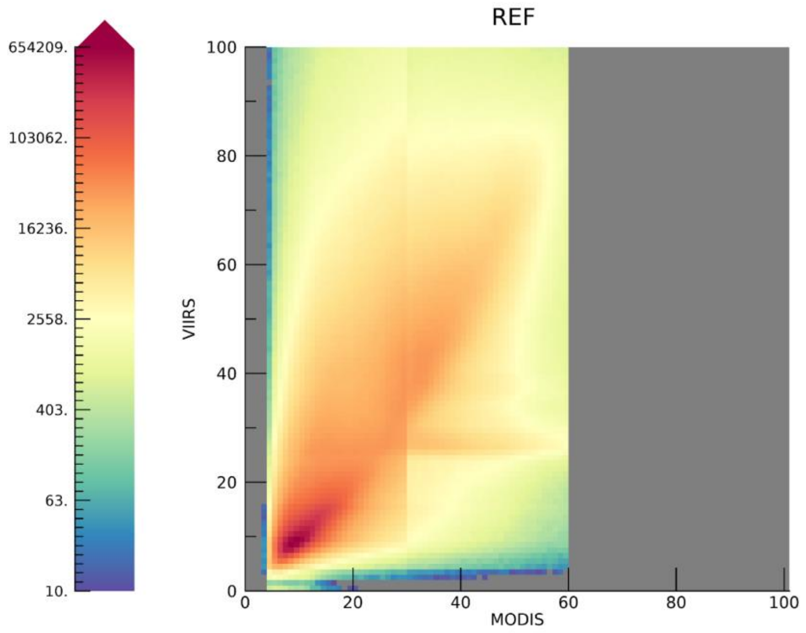


Mean Daily Cloud Optical Depth values are stable and compare well between NOAA-21, NOAA-20, and S-NPP

#CIMSS Long Term Product Monitoring website:
https://cimss.ssec.wisc.edu/clavrx/

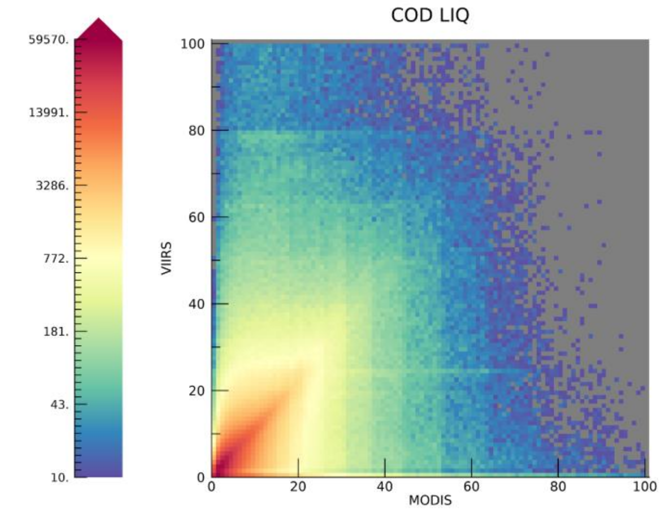
MODIS AQUA



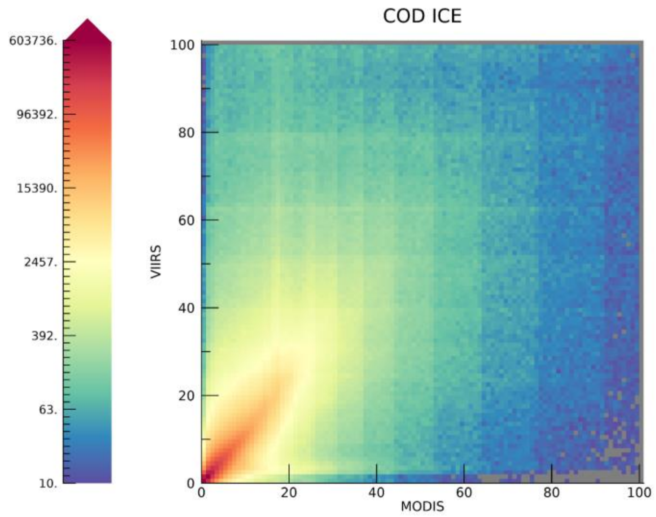


- MYD06 MODIS on Aqua
- 1km spatial resolution (MODIS) vs 750m (VIIRS)
- Nearest neighbor pixels used for comparisons
- COLLOC software used from CIMSS.
- There is no exact temporal and spatial collocation.
- Images show all pixel scatterplots. The analysis is done for phase-separated collocations (see next slide)
- **COD comparisons are excellent**
- **CPS comparisons are excellent, especially for particle sizes < 30 microns**
- See slide 36 for overall statistics

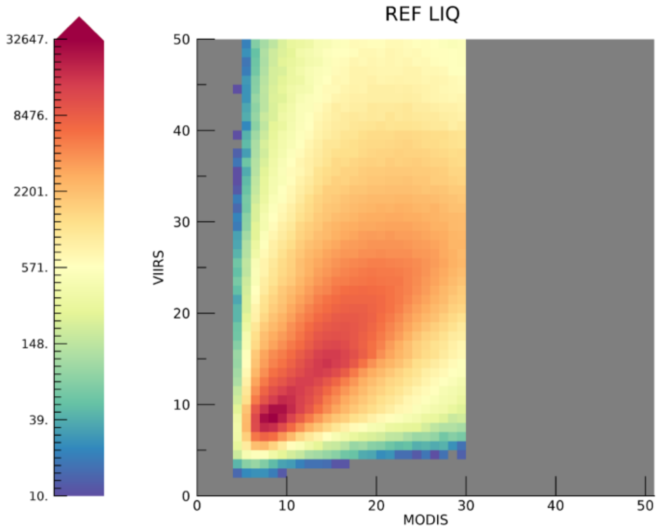
MODIS AQUA - Phase Partitioned Comparisons



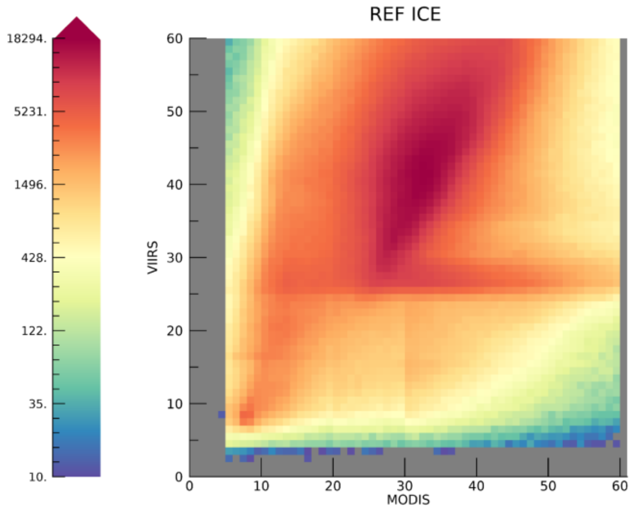
Bias: 0.421
Precision: 8.958
Correlation: 0.548
% in Specs: 66.5%



Bias: 1.751
Precision: 6.84
Correlation: 0.743
% in Specs: 72.6%



Bias: 1.633 um
Precision: 5.689
Correlation: 0.582
% in Specs: 64.8%

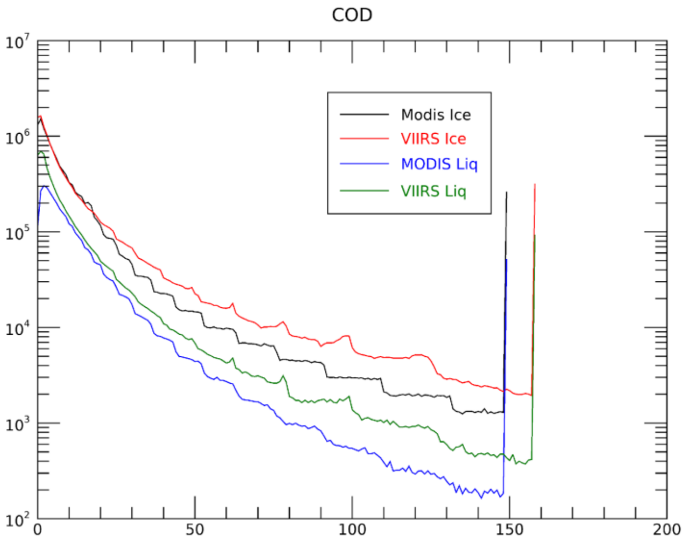


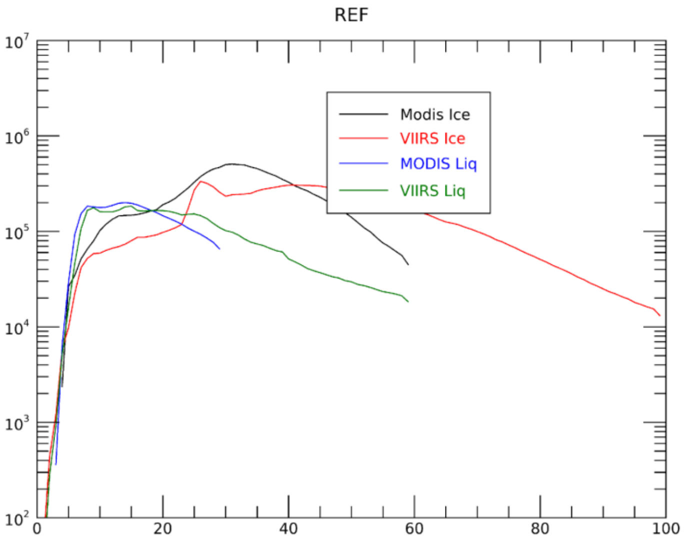
Bias: 7.97um
Precision: 13.3um
Correlation: 0.425
% in Specs: 45.6%

MEET REQUIREMENTS
CLOSE

See slide 36 for a comprehensive summary of the results

MODIS AQUA Comparisons





- MODIS retrieval has different valid ranges:
- COD 150 vs. 160 for the upper limit
- CPS liquid: MODIS is up to 30 microns. VIIRS up to 60 microns
- CPS ice: MODIS up to 60 microns, VIIRS up to 150 microns

Results are reasonable given NOAA-21 VIIRS and MODIS spatiotemporal collocation uncertainties

Error Budget for 10-13 June 2023

Product	Validation Source	Accuracy	Specs	Precision	Specs	Inside Specs
COD Water	MODIS	0.421	2 or 20%	8.95/25%	2 or 20%	86.5%
COD Ice	MODIS	1.751	3 or 30%	(6.84/) 22%	3 or 30%	74.3%
CPS Water	MODIS	1.63 µm	4µm	5.68µm	4µm	78.5%
CPS Ice	MODIS	7.97µm	10µm	13.2µm	10µm	70.2%
LWP DCOMP	AMSR2	23.7 mm	25mm	41.3mm	50mm	83.9%
LWP NCOMP	AMSR2	8.9 mm	25mm	60mm	50mm	76.3%

- **Accuracy specifications:** Quantitative evaluation thresholds are **met** for all tests.
- **Precision specifications:** Quantitative evaluation thresholds are **not met** for most of the tests, but **reasonably close**.
- We interpret reduced precision as resulting from the non-exact temporal and spatial collocation and somewhat limited evaluation dataset.
- These results are similar to NOAA-21 and S-NPP Validated Maturity results (see backup slides)

Requirement Check List – VIIRS Cloud optical properties

DPS	Requirement	Performance
DPS-473	The Cloud Optical Depth product shall provide cloud optical depth, globally, day and night, whenever detectable clouds are present, at the refresh rates of the instrument.	YES for DCOMP day YES for NCOMP night
DPS-477	The Cloud Optical Depth product shall provide cloud optical depth with a measurement precision of the greater of 30% or 3 optical depths in daytime; and the greater of 30% or 0.8 optical depths at night.	Not met, but reasonable precision statistics given limited dataset and spatiotemporal matching uncertainties
DPS-478	The Cloud Optical Depth product shall provide cloud optical depth with a measurement accuracy of 20% in daytime and 30% at night.	MET
DPS-465	The Cloud Particle Size Distribution product shall provide the cloud effective particle size, at cloud tops, globally, day and night, whenever detectable clouds are present, at the refresh rates of the instrument.	YES for DCOMP day YES for NCOMP night
DPS-468	The Cloud Particle Size Distribution product shall provide cloud effective particle size over a range from 2 to 50 microns for ice and water in daytime and for ice at night; and 2 to 32 microns for water at night.	MET
DPS-469	The Cloud Particle Size Distribution product shall provide cloud effective particle size with a measurement precision of: the greater of 25% or 4 micron for water; greater of 25% or 10 micron for ice.	Not met, but reasonable precision statistics given limited dataset and spatiotemporal matching uncertainties

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Product validation
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

DCOMP/NCOMP Users

- Cloud Base Height uses DCOMP as an input product
  - DCOMP is sufficient for their use. Qualitatively, NLCOMP retrievals look reasonable.
  - Cloud Base Height has reached Provisional Maturity Status
- COMP products are used in scientific research
  - Routinely compared with independent retrievals from international sensors

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Product validation
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

Risks, Actions, and Mitigations

Identified Risk	Description	Impact	Action/Mitigation and Schedule
NCCF Processing	NCCF DCOMP files generation for nighttime granules	Medium	Algorithm developers work with ASSISTT to clarify day versus night cloud optical and microphysical property retrievals within each output file
File content issues	See slide 22 for a summary and/or backup slides for specific details	Medium	Algorithm developers work with ASSISTT to rectify various file content issues described in this review
CALIPSO observations no longer available	CALIPSO - a spaceborne lidar - has served as independent NCOMP validation source, but are no longer available as of about July 2023 due to CALIPSO end-of-life.	Medium	The team will attempt to find new spaceborne validation sources. Possibilities include the upcoming European EarthCARE and US-Japan Atmosphere Observing System (AOS) missions.

Check List - Provisional Maturity

Beta Maturity End State	Assessment
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.	Yes, although some precision values fall outside of specifications likely due to spatiotemporal matching issues. Larger validation datasets should improve the statistics.
Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.	Yes
Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.	Yes, the various review presentations contain all of this information.
Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.	Yes

Documentations

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes (will be updated after review)
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes (will be updated after review, if necessary)
System Maintenance Manual (for ESPC products)	Yes (OSPO)
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Conclusion

- Cal/Val results summary:

The Cloud Science Team recommends algorithm Provisional Maturity for both DCOMP and NCOMP effective 30 March 2023

Path Forward: Planned Improvements

- **Next delivery plans:**
  - Address outstanding DCOMP issues (see Slide 21 and backup slides for more details)
  - Estimated software delivery date: April 2024, dependent on Validated Maturity schedule and ASSISTT schedule

- **Future plans** (as they become available in the SAPF):

  - **DCOMP:** Separate DCOMP and NLCOMP? (Or at least minimally include a DCOMP versus NLCOMP retrieval flag in a future software update)

  - **NCOMP**: Transition to NCOMP derived from Enterprise Cloud Height algorithm
    - Allows future algorithm development
    - Simplifies operational processing since this algorithm is already part of the Enterprise Cloud Product software suite

  - **Both** : Incorporate feedback from users as they become available.

- Long term monitoring will continue on a routine basis.

- Continue interactions with International Cloud Working Group on comparing JPSS DCOMP to algorithms from other groups.

Pathway to Validated Maturity

- Update Provisional README to describe DCOMP issues outlined in the review and explicitly outline the optimal way to use DCOMP products
- Recommend that Validated Maturity review be performed on products created by NCCF with DCOMP issues outlined in this review resolved
- Recommended Validated Maturity Review date: No sooner than July 2024 to allow for both updated software implementation and a more robust seasonal cycle of data to be analyzed
- Similar evaluation activities will be conducted for Validated Maturity:
  - SDR & EDR archive of golden days is being compiled
  - Engage other teams begin application-specific analyses.
  - Take advantage of opportunities for threshold adjustments.

Backup Slides

NOAA-20 DCOMP Validated Maturity - Summary

Product	Validation Source	Accuracy	Specs	Precision	Specs	Inside Specs
COD Water	MODIS	2.	3 or 30%	25%	20%	86.5%
COD Ice	MODIS	2.4	3 or 30%	9.7	20%	74.3%
CPS Water	MODIS	0.3 µm	4µm	5.0 µm	4µm or 25%	78.5%
CPS Ice	MODIS	7.9µm	10µm	11.0µm	10µm or 25%	70.2%
LWP	AMSR2	23.7 mm	50mm	41.3mm	50mm	73.9%

Accuracy of validation is inside requirement range for all products and validation sources.

Precision was only met for LWP AMSR2 validation, but close for validation with MODIS. We see the main reason for this in the high sensitivity of validation results on also small spatial and temporal observation differences.

For ice clouds, the different assumptions of particle habits and resulting phase function can also have an impact on validation results. Calibration issue in channel M5 also have an impact for all products.

S-NPP DCOMP Validated Maturity - Summary

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	✔

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NOAA-20 NCOMP Validated Maturity - Summary

Product	Validation Source	Accuracy	Specs	Precision	Specs
COD Water	Indirect AMSR2	N/A	30%	N/A	0.8 or 30%
COD Ice	CALIOP	9.8%	30%	0.98 or 50.1%	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	-9.3 g/m^2 or 23.2%	25 g/m^2 or 15%	28.7 g/m^2 or 71.6%	25 g/m^2 or 40%
IWP	CALIOP	-9.3 g/m^2 or 23.2%	25 g/m^2 or 71.6%	23.2 g/m^2 or 71.6%	25 g/m^2 or 40%

S-NPP NCOMP Validated Maturity - Summary

Product	Validation Source	Accuracy	Specs	Precision	Specs
COD Water	Indirect AMSR2	N/A	30%	N/A	0.8 or 30%
COD Ice	CALIOP	9.8%	30%	0.98 or 50.1%	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	-9.3 g/m^2 or 23.2%	25 g/m^2 or 15%	28.7 g/m^2 or 71.6%	25 g/m^2 or 40%
IWP	CALIOP	-9.3 g/m^2 or 23.2%	25 g/m^2 or 71.6%	23.2 g/m^2 or 71.6%	25 g/m^2 or 40%

DCOMP Issues:

- DCOMP is currently being processed within SAPF at NCCF

The last implementation period included the Nighttime Lunar COMP (NLCOMP) algorithm for night granules, which uses the reflectance from back-scattered moonlight in the DNB channel.

This situation can be confusing to users for several reasons:

1. The ‘Daytime’ product name is misleading as the algorithms it employs, while using similar methods, yield significantly different levels of precision.

1. The above discrepancy must be adequately communicated to the user, otherwise the user will likely be confused

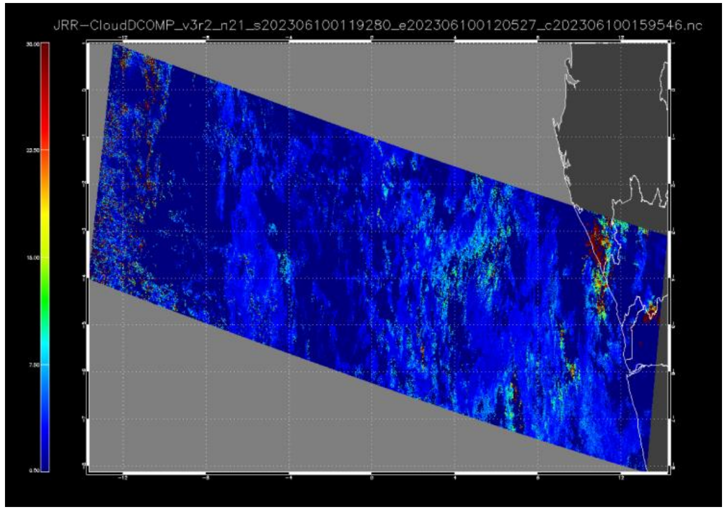
DCOMP Issue with nighttime granules

- There are DCOMP files with only nighttime pixels which have COD and REF values:

```
WALT_GIT_IDL>ncdf_list,filename,/var

 /Volumes/MASP1/DATA/NOAA21_REVIEW/20230610/JPSSRR-CLOUDDCOMP-IT/JRR-CloudDCOMP_v3r2_n21_s202306100119280_e202306100120527_c202306100159546.nc
     # dimensions: 4
     # Variables: 34
     # Global attributes: 42
     There are no unlimited dimensions.

     Variables
           0  StartRow:                    LONG  1
           1  StartColumn:                 LONG  1
           2  Latitude:                    FLOAT(3200,768) = FLOAT(Columns,Rows)
           3  Longitude:                   FLOAT(3200,768) = FLOAT(Columns,Rows)
           4  CloudMicro_Mode:             LONG  5
           5  DayNightFlag:                LONG  0
           6  NumOfQualityFlag:            LONG  7
           7  CloudMicroEffRad:            FLOAT(3200,768) = FLOAT(Columns,Rows)
           8  CloudMicroIWP:               FLOAT(3200,768) = FLOAT(Columns,Rows)
           9  CloudMicroLWP:               FLOAT(3200,768) = FLOAT(Columns,Rows)
          10  CloudMicroVisOD:             FLOAT(3200,768) = FLOAT(Columns,Rows)
          11  VisOD_uncertainty:           FLOAT(3200,768) = FLOAT(Columns,Rows)
          12  EffRad_uncertainty:          FLOAT(3200,768) = FLOAT(Columns,Rows)
          13  EQualityFlag:                INT(3200,768) = INT(Columns,Rows)
          14  MaxOpticalDepth:             FLOAT  99.9993
          15  MaxParticleSize:             FLOAT  99.9942
          16  MeanOpticalDepth:            FLOAT  4.74212
          17  MeanParticleSize:            FLOAT  15.5791
          18  MinOpticalDepth:             FLOAT  0.444968
          19  MinParticleSize:             FLOAT  2.77121e-08
          20  StdDevOpticalDepth:          FLOAT  7.66269
          21  StdDevParticleSize:          FLOAT  16.3395
          22  NightTimePixPct:             FLOAT  100.000
          23  TerminatorPixPct:            FLOAT  0.00000
          24  DayTimePixPct:               FLOAT  0.00000
```



This is a UTC 01:20 file over Longitudes around 0.
Clearly, night from location and time

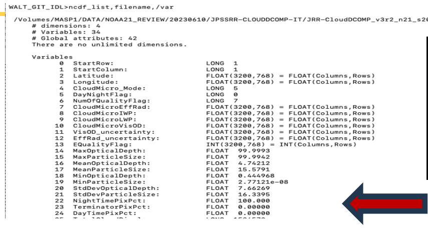
Mixed up DCOMP and NLCOMP (but why are there COD of 60??

The area in these files are 100% night time pixels.

DCOMP Issue with nighttime granules

- DCOMP files with only Nighttime pixels have values:
- Test:
  - if (DayTimePixPct EQ 0. and MeanOpticalDepth .gt. 0.) then count++
-
  - This is the case for many days:
    - S20230910: 119 out of 1013
    - S20230810: 171 out of 860
    - S20230710: 323 out of 1013
    - S20230610: 427 out of 1013
    - S20231010:   90 out of 1013
  - This is also the case for this version of files from NPP and J01
  - A user may filter those files with *DayRimePixPc*t attribute, but:
    - Many files have mixed Day/Night/Terminator, where the erroneous pixels can't be determined.
    - QFs say "valid" retrieval for these files. If you are not aware of this, you run in difficulties
    - A user cannot filter bad and good pixels from the files
  - DCOMP has a complete set of files (1012), NCOMP only the nighttime granules

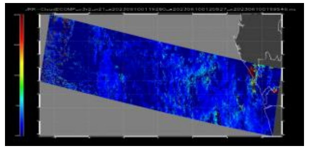
DCOMP Issue with nighttime granules



```
WALT_GIT_IDL>ncdf_list,filename,/var

 /Volumes/MASP1/DATA/NOAA21_REVIEW/20230610/JPSSRR-CLOUDDCOMP-IT/JRR-CloudDCOMP_v3r2_n21_s202306100119280_e202306100120527_c202306100159546.nc
    # dimensions: 4
    # Variables: 34
    # Global attributes: 42
    There are no unlimited dimensions.

    Variables
         0  StartRow:                   LONG   1
         1  StartColumn:                LONG   1
         2  Latitude:                   FLOAT(3200,768) = FLOAT(Columns,Rows)
         3  Longitude:                  FLOAT(3200,768) = FLOAT(Columns,Rows)
         4  CloudMicro_Mode:            LONG   5
         5  DayNightFlag:               LONG   0
         6  NumOfQualityFlag:           LONG   7
         7  CloudMicroEffRad:           FLOAT(3200,768) = FLOAT(Columns,Rows)
         8  CloudMicroIWP:              FLOAT(3200,768) = FLOAT(Columns,Rows)
         9  CloudMicroLWP:              FLOAT(3200,768) = FLOAT(Columns,Rows)
        10  CloudMicroVisOD:            FLOAT(3200,768) = FLOAT(Columns,Rows)
        11  VisOD_uncertainty:          FLOAT(3200,768) = FLOAT(Columns,Rows)
        12  EffRad_uncertainty:         FLOAT(3200,768) = FLOAT(Columns,Rows)
        13  EQualityFlag:               INT(3200,768) = INT(Columns,Rows)
        14  MaxOpticalDepth:            FLOAT   99.9993
        15  MaxParticleSize:            FLOAT   99.9942
        16  MeanOpticalDepth:           FLOAT   4.74212
        17  MeanParticleSize:           FLOAT   15.5791
        18  MinOpticalDepth:            FLOAT   0.444968
        19  MinParticleSize:            FLOAT   2.77121e-08
        20  StdDevOpticalDepth:         FLOAT   7.66269
        21  StdDevParticleSize:         FLOAT   16.3395
        22  NightTimePixPct:            FLOAT   100.000
        23  TerminatorPixPct:           FLOAT   0.00000
        24  DayTimePixPct:              FLOAT   0.00000
```



- DCOMP files with only Nighttime pixels have values:
- Test:
  - if (DayTimePixPct EQ 0. and MeanOpticalDepth .gt. 0.) then count++
-
  - This is the case for many days:
    - S20230910: 119 out of 1013
    - S20230810: 171 out of 860
    - S20230710: 323 out of 1013
    - S20230610: 427 out of 1013
    - S20231010:   90 out of 1013

  - This is also the case for the new version of files from npp and j01
  - Many files have mixed Day/Night/Terminator, where the erroneous (?) pixels can’t be determined.
  - QFs say “valid” retrieval for these files.
  - A user cannot filter bad and good pixels from the files

DCOMP Issue with nighttime granules

- Conclusion:
  - Mixing nighttime granules in DCOMP files and folders makes it very challenging, if possible, for the user to utilize this dataset with sufficient accuracy.
  - We recommend addressing these errors before undertaking the Validated Maturity Review. The NOAA-21 Beta/Provisional README file should contain language that explicitly advertises these issues to prevent confusion and improper use.

Other Issues

- DCOMP: ‘EQualityFlag’:
- Variable is H5T_INTEGER [3200, 768]

```
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    25    25    25    25    25
25    25    25    25    62    62    62    62    25
62    62    62    62    62    62    62    62    62
 1     1     1     1    17    17    17    62    62
17    17    17    17    17    17    17    17    17
62    62
```

```
WALT_GIT_IDL>qf =   d[varnames[3]]
WALT_GIT_IDL>qf['attributes']
{
    "long_name": "Cloud Micro Quality Flag",
    "var_name": "EQualityFlag",
    "_FillValue": -999,
    "coordinates": "Longitude Latitude",
    "units": "1",
    "valid_range": [0, 6]
}
WALT_GIT_IDL>
```

Table 15 Quality Flags in DCOMP output

	Bit	Description	When to apply
DCOMP_PRCS_FLAG	**00000**	0 - not processed 1- processed	**0 - not processed 1- processed**
DCOMP_QF_COD_VALID	1	0 –Valid retrieval 1- not valid	If Q1/B0 EQ ‘1’
DCOMP_QF_REF_VALID	2	0 –Valid retrieval 1- not valid	If Q1/B0 EQ ‘1’
DCOMP_QF_COD_DEGRADED[1]	3	0 –no 1- degraded	If Q1/B0 EQ ‘1’
DCOMP_QF_REF_DEGRADED[2]	4	0 –no 1- degraded	If Q1/B0 EQ ‘1’
DCOMP_QF_CONVERGENCY	5	0 – convergent 1 - not	If Q1/B0 EQ ‘1’
DCOMP_QF_GLINT	6	0 – no glint 1- glint	If Q1/B0 EQ ‘1’

Valid Range is set from [0,6], but values are up to 62.

Unlike NCOMP this seems to be bit-wise QF.
The variable should be a BYTE array, and Flag names for each bit should be in attributes

Other Issues

- DCOMP:
  - Quality flags should be defined in BYTE and not in INTEGER.
  - There is no processing flag in the DCOMP files.
  - The QF bit 1 gives the information if a pixel is processed. However, the user may want to know if a pixel is cloud-free or if a pixel is not processed because it is outside the required solar zenith angle.
  - The maximal value of COD and CPS in the data arrays and in the global attribute does not correspond (158. vs ~99.) [MaxOpticalDepth] and [MaxParticleSize]
  - The references attribute is empty. We should add the ATBD and Walther&Heidinger 2013, and Walther,Heidinger&Miller 2015

Other Issues DCOMP

- LWP and IWP have both values for every pixel.
- There should be only one of both values for each pixel because there is either ice or water phase.
- We found a software version which explain this behavior:

```
if ( dcomp_out % cod .gt. 0 .and. dcomp_out % cps .gt. 0) then
   output % lwp % d ( elem_idx, line_idx)  = 5./ 9. * dcomp_out % cod * dcomp_out % cps
   output % iwp % d ( elem_idx, line_idx)  = 5./ 9. * dcomp_out % cod * dcomp_out % cps
end if
```

But it should be this (as in CLAVR-x code):

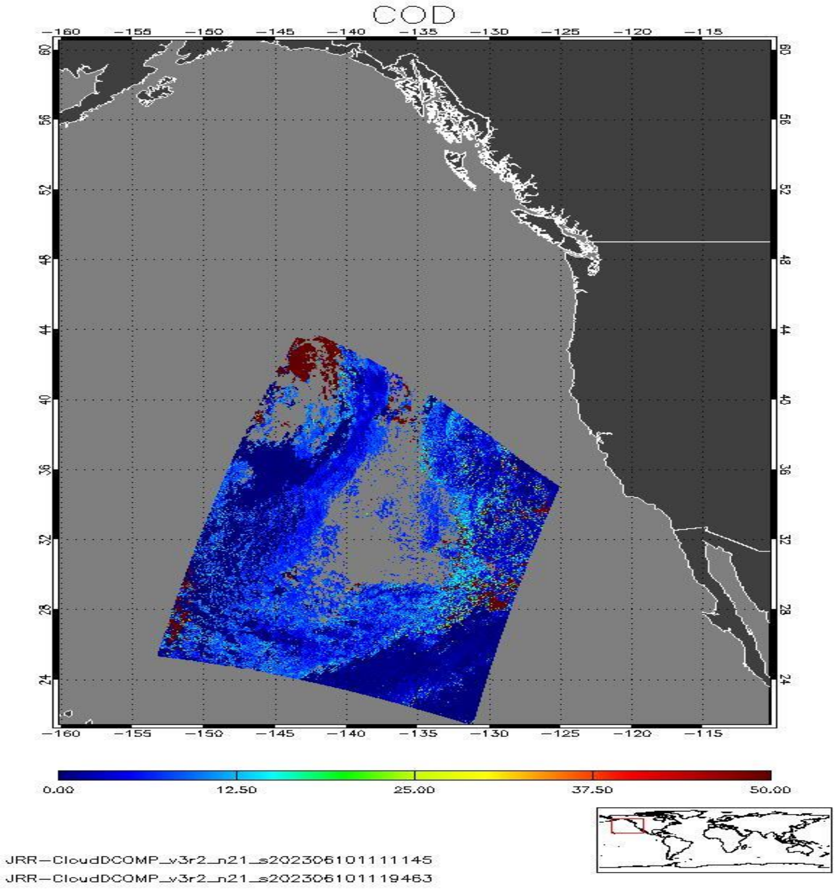
```
! - compute lwp
  where ( water_phase_array(1:dim_1_w,1:dim_2_w) &
    .and. .not. btest ( quality_flag(1:dim_1_w,1:dim_2_w) , 1 )  &
    .and. .not. btest ( quality_flag(1:dim_1_w,1:dim_2_w) , 2 ) )
    output % lwp % d(1:dim_1_w,1:dim_2_w) =  output % cod % d(1:dim_1_w,1:dim_2_w) &
      & * output % cps % d(1:dim_1_w,1:dim_2_w) * 5.0 / 9.0
  end where

    ! - compute lwp
  where ( .not. water_phase_array(1:dim_1_w,1:dim_2_w) &
    .and. .not. btest ( quality_flag(1:dim_1_w,1:dim_2_w) , 1 )  &
    .and. .not. btest ( quality_flag(1:dim_1_w,1:dim_2_w) , 2 ) )
    output % iwp % d(1:dim_1_w,1:dim_2_w) =  (output % cod % d(1:dim_1_w,1:dim_2_w)  ** (1/0.84)
) / 0.065
  end where
```

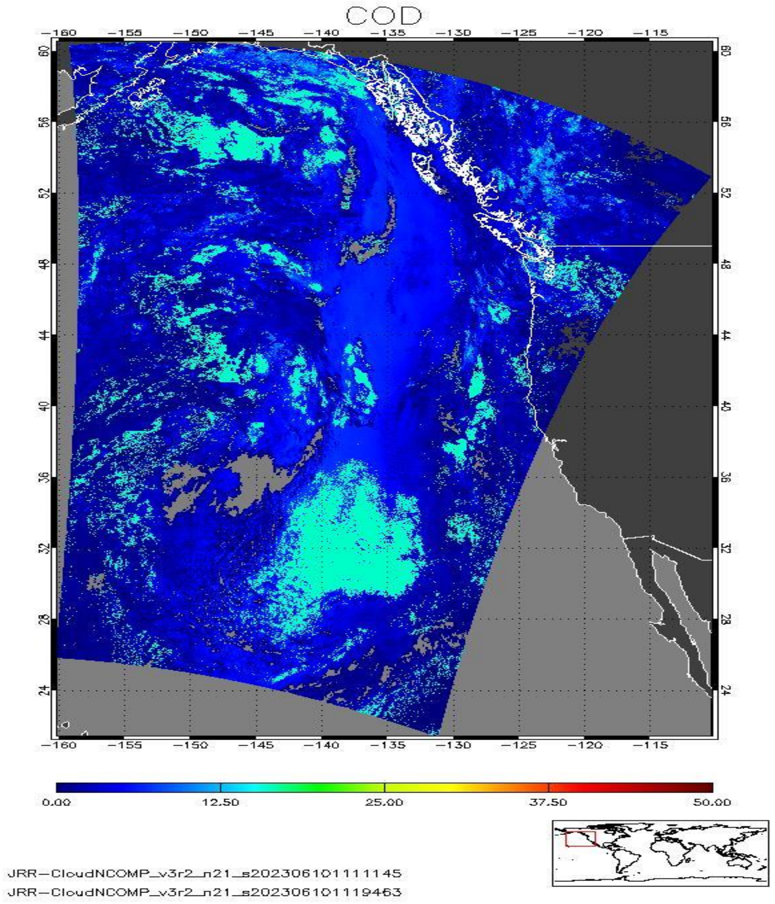
The NLCOMP files of DCOMP product

- The NLCOMP nighttime DCOMP findings exhibit a gap in capturing thicker cloud data, specifically missing information on COD at the upper edge.

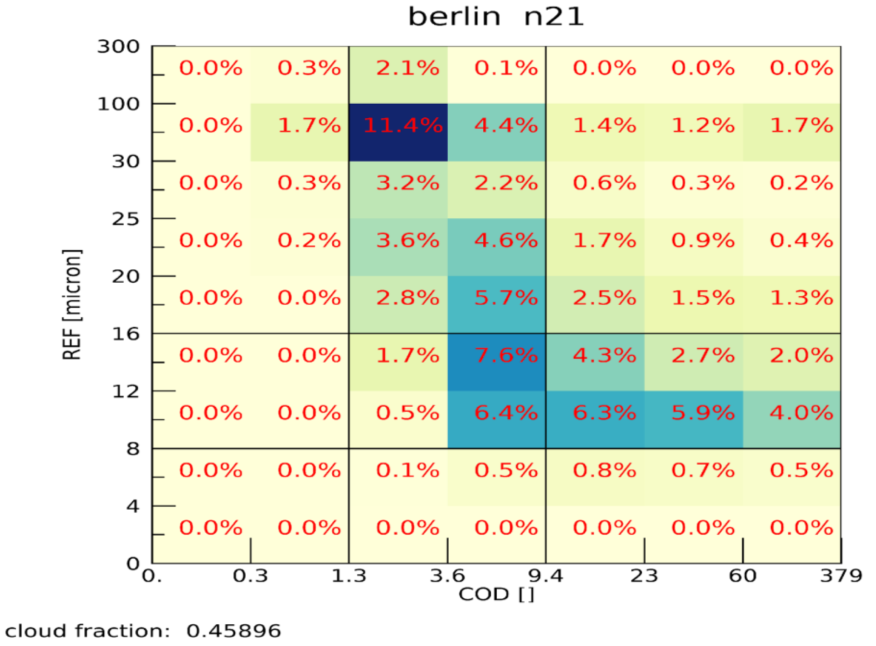
NLCOMP

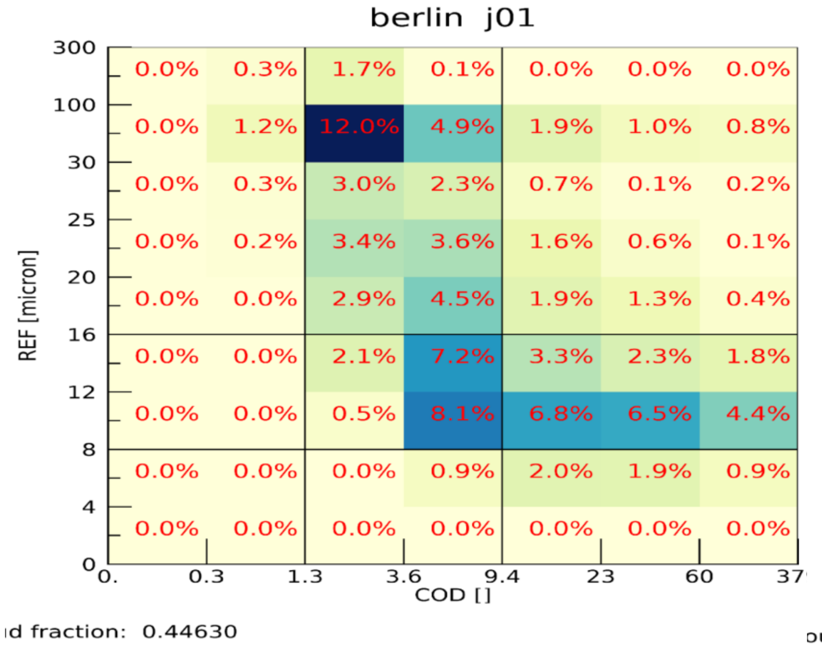


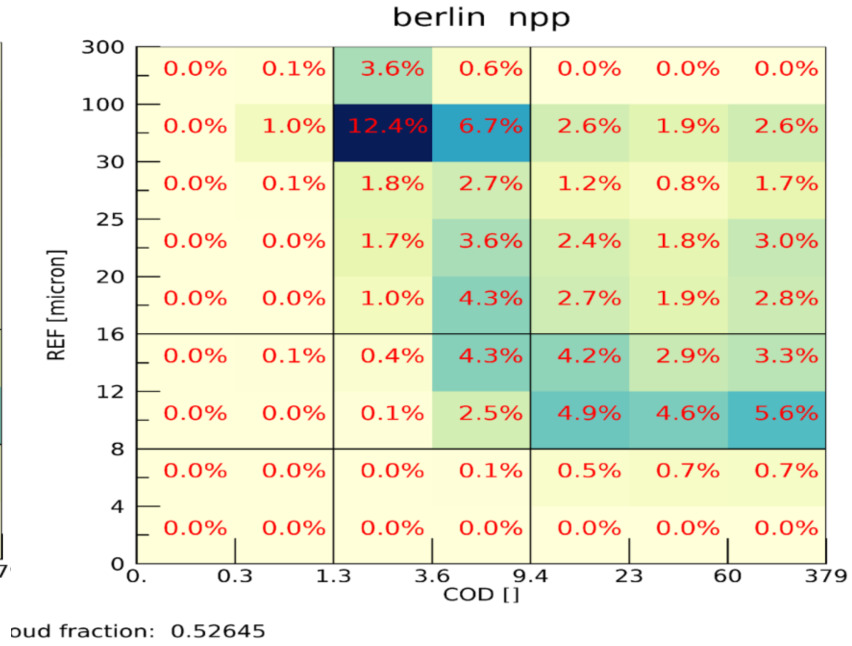
NCOMP



Validation results (V) –monitoring of SNPP N-20 N-21







The JPSS satellites fly at different crossing times. Since clouds have a diurnal cycle, we don't expect exact histograms of cloud products.

NLCOMP output for all three satellites is in sync.
NLCOMP was not validated before.