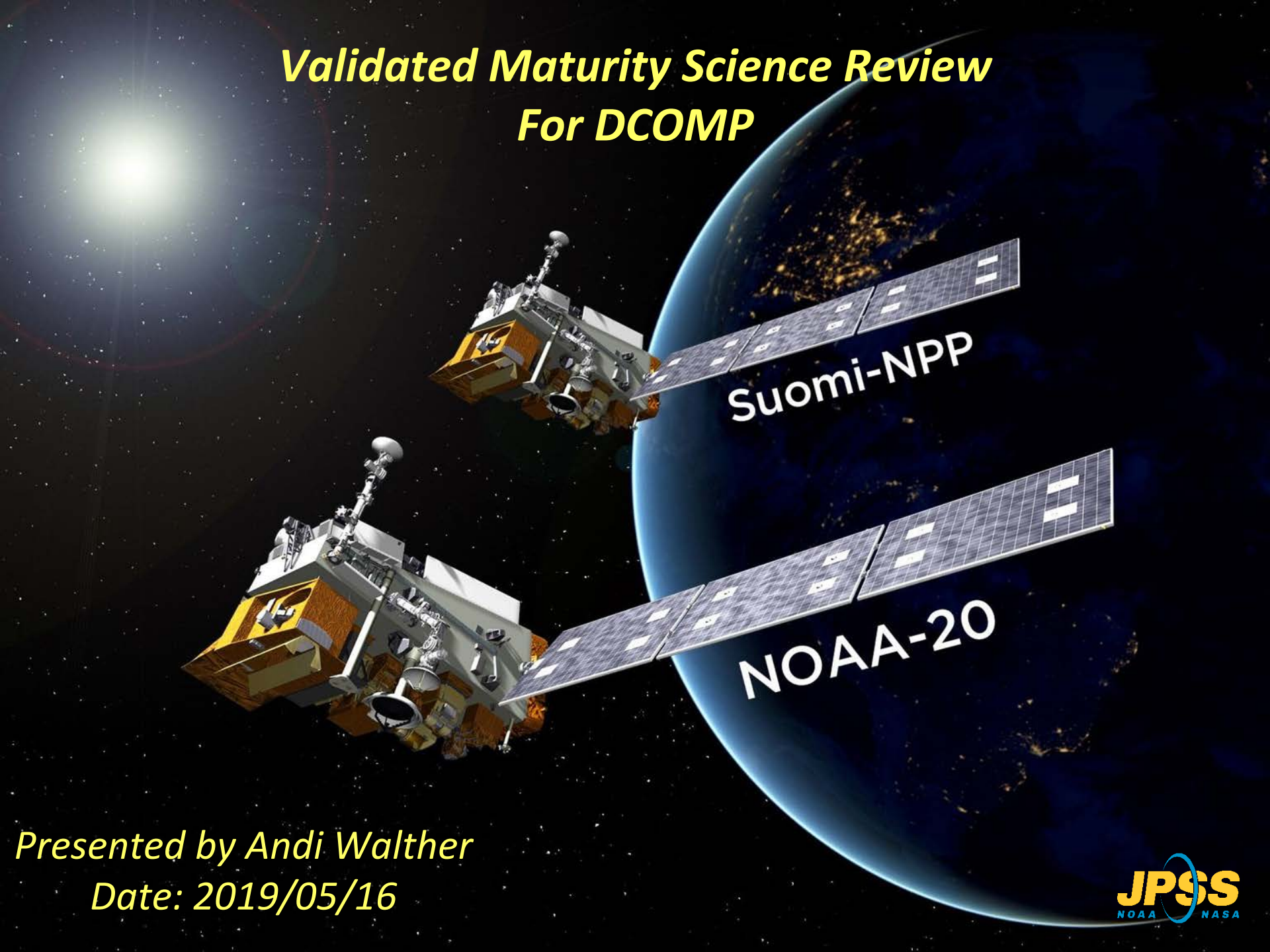
Validated Maturity Science Review For DCOMP



Presented by Andi Walther

Date: 2019/05/16

JPSS Data Products Maturity Definition

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.

VALIDATED MATURITY REVIEW MATERIAL

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

NOAA-20 DCOMP Cal/Val Team

Algorithm Cal/Val Team Members

Name	Organization	Major Task
Andi Walther	CIMSS	Lead, Algorithm development, validation
Andrew Heidinger	NOAA/STAR	Science support
William Straka	CIMSS	Supports implementation
David Donahue	OSPO	Cloud Algorithm PAL
Shuang Qiu	OSPO	Product Area Lead

Product Requirements (JERD) and Observed Validation

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	partly

Processing Environment and Algorithms

- DCOMP is the Daytime Cloud Optical and Microphysical Properties algorithm of the NOAA-AWG retrieval scheme PATMOS-x.
- DCOMP was developed for GOES-AWG and works presently on VIIRS-SNPP and VIIRS-NOAA-20, MODIS, GOES, SEVIRI, MSAT, GOES-ABI and others.
- DCOMP is a FORTRAN 90/95 package which works with the identical code for all sensors and software environments (e.g. CLAVR-x, GEOCAT, FRAMEWORK).
- DCOMP uses pre-computed cloud parameters stored in LUTs. (NCDF4 format)

- DCOMP currently being processed within SAPF at NDE:
  - Operational Code base **v2r0** (February 2018 Science code delivery).
  - Current code (**v2r0**) running in NDE Operational String since March 2019.

- Provisional Review (November 2018):

DCOMP is close to requirements. Accuracy spec is always met except for COD ice clouds (there it is close). We expect an improvement once the calibration differences between MODIS and VIIRS are solved.

- Improvements since Provisional Review

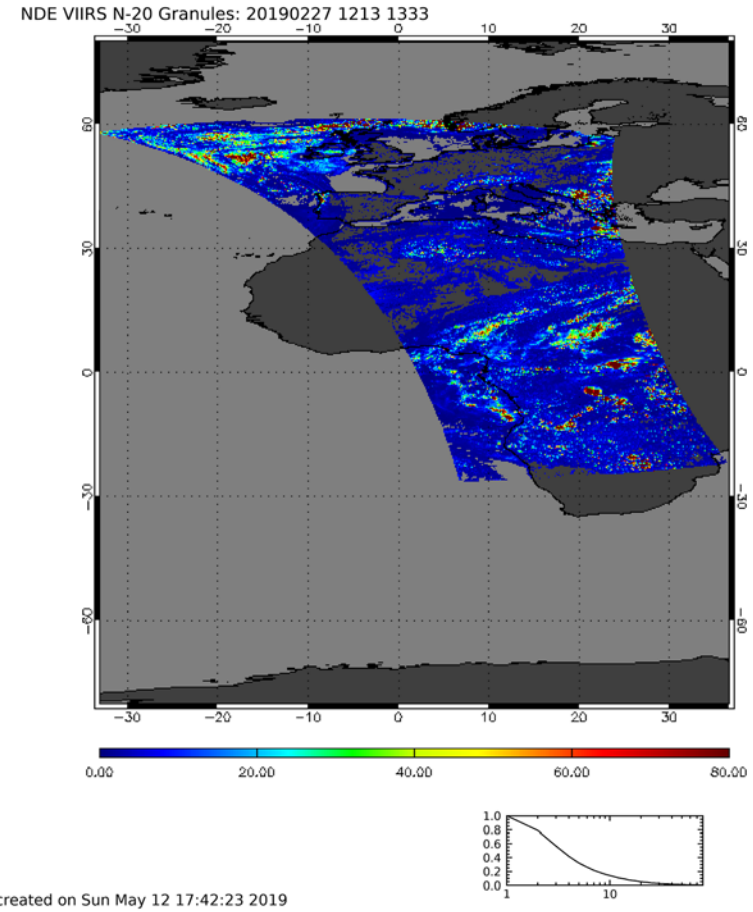
We did not change DCOMP code or LUT since Provisional. A pre-planned product improvement for DCOMP retrievals over snow have not yet been implemented and scheduled for next science code update.

- Algorithm performance evaluation
  - Validation data sets (type, periods, coverage)

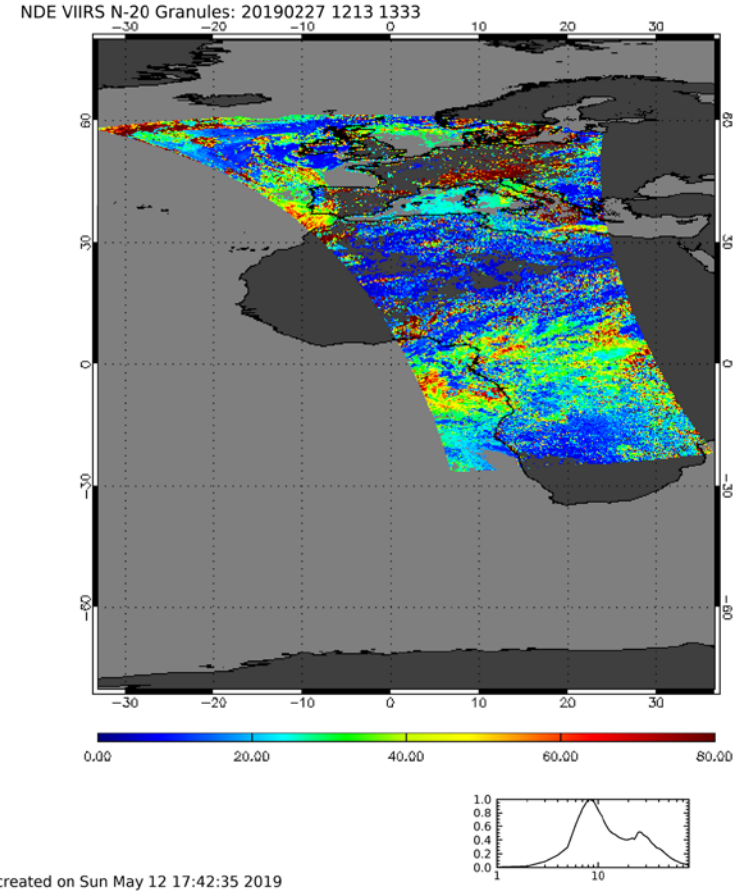
    63 Days (from June 2018-March 2019)
    - NOAA-20 NDE
    - CLAVR-x
    - MODIS/AQUA
    - GCOM-W/ AMSR2
  - Validation strategies / methods
    - Visual inspection
    - Comparison with MODIS Science team products for COD and CPS
    - Comparison with GCOM-W Microwave-based AMSR2 Liquid Water Path
    - Comparison between N20 and SNPP

Validation results (I) – Visual Inspection

Cloud Optical Thickness NDE

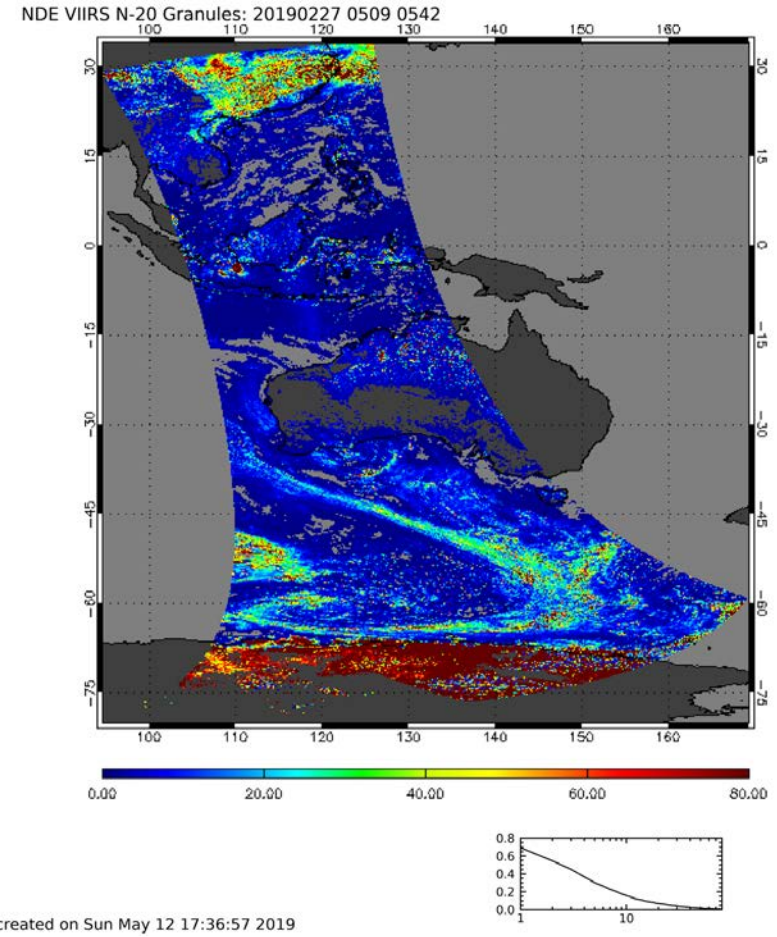


Cloud Effective Radius NDE

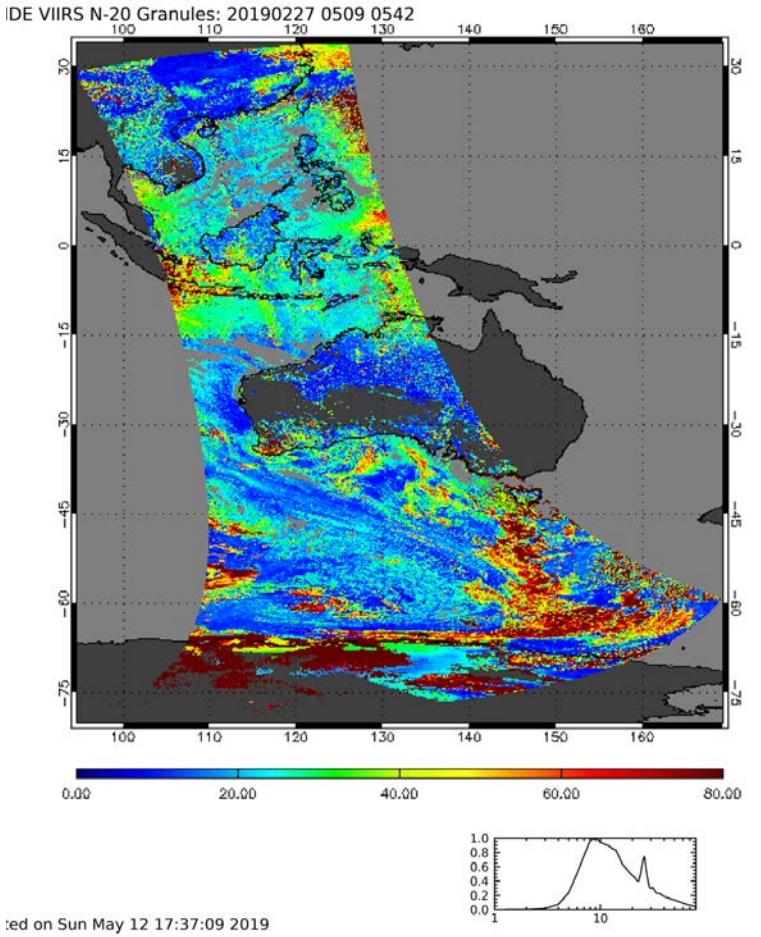


Validation results (I) – Visual Inspection

Cloud Optical Thickness NDE



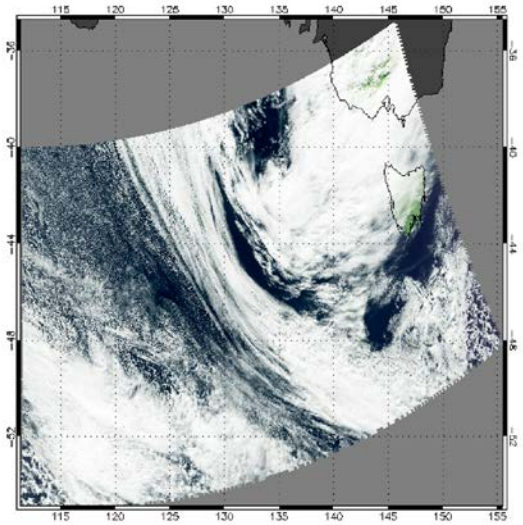
Cloud Effective Radius NDE



Validation results (I) – MODIS

True Color Mosaic

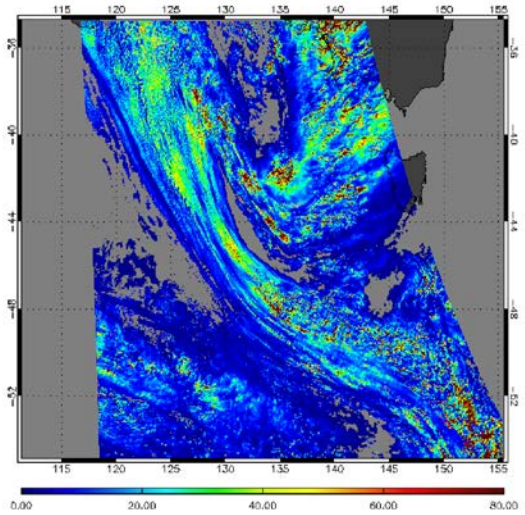
NDE VIIRS N-20 Granule: 201808300512



created on Fri Nov 23 20:52:32 2018

Cloud Optical Thickness MODIS

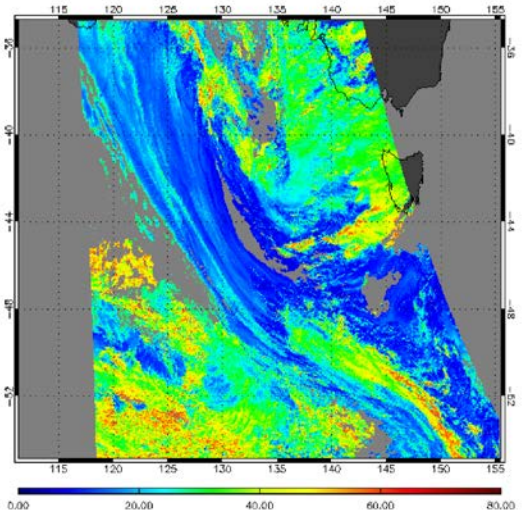
MODIS Granule: 201808300512



created on Fri Nov 23 20:52:37 2018

Cloud Effective Radius MODIS

MODIS Granule: 201808300512



created on Fri Nov 23 20:53:08 2018

Validation results (II) – MODIS

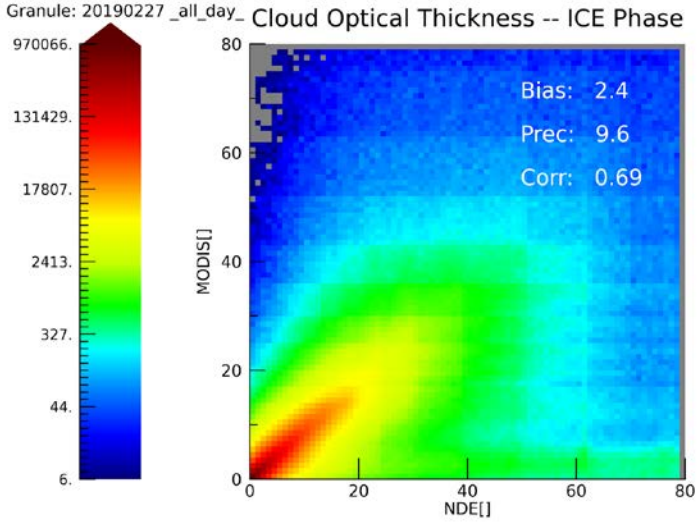
Comparison study with MODIS is not an independent validation source because both are based on same or very similar retrieval method.

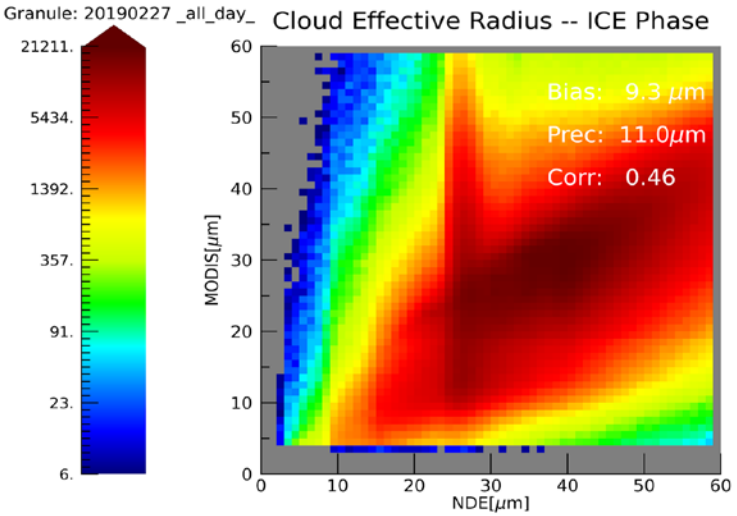
Spatial and temporal differences in inhomogeneous cloud fields have a big impact if compared in a pixel-to-pixel scatterplot. ⇒ precision measures are likely not good.

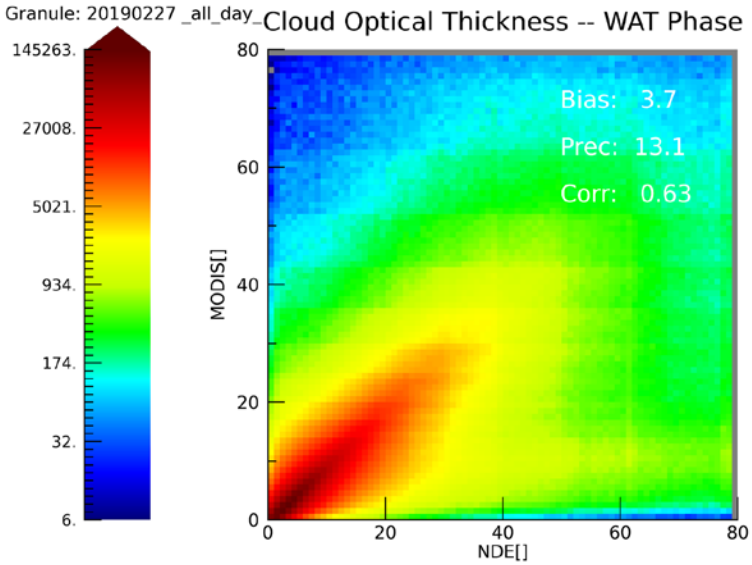
MODIS - VIIRS comparison criteria:

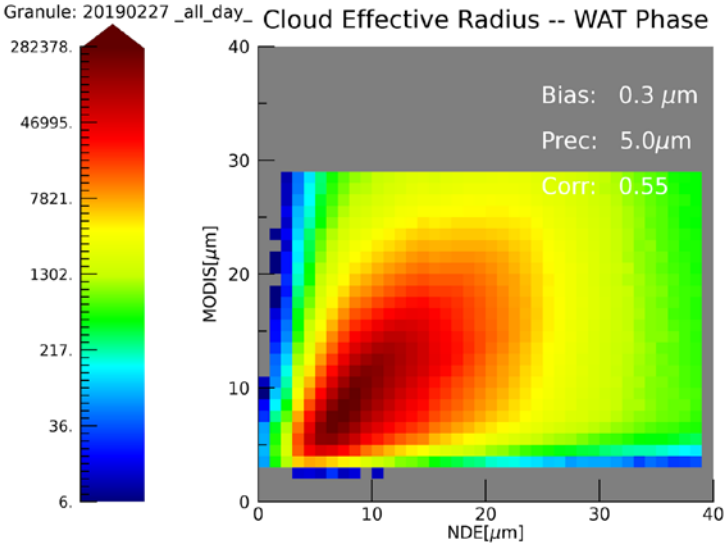
- Nearest neighbor pixel
- Time window up to 10 minutes
- Distance up to 5km.
- We use both, NDE Cloud phase with MODIS cloud phase, for phase grouping.

Validation results (II) – MODIS

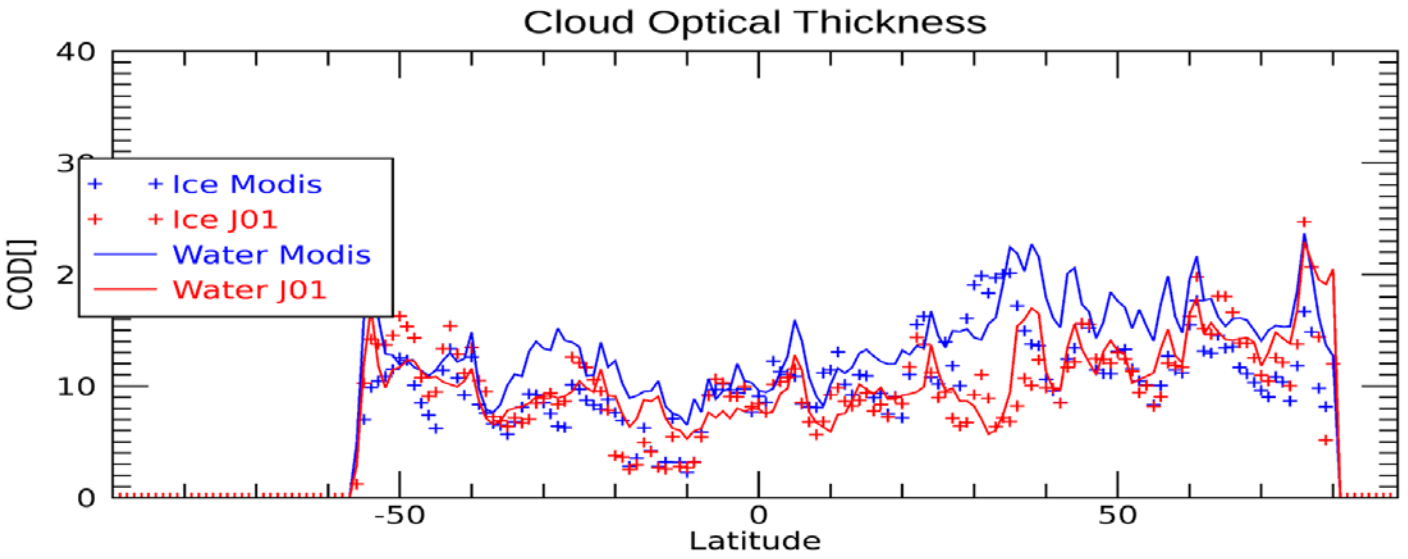


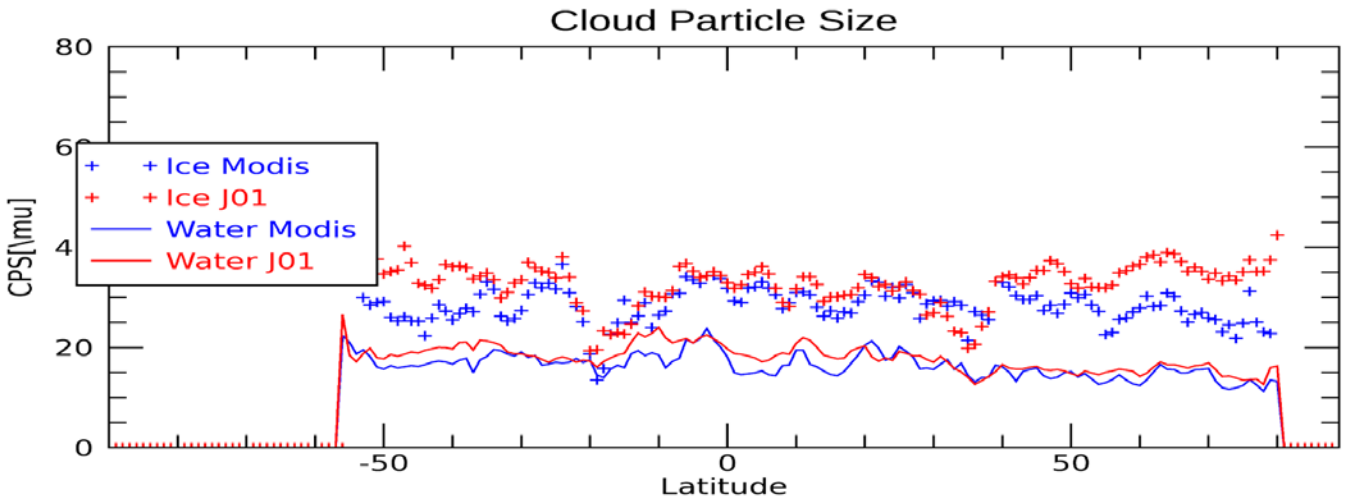






Validation results (II) – MODIS



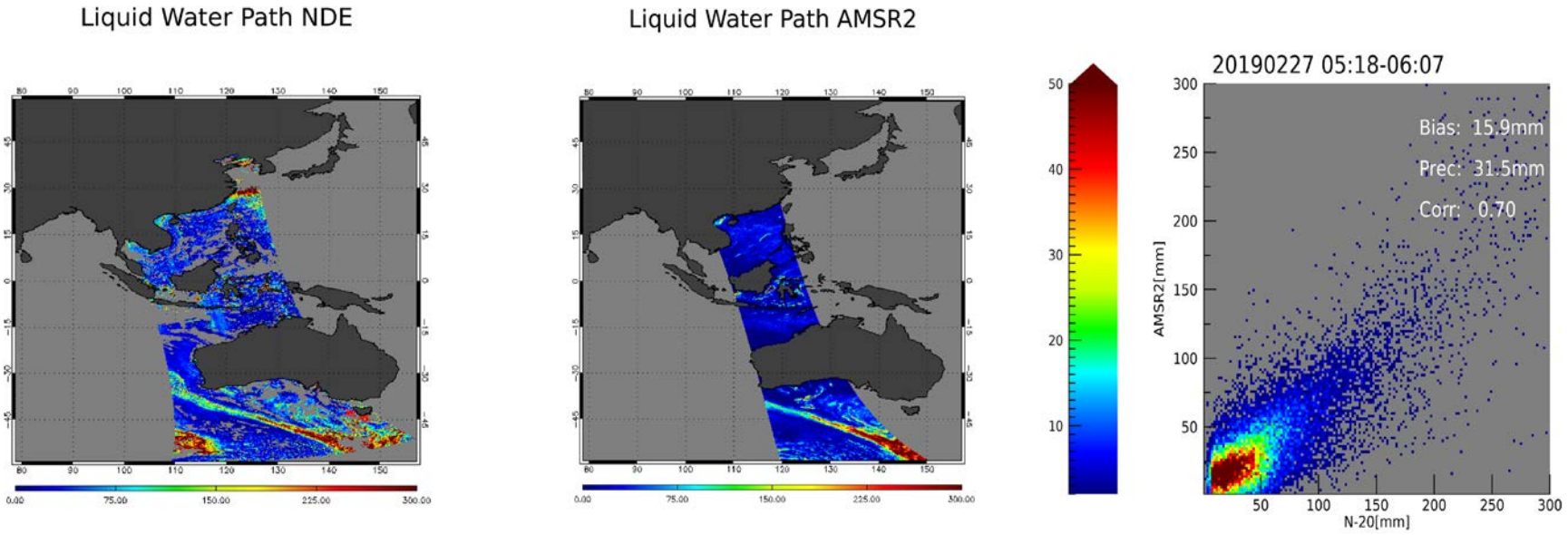


Validation results (III) – AMSR-2

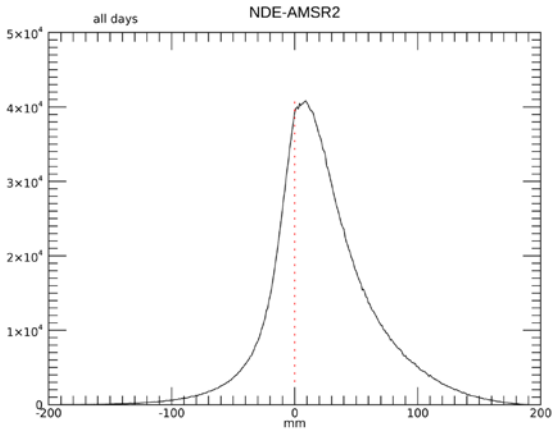
Comparison to Microwave-based AMSR2 Cloud Liquid Water Path

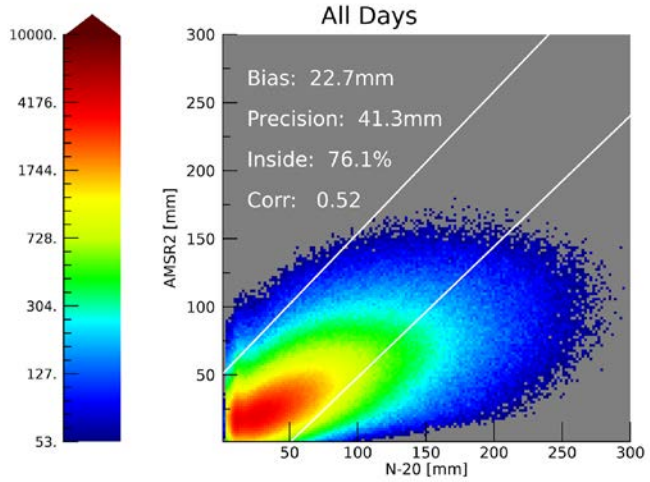
+The only Independent validation source

- Assumptions needed to compute LWP rom COD/CPS
- Only for water clouds over land
- Different spatial resolution
- Microwave measurement is impacted by rain, ice clouds and land surface



Validation results (III) – AMSR-2





All observed days are in the same range of comparison results. The requirements for accuracy and precision are met for all days and for whole period. PASS

However, the NDE retrieval seems to systematically overestimate high liquid water path values.

Possible reasons are filtering technique, the too high CPS for water clouds as seen in the MODIS comparisons, and the overestimation of COT for saturated clouds for which DCOMP has no information skill.

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data
    - Reflectance M5, M12
  - Ancillary Data
    - Surface albedo MODIS climatology*
    - Atmospheric profile of water vapor (NWP)
    - Ozone (NWP)
  - Upstream algorithms
    - Cloud Mask
    - Cloud Phase
    - Cloud Top Pressure
  - LUTs / PCTs
    - Pre-calculated functions of Cloud reflectance, transmission, spherical albedo
- Evaluation of the effect of required algorithm inputs (see next slide)
  - Study / test cases
  - Results

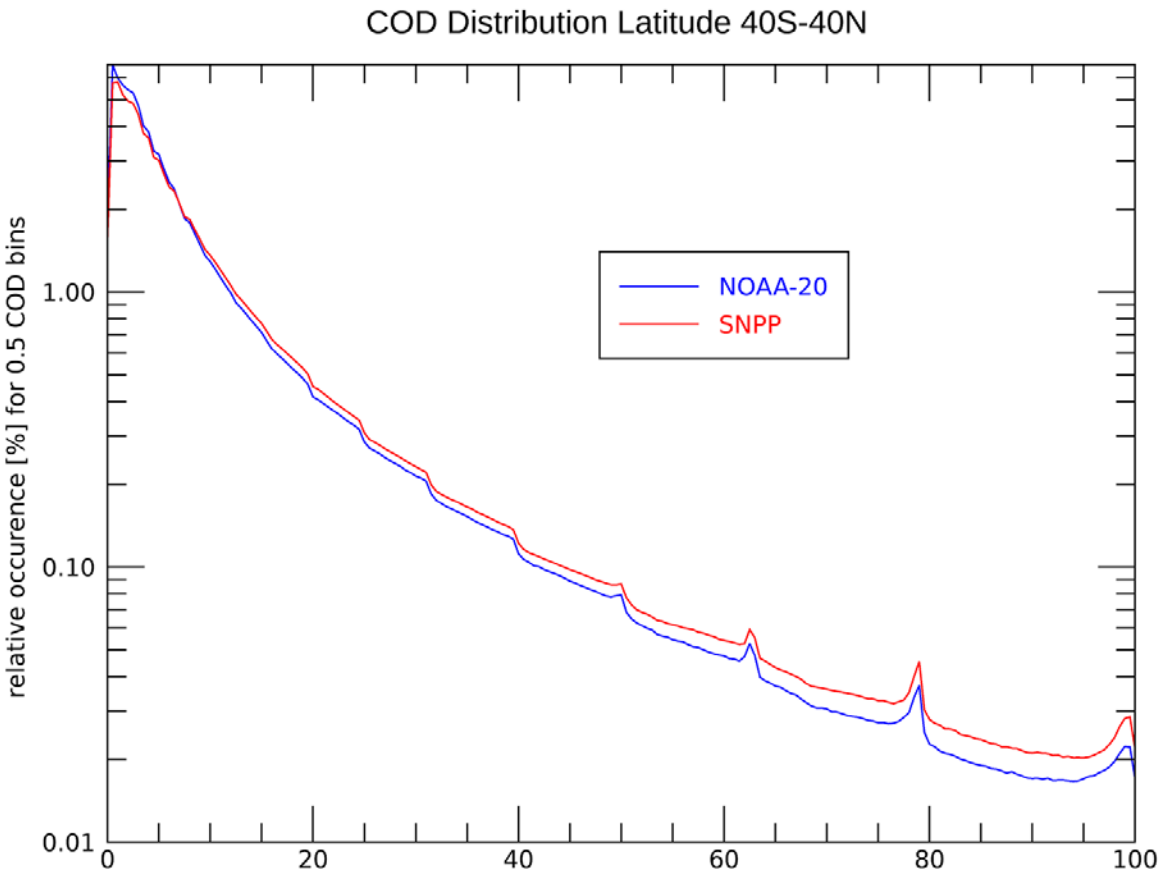
*** From the GOES-R AWG Project - Needs Updating.**

Evaluation of the effect of required algorithm inputs

- **Recent discussions state that M5 on SNPP is 5% too bright.**
- The observed COT bias between MODIS and NDE may be a consequence of this calibration difference between VIIRS and MODIS.
- This may have also impact on cloud mask, phase and ACHA. The Cloud mask SNPP LUT automatically tuned out this calibration error so we expect NOAA-20 to ‘miss’ cloud due to this issue.
- There are other issues that may be related to the SDR or SDR parameters in the SAPF.

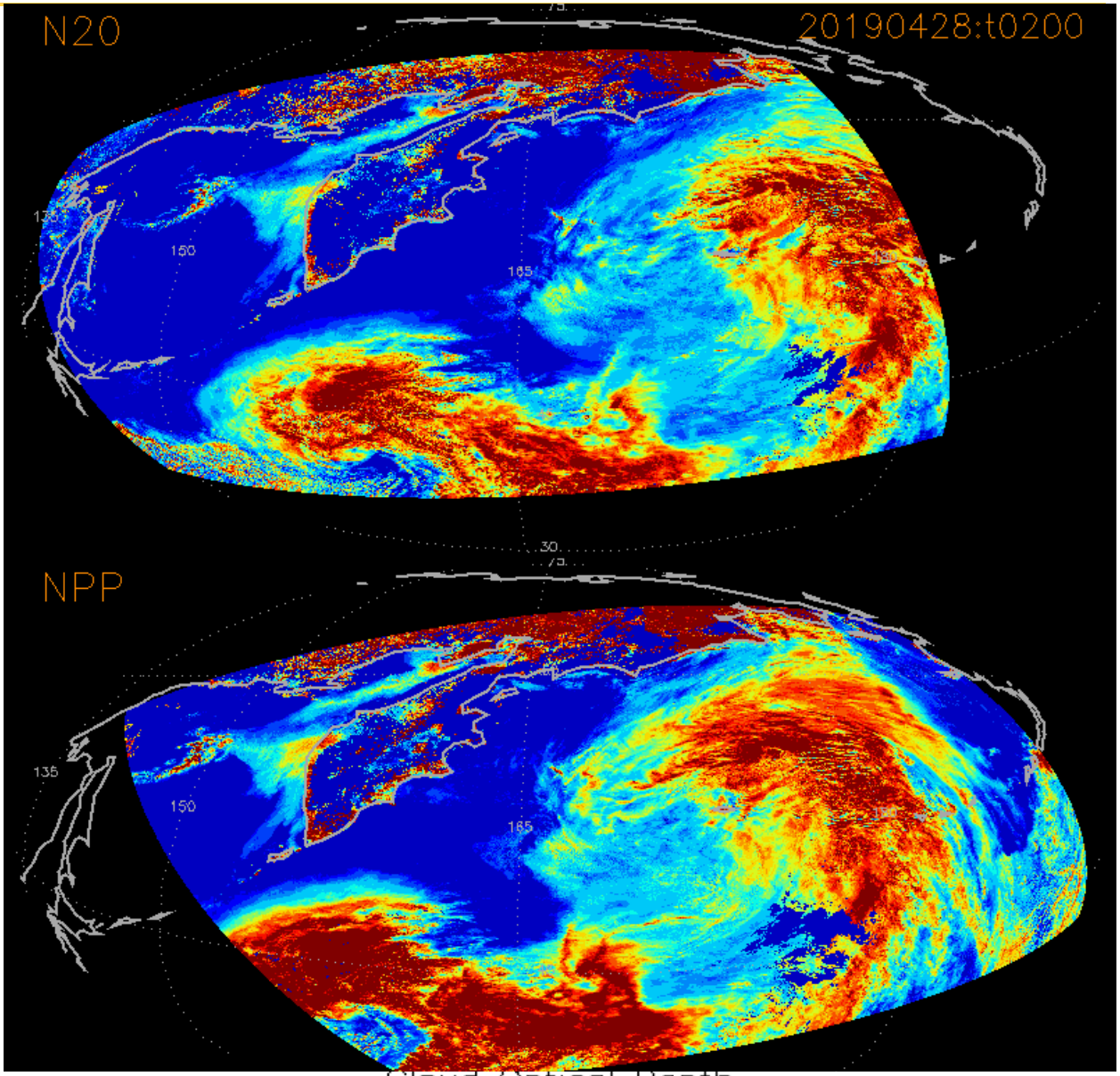
Visual Comparison of SNPP and NOAA-20 Cloud Optical Depth

- Image shows a distribution of DCOMP Cloud Optical Depth between NOAA-20 and SNPP between 40°S to 40°N
- SNPP data are 51 minutes ahead of NOAA-20.
- For the most part, the distribution between NOAA-20 and SNPP are in good agreement
- However, the impact of the 5% larger reflectances in SNPP M5 versus NOAA-20 M5 can clearly be seen. A further example is shown on the next slide



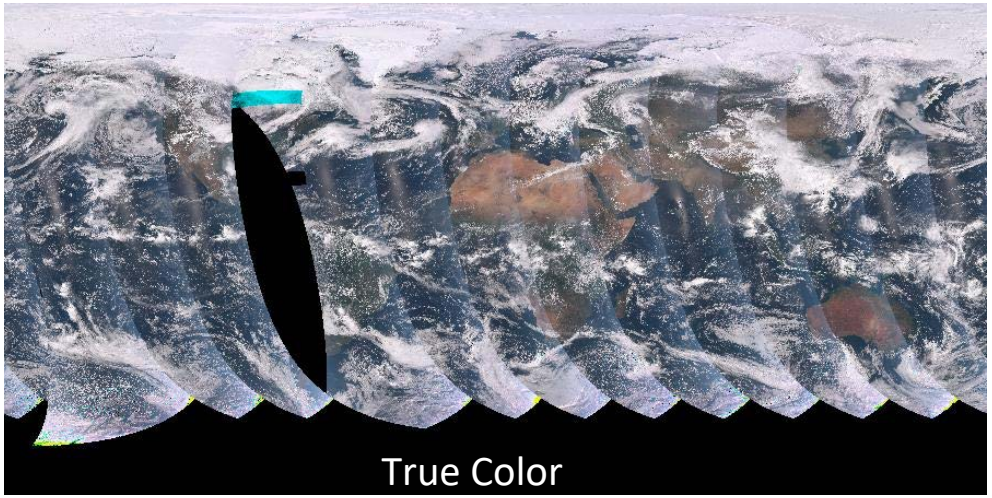
Visual Comparison of SNPP and NOAA-20 Cloud Optical Depth

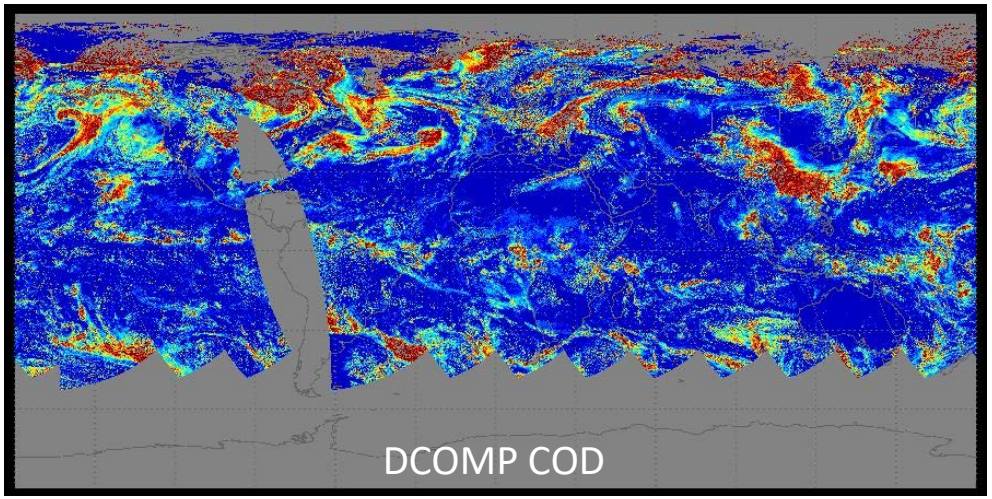
- Images show NOAA-20 and SNPP DCOMP Cloud Optical Depth over roughly the same region. *Map projections are the same.*
- SNPP data are 51 minutes ahead.
- Visual inspection shows overall good agreement.
- As mentioned previously, the impact of the 5% larger reflectances in SNPP M5 versus NOAA-20 M5 is evident in the thickest clouds.
- Values of both over snow are erroneously high. The science code addressing issue was not provided until after the v2r1 delivery. It is currently implemented in the code for the next science code delivery and the Cloud Team will work with ASSISTT to verify implementation

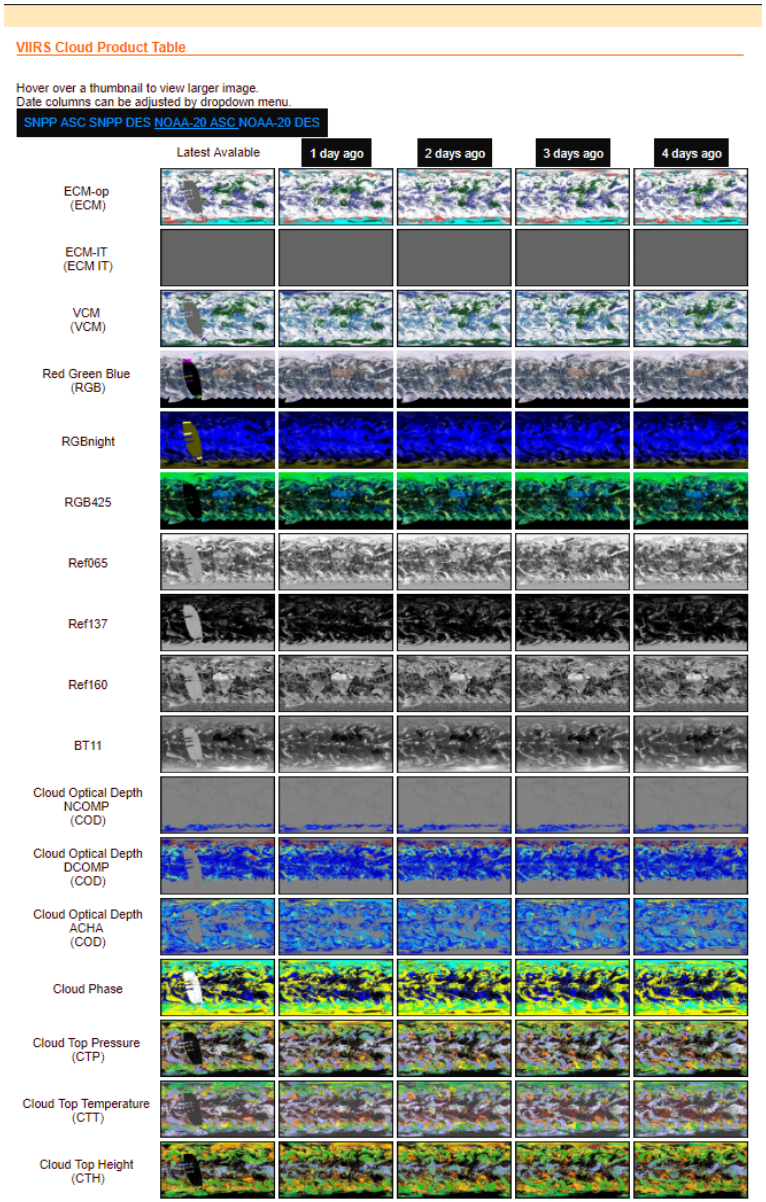


Routine Long Term Monitoring

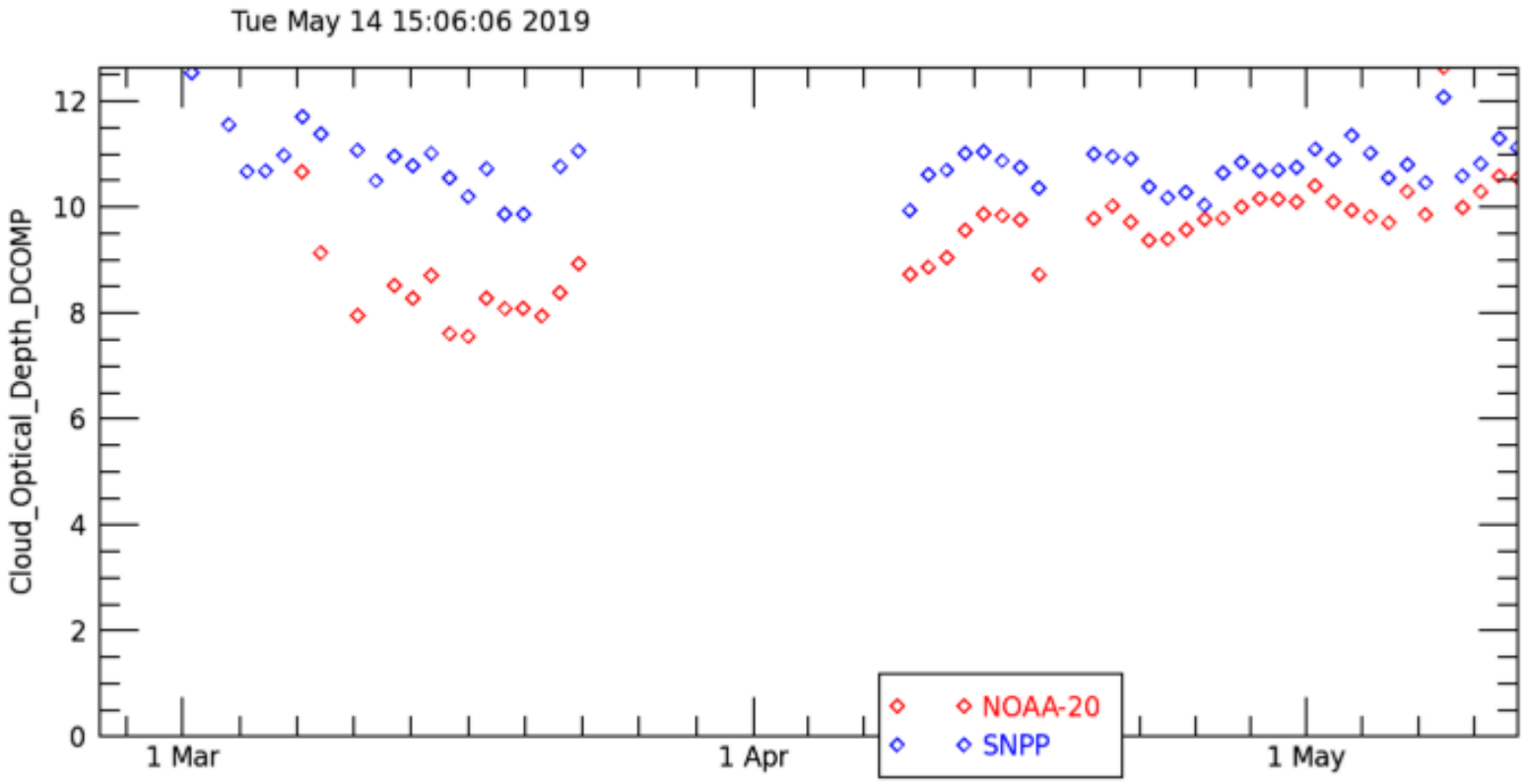
http://cimss.ssec.wisc.edu/clavrx/viirs_img/



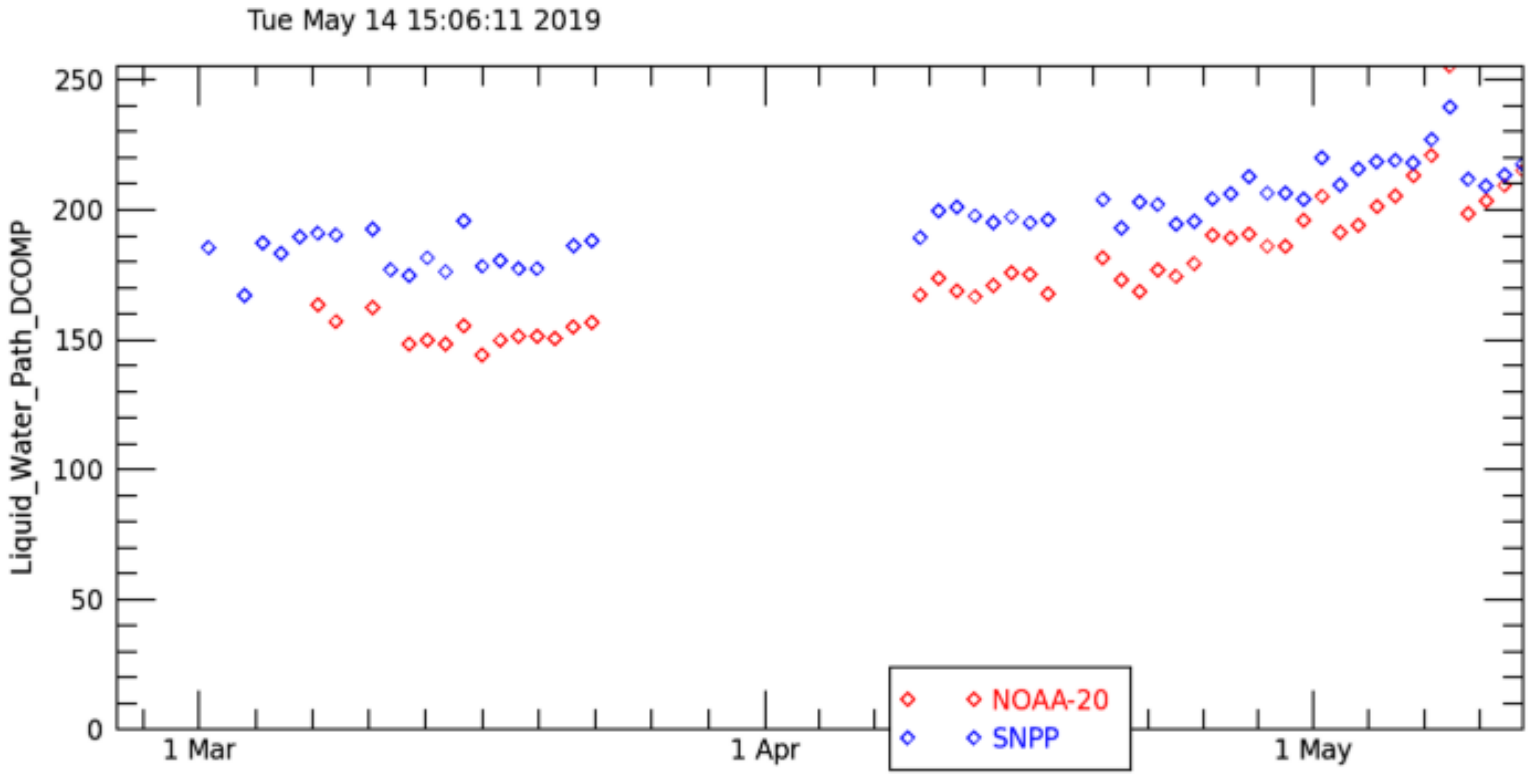




Long-Term Monitoring of DCOMP Optical Depth

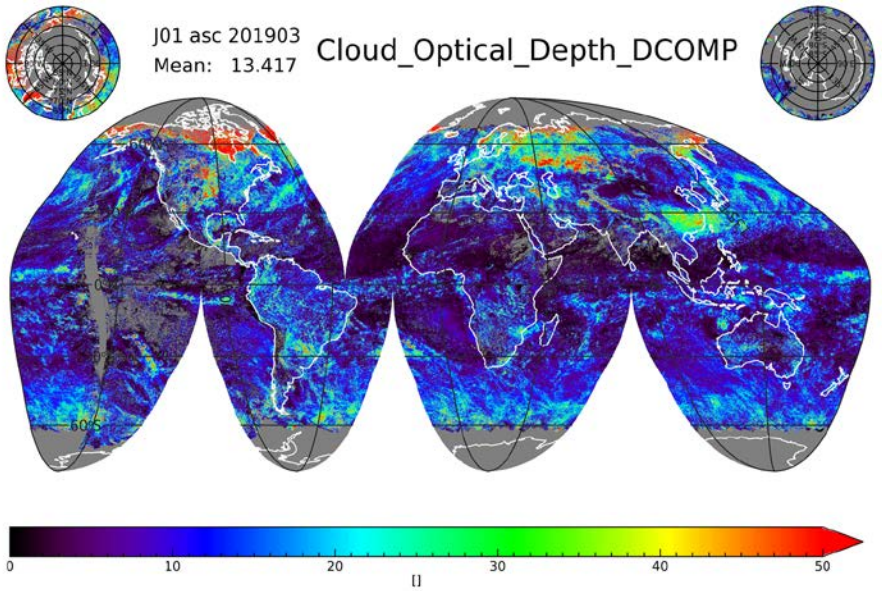


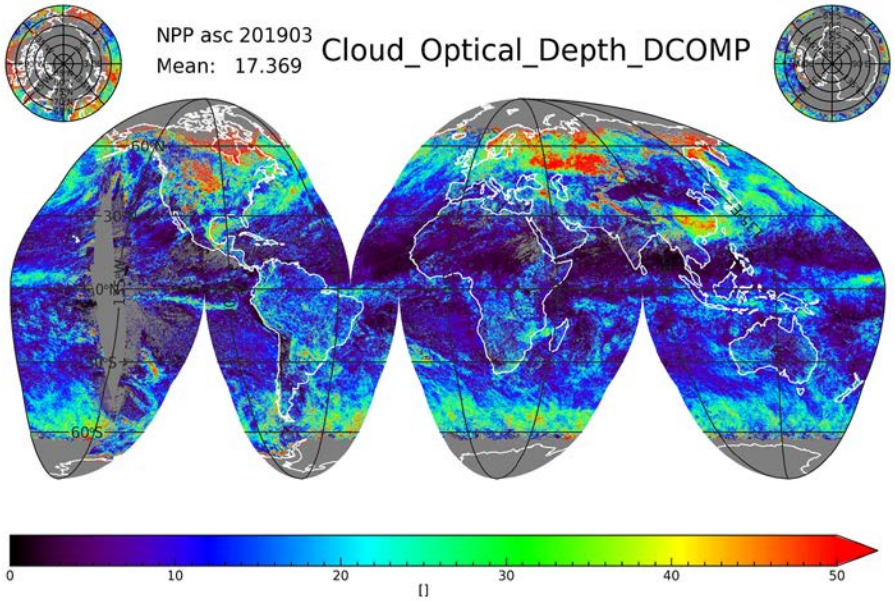
Long-Term Monitoring of DCOMP Liquid Water Path

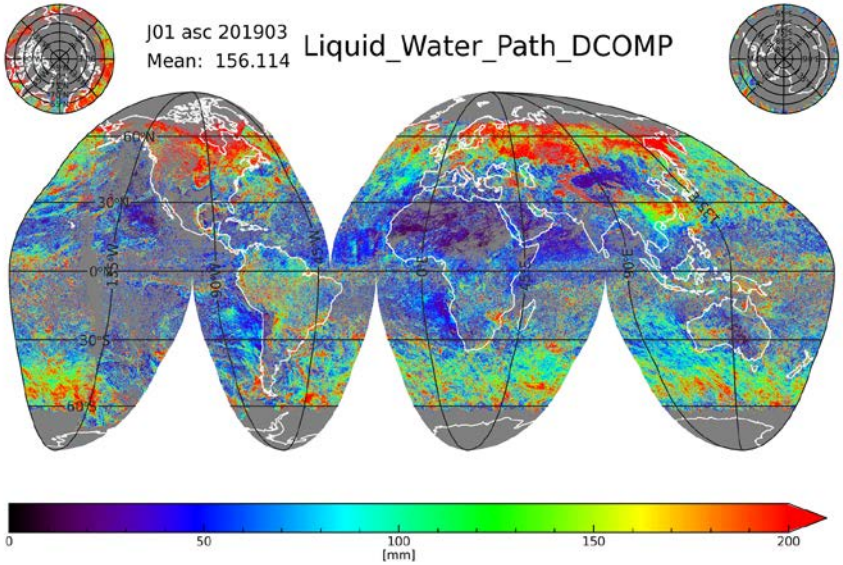


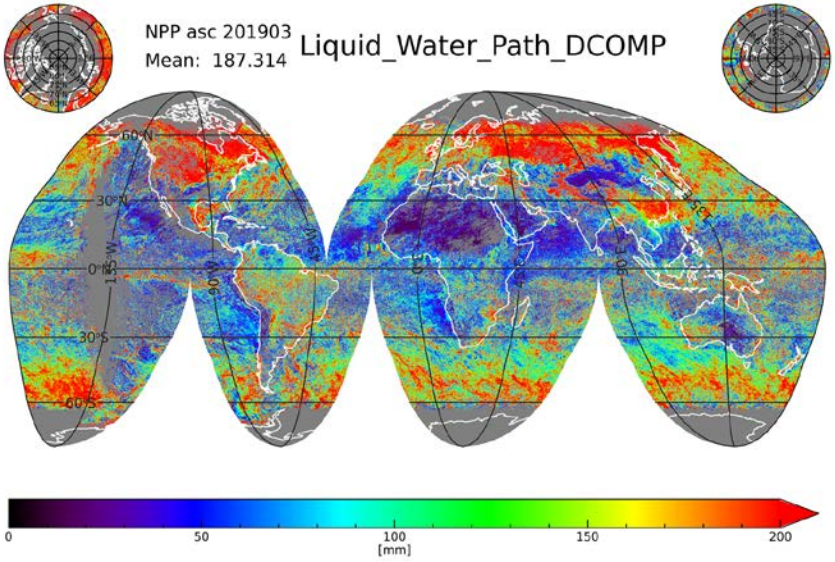
- Liquid Water Path is proportional to the product of optical depth and effective radius.

Long-Term Monitoring of DCOMP

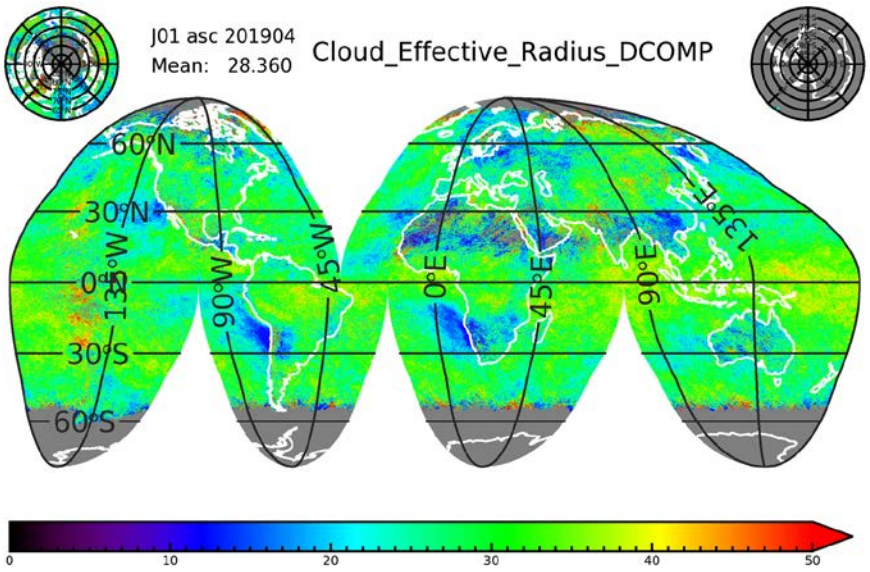


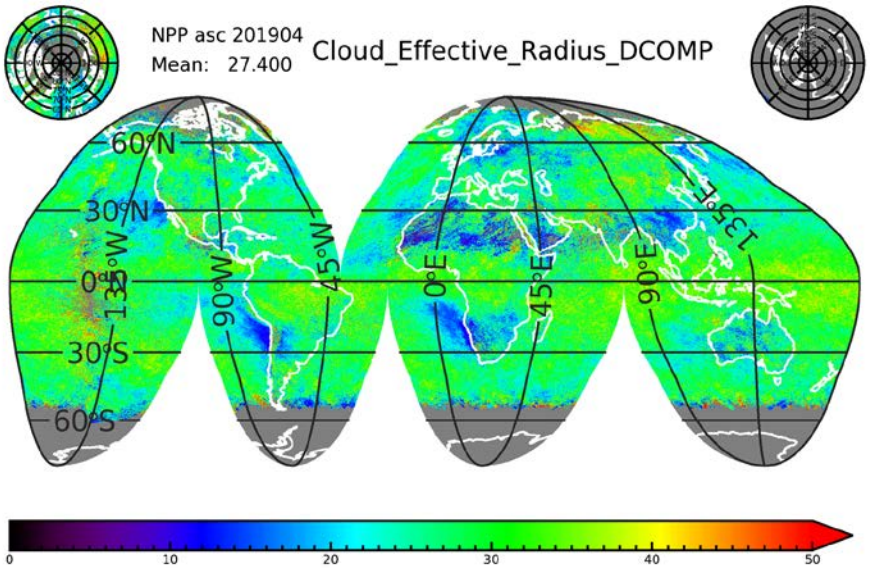


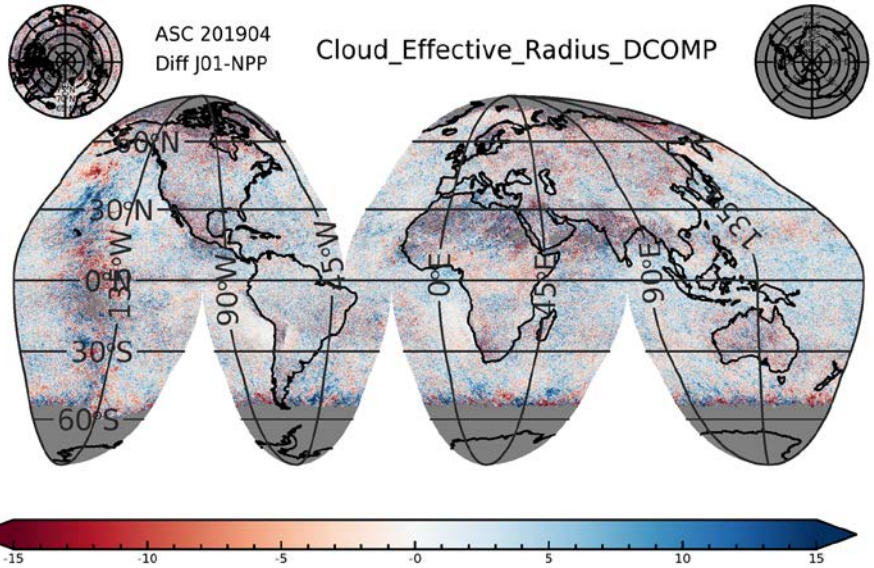




Long-Term Monitoring of DCOMP: CPS







Long-Term Monitoring of DCOMP: CPS

- CPS product v1r2 shows partly very high erroneous values of partly 10000 or more.

	Max	count over 500	over 2000
JRR-CloudDCOMP_v1r2_npp_s201808301103240_e201808301104481_c201808301215260.nc filemax:	962.740	182.000	0.00000
JRR-CloudDCOMP_v1r2_npp_s201808301104494_e201808301106135_c201808301216280.nc filemax:	750.774	186.000	0.00000
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JRR-CloudDCOMP_v1r2_npp_s201808301134411_e201808301136053_c201808301229100.nc filemax:	1510.60	1319.00	0.00000

- Valid Range is from 0 micron to 160.
- COD has the expected range up to 160.

Error Budget

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.

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
NREL	National Renewable Energy Laboratory	solar insolation calculations	• Using COD and CPS as an input for NREL models to compute solar insolation • Interest in highest spatial resolution and data from multiple sensors
CWB	Central Weather Bureau (Taiwan)	Cloud products for NWP	Use DCOMP data mainly on AHI/HIMAWARI sensor
DWD	German Weather Service	Climate applications	Use DCOMP Level2b (daily 0.1 x 0.1) data for long-term satellite based cloud time series.
HYDRO	CIMSS	Rain rate, Rain mask	

Risks, Actions, and Mitigations

Identified Risk	Description	Impact	Action/Mitigation and Schedule
NDE Processing	NDE processing issue	Low	Closed - Issue fixed with sufficient time for full validation analyses,
	Precision	Low	Validation data filtering improved results
	Glint areas	Low	Potential glint areas are set as quality flag.
High optical property and effective particle values over snow	Values of both over snow are erroneously high.	Medium	**In Process** - The science code addressing issue is currently being integrated for v2r2 science code delivery.
CPS	CPS product shows many extreme high values outside valid range	Medium	Values above 160 micron should be set to 160 micron. This will be fixed in the science code for the next delivery.

Documentations

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes (Provisional. Full Validation ReadMe will be provided after review)
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	As requested. LTM of algorithm is performed regularly via Cloud Team website

Check List - Validated Maturity

Validated Maturity End State	Assessment
Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).	Yes
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.	Yes Anomalies over snow which are present in v2r0 and high REF will be addressed in next science code delivery (integration into SAPF being performed)
Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.	yes
Product is ready for operational use based on documented validation findings and user feedback.	with limitations
Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument	Yes LTM currently being performed on routine basis via Cloud Team website

Conclusion

- DCOMP products were validated against MODIS science team products and GCOM-W/AMSR2 liquid water path.
- Accuracy is in the expected range outside snow areas.
- Both products suffer from calibration offset of M5 channel.
- CPS has many values outside product range, partly very high.
  - DCOMP SPS algorithm is processed in log-space. Information depth is low for high CPS values, so that last iteration step can lead to very high values
  - The next version of science code will cap high values at a realistic value.

Path Forward: Planned Improvements

- Next delivery plans:
  - Fix in science code for erroneously high values over snow has been delivered and is currently being integrated into to the SAPF for the next science code delivery (v2r2). The Cloud Team will work with ASSISTT to verify it's implementation prior to the DAP delivery to the JPSS EDR Processing system. We will also implement a fix for peak values of CPS

- Future plans (as they become available in the SAPF):
  - Capability to use DNB Lunar Reflectance for nighttime visible optical properties (requested input from Cloud Base algorithm) is currently within the science code. The DNB Lunar Reflectance is currently being integrated into the SAPF. Once integrated and verified, the Cloud team will verify Lunar DCOMP output.
  - 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.

Backup Material

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	

Path Forward (1-2 slides)

- Lessons learned for N20 Cal Val
- Planned improvements
- Future Cal/Val activities / milestones

Validated Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Validated Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward
- Summary

Validated Maturity Review - Exit Criteria

- Validated Maturity Performance is well characterized and meets/exceeds the requirements:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Validated Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Validated Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward