NOAA-20 VIIRS Daytime (DCOMP) Beta Maturity

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VIIRS DCOMP Team

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Outline

- DCOMP Description
- DCOMP Status in NDE
- SDR Issues
- Evaluation of the DCOMP
- Beta Maturity Conclusions
- Path Forward to Provisional
- Future Plans

STAR ECM Cal/Val Team

Name	Organization	Major Task
Andrew Heidinger	NESDIS/STAR	Cloud Team Lead
Andi Walther	CIMSS	DCOMP Lead
William Straka	CIMSS	ASSISTT integration

Enterprise Daytime Cloud Optical and Microphysical Properties (DCOMP)

NDE-DCOMP Overview

- Supports many sensors and is part of the NOAA Enterprise Algorithm Suite.
- It uses Nakajima-King bi-spectral approach with one channel in visible range and a weakly absorbing channel in near-IR.
- The primary output is Cloud Optical Thickness (COT) and Cloud Particle Size (CPS), which is represented by the effective radius of a cloud (REF).
- Liquid Water Path and Ice Water Path are calculated from COT and CPS.
- COT and REF are radiative parameters. Thus, it is not possible to validate them directly from in-situ measurements without making assumptions about scattering properties of cloud particles.
- Reference:

Walther, A. and A. K. Heidinger, 2012: *Implementation of the Daytime Cloud Optical and Microphysical Properties algorithm (DCOMP) in PATMOS-x*. Journal of Applied Meteorology and Climatology, 51, 7, pp.1371-1390.

DCOMP Channels

- DCOMP is currently set up to run with the M6 (0.64mm) and M11 (2.2mm)
- DCOMP can be used with the M7 or M12 Band instead of the M11 Band
- It also can use Visible Reflectance from backscattered moonlight (“lunar reflectance”) from DNB, but this is currently not set up within NDE

		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
Reflective Bands	VisNIR	M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58
Reflective Bands	VisNIR	M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58
Reflective Bands	VisNIR	M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58
Reflective Bands	VisNIR	I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789
Reflective Bands	VisNIR	M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58
Reflective Bands	VisNIR	M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58
Reflective Bands	VisNIR	I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789
Reflective Bands	VisNIR	M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58
Reflective Bands	S/MWIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58
Reflective Bands	S/MWIR	M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58
Reflective Bands	S/MWIR	I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789
Reflective Bands	S/MWIR	M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58
Reflective Bands	S/MWIR	M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58
Emissive Bands	S/MWIR	I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789
Emissive Bands	S/MWIR	M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58
Emissive Bands	S/MWIR	M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58
Emissive Bands	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58
Emissive Bands	LWIR	M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58
Emissive Bands	LWIR	I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789
Emissive Bands	LWIR	M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58

DCOMP overview

VIIRS NDE mode is DCOMP-2. Use of channel combination at 0.6 and 2.2 micron (M5/M11)

DCOMP input:

- Reflectance
- Cloud mask
- Cloud top temperature, Cloud height
- Cloud Phase
- Static Aux data (white sky surface albedo, NWP clear-sky temperature and humidity profiles, snow mask)

Users of the DCOMP

- Cloud studies (convective nowcasting.., etc.)
- Enterprise Cloud Algorithms (Cloud Base and CCL)
- Basis of application retrievals for precipitation, cloud transmission, aviation (icing threat)
- Solar insolation retrieval

Enterprise DCOMP NDE Status

NDE/STAR VIIRS DCOMP Production Status

Algorithm	Suomi NPP	NOAA-20
April 2017 and January 2018 DAP January 2018 DAP contains code to run both NPP and N20	NDE February 23, 2018	NDE Currently in I&T (Data available since 28 March, 2018)
February 2018 Science Code delivery	STAR Systematic production since June, 2018 NDE (Estimated Delivery in Aug 2018)	STAR Systematic production since June, 2018 NDE (Estimated Delivery in Aug 2018)

DCOMP Deliveries

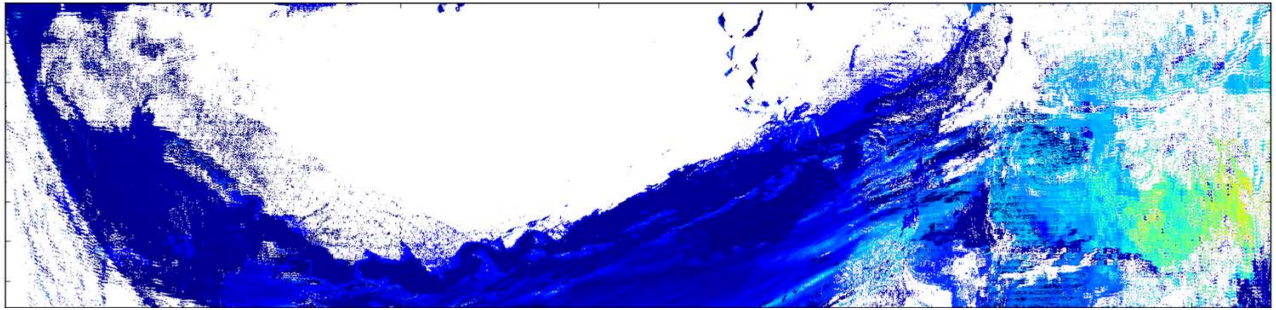
- Current Operational Version (NPP-only)
  - April 2017 DAP
- Current I&T Version
  - January 2018 DAP
  - Contains no code changes from previous DAP delivery except to be able to read in NOAA-20 specific LUTs
- February 2018 science code delivery
  - Estimated DAP delivery to NDE in August 2018

DCOMP v1r2 Integration Results

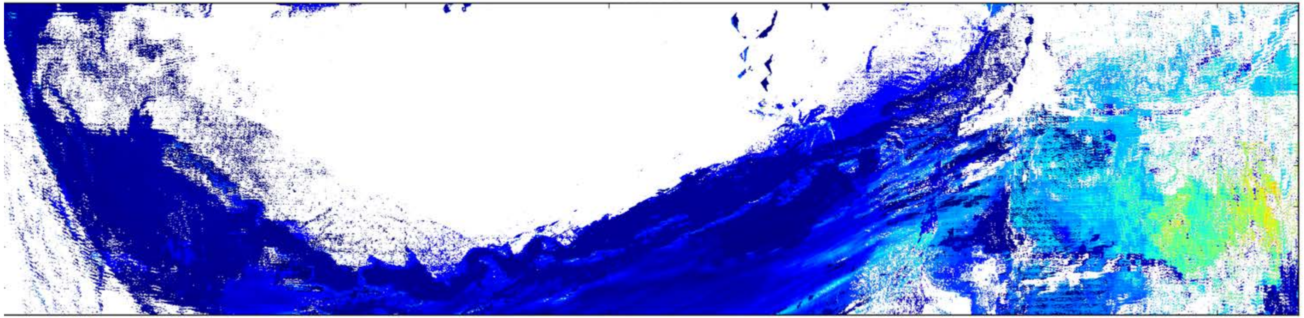
- Analysis was performed using GLANCE (which is used for algorithm integration verification) with an epsilon of 0 (i.e. a perfect match).
    - Small differences are to be expected due to slight run to run rounding differences.

- Due an issue discovered in ECM beta, which was fixed within NDE in mid-June, a verification test was performed using that data being run at NDE against locally run SAPF data to ensure that the code was integrated and being run correctly. Only two were daytime images (one NPP and one N20) for comparison
    - 0045Z on 8 April, 2018 (NOAA-20) - **Shown**
    - 1743Z on 16 Dec, 2016 (SNPP)

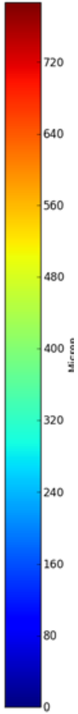
DCOMP v1r2 Integration Results (CPS)



CIMSS SAPF



NDE SAPF



DCOMP v1r2 Integration Results

- Correlation between NDE and CIMSS SAPF run : 0.9866
  - Similar results for the 1743Z on 16 Dec, 2016 case (not shown)

- Mean difference : -0.07130

- Number of points different less than 4% of total pixels with an **exact** match

- As mentioned previously, it is expected that there will be differences due to machine and run to run differences, and minor differences (as seen) are as expected.

SDR Issues

SDR Issues at BETA Review

- **M5 on SNPP is 5% too bright.**
- Our initial looks at NOAA-20 indicates that it's M5 calibration does not suffer from this.
- Our SNPP LUT automatically tuned out this calibration error so we expect NOAA-20 to 'miss' cloud due to this issue.
- There are other issues (tbd) that may be related to the SDR or SDR parameters in the SAPF.
- **Generation of a NOAA-20 LUT will solve this. However, it would be beneficial if we could apply corrections to SNPP to make one single LUT for both.**

Evaluation of the NDE DCOMP

Requirements COD (Day)

- 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 4km.
- JERD-2483   The algorithm shall produce a cloud optical depth product that has a measurement range of 0.3-64.
- JERD-2484   The algorithm shall produce a cloud optical depth product that has measurement precision of greater of 30% or 3.0.
- JERD-2485   The algorithm shall produce a cloud optical depth product that has measurement accuracy of greater of Liquid Phase: 2 or 20% and Ice Phase: 3 or 30%.

Requirements CPS (Day)

- JERD-2430 The algorithm shall produce a cloud particle size distribution product that has a horizontal cell size of 0.8 km.
- JERD-2482 The algorithm shall produce a cloud particle size distribution product that has a mapping uncertainty (3 sigma) of 4km.
- JERD-2483 The algorithm shall produce a cloud particle size distribution product that has a measurement range of 2 to 50μm.
- JERD-2484 The algorithm shall produce a cloud particle size distribution product that has measurement precision of greater of 4μm or 25% for water and greater of 10μm or 25% for ice.
- JERD-2485 The algorithm shall produce a cloud particle size distribution product that has measurement accuracy of greater of 4μm or 30% for water and 10μm for ice.

Requirements				
Product	Range	Accuracy	Precision	
COD	0.5-64	2 or 20% (liquid) 3 or 30% (ice)	2 or 20% (liquid) 3 or 30% (ice)	> 65 degree solar zenith
CPS	2-50µm	4µm /10µm (liquid/ice)	4µm /10µm	> 65 degree solar zenith
LWP		50g/m2	30%	> 65 degree solar zenith
IWP		100g/m2	40%	> 65 degree solar zenith

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)
1. <u>Beta</u> o Product is minimally validated, and may still contain significant identified and unidentified errors. o Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose. o Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.
2. <u>Provisional</u> o 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. o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose. o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists. o Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.
3. <u>Validated</u> o Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal). o 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. o Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose. o Product is ready for operational use based on documented validation findings and user feedback. o Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Validation strategies

- **Cloud Optical parameters are difficult to validate!** Optical properties are radiative parameters. Thus, it is not possible to validate COD directly from in-situ observations without making assumptions about scattering properties of cloud particles. → **Validation sources are rare!**
- Retrieval uncertainties of other parameters (e.g. Cloud mask, phase height, snow mask) will heavily affect uncertainty in DCOMP retrievals. As an example, in the event of false classification of cloud phase, COD can be wrong by 50% [Wolters et al. 2008].

Evaluation Methodology

We have chosen independent sources of cloudiness that provide qualitative and quantitative analysis of the performance over a short time.

We also compare to non-NDE generation DCOMP data to diagnose NDE-specific issues.

Our Specific Evaluation Methodology applied here:

1. Visual inspection of NDE DCOMP against CLAVR-x DCOMP and MODIS MYD06
2. Validation against MODIS MYD06 collection 6 products
3. Visual inspection against AMSR2

Data Used in this Analysis

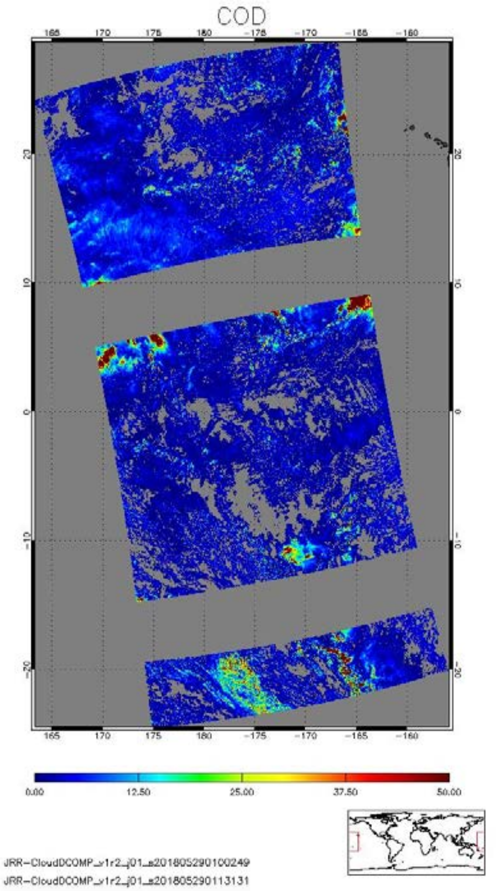
- NOAA-20 NDE v1r2 from
- NOAA-20 CLAVR-x
- NASA AQUA/MODIS
- JAXA-GCOM-W AMSR2

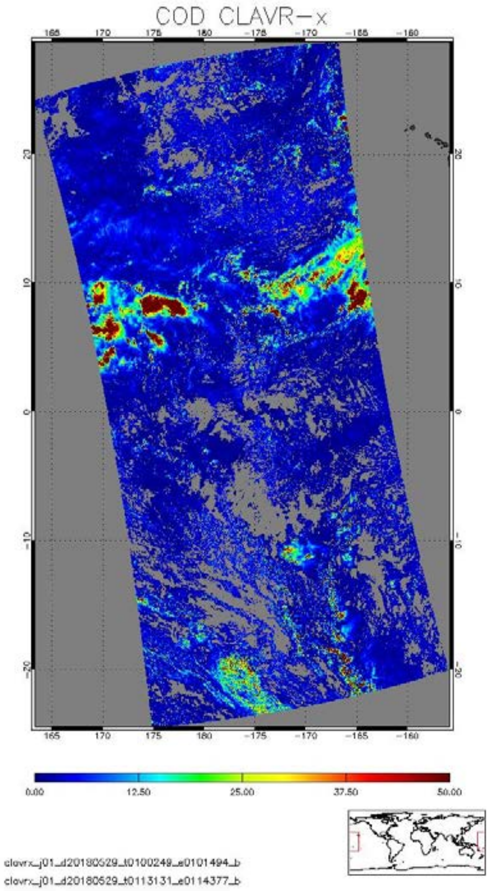
Visual Comparisons with CLAVR-x DCOMP

Comparison to CLAVR-x

- CLAVR-x DCOMP is development
- Current CLAVR-x code contains newest development work.

COT comparison to CLAVR-x



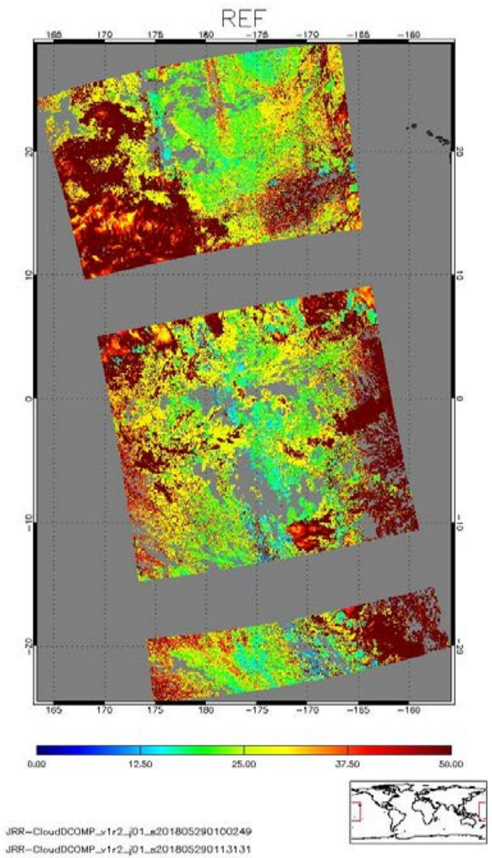


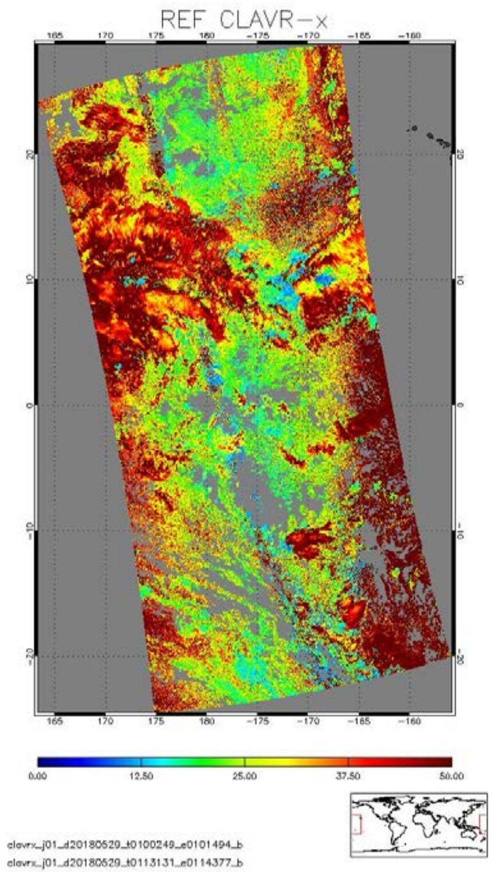
NDE shows missing granules for all test dates.

Visual check shows high agreement with current CLAVR-x.

No obvious erroneous pattern.

CPS comparison to CLAVR-x





NDE shows missing granules for all test dates.

Visual check shows high agreement with current CLAVR-x.

No obvious erroneous pattern.

Conclusions from visible evaluation and comparison to CLAVR-x

- DCOMP/NDE show no obvious erroneous pattern.
- DCOMP om NDE and current development code of DCOMP in CLAVR-x show very high agreement
- This test reached beta status.

Comparison to AQUA/MODIS

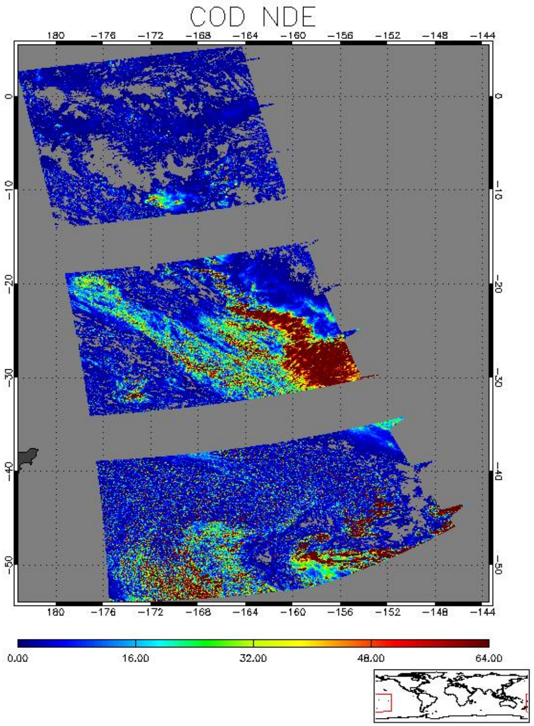
DCOMP MODIS validation

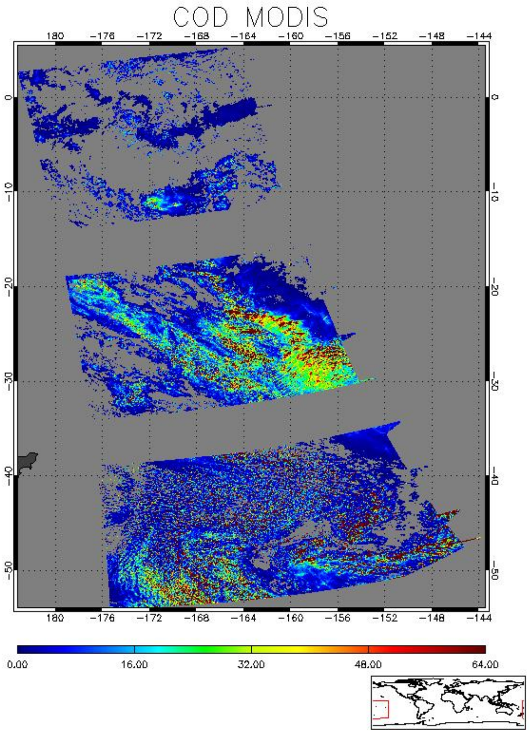
- MODIS Science team collection 6 products on AQUA for COD and CPS.
- **Problems/Challenges:**
- MODIS and VIIRS have **different spatial resolution**.
- Spatial and temporal **co-location** differences (windows are 10km and 600sec)
- MODIS approach is similar to DCOMP approach. The MODIS products are therefore **not** an **independent** validation source.
- **Basic assumptions** may be different (cloud phase, cloud height, surface conditions). These assumptions are beyond control of DCOMP and have to be tested/validated
- **Calibration differences** between MODIS-AQUA and NPP suspected (see SDR issue)
- Thus, **perfect match cannot be expected**
- Solutions:
- The 1:1 comparisons shouldn't seen as validation/performance truth.
- COD-CTP joint histograms
- Compare only results with same phase

Comparison to MODIS

- MODIS products are based on same approach. Thus, they are not independent validation source.
- We use matchup files of VIIRS on JPSS and MODIS on AQUA for 6 days.
- MODIS-AQUA MYD06 collection 6 files.
- Matchup criteria are 10 km spatial and 10 minutes temporal distance maximum
- For Beta: Use of Nearest Neighbor , Provisional: use of MODIS grid averages.
- Comparison for all pixels, and grouped in liquid and ice water phase.
- For Beta: no additional filtering. Provisional: we will add quality flag analysis, filtering over snow surface, high solar and viewing zenith angles, more strict time and space window and thin cloud exclusion for CPS and more)

Comparison COD

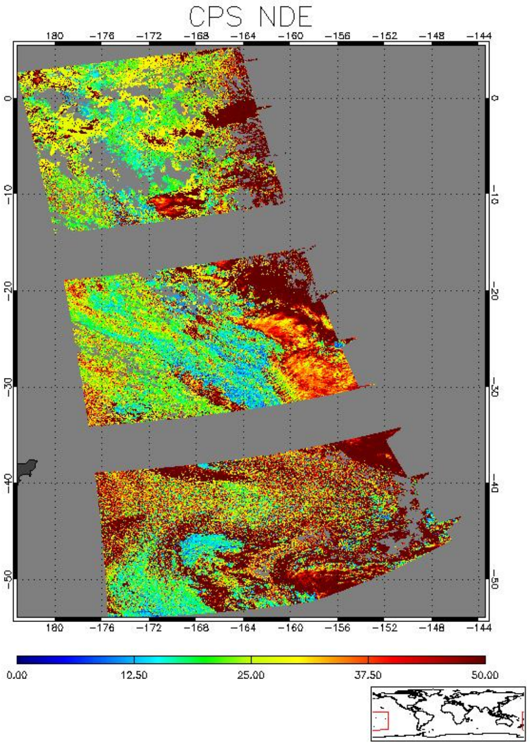


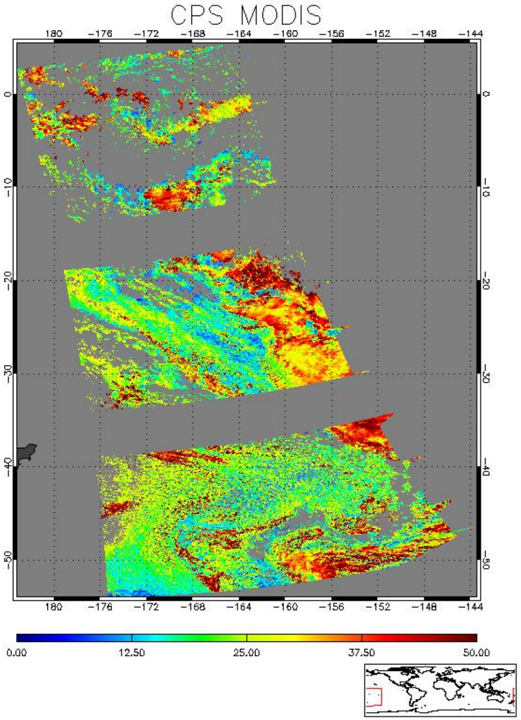


Maps show colocated pixels of JPSS and AQUA only.

Thick cloud show some differences. Information depth for thick clouds is low due to saturation effects, so we expected this.

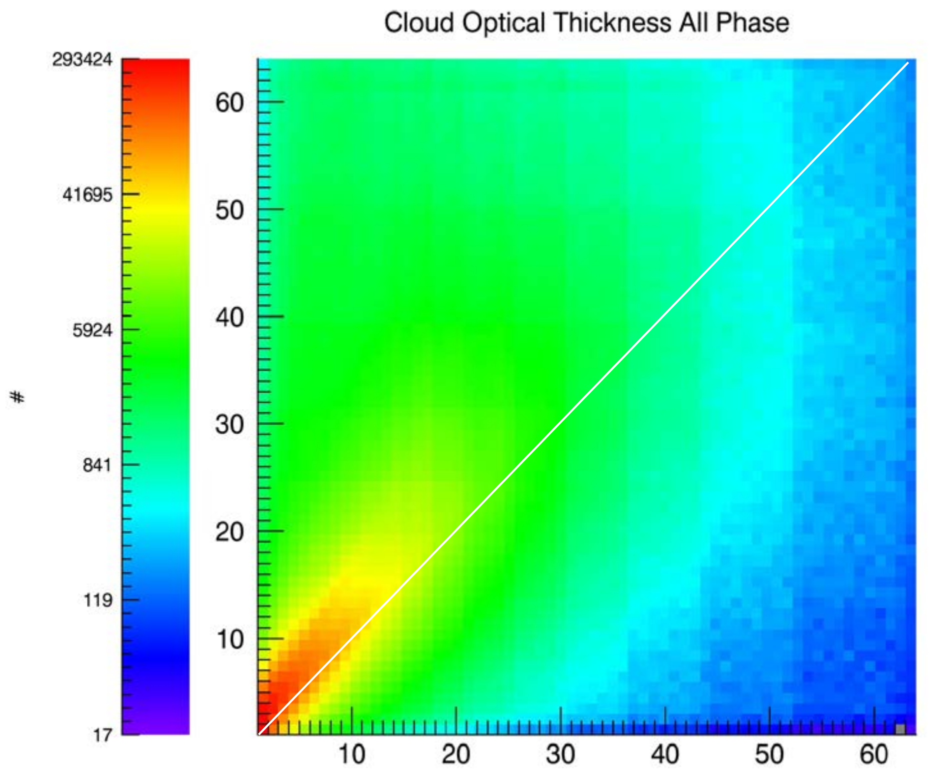
Comparison CPS





CPS for very thin clouds are higher than retrieved for MODIS

Comparison to MODIS/AQUA

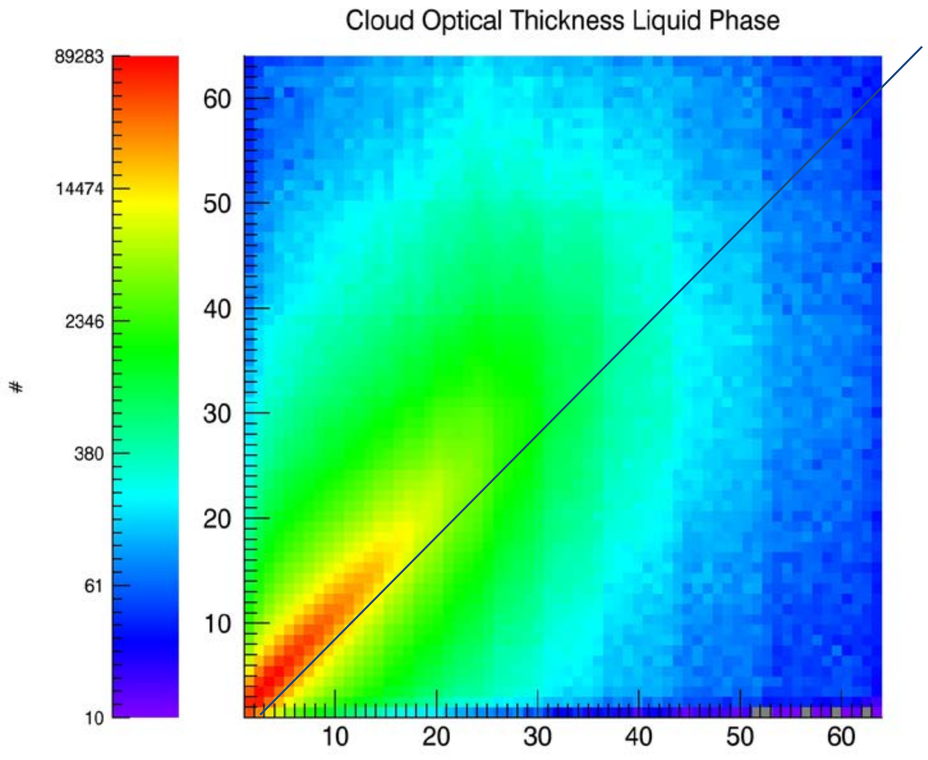


Accuracy: 5.3

Precision: 11.6

Correlation: 0.6

Comparison to MODIS/AQUA

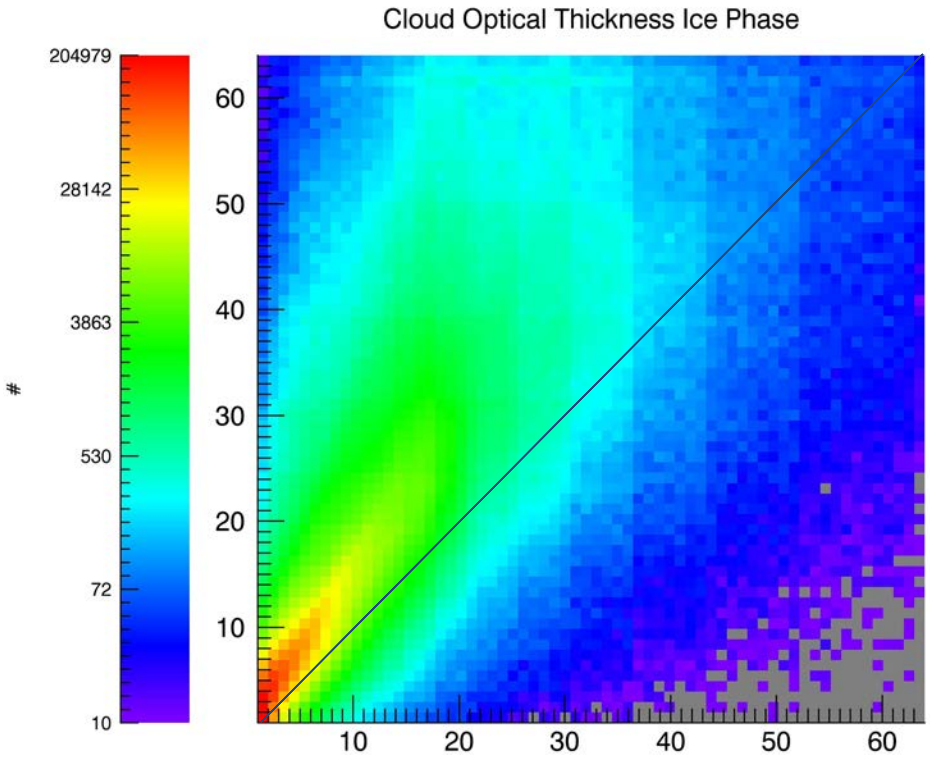


Accuracy: 2.11

Precision: 9.12%

Correlation: 0.68

Comparison to MODIS/AQUA

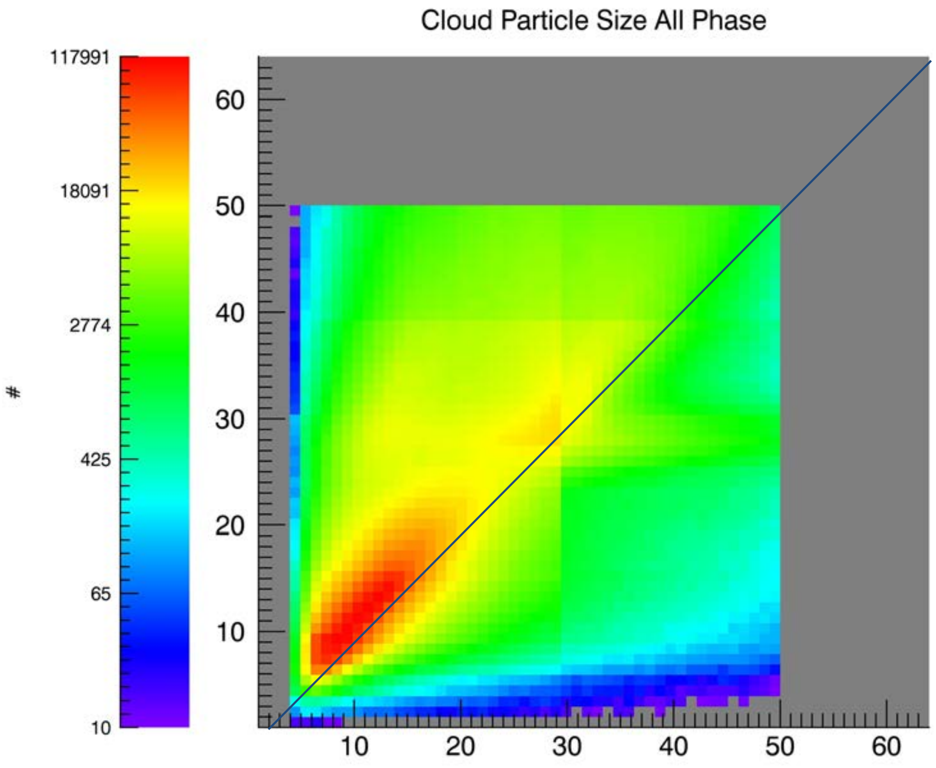


Accuracy: 5.43

Precision: 8.39%

Correlation: 0.77

Comparison to MODIS/AQUA

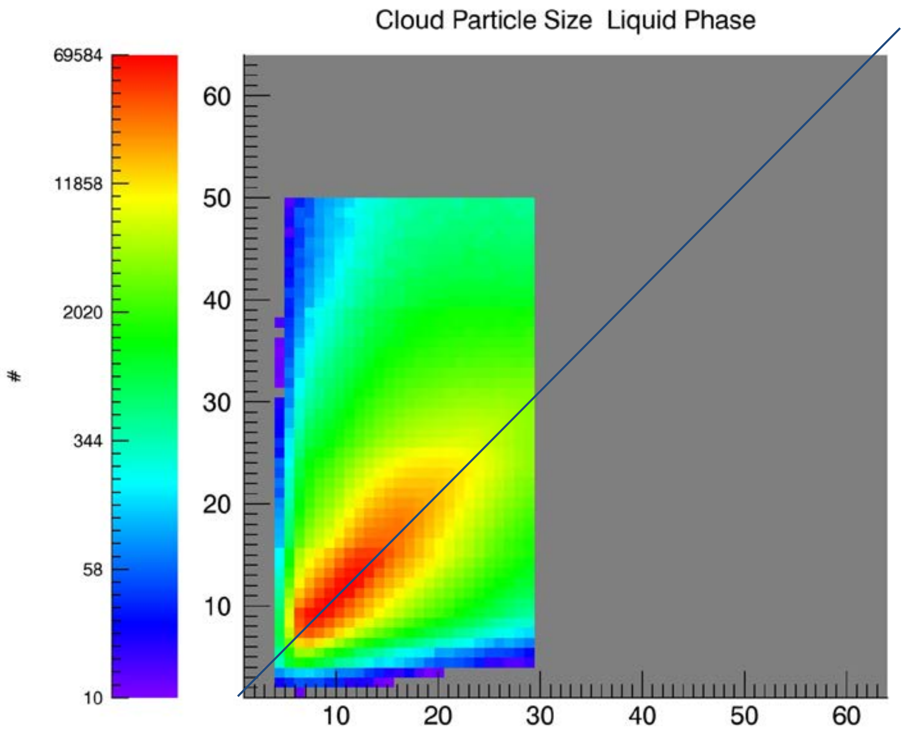


Accuracy: -4.37μm

Precision: 9.34%

Correlation: 0.64

Comparison to MODIS/AQUA

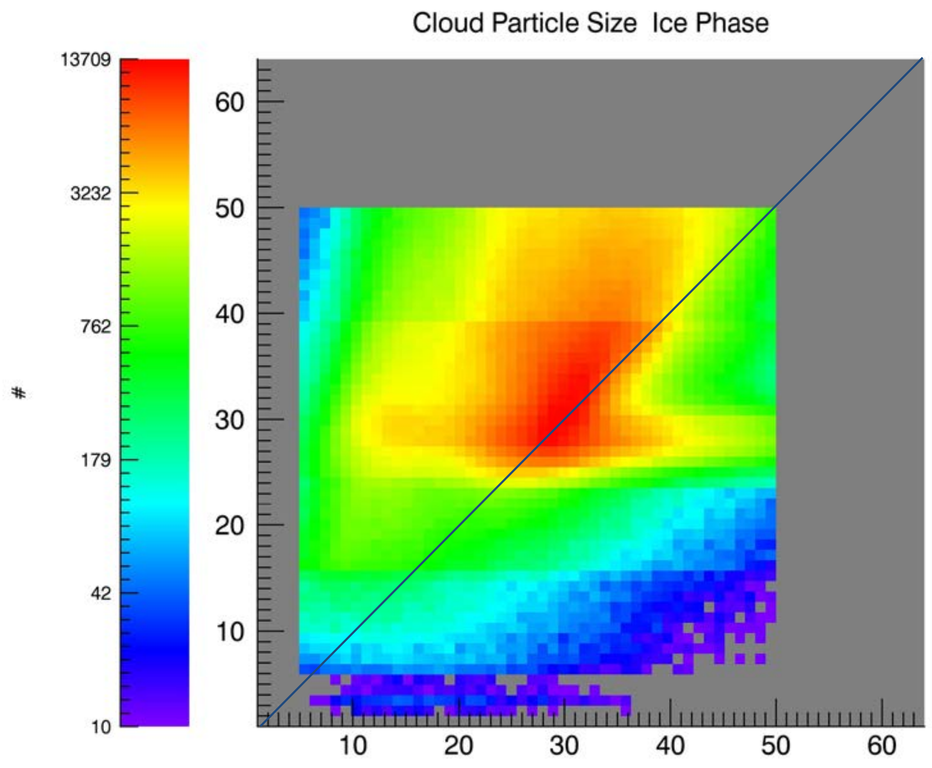


Accuracy: -2.45μm

Precision: 6.49%

Correlation: 0.60

Comparison to MODIS/AQUA



Accuracy: 6.61μm

Precision: 10.35%

Correlation: 0.38

Conclusions from MODIS Comparisons

- DCOMP NDE NOAA-20 performs similarly to MODIS.
- Pixel to pixel comparison shows results in specs or close, even we didn’t filter much.
- Further filtering will bring results in specs (more strict time and spatial window)
- Points out specific regions of differences that are investigated later.
- Conclusion: Beta review for this test are passed, and Provisional seems to be very close to pass.

Comparison to AMSR-2

Validation with AMSR-2

Used Data: GCOM-W Advanced Microwave Scanning Radiometer 2 (AMSR2) data.

Measures integrated cloud liquid water with a microwave-based sensor.

- Advantages:
  - Microwave based products of Liquid Water Path are only satellite-based independent validation source.
  - Evaluates Liquid Water Path, which is computed from COD and CPS, and is therefore a test for both products.
- Challenges and limitations:
  - Very different pixel size (AMSR2-15km).
  - Limitations: liquid clouds, only over ocean, no-rain
  - 1:1 pixel validation requires extensive filtering
  - Every AMSR2 pixel has a non-zero value

Validation with AMSR-2

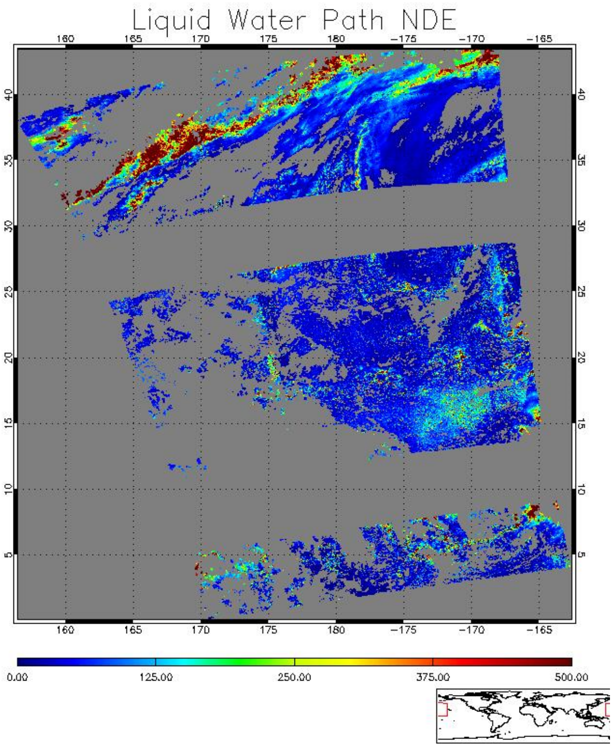
Methods for Beta:

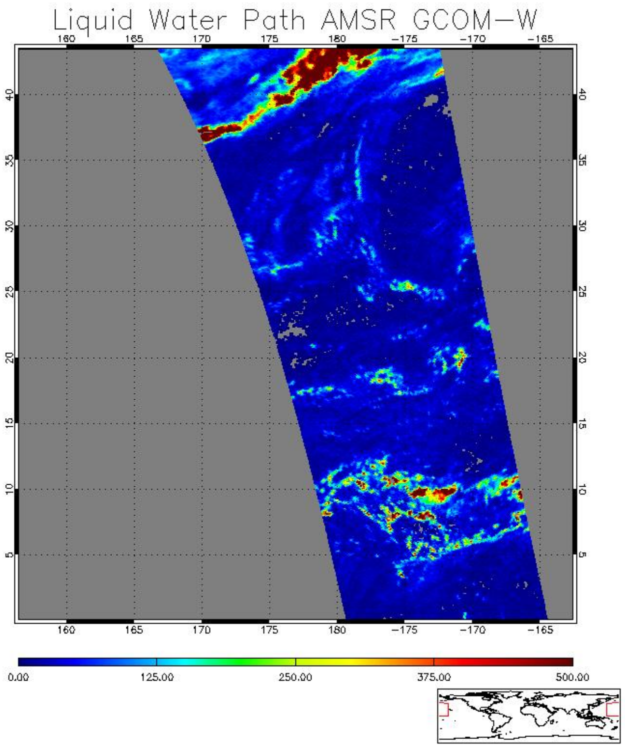
- Visual comparison of three days of data
- Inspection of possible regions with high bias for further analysis.

Provisional:

- Grid-to-grid colocation
- Applying several filters for
  - JPSS liquid water amount and pixel homogeneity in one AMSR2 grid box
  - Thin cloud exclusion
  - Rain exclusion

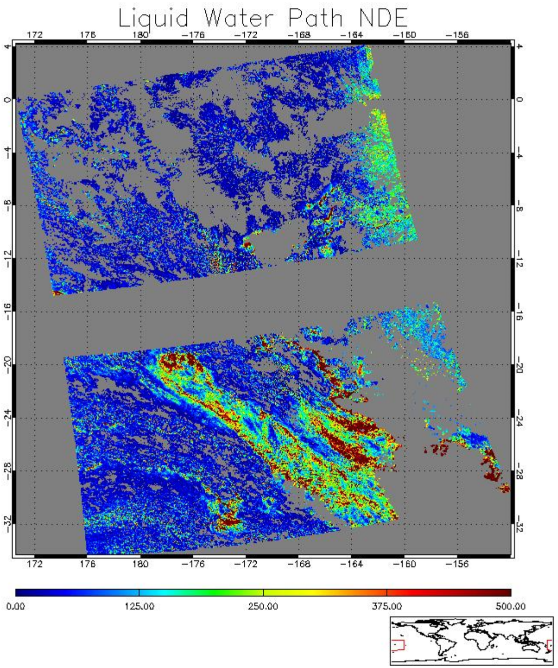
Visual comparison

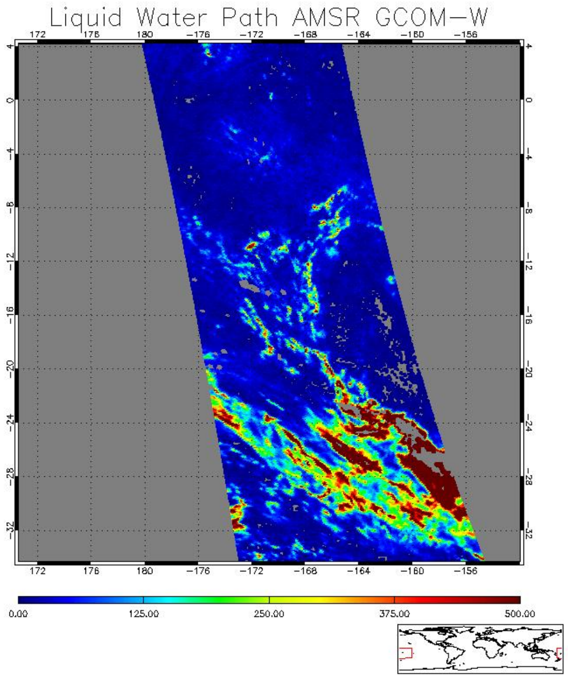




Visual inspection shows matching Liquid Water Path pattern.

Visual comparison





Visual inspection shows agreement for Liquid Water Path pattern.

Ice clouds are excluded in NDE.

Conclusions from AMSR2 Comparisons

- DCOMP NDE NOAA-20 LWP comparison to microwave based LWP from AMSR2 show similar pattern and LWP values.
- Differences are in expected range for the evaluation of LWP with microwave based sensors.
- Conclusion: Visual inspection of LWP with AMSR2 LWP product meets beta requirements.

Investigation of Issues

Issue

Missing granules.

This is a PDA issue and will be resolved in the June 2018 DAP (will be in Ops ~end 2018).

DCOMP Issue 1

Issue: Partly higher CPS values for thin clouds in comparison to MODIS

We will analyse this issue for a larger data set at the provisional. Reason is that for very thin clouds DCOMP has only low information depth for the CPS output. It is initially also not clear if MODIS has a more realistic value.
Another method to analyse this is to use CALIOP for cirrus cloud CPS.

DCOMP Issue 2

High and unrealistic values of COT over snow.

We implemented an updated over snow algorithm which will be implemented in the next NDE software update. The updated code will use 1.6 micron channel instead the 0.6 micron channel to reduce surface reflectance term.

Beta Maturity Conclusions

- **The Cloud Team recommends Beta Maturity at this time.**

Pathway to Provisional

- We expect to apply the same activities to be conducted for Provisional Maturity:
  - We are gathering an archive of golden days where we save SDRs and EDRs spread from April 2018 to August 2018. This collection is underway.
  - We hope to engage the teams in the summer and begin application-specific analysis.
  - We will take advantage of opportunities for threshold adjustments.

Risks for Provisional

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

- **NDE processing issues (Moderate)**
  - Issues with ECM missing certain clouds
    - Due to ECM LUT issue
    - **Resolved** as of June 2018, but data prior to June 11 has this issue
  - Missing granules in NDE processing
    - Currently being addressed in June 2018 DAP delivery. Expected operations in late 2018

Future Plans of DCOMP

- Use of DNB Lunar Reflectance is included in code and we hope someday that can be turned on as soon as it is integrated into the SAPF.
- Considering more snow/no-snow surface auxiliary map information.