GOES-R AWG Cloud Team Nighttime Cloud Optical and Microphysical Properties (NCOMP)

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- Validation Strategy
- Validation Results
- Summary

Executive Summary

- The ABI Cloud Nighttime Optical and Microphysical Properties (NCOMP) algorithm generates the products Cloud Particle Pize (CPS), Cloud Optical Depth (COD), Liquid Water Path (LWP) and Ice Water Path (IWP).
- Version 5 was delivered in June 2010. 100% ATBD is on track for a July delivery.
- NCOMP is based on a variation of NASA Langley's Solar-infrared Infrared Split-window Technique adapted to meet GOES-R needs.
- Validation strategy includes the comparison of SEVIRI output to MODIS measurements for COD and CPS and comparison to AMSR-E measurements for LWP.

Algorithm Description

- NASA Langley's Solar-infrared Infrared Split-window Technique (SIST) has been adapted to accept input cloud temperature and phase that is determined in upstream GOES-R algorithms.
- NCOMP assumes fully-filled, single-layer, homogenous cloud pixels.
- A cloud emittance parameterization developed by Minnis et al. (1998), is used to relate clear temperatures, cloudy temperatures and COD to cloud emittance. These emittances are used to compute simulated temperatures for a set of COD and CPS.
- An iterative error minimization scheme using the 3.9, 11.2 and 12.3 µm channels solves for COD and CPS.
- Liquid water or ice path (LWP/IWP) are calculated from COD and CPS.

ABI Channels for NCOMP

ABI Band	Wavelength Range (μm)	Central Wavelength (μm)	Central Wavenumber (cm-1)	sub-satellite IGFOV (km)	Sample Use
1	0.45-0.49	0.47	21277	1	
2	0.59-0.69	0.64	15625	0.5	
3	0.846-0.885	0.865	11561	1	
4	1.371-1.386	1.378	7257	2	
5	1.58-1.64	1.61	6211	1	
6	2.225 - 2.275	2.25	4444	2	
7	3.80-4.00	3.90	2564	2	NCOMP
8	5.77-6.6	6.19	1616	2	
9	6.75-7.15	6.95	1439	2	
10	7.24-7.44	7.34	1362	2	
11	8.3-8.7	8.5	1176	2	NCOMP
12	9.42-9.8	9.61	1041	2	
13	10.1-10.6	10.35	966	2	
14	10.8-11.6	11.2	893	2	NCOMP
15	11.8-12.8	12.3	813	2	NCOMP
16	13.0-13.6	13.3	752	2	NCOMP

Currently used by NCOMP

Possible future use in NCOMP

NCOMP Processing Schematic

CTT = Cloud-Top Temperature

CTYPE = Cloud Type

BT7 = Channel 7 Brightness Temperature

BT14 = Channel 14 Brightness Temperature

BT15 = Channel 15 Brightness Temperature

COD = Cloud Optical Depth

CPS = Cloud Particle Size

LWP = Liquid Water Path

IWP = Ice Water Path

INPUT: CTT, CTYPE
BT_7, BT_{14}, BT_{15}

↓

Retrieval Algorithm
(error minimization technique)

↓

OUTPUT: COD, CPS

↓

Calculate LWP or IWP

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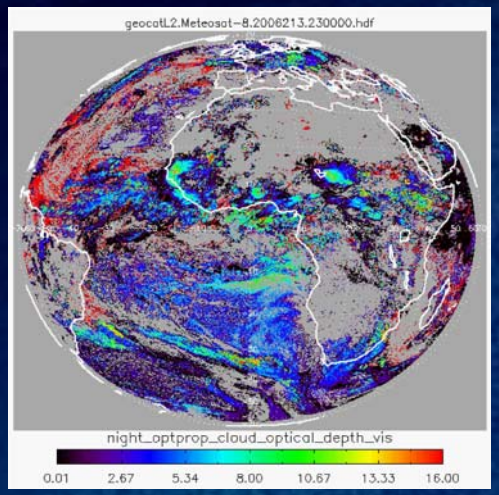
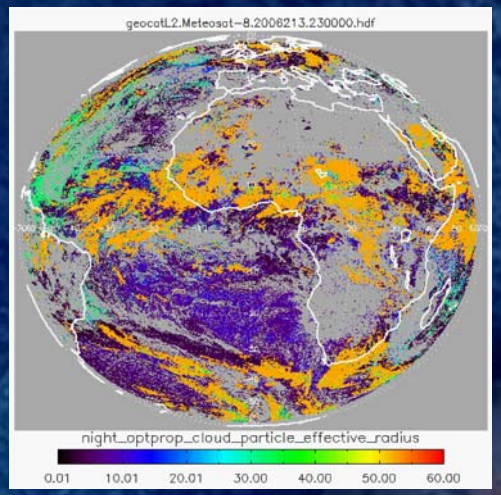
OUTPUT: LWP or IWP, Quality Flags

NCOMP Example Output

August 1, 2006 23:00 UTC1

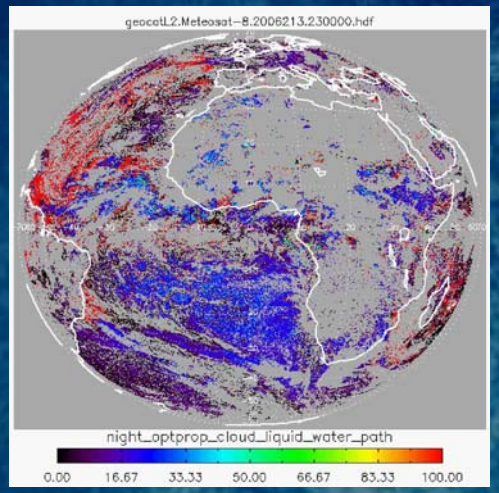
Cloud Optical Depth

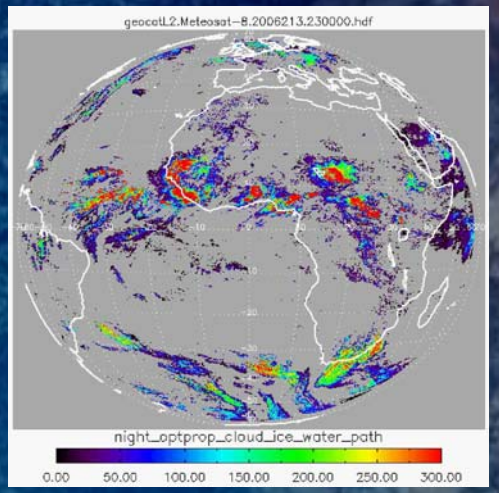




Cloud Particle Size (μm)

LWP (g/m^2)





IWP (g/m^2)

Algorithm Changes from 80% to 100%

- Extensive code revisions to meet coding standards.

- Included capability to use NCOMP with 82 <= sza < 90
  - qualitative products only

- Revised calculation of CPS for ice clouds accounting for differences in definition of ice cloud diameter and radius.

- Quality Flags standardized.

ADEB and IV&V Response Summary

- All ATBD errors and clarification requests have been addressed

- No feedback required substantive modifications to the approach

Requirements

Product	Range	Accuracy	Precision	Latency	Horizontal resolution
Cloud Optical Depth	1 < COD < 5	30%	max of 0.8 or 30%	5min	2km
Cloud Particle Size	water: 2 < CPS < 32 μm ice: 2 < CPS < 50 μm	water: max of 4 μm or 30% ice: 10 μm	water: max of 4 μm or 25% ice: max of 10 μm or 25%	5min	2km
Liquid Water Path	25 < LWP < 100 g/m^2	greater of 25 g/m^2 or 15%	greater of 25 g/m^2 or 40%	5min	2km
Ice Water Path	25 < IWP < 175 g/m^2	greater of 25 g/m^2 or 30%	greater of 25 g/m^2 or 40%	5min	2km

Qualifiers

These are made with the following qualifiers:

- Local zenith angle < 65 degrees
- 82 <= solar zenith angle < 90: qualitative
- Solar zenith angle >= 90: quantitative
- 1 < COD < 5
- Cloud Top Temperature and Cloud Type available

NCOMP Validation Approach

- LWP – best validation sources of all NCOMP products
  - » Microwave LWP measurements by AMSR-E, SSM-I and ground-based microwave profilers (MWR)
  - » Additional sources:
    - – SEVIRI products from EUMETSAT and others
    - – NASA LaRC CERES MODIS and SEVIRI products

* MODIS MYD06 night products unavailable

* CLOUDSAT (limited for thin clouds)

NCOMP Validation Approach

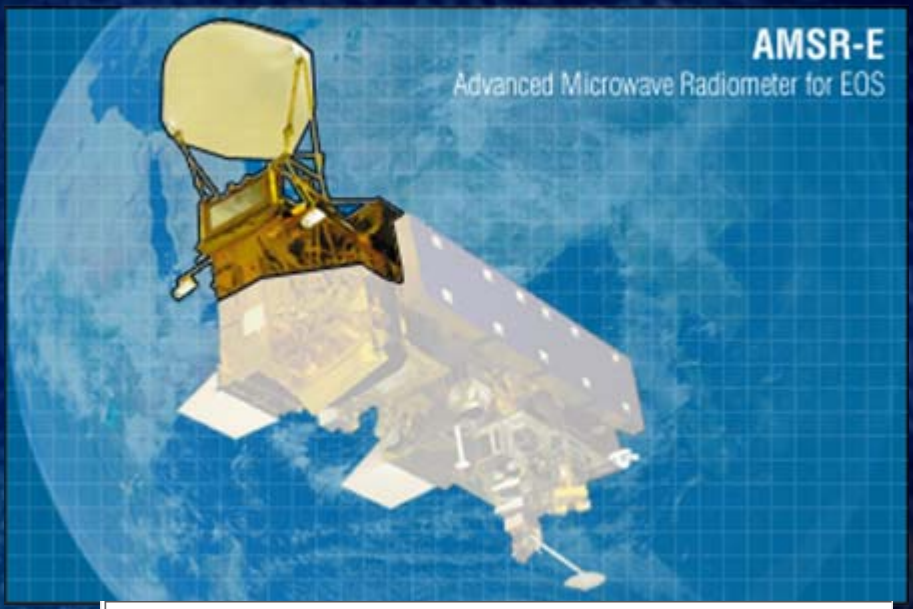
- COD, CPS and IWP
  - » comparable products from other institutes are the most useful sources:
    - – SEVIRI products from EUMETSAT and others
    - – NASA LaRC CERES MODIS and SEVIRI products
  - » Additional sources::
    - – CALIPSO (thin ice clouds only)
    - – Surface LIDAR (COD, CPS and IWP)
    - – Surface Radar (CPS)

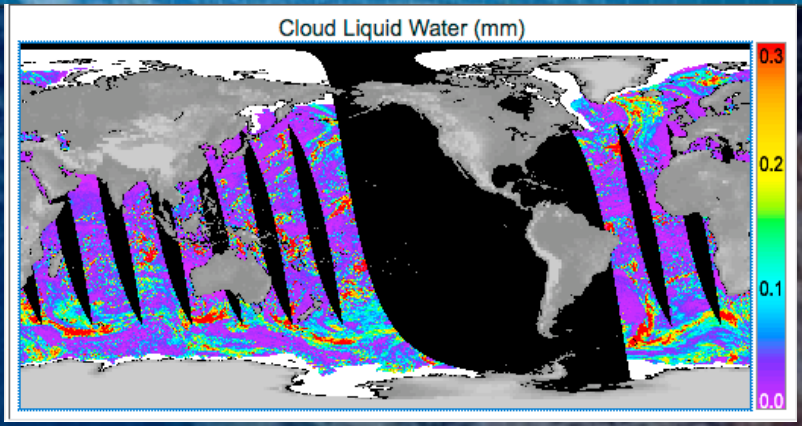
* MODIS MYD06 night products unavailable

* CLOUDSAT (limited for thin clouds)

Validation Source: AMSR-E

- The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) is a passive microwave radiometer mounted on AQUA, an A-TRAIN satellite, capable to retrieve liquid water path above ocean surface.
- Spatial resolution is about 20 kilometers with a swath of approx. 1450 km.

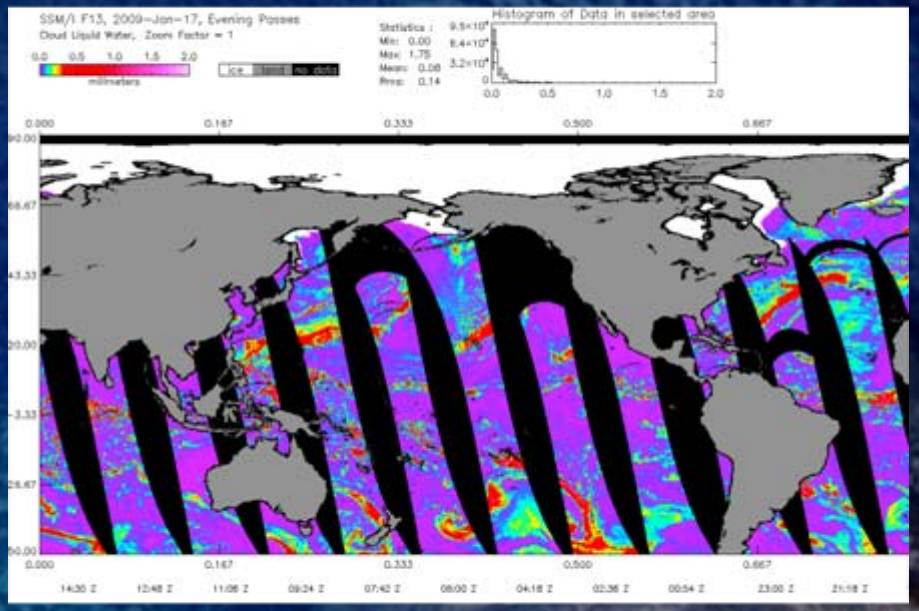




Example of daily coverage AMSR-E observations
From http://www.remss.com/

Validation Source: SSM/I

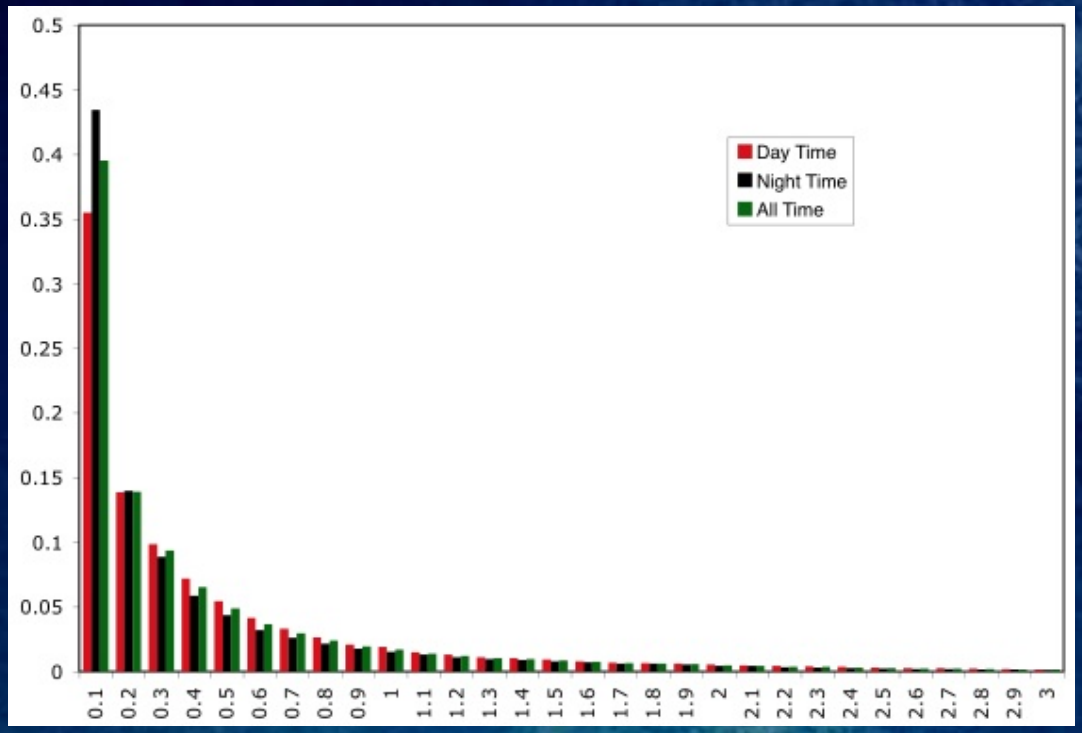
- Special Sensor Microwave Imager (SSM/I).
- Measures LWP over ocean surface.
- Long term data series with more than 20 years of LWP data over sea.
- 25 kilometers spatial resolution with a swath of 1400 km



Example of daily coverage SSM/I observations
From http://www.remss.com/ssmi/ssmi_browse.html

Validation Source: CALIPSO

Frequency Histogram of CALIPSO-derived COD for transparent clouds with a single ice layer
July 2006



Comparing NCOMP to these products allows for consistency checks between day and night as well as validation for the nighttime clouds.

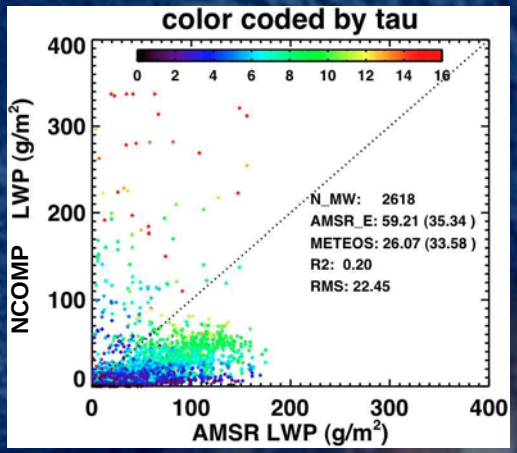
Validation Results

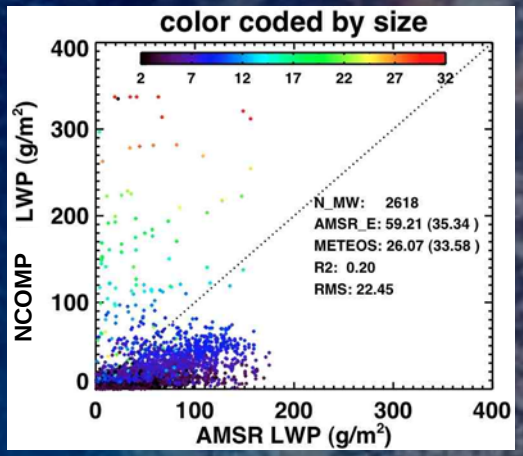
$LWP_{AMSR\text{-}E}$ compared to LWP_{NCOMP}

24-25 August 2006

$LWP_{AMSR\text{-}E}$ usually > LWP_{NCOMP} , but NCOMP is limited to LWP < 100 g/m^2 due to τ limitation.

LWP_{NCOMP} often seems too low even for small LWP clouds. Examining both the NCOMP particle size and τ shows that both are often underestimated resulting in low LWP.



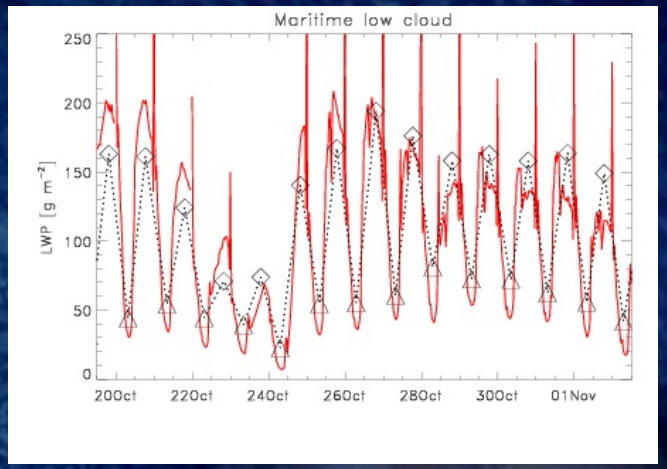


Validation Results

Liquid Water Path Accuracy

From VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) field program: LWP_{SIST} (red line) derived from GOES-12 data compared to LWP_{AMSR-E} (diamond) from 80-90º W and 15-25ºS.

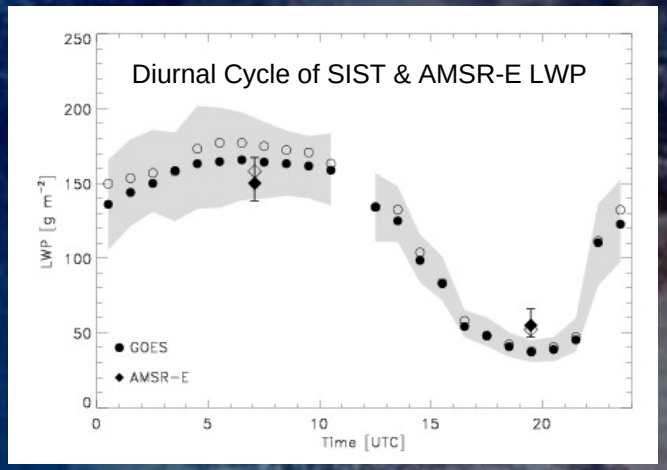
Stratocumulus clouds off the coast of Chile. LWP peaks are nighttime while valleys are daytime. Note that SIST (NCOMP equivalent) is performed at night, VISST performed during day.



Mean diurnal cycle over same period shows expected maximum before sunrise and minimum mid-day and reiterates good agreement between AMSR-E and SIST(NCOMP)

Shading and error bars are the 25th and 75th percentiles.

Need to rectify differences between these results and previous scatter plot.

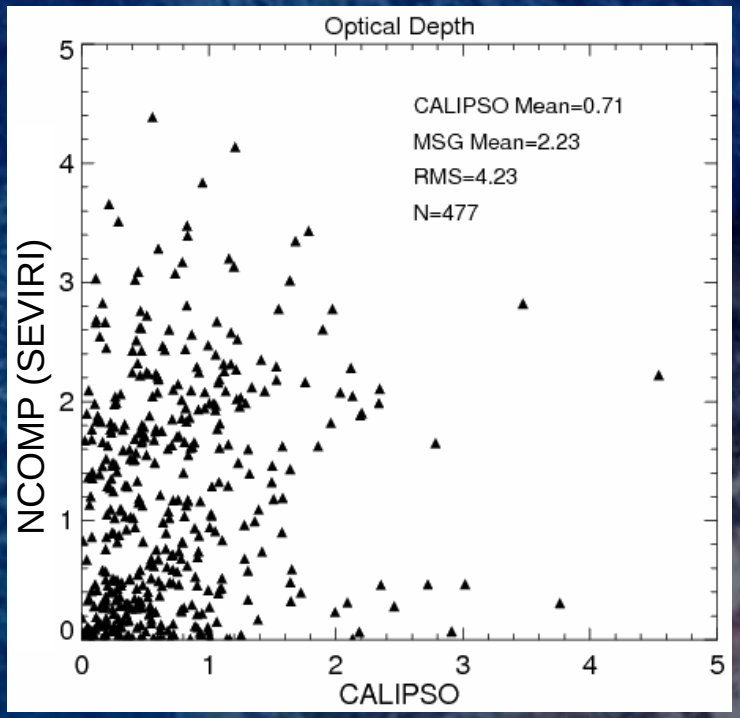


Validation Results

COD_{NCOMP} Compared to $COD_{CALIPSO}$

from 25 Aug 2006 (nadir only)

$COD_{CALIPSO}$ generally < COD_{NCOMP} although this is expected as CALIPSO is much more sensitive to aerosols and very thin clouds.

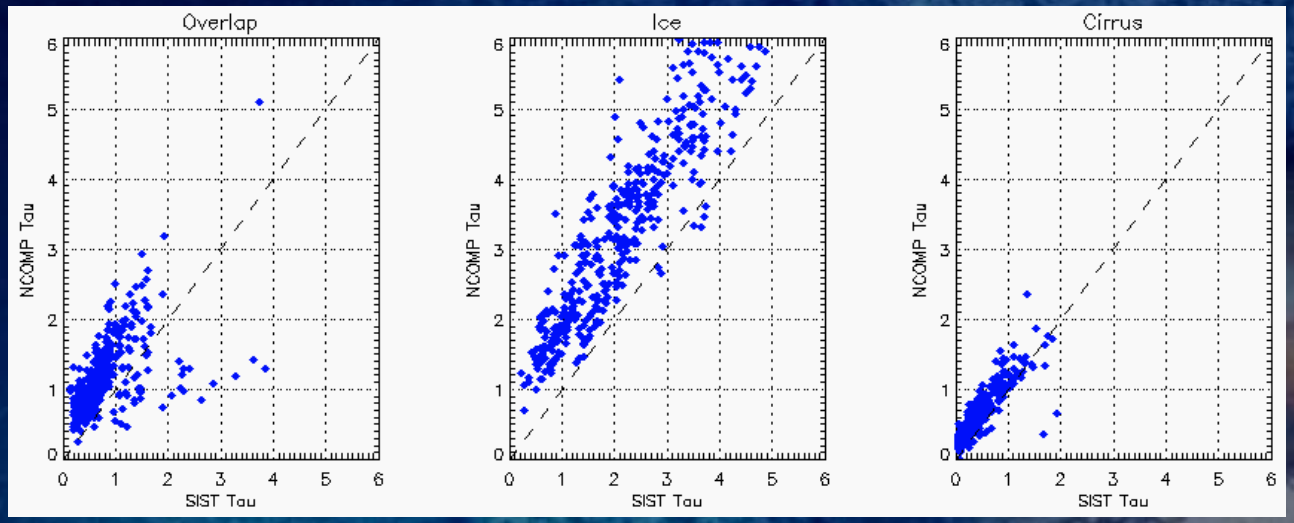


Validation Results

Comparison of COD_{NCOMP} with COD_{SIST}

3-4 Aug 2006 over Europe

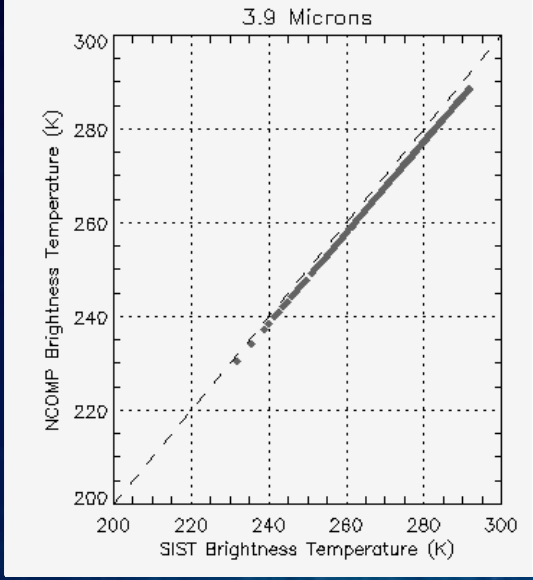
Separated by GOES-R Cloud Types

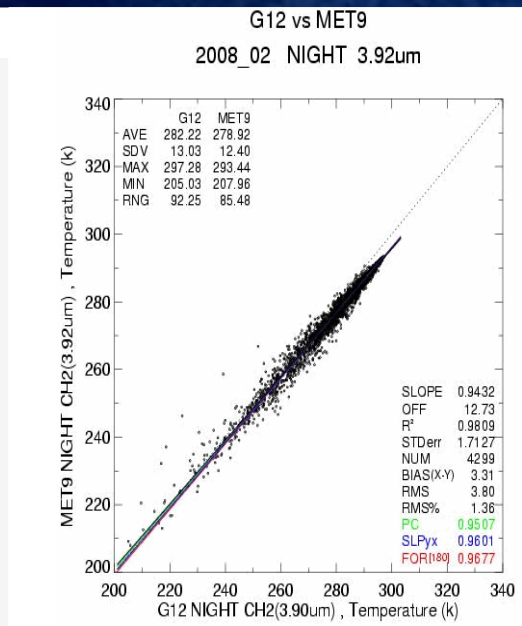


COD_{NCOMP} compares favorably to COD_{SIST}, but has a high bias, particularly for optically thick ice clouds

Validation Results

Calibration's Likely Role in High Bias





- The 3.9 µm temperature comparison is almost identical to the calibration plot, indicating that the GOES-R framework is using nominal SEVIRI calibrations. The GOES-12 LaRC values are well-calibrated to MODIS.

- The low $T_{3.9}$ values from SEVIRI/GOES-R, when used in NCOMP, result in an overestimation of COD, hence an overestimation of IWP.

Validation Summary

- COD results are promising, but calibration is important
- LWP very good for SIST, but need to understand differences between NCOMP and SIST (matching problem?)
- CPS and IWP are also underway, but need to compensate for all differences in retrieval and measurement differences
- Carefully choosing single layer cases is crucial whether processing a case study or months of data
- June is ATBD month, hence much more validation will be done allowing performance to be compared to requirements

Summary

- ABI Nighttime Microphysical Parameter Algorithm provides microphysical parameters COD and CPS for daytime observations. The cloud water and ice content are derived from the COD and CPS.

- Version 5 has been delivered and the 100% ATBD is in progress.

- These products are expected to meet requirements and should be useful to downstream applications (AMV).