Provisional Maturity Science Review For NOAA-21 Enterprise Cloud Products

Presented by Mark Kulie
Date: 10/26/2023

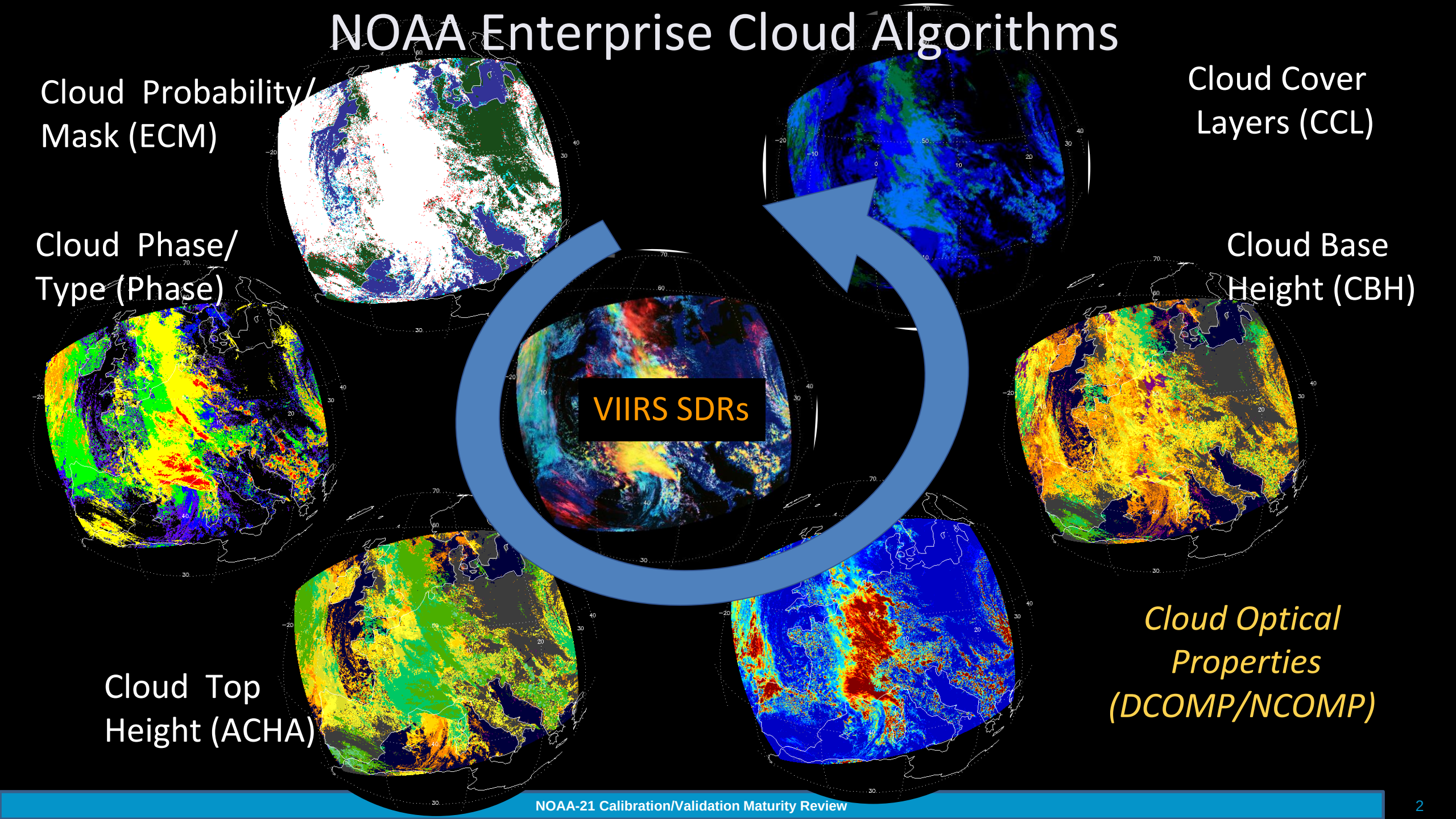
NOAA Enterprise Cloud Algorithms

Cloud Probability/ Mask (ECM)

Cloud Cover Layers (CCL)

Cloud Phase/ Type (Phase)

Cloud Base Height (CBH)



Cloud Top Height (ACHA)

Cloud Optical Properties (DCOMP/NCOMP)

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.

Cloud Product Maturity Reviews

- Enterprise Cloud Mask (ECM): Provisional
- All Others: Combined Beta/Provisional

Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Provisional 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/Downstream-Products feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward (to the next maturity stage)
- Summary

Maturity Review - Exit Criteria

- Provisional 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 Maturity Review Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Provisional Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward (to the next maturity stage)

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

Overview

- Product names/labels
  - NCCF/NDE = Operational (OPS) products
  - NOAA-21 products obtained most directly from NDE.
  - CLAVR-x: Clouds from AVHRR Extended
    - Underlying enterprise cloud product processing software suite
    - Can create products locally as sanity check

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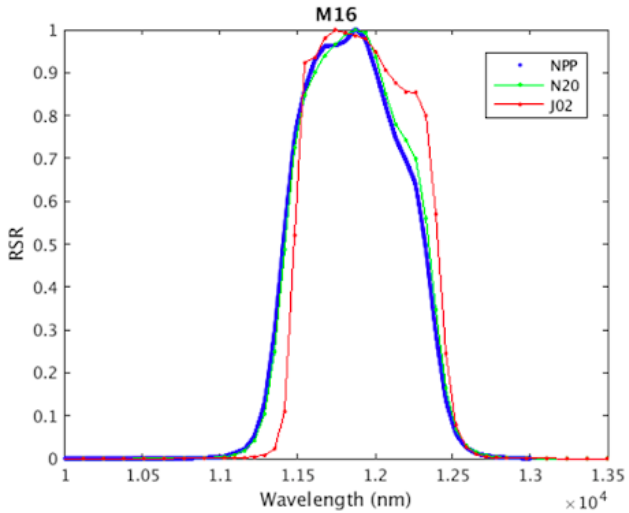
    - Can create products locally as sanity check
- Data availability - perpetual issue for reviews
- Validation not a trivial task
- JPSS constellation consistency
  - VIIRS products have been previously validated
  - Sensor differences (e.g., spectral response functions (SRF)) exist
  - Some products sensitive to these differences

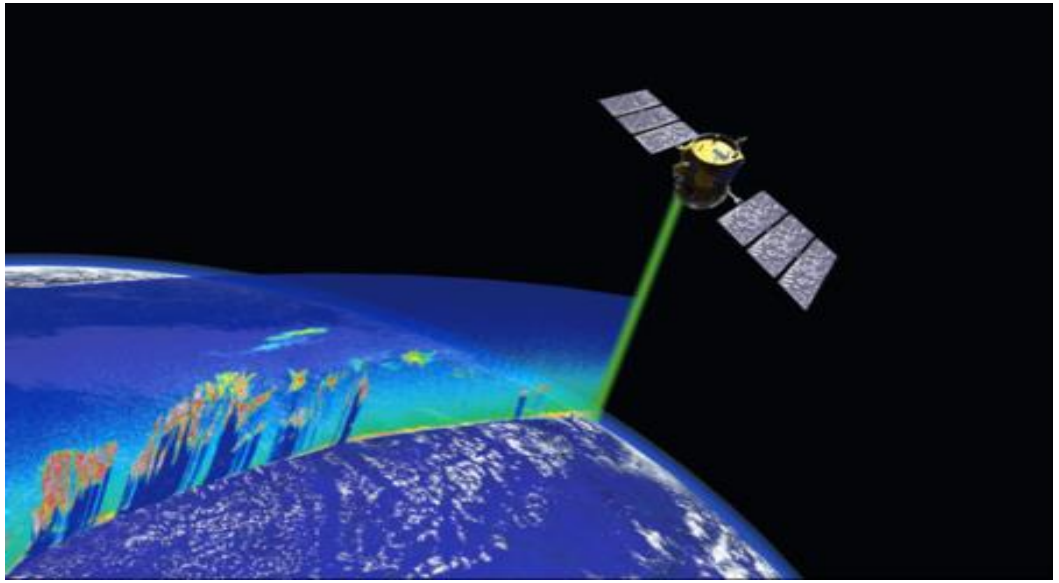


Overview

- Near future desires
  - Developers for current operational Cloud Top Phase product no longer actively working on the algorithm
  - No further algorithm development and innovation
  - Adopt Cloud Top Phase generated by CLAVR-x suite

CALIPSO Mitigation

- CALIOP is a spaceborne lidar onboard of CALIPSO (NASA Earth Science Mission).
- CALIOP products heavily utilized in algorithm development and validation
- CALIPSO no longer operational
- Minimal CALIPSO data available for this review
- Moving forward:
  - EarthCARE (European spaceborne lidar - 2024 launch)
  - Ground-based profiling radar/lidar (e.g., DOE ARM)
  - Atmosphere Observing System (AOS) - NASA radar/lidar (late 2020's launch)
  - Cultivate other datasets of opportunity



Provisional Maturity Science Review For NOAA-21 Enterprise Cloud Mask (ECM)

CIMSS ECM Team: Coda Phillips, Yue Li, Mike Foster, William Straka

NOAA Cloud Science Team Lead: Mark Kulie

the NOAA-21

ECM has

Presented by Coda Phillips, Yue Li, Mark Kulie

Date: 10/26/2023

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STAR ECM Cal/Val Team

Name	Organization	Major Task
Mark Kulie	NESDIS/STAR	Cloud Team Lead
Andrew Heidinger	NESDIS	ECM developer
Mike Foster	CIMSS	CIMSS ECM PI
Coda Phillips	CIMSS	ECM Lead Developer
Yue Li	CIMSS	Cal/val
William Straka	CIMSS	ASSISTT integration
David Donahue	OSPO	Cloud Algorithm PAL
Shuang Qiu	OSPO	JPSS Product Area Lead

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Enterprise Cloud Mask (ECM) Overview

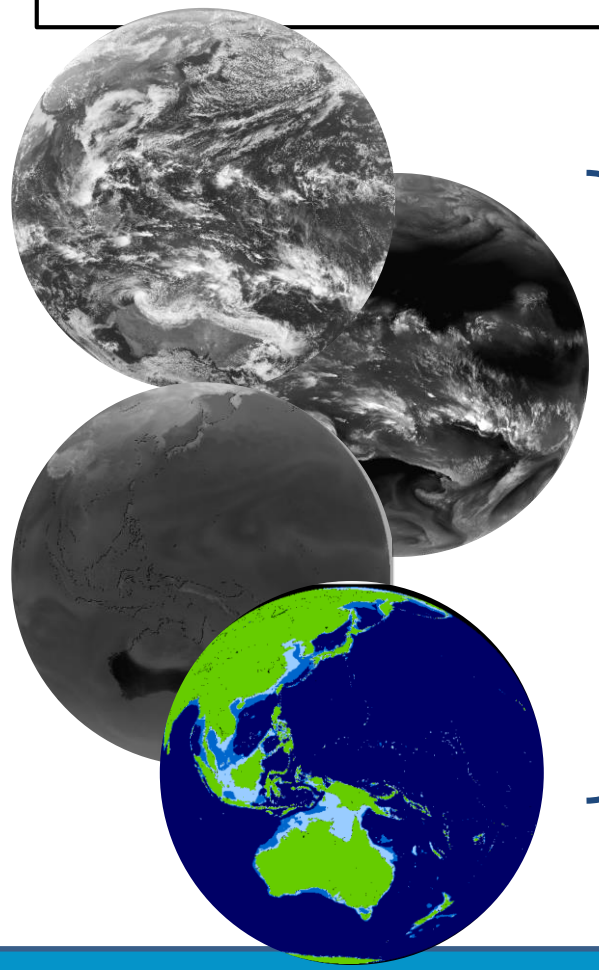
How The Enterprise Cloud Mask (ECM) Works

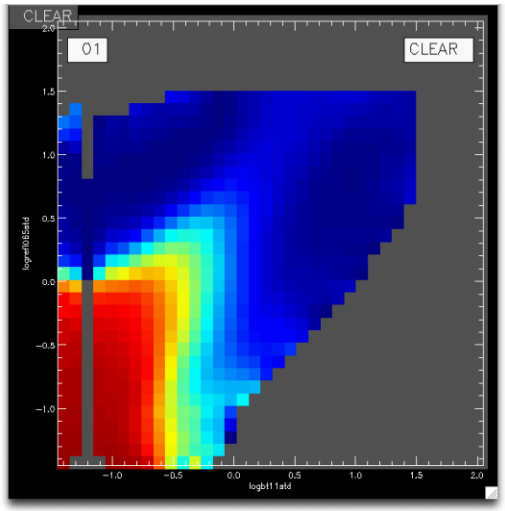
Input: Classifiers based on combinations of Reflectance, Brightness Temperature, Clear-Sky Estimates and Ancil Data

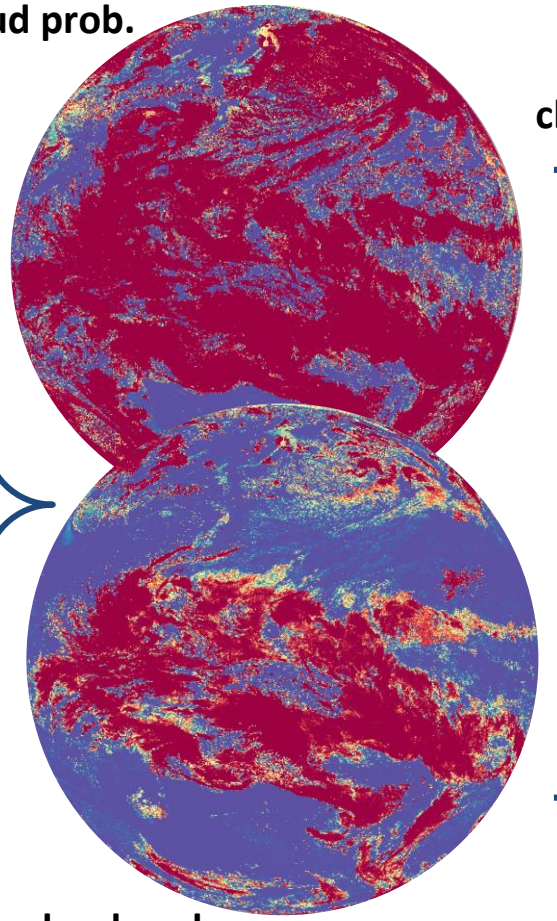
Algorithm: Look Up Tables **(**LUTs) for each Classifier for each surface for clear, water and ice cloud

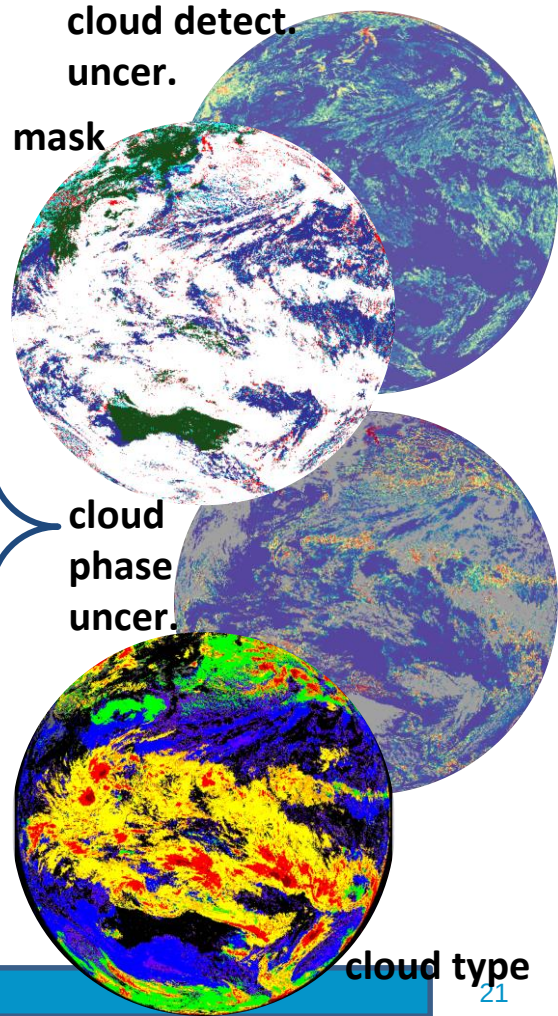
Fundamental Output:
Cloud Probability and Ice Cloud Probability + QC Bits

Derived Output:
Cloud Mask and Cloud Type + uncertainties



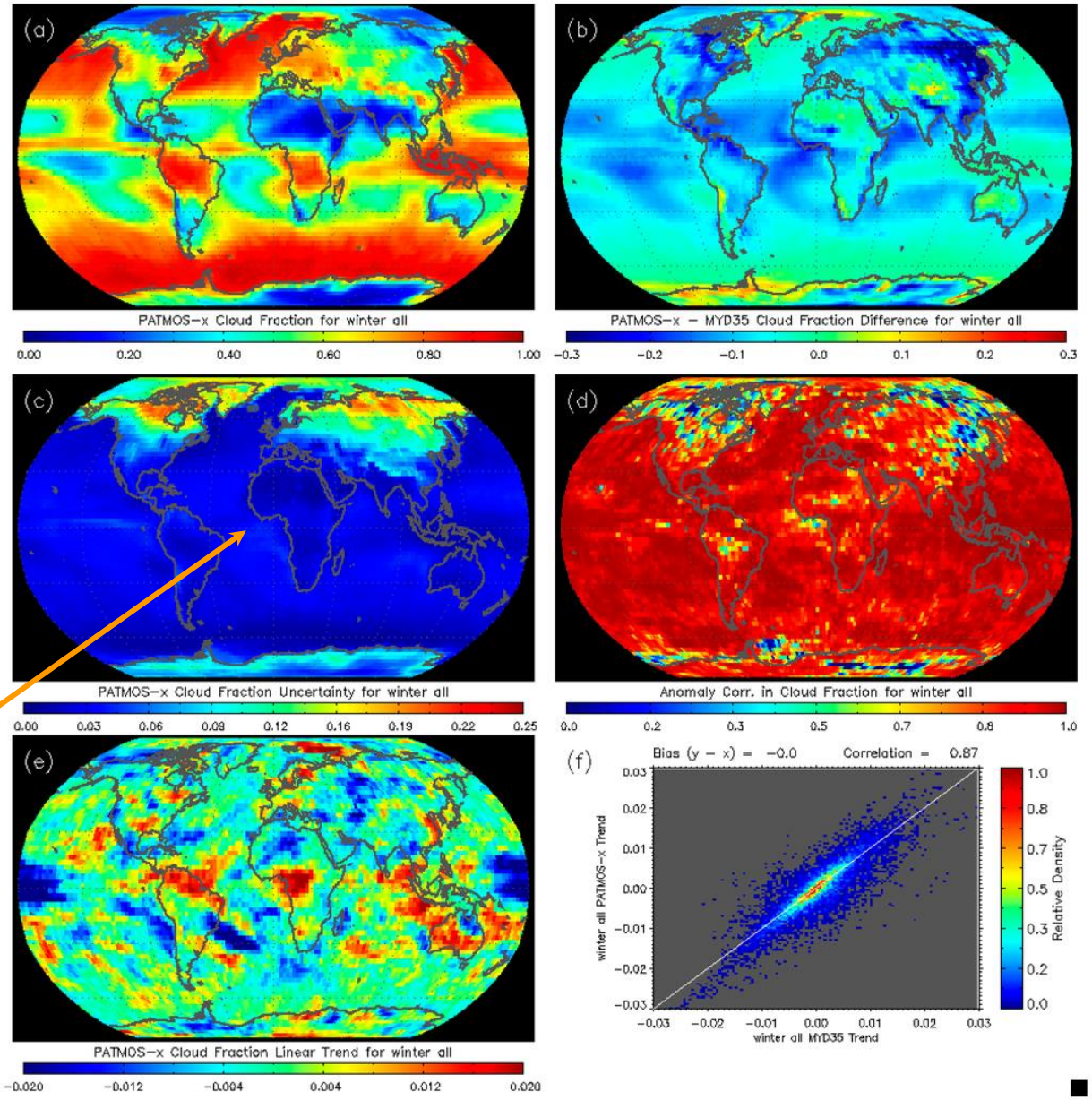






ECM Heritage

- ECM has run for years on AVHRR, GOES in OSPO and other sensors in STAR.
- PATMOS-x is a NOAA Climate Program that uses NOAA Enterprise algorithms to make climate records.
- These results show the NOAA Enterprise applied to the entire AQUA/MODIS record.
- Shows the nice stability in spatial and temporal variation.
- Shows the benefits of a probabilistic mask in that an uncertainty measure is provided.



Heidinger, Andrew; Foster, Michael; Botambekov, Denis; Hiley, Michael; Walther, Andi and Li, Yue. Using the NASA EOS A-train to probe the performance of the NOAA PATMOS-x cloud fraction CDR. Remote Sensing, Volume 8, Issue 6, 2016, doi:10.3390/rs8060511.

ECM Channels

- ECM uses everything except
  - M1-M4
  - M6
  - M8

- ECM version ***v3r2*** (applied to N21) utilizes DNB lunar reflectance to aid nighttime cloud detection

- Future LUTs will also utilize the I-Bands & stats within M-band (capability is currently available within the SAPF)

- Note - The SRF for NPP/N20 and N21 for the 11µm and 12µm BT channels are noticeably different.

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

Requirement Check List – VIIRS Cloud Mask

DPS	Requirement	Performance
DPS-435	The Cloud Mask product shall provide a cloud mask for the total cloud cover, globally whenever detectable clouds are present, at the refresh rates of the instrument.	
DPS-436	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing, averaged globally, of 87%.	
DPS-596	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over ocean of 92% in daytime, and 90% at night.	
DPS-597	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over snow-free land of 90% in daytime, and 88% at night.	
DPS-598	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over desert of 85% in daytime and at night.	
DPS-599	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over snow-covered land of 88% in daytime, and 85% at night.	
DPS-600	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over sea ice of 82% in daytime, and 72% at night.	
DPS-601	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over Antarctica and Greenland of 80% in daytime, and 70% at night.	

Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data
  - Ancillary Data
  - Upstream algorithms
  - Lookup Tables (LUTs) /Processing Coefficient Tables (PCTs)

Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data (per ATBD)
    - Calibrated solar reflectance % (0-100%) for 0.65 um channel and other VIS channels as needed by the LUT
    - Calibrated radiances (3.75, 10.3, and 11 um)
    - Calibrated brightness temps (BT) for all IR channels
    - Calibrated lunar reflectance % for VIIRS Day-Night Band (DNB)
    - Bad pixel mask for each channel
    - Space mask
    - Derived 3.75 um channel emissivity
    - 3.75 um channel solar energy
    - Sensor viewing zenith angle
    - Relative azimuth angle
    - Glint zenith angle
    - Scattering angle
    - Cosine of sensor, satellite, and solar zenith angles
    - Number of lines and elements for the given segment

Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data
  - Ancillary Data (per ATBD)
    - Surface type/elevation
    - MODIS land mask
    - Coast mask
    - Snow mask
    - Surface emissivity
    - Ocean glint mask
    - Daily SST
    - NWP surface temperature & uniformity
    - Clear-sky IR Radiative Transfer Model (RTM) calculations
    - Clear-sky reflectance
    - IR valid pixel mask
    - Derived top of the tropopause emissivity
    - Max/min/standard deviation of IR resolution 0.65 um reflectance
    - Max 10.3 and 11 um BT

Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data
  - Ancillary Data
  - Upstream algorithms
  - LUTs / PCTs

NOAA Enterprise Cloud Algorithms

Cloud Probability/ Mask

Cloud Cover Layers

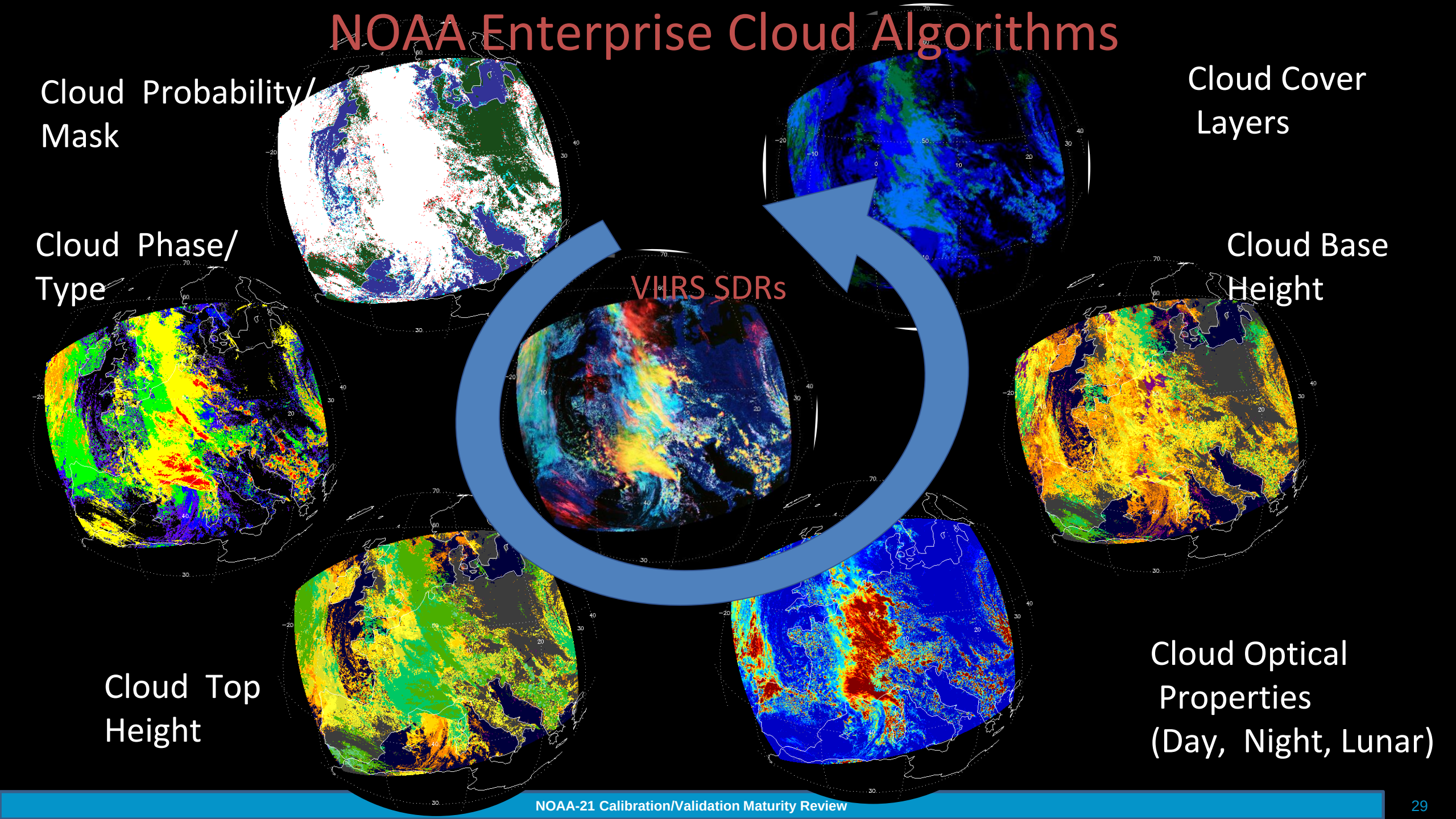
Cloud Phase/ Type

VIIRS SDRs

Cloud Base Height

Cloud Top Height

Cloud Optical Properties (Day, Night, Lunar)



Algorithm Inputs

- Required Algorithm Inputs
  - Primary Sensor Data
  - Ancillary Data
  - Upstream algorithms
  - LUTs / PCTs
    - Large LUT
    - 1D, 2D, 3D classifiers
      - btd (BT difference between various channel combinations)
      - std (standard deviation of a 3x3 array centered on the pixel)
      - etropo (emissivity referenced to tropopause)
      - ref (reflectance)
      - e.g., “bt11_btd3811_night” = Night + 11 um BT + 3.8-1.1 um BT difference
      - Exact classifiers used by a given sensor are dynamic and can change based on LUT updates
    - Surface type and other static ancillary data

ECM Training for NOAA-21

- Training of each sensor is a several step process:
  - ➢ Creating collocation files of SDR VIIRS with CALIOP cloud level-2 product.
  - ➢ Processing VIIRS files to EDR level.
  - ➢ Creating an IDL *.sav file, which will contain all necessary information.
  - ➢ Running IDL tools that create ECM LUT.

- Each sensor has to be trained individually because they have unique characteristics (channel degradation, etc.). Until NOAA-21 VIIRS ECM training is completed, LUT from S-NPP/N20 VIIRS ECM will be used.

- Creation of a new ECM LUT requires at least 1 year worth data set (optimally).

- **Considering NOAA-20 + SNPP LUT to accelerate the process, but requires calibration homogenization.**

Enterprise Cloud Mask Status

ECM Deliveries

- Current Operational Version (NPP, NOAA-20)
  - April 2019 Delivered Algorithm Package (DAP)

- Current Integration & Testing (I&T) Version (NPP, NOAA-20, NOAA-21)
  - January 2020 DAP
  - No code changes from previous DAP delivery
  - Contains SAPF tuned LUT
    - Includes the usage of the Lunar Reflectance from the DNB.
  - ECM Algorithm - Enterprise Cloud Mask Algorithm v2.2.0
  - Processing Version tag: v3r2
  - New lookup and science code currently being worked on for Validated status maturity level

Sensor Data Record (SDR) Issues

SDR Issues at BETA Review

- No issues seen in the sensor data aside from known NPP/NOAA-20/NOAA-21 spectral response function (SRF) differences.

- New LUT will be verified after it is generated.

ECM Evaluation

Evaluation Methodology

- Independent sources were chosen that allow qualitative and quantitative performance analyses over a short time period.

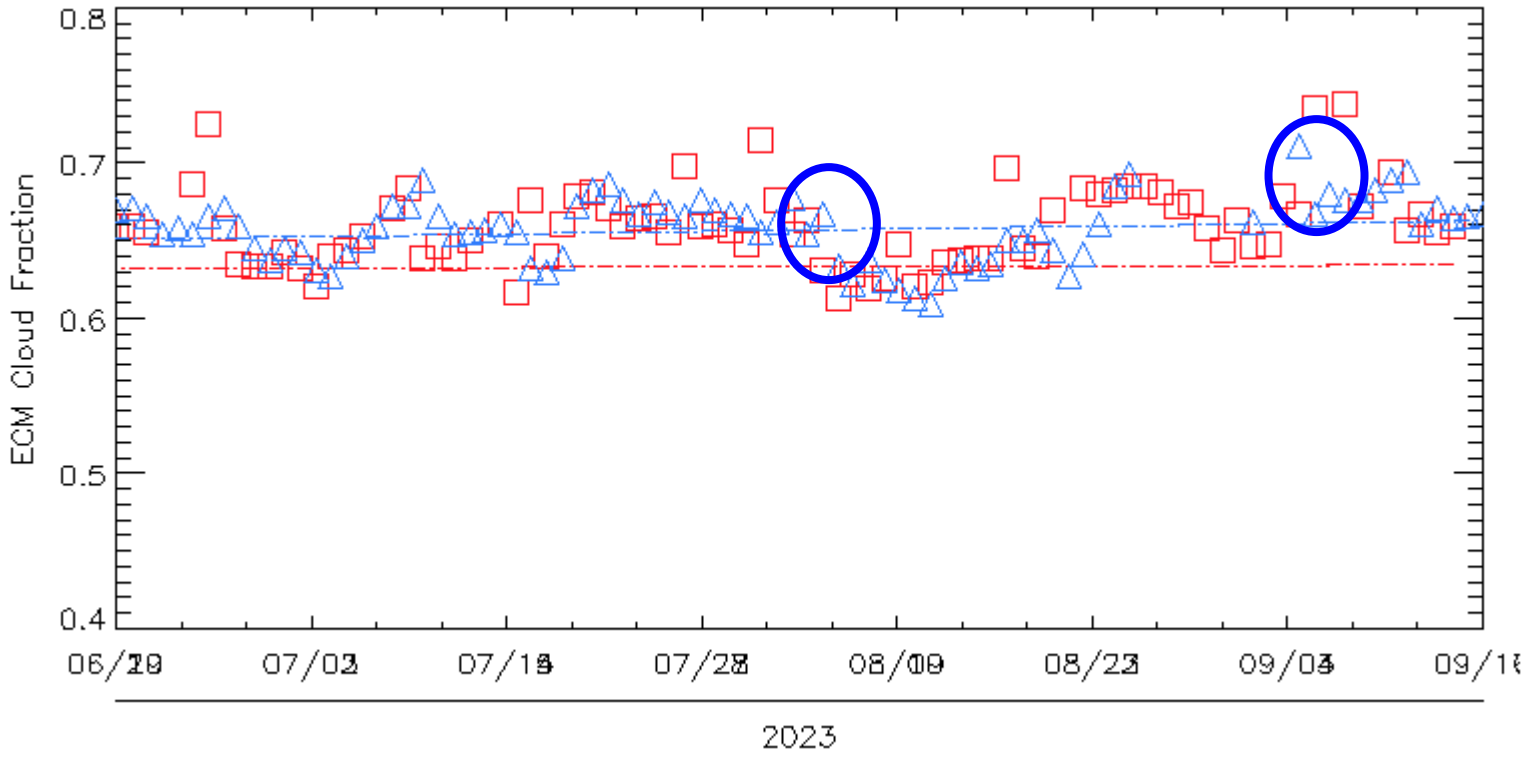
- OPS-specific issues are diagnosed by ECM generated by local CLAVR-x processing

- Specific Evaluation Methodology:
  1) Visual inspection of OPS ECM against CLAVR-x ECM (Qualitative)
  2) NDE Global Cloud Fraction comparisons: SNPP, NOAA-20, NOAA-21 (Quantitative)
  3) Validation against NASA CALIPSO/CALIOP (Quantitative - Gold Standard Truth)
  4) Validation against NASA MODIS cloud products

Data Used in this Analysis

- NOAA-21/20/NPP OPS v3r2 and CLAVR-x from May/June, 2023.
- NOAA-21/20/NPP OPS v3r2 May 16-June 14, 2023 (Long-term monitoring quick looks)
- NASA AQUA/MODIS Collection 6.1 from two weeks in May/June, 2023.
- CALIPSO Comparison: 9 days in May/June, 2023.

NOAA-20, NOAA-21 Cloud Fractions (Ascending Mode)



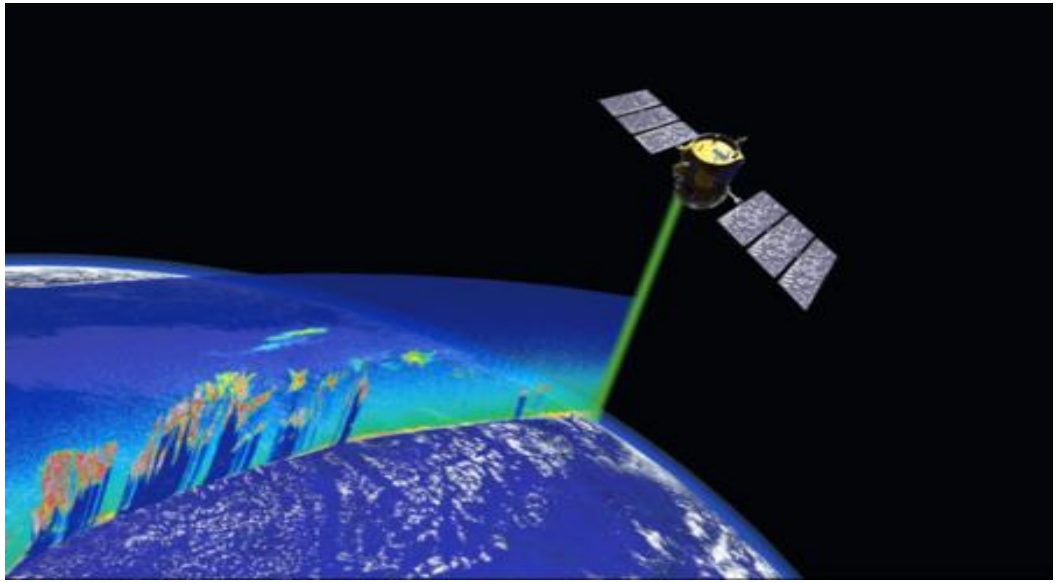
Limited NOAA-21 Data

https://cimss.ssec.wisc.edu/clavrx/realtime-products/viirs/viirs-cloud-product-trends/

Comparison to CALIPSO/CALIOP

CALIOP Comparison Description

- CALIOP is a lidar onboard of CALIPSO.
- **CALIOP Cloud algorithm results are considered as “Truth”.**
- 9 days of CALIOP and NOAA-21 Matchup data are used from May and June, 2023.
- Filters applied to NOAA-21:
  - Scan time difference ± 15 minutes,
  - Sensor Zenith Angle < 80.0.
- Filters applied to CALIOP:
  - 90N - 90S,
  - COD = 0.0 or > 0.4,
  - 5km cloud fraction 0 or 1 (to avoid edges of cloud).



Validation of NCCF NOAA-21 ECM (1)

Algorithm	Sample size	Cloud Fraction				Required Detection	Probability of		
		CALIOP	VIIRS N21	Pr. Clear	Pr. Cloudy		Correct Detect.	False Detect.	Missed Cloud
Global, Ocean/Land, Day/Night, No Snow & Ice									
ECM NCCF	170863	0.825	0.851	0.033	0.037	0.870	0.928	0.049	0.023
ECM CLAVR-x	170860	0.825	0.869	0.037	0.032	0.870	0.929	0.057	0.013
Global, Ocean, Day, No Snow & Ice									
ECM NCCF	59608	0.810	0.850	0.017	0.032	0.920	0.919	0.061	0.020
ECM CLAVR-x	59607	0.810	0.852	0.023	0.027	0.920	0.923	0.060	0.018
Global, Ocean, Night, No Snow & Ice									
ECM NCCF	43963	0.945	0.969	0.010	0.016	0.900	0.964	0.030	0.006
ECM CLAVR-x	43963	0.945	0.979	0.007	0.019	0.900	0.958	0.038	0.004

Validation of NCCF NOAA-21 ECM (2)

Algorithm	Sample size	Cloud Fraction				Required Detection	Probability of		
		CALIOP	VIIRS N21	Pr. Clear	Pr. Cloudy		Correct Detect.	False Detect.	Missed Cloud
Global, Land, Day, No Snow & Ice									
ECM NCCF	67050	0,.762	0.775	0.062	0.055	0.900	0.913	0.050	0.037
ECM CLAVR-x	67048	0.762	0.812	0.070	0.044	0.900	0.917	0.067	0.016
Global, Land, Night, No Snow & Ice									
ECM NCCF	242	0.343	0.492	0.144	0.107	0.880	0.835	0.157	0.008
ECM CLAVR-x	242	0.343	0.591	0.198	0.169	0.880	0.736	0.256	0.008

Explanation for the land/night validation: compared to other categories, there are very limited matchup data for night only over land. This causes fluctuations in the stats. For instance, for the Beta review, there were only 82 samples which showed high correct detection percentage but also unrealistic results such as false detection of 0 and total cloud fraction of 1.

Conclusions from CALIPSO Comparisons

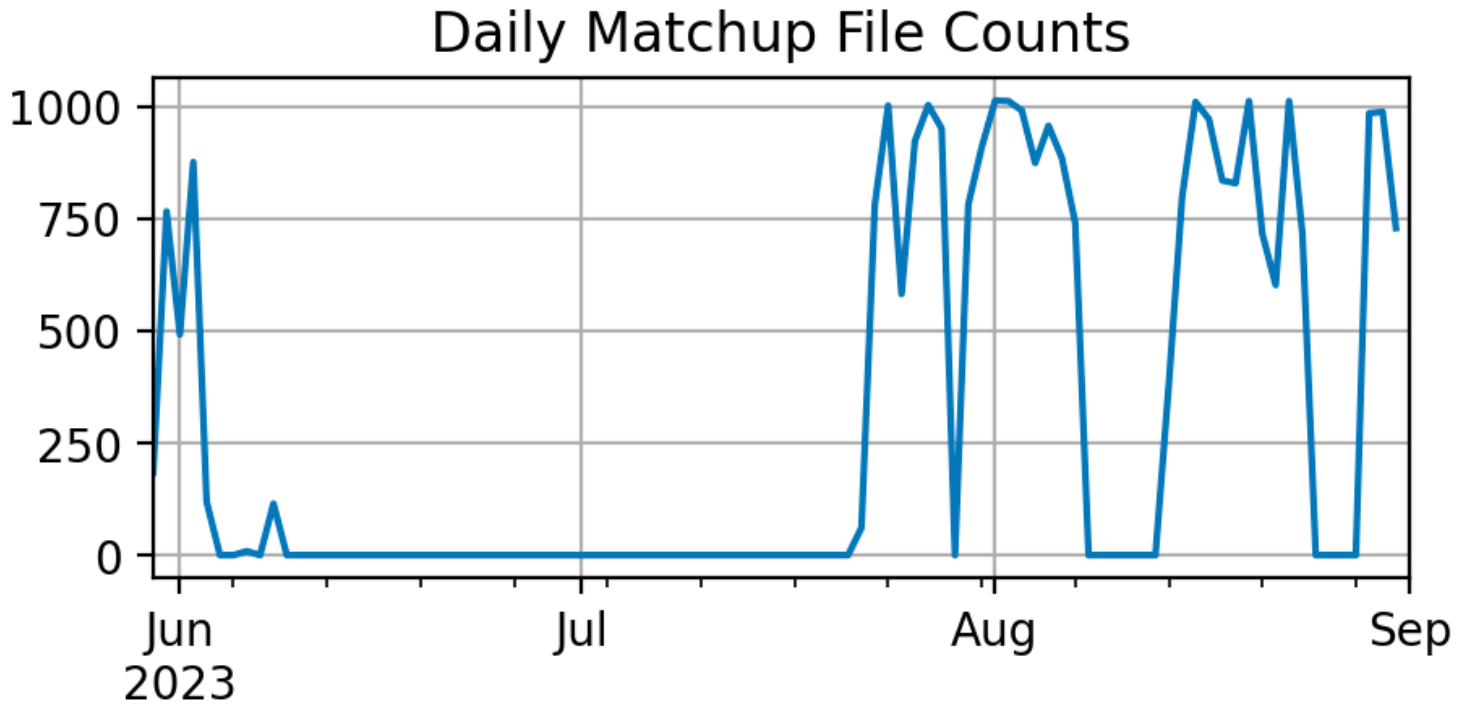
- NDE/OPS ECM performs well globally
- Surface type and day versus night comparisons also excellent
- Nighttime land comparisons are only category (slightly) below validation specs
- Limited dataset caveat applies

NOAA-21 & NOAA-20 Matchup

VIIRS Train

Current orbit configuration has NOAA-21 about 20 minutes behind NOAA-20

The following analysis is based on boreal summer data

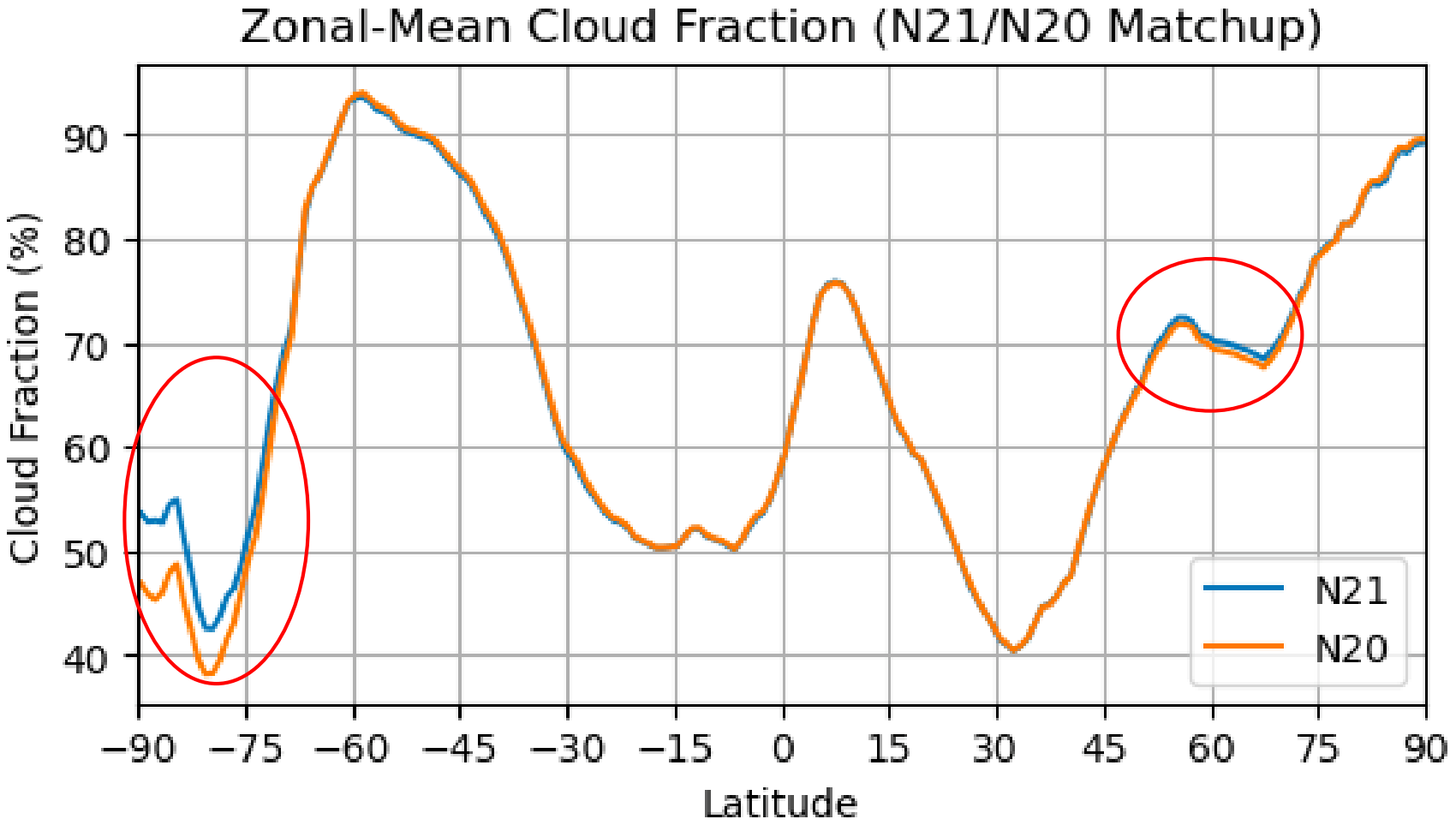


NOTE:
after NOAA-21 is fully commissioned the configuration will change to NOAA-21, Suomi NPP, NOAA-20

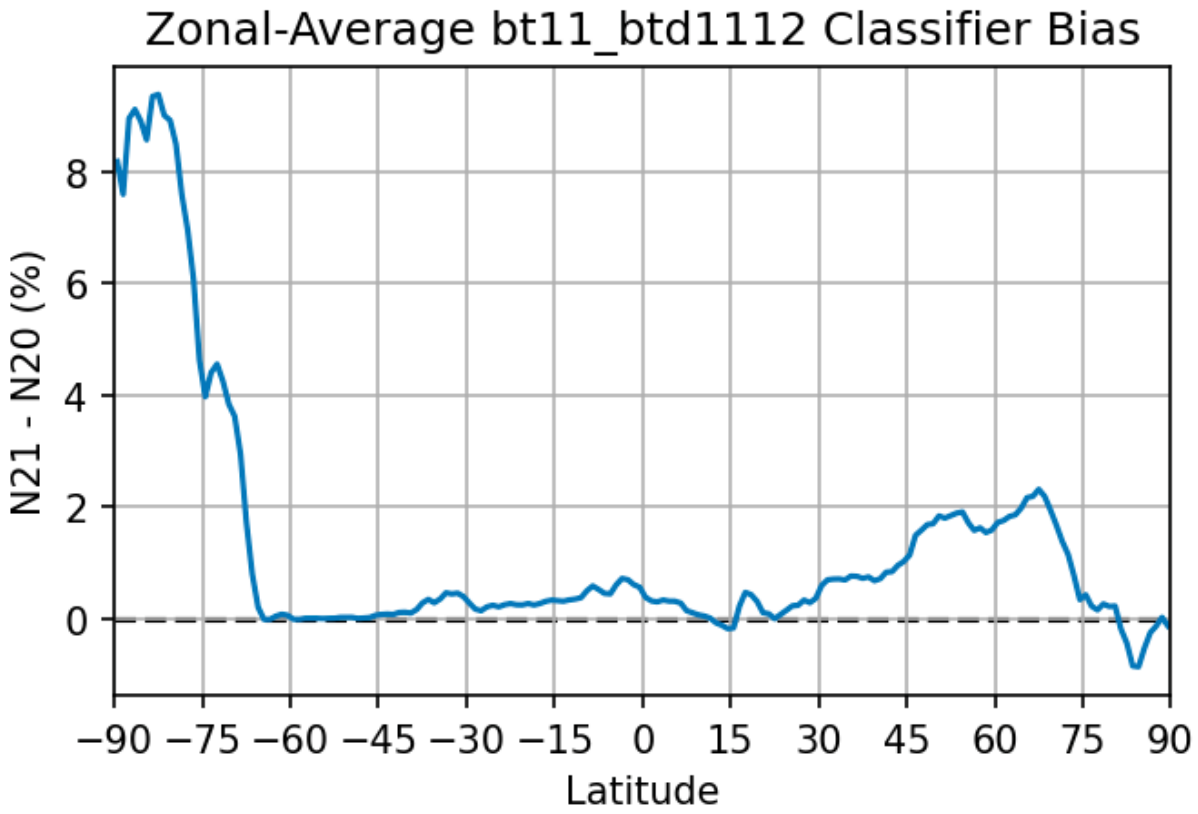
Zonal-Mean Cloud Fraction

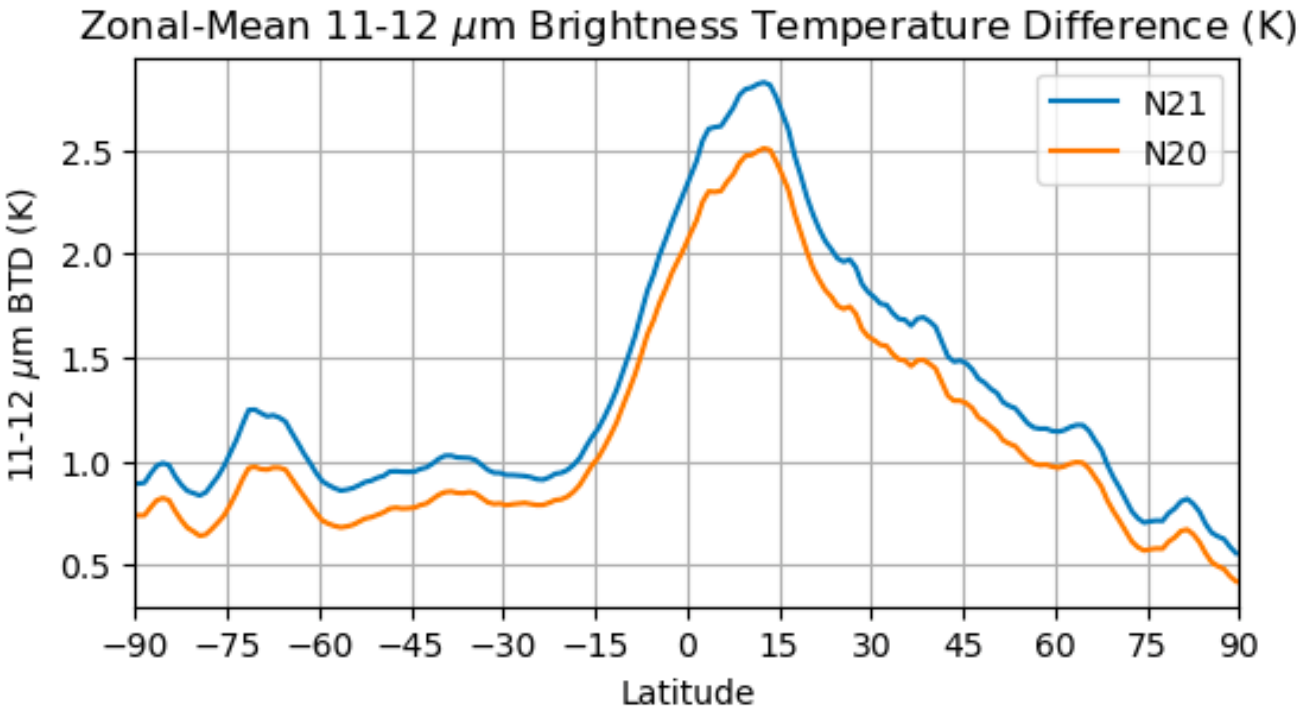
The (summer) cloud fraction is very similar between NOAA-21 and NOAA-20

EXCEPT in the **Antarctic** where average cloud fraction is **~10% higher**



Cloud Detection Bias Traceable to Single Feature (11-12μm Brightness Temp Diff.)

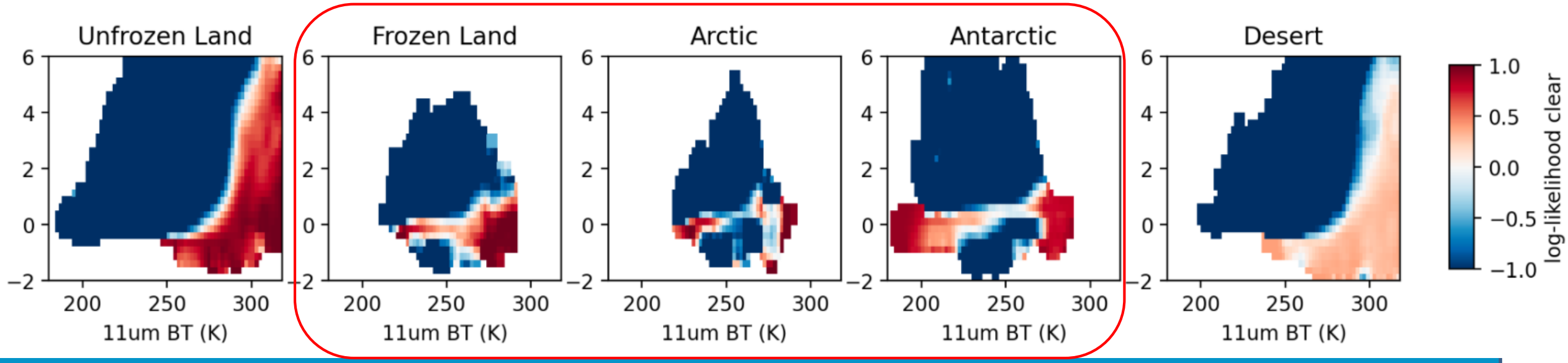




Why is only the Antarctic affected?

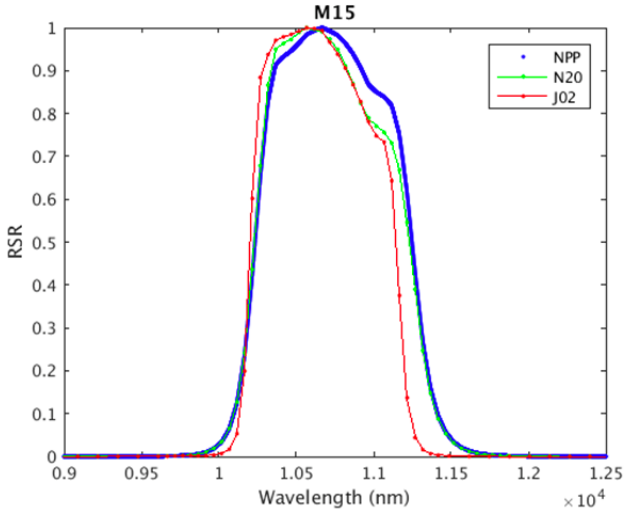
1. bt11_btd1112 is *only enabled over land*
2. It is 1/15 classifiers over Unfrozen Land, but only 1/11 over Antarctic
3. 11-12µm BTD is relied upon much more over Frozen Land, Arctic, and Antarctic

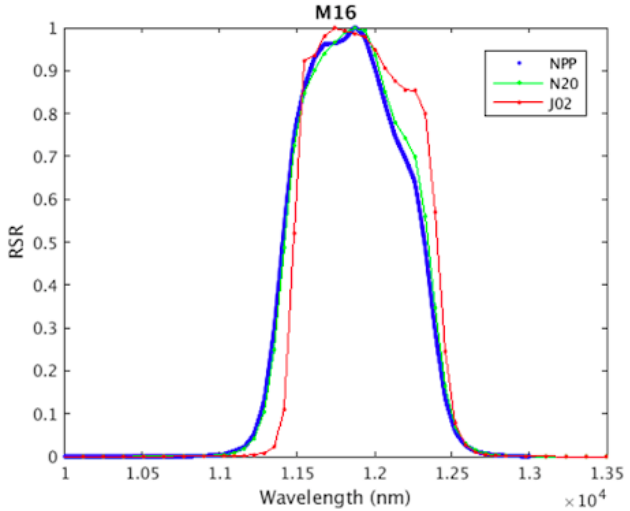
It's quite possible that performance will deteriorate over NH land this winter



N21/N20 Matchup Summary

- Cloud mask is very similar, except in the Antarctic regions
- The differences in the Antarctic can be traced to differences in the NPP/N20 and N21 11-12µm BT difference
- The Cloud team consulted with VIIRS SDR team and they agreed that the most likely source of difference was due to the spectral response differences between NOAA-20 and NOAA-21 (shown below)
- This most affects land and polar night likely exacerbates the cloud fraction bias, may get better this winter
- Best s[illegible]g N21 data

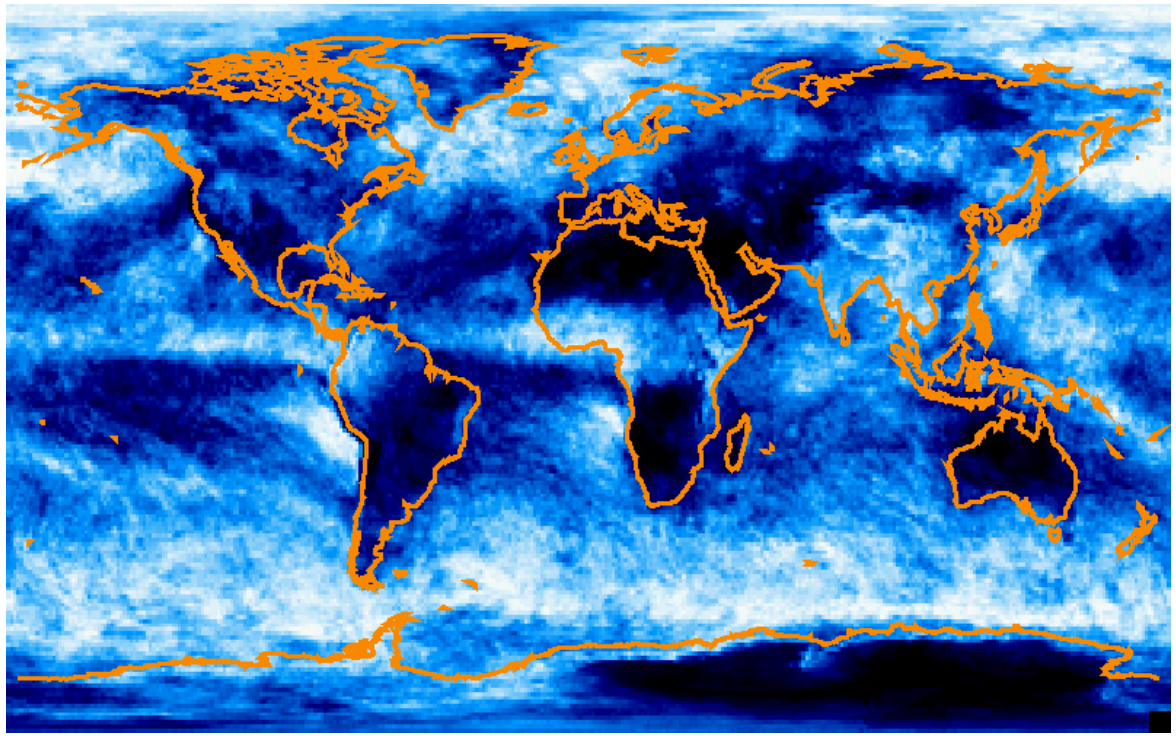


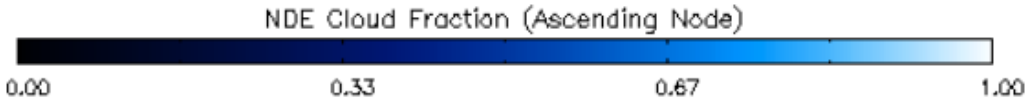


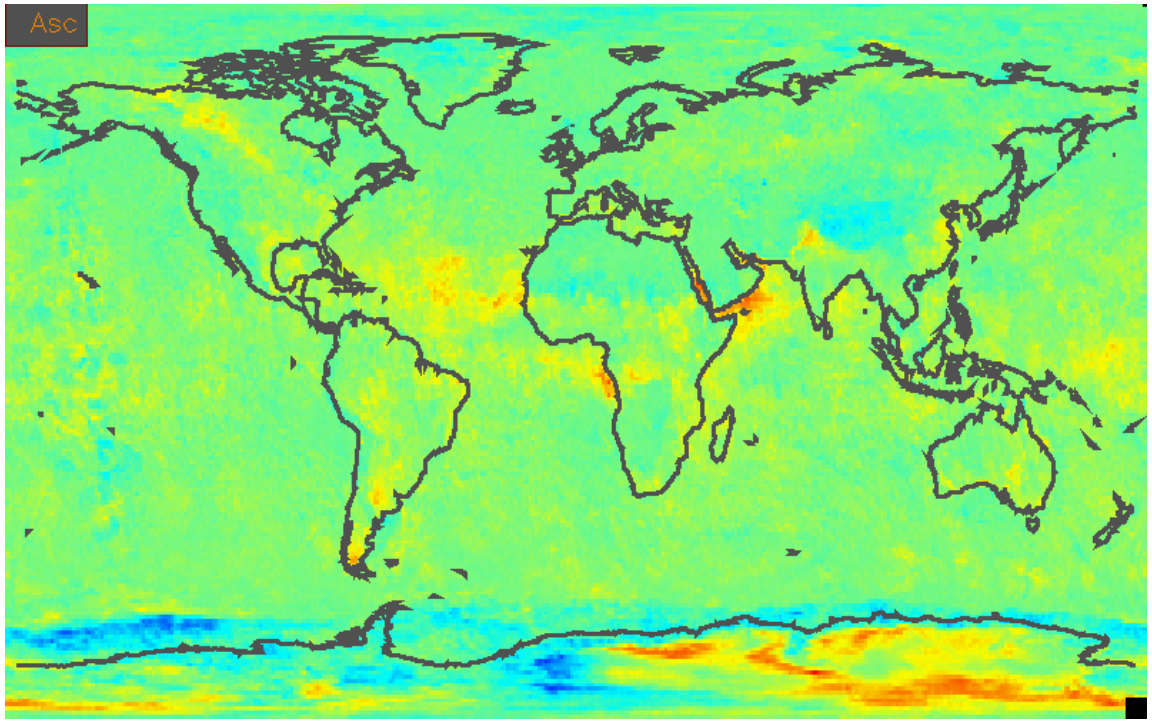
Images courtesy of NOAA VIIRS Cal/Val Team

Comparison to AQUA/MODIS Collection 6.1

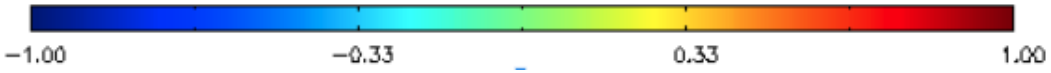
Cloud Fraction Ascending Node







Difference between MODIS and NOAA-21 NCCF

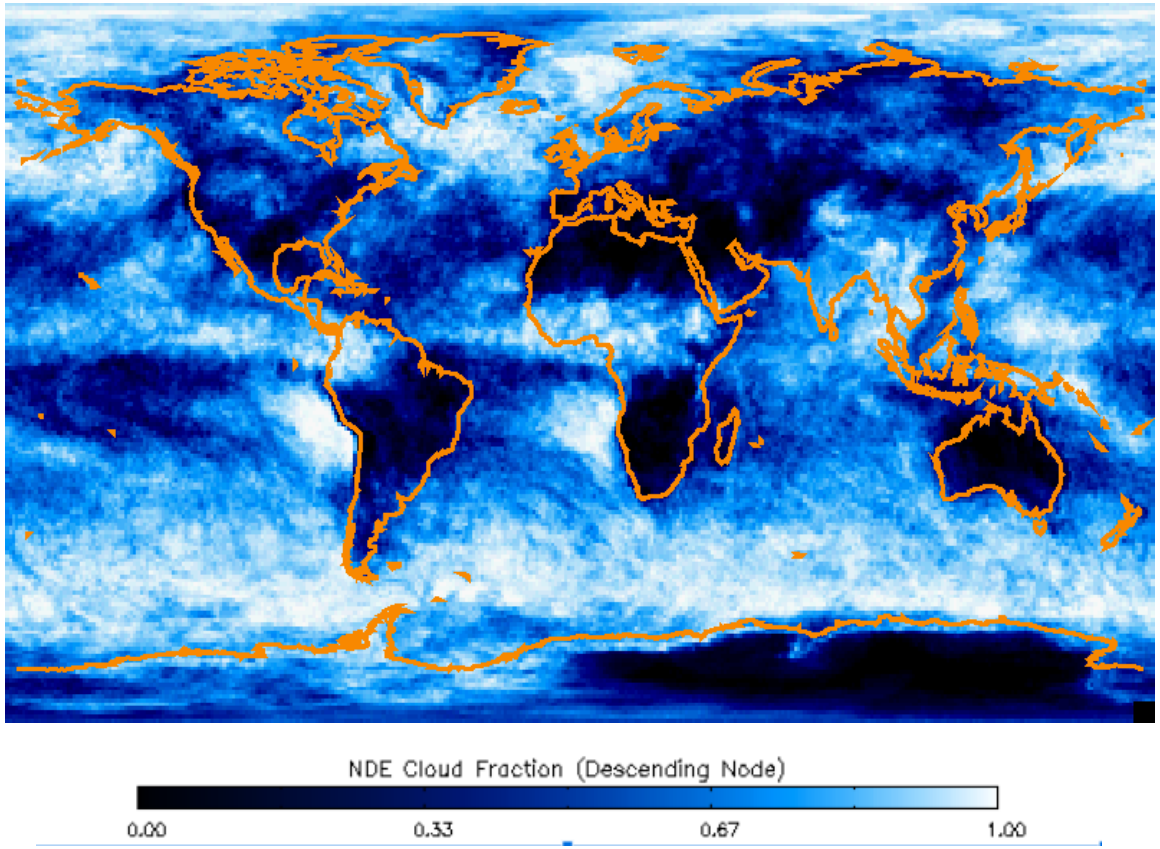


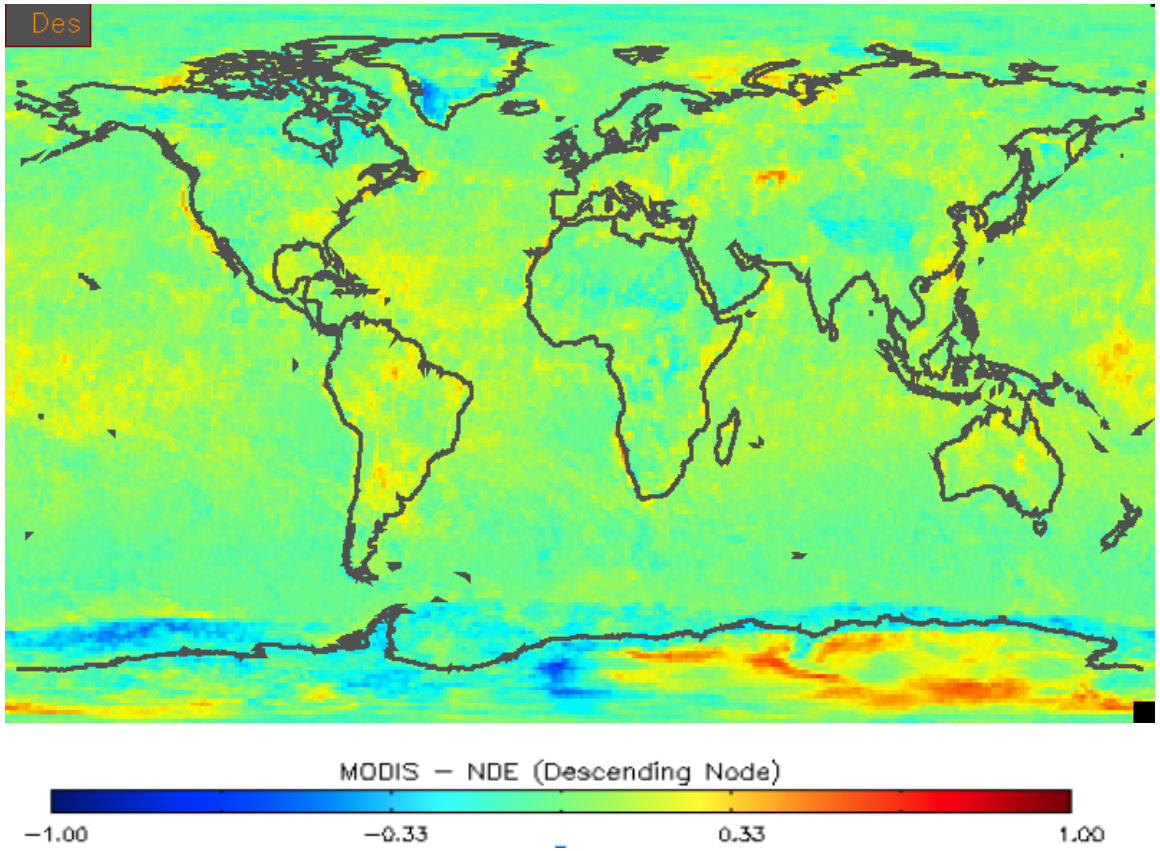
Red = Cloud Observed by MODIS but Missed in NCCF N21.

Blue = Cloud Observed by NCCF but Missed in MODIS.

Green = Good Agreement.

Cloud Fraction Descending Node





Red = Cloud Observed by MODIS but Missed in NCCF N21.

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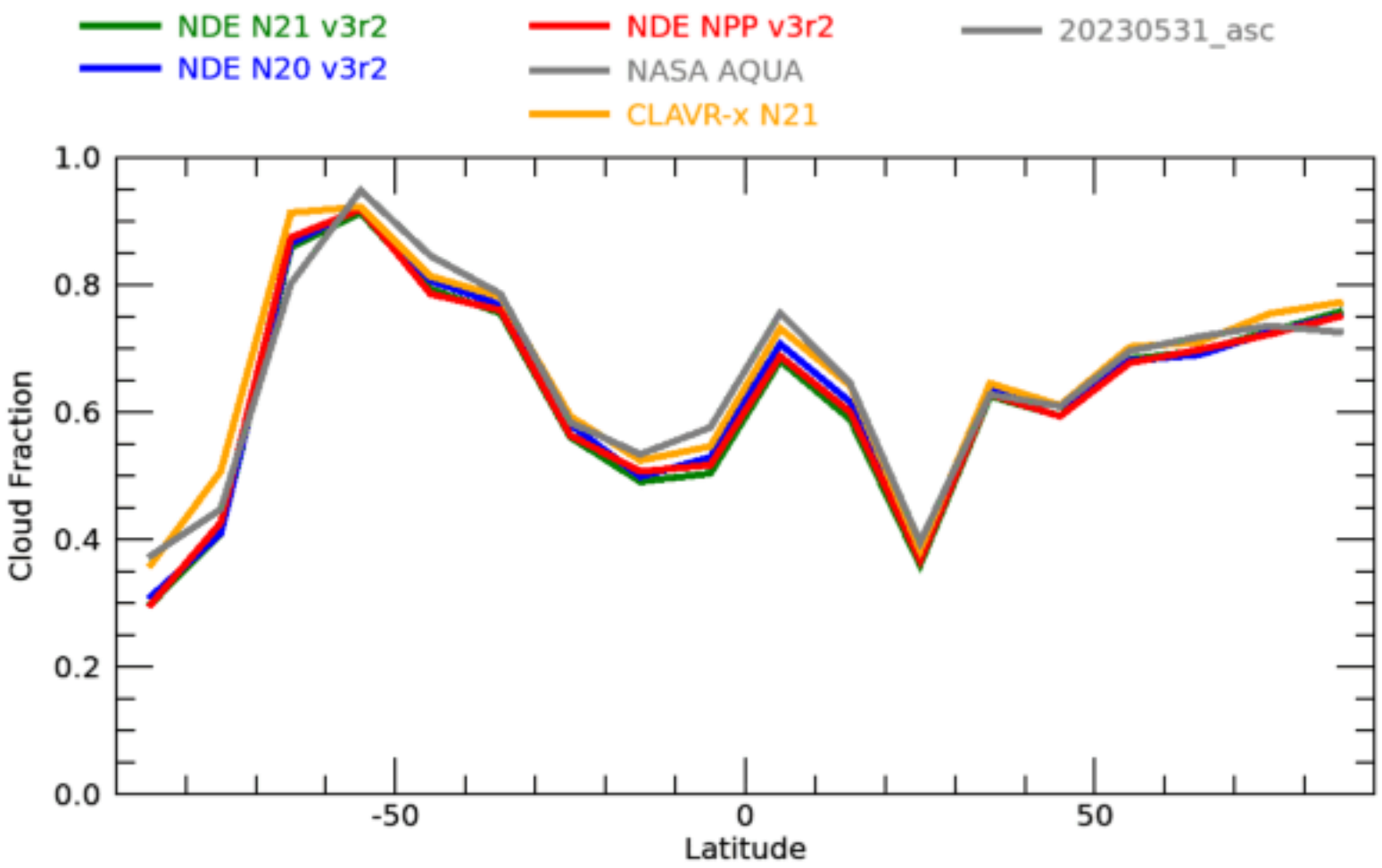
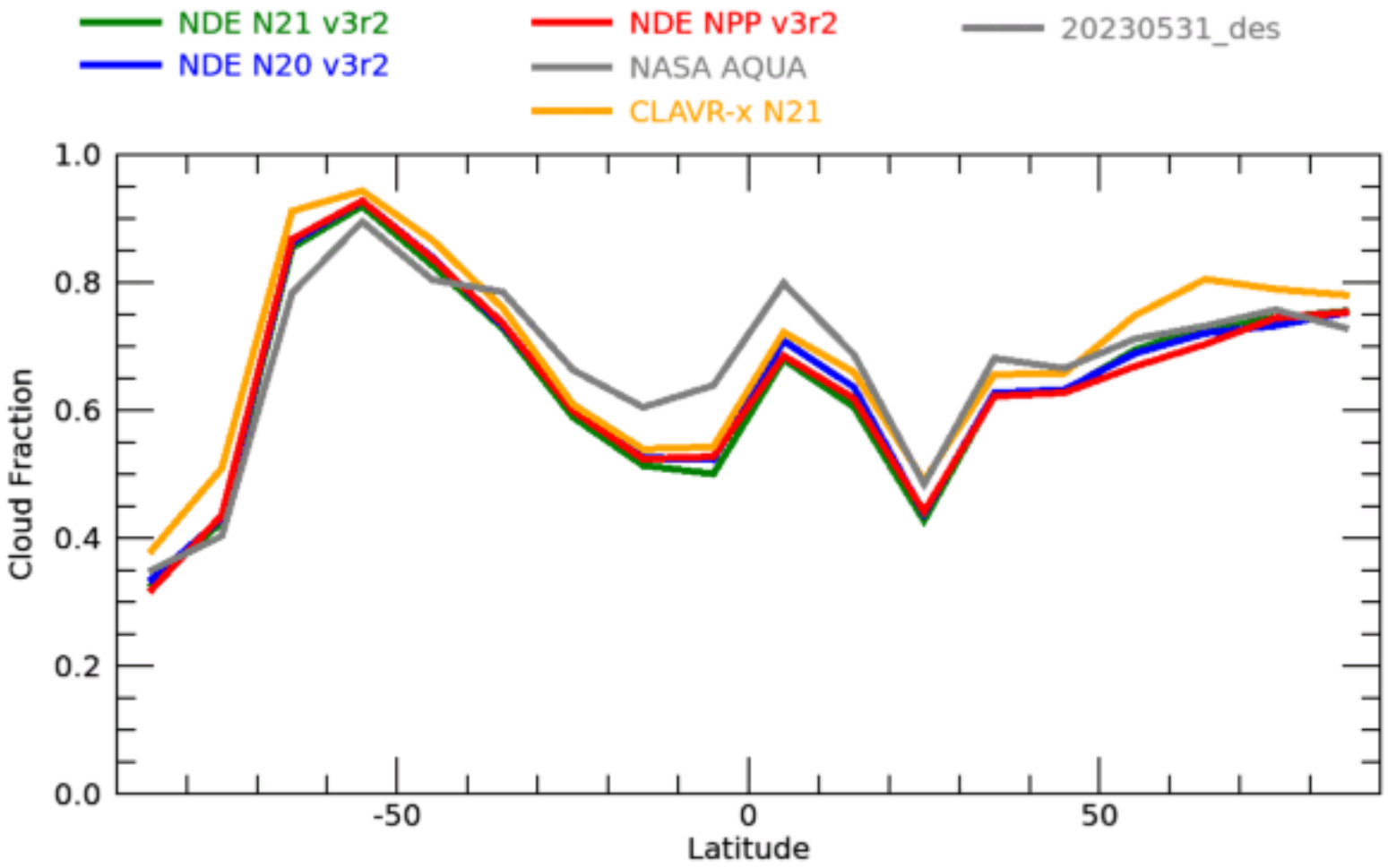
Cloud Fraction Zonal (Ascending)



Cloud Fraction Zonal (Descending)



Statistics: Global

Global mean cloud fraction [%]

	NCCF N21	Clavr-x N21	NCCF N20	Clavr-x N20	NCCF NPP	Clavr-x NPP	Clavr-x Aqua	MODIS C6 Aqua
Ascending	64.0	66.4	63.6	66.7	63.4	66.5	73.2	67.4
Descending	65.1	68.4	65.0	68.7	64.5	68.4	75.0	69.5

Statistics: 60ºN - 60ºS

Mean cloud fraction [%]

	NCCF N21	Clavr-x N21	NCCF N20	Clavr-x N20	NCCF NPP	Clavr-x NPP	Clavr-x Aqua	MODIS C6 Aqua
Ascending	62.8	65.0	62.8	64.7	62.7	65.0	70.0	67.7
Descending	64.4	67.5	65.0	67.7	64.3	67.9	72.9	70.5

Conclusions from MODIS Comparisons

- Comparisons with Aqua MODIS were conducted using two weeks of data
- NOAA-21 ECM (NCCF/NDE) performs similarly to CLAVR-x and MODIS in non-polar regions.
- Similar to the Beta review, differences are greatest over the Antarctic region. This is likely due the the SRF issues previously noted. However, cancellation effects over different regions reduce the differences in zonal averages.

Requirement Check List – VIIRS Cloud Mask

DPS	Requirement	Performance
DPS-435	The Cloud Mask product shall provide a cloud mask for the total cloud cover, globally whenever detectable clouds are present, at the refresh rates of the instrument.	✓
DPS-436	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing, averaged globally, of 87%.	✓
DPS-596	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over ocean of 92% in daytime, and 90% at night.	✓
DPS-597	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over snow-free land of 90% in daytime, and 88% at night.	✓
DPS-598	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over desert of 85% in daytime and at night.	✓
DPS-599	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over snow-covered land of 88% in daytime, and 85% at night.	✓
DPS-600	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over sea ice of 82% in daytime, and 72% at night.	✓
DPS-601	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing over Antarctica and Greenland of 80% in daytime, and 70% at night.	✓

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

ECM Users

- Downstream Enterprise Clear-Sky Applications.
- Enterprise Cloud Algorithms.
- NCEP VIIRS/CrIS Radiance Assimilation.
- VIIRS Polar Winds.
- Potential External ECM Users.

ECM User Feedback

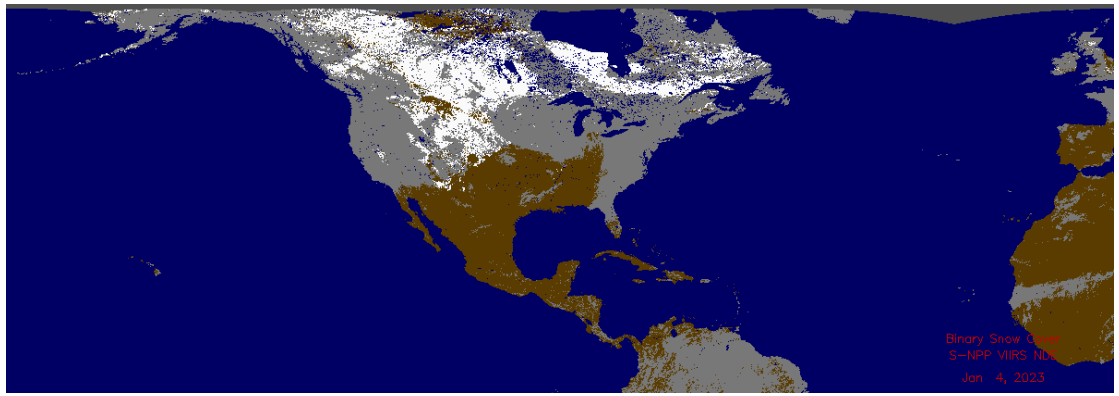
- Downstream cloud products meet Beta/Provisional Maturity specifications
  - Cloud Top Phase
  - Cloud Top Properties (Height, Pressure, Temperature)
  - Cloud Base Height
  - Cloud Cover Layers

- Non-cloud downstream products meet Beta and/or Provisional Maturity specifications
  - Sea Surface Temperature
  - Aerosol products
  - Cryosphere products

ECM User Feedback

Cryosphere products:

- Difficulty identifying low stratus clouds over snow in NH winter (Dec, Jan, Feb).
- High latitudes (above 60N) primarily affected.
- Cold land surface and temperature inversions.
- Scenes labeled as clear-sky and is not recognized as "snow", it is assumed as "snow free" which causes gaps in the snow product (see below).
- **Since there has been no change since Beta, the Cryo team has no new comments**

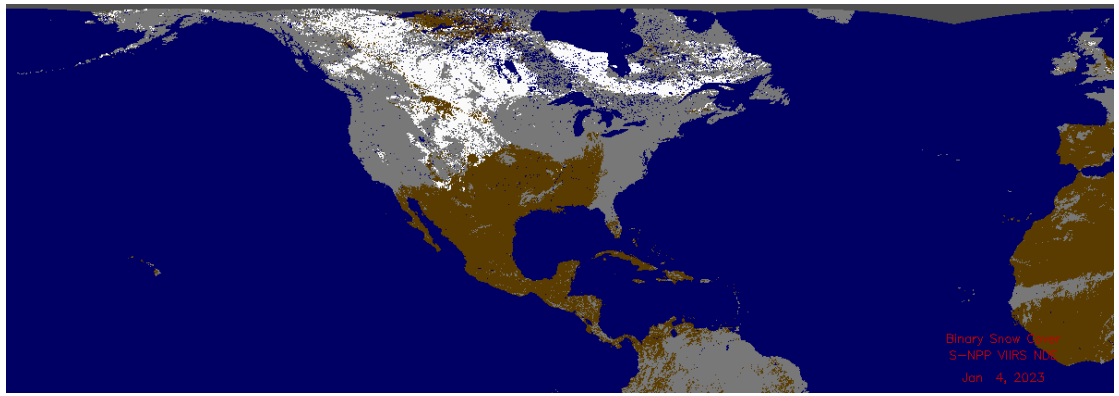


White = snow (cloud free)
Gray = cloudy

ECM User Feedback

Cryosphere products:

- Difficulty identifying low stratus clouds over snow in NH winter (Dec, Jan, Feb).
- High latitudes (above 60N) primarily affected.
- Cold land surface and temperature inversions.
- Scenes labeled as clear-sky and is not recognized as "snow", it is assumed as "snow free" which causes gaps in the snow product (see below).
- **Since there has been no change since Beta, the Cryo team has no new comments**
- Cloud Team will work with users to address ECM-related issues
- Cloud Team encourages users to derive application-specific cloud probability thresholds



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- Conclusion
- Path Forward

Documentations

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes#
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)	Yes

Check List - Provisional Maturity

Provisional 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.	✓
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.	✓

Pathway to Validated Maturity

- Same activities will be conducted for Validated Maturity:
  - Archive of golden days is being compiled
    - SDRs and EDRs.
  - Engage other teams begin application-specific analyses.
  - Take advantage of opportunities for threshold adjustments (updated code and LUTs)
    - **Current LUT meets spec, however, SRF differences in the 11µm and 12µm, NOAA-21 will need it's own LUT for best performance.**

Risks for Validated Maturity

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

- **I&T string and STAR data dropouts (Moderate)**
  - Lack of consistent global datastream over the full period may prevent necessary information needed for Validated Maturity validation
  - I&T string used to ensure latest code and LUTs are available.
- **CALIPSO/CALIOP Data Availability (High)**
  - Sensor at End of Life
- **Updated ECM LUT (Low)**
  - While not necessary to meet spec, the cloud team will be updating the ECM LUT for NOAA-21 due to N21 VIIRS SRF differences in anticipation of the Full Maturity Review.

Provisional Maturity Conclusions

- NOAA-21 ECM meets specifications, despite some differences with NPP/NOAA-20 ECM products

- Cloud Team recommends ECM **Provisional** maturity status.
  - A new NOAA-21 LUT will be developed to improve performance.

- Effective date: March 30, 2023

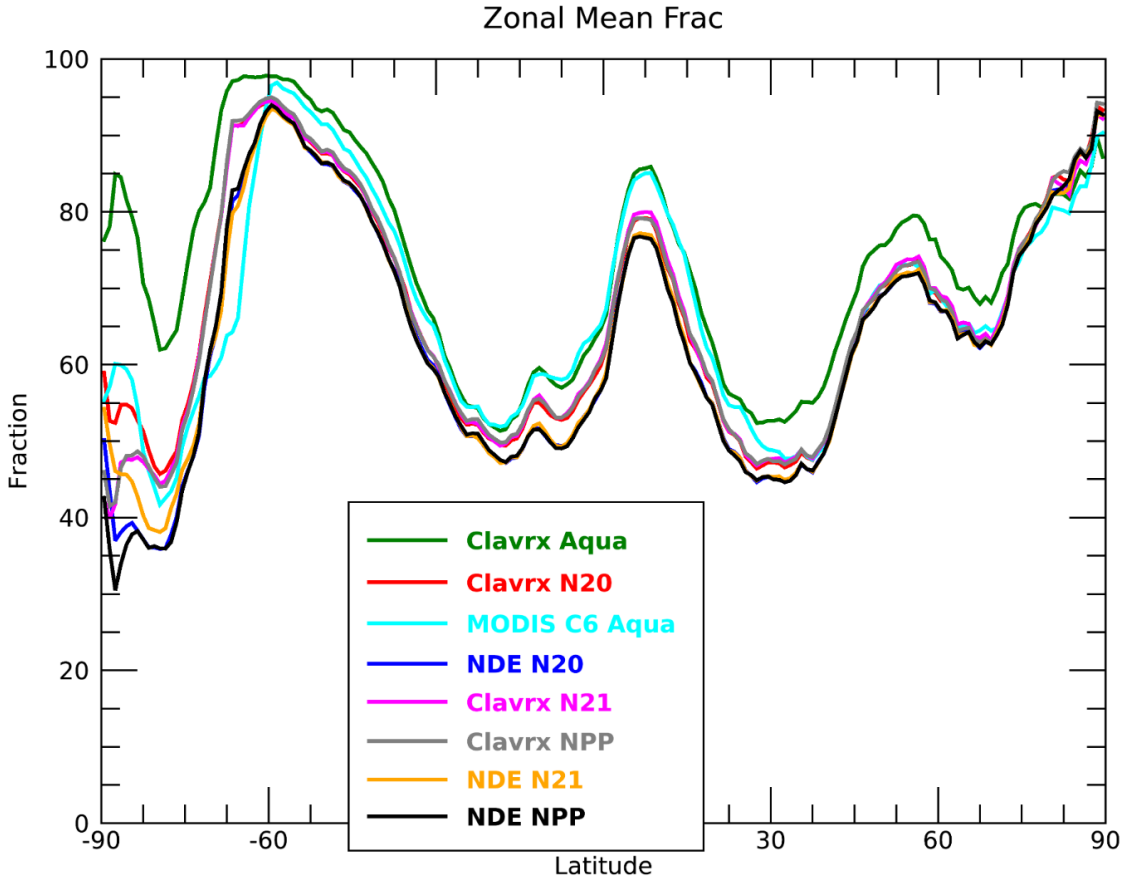
Future ECM Plans

- New LUT for VIIRS and ABI under development
  - The current ECM Lookup Table is planned to be updated later this year. A science code update will also occur to allow for added classifiers.
  - This update will also occur for GOES-R ABI at the same time

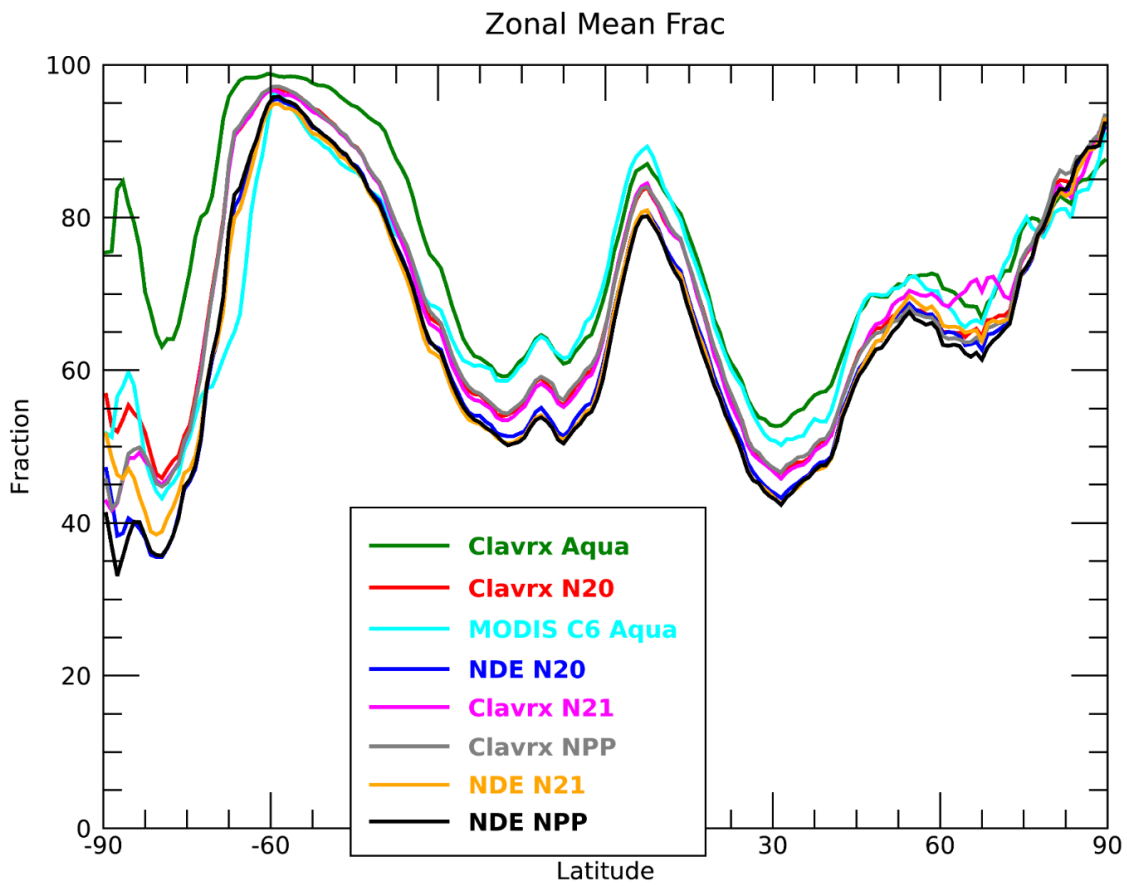
- ECM Team seeks feedback from its users on issues with the current table that can be addressed in the update.

Backup Slides

Backup Slides



Ascending



Descending

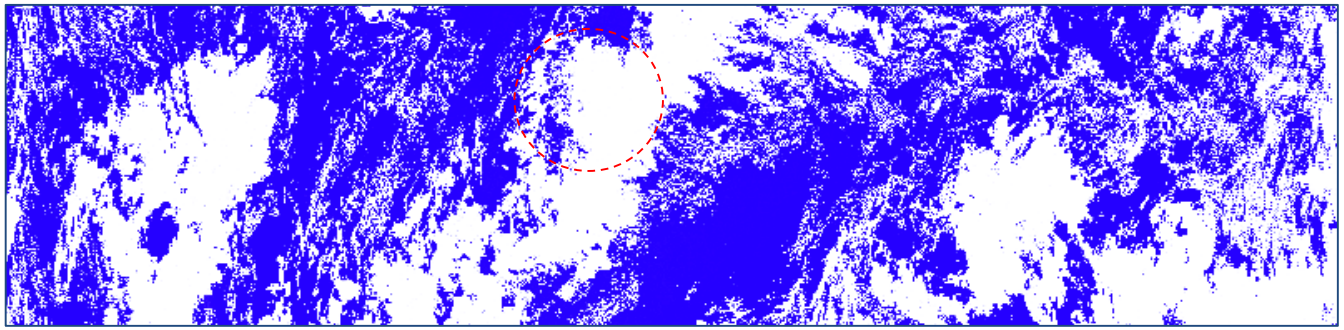
- Zonal mean cloud fraction using two weeks of data (May and June 2023)
- NCCF/NDE NOAA-21 is consistent with the other Enterprise products.

Visual Comparisons with CLAVR-x

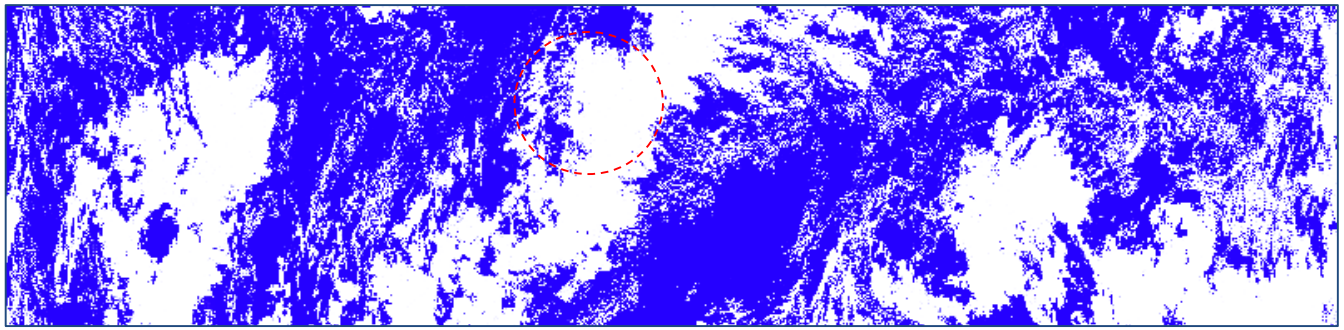
- Qualitative quick glance analysis
- Verify that ECM integrated correctly in NCCF/OPS environment
- Any easily discernible differences?

Day Ocean

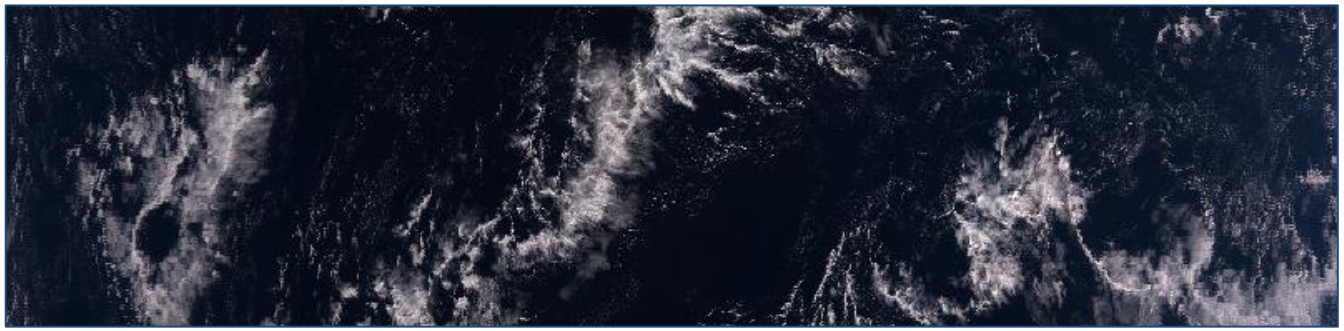
NOAA-21 2023-05-31 22:11



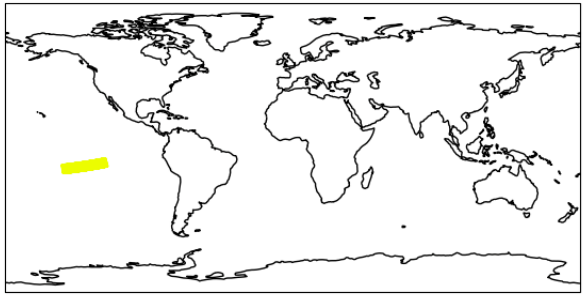
CLAVR-x



NCCF



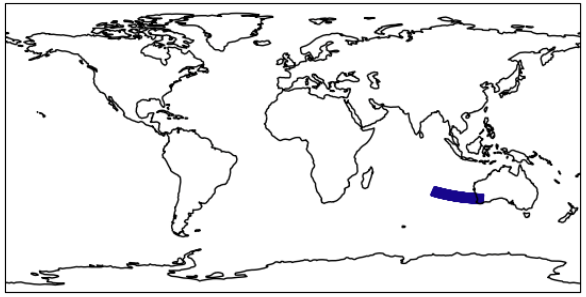
RGB

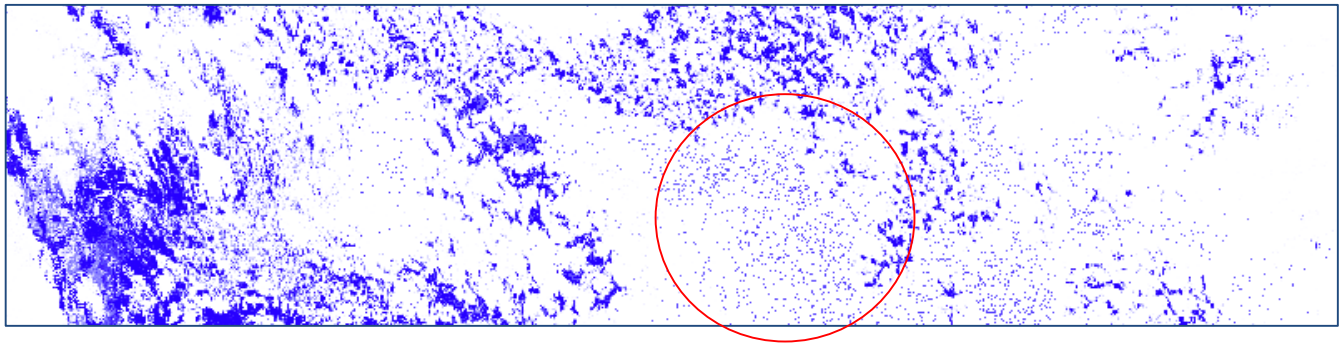


- Very high degree of similarity
- Not identical (squint at red circle)
- Differences not concerning

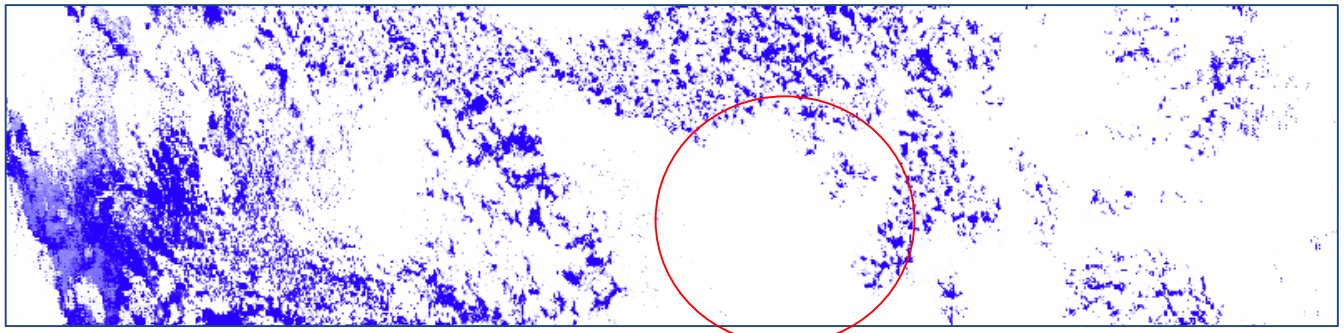
Night Ocean

NOAA-21 2023-05-31 18:09

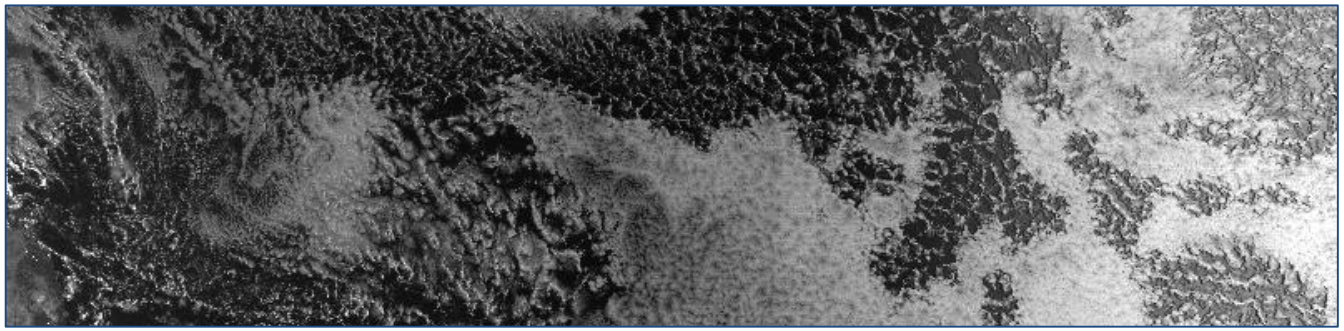




CLAVR-x



NCCF

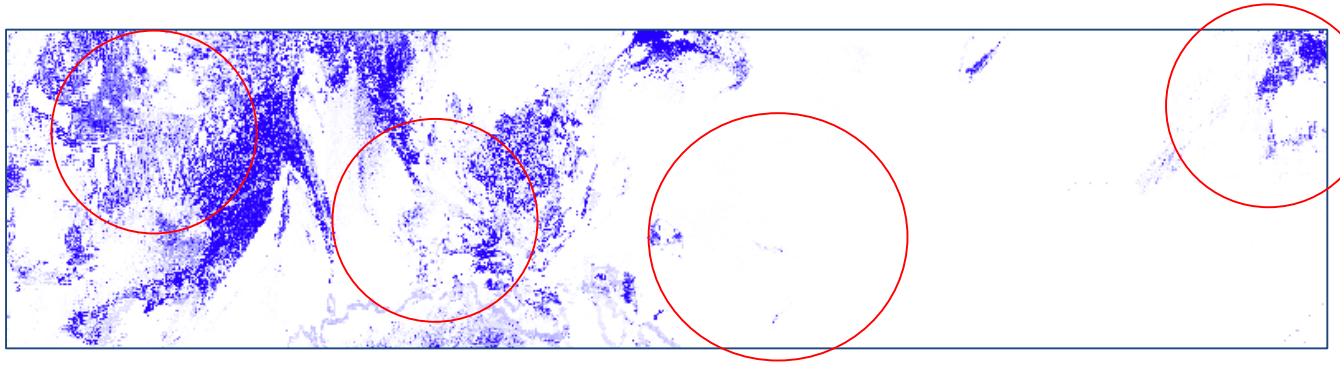


DNB

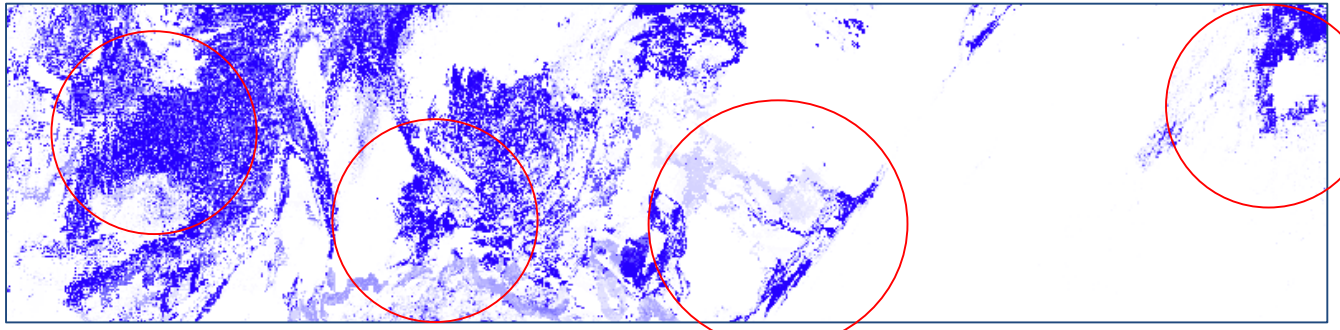
- Mostly similar
- Cause of differences is currently unknown
- Differences are not concerning, NDE looks better than CLAVR-x in this case

Twilight Ocean (Sea Ice)

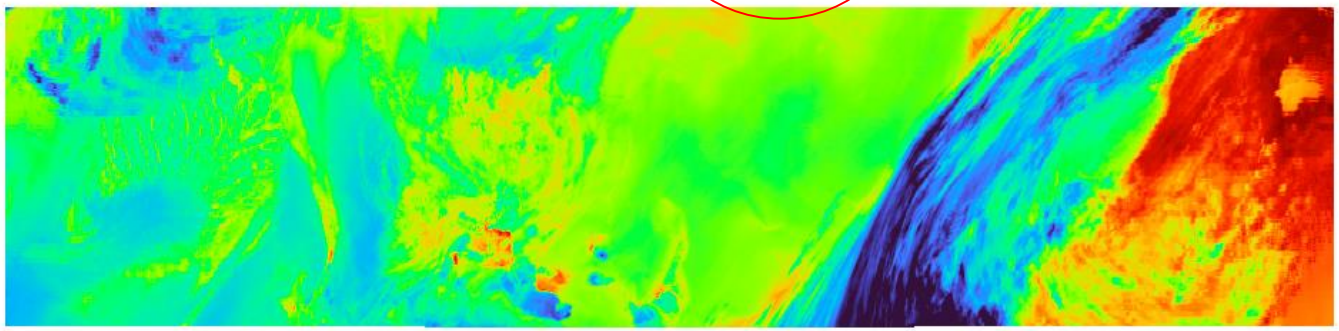
NOAA-21 2023-05-31 23:35

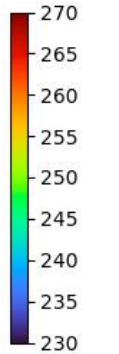


CLAVR-x

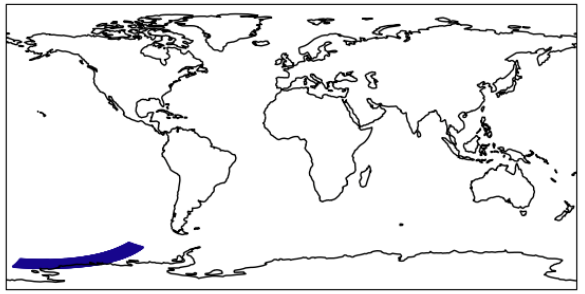


NCCF

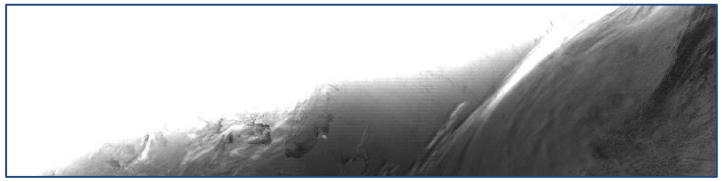




M15 BT

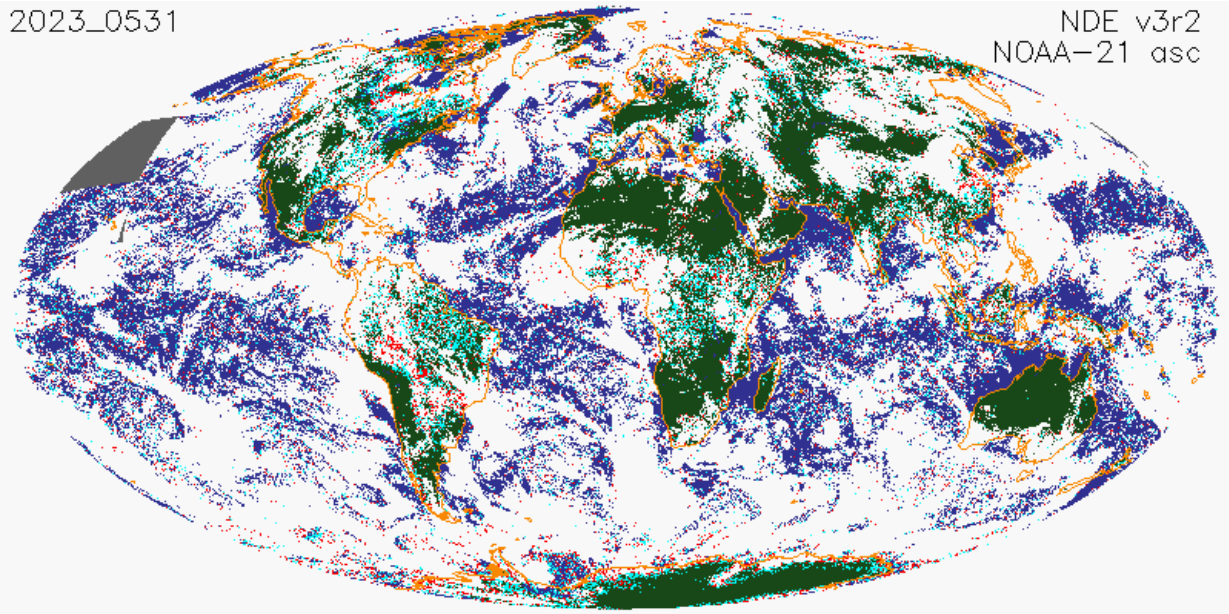


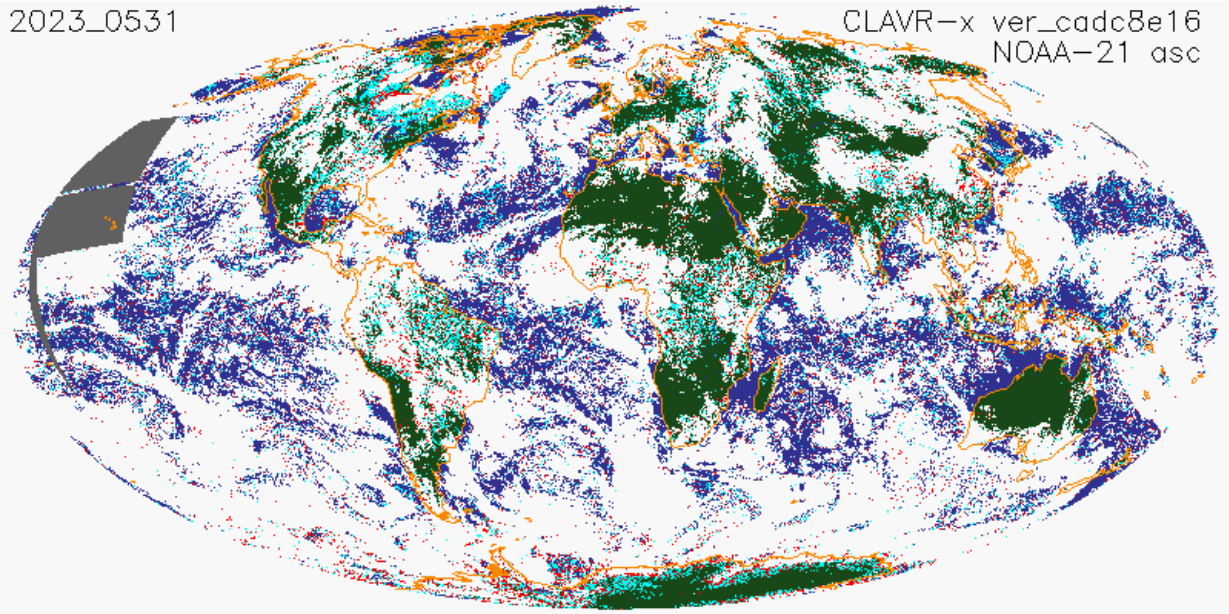
- Significant differences
- Cause of differences is currently unknown
- Unclear which is better

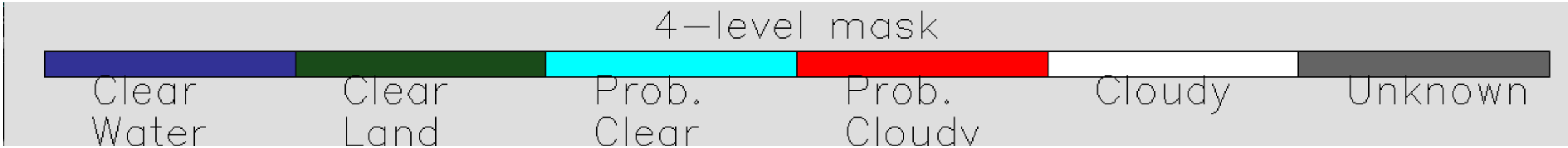


DNB

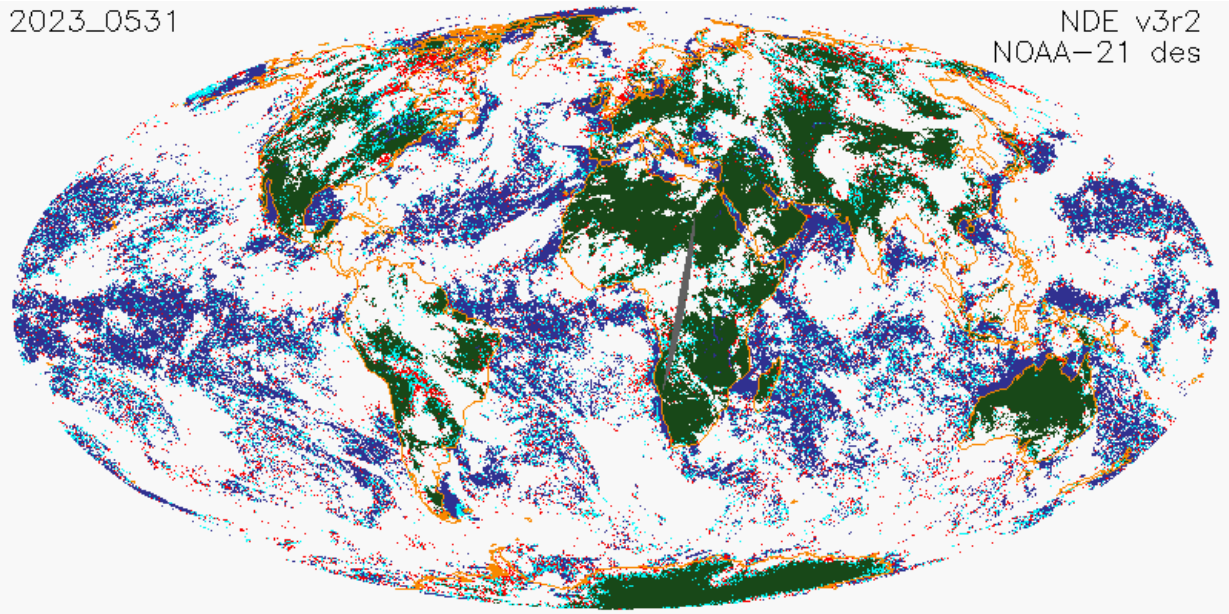
NOAA-21 Cloud Mask Level2b (Ascending)

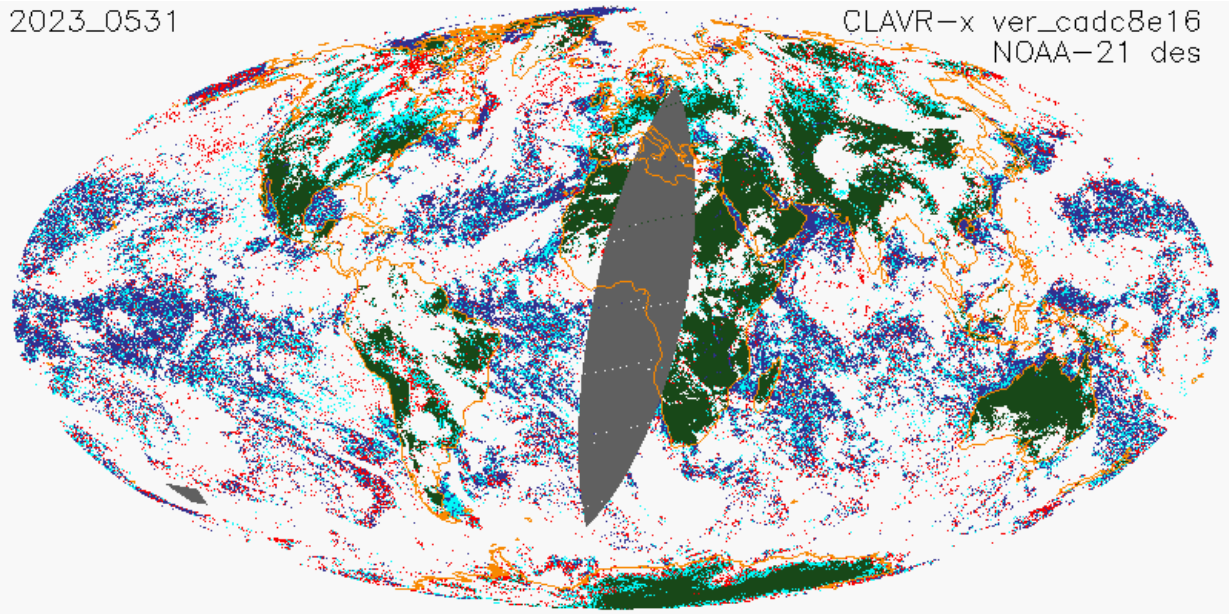


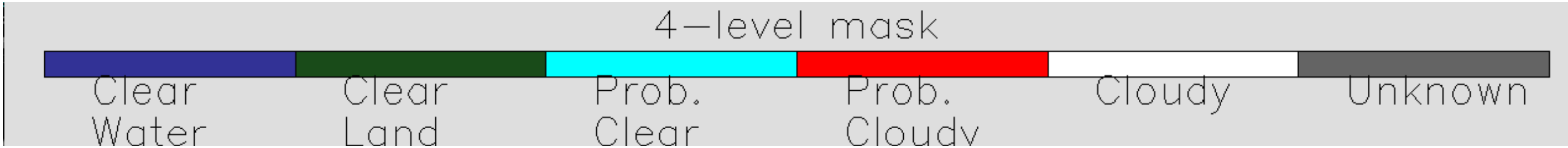




NOAA-21 Cloud Mask Level2b (Descending)

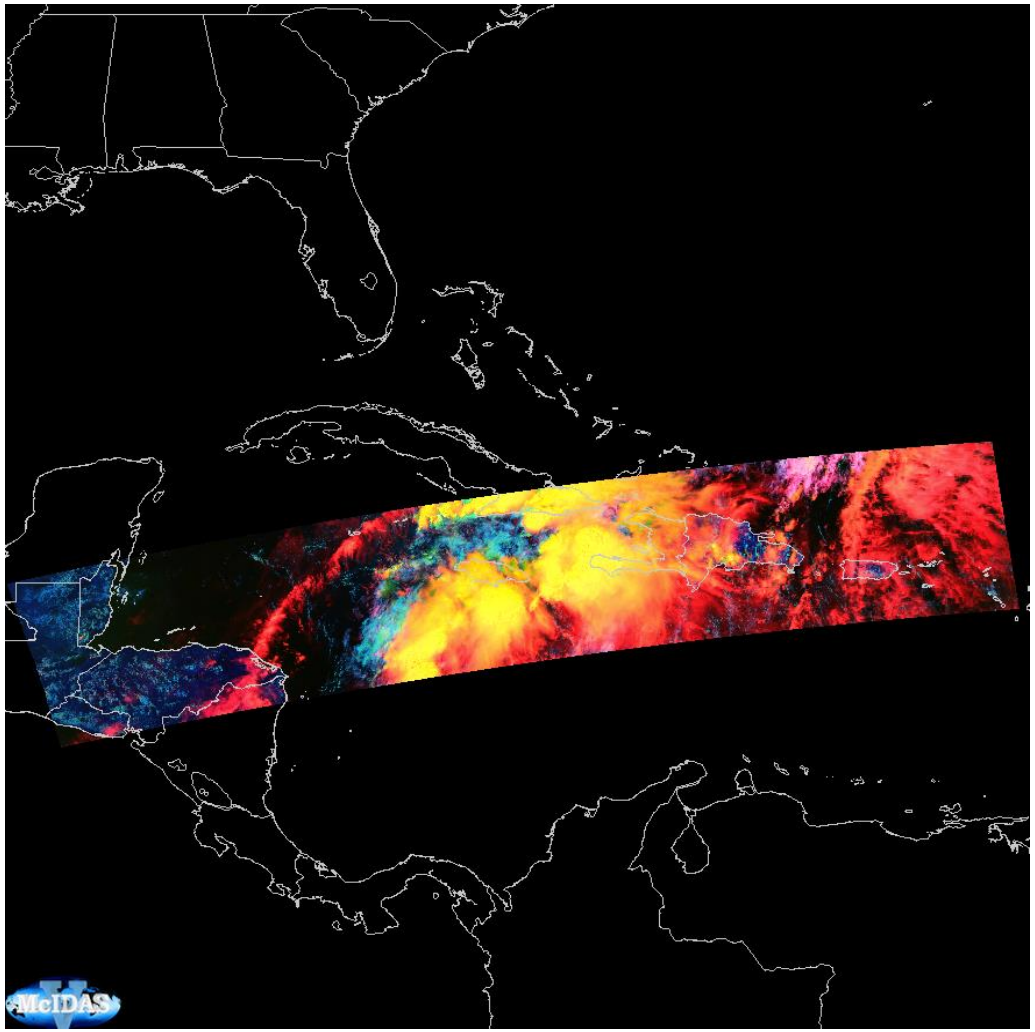


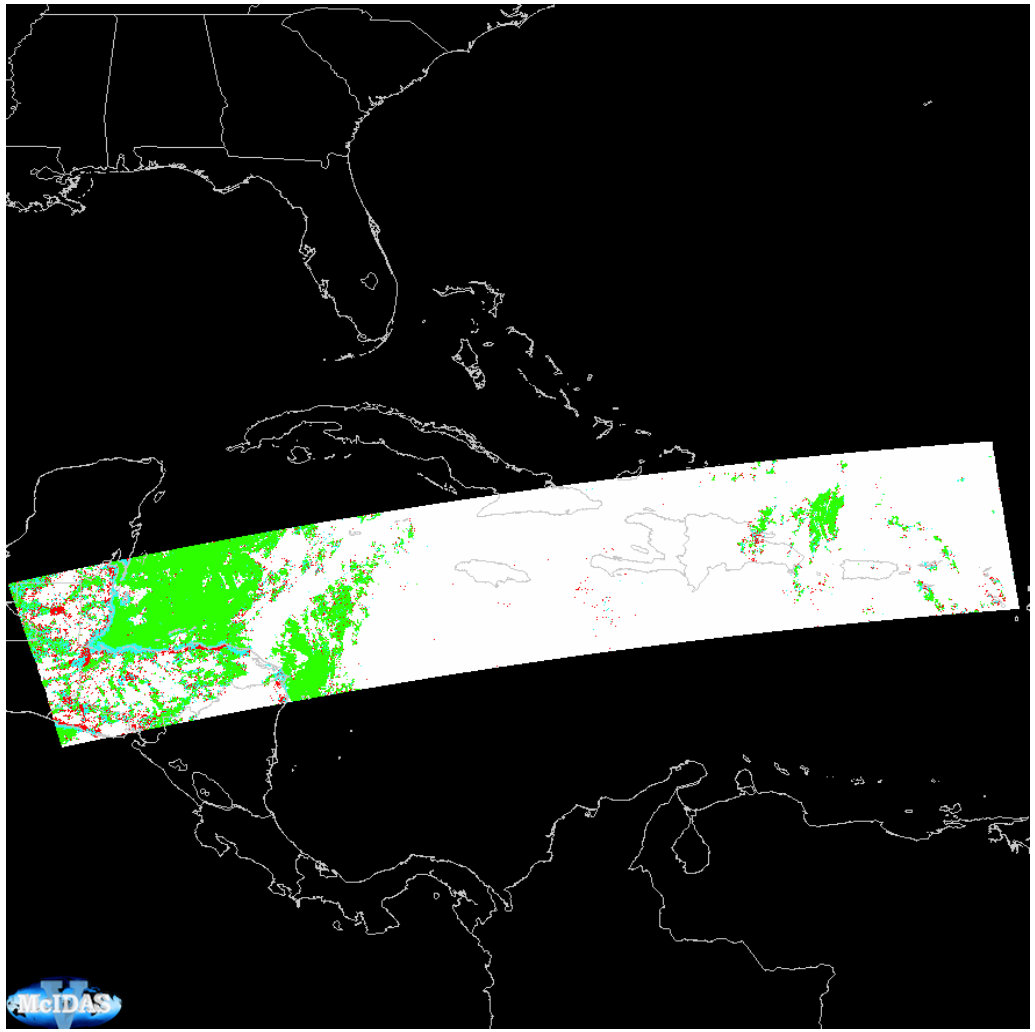




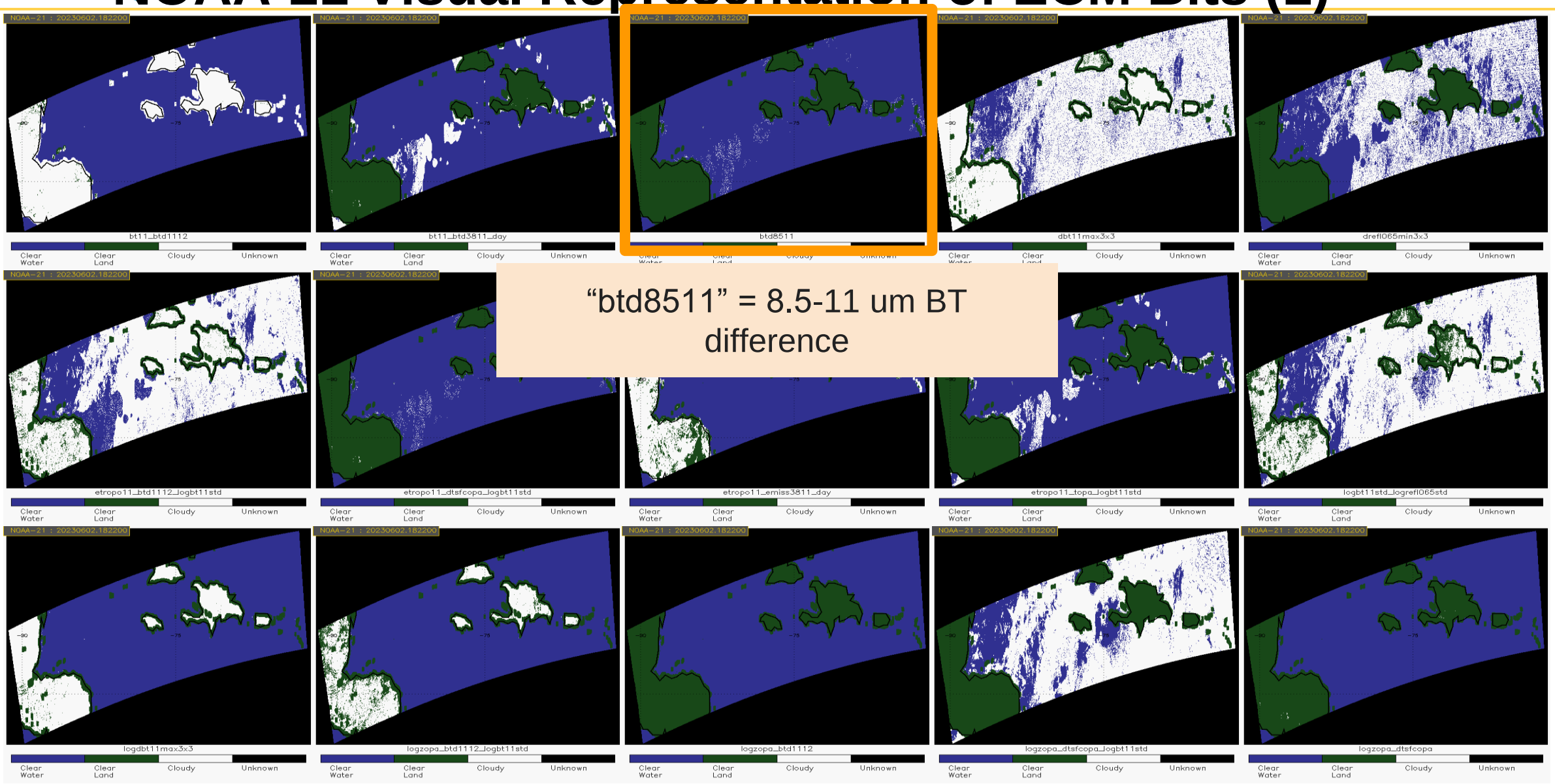
Ascending (Day) NOAA-21 Scene for ECM Bit Displa

NOAA-21 2023-06-02 18:18 UTC



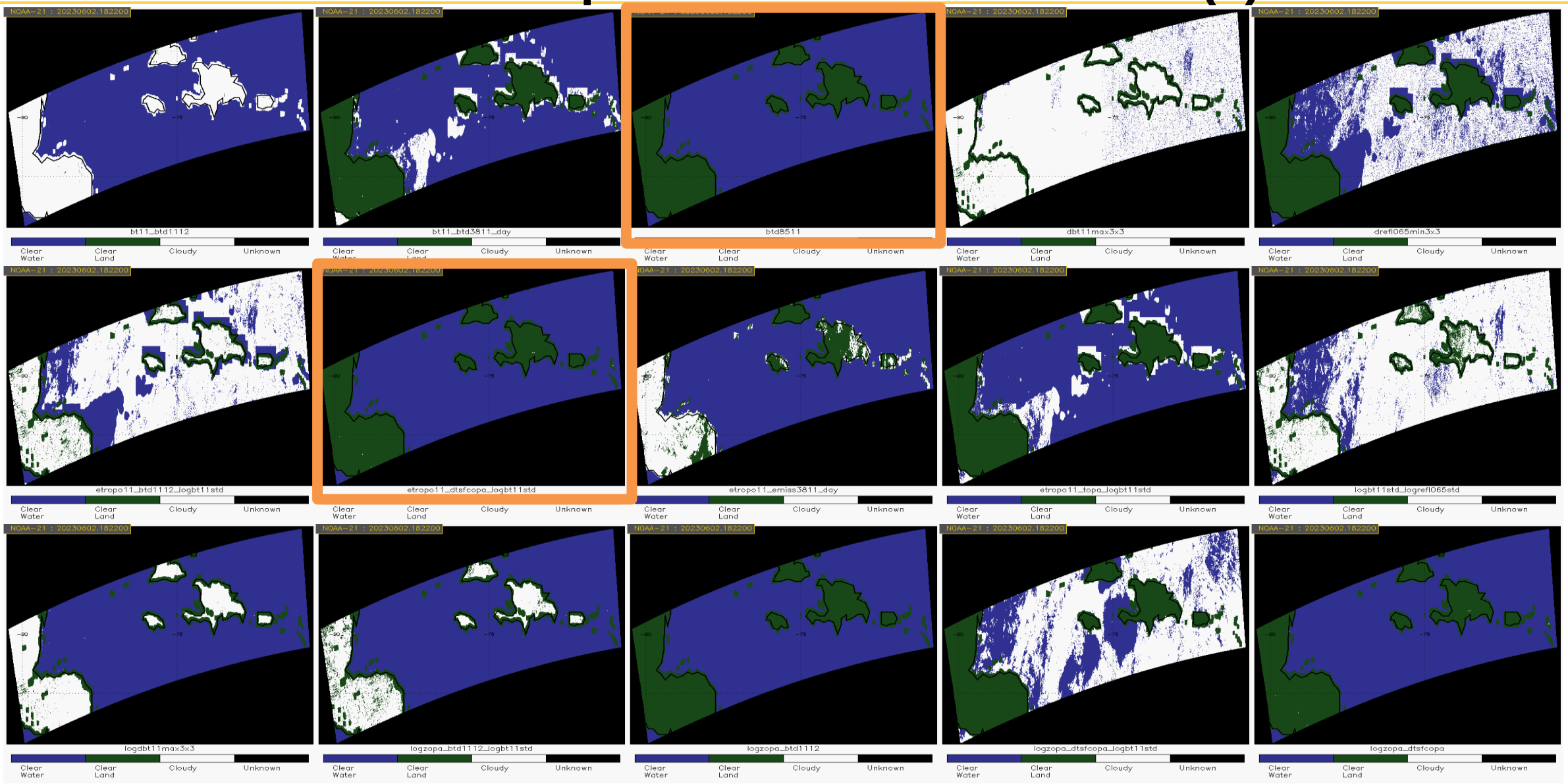


NOAA-21 Visual Representation of ECM Bits (1)

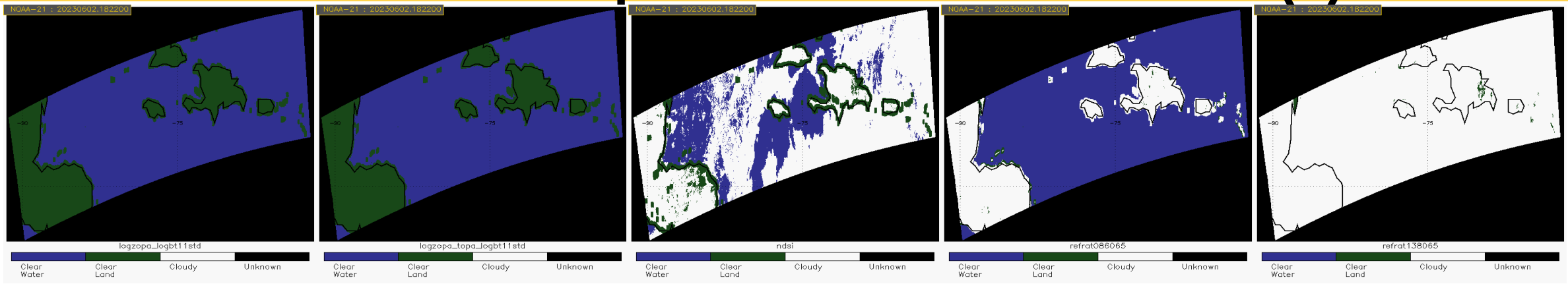


"btd8511" = 8.5-11 um BT difference

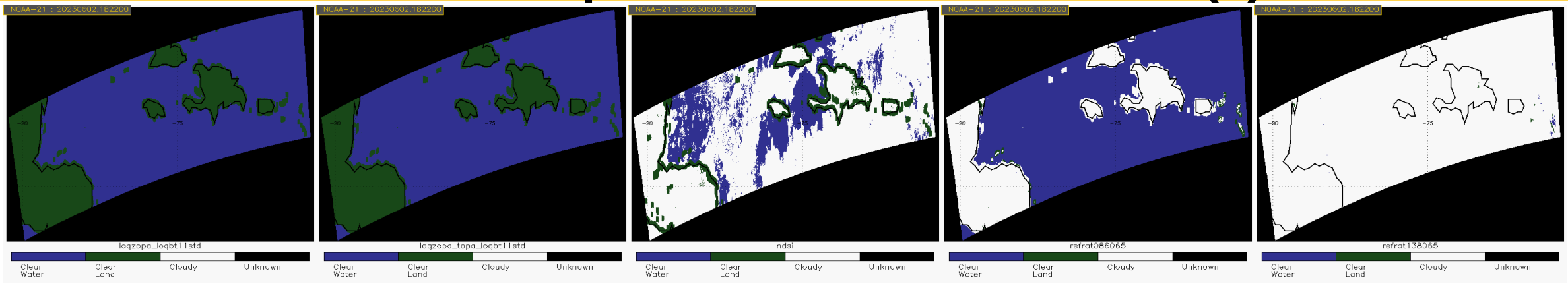
NOAA-21 Visual Representation of ECM Bits (1)



NOAA-21 Visual Representation of ECM Bits (2)

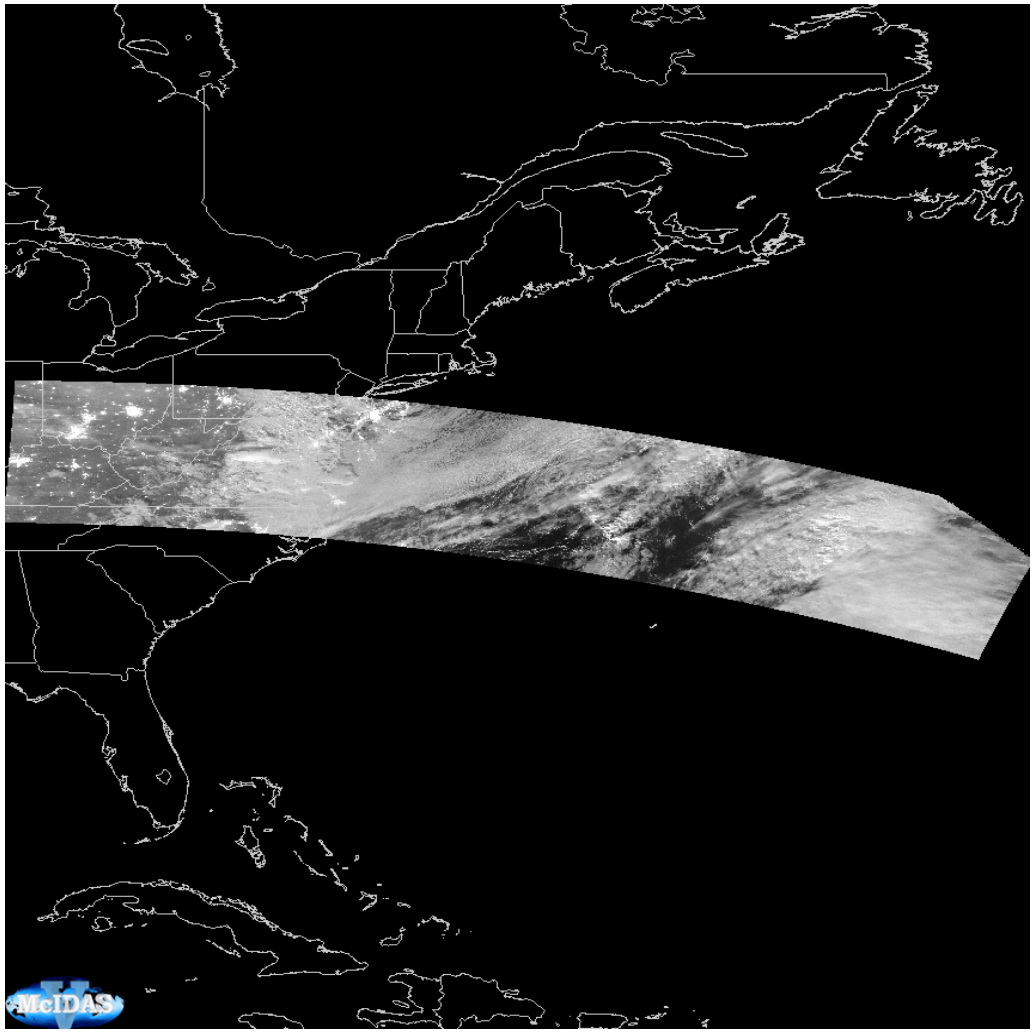


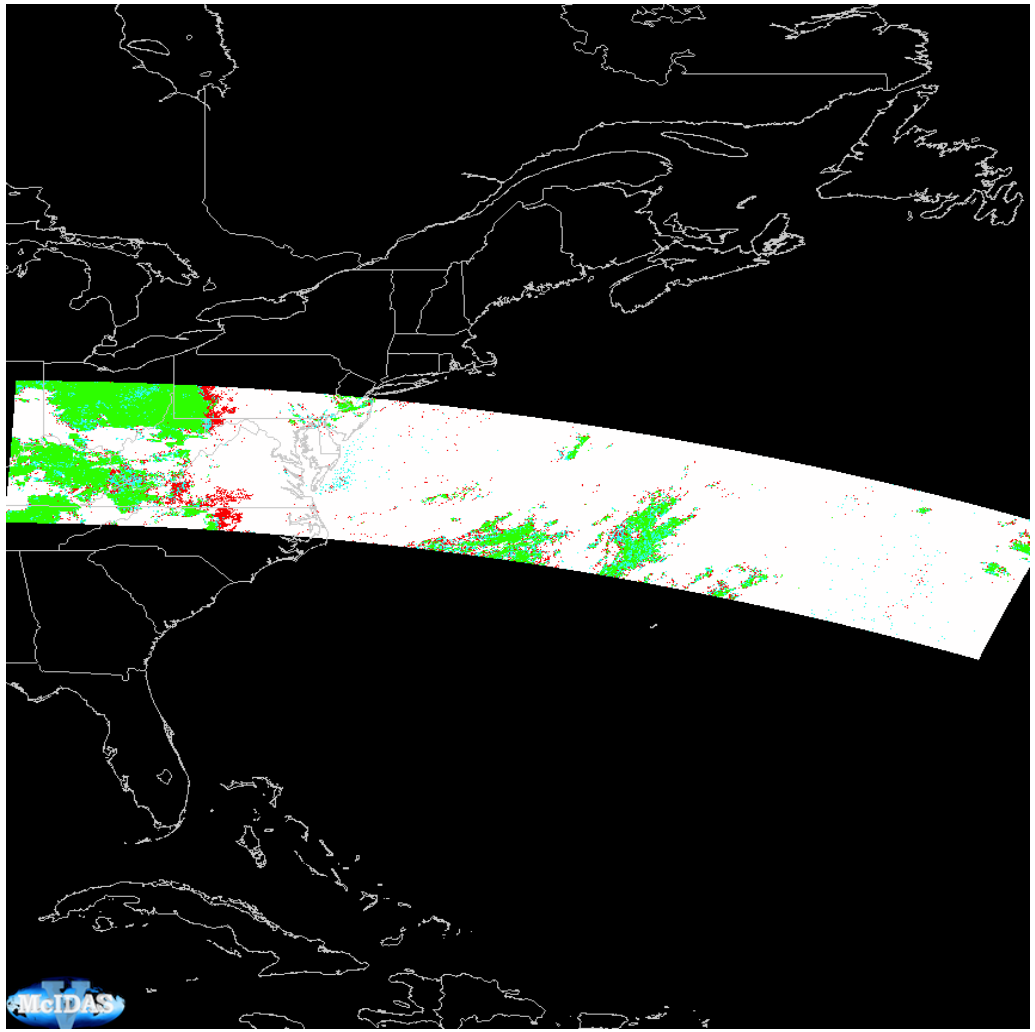
NOAA-21 Visual Representation of ECM Bits (2)



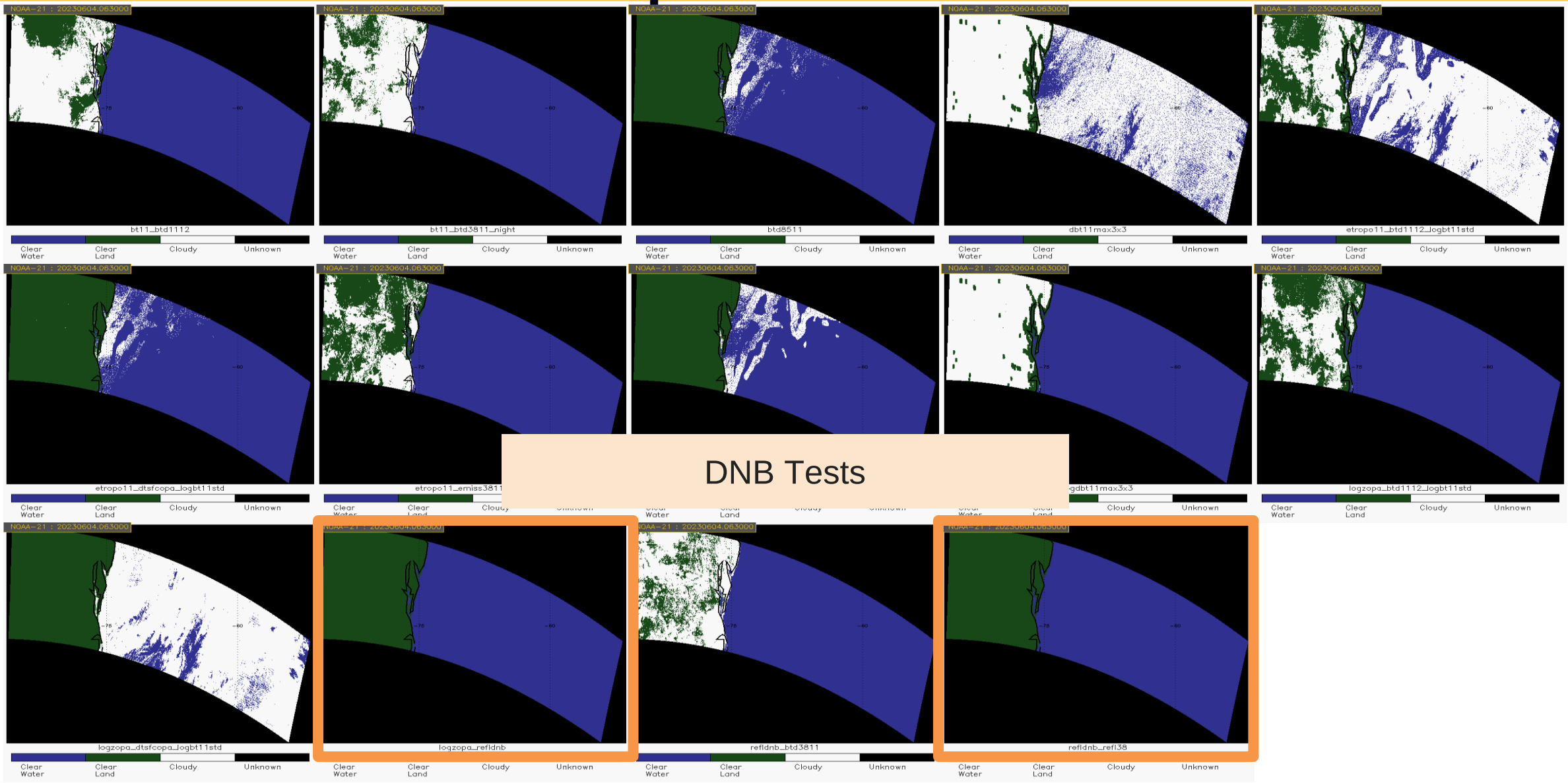
Descending (Night) NOAA-21 Scene for ECM Bit Display

2023-06-04 06:25 UTC



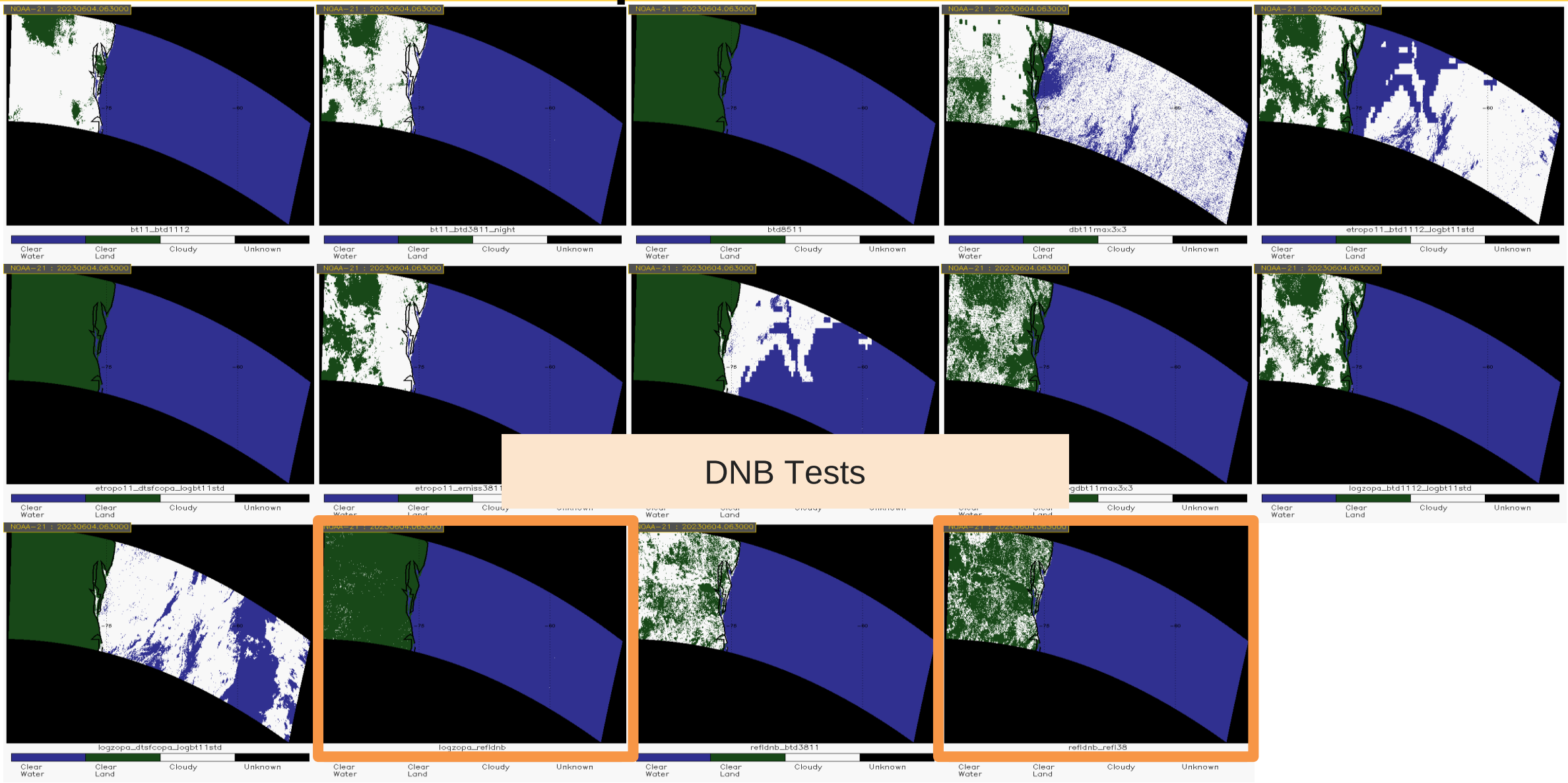


NOAA-21 Visual Representation of ECM Bits



DNB Tests

NOAA-21 Visual Representation of ECM Bits



DNB Tests

Conclusions from Visual Comparisons

Issue	Comment
Differences between NCCF and CLAVR-x ECM results	Mostly minor differences, but some scenes (e.g., twilight ocean + sea ice) show more significant differences. Cause uncertain. Will continue investigating.
Differences in ECM packed bits between NCCF and CLAVR-x	Differences in individual tests observed, including DNB differences. Cause uncertain. Will continue investigating.
Missing granules.	This is a PDA/NCCF distribution issue for the IT string