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

VIIRS Cloud Mask Team

NOAA/NESDIS: Mark Kulie and Andrew Heidinger

CIMSS: Coda Phillips, Yue Li , Steve Wanzong, William Straka, Jay Hoffman, and Mike Foster

Presented by Mark Kulie

Date: 06/22/2023

JPSS Data Products Maturity Definition

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.

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

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STAR ECM Cal/Val Team

Name	Organization	Major Task
Mark Kulie	NESDIS/STAR	Cloud Team Lead
Andrew Heidinger	NESDIS	ECM development, validation
Mike Foster	CIMSS	ECM development, validation
Coda Phillips	CIMSS	ECM development, validation
William Straka	CIMSS	ASSISTT integration
Yue Li	CIMSS	ECM development, validation
Steve Wanzong	CIMSS	ECM development, validation
Jay Hoffman	CIMSS	Long-term monitoring
David Donahue	OSPO	Product Area Lead

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Enterprise Cloud Mask (ECM) Overview

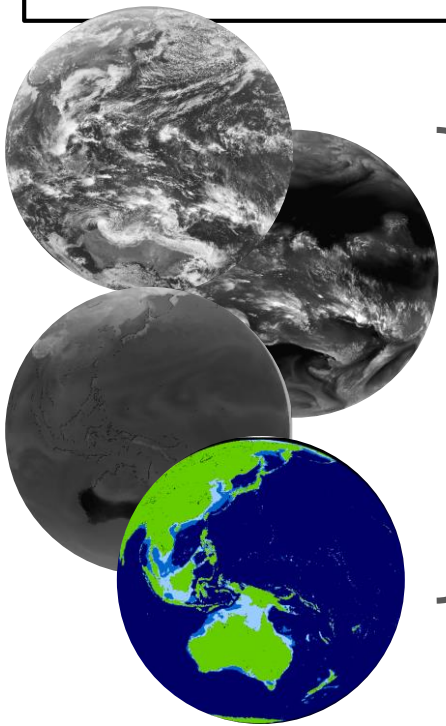
How The Enterprise Cloud Mask (ECM) Works

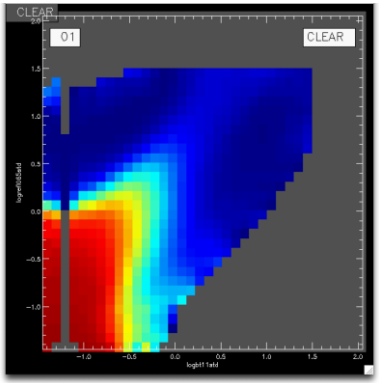
Input: Classifiers based on combinations of Reflectance, Brightness Temperature, Clear-Sky Estimates and Ancil Data

Algorithm: LUTs for each Classiifer for each surface for clear, water and ice cloud

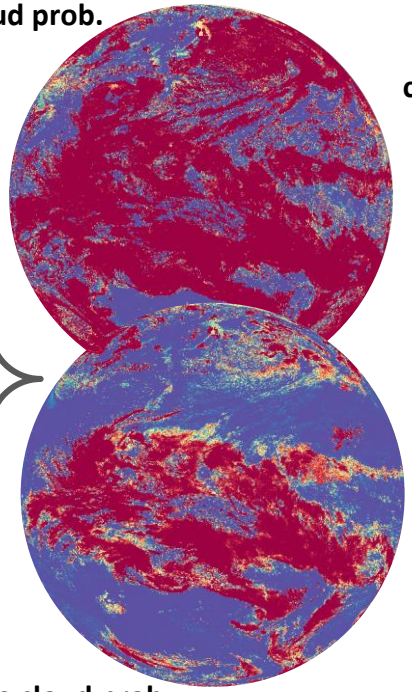
Fundamental Output:
Cloud Probability and Ice Cloud Probability + QC Bits

Derived Output:
Cloud Mask and Cloud Type + uncertainties





cloud prob.

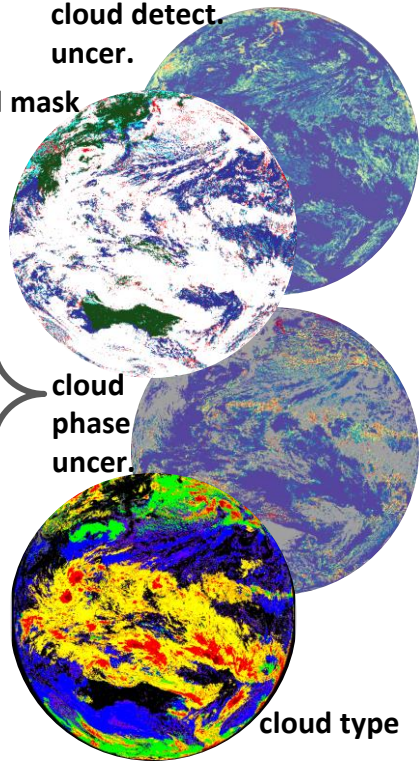


ice cloud prob.

cloud detect. uncer.

cloud mask

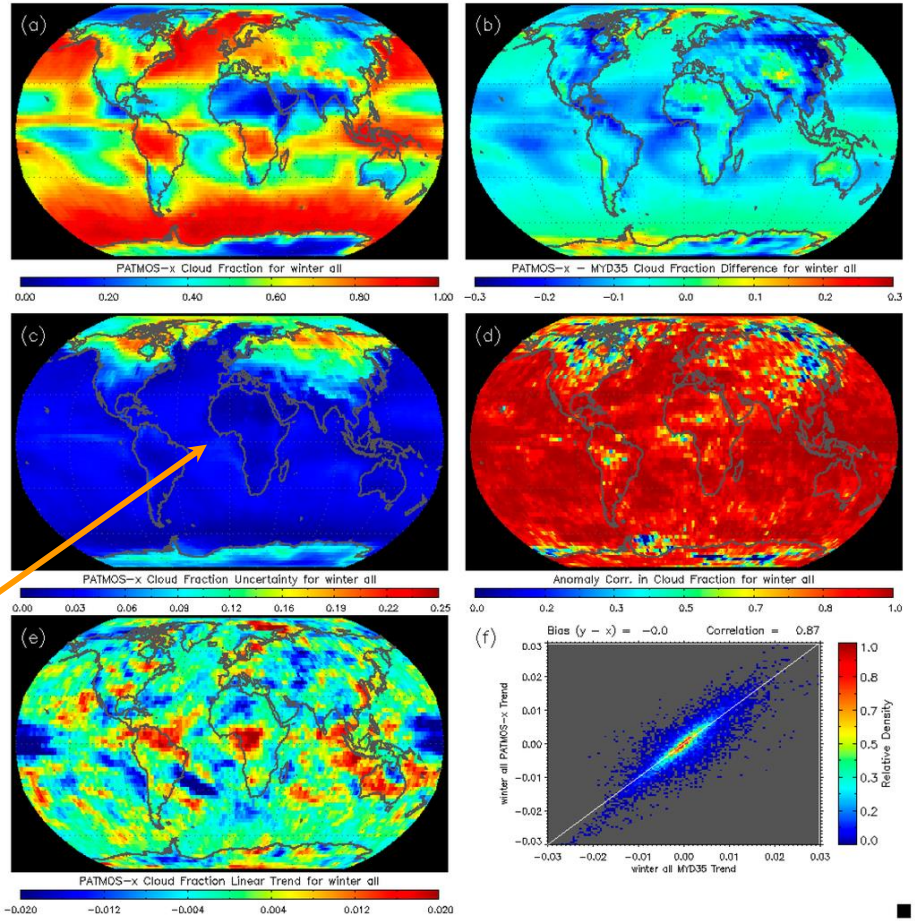
cloud phase uncer.



cloud type

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)

		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
  - LUTs / 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

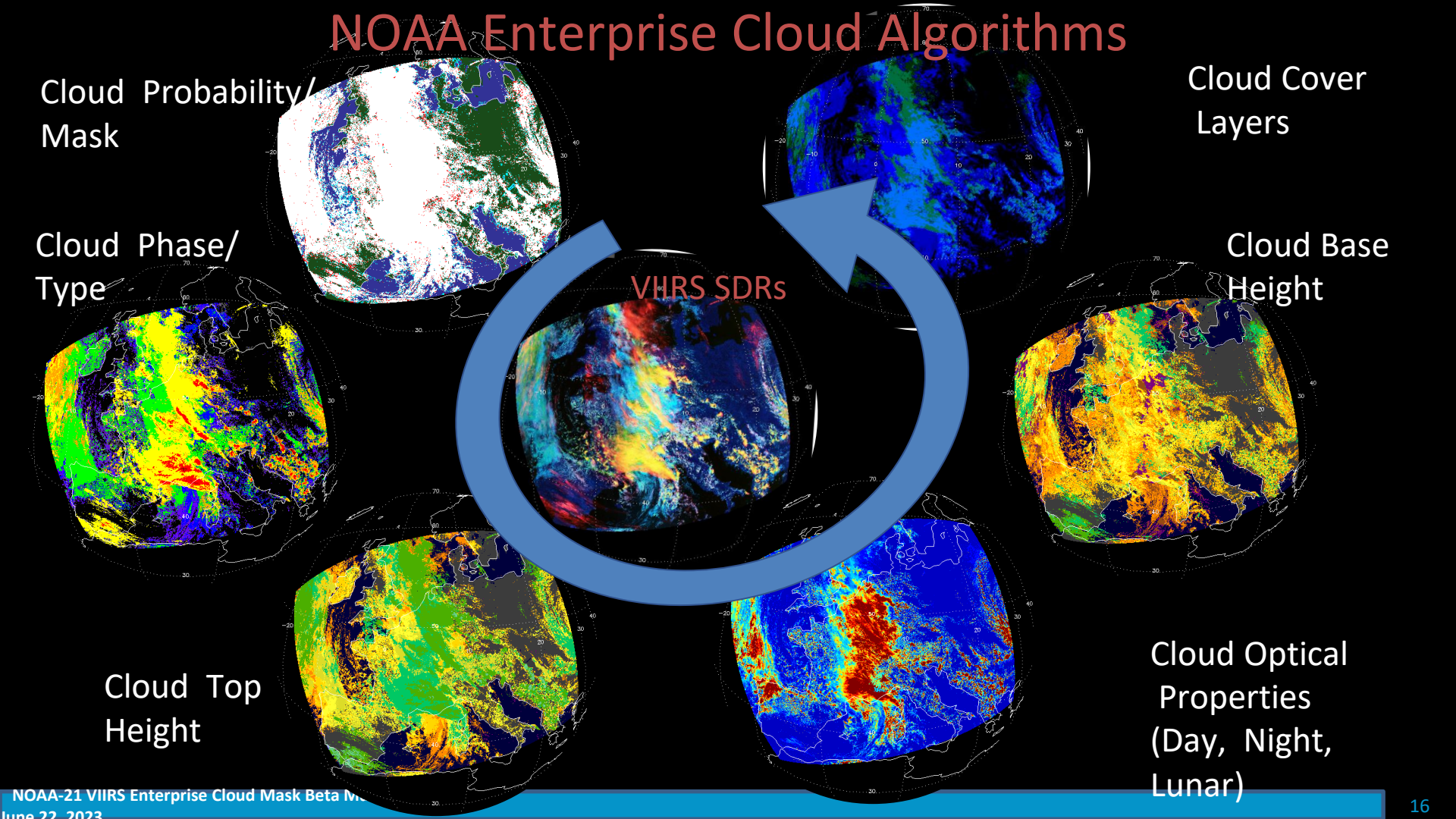
Algorithm Inputs

- 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



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.**

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Enterprise Cloud Mask NDE Status

ECM Deliveries

- Current Operational Version (NPP, NOAA-20)
  - April 2019 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

Sensor Data Record (SDR) Issues

SDR Issues at BETA Review

- **M5 on SNPP is 5% too bright.**
- NOAA-20 and NOAA-21 initial analysis: M5 calibration appears fine.
- SNPP LUT automatically tuned out this calibration error so we expect NOAA-20/21 to ‘miss’ cloud due to this issue.
- TBD issues that may be related to the SDR or SDR parameters in the SAPF.
- **New LUT will be verified after it is generated.**

Evaluation of the NCCF/NDE# ECM

#NCCF and NDE are used interchangeably in this review since the Cloud Team received NOAA-21 product datasets most directly from NDE. Datasets listed as NCCF or NDE are considered the operational products.

Evaluation Methodology

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

- NCCF/OPS-specific issues are diagnosed by ECM generated by non-NCCF processing (e.g., Clouds from AVHRR Extended "CLAVR-x" processing system @ CIMSS).

- Specific Evaluation Methodology:
  1) Visual inspection of NCCF/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) Clear Sky Radiance (CSR) bias analysis (Quantitative)

Data Used in this Analysis

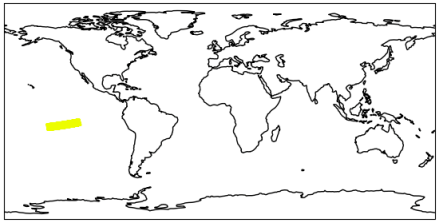
- NOAA-21 NCCF v3r2 from June 1, 2023 for Clear-sky analysis.
- NOAA-21/20/NPP NCCF v3r2 and CLAVR-x from May 31, 2023.
- NOAA-21/20/NPP NCCF v3r2 May 16-June 14, 2023 (Long-term monitoring quick looks)
- NASA AQUA/MODIS Collection 6.1 from May 31, 2023.
- CALIPSO Comparison: May 31, 2023.

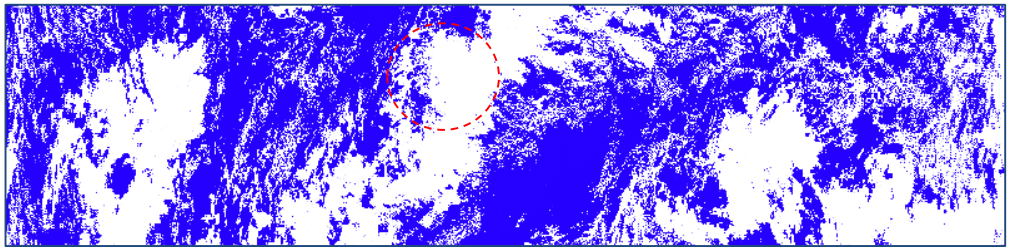
Visual Comparisons with CLAVR-x

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

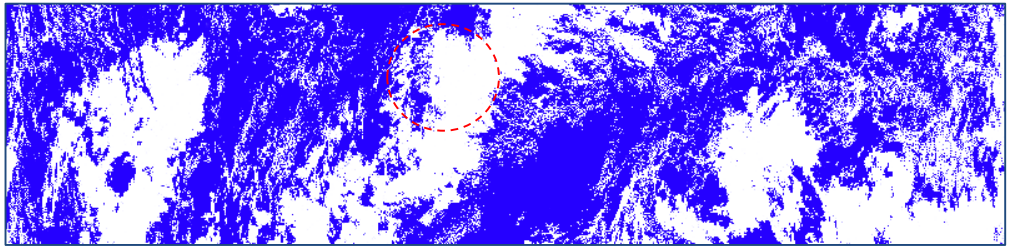
Day Ocean

NOAA-21 2023-05-31 22:11

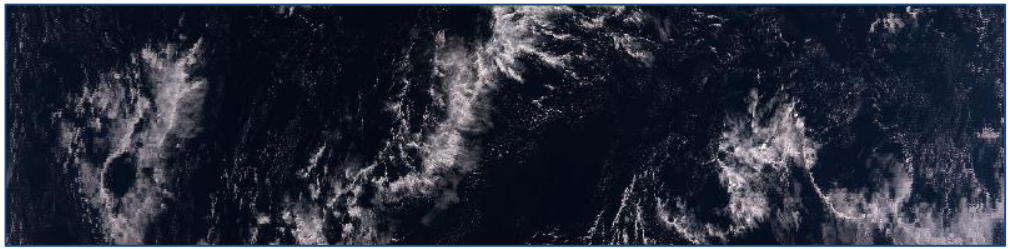




CLAVR-x



NCCF

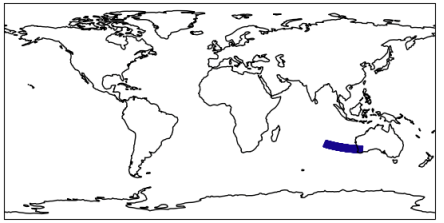


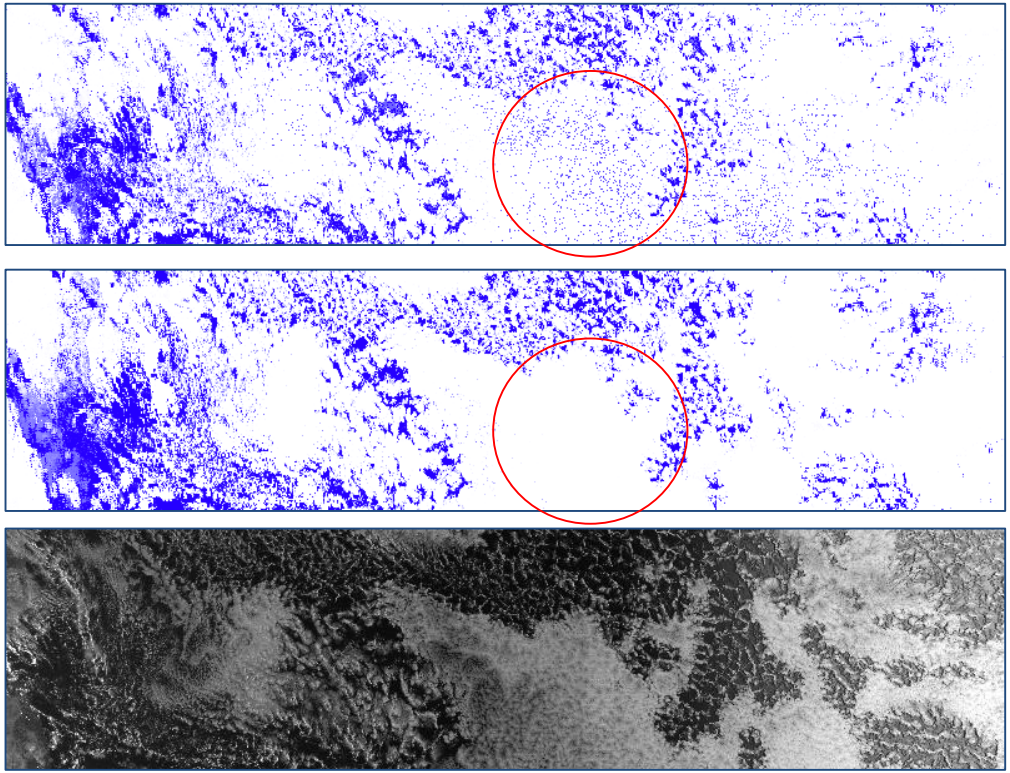
RGB

- 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

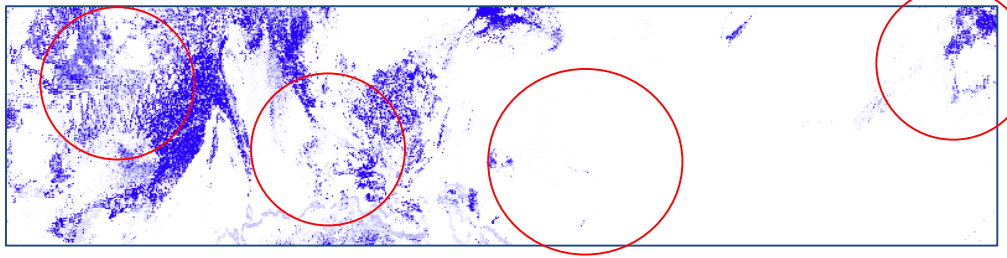
NCCF

DNB

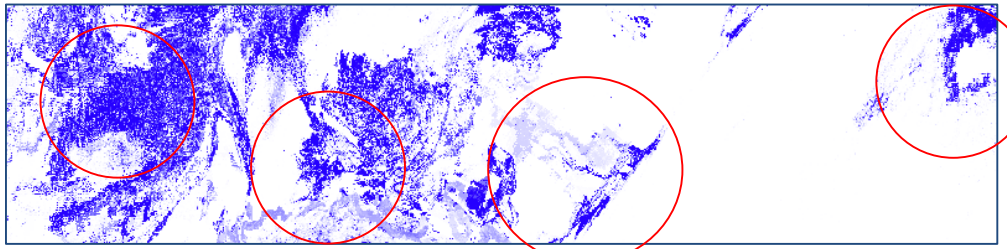
- Mostly similar
- Cause of differences is currently unknown
- Differences are not concerning, NDE looks better than CLAVR-x in this case

Twilight Ocean (Sea Ice)

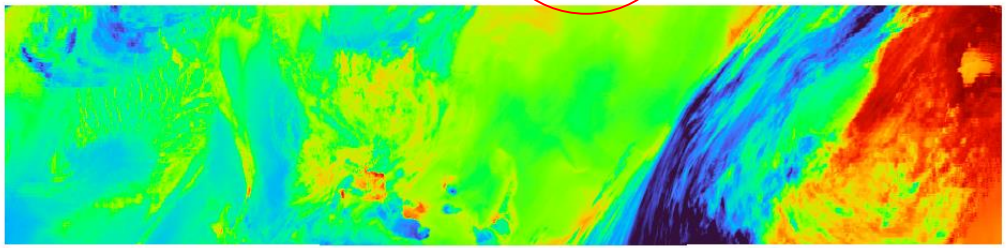
NOAA-21 2023-05-31 23:35



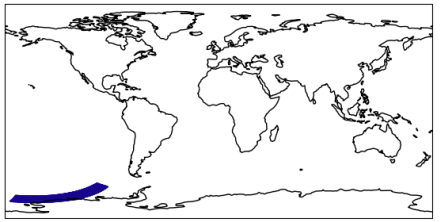
CLAVR-x



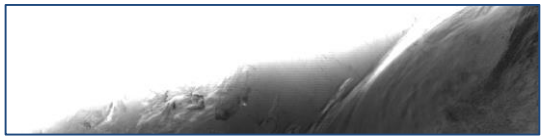
NCCF



M15 BT



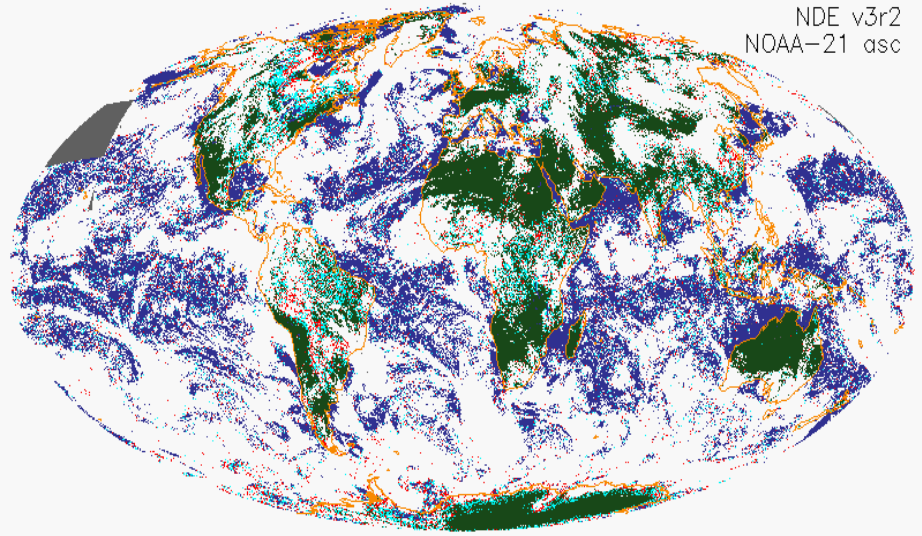
- Significant differences
- Cause of differences is currently unknown
- Unclear which is better



DNB

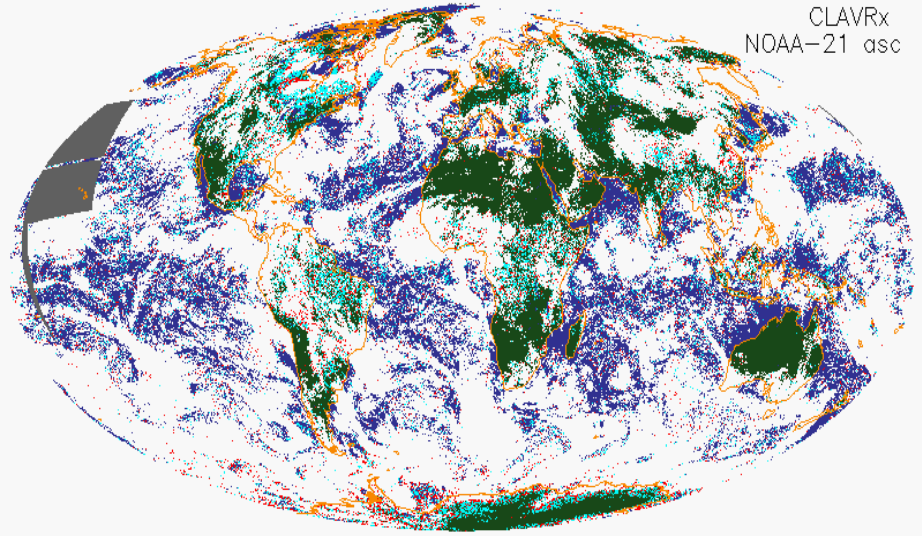
Global Ascending

NOAA-21 2023-05-31 **NCCF**



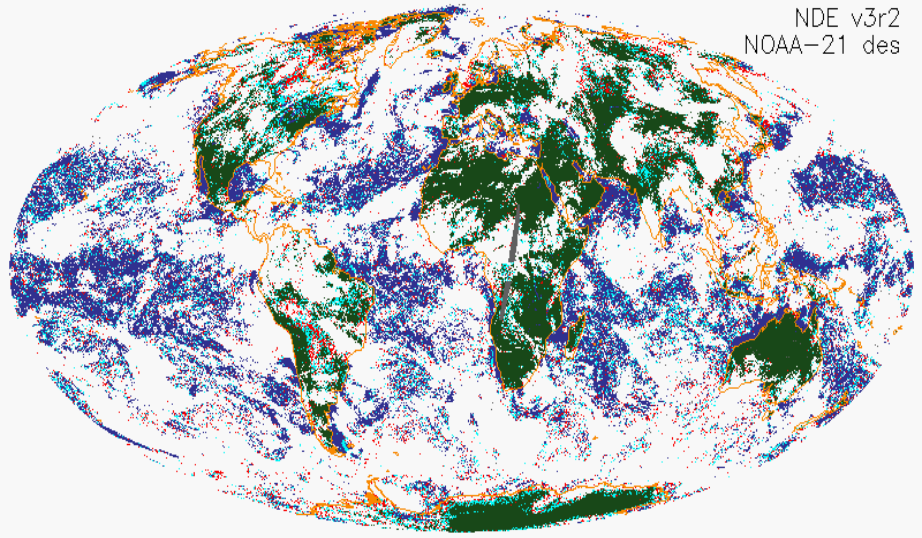
Global Ascending

NOAA-21 2023-05-31 **CLAVR-x**



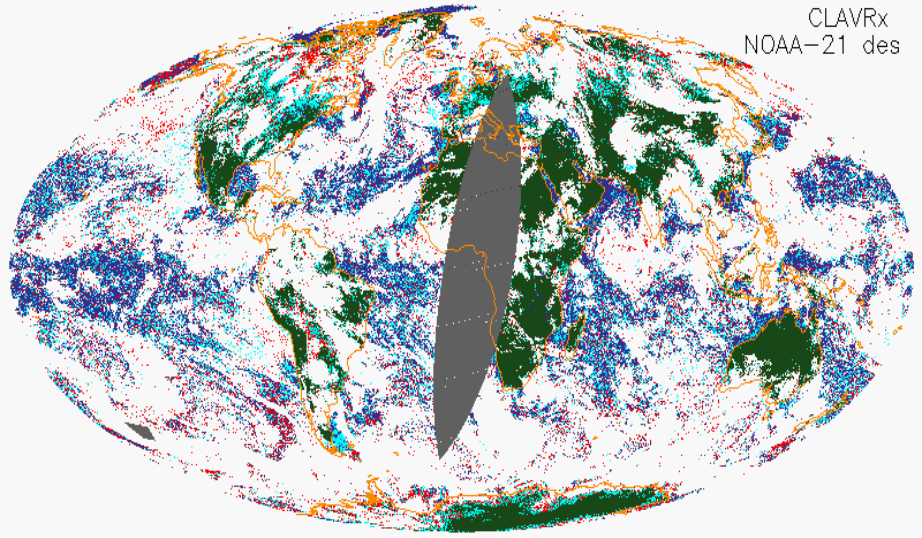
Global Descending

NOAA-21 2023-05-31 **NCCF**



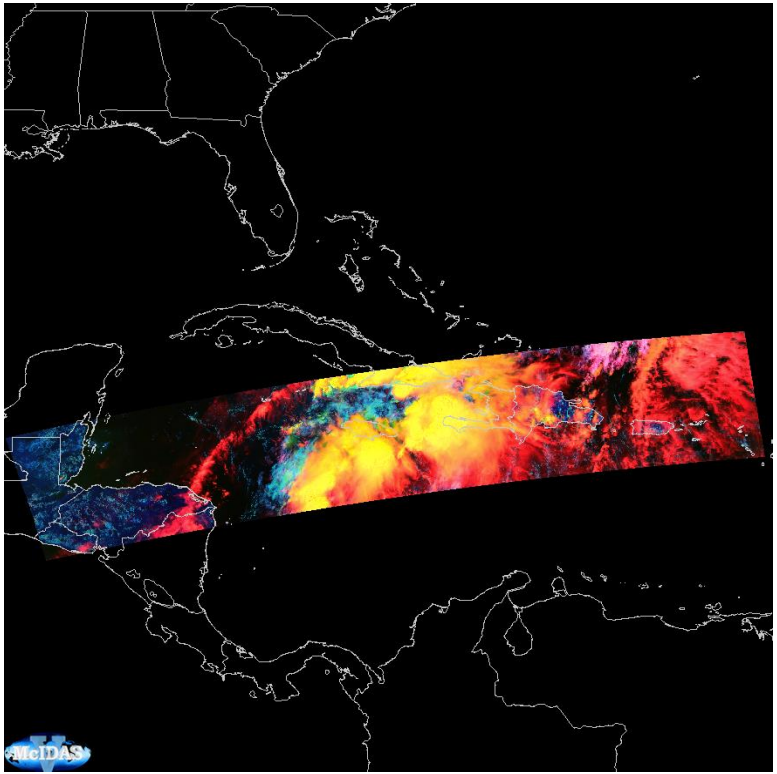
Global Descending

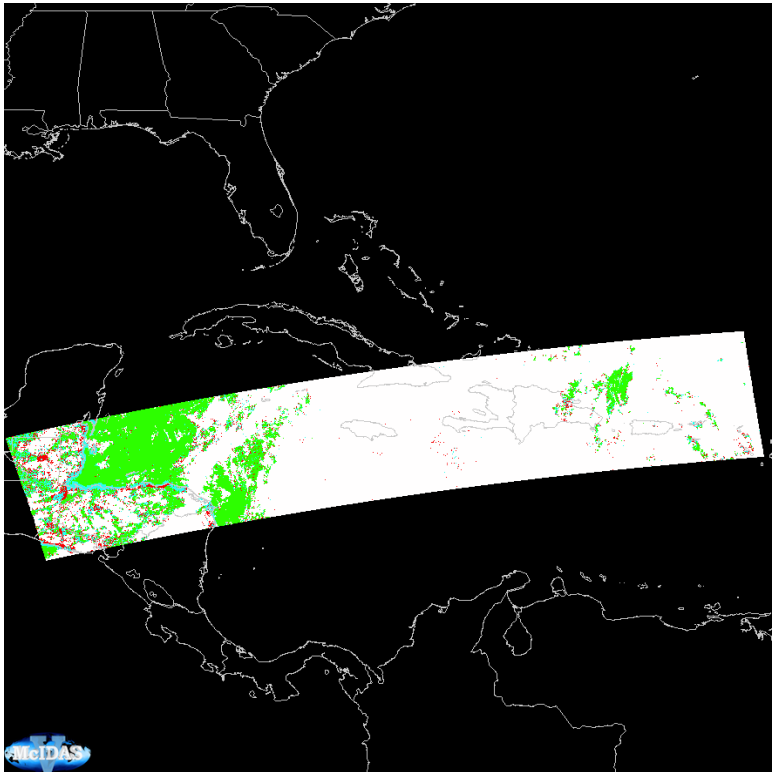
NOAA-21 2023-05-31 **CLAVR-x**



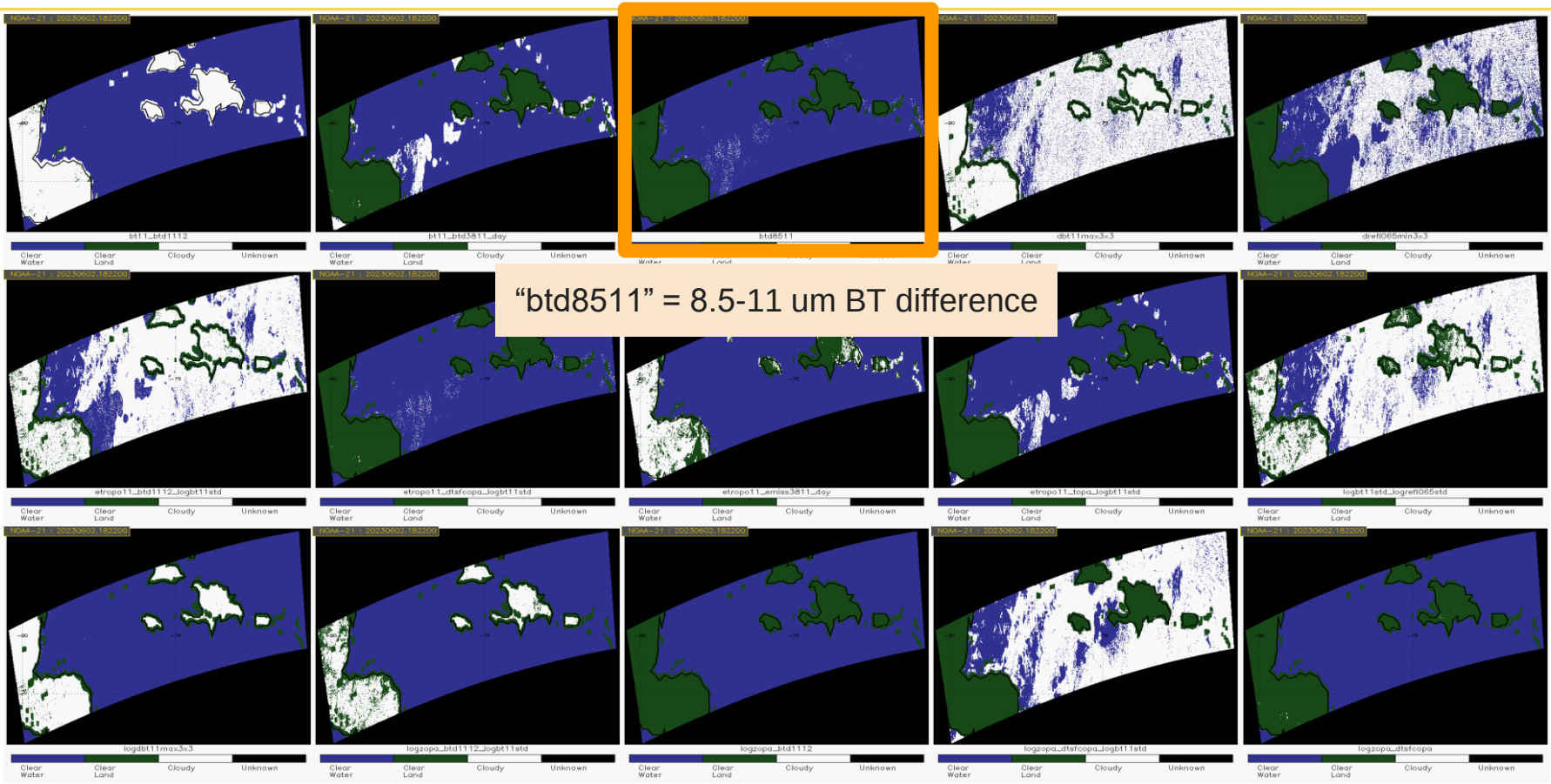
Ascending (Day) NOAA-21 Scene for ECM Bit Display

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



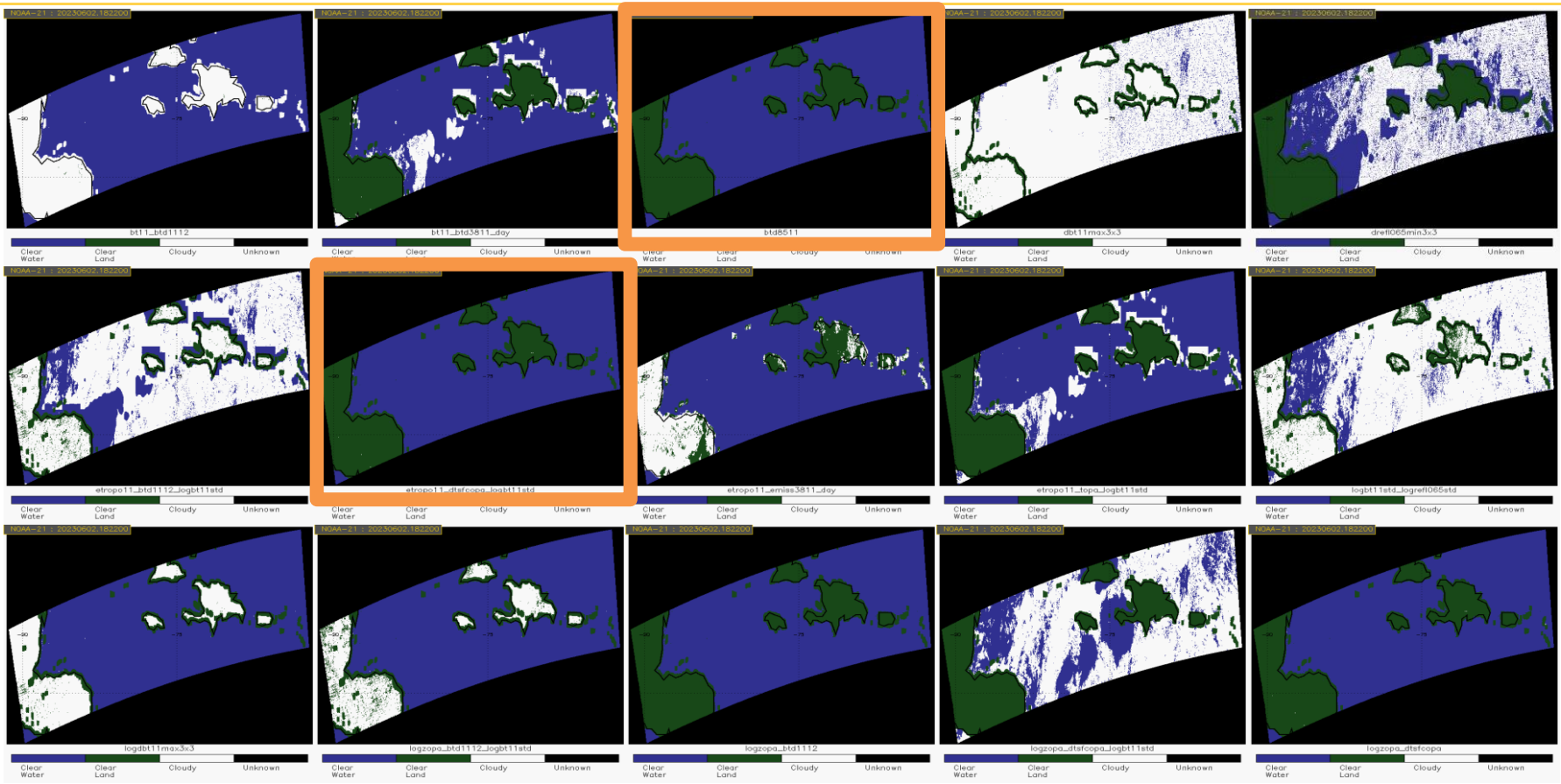


NOAA-21 Visual Representation of ECM Bits (1) (NCCF)

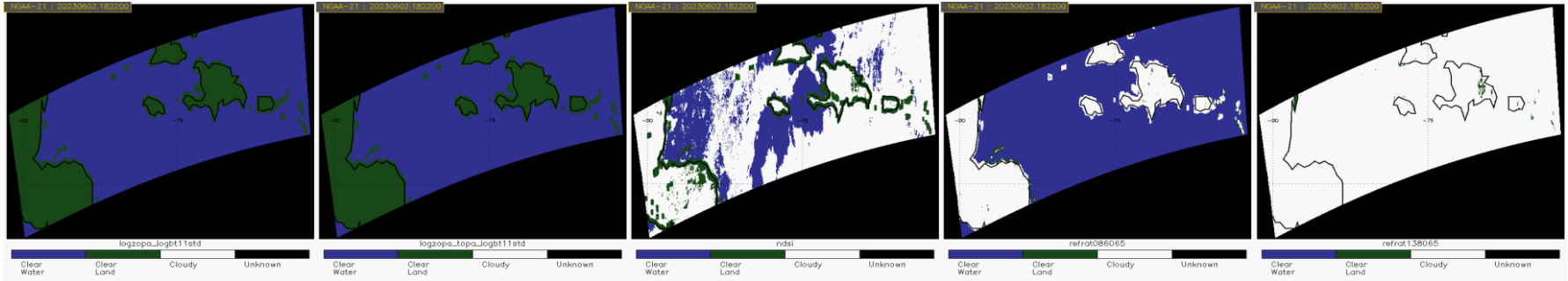


"btd8511" = 8.5-11 um BT difference

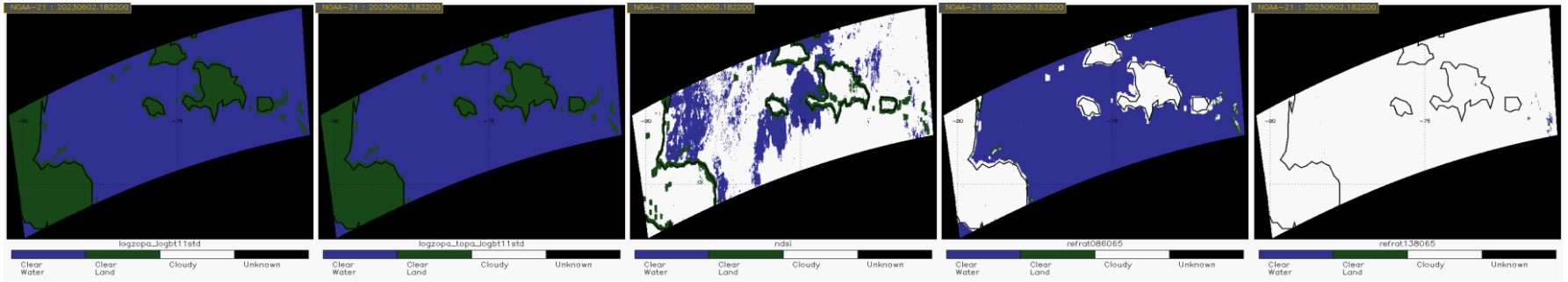
NOAA-21 Visual Representation of ECM Bits (1) (CLAVRx)



NOAA-21 Visual Representation of ECM Bits (2) (NCCF)

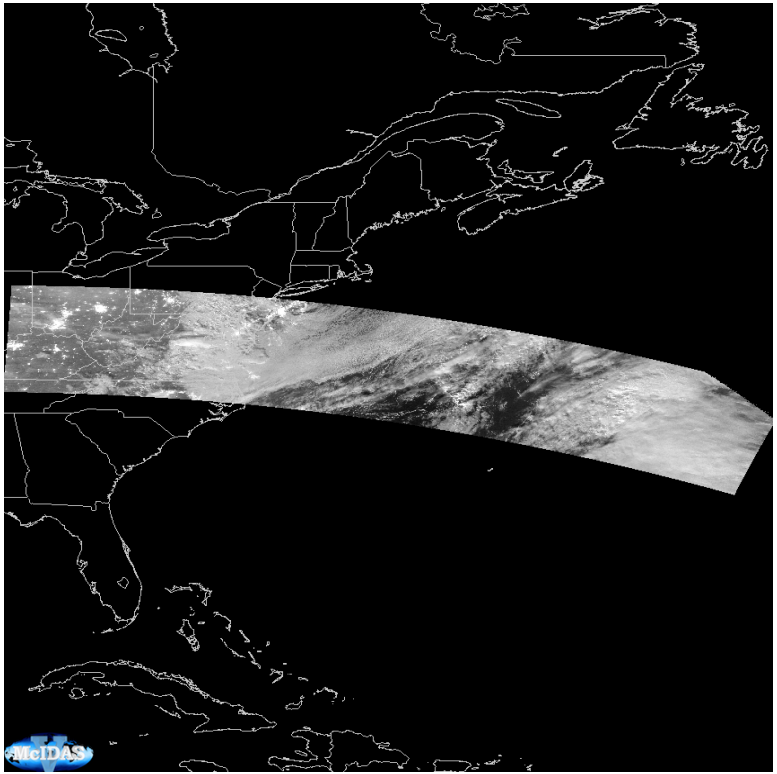


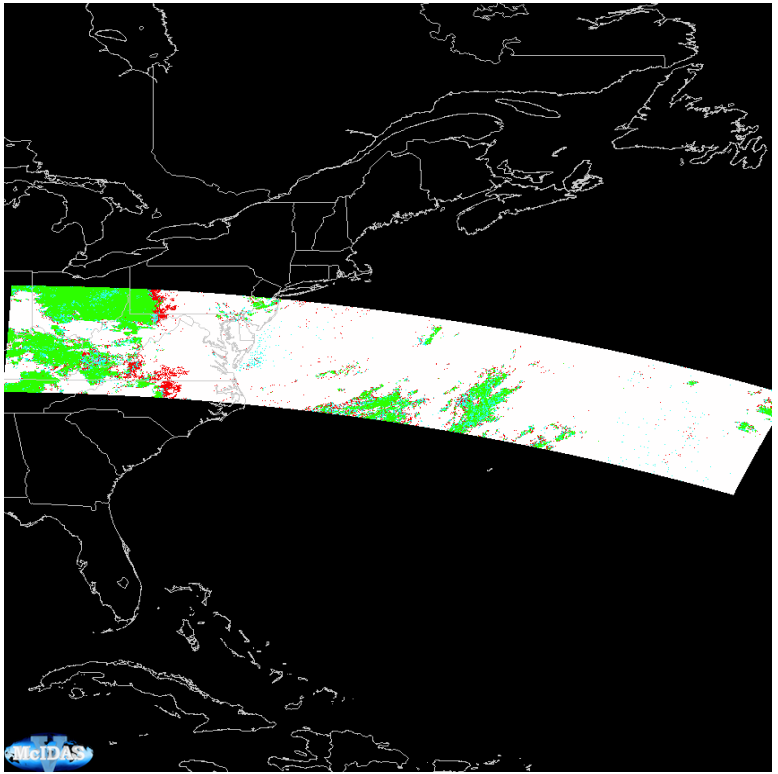
NOAA-21 Visual Representation of ECM Bits (2) (CLAVRx)



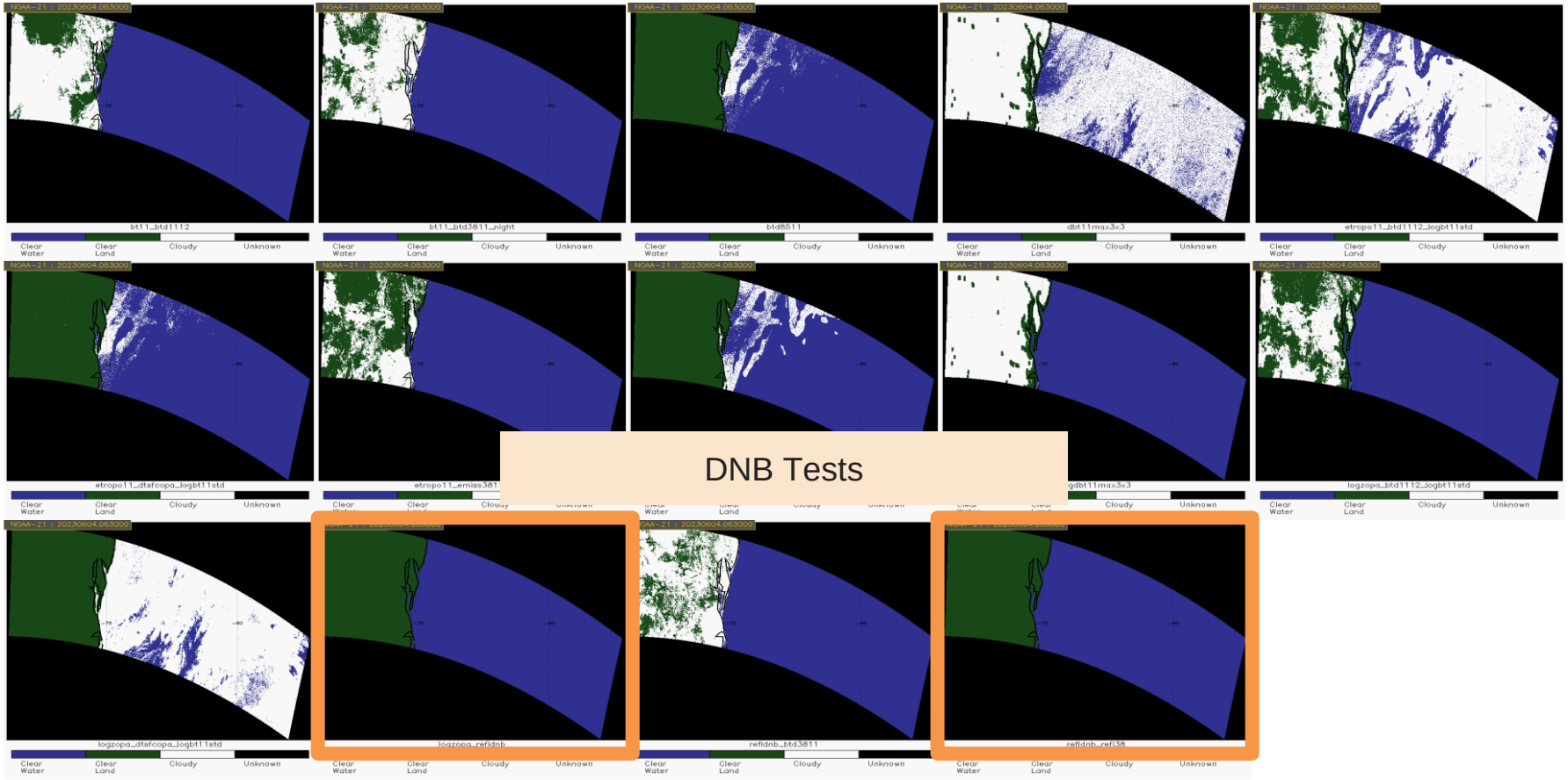
Descending (Night) NOAA-21 Scene for ECM Bit Display

2023-06-04 06:25 UTC

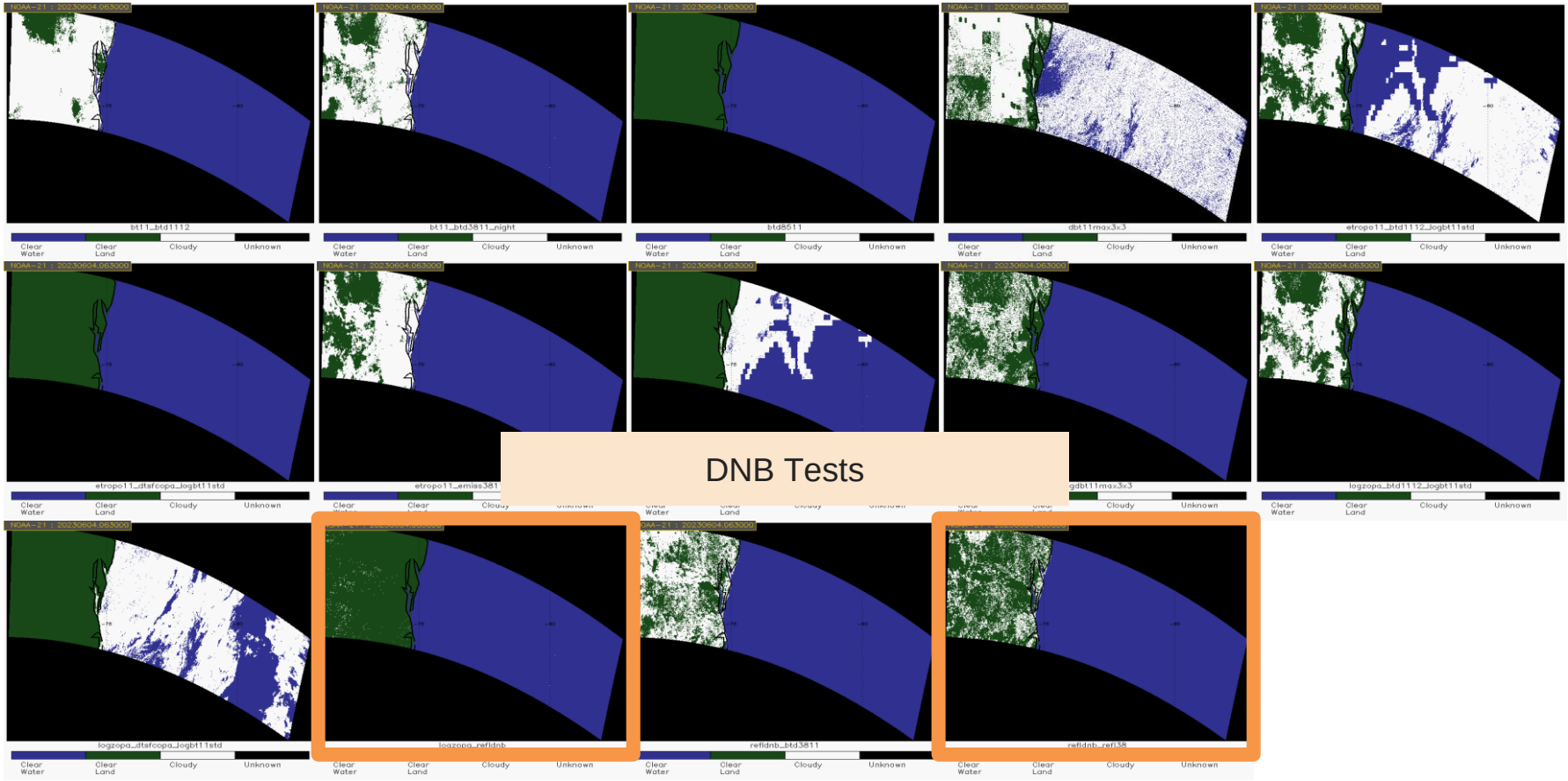




NOAA-21 Visual Representation of ECM Bits (NCCF)



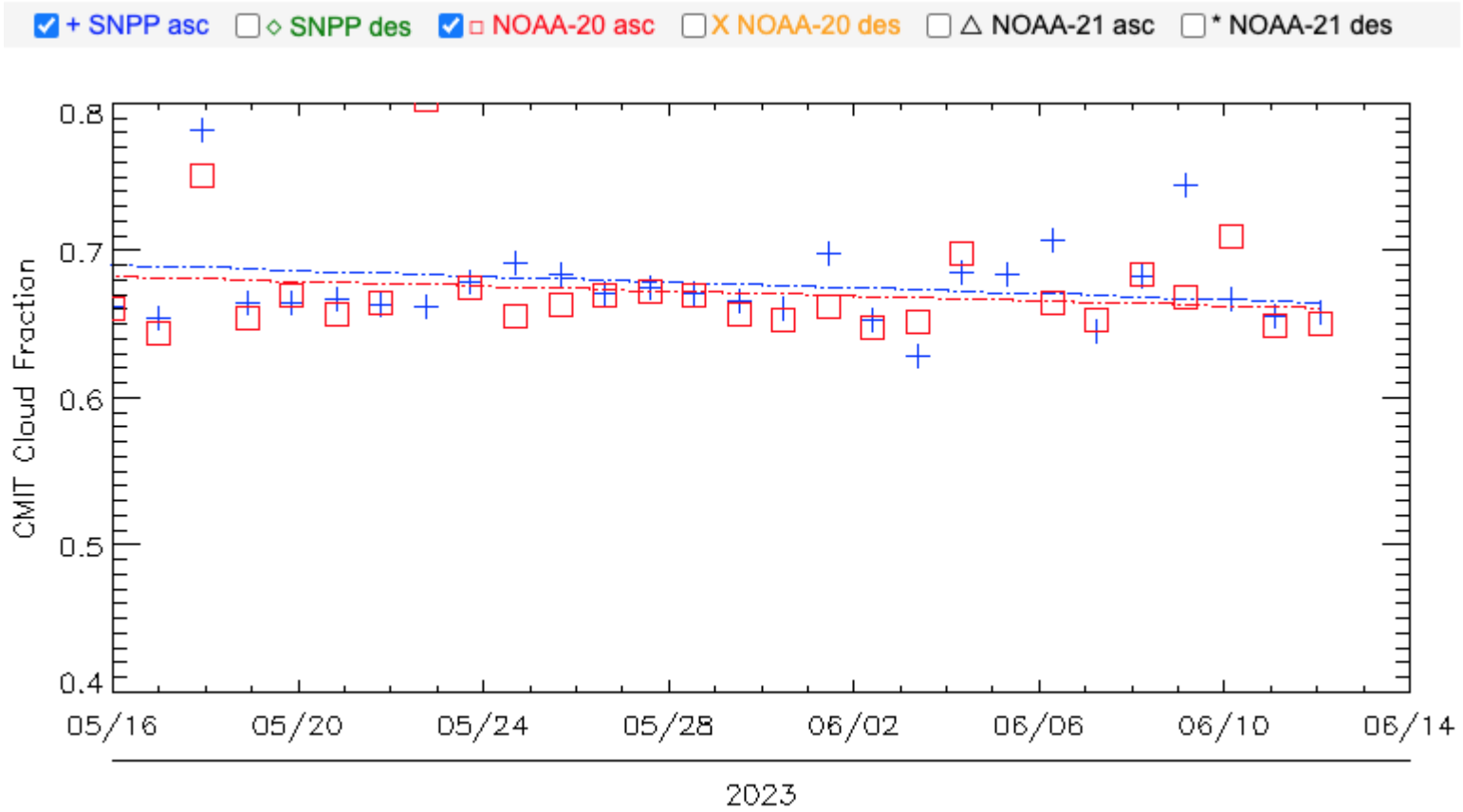
NOAA-21 Visual Representation of ECM Bits (CLAVRx)



Conclusions from Visual Comparisons

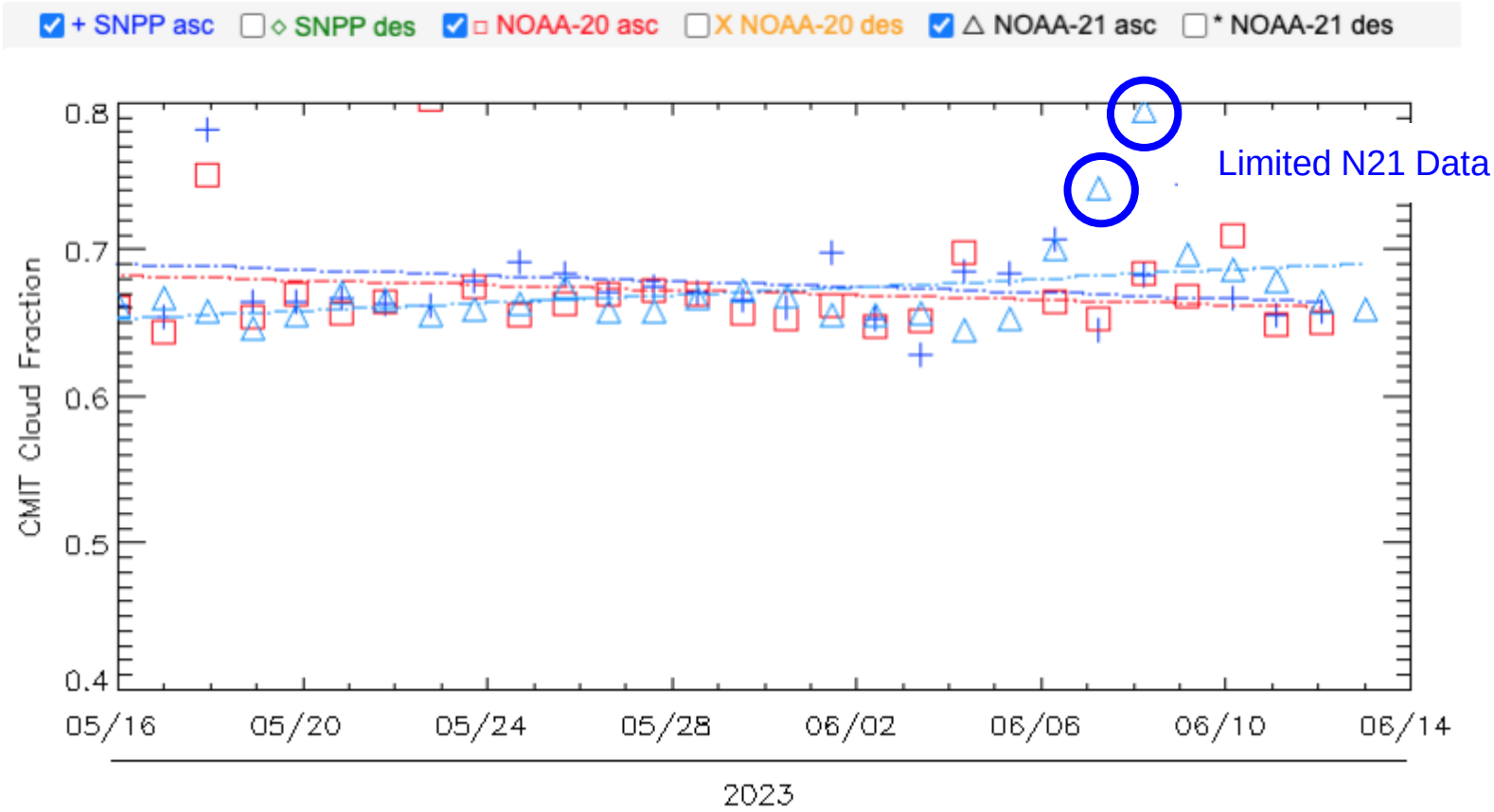
Issue	Comment
Differences between NCCF and CLAVR-x ECM results	Mostly minor differences, but some scenes (e.g., twilight ocean + sea ice) show more significant differences. Cause uncertain. Will continue investigating.
Differences in ECM packed bits between NCCF and CLAVR-x	Differences in individual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

CIMSS Long Term Monitoring Tool - Quick Glance Quantitative Sanity Check



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

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

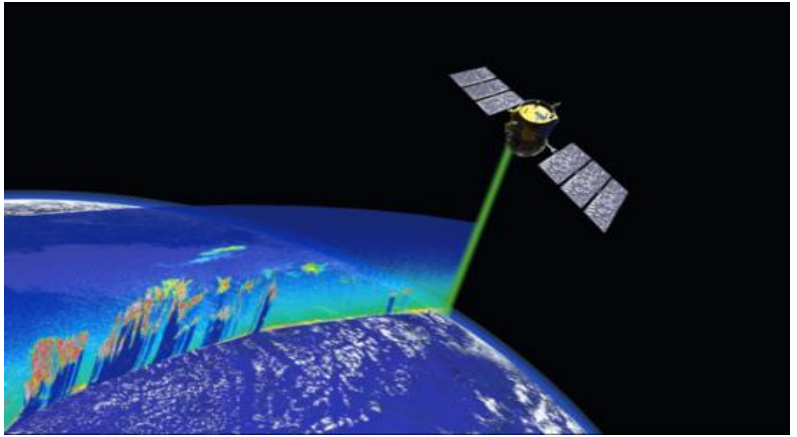


https://cimss.ssec.wisc.edu/clavrx/realtime-products/viirs/viirs-cloud-product-trends/

Comparison to CALIPSO/CALIOP

CALIOP Comparison Description

- CALIOP is a lidar onboard of CALIPSO.
- **CALIOP Cloud algorithm results are considered as "Truth".**
- One day of CALIOP and NOAA-21 Matchup data is used from 05/31/2023.
- 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 NDE	29780	0.879	0.895	0.025	0.030	0.870	0.948	0.034	0.018
ECM CLAVR-x	29780	0.879	0.912	0.021	0.029	0.870	0.950	0.041	0.009
Global, Ocean, Day, No Snow & Ice									
ECM NDE	13033	0.890	0.895	0.009	0.010	0.920	0.968	0.018	0.014
ECM CLAVR-x	13033	0.890	0.903	0.007	0.013	0.920	0.968	0.022	0.010
Global, Ocean, Night, No Snow & Ice									
ECM NDE	7952	0.994	0.996	0.003	0.006	0.900	0.993	0.005	0.002
ECM CLAVR-x	7952	0.994	0.994	0.006	0.008	0.900	0.990	0.005	0.005

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 NDE	8713	0,.756	0.802	0.070	0.083	0.900	0.875	0.085	0.040
ECM CLAVR-x	8713	0.756	0.849	0.054	0.073	0.900	0.886	0.104	0.011
Global, Land, Night, No Snow & Ice									
ECM NDE	82	1.000	0.976	0	0	0.880	0.976	0	0.024
ECM CLAVR-x	82	1.000	0.976	0	0	0.880	0.976	0	0.024

Requirement Check List – VIIRS Cloud Mask

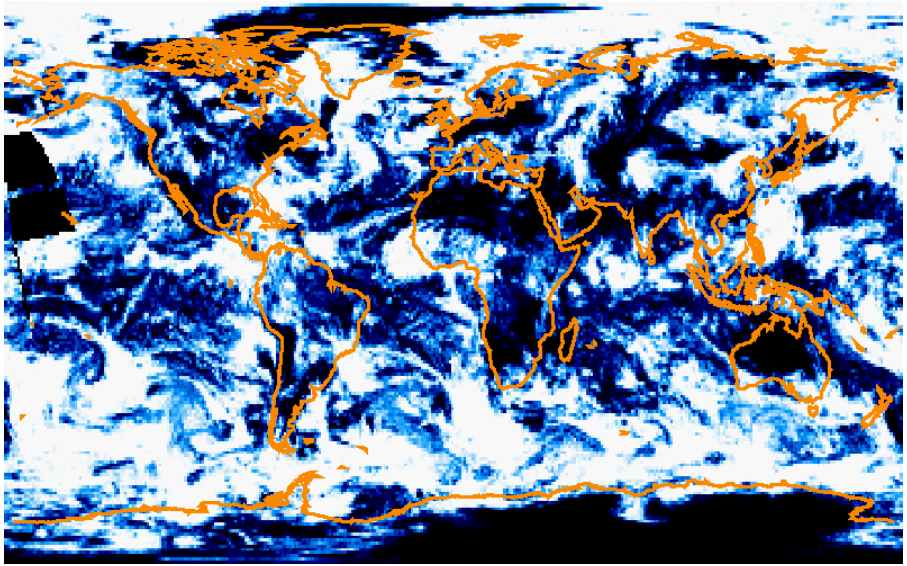
DPS	Requirement	Performance
DPS-435	The Cloud Mask product shall provide a cloud mask for the total cloud cover, globally whenever detectable clouds are present, at the refresh rates of the instrument.	Pass
DPS-436	The Cloud Mask product shall provide a cloud mask for the total cloud cover with a probability of correct typing, averaged globally, of 87%.	Pass
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.	Pass
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.	Partial Pass
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.	N/A
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.	N/A
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.	N/A
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.	N/A

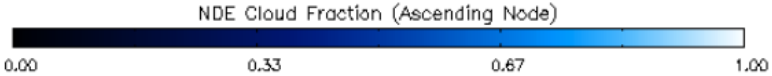
Conclusions from CALIPSO Comparisons

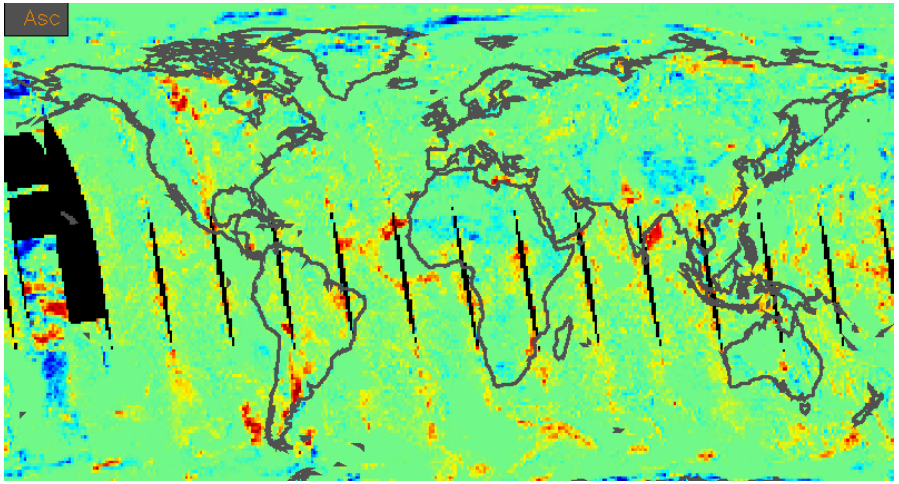
- NDE/OPS ECM performs well globally
- Surface type and day versus night comparisons also excellent
- Daytime land comparisons are only category (slightly) below validation specs
- Limited dataset caveat applies

Comparison to AQUA/MODIS Collection 6.1

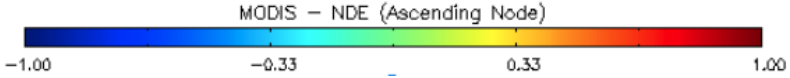
Cloud Fraction Ascending Node







Difference between NOAA-21 NCCF and MODIS

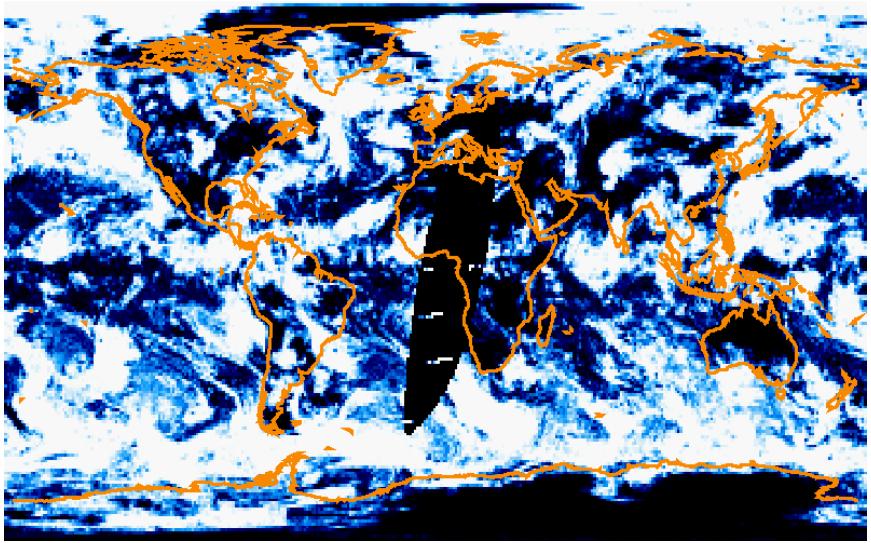


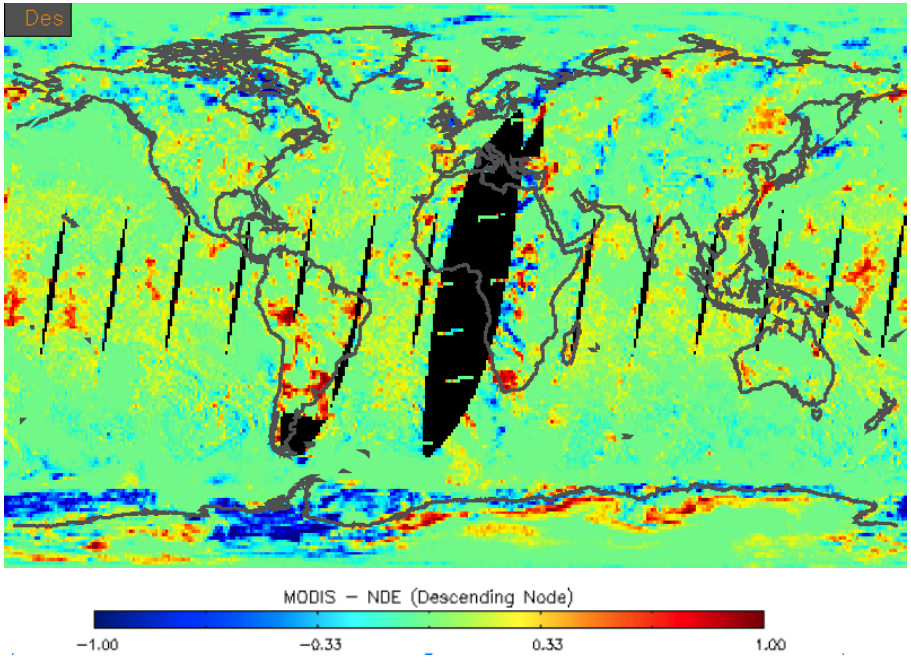
Red = Cloud Observed by MODIS but Missed in NCCF N21.

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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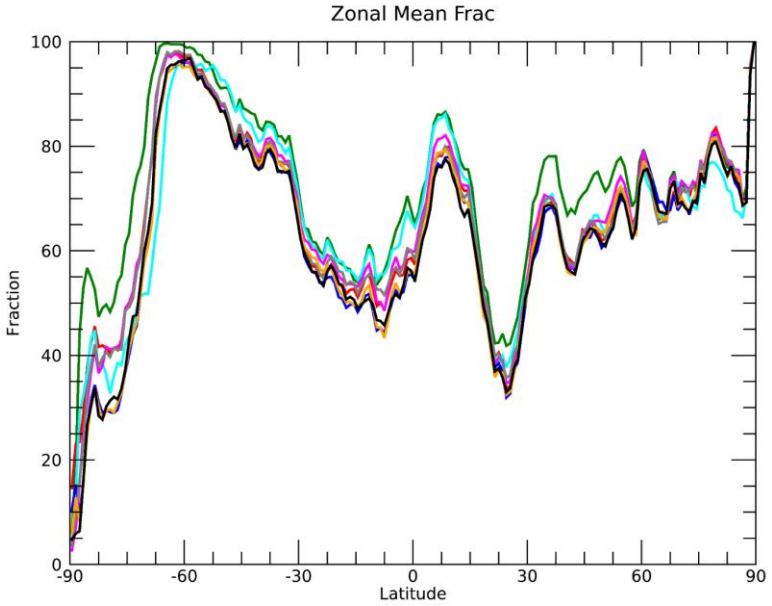
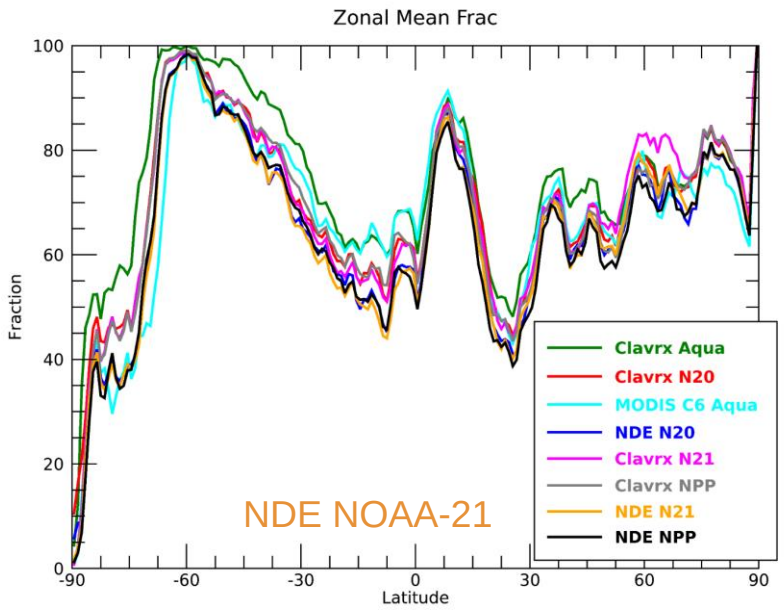
Zonal Distribution of Cloud Fraction



Ascending



Descending

- Zonal mean cloud fraction using one day of data (5/31/2023)
- NCCF/NDE NOAA-21 is consistent with the other Enterprise products.

Global Stats

Global mean cloud fraction [%]

	NDE N21	Clavr-x N21	NDE N20	Clavr-x N20	NDE NPP	Clavr-x NPP	Clavr-x Aqua	MODIS C6 Aqua
Ascending	63.1	66.0	63.2	66.1	63.0	65.8	71.3	66.0
Descending	65.1	69.5	65.4	69.3	64.7	68.9	74.3	67.8

Stats 60ºN - 60ºS

Mean cloud fraction [%]

	NDE N21	Clavr-x N21	NDE N20	Clavr-x N20	NDE NPP	Clavr-x NPP	Clavr-x Aqua	MODIS C6 Aqua
Ascending	63.8	66.0	63.9	65.6	63.6	65.8	71.1	68.2
Descending	66.2	70.0	66.8	69.9	66.0	70.0	75.6	72.0

Conclusions from MODIS Comparisons

- NOAA-21 ECM (NCCF/NDE) performs similarly to CLAVR-x and MODIS in non-polar regions.
- Antarctic region: cloud detection is much less in ascending mode, and cancellation effects are observed in descending mode.
- Highlights specific regions to be investigated further.

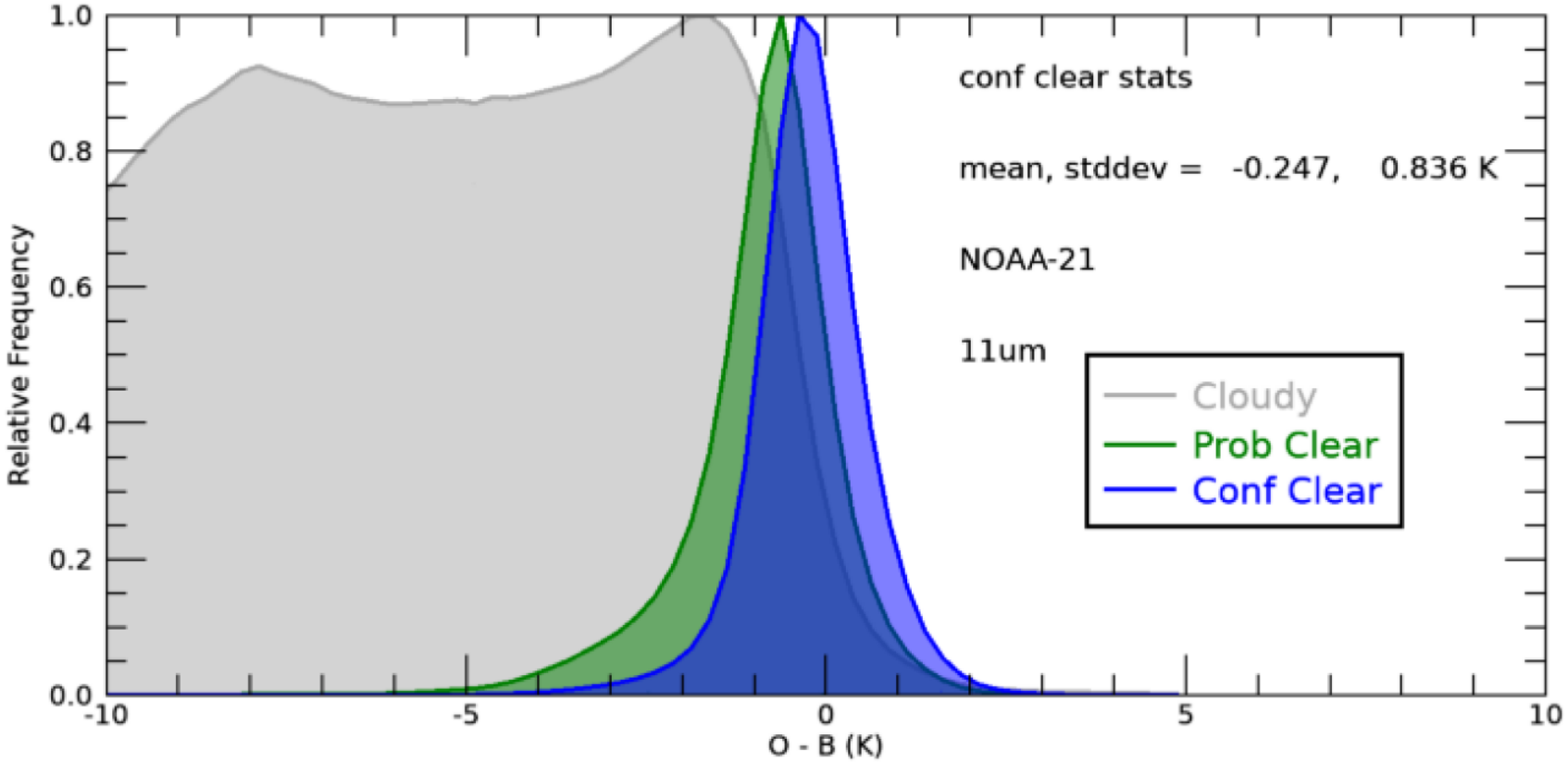
Clear Sky Radiance (CSR) Bias Analysis

Methodology

- Over ice-free oceans, the clear-sky calculation for VIIRS IR Channels is accurate.
- CLAVR-x was run using a fast RTM (RTTOV) on June 1, 2023 for NOAA-21.
- For truly clear pixels, the distribution of the bias in the observed (O) radiance relative to the clear-sky calculation (B) should be a gaussian distribution centered on 0K.
- Cloud contamination is most often seen as a cold tail on this distribution.
- This method fails to discriminate clouds whose temperatures are near the clear-sky value.
- This analysis is relevant since VIIRS cloud mask used in CrIS Radiance Assimilation

Results

NDE Mask + CLAVR-x (Ancil) Results for 11 μm



Clear-Sky Radiance Conclusions

- NCCF/NDE Cloud Mask combined with CLAVR-x RTM and L1b results in a O-B distribution that looks correct (narrow gaussian centered on 0K without a cold tail).
- Same cloud mask run through CLAVR-x yields a similar O-B distribution.
- Other channels were similar (8.5 and 12 μm)

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

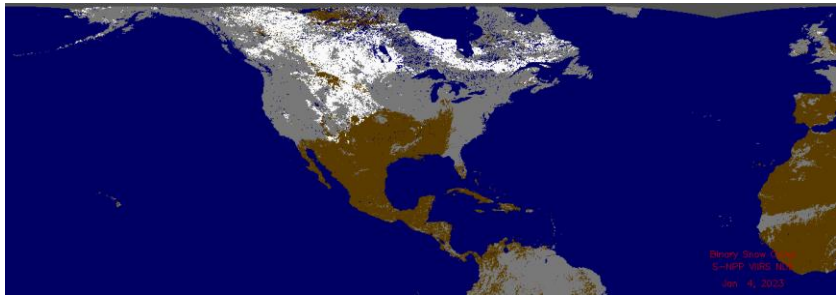
ECM Users

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

ECM User Feedback

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).

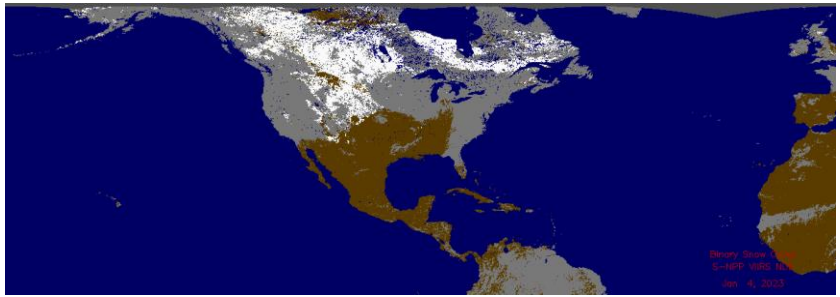


White = snow (cloud free)
Gray = cloudy

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).
- 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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Beta Maturity Conclusions

- Recommendation: NOAA-21 ECM **passes** the Beta Maturity review based on qualitative and quantitative analyses
- Effective date: March 30, 2023
- 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.

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 - Beta Maturity

Beta Maturity End State	Assessment
Product is minimally validated, and may still contain significant identified and unidentified errors	Yes. Verification of only the ECM cloud mask/probabilities as well as the packed bits and DQF was performed. Other flags (smoke, fire, dust) have not been performed.
Information/data from validation efforts can only be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose	Yes. Limited dataset over a few weeks have been performed. This also was only over the spring/early summer season.
Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists	Yes. See slides

Pathway to Provisional

- Same activities will be conducted for Provisional Maturity:
  - Archive of golden days is being compiled
    - SDRs and EDRs (May 2023 to August 2023).
  - Engage other teams begin application-specific analyses.
  - Take advantage of opportunities for threshold adjustments.

Risks for Provisional

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

- **NCCF/NDE I&T and STAR data dropouts(Moderate)**
  - Lack of consistent global datastream over the full period may prevent necessary information needed for Provisional validation
  - **The ECM team would like to have the ECM I&T data for N21 on CLASS or an accessible portal.**
- **CALIPSO/CALIOP Data Availability (Moderate)**
  - Sensor near end-of-lifetime
- **Updated ECM LUT**
  - While not necessary to meet spec, the cloud team will be updating the ECM LUT in November, 2023 in anticipation of the Full Maturity Review.

Future ECM Plans

- NOAA-20 “Future Plans” list have been addressed and implemented
  - E.g., reporting the 3-D classifiers, flexible bit information, DNB Lunar Reflectance
- New LUT for VIIRS and ABI under development
  - I-band information and M-band stats as new classifiers
  - The capability to read this information is currently implemented in VIIRS processing system
  - Will verify its integration once a new LUT is available.
- Continual ECM improvements based on user feedback

Backup Slides