NOAA-20 VIIRS Enterprise Cloud Mask (ECM) Provisional Maturity

October 2, 2018

VIIRS Cloud Mask Team

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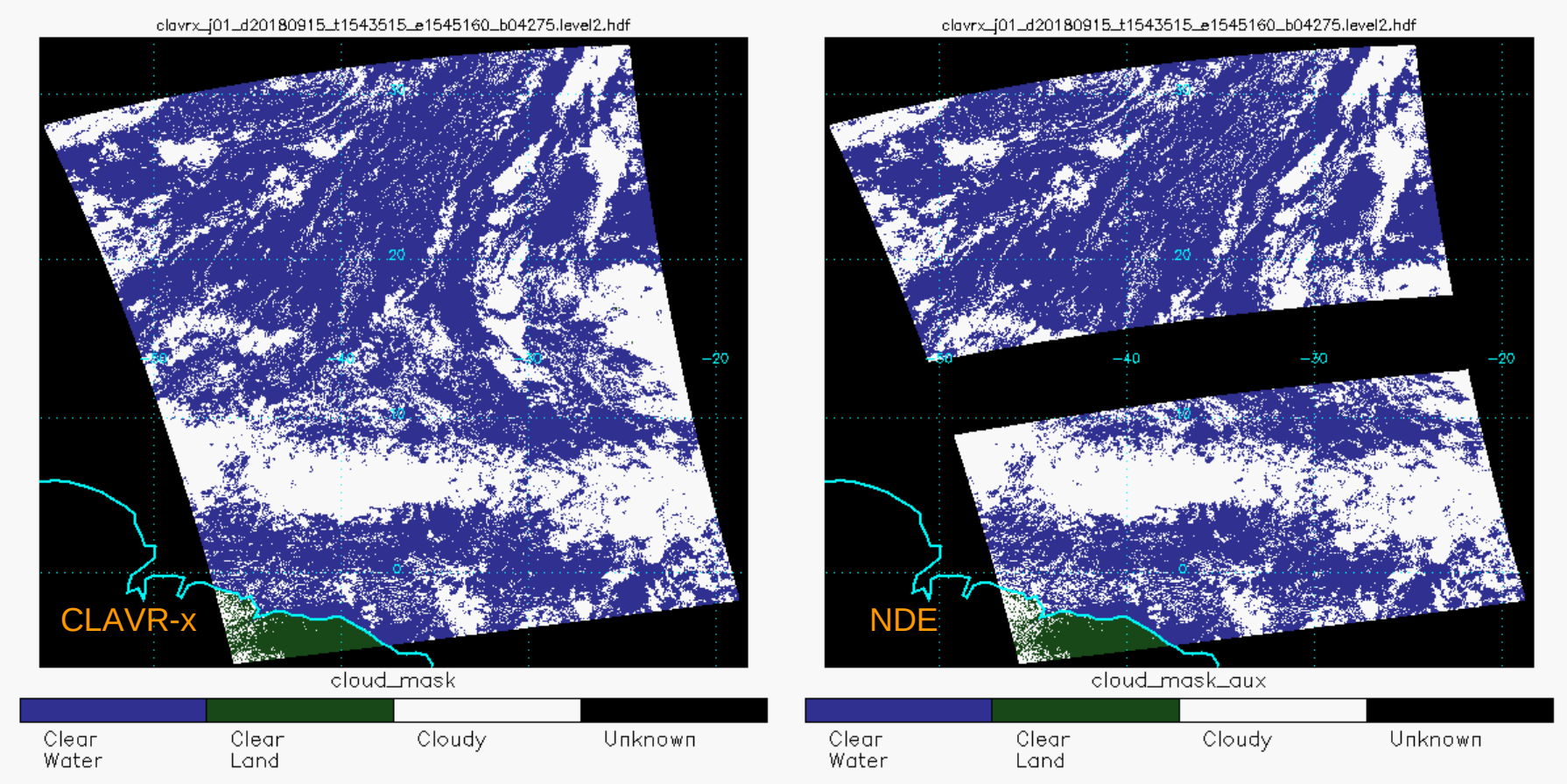
Executive Summary

- Provisional analysis utilizing CALIPSO shows an improvement over Beta.
- The MODIS and SST analysis shows continued good daytime performance.
- While both the MODIS and SST analysis meet requirements at night, both show a **degradation** in the nighttime (ocean) performance from Beta.
  - This particularly for low stratus clouds at night.
  - Currently there is no clear reason for this degradation in detection capability

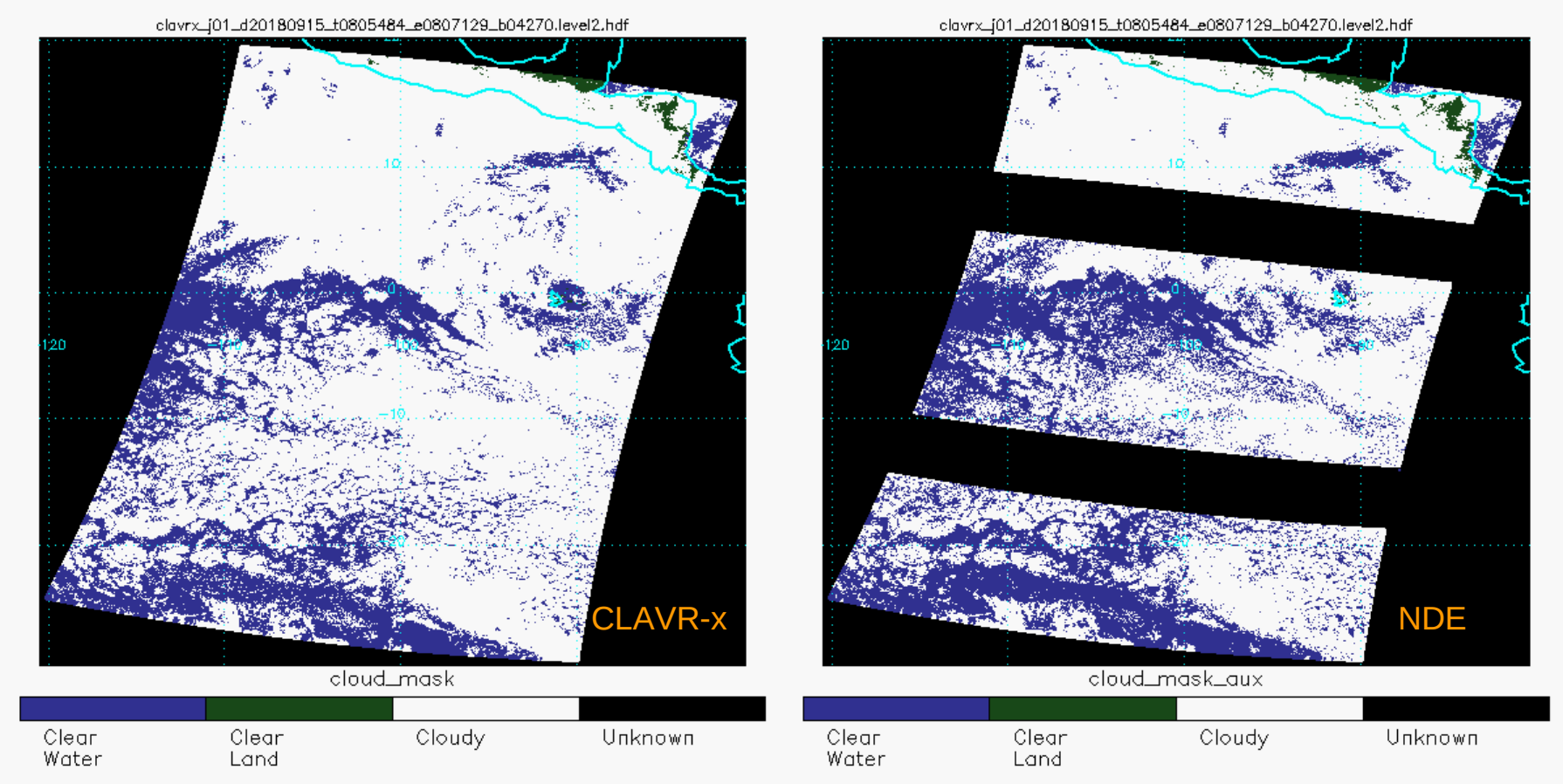
Summary of issues from Beta and status

Issue	Status	Comment
Lack of Confidently Clear over Ocean at night.	FIXED (see comment)	A patch to v1r2 was delivered in June 2018 but not applied due to decision at NDE. Will be implemented in v2r0. Cloud Team still encourages teams to use cloud probability
Missing Low cloud at night	FIXED	See next slide for discussion
Missing granules.	FIXED (see comment)	A patch to v1r2 was delivered by ASSISTT in June 2018 but not applied due to decision at NDE. Will be implemented in v2r0. Will hopefully be in Ops ~end 2018 pending SPSRB Review.

Visual Comparison: Day Ocean



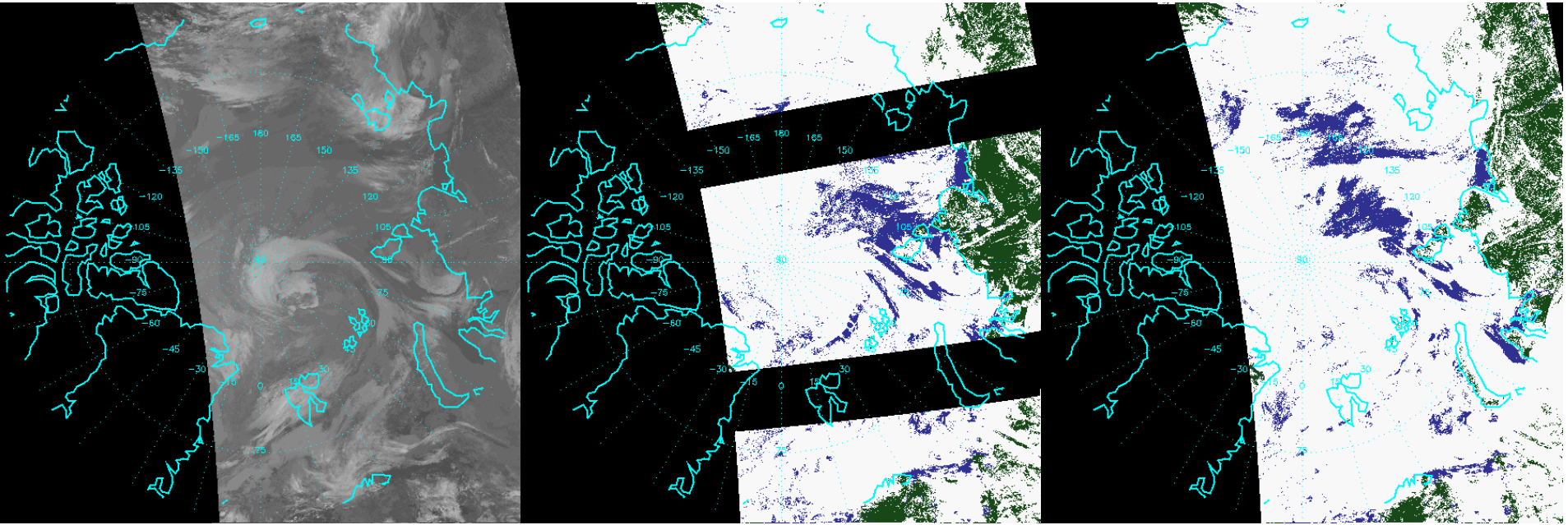
Visual Comparison: Night Ocean



Visual Comparison: Arctic

September 15, 2018, NOAA-20

11μm BT | NDE ECM | CLAVR-x ECM



Similar performance of NDE to CLAVR-x after fixing ECM LUT

Conclusions from Visual Comparisons

Issue:	Comment:
Cloud Mask Test Bits	Perform as expected.
Day Ocean.	Perform as expected.
Night Ocean.	Notably less cloud than CLAVR-x
Arctic Performance.	Perform as expected after ECM LUT fix.
Missing granules.	Fixed with v2r0 implementation

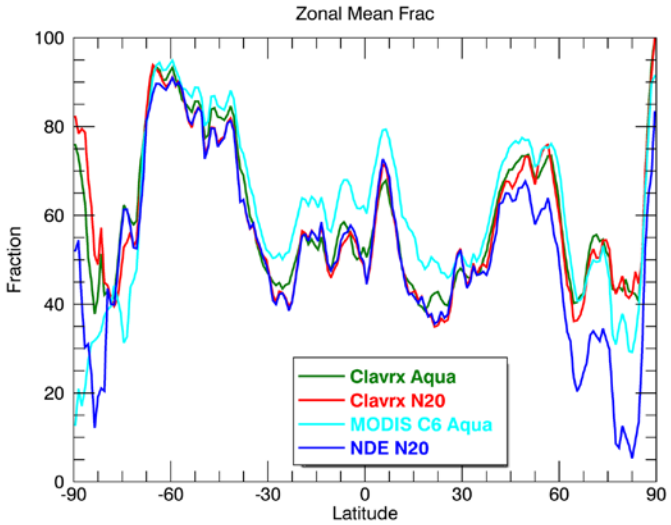
CALIPSO Validation of NDE NOAA-20 ECM

Algorithm	Sample Size	Cloud fraction				Required Detection	Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy		Detection	False Detect.	Missed Cloud
	Global, Ocean/Land, Day/Night, No Snow/Snow/Ice								
ECM NDE	14603712	0.680	0.664	0.139	0.106	0.870	0.875	0.061	0.063
ECM CLAVR-x	14603712	0.680	0.678	0.088	0.086	0.870	0.884	0.061	0.055
	Ocean, Day, Global, No Snow/Snow/Ice								
ECM NDE	4408608	0.728	0.711	0.026	0.020	0.920	0.941	0.020	0.039
ECM CLAVR-x	4408608	0.728	0.711	0.022	0.022	0.920	0.947	0.019	0.034
	Ocean, Night, Global, No Snow/Snow/Ice								
ECM NDE	5136840	0.735	0.783	0.096	0.064	0.900	0.911	0.069	0.020
ECM CLAVR-x	5136840	0.735	0.761	0.084	0.029	0.900	0.931	0.034	0.035
	Land, Day, Global, No Snow/Snow/Ice								
ECM NDE	1217016	0.563	0.485	0.043	0.028	0.900	0.908	0.018	0.074
ECM CLAVR-x	1217016	0.563	0.491	0.039	0.022	0.900	0.918	0.014	0.068
	Land, Night, Global, No Snow/Snow/Ice								
ECM NDE	1199424	0.621	0.556	0.072	0.075	0.880	0.892	0.047	0.061
ECM CLAVR-x	1199424	0.621	0.581	0.074	0.054	0.880	0.906	0.042	0.052

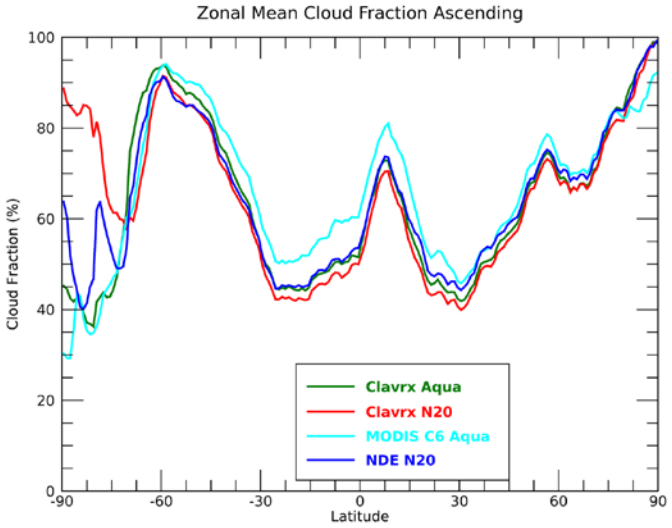
- This stats are calculated based on VIIRS - CALIOP data from 24 days in 2018 (from 2018-122 to 2018-252).
- Both ECM NDE and ECM CLAVR-x meet required specification.

ECM NDE - I&T ECM NDE
ECM CLAVR-x - ECM produced by CLAVR-x
No Snow/Snow/Ice = Snow/Ice Filter Applied

MODIS Comparison: Difference with Beta (Daytime)



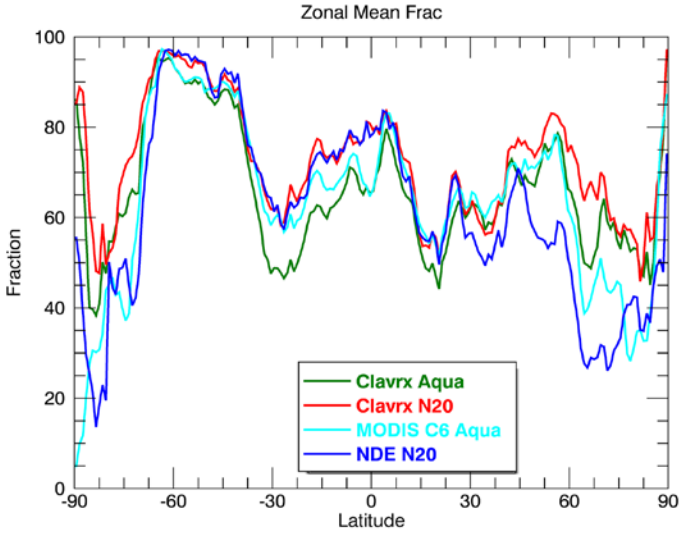
Beta

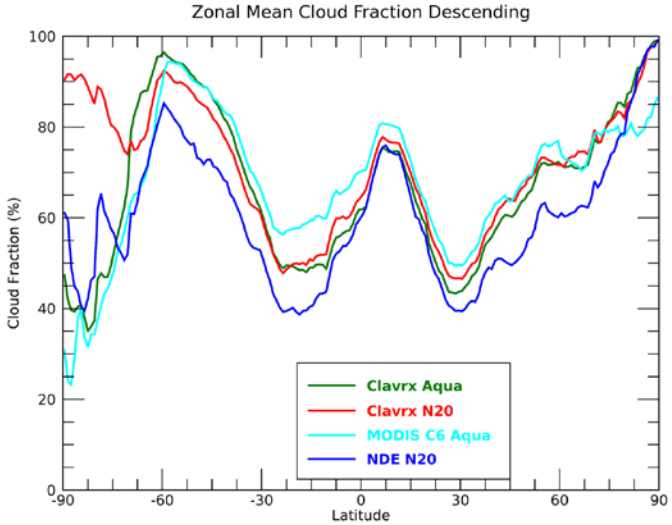


Provisional

- Beta was done in the Spring with less data so curves show look different.
- NDE N20 is in-line with CLAVR-x (as expected).

MODIS Comparison: Difference with Beta (Nighttime)





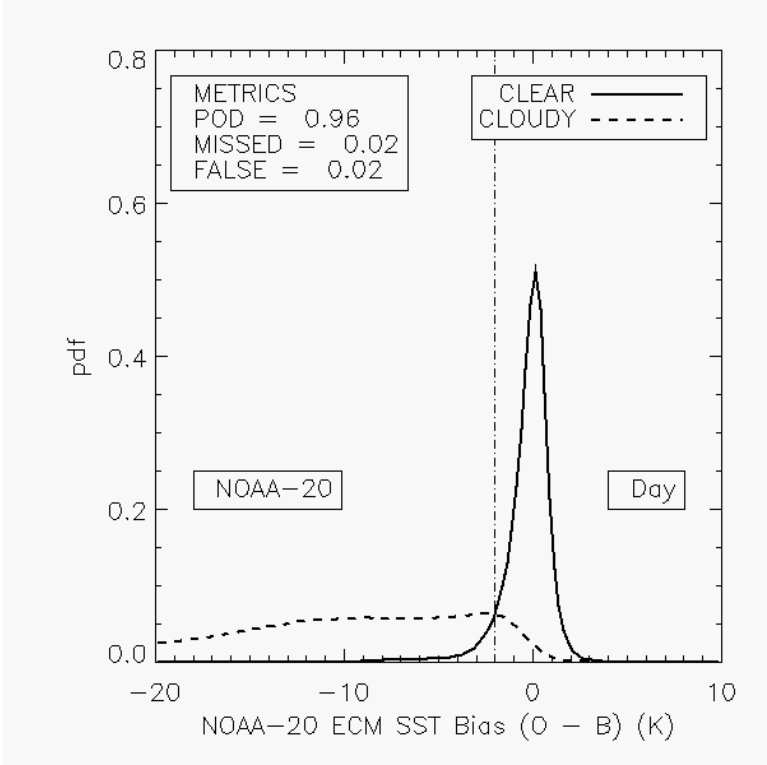
Beta

Provisional

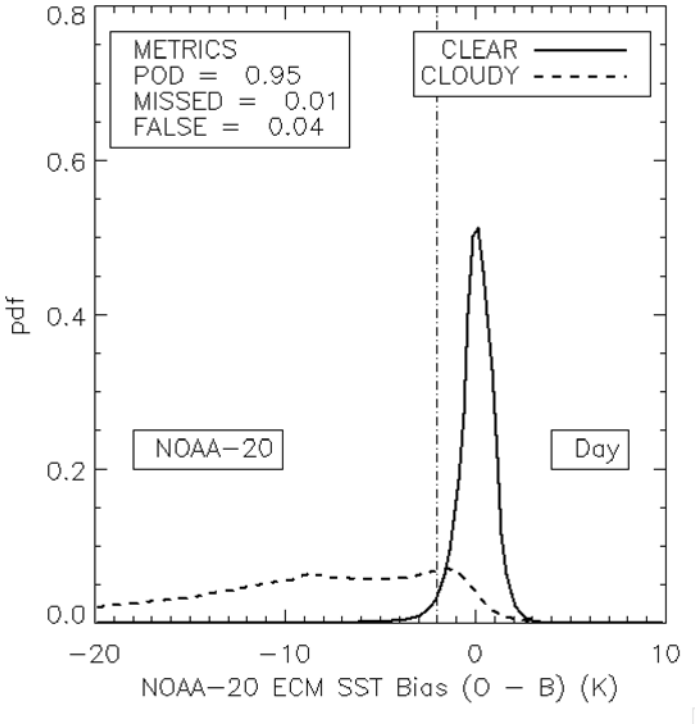
- Beta was done in the Spring with less data so curves show look different.
- NDE NOAA-20 seems to be relatively lower than it was in Beta

Change from Beta in Daytime SST Analysis

Beta

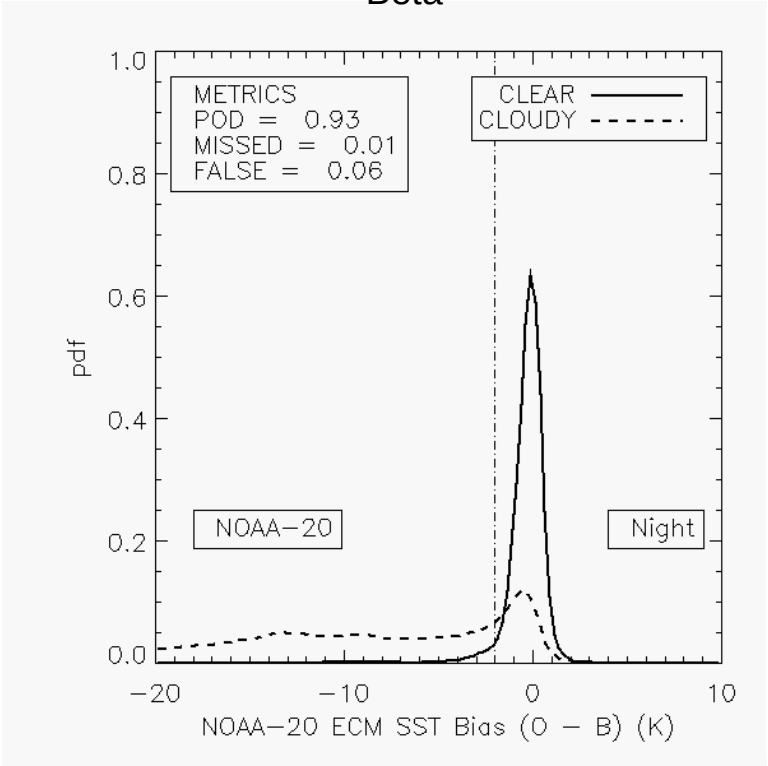


Provisional

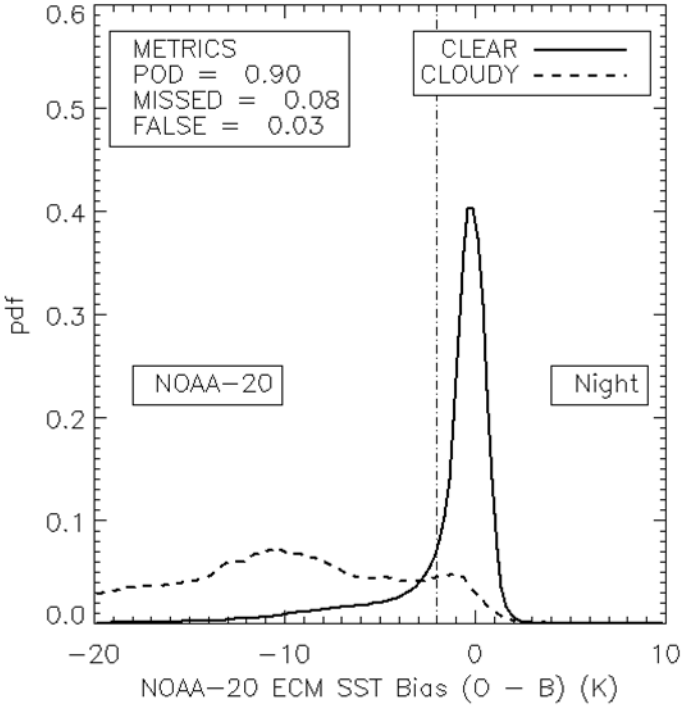


Change from Beta in Nighttime SST Analysis

Beta

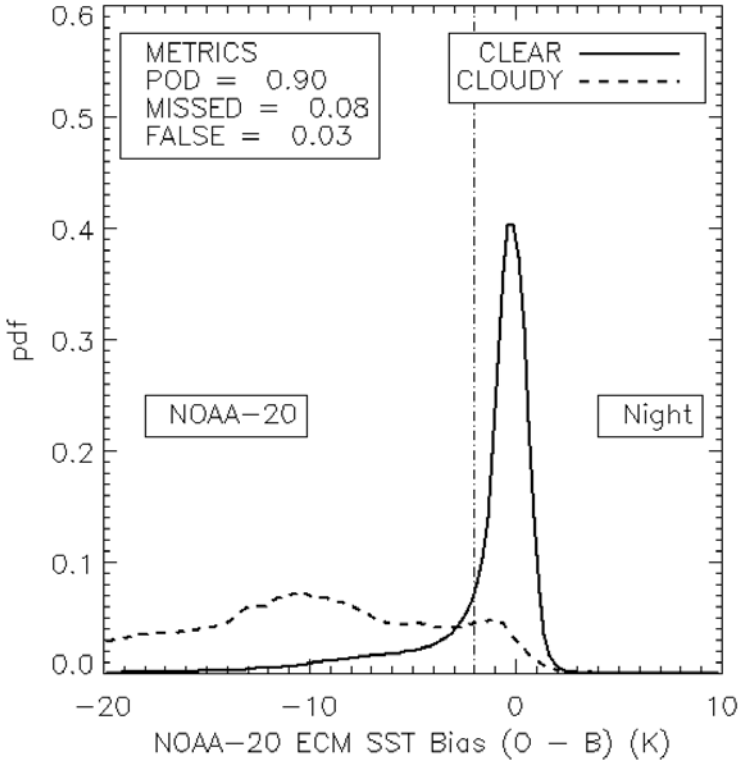


Provisional

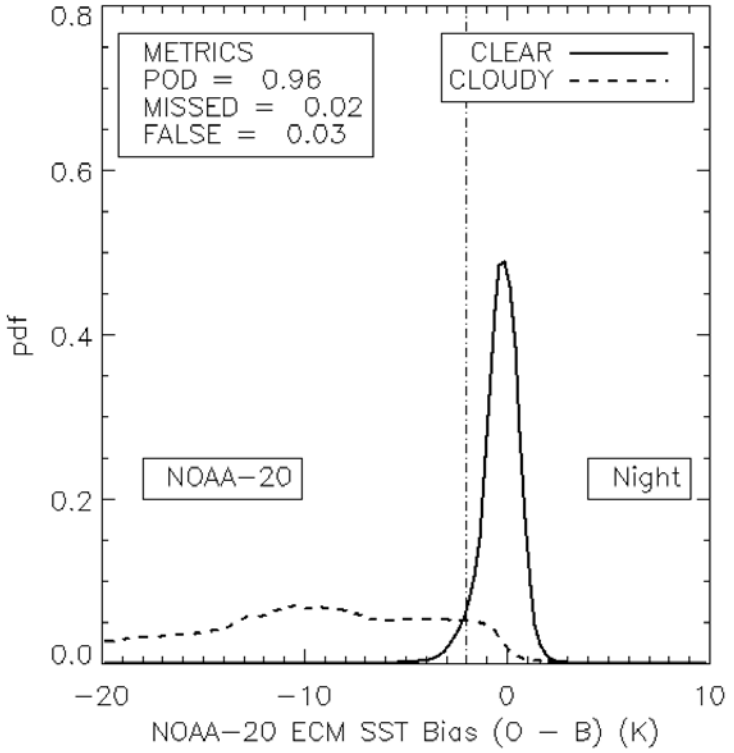


Comparison of NDE and CLAVR-x Night SST Analysis

NDE



CLAVR-x



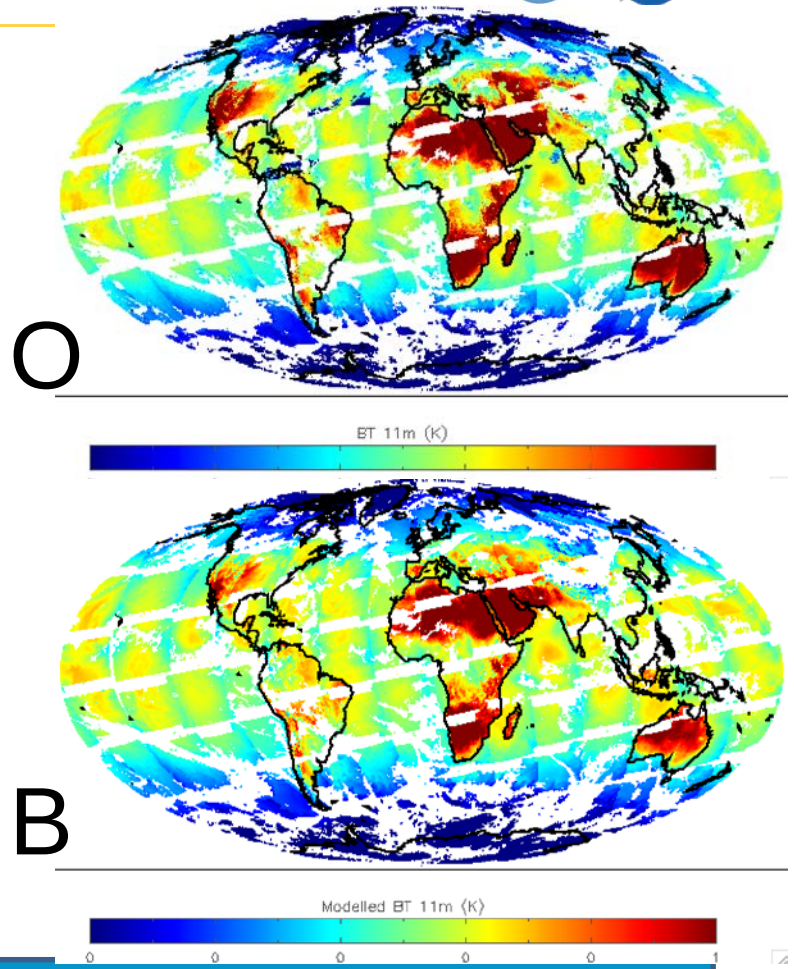
VIIRS All-Sky Radiance

Background

- GOES-16 All-Sky Radiance is the radiance product generated from GOES-16 IR channels for NWP Radiance Assimilation. Already used by ECMWF, monitored by NCEP
- This is similar to the VIIRS + CRIS radiance products but those aren't made yet for NOAA-20.
- NCEP has expressed interest in a VIIRS ASR product and that is what we are using to evaluate the ECM.
- This replaces our "SST" analysis as it more relevant to our users. (SST has it own mask)

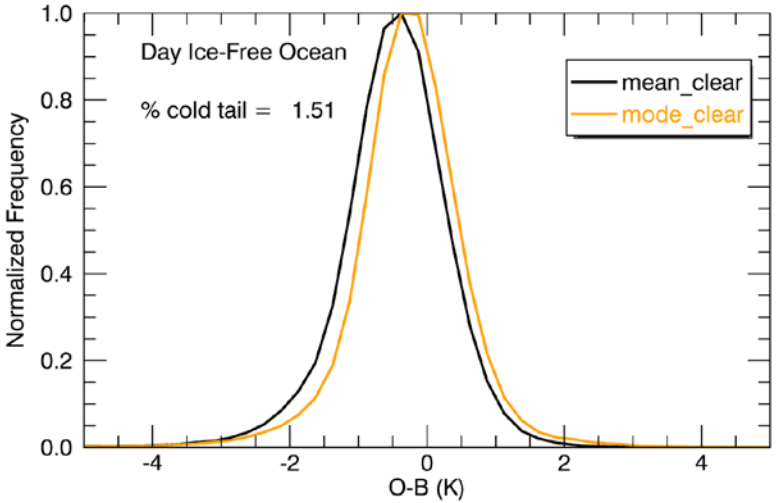
Method

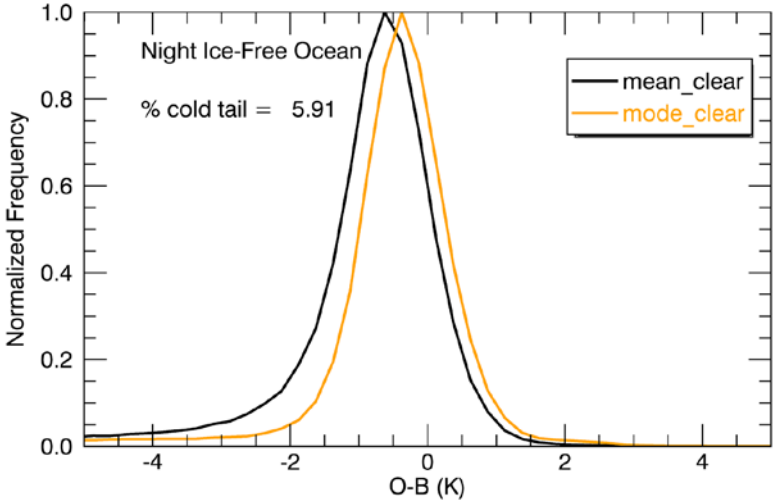
- We used 32x32 pixel arrays which results in grids with a similar spacing to GOES-16
- Require 10% of pixels to be clear to make a result
- We stored Mean and Mode of Clear Distribution - though only mean is used.
- CAVEATS: PFAAST and low-res GFS used.



VIIRS ASR over Ocean

- As we did with SST, we make O-B distribution and infer cloud mask performance
- ASR requires 10% clear pixels which automatically prevents some cloud contamination.
- As with SST, we see degradation at night relative to day. (same issue).
- We defined cold tail as pixels with O-B < mean peak -2 K.
- Performance is acceptable though spec for ASR is unknown





Pathway to Full Maturity

- We expect to apply the same activities to be conducted for Full Maturity:
  - We continue to gather an archive of golden days where we save SDRs and EDRs spread from June 2018. This collection is ongoing.
  - We hope to continue to engage the teams and continue application-specific analysis.
  - We will take advantage of opportunities for table adjustments.
  - The NOAA-20 specific LUT will be developed by April 2019, one 1 year of good data (i.e non-beta) imagery is available. Collection of collocations needed for LUT generation is on going to span seasonal variations.

Risks for Full Validation

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

- **NDE processing issues (Moderate)**
  - Missing granules in NDE processing
    - Currently being addressed in August 2018 DAP delivery. Will be transitioned to NDE I&T late 2018 and expected operations in late 2018, pending SPSRB approval.
  - **The lack of understanding of the team on how NDE processes the ECM impairs the ability of the Cloud Team to fully and easily diagnose these issues.**

- **Similar SDR issues as beta**
  - **M5 on SNPP is 5% too bright.**
  - Our initial looks at NOAA-20 indicates that it's M5 calibration does not suffer from this.
  - Our SNPP LUT automatically tuned out this calibration error so we expect NOAA-20 to 'miss' cloud due to this issue.
  - **NOAA-20 specific ECM LUT may solve this issue.**
    - Training requires data from all seasons. Expected delivery by **April 2019**
    - Training details in Backup slide section

Risks for Full Validation

– **New issues (Moderate)**

- An evaluation of the ECM has shown that some low cloud over the ocean at night is still being marked with a low probability of being cloud (discussed in ASR analysis section)
  – **Will reevaluate when NOAA-20 specific LUT is developed and 2-D classifiers are integrated into SAPF processing.**

- The ECM team continues to encourage teams to identify areas they feel are of concern for the team to investigate and try and mitigate

Future Plans of ECM

- Next delivery plans
  - Use of 2-D Luts adds in low cloud detection. This coded in delivered ECM but not turned on because of the bit issue.
  - We need to add flexibility to the reporting of the bits. ECM runs on many sensors and will evolve. We would like to add a file attribute that tells which tests were on and adjust the packed bits based on that attribute.
  - We need more diagnostic information.
    - we need to add snow/ice information.
    - we need a unique ECM LUT identifier added as a file attribute.
    - we need a unique ECM code version added as a file attribute.
    - we need a file attribute that tells us which channels were used.
- Future plans (as they become available in the SAPF
  - Use of DNB Lunar Reflectance is included in code and we hope someday that can be turned on.
  - We would also like to use the I-Band stats.

Conclusions

- Provisional analysis utilizing CALIPSO shows an improvement over Beta.
- The MODIS and SST analysis shows continued good daytime performance.
- While both the MODIS and SST analysis meet requirements at night, both show a **degradation** in the nighttime (ocean) performance from Beta.
  - This particularly for low stratus clouds at night.
  - Currently there is no obvious reason for this degradation in detection capability
- **The Cloud Team recommends Provisional Maturity at this time pending the swap out of the LUT (i.e. with the CLAVR-x/MODIS derived LUT (used in v1r1))**

Programmatic Concerns

- ECM data for provisional was limited by two factors
  - Consistent 20% missing granules (scheduled to be fixed imminently, but too late for Provisional)
  - Two months with an incorrect LUT on the NDE I&T string
- Latest science fix delivered this year will not be implemented until 2019 (at the latest)
- Communication with NDE and users remains a challenge
- A known identified issue with low clouds will be addressed in the next delivery, but this may not become operational until 2020

Full Briefing

Outline

- ECM Description
- ECM Status in NDE
- Status of issues from Beta
- Evaluation of the ECM
- Provisional Maturity Conclusions
- Pathway to Full Validation
- Future Plans

STAR ECM Cal/Val Team

Name	Organization	Major Task
Andrew Heidinger	NESDIS/STAR	Cloud Team Lead
Thomas Kopp	Aerospace	User/Program Interaction. Visual/Manual Analysis
Denis Botambekov	CIMSS	Algorithm training, verification
William Straka	CIMSS	ASSISTT integration
Jay Hoffman	CIMSS	SAPF processing for training data
Shuang Qiu	OSPO	Product Area Lead

Enterprise Cloud Mask Review

Enterprise Cloud Mask

- Supports many sensors and its part of the NOAA Enterprise Algorithm Suite.
- It is probabilistic, using machine learning (naive Bayesian formulation) and NASA CALIPSO data as its training.
- The primary output is the cloud probability (0 - 1 floating point number).
- The 4-Level cloud mask is derived solely from the cloud probability.
- ***We strongly encourage algorithm teams to derive their own threshold on the cloud probability for their own applications.***
- Enterprise mask is comprised of multiple classifiers (aka tests). A 4-level mask from each classifier is also available. It is packed into sets of bytes.
- The demand for one algorithm to serve many sensors drove the ECM development.

How to Use the Enterprise Cloud Mask

- The fundamental output of the ECM is the cloud probability.
- Users should not use the 4-level cloud mask.
- Users should use thresholds on the cloud probability to determine what is clear for their applications.
- Threshold will vary with surface type and application.
- Probably clear and probably cloudy in VCM are not tied directly to cloud probability.

Users of the ECM

- Downstream Enterprise Clear-Sky Applications.
- Enterprise Cloud Algorithms.
- NCEP VIIRS/CrIS Radiance Assimilation and VIIRS ASR.
- VIIRS Polar Winds, NUCAPS.
- Potentially External VCM Users (we know of none).

Enterprise Cloud Mask NDE Status

NDE/STAR VIIRS ECM Production Status

Algorithm	Suomi NPP	NOAA-20
February 2018 DAP w/o April patch (missing granules) August 2017 Science Code delivery **(v1r2)**	**NDE** **Currently in Operations since 1200 UTC on 13 August 2018**	**NDE** In I&T since 28 March, 2018 until 28 September
August 2018 DAP February 2018 Science Code delivery (v2r0)	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**
Jan/Feb 2019 DAP August 2018 Science Code delivery (v2r1)	**Delivery and development in progress** Delivery schedule provided by ASSISTT	**Delivery and development in progress** Delivery schedule provided by ASSISTT

NDE/STAR VIIRS ECM LUT Status

Algorithm	Suomi NPP	NOAA-20
February 2018 DAP w/o April patch (missing granules) August 2017 Science Code delivery **(v1r2)**	**June 2018 redelivery of NPP Tuned LUT** **Apriori LUT**	**June 2018 redelivery of NPP Tuned LUT** **Apriori LUT**
August 2018 DAP February 2018 Science Code delivery (v2r0)	**June 2018 redelivery of NPP Tuned LUT** **Apriori LUT**	**June 2018 redelivery of NPP Tuned LUT** **Apriori LUT**
Future		**Anticipated N20 tuned LUT by April 2018 (per Cloud project plans)**

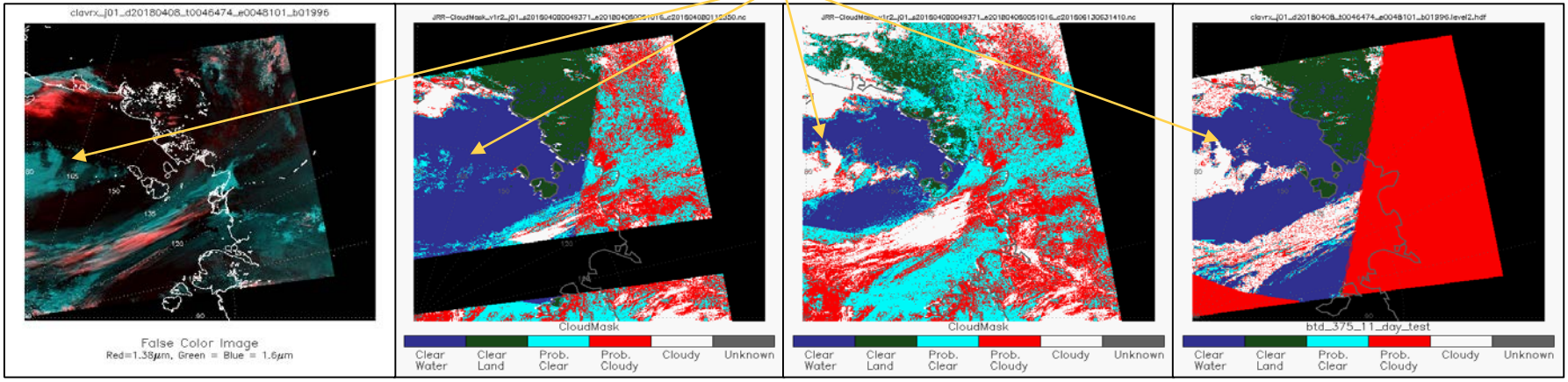
Issues from Beta Review

Summary of issues from Beta and status

Issue	Status	Comment
Lack of Confidently Clear over Ocean at night.	FIXED (see comment)	A patch to v1r2 was delivered in June 2018 but not applied due to decision at NDE. Will be implemented in v2r0. Cloud Team still encourages teams to use cloud probability
Missing Low cloud at night	FIXED	See next slide for discussion
Missing granules.	FIXED (see comment)	A patch to v1r2 was delivered by ASSISTT in June 2018 but not applied due to decision at NDE. Will be implemented in v2r0. Will hopefully be in Ops ~end 2018 pending SPSRB Review.

Missed Low Cloud at Night

Low Level Cloud over Arctic



RGB | ECM (before fix) | ECM (after fix) | BTD_375_11_Day Test

NOAA-20, 2018-04-08 00:46 UTC

- During NOAA-20 ECM Beta Review was discovered an error in ECM LUT, which was affecting BTD_375_11_Day test performance.
- Corrected ECM LUT was delivered to NDE and was implemented to I&T stream on 13 June 2018.

Provisional Validation Evaluation

Requirements

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)
1. Beta o Product is minimally validated, and may still contain significant identified and unidentified errors. o Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose. o Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.
2. Provisional o Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts. o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose. o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists. o Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.
3. Validated o Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal). o Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level. o Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose. o Product is ready for operational use based on documented validation findings and user feedback. o Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Requirements for Cloud Mask

- Requirements for have not changed since Beta and are located in the Backup slide material

Evaluation of the NDE ECM

Evaluation Methodology

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

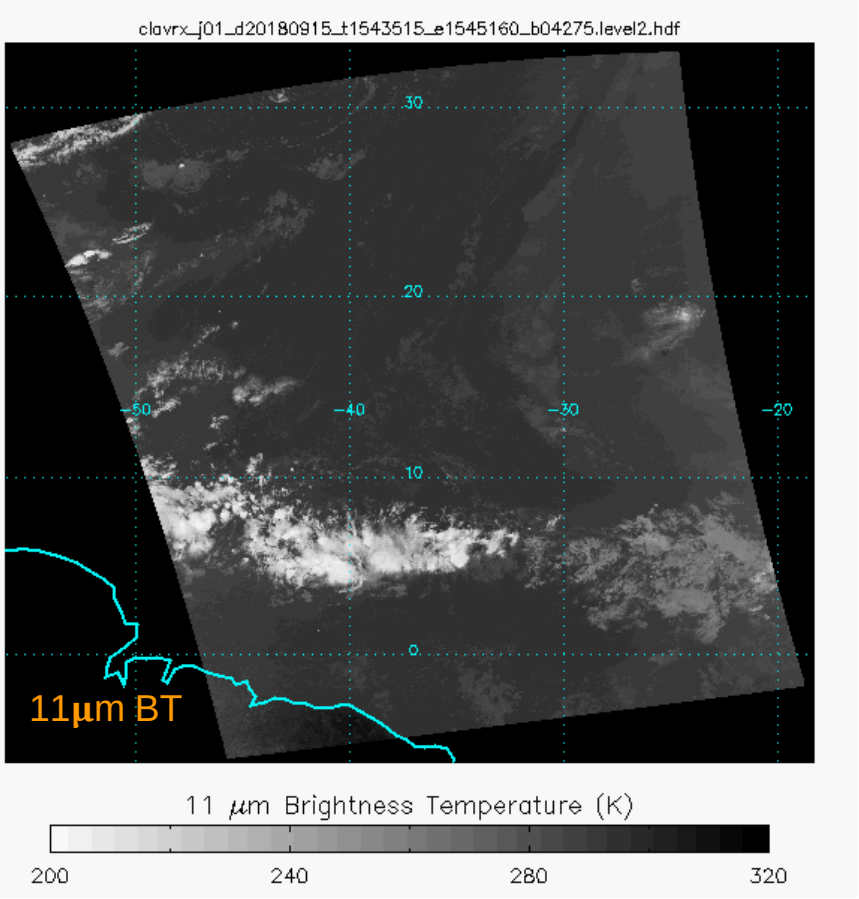
We also compare to non-NDE generation ECM data to diagnose NDE-specific issues.

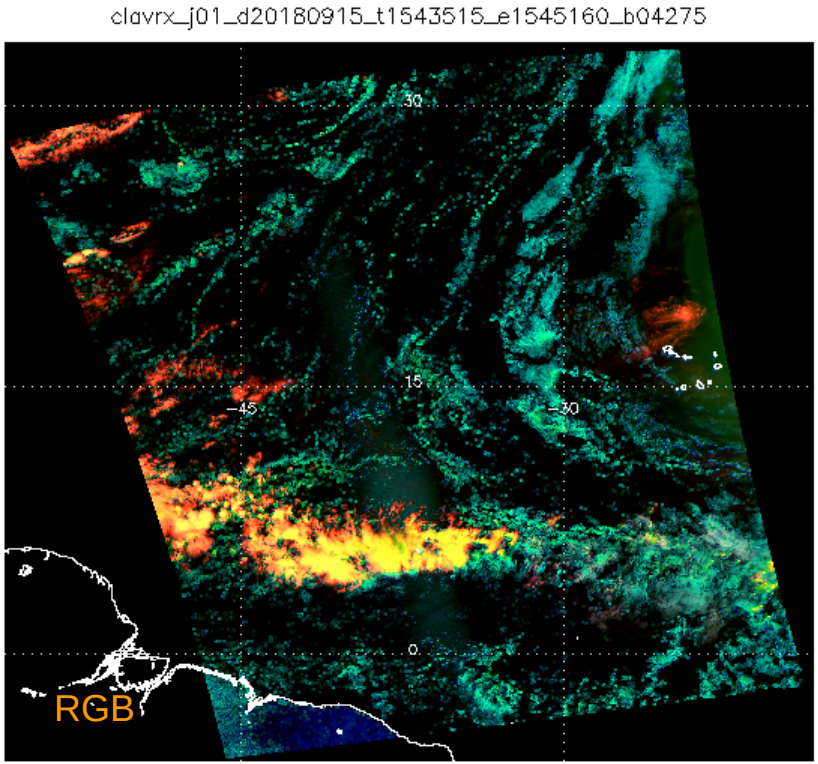
Our Specific Evaluation Methodology applied here:

1. Visual inspection of NDE ECM against CLAVR-x ECM and IDPS VCM.
2. Comparison of Global Cloud Fraction from NDE to NASA MODIS MYD35
3. Validation against NASA CALIPSO/CALIOP
4. Analysis of SST biases

Visual Comparisons with CLAVR-x ECM

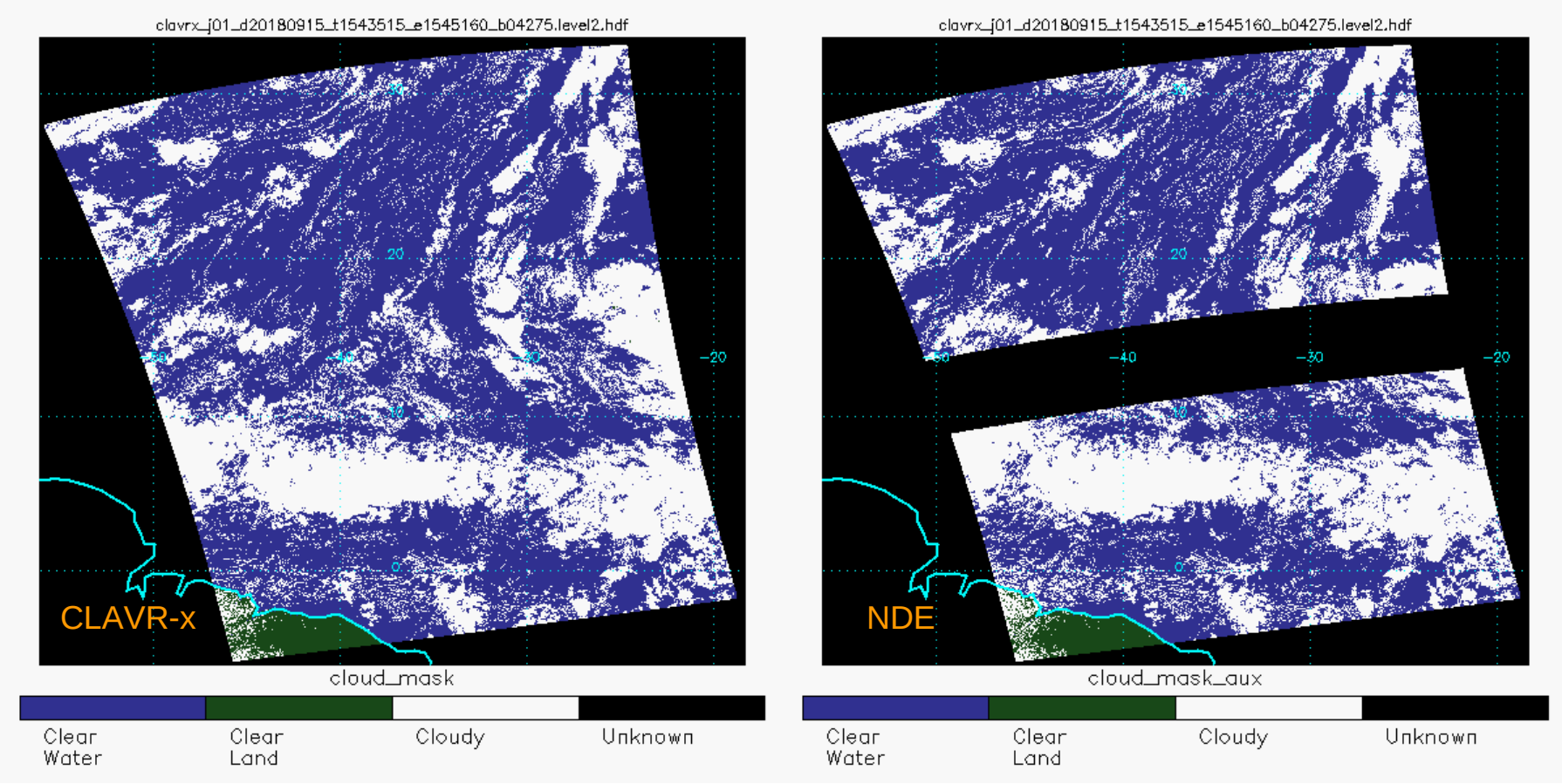
Day Ocean





False Color Image
Red=1.38μm, Green = 0.65μm, Blue = 1.6μm

Day Ocean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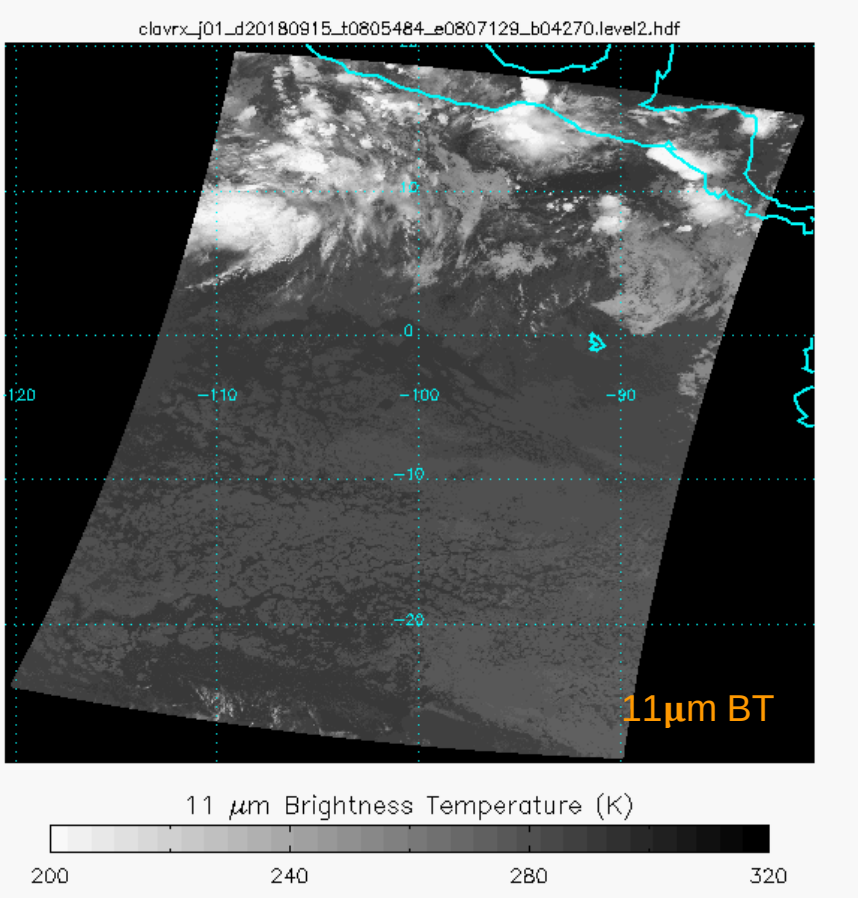
CLAVR-x
cloud_mask
Clear Water
Clear Land
Cloudy
Unknown
clavrx_j01_d20180915_t1543515_e1545160_b04275.level2.hdf
NDE
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown

Night Ocean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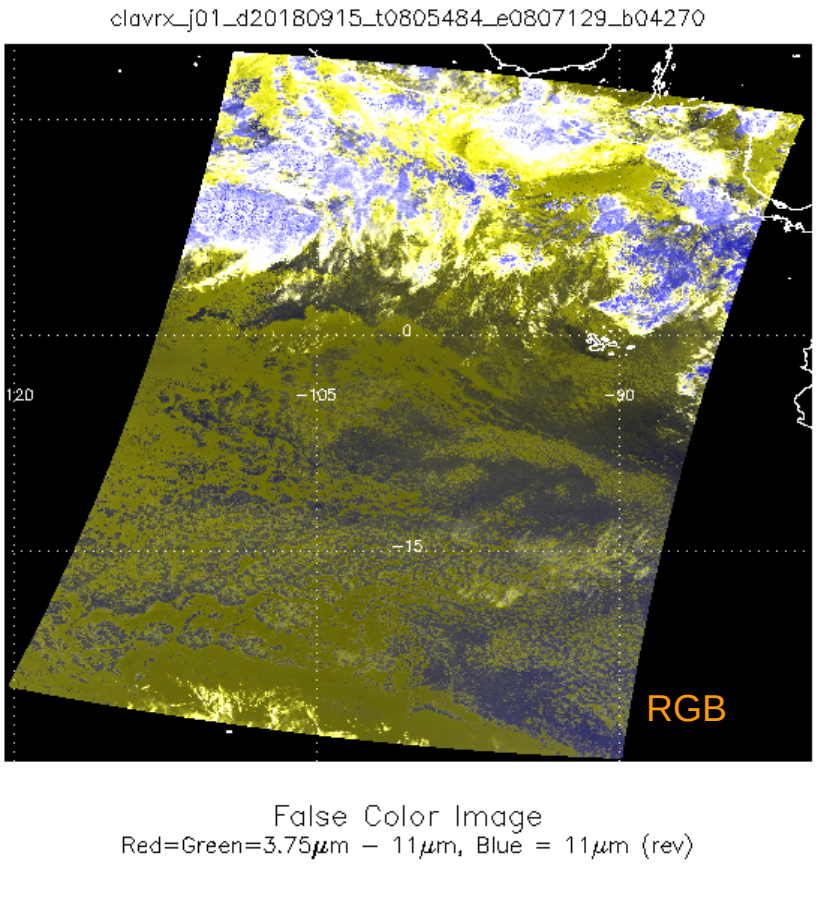
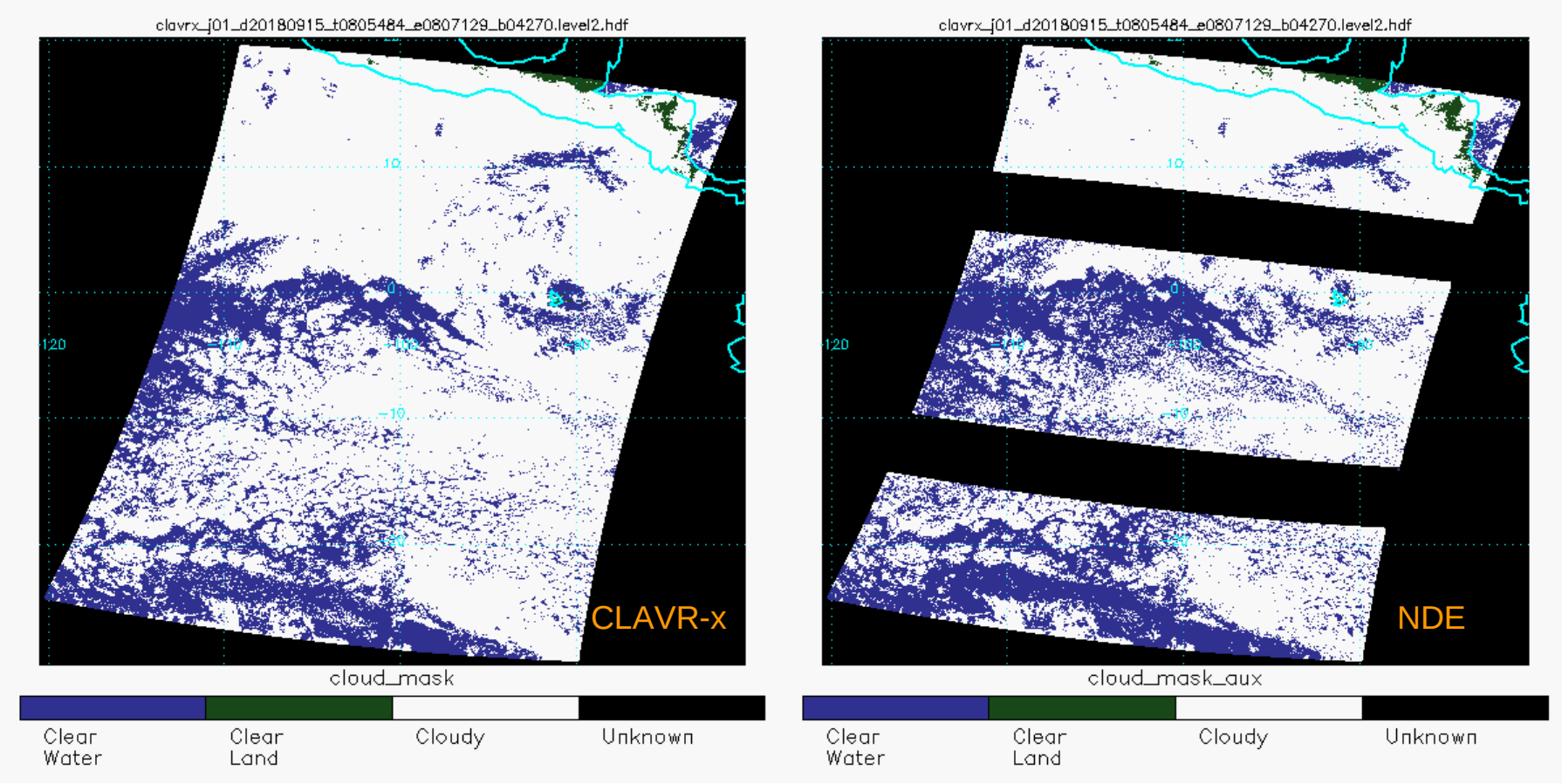
11µm BT
11 µm Brightness Temperature (K)
200
240
280
320


clavrx_j01_d20180915_t0805484_e0807129_b04270
RGB
False Color Image
Red=Green=3.75µm – 11µm, Blue = 11µm (rev)

Night Ocean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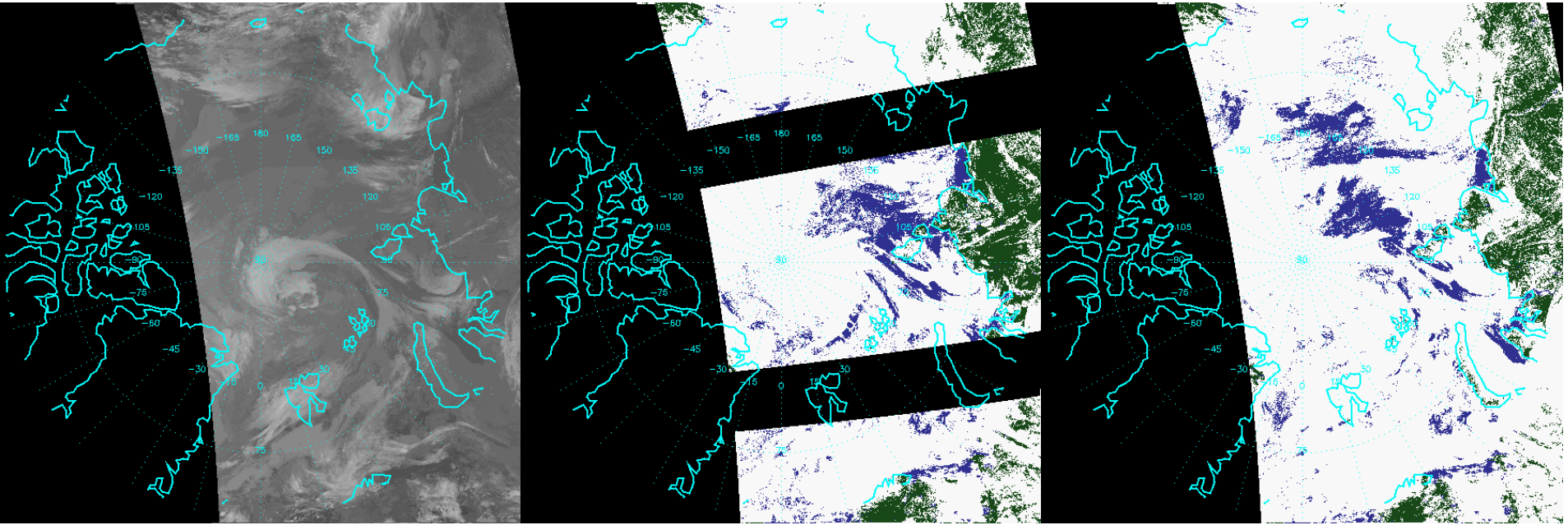
CLAVR-x
cloud_mask
Clear Water
Clear Land
Cloudy
Unknown
clavrx_j01_d20180915_t0805484_e0807129_b04270.level2.hdf
NDE
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown

Arctic Example

September 15, 2018, NOAA-20

11μm BT | NDE ECM | CLAVR-x ECM



Similar performance of NDE to CLAVR-x after fixing ECM LUT

Conclusions from Visual Comparisons

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Arctic Performance.	Perform as expected after ECM LUT fix.
Missing granules.	Fixed with v2r0 implementation

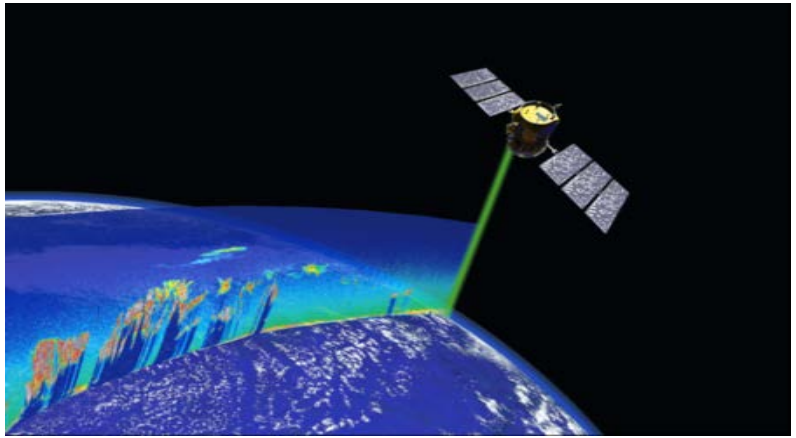
Comparison to CALIPSO/CALIOP

Data Used in this Analysis

- NOAA-20 NDE v1r2 from April 8, 2018 for SST and MODIS Comparisons.
- NOAA-20 CLAVR-x from April 8, 2018.
- NASA AQUA/MODIS from April 8, 2018.
- 24 days for CALIPSO Comparison: from May 02 to September 09, 2018.

CALIOP Comparison Description

- CALIOP is a lidar onboard of CALIPSO.
- CALIOP Cloud algorithm results are considered as “Truth”.
- 24 days of CALIOP and NOAA-20 Matchup data are used between 2018-122 and 2018-252.
- Filters applied to NOAA-20:
  - Scan time difference ± 12 minutes,
  - Sensor Zenith Angle < 70.0.
- 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 NDE NOAA-20 ECM

Algorithm	Sample Size	Cloud fraction				Required Detection	Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy		Detection	False Detect.	Missed Cloud
	Global, Ocean/Land, Day/Night, No Snow/Snow/Ice								
ECM NDE	14603712	0.680	0.664	0.139	0.106	0.870	0.875	0.061	0.063
ECM CLAVR-x	14603712	0.680	0.678	0.088	0.086	0.870	0.884	0.061	0.055
	Ocean, Day, Global, No Snow/Snow/Ice								
ECM NDE	4408608	0.728	0.711	0.026	0.020	0.920	0.941	0.020	0.039
ECM CLAVR-x	4408608	0.728	0.711	0.022	0.022	0.920	0.947	0.019	0.034
	Ocean, Night, Global, No Snow/Snow/Ice								
ECM NDE	5136840	0.735	0.783	0.096	0.064	0.900	0.911	0.069	0.020
ECM CLAVR-x	5136840	0.735	0.761	0.084	0.029	0.900	0.931	0.034	0.035
	Land, Day, Global, No Snow/Snow/Ice								
ECM NDE	1217016	0.563	0.485	0.043	0.028	0.900	0.908	0.018	0.074
ECM CLAVR-x	1217016	0.563	0.491	0.039	0.022	0.900	0.918	0.014	0.068
	Land, Night, Global, No Snow/Snow/Ice								
ECM NDE	1199424	0.621	0.556	0.072	0.075	0.880	0.892	0.047	0.061
ECM CLAVR-x	1199424	0.621	0.581	0.074	0.054	0.880	0.906	0.042	0.052

- This stats are calculated based on VIIRS - CALIOP data from 24 days in 2018 (from 2018-122 to 2018-252).
- Both ECM NDE and ECM CLAVR-x meet required specification.

ECM NDE - I&T ECM NDE
ECM CLAVR-x - ECM produced by CLAVR-x
No Snow/Snow/Ice = Snow/Ice Filter Applied

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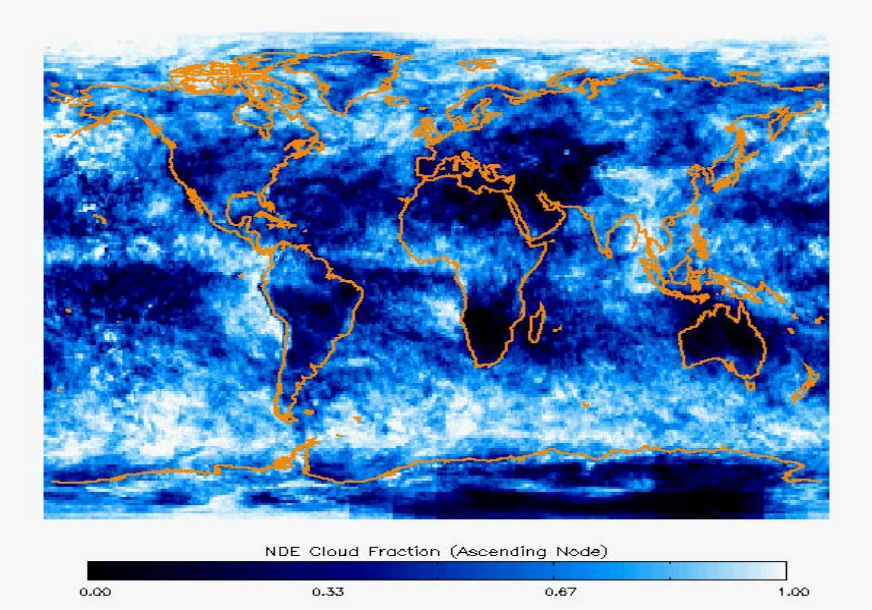
ECM NDE - I&T ECM NDE
ECM CLAVR-x - ECM produced by CLAVR-x
No Snow/Snow/Ice = Snow/Ice Filter Applied

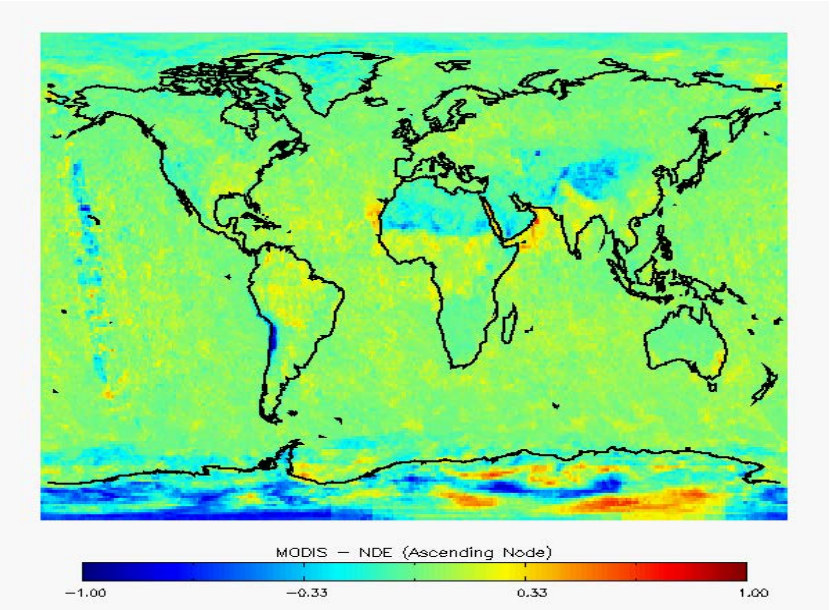
Conclusions from CALIPSO Comparisons

- During Beta Review ECM NDE showed a good performance, but slightly below the required specifications.
- An issue with ECM LUT was found, fixed and implemented in June 2018.
- 24 days after LUT fix of CALIOP - VIIRS collocation statistical analysis of the ECM performance shows that ECM now meets required specification.

Comparison to AQUA/MODIS

Cloud Fraction Ascending Node





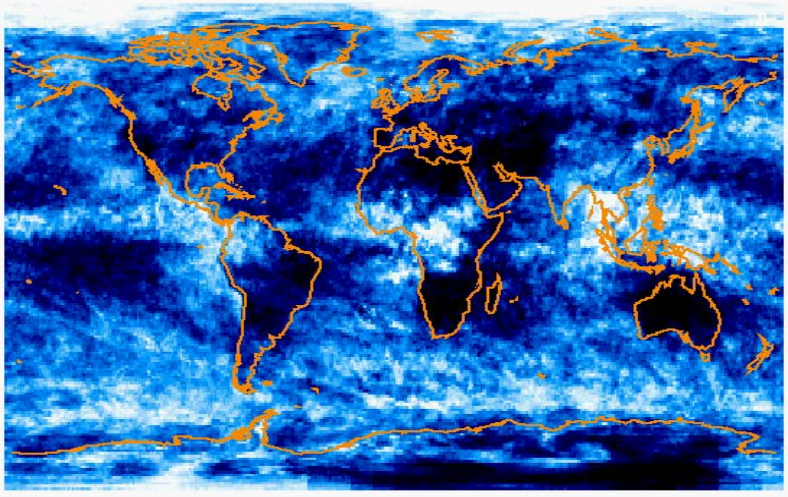
Outside of Antarctica and Tibet, no systematic differences between NDE ECM and MODIS.

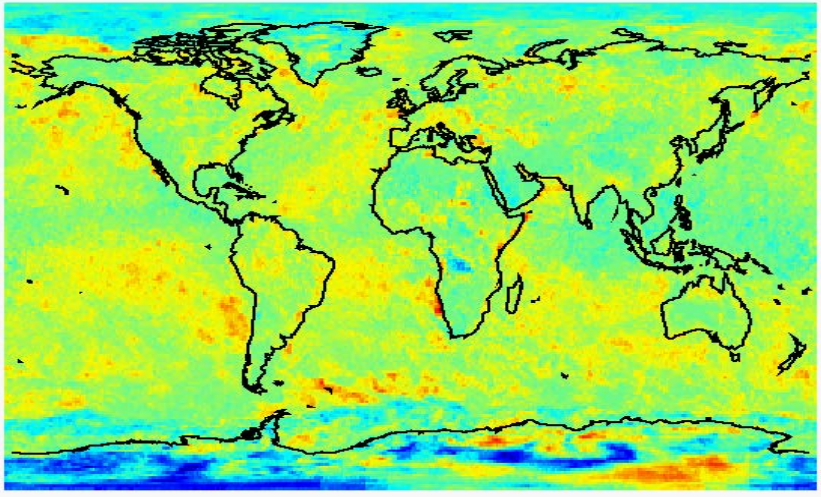
Red = Cloud Observed by MODIS but Missed in NDE.

Blue = Cloud Observed by NDE but Missed in MODIS.

Green = Good Agreement.

Cloud Fraction Descending Node





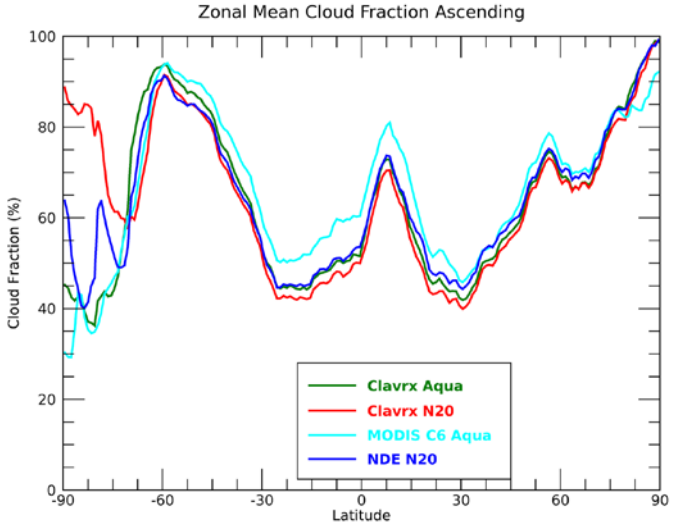
NDE ECM seems to miss cloud over nighttime ocean relative to MODIS

Red = Cloud Observed by MODIS but Missed in NDE.

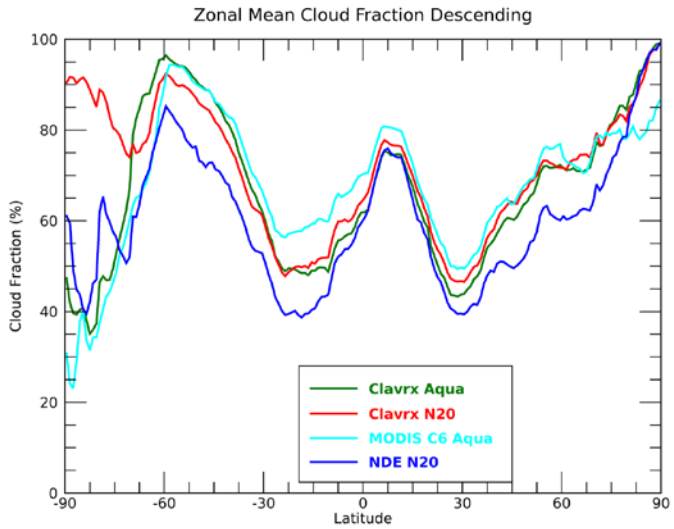
Blue = Cloud Observed by NDE but Missed in MODIS.

Green = Good Agreement.

Zonal Distribution of Cloud Fraction



Ascending



Descending

- Used 12 day of data, including 9 days after Beta;
- NDE N20 tends to be lower than others in the descending track.

Global Stats

Global mean cloud fraction

	NDE N20	Clavr-x N20	Clavr-x Aqua	MODIS C6 Aqua
Ascending	64.1%	64.2%	63.3%	65.9%
Descending	60.2%	71.2%	66.8%	67.8%

Percentage of data within 10% cloud fraction of MODIS C6 Aqua and NOAA-20 CLAVR-x

		Clavr-x Aqua	Clavr-x N20	NDE N20
Ascending	MODIS C6 Aqua	76.5%	62.0%	69.3%
	N20 Clavr-x			87.8%
Descending	MODIS C6 Aqua	68.5%	64.7%	40.4%
	N20 Clavr-x			61.2%

Stats 60ºN - 60ºS

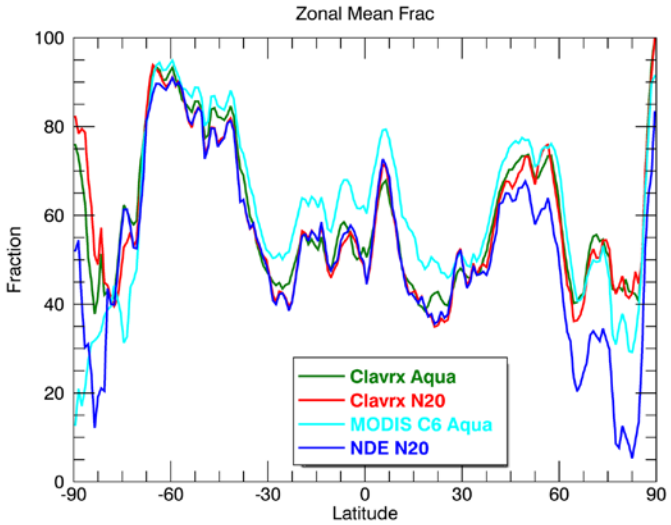
Global mean cloud fraction

	NDE N20	Clavr-x N20	Clavr-x Aqua	MODIS C6 Aqua
Ascending	60.8%	58.0%	60.3%	65.8%
Descending	56.8%	65.2%	64.5%	69.6%

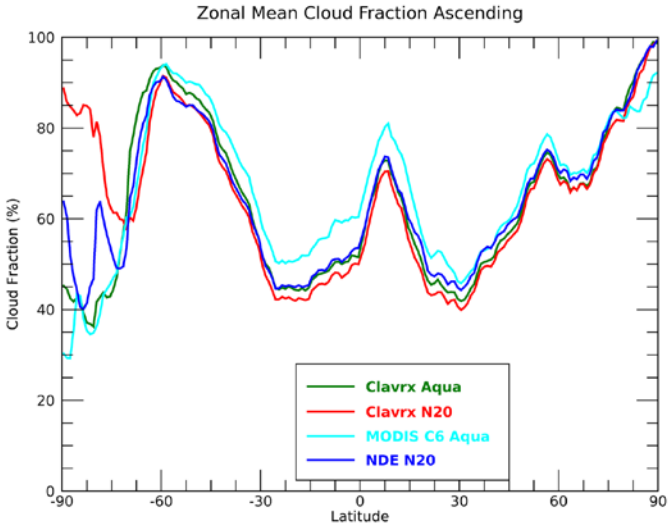
Percentage of data within 10% cloud fraction of MODIS C6 Aqua and NOAA-20 CLAVR-x

		Clavr-x Aqua	Clavr-x N20	NDE N20
Ascending	MODIS C6 Aqua	83.2%	64.6%	73.8%
	N20 Clavr-x			96.0%
Descending	MODIS C6 Aqua	78.0%	75.5%	40.8%
	N20 Clavr-x			65.0%

Difference with Beta (Daytime)



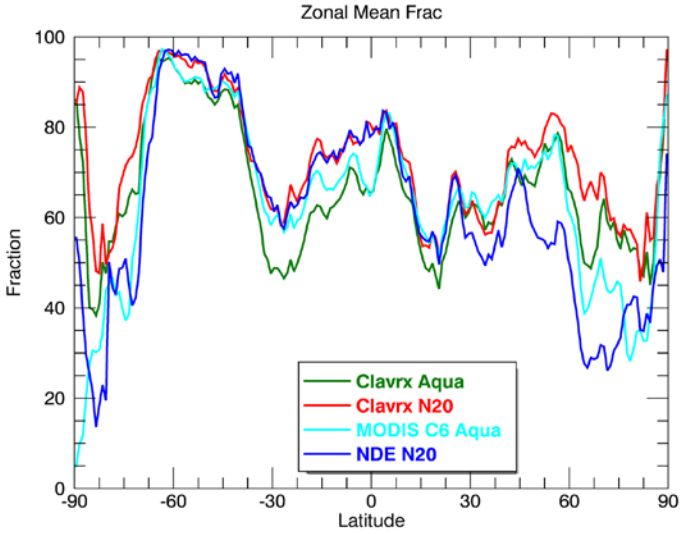
Beta



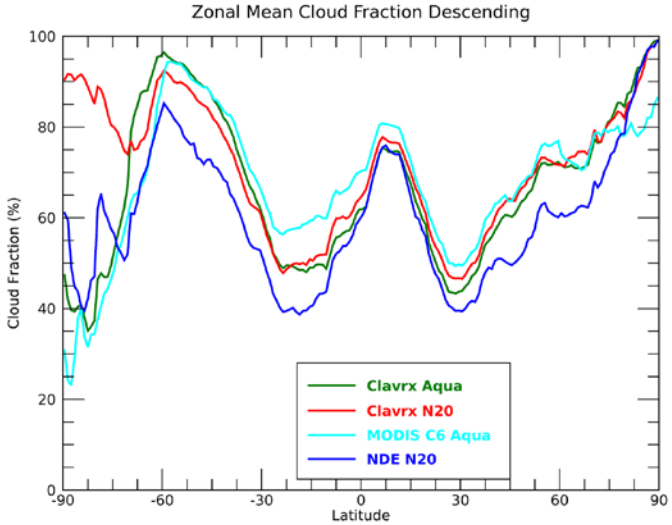
Provisional

- Beta was done in the Spring with less data so curves show look different.
- NDE N20 is in-line with CLAVR-x (as expected).

Difference with Beta (Nighttime)



Beta



Provisional

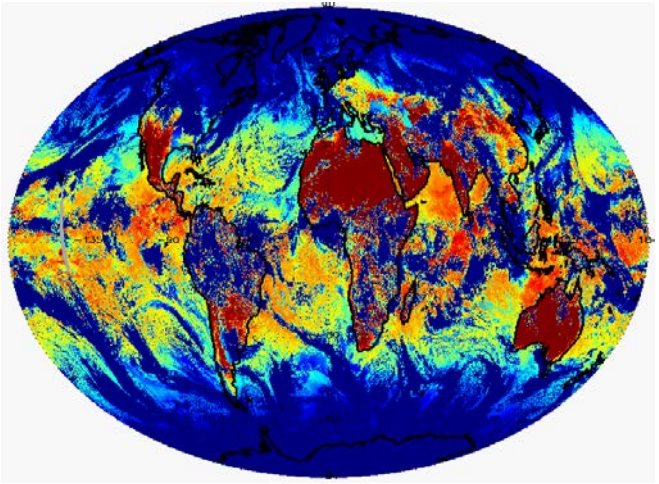
- Beta was done in the Spring with less data so curves show look different.
- NDE NOAA-20 seems to be relatively lower than it was in Beta

Conclusions from MODIS Comparisons

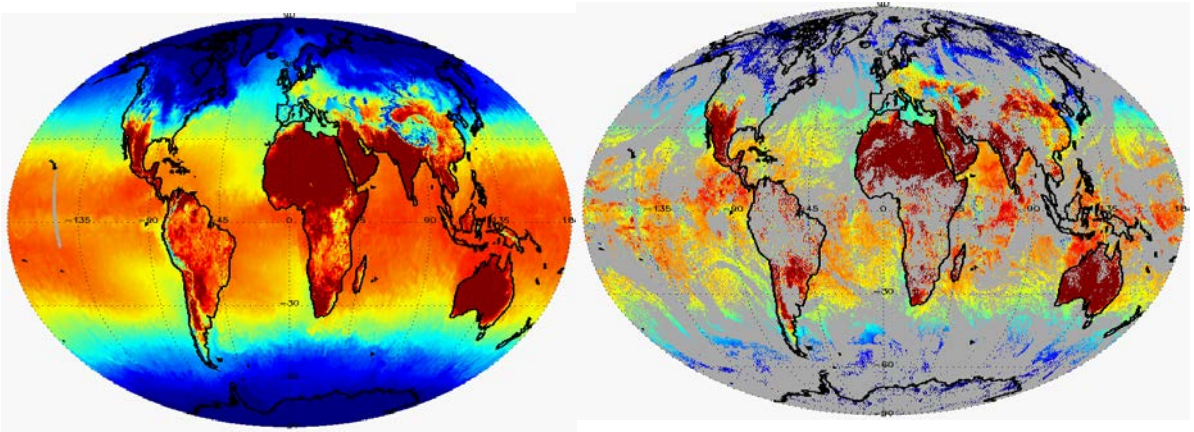
SST Bias Analysis

SST Comparison Description

- Sea Surface Temperature (SST) is very sensitive to the presence of cloud.
- If we compute SST for all pixels, we can compare observed SST to a background SST.
- Clear pixels with negative SST biases are likely missed cloud.
- Cloudy pixels with small SST biases are likely false cloud.
- This analysis uses OISST.
- SST computed using NLSST coefficients trained for this analysis.
- NOAA-20 April 8, 2018 used.
- Not the NDE SST Product.



SST Unmasked

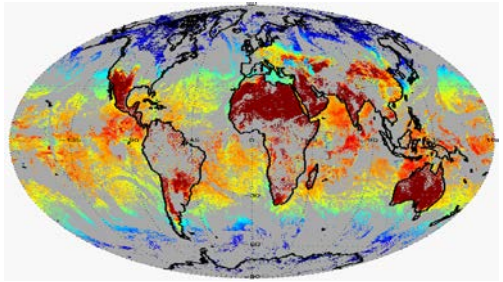


OISST

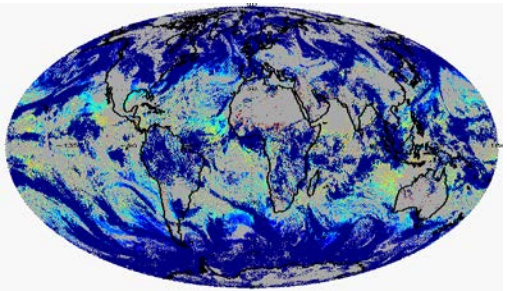
Masked SST

SST Comparison Description

O (observations)

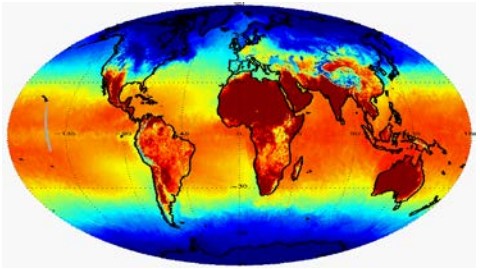


Cloud Masked SST

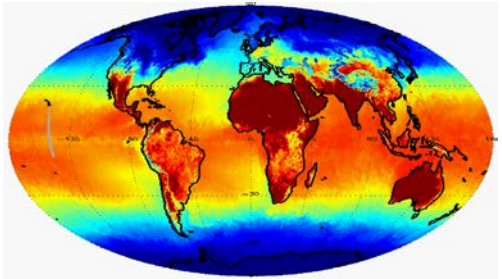


Clear Masked SST

B (background)

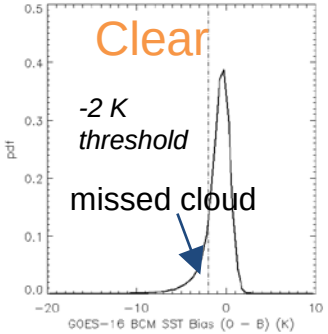


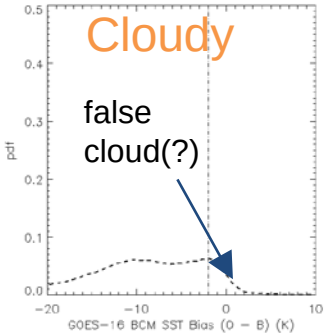
OISST



OISST

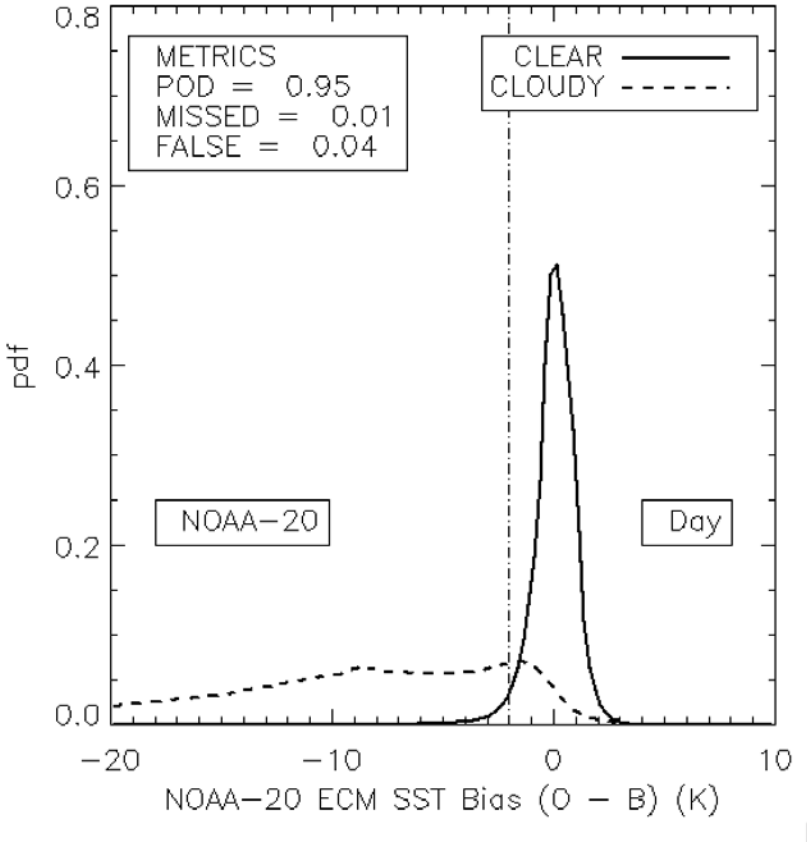
O-B (bias)





Cloud Mask Performance for Day Time

- Solid line is the SST Bias distribution for clear pixels.
- Dashed line is the SST Bias distribution for cloudy pixels.
- Vertical line shows a bias of -2 K. A guess at the threshold for cloud contamination.
- Clear pixels to the left of this line are considered missed cloud.
- Cloudy pixels to the right of this line are considered false clouds.
- We interpret this performance as good.



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- Vertical line shows a bias of -2 K. A guess at the threshold for cloud contamination.
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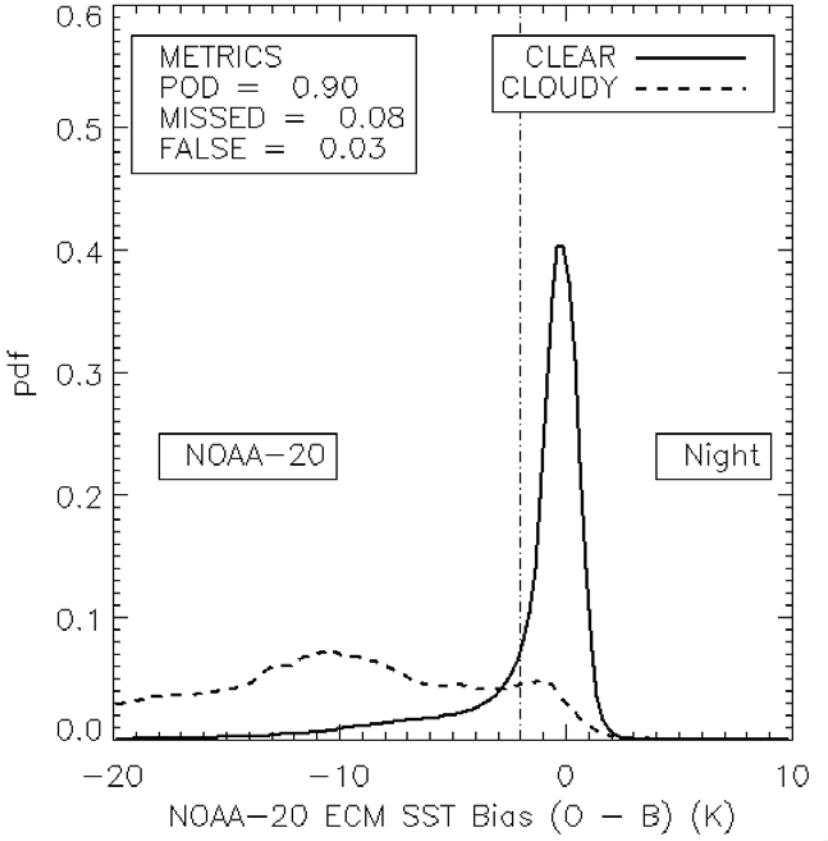
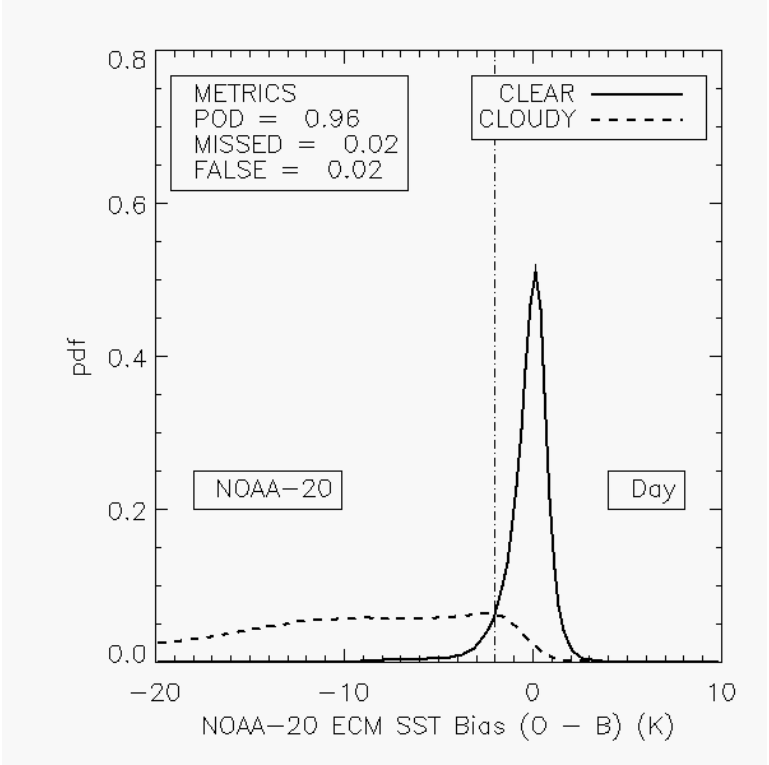
- Cloudy pixels to the right of this line are considered false clouds.
- This performance meets spec but is worse than seen in during Beta.

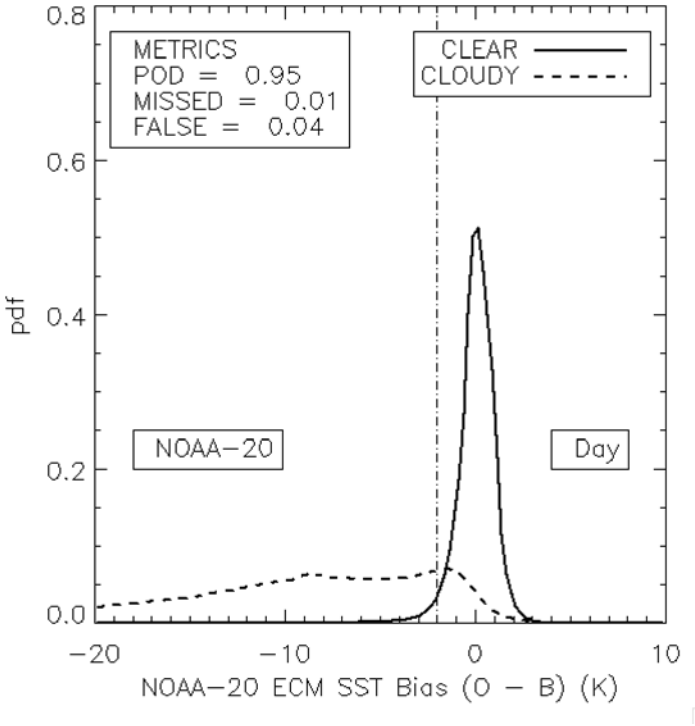


Change from Beta in Daytime SST Analysis

Beta



Provisional



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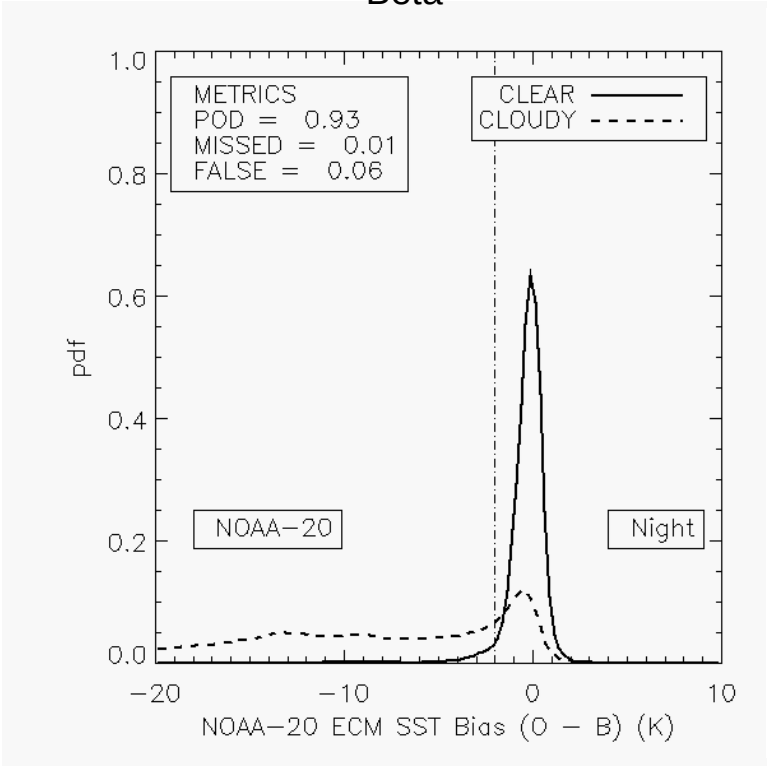
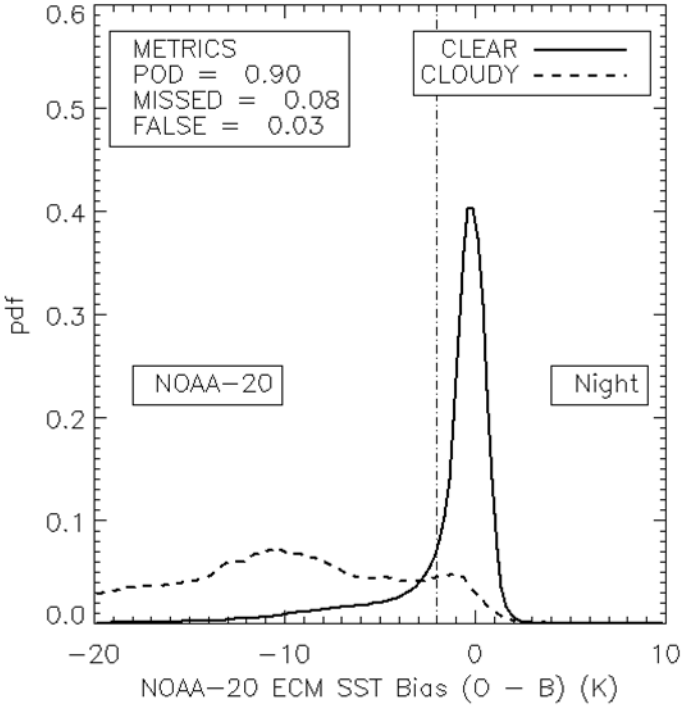
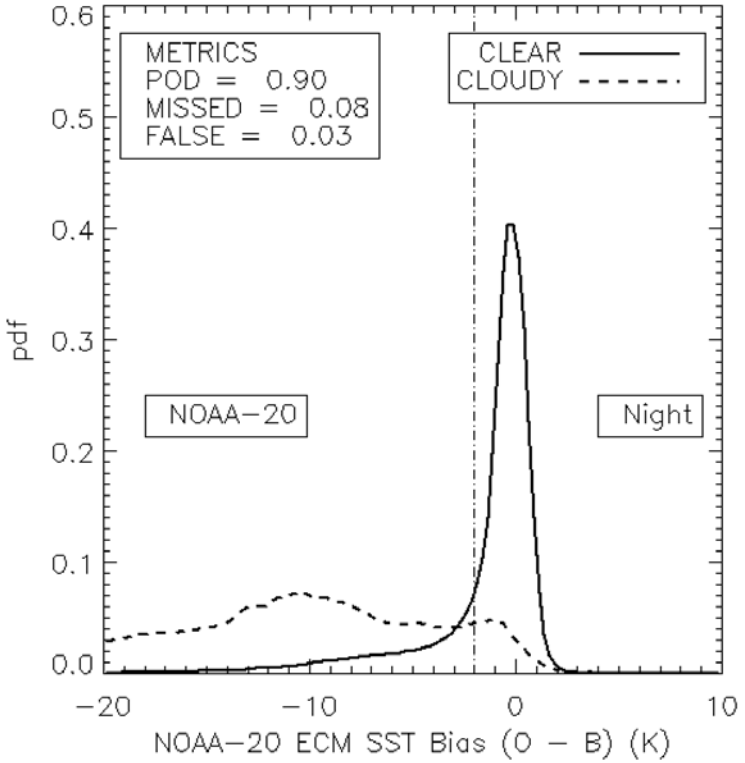


Provisional

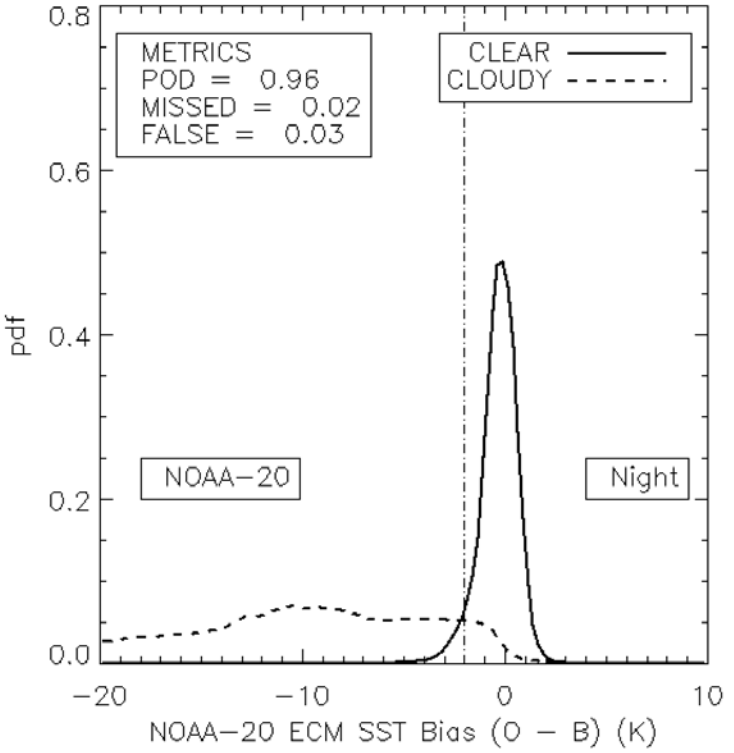


Comparison of NDE and CLAVR-x Night SST Analysis

NDE



CLAVR-x



Conclusions from SST Analysis

- Binary ECM seems to perform well over a large sample of ice-free oceanic pixels.
- NDE ECM and CLAVR-x ECM give similar stats during day.
- Provisional NDE ECM is worse over night ocean than seen with Beta.
- Reason is unknown, but the NDE table updated performed after Beta is suspected.

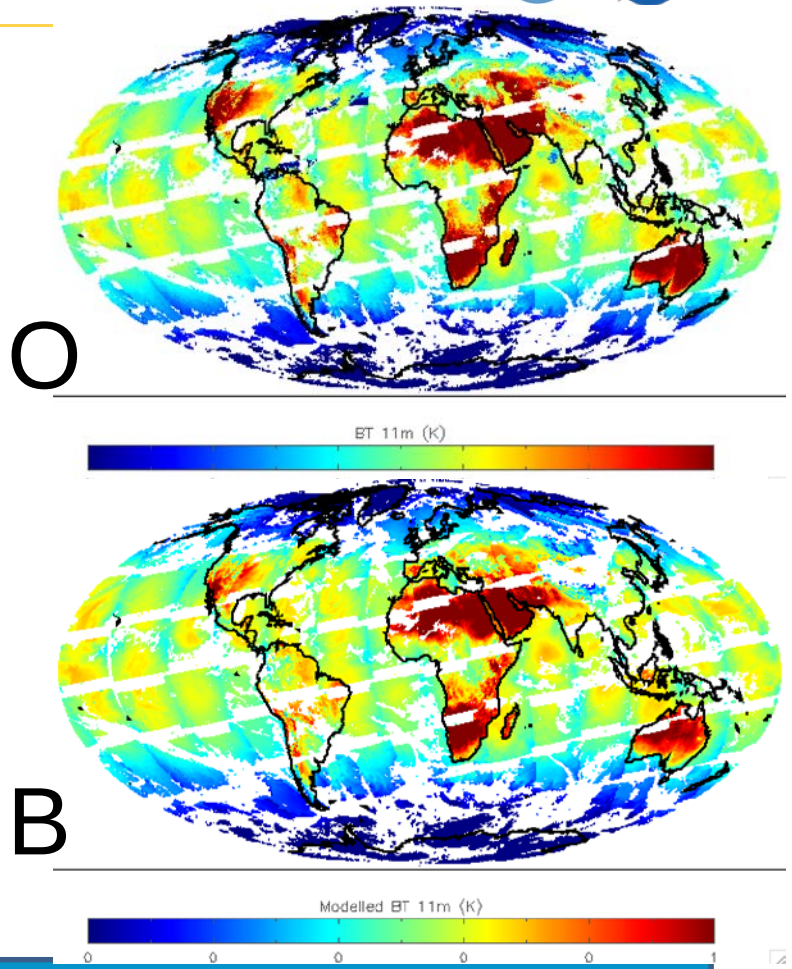
VIIRS All-Sky Radiance

Background

- GOES-16 All-Sky Radiance is the radiance product generated from GOES-16 IR channels for NWP Radiance Assimilation. Already used by ECMWF, monitored by NCEP
- This is similar to the VIIRS + CRIS radiance products but those aren't made yet for NOAA-20.
- NCEP has expressed interest in a VIIRS ASR product and that is what we are using to evaluate the ECM.
- This replaces our "SST" analysis as it more relevant to our users. (SST has it own mask)

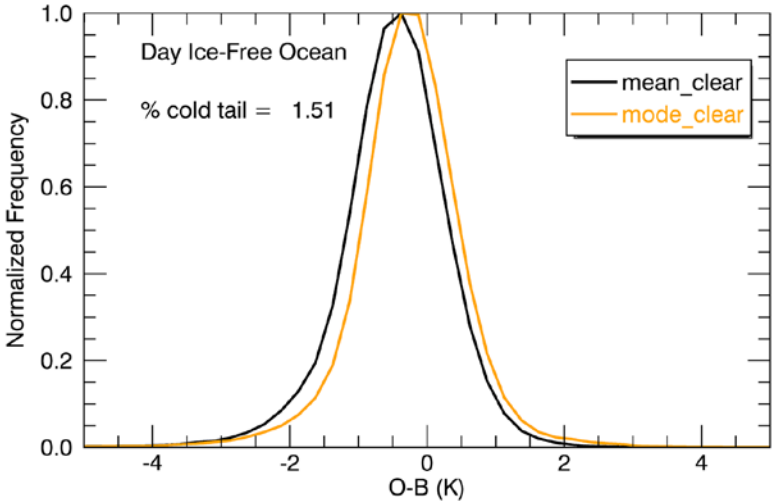
Method

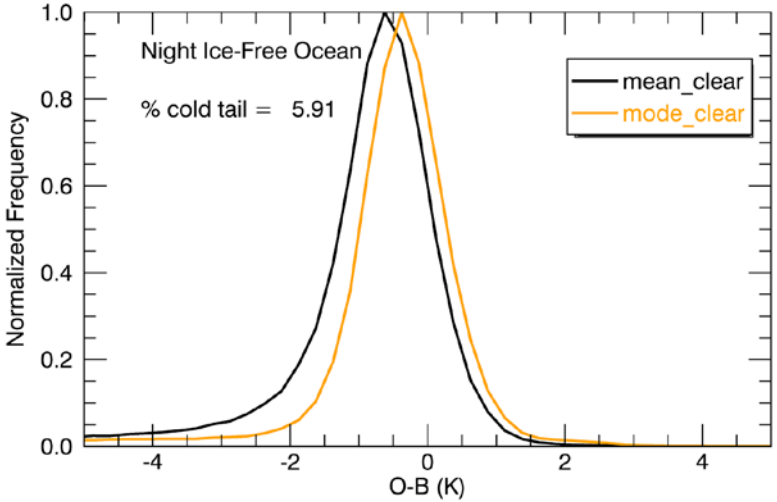
- We used 32x32 pixel arrays which results in grids with a similar spacing to GOES-16
- Require 10% of pixels to be clear to make a result
- We stored Mean and Mode of Clear Distribution - though only mean is used.
- CAVEATS: PFAAST and low-res GFS used.



VIIRS ASR over Ocean

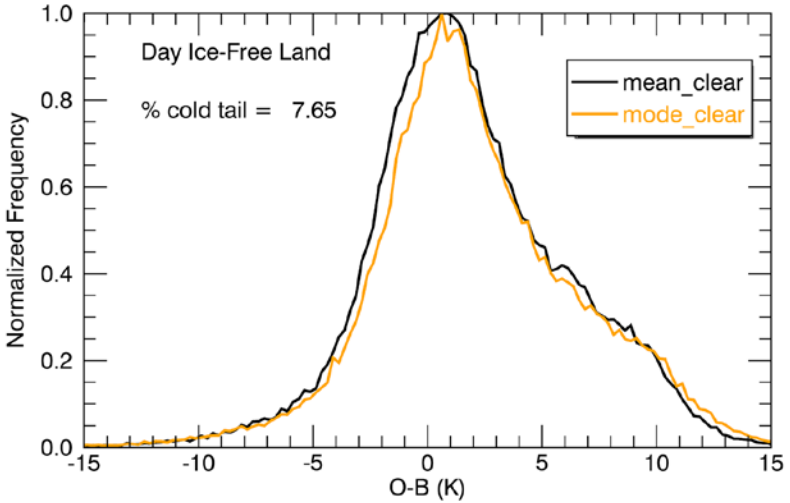
- As we did with SST, we make O-B distribution and infer cloud mask performance
- ASR requires 10% clear pixels which automatically prevents some cloud contamination.
- As with SST, we see degradation at night relative to day. (same issue).
- We defined cold tail as pixels with O-B < mean peak -2 K.
- Performance is acceptable though spec for ASR is unknown

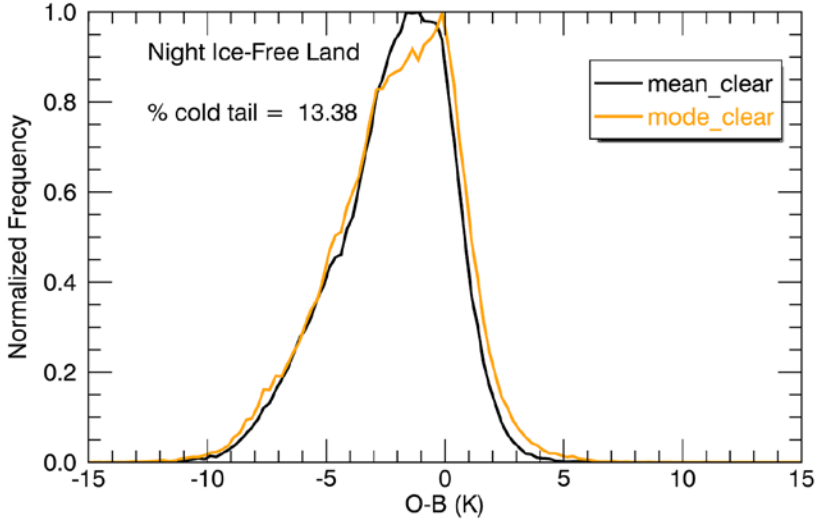




VIIRS ASR over Land

- Values of O-B computed for snow/ice free land.
- NWP land surface temperatures are biased so the distributions are expected to be less sharp.
- We assumed an O-B < mean peak - 4K as potential cloud contamination.





Provisional Maturity Conclusions

Provisional Maturity Conclusions

- There *were* serious issues with the NDE ECM v1r2 on NOAA-20 for **beta**. These issues were due to a corrupted LUT in the NDE system.
  - These issues have been addressed and **FIXED** within the NDE system in June

- Some areas of improvement continue to be found and will be addressed in subsequent science code deliveries.

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

Pathway to Full Validation

Pathway to Full Maturity

- We expect to apply the same activities to be conducted for Full Maturity:
  - We continue to gather an archive of golden days where we save SDRs and EDRs spread from June 2018. This collection is ongoing.
  - We hope to continue to engage the teams and continue application-specific analysis.
  - We will take advantage of opportunities for table adjustments.
  - The NOAA-20 specific LUT will be developed by April 2019, one 1 year of good data (i.e non-beta) imagery is available. Collection of collocations needed for LUT generation is on going to span seasonal variations.

Risks for Full Validation

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

- **NDE processing issues (Moderate)**
  - Missing granules in NDE processing
    - Currently being addressed in August 2018 DAP delivery. Will be transitioned to NDE I&T late 2018 and expected operations in late 2018, pending SPSRB approval.
  - **The lack of understanding of the team on how NDE processes the ECM impairs the ability of the Cloud Team to fully and easily diagnose these issues.**

- **Similar SDR issues as beta**
  - **M5 on SNPP is 5% too bright.**
  - Our initial looks at NOAA-20 indicates that it's M5 calibration does not suffer from this.
  - Our SNPP LUT automatically tuned out this calibration error so we expect NOAA-20 to 'miss' cloud due to this issue.
  - **NOAA-20 specific ECM LUT may solve this issue.**
    - Training requires data from all seasons. Expected delivery by **April 2019**
    - Training details in Backup slide section

Risks for Full Validation

- **New issues (Moderate)**
  - An evaluation of the ECM has shown that some low cloud over the southern Atlantic is still being marked with a low probability of being cloud (discussed in ASR analysis section)
    - **Will reevaluate when NOAA-20 specific LUT is developed and 2-D classifiers are integrated into SAPF processing.**
  - The ECM team continues to encourage teams to identify areas they feel are of concern for the team to investigate and try and mitigate

Future Plans

Future Plans of ECM

- Next delivery plans
  - Use of 2-D Luts adds in low cloud detection. This coded in delivered ECM but not turned on because of the bit issue.
  - We need to add flexibility to the reporting of the bits. ECM runs on many sensors and will evolve. We would like to add a file attribute that tells which tests were on and adjust the packed bits based on that attribute.
  - We need more diagnostic information.
    - we need to add snow/ice information.
    - we need a unique ECM LUT identifier added as a file attribute.
    - we need a unique ECM code version added as a file attribute.
    - we need a file attribute that tells us which channels were used.
- Future plans (as they become available in the SAPF
  - Use of DNB Lunar Reflectance is included in code and we hope someday that can be turned on.
  - We would also like to use the I-Band stats.

Backup Material

Backup Material - Requirements

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)
1. Beta o Product is minimally validated, and may still contain significant identified and unidentified errors. o Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose. o Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.
2. Provisional o Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts. o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose. o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists. o Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.
3. Validated o Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal). o Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level. o Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose. o Product is ready for operational use based on documented validation findings and user feedback. o Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Requirements for Cloud Mask

- Requirements for have not changed since Beta and are located in the Backup slide material

Requirements (1)

- JERD-2429 The algorithm shall produce a cloud mask product that has a horizontal cell size of 0.8 km at Nadir.
- JERD-2478 The algorithm shall produce a cloud mask product that has a horizontal reporting interval the same as the cloud mask horizontal cell size.
- JERD-2479 The algorithm shall produce a cloud mask product that has a mapping uncertainty, (3 sigma) of 4 km.
- JERD-2480 The algorithm shall produce a cloud mask product that has measurement range of cloudy/not cloudy.

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- JERD-2480 The algorithm shall produce a cloud mask product that has measurement range of cloudy/not cloudy.

Requirements (2)

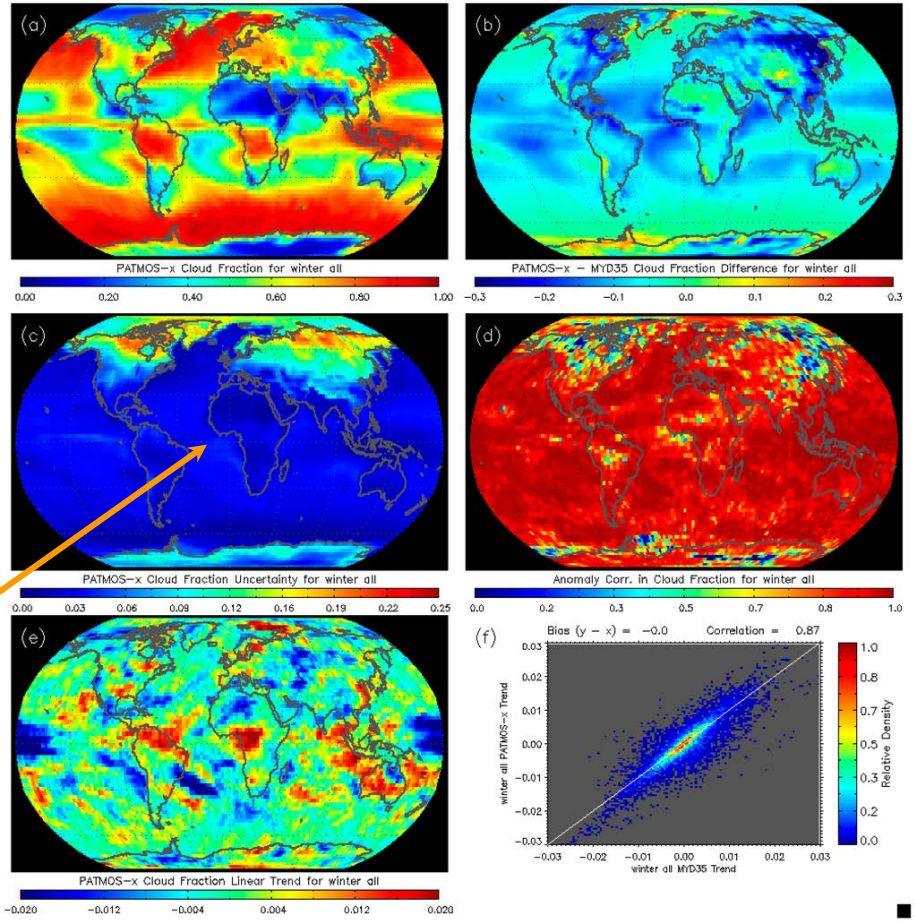
JERD-2481 The algorithm shall produce a cloud mask product that has a probability of correct typing of:

- 87% Globally
- 92% Ocean, Day
- 90% Ocean, Night
- 90% Snow-free Land, Day
- 88% Snow-free Land, Night
- 85% Desert, Day
- 85% Desert, Night
- 88% Snow-covered land, Day
- 85% Snow-covered land, Night
- 82% Sea-Ice, Day
- 72% Sea-Ice, Night
- 80% Antarctica and Greenland, Day
- 70% Antarctica and Greenland, Night

Other Backup Material

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

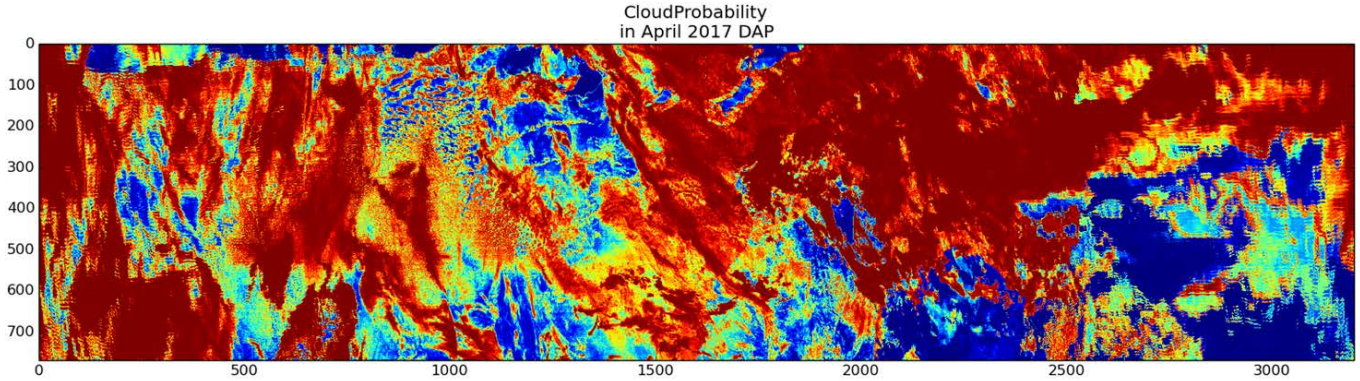
- ECM uses everything except
  - M1-M4
  - M6
  - M8
- ECM can use these bands but not in NDE yet.
  - I-Bands Stats within M-band
  - Lunar Reflectance from DNB

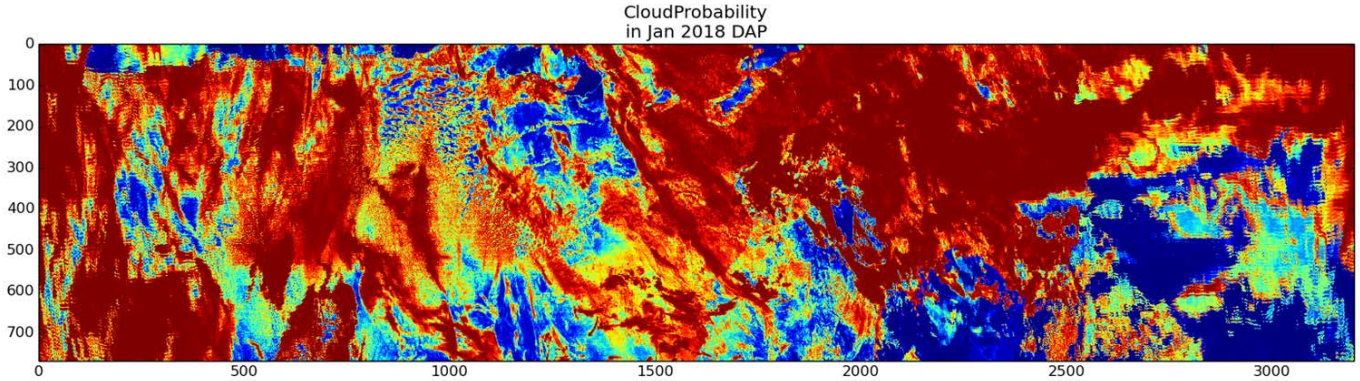
		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan) Nadir	End of Scan
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 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
	SWMIR	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
Emissive Bands		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
	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

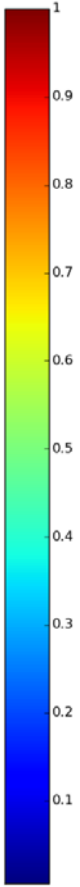
ECM v1r2 Integration Results

- Comparisons were done using NPP on Day 270, 2013 at 2015Z (Day, United States) and Day 293, 2017 at 1703Z (night over ocean).
- NPP was chosen since it is the only VIIRS instrument available from both the February 2018 DAP (current operational algorithm and I&T algorithm).
- ECM science code was last updated for the February 2018. Both runs used the *same* LUT as the current I&T string.
- Analysis was performed using GLANCE (which is used for algorithm integration verification) with an epsilon of 0 (i.e. a perfect match).
  - Small differences are to be expected due to slight run to run rounding differences.
- Only Day 293, 2017 at 1703Z is shown, but other case shows similar results.
- After LUT issue was identified, 4 other “golden granules” were chosen to be a verification check prior to promotion to the I&T string. These have been performed and verified for both v1r2 and v2r0

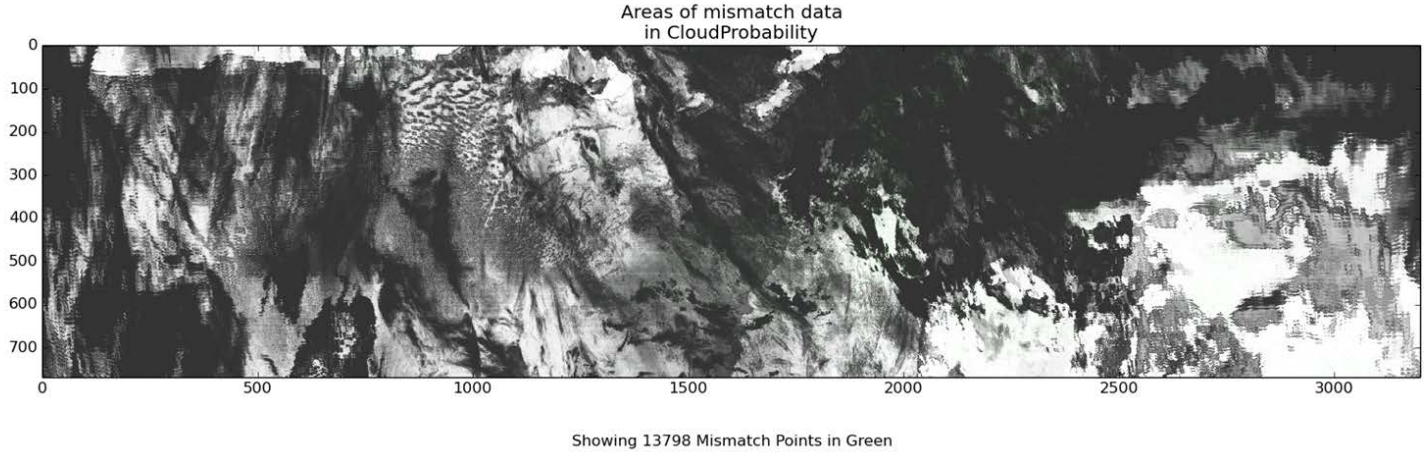
ECM v1r2 Integration Results







ECM v1r2 Integration Results



- Correlation between April 2018 DAP and January 2018 DAP - 0.9999
- Mean difference 0.0002067
- Number of points different less than 0.5% of total pixels

- This shows that while not *exactly* the same, differences are as expected due to rounding differences which occur from run to run.
- Results show any upstream differences have little to no impact on the ECM
- This means the analysis shown in August 2017 with the new LUT remains valid for NPP

ECM v1r2 Integration Results

- Initial Comparisons were done using NPP on Day 270, 2013 at 2015Z (Day, United States) and Day 293, 2017 at 1703Z (night over ocean).
- Analysis was performed using GLANCE (which is used for algorithm integration verification) with an epsilon of 0 (i.e. a perfect match).
  - Small differences are to be expected due to slight run to run rounding differences.
- After LUT issue was identified, 4 other “golden granules” were chosen to be a verification check prior to promotion to the I&T string. These have been performed and verified for both v1r2 and v2r0
- All comparisons with I&T against offline processing show high correlation between I&T and offline processing after ensuring same (correct) LUT being used.

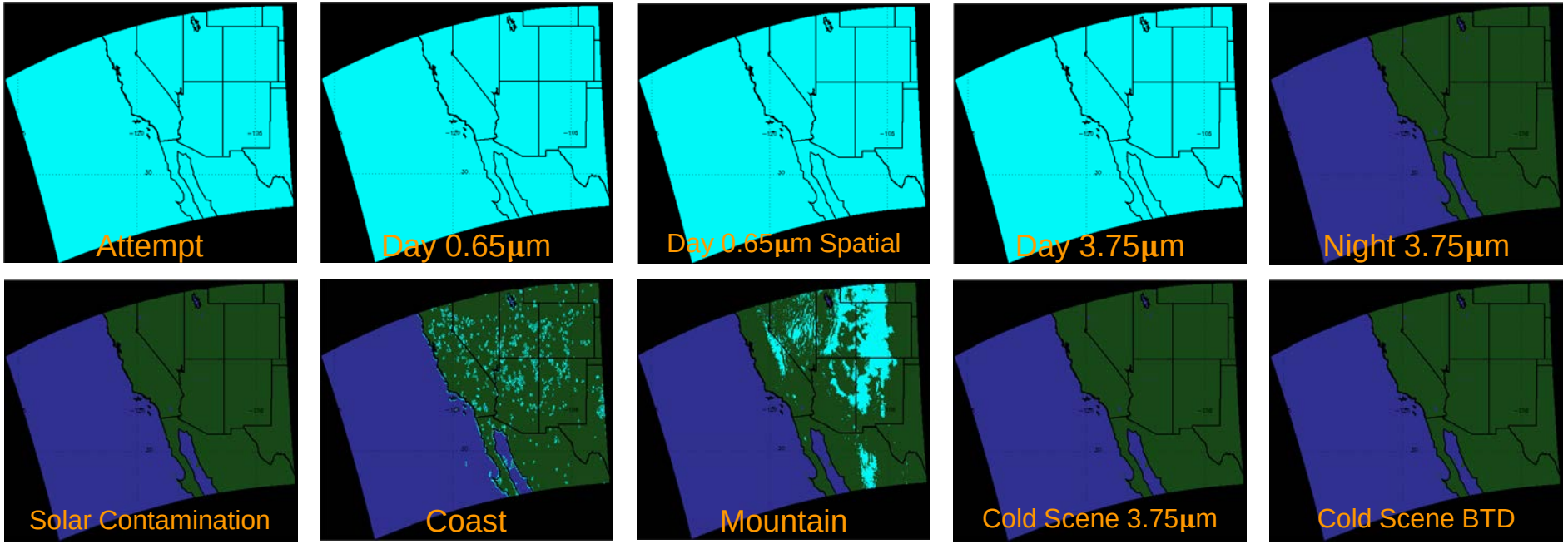
SDR Issues

- **Similar SDR issues as beta**
  - **M5 on SNPP is 5% too bright.**
  - Our initial looks at NOAA-20 indicates that it's M5 calibration does not suffer from this.
  - Our SNPP LUT automatically tuned out this calibration error so we expect NOAA-20 to 'miss' cloud due to this issue.

- There are other issues (tbd) that may be related to the SDR or SDR parameters in the SAPF.

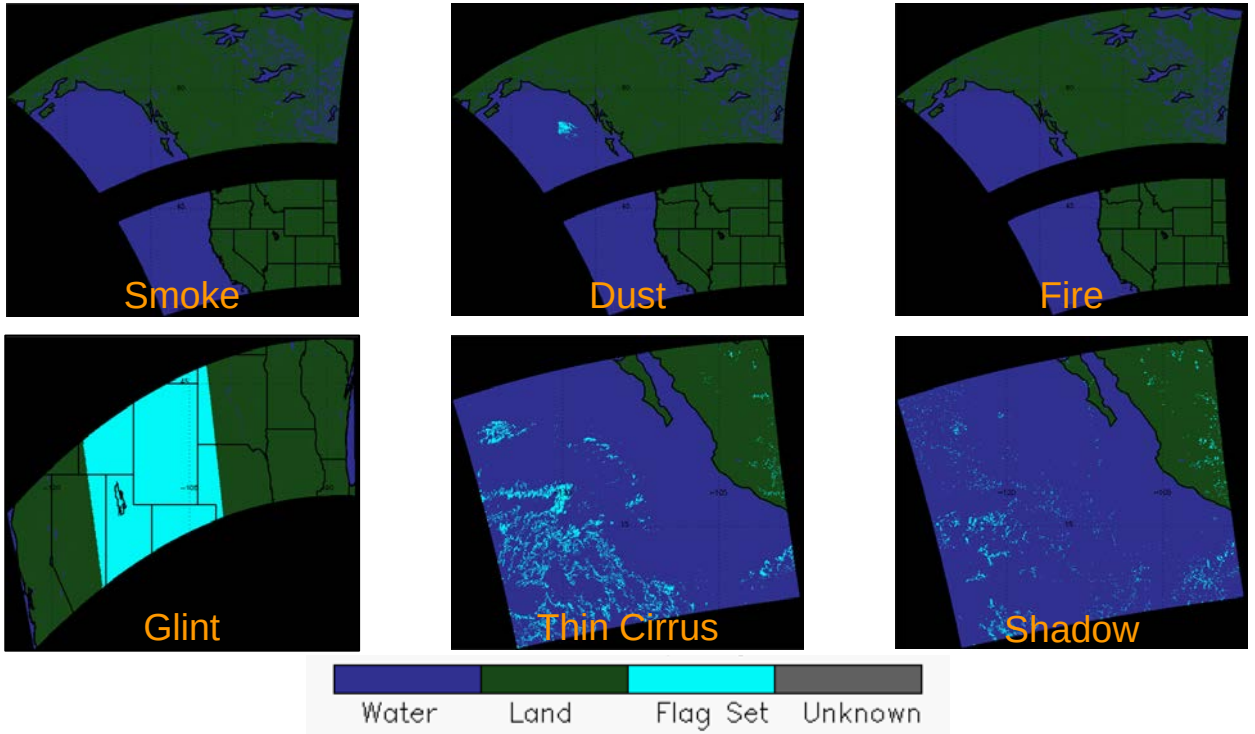
- **Generation of a NOAA-20 LUT will solve this. However, it would be beneficial if we could apply corrections to SNPP to make one single LUT for both.**

VISUAL Verification of ECM Bits (1)



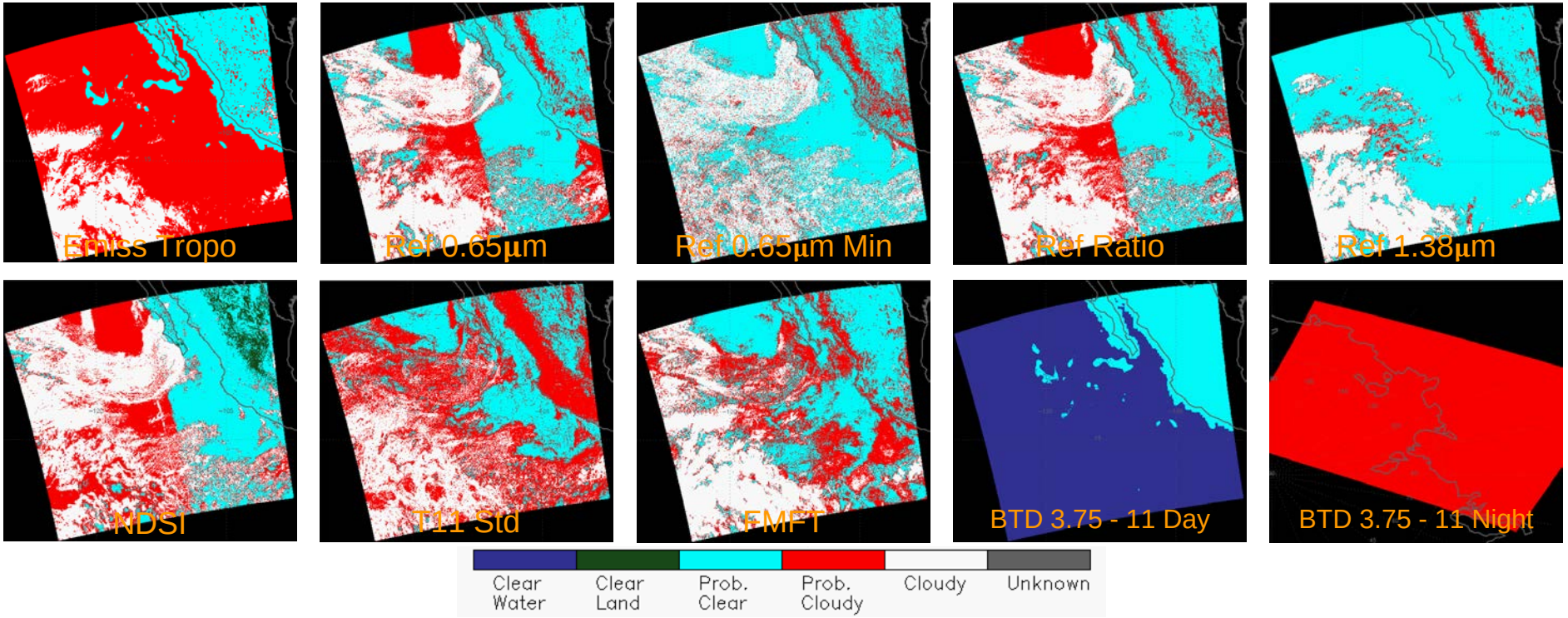
VIIRS / NOAA-20, 2018-09-15 20:48 - 20:52 UTC

VISUAL Verification of ECM Bits (2)



- Land team has asked to add a glint flag over land surface. Implemented in version v2r0 (see slide 11).
- Shadow bit is NOT used. Shadow is calculated during ACHA and saved in Cloud Height file.
- All other bits are working as expected.

VISUAL Verification of ECM Bits (3)



ECM Training for NOAA-20

- 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-20 VIIRS ECM training is completed, LUT from S-NPP VIIRS ECM will be used.

- Creation of a new ECM LUT requires at least 1 year worth data set (optimally).
  - ➢ The NPP LUT used over 10,000 granules from all seasons of the year.
  - ➢ Training is limited to CALIOP collocations, which means that some features may not be observed.

- Approximate time for NOAA-20 VIIRS LUT training is April 2019.

- **Considering NOAA-20 + SNPP LUT to speed this up but requires homogenization of calibration.**

Programmatic Concerns

- ECM data for provisional was limited by two factors
  - Consistent 20% missing granules (scheduled to be fixed imminently, but too late for Provisional)
  - Two months with an incorrect LUT on the NDE I&T string
- Latest science fix delivered this year will not be implemented until 2019 (at the latest)
- Communication with NDE and users remains a challenge
  - ECM has been unable to obtain consistent interaction with the Cloud PAL
- A known identified issue with low clouds will be addressed in the next delivery, but this may not become operational until 2020
- Feedback to the ECM team has expressed dissatisfaction on the time needed to implement repairs

Conclusions

- Provisional analysis utilizing CALIPSO shows an improvement over Beta.
- The MODIS and SST analysis shows continued good daytime performance.
- While both the MODIS and SST analysis meet requirements at night, both show a **degradation** in the nighttime (ocean) performance from Beta.
  - This particularly for low stratus clouds at night.
  - Currently there is no obvious reason for this degradation in detection capability
- Our short term path forward is to use the CLAVR-x/MODIS derived LUT. This will not cause any major degradation in performance while we address the nighttime low cloud issue with NOAA-20
- **The Cloud Team recommends Provisional Maturity at this time pending the swap out of the LUT with the CLAVR-x/MODIS derived LUT (used in v1r1)**