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

April 18, 2018

VIIRS Cloud Mask Team

Andrew Heidinger (STAR), Thomas Kopp(Aero),

Denis Botambekov, Yue Li (CIMSS), William Straka (CIMSS/ASSISTT)

Outline

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

STAR ECM Cal/Val Team

Name	Organization	Major Task
Andrew Heidinger	NESDIS/STAR	Cloud Team Lead
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

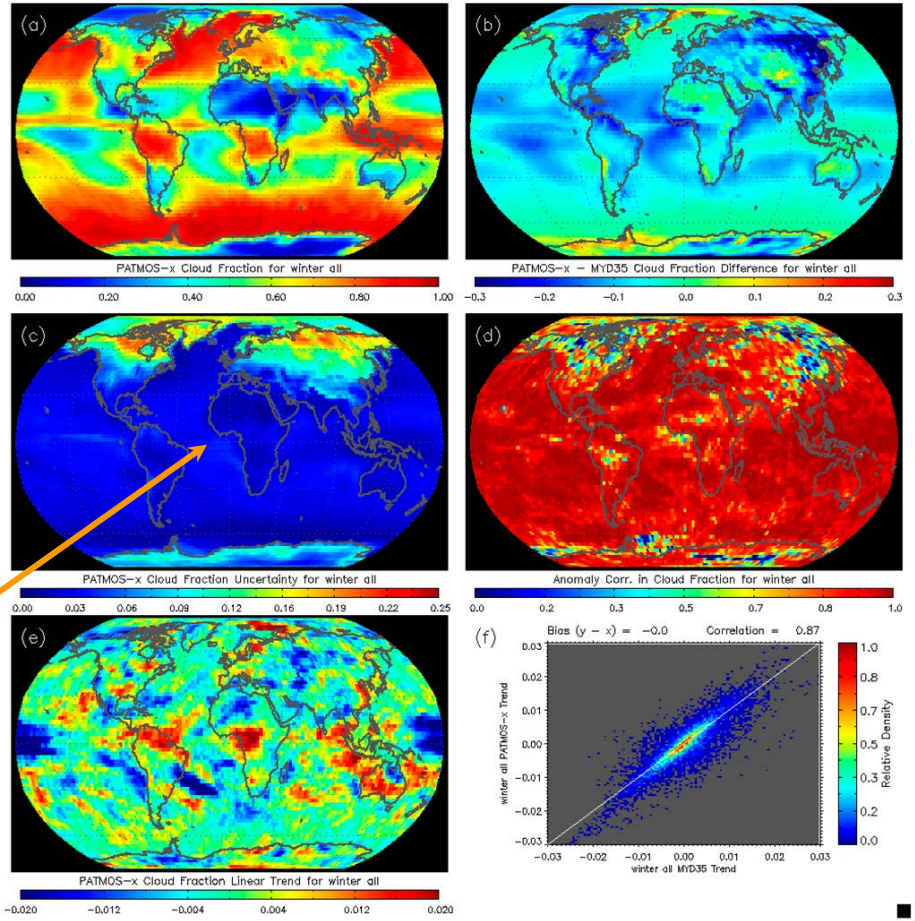
- Supports many sensors and its part of the NOAA Enterprise Algorithm Suite.
- It is probabilistic, using machine learning (naive Bayesian formulation) and NASA CALIPSO data as its training.
- The primary output is the cloud probability (0 - 1 floating point number).
- The 4-Level cloud mask is derived 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.

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
	S/MMIR	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

Users of the ECM

- Downstream Enterprise Clear-Sky Applications.
- Enterprise Cloud Algorithms.
- NCEP VIIRS/CrIS Radiance Assimilation (Jim Jung will represent this).
- VIIRS Polar Winds.
- Potentially External VCM Users (we know of none).

Enterprise Cloud Mask NDE Status

NDE/STAR VIIRS Enterprise Cloud Mask Production Status

Algorithm	Suomi NPP	NOAA-20
April 2017 DAP	NDE February 23, 2018	N/A
January 2018 DAP Contains no code changes from April DAP delivery Contains SAPF tuned LUT for NPP. N20 uses same LUT	STAR Systematic production since March, 2018 NDE Currently in I&T (Data available since 28 March, 2018)	STAR Systematic production since February, 2018 NDE Currently in I&T (Data available since 28 March, 2018)

ECM Deliveries

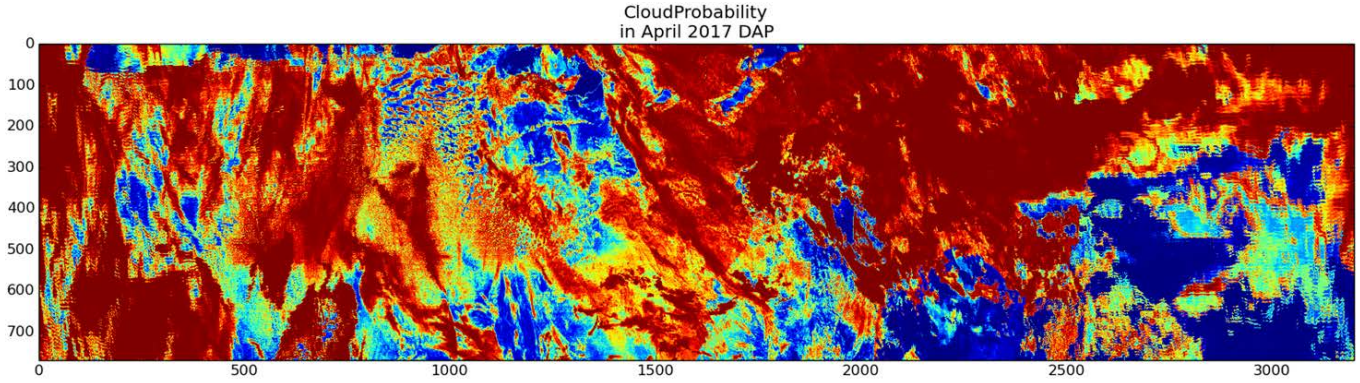
- Current Operational Version (NPP-only)
  - April 2017 DAP

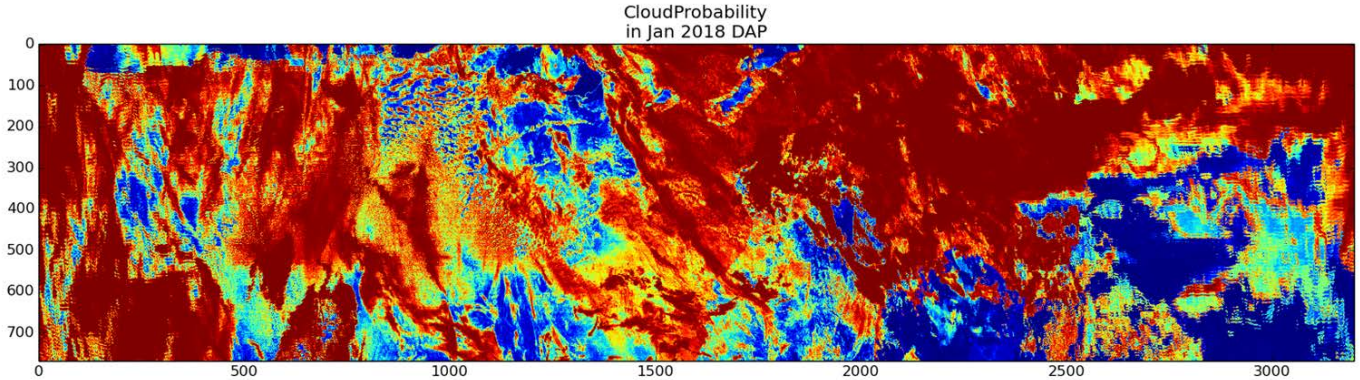
- Current I&T Version
  - January 2018 DAP
  - Contains no code changes from previous DAP delivery
  - Contains SAPF tuned LUT
    - As shown at August 2017 Science Meeting, this increases probability of correct detection over current operational code.

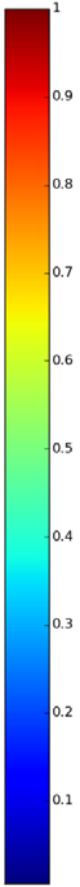
ECM v1r2 Integration Results

- 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 April 2017 DAP (current operational algorithm) and the January 2018 (I&T algorithm).
- ECM science code was last updated for the April 2017. 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.

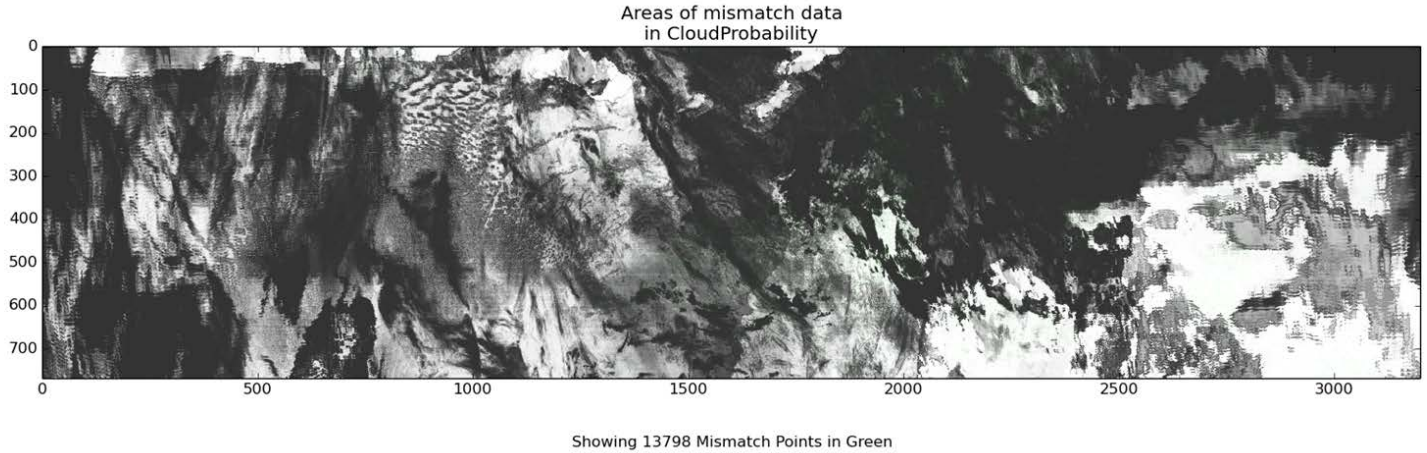
ECM v1r2 Integration Results







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

SDR Issues

SDR Issues at BETA Review

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

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).

- 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.**

Evaluation of the NDE ECM

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.

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

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.

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

Our Aerospace manual analysis will used for training for the run up to provisional.

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.
- 4 days for CALIPSO Comparison: March 31, April 3, 5, and 8, 2018.

Visual Comparisons with CLAVR-x ECM and VCM

Day Ocean

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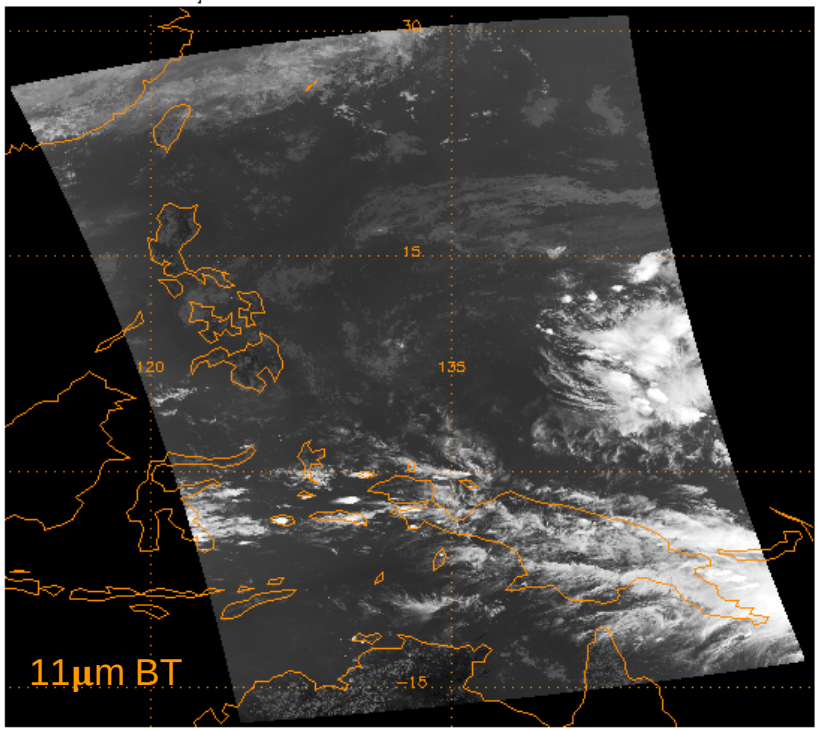

11 μm Brightness Temperature (K)

200 240 280 320

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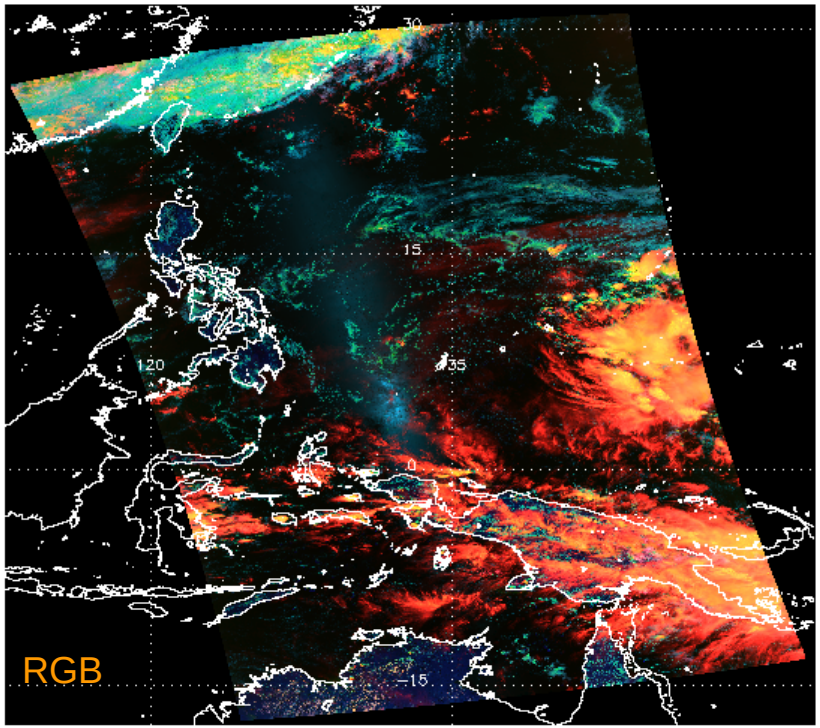

False Color Image

Red=1.38μm, Green = 0.65μm, Blue = 1.60μm

Day Ocean

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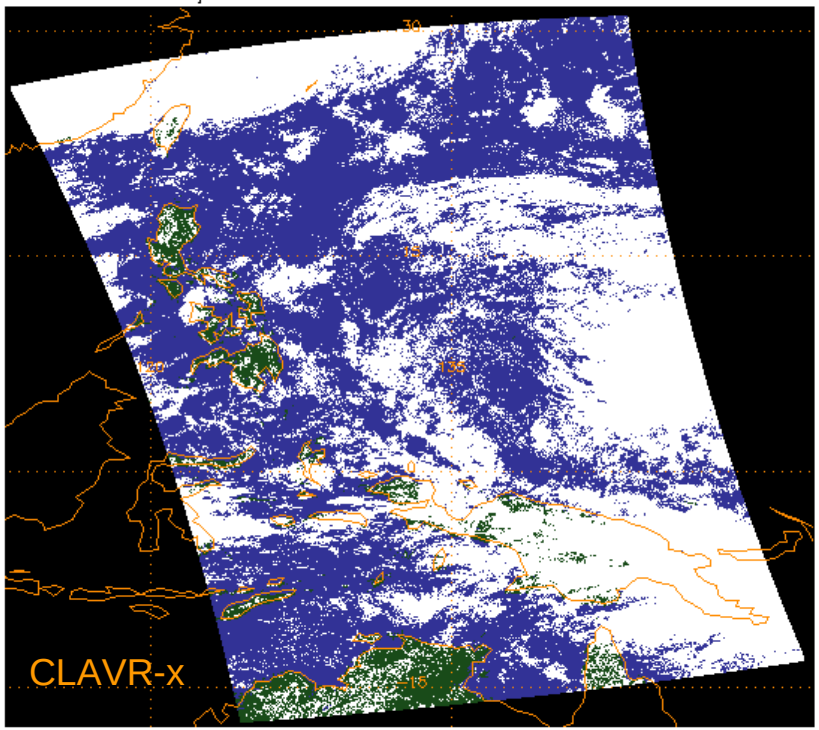

cloud_mask

Clear Water | Clear Land | Cloudy | Unknown

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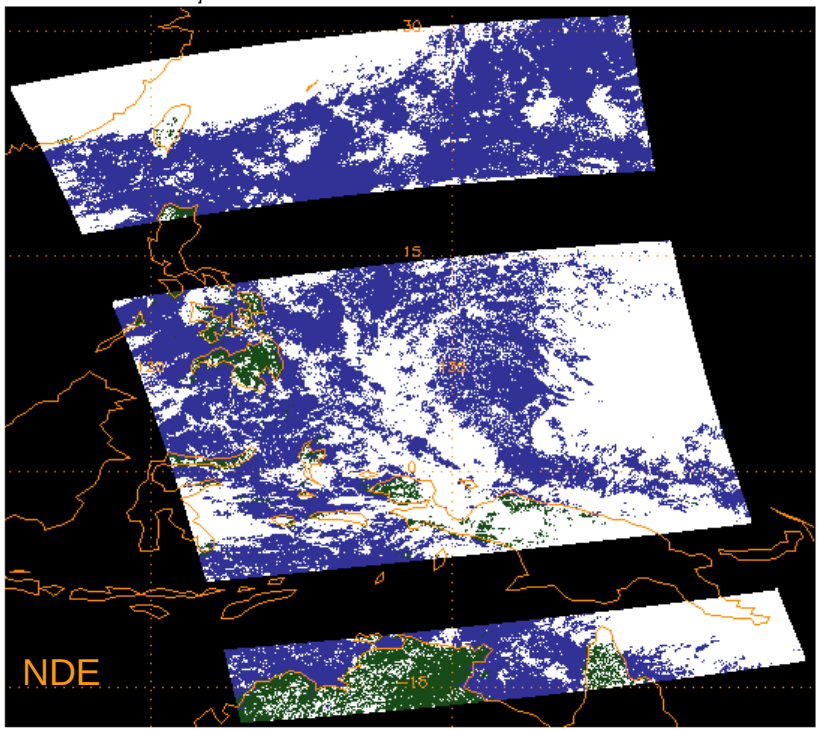
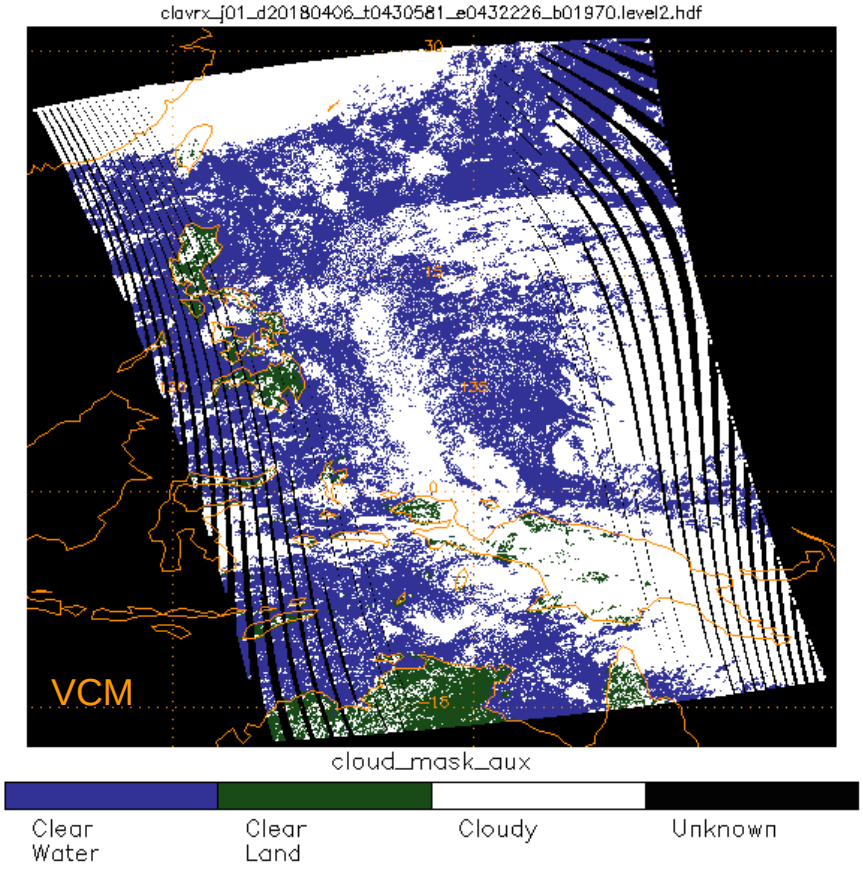


cloud_mask_aux

Clear Water | Clear Land | Cloudy | Unknown

Day Ocean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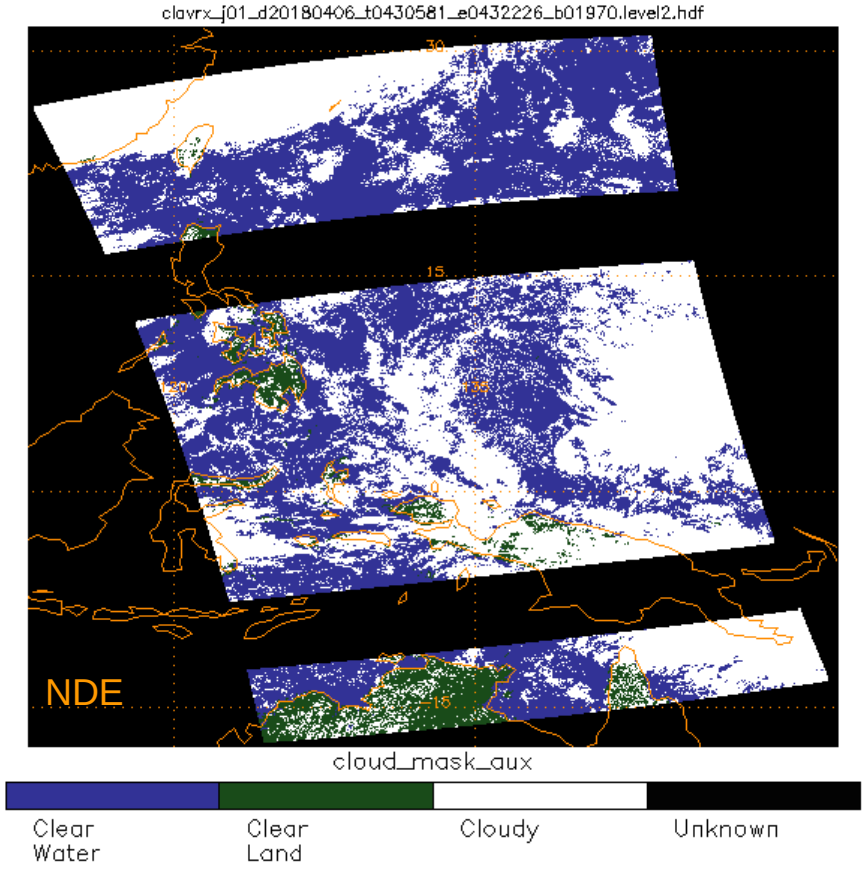
VCM
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown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NDE
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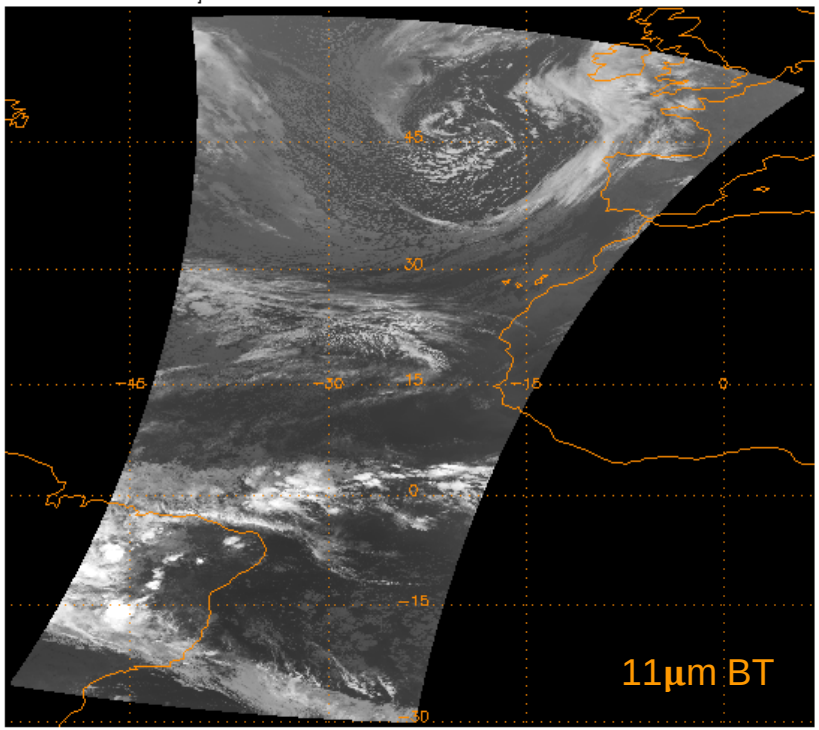
Clear Water
Clear Land
Cloudy
Unknown

Night Ocean

clavrx_j01_d20180406_t0339452_e0341097_b01969.level2.hdf



11 μm Brightness Temperature (K)

200 240 280 320

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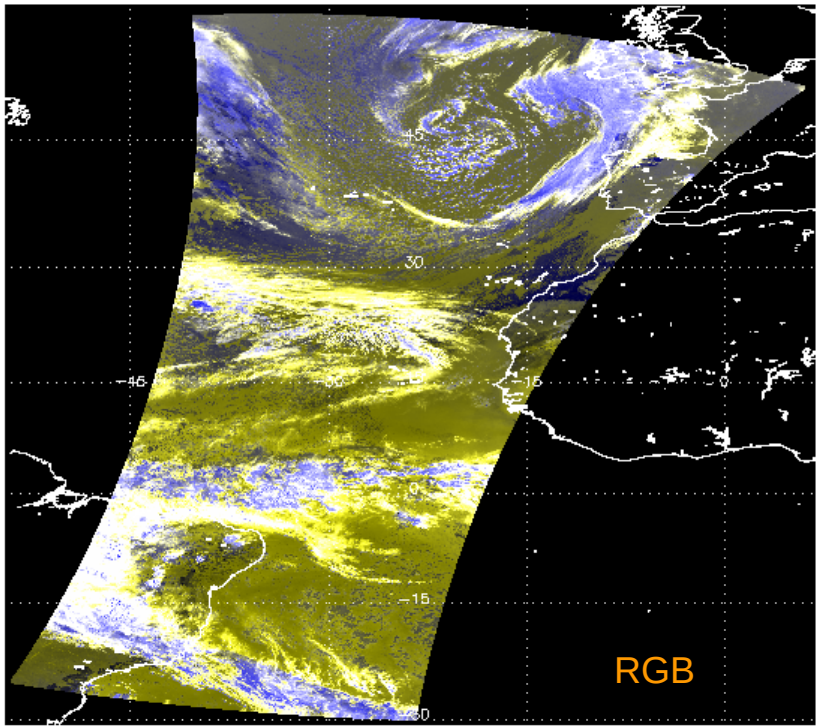
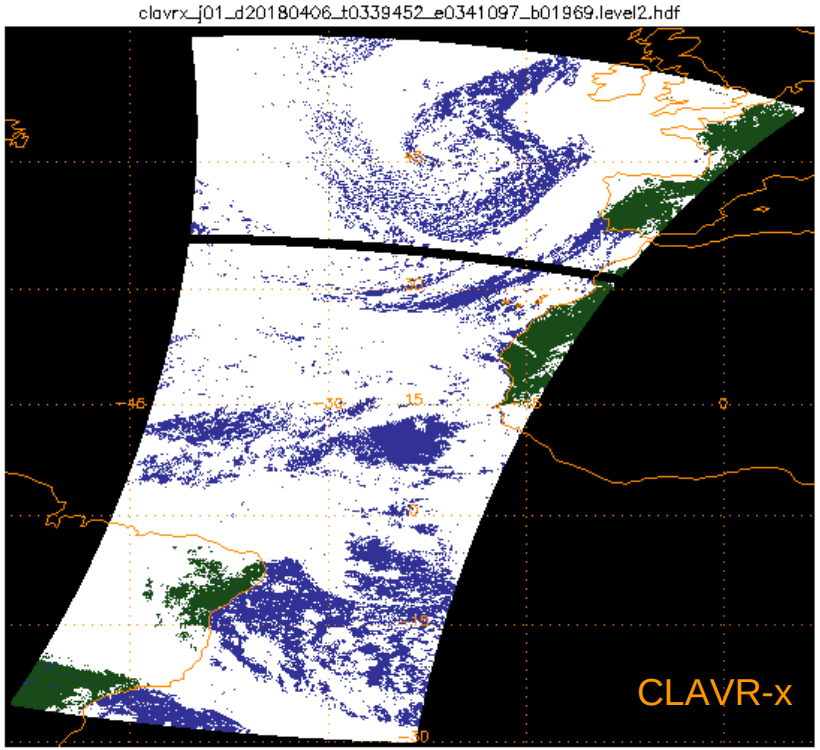


False Color Image

Red=Green=3.75μm – 11μm, Blue = 11μm (rev)

Night Ocean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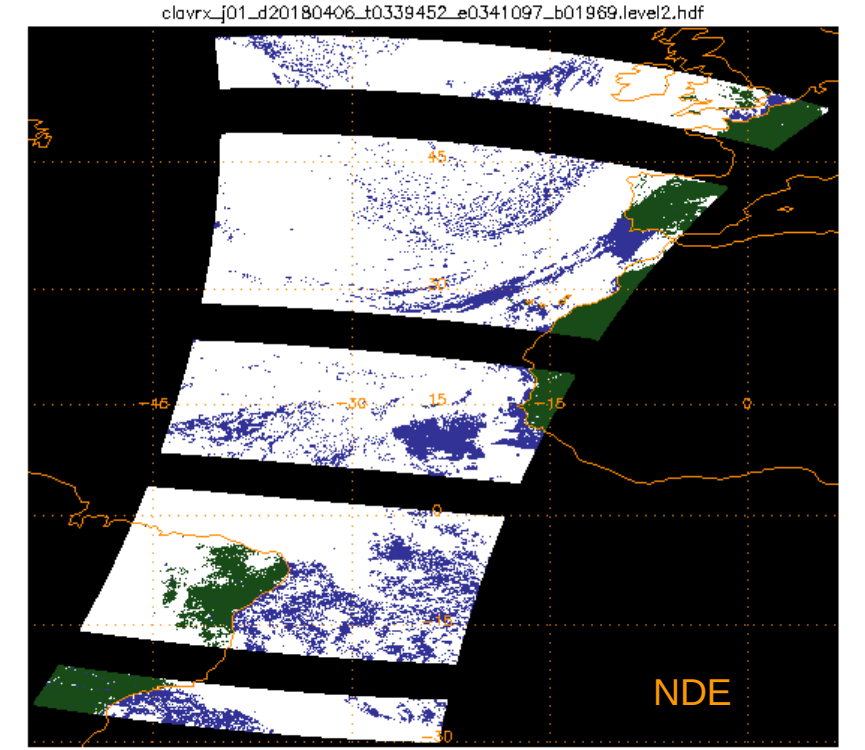
CLAVR-x
cloud_mask
Clear Water
Clear Land
Cloudy
Unknown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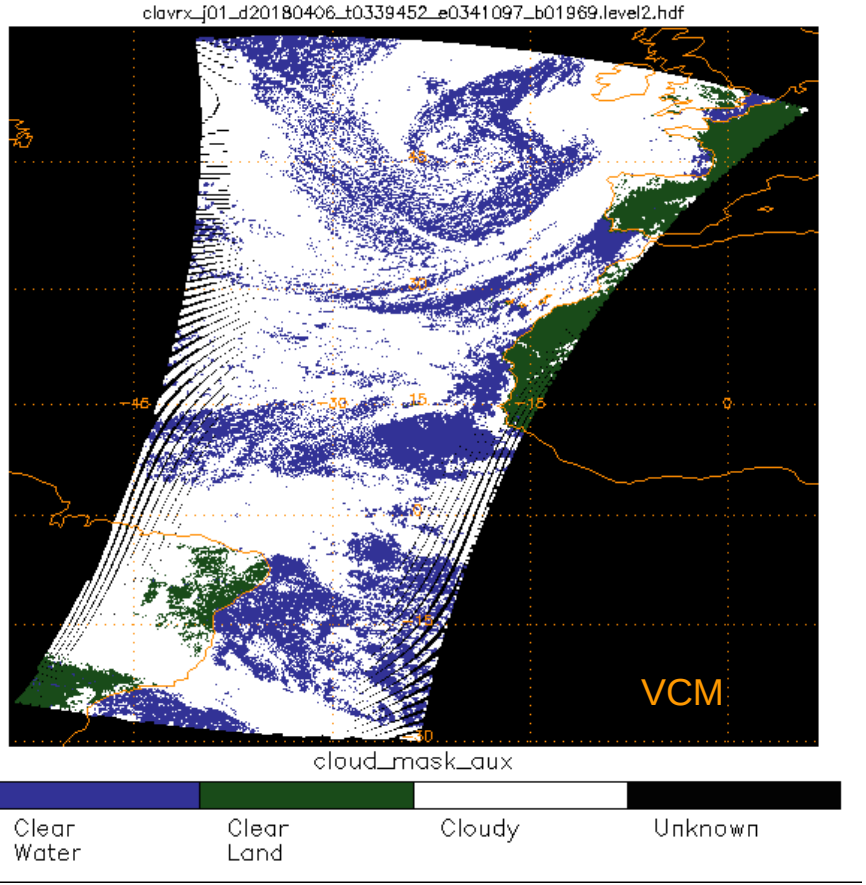
NDE
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown

Night Ocean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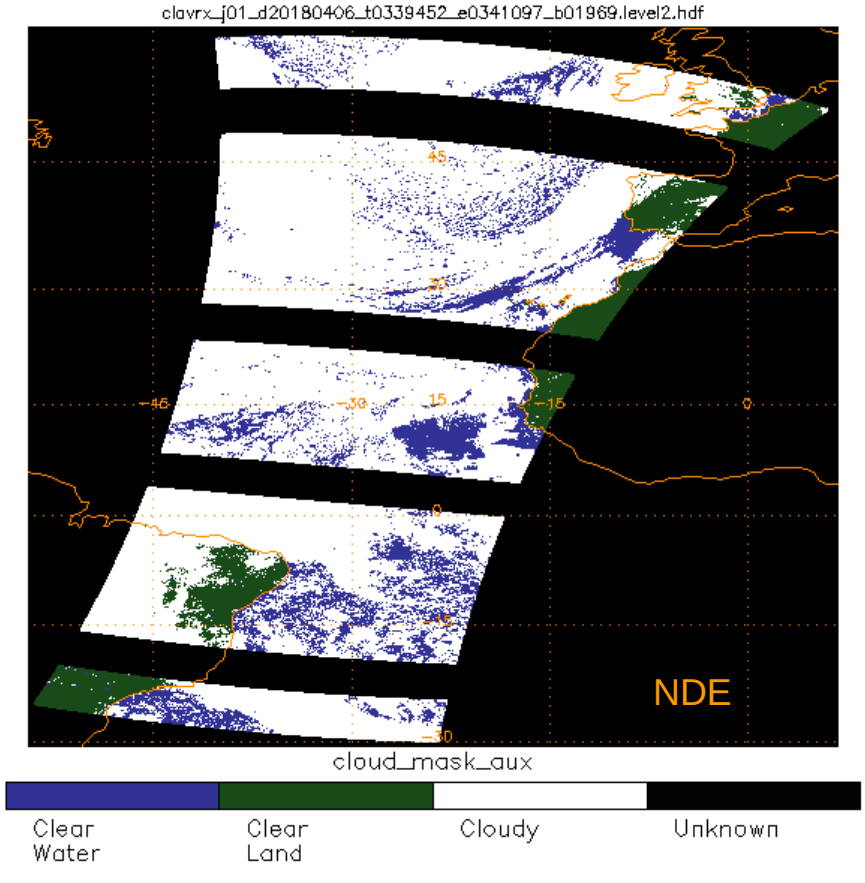
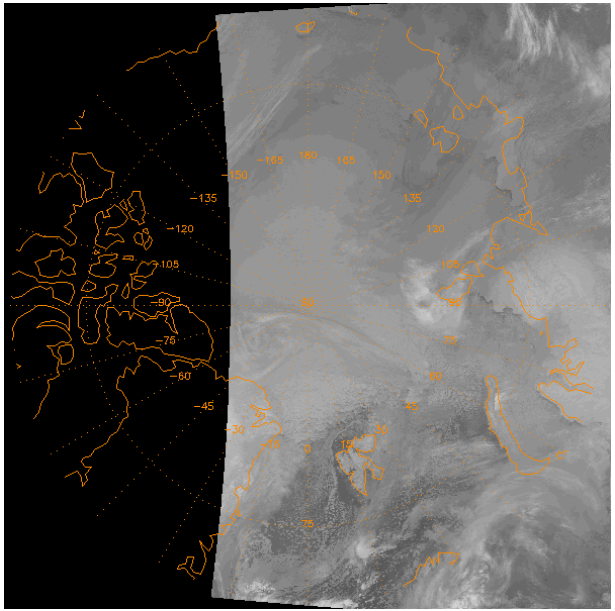
VCM
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown


clavrx_j01_d20180406_t0339452_e0341097_b01969.level2.hdf
NDE
cloud_mask_aux
Clear Water
Clear Land
Cloudy
Unknown

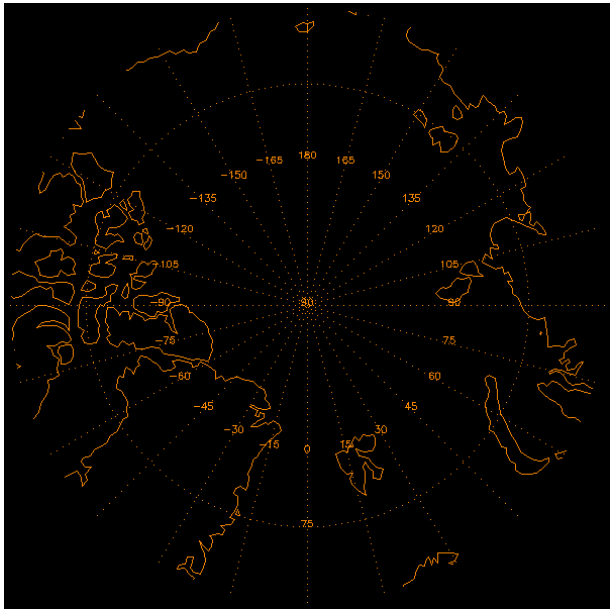
Arctic Example

April 6, 2018 NOAA-20

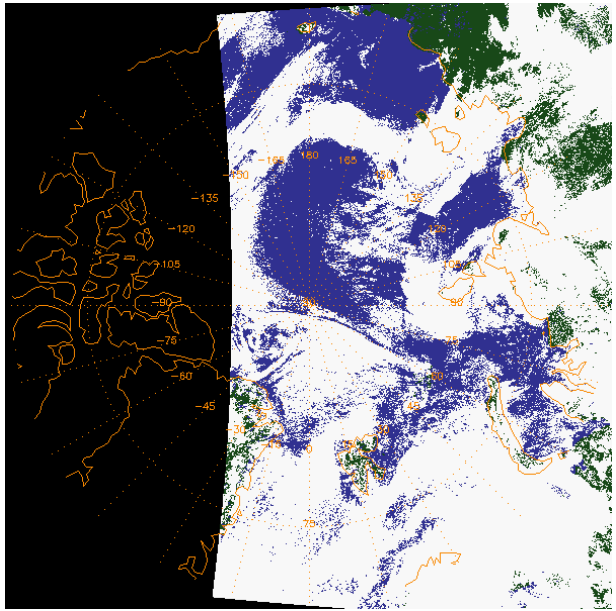
11μm BT



NDE ECM

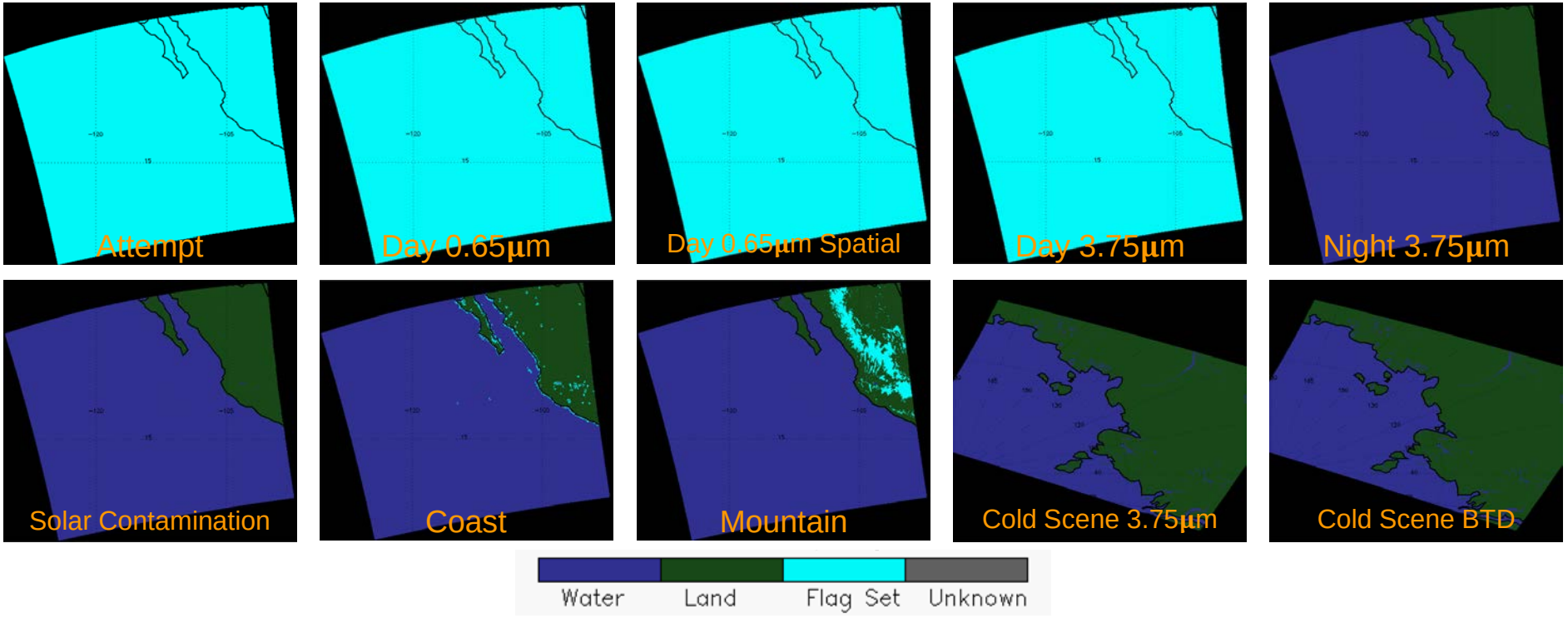


CLAVR-x ECM



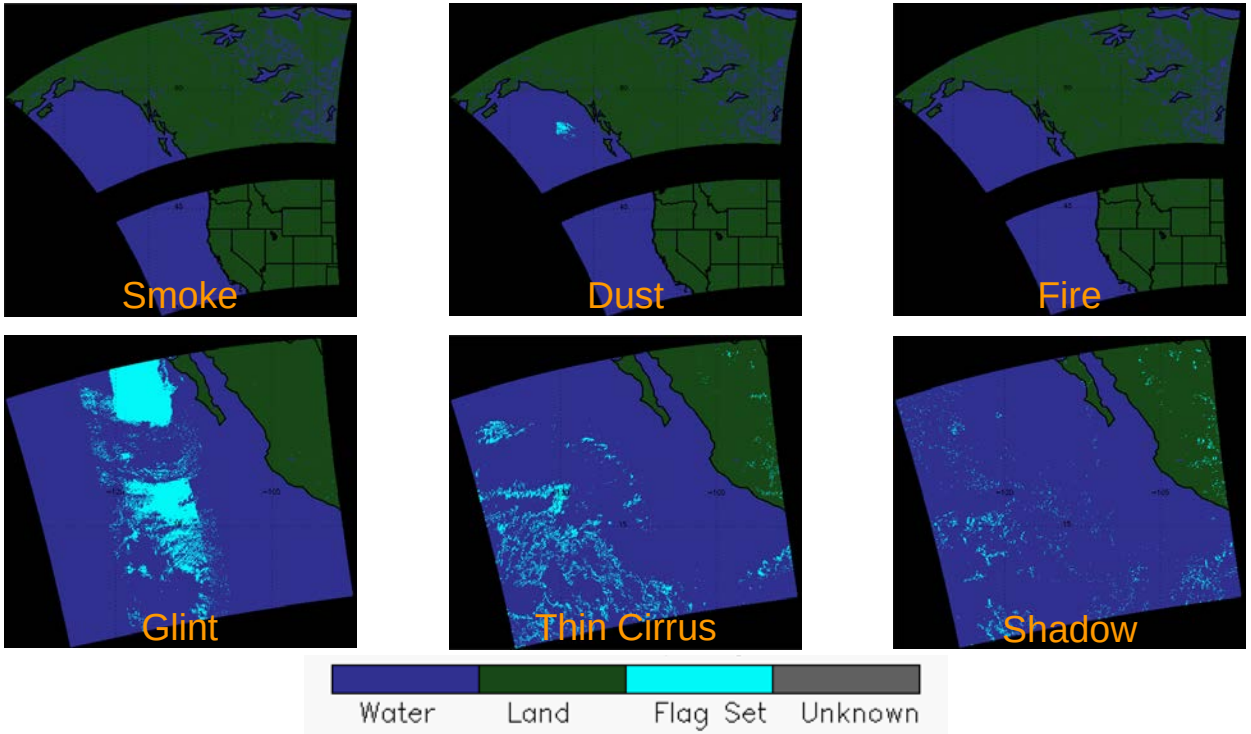
Much fewer clouds in NDE than CLAVR-x

VISUAL Verification of ECM Bits (1)



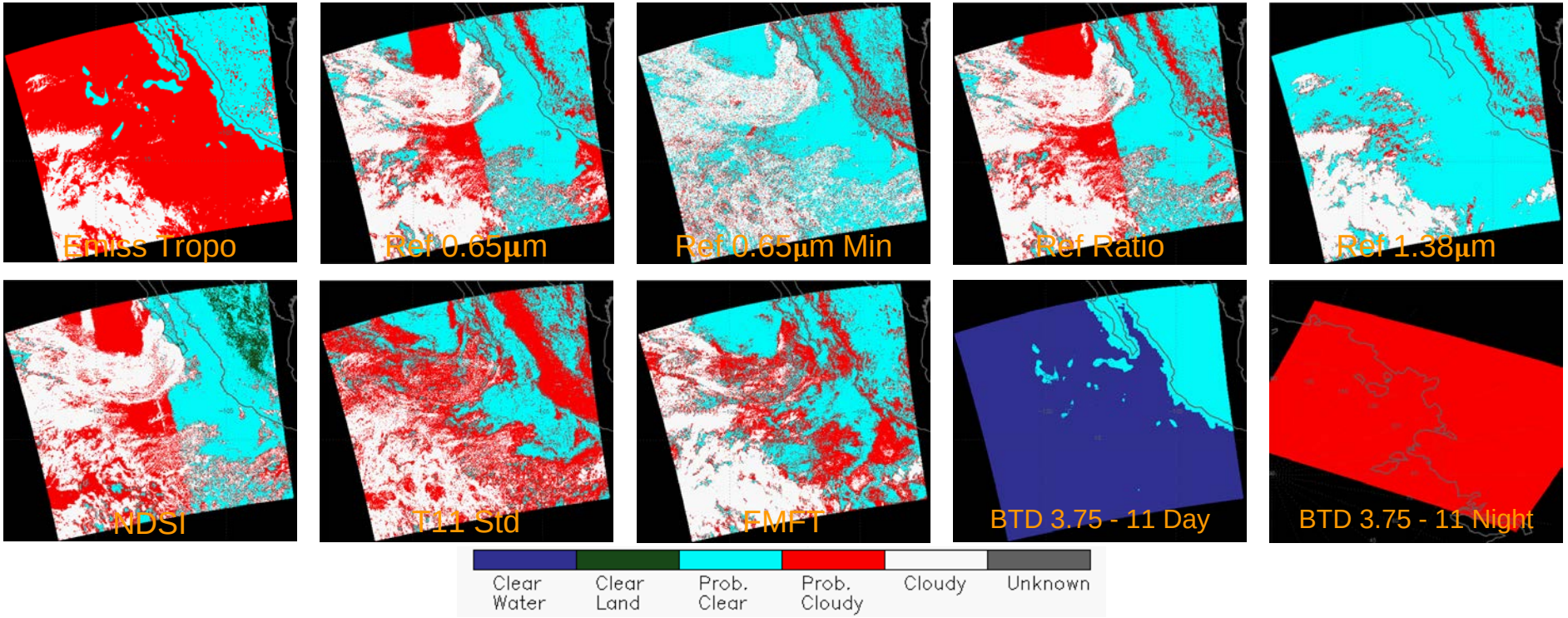
- All above bits are working as expected, except for the 3.75µm Cold scene bit.
- 3.75um Cold scene bit issue suggests that NDE is **NOT** reading in M12.

VISUAL Verification of ECM Bits (2)



- Fire bit, uses M12 BT, is NOT populated. This suggests that NDE does NOT reading in M12 band.
- 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)



- BTD 3.75 - 11µm both Day and Night tests are NOT performing as expected. As already mentioned, this suggests that NDE is **not** reading in M12 band.
- All other bits are working as expected.

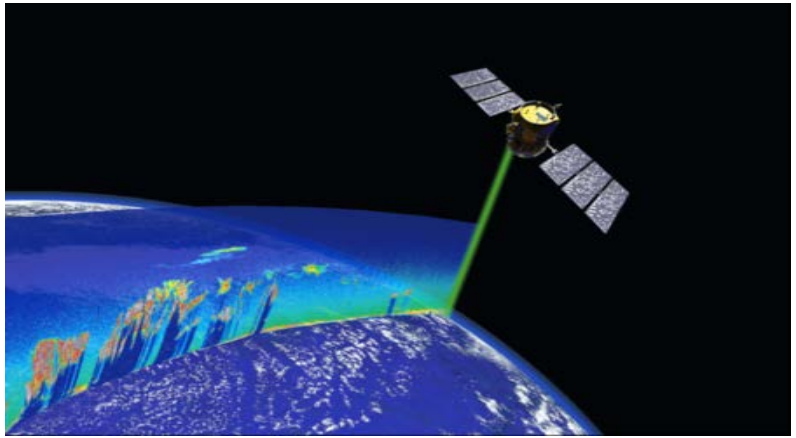
Conclusions from Visual Comparisons

Issue	Comment
Lack of Confidently Clear over Ocean at night.	The cloud probability values never go below 0.01 at night (confidentiality clear threshold). This number should be optimized over every surface type with the application team. NOAA-20 LUT will impact this.
Day Ocean detects more cloud than VCM.	Expected.
Night Ocean detects more cloud than VCM.	Expected.
Poor Arctic Performance.	Discussed in Detail Later.
Missing granules.	This is a PDA issue and will be resolved in the June 2018 DAP (will be in Ops ~end 2018).

Comparison to CALIPSO/CALIOP

CALIOP Comparison Description

- CALIOP is a lidar onboard of CALIPSO.
- CALIOP Cloud algorithm results are considered as “Truth”.
- 4 days of CALIOP and NOAA-20 Matchup data are used 03/31, 04/03, 04/05, and 04/08 from 2018.
- 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).



2017 Before New ECM LUT Delivery, SNPP

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	620281	0.667	0.604	0.087	0.045	-	0.880	0.029	0.091
FW OLD LUT	620281	0.668	0.621	0.090	0.046	-	0.873	0.055	0.072
FW NEW LUT	620281	0.668	0.638	0.140	0.074	-	0.895	0.042	0.063
	Ocean, Day, Global, No Snow/Snow/Ice								
ECM NDE	132151	0.659	0.649	0.013	0.007	0.940	0.930	0.030	0.040
FW OLD LUT	132151	0.657	0.644	0.020	0.009	0.940	0.943	0.022	0.035
FW NEW LUT	132151	0.657	0.629	0.033	0.017	0.940	0.953	0.025	0.022
	Ocean, Night, Global, No Snow/Snow/Ice								
ECM NDE	165140	0.705	0.686	0.048	0.029	0.850	0.917	0.032	0.051
FW OLD LUT	165140	0.706	0.673	0.082	0.058	0.850	0.925	0.031	0.044
FW NEW LUT	165140	0.706	0.695	0.201	0.073	0.850	0.936	0.027	0.037
	Land, Day, Global, No Snow/Snow/Ice								
ECM NDE	88247	0.512	0.426	0.019	0.011	0.900	0.895	0.014	0.091
FW OLD LUT	88247	0.512	0.474	0.052	0.022	0.900	0.900	0.041	0.059
FW NEW LUT	88247	0.512	0.438	0.059	0.025	0.900	0.913	0.026	0.061
	Land, Night, Global, No Snow/Snow/Ice								
ECM NDE	37577	0.693	0.604	0.081	0.031	0.880	0.902	0.004	0.093
FW OLD LUT	37577	0.694	0.575	0.097	0.040	0.880	0.896	0.017	0.097
FW NEW LUT	37577	0.694	0.609	0.314	0.090	0.880	0.908	0.028	0.063

ECM NDE - Operational ECM NDE
FW OLD LUT - Framework ECM with current operational LUT
FW NEW LUT - Framework ECM with the new LUT
No Snow/Snow/Ice = Snow/Ice Filter Applied

- The previous ECM LUT was based on the MODIS - CALIOP collocation data. The new LUT is calculated on the 1 year (2015) of VIIRS - CALIOP data.
- The new LUT gives around 1-2% improvement of ECM performance.
- This stats are calculated based on VIIRS - CALIOP data from 2015-08-15 and 2015-08-31.
- New LUT is delivered to NDE in August 2017, in ops in early 2018.

2018 New ECM LUT Verification, SNPP

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	661017	0.676	0.614	0.132	0.131	-	0.887	0.041	0.072
ECM CLAVR-x	661017	0.676	0.628	0.065	0.067	-	0.904	0.029	0.067
	Ocean, Day, Global, No Snow/Snow/Ice								
ECM NDE	138054	0.660	0.649	0.081	0.057	0.940	0.944	0.022	0.034
ECM CLAVR-x	138054	0.660	0.644	0.050	0.029	0.940	0.958	0.020	0.022
	Ocean, Night, Global, No Snow/Snow/Ice								
ECM NDE	162148	0.695	0.656	0.148	0.125	0.850	0.917	0.041	0.042
ECM CLAVR-x	162148	0.695	0.663	0.079	0.066	0.850	0.925	0.032	0.043
	Land, Day, Global, No Snow/Snow/Ice								
ECM NDE	98151	0.554	0.493	0.082	0.081	0.900	0.910	0.036	0.054
ECM CLAVR-x	98151	0.554	0.501	0.061	0.042	0.900	0.923	0.021	0.056
	Land, Night, Global, No Snow/Snow/Ice								
ECM NDE	41260	0.700	0.610	0.187	0.090	0.880	0.906	0.019	0.075
ECM CLAVR-x	41260	0.700	0.629	0.154	0.087	0.880	0.911	0.028	0.061

- After NDE implemented New ECM LUT in February 2018 they provided 2.5 month of Cloud EDRs for verification.
- This stats are calculated based on VIIRS - CALIOP data from 2014-10-23 and 2015-01-03.
- NEW LUT on SNPP shows expected increase in performance (see previous slide), and meets required specifications.

ECM NDE - Offline SAPF run using new LUT and proper channel configuration
ECM CLAVR-x - ECM produced by CLAVR-x
No Snow/Snow/Ice = Snow/Ice Filter Applied

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	608488	0.680	0.644	0.169	0.116	-	0.845	0.060	0.095
ECM CLAVR-x	691366	0.684	0.688	0.093	0.076	-	0.874	0.065	0.061
VCM IDPS	691366	0.684	0.619	0.076	0.027	-	0.855	0.042	0.103
	Ocean, Day, Global, No Snow/Snow/Ice								
ECM NDE	153062	0.736	0.711	0.034	0.028	0.940	0.921	0.027	0.052
ECM CLAVR-x	183692	0.734	0.711	0.019	0.012	0.940	0.945	0.016	0.039
VCM IDPS	183692	0.734	0.723	0.083	0.028	0.940	0.930	0.030	0.040
	Ocean, Night, Global, No Snow/Snow/Ice								
ECM NDE	199778	0.761	0.830	0.170	0.166	0.850	0.891	0.089	0.020
ECM CLAVR-x	214035	0.764	0.771	0.084	0.029	0.850	0.920	0.044	0.036
VCM IDPS	214035	0.764	0.714	0.082	0.037	0.850	0.906	0.024	0.070
	Land, Day, Global, No Snow/Snow/Ice								
ECM NDE	46115	0.516	0.435	0.053	0.034	0.900	0.890	0.015	0.095
ECM CLAVR-x	50709	0.543	0.469	0.036	0.024	0.900	0.918	0.014	0.068
VCM IDPS	50709	0.543	0.448	0.036	0.007	0.900	0.901	0.011	0.088
	Land, Night, Global, No Snow/Snow/Ice								
ECM NDE	40450	0.587	0.456	0.302	0.076	0.880	0.852	0.008	0.140
ECM CLAVR-x	49976	0.601	0.571	0.074	0.044	0.880	0.906	0.032	0.062
VCM IDPS	49976	0.601	0.532	0.038	0.005	0.880	0.906	0.009	0.085

ECM NDE - I&T ECM NDE
ECM CLAVR-x - ECM produced by CLAVR-x
VCM IDPS - VIIRS Cloud Mask produced by IDPS
No Snow/Snow/Ice = Snow/Ice Filter Applied

- This stats are calculated based on VIIRS - CALIOP data from 2018-03-31, 2018-04-03, 2018-04-05, and 2018-04-08.
- ECM NDE is slightly below required specification (Red numbers) over Ocean Day, Land both Day and Night.
  - This is likely due to issues previously noted in NDE processing.
- ECM CLAVR-x meets the specs.
- VCM IDPS meets the specs except Ocean Day, where it is 1% below the requirement

Summary of CALIPSO

NDE ECM numbers from last 3 validations. ECM code is unchanged.

	Spec	SNPP NDE LUT	SNPP ASSISTT SAPF LUT	NOAA-20 NDE SAPF LUT
Global	0.87	0.880	0.887	0.845
Ocean Day	0.94	0.930	0.944	0.921
Ocean Night	0.85	0.917	0.917	0.891
Land Day	0.90	0.895	0.910	0.890
Land Night	0.88	0.902	0.906	0.852

Caveats:

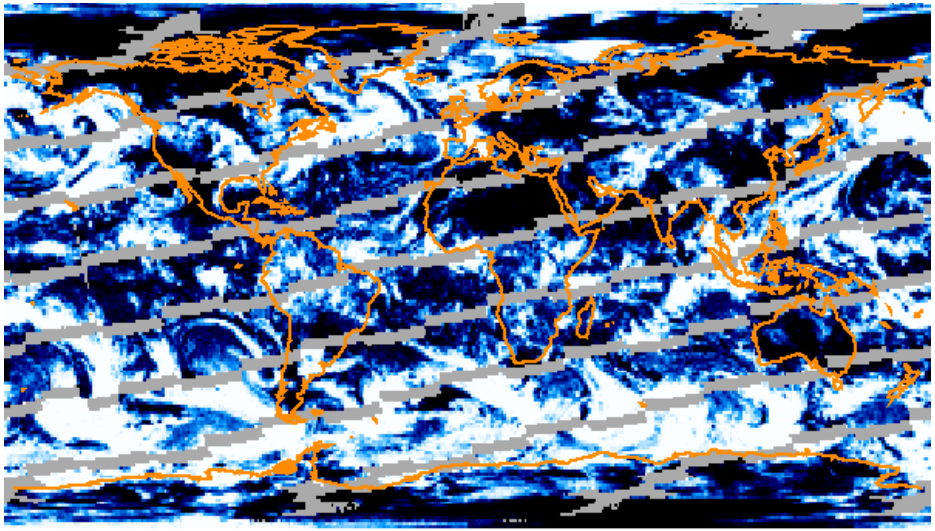
1. SNPP M5 is 5% brighter than NOAA-20 M5. Not accounted for yet.
2. NOAA-20 Sample Size is small.
3. All results over emphasize high latitudes.
4. We used an optical depth limit of 0.4 (GOES-R) not 1.0 as in JPSS L1RD.

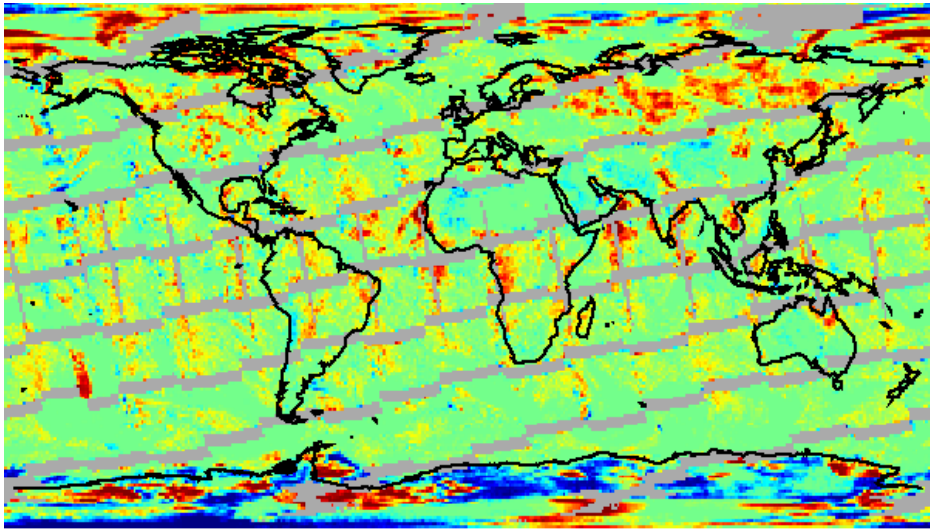
Conclusions from CALIPSO Comparisons

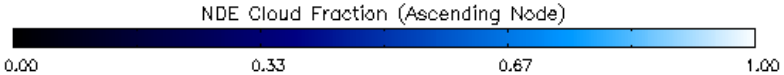
- Cloud team has delivered a new ECM LUT to NDE in 2017, which is based on VIIRS S-NPP and CALIOP collocation data.
- In February 2018 NDE provided test data. Evaluation showed expected increase in the ECM performance.
- Overall, ECM NDE shows a good performance, even it is slightly below the required specifications.
- We can not explain the decrease in performance for the NOAA-20 NDE results.

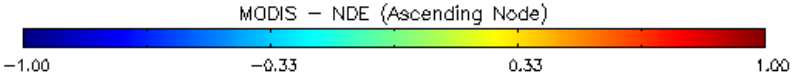
Comparison to AQUA/MODIS

Cloud Fraction Ascending Node







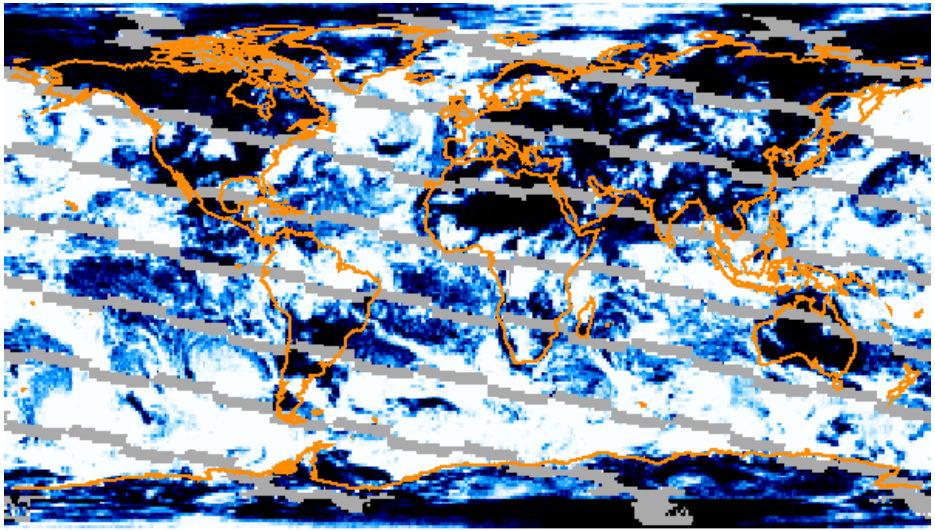


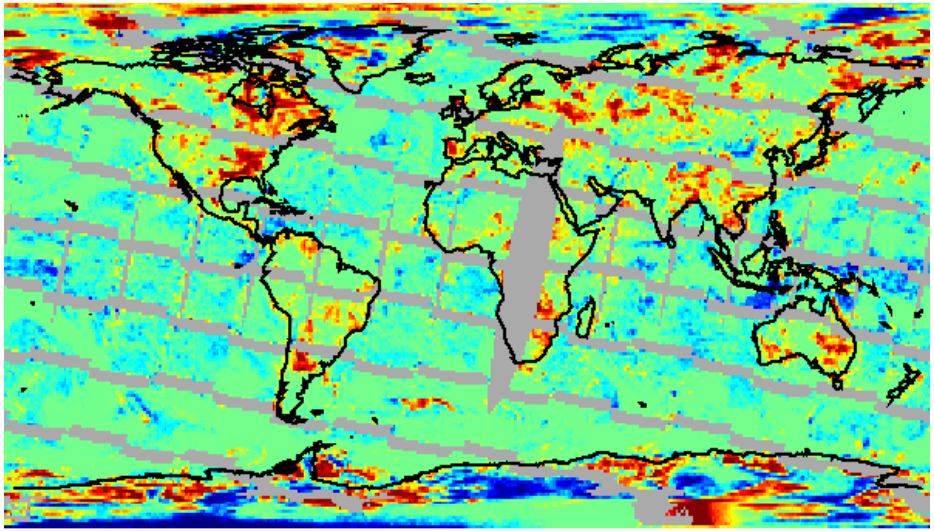
Red = Cloud Observed by MODIS but Missed in NDE.

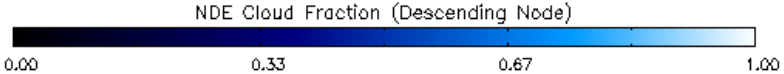
Blue = Cloud Observed by NDE but Missed in MODIS.

Green = Good Agreement.

Cloud Fraction Descending Node





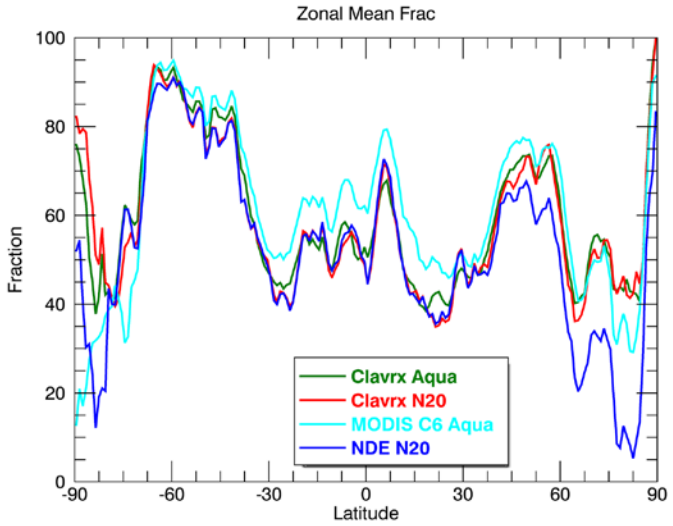


Red = Cloud Observed by MODIS but Missed in NDE.

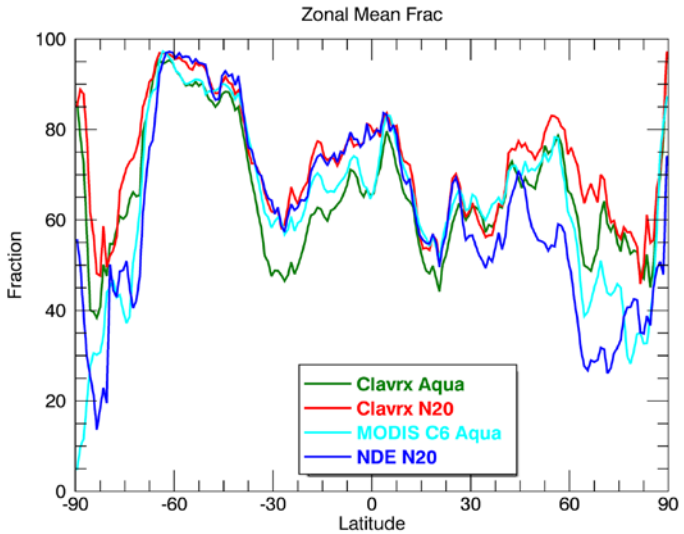
Blue = Cloud Observed by NDE but Missed in MODIS.

Green = Good Agreement.

Zonal Distribution of Cloud Fraction



Ascending



Descending

- NDE NOAA-20 is generally consistent with the other Enterprise products between 45ºN and 60ºS.
- The lower cloud fraction in polar regions in NDE NOAA-20 needs investigation.

Global Stats

Global mean cloud fraction

	NDE N20	Clavr-x N20	Clavr-x Aqua	MODIS C6 Aqua
Ascending	52.3%	58.9%	59.5%	60.8%
Descending	61.6%	72.5%	65.9%	63.8%

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	67.1%	59.0%	56.9%
	N20 Clavr-x			75.2%
Descending	MODIS C6 Aqua	63.0%	55.3%	56.0%
	N20 Clavr-x			52.7%

Stats 60ºN - 60ºS

Global mean cloud fraction

	NDE N20	Clavr-x N20	Clavr-x Aqua	MODIS C6 Aqua
Ascending	57.5%	58.5%	60.0%	66.3%
Descending	70.3%	74.1%	67.4%	71.0%

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	75.5%	64.9%	63.6%
	N20 Clavr-x			88.6%
Descending	MODIS C6 Aqua	75.3%	65.7%	63.0%
	N20 Clavr-x			60.0%

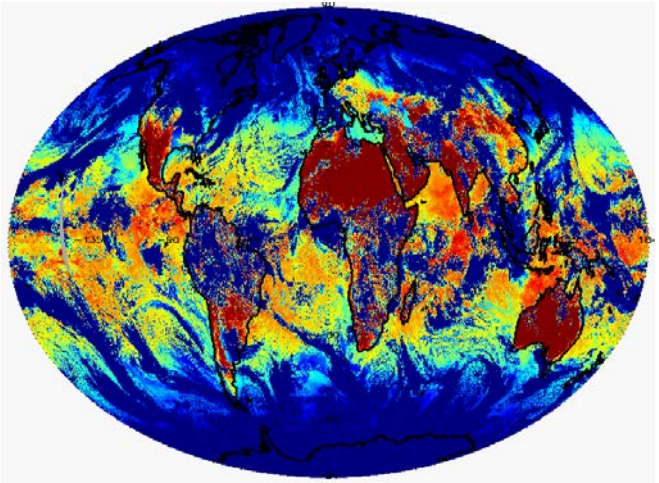
Conclusions from MODIS Comparisons

- ECM NDE NOAA-20 performs similarly to CLAVR-x and MODIS in non-polar regions.
- In polar regions, the detection of cloudy regions is much less.
- Points out specific regions of differences that are investigated later.

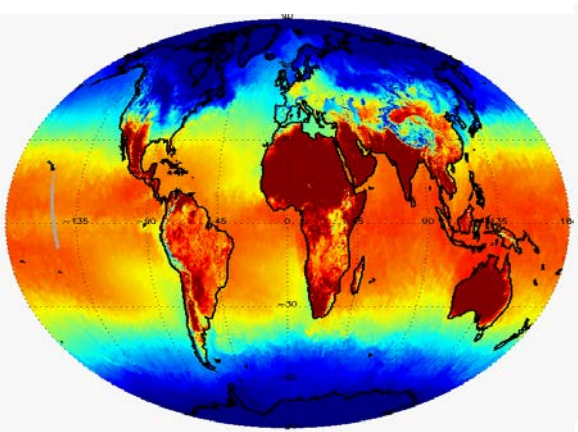
SST Bias Analysis

SST Comparison Description

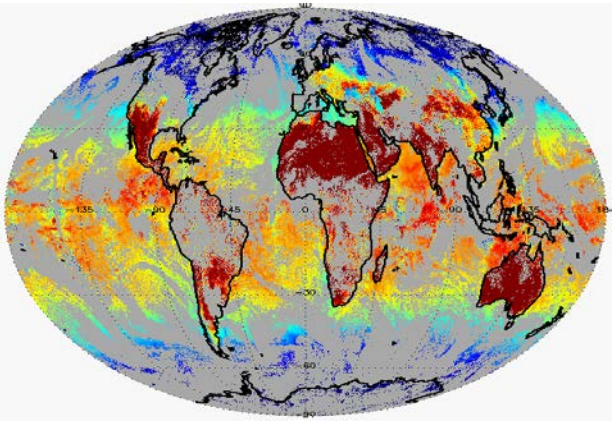
- Sea Surface Temperature (SST) is very sensitive to the presence of cloud.
- If we compute SST for all pixels, we can compare observed SST to a background SST.
- Clear pixels with negative SST biases are likely missed cloud.
- Cloudy pixels with small SST biases are likely false cloud.
- This analysis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



SST Unmasked



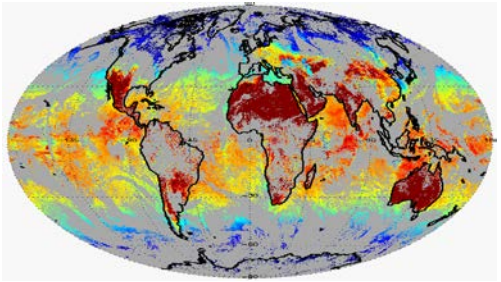
OISST



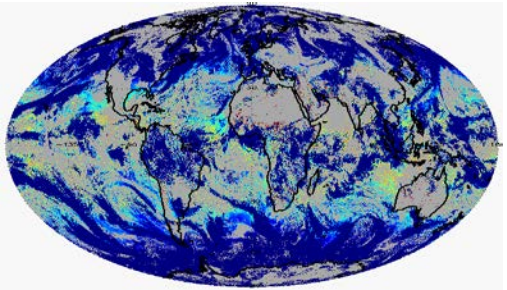
Masked SST

SST Comparison Description

O (observations)

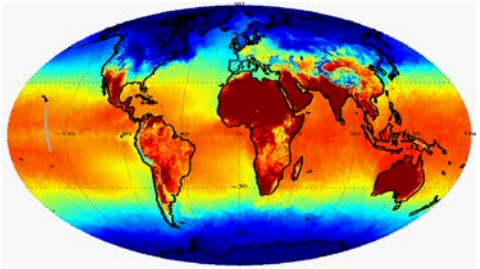


Cloud Masked SST

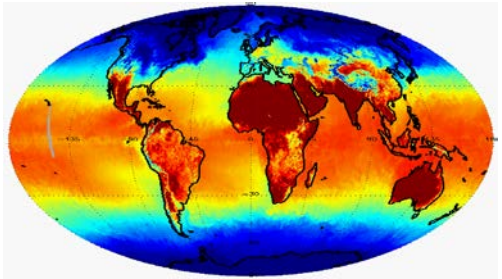


Clear Masked SST

B (background)

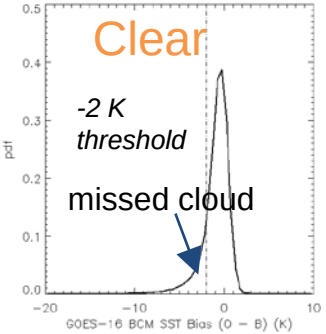


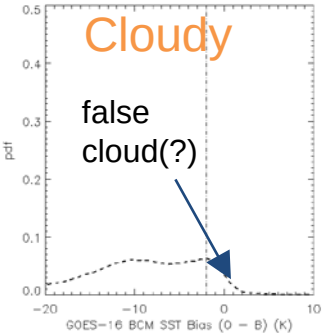
OISST



OISST

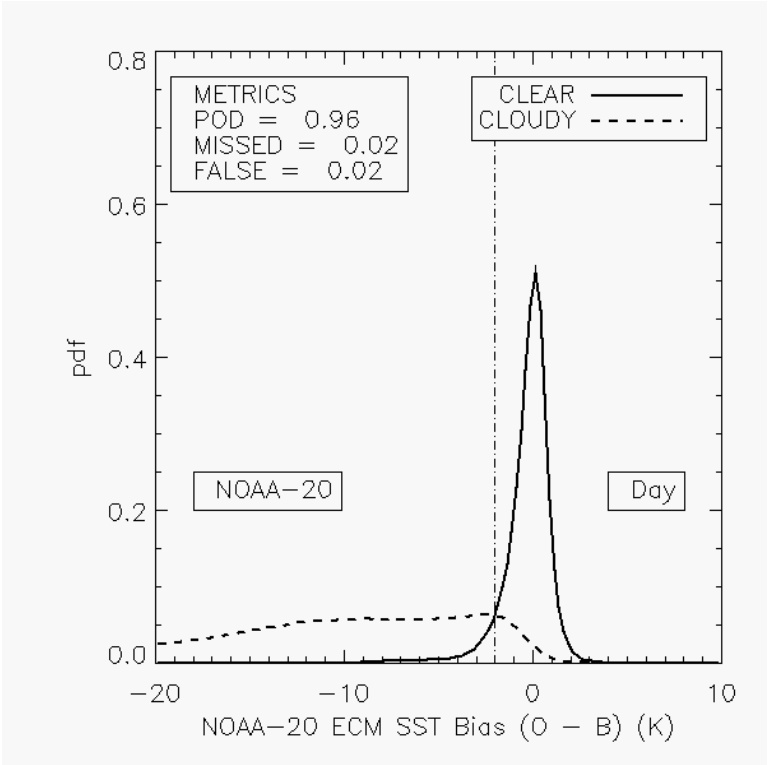
O-B (bias)





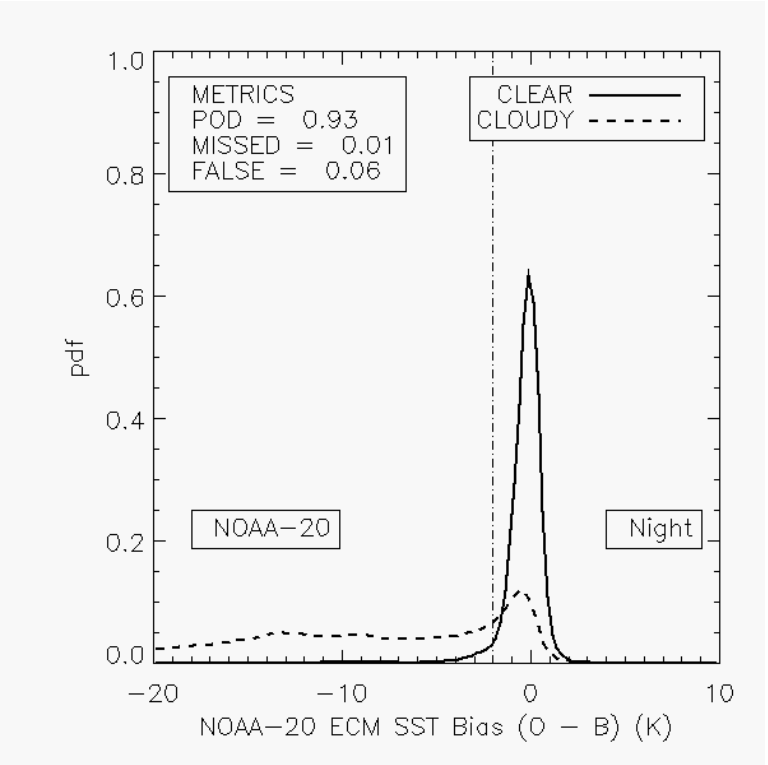
Cloud Mask Performance for Day Time

- 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.



Cloud Mask Performance for Night 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.



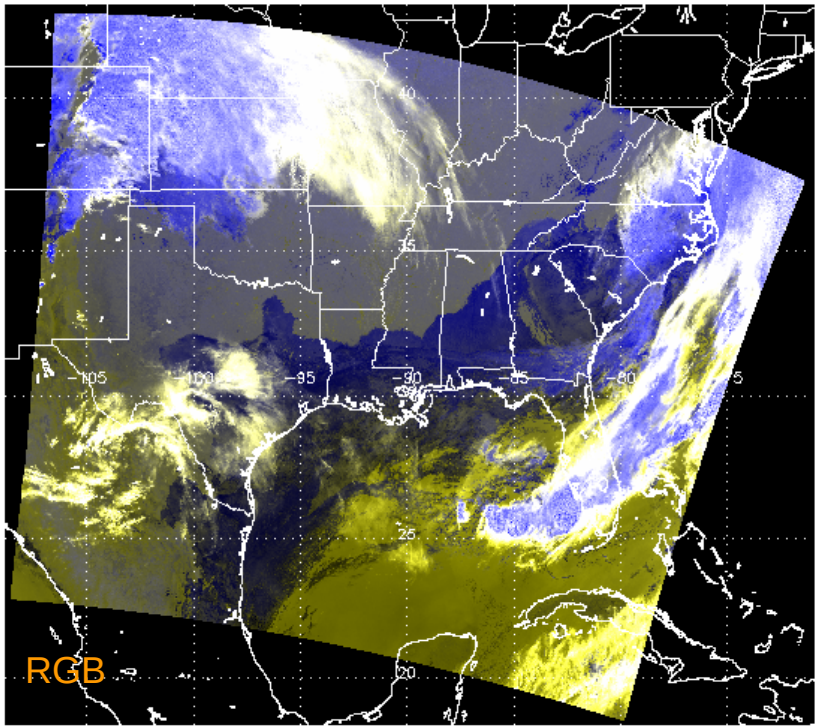
Conclusions from SST Analysis

- Binary ECM seems to perform well over a large sample of ice-free oceanic pixels.
- NDE ECM and CLAVR-x ECM give similar stats.

Investigation of Issues

Missed Low Cloud at Night

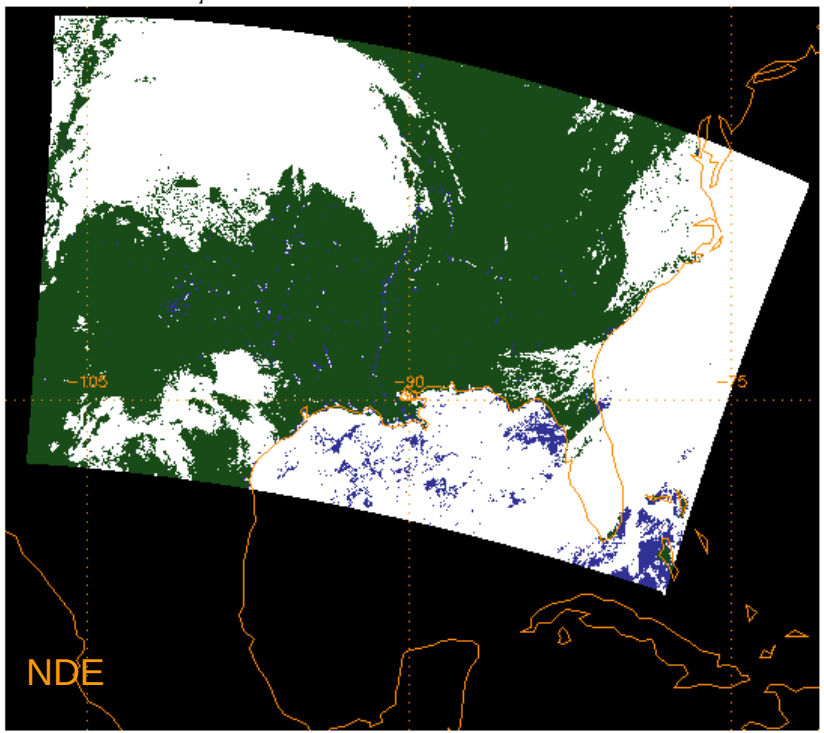
clavrx_j01_d20180408_t0752070_e0753297_b02000



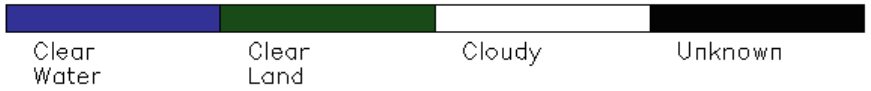
False Color Image

Red=Green=3.75μm – 11μm, Blue = 11μm (rev)

clavrx_j01_d20180408_t0752070_e0753297_b02000.level2.hdf



cloud_mask_aux



Missed Low Cloud at Night

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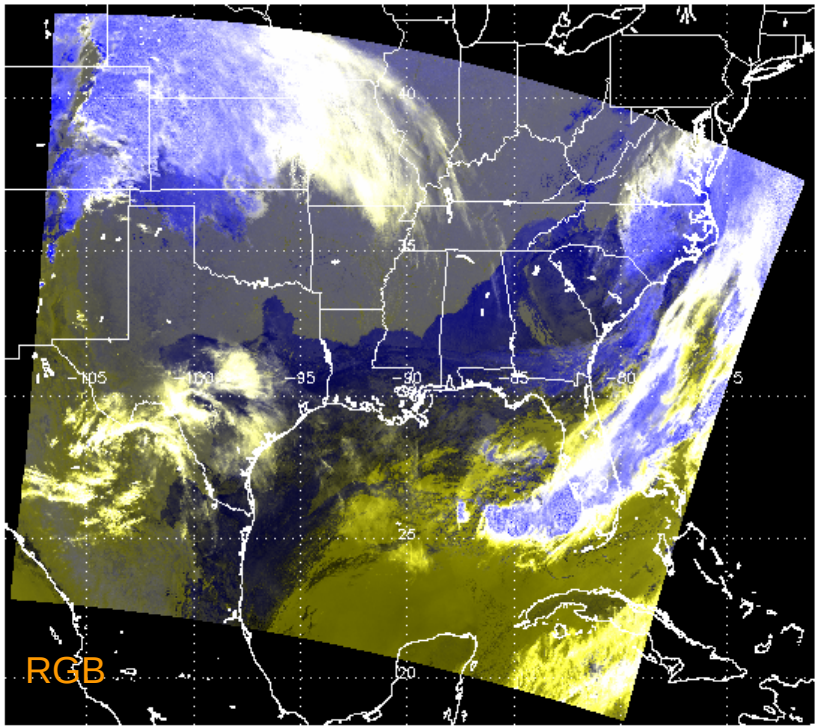

False Color Image

Red=Green=3.75μm – 11μm, Blue = 11μm (rev)

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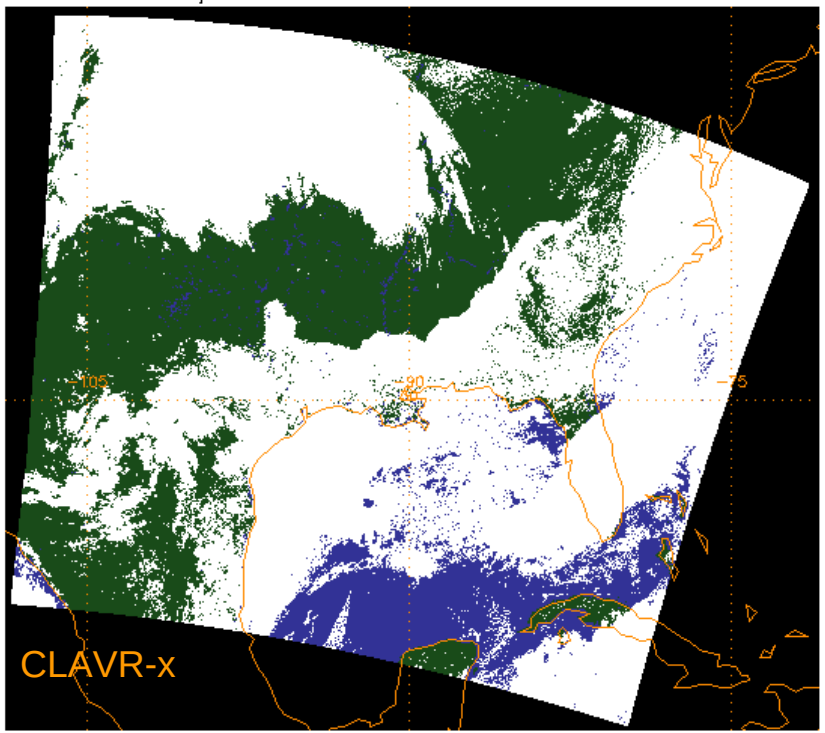
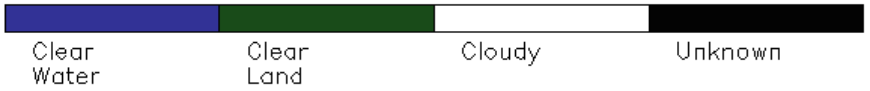
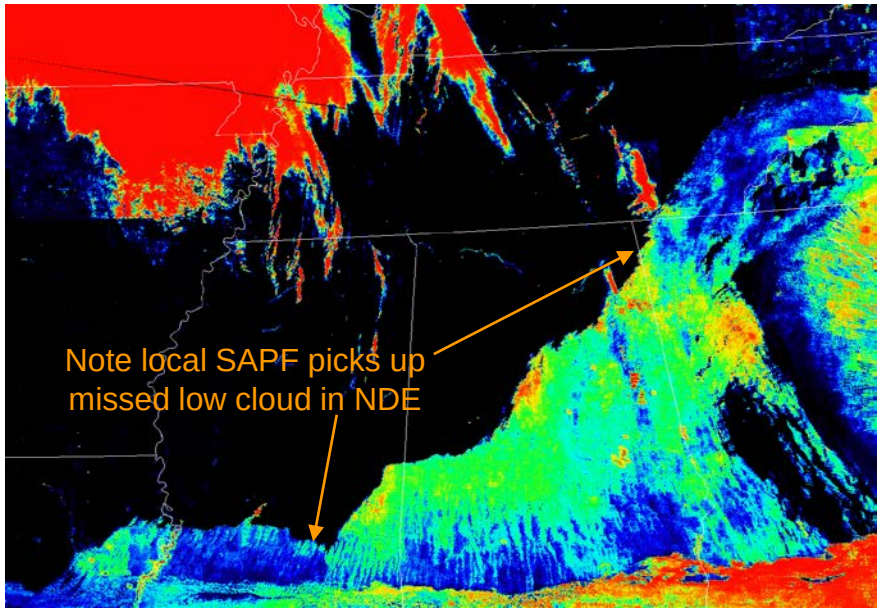


cloud_mask

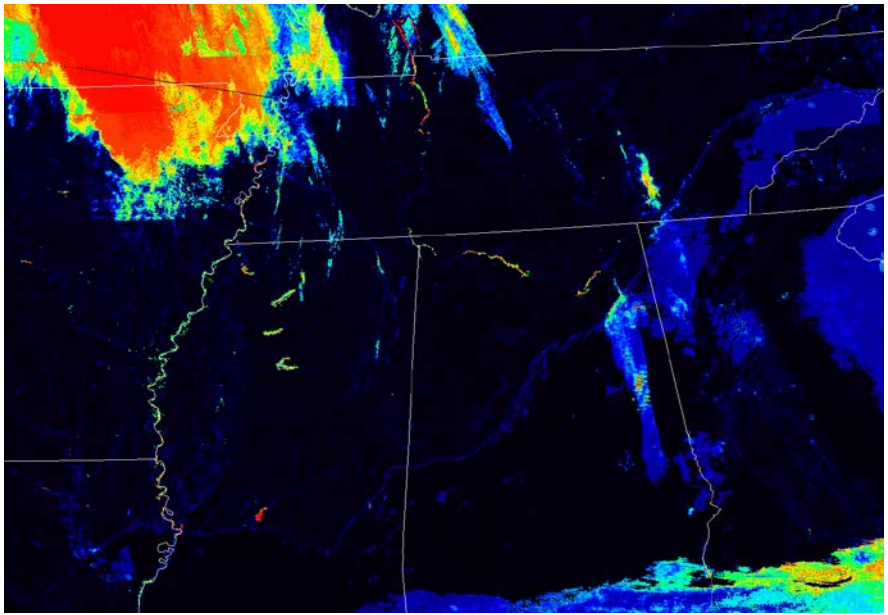


Missed Low Cloud at Night

Comparison of Cloud Probability from Local vs NDE SAPF run



Offline SAPF



NDE

They should be the same, any difference points to a problem

Expected Cause and Solution

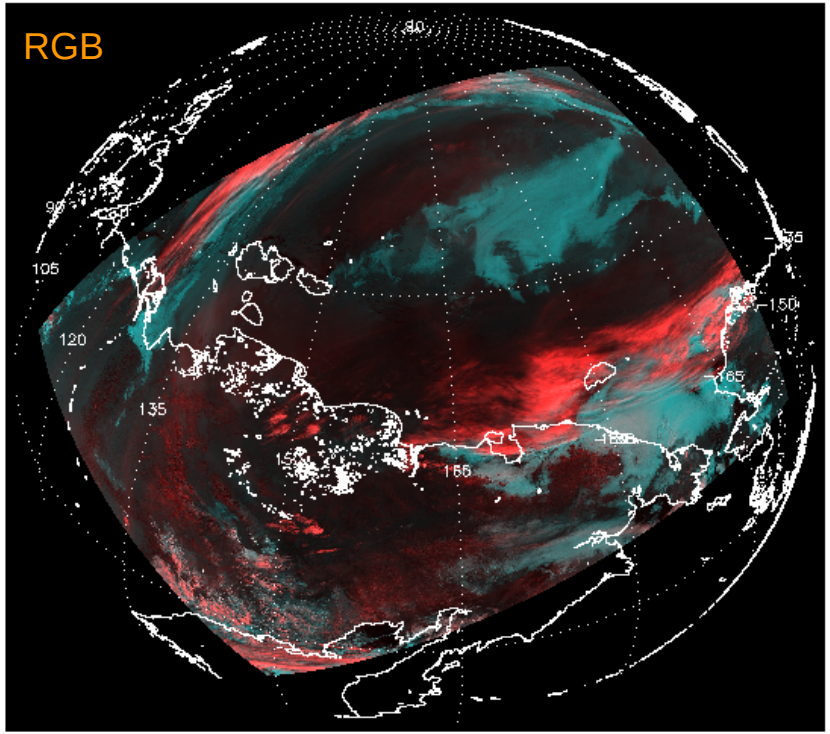
- Running the SAPF locally, using the **same** inputs (OISST, GFS) utilitizing the same SDR inputs show results more similar to CLAVR-x.

- Analysis by the Cloud Team indicates the issue is a **NDE-specific** issue and **not** issue with the SAPF processing system or of the implementation of the ECM within the SAPF.

- The Cloud Team, along with ASSISTT is verifying with NDE regarding this issue.

Missed Liquid Cloud Arctic Day

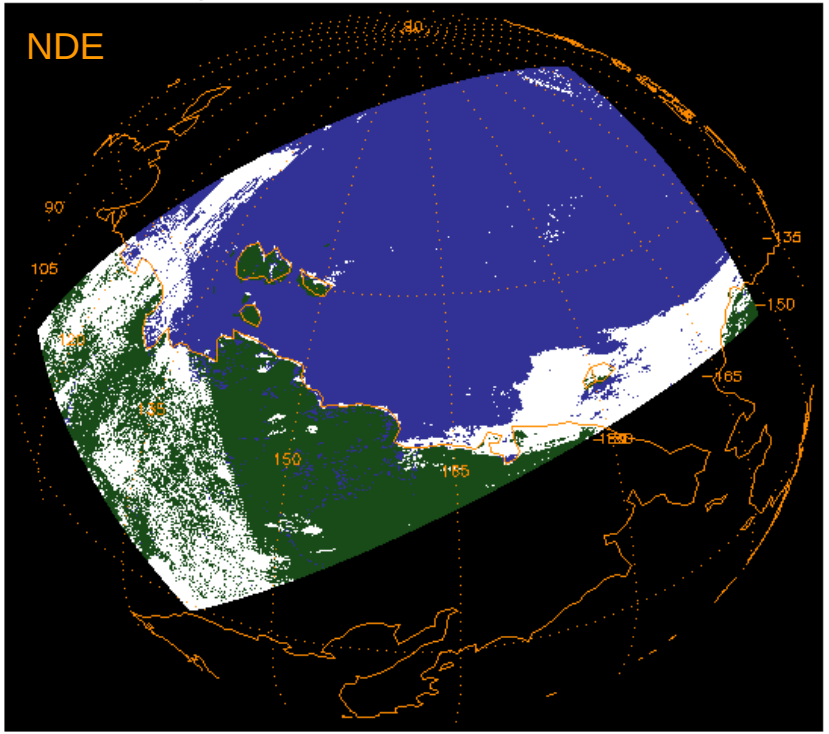
clavrx_j01_d20180408_t0045216_e0046462_b01996



False Color Image

Red=1.38μm, Green = 1.60μm, Blue = 1.60μm

clavrx_j01_d20180408_t0045216_e0046462_b01996.level2.hdf

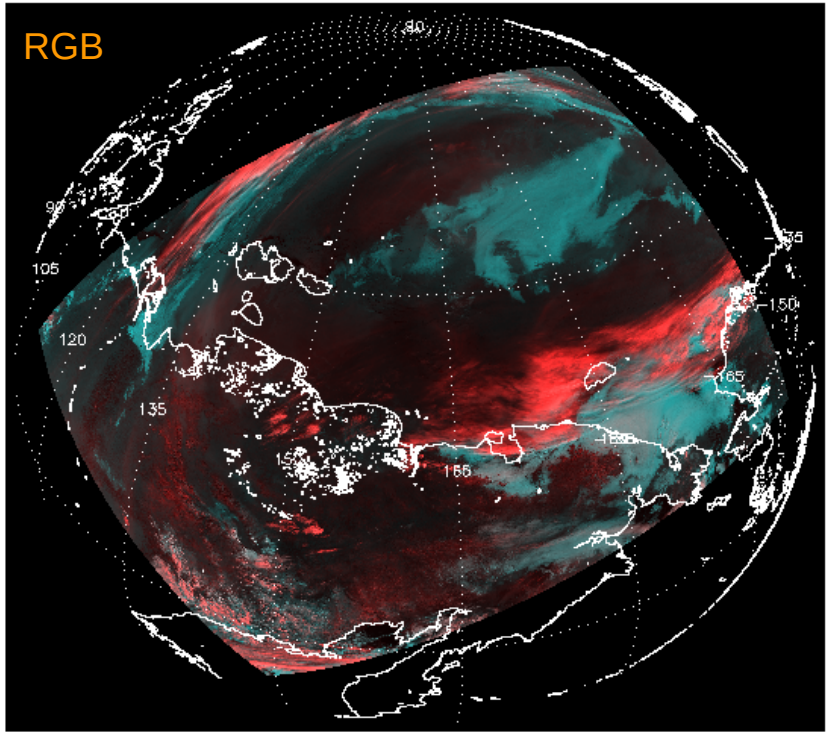


cloud_mask_aux

Clear Water	Clear Land	Cloudy	Unknown

Missed Liquid Cloud Arctic Day

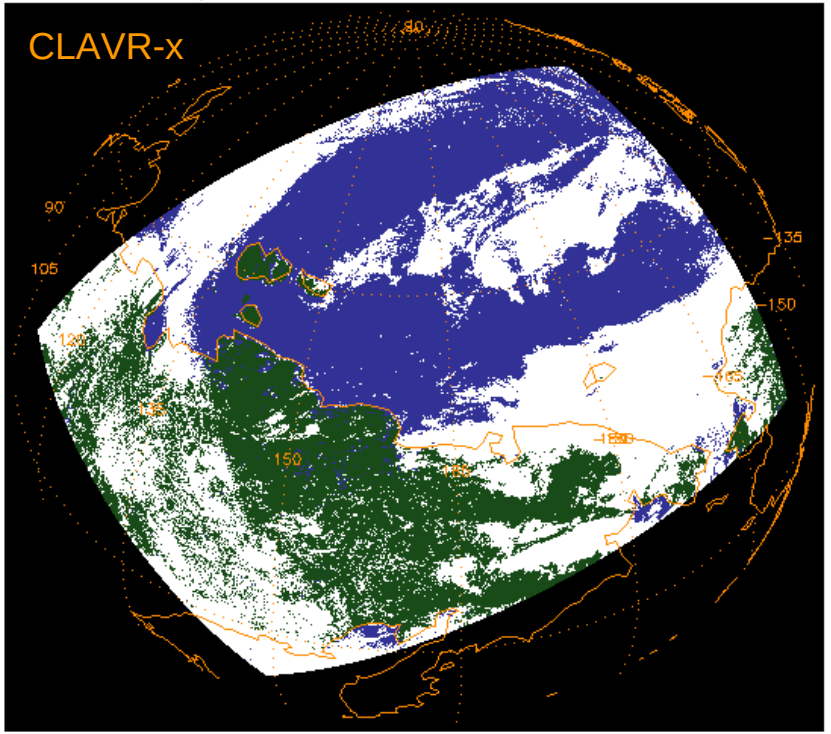
clavrx_j01_d20180408_t0045216_e0046462_b01996



False Color Image

Red=1.38μm, Green = 1.60μm, Blue = 1.60μm

clavrx_j01_d20180408_t0045216_e0046462_b01996.level2.hdf

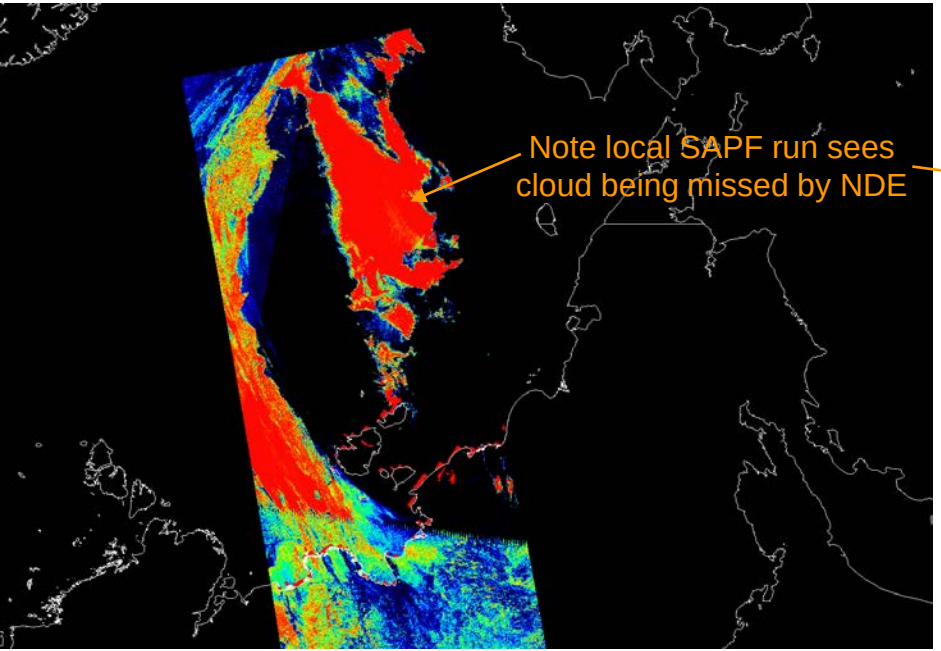


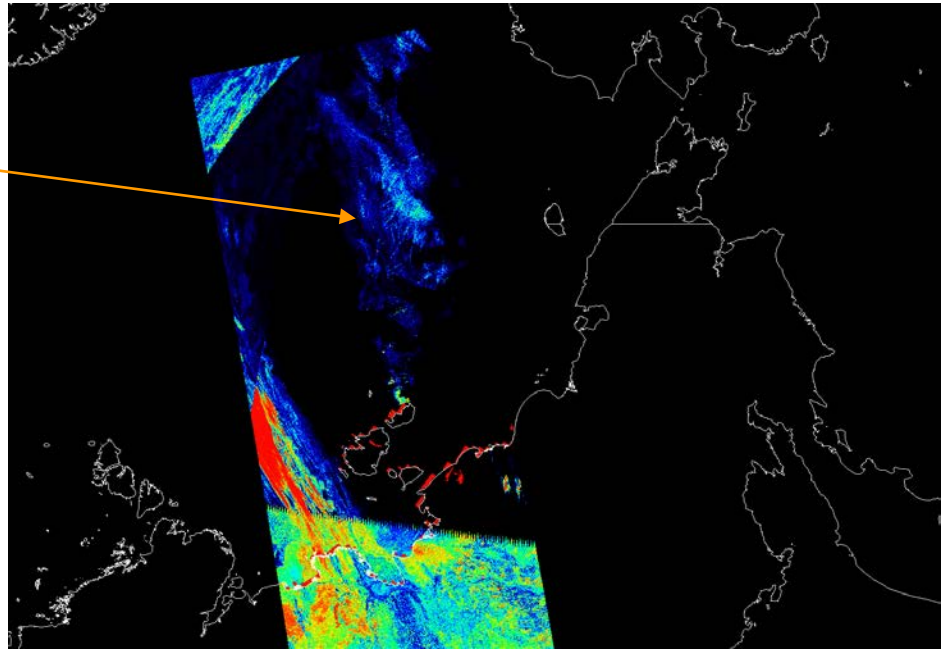
cloud_mask

Clear Water	Clear Land	Cloudy	Unknown

Missed Liquid Cloud Arctic Day

Comparison of Cloud Probability from Local vs NDE SAPF run





Offline SAPF

NDE

They should be the same, any difference points to a problem

Expected Cause and Solution

- Given that the local SAPF run, using the **same** inputs (OISST, GFS) utilitizing the same SDR inputs show results more similar to CLAVR-x.

- This analysis seems to indicate the issue is a **NDE-specific** issue and **not** an issue with the SAPF processing system or of the implementation of the ECM within the SAPF.

- The Cloud Team, along with ASSISTT is verifying with NDE regarding this issue.

Beta Maturity Conclusions

- There are serious issues with the NDE ECM v1r2 on NOAA-20.
- Based on analysis of offline runs of the SAPF, we feel most of these issues stem from NDE and **not** the ECM or SAPF, and can be fixed.
- The ECM run in CLAVR-x and in SAPF (run locally) appears not to suffer from this issues.
- **The Cloud Team recommends Beta Maturity at this time.**

Pathway to Provisional

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

Risks for Provisional

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

- **NDE processing issues (Major)**
  - Various channels not being used in NDE processing of ECM
    - Initial analysis points to NDE not utilizing all required channels for the ECM, resulting in degraded ECM performance.
    - ASSISTT and NDE are work on verifying NDE implementation
  - Missing granules in NDE processing
    - Currently being addressed in June 2018 DAP delivery. Expected operations in late 2018
  - **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.**
- **Misclassification of confidently clear to probably clear (Moderate)**
  - Initial fix of constant threshold to be applied in June 2018 DAP
  - Teams are encouraged to use the cloud probabilities rather than 4-level masks in their processing (and thereby derive their own clear/cloudy threshold)
- **NOAA-20 specific ECM LUT**
  - Training requires data from all seasons. Expected delivery by April 2019 DAP

Future Plans of ECM

- 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.
- 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