NOAA-20 VIIRS Enterprise Cloud Phase (ECP) Provisional Maturity

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VIIRS Cloud Phase Team

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Outline

- Description
- Status in NDE
- SDR Issues
- Evaluation
- Provisional Maturity Conclusions
- Path Forward to Full Validation Maturity
- Future Plans

STAR ECP Cal/Val Team

Name	Organization	Major Task
Michael Pavolonis	NESDIS/STAR	Cloud Phase PI
Corey Calvert	CIMSS	Algorithm development and validation
Jason Brunner	CIMSS	Algorithm development and validation
William Straka	CIMSS	ASSISTT integration
Shuang Qiu	OSPO	Product Area Lead

Enterprise Cloud Phase Review

How to Use the Enterprise Cloud Phase

- **The fundamental output of the ECP is the cloud phase.**

- **The cloud phase output corresponds to the following cloud phase categories**
  - **0 – Clear**
  - **1 – Liquid water phase**
  - **2 – Supercooled water phase**
  - **3 – Mixed phase**
  - **4 – Ice phase (opaque, semi-transparent, multi-layered)**
  - **5 – Unknown**

Importance: used by downstream cloud algorithms, including cloud height, which is critical for assigning the height of VIIRS polar wind vectors

ECP Channels

- **ECP uses the following channels**
  - **M14**
  - **M15**
  - **M16**

		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/MWIR	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

Enterprise Cloud Phase NDE Status

NDE/STAR VIIRS ECP 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** **Currently in I&T since 28 March, 2018**
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

SDR Issues

SDR Issues

- **No known issues.**

Evaluation of the NDE ECP

Requirement Check List – Cloud Type/Phase

JERD	Requirement	Meet Requirement (Y/N)?
JERD-2432	The algorithm shall produce a cloud phase product that has a horizontal cell size of 0.8 km	Y
JERD-2490	The algorithm shall produce a cloud phase product that has a mapping uncertainty (3 sigma) of 4 km	Y
JERD-2491	The algorithm shall produce a cloud phase product that has a measurement accuracy of:	
	60% Correct Classification (Cloud Type) &	Y
	80% correct classification (Cloud Phase)	Y

Evaluation Methodology

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

Our Specific Evaluation Methodology applied here:

1. **Validation against NASA CALIPSO/CALIOP**

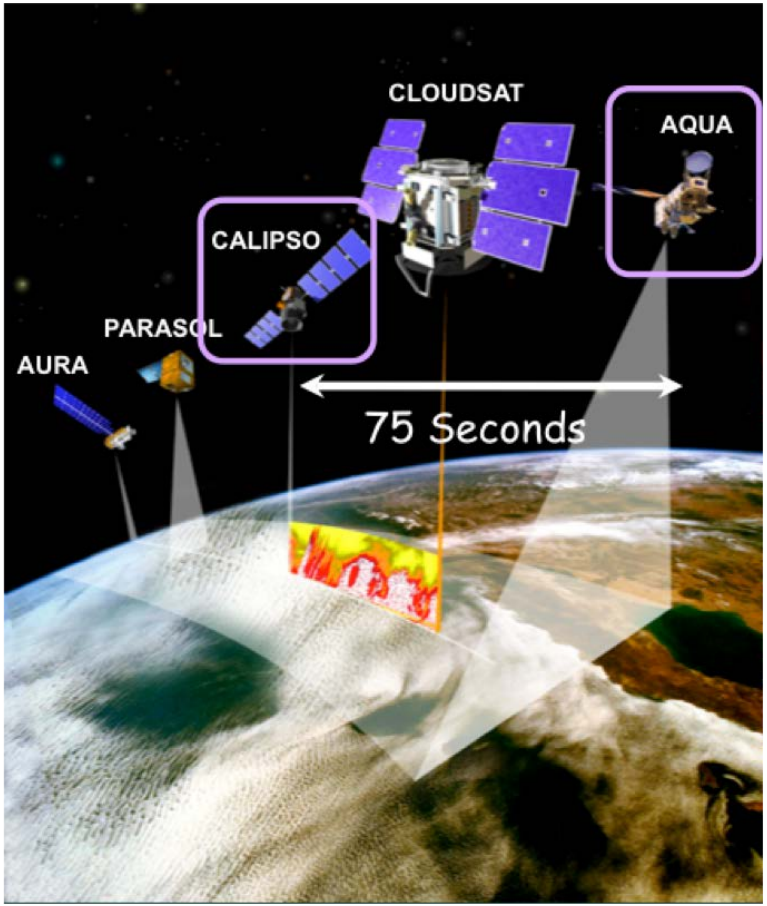
1. **Comparison NDE ECP to GOES-16 phase from the ground system**

1. **Visual S-NPP vs NOAA-20 comparisons**

Comparison to CALIPSO/CALIOP

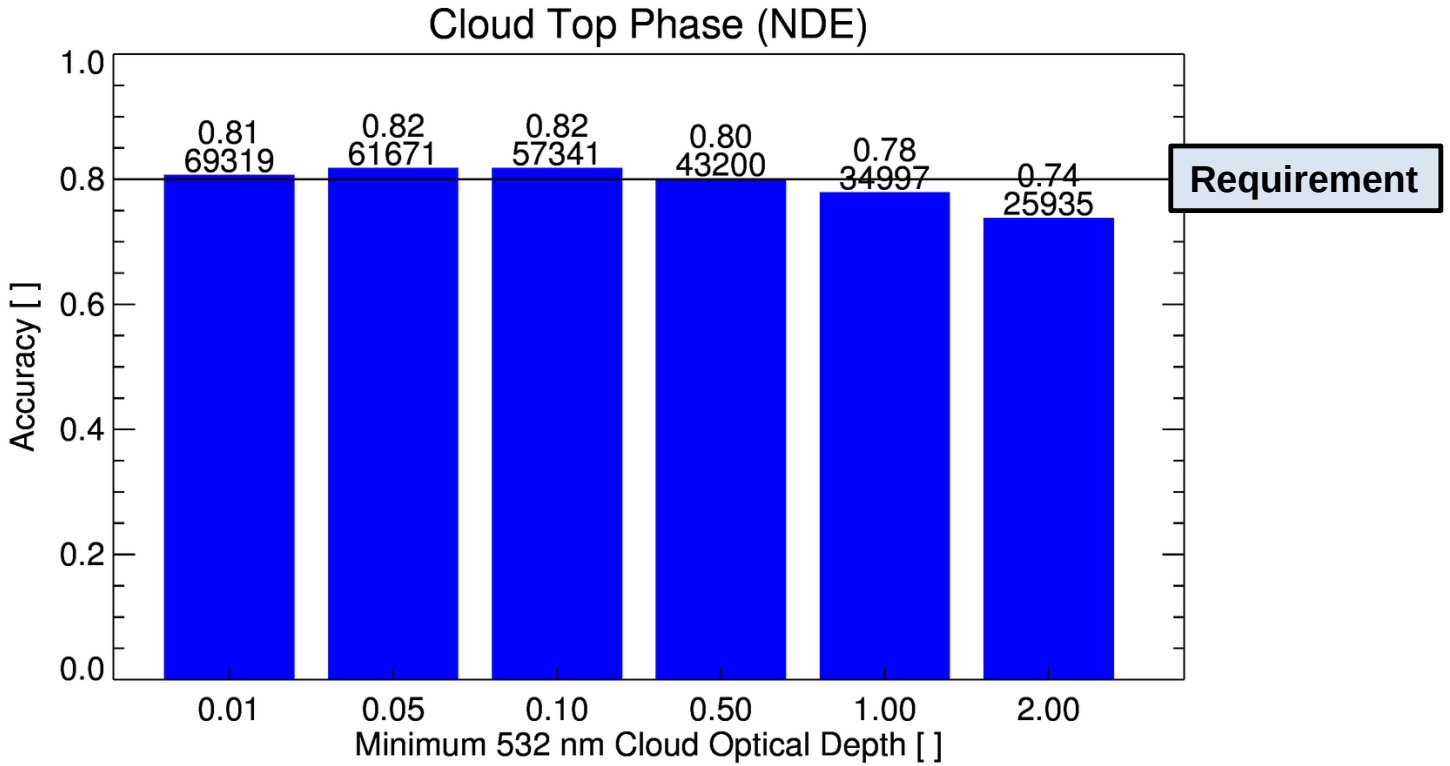
CALIPSO vs NOAA-20 Comparison Description

- CALIOP is a lidar, with depolarization, on board the CALIPSO satellite in the NASA A-Train.
- The CALIOP 1 and 5 km vertical feature mask products are merged to derive the cloud phase of the highest cloud layer with CALIOP 532 nm optical depth > 0.01
- 3 days of CALIOP and NOAA-20 Matchup data are used
- Validation analysis is a function of the CALIOP 532 nm cloud optical depth



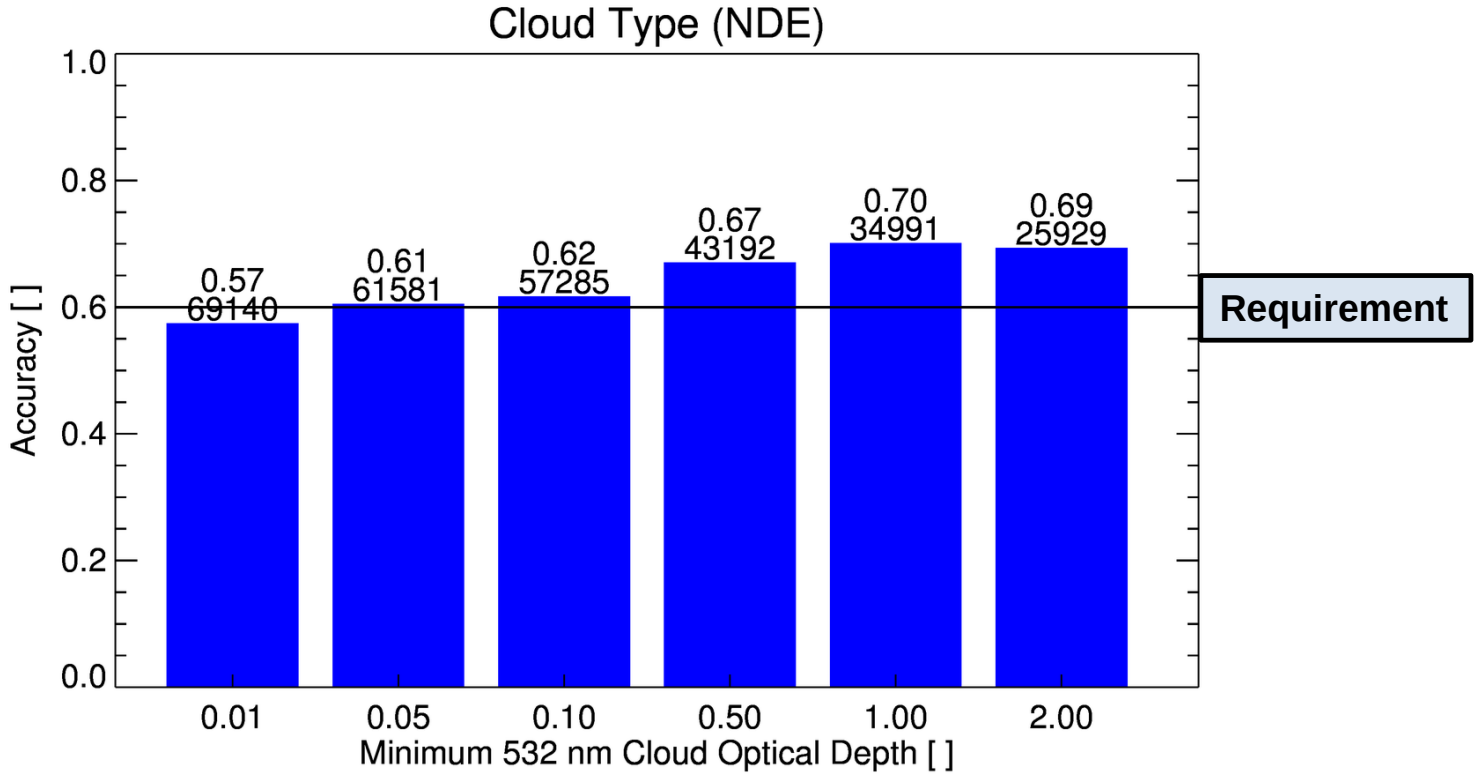
CALIPSO vs NOAA-20 Validation

Overall, the NOAA-20 cloud top phase product meets the accuracy specification. Classification of optically thick clouds mid level clouds remains a challenge.

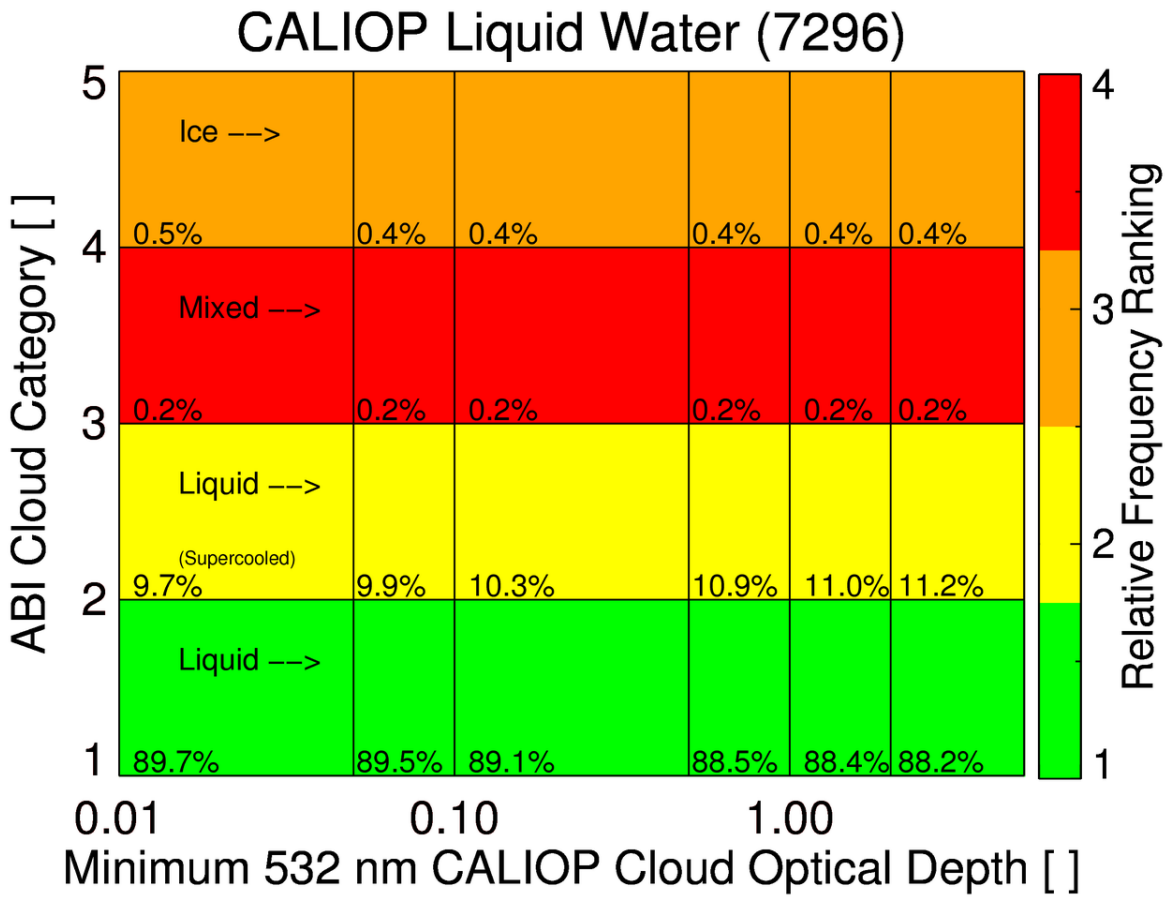


CALIPSO vs NOAA-20 Validation

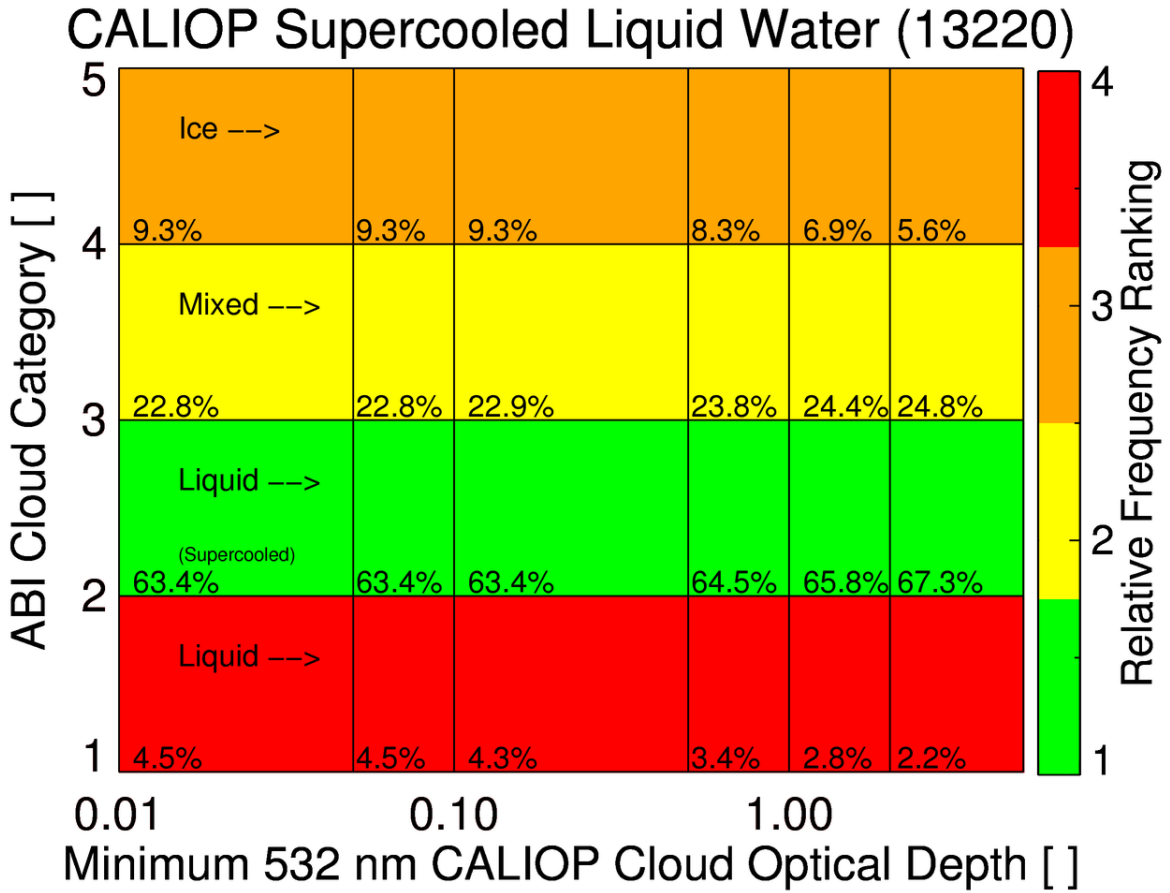
Overall, the NOAA-20 cloud type product meets the accuracy specification. Identification of very thin cirrus that overlap lower cloud layers remains a challenge.



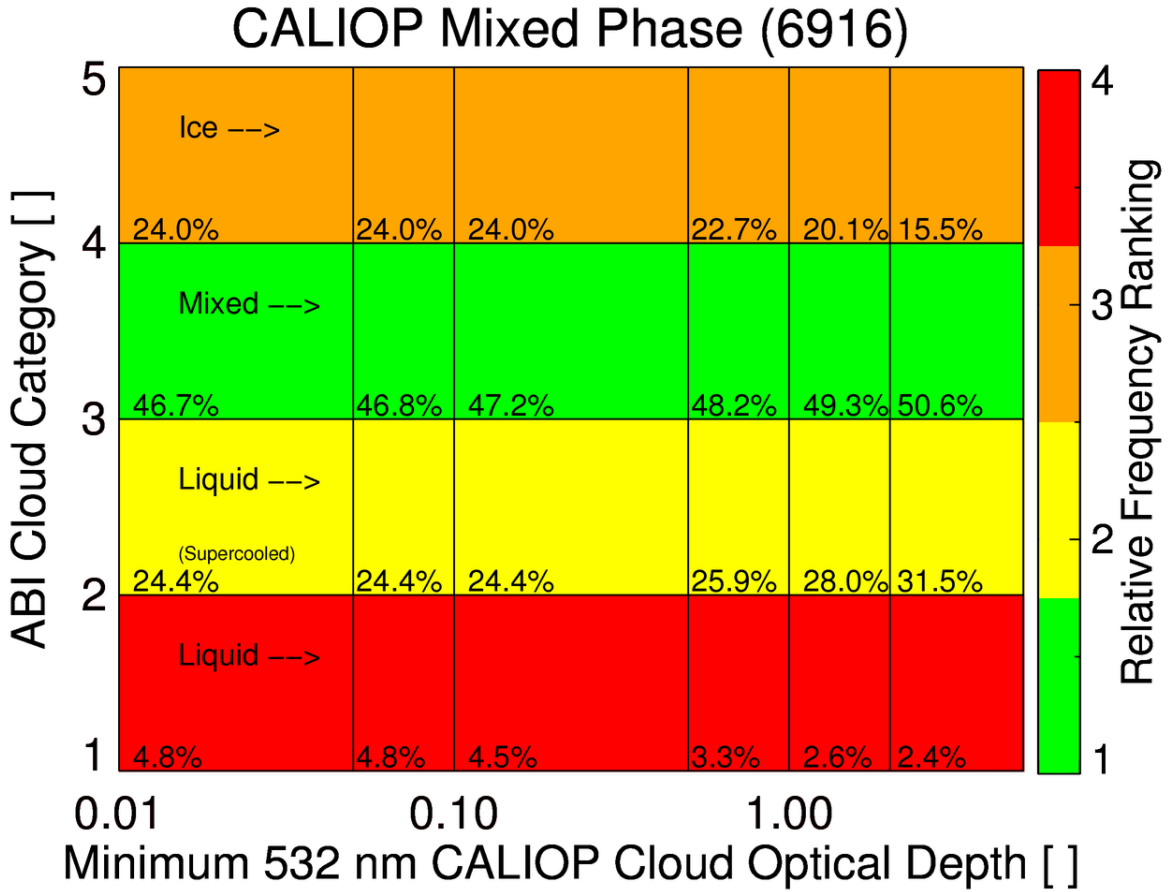
NOAA-20 Liquid Phase Validation



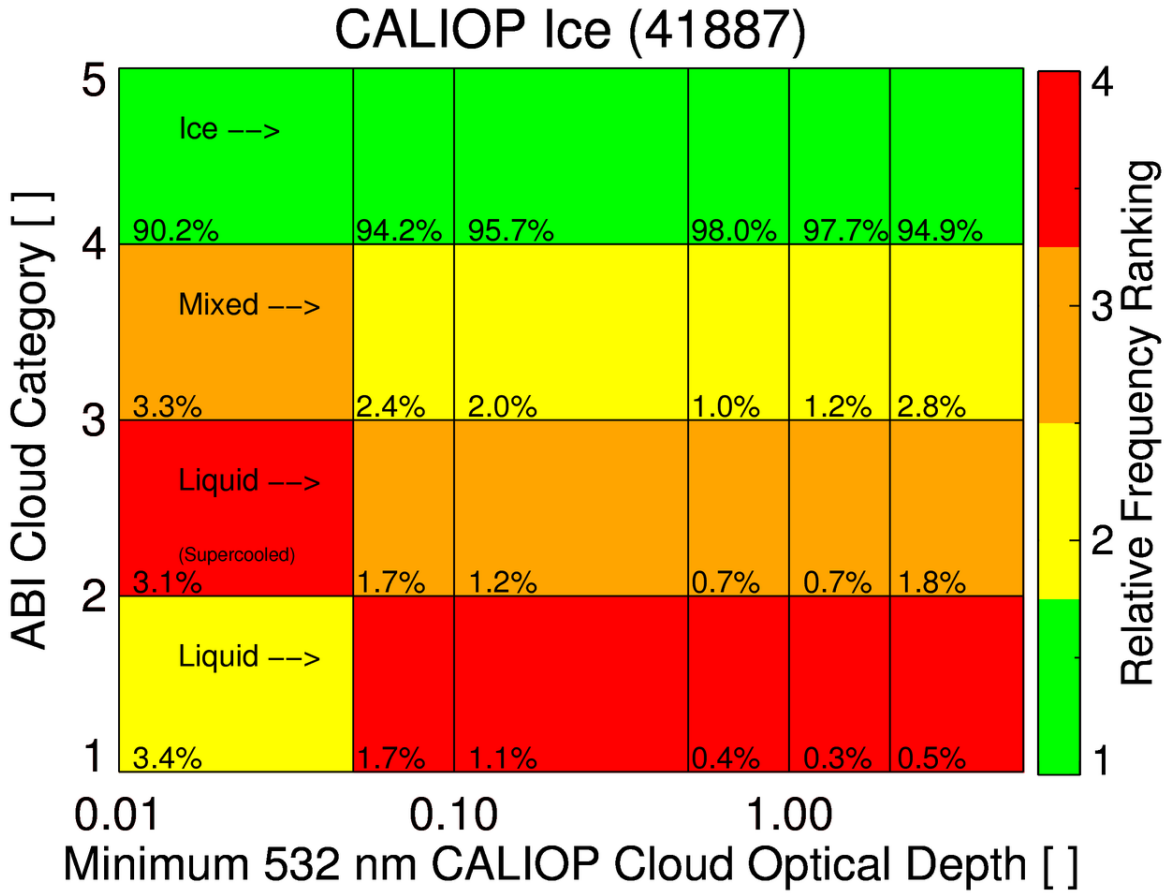
NOAA-20 Supercooled Phase Validation



NOAA-20 Mixed Phase Validation



NOAA-20 Ice Phase Validation



Comparison with GOES-16

NOAA-20 vs GOES-16 Comparison

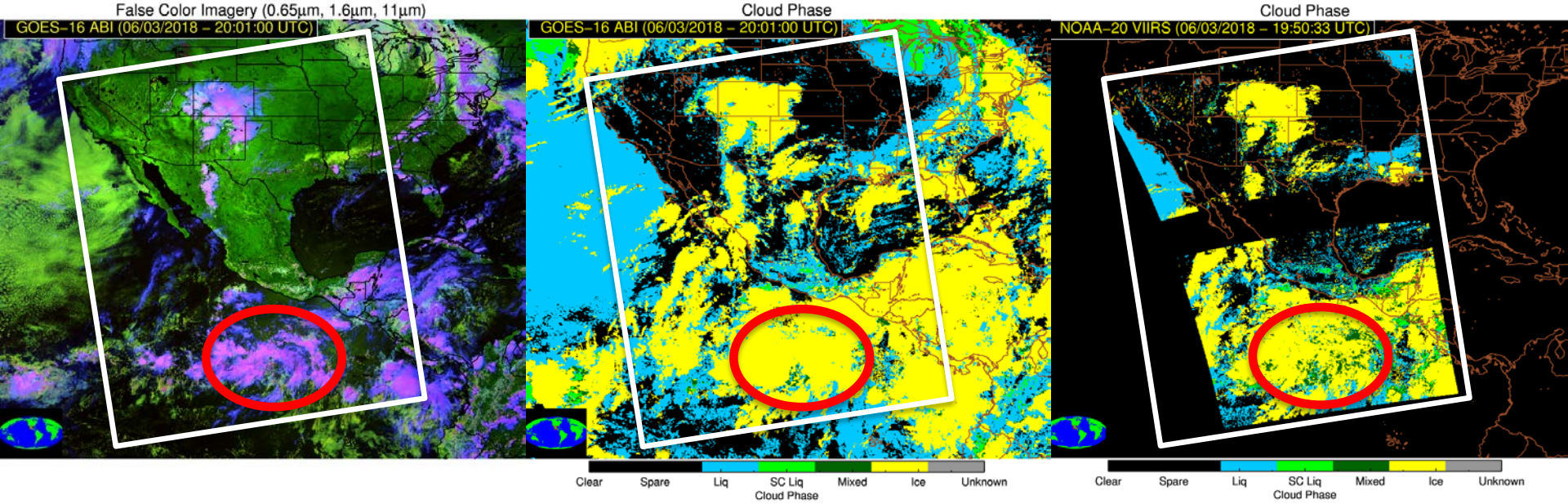
- NOAA-20 phase was co-located with GOES-16 phase for June 3, 2018.
- Co-located pixels where both NOAA-20 and GOES-16 indicated cloudy pixels and the GOES-16 viewing angle was <60 deg were used
- 152,758,528 pixels were used in this analysis

GOES-16 vs. NOAA-20 Cloud Phase Confusion Matrix				
GOES-16 Ice	8,734,491	2,031,734	5,792,521	64,076,122
GOES-16 Mixed	473,172	1,188,828	1,723,801	501,344
GOES-16 SC	1,367,316	5,152,019	843,511	291,588
GOES-16 Liquid	53,500,024	2,019,870	705,014	4,357,167
	NOAA-20 Liquid	NOAA-20 SC	NOAA-20 Mixed	NOAA-20 Ice

NOAA-20 vs GOES-16 Comparison

- **Red circle highlights area where NOAA-20 phase returns a higher number of mixed phase pixels where GOES-16 phase indicates ice phase**

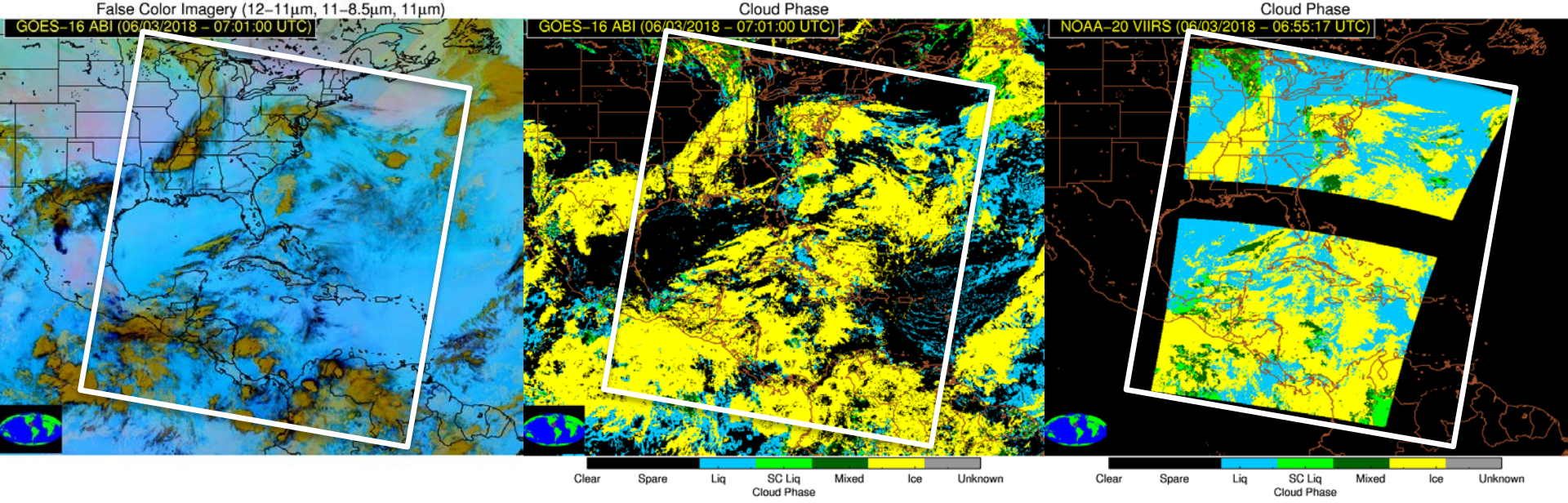
- **This specific difference in phase classification between GOES-16 and NOAA-20 shows up in the confusion matrix and appears to occur most often near cloud edges**



NOAA-20 vs GOES-16 Comparison

- The lack of 'clear' pixels in the NOAA-20 cloud phase was the result of a threshold issue in the ECM when determining the 4-level cloud mask (this issue has since been resolved)

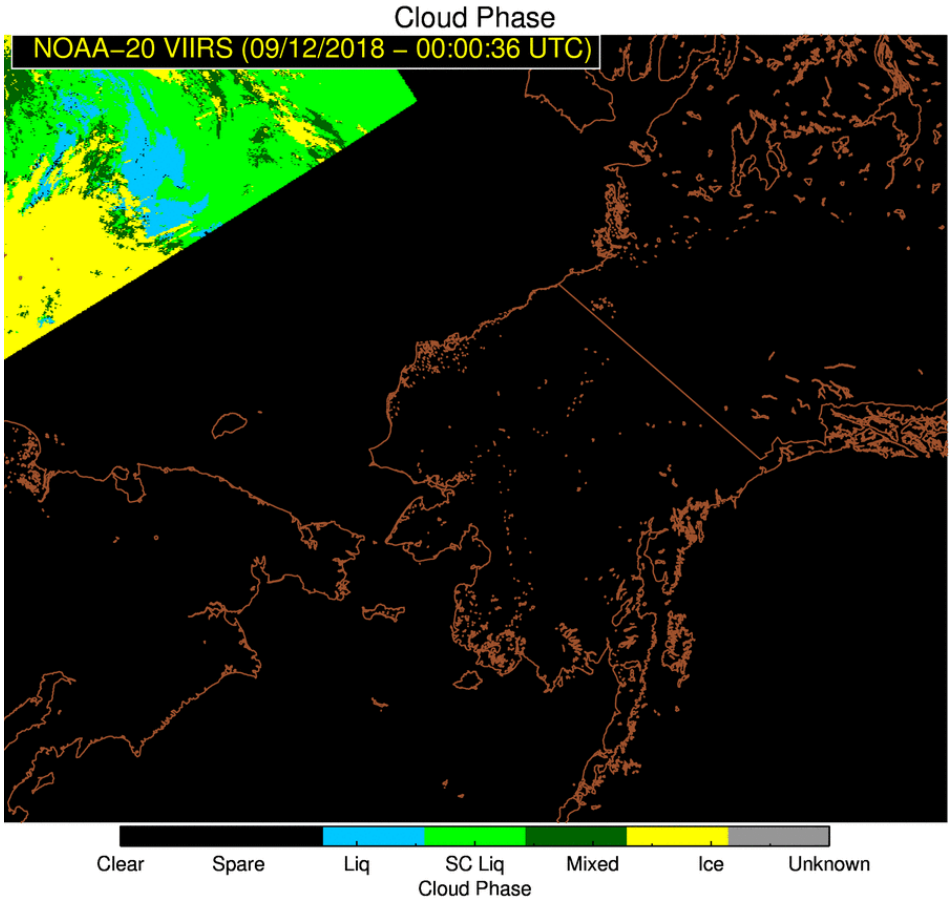
- The ECM team recommends a threshold-based approach using the cloud mask probability product over the 4-level cloud mask
  - The ECP algorithm should be updated to utilize the ECM as recommended



S-NPP and NOAA-20 Continuity

S-NPP and NOAA-20 Continuity

- **Animation composed of sequential cloud phase images from NOAA-20 and S-NPP for September 12, 2018**
- **There are still a large number of NOAA-20 granule outages**
- **Other than the granule outages there do not appear to be any major artifacts between the two phase products**



Investigation of Downstream Issues

Investigation of Downstream Issues

- The overall Enterprise Cloud Phase Algorithm works well

- However, when the cloud phase is wrong, it has a large impact on the cloud height retrieval.

- There are 2 potential issues the phase team may want to track
  1. Ice cloud phase on the edges of water cloud
  2. Determination of ice phase when NIR imagery indicates otherwise

- Previously published research has shown that these issues can be mostly mitigated by incorporating near-infrared measurements. The use of near-infrared measurements is complicated by highly variable surface reflectance and sun geometry. Thus, the mitigation strategy adds complexity to the algorithm.

Provisional Maturity Conclusions

- **Comparisons to CALOP indicate that the NOAA-20 cloud phase and type products meet the accuracy specifications**

- **The performance of the NOAA-20 cloud phase and type products is consistent with the S-NPP and GOES-16 products**

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

Pathway to Full Validation

- The CALIOP analysis will be extended to encompass much more of the seasonal cycle
- NOAA-20 vs. S-NPP consistency will continued to be assessed
- NOAA-20 specific threshold tuning may improve performance

Risks for Full Validation

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

- **NDE processing issues (Moderate)**
  - **Missing granules in NDE processing**
    - **Addressed in August 2018 delivery (v2r0)**
    - **Fix currently running in I&T string (as of 28 Sept 2019). Expected operations in late 2018**

- **Situational performance issues (Low)**
  - **As with S-NPP, these issues do not pose a risk to achieving full validation.**

Future Plans of ECP

- Update the use of the 4-level cloud mask to a threshold-based cloud mask using the cloud probabilities

- Incorporating near-IR channels should improve product performance and largely mitigate the situational performance issues noted. Near-IR channels are being incorporated into the enterprise and baseline algorithms for GOES-R, so leveraging of those efforts for VIIRS is possible.

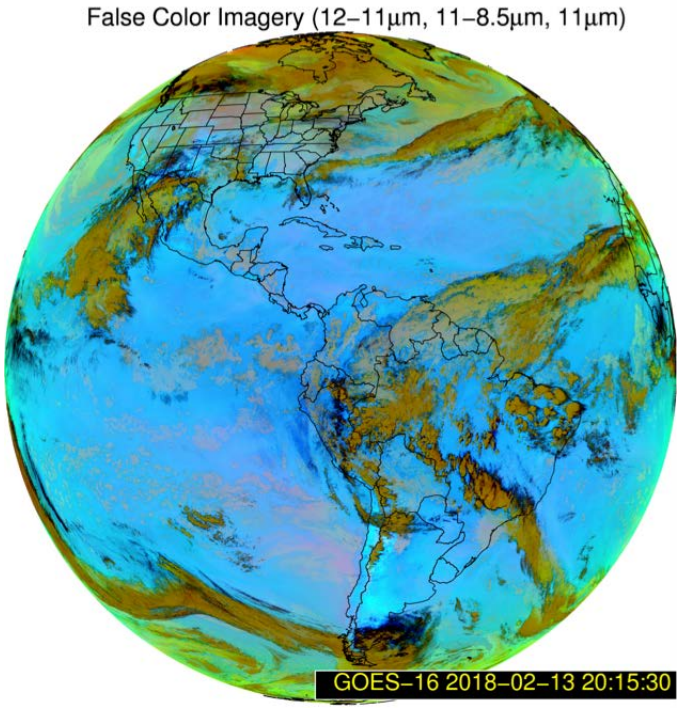
Backup Material

Enterprise Cloud Phase

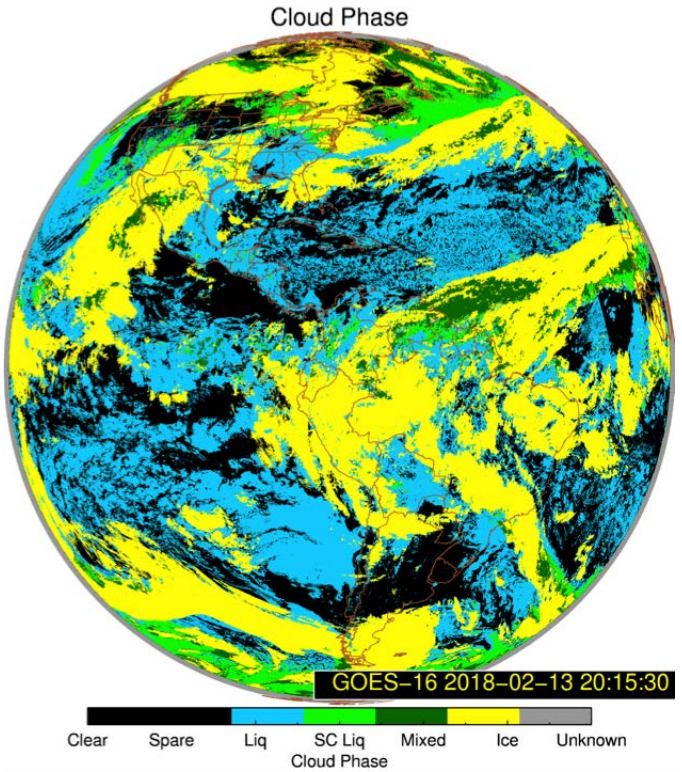
- Supports many sensors and its part of the NOAA Enterprise Algorithm Suite.
- It uses NASA CALIPSO data for its training.
- The primary output is the cloud phase (integer values 0 – 5).
- Enterprise phase is determined using multiple threshold-based radiometric tests.
- The demand for one algorithm to serve many sensors drove the ECM development.

ECP Heritage

- **ECP has run for years on GOES in OSPO and other sensors in STAR.**



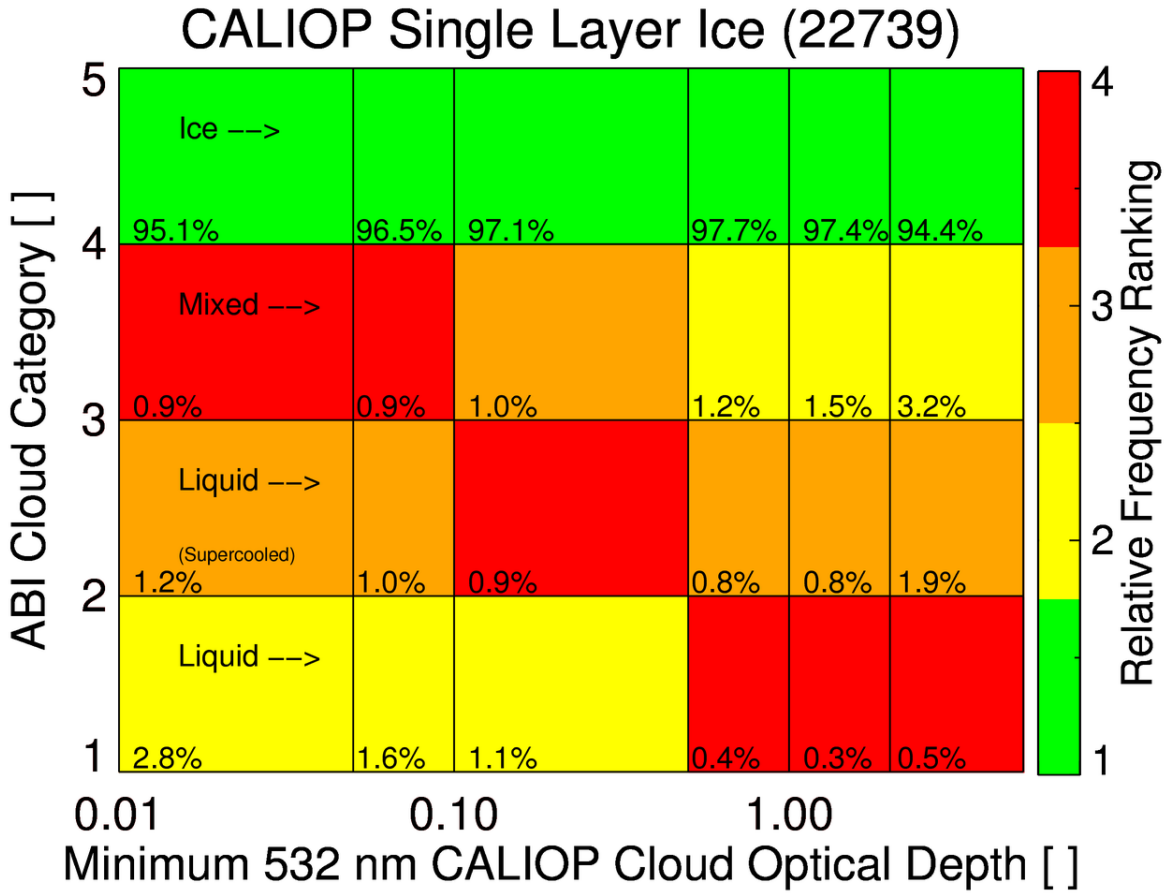
- **Here is an example of the NOAA Enterprise Cloud Phase applied to GOES-16.**



Data Used in this Analysis

- NOAA-20 NDE v1r2 from June 3 and September 12, 2018 for GOES-16 and S-NPP Comparisons.
- GOES-16 ground system output from June 3, 2018.
- S-NPP NDE v1r2 from September 12, 2018.
- 3 days for CALIPSO Comparison: June 19, July 5 and Sept. 4, 2018.

NOAA-20 Single Layer Ice Phase Validation



NOAA-20 Multi-Layer Ice Phase Validation