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

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VIIRS Cloud Phase Team
Michael Pavolonis (STAR), Corey Calvert (CIMSS),
Jason Brunner (CIMSS)
Outline

• Description
• Status in NDE
• SDR Issues
• Evaluation
• Provisional Maturity Conclusions
• Path Forward to Full Validation Maturity
• Future Plans
# STAR ECP Cal/Val Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Major Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Pavolonis</td>
<td>NESDIS/STAR</td>
<td>Cloud Phase PI</td>
</tr>
<tr>
<td>Corey Calvert</td>
<td>CIMSS</td>
<td>Algorithm development and validation</td>
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<tr>
<td>Jason Brunner</td>
<td>CIMSS</td>
<td>Algorithm development and validation</td>
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<tr>
<td>William Straka</td>
<td>CIMSS</td>
<td>ASSISTT integration</td>
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<tr>
<td>Shuang Qiu</td>
<td>OSPO</td>
<td>Product Area Lead</td>
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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
Enterprise Cloud Phase NDE Status
<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Suomi NPP</th>
<th>NOAA-20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>February 2018 DAP</strong></td>
<td>NDE Currently in Operations since 1200 UTC on 13 August 2018</td>
<td>NDE Currently in I&amp;T since 28 March, 2018</td>
</tr>
<tr>
<td>w/o April patch (missing granules)</td>
<td>August 2017 Science Code delivery (v1r2)</td>
<td></td>
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<tr>
<td><strong>August 2018 DAP</strong></td>
<td>STAR Systematic production since June, 2018</td>
<td>STAR Systematic production since June, 2018</td>
</tr>
<tr>
<td>February 2018 Science Code delivery (v2r0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jan/Feb 2019 DAP</strong></td>
<td>Delivery and development in progress</td>
<td>Delivery and development in progress</td>
</tr>
<tr>
<td>August 2018 Science Code delivery (v2r1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery schedule provided by ASSISTT</td>
<td>Delivery schedule provided by ASSISTT</td>
</tr>
</tbody>
</table>
SDR Issues

• No known issues.
Evaluation of the NDE ECP
## Requirement Check List – Cloud Type/Phase

<table>
<thead>
<tr>
<th>JERD</th>
<th>Requirement</th>
<th>Meet Requirement (Y/N)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>JERD-2432</td>
<td>The algorithm shall produce a cloud phase product that has a horizontal cell size of 0.8 km</td>
<td>Y</td>
</tr>
<tr>
<td>JERD-2490</td>
<td>The algorithm shall produce a cloud phase product that has a mapping uncertainty (3 sigma) of 4 km</td>
<td>Y</td>
</tr>
<tr>
<td>JERD-2491</td>
<td>The algorithm shall produce a cloud phase product that has a measurement accuracy of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60% Correct Classification (Cloud Type) &amp;</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>80% correct classification (Cloud Phase)</td>
<td>Y</td>
</tr>
</tbody>
</table>
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
2. Comparison NDE ECP to GOES-16 phase from the ground system
3. 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
Overall, the NOAA-20 cloud top phase product meets the accuracy specification. Classification of optically thick clouds mid level clouds remains a challenge.
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

CALIOP Liquid Water (7296)

- Ice
  - 0.5%

- Mixed
  - 0.4%

- Liquid
  - 9.7%
  - (Supercooled)
    - 9.9%
    - 10.3%
    - 10.9%
  - Liquid
    - 89.7%
    - 89.5%
    - 89.1%
  - 88.5%
  - 88.4%
  - 88.2%

Relative Frequency Ranking

Minimum 532 nm CALIOP Cloud Optical Depth [ ]

0.01  0.10  1.00
NOAA-20 Mixed Phase Validation

CALIOP Mixed Phase (6916)

Ice --->
24.0% 24.0% 24.0% 22.7% 20.1% 15.5%

Mixed --->
46.7% 46.8% 47.2% 48.2% 49.3% 50.6%

Liquid --->
24.4% 24.4% 24.4% 25.9% 28.0% 31.5%

(Supercooled)

Liquid --->
4.8% 4.8% 4.5% 3.3% 2.6% 2.4%

Minimum 532 nm CALIOP Cloud Optical Depth [ ]

Relative Frequency Ranking
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**

<table>
<thead>
<tr>
<th></th>
<th>GOES-16 Ice</th>
<th>GOES-16 Mixed</th>
<th>GOES-16 SC</th>
<th>GOES-16 Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOES-16 Ice</td>
<td>8,734,491</td>
<td>2,031,734</td>
<td>5,792,521</td>
<td>64,076,122</td>
</tr>
<tr>
<td>GOES-16 Mixed</td>
<td>473,172</td>
<td>1,188,828</td>
<td>1,723,801</td>
<td>501,344</td>
</tr>
<tr>
<td>GOES-16 SC</td>
<td>1,367,316</td>
<td>5,152,019</td>
<td>843,511</td>
<td>291,588</td>
</tr>
<tr>
<td>GOES-16 Liquid</td>
<td>53,500,024</td>
<td>2,019,870</td>
<td>705,014</td>
<td>4,357,167</td>
</tr>
<tr>
<td>NOAA-20 Liquid</td>
<td></td>
<td></td>
<td></td>
<td></td>
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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
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.
• 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.
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.