MEMORANDUM FOR: The JPSS Program Record
SUBMITTED BY: JPSS VIIRS Nighttime Cloud Optical Properties (NCOMP) Team:
Patrick Minnis (NASA LaRC/SSAI),
Patrick Heck (CIMSS), Christopher Yost (SSAI),
William Straka (CIMSS/ASSISTT),
Andrew Heidinger (NOAA, Cloud Team Lead),
CONCURRED BY: JPSS Algorithm Management Project Lead Arron Layns
JPSS STAR Program Manager Lihang Zhou
APPROVED BY: JPSS Program Scientist Mitch Goldberg

SUBJECT: NOAA-20 VIIRS NCOMP validated maturity status
DATE: 05/16/2019

Validated maturity status declaration for NOAA-20 VIIRS Enterprise Nighttime Cloud Optical Properties
Maturity Review Date: 05/16/2019
Effective Date: 05/16/2019
Operational System: NDE, Version 2.0

The JPSS Algorithm Maturity Readiness Review Board approved the NOAA Enterprise Nighttime Cloud Optical Properties at validated maturity level quality as of 05/16/2019 (effective date), based on JPSS Validation Maturity Review held on 05/16/2019.

1. Validated Maturity stage definition

The Definition of Validated maturity stage is available at the JPSS Algorithm Maturity Matrix webpage: https://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

2. Algorithm Description:

The NDE VIIRS Enterprise Nighttime Cloud Optical Properties products contain Cloud Optical Depth (COD) and Cloud Particle Size (CPS). COD is an estimation of the optical depth from VIIRS assuming that the observation is a single-layer cloud. Similarly, CPS assumes a single layer. The Nighttime Cloud Optical Properties (NCOMP) algorithm utilizes an iterative minimum error scheme that utilizes measured and modeled top of atmosphere temperatures from three VIIRS channels. The algorithm is a variation of the Shortwave-infrared Infrared Split-window Technique (SIST) of Minnis et al 1998, 2009) that was developed for various applciations, including application to MODIS data as part of the Clouds and the Earth's Radian Energy System (CERES) program. The algorithm includes utlizes cloud emittance parameterizations when modeling TOA temperatues and evaluating potential solutions. Unlike SIST, NCOMP's cloud phase and temperature are determined by upstream NDE VIIRS algoirithsm, Cloud Phase/Type and Cloud Top Temperature, respectively. The NCOMP algorithm processes all nighttime VIIRS pixels which are detected as cloudy from the cloud mask algorithm and have valid Cloud Top Phase and Temperature. Additionally, NCOMP processes pixels with solar zenith angles between 82º and 90º, but product specifications in those portions of twilight have not been evaluated nor are they required to be met. Note that non-NDE products Liquid Water Path and Ice Water Path that are derived directly from COD and CPS are also included in the products. Specific details on the output are documented below. An extensive description of the NCOMP algorithm and products may be found in the NCOMP ATBD (https://www.star.nesdis.noaa.gov/jpss/Docs.php).

Product requirements for the NCOMP are documented in the Joint Polar Satellite System (JPSS) Level 1 Requirements Document Supplement and are available at at http://www.jpss.noaa.gov/assets/pdfs/technical_documents/level_1_requirements_supplement.pdf. This information is also provided in the JPSS NESDIS Environmental Satellite Processing Center (ESPC) Requirements Document (JERD) Volume 2 (https://www.star.nesdis.noaa.gov/jpss/documents/Requirements/JERDV2_JPSS-REQ-1004_Version2.0.pdf).

Measurement Accuracy for COD JERD 2477	30% (where 1< COD < 5)
Measurement Accuracy for CPS (water cloud) JERD 2477	4µm or 30% (where 1< COD < 5 and 2µm < CPS < 32µm)
Measurement Accuracy for CPS (ice cloud) JERD 2477	10µm (where 1< COD < 5 and 2µm < CPS < 50µm)

Measurement Precision for COD JERD 2476	0.8 or 30% (where 1< COD < 5)
Measurement Precision for CPS (water cloud) JERD 2476	4µm or 25% (where 1< COD < 5 and 2µm < CPS < 32µm)
Measurement Precision for CPS (ice cloud) JERD 2476	10µm or 25% (where 1< COD < 5 and 2µm < CPS < 50µm)

The key product outputs in the NCOMP are:

- Cloud Optical Depth
- Cloud Particle Size

Quality flags

The current data quality flags are placed in "QualityFlag". The details are illustrated in Tables 1.

Table 1. Nighttime Cloud Optical Properties quality flags

Flag Value	Description
0	Succesful retrieval
1	Viewing Zenigh Angle ≥ 65.0º
2	Solar Zenigh Angle < 82º
3	Cloud Type indicates it is not a cloud
4	Cloud Type has an unknown value
5	Cloud Temperature is < 0.0 ©
6	No retrieval: Minimum error model for water = 0
7	No retrieval: Minimum error model for ice = 0

Product evaluation/validation

- Monitoring global gridded comparisons of COD and CPS between S-NPP and NOAA-20 in February 2019.
- Visual comparisons individual granules were conducted with the NOAA-20 NCOMP products generated outside of NDE at NASA LaRC using SIST.
- COD was compared with CALIOP lidar products for 40 days in the fall/winter of 2018.
- IWP was compared to CALIOP lidar products for the same 40 days, providing an indirect verification that CPS and COD are reasonable for ice clouds.

- Similarly, LWP was compared to AMSR2 products for 40 days, providing an indirect verification that CPS and COD are reasonable for water clouds.
- The current NCOMP products for NOAA-20 (v2r0) meets the JERD spec when COD is within the specification range.

Product availability/reliability

- NOAA-20 Enterprise Nighttime Cloud Optical Properties EDR data (v2r0) were produced on the NDE Integration and Testing (I&T) string since March 2019
- Missing data stream occurred in the NDE processing during the scheduled maintenance
- Unrealistic Cloud Temperature or Type can impact NCOMP performance, as can innacuracies in NWP input.

Algorithm performance dependence

The performance of the VIIRS NCOMP products depend on the performance of the VIIRS Cloud Top Temperature and Cloud Type/Phase algorithms, as well as the cloud mask product. Issues noted in the Cloud Mask Validated Maturity Readme file will affect ACHA and thus NCOMP. Uncertainties of those upstream retrievals for multi-layered clouds are also inherited into NCOMP products.

Known errors/issues/limitations

- Any issue on NDE (e.g. missing granules) will negatively impact NCOMP. This is only for data marked with the v1r2 file name label.
- Errors in the upstream CTH (ACHA) and Cloud Phase retrievals directly affect the NCOMP product quality.
- The NCOMP is optimal for single layer clouds and may not be ‘ceiling’ for multi-layered cloudy scenes.

3. Changes since last maturity stage

This is the validated maturity declaration of the NOAA-20 NDE VIIRS Enterprise NCOMP product.

4. Review board recommendations

N/A

5. Path Forward/Future Plan

- Focus on specific scenarios for which the products are not performing well
- Continue to validate the product over an extended period
- Evaluate improvements in cloud emittance parameterizations.
- Implement improved IWP formulation.

- Evaluate performance of a neural net technique to expand retrieval range for ice cloud optical depth
- Support the JPSS EDR Long Term Monitoring (https://www.star.nesdis.noaa.gov/jpss/EDRs/index.php)
- Further improvement for nighttime and multi-layer clouds

6. Additional Items to note

The cloud team welcomes any feedback on user issues and suggestions on the evolution of NCOMP.

Point of Contact:

Name: Patrick Heck
Email: pwheck@ssec.wisc.edu
Phone: 608-262-7889