MEMORANDUM FOR:	The JPSS Program Record
SUBMITTED BY:	JPSS Cloud Team Lead, Andrew Heidinger
CONCURRED BY:	JPSS Algorithm Management Project Lead Arron Layns
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APPROVED BY:	JPSS Program Scientist Mitch Goldberg

SUBJECT:	NOAA-20 Product Beta maturity status
DATE:	April 18, 2018

Beta maturity status declaration for NOAA-20 Enterprise Cloud Mask (ECM)

Maturity Review Date:	**04/18/2018**
Effective Date:	**04/18/2018**
Operational System:	**NDE, Version v1r2**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the NOAA Enterprise Cloud Mask to the public with a Beta maturity level quality as of 04/18/2018 (effective date), based on JPSS Validation Maturity Review held on 04/18/2018 (link to review artifacts).

1. Definition of Beta:
     - Product is minimally validated, and may contain significant identified and unidentified errors.
     - Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
     - Documentation of product performance and identified product performance anomalies, including recommended strategies, exists.
2. Algorithm Description:
     The Enterprise Cloud Mask (ECM) product is a single product containing the results of the ECM and numerous details of the individual components that are used to determine the result. Fundamentally the ECM uses naïve Bayesian logic to determine the probability a given pixel contains a cloud. The output is a decimal fraction between 0.0 and 1.0, where 1.0 indicates 100% certainty the pixel contains a cloud. These numbers are also used to derive the 4-category output preferred by many users (e.g. confidently cloudy, probably cloudy, probably clear, confidently clear). It is recommended users apply the available probability to derive their own definition of what pixels are considered cloudy, given this often varies depending on use. Specific details on the output are below. An extensive description of the ECM may be found in the ECM ATBD (**A Naïve Bayesian Cloud Mask Delivered to NOAA Enterprise**).
     The Collection Short Name for the ECM from N20 is:
     JRR-CloudMask_j01_sYYYYMMDDSSSSSSS_eYYYYMMDDSSSSSSS_cYYYYMMDDSSSSSS
     where YYYY is the year in 4 digits, MM the month, DD the day, and SS the seconds down to the sixth or seventh significant digit depending on whether the reference is to the start

time of the granule (s), the end time of the granule (e), or the time it was created (c).

Product requirements for the ECM are now specified in the JPSS National Environmental Satellite, Data, and Information Service (NESDIS) Environmental Satellite Processing Center (ESPC) Requirements Document (JERD) Volume 2: Science Requirements. These requirements are:

Applicable Conditions:
1. Requirements apply whenever detectable clouds are present.
2. Cloud Mask shall be computed and reported for the total cloud cover.

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.

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, and
70% Antarctica and Greenland, Night.

Notes:
1. Attribute (a) (Horizontal Cell Size) shows the Cloud Map HCS as 0.8 km which is approximately the VIIRS M band Nadir pixel size.
2. Cloud Optical Thickness (COT) is defined as the extinction (scattering plus absorption) per unit length, integrated over each and every distinguishable cloud layer in a vertical column and all distinguishable cloud layers in aggregate, in a vertical column of the atmosphere.

The key product outputs in the ECM are:
● cloud probability

- 4-level cloud mask
- individual cloud classifier results expressed as a 4-level mask
- diagnostic bits
- non-cloud detection test output (smoke, dust, fire, glint)
- thin cirrus flag
- cloud adjacency flag

Quality Flags are placed in the "CloudMaskPacked" aspect of the Netcdf output and are detailed below.

Table 1: *Cloud mask tests and flags and their descriptions.*

Byte	Bit	Flag Description Key	Result
0	0	Cloud Mask Attempted Flag	1 = Yes 0 = No
	1	Daytime Visible Tests Attempted	1 = Yes 0 = No
	2	Daytime Spatial Uniformity Tests Attempted	1 = Yes 0 = No
	3	4 μm Daytime Tests Attempted	1 = Yes 0 = No
	4	4 μm Nighttime Tests Attempted	1 = Yes 0 = No
	5	Solar Contamination Flag	1 = Yes 0 = No
	6	Coast / No Coast Flag	1 = Yes 0 = No
	7	Mountain / No Mountain Flag	1 = Yes 0 = No
1	0	Forward Scattering Flag	1 = Yes 0 = No
	1	3.75 μm Cold Scene Flag	1 = Yes 0 = No
	2	11 μm Cold Scene Flag	1 = Yes 0 = No
	3	Oceanic Glint Flag	1 = Yes 0 = No
	4	Smoke Contamination Flag	1 = Yes 0 = No
	5	Dust Contamination Flag	1 = Yes 0 = No
	6	Shadow Contamination Flag	1 = Yes 0 = No
	7	Fire Contamination Flag	1 = Yes 0 = No
2	0-2	Surface Type Used for Thresholds	001 = Deep Ocean 010 = Shallow Water 011 = Land 100 = Snow 101 = Arctic 110 = Antarctic + Greenland 111 = Desert
	3	Thin Cirrus Flag	1 = Yes 0 = No
	4-5	BT11 – 11 μm Thermal Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	6-7	RTCT – Relative Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy

3	0-1	BT11STD – 11µm Thermal Uniformity Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	2-3	ETROP – Emissivity at Tropopause Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	4-5	BTD11_12 – 11 and 12 µm Split-Window Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	6-7	BTD11_6.7 – 11 and 6.7 µm Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
4	0-1	BTD11_6.7 – 11 and 6.7 µm Thermal Covariance Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	2-3	BTD11_8.5 – 11 and 8.5 µm Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	4-5	SPARE	
	6-7	BTD4_11 _Day – Daytime 4 – 11 µm Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
5	0-1	BTD4_11 _Night – Nighttime 4 – 11 µm Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	2-3	SPARE	
	4-5	Ref0.63 – 0.63 µm Reflectance Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	6-7	Ref0.63STD – 0.63 µm Reflectance Uniformity Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
6	0-1	RVCT – Relative Visible Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	2-3	Ref_Ratio – Reflectance Ratio Test	00 = Clear 01 = Probably Clear

			10 = Probably Cloudy
			11 = Cloudy
	4-5	Ref1.38 – 1.38 μm Reflectance Test	00 = Clear
			01 = Probably Clear
			10 = Probably Cloudy
			11 = Cloudy
	6-7	NDSI – NDSI Test	00 = Clear
			01 = Probably Clear
			10 = Probably Cloudy
			11 = Cloudy

Product evaluation/validation
- Visual comparisons were done with the NOAA-20 ECM generated outside of NDE
- Global cloud fraction comparisons were performed with the NASA AQUA/MODIS MYD35 C6.1 Cloud Mask Product
- PC values were computed using the 1 and 5 km Cloud Layer Product from the NASA CALIPSO/CALIOP Sensor.
- Clear and Cloudy SST biases were computed to estimate performance over ice-free oceans.

Product availability/reliability
- NOAA-20 ECM EDR data were produced on the NDE Integration and Testing (I&T) string since 03/26/2018. Data availability was not reliable as the NDE I&T string during the beta test period as a result of scheduled maintenance throughout. As such, data availability was not reliable from 2 April to 20 April.
- Roughly 25% of the ECM files are missing for any given day due to known product distribution at NESDIS Environmental Satellite Processing and Distribution Services (ESPDS) Product Distribution and Access (PDA) system. This issue exists on both the operational and I&T strings of NDE. A resolution has been identified and will be fixed on the I&T string in mid to late 2018 and will be transitioned to the operational string late 2018, early 2019.

Algorithm performance dependence
- It appears that all needed channels are not being ingest by the NOAA-20 ECM. Because of this, the ECM appears to be missing the following clouds
  - low clouds at night
  - water phased clouds over snow/ice
  - thin cirrus as shown in the thin cirrus bit (this does not impact the overall ECM probability but does negate the use of this bit, which is employed by certain downstream products)
  - In addition, the Fire bit is not being set within the ECM bit structure due to its dependency on the M12 band.
- The default cloud probability thresholds are set too tight for ocean pixels and this results in reduced number of confidently clear pixels in the 4-level mask.

Known errors/issues/limitations
- We encourage users looking to detect clears to ignore the 4-level mask and use the

cloud probability and to define a clear/cloud threshold that is optimal for their application.

- The NOAA-20 ECM is running with a LUT generated from SNPP. We feel the SNPP M5 channel is brighter than the NOAA-20 M5 channel and this may reduce the efficacy of the M5 cloud detection classifiers.
- Any issues on NDE (e.g. missing SDR granules) will negatively impact the ECM

3. Changes since last maturity stage
   ○ Not Applicable
4. Review board recommendations
   ○
5. Path Forward/Future Plan
   ○ Work with NDE to ensure all needed channels are running.
   ○ Add needed diagnostic attributes to improve our ability to diagnose these issues.
   ○ Improve the diagnostic information at the pixel-level
   ○ Generate a NOAA-20 LUT
6. Additional Items to note
   ○ The Cloud Team welcomes any feedback on user issues and suggestions on the evolution of the ECM.

Additional information is available in the NOAA Enterprise Cloud Mask algorithm theoretical basis document (ATBD) and validation maturity review briefing, which can be accessed at:

http://www.star.nesdis.noaa.gov/jpss/Docs.php

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