



Read-me for Data Users

MEMORANDUM FOR: The JPSS Program Record
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SUBJECT: NOAA-20 NVPS VI & GVF Products Validated maturity status
DATE: 04/23/2020

Validated maturity status declaration for VIIRS NDE Vegetation Products System--Vegetation Indices & Green Vegetation Fraction EDR

Maturity Review Date: 04/23/2020
Effective Date: 04/23/2020
Operational System: NDE, NVPS VI Version #v1r4, NVPS GVF Version#v2r3

The JPSS Algorithm Maturity Readiness Review Board approved the release of the JPSS VIIRS NDE Vegetation Products System--Vegetation Indices & Green Vegetation Fraction EDR to the public with a Validated maturity level quality as of 04/23/2020 (effective date), based on JPSS Validation Maturity Review held on 04/23/2020.

(https://drive.google.com/open?id=13F5S517ntc_aouZodQgYr8djkuIHSP0c).

1. Validated maturity stage definition (refer to the AMM webpage for maturity definition: <https://www.star.nesdis.noaa.gov/jpss/documents/Status/DataProductMaturityLevelDefinitions.pdf> .

The definition is also given below.)

- 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 and Product Description:

Refer to the delivered Algorithm Theoretical Basis Documents (ATBDs) for algorithm description:

https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_VIIRS_VI_v1.0.pdf

https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_GVF_v3.0.pdf

List of Products (Collection Short Name (CSN))

- NOAA 20 VIIRS VI with six products:
 - Daily Global (4km) VI
 - Daily Regional (1km) VI
 - Weekly Global (4km) VI
 - Weekly Regional (1km) VI
 - 16-day Global (4km) VI
 - 16-day Regional (1km) VI

- NOAA 20 VIIRS GVF with two products
 - Weekly Global (4km) GVF
 - Weekly Regional (1km) GVF

Product requirements/Exclusions

Product requirements and exclusions are specified in the Joint Polar Satellite System (JPSS) Level 1 Requirements Document (L1RD) and the JPSS ESPC Requirements Document (JERD).

Refer to the Joint Polar Satellite System (JPSS) Level 1 Requirements Document Supplement (L1RDS) at https://www.jpss.noaa.gov/assets/pdfs/technical_documents/L1RDS.pdf

Each of six VI products includes the following data fields:

- 1) Three gridded VI data sets: NDVI_TOA, EVI_TOC and NDVI_TOC;
- 2) Five aggregated reflectance bands: I1_TOA, I2_TOA, I1_TOC, I2_TOC, and M3_TOC
- 3) Geometry Information: RAA: Relative Azimuth Angle, SZA: Solar Zenith Angle, and VZA: Viewing Zenith Angle;
- 4) Four Quality Flags (QFs).
- 5) Geospatial Coordinates: latitude, longitude

A description of these data is given in Table 1.

Table 1: Data Fields of the NVPS VI Products

Data Name	Data Description	Data Type	Dimension	Fill Value	Scale	offset	Data Range
NDVI_TOA	Top of Atmosphere Normalized Difference Vegetation Index	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[-1,1]
NDVI_TOC	Top of Canopy Normalized Difference Vegetation Index	16-bit Integer	5000x10000 (Global)	-32768	10000	0	[-1,1]

			10384x28889 (Regional)				
EVI_TOC	Top of Canopy Enhanced Vegetation Index	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[-1,1]
I1_TOA	Top of Atmosphere Reflectance band	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[0,1]
I2_TOA	Top of Atmosphere Reflectance band	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[0,1]
I1_TOC	Top of Canopy Reflectance band	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[0,1]
I2_TOC	Top of Canopy Reflectance band	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[0,1]
M3_TOC	Top of Canopy Reflectance band	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	10000	0	[0,1]
SZA	Solar Zenith Angle	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	100	0	[0,90]
VZA	Viewing Zenith Angle	16-bit Integer	5000x10000 (Global) 10384x28889	-32768	100	0	[0,90]

			(Regional)				
RAA	Relative Azimuth Angle	16-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-32768	100	0	[-180,180]
QF1	Quality Flag Byte 0 (See Table 3-5)	8-bit unsigned character	5000x10000 (Global) 10384x28889 (Regional)	255	1	0	[0, 255]
QF2	Quality Flag Byte 1 (See Table 3-5)	8-bit unsigned character	5000x10000 (Global) 10384x28889 (Regional)	2	1	0	[0, 255]
QF3	Quality Flag Byte 2 (See Table 3-5)	8-bit unsigned character	5000x10000 (Global) 10384x28889 (Regional)	0	1	0	[0, 255]
QF4	Quality Flag Byte 3 (See Table 3-5)	8-bit unsigned character	5000x10000 (Global) 10384x28889 (Regional)	0	1	0	[0, 255]
Latitude	Geospatial coordinate	32-bit float	5000x1 (Global) 10384x1 (Regional)	-999.0	1	0	[-90°,90°] [-7.5°,90°]
Longitude	Geospatial coordinate	32-bit float	10000x1 (Global) 28889x1 (Regional)	-999.0	1	0	[-180°,180°] [-230°,30°]

The details of the bit layout of the four quality flags are listed in Table 2.

Table 2: Bit Layout of the Four QFs in NVPS VI Product

Quality Flag Name	Elements of Quality Flag	Description	Bit Position In a Byte
QF1	TOA NDVI Overall Quality	0 = Low 1= High NOTE: TOA NDVI quality is set to high (1) if ALL of these conditions are met: 1) I1 TOA reflectance flag = available; 2) I2 TOA reflectance flag = available 3) Cloud Confidence flag = confidently clear 4) Thin Cirrus flag = no thin cirrus; 5) Solar Zenith Angle < 65 deg 6) Sun glint (Geometry based) = none; 7) No adjacency clouds 8) No cloud shadows; 9) No snow/ice 10) Aerosol quantity =“low” or “medium” or “climatology” 11) Cloud mask quality = “high” or “medium”	0
	TOC EVI Overall Quality	0 = Low 1 = High NOTE: EVI quality is set to high (1) if ALL of these conditions are met: 1) I1 Surface reflectance flag = available ; 2) I2 Surface reflectance flag = available 3) M3 Surface reflectance flag = available; 4) Cloud Confidence flag = confidently clear; 5) Thin Cirrus flag = no thin cirrus; 6) Solar Zenith Angle < 65 degree 7) Sun glint (Geometry based) = none; 8) EVI range flag = in range 9) No adjacency clouds; 10) No cloud shadows 11) No snow/ice; 12) Aerosol quantity =“low” or “medium” or “climatology” 13) Cloud mask quality = “high” or “medium”	1
	TOC NDVI Overall Quality	0 = Low 1 = High NOTE: TOC NDVI quality is set to high (1) if ALL of these conditions are met: 1) I1 Surface reflectance flag = available ; 2) I2 Surface reflectance flag = available 3) Cloud Confidence flag = confidently clear; 4) Thin Cirrus flag = no thin cirrus; 5) Solar Zenith Angle < 65 degree 6) Sun glint (Geometry based) = none	2

		<p>7) No adjacency clouds</p> <p>8) No cloud shadows</p> <p>9) No snow/ice</p> <p>10) Aerosol quantity = "low" or "medium" or "climatology"</p> <p>11) Cloud mask quality = "high" or "medium"</p>	
	I1 TOA Reflectance	<p>0 = Not Available</p> <p>1 = Available</p>	3
	I2 TOA Reflectance	<p>0 = Not Available</p> <p>1 = Available</p>	4
	I1 Surface Reflectance	<p>0 = Not Available</p> <p>1 = Available</p>	5
	I2 Surface Reflectance	<p>0 = Not Available</p> <p>1 = Available</p>	6
	M3 Surface Reflectance	<p>0 = Not Available</p> <p>1 = Available</p>	7
QF2	EVI Range	<p>1 = Out of Range</p> <p>0 = In Range</p>	0
	Land/Water	<p>001= deep ocean (1)</p> <p>010= shallow water (2)</p> <p>011= land (3)</p> <p>100= snow (4)</p> <p>101= arctic (5)</p> <p>110= Antarctic + Greenland (6)</p> <p>111= desert (7)</p>	1-3
	Cloud Confidence	<p>11 = Confidently Cloudy</p> <p>10 = Probably Cloudy</p> <p>01 = Probably Clear</p> <p>00 = Confidently Clear</p>	4-5
	Sun Glint	<p>11 = Geometry & Wind</p> <p>10 = Wind Speed Based</p> <p>01 = Geometry Based</p> <p>00 = None</p>	6-7
QF3	Thin Cirrus (reflective)	<p>1 = Cloud</p> <p>0 = No Cloud</p>	0
	Stratification – Solar Zenith Angle	<p>1 = 65 Degrees <= SZA <= 85 Degrees</p> <p>0 = SZA < 65 Degrees or SZA > 85 Degrees</p>	1
	*Excl – AOT > 1.0	<p>1 = AOT > 1.0</p> <p>0 = AOT <= 1.0</p>	2

	Excl – Solar Zenith Angle > 85 Deg	1 = SZA > 85 degrees 0 = SZA <= 85 degrees	3
	Snow/Ice	0 = False (no) 1 = True (yes)	4
	Adjacent to Clouds	0 = False (no) 1 = True (yes)	5
	Aerosol Quantity	00 = Climatology 01 = Low 10 = Average 11 = High	6-7
QF4	Cloud Shadows	0 = False (no) 1 = True (yes)	0
	Aerosol Optical Thickness Quality	00 = High Quality 01 = Degraded Quality 10 = Excluded Quality 11 = Not Produced	1-2
	Cloud Mask Quality	00 = Poor 01 = Low 10 = Medium 11 = High	3-4
	Spare Bits	Initialized to 0	5-7

Note that the bits in a quality flag are numbered from right (bit index #0) to left (bit index #7) with a default value of 1. Therefore for each bit, “1” also represents the situation of missing data. And the bits value is calculated from right to left, e.g. bits 1-0 xy (10), x is bigger bit and y is smaller bit, its value is equal to $2^x + 2^y$. A visual example of this format is shown below.

Bit Index #	7	6	5	4	3	2	1	0
	0	0	1	0	1	0	1	0

Each of two GVF products includes the following data fields:

- 1) GVF
- 2) Number of Pixels
- 3) Geospatial Coordinates: latitude, longitude

The description of these data fields is given in Table 3.

Table 3: Data Fields of the NVPS GVF Product

Data Name	Data Description	Data Type	Dimension	Fill Value	Scale	offset	Data Range
GVF	Green Vegetation Fraction	8-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	-128	100	0	[0,100]
Number_Of_Pixels	Number of Pixels	8-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	255	1	0	[0,255]
Latitude	Geospatial coordinate	32-bit float	5000x1 (Global) 10384x1 (Regional)	-999.0	1	0	[-90°,90°] [-7.5°,90°]
Longitude	Geospatial coordinate	32-bit float	10000x1 (Global) 28889x1 (Regional)	-999.0	1	0	[-180°,180°] [-230°,30°]

Product evaluation/validation

Three methods as shown in the review presentation (file

Validated_Maturity_VIIRS_VI_GVF_NOAA20_23April2020_updated in

https://drive.google.com/open?id=13F5S517ntc_aouZodQgYr8djkuIHSPOc have been used in the product evaluation/ validation:

- Cross comparison with other satellite VI & GVF products including SNPP VIIRS VI & GVF, AQUA MODIS VI, and AVHRR GVF
- Validation against ground data from PhenoCam and high resolution Google Earth images
- Global and regional NOAA 20 VI & GVF data long term monitoring. See https://www.star.nesdis.noaa.gov/jps/EDRs/products_VegIndex.php .

Product availability/reliability

- {NOAA-20 VIIRS VI & GVF EDR} data have been produced since 06/04/2019.

Algorithm performance dependence

- The algorithm performance is dependent on the sensor data quality. The sensor data is assumed to be well calibrated in both radiance and geolocation.
- The algorithm performance relies on the quality of upstream datasets such as enterprise red, near-infrared, and blue reflectance at top of atmosphere and canopy.
- The algorithm performance is dependent on the cloud condition, aerosol optical depth, and viewing geometry condition.
- The algorithm performance has regional and seasonal dependency.

Known errors/issues/limitations

- Accuracy and precision statistics are worse than specification for the highest VI values. These represent a small fraction of high quality VI values.

3. Changes since last maturity stage

- The quality flag (QF1 in table 2) has been updated due to change of NVPS VI implementation
- The biweekly compositing algorithm in VI has been updated by using previous 2 weekly composites and recent 2 daily intermediate results instead of 16 daily intermediate results to make compositing. The running time of updated implementation has decreased in 75% compared to previous version

4. Review board recommendations

The review team recommended that NOAA20 Vegetation Index and NOAA20 Green Vegetation Fraction have reached Validated Maturity.

See https://drive.google.com/file/d/12VNMi_NHM1wH7nNyZmG9gLm00iG3Q0j4/view

5. Path Forward/Future Plan

- Product refinement
 - Improve GVF smoothing algorithm.
 - Increase number of VI quality ranks.
 - Implement improvements for VI & GVF to speed up processing.
- Validation
 - Local long term monitoring tool is under development
 - STAR long term monitoring tool will be updated regularly.
 - In situ and cross satellite data comparisons will continue.

6. Additional items to note

NA



Read-me for Data Users

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