Suomi NPP VIIRS Vegetation Index EDR

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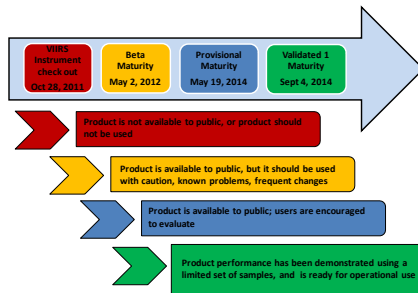
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Introduction

Vegetation Indices from satellite instruments in polar orbits are used to monitor the environment including drought, the health of ecosystems, forest fires, crop monitoring, as well as for weather forecasting and climate research. The Visible Infrared Imaging Radiometer Suite (VIIRS) Vegetation Index (VI) Environmental Data Record (EDR) from Suomi NPP and JPSS will provide both: continuity with vegetation indices from NOAA Polar-Orbiting Operational Environmental Satellites (POES) and the NASA Earth Observing Satellites, specifically Aqua and Terra satellites. Suomi NPP was launched in October 2011, and JPSS1 will be launched no later than the 2nd quarter of FY 2017. The Suomi NPP VIIRS Vegetation Index operational product includes two vegetation indices: the Top of the Atmosphere (TOA) Normalized Difference Vegetation Index (NDVI), and the Top of the Canopy (TOC) Enhanced Vegetation Index (EVI). The VI EDR was promoted to Validated 1 maturity status in September 04, 2014, and it is now available to the general public through NOAA's Comprehensive Large Array-Data Stewardship System (CLASS). A series of improvements to the VI EDR product including enhancing the Quality Flags (QF) were implemented in build Mx8.4 (May 2014). A more comprehensive set of QFs was necessary to allow users to better screen suspicious quality pixels that could not be screened with the original set of QFs. The additional QFs include: snow/ice, cloud shadows, cloud adjacency, and aerosol quantity. The ongoing validation efforts and product improvements will lead to the VI EDR reaching Validated 2 maturity status in the near term. For JPSS1, the Vegetation Index algorithm from Suomi NPP will be updated to include a third vegetation index, the TOC NDVI. The new TOC NDVI is currently under development at NOAA/STAR, and the algorithm change package will be delivered to the JPSS Ground Project's Data Product Engineering (DPE) Integrated Product Team (IPT) in early FY 2015 for further testing and implementation.

SNPP VIIRS Vegetation Index EDR Product Description

The Vegetation Index EDR provides the Normalized Difference Vegetation Index (NDVI), the Enhanced Vegetation Index (EVI), and per-pixel quality flags (QFs) at 375 m.
The NDVI is derived from Top-of-the-Atmosphere (TOA) I1 and I2 bands.

$$NDVI = (\rho_{I2}^{TOA} - \rho_{I1}^{TOA})/(\rho_{I2}^{TOA} + \rho_{I1}^{TOA})$$

The EVI is derived from Top-of-Canopy (TOC) I1 and I2, and M3 bands

$$EVI = (1+L)\cdot\frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + C_1\cdot\rho_{I1}^{TOC} - C_2\cdot\rho_{M3}^{TOC} + L}$$

ρ_{M3}^{TOC} Surface reflectance band M3 (488 nm)

ρ_{I1}^{TOC} Surface reflectance band I1 (640 nm)

ρ_{I2}^{TOC} Surface reflectance band I2 (865 nm)

ρ_{I1}^{TOA} Top of the atmosphere reflectance band I1 (640 nm)

ρ_{I2}^{TOA} Top of the atmosphere reflectance band I2 (865 nm)

C_1, C_2 and L are constants

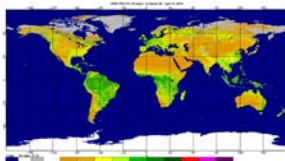**JPSS Level 1 Requirements for the Vegetation Index EDR**

Table 5.5.9 – Vegetation Indices (VIIRS)

EDR Attribute	Threshold	Objective
Vegetation Indices Applicable Conditions		
1. Clear, land (not ocean),day time only		
a. Horizontal Cell Size	0.4 km	0.25 km
b. Mapping Uncertainty, 3 Sigma	4 km	1 km
c. Measurement Range		
1. NDVITOA	-1 to +1	NS
2. EVI (1)	-1 to +1	NS
3. NDVITOC	-1 to +1	NS
d. Measurement Accuracy - NDVI_TOA (2)	0.05 NDVI units	0.03 NDVI units
e. Measurement Accuracy - NDVI_TOC (2)	0.04 NDVI units	0.02 NDVI units
f. Measurement Accuracy - EVI (2)	0.05 EVI units	NS
g. Measurement Precision - EVI (2)	0.04 EVI units	NS
h. Measurement Precision - NDVI_TOC (2)	0.05 NDVI units	NS
i. Measurement Precision - NDVI_TOC (2)	0.04 NDVI units	NS
j. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	24 hrs.

Notes:
1. EVI can produce faulty values over snow, ice, and residual clouds (EVI > 1).
2. Accuracy and precision performance will be verified and validated for an aggregated 4 km horizontal cell to provide for adequate comparability of performance across the scan.

Vegetation Index EDR Product Timeline

Validation Stages Maturity Definition

Validated Stage 1:
Using a limited set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 2:
Using a moderate set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 3:
Using a large set of samples representing global conditions over four seasons, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Path Forward – Planned Improvements

-Implementation of DR7039 - TOC-EVI backup algorithm
-Implementation of DR7697 – Redefine Granule Level Summary QF and pro Pixel Overall QFs
-Implementation of DR 7041, Code change and implementation of a revised EVI equation
-Temporal compositing (weekly, 16-day, monthly), and spatial compositing (global) (DR7488)
-JPSS1 TOC NDVI Test Readiness Review (Oct 2014)
-JPSS1 TOC NDVI Algorithm Readiness Review (Mar 2015)

User Precautions

Known issues to date are described below:
-Cloud Shadows QF is currently known to overestimate shadow affected areas. Use this flag with caution
-Aerosol Quantity QF. Use this flag to identify the source of aerosol information and the degree of aerosol contamination in individual pixels
-Cloud Adjacency QF. This flag can overestimate affected areas.
-Snow/Ice QF. Use this flag to screen pixels with suspicious EVI values over snow/ice-covered surfaces
-Incremental improvements in the VIIRS VI-EDR operational product are expected as the quality of the upstream products (VCM-IP and SR-IP as well as Aerosol Optical Thickness IP) continues to improve
-TOC EVI data can contain unrealistically high/low values over snow/ice covered areas at high latitudes, over clouds, and over cloud shadows
-The quality of the VI-EDR is sensitive to the performance of the VIIRS Cloud Mask (VCM) and Surface Reflectance (SR) Intermediate Products (IPs)

SNPP VIIRS Vegetation Index EDR Validation Results

VIIRS vs. MODIS Global Comparison
- *Radiometric accuracies* of VIIRS VI EDR were evaluated and estimated by global cross-comparison with Aqua MODIS
  - Using observation pairs along overlapping orbital tracks
    - Four view zenith (VZ) angle bins
      - VZ < 7.5°, 20° < VZ < 27.5°, 40° < VZ < 47.5°, 55° < VZ < 62.5°
  - Sets of three days of data to obtain global coverage
    - DOY 104, 106, and 109,2014
    - DOY 120, 122, and 125, 2014
   - DOY 136, 138, and 141, 2014
    - DOY 152, 154, and 157, 2014

Figures indicating VIIRS-MODIS overlapping orbital tracks (V2 < 7.5°)

VIIRS VI EDR APU Metrics
MODIS Reference; All Data Days

Subset Time Series Analysis

VIIRS vs. Tower NDVI Time Series

Matchup Analysis. Surface Reflectance and VI Cutouts collected daily at 229 Aeronet sites: North America Example
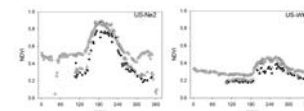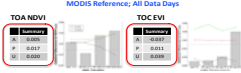

Example of Cutouts of TOA NDVI at Barcelona. First 3 weeks in April
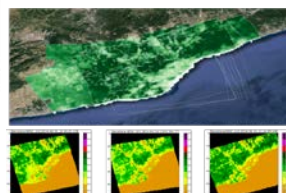
Product Performance Estimates

Attribute Analyzed	L1RD Threshold (VI units)	Analysis Validation Results	Error Summary
TOA NDVI Accuracy	0.05	0.005	Global comparison with Aqua MODIS (no spectral correction)
TOA NDVI Precision	0.04	0.017	Global comparison with Aqua MODIS (no spectral correction)
TOA NDVI Uncertainty	0.06	0.020	Global comparison with Aqua MODIS (no spectral correction)
TOC EVI Accuracy	0.05	0.037	Matchup data analysis (atmospheric correction error)
		0.004	Global comparison with Aqua MODIS (no spectral correction)
TOC EVI Precision	0.04	0.011	Global comparison with Aqua MODIS (no spectral correction)
		0.015	Matchup data analysis (atmospheric correction error)
TOC EVI Uncertainty	0.06	0.039	Global comparison with Aqua MODIS (no spectral correction)
		0.016	Matchup data analysis (atmospheric correction error)

Vegetation Index EDR Data Access

The primary source for S-NPP products is via NOAA's Comprehensive Large Array-Data Stewardship System (CLASS) web site (http://www.class.ngdc.noaa.gov/saa/products/welcome). Data delivered to CLASS from the Interface Data Processing Segment (IDPS) has a latency of 6 hours.

Acknowledgements and Disclaimer

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SNPP VIIRS Vegetation Index EDR Quality Flags

*Four additional QFs added to the VI EDR official product on build Mx8.4