



Performance of Suomi NPP VIIRS Vegetation Index EDR

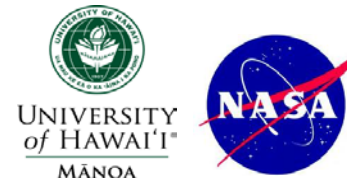
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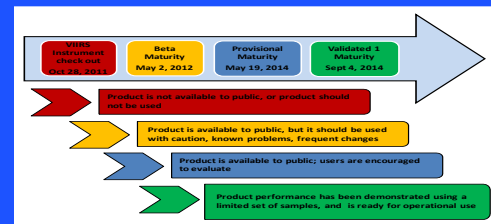
NOAA Satellite Science Week meeting, Boulder, Colorado February 23 - 27, 2015



Introduction

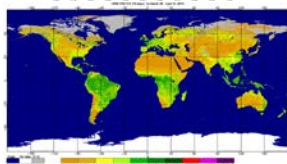
SNPP VIIRS Vegetation Index EDR Validation Results

Vegetation Index EDR Product Timeline



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 JPSS1 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. 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 summer 2015. 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 and Services (DPES) Integrated Product Team (IPT) in spring 2015 for further testing and implementation. The granulated format of the VI-EDR official product is not user friendly. Level 3 gridded Vegetation Indices are desirable for Numerical Weather Prediction (NWP), modeling and most applications; therefore the STAR/JPSS Land Team is planning additional improvements to the VI EDR which include temporal (weekly, monthly) and spatial (global) composites.

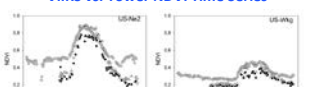
SNPP VIIRS TOA NDVI October 14, 2014



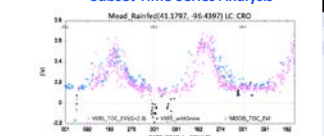
VIIRS vs. MODIS Global Comparison
Radiometric accuracies of VIIRS VI EDR were evaluated and estimated by global cross-comparison with Aqua MODIS (Using observation pairs along overlapping orbital tracks)



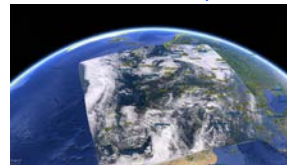
VIIRS vs. Tower NDVI Time Series



Subset Time Series Analysis



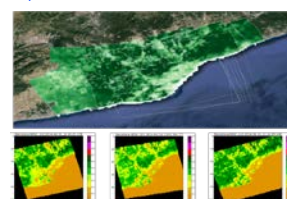
SNPP VIIRS RGB Composite



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



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



Product Performance Estimates

Attribute Analyzed	L1ND Threshold (VI units)	Analysis/Validation Results	Error Summary
TOA NDVI Accuracy	0.05	0.005	Global comparison with Aqua MODIS
TOA NDVI Precision	0.04	0.017	Global comparison with Aqua MODIS
TOA NDVI Uncertainty	0.06	0.036	Global comparison with Aqua MODIS
TOC EVI Accuracy	0.05	0.037	Global comparison with Aqua MODIS
TOC EVI Precision	0.04	0.024	Matchup data analysis (atmospheric correction)
TOC EVI Uncertainty	0.06	0.011	Global comparison with Aqua MODIS (no atmospheric correction)
		0.016	Matchup data analysis (atmospheric correction)
		0.039	Global comparison with Aqua MODIS (no atmospheric correction)
		0.016	Matchup data analysis (atmospheric correction)

SNPP/JPSS1 VIIRS Vegetation Index EDR Product Description

The SNPP VIIRS Vegetation Index EDR consists of two vegetation indices:
 1) Normalized Difference Vegetation Index (NDVI^{TOA}) from top-of-atmosphere (TOA) reflectances
 2) Enhanced Vegetation Index (EVI^{TOC}) from top-of-canopy (TOC) reflectances
 These indices are produced at the VIIRS image channel resolution (375 m at nadir), over land in granule style (swath form), and the file format is HDF5.

An additional Vegetation Index is being added for JPSS1: The Normalized Difference Vegetation Index (NDVI^{TOC}) from top-of canopy (TOC) reflectances.

$$NDVI^{TOA} = \frac{\rho_{M3}^{TOA} - \rho_{I1}^{TOA}}{\rho_{M3}^{TOA} + \rho_{I1}^{TOA}}$$

$$EVI^{TOC} = (1 + L) \cdot \frac{\rho_{12}^{TOC} - \rho_{11}^{TOC}}{\rho_{12}^{TOC} + C_1 \cdot \rho_{11}^{TOC} - C_2 \cdot \rho_{M3}^{TOC} + L}$$

$$NDVI^{TOC} = \frac{\rho_{12}^{TOC} - \rho_{11}^{TOC}}{\rho_{12}^{TOC} + \rho_{11}^{TOC}}$$

ρ_{M3}^{TOA} Surface reflectance band M3 (488 nm)
 ρ_{I1}^{TOA} Surface reflectance band I1 (640 nm)
 ρ_{12}^{TOC} Surface reflectance band I2 (865 nm)
 ρ_{11}^{TOA} Top of atmosphere reflectance band I1 (640 nm)
 ρ_{12}^{TOC} Top of atmosphere reflectance band I2 (865 nm)
 C_1, C_2 and L are constants

SNPP VIIRS Vegetation Index EDR Quality Flags

Byte	VIIRS VI Flag	Result	Bits
0	Overall NDVI Quality	1 = High 0 = Low NOTE: NDVI quality is set to high (1) if ALL of these conditions are met: 1)1) TOA reflectance flag = avail 2)2) TOA reflectance flag = avail 3)3) Surface reflectance flag = avail 4)4) Cloud Confidence flag = confidently clear 5)5) Thin Cirrus flag = no thin cirrus 6)6) Solar Zenith Angle < 65 deg 7)7) Sun glint (Observatory based) = none 8)8) Sun glint (Observatory based) = none	1
	Overall EVI Quality	1 = High 0 = Low NOTE: EVI quality is set to high (1) if ALL of these conditions are met: 1)1) Surface reflectance flag = avail 2)2) Surface reflectance flag = avail 3)3) Surface reflectance flag = avail 4)4) Cloud Confidence flag = confidently clear 5)5) Thin Cirrus flag = no thin cirrus 6)6) Solar Zenith Angle < 65 deg 7)7) Sun glint (Observatory based) = none 8)8) Sun glint (Observatory based) = none	1
1	I1 TOA Reflectance	0 = Available 1 = Not Available	1
	I2 TOA Reflectance	0 = Available 1 = Not Available	1
	I1 Surface Reflectance	0 = Available 1 = Not Available	1
	I2 Surface Reflectance	0 = Available 1 = Not Available	1
	M3 Surface Reflectance	0 = Available 1 = Not Available 2 = Out of Range 3 = In Range	1

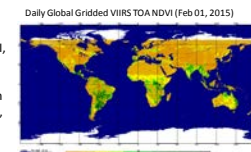
Byte	VIIRS VI Flag	Result	Bits
1	Land/Water	101 = Coastal 011 = Sea Water 010 = Inland Water 001 = Land / No Desert 000 = Land & Desert	3
	Cloud Confidence	11 = Confidently Cloudy 10 = Probably Cloudy 01 = Probably Clear 00 = Confidently Clear	2
	Sun Glint	11 = Geometry & Wind 10 = Wind Speed Based 01 = Geometry Based 00 = None	2
1	Thin Cirrus (reflective)	1 = Cloud 0 = No Cloud	1

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

Byte	VIIRS VI Flag	Result	Bits
1	Stratification - Solar Zenith Angle	1 = 65 Degrees < SZA <= 85 Degrees 0 = SZA < 65 Degrees or SZA > 85 Degrees	1
	Excl - AOT > 1.0	1 = AOT > 1.0 0 = AOT <= 1.0	1
2	Excl - Solar Zenith Angle > 85 Deg	1 = SZA > 85 degrees 0 = SZA <= 85 degrees	1
	*Snow/ice	0 = False (no) 1 = True (yes)	1
2	*Adjacent Clouds	0 = False (no) 1 = True (yes)	1
	*Aerosol Quantity	00 = Climatology 01 = Low 10 = Average 11 = High	2
2	*Cloud Shadows	0 = False (no) 1 = True (yes)	1

Path Forward - Planned Improvements

Prospective users (NWS/NCEP) of the VIIRS Vegetation index EDR product want a Level 3 suite of global gridded vegetation products including TOC EVI, TOC NDVI, TOA NDVI, LAI, FPAR, and Green Vegetation Fraction (already operational at NDE) for applications in Numerical Weather Prediction (NWP), modeling, and climate studies. NESDIS/STAR is embarking in the development of common algorithms to support the Strengthening NESDIS initiative, and the future NESDIS Ground Enterprise Architecture System (GEARS). The gridding algorithm/software used by the NDE VIIRS Green Vegetation Fraction operational product could be implemented for other land applications/products. Planned improvements to the VI-EDR include:
 -Implementation of DR7039 - TOC-EVI backup algorithm
 -Implementation of DR7697 - Redefine Granule Level Summary QF and pro Pixel Overall QFs
 -Temporal compositing (weekly, 16-day, monthly), and spatial compositing (global) (DR7488)
 -JPSS1 TOC NDVI Algorithm Readiness Review (May 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
 - 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

Vegetation Index EDR Data Access

The primary source for SNPP 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

This work has been supported by the NOAA JPSS Office (NJO). The views, opinions, and findings contained in this poster are those of the author(s) and should not be construed as an official National Oceanic and Atmospheric Administration or U.S. Government position, policy, or decision.