Provisional Maturity Science Review For NOAA-21 Vegetation Index , Green Vegetation Fraction

Prepared by
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Version 1: 01/24/2024

JPSS/GOES-R Provisional Maturity Definition

1. Beta

- Product is minimally validated, and may still 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 remediation strategies, exists.

2. Provisional

- **Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.**
- **Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.**
- **Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.**
- **Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.**

3. Validated

- 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.

Outline

- Vegetation Index and Green Vegetation Fraction Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Processing environment
  - No appropriate in-situ reference available
  - *Visual inspection*
  - *Cross-comparison analysis with other data sets*
  - Error budget
- User Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

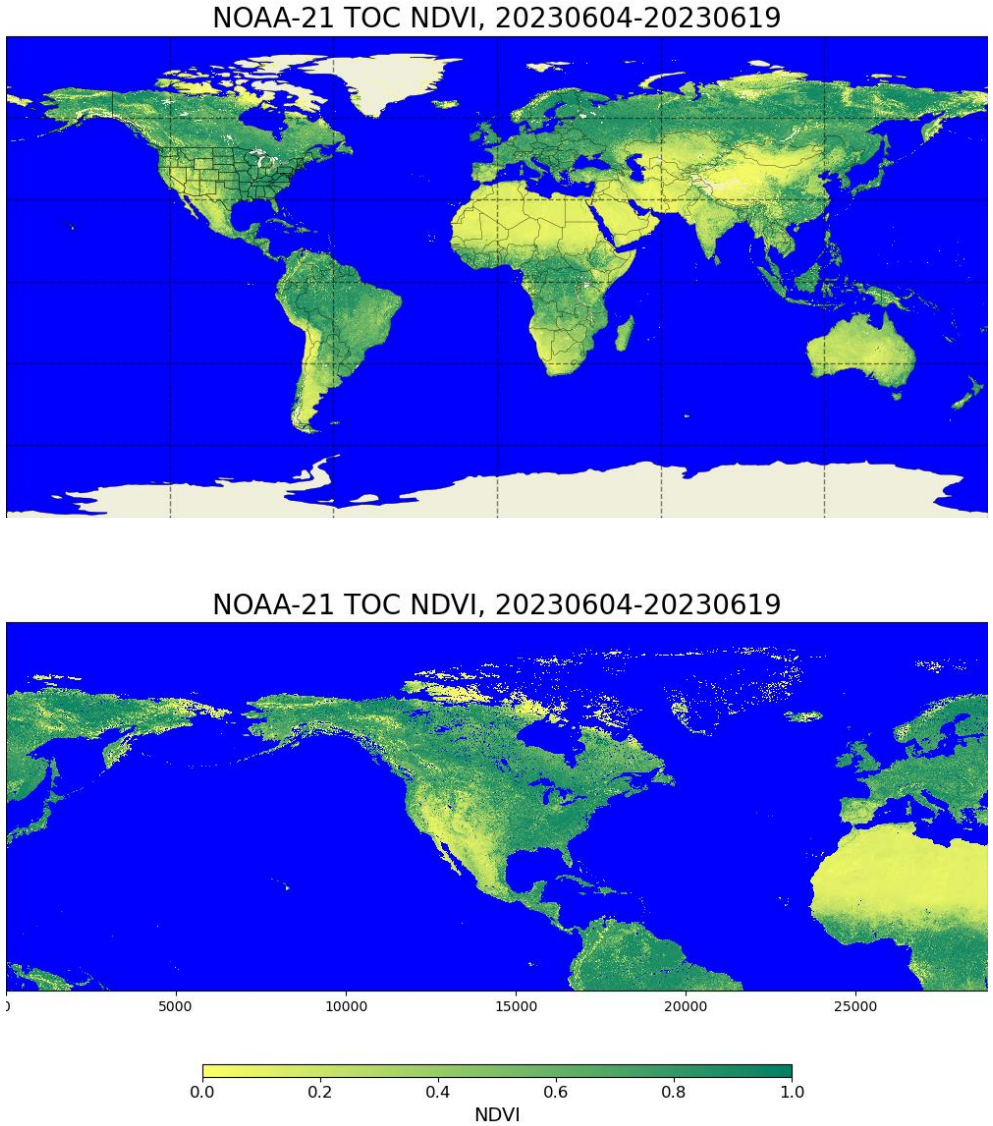
NOAA-21 VI and GVF Algorithm Cal/Val Team

Algorithm Cal/Val Team Members

	Name	Organization	Major Task
STAR Science Team	Ivan Csiszar	NOAA/NESDIS/STAR	Land Lead
	Yunyue Yu	NOAA/NESDIS/STAR	Science Team Lead, algorithm development/improvement, calibration/validation, team management
	Corinne Carter	NOAA Affiliate, UMD/CISESS	Algorithm development/improvement, product monitoring
	Zhangyan Jiang	NOAA Affiliate, IMSG	Algorithm development/improvement, product monitoring
	Yuan Zhou	NOAA Affiliate, UMD/CISESS	Algorithm development/improvement, product monitoring
JPSS ASSISTT	Michael Butler	NOAA Affiliate, GAMA-1	ASSISTT lead
	Valerie Mikles	NOAA Affiliate, IMSG	Algorithm System integration
	Michael Wilson	NOAA Affiliate, IMSG	Algorithm System integration
NOAA/EMC	Stan Benjamin	NOAA Federal	HRRR model
	Tanya Smirnova	NOAA Affiliate	HRRR model

Overview-VI

- Vegetation Index (VI) is one key parameter to specify the boundary condition in global climate models, weather forecasting models and numerous remote sensing applications for monitoring environmental state and its change
- VIIRS VIs are inherited products from MODIS VI and AVHRR VI
  - **TOA NDVI:** Top of the Atmosphere Normalized Difference Vegetation Index is most directly related to absorption of photosynthetically active radiation, but is often correlated with biomass or primary productivity
  - **TOC NDVI:** Top of the Canopy Normalized Difference Vegetation Index is a functional response to ground cover, plant leaf area, leaf orientation, solar zenith angle and atmospheric optical depth.
  - **TOC EVI:** Top of the Canopy Enhanced Vegetation Index was developed to optimize the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a reduction in atmosphere influences
- Product Description: Daily, weekly and biweekly at global (4 km) and *regional level (North America and surroundings,1 km)*



Overview-VI (2)

Three vegetation indices are included in the VIIRS VI product

TOA NDVI is derived from TOA red (I1) and NIR (I2) reflectance

$$NDVI^{TOA} = \frac{\rho_{I2}^{TOA} - \rho_{I1}^{TOA}}{\rho_{I2}^{TOA} + \rho_{I1}^{TOA}}$$

TOC NDVI is derived from TOC red (I1) and NIR (I2) reflectance

$$NDVI^{TOC} = \frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + \rho_{I1}^{TOC}}$$

TOC EVI is derived from TOC red (I1), NIR (I2), and blue (M3) reflectance

$$EVI^{TOC} = G\,\frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + C1.\,\rho_{I1}^{TOC} - C2\,.\,\rho_{M3}^{TOC} + L}$$

where G = 2.5, C1 = 6.0, C2 = 7.5, and L = 1.0

VI Product Requirements

- Product performance requirements from JPSS Data Product Specification (DPS)

Table 5.5.9 - Vegetation Index (NDVI) (VIIRS)		
EDR Attribute	**Threshold**	**Objective**
NDVI Applicable conditions: 1. Clear, daytime only		
a. Horizontal Cell Size	4 km	1 km
b. Mapping Uncertainty, 3 Sigma	4 km	1 km
c. Measurement Range		
1. NDVI (NDVI Units)	-1 to +1	
2. EVI (EVI Units) (1)	-1 to +1	
3. $NDVI_{TOC}$ ($NDVI_{TOC}$ Units) (1)	-1 to +1	
d. Measurement Accuracy - NDVI	0.05 NDVI units	0.03 NDVI units
e. Measurement Precision - NDVI	0.04 NDVI units	0.02 NDVI units
f. Measurement Uncertainty - EVI	0.11 EVI units	None
g. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	24 hrs.
h. TOC	As part of the Vegetation Index EDR processing, the system shall deliver a Top of Canopy NDVI ($NDVI_{TOC}$) product.	
		v2.2, 9/23/12

VIIRS Green Vegetation Fraction Product Overview

NOAA-21 VIIRS Green Vegetation Fraction (GVF) Algorithm

- VIIRS GVF algorithm is a modified version of Gutman and Ignatov's (1998) GVF algorithm
- VIIRS GVF algorithm uses VIIRS I1, I2 and M3 TOC reflectances as input
- VIIRS GVF is derived form EVI

The Enhanced Vegetation Index (EVI)

$$EVI = G\frac{\rho_{\text{NIR}} - \rho_{\text{red}}}{\rho_{\text{NIR}} + C_1 \cdot \rho_{\text{red}} - C_2 \cdot \rho_{\text{blue}} + 1}$$

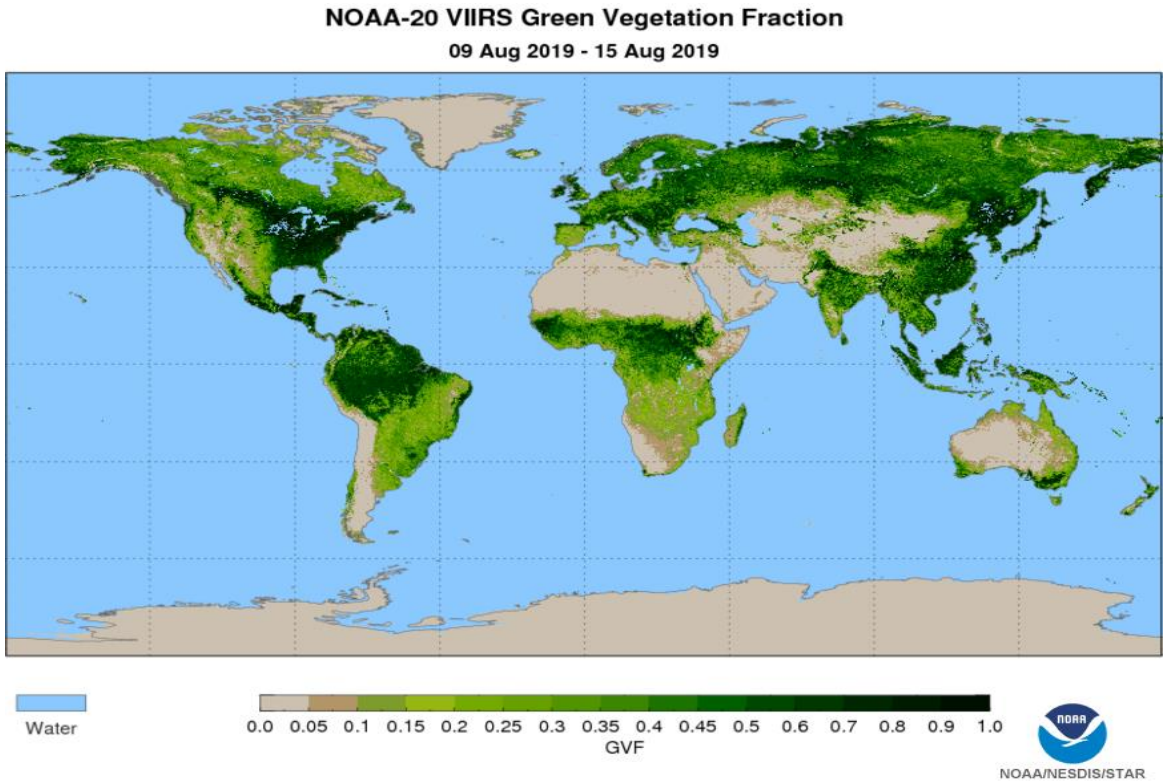
The Green Vegetation Fraction

$$GVF = \frac{EVI - EVI_0}{EVI_\infty - EVI_0}$$

VIIRS GVF Algorithm generates two products

1. *Weekly Global at 4 km res*
2. *Weekly Regional at 1 km; (Lat 7.5°S - 90°N, Lon 130°E - 30°E)*

- Weekly (updated daily) GVF products
- Projection: Lat/Lon
- Output file format: NetCDF4
- VIIRS GVF available at NOAA/CLASS



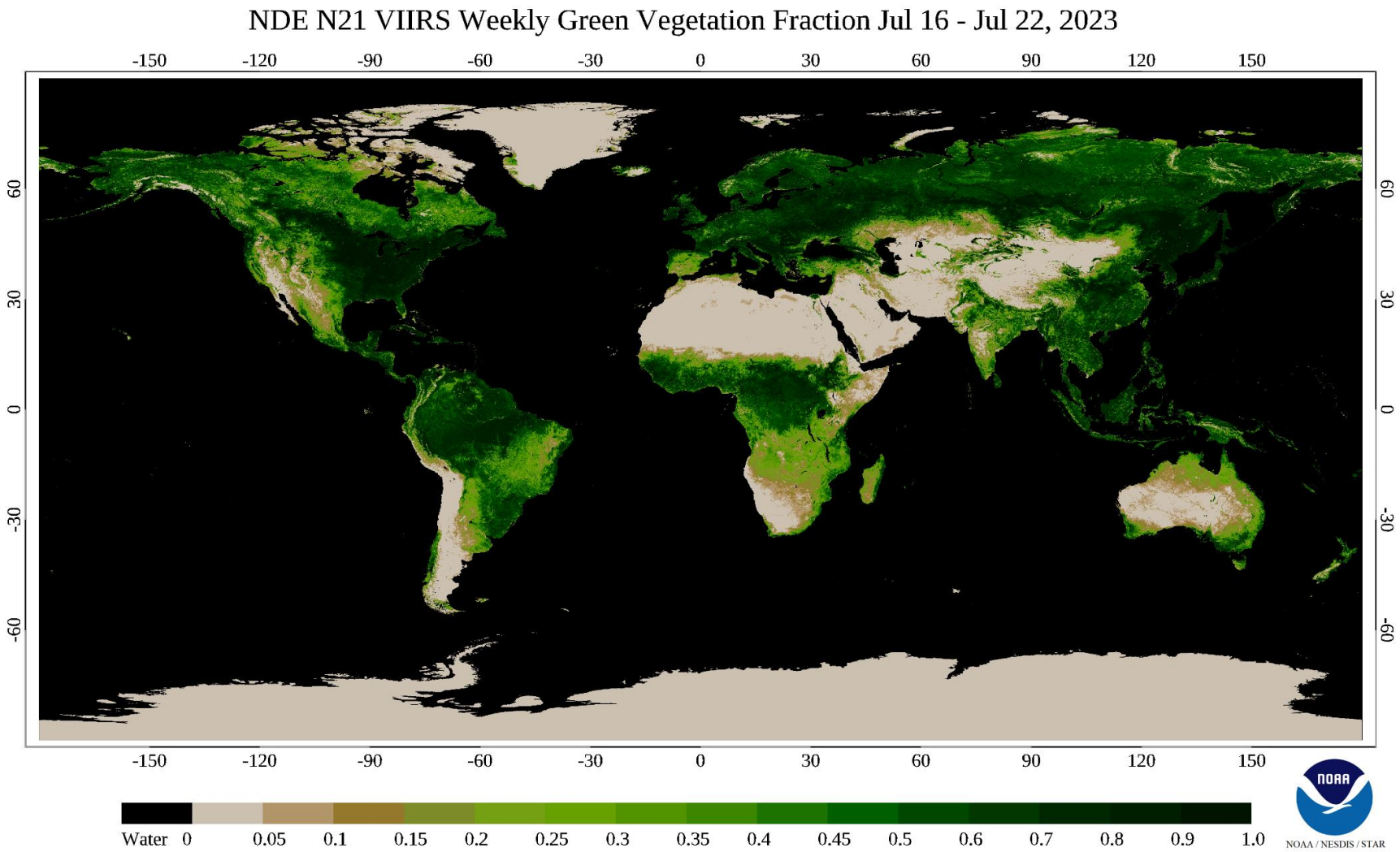
GVF Product Requirements

Attribute	Threshold	Objective
Horizontal Cell Size	16 km	1 km (regional), 4km (global)
Vertical Reporting Interval	NS	NS
Mapping Uncertainty, 3 Sigma	4km	1km
Measurement Precision*		
Global	15%	8%
Regional	15%	8%
Measurement Accuracy*		
Global	12%	5%
Regional	12%	5%
Refresh	24 hours	24 hours

*For the purpose of these requirements, “accuracy” is defined as absolute value of mean difference, and “precision” as RMS of (difference – mean difference), no matter the source of the reference data

Visual Assessment of Global GVF

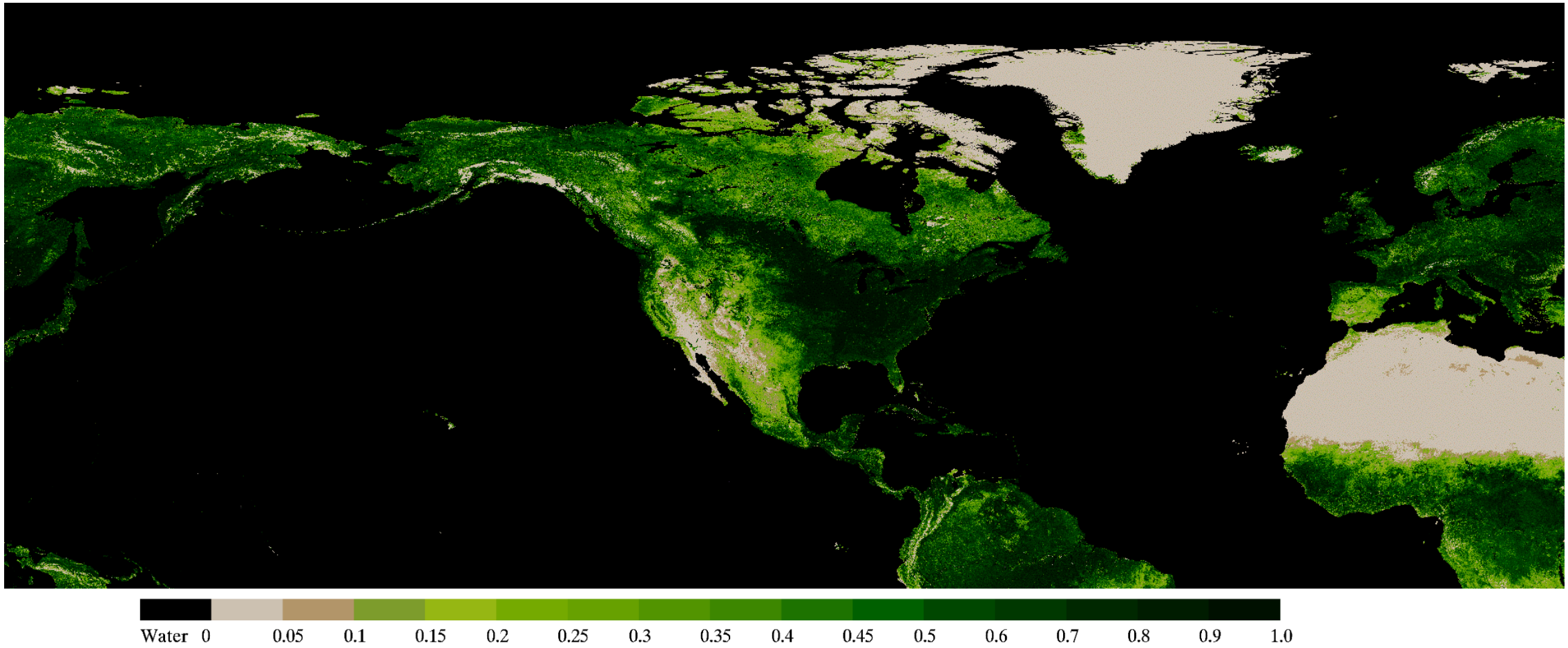
- The weekly global GVF map showed reasonable patterns of green vegetation fraction in July.



Visual Assessment of Regional GVF

- The weekly regional GVF map showed reasonable patterns of green vegetation fraction in July in the regional domain centered on North America

NOAA-21 VIIRS weekly regional GVF map (July 16-22, 2023)



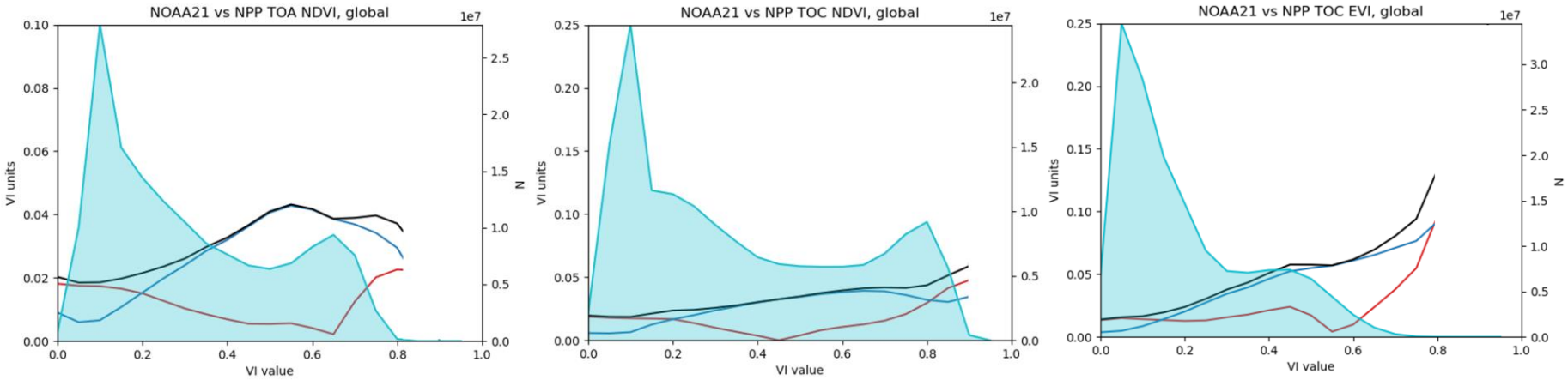
Processing Environment and Algorithms

- Processing environment and algorithms
  - System: NDE/NCCF
  - Higher-level code is Bash scripts, while lower-level code is C++
  - These are enterprise algorithms, with the same code capable of running with data from SNPP, NOAA-20, or NOAA-21 VIIRS
- Algorithm version
  - VI algorithm version: v2r1
  - GVF algorithm version: v3r0
  - Most recent algorithm delivery (code and documentation) was May 17, 2021
- Dataset
  - Data used for this provisional review : 20230614-20230809 and 20231014-20231213, obtained from SCDR

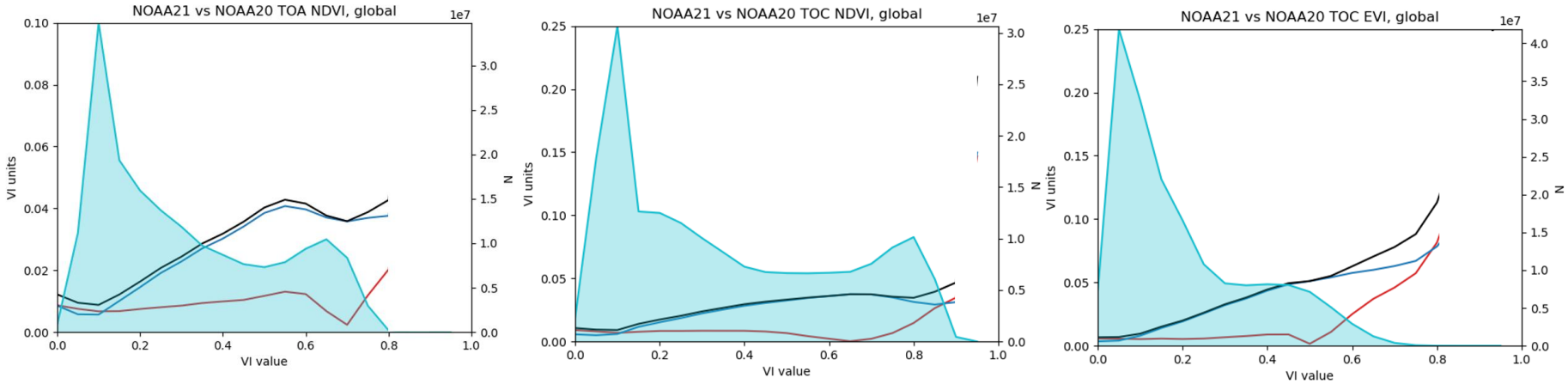
NOAA-21 vs. NOAA-20/SNPP Vegetation Index, stratified by VI value

Mean absolute difference
Standard deviation
RMS difference
Number of pixels

NOAA-21 *vs* SNPP



NOAA-21 *vs* NOAA-20

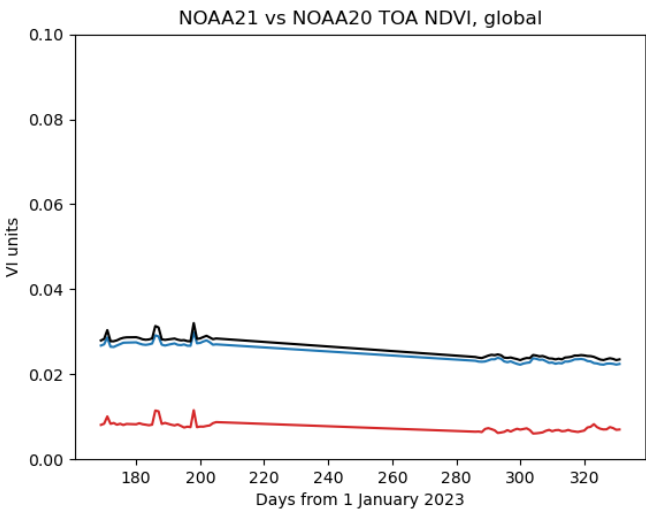


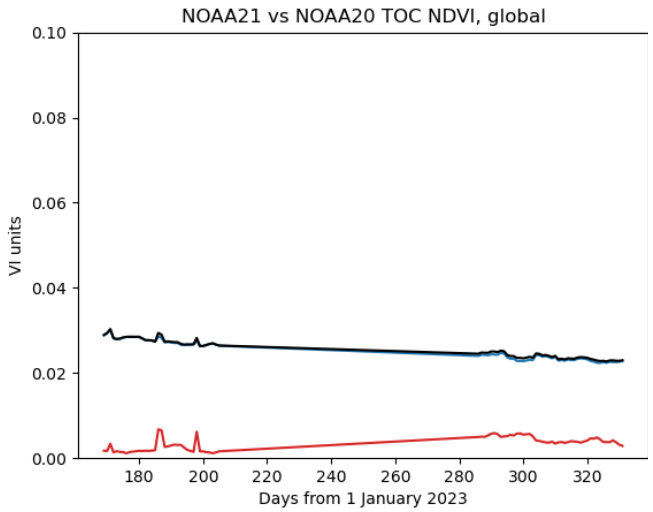
All statistics meet specifications, except for a small number of high VI value pixels.

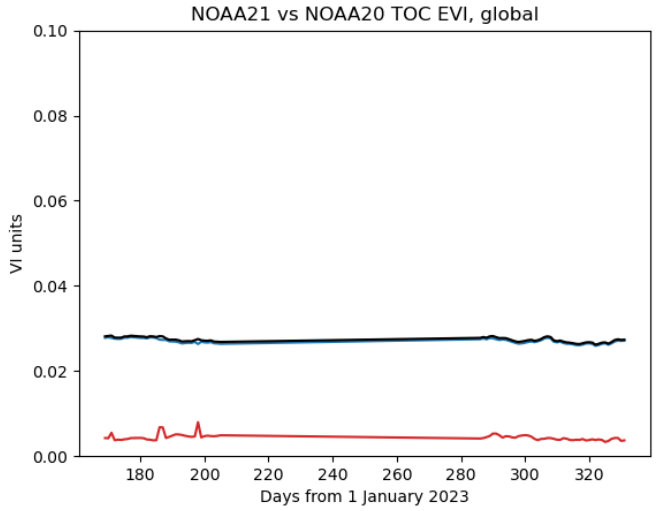
NOAA-21 vs. NOAA-20/SNPP VI statistics, time series

Mean absolute difference
Standard deviation
RMS difference

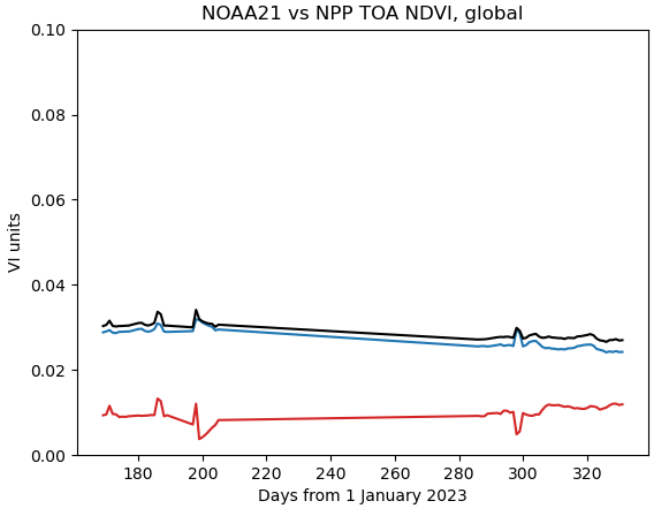
NOAA-21 *vs* NOAA-20

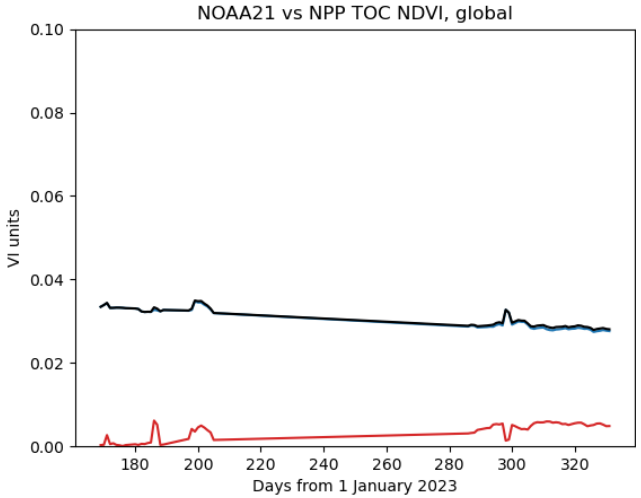


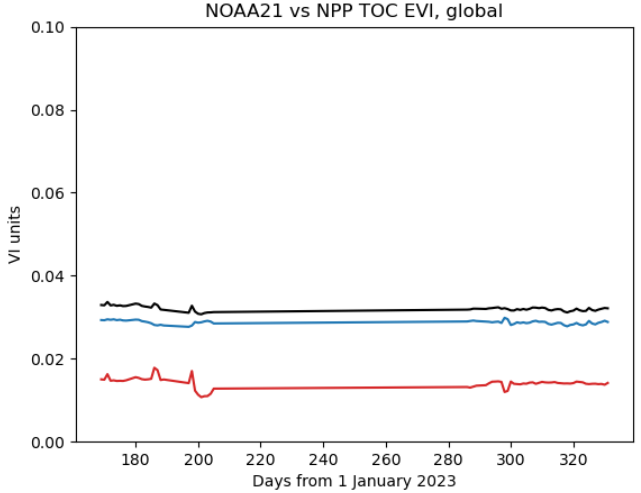




NOAA-21 *vs* SNPP







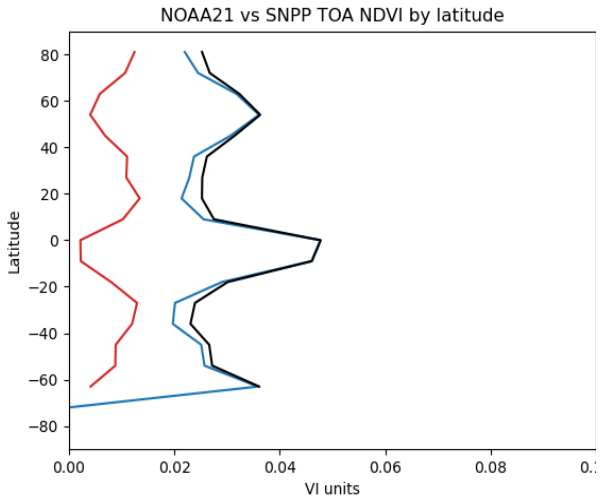
- Statistics meet specifications across time series
- Straight lines in middle of time series represent data gap between 20230809 and 20231014.

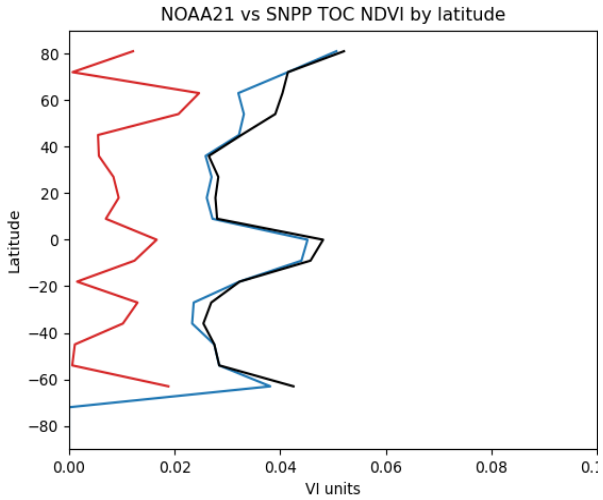
NOAA-21 vs. SNPP VI statistics, stratified by latitude

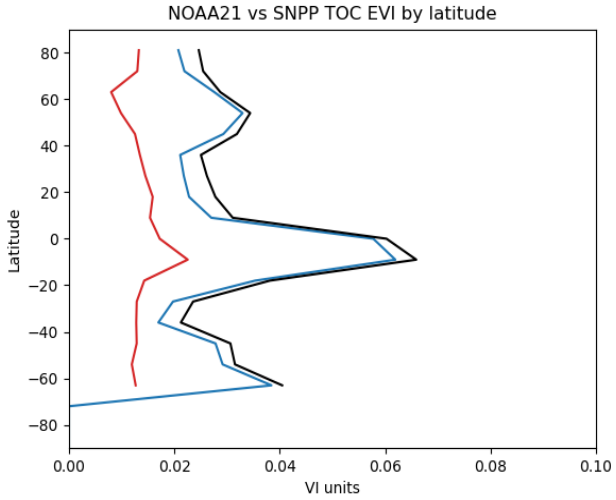
Mean absolute bias
Standard deviation
RMS difference

- RMS differences rarely exceeded 0.05 VI units.
- Differences were greatest at high latitudes and near the equator. This is to be expected, because these are the latitudes with the most cloud cover.

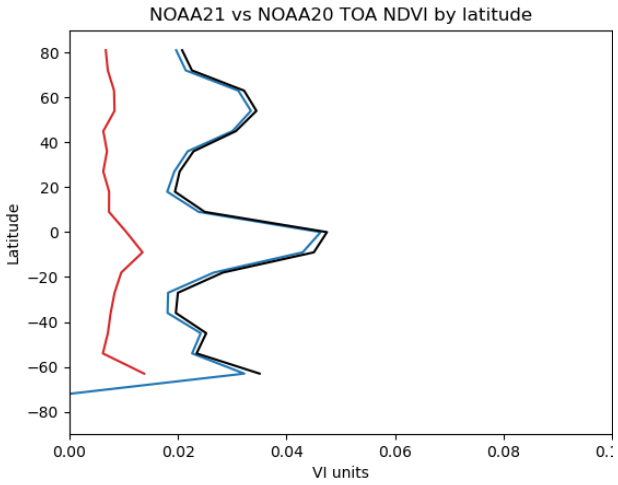
NOAA-21 *vs* SNPP

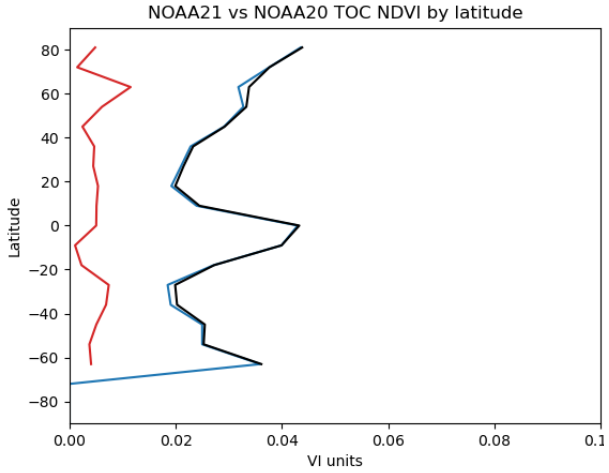


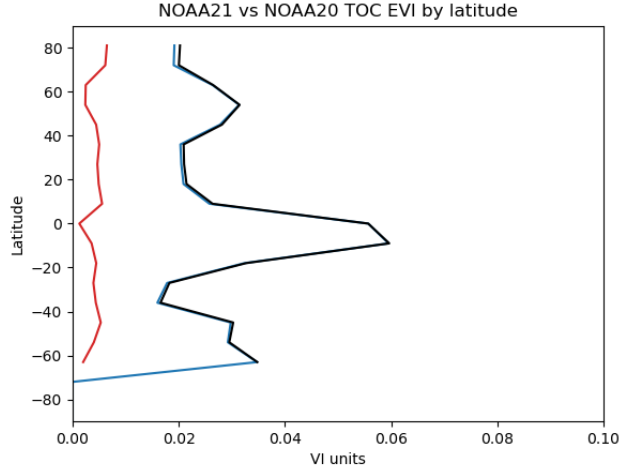




NOAA-21 *vs* NOAA-20P

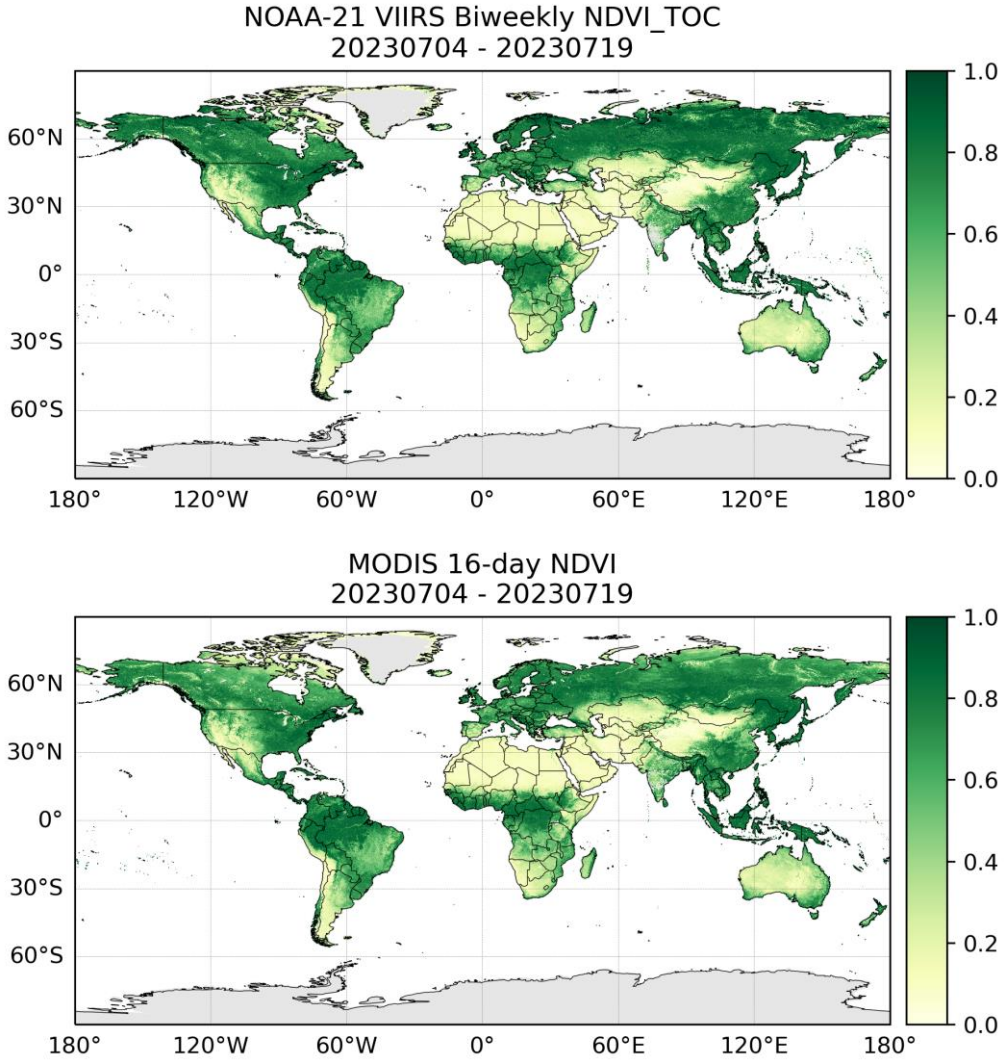




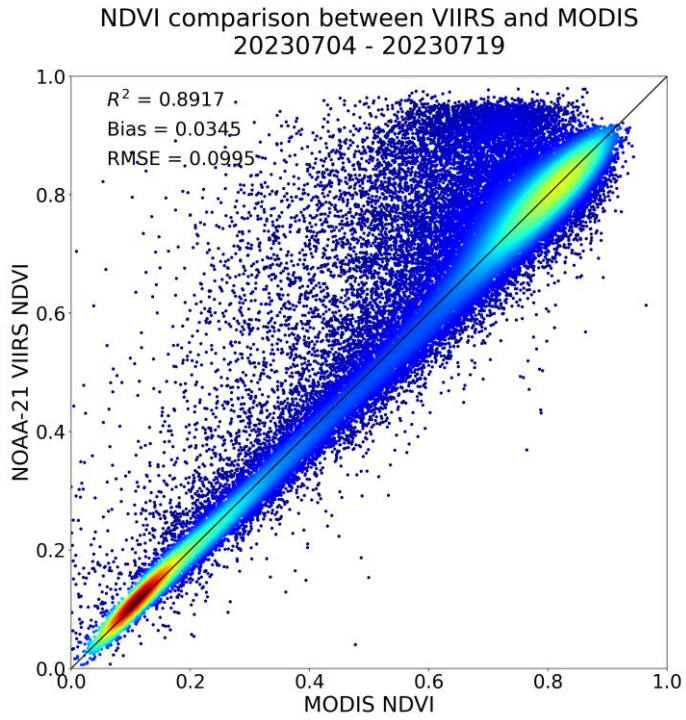


Global VI Inter-sensor Comparison with MODIS

- VIIRS 4km global v.s. MODIS 5km **TOC NDVI** product, a July case



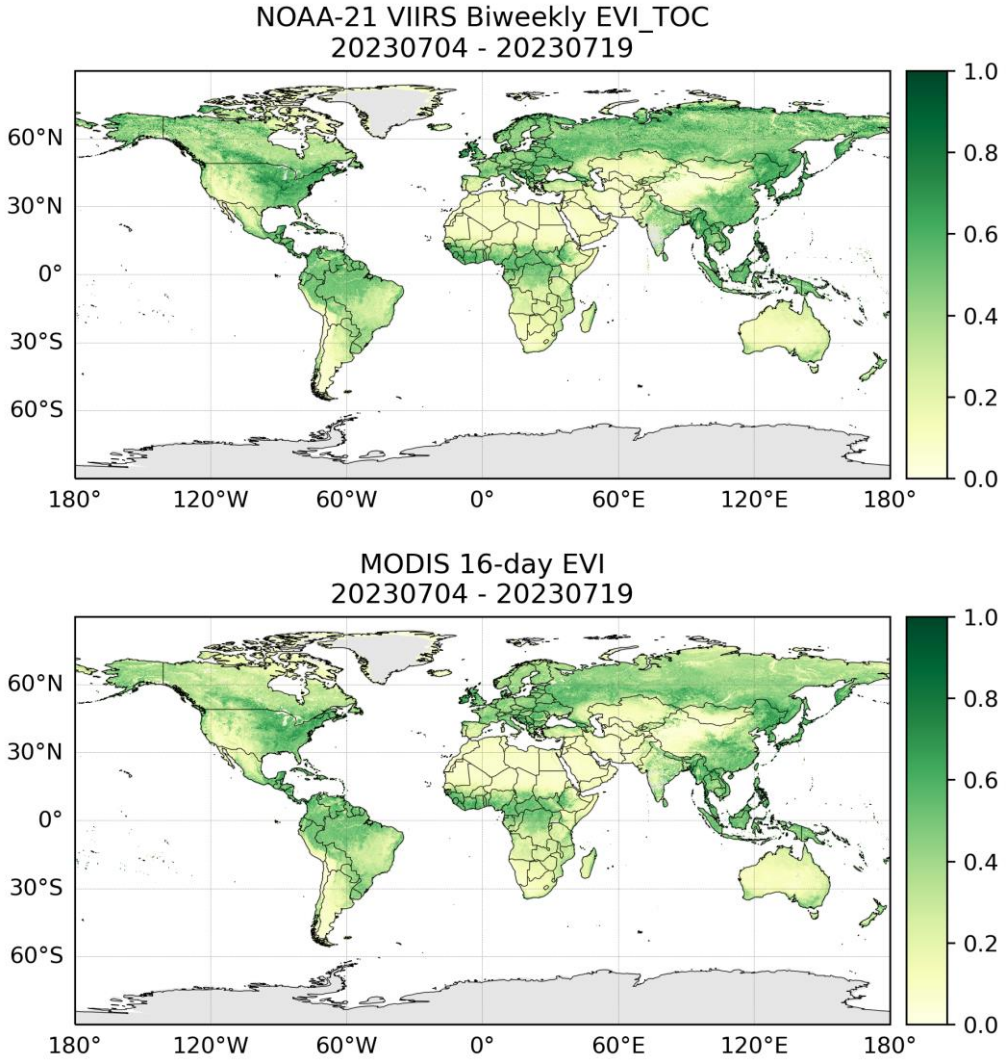
- VIIRS 4km global biweekly NDVI_TOC v.s. MODIS 5km 16-day NDVI (MxD13C1).
- VIIRS Biweekly VI product of 20230719 is selected to match with MODIS VI product of 20230704 due to the different definition of temporal composite between the two products.



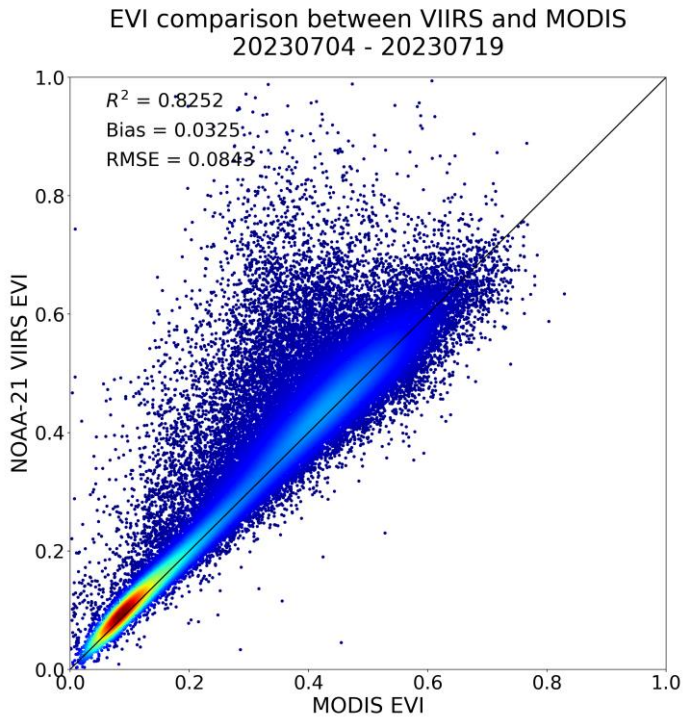
- Visual assessment shows similar distribution patterns at globe, and quantitative comparison also indicates high correlation (R^2 = 0.8917) and consistency (RMSE = 0.0995) between the two products.
- Minor differences are due to different band configurations between the two sensors and different temporal composite strategies.

Global VI Inter-sensor Comparison with MODIS

- VIIRS 4km global v.s. MODIS 5km **TOC EVI** product, a July case



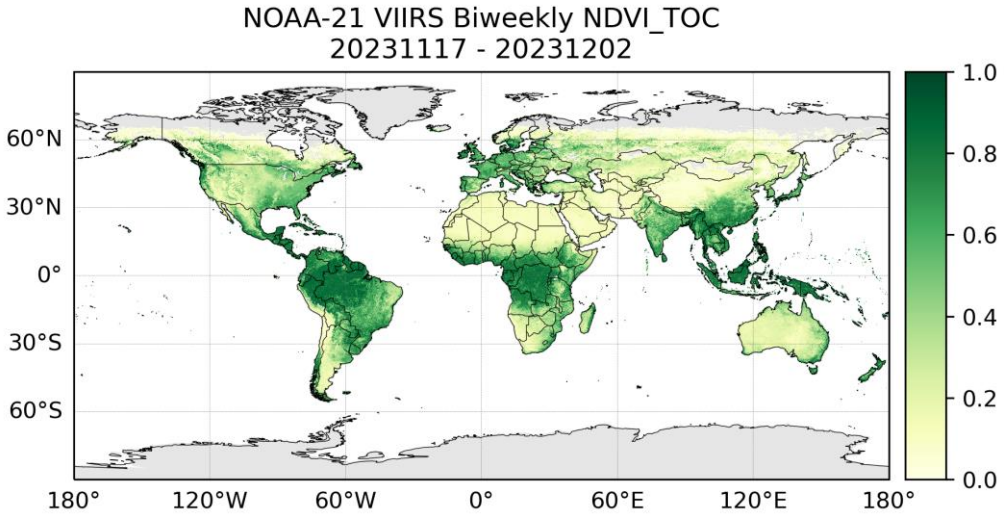
- VIIRS 4km global biweekly EVI_TOC v.s. MODIS 5km 16-day EVI (MxD13C1).
- VIIRS Biweekly VI product of 20230719 is selected to match with MODIS VI product of 20230704 due to the different definition of temporal composite between the two products.

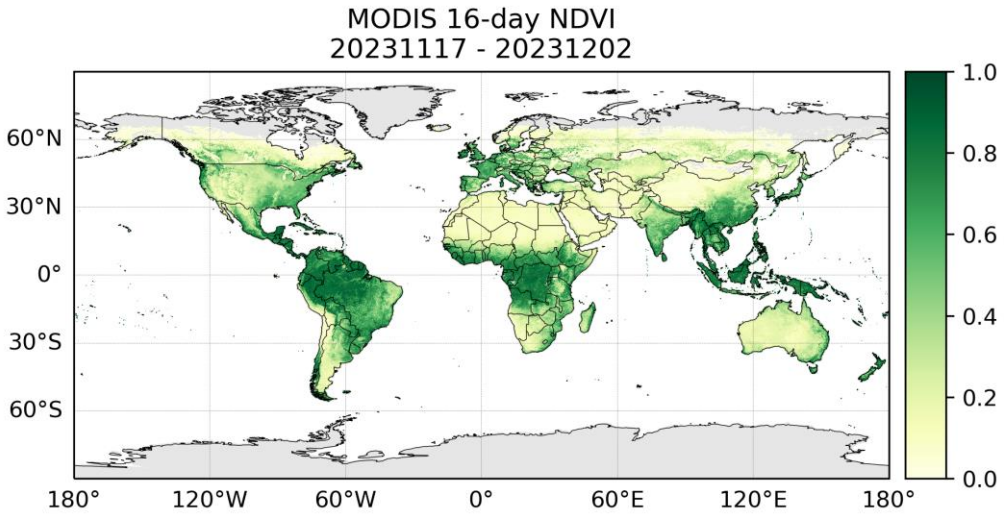


- Visual assessment shows similar distribution patterns at globe, and quantitative comparison also indicates high correlation (R^2 = 0.8252) and consistency (RMSE = 0.0843) between the two products.
- Minor differences are due to different band configurations between the two sensors and different temporal composite strategie.

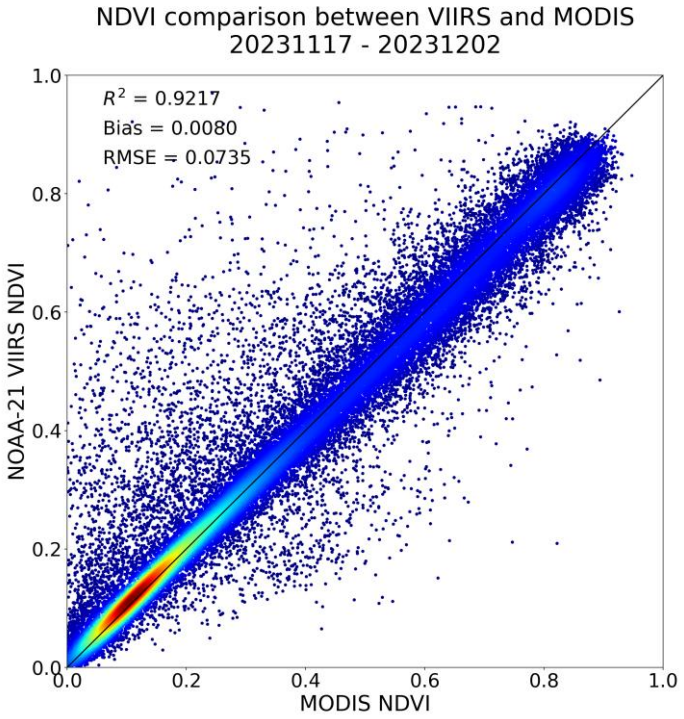
Global VI Inter-sensor Comparison with MODIS

- VIIRS 4km global v.s. MODIS 5km **TOC NDVI** product, a December case





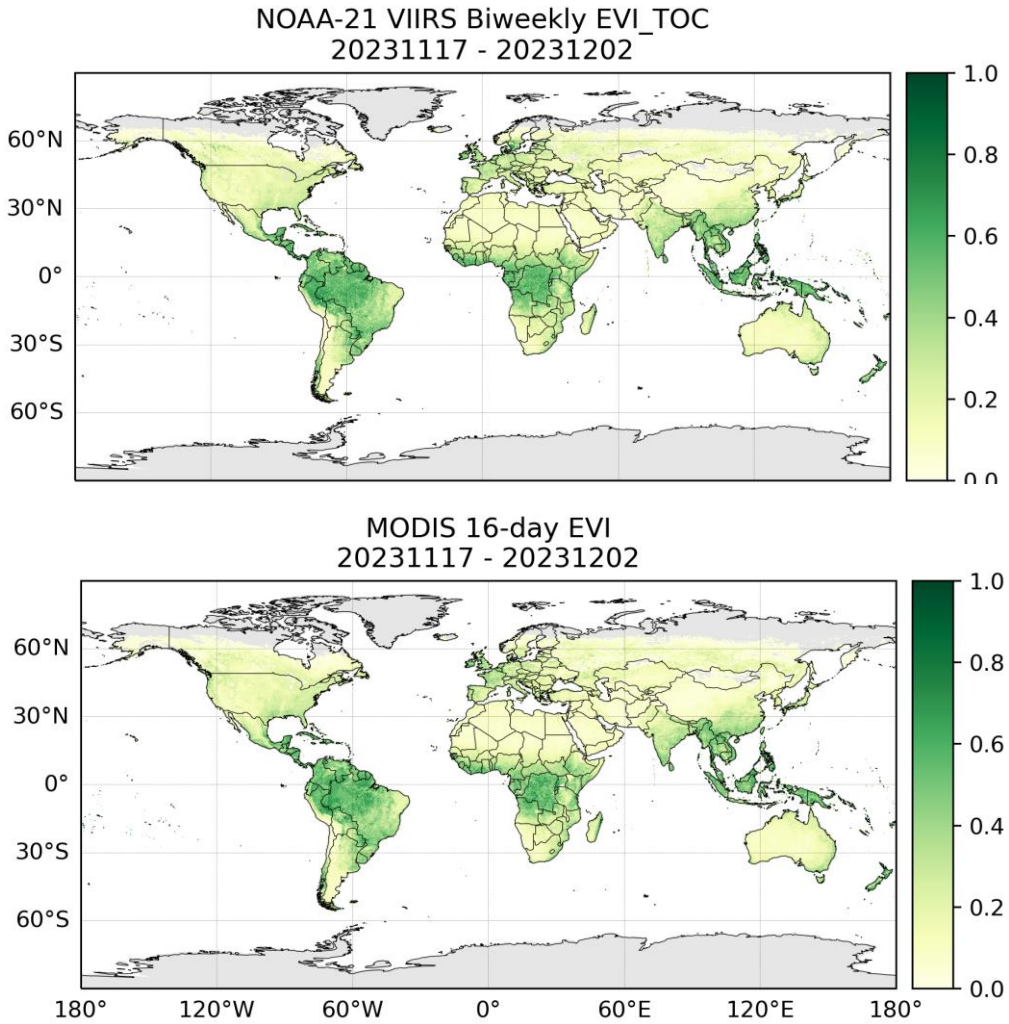
- VIIRS 4km global biweekly NDVI_TOC v.s. MODIS 5km 16-day NDVI (MxD13C1).
- VIIRS Biweekly VI product of 20231202 is selected to match with MODIS VI product of 20231117 due to the different definition of temporal composite between the two products.



- Visual assessment shows similar distribution patterns at globe, and quantitative comparison also indicates high correlation (R^2 = 0.9217) and consistency (RMSE = 0.0735) between the two products.
- Consistency is higher in NH winter than that in summer.

Global VI Inter-sensor Comparison with MODIS

- VIIRS 4km global v.s. MODIS 5km **TOC EVI** product, a December case



- VIIRS 4km global biweekly EVI_TOC v.s. MODIS 5km 16-day EVI (MxD13C1).
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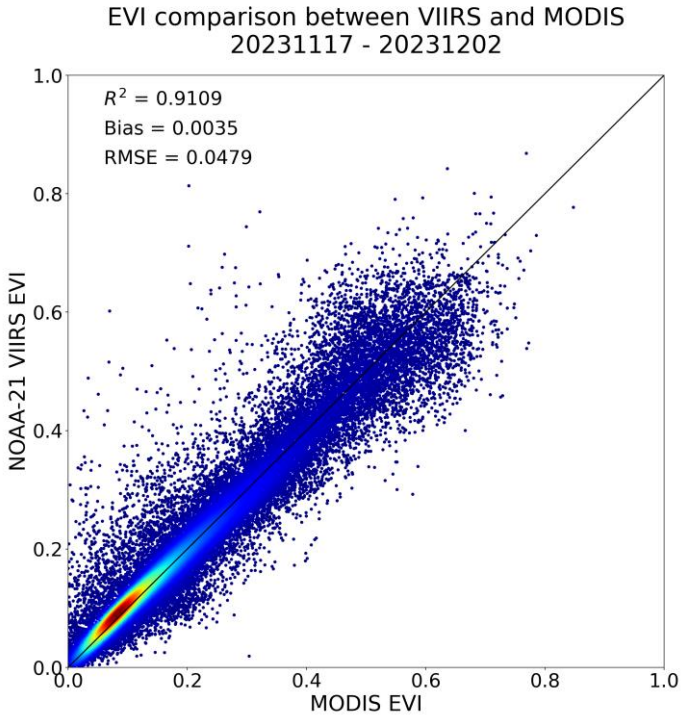


- Visual assessment shows similar distribution patterns at globe, and quantitative comparison also indicates high correlation (R^2 = 0.9109) and consistency (RMSE = 0.0479) between the two products.
- Consistency is higher in NH winter than that in summer.

Regional VI Inter-sensor Comparison with MODIS

In the Back-up

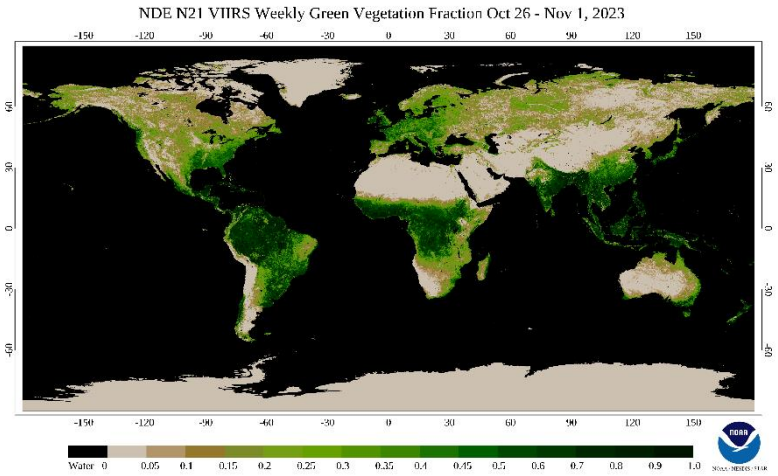
NOAA-21 GVF Evaluation Methods

- Compared the NOAA-21 GVF with NOAA-20 GVF and SNPP GVF and found them the NOAA-21 GVF is consistent with them

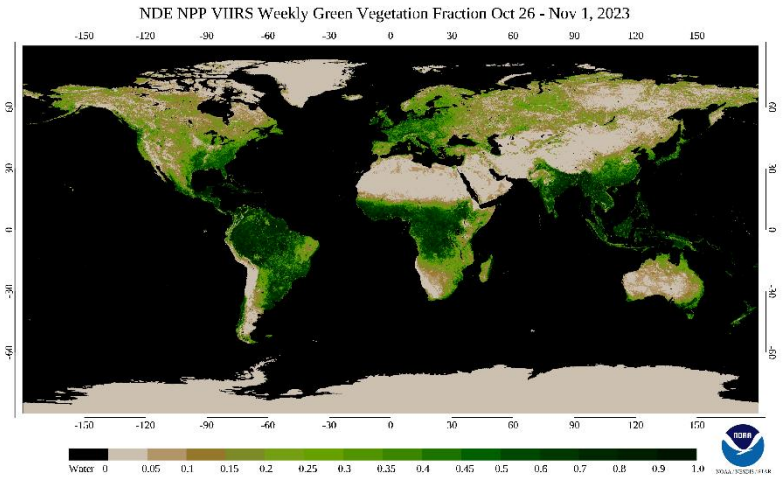
- Validated the NOAA-21 GVF using high resolution Google Earth satellite images and found that the NOAA-21 GVF was consistent with the Google Earth data

Compare N21 GVF with SNPP GVF

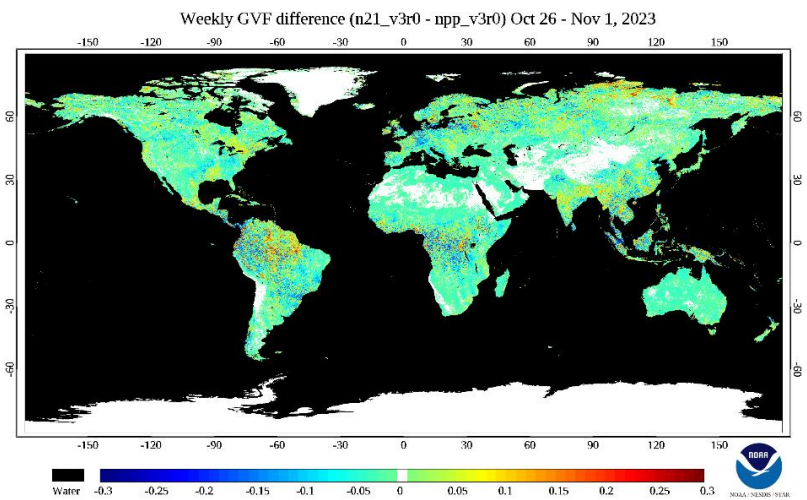
N21 GVF



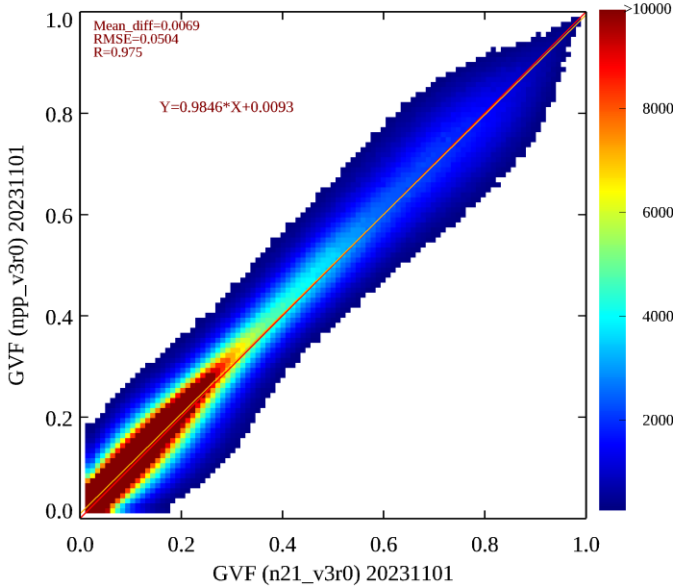
SNPP GVF

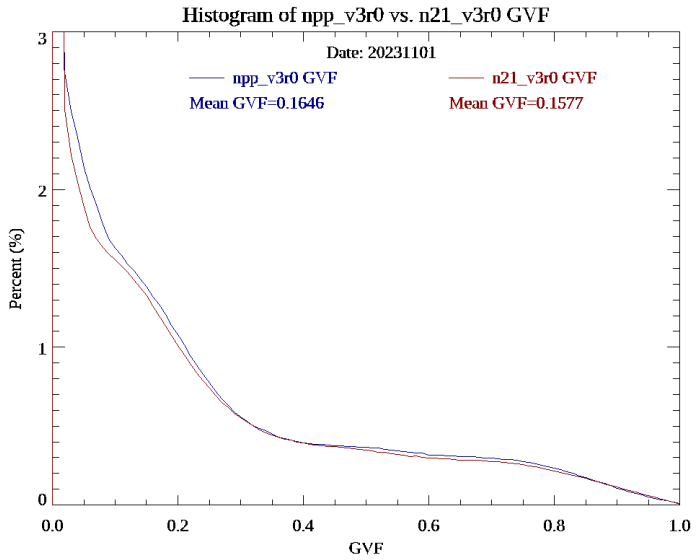


GVF difference



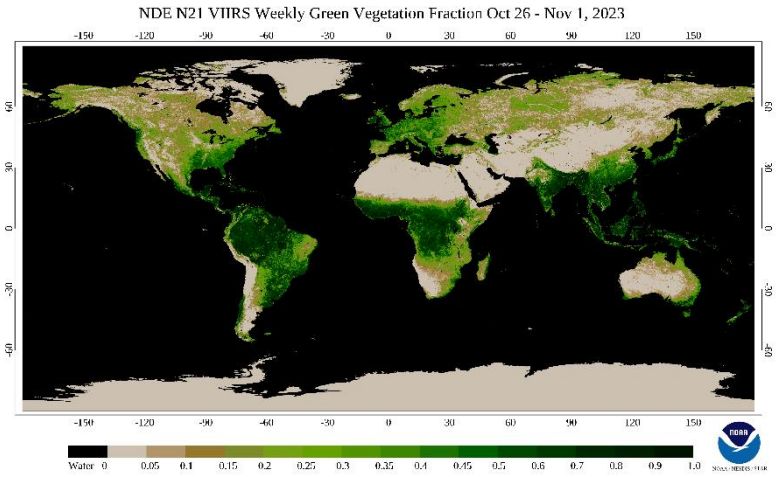
- The N21 GVF map is consistent with the operational SNPP GVF
- The GVF difference map showed very small difference globally
- GVF histograms of the two GVF datasets matched very well



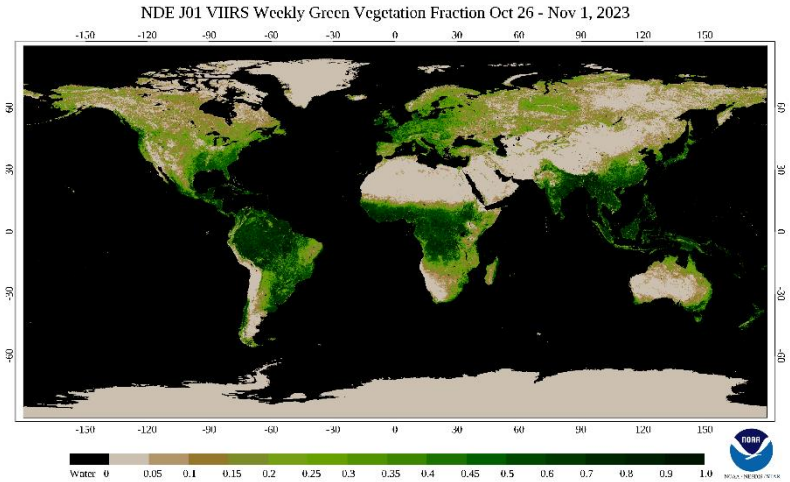


Compare N21 GVF with N20 GVF

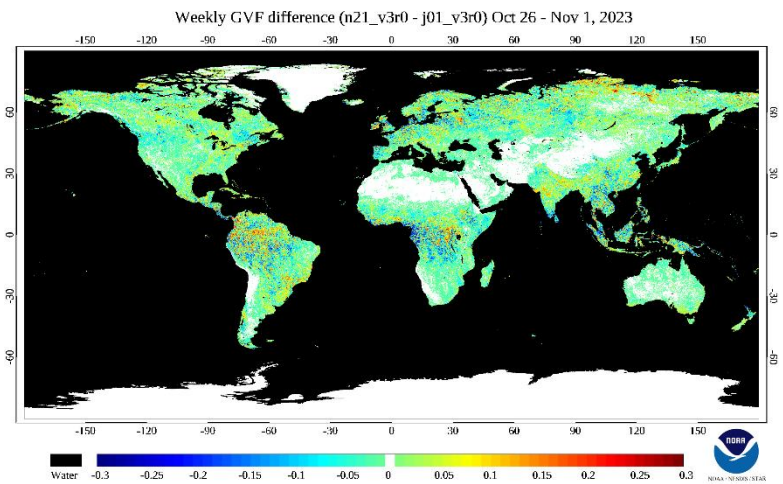
N21 GVF



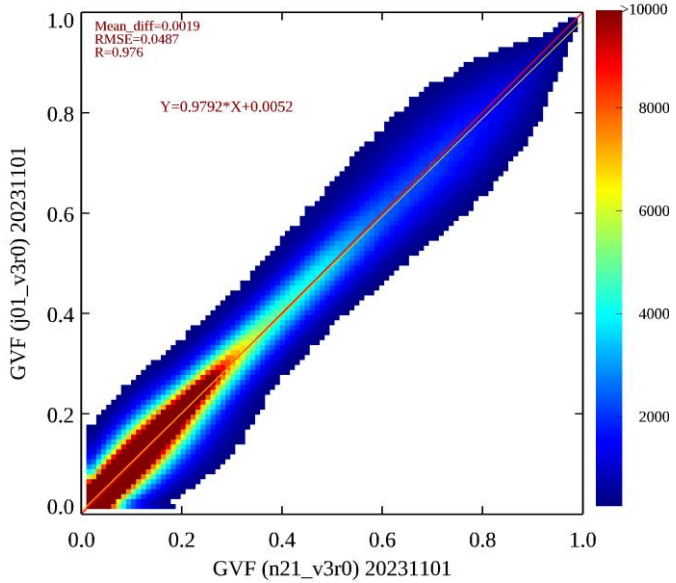
N20 GVF

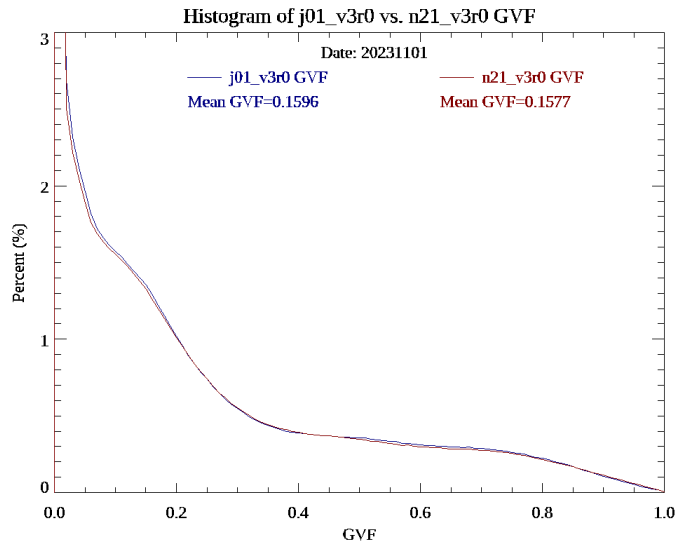


GVF difference



- The N21 GVF map is consistent with the operational N20 GVF.
- The GVF difference map showed very small difference globally
- GVF histograms of the two GVF datasets matched very well





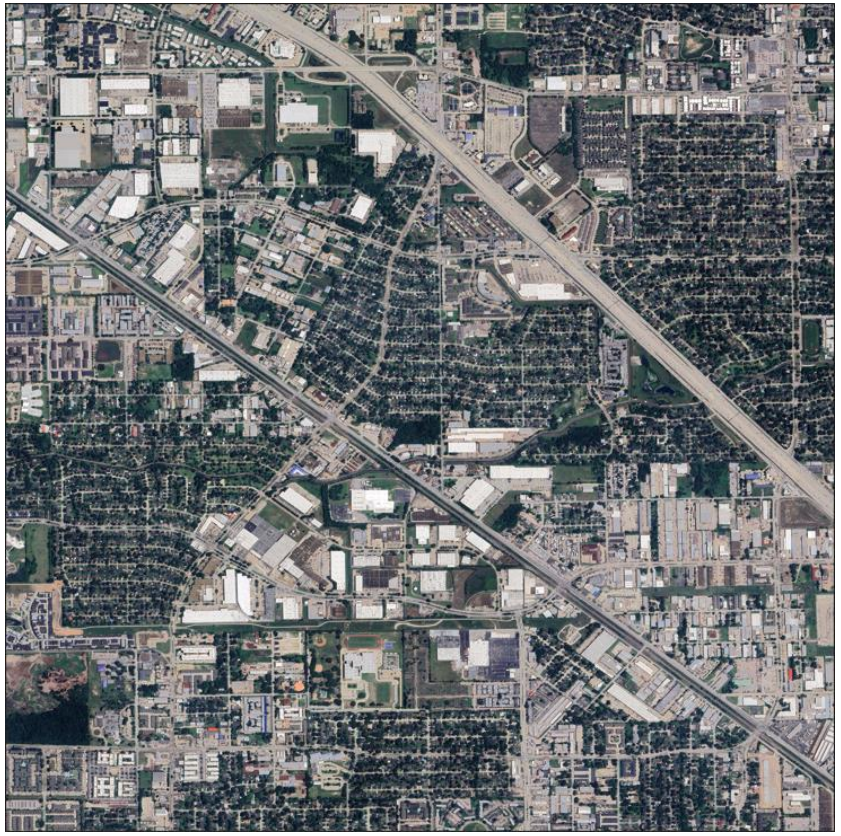
Validate GVF using Google Earth images: Data and method

- High resolution (~1-m) RBG images with imagery dates are available on Google Earth
- Google Earth images over VIIRS GVF pixels, areas of 0.036° by 0.036°, were downloaded from Google Earth
- Green pixels on the high resolution Google Earth images were extracted by using a Green Color index (GCI)
  - ***GCI = (3*Green-2.4*Red-Blue)/(Red+Green+Blue)***
  - ***If GCI > 0 then the pixel is classified as a green vegetation pixel***
  - ***GVF = percentage of pixels where GCI > 0***
- GVF of Google Earth images were compared with NOAA-21 VIIRS GVF
- 36 high resolution Google Earth images were downloaded from Google Earth for GVF validation

Google Earth results example: Houston

High resolution Google Earth image:

(6912×6912) pixels



Google Earth image over a 0.036-degree VIIRS GVF pixel

(5/30/2023)

Classified image (vegetation pixel: green)

Google Earth GVF=0.253
N21 VIIRS GVF=0.220

Google Earth results example: Alhambra_valley

High resolution
Google Earth image:

(6912×7168) pixels

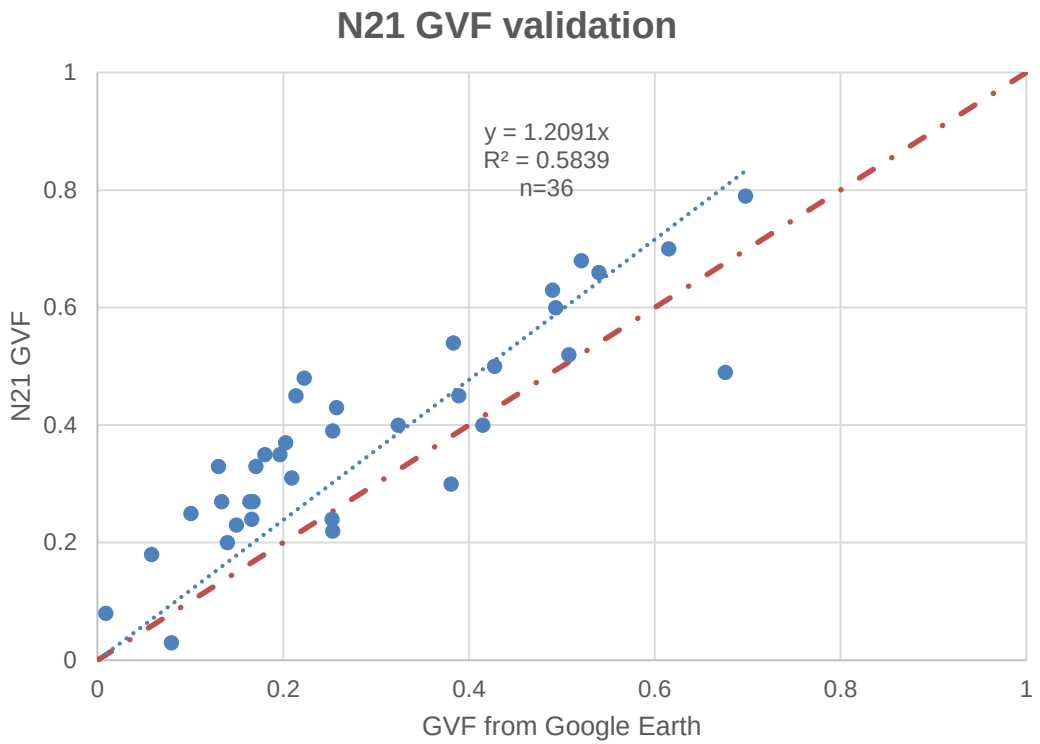
Google Earth image over a 0.036-degree VIIRS GVF pixel

Classified image
(vegetation pixel: green)

(7/27/2023)

Google Earth GVF=0.257
N21 VIIRS GVF=0.43

VIIRS 4-km GVF compared with Google Earth GVF



- Overall, NOAA-21 VIIRS GVF is consistent with the GVF derived from Google Earth images
- The NOAA-21 VIIRS GVF has relatively low bias (0.093), precision (0.089), and small uncertainty (0.128), that are within the threshold values of the requirement.
- There is a positive bias between NOAA-21 GVF and that from Google Earth

	Accuracy	Precision	Uncertainty
NOAA-21 GVF	0.093	0.089	0.128
Requirement	0.12	0.15	0.17

VIIRS GVF/ Google Earth validation conclusion

- High resolution (~1m) green pixels can be identified using a green color index and GVF can be derived from Google Earth RGB images
- Fairly good agreement was found between the VIIRS GVF and the GVF derived from Google Earth images
- The VIIRS GVF has relatively low bias (0.093), and small uncertainty (0.128), indicating that N21 GVF met the requirements
- Only 4 months of N21 GVF data are available for validation. The number of Google Earth images is limited within the 4-month period.
- The N21 GVF data were produced on the NDE I&T environment (not operational run) and data production is discontinuous, which may impact the quality of the data since the GVF algorithms relays on a short term (weekly) and a long term (15 weeks) temporal smoothing processes
- Further validation is needed when more N21 GVF are available, particularly for a long term time series comparison

Error Budget - VI

Attribute Analyzed	Requirement/ Threshold	Pre-Launch Performance	On-orbit Performance		Meet Requirement ?	Additional Comments
			NOAA-21 vs NOAA-20	NOAA-21 vs. SNPP		
Accuracy (TOA NDVI)	0.05	NA	0.00753	0.00983	Yes	NA
Precision (TOA NDVI)	0.04	NA	0.0248	0.0271	Yes	NA
Accuracy (TOC NDVI)	0.05	NA	0.00355	0.00373	Yes	NA
Precision (TOC NDVI)	0.04	NA	0.0251	0.0304	Yes	NA
Uncertainty (TOC EVI)	0.11	NA	0.0274	0.0321	Yes	NA

VI errors are mean values across all available data from 20230614-20230809 and 20231014-20231213. Comparisons are between NOAA-21 and NOAA-20, and between NOAA-21 and SNPP, as no independent comparisons are possible due to the nature of the VI variable.

Error Budget - GVF

Attribute Analyzed	Requirement/ Threshold	Pre-Launch Performance	On-orbit Performance			Meet Requirement ?	Additional Comments
			NOAA-21 vs NOAA-20	NOAA-21 vs. SNPP	NOAA-21 vs. Google Earth		
Accuracy	12%	NA	0.19%	0.69%	9.3%	Yes	NA
Precision	15%	NA	4.87%	5.04%	8.9%	Yes	NA

GVF errors are mean values across all available data from 20230614-20230809 and 20231014-20231213. Comparisons are between NOAA-21 and NOAA-20, between NOAA-21 and SNPP, and between NOAA-21 and Google Earth data.

User Engagement

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Helin Wei	NCEP/EMC	EMC NWP models	VIIRS GVF is replacing AVHRR-based 5-year climatology GVF in EMC models.
Heshun Wang	NOAA/STAR	Land Surface Emissivity (LSE) product	GVF is an essential input data for the NOAA LSE product, which is based on the vegetation cover method. VIIRS daily rolling weekly GVF is used to account for the LSE dynamic variation. The LSE product has been operationally used in the VIIRS LST product and will be incorporated into the GOES16/17 ABI LST product in the future.
Tanya Smirnova	NOAA/ESRL	RAP and HRRR models	VIIRS GVF is used in RAPv4 and HRRRv3 models at NCEP.
Jonathan Case	NASA/SPoRT	NASA/SPoRT land surface model	VIIRS GVF is imported into NASA/SPoRT's real-time Noah land surface model runs using the NASA Land Information System framework.
CLASS	NOAA	Archive	VIIRS VI and GVF data are archived in the NOAA CLASS system, where they are available to the general public.

Risks, Actions, and Mitigations

Identified Risk	Description	Impact	Action/Mitigation and Schedule
Missing data	NOAA-21 VI and GVF in the I&T environment, where it is currently being produced, has issues with missing data, including a stretch of missing data between August and October 2023.	High	Once NOAA-21 processing is moved into the operational environment, missing data should be less frequent
Missing historical data	When GVF processing has been re-started in the past, it has been done without the required historical data	Moderate	Whenever an update to GVF is put into production, it should be checked whether this historical data are being used in processing.
Operations slow to address issues	When changes were made to the VI and GVF code in the past to resolve issues, these changes have taken a long time (months) to be reflected in operations.	High	Every time a change is made to resolve an issue, the operations team must act on it quickly. The science team must provide feedback to the operational team on these issues and their resolution.

Documentation

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes (For NOAA-21 Provisional Maturity specifically)
Algorithm Theoretical Basis Document (ATBD)	Yes*
Algorithm Calibration/Validation Plan	Yes*
(External/Internal) Users Manual	Yes*
System Maintenance Manual (for ESPC products)	Yes*
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	In preparation*
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes*

The asterisk (*) indicates a document shared with NOAA-20 and S-NPP counterpart VI and GVF products.

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.	Yes. The products have been validated against VI and GVF from the other JPSS satellites and against VI from MODIS, with global coverage and a months-long time series
Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.	Yes. The validation demonstrates a high probability that the product meets specifications, referring to the consistency between NOAA-21 and the NOAA-20, SNPP counterparts which both meet specifications.
Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.	Yes. This document has recorded that the VI and GVF products meet specifications.
Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.	Yes. The product is recommended for operational use.

Conclusion

- The NOAA-21 VIIRS Vegetation Index and Green Vegetation Fraction products were evaluated using data from June to December 2023 (with some data gaps).
- Comparisons with counterpart products from NOAA-20/S-NPP, MODIS, and Google Earth data indicate that the NOAA-21 performance meets the specified product requirements.
- The Vegetation Team recommends releasing the NOAA-21 Vegetation Index and Green Vegetation Fraction products as a provisional maturity version on the date specified in the Provisional Maturity Readme file.

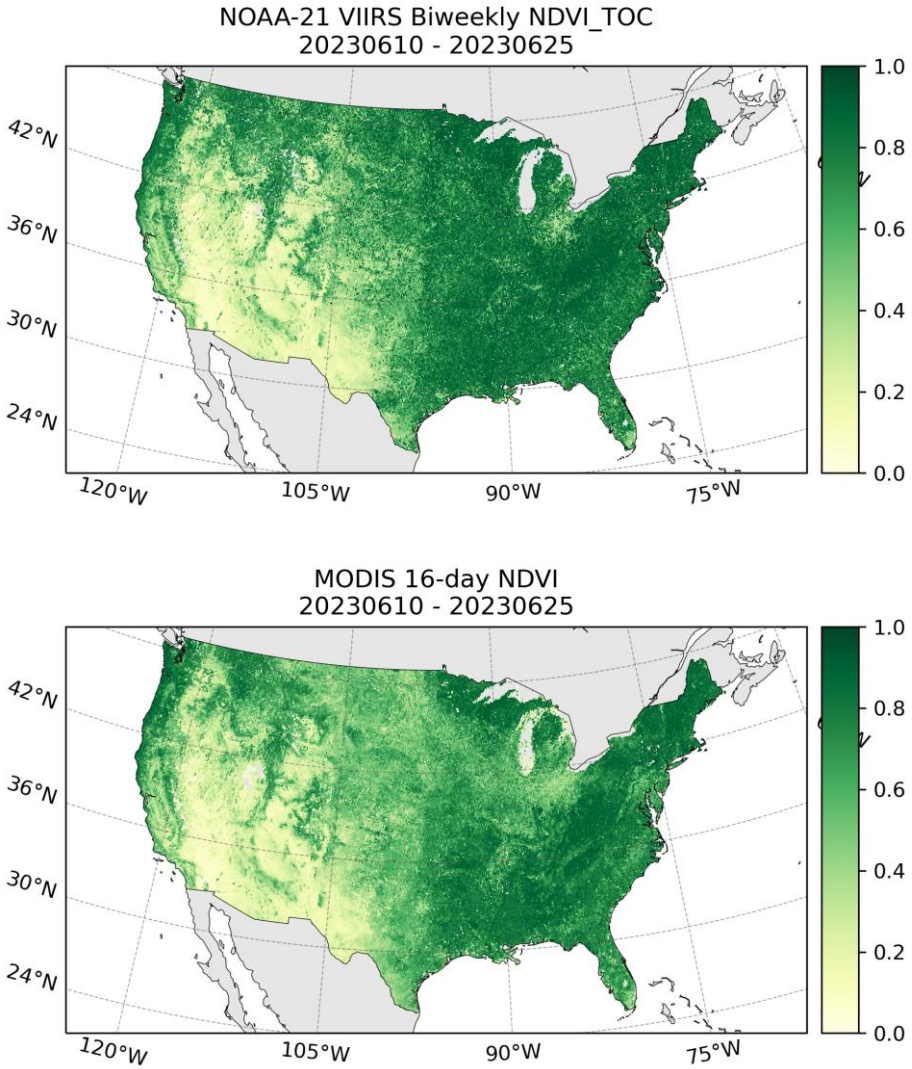
Path Forward

- Future Cal/Val activities
  - Implement the LTM adaptations with routine NOAA-21 VI and GVF data; routine cross-comparisons
  - Search for qualified in-situ reference data
  - Validated maturity Review
- User engagement
  - Application in NCEP models and in producing NESDIS/ STAR data
- Improved VI and GVF products
  - 1km global VI and GVF products
  - High resolution VI and GVF data
  - Blended VI and GVF products with all available VIIRS data

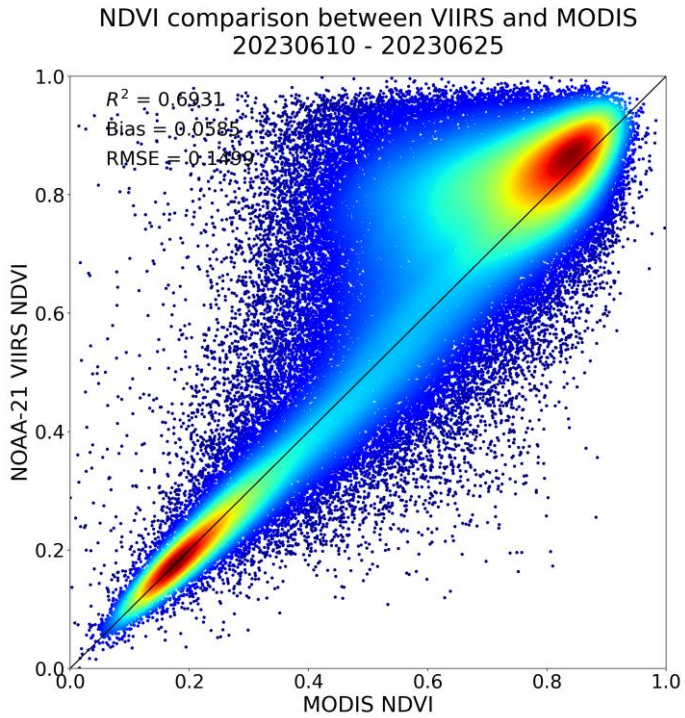
Back-up slides

CONUS VI Inter-sensor Comparison with MODIS

- VIIRS 1km CONUS v.s. MODIS 1km **TOC NDVI** product, a June case



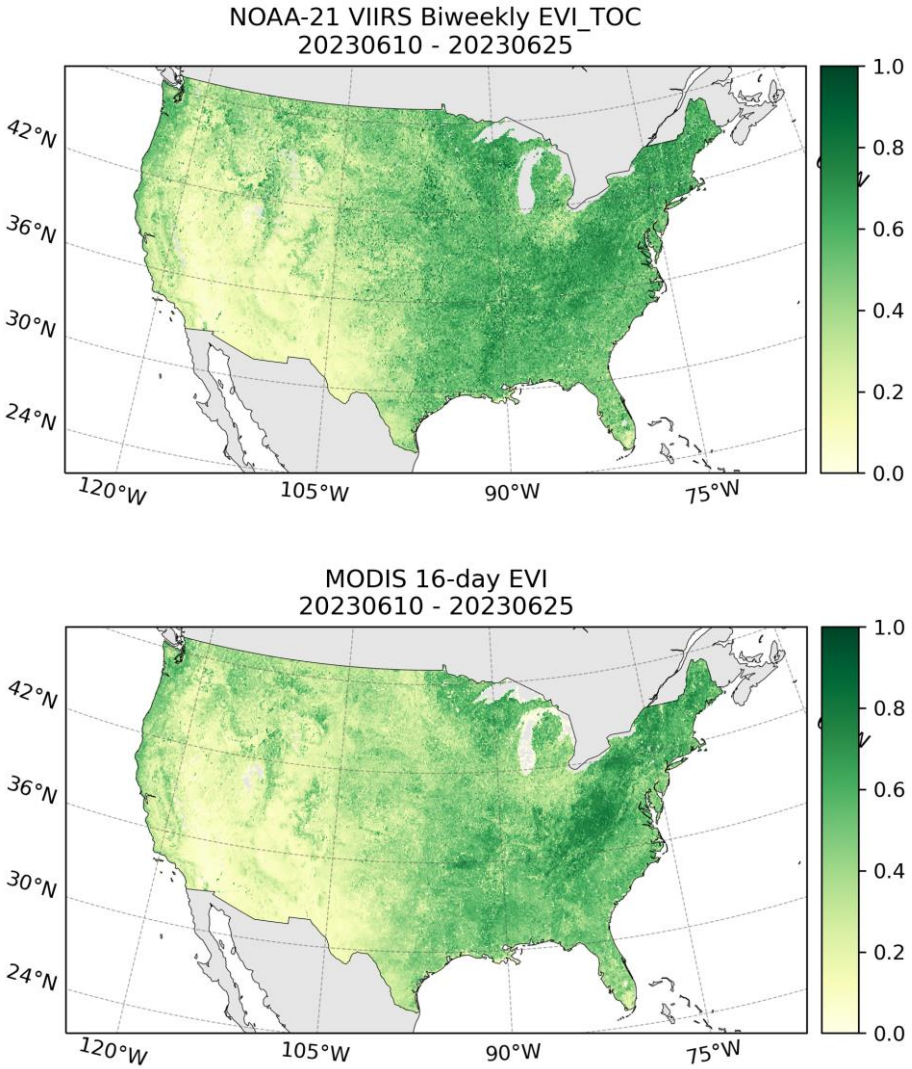
- VIIRS 1km regional biweekly NDVI_TOC v.s. MODIS 1km 16-day NDVI (MxD13A2).
- VIIRS Biweekly VI product of 20230625 is selected to match with MODIS VI product of 20230610 due to the different definition of temporal composite between the two products.



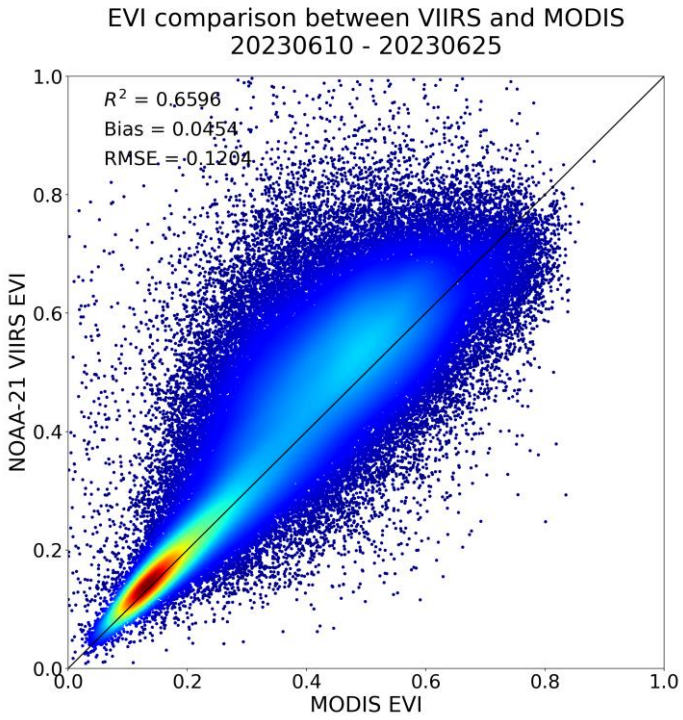
- Visual assessment shows similar distribution patterns at CONUS, and quantitative comparison also indicates moderate correlation (R^2 = 0.6931) and consistency (RMSE = 0.1499) between the two products.
- Differences are mainly due to the VZA exclusion and temporal composite strategies.

CONUS VI Inter-sensor Comparison with MODIS

- VIIRS 1km CONUS v.s. MODIS 1km **TOC EVI** product, a June case



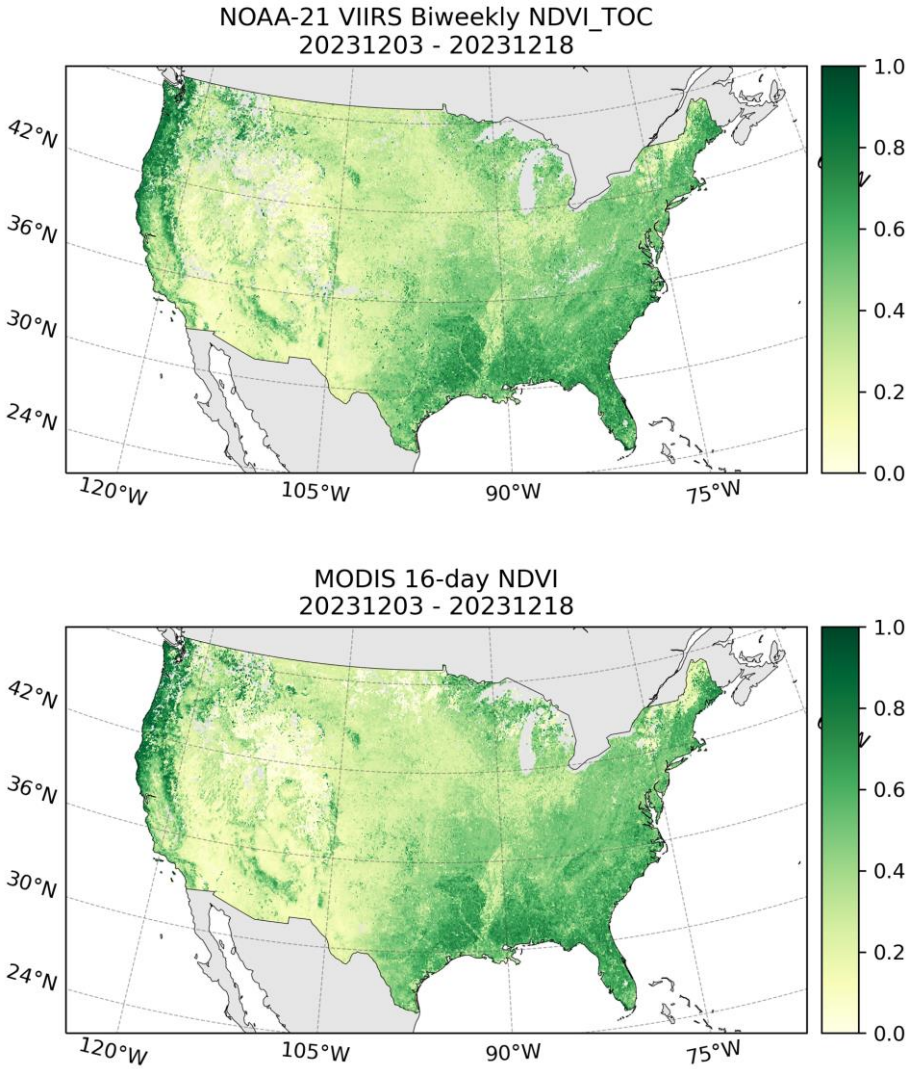
- VIIRS 1km regional biweekly EVI_TOC v.s. MODIS 1km 16-day EVI (MxD13A2).
- VIIRS Biweekly VI product of 20230625 is selected to match with MODIS VI product of 20230610 due to the different definition of temporal composite between the two products.



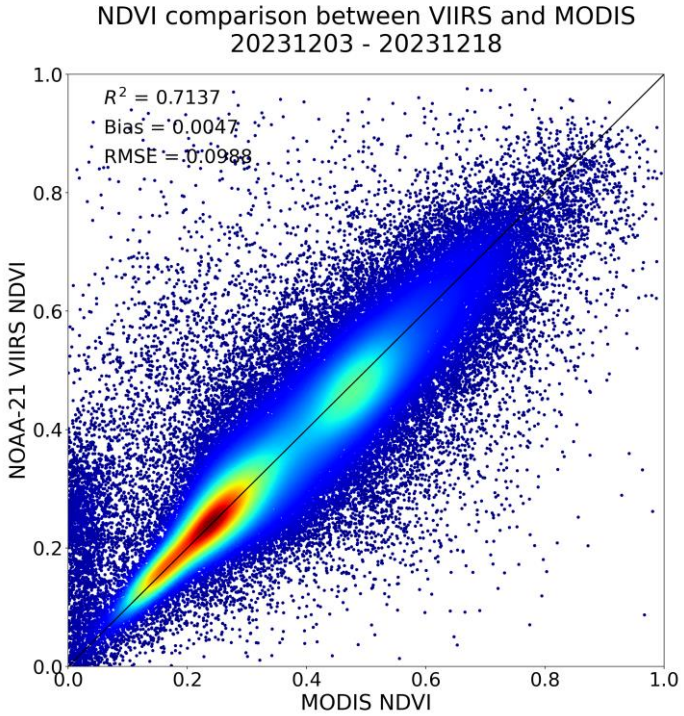
- Visual assessment shows similar distribution patterns at CONUS, and quantitative comparison also indicates moderate correlation (R^2 = 0.6598) and consistency (RMSE = 0.1288) between the two products.
- Differences are mainly due to the VZA exclusion and temporal composite strategies.

CONUS VI Inter-sensor Comparison with MODIS

- VIIRS 1km CONUS v.s. MODIS 1km **TOC NDVI** product, a December case



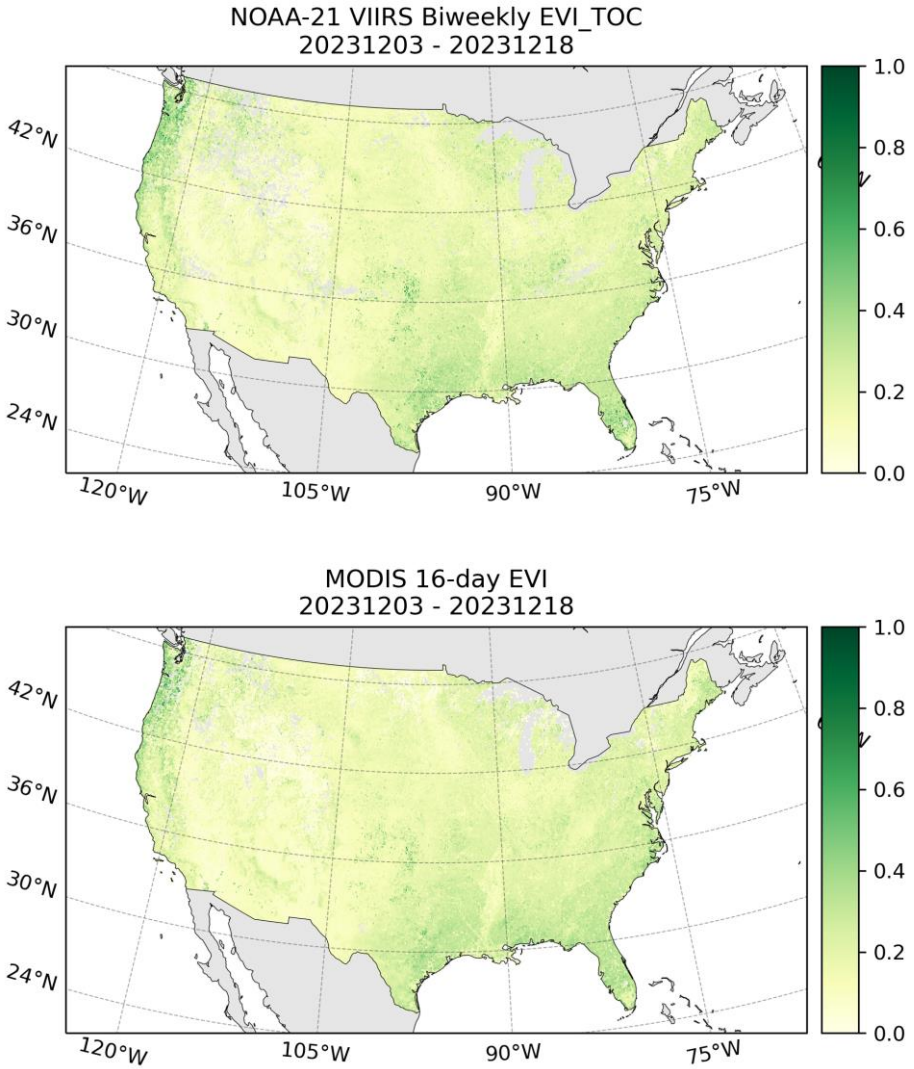
- VIIRS 1km regional biweekly NDVI_TOC v.s. MODIS 1km 16-day NDVI (MxD13A2).
- VIIRS Biweekly VI product of 20231218 is selected to match with MODIS VI product of 20231203 due to the different definition of temporal composite between the two products.



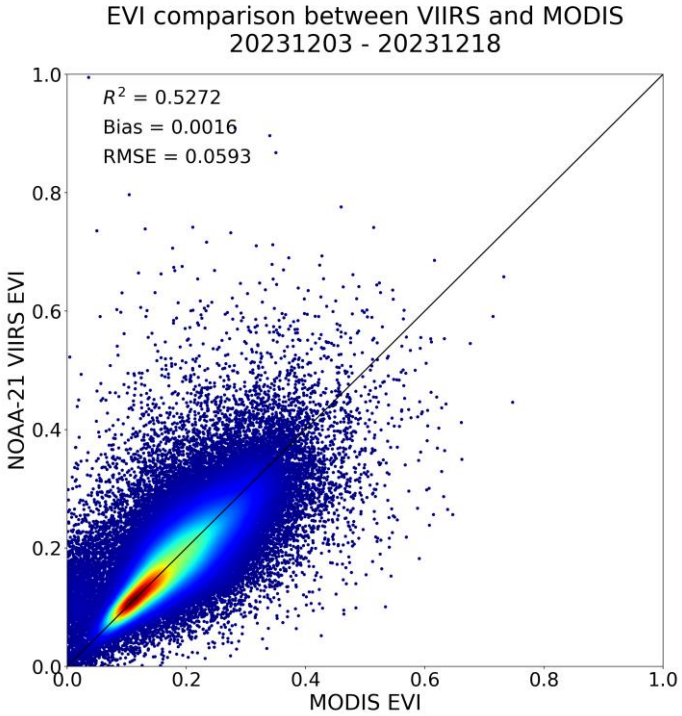
- Visual assessment shows similar distribution patterns at CONUS, and quantitative comparison also indicates high correlation (R^2 = 0.7137) and consistency (RMSE = 0.0988) between the two products.

CONUS VI Inter-sensor Comparison with MODIS

- VIIRS 1km CONUS v.s. MODIS 1km **TOC EVI** product, a December case



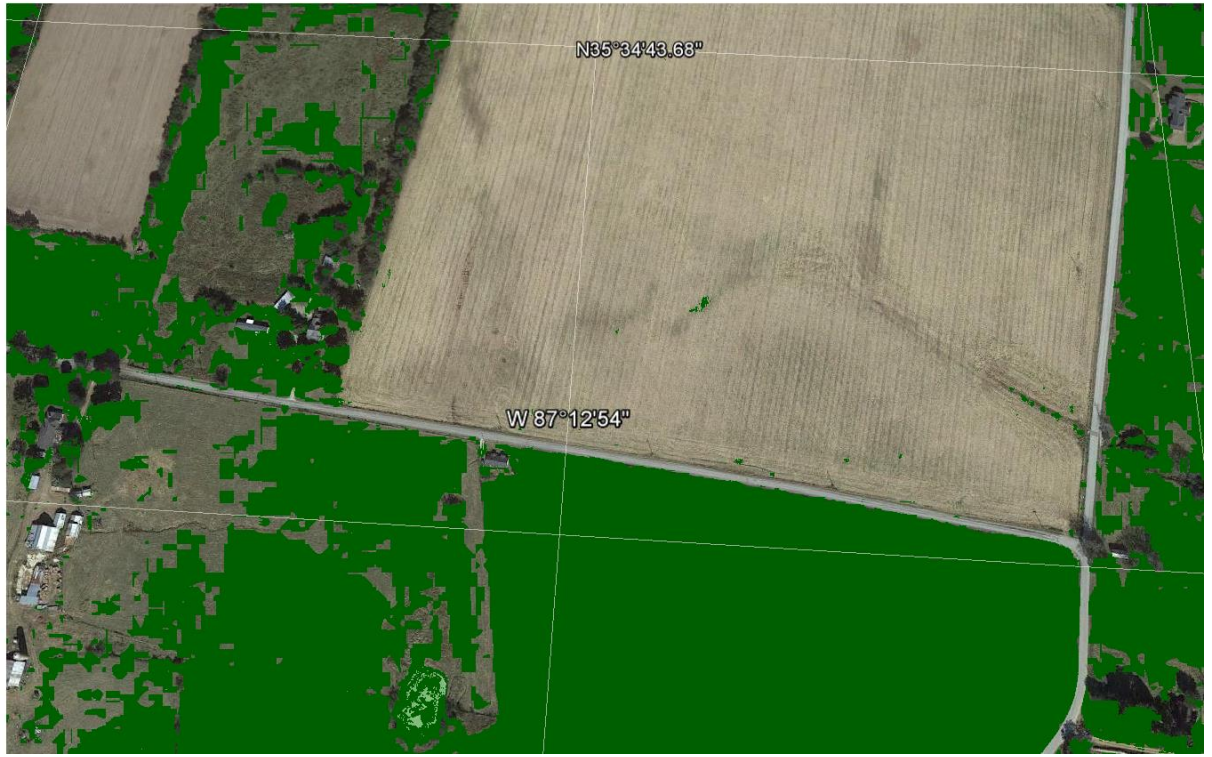
- VIIRS 1km regional biweekly EVI_TOC v.s. MODIS 1km 16-day EVI (MxD13A2).
- VIIRS Biweekly VI product of 20231218 is selected to match with MODIS VI product of 20231203 due to the different definition of temporal composite between the two products.



- Visual assessment shows similar distribution patterns at CONUS, and quantitative comparison also indicates moderate correlation (R^2 = 0.5272) and high consisteny (RMSE = 0.0593) between the two products.
- Lower correlation is due to the lack of high EVI samples over CONUS in the wintertime.

Example of High resolution Google Earth image image

Google Earth image



Classified image

(GVF=0.34)

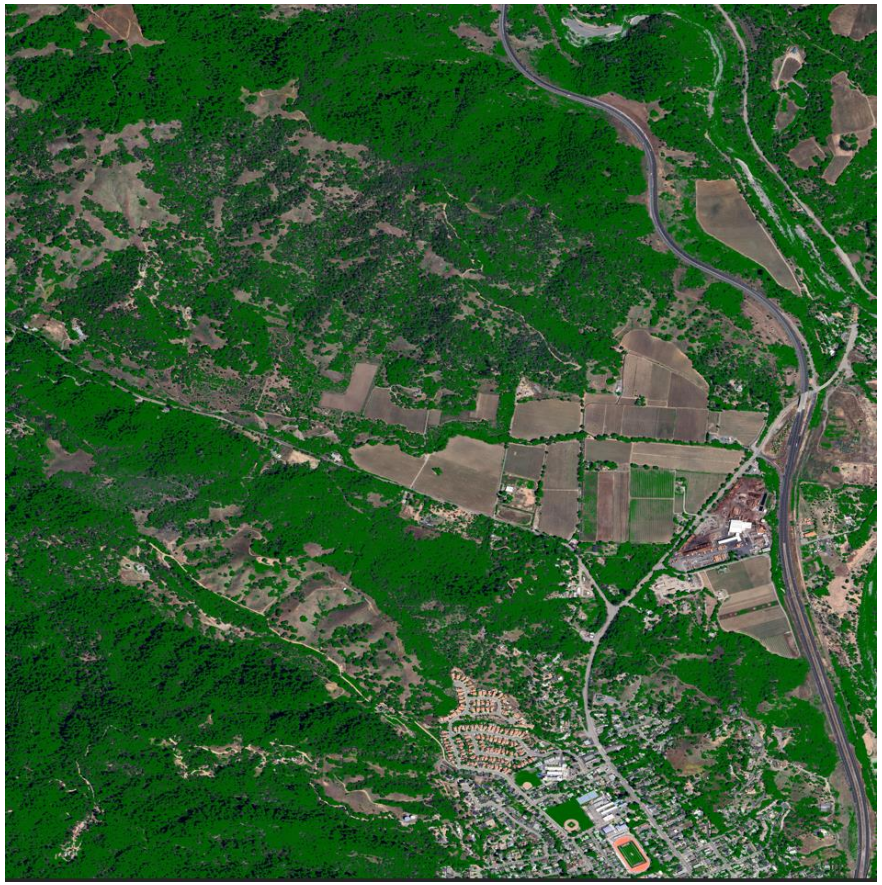
- Green pixels are classified and counted
- GVF= $\frac{Green\ pixels}{total\ pixels}$

Google Earth results example: Cloverdale

High resolution
Google Earth image:

(6912×6912) pixels

Google Earth image over a 0.036-degree VIIRS GVF pixel



Classified image
(vegetation pixel: green)

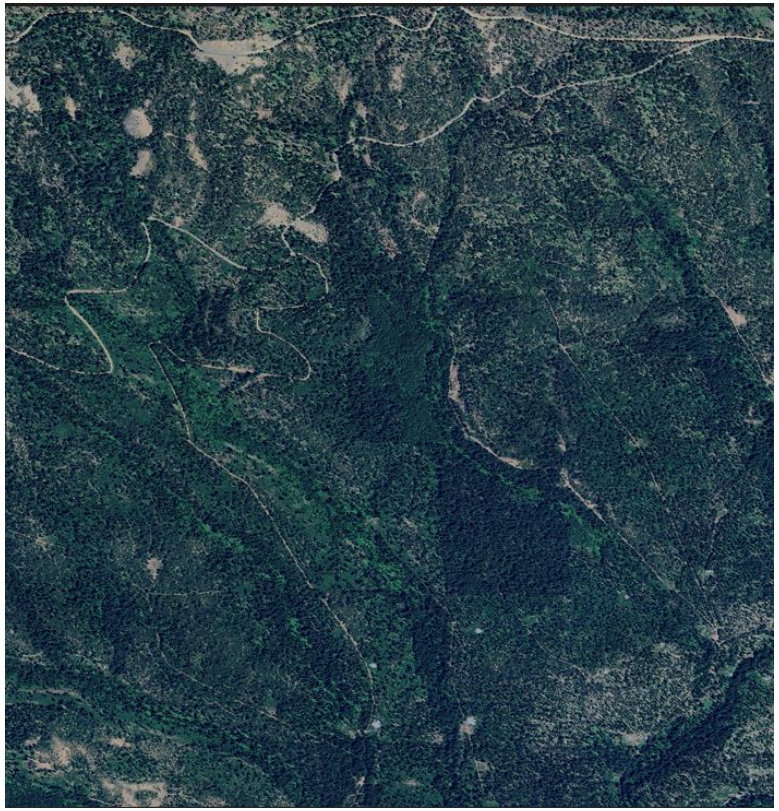
(5/30/2023)

Google Earth GVF=0.400
N21 VIIRS GVF=0.414

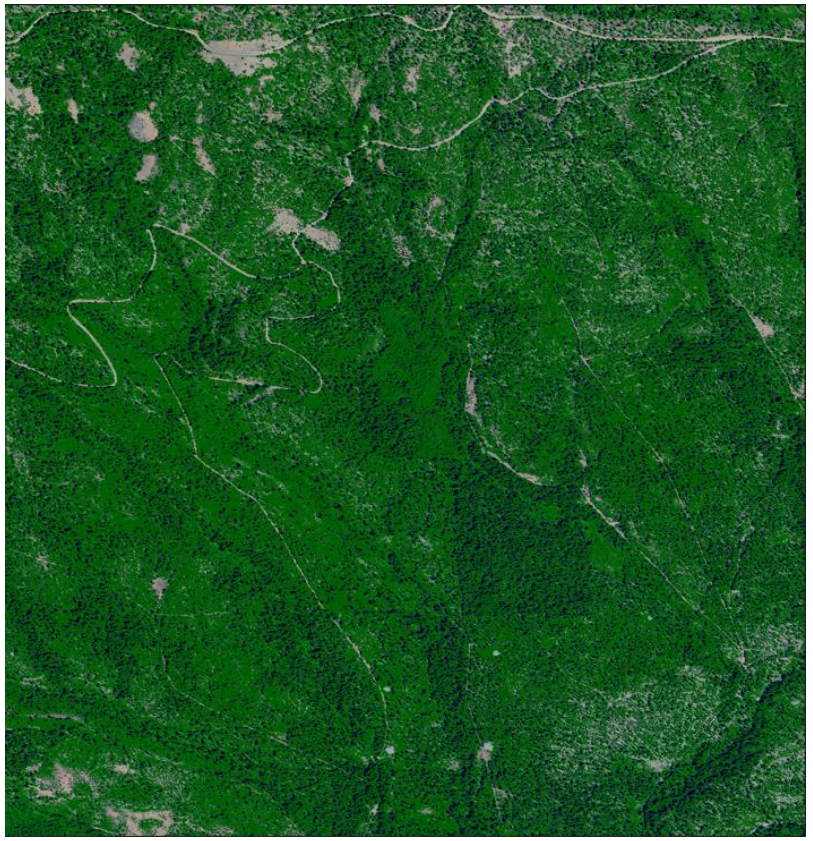
Google Earth results example: Mt_adams2

High resolution
Google Earth image:

(6912×7168) pixels



Google Earth image over a 0.036-degree VIIRS GVF pixel



Classified image
(vegetation pixel: green)

(8/9/2023)

Google Earth GVF=0.507
N21 VIIRS GVF=0.520

Google Earth results example: La_Jolla_ranch

High resolution
Google Earth image:

(6912×6912) pixels

Google Earth image over
a 0.036-degree VIIRS
GVF pixel

(8/9/2023)

Classified image
(vegetation pixel: green)

Google Earth GVF=0.427
N21 VIIRS GVF=0.500

Google Earth results example: Quincy

High resolution
Google Earth image:

(6912×6912) pixels

Google Earth image over a 0.036-degree VIIRS GVF pixel

Classified image
(vegetation pixel: green)

(6/16/2023)

Google Earth GVF=0.493
N21 VIIRS GVF=0.600