Office of Satellite and Product Operations
Environmental Satellite Processing Center

NVPS Green Vegetation Fraction External Users' Manual

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U.S. Department of Commerce
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Environmental Satellite Processing Center

NVPS Green Vegetation Fraction External Users' Manual

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Changes/Revisions Record

This external users' manual is changed as required to reflect system, operational, or organizational changes. Modifications made to this document are recorded in the Changes/Revisions Record below. This record will be maintained throughout the life of the document.

Version Number	Date	Description of Change/Revision	Section/Pages Affected	Changes Made by Name/Title/ Organization
4.1	01/2023	Original Version	All	Lindeman
4.2	05/2024	Updated for NCCF; Added links to product monitoring and visualization; Updated OSGS to OCS; Updated to latest document template	3.5; 3.5.1; All	Augenbaum
4.3	06/04/2024	Transfer contents to latest template, perform minor editing and formatting	All	Hannah Willett, Technical Writer, ERT Inc.
4.3	06/04/2024	Quality Assurance	All	Clint Sherwood, Quality Assurance Manager, ERT Inc.

Preface

This document comprises the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS), Office of Satellite and Product Operations (OSPO), publication of this NVPS Green Vegetation Fraction (GVF) External Users' Manual. This document reflects current operations for the DOC/NOAA/NESDIS Environmental Satellite Processing Center (ESPC) (NOAA5045) information technology systems. This document describes the established ESPC procedures for external users of GVF in accordance with Federal, DOC, NOAA, NESDIS and OSPO requirements.

Future updates and revisions to this document will be produced and controlled by DOC/NOAA/NESDIS for ESPC information technology systems.

The published version of this document can be found at the OSPO SharePoint Products Library.

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1. Products

This is an External Users' Manual (EUM) document describing the NDE Vegetation Products System (NVPS) Green Vegetation Fraction (GVF) software package, which generates a consistent set of global and regional gridded vegetation products from Visible Infrared Imaging Radiometer Suite (VIIRS) observations for initializing environmental models and monitoring land use and land cover change.

The intended users of the EUM are end users of the output files and the product verification and validation (V&V) teams. The purpose of this document is to provide the document's users with information describing how to acquire the product, understand the product's features, and use any data associated with the products. External users are classified as those who do not have direct access to the processing system.

1.1. Product Overview

The main function of the GVF system is to produce GVF as a NOAA-Unique Product (NUP) from data from the VIIRS sensor onboard the Suomi National Polar-orbiting Partnership (SNPP) satellite and the Joint Polar Satellite System (JPSS) series of satellites. To meet the data needs of NCEP and other potential users, GVF is produced as a daily rolling weekly composite at 4-km resolution (global scale) and 1-km resolution (regional scale) encompassing North America.

Figure 1-1 depicts an image of the global GVF product image.

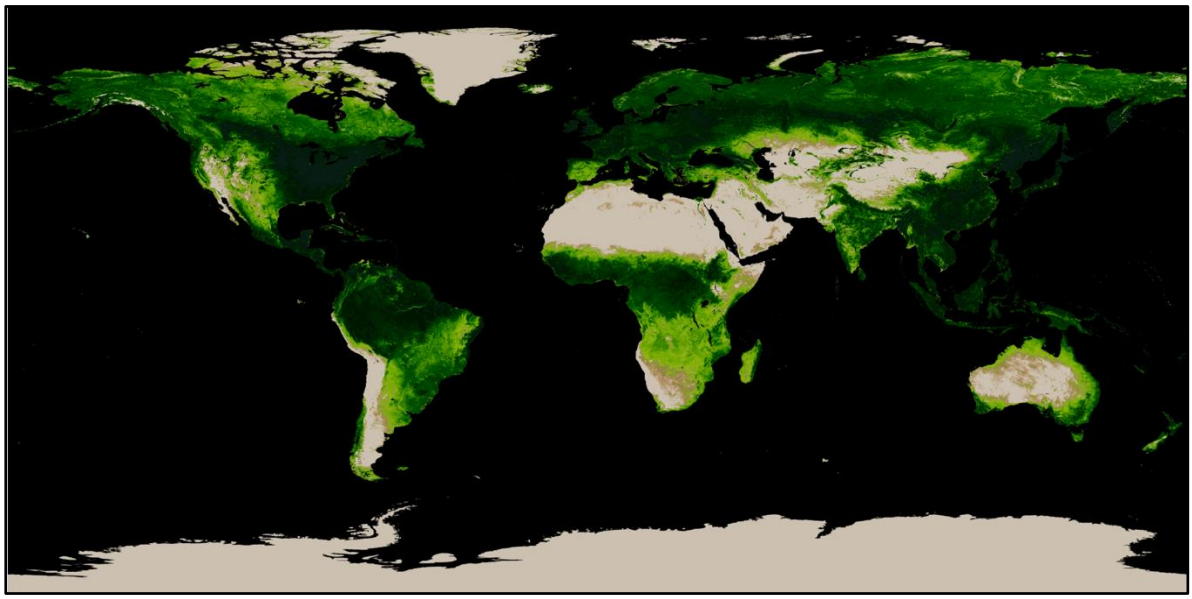

Figure 1-1 - Global GVF Product Image

Note that this product system is one of two products for NVPS – the other being Vegetation Index (VI). Further information and references for VI can be found in section **Error! Reference source not found.**.

The NVPS GVF product system produces six output files per day – global and regional domains in text, NetCDF and tif (image) formats.

1.1.1. Product Requirements

Running the NVPS GVF package requires an intermediate product (IP) from the daily gridded surface reflectance products of the corresponding NVPS VI process.

1.1.2. Product Team

The NVPS GVF products development team consists of members from Office of Common Services (OCS), National Environmental Satellite, Data, and Information Service (NESDIS), Office of Satellite and Product Operations (OSPO), and National Weather Service (NWS). The roles and contact information for the different product team members are identified in Table 1-1.

Table 1-1 - Product Team Members

Team Member	Organization	Role	Contact Information
Walter Wolf	OCS	Product Portfolio Management Lead	walter.wolf@noaa.gov
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Shukming (Eva) Wu	OCS	ASSISTT	
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1.1.3. Product Description

The main function of the GVF system is to produce GVF as a NUP from data from the VIIRS sensor onboard the Suomi National Polar-orbiting Partnership (SNPP) satellite and NOAA-20 satellite, for applications in numerical weather and seasonal climate prediction models at the National Centers for Environmental Prediction (NCEP). The retrieval algorithm uses VIIRS red (I1), near-infrared (I2) and blue (M3) bands centered at 0.640 μm, 0.865 μm and 0.490 μm, respectively, to calculate the Enhanced Vegetation Index (EVI) and derive GVF from EVI. The initial input to the GVF algorithm is reflectance that have already been gridded within the VI algorithm. To meet the data needs of NCEP and other potential users, GVF is produced as a daily rolling weekly composite at 4-km resolution (global scale) and 1-km resolution (regional scale – North America).

Current numerical weather prediction models and land surface monitoring systems require real time, large-scale land surface information for modeling initialization and monitoring land cover change. Daily global observations of the VIIRS onboard JPSS are an excellent data source for such information. Thus, the NOAA JPSS Land Team has developed a NVPS to produce VI and GVF.

GVF produces rolling weekly (meaning, output is produced every day covering seven days) final products, at 4km resolution for the entire world and 1km resolution for a region encompassing all of North America. GVF also produces intermediate output files for its own use in later executions. Six

GVF output files are produced daily – two NetCDF files, two tif image files, and two text files. The file pairs are generated for the global and regional scales.

Table 1-2 – NVPS Green Vegetation Fraction Products

Product Category	Algorithm	Products
NDE Vegetation Products System (NVPS)	Green Vegetation Fraction (GVF) subsystem	NetCDF, Geotiff, and text output files containing all the derived variables of the GVF product

1.2. Product History

The Office of Common Services (OCS) Algorithm Scientific Software Integration and System Transition Team (ASSISTT) group produces meteorological products designed for operational use. ASSISTT transitions meteorological product algorithms created by science/academic research teams into products for use and disseminated by NOAA operations.

The algorithm was developed by scientists and developers of STAR GVF team. The previous GVF operational product was based on Top of the Atmosphere (TOA) Normalized Vegetation Index (NDVI) derived from the AVHRR sensor (NOAA-19). With the launch of the Earth-observing satellites SNPP and J01 (NOAA-20), the VIIRS onboard SNPP and NOAA-20 have acquired measurements since November 2011. Hence NESDIS has sustained the production of a new real-time weekly GVF product from VIIRS. The VIIRS GVF is based on the Top of Canopy (TOC) EVI.

NVPS GVF is an upgrade to the S-NPP VIIRS GVF system that has been running operationally at NDE since February 2015. The S-NPP VIIRS GVF software system has been enhanced to generate along with the GVF products a gridded version (globally and regionally) of the VIIRS VI EDR products.

1.3. Product Access

The 6 products created on a daily basis from the NVPS GVF product system are in text, NetCDF and tif (image) formats. The filenames are shown in Table 1-3.

Table 1-3 - NVPS GVF Product Output Files

File	Description	Format	Size/file
GVF-WKL-REG _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss].nc	This is the weekly regional GVF product	netCDF4	Typical file size 65 MB.
GVF-WKL-GLB _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss].nc	This is the weekly global GVF product	netCDF4	Typical file size 11 MB.
GVF-WKL-REG _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss].tif	Browse image of the regional GVF product	Geotiff	Typical file size 34 MB
GVF-WKL-GLB _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss].tif	Browse image of the weekly global GVF product	Geotiff	Typical file size 5 MB
GVF-WKL-REG _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss]_stat.txt	Statistics file of the weekly regional GVF product for monitoring purposes	text	Typical file size 10 KB

File	Description	Format	Size/file
GVF-WKL-GLB _vxry_sid_s[YYYYMMDD1]_e[YYYYMMDD7] _c[YYYYMMDDhhmmsss]_stat.txt	Statistics file of the weekly global GVF product for monitoring purposes	text	Typical file size 10 KB

Descriptions of the lettering used in the output filenames are listed in Table 1-4.

Table 1-4 - NVPS GVF Output Files Standard Name Description

Sequence	Description
GVF	Green Vegetation Fraction
VI	Vegetation Indices (NDVI, EVI)
NDVI	Normalized Difference Vegetation Index
EVI	Enhanced Vegetation Index
DLY	Daily (1-day temporal scale)
WKL	Weekly (7-day temporal resolution)
BWKL	Biweekly (16-day temporal resolution, in term of conventions)
GLB	Global (spatial resolution: 4-km)
REG	Regional (spatial resolution:1-km)
TOA	Top of Atmosphere
TOC	Top of Canopy
vxry	Version (e.g., v2r2)
sid	Indicates the observations from JPSS-01
s	start (data observation time)
e	end (data observation time)
c	current (data processing time)
YYYYMMDD	4-digit year, 2-digit month, and 2-digit day
hhmmsss	2-digit hour, 2-digit minute, 2-digit second, and 1-digit fractional second
.nc	netCDF4 file
.tif	GeoTiff image file
stat.txt	Text file stored statistics analysis results

Examples of the output filenames are:

GVF-WKL-GLB_v3r0_j01_s20200410_e20200416_c202301041524440.nc

GVF-WKL-REG_v3r0_j01_s20200410_e20200416_c202301041527160.nc

GVF-WKL-GLB_v3r0_j01_s20200410_e20200416_c202301041524440.tif GVF-WKL-REG_v3r0_j01_s20200410_e20200416_c202301041527160.tif

GVF-WKL-GLB_v3r0_j01_s20200410_e20200416_c202301041524440_stat.txt GVF-WKL-REG_v3r0_j01_s20200410_e20200416_c202301041527160_stat.txt

The GVF product includes the following data fields:

1) GVF;
2) Number of Pixels;

3) Geospatial Coordinates: latitude, longitude

The descriptions of these data fields are listed in Table 1-5.

Table 1-5 - Data Fields of the NVPS GVF Products

Data Name	Data Description	Data Type	Dimension	Units	Data Range
Number_Of_Pixels	Number of Pixels	8-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	n/a	[0,255]
gvf_4km **OR** gvf_1km 4km – global, 1km – regional	Green Vegetation Fraction	8-bit Integer	5000x10000 (Global) 10384x28889 (Regional)	percent	[0,100]
Latitude	Geospatial coordinate	32-bit float	5000x1 (Global) 10384x1 (Regional)	degrees	[-90º,90º] [-7.5º,90º]
Longitude	Geospatial coordinate	32-bit float	10000x1 (Global) 28889x1 (Regional)	degrees	[-180º,180º] [-230º,30º]
plate_carree	Plate Carree projection corner lats/lons and resolution*	short	0	see attribute desc*	lat: [-90, 90] lon: [-180,180]
quality_information**	product quality information**	string	0	see attribute desc**	n/a

* plate_carree values are located in variable attributes = [geospatial_lat_max, geospatial_lat_min, geospatial_lat_resolution, geospatial_lat_units, geospatial_lon_max, geospatial_lon_min, geospatial_lon_resolution, geospatial_lon_units, grid_mapping_name, latitude_of_projection_origin, longitude_of_central_meridian, standard_parallel_1]
** quality_information values are located in variable attributes = [total number of retrievals, percentage of optimal retrievals, percentage of bad retrievals]

Metadata contained in the NetCDF files is listed in Table 1-6.

Table 1-6 – NVPS GVF Metadata

Attribute	Description	Type	Array Size
_NCProperties	NetCDF and HDF version numbers, will be automatically generated	String	Scalar
cdm_data_type	States the geographic category the product represents	String	Scalar
creator_email	Email for the algorithm development team	String	Scalar
creator_name	Indicates the line office and algorithm team responsible for product development	String	Scalar
creator_url	The url address for the algorithm team responsible for product development	String	Scalar
date_created	UTC time the product file was created in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar

Attribute	Description	Type	Array Size
geospatial_lat_max	Maximum latitude within the geospatial bounds	Float	Scalar
geospatial_lat_min	Minimum latitude within the geospatial bounds	Float	Scalar
geospatial_lat_resolution	The latitudinal resolution	Float	Scalar
geospatial_lat_units	Indicates unit associated with geospatial latitude	String	Scalar
geospatial_lon_max	Maximum longitude within the geospatial bounds	Float	Scalar
geospatial_lon_min	Minimum longitude within the geospatial bounds	Float	Scalar
geospatial_lon_resolution	The longitudinal resolution	Float	Scalar
geospatial_lon_units	Indicates unit associated with geospatial longitude	String	Scalar
history	Indicates algorithm name and version responsible for creating the file	String	Scalar
id	Unique identifier for the product	String	Scalar
institution	Indicates institution responsible for product file	String	Scalar
instrument	Name of the relevant satellite instrument	String	Scalar
keywords	Searchable words or phrases associated with this product	String	1
metadata_link	Contains a URL where detailed metadata or a product information page is located	String	Scalar
naming_authority	Organization responsible for providing the "id" attribute	String	Scalar
platform	Satellite platform (name) associated with this product	String	Scalar
processing_level	Level of processing associated with product file	String	Scalar
production_environment	Processing string responsible for generating the product	String	Scalar
production_site	Processing site for the product	String	Scalar
project	Indicates the name(s) of the project(s) responsible for generating the original data used as input to the processing system	String	Scalar
publisher_email	Provides an email that can be used to contact the person or entity who is responsible for publishing the output files to the proper end users	String	Scalar
publisher_name	Provides the name of the organization responsible for the product's publication	String	Scalar
publisher_url	Provides URL of publisher's website	String	Scalar
source	Provides a list of all significant input files into the product system as a comma separated list	String	Scalar
standard_name_vocabulary	Provides the name and corresponding version number of the controlled vocabulary used	String	Scalar
summary	Provides a brief summary of the product	String	Scalar
time_coverage_end	Indicates the end time of the observation associated with the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
time_coverage_start	Indicates the start time of the observation associated with the file in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second format	String	Scalar
title	Provides the short name for the product	String	Scalar

2. Algorithm

2.1. Algorithm Overview

The NVPS will produce daily rolling weekly Green Vegetation Fraction. The GVF output files include a 0.009° (1-km) GVF regional file, and a 0.036° (4-km) GVF global file, both in NetCDF4 format. The daily rolling weekly production scheme means that the GVF products are derived from VIIRS input data from the past 7 days, but the output is generated every day. Since both VI and GVF use daily gridded surface reflectance as intermediate data, the GVF algorithm starts from reading in the daily gridded surface reflectance.

The GVF system generates daily rolling weekly Green Vegetation Fraction through the following steps:

Step 1: A gridded daily surface reflectance map including surface reflectances in bands I1, I2, and M3 produced by the VI unit is read in to the GVF unit, and the gridded reflectances are screened according to a cloud detection algorithm and a solar zenith angle threshold. At the end of a 7-day period, the daily surface reflectance maps of the 7 days are composited to produce a weekly surface reflectance map using the MVA-SAVI compositing algorithm, which selects, at each GVF grid point (pixel), the observation with maximum view-angle adjusted SAVI value in the 7-day period. The 7-day compositing is conducted daily using data in the previous 7 days as input data, which is called daily rolling weekly compositing. Quality flag information of composited pixels is saved.

EVI is then calculated from the daily rolling weekly composited VIIRS surface reflectance data in bands I1, I2 and M3.

Step 2: High frequency noise in EVI is reduced by applying a 15-week digital smoothing filter on EVI.

Step 3: First take the average of the previous 7 days worth of smoothed EVI data and then calculate GVF at each grid with the fine resolution (0.003 degree). GVF is calculated by comparing the smoothed EVI against the global maximum and minimum EVI values assuming a linear relationship between EVI and GVF.

Step 4: GVF is aggregated to 0.009 degree and 0.036 degree resolutions for output maps. Potential gaps on the output maps at high latitudes are filled using monthly VIIRS GVF climatology.

The GVF product is smoothed and therefore no quality flags are provided in the output file. For detailed information about the GVF algorithm, see the GVF Algorithm Theoretical Basis Document (https://www.ospo.noaa.gov/products/documents/GVF_ATBD_V4.1.pdf).

2.1.1. Pre-Processing Steps

Pre-processing is not required for NVPS GVF.

2.2. Input Satellite Data

2.2.1. Satellite Instrument Overview

The NVPS GVF processing system requires NVPS VI products created by VIIRS satellite data. Thus, GVF indirectly uses the VIIRS data originating from SNPP, N0AA-20, or NOAA-21.

2.2.2. Satellite Data Preprocessing Overview

There are no pre-processing steps performed on the input satellite data for the NVPS GVF Products algorithm package.

2.2.3. Input Satellite Data Description

This version of GVF may process SNPP, NOAA-20, or NOAA-21 data. Only data from a single satellite should be provided as the input for a single execution. A sample input filename is:

VI-SR-J01_s<YYYYMMDD>_e<YYYYMMDD>_h<HR>v<VR>_cYYYYMMDDhhmmsss.h5

where

s<YYYYMMDD>	→	the start time in 4-digit year, 2-digit month, 2-digit day
e<YYYYMMDD>	→	the end time in 4-digit year, 2-digit month, 2-digit day
c<YYYYMMDDhhmmsss>	→	the creation time in 4-digit year, 2-digit month, 2-digit day, 2-digit hour, 2-digit minute, 2-digit second, 1 digit tenths of a second format associated with the file
VI-SR	→	intermediate product (IP) from the daily gridded surface reflectance products of VI (Vegetation Index) process
J01	→	Satellite platform
h<HR>	→	horizontal range of [00, 19]
v<VR>	→	vertical range of [00, 09]

2.3. Ancillary Data Files

Previous NVPS GVF intermediate file data can be used for current GVF processing, though this is optional. Two types of the intermediate data would be required - unsmoothed and smoothed GVF EVI data. The unsmoothed GVF-EVI files are weekly composited files from the previous 14 weeks. The smoothed GVS-ASEVI-P1 files consist of 7 daily rolling IP EVI files after 15 weeks of smoothing.

2.3.1. Static Ancillary Data

Static ancillary data files are included in the package delivered to operations. Climatological data and the watermask are needed to generate the NVPS GVF products.

2.3.2. Other Required Inputs

Two configuration YAML files are used in the NVPS GVF products processing system: one responsible for launching the Docker container and another responsible for running the NVPS GVF processing package.

3. Performance

3.1. Product Testing

3.1.1. Test Data Description

Test cases will be provided with each delivery of the processing package to ensure product verification can occur before the system becomes operational. Each test case will provide the necessary input data files, and their corresponding output data files. Once end users of the products are satisfied that all requirements have been sufficiently met, the products will be transitioned into operations.

3.1.2. Unit Test Plans

Testing of all products produced by the processing package will occur with each software update. The Office of Common Services (OCS) is responsible for testing each algorithm and script to ensure all requirements are met. Before each product becomes operational, the products must be tested to ensure they run successfully on the intended system. If there are any issues that arise during testing procedures, all relevant groups must work together to "iron-out" these issues.

3.2. Product Accuracy

3.2.1. Test Results

See section **Error! Reference source not found.**.

3.2.2. Product Accuracy

3.3. Product Quality

Details about product quality are listed in Table 1-5 - specifically the variable quality_information.

3.4. External Product Tools

No external product tools are provided.

3.5. Output Files

NVPS GVF final products are available on PDA for user subscription. The data retention time on PDA is the standard 7 days.

3.5.1. Product Monitoring and Visualization

Product quality is monitored using the NCCF Product Monitoring Tool at https://nccf.espc.nesdis.noaa.gov/mtool/index.html.

Users can use this page to monitor hourly summaries of the NVPS GVF quality based on parameter thresholds determined by the PAL.

The NCCF Products Visualization Page at https://www.ospo.noaa.gov/products/land/gvf/ can also be used to view global images of select parameters in near real-time. These images are updated weekly

4. Product Status

4.1. Operations Documentation

Vargas, M., Miura, T., Shabanov, N., & Kato, A. (2013). An initial assessment of Suomi NPP VIIRS vegetation index EDR. Journal of Geophysical Research-Atmospheres, 118, 12301-12316.

NESDIS/STAR (2021): Vegetation Index (VI) Product Algorithm Theoretical Basis Document (ATBD) v2.1

NESDIS/STAR (2021): Green Vegetation Fraction (GVF) Product Algorithm Theoretical Basis Document (ATBD) v4.1

NESDIS/STAR (2022): NDE Vegetation Products System (NVPS) External Users' Manual (EUM) v2.2

NESDIS/STAR (2022): NDE Vegetation Products System (NVPS) System Maintenance Manual (SMM) v2.2

NESDIS/STAR (2022): NVPS VI Product Delivery memo, Readme file, PCF_PSF doc, and Production Rules doc

NESDIS/STAR (2022): Normalized Vegetation Products System (NVPS) Vegetation Index (VI) External Users' Manual

NESDIS/STAR (2022): Normalized Vegetation Products System (NVPS) Vegetation Index (VI) System Maintenance Manual

NESDIS/STAR (2022): Normalized Vegetation Products System (NVPS) Green Vegetation Fraction (GVF) System Maintenance Manual

4.2. Maintenance History

5. Acronyms

Acronym	Definition
ASSISTT	Algorithm Scientific Software Integration and System Transition Team
CM	Configuration Management
EUM	External Users' Manual
EVI	Enhanced Vegetation Index
GVF	Green Vegetation Fraction
IP	Intermediate Product
JPSS	Joint Polar Satellite System
NCEP	National Centers for Environmental Prediction
NDE	NPP Data Exploitation
NDVI	Normalized Vegetation Index
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NUP	NOAA-Unique Product
NVPS	NDE Vegetation Products System
NWS	National Weather Service
OCS	Office of Common Services
OSPO	Office of Satellite and Product Operations
PAL	Product Area Lead
PDA	Product Data Assimilation
QA	Quality Assurance
SNPP	Suomi National Polar-orbiting Partnership
TOA	Top of the Atmosphere
TOC	Top of Canopy
V&V	Verification and Validation
VI	Vegetation Index
VIIRS	Visible Infrared Imaging Radiometer Suite