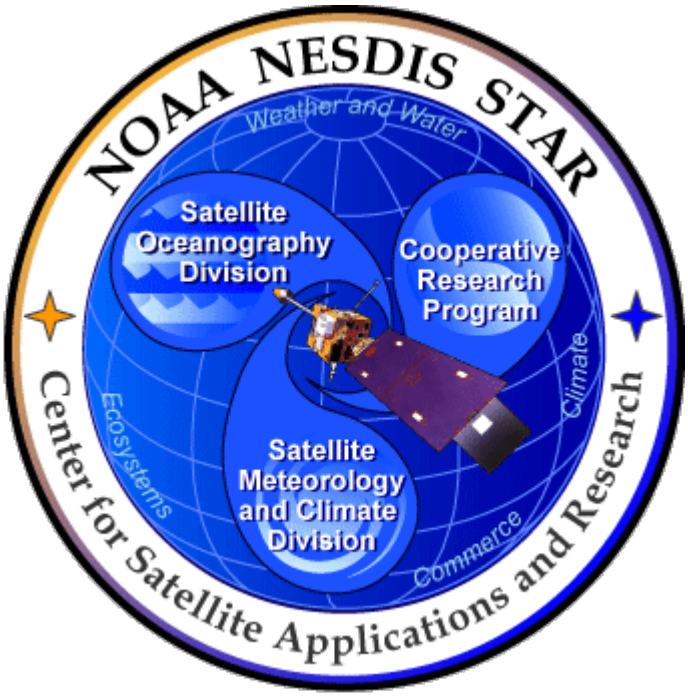

NOAA NESDIS
CENTER for SATELLITE APPLICATIONS and RESEARCH

The NESDIS Data Exploitation (NDE) I-band (375m) Active Fire Environmental Data Record (EDR)

External Users Manual

Version 1.0

TITLE: NDE ACTIVE FIRES I-BAND EDR EXTERNAL USERS MANUAL VERSION 1.0

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DOCUMENT HISTORY
DOCUMENT REVISION LOG

The Document Revision Log identifies the series of revisions to this document since the baseline release. Please refer to the above page for version number information.

DOCUMENT TITLE: NDE Active Fires I-Band External Users Manual			
DOCUMENT CHANGE HISTORY			
Revision No.	**Date**	**Revision Originator Project Group**	**CCR Approval # and Date**
1.0	June 8, 2020	Original based on Active Fires M-Band EUM 1.6 Modified for I-Band by Michael Wilson	

LIST OF CHANGES

Significant alterations made to this document are annotated in the List of Changes table.

DOCUMENT TITLE: NDE Active Fire External Users Manual					
LIST OF CHANGE-AFFECTED PAGES/SECTIONS/APPENDICES					
Version Number	**Date**	**Changed By**	**Page**	**Section**	**Description of Change(s)**
1.0	June 8, 2020	Michael Wilson	(all)	(all)	Changed M-Band specific information to I-Band equivalents.

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1. PRODUCTS

This is an External Users Manual (EUM) document describing the operational NOAA NDE Active Fire (NDEAF) I-Band Environmental Data Record product and output file. The NDEAF product is a subset of the Suomi NPP VIIRS 375-m I-Band active fire product and was developed at the University of Maryland within the framework of the NASA Suomi NPP Science Program. The work to transition the algorithm to NOAA operations was completed as part of the NOAA JPSS Product Development, Calibration and Validation program led by the NOAA NESDIS Center for Satellite Applications and Research (STAR). It will be delivered to the NESDIS Data Exploitation (NDE) team and integrated into the NDE Data Handling System (DHS) where it will be run in a pre-operational manner. After a preliminary testing period, the NDE DHS will, in turn, be delivered to the Office of Satellite and Product Operations (OSPO) to be run operationally. The product is intended to process input data from Suomi NPP, NOAA-20 and future compatible data from the JPSS series.

The intended users of this EUM are end users of the operational output products and files, and the product verification and validation (V&V) teams. The purpose of the EUM is to provide product users and product testers with information that will enable them to acquire the product, understand its features, and use the data. External users are defined as those users who do not have direct access to the processing system (those outside of the OSPO and NDE). The output files are defined as those leaving the NDE DHS (running within ESPC) as opposed to those that are output by the NDEAF processing, but available only internally within the NDE.

1.1. Product Overview

1.1.1. Product Requirements

All NDEAF basic and derived requirements are available in the NDEAF Requirements Allocation Document (RAD). These requirements identify the users and their needs with respect to file content, format, latency, and quality.

1.1.2. Product Team

The NDEAF Development product team consists of members from STAR (including affiliates), the University of Maryland, and OSPO. 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
Ivan Csiszar	STAR	STAR Product Lead	5830 University Research Court Riverdale, MD. 20740 Phone: 301-683-3583 Email: Ivan.Csiszar@noaa.gov
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1.1.3. Product Description

The NDEAF product was developed to generate (1) a 2-dimensional array representing fire and thematic classes for each pixel (2) fire radiative power (FRP) for each pixel identified as “fire” by the fire detection algorithm. The algorithm processes all daytime and nighttime VIIRS pixels globally. Details on the content of all NDEAF external output files are shown in section 1.3.

1.2. Product History

The product described here includes the geolocation and Fire Radiative Power (FRP) of pixels for which fires are detected, and a full mask consisting of a two-dimensional array of values representing fire and other relevant thematic classes (e.g., cloud) of each pixel in a swath data granule globally over all land and water surface types. It provides continuity to the 750 m VIIRS M-band, the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Very High Resolution Radiometer (AVHRR) active fire data records. This product consists of a hybrid algorithm combining qualities of the 375 m and 750 m VIIRS data. The higher resolution data (channels I1-I5) are the primary drivers of the fire detection component, whereas the 750 m data (specifically the dual-gain M13 channel) are used primarily in the fire radiative power (FRP) retrievals. The 375 m fire algorithm supersedes the baseline VIIRS 750 m active fire detection and characterization algorithm which was designed based on the 1 km MODIS *Fire and Thermal Anomalies* (MOD14/MYD14) Collection 6 product and incorporates code updates and methodological advances derived from several years of algorithm development and validation. Compared to other coarser resolution (($\geq$1 km) satellite fire detection products, the VIIRS 375 m data provide greater response over fires of relatively small area, as well as improved mapping of large fire perimeters. (A non-operational, science-quality version of the product is currently produced

in a non-operational setting within NASA's Land Science Investigator-led Processing System - SIPS.) The NDEAF product for I-Band is scheduled to go operational in NDE in 2020.

1.3. Product Access

All NDEAF output data files will be made available by the NDE DHS on the NDE data distribution server at ESPC in a near real time manner. For access to this server, information about data files, and associated documentation, the NDEAF (i.e. Land) PAL should be contacted (see Table 1-1).

The NESDIS Policy on Access and Distribution of Environmental Data and Products is provided at: http://www.ospo.noaa.gov/Organization/About/access.html.
In order to obtain the near real time data, users need to fill out the Data Access Request Form located on this site and submit to the PAL with a copy to nesdis.data.access@noaa.gov. This address provides the OSPO Data Access Team a copy of the correspondence. Once the request is approved by the OSPO management the data will be delivered by the Data Distribution System (DDSProd) currently distributing the ESPC data products and later by the Product Distribution and Access (PDA) system. The ESPC Data Distribution Manager, Donna McNamara (donna.mcnamara@noaa.gov) should be contacted for any data accessibility and data distribution problems. The data format is defined in the Table 1.2

CLASS will be archiving the NDEAF data products for distributing to the non-real-time users. NDE pushes the data to CLASS with the associated metadata in the standard formats. CLASS will archive the NDEAF product in netCDF4 format with associated metadata.

Table 1-2 lists the external distributed NDEAF files and their formats. Tables 1-3 to 1-6 show the detailed content of each output files listed in Table 1-2. Details of the Fire Tests listed in Table 1-6 are described in the NDE Active Fire Algorithm Theoretical Basis Document.

Table 1-2 NDE Active Fire Output Files

File	Description	Format	Size/file
AF-Iband_v1r0_npp_s????????????? ?_e?????????????_c????????? ?????.nc AF-Iband_v1r0_j01_s????????????? _e?????????????_c?????????? ????.nc	This is the granule output file containing all the derived variables of the AF product.	netCDF4	1.2 MB/granule for ~1000 granules/day and 2 platforms: ~2.4 GB/day
AF-Iband_v1r0_npp_s????????????? ?_e?????????????_c????????? ?????.txt AF-Iband_v1r0_j01_s????????????? _e?????????????_c?????????? ????.txt	This is an ASCII table containing only the active fires found in a granule (subset of parameters described as “Sparse data array” in Table 1-3).	ASCII text	200 KB/granule for ~1000 granules/day and 2 platforms: ~400 MB/day

Table 1-3 NDE Active Fire File

Name	Type	Description	Dimension	Units	Range
fire_mask	8 bit integer	Fire Mask	6400 x 1536	unitless	0 - 9
fire_qa	32 bit Integer	Fire algorithm QA mask	6400 x 1536	unitless	0 - 31

FP_line	16 bit Integer	Fire pixel line	Sparse data array 1 – N	unitless	0 –1535
FP_sample	16 bit Integer	Fire pixel sample	Sparse data array 1 – N	unitless	0 – 6399
FP_latitude	32 bit Float	Fire pixel latitude	Sparse data array 1 – N	degrees	-90 – 90
FP_longitude	32 bit Float	Fire pixel longitude	Sparse data array 1 – N	degrees	-180 – 180
FP_T4	32 bit Float	I04 Brightness Temperature	Sparse data array 1 - N	Kelvin	As defined in SDR**
FP_T5	32 bit Float	I05 Brightness Temperature	Sparse data array 1 - N	Kelvin	As defined in SDR**
FP_MeanT4	32 bit Float	I04 Brightness Temperature of Background	Sparse data array 1 - N	Kelvin	As defined in SDR**
FP_MeanT5	32 bit Float	I05 Brightness Temperature of Background	Sparse data array 1 - N	Kelvin	As defined in SDR**
FP_MeanDT	32 bit Float	Mean Background Brightness Temperature Difference	Sparse data array 1 - N	Kelvin	N/A
FP_MAD_T4	32 bit Float	Background I04 Brightness Temperature Difference Mean Absolute Deviation	Sparse data array 1 - N	Kelvin	N/A
FP_MAD_T5	32 bit Float	Background I05 Brightness Temperature Difference Mean Absolute Deviation	Sparse data array 1 - N	Kelvin	N/A
FP_MAD_DT	32 bit Float	Background Brightness	Sparse data array 1 - N	Kelvin	N/A

		Temperature Difference Mean Absolute Deviation			
FP_power	32 bit Float	Fire radiative power	Sparse data array 1 – N	MW	0 - 5000
FP_Rad13	32 bit Float	M13 Radiance of Fire Pixel	Sparse data array 1 – N	W/ (m^2 *sr*µm)	As defined in SDR**
FP_MeanRad13	32 bit Float	M13 Radiance of Background	Sparse data array 1 – N	W/ (m^2 *sr*µm)	As defined in SDR**
FP_AdjCloud	16 bit Integer	Number of Adjacent Cloud Pixels	Sparse data array 1 – N	unitless	0-8
FP_AdjWater	16 bit Integer	Number of Adjacent Water Pixels	Sparse data array 1 – N	unitless	0-8
FP_WinSize	16 bit Integer	Background Window Size	Sparse data array 1 – N	unitless	0 - 35
FP_confidence	8 bit Integer	Fire detection confidence (fire mask equivalent)	Sparse data array 1 – N	unitless	7-9
FP_day	8 bit Integer	Day Flag for Fire Pixel	Sparse data array 1 – N	unitless	0 - day 1-night 2 - both
FP_SolZenAng	32 bit Float	Solar Zenith Angle of Fire Pixel	Sparse data array 1 – N	degrees	-180 - 180
FP_SolAziAng	32 bit Float	Solar Azimuth Angle of Fire Pixel	Sparse data array 1 – N	degrees	-180 - 180
FP_ViewZenAng	32 bit Float	Viewing Zenith Angle of Fire Pixel	Sparse data array 1 – N	degrees	-180 - 180
FP_ViewAzAng	32 bit Float	Viewing Azimuth Angle of Fire Pixel	Sparse data array 1 – N	degrees	-180 - 180

FP_Persistent AnomalyCategory	8 bit Integer	Persistent Industrial Nature Source	Sparse data array 1 – N	unitless	0: no persistent anomaly; 1: oil or gas flare; 2: volcano 3: solar panel; 4: urban (currently not used) 5: unclassified
* N is a dimension of sparse data array; defined in “nfire” variable					

** https://www.star.nesdis.noaa.gov/jpss/documents/UserGuides/VIIRS_SDR_Users_Guide.pdf

Table 1-4 Details of 2-dimensional arrays within the NDEAF output file

Output	Type	Pixel Class	Definition
Fire Mask	**8 bit unsigned integer**	**0**	Not processed
		1	*On-board Bowtie* deletion
		2	Sun glint
		3	Water
		4	Clouds
		5	Land
		6	Unclassified
		7	Low confidence fire pixel
		8	Nominal confidence fire pixel
		9	High confidence fire pixel
Fire Algorithm QA Mask	**32 bit unsigned integer**	Details in Table 1-6	

Table 1-5 Details of the OSPO Monitoring QA within the NDEAF output file

Name	Type	Description	Units	Range
fire_mask_0	32 bit Float	Percentage of fire_mask = 0 (missing input data)	percent	0% - 100%
fire_mask_4	32 bit Float	Percentage of fire_mask = 4 (cloud)	percent	0% - 100%
fire_mask_7	32 bit Float	Percentage of fire_mask = 7 (fire – low confidence)	percent	0% - 100%
fire_mask_8	32 bit Float	Percentage of fire_mask = 8 (fire – nominal confidence)	percent	0% - 100%
fire_mask_9	32 bit Float	Percentage of fire_mask = 9 (fire – high confidence)	percent	0% - 100%
max_detections_col	32 bit Integer	Maximum number of fire detections in a single column	unitless	0 – 1535
max_detections_row	32 bit Integer	Maximum number of fire detections in a single row	unitless	0 – 6399
mean_frp	32 bit Float	Mean Fire Radiative Power	MW	0 – 5000
number_of_detections	32 bit Integer	Number of Fire Detections	unitless	0 – 5000
total_frp	32 bit Float	Total Fire Radiative Power	MW	0 - 25000000

Table 1-6 Details of the Quality Assessment (QA) mask within the NDEAF output file.

Bit	Description
0	Channel I1 quality (0 = nominal (or nighttime), 1 = non-nominal)
1	Channel I2 quality (0 = nominal (or nighttime), 1 = non-nominal)
2	Channel I3 quality (0 = nominal (or nighttime), 1 = non-nominal)

3	Channel I4 quality (0 = nominal, 1 = non-nominal)
4	Channel I5 quality (0 = nominal, 1 = non-nominal)
5	Geolocation data quality (0 = nominal, 1 = non-nominal)
6	Channel M13 quality (0 = nominal, 1 = non-nominal)
7	Unambiguous fire (0 = false, 1 = true [night only])
8	Background pixel (0 = false, 1 = true)
9	Bright pixel rejection (0 = false, 1 = true)
10	Candidate pixel (0 = false, 1 = true)
11	Scene background (0 = false, 1 = true)
12	Test 1 (0 = false, 1 = true)
13	Test 2 (0 = false, 1 = true)
14	Test 3 (0 = false, 1 = true)
15	Test 4 (0 = false, 1 = true) (day)
16	Pixel saturation condition (0 = false, 1 = true) (day)
17	Glint condition (0 = false, 1 = true) (day)
18	Potential South Atlantic magnetic anomaly pixel (0 = false, 1 = true)
19	Fire pixel over water (0 = false, 1 = true)
20	Persistence test (0 = false, 1 = true)
21	Persistence test (0 = false, 1 = true) Number of previous co-located detections < 3
22	Residual *bowtie* pixel (0 = false, 1 = true)
23-25	Persistent anomaly category
26-31	Reserved for future use

2. ALGORITHM

2.1. Algorithm Overview

The I-band NDEAF product is generated using a hybrid thresholding- contextual algorithm for fire detection and a radiance method to calculate fire radiative power. The retrieval algorithm runs inside a system of supporting software. This system builds on heritage algorithm developed during the NASA Earth Observing System mission to use data from the MODIS instrument. It was subsequently redesigned and tailored to process VIIRS data. This algorithm is continuity to the 750 m VIIRS M-band algorithm, with necessary changes to account for the specific characteristics of the VIIRS I-band data. It is a hybrid algorithm combining qualities of the 375 m and 750 m VIIRS data. The higher resolution data are the primary drivers of the fire detection component, whereas the 750 m data are used primarily in the fire radiative power (FRP) retrievals. Compared to other coarser resolution satellite fire detection products, the algorithm provides greater response over fires of relatively small

area, as well as improved mapping of large fire perimeters. The I-band NDEAF retrieval algorithm has a flexible modular design that in principle enables it to process data from various instruments that provide compatible radiometric measurements necessary for the algorithm. For information about the I-band NDEAF algorithm, see the NDE 375m Active Fire Algorithm Theoretical Basis Document (NESDIS/STAR, 2020). The following sections describe the input files.

2.2. Input Satellite Data

2.2.1. Satellite Instruments

I-band NDEAF is a system operated within the NDE DHS by OSPO. It uses data from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (S-NPP) and NOAA-20 platforms, and on future satellites of the Joint Polar Satellite System (JPSS). . S-NPP and NOAA-20 were launched on October 28, 2011 and November 8, 2017, respectively. They are in sun synchronous orbits with a 1:30pm ascending-node orbit at an altitude of ≈829 km, separated by 50 minutes (i.e. half of an Earth orbit).

The VIIRS instrument is a whiskbroom scanning radiometer with a swath width of 3060 km, providing full daily coverage both in the day and night side of the Earth. It has 22 spectral bands covering the spectrum between 0.412 μm and 12.01 μm, including 16 moderate resolution bands (M-bands) with a spatial resolution of 750 m at nadir, 5 imaging resolution bands (I-bands) – with a spatial resolution of 375 m at nadir, and one panchromatic DNB with a 750 m spatial resolution throughout the scan. Further details of the VIIRS sensor and the VIIRS SDR product can be found in the Visible Infrared Imaging Radiometer Suite (VIIRS) Sensor Data Record (SDR) User's Guide (NOAA Technical Report NESDIS 142A).

2.2.2. Satellite Data Preprocessing Overview

The VIIRS Raw Data Records (RDRs) are pre-processed into Sensor Data Records (SDRs) by the VIIRS SDR and VIIRS Geolocation algorithms. The preprocessing includes the geolocation and radiometric calibration of the raw sensor output. The I-band NDEAF system uses the terrain-correct geolocation product. Details of the VIIRS SDR algorithm are described in the JPSS VIIRS Radiometric Calibration ATBD and the JPSS VIIRS Geolocation ATBD.

2.2.3. Input satellite data description

The I-band NDEAF detection and FRP retrieval algorithms require radiometric measurements that provide quantitative information on the radiant output from hot spots and surrounding fire-free surfaces, as well as information on environmental and observing conditions necessary to eliminate potential false detection and identify exclusion zones (e.g. cloud obscuration, sun glint). The primary band for fire detection and characterization is I4, and the dual-gain M13 band is used for FRP retrieval. Both I4 and M13 carry the radiative signal from hot spots. Table 2-1 provides a summary of the input VIIRS Sensor Data Record files used by the algorithm.

Table 2-1 Input VIIRS SDR data used by the NDEAF I-Band algorithm

Algorithm	Input to AF	HDF5 file
VIIRS-SDR	latitude longitude view zenith angle solar zenith angle view azimuth angle solar azimuth angle	GITCO_*.h5
VIIRS-SDR	Un-aggregated M13 radiance	IVCDB_*.h5
VIIRS-SDR	M13 brightness temperature M13 QF1 M13 radiance	SVM13_*.h5
VIIRS-SDR	I1 scaled brightness temperature, QF1	SVI01_*.h5
VIIRS-SDR	I2 scaled brightness temperature, QF1	SVI02_*.h5
VIIRS-SDR	I3 scaled brightness temperature, QF1	SVI03_*.h5
VIIRS-SDR	I4 scaled reflectance, QF1	SVI04_*.h5
VIIRS-SDR	I5 scaled reflectance, QF1	SVI05_*.h5

2.3. Input Ancillary Data – The VIIRS Granulated Land/Water Mask

The VIIRS Granulated Land Water Mask product is produced by the included granulation software, The data set is derived from gridded MODIS based global land-water mask of 15'' (~500m) resolution. A granulation process is implemented to that data set in order to create data arrays of identical dimensions and projection type as the input SDR files.

3. PERFORMANCE

3.1. Product Testing

3.1.1. Test Data

Description of all NDEAF I-band test data (input, output) used in unit and system tests is provided in the NDE Active Fire Algorithm Readiness Review Report (NESDIS/STAR, 2020). This is available by contacting the NDE Active Fire Product Area Lead (PAL) at OSPO.

3.1.2. Test Plans

Description of all NDEAF I-band test plans used in unit and system tests is provided in the NDE Active Fire Algorithm Readiness Review Report (NESDIS/STAR, 2020). These are available by contacting the NDE Active Fire Product Area Lead (PAL) at OSPO.

3.2. Product Accuracy

3.2.1. Test Results

Description of all NDEAF I-band test results from the unit and system tests is provided in the NDE Active Fire Algorithm Readiness Review Document (NESDIS/STAR 2020). These are available by contacting the NDE Active Fire Product Area Lead (PAL) at OSPO.

3.2.2. Product Accuracy

Explicit comprehensive validation of the accuracy of the product has not yet been conducted due to the lack of independent reference data. This work is scheduled to be continued during the Validation phase and will be performed after to the delivery of the operational code as part of the product maturity evaluation work. When this occurs, all testing documents will be updated and made available through the NDEAF I-band PAL. However, product accuracy estimates can be made via theoretical calculations and via relating to the performance of the heritage MODIS and NDEAF 750m (M-band) product. These accuracy estimates are described in the NDE Active Fire Algorithm Theoretical Basis Document.

3.3. Product Quality

The various bits within the two-dimensional Quality Assessment (QA) array listed Table 1-6 describe various aspects of the observing and environmental conditions and the corresponding performance of the various steps if the active fire detection algorithm. The fire mask array variable shown in Table 1-4 also includes an indication of missing or non-processed data. Additionally, fire detections are provided based on their detection confidence value in the fire mask array variable (values 7 to 9). Further details on the QA bits and detection confidence are described in the NDE 375m Active Fire Algorithm Theoretical Basis Document.

3.4. Analysis Tools

No external product tools are supplied. The NDEAF I-band output files are netCDF4 and ASCII files. External users can choose their own tools to display and analyze these output files.

4. PRODUCT STATUS

4.1. Operations Documentation

Operational logs contain the information regarding the changes made to science, instruments, and systems. Basically the Configuration Management system will have the detailed information about these changes, but operational logs keep the high level description of these changes.

NESDIS/STAR (2020), NDE I-band (375m) Active Fire Algorithm Theoretical Basis Document, Version 1.0.

NESDIS/STAR (2020), NDE I-band (375m) Active Fire System Maintenance Manual, Version 1.0.

NESDIS/STAR (2020), NDE I-band (375m) Active Fire Algorithm Readiness Review Report (ARRR)

NDE Operations Handbook Version 1.0 (2013)

4.2. Maintenance History

The System Maintenance Manual (SMM) will be updated to reflect the changes that will be required to maintain the **NDE Active Fire** system within the ESPC environment. Information regarding the changes to the products is tracked by the Operational logs and will be available to users on request. Product metadata will be updated as per the changes required in the product including the version number, quality flags etc.

END OF DOCUMENT