Read-me for Data Users

MEMORANDUM FOR: The Record
FROM: Ivan Csiszar, JPSS Active Fire Team Lead
SUBJECT: Suomi NPP NDE Active Fire Validated maturity status and public release
DATE: 12/13/2016

Validated maturity status declaration for Active Fire
Algorithm Readiness Review Date: 06/18/2015
Effective Date: 03/15/2016
Operational System: NDE, Version 1.2

The NOAA NESDIS Satellite Product and Services Review Board (SPSRB) approved the operational production and public release of the Suomi NPP NDE VIIRS Active Fire product on January 20, 2016. Based on evaluation results presented at the Algorithm Readiness Review held on June 18, 2015, the product is considered to have Validated maturity as defined by the NOAA JPSS program.

1. **Maturity stage definition**
   The Definition of validated maturity stage is available at the JPSS Algorithm Maturity Matrix webpage: http://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php

2. **Algorithm Description:**
   The NDE VIIRS Active Fire product is consistent with the MODIS Collection 6 algorithm and includes (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. The detection algorithm uses a hybrid approach to detect fires based on fixed thresholds and dynamically adjusted contextual tests. The retrieval of FRP is based on a single-band algorithm, using radiometric information from VIIRS band M13.

   The image classification product (fire mask) is the primary science data set consisting of a two dimensional array with same size as the input VIIRS 750 m data used by the fire algorithm. The VIIRS AF fire mask contains nine different pixel classes; three of those classes are used to flag fire-affected pixels along with their detection confidence. FRP retrievals and other supporting data such as fire pixel image element [x] and [y], and latitude/longitude are stored in vector format, each containing *N* records describing the number of fire pixels detected. The product is generated in netCDF4 format.

   Detailed information on the content of the netCDF4 data file is available in the NDE VIIRS Active Fire EDR Algorithm Theoretical Basis document http://www.star.nesdis.noaa.gov/jpss/fires.php .

Product requirements/Exclusions (L1RDS)

VIIRS Active Fire product requirements are documented in the Joint Polar Satellite System (JPSS) Level 1 Requirements Supplement (L1RDS). The current version of the L1RDS is available at http://www.jpss.noaa.gov/technical_documents.html. Appendix D of the L1RDS describes performance exclusions for the Suomi NPP products. However, the NDE VIIRS Active Fire product meets the full set of JPSS Level 1 requirements also for Suomi NPP. (The IDPS VIIRS Active Fire product meets the JPSS Level 1 requirements only with the exclusions applicable.) VIIRS Active Fire product requirements are also documented in the JPSS ESPC Requirements Document (JERD) Volume 2: Science Requirements Version 2.0.

Quality flags

The various bits within the two-dimensional Quality Assessment (QA) array within the netCDF4 product file 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 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 Active Fire Algorithm Theoretical Basis Document available at http://www.star.nesdis.noaa.gov/jpss/fires.php

Product evaluation/validation

VIIRS AF algorithm retrieval errors are validated using coincident ground-based and high spatial resolution airborne reference data acquired over prescribed fires as well as other fires of opportunity (e.g., wildfires). Currently, availability of quality reference fire data is limited to test-case studies involving ground and airborne sampling of relatively small (<1000 ha) active fires. The VIIRS AF data quality assessment also builds on product inter-comparison using near-coincident active fire data from other spaceborne instruments of similar or higher spatial resolution. Product inter-comparison results using Suomi NPP/VIIRS and Aqua/MODIS near-coincident active fire data showed high level of agreement between the two products, allowing for tracing back the accuracy of the VIIRS active fire product to the extensively validated MODIS active fire product.

Product availability/reliability

The NDE VIIRS Active Fire data have been produced since 03/15/2016. The entire available data record is at the Validated maturity level. Daily maps of the product are available at the STAR JPSS Long-term Monitoring website at http://www.star.nesdis.noaa.gov/jpss/EDRs/products_activeFires.php .

Algorithm performance dependence

The performance of the VIIRS Active Fire product largely depends on the performance of the VIIRS SDR product. Past issues included dual-gain calibration mismatch, look-up table and quality flag errors (see product maturity documents of the IDPS VIIRS Active Fire product). The VIIRS

SDR issues have been mostly resolved by the time of the operational NDE VIIRS Active Fire product.

Known errors/issues/limitations

The algorithm used by the NDE VIIRS Active Fire product is tuned to minimize omission and commission errors globally. Therefore, regionally tuned algorithms may produce better detection results.

3. **Changes since last maturity stage**

   The NDE VIIRS Active Fire product is deemed to be at the Validated maturity stage from the beginning of the operational production (March 15, 2016).

4. **Review board recommendations**

   N/A

5. **Path Forward/Future Plan**

   The NOAA JPSS Active Fire team continues product validation and product improvements, including implementation of multi-band hybrid algorithms. Reprocessing of the entire Suomi NPP data record is planned after the reprocessing and evaluation of the VIIRS SDR data record.

6. **Additional Items to note**

   None.

Additional information is available in the {JPSS Product} algorithm theoretical basis document (ATBD) and validation maturity review briefing, which can be accessed at:

http://www.star.nesdis.noaa.gov/jpss/Docs.php

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IDPS VIIRS Active Fire (AF) Application Related Product (ARP) Release, Validated Stage 1 Data Quality
January 2015 (updated on December 13, 2016)
Read-me for Data Users

The JPSS Algorithm Engineering Review Board (AERB) released the Suomi NPP VIIRS Active Fire (AF) product to the public with a Stage 1 Validation level maturity with an effectivity date of August 13, 2014. The effectivity date corresponds to the Transition to Operations of IDPS Mx8.5, which included the implementation of multiple VIIRS Sensor Data Record (SDR) fixes. This assessment is based on both qualitative and quantitative analysis of the VIIRS Active Fire application related product for which the short name is "VIIRS-AF-EDR". Quantitative evaluation is predominantly based on correlative analysis with the Aqua MODIS Thermal Anomalies and Fire product (MYD14). ***VIIRS-AF-EDR is at Stage 1 validation level with the caveat that spurious detections occur in a limited, but well-defined set of circumstances as described below.***

Validated Stage 1 quality is defined as:

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

The Board recommends that users be informed of the following product information and characteristics when evaluating the VIIRS-AF-EDR:

1. **Product Requirements:** Product requirements are now documented in the Joint Polar Satellite System (JPSS) Level 1 Requirements Supplement (L1RDS) and include a spatially explicit fire mask and fire radiative power (FRP) retrieval for the Active Fires product over the entire globe, including water. These requirements apply only to future satellites, starting with JPSS 1. Appendix D of the L1RDS describes performance exclusions for the Suomi NPP products. According to these exclusions, the **Suomi NPP product is required to deliver a list of locations of pixels with fire detections over clear land only**.

2. **Algorithm Description**. The Suomi NPP VIIRS-AF-EDR is based upon the MODIS (Moderate Resolution Imaging Spectroradiometer) Thermal Anomalies and Fire product Version 4 code, adapted for use with the VIIRS data. VIIRS-AF-EDR provides the latitude and longitude of pixels in which the algorithm detected hot targets, which are predominantly fires burning at the time of the observation. The Suomi NPP requirement exclusions reduce the requirements to the delivery of a list of pixel locations with fire detections over land, making them equivalent to the heritage requirements of the National Polar Orbiting Environmental Satellite System (NPOESS). The current IDPS product was designed to meet these heritage requirements and the Validated Stage 1 evaluation was also performed against these heritage requirements.

3. **Product Evaluation.** Quantitative evaluation to date is predominantly based on correlative analysis with the Aqua MODIS Thermal Anomalies and Fire product (MYD14). Though the VIIRS processing algorithm is an earlier version of the current MODIS algorithm, the differences do allow for product inter-comparison for validation analysis. Due to the high dependency of input SDR data, quantitative evaluation also includes the frequency of obviously spurious detections in the data product. Such spurious detections are identified based on the presence of detections over large, continuous segments of fire detections within single VIIRS scan lines.

Starting with the Beta release if the product on April 3, 2012, the product has been performing well in comparison to Aqua MODIS over significant evaluation periods, with the exception of spurious detections along VIIRS scanlines. Validated Stage 1 Maturity status is tied to the transition to operations of IDPS Build Mx8.5, which includes the implementation of 474-CCR-14-1667: VIIRS SDR Multiple Issues/Quality Flags & Calibration (ADRs 7110, 7111, 7112, 7227, 7313, 7448, 7449). Analysis showed that, as a result of this SDR code change, the frequency of spurious detections was further reduced to a limited set of circumstances and previous spurious detections observed over a 4-month period in Mx8.4 were removed by the Mx8.5 SDR algorithm.

4. **Quality Flags.** The product includes four bytes of quality flags (QFs) as listed in the table below. However, as only fire pixels are written to the sparse array of the current product, some of the bits, by default, are set to 0 or 1 for all pixels included in the output file (see comments below). Additional QFs describe observing and environmental conditions and results of various tests by the detection algorithm; advanced users are encouraged to analyze the need and applicability of these QFs for their particular application.

   The bits describing the validity of the various fire tests (QF2, bits 0-6) are set only in several distinct configurations both daytime and nighttime based on the logic of the fire detection algorithm:

   Daytime: Test 1 or (Test 2 and Test 3 and Test 4 and (Test 5 or Test 6))

   Nighttime: Test 1 or (Test 2 and Test 3 and Test 4)

   Users are recommended to use QF4 (Fire Detection Confidence) as the primary quality indicator of the product. The recommended classification of detection confidence is as follows:

   QF4 <20% - low confidence;

   20%<QF4<80% - medium confidence;

   QF4>80% - high confidence.

   It is not recommended to use Input Data Quality (QF3, bit 6) as it may not indicate the true overall quality of the input SDR data in some situations due to ongoing SDR changes. This bit is also currently set to “Poor” for all nighttime cases as well as some daytime cases.

QF	Bit	Description	Value	Comment
QF1	0	Adjacent Cloud Flag	0 = No 1 = Yes	Recommended for advanced use
	1	Adjacent Water Flag	0 = No 1 = Yes	Recommended for advanced use
	2-5	Search Window Size (number of pixels used)	1-10	Recommended for advanced use
	6	Sun Glint	0 = No 1 = Yes	Recommended for advanced use
	7	Sun Glint Override	0 = No 1 = Yes	Not to be used; set to 0 for all pixels
QF2	0	Fire Test 1 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	1	Fire Test 2 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	2	Fire Test 3 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	3	Fire Test 4 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	4	Fire Test 5 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	5	Fire Test 6 Valid	0 = No 1 = Yes	Limited use to assess algorithm performance
	6	Input Data Quality	0 = Good 1 = Poor	Not recommended; all nighttime set to 1
	7	Day/Night	0 = Night 1 = Day	Recommended
QF3	0	False Alarm Override	0 = No 1 = Yes	Not to be used; set to 0 for all pixels
	1	Water Contamination Override	0 = No 1 = Yes	Not to be used; set to 0 for all pixels
	2-7	Spare Bits	Initialized to 0	Not used
QF4	0-7	Fire Detection Confidence	0 – 100%	Recommended as primary quality indicator

5. **Known Errors**.

   a. Spurious detections occur, with a frequency of approximately a few times a month, at high northern latitudes, presumably due to calibration mismatch at the beginning of a new VIIRS data transmission. The VIIRS SDR team is working on addressing the problem.

   b. Spurious detections may occur during lunar intrusion events along the edges of exclusion zones of the lunar intrusion contamination. Lunar intrusion events occur two times within each lunar cycle.

c. A mismatch was detected between Radiance and brightness temperature, which has a small impact on detection performance. This issue is being worked by the VIIRS SDR team through 474-CCR--2321- VIIRS Radiance and Reflectance/Brightness Temp. Upper Bounds & QF Inconsistent (ADR 7294) scheduled for implementation in IDPS Mx8.9.

d. Additional spurious detections have occurred in data products generated within Direct Broadcast (DB) environments. Those errors are typically related to issues specific to DB data transmission and are not present in corresponding IDPS data. Producers of DB processing packages have implemented additional software to reduce or eliminate these additional spurious detections. **The DB-related issues do not impact the maturity of the IDPS product.**

6. **Future Work**. The next step in the VIIRS-AF-EDR product validation process is to perform product validation over additional samples of reference data from MODIS and limited airborne and in-situ data sets. Continuous long-term monitoring of the product is being carried out to track internal product consistency and spurious detections. Validation will also include expanded VIIRS-AF-EDR products under development to in order to meet the new Level 1 requirements for processing VIIRS data from the JPSS 1 satellite. These algorithm changes incorporate new MODIS Collection 6 algorithm components, and the tuning of the algorithm to VIIRS sensor characteristics.

More information about VIIRS and the VIIRS-AF-EDR product can be found at the following websites, where users can find the Algorithm Theoretical Basis Document (ATBD), Operational Algorithm Description (OAD) document, Common Data Format Control Book (CDFCB), and product examples:

http://www.star.nesdis.noaa.gov/jpss/

Additionally, the VIIRS Sensor Data Record (SDR) Readme document s is available at:
http://www.star.nesdis.noaa.gov/jpss/documents/AMM/VIIRS_SDR_Validated_ReadMe.pdf

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