MEMORANDUM FOR:	The JPSS Program Record
SUBMITTED BY:	JPSS VIIRS Active Fire Team Lead, Ivan Csiszar
CONCURRED BY:	JPSS Algorithm Management Project Lead Lihang Zhou
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SUBJECT:	NOAA-21 Provisional maturity status and public release
DATE:	06/01/2023

Provisional maturity status declaration for VIIRS I-band Active Fire
Maturity Review Date: **06/01/2023**
Effective Date: **03/30/2023**
Operational System: **NDE 2.0, Version XXX**

The JPSS Algorithm Maturity Readiness Review Board approved the release of the JPSS VIIRS Active Fire Product to the public with a Provisional maturity level quality as of 03/30/2023 (effective date), based on JPSS Validation Maturity Review held on 06/01/2023 (link to review artifacts).

1. **Maturity stage definition (http://www.star.nesdis.noaa.gov/jpss/AlgorithmMaturity.php)**

   a. 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 select locations, periods, and associated ground truth or field campaign efforts.
   b. Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).
   c. Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.
   d. Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.

2. **Algorithm Description:**

   The NDE VIIRS I-band Active Fire product 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. Pixels with potential false detections due to non-fire sources or persistent thermal anomalies are flagged. 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 the same size as the input VIIRS 375 m data used by the fire algorithm. The VIIRS I-band 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 I-band Active Fire EDR Algorithm Theoretical Basis document https://www.star.nesdis.noaa.gov/jpss/fires.php

The processing algorithms and the output data formats for VIIRS on Suomi NPP, NOAA-20 and NOAA-21 are identical, with the exception of the coefficient used in the fire radiative power retrieval, which has been updated due to the shift of the NOAA-21 VIIRS M13 band spectral response function.

List of Products: AF_Iband_VIIRS_EDR, AF_Iband_VIIRS_ASCII_List

Product requirements/Exclusions (DPS):

- The Active Fires product is based on the detection and analysis of the radiative signature of natural or anthropogenic surface fires as received by the sensor. The product includes the geolocation and fire radiative power of pixels for which fires are detected, and a full mask consisting of a two-dimensional array of values representing the fire and other relevant thematic classes (e.g., cloud) of each pixel in a swath data granule.

- DPS-32 The Active Fires product shall provide fire radiative power, with a measurement uncertainty of 50%, over the measurement range of the instrument.

- DPS-33 The Active Fires product shall provide a per-pixel fire mask and fire radiative power, calculated from infrared imager calibrated data, globally day and night, under clear sky conditions between clouds, at the refresh rates of the instrument.

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 in the active fire detection algorithm. The QA array now includes flags for non-fire sources or persistent thermal anomalies. 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 VIIRS I-band Active Fire Algorithm Theoretical Basis Document available at https://www.star.nesdis.noaa.gov/jpss/fires.php .

Product evaluation/validation

As a primary validation approach, the VIIRS I-band 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. Such prior validation included, for example, comparisons of Suomi NPP and NOAA-20 data with high-resolution airborne imagery from the FIREX-AQ campaign in 2019, which confirmed the accuracy of the spatial distribution and fire radiative power retrievals of VIIRS I-band fire detections.

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, NOAA-20 and NOAA-21 VIIRS near-coincident active fire data showed high level of consistency between the three products, allowing for tracing back the accuracy of the NOAA-21 VIIRS active fire product to the more extensively validated Suomi NPP and NOAA-20 active fire products.

While the quality of NOAA-21 top-of-atmosphere Fire Radiative Power data is compatible to those derived from Suomi NPP and NOAA-20, the spectral shift of the VIIRS M13 Spectral Response Function towards a more transparent spectral region of the atmosphere results in a minor (up to ~10%) positive bias between NOAA-21 and Suomi NPP or NOAA-20.

Product availability/reliability

NOAA-21 VIIRS I-band Active Fire data were produced since 02/09/2023 in the NDE Integration and Testing environment, but data before 02/23/2023 were not reliable because of ongoing calibration and validation activities of the input NOAA-21 VIIRS SDR data.

Algorithm performance dependence

The performance of the VIIRS Active Fire product largely depends on the performance of the VIIRS SDR product, in particular SDR algorithm output for saturated measurements (such as radiance folding), saturation levels and calibration accuracy. Past issues included dual-gain calibration mismatch, look-up table and quality flag errors (see product maturity documents of the IDPS Suomi NPP VIIRS Active Fire product). The performance of the NOAA-21 VIIRS SDR is deemed to be adequate so that these past issues are not present in the NOAA-21 product.

Known errors/issues/limitations

1. The baseline VIIRS I-band active fire product is known to exclude possible fire detections and FRP retrievals due to a conservative internal cloud mask. This issue is being addressed by the STAR Fire Science Team.
2. The persistent anomaly database, which is used to trigger flags for non-fire and persistent anomaly sources in the product, requires continuous updates and/or accurate detection approaches.

3. **Changes since last maturity stage: N/A**

4. **Review board recommendations**

5. **Path Forward/Future Plan**

   The JPSS VIIRS I-band Active Fire baseline processing capability is transitioning to a new Enterprise Fire Software base. This transition includes some changes in the output science content and format, but essentially no change in the science processing algorithm and product detection and FRP retrieval performance.

   Continuing development includes the improvement of the persistent anomaly database and the automated detection of some persistent anomalies.

   The VIIRS active fire processing capability will eventually be incorporated in the NESDIS Next Generation Fire System, which will provide fire information in a new service delivery framework.

6. **Additional Items to note**

Additional information is available in the JPSS VIIRS Active Fire 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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