LATEST RESULTS OF THE DEVELOPMENT AND EVALUATION OF THE SUOMI NPP VIIRS ACTIVE FIRE PRODUCTS

Ivan Csiszar¹, Wilfrid Schroeder², Louis Giglio², Evan Ellicott², Christopher O. Justice²

¹NOAA/NESDIS Center for Satellite Applications and Research, Camp Springs, MD
²University of Maryland, College Park, MD

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## VIIRS Heritage: MODIS and AVHRR

<table>
<thead>
<tr>
<th>VIIRS</th>
<th>MODIS Equivalent</th>
<th>AVHRR-3 Equivalent</th>
<th>OLS Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band</td>
<td>Range (um)</td>
<td>HSR (m)</td>
<td>Band</td>
</tr>
<tr>
<td>DNB</td>
<td>0.500 - 0.900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>0.402 - 0.422</td>
<td>750</td>
<td>8</td>
</tr>
<tr>
<td>M2</td>
<td>0.436 - 0.454</td>
<td>750</td>
<td>9</td>
</tr>
<tr>
<td>M3</td>
<td>0.478 - 0.498</td>
<td>750</td>
<td>10</td>
</tr>
<tr>
<td>M4</td>
<td>0.545 - 0.565</td>
<td>750</td>
<td>12</td>
</tr>
<tr>
<td>I1</td>
<td>0.600 - 0.680</td>
<td>375</td>
<td>1</td>
</tr>
<tr>
<td>M5</td>
<td>0.662 - 0.682</td>
<td>750</td>
<td>13</td>
</tr>
<tr>
<td>M6</td>
<td>0.739 - 0.754</td>
<td>750</td>
<td>15</td>
</tr>
<tr>
<td>I2</td>
<td>0.846 - 0.885</td>
<td>375</td>
<td>2</td>
</tr>
<tr>
<td>M7</td>
<td>0.846 - 0.885</td>
<td>750</td>
<td>16</td>
</tr>
<tr>
<td>M8</td>
<td>1.230 - 1.250</td>
<td>750</td>
<td>5</td>
</tr>
<tr>
<td>M9</td>
<td>1.371 - 1.386</td>
<td>750</td>
<td>26</td>
</tr>
<tr>
<td>I3</td>
<td>1.580 - 1.640</td>
<td>375</td>
<td>6</td>
</tr>
<tr>
<td>M10</td>
<td>1.580 - 1.640</td>
<td>750</td>
<td>6</td>
</tr>
<tr>
<td>M11</td>
<td>2.225 - 2.275</td>
<td>750</td>
<td>7</td>
</tr>
<tr>
<td>I4</td>
<td>3.550 - 3.930</td>
<td>375</td>
<td>20</td>
</tr>
<tr>
<td>M12</td>
<td>3.660 - 3.840</td>
<td>750</td>
<td>20</td>
</tr>
<tr>
<td>M13</td>
<td>3.973 - 4.128</td>
<td>750</td>
<td>21</td>
</tr>
<tr>
<td>M14</td>
<td>8.200 - 8.700</td>
<td>750</td>
<td>29</td>
</tr>
<tr>
<td>I5</td>
<td>10.500 - 12.400</td>
<td>375</td>
<td>31</td>
</tr>
<tr>
<td>M16</td>
<td>11.538 - 12.488</td>
<td>750</td>
<td>32</td>
</tr>
</tbody>
</table>

**VIIRS OLS Equivalent:**
- DNB: 0.580 - 0.910 (550)
- PMT: 0.510 - 0.860 (2700)

**MODIS Equivalent:**
- HRD: 0.580 - 0.910 (550)
- PMT: 0.510 - 0.860 (2700)

**AVHRR-3 Equivalent:**
- HRD: 10.300 - 12.900 (550)
VIIRS active fire product development

NOAA: “real-time NOAA operational applications”
- Operational product generated by IDPS (Interface Data Processing Segment)
- Part of integrated processing chain
- Low latency
- Detections only
- Locations only (no fire mask)

Algorithm updates

Upstream processing updates

VIIRS Fire Team

NASA: “science, long-term continuity + added value NRT”
- Experimental MODIS continuity product a at the Land PEATE (Product Evaluation and Test Element)
- Detections, Fire Mask and Fire Radiative Power, CMG
- Spatially explicit fire mask
- Spatial and temporal aggregates – heritage deliver systems (RR, FIRMS)

DIRECT READOUT
- Can run IDPS, NASA or locally developed code
- Stand-alone

Algorithm synchronization, end user feedback
Spatial Resolution Comparisons for VIIRS, AVHRR, MODIS and OLS at Nadir and Across Swath

Because of aggregation VIIRS has much better resolution away from nadir, pixel area 8 times smaller than AVHRR or MODIS

Northrup Grumman & Raytheon
MODIS and VIIRS fire detections at nadir: modeling

VIIRS spatial resolution is higher than that of MODIS; in general, VIIRS is expected to detect smaller fires at nadir.

90% probability of detection; boreal forest; nadir view.
Background of Active Fires ARP Product

- Represents **continuity** with NASA EOS **MODIS** and NOAA POES **AVHRR** fire detection (and also international missions such as (A)ATSR)

- **VIIRS design allows for radiometric measurements** to detect and characterize active fires over a wide range of observing and environmental conditions

- Product is expected to be used by **real-time resource and disaster management; air quality monitoring; ecosystem monitoring; climate studies** etc.

NW Canada
07 July 2013
20:14:55-20:20:34 UTC
## L1RD Requirements: current (v2.9)

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>THRESHOLD</th>
<th>OBJECTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Horizontal Cell Size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Nadir</td>
<td>0.80 km</td>
<td>0.25 km</td>
</tr>
<tr>
<td>2. Worst case</td>
<td>1.6 km</td>
<td></td>
</tr>
<tr>
<td><strong>b. Horizontal Reporting Interval</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HCS</td>
<td></td>
</tr>
<tr>
<td><strong>c. Horizontal Coverage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Global</td>
<td>Global</td>
</tr>
<tr>
<td><strong>d. Mapping Uncertainty, 3 sigma</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 km</td>
<td>0.75 km</td>
</tr>
<tr>
<td><strong>e. Measurement Range</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Fire Radiative Rower (FRP)</td>
<td>1.0 to 5.0 (10)^3 MW</td>
<td>1.0 to 1.0 (10)^4 MW</td>
</tr>
<tr>
<td>2. Sub-pixel Average Temperature of Active Fire</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3. Sub-pixel Area of Active Fire</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>f. Measurement Uncertainty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Fire Radiative Rower (FRP)</td>
<td>50%</td>
<td>20%</td>
</tr>
<tr>
<td>2. Sub-pixel Average Temperature of Active Fire</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3. Sub-pixel Area of Active Fire</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>g. Refresh</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 90% coverage of the globe every 12 hours (monthly average)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>h. Latency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>See L1S00015</td>
<td>15 min</td>
</tr>
</tbody>
</table>

**Current IDPS product was designed to meet heritage NPOESS requirements., which have been baselined according to L1RDS S-NPP Performance Exclusions (Appendix D). Spatially explicit fire mask and fire characterization are “uppers” in the JPSS L1RD for J1 and beyond.**
Spurious Fire Detections in Beta

- After the Beta effectivity date (April 3, 2012), scanlines with spurious fire detections were observed approximately once a day.

- The current active fire code excludes non-land pixels and pixels flagged as cloud by the internal cloud mask—issues are detected only for a fraction of the granules.

- It is imperative to improve the quality and quality flagging of the input SDR data.
Improvements in input M13 SDR led to significant drop in spurious detections along scan lines

Effectivity date for Provisional Maturity (i.e. ready for operational evaluation): October 16, 2012 (first full day after the implementation of Mx6.3 on October 15)

Occurrence of spurious detections along scan lines
Aqua MODIS vs. Suomi NPP VIIRS

MODIS angular sampling

MODIS angular sampling

Replacement algorithm (MODIS C6)
MODIS V6 code running on VIIRS data at LCF and in LandPEATE

- Spatially explicit fire mask and FRP -> new JPSS L1 Requirements Supplement
- Additional data layers for CMG
- Ocean processing for gas flares, a new false-alarm rejection test over tropical regions, and dynamic potential fire thresholds
IDPS algorithm (MODIS C4)
MODIS Version 4 algorithm running on VIIRS data

Sparse array of fire pixels – no spatially explicit fire mask
No FRP
Land-only processing
West Fork Complex: 6/14 - 7/4/2013

Landsat-8 background: July 31, 2013
West Fork Complex: 6/14 - 7/4/2013
Landsat-8 background: July 31, 2013

VIIRS FRP
MW
- 0 - 97
- 98 - 246
- 249 - 469
- 470 - 924
- 925 - 2389

Creede
Wagon Wheel Gap
South Fork
Windy Pass
Papoose
West Fork
Pagosa Springs
VIIRS replacement vs. IDPS

Rimfire, CA: August 17th - 28th

- VIIRS IDPS count
- VIIRS experimental count

VIIRS IDPS
Peak day and count: August 22nd, 263
Total count = 1597

VIIRS experimental
Peak day and count: August 26th, 300
Total count = 1815

See also presentation J6.2 (Ellicott et al.)
I-band detection: great potential, but sub-optimal sensor

Abnormally low BT (208<>300K) within active fire perimeter and coinciding with outline of head fire where highest temperatures typically occur

208K prevailing among those pixels although higher/intermediate values are also found
Global fires from I-band data

VIIRS 375 m fire algorithm output showing the accumulated daytime nominal confidence fire pixels (upper left), low confidence daytime pixels (upper right), nighttime fire pixels (purple; lower left), and SAMA-related low confidence nighttime pixels (dark blue; lower right) during 1–30 August 2013.


See also presentation J6.3 (Coen et al.)
Validation overview

• Continuing correlative analysis with Aqua MODIS
  – Comparisons reflect expected differences in detections
  – No noticeable change between 2012 (post-beta) and 2013, excluding spurious VIIRS detections

• Airborne fire observations
  – Ongoing efforts with USFS and NASA assets

• High resolution satellite data
  – Continuing collaboration with DLR on TET-1
  – First sample data received
  – NOAA-DRL MOU is reaching completion

• End user feedback
  – Outreach through proving ground and GOFC-GOLD Fire
Validation Using Near-Coincident Airborne Reference Data

USFS NIROPS
06 Aug 21:36 PDT

- Red: Fire-affected Area
- Yellow: Intense Heat
Validation Using Near-Coincident Airborne Reference Data

VIIRS
07 Aug 02:50 PDT

Brightness Temp (K)
- 295-315
- 316-325
- 326-335
- 336-345
- 346-355
- 356-367
Validation Using Near-Coincident Airborne Reference Data
Validation Using Near-Coincident Airborne Reference Data
Validation: satellite-based reference data

MIR grayscale image

ground track

July 17, 2013 19:23 UTC
DRL TET-1: 42m (SW, NIR), 370m (MIR, LWIR), high saturation

courtesy E. Lorentz et al., DLR
Progress with DLR/TET-1 Data

Successful coordinated acquisitions with VIIRS over the U.S. and abroad

MW IR
FRP over MW IR
VIIRS 375 m detections over TET-1 FRP (VIIRS trailing TET-1 ~ 40 min)

Five channels (40-370 m resolution)

Spectral radiance (W/m²sr)

TET-1 Swath Preview and Ordering Tool Developed
VIIRS Active Fire Product Website

viirsfire.geog.umd.edu
VIIRS fire data access

• Options:
  – NOAA CLASS Web
    • www.class.noaa.gov
  – NASA LAADSWeb
    • ladsweb.nascom.nasa.gov/data/search.html
  – NOAA CLASS ftp (anonymous)
    • ftp-npp.class.ngcd.noaa.gov
  – NASA LAADS ftp (anonymous)
    • ladsweb.nascom.nasa.gov

• Detailed instructions:
  viirsfire.geog.umd.edu/Documents/VIIRS_data_tutorial.pdf
VIIRS fire data access options

Order Spatial Subsets*

No

Order Daily Bundles

No

Order HDF5

LAADS FTP "/allData/3000"

Yes

NOAA CLASS URL (HDF5 only)

Order HDF4

LAADS FTP "/allData/3001"

NOAA CLASS FTP

LAADSWeb URL (HDF4 & 5)

Yes (HDF5 only)
“NPP products will be released to the user community over a time frame of several months. As products become available please go to the Suomi NPP FAQ to determine which products can be ordered. All newly released products will be 'beta'. Please see Product Maturity Level page to determine level of quality for each product.”

- Frequently asked questions (FAQ)
- Product Maturity Levels
- Tutorial on Data Access

http://www.class.ncdc.noaa.gov/notification/pdfs/VIIRS_Active%20Fire%20ARP_Release_Readme_final.pdf
Challenges

• **Product Latency**
  – Early fire detection is critical
  – CLASS latency is insufficient for NRT applications
  – DB processing is key
  – need also direct access to IDPS output to serve end users outside of the DB network and for development / demonstration purposes

• **Algorithm Improvements**
  – Algorithm validation and development are still ongoing
  – IDPS algorithm prior to Mx6.3 produced spurious scan-lines
  – replacement algorithm needs evaluation before end-user access

• **Provision > Validation (L1, L2, L3)**
  – MODIS as references serves as initial evaluation source for consistency (i.e. expected relative performance due to sensor differences)
  – Collection of “truth” reference data is costly and logistically difficult
    • Airborne high resolution radiometers
    • In-situ data (mainly from field campaigns)
    • Reference satellite data (e.g. DLR German Space Agency TET / BIROS missions)

• **Science and applications**
  – Algorithm and product suitability, continuity, long-term monitoring, reprocessing
Summary and Conclusions

• Active Fires product has been declared **Provisional maturity** and is publicly available
  – Operational evaluation ongoing
  – To be declared operational by NOAA in early 2014
• User Readiness and Proving Ground activities are reaching out various **domestic and international end users** - goal is the continuity and enhancement of the MODIS product suite – LANCE, RR, FIRMS
• Implementation of **DB processing systems** is underway domestically and internationally
  – Continuing coordination regarding product evaluation and algorithm versioning is critical
• More work is needed to implement **new MODIS algorithm components** (C6) and **sensor-specific tuning** in the VIIRS product, product content and product suite
  – Use of **I band - DNB data** (detection, validation, fused products)
  – Use of **shortwave data** (NightFire)
• **Validation** of global product remains crucial and will be challenging