USE OF VIIRS FIRE PRODUCTS TO SUPPORT FIRE MANAGEMENT

Presented by Ivan Csiszar
NOAA/NESDIS Center for Satellite Applications and Research (STAR),
College Park, Maryland, USA

with significant contribution by
W. Schroeder, L. Giglio, E. Ellicott, C.O. Justice
University of Maryland, Department of Geographical Sciences, College
Park, Maryland, USA

M. Tsidulko, V. Mikles, W. Wolf
NOAA/NESDIS STAR Algorithm Integration Team
College Park, MD, USA
How do we support fire management?

• Improve the quality of the VIIRS fire products

• Facilitate access to the products

• Interact with operational fire management

• Provide improved data for modeling applications
VIIRS active fire product development

**NOAA: real-time NOAA operational applications**

- Current operational M-band product generated by IDPS\(^1\)
- Part of integrated processing chain
- Low latency; detections only
- Locations only (no fire mask)
- New operational product within NDE\(^2\); consistent with NASA product

**Algorithm updates**

**Upstream processing updates**

**VIIRS Fire Team**

**NOAA Proving Ground**

**NASA Applied Science**

- Algorithm synchronization, end user feedback

**DIRECT READOUT (CSPP, IPOPP)**

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

**NASA: science, long-term continuity + added value NRT**

- M-band MODIS continuity product at Land SIPS\(^3\)
- Detections, Fire Mask and Fire Radiative Power, CMG
- Spatially explicit fire mask
- Spatial and temporal aggregates – heritage delivery systems (RR, FIRMS)
- Experimental I-band product

---

\(^1\) Interface Data Processing Segment; \(^2\) Suomi NPP Data Exploitation; \(^3\) Science Investigator-led Processing System
NOAA VIIRS product status

• The **current Suomi NPP 750m Active Fire product** in IDPS is stable and operational
  – provides fire locations over land
  – product monitoring and maintenance is ongoing

• A **new 750m VIIRS fire algorithm** is transitioning into NOAA operations
  – global mask of thematic classes including water, cloud, non-fire clear land and fire at three confidence levels
  – fire radiative power for each fire-affected pixel
  – new algorithm elements to improve detection performance
  – the product is **tailored subset of the NASA science product** for real-time NOAA operations
  – **continuity with** the **MODIS** MOD14/MYD14 product
  – support NWS integration into **AWIFS-II**
**Baseline 750 m product** builds on MODIS C6 *Fire and Thermal Anomalies* (MOD14/MYD14) algorithm
- Provides fire mask, fire radiative power retrievals, plus additional metadata
  - Mimics MOD14/MYD14 science data format & nomenclature
- Currently implemented/maintained at Land SIPS (**NPP_VAFIRE_L2D**)
- Currently implemented/maintained in IPOPP serving the DB community
- Latest algorithm being ported to NESDIS in order to replace operational version in IDPS (based on outdated Collection 4 version)

**New 375 m product** based on similar MOD14/MYD14 architecture
- Provides fire mask, limited fire retrievals (frequent saturation), plus additional metadata
  - Resembles MOD14/MYD14 science data format & nomenclature
- Currently running at the USDA Remote Sensing Applications Center (RSAC), and in fire monitoring systems in South Africa and Brazil
- Being ported to IPOPP
- To be ported to Land SIPS
- Long-term plan is to implement in NOAA operations
Suomi NPP/VIIRS AF and Aqua/MODIS MYD14 fire detection data produced for the King fire/California on 14-19 September 2014
Frequent spurious detections in early IDPS product

Frequent occurrence of spurious scanlines during the first ~10 months of production

The active fire team has been working with the VIIRS SDR team to diagnose and reduce input data anomalies; and improve quality flagging to enable filtering of corrupt data.
IDPS Suomi NPP Active Fire Product: data anomalies and product maturity (2/1)

2012

April 3, 2012
IDPS Mx5.3

October 16, 2012
IDPS Mx6.3

2013

Day of Year

$N_{\text{max}}$: maximum number of detections within a scanline

Day of Year
IDPS Suomi NPP Active Fire Product: data anomalies and product maturity (2/2)

2014

N_max Provisional

August 13, 2014
IDPS Mx8.5

Validated stage 1

2015

N_max

Day of Year

removed by Mx8.5 SDR fix

No anomalies detected so far in 2015

N_max: maximum number of detections within a scanline
VIIRS fire mask over Central America and North-West South America on 3/1/2015 at 6:33 UTC. The horizontal lines are bow-tie deletions in the VIIRS granule.

VIIRS fire mask generated at NOAA/NESDIS/STAR from IDPS input data. The NOAA Level-2 product is a tailored version of the NASA science product developed at UMD.

FRP: 4.36 – 212.39 MW (nighttime)

Data processed by STAR Algorithm Integration Team from IDPS input
NOAA operational version

IDPS input
(85.7 sec granules)
NASA Science Product

NASA hdf4 input
(~5 minute granules)
# NDE VIIRS Active Fire Output

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Dimension</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>fire mask</td>
<td>8 bit integer</td>
<td>Fire mask</td>
<td>3200 x 768</td>
<td>unitless</td>
<td>0 - 9</td>
</tr>
<tr>
<td>algorithm QA</td>
<td>32 bit Integer</td>
<td>Fire algorithm QA mask</td>
<td>3200 x 768</td>
<td>unitless</td>
<td>0 - 31</td>
</tr>
<tr>
<td>[18 diagnostic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>variables to be</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>completed]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FP_confidence</td>
<td>8 bit Integer</td>
<td>Fire detection confidence</td>
<td>Sparse data</td>
<td>%</td>
<td>0 – 100</td>
</tr>
<tr>
<td>FP_land</td>
<td>8 bit Integer</td>
<td>Land pixel flag</td>
<td>Sparse data</td>
<td>unitless</td>
<td></td>
</tr>
<tr>
<td>FP_latitude</td>
<td>32 bit Float</td>
<td>Fire pixel latitude</td>
<td>Sparse data</td>
<td>degrees</td>
<td>-90 - 90</td>
</tr>
<tr>
<td>FP_line</td>
<td>16 bit Integer</td>
<td>Fire pixel line</td>
<td>Sparse data</td>
<td>unitless</td>
<td>0 - 768</td>
</tr>
<tr>
<td>FP_longitude</td>
<td>32 bit Float</td>
<td>Fire pixel longitude</td>
<td>Sparse data</td>
<td>degrees</td>
<td>-180 - 180</td>
</tr>
<tr>
<td>FP_power</td>
<td>32 bit Float</td>
<td>Fire radiative power</td>
<td>Sparse data</td>
<td>MW</td>
<td>0 - 5000</td>
</tr>
<tr>
<td>FP_sample</td>
<td>16 bit Integer</td>
<td>Fire pixel sample</td>
<td>Sparse data</td>
<td>unitless</td>
<td>0 – 3200</td>
</tr>
<tr>
<td>Nfire [TBC]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Details of two-dimensional arrays within the NDE VIIRS Active Fire output file

<table>
<thead>
<tr>
<th>Output</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Mask</td>
<td>8-bit unsigned integer</td>
<td>Missing – 0 Brightness temperatures for M13 or M15 unavailable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scan – 1 Not processed (trim)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other – 2 Not processed (other reason)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water – 3 Pixel classified as non fire water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cloud – 4 Pixel classified as cloudy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Fire – 5 Pixel classified as non fire land</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unknown – 6 Pixel with no valid background pixels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fire Low – 7 Fire pixel with confidence strictly less than 20% fire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fire Medium – 8 Fire pixel with confidence between 20% and 80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fire High – 9 Fire pixel with confidence greater than or equal to 80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire Algorithm QA Mask</th>
<th>32-bit unsigned integer</th>
<th>Details in Table 1-3</th>
</tr>
</thead>
</table>
### Details of the Quality Assessment (QA) mask within the NDE VIIRS Active Fire output file

<table>
<thead>
<tr>
<th>Bits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Surface Type (water=0, coastal=1, land=2)</td>
</tr>
<tr>
<td>2-3</td>
<td>Atmospheric correction</td>
</tr>
<tr>
<td>4</td>
<td>Day/Night (daytime = 1, nighttime = 0)</td>
</tr>
<tr>
<td>5</td>
<td>Potential fire (0/1)</td>
</tr>
<tr>
<td>6-10</td>
<td>Background window size parameter</td>
</tr>
<tr>
<td>11</td>
<td>Fire Test 1 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>12</td>
<td>Fire Test 2 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>13</td>
<td>Fire Test 3 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>14</td>
<td>Fire Test 4 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>15</td>
<td>Fire Test 5 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>16</td>
<td>Fire Test 6 valid (0 - No, 1 - Yes)</td>
</tr>
<tr>
<td>17-19</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>Adjacent clouds (0/1)</td>
</tr>
<tr>
<td>21</td>
<td>Adjacent water (0/1)</td>
</tr>
<tr>
<td>22-23</td>
<td>Sun Glint Level (0-3)</td>
</tr>
<tr>
<td>24</td>
<td>Sun Glint rejection</td>
</tr>
<tr>
<td>25</td>
<td>False Alarm 1 (excessive rejection of legitimate background pixels)</td>
</tr>
<tr>
<td>26</td>
<td>False Alarm 2 (water pixel contamination)</td>
</tr>
<tr>
<td>27</td>
<td>Amazon forest-clearing rejection test</td>
</tr>
<tr>
<td>28-31</td>
<td>N/A</td>
</tr>
</tbody>
</table>
VIIRS FRP evaluation

MODIS/VIIRS gridded data (0.5 degree) of near-coincident fires (<1km from each other) over different parts of the globe including atmospheric correction of both data sets.

Comparison of FRP retrievals of gas flares in the Middle East on May 9, 12, 15, 18, 24 2015. TET-1: Technology Experiment Carrier-1 by German Aerospace Agency DRL; dedicated 185m unsaturated measurements for hotspot characterization.
Small experimental fire implemented for the validation of same-day Landsat-8 and Suomi-NPP/VIIRS fire detection data in Brazil, Jan/2015. Tower-mounted radiometers provided 1Hz fire radiant flux data coincident with satellite overpasses.
Direct broadcast support

• Missing / noisy data in Direct Broadcast transmission can result in incorrect SDR calibration and spurious detections.
• The frequency of DB data anomalies depend on the performance of the local DB processing system.
• Spurious detections can also be filtered by empirical techniques.
• Regular updates to include algorithm improvements is critical.

Further fixes are needed to account for large data gaps – usually in DB – NASA DLR patch

CSPP V2.0 (SDR Mx8.4)
CSPP V2.1 (SDR Mx8.6)

CSPP: Community Satellite Processing Package (UW-Madison)

Spurious detections removed in new version of CSPP

Courtesy Isabel Cruz CONABIO, Mexico
VIIRS Fire Data and Evaluation Portal

VIIRS 750m and 375m products over North America

Global VIIRS 750m product

VIIRS Daily Global Active Fire Map

GLOBAL data download

Select a Date

09/04/2015

Search

CONUS data download

Select a Date

09/04/2015

Search

viirsfire.geog.umd.edu

Products in various formats
Global VIIRS fire data access

• Options:
  – NOAA CLASS Web
    • www.class.noaa.gov
  – NASA LAADS Web
    • 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
Improving spatial resolution: from the 750m M-band product...

VIIRS M-band RGB (bands 3-2-1) + fire mask:
July 18, 2014 at 2150 UTC

Carlton Complex, WA

http://viirsfire.geog.umd.edu/
...towards the 375m I-band product

VIIRS I-band RGB (bands 3-2-1) + fire mask:
July 18, 2014 at 2150 UTC

http://viirsfire.geog.umd.edu/
VIIRS M-band RGB (bands 3-2-1) + fire mask: May 7, 2015 at 2050 UTC
VIIRS I-band RGB (bands 3-2-1) + fire mask:
May 7, 2015 at 2050 UTC
Sample of web-based resources

- USFS Remote Sensing Applications Center (RSAC)
- Geographic Information Network of Alaska - GINA (Puffin Feeder)
- UMD VIIRS AF website (viirs.geog.umd.edu)
- Geospatial Multi-Agency Coordination (GeoMAC)
- Geographical Area Coordination Centers (GACCs) – e.g. Northwest Interagency Coordination Center (NWCC)
- Hazard Mapping System (HMS)
- Infusing satellite Data into Environmental Applications (IDEA)
- Western Regional Air Partnership’s (WRAP) Fire Emissions Tracking System (FETS)
- Real-time Air Quality Modeling System (RAQMS)
Alaska: a key focus area

Geographic Information Network of Alaska

Suomi NPP

Suomi NPP is NASA's next Earth-observing research satellite. It is the first of a new generation of satellites that will observe many facets of our changing earth. Successfully launched Oct. 2011 and will act as a bridge between current polar-orbiting satellites (e.g., NPP and MODIS) and the next generation weather satellites. The sensor of major interest is the VIIRS instrument, a next-generation MODIS-like sensor.

- http://polarorbit.nsstc.nasa.gov/
- http://polarorbit.nsstc.nasa.gov/usn.html

AICC and GINA to get VIIRS AF in user-friendly format for operations.
Alaska VIIRS fire data access

- **GINA:**
  - KML feed
    - [http://kml.gina.alaska.edu/](http://kml.gina.alaska.edu/)
  - Imagery
    - [http://feeder.gina.alaska.edu](http://feeder.gina.alaska.edu)

- **USFS RSAC**
  - GIS Fire Detections
  - KMLs

- **AK Interagency Coordination Center**
  - [http://fire.ak.blm.gov/predsvcs/maps.php](http://fire.ak.blm.gov/predsvcs/maps.php)
Healy Lake Fire (Alaska)

MODIS
Terra – 10:30
and
Aqua – 1:30
Healy Lake Fire (Alaska)

VIIRS 750m
Suomi NPP – 1:30
Healy Lake Fire (Alaska)

Fire Activity Detected By VIIRS
- Last 0 To 6 Hours
- Last 6 To 12 Hours
- Last 12 To 24 Hours
- 6 Days Previous To Last 24 Hours

Updated: 0630 MDT

VIIRS 375m
Suomi NPP – 1:30

Legend
- Fire Detection Centroid
- Fire Detection Footprint
- Fire Detection Footprint
- HEALY LAKE
Healy Lake Fire (Alaska)

Landsat-8 30m
10:00
(low revisit frequency)
Three days of sample data (May 29-31, 2015) from the new NDE Active Fire product over North America have been provided to the HRRRR team for testing and evaluation. Product integration is underway.
Summary and path forward

- Algorithm readiness
  - Transition of experimental products into full NOAA operations
    - VIIRS 750m FRP (ongoing); 375m detection (future)
  - Science support to ensure algorithm updates in direct broadcast packages
    - CSPP and IPOPP support and coordination
  - Support product delivery to end users
    - e.g. GINA Alaska and Alaska Fire Service

- Data latency
  - Rapid delivery from direct broadcast systems
  - Global delivery with ~2-hour latency upcoming

- Direct end user support
  - Visualization through combined multi-product systems
    - NOAA STAR IDEA, AWIPS-II

- Improving emission estimates and smoke forecast
  - e.g. VIIRS FRP to NOAA’s High Resolution Rapid Refresh (HRRR) system

- International outreach and collaboration
  - Global Observation of Forest and Landcover Dynamics
  - DLR German Aerospace Center TET-1 (Technology Experiment Carrier) mission
    - Product validation and technology demonstration