The Suomi NPP Mission and the VIIRS Fire Detection Capability

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National Environmental Satellite, Data, and Information Service (NESDIS)
National Oceanic and Atmospheric Administration (NOAA)
JPSS Overview

- JPSS is the next generation of U.S. civil operational polar-orbiting satellites. The JPSS program is a partnership between NOAA and NASA, including agreements with EUMETSAT, JAXA and DoD.

- Polar satellites, like JPSS, are critical for forecasts beyond 48 hours and increase the accuracy of forecasts three to seven days in advance of a severe weather event.

- JPSS represents significant technological and scientific advances in environmental monitoring and helps advance weather forecasting, environmental assessments and climate monitoring.

- JPSS provides operational continuity of satellite-based observations and products beyond NOAA Polar-orbiting satellites and NASA Earth-observing satellites.
The JPSS Enterprise

JPSS consists of:
- Suomi NPP* satellite, JPSS-1 satellite, and JPSS-2 satellite
- Four primary instruments
- Global ground system (Alaska, Colorado, Maryland, West Virginia, Norway, Antarctica)

NOAA Responsibilities:
- End-to-end responsibility, requirements, funding, delivering to National Weather Service
- Operations, data product science, enterprise ground services

NASA Goddard Space Flight Center Responsibilities:
- Systems Engineering lead
- Procurement and acquisition
- Safety and Mission Assurance

### JPSS Schedule

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<table>
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<tbody>
<tr>
<td>Launch Dates*</td>
<td>No later than 2nd Quarter FY 2017 (JPSS-1); 1st Quarter FY 2022 (JPSS-2)</td>
</tr>
</tbody>
</table>
| Program Architecture | 3 Satellites (Suomi NPP, JPSS-1, JPSS-2)  
Suomi NPP: 5-year operational design life; JPSS-1: 7-year operational design life |
| Program Operational Life | FY 2012 - FY 2025 |
| Program Life-cycle (FY 2014 President’s Budget) | $11.349 billion |

*Suomi-NPP is a joint NASA / NOAA mission

*Launch Date based on FY 2014 President’s Budget Request
Suomi NPP is producing outstanding data
- The satellite is healthy and producing a high availability of data (~99.99%)
- Operations of the satellite transferred from NASA to NOAA in 2013
- Suomi NPP is the primary operational polar-orbiting satellite for NOAA

JPSS-1 is executing as planned
- Instruments and spacecraft are proceeding well
- Instruments are assembled and undergoing testing; two have been delivered for integration
- The spacecraft bus is built and undergoing testing
- Development and implementation of the new ground data processing system are underway

JPSS-2 procurement activities are progressing well
- The VIIRS sensor is under contract and others are in evaluation
- The spacecraft bus procurement is underway
Why JPSS?

JPSS provides continuity of Earth’s key observations, including oceans, clouds, ozone, snow, ice, vegetation and atmosphere—ensuring a continuous series of global weather data. Data from JPSS instruments provide more than 30 years of consistent observations that have allowed scientists to monitor the climate.

The two most important uses:

- **JPSS provides the most critical data for numerical weather prediction to ensure accurate forecasts 3-7 days ahead of a significant weather event, giving high confidence to emergency managers and decision makers**
- **Operational weather and environment satellite observations for Alaska and Polar Regions operational forecasting**

NOAA’s environmental satellites are the backbone of life-saving weather forecasts and advance hazardous outlooks. There is no substitute for the role they play in the U.S. and around the world.

In the last three years, the U.S. experienced more than 30 disasters surpassing $1Billion. The demand for these products has never been greater.

**Without JPSS, the Nation will experience an immediate degradation in weather forecasting capability**
Enhanced data products include:

- Drought
- Ozone
- Atmospheric temperature/moisture profiles
- Hurricane intensity and position
- Thunderstorms, tornado potential
- Alaska “nowcasting” (e.g. ice detection)
- Significant precipitation and floods
- Dense fog
- Volcanic ash
- Fire and smoke
- Sea surface temperature, ocean color
- Sea ice extent and snow cover /depth
- Polar satellite derived winds (speed/direction/height)
- Vegetation greenness indices and health
JPSS provides a wide range of capabilities

- Microwave – provides temperature and moisture soundings in cloudy conditions and rainfall rates, sea ice, snow, surface temperature

- Infrared – provides high vertical resolution temperature and moisture soundings in clear and cloud corrected regions; atmospheric chemistry - CO, CH4, SO2, ... and cloud products

- Visible (day & night) and Infrared Imagery (including deep blue channels) – chlorophyll, cloud imagery, cloud products, SST, Active Fires, Smoke, Aerosols, land products, Snow, Ice, oil spills... at exceptional resolution/global coverage

- UV - ozone - Aerosols over bright surfaces, SO2 plumes, NOx (air quality)...
JPSS Spacecraft

Ozone Mapping Profiler Suite

Advanced Technology Microwave Sounder

Cross-track Infrared Sounder

Visible Infrared Imaging Radiometer Suite

Clouds and the Earth's Radiant Energy System
ATMS offers more channels, better resolution and a wider swath than previous legacy microwave instruments. This improves the accuracy of short- and medium-term forecasting, storm tracking and, with continued measurements over time, climate prediction models. It helps collect essential data for accurate near-term weather predictions needed for farming, commercial and defense aircraft flight path planning, terrestrial extreme weather preparedness and oceanographic inputs for civilian and defense ships. ATMS measurements also provide rainfall rates, snow and ice information.

**AMSU vs ATMS**

- **ATMS:**
  - higher resolution
  - wider swath
  - much smaller gaps between passes
Sandy Simulation Experiments

Experimental results showing improvements in Sandy track forecasts from Hurricane Weather Research Forecast model with ATMS

<table>
<thead>
<tr>
<th>HWRF-NCEP Operational</th>
<th>Modified HWRF-NCEP with ATMS</th>
</tr>
</thead>
</table>

| Resolution: ATMS vs AMSU |

ECMWF with and without polar-orbiting satellite data
CrIS long-wave surface temperature channel
CrIS and ATMS provide continuity of essential atmospheric sounding information for weather forecasting.

Hyperspectral Infrared Sounders (e.g. CrIS) and Advanced Microwave Sounders (e.g. ATMS) are the top two contributors for reducing forecast errors.

<table>
<thead>
<tr>
<th>Contributor</th>
<th>Forecast error reduction contribution (%)</th>
</tr>
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<tbody>
<tr>
<td>Three AMSUs: METOP, POES, AQUA (T)</td>
<td>~12%</td>
</tr>
<tr>
<td>IASI: IR Atmos Interferometer on METOP (T,H)</td>
<td>~12%</td>
</tr>
<tr>
<td>AIRS: Atmos IR Sounder on Aqua (T,H)</td>
<td>~12%</td>
</tr>
<tr>
<td>AIREP: Aircraft T, H, and winds</td>
<td>~12%</td>
</tr>
<tr>
<td>GPSRO: RO bending angles from COSMIC, METOP</td>
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</tr>
<tr>
<td>TEMP: Radiosonde T, H, and winds</td>
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</tr>
<tr>
<td>QuikSCAT: sfc winds over oceans</td>
<td>~12%</td>
</tr>
<tr>
<td>SYNOP: Sfc P over land and oceans, H, and winds over oceans</td>
<td>~12%</td>
</tr>
<tr>
<td>AMSU-B: Adv MW Sounder B on NOAA POES</td>
<td>~12%</td>
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<tr>
<td>GOES winds</td>
<td>~12%</td>
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<tr>
<td>METEOSAT winds</td>
<td>~12%</td>
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<tr>
<td>Ocean buoys (Sfc P, H and winds)</td>
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<tr>
<td>PILOT: Pilot balloons and wind profilers (winds)</td>
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<tr>
<td>HIRS: High-Resol IR Sounder on NOAA POES (T,H)</td>
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<td>MSG: METEOSAT 2nd Generation IR rad (T,H)</td>
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<tr>
<td>MHS: MW humidity sounder on NOAA POES and METOP (H)</td>
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<tr>
<td>AMSRE: MW imager radiances (clouds and precip)</td>
<td>~12%</td>
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<tr>
<td>SSMI: Special Sensor MW Imager (H and sfc winds)</td>
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<tr>
<td>GMS: Japanese geostationary satellite winds</td>
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<tr>
<td>MODIS: Moderate Resolution Imaging Spectroradiometer (winds)</td>
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<tr>
<td>GOES IR rad (T,H)</td>
<td>~12%</td>
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<tr>
<td>MTSATIMG: Japanese geostationary sat vis and IR imagery</td>
<td>~12%</td>
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<tr>
<td>METEOSAT IR Rad (T,H)</td>
<td>~12%</td>
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<tr>
<td>O3: Ozone from satellites</td>
<td>~12%</td>
</tr>
</tbody>
</table>

From ECMWF

CrIS impact is similar to AIRS or IASI ~ 12%

ATMS impact similar to single AMSU + single MHS ~ 9%

Losing one orbit would be about a 20% degradation in forecast accuracy.
OMPS tracks the health of the ozone layer and measures the concentration of ozone in the Earth's atmosphere. Data from OMPS continues three decades of total ozone and ozone profile records, which fulfill the U.S. treaty obligation to monitor ozone concentrations for the Montreal Protocol. This important data is used by ozone assessment researchers and policy makers to create global climate models.

Credit: NOAA/NASA
OMPS improved spatial resolution for better monitoring of aerosols and SO2.

- Current OMPS nadir resolution is at 50 km, but the instrument is capable of 10 km resolution.
- Users for monitoring volcanic ash and SO2 plumes have requested higher spatial resolution (USGS and NOAA and CEOS/CGMS/WMO).
- Volcano SO2 alerts for air quality (big issue for Hawaii).
- EPA monitors industrial SO2.
- 50 km resolution is simply too coarse.
- OMPS aerosols better than VIIRS over bright surfaces (deserts).

OMPS Capabilities: Volcanic SO2

OMPS Capabilities: Pollution SO2

VIIRS sees the ash, but OMPS sees the SO2

OMPS aerosols over generally bright surfaces from fires.
CERES measures reflected sunlight and thermal radiation emitted by the Earth and helps provide measurements of the spatial and temporal distribution of Earth's Radiation Budget (ERB) components. Measurements from CERES help scientists understand the links between the Earth's incoming and outgoing energy and the properties of the atmosphere that affect that energy. The observations from CERES FM6 help measure the effect of clouds on the energy balance, which strongly influences both weather and climate.
VIIRS – the work horse for environmental assessments

VIIRS RGB (True Color), 20111122

R : M05 (0.672 μm); G : M04 (0.555 μm); B : M02 (0.445 μm)
Visible Infrared Imaging Radiometer Suite (VIIRS)

VIIRS collects visible and infrared imagery and global observations of land, atmosphere and cryosphere. It offers more spectral bands, higher resolution, and greater accuracy resulting in the largest number of products to include land and sea surface temperatures, clouds, fire, smoke, snow, ice, vegetation, and ocean chlorophyll. VIIRS is a major advancement over AVHRR, which degraded spatial resolution. VIIRS generates products for operational weather community that improves weather, flooding and storm forecasting abilities, which help to protect life and property.
Comparing MODIS (250m) to VIIRS (375m) Edge of Scan
Satellite Ice Imagery

This page is used to post satellite images of sea ice. Resolution of the images ranges from 250 meters to 4 kilometers. Sources for the images are POES AVHRR from NWS Alaska Region. Images are added to this page as cloud cover and time permit.

Click on each image for a larger view:

Bering Strait Region
NPP Suomi VIIRS False Color Satellite Image
29 March 2013 at 0011Z
http://pafc.arh.noaa.gov/ice.php

The NWS Sea Ice Program in Anchorage, AK utilizes ArcGIS 10.2 to bring in data from numerous sources including GINA. After data is ingested into the program the sea ice analyst turns on recent satellite images to discern areas of unique sea ice thickness and concentration. These areas are then outlined in polygon shapes and the attributes of each shape are determined to label the areas ice characteristics. Once the analysis has been completed the ice analyst creates analysis image graphics and ArcGIS shapefiles that are posted to the webpage every Monday, Wednesday, and Friday.

(far left) NWS sea ice charts and forecast are created in ArcGIS using satellite imagery from GINA Puffin Feeder and other sources.

Crabbing Vessel Calls on the NWS Sea Ice Program for Navigation Help

The northernmost vessel in the Bering Sea Crab fleet, the Kiska Sea, contacted the NWS Sea Ice Program on February 10, 2013 asking if their crab pots were in danger of being overrun by sea ice. Calls between the Kiska Sea and the Sea Ice Program over the next three days continued the exchange of ice information, assisting the captain in finding his lost gear through the increasing ice field. On February 13 the vessel was surrounded by sea ice, some in excess of three feet thick. DNB images from the previous night clearly showed the lights from Kiska Sea and the ice pack around the vessel. NWS Sea Ice personnel were able to assist the captain to plot a track out of the ice pack, avoiding areas of thicker and higher concentrations sea ice. The timeliness of the DNB images provided an essential tool for this vessel assist.

(left) Experts at the NWS Sea Ice Program were able to use GINA satellite imagery to help a lost crab boat get out of sea ice.
Day Night Band offers new applications
S-NPP and JPSS Data Products
From NOAA available in real-time

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<th>CrIS/ATMS (3)</th>
<th>OMPS (2)</th>
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<td>ATM VERT MOIST PROFILE</td>
<td>O$_3$ TOTAL COLUMN</td>
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<td>CLOUD BASE HEIGHT</td>
<td>ATM VERT TEMP PROFILE</td>
<td>O$_3$ NADIR PROFILE</td>
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<td>CLOUD COVER/LAYERS</td>
<td>CARBON (CO2, CH4, CO)</td>
<td>SO2 and Aerosol Index</td>
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<td>CLOUD EFFECTIVE PART SIZE</td>
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<td>ATMS (11)</td>
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<td>LAND SURFACE EMISSIVITY</td>
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<td>LAND SURFACE TEMPERATURE</td>
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<td>GCOM AMSR-2 (11)</td>
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<td>SEA SURFACE TEMPERATURE</td>
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<tr>
<td>SURFACE TYPE</td>
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S-NPP and JPSS Data Products From NOAA available in real-time

**VIIRS (24)**
- ALBEDO (SURFACE)
- CLOUD BASE HEIGHT
- CLOUD COVER/LAYERS
- CLOUD EFFECTIVE PART SIZE
- CLOUD OPTICAL THICKNESS
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- SEA ICE CHARACTERIZATION
- SNOW COVER
- SEA SURFACE TEMPERATURE
- LAND SURFACE TEMP
- SURFACE TYPE

**CrIS/ATMS (3)**
- ATM VERT MOIST PROFILE
- ATM VERT TEMP PROFILE
- CARBON (CO2, CH4, CO)

**OMPS (2)**
- O3 TOTAL COLUMN
- O3 NADIR PROFILE
- SO2 and Aerosol Index

**ATMS (11)**
- CLOUD LIQUID WATER
- PRECIPITATION RATE
- PRECIPITABLE WATER
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- ICE WATER PATH
- LAND SURFACE TEMPERATURE
- SEA ICE CONCENTRATION
- SNOW COVER
- SNOW WATER EQUIVALENT
- ATM TEMPERATURE PROFILE
- ATM MOISTURE PROFILE

**GCOM AMSR-2 (11)**
- CLOUD LIQUID WATER
- PRECIPITATION TYPE/RATE
- PRECIPITABLE WATER
- SEA SURFACE WINDS SPEED
- SOIL MOISTURE
- SNOW WATER EQUIVALENT IMAGERY
- SEA ICE CHARACTERIZATION
- SNOW COVER/DEPTH
- SEA SURFACE TEMPERATURE
- SURFACE TYPE

Blue - currently available in CSPP
Proving Ground and Risk Reduction Air Quality Portal

http://www.star.nesdis.noaa.gov/smcd/spb/aq/
VIIRS can identify river ice jams which can lead to large flood events.

Flooding from ice jams can occur in a very short time.

Galena, Alaska on May 28, 2013
SNPP/VIIRS false-color image (composited by Imager bands 3, 2, 1) June 30, 2014 17:02 (UTC) around Asuncion, Paraguay

Sanmei Li (GMU)
Weekly composite of VIIRS Vegetation Index and Surface Temperature (Window BT) July 8 – 14, 2013
# VIIRS Bands for Fire Detection

<table>
<thead>
<tr>
<th>Band</th>
<th>Range (um)</th>
<th>HSR (m)</th>
<th>MODIS Equivalent</th>
<th>AVHRR-3 Equivalent</th>
<th>OLS Equivalent</th>
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<tr>
<td>DNB</td>
<td>0.500 - 0.900</td>
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<tr>
<td>M1</td>
<td>0.402 - 0.422</td>
<td>750</td>
<td>8 0.405 - 0.420</td>
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<tr>
<td>M2</td>
<td>0.436 - 0.454</td>
<td>750</td>
<td>9 0.438 - 0.448</td>
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<tr>
<td>M3</td>
<td>0.478 - 0.498</td>
<td>750</td>
<td>3 0.459 - 0.479</td>
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<td>M4</td>
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<td>750</td>
<td>4 0.545 - 0.565</td>
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<td>M5</td>
<td>0.600 - 0.680</td>
<td>375</td>
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<td>250</td>
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<td>750</td>
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<td>0.846 - 0.885</td>
<td>375</td>
<td>2 0.841 - 0.876</td>
<td>250</td>
<td>2 0.720 - 1.000</td>
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<tr>
<td>M8</td>
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<td>750</td>
<td>5 0.819 - 0.876</td>
<td>1000</td>
<td>500</td>
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<tr>
<td>M9</td>
<td>1.371 - 1.386</td>
<td>750</td>
<td>26 1.360 - 1.390</td>
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<td>M10</td>
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<td>6 1.628 - 1.652</td>
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<td>4</td>
<td>10.300 - 11.300</td>
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<tr>
<td>I2</td>
<td>2.050 - 2.250</td>
<td>1000</td>
<td>5 11.500 - 12.500</td>
<td>1100</td>
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Background of VIIRS IDPS Active Fire 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
The VIIRS sensor provides excellent capabilities for fire detection and characterization.

The operational SNPP VIIRS Active Fire product is being integrated into operations by NOAA and fire management agencies.

The science team is developing a suite of improved products, including fire radiative power to characterize the fire intensity.

End users are engaged through Proving Ground and User Readiness efforts.

Fire detections from the operational Suomi NPP VIIRS Active Fire product in NW US on July 24, 2014. Data in various user-friendly formats are available from the product evaluation portal at viirsfire.geog.umd.edu.
Development of Spatially Refined Satellite Fire Products
Enabling Improved Fire Mapping

Grass fire in Southern Brazil, 26-31 March 2013

Aqua/MODIS 1 km
Spotty detection pixels and coverage gap at low latitudes

S-NPP/VIIRS 750 m
Spotty detection pixels

S-NPP/VIIRS 375 m
Improved fire line mapping

Credit: Wilfrid Schroeder (UMD)
See for example: Schroeder et al., 2014
Integrating various satellite data is well recognized and emphasized.
LANDSAT 8 (30 meter resolution vs VIIRS 375 meter resolution)

But Landsat has a 16 day repeat cycle – it will not observe this location for another 16 days
The M7,8,10 spectral bands are well placed to record the peak radiant emissions from flares. During daylight hours the signal is overwhelmed by sunlight. At night combustion sources stand out clearly against the noise background.
Combustion parameters:
Source ID=SVM10_npp_d20130911_t2226433_e2232237_IR_source_232
Lat=30.747845 Lon=48.279762 deg.
Temperature=1666 deg. K
Radiant heat intensity=84.57 W/m2
Radiant heat=51.13 MW
Source footprint=117.01 m2
Methane equivalent=1.381 m3/s
CO2 equivalent=2528.750 g/s
Cloud state=clear
Time=11-Sep-2013 22:27:57
Lac-Megantic, Quebec Fire Detected by VIIRS at Night

NGDC’s VIIRS Nightfire product provides temperature, source size and radiant heat worldwide on a nightly basis.

Combustion parameters:
- Source ID=SVM10_npp_d20130706_t0619460
- Lat=45.575085 Lon=-70.879578 deg.
- Temperature=1274 deg. K
- Radiant heat intensity=58.64 W/m²
- Radiant heat=47.19 MW
- Source footprint=315.91 m²
- Cloud state=clear
- Time=06-Jul-2013 06:24:48

IR source radiance

Wm²/°m

1 2 3 4

Wavelength, μm
Summary

JPSS is a major contributor to the global observing system.

Suomi NPP instruments are performing exceptionally well!!

The NOAA satellite climate data records from 1970s will be continued by JPSS.

JPSS has a Proving Ground and Risk Reduction program to improve applications.

International partnerships are essential.

Observations coupled with modeling, data fusion, with the underpinning research, are essential for transforming observations to the products, applications, and services needed to address environmental impacts on society.

VIIRS Active Fire is a critical operational product.

Work is underway to integrate the MODIS continuity algorithm into NOAA operations.
For Direct Readout, GOES/POES, and GOES-R/JPSS Users

April 27 – May 1, 2015

Location: Greenbelt Marriott Hotel in Greenbelt, Maryland, USA