Aerosol Products from NOAA Operational Satellites

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Aerosol Observability Workshop, Naval Research Laboratory, Monterey, CA

NOAA National Environmental Satellite, Data, and Information Service (NESDIS) provides timely access to global environmental data from satellites and other sources to promote, protect, & enhance the Nation's economy, security, environment, & quality of life.

NESDIS Responsibilities

• Acquire and manage the Nation's operational environmental satellites

• Operate the NOAA National Data Centers

• Provide data and information services including Earth system monitoring

• Perform official assessments of the environment

• Conduct related research

Overview

Currently Operational:

- GOES Aerosol Optical Depth Product
- AVHRR Aerosol Optical Depth Product
- Hazard Mapping System (HMS)
    - Wildfire Automated Biomass Burning Algorithm (WF_ABBA)
    - Fire Identification Mapping and Monitoring Algorithm (FIMMA)
    - MODIS Fire Detects
- Automated Smoke Detection and Tracking Algorithm (ASDTA)
- GOES Biomass Burning Emissions Product (GBBEP)

Future Sensors:

- GOES-R Advanced Baseline Imager
- Joint Polar Satellite Systems (JPSS) VIIRS

NESDIS Aerosol Data Policy and Applications

Aerosol Observability Workshop, Naval
Research Laboratory, Monterey, CA

GOES Aerosol Optical Depth Product Status: Operational

- Quantitative measure of atmospheric aerosol loading that has been shown to be a proxy for surface particulate matter pollution, PM2.5 (aerosol mass in $\mu g/m^3$).

  - *Single channel retrieval using measured visible channel reflectances from GOES Imager.*
  - *IR channels used in identifying clouds.*
  - *Physical retrieval that separates contribution of surface from aerosols.*
  - *Retrievals over clear sky and dark vegetative pixels only.*

- Product specifications

  - *Name: GOES Aerosol and Smoke Product (GASP)*
  - *Satellites: GOES-East (15ºN – 66ºN & 151ºW – 52ºW)*
    GOES-West (14ºN – 75ºN & 180ºW – 50ºW)
  - *Accuracy: 0.04 (GOES-E) ; 0.06 (GOES-W)*
  - *Spatial resolution: 4 km at nadir*
  - *Temporal resolution: 30 minutes (sunlit portion of the day)*
  - *Latency: within one hour of data capture*
  - *Data format: binary file and JPEG imagery*
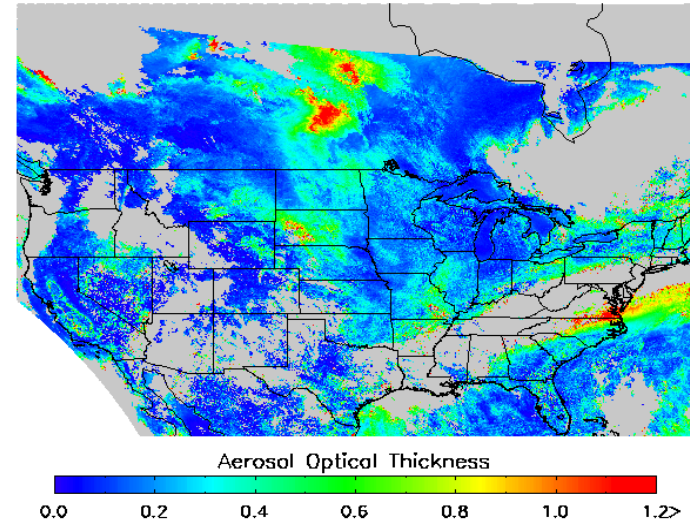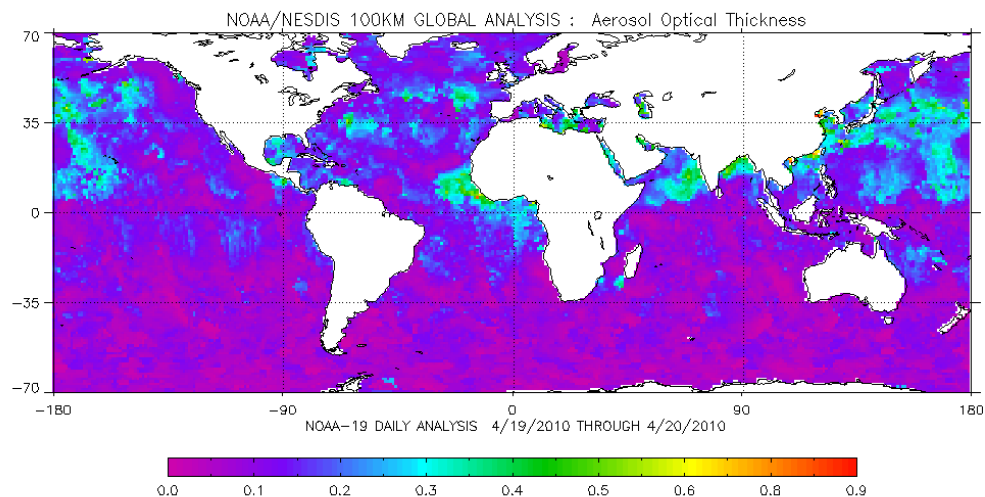 - *Data availability: 2003 - present*
  - *Imagery/Data link:*

  http://www.ssd.noaa.gov/PS/FIRE/GASP/gasp.html
  http://www.ssd.noaa.gov/PS/FIRE/GASP/gasp-west.html
  ftp://satepsanone.nesdis.noaa.gov/GASP/AOD-WEST/
  ftp://satepsanone.nesdis.noaa.gov/GASP/AOD/

Knapp, JGR, 2002, 2005 ; Knapp et al., IJRS, 2006; Prados et al., JGR, 2007; Kondragunta et al., JAMC, 2008

AVHRR Aerosol Optical Depth Product Status: Operational

- Quantitative measure of atmospheric aerosol loading:
  - *Single channel retrieval using measured visible channel reflectances from AVHRR Imager.*
  - *IR channels used in identifying clouds.*
  - *Ocean reflectance computed.*
  - *Retrievals over Ocean only.*

- Product specifications
  - *Name: AVHRR Aerosol Optical Thickness*
  - *Satellites: NOAA-19, NOAA-18, NOAA-17, NOAA-16, MetOP-1*
  - *Accuracy: 37%*
  - *Spatial resolution: 8 km/daily, 100 km analysis weekly/monthly*
  - *Temporal resolution: daily, weekly, monthly*
  - *Latency: daily*
  - *Data format: binary file and JPEG imagery*
 - *Data availability: 2003 - present*
  - *Data link:*

  http://www.osdpd.noaa.gov/ml/air/aeroprod.html

NOAA/NESDIS 100KM GLOBAL ANALYSIS : Aerosol Optical Thickness

NOAA-19 DAILY ANALYSIS 4/19/2010 THROUGH 4/20/2010

Ignatov et al, "Operational Aerosol Observations (AEROBS) from AVHRR/3 On Board NOAA-KLM Satellites" J. Atmos and Ocean Tech, Vol 21, pg 3-26, 2004

Aerosol Observability Workshop, Naval Research Laboratory, Monterey, CA

Hazard Mapping System (HMS)

Operational daily fire and smoke analysis for North America using seven geostationary (GOES) and polar orbiting (POES and MODIS) satellites

•The HMS integrates satellite data from different platforms with the output from automated fire detection algorithms for the different instruments as well as various ancillary data layers that aid analysts in their decision making process.

•Analysts review fire detects from the algorithms and either retain them in the analysis or delete them if they feel they are false detects. Analysts also scan the satellite imagery and add hotspots that the algorithms have not detected.

Analysis day: 20100419
Map generated: 1603 GMT 20100420
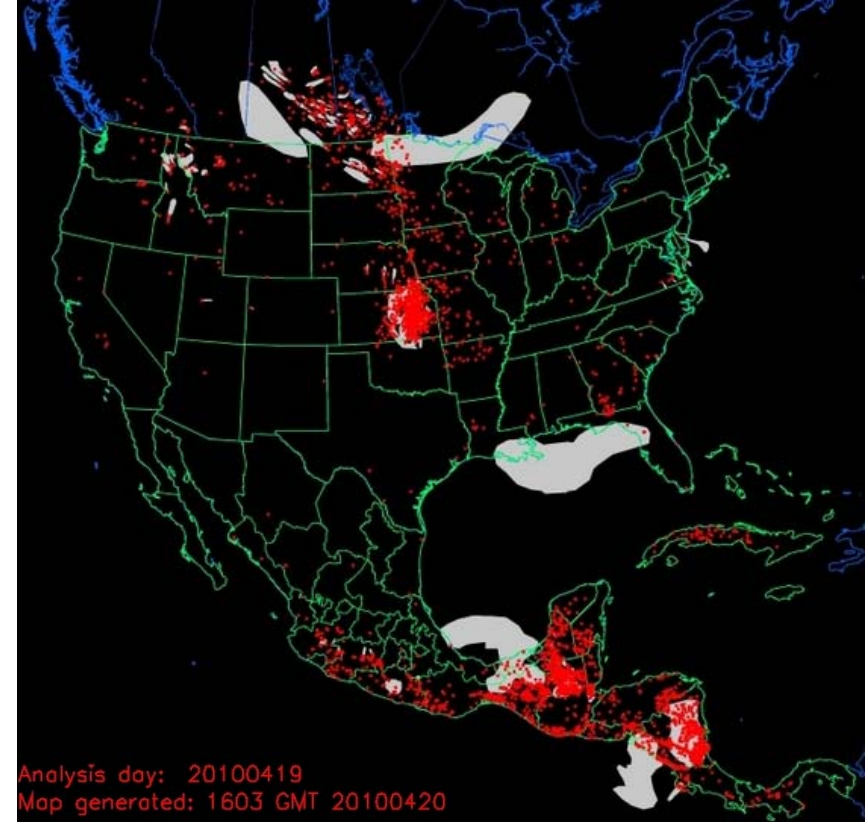
| Satellite Sensor	SWIR nominal resolution	Refresh Rate	Geographic coverage	Automated detection algorithm
GEOSTATIONARY GOES-East GOES-West	4km	15 minutes	CONUS/Canada/ Central America	WFABBA
			Western half of CONUS/Alaska/Hawaii	
POLAR NOAA-15/17/18 MODIS Terra MODIS Aqua	1km	Twice/day low/mid latitudes More frequent at high latitudes	Most of North/Central America except NOAA-15 which does not cover Western US	FIMMA MODIS

April 27-29, 2010

Wildfire Automated Biomass Burning Algorithm (WF_ABBA)

Product developed by the biomass burning monitoring team at CIMSS using the GOES Imager, Meteosat SEVIRI, and MTSAT JAMI to detect and monitor fires (wildfires, prescribed burns and agricultural burns) globally. The WF-ABBA runs all available imagery data from supported geostationary satellites.

The WF_ABBA fire product includes: fire location (lat./lon.), estimates of instantaneous fire size, temperature, and radiative power, ~4 and ~11 micron observed brightness temperatures, background brightness temperatures, albedo statistics, ecosystem type, and a detection classification flag. The product also produces a mask identifying on a per-pixel basis whether the pixel has a fire, does not have a fire, or no determination could be made due to clouds, solar block-out zones, ecosystem type, etc…

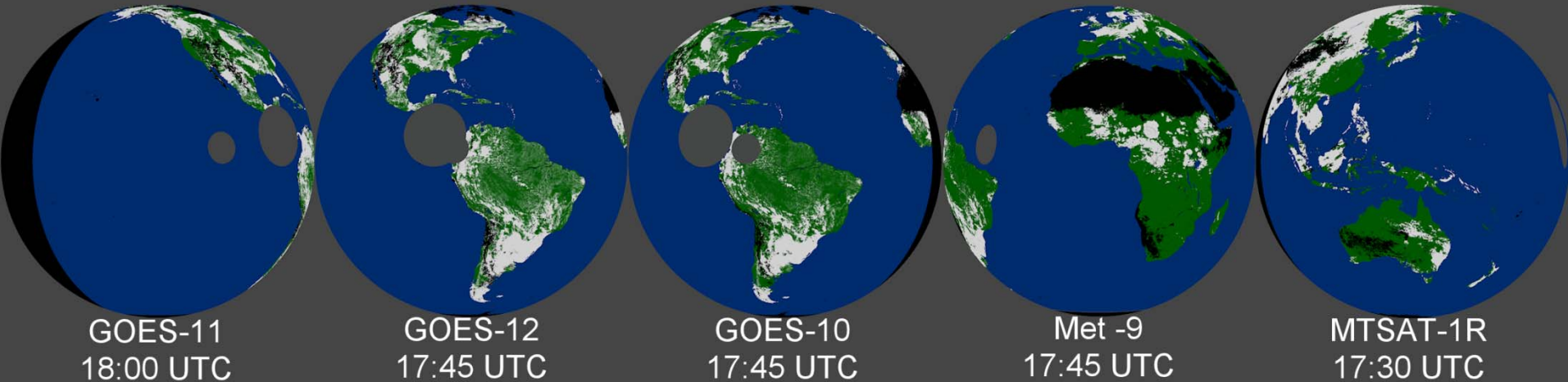Binary Data:

ftp://satepsanone.nesdis.noaa.gov/FIRE/ABBA/
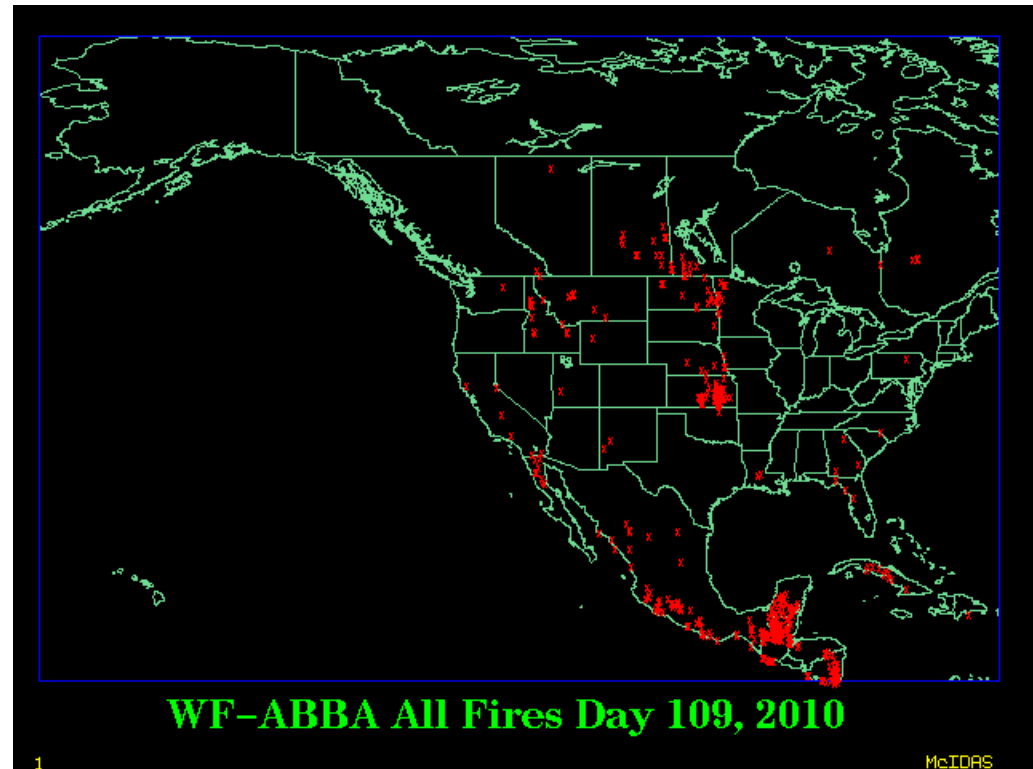
WF_ABBA daily fires summary from NESDIS Operations

Prins, E. M. and W. P. Menzel, 1994: Trends in South American biomass burning detected with the GOES visible infrared spin scan radiometer atmospheric sounder from 1983 to 1991, *Jour. Geo. Res.*, 99, 16719-16735.
Prins, E. M. and W. P. Menzel, 1992: Geostationary Satellite detection of biomass burning in South America, *Int. J. of Remote Sensing*, 13, 2783-2799.

Examples of Global WF_ABBA

Global WF_ABBA Fire and Metadata Mask on 3 September 2009 at ~17:45 UTC

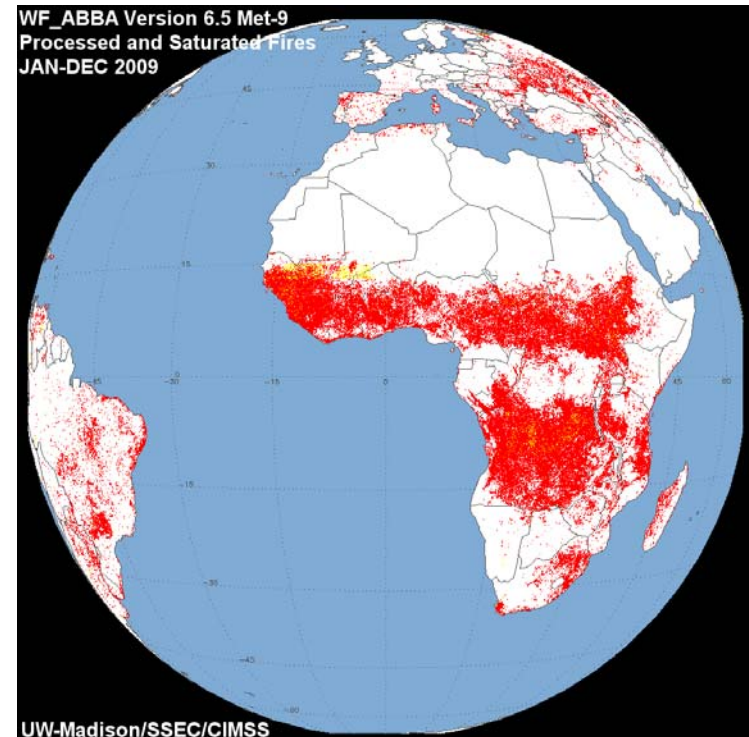| GOES-11 | GOES-12 | GOES-10 | Met -9 | MTSAT-1R |
| 18:00 UTC | 17:45 UTC | 17:45 UTC | 17:45 UTC | 17:30 UTC |

Above: Examples of WF_ABBA mask for all supported satellites on 3 September 2009. Green indicates fire-free land, light gray indicates opaque clouds, dark gray indicates solar block-out zones, and black indicates other regions excluded from fire detection.

Right: Summary of WF_ABBA processed (red) and saturated (yellow) fires detected with Meteosat-9 SEVIRI in 2009. Processed fires have estimated fire properties (size, temperature, and radiative power).

Binary Data:

ftp://satepsanone.nesdis.noaa.gov/FIRE/forPo/

WF_ABBA Version 6.5 Met-9
Processed and Saturated Fires
JAN-DEC 2009

UW-Madison/SSEC/CIMSS

# Fire Identification Mapping and Monitoring Algorithm (FIMMA)

The FIMMA is an automated algorithm to detect fires from Advanced Very High Resolution Radiometer (AVHRR) data from NOAA polar-orbiting satellites. The FIMMA product was developed by CIRA by modifying an algorithm developed at the University of Maryland. The current version uses geo-corrected High Resolution Picture Transmission (HRPT) AVHRR data over the US (including Alaska and Hawaii).

Files are available in comma delimited format (Lon, Lat, Channel 3b, 4, 5 brightness temperatures, and Landcover) covering North America.

This product occassionally suffers from false detects due to satellite noise, high surface temperatures, or stong solar reflectivity. Attempts to eliminate this noise in this automated algorithm may have filtered true fires. Users are advised to use the HMS fire product for better accuracy.

Binary Data:

ftp://satepsanone.nesdis.noaa.gov/FIRE/FIMMA

FIMMA All Fires Day 109 2010
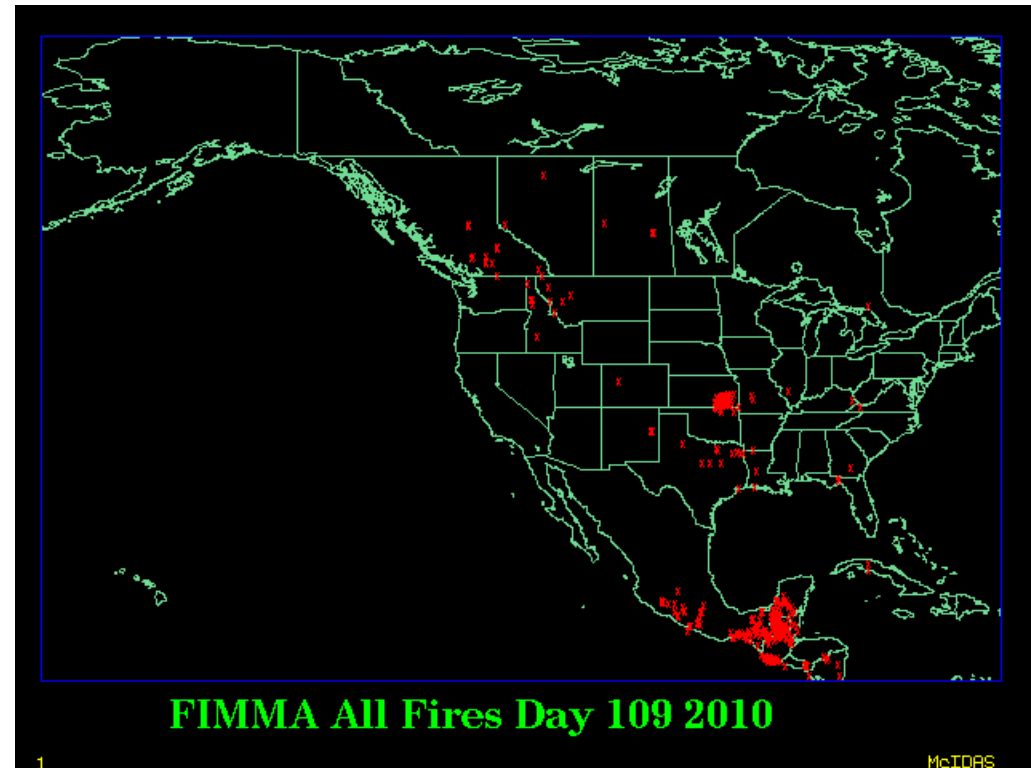
FIMMA daily fires summary from NESDIS Operations

Li, Z., R. Fraser, J. Jin, A. A. Abuelgasim, I. Csiszar, P. Gong, R. Pu, and W. Hao, Evaluation of algorithms for fire detection and mapping across North America from satellite, J. Geophys. Res., 108(D2), 4076, doi:10.1029/2001JD001377, 2003.

MODIS Fire Detects

OSDPD produces TERRA & AQUA MODIS fire products using data from the near real-time NASA [MODIS Rapid Response System](#). The fire algorithm was developed by the [MODIS Fire and Thermal Anomalies team](#).

OSDPD extracts the fire positions and confidence values from NASA HDF files and place them into comma-delimited ascii files.

Fire locations represent the approximate location of the fire pixel and do not represent the actual fire size.

The Near Real Time Processing System is not considered operational. We do not guarantee 24/7 access to this data at this time.

Binary Data:

ftp://satepsanone.nesdis.noaa.gov/FIRE/MODIS
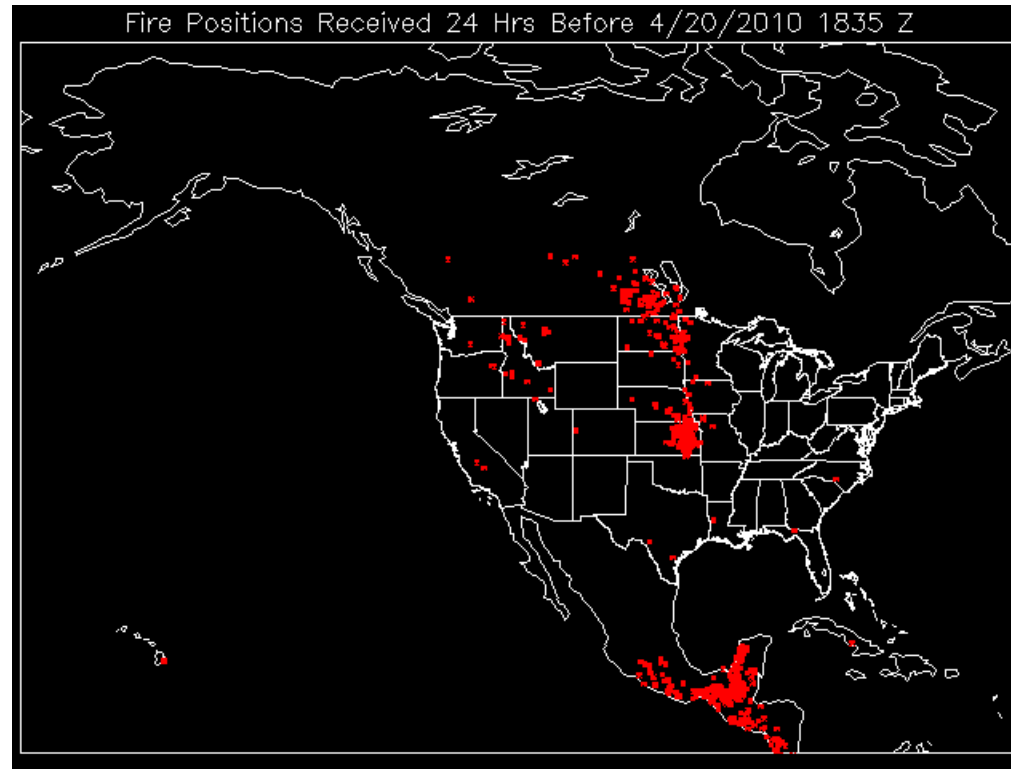
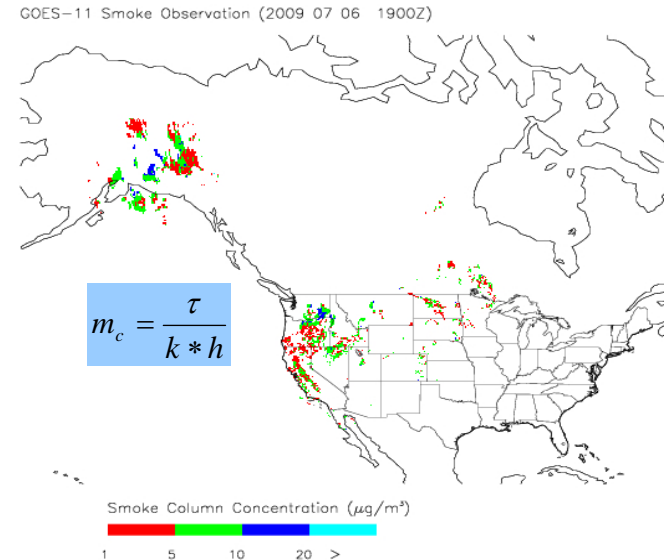MODIS daily fires summary from NESDIS Operations

Giglio, L., Csiszar, I., Justice, C.O. 2006. Global distribution and seasonality of active fires as observed with the Terra and Aqua MODIS sensors. *Journal of Geophysical Research - Biogeosciences*, Vol 111, G02016, doi:10.1029/2005JG000142.
Schroeder, W., Prins, E., Giglio, L., Csiszar, I., Schimdt, C., Morisette, J., Morton, D. 2008. Validation of GOES and MODIS active fire detection products using ASTER and ETM+ data. *Remote Sensing of Environment 112 (2008) 2711–2726.*

Automated Smoke Detection and Tracking Algorithm (ASDTA)
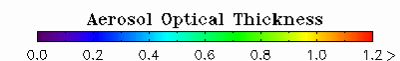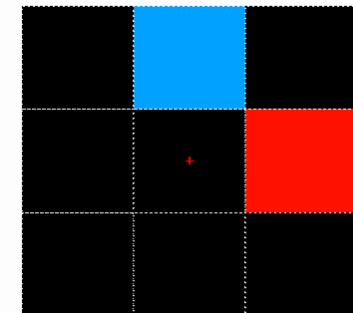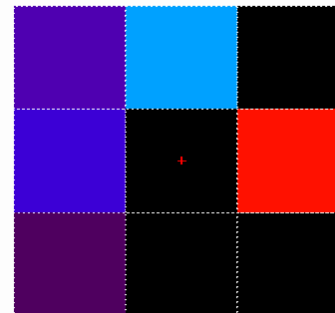## Status: Operational

- Semi-quantitative retrieval of column average smoke concentration ($\mu g/m^3$) using AOD and fire hot spots from GOES
  - Uses source apportionment and pattern recognition techniques to isolate smoke aerosols from other type of aerosols
  - Smoke mass concentration (m_c) is obtained using AOD (τ), mass extinction efficiency (k), and aerosol height (h)

- Product specifications
  - *Name:* ASDTA
  - *Satellites:* GOES-East and GOES-West (includes Alaska and Hawaii)
  - *Accuracy:* 40%
  - *Spatial resolution:* 0.15°
  - *Temporal resolution:* hourly
  - *Latency:* one day
  - *Data format:* binary file, GRIB file, JPEG imagery
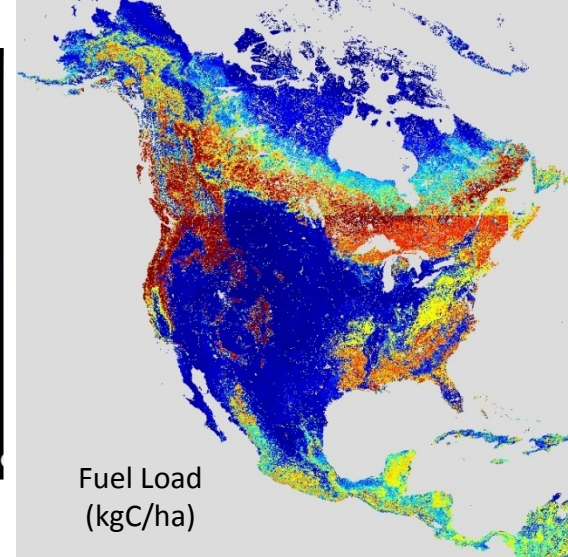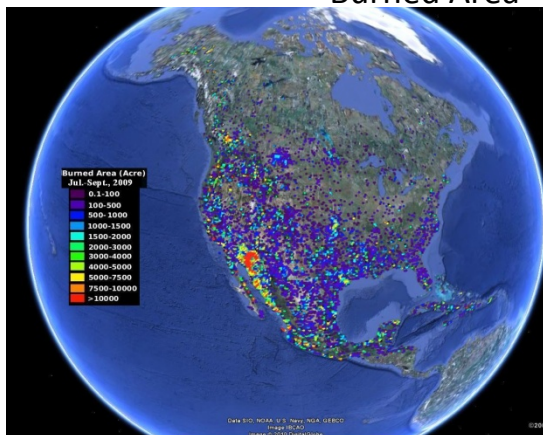 - *Data availability:* 2007 - present
  - *Data link:* ftp://satepsanone.nesdis.noaa.gov/FIRE/HMS/SMOKE

GOES-11 Smoke Observation (2009 07 06 1900Z)

$$m_c = \frac{\tau}{k * h}$$

Smoke Column Concentration ($\mu g/m^3$)

1   5   10   20   >

Animation of Smoke Plume Detection

Original AOD Image	Smoke AOD Image

Aerosol Optical Thickness

0.0   0.2   0.4   0.6   0.8   1.0   1.2 >

GOES Biomass Burning Emissions Status: Operational

Burned Area

Fuel Load (kgC/ha)

- Conventional approach uses fuel load, burned area, fraction of fuel consumed, and emissions factors to determine emissions.

- Product specifications
  - *Name:* GBBEP
  - *Satellites: GOES-East and GOES-West (includes Alaska)*
  - *Accuracy: 30%*
  - *Spatial resolution: 4 km at nadir*
  - *Temporal resolution: hourly*
  - *Latency: one day*
  - *Data format: binary file, JPEG imagery*
 - *Data availability: 2002 - present*
  - *Data link:* **http://satepsanone.nesdis.noaa.gov/pub/EPA/GBBEP/**

2005 Seasonal Composite

PM2.5 emission (ton)
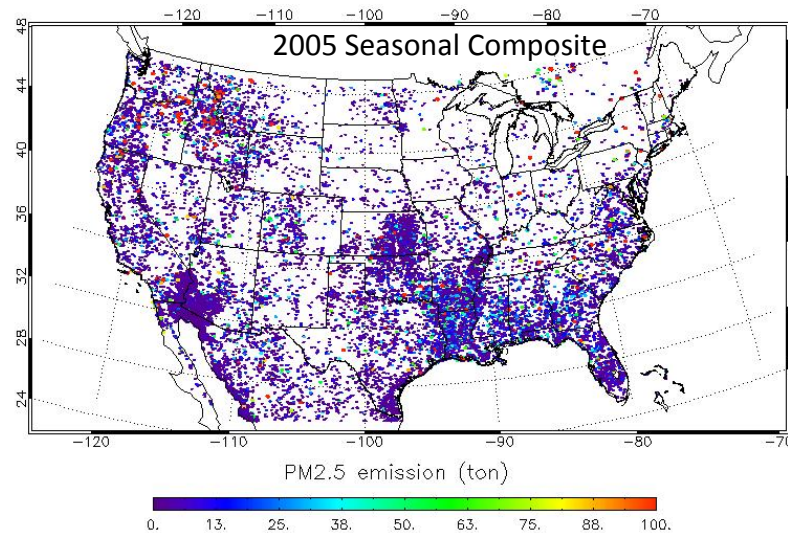
Zhang et al., Near real time monitoring of biomass burning particulate emissions (PM2.5) across contiguous United States using multiple satellite instruments, Atmospheric Environment 42 (2008) 6959–6972

Global Biomass Burning Emissions Product from a Constellation of Geostationary Satellites
Status: Experimental

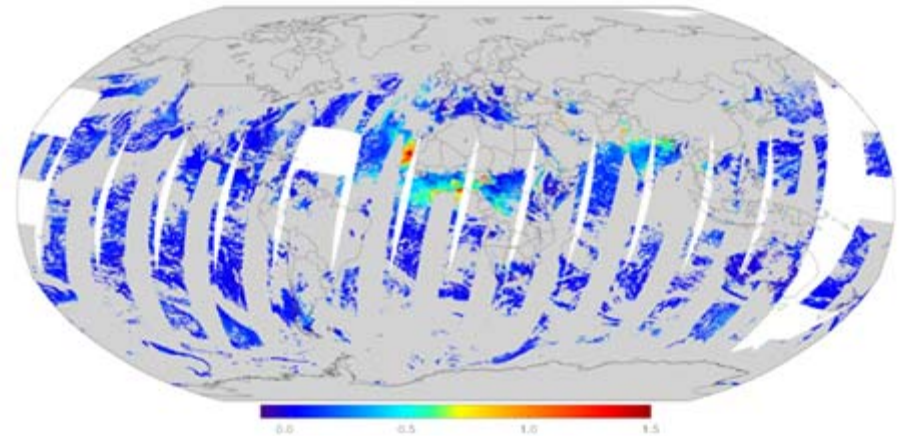**Hourly Biomass Burning Aerosols on Sept. 16, 2009**
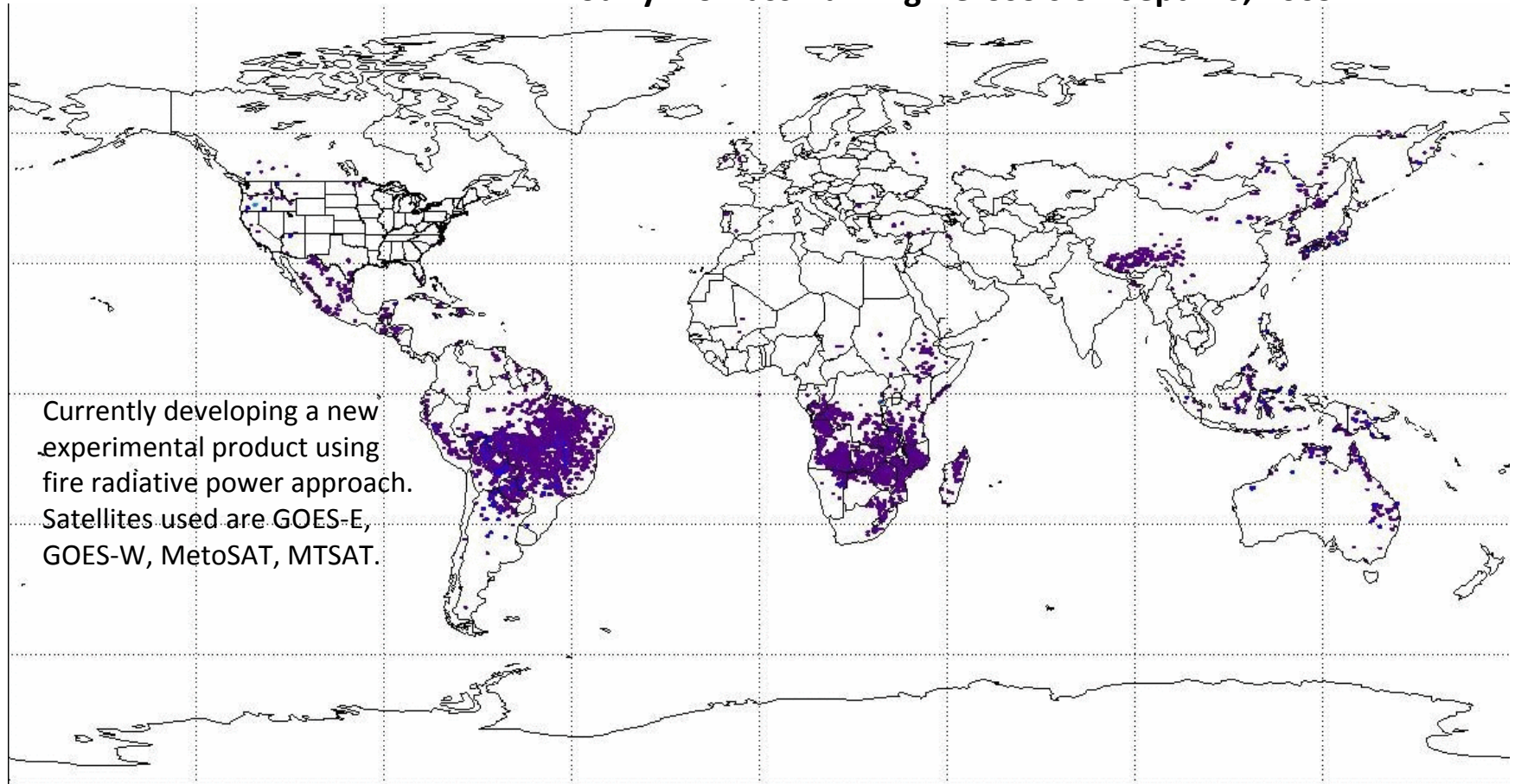
Currently developing a new experimental product using fire radiative power approach. Satellites used are GOES-E, GOES-W, MetoSAT, MTSAT.

Aerosol Products from Next Generation NOAA Satellite Sensors
GOES-R Advanced Baseline Imager

- ABI is a multi-channel Imager that will provide Suspended Matter/Aerosol Optical Depth

  - MODIS/VIIRS algorithms have been adapted for ABI

  - Algorithm tested using seven years of MODIS radiances as proxy data

GOES-R ABI AOD (1/28/2008)

| Range	Land		Water	
	AOD	*Accuracy*	*AOD*	*Accuracy*
Low	<0.04	0.06	<0.4	0.02
Medium	0.04-0.8	0.04		
High	>0.8	0.12	>0.4	0.10

Laszlo I., P. Ciren, H. Liu, S. Kondragunta, J. D. Tarpley and M. D. Goldberg, 2008: Remote sensing of aerosol and radiation from geostationary satellites, *Adv. Space Res.*, 41, 11, 1882-1893, doi: 10.1016/j.asr.2007.06.047

Aerosol Observability Workshop, Naval Research Laboratory, Monterey, CA

Aerosol Products from Next Generation NOAA Satellite Sensors
GOES-R Advanced Baseline Imager

March 6. 2006

- ABI is a multi-channel imager that will provide Aerosol Dust/Smoke detection (imagery products)
  - MODIS/AVHRR dust/smoke detection algorithm adapted for ABI
  - Algorithm tested using MODIS RGB imagery and CALIPSO data for 36 case studies


MODIS RGB

ABI Dust Flag
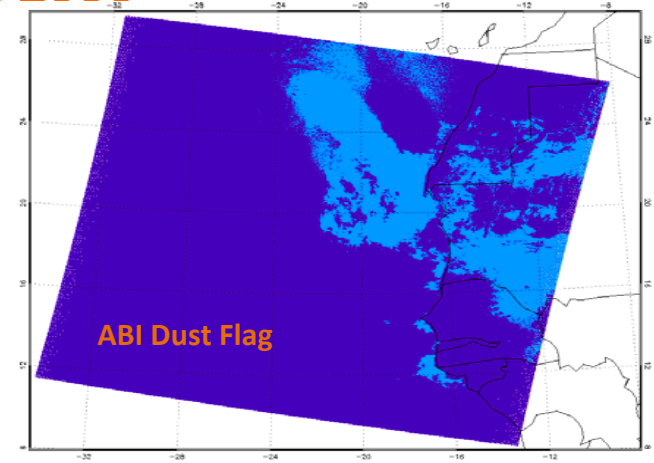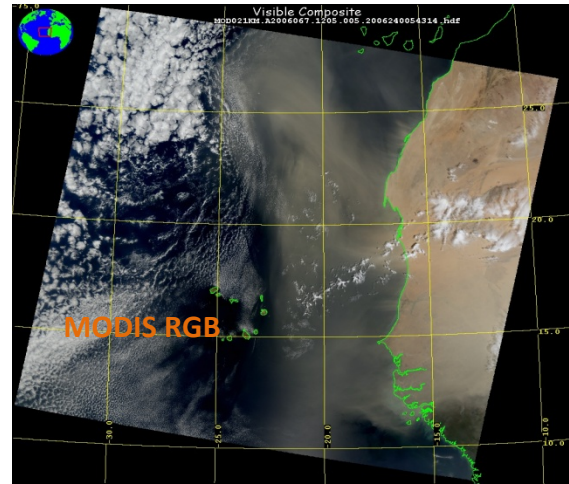
Product	Accuracy (vs. MODIS)		Accuracy (vs. CALIPSO)
	Land	Water	Land/Water
Dust	6.4%	1.9%	19%
Smoke	12.1%	16.3%	25%

Aerosol Products from Next Generation NOAA Satellite Sensors Joint Polar Satellite Systems (JPSS) VIIRS

- VIIRS is a multi-channel Imager that will provide Aerosol Optical Depth, Aerosol Particle Size, Suspended Matter (smoke/dust classification products

  – NESDIS is validating the algorithm/product. Official product will be available through system prime. Additional improved products through NESDIS (JPSS data exploitation project) are anticipated.

8/8 2006

VIIRS AOD

MODIS AOD
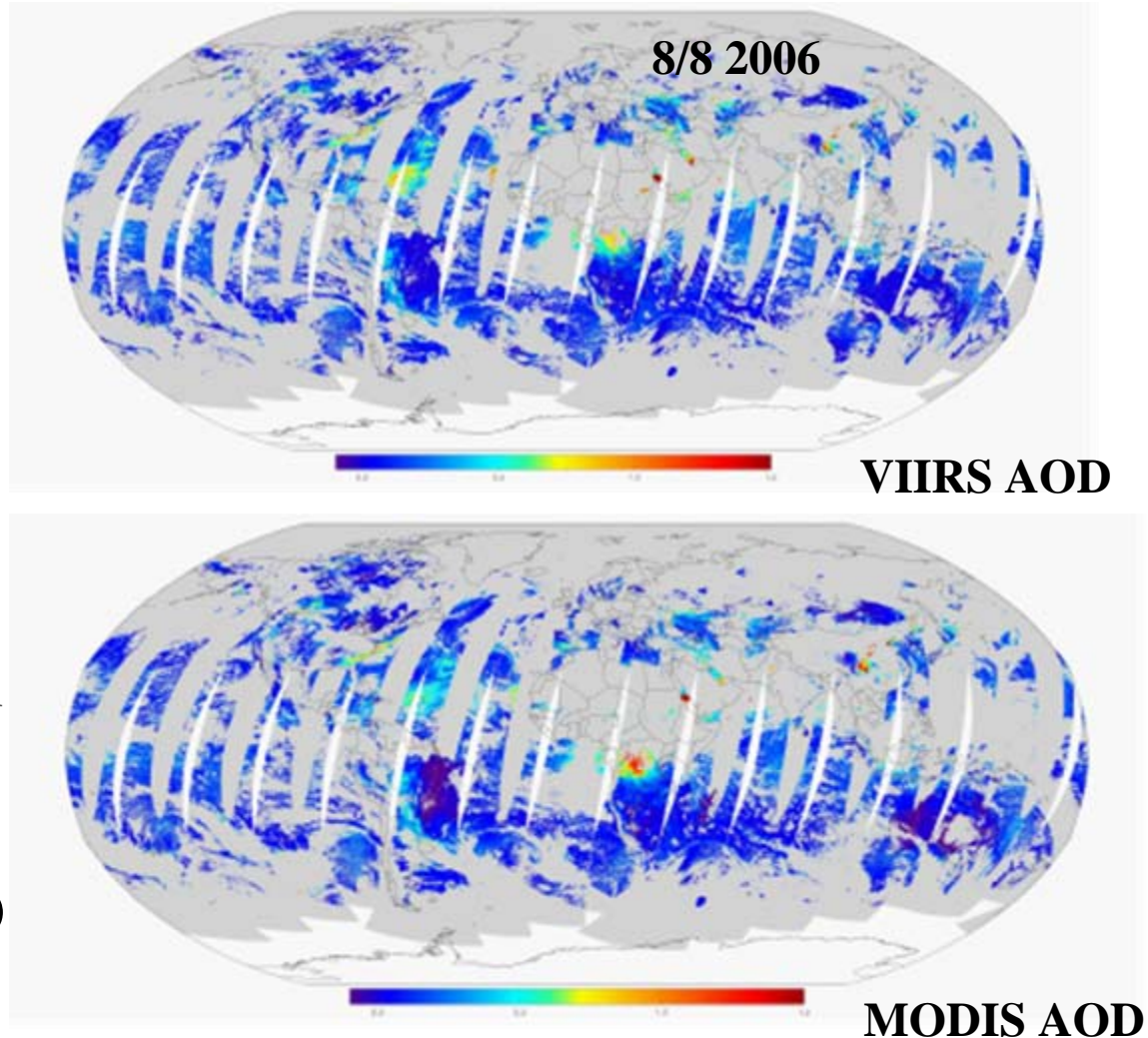
NESDIS Aerosol Data Policy and Applications

- All products, *if operational*, are available for public use on public domain (DDS, Data Distribution System) from OSDPD (Office of Satellite Data Production and Distribution). They have 24-hr/7-day technical support.
  - NOAA is not responsible for products developed by non-NOAA personnel using NOAA satellite data.
  - All NOAA products have PALs (Product Area Leads) who receive feedback from users and who provide product upgrades/outage etc. information to the users. PALs get science guidance from algorithm developers at STAR (Center for Satellite Applications and Research).
  - Users interested in these products should contact the PALs
  - Requests for new products must come through submission of a user request from at **http://projects.osd.noaa.gov/spsrb/**
- All products, *if experimental*, are available for testing and potential applications through STAR PIs. They do not have 24-hr/7-day technical support.
- List of OSDPD PALs:
  - GOES AOD (Matthew.Seybold@noaa.gov)
  - HMS (Mark.Ruminski@noaa.gov)
  - Fires (Gilberto.Vicente@noaa.gov)
  - Emissions (Gilberto.Vicente@noaa.gov)
  - GOES ASDTA (Matthew.Seybold@noaa.gov)
  - MODIS and AVHRR AOD (Hangjun.Ding@noaa.gov)
- Science support from STAR:
  - GOES AOD (Shobha.Kondragunta@noaa.gov)
  - Fires (Chris.Schmidt@ssec.wisc.edu, Ivan.Csiszar@noaa.gov)
  - Emissions (Shobha.Kondragunta@noaa.gov)
  - GOES ASDTA (Shobha.Kondragunta@noaa.gov)
  - AVHRR AOD (Istvan.Laszlo@noaa.gov)

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