

VIIRS Satellite Products: New High-Resolution Aerosol Products for Air Quality Applications

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PENNSSTATE



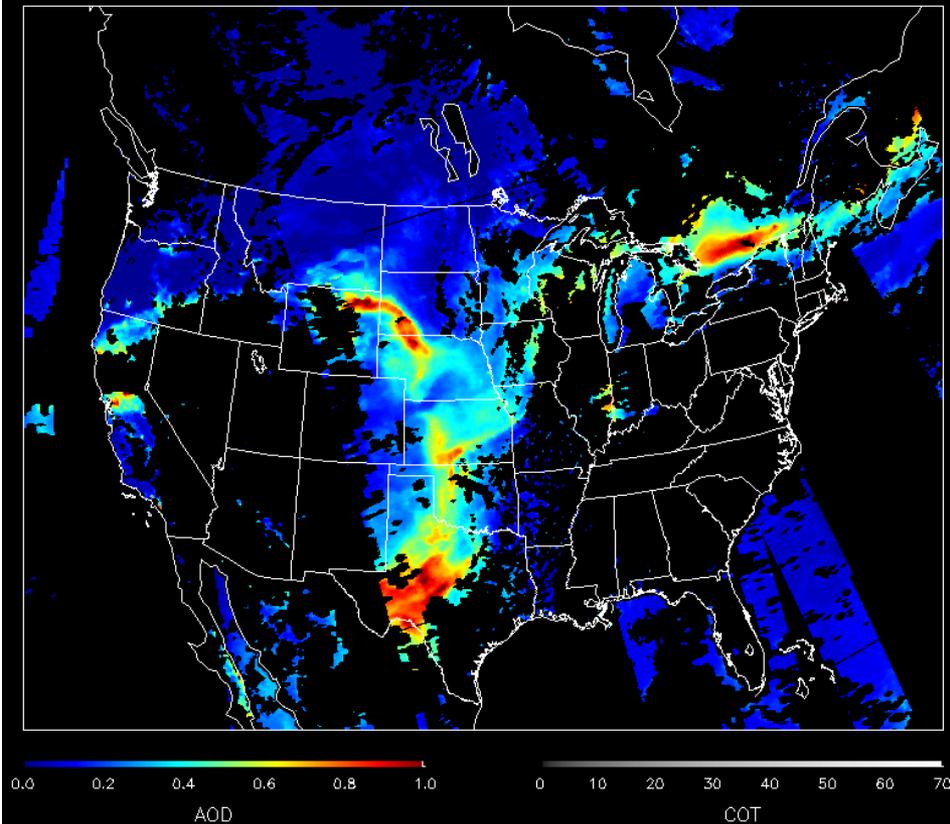
Satellite Aerosol Optical Depth (AOD)

- AOD indicates areas of high particulate matter in the atmosphere associated with smoke plumes, haze, and blowing dust
- Air quality forecasters, modelers, analysts use AOD for retrospective and near real-time applications:
 - Poor air quality case studies/retrospective analysis
 - Exceptional Events
 - Forecasting
- Near real-time and archived AOD imagery are available on the NOAA IDEA website:
<http://www.star.nesdis.noaa.gov/smcd/spb/aq/>

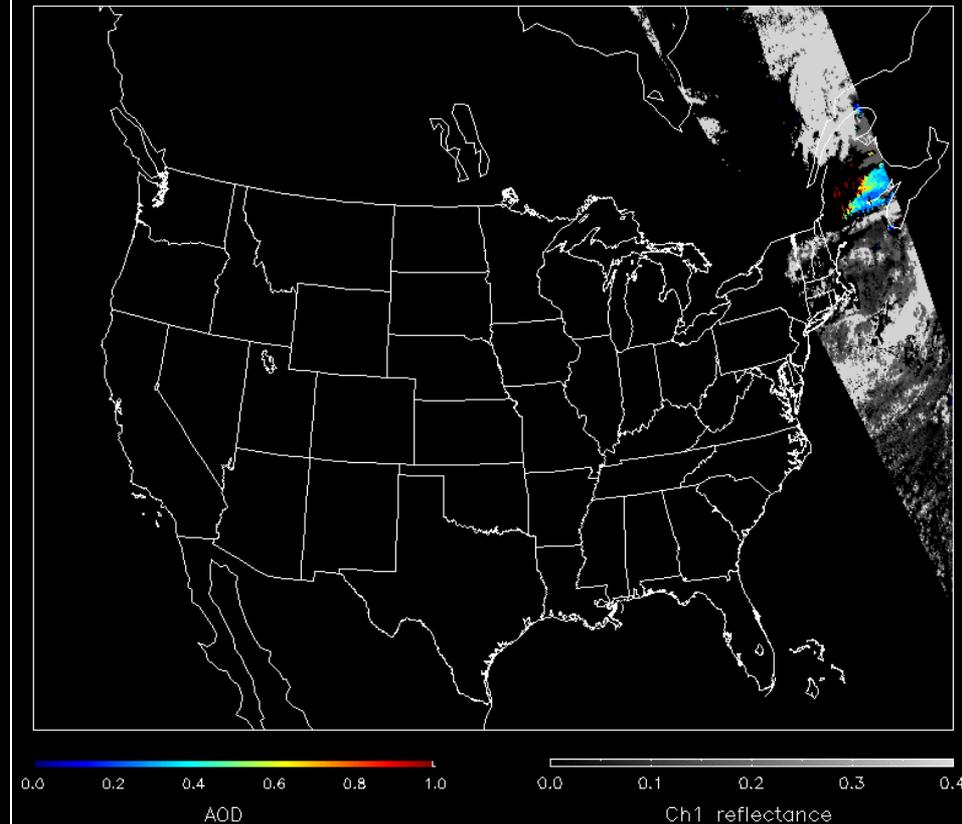
Available AOD Products (on IDEA)

- Current AOD observations from polar-orbiting (Terra, Aqua) and geostationary (GOES) satellites
 - MODIS AOD: high accuracy; 10 km and 3 km resolution
 - GASP: high refresh rate; 4 km resolution

MODIS (Aqua) 2013 08 19



GASP EAST AOD 2013 08 19 1015 UTC



New High Resolution AOD from VIIRS

- Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on Suomi-NPP satellite, launched Oct 28, 2011
- Polar-orbiting satellite with afternoon overpass, similar to Aqua (~1:30 PM local time)
- 22 spectral channels (bands)
- **2 high spatial resolution AOD products:**
 - Intermediate Product (IP): 750 m resolution
 - Environmental Data Record (EDR): 6 km resolution
- Note: official designation is VIIRS Aerosol Optical Thickness (AOT); this is just another name for AOD
- VIIRS AOT is on IDEA website, along with MODIS AOD and GASP!

National Satellite AOD and Natural Color Images

(Images download links has been moved to the bottom of this page)

◀ PREVIOUS FORECAST DAY NEXT FORECAST DAY ▶

2014 January 28 0015 Go

Product description

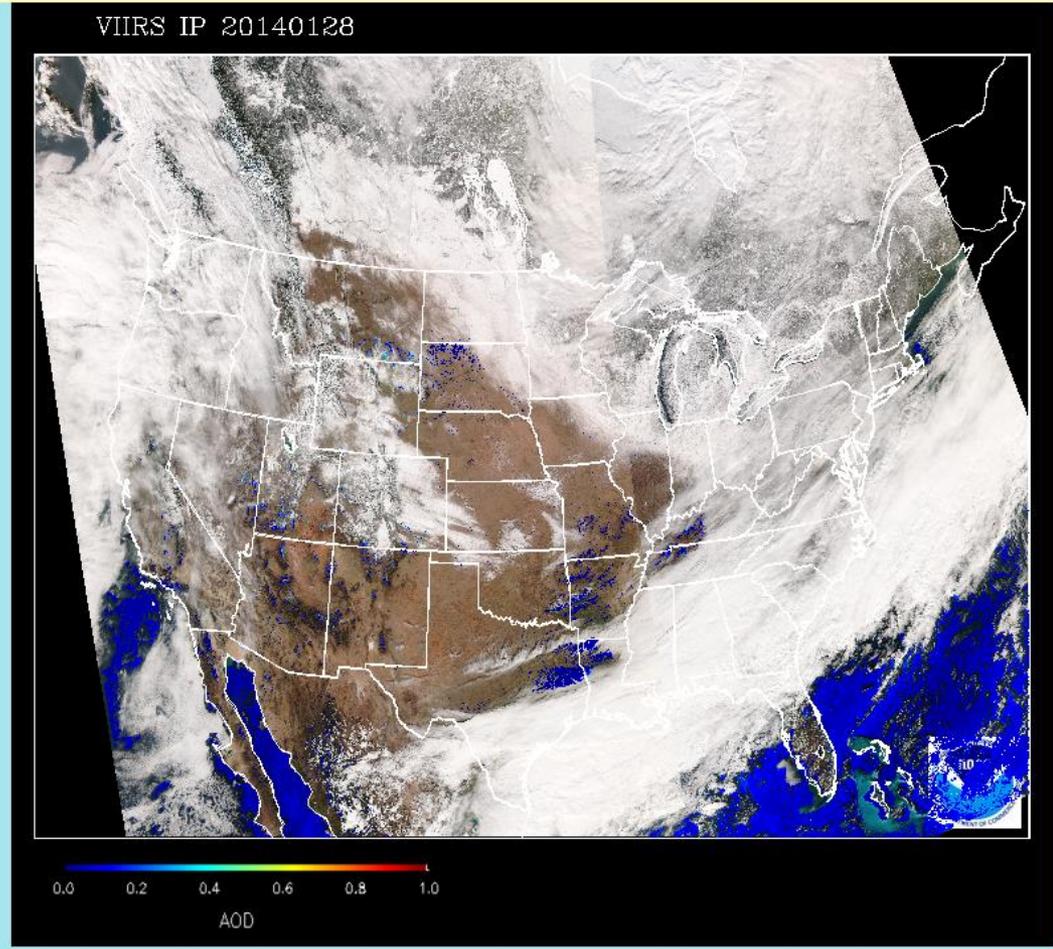
Choose plot type: MODIS (Terra) MODIS (Aqua) GASP animated GASP west animated
 GASP fixed frame GASP west fixed frame VIIRS EDR VIIRS IP

AOD opacity

change AOT opacity

select date

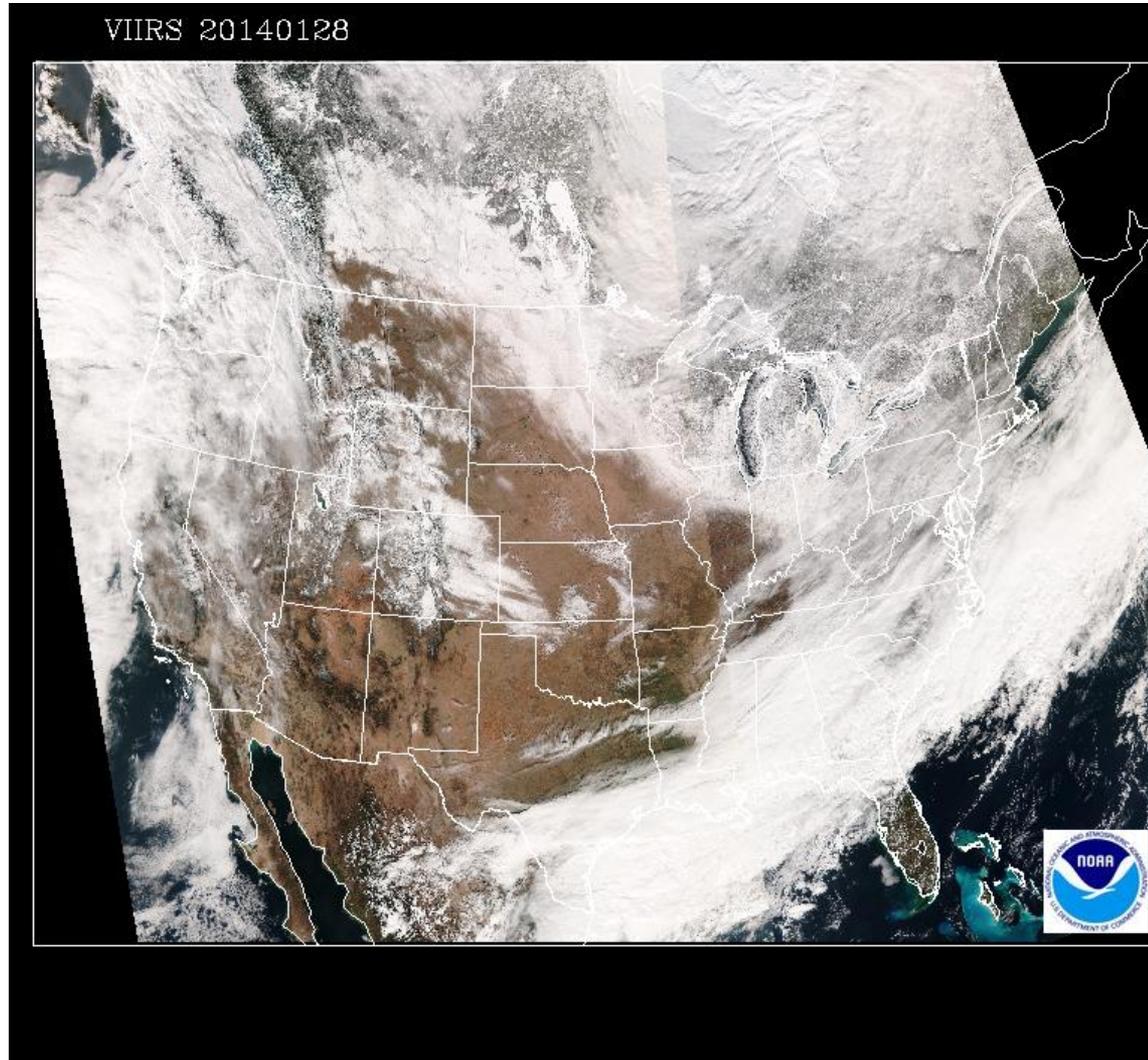
select AOD product



download imagery (not shown)

VIIRS True Color Imagery (RGB)

- Combination of **red**, **green**, and **blue** bands of VIIRS
- 750 m resolution
- Looks like a photograph
- Useful for visually identifying areas of smoke, haze, and dust
- Complements AOD imagery
- Also on IDEA!



VIIRS AOD/RGB Interactive Visualization on IDEA

VIIRS CONUS True Color (RGB) and Aerosol Images

select date

select version of AOT and quality flags

change RGB/AOT opacity

visualization options

download imagery

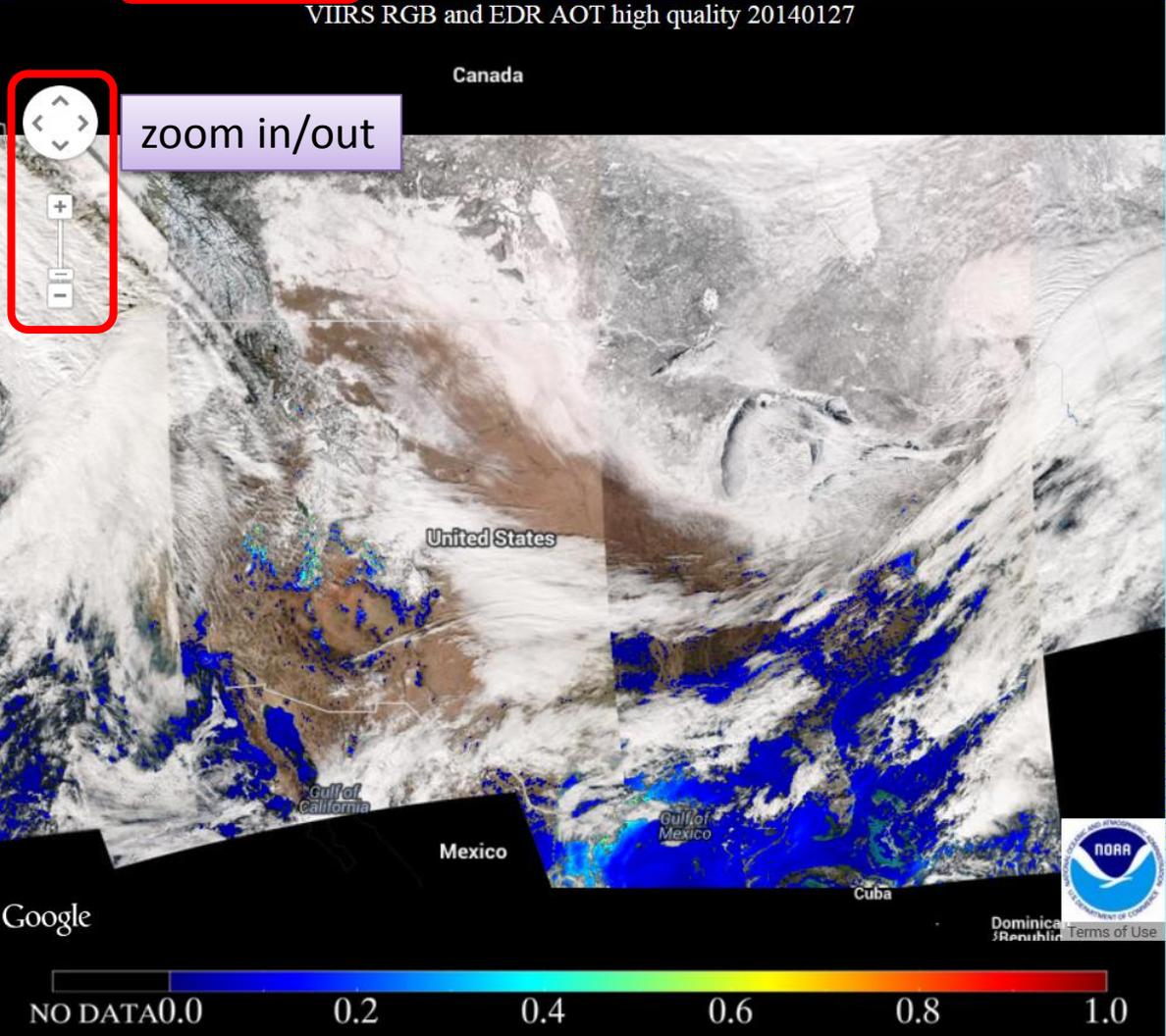
SELECT PLOT

PREVIOUS FORECAST DAY

NEXT FORECAST DAY

select date 20140127 Go

Product Description



zoom in/out

Navigation controls: a circular zoom-in/out button and a vertical slider for zoom level.

Select AOT & Quality

- EDR High
- EDR High & Medium
- IP High
- IP High *
- IP High & Degraded

RGB Opacity

AOD Opacity

Toggle Dust Mask

Toggle Fire Hotspots

Toggle County

- Image Files Download:
- RGB
 - RGB & EDR AOT (high)
 - RGB & EDR AOT (high and medium)
 - RGB & IP AOT (high)
 - RGB & IP AOT (high*)
 - RGB & IP AOT (high and degraded)

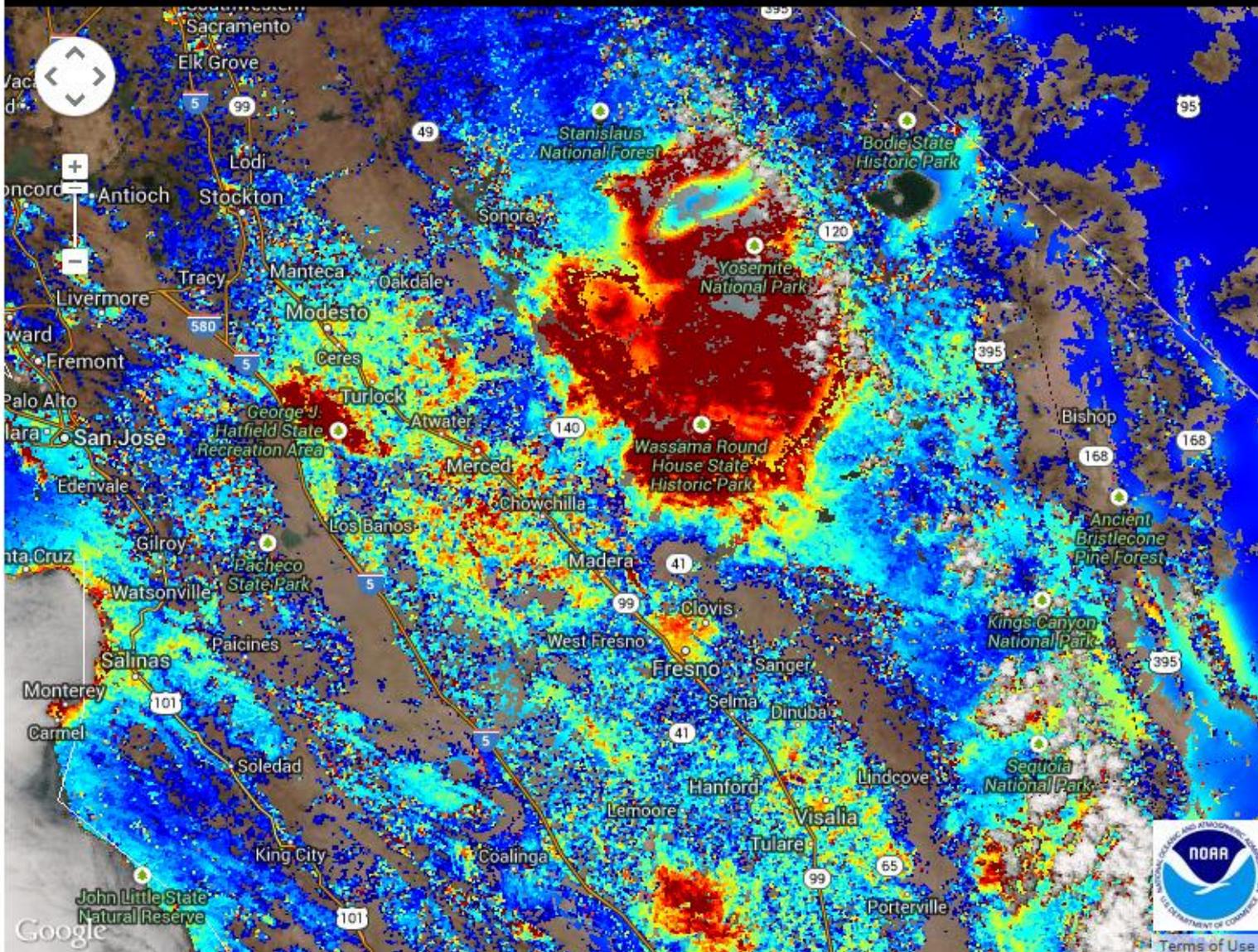
VIIRS Intermediate Product (IP) AOT

- 750 m resolution
- IP was for originally intended internal use only but NOAA decided to release it for public use
- 4 quality flags: High, Degraded, Excluded, Not Produced (see *Product Description* on IDEA for more info)
- IP AOT on IDEA:
 - **IP High:** cloud-free IP AOT of the highest quality (use for *quantitative* applications)
 - **IP High*:** IP High AOT plus degraded AOT due to cirrus clouds or soil-dominated surfaces (use for *qualitative* applications; comparable to MODIS Aqua AOD)
 - **IP High & Degraded:** IP High AOT plus all degraded AOT (use in situations when the quality filters are too rigorous, such as a smoke plume)

VIIRS Aerosol Algorithm Data Screening Criteria

Condition	Pixel Quality Level			Applies to:		Detected by:	
	Degraded	Excluded	Not Produced	Land	Ocean	VCM	Internal Tests
Out of Spec Range		X		X	X		X
Coastal or Inland Water			X			X	
Cloud Contamination			X	X	X	X	X
Cloud Adjacency	X			X	X		X
<i>Cirrus</i>	X			X	X	X	X
Invalid SDR data			X	X	X		X
Sun Glint			X	X	X	X	X
Cloud Shadow	X			X	X	X	
Snow/Ice			X	X	X	X	X
Fire			X	X		X	X
<i>Soil Dominated</i>	X			X			X
Bright Surface			X	X			X
Turbid Water			X		X		X
Ephemeral Water			X	X			X
$65^\circ \leq \text{SolZA} < 80^\circ$	X			X	X		X
$\text{SolZA} \geq 80^\circ$			X	X	X		X
Large Retrieval Residual	X			X	X		X

VIIRS RGB and IP AOT high & degraded quality 20130909



Select AOT & Quality

EDR High

EDR High & Medium

IP High

IP High *

IP High & Degraded

RGB Opacity

AOT Opacity

Toggle Dust Mask

Toggle Fire Hotspots

Toggle County

Image Files Download:

- RGB
- RGB & EDR AOT (high)
- RGB & EDR AOT (high and medium)
- RGB & IP AOT (high)
- RGB & IP AOT (high*)
- RGB & IP AOT (high and degraded)



Terms of Use



VIIRS Environmental Data Record (EDR) AOT

- Aggregated from IP AOT retrievals in a 8×8 pixel box
- 6 km resolution
- Official VIIRS AOT product for public
- 3 quality flags: High, Medium, Low (see *Product Description* on IDEA for more info)
- EDR quality flag based on number of IP AOT pixels with a particular quality flag falling inside or outside a threshold number
 - e.g., **EDR High** AOT are comprised of > 16 IP pixels (out of a possible 64) and all of the IP pixels are **IP High** quality
- EDR AOT on IDEA:
 - **EDR High**
 - **EDR High & Medium**

VIIRS RGB and EDR AOT high & medium quality 20130909

Select AOT & Quality

EDR High

EDR High & Medium

IP High

IP High *

IP High & Degraded

RGB Opacity

AOT Opacity

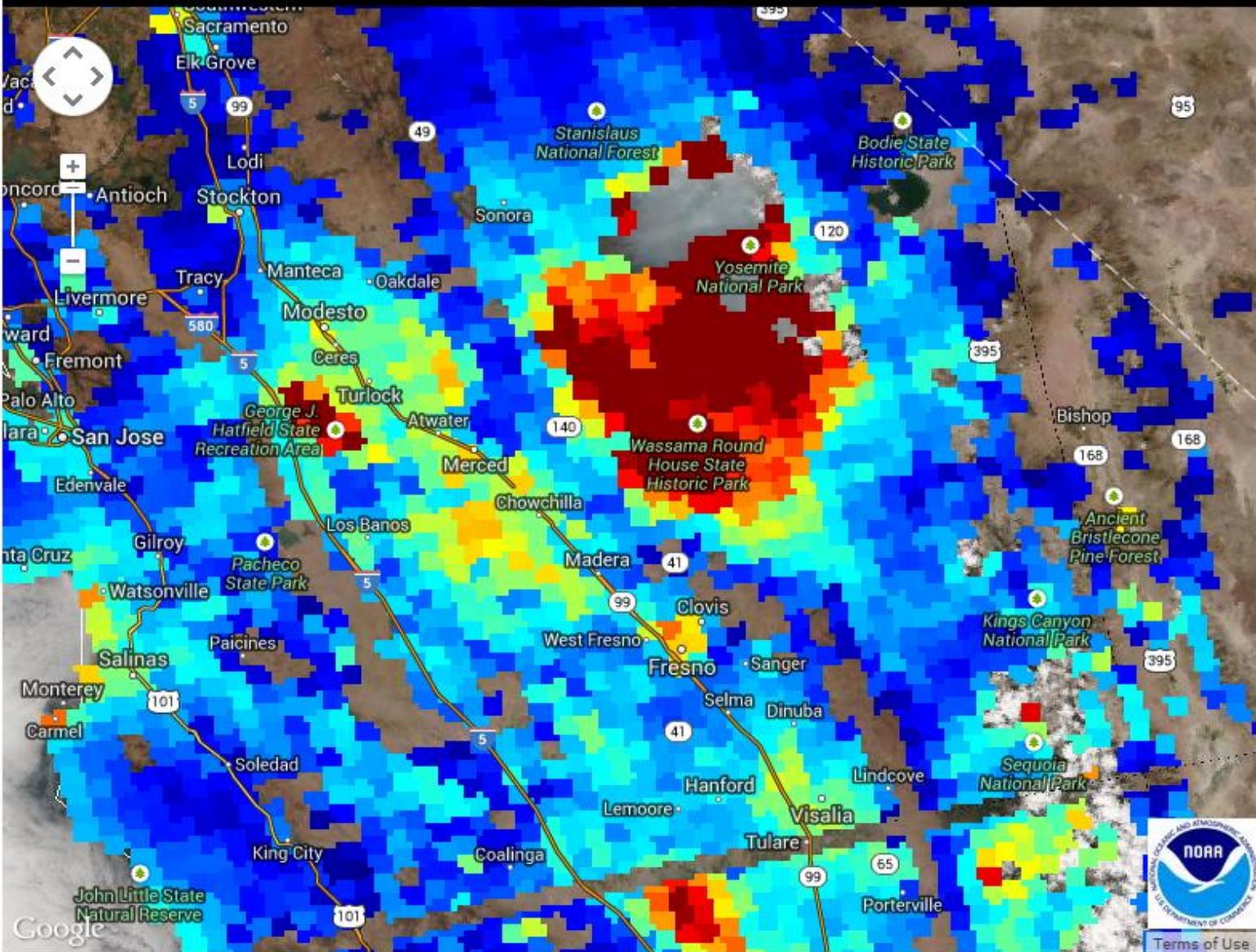
Toggle Dust Mask

Toggle Fire Hotspots

Toggle County

Image Files Download:

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- RGB & IP AOT (high and degraded)

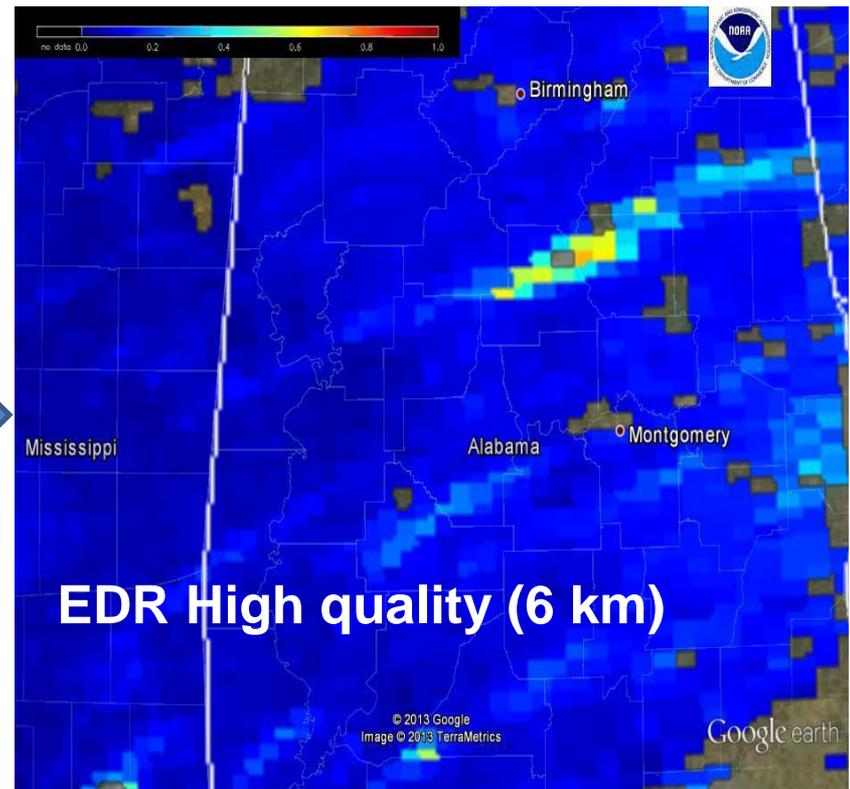
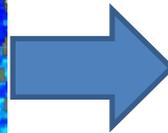
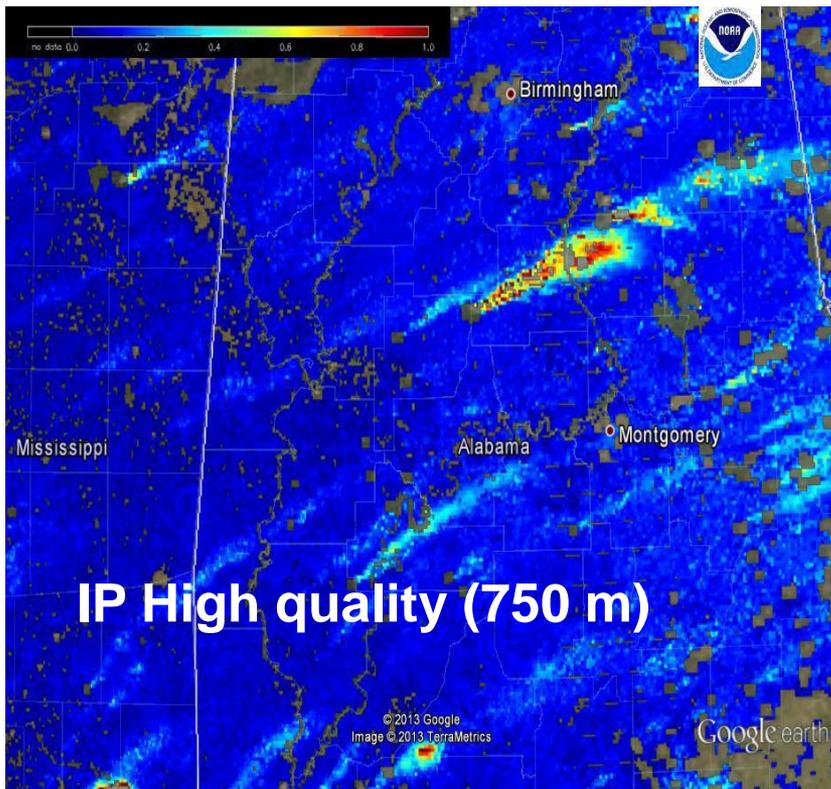


Terms of Use



Apparent Differences in IP/EDR AOT Coverage

- Spatial resolution of IP (750 m) vs. EDR (6 km) pixels
- Need > 16 IP High AOD pixels for EDR High AOT pixel
- Lat/Lon used for center of IP AOT pixels and EDR AOT pixels is different



Validation Status of VIIRS AOT Products

- VIIRS AOT products are **provisional** now but will become validated in **May 2014**.
- Provisional data:
 - Product quality may not be optimal
 - Product accuracy is determined for a broader (but still limited) set of conditions
 - No requirement to demonstrate compliance with specifications
 - Incremental product improvements are still occurring
 - The general research community is encouraged to participate in the QA and validation of the product, but users need to be aware that product validation and QA are ongoing
 - Users are urged to consult the EDR product status document prior to use of the data in publications
 - **The data are ready for operational evaluation**

Advantages of VIIRS for Air Quality Applications

- High resolution 750 m IP product resolves variations in AOD on urban scale
 - Higher resolution than MODIS Collection 6 AOD 3 km product
- 6 km resolution EDR product is useful for large scale air quality events, like large wildfires
 - Higher resolution than MODIS Collection 5 AOD 10 km product
- Quality flag options give user more control over data
 - Use High quality IP/EDR for most applications
 - Use IP High* or Degraded quality if situation warrants
- VIIRS has wider swath (3000 km) than MODIS (2330 km)
 - No gaps b/w adjacent VIIRS observations
 - Higher spatial resolution at swath edges vs. MODIS

NOAA Satellite Air Quality Proving Ground (AQPG)

- NOAA AQPG program providing training and outreach to the air quality satellite user community on new aerosol products from S-NPP/VIIRS and GOES-R/ABI
 - Training videos on YouTube (<http://www.youtube.com/watch?v=vuoDpVafZAA> and <http://youtu.be/k17IYMCcHvY>)
 - Annual AQPG meetings for user community
 - Article in *EM*, A&WMA's magazine for environmental managers
- Advisory Group of 40 air quality forecasters and analysts from federal, state, and local agencies
 - Receiving hands-on training on aerosol products
 - Providing feedback to NOAA on VIIRS and ABI aerosol product development

Examples of User Feedback on VIIRS AOT

Request/Comment	Status
Change VIIRS AOT retrieval lower bound from 0 to -0.05 so it will match MODIS AOD coverage	<i>In progress</i>
Standardize the AOT quality flag names for EDR and IP (e.g., “high,” “medium,” “degraded”)	<i>The quality flag names reflect the VIIRS AOT IP and EDR products. They are not consistent because IP AOT was not intended for release to the public.</i>
Implement the interactive Google map style visualization for MODIS AOD on IDEA	<i>Not currently possible due to the labor, computing time, storage increase needed</i>
Keep the zoom-in area unchanged when switching from one day to another in the interactive Google map visualization	<i>In progress</i>
Add option to save zoomed-in images in the interactive Google map visualization	<i>We are researching how to make this change and hope to complete it soon</i>
Overlay wind and in situ PM _{2.5} monitor observations in the interactive Google map visualization	<i>We decided not to make this change at this time since users can open VIIRS AOT in Google Earth and add layers there</i>
Fire hotspots are too large at the highest zoom level	<i>We reduced the hotspots to half their original size</i>

Next Steps for the AQPG/VIIRS AOT Products

- 2-3 training/informational webinars planned for 2014 to keep Advisory Group members updated on product development
- Preparing journal article on case study of VIIRS AOT data
- 2014 annual AQPG meeting in Oct/Nov
- Satellite data users: begin using VIIRS AOT and send me your feedback/questions! (akh157@psu.edu)

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- AQPG Advisory Group Members

