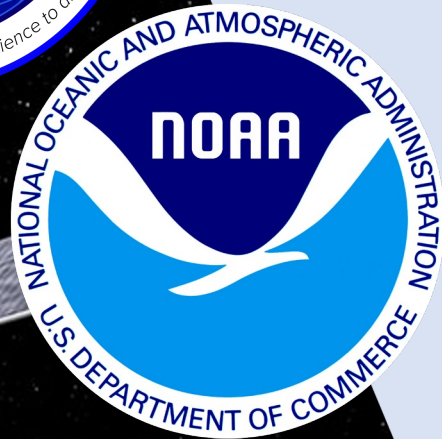




Virtual Alaska Weather Symposium (VAWS)
June 12, 2024



Detecting and Tracking Smoke & Blowing Dust using JPSS VIIRS Aerosol Products

Amy K. Huff¹,

Pubu Ciren¹, Hongqing Liu¹, Mi Zhou¹, Hai Zhang¹,
Shobha Kondragunta² and Istvan Laszlo²

National Environmental Satellite,
Data, and Information Service

Aerosols and Atmospheric Composition Science Team

¹IMSG at NOAA/NESDIS/STAR

²NOAA/NESDIS/STAR

Toxic wildfire smoke raises health risks across the country Nov 2022



Photo: U.S. Forest Service/AP

Historic Saharan dust event fouls air along Gulf Coast as next blast enters Caribbean Jun 2020



Photo: NWS Corpus Christi

Smoke from Canadian wildfires engulfs East Coast, upending daily life Jun 2023



Photo: REUTERS/Shannon Stapleton

What's with all that Houston haze? It's dust from a West Texas haboob Mar 2021



Photo: KPRC-TV 2 Houston

Wildfire smoke is choking Seattle, obscuring the view and blocking out the sun Sep 2018



Photo: Eric Martyn/Reuters

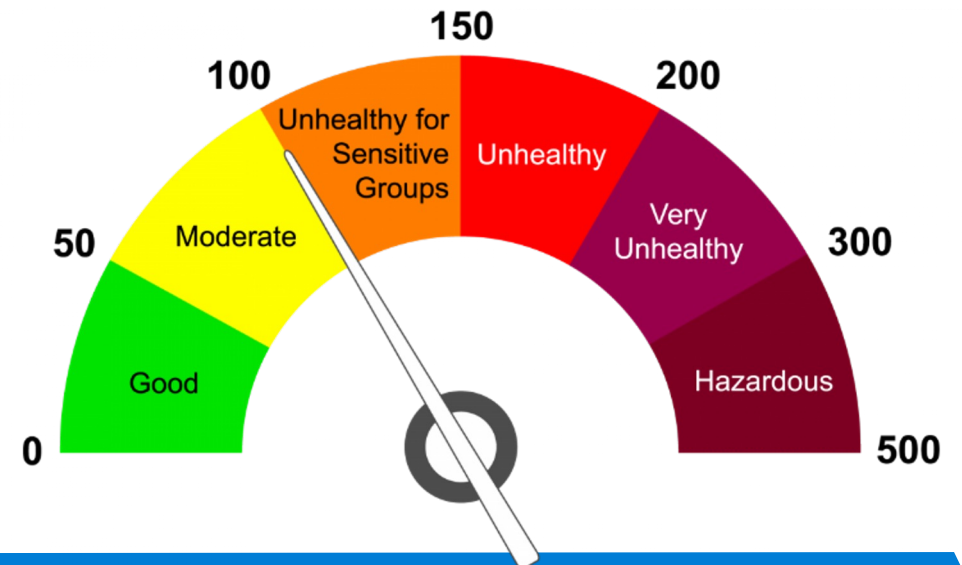
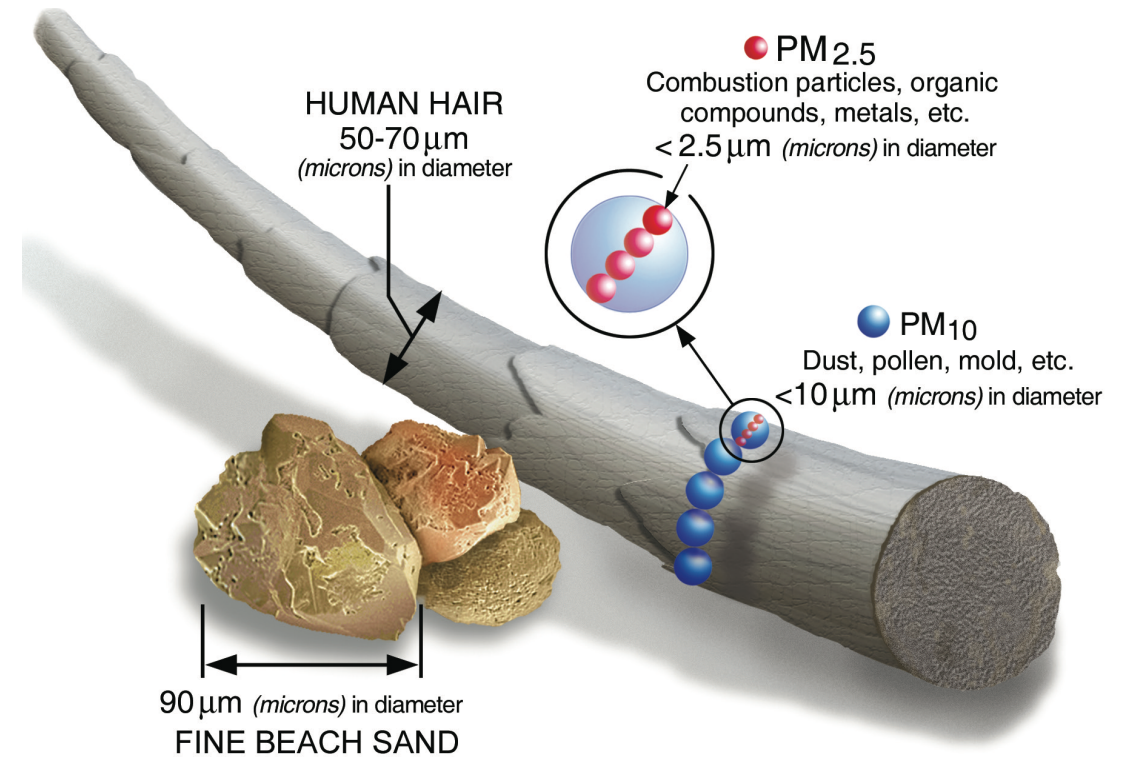
Smoke from Nova Scotia fires wafts into U.S. as Canada bakes and burns May 2023



Photo: KIRO-TV 7 Seattle

Smoke & Dust Contain PM_{2.5}

- PM_{2.5} (fine particulate matter): very small aerosols, diameter $\leq 2.5\mu\text{m}$
 - Solid, liquid, and mixed phase particles
 - Wide variety of natural & man-made sources
- PM_{2.5} is harmful to human health
 - Particles are so small they penetrate deep into lungs & pass into bloodstream
 - **Sensitive Groups** are at greatest risk: children, seniors, people with existing respiratory or cardiovascular diseases
- US EPA's Air Quality Index (AQI) communicates PM_{2.5} concentrations
 - Code Orange or higher: take action to limit exposure!



Images credit: [US EPA](#)

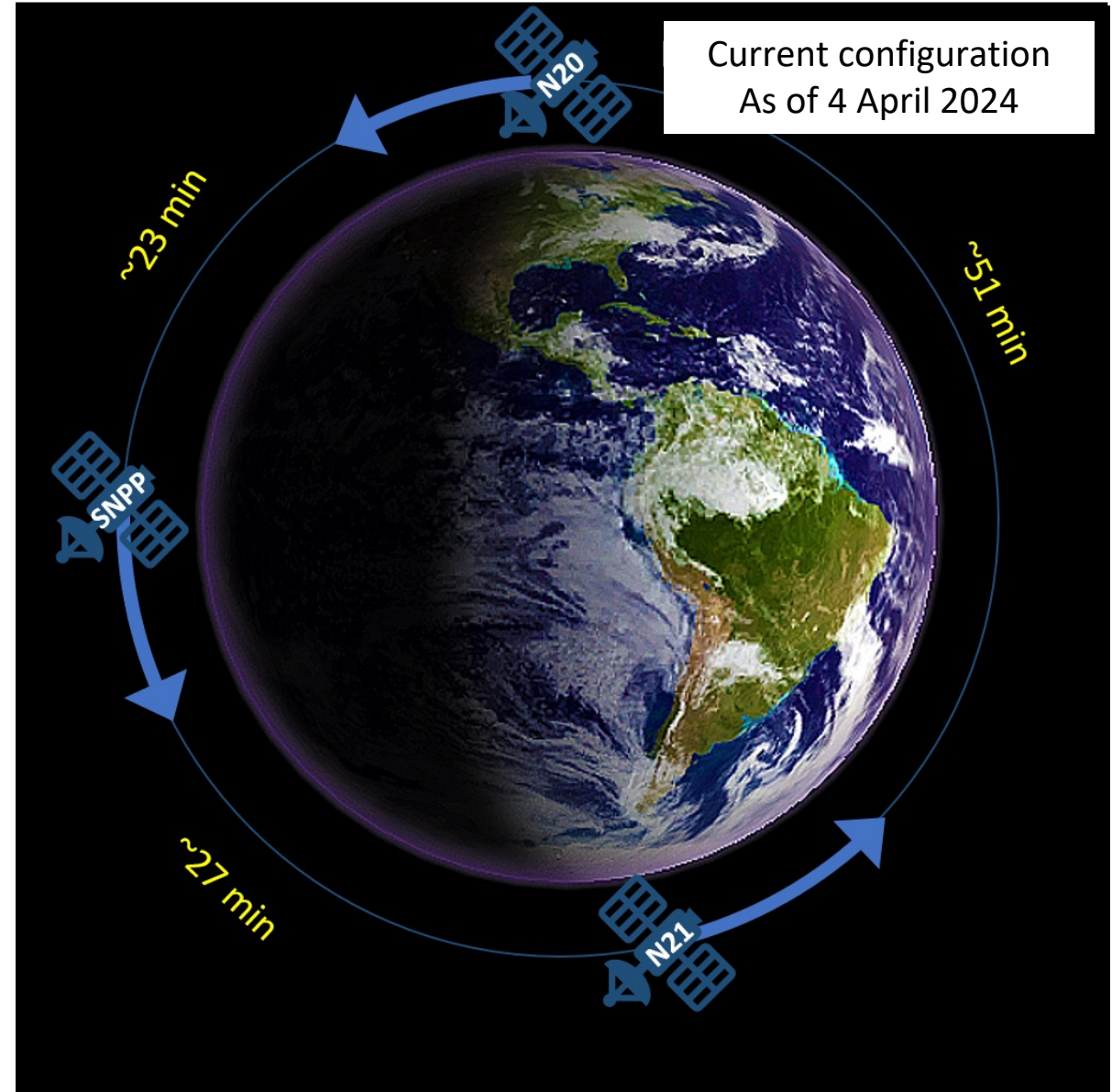
Smoke and Dust Aerosols in the Atmosphere

- Smoke and dust aerosols are hazardous to human health and welfare
 - Degrade surface air quality
 - Reduce visibility
- **Relevance for Alaska:**
 - Trend towards longer and more severe wildfire seasons
 - Extended periods of drought in the US & Canada
 - Smoke plumes from wildfires are becoming larger, thicker, and are transported further
 - Impacts can range from mesoscale to synoptic scale
 - Occasional blowing dust events occur during strong outflow from river valleys (e.g. Copper River Delta)



VIIRS on NOAA/NASA JPSS Polar-Orbiting Satellites

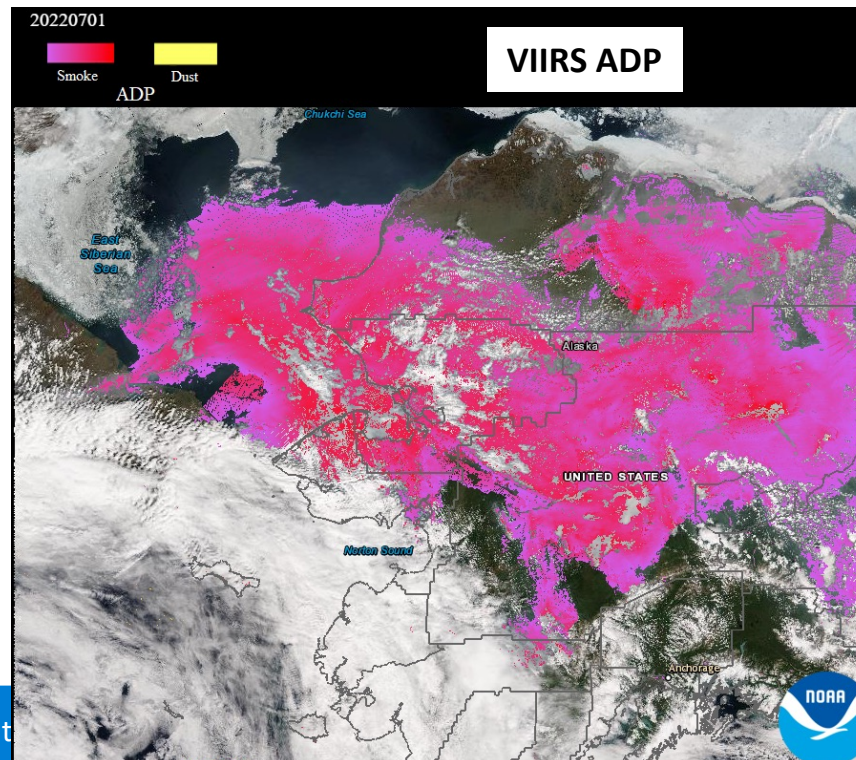
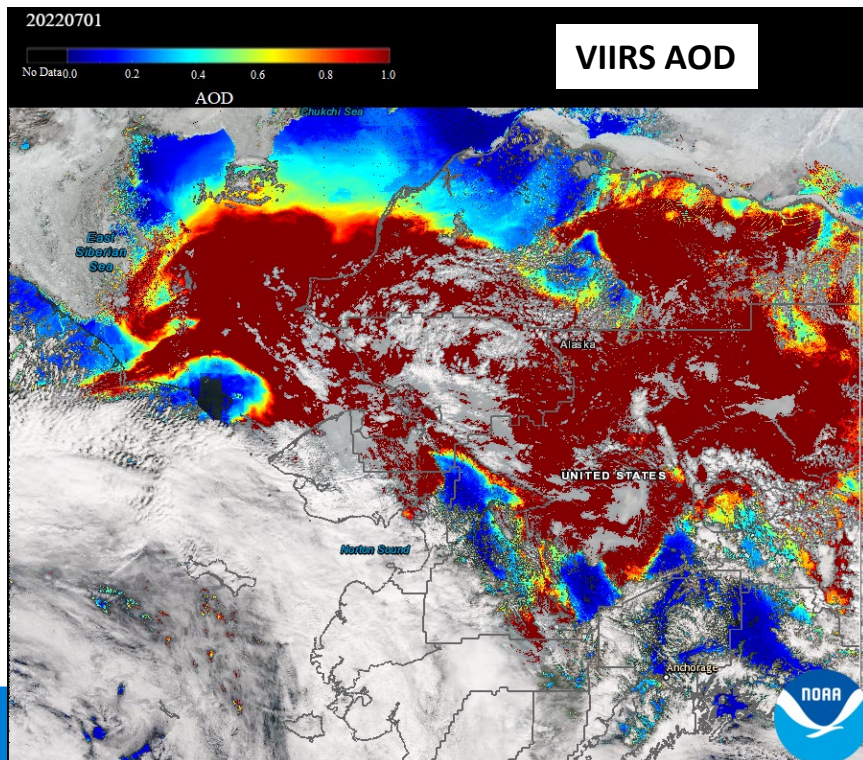
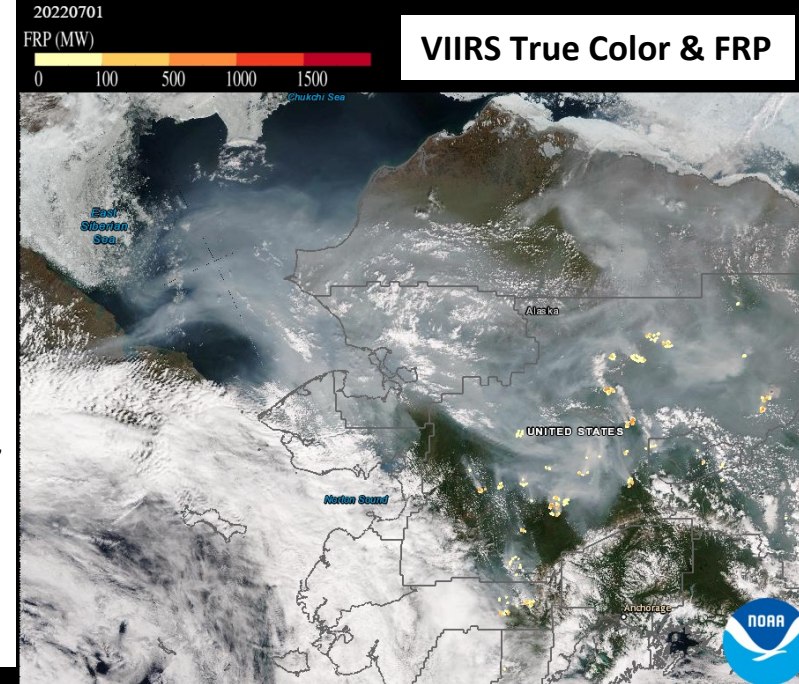
- End users in research and operations need to detect & track smoke/dust aerosols
 - Operational forecasting, emergency management
 - Model DA/validation, trends analysis
- Daily global aerosol observations available from Visible Infrared Imaging Radiometer Suite (VIIRS) on JPSS satellites
 - SNPP, launched October 2011
 - NOAA-20, launched November 2017
 - NOAA-21, launched November 2022
- Satellites offset by ~25-50 minutes
 - 1:30 pm local time equator crossing (day)
 - 1-2 aerosols observations per day per satellite
 - More observations at high latitudes due to overlapping orbits



VIIRS Aerosol Products

- Aerosol optical depth (AOD) is a **quantitative** measure of aerosol loading
 - Integral of extinction of radiation by aerosols due to scattering and absorption in an atmospheric column
 - AOD is unitless; values typically 0-1 in the US
 - Larger values for high concentrations of aerosols
 - Lower values for clean/clear atmosphere
- Surface PM_{2.5} concentrations can be estimated from AOD

Thick smoke from wildfires spread across Alaska on July 1, 2022



- Aerosol detection product (ADP) is a **qualitative** indicator of smoke & dust aerosols
 - Also called smoke and dust mask
- Quickly identifies location & intensity of smoke and dust plumes

VIIRS AOD Algorithm Overview

- An algorithm is a “formula” to calculate (retrieve) AOD
 - AOD is a Level 2 product, uses Level 1b data (spectral bands) as input (VIIRS Sensor Data Records, SDRs)
 - Level 2 VIIRS products are called Environmental Data Records (EDRs)
- The biggest challenge in retrieving AOD is isolating the extinction of sunlight by aerosols
 - Need to separate aerosol signal from surface reflectance, scattering by clouds, and absorption by trace gases
- VIIRS AOD algorithm is a “multi-band” algorithm:
 - Table lists VIIRS bands used in AOD algorithm
 - Different algorithms for AOD retrieved over land and water
 - Key feature: 2.2 μm band to estimate surface reflectance over land
 - Internal tests use various bands to screen for “unfavorable” conditions, where it’s difficult or impossible to retrieve AOD

VIIRS bands used in AOD algorithm

VIIRS Band	Wavelength (μm)	AOD Retrieval		Internal Test	
		Land	Water	Land	Water
M1	0.412	X		X	X
M2	0.445	X		X	X
M3	0.488	X		X	X
M4	0.555		X	X	X
M5	0.672	X	X	X	X
M6	0.746		X		
M7	0.865		X	X	X
M8	1.24		X	X	
M9	1.38			X	X
M10	1.61		X		X
M11	2.25	X	X	X	X
M15	10.76			X	X
M16	12.01			X	

VIIRS AOD algorithm developed by Hongqing Liu (IMSG) and Istvan Laszlo (NOAA)

Illustration of Multi-Channel AOD Retrieval

- AOD retrieved by comparing TOA reflectances observed in multiple bands with those computed for range of discrete AOD values and aerosol models
- Separate AOD algorithms for over land & water due to distinct surface properties and aerosol types
 - Water: 4 fine and 5 coarse mode aerosol models
 - Land: generic, dust, smoke, urban aerosol models
- **A simplified version of a multi-channel AOD retrieval is shown in the figure**
 - Example is for two aerosol models and two satellite spectral channels (bands)
 - Objective is to minimize residual (difference b/w calculated & observed reflectances)
 - Retrieved AOD = 1.0 using aerosol model 2

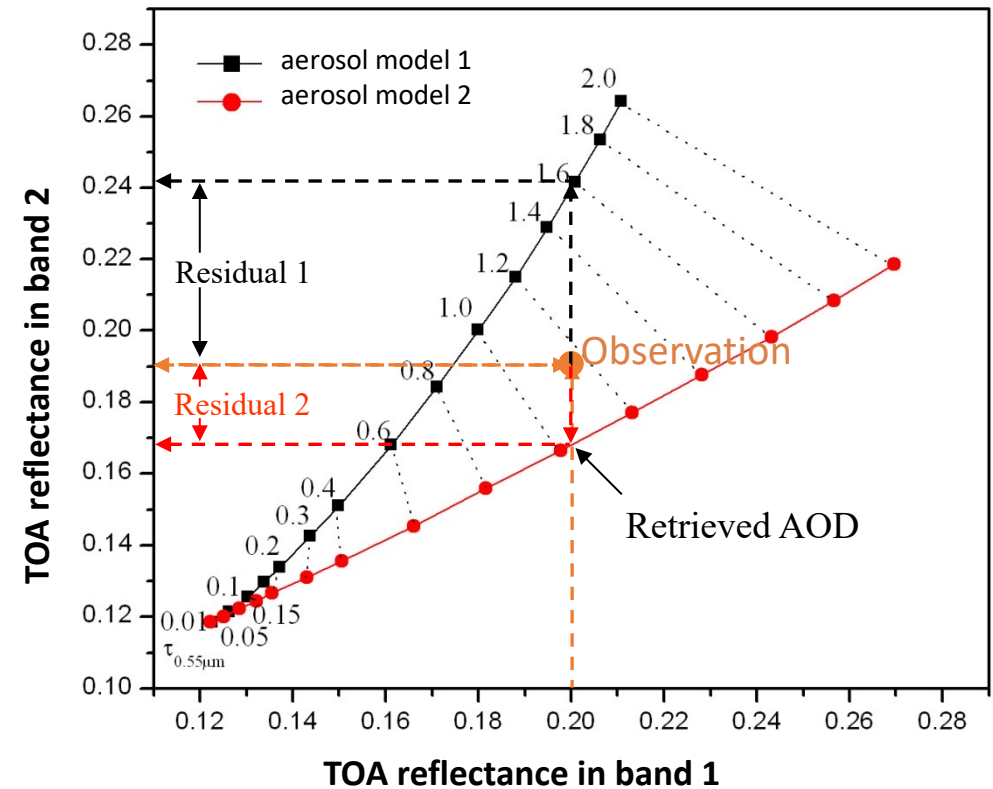
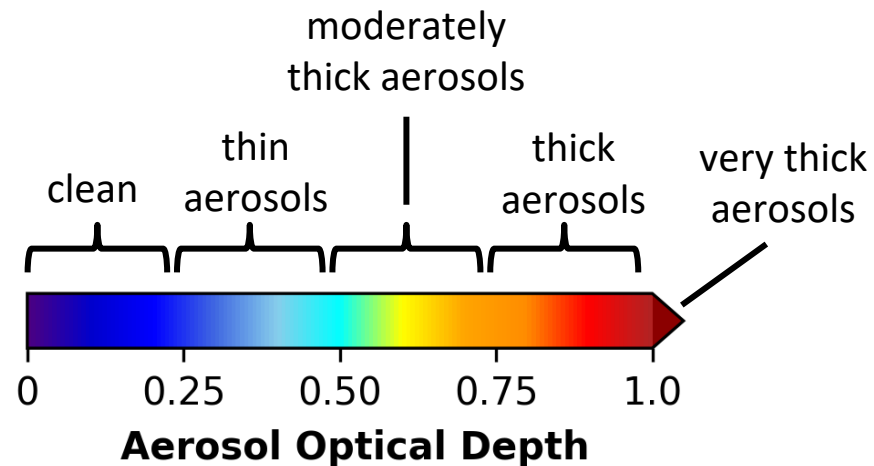


Figure credit: Shobha Kondragunta (NOAA)

VIIRS AOD Specifications and Availability

- AOD is available from VIIRS on SNPP, NOAA-20, and NOAA-21
- VIIRS AOD is reported at **550 nm**
- VIIRS AOD data range: [-0.05, 5]
 - AOD is unitless!
 - Values typically range from 0 to 1
 - AOD >1 for very thick aerosols, such as thick smoke
 - Negative values indicate **uncertainty** in the AOD retrieval (think of them as very small positive AODs)



Sensor	Satellite	Spatial Resolution (km) at nadir	Coverage	Maturity Stage	Availability Starting
VIIRS	SNPP	0.75	Global	Fully Validated	7/6/2017
	NOAA-20			Fully Validated	3/7/2019
	NOAA-21			Fully Validated	6/22/2023

AOD Data Quality Flags

- AOD data files include quality flags
 - Overall quality flag expresses confidence in AOD data
 - Figure: example of ABI overall AOD quality flags; VIIRS AOD quality flags are very similar
- **High quality AOD:** most accurate, use for quantitative applications (e.g., modeling)
- **Medium quality AOD:** some uncertainty, use for qualitative applications (e.g., forecasting)
- **Low quality AOD:** high uncertainty, avoid for most applications
- AOD is **not retrieved** in areas with:
 - Clouds
 - Snow or ice
 - Sun glint (measurement artifact; occurs when sunlight reflects off surface of ocean/lake at same angle that sensor is viewing surface)
 - Nighttime (need sunlight)

H	High Quality
M	Medium Quality
Low Quality	
L1	Contradicting Cloud Masks
L2	Low Satellite Angle
L3	Low Sun Angle
L4	Out of Spec Range
L5	Coastal Area
L6	Shallow Inland Water
L7	High Residual
L8	High Inhomogeneity
No Retrieval	
N1	Invalid Input
N2	Cloud
N3	Snow
N5	Sun Glint

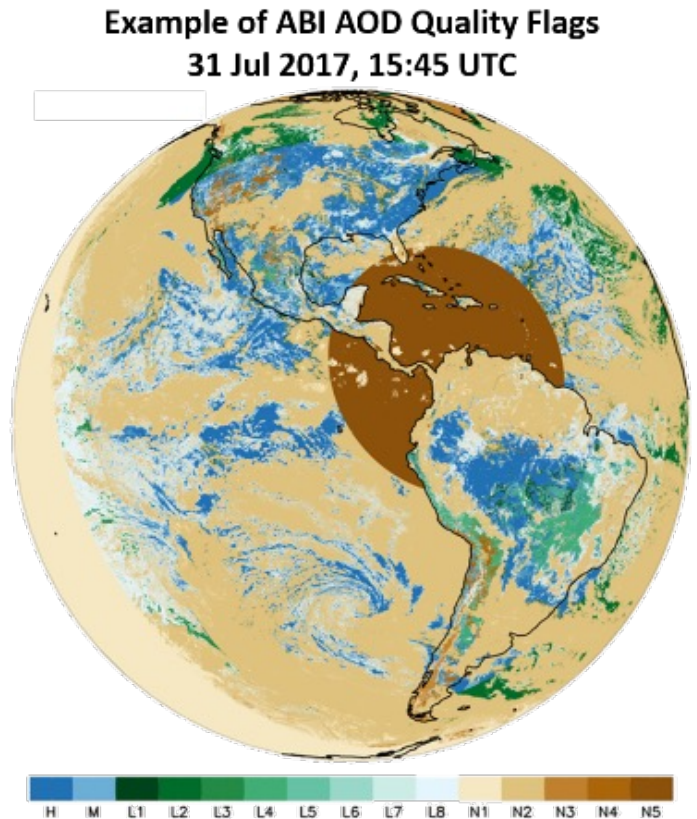
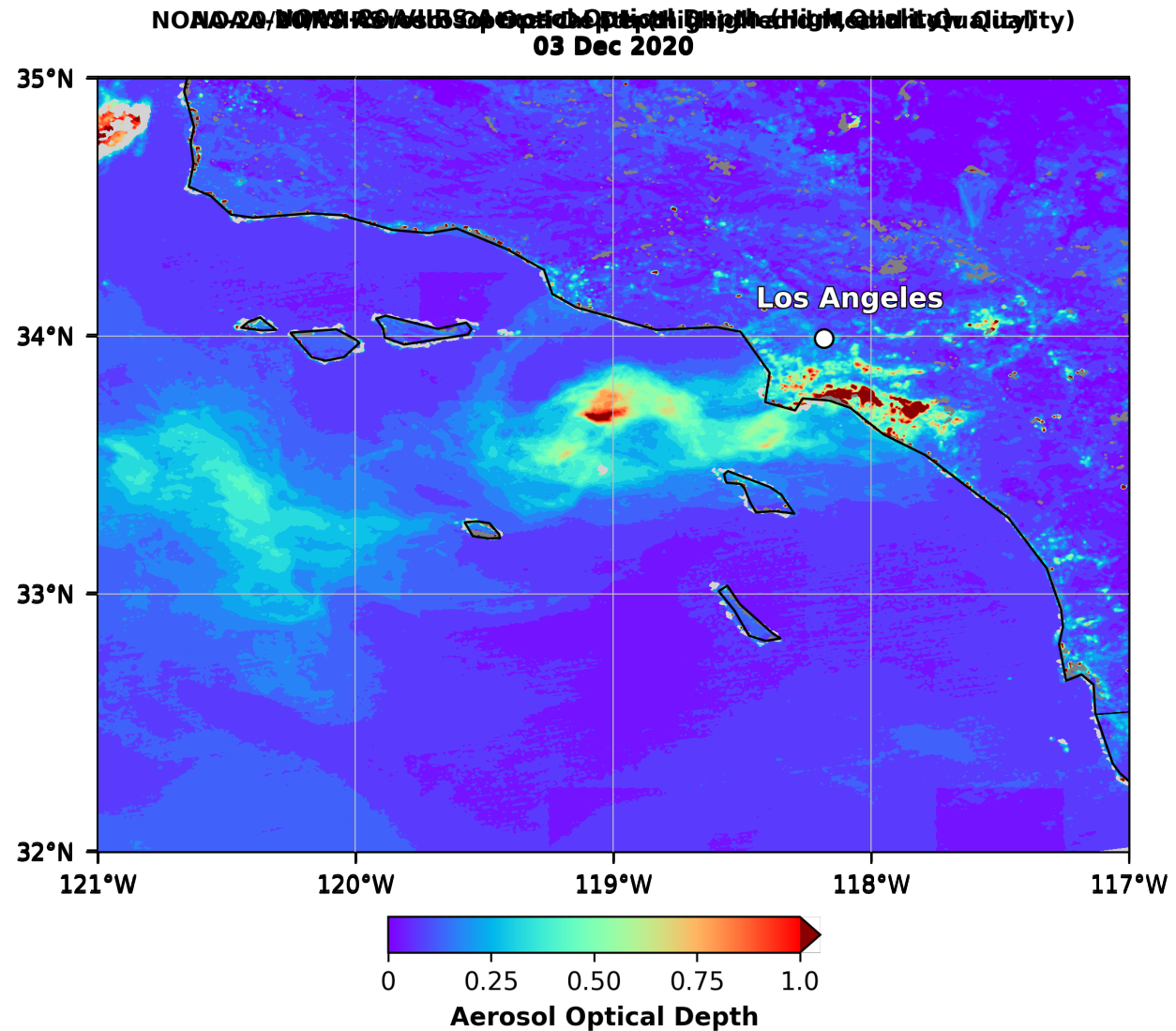


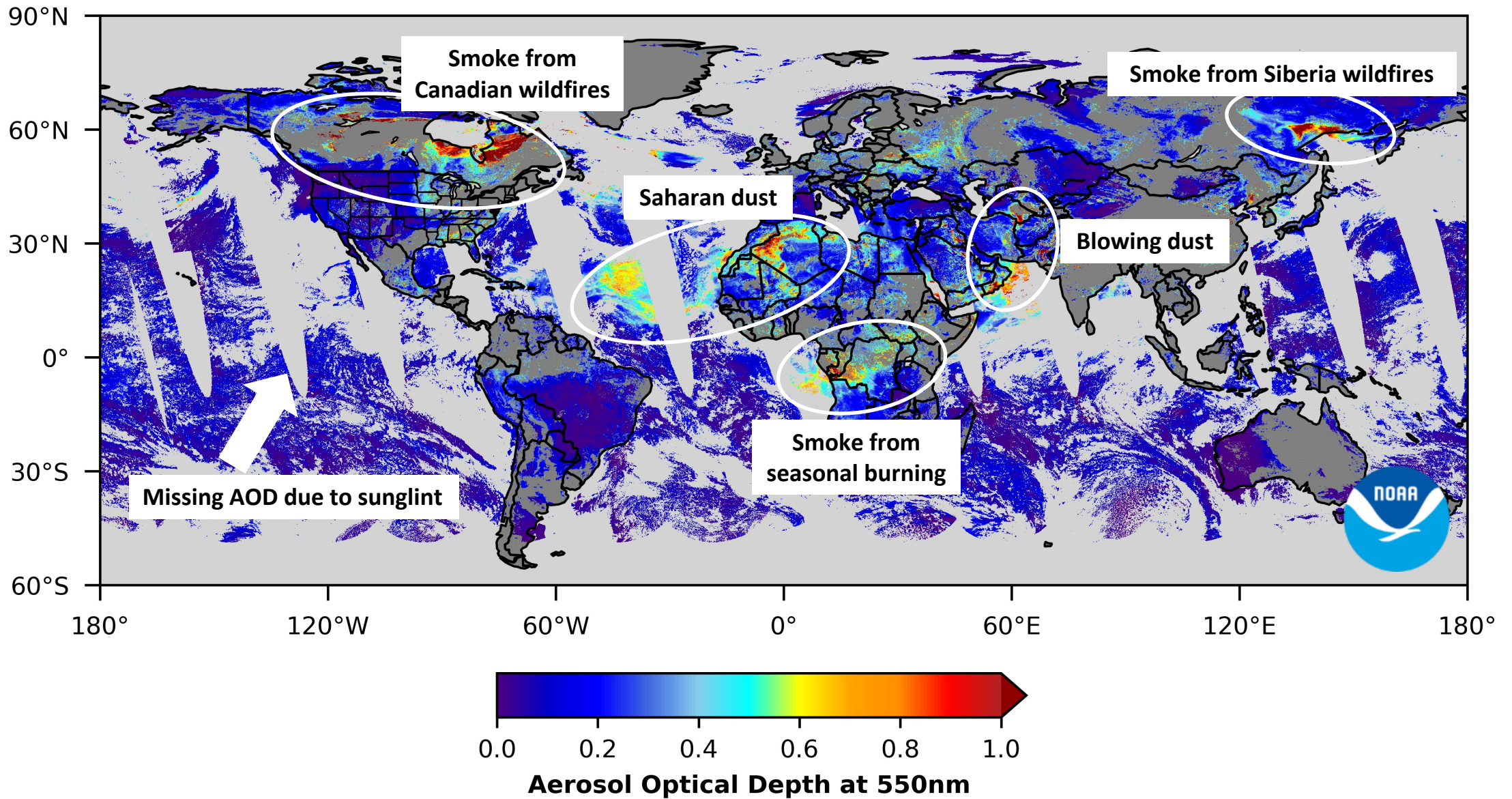
Figure credit: Mi Zhou (IMSG) & Istvan Laszlo (NOAA)

Examples of High, Medium, and Low Quality AOD

- Example: Smoke from wildfires near Los Angeles, CA on December 3, 2020
- **High quality AOD** is most accurate but is missing part of the smoke plume, also gaps along coastlines (very stringent screening)
- **High + medium quality AOD (“top 2 qualities”)** fills in most of the smoke plume and some of the gaps along coastlines
- **High + medium + low quality AOD (“all qualities”)** fully resolves the smoke plume & fill most of the gaps along coastlines, but at the expense of erroneous high AOD values over inland shallow lakes
- Use the appropriate AOD quality flags for your application
 - Avoid low quality AOD for most situations!



Example of Global VIIRS AOD: July 2, 2023



JPSS Data Product Validation



- VIIRS products must meet specific requirements, set by the JPSS Program
- Validation is the process of determining if a satellite product meets these requirements
 - Does the product satisfy its intended use in its intended environment?
- Validation maturity stages:
 - Beta
 - Product is minimally validated, and may still contain significant identified and unidentified errors
 - Provisional
 - Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements
 - Product is recommended for potential operational use (user decision)
 - Full
 - Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal)
 - Product is ready for operational use

[Complete definitions of data product maturity validation stages](#)

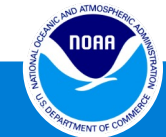
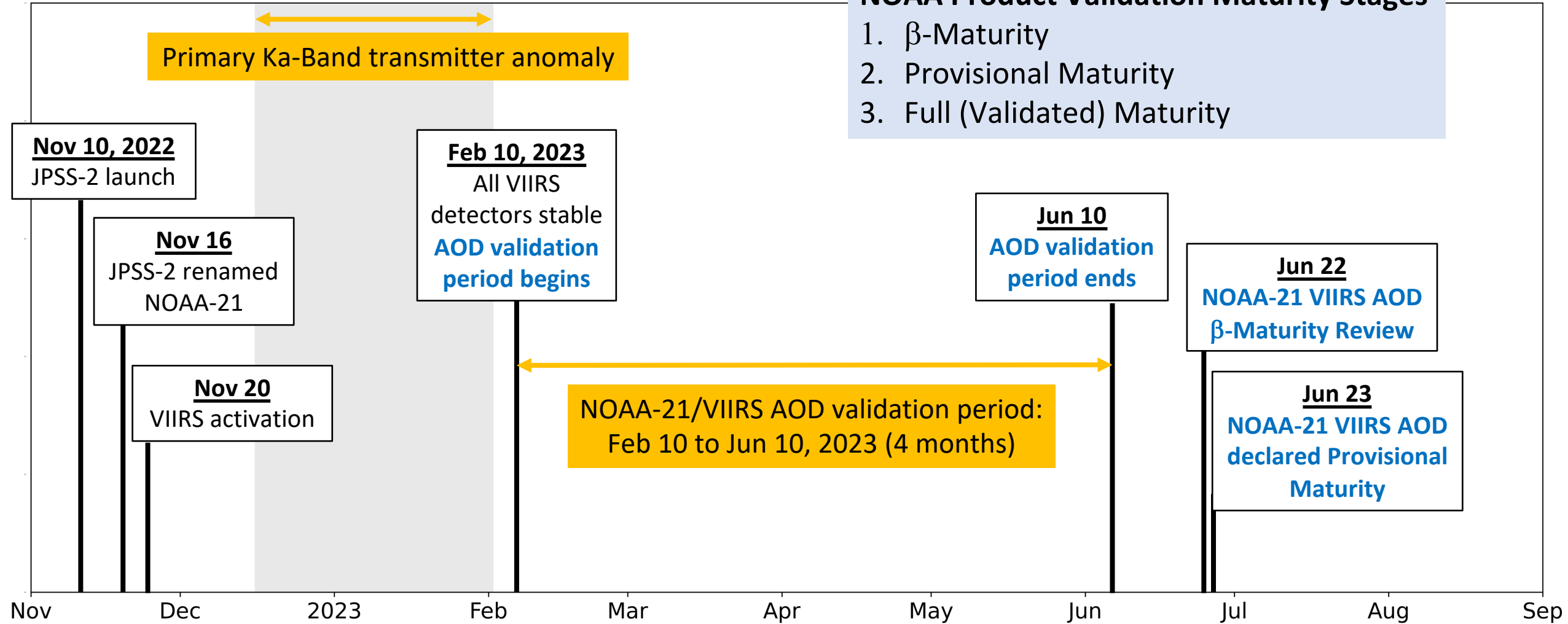


Example: NOAA-21 VIIRS AOD Validation Timeline

Data Outage
Dec 16, 2022 – Feb 2, 2023

NOAA Product Validation Maturity Stages

1. β -Maturity
2. Provisional Maturity
3. Full (Validated) Maturity



VIIRS AOD Validation Requirements

- AOD data are quantitatively validated with “ground truth” data:
 - Global matchups with AOD from the Aerosol Robotic Network (AERONET)
 - AERONET: global network of ground-based sunphotometers
- Validation strategies/methods:
 - Compare high quality VIIRS AOD from S-NPP, NOAA-20, NOAA-21 to corresponding AERONET matchups
 - Assess VIIRS AOD retrieval performance in terms of accuracy and precision relative to AERONET AOD
 - Accuracy: absolute value of mean (VIIRS-AERONET) retrieval error
 - Precision: standard deviation of mean (VIIRS-AERONET) retrieval error
 - Also qualitative inter-comparison with comparable satellite products

Results show that VIIRS AOD meets requirements!

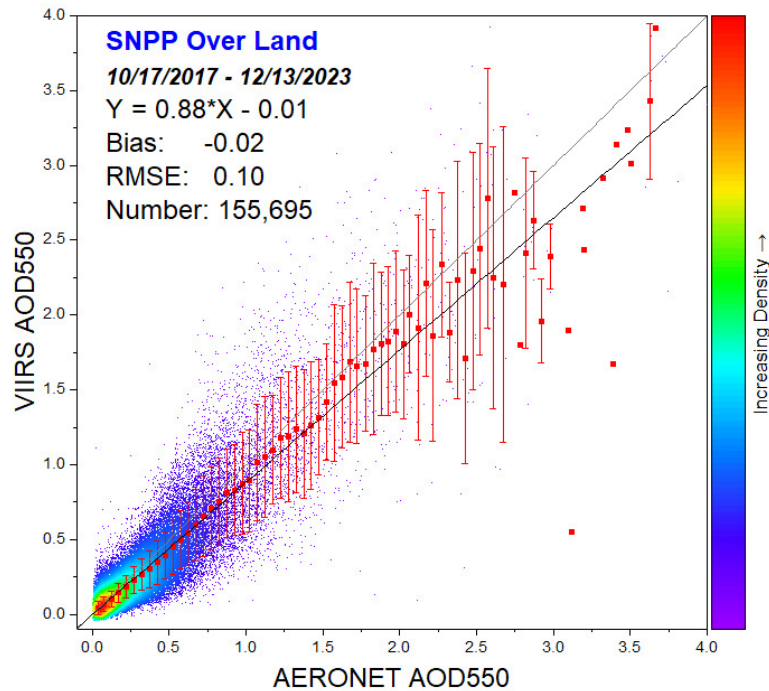
VIIRS AOD Requirements			
VIIRS AOD Range		Accuracy	Precision
Over Ocean	AOD < 0.3	0.08	0.15
	AOD ≥ 0.3	0.15	0.35
Over Land	AOD < 0.1	0.06	0.15
	0.1 ≤ AOD ≤ 0.8	0.05	0.25
	AOD > 0.8	0.20	0.45



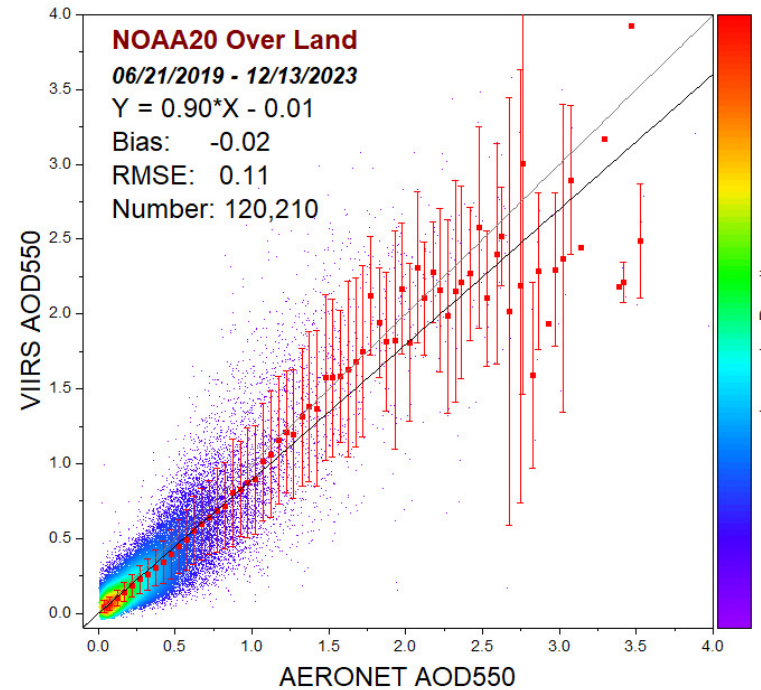
Locations of AERONET Sunphotometers (2023)

VIIRS AOD Validation over Land

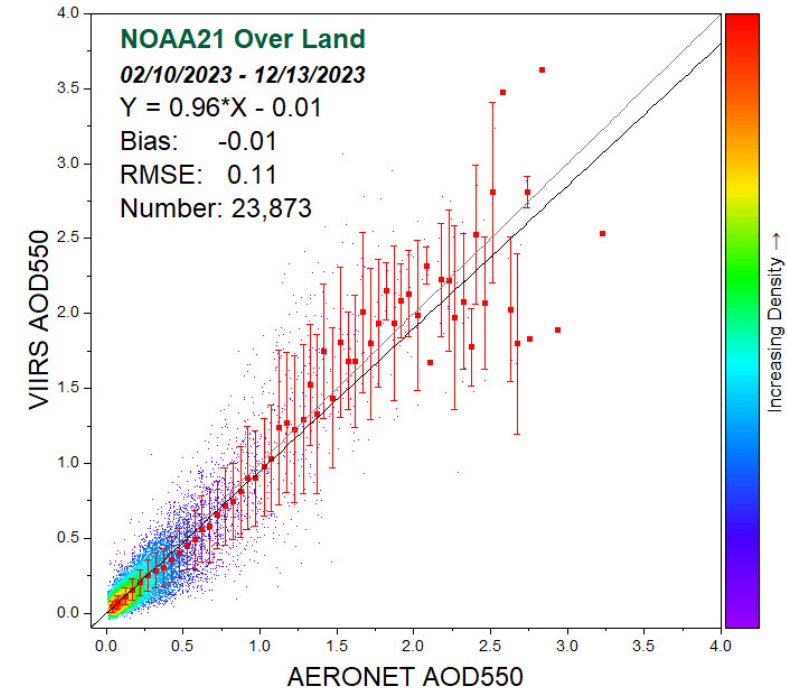
SNPP



NOAA-20



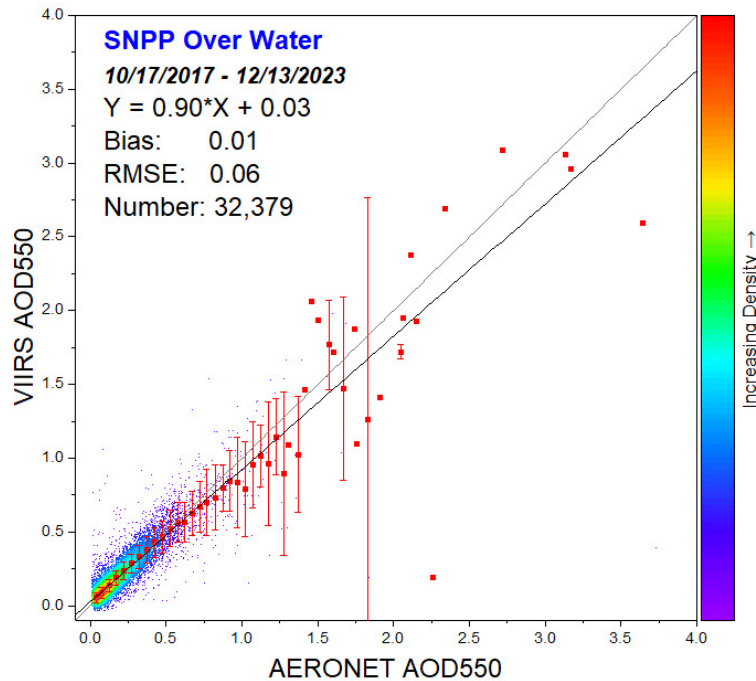
NOAA-21



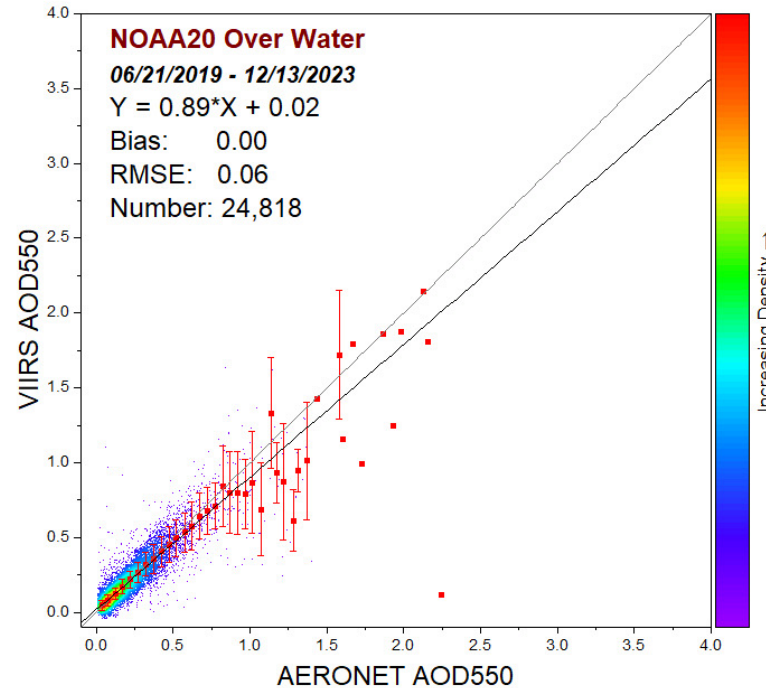
- Biases (-0.01 to -0.02) and RMSEs (0.10 to 0.11) of VIIRS AOD over land are very similar
- Fewer number of NOAA-21 matchups due to short analysis period (10 months, through Dec 13, 2023)
- VIIRS AOD bias & standard deviation lowest for AOD < 1 (also greatest data density)

VIIRS AOD Validation over Water

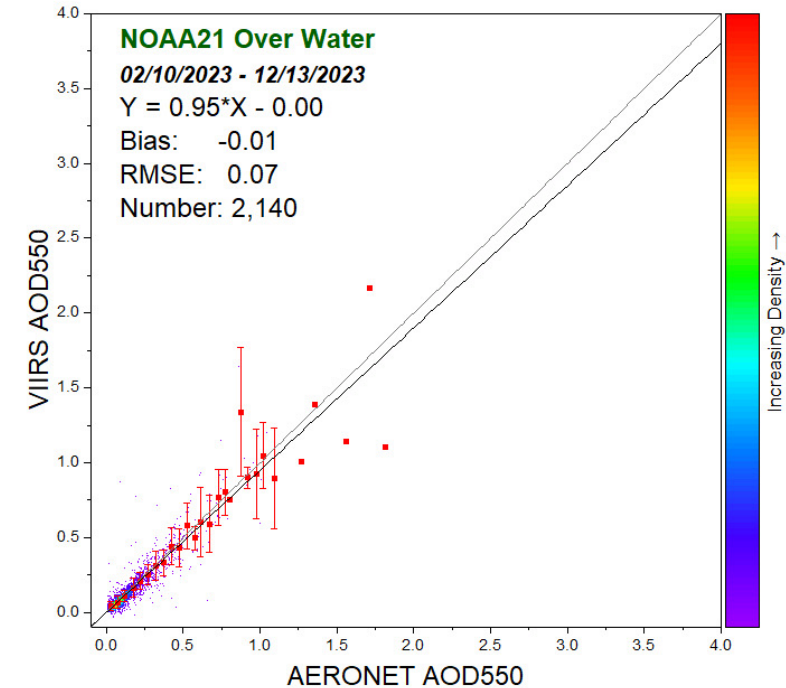
SNPP



NOAA-20



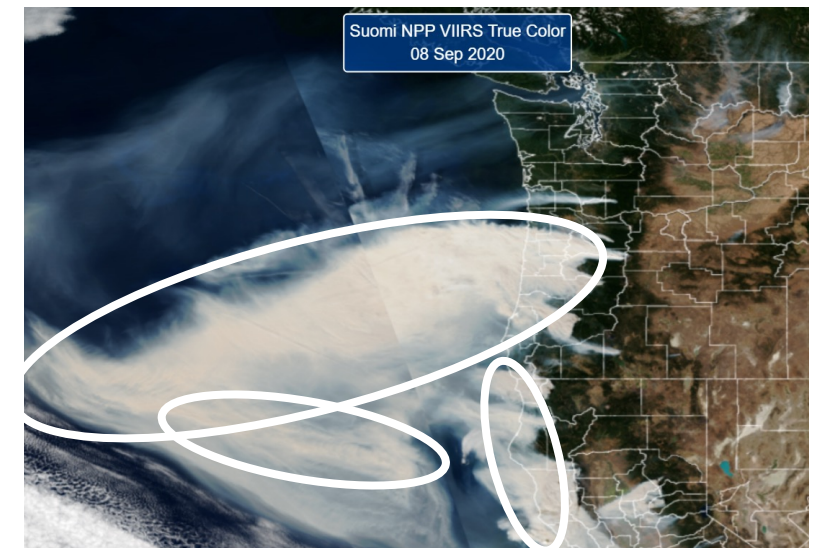
NOAA-21



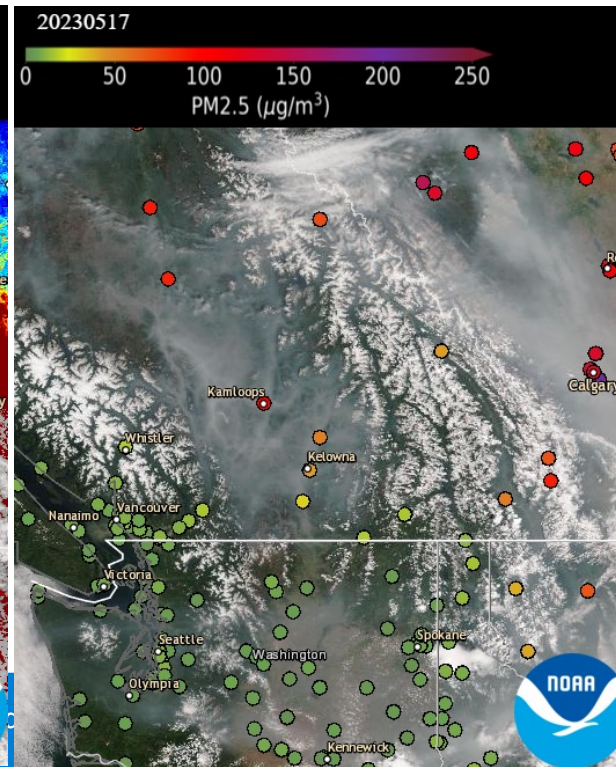
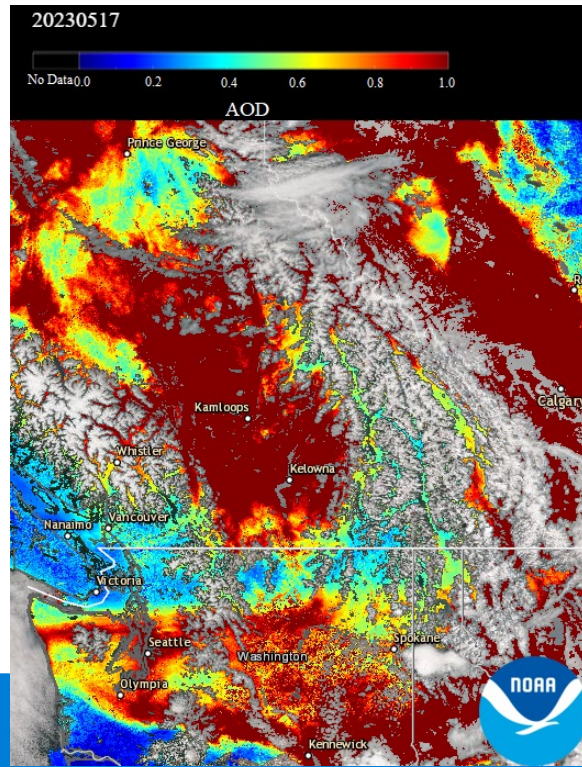
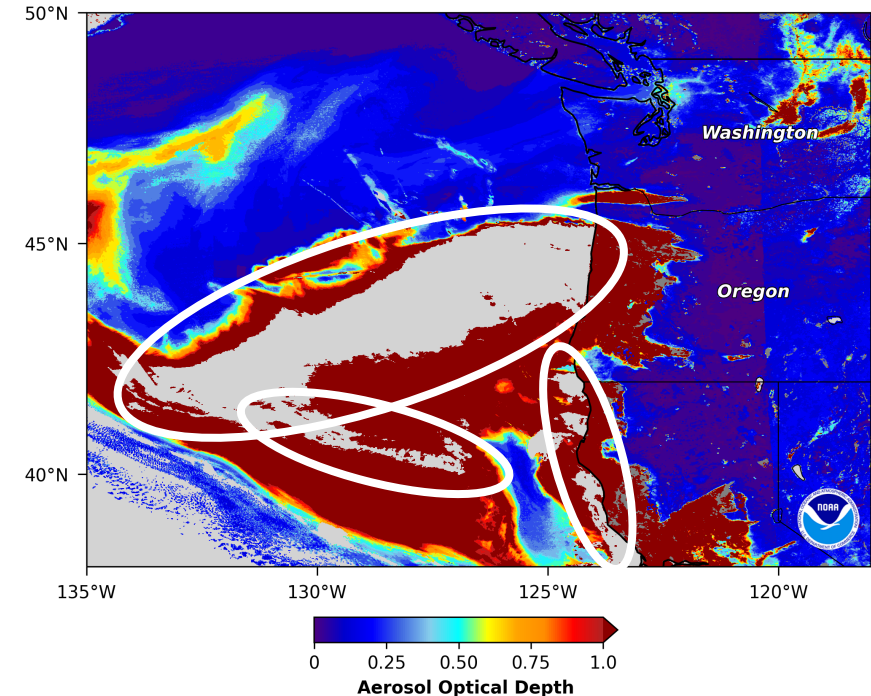
- Biases (0.01 to -0.01) and RMSEs (0.06 to 0.07) of VIIRS AOD over water are very similar
- Fewer number of NOAA-21 matchups due to short analysis period (10 months, through Dec 13, 2023)
- VIIRS AOD bias & standard deviation lowest for AOD < 1 (also greatest data density)

User Awareness for VIIRS AOD

- Gaps can occur in smoke detection for thick smoke plumes
 - Upstream Cloud Mask misidentifies thick smoke as cloud
 - Example: smoke from Oregon/California wildfires, Sep 8, 2020
- AOD is a vertical column measurement, so it does not identify the altitude where aerosols are located in the atmosphere
 - Aerosols can be aloft
 - PM_{2.5} measurements indicate if aerosols are reaching the surface



S-NPP/VIIRS Aerosol Optical Depth
08 Sep 2020



VIIRS true color image (top) from [JSTAR Mapper website](#)
VIIRS AOD & PM_{2.5} images (left) from [AerosolWatch website](#)

Next Steps for VIIRS AOD Algorithm

- Update spectral land-surface reflectance relationships derived from NOAA-21 VIIRS observations (short term)
- Attempt to improve regional and seasonal performance by expanding/revising candidate aerosol models and surface reflectance relationships (long term)
 - New atmosphere look-up table (LUT) for VIIRS with new over-land aerosol models and solar/view zenith angle thresholds planned to be implemented in operations on June 30 (but can slip by a month)
- Continue pursuing application of machine learning (ML) in determining surface reflectances needed in AOD retrieval over land (long term)

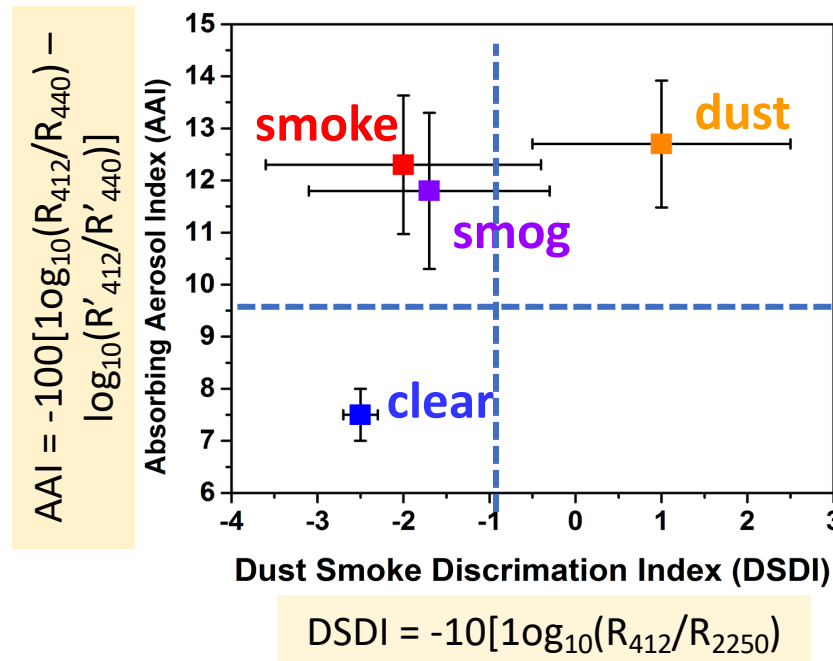


Aerosol Detection Product (ADP) Algorithm Overview

- ADP algorithm uses spatial & spectral **threshold tests** to separate smoke & dust aerosols from clouds and clear sky over water and land
 - Absorbing Aerosol Index (AAI)** uses VIIRS bands M1 & M2 to identify absorbing aerosols, including smoke and dust
 - Dust Smoke Discrimination Index (DSDI)** uses VIIRS bands M1 & M11 to separate smoke from dust

- Internal tests use various bands to screen for “unfavorable” conditions, where it’s difficult or impossible to retrieve ADP

- e.g., snow test, bright pixel test, turbid water test



VIIRS bands used in the ADP algorithm

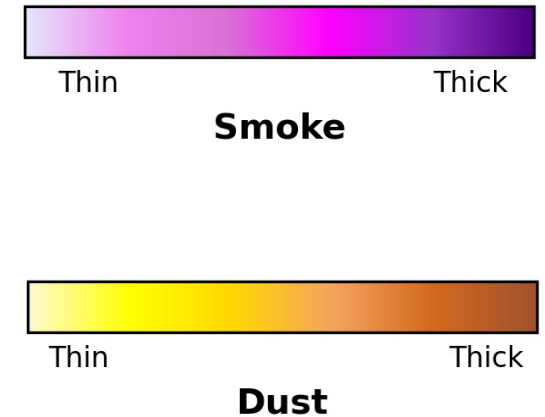
VIIRS Band	Central Wavelength (μm)	Dust Detection	Smoke Detection
M1	0.412	X	X
M2	0.445	X	X
M3	0.488	X	X
M4	0.555		X
M5	0.672	X	X
M6	0.746		X
M7	0.865	X	X
M8	1.24	X	X
M9	1.38	X	
M10	1.61		X
M11	2.25	X	X
M12	3.70	X	X
M13	4.05		X
M15	10.76	X	X
M16	12.01	X	

VIIRS ADP algorithm developed by Pubu Ciren (IMSG) and Shobha Kondragunta (NOAA)



VIIRS ADP Specifications and Availability

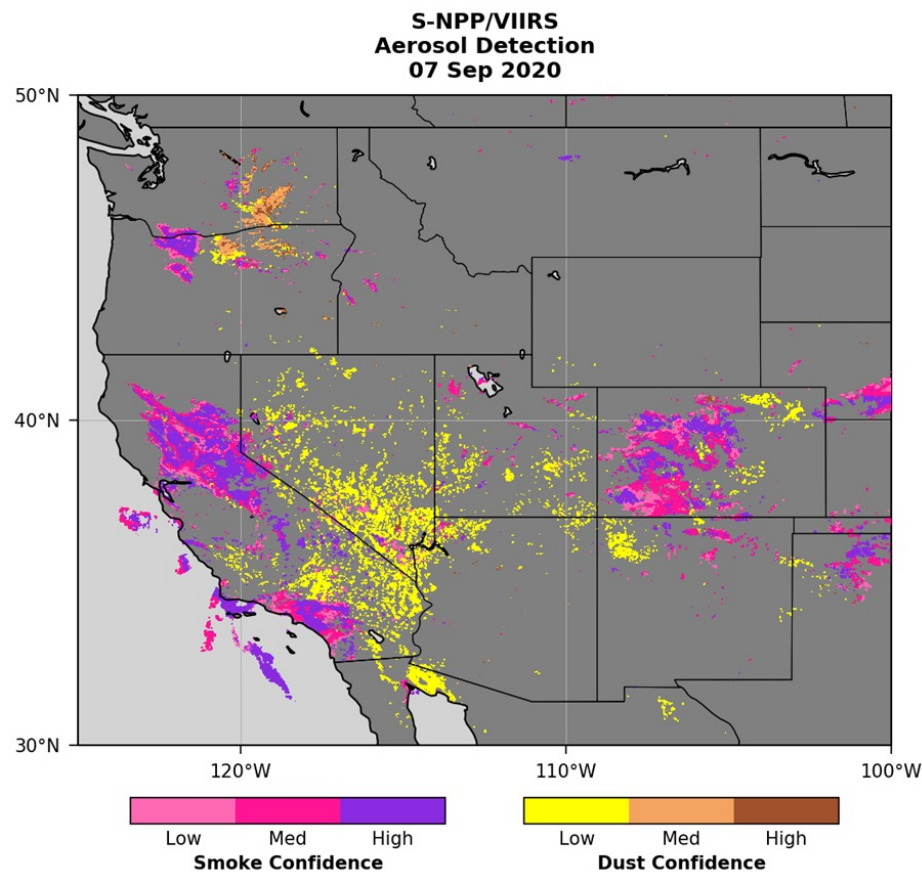
- ADP is available from VIIRS on SNPP, NOAA-20, and NOAA-21
- VIIRS has a deep-blue band (M1, 412 nm), which allows for calculation of the **Scaled Absorbing Aerosol Index (SAAI)**
 - $SAAI = AAI - \text{threshold}$
- VIIRS SAAI indicates:
 - Presence of smoke or dust (“yes”/”no” flag)
 - Relative intensity (thin to thick) of smoke or dust



Sensor	Satellite	Spatial Resolution (km) at nadir	Coverage	Maturity Stage	Availability Starting
VIIRS	SNPP	0.75	Global	Fully Validated	8/13/2018
	NOAA-20			Fully Validated	1/31/2019
	NOAA-21			Fully Validated	6/22/2023

ADP Data Confidence Flags

- ABI ADP data files include a confidence flag
 - Expresses confidence in the ADP retrieval
 - Figure: example of VIIRS ADP confidence flags
- **Qualitative applications** (e.g., operational forecasting): use **all confidences** data (high + medium + low)
- **Quantitative applications** (e.g., modeling): use **“top 2” confidences** data (high + medium)
- ADP is **not retrieved** in areas with:
 - Clouds
 - Snow or ice
 - Nighttime (need sunlight)



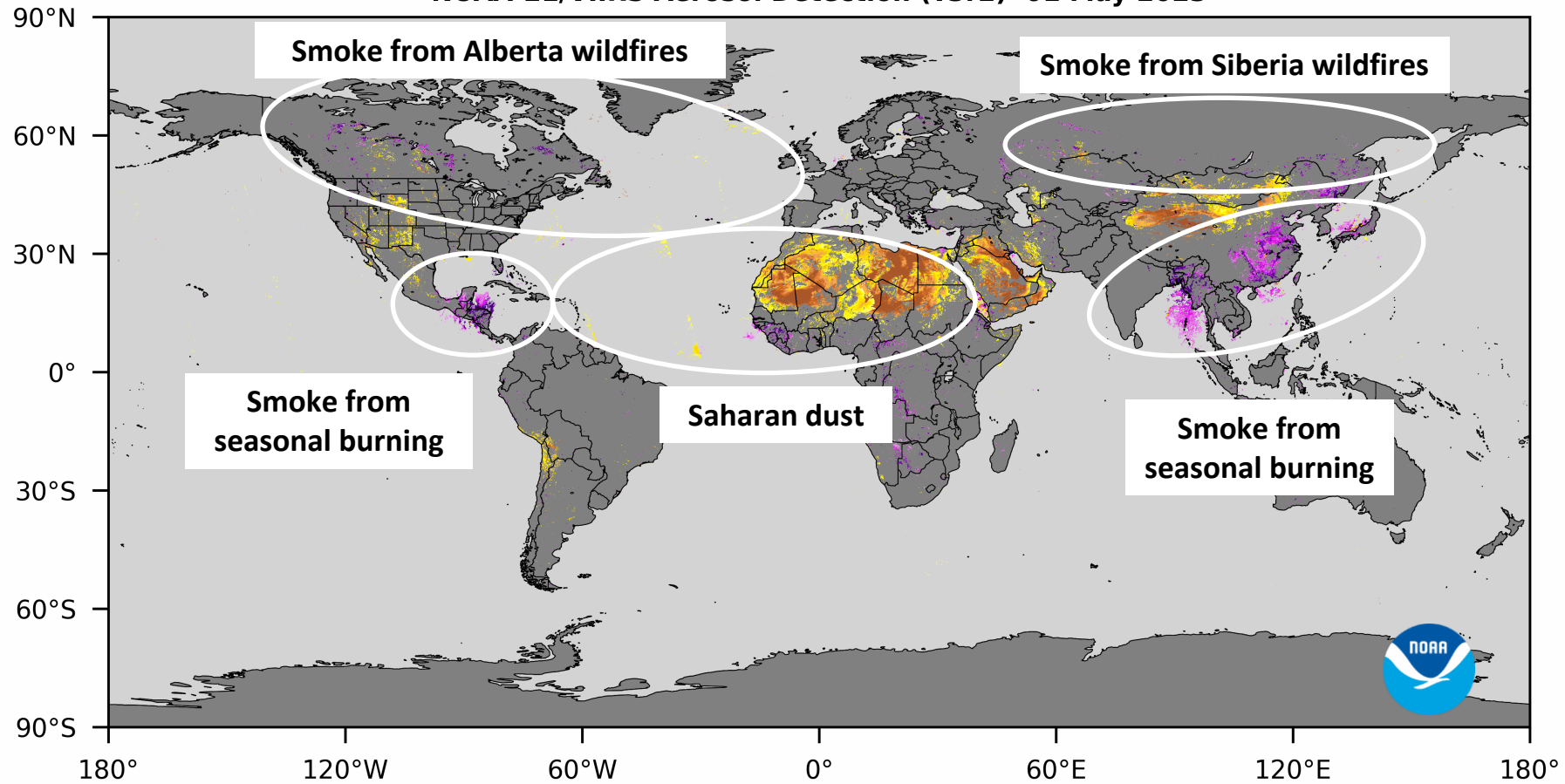
Unlike AOD, ADP is retrieved over sun glint regions, but it is not recommended for dust aerosols (use smoke detection only)!

The Confidence Value (CV) is determined by how close the spectral difference is to the threshold criteria

Confidence Flag	Threshold Criteria
High	CV > 0.5
Medium	0.25 < CV > 0.5
Low	CV < 0.25 <ul style="list-style-type: none"> • Pixel adjacent to cloud • Turbid water • Bright pixel • Pixel adjacent to snow/ice • Cloud shadow • Sun glint
Not Retrieved	<ul style="list-style-type: none"> • Cloud • Snow/ice

Example of Global VIIRS ADP

NOAA-21/VIIRS Aerosol Detection (v3r2) 01 May 2023



Smoke



Dust



VIIRS ADP Validation Requirements

- Quantitative validation of VIIRS ADP with “truth data” matchups:
 - AERONET global sunphotometers
 - CALIPSO/CALIOP vertical feature mask (VFM) (space-based lidar)
- ADP must meet **specific requirements** for detection of smoke & dust over land and water
 - Measured by **Probability of Correct Detection (POCD)**
 - Also called **Hit Rate**
 - Calculated using 2x2 contingency table
- Also qualitative inter-comparison with comparable satellite products

2x2 Contingency Table

VIIRS ADP	Truth Data	
	Yes	No
Yes	A	B
No	C	D

A = true positive (correct detection)

B = false positive (false detection)

C = false negative (missed detection)

D = true negative (null detection)

VIIRS ADP Requirements		
Detection Type		POCD (%)
Smoke	Over Land	80
	Over Water	70
Dust	Over Land	80
	Over Water	

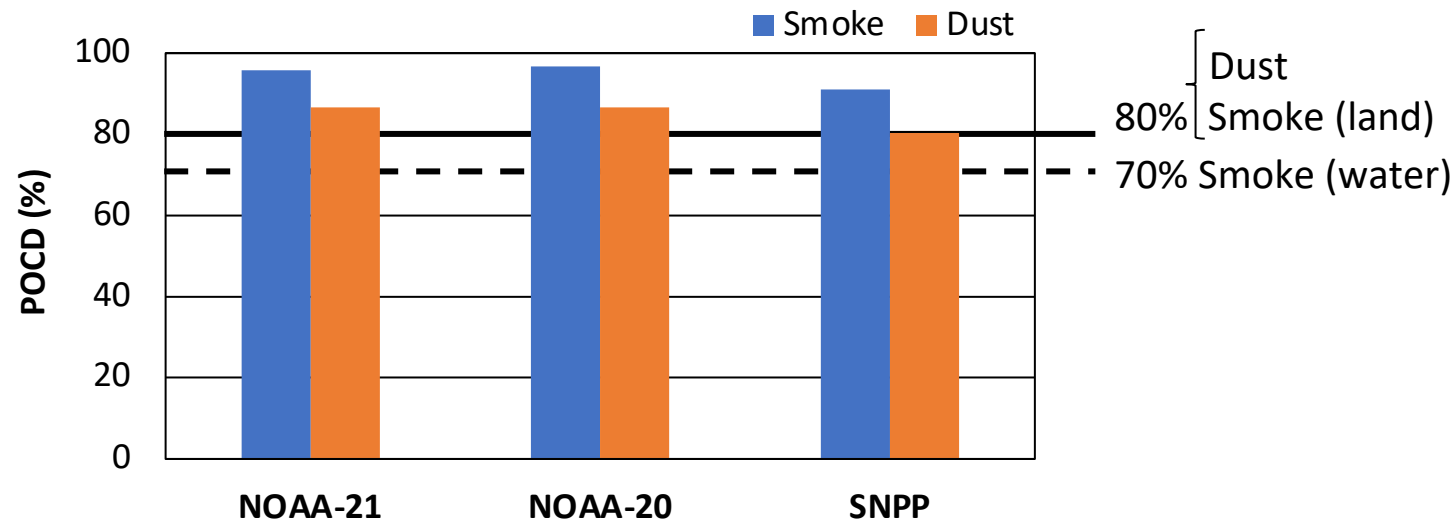
$$\text{Probability of Correct Detection (POCD)} = \frac{A}{A + C}$$

VIIRS ADP Validation with AERONET

- AERONET aerosol type (smoke, dust) based on:
 - AERONET AOD interpolated to 550nm
 - AERONET Ångström exponent at 440nm/870nm
- **VIIRS ADP meets requirements for all 3 satellites!**
 - For example, NOAA-21:
 - Smoke: 95.8% POCD
 - Dust: 86.6% POCD
- NOAA-21 POCD values very close to those for NOAA-20; slightly higher than S-NPP
 - Smoke is more likely to be correctly identified than dust

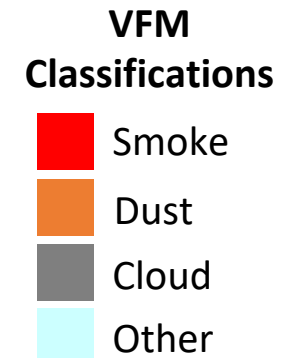
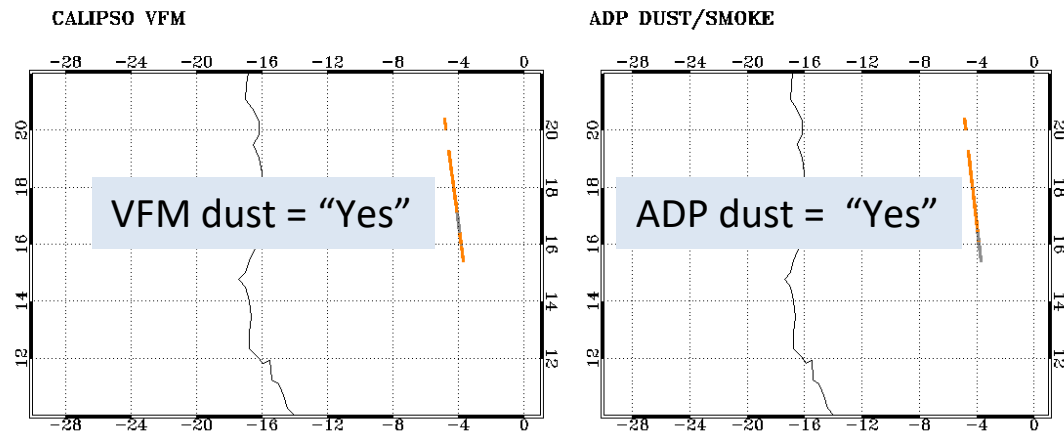
AERONET Detections (Level 1.5 data)		AOD @550nm	Ångström Exponent (440nm/870nm)
Smoke	Yes	> 0.2	> 1.0
	No		< 0.5
Dust	Yes	> 0.2	< 0.5
	No		> 1.0

VIIRS ADP/AERONET
Probability of Correct Detection (POCD)



VIIRS ADP Validation with CALIPSO VFM

- CALIPSO science mission ended on August 1, 2023
 - Satellite orbit had drifted substantially (from 1:30 pm to ~3:15 pm local time)
 - Fewer matchups compared to AERONET validation, especially for dust
 - Most matchups were over high latitudes
 - VRM no longer available for validation!



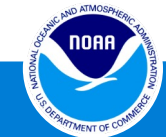
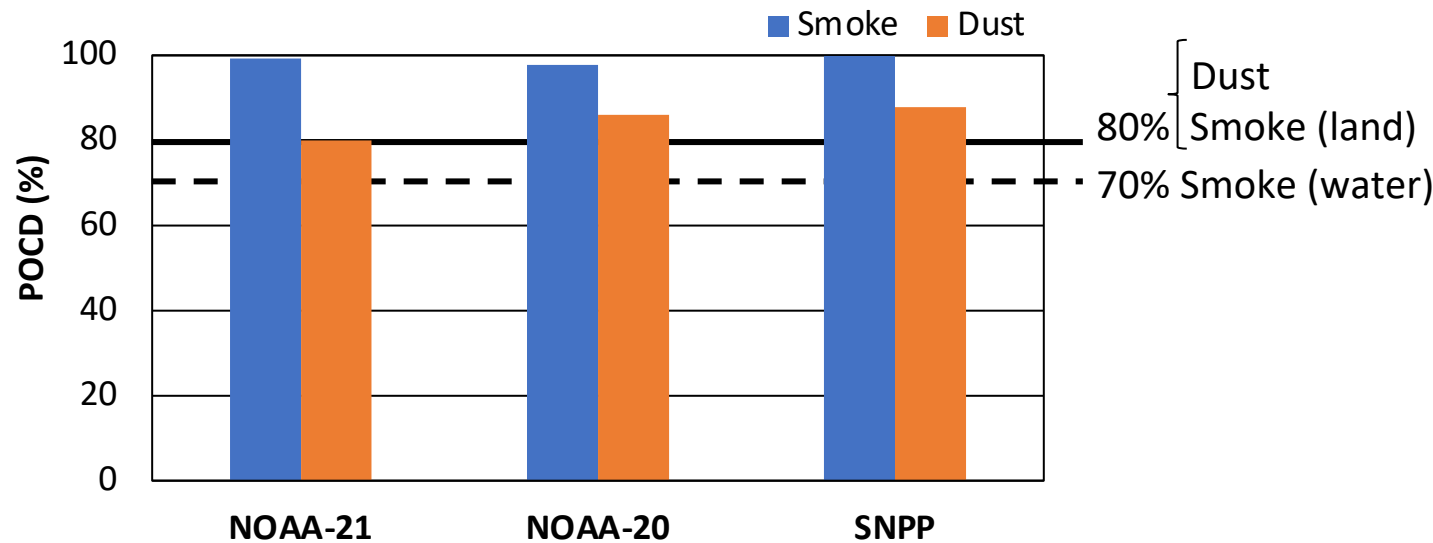
- **VIIRS ADP meets requirements for all 3 satellites!**

- For example, NOAA-21:
 - Smoke: 99.2% POCD
 - Dust: 80.0% POCD

- NOAA-21 POCD values are similar to those for NOAA-20 and S-NPP

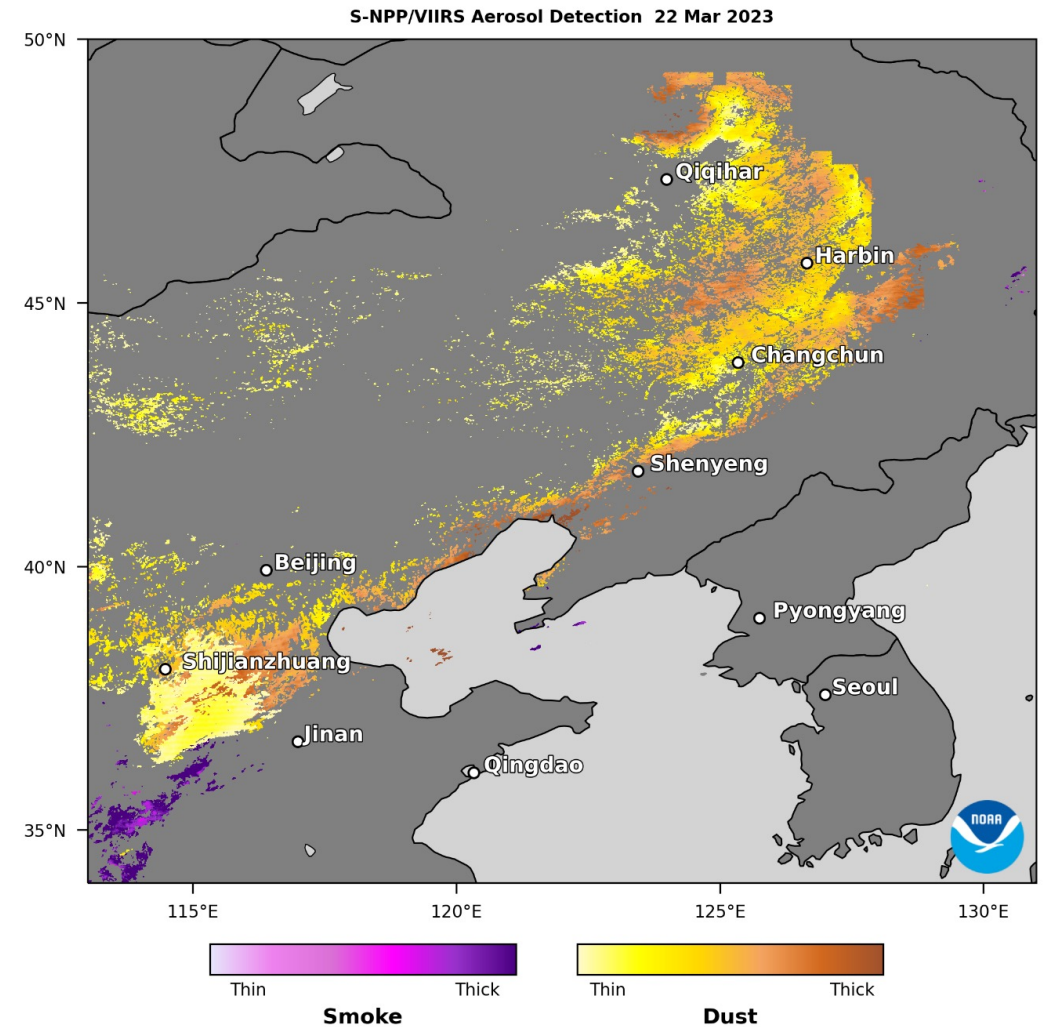
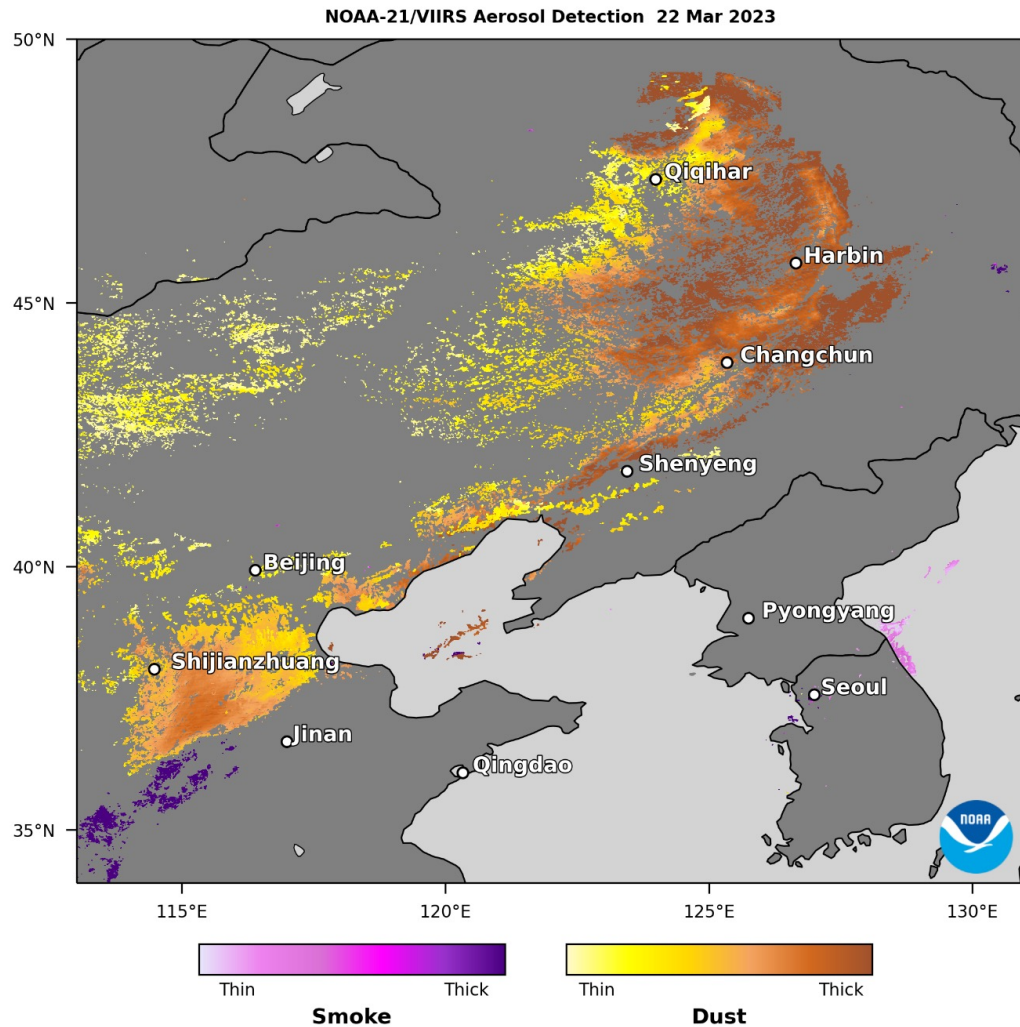
- Smoke is more likely to be correctly identified than dust (similar to AERONET results)

**VIIRS ADP/CALIPSO VFM
Probability of Correct Detection (POCD)**



Example of VIIRS ADP Validation: Inter-Sensor Comparison

Sandstorm in northern China: March 22, 2023



NOAA-21 VIIRS ADP is consistent with:

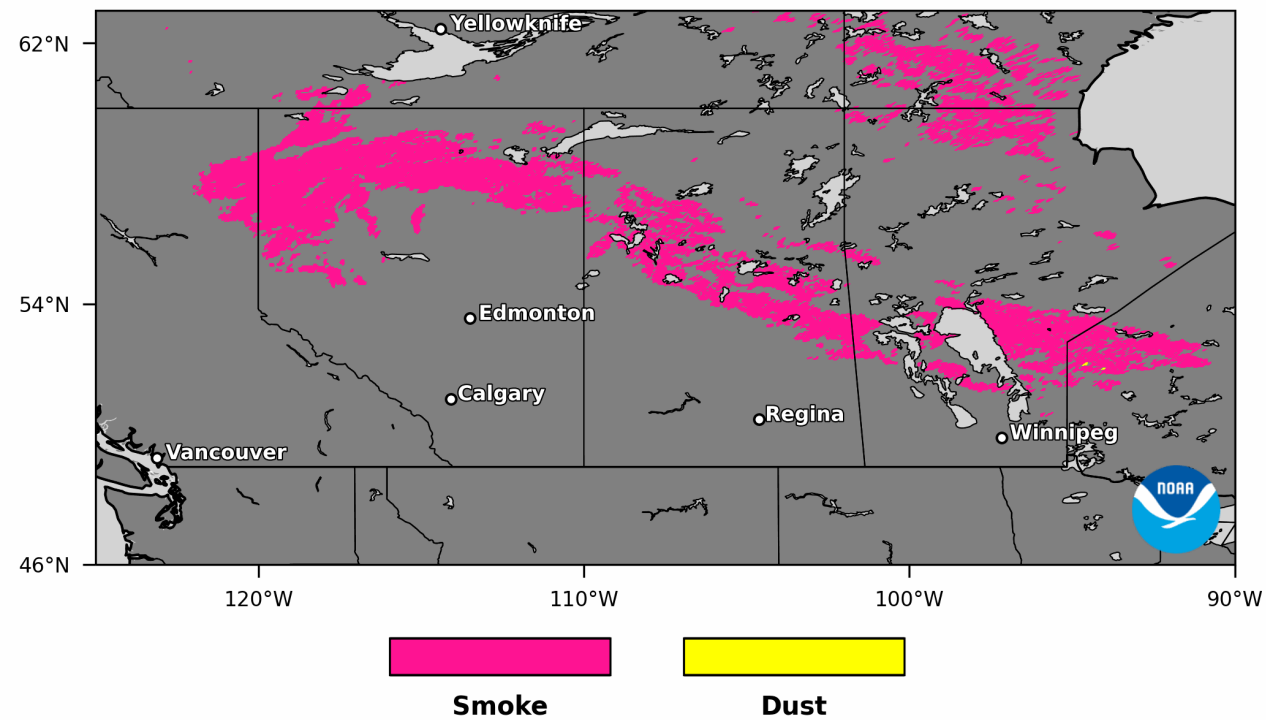
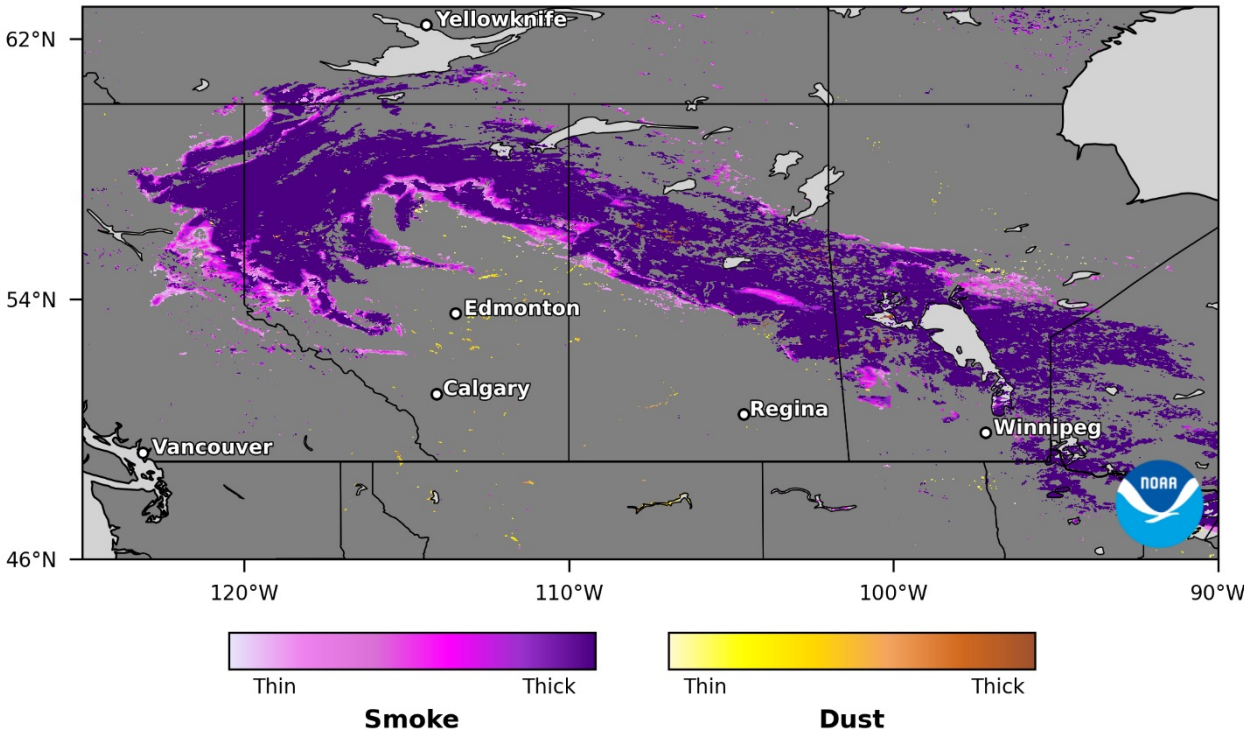
- Spatial coverage & relative thickness of NOAA-20 & S-NPP/VIIRS ADP

Example of VIIRS ADP Validation: Inter-Sensor Comparison

Wildfires in Alberta, Canada: May 15, 2023

NOAA-21/VIIRS Aerosol Detection 15 May 2023

GOES-18/ABI Aerosol Detection 15 May 2023 19:30 UTC

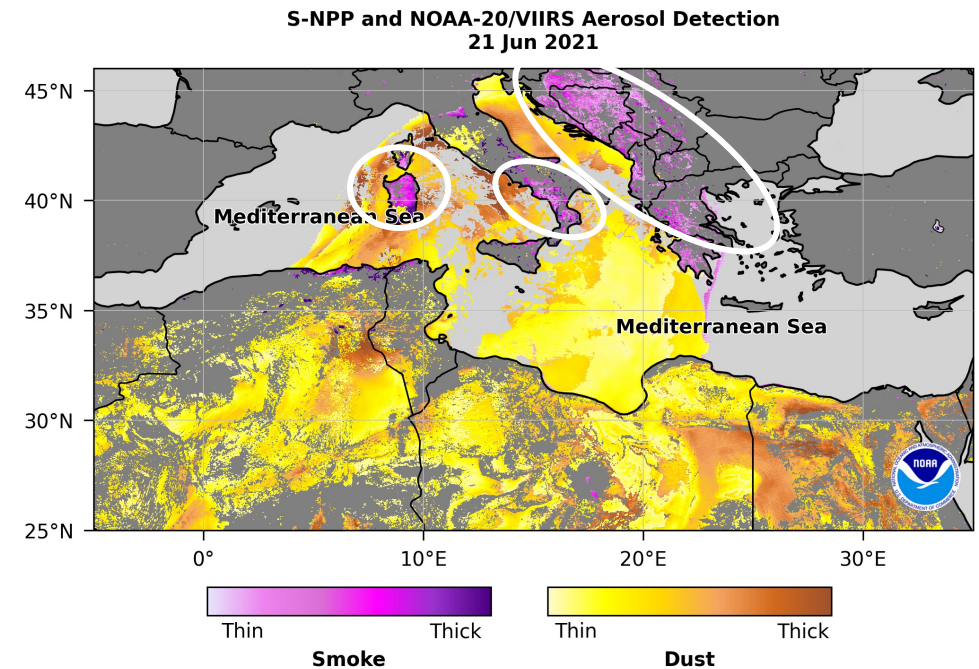
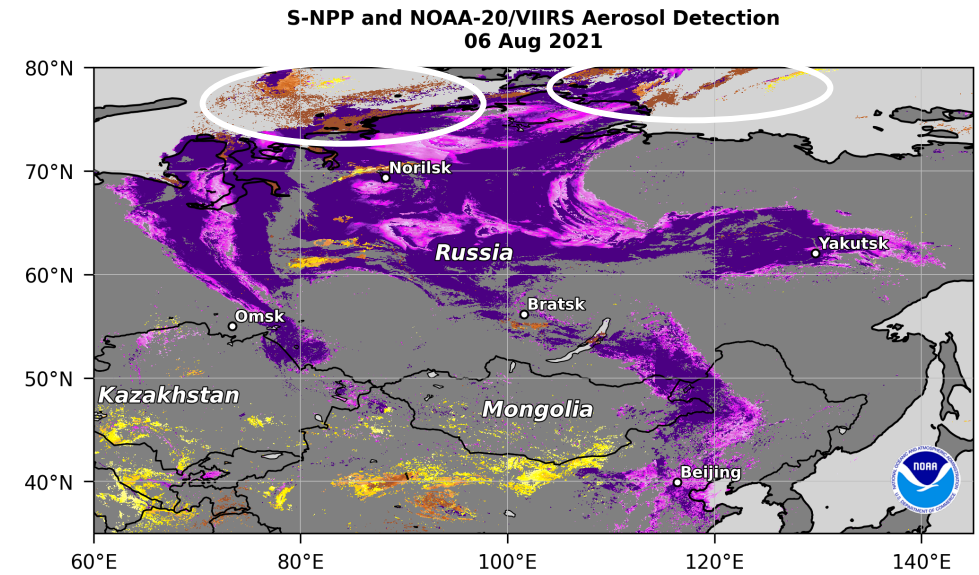


NOAA-21 VIIRS
ADP is
consistent with:

- Spatial coverage & relative thickness of NOAA-20 & S-NPP/VIIRS ADP
- Spatial coverage and intensity of S5P/TROPOMI CO (indicator of biomass burning)
- Spatial coverage of GOES-18/ABI ADP
 - Only smoke/dust flags (“yes/no”) retrieved by ABI (no 412 nm band)

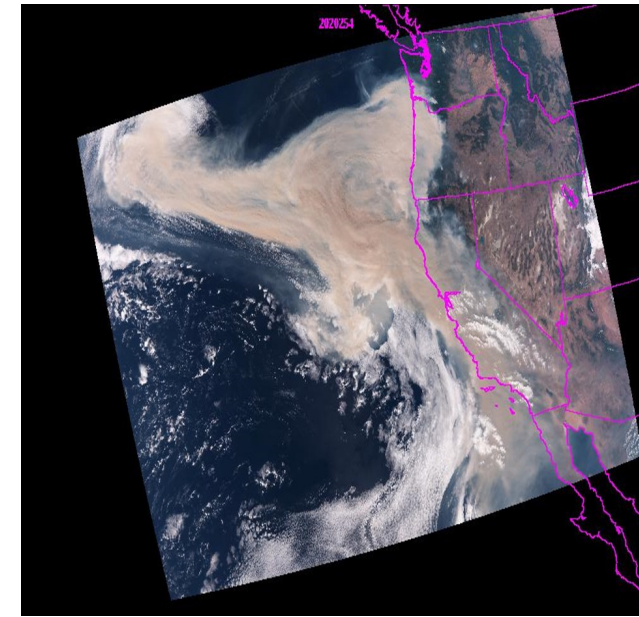
User Awareness for VIIRS ADP

- ADP is **most accurate for thick smoke/dust over dark surfaces** (e.g., water, vegetation)
- ADP is less accurate over arid & semi-arid regions due to lower contrast b/w aerosols and surface
- Gaps can occur in smoke detection for thick smoke plumes
 - Upstream Cloud Mask misidentifies thick smoke as cloud
 - Uniformity test fails (smoke plumes are assumed to be more uniform than clouds)
- Thick smoke plumes that appear brown in true color imagery may be misclassified as thick dust over both land and water (top image)
- Thin dust plumes over vegetated surfaces may be misclassified as smoke (bottom image)
- Sulfur dioxide (SO₂) plumes from volcanic eruptions may be identified as smoke



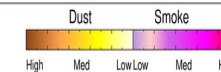
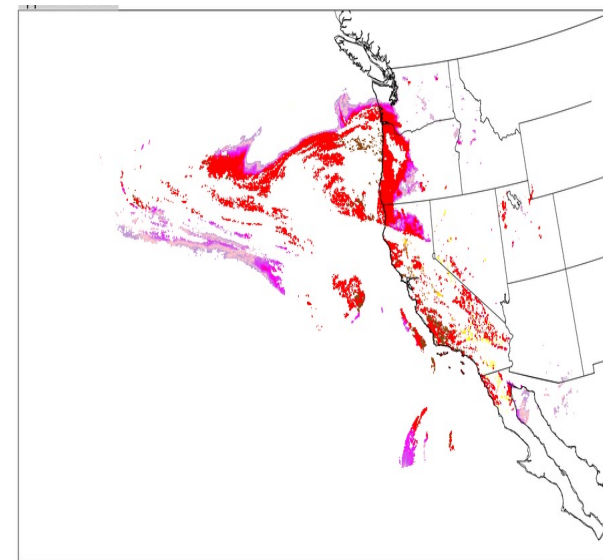
Next Steps for VIIRS ADP Algorithm

- Explore alternative validation datasets to mitigate the loss of CALIPSO VFM data
 - ESA/JAXA EarthCARE satellite’s atmospheric lidar (ATLID); launched May 28, 2024
 - PM_{2.5} chemical composition data from the Chemical Speciation Network (CSN)
- Callback for thick brown-colored smoke plumes (missing or misclassified as thick dust)
 - Developed a method to “call back” these smoke plumes using VIIRS AOD and Sentinel 5-P TROPOMI CO
 - Being used in research currently
 - Still being evaluated for possible promotion to operational VIIRS ADP algorithm

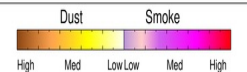
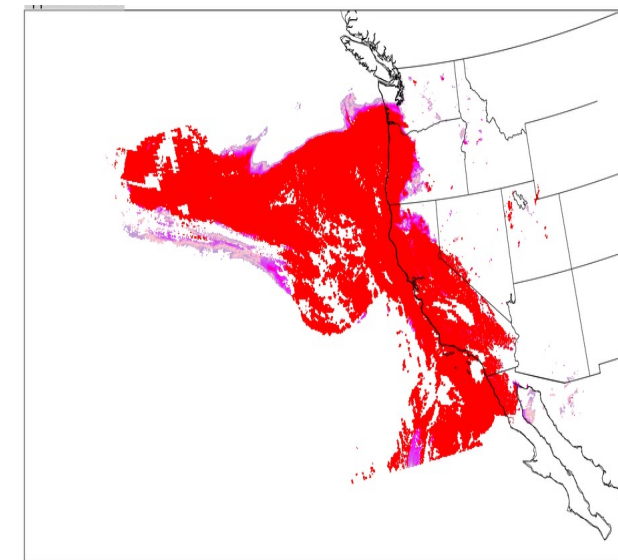


VIIRS true color image showing thick, brown-colored smoke plume on Sep 10, 2020

Operational VIIRS ADP



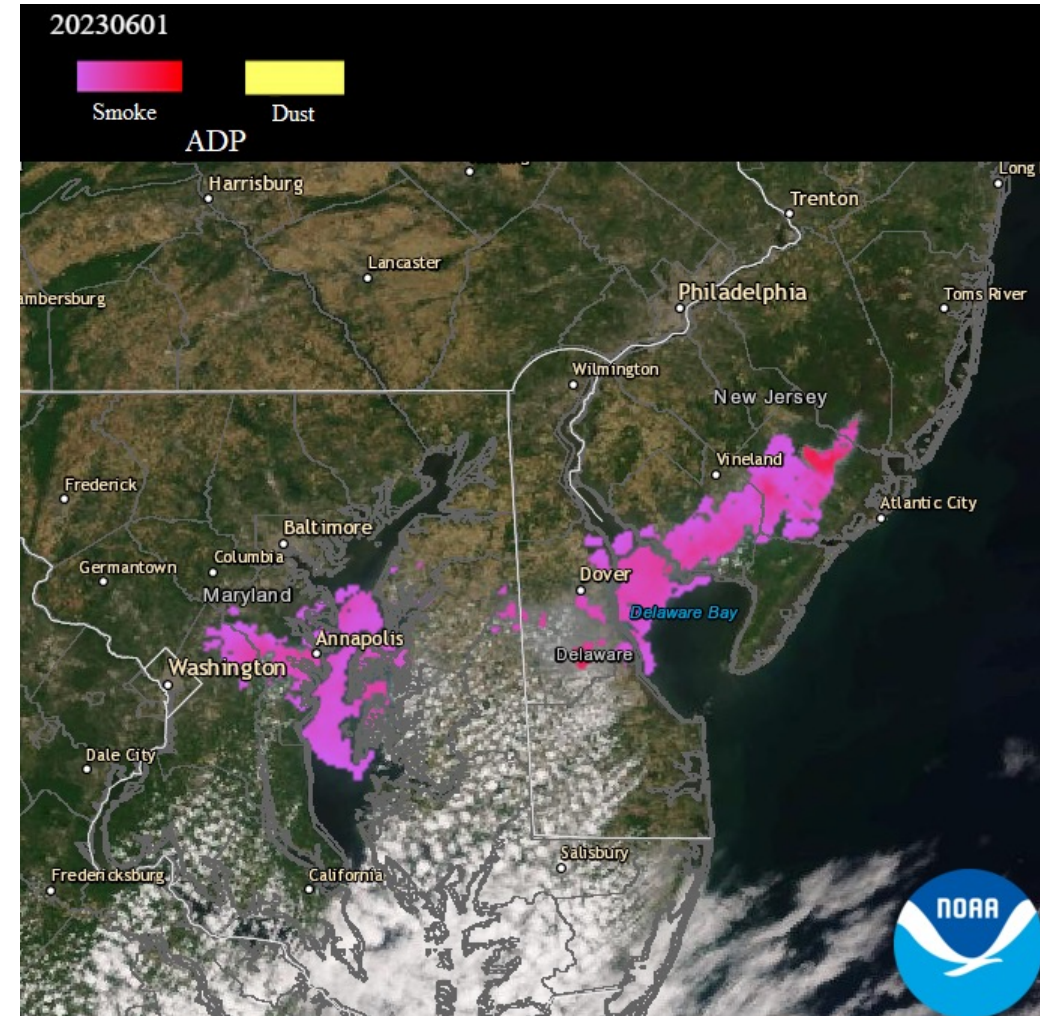
VIIRS ADP with smoke “call back”



ADP Complements RGB Imagery for Smoke & Dust

- **Color composite (RGB) imagery** is commonly used to identify smoke & dust, e.g.:
 - True Color
 - Dust RGB
 - CIRA's DEBRA product
- RGB imagery must be **manually interpreted** by a human analyst
 - Colors designate areas of smoke or dust
- **ADP automatically identifies smoke & dust** using its (physical) algorithm
 - Visual interpretation is not necessary!
- ADP provides decision support for operational forecasting
- Automated data analysis of smoke & dust events is possible using ADP
 - Write code to analyze smoke/dust pixels detected by VIIRS

Example: Smoke from Allen Road Fire, NJ

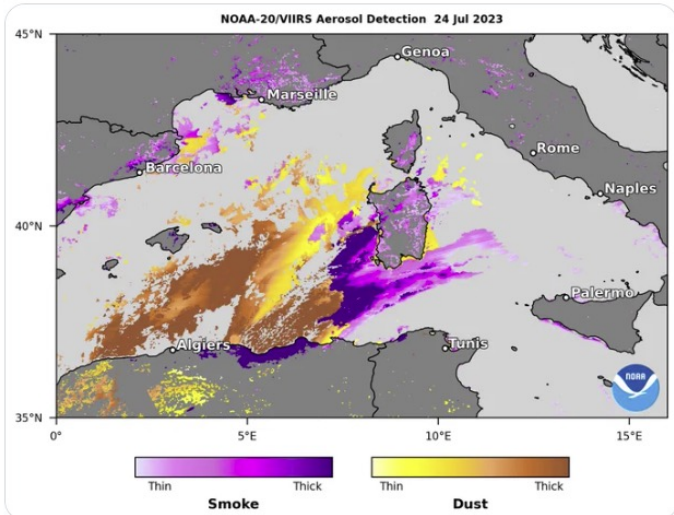


VIIRS true color & ADP images from the [AerosolWatch website](#)

Examples of User Feedback (VIIRS ADP)

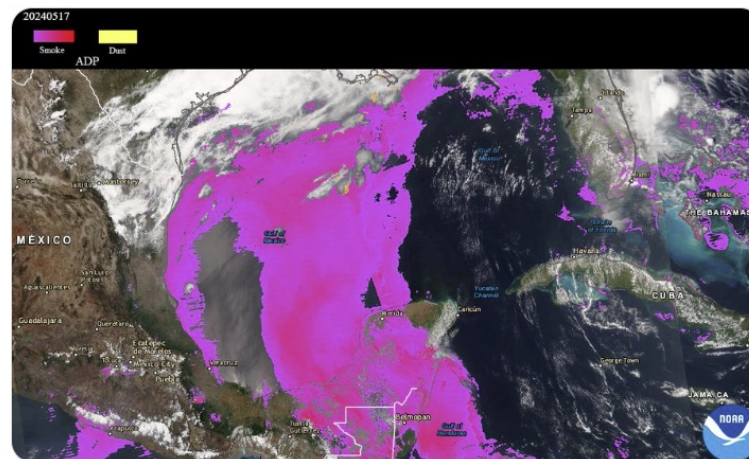
Name	Organization	Application	Feedback on S-NPP & NOAA-20 VIIRS ADP
Joel Dreesen & James Boyle	Maryland Department of the Environment (MDE)	Operational air quality forecasting & event analysis	<ul style="list-style-type: none"> In times of operational ambiguity, the dust and smoke mask is another tool to properly identify aerosols. It's very useful for post-analysis. Given the number of smoky days this summer, I check Aerosolwatch and use the VIIRS ADP imagery for our post-exceedance write ups and analysis.
Partha Bhattacharjee	NOAA NWS	Global aerosol model (GEFS-Aerosols) verification	<ul style="list-style-type: none"> The masks are particularly useful to identify events like dust plumes over the Atlantic and smoke events over North America.

AerosolWatch @AerosolWatch · Jul 25
 Yesterday 24 Jul, #NOAA20 #VIIRS aerosol detection observed thick #smoke (purple shading) from deadly #wildfires burning near the coast of #Algeria, mixed with thick #SaharanDust (brown shading) blowing over the #MediterraneanSea. @NOAASatellites @JPSSProgram @Pierre_Markuse



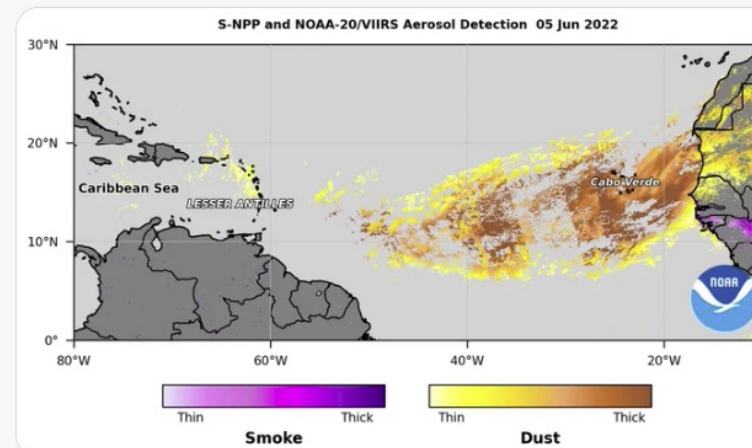
13 26 2,189

AerosolWatch @AerosolWatch
 Here's another view of the #smoke (lavender/pink shading) that covered the #YucatanPeninsula and western #GulfofMexico on 17 May, from the @JPSSProgram #VIIRS aerosol detection product (ADP) via the #NOAA20 & #SNPP satellites. @NOAASatellites @BzGEO @Karma_lobsang12



10:17 AM · May 20, 2024 · 704 Views

AerosolWatch @AerosolWatch · Jun 6, 2022
 Very large plume of thick #SaharanDust (brown shading) is moving west across #AtlanticOcean, engulfing #CaboVerde & on the way to the #Caribbean, shown by #VIIRS aerosol detection from #SNPP & #NOAA20 on 5 Jun. @JPSSProgram @aire_sergio_rod @SanGasso @DustyCRyder @m_parrington

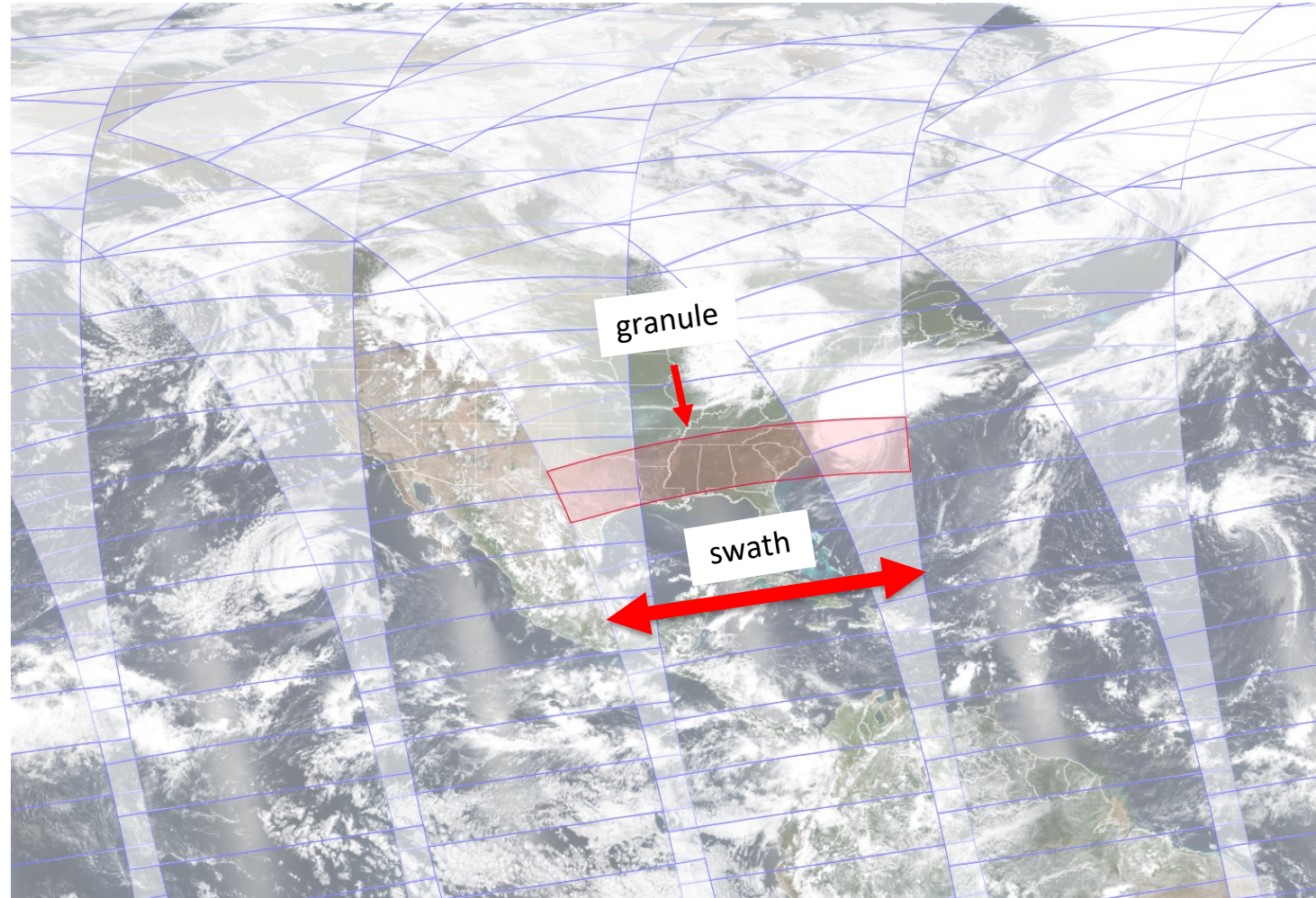


1 10 31



VIIRS AOD & ADP EDR Data Files are Distributed as Granules

- VIIRS scans a **swath** (cross-track) as it orbits (moves along-track) on SNPP, NOAA-20, or NOAA-21
 - 1 swath scan is ~3040 km x 12 km
 - Swaths overlap (illustrated in figure)
- VIIRS Environmental Data Record (EDR) data files (e.g., AOD & ADP) are distributed as **granules**
 - 1 granule = 48 scans
 - ~85 seconds of data
 - ~570 km in the along-track direction
 - Makes file sizes more manageable for end users
 - NetCDF4 (.nc) file format



VIIRS granules image from the [JSTAR Mapper website](#)

NOAA Open Data Dissemination (NODD) Program

<https://www.noaa.gov/information-technology/open-data-dissemination>

- The goal of the NODD Program is to make it easy for end users to access NOAA data
 - Remove obstacles to the public use of NOAA data
- Funded through public-private partnerships
- Putting NOAA data on commercial cloud platforms
 - Amazon Web Services (AWS)
 - Google Earth Engine
 - Microsoft Azure
- Limitations:
 - NODD is not an operational source of satellite data
 - Data availability gaps are infrequent, but they can occur
 - Full archive of JPSS/VIIRS data are **not** available (see next slide)
 - If you need older data, must order from NOAA's [CLASS](#)



The NODD is a new, easy way to access NOAA satellite data files!

Think of the NODD as a data archive, but in the cloud instead of on a physical server!



NODD on Amazon Web Services (AWS)

- NODD on AWS is very user-friendly
 - Free and easy!
 - No registration or password required!
 - You do NOT need an AWS cloud account!
 - Download data files manually or programmatically (e.g., using Python)
 - Powerful Python packages for AWS S3 buckets
- AWS S3 buckets updated in **near real-time**
 - ~50 min for VIIRS data
- Operational and reprocessed AOD & ADP EDR files
 - Operational: fast latency (NRT)
 - Reprocessed: re-generated using best possible calibration updates to the VIIRS Sensor Data Records (SDRs) and latest VIIRS AOD/ADP algorithm updates

JPSS NODD on AWS

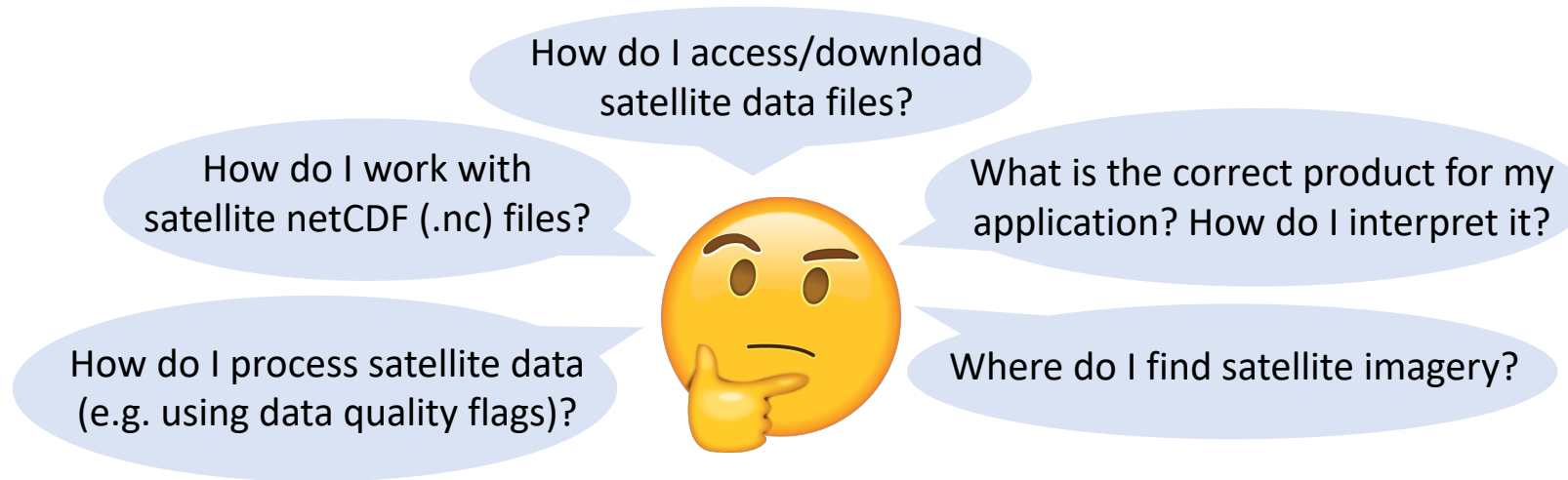
Satellite	Data Archive Start Date for Operational Data Files (through present)	
	AOD EDRs	ADP EDRs
SNPP	29 Oct 2022	29 Oct 2022
NOAA-20	29 Oct 2022	29 Oct 2022
NOAA-21	6 Sep 2023	6 Sep 2023

Satellite	Data Archive Dates for Reprocessed Data Files	
	AOD EDRs	ADP EDRs
SNPP	2012-2022	2012-2022
NOAA-20	2018-2022	2018-2022





STAR Atmospheric Composition Training Program



- Hands-on training program for end users; began in 2020
- Breaking down barriers preventing wider user of STAR products
- Targeted sessions for specialized user groups (e.g., air quality forecasters) and more general sessions at scientific meetings
- Focus is on **proper workflow** for satellite data using **Python**:
 - Search for/download satellite data files from online archives
 - Open/read netCDF satellite data files
 - Process/analyze/visualize satellite data

STAR Training Program Objectives

1. Increase access to STAR's aerosol, fire & trace gas satellite data
2. Promote proper use of the satellite products in operations & research



STAR Training Website: Resources for End Users

<https://www.star.nesdis.noaa.gov/atmospheric-composition-training/>



STAR Atmospheric Composition Product Training

Featuring Aerosol, Fire, and Trace Gas Satellite Products from ABI, VIIRS, and TROPOMI

Home

Training Courses

Agendas & links to hands-on tutorials for specific training courses

Software ▾

Instructions & links to install Anaconda & Python packages, set-up Jupyter Notebook

Python Tutorials ▾

Examples of annotated Python code used in training tutorials (additional tutorials coming soon!)

Satellite Data ▾

Everything users need to work with satellite data files, including links to Algorithm Theoretical Basis Documents (ATBDs)

Glossary

Extensive glossary of satellite sensor and data terminology

Reference Links ▾

Links to info on satellites, imagery, and Python resources

Thanks to Donovan Kelly, Jr. (Axiom Consulting) & Lori Brown (Axiom Consulting) for design of the website



VIIRS Aerosol Products Imagery on NOAA Websites

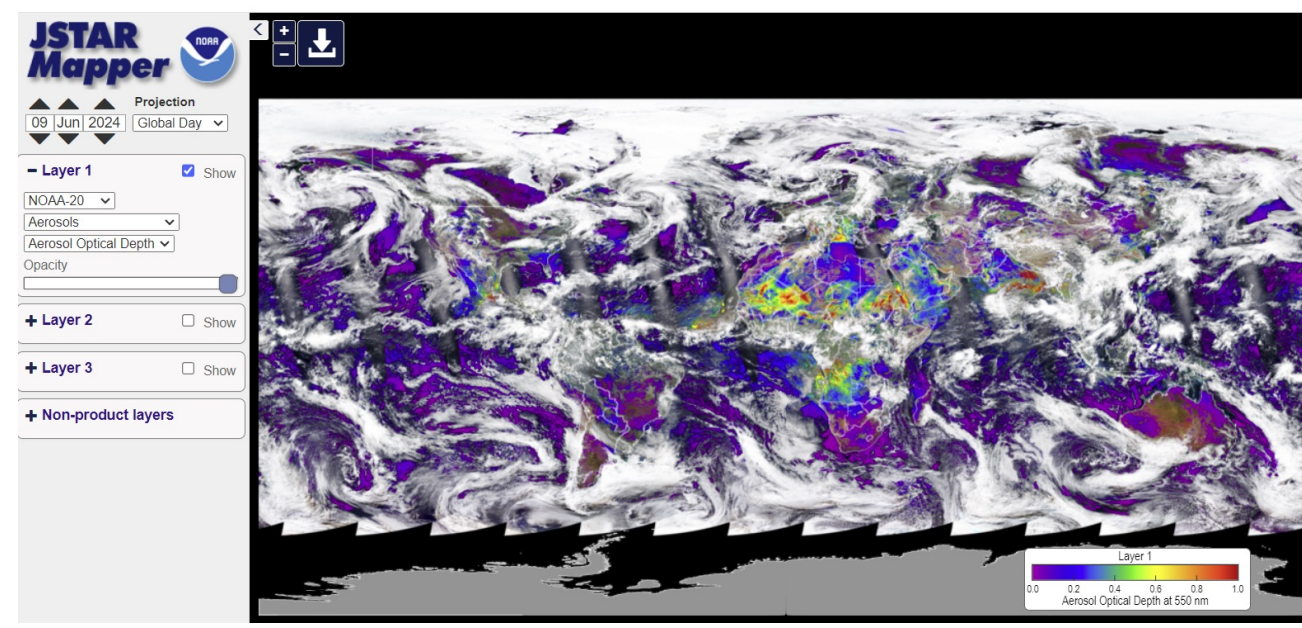
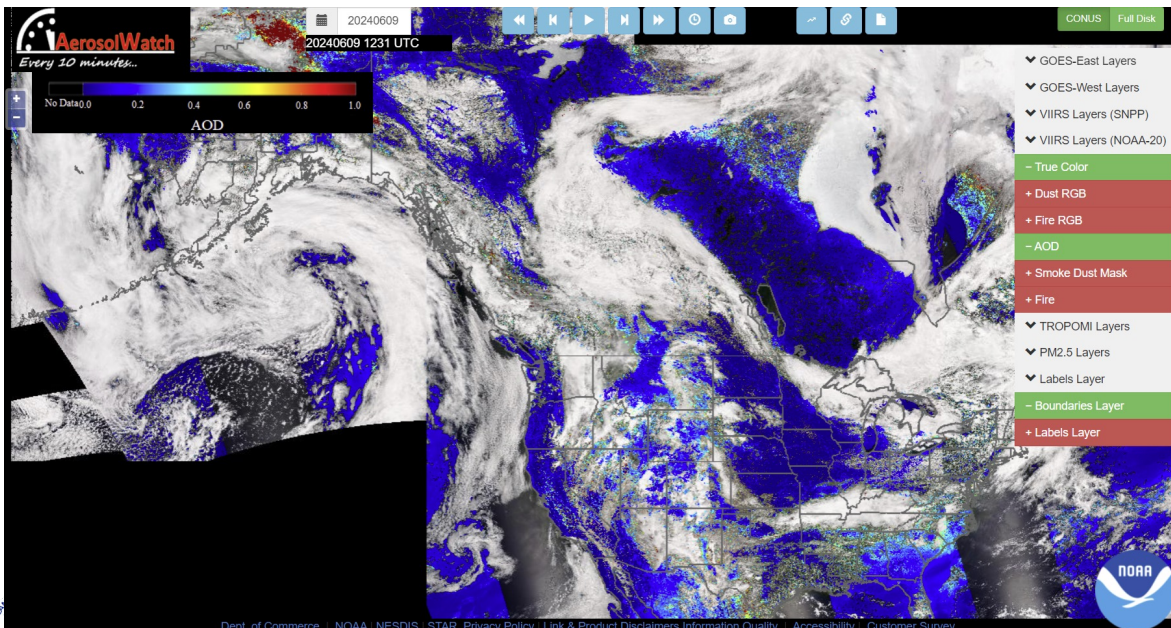
[Aerosol Watch website](#)

Developed by S. Kondragunta (NOAA) & H. Zhang (IMSG)

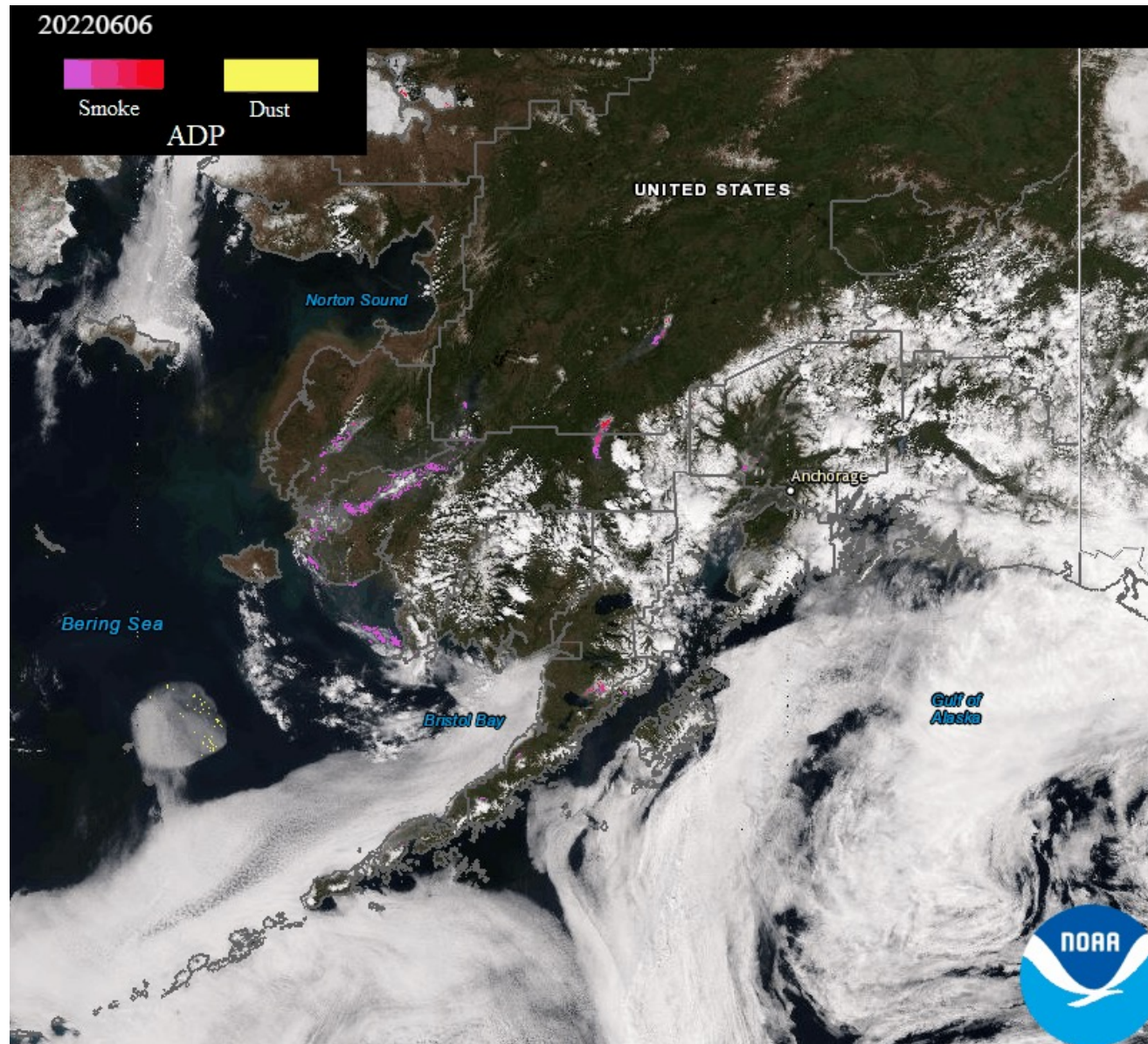
[JSTAR Mapper website](#)

Developed by T. Atkins (IMSG), L. Brown (IMSG),
R. Smith (Carr Ast.), C. Brown (IMSG) & L. Zhou (NOAA)

Coverage	Aerosol & Related Products	Archive Starts	Coverage	Aerosol & Related Products	Archive Starts
North & Central America (including Alaska)	VIIRS AOD VIIRS ADP VIIRS Fire Radiative Power VIIRS AOD-estimated daily PM _{2.5} TROPOMI CO	Jan 2018	Global	VIIRS AOD VIIRS ADP VIIRS Fire Radiative Power TROPOMI UV AI, CO, NO ₂	Aug 2017

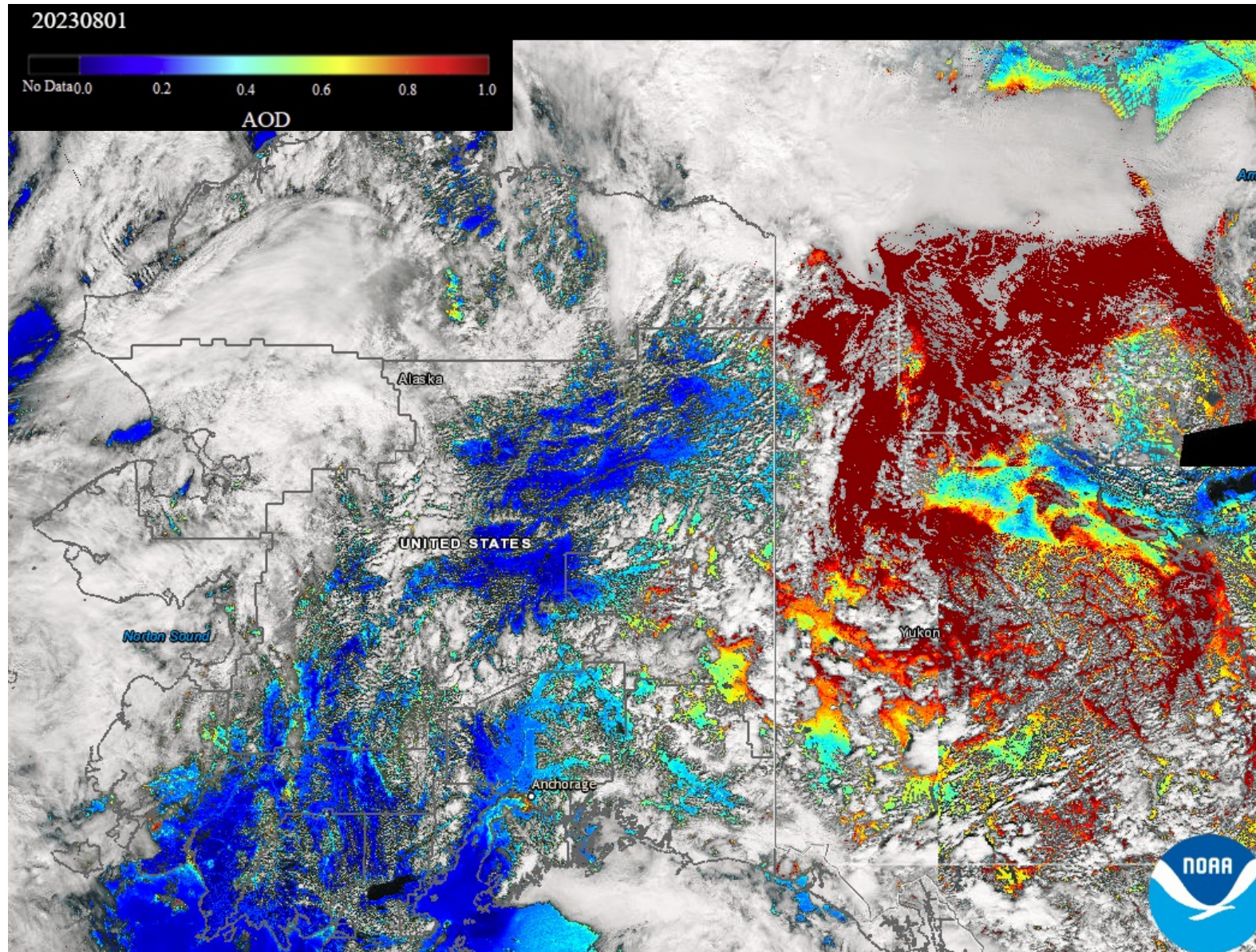


NOAA-20 VIIRS ADP Tracks Wildfire Smoke: June 6-11, 2022



- Smoke plumes detected from multiple new fires in southwest/central Alaska on June 6
- Smoke plumes became larger & thicker, moved southward June 7-11

SNPP VIIRS AOD Tracks Wildfire Smoke: August 1-7, 2023



- Smoke transported to Alaska from wildfires in Canada
- Also smoke from intensifying wildfires in Alaska

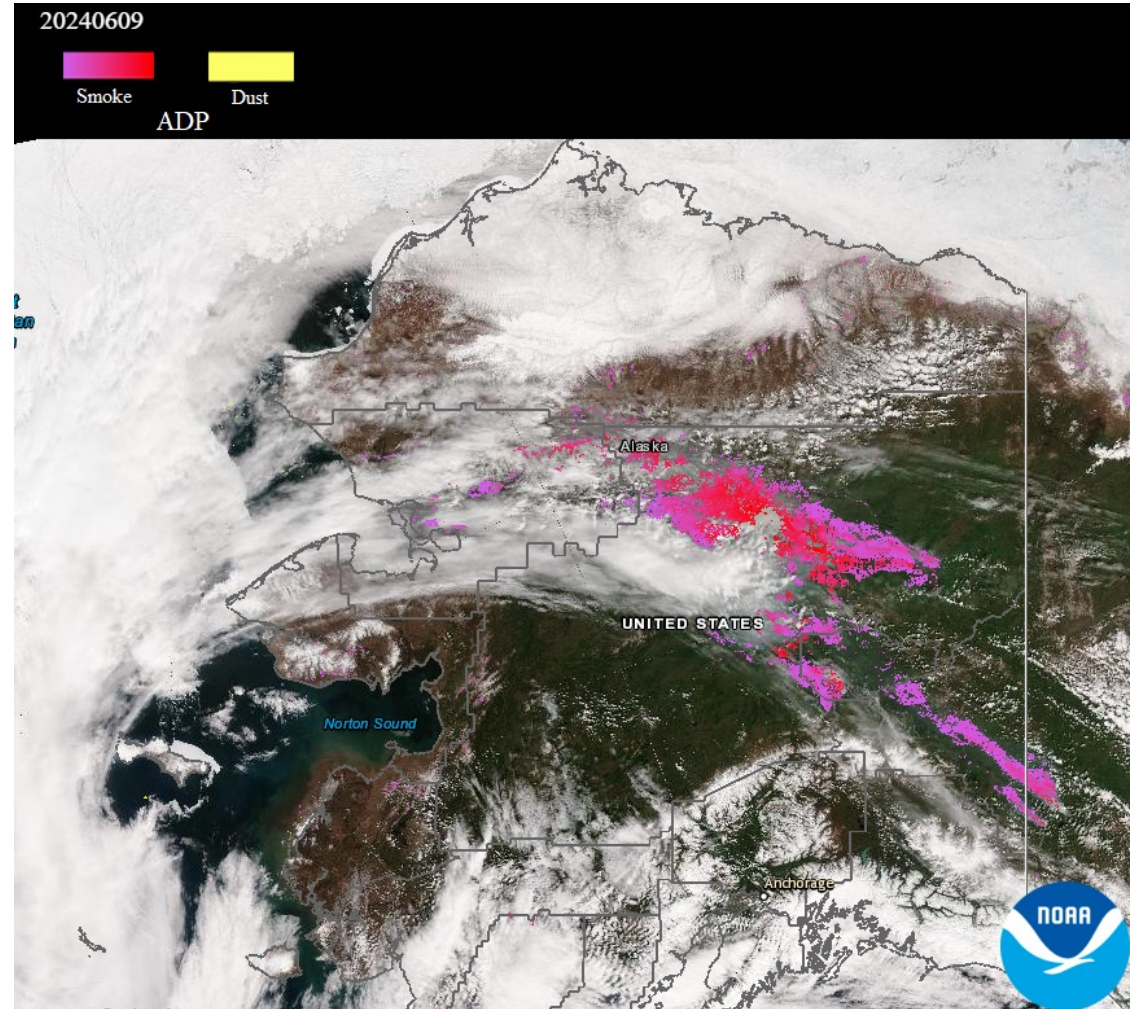
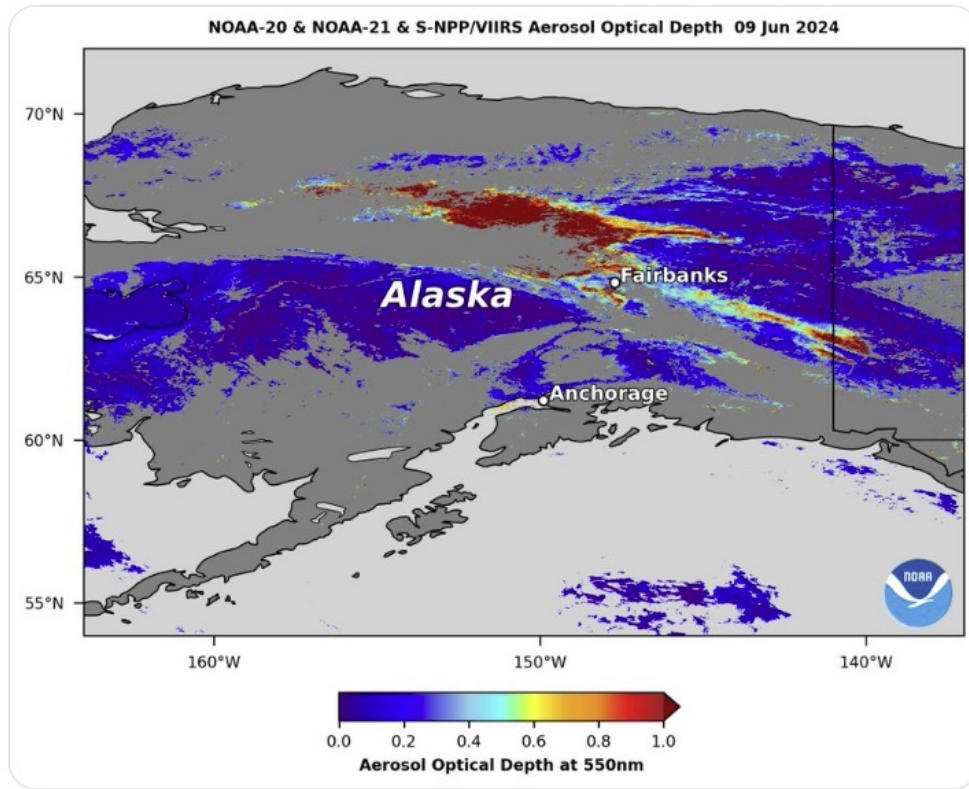
VIIRS AOD Detects Wildfire Smoke: June 9, 2024



AerosolWatch
@AerosolWatch

...

Intensifying #wildfires near the #Alaska/#YukonTerritory border & SE of #Fairbanks emitted thick #smoke (dark red shading) that moved westward on 9 June, observed by #VIIRS aerosol optical depth (AOD) from @JPSSProgram satellites. @NOAASatellites @uafgina @m_parrington

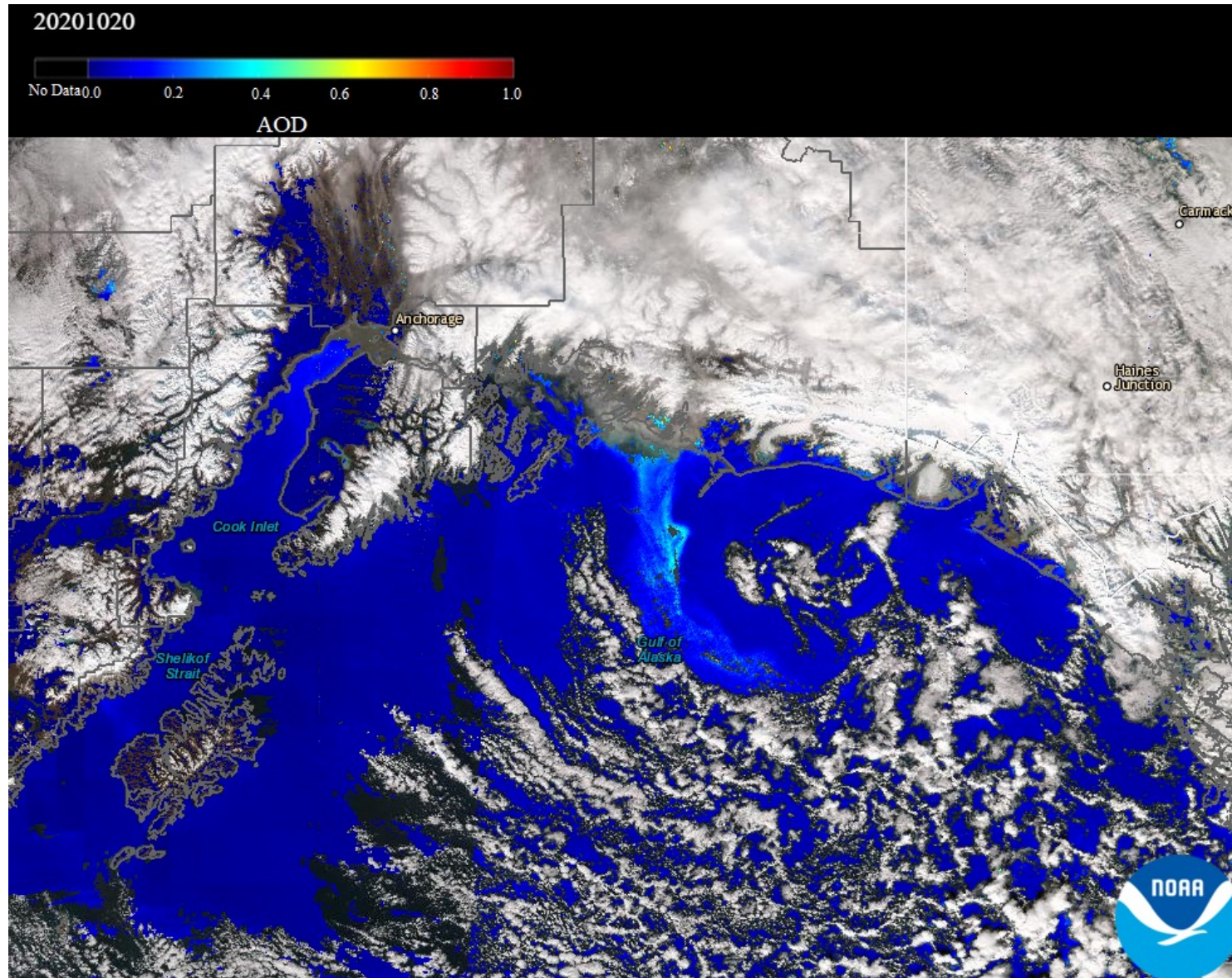


VIIRS ADP image from the [AerosolWatch website](#)

11:21 AM · Jun 10, 2024 · 818 Views

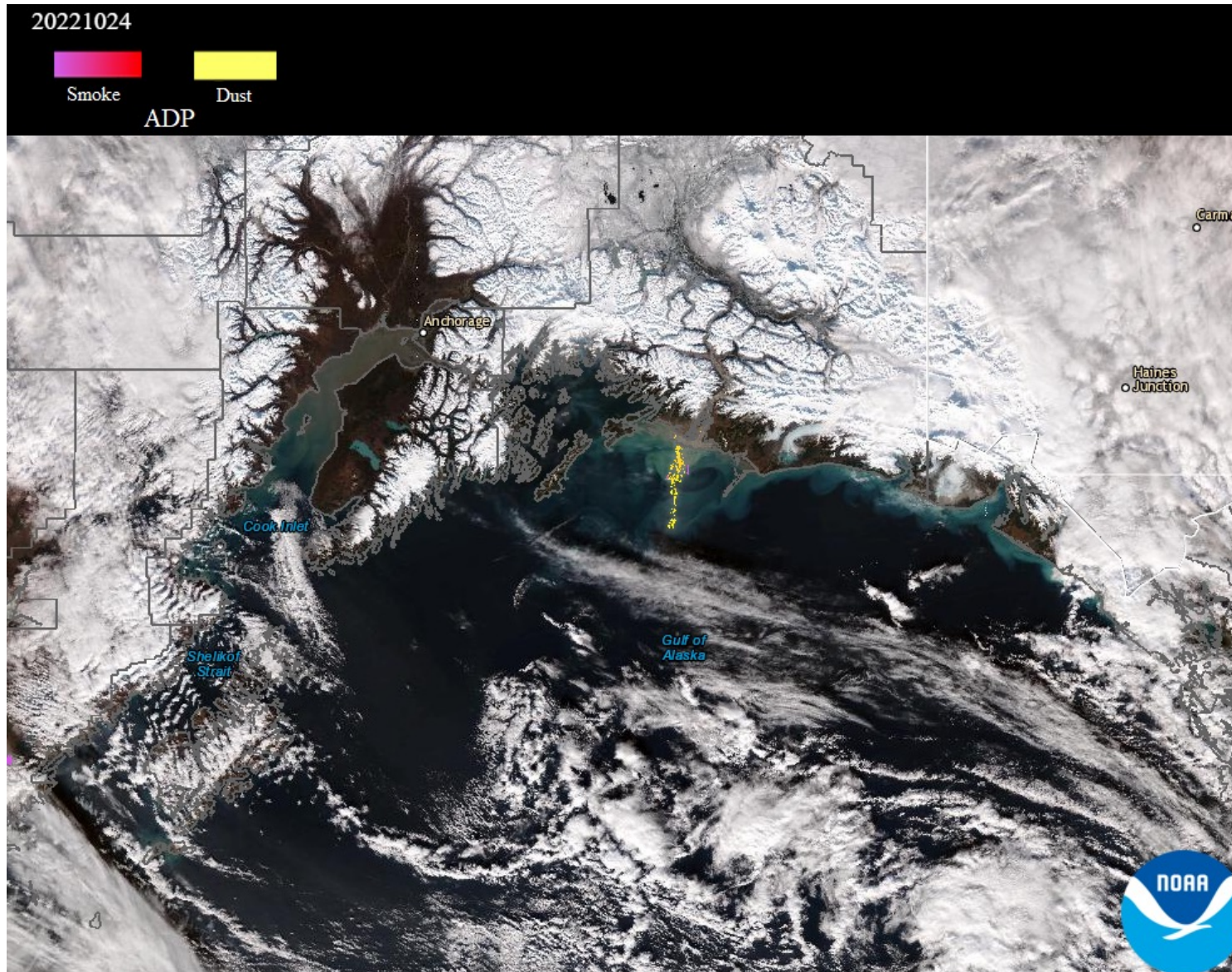


SNPP VIIRS AOD Detects Blowing Dust: October 20, 2020



- Dust blowing from the Copper River Delta over the Gulf of Alaska

NOAA-20 VIIRS ADP Detects Blowing Dust: October 24, 2022



- Dust blowing from the Copper River Delta over the Gulf of Alaska

VIIRS AOD & ADP Detect and Track Smoke & Dust

- Strengths:
 - Automatically identify smoke & dust aerosols
 - No need to rely on visual interpretation of RGB imagery
 - Complement RGB imagery products
 - Quality/Confidence flags permit filtering of AOD & ADP for specific applications
 - For Alaska: multiple high-spatial-resolution VIIRS aerosol observations per day!
- Limitations:
 - Daytime products only
 - Smoke/dust aerosols may not be at the surface
 - No retrievals over areas with clouds, snow/ice
 - Data gaps can occur for thick smoke plumes
- Follow us on **Twitter** [@AerosolWatch](https://twitter.com/AerosolWatch) for the latest product updates and event analysis!

- VIIRS AOD:
 - Most accurate for $0.1 \leq \text{AOD} \leq 0.8$
 - Can be used to estimate surface $\text{PM}_{2.5}$ concentrations (fill gaps in ground monitor network)

- VIIRS ADP:
 - Most accurate for thick plumes over dark surfaces
 - Less accurate for thin plumes over arid & semi-arid regions



AerosolWatch
@AerosolWatch

