Overview of Aerosol Products from NOAA Next Generation Operational Satellites

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Remote Sensing of Air Quality (1)

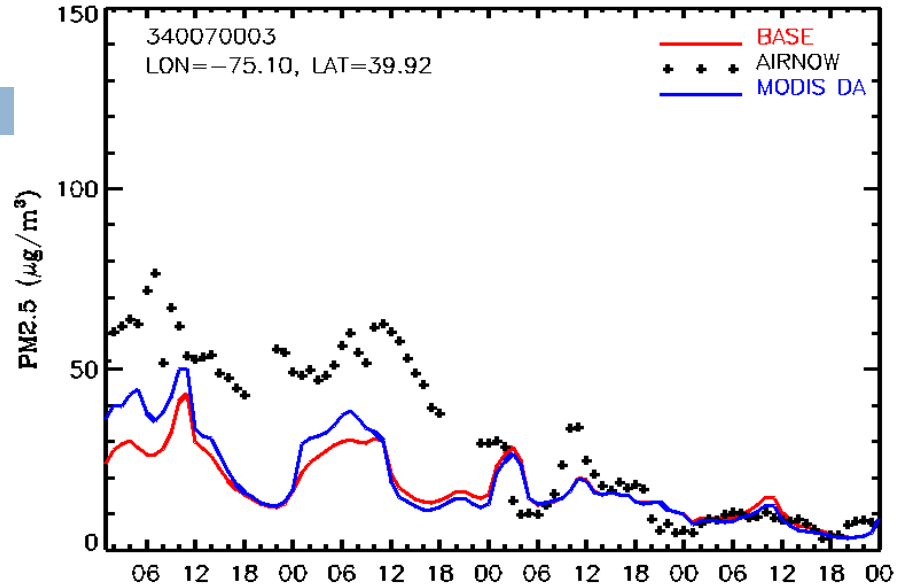
- Satellites indicate areas of high particulate matter in the atmosphere associated with smoke plumes, blowing dust, and haze
- Aerosol satellite products have many air quality applications:
  - Modeling
  - Retrospective analysis (Exceptional Events)
  - Near real time monitoring

For satellite products to complement ground measurements of aerosols/air quality, higher spatial and temporal resolution is a MUST

VIIRS true color
Oct 9, 2017: Northern CA Wildfires

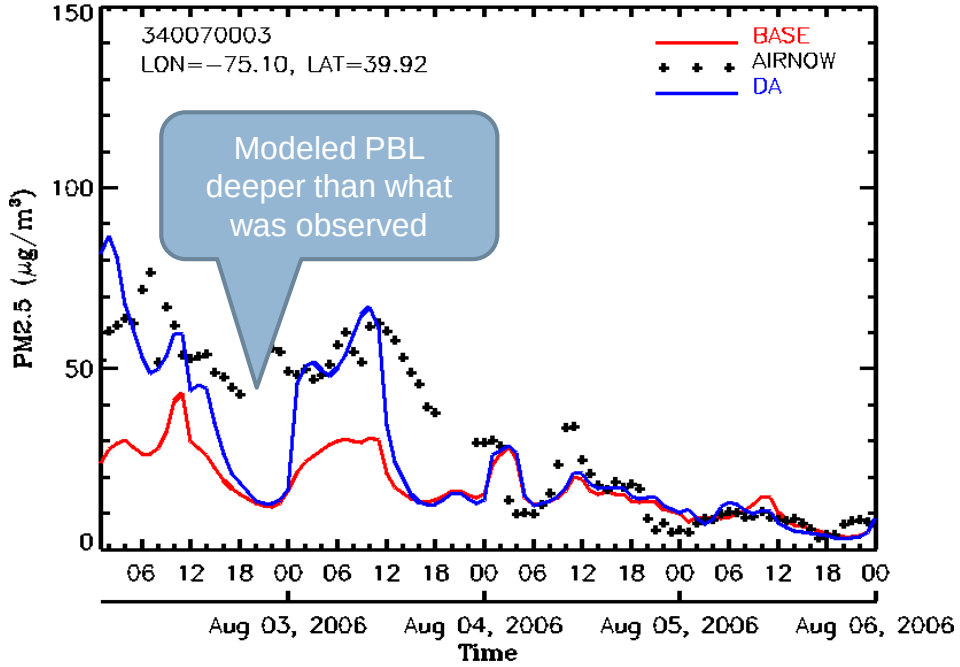
Remote Sensing of Air Quality (2)

WRF-CMAQ run of an urban/industrial pollution event in the central/eastern US using Aqua and Terra MODIS AOD (two observations per day) assimilation.



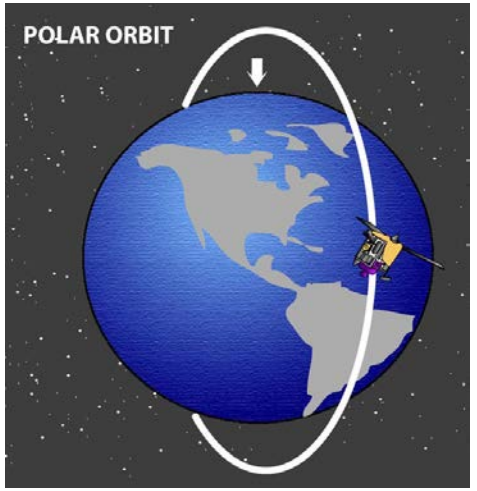
Breaking the temporal barrier in observation space is important

WRF-CMAQ run of an urban/industrial pollution event in the central/eastern US using legacy GOES AOD (twelve observations per day) assimilation.

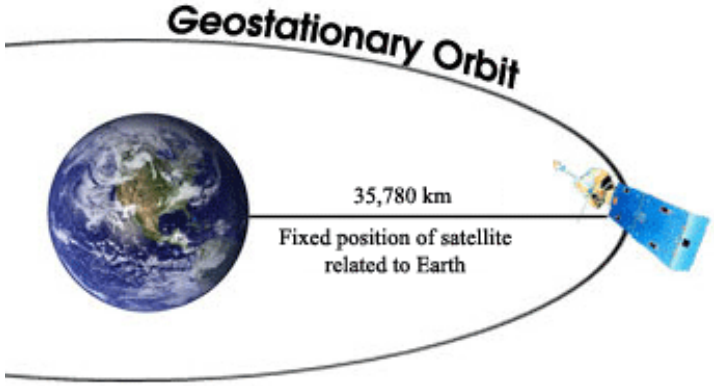


New Generation Satellite Products

- JPSS: polar-orbiting satellites
  - Low Earth orbit (~825 km above surface)
  - Global coverage
  - Only 1-2 measurements per day
  - Provide 85% of data used in numerical weather prediction

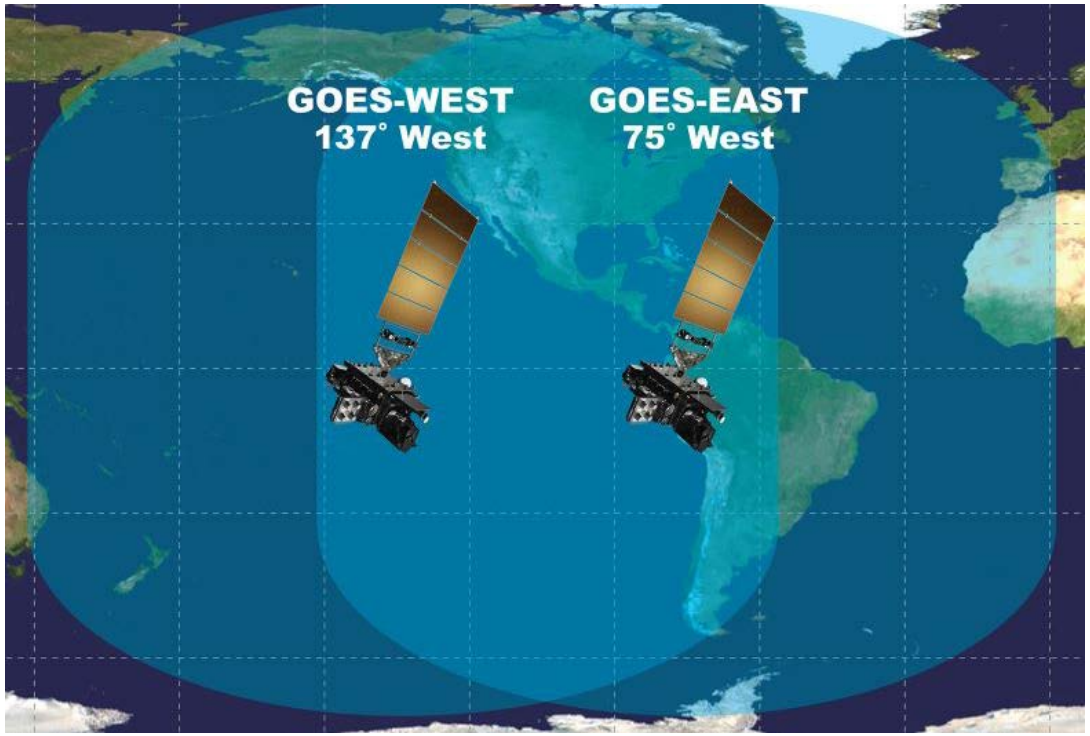


- GOES-R series: geostationary satellites
  - High-altitude orbit (~35,800 km)
  - Orbital speed of satellite matches rotation speed of Earth, so coverage limited to specific (constant) location
  - Nearly continuous measurements
  - Meteorological satellites, used to monitor severe storm development, natural hazards



GOES-R Series

- Revolutionary new geostationary satellites
- "Like going from black and white TV to HD"
- GOES-16 launched Nov 19, 2016 (now GOES-East)
- GOES-17 launched Mar 1, 2018 (will be GOES-West)

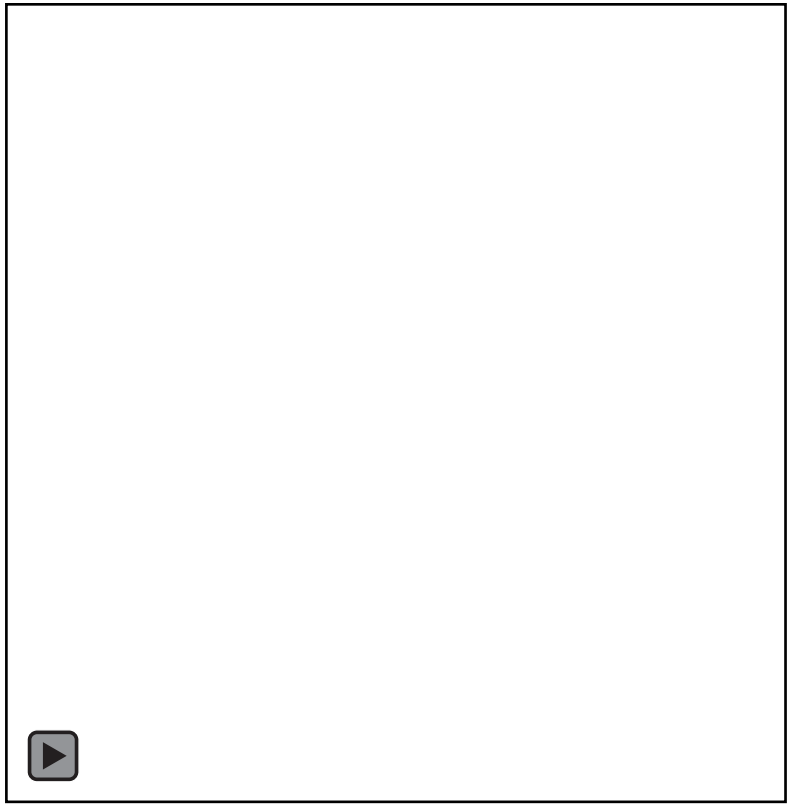


New Generation GOES Imager

- Advanced Baseline Imager (ABI) is one of 6 instruments on GOES-R series satellites
- Huge leap forward in geostationary satellite technology
- ABI has 16 spectral bands vs. 5 on previous GOES imager
  - New products
  - Higher accuracy
  - Higher spatial resolution
- Aerosol Products (5-minute CONUS)
  - Aerosol Optical Depth at 2 km
  - Aerosol Type at 2 km
  - Imagery: Geocolor, Dust RGB

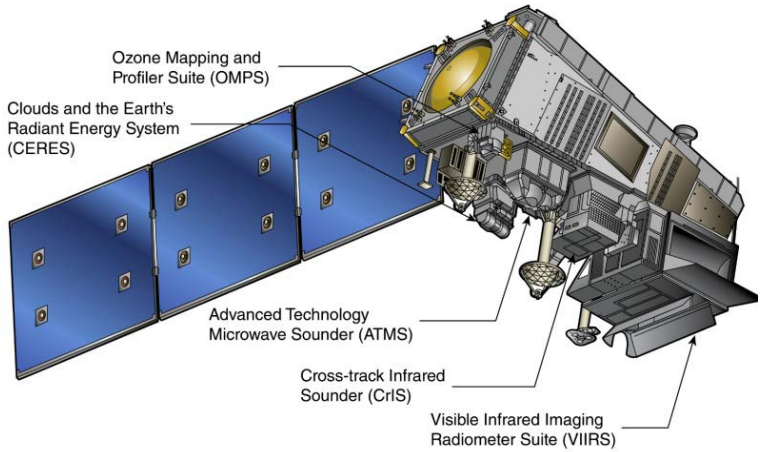
New Generation Polar Satellites

- Orbit Earth 14 times/day, pole to pole
- Image entire globe 2 times/day
  - Global coverage!
- SNPP launched Oct 2011
- JPSS-1 (NOAA-20) launched Nov 18, 2017
  - Orbits 50 min ahead of SNPP, early afternoon overpass time
- Follow-on to NASA suite of earth-observing satellites: Terra, Aqua, and Aura
- Research applications, also input to NWP

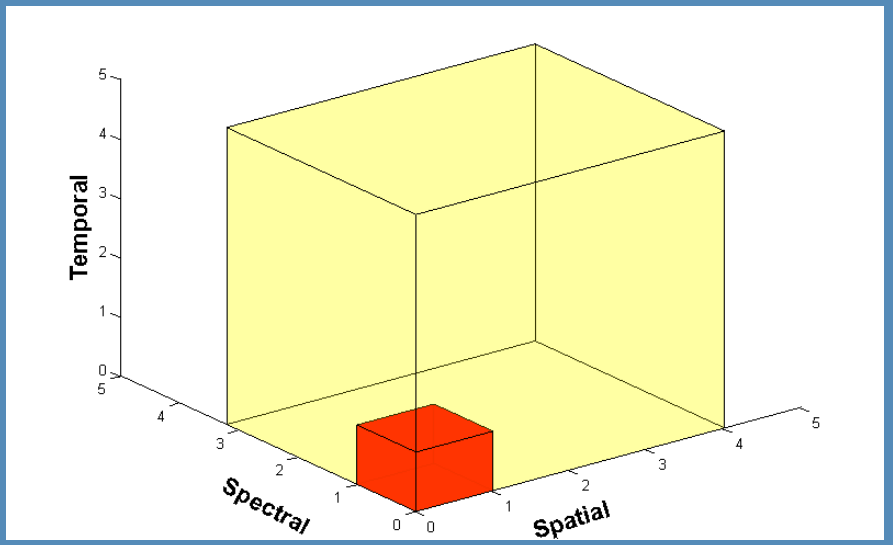


VIIRS

- Visible Infrared Imaging Radiometer Suite (VIIRS) is one of 5 instruments on SNPP
- VIIRS has 22 spectral bands with high spatial resolution (750 m)
  - Follow-on to MODIS on Terra and Aqua satellites
- Afternoon overpass time, so observations made ~1:30 PM local time (1 day temporal resolution for aerosol products)
- So "today's" near-real time VIIRS observations are available in the mid-afternoon, typically ~2-3 hours after overpass
  - Very useful for post-analysis
- VIIRS aerosol products:
  - AOD
  - Smoke/dust mask
  - True color imagery (RGB)
  - Dust RGB



GOES-R ABI



5x Faster coverage (5-minute full disk vs. 25-minute)

4x Improved spatial resolution (2 km IR vs. 4 km)

3x More spectral bands (16 on ABI vs. 5 on the current imager)

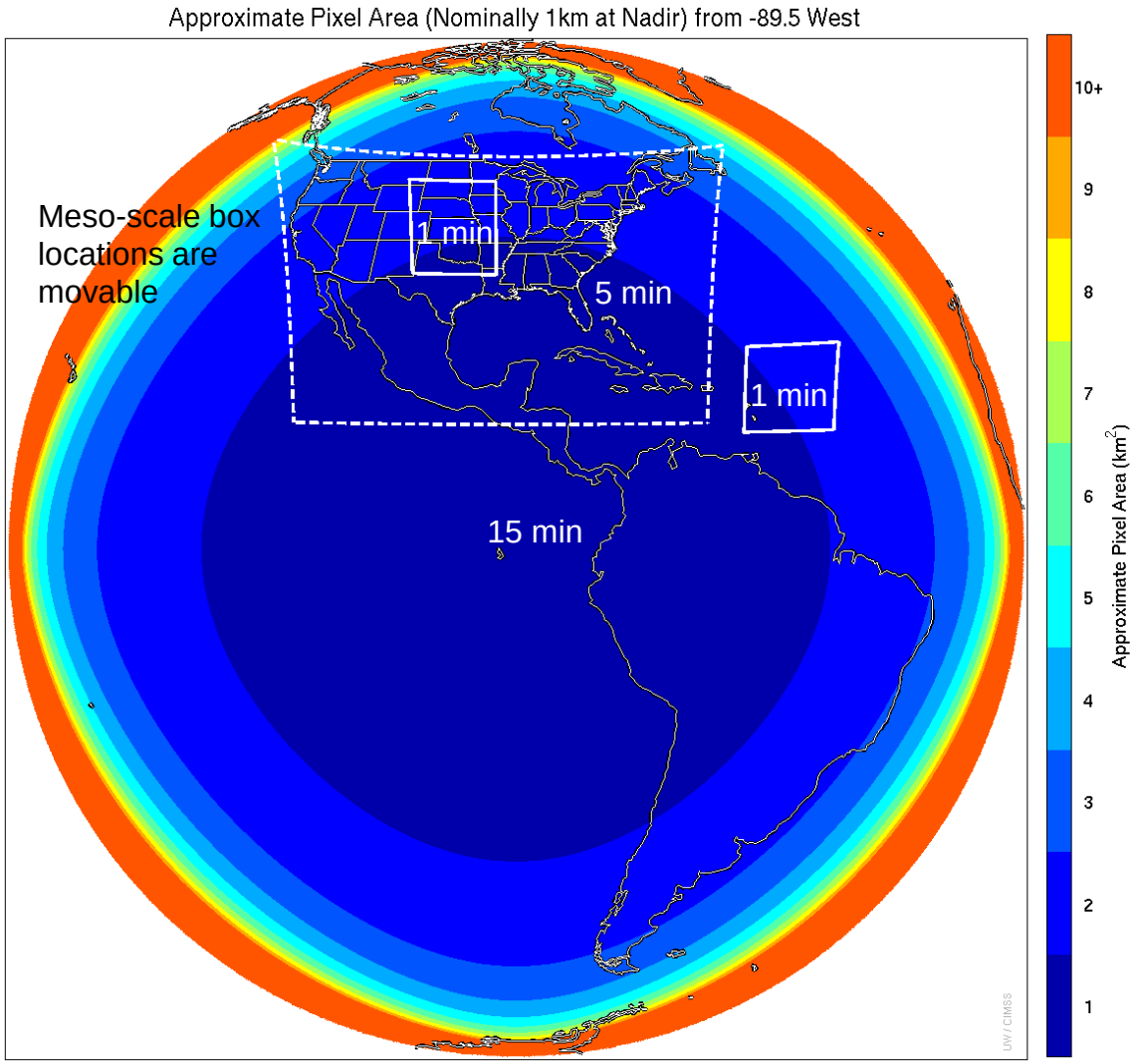
Tim Schmidt, NOAA

0.47
0.64
0.86
1.6
1.38
2.2
3.9
6.2
6.7
7.3
8.5
9.7
10.3
11.2
12.3
13.3

Domain	Legacy GOES			
	AOD	Geo Color RGB	Dust RGB	Smoke/Dust Mask
CONUS	X			
Full Disk				
Mesoscale				

Domain	GOES-R/S			
	AOD	Geo Color RGB	Dust RGB	Smoke/Dust Mask
CONUS	X	X	X	X
Full Disk	X	X	X	X
Mesoscale		X	X	X

Onboard calibration * Better navigation * On demand mesoscale



Default Operational Mode:

Full Disk 15 min

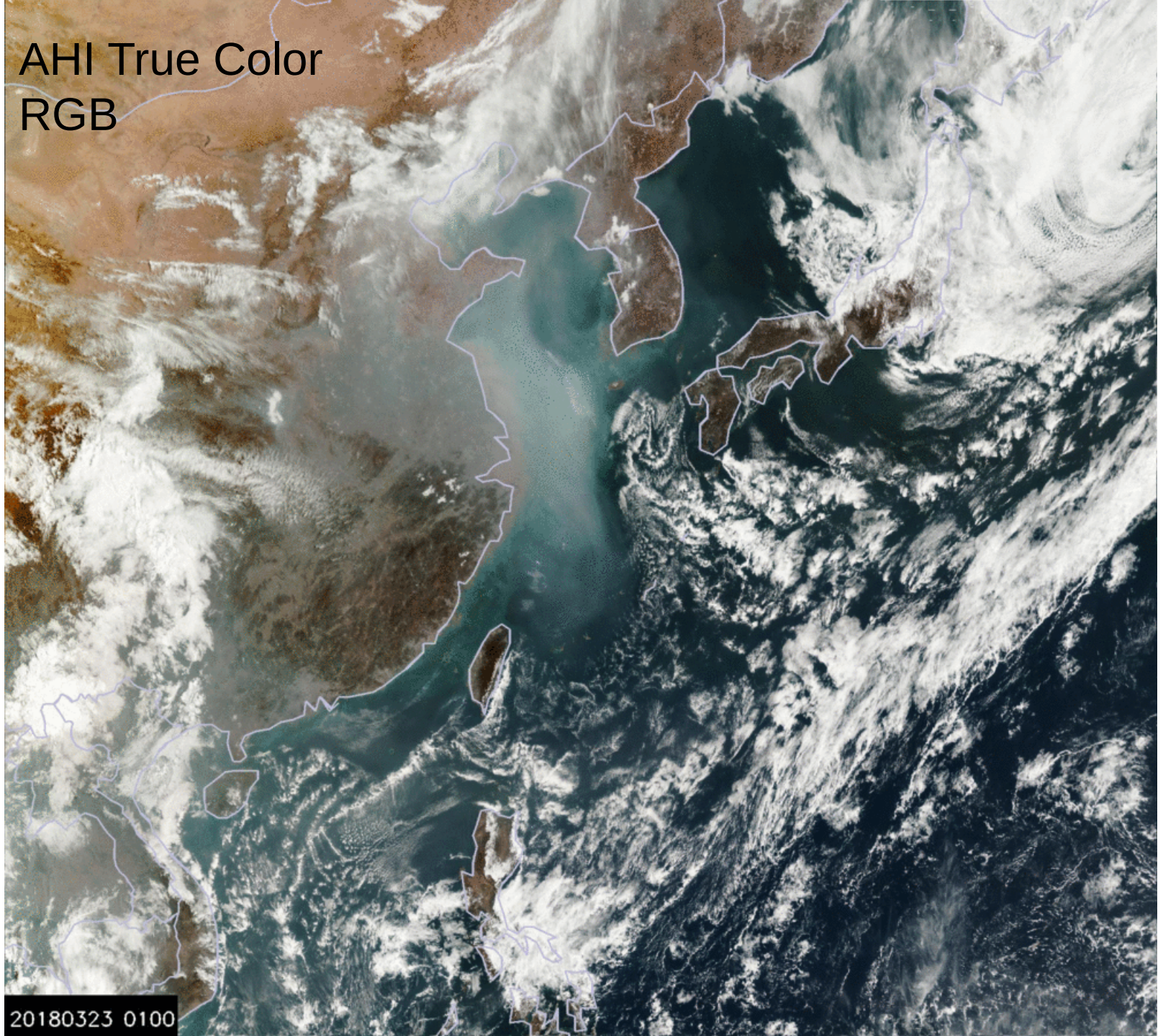
CONUS 5 min

Mesoscale 1 min

Proposed mode to be consistent with AHI

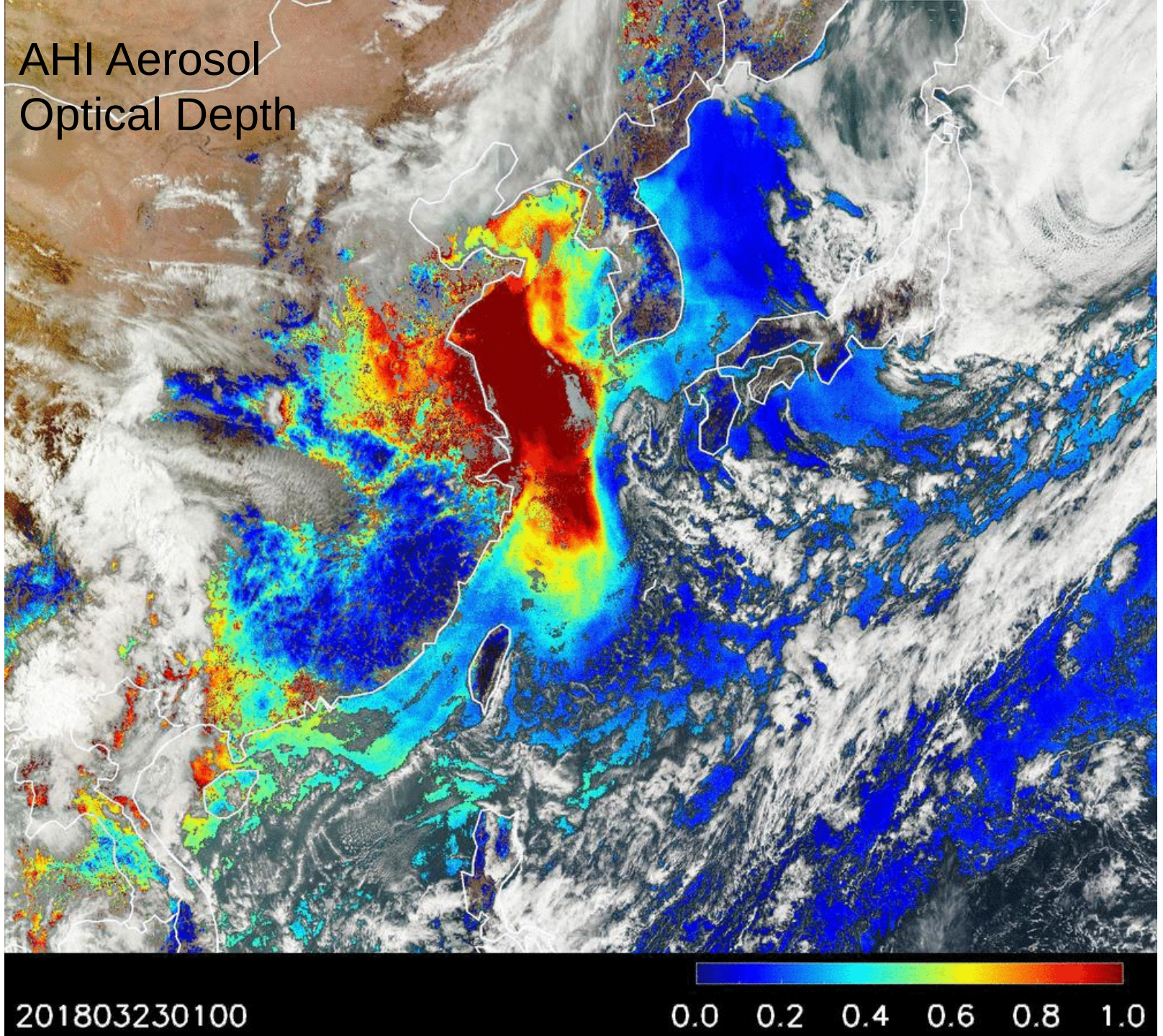
Full Disk 10 min

Tim Schmidt, NOAA

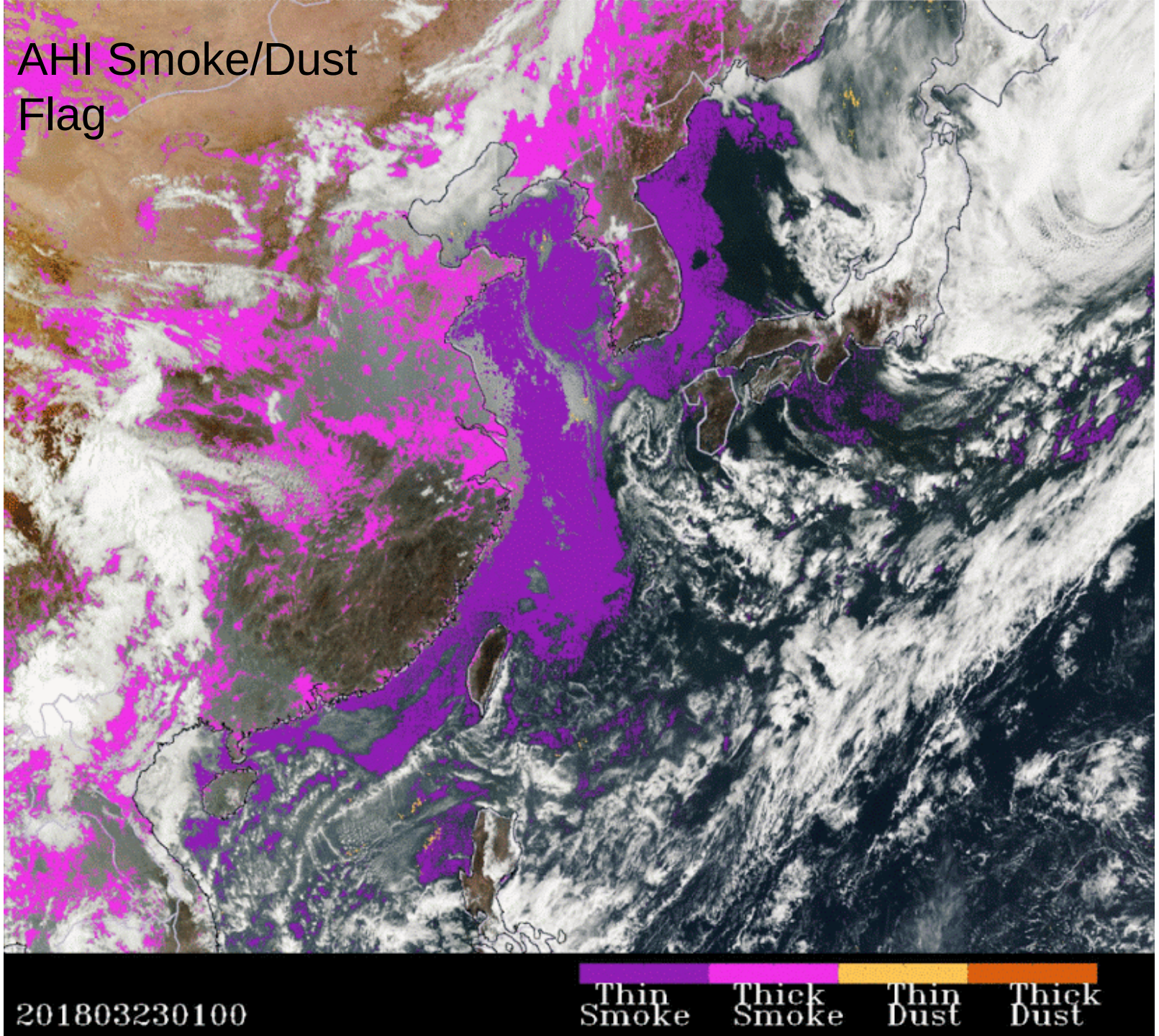


Wide-spread smog

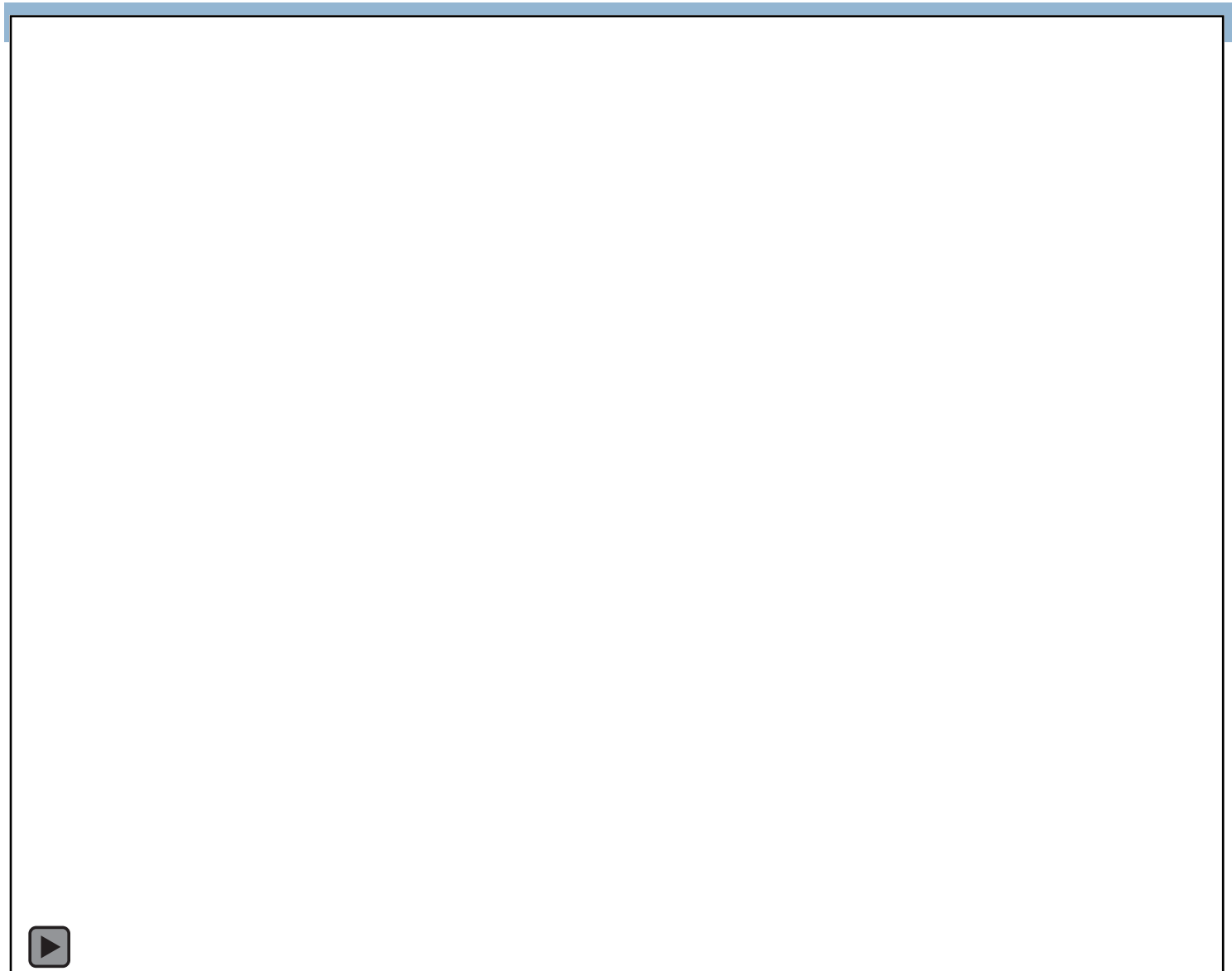
AOD algorithm able to capture what is likely urban/industrial pollution



Aerosol detection algorithm retrieving the pollution as smoke. Likely because pollution in China is highly absorbing (brown/black carbon) and has optical properties similar to biomass burning smoke?



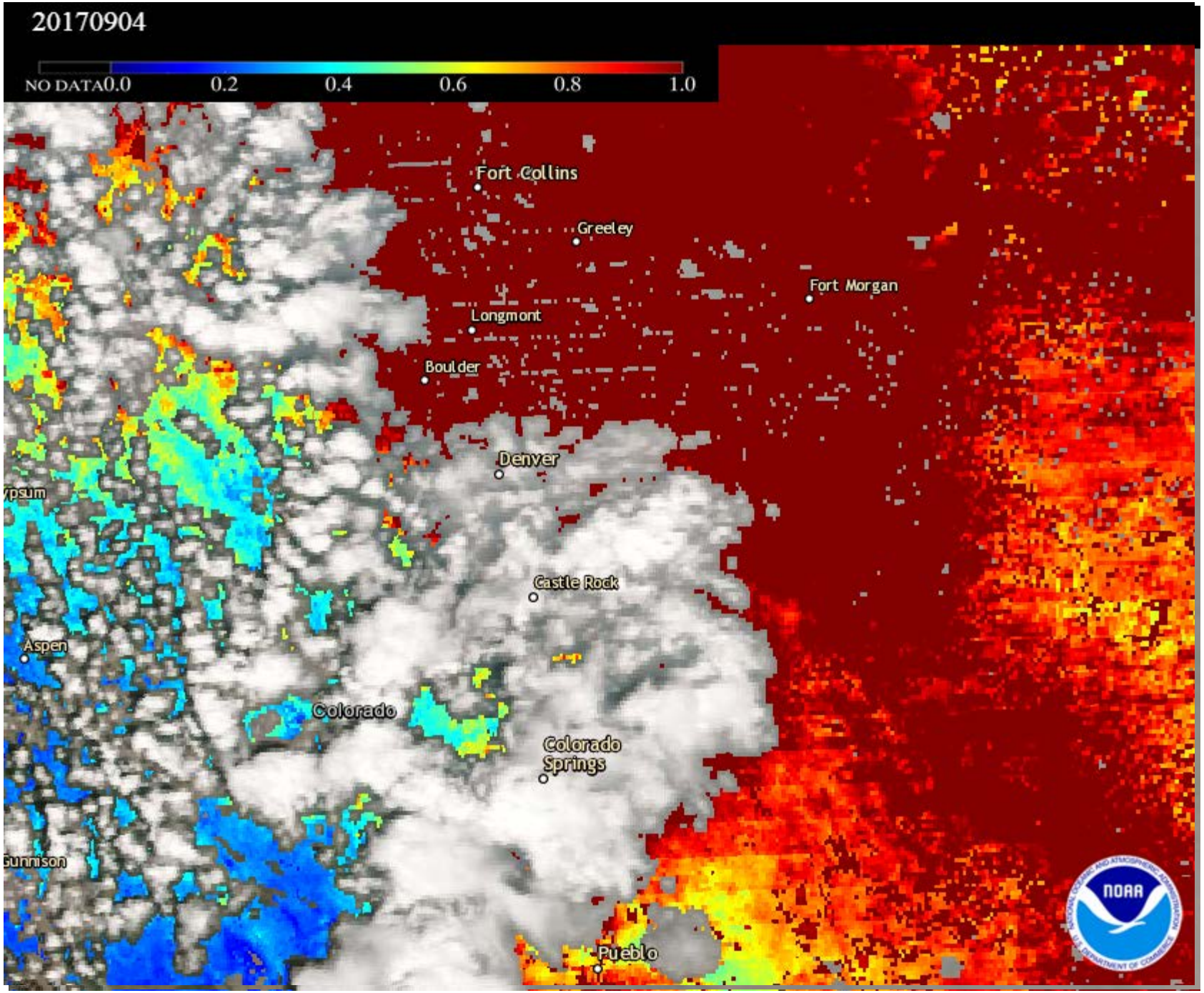
GOES-R ABI New Capabilities: 0.5 km Visible band every 5 minutes



Smoke from several small plumes blend together and become one large plume.

Tim Schmidt, NOAA

SNPP
VIIRS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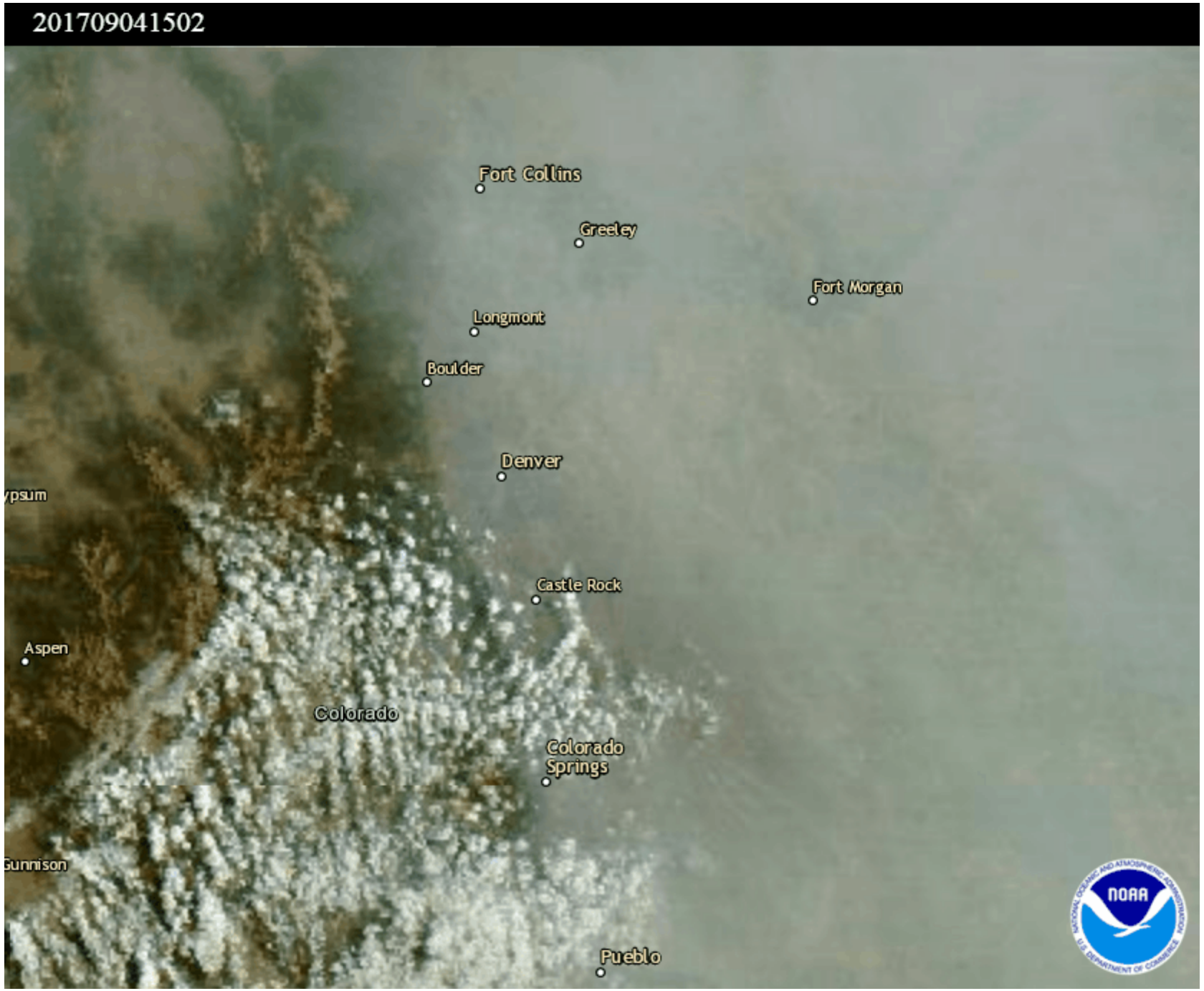
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Castle Rock
Aspen
Colorado
Colorado Springs
Pueblo

GOES-16 ABI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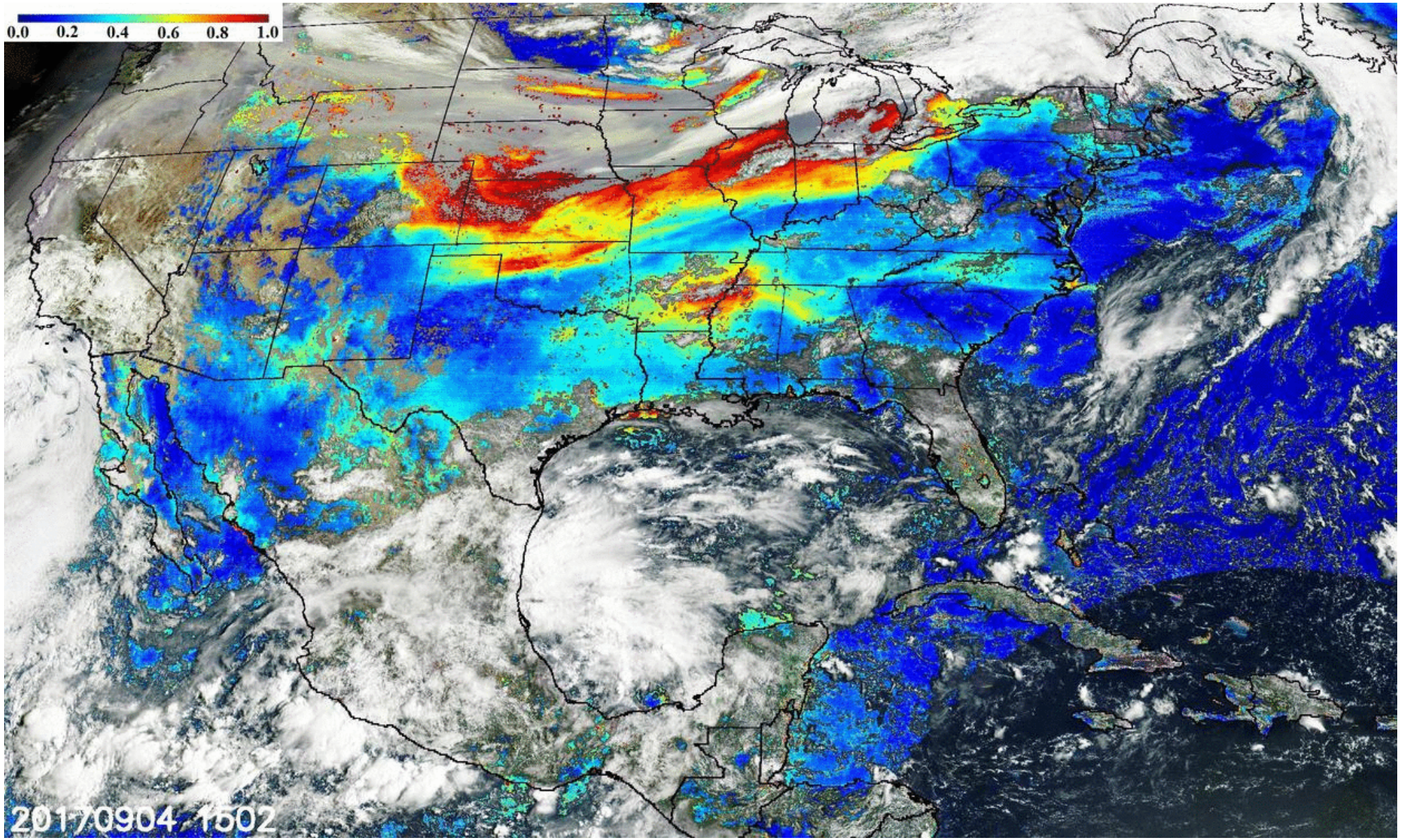
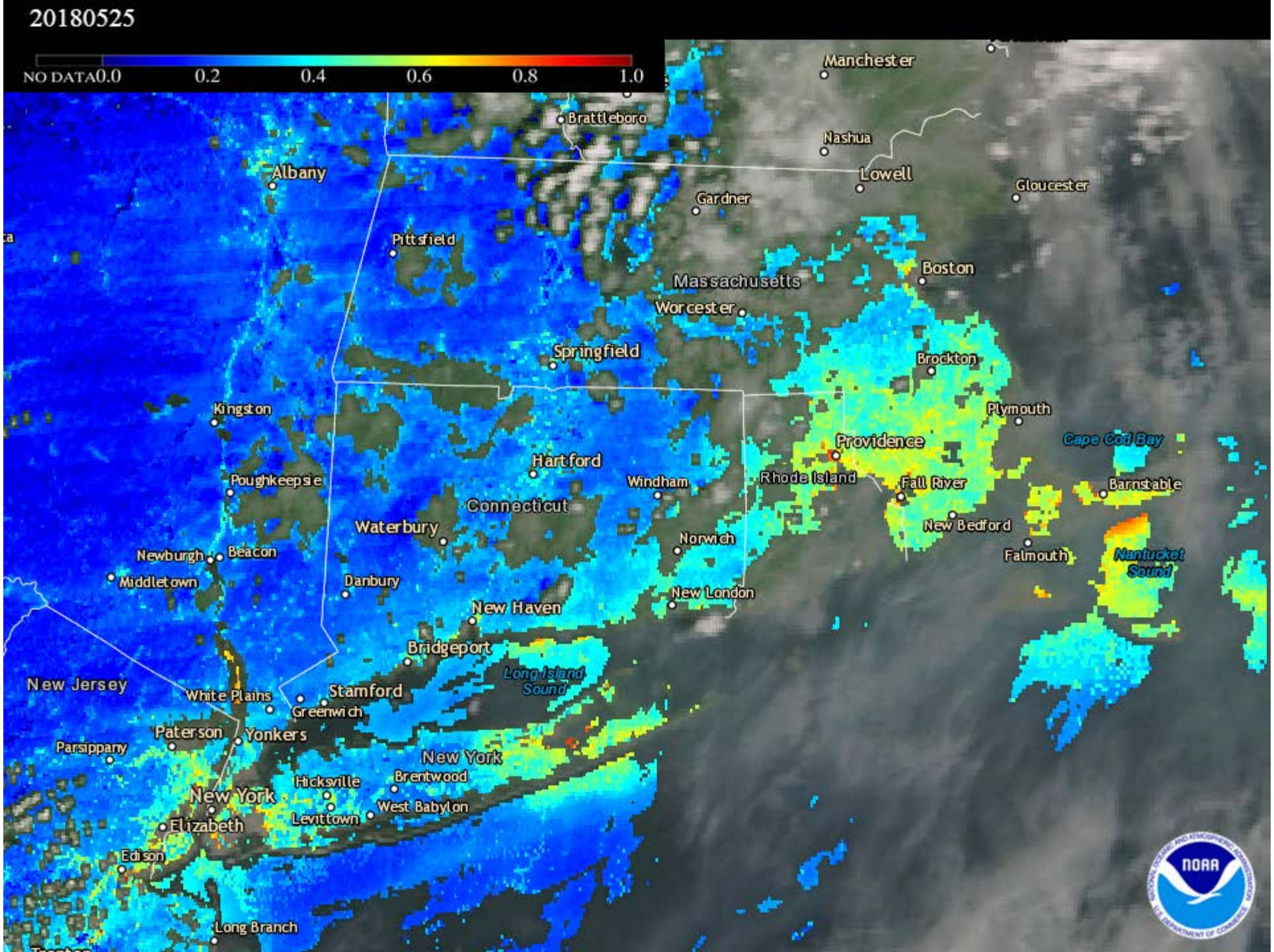
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Castle Rock
Aspen
Colorado
Colorado Springs
Pueblo

GOES-16 ABI

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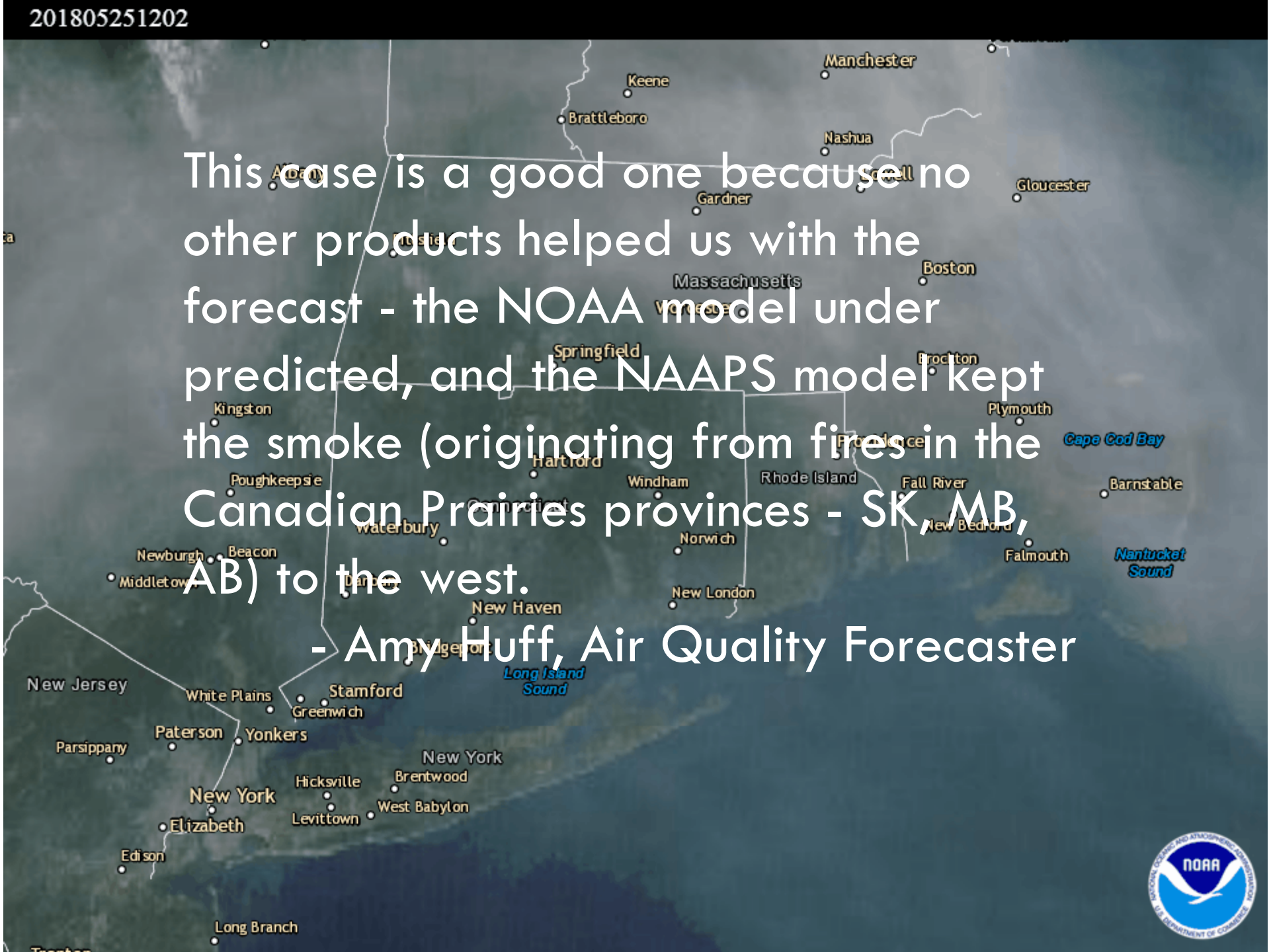
Brattleboro
Nashua
Albany
Lowell
Gloucester
Gardner
Pittsfield
Boston
Massachusetts
Worcester
Springfield
Brockton
Kingston
Plymouth
Providence
Cape Cod Bay
Hartford
Poughkeepsie
Windham
Rhode Island
Fall River
Barnstable
Connecticut
Waterbury
New Bedford
Norwich
Newburgh
Beacon
Falmouth
Nantucket Sound
Middletown
Danbury
New London
New Haven
Bridgeport
Long Island Sound
New Jersey
White Plains
Stamford
Greenwich
Paterson
Yonkers
Parsippany
New York
Hicksville
Brentwood
New York
West Babylon
Levittown
Elizabeth
Edison
Long Branch

SNPP
VIIRS

SNPP
VIIRS



This case is a good one because no other products helped us with the forecast - the NOAA model under predicted, and the NAAPS model kept the smoke (originating from fires in the Canadian Prairies provinces - SK, MB, AB) to the west.

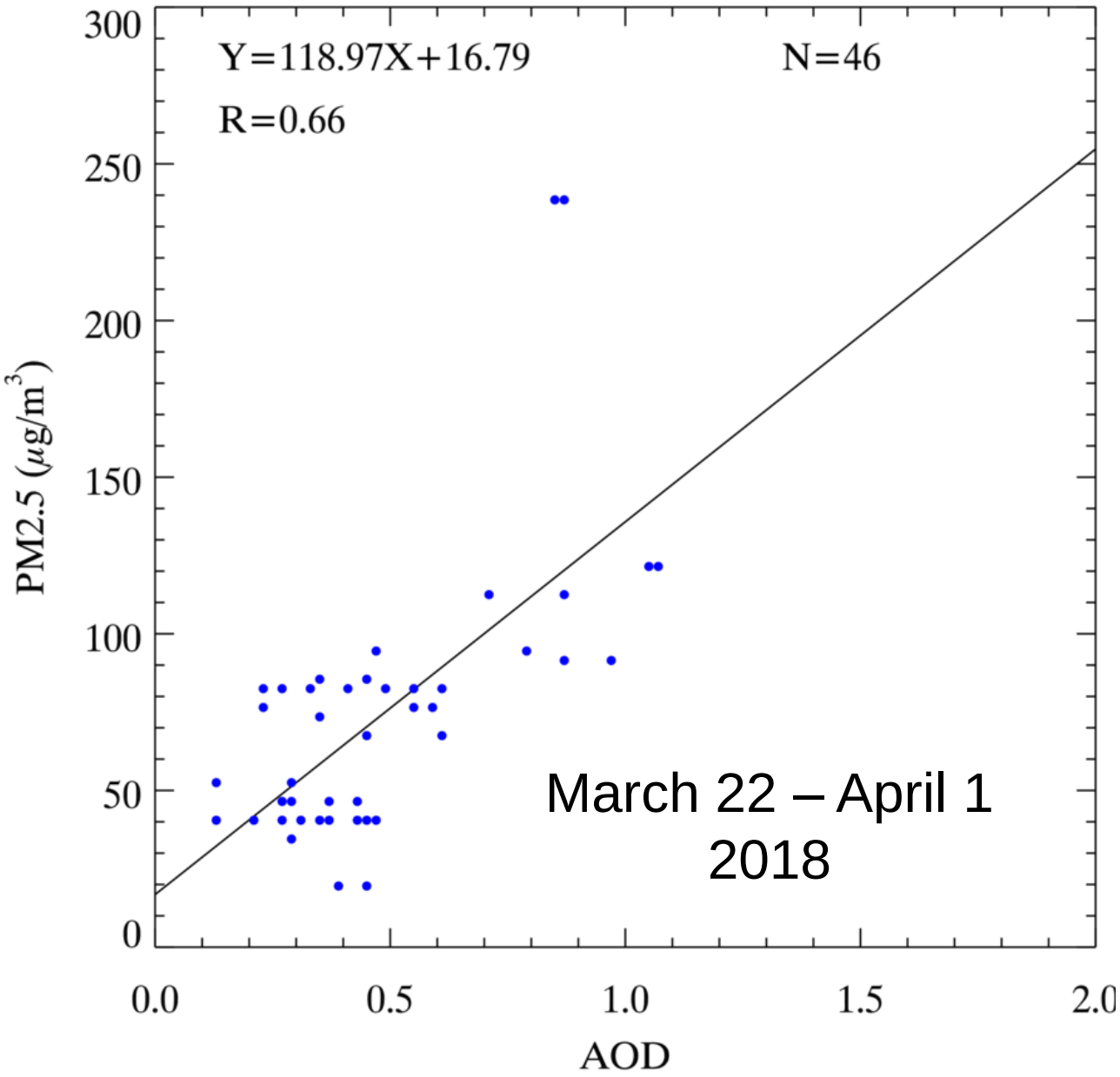
- Amy Huff, Air Quality Forecaster

- Analysis of historic data of AOD and PM2.5 data is needed first to generate regression models
- Regression models can be applied in near real time

AOD = PM2.5 x H x S

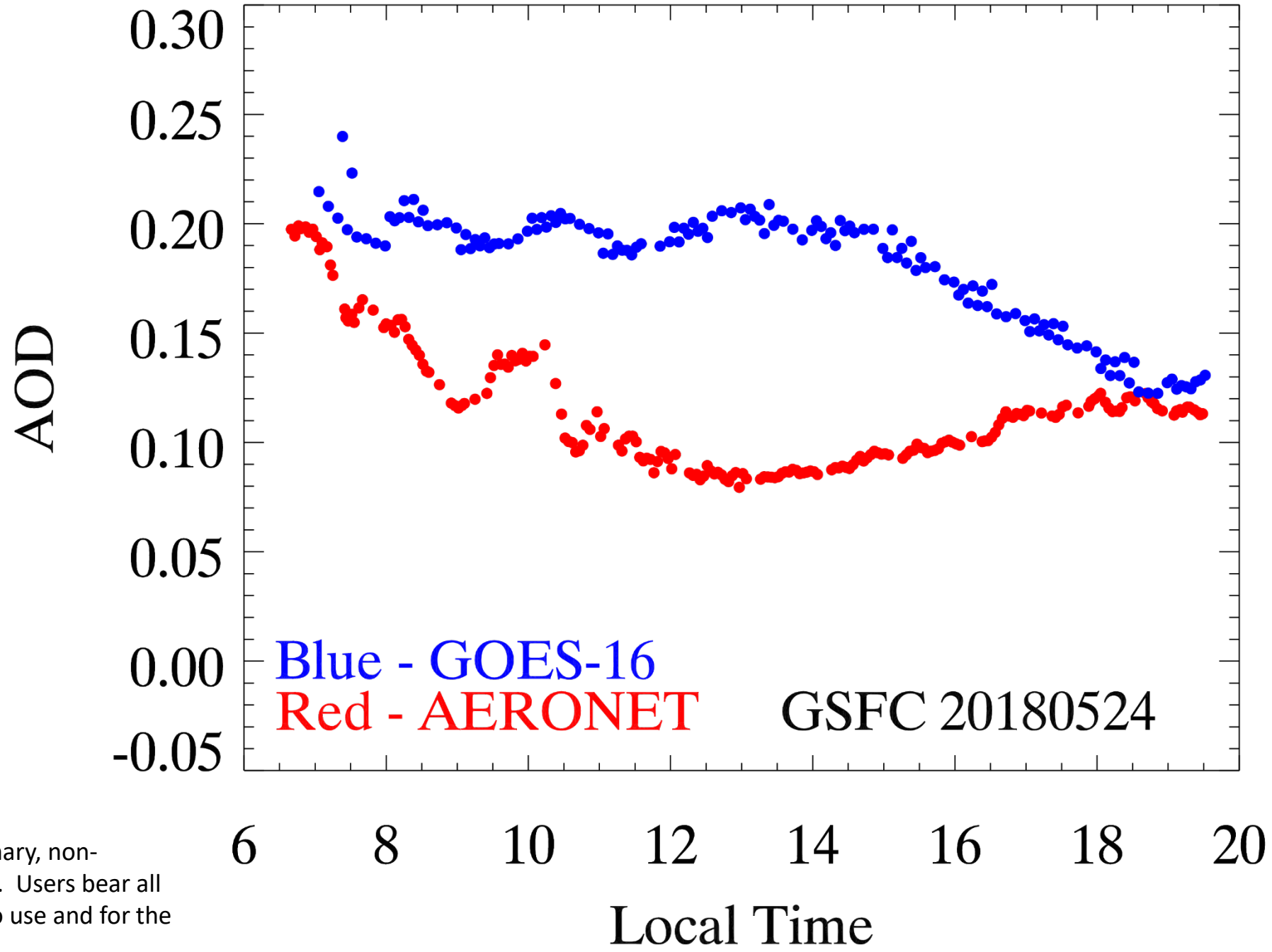
H – aerosol layer height
S – aerosol mass extinction coefficient
(depends on type of aerosol)

AHI AOD vs. PM2.5
Beijing, China



BREAKING THAT TEMPORAL BARRIER

Satellite observations can now compete with high temporal ground observations with added benefit of observing large geographic regions that are cloud/snow free



NOAA satellite aerosol products extend the monitoring capability of air quality from regional to global scale at high temporal and spatial resolution

Data Characteristic		ABI	VIIRS
Orbit		Geostationary	Polar-orbiting
Observation Time		Continuous during daylight	~1:30 PM
Data Coverage		Centered on 75 °W	Global
Temporal Resolution		5 min (CONUS view)	2 per day (SNPP, NOAA-20)
Latency		20 min (on AerosolWatch)	2-3 hours (on AerosolWatch)
Spatial Resolution	**RGB**	1 km (GeoColor, CONUS view)	750 m
	AOD	2 km (CONUS view)	750 m
Product Status (April 2018)		RGBs: provisional Aerosol: β-maturity	Fully validated