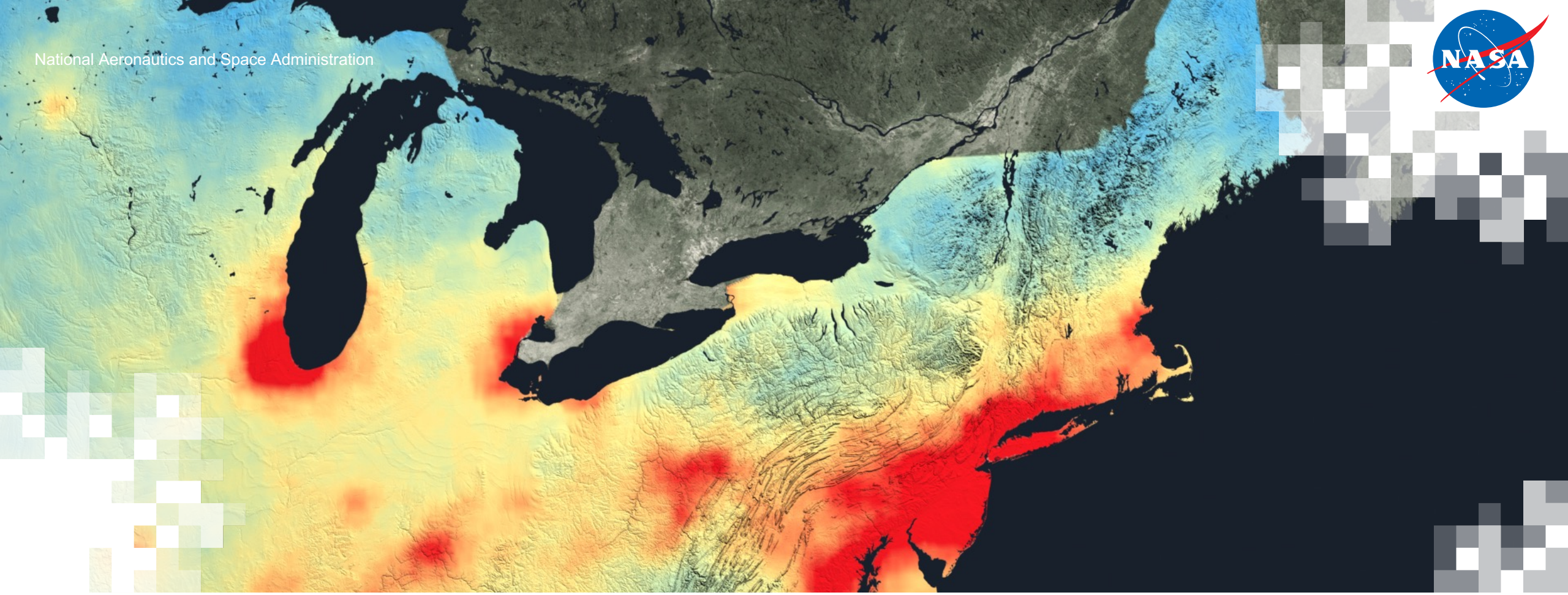

Satellite Imagery and Data Formats

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NASA Air Quality Remote Sensing Training for EPA, March 21-23, 2023

Learning Objectives

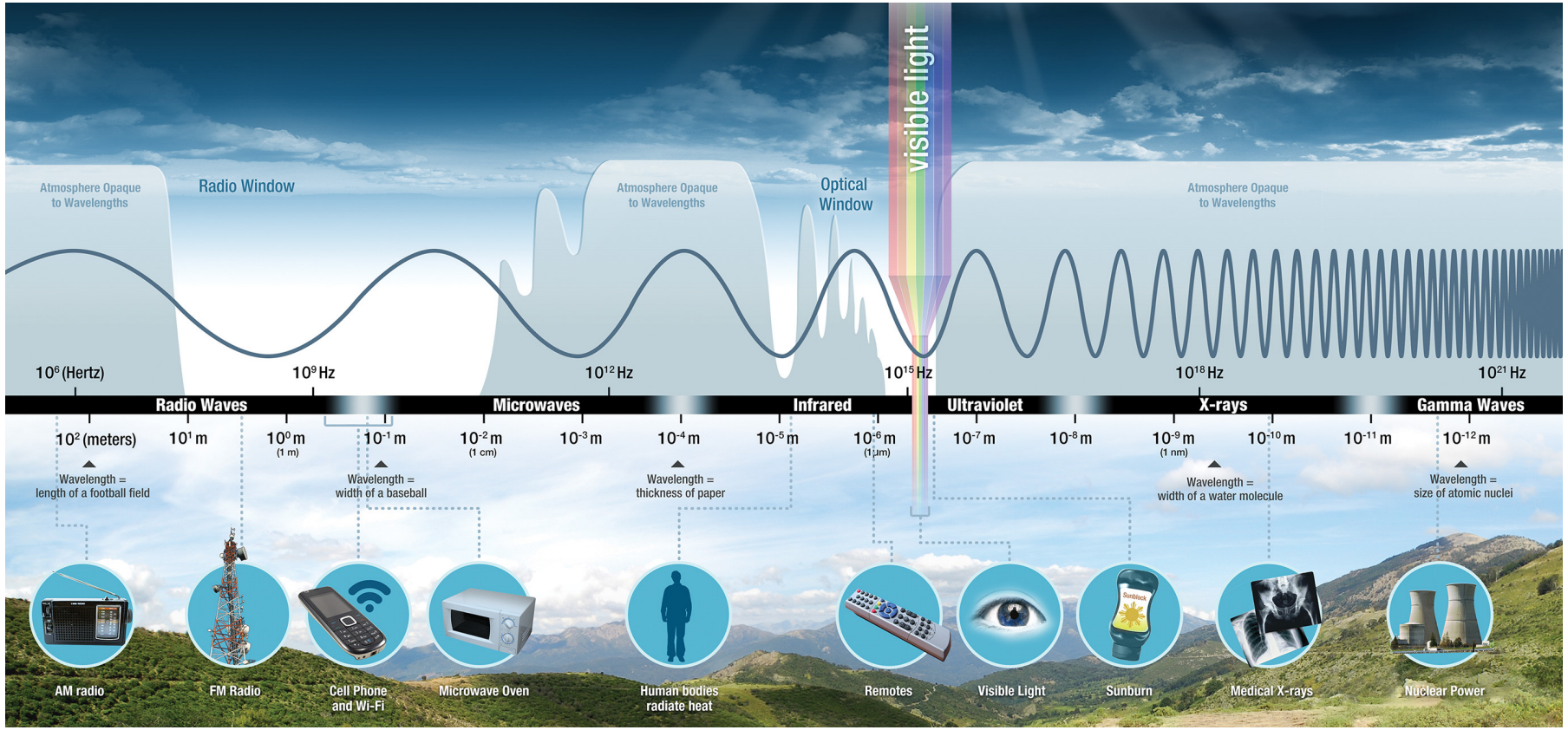
By the end of this presentation, you will be able to:

- Recognize satellite imagery, label features, and recite applications of satellite imagery
- Access and perform basic analysis of satellite imagery
- List the different satellite data levels

Visible Image Science

- Visible satellite images are essentially photographs.
- All the energy collected by the visible sensors (cameras) onboard satellites are light energy from the sun, reflected by the Earth.
- The reflectance is a measure of albedo, which is the percentage of light energy reflected by the Earth.
- The higher the albedo, the more light is being reflected back into space (i.e., clouds appear bright).
- The lower the albedo, the more light is being absorbed (i.e., water appears dark).

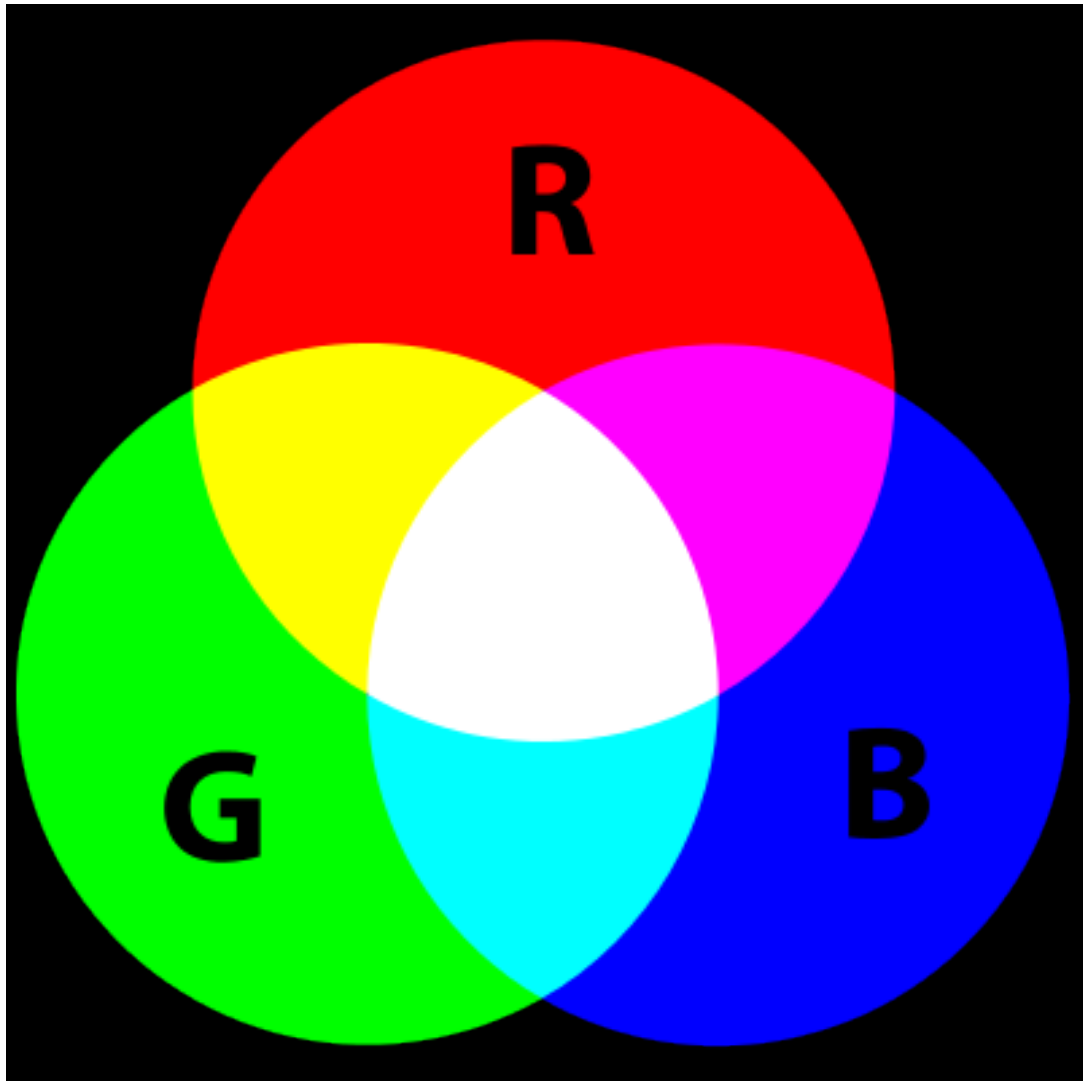
Wavelength Selection



Remote sensing instruments typically make observations at many discrete wavelengths, or **wavelength bands**.

RGB Imagery

- Create an image using any 3 bands
- Load red, green, and blue satellite bands into corresponding display channels
- Simulates what the human eye sees



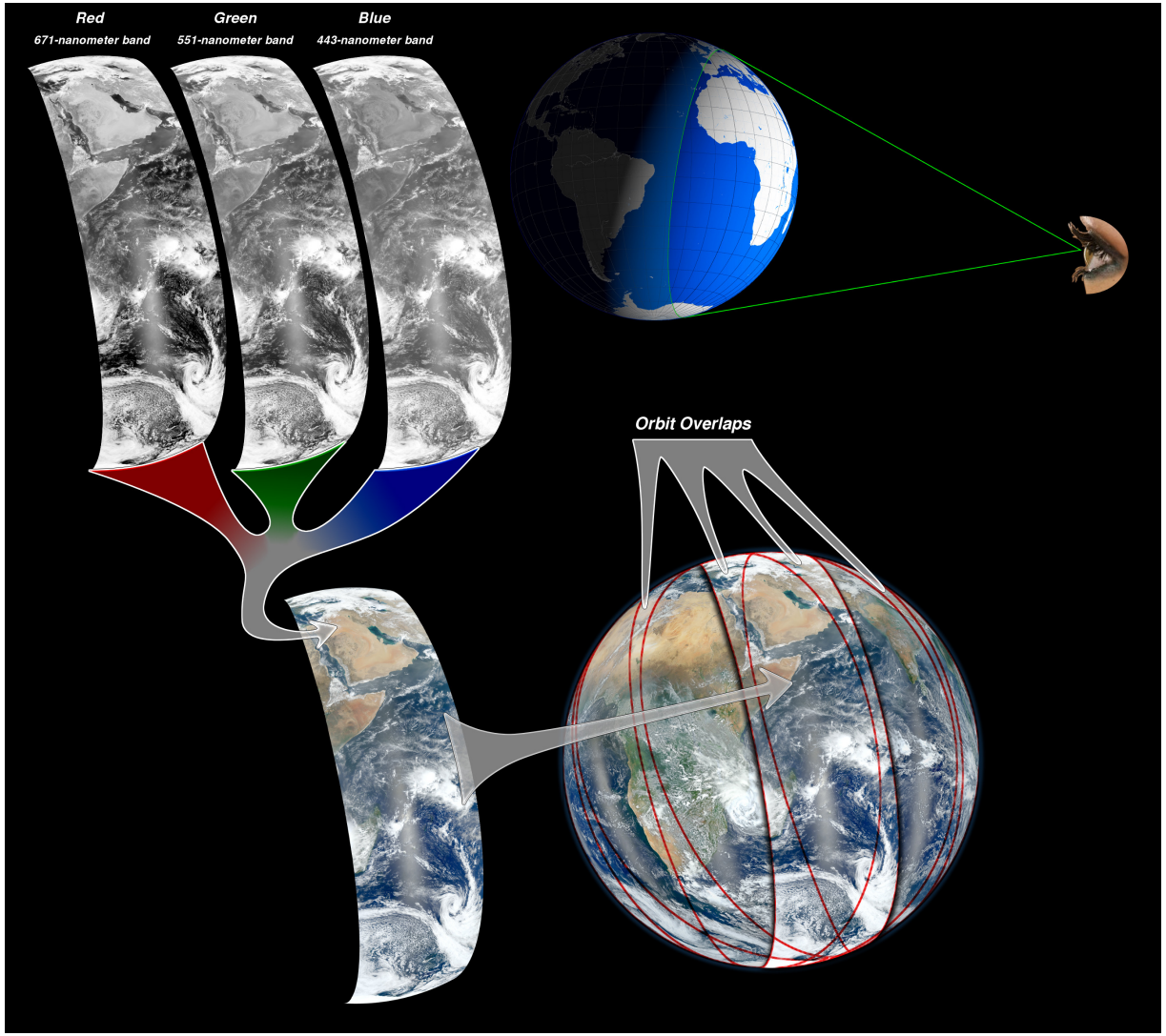
True Color Image (or RGB)

A MODIS "true color image" will use MODIS visible wavelength bands 1, 4, and 3.

R = 0.66 µm

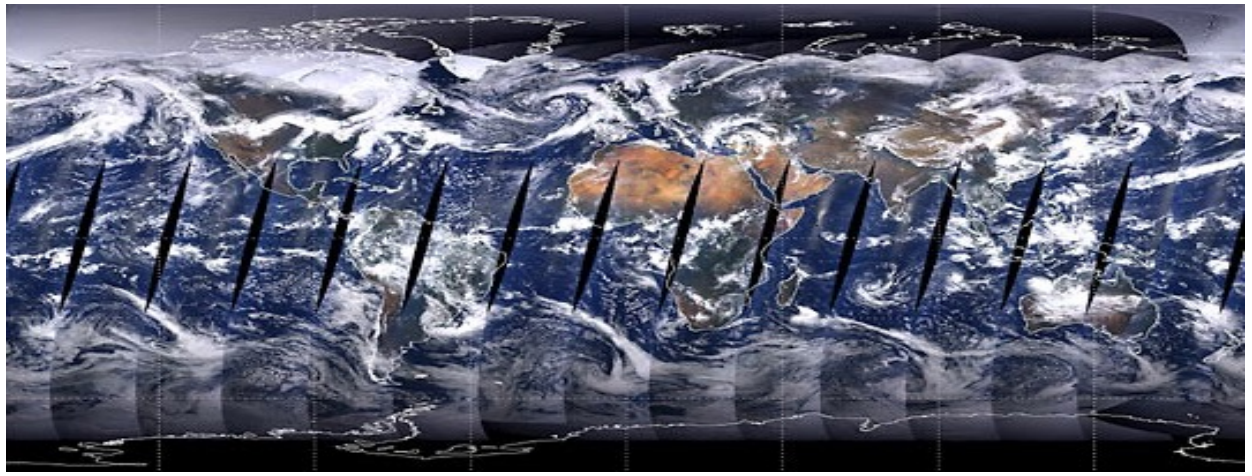
G = 0.55 µm

B = 0.47 µm



Moderate Resolution Imaging Spectroradiometer

- MODIS
  - Spatial Resolution:
    - 250 m, 500 m, 1 km
  - Platform(s):
    - Terra & Aqua
  - Temporal Resolution:
    - 2000 – Present
    - Daily, 8-day, 16-day, monthly, quarterly, yearly
  - Data Format:
    - Hierarchal Data Format – Earth Observing System (HDF-EOS)



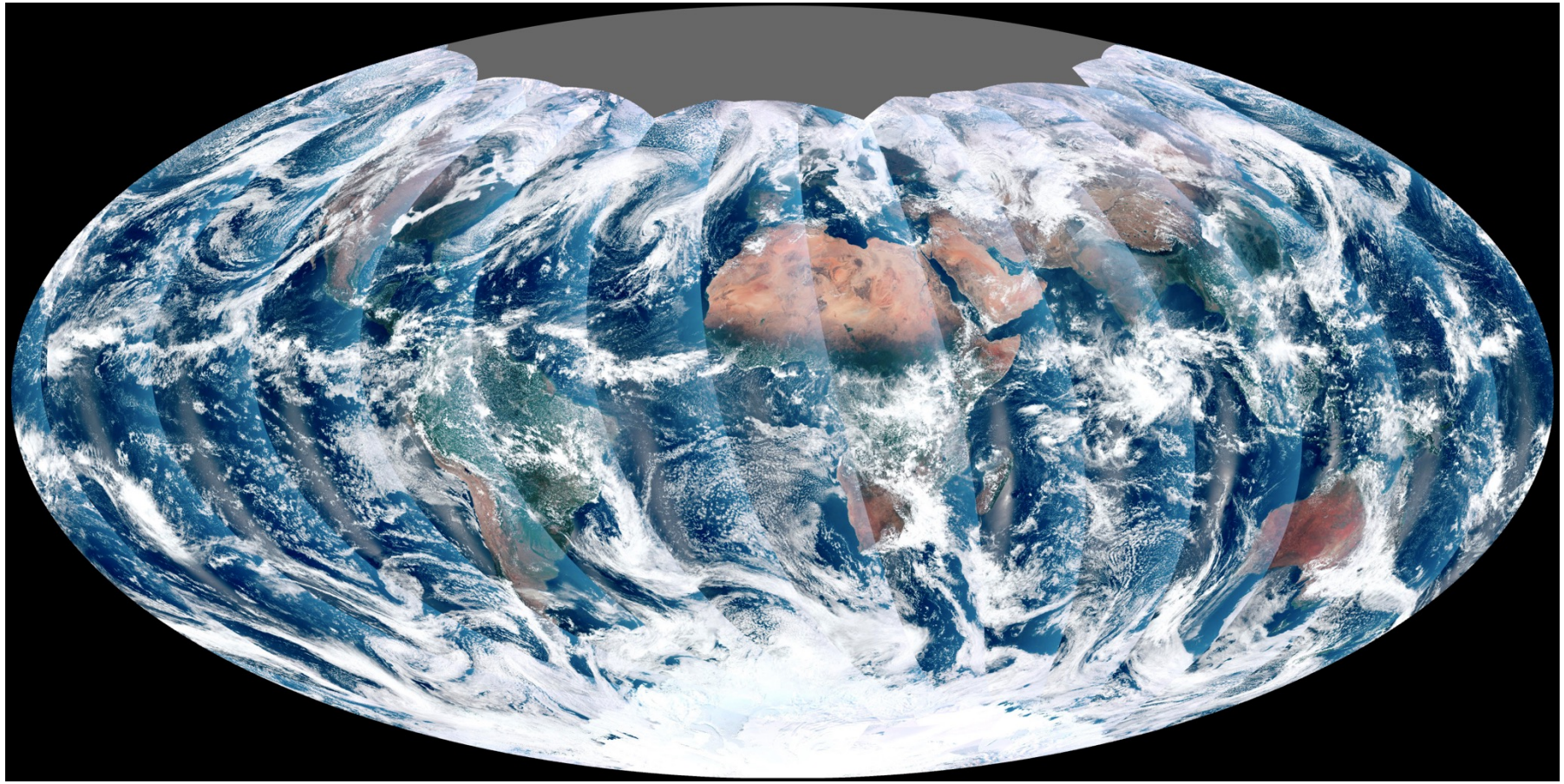
  - Spectral Coverage:
    - 36 Bands (major bands include red, blue, IR, NIR, MIR)
      - Bands 1-2: 250 m
      - Bands 3-7: 500 m
      - Bands 8-36: 1,000 m

MODIS Reflected Solar Bands

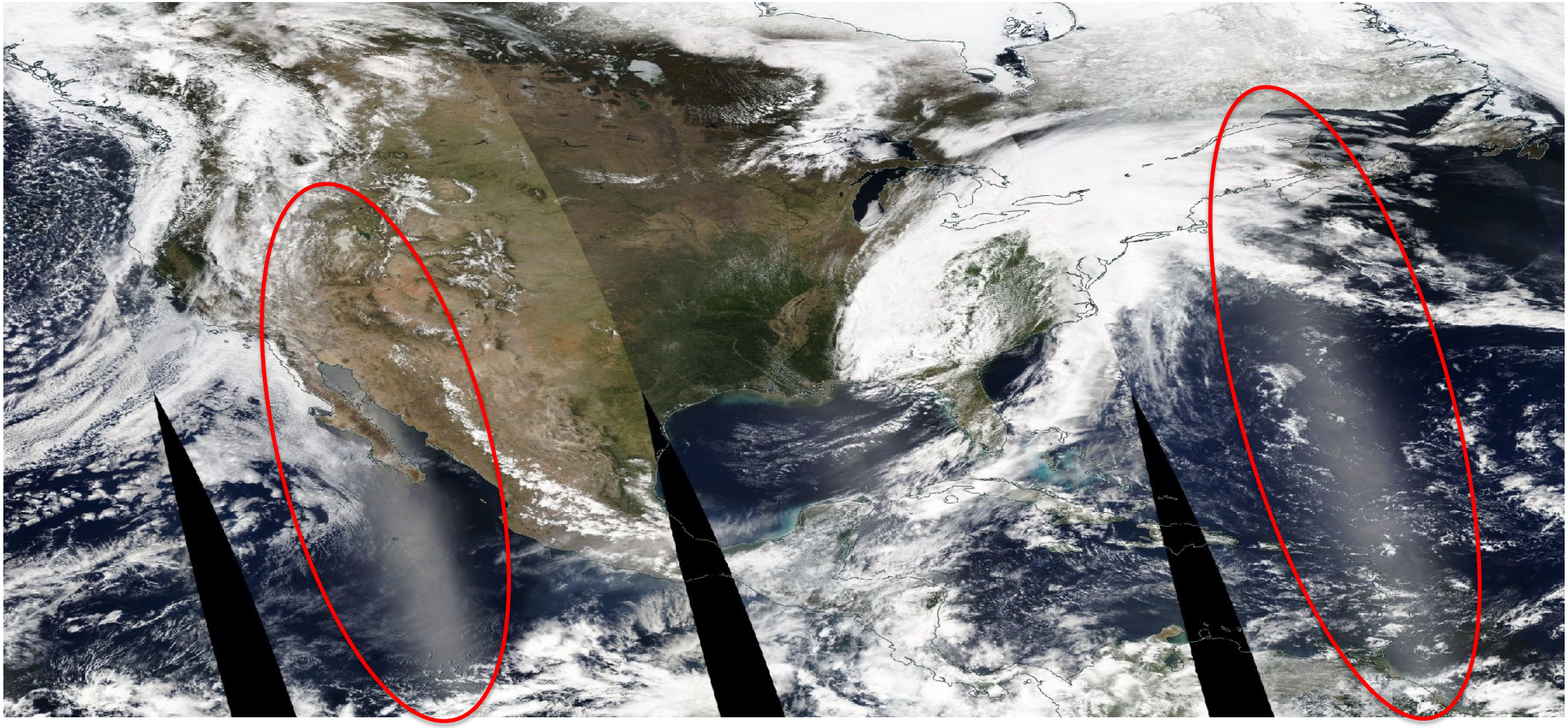
	Primary Use	Band No.	Bandwidth (nm)
250 m	Land/Cloud Boundaries	1**	620-670
		2**	841-876
500 m	Land/Cloud Properties	3*	459-479
		4*	545-565
		5*	1230-1250
		6*	1628-1652
		7*	2105-2155
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420
		9	438-448
		10	483-493
		11	526-536
		12	546-556
		13	662-672
		14	673-683
		15	743-753
		16	862-877
	Atmospheric Water Vapor	17	890-920
		18	931-941
		19	915-965

* 500m Spatial Resolution
** 250m Spatial Resolution

VIIRS Image

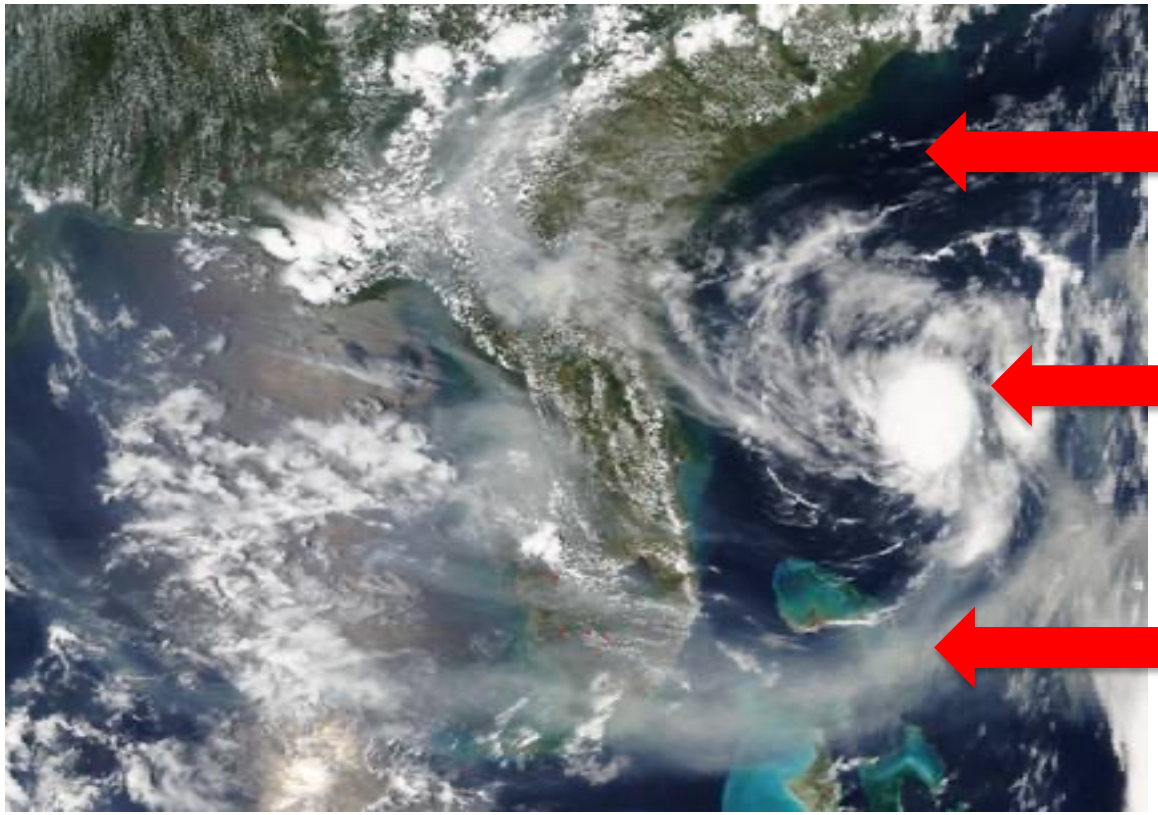


Glint



Doing More with Satellite Imagery

If we understand the physics of how particular wavelengths interact with objects, we can create images to emphasize what we want to see.

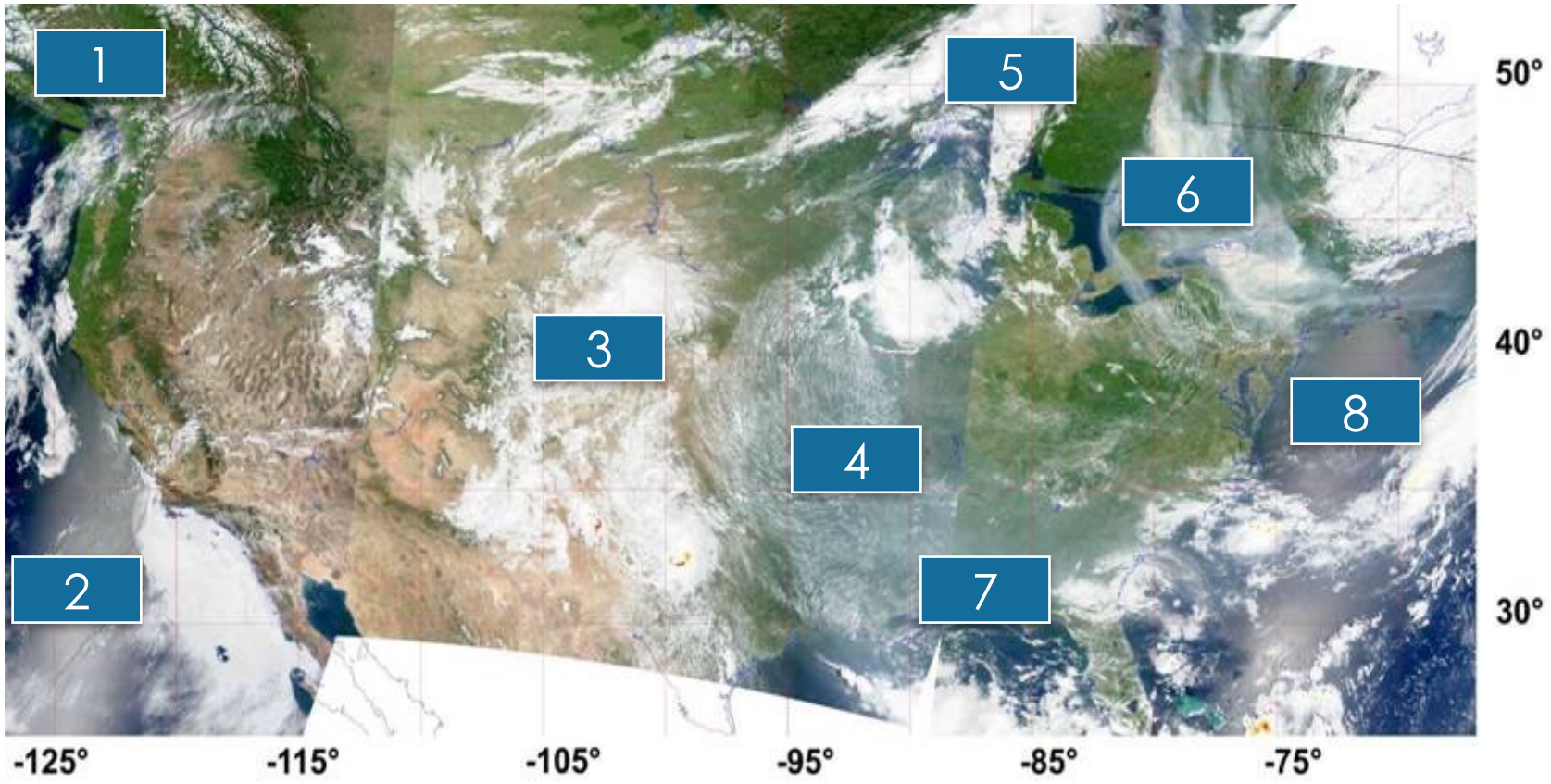


In visible imagery, water is dark because it absorbs most of the energy.

Clouds are white because they reflect most incoming energy.

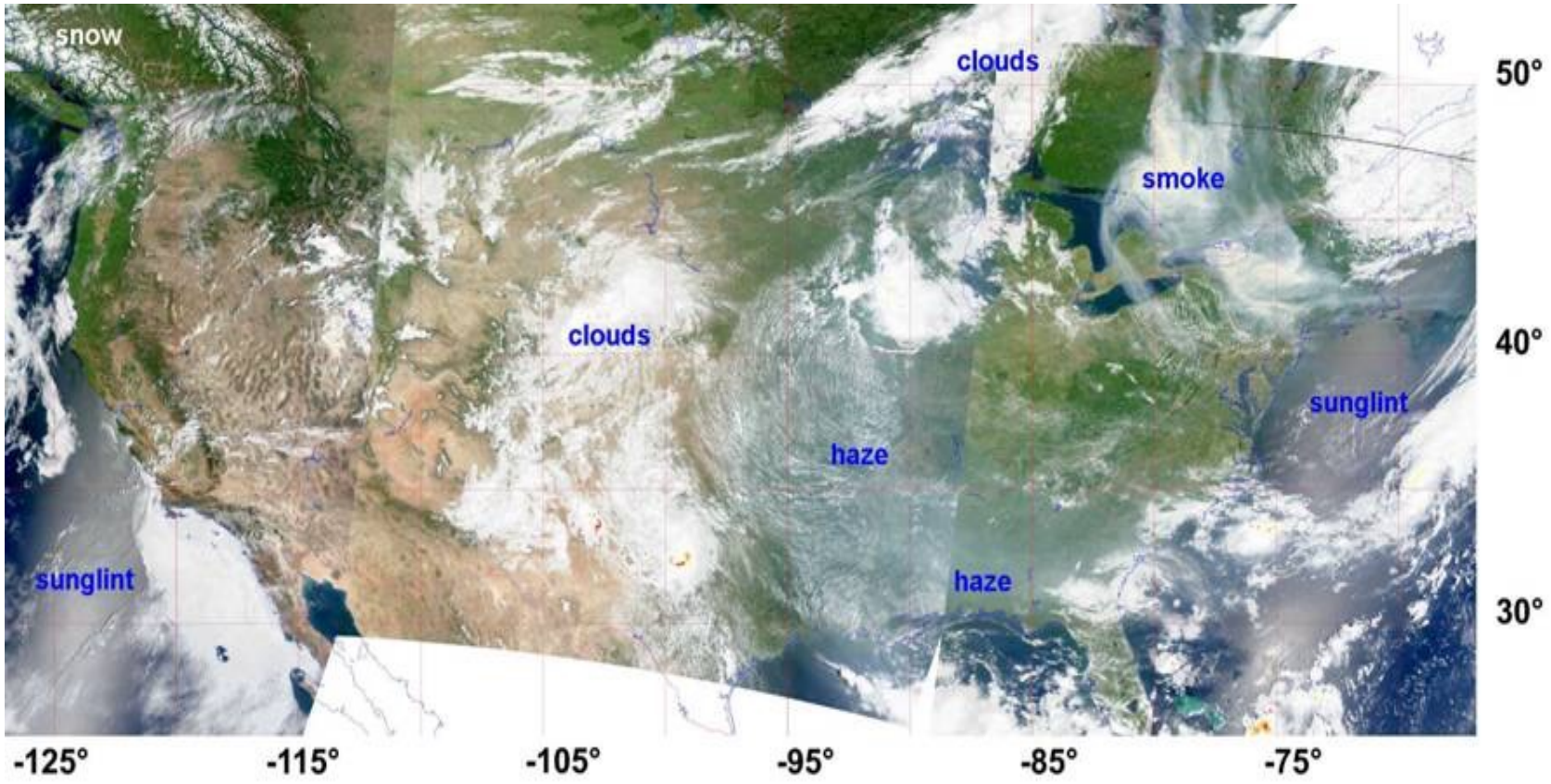
Pollution is hazy depending on its absorption properties.

What can we learn from true color imagery?



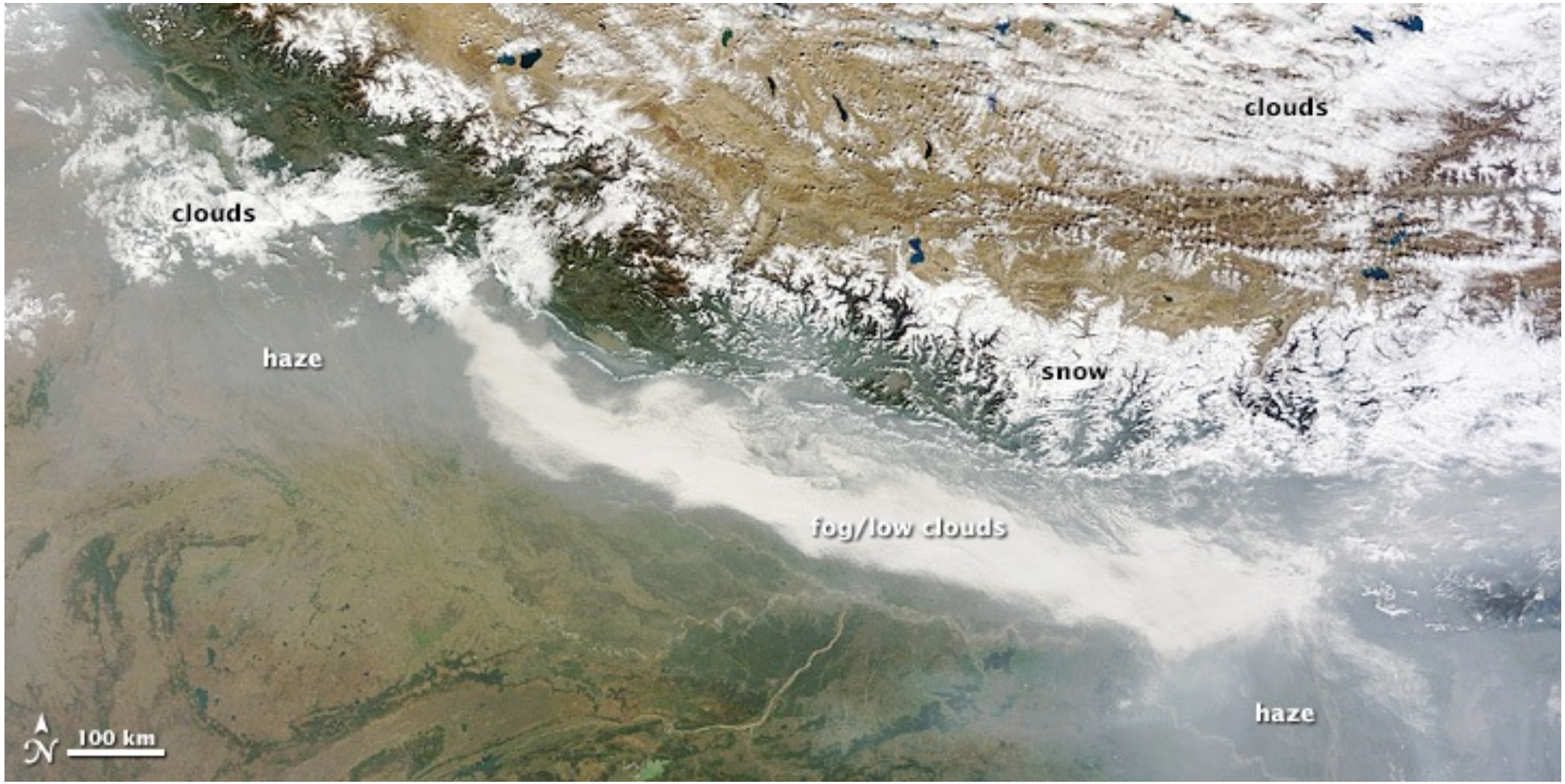
(Possible) identification of land, ocean, and atmosphere features

What can we learn from true color imagery?



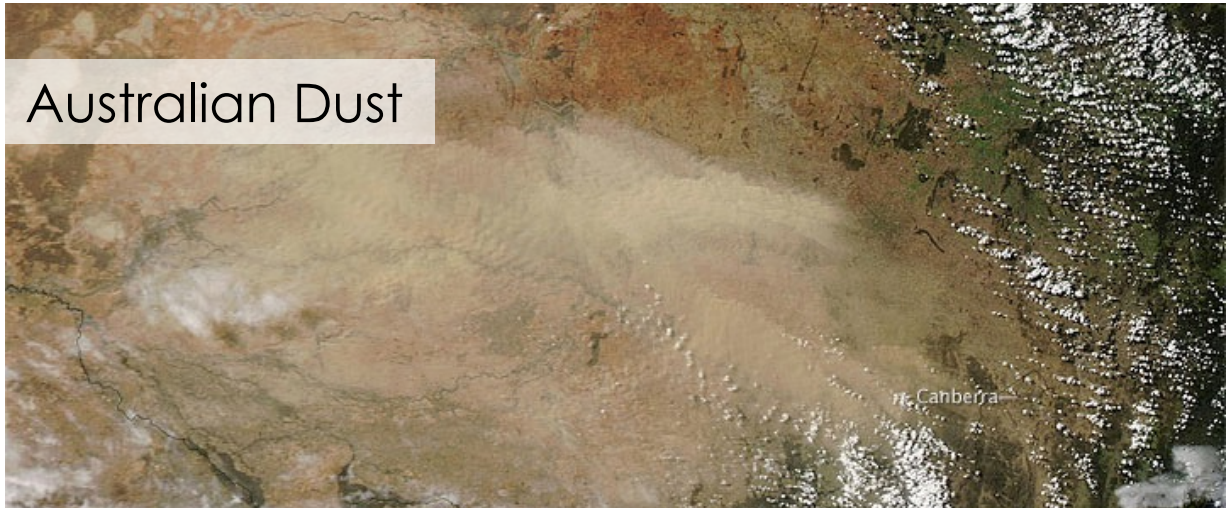
(Possible) identification of land, ocean, and atmosphere features

Features in True Color (Atmosphere)



Feature Identification

More reliable when a clear source is in the image

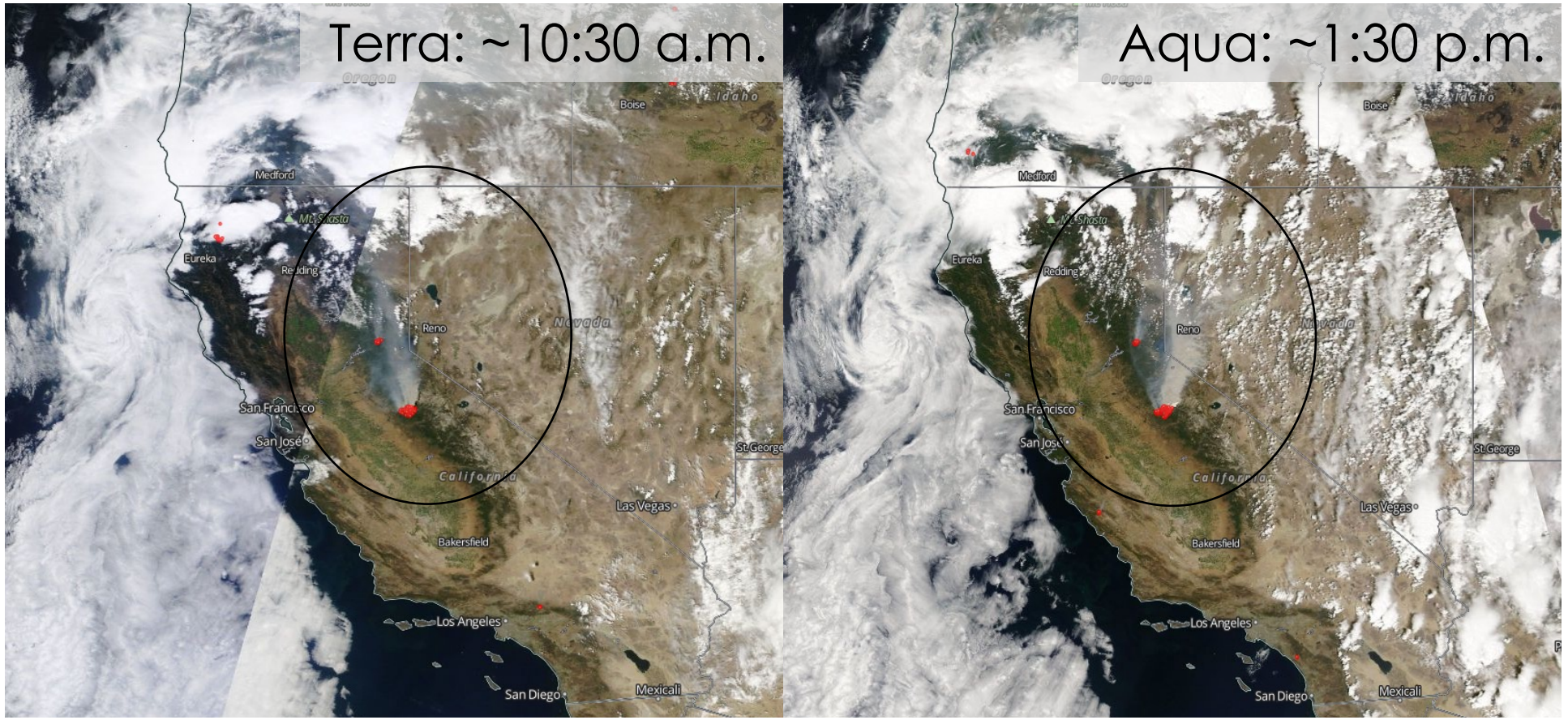


Feature Identification

More reliable when a clear source is in the image

Using Time Series Imagery

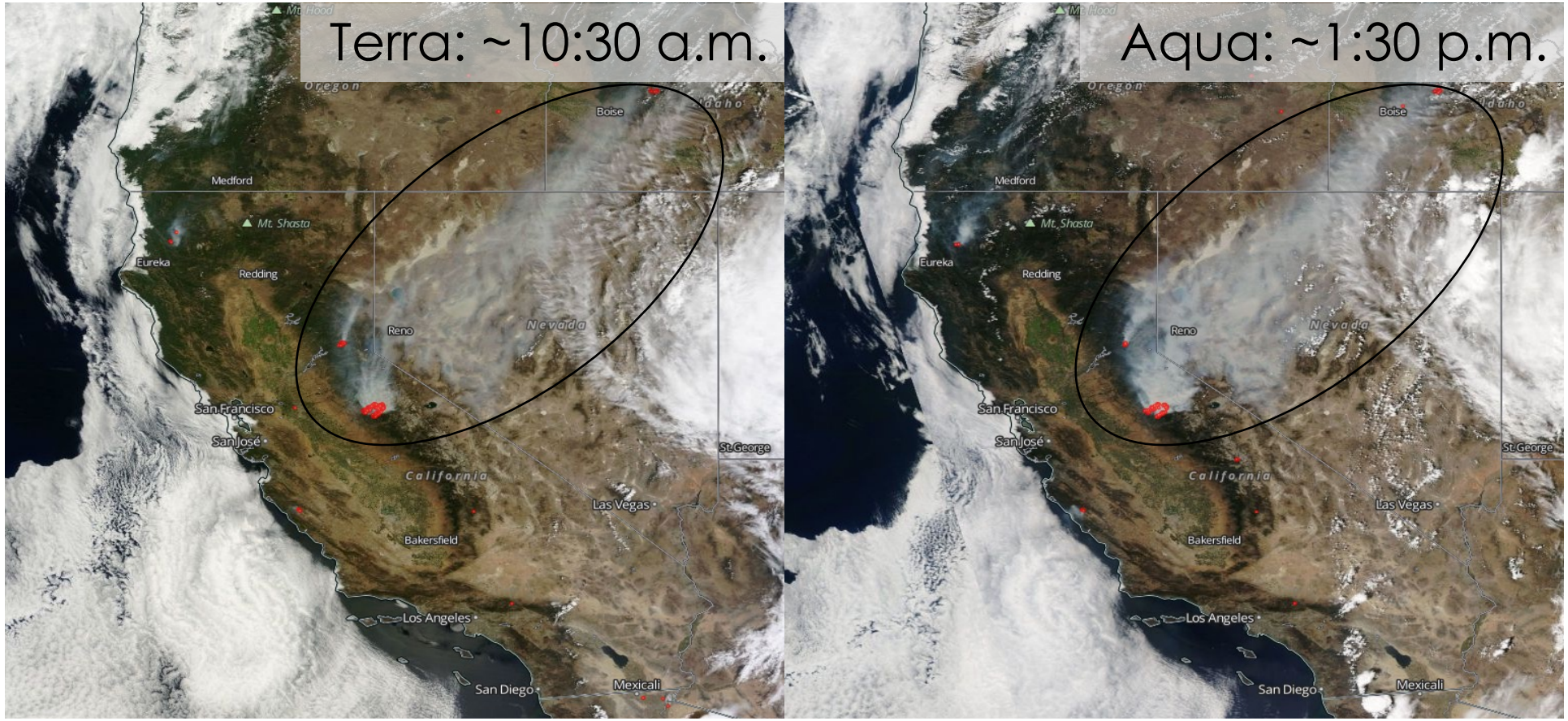
Smoke Transport – Rim Fire



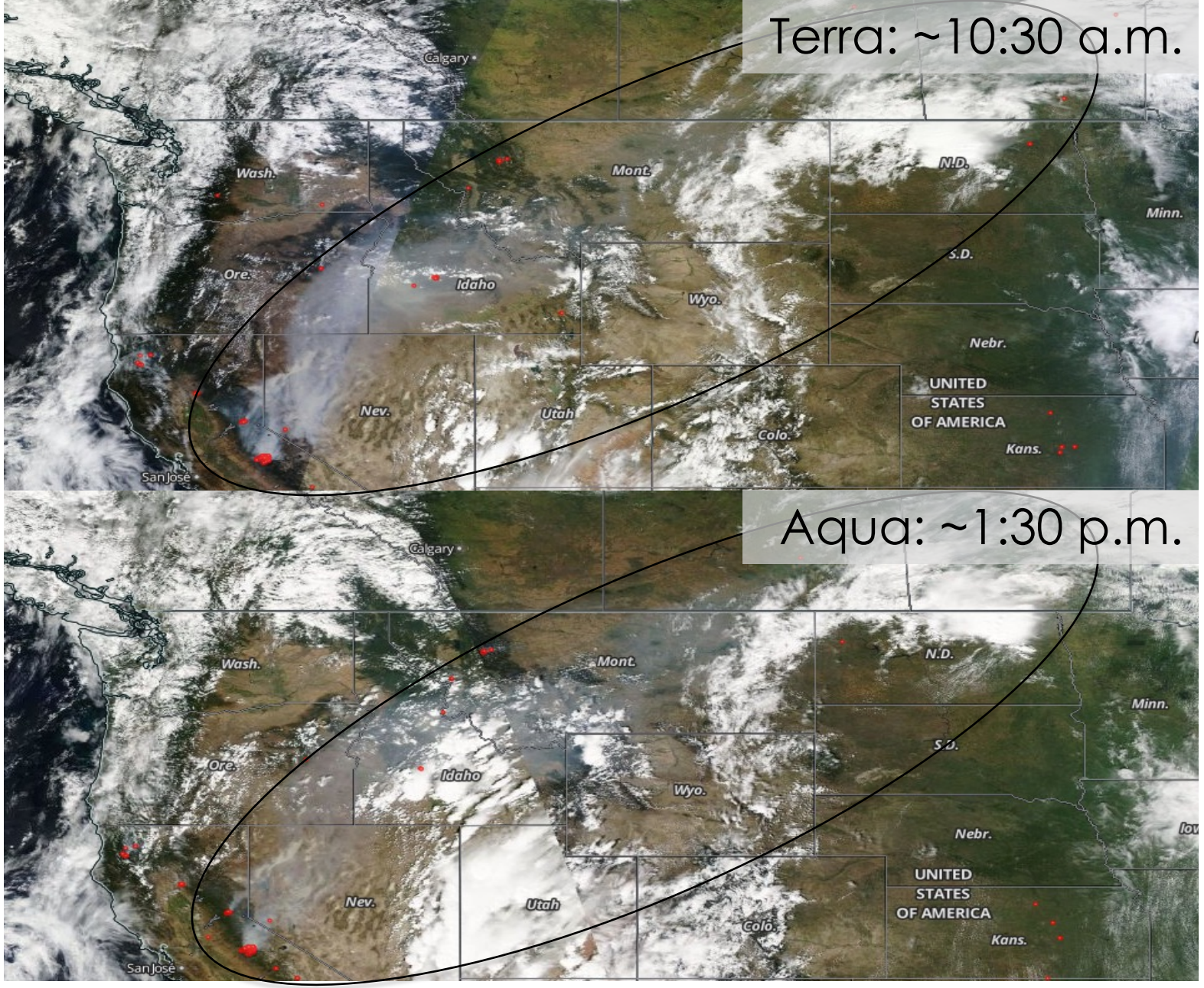
August 22, 2013; Images from NASA Worldview

Using Time Series Imagery

Smoke Transport – Rim Fire

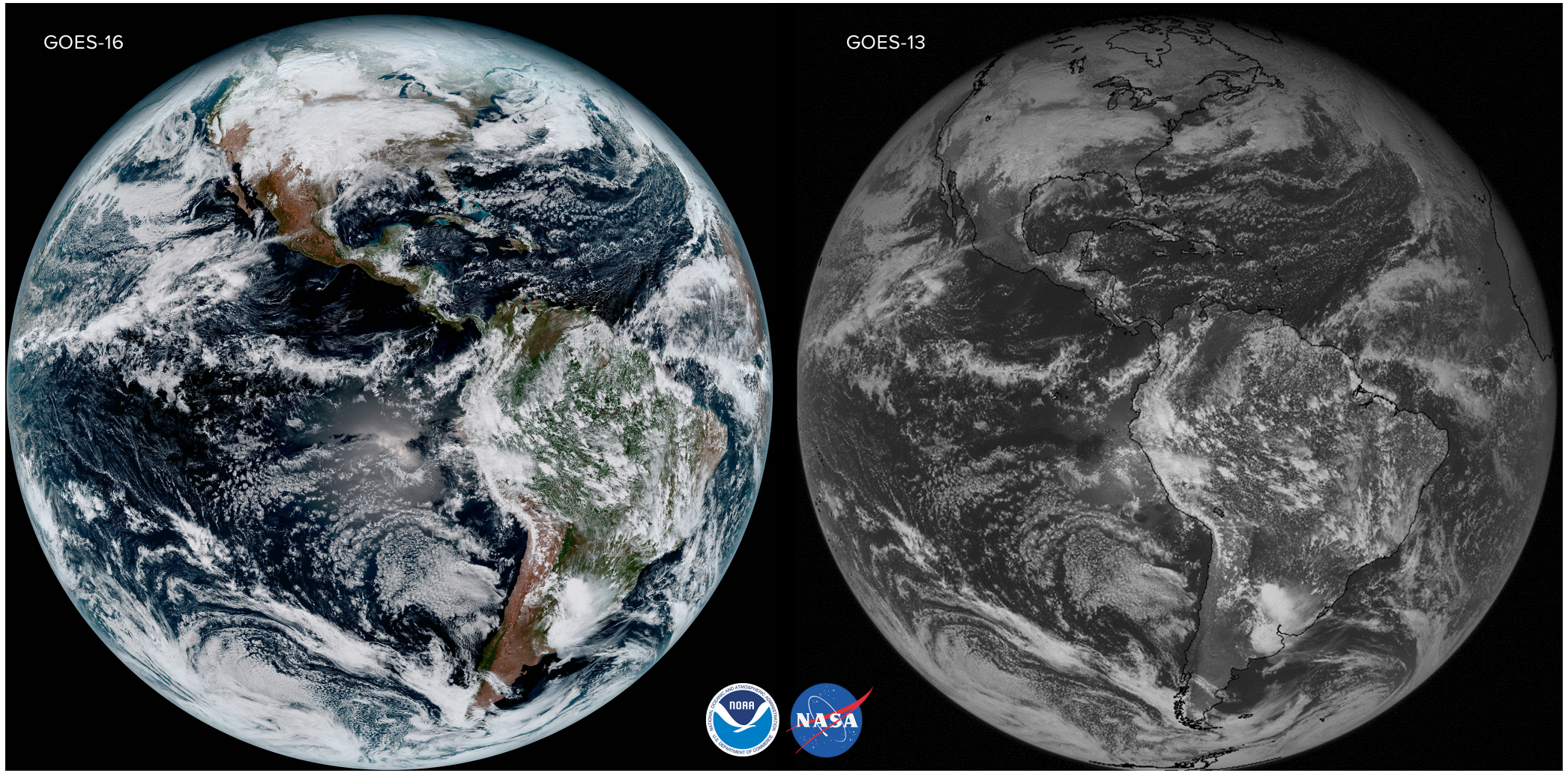


August 23, 2013; Images from NASA Worldview



August 24, 2013; Images from NASA Worldview

Geostationary Observations – GOES-16 (East)



Source: http://rammb-slider.cira.colostate.edu

GOES-16: Smoke Transport over the Northwest

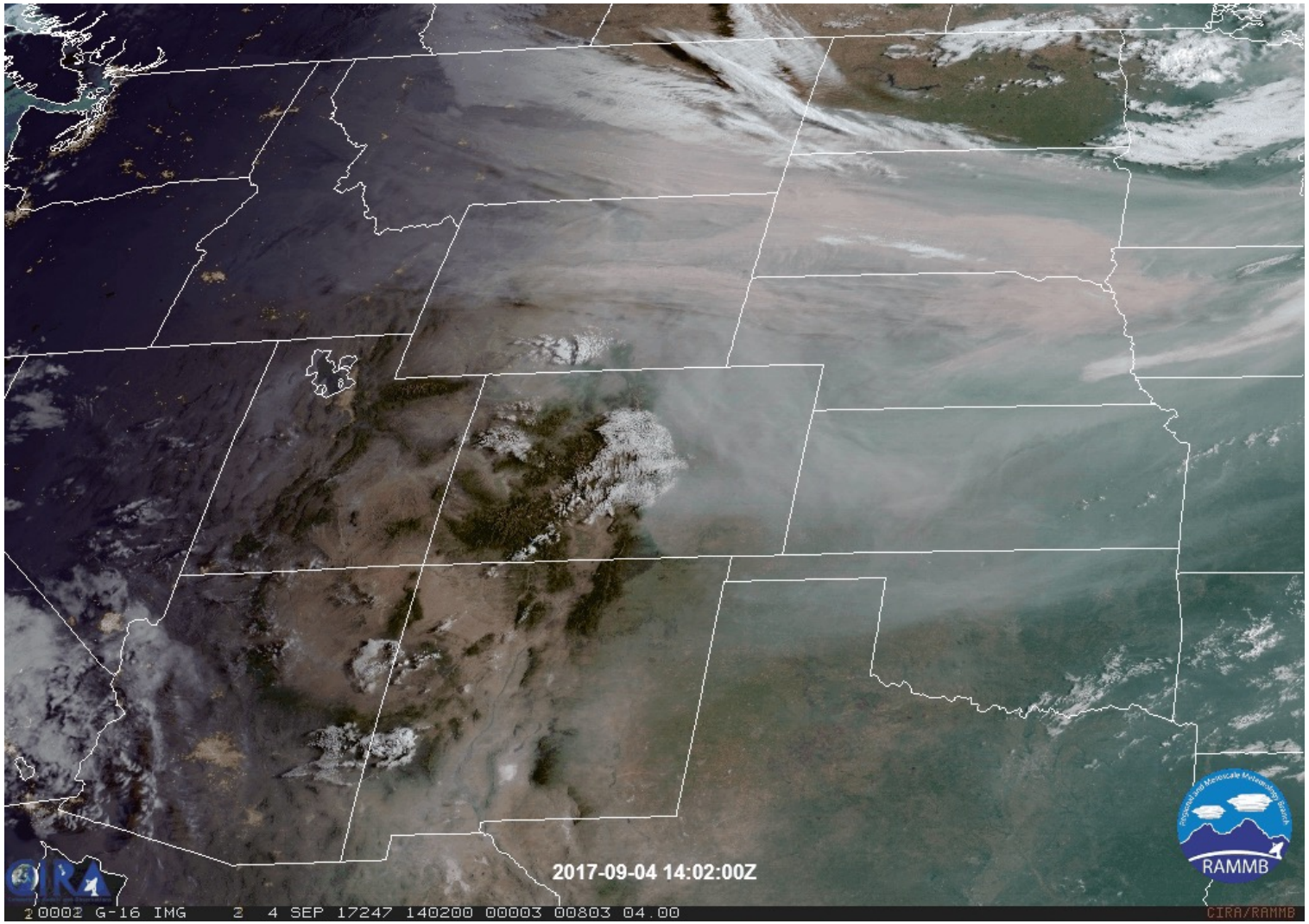


Image: RMMB

GOES-16 Loop: Dust

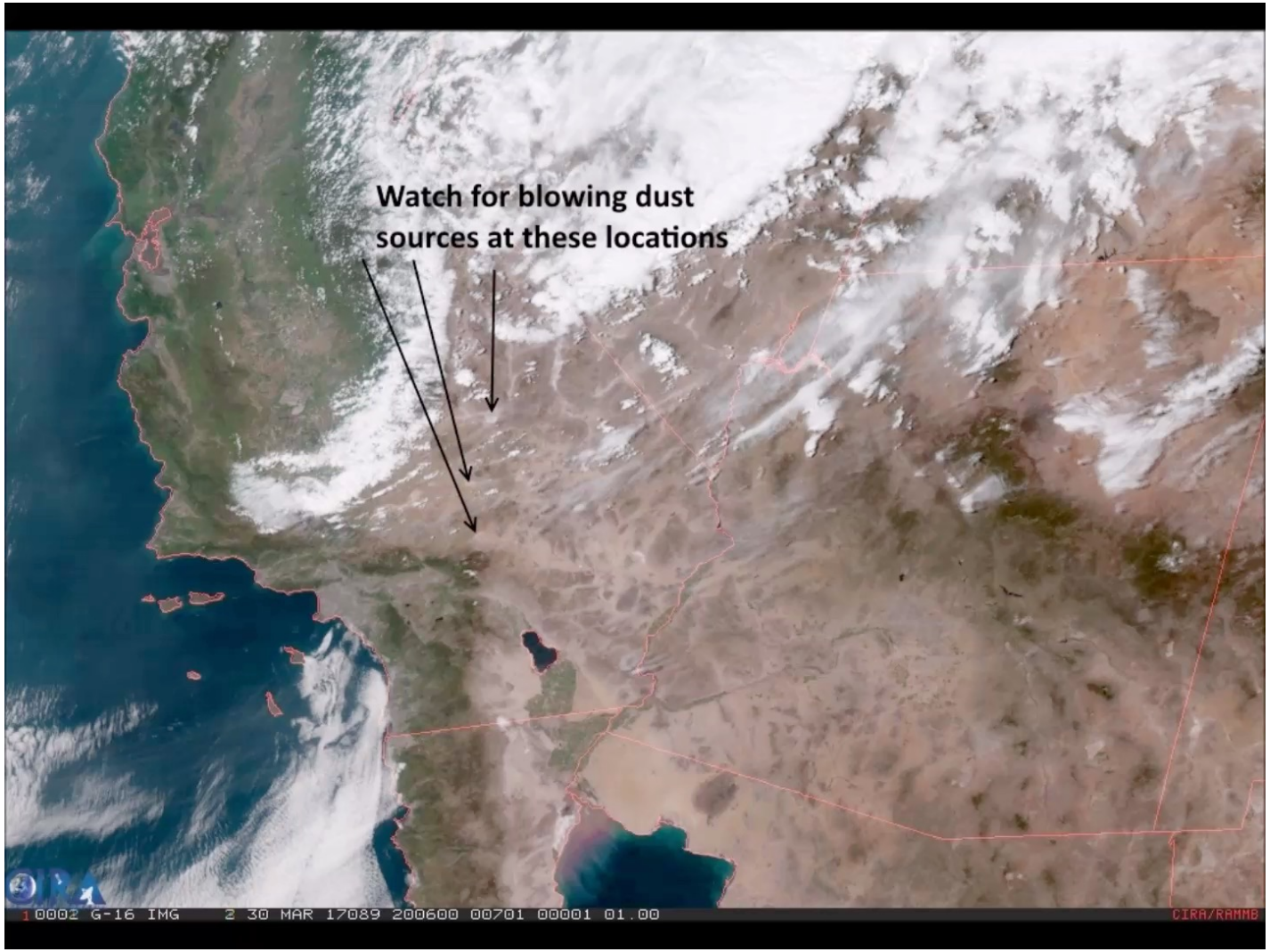


Image: RMMB

GOES-16 Loop: Smoke Over the Southeast U.S.

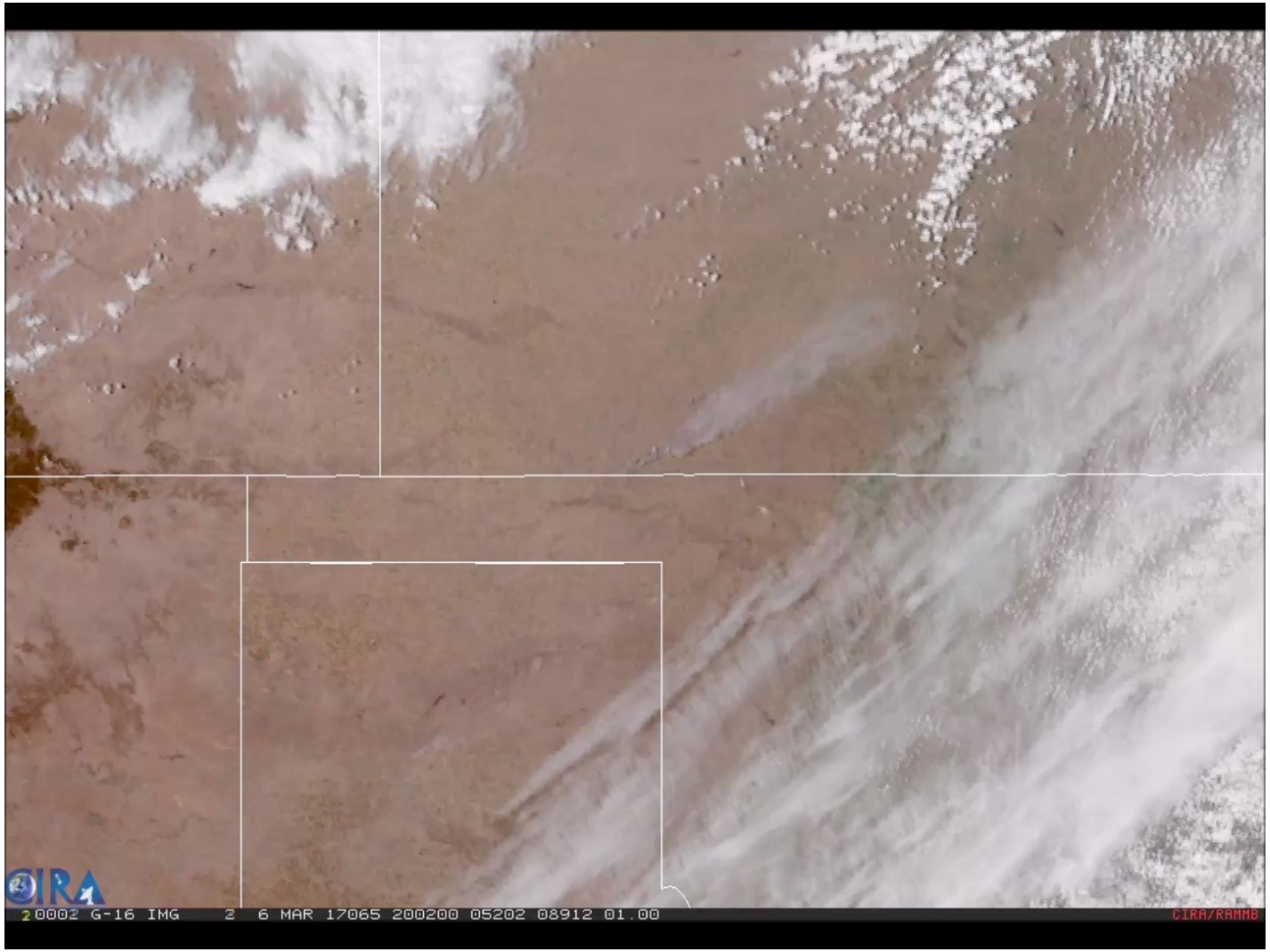
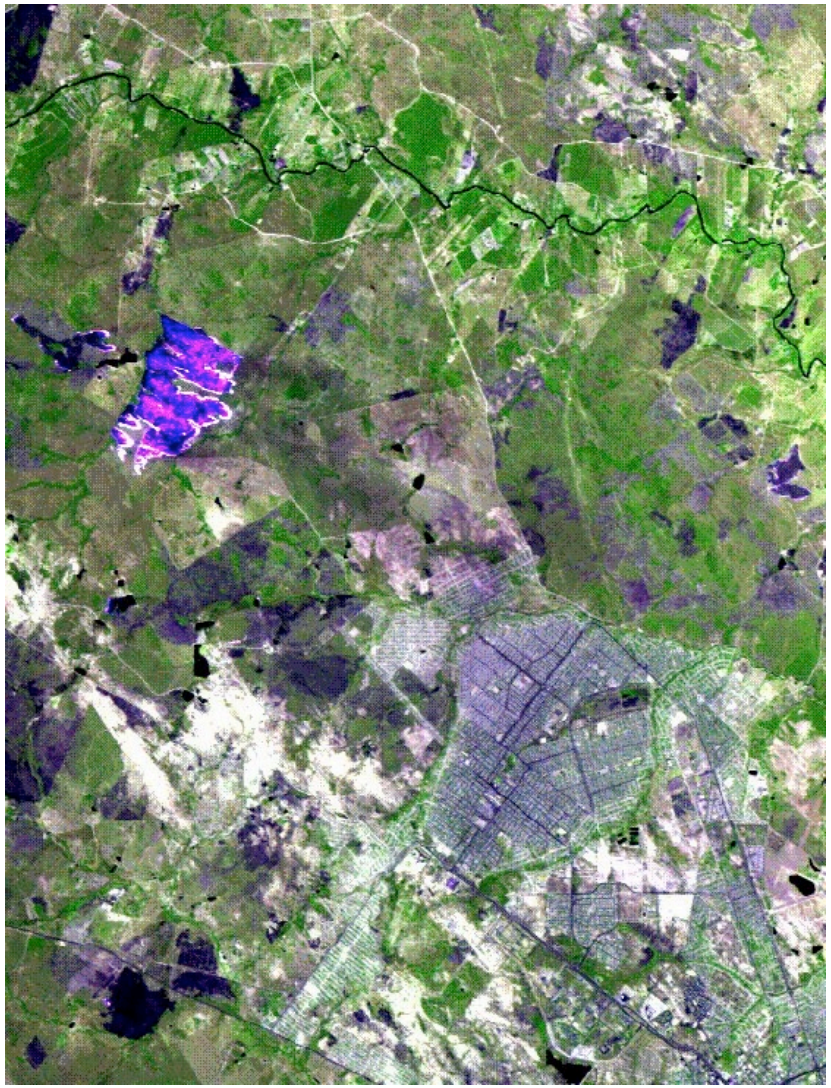


Image: RMMB

False Color Images

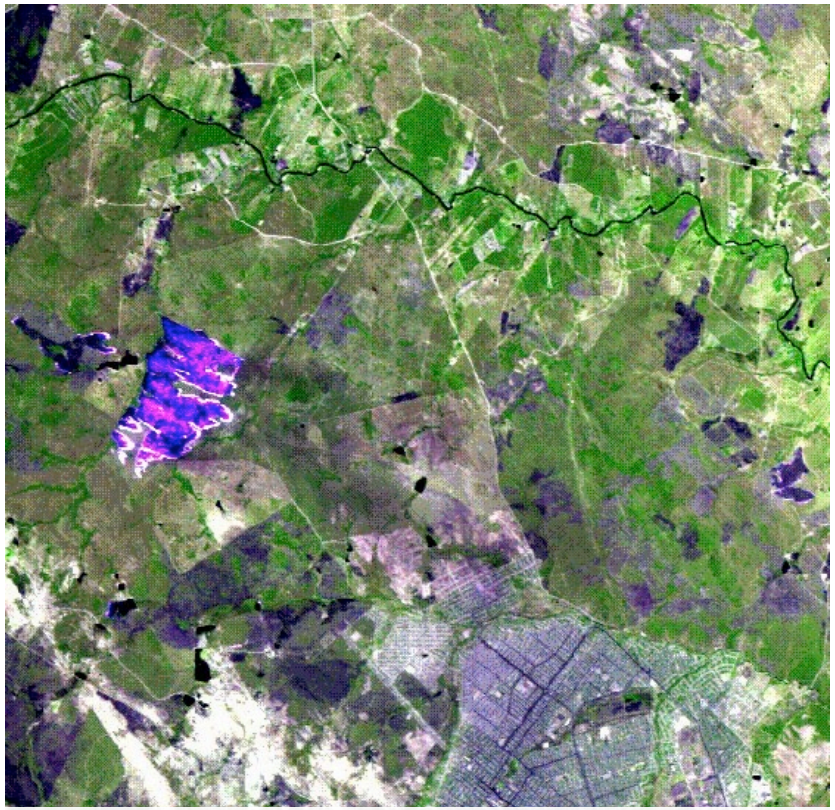
- Load bands into the red, green, and blue display channels
- Do not correspond to the visible red, green, and blue wavelengths

R = 1.6 µm
G = 1.2 µm
B = 2.1 µm



True vs. False Color Images

R = 0.66 µm
G = 0.55 µm
B = 0.47 µm



R = 1.6 µm
G = 1.2 µm
B = 2.1 µm

Change in Vegetation Color from Space

Earth Observatory Story

An article on feature detection in an image:

http://earthobservatory.nasa.gov/Features/ColorImage/page2.php

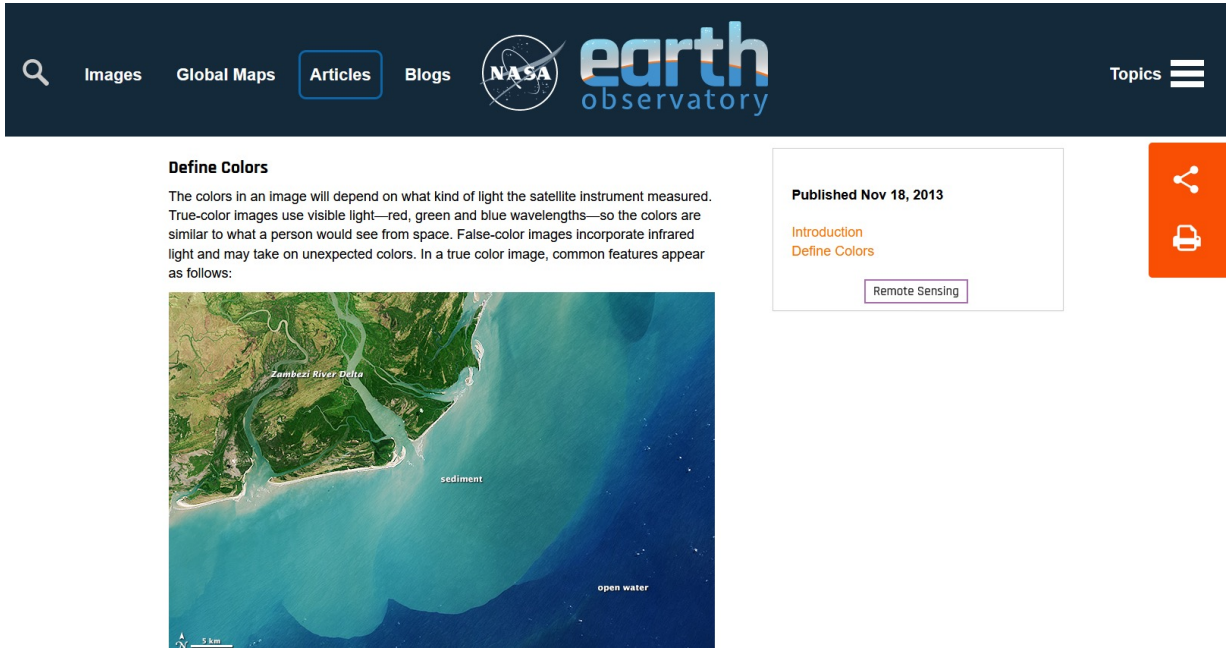


Image Archive and Gallery Links

- ARSET Satellite Imagery Overview and Links
  - http://airquality.gsfc.nasa.gov/
- NASA's Land, Atmosphere Near real-time Capability for EOS (LANCE)
  - https://lance.modaps.eosdis.nasa.gov/
- NASA's Visible Earth
  - http://visibleearth.nasa.gov
- NASA's Earth Observatory
  - http://earthobservatory.nasa.gov
- NASA's Earth Observations (NEO)
  - https://earthobservatory.nasa.gov/
- MODIS-Atmos (MODIS Atmosphere Product Reference Site)
  - http://modis-atmos.gsfc.nasa.gov/IMAGES/index.html

Data Processing Levels

L0: Raw Instrument Data

L1: Geolocated & Calibrated

L2: Products Derived from L1B

L3: Gridded

L4: Model Output: Derived Variables

Harder to Use

Easier to Use

Data Levels

Orbital Data (Levels 0, 1, 2)

- More user control
- Highest spatial/temporal resolution
- Harder to use

Gridded Data Products (Levels 3, 4)

- Less user control
- Lower spatial/temporal resolution, but gridded
- May be available at multiple spatial/temporal resolutions
- More web tools available for analysis and access
- Easier to use

Aerosol Data Product Hierarchy

Level 1 Products

- Raw data with and without applied calibration
- No aerosol data

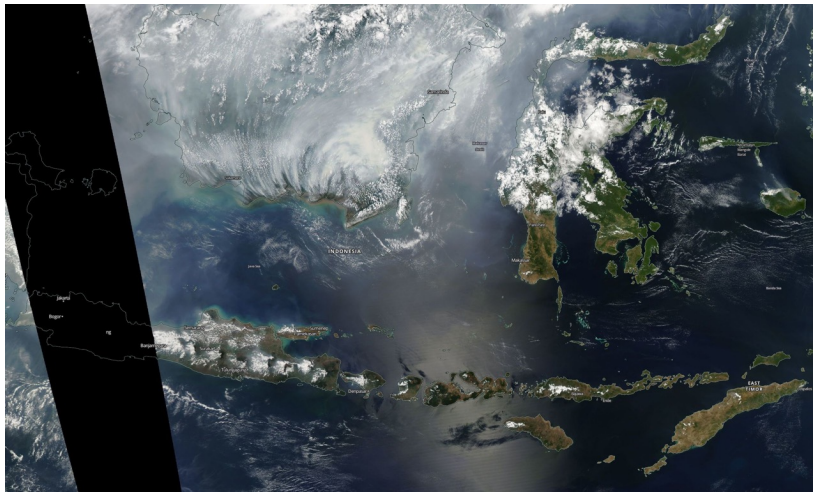
Level 2 Products

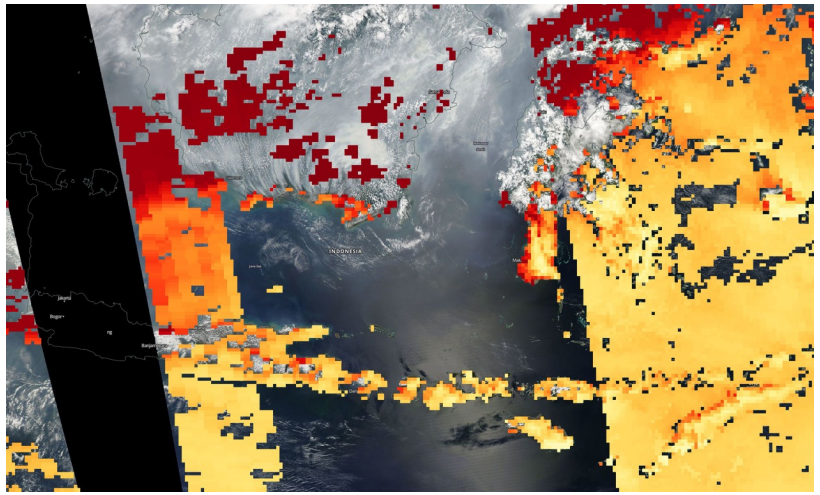
- Geophysical products
- Aerosol data

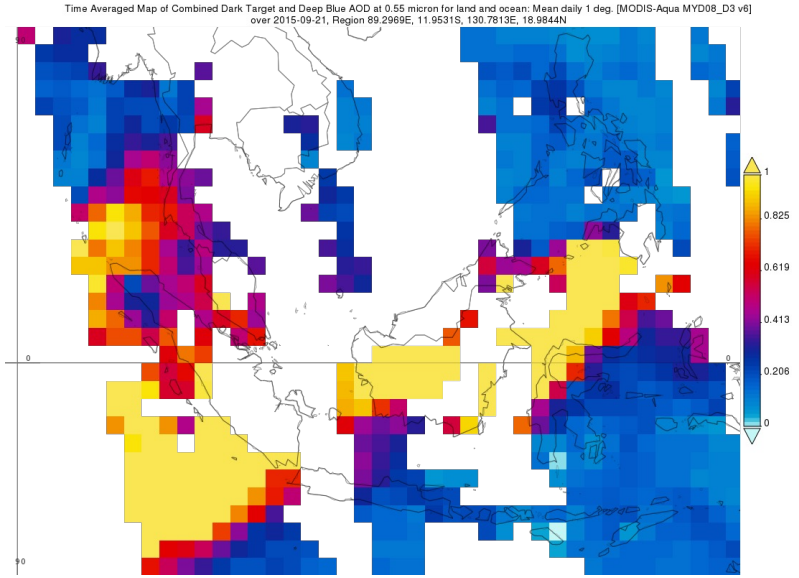
Level 3 Products

- Globally gridded geophysical products
- Aerosol data

Levels of Data







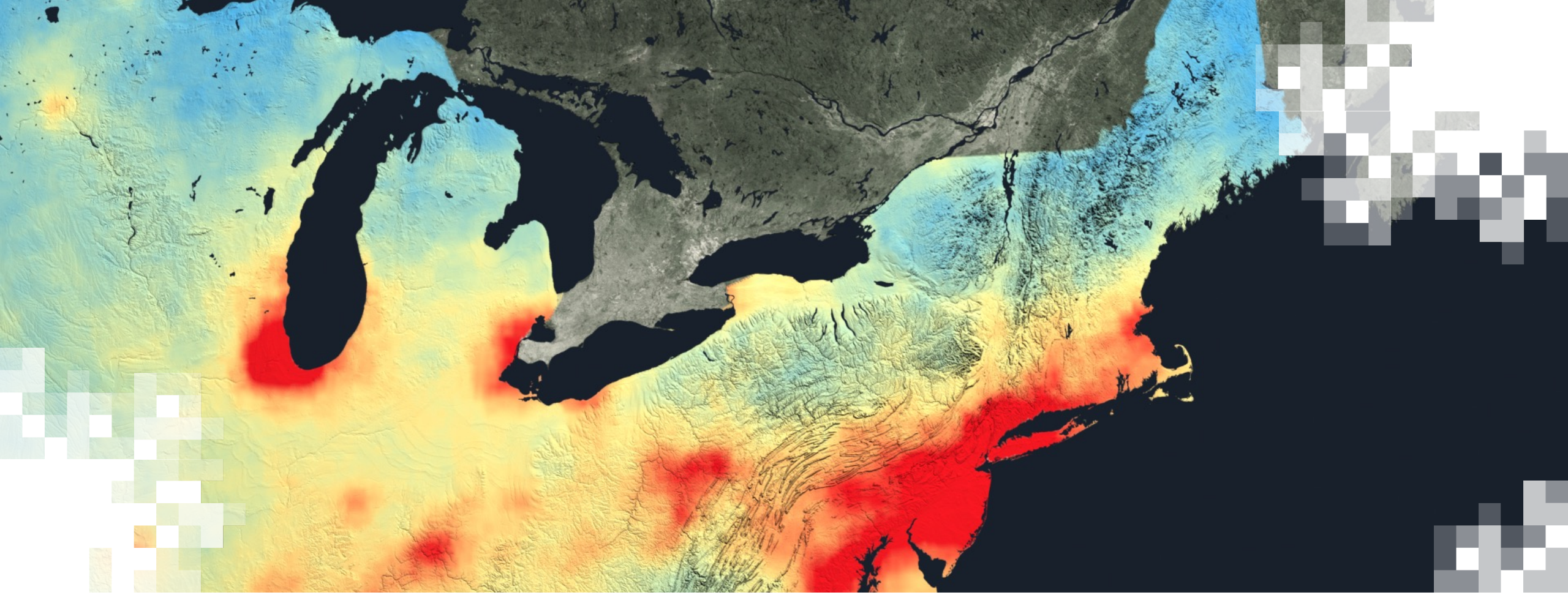
Level 1B
Calibration to Radiance

Level 2
Aerosol Retrieval Algorithm

Level 3
Spatial and Temporal Averaging

Questions & Discussion Prompts

- What are the differences between true color and false color images?
- What are three applications of true color images for air quality monitoring?
- Does access of near real-time, true color imagery provide any useful information to air quality forecasters?
- What level data would a gridded monthly average of carbon monoxide columns be considered?



Questions?