National Aeronautics and Space Administration

Satellite Imagery Access, Interpretation, and Tools for Dust, Smoke, and Pollution Monitoring

Pawan Gupta

Satellite Remote Sensing of Air Quality, 18-19 November 2018

Learning Objectives

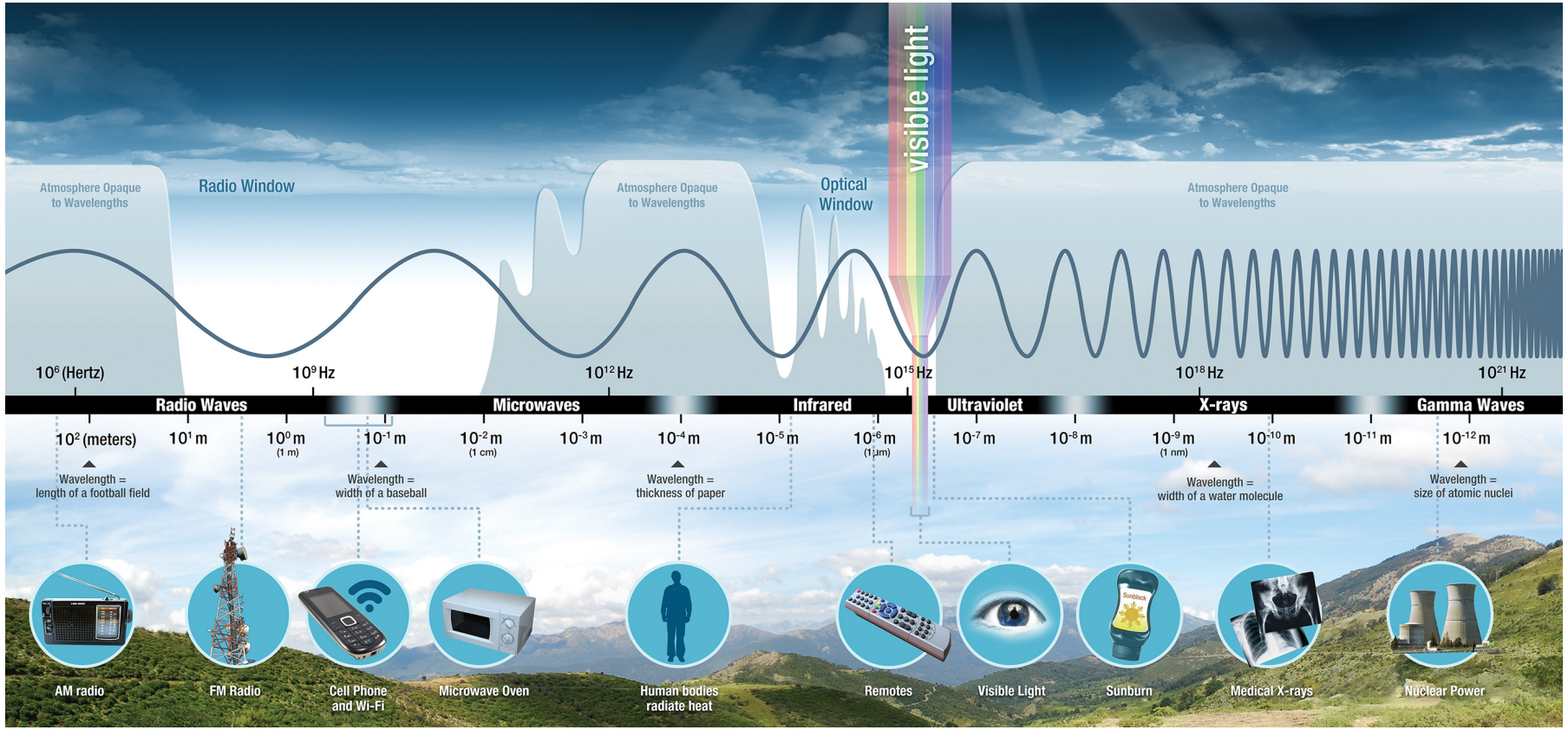
By the end of this presentation, you will be able to:

- Recognize satellite imagery, label features, and recite applications of satellite imagery
- Access and perform basic analysis of satellite imagery

Visible Image Science

- Visible satellite images are essentially photographs
- All the energy collected by the visible sensors (cameras) onboard the satellite is 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 reflected back into space (i.e. clouds appear bright)
- The lower the albedo, the more light energy is absorbed (i.e. water appears dark)

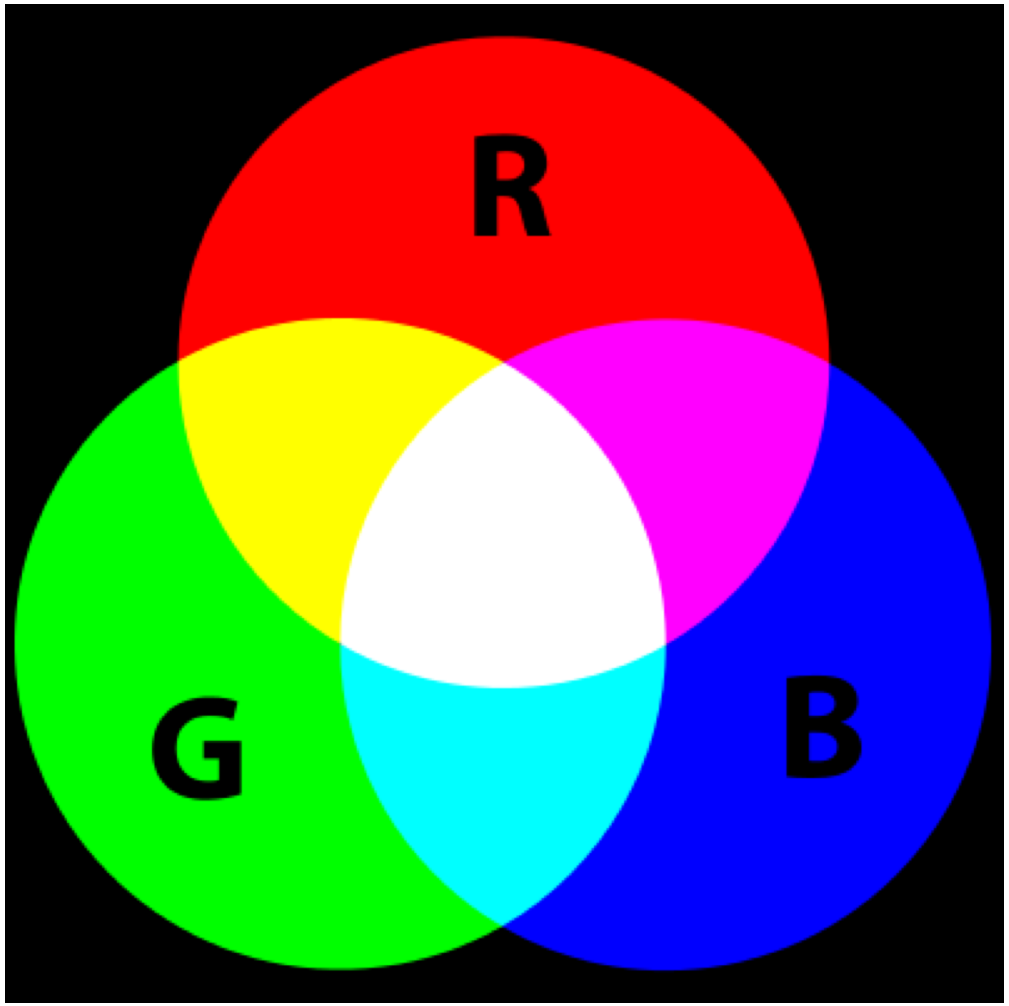
Wavelength Selection



Earth observing satellite 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



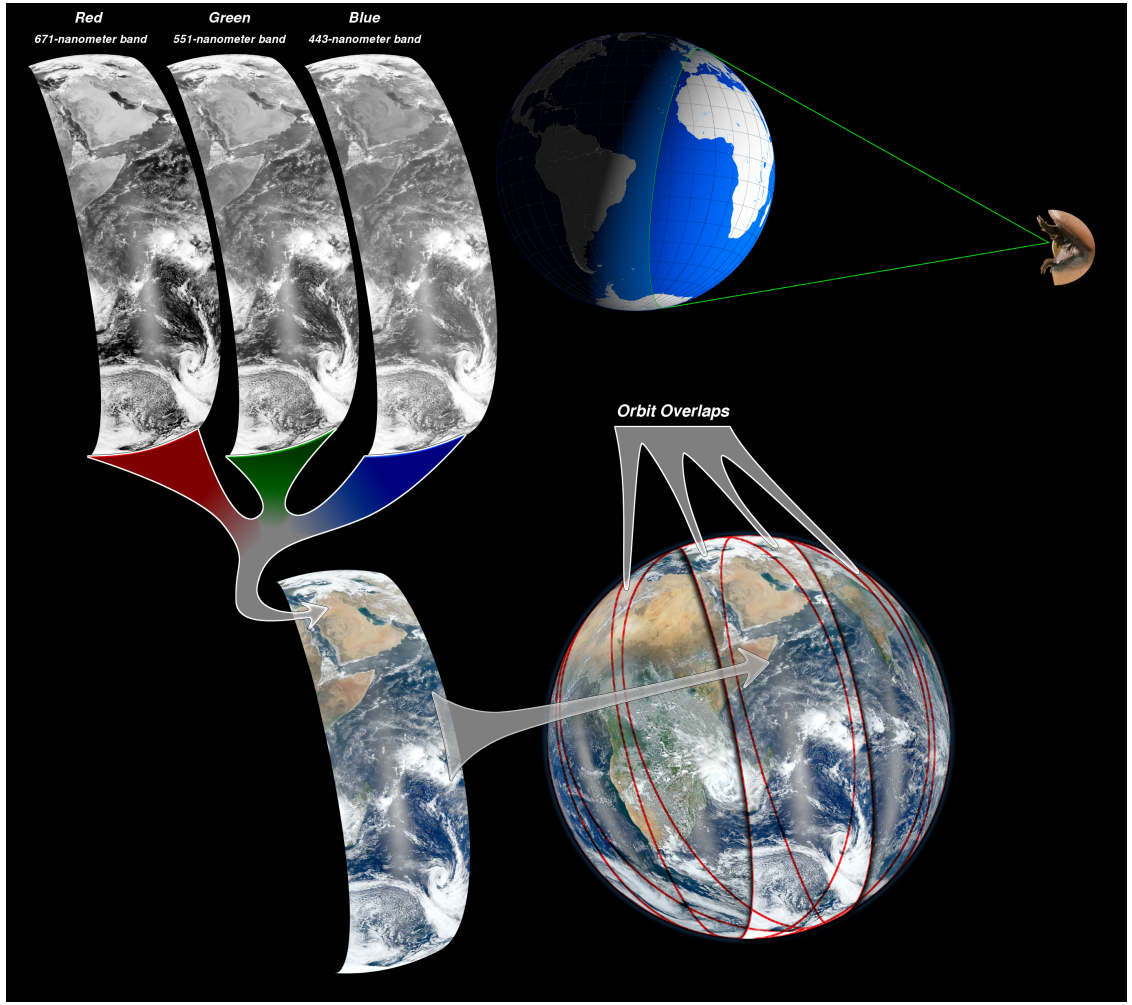
True Color Image (or RGB)

A MODIS “true color image” will use MODIS visible wavelength bands 1, 4, 3

R = 0.66 µm

G = 0.55 µm

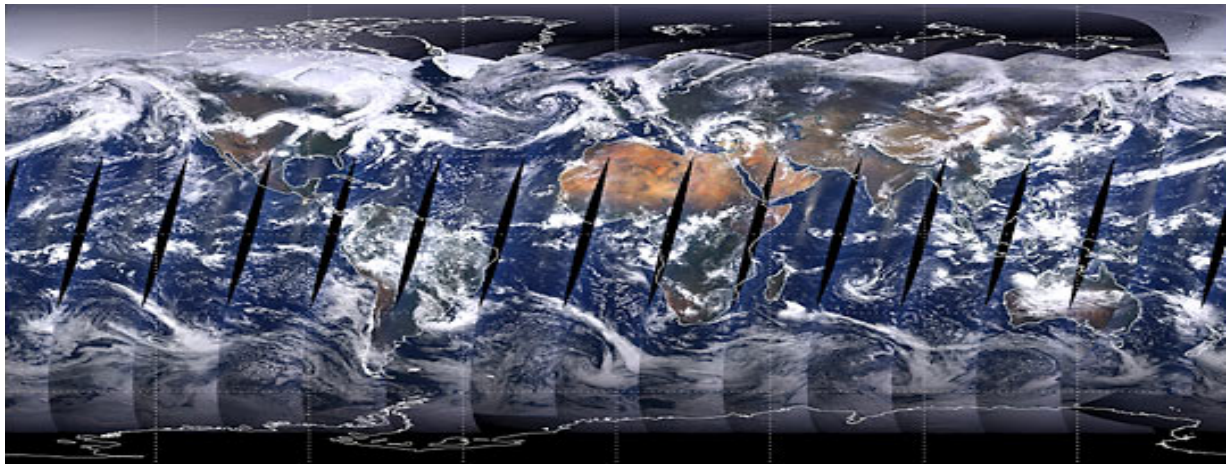
B = 0.47 µm



Moderate Resolution Imaging Spectroradiometer

MODIS

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



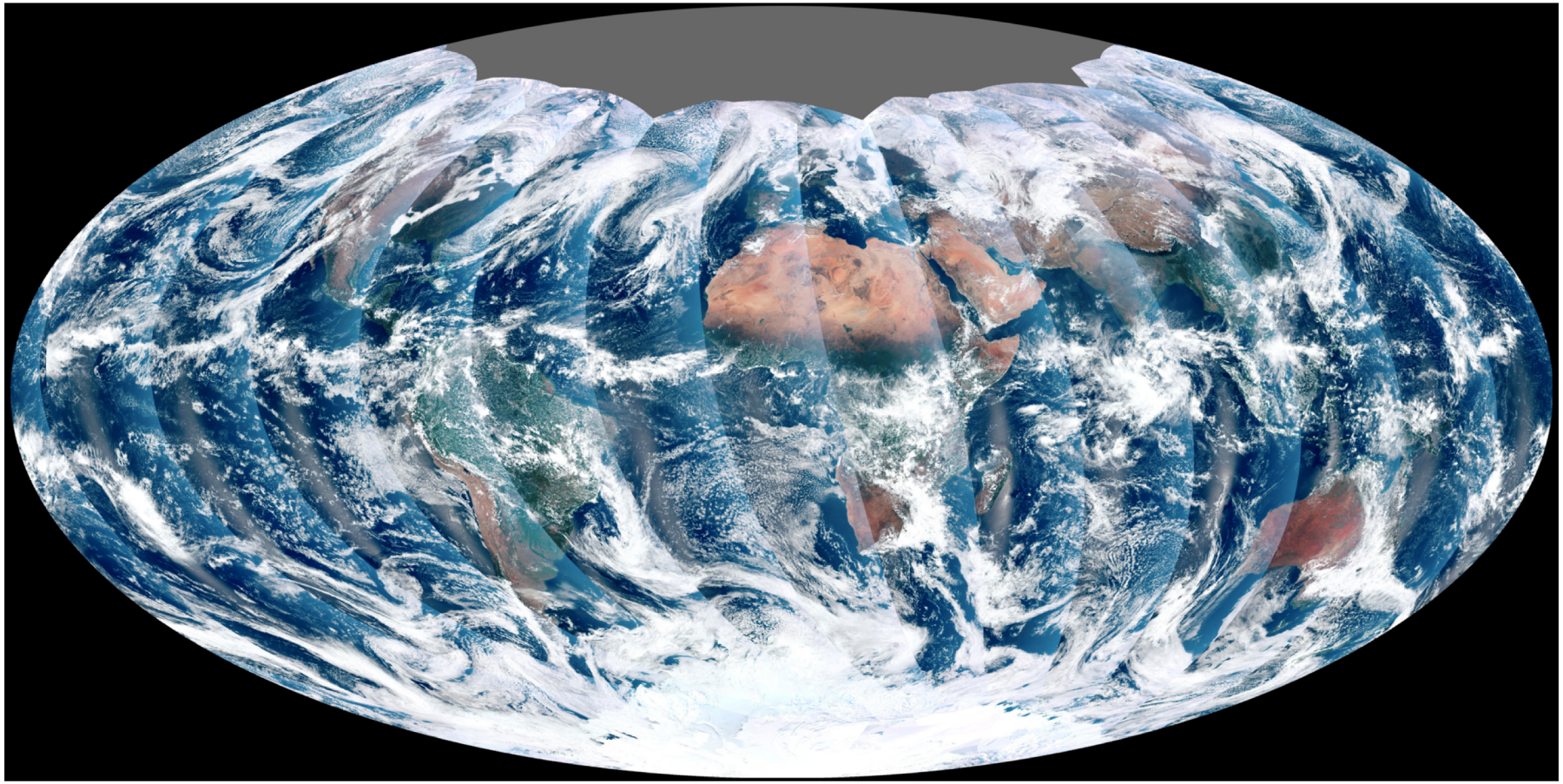
- Spectral Coverage
  - 36 bands (major bands include red, blue, IR, NIR, MIR)
    - Bands 1-2: 250 m
    - Bands 3-7: 500 m
    - Bands 8-36: 1,000 m

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

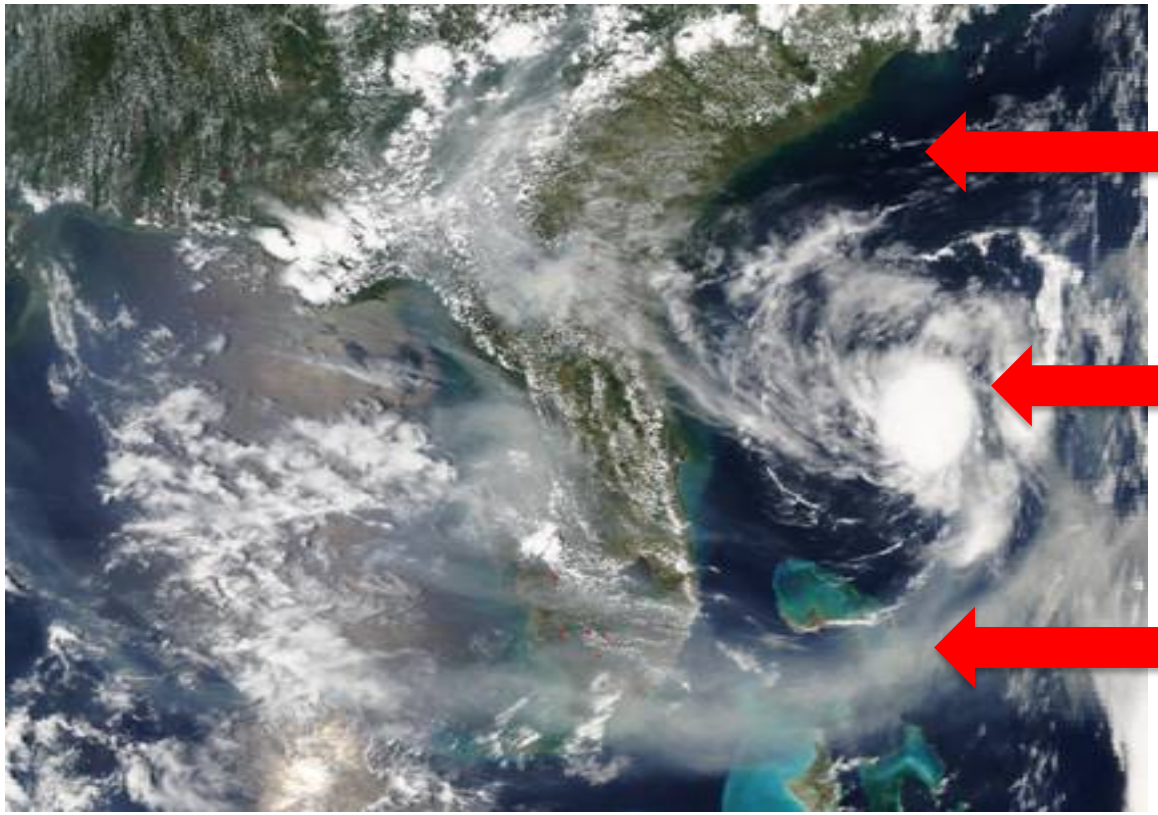
* 500m Spatial Resolution
** 250m Spatial Resolution

VIIRS Image



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

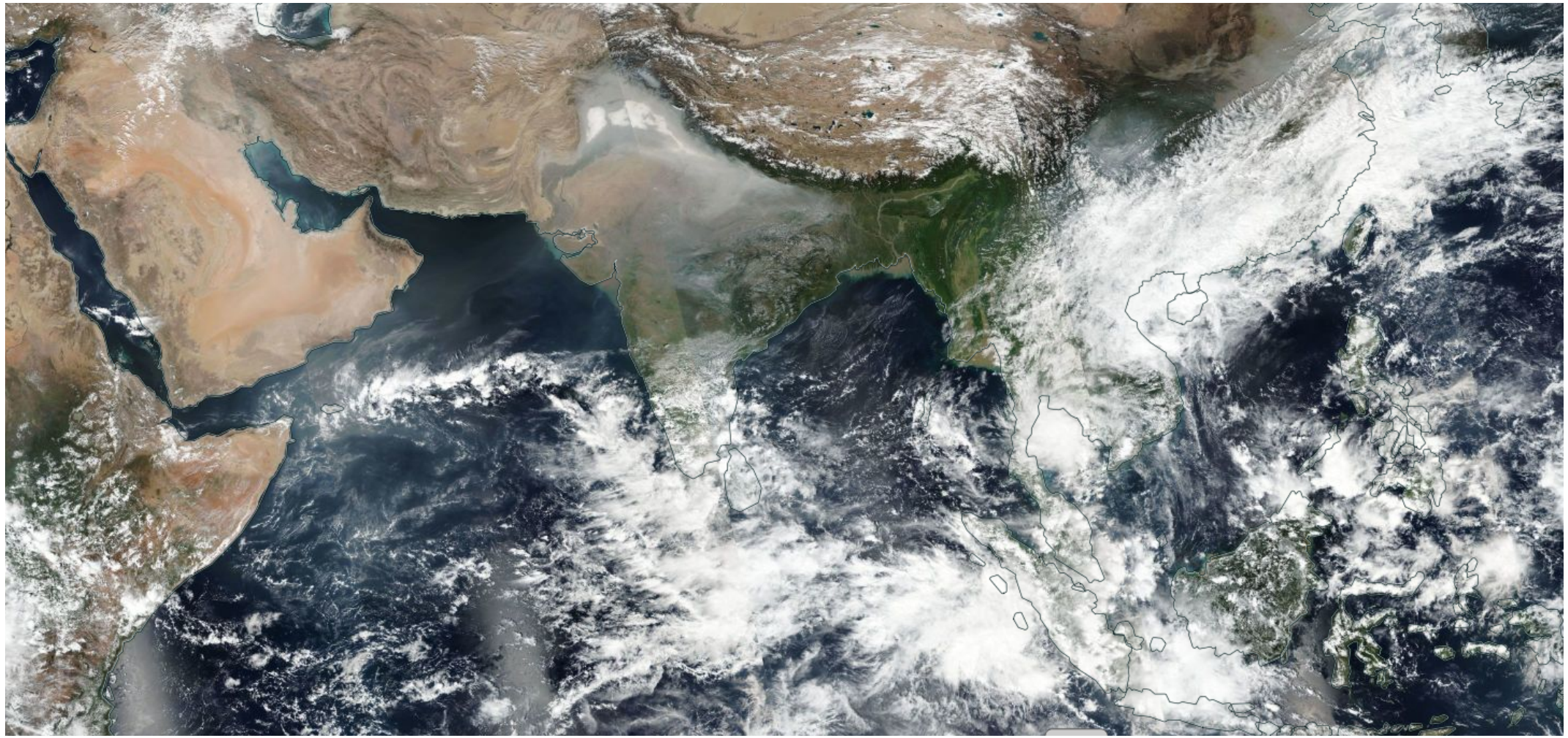


Visible imagery water is dark because it absorbs most of the energy

Clouds are white because they reflect most incoming energy

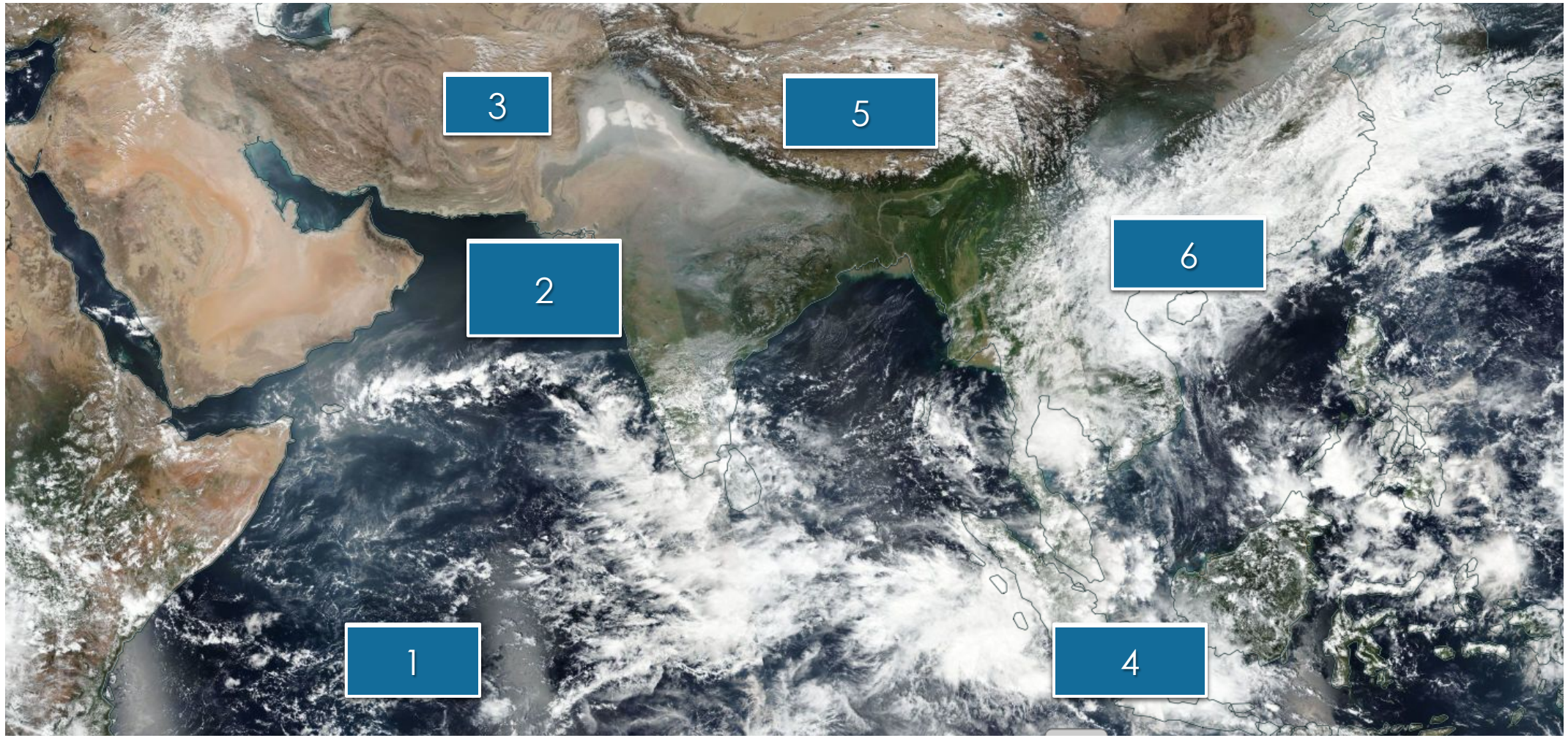
Pollution is hazy depending on its absorption properties

What can we learn from true color imagery?



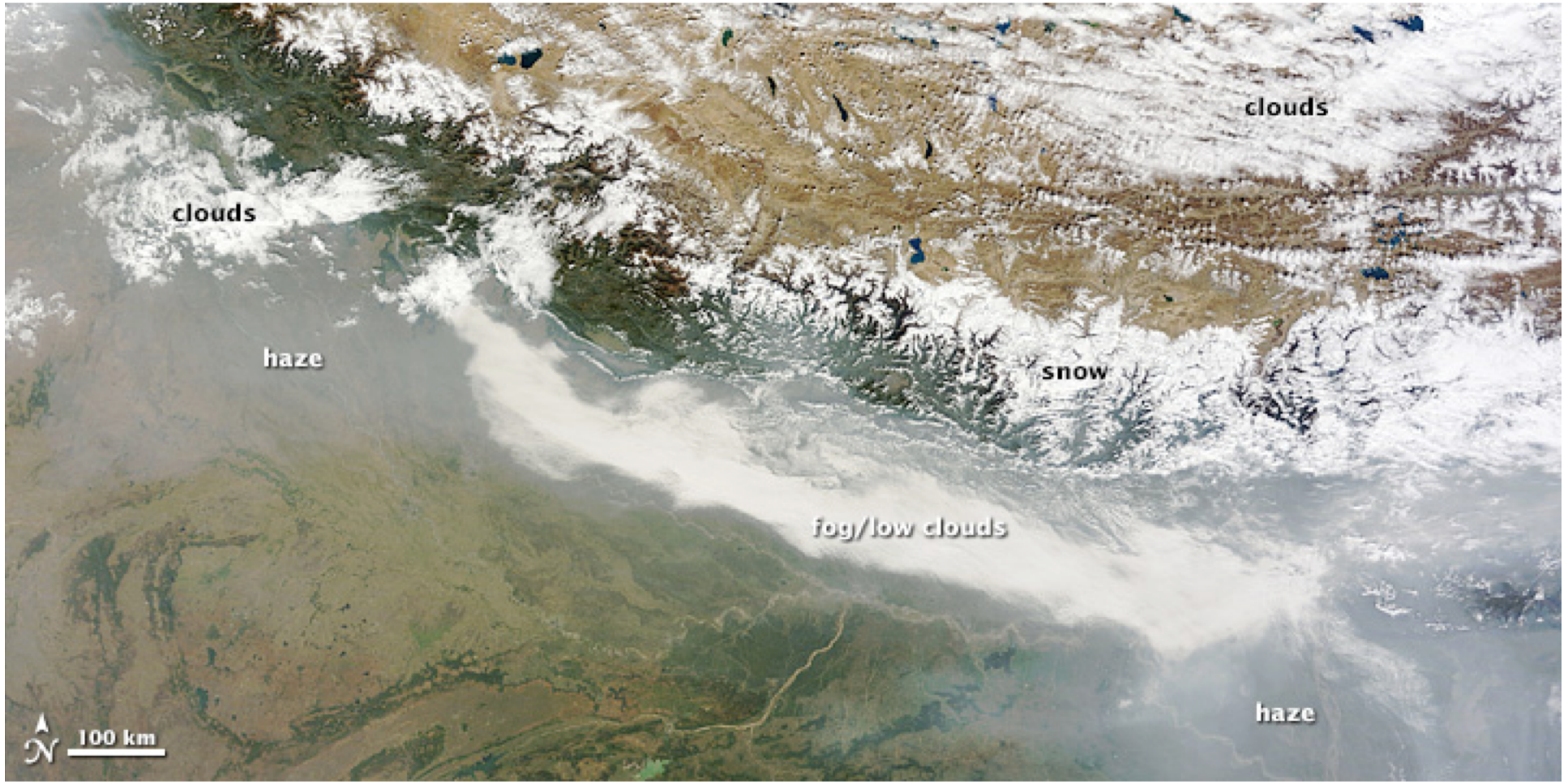
(Possible) identification of land, ocean, and atmosphere features

What can we learn from true color imagery?

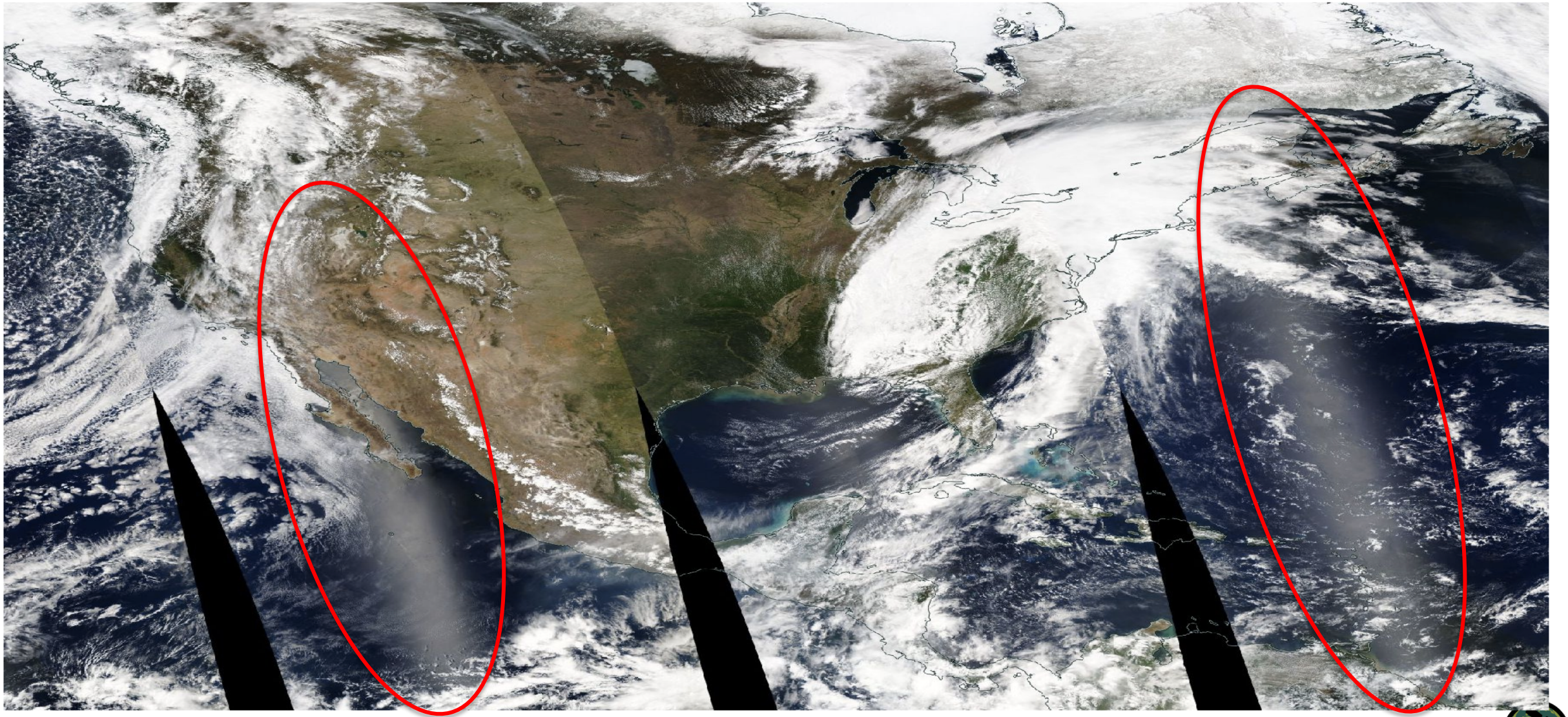


(Possible) identification of land, ocean, and atmosphere features

Features in True Color (Atmosphere)

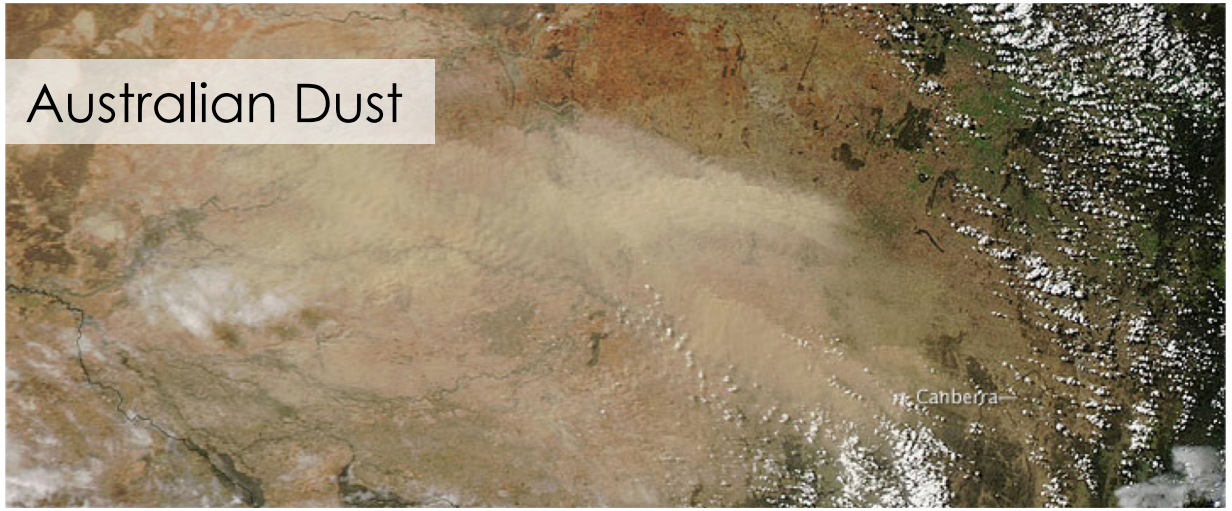


Glint



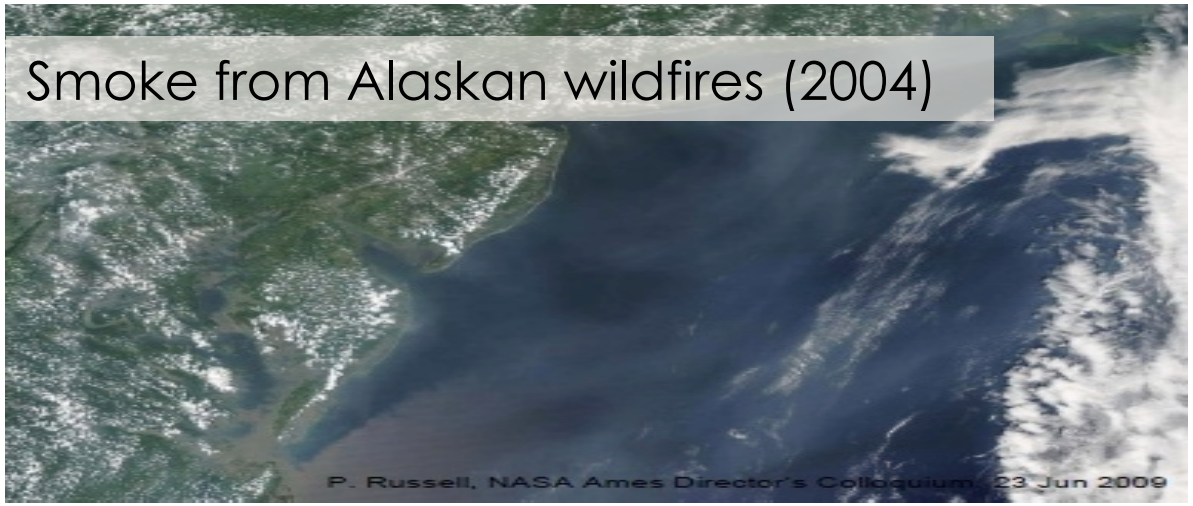
Feature Identification

More reliable with clear source in image



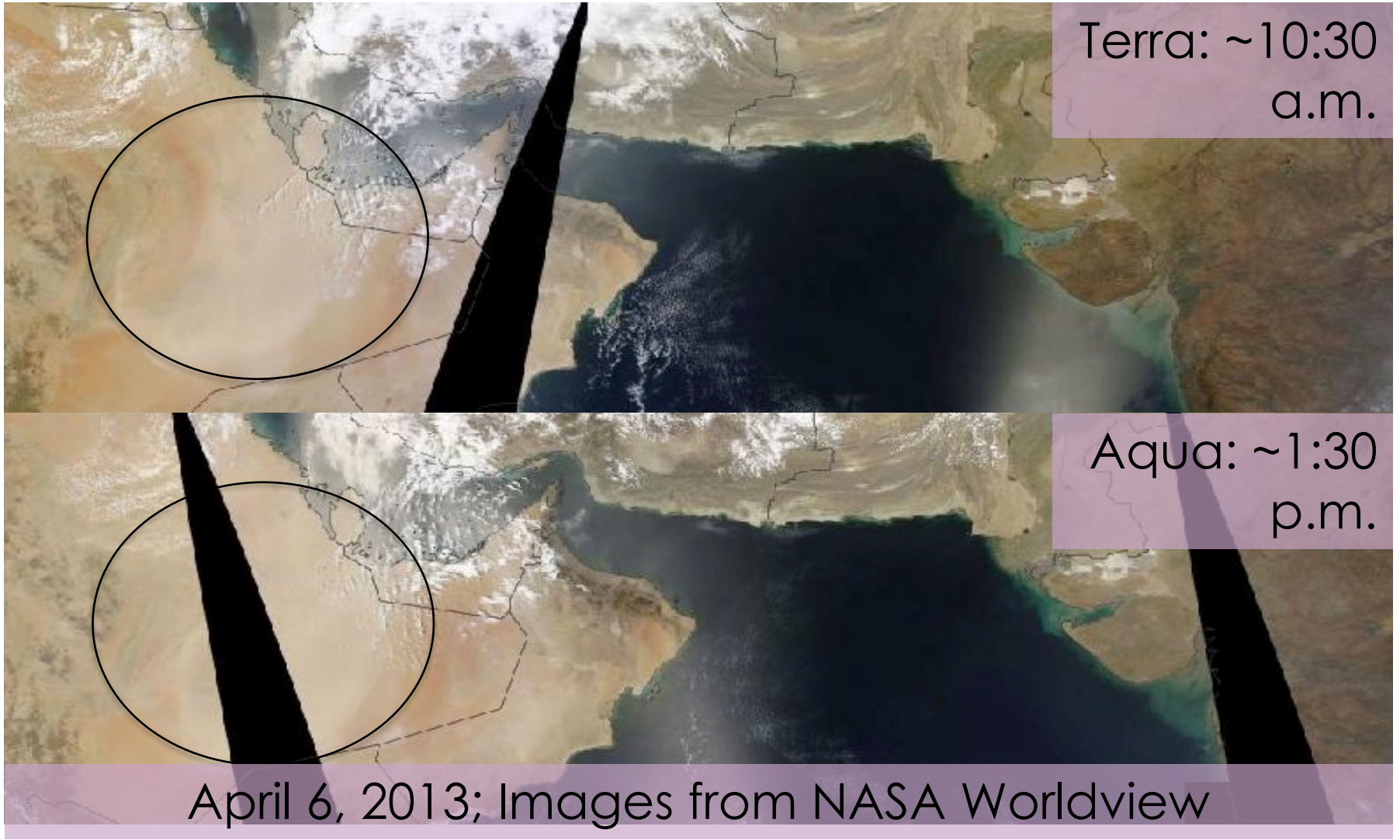
Feature Identification

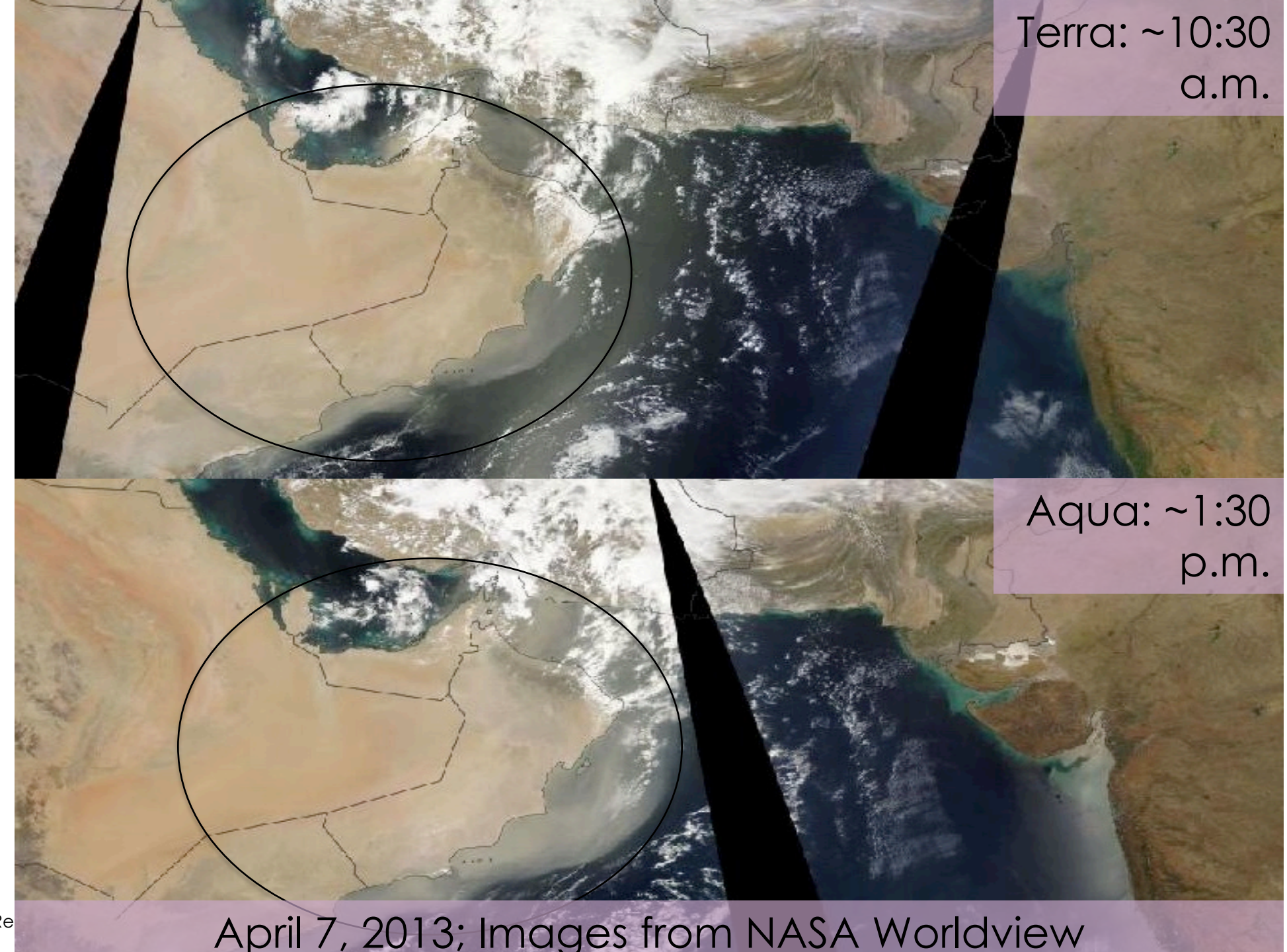
More reliable when a clear source is in the image



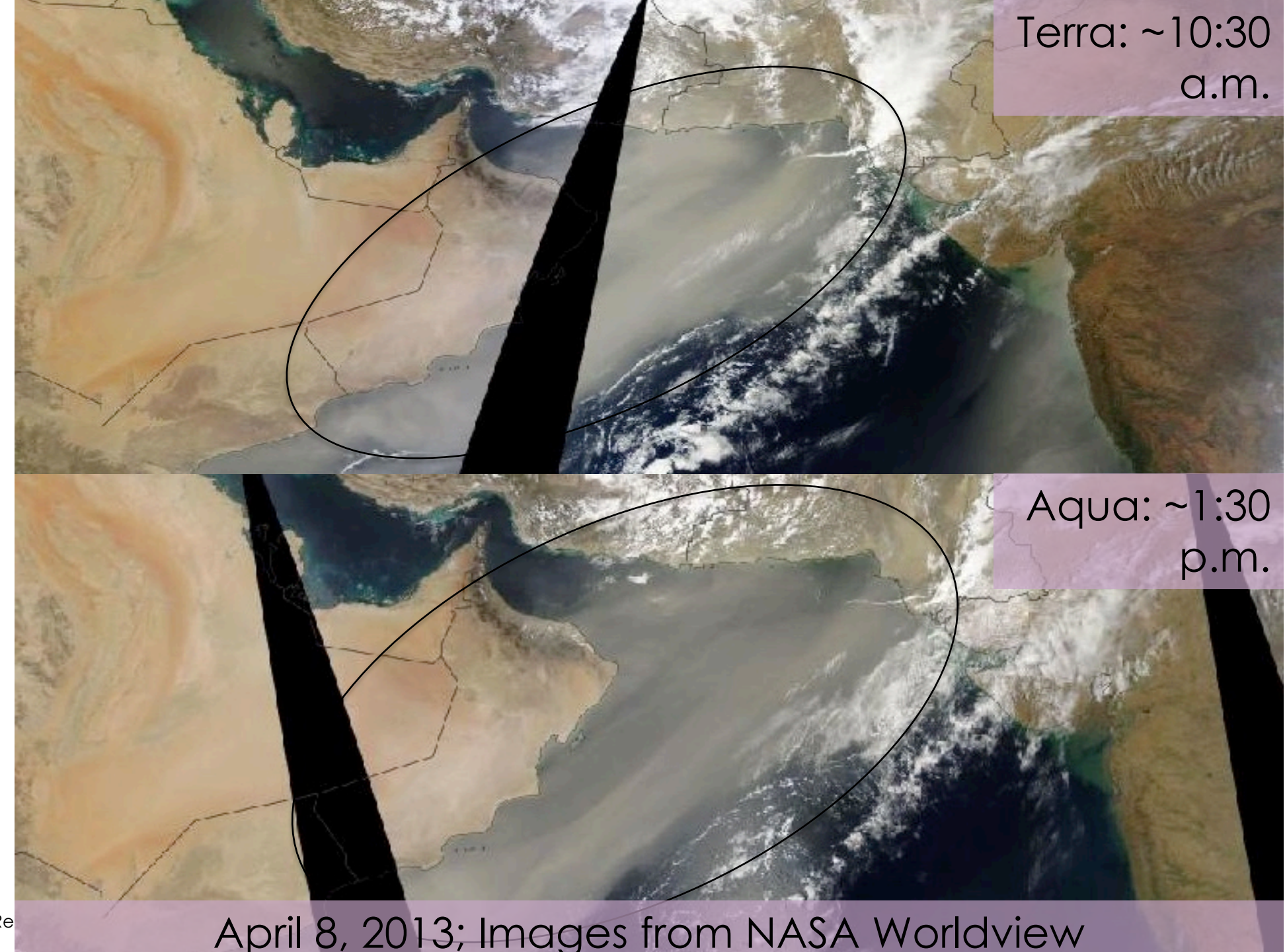
Using Time Series Imagery

Dust Transport



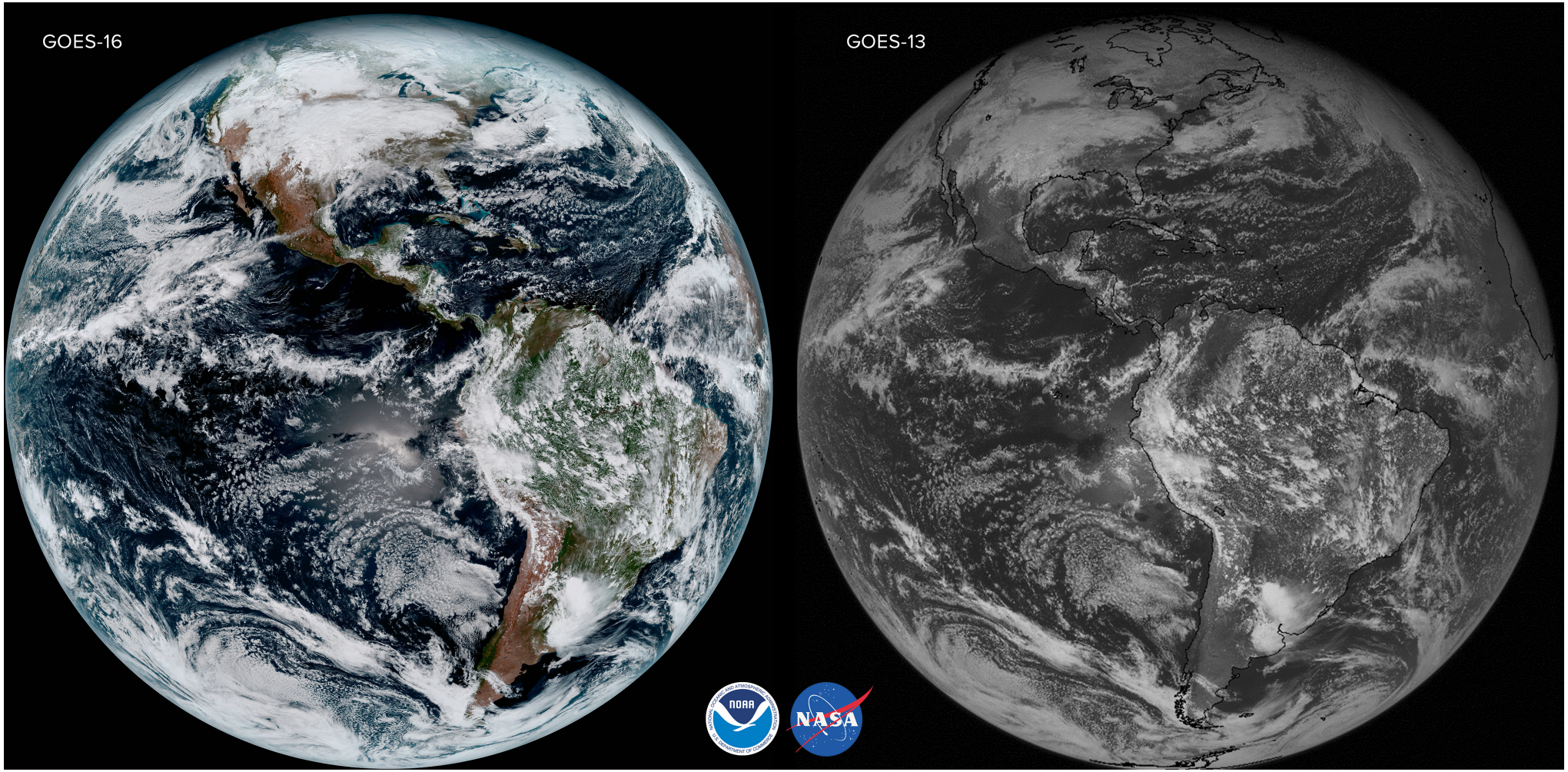


April 7, 2013; Images from NASA Worldview



April 8, 2013; Images from NASA Worldview

Geostationary Observations – GOES-16 (East)



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

GOES-16 Loop: Dust

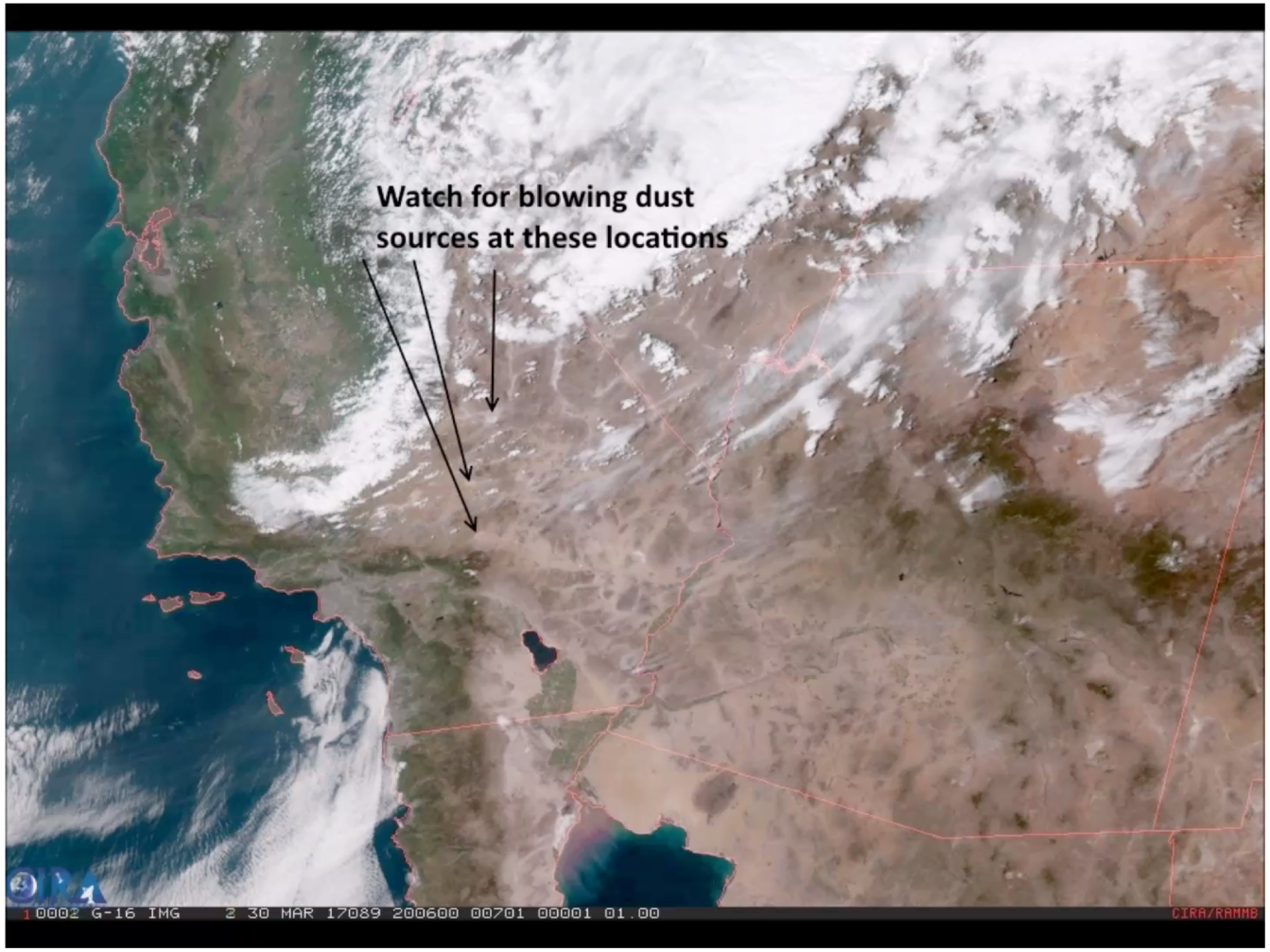


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdis/online/loop.asp?data_folder=loop_of_the_day/goes-16/20170330000000&number_of_images_to_display=100&loop_speed_ms=100

HIMAWARI-8 Loop: Fog and Smoke over Australia

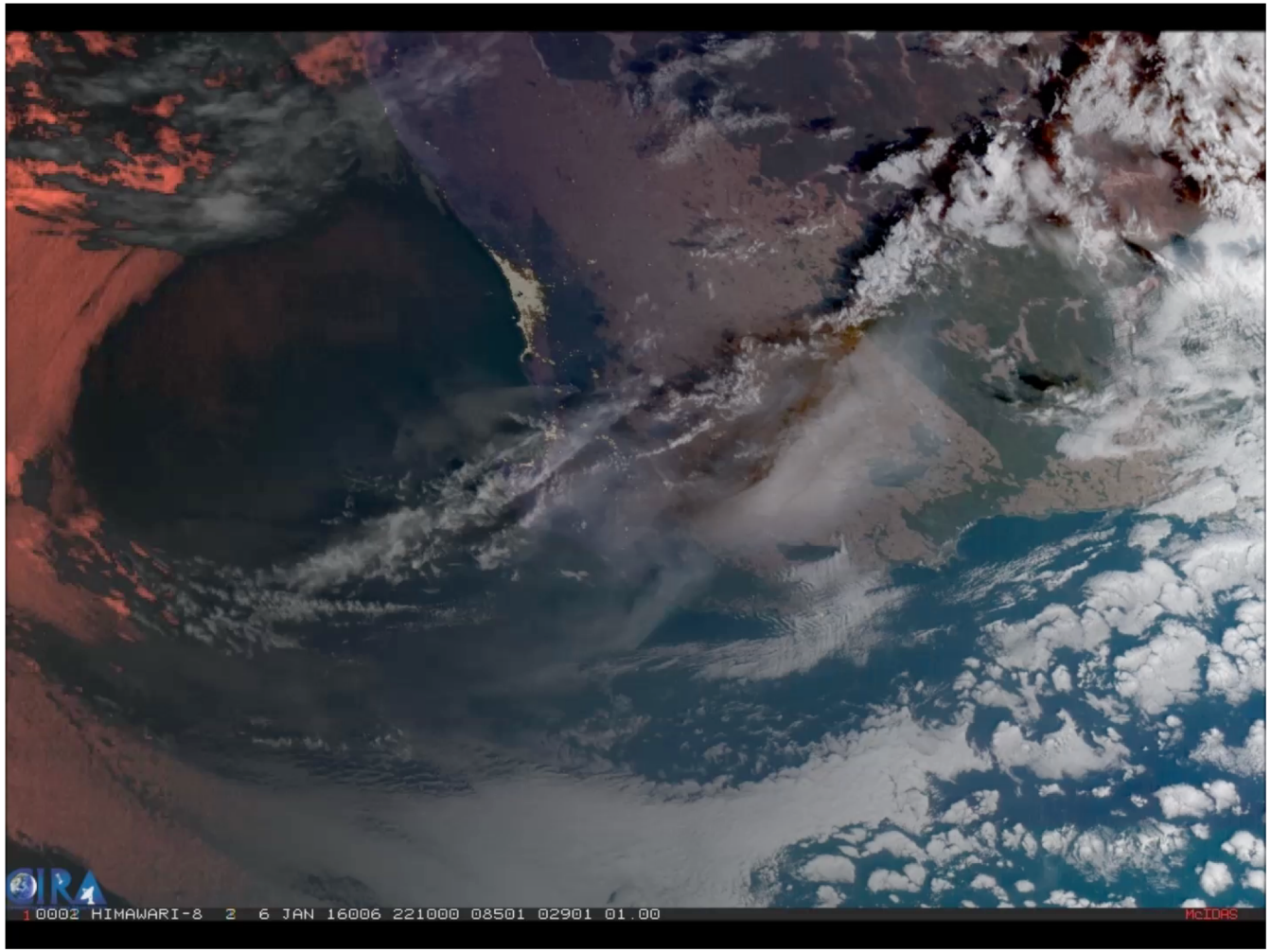


Image: NOAA CoRP, STAR:
http://rammb.cira.colostate.edu/ramsdis/online/loop.asp?data_folder=loop_of_the_day/himawari/20160107000000&number_of_images_to_display=100&loop_speed_ms=100

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

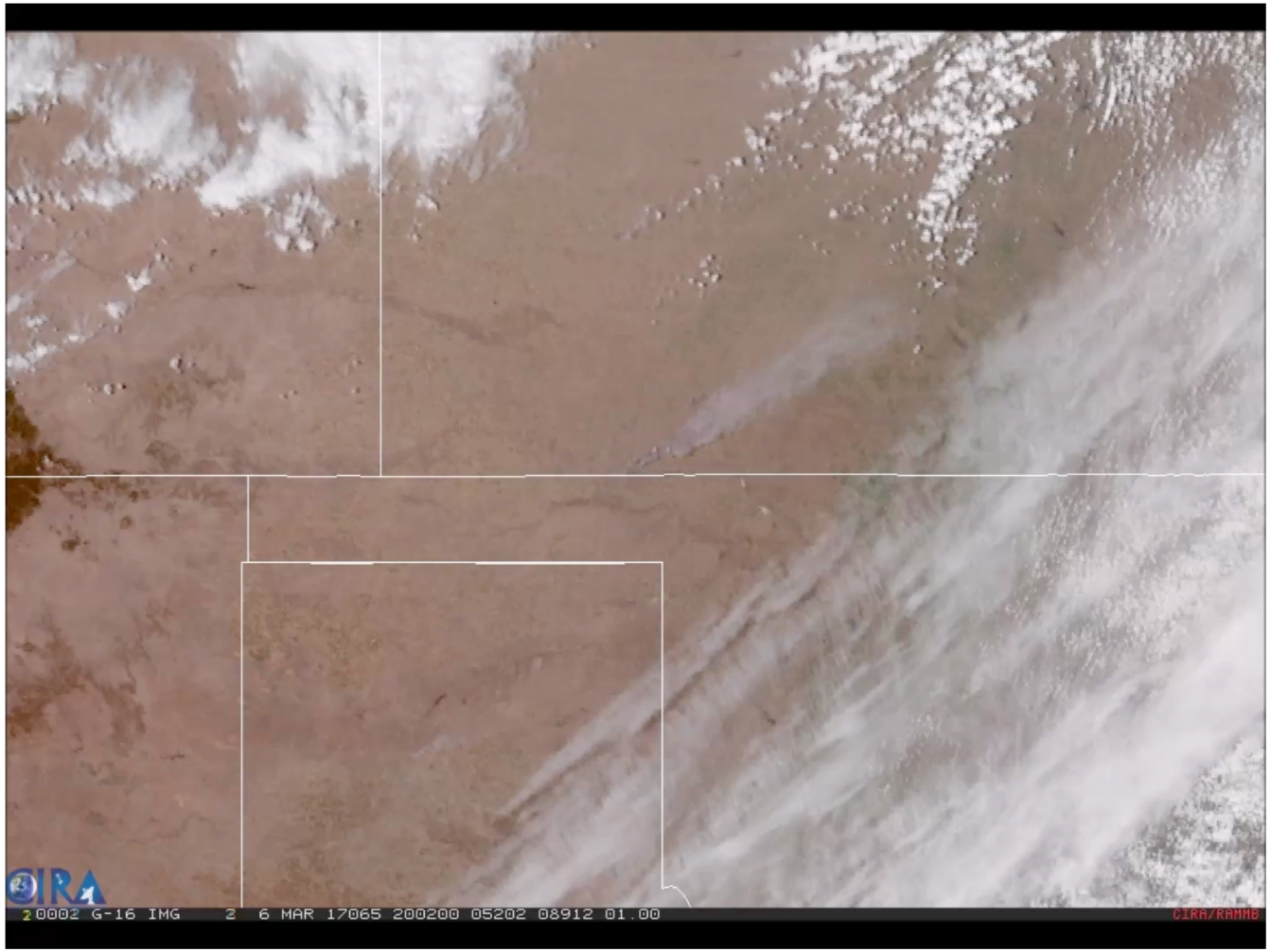
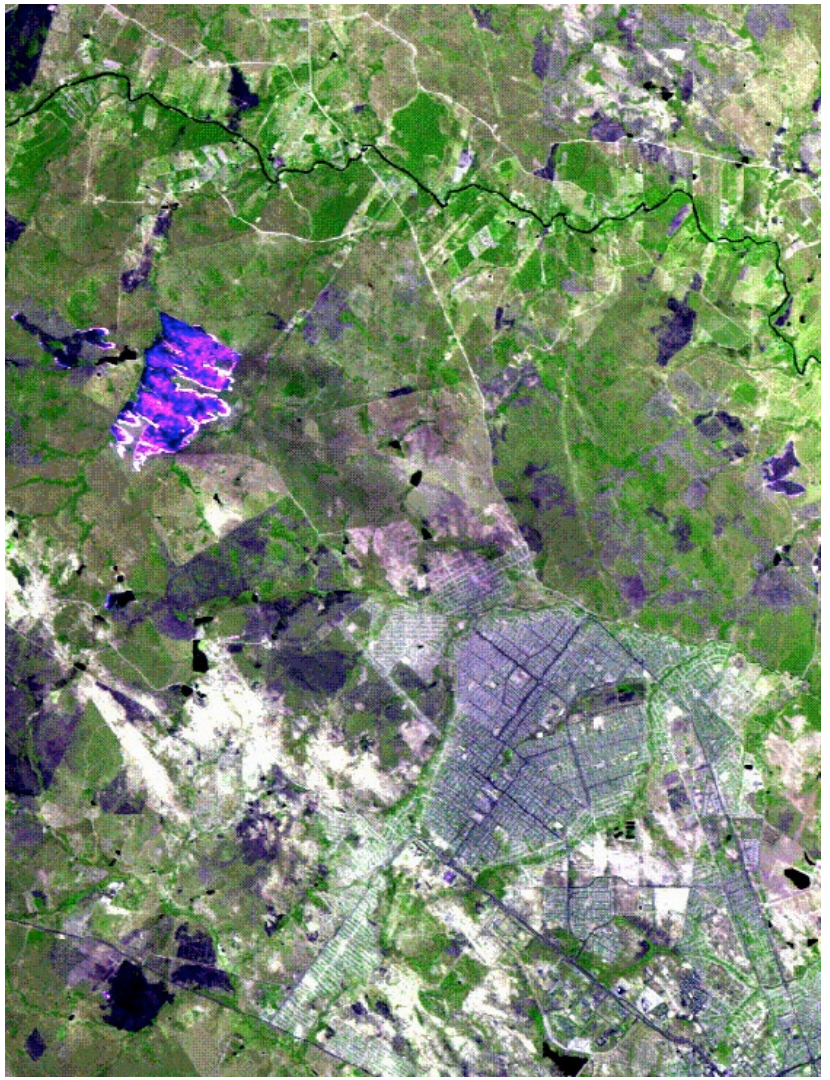


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdis/online/loop.asp?data_folder=loop_of_the_day/goes-16/20170306000000&number_of_images_to_display=100&loop_speed_ms=100

False Color Images

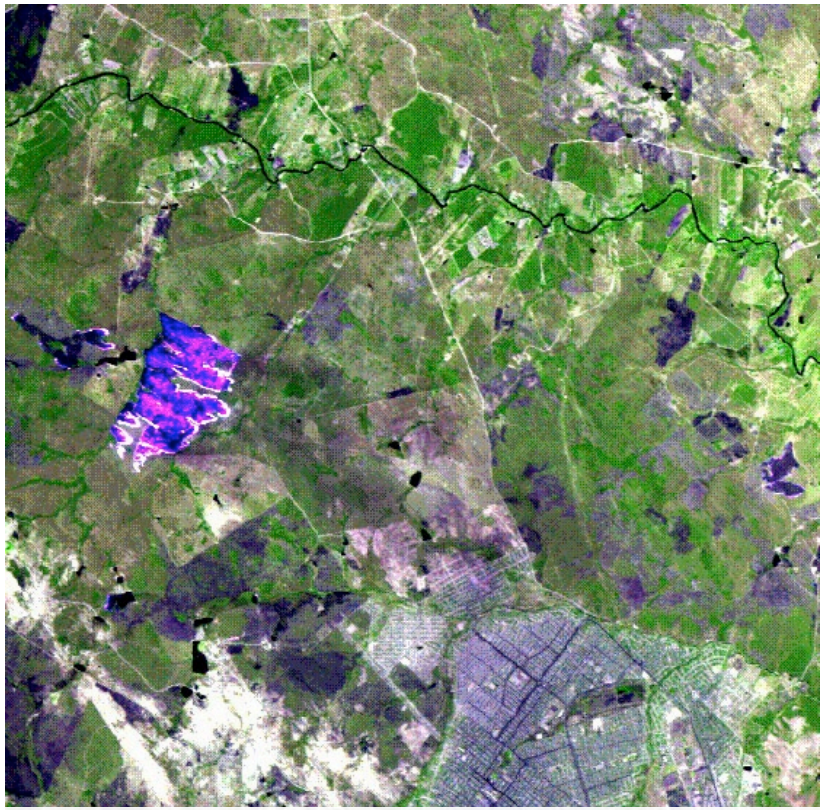
- Load bands into the red, green, and blue display channels
- Do not correspond to the visible red, green, and blue wavelengths

R = 1.6 µm
G = 1.2 µm
B = 2.1 µm



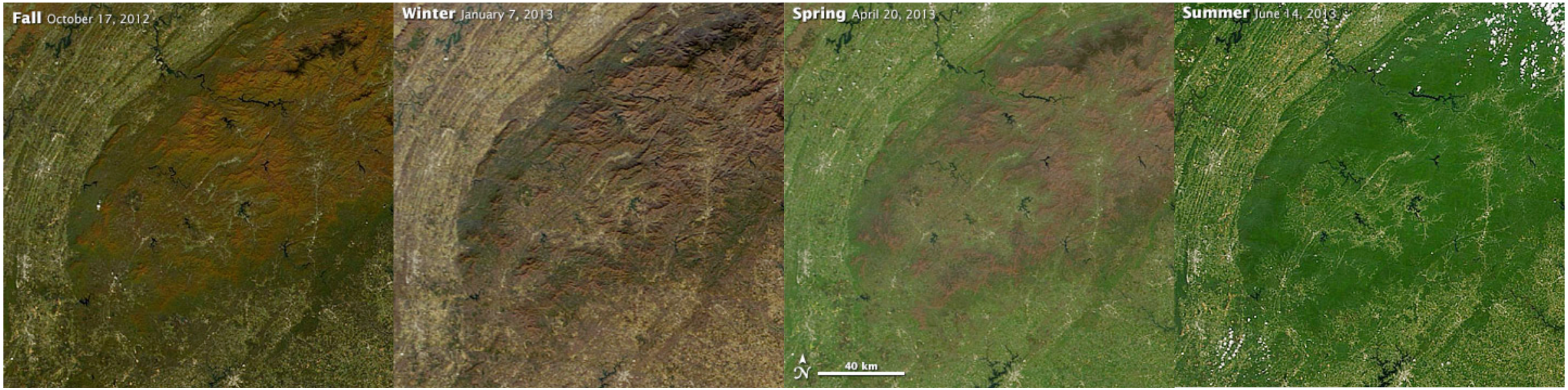
True vs. False Color Images

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

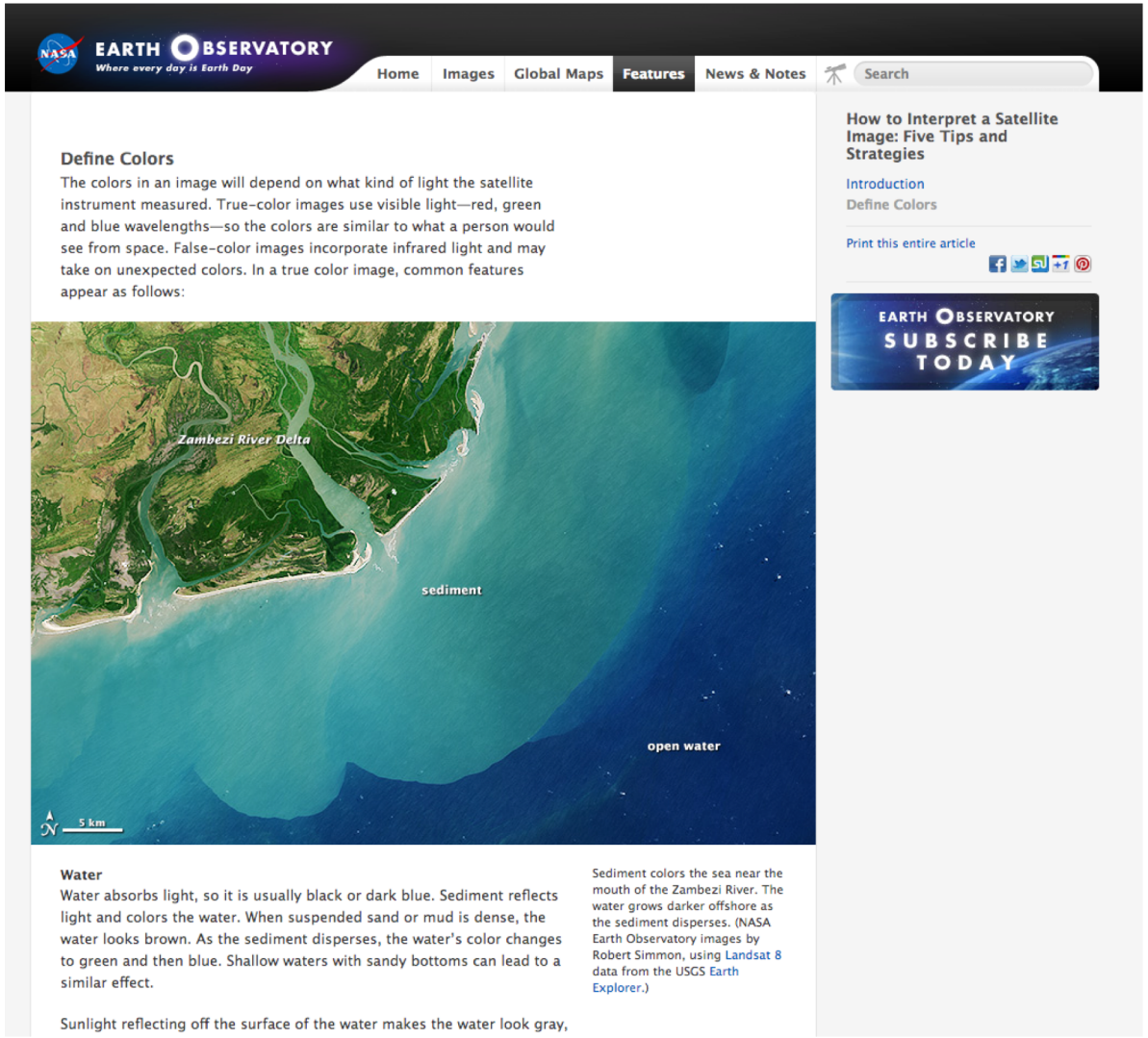


Image Archive and Gallery Links

- ARSET Satellite Imagery Overview and links
  - http://airquality.gsfc.nasa.gov/index.php?section=64
- MODIS Rapid Response Site
  - http://earthdata.nasa.gov/data/near-real-time-data/rapid-response
- NASA's Visible Earth
  - http://visibleearth.nasa.gov
- NASA's Earth Observatory
  - http://earthobservatory.nasa.gov
- NASA's Earth Observations (NEO)
  - http://neo.sci.gsfc.nasa.gov
- MODIS-Atmos (MODIS Atmosphere Product Reference Site)
  - http://modis-atmos.gsfc.nasa.gov/IMAGES/index.html
- GLIDER Tool
  - http://www.ssec.wisc.edu/hydra

Tour of Some Useful Image Archives

- Earth Observatory: Events & More
  - http://earthobservatory.nasa.gov

- Worldview: Near Real-Time
  - http://earthdata.nasa.gov/labs/worldview

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?

Questions?