

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

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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

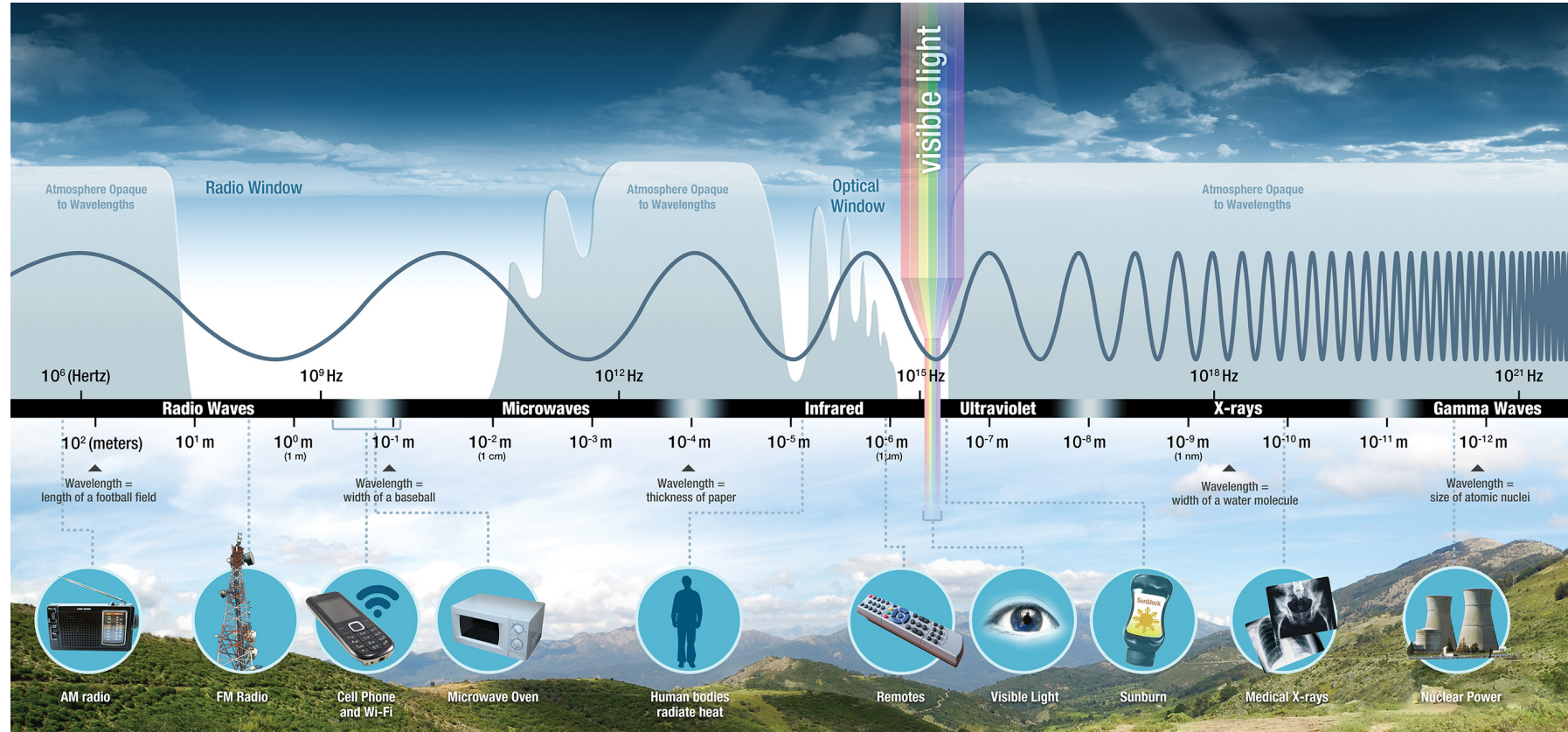


Visible Image Science

- 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

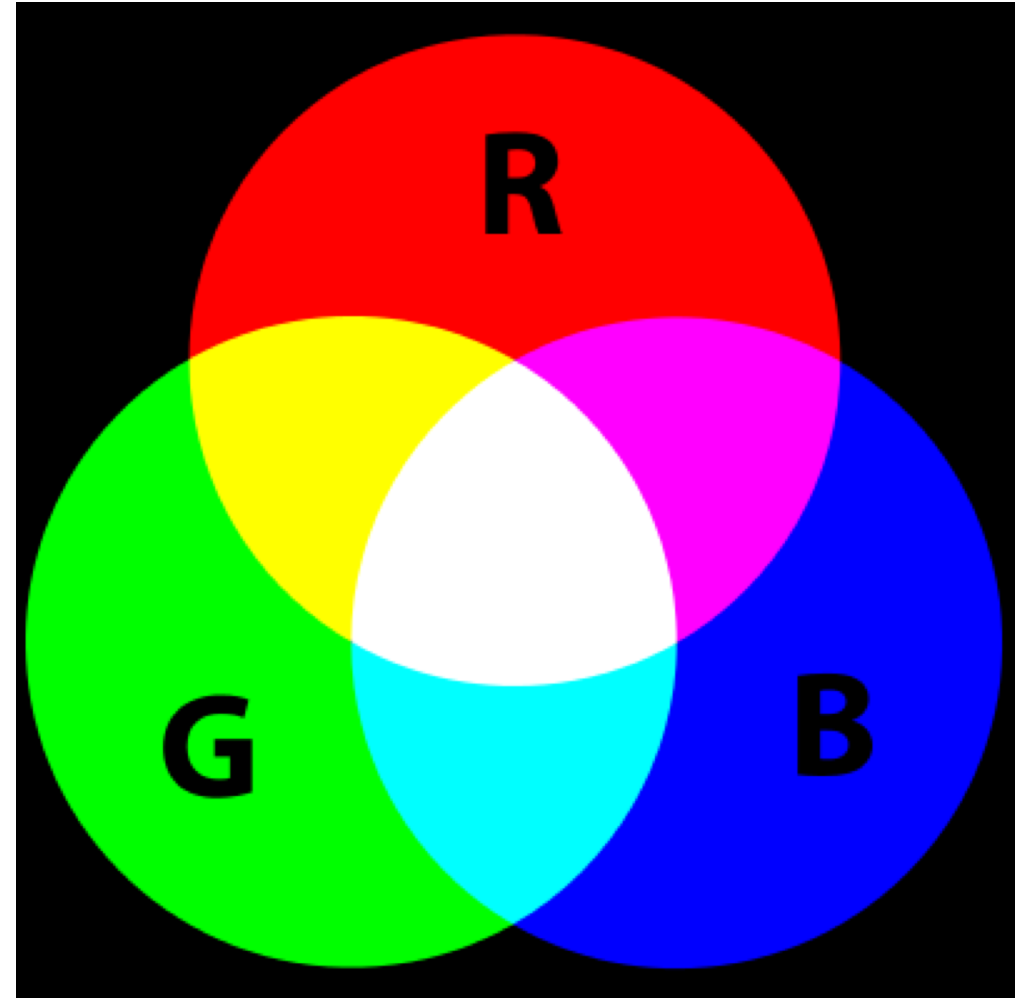


Earth observing satellite remote sensing instruments typically make observations at many discrete wavelengths, or **wavelength bands**



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



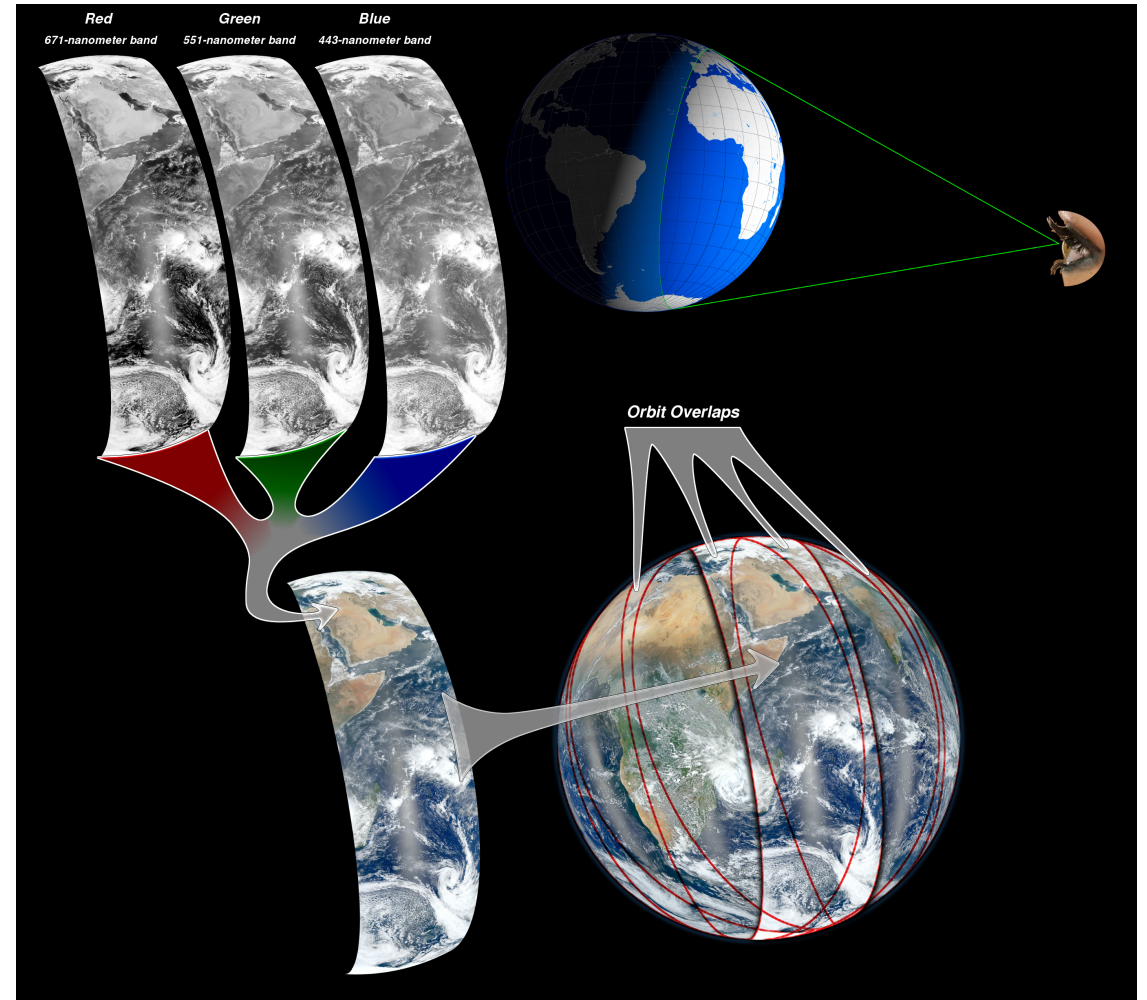
True Color Image (or RGB)

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

R = 0.66 μm

G = 0.55 μm

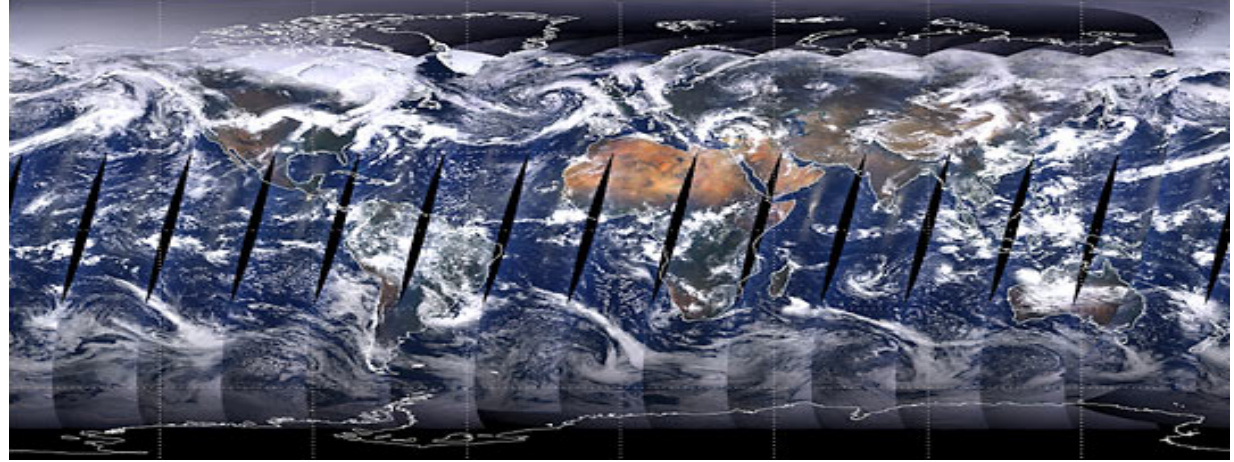
B = 0.47 μm



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
 - Hierarchical 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

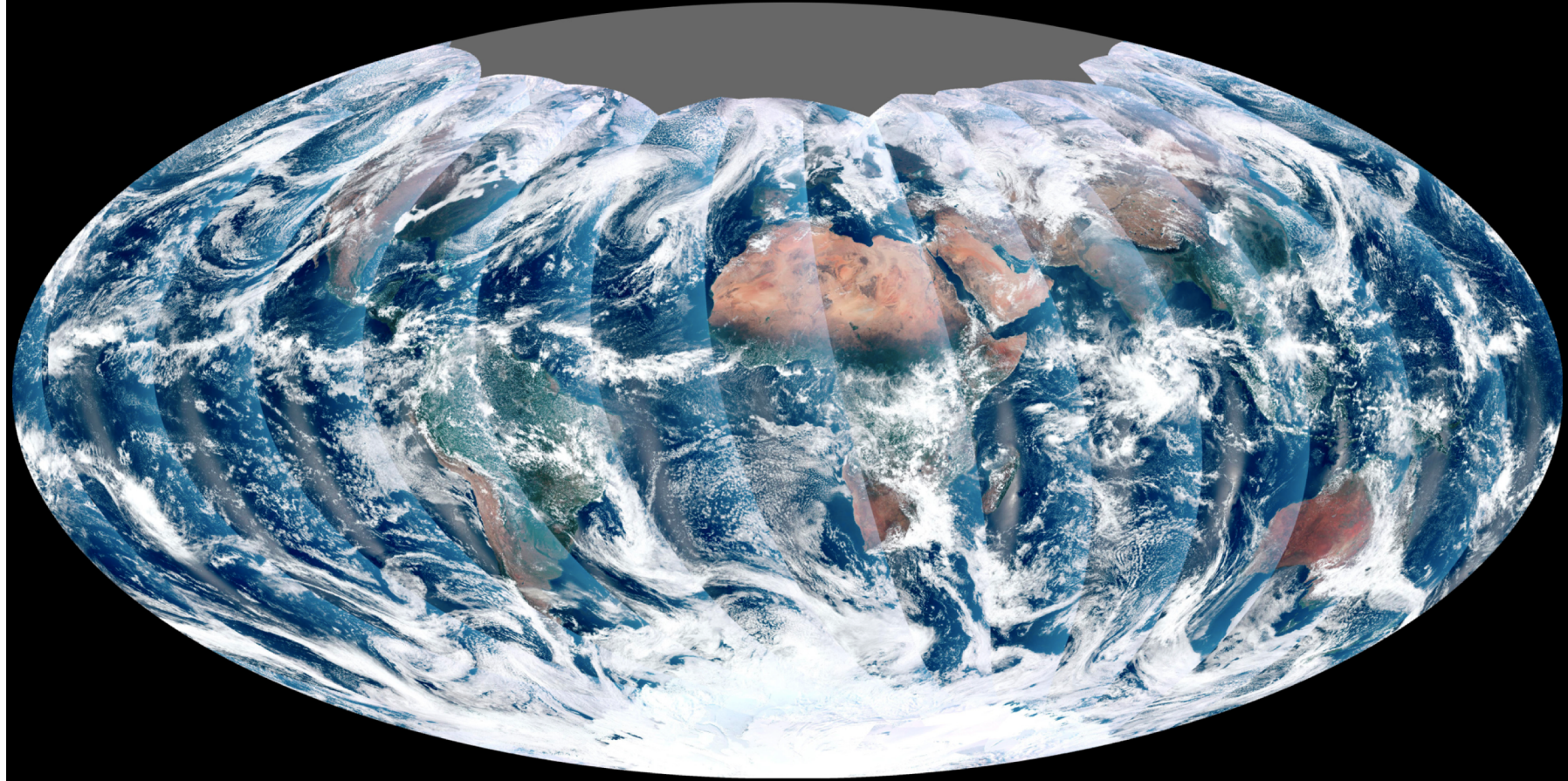
	Primary Use	Band No.	Bandwidth (nm)
250 m	Land/Cloud Boundaries	1**	620-670
		2**	841-876
500 m	Land/Cloud Properties	3*	459-479
		4*	545-565
		5*	1230-1250
		6*	1628-1652
		7*	2105-2155
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420
		9	438-448
		10	483-493
		11	526-536
		12	546-556
		13	662-672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

* 500m Spatial Resolution

** 250m Spatial Resolution

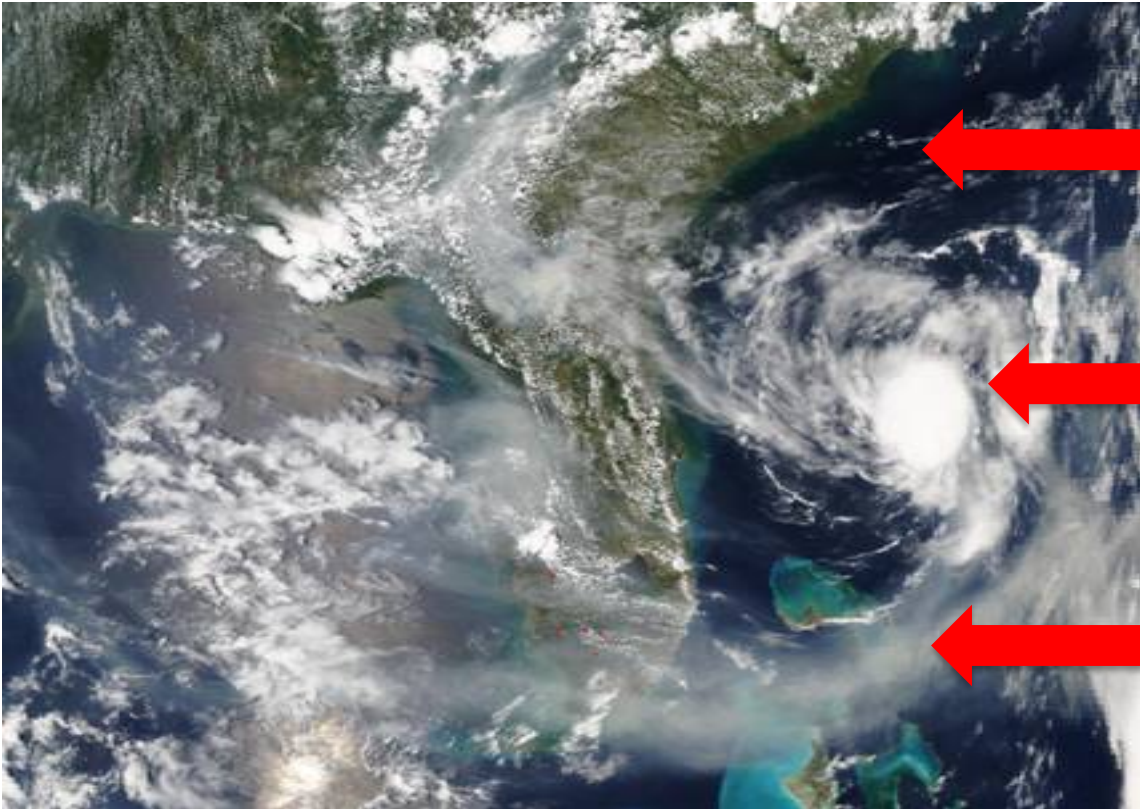


VIIRS Image



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



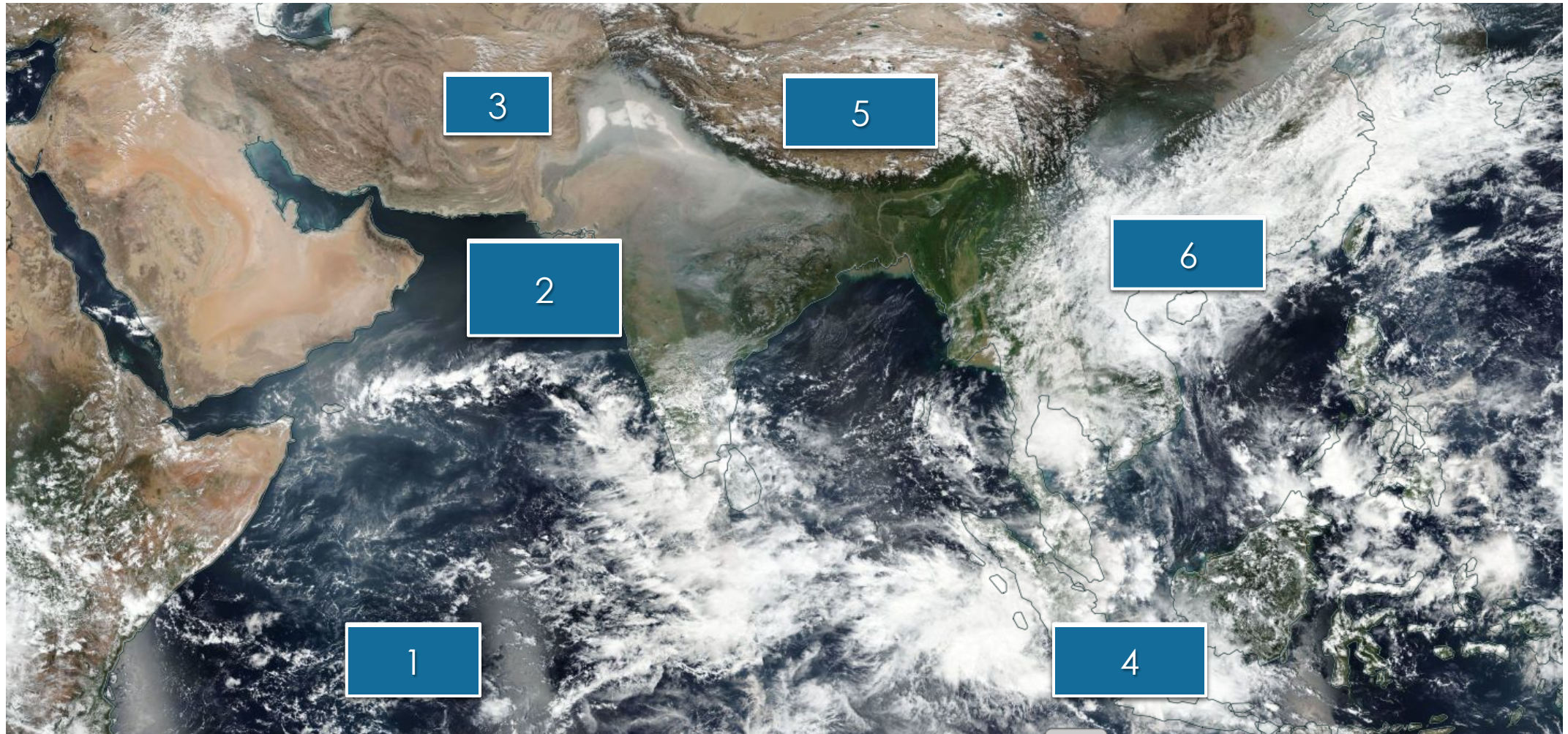
What can we learn from true color imagery?



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



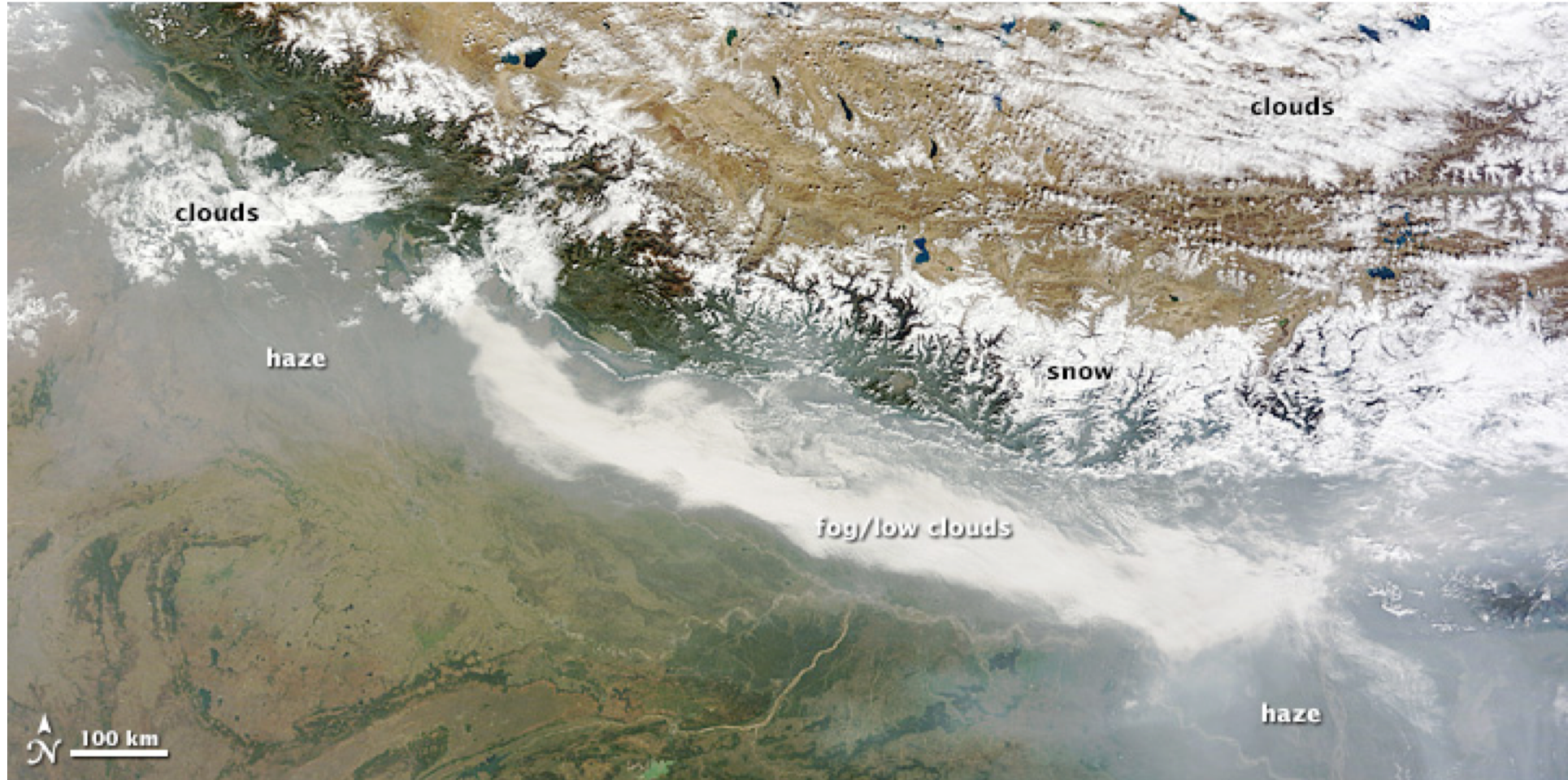
What can we learn from true color imagery?



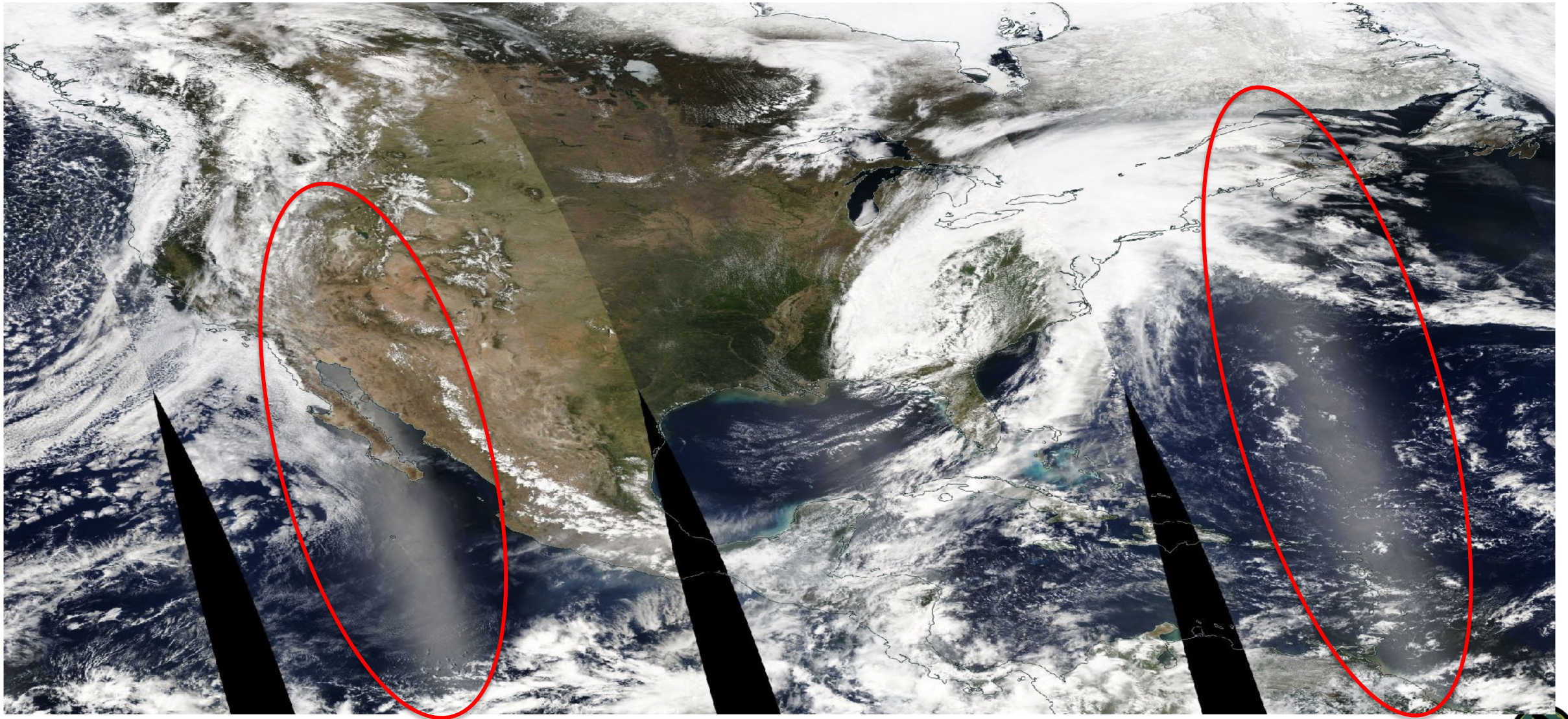
(Possible) identification of land, ocean, and atmosphere features



Features in True Color (Atmosphere)



Glint



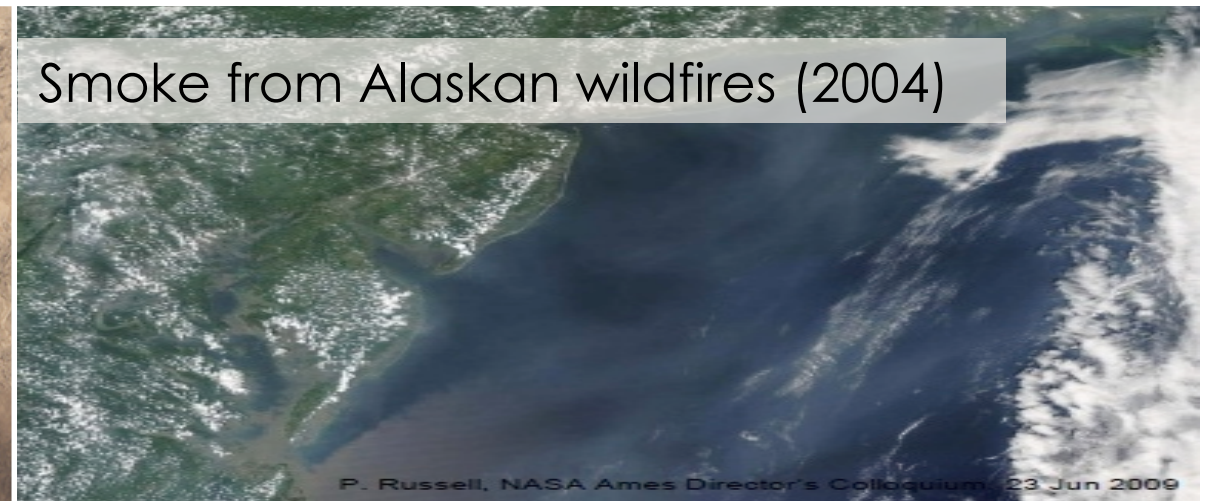
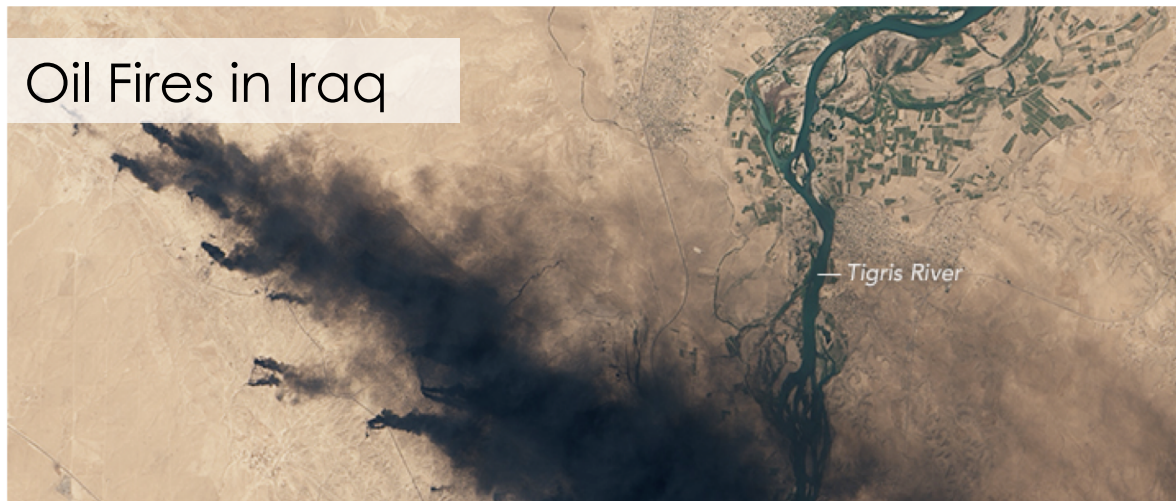
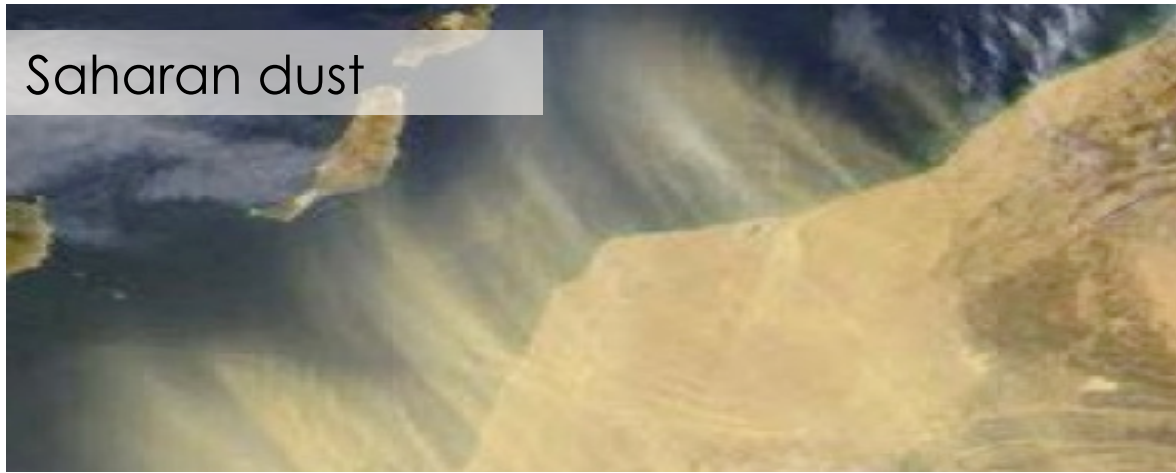
Feature Identification

More reliable with clear source in image



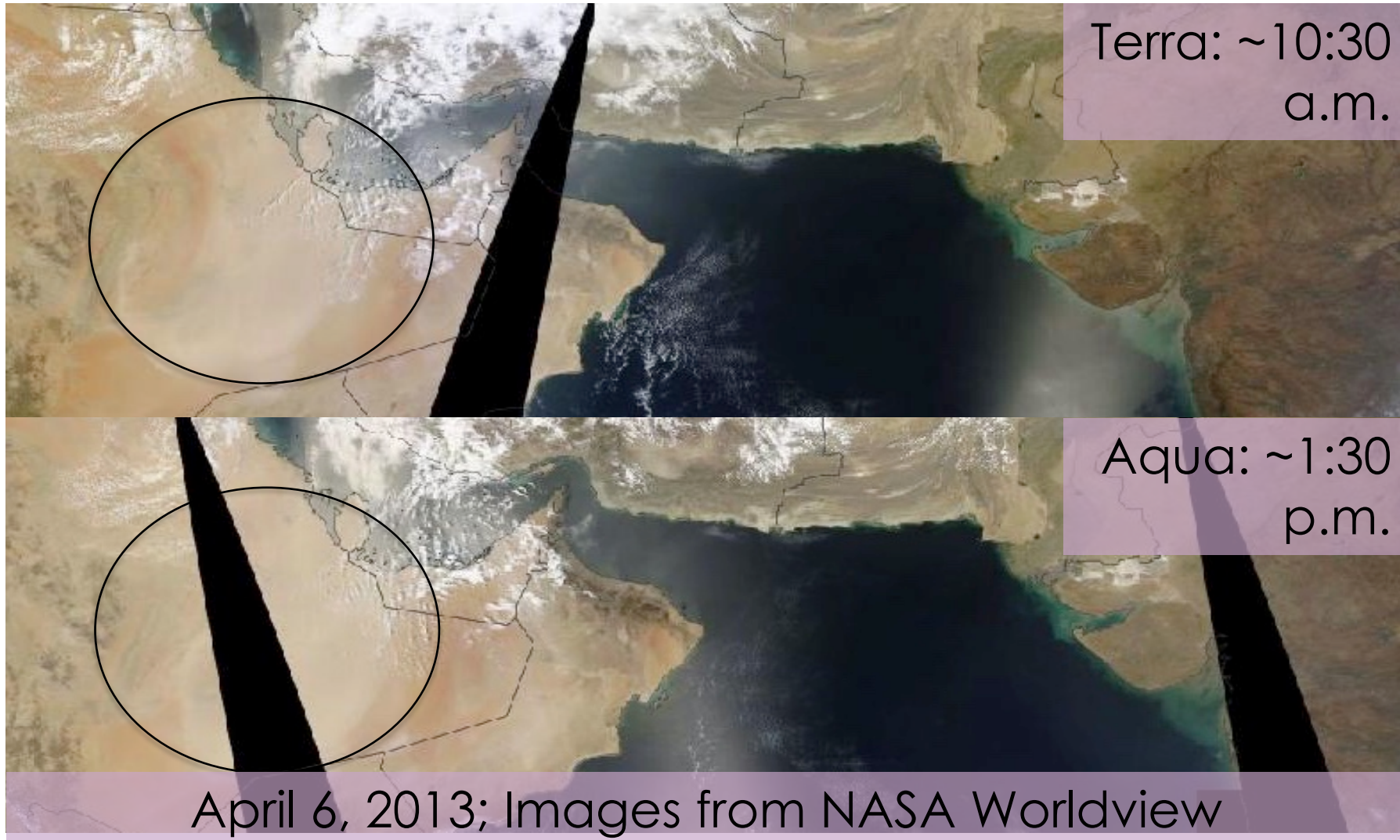
Feature Identification

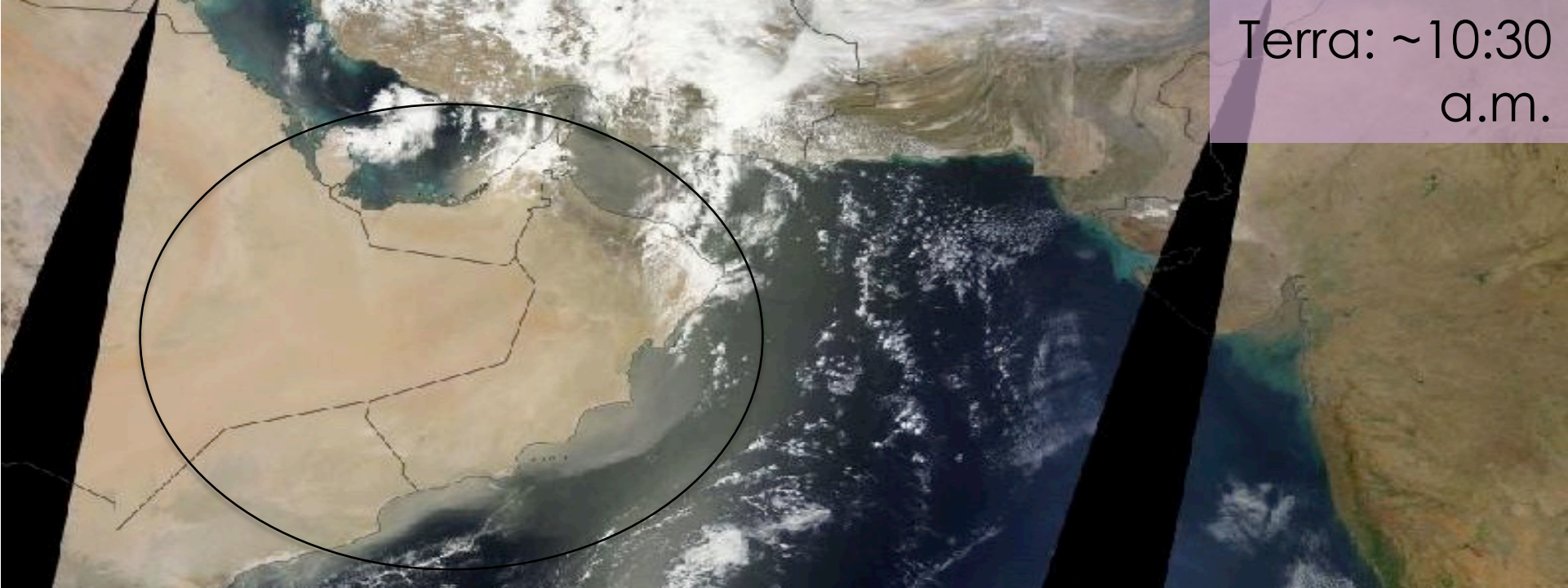
More reliable when a clear source is in the image



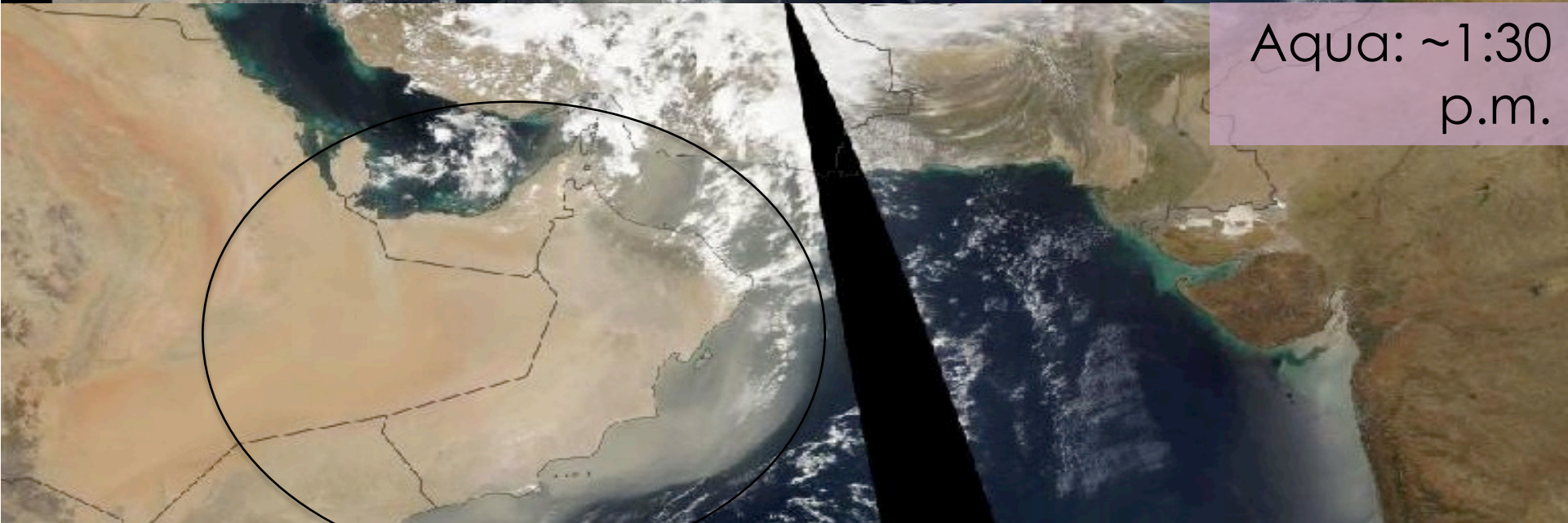
Using Time Series Imagery

Dust Transport



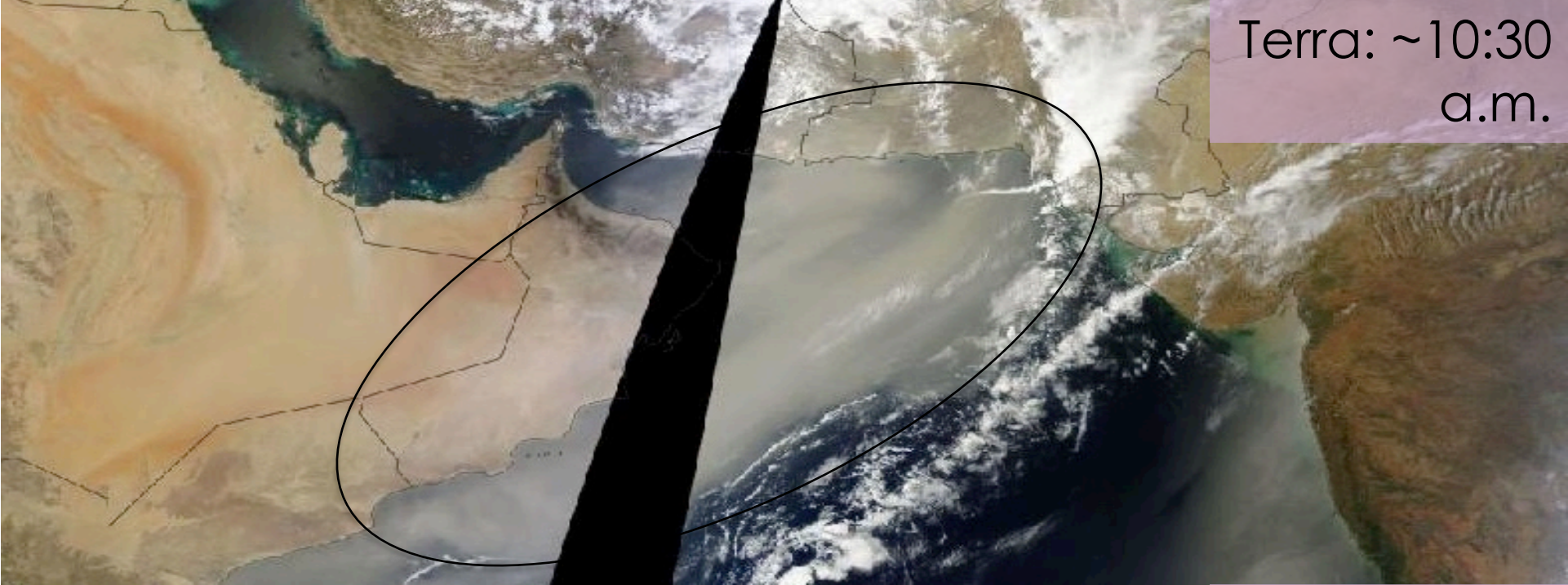


Terra: ~10:30
a.m.

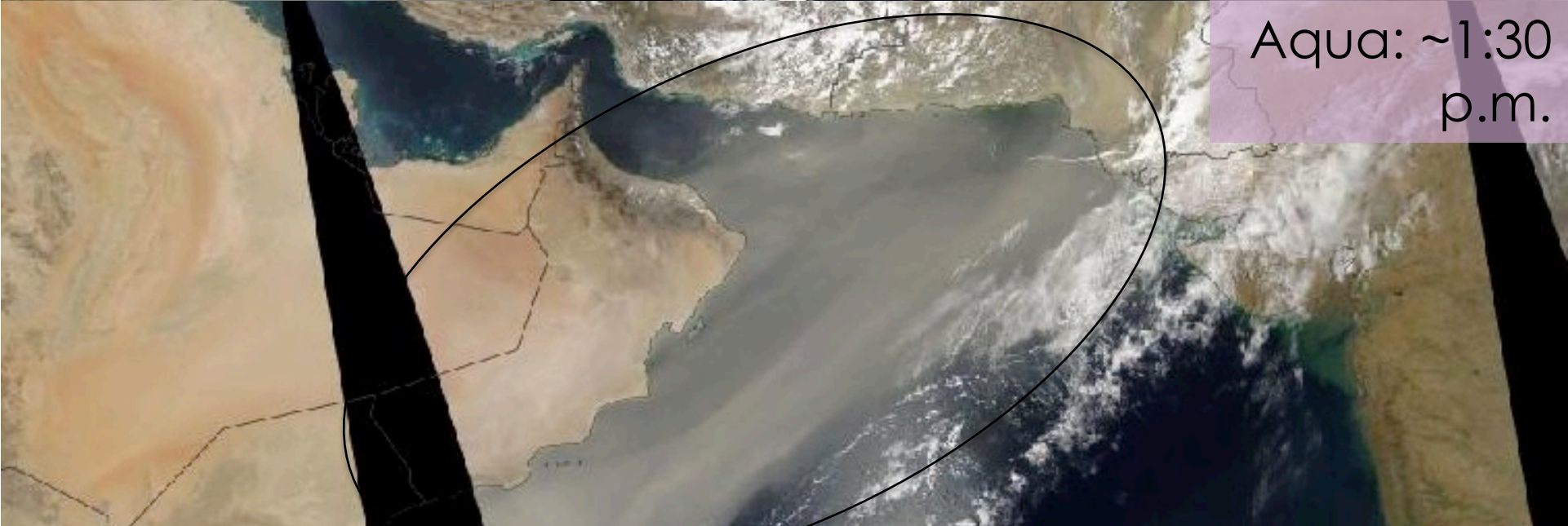


Aqua: ~1:30
p.m.





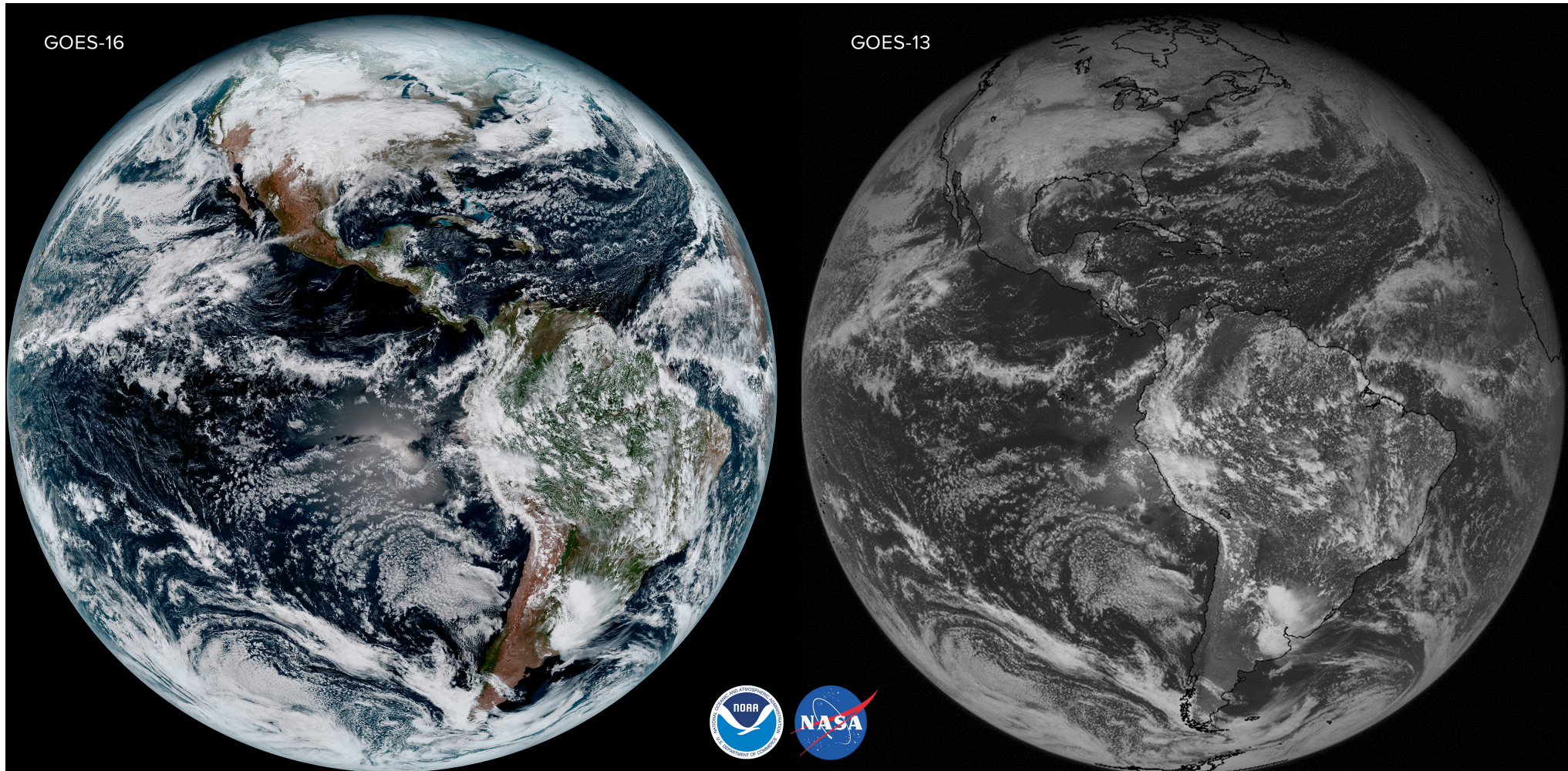
Terra: ~10:30
a.m.



Aqua: ~1:30
p.m.



Geostationary Observations – GOES-16 (East)



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



GOES-16 Loop: Dust

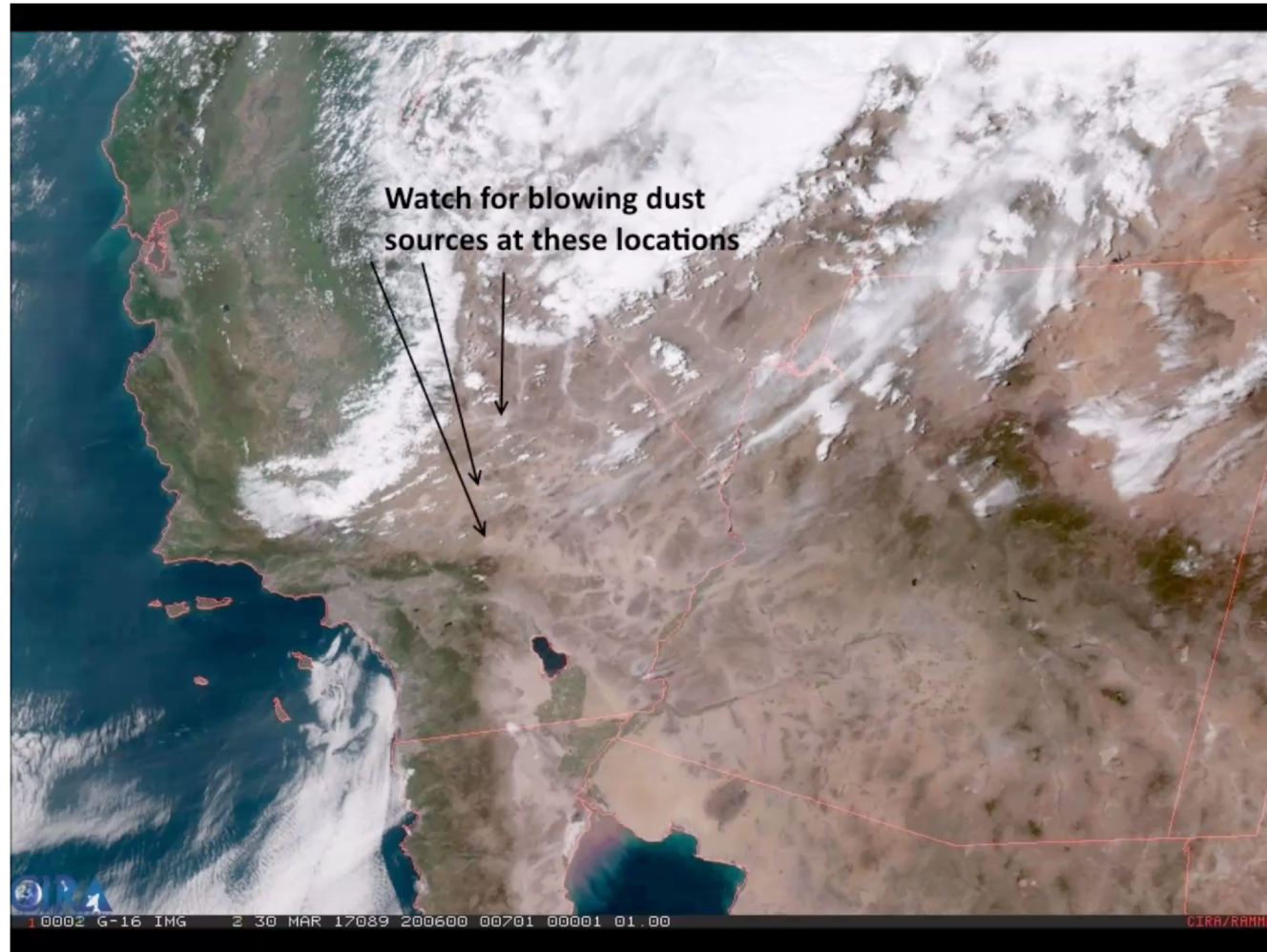


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsdisk/online/loop.asp?data_folder=loop_of_the_day/goes-16/20170330000000&number_of_images_to_display=100&loop_speed_ms=100



HIMAWARI-8 Loop: Fog and Smoke over Australia

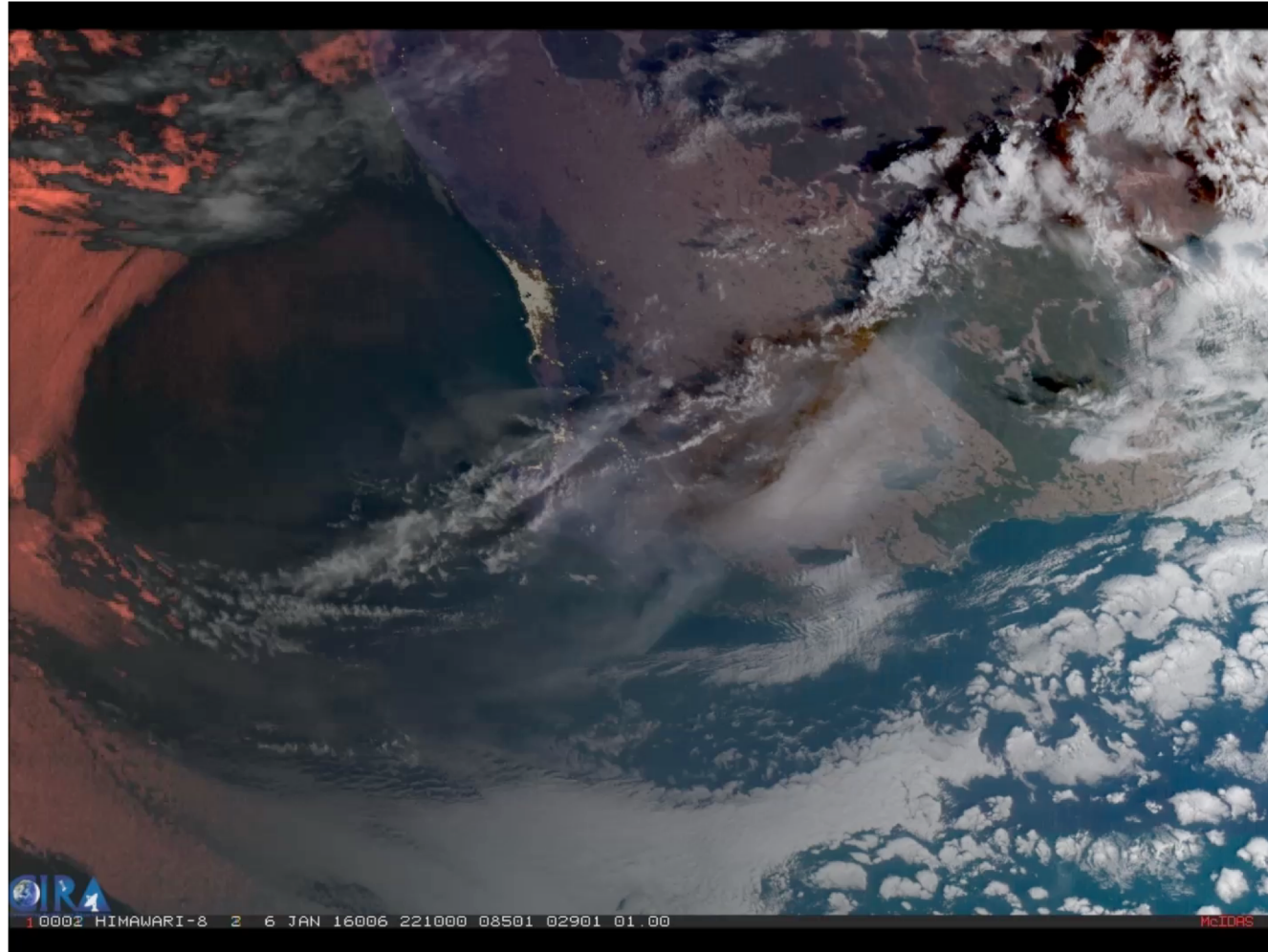


Image: NOAA CoRP, STAR:

http://rammb.cira.colostate.edu/ramsdms/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.

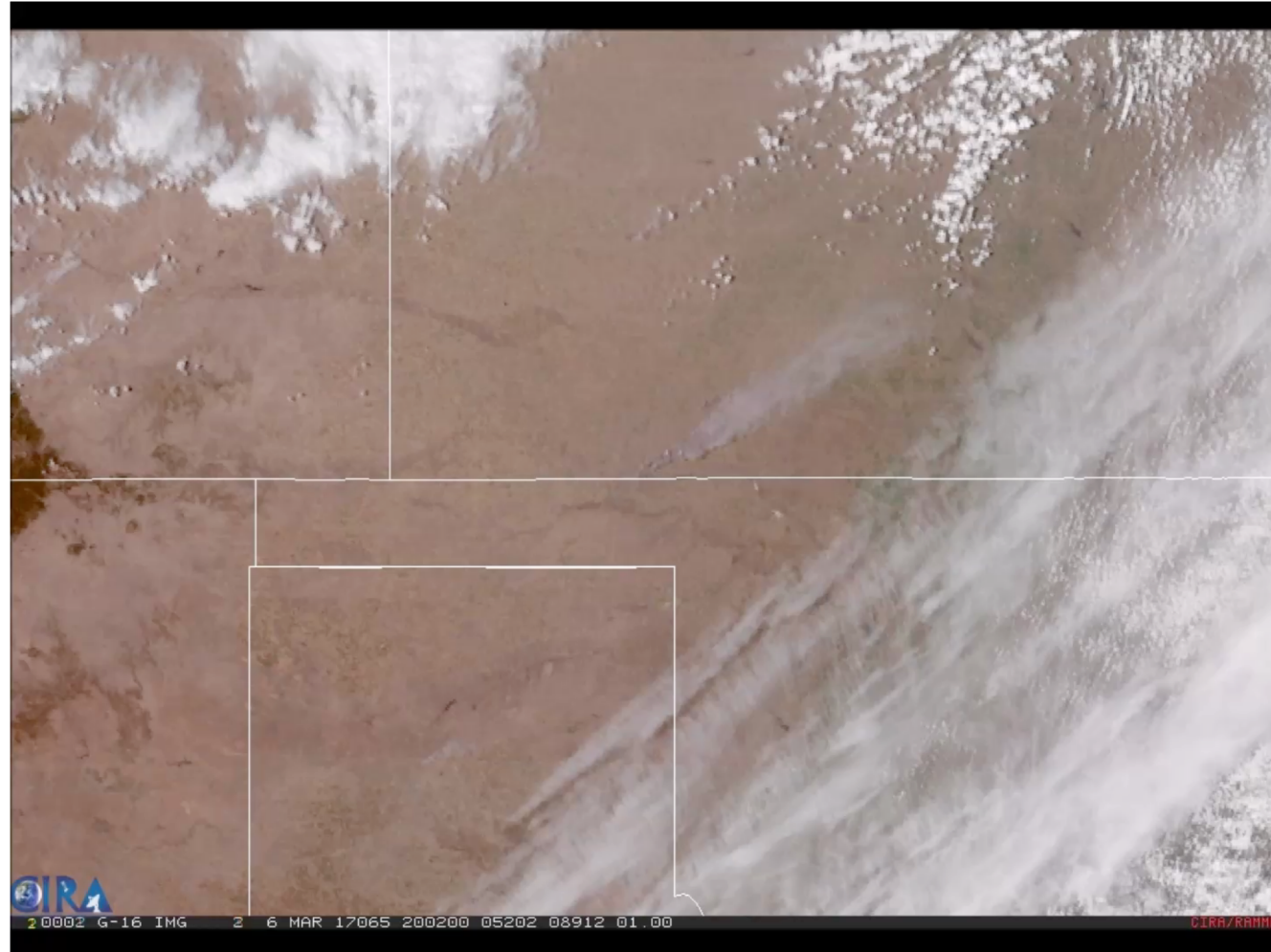


Image: NOAA CoRP, STAR: http://rammb.cira.colostate.edu/ramsd/online/loop.asp?data_folder=loop_of_the_day/goes-16/20170306000000&number_of_images_to_display=100&loop_speed_ms=100



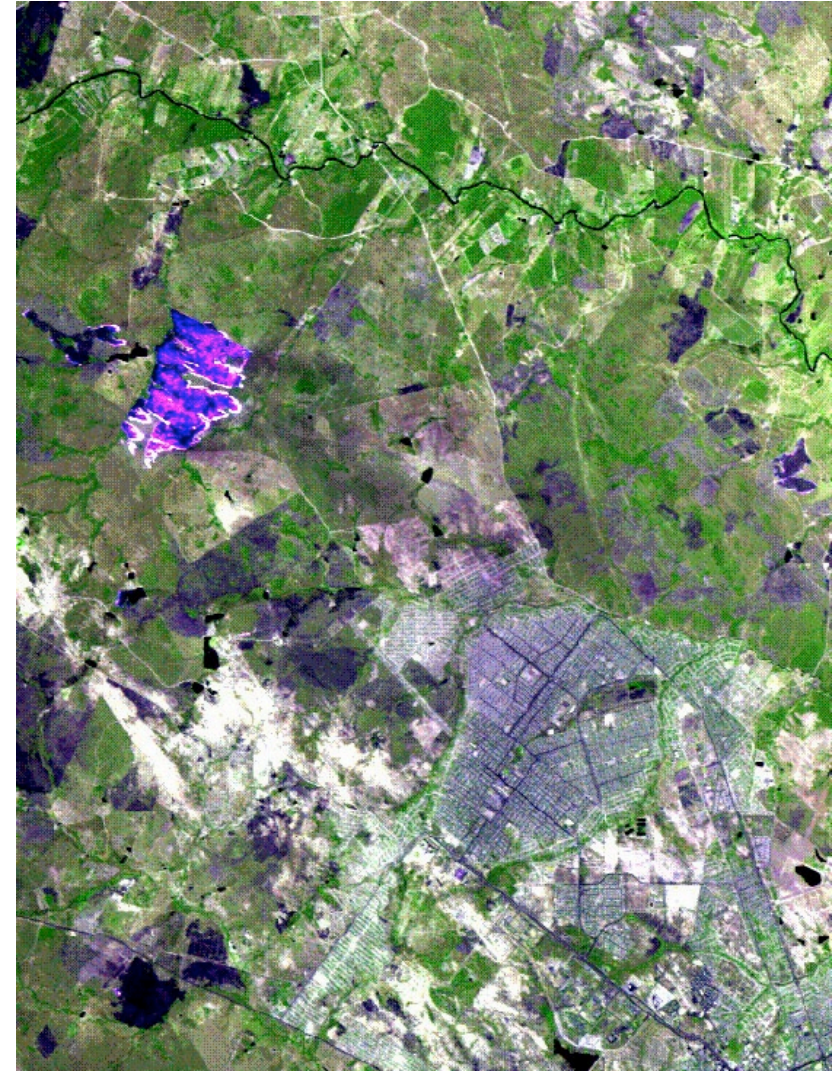
False Color Images

- 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

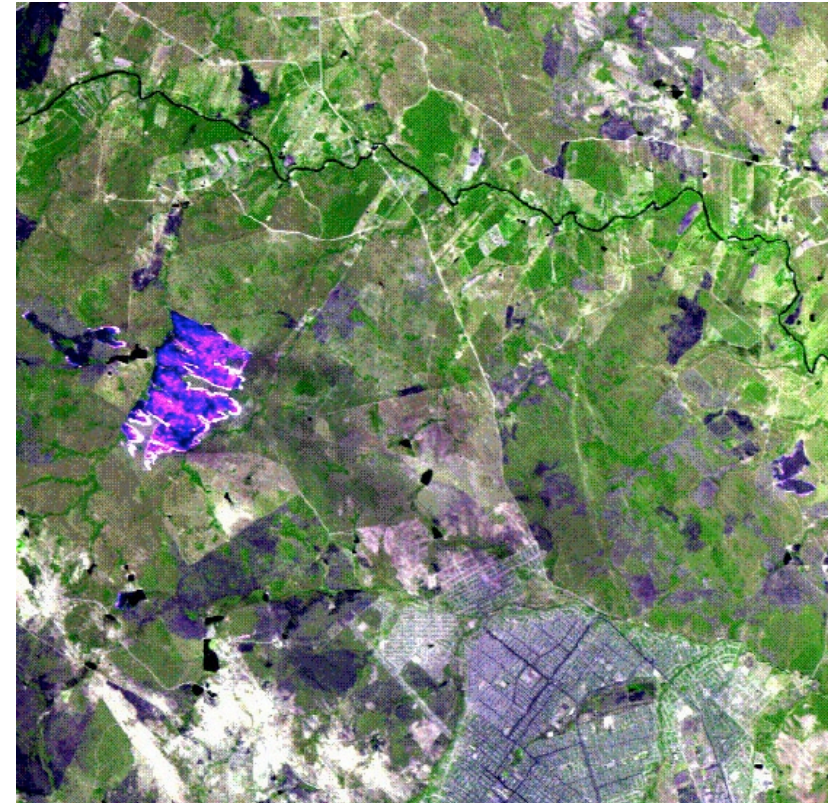
B = 2.1 μm



True vs. False Color Images



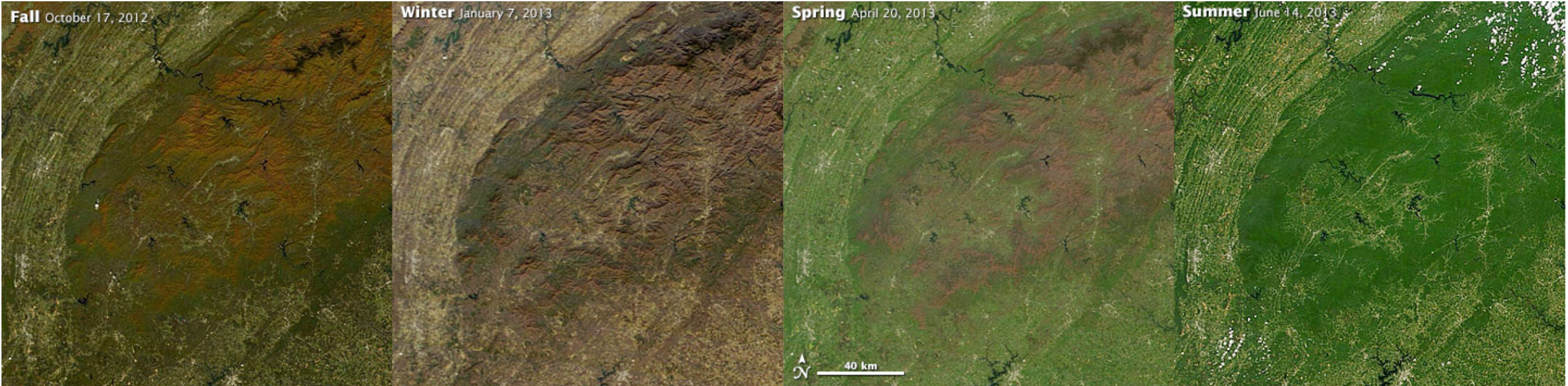
R = 0.66 μm
G = 0.55 μm
B = 0.47 μm



R = 1.6 μm
G = 1.2 μm
B = 2.1 μm



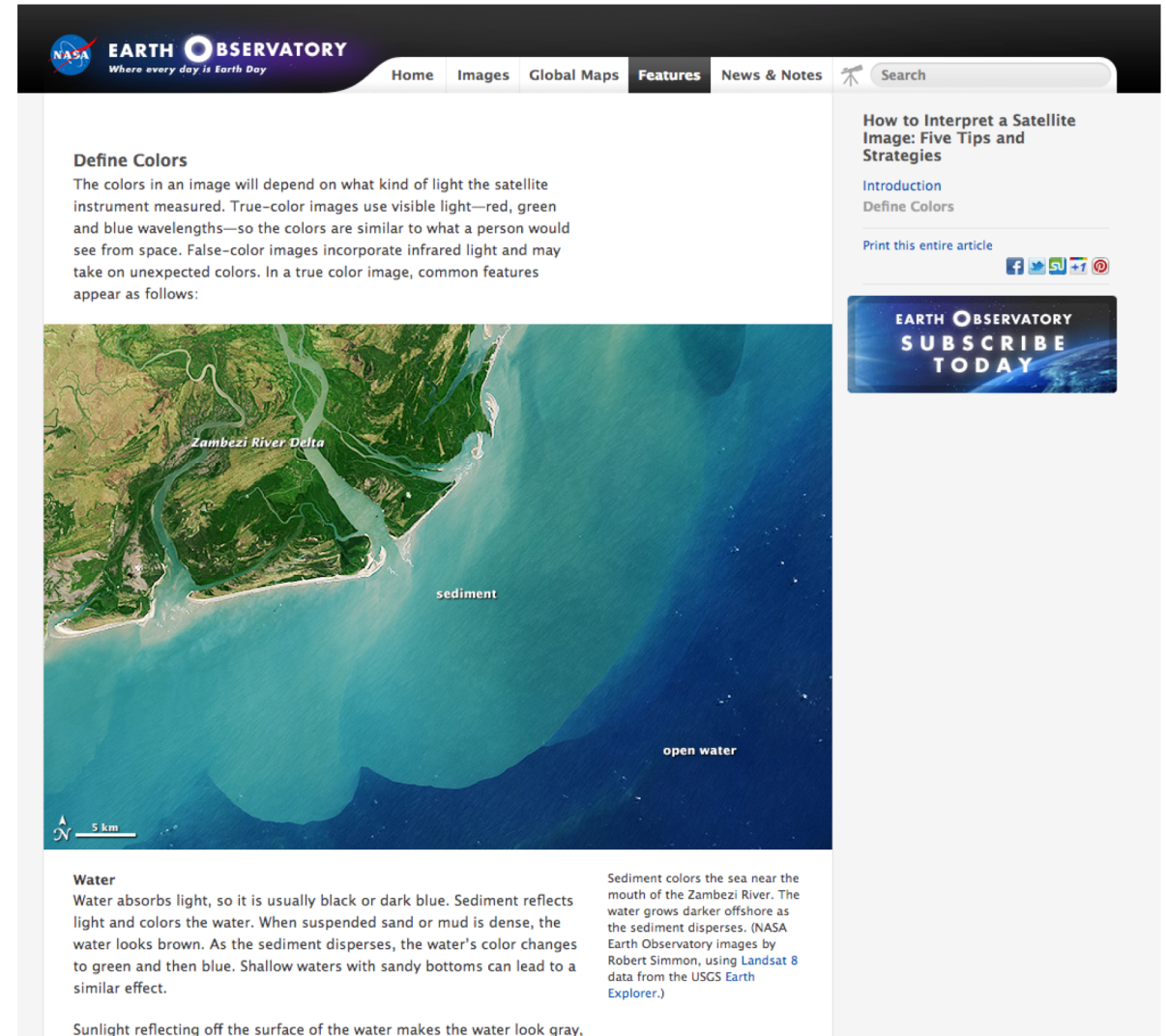
Change in Vegetation Color from Space



Earth Observatory Story

An article on feature detection in an image:


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



The screenshot shows the NASA Earth Observatory website. The header includes the NASA logo, the text "EARTH OBSERVATORY Where every day is Earth Day", and navigation links for Home, Images, Global Maps, Features, News & Notes, and a search bar. The main article is titled "How to Interpret a Satellite Image: Five Tips and Strategies" and includes sub-sections for "Introduction" and "Define Colors". The "Define Colors" section explains that true-color images use visible light (red, green, blue) and false-color images use infrared light. Below the text is a satellite image of the Zambezi River Delta, showing a large area of light blue water labeled "sediment" and a darker blue area labeled "open water". A scale bar indicates 5 km. To the right of the article is a "SUBSCRIBE TODAY" button and social media sharing icons.

Define Colors

The colors in an image will depend on what kind of light the satellite instrument measured. True-color images use visible light—red, green and blue wavelengths—so the colors are similar to what a person would see from space. False-color images incorporate infrared light and may take on unexpected colors. In a true color image, common features appear as follows:



Water

Water absorbs light, so it is usually black or dark blue. Sediment reflects light and colors the water. When suspended sand or mud is dense, the water looks brown. As the sediment disperses, the water's color changes to green and then blue. Shallow waters with sandy bottoms can lead to a similar effect.

Sunlight reflecting off the surface of the water makes the water look gray,

Sediment colors the sea near the mouth of the Zambezi River. The water grows darker offshore as the sediment disperses. (NASA Earth Observatory images by Robert Simmon, using Landsat 8 data from the USGS Earth Explorer.)

EARTH OBSERVATORY
SUBSCRIBE
TODAY



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

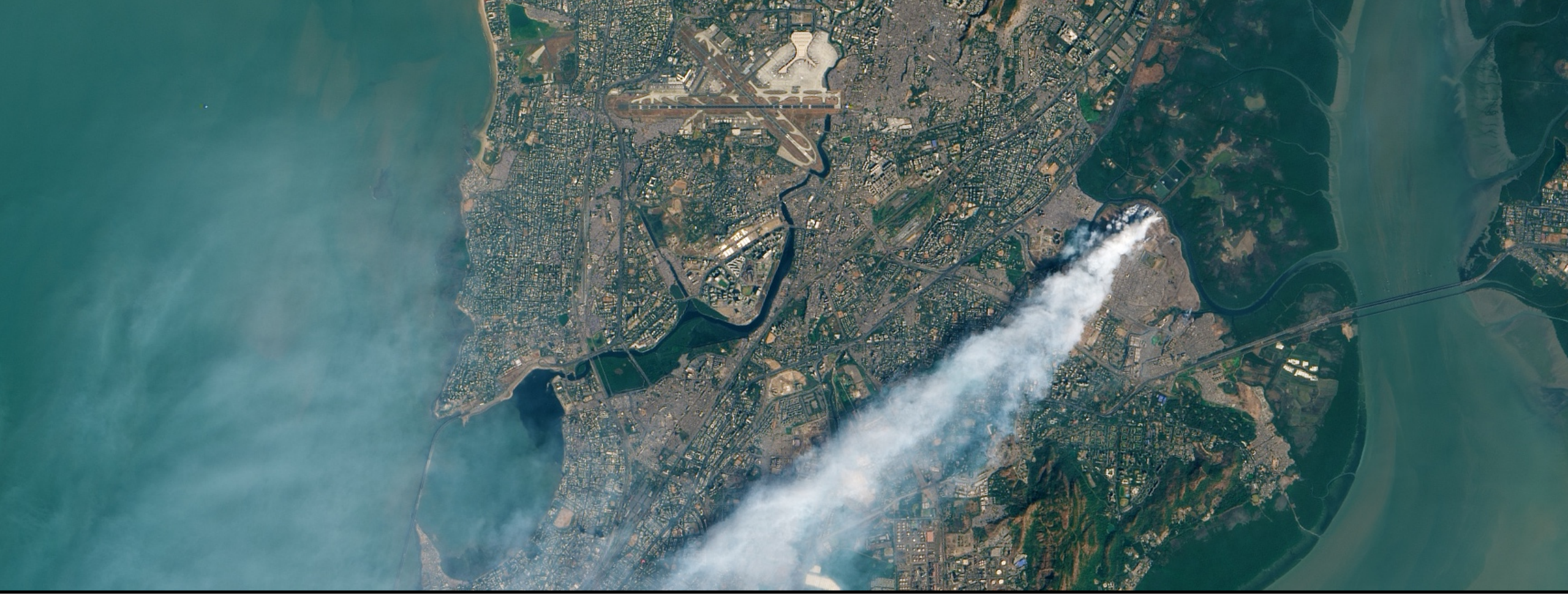
- Earth Observatory: Events & More
 - <http://earthobservatory.nasa.gov>
- Worldview: Near Real-Time
 - <http://earthdata.nasa.gov/labs/worldview>



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?