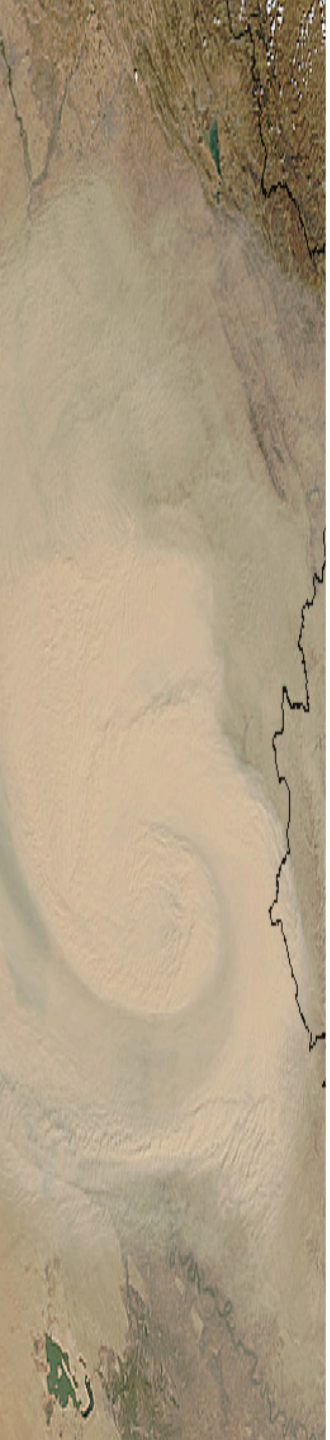


National Aeronautics and
Space Administration

ARSET
Applied Remote Sensing Training
http://arset.gsfc.nasa.gov
@NASAARSET

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

The Practical Use of Satellite Observations for Visibility and Air Quality Analysis

Monday, September 26, 2016
Atmospheric Optics: Aerosols, Visibility, and the Radiative Balance
Jackson Hole, Wyoming, USA

Objectives

1. Learn about satellite data formats and levels

2. Learn about visible satellite imagery, feature detection, and applications

3. Provide a live demonstration and hands-on exercise on accessing and analyzing satellite imagery

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

Data Formats

Text/ASCII

- Pros: easy to read and examine right away
- Cons: large data files, not always available

Binary: HDF, NetCDF, OpenDAP

- Pros: less space, more information (metadata, SDS)
- Cons: Needs specific tools or code to read the data

KML or KMZ (zipped KML)

- Pros: easy 2D & 3D visualization of data through free tools; data files are similar in size and easier to download

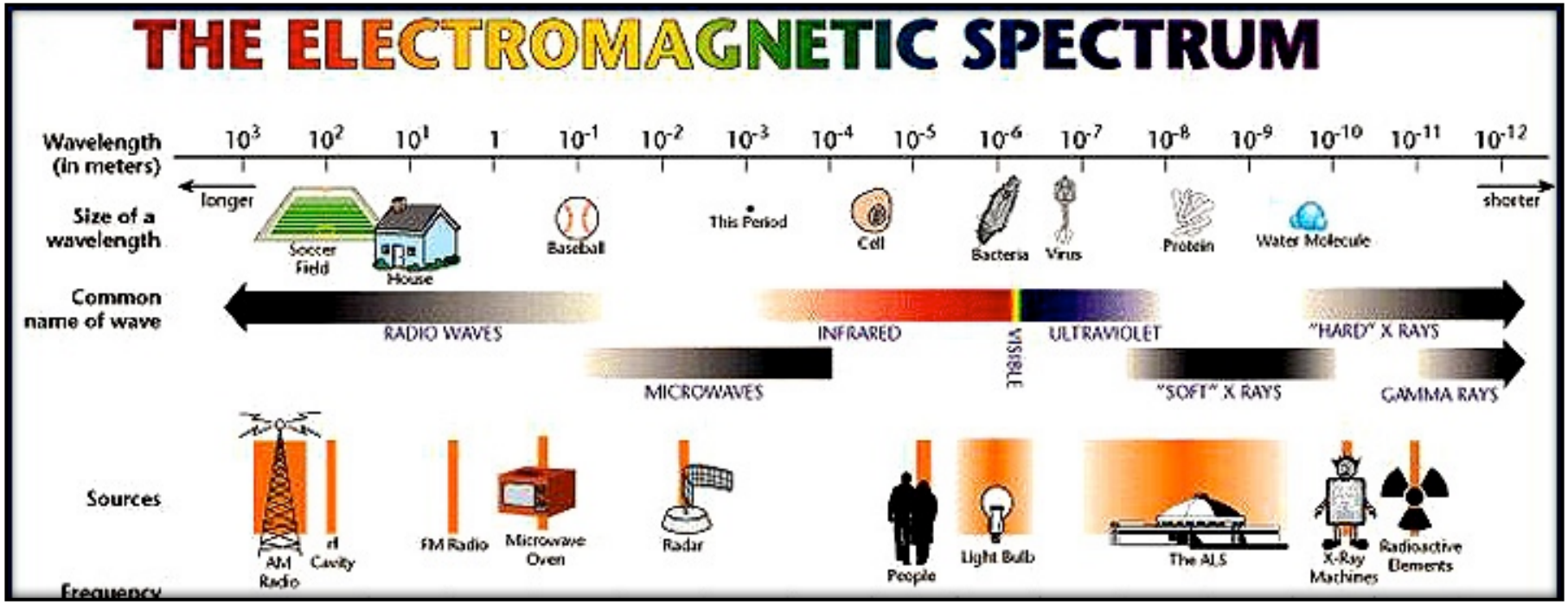
Shapefile/Geotiff

- GIS applications
- May or may not work with open source

Visible Image Science

- Visible satellite images are essentially photographs
- (Almost) all the energy collected by the visible sensors (cameras) on board 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. cloud appears bright)
- The lower the albedo, the more light energy is absorbed (i.e. water appears dark)

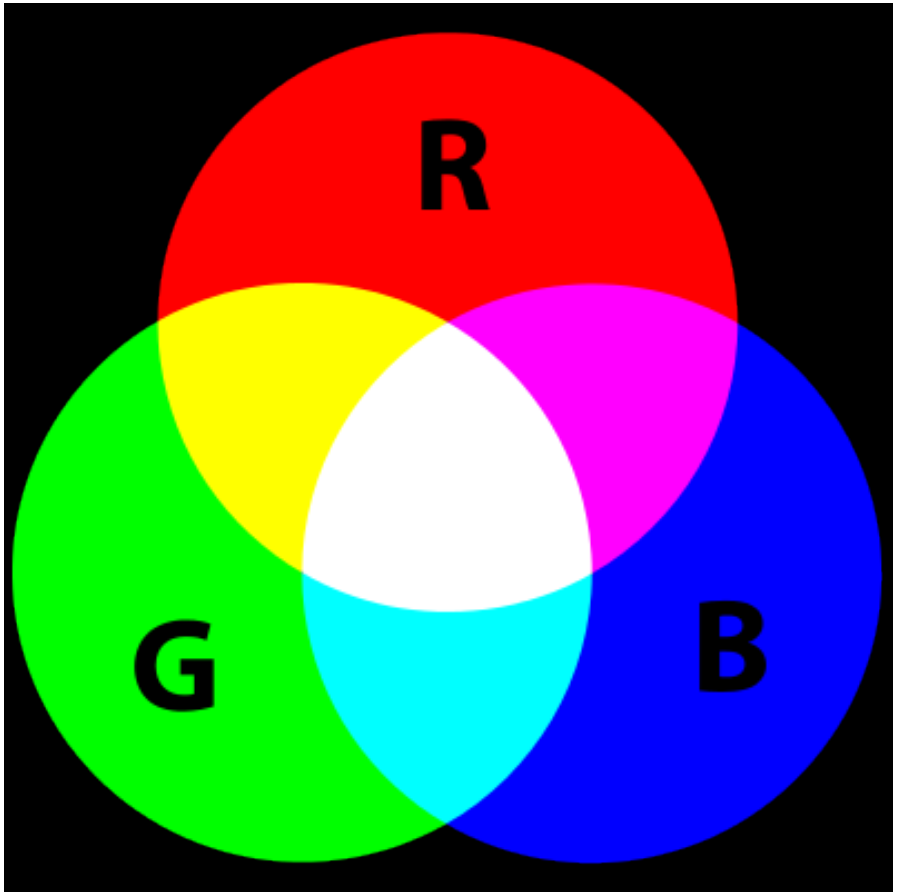
Wavelength Selection



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



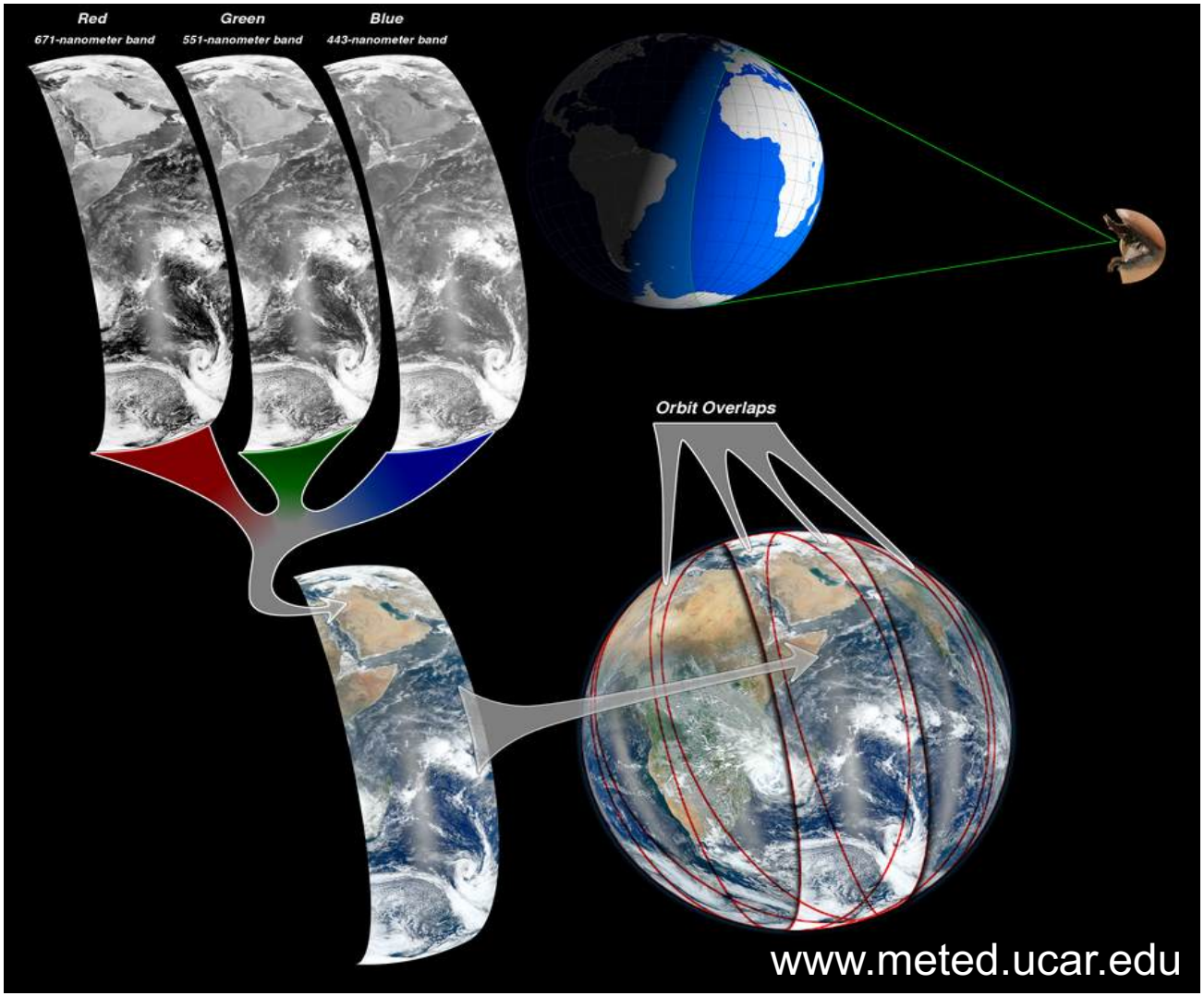
True Color Image (or RGB)

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

R = 0.66 µm

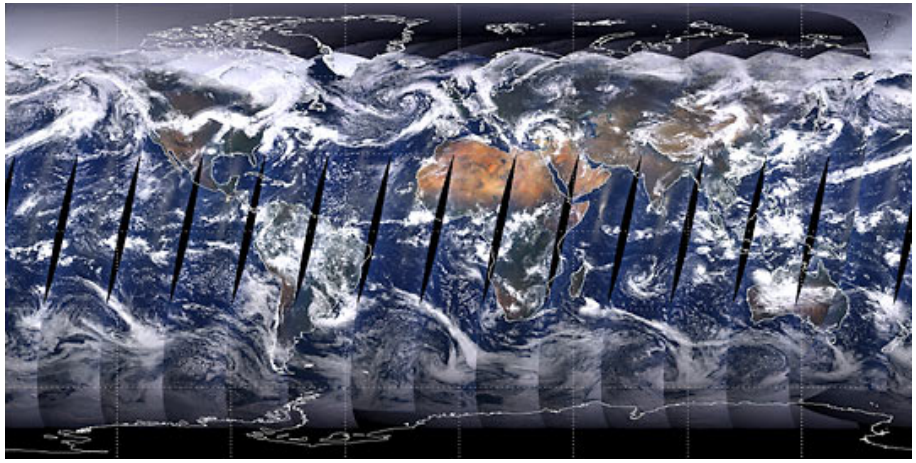
G = 0.55 µm

B = 0.47 µm



Moderate Resolution Imaging Spectroradiometer

MODIS



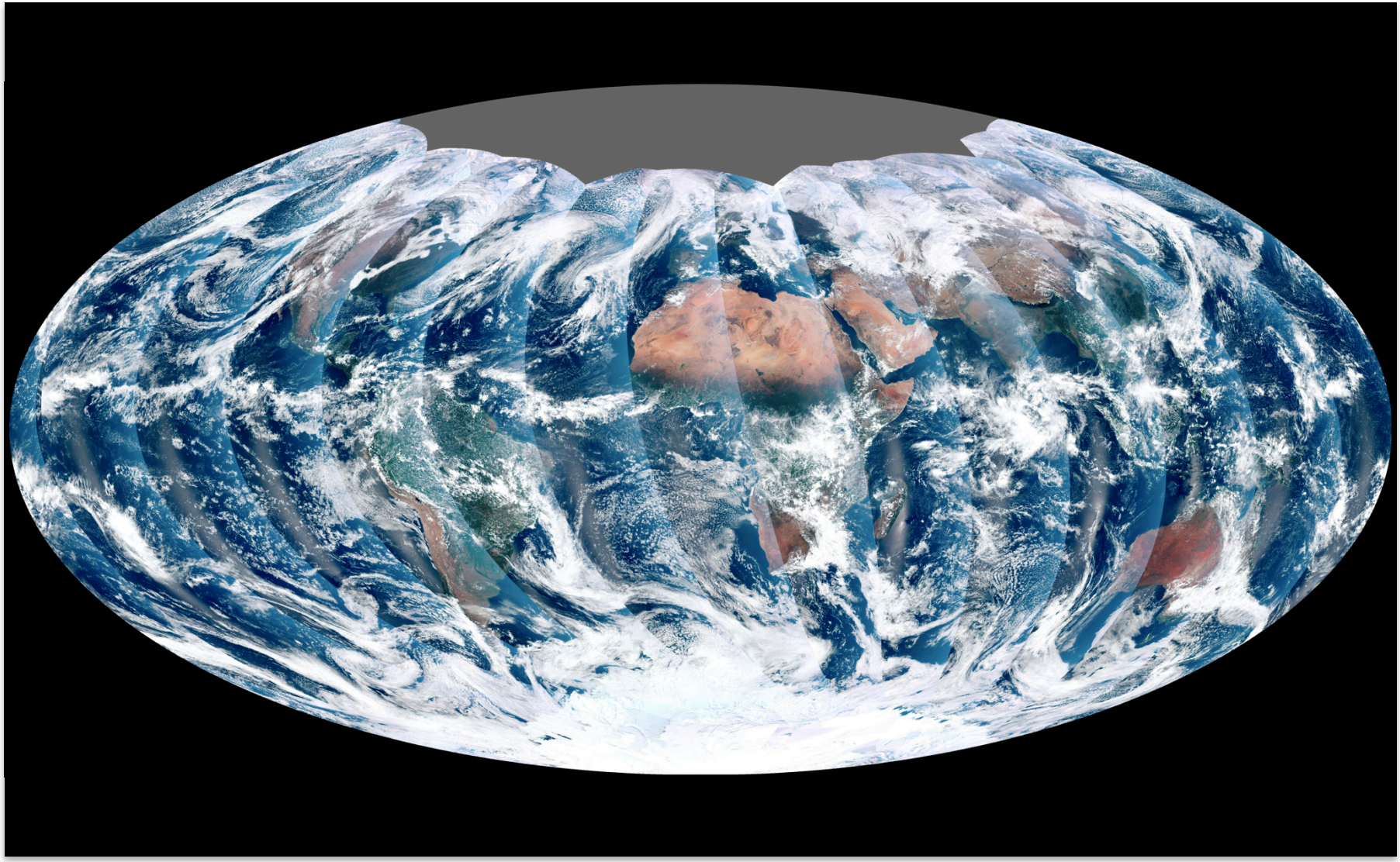
- **Spatial Resolution**
  - 250m, 500m, 1km
- **Platform**
  - Terra & Aqua
- **Temporal Resolution**
  - 2000-present
  - Daily, 8-day, 16-day, monthly, quarterly, yearly
- **Data Format**
  - Hierarchal Data Format – Earth Observing System Format (HDF-EOS)
- **Spectral Coverage**
  - 36 bands (major bands include red, blue, IR, NIR, MIR)
    - Bands 1-2: 250m
    - Bands 3-7: 500m
    - Bands 8-36: 1,000m

MODIS Reflected Solar Bands

* 500m Spatial Resolution
** 250m Spatial Resolution

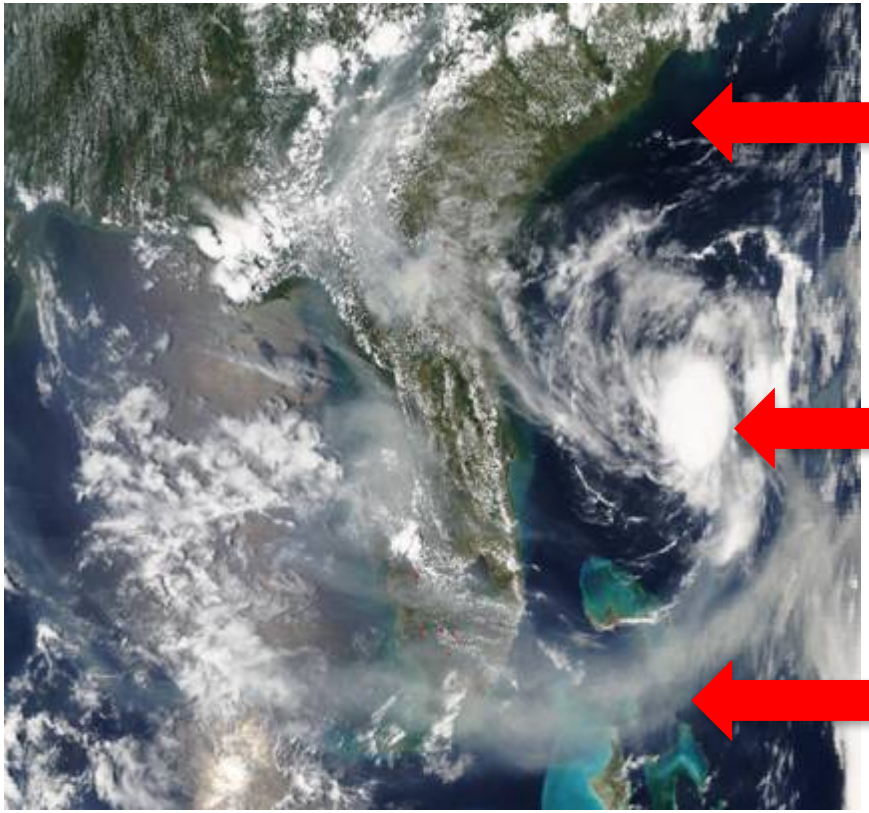
	Primary Use	Band No.	Bandwidth (nm)
250m	Land/Cloud Boundaries	1**	620-670
		2**	841-876
500m	Land/Cloud Properties	3*	459-479
		4*	545-565
		5*	1230-1250
		6*	1628-1652
		7*	2105-2155
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420
		9	438-448
		10	483-493
		11	526-536
		12	546-556
		13	662-672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

VIIRS Image



Doing More with Satellite Imagery

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

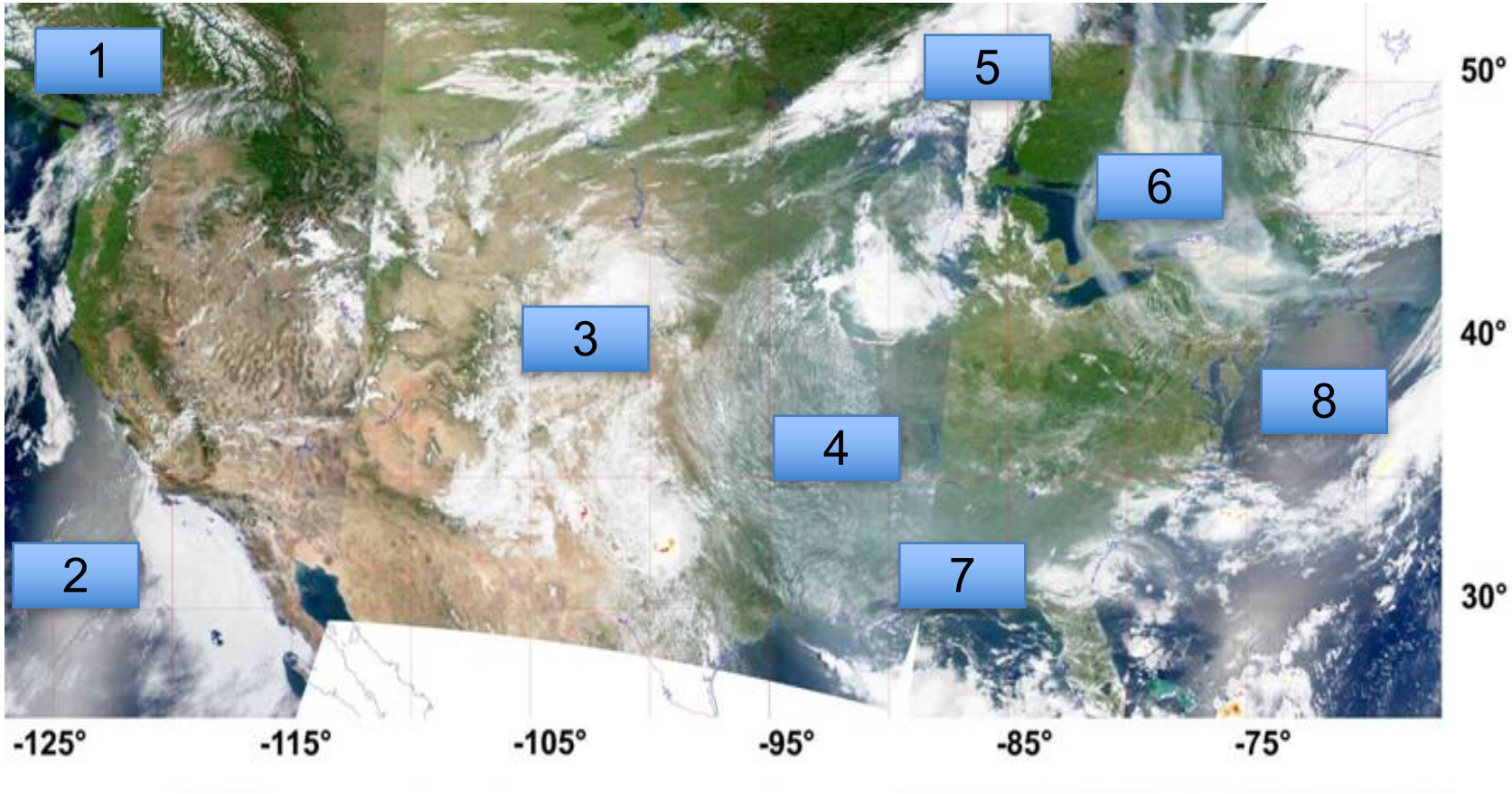


Visible imagery water is dark because it absorbs most of the energy

Clouds are white because most incoming energy is reflected

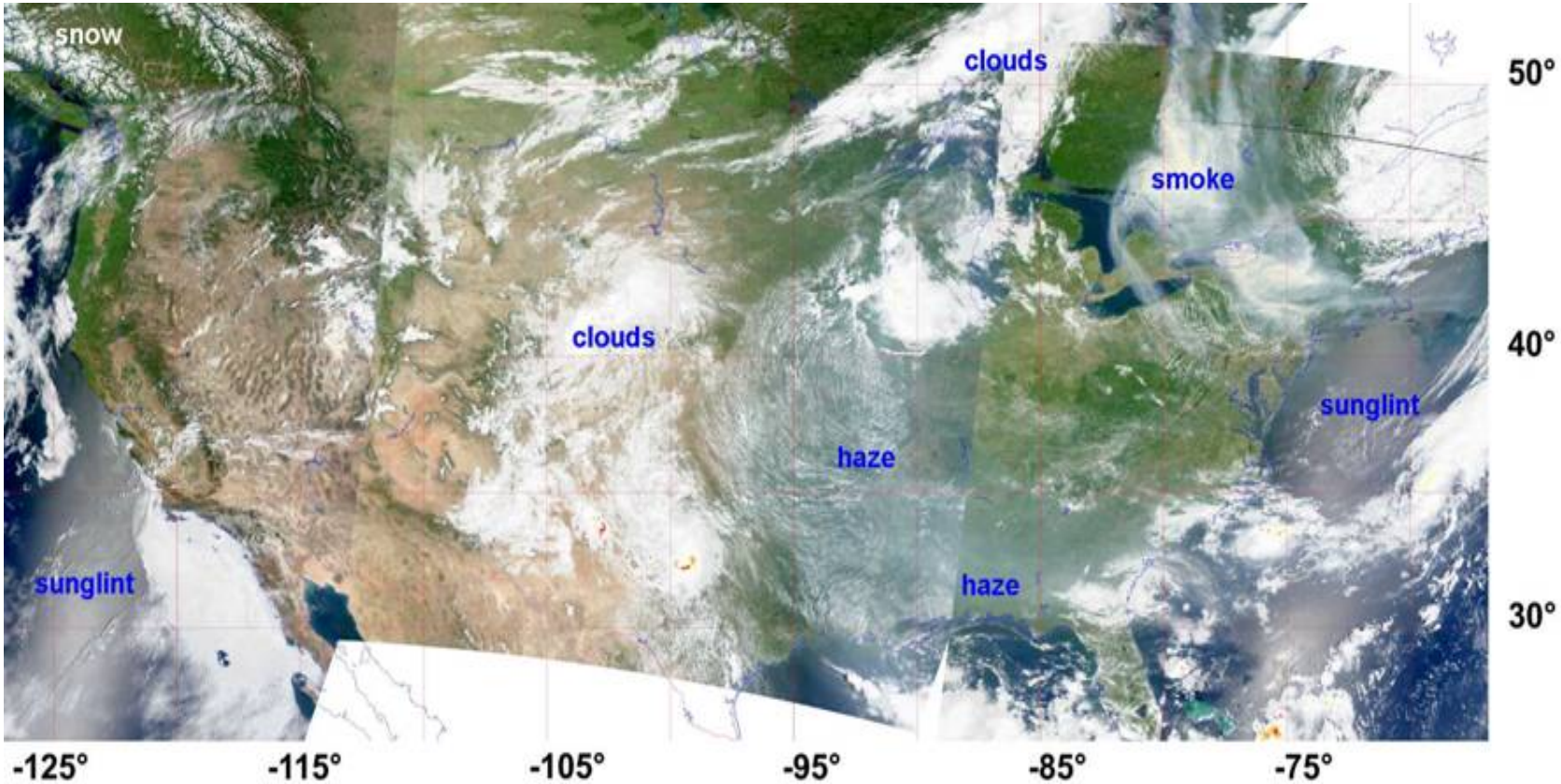
Pollution is hazy depending on its absorption properties

What can we learn from true color imagery?



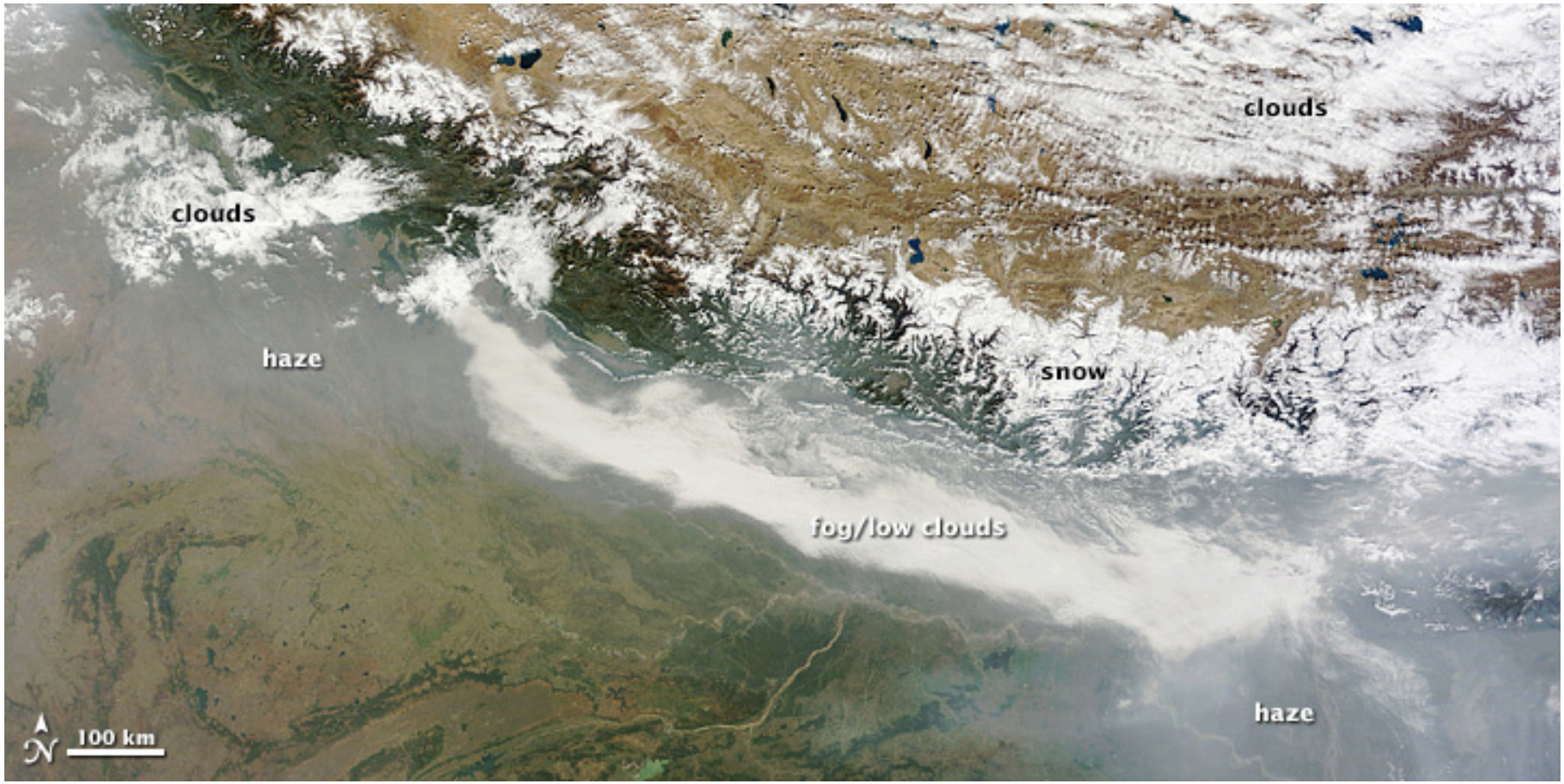
(Possible) identification of land, ocean, and atmosphere features

What can we learn from true color imagery?

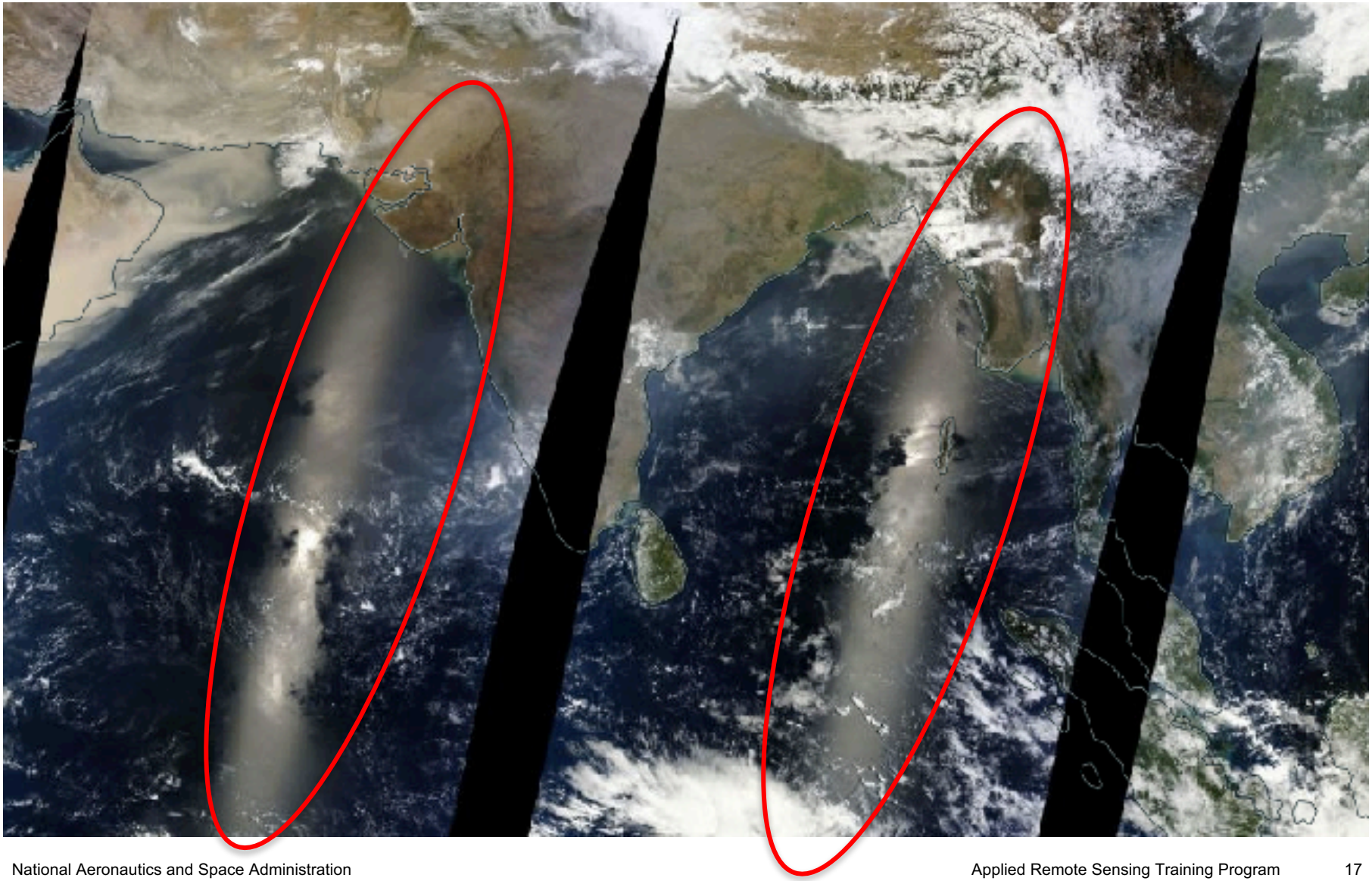


(Possible) identification of land, ocean, and atmosphere features

Features in True Color (Atmosphere)



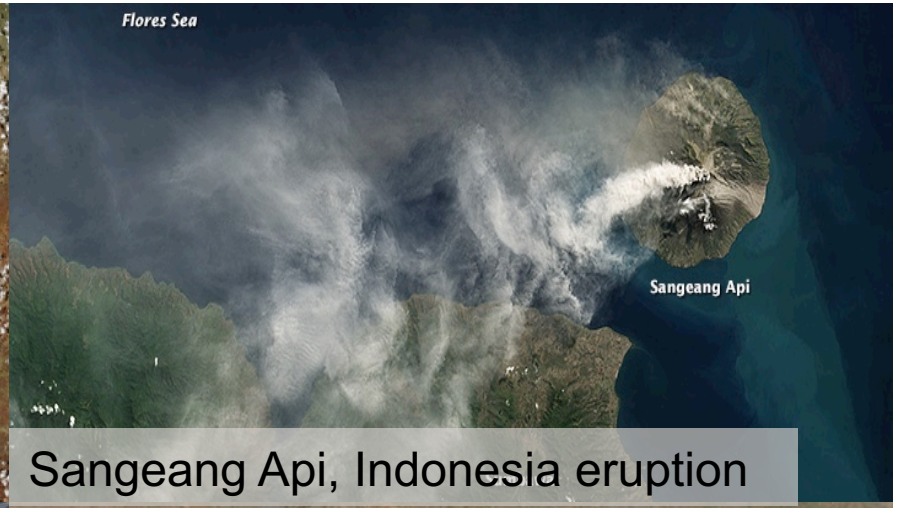
Glint



Feature Identification

More reliable when a clear source is in the image

Australian dust



Sangeang Api, Indonesia eruption

Urban-industrial/smoke pollution?

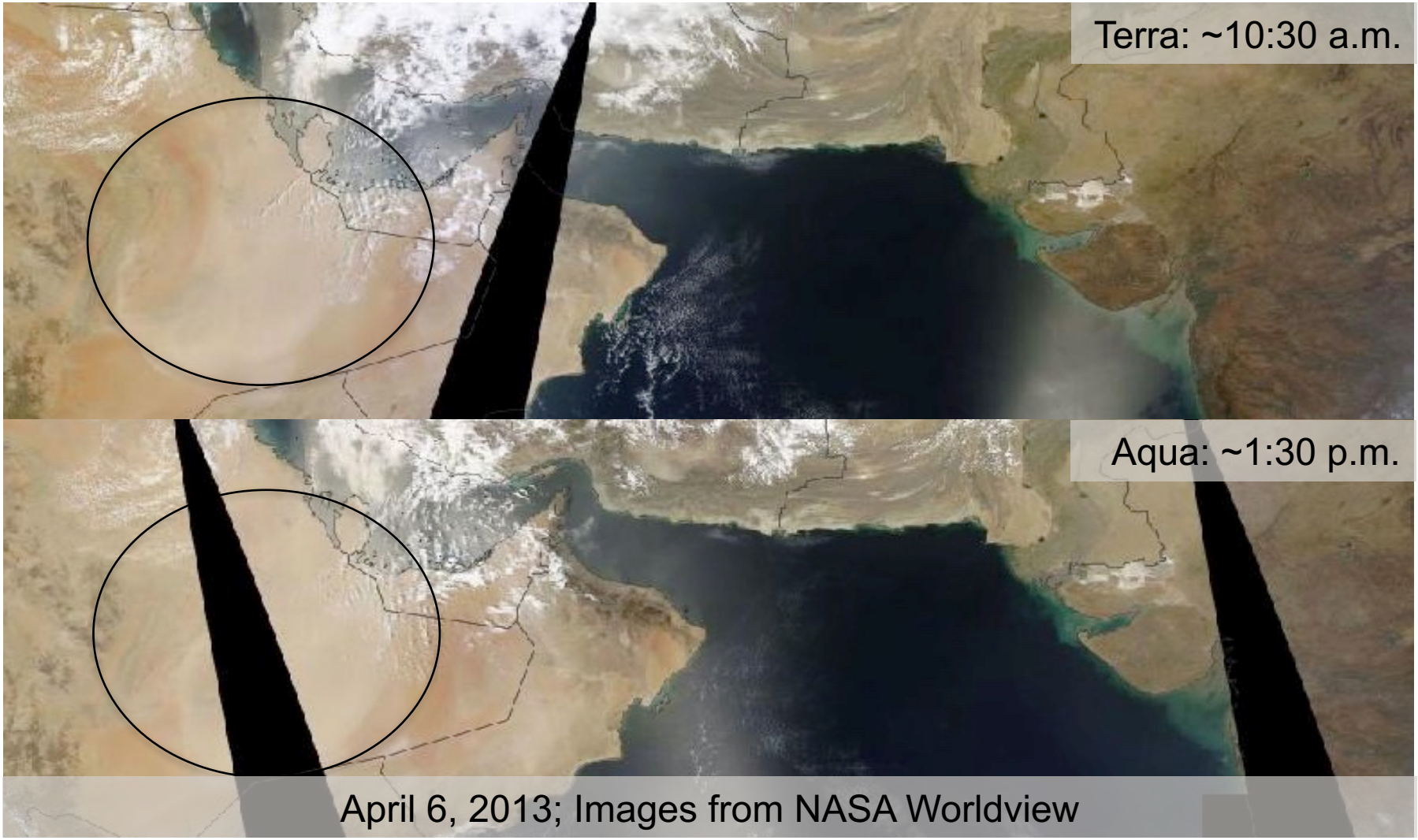
Indian oil fires

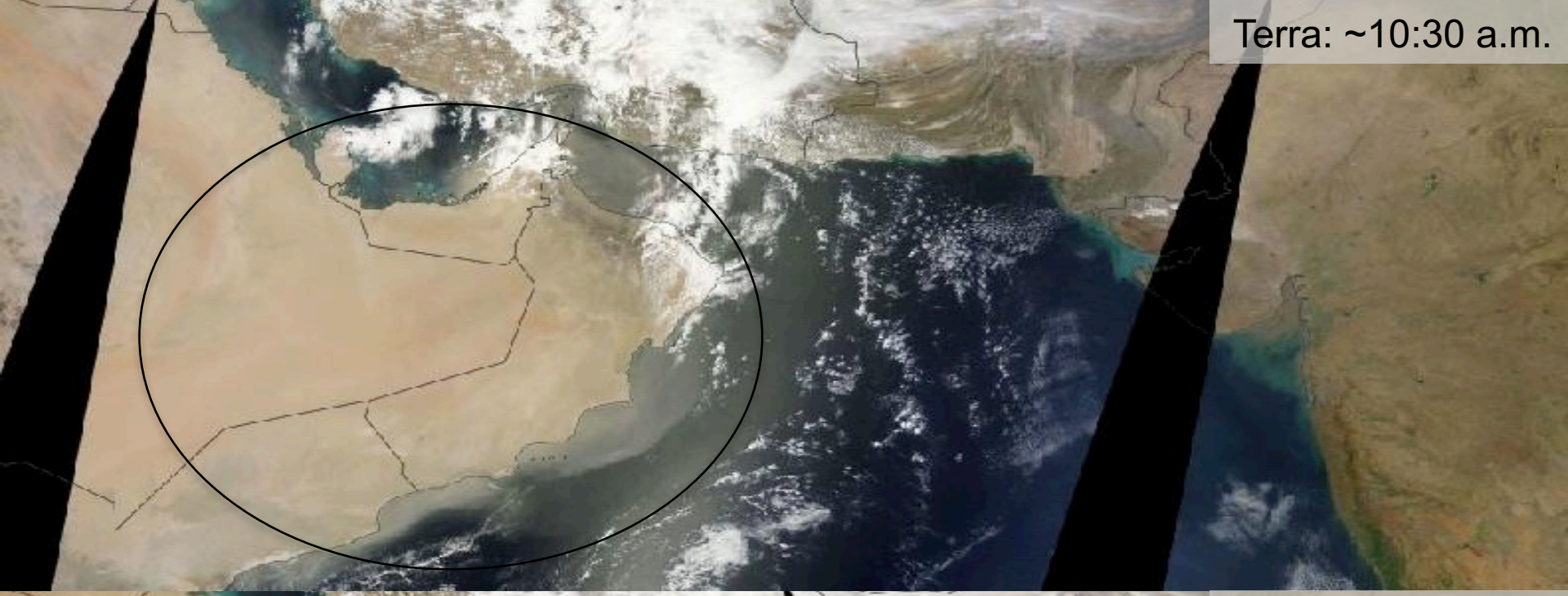
Feature Identification

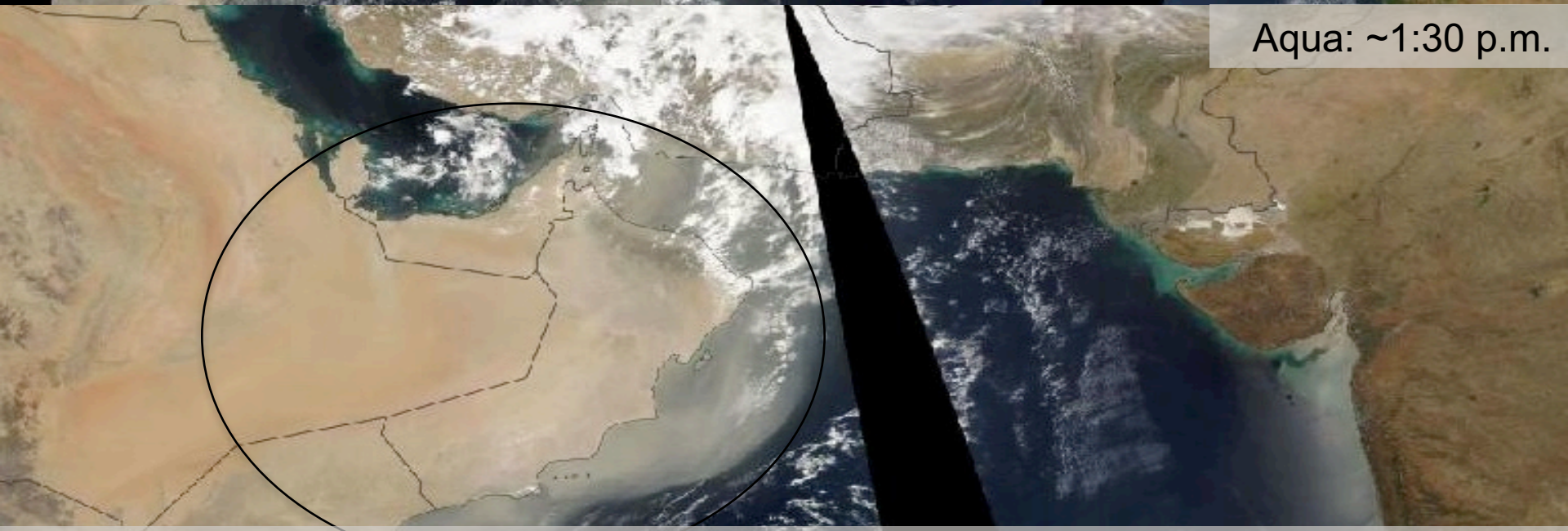
More reliable when a clear source is in the image

Using Time Series Imagery

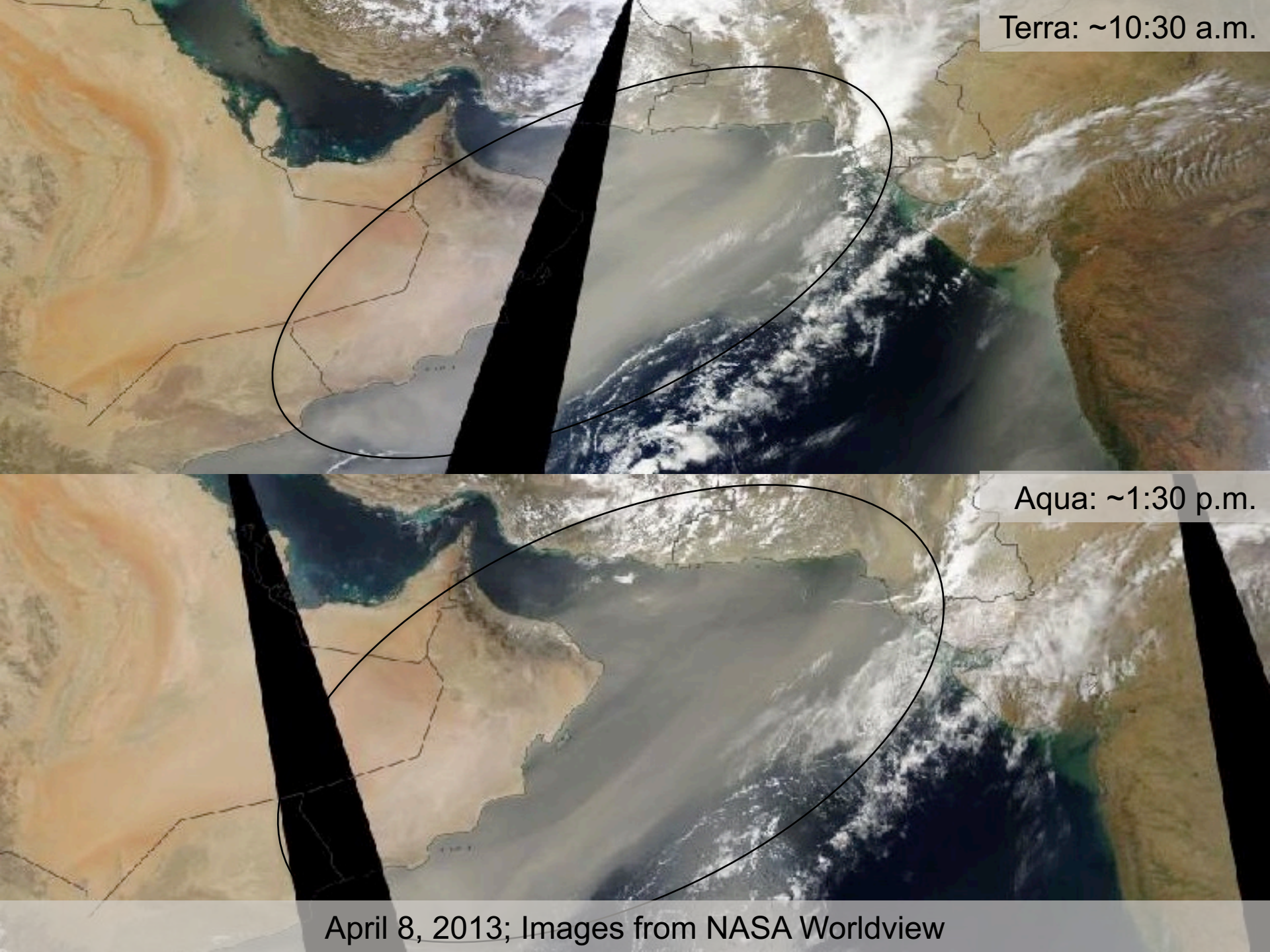
Dust Transport







April 7, 2013; Images from NASA Worldview

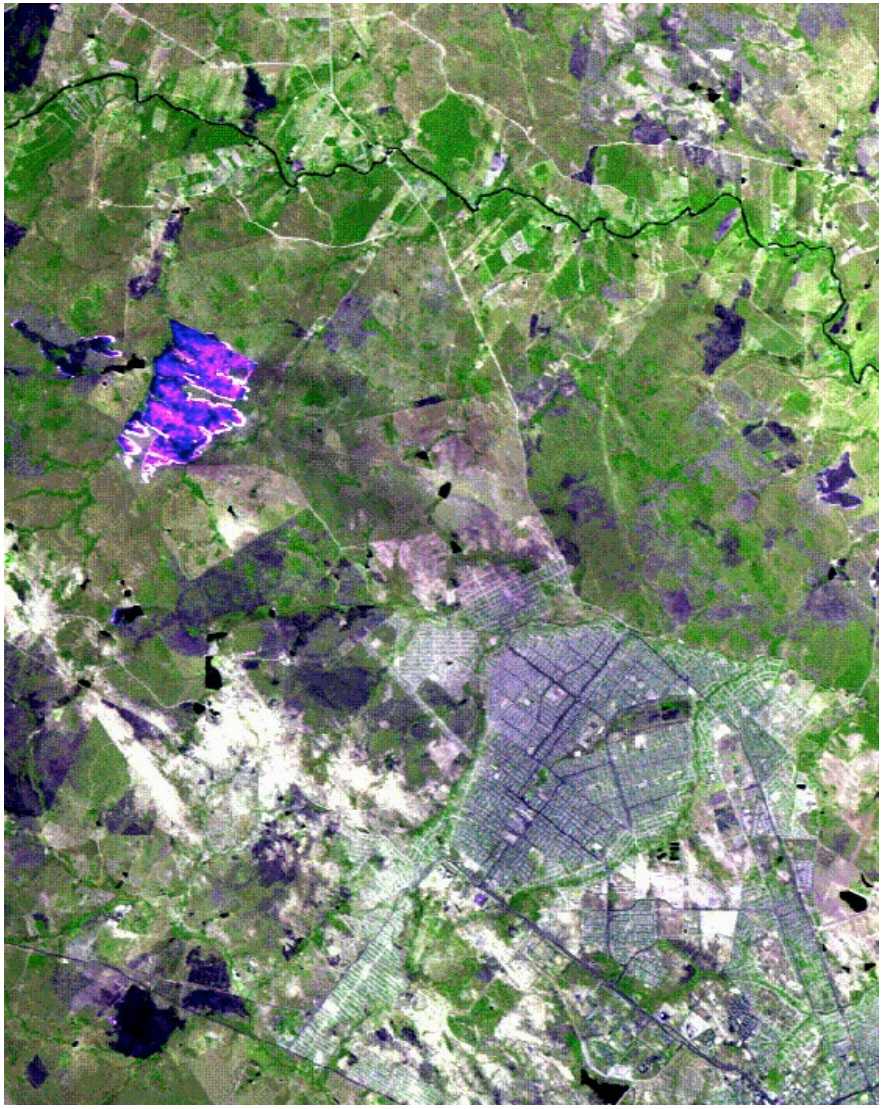


April 8, 2013; Images from NASA Worldview

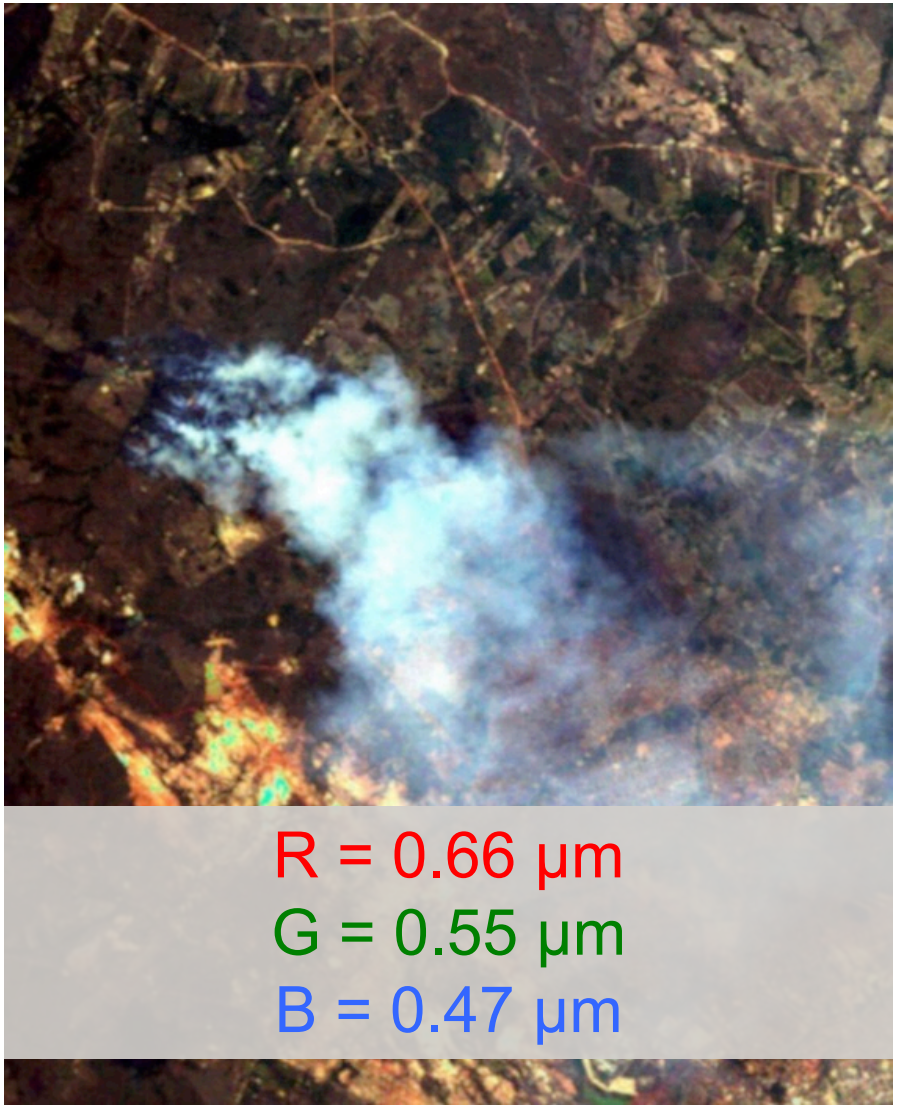
False Color Images

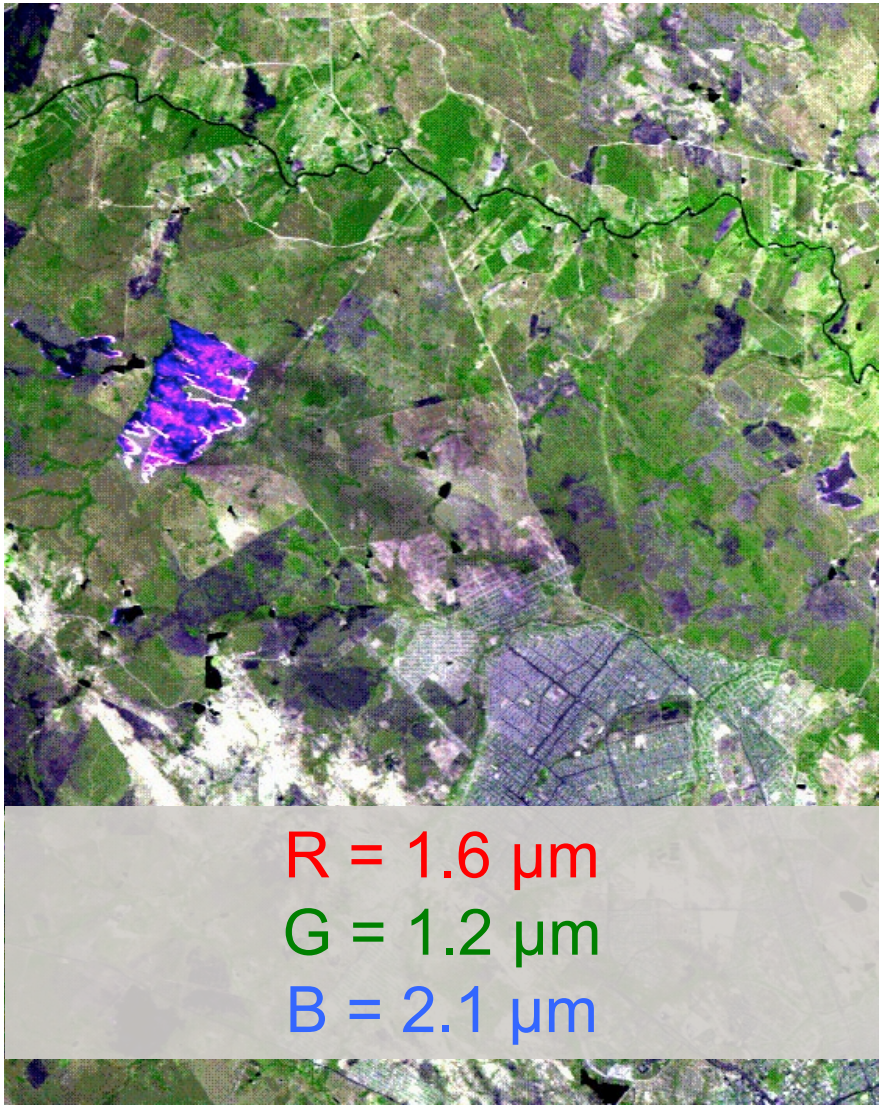
- Load bands into the red, green, and blue display channels
- Do not correspond to the visible red, green, and blue wavelengths

R = 1.6 µm
G = 1.2 µm
B = 2.1 µm

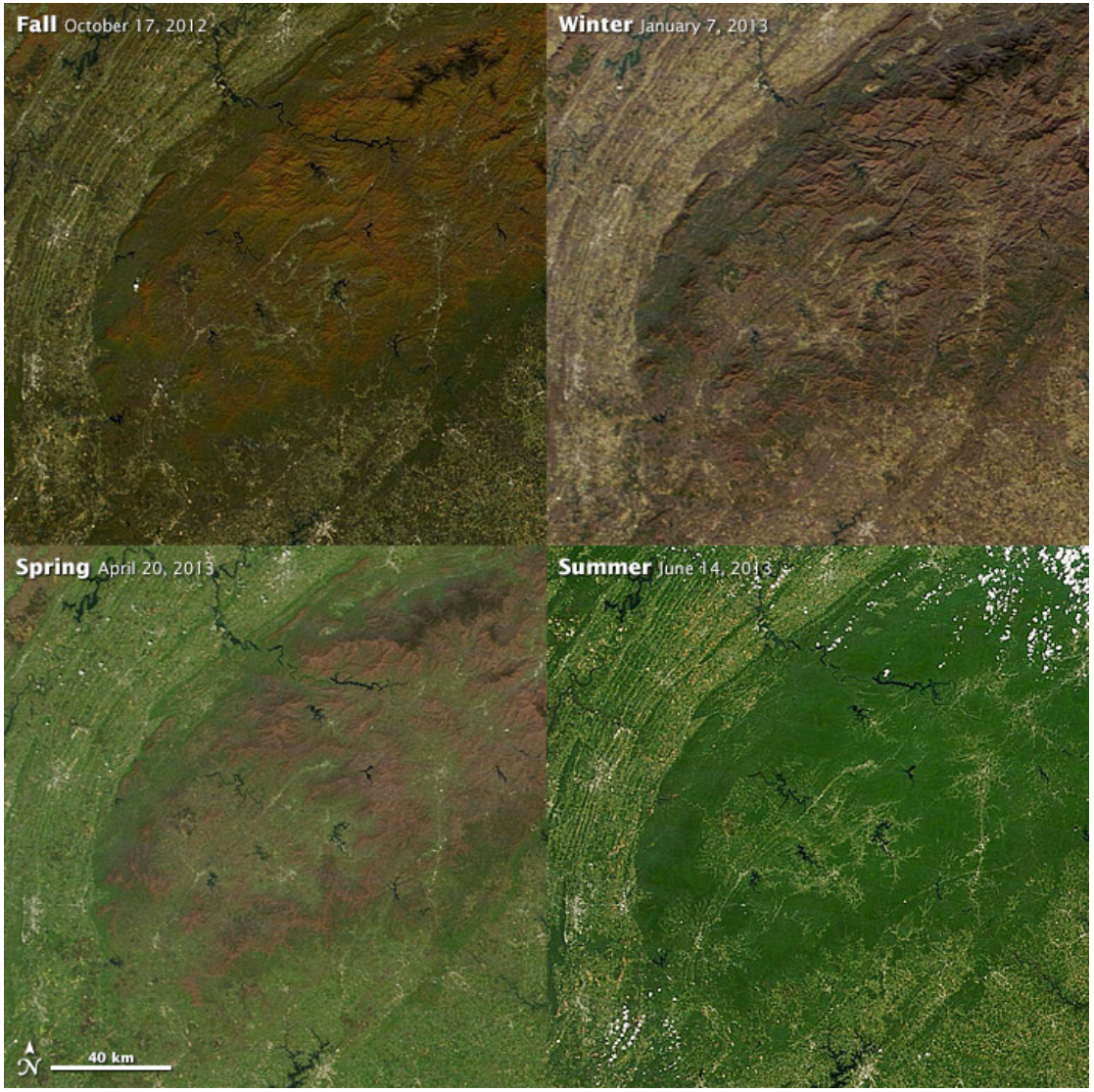


True vs. False Color Images



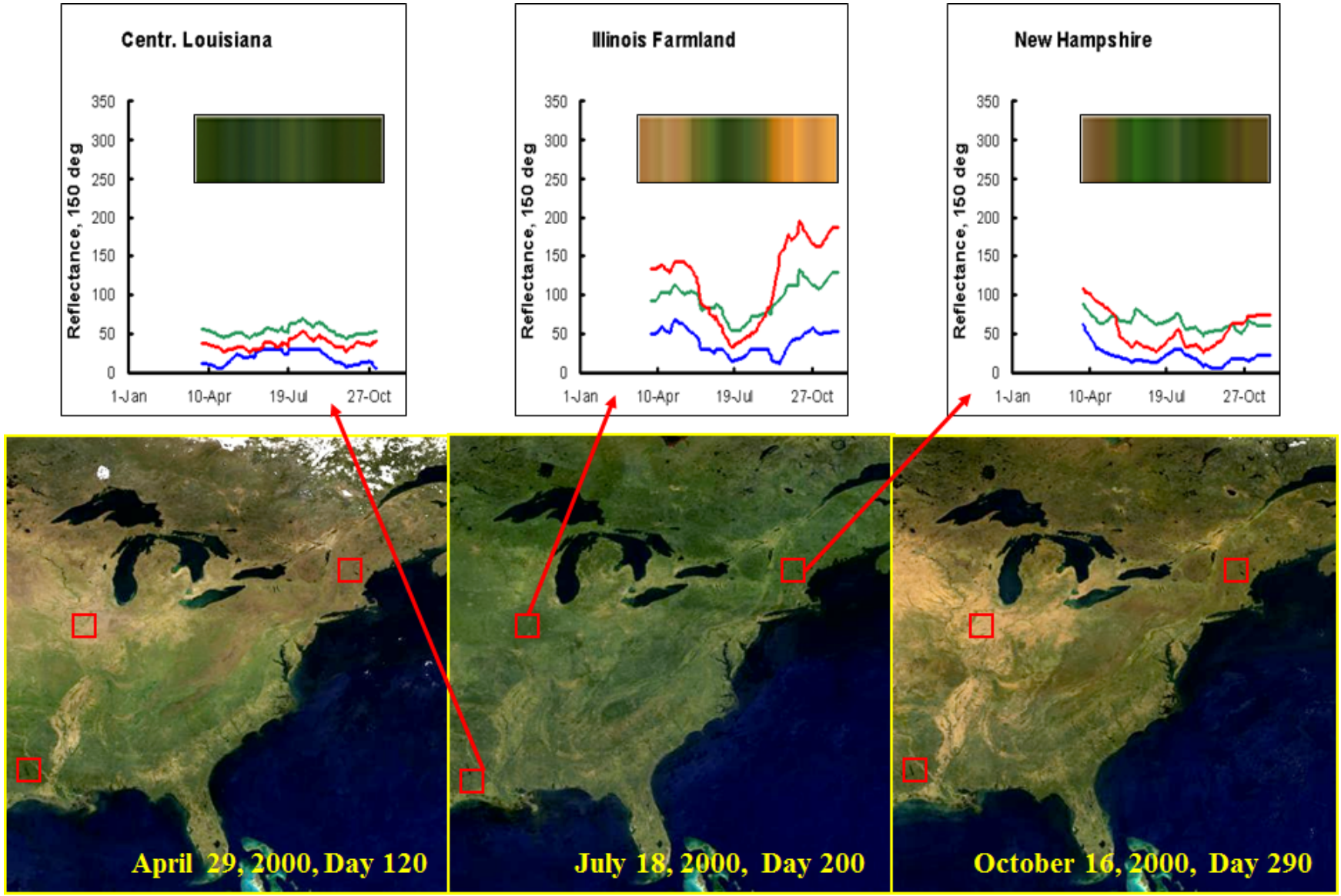


Change in Vegetation Color from Space



http://earthobservatory.nasa.gov/

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

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, silver, or white. This phenomenon, known as sunglint, can highlight wave features or oil slicks, but it also masks the presence of sediment or phytoplankton.

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.)

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

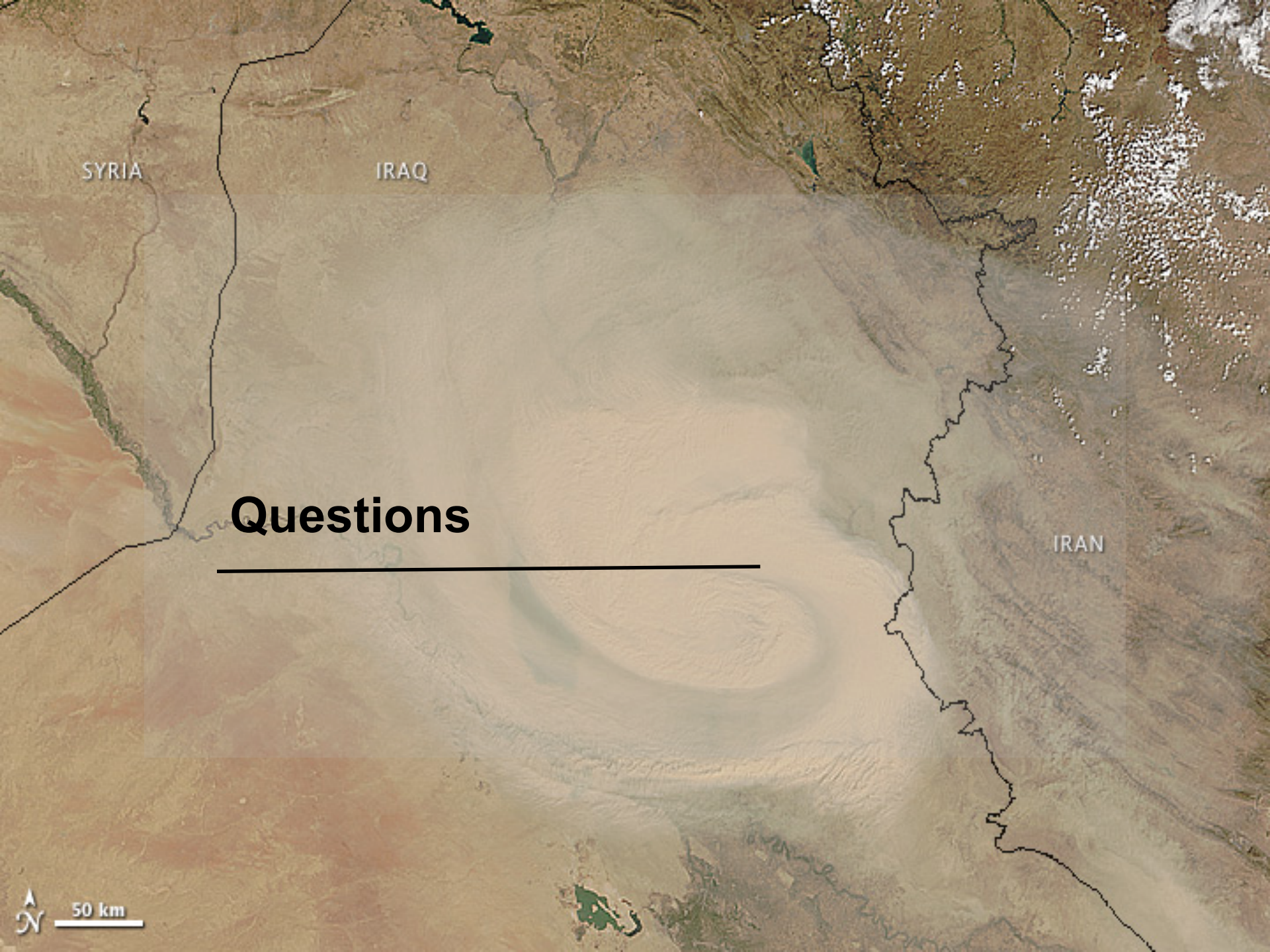
Tour of Some Useful Image Archives

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

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

Questions and Discussion Points

- What is difference between true color and false color image
- List three applications of true color images for air quality monitoring
- Does access of near real time true color image provide any useful information to air quality forecasters?



Questions