



ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

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

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**Pawan Gupta, Melanie Follette-Cook**

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2nd International Smoke Symposium

Long Beach, CA, 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

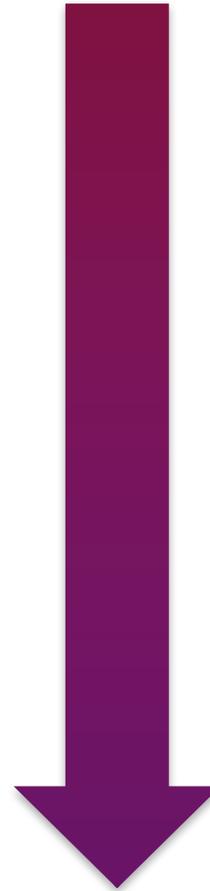
L2: Products derived from L1B

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

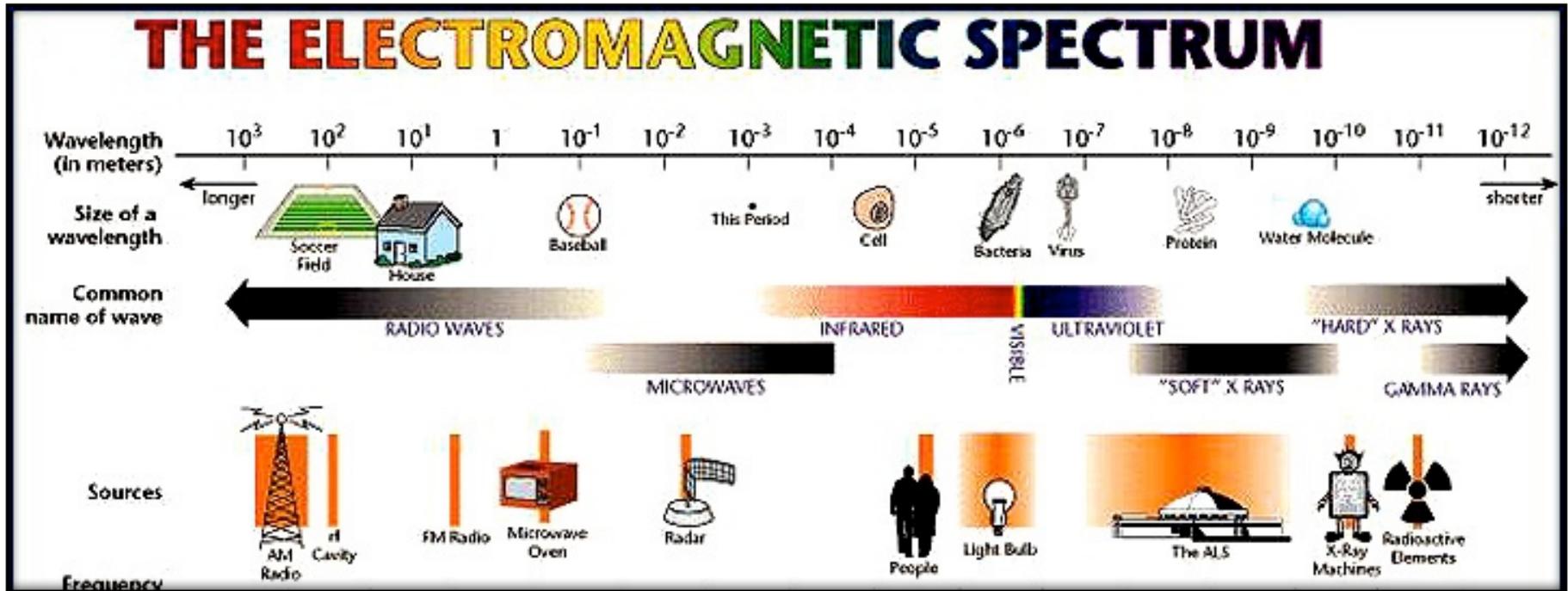
## Shapefile/Geotiff

- 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)

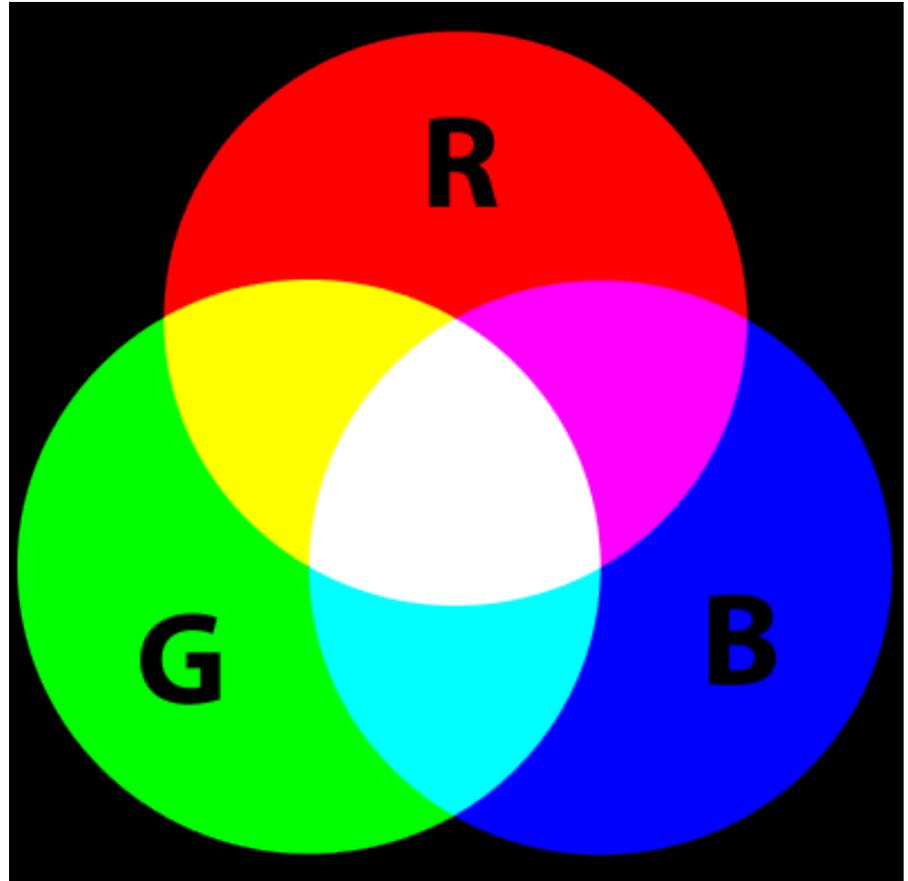
# Wavelength Selection



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



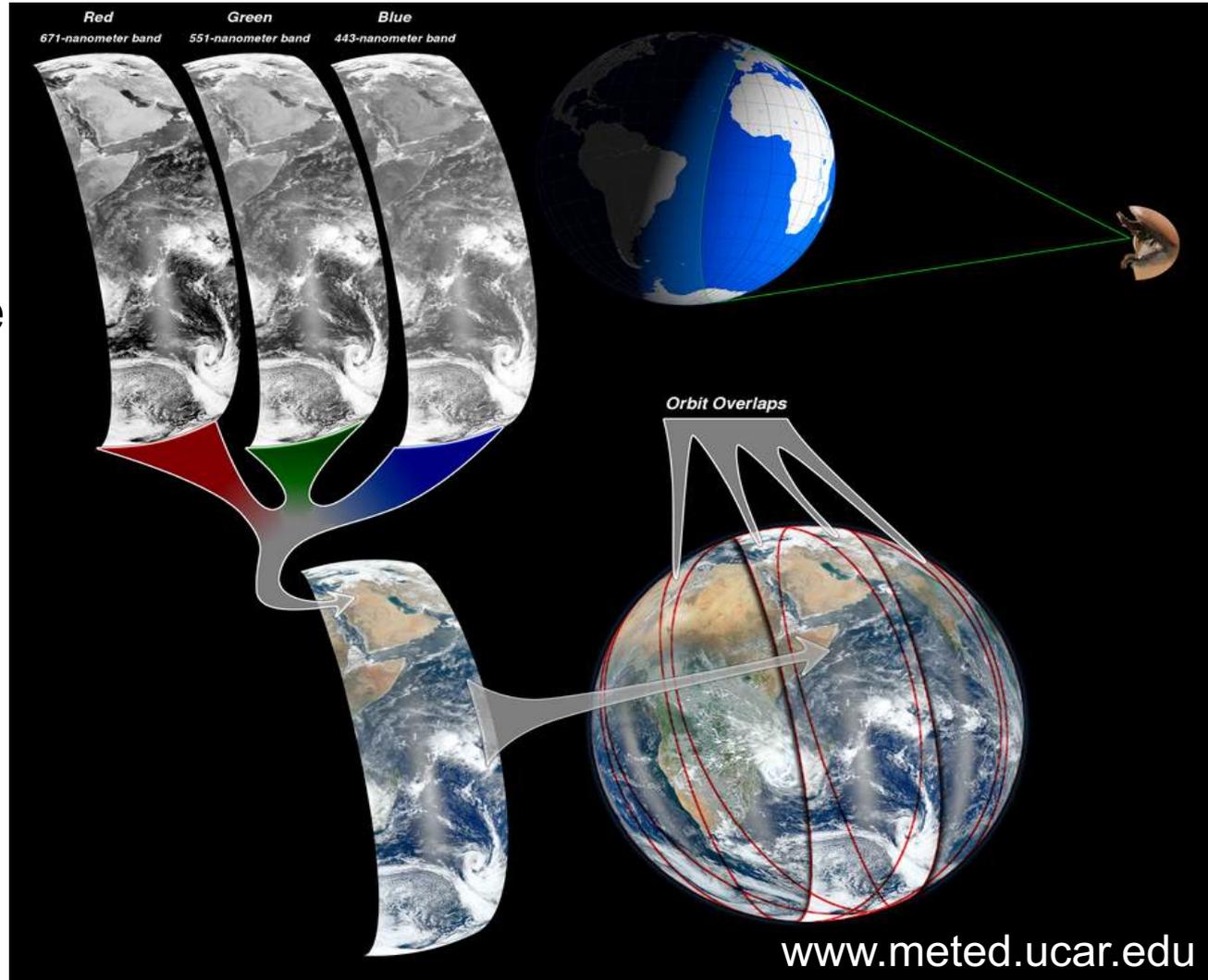
# True Color Image (or RGB)

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

R = 0.66  $\mu\text{m}$

G = 0.55  $\mu\text{m}$

B = 0.47  $\mu\text{m}$



[www.meted.ucar.edu](http://www.meted.ucar.edu)

# 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**

- Hierarchical Data Format – Earth Observing System Format (HDF-EOS)

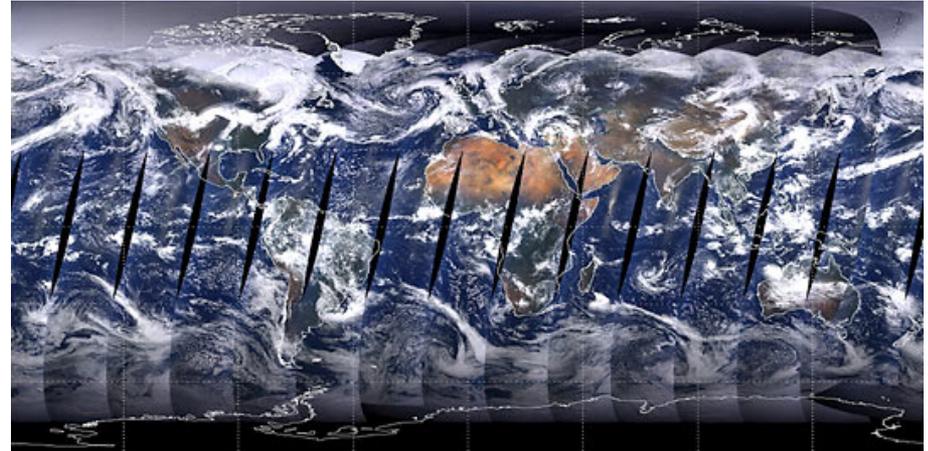
- **Spectral Coverage**

- 36 bands (major bands include red, blue, IR, NIR, MIR)

- Bands 1-2: 250m

- Bands 3-7: 500m

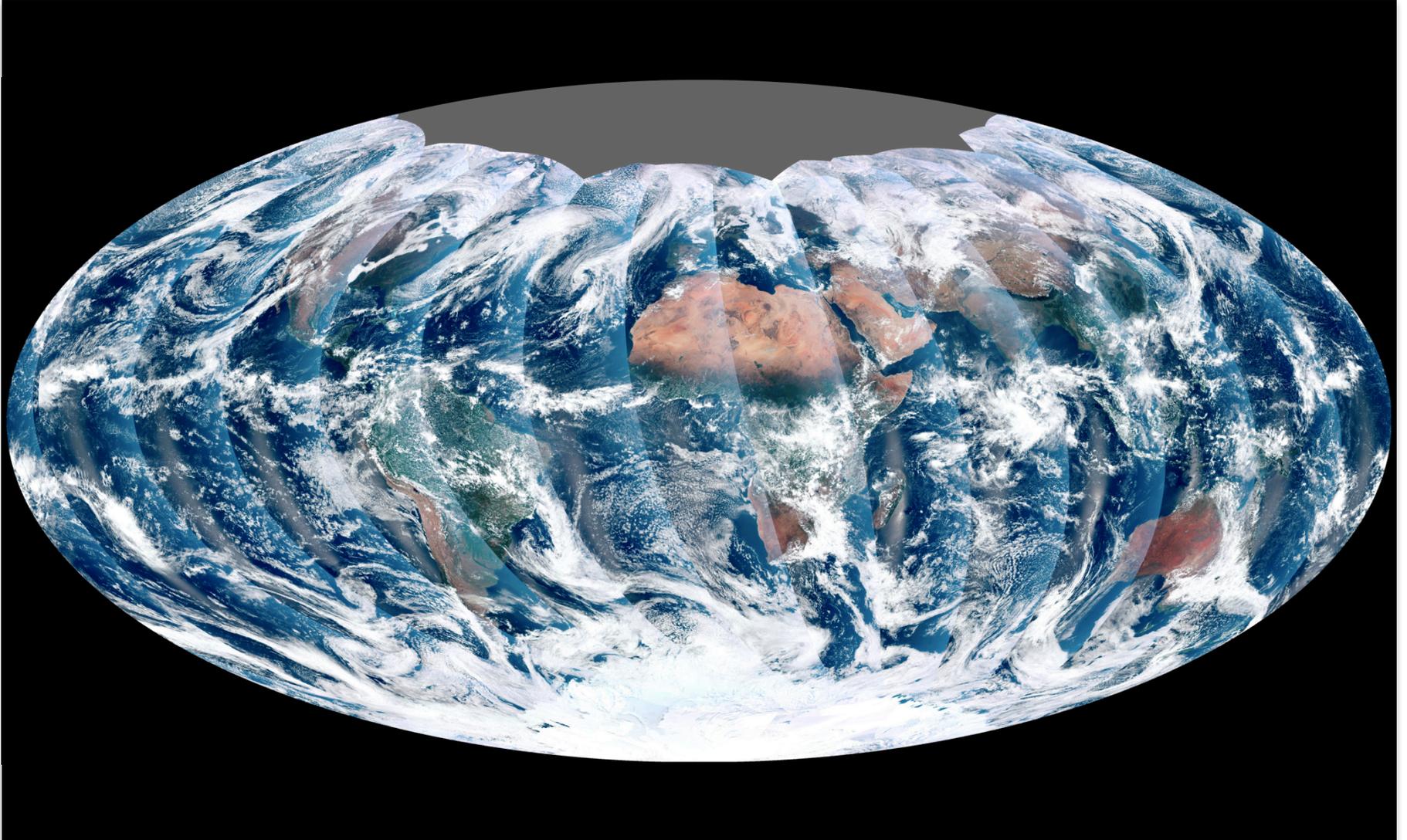
- Bands 8-36: 1,000m



# MODIS Reflected Solar Bands

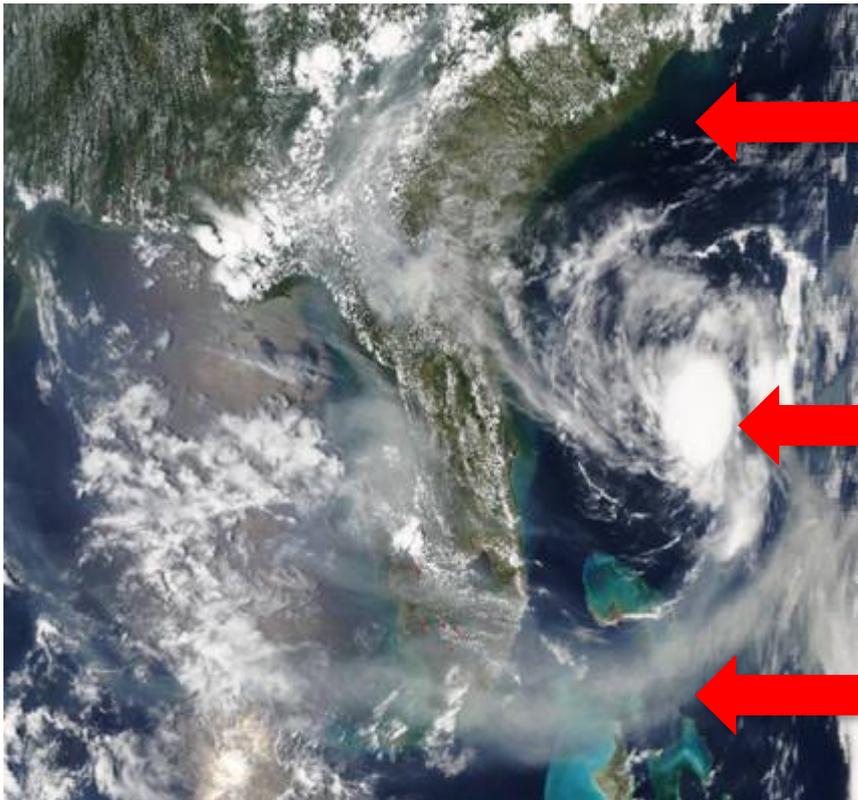
	Primary Use	Band No.	Bandwidth (nm)	
250m	Land/Cloud Boundaries	1**	620-670	* 500m Spatial Resolution ** 250m Spatial Resolution
		2**	841-876	
500m	Land/Cloud Properties	3*	459-479	
		4*	545-565	
		5*	1230-1250	
		6*	1628-1652	
		7*	2105-2155	
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420	
		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

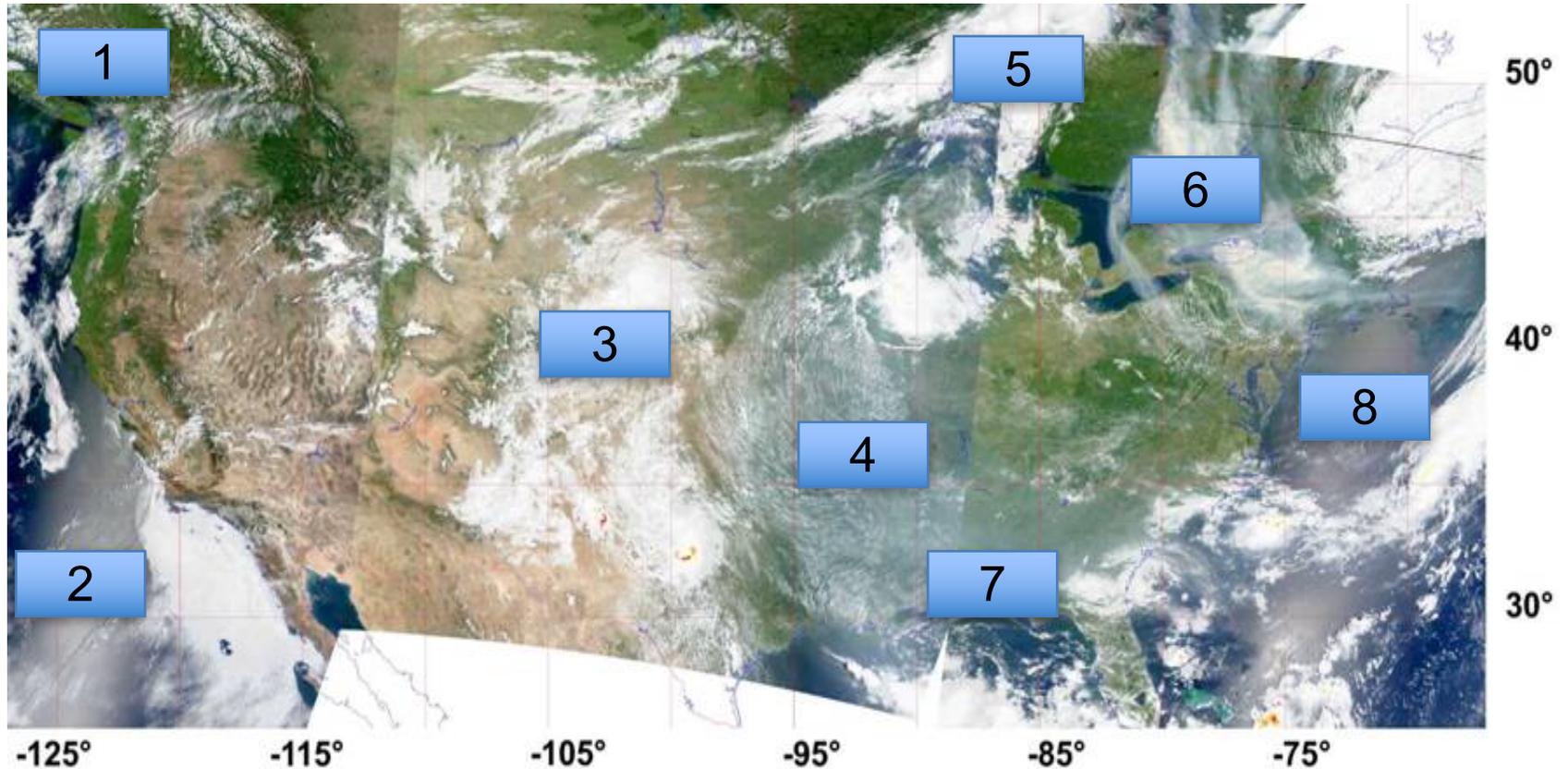


Visible imagery water is dark because it absorbs most of the energy

Clouds are white because most incoming energy is reflected

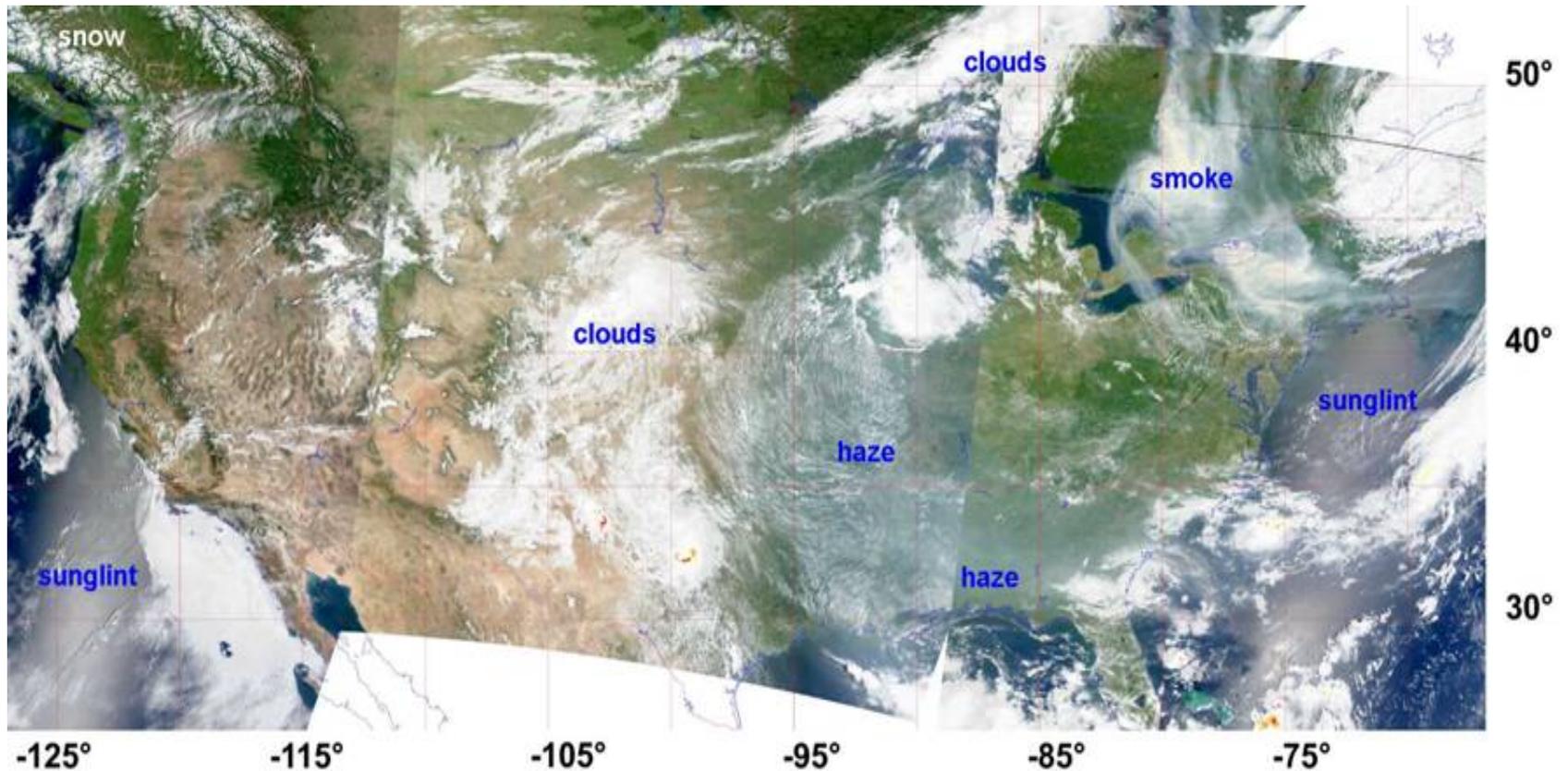
Pollution is hazy depending on its absorption properties

# What can we learn from true color imagery?



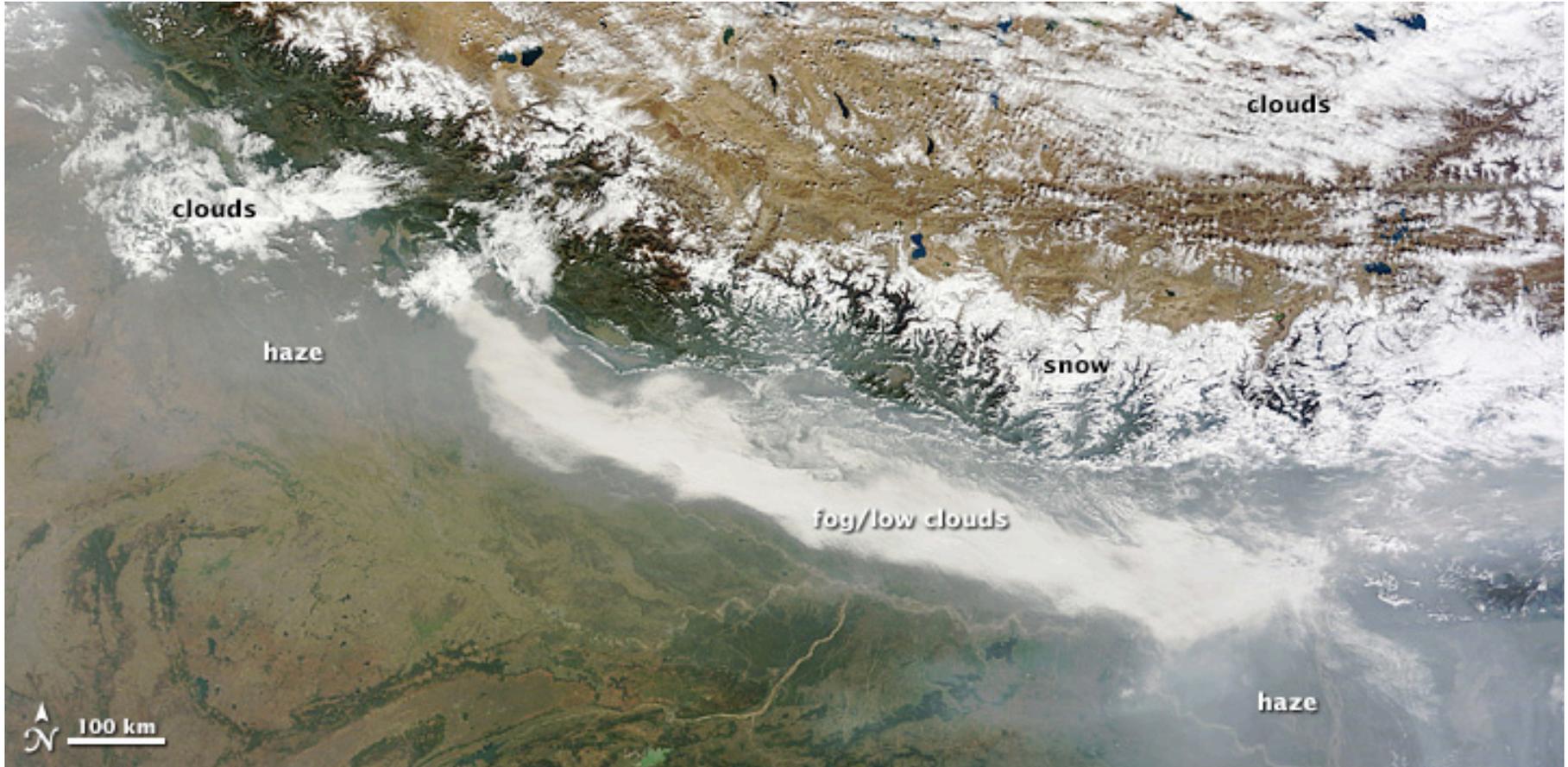
(Possible) identification of land, ocean, and atmosphere features

# What can we learn from true color imagery?

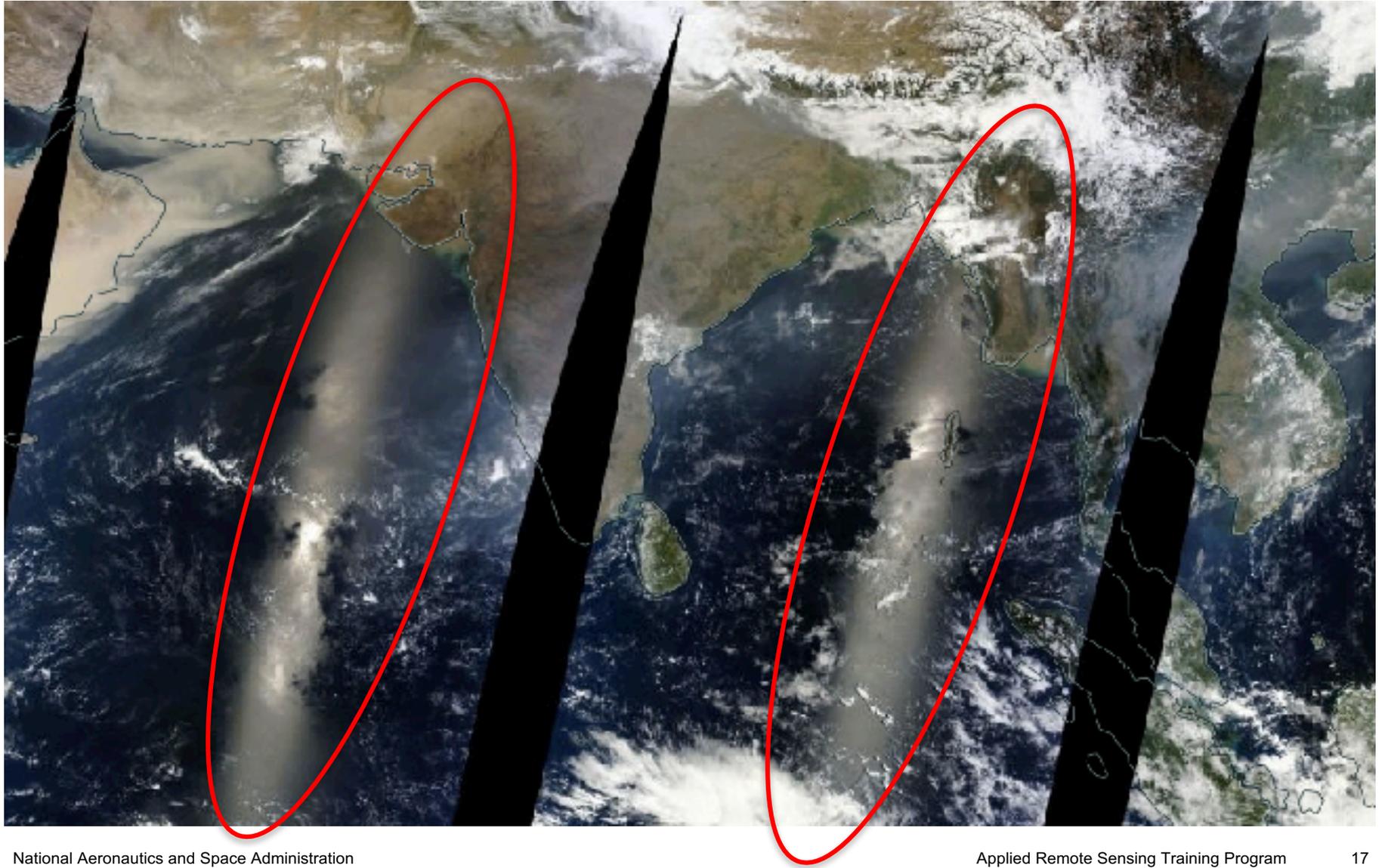


(Possible) identification of land, ocean, and atmosphere features

# Features in True Color (Atmosphere)

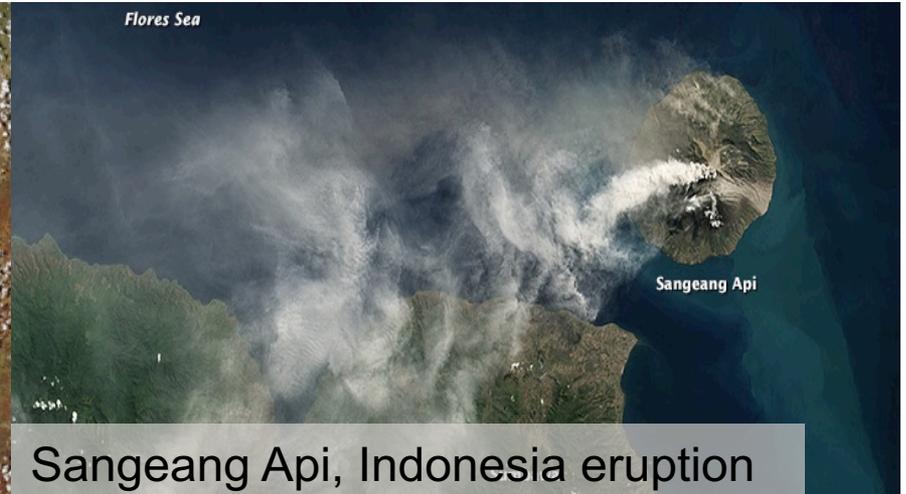
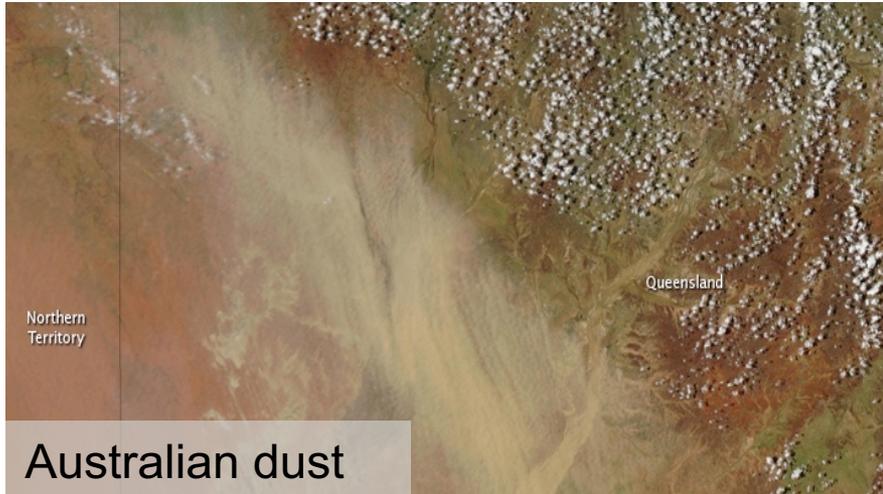


# Glint



# Feature Identification

More reliable when a clear source is in the image



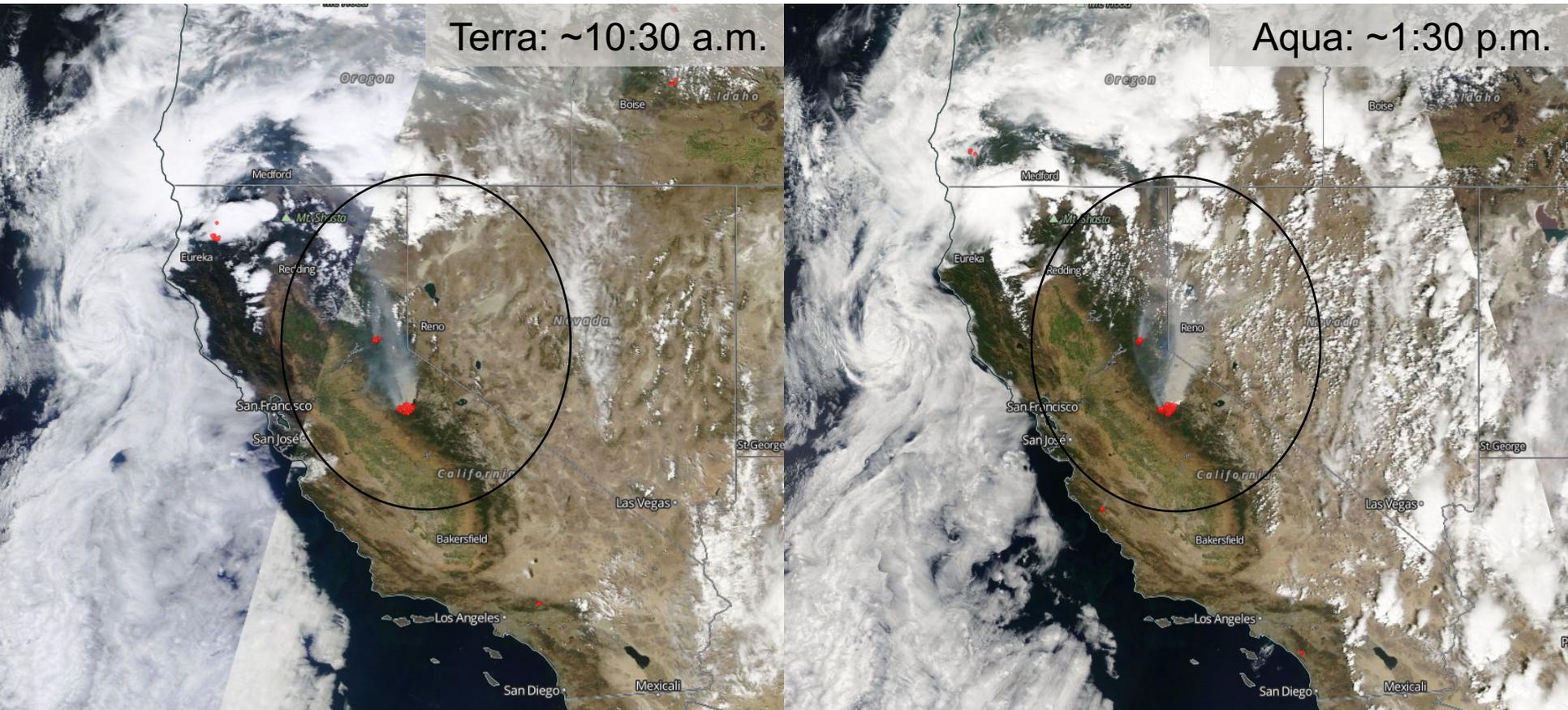
# Feature Identification

More reliable when a clear source is in the image



# Using Time Series Imagery

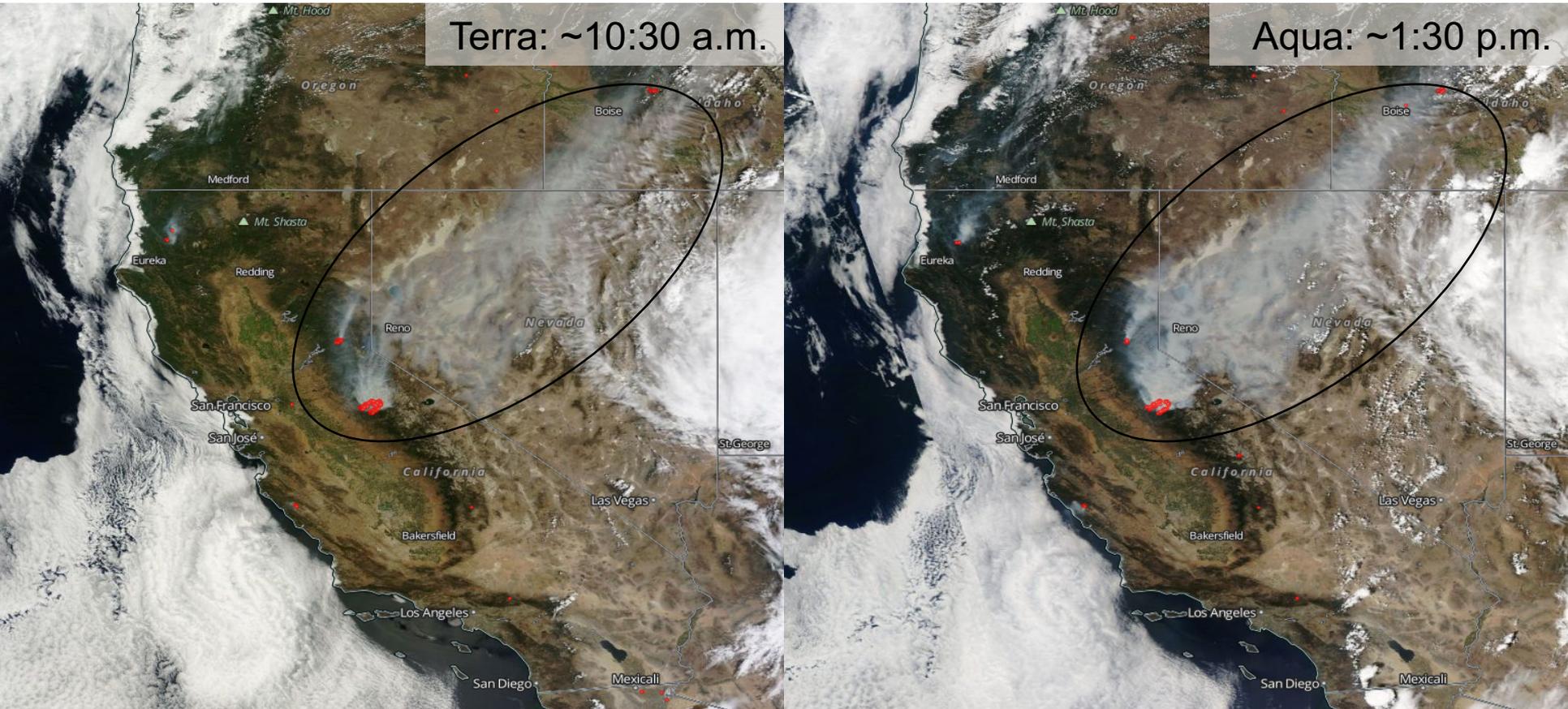
## Smoke Transport – Rim Fire



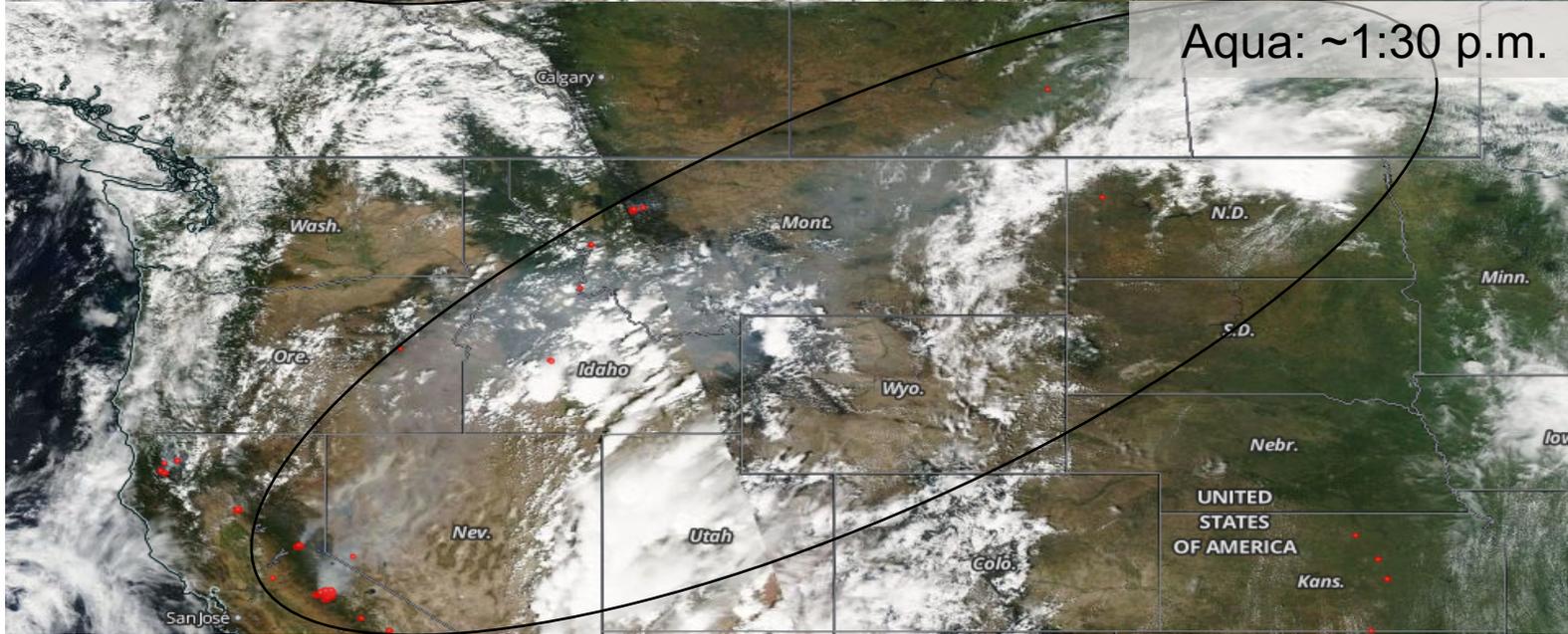
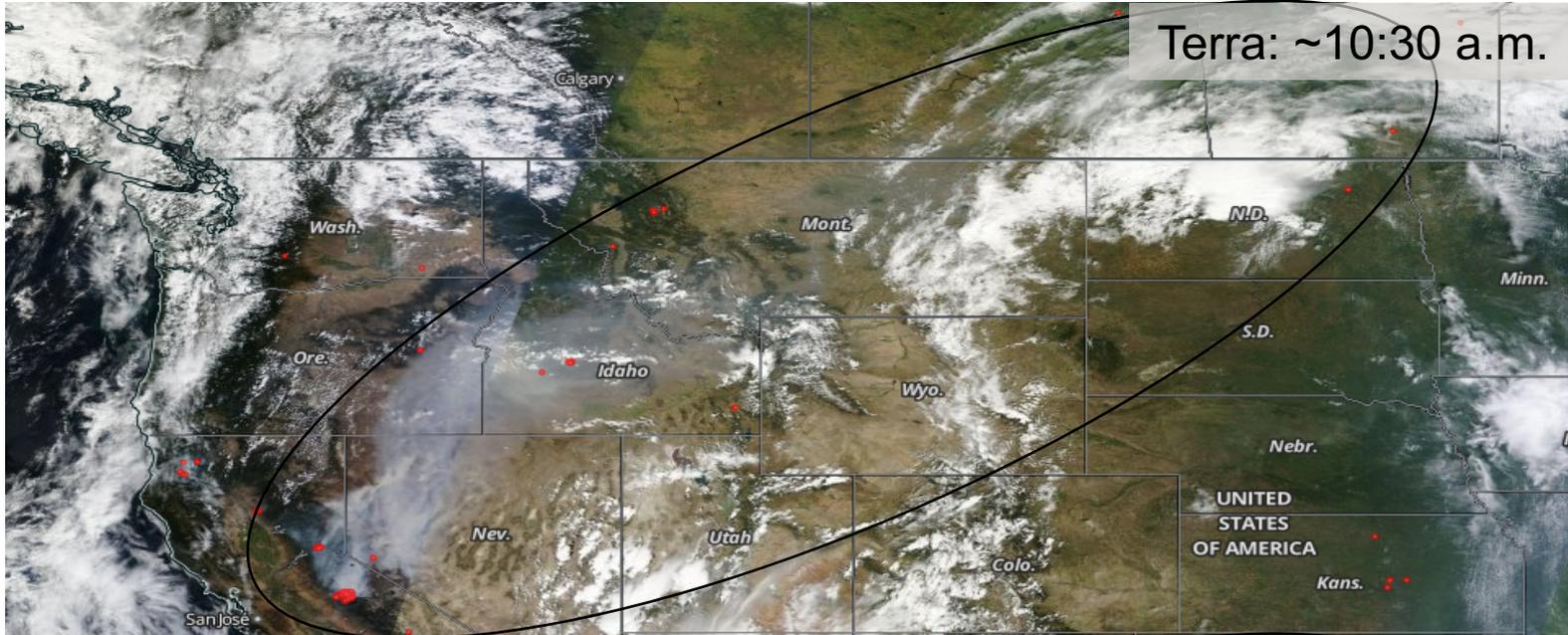
August 22, 2013; Images from NASA Worldview

# Using Time Series Imagery

## Smoke Transport – Rim Fire

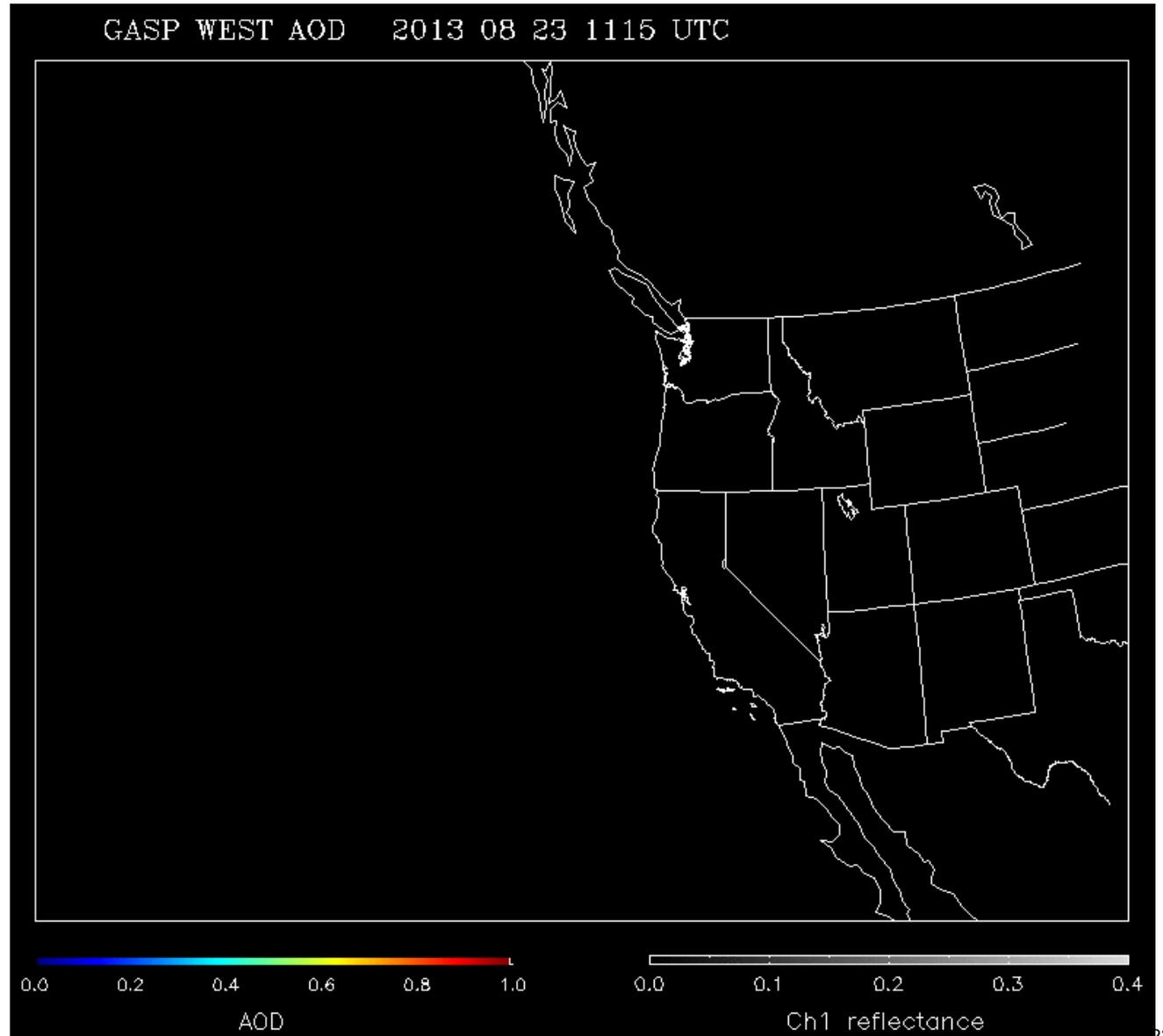


August 23, 2013; Images from NASA Worldview



August 24, 2013; Images from NASA Worldview

# RGB from Geostationary



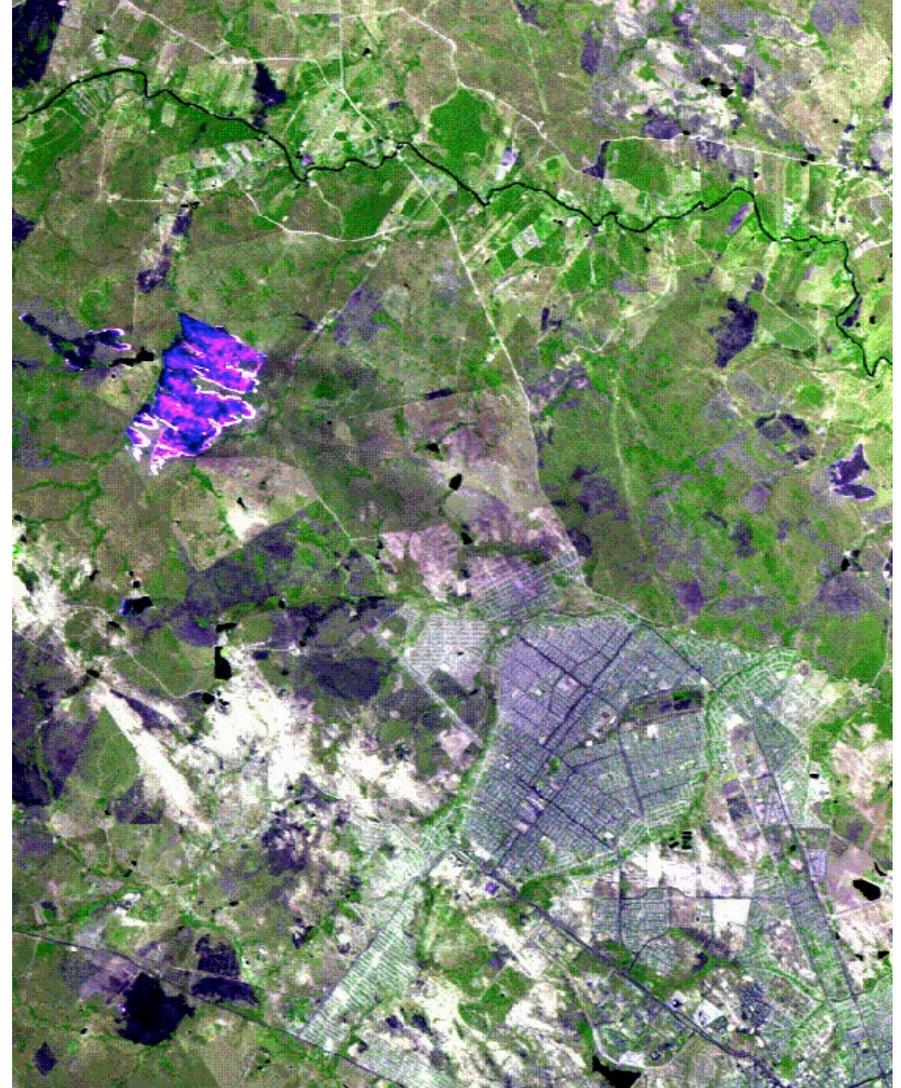
# False Color Images

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

R = 1.6  $\mu\text{m}$

G = 1.2  $\mu\text{m}$

B = 2.1  $\mu\text{m}$



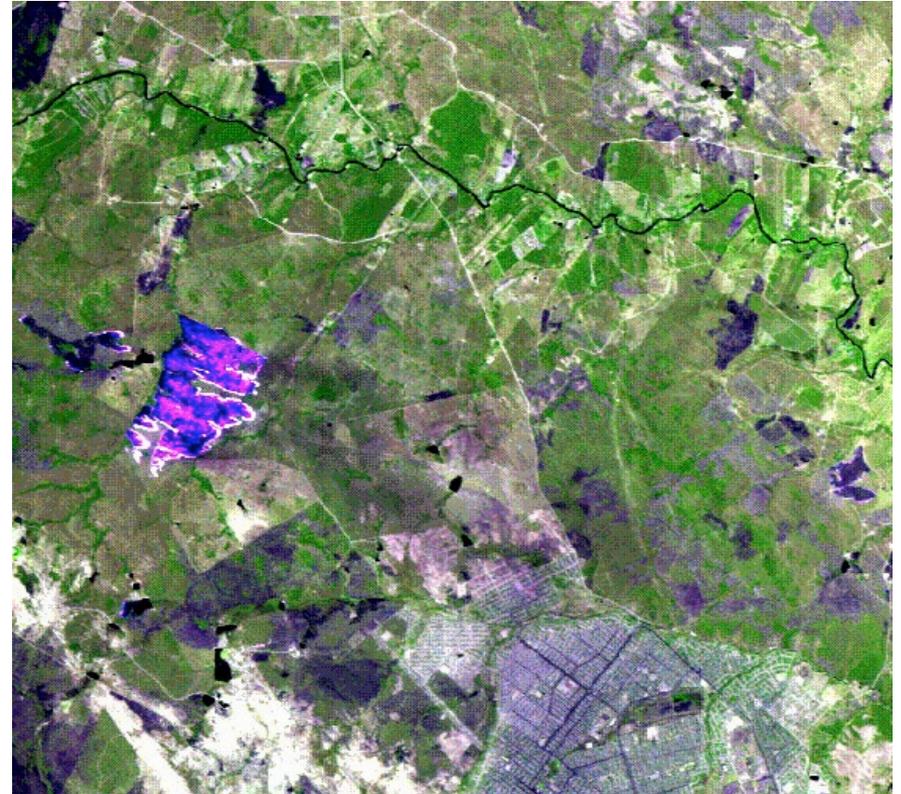
# True vs. False Color Images



R = 0.66  $\mu\text{m}$

G = 0.55  $\mu\text{m}$

B = 0.47  $\mu\text{m}$

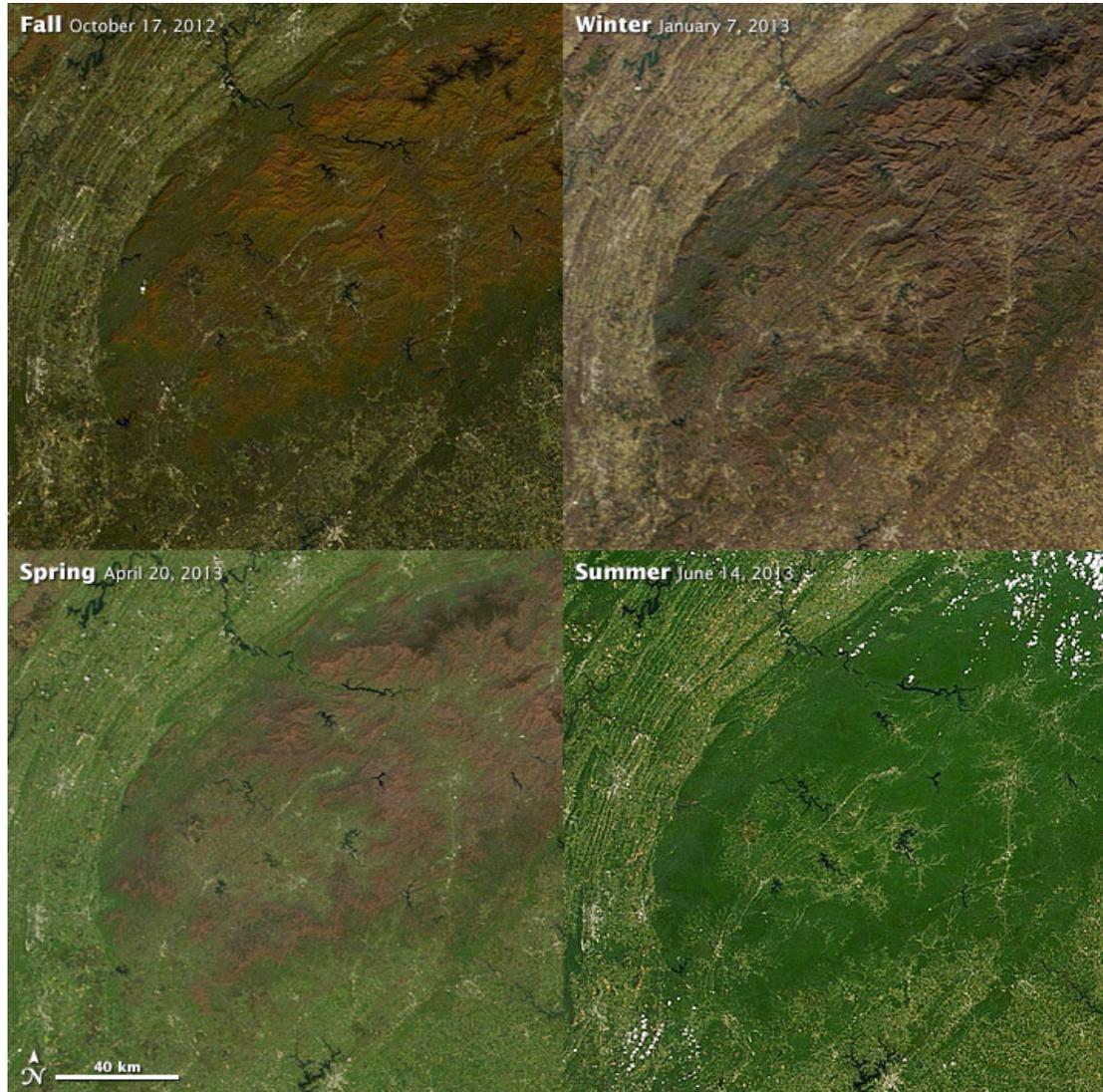


R = 1.6  $\mu\text{m}$

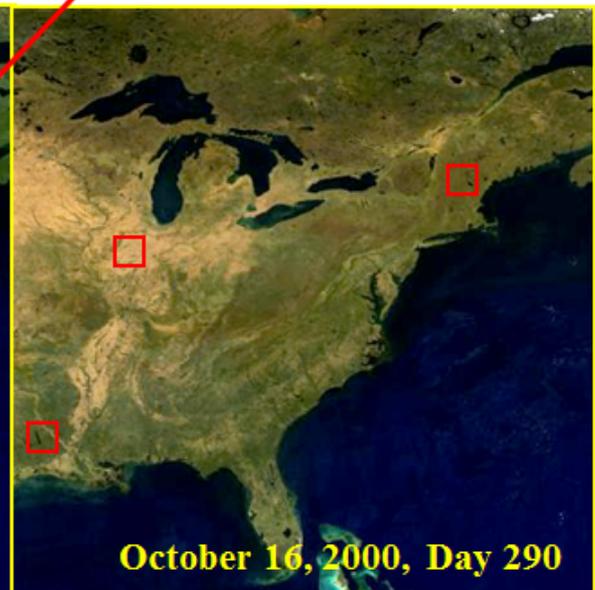
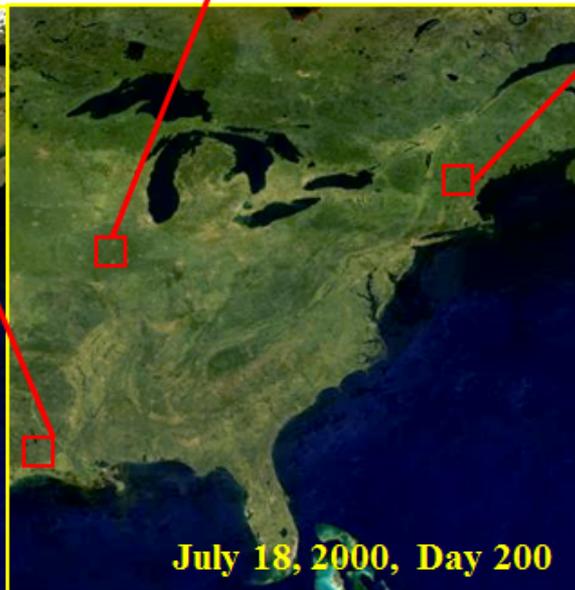
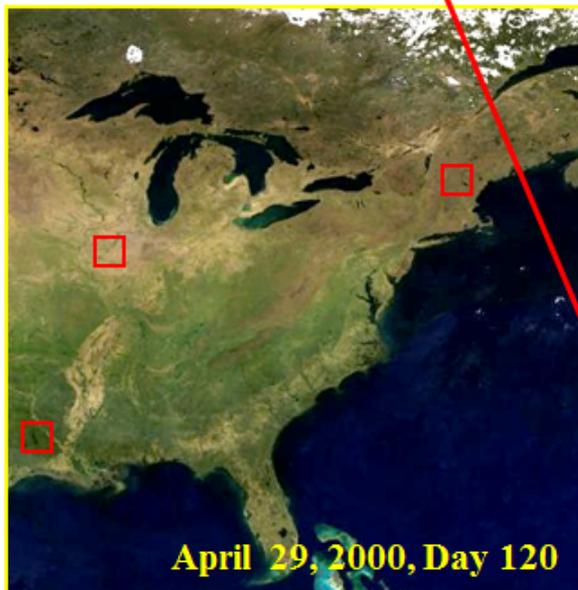
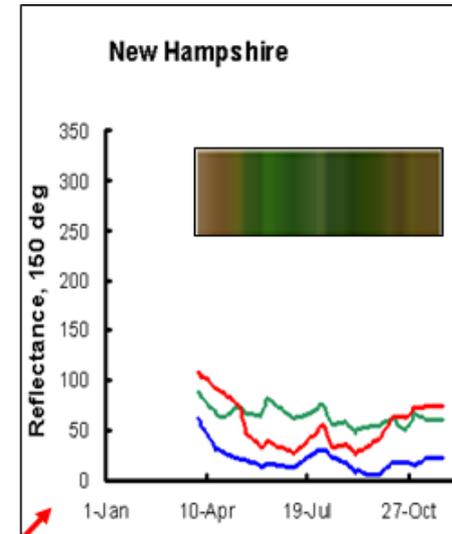
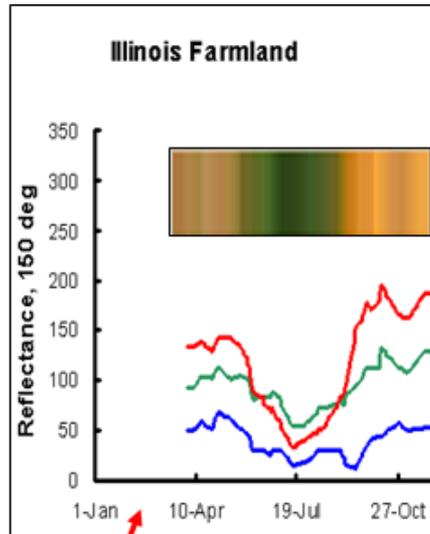
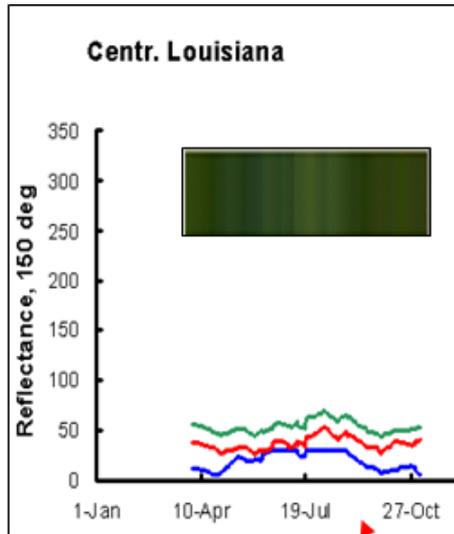
G = 1.2  $\mu\text{m}$

B = 2.1  $\mu\text{m}$

# Change in Vegetation Color from Space



# 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 sun glint, 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 the difference between true color and false color imagery?
- What are 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?

A satellite image of the Mediterranean Sea region, showing the sea and surrounding landmasses. A semi-transparent dark grey rectangular overlay covers the central part of the image. The word "Questions" is written in bold black text on the left side of this overlay. A horizontal black line is drawn below the text. Several red dashed lines are drawn on the landmasses, primarily in the Balkans and the eastern coast of the Mediterranean, indicating specific areas of interest or study.

# Questions

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