



ARSET

Applied Remote Sensing Training

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# Introduction to Satellite Remote Sensing for Air Quality Applications

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*Webinar Session 2 – July 13, 2016*

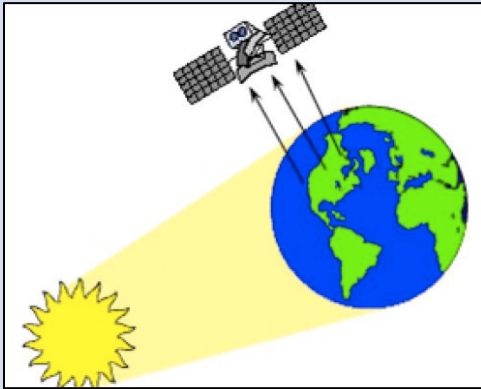
**Visible Satellite Imagery**

# Session 2 - Outline

1. What are true and false color images?
2. What can we learn from images?
3. A tour of useful image archives

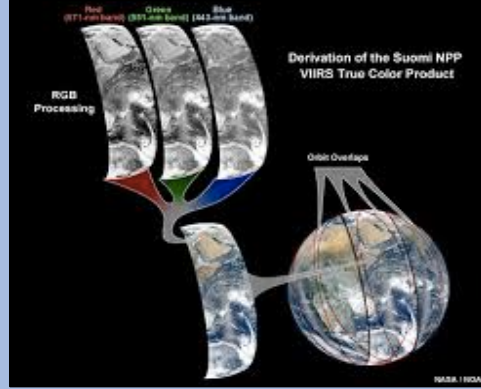
Today's Instructor: **Pawan Gupta**  
GESTAR/USRA, Code 614  
NASA Goddard Space Flight Center  
Greenbelt, MD 20771, USA  
[pawan.gupta@nasa.gov](mailto:pawan.gupta@nasa.gov)  
<http://arset.gsfc.nasa.gov/people/pawan-gupta-0>

# 5 Weeks Webinar Series: Agenda



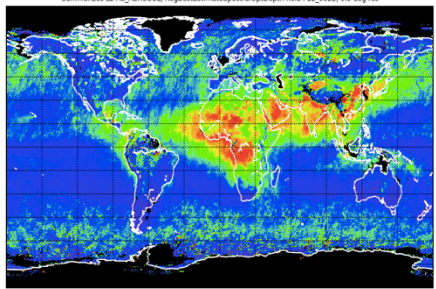
A diagram illustrating the fundamental process of remote sensing. A yellow sun on the left emits a beam of light towards a blue and green Earth. A satellite in orbit above the Earth is shown with three arrows pointing towards the planet, representing the collection of data from a distance.

**Week 1: Fundamental of Remote Sensing**



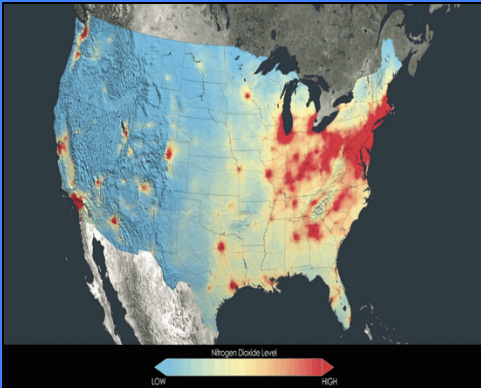
A diagram showing the derivation of satellite imagery. It features three satellite orbits labeled 'Red (865 nm band)', 'Green (665 nm band)', and 'Blue (445 nm band)'. The text 'Derivation of the Suomi NPP VIIRS True Color Product' is present. Below the orbits, a globe shows 'Orbit Overlaps'. The text 'RGB Processing' is also visible. The NASA/NOAA logo is in the bottom right corner.

**Week 2: Satellite Imagery**



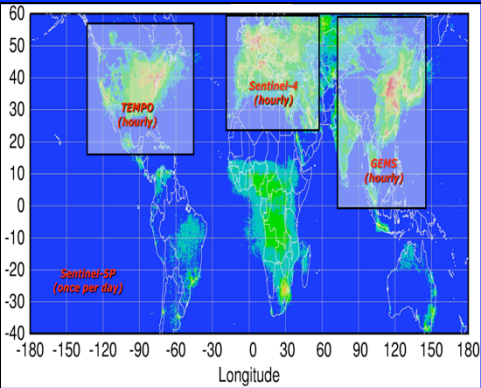
A global map showing aerosol data. The map uses a color scale from blue (0.00) to red (1.00) to represent optical depth. The text 'Optical depth average ANN 2013 F15\_0031 All, Blue, All' and 'Summarizes L2\_AS\_AEROSOL\_#regBestEstimateSpectralOptDepth field F12\_0022, 0.5 deg res' is at the top. A color scale legend for 'Optical Depth' is at the bottom.

**Week 3: Aerosol Data**



A map of the United States showing trace gas data. The map uses a color scale from blue (LOW) to red (HIGH) to represent Nitrogen Dioxide Level. A legend at the bottom indicates 'Nitrogen Dioxide Level' with 'LOW' and 'HIGH' labels.

**Week 4: Trace Gas Data**



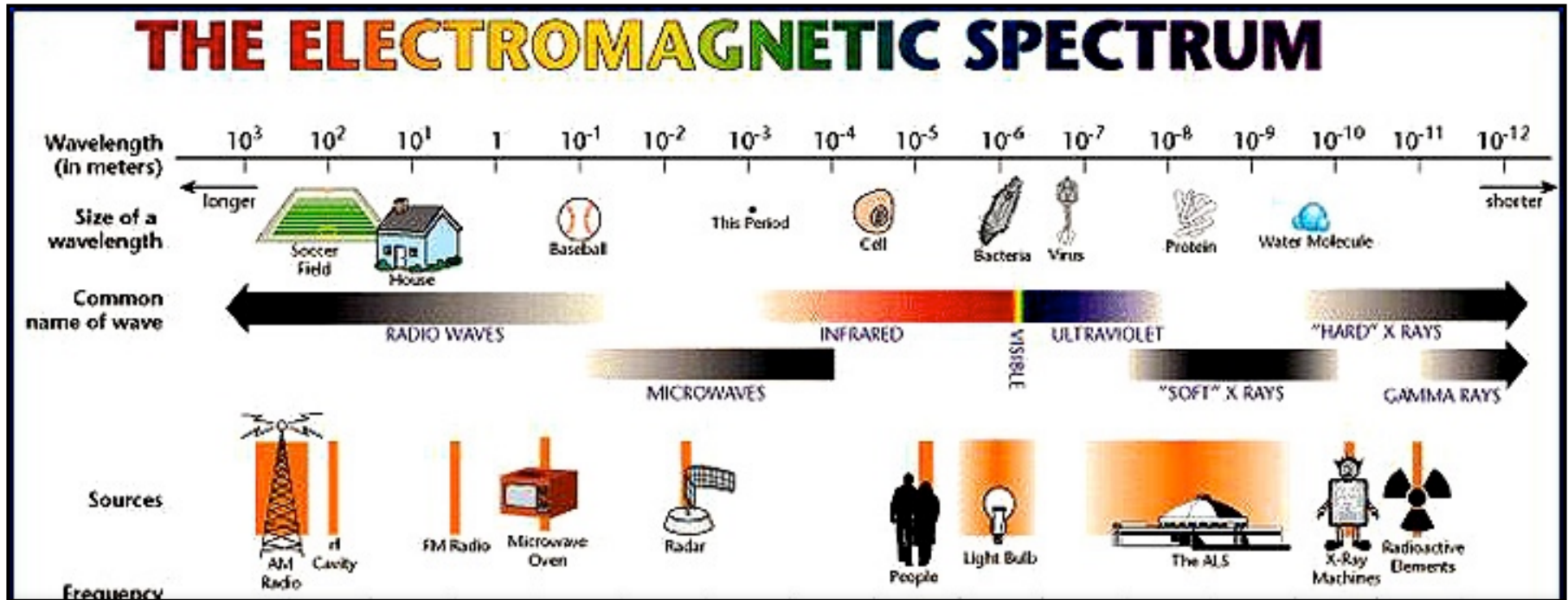
A world map showing future capabilities. The map uses a color scale from blue to red to represent data. Three inset boxes are labeled 'TEMPO (hourly)', 'Sentinel-4 (hourly)', and 'GENS (hourly)'. A legend at the bottom left indicates 'Sentinel-5P (once per day)'. The x-axis is labeled 'Longitude' and the y-axis is labeled with latitude values from -40 to 60.

**Week 5: Future Capabilities**

# Visible Image Science

- Visible satellite images are essentially photographs
- 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)

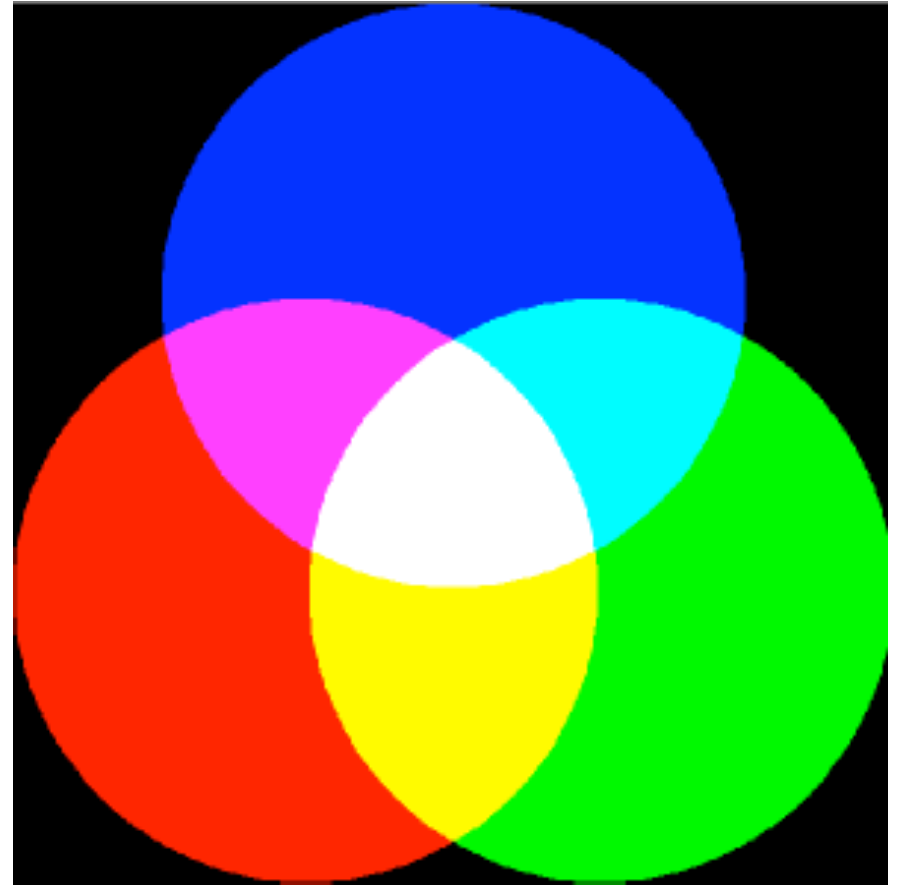
# Wavelength Selection



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

# RGB Images

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



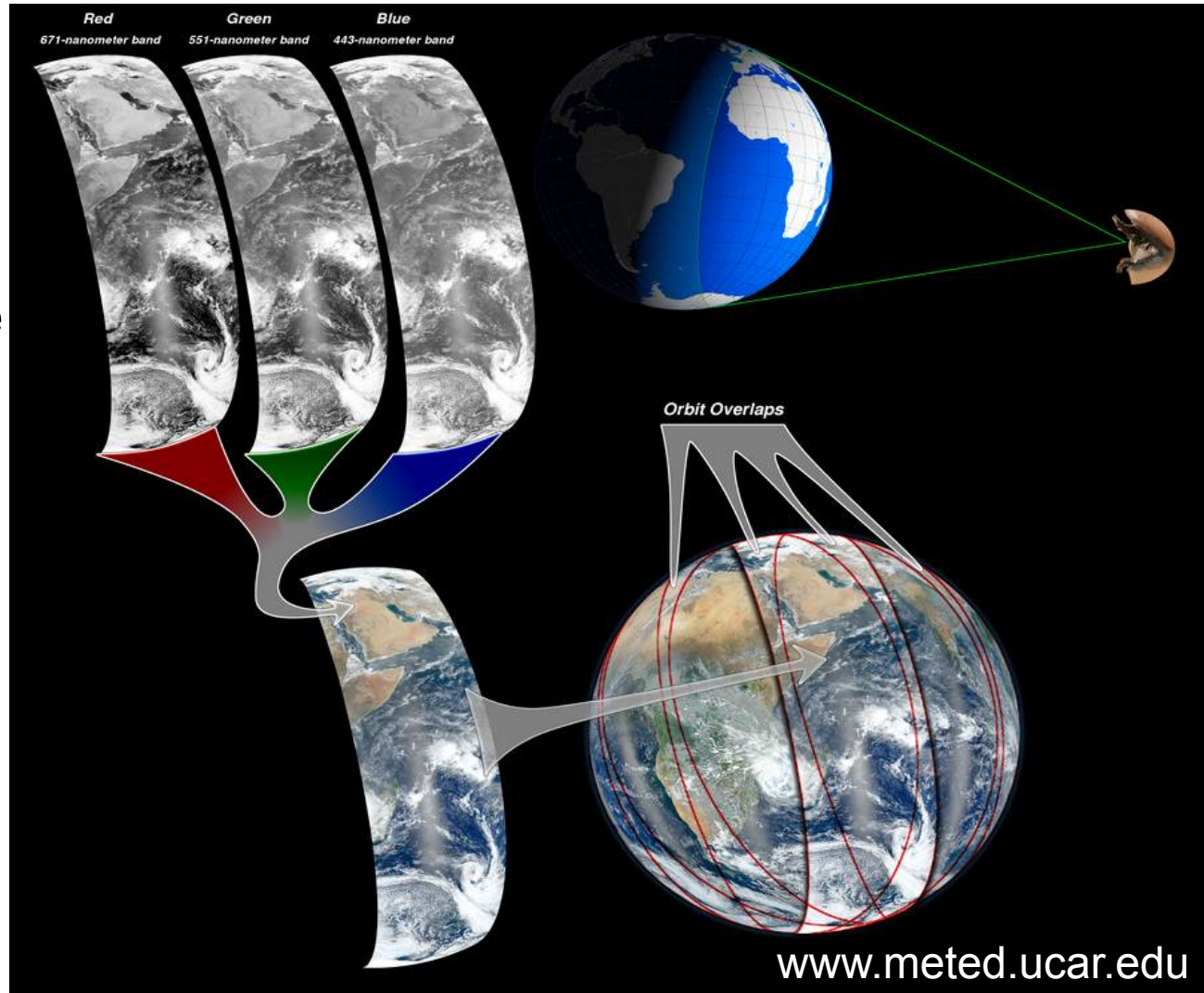
# True Color Image (or RGB)

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

- **Temporal Resolution**

- Daily, 8-day, 16-day, monthly, quarterly, yearly

- 2000 – present

- **Platform**

- Terra & Aqua

- **Data Format**

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

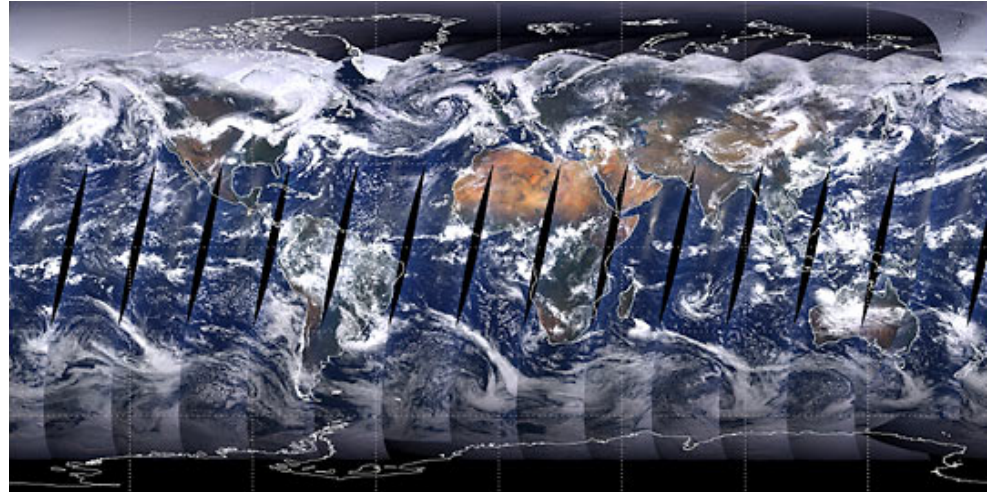
- **Spectral Coverage**

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

- Bands 1-2: 250m

- Bands 3-7: 500m

- Bands 8-36: 1000m

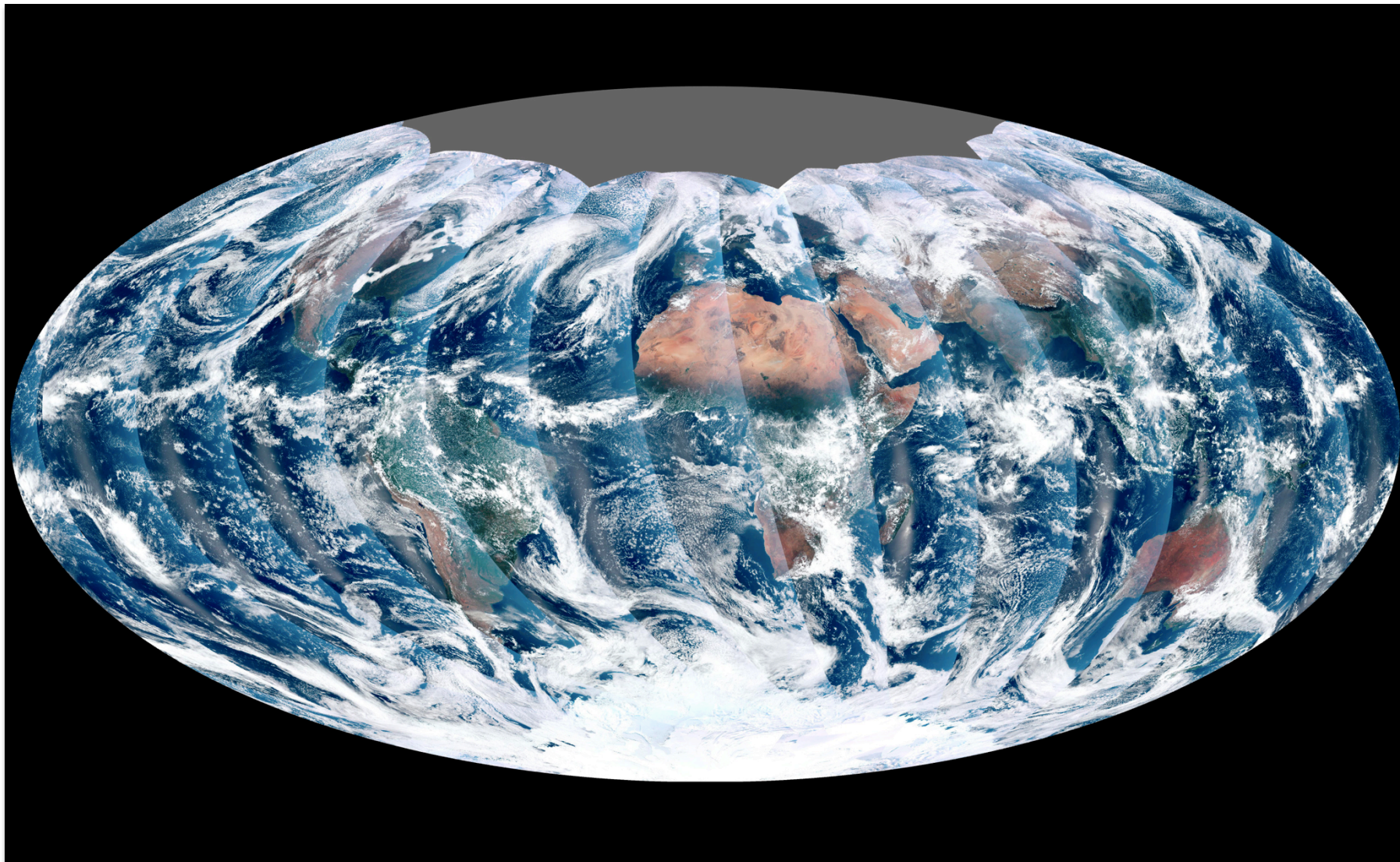




# MODIS Reflected Solar Bands

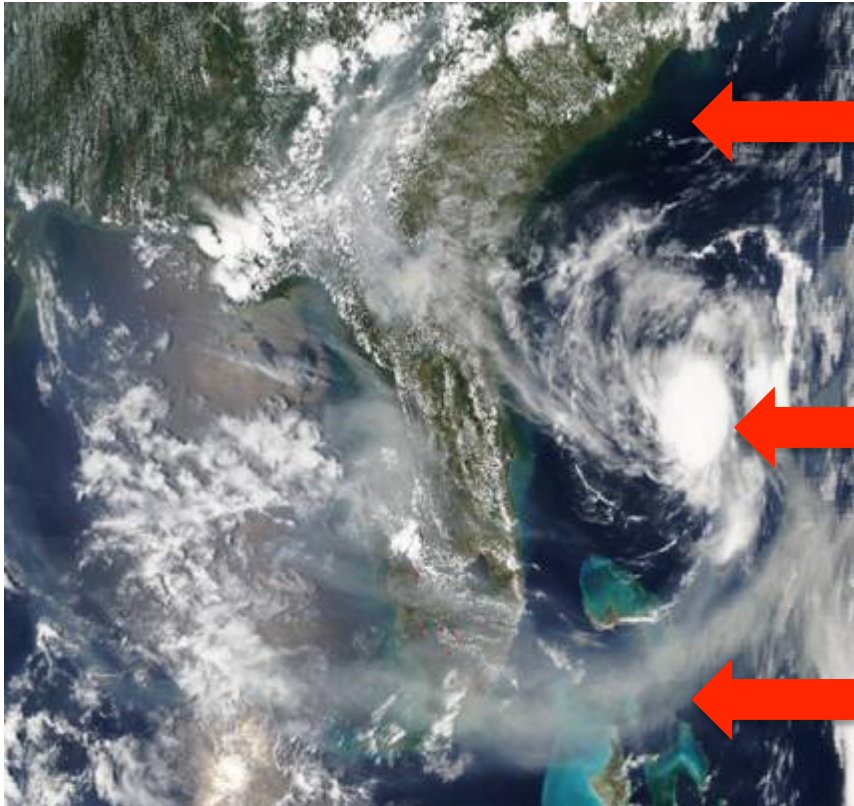
	Primary Use	Band No.	Bandwidth (nm)	
250m	Land/Cloud Boundaries	1**	620-670	* 500m Spatial Resolution ** 250m Spatial Resolution
		2**	841-876	
500m	Land/Cloud Properties	3*	459-479	
		4*	545-565	
		5*	1230-1250	
		6*	1628-1652	
		7*	2105-2155	
	Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420	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

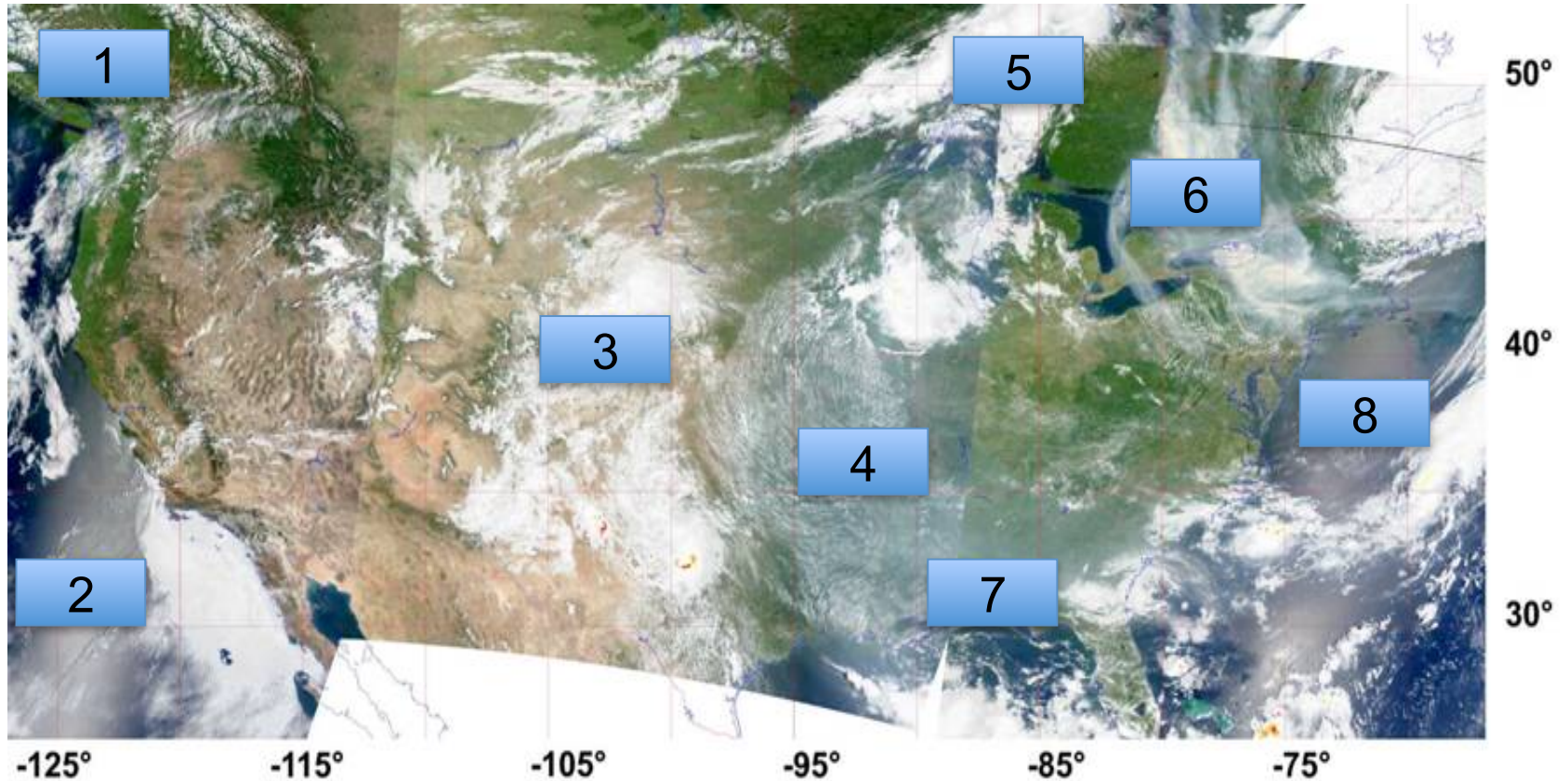


Visible imagery water is dark because it absorbs most of the energy

Clouds are white because most incoming energy is reflected

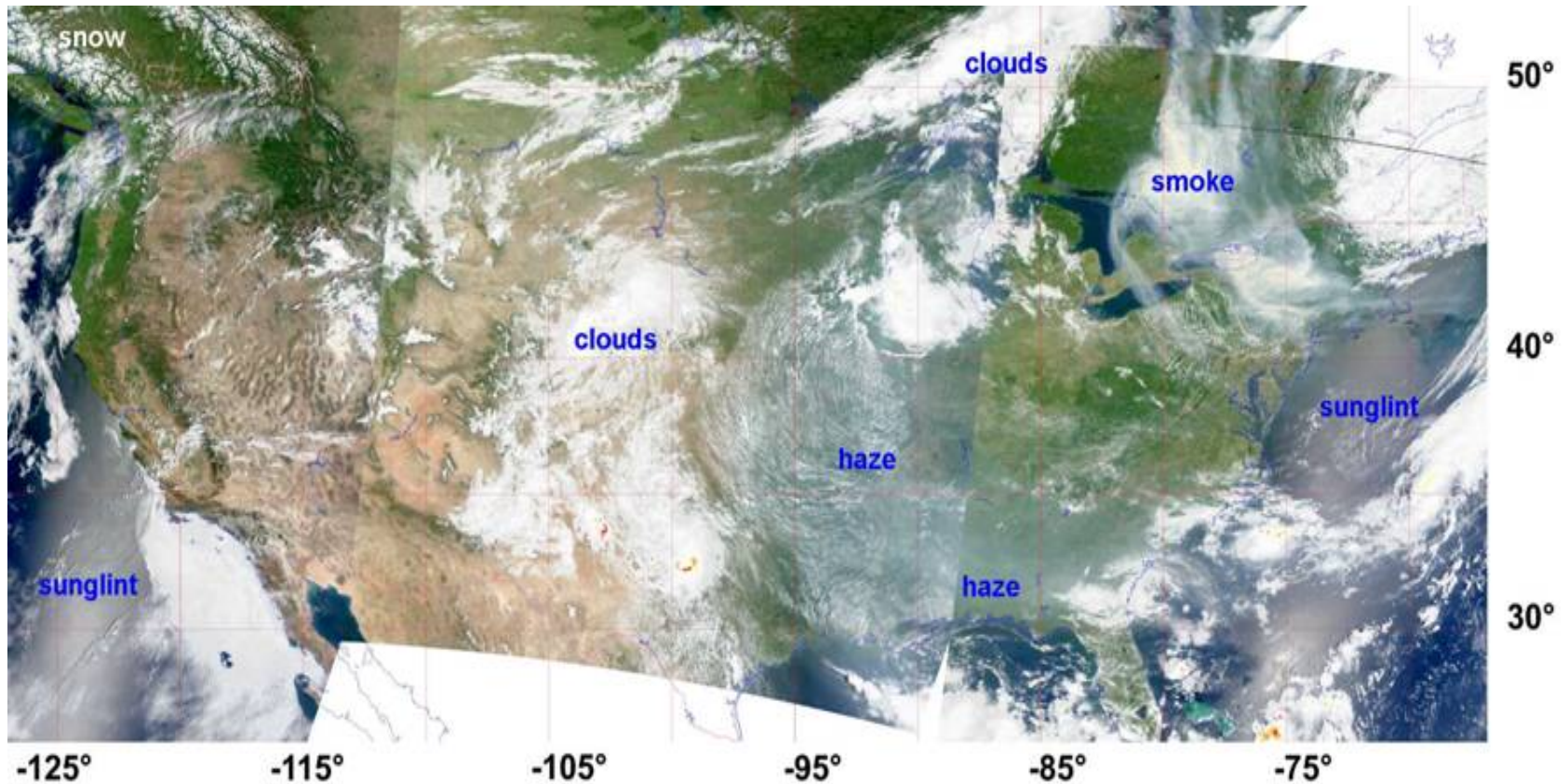
Pollution is hazy depending on its absorption properties

# What can we learn from true color imagery?



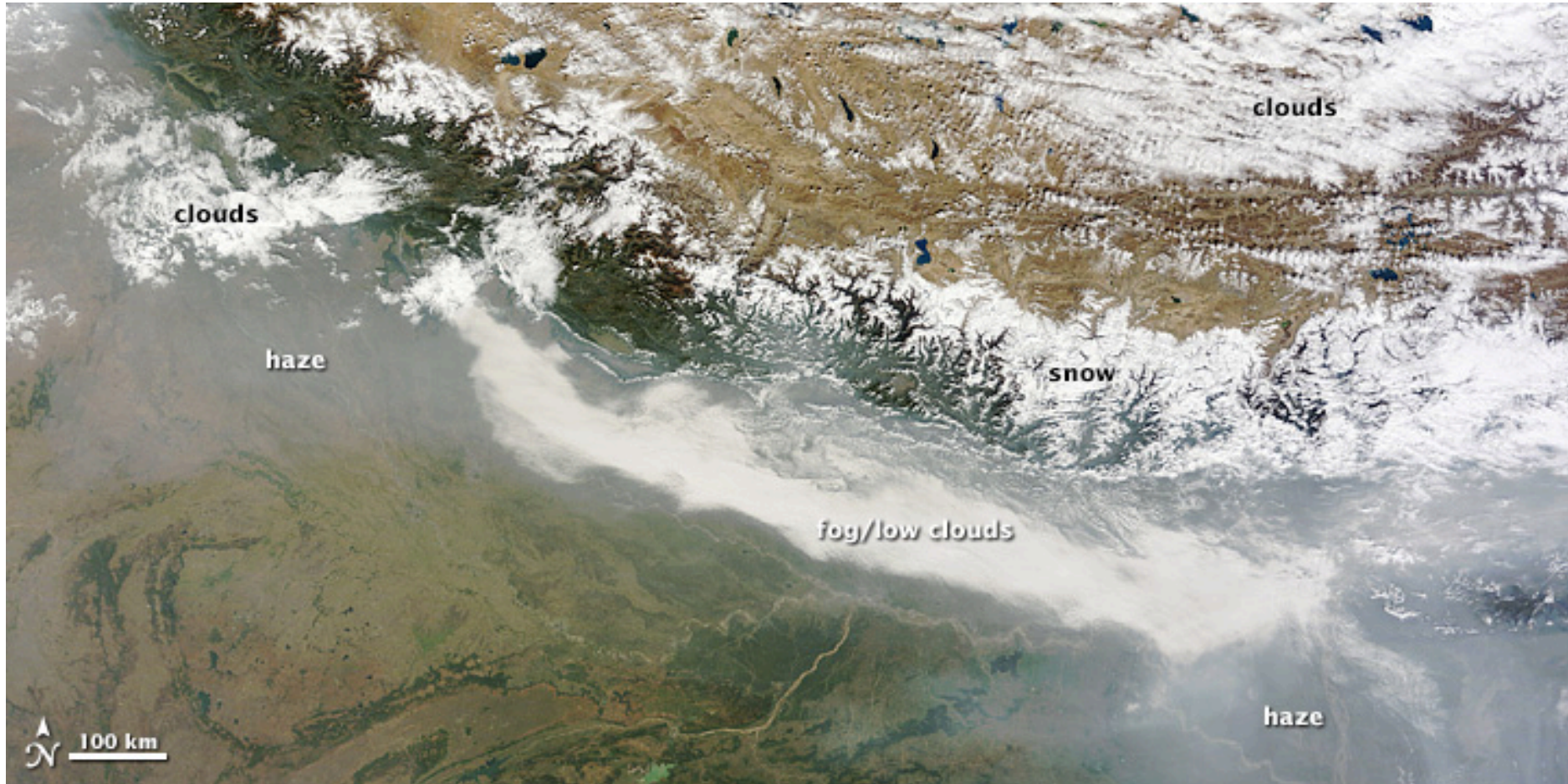
(Possible) Identification of land, ocean, and atmosphere features

# What can we learn from true color imagery?

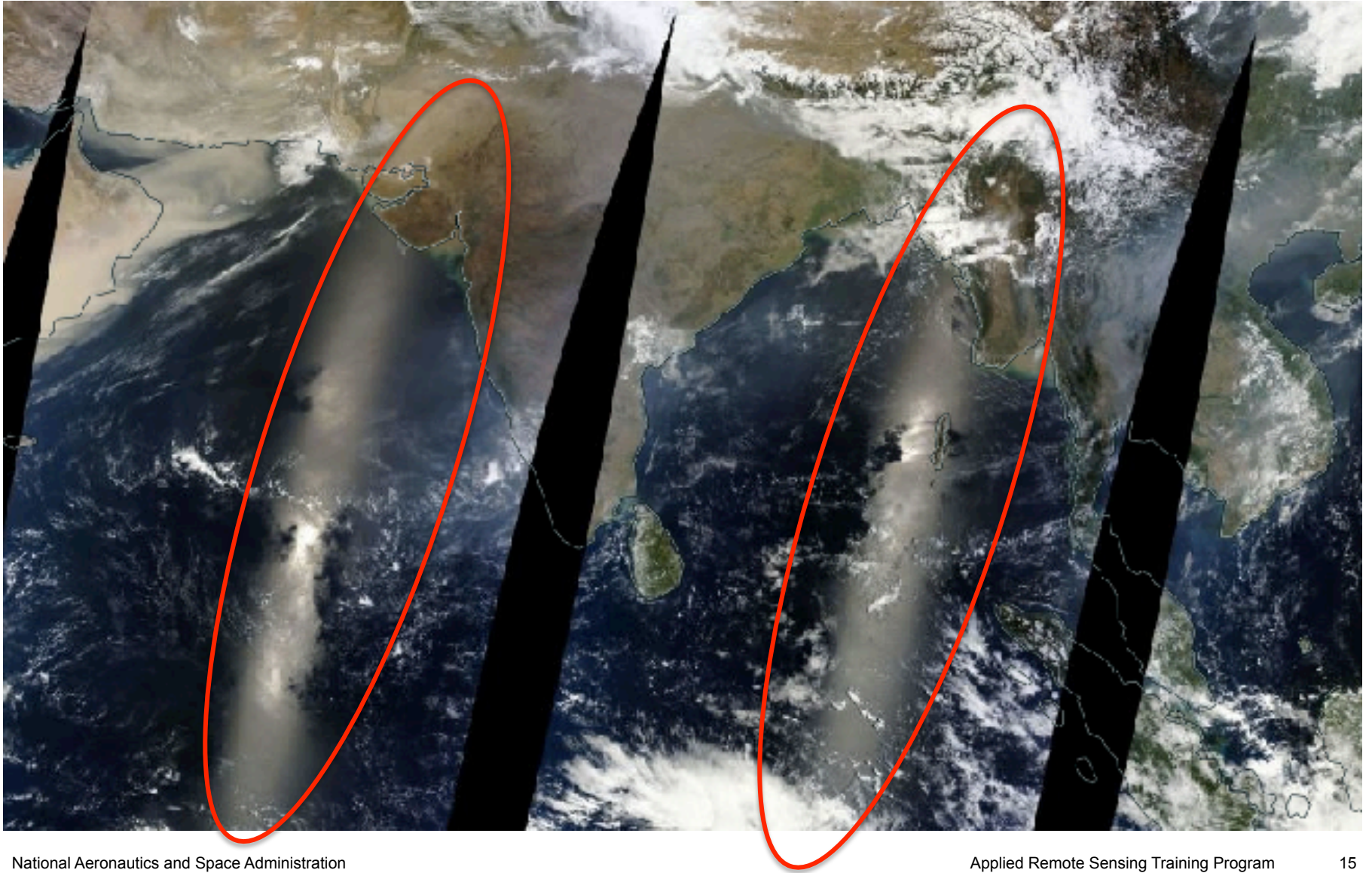


(Possible) Identification of land, ocean, and atmosphere features

# Features in True Color (Atmosphere)

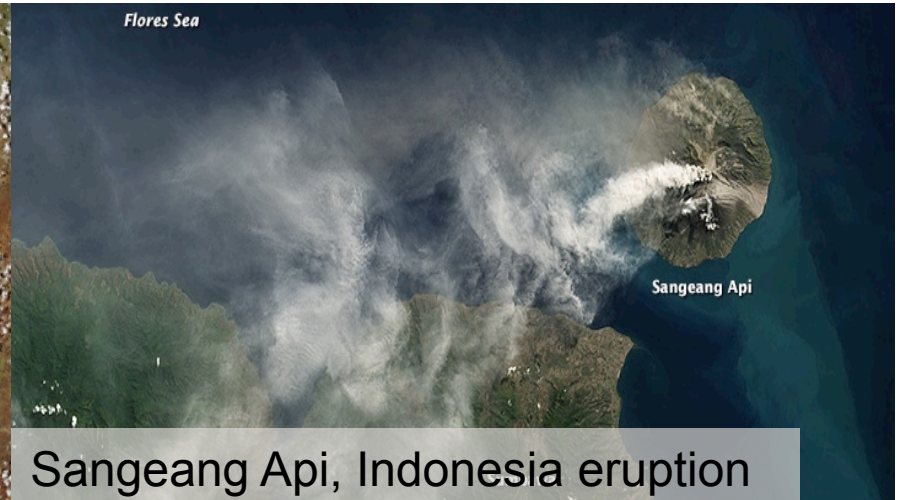
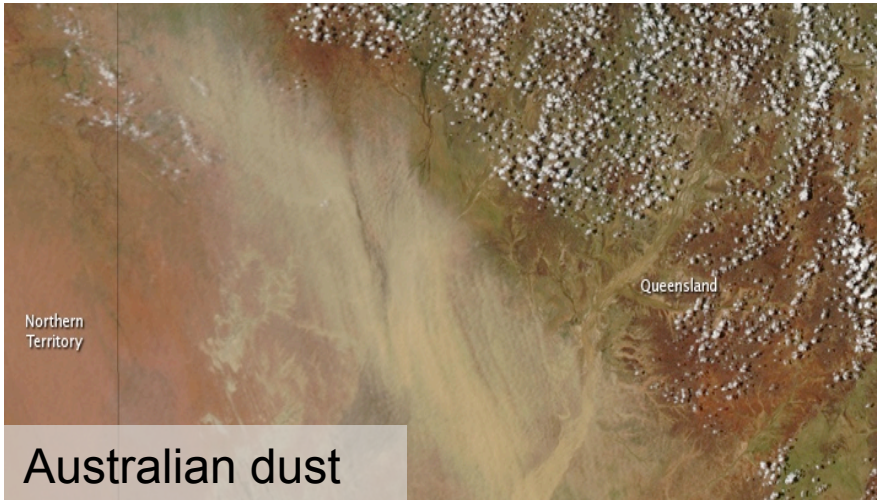


# Glint



# Feature Identification

More reliable when a clear source is in the image





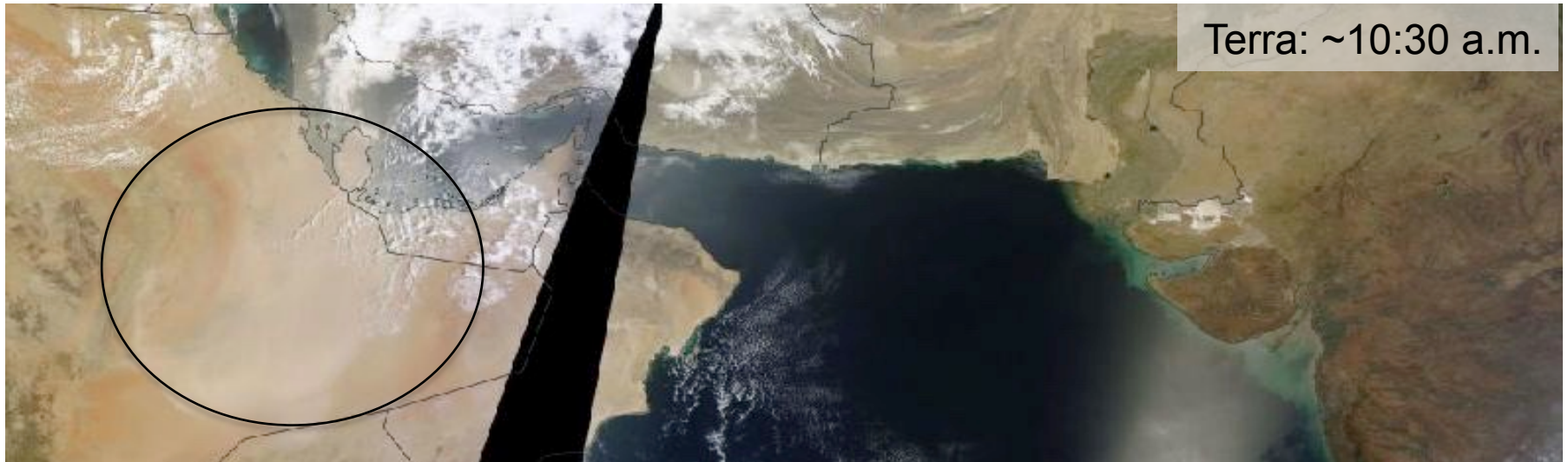
# Feature Identification

More reliable when a clear source is in the image



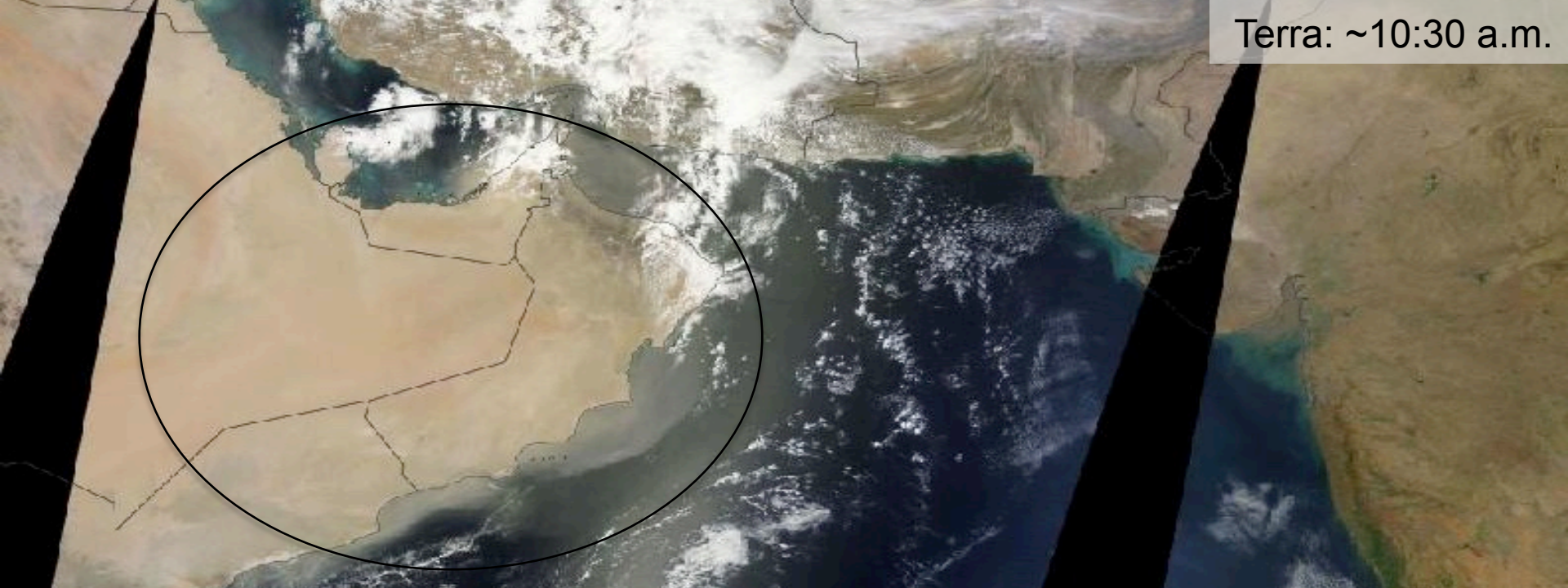
# Using Time Series Imagery

## Dust Transport

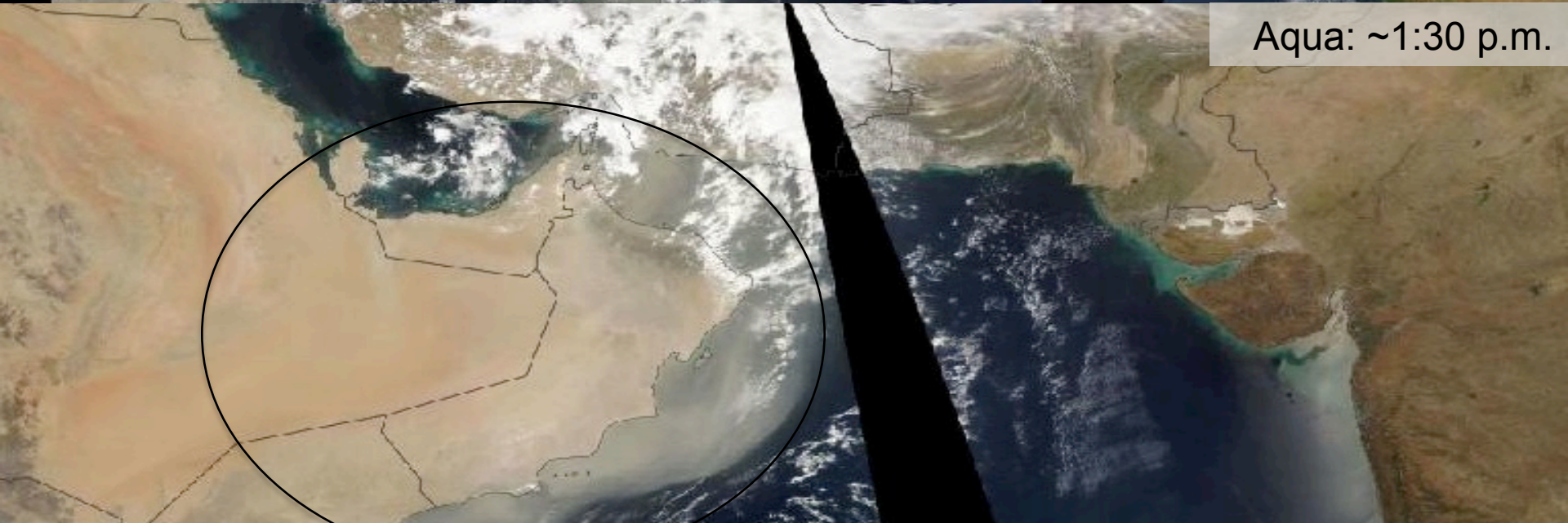


April 6, 2013; Images from NASA Worldview

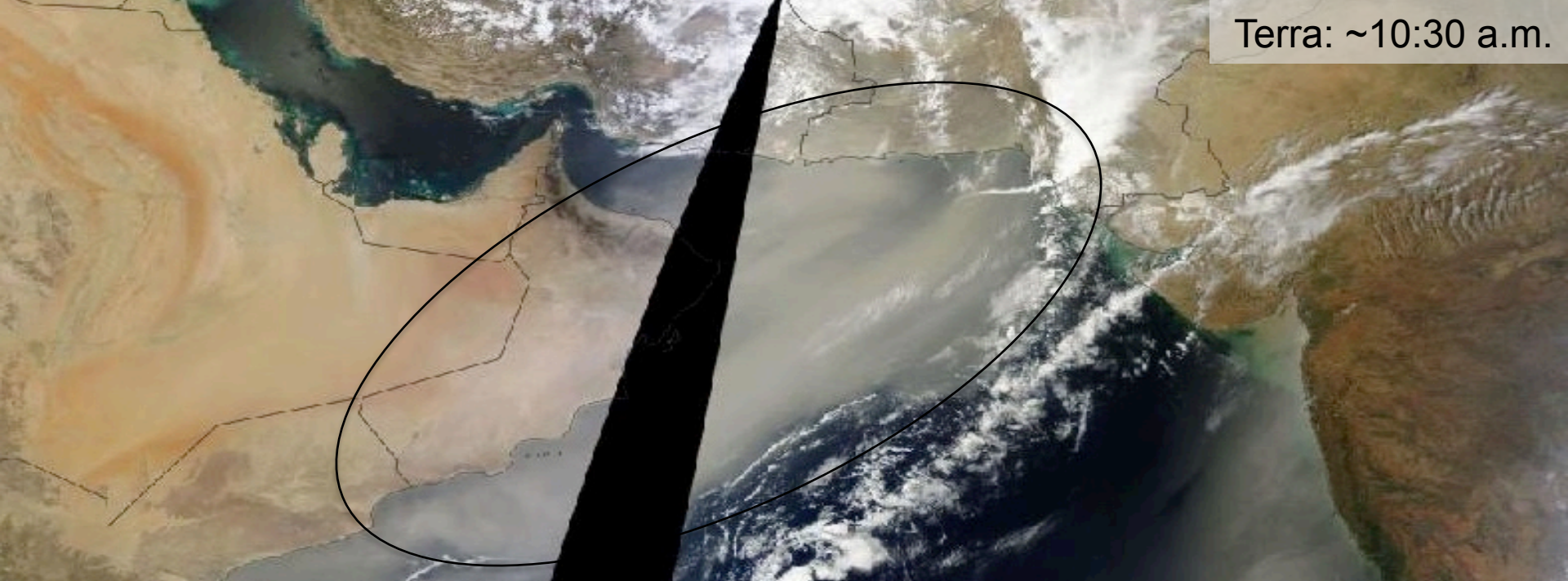
Terra: ~10:30 a.m.



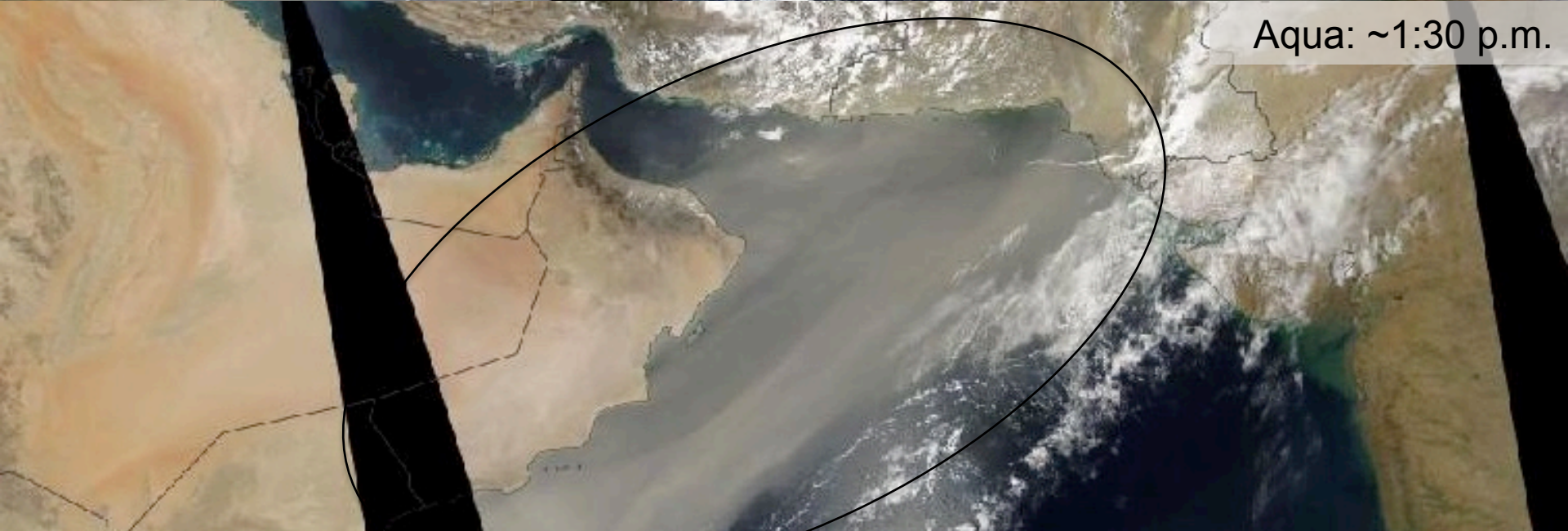
Aqua: ~1:30 p.m.



April 7, 2013; Images from NASA Worldview



Terra: ~10:30 a.m.



Aqua: ~1:30 p.m.

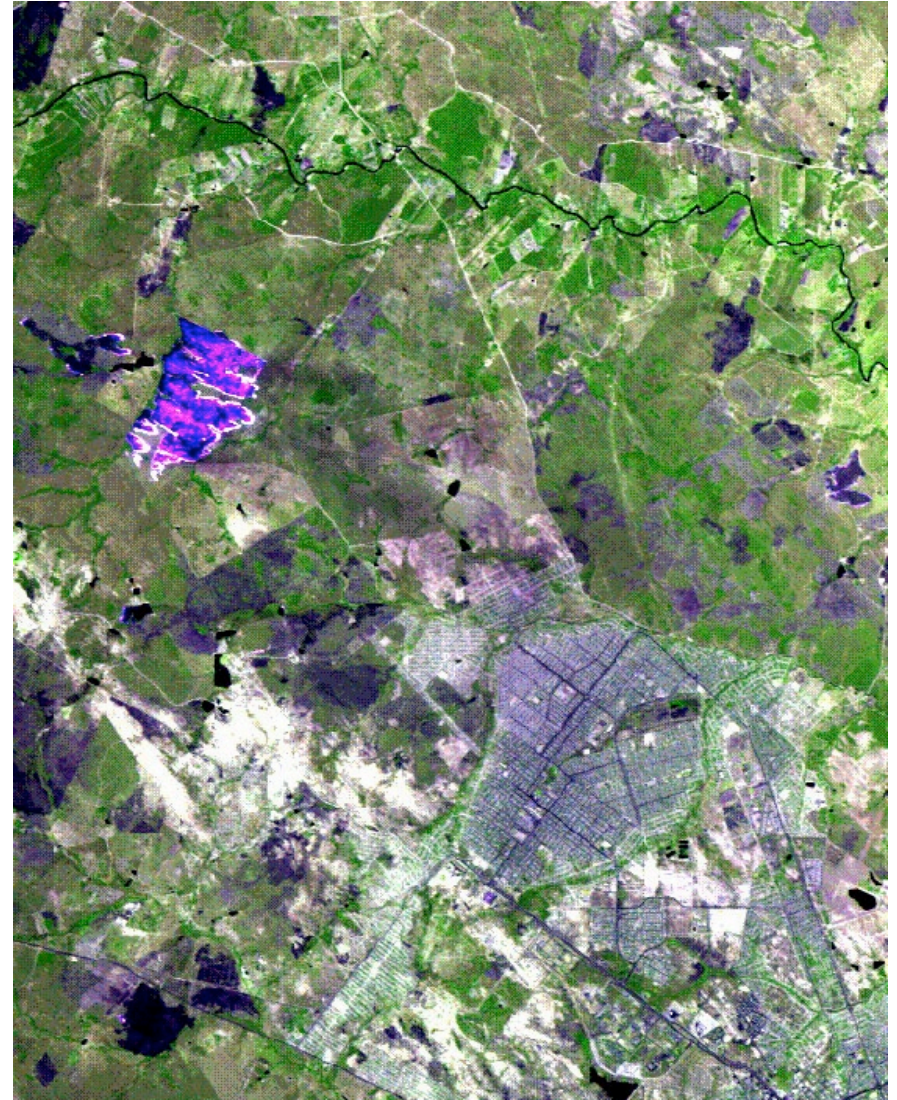
# False Color Images

- 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

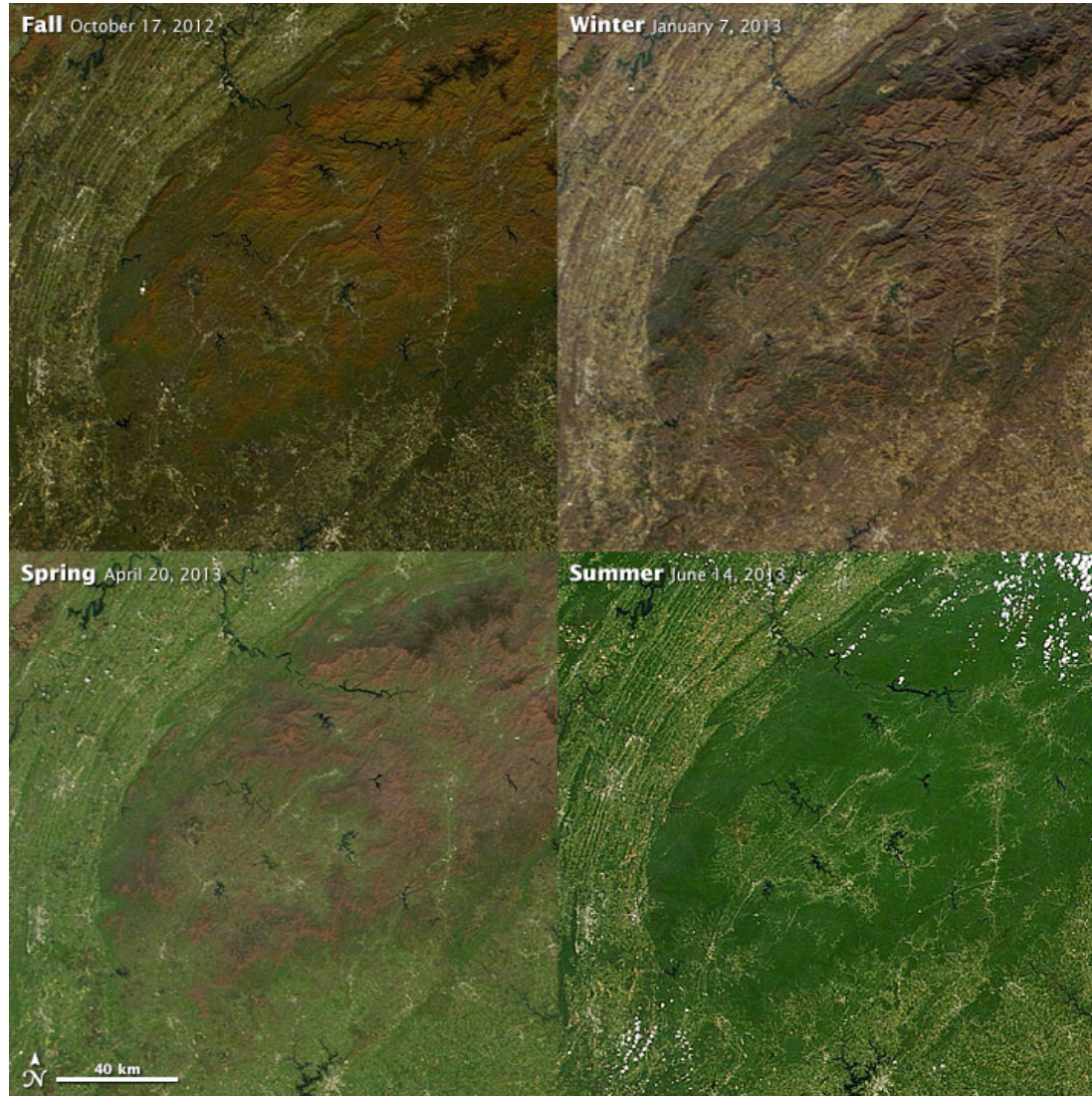


R = 0.66  $\mu\text{m}$   
G = 0.55  $\mu\text{m}$   
B = 0.47  $\mu\text{m}$



R = 1.6  $\mu\text{m}$   
G = 1.2  $\mu\text{m}$   
B = 2.1  $\mu\text{m}$

# Change in vegetation color from space



# Earth Observatory Story

*An article on feature detection in an image*

[http://earthobservatory.nasa.gov/Features/ColorImage/  
page2.php](http://earthobservatory.nasa.gov/Features/ColorImage/page2.php)



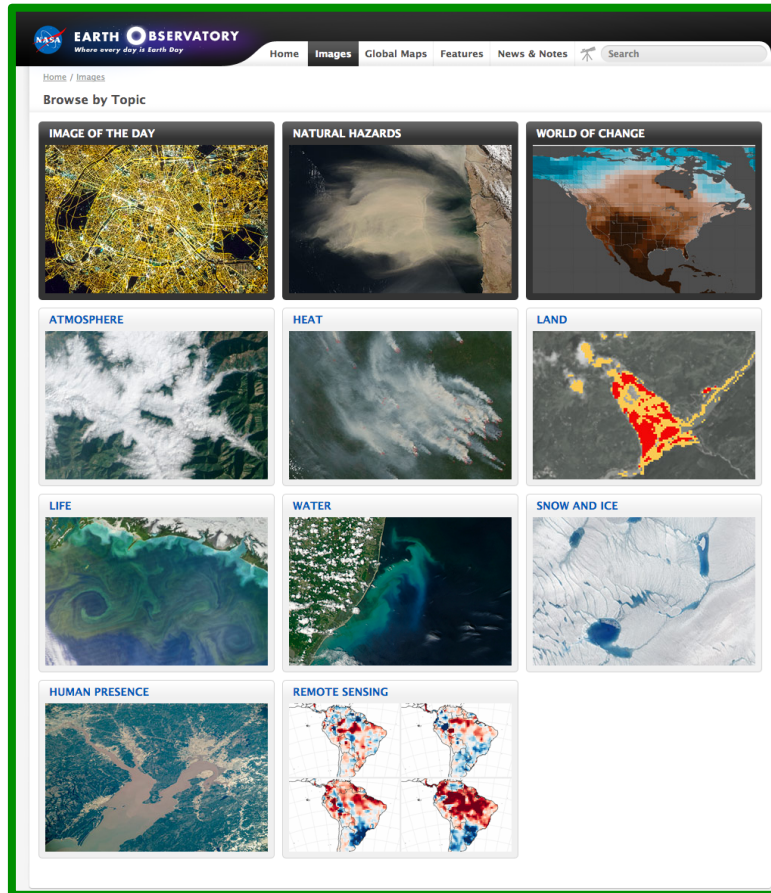
# Image Archive and Gallery Links

- 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

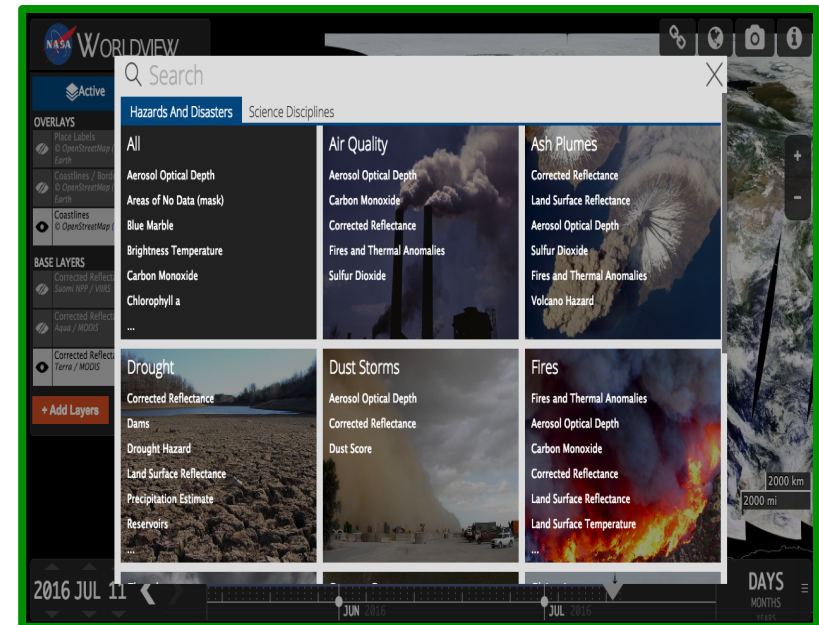
- **Earth Observatory**

- <http://earthobservatory.nasa.gov>



- **Worldview: Near Real-Time**

- <http://earthdata.nasa.gov/labs/worldview>



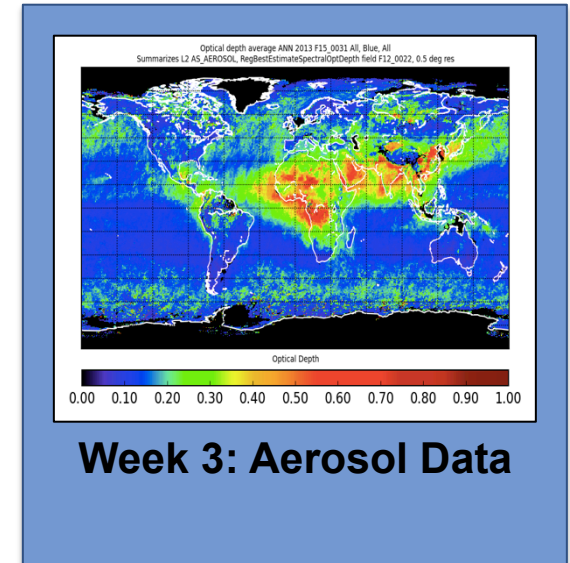
A satellite-style map of the Pacific Northwest region of the United States, showing the coastline, the Columbia River, and the surrounding land. A semi-transparent grey rectangular overlay covers the central part of the map. The text "NO ASSIGNMENTS" is written in large, bold, black, sans-serif capital letters across the center of the overlay. A thin black horizontal line is positioned directly below the text.

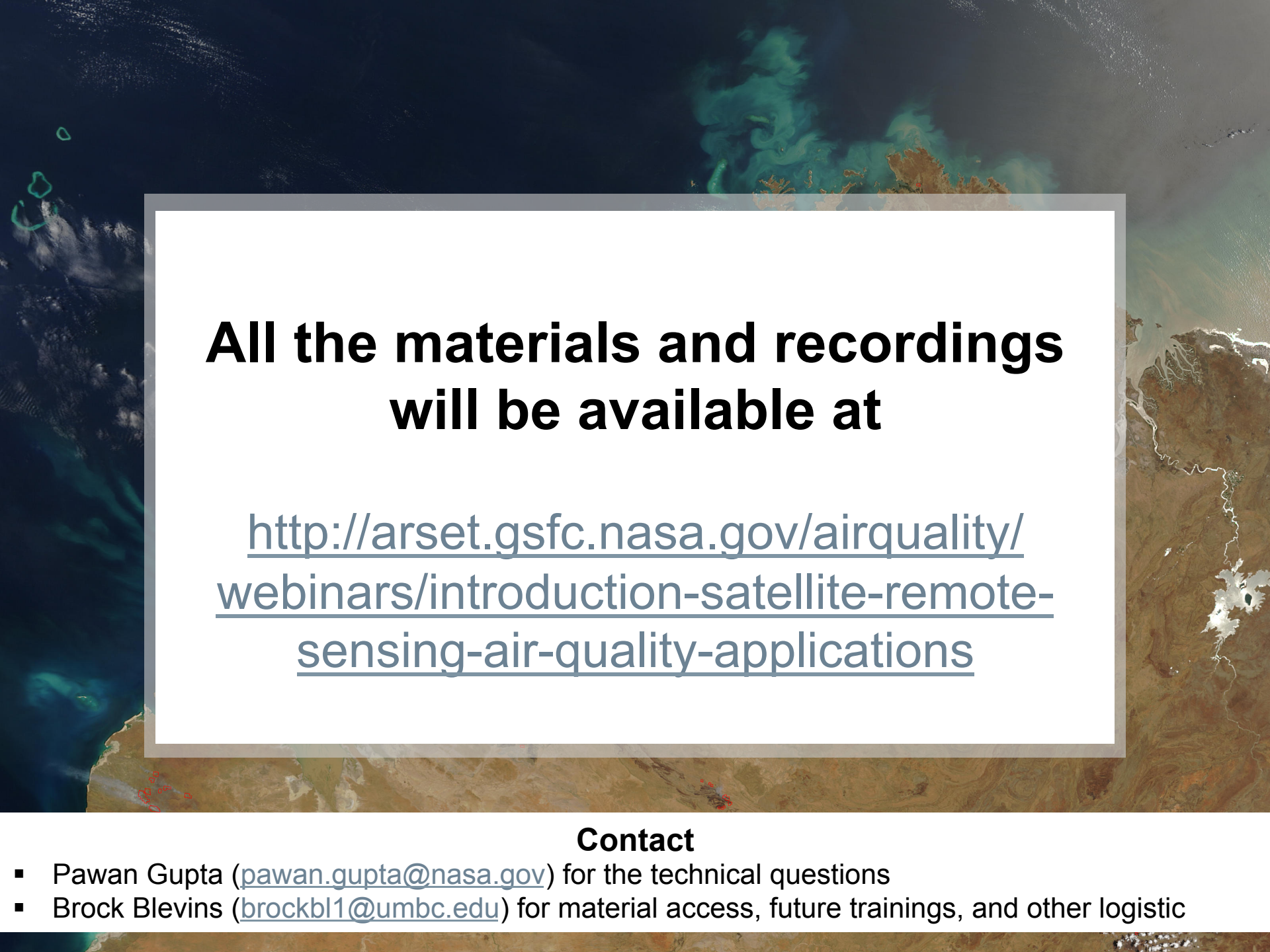
**NO ASSIGNMENTS**

# Next Week

## NASA Aerosol Products for Particulate Matter Air Quality

- Remote sensing of aerosols,
- NASA satellite aerosol products, and
- Aerosol products as a surrogate for **PM2.5**





**All the materials and recordings  
will be available at**

[http://arset.gsfc.nasa.gov/airquality/  
webinars/introduction-satellite-remote-  
sensing-air-quality-applications](http://arset.gsfc.nasa.gov/airquality/webinars/introduction-satellite-remote-sensing-air-quality-applications)

### **Contact**

- Pawan Gupta ([pawan.gupta@nasa.gov](mailto:pawan.gupta@nasa.gov)) for the technical questions
- Brock Blevins ([brockbl1@umbc.edu](mailto:brockbl1@umbc.edu)) for material access, future trainings, and other logistic