

Satellite Imagery

Introduction to Remote Sensing and Air Quality
Applications for the Indian Sub-Continent and
Surrounding Regions

ARSET

Applied Remote Sensing Training

A project of NASA Applied Sciences



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.
4. Assignment #2



RGB Images

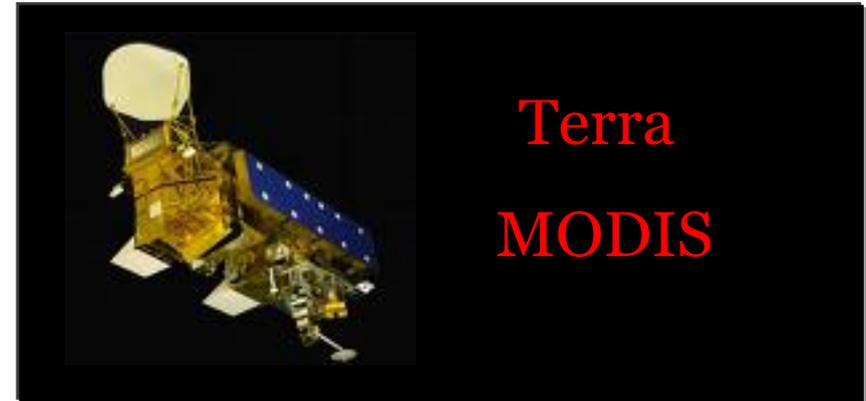
Red, Green and Blue correspond to the three color receptors in the human eye.

These 3 colors are also the basis for all color display technologies from LCD sub-pixels to television color “guns”.



Remote Sensing of Radiation

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



36 wavelength bands
covering the wavelength
range 405 nm (blue) to
14.385 μm (infrared)

MODIS Reflected Solar Bands

	Primary Use	Band No.	Bandwidth (nm)	Spectral Radiance	Required SNR	
250 M	Land/Cloud Boundaries	1**	620-670	21.8	128	
		2**	841-876	24.7	201	
500 M	Land/Cloud Properties	3*	459-479	35.3	243	
		4*	545-565	29.0	228	
		5*	1230-1250	5.4	74	
		6*	1628-1652	7.3	275	
		7*	2105-2155	1.0	110	
		Ocean Color/ Phytoplankton/ Biogeochemistry	8	405-420	44.9	880
			9	438-448	41.9	838
10	483-493		32.1	802		
11	526-536		27.9	754		
12	546-556		21.0	750		
13	662-672		9.5	910		
14	673-683		8.7	1087		
15	743-753		10.2	586		
Atmospheric Water Vapor	16	862-877	6.2	516		
	17	890-920	10.0	167		
	18	931-941	3.6	57		
	19	915-965	15.0	250		

* 500m Spatial Resolution

** 250m Spatial Resolution

Spectral Radiance values are in $W/m^2\text{-}\mu\text{m-sr}$

SNR = Signal-to-noise ratio

MODIS Thermal Bands

Primary Use	Band	Bandwidth (μm)	Spectral Radiance	Required NEDT (K)
Surface/Cloud Temperature	20	3.660-3.840	0.45(300K)	0.05
	21	3.929-3.989	2.38(335K)	2.00
	22	3.929-3.989	0.67(300K)	0.07
	23	4.020-4.080	0.79(300K)	0.07
Atmospheric Temperature	24	4.433-4.498	0.17(250K)	0.25
	25	4.482-4.549	0.59(275K)	0.25
Cirrus Clouds Water Vapor	26	1.360-1.390	6.00	150 (SNR)
	27	6.535-6.895	1.16(240K)	0.25
	28	7.175-7.475	2.18(250K)	0.25
	29	8.400-8.700	9.58(300K)	0.05
Ozone	30	9.580-9.880	3.69(250K)	0.25
Surface/Cloud Temperature	31	10.780-11.280	9.55(300K)	0.05
	32	11.770-12.270	8.94(300K)	0.05
Cloud Top Altitude	33	13.185-13.485	4.52(260K)	0.25
	34	13.485-13.785	3.76(250K)	0.25
	35	13.785-14.085	3.11(240K)	0.25
	36	14.085-14.385	2.08(220K)	0.35

Spectral Radiance values are in $\text{W}/\text{m}^2\text{-}\mu\text{m}\text{-sr}$
 NEDT = Noise-equivalent temperature difference

RGB Images and Remote Sensing Instruments

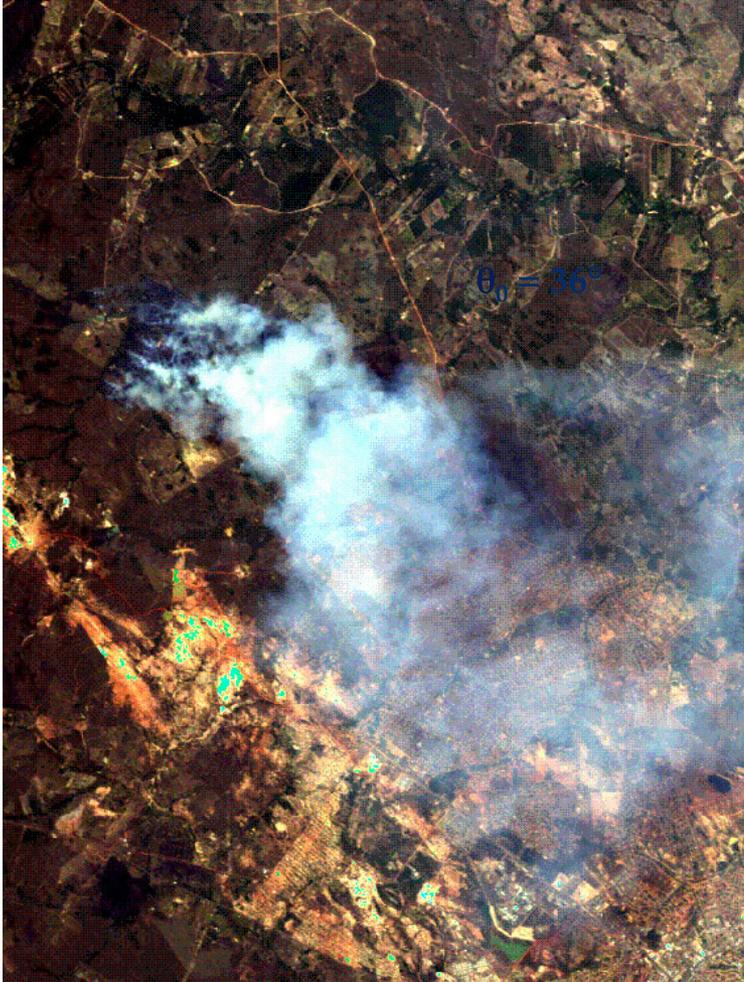
We can create an image by selecting any three bands and load them into the “Red” “Green” and “Blue” display channels.

“True Color Image”

To simulate what the human eye sees we load the red, green and blue satellite bands into the corresponding display channels.



True Color Image



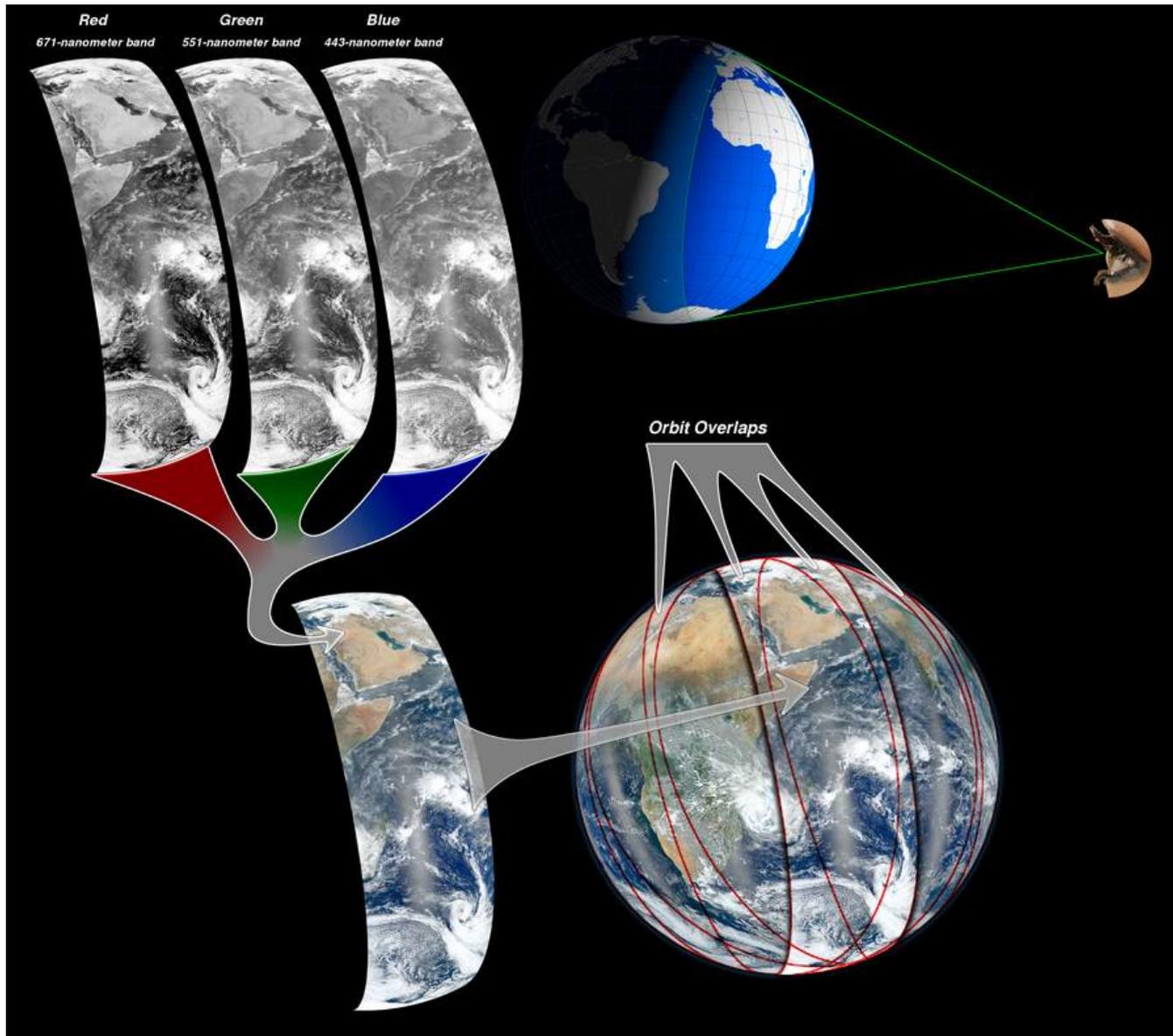
A MODIS
“True Color Image”
will use MODIS
visible wavelength bands
1-4-3

R = 0.66 μm

G = 0.55 μm

B = 0.47 μm

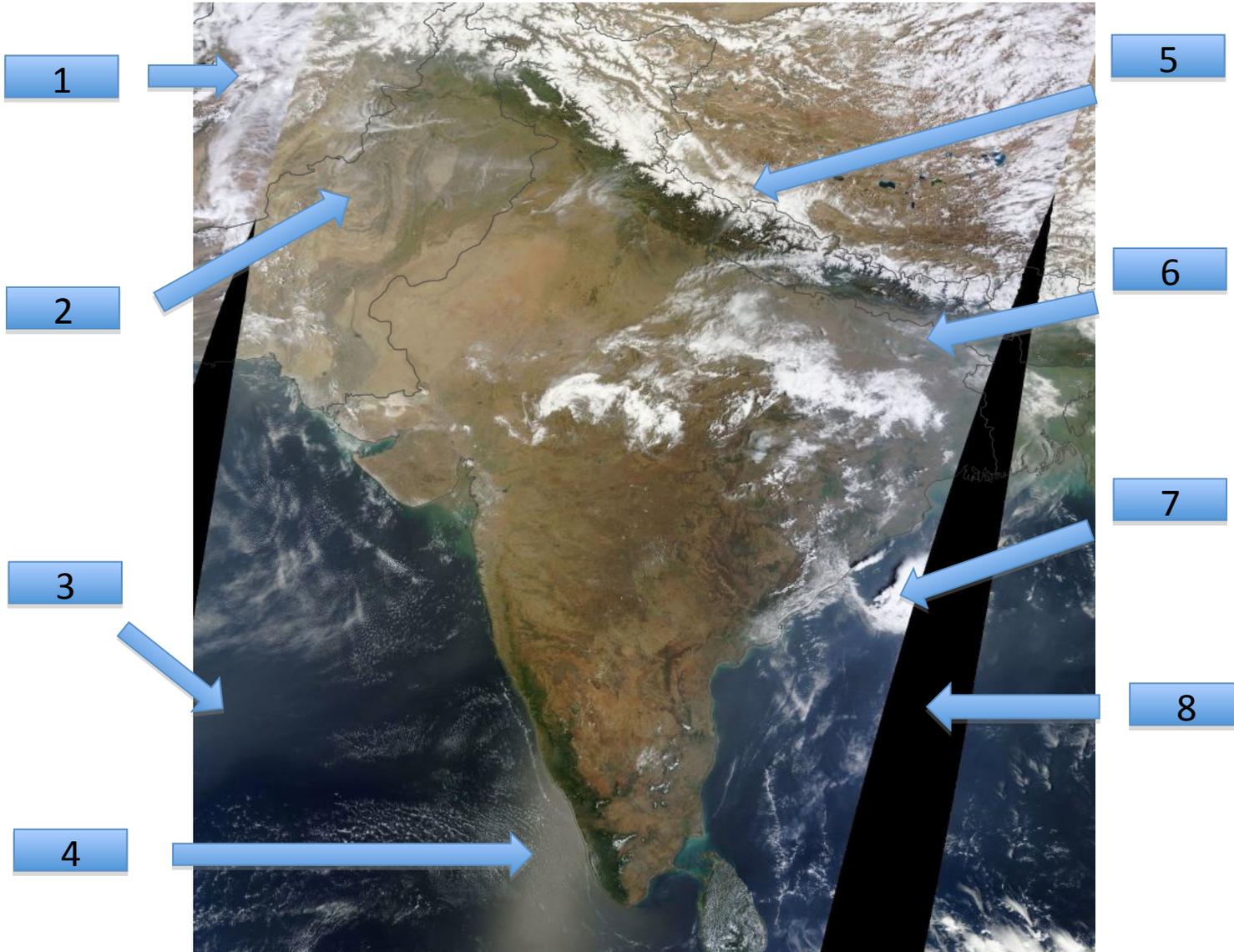
True Color Image from VIIRS



What can we learn from true color imagery?

MODIS Terra Image from April 19 2013

<http://1.usa.gov/1cNFDQh>

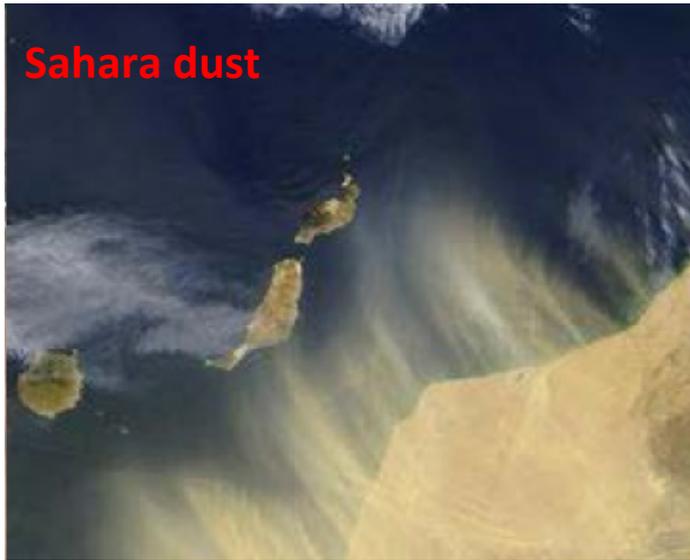


Feature Identification is more reliable when a clear source can be seen in the image.



Images
Courtesy of
Phil
Russell
NASA AMES

Feature Identification is more reliable when a clear source can be seen in the image.



Images
Courtesy of
Phil
Russell
NASA AMES

Using Imagery to Detect Dust Transport



April 6, 2013

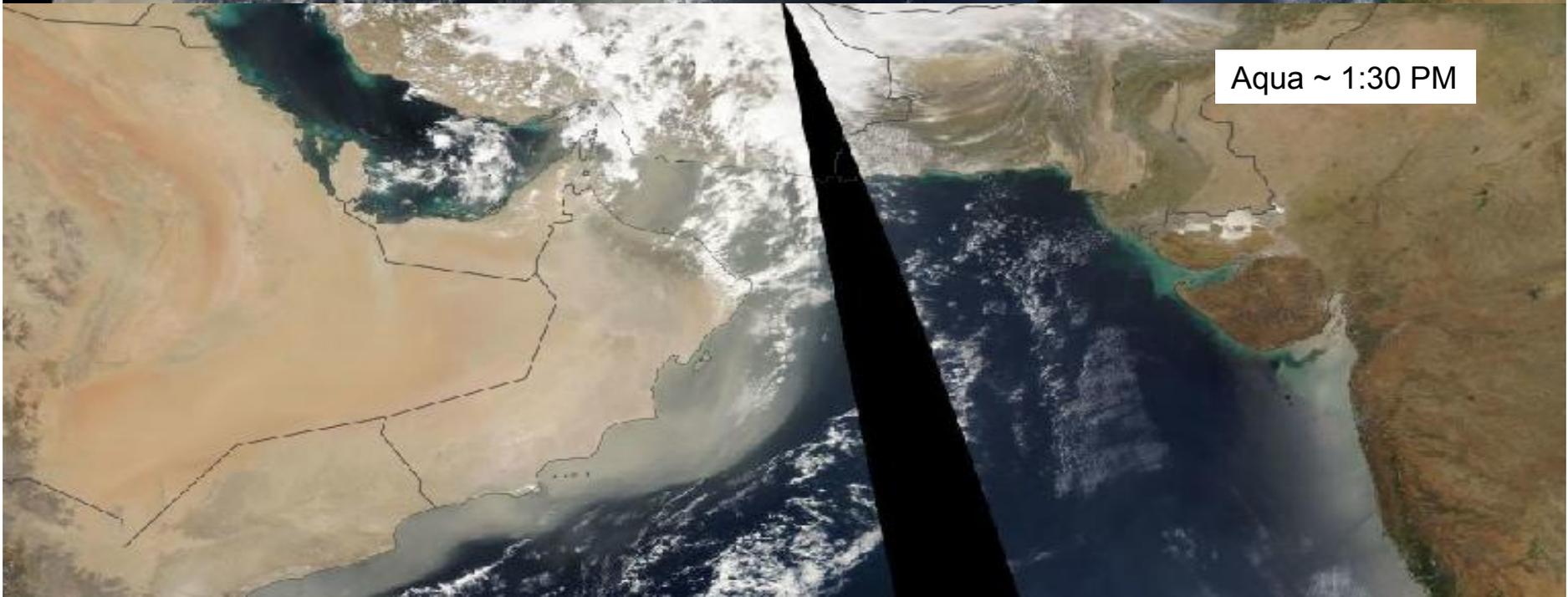
Images from NASA Worldview

April 7, 2013
Worldview

Images from NASA

Terra ~ 10:30 AM

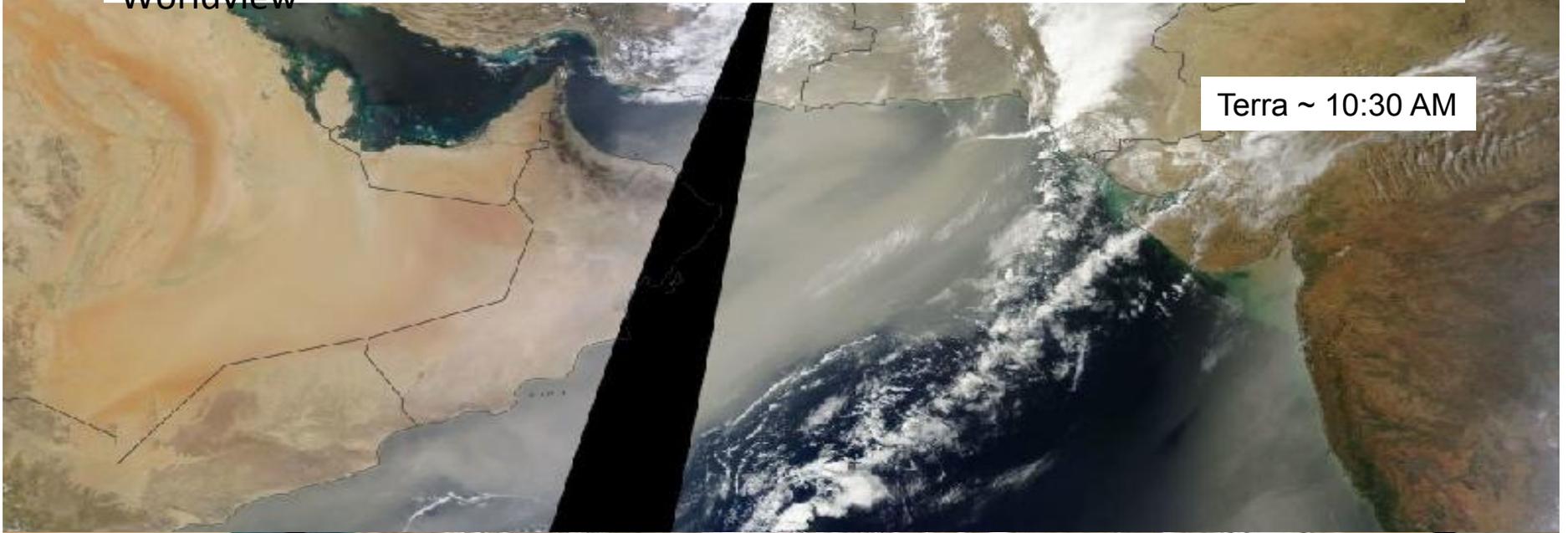
Aqua ~ 1:30 PM



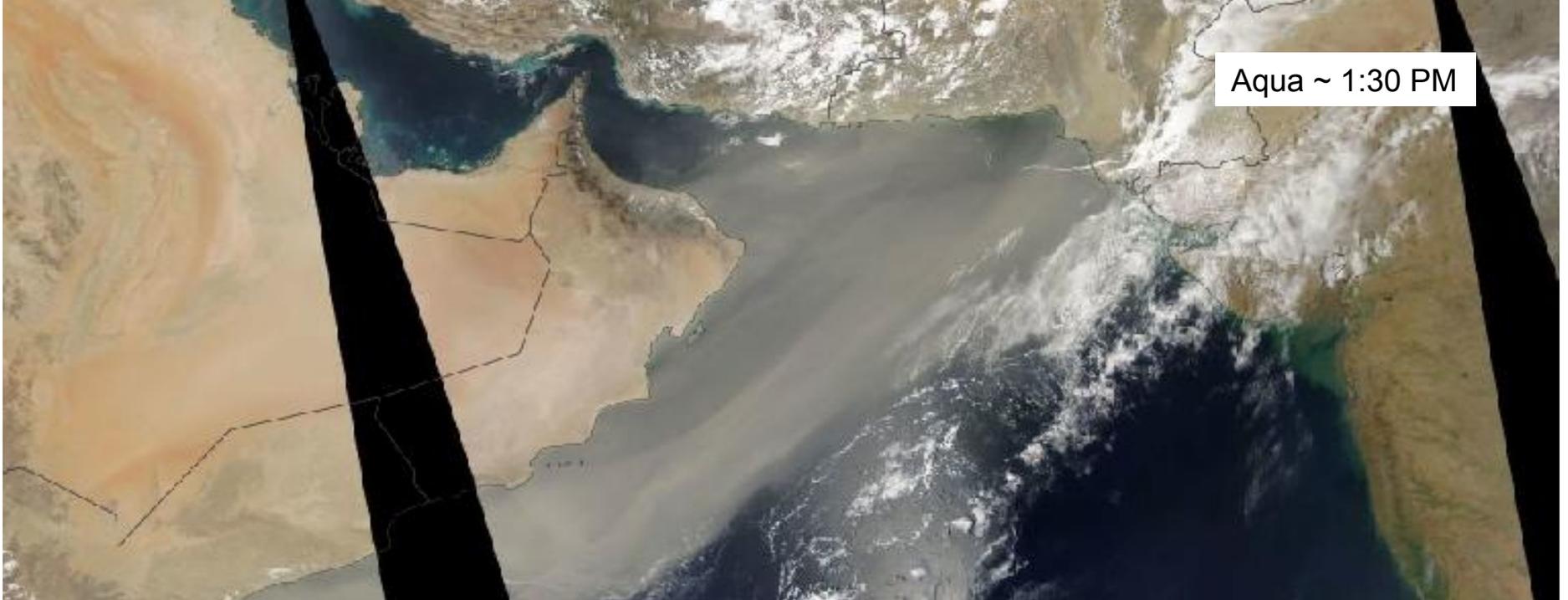
April 8, 2013
Worldview

Images from NASA

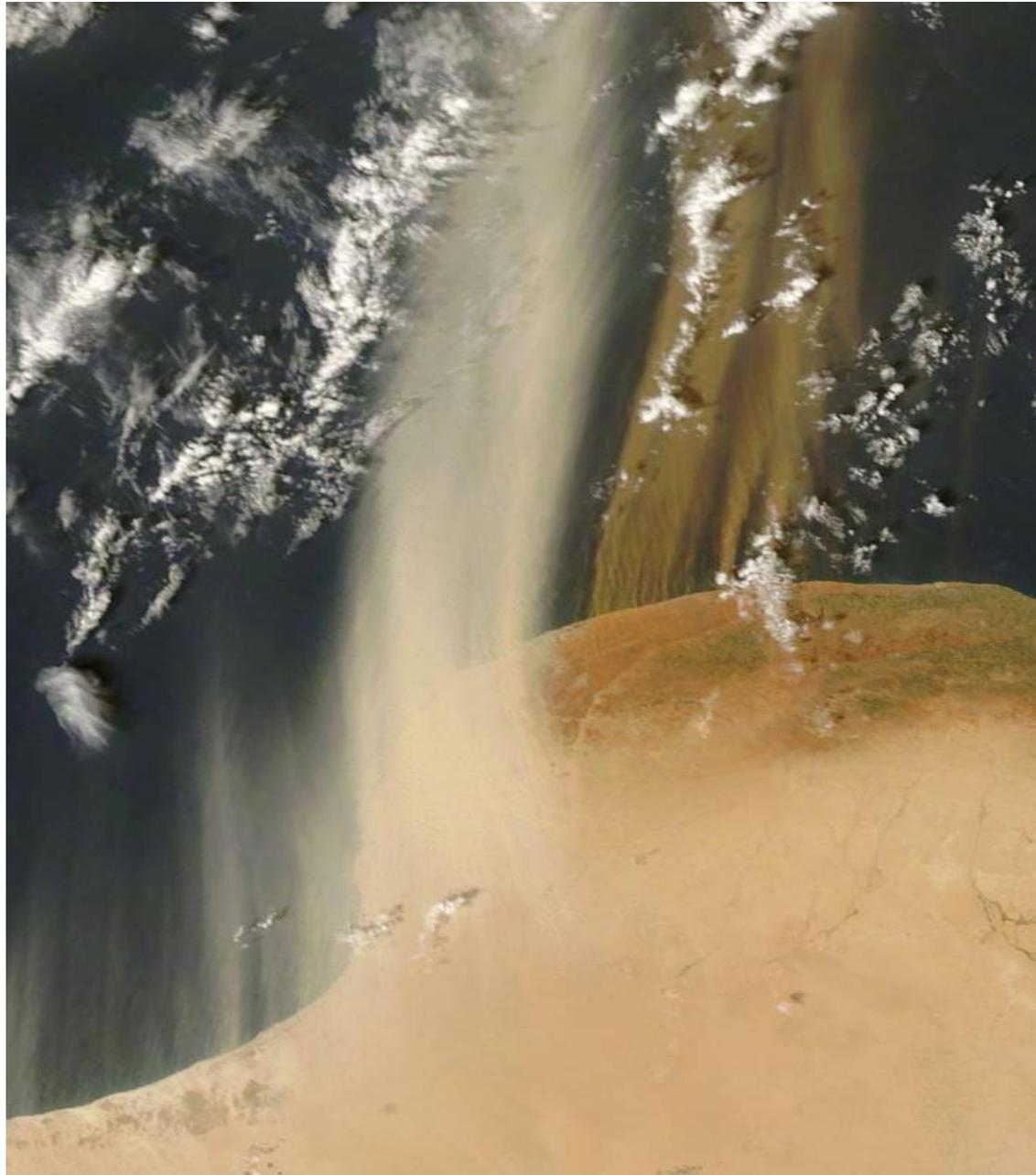
Terra ~ 10:30 AM



Aqua ~ 1:30 PM

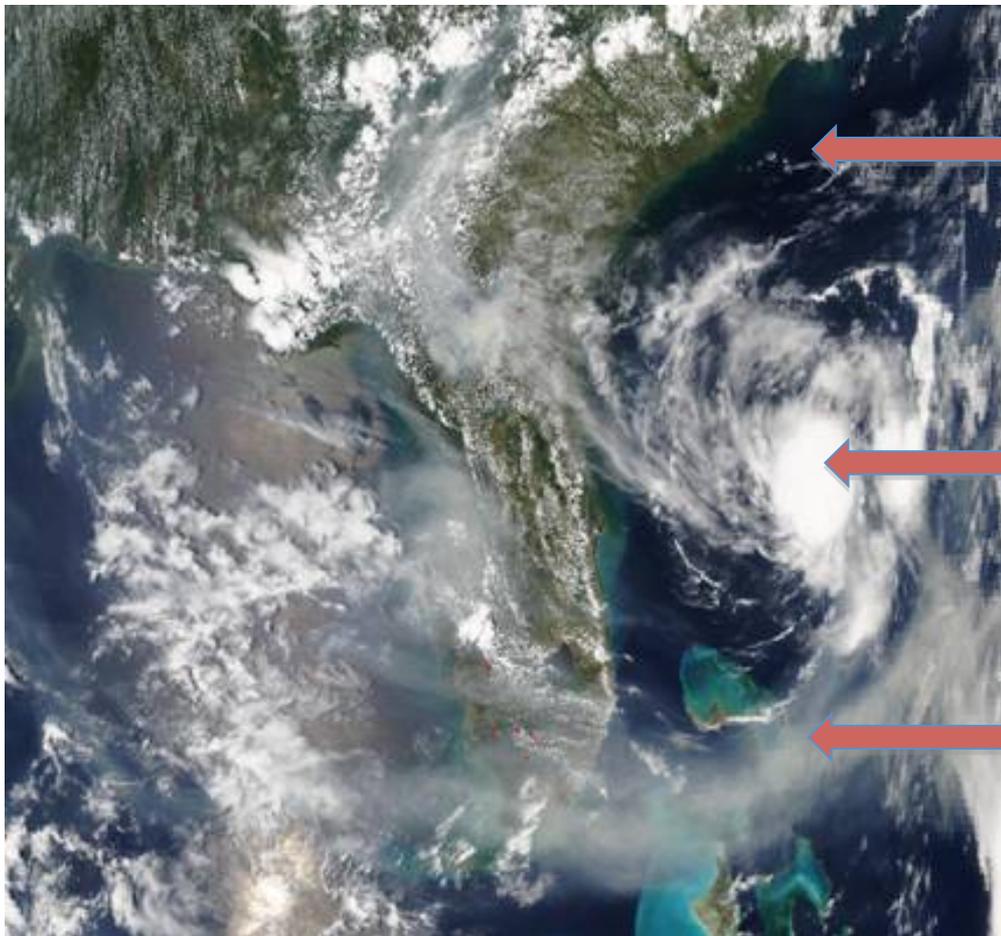


The color of dust or smoke can tell us something about chemical properties.



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



In visible imagery water is dark because it absorbs most of the energy.

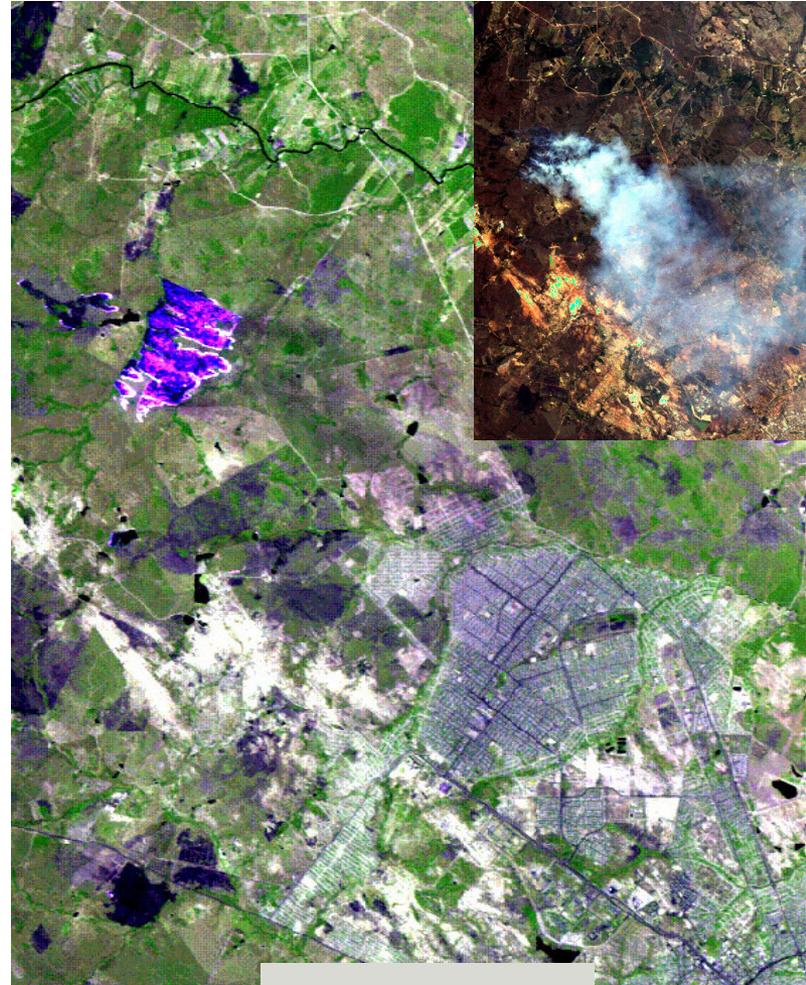
Clouds are white because most of the incoming energy is reflected

Pollution is hazy depending upon its absorptive properties

False Color Images

“False Color Image”

To enhance particular features we want to see in an image we load bands into the red, green and blue display channels which do not correspond to the visible red, green, and blue wavelengths.

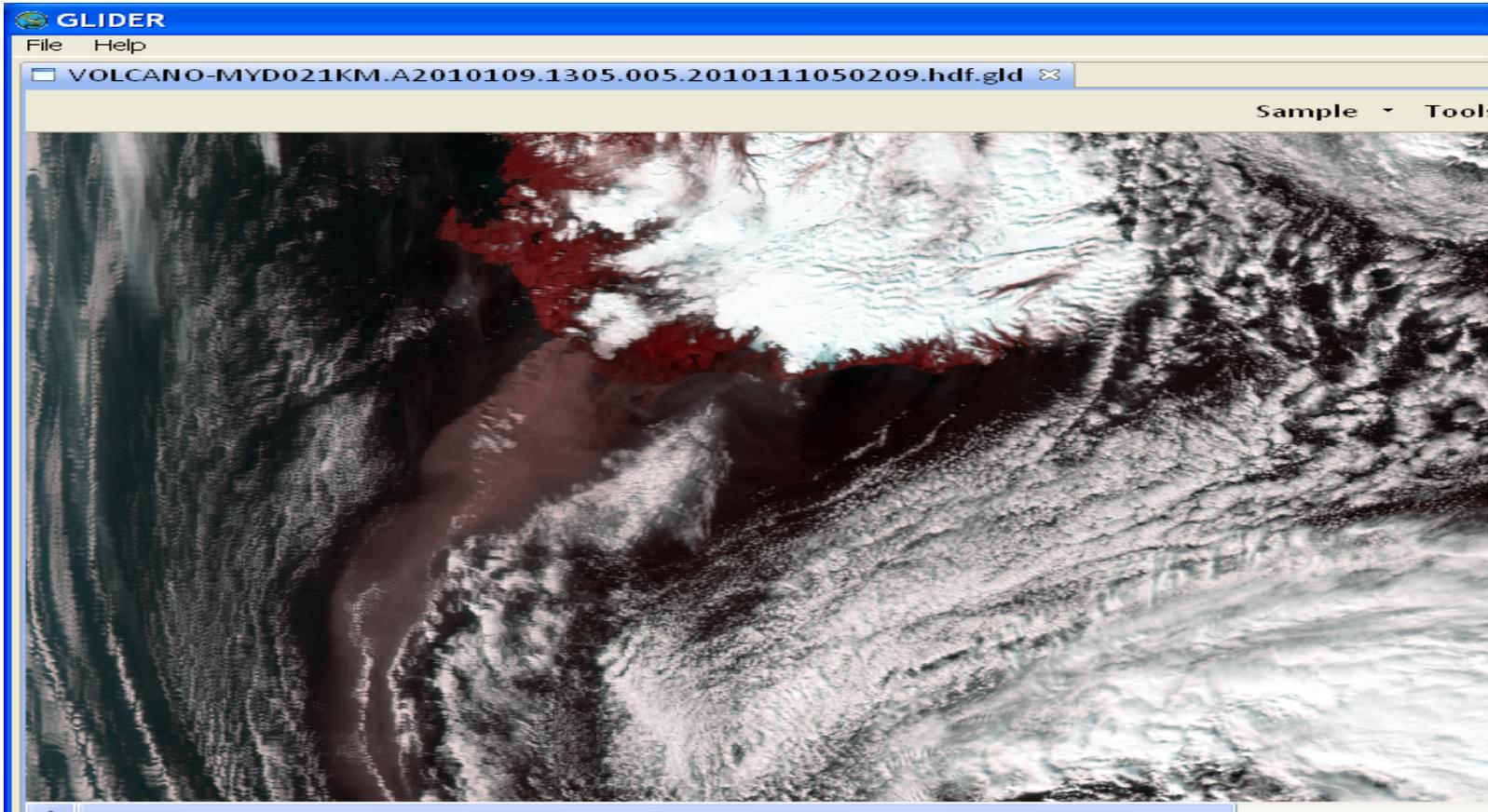


R = 1.6 μm

G = 1.2 μm

B = 2.1 μm

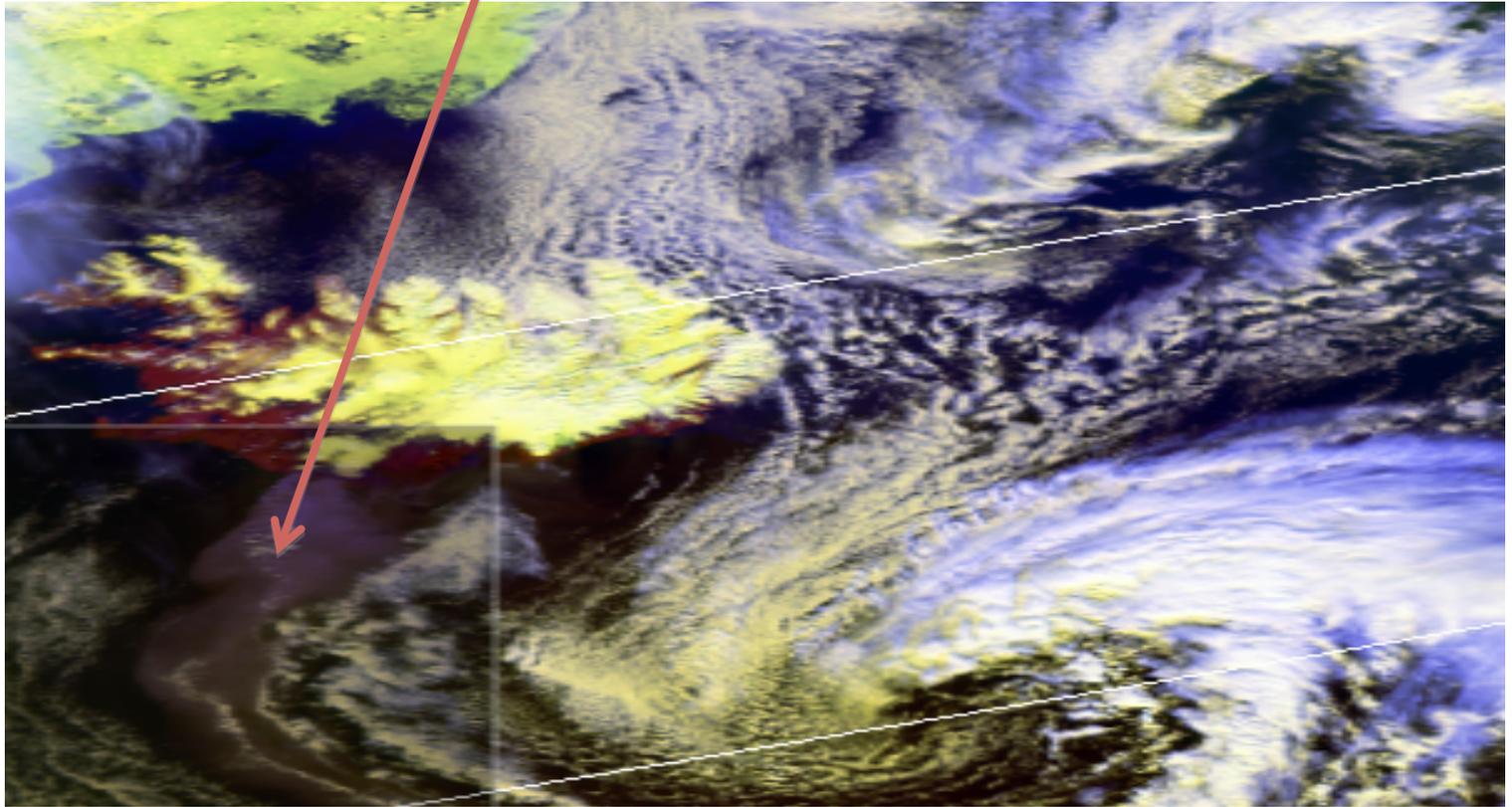
Volcanic Ash



- R:0.645 um, G : 0.858um, B : 0.469 um (All channels equalized)

Additional Display Enhancements

Volcanic Ash

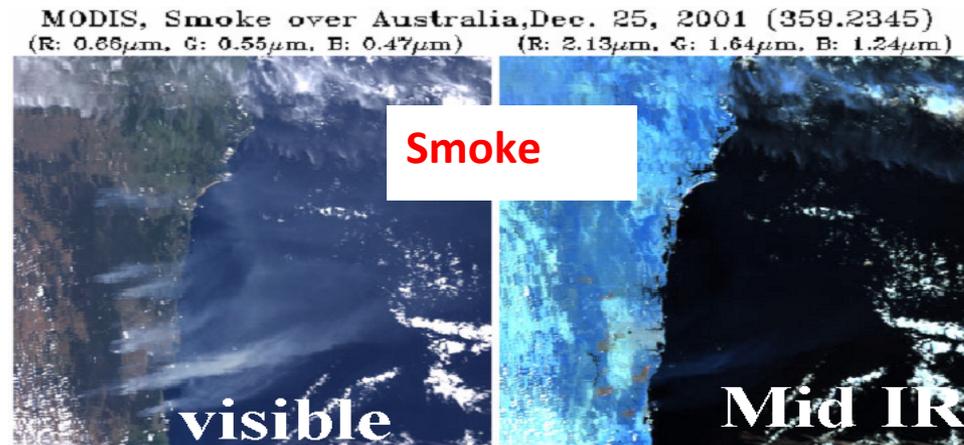
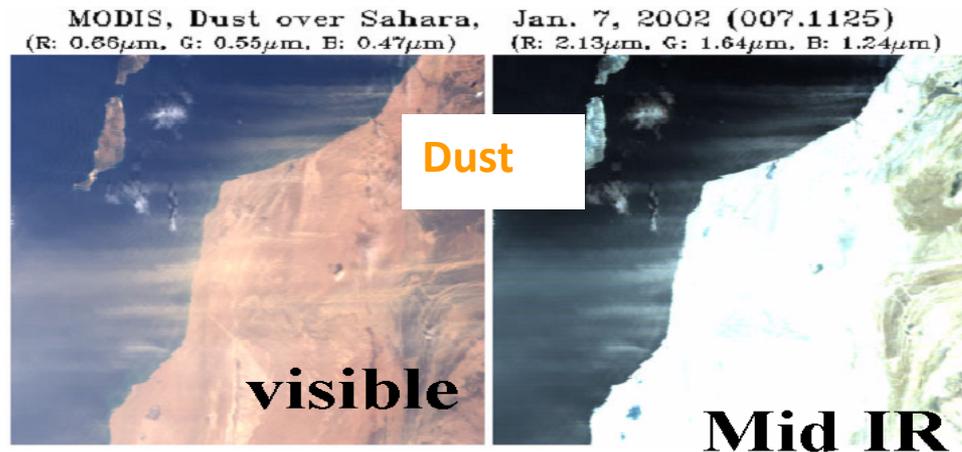


- R:0.645 μm , G : 0.858 μm , B : 11.03 μm (All channels equalized, B channel also flipped)

Spectral optical properties of aerosol

The distinction of aerosol types is made possible by:

1. The wide spectral range of the MODIS sensor.
2. Understanding how light interacts with the particles, gases and surfaces it interacts with.

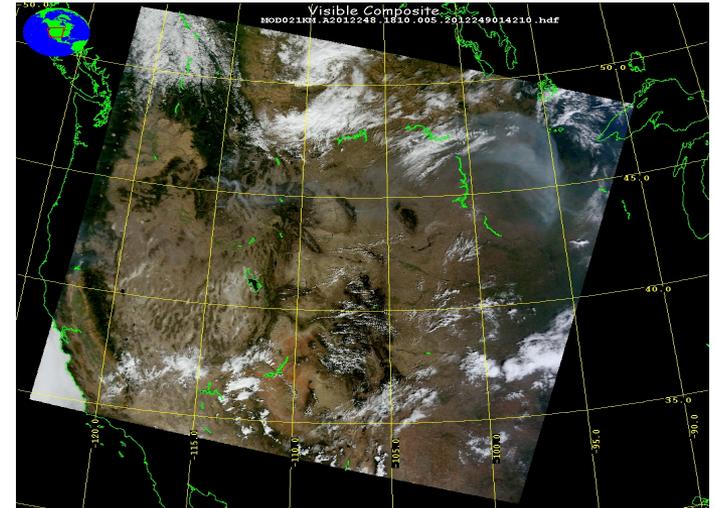
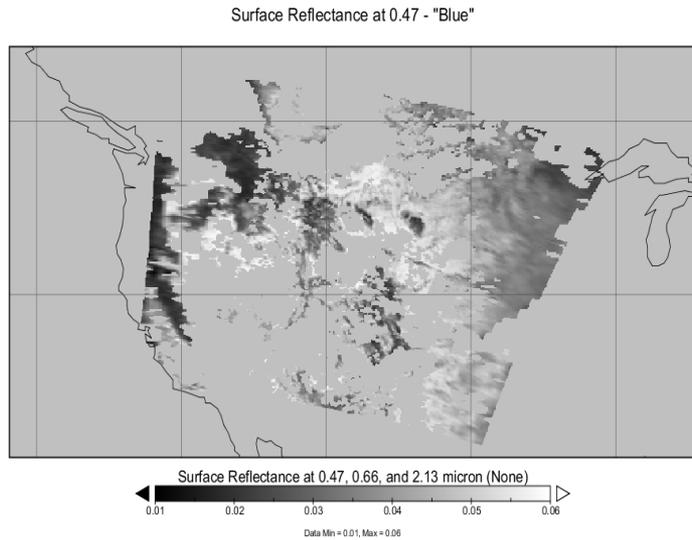


from Y. Kaufman

Spectral Images vs Color Maps 1

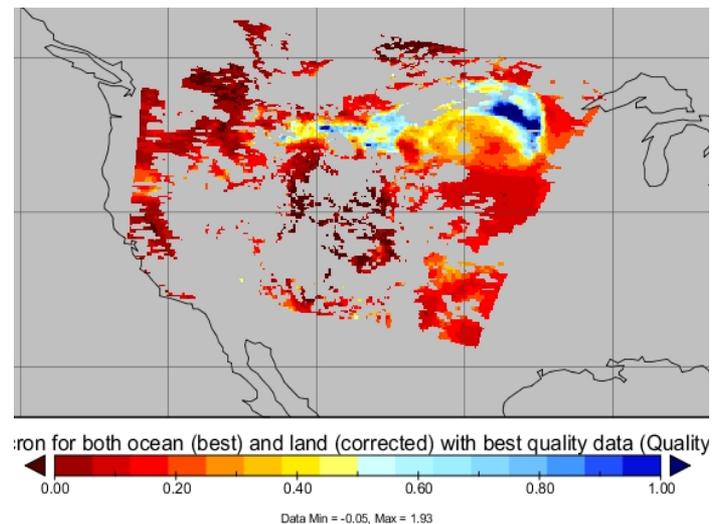
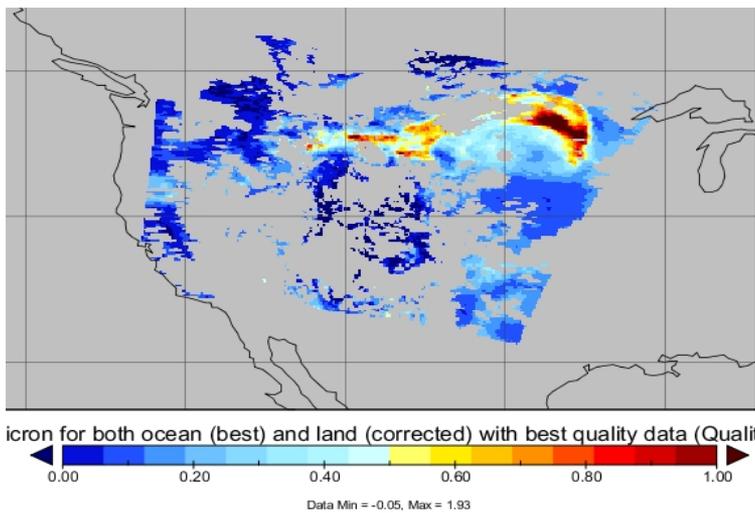
Single Channel Image

True Color Image



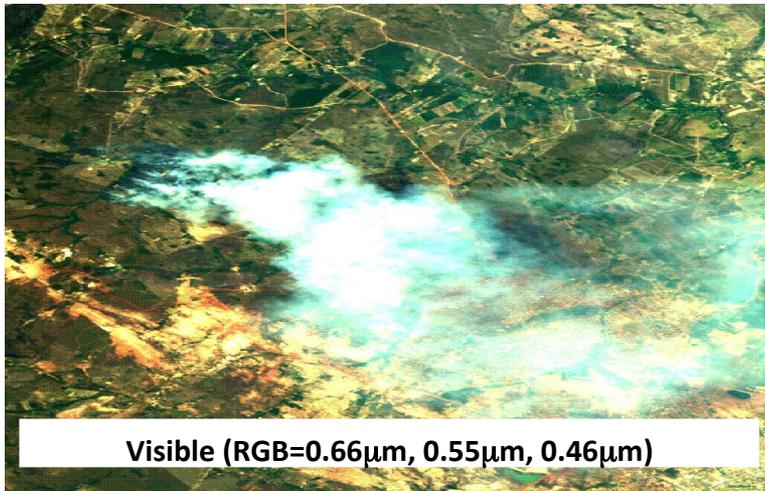
Color Maps

Values of AOD are assigned colors. There is no intrinsic value to the color.

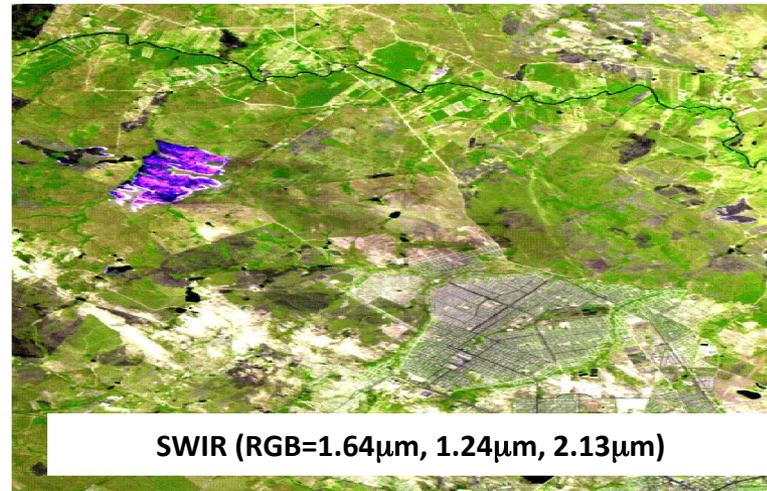


Spectral Images vs Color Maps

True Color Image

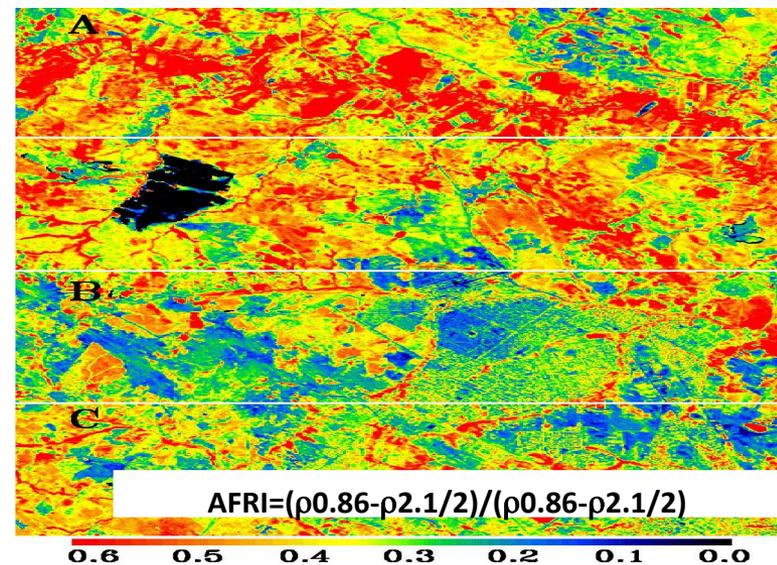
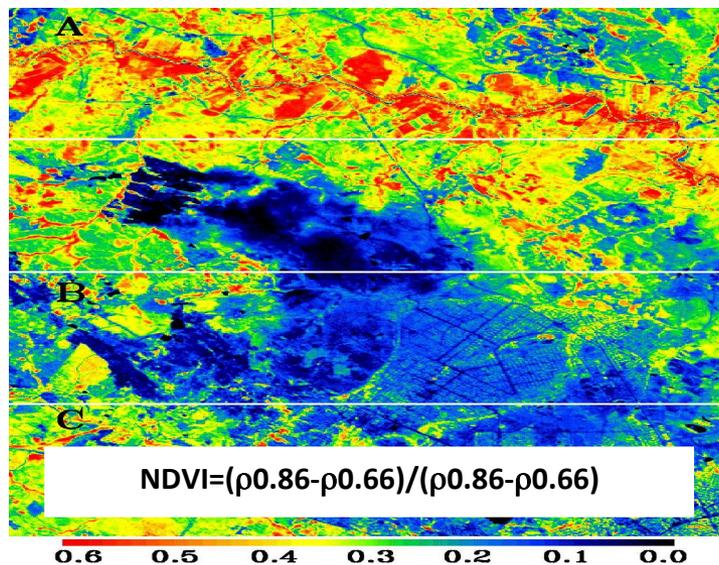


False Color Image



Color Maps

Values are assigned colors according to the scale below each image.
Spectral information is used to detect chlorophyll. High values indicate more vegetation.



A Brief Tour of Some Useful Image Archives

World View

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

MODIS Rapid Response Site - Imagery

<http://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/realtime.cgi>

MODIS Rapid Response Site - FAQ

<https://earthdata.nasa.gov/data/near-real-time-data/faq>

MODIS-Atmos Site

<http://modis-atmos.gsfc.nasa.gov/IMAGES/index.html>

MODIS Rapid Response Site

- MODIS only image archive which is easy to search.
- Quick posting of new MODIS images.
- Links to data used to generate MODIS images.
- Collections of images by region and by association with ground based instruments

NASA's Visible Earth

- A tremendous archive of images **and animations** from and about many sensors.
- Search results can be too large to browse through unless many conditions are added to the search.

NASA's Earth Observatory

- Site designed for outreach and education.
- Images and stories of Earth Science phenomena are linked.
- Subscriptions to newsletters to keep track of recent stories and Natural Hazards.

NASA Earth Observations (NEO)

Site designed for outreach and education.

- Can explore several remote sensing products with an easy to use interface.
- The ability to quickly produce high quality graphic images from the site.
- The ability to quickly create products that can be mapped onto Google Earth.

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 Earth Observations (NEO)

<http://neo.sci.gsfc.nasa.gov>

MODIS- Atmos (MODIS Atmosphere Product Reference Site)

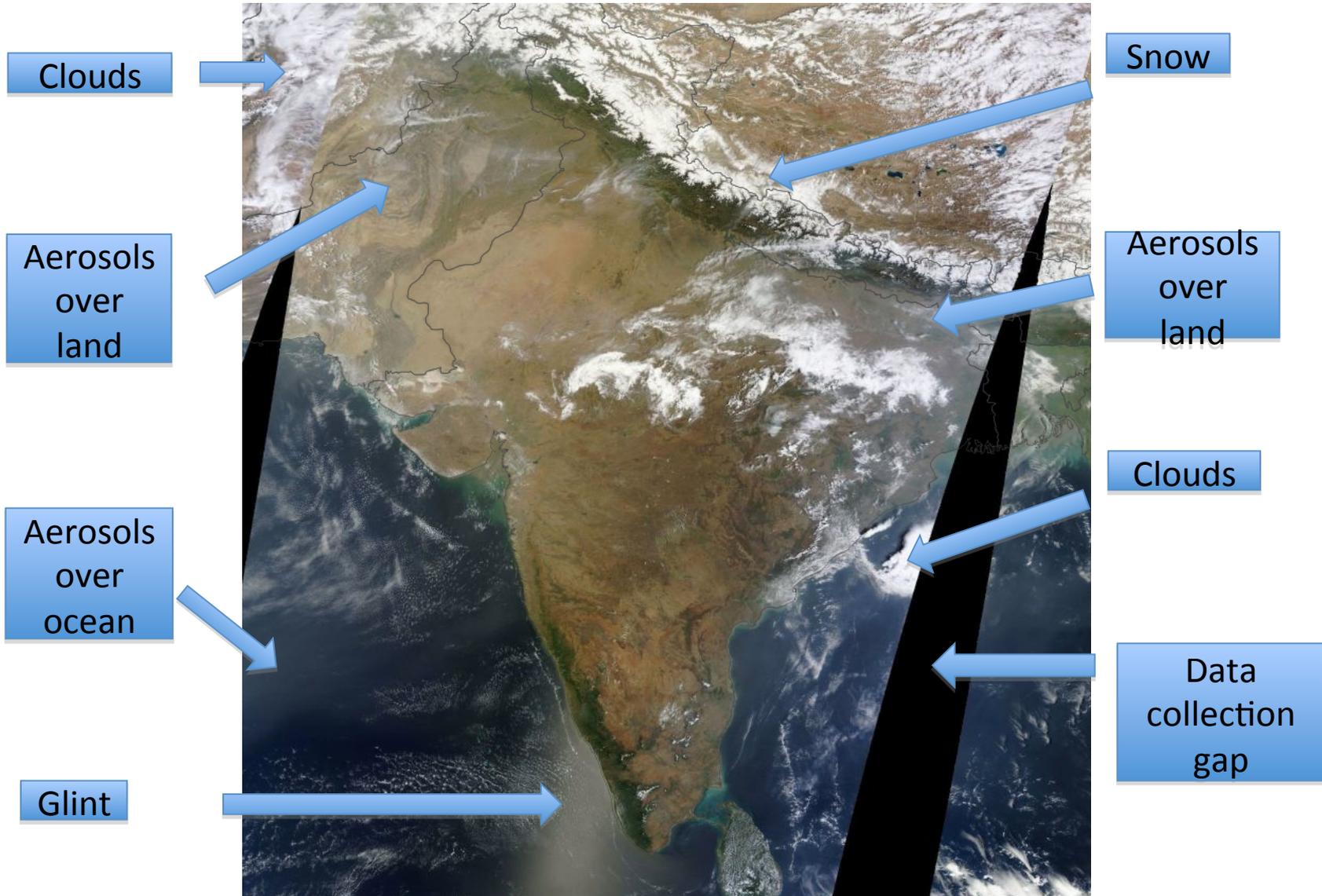
<http://modis-atmos.gsfc.nasa.gov/IMAGES/index.html>

•GLIDER Tool

<http://www.ssec.wisc.edu/hydra/>

What can we learn from true color imagery?

MODIS Terra Image from April 19 2013



Week 2 Assignment

[https://docs.google.com/forms/d/
1hh230sH7bKn1wbV_54XSYkOYCUpf13GICKZY
90c7eCM/viewform](https://docs.google.com/forms/d/1hh230sH7bKn1wbV_54XSYkOYCUpf13GICKZY90c7eCM/viewform)