Satellite Imagery

NASA ARSET- AQ – EPA Training
September 29, 20144

ARSET - AQ

Applied Remote SEnsing Training – Air Quality

A project of NASA Applied Sciences

Outline

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

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

250 M

500 M

Primary Use	Band No.	Bandwidth (nm)	Spectral Radiance	Required SNR
Land/Cloud Boundaries	1**	620-670	21.8	128
	2**	841-876	24.7	201
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
	16	862-877	6.2	516
Atmospheric Water Vapor	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-um-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	26	1.360-1.390	6.00	150 (SNR)
Water Vapor	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 W/m^2-um-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”

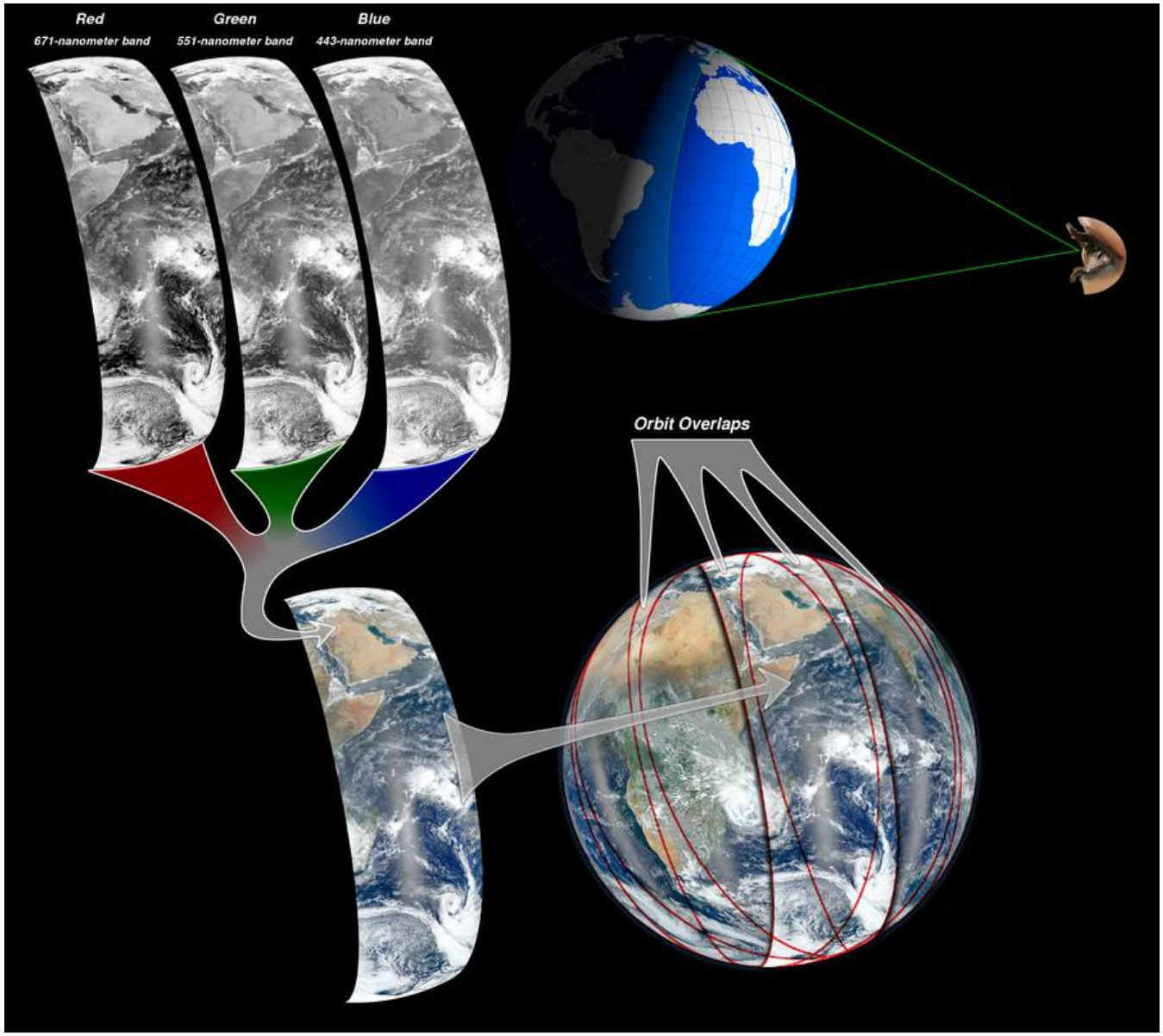
To simulate what the human eye sees we load the red, green and blue satellite bands into the corresponding display channels.

True Color Image

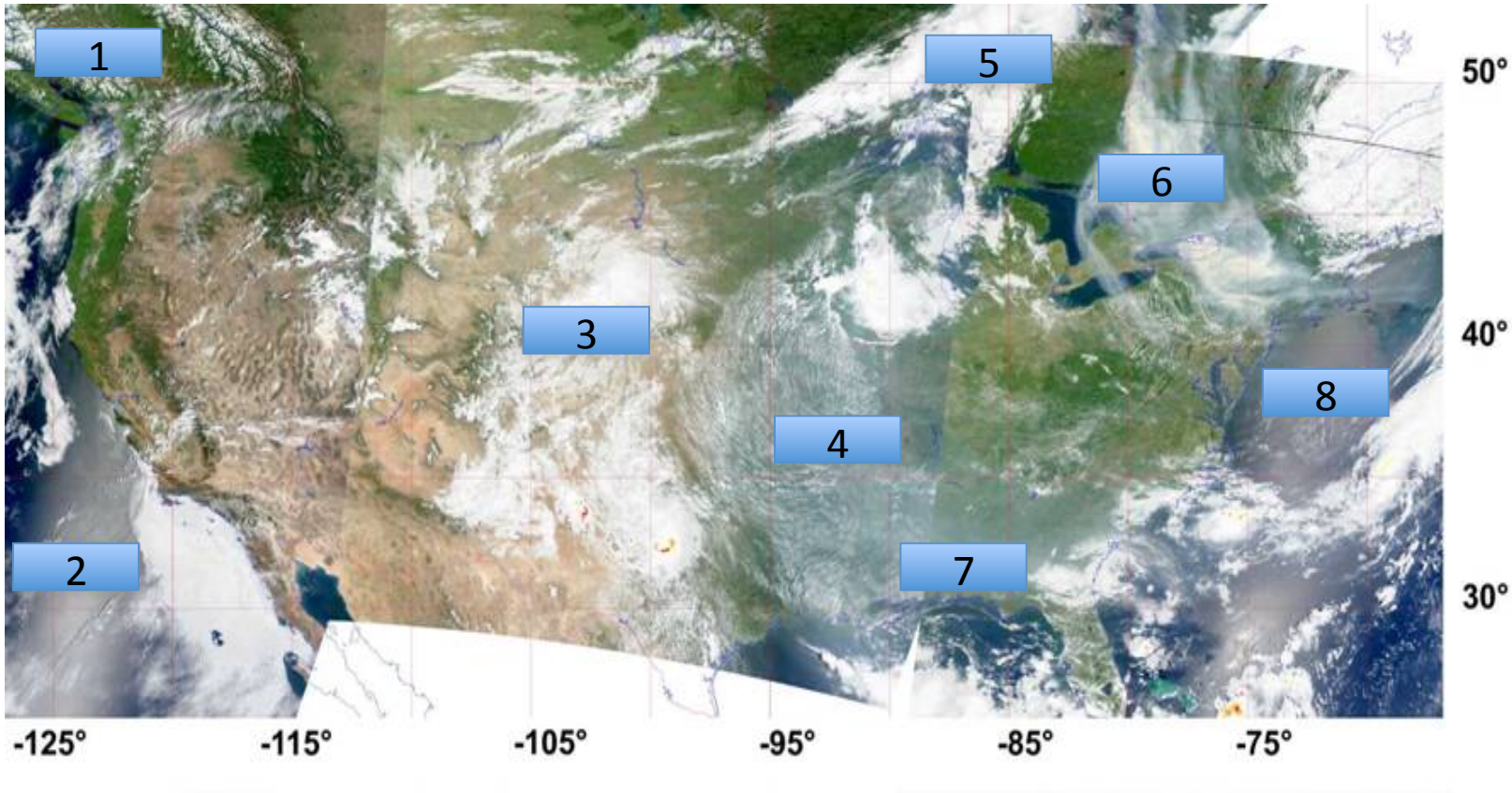
A MODIS
"True Color Image"
will use MODIS
visible wavelength bands
1-4-3

R = 0.66 μm
G = 0.55 μm
B = 0.47 μm

True Color Image from VIIRS

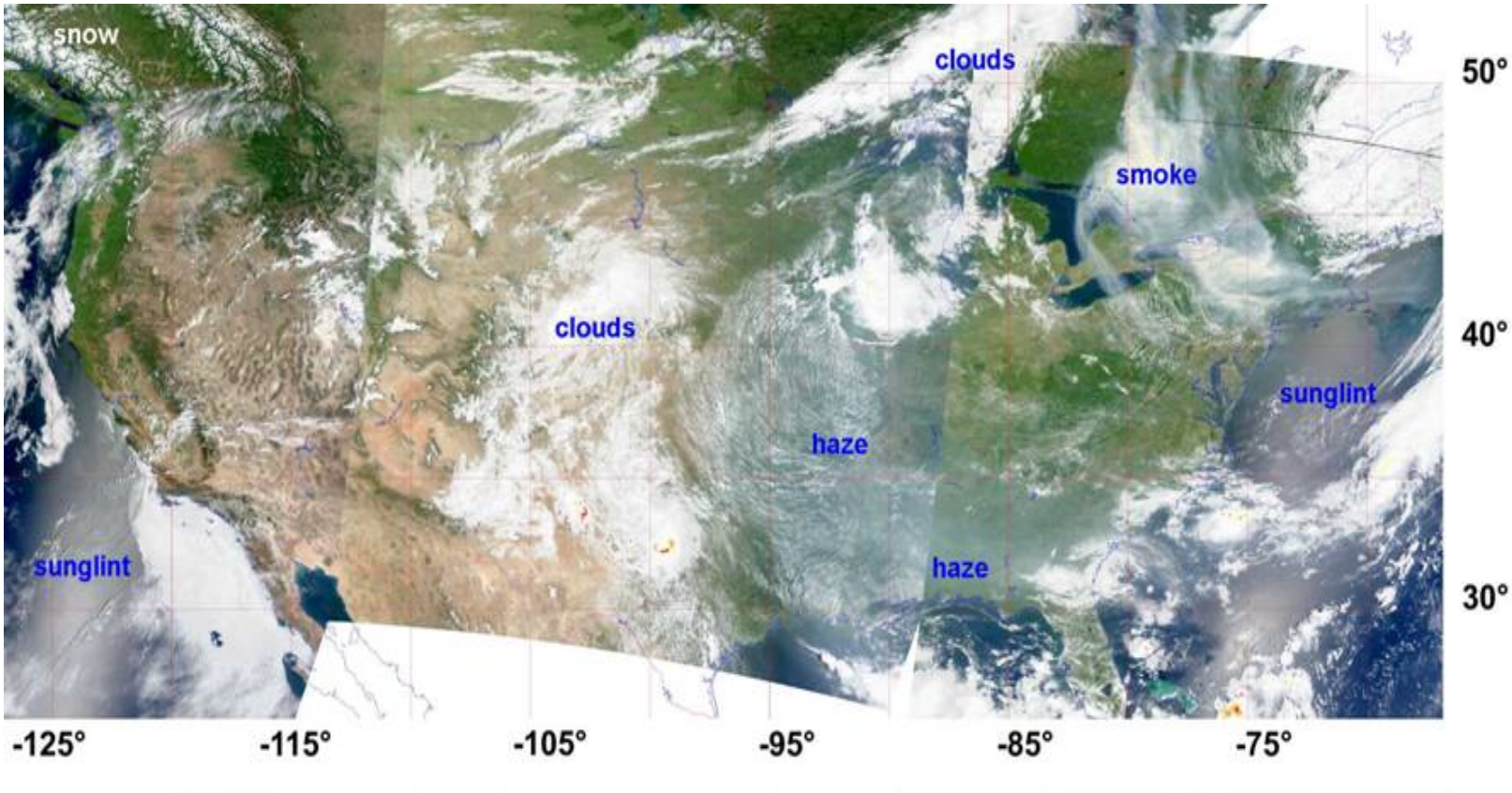


What can we learn from true color imagery?



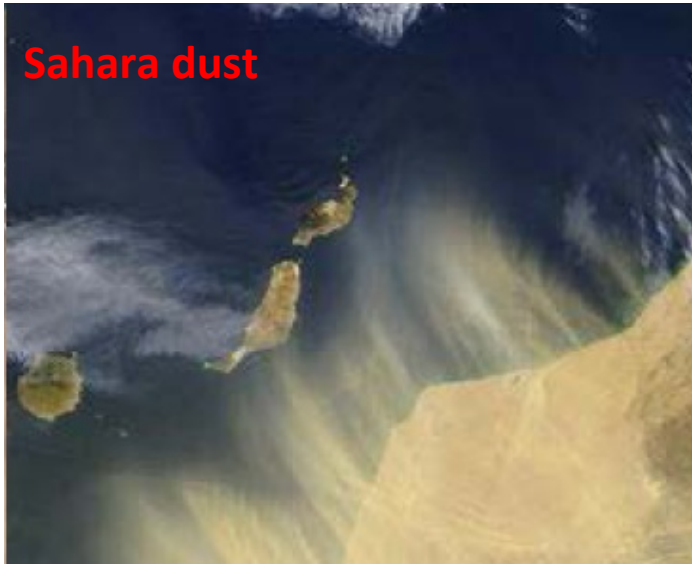
(Possible) Identification of land, ocean and atmosphere features

What can we learn from true color imagery?



(Possible) Identification of land, ocean and atmosphere features

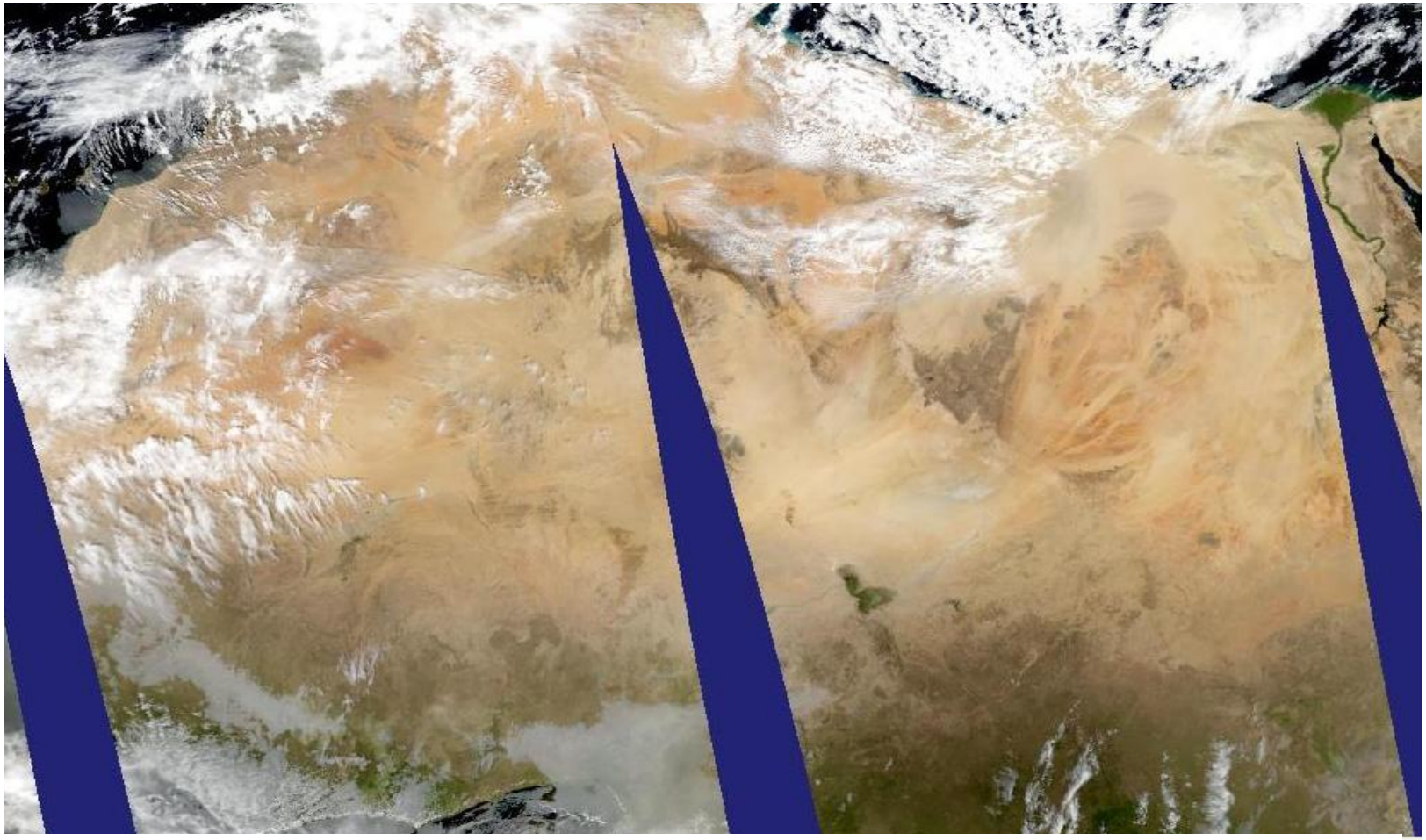
Feature Identification is more reliable when a clear source can be seen in the image.



Images Courtesy of Phil Russell NASA AMES

Using Imagery to Detect Transport

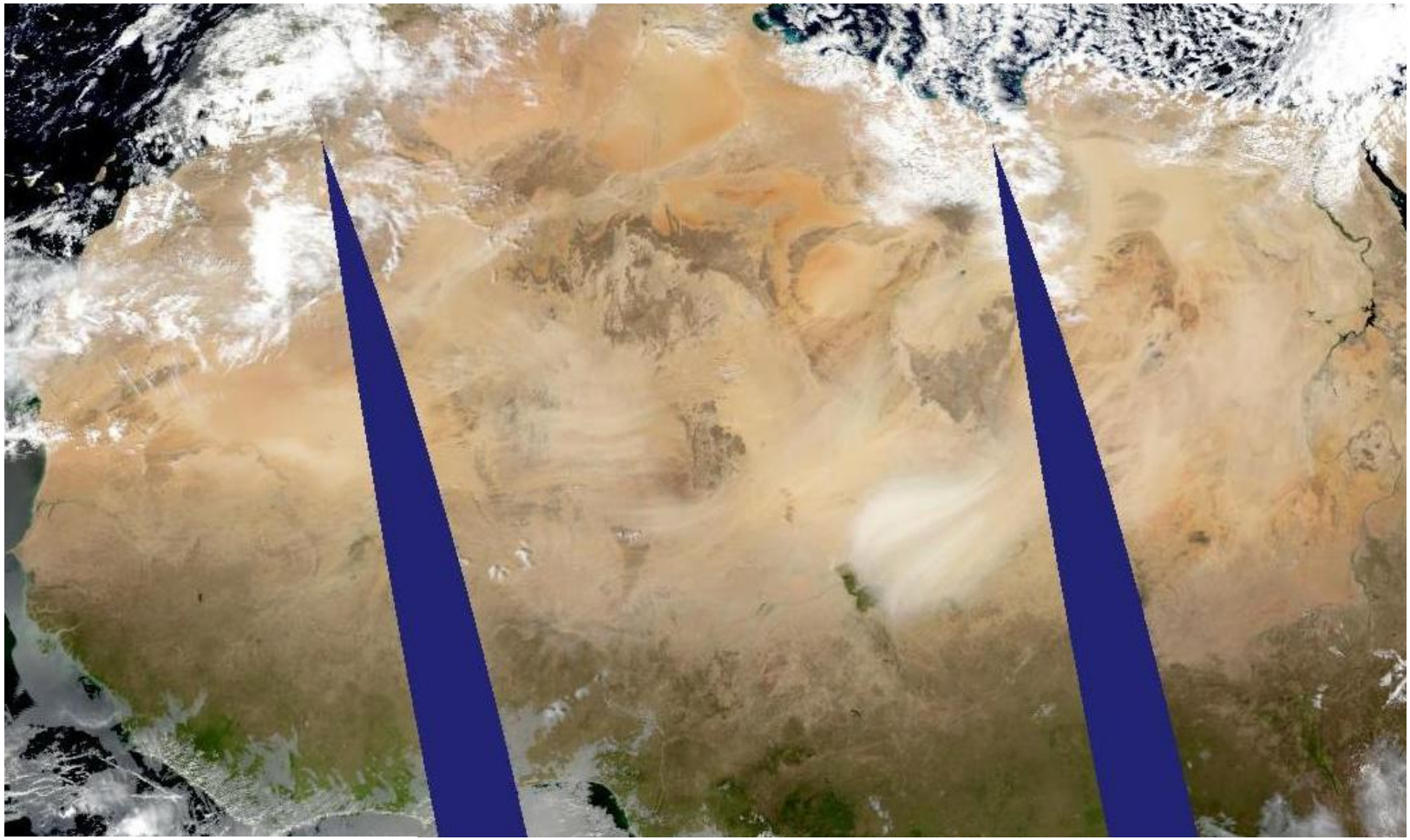
Saharan Dust



17 February 2008, Aqua

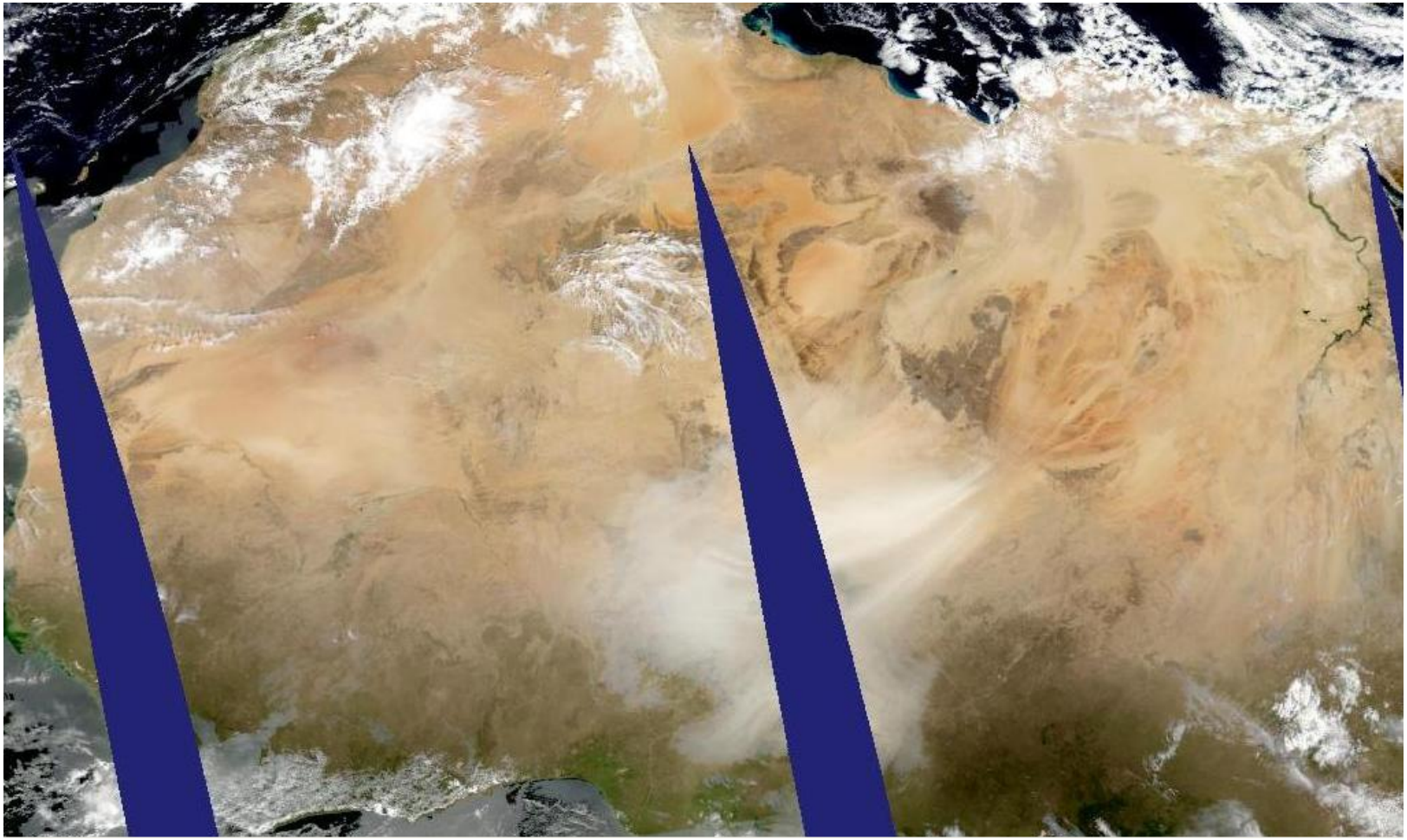
Images courtesy of Yuval Ben-Ami

Plume's area ~55,600 km^2 = ~4.5 × area of Maryland



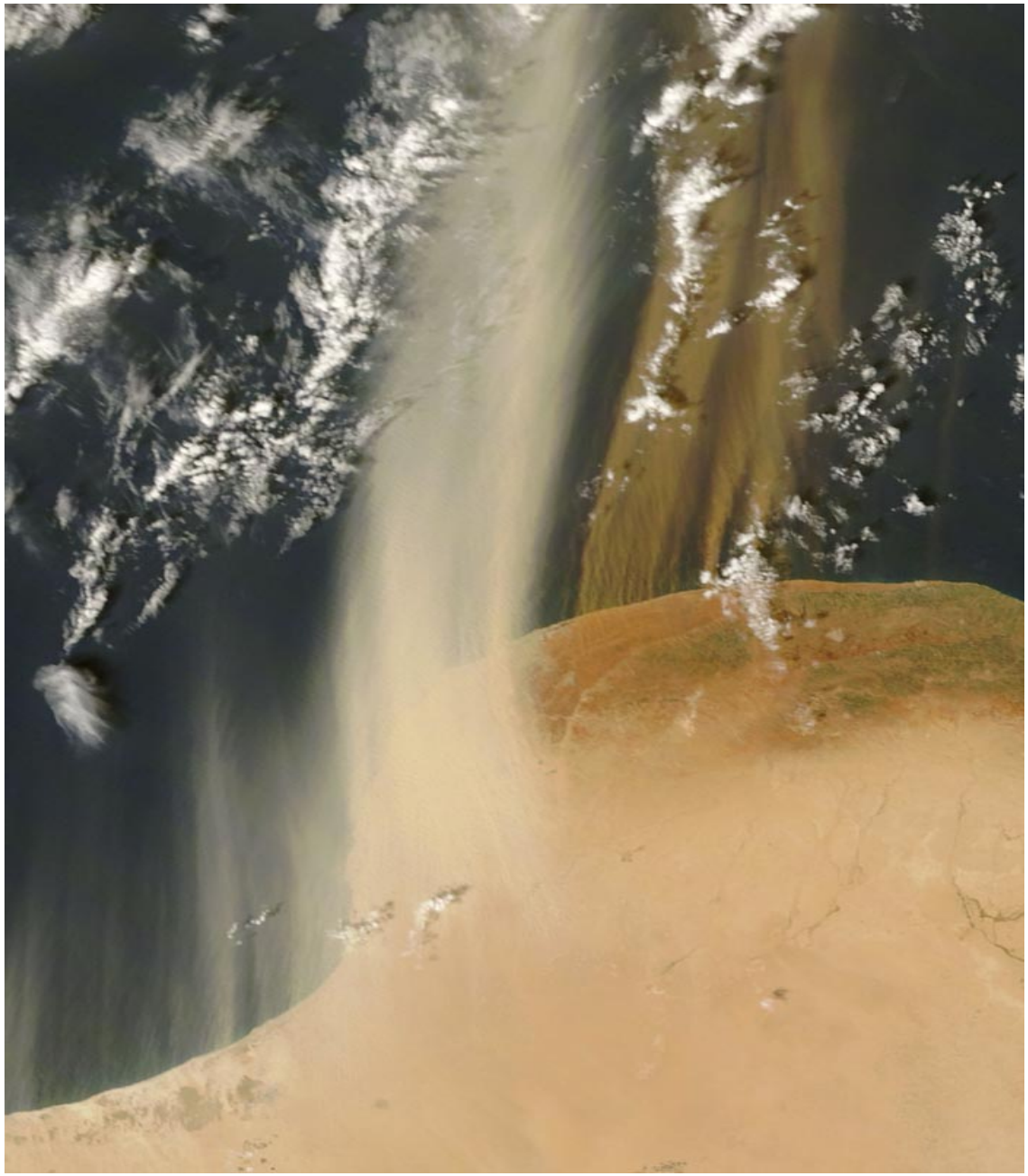
18 February 2008, Aqua

Geographic extent and transport of aerosols



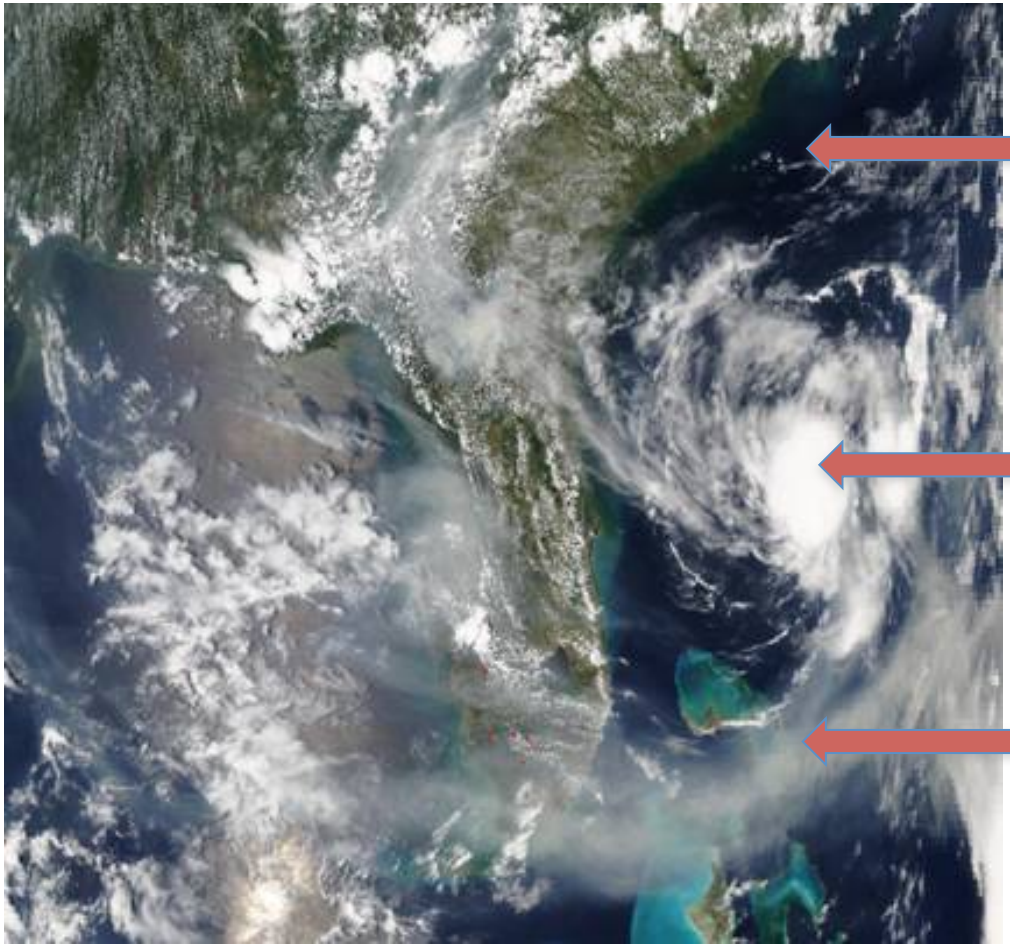
19 February 2008, Aqua

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.

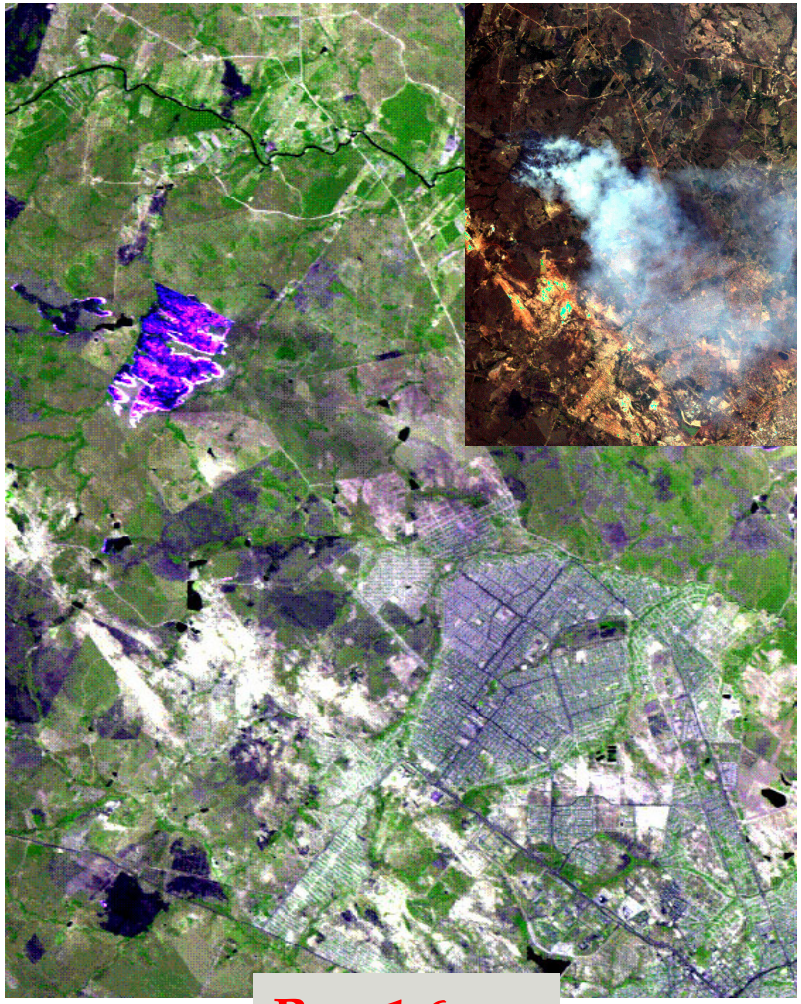
Clouds are white because most of the incoming energy is reflected

Pollution is hazy depending upon its absorptive properties

False Color Images

"False Color Image"

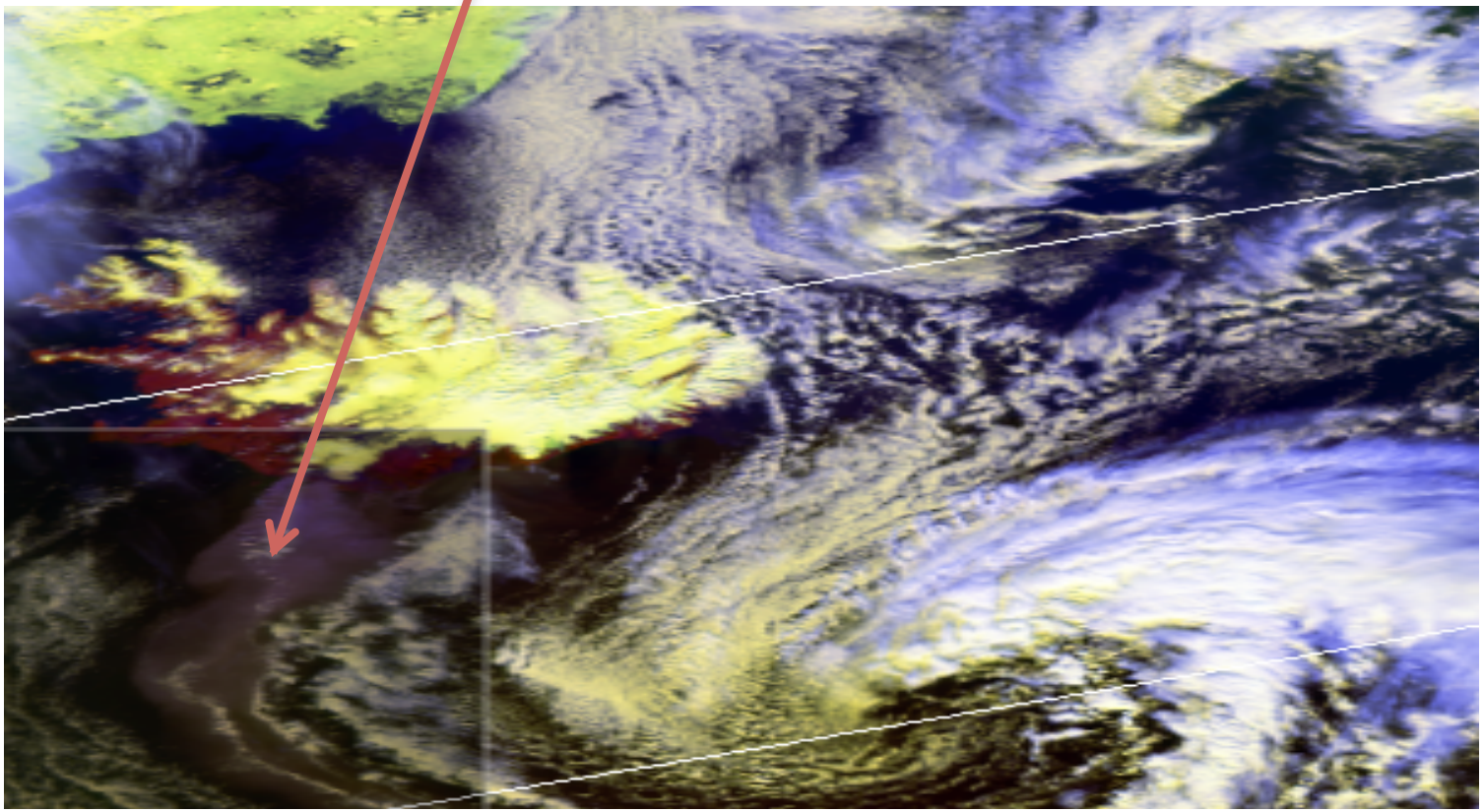
To enhance particular features we want to see in an image we load bands into the red, green and blue display channels which do not correspond to the visible red, green, and blue wavelengths.



R = 1.6 μm
G = 1.2 μm
B = 2.1 μm

Additional Display Enhancements

Volcanic Ash



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

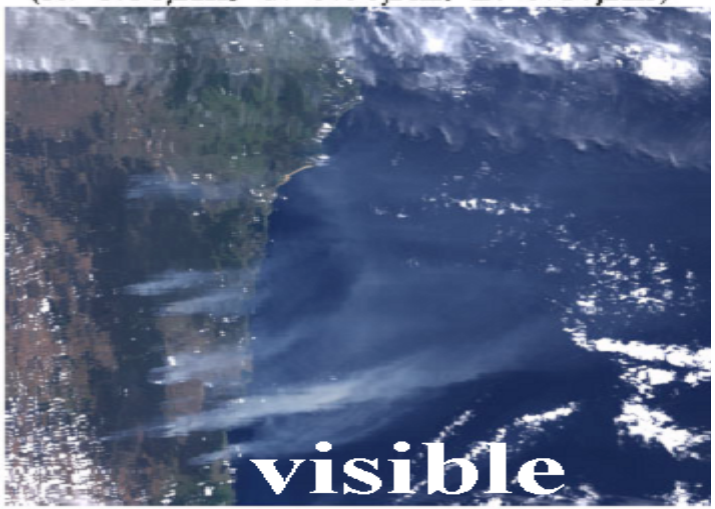
Using False Color Images to Identify aerosol types

Both dust and smoke interact with the shorter wavelengths reflecting light back to the sensor.

MODIS, Dust over Sahara,
(R: 0.66μm, G: 0.55μm, B: 0.47μm)

Dust

MODIS, Smoke over Austral
(R: 0.66μm, G: 0.55μm, B: 0.47μm)



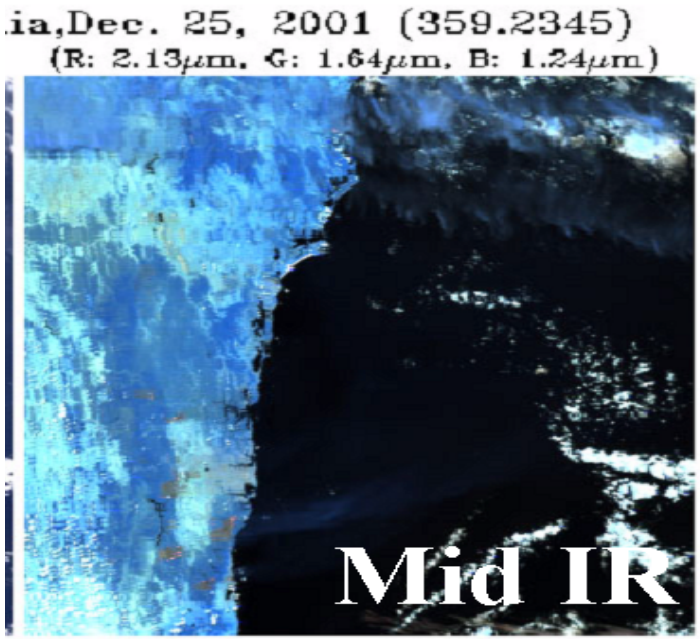
Smoke

from Y. Kaufman

Spectral optical properties of aerosol

Dust particles interact with the longer infrared wavelengths but not the smaller smoke particles which remain invisible.

Dust



Smoke

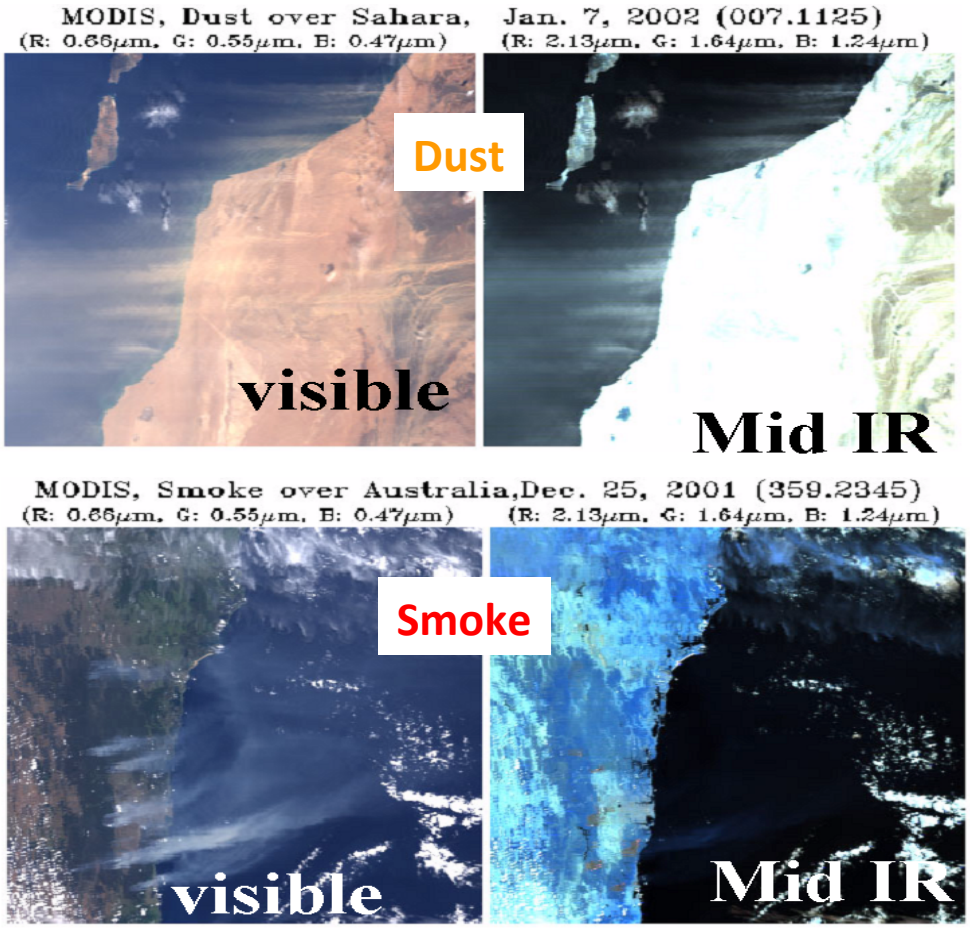
from Y. Kaufman

Spectral optical properties of aerosol

The distinction of aerosol types is made possible by:

1. The wide spectral range of the MODIS sensor.

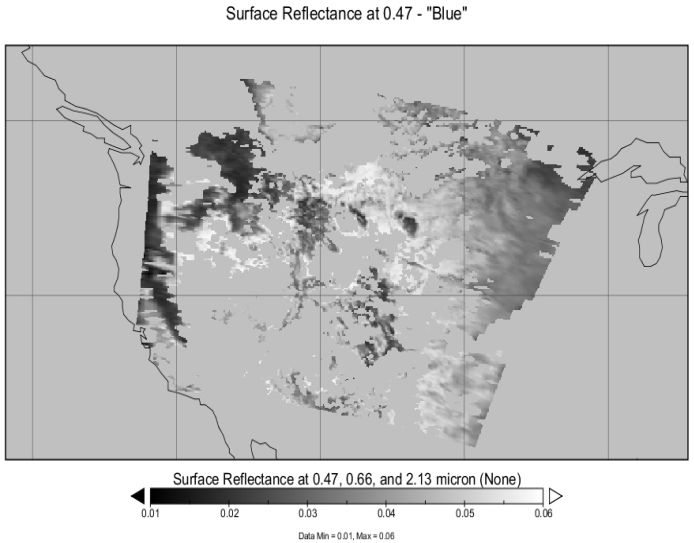
2. Understanding how light interacts with the particles, gases and surfaces it interacts with.



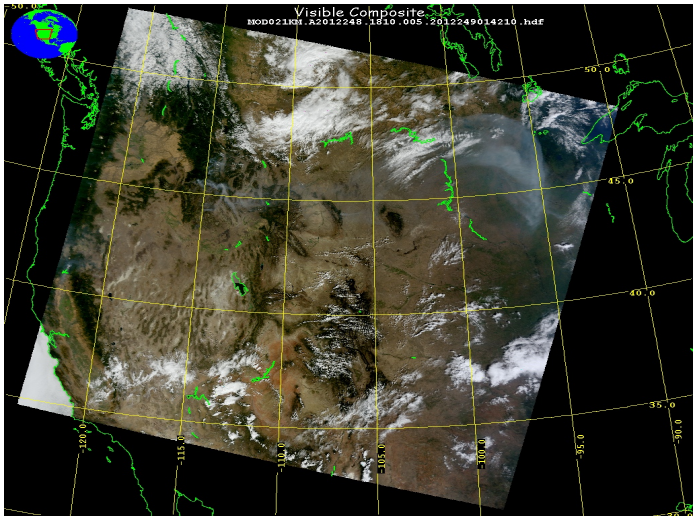
from Y. Kaufman

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.

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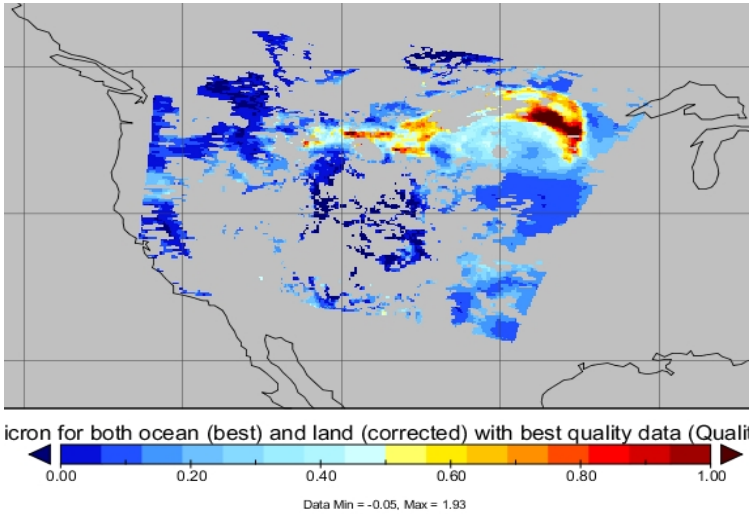
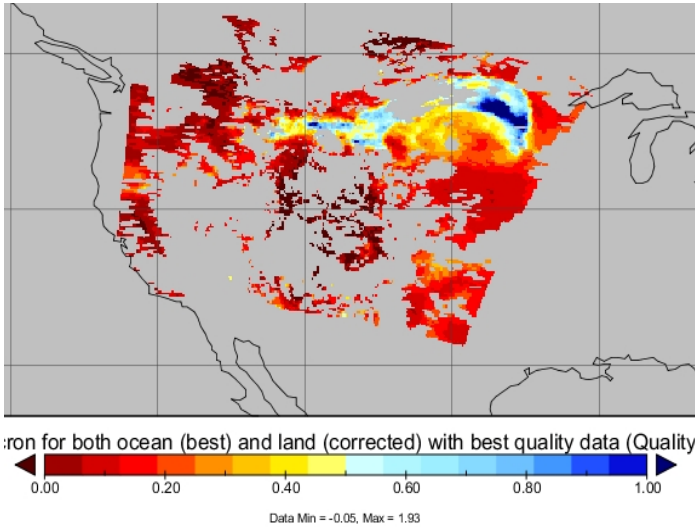
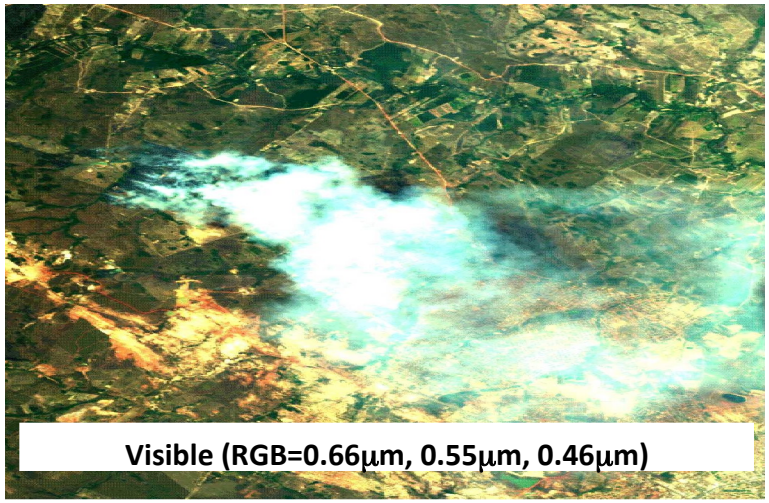


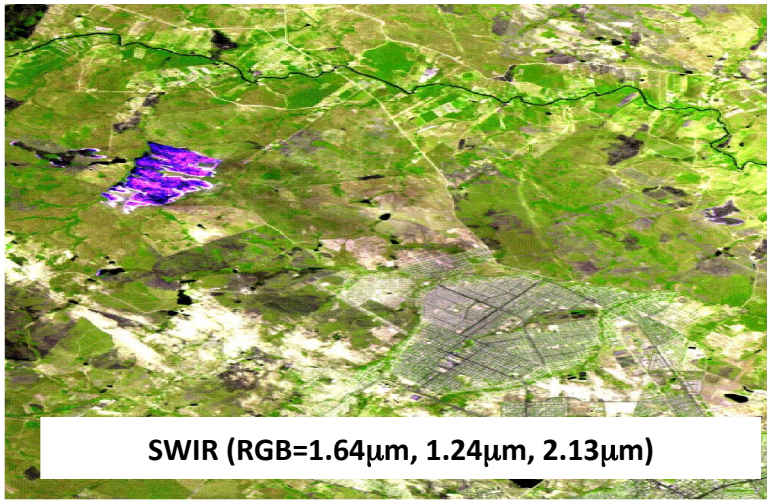


Spectral Images vs Color Maps

True Color Image

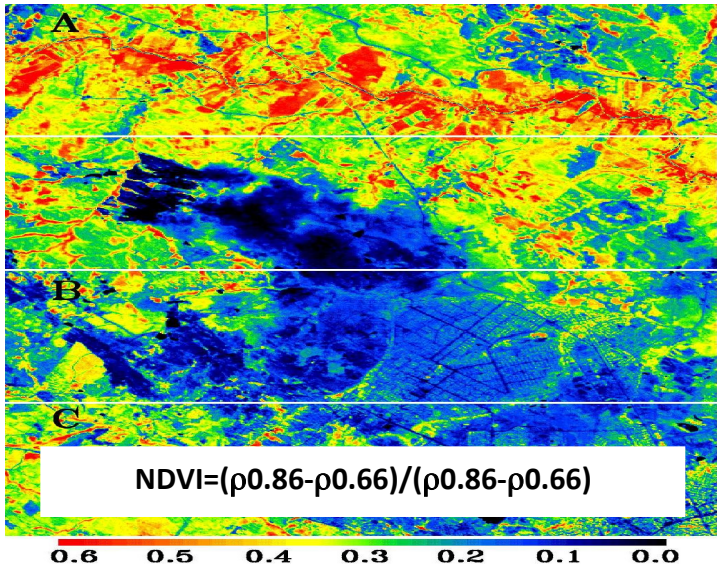


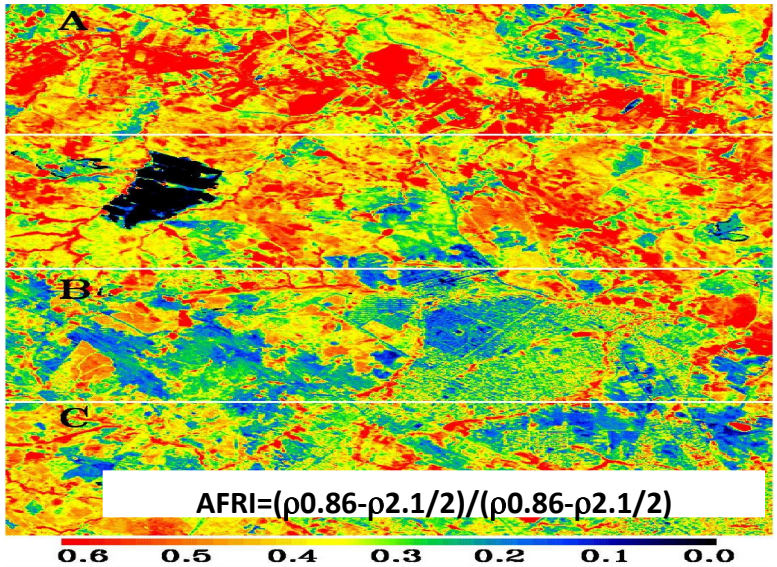
False Color Image



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.





MODIS Rapid Response Site

http://lance.nasa.gov/imagery/rapid-response

- 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

http://visibleearth.nasa.gov

- 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

http://earthobservatory.nasa.gov

- 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)

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

- 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.

A Brief Tour of Some Useful Image Archives

MODIS Rapid Response Site

http://earthdata.nasa.gov/data/near-real-time-data/rapid-response
http://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/realtime.cgi

MODIS-Atmos Site

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

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 Today

http://ge.ssec.wisc.edu/modis-today/

World View

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