Environmental Applications of Satellite Remote Sensing

*Eric Ariel L. Salas **
Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Las Cruces, New Mexico, 88003, USA

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Eric A.L. Salas

BSc in Civil Engineering
University of San Carlos, Philippines

MSc in Geo-Information
Wageningen University, The Netherlands

PhD in Geospatial Science and Engineering
South Dakota State University, USA

Postdoc Research Geoscientist
NMSU, FWCE

What is Remote Sensing?

"The science and art of obtaining information about an object, area, or phenomenon….

…through the analysis of data acquired by a device

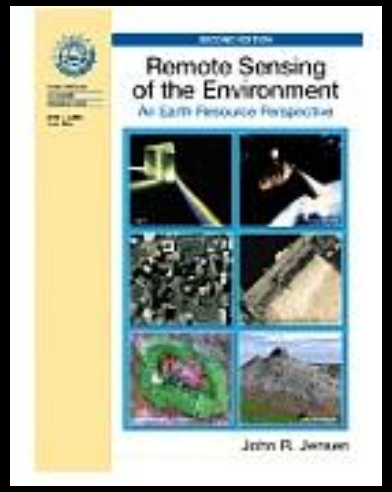
…that is not in contact with the object, area or phenomenon

Using this definition, what are some examples of remote sensing?

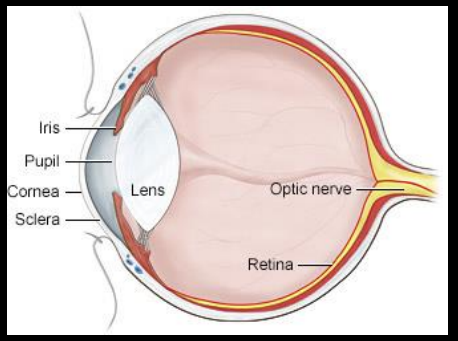
Remote Sensing in the Classroom

Energy Source

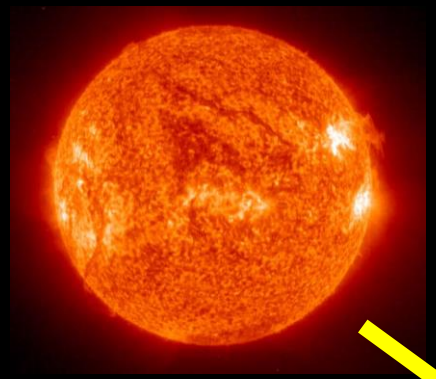
Object being remotely sensed (target)



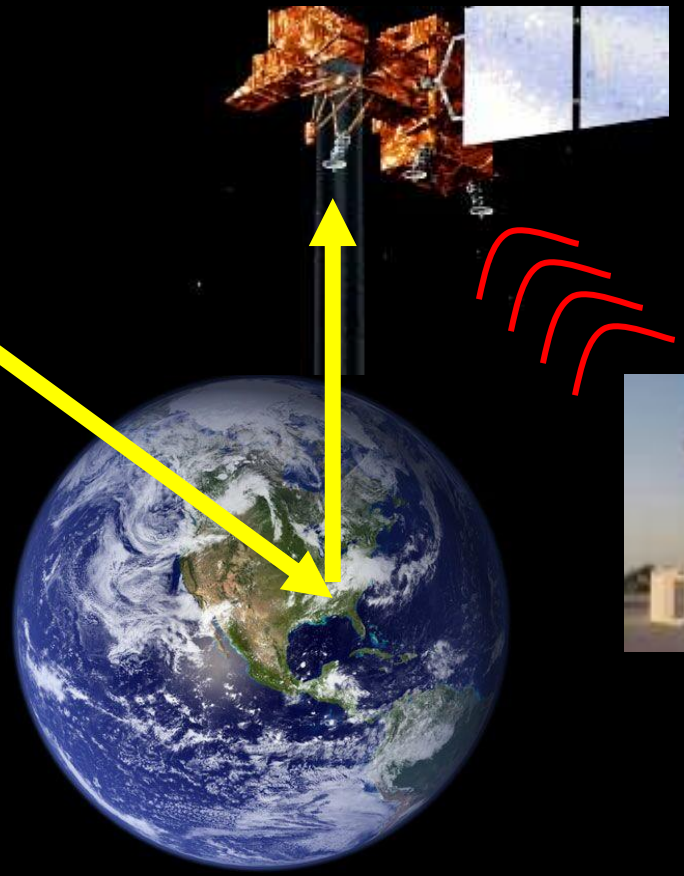
Remote Sensing Sensor

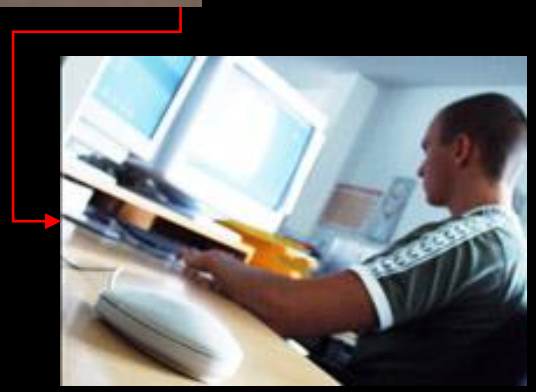


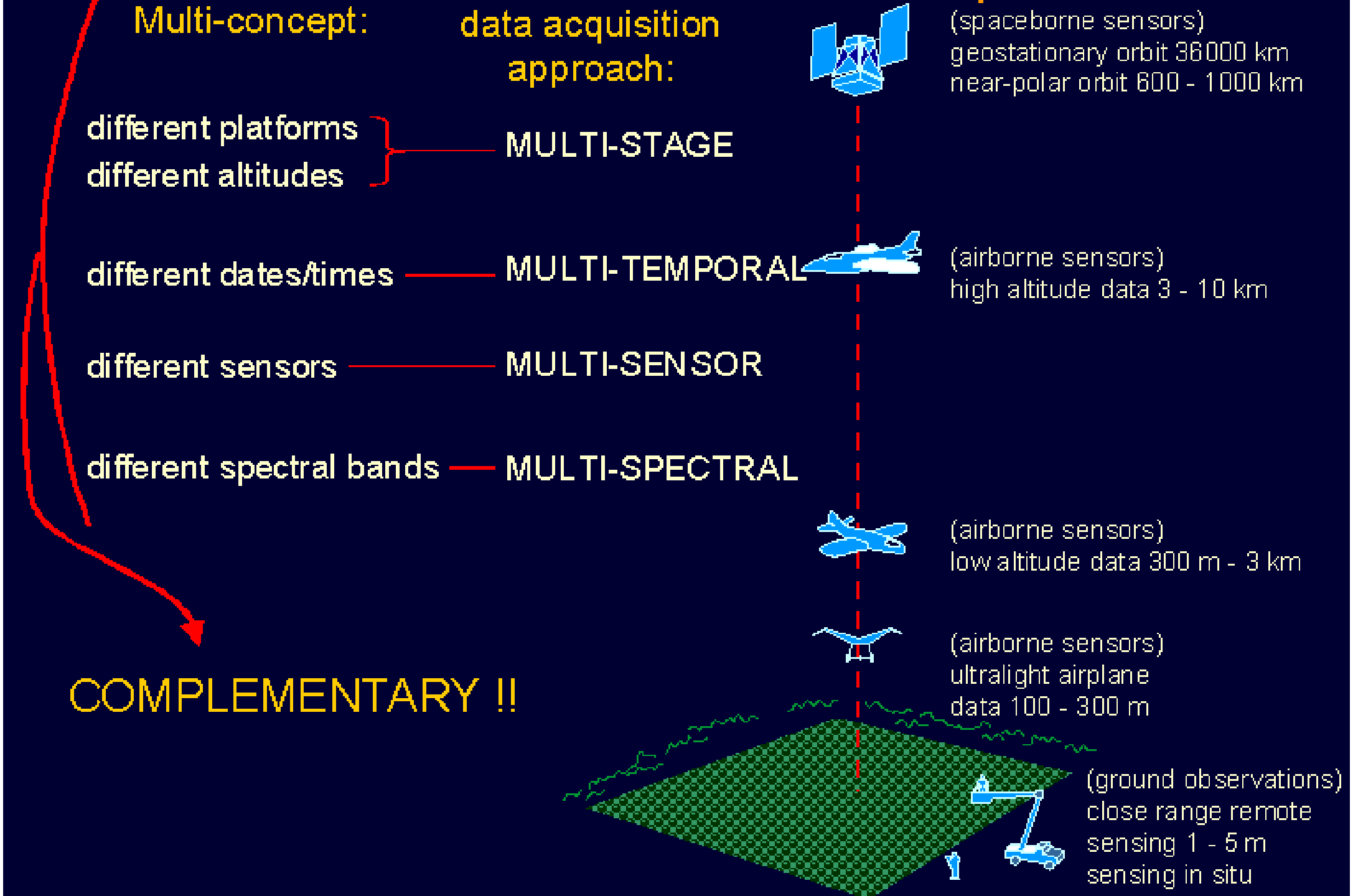
Example of a Traditional Remote Sensing System



EM Radiation





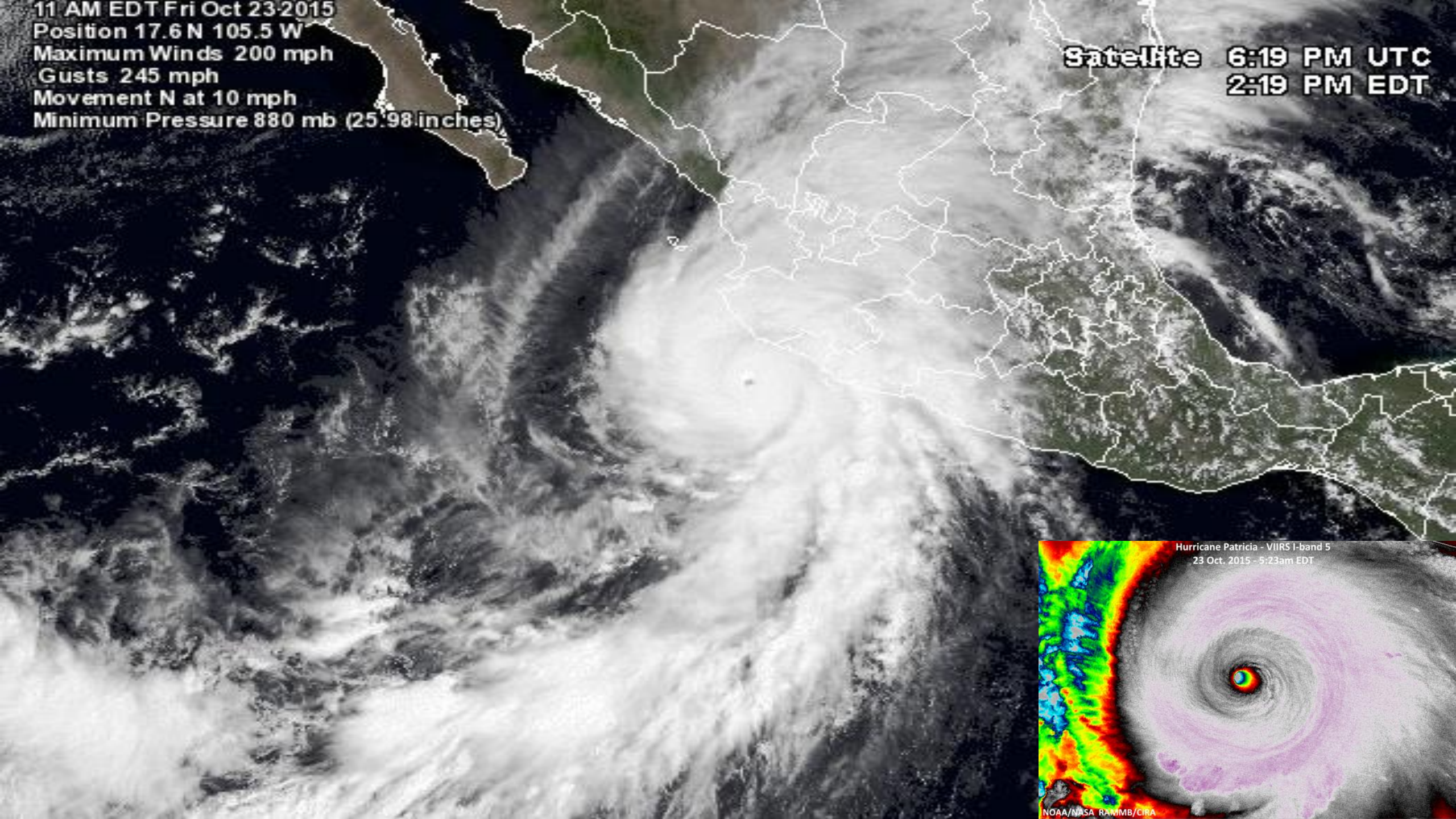


Credit: www.wur.nl

Remote Sensing Advantages

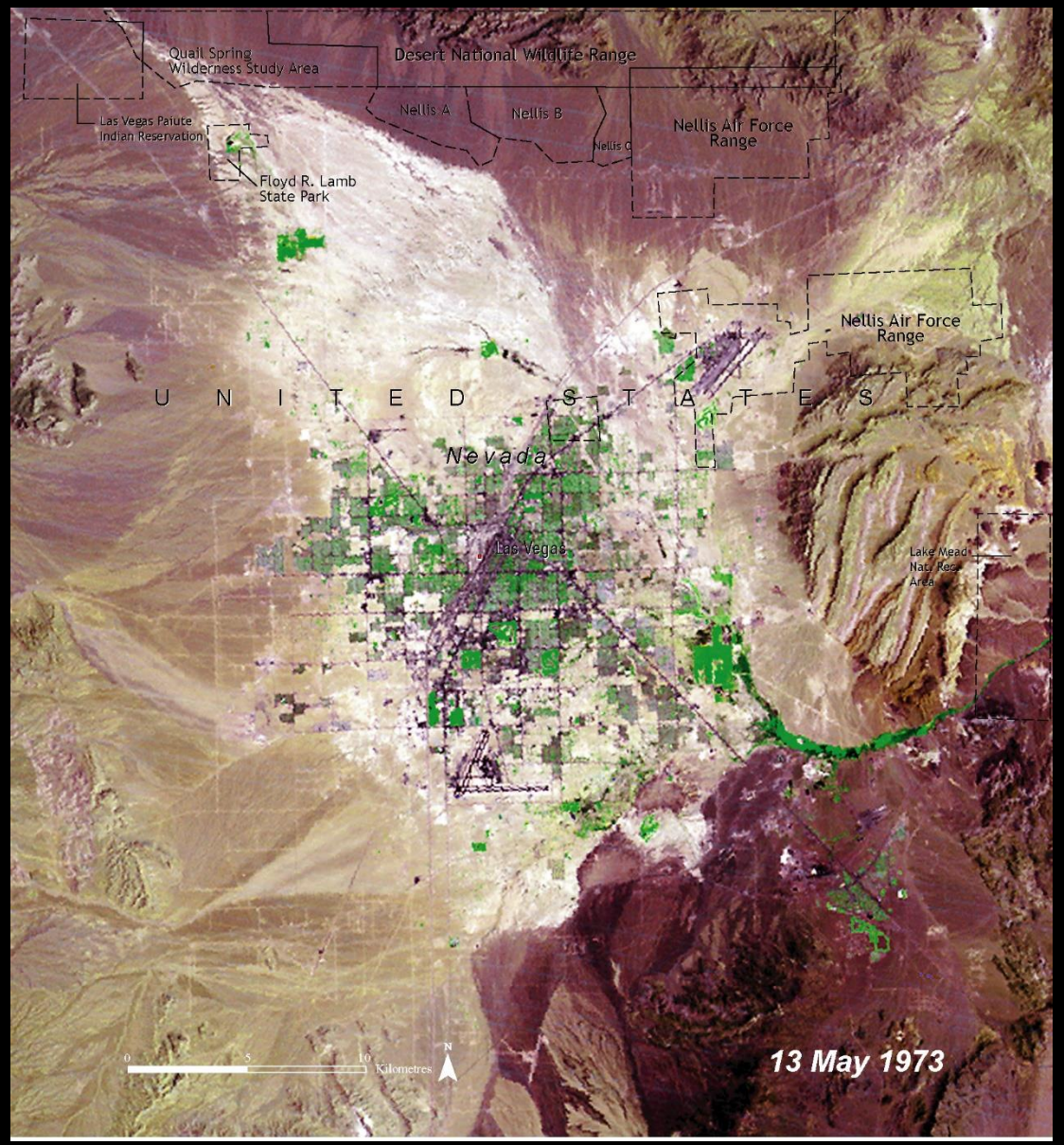
- Offers a synoptic perspective
- Uses a unique vantage point
- Employs extra-visual information
- Serves as a historical and permanent record
- Can be cost-effective

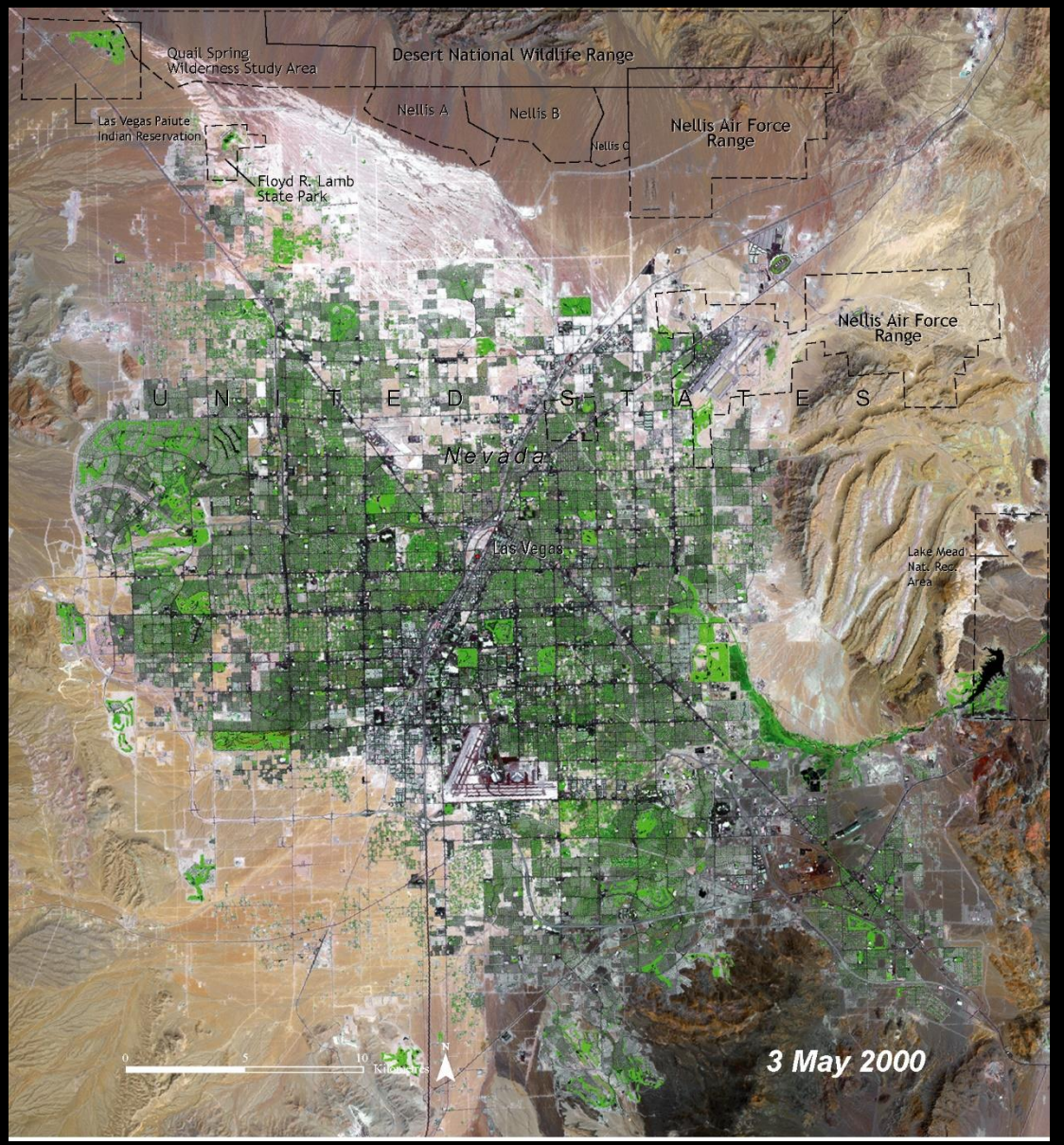
This area is in North Carolina. What can you tell me about it?

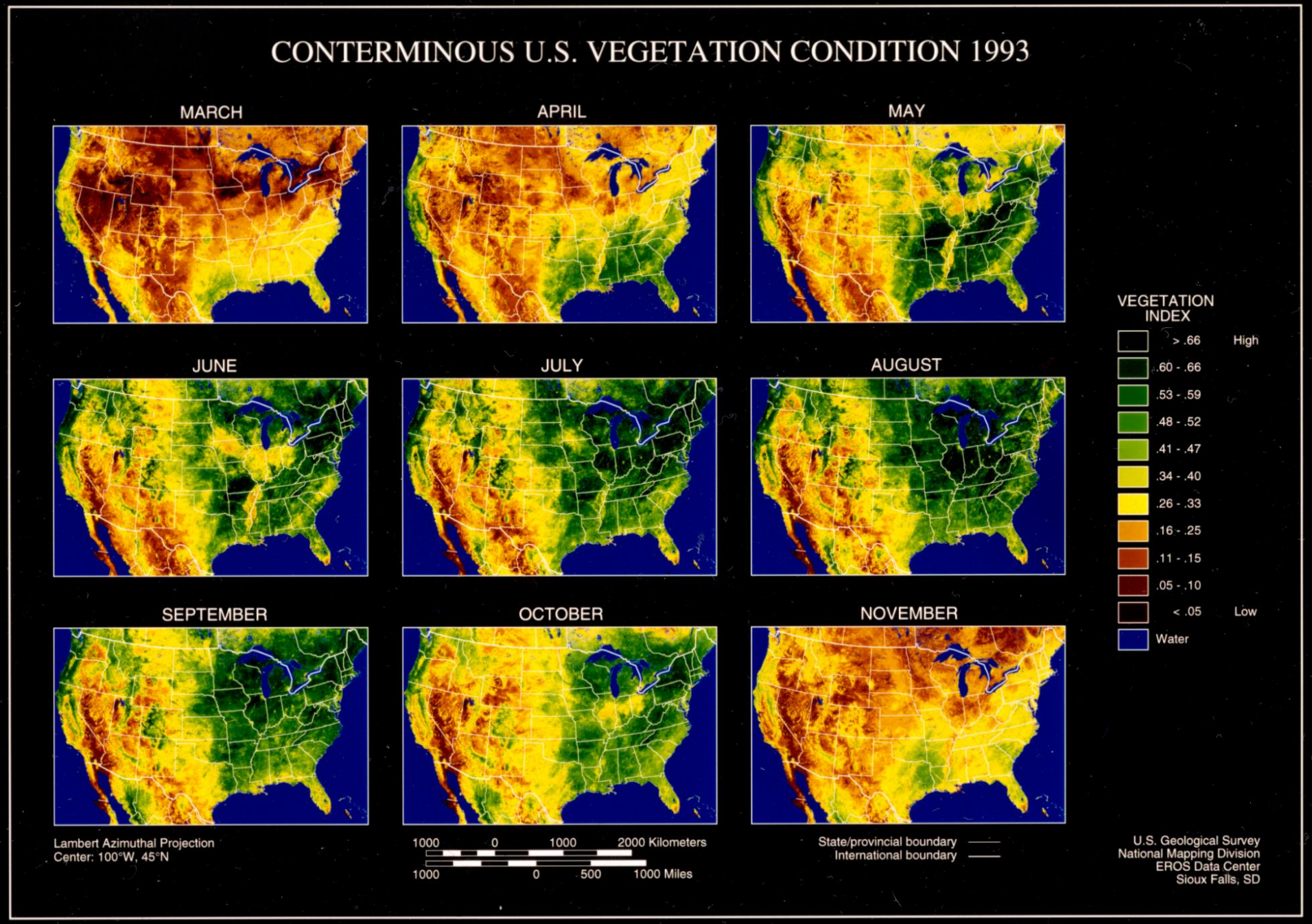

11 AM EDT Fri Oct 23 2015
Position 17.6 N 105.5 W
Maximum Winds 200 mph
Gusts 245 mph
Movement N at 10 mph
Minimum Pressure 880 mb (25.98 inches)
Satellite 6:19 PM UTC
2:19 PM EDT
Hurricane Patricia - VIIRS I-band 5
23 Oct. 2015 - 5:23am EDT
NOAA/NASA RAMMB/CIRA

Satellite data can provide broad perspectives. Based on this image mosaic, where is the most dense forest located in Africa?

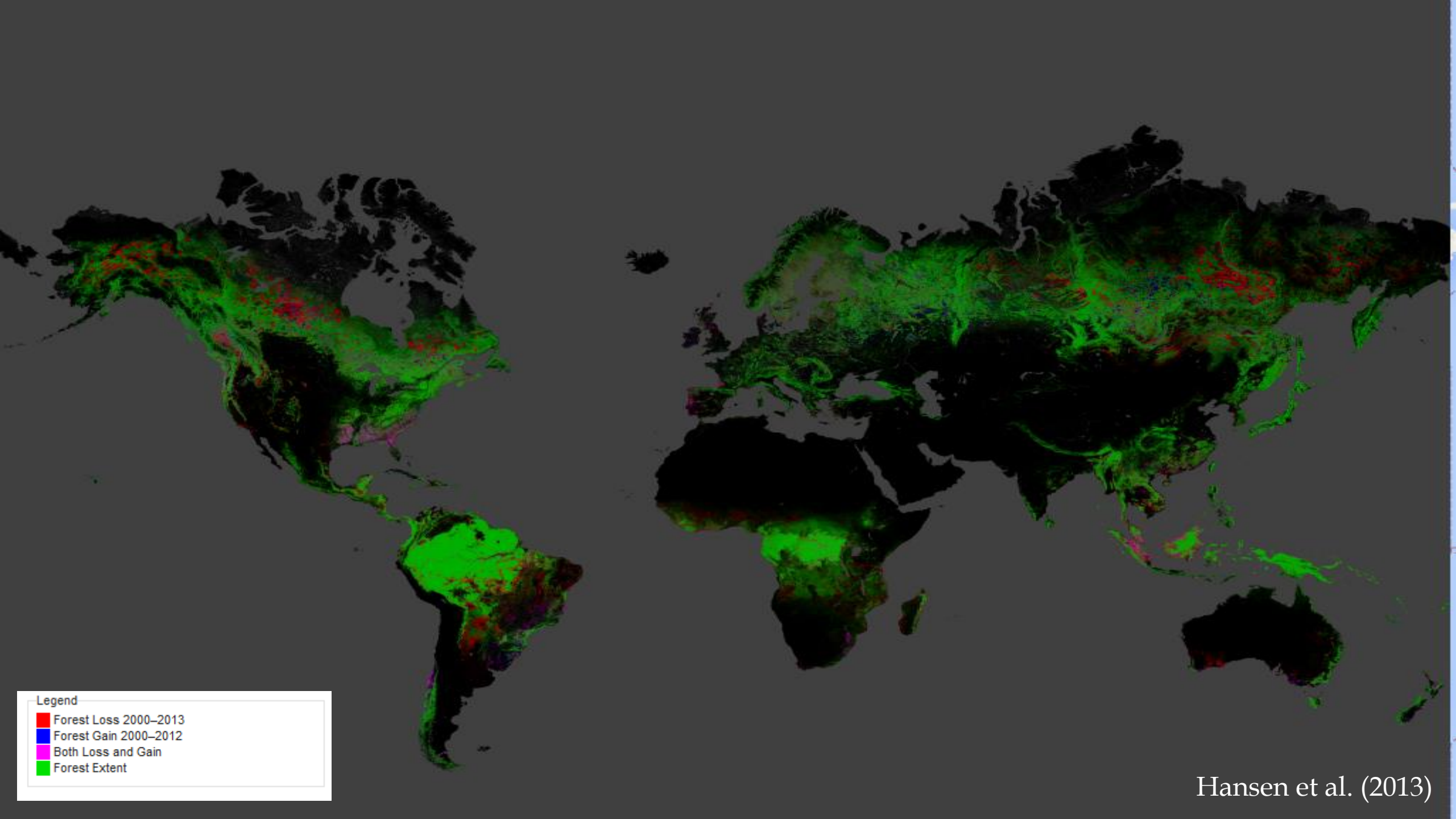
Detecting Changes Over Longer Time Periods





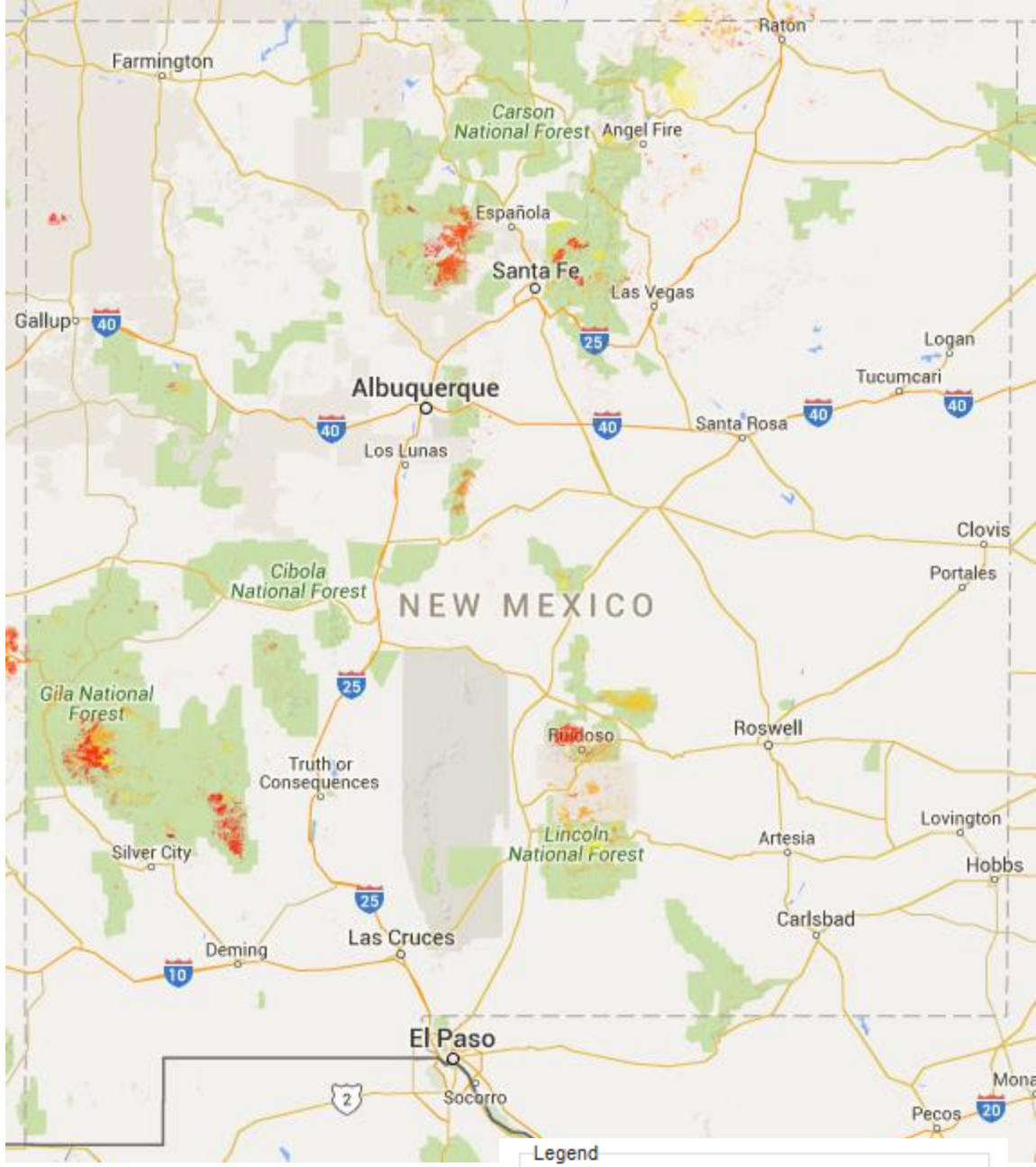

CONTERMINOUS U.S. VEGETATION CONDITION 1993
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
VEGETATION INDEX
> .66 High
.60 - .66
.53 - .59
.48 - .52
.41 - .47
.34 - .40
.26 - .33
.16 - .25
.11 - .15
.05 - .10
< .05 Low
Water
Lambert Azimuthal Projection
Center: 100°W, 45°N
1000 0 1000 2000 Kilometers
1000 0 500 1000 Miles
State/provincial boundary
International boundary
U.S. Geological Survey
National Mapping Division
EROS Data Center
Sioux Falls, SD

Credit: USGS



Hansen et al. (2013)

Percent Tree Cover 2000



Forest Loss

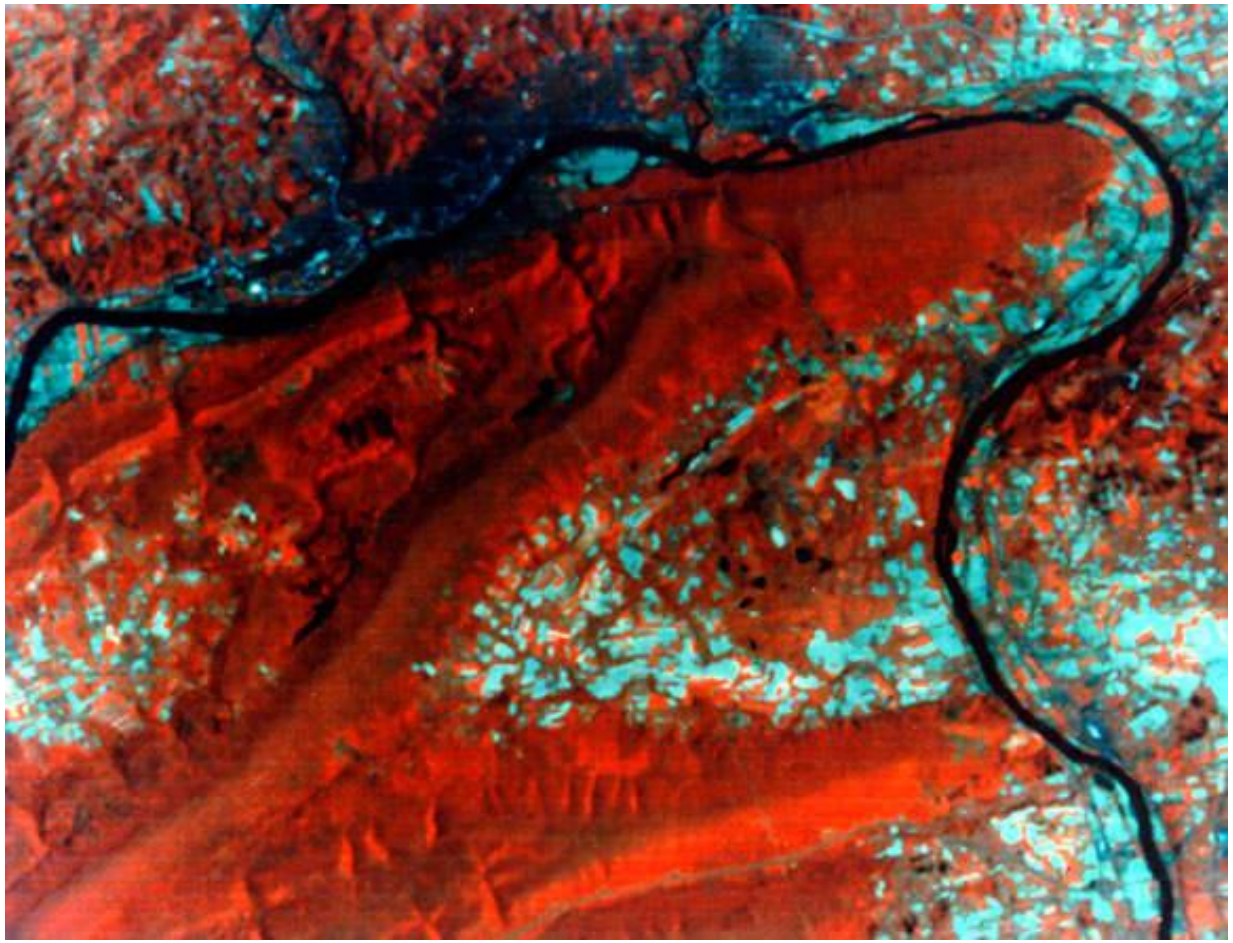
Patagonia Glacier, Argentina

Upper photo taken by Space Shuttle astronaut in 1994; lower photo taken by ISS astronaut in 2002

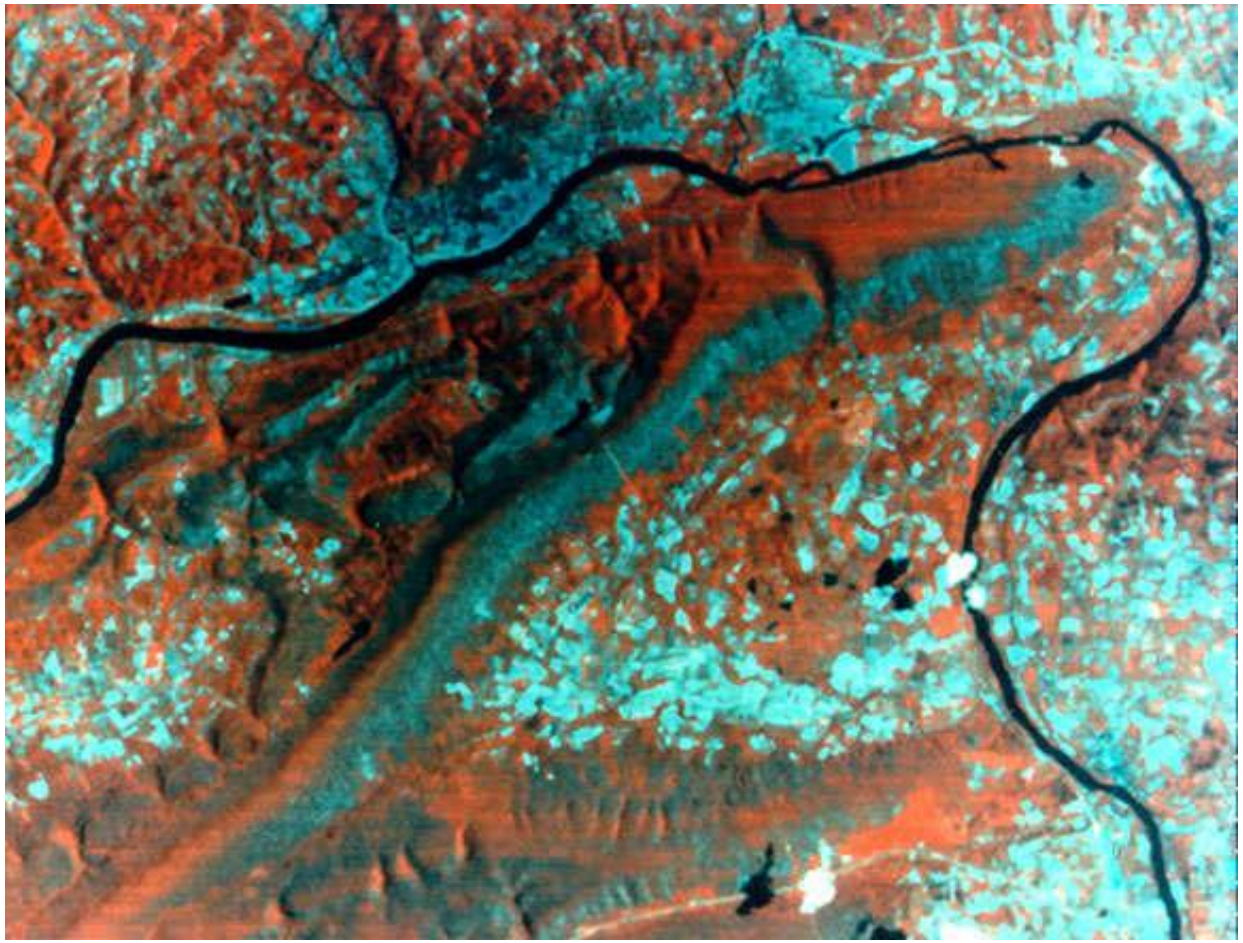
Disaster Monitoring

LANDSAT is continuously used for monitoring consequences of natural disasters.

Banda Aceh, on the island of Sumatra, before and after the devastating tsunami in 2004 that killed approximately 167,000 people.



May 1977



July 1977

Infestation of gypsy moths on forested regions in Pennsylvania.

Credit: Goddard Space Flight Center

What do we study with remote sensing?

- Mapping the extent and condition of resources
  - Cropland
  - Forests
  - Habitat
  - Urban growth
- Monitoring emergency events
  - Fire
  - Storms
  - Floods
- Explore for minerals
- Measure the extent of global environmental change
- Water resources

What do we measure with remote sensing?

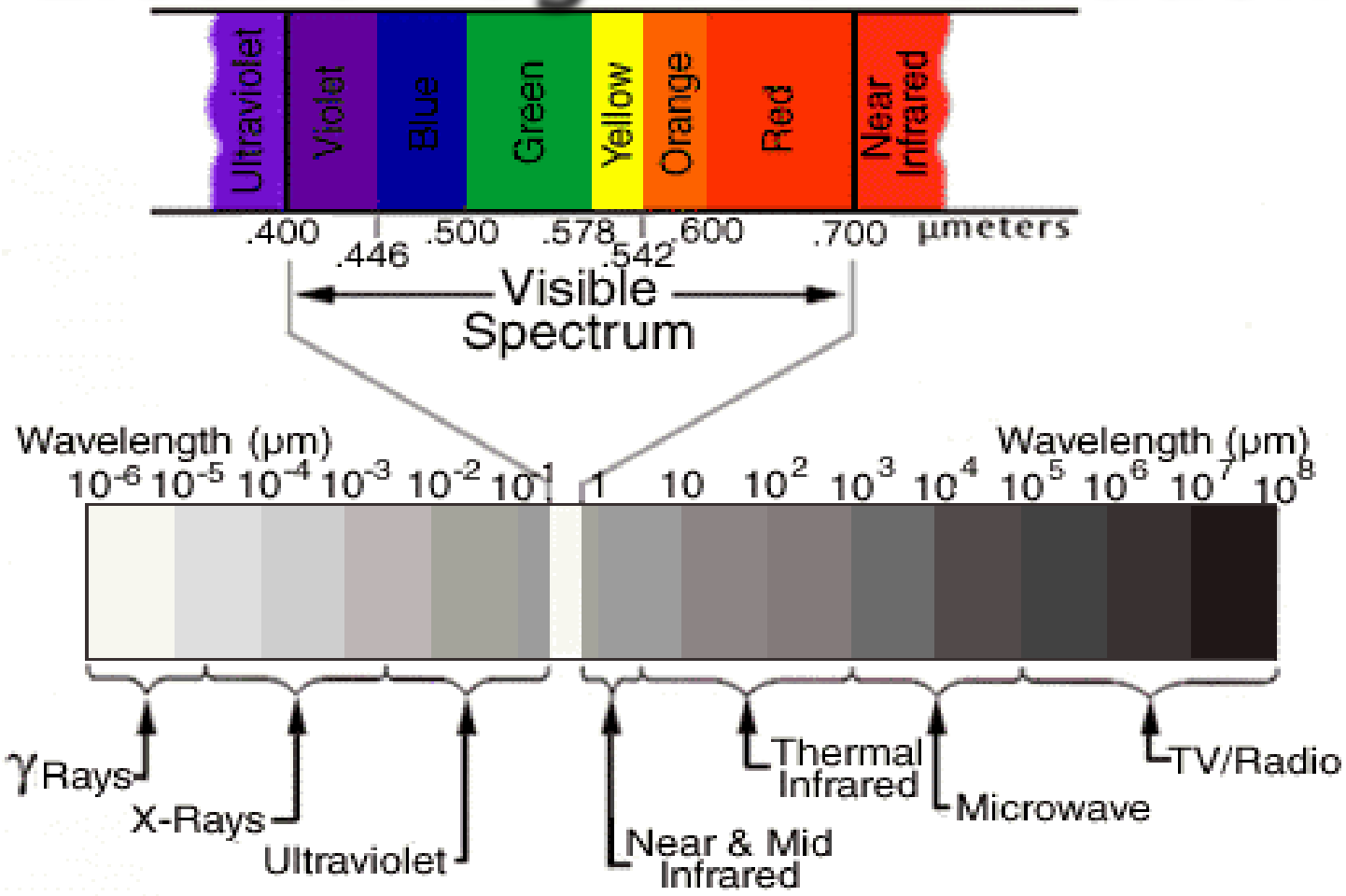
- Geographic location
- Topography and bathymetry
- Vegetation properties
  - Chlorophyll concentration
  - Biomass
  - Leaf area
  - Water
  - Absorbed photosynthetically active radiation

What do we measure with remote sensing?

- Water resources
  - Snow pack extent
  - Pollution and sedimentation
  - Surface water area, volume
- Surface temperature
- Soil moisture
- Surface roughness
- Evapotranspiration
- Land use and land cover
- And many others…

Can point-and-shoot cameras do the same job as remote sensing images?

Electromagnetic Radiation



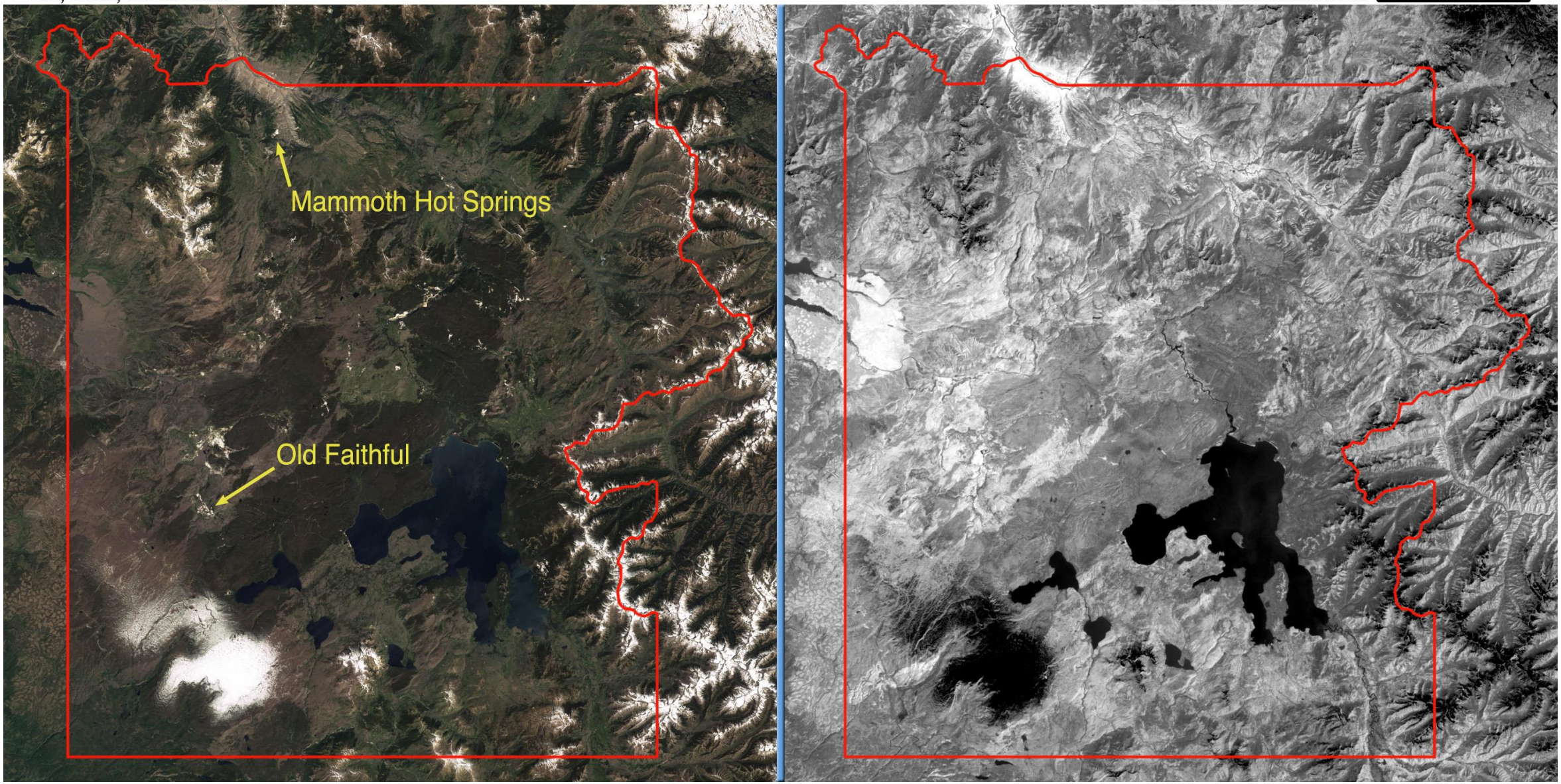
Stronger ⟷ Weaker

Yellowstone National Park – July 13, 1999

Landsat natural-color image –
Red, Green, and Blue bands

Landsat thermal image –
Heat emitted from land surface

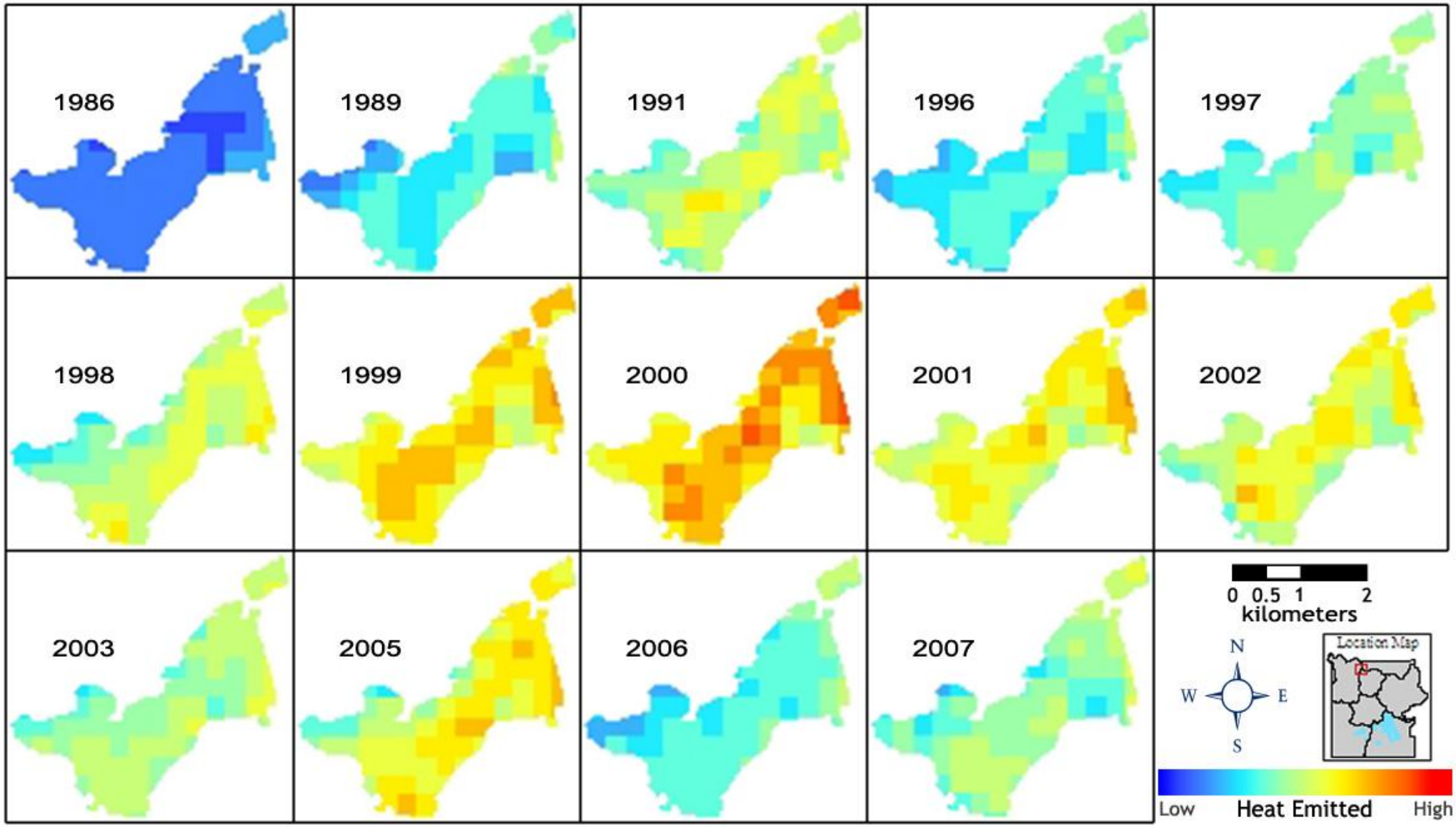
Low High



http://www.nasa.gov/topics/earth/features/yellowstone-heat.html

Mammoth Hot Springs Terraces at Yellowstone National Park

Satellite Measurements of Heat Emitted



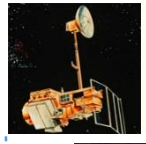
http://www.nasa.gov/topics/earth/features/yellowstone-heat.html

Landsat Generation

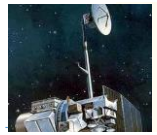
Landsat 1 — 1972 to 1978

Landsat 2 — 1975 to 1982

Landsat 3 — 1978 to 1983



Landsat 4 — 1982 to 1993



Landsat 5 — 1984 to June 2013

Landsat 6

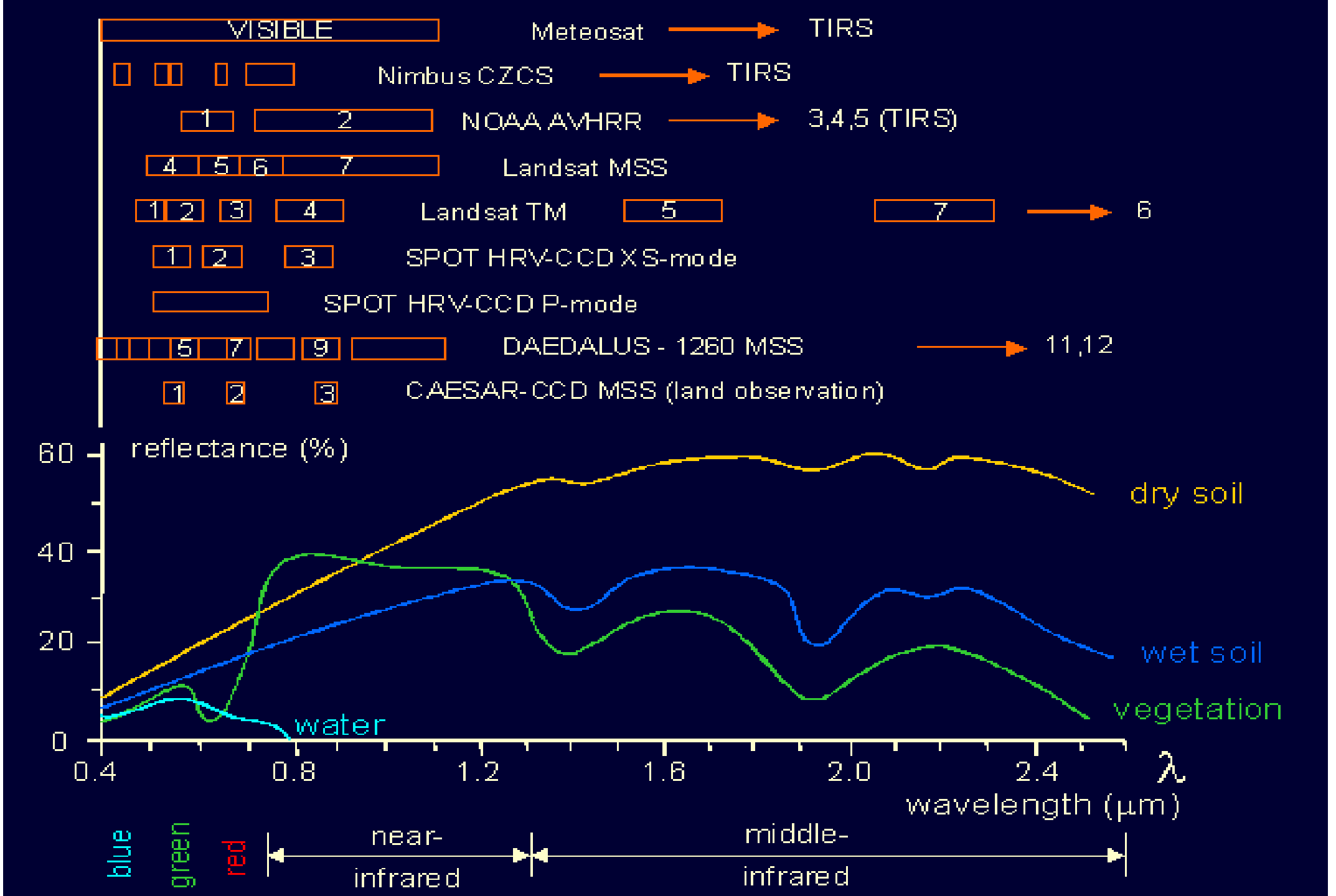
Landsat 7 — 1999 to Present

Landsat 8 — 2013 to Present

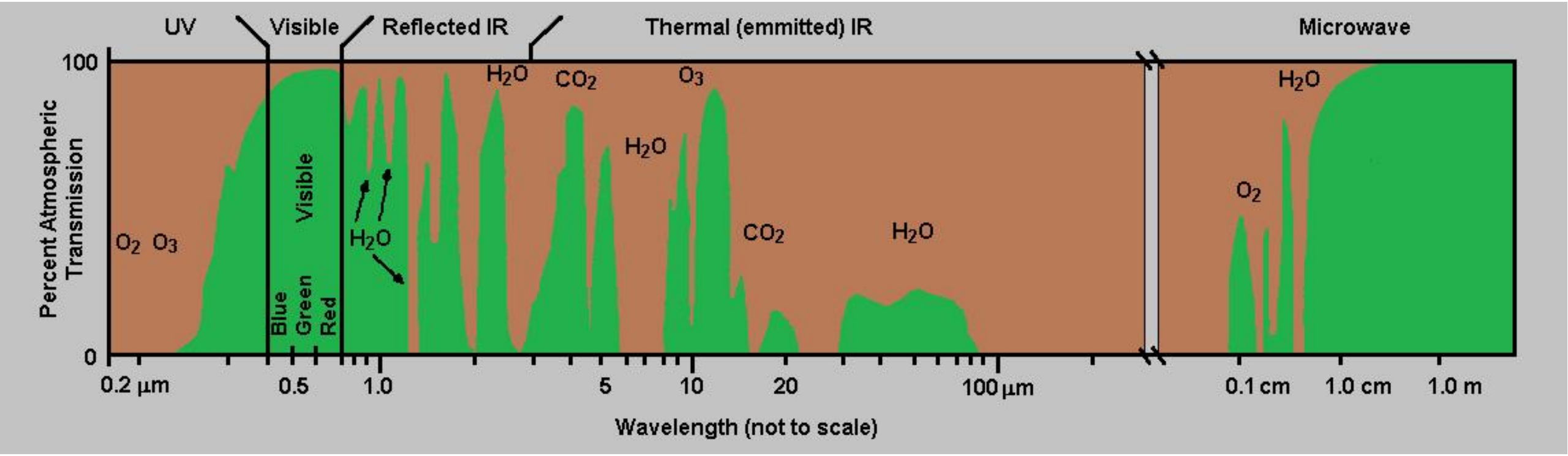
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

Landsat and MODIS Bands

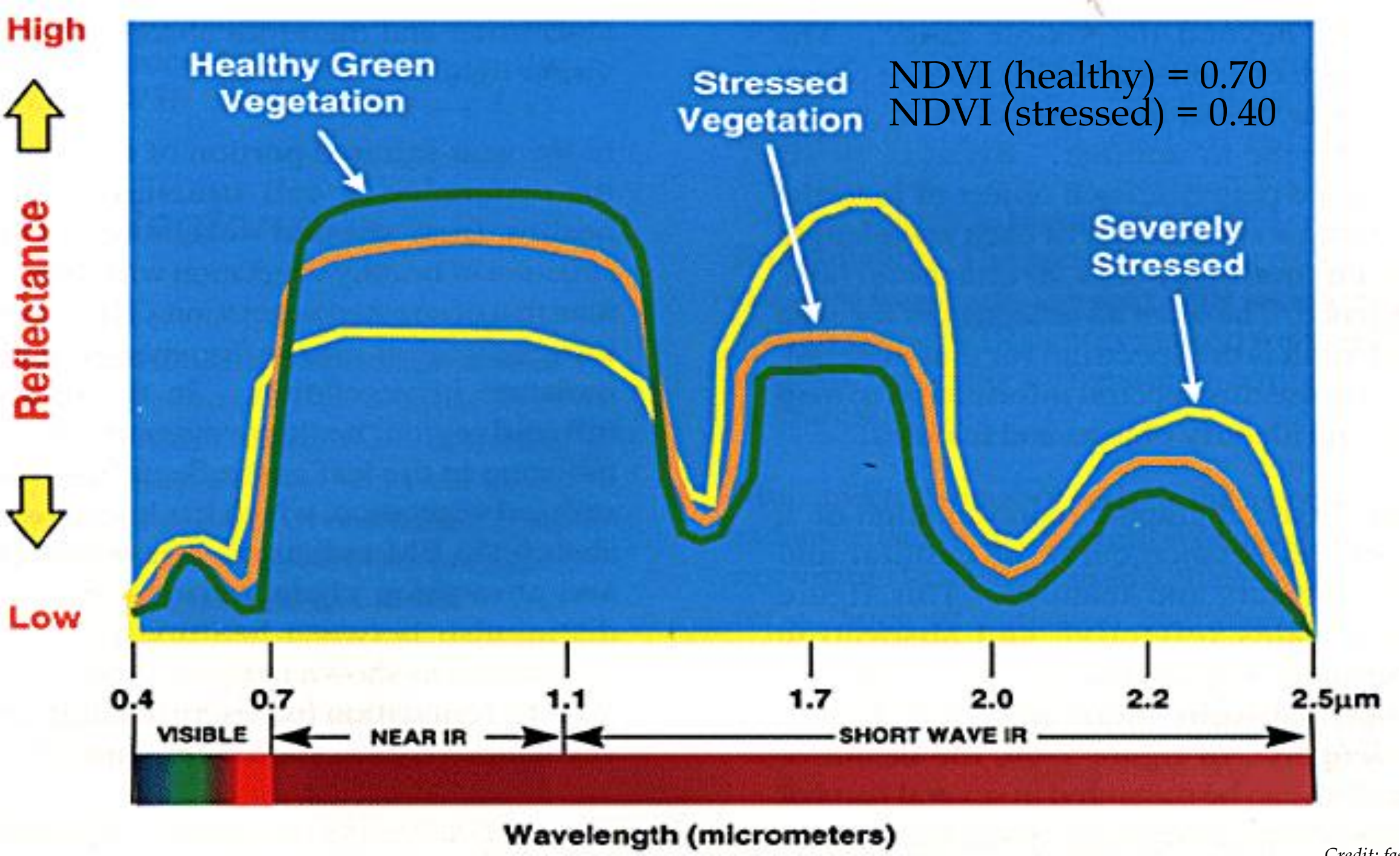
Landsat TM, ETM+ (30m)			MODIS 500m		
Band	Wavelength (μm)	Descrip.	Band	Wavelength (μm)	Descrip.
1	0.45 - 0.52	Blue	1	0.62-0.67	Red
2	0.52 - 0.60	Green	2	0.841-0.876	Near IR
3	0.63 - 0.69	Red	3	0.459-0.479	Blue
4	0.76 - 0.90	Near IR	4	0.545-0.565	Green
5	1.55 - 1.75	Mid IR	5	1.230-1.250	Mid IR
6	10.40 - 12.50	Thermal	6	1.628-1.652	Mid IR
7	2.08 - 2.35	Mid IR	7	2.105-2.155.	Mid IR


VISIBLE
Meteosat
TIRS
Nimbus CZCS
TIRS
1
2
NOAA AVHRR
3,4,5 (TIRS)
4
5
6
7
Landsat MSS
1
2
3
4
Landsat TM
5
7
6
1
2
3
SPOT HRV-CCD XS-mode
SPOT HRV-CCD P-mode
5
7
9
DAEDALUS - 1260 MSS
11,12
1
2
3
CAESAR-CCD MSS (land observation)
reflectance (%)
60
40
20
0
dry soil
wet soil
vegetation
water
0.4
0.8
1.2
1.6
2.0
2.4
λ
wavelength (µm)
blue
green
red
near-
infrared
middle-
infrared

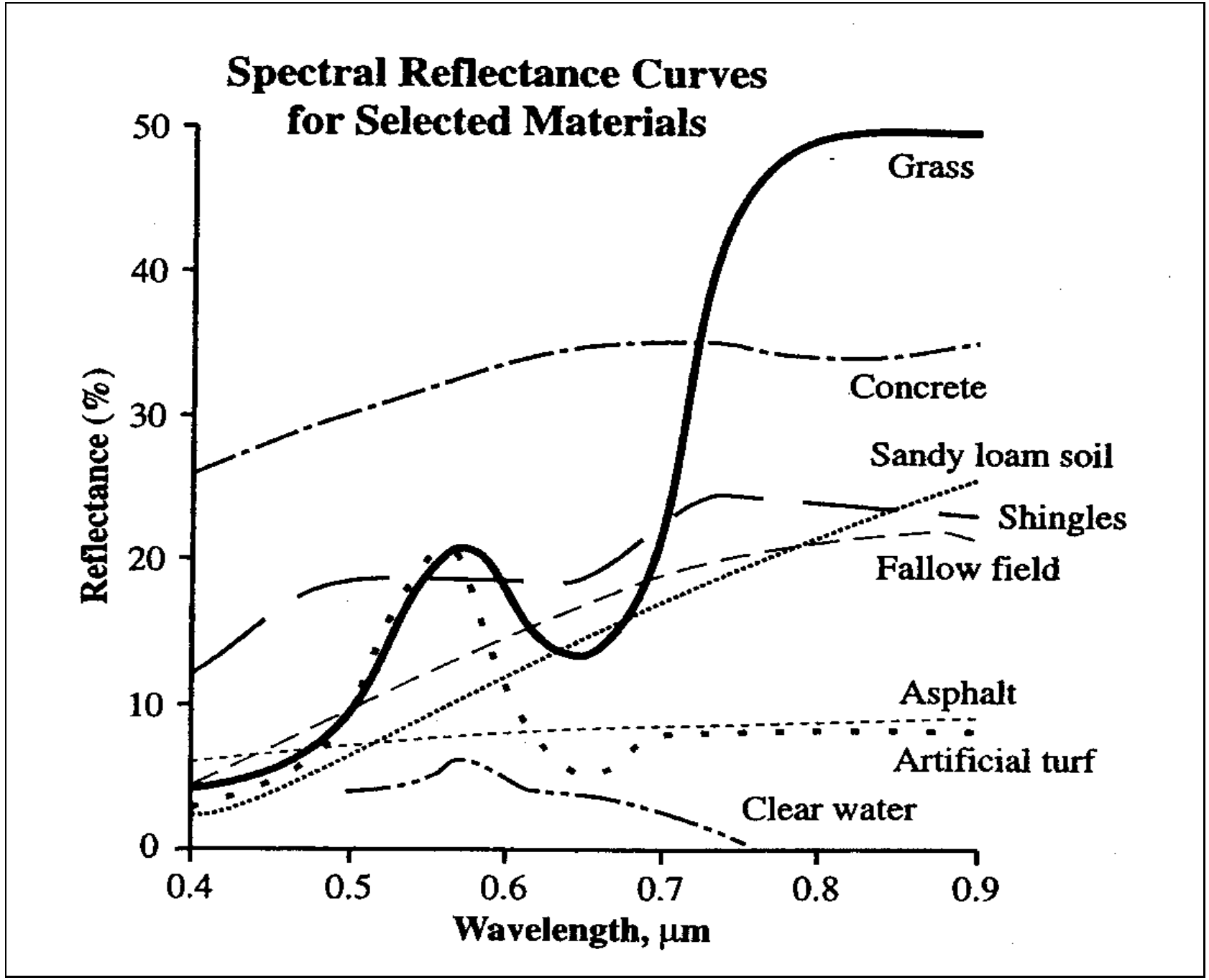
Atmospheric Window

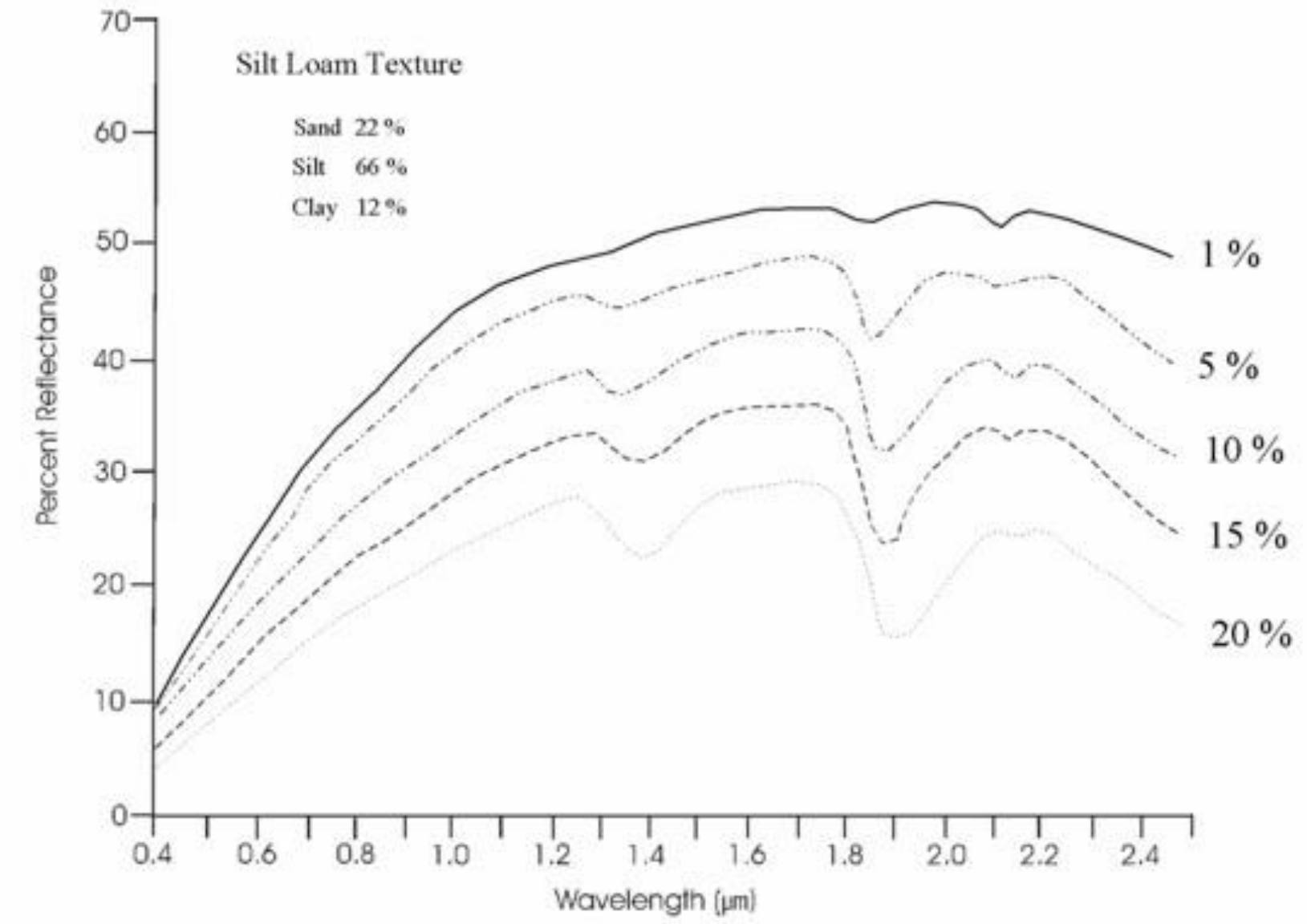


Credit: www.oneonta.edu

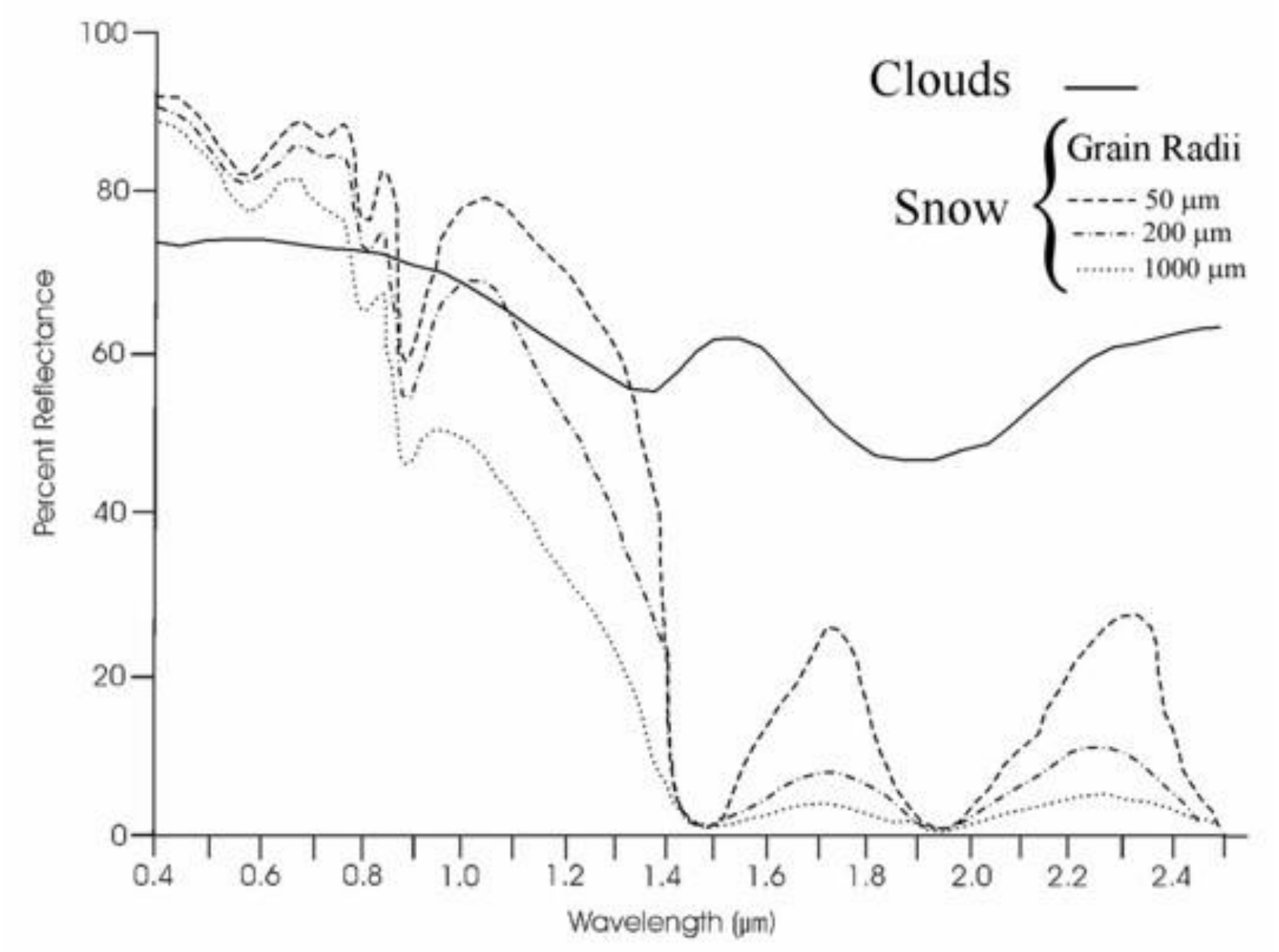


Credit: fas.org

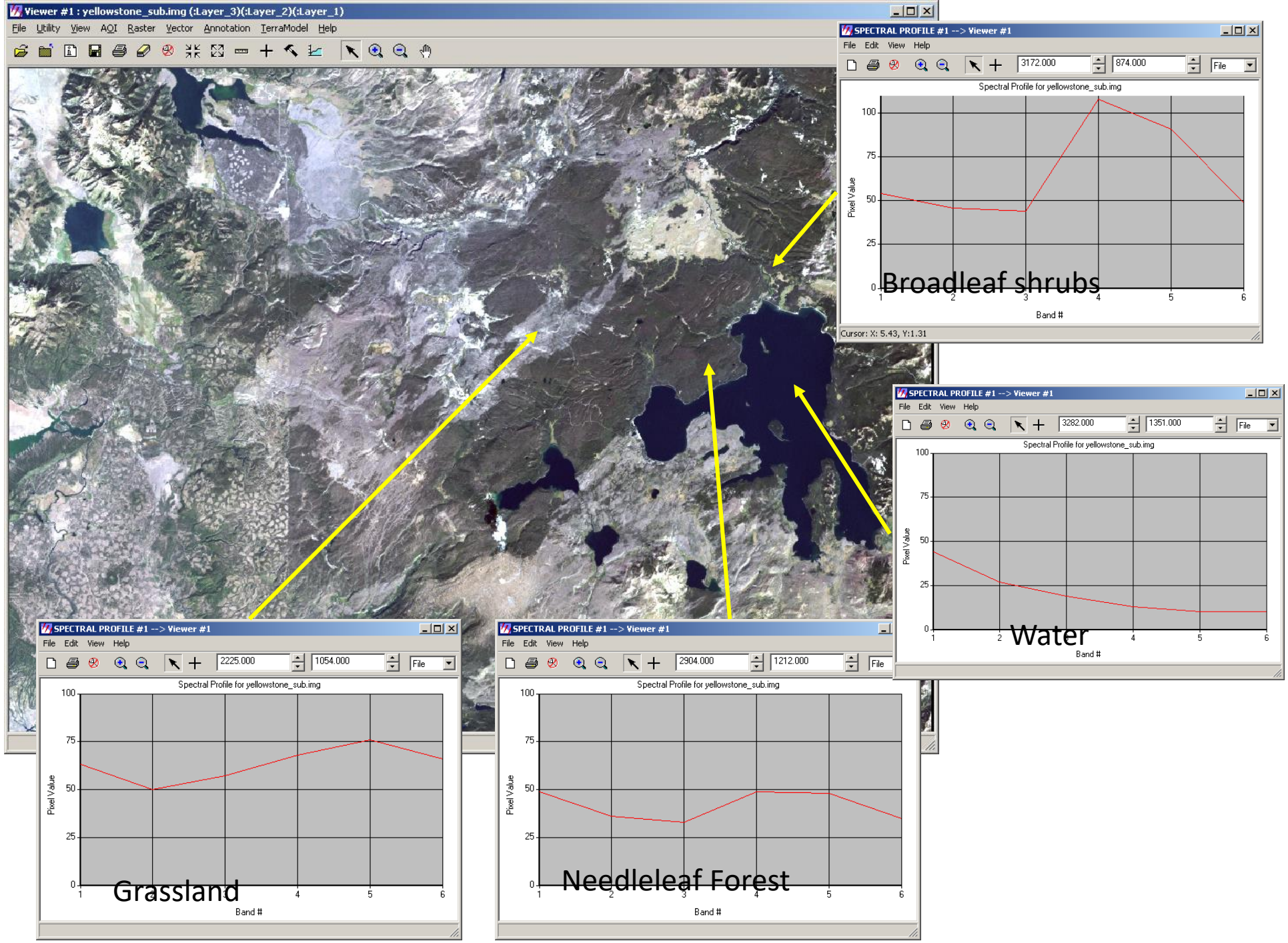

Spectral Reflectance Curves
for Selected Materials
Reflectance (%)
50
40
30
20
10
0
0.4
0.5
0.6
0.7
0.8
0.9
Wavelength, μm
Grass
Concrete
Sandy loam soil
Shingles
Fallow field
Asphalt
Artificial turf
Clear water



Soil reflectance and percent moisture.



Snow, ice, and clouds…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File Utility View AOI Raster Vector Annotation TerraModel Help
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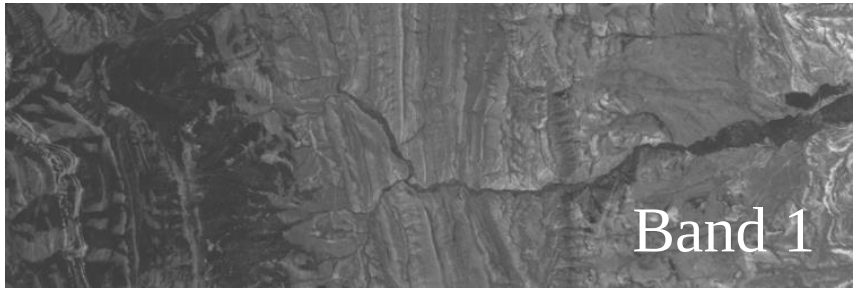
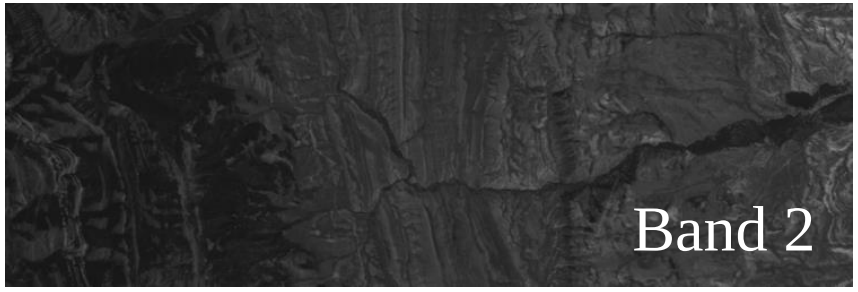
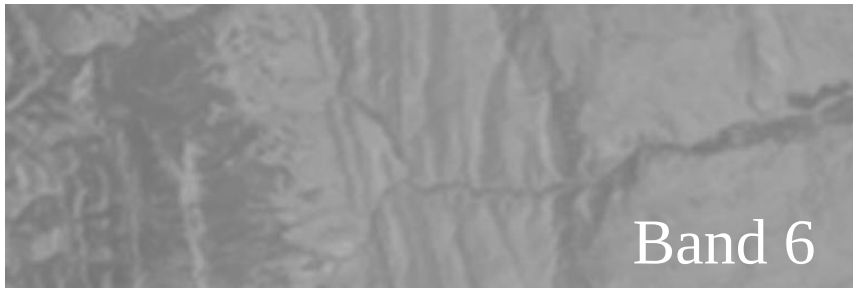
3172.000
874.000
Spectral Profile for yellowstone_sub.img
Pixel Value
Band #
Broadleaf shrubs
Cursor: X: 5.43, Y:1.31
SPECTRAL PROFILE #1 --> Viewer #1
3282.000
1351.000
Spectral Profile for yellowstone_sub.img
Water
SPECTRAL PROFILE #1 --> Viewer #1
2225.000
1054.000
Spectral Profile for yellowstone_sub.img
Grassland
SPECTRAL PROFILE #1 --> Viewer #1
2904.000
1212.000
Spectral Profile for yellowstone_sub.img
Needleleaf Forest


Band 1

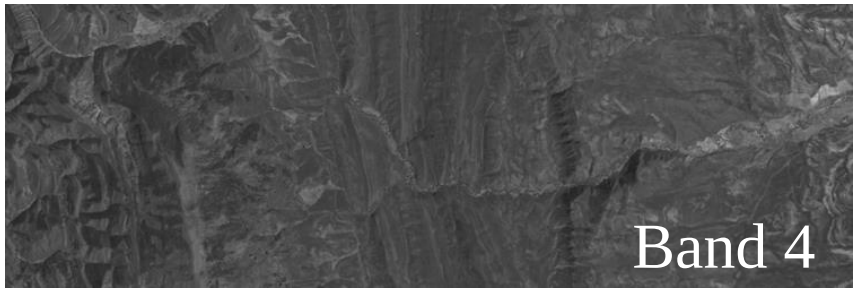

Band 5

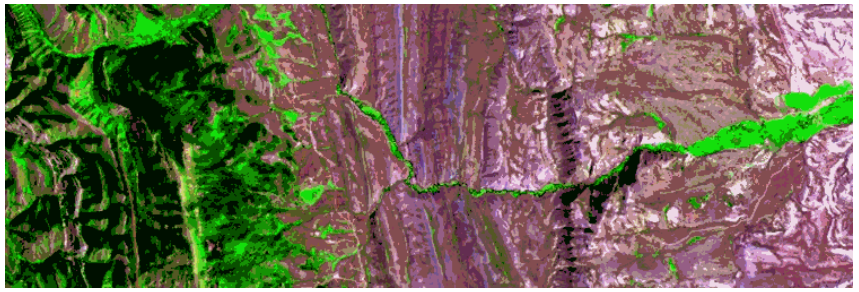

Band 2


Band 6

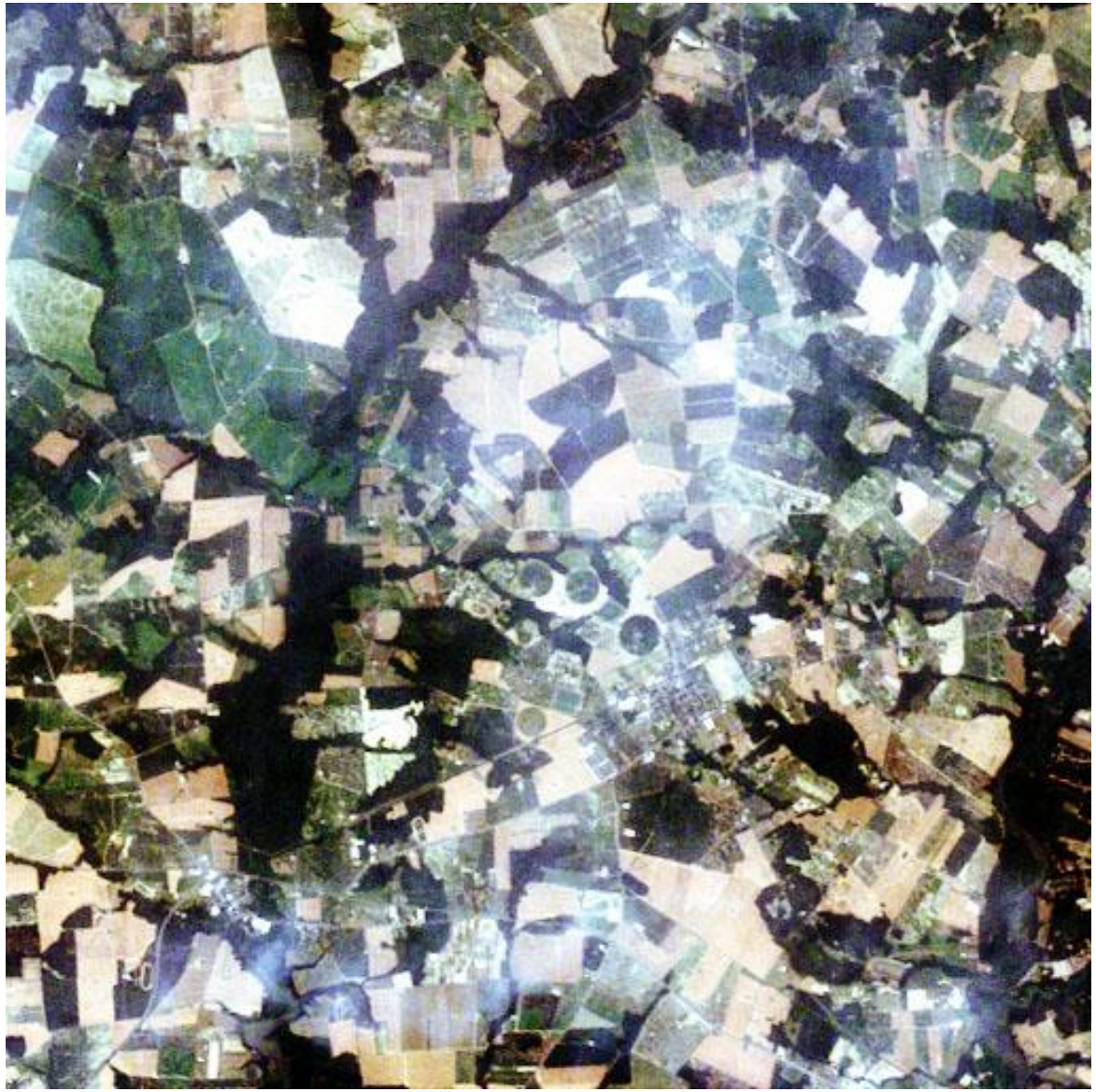

Band 3


Band 7

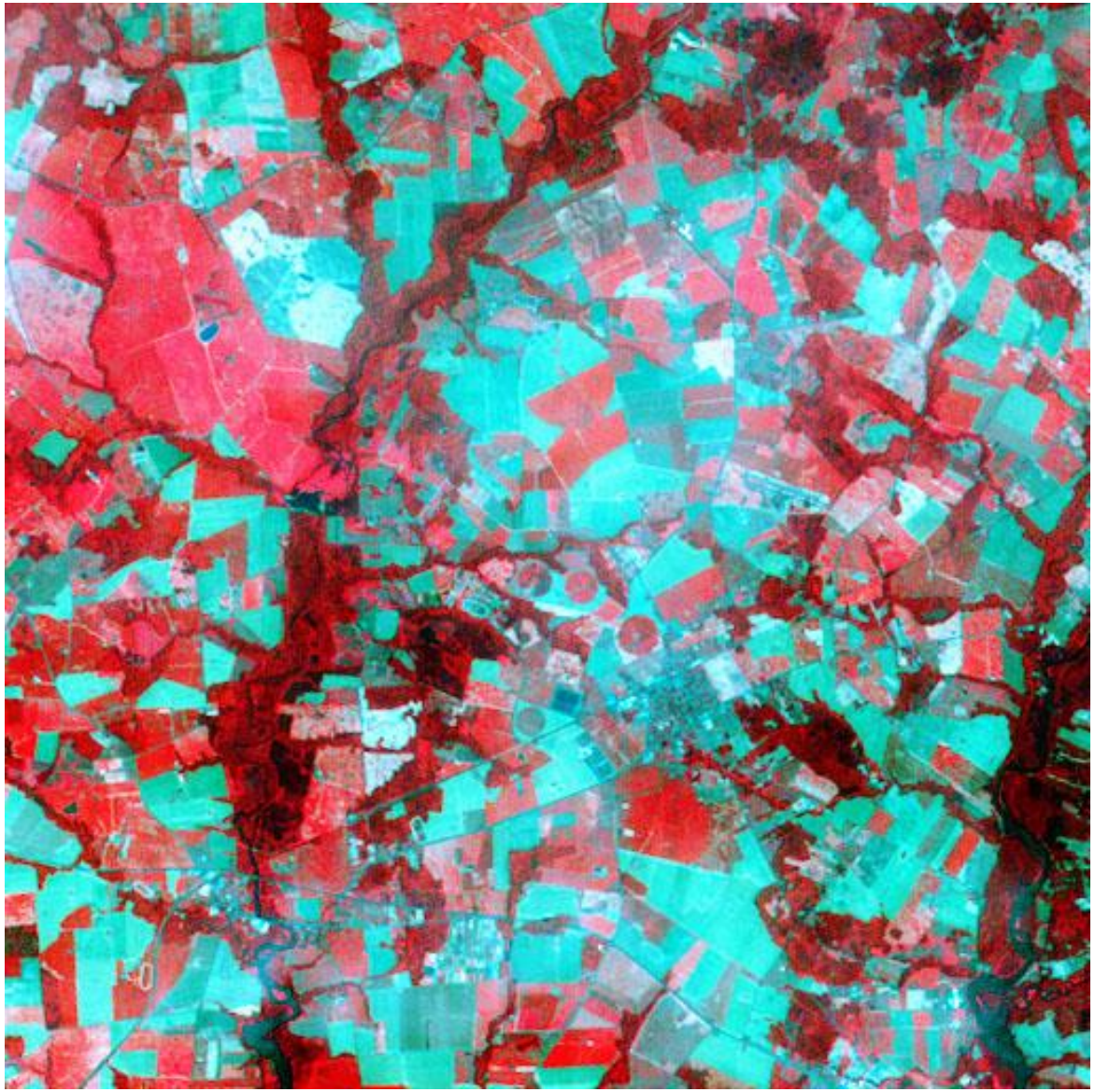

Band 4



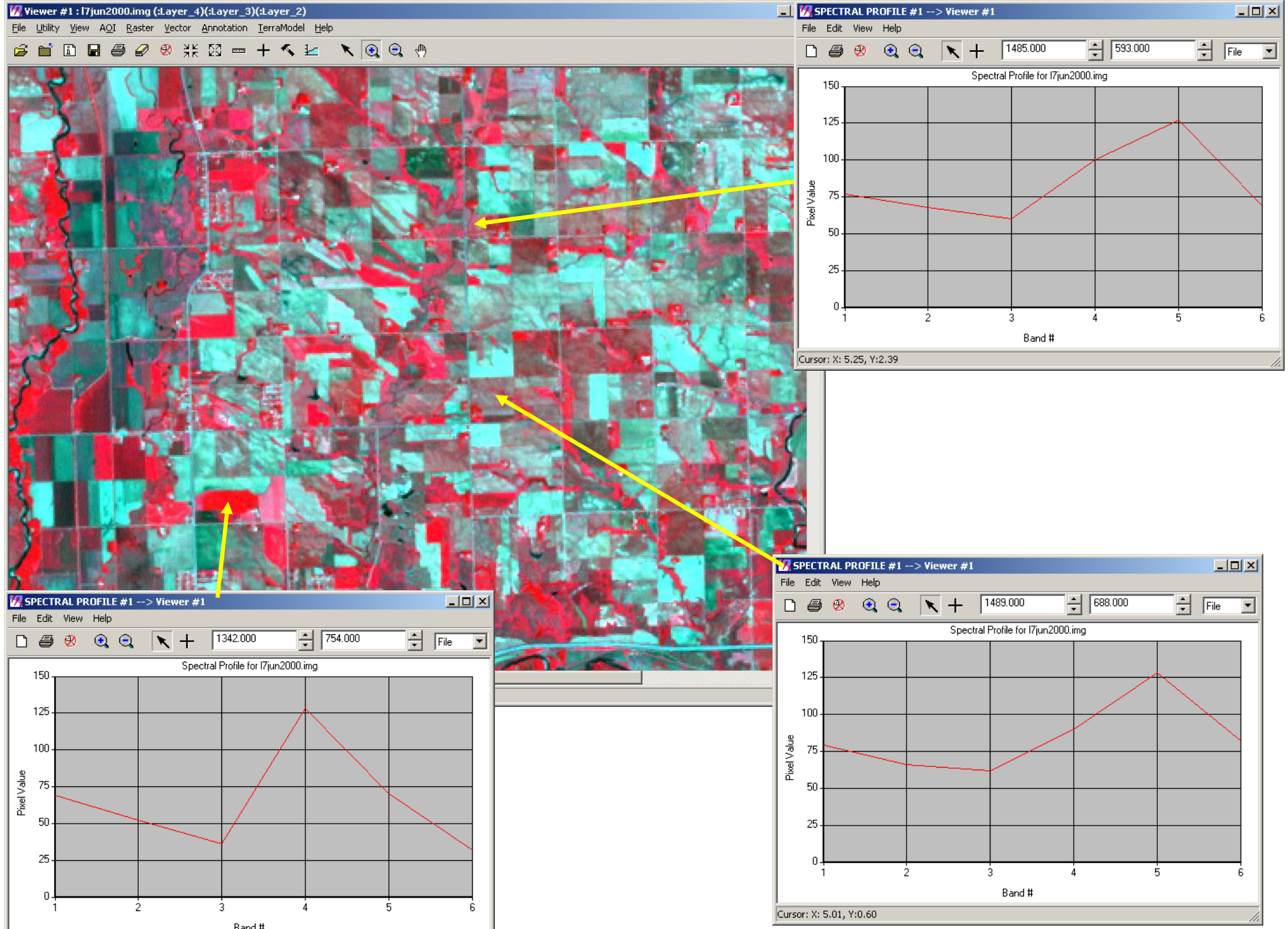
TM band 1:	blue	"true colour"
TM band 2:	green	
TM band 3:	red	
TM band 2:	blue	"false colour"
TM band 3:	green	
TM band 4:	red	
SPOT band 1:	blue	"false colour"
SPOT band 2:	green	
SPOT band 3:	red	



TM bands 3, 2 and 1 (R,G, B)



TM bands 4, 3 and 2 (R,G,B)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593.000
File
Spectral Profile for l7jun2000.img
Pixel Value
Band #
Cursor: X: 5.25, Y:2.39
SPECTRAL PROFILE #1 --> Viewer #1
File Edit View Help
1342.000
754.000
File
Spectral Profile for l7jun2000.img
Pixel Value
Band #
SPECTRAL PROFILE #1 --> Viewer #1
File Edit View Help
1489.000
688.000
File
Spectral Profile for l7jun2000.img
Pixel Value
Band #
Cursor: X: 5.01, Y:0.60

USGS Global Visualization Viewer - Windows Internet Explorer

http://glovis.usgs.gov/

USGS Global Visualization Viewer

USGS
science for a changing world

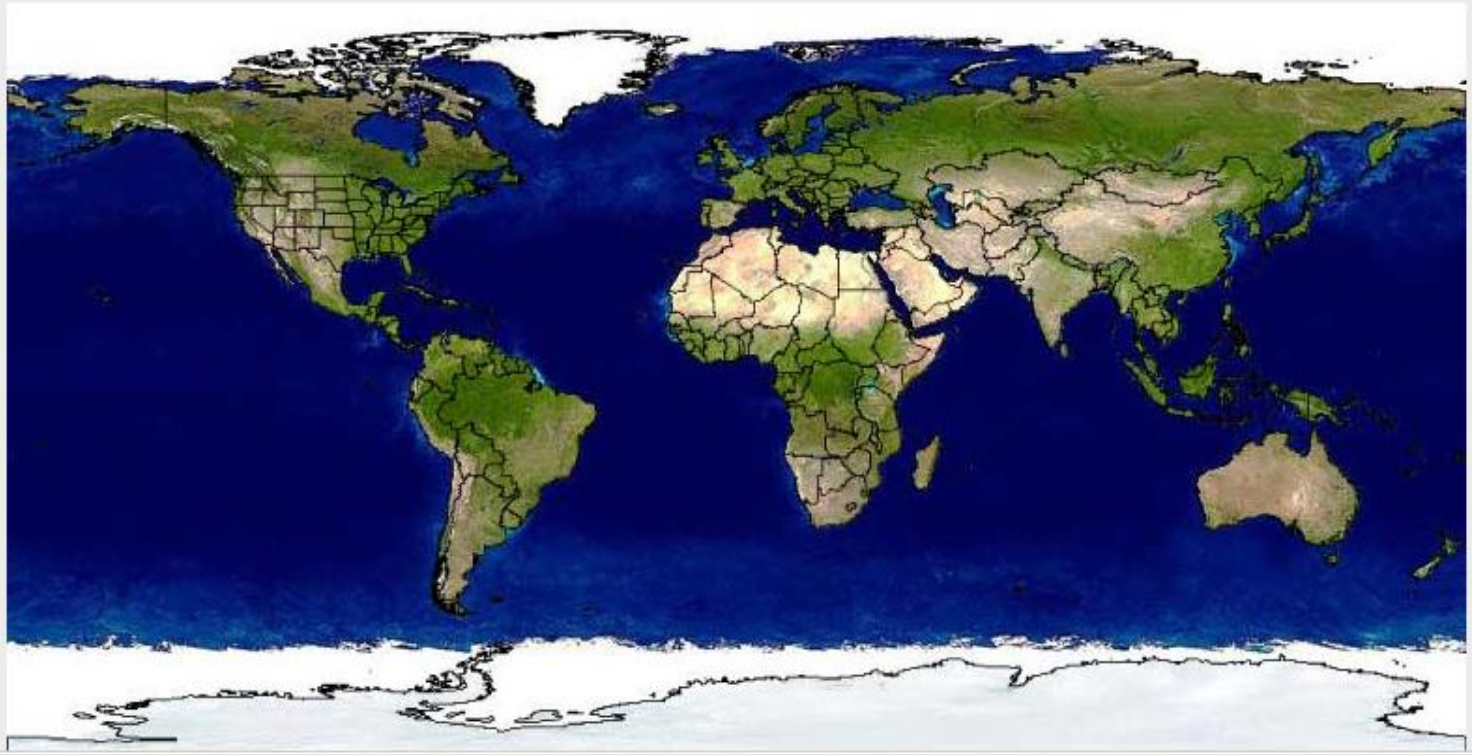
Earth Resources Observation and Science Center (EROS)

USGS Global Visualization Viewer

Select a collection, then click on the Global Locator Map to view satellite browse images in that area.

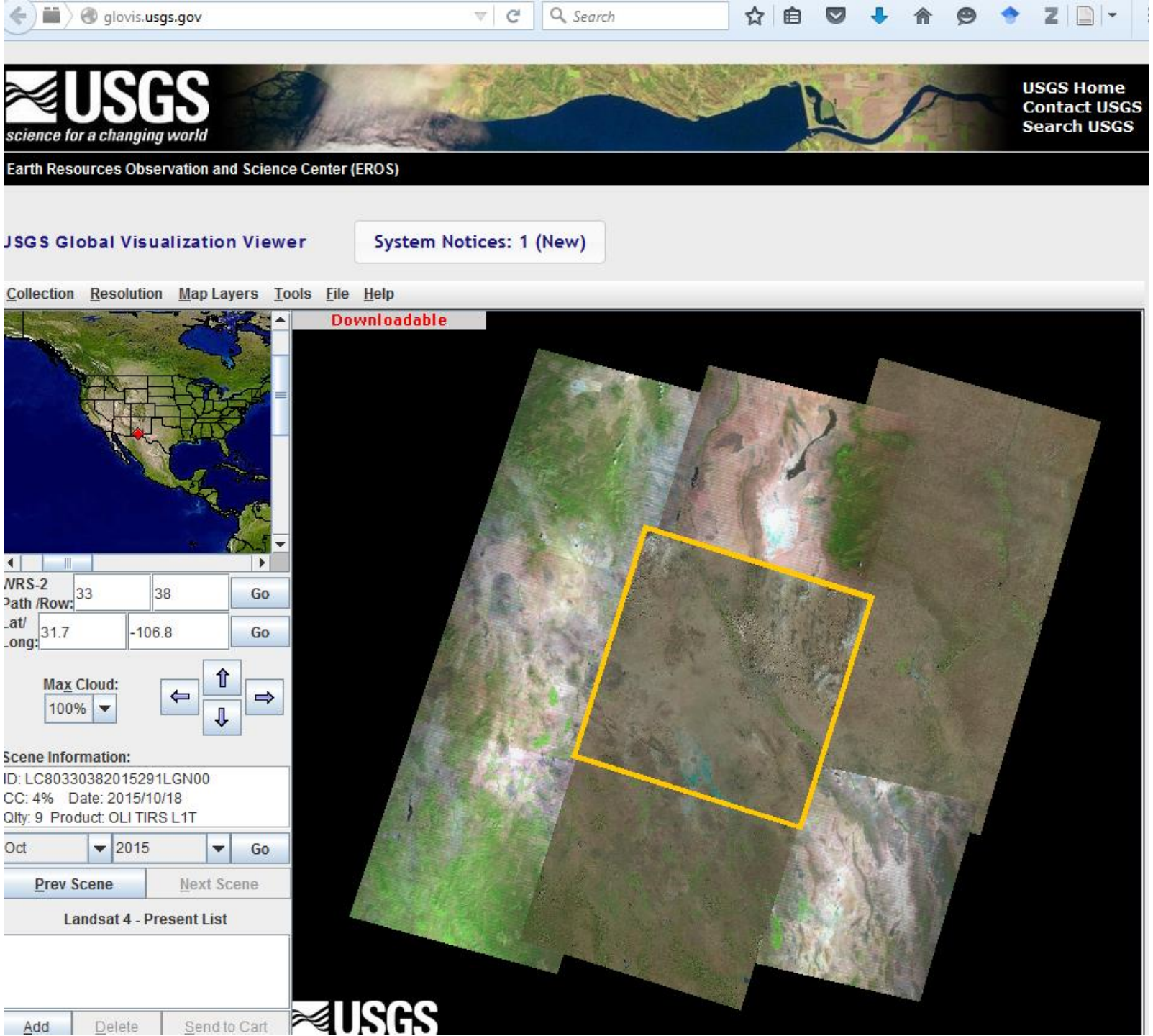
Select Collection Landsat Archive Landsat 4-5 TM View Images

Latitude 36.5 Longitude -98.3



javascript:submitForm()

Internet 100%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Resolution
Map Layers
Tools
File
Help
Downloadable
WRS-2
Path /Row:
33
38
Go
Lat/
Long:
31.7
-106.8
Go
Max Cloud:
100%
Scene Information:
ID: LC80330382015291LGN00
CC: 4% Date: 2015/10/18
Qlty: 9 Product: OLI TIRS L1T
Oct
2015
Go
Prev Scene
Next Scene
Landsat 4 - Present List
Add
Delete
Send to Cart
USGS

Remote Sensing Limitations

- Remote sensing is not a *solution to all difficulties*
- It simply provides *some* of the spatial, spectral, and temporal information about phenomena of interest
- Humans can introduce errors
- Remotely sensed data can be expensive to collect and analyze
- Need for linking ground observations with remote sensing observations (reality check)

Finally, remote sensing is a tool or technique that enables scientific discovery.

References

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Thank You.

Questions?

Contact:
easalas@nmsu.edu
Knox Hall, Rm 111