Spectral reflectance characteristics (Plants, Soil, Water)

Dr. Alan Belward

Knowledge for Sustainable Development and Food Security Unit

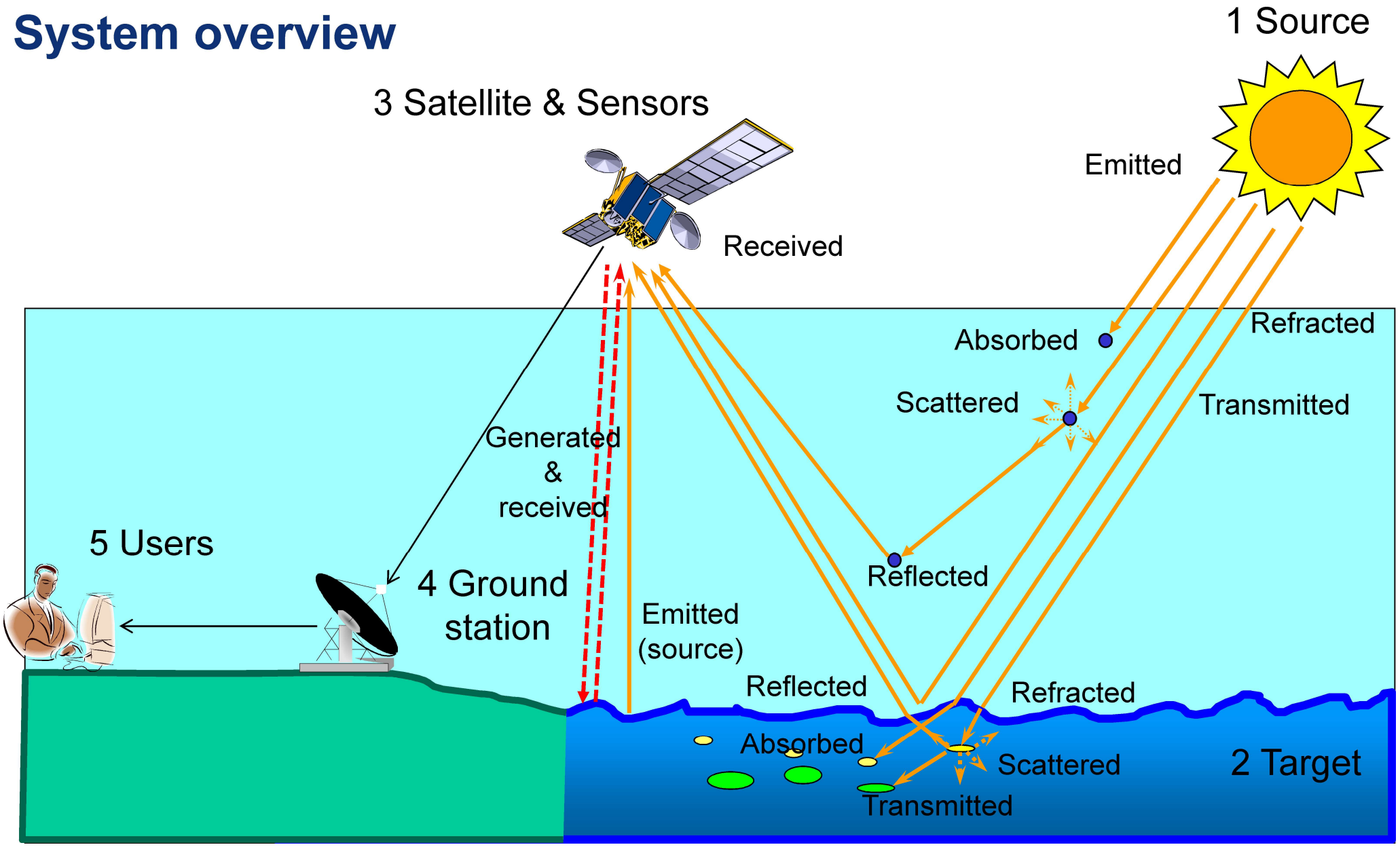
Directorate for Natural Resources

European Commission

Joint Research Centre

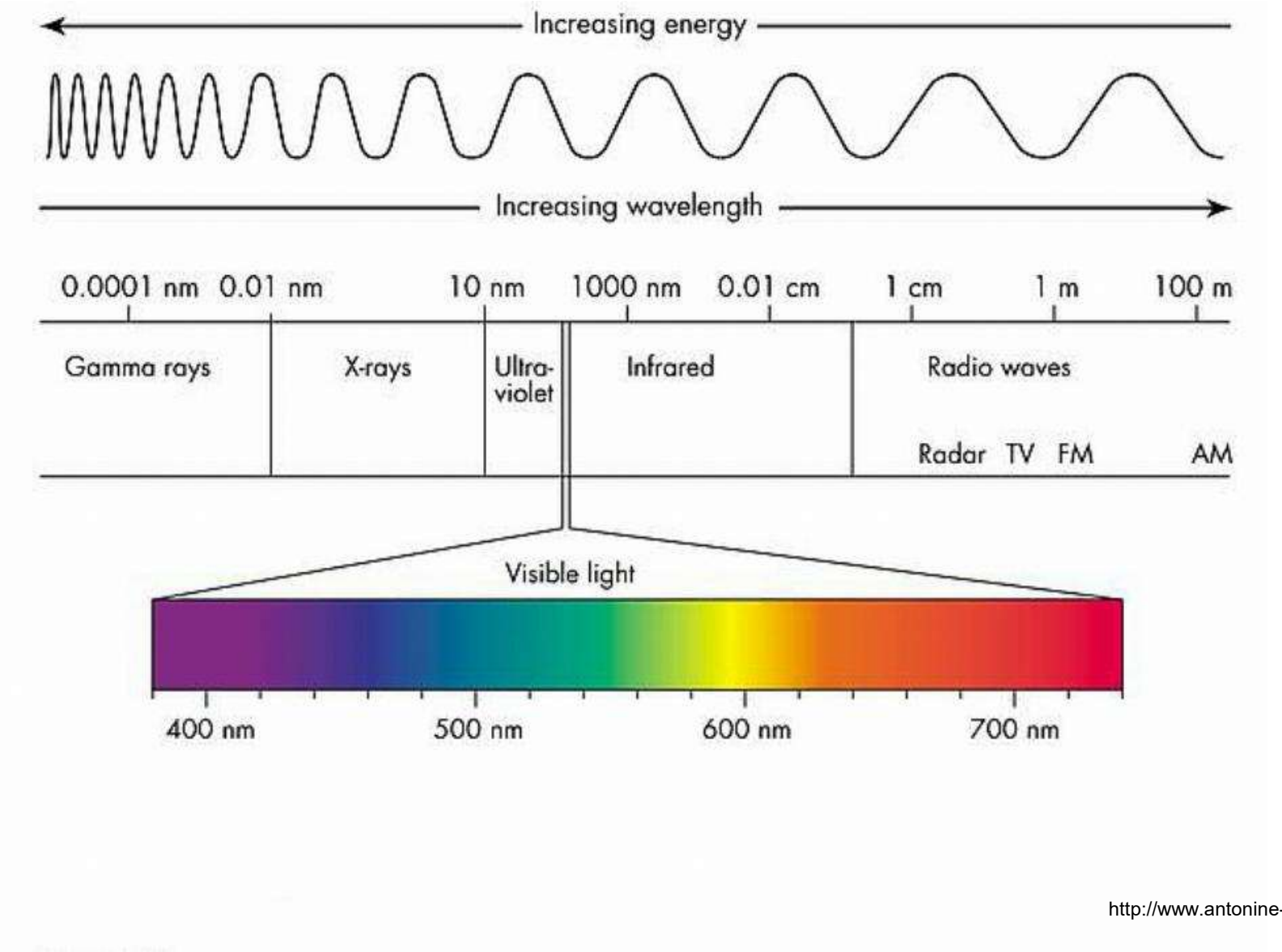
http://bioval.jrc.ec.europa.eu/

System overview



Target

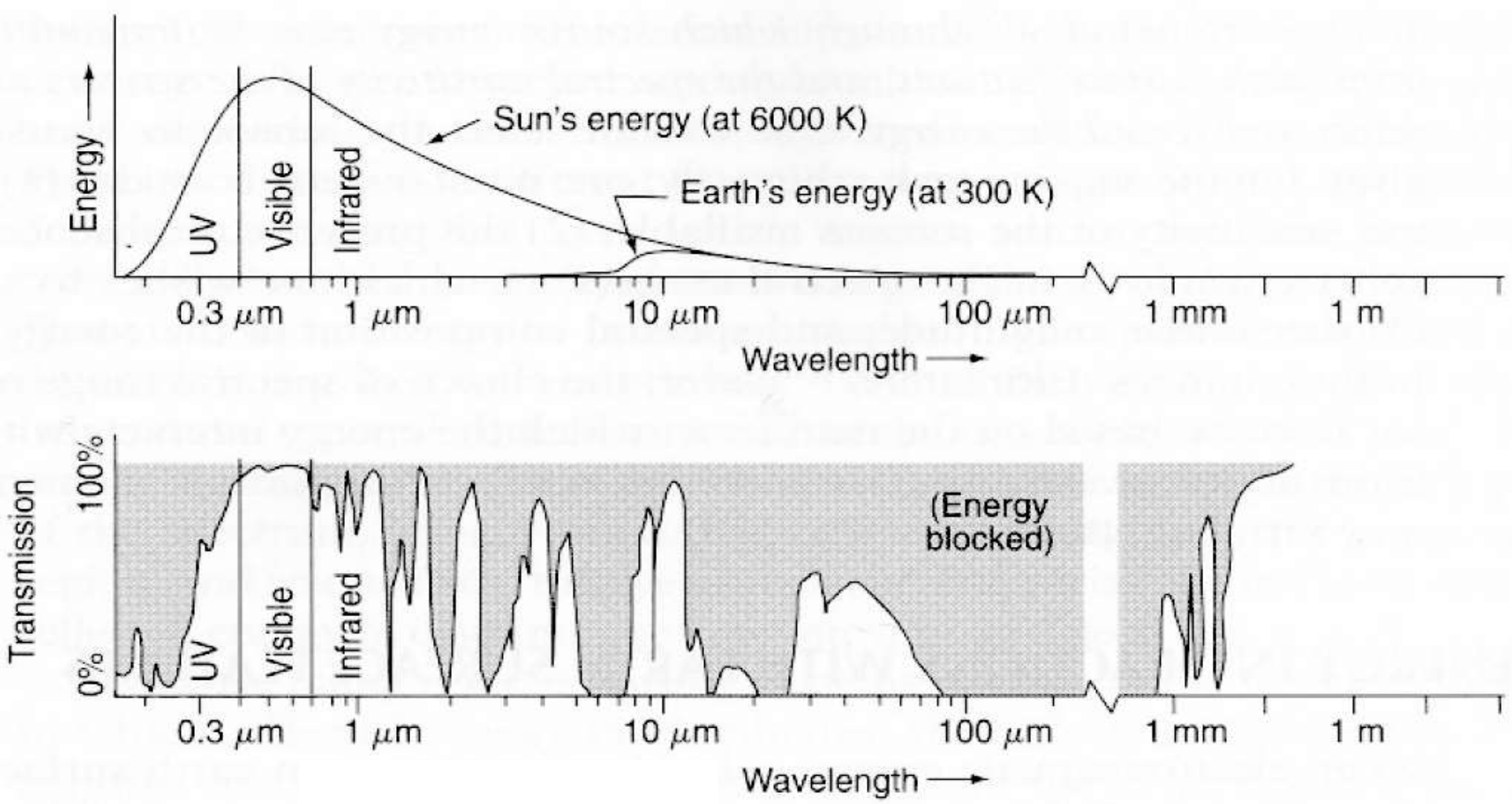
Optical spectrum 0.3 to 14 µm



http://www.antonine-education.co.uk/

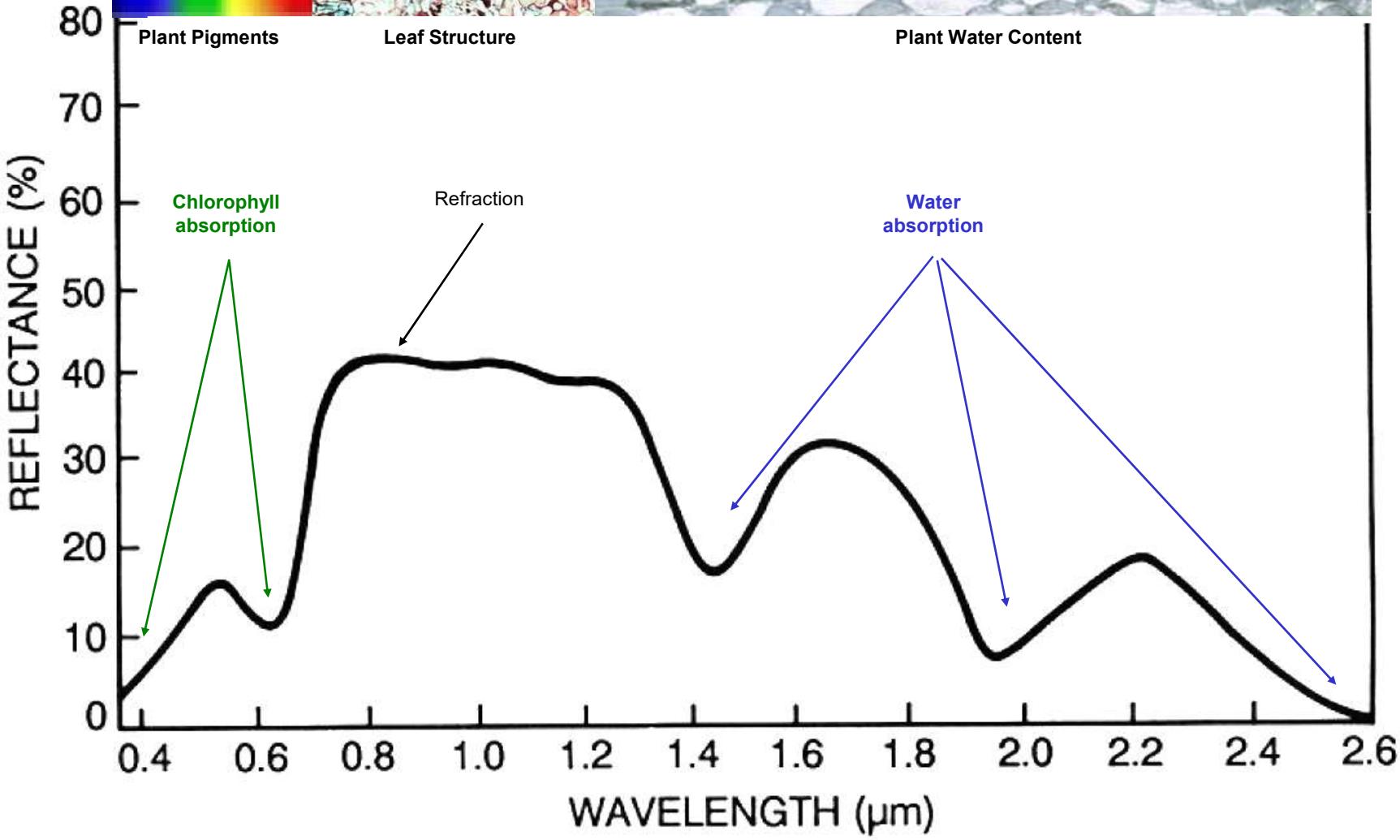
Lillesand, Kiefer and Chipman, 2008, Remote Sensing and Image Interpretation 6th edition (Wiley & Sons)

The reflective portion, 0.3 to 2.5 µm



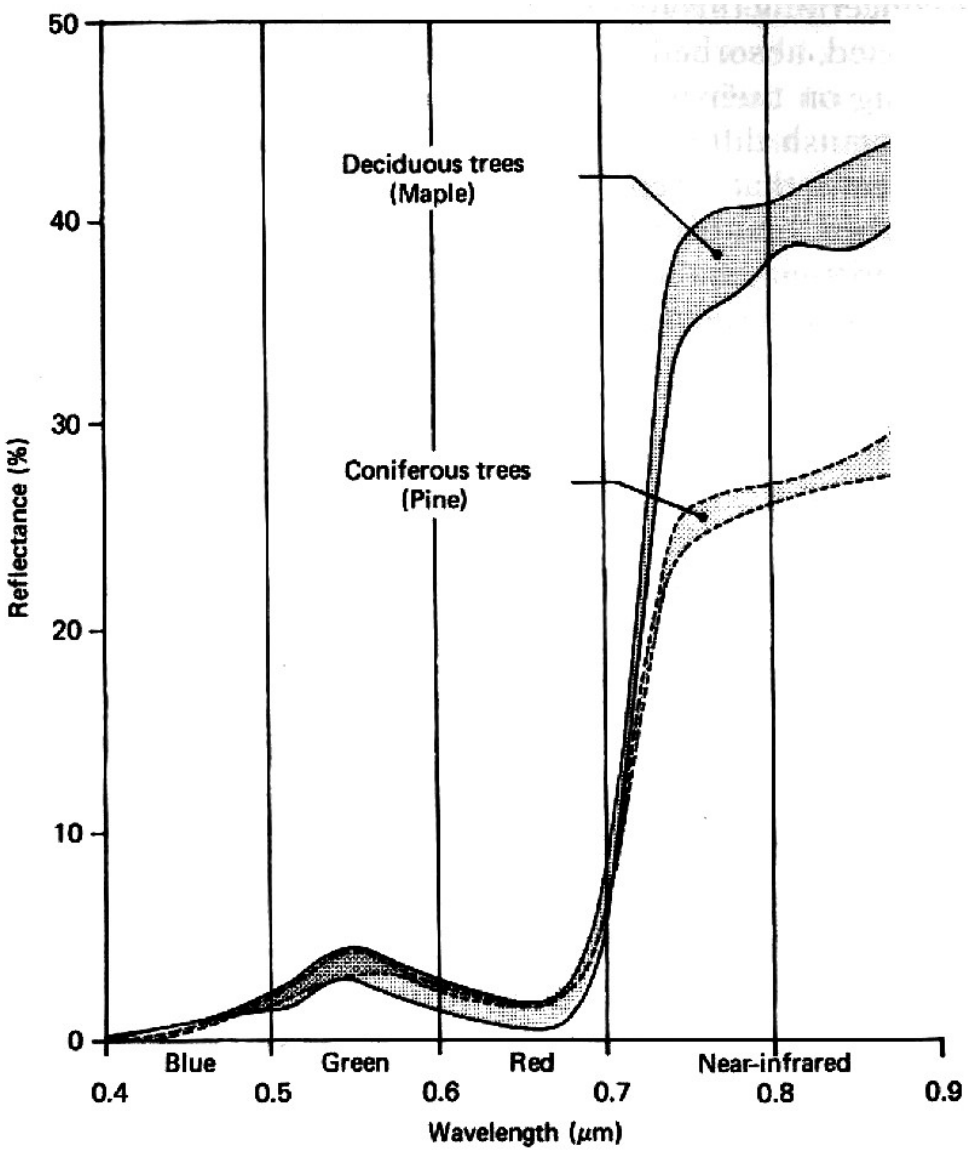
Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991

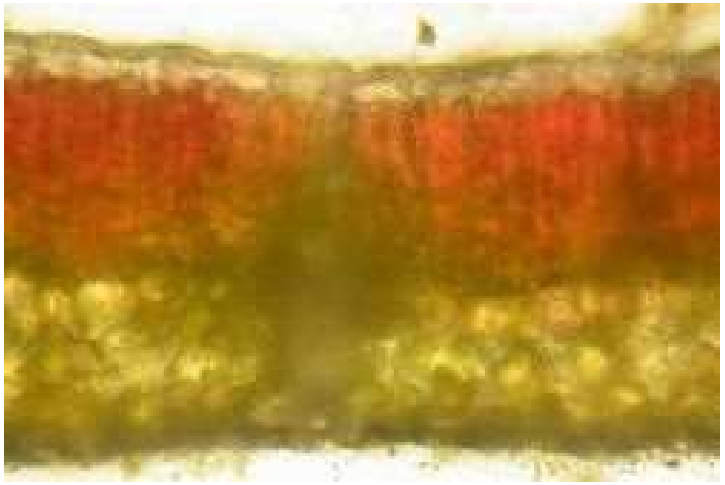
Spectral reflectance curve for fresh green vegetation



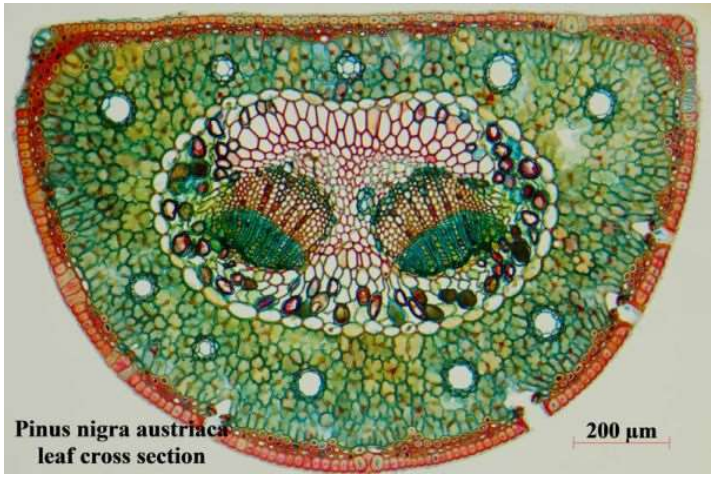
Lillesand, Kiefer & Chipman, Remote Sensing and Image Interpretation, 6th Edition May 2008 (Wiley & Sons)

Leaf structure

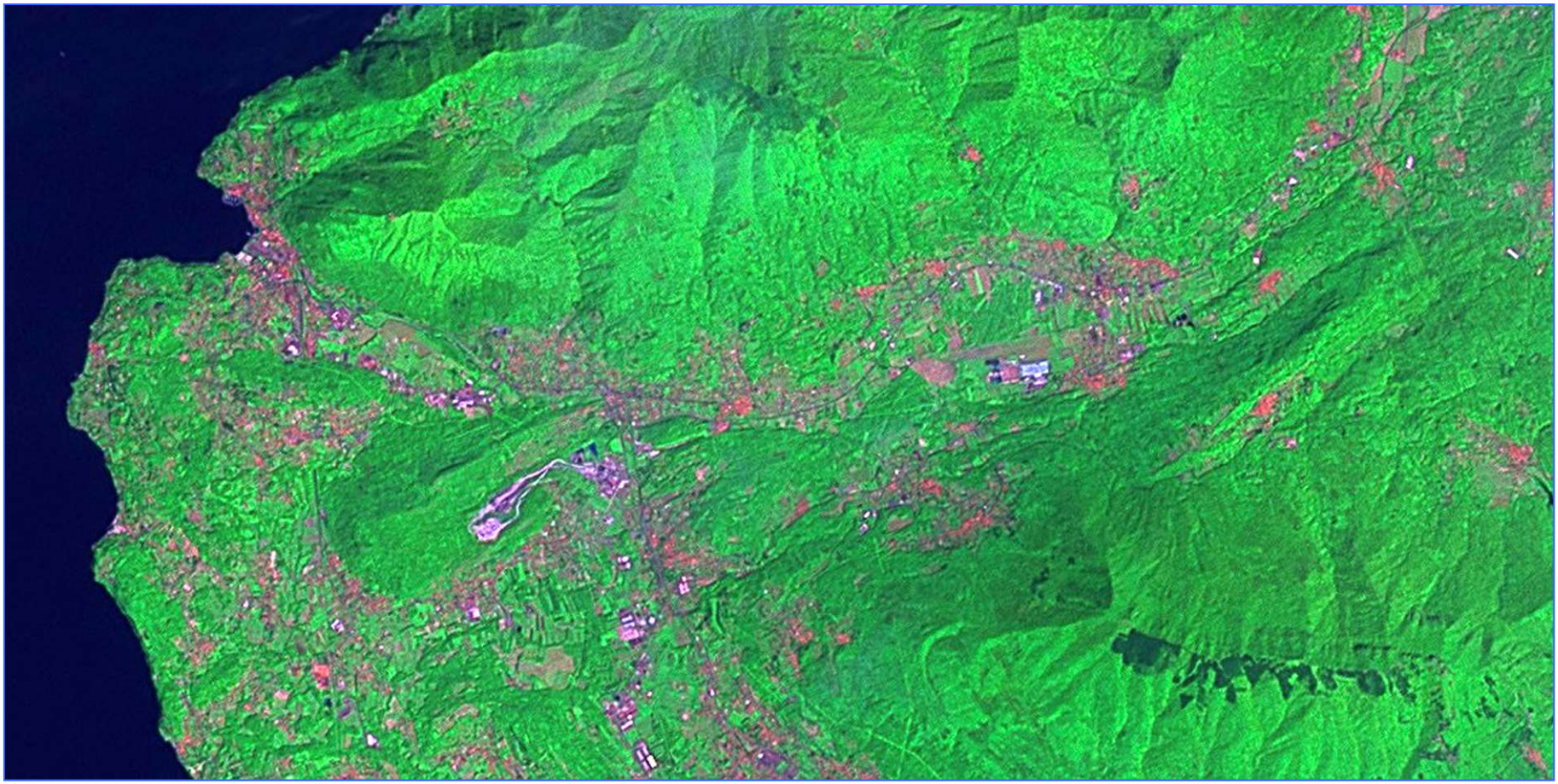




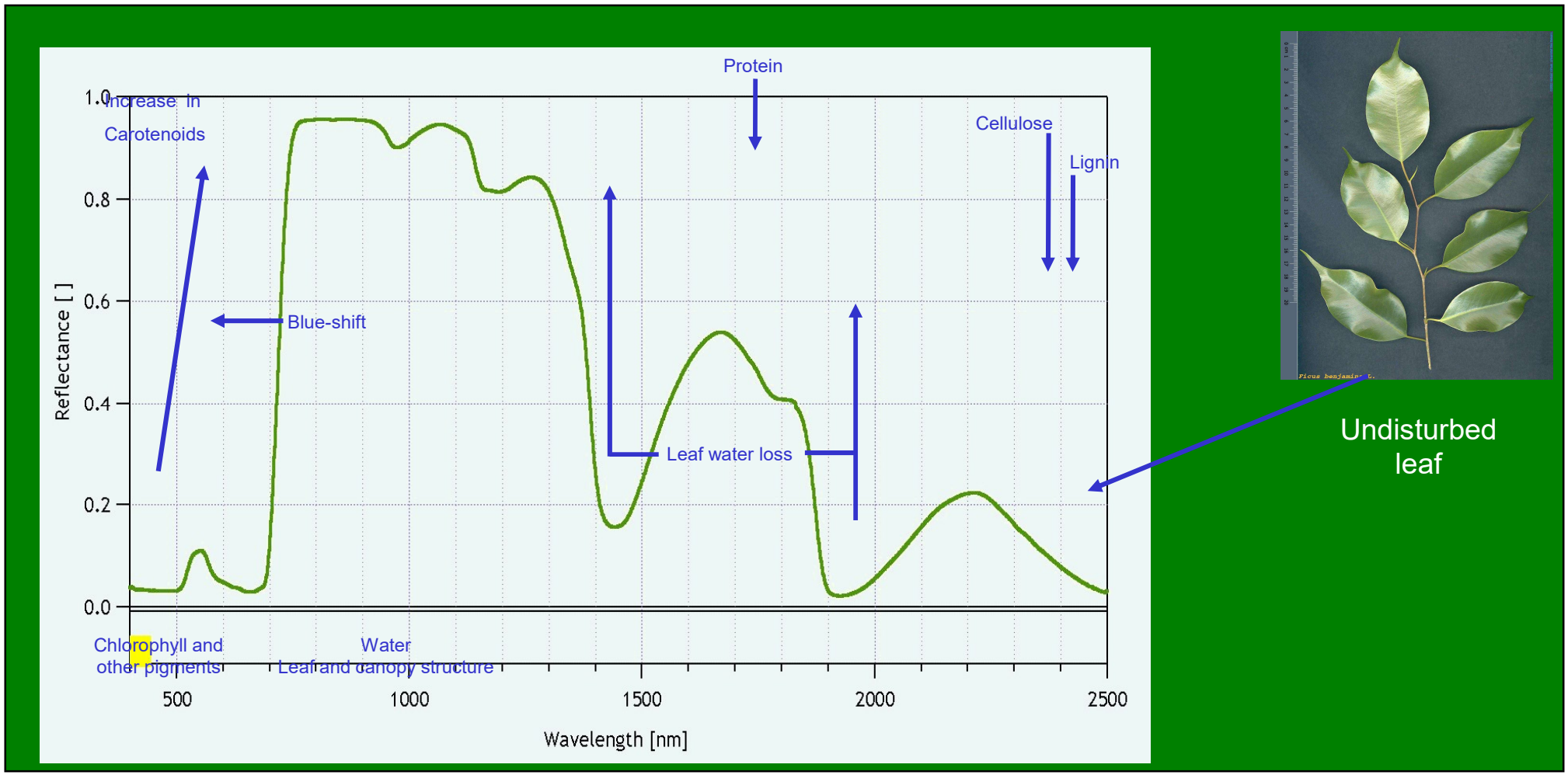
http://harvardforest.fas.harvard.edu/research/leaves/science.html



http://www.microscopy-uk.org.uk/



‘Senescence’ of a *Ficus benjamina* L. leaf



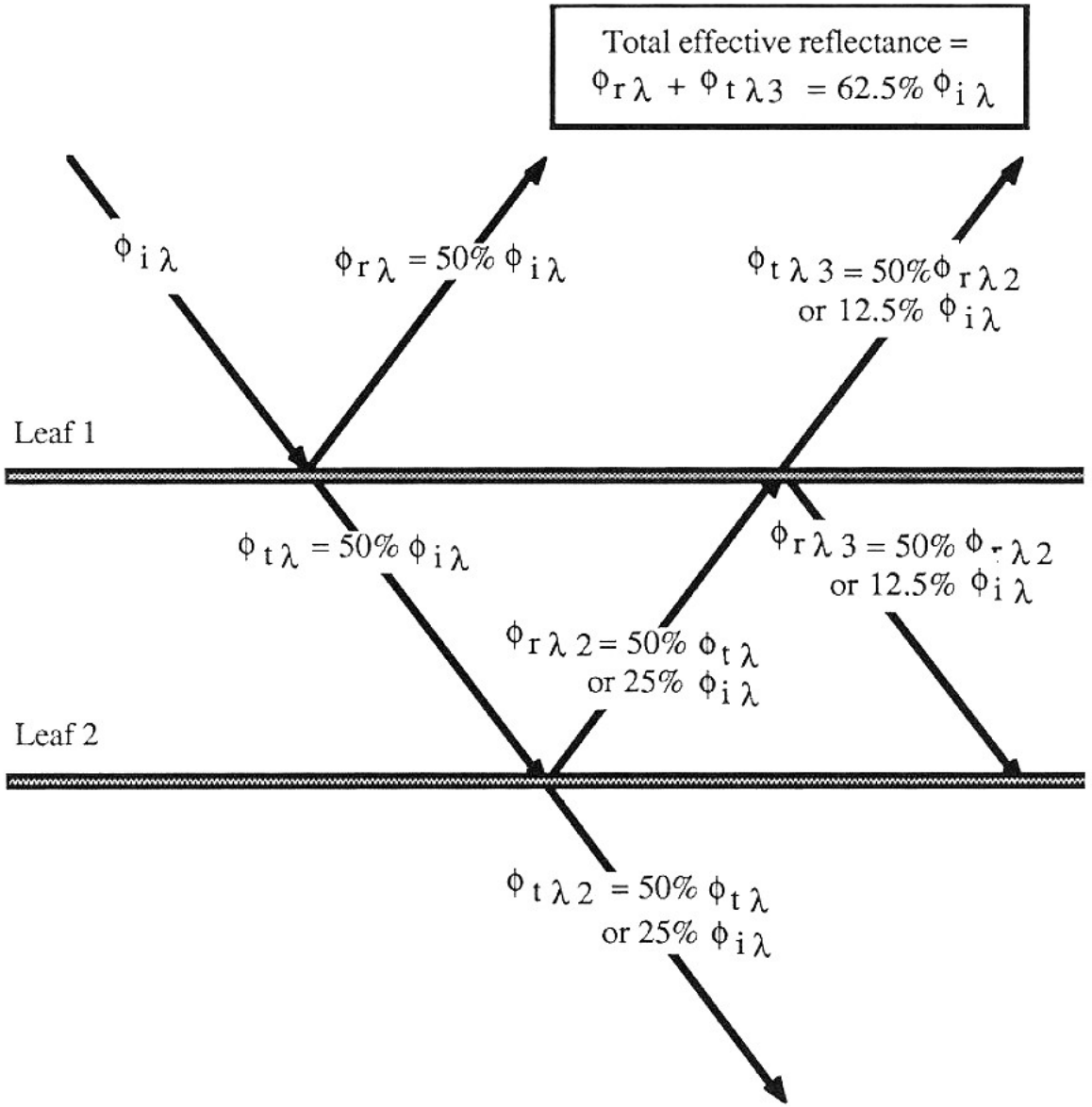
Each time step is 10 mins., total duration 8 hrs

Measurement is *reflectance plus reflected transmittance*

Schaepman, M. (2007) Spectrodirectional Remote Sensing: From Pixels to Processes. *International Journal of Applied Earth Observation and Geoinformation*, **9**, 204-223.

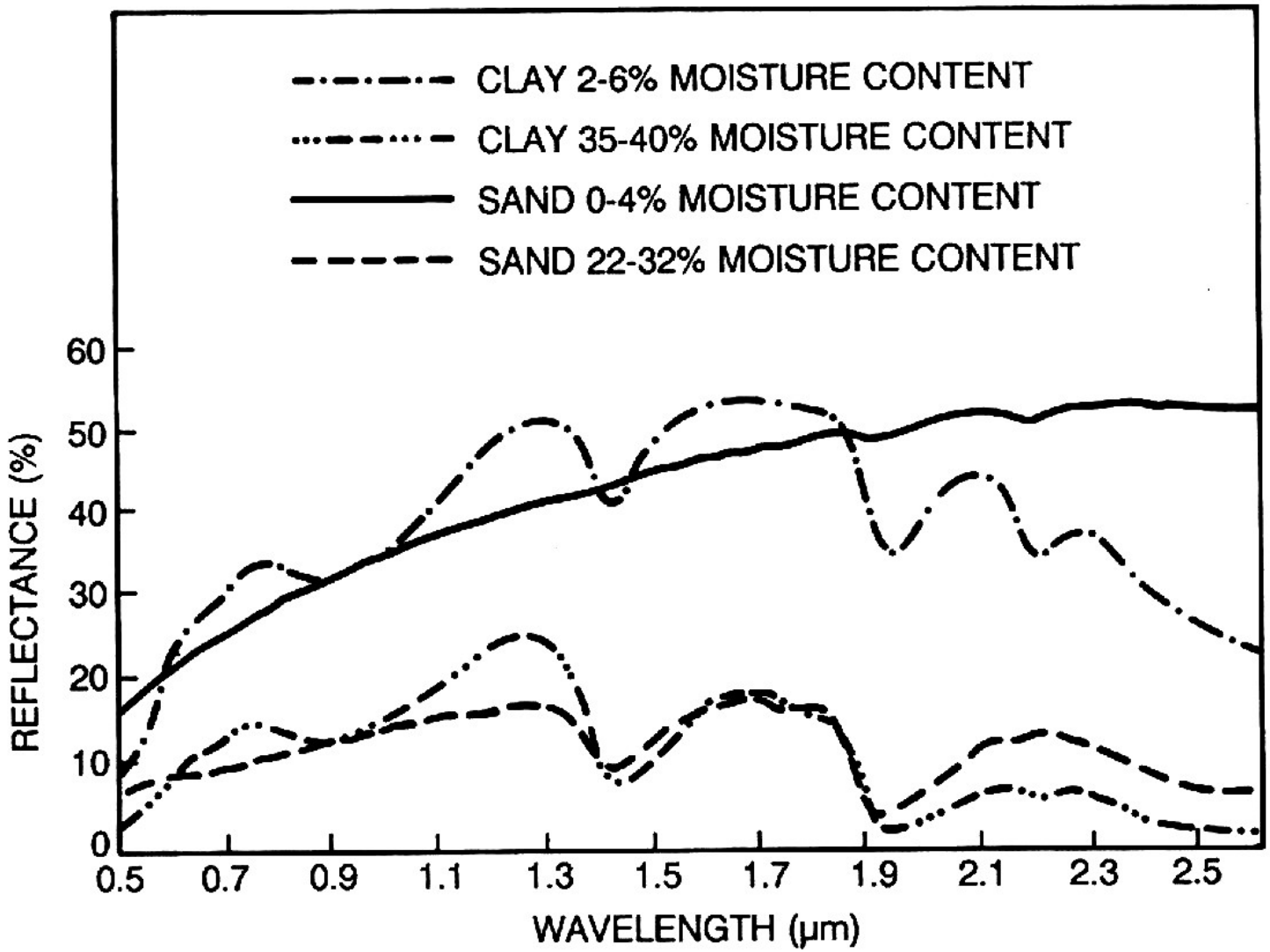
Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991

Effect of multiple leaf layers on NIR reflectance



Soil

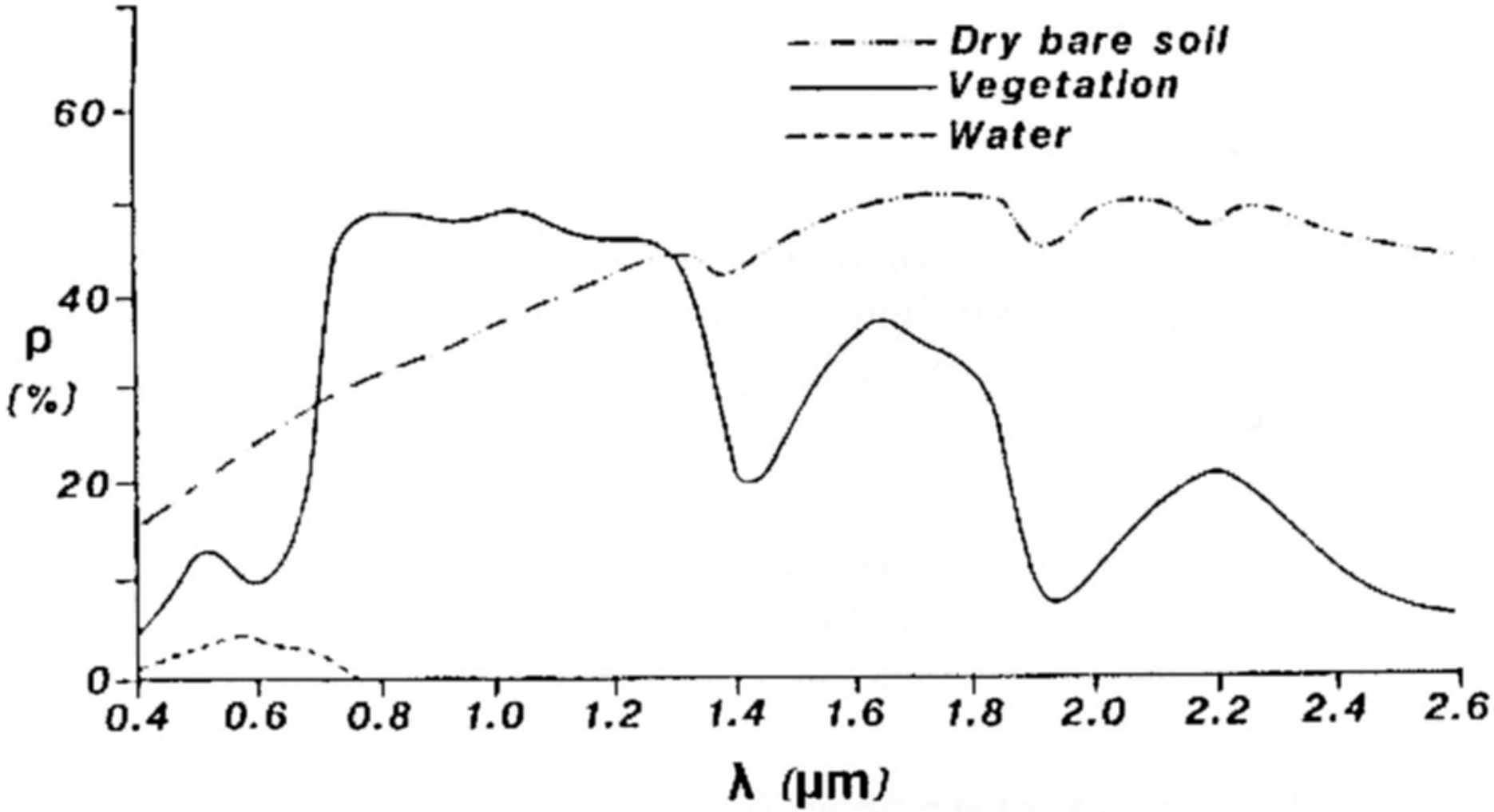
Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991



Soil moisture / organic matter

Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries
edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991

Spectral response – spectral reflectance curves

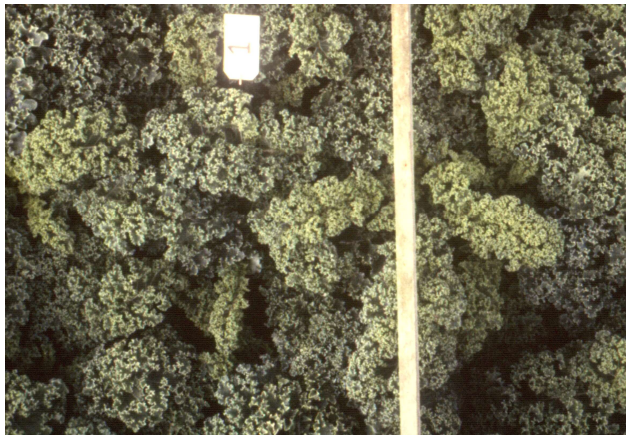


Thousand headed Kale development over time

23rd June

11th July

18th July

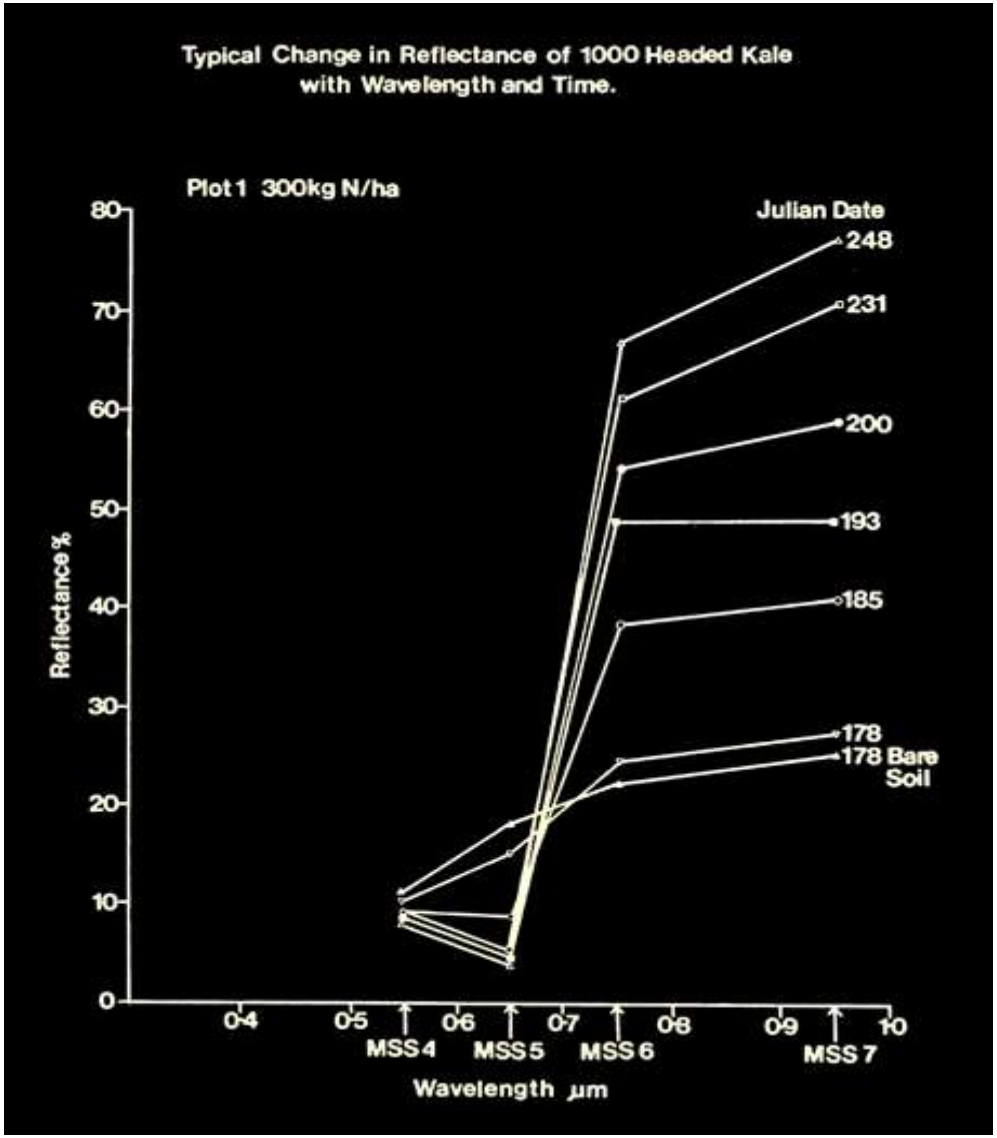


5th August

18th August

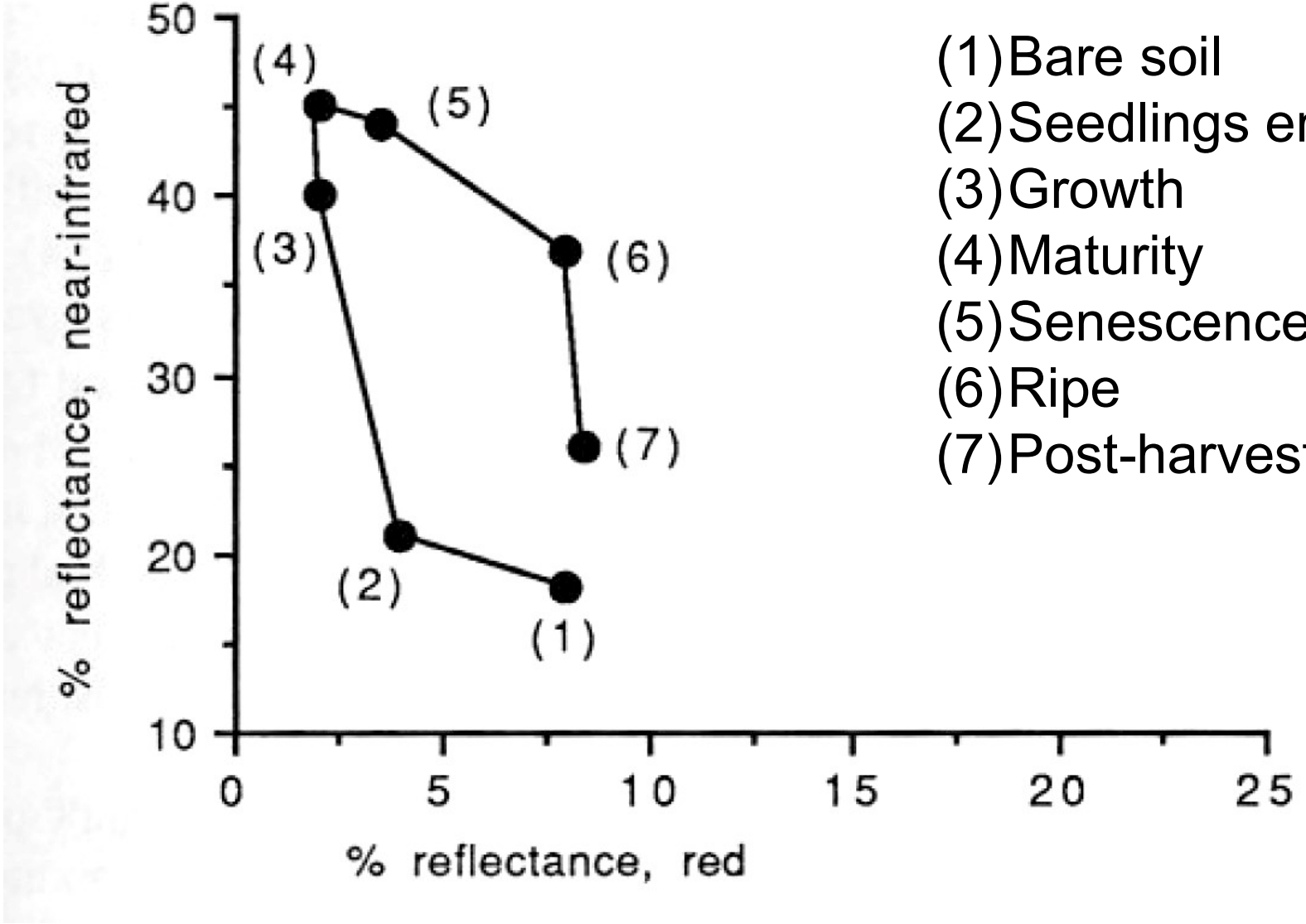
NVRS, A. Belward

Kale, spectral response



Growth and differentiation

Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991

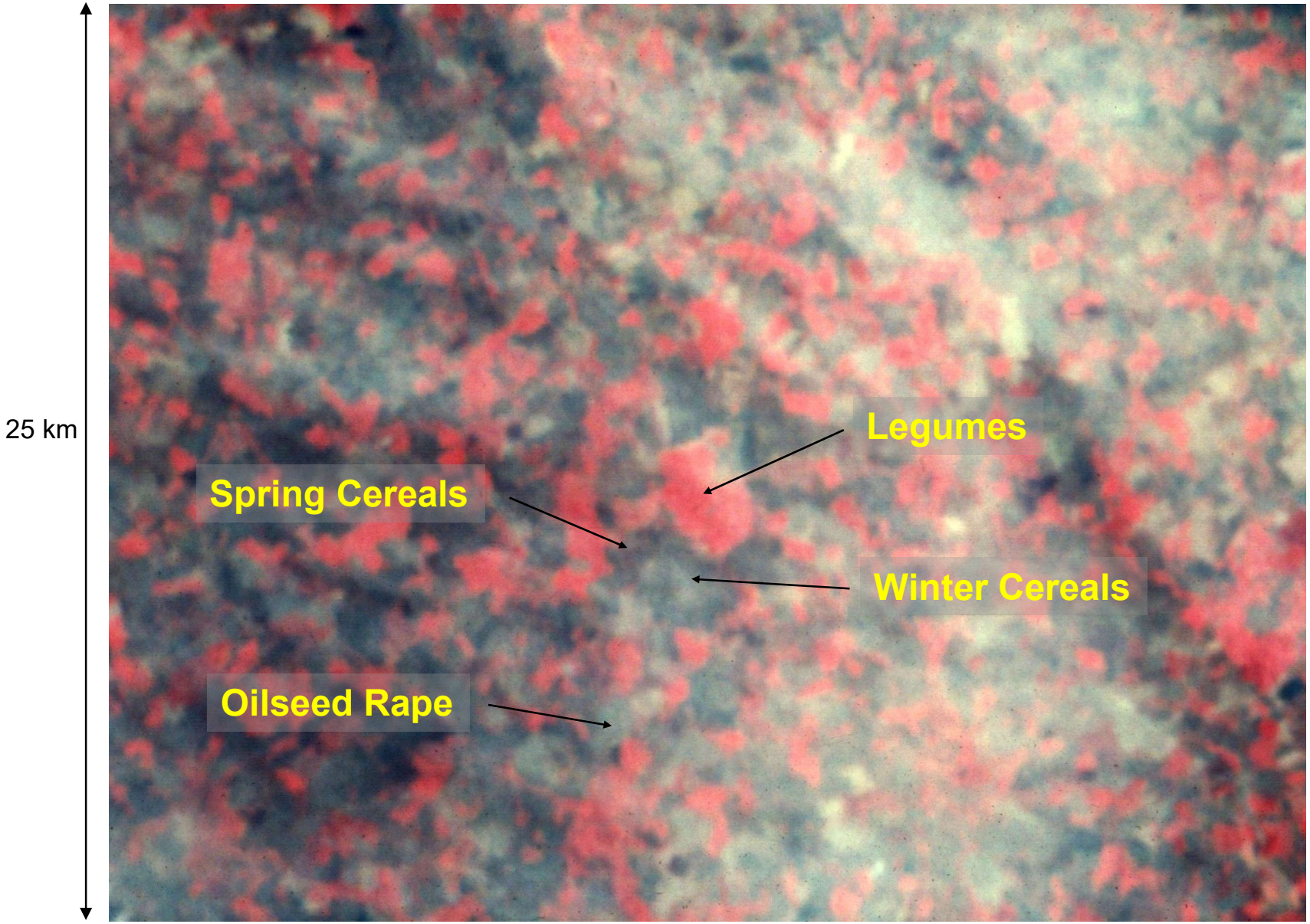


(1) Bare soil
(2) Seedlings emerge
(3) Growth
(4) Maturity
(5) Senescence
(6) Ripe
(7) Post-harvest stubble

Source: Belward

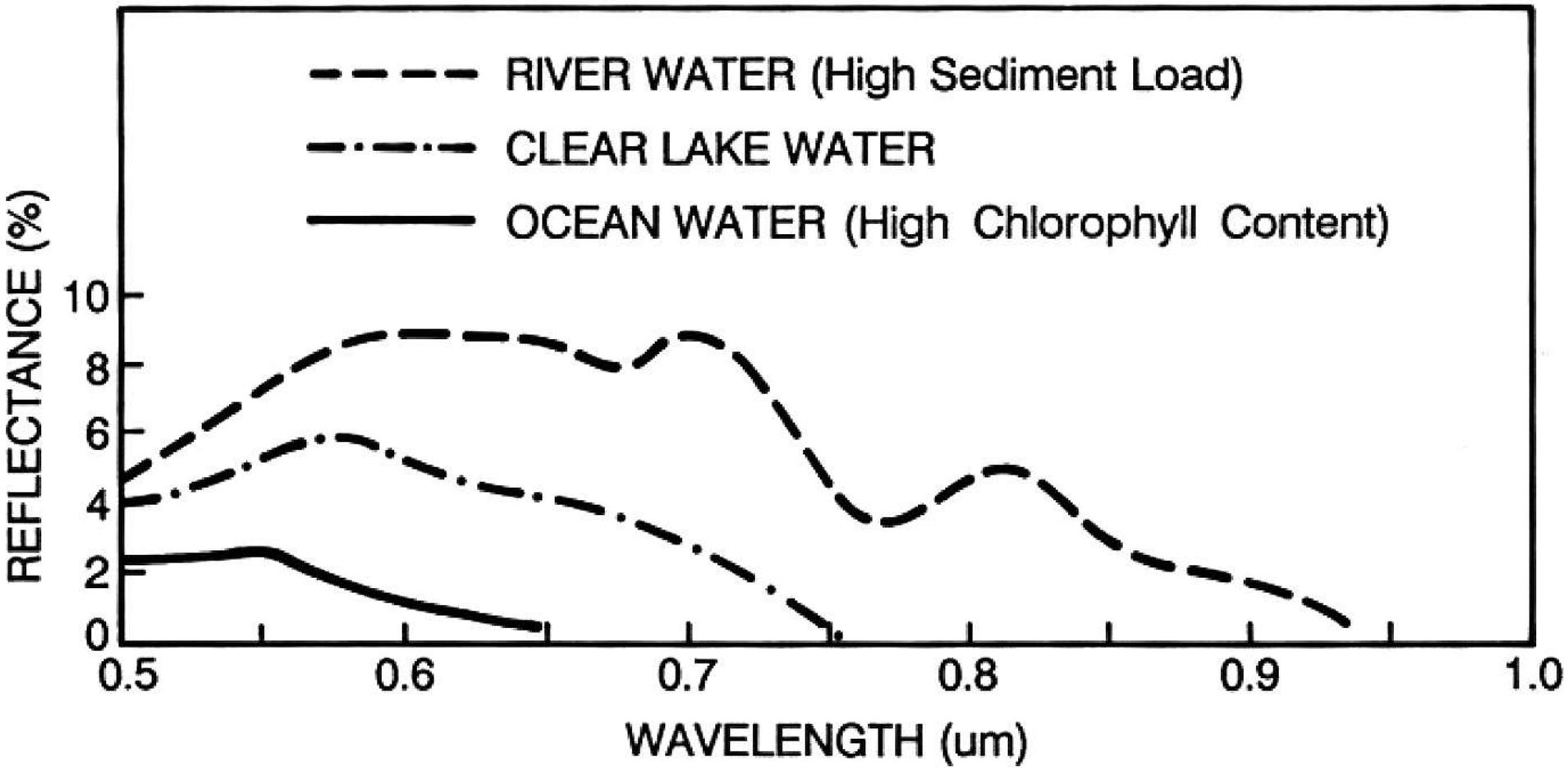
Source: Belward, Landsat MSS February, April, May, August 83

The multitemporal dimension

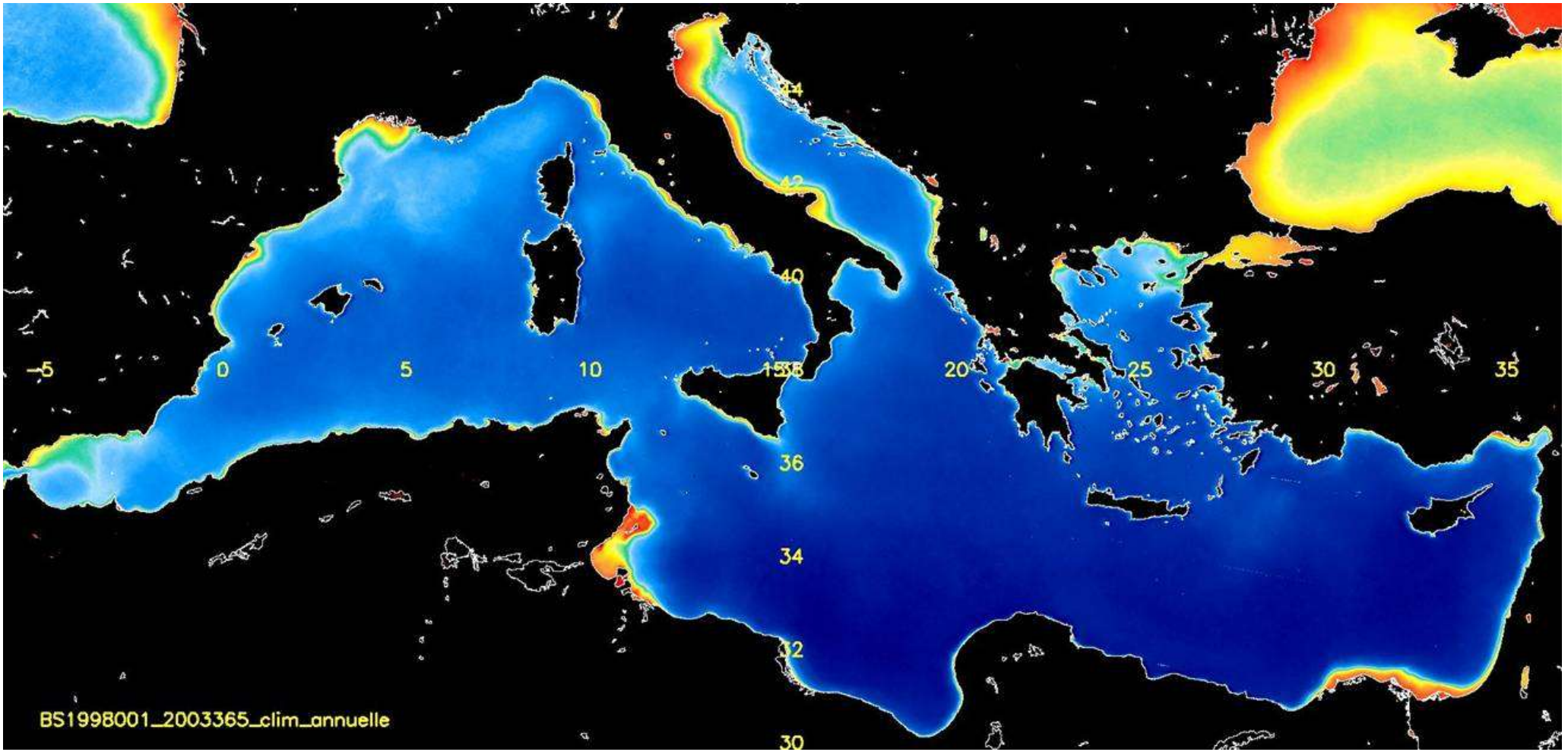


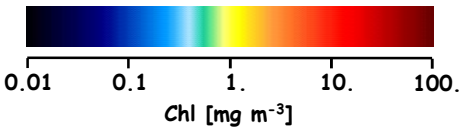
Water

Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991



chlorophyll climatological annual mean from SeaWiFS (1998-2003)

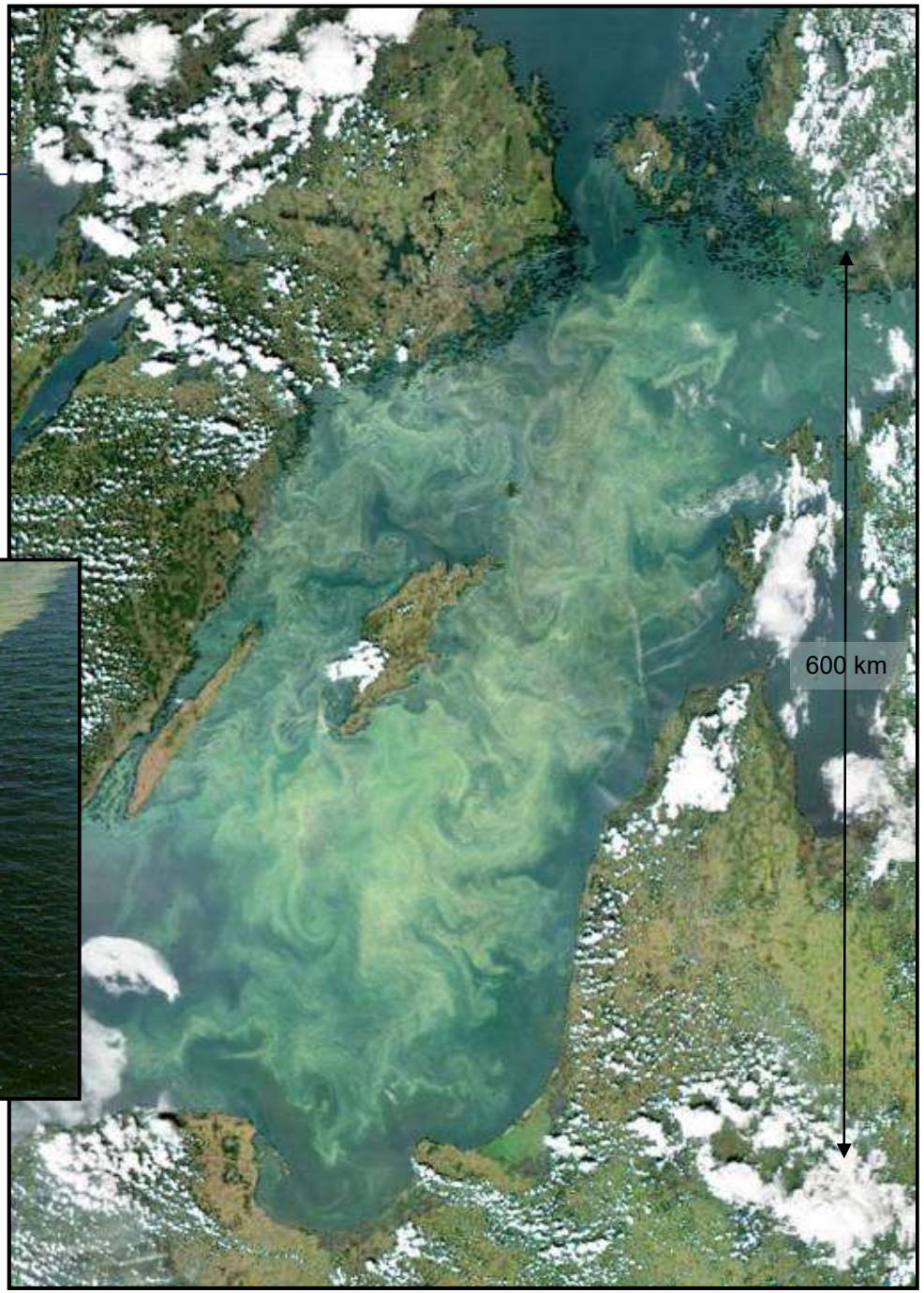




Source V. Barale

Ocean colour

- Cyanobacterial bloom
- Baltic sea 8th July 2005
- SeaWifs



Source A. Stips, F. Melin (JRC)
http://ioc.unesco.org/gpsbulletin/GPS1&2/Vol2ar1.jpg


Rio Negro
Dissolved Organic Matter
Rio Solimões
Rich with Andean sediments
MISR Manaus (NASA)
http://img527.imageshack.us/img527/6031/encotrerlosrq4.png

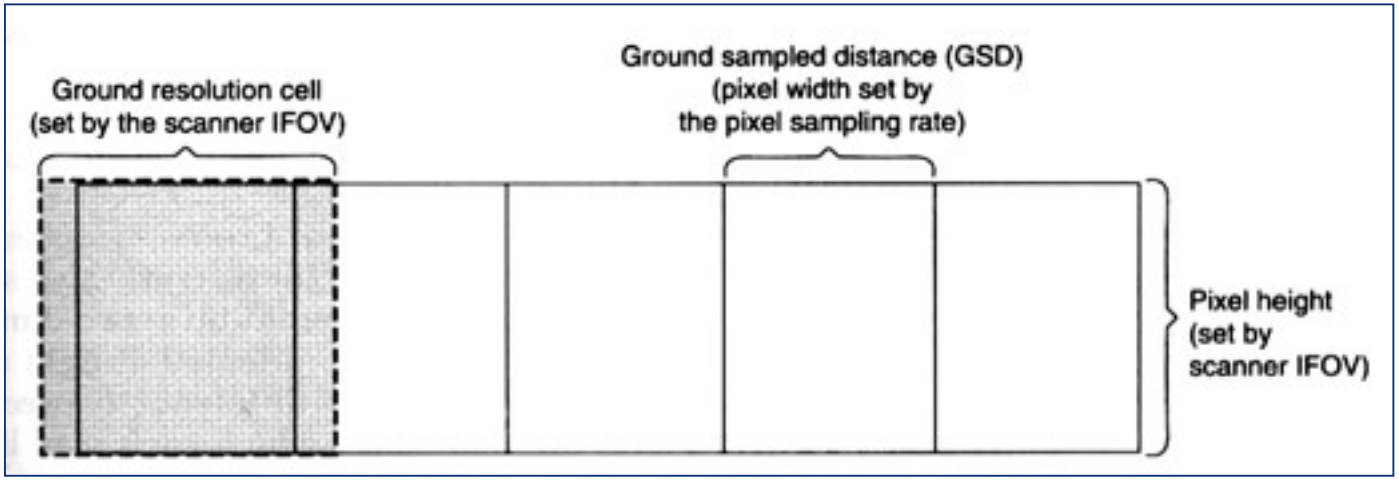
http://www.satimagingcorp.com/satellite-sensors/spot-5.html
Landsat

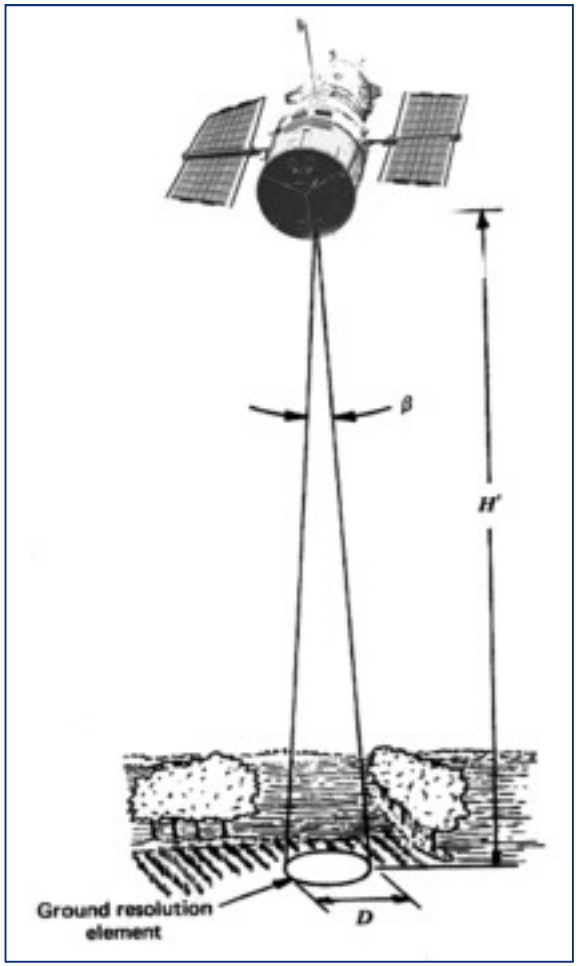
- Sensors capture the EMR incident with them and convert this into a permanent record

- The Sensor is mounted on a platform, in this case a satellite

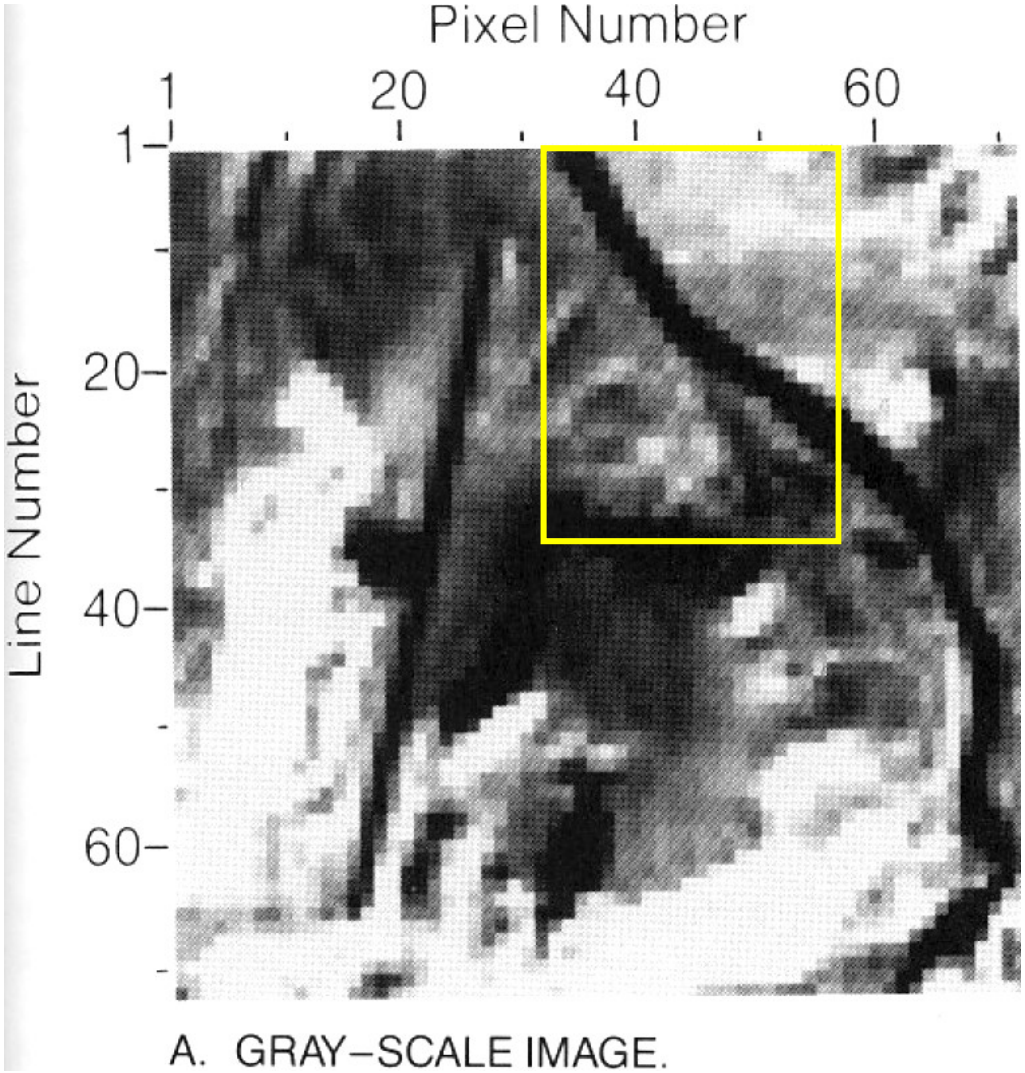
Spatial characteristics

- Spatial resolution defines the level of spatial detail in an image. Indicative of the size of objects on the ground that can be seen as separate entities in the image
- Instantaneous Field of View (IFOV) – the cone angle within which incident energy is focused on the detector
- Pixel size – in part a function of the IFOV, but also determined by the way in which the radiometric signal is sampled
- Scene size – determined by the number of detectors and the viewing angle of the instrument in the across track dimension…arbitrary along track

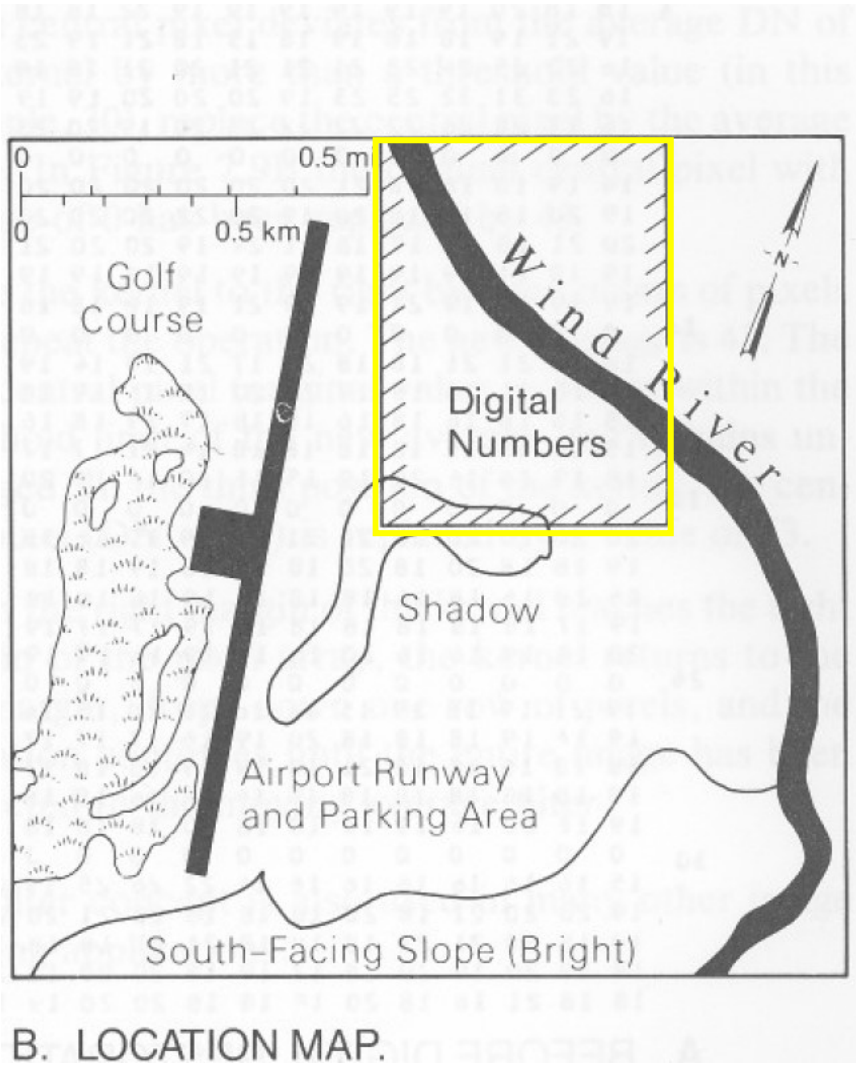




Structure of a digital image

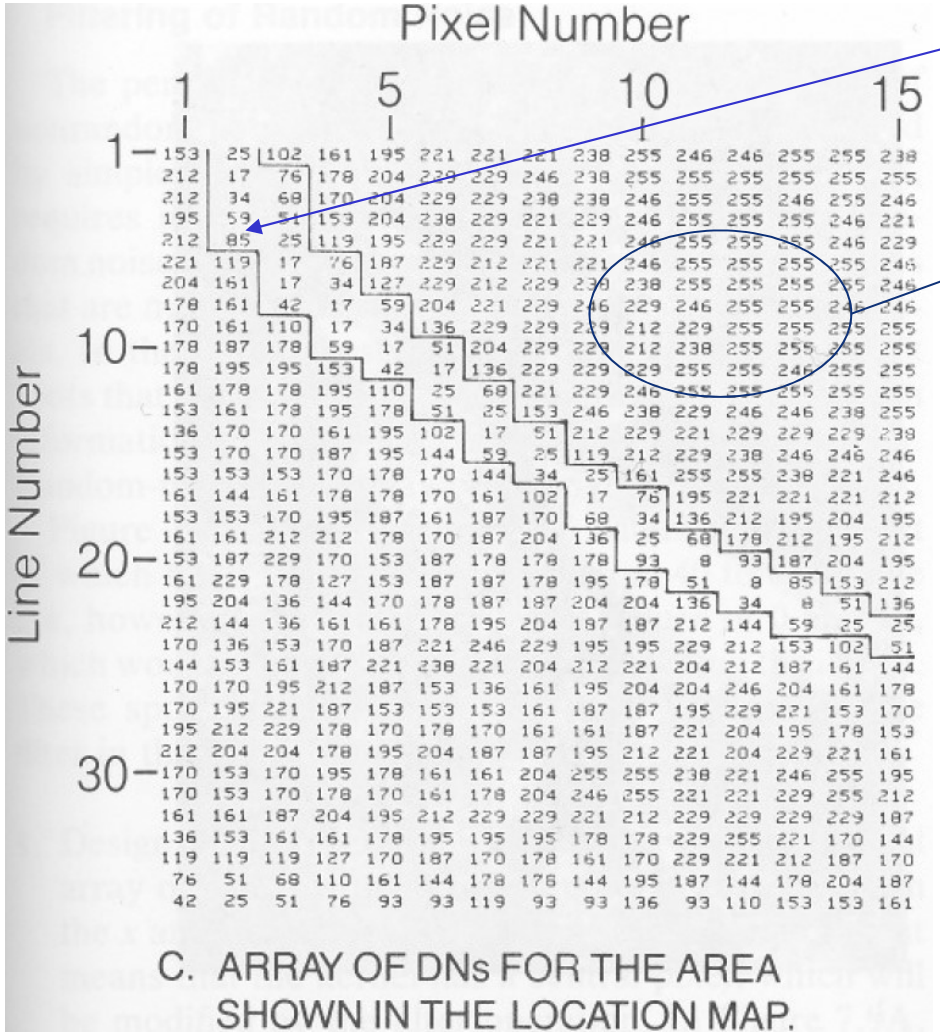


A. GRAY–SCALE IMAGE.

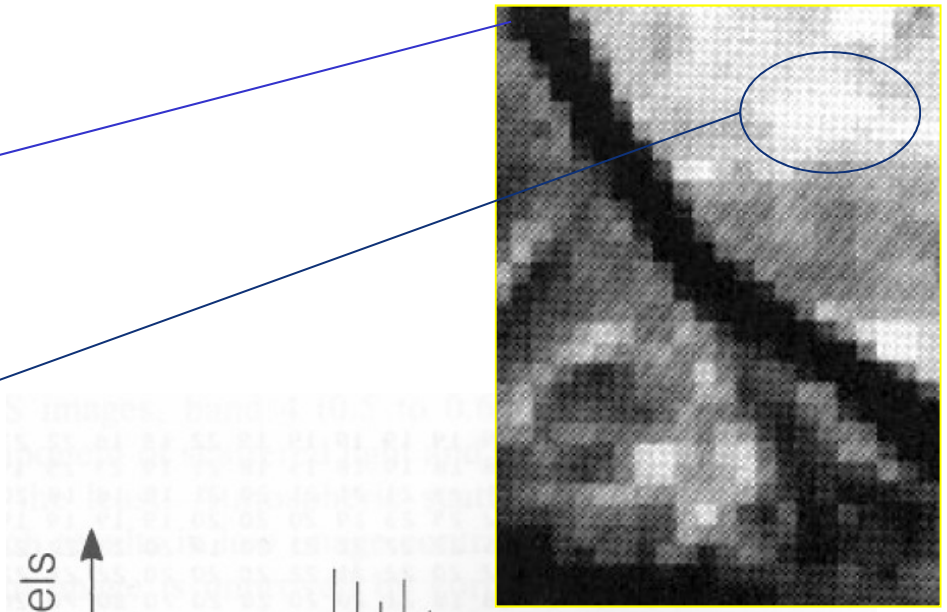


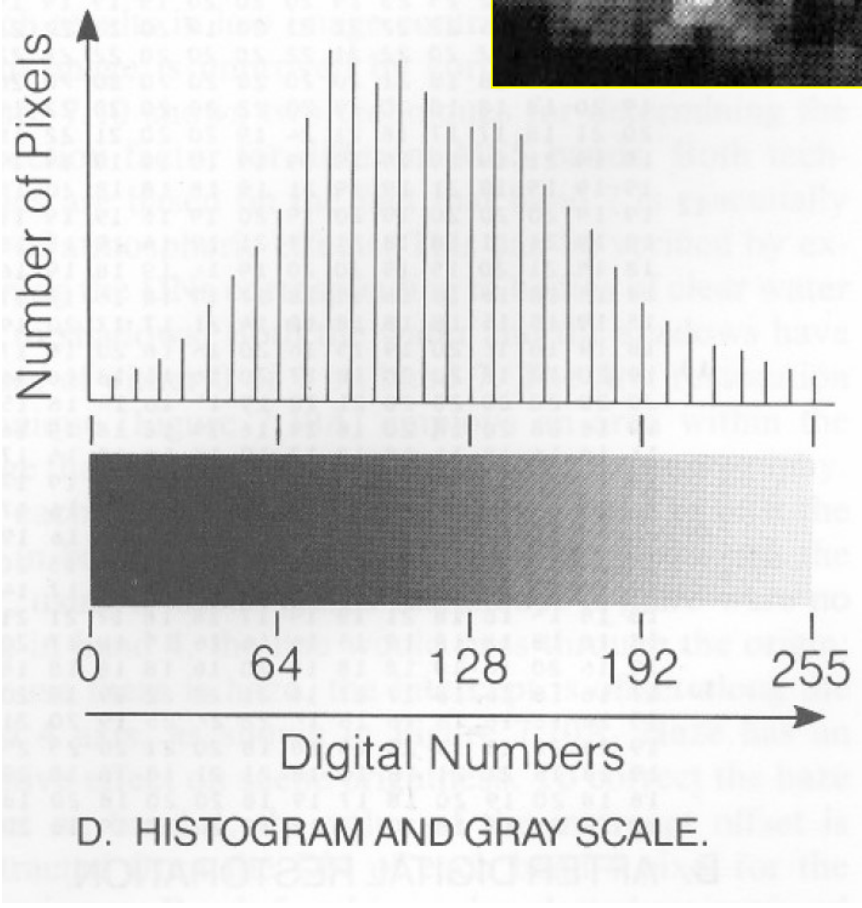
B. LOCATION MAP.

Structure of a digital image

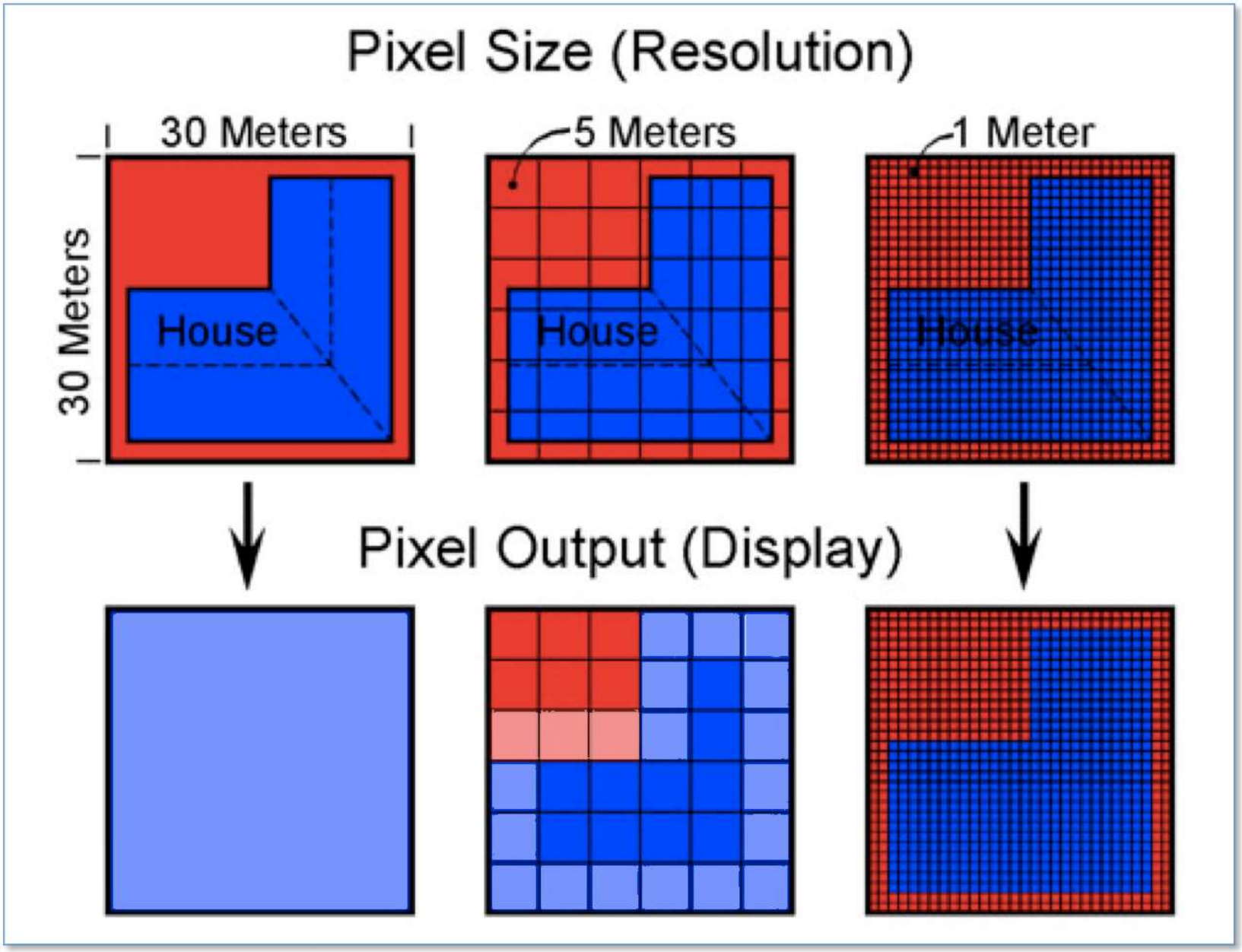


C. ARRAY OF DNs FOR THE AREA SHOWN IN THE LOCATION MAP.



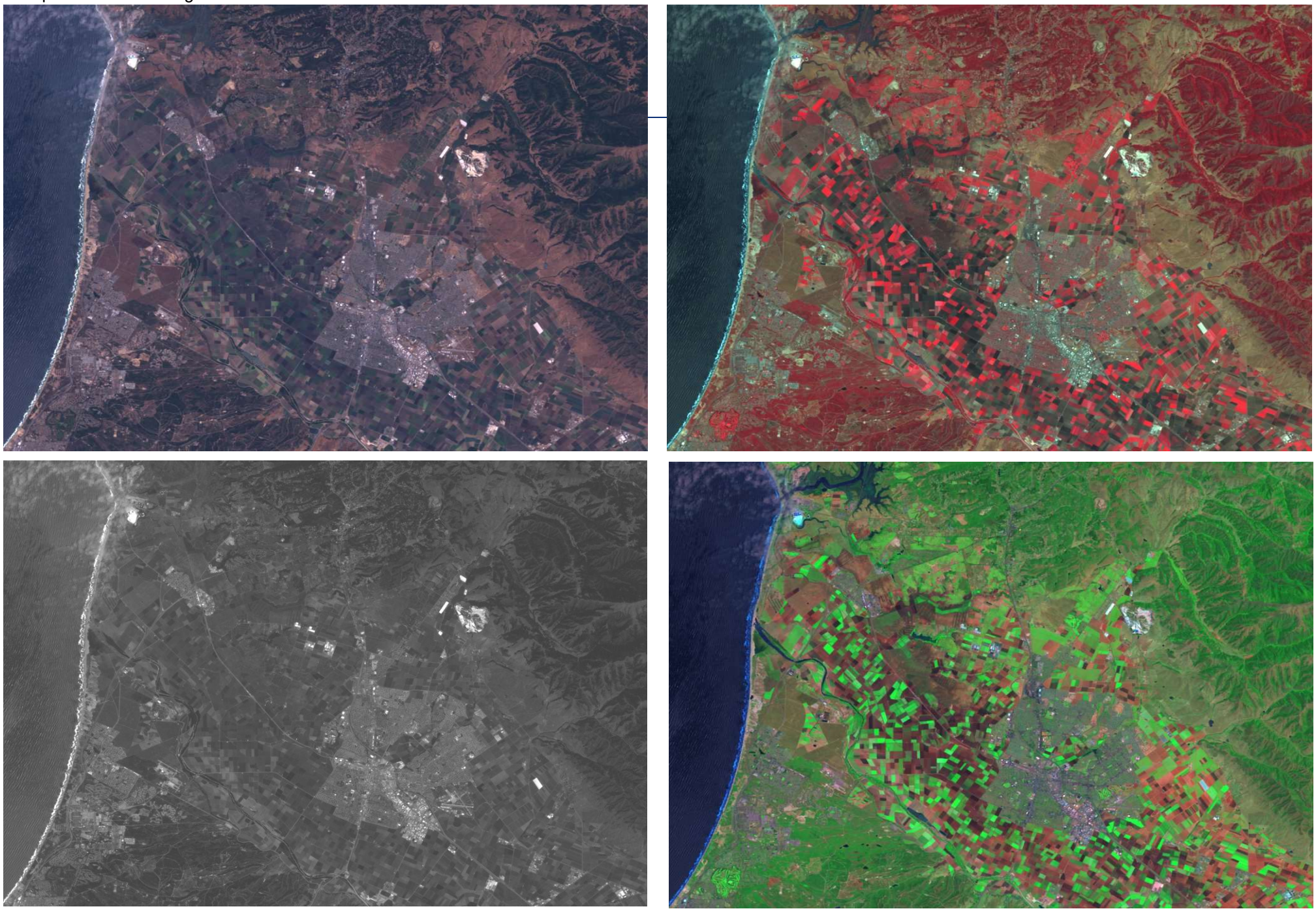


D. HISTOGRAM AND GRAY SCALE.

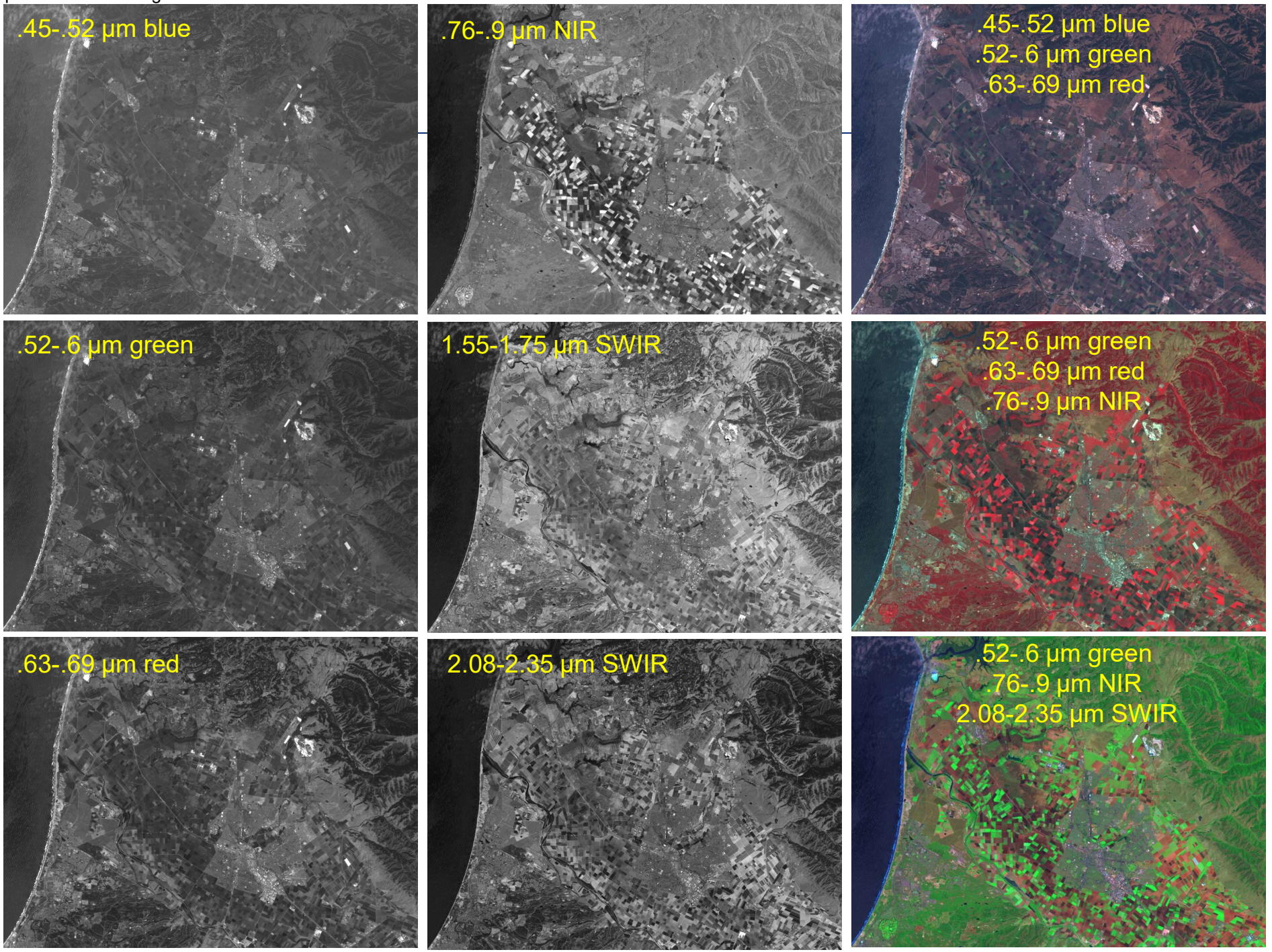


http://www.satimagingcorp.com/media/images/spatial-resolution.jpg

https://zulu.ssc.nasa.gov/mrsid/tutorial/Landsat%20Tutorial-V1.html



https://zulu.ssc.nasa.gov/mrsid/tutorial/Landsat%20Tutorial-V1.html



Primary Colors

Secondary Colors

Tertiary Colors

RGB

R

Red

G

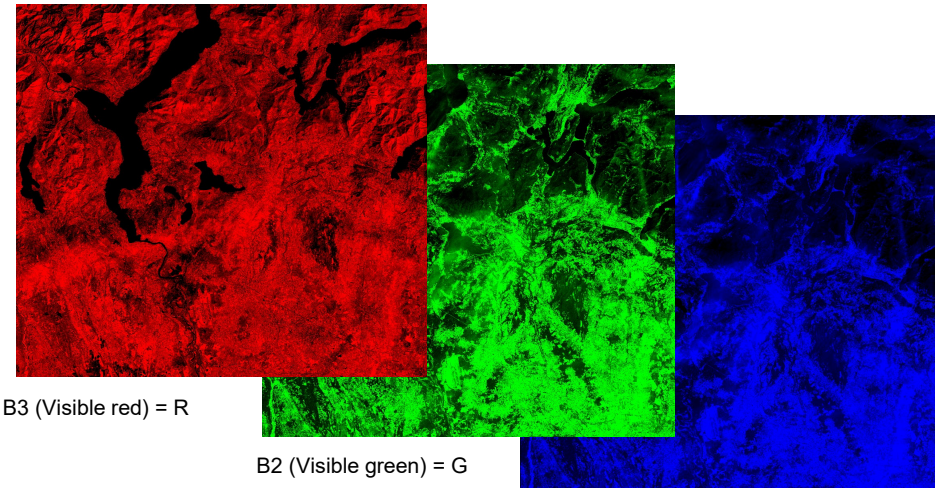
Green

B

Blue

http://upload.wikimedia.org/wikipedia/commons/3/33/Beyoglu_4671_tricolor.png
http://www.colormatters.com/color-and-design/basic-color-theory

Band combinations – and display



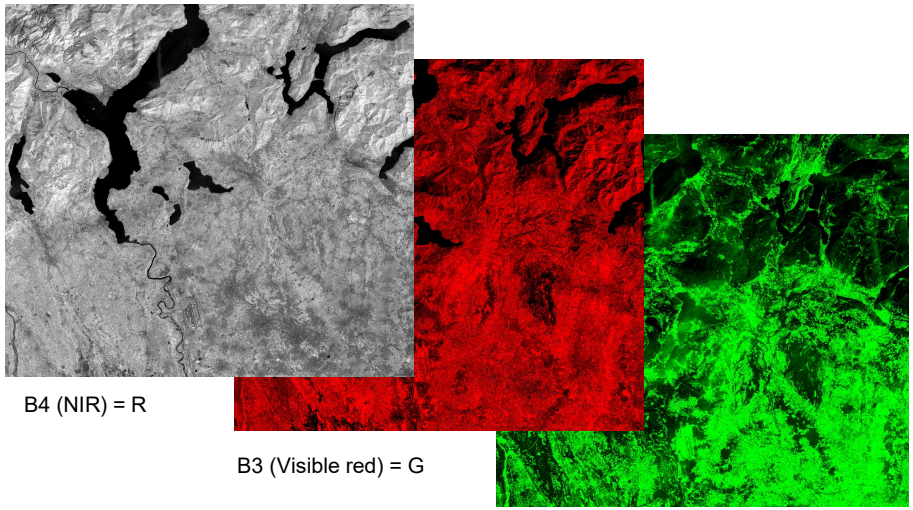
B3 (Visible red) = R

B2 (Visible green) = G

B1 (Visible blue) = B

RGB

True-Color Composite (321)



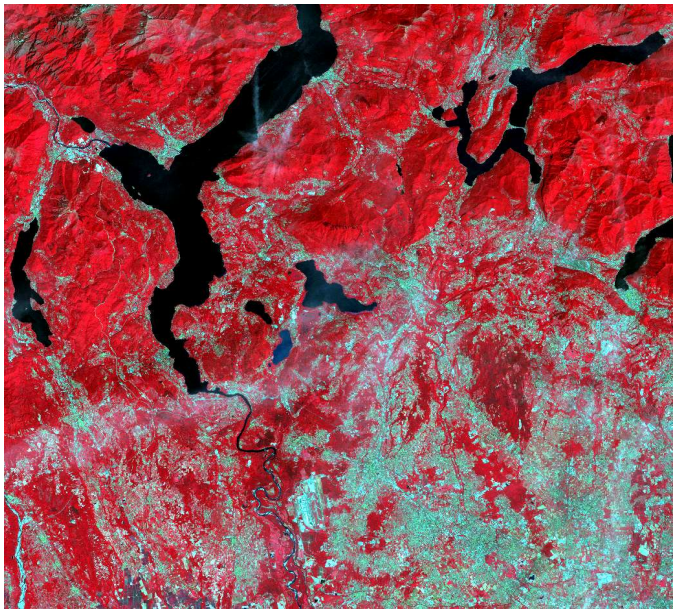
B4 (NIR) = R

B3 (Visible red) = G

B2 (Visible green) = B

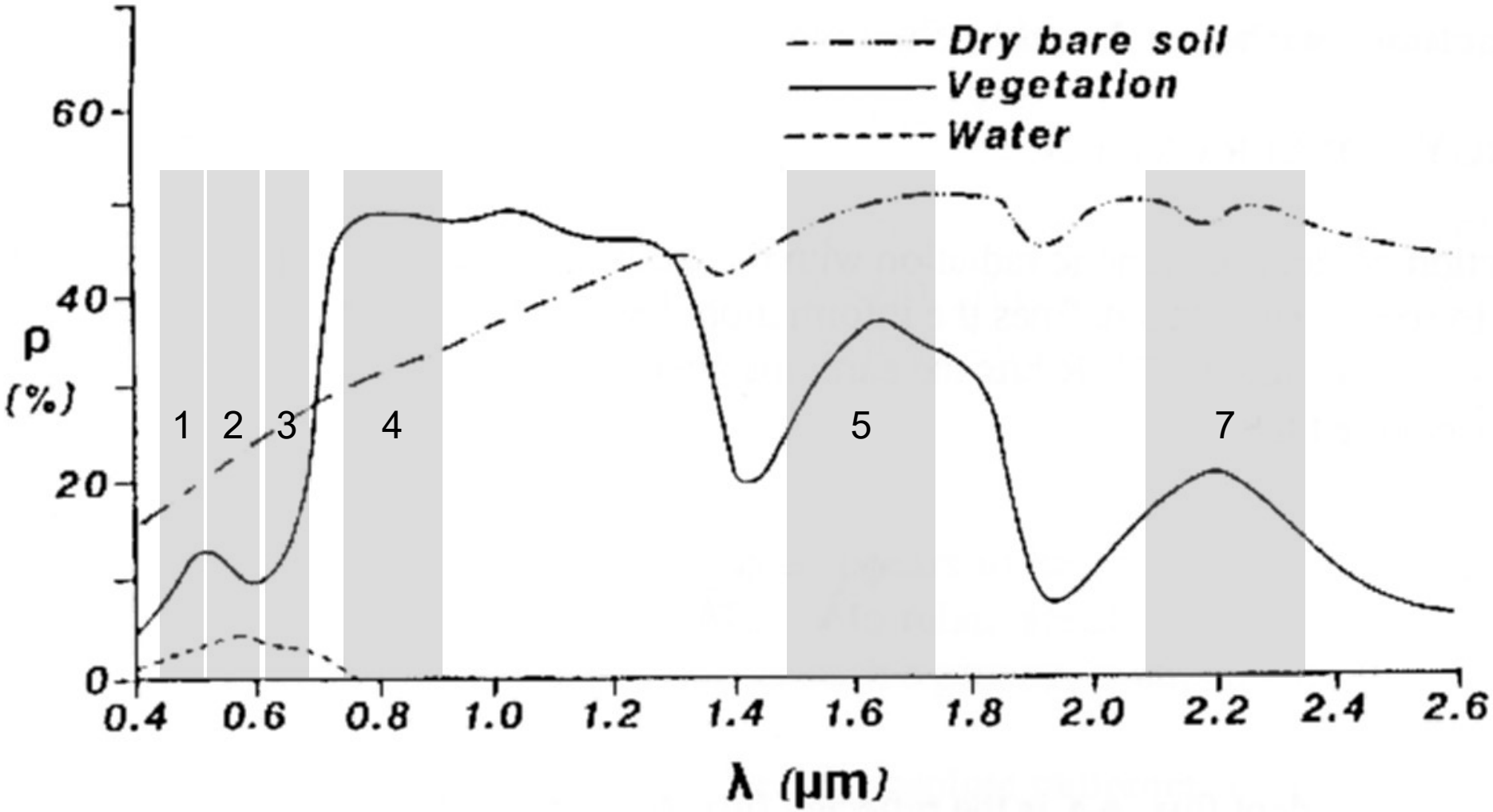
RGB

Near Infrared Composite (432)

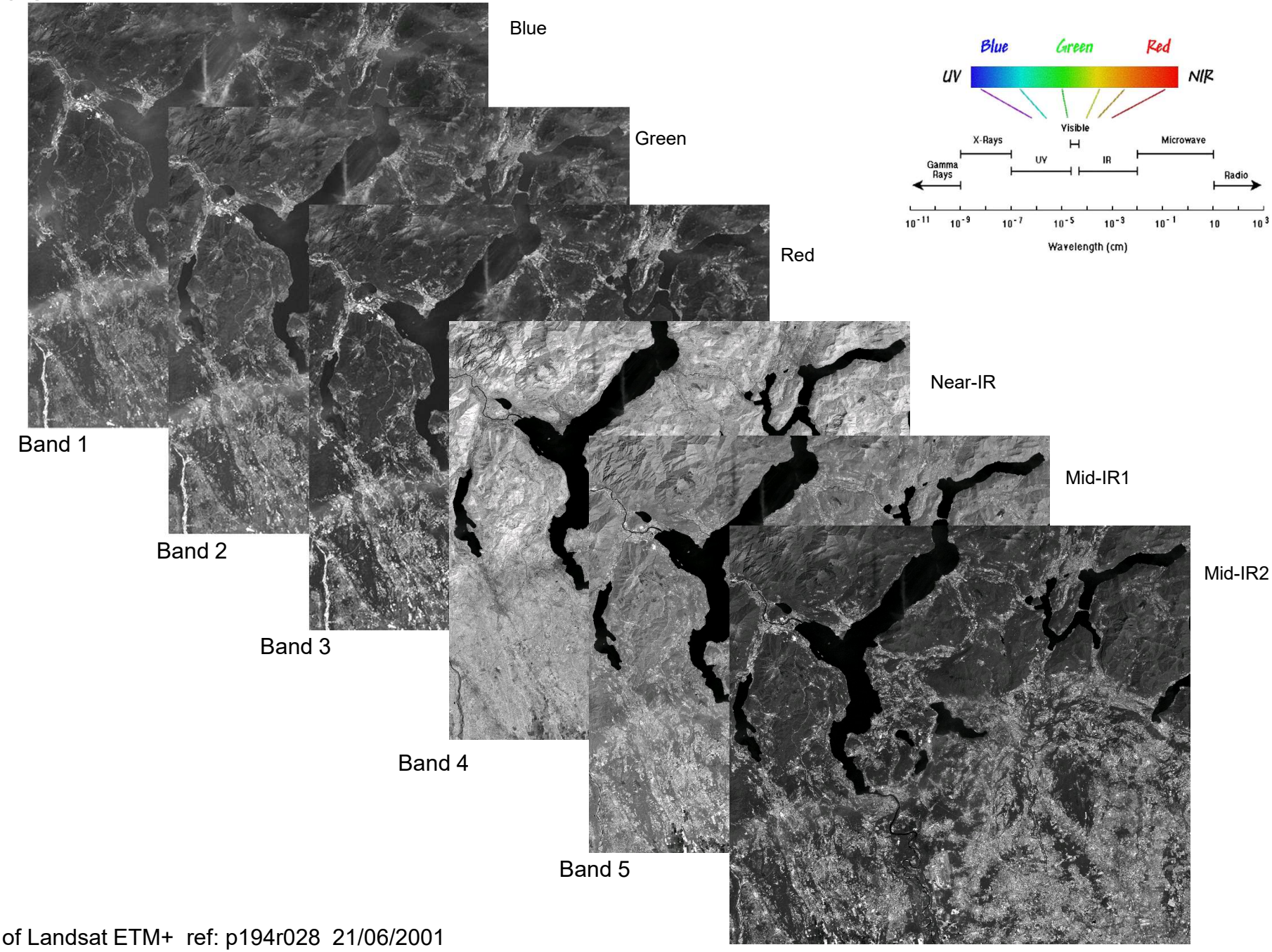


Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries edited by A. S. Belward and C. R. Valenzuela (Kluwer Academic: Dordrecht) 1991

TM bands overlaying spectral “signature” curves

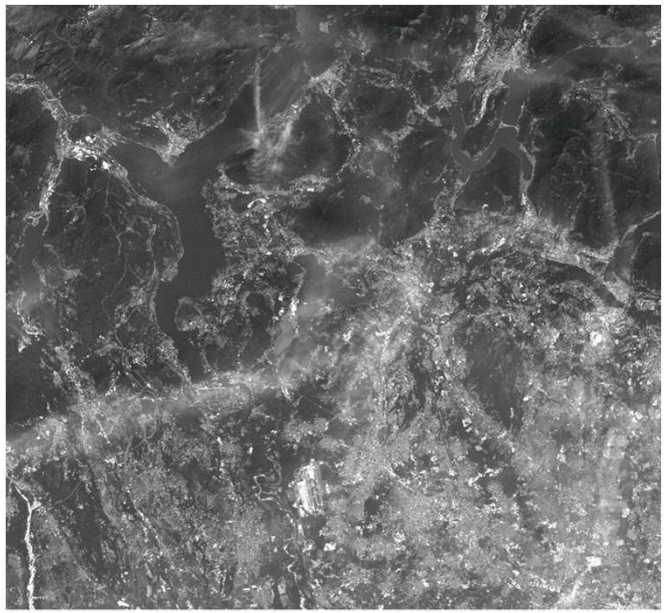


Dario Simonetti JRC

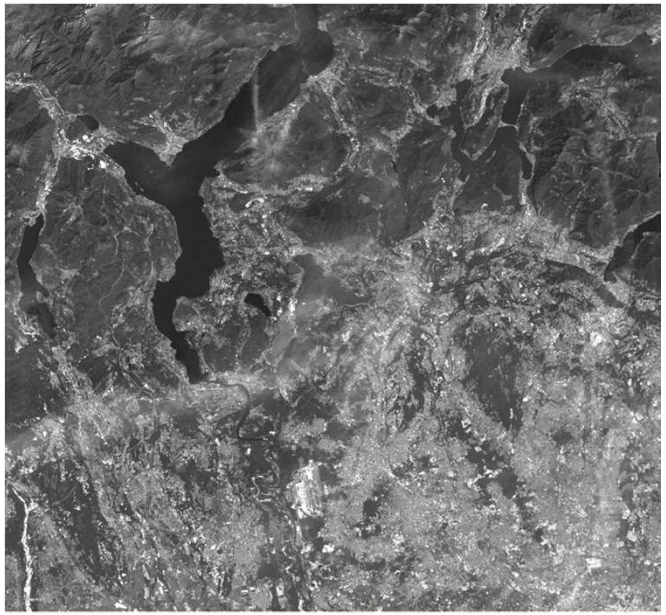


Subset of Landsat ETM+ ref: p194r028 21/06/2001

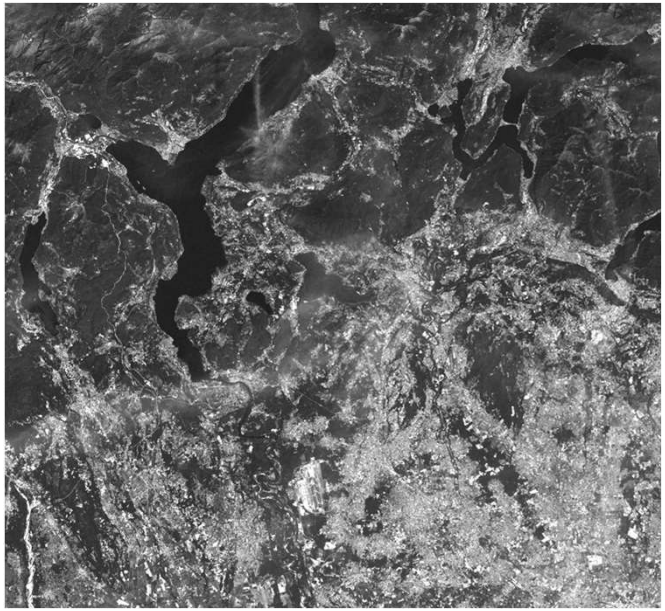
Band 1 0.450 – 0.515 µm

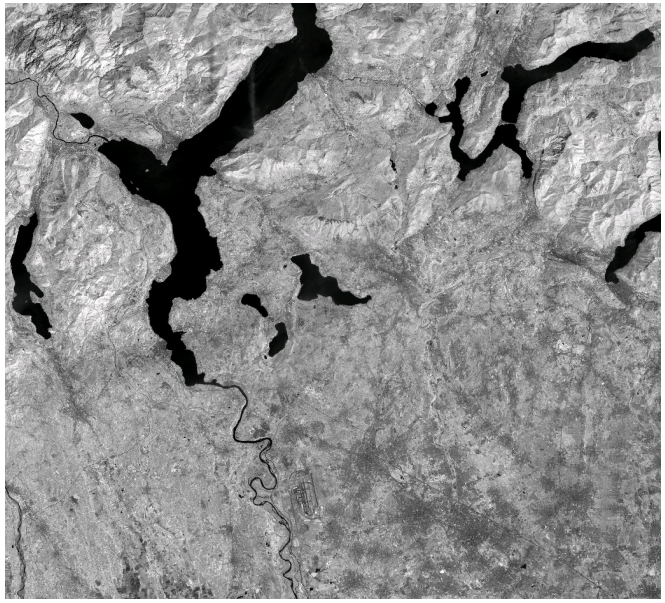


Band 2 0.525 – 0.605 µm



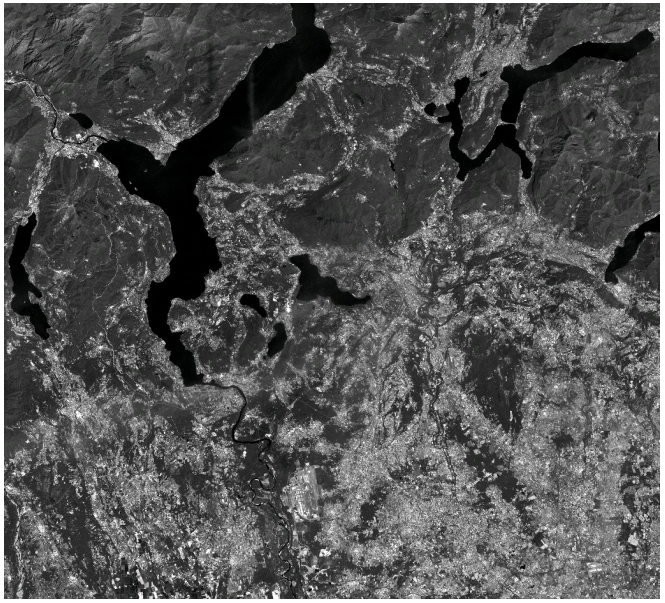
Band 3 0.630 – 0.690 µm





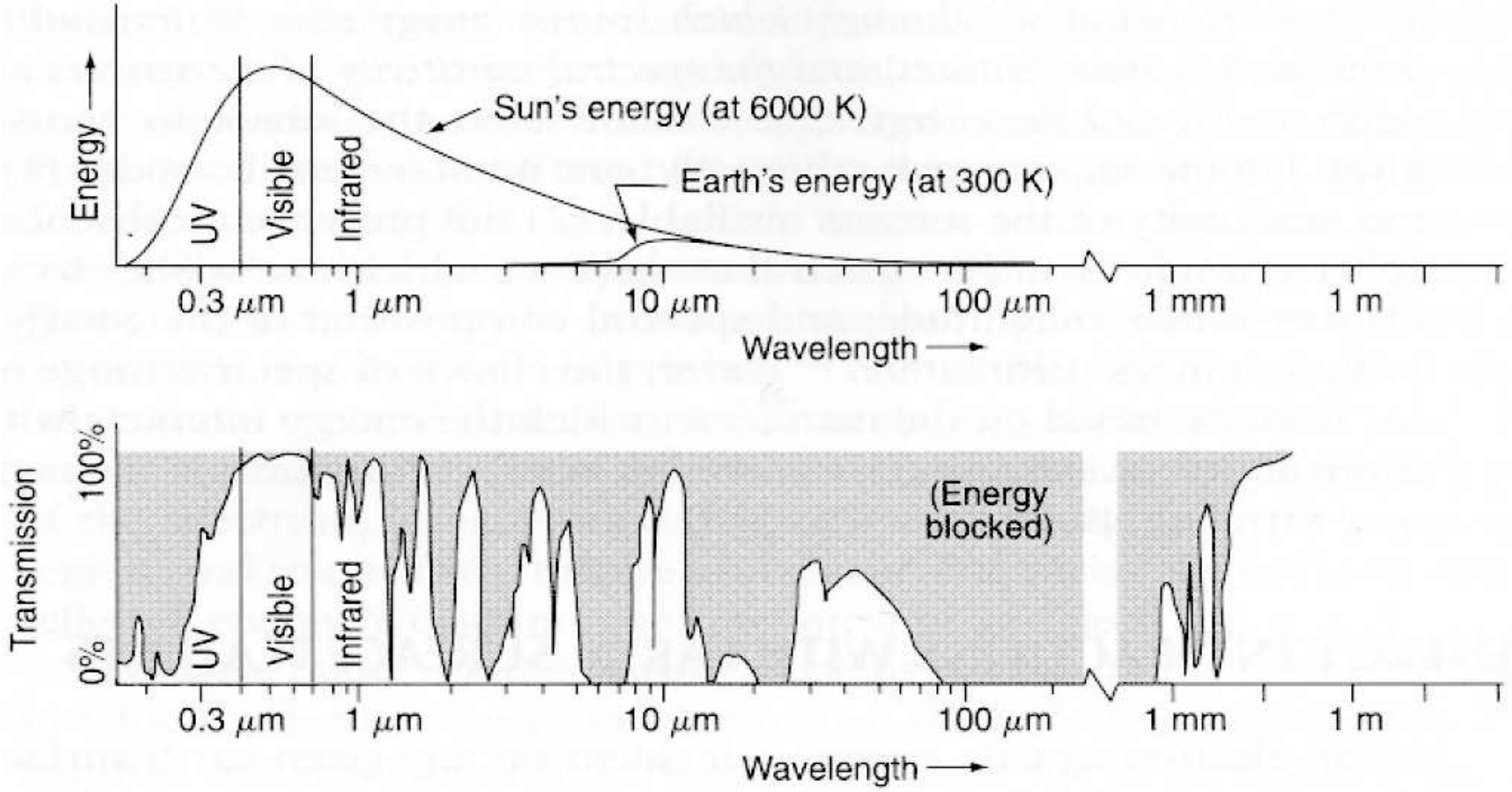
Band 4 0.750 – 0.900 µm

Band 5 1.55 – 1.75 µm



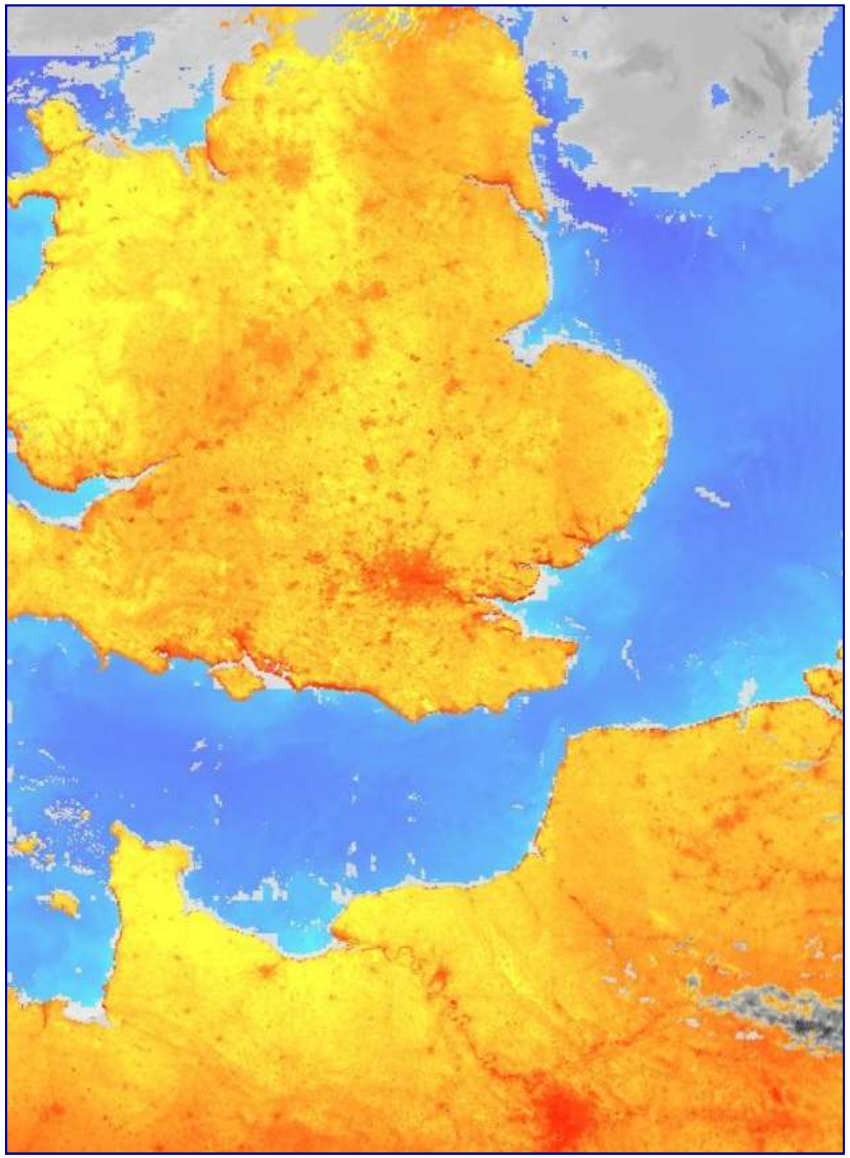
Band 7 2.09 – 2.35 µm

The thermal portion 3 to 14 µm



Options from space

- "low resolution" "meteorological" satellites
  - Typically in the order of 1 km measurements
- Sea Surface Temperature, Land Surface Temperature Cloud top temperature, evapotranspiration and fire monitoring are among key applications

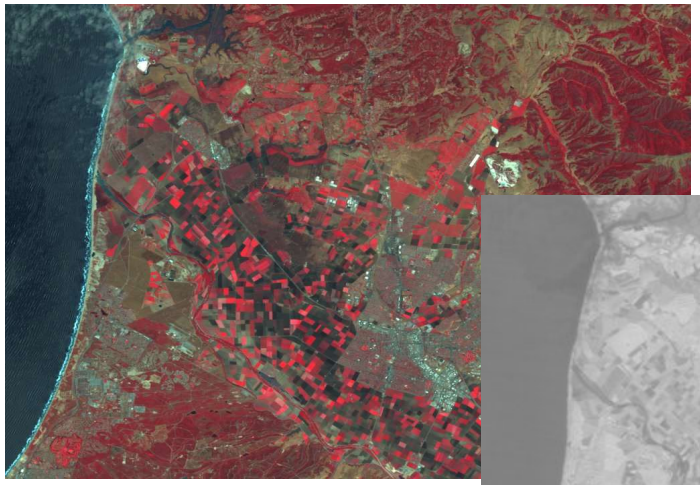


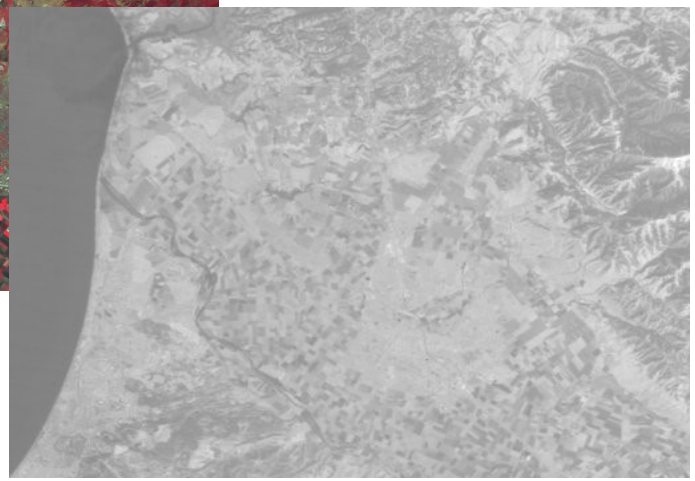
AATSR LST image of Southern UK and Northern France obtained on 16 July 2005 (night-time) Source ESA

https://zulu.ssc.nasa.gov/mrsid/tutorial/Landsat%20Tutorial-V1.html
http://asterweb.jpl.nasa.gov/gallerymap.asp

Options from space

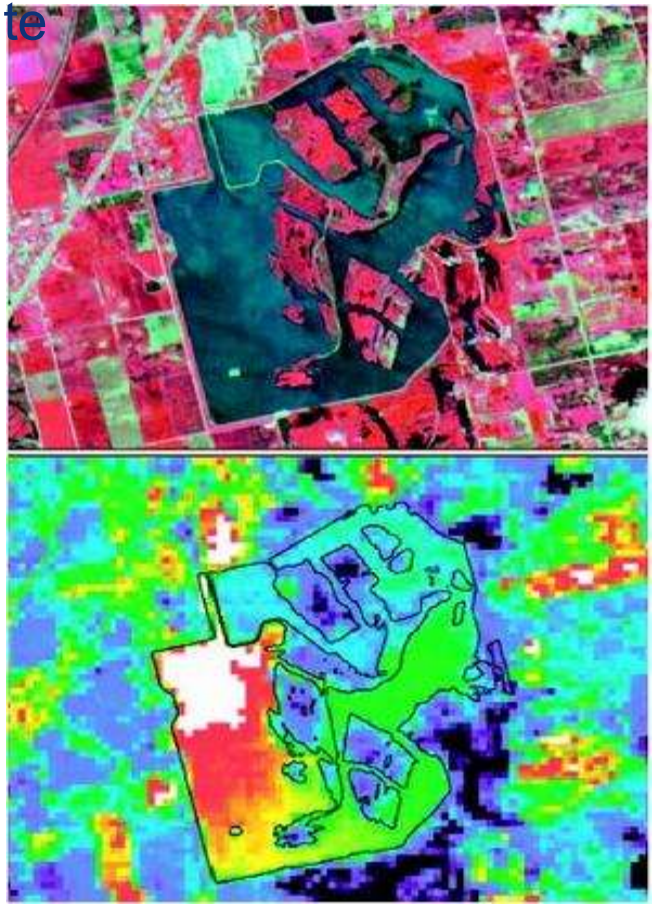
- "moderate to high resolution" environmental satellites
  - Typically less than 100 m
  - Landsat Thermal, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on the Terra satellite



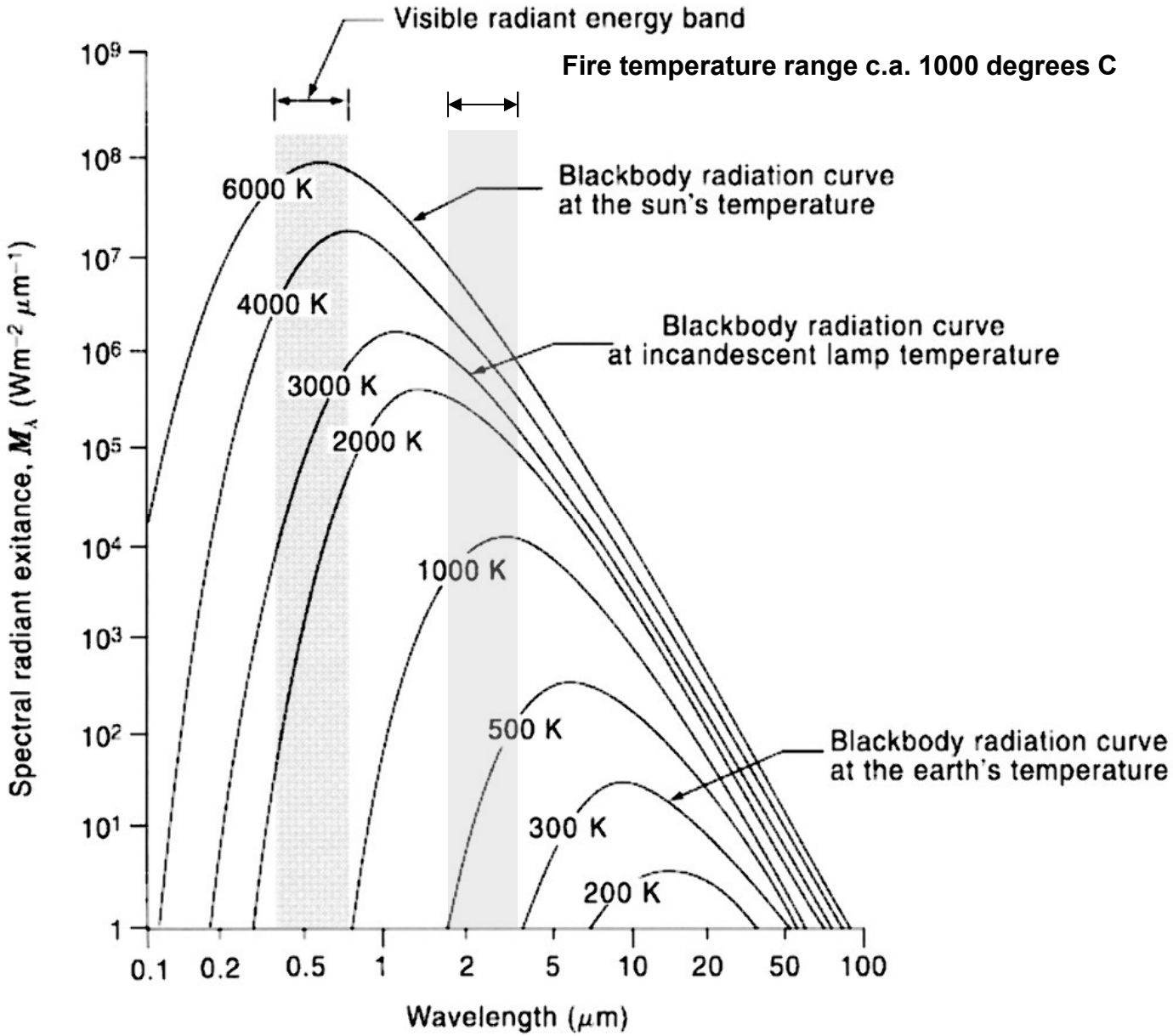


Landsat's thermal channel *cf* False Colour Composite

Joliet 29, a coal-burning power plant in Illinois: ASTER Thermal Infrared band was color-coded to represent heat emitted from the surface. The progression from warmest to coolest is shown with the following colors: white, red, orange, yellow, green, blue, and black. (Image courtesy NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan Aster Science Team



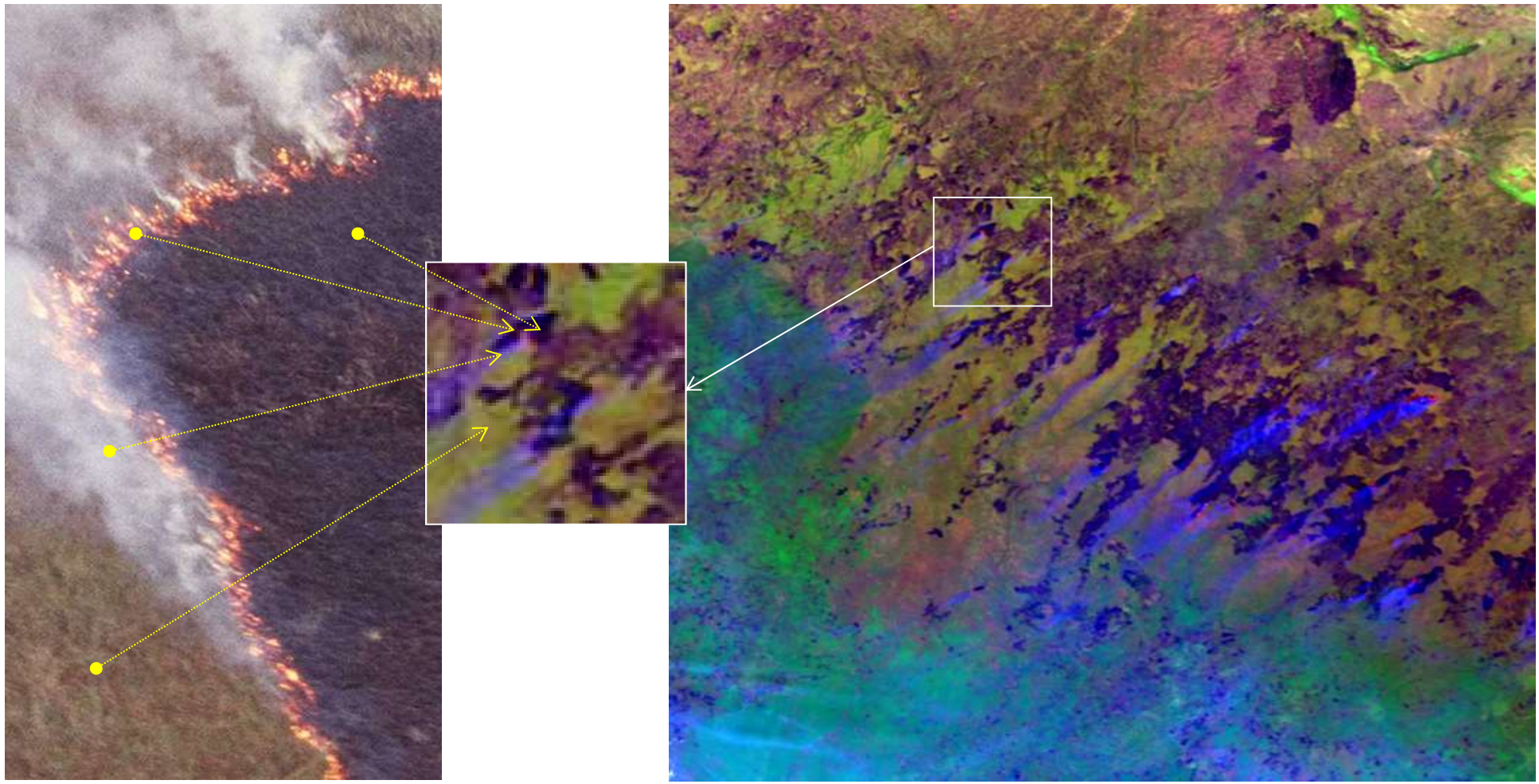
Relationship between M_λ and λ for objects at different temperatures



Active fire detection, burnt area measurement

Helicopter view

SPOT-VGT 1 km resolution – RCA Sudan border - ~ 500 km x 500 km



Source J-M. Gregoire

Another perspective, new rules…

http://i196.photobucket.com/albums/aa32/sajro/Rain.gif
http://earthsci.org/processes/weather/weaimages/ccprcess.gif

Tobacco smoke particles are typically 0.1 to 1 micron

- A totally different scale to optical – up to a million times bigger
- Interactions at the “structural” scale, rather than cellular/molecular scale

0.02 mm = 20 µm

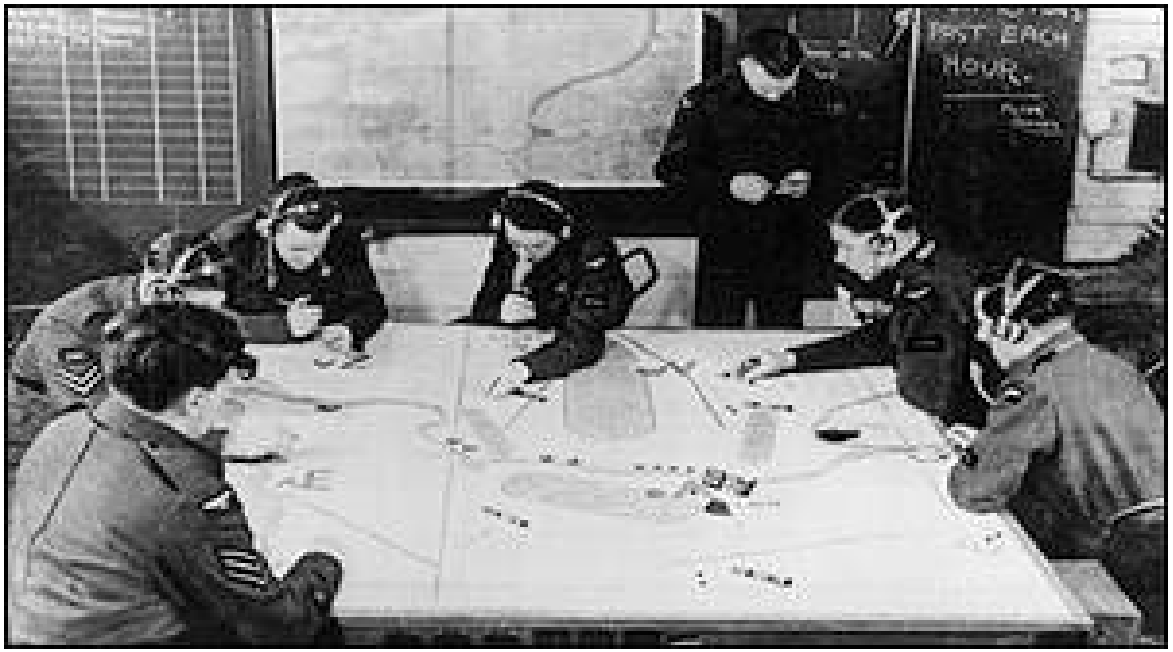
2 mm = 2000 µm

0.02 mm

2 mm

Active microwave remote sensing

- RAdio Detection And Ranging (RADAR)

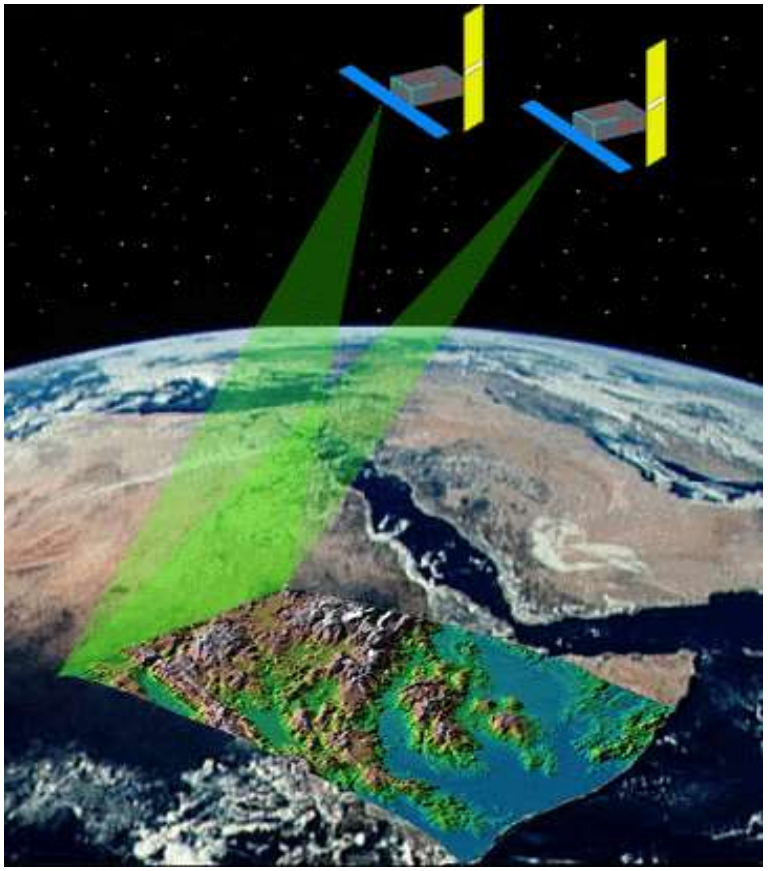


- Detects objects, determines distance away from EMR source, and the angular position

http://news.bbc.co.uk/1/hi/uk/825656.stm

Radar

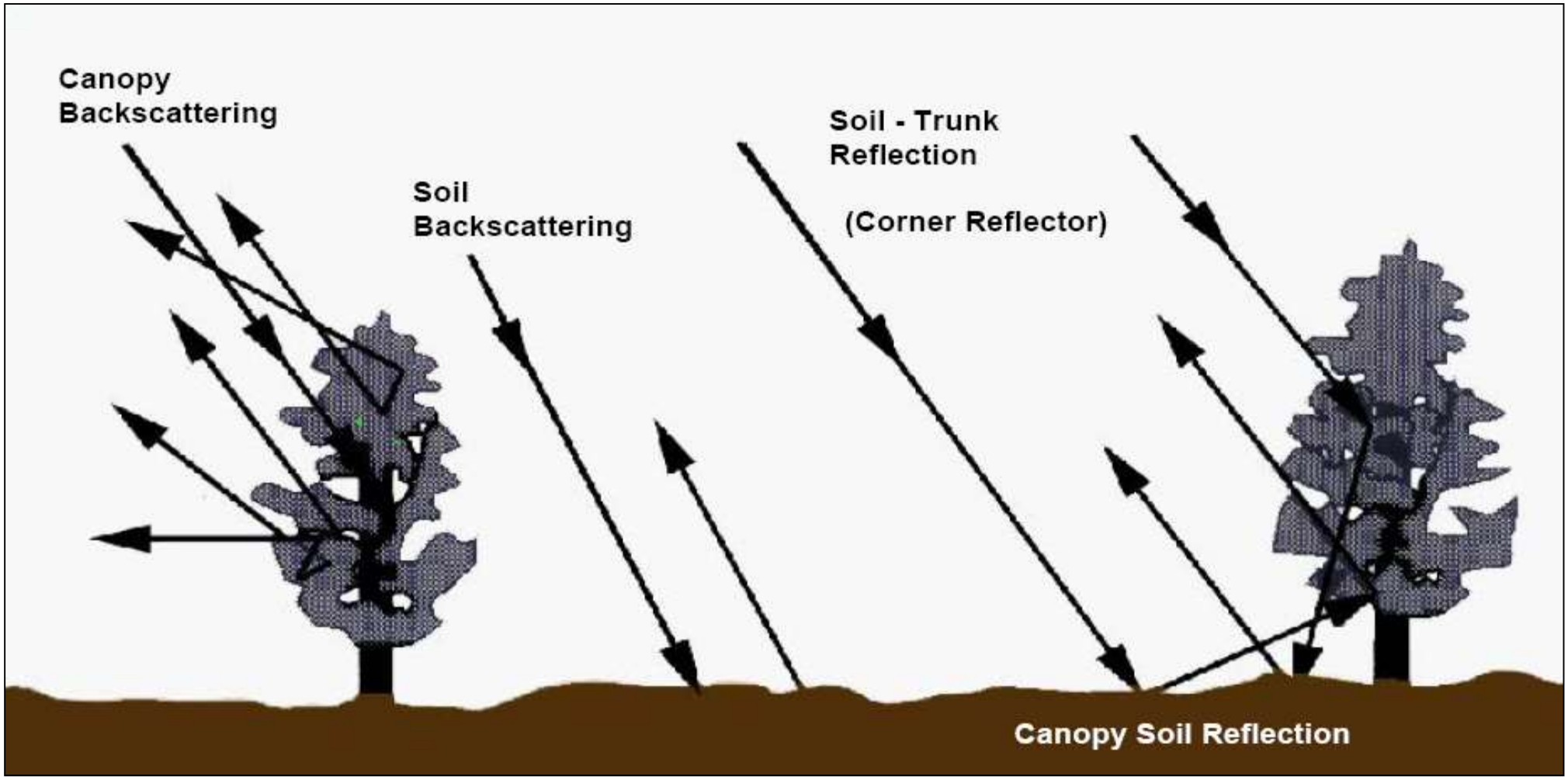
- Antenna slung below the platform and pointing to one side
  - Side Looking “airborne” Radar (SLAR) and Synthetic Aperture Radar (SAR) are the common systems
  - It transmits microwave EMR towards the earth’s surface
  - It receives that portion of the transmitted energy which is reflected – backscattered - from the surface to the antenna
  - It records the strength –amplitude- of the returned signal and the time…(because c is constant this can then be translated into distance from the antenna)
- As the platform progresses it accumulates observations…i.e. a strip is ‘illuminated” to one side of the platform



http://www.stanford.edu/group/radar/group.html

Volume scattering

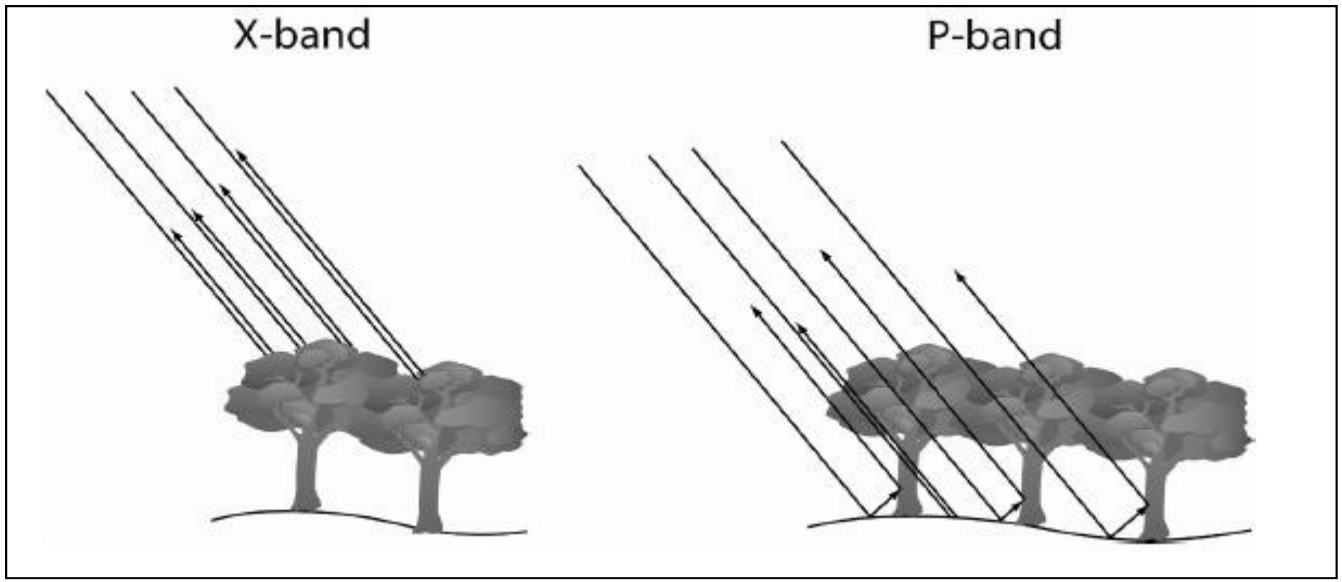
Radar remote sensing tutorial from the
Canada Centre for Remote Sensing
http://www.ccrs.nrcan.gc.ca/resource/tutor/
gsarcd/index_e.php



Geometric characteristics

http://forsys.cfr.washington.edu/JFSP06/radar_overview.htm

- Leaves, stems, branches, trunks, canopies, gaps in canopies
- Soil clods, plough furrows, terraces, land form and topography
- Water body waves and surfaces, snow fields, ice sheets…
- Man-made structures (smooth roads, sharp angles of buildings, metal objects)



Summary

- The fate of a photon depends on its energy level, what it interacts with and when
- Spectral reflectance properties of objects can be used to differentiate between objects and to monitor changes in the state and condition of an object over time
- Understanding spectral properties is the key to interpreting remotely sensed data