Remote Sensing

David Orme

October 23 2016

Overview

1. Remote sensing concepts
2. Resolution:
   - Spectral
   - Spatial
   - Temporal
3. Earth observation products

Mapping landscapes manually

Pros

- Very fine level of detail

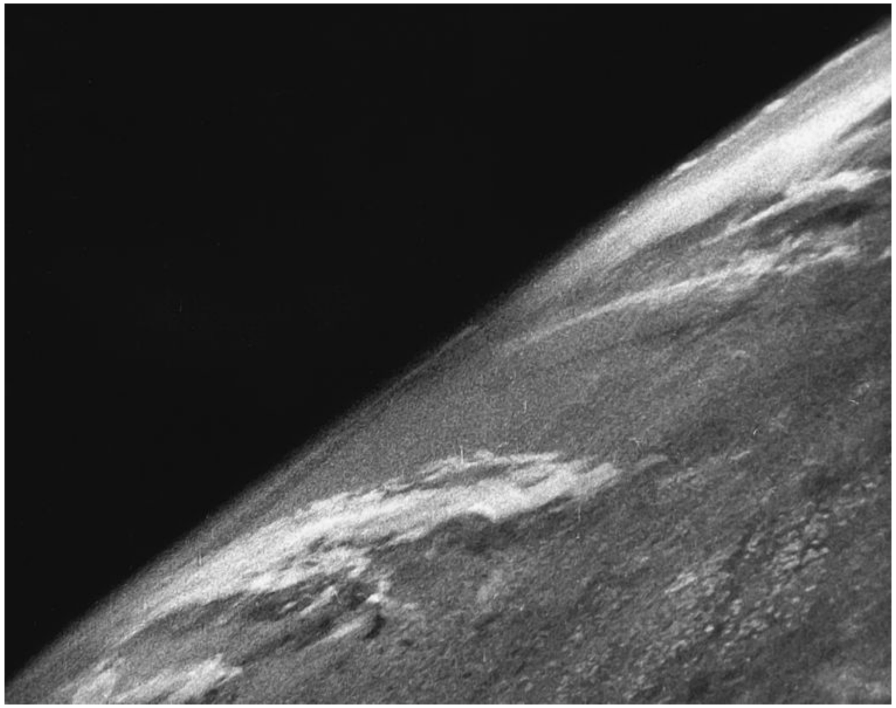
Cons

- Expensive
- Slow
- Inconsistency between locations and sampling periods

Maps from images

Aerial photography (1900s)

Using satellite imagery (1950s)



Remote sensing

Remote sensors can be:

Passive: sense reflected solar radiation

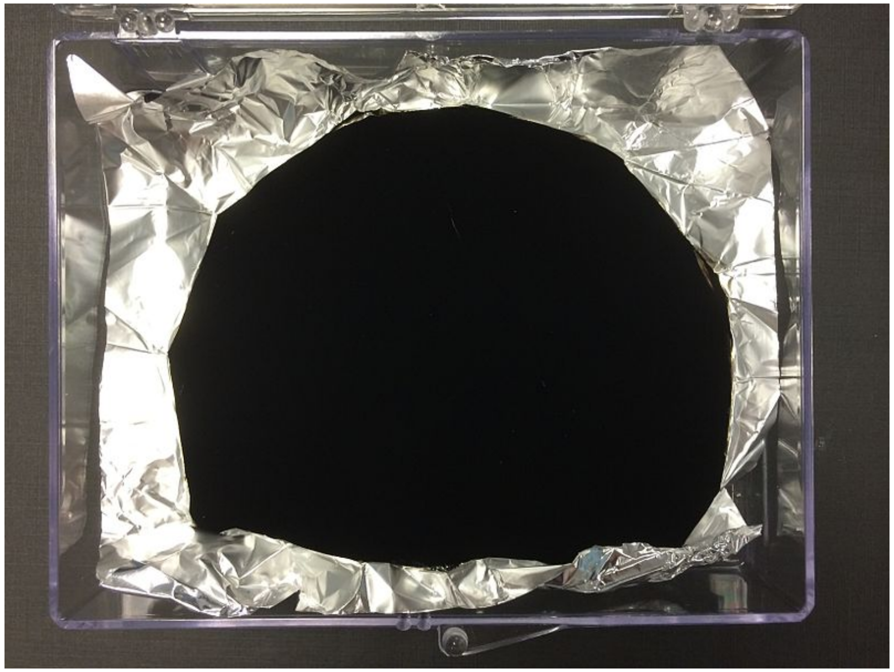
Active: emit and sense reflected

- LIDAR (light)
- RADAR (microwaves)
- Alteration in reflected light
- Trip time gives heights

Reflectance

Albedo: the proportion of radiation reflected from a surface
Note that texture and angle **strongly** affect albedo.

Snow



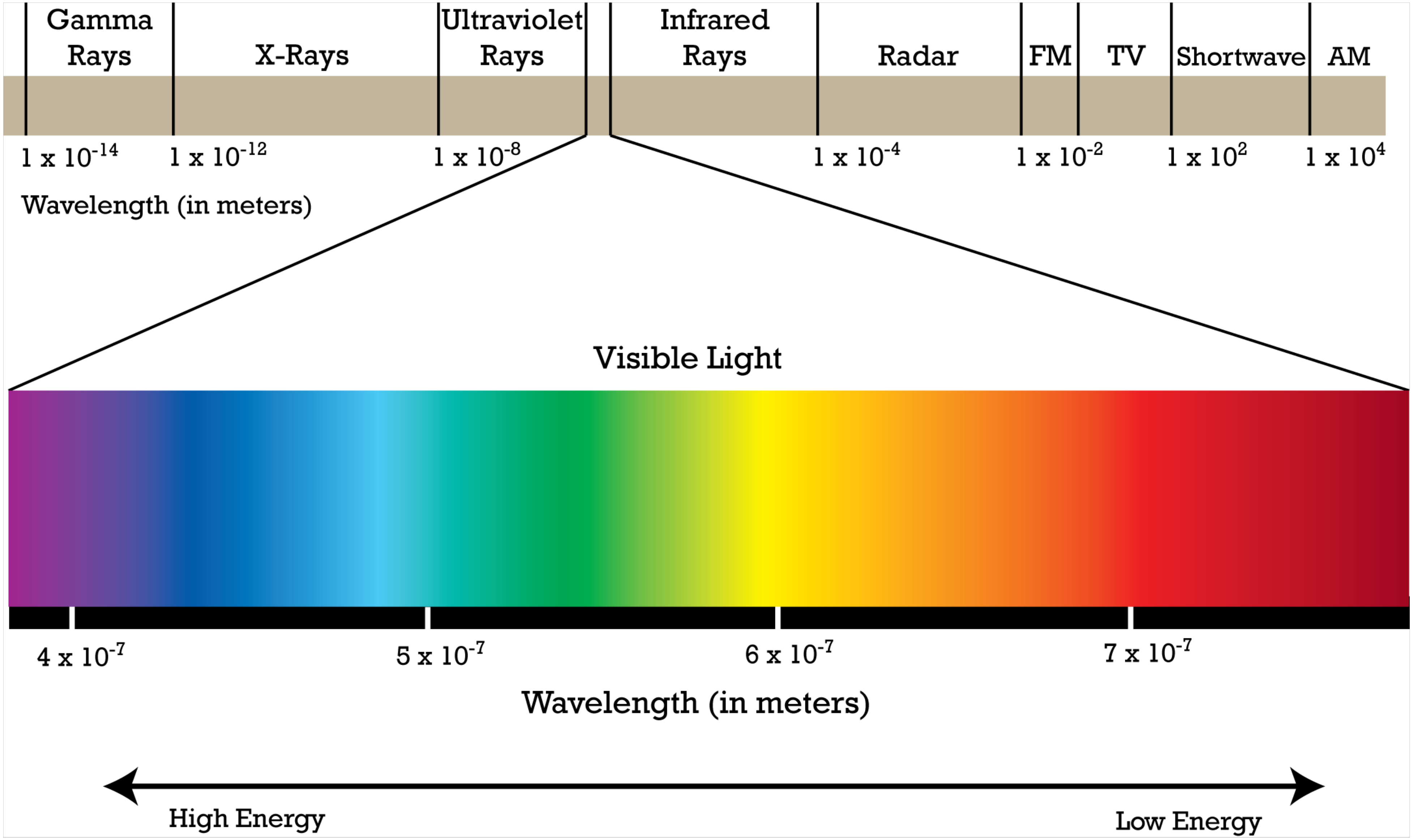
Vantablack

Reflectance

Monochrome images

- Different objects have different albedo
- Construct maps by looking at contrast, texture and edges

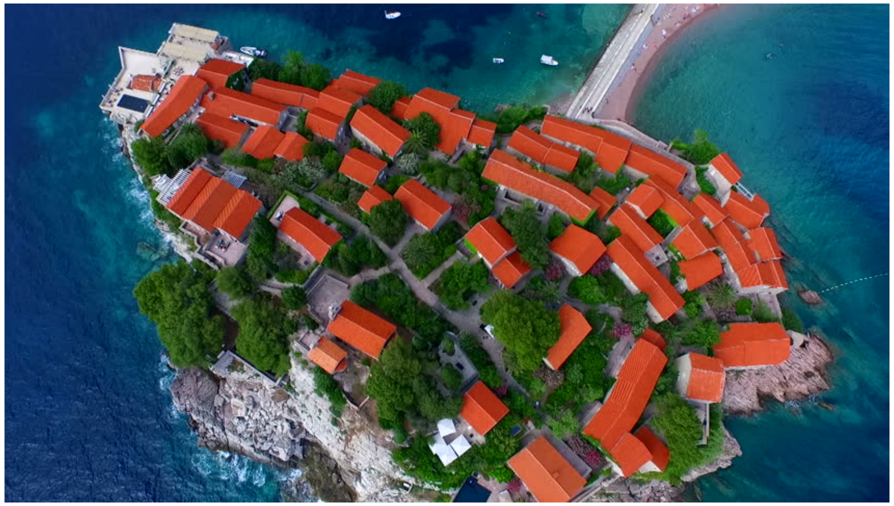
Electromagnetic spectrum



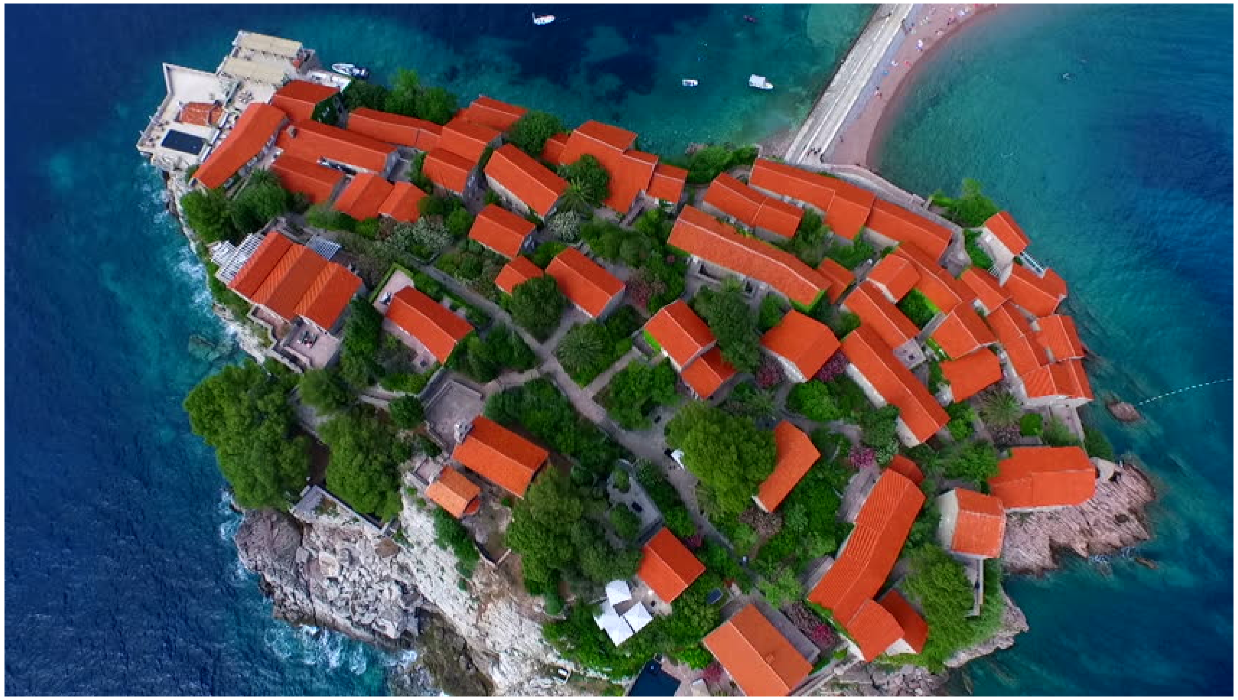
Reflectance

Multispectral images

- The albedo of a surface varies with the wavelength of the radiation
- Different surfaces have different reflectance profiles
- Composed of multiple layers recording reflectance in different wavelengths

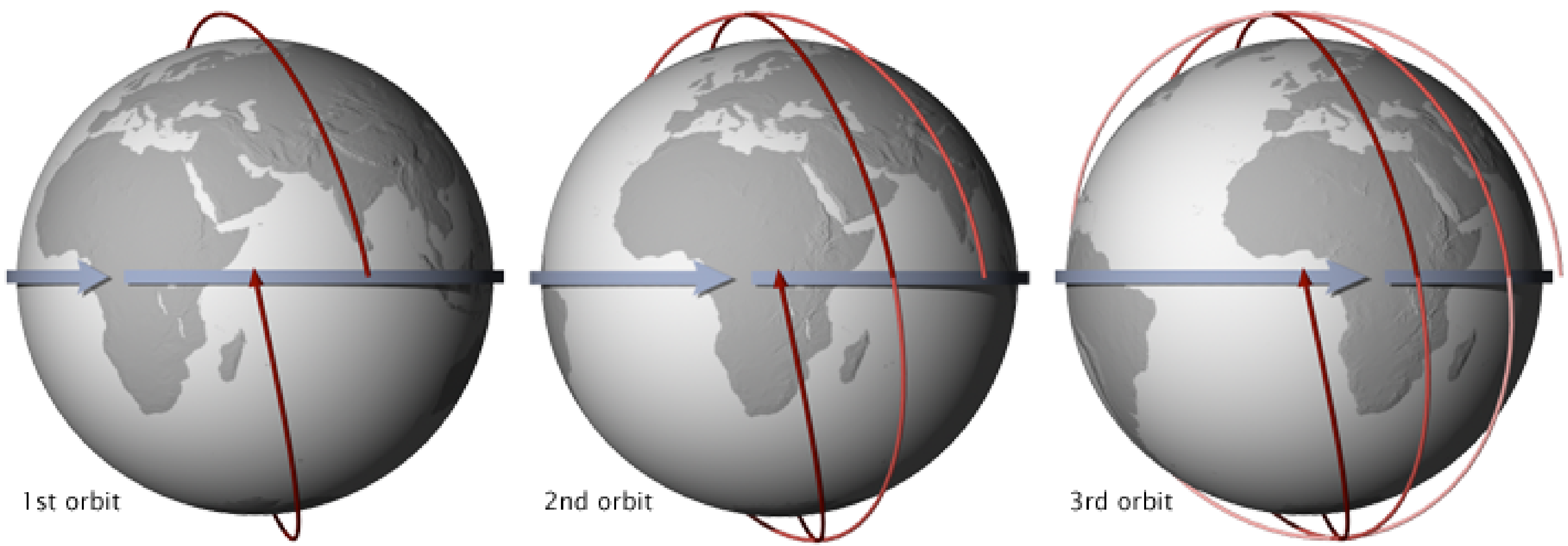


Reflectance



Satellite orbits

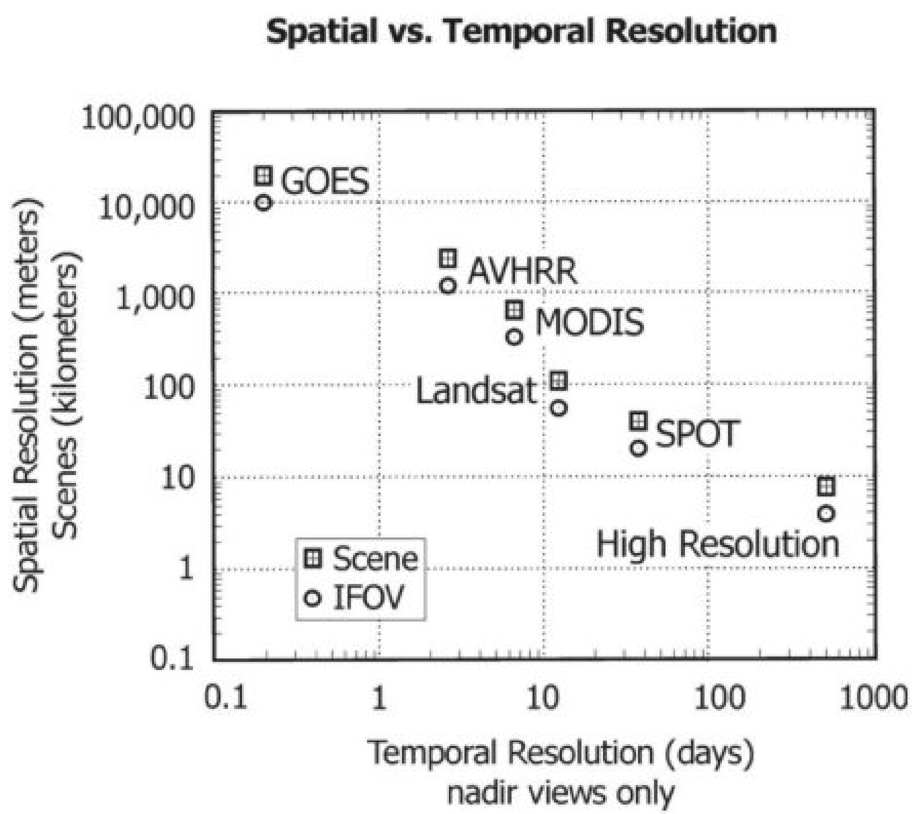
- High earth geostationary orbits (weather satellites),
- Mid earth orbits (navigation and communications)
- Low earth orbits (earth observation) including :
- **Sun synchronous** orbit, controlling the time of day of observation.



Spatiotemporal resolution

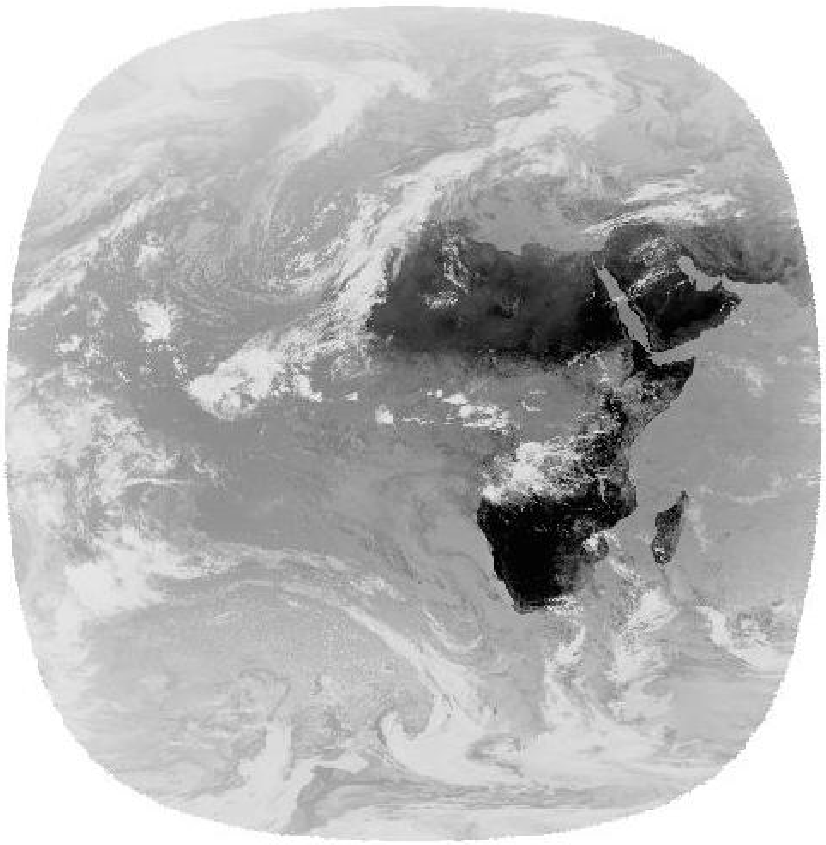
Low earth orbits:

- Close to the planet
- High spatial resolution
- Narrow path widths
- Small scenes
- Less frequent images
- Satellite **constellations** can increase temporal resolution



Spatiotemporal resolution

To put it another way:

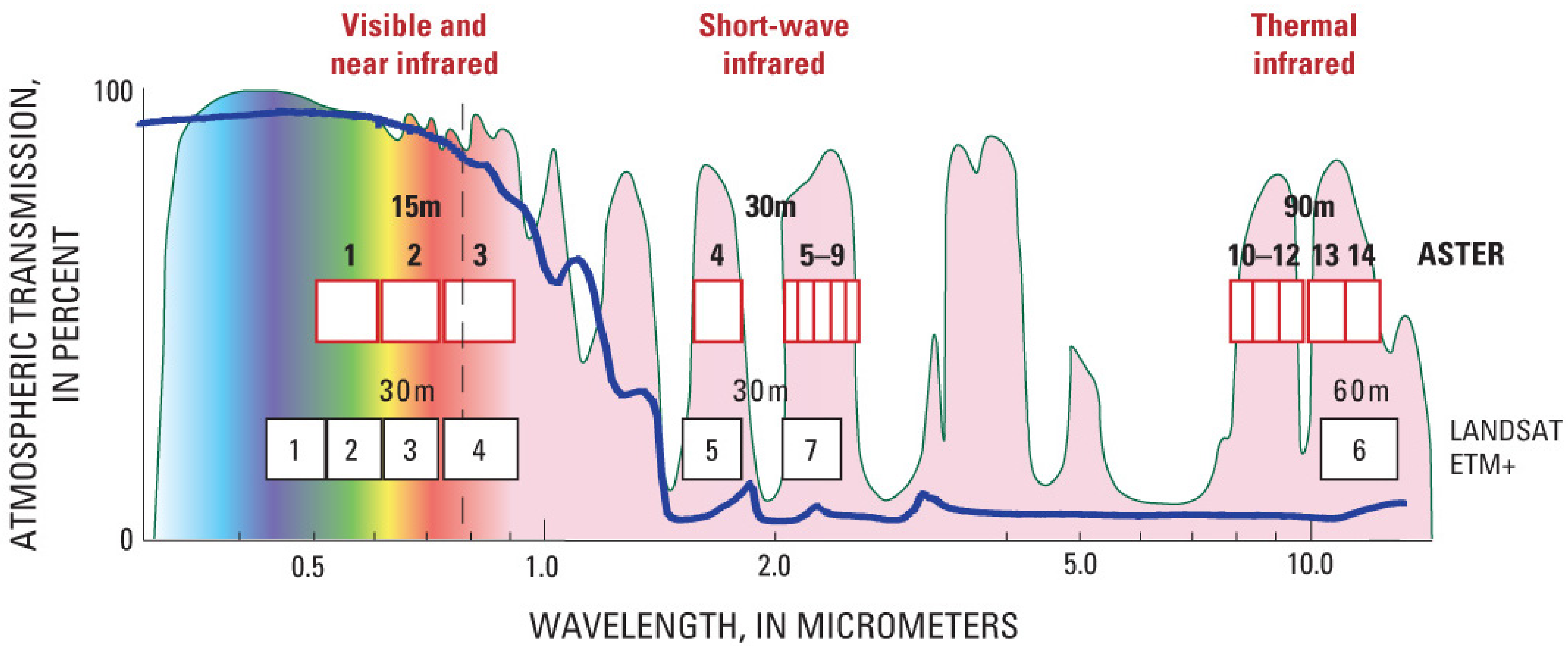


HEO: Meteosat

LEO: Pleiades

Spectral resolution

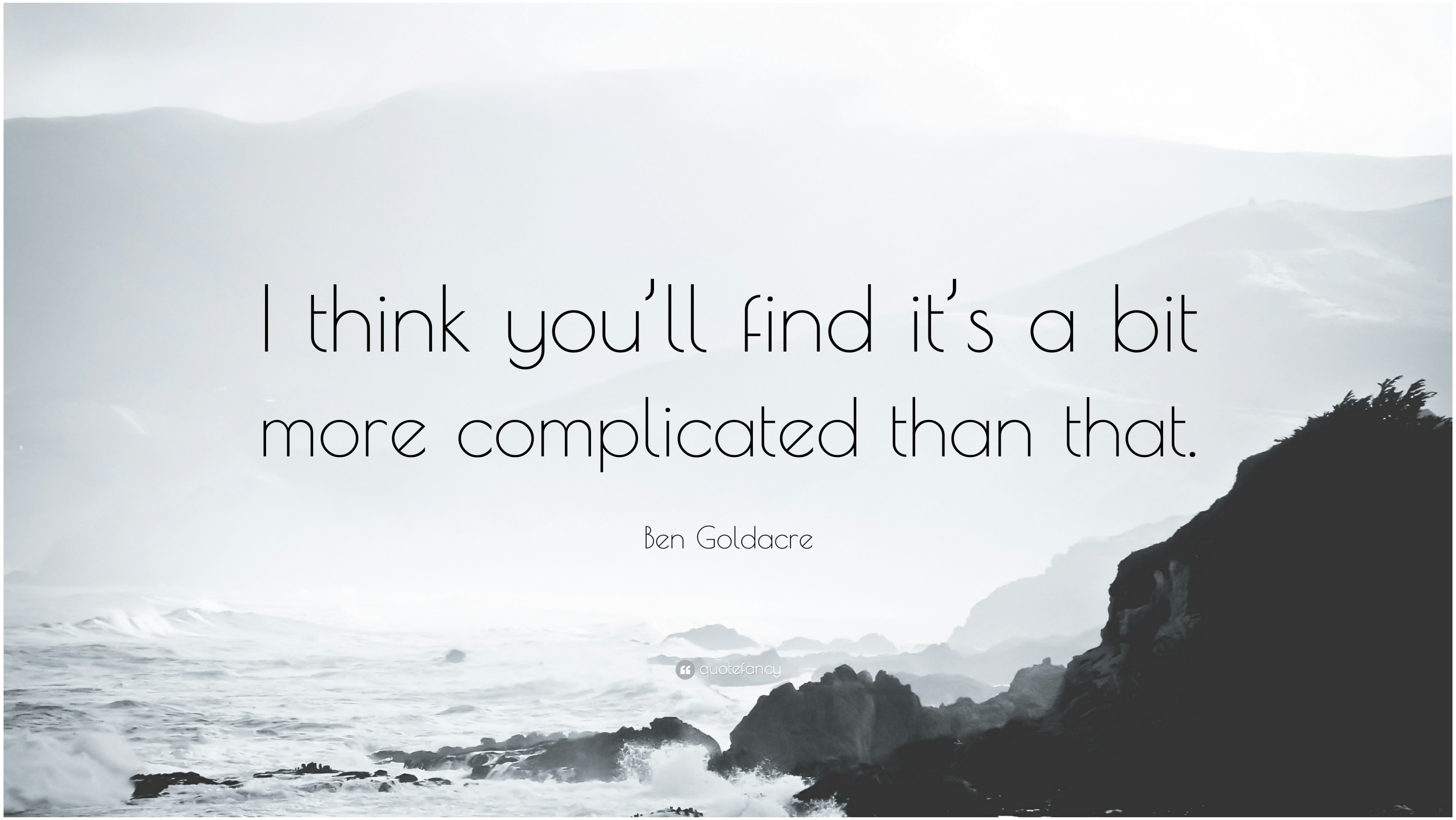
- Determined by the satellite mission
- Constrained by absorption of radiation by the atmosphere
- Light gathering sets resolution and band width



Example platforms

Satellite	N	Bands	Revisit	Resolution (m)
Pleiades	2	5	1 day	2 / 0.5
Rapid Eye	5	5	1 day	5
Spot 7	1	5	2 - 3 days	6 / 1.5
ASTER	1	14	16 days	90 / 30 / 15
Landsat 8	1	11	16 days	100 / 30 / 15
MODIS Terra	1	36	1 - 2 days	1000 / 500 / 250

Using satellite images

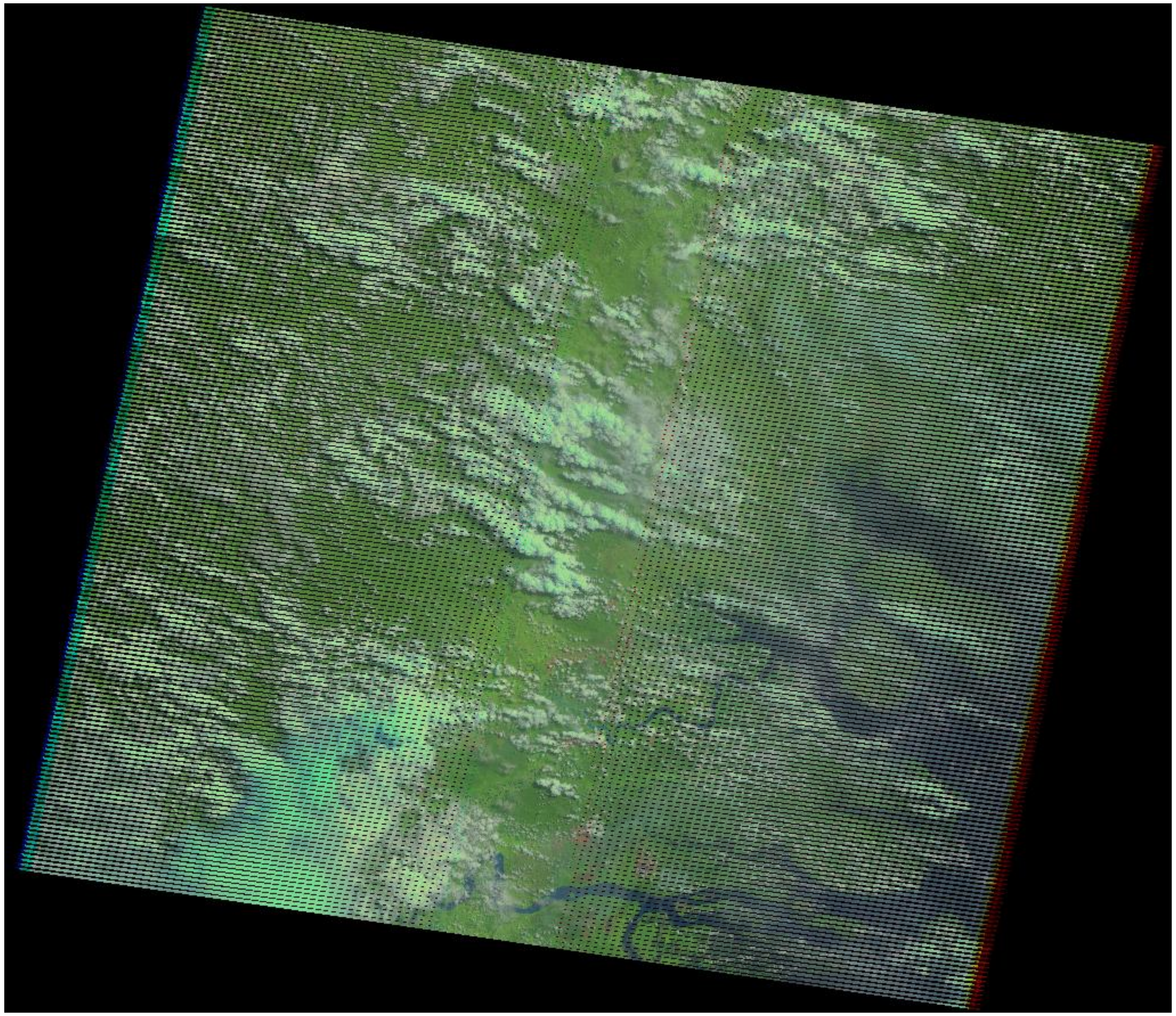


Using satellite images

Multiple steps may be needed to use data:

- **Georeferencing**: where is the image?
- **Orthorectification**: remove perspective and terrain effects
- **Calibration**: convert the sensor value (an integer) to an actual reflectance value
- **Atmospheric correction**: aerosols and water vapour can all impose spectral biases on reflected light and vary on a daily basis.

Using satellite images



Landsat 7 ETM+: 21st August 2016

Earth observation products

Use satellite reflectance data to produce derived maps

- Use standardised algorithms
- Map land surface traits at global scale
- Temporal scales: daily to annual
- Resolution: 250 m to > 8 km spatial resolution
- Validation: many have pixel by pixel 'accuracy'

Four examples of increasing complexity

Vegetation indices

Simple direct calculation from sensor values:

- Normalized Difference Vegetation Index (**NDVI**):

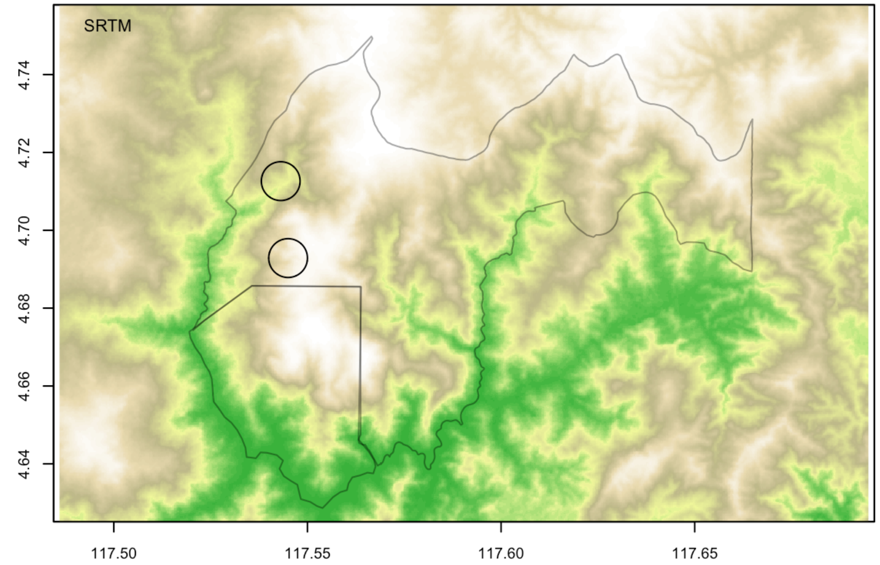
$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

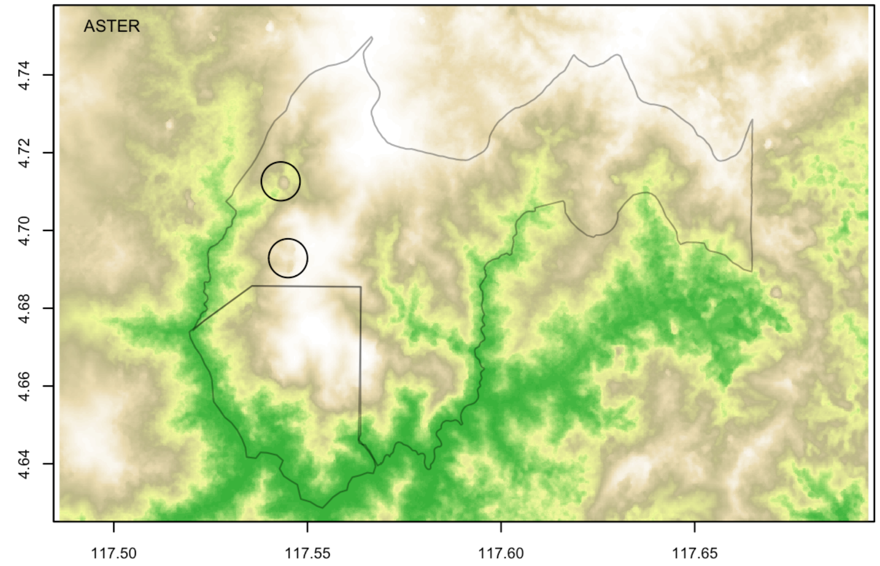
- Enhanced Vegetation Index (**EVI**):

$$EVI = G \times \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + C_1 \times \mathrm{RED} - C_2 \times \mathrm{Blue} + L)}$$

Digital elevation models

- Shuttle Radar Topography Mission (SRTM)
- ASTER Terra DEM (stereoscopy)
- Both near global with 30 metre resolution





Fire signatures

Live fires:

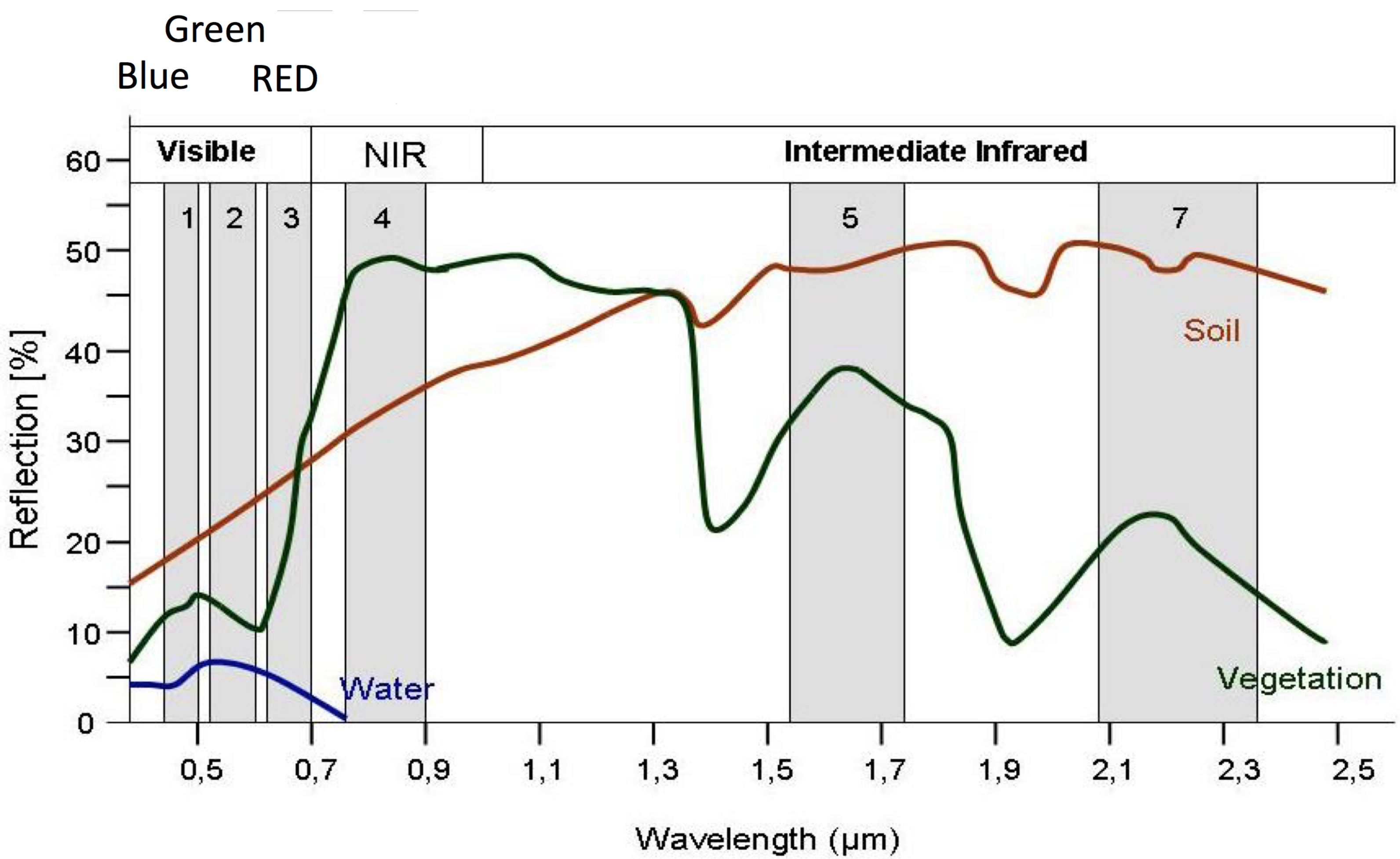
- Spectral signature in Infrared bands
- http://fires.globalforestwatch.org/map
- e.g. MODIS daily and 8 day fire observations at 1km resolution
- e.g. SPOT: annual fire frequencies (2000 - 2007)

Burned area:

- Change detection in successive images around fire pixels
- e.g. MODIS: monthly burned area in 500m pixels

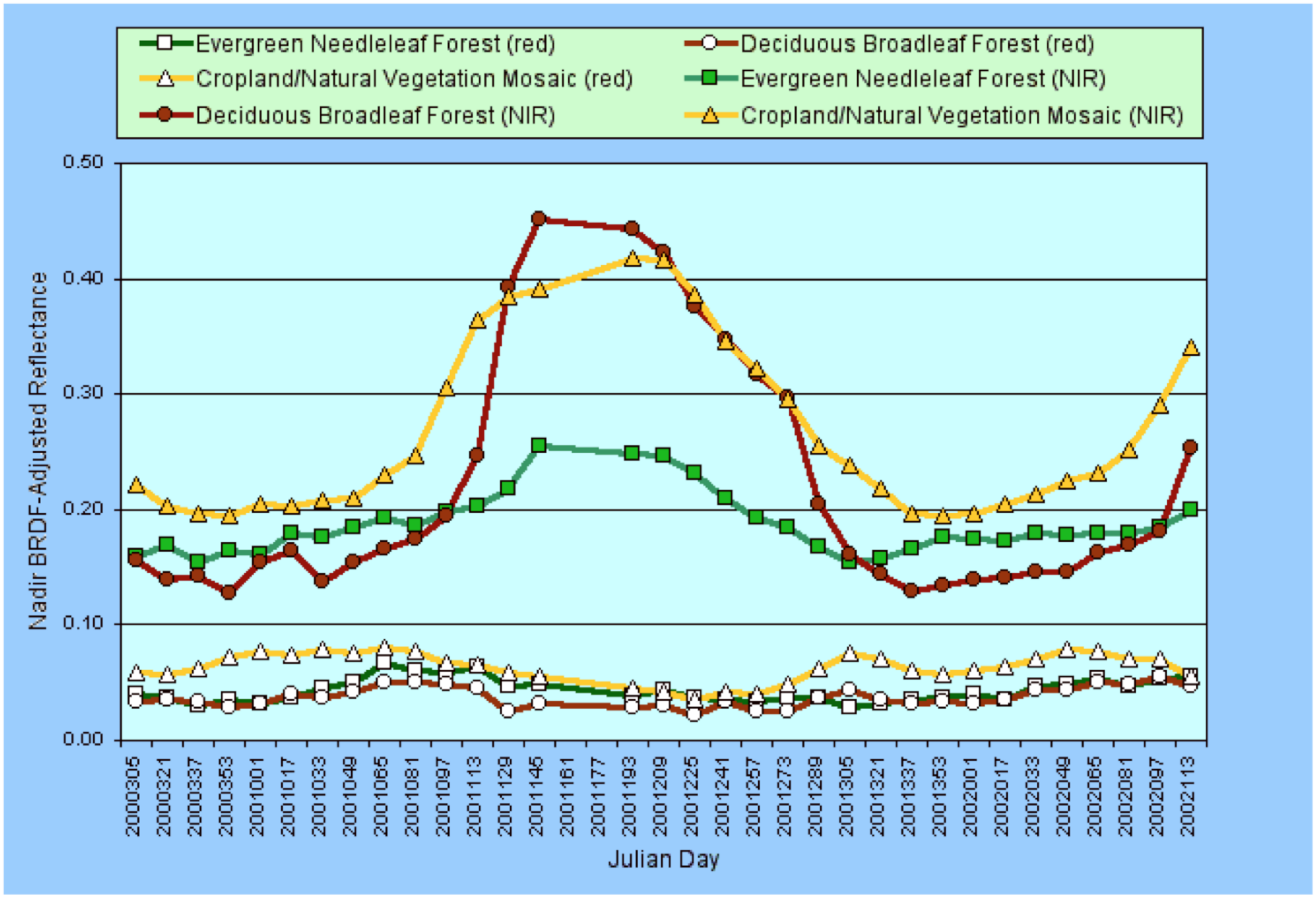
Land cover

Spectral signatures differ **between different surfaces**:



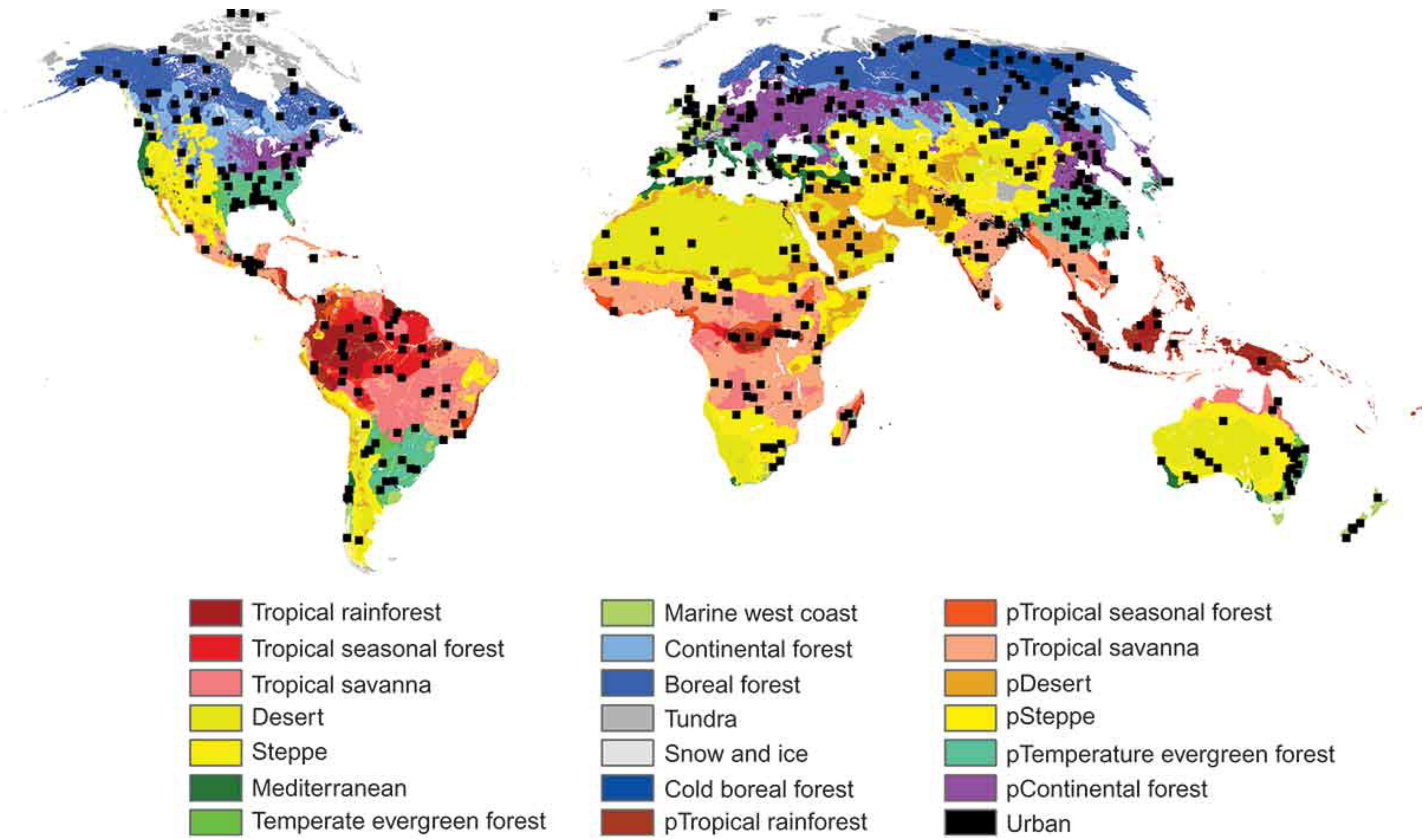
Land cover

Spectral signatures differ **over time**:



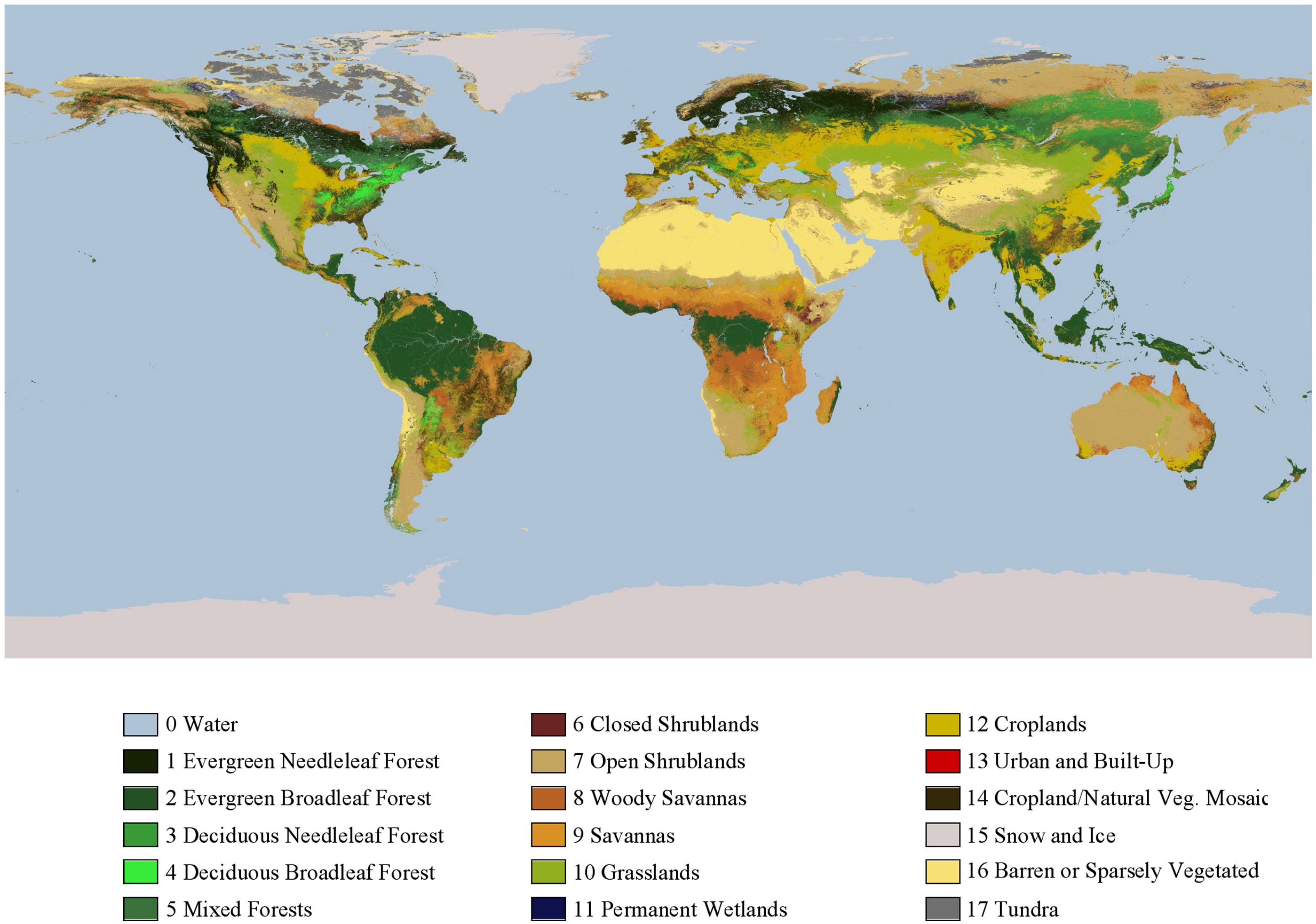
Land cover

Ground sampling ties spectral signatures to habitats



Land cover

Profiles can then be used to **classify** pixels to habitats



Land cover

Examples:

- MODIS: Annual summaries at 500 metre resolution using five different classification schemes
- http://landcover.org/data/
- Global Forest Change

Productivity

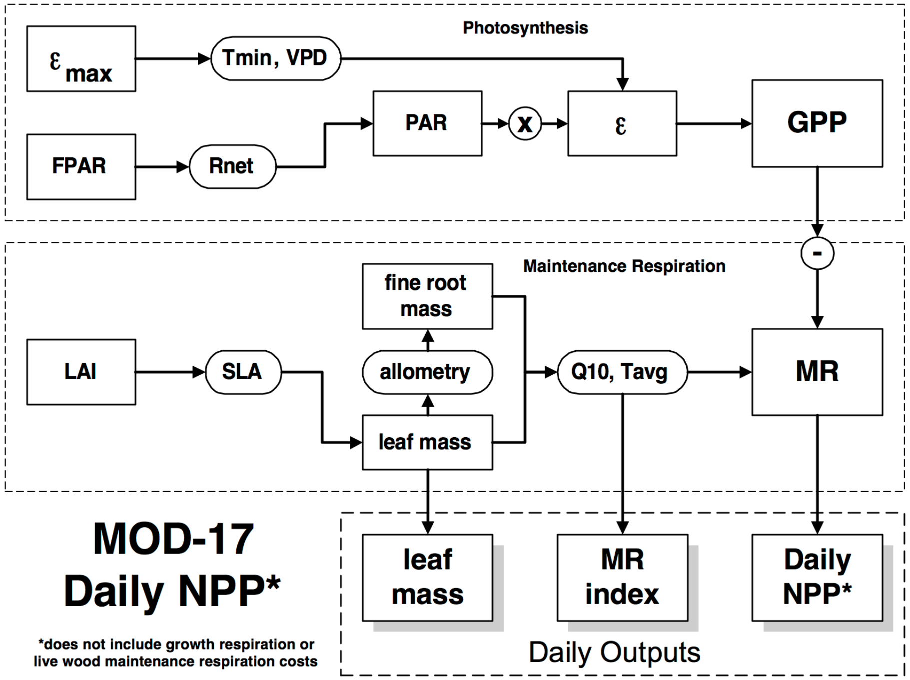
Plants use light to store carbon. If we know:

- The amount of photosynthetically active light absorbed
- The radiation conversion efficiency, given
  - the temperature and
  - humidity.
- Respiration costs.

Then we can predict gross and net primary productivity.

Productivity

- Remotely sensed reflected light
- Ground measured incident light
- Biome based models for:
  - conversion efficiency
  - respiration



Obtaining data

- http://reverb.echo.nasa.gov/
- http://earthexplorer.usgs.gov/
- http://srtm.csi.cgiar.org/
- https://earth.esa.int/web/guest/eoli