

Remote Sensing

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Overview

- Remote sensing concepts
- Resolution
 - Spectral
 - Spatial
 - Temporal
- Earth observation products

Mapping landscapes manually

Pros

- Very fine level of detail

Cons

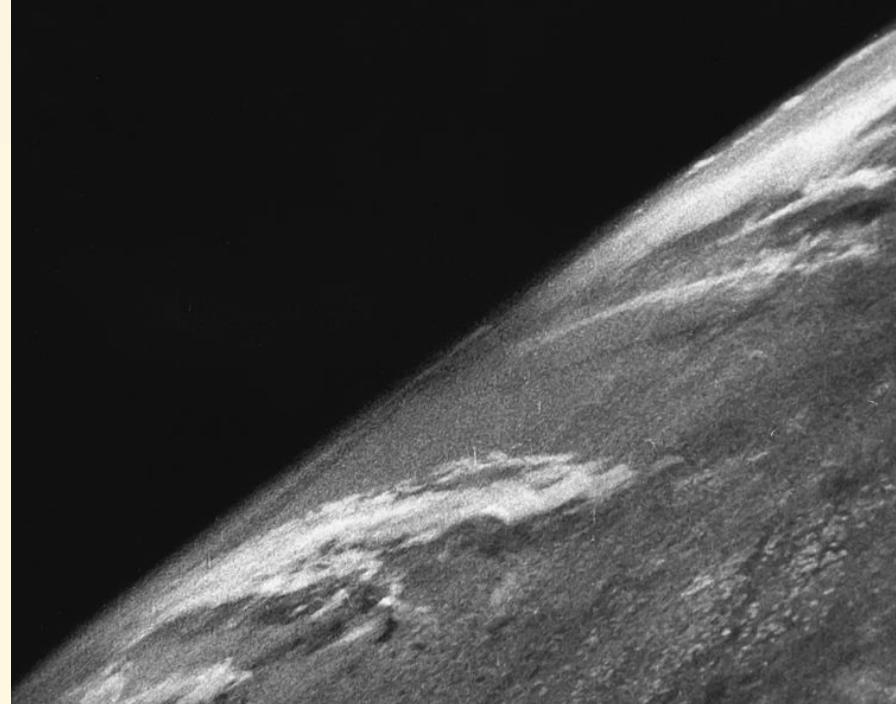
- Expensive
- Slow
- Inconsistency between locations and sampling periods

Maps from images

Aerial photography
(1900s)



Satellite imagery
(1950s)



Remote sensing

Remote sensors can be:

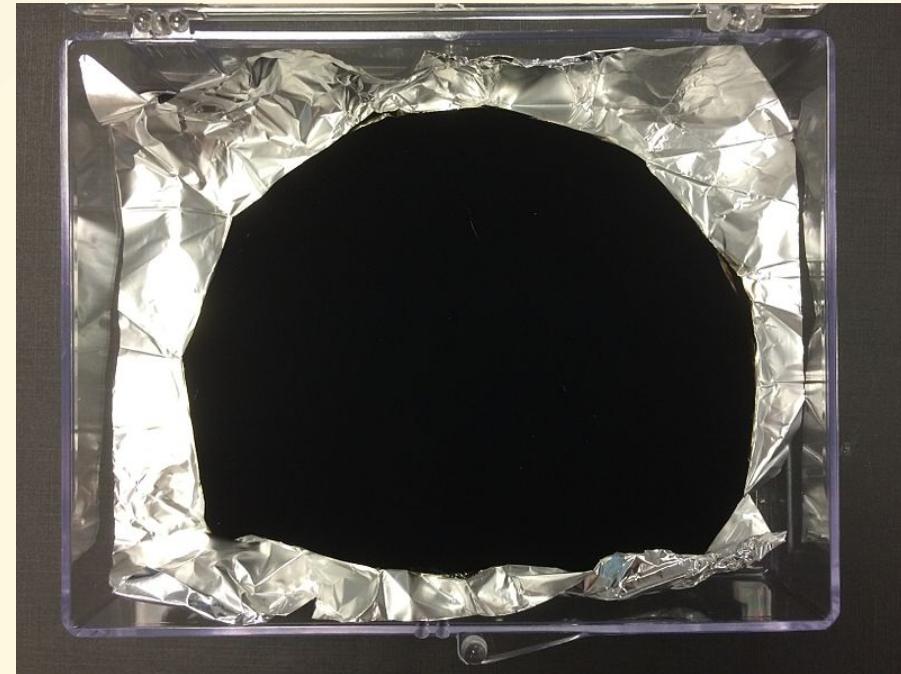
Passive: sense reflected solar radiation

Active: emit radiation and sense reflection

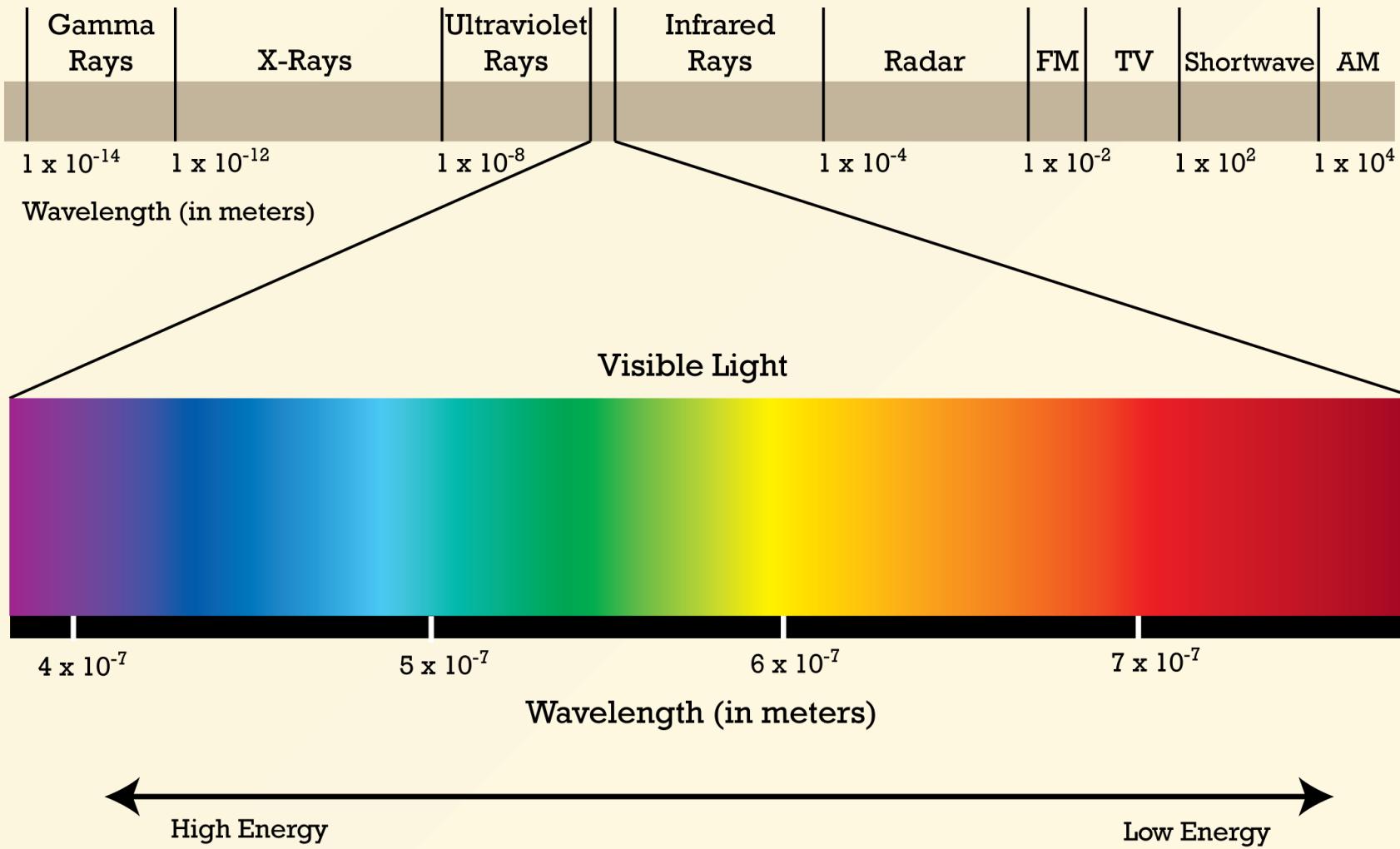
- LIDAR (light)
- RADAR (microwaves)
- Alteration in reflected light
- Trip time gives heights

Reflectance

Albedo: the proportion of radiation reflected from a surface, **strongly** affected by texture and angle of incidence.



Electromagnetic spectrum



Reflectance

Monochrome images

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



Reflectance

Multispectral images

- Albedo of surfaces vary with wavelength
- Compare **bands** recording reflectance in different wavelengths

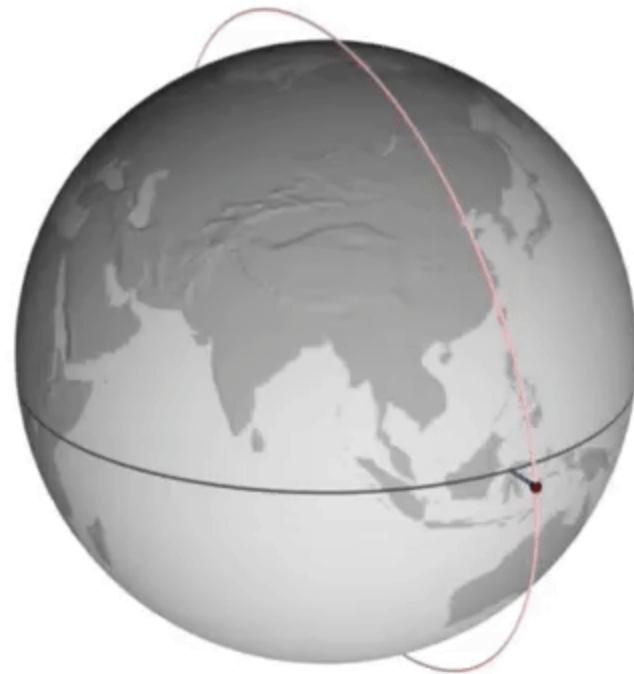


Reflectance



Satellite orbits

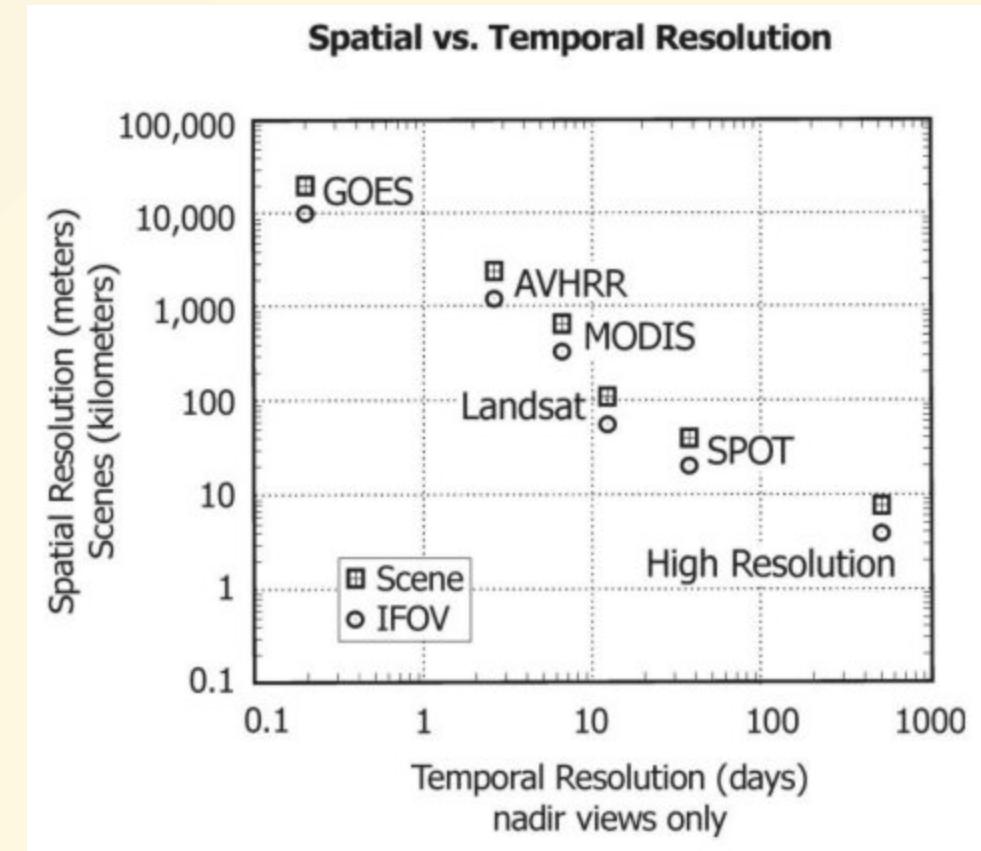
- **High earth** geostationary orbits (weather satellites),
- **Mid earth orbits** (navigation and communications)
- **Low earth orbits** (earth observation)
- **Sun synchronous** orbit (same time of day)



Spatiotemporal resolution

Low earth orbits:

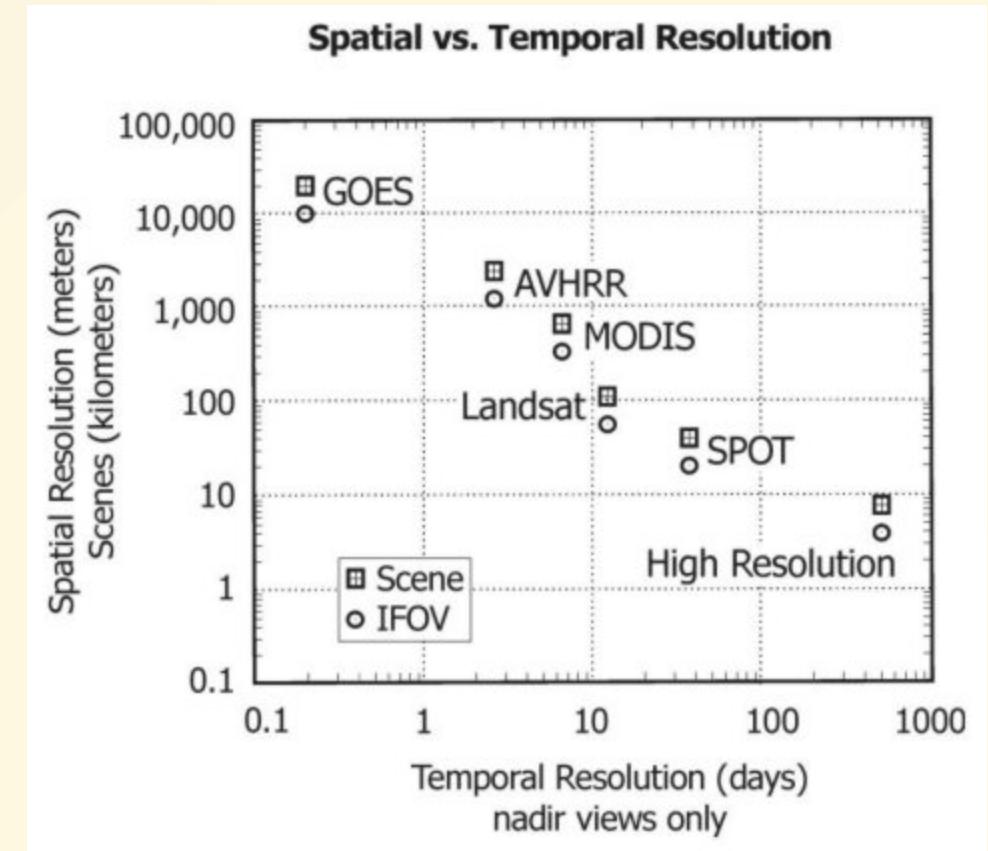
- Close to the planet
- High spatial resolution
- Narrow path widths
- Small scenes
- Less frequent images
- Use **constellations** of satellites



Spatiotemporal resolution

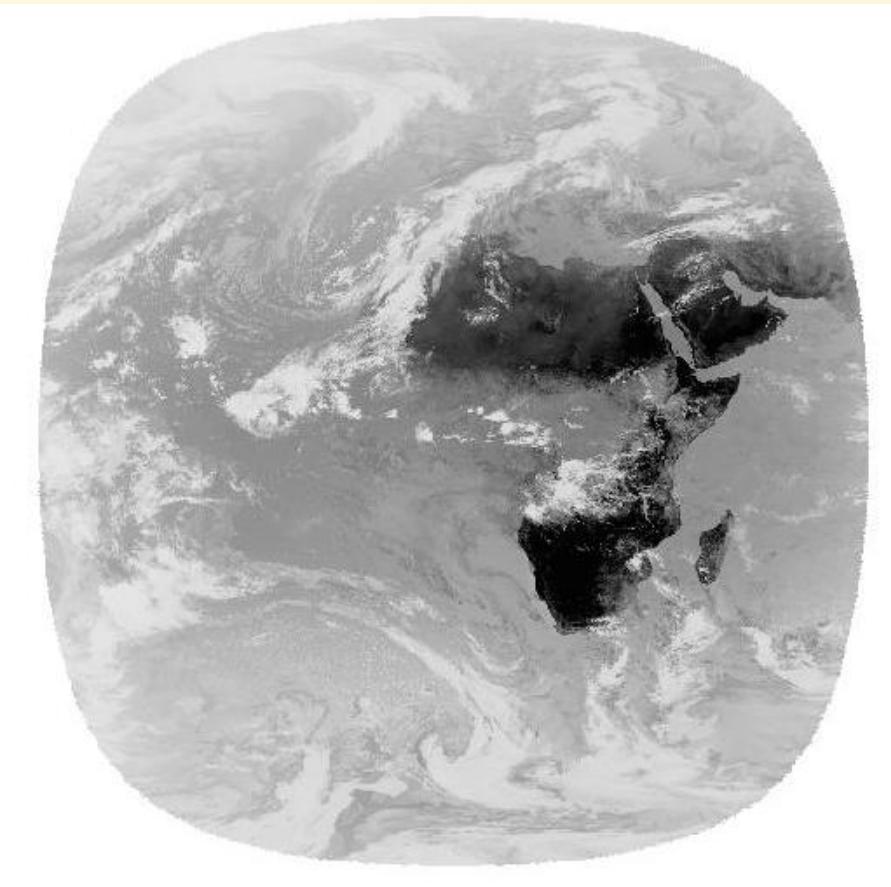
High earth orbits:

- Far out in space
- Low spatial resolution
- No path width
- Global scenes
- Can take images constantly

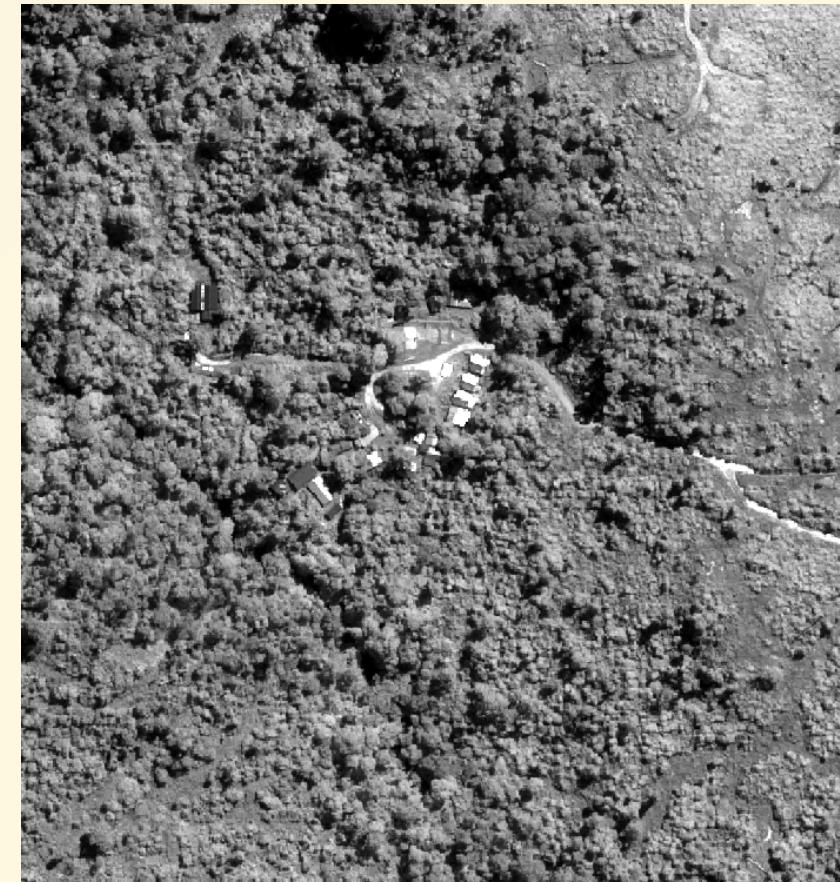


Spatiotemporal resolution

Meteosat

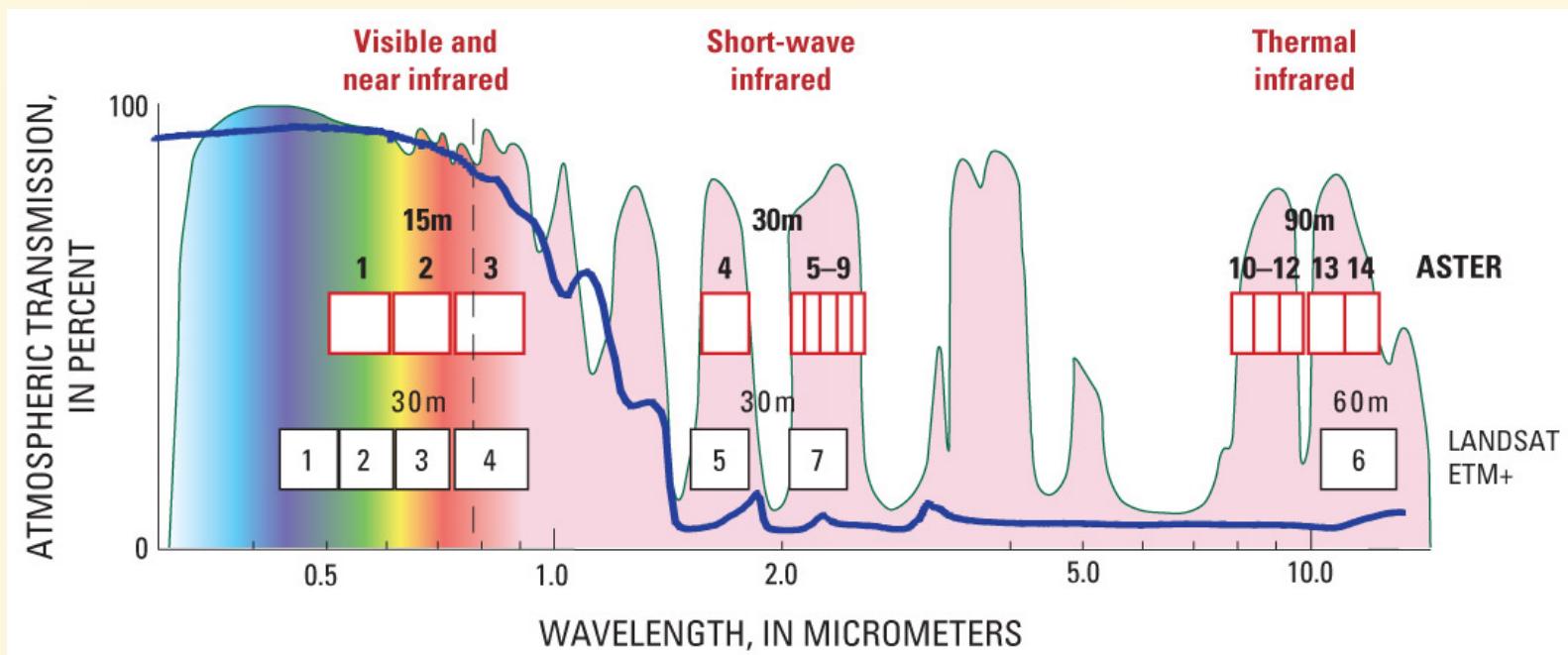


Pleiades



Spectral resolution

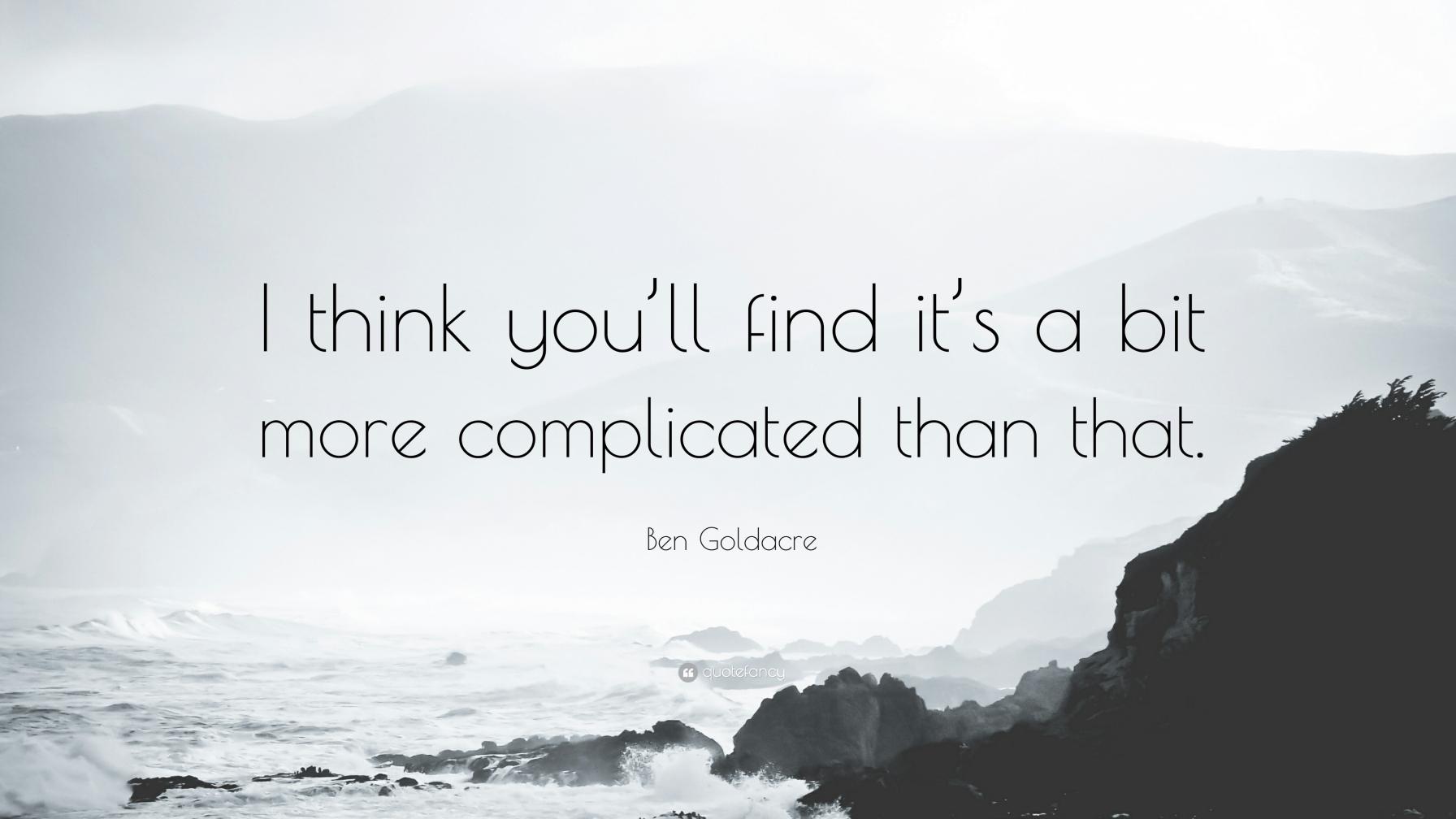
- Determined by the satellite mission
- Atmospheric absorption of radiation
- Light-gathering sets resolution and band width



Example platforms

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

Using satellite images



I think you'll find it's a bit
more complicated than that.

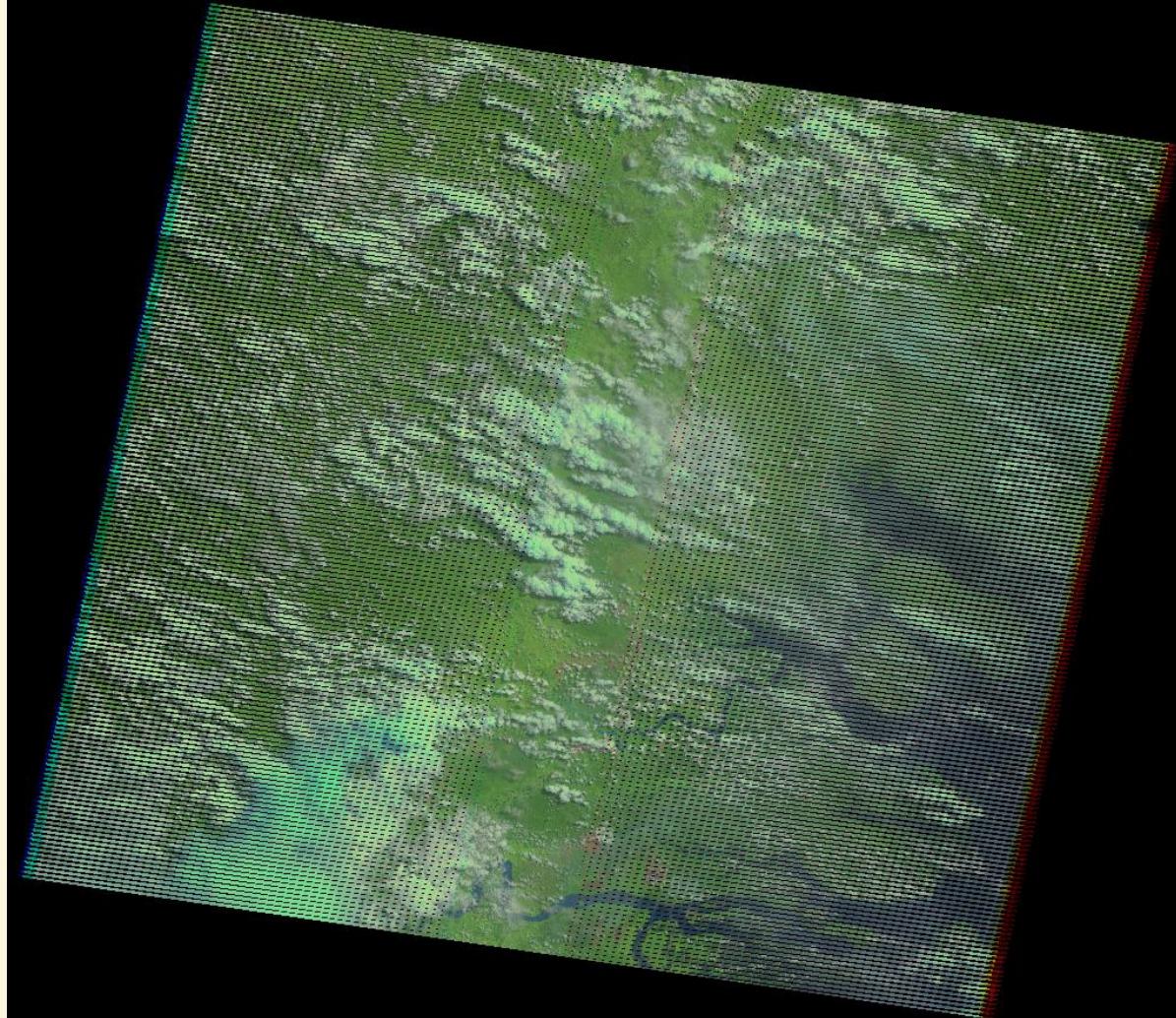
Ben Goldacre

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



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:

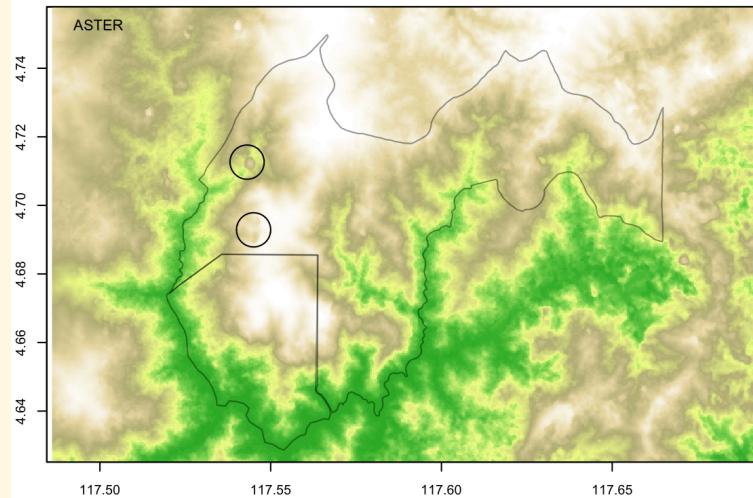
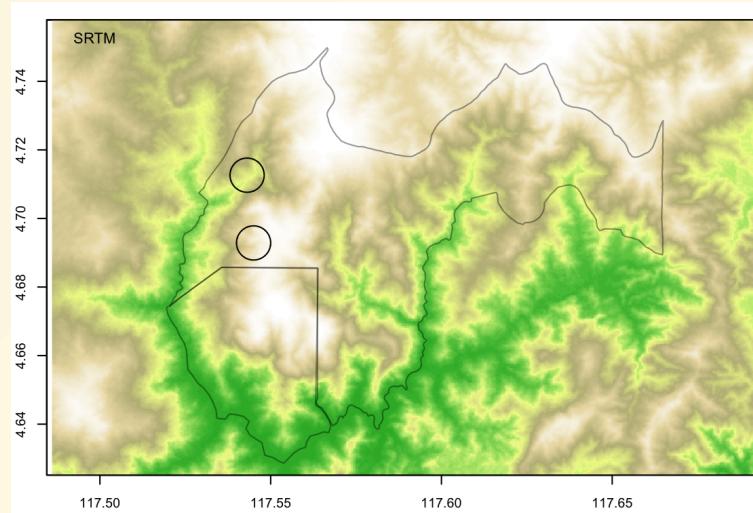
$$\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}$$

- Enhanced Vegetation Index:

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

Digital elevation models

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



Fire signatures

Live fires:

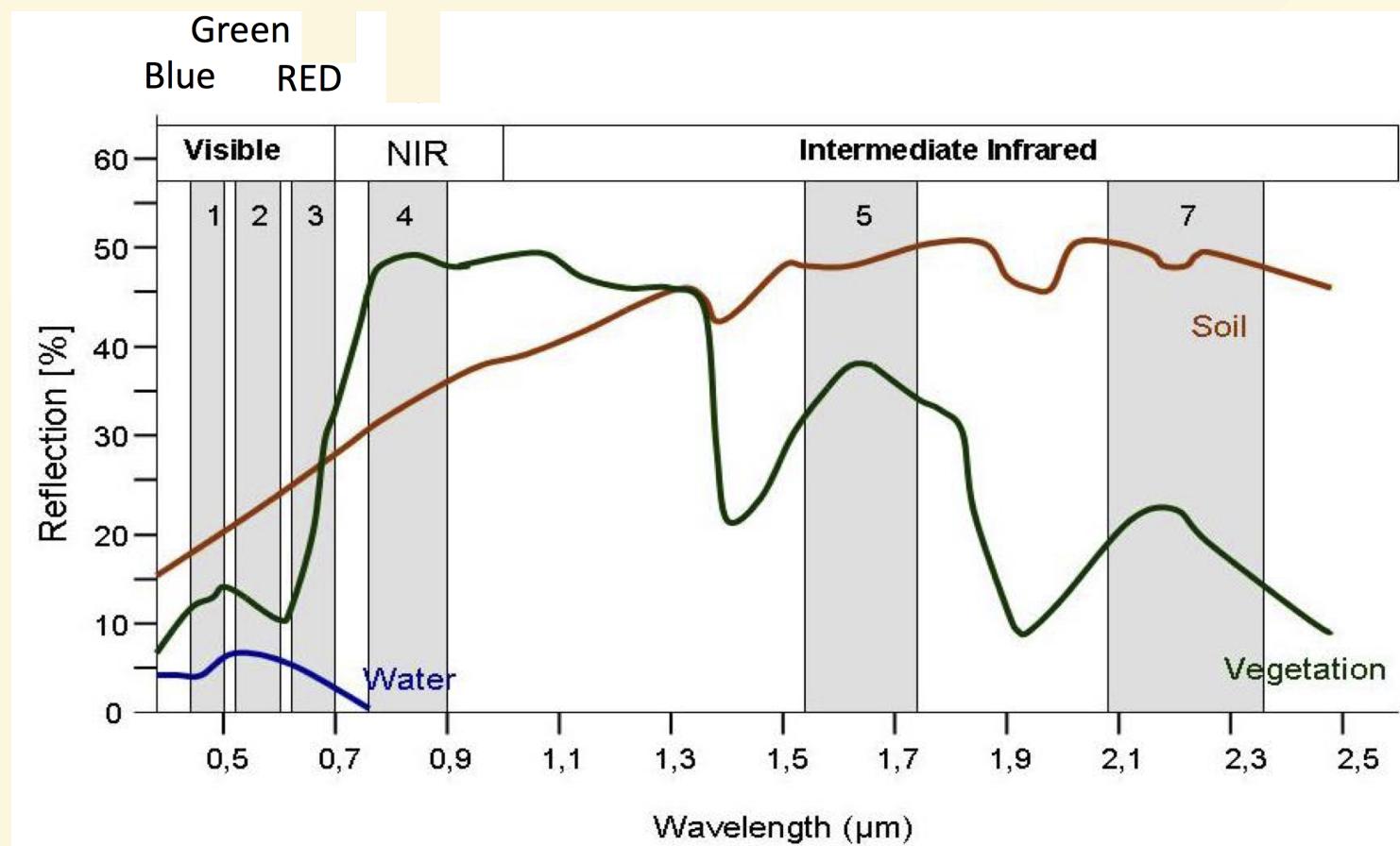
- Spectral signature in **Infrared bands**
- <http://fires.globalforestwatch.org/map>
- MODIS daily and 8 day fire observations at 1km resolution
- SPOT: annual fire frequencies (2000 - 2007)

Burned area:

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

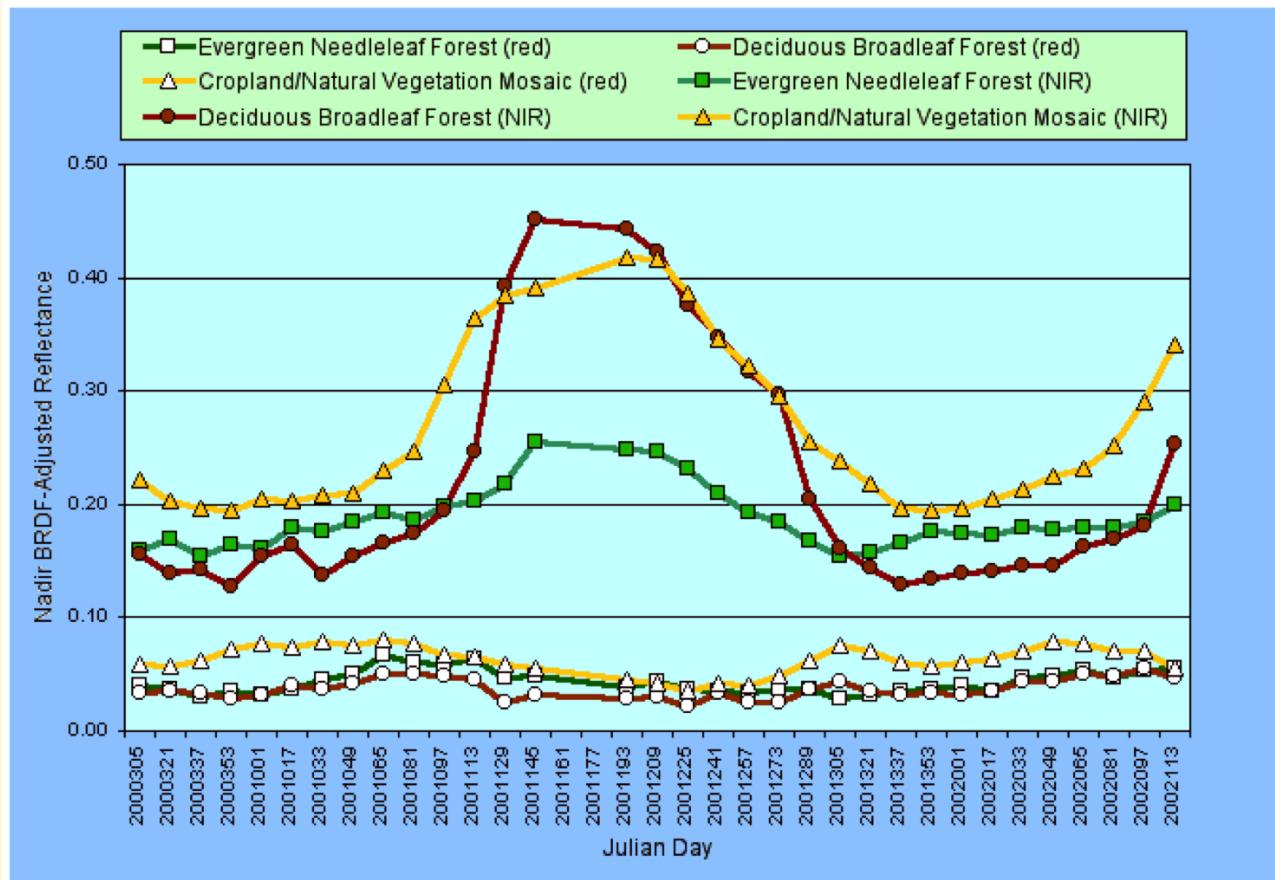
Land cover

Spectral signatures differ **between different surfaces**:



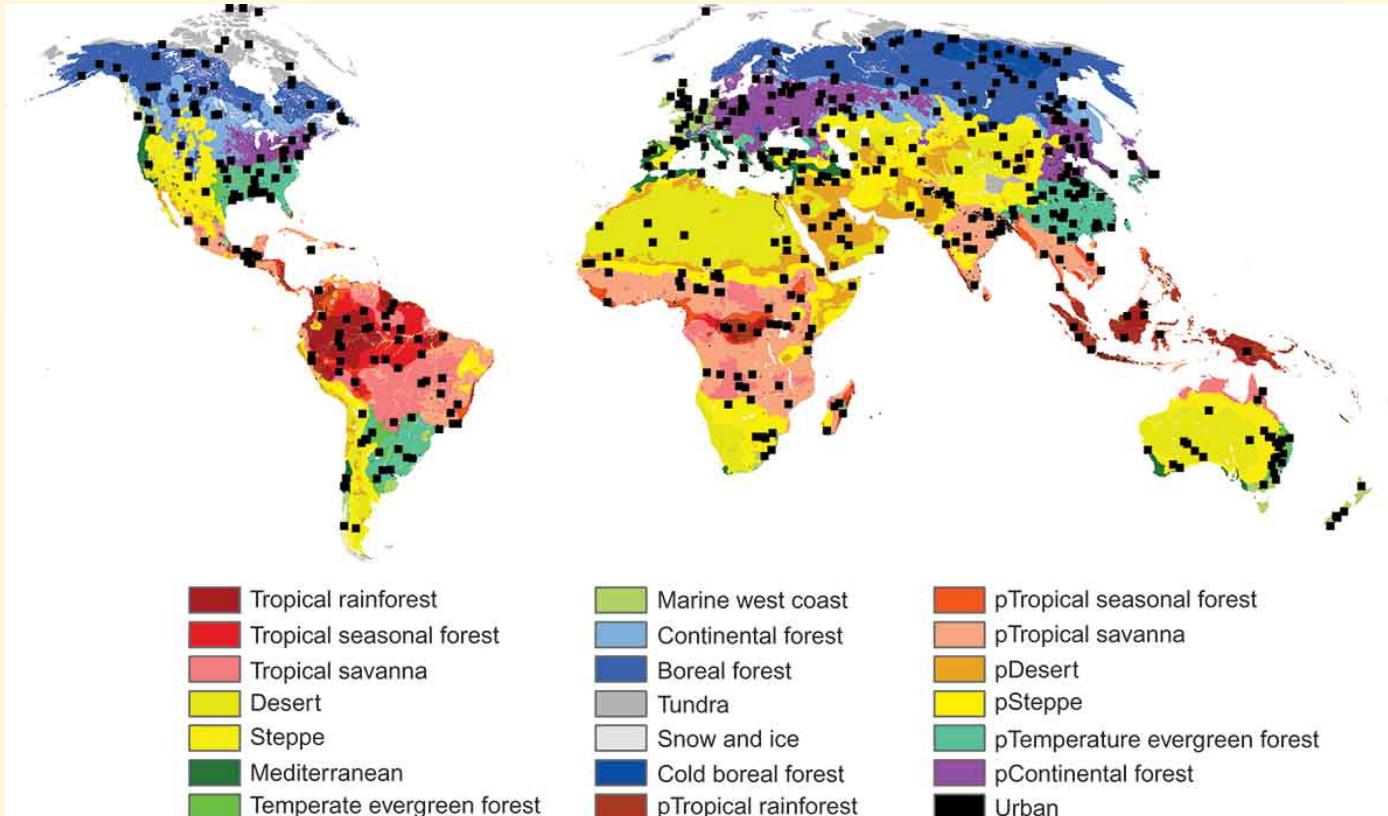
Land cover

Spectral signatures differ **over time**:



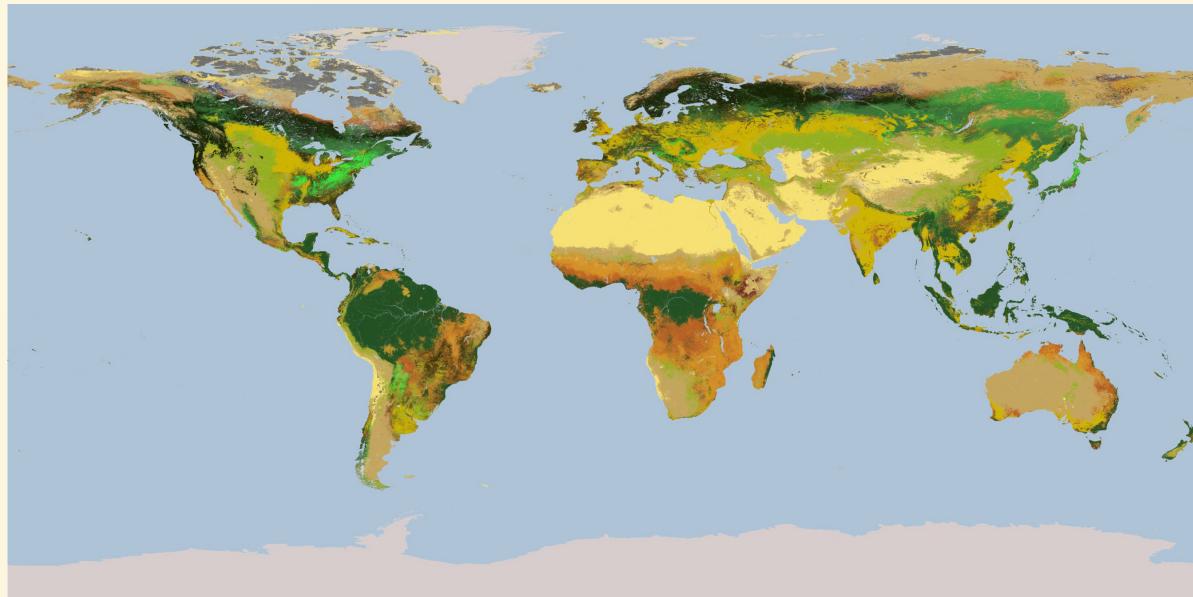
Land cover

Ground sampling ties spectral signatures to habitats



Land cover

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



0 Water	6 Closed Shrublands	12 Croplands
1 Evergreen Needleleaf Forest	7 Open Shrublands	13 Urban and Built-Up
2 Evergreen Broadleaf Forest	8 Woody Savannas	14 Cropland/Natural Veg. Mosaic
3 Deciduous Needleleaf Forest	9 Savannas	15 Snow and Ice
4 Deciduous Broadleaf Forest	10 Grasslands	16 Barren or Sparsely Vegetated
5 Mixed Forests	11 Permanent Wetlands	17 Tundra

Land cover

Examples:

- MODIS: Annual summaries at 500 metre resolution using five different classification schemes
- <http://landcover.org/data/>
- [Global Forest Change](#)

Productivity

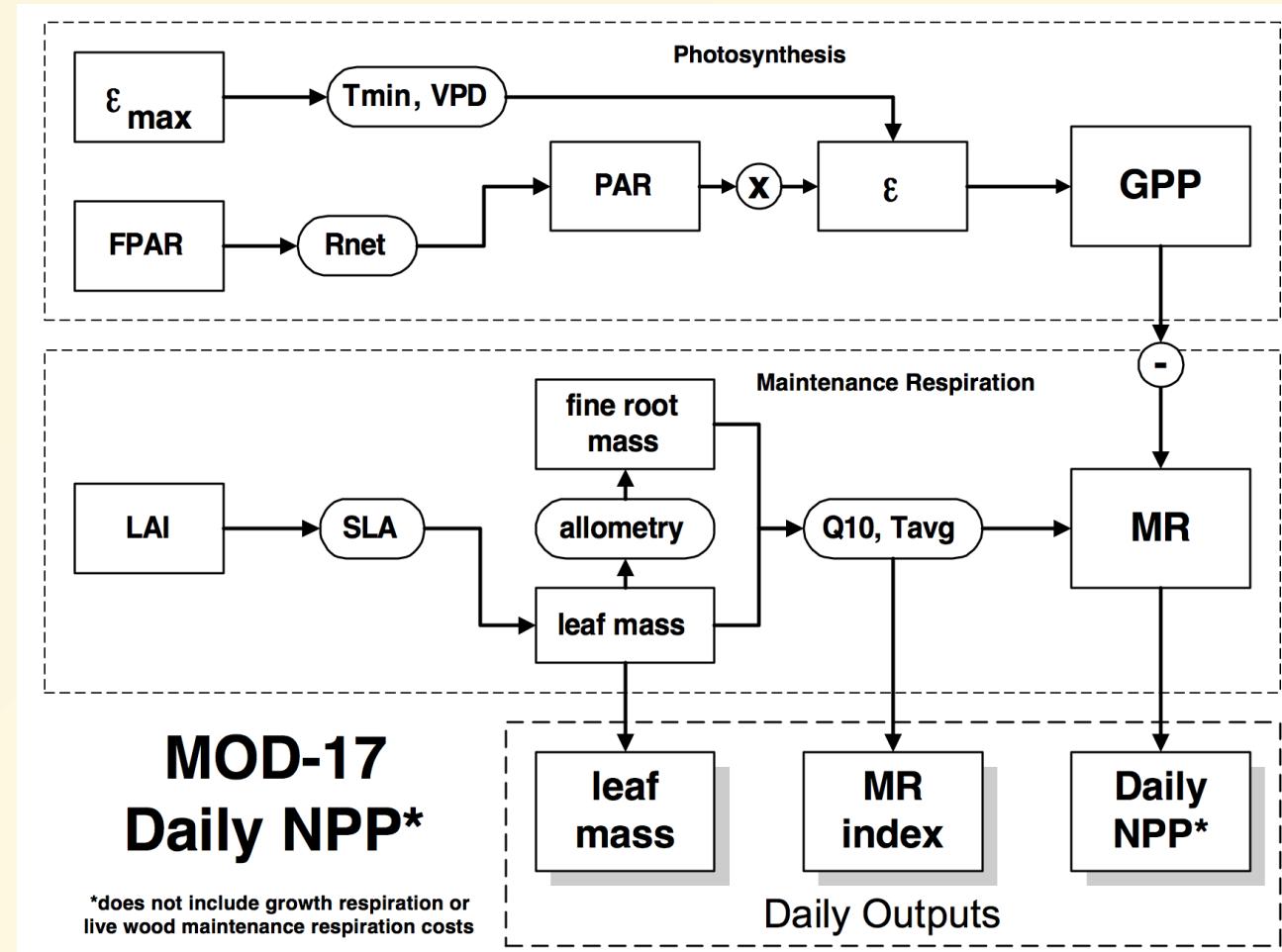
Plants use light to store carbon. If we know:

- 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 models for **conversion efficiency** and **respiration**



Obtaining data

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