REMOTE SENSING

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OVERVIEW

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

MAPPING LANDSCAPES MANUALLY

Pros

- Very fine level of detail

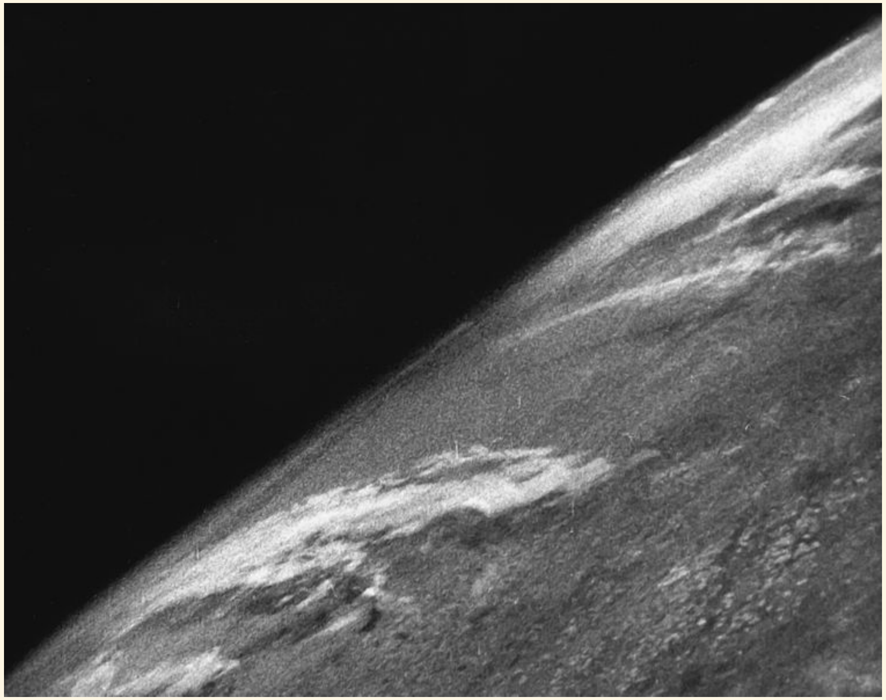
Cons

- Expensive
- Slow
- Inconsistency between locations and sampling periods

MAPS FROM IMAGES

Aerial photography (1900s)

Satellite imagery (1950s)



REMOTE SENSING

Remote sensors can be:

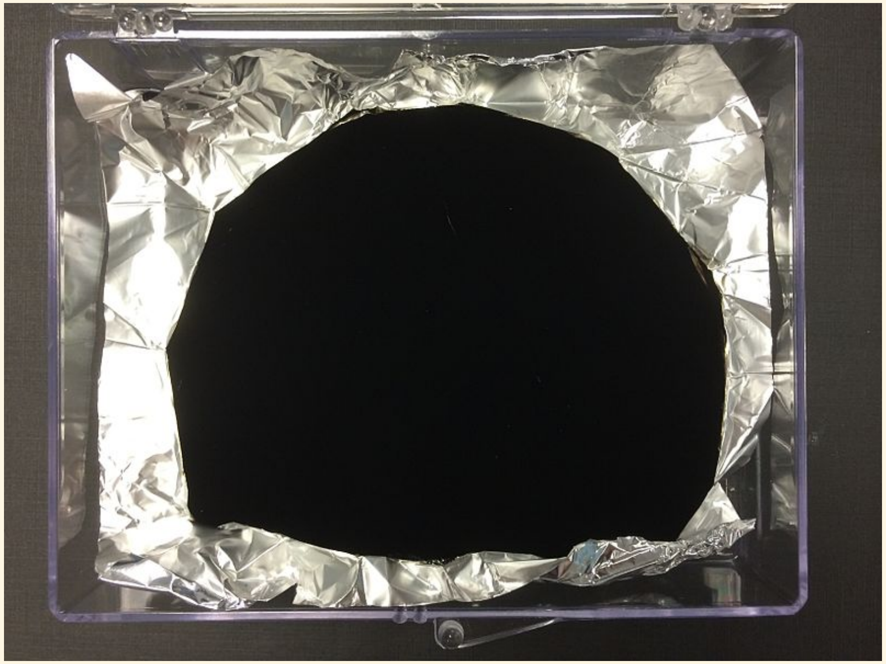
Passive: sense reflected solar radiation

Active: emit radiation and sense reflection

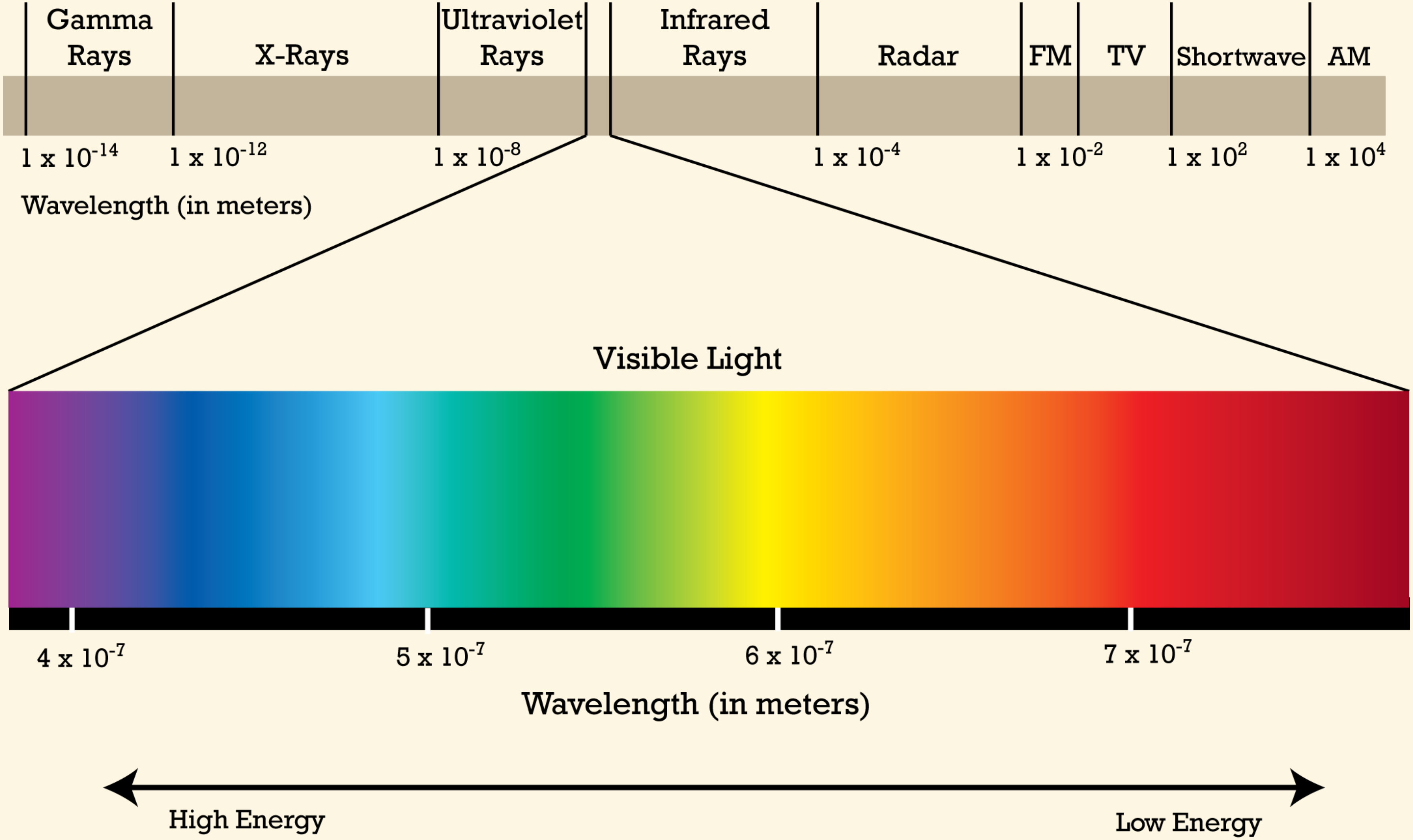
- LIDAR (light)
- RADAR (microwaves)
- Alteration in reflected light
- Trip time gives heights

REFLECTANCE

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



ELECTROMAGNETIC SPECTRUM



REFLECTANCE

Monochrome images

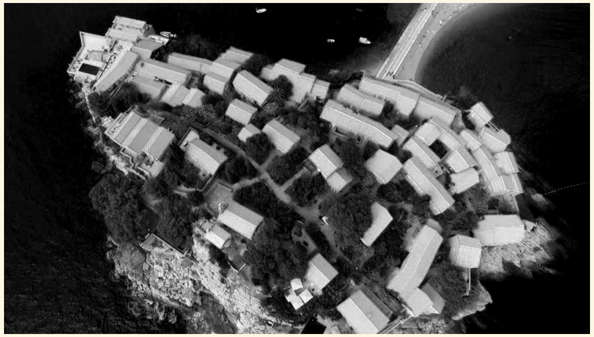
- Different objects have different albedo
- Construct maps by looking at contrast, texture and edges

REFLECTANCE

Multispectral images

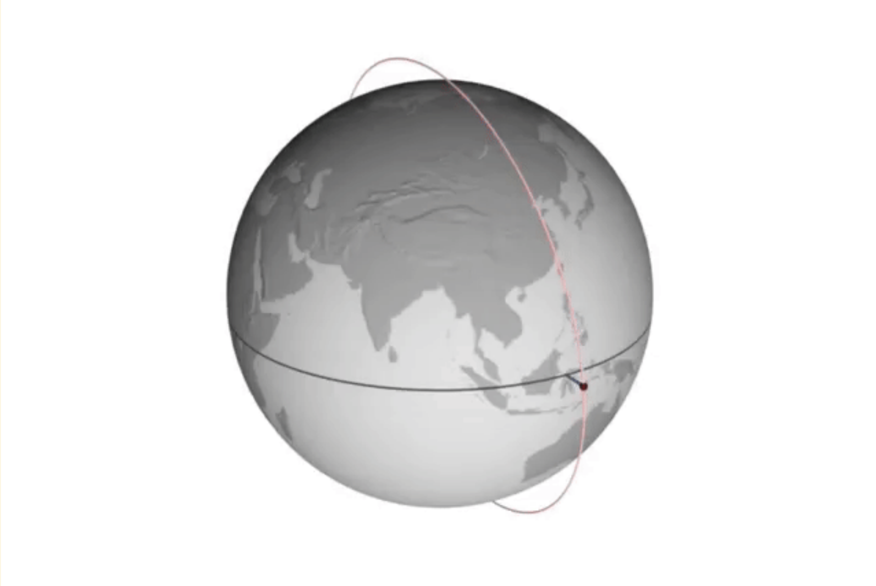
- Albedo of surfaces vary with wavelength
- Compare **bands** recording reflectance in different wavelengths

REFLECTANCE



SATELLITE ORBITS

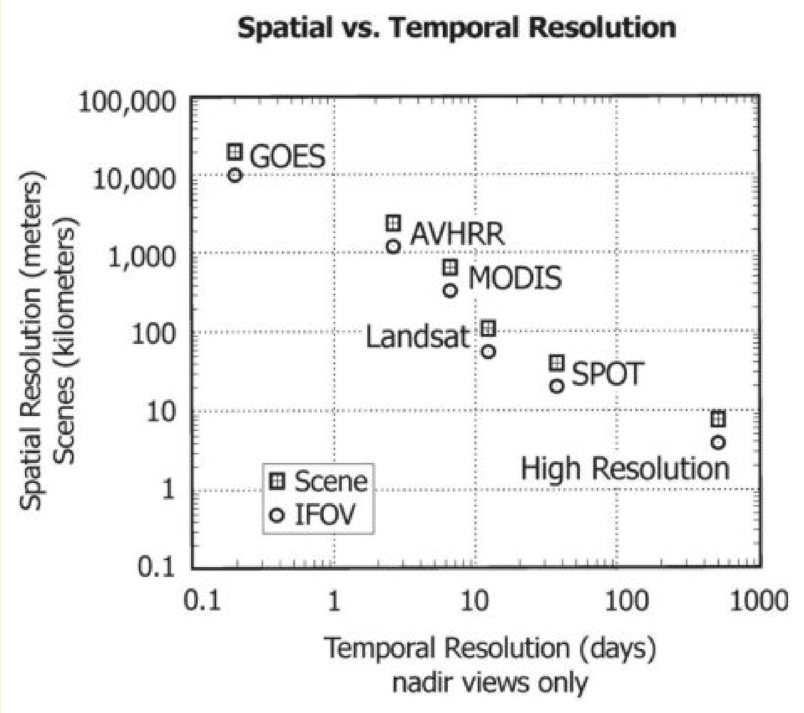
- **High earth** geostationary orbits (weather satellites),
- **Mid earth orbits** (navigation and communications)
- **Low earth orbits** (earth observation)
- **Sun synchronous** orbit (same time of day)



SPATIOTEMPORAL RESOLUTION

Low earth orbits:

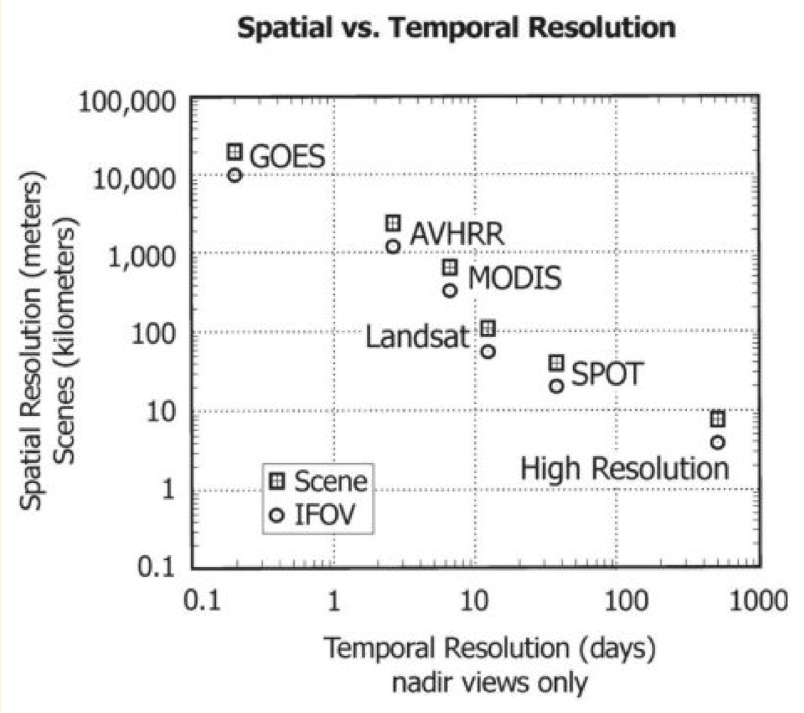
- Close to the planet
- High spatial resolution
- Narrow path widths
- Small scenes
- Less frequent images
- Use **constellations** of satellites



SPATIOTEMPORAL RESOLUTION

High earth orbits:

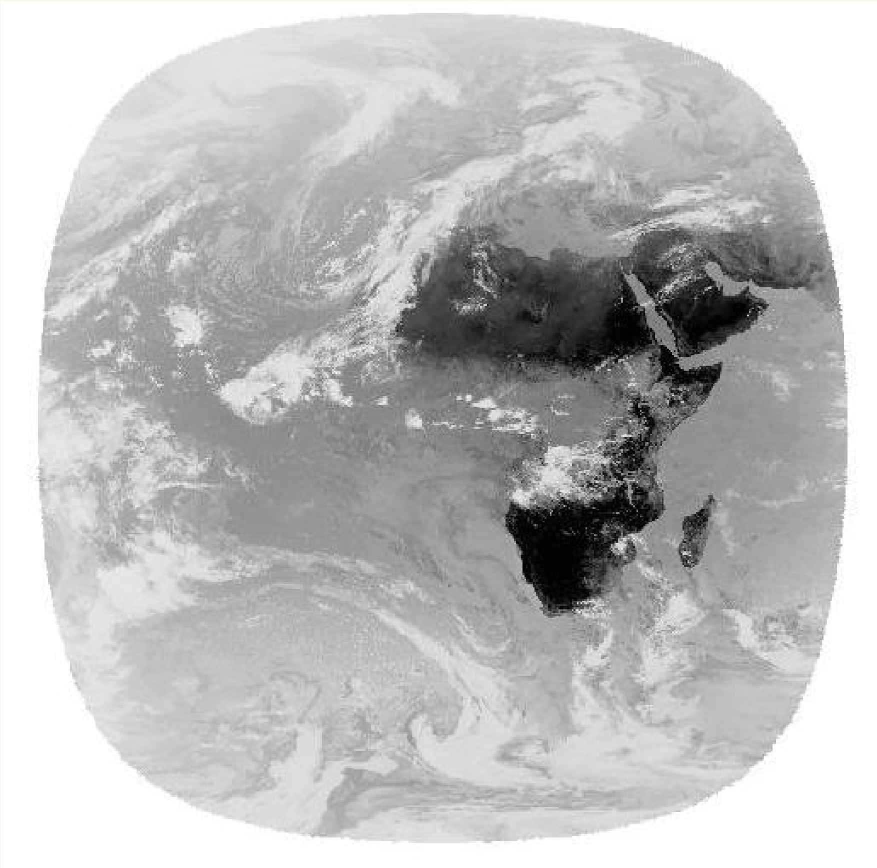
- Far out in space
- Low spatial resolution
- No path width
- Global scenes
- Can take images constantly



SPATIOTEMPORAL RESOLUTION

To put it another way:

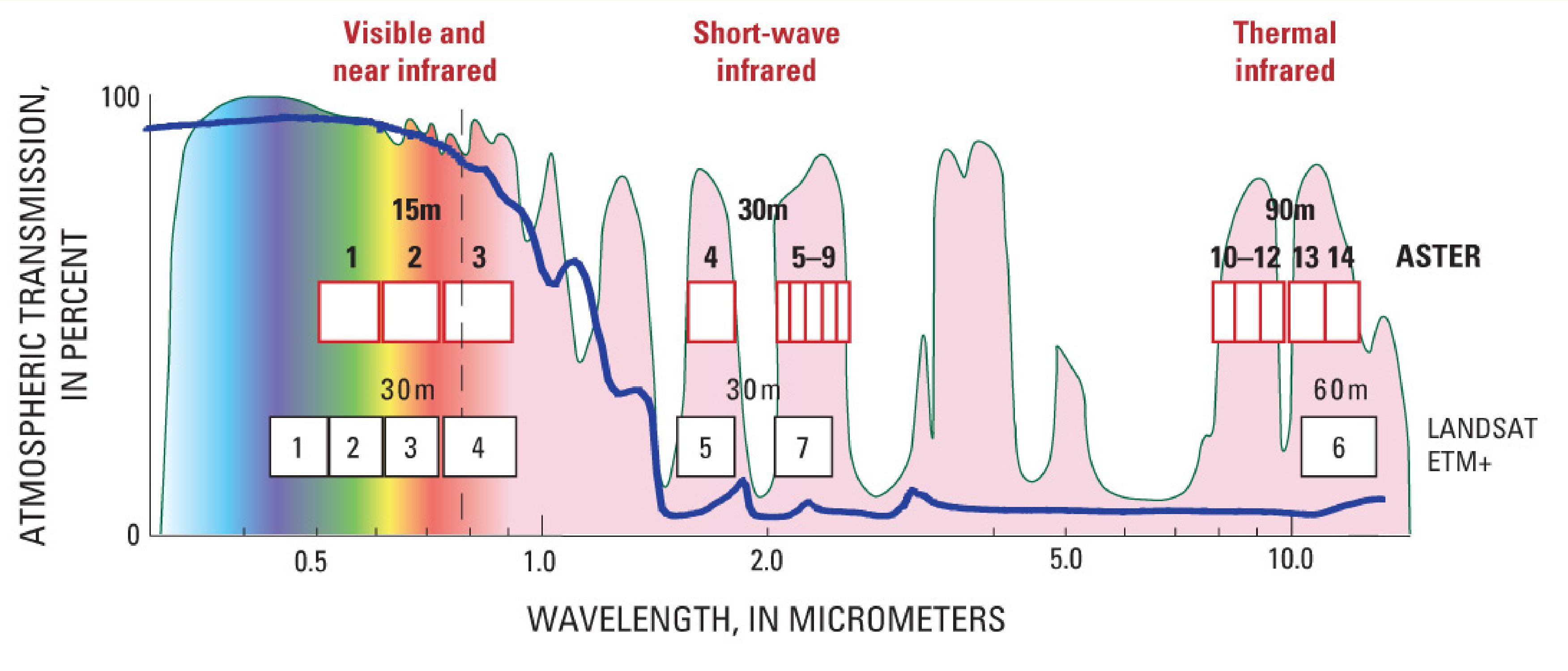
Meteosat



Pleiades

SPECTRAL RESOLUTION

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

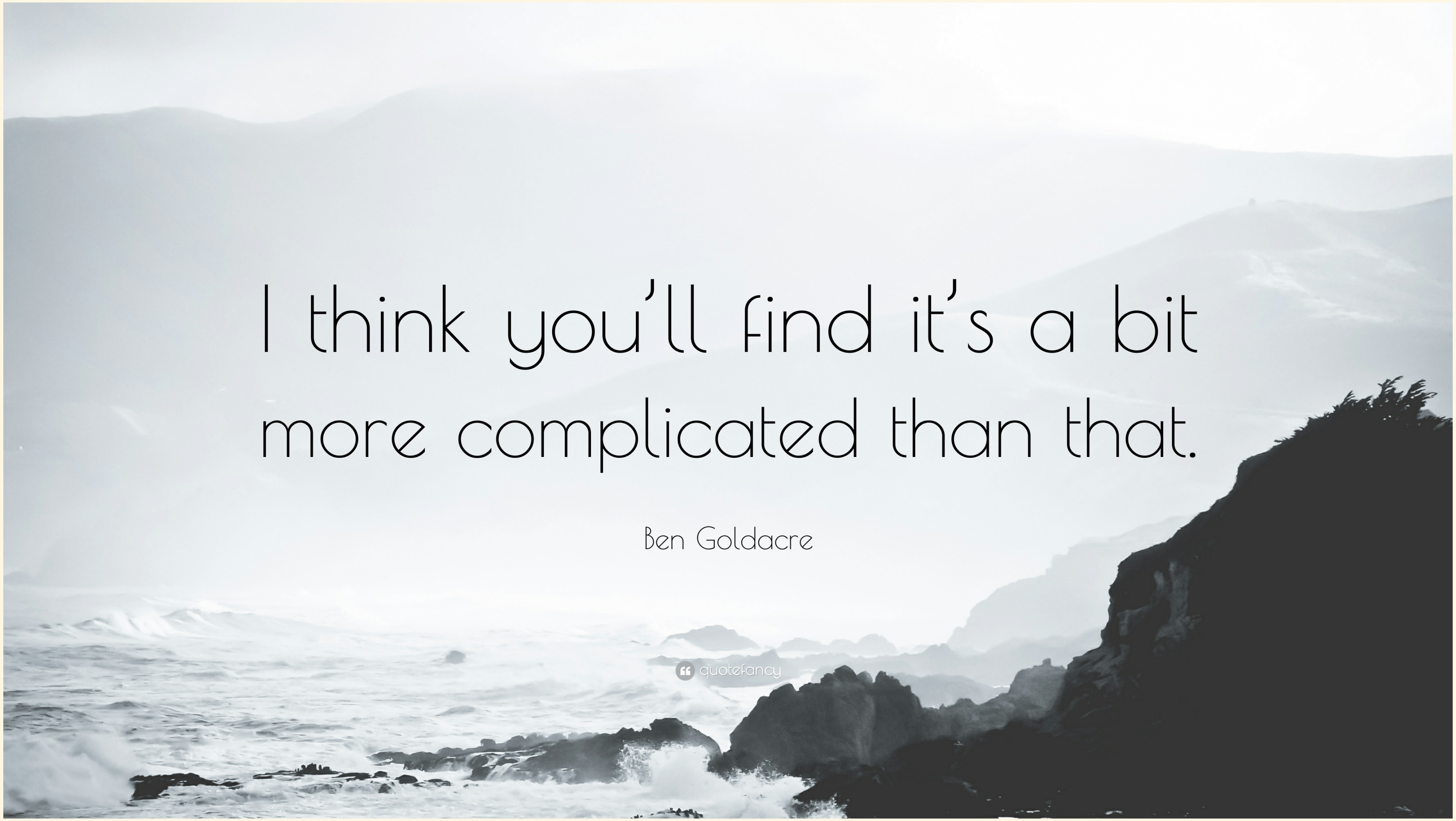


Visible and near infrared
Short-wave infrared
Thermal infrared
ATMOSPHERIC TRANSMISSION, IN PERCENT
100
0
15m
1
2
3
30m
4
5–9
90m
10–12
13
14
ASTER
30m
1
2
3
4
30m
5
7
60m
6
LANDSAT ETM+
0.5
1.0
2.0
5.0
10.0
WAVELENGTH, IN MICROMETERS

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

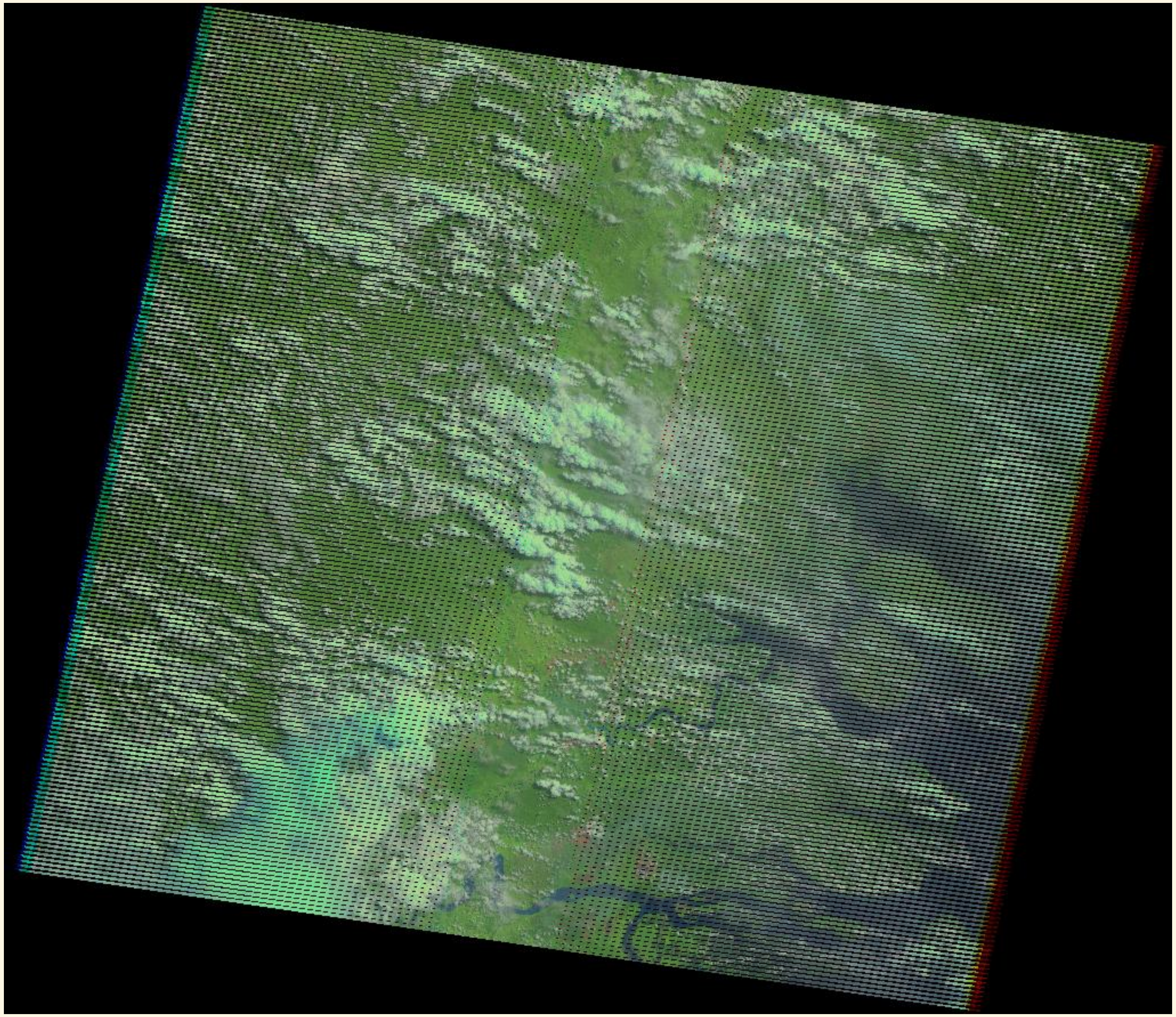


USING SATELLITE IMAGES

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:

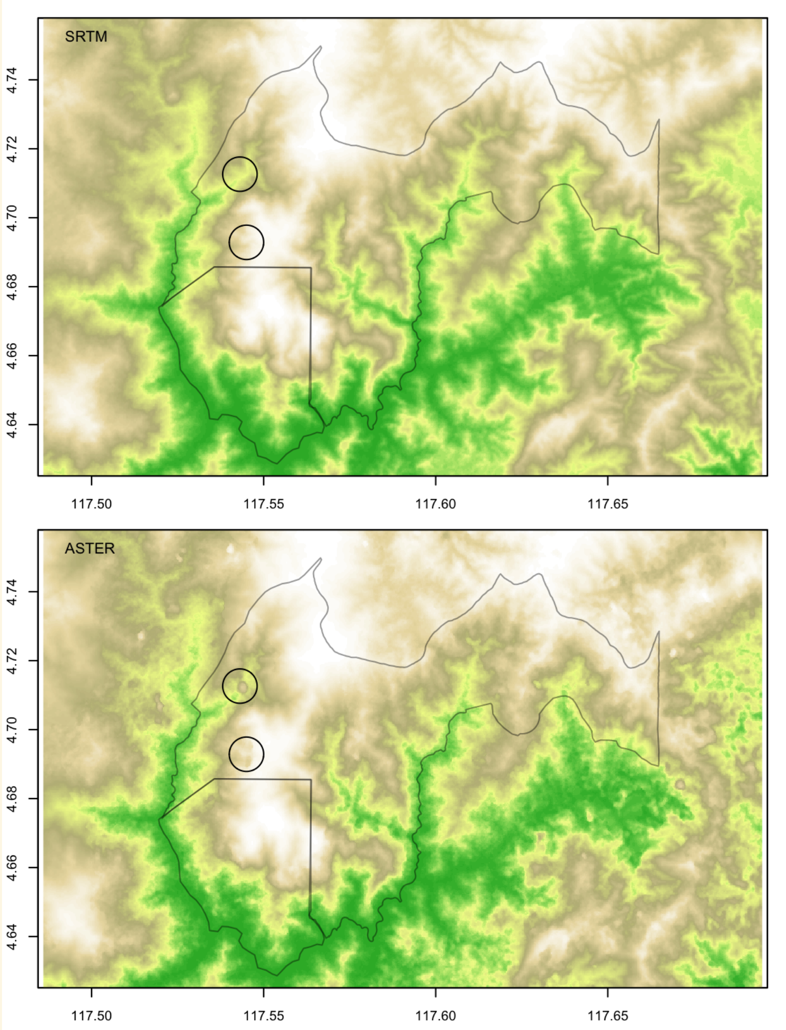
$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

- Enhanced Vegetation Index:

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

DIGITAL ELEVATION MODELS

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



FIRE SIGNATURES

Live fires:

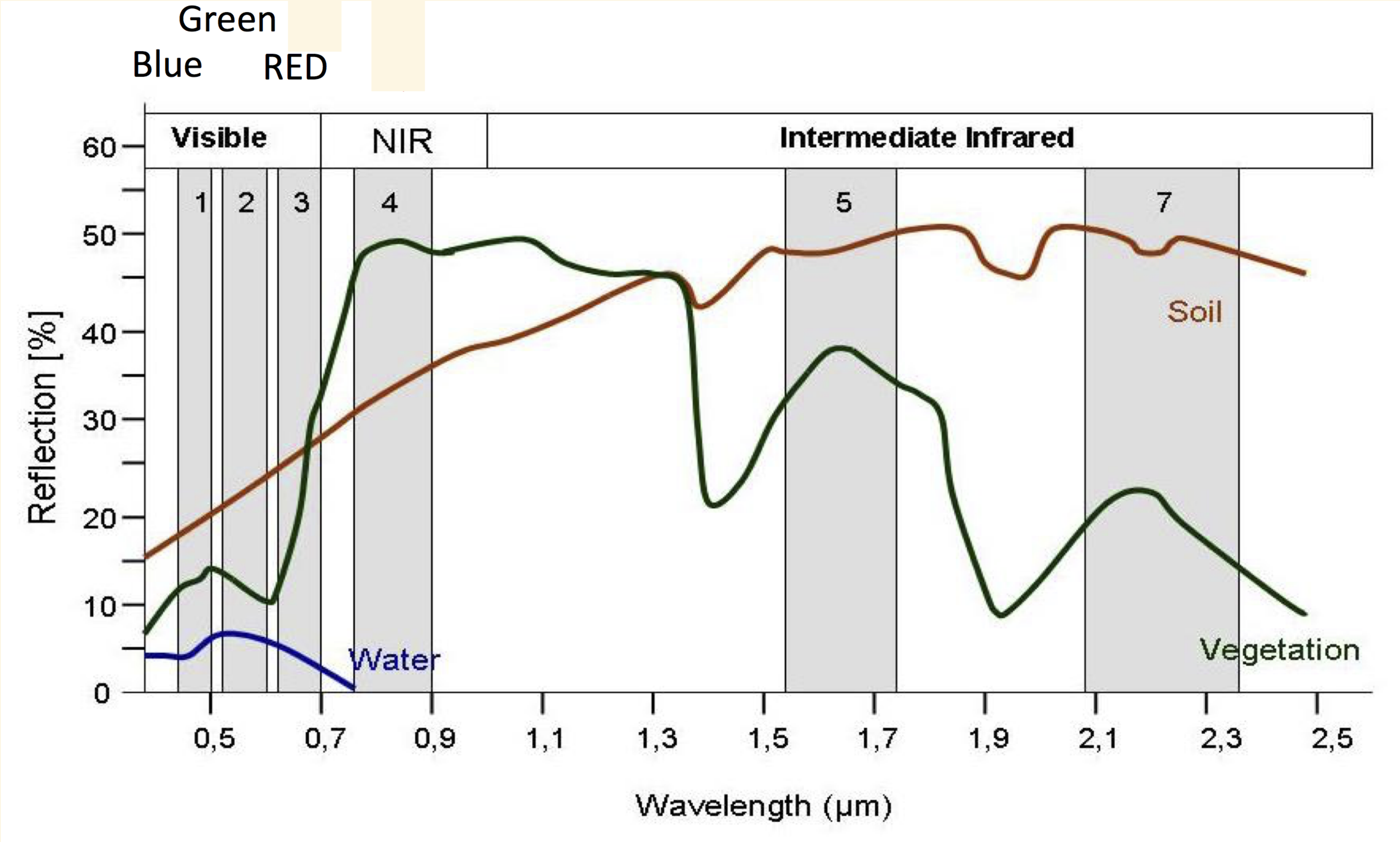
- Spectral signature in **Infrared bands**
- http://fires.globalforestwatch.org/map
- MODIS daily and 8 day fire observations at 1km resolution
- SPOT: annual fire frequencies (2000 - 2007)

Burned area:

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

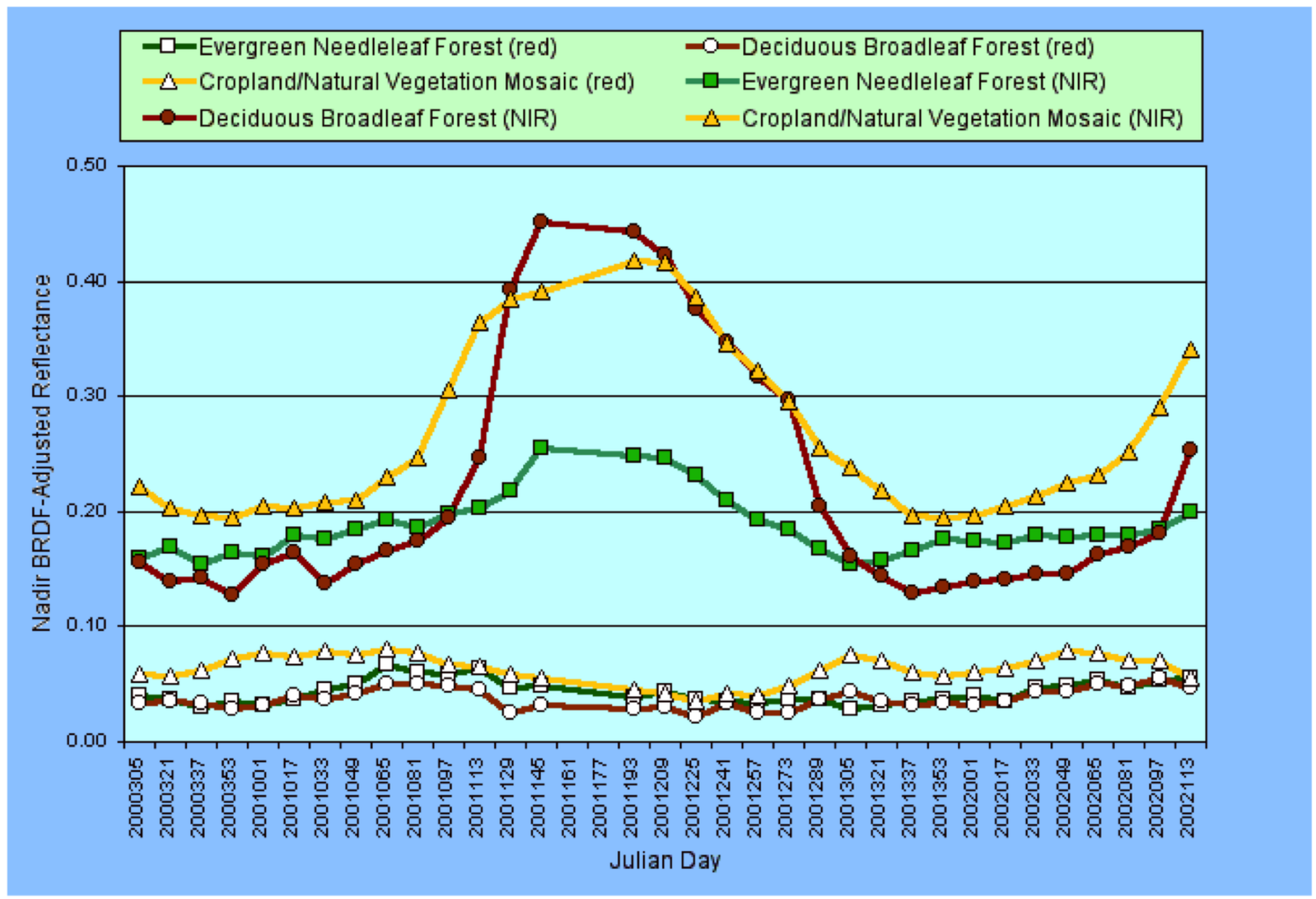
LAND COVER

Spectral signatures differ **between different surfaces:**



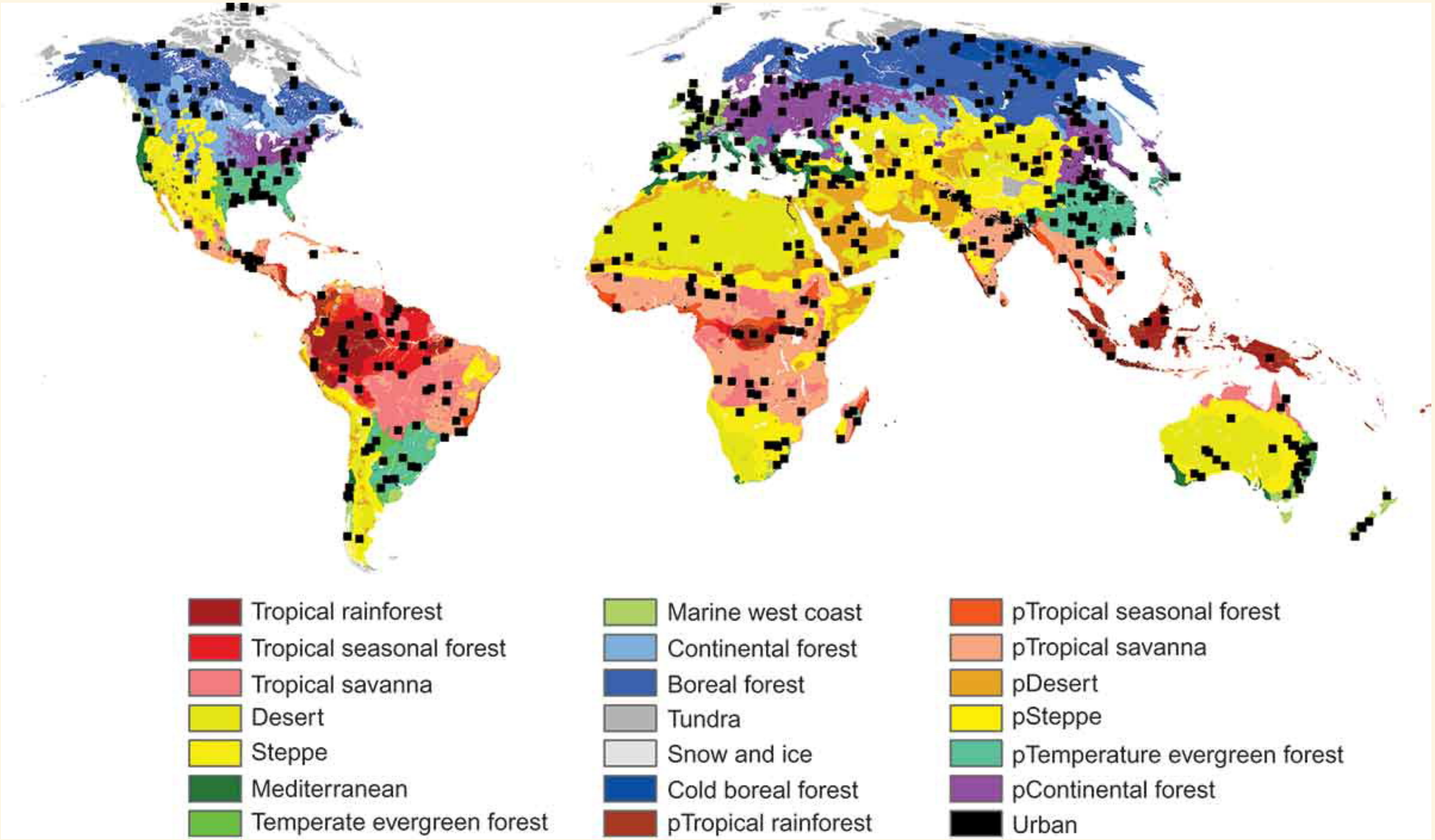
LAND COVER

Spectral signatures differ **over time**:



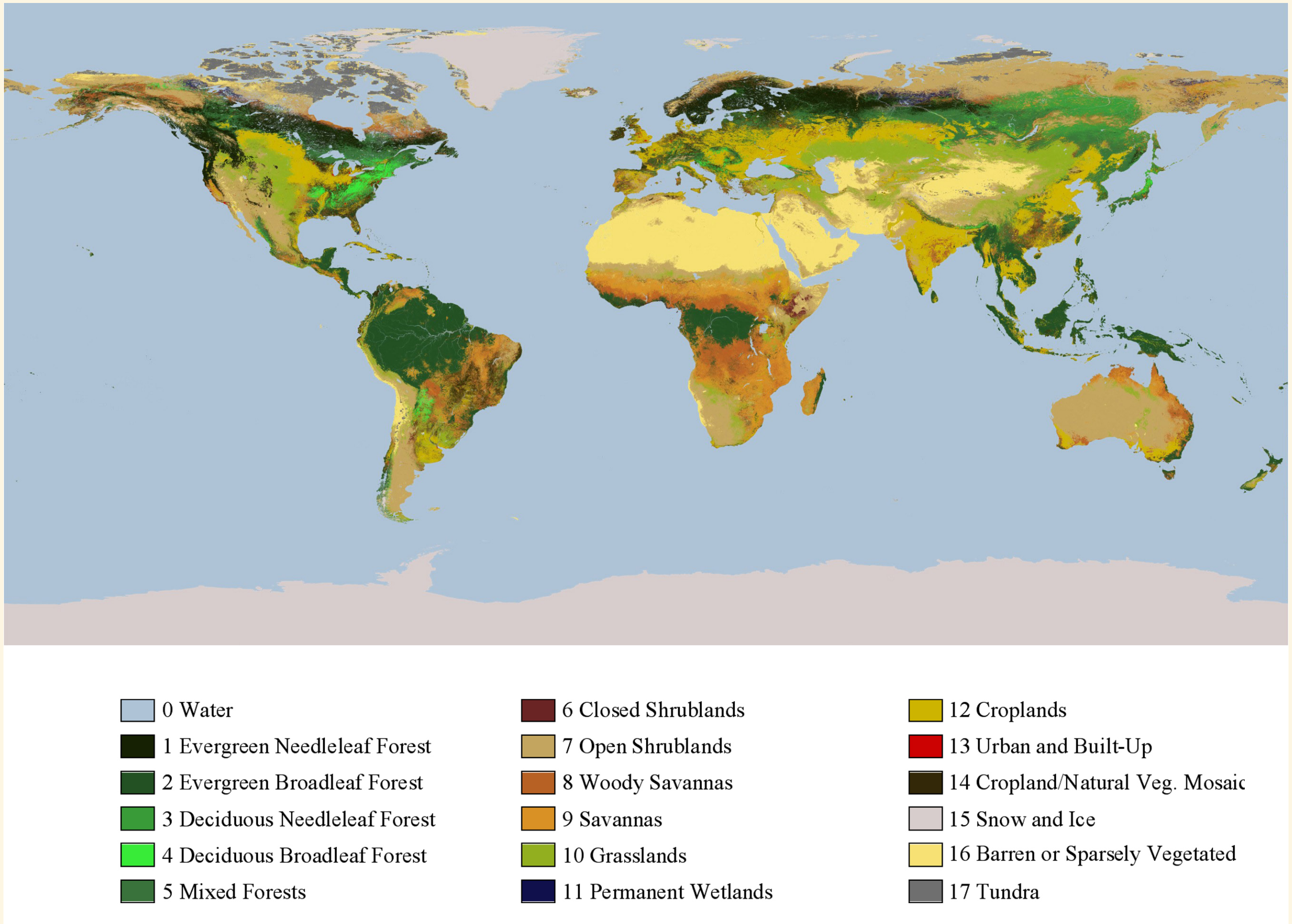
LAND COVER

Ground sampling ties spectral signatures to habitats



LAND COVER

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



LAND COVER

Examples:

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

PRODUCTIVITY

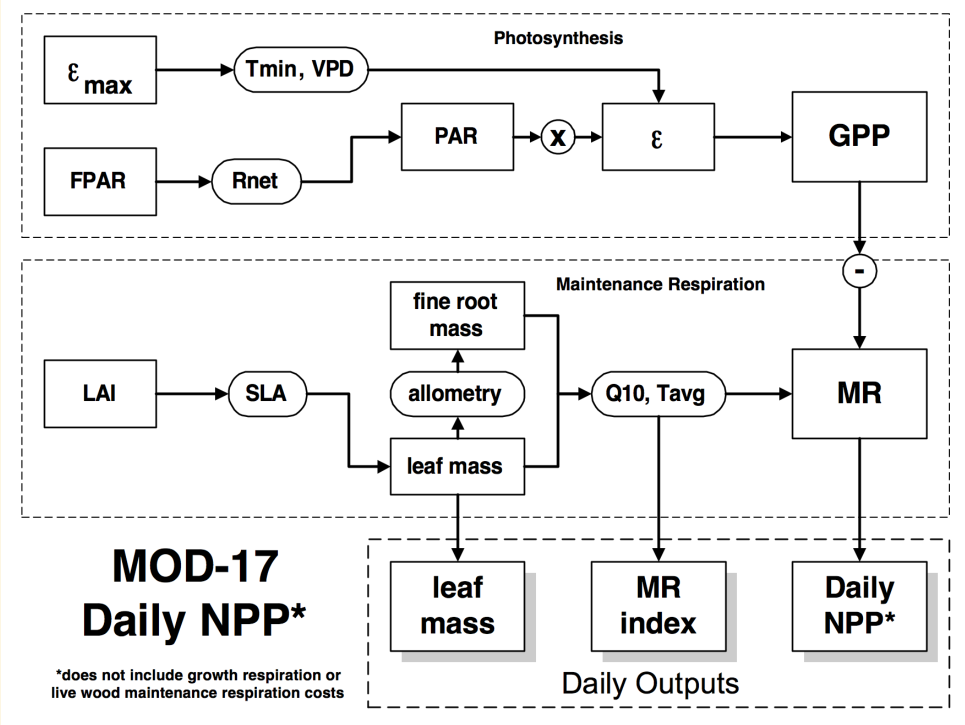
Plants use light to store carbon. If we know:

- 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