SPECTRAL BANDS USED IN RS

Spectral Bands used in Remote Sensing are:

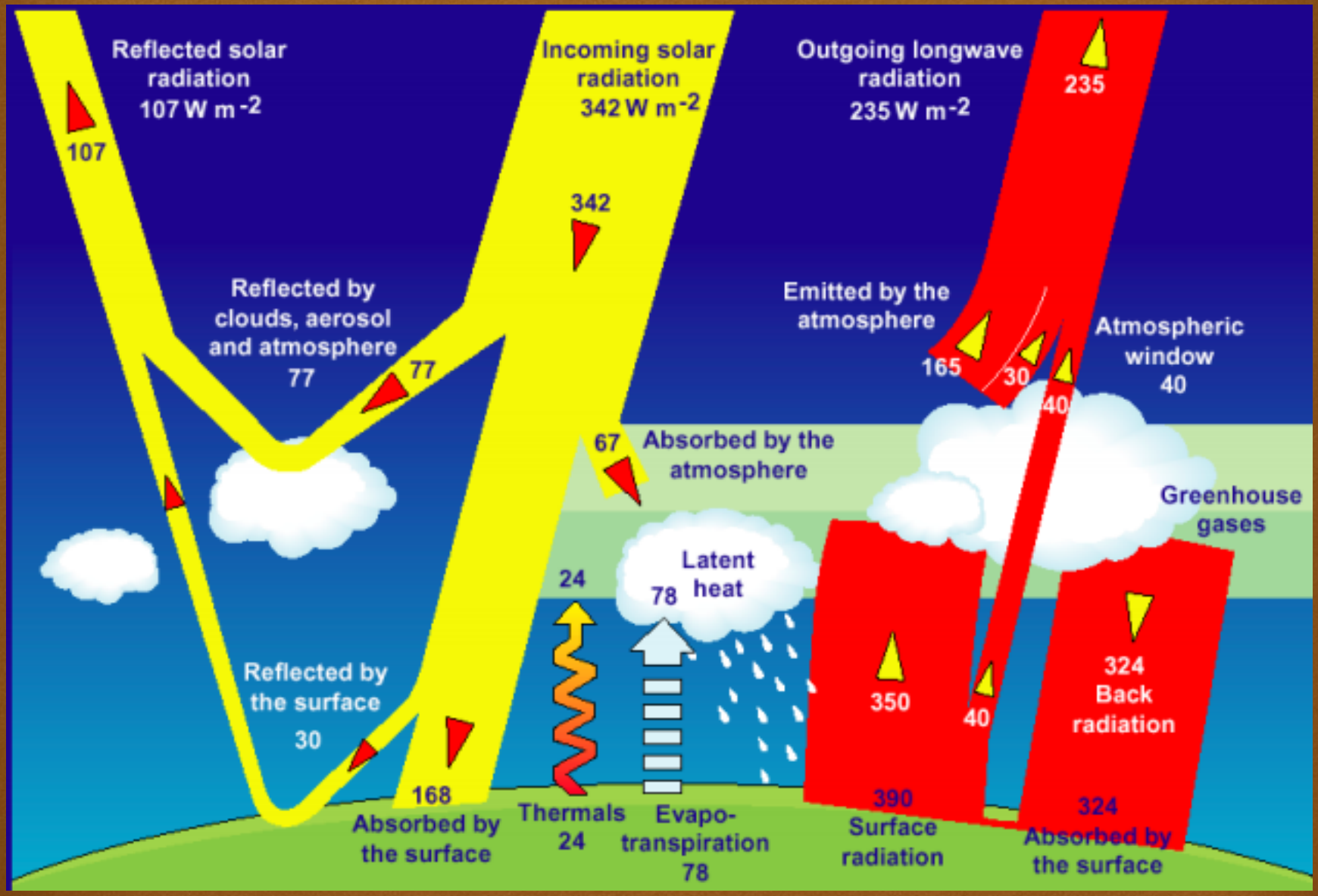
1) Visible between .4 and .7 µm (Reflective Band)
2) NIR / MIR between .7 and 3 µm (Reflective Band)
3) FIR between 4 and 15 µm (Emissive Band)

→ About 99% of the energy observed between 0 and 4 µm is solar reflected energy. Only 1% is observed above 4 µm

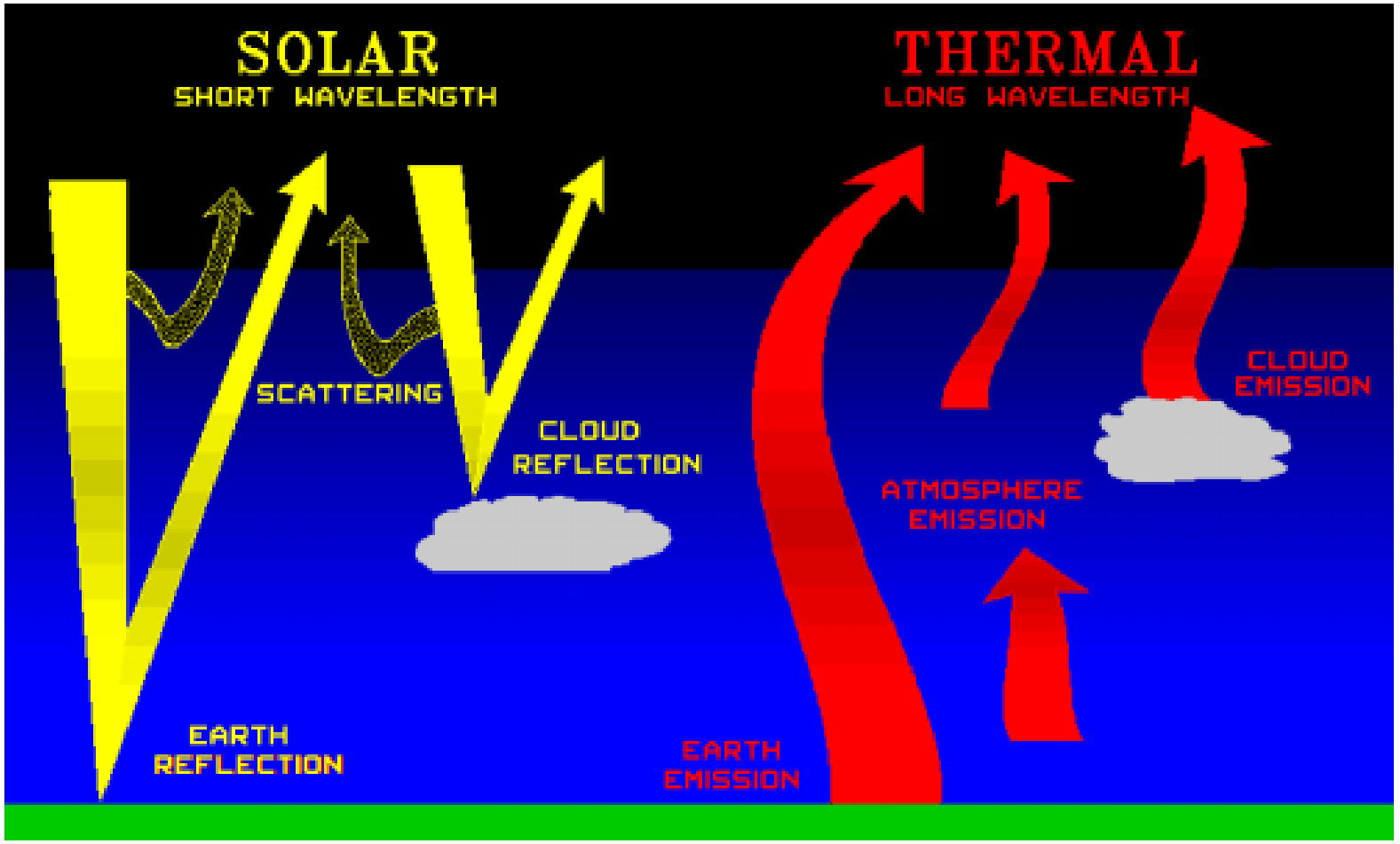
→ Emissive Band is used to observe terrestrial energy emitted by the Earth system in the IR between 4 and 15 µm

- About 99% of the energy observed in this range is emitted by the Earth
- Only 1% is observed below 4 µm
- At 4 µm the solar reflected energy can significantly affect the observations of the Earth emitted energy

SPECTRAL BANDS USED IN RS



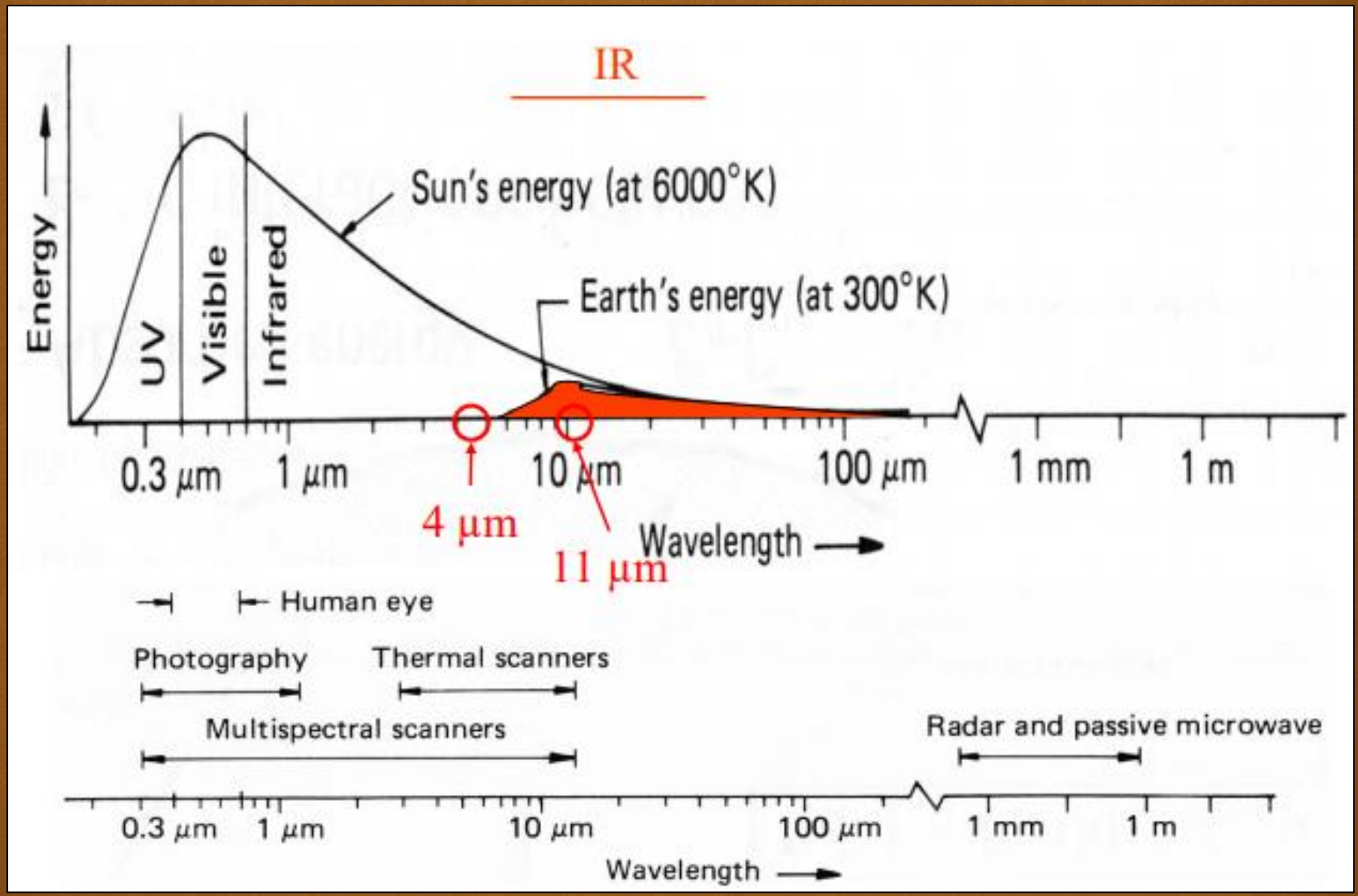
SPECTRAL BANDS USED IN RS



Visible & Near IR
(Reflective Bands)

Infrared (IR)
(Emissive Bands)

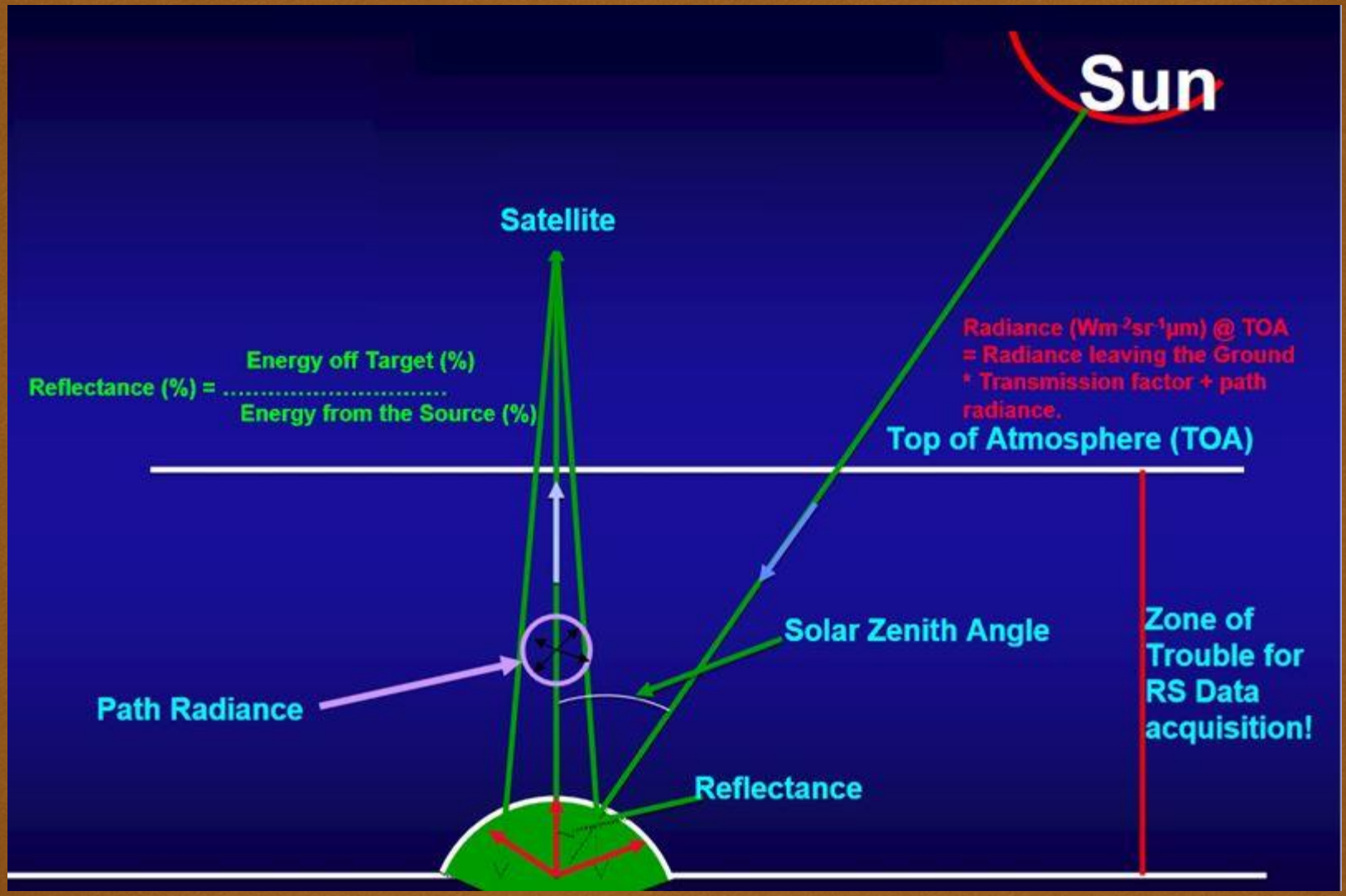
SPECTRAL CHARACTERISTICS (Thermal)



SPECTRAL REFLECTANCE

- To properly compare different reflective channels we need to convert observed radiance into a target physical property
- In the visible and near infrared this is done through the ratio of the observed radiance divided by the incoming energy at the top of the atmosphere
- The physical quantity is the Reflectance i.e. the fraction of solar energy reflected by the observed target
- **Path radiance** is the **radiance** detected by a space borne sensor above a non-reflective surface, and is the result of backscattering by particles and molecules in the atmosphere.
- Top of Atmosphere (ToA) reflectance : unit less measurement that provides the ratio of radiation reflected to the incident solar radiation on a given surface.
- ToA can be computed from satellite measured spectral radiance using the mean solar spectral irradiance and the solar zenith angle
- Bottom of Atmosphere (BoA) reflectance: Obtained after atmospheric correction. Preserves the reflection off the surface below atmosphere

SPECTRAL REFLECTANCE



SPECTRAL SIGNATURES IN REMOTE SENSING

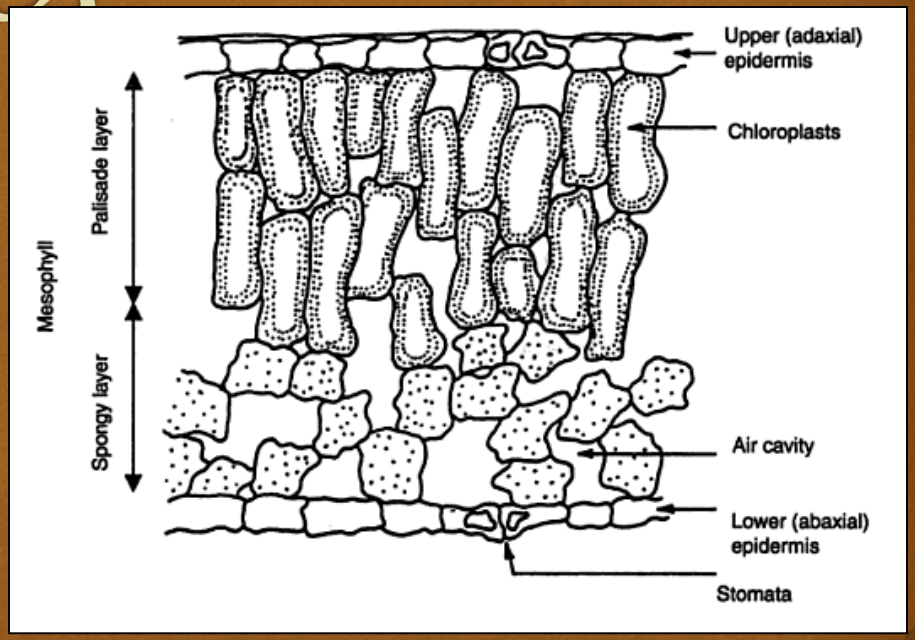
- Signature → The characteristic feature that enables an object (target) to be identified (recognized)
- In remote sensing, the object is identified using variation in "Wavelength" as the key parameter
- Spectral Signature → Specific combination of emitted, reflected, or absorbed electromagnetic radiation at varying wavelengths, which can uniquely identify the object
- Spectral signature of an object depends on

    a) Wavelength of EM radiation

    b) Material of interaction

LEAF STRUCTURE - TERMINOLOGY

- Epidermis covers the Upper and Lower surfaces
- Epidermis are intercepted by openings called Stomata
- Each Stomata is surrounded by two guard cells
- Stomata regulates the exchange of gasses and water vapour from leaves
- The tissue between two epidermal layers is Mesophyll
- Mesophyll consists of elongated cells in rows and/or irregularly arrange cells in layers
- Leaf pigments are found in Chloroplasts
- Plants absorb energy in UV and Visible region for Photosynthesis



SPECTRAL SIGNATURE OF VEGETATION

- VISIBLE REGION (0.4 – 0.7 Mm)

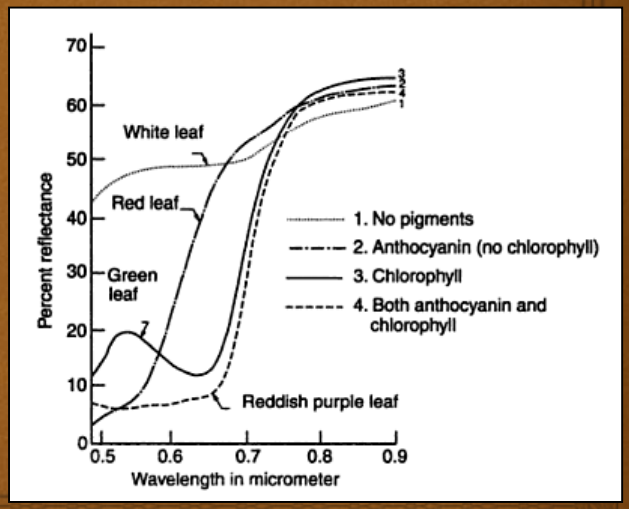
→ Chlorophyll content of the leaf controls reflectance in visible region

→ Absorption of leaf pigments dominates the reflectance characteristics in visible region

→ Incident radiation is completely absorbed in BLUE (~ 0.45 µm) and RED (~ 0.67 µm) regions

→ Spectral reflectance is high (peak) at a wavelength of about 0.55 µm (GREEN band)

→ Leaves with Low Chlorophyll content and other pigments will have different spectral response



SPECTRAL SIGNATURES OF VEGETATION

- INFRA RED REGION
- ***Near Infrared region*** (0.7 to 1.3 µm)

→ Internal structure of the leaf controls the reflectance in Near IR

→ The mesophyll arrangement dominates reflectance/transmittance/ absorbance in this region

- ***Short Wave Infrared region*** (1.3 to 2.7 µm)

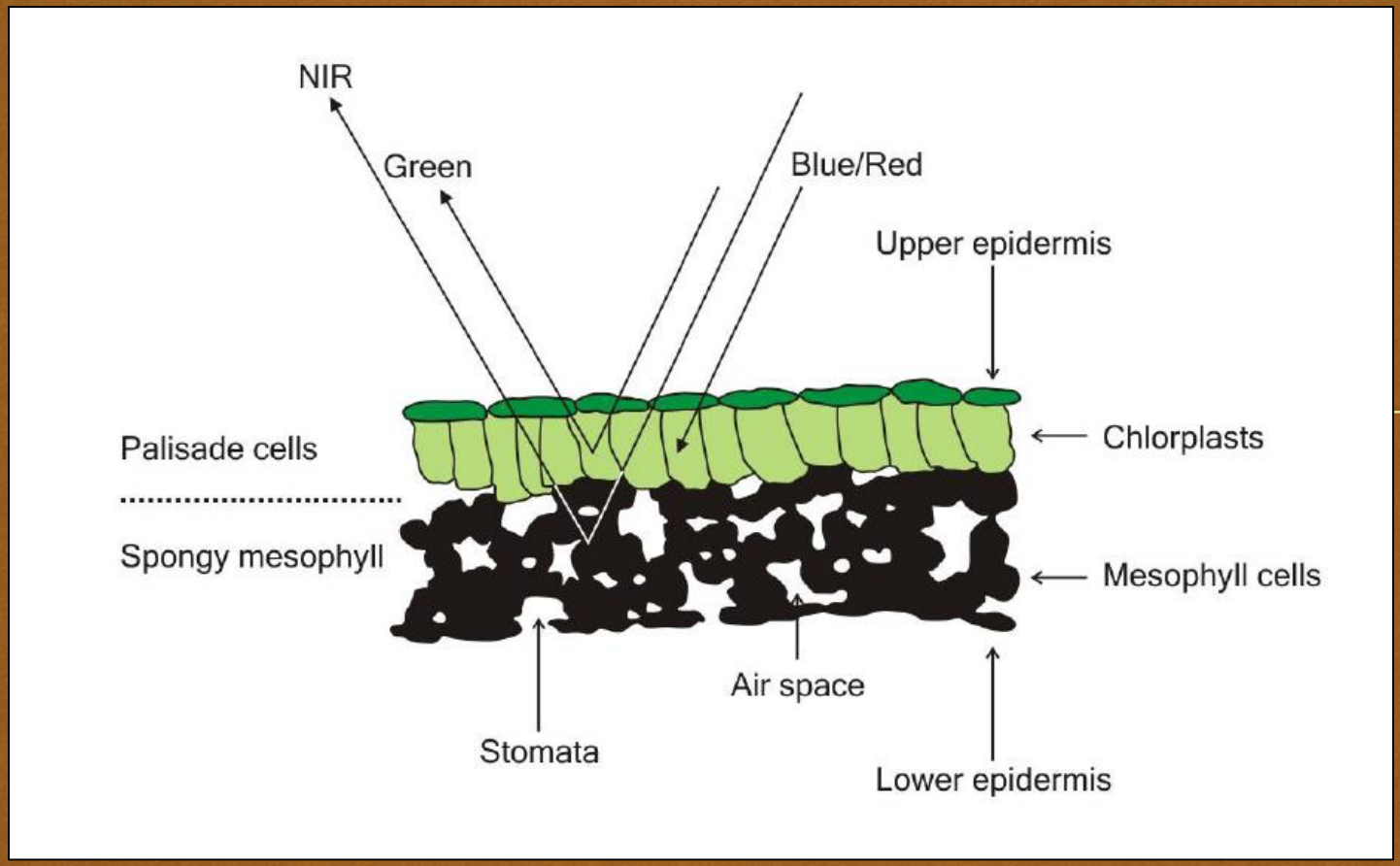
→ Moisture content of the leaf controls the reflection characteristics

→ Three water absorption bands are present in this region (1.4, 1.9, and 2.7 µm)

→ Absorption is a function of moisture content of the leaf and thickness

→ Less moisture content in leaf results in high reflectance

SPECTRAL REFLECTANCE OF VEGETATION



Spectral Reflectance Characteristics of Vegetation

SPECTRAL SIGNATURES OF VEGETATION

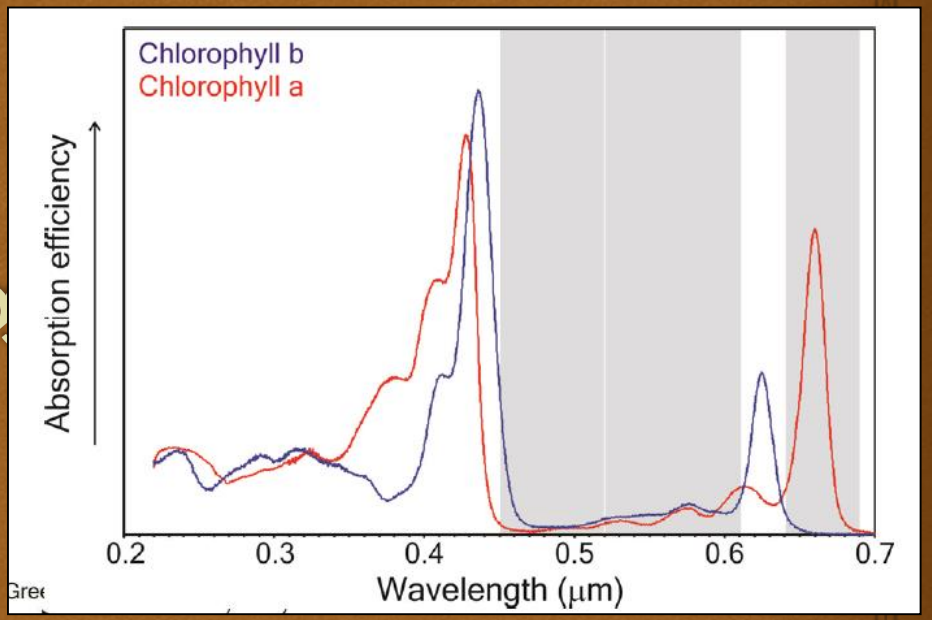
Chlorophyll

→ A green pigment found in chloroplasts of algae and plants

→ Useful in photo sysnthesis

→ Absorbs all energy in BLUE and RED bands

→ Chlorophyll consists of Chlorophyll a and b compounds



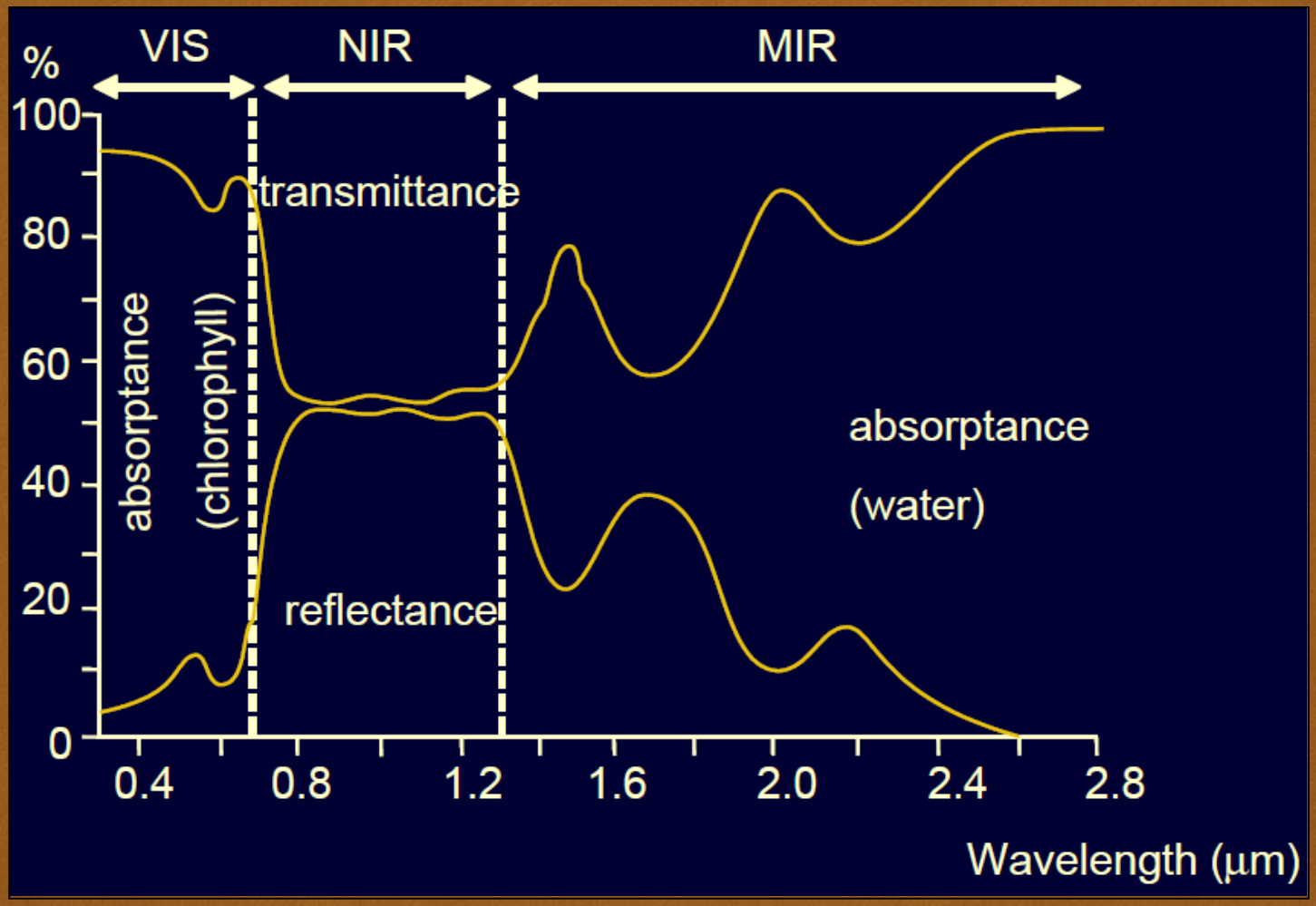
Chorophyll a

→ Specific form of chlorophyll used in oxygenic photo synthesis

Chlorophyll b

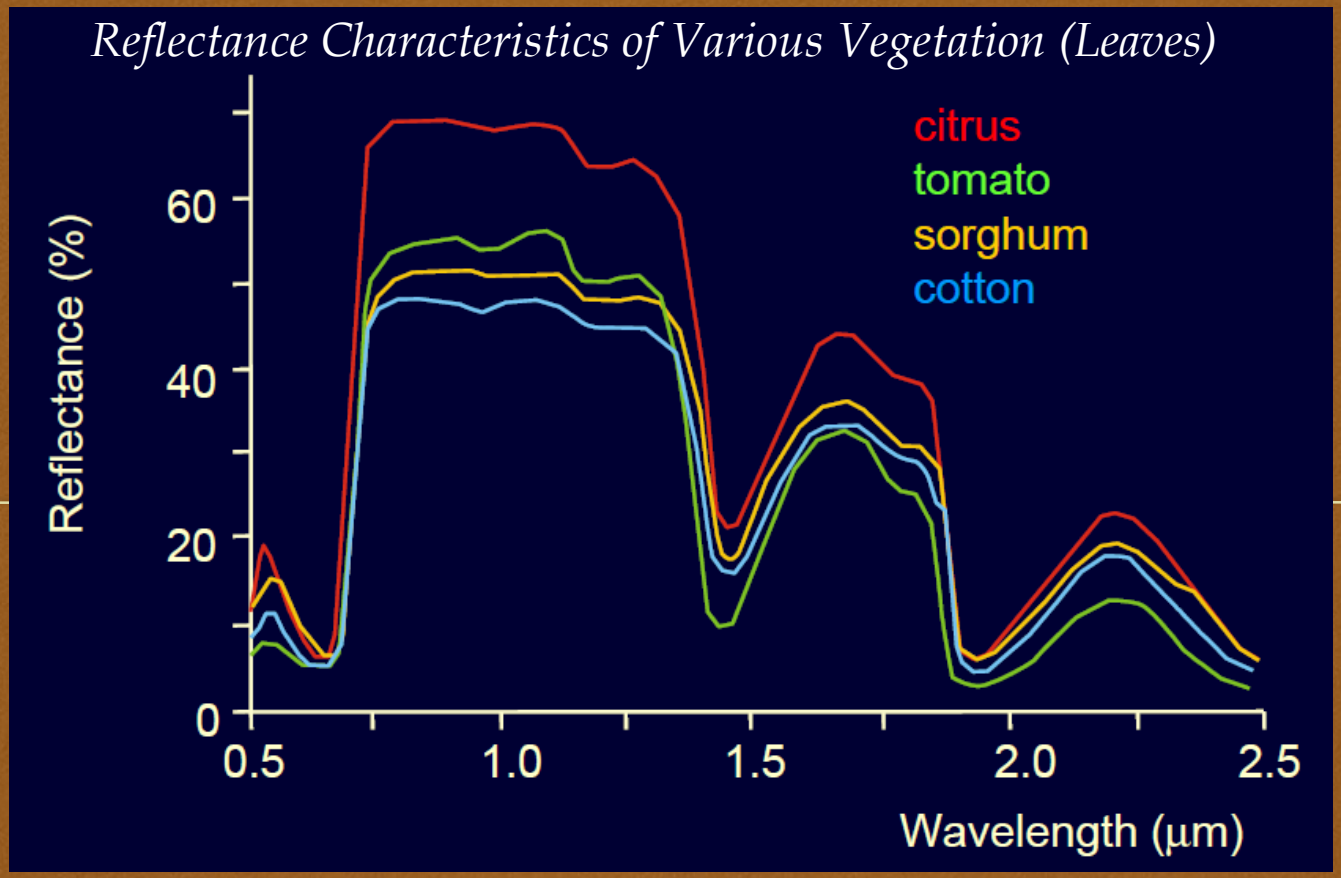
→ Helps in photo synthesis by absorbing light energy

SPECTRAL SIGNATURES OF VEGETATION

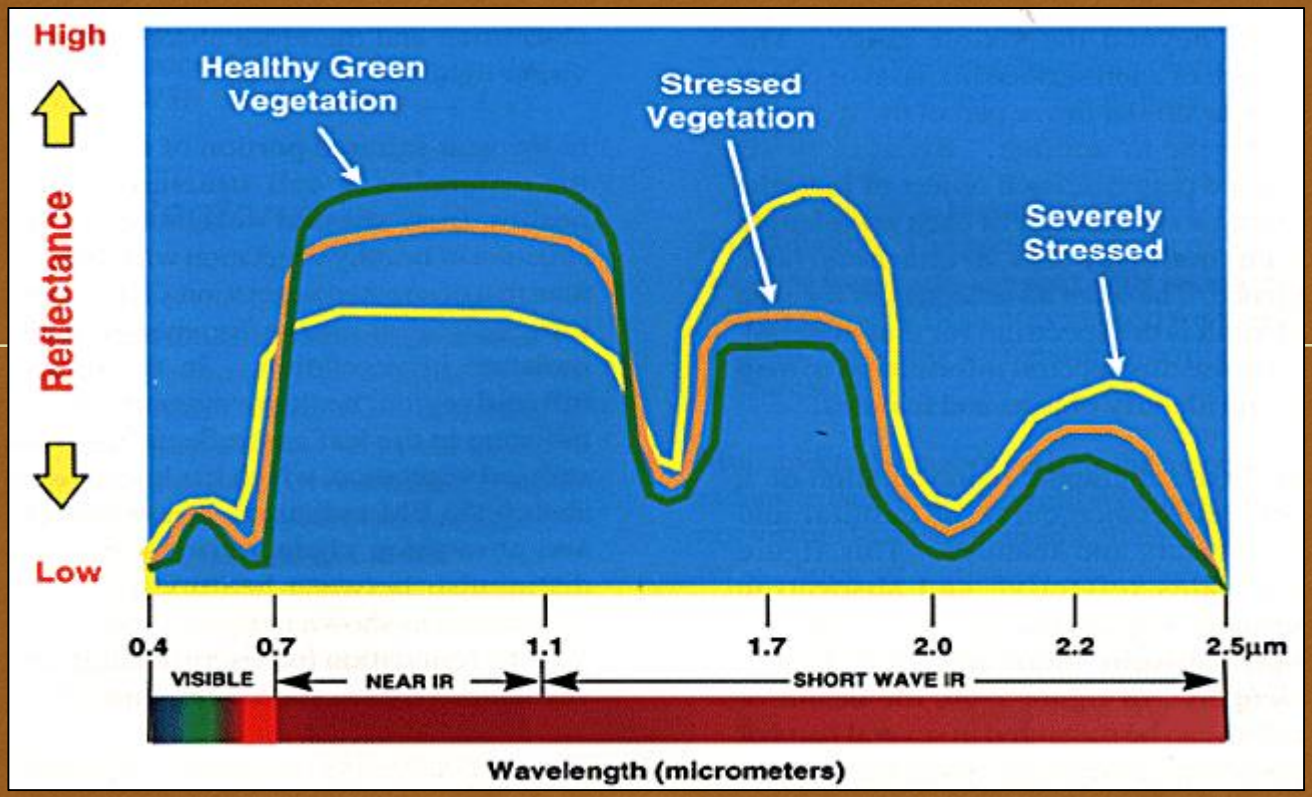


Spectral distribution of Reflectance, Transmittance, and Absorption

SPECTRAL SIGNATURES OF VEGETATION

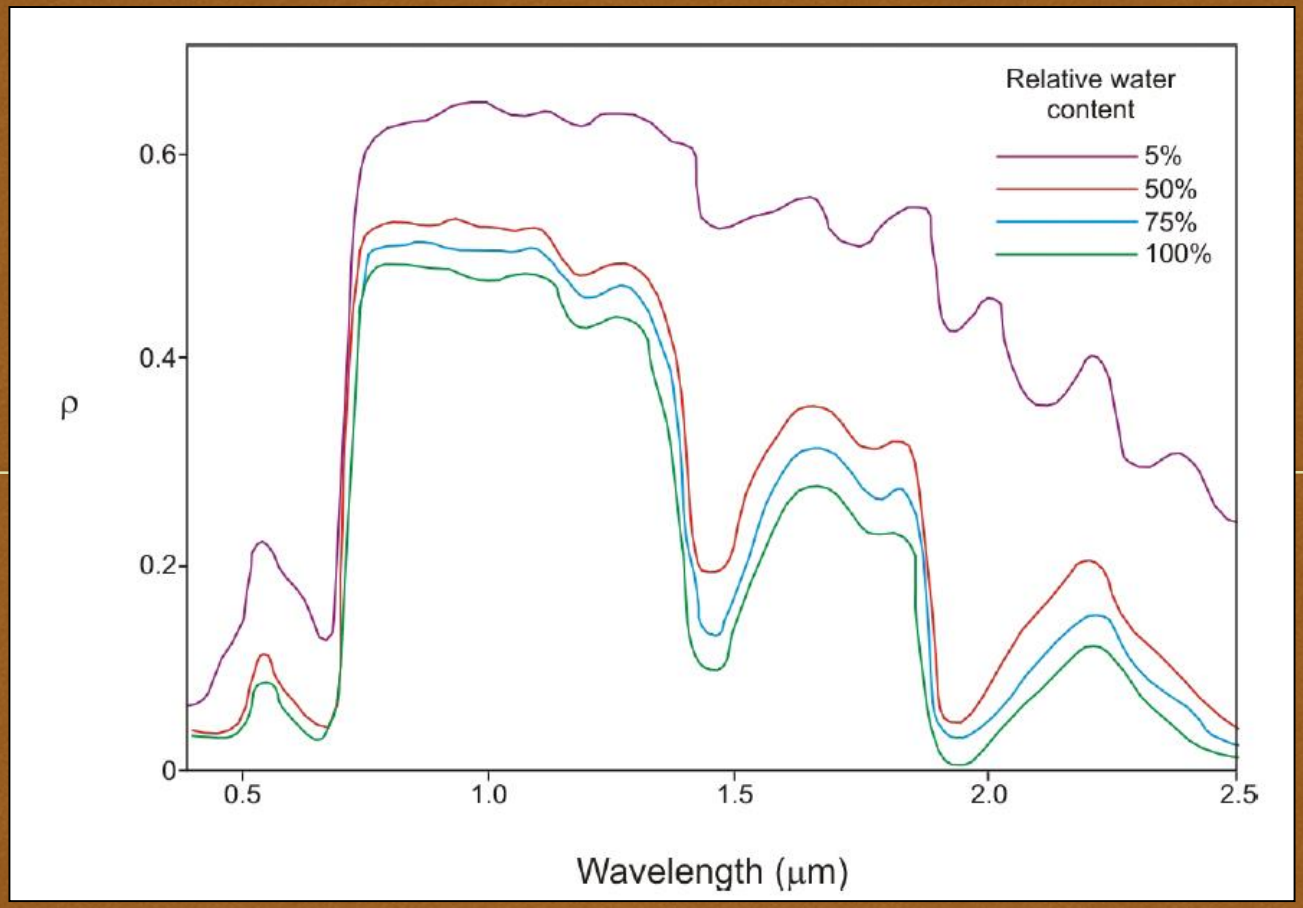


SPECTRAL SIGNATURES OF VEGETATION



Effect of Vegetation Health on Spectral Reflectance

SPECTRAL SIGNATURES OF VEGETATION

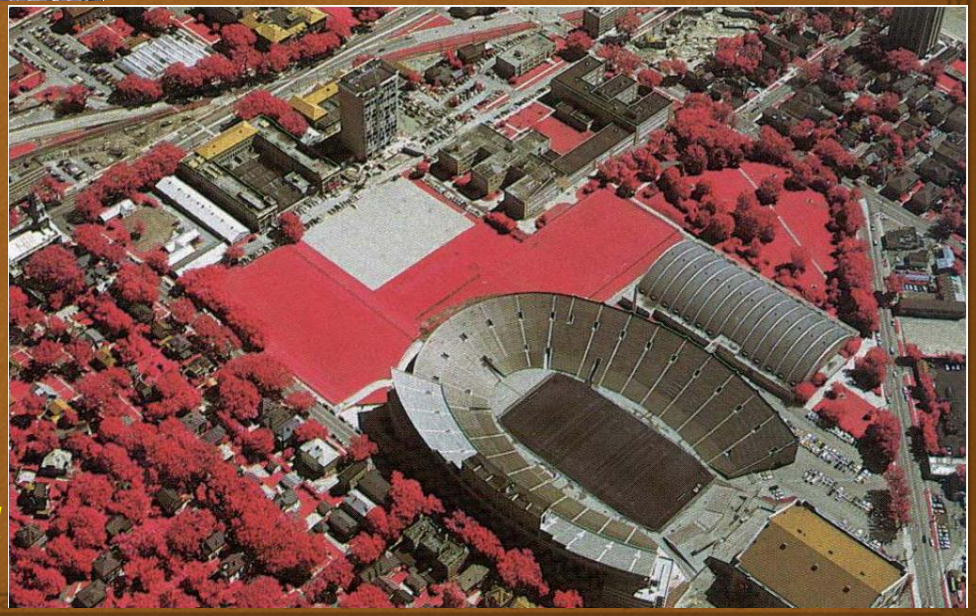


Effect of water content of the vegetation on Spectral Reflectance

MULTI SPECTRAL SATELLITE IMAGE

SPOT THE DIFFERENCES ….

Satellite Image in Visible Band



Satellite Image in Infra Red Band

VEGETATION INDICES

1. Difference Vegetation Index (DVI)

- Crop parameters (growth rate, health, ..) can be related to spectral reflectance using vegetation indices

- DVI is given by: $DVI = NIR - RED$

- Simplest vegetation index
- Sensitive to the amount of vegetation
- Does not deal with difference between reflectance and radiance caused by the atmosphere or shadows

VEGETATION INDICES

2. Simple Ratio / Spectral Ratio (SR)

- Ratio based index
- SR is given by: $SR = NIR / RED$
- High for vegetation
- Low for soil, ice, water, etc.
- Indicates amount of vegetation, and its stress condition
- Reduces the effects of atmospheric and topography

VEGETATION INDICES

3. Normalized Difference Vegetation Index (NDVI)

- NDVI is given by: $NDVI = \frac{NIR-VIS}{NIR+VIS}$ $NDVI = \frac{NIR-RED}{NIR+RED}$

NIR → Reflectance in Near Infrared band (as a fraction of incident radiation) [Range: 0 to 1]
VIS → Reflectance in Visible band (as a fraction of incident radiation) [Range: 0 to 1]

- NDVI varies from -1 to + 1

Applications:
1) An NDVI of close to -1 represents water body
2) An NDVI of close to zero (-0.1 to +0.1) represents barren areas of rock, sand, snow, …
3) An NDVI of low positive values (0.2 to 0.4) represents grasslands, shrubs
4) An NDVI of close to +1 represents temperate and tropical forests
5) Does not eliminates atmospheric effects, minimizes topographic effects

TEMPORAL REFLECTANCE OF VEGETATION

- When the crop emerges after sowing, the crop is spectrally detectable (vegetation index > threshold value).
- This period is called as Spectral emergence date
- The vegetation index increases continuously as the crop cover increases (to peak)
- The vegetation index decreases as the crop begins to senesce
- Vegetation index falls below threshold after harvesting

Analytical methods can be used to fit crop growth profile in terms of spectral reflection (particularly in Infra red region)

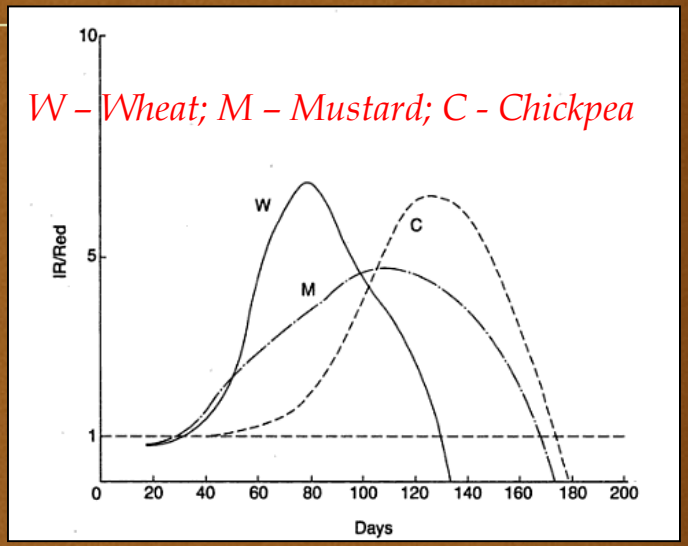
$$\rho(t) = \rho_o + (\rho_m - \rho_o)\,(2\beta\, e/\alpha)^{\alpha/2}\,((t - t_o)^{\alpha} \exp[-\beta(t - t_o)^2]$$

ρ_0 → Reflectance at t = 0

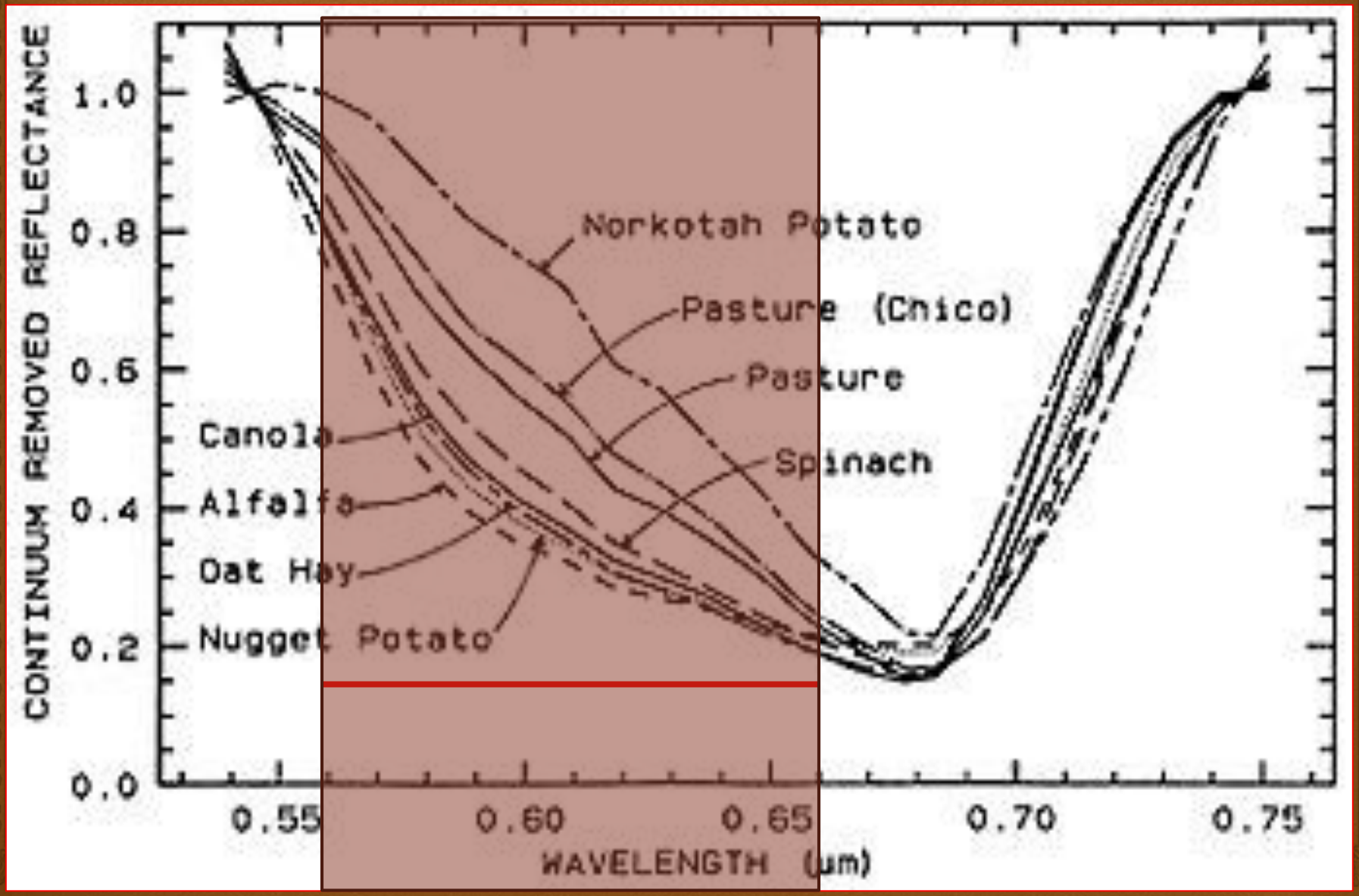
ρ_m → Maximum reflectance from crop

(occurs at $t_p = \sqrt{\frac{\alpha}{2\beta}}$)

α and β are crop condition related constants

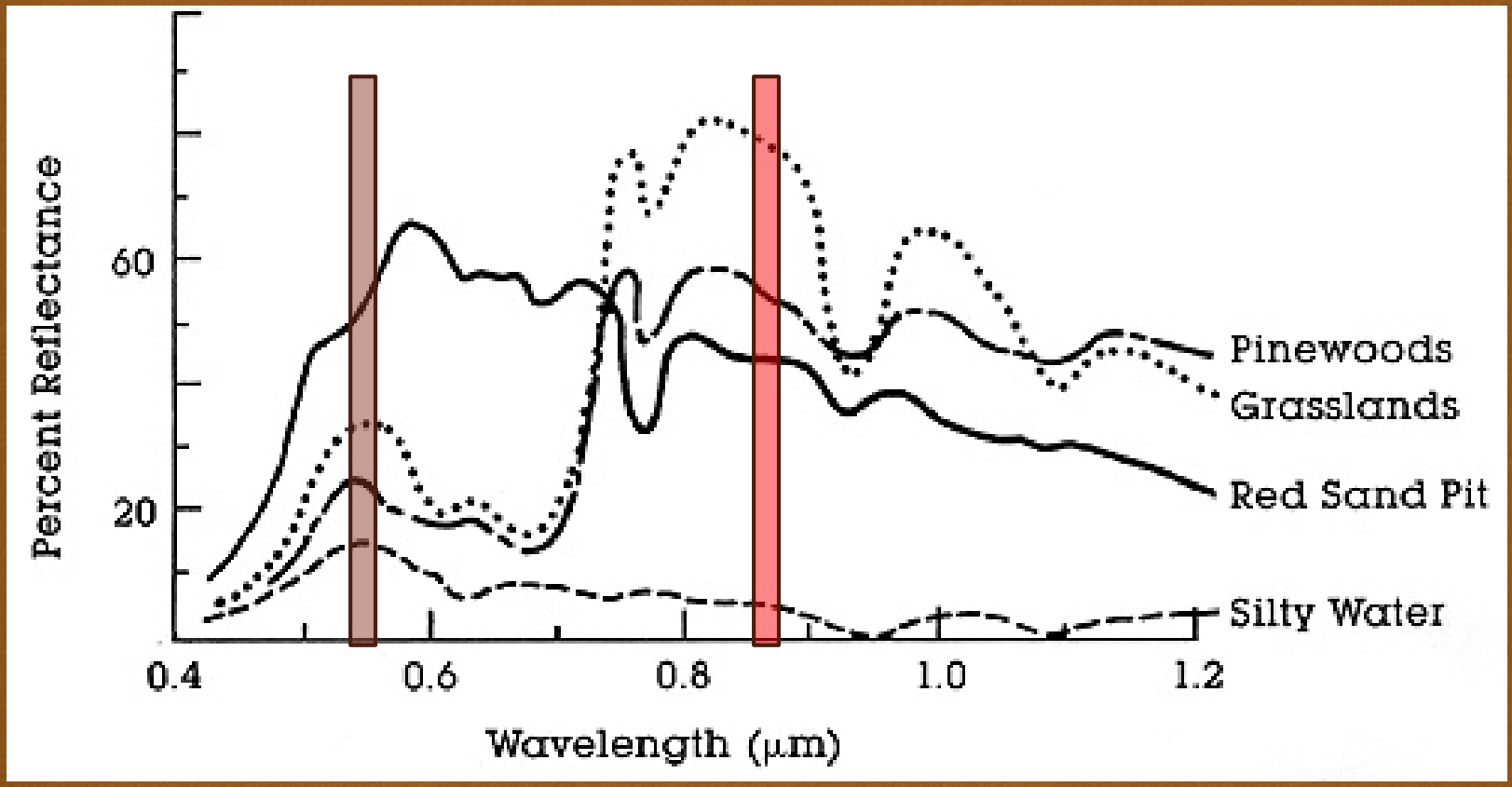


Some crops distinguishable by separations in 0.56 to 0.66 μm interval



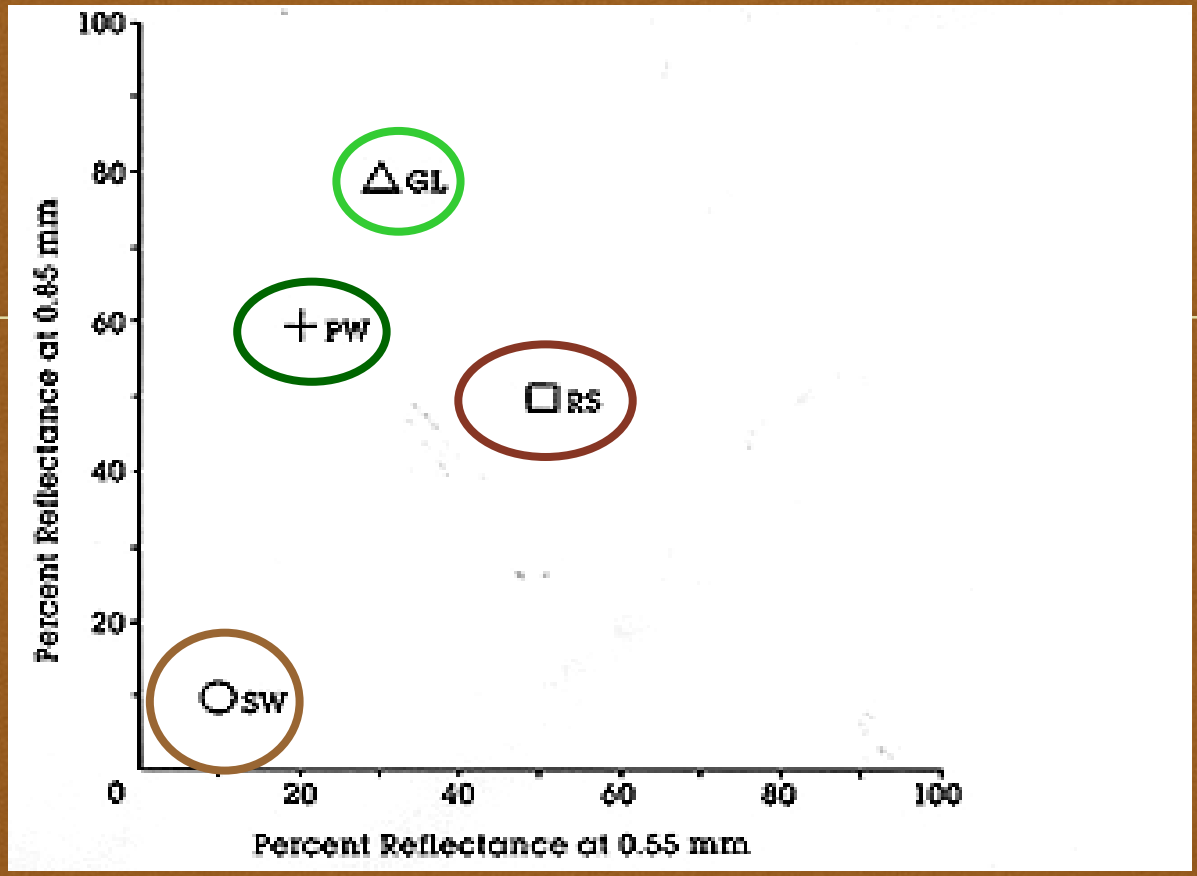
Spectral Signatures of 4 Materials

Band 1 = 0.55 um Band 2 = 0.85 um

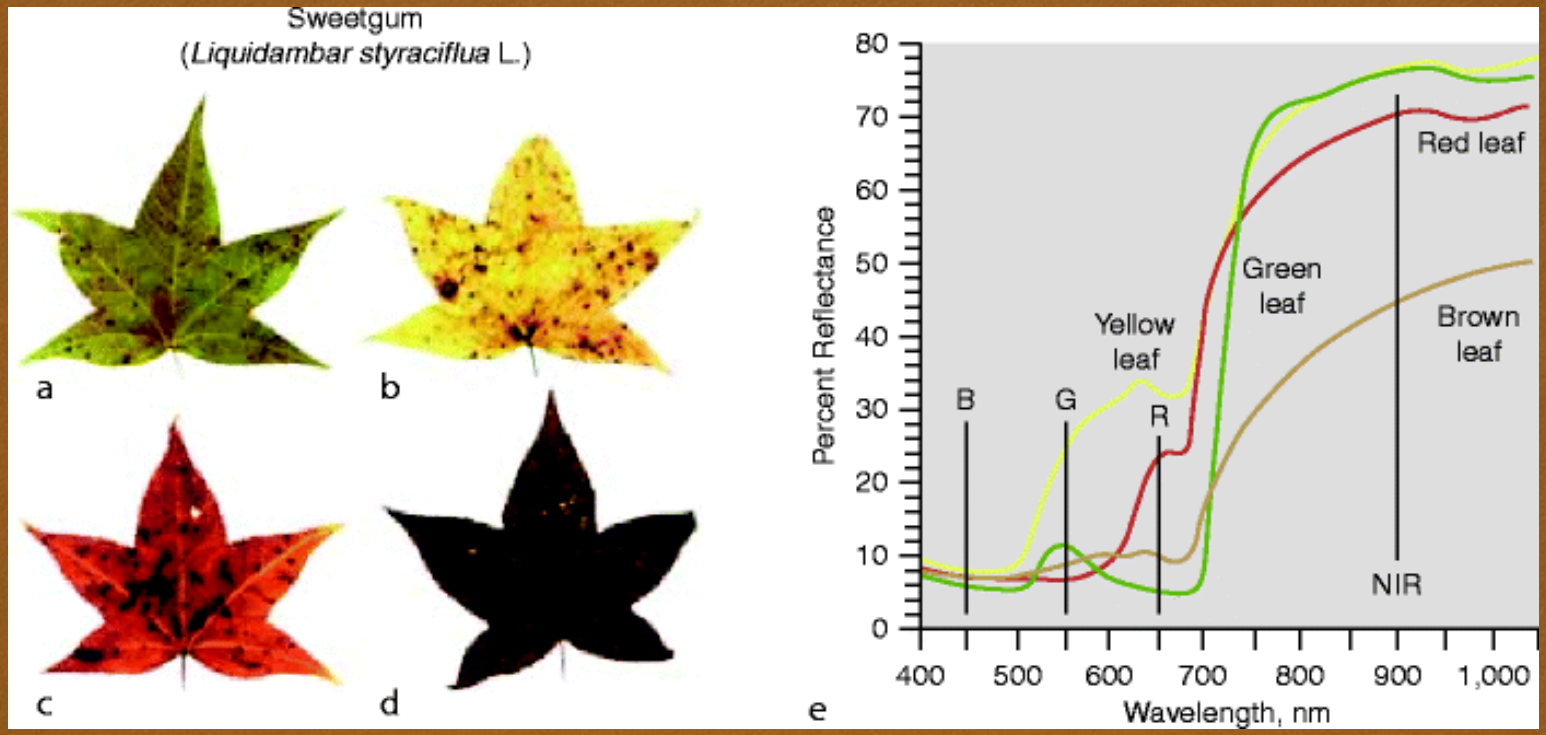


Spectral Signatures of 4 Materials

GL = grasslands PW = pinewoods
RS = red sand SW = silty water



Spectral Reflectance Curve - Vegetation

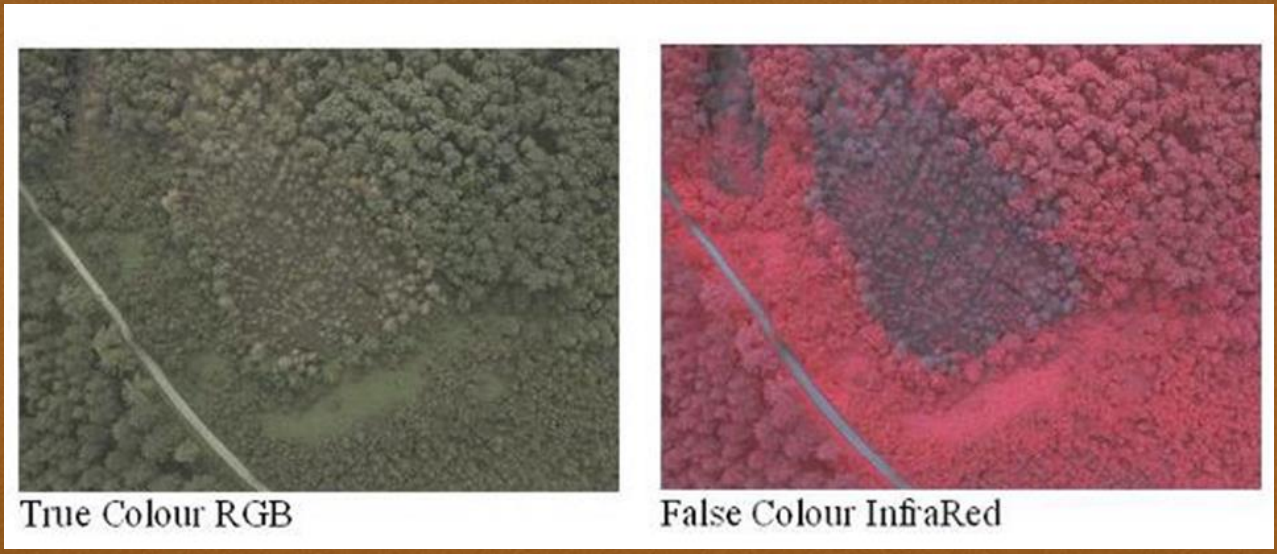


- As a plant stops or reduces chlorophyll production, it absorbs less in the red bands (therefore reflects more red) producing yellow color of dying vegetation.
- Red color of some leaves produced by carotenoids which are always present but usually masked by chlorophyll

Spectral Reflectance Curve - Vegetation

Remote sensed imagery can be used to detect stressed or diseased plants

- High NIR reflectance / Low visible reflectance = Healthy
- Low NIR reflectance / High visible reflectance = Unhealthy



Ground Truthing

Ground-truthing is when you validate your remotely sensed data with data from the "ground".

Ground-truthing varies with the type of data and your goals.

Examples:

Measuring vegetation reflectance and comparing it with satellite data

Performing object recognition and comparing with the actual objects on the ground

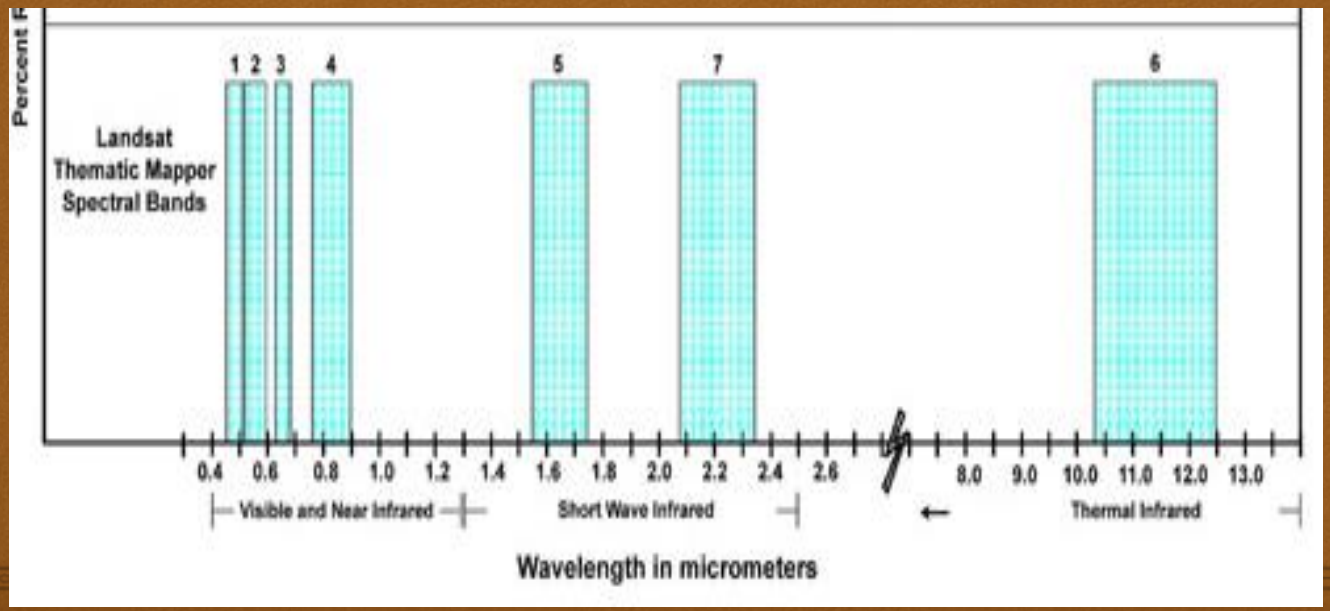
LANDSAT THEMATIC BANDS (Multi Spectral)

BLUE (0.45-0.52 µm): water penetration, soil/veg. discrimination.

GREEN (0.52-0.60 µm): green reflectance peak for discrimination and vigor assessment.

RED (0.63-0.69 µm): chlorophyll absorption for species differentiation.

NEAR IR (0.76-0.90 µm): determining vegetation types, vigor, and biomass content, delineating water bodies, soil moisture

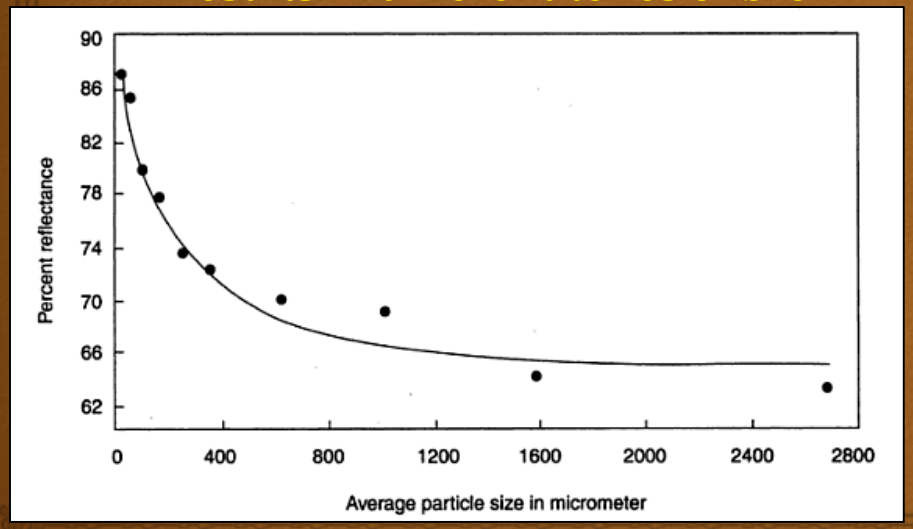


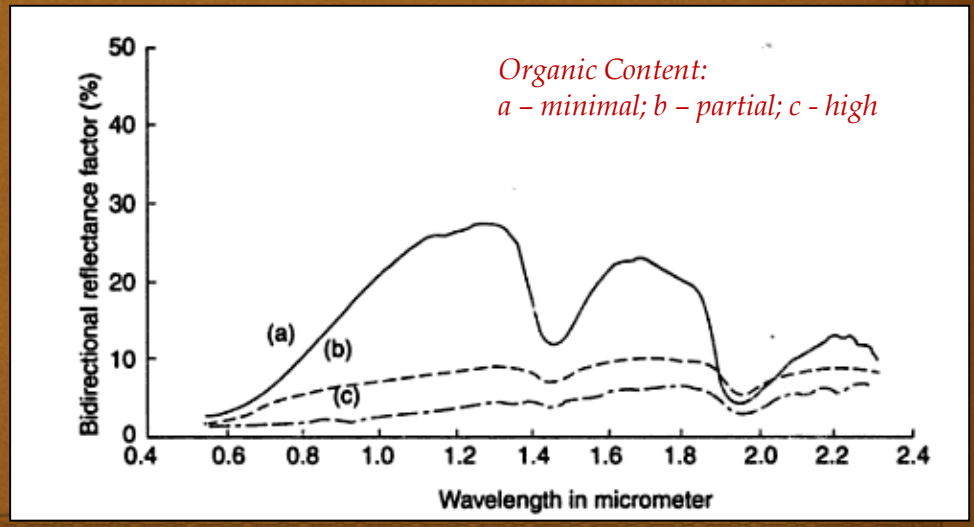
SPECTRAL SIGNATURE OF SOIL

- Reflectance of soil in visible region depends on property of top soil
- Reflectance of soil is highly affected by soil moisture; texture; structural arrangements
- Reflectance of soil is less affected by chemical composition
- Northern latitudes have black soils and tropical regions have red soils.
- Soil reflectance decreases as organic matter increases.
- As soil moisture increases, reflectance of soil decreases at all wavelengths.
- Texture of soil will cause increased reflectance with decreased particle size, i.e., the bigger particles (rocks, sand, and soils) basically cast a larger shadow.

SPECTRAL SIGNATURE OF SOIL

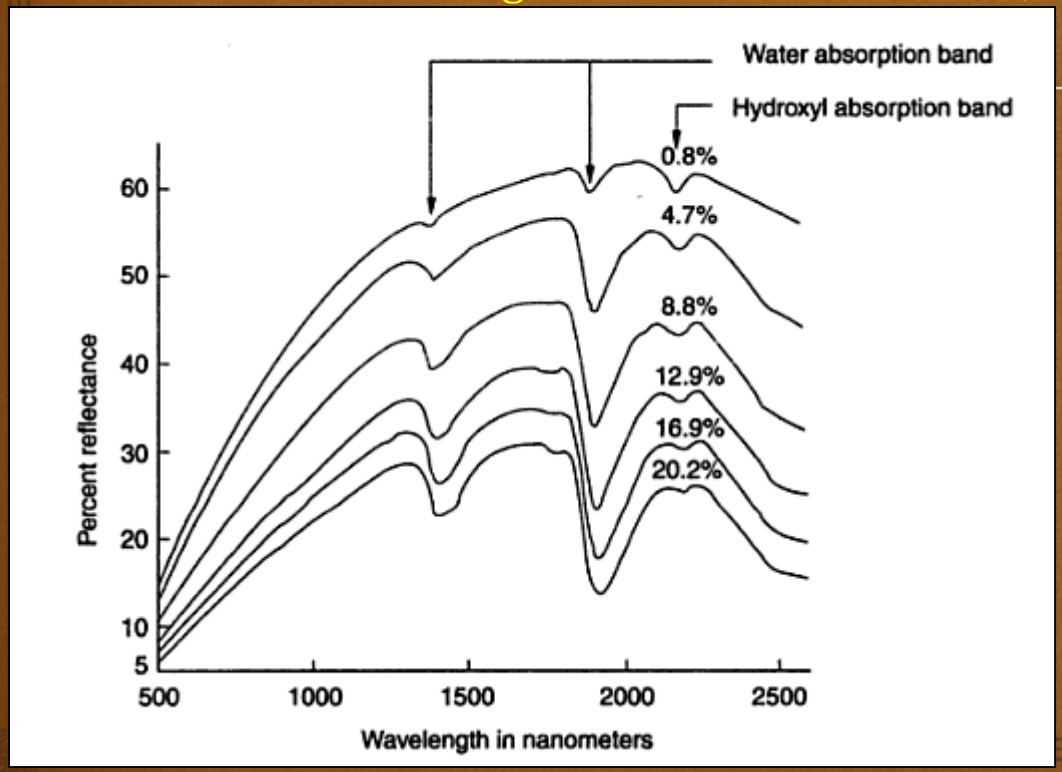
- Soil reflectance increases as particle size decreases
- Notable increase in reflectance occurs when particle size is less than 400 µ
- Rougher soil results in lower reflectance
- Structure-less soils gives higher (15 to 20%) reflectance than well defined soils
- Dark colour in the surface horizons is associated with organic content
- 5% or more organic matter results in black colour, and lower organic matter results in different tones of brown

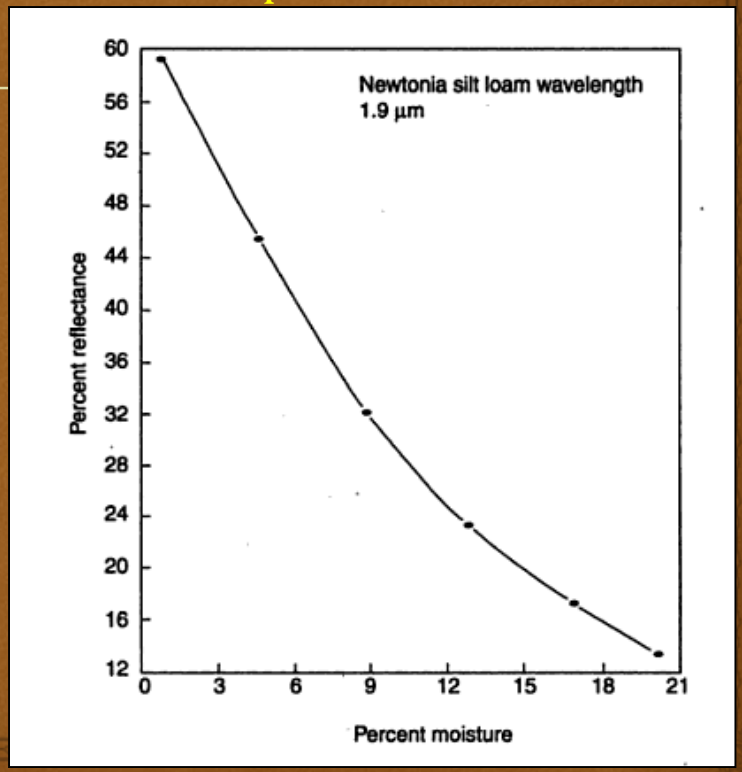




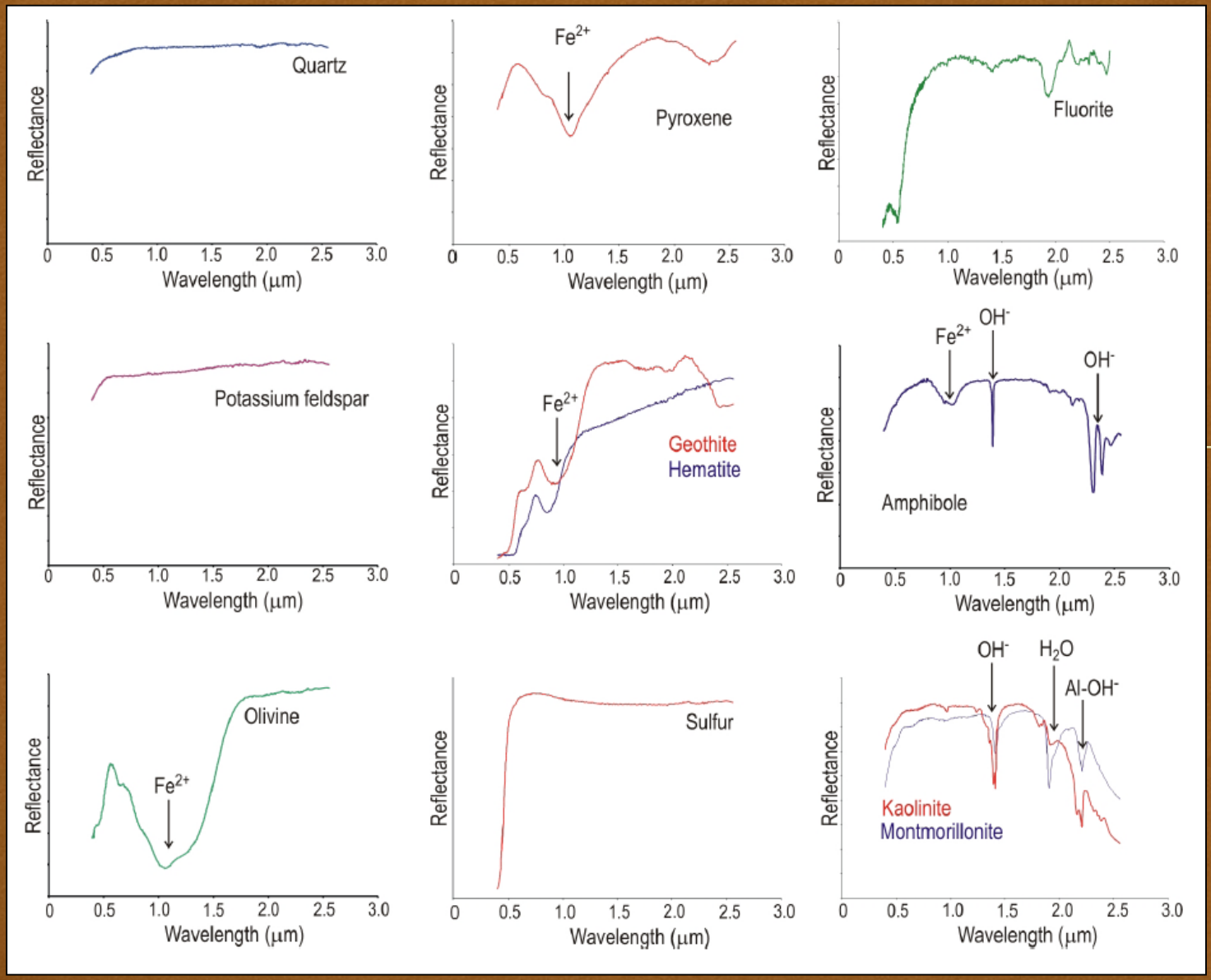
EEFECT OF SOIL MOISTURE

- Wet soil (increases soil moisture) appears dark in visible region due to absorption of incident waves by water
- Water absorption bands: 1.4 μm; 1.9 μm; and 2.7 μm
- Relation between albedo and soil moisture is approximately linear
- Soil moisture changes the reflectance values, but not the shape





SPECTRAL REFLECTANCE OF ROCKS

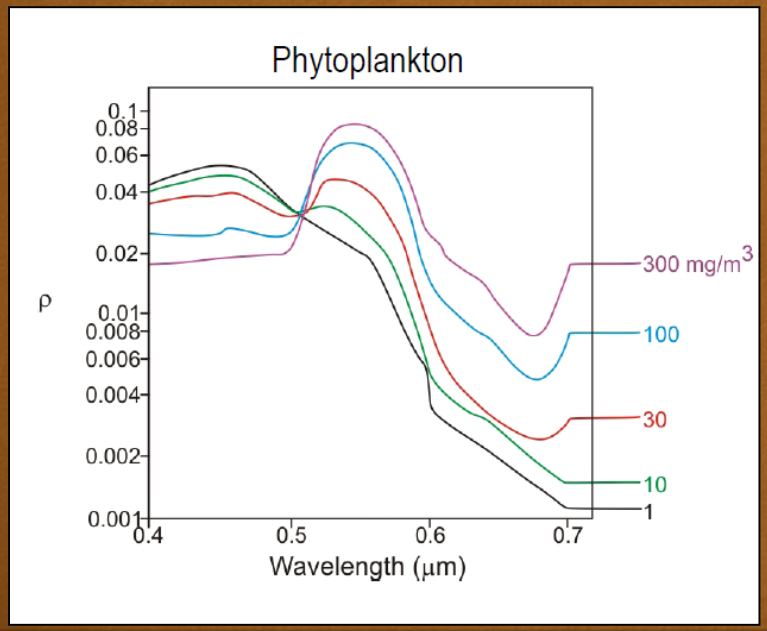


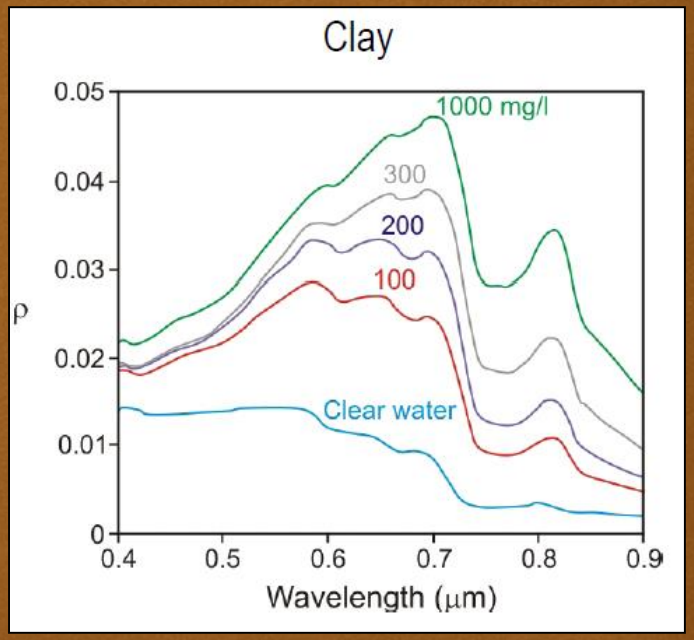
SPECTRAL SIGNATURE OF WATER

- Reflectance properties of water are function of water and material in the water (organic and inorganic)
- Water is reflected in Visible region only. Water absorbs almost all infra red wavelength
- Generally water reflect high in the visible spectrum, however, clearer water has less reflectance than turbid water.
- In the Near IR and Mid-IR regions water increasingly absorbs the light making it darker.
- This phenomena is dependent upon water depth and wavelength.
- Increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer water) of the spectrum.

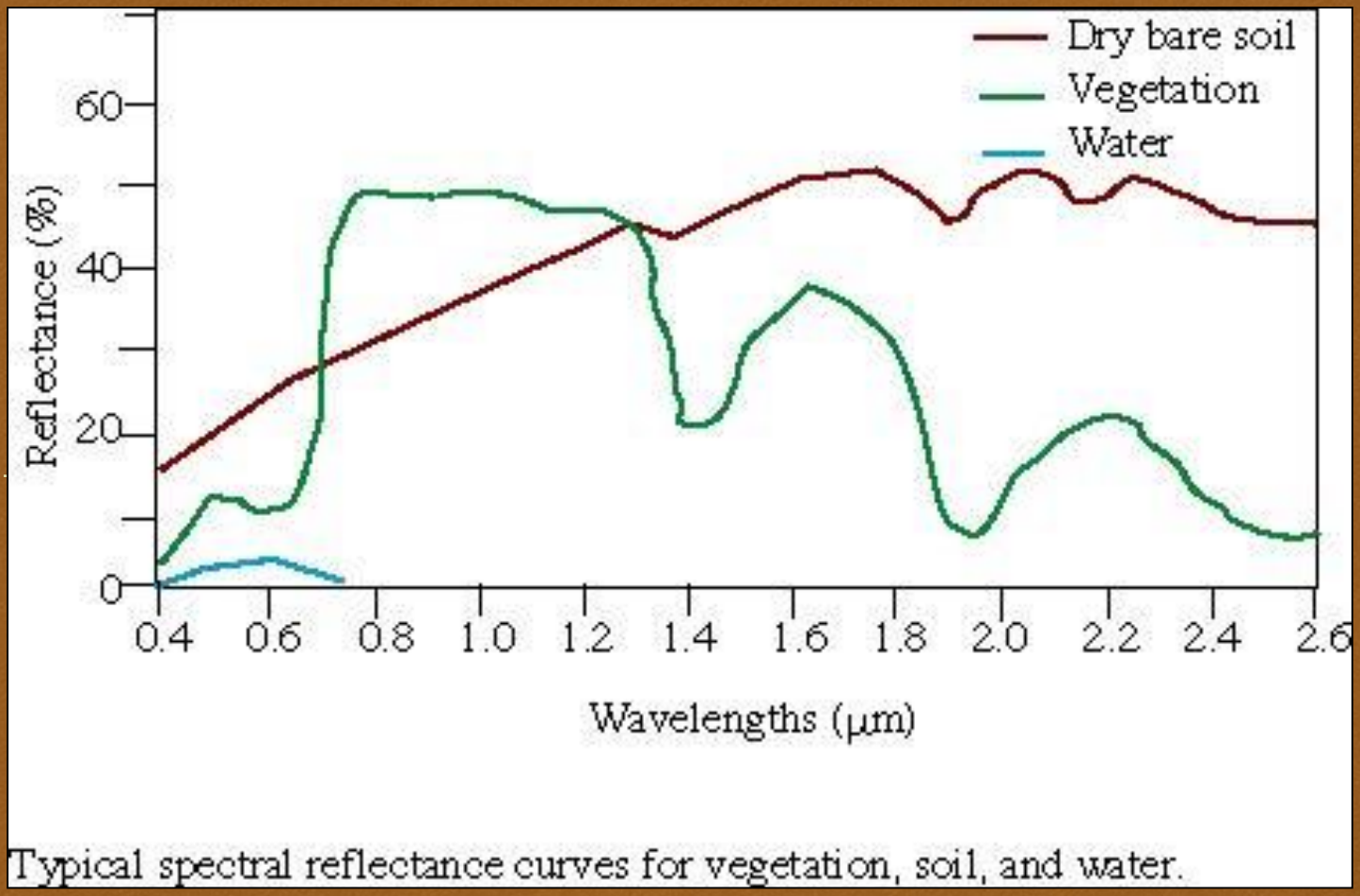
EFFECT OF SEDIMENTS IN WATER

- More the suspended sediments in water, higher is the reflectance
- An increase in Chlorophyll content in water will decrease blue and red wavelengths; and increase green wavelength





CONCLUDING REMARKS



Typical spectral reflectance curves for vegetation, soil, and water.

QUESTIONS?