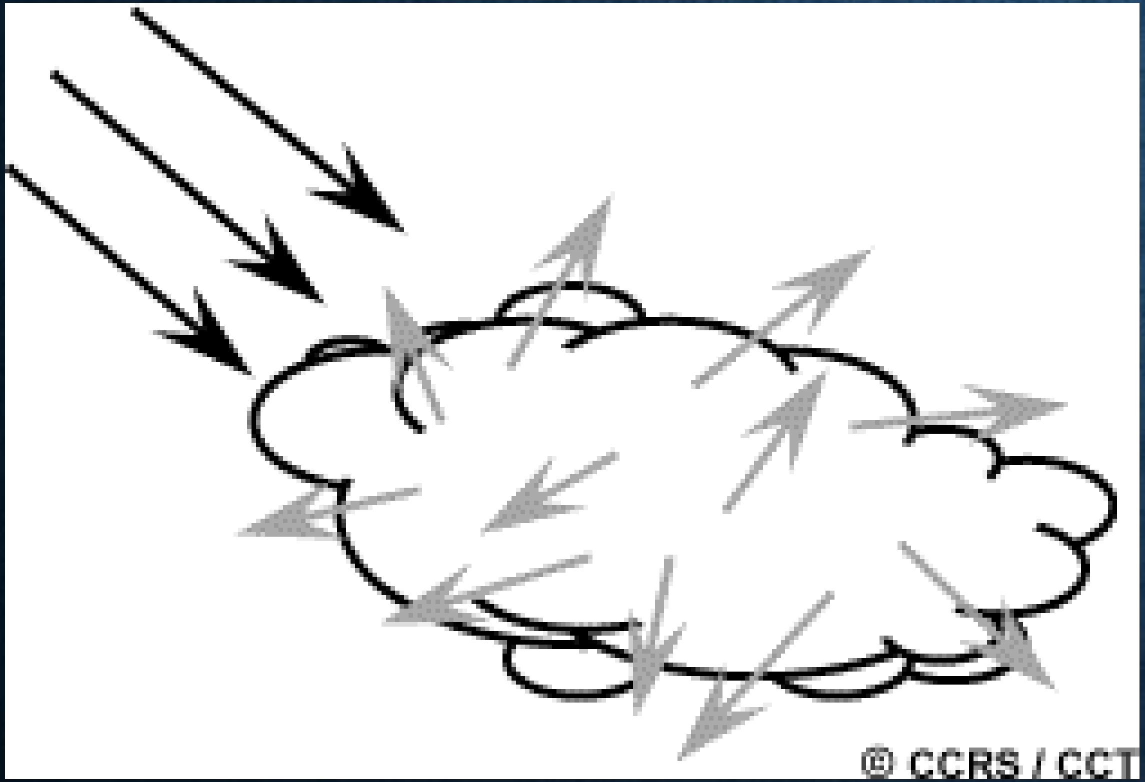
SPECTRAL SIGNATURE-SPECTRAL REFLECTANCE CHARACTERISTICS OF VEGETATION, SOIL AND WATER

NONSELECTIVE SCATTERING

- This occurs when the particles are much larger than the wavelength of the radiation.
- Water droplets and large dust particles can cause this type of scattering.
- Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally.
- This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).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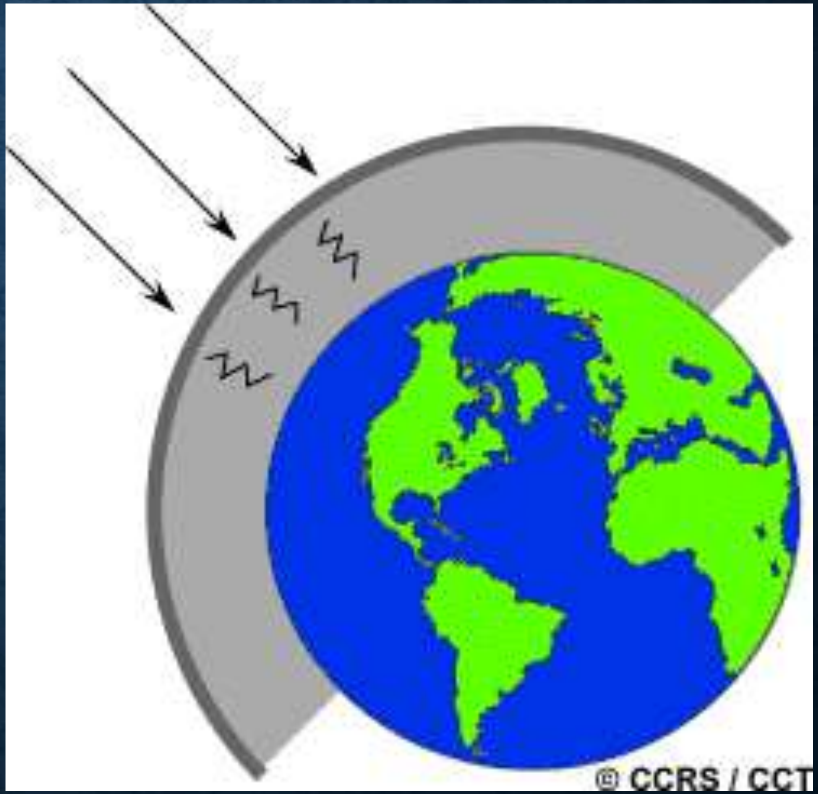
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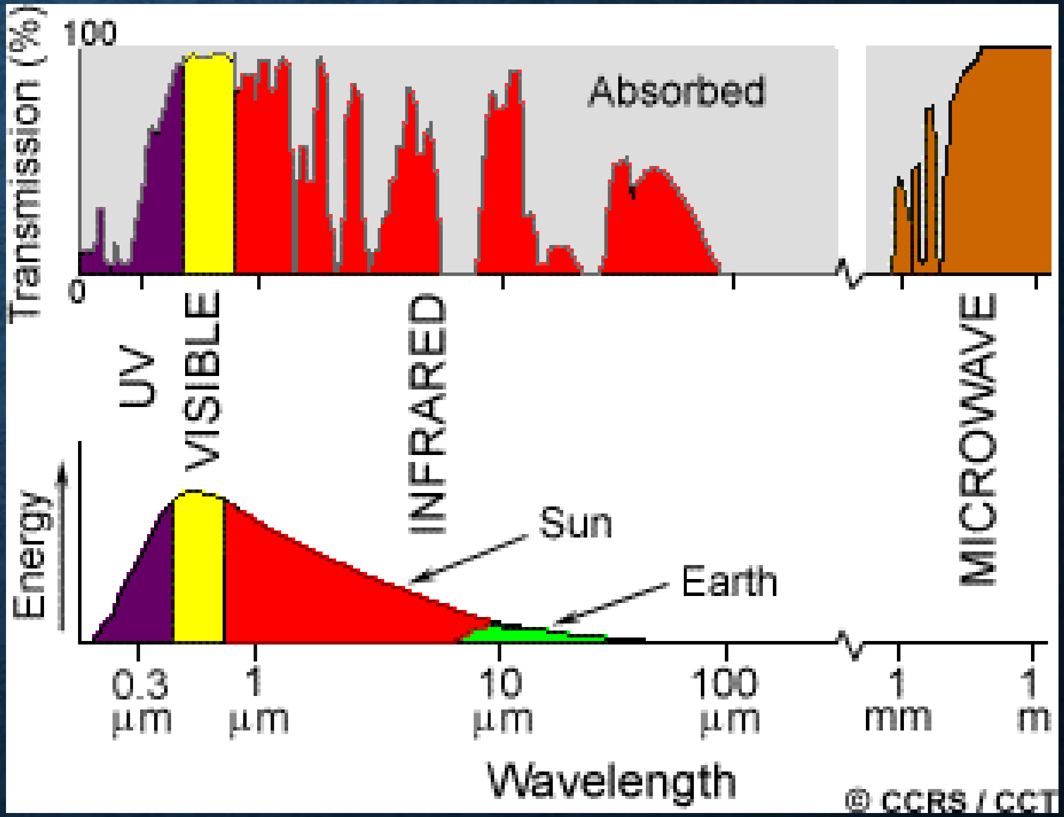
- **Absorption** is the other main mechanism at work when electromagnetic radiation interacts with the atmosphere. In contrast to scattering, this phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths. Ozone, carbon dioxide, and water vapour are the three main atmospheric constituents which absorb radiation.
- **Ozone** serves to absorb the harmful (to most living things) ultraviolet radiation from the sun. Without this protective layer in the atmosphere our skin would burn when exposed to sunlight.

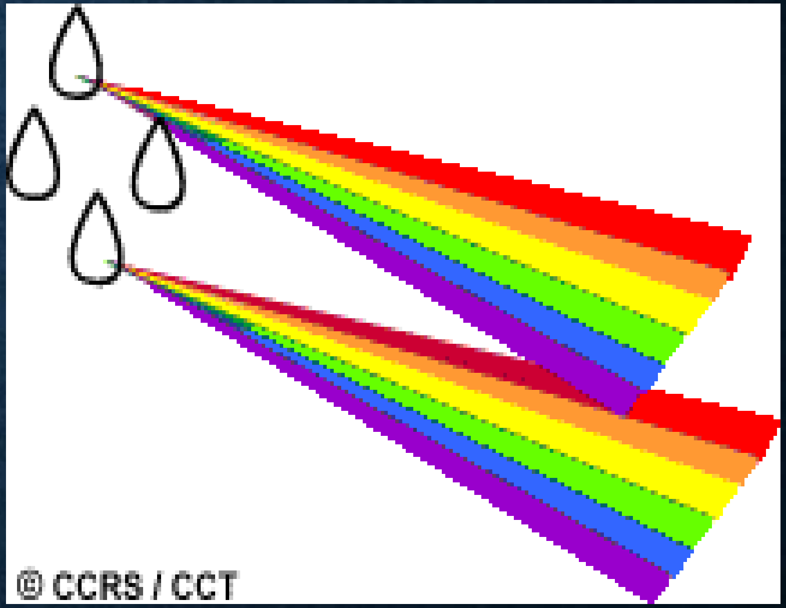
- Because these gases absorb electromagnetic energy in very specific regions of the spectrum, they influence where (in the spectrum) we can "look" for remote sensing purposes. Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called **atmospheric windows**

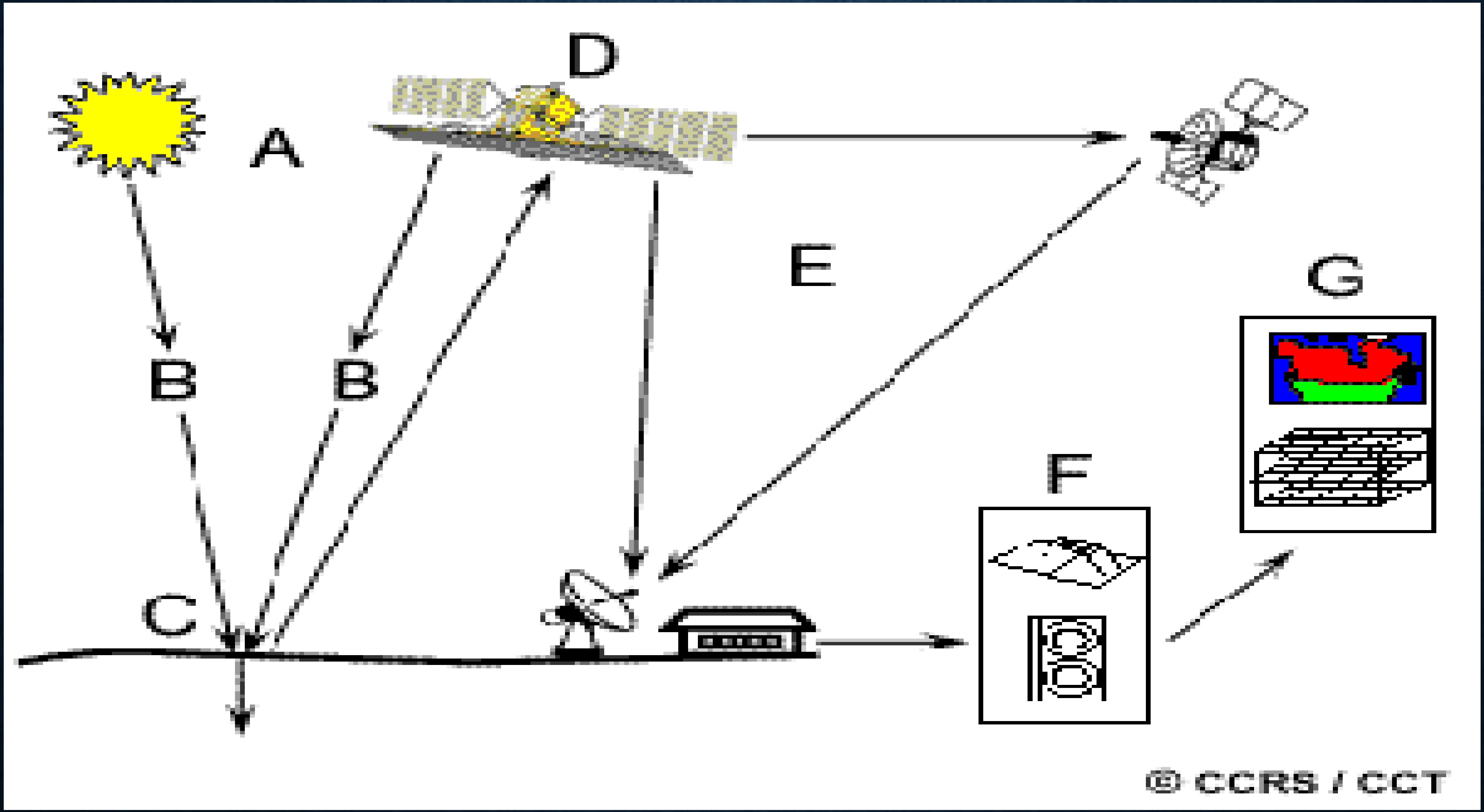


- By comparing the characteristics of the two most common energy/radiation sources (the sun and the earth) with the atmospheric windows available to us, we can define those wavelengths that we can use most effectively for remote sensing.
- The visible portion of the spectrum, to which our eyes are most sensitive, corresponds to both an atmospheric window and the peak energy level of the sun.
- Note also that heat energy emitted by the Earth corresponds to a window around 10 µm in the thermal IR portion of the spectrum, while the large window at wavelengths beyond 1 mm is associated with the microwave region.
- Now that we understand how electromagnetic energy makes its journey from its source to the surface (and it is a difficult journey, as you can see) we will next examine what happens to that radiation when it does arrive at the Earth's surface.

OCCURRENCE OF RAINBOW

- Water droplets act as tiny, individual prisms.
- When sunlight passes through them, the constituent wavelengths are bent in varying amounts according to wavelength.
- Individual colours in the sunlight are made visible and a rainbow is the result, with shorter wavelengths (violet, blue) in the inner part of the arc, and longer wavelengths (orange, red) along the outer arc.
- If scattering of radiation in the atmosphere did not take place, then shadows would appear as jet black instead of being various degrees of darkness.
- Scattering causes the atmosphere to have its own brightness (from the light scattered by particles in the path of sunlight) which helps to illuminate the objects in the shadows.





A
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RADIATION - TARGET INTERACTIONS

- Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface.
- There are three (3) forms of interaction that can take place when energy strikes, or is **incident (I)** upon the surface. These are: **absorption (A)**; **transmission (T)**; and **reflection (R)**.
- The total incident energy will interact with the surface in one or more of these three ways.
- The proportions of each will depend on the wavelength of the energy and the material and condition of the feature.

- Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through a target.
- Reflection (R) occurs when radiation "bounces" off the target and is redirected. In remote sensing, we are most interested in measuring the radiation reflected from targets.
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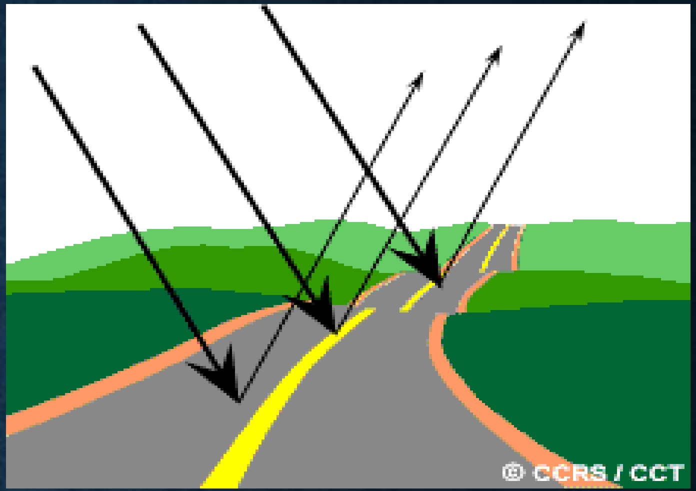
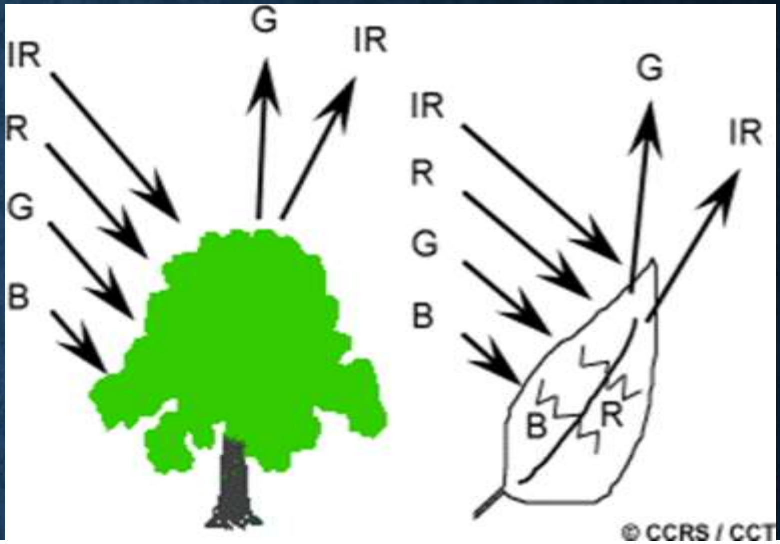
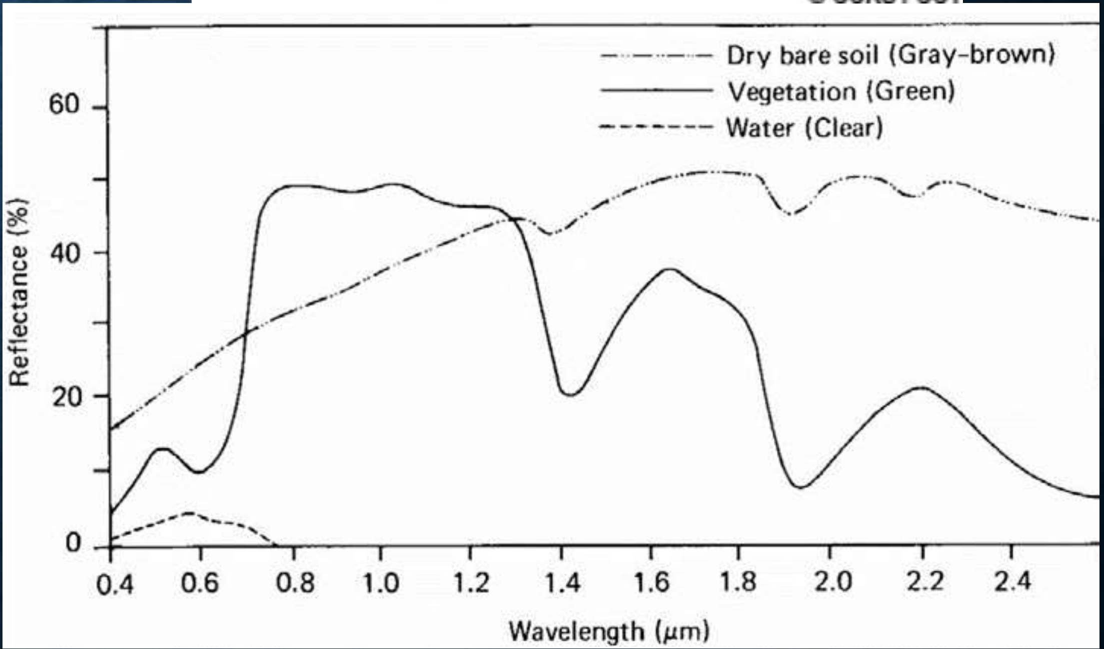
- **Diffuse reflection occurs** when the surface is rough and the energy is reflected almost **uniformly in all directions.**
- Most earth surface features lie somewhere between perfectly specular or perfectly diffuse reflectors.
- Whether a particular target reflects specularly or diffusely, or somewhere in between, depends on the **surface roughness of the feature in comparison to the wavelength of the incoming radiation**.
- If the wavelengths are much smaller than the surface variations or the particle sizes that make up the surface, diffuse reflection will dominate. For example, fine-grained sand would appear fairly smooth to long wavelength microwaves but would appear quite rough to the visible wavelengths.



SPECTRAL REFLECTANCE OF VEGETATION, SOIL, AND WATER

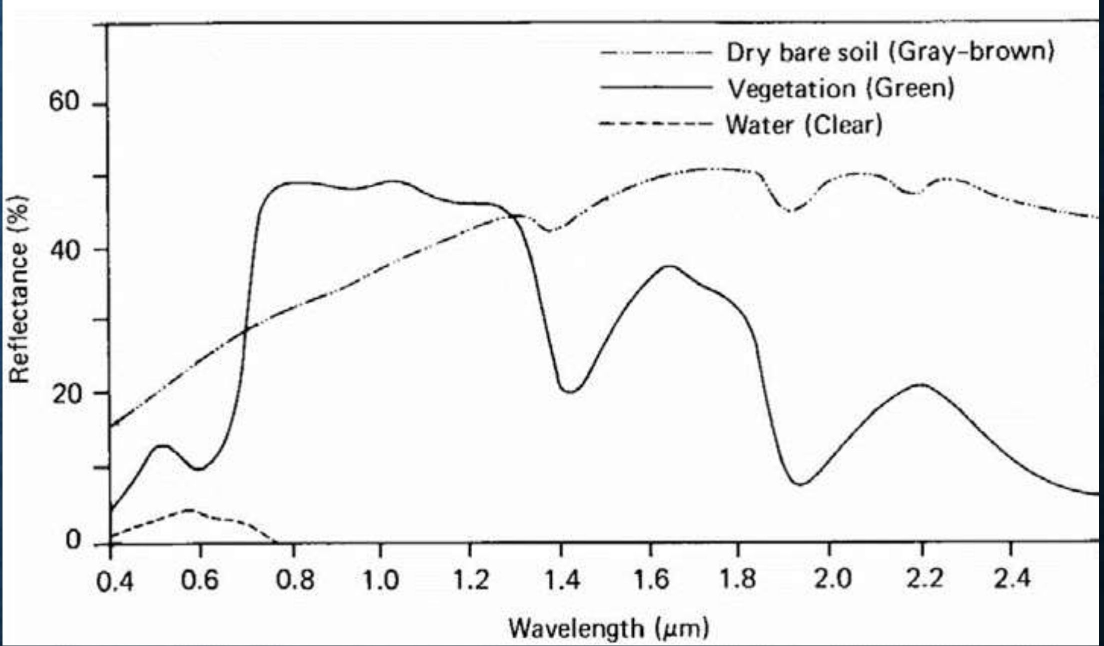
- Earth's surface and how energy at the **visible** and **infrared wavelengths interacts with them**.
- Typical spectral reflectance curves for **three basic types of earth features: healthy green vegetation, dry bare soil (gray-brown loam), and clear lake water**.
- The lines in this figure represent average reflectance curves compiled by measuring a large sample of features.
- Note how distinctive the curves are for each feature.
- In general, the configuration of these curves is an indicator of the type and condition of the features to which they apply.





VEGETATION

- Spectral reflectance curves for healthy green vegetation almost always manifest the "peak-and-valley" configuration illustrated in the figure.
- The valleys in the visible portion of the spectrum are dictated by the pigments in plant leaves.
- Chlorophyll, for example, strongly absorbs energy in the wavelength bands centered at **about 0.45 and 0.67 μm**.
- Hence, our eyes perceive healthy vegetation as green in color because of the very **high absorption of blue** and **red energy by plant leaves** and the very high reflection of green energy.



VEGETATION

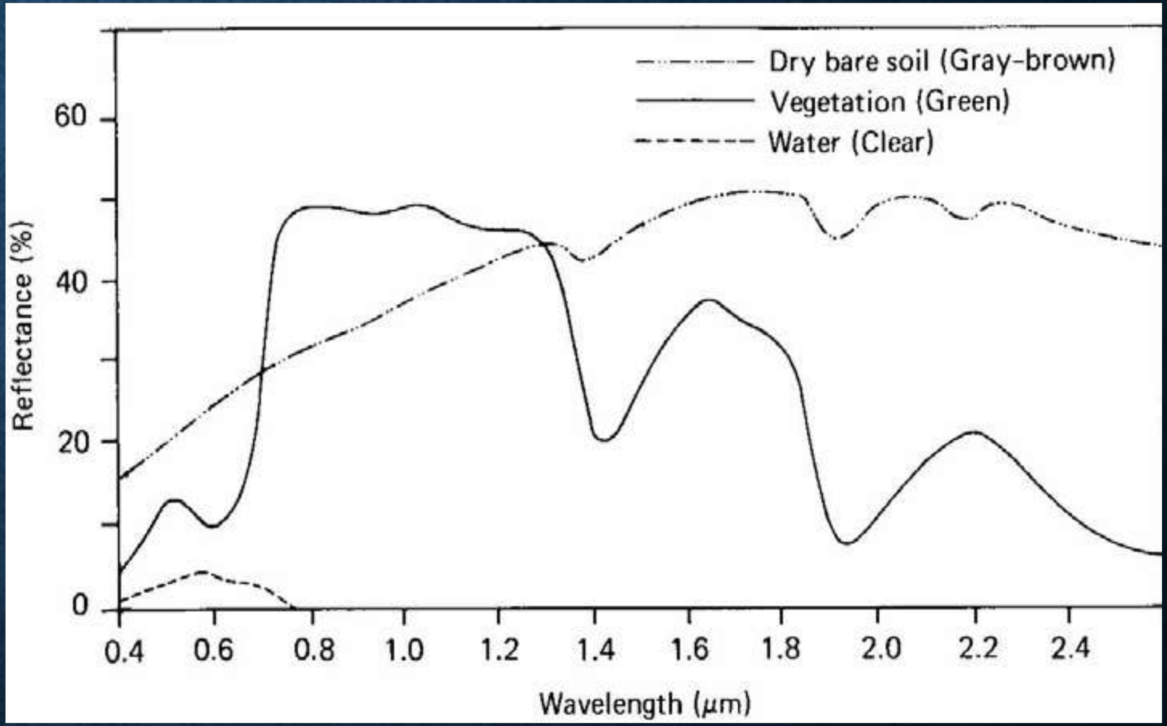
- If a plant is subject to some form of stress that interrupts its normal growth and productivity, it may decrease or cease chlorophyll production. The result is less chlorophyll absorption in the blue and red bands. Often the red reflectance increases to the point that we see the plant turn yellow (combination of green and red).
- In near-infrared portion of the spectrum at about 0.7 μm, the reflectance of healthy vegetation increases dramatically. In the range from about 0.7 to 1.3 μm, a plant leaf typically **reflects 40 to 50 percent of the energy incident** upon it.
- Plant reflectance in the range 0.7 to 1.3 μm results primarily from the internal structure of plant leaves.
- multiple layers of leaves in a plant canopy provide the opportunity for multiple transmittance and reflectance. Hence, the near-infrared reflectance increases with the number of layers of leaves in a canopy, with the reflection maximum achieved at about eight leaf layers

VEGETATION

- Beyond 1.3 µm, energy incident upon vegetation is essentially absorbed or reflected, with little to no transmittance of energy.
- Dips in reflectance occur at 1.4, 1.9, and 2.7 µm because water in the leaf absorbs strongly at these wavelengths. Accordingly, wavelengths in these spectral regions are referred to as water absorption bands.
- Reflectance peaks occur at about 1.6 and 2.2 µm, between the absorption bands. Throughout the range beyond 1.3 µm, **leaf reflectance is approximately inversely related to the total water present in a leaf**. This total is function of both the moisture content and the thickness of a leaf.

SOIL

- Soil curve in the figure shows considerably less peak-and-valley variation in reflectance.
- That is, the factors that influence soil reflectance act over less specific spectral bands.
- Some of the factors affecting soil reflectance are **moisture content**, **soil texture**, **surface roughness**, presence of **iron oxide**, and **organic matter content.**

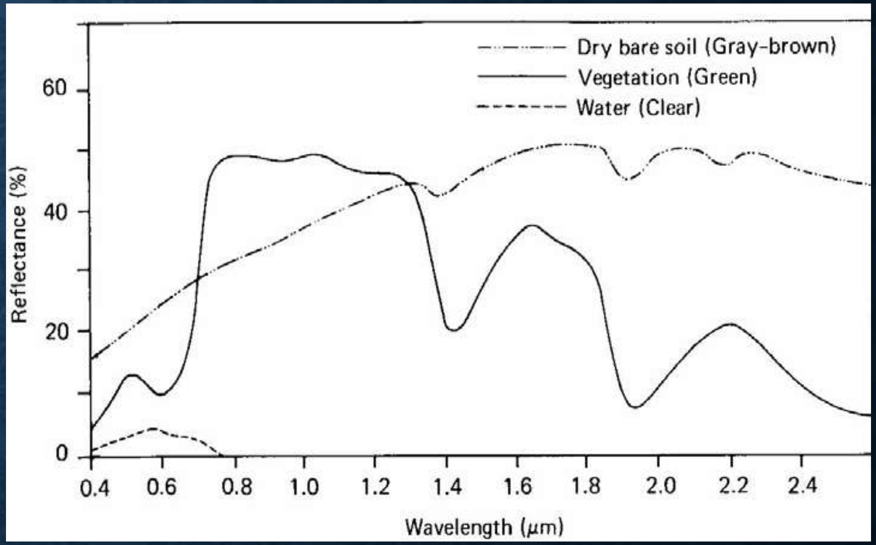


SOIL

- The presence of moisture in soil will decrease its reflectance. As with vegetation, this effect is greatest in the water absorption bands at about 1.4, 1.9, and 2.7 µm (clay soils also have hydroxyl absorption bands at about 1.4 and 2.2 µm)
- Soil moisture content is strongly related to the **soil texture**: **coarse, sandy soils are usually well drained, resulting in low moisture content and relatively high reflectance**; poorly drained fine textured soils will generally have lower reflectance.
- Two other factors that reduce soil reflectance are **surface roughness** and **content of organic matter**. The presence of iron oxide in a soil will also significantly **decrease reflectance**, at least in the visible wavelengths. In any case, it is essential that the analyst be familiar with the conditions at hand

WATER

- The spectral reflectance of water, probably the most distinctive characteristics is the energy absorption at **near-infrared wavelengths**.
- In short, water absorbs energy in these wavelengths whether we are talking about water features → (such as lakes and streams) or water contained in vegetation or soil.
- Locating and delineating water bodies with remote sensing data are done most easily in near-infrared wavelengths because
- various conditions of water bodies manifest themselves primarily in visible wavelengths.
- The energy / matter interactions at these wavelengths are very complex and depend on a number of interrelated factors.
- For example, the reflectance from a water body can stem from an interaction with the water's surface (specular reflection), with **material suspended in the water**, or with the bottom of the water body.



WATER

- Even with deep water where bottom effects are negligible, the reflectance properties of a water body are a function of not only the water, but also the **material in the water** of this absorption property
- Clear water absorbs relatively little energy having wavelengths less than about 0.6 µm. High transmittance typifies these **wavelengths with a maximum in the blue-green portion of the spectrum**
- The turbidity of water changes (because of the presence of organic or inorganic materials), transmittance - and therefore reflectance - changes dramatically.
- For example, waters containing large quantities of suspended sediments resulting from soil erosion normally have much higher visible reflectance than other "clear" water in the same geographic area. Likewise, the reflectance of water changes with the chlorophyll concentration involved.
- Increases in chlorophyll concentration tend to decrease water reflectance in blue wavelengths and increase it in green wavelengths. These changes have been used to monitor the presence and estimate the concentration of algae via remote sensing data.

THANK YOU