Electromagnetic Radiation (EMR) and its application in Remote Sensing

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Nuclear reactions produce a full spectrum of electromagnetic radiation, these waves travel through space largely unchanged.
What is electromagnetic radiation (EMR)?

...is a wave that propagates (radiates) through a vacuum at the speed of light (just under 300 000 m/s) and transfers energy from one place to another.

...these waves carry energy as synchronized oscillations of electric and magnetic fields that are perpendicular to each other and perpendicular to the direction of travel.

...although it is a wave, it also can be detected as discrete ‘particles’ of light called photons.
What is electromagnetic radiation (EMR)?

1. Electromagnetic energy is generated by several mechanisms:
   - Changes in the energy levels of electrons
   - Acceleration of electrical charges
   - Nuclear decay of radioactive substances
   - Nuclear reactions (fission and fusion)
   - Thermal motion of atoms and molecules

2. All objects above absolute zero (-273.15 °C) emit EMR.

3. The amount of EMR and the wavelengths emitted depend on the temperature of the object.

4. As the temperature of an object increases, the total EMR increases while the wavelength of the peak shortens.
• What are these? galaxies

• Why are they different colours? they represent the combined temperature of all the stars in each galaxy

• How cold is space? -270.45 °C or 2.7 K
• What would happen to a Rubik Cube, if you could throw it into space?

If it was far from any stars or planets it will eventually come into thermal equilibrium with the cosmic microwave background which is thermal radiation of 2.7 K

It would not glow...
Deep space as seen by NASA’s Hubble Telescope

• So what would you see if you lit it by the white spotlight of your passing spaceship?

You would see the colours as you see them here...

But why do we see them anyway?

• What does this tell us about EMR?

Objects can show colour because:
• They are *radiating* EMR
• They are *reflecting* EMR
• They are *absorbing* EMR

Objects can also:
• *Conduct* (or transmit) EMR

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Squares this colour appear **green** because the pigment on the surface *absorbs* most incoming white light, but *reflects* green light.

Squares this colour appear **white** because the pigment on the surface *reflects* all incoming white light.

The underlying material appears **black** because the pigment on the surface *absorbs* all incoming white light.
99% of the energy of solar radiation is contained in a narrow band comprising:

- near ultraviolet
- visible
- near infrared

On a clear day on earth:

- 40% of solar radiation is **visible light**
- 51% is **infrared radiation** (warmth)

The earth’s atmosphere modifies incoming solar radiation.
Processes that occur in the atmosphere:

- Reflection
- Scattering
- Refraction
- Absorption
**Albedo** is a measure of how much light that hits a surface is reflected without being absorbed. Something that appears white reflects most of the light that hits it and has a high albedo, while something that looks dark absorbs most of the light that hits it, indicating a low albedo.
Spectral signatures are the characteristic curves associated with different surfaces (including types of vegetation) that show the extent to which EMR of a particular wavelength is reflected. Whereas the albedo tells you the proportion of total radiation that is reflected, the spectral signature tells us which wavelengths are either absorbed (a trough in the spectral signature) or reflected (a peak in the spectral signature).
How can spectral signatures be determined?

Digital camera

How your digital camera converts captured light into image pixels

The colour filter array
The 'photosites' on the sensor only measure the brightness of the light, not its colour. So that colour information is gathered, each photosite has a red, green or blue filter. These are arranged in a mosaic known as a Bayer pattern, after the boffin that came up with it. He found that by using twice as many green filters as blue or red, you get a sharper image. A demosaicing process turns this raw data into the full-colour grid of pixels in the recorded images.
How can spectral signatures be determined?

The MSI measures the Earth's reflected radiance in 13 spectral bands.

- 290km swath width
- Light collected by a 3-mirror telescope
- Focussed by a dichroic beam splitter which separates into 2 channels:
  - Visible + Near Infrared [VNIR]
  - Short Wave Infrared [SWIR]
- 2 separate arrays of 12 staggered detectors to cover the full field of view
The sun emits EMR, mostly in a narrow band from *near ultraviolet* through *visible* to *near infrared* (*shortwave radiation*).

Some is scattered and reflected by the atmosphere, clouds and particles (26%); some is reflected back from the surface (4%).

19% is absorbed by clouds and the atmosphere.

51% is absorbed by the earth.

Longwave radiation (heat) in the *infra-red* is radiated back out.

Multispectral sensors on satellites measure reflected shortwave (*visible*) and radiated longwave (*infrared*), providing samples of *spectral signatures* for each pixel.