Waves and photons

Electromagnetic (EM) energy can be modelled in two ways: by waves or by energy bearing particles called photons. In the wave model, electromagnetic energy is considered to propagate through space in the form of sine waves.

These waves are characterized by electrical (E) and magnetic (M) fields, which are perpendicular to each other. For this reason, the term electromagnetic energy is used.

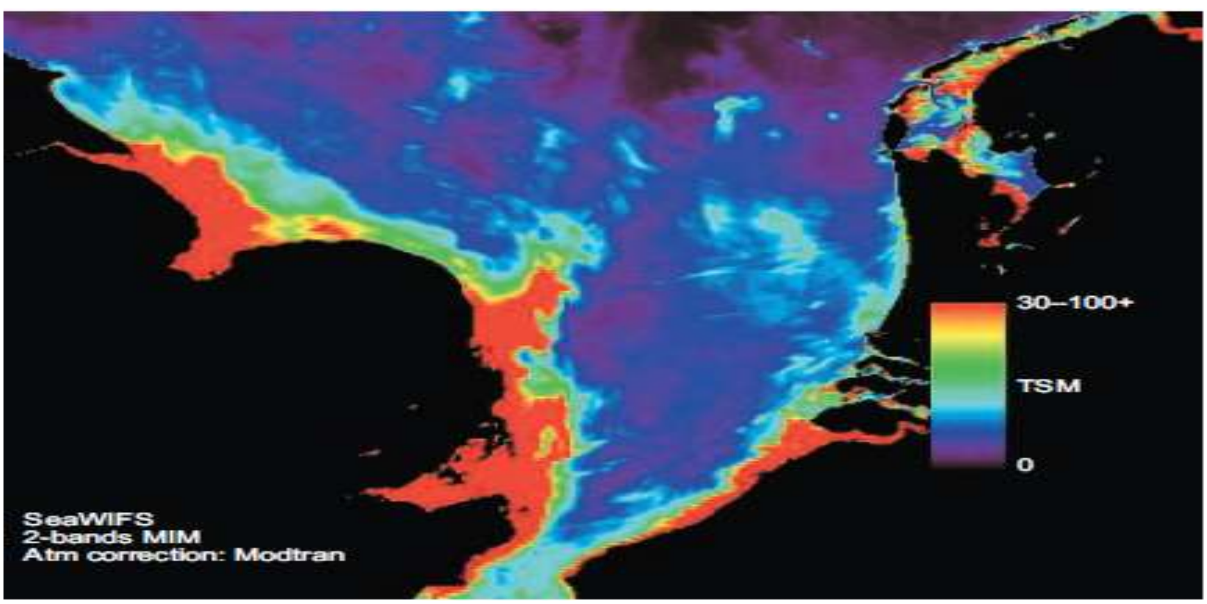
Multispectral scanner

An instrument is a measuring device for determining the present value of a quantity under observation. A scanner is an instrument that obtains observations in a point-by-point and line-by-line manner. In this way, a scanner fundamentally differs from an aerial camera, which records an entire image in only one exposure.

The multispectral scanner is an instrument that measures the reflected sunlight in the visible and infrared spectrum. A sensor systematically scans the Earth's surface, thereby measuring the energy reflected by the viewed area. This is done simultaneously for several wavelength bands, hence the name multispectral scanner.

A wavelength band or spectral band is an interval of the electromagnetic spectrum for which the average reflected energy is measured. Typically, a number of distinct wavelength bands are recorded, because these bands are related to specific characteristics of the Earth's surface. For example, reflection characteristics in the range of 2 µm to 2.5 µm (for instance, Landsat TM band 7) may give information about the mineral composition of the soil, whereas the combined reflection characteristics of the red and near infrared bands may tell something about vegetation, such as biomass and health.

The definition of the wavebands of a scanner, therefore, depends on the applications for which the sensor has been designed. An example of multispectral data for geological applications is given in Figure below

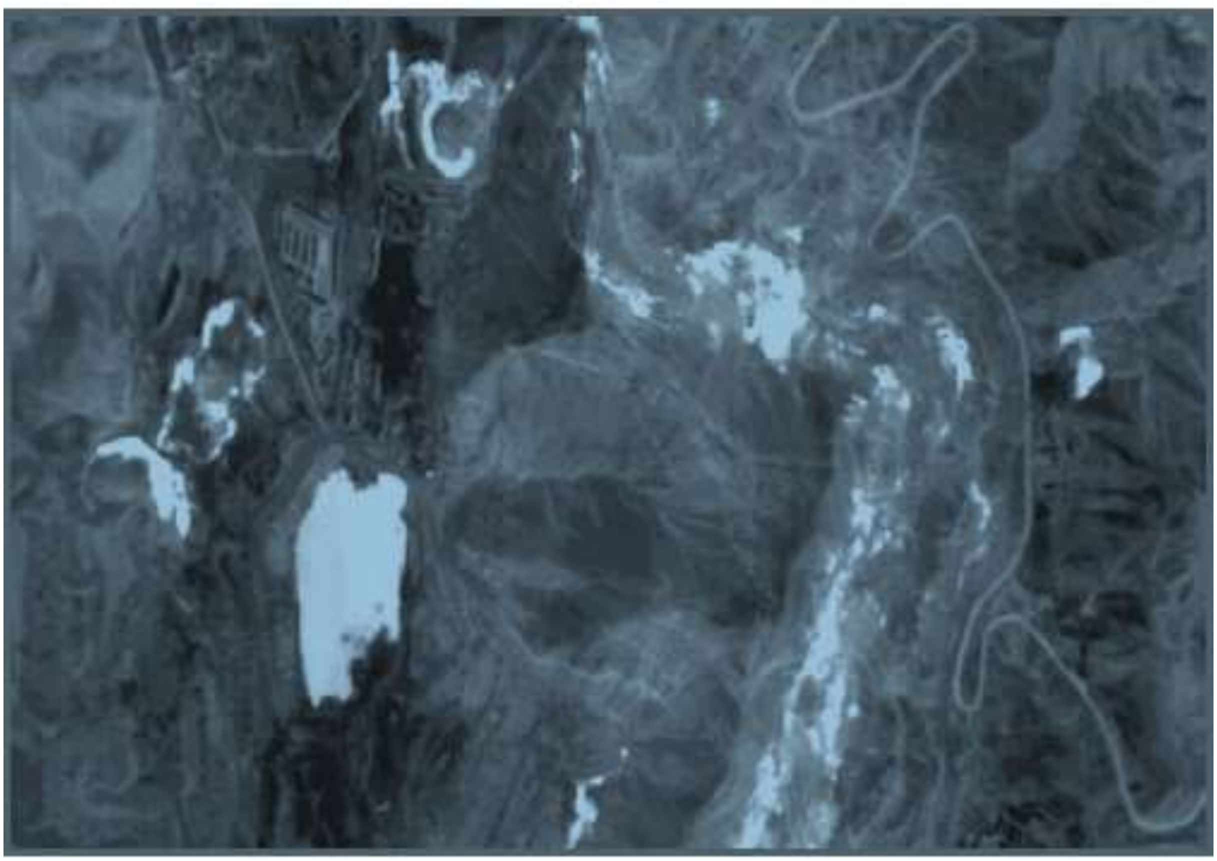


Thermal scanner

Thermal scanners measure thermal data in the range of 8 μm to 14 μm. Wavelengths in this range are directly related to an object's temperature. For instance, data on cloud, land and sea surface temperature are indispensable for weather forecasting.

For this reason, most remote sensing systems designed for meteorology include a thermal scanner.

Thermal scanners can also be used to study the effects of drought on agricultural crops (water stress), and to monitor the temperature of cooling water discharged from thermal power plants.



Microwave radiometer

Long wavelength EM energy (1 cm to 100 cm) is emitted from the objects on, or just below, the Earth's surface. Every object with a temperature above the absolute temperature of zero Kelvin emits radiation, called the blackbody radiation

Blackbody Theorem

All matter with a temperature above absolute zero (0 K, where n °C = n+273 K) radiates EM energy due to molecular agitation. Agitation is the movement of the molecules. This means that the Sun, and also the Earth, radiate energy in the form of waves.

Matter that is capable of absorbing and re-emitting all EM energy

that it receives is known as a blackbody. For blackbodies both the emissivity (ε), and the absorptivity(α), are equal to (the maximum value of) 1.

The amount of energy radiated by an object depends on

1- Its absolute temperature,

2- Its emissivity,

3- And is a function of the wavelength.

In physics, this principle is defined by Stefan-Boltzmann's Law. A blackbody radiates a continuum of wavelengths. The radiation emitted by a blackbody at different temperatures is shown in Figure below.

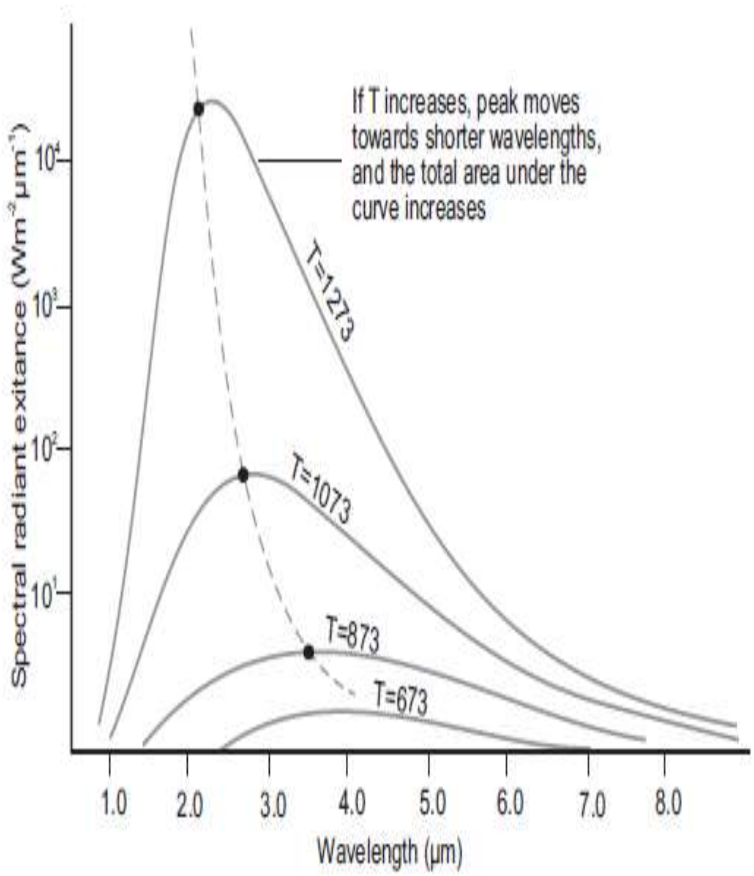


Figure 2.4: Blackbody radiation curves based on Stefan-Boltzmann's law (with temperatures, *T*, in K).

Note the units in this figure: the x-axis indicates the wavelength and the y-axis indicates the amount of energy per unit area. The area below the curve, therefore, represents the total amount of energy emitted at a specific temperature.

Out line of blackbodies curve

i- A higher temperature corresponds to a greater contribution of shorter wavelengths.

ii- The peak radiation at 400 °C (673 K) is around 4 μm while the peak radiation at 1000 °C is at 2.5 μm.

ii- The emitting ability of a real material compared to that of the blackbody is referred to as the material's emissivity.

iii- Blackbodies are hardly found in nature; most natural objects have emissivities less than one.

This means that only part, usually between 80–98%, of the received energy is reemitted. Consequently, part of the energy is absorbed.