→ INFRARED WEBCAM HACK

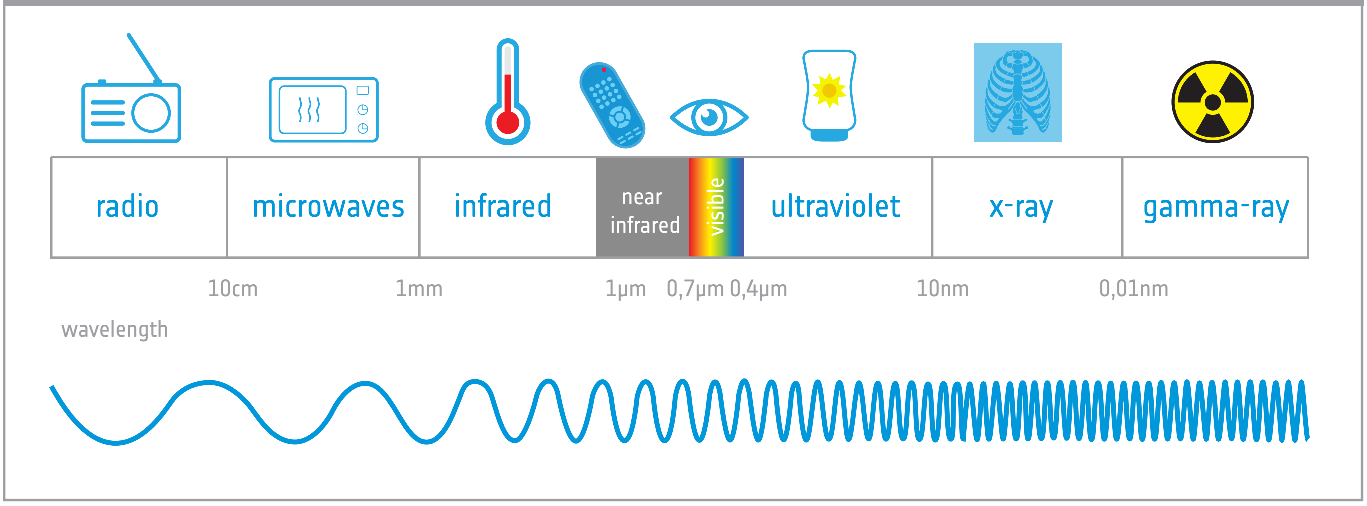
Using infrared light to observe the world in a new way

→ Worksheet 1

The electromagnetic spectrum categorises the electromagnetic radiation that exists, including infrared radiation(Figure 1). Most electromagnetic radiation emitted by the Sun is reflected or absorbed by Earth's atmosphere. However, some radiation like visible radiation, radio waves, and part of infrared can pass through the atmosphere.

Objects with different surface features reflect and absorb the Sun's radiation in different ways. The reflected radiation contains information about the surface of the object, and enables us to see the colour and form of the object. The human eye can only see a very limited range of the spectrum, the visible light. However we can use different instruments to see what is invisible to us. Earth observation satellites, for example, carry scientific instruments that can see in the visible and the infrared range, as well as other ranges of the electromagnetic spectrum.

Figure 1



↑The electromagnetic spectrum categorises different types of radiation, from the longest (radio) to the shortest (gamma ray) wavelengths.

In this resource, we will focus on the near-infrared and visible parts of the spectrum. Infrared radiation is divided into different parts, just like visible light is divided into different colours. Near-infrared radiation, with its slightly longer wavelengths than visible light,is reflected by vegetation, delivering detailed information about plants on Earth. That is why this part of the electromagnetic spectrum is used in Earth bservation satellites to monitor Earth's vegetation.

Figure 2

↑ The European Sentinel-2 satellite carries an high-resolution multispectral imager with 13 spectral bands for a new perspective of our land and vegetation.

→ Background

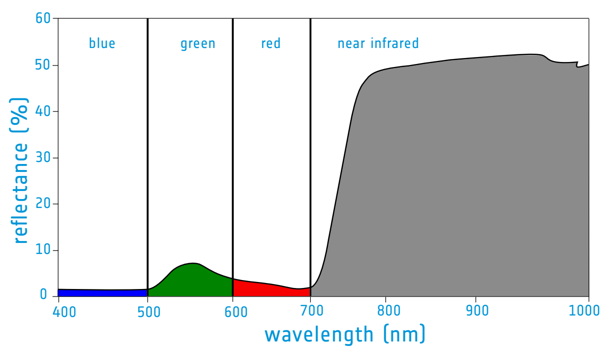
Vegetation monitoring

Plants have a particular way of reflecting electromagnetic radiation. The chlorophyll in the plants absorbs light to get energy for the photosynthesis process. But only the red and blue part of the visible light are needed. The green light is reflected, which explains why leaves appear green to us. The near-infrared light is not needed for the photosynthesis, therefore most of the light is reflected by the cell structure of the leaf.

Figure 3 shows the percentage of reflected radiation, also called reflectance, for a healthy plant. The blue light is absorbed almost completely by the chlorophyll, about 10% of the green light is reflected, and the red light is absorbed almost completely. Moving to slightly longer wavelengths, about 50% of the near-infrared light is reflected. The combination of low visible reflectance and high near-infrared reflectance is a characteristic of most plant types.

When a plant becomes less healthy, for example due to water scarcity, it reflects more of the visible red light and less of the near-infrared light. This can also be seen in autumn when leaves turn yellow and red, due to phenology. The bigger the difference between the reflected red and near-infrared light, the healthier a plant is. This fact is used in Earth observation to calculate indices which help us obtain information about the health of plants on a large scale.

Figure 3



↑ Percentage of radiation reflected by a healthy plant for the wavelengths of visible light and near-infrared light.

True colour and false colour images

A way to visualise reflected near-infrared light is to create false colour images, making use of the fact that cameras carried by satellites can 'see' more than just the visible part of light. A false colour image uses at least one wavelength outside the visible range, and as a result the colours in the final image may not be what we expect them to be. For example, grass is not always green! A true colour image combines actual measurements of reflected red, green, and blue light. The result looks like the world as we are used to seeing it.

The false colour image shows reflected near-infrared light as red, red light as green, and green light as blue. Since plants reflect more near-infrared than green, vegetation areas will appear red. The brighter and richer red indicates a higher reflectance in the near-infrared, therefore indicating more and healthier vegetation. In the true colour image, the vegetation appears green, like we are used to seeing it.

Overall, the reflectance in the visible light is much lower than the one in the near-infrared, and the image is darker. This makes it harder to identify water bodies in the real colour image, because the reflectance is also very low. In the false colour image, the water bodies can be clearly identified due to the high difference in reflectance for water and the surrounding vegetation (high reflectance). Water absorbs most of the incoming light– near-infrared, red, and green – and therefore has a very low reflectance.