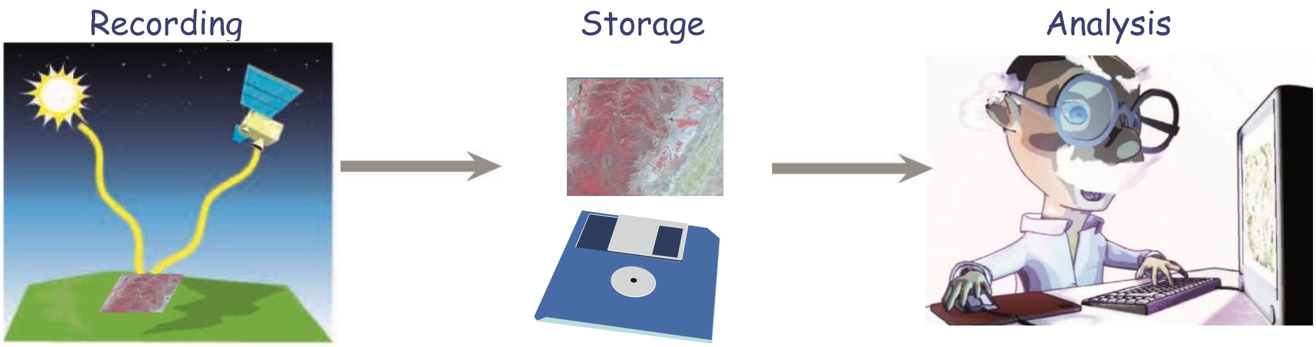
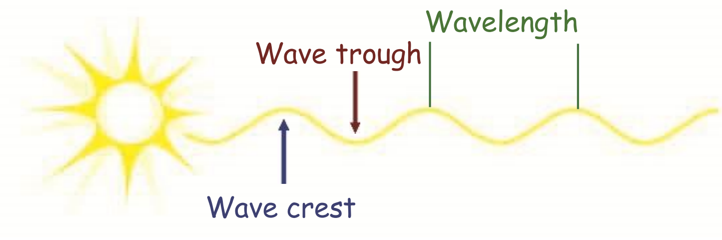
What is Remote Sensing?

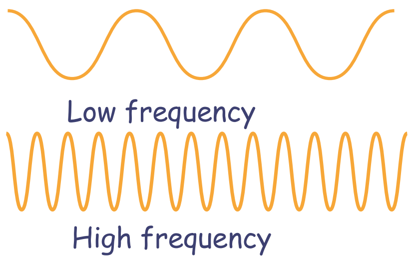
The term *remote sensing* refers to the contactless acquisition of information about the Earth's surface. To make this clearer, remote sensing can be compared to astronomy. In astronomy, the universe with its planets and stars is observed from the Earth. This observation takes place over a great distance. You collect information about the stars and planets, but do not come into direct contact with them.



The difference between remote sensing and astronomy is that the Earth is observed rather than the outer space. For this purpose, measuring devices, so-called *remote sensing sensors*, are attached to aircraft or satellites. These sensors record *electromagnetic waves from* a distance and then store them as *image data*.

So what are *electromagnetic waves*? They are electric and magnetic fields that move through space with characteristic oscillations. Like a water wave, they have a *crest* and a *trough*.





The distance from one crest to the next is called the *wavelength*. The smaller the wavelength, the more troughs and crests there are. The distance of wave troughs and crests per time unit is called *frequency*.

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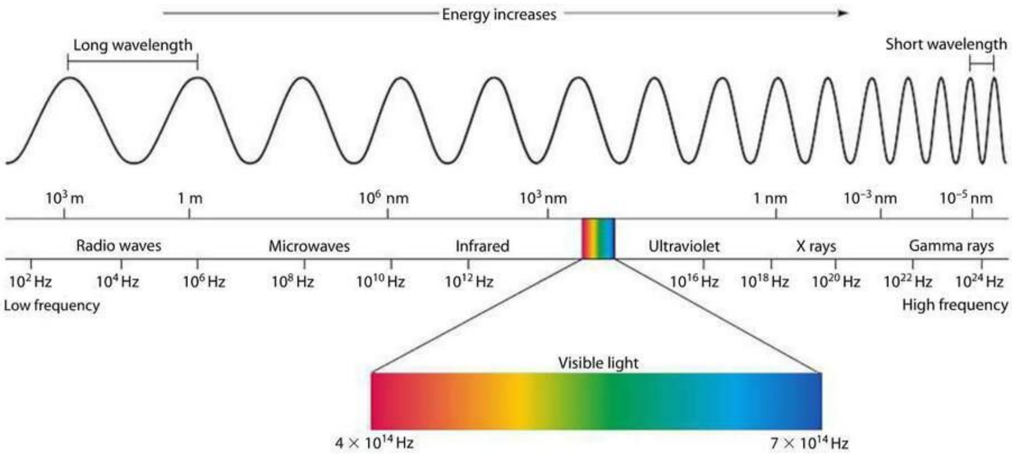
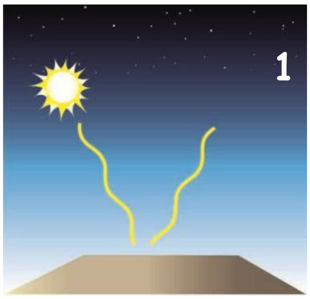
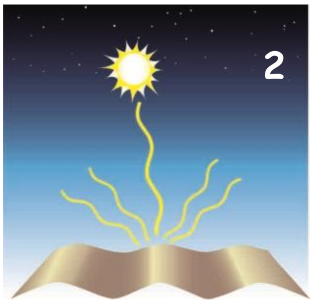
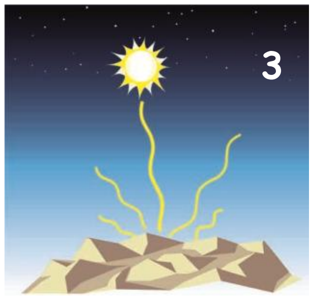
The most important source of electromagnetic radiation for remote sensing is the Sun. In addition to visible light, there are other electromagnetic waves. Many of these wavelength ranges are familiar to us from everyday life: These include *radio waves and microwaves* but also *heat rays* and *X-rays*. They all differ in their wavelengths and frequencies. Based on these properties, they can be classified in the *electromagnetic spectrum*. The figure below shows the electromagnetic spectrum schematically according to wavelength ranges.



However, electromagnetic waves also have other properties. They interact with objects. For example, when they hit a surface, they can be *reflected* and *absorbed*.







The way in which sunlight is reflected, for example, depends *on the roughness* of the surface. If the surface is smooth (Fig. 1), the light is reflected at the same angle as it enters. This is referred to as *specular reflection*. If the roughness is of the same order of magnitude as the wavelength of the light (Fig. 2), it is reflected back evenly in all directions (*diffuse reflection*). Surfaces found in nature are almost always irregular (Fig. 3), so that the light is reflected to different degrees in different directions (*mixed reflection*).

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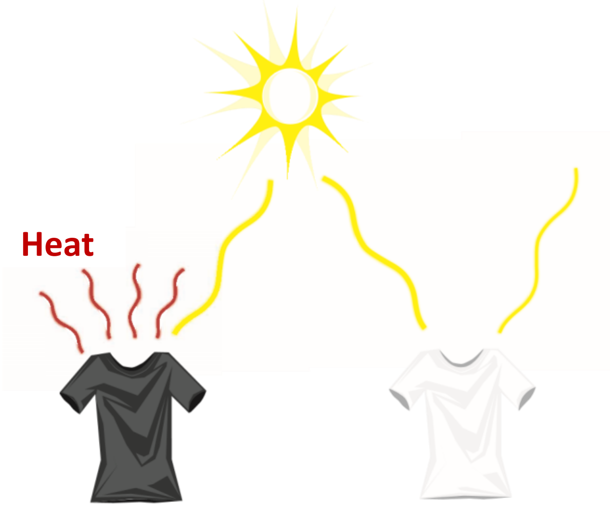
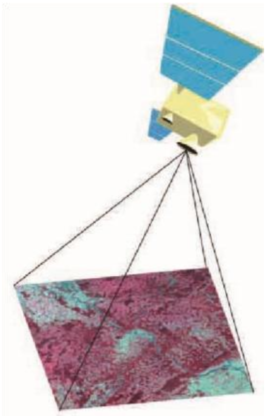
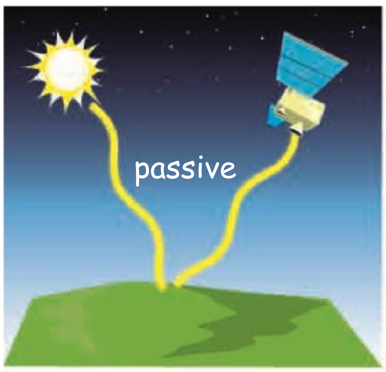
In addition, electromagnetic waves, such as sunlight, can also be absorbed by surfaces. The absorbed energy is converted into *heat*. This type of energy conversion is called *absorption*. It is important to note that not all objects absorb the same amount of energy: A black T-shirt, for example, absorbs much more sunlight than a white T-shirt. This is why you sweat more in a black T-shirt in summer than in a white one. Different land surfaces, such as snow and asphalt, behave in a similar way.

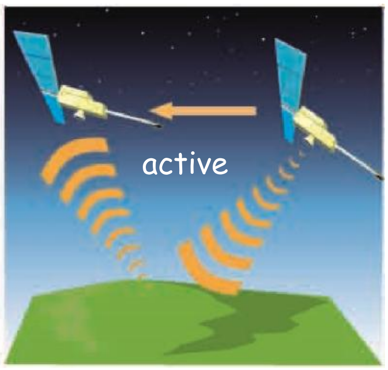


There are various recording sensors used in remote sensing. Depending on the purpose and period of observation, they are either attached to a *satellite* or an *aircraft*. Satellites have the advantage that they regularly fly over the entire globe and can provide comparatively inexpensive images. Aircraft images are more expensive, but can also capture smaller objects as they are closer to the Earth's surface.



Recording systems can be differentiated according to the type of electromagnetic radiation used. There are recording systems that work with the Sun's rays reflected on the Earth's surface. These recording systems are referred to as *passive* recording systems (bottom left). Another approach is used by *active* recording systems. These emit *microwaves* onto the Earth's surface and then pick up the radiation that was reflected from the Earth's surface (bottom right).





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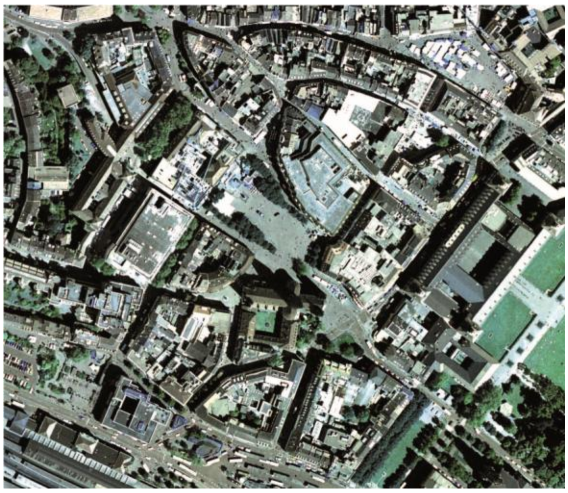
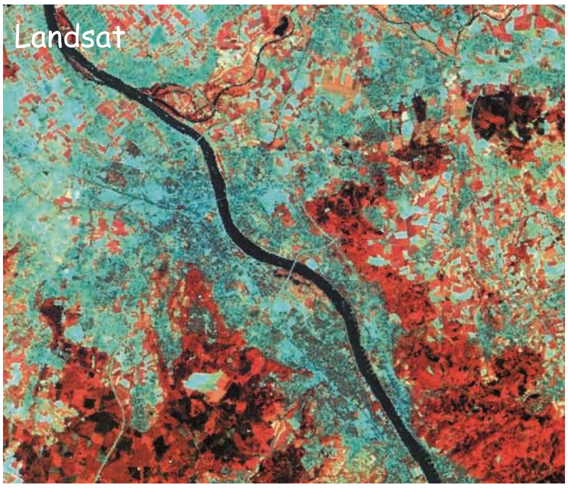
The three images illustrate the characteristics of the different types of remote sensing images. Figure 1 is an *aerial image* of Bonn city center, Germany. The individual spectral ranges of visible light (red, green, blue) are recorded together as one area in aerial images. As aerial photographs are taken at a short distance from the Earth's surface, it is often possible to see many details.



1 Aerial image

Figure 2 shows the city of Bonn and its surroundings in the image of a *multispectral scanner*. More precisely, it is a false color image. Multispectral sensors record the different areas of solar radiation separately from each other in so-called *channels*. This means that the otherwise invisible infrared radiation can also be recorded and displayed in red, as in image 2.



2 Multispectral image

Figure 3 is a *radar image* of the city of Bonn and its surroundings. It is not in color, but uses shades of gray to show how the Earth's surface has changed the *reflected microwaves*. The waves easily penetrate cloud layers and some can even penetrate the Earth's surface.

3 Radar image

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Remote sensing on the Moon:

In addition to remote sensing on our home planet Earth, satellite-based remote sensing with the parameters presented also offers numerous advantages for the exploration of our Earth's satellite. There are also satellites in orbit around the Moon that are responsible for high-resolution images of the lunar surface at all times. Compared to satellite-based Earth observation, remote sensing on the Moon offers the advantage that there is no atmosphere and therefore no influence on the images from any weather phenomena. In addition, the satellites observing the Moon can fly in a lower orbit, as the Moon has a lower gravity than the Earth. This makes detailed images possible. However, the number of satellites observing the Moon and therefore the selection of satellite data is smaller than with Earth-observing satellites.

Satellite-based lunar observation is highly relevant, as there is hardly any ground-based data available from the Moon and satellites also have the great potential to provide a global perspective of the lunar surface.

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