Email: AlisonCaldwell@compuserve.com

# Introduction to Remote Sensing

Remote sensing is the ability to gather information without being in direct contact with it. The information is gathered by instruments - at the natural level by our eyes, or by cameras or radiometers (which measure radiation). The instruments can be mounted on various platforms such as aircraft or satellites. Teachers are familiar with aircraft borne cameras and their resulting remote sensing products - oblique and vertical air photos. Satellite remote sensing involves the use of orbiting satellites as platforms and radiometers as instruments. The most well known examples are the weather satellites like Meteosat and NOAA series. Today there are hundreds of satellites orbiting the earth collecting data on many aspects of the earth's surface and the atmosphere.

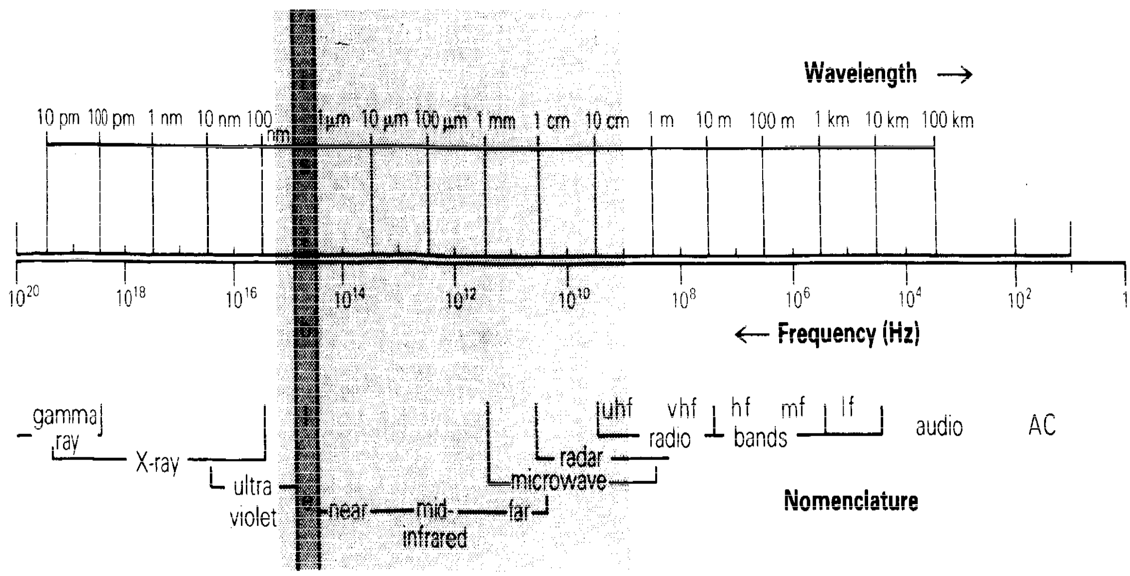
One example of an earth observation satellite is Landsat 5 which carries a sensor called "Thematic Mapper", usually shortened to "TM", which builds up a complete coverage of the Earth every 16 days.

The Electromagnetic Spectrum and Bands

What is the information being collected? It is measurements of electromagnetic radiation. The electromagnetic spectrum is a continuum of energy from short wave high frequency cosmic waves to longer wavelength low frequency radio waves (Figure 2). Our eyes are sensitive to the visible part of the electromagnetic spectrum. Within the visible spectrum our eyes can see the different colours which are variations in the wavelengths.

Figure 1 - The Electromagnetic Spectrum

## The Electromagnetic Spectrum; Wavelengths used for Remote Sensing



Email: AlisonCaldwell@compuserve.com

The shortest wavelength end includes X-rays and the band to which our eyes are sensitive, called the 'visible', which lies between 0.39 and 0.76 micrometres or 'microns (millionths of a metre). Within this band there is a relation between wavelength and the colour of light such that the shortest is violet light (0.390 to 0.455 microns) and the longest is red light (0.620 to 0.760 microns). These ends of the visible spectrum act to define wavelengths shorter than violet as the 'ultraviolet' and those longer than red as the 'infrared'. In fact very much longer wavelengths are not termed infrared but fall into the category of microwaves (millimetre wavelengths) and radiowaves (many tens of metres).

Some sensors detect reflected radiation and others emitted radiation. Incoming sunlight (solar radiation) is reflected, absorbed or transmitted by the earth's surface and atmosphere. The reflected energy is measured by the optical sensors on Landsat's TM.

As a result of the scattering and absorption of this reflected radiation by the atmosphere, satellite remote sensing can only use certain 'windows' in the spectrum. The TM for example is built to record radiation in only some parts of the electromagnetic spectrum - these parts are known as bands.

The TM records the reflectance or emittance for each of its bands. It does this in a digital format, 0 for no radiation reflectance and 255 for the maximum. These numbers are then transmitted to the earth and are used to construct remotely sensed images. These images, then, are not photographs and using image processing software the operator can make the different bands any colour that might be desired. (Incidentally, "image processing software" is no longer some kind of specialist technology. Packages like Paint shop Pro do similar things and are widely used in computer graphics and photographic work). Although some satellite images are obtained photographically, for the most part they are not.

## How Big? Pixels, Resolution and Scale

Pixel, the word itself sounds small and mischievous! Pixels, or picture elements are certainly small, they are the basic building blocks of images. For example each of the Landsat Thematic Mapper's scan lines are approximately 30 m wide, these lines are divided into slices so the pixels are roughly 30 m square. It is reflectance for each of the TM's bands for each pixel which is the digital data base used by the computer to generate images.

This unit area represents the resolution of the sensing system and it gives us an idea of the smallest features which can be seen on the images. Landsat 5's TM 30 m x 30m pixels are about the size of a tennis court. When you look at images you can see the influence this has on the kind of detail shown of urban areas compared to the identification of discrete features in the rural landscape. However, features smaller than 30 m can sometimes be detected if their reflectance contrasts strongly with their surroundings, especially if they are linear such as hedges and roads.

Other satellite remote sensing systems have different pixel sizes. One of the sensors on the French satellite SPOT (Systeme Probatoire d'Observation de la Terre) has a 10 m pixel, Landsat's other sensor, the Multispectral Scanner (MSS) has a pixel size of about 80 m and Meteosat has a pixel size of 2.5 km - thunderstorms are fairly large phenomena!

## How are the Images Produced?

Landsat 5's Thematic Mapper collects data in digital form, as a number (ranging from 0-255) for each pixel's reflectance in each of the TM's bands. These streams of numbers, together with the orbital details of the spacecraft, are transmitted to a ground station. Here a 4.5 m steerable dish receives it and the data is stored on computer compatible magnetic tape. As it is in a digital format this data can be computer processed.

Image processing. The manipulation of the numbers to enhance or analyse the image is a vast and fascinating field in its own right. Image processing begins with operations such as geometric transformation. In this process computers stretch the image like a 'rubber sheet' to fit a map. Satellites pitch, yaw, roll and vary their speed and height, all of which affects the resulting image. Ground control points like airfields, road intersections, bridges, headlands and so on, are used to match the satellite image with standard map projections.

Contrast stretching is another initial step. The TM sensors have to cope with reflectance ranges from sunlit fresh snow to winter illuminated black lava ash. Any individual Landsat scene may therefore only record on a limited part of the instrument's total range, in other words it may use only part of the 256 level grey scale. The resulting raw image is therefore even toned and murky. Just as we crispen up a TV picture by fiddling with the contrast, so the image analysis computer can spread out the available data over the whole grey scale range. By this process quite subtle variations can be made to stand out.

A whole range of other processes can be used on the raw data. It is not just a matter of cleaning up the data for cosmetic reasons, the processing is designed to increase the amount of information which can be obtained.

Individual bands may be produced as 'black and white' images. These may resemble black and white air photos, but on a smaller scale i.e. covering a larger area. However, they are based on reflectance in only one band and the band may be of part of the infra red area of the spectrum. In this case some care is needed in the interpretation of their light and dark tones. It is these individual bands which are the data for a further stage - the production of colour composites.

Colours

'What do the colours mean?' This is one of the more basic questions asked when pupils and students first examine colour composites.

Like many simple questions it is not easy to answer. The 'meaning' of colour varies with the sensor, the processing and the date. The significance of the latter is the easiest to appreciate - Landsat images after all are for a specific date or time. Plants grow and die, soil moisture changes, inter-tidal areas are water-covered to different degrees and so on, at different dates. Sensors and processing are the other variables.

A composite image is one built up from the data in three bands. Three images, one for each band, are combined. For example if we took a TM band 1 image and projected it through the blue colour gun of the computer's VDU, added TM band 2 through the green colour gun and finally TM band 3 through the red colour gun a true colour composite is produced. This is a process like the one which occurs with colour film. When it is exposed in your camera each layer of emulsion is sensitive to only part (i.e.) a band of the spectrum, but combined they give us colour picture.

Remote sensing often involves using information from beyond the visible part of the electromagnetic spectrum. The near and middle infra red, sensed by TM bands 4, 5 and 7, contains useful environmental information. It is for this reason that remote sensing generally does not use simulated natural colour composites. As we cannot see this infra red radiation, an arbitrary colour has to be invented for us - a process known as false colour composite generation.

False colour composites can give us far more information about the land, especially vegetation. This is because reflectance in the visible bands is determined largely by the pigmentation of the plant but in the infra red by the plant physiology and moisture status. The latter two vary much more than pigmentation as types of vegetation and their condition vary across and area and from season to season.