Defect Detection

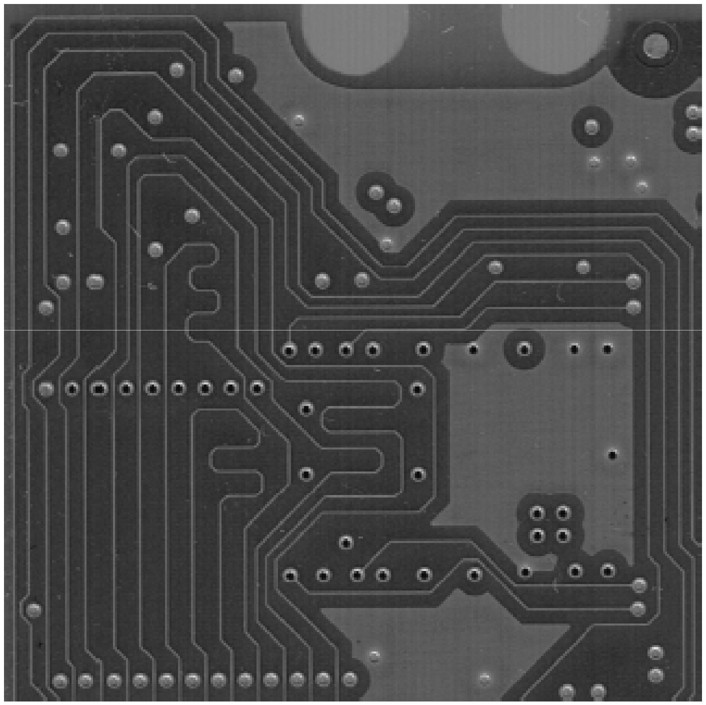


Image g[x,y] (No defect)

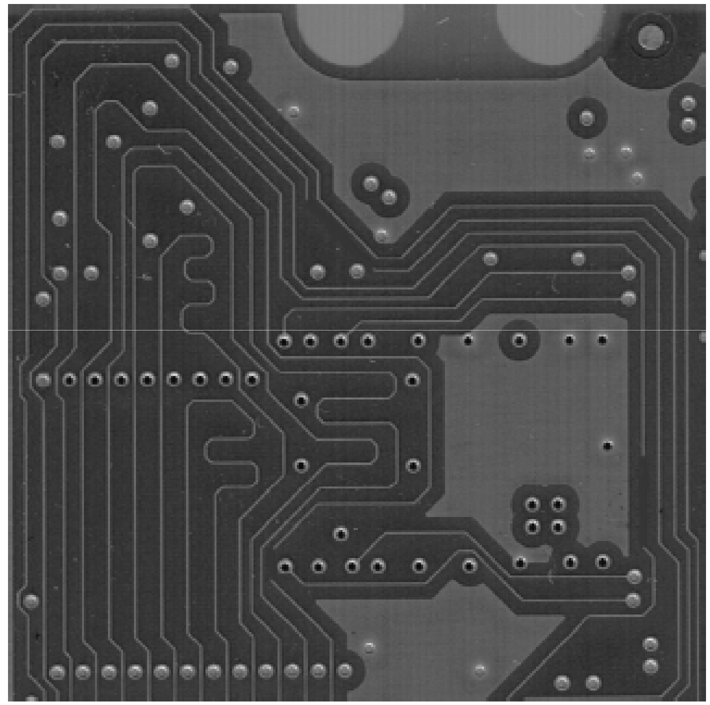
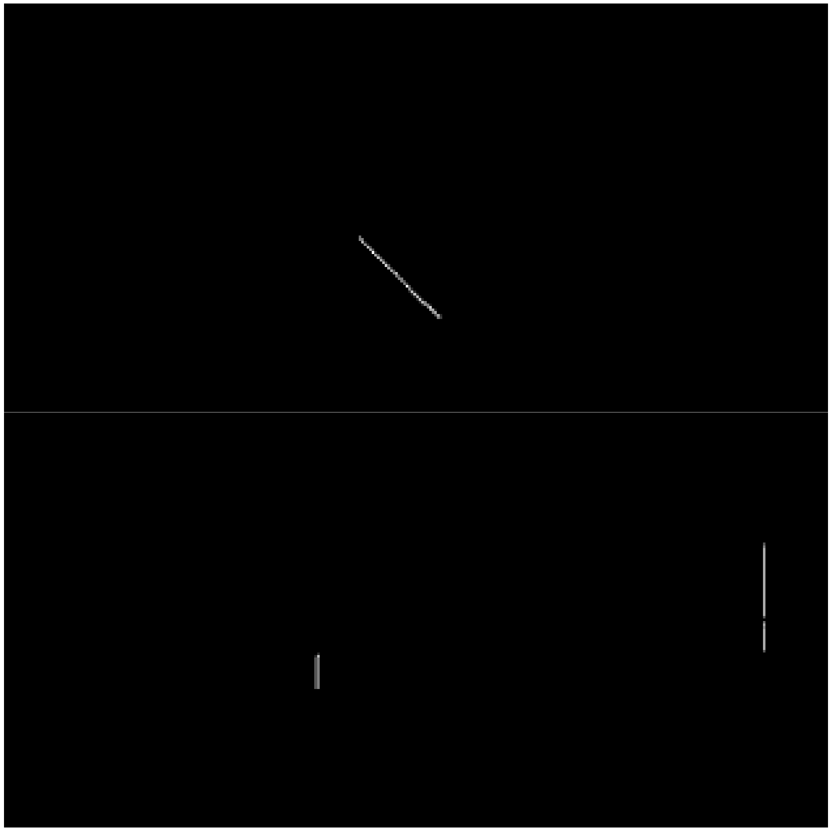
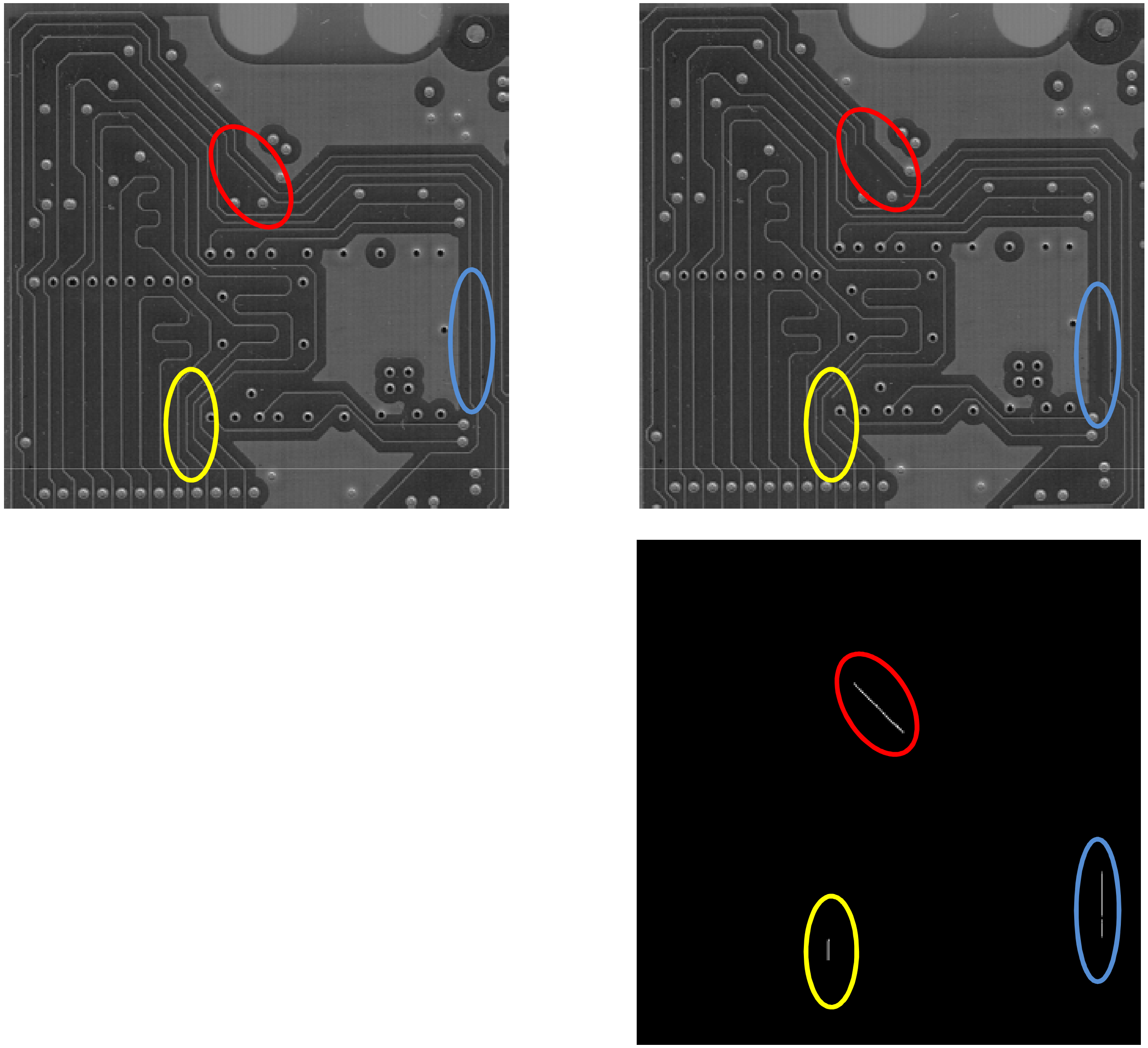


Image g[x,y] (with defect)

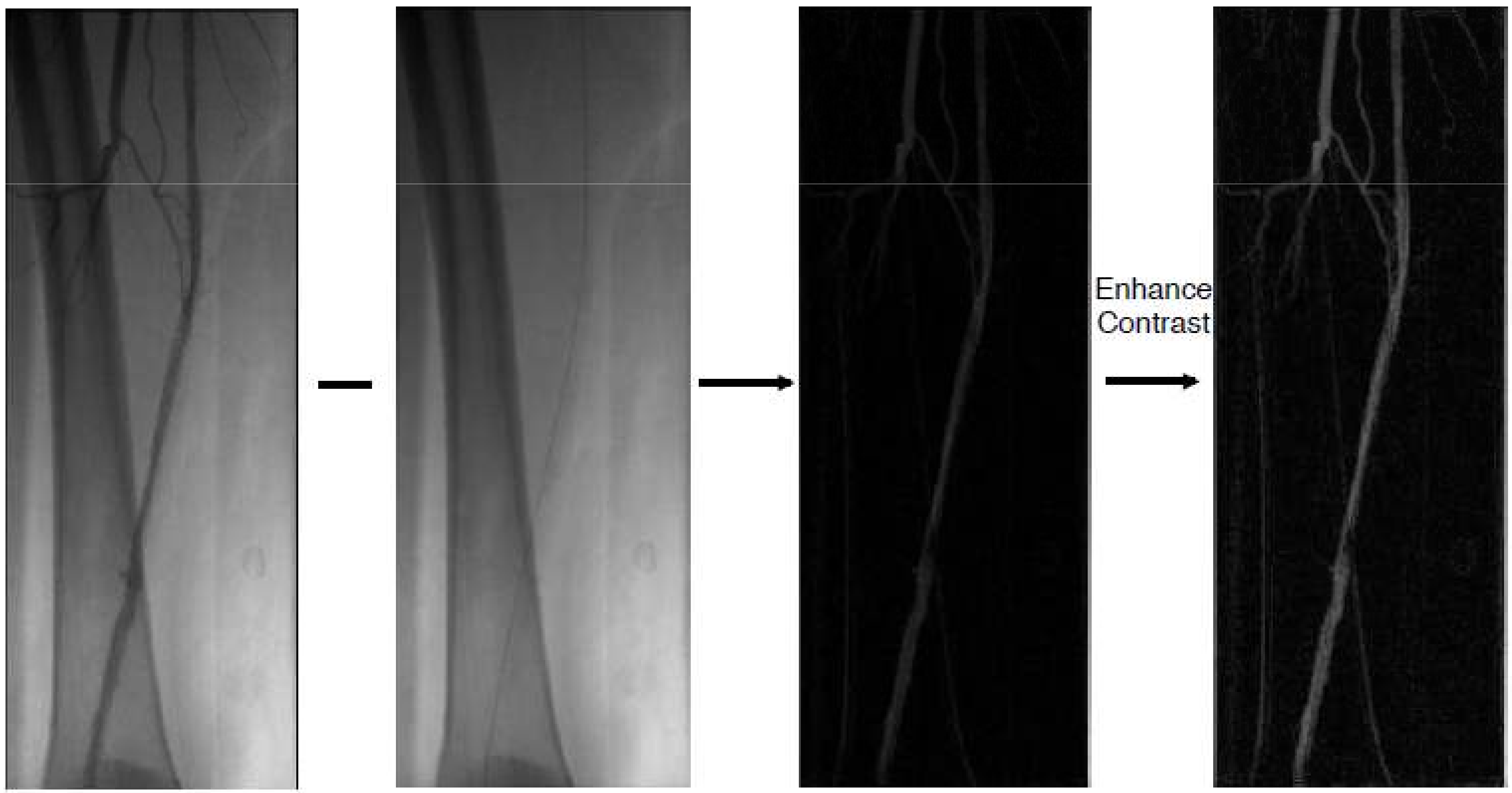
Defect Detection





Applications in Medicine

- Digital subtraction angiography

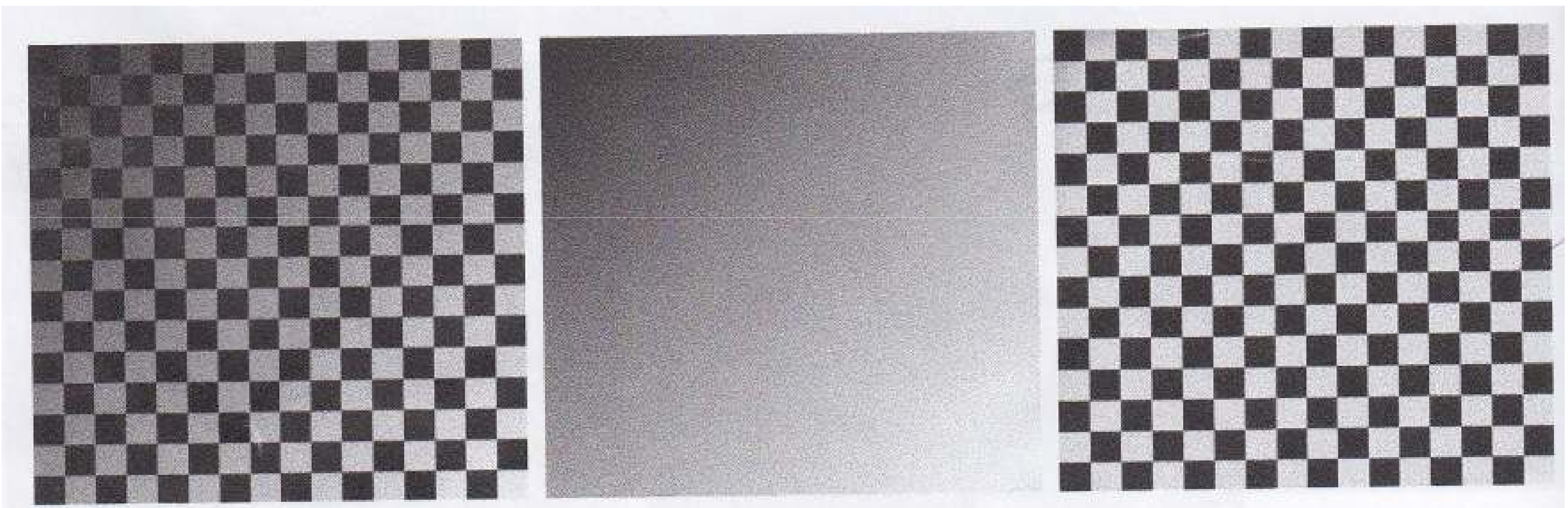


Multiplication/Division

- Used to adjust brightness of the image.

Multiplication by 2

Using image multiplication and division for shading correction and masking



Scaling of Images

- After arithmetic operations the values of the resulting images may have values that are out of range (0-255), so, it is needed to scale the values at the end of the analysis.

$$\begin{bmatrix} 510 & 255 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 255 & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 255 & 255 \\ 0 & 0 \end{bmatrix}$$

$$\downarrow$$

$$\begin{bmatrix} 255 & 255 \\ 0 & 0 \end{bmatrix}$$ Without scaling

Scaling of Images

- After arithmetic operations the values of the resulting images may have values that are out of range (0-255), so, it is needed to scale the values at the end of the analysis.

$$\begin{bmatrix} 0 & -255 \\ 255 & 255 \end{bmatrix} = \begin{bmatrix} 255 & 0 \\ 255 & 255 \end{bmatrix} - \begin{bmatrix} 255 & 255 \\ 0 & 0 \end{bmatrix}$$

$$\downarrow$$

$$\begin{bmatrix} 0 & 0 \\ 255 & 255 \end{bmatrix}$$ Without scaling

Scaling of Images

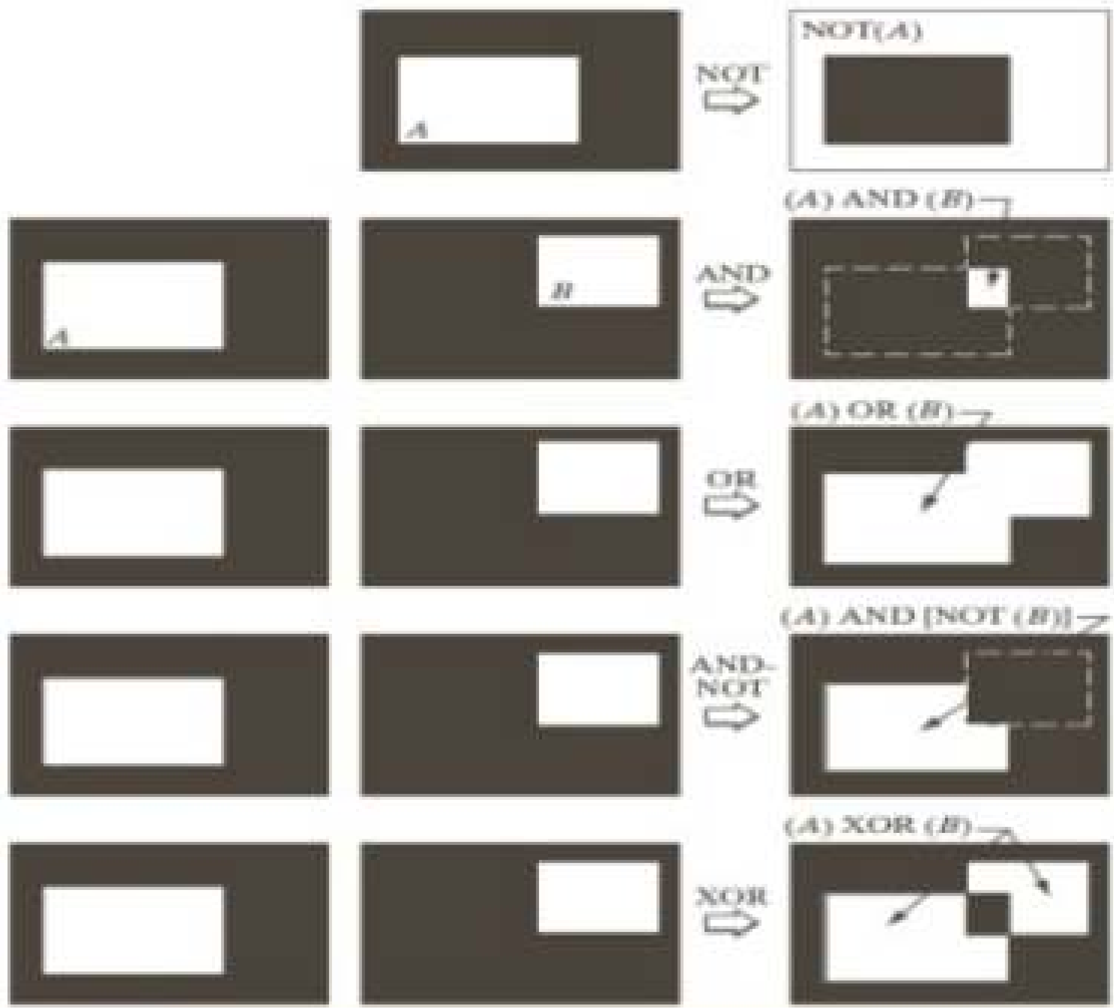
$$I_{out} = K * \left(\frac{I - \min(I)}{\max(I) - \min(I)} \right)$$

K is the number of levels used to represent the image (255)

$$I = \begin{bmatrix} 510 & 255 \\ 0 & 0 \end{bmatrix} \longrightarrow I_{out} = \begin{bmatrix} 255 & 128 \\ 0 & 0 \end{bmatrix}$$

$$I = \begin{bmatrix} 0 & -255 \\ 255 & 255 \end{bmatrix} \longrightarrow I_{out} = \begin{bmatrix} 128 & 0 \\ 255 & 255 \end{bmatrix}$$

Logical Operations

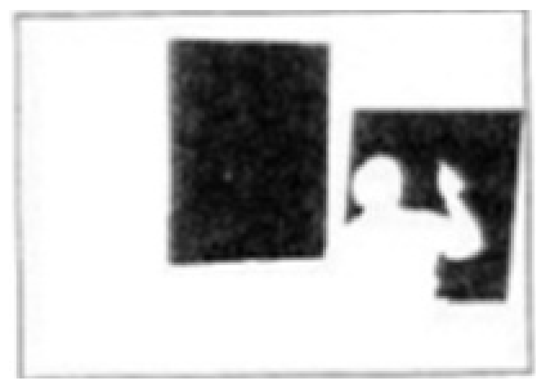


AND Operator

The AND Operator is used to mask out part of an image.

$O(x,y)$

$I_1(x,y)$

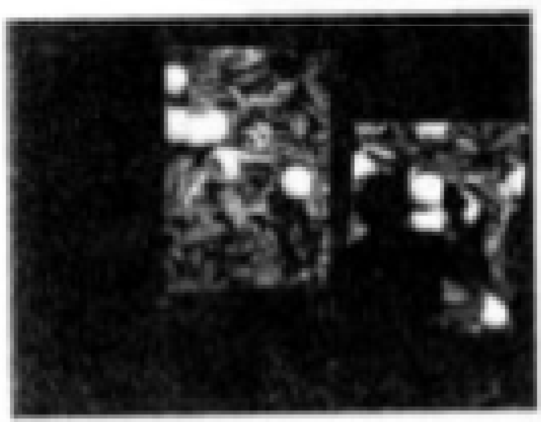


$I_2(x,y)$

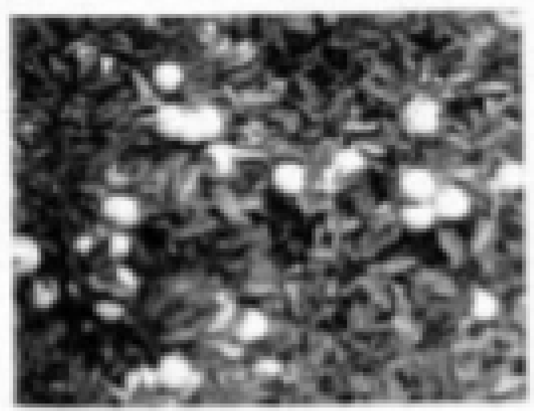
$$O(x,y)=I_1(x,y) \text{ AND } I_2(x,y)$$

OR Operator

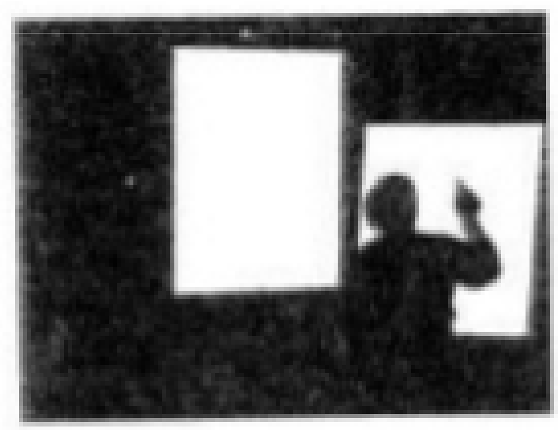
Parts of another image can added with a logical operator OR.



O(x,y)

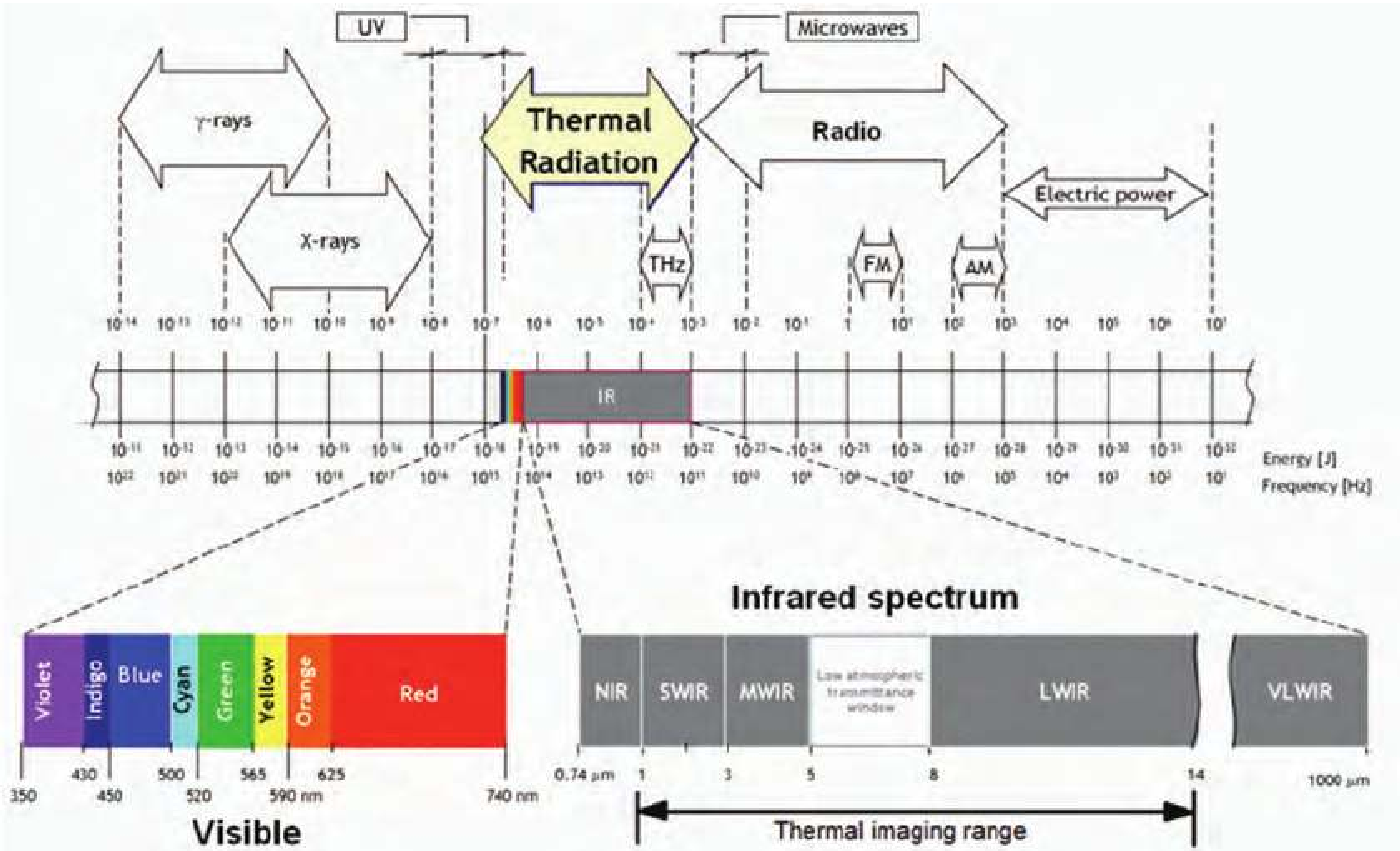


$I_1(x,y)$



$I_2(x,y)$

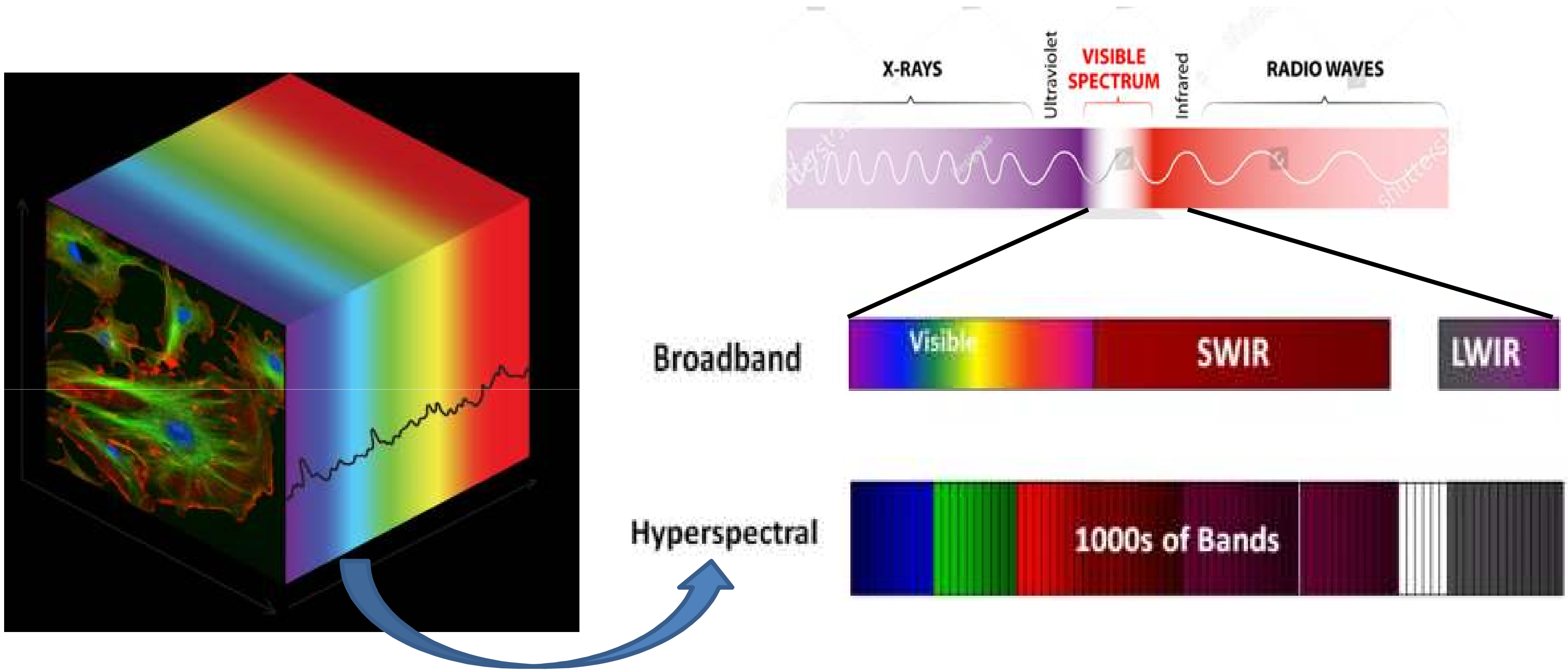
$$O(x,y)=I_1(x,y) \text{ OR } I_2(x,y)$$



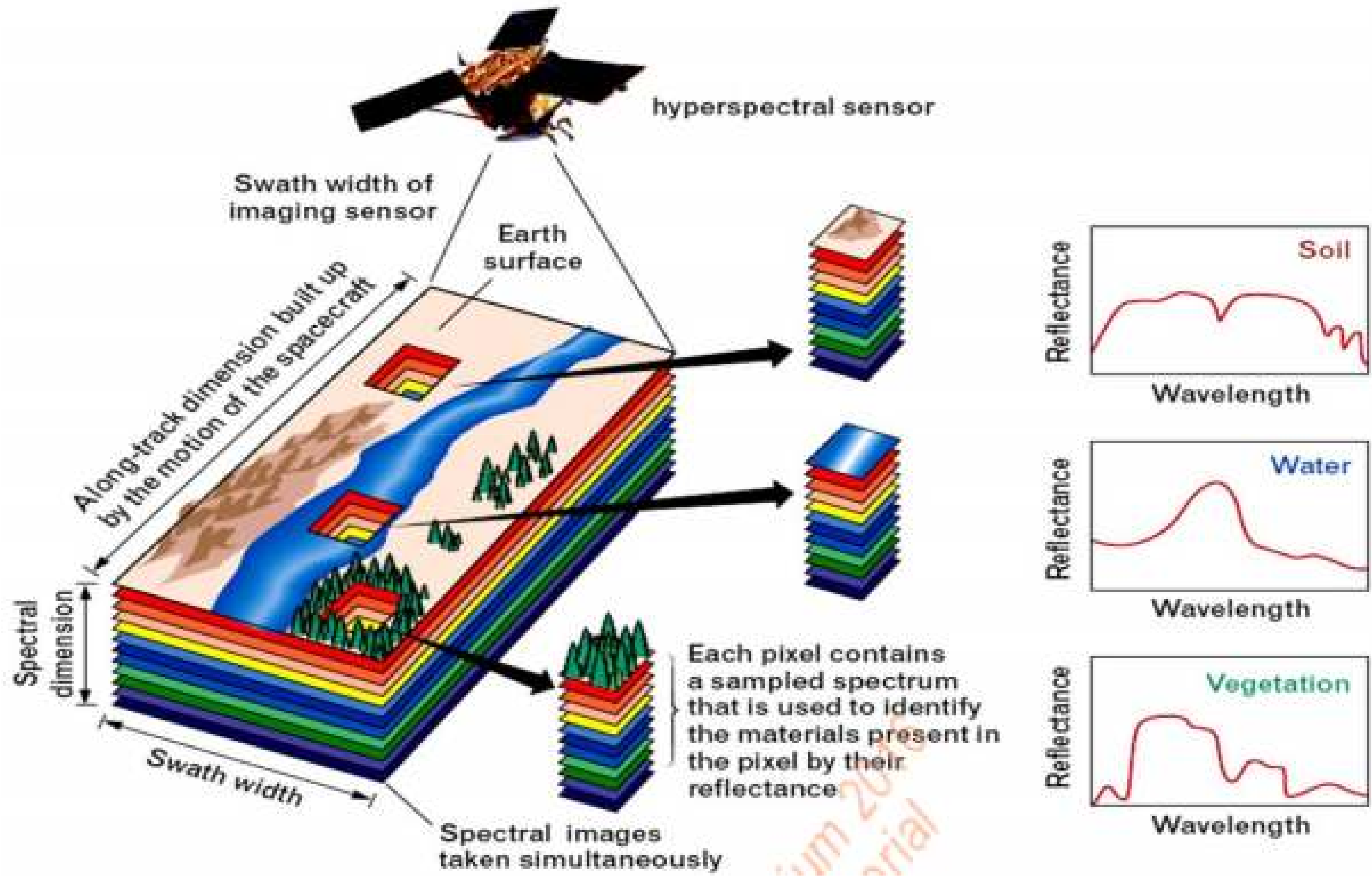
Humans can see visible light which has spectral range between 400 to 700 nanometers. Hyperspectral cameras capture information in the range of 200 to above 2500 nanometers.

Materials that appear similar under visible light may appear different under infrared or ultraviolet light.

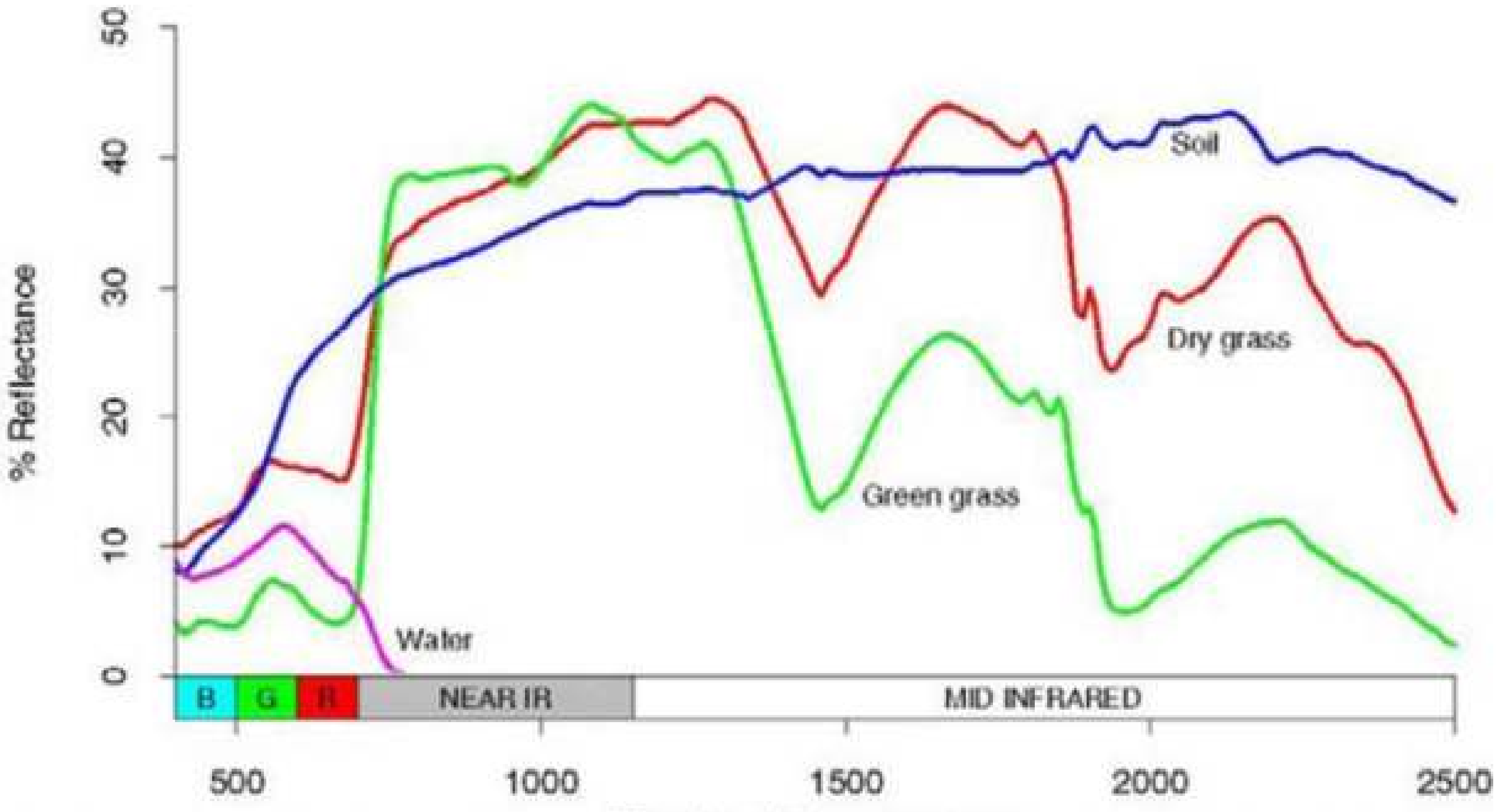
What is a Hyperspectral Image?



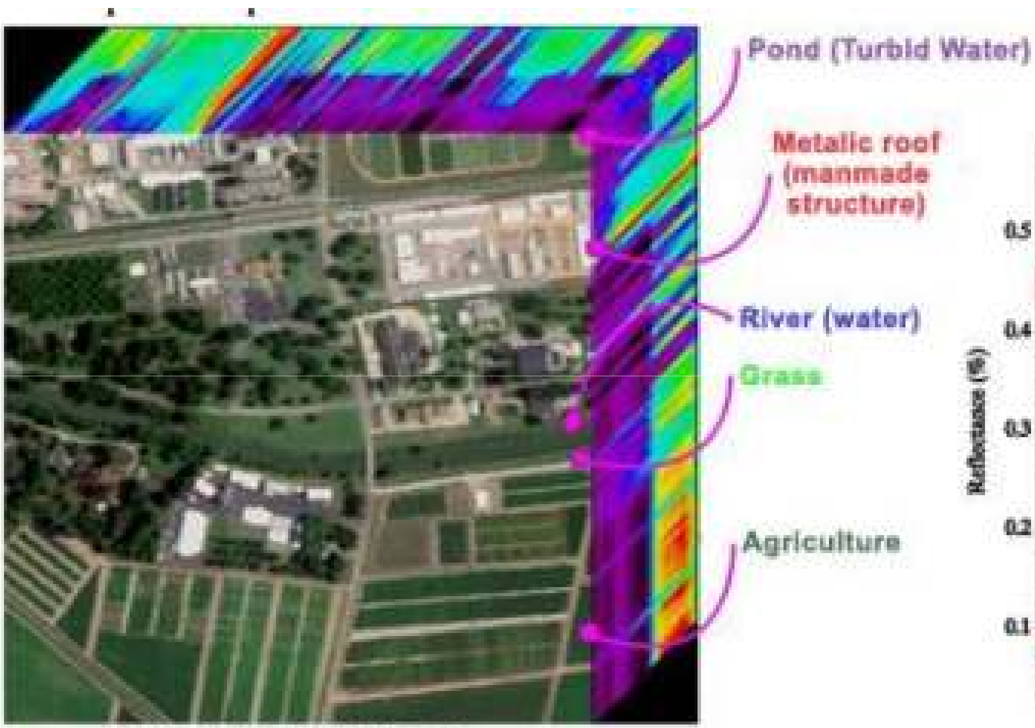
A hyperspectral image is a stack of several images taken at different wavelengths.


hyperspectral sensor
Swath width of imaging sensor
Earth surface
Along-track dimension built up by the motion of the spacecraft
Spectral dimension
Swath width
Spectral images taken simultaneously
Each pixel contains a sampled spectrum that is used to identify the materials present in the pixel by their reflectance
Soil
Reflectance
Wavelength
Water
Reflectance
Wavelength
Vegetation
Reflectance
Wavelength

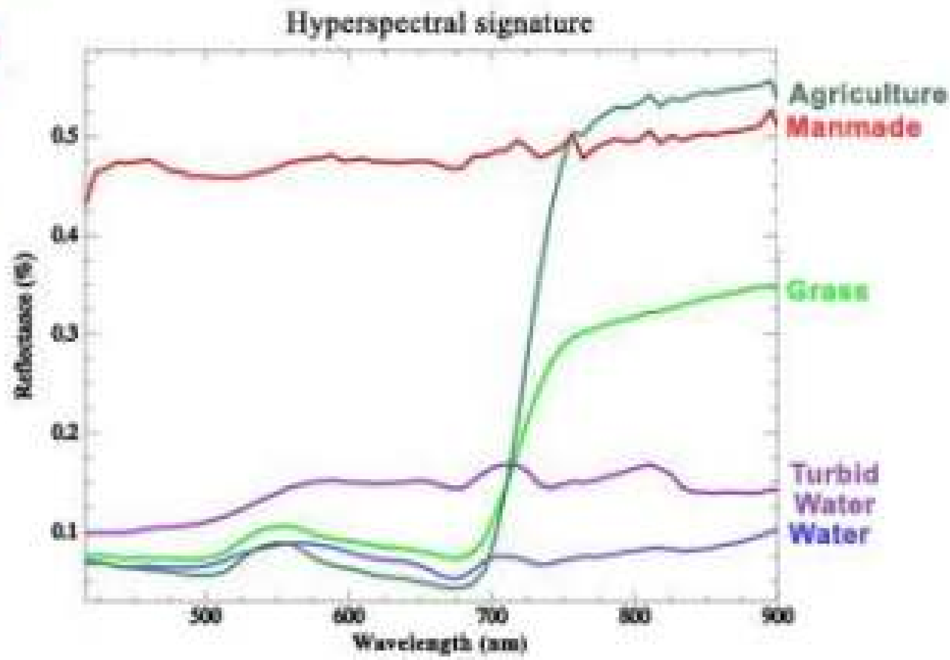
Spectral Signatures



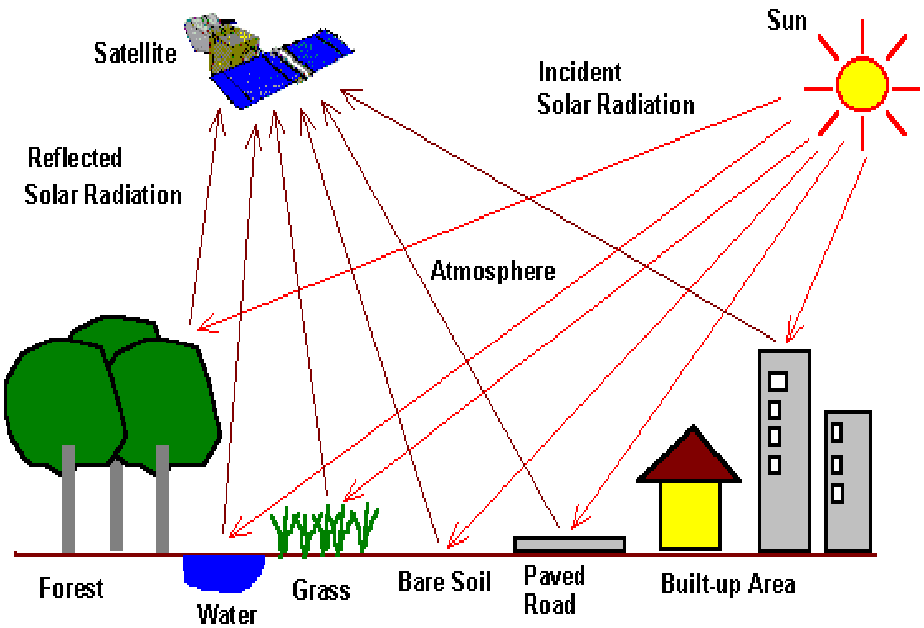
Hyperspectral Image

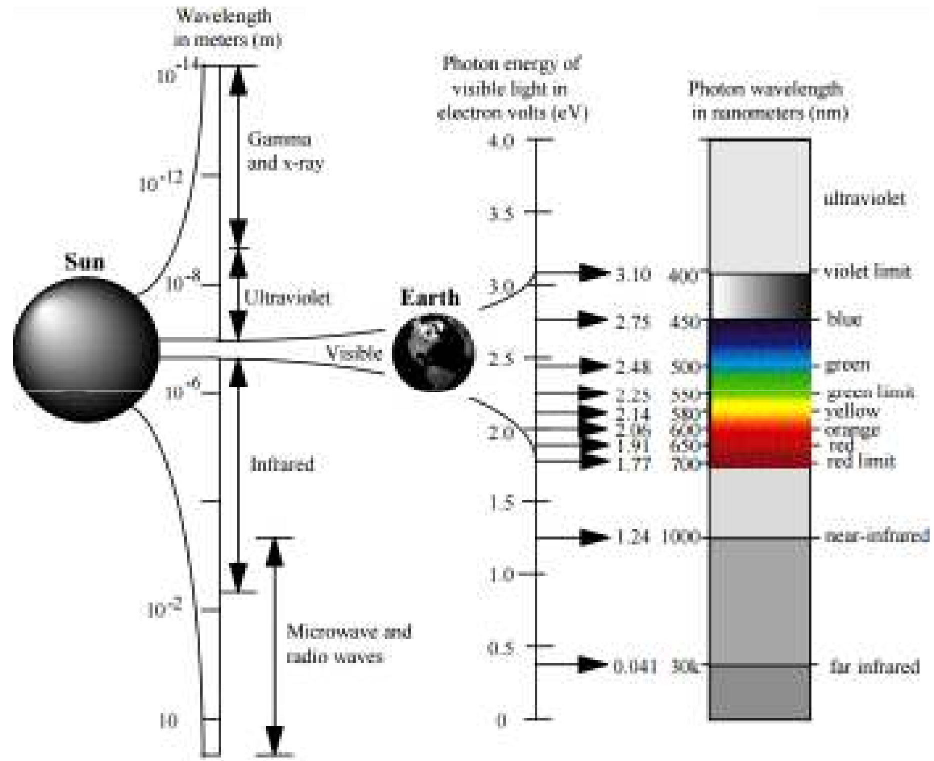


Spectral block with 64 bands
from 415 nm to 900 nm

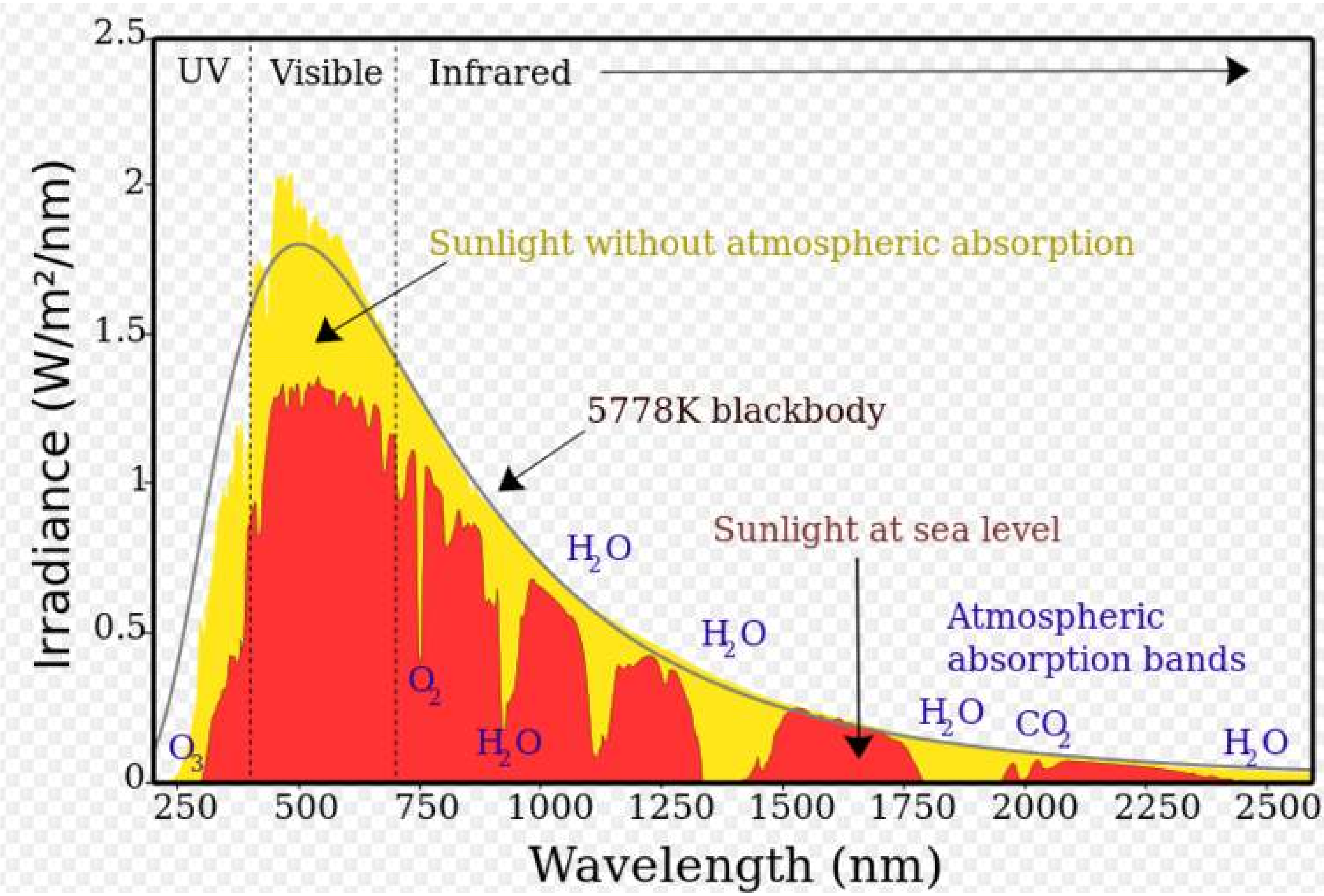


Hyperspectral Image used for Remote Sensing Applications

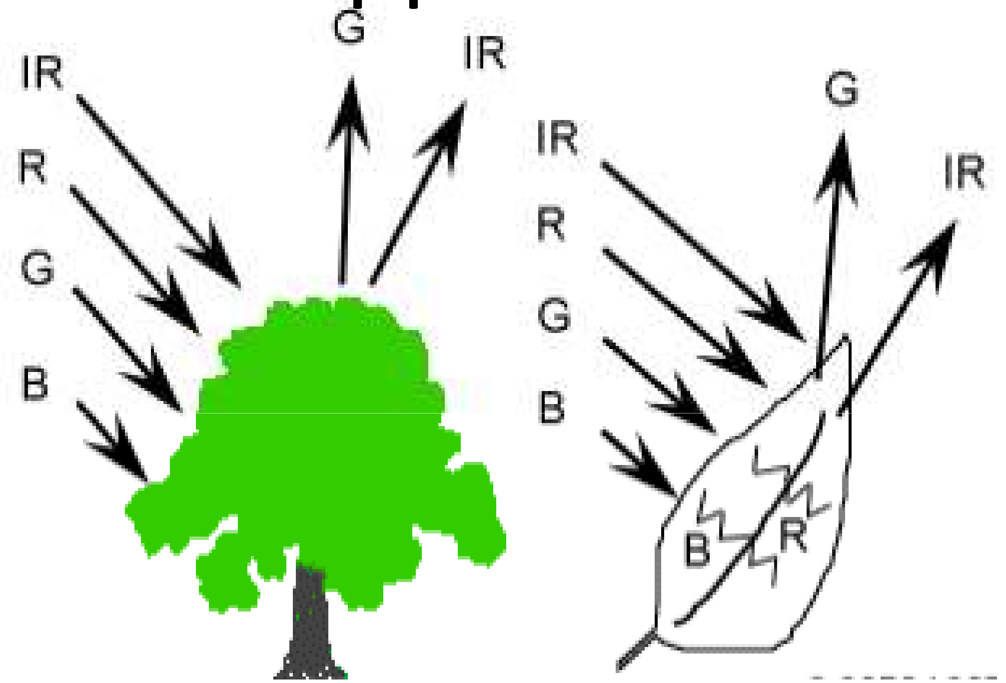




Spectrum of Solar Radiation (Earth)

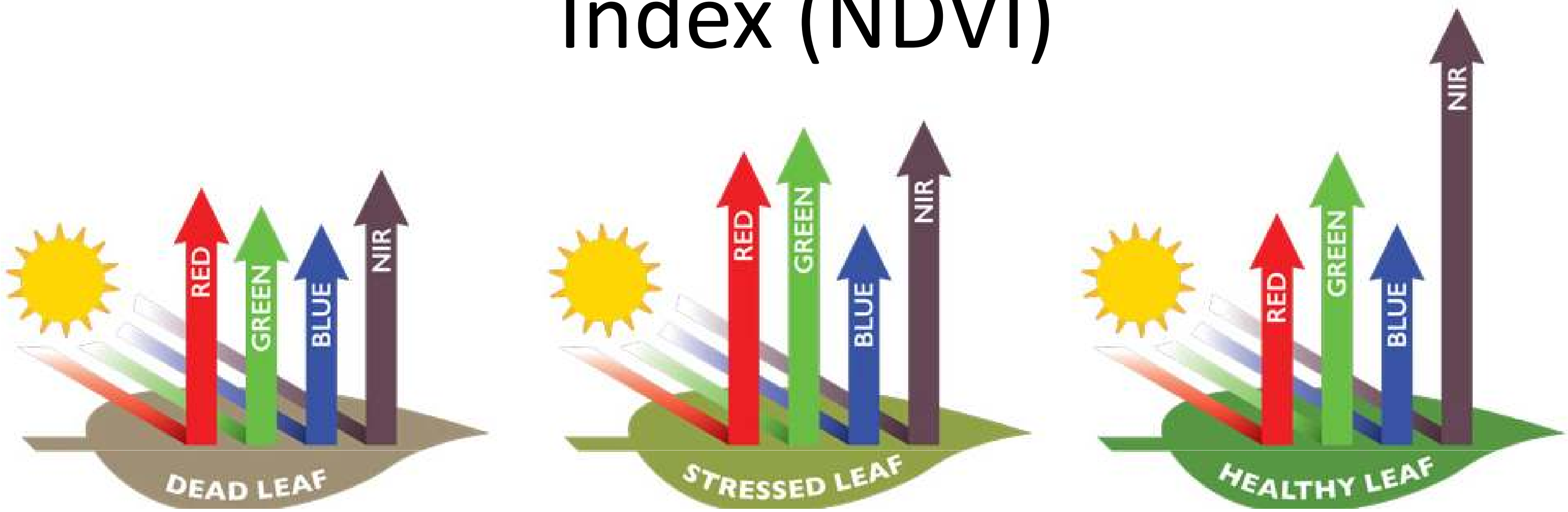


Hyperspectral Images for Vegetation Applications



Chlorophyll strongly absorb radiation in the red and blue wavelengths but reflects green wavelengths. The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths.

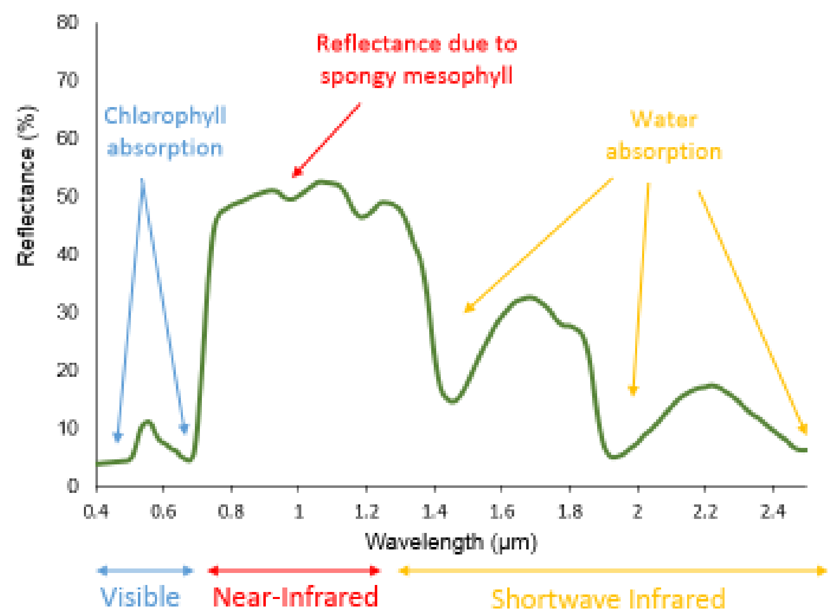
Normalized Difference Vegetation Index (NDVI)

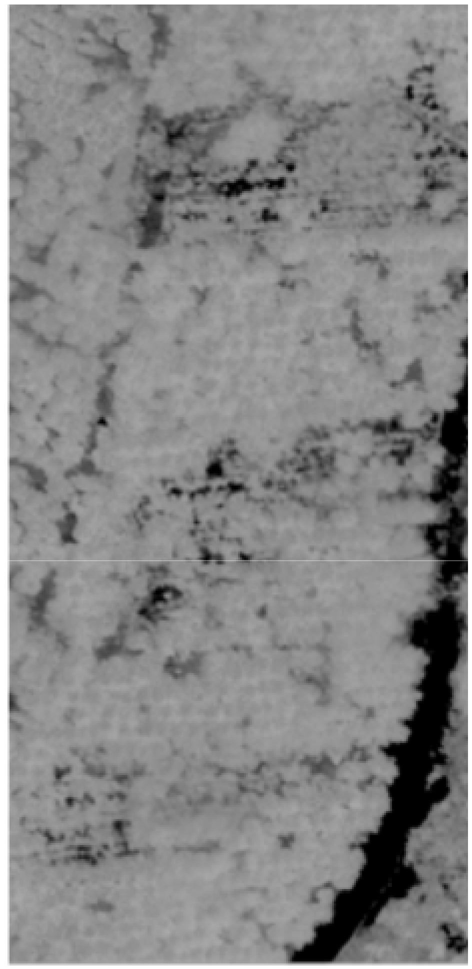


$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$-1 \leq NDVI \leq 1$$

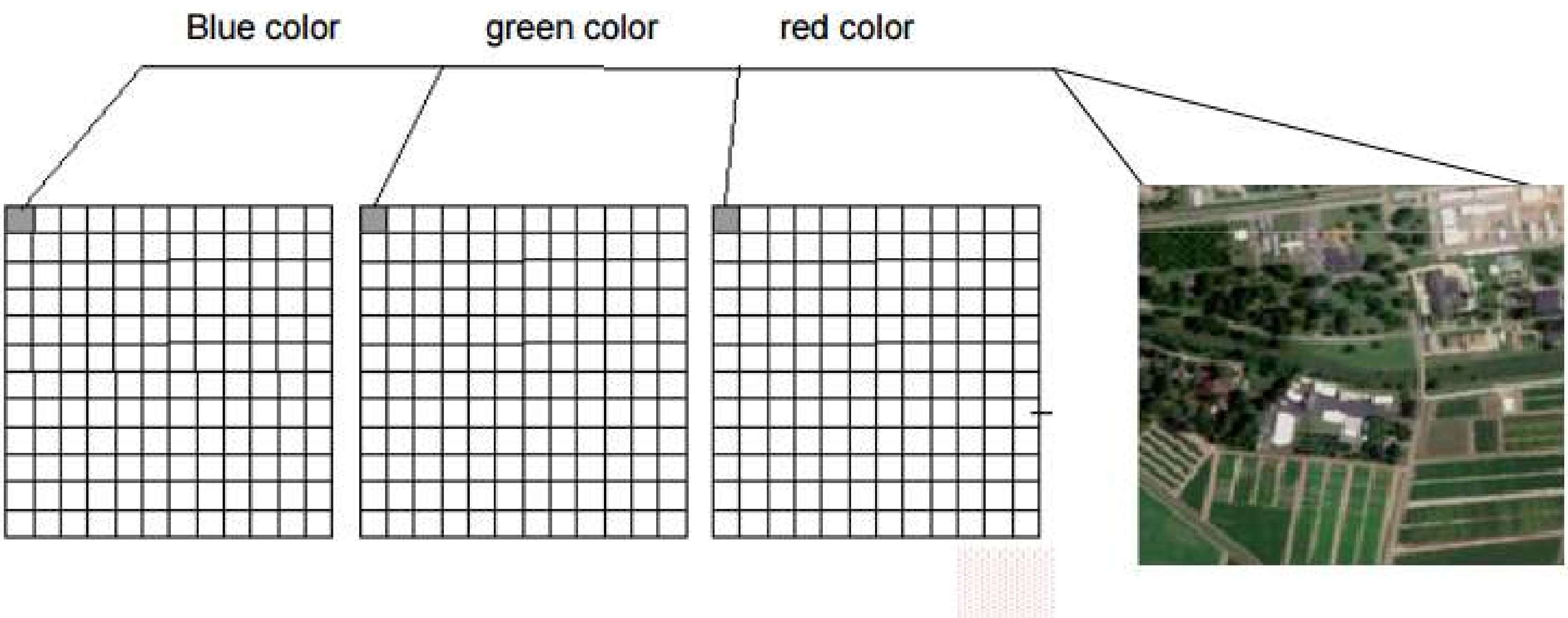
Soil≤0 Vegetation>0



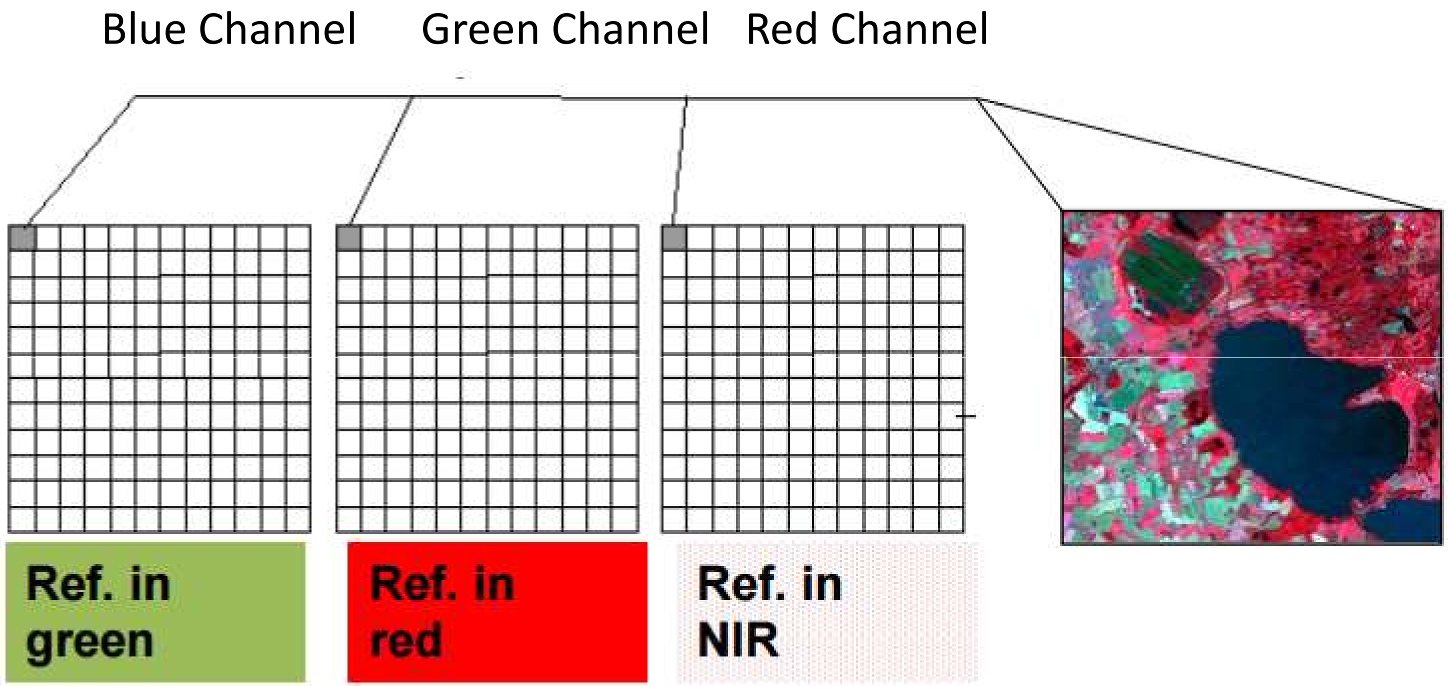


$$I_{NDVI} = \frac{I_{NIR} - I_{RED}}{I_{NIR} + I_{RED}}$$

Color Representation



False Color



Vegetation appears in different shades of red depending on the types and conditions of the vegetation ,Clear water appears dark-bluish (higher green band reflectance), while turbid water appears cyan (higher red reflectance due to sediments) compared to clear water. Bare soils, roads and buildings may appear in various shades of blue, yellow or grey, depending on their composition.

Normal Color Photo
(Blue, Green, Red)

False Color Composite Photo
(Green, Red, NIR)

Other Combinations of Bands

- Shortwave infrared light highlights the difference between clouds, ice, and snow, all of which are white in visible light.
- Thermal infrared, usually shown in tones of gray to illustrate temperature.
- floods are best viewed in shortwave infrared, near infrared, and green light because muddy water blends with brown land in a natural color image.