Remote Sensing Data as a Digital Image And Introductory DIP

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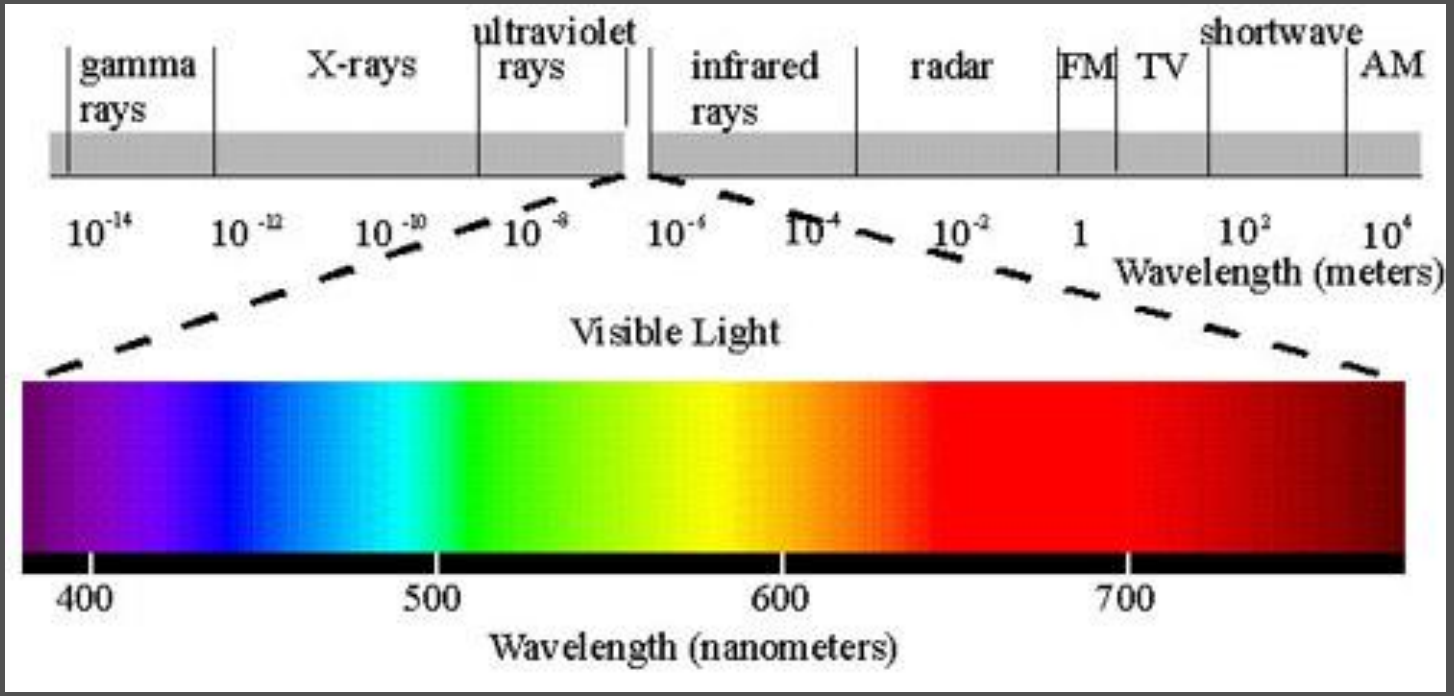
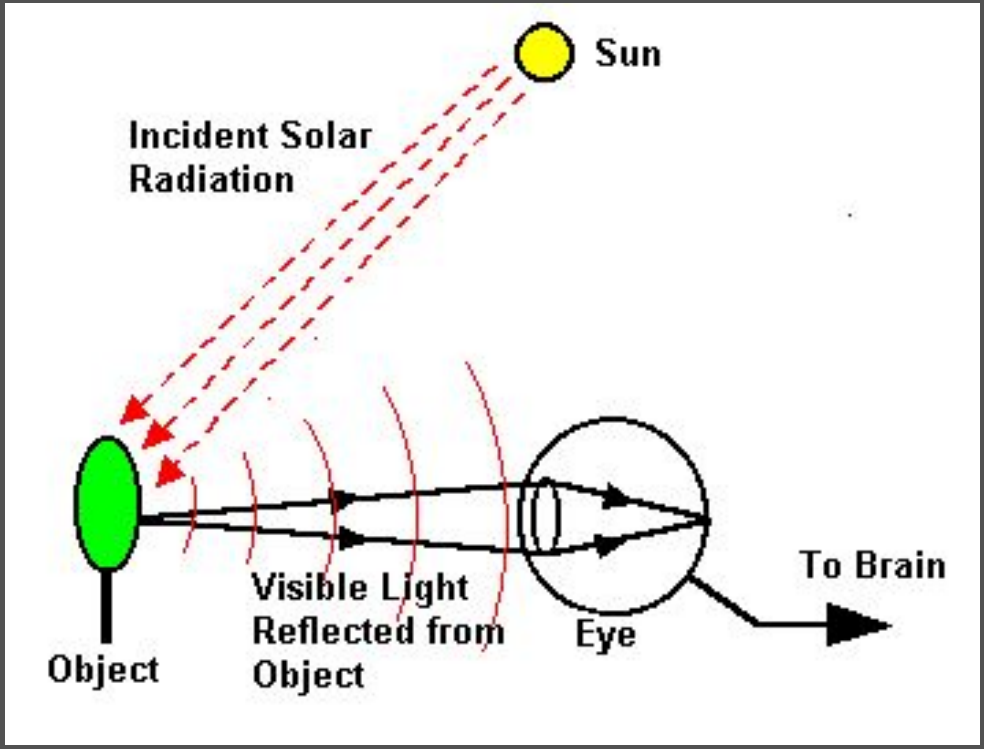
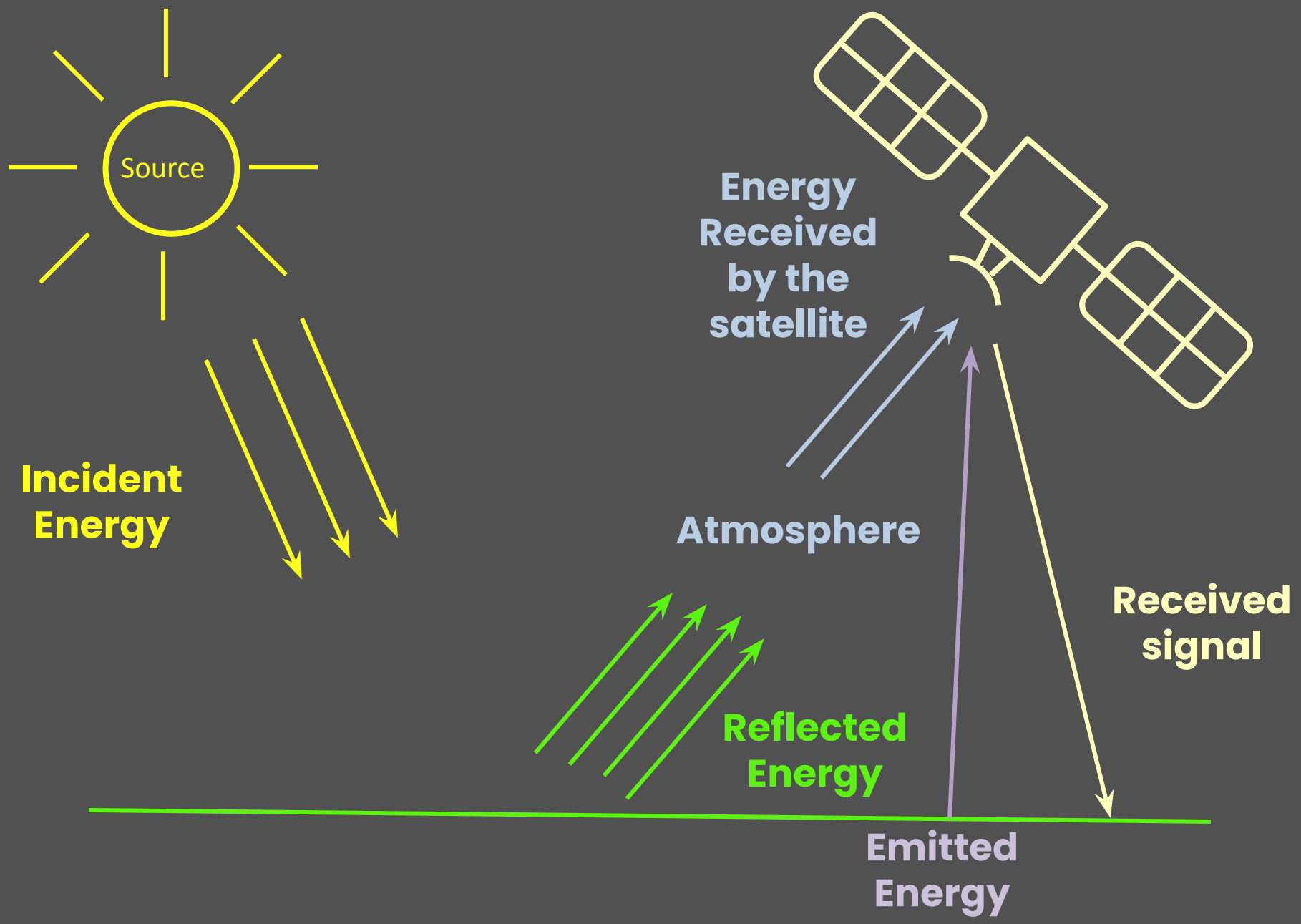
How do we see?



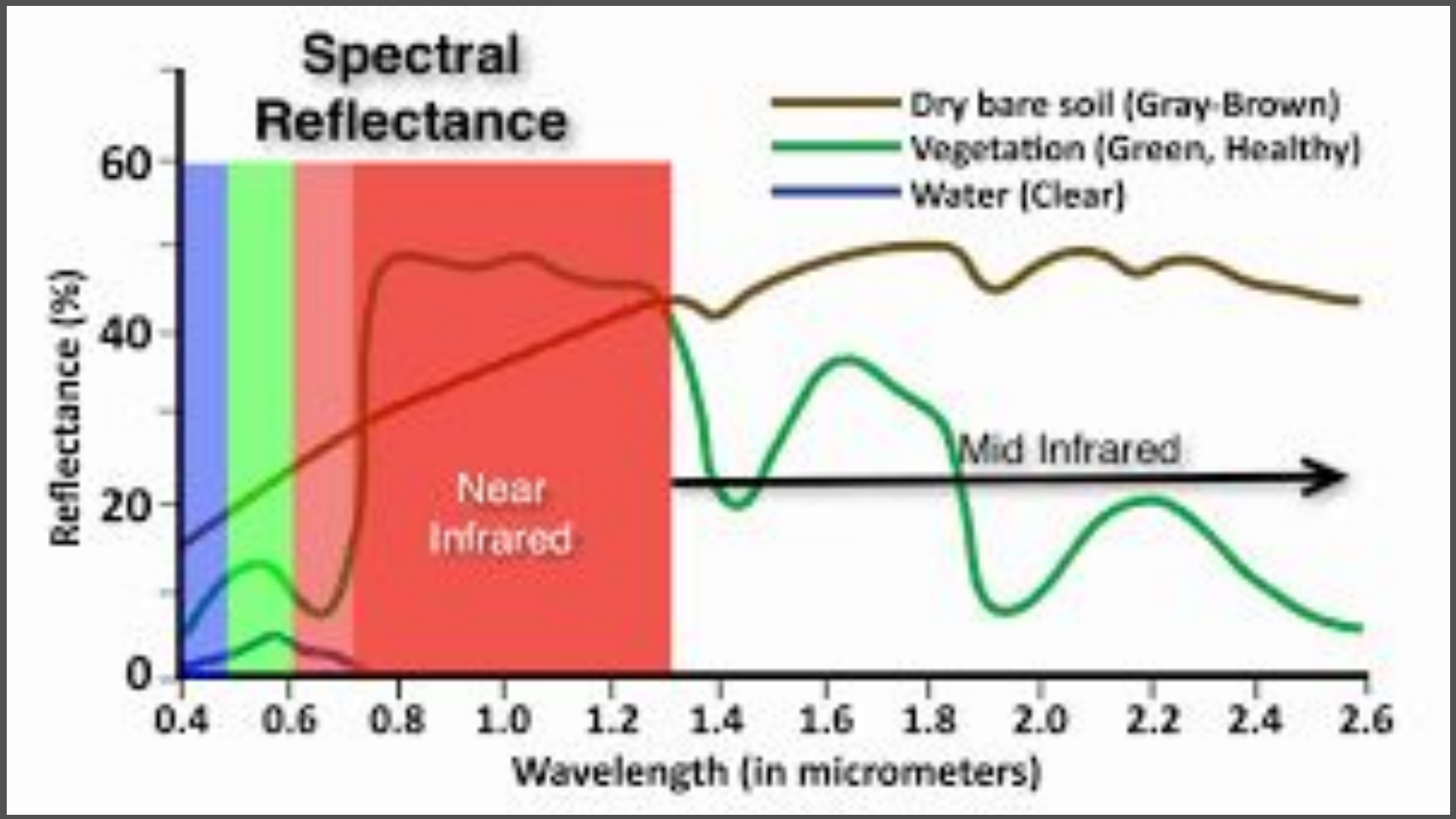
Materials respond differently to different regions of the electromagnetic spectrum. Some portions are reflected and others are absorbed. A graphical representation is what we call the spectrum of the material.

A Remote Sensing Camera. How does it look? What are its components?




Source
Incident Energy
Energy Received by the satellite
Atmosphere
Reflected Energy
Received signal
Emitted Energy

Spectral Reflectance Curve

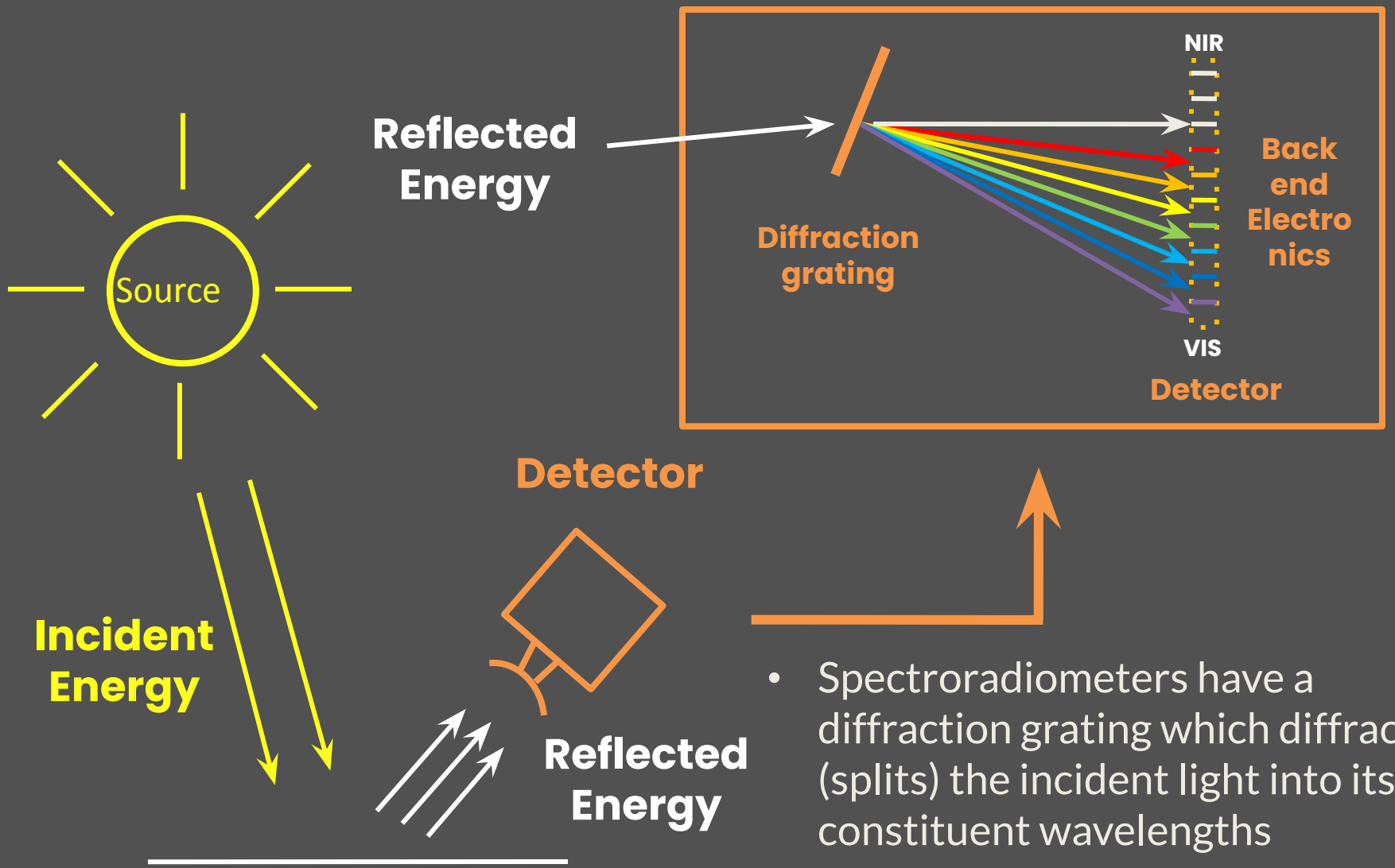


Different land cover types depict different spectrum.

Image source: Boldbayer R 2020

How do we get satellite images from this?

How are images generated



- Spectroradiometers have a diffraction grating which diffracts (splits) the incident light into its constituent wavelengths
- One detector cell for each wavelength

For an Imaging a Line

P1	P2	P3	P4	P5	P6	P7	B1
P1	P2	P3	P4	P5	P6	P7	B2
P1	P2	P3	P4	P5	P6	P7	B3
P1	P2	P3	P4	P5	P6	P7	B4

For an Imaging a Frame

L1P1	L1P2	L1P3	L1P4	L1P5	L1P6	L1P7
L2P1	L2P2	L2P3	L2P4	L2P5	L2P6	L2P7
L3P1	L3P2	L3P3	L3P4	L3P5	L3P6	L3P7
L4P1	L4P2	L4P3	L4P4	L4P5	L4P6	L4P7

B1

L1P1	L1P2	L1P3	L1P4	L1P5	L1P6	L1P7
L2P1	L2P2	L2P3	L2P4	L2P5	L2P6	L2P7
L3P1	L3P2	L3P3	L3P4	L3P5	L3P6	L3P7
L4P1	L4P2	L4P3	L4P4	L4P5	L4P6	L4P7

B3

L1P1	L1P2	L1P3	L1P4	L1P5	L1P6	L1P7
L2P1	L2P2	L2P3	L2P4	L2P5	L2P6	L2P7
L3P1	L3P2	L3P3	L3P4	L3P5	L3P6	L3P7
L4P1	L4P2	L4P3	L4P4	L4P5	L4P6	L4P7

B3

L1P1	L1P2	L1P3	L1P4	L1P5	L1P6	L1P7
L2P1	L2P2	L2P3	L2P4	L2P5	L2P6	L2P7
L3P1	L3P2	L3P3	L3P4	L3P5	L3P6	L3P7
L4P1	L4P2	L4P3	L4P4	L4P5	L4P6	L4P7

B2

Pushbroom Imaging

P1	P2	P3	P4	P5	P6	P7	B1
P1	P2	P3	P4	P5	P6	P7	B2
P1	P2	P3	P4	P5	P6	P7	B3
P1	P2	P3	P4	P5	P6	P7	B4
Satellite (detector) moves to capture next line							
P1	P2	P3	P4	P5	P6	P7	B1
P1	P2	P3	P4	P5	P6	P7	B2
P1	P2	P3	P4	P5	P6	P7	B3
P1	P2	P3	P4	P5	P6	P7	B4
Satellite (detector) moves to capture next line							
P1	P2	P3	P4	P5	P6	P7	B1
P1	P2	P3	P4	P5	P6	P7	B2
P1	P2	P3	P4	P5	P6	P7	B3
P1	P2	P3	P4	P5	P6	P7	B4

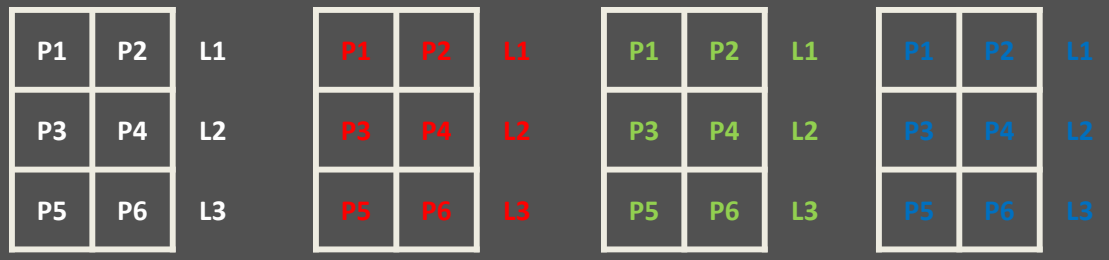
Whiskbroom Imaging

P1	MIRROR	P2	MIRROR	P3	MIRROR	P4	MIRROR	P5	MIRROR	P6	MIRROR	P7	B1
P1		P2		P3		P4		P5		P6		P7	B2
P1		P2		P3		P4		P5		P6		P7	B3
P1		P2		P3		P4		P5		P6		P7	B4
Satellite (detector) moves to capture next line													
P1	MIRROR	P2	MIRROR	P3	MIRROR	P4	MIRROR	P5	MIRROR	P6	MIRROR	P7	B1
P1		P2		P3		P4		P5		P6		P7	B2
P1		P2		P3		P4		P5		P6		P7	B3
P1		P2		P3		P4		P5		P6		P7	B4
Satellite (detector) moves to capture next line													
P1	MIRROR	P2	MIRROR	P3	MIRROR	P4	MIRROR	P5	MIRROR	P6	MIRROR	P7	B1
P1		P2		P3		P4		P5		P6		P7	B2
P1		P2		P3		P4		P5		P6		P7	B3
P1		P2		P3		P4		P5		P6		P7	B4

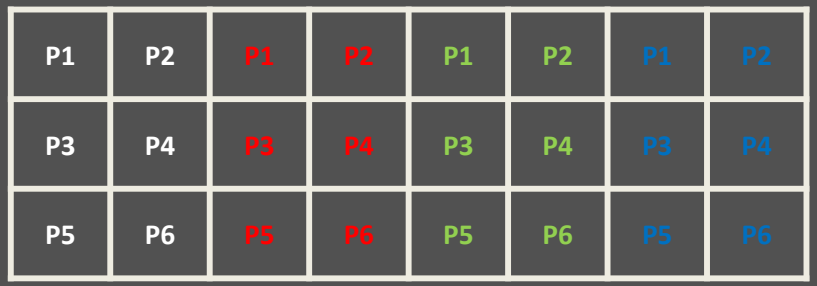
How is Raster Data Stored?

Assume image with 4 bands, 2 pixels in a line and 3 lines of data. Thus we get:

- # px (w): 2
- # px (h): 3
- # bands: 4



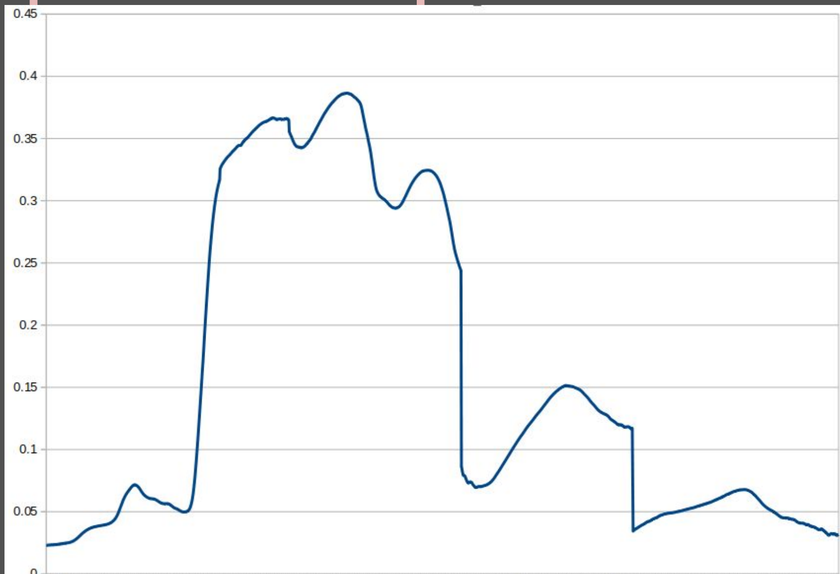
Band Interleaved by Line: BIL

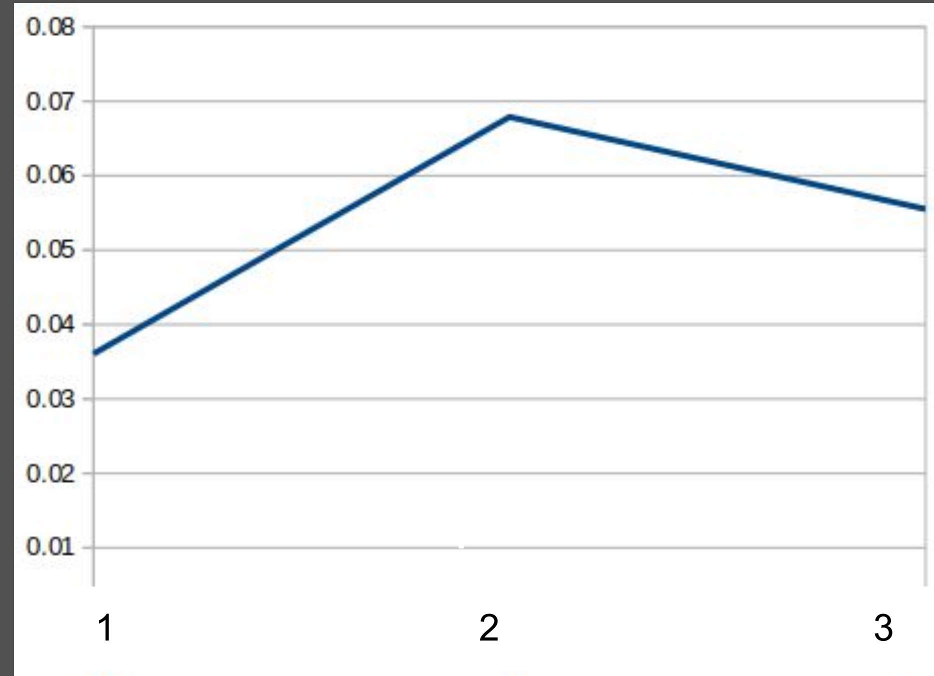


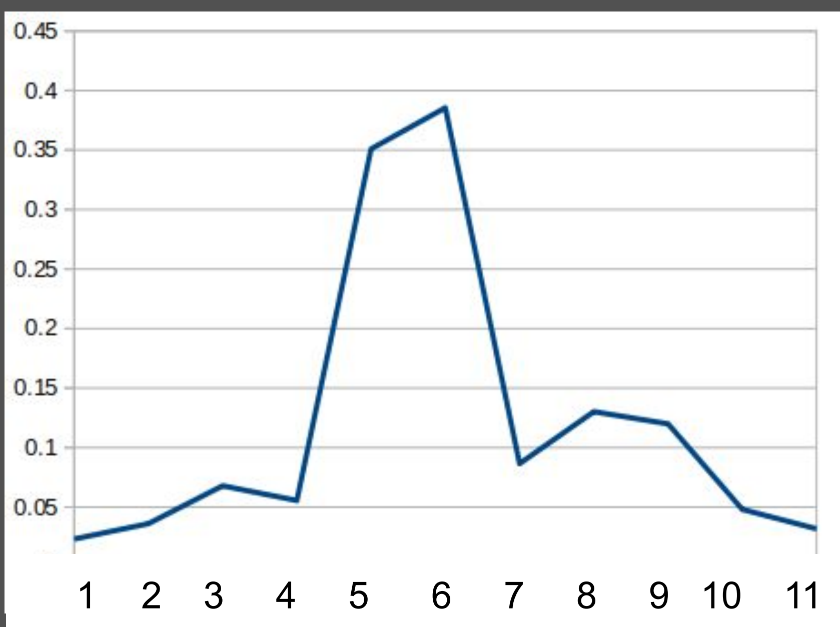
Band Interleaved by Pixel: BIP

Band Sequential : BSQ

Satellite Bands and the Spectral Response Curve







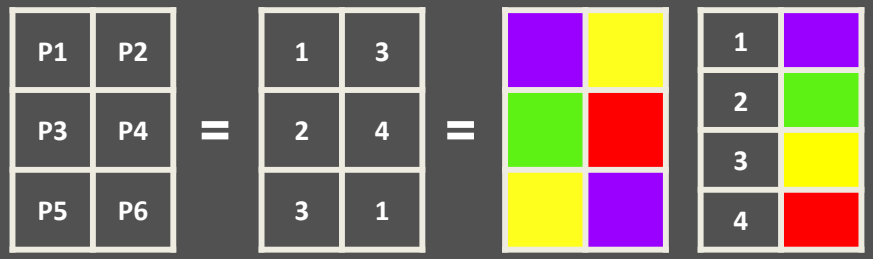
Let's Recap

- We have understood how imaging of satellite data is undertaken
- Spectral bands as representation of wavelength
- Spectral profile
- Matrix representation of satellite data

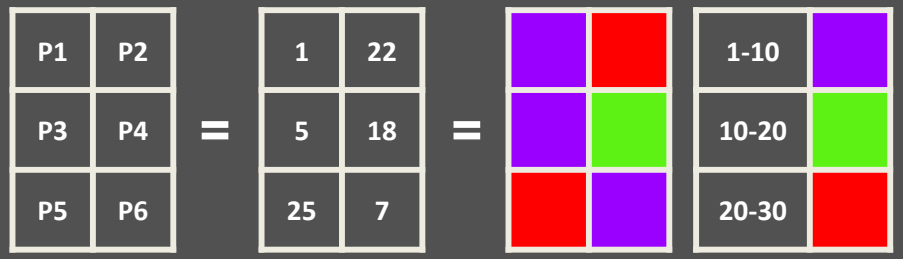
Question: How do we visualize the data?

Single Band Visualization

Single band pseudocolor representation

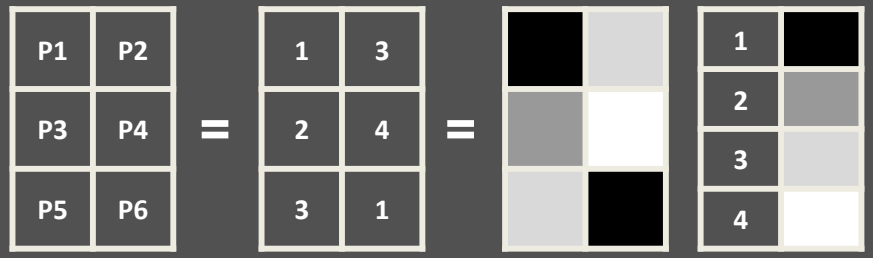


Case 1 : Give each unique value one color

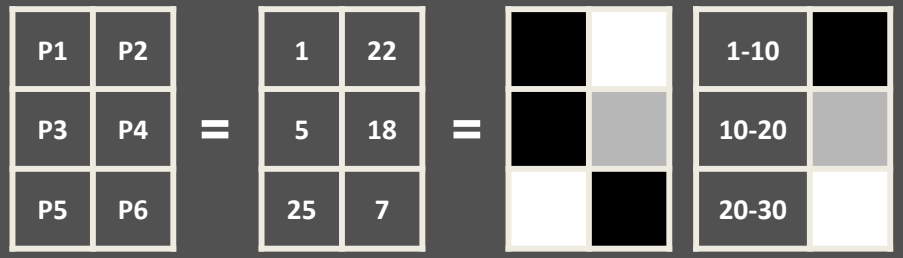


Case 2: Give a range of values one color

Single band grayscale representation



Case 1 : Give each unique value one color

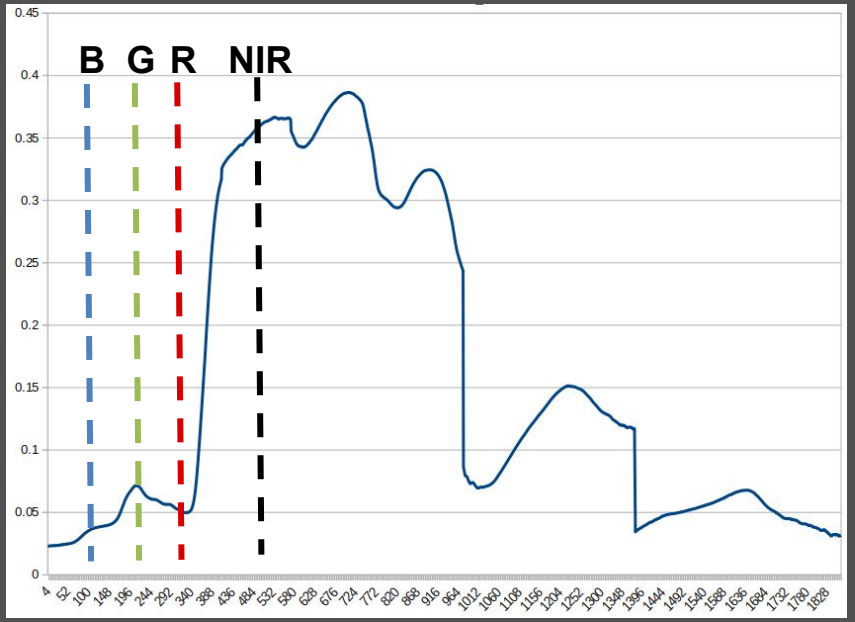


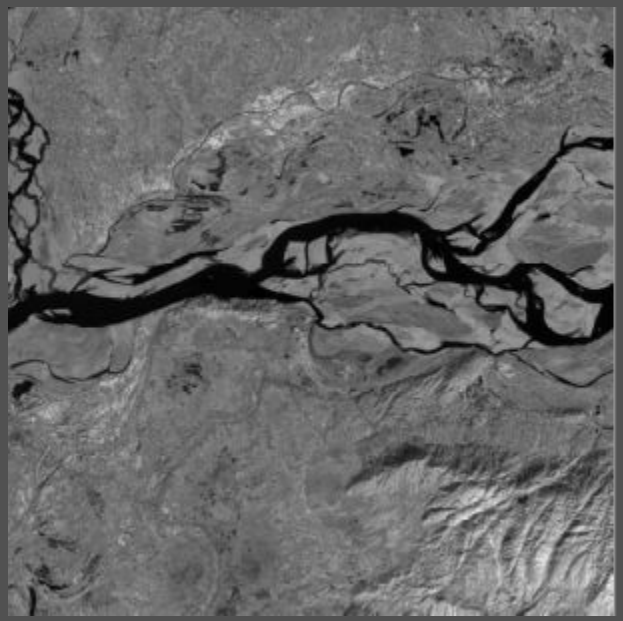
Case 2: Give a range of values one color

This can be thought as a special case of pseudocolor with the colorbar in shades of gray

Color Composites

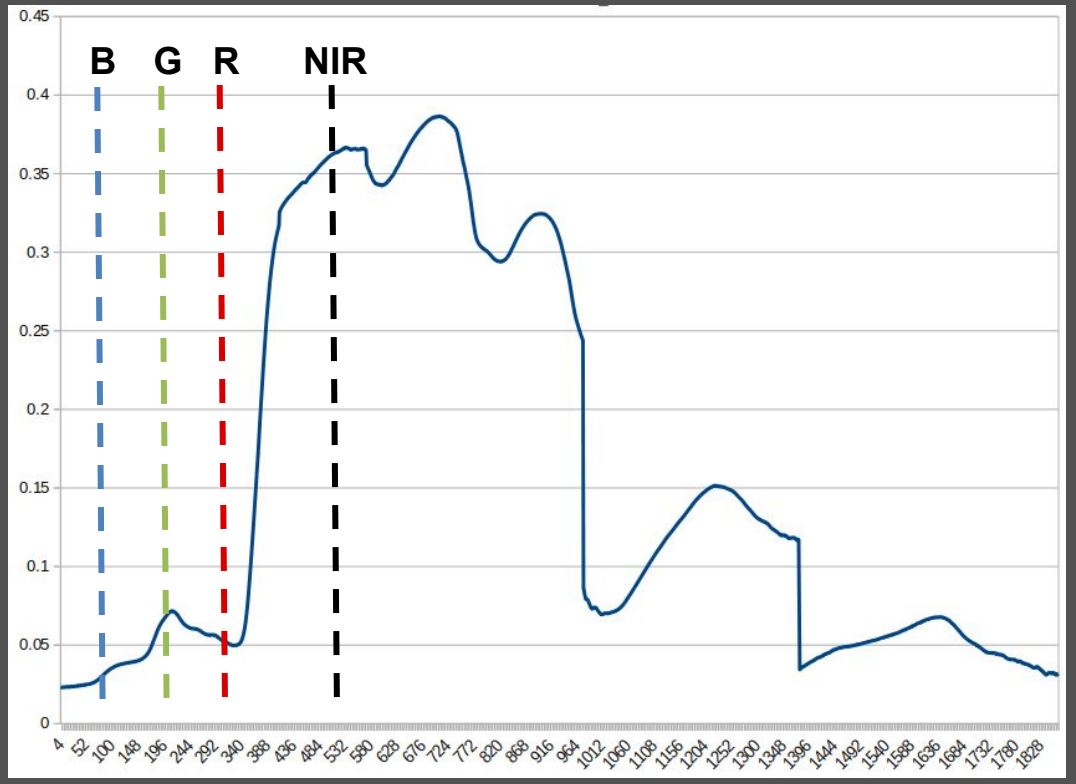
Software Visualization Channel	Satellite Band True Color	Satellite Band Standard False Color
Red	Red	NIR
Green	Green	Red
Blue	Blue	Green





Band Ratios and Spectral Indices

- Based on the spectral profile of the target, some ratios can result in exaggerated values that simplify identifying the target. Eg NIR/Red for veg
- High NIR and low red results in large values for the ratios.
- Normalization to ensure values fall in a specific range helps generalize. Eg NDVI



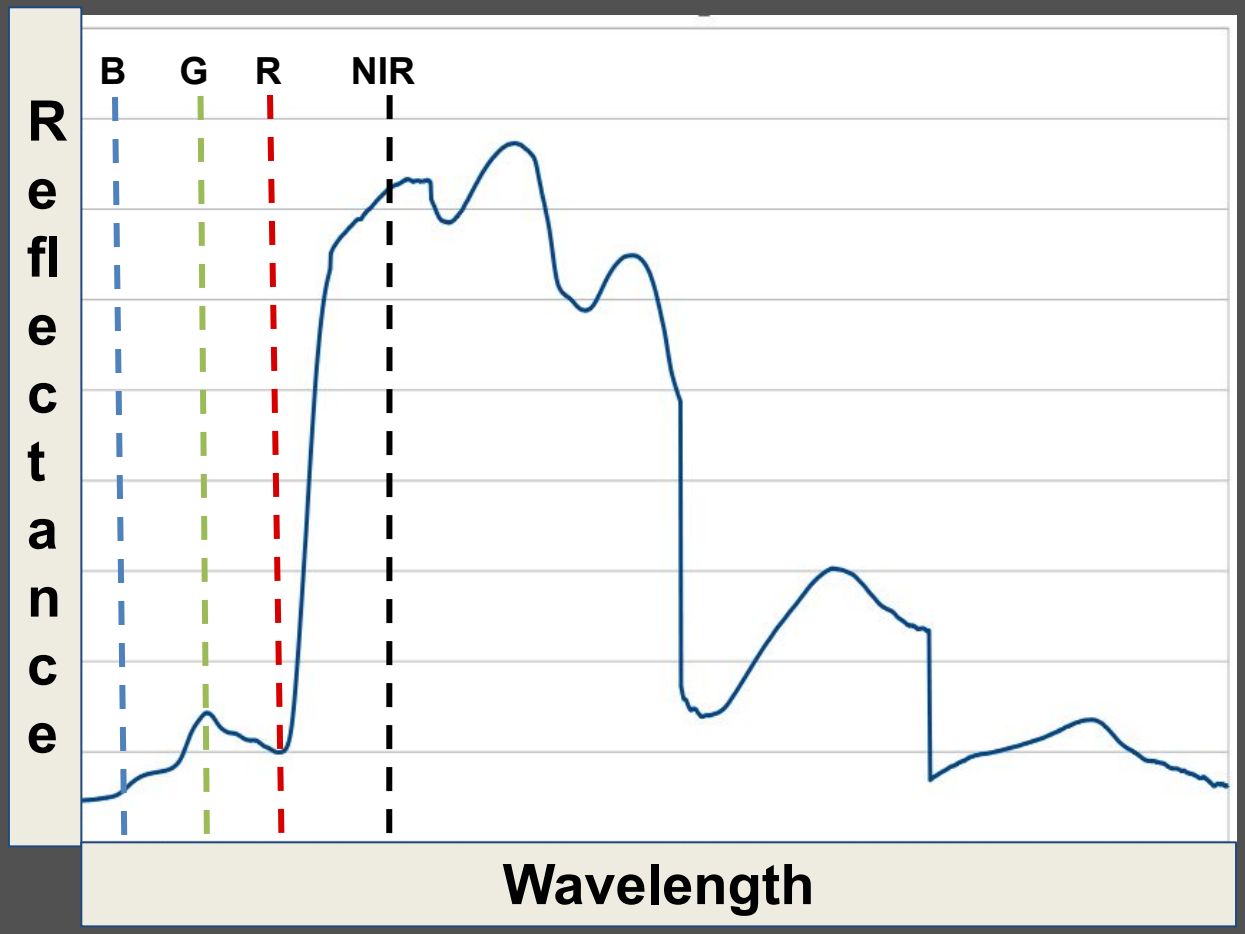
NDVI=(NIR - Red) / (NIR + Red)

For veg: High NIR, low Red. So values will be high and close to 1

Urban: close to 0 as both NIR and Red is high

Water: Negative as NIR is lower than Red

Thresholding Spectral Indices



NDVI=(NIR - Red) / (NIR + Red)

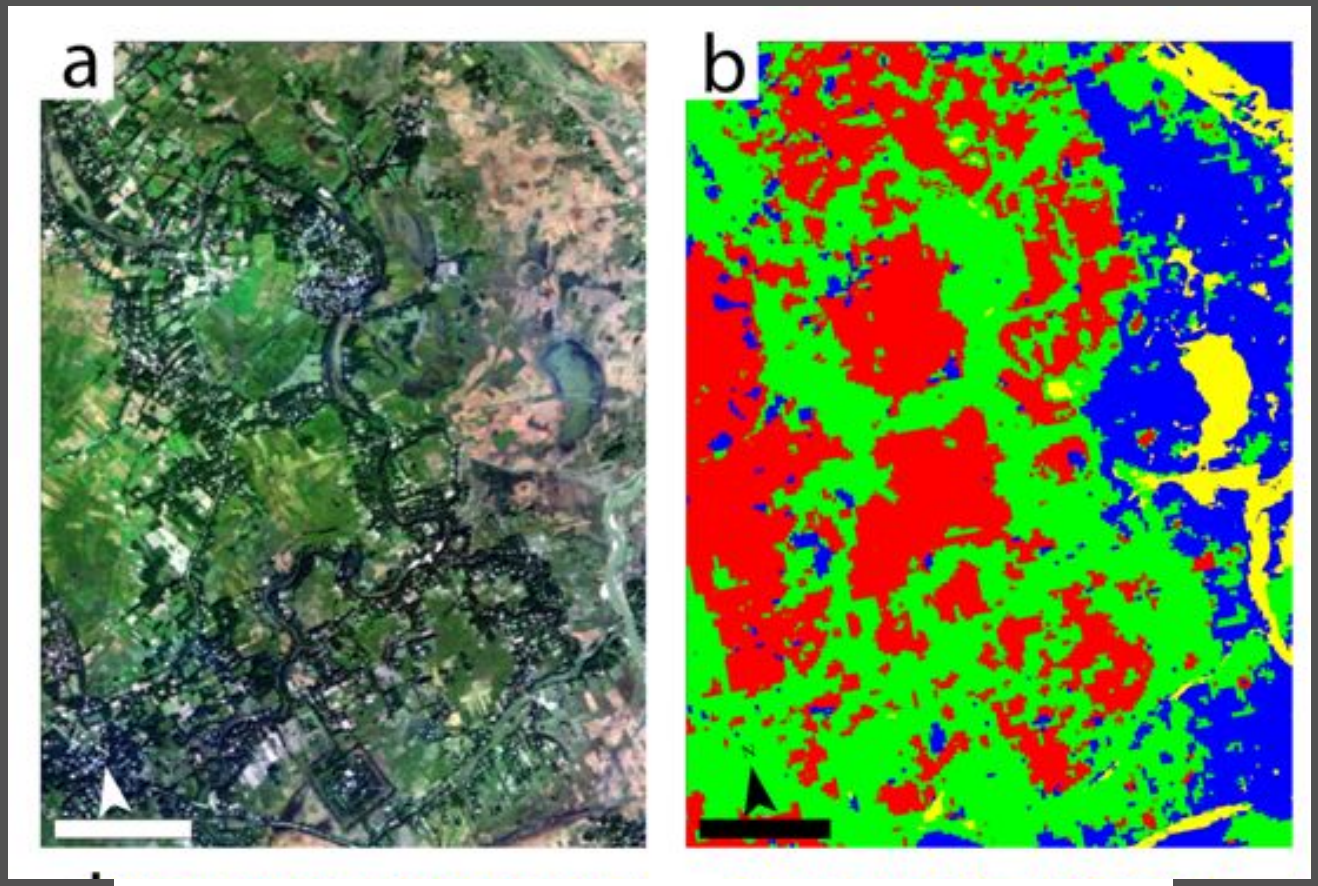
For veg: High NIR, low Red. So values will be high and close to 1

Urban: close to 0 as both NIR and Red is high

Water: Negative as NIR is lower than Red

Why Classification?

- A user / decision maker is not interested in brightness values, but the information relayed

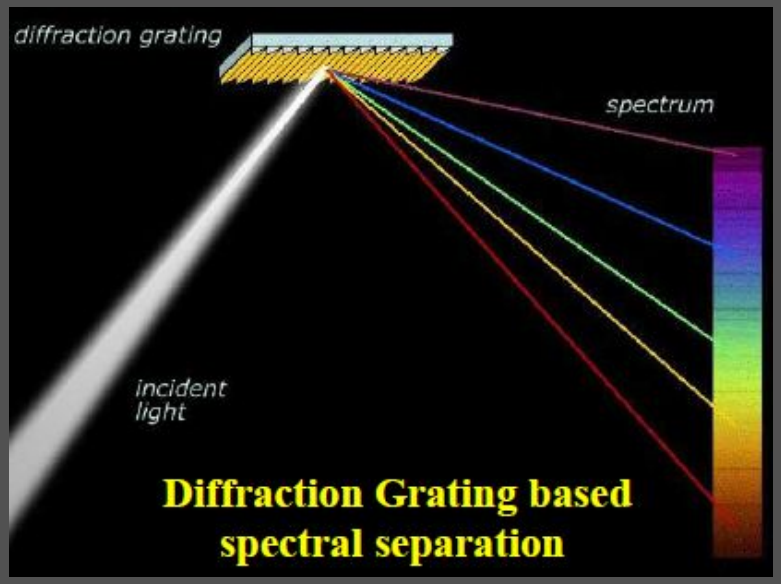


a: True Color Image

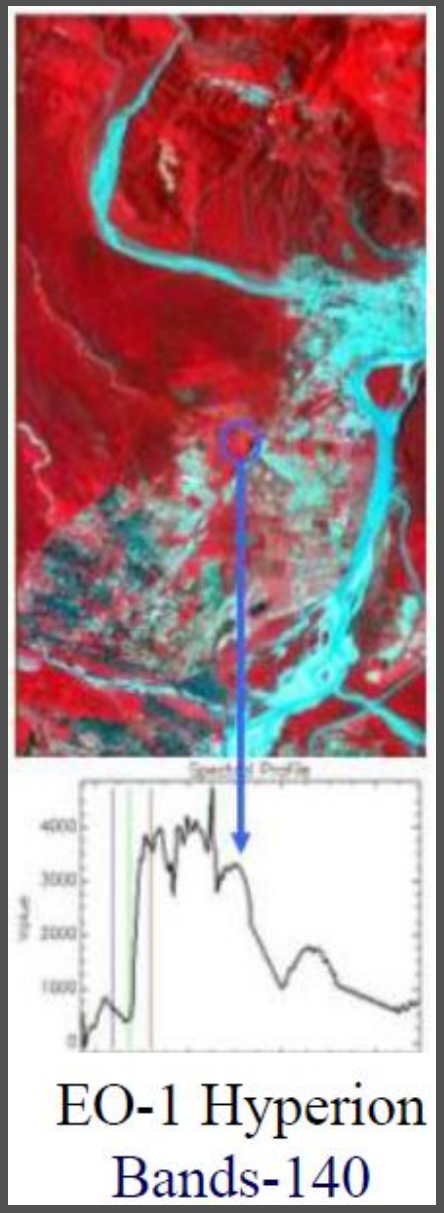
b: Classified Image

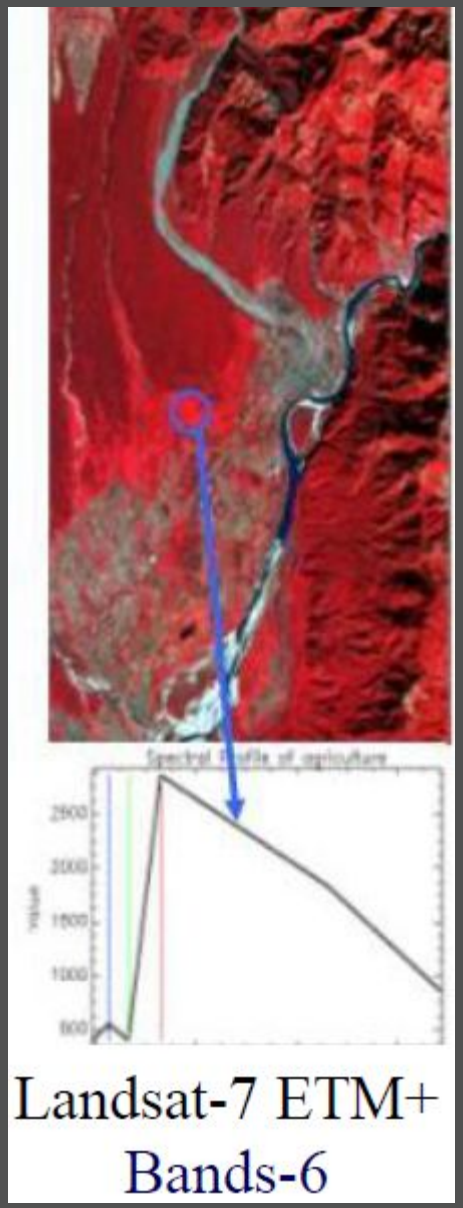
Source: Anilkumar et al 2018

Spectral Resolution

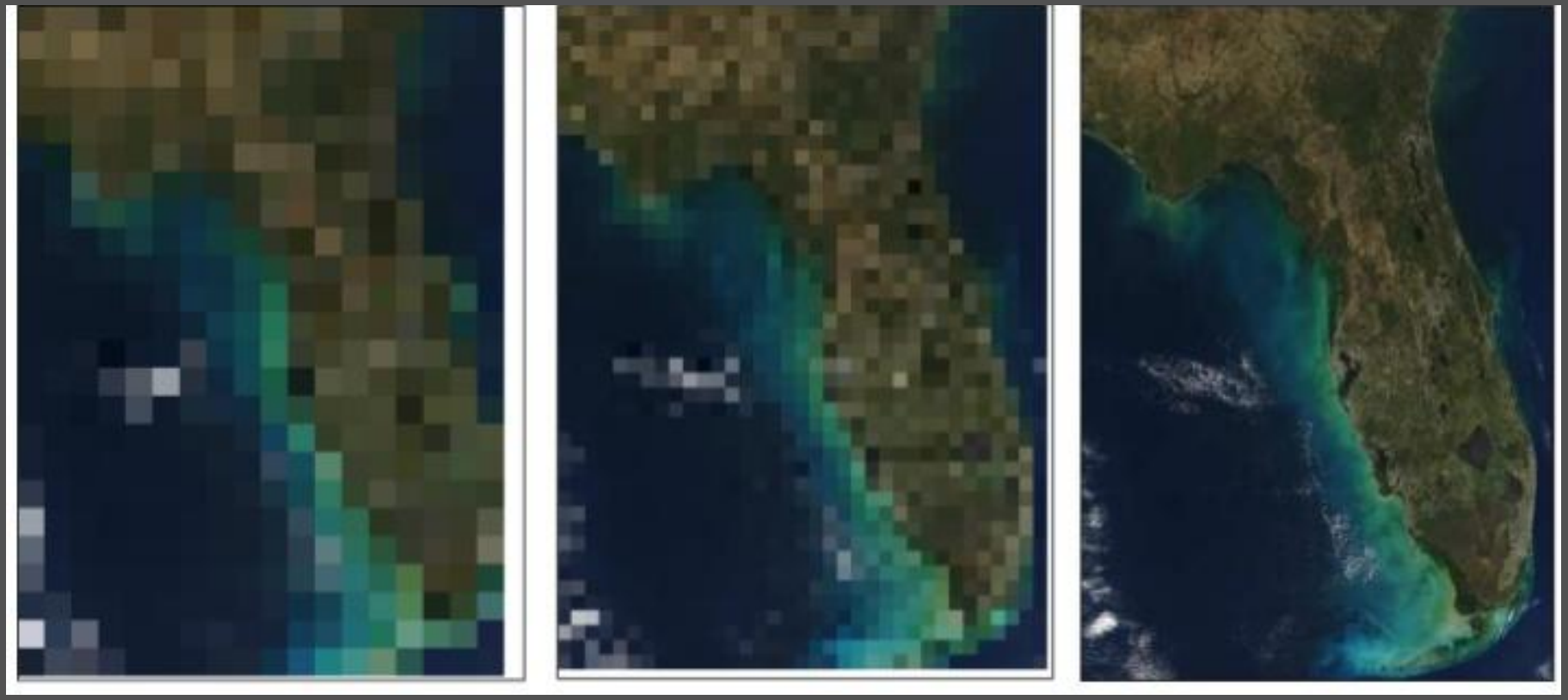


- Incident light is divided into the spectral components which are detected by the detector.
- Depending upon sampling and whether broad band or narrow bandwidth is taken, we have **multispectral** or **hyperspectral.**

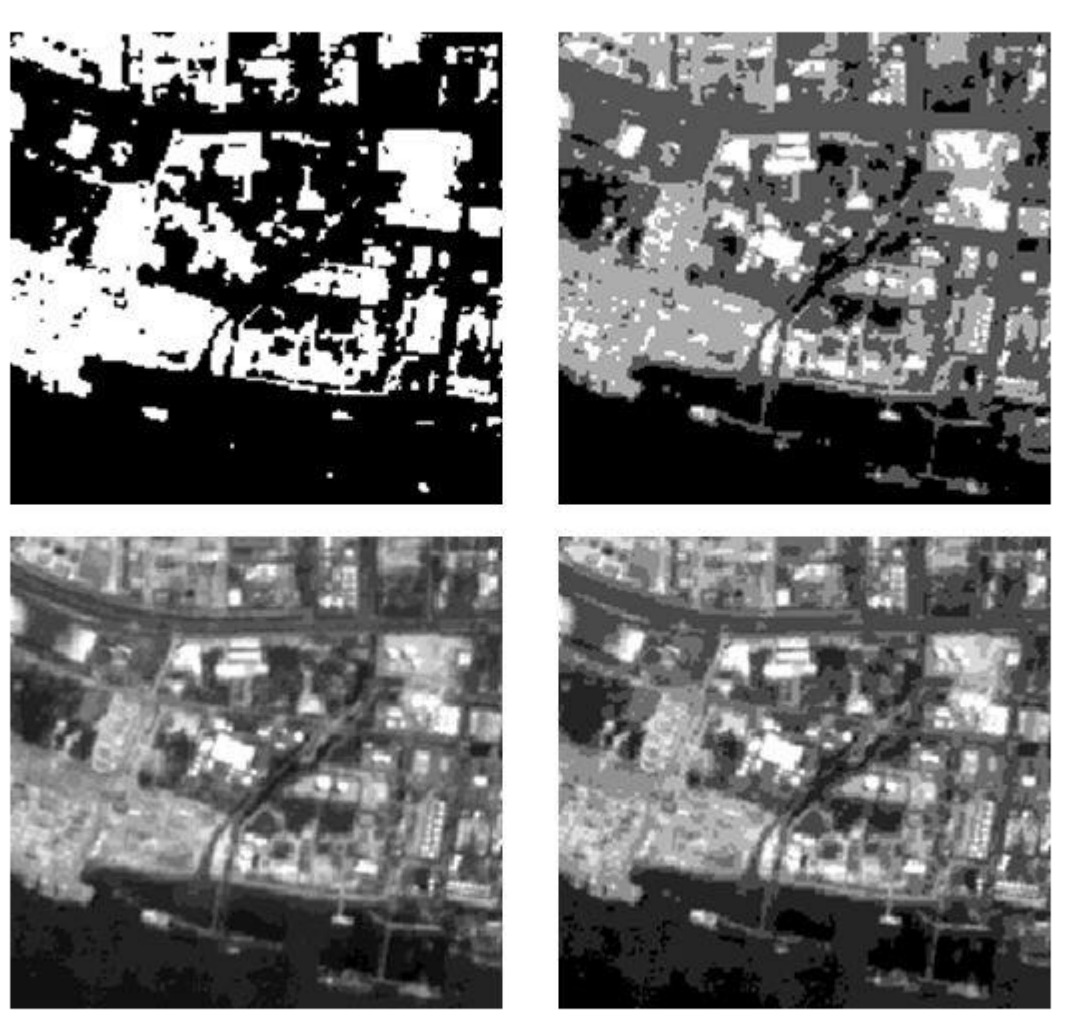




Spatial Resolution



Changing Grey Levels: Radiometric Resolution



Data Download

- USGS Earth Explorer: https://earthexplorer.usgs.gov/
- ESA/Copernicus: https://scihub.copernicus.eu/dhus/#/home
- ISRO/Bhoonidhi: https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html
- Private Players: Eg https://www.planet.com/get-started/
- Spectral library: https://crustal.usgs.gov/speclab/QueryAll07a.php

Alternately, access data through other options:

- Google Earth engine
- Microsoft Planetary Computer
- Amazon Web Services

THANK YOU!

In case of queries, drop me an email at
ritu.anilkumar@nesac.gov.in