

# EDS 223: Geospatial Analysis & Remote Sensing

## Week 7



USGS via Unsplash

# Welcome!

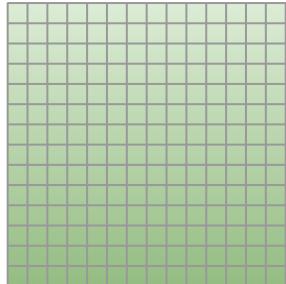
- Image resolutions
- Digital images
- True/False color imagery

# Image resolutions

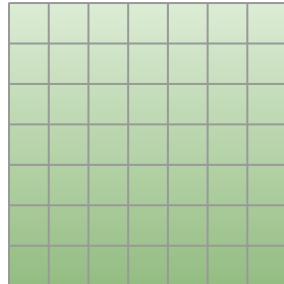
- Spatial
- Temporal
- Spectral
- Radiometric

# Spatial resolution

- Measure of the smallest angular or linear separation between two objects
  - The smallest feature that can be detected
  - Usually refers to the size of one pixel



high, fine,  
better

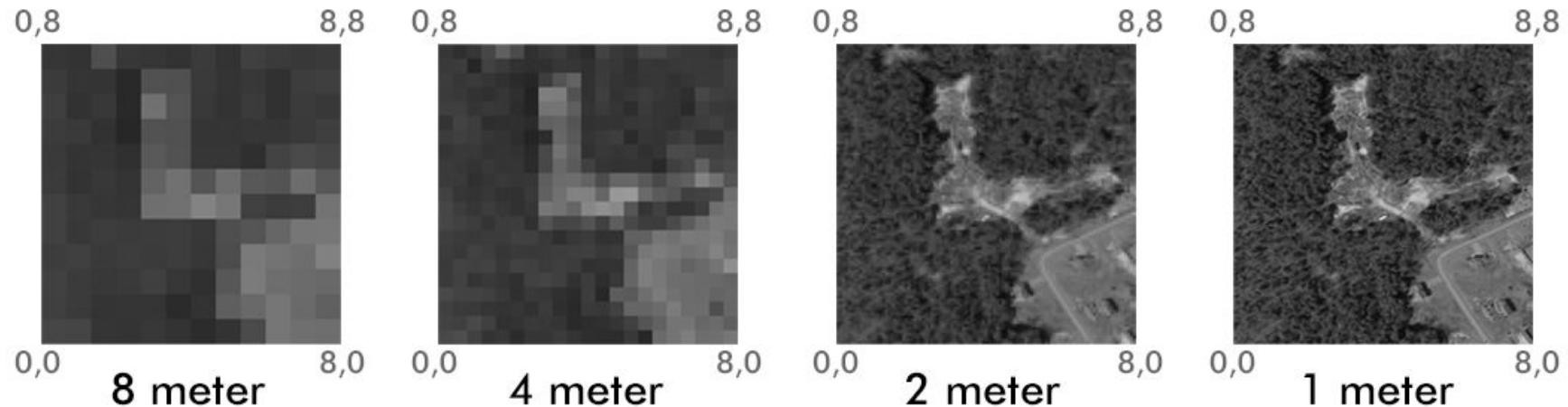


low, coarse,  
worse

Better resolution	Worse resolution
0.5 m	20 m

# Spatial resolution

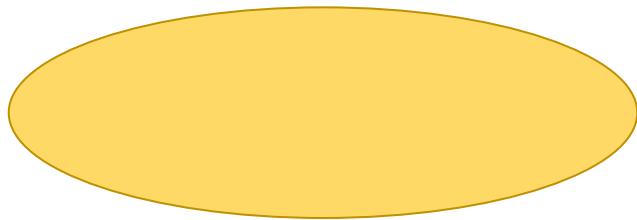
Raster over the same extent, at 4 different resolutions



# Spatial resolution



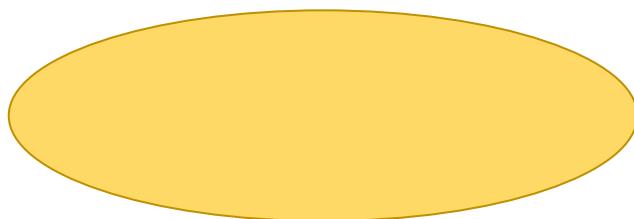
# Spatial resolution



# Spatial resolution



↑ Lit area    ↑ Distance from source



# Spatial resolution



↑ Lit area    ↑ Distance from source



# Spatial resolution



↑ Lit area    ↑ Distance from source



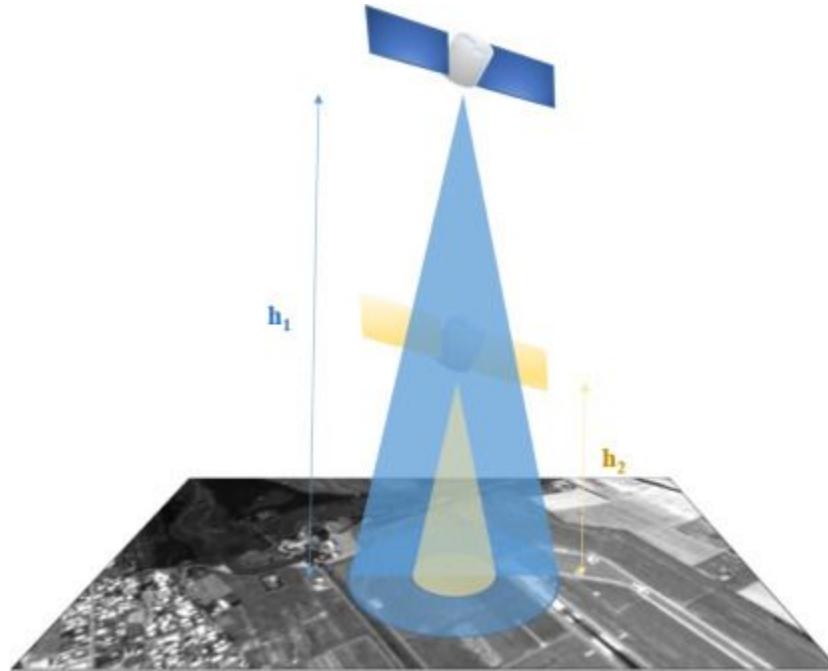
# Spatial resolution



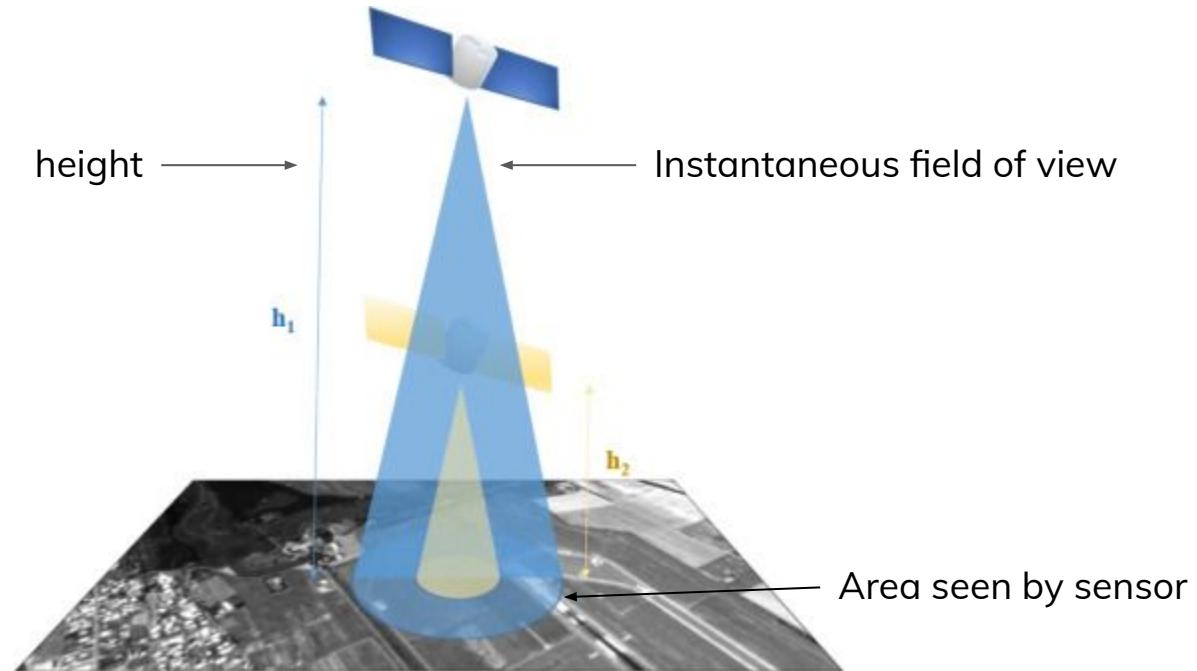
↑ Lit area      ↑ Distance from source  
↑ Lit area      ↑ size of source



# Spatial resolution

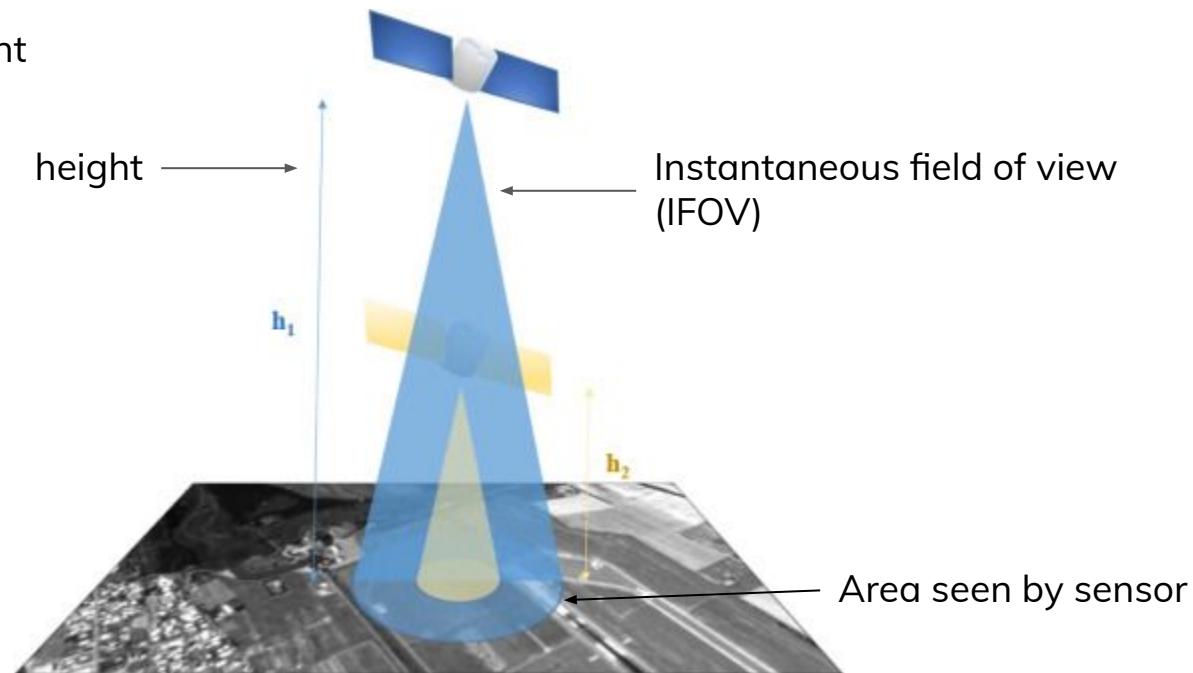


# Spatial resolution



# Spatial resolution

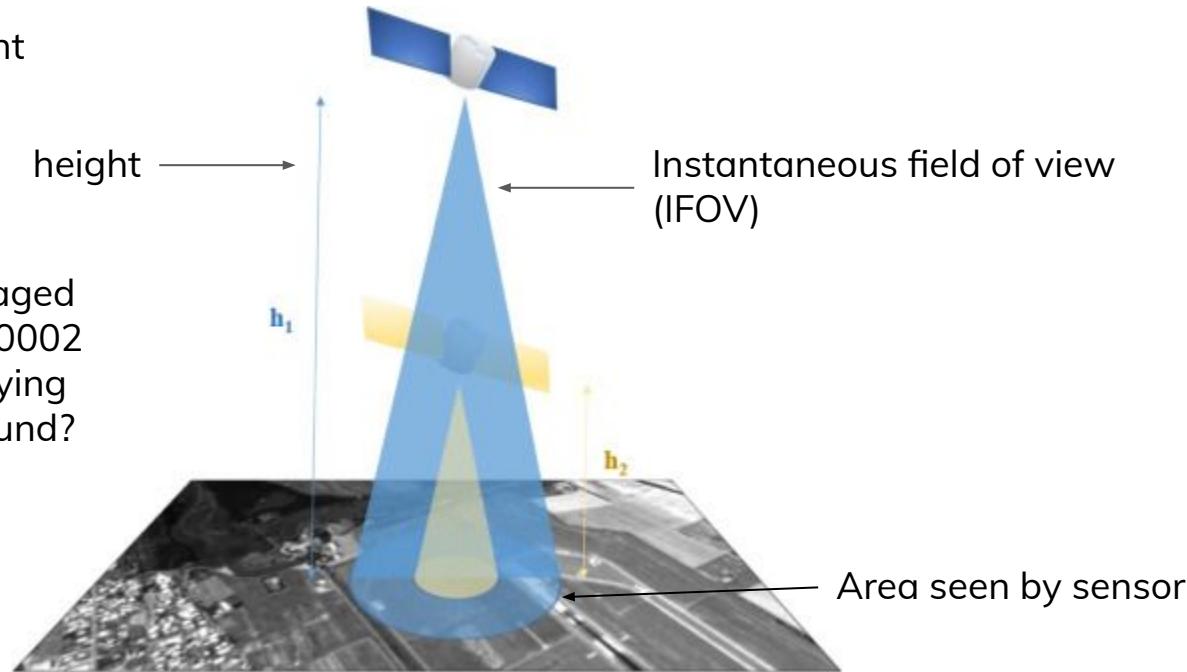
Pixel length = IFOV x height



# Spatial resolution

Pixel length = IFOV x height

What is the pixel length imaged by a sensor if the IFOV is 0.0002 radians and the aircraft is flying 5000 meters above the ground?

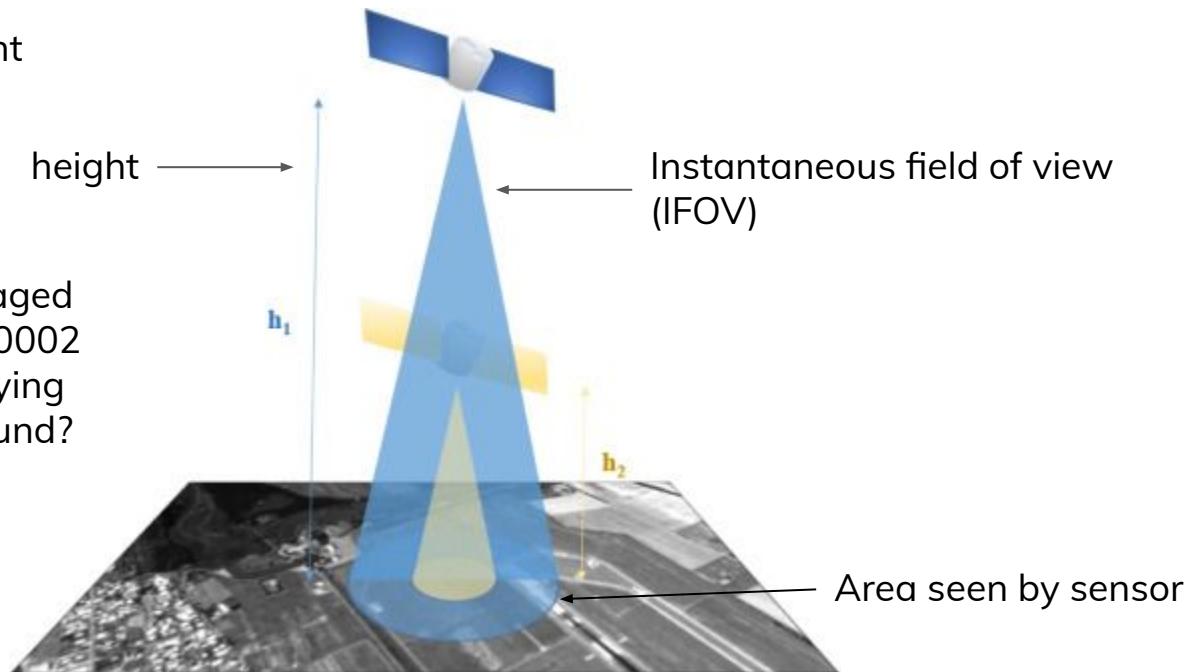


# Spatial resolution

Pixel length = IFOV x height

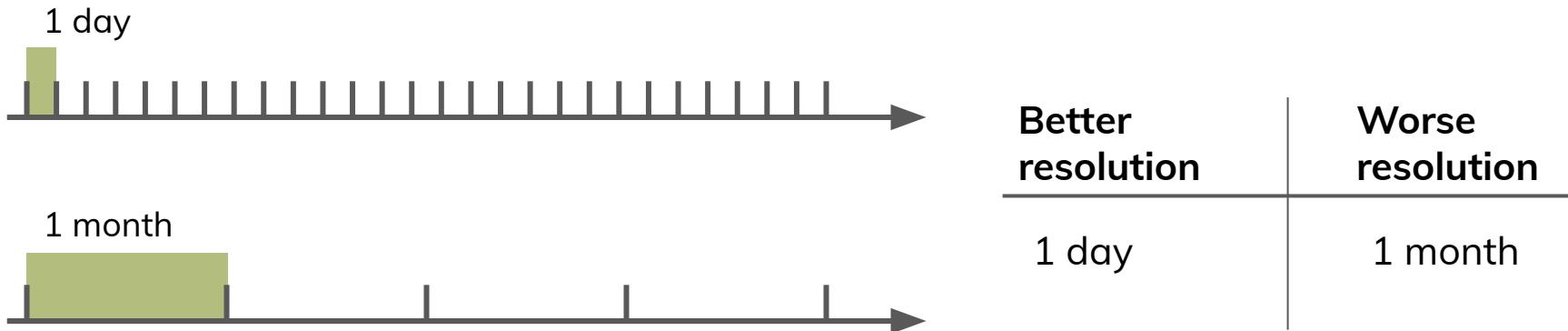
What is the pixel length imaged by a sensor if the IFOV is 0.0002 radians and the aircraft is flying 5000 meters above the ground?

$$\begin{aligned}\text{Pixel length} \\ = 0.0002 \text{ radians} * 5000 \text{ m} \\ = 1 \text{ m}\end{aligned}$$



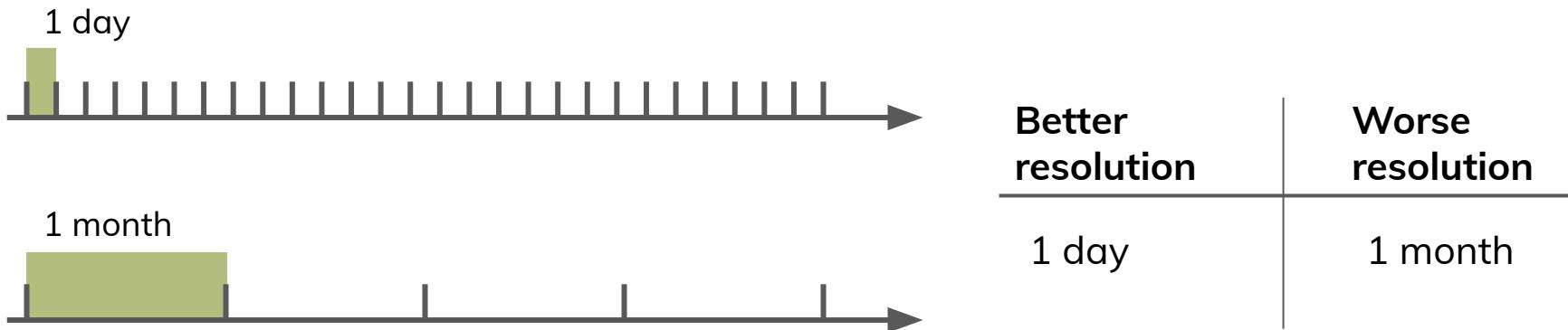
# Temporal resolution

- Time interval between acquisitions of a particular area



# Temporal resolution

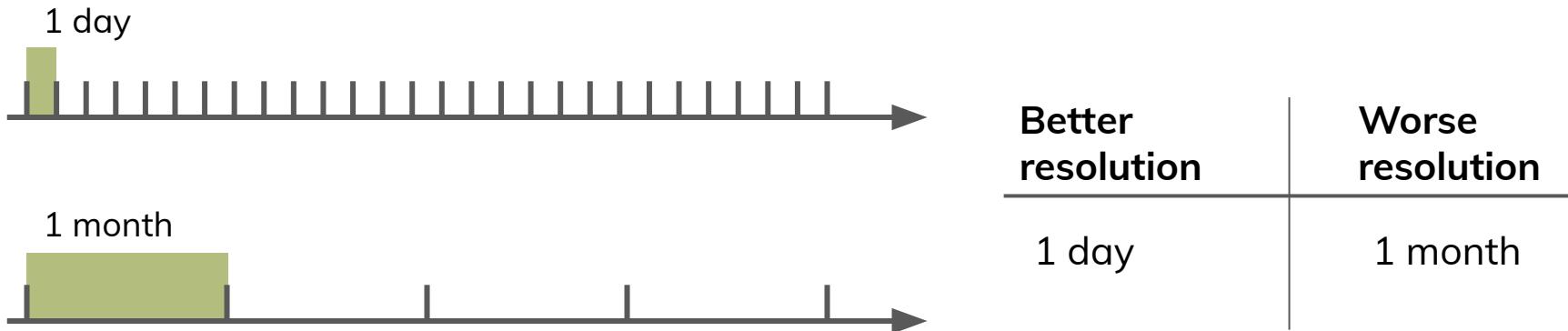
- Time interval between acquisitions of a particular area



- Factors determining temporal resolution:
  - satellite/sensor capabilities, orbit

# Temporal resolution

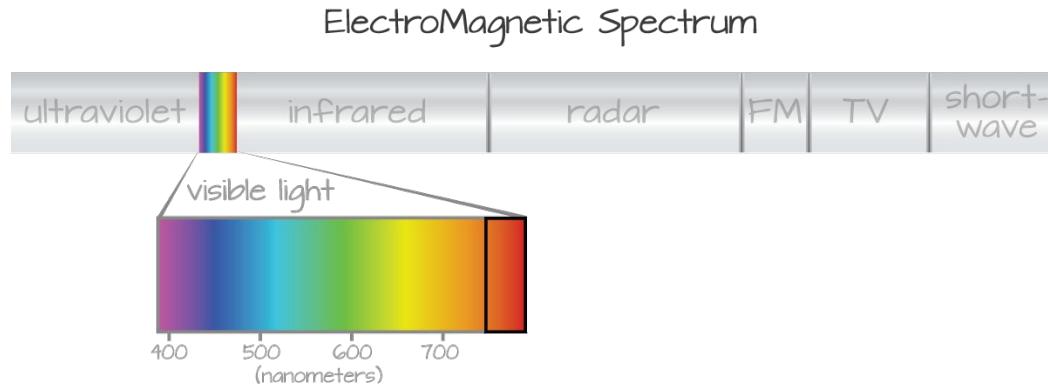
- Time interval between acquisitions of a particular area



- Factors determining temporal resolution:
  - satellite/sensor capabilities, orbit
- Factors affecting ACTUAL resolution:
  - Clouds, sunlight

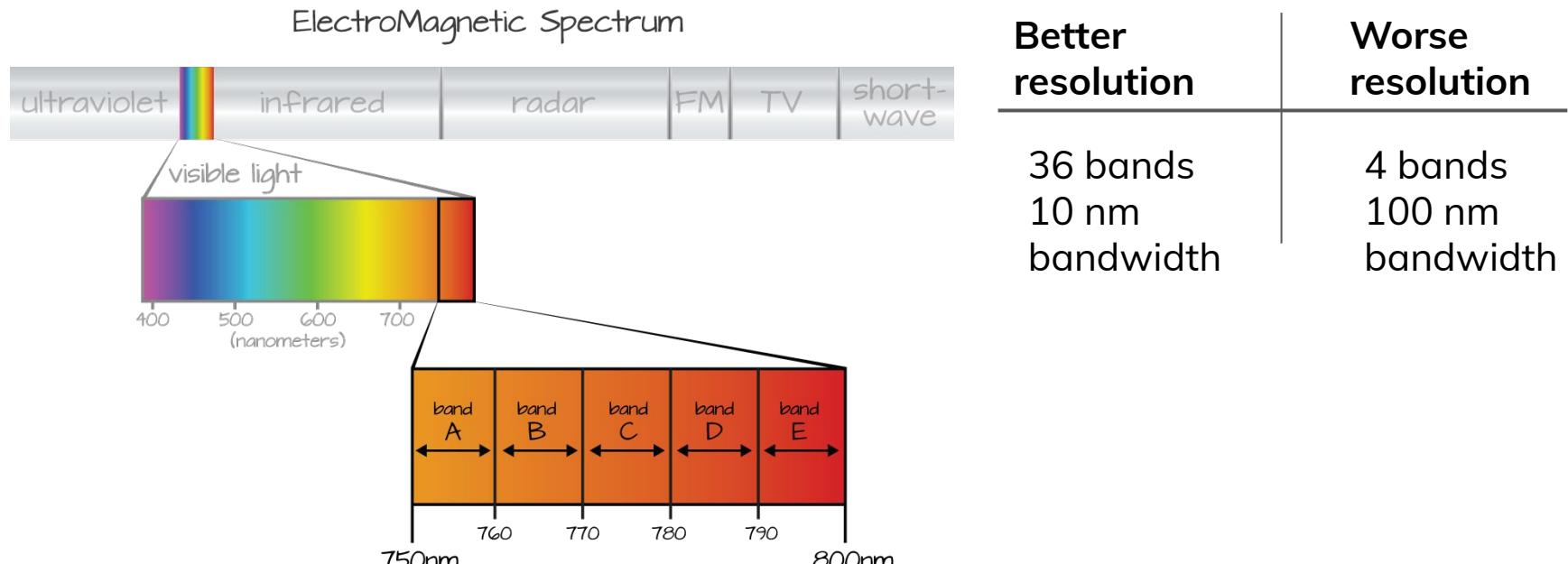
# Spectral resolution

- Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels



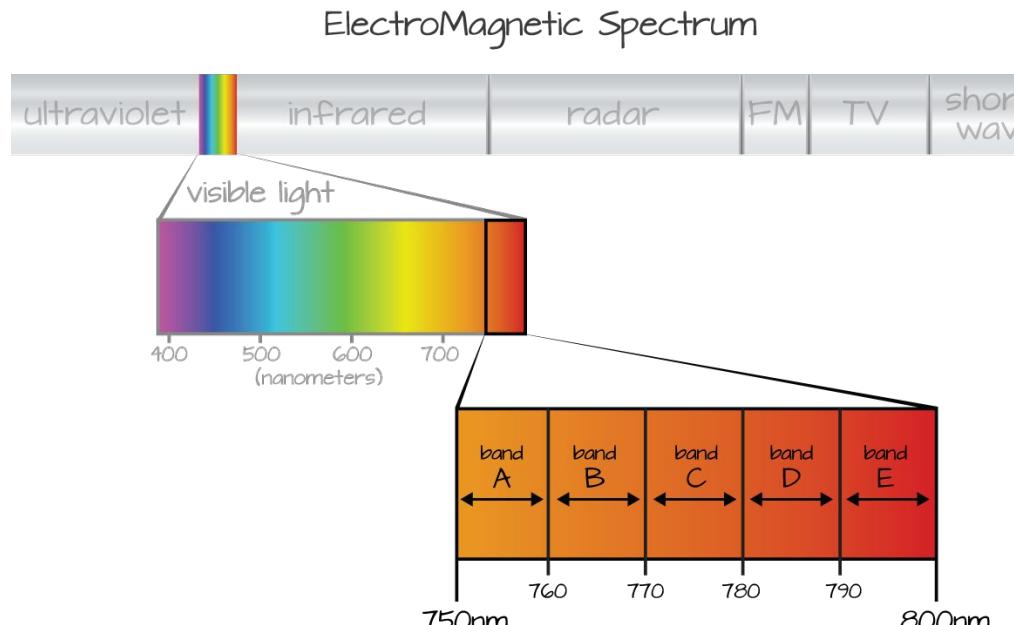
# Spectral resolution

- Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels

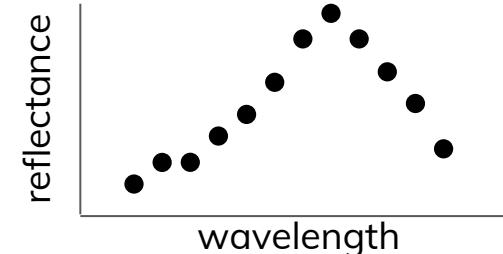


# Spectral resolution

- Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels

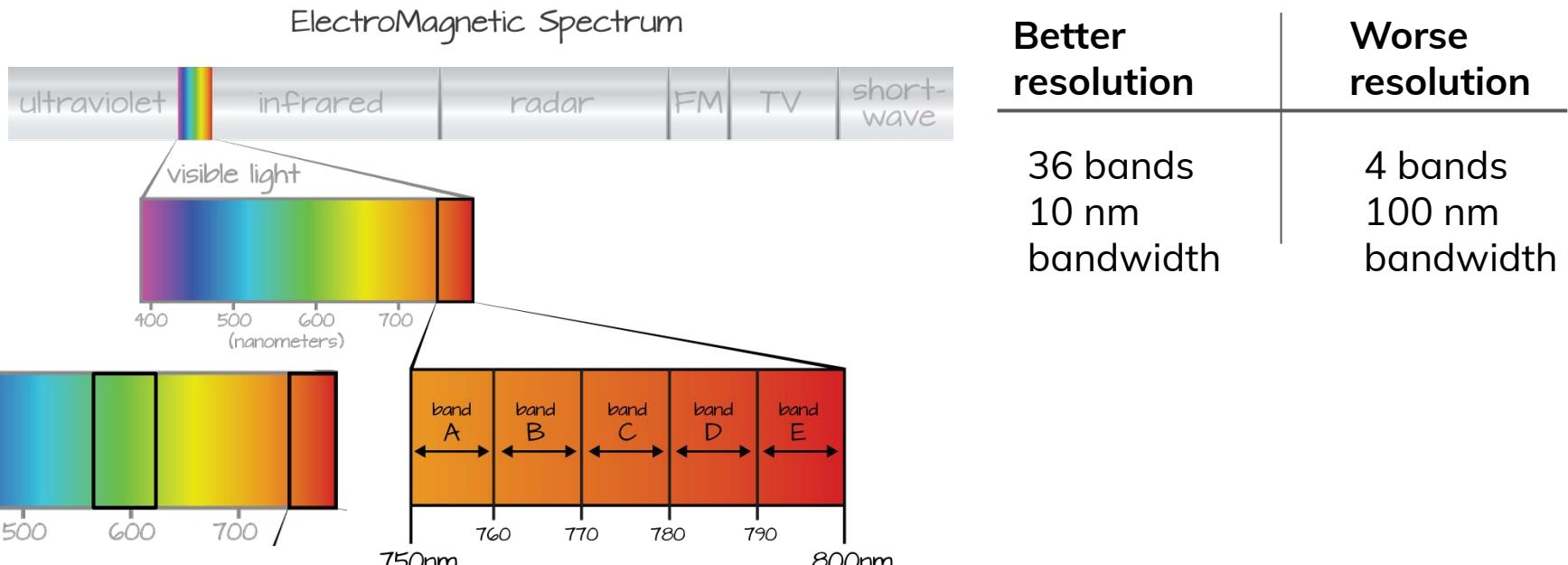


Better resolution	Worse resolution
36 bands	4 bands
10 nm bandwidth	100 nm bandwidth



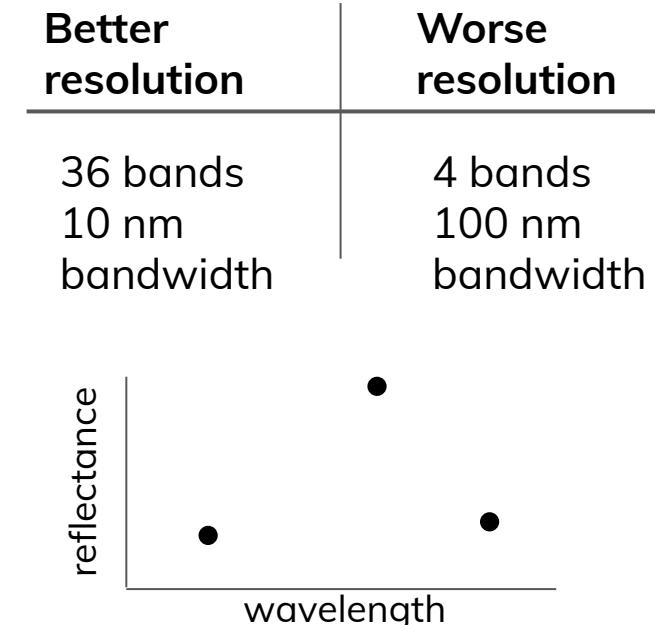
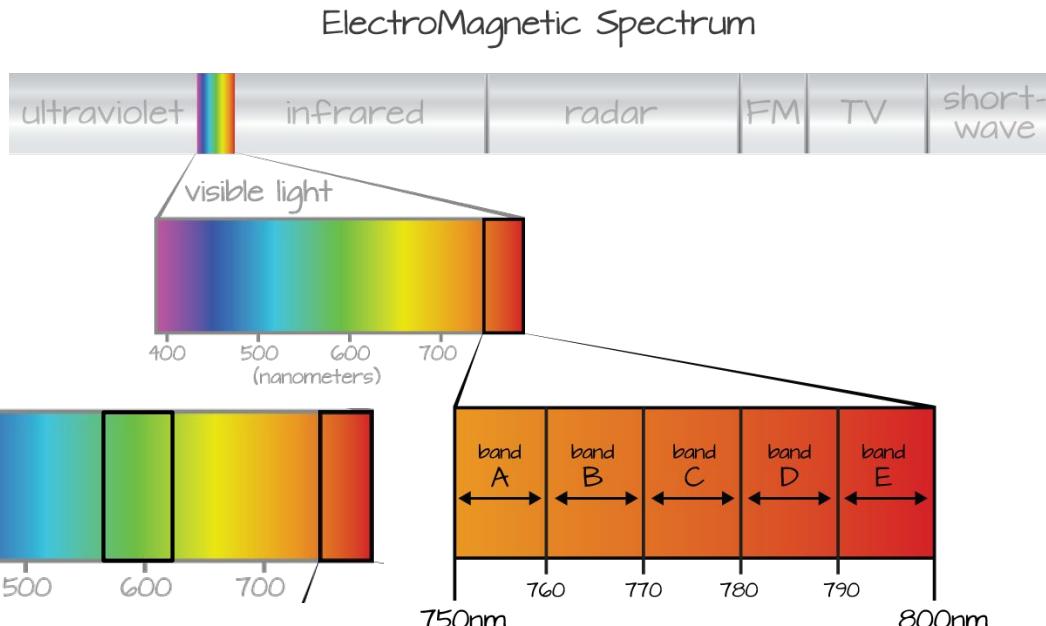
# Spectral resolution

- Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels

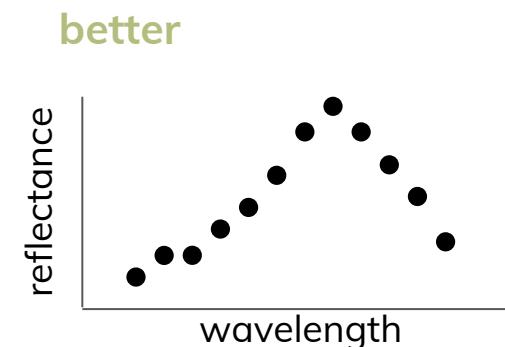
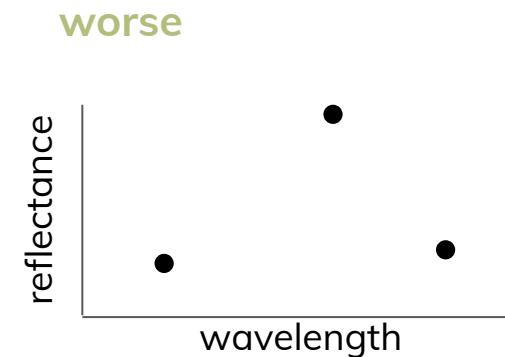
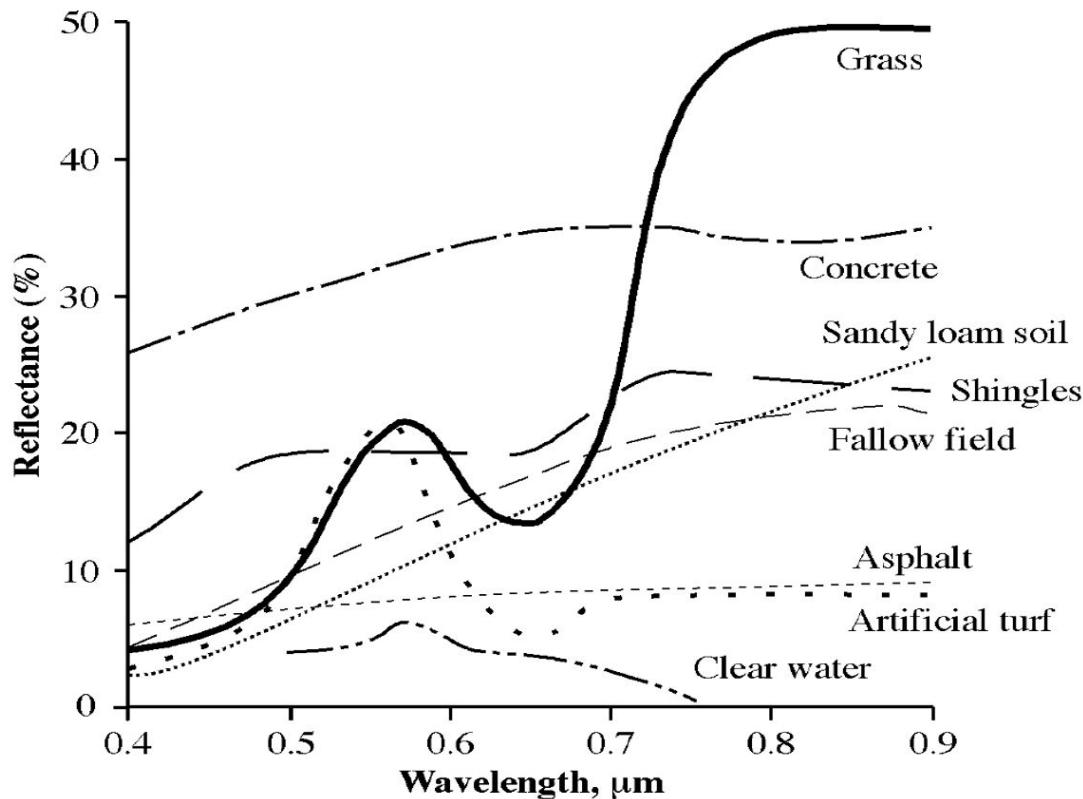


# Spectral resolution

- Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels



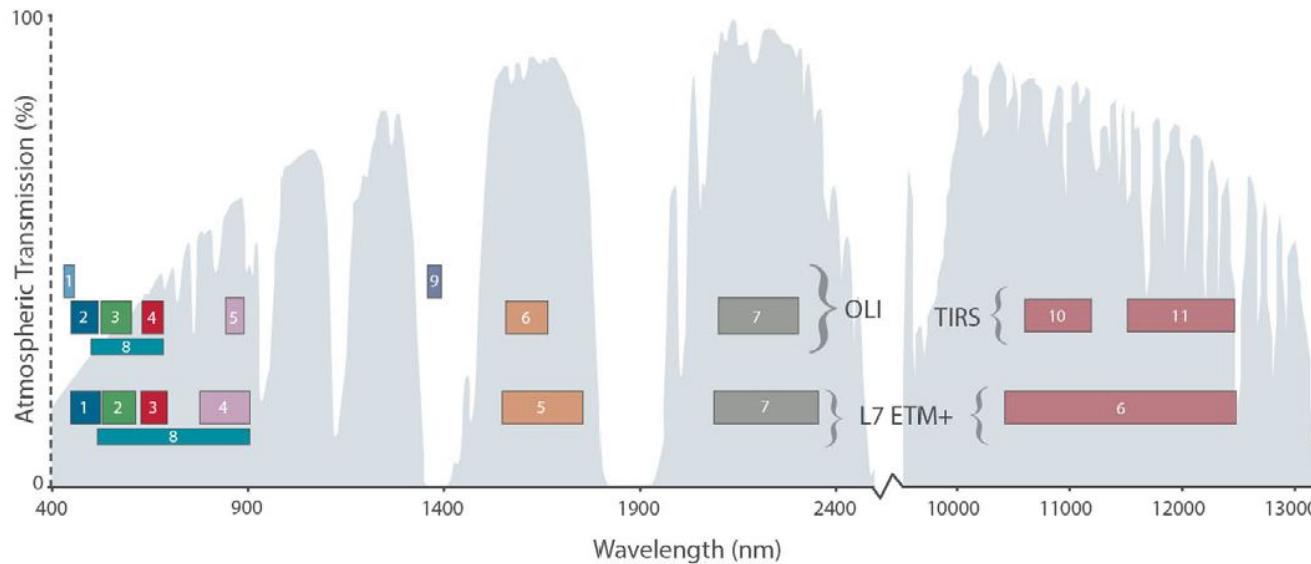
# Spectral resolution



# Spectral resolution

Landsat 8

Landsat 7

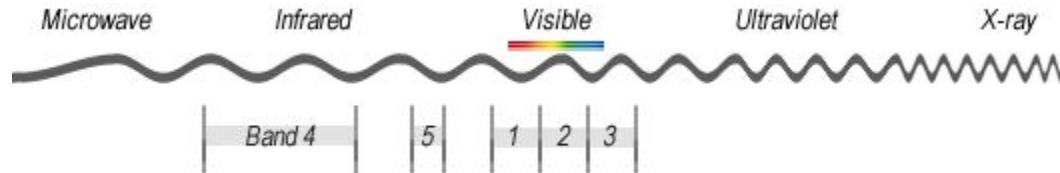


Landsat 8 Bands

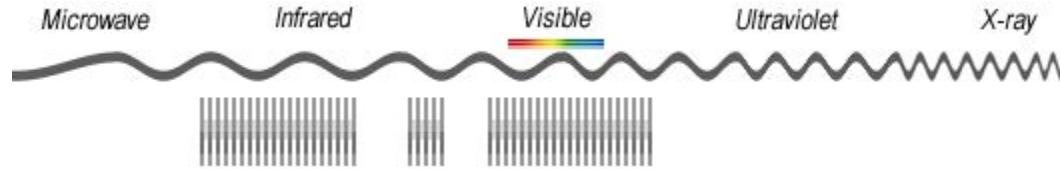
Band	Wavelength range (nm)	Spatial Resolution (m)	Spectral Width (nm)
Band 1 - Coastal aerosol	430 - 450	30	2.0
Band 2 - Blue	450 - 510	30	6.0
Band 3 - Green	530 - 590	30	6.0
Band 4 - Red	640 - 670	30	0.03
Band 5 - Near Infrared (NIR)	850 - 880	30	3.0
Band 6 - SWIR 1	1570 - 1650	30	8.0
Band 7 - SWIR 2	2110 - 2290	30	18
Band 8 - Panchromatic	500 - 680	15	18
Band 9 - Cirrus	1360 - 1380	30	2.0

# Spectral resolution

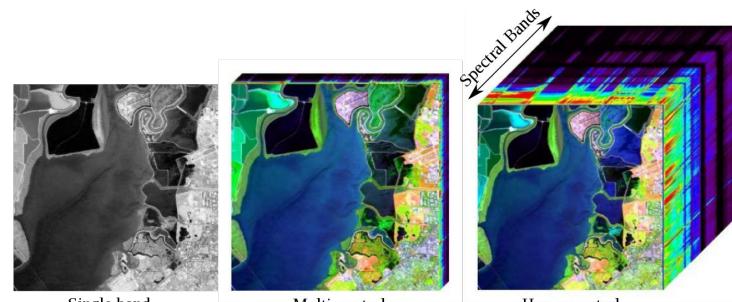
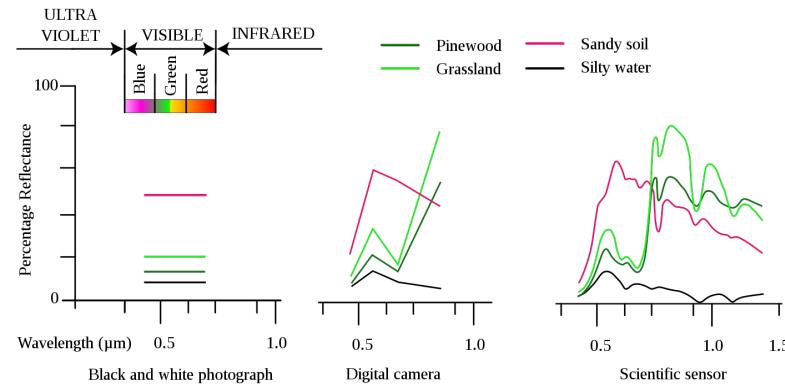
Multispectral



Hyperspectral

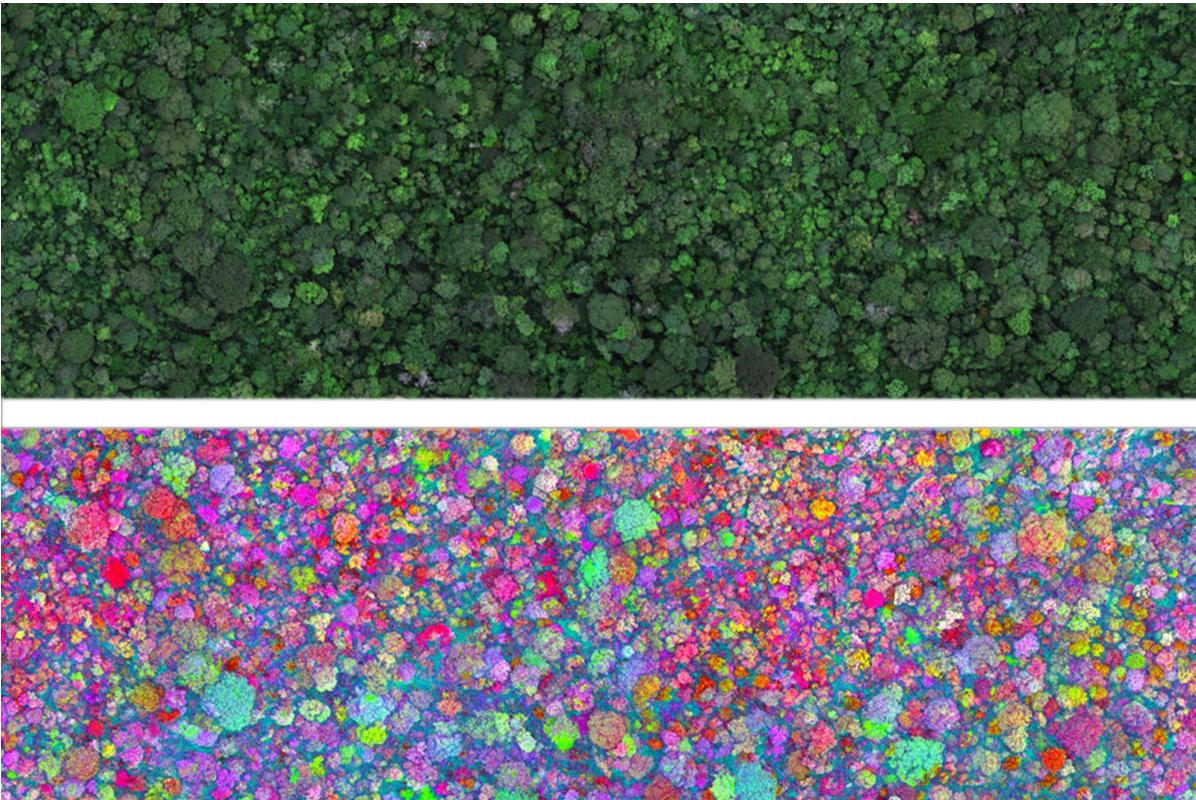


# Spectral resolution



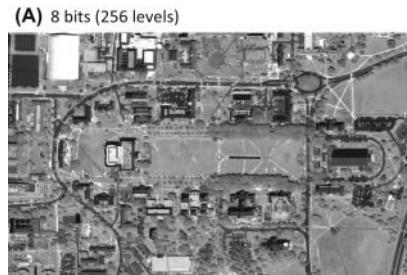
This work is licensed under a Creative Commons Attribution 3.0 Unported License.  
Author: <http://commons.wikimedia.org/wiki/User:Arbeck>

# Spectral resolution



# Radiometric resolution

- Number of different output numbers in each band of data
  - Determined by the number of bits into which the recorded radiation is divided
  - “Dynamic range”



Better  
resolution

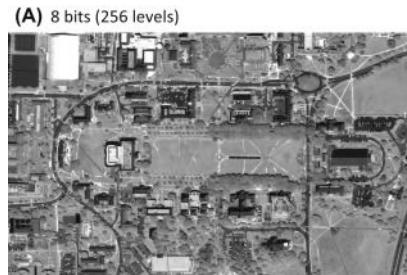
8 bit

Worse  
resolution

2 bit

# Radiometric resolution

- Number of different output numbers in each band of data
  - Determined by the number of bits into which the recorded radiation is divided
  - “Dynamic range”



Better  
resolution

8 bit

Worse  
resolution

2 bit

# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

1 bit      0 or

1

# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

	Number of possible values	Possible values
1 bit	2	0-1

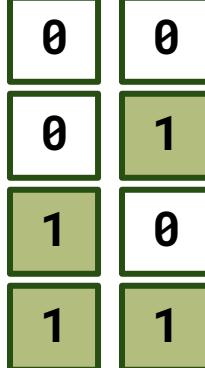
or



The diagram shows two options for a bit value. The first option is a white square containing the number '0'. The second option is a green square containing the number '1'.

# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

		Number of possible values	Possible values
1 bit		2	0-1
2 bit		4	0-3

# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

		Number of possible values	Possible values																								
1 bit	<table><tr><td>0</td></tr><tr><td>1</td></tr></table> or	0	1	2	0-1																						
0																											
1																											
2 bit	<table><tr><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table> or <table><tr><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table> or <table><tr><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table> or	0	0	0	1	1	0	1	1	0	0	0	1	1	0	1	1	0	0	0	1	1	0	1	1	4	0-3
0	0																										
0	1																										
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# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

	Number of possible values	Possible values
1 bit	2	0-1
2 bit	4	0-3
n bit	$2^n$	0 - $(2^n - 1)$

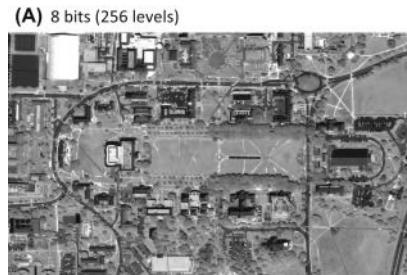
# What is a bit?

- A single placeholder which can be a 0 (off) or 1 (on)

	Number of possible values	Possible values
1 bit	2	0-1
2 bit	4	0-3
8 bit	256	0-255
n bit	$2^n$	0 - $(2^n - 1)$

# Radiometric resolution

- Number of different output numbers in each band of data
  - Determined by the number of bits into which the recorded radiation is divided
  - “Dynamic range”



Better  
resolution

8 bit

Worse  
resolution

2 bit

# Image resolutions

- **Spatial**
  - Measure of the smallest angular or linear separation between two objects
    - Pixel size
- **Temporal**
  - Time interval between acquisitions of a particular area
    - Revisit time
- **Spectral**
  - Number of dimensions (or bands) of a specific wavelength to which a remote sensing instrument is sensitive and the range of those channels
    - Number and range of bands
- **Radiometric**
  - Number of different output numbers in each band of data
    - Number of shades of grey

# Image resolutions

↑ Spatial resolution ↓ Less light collected

↑ Temporal resolution ↓ Less light collected

↓ Radiometric resolution

↓ Spatial resolution

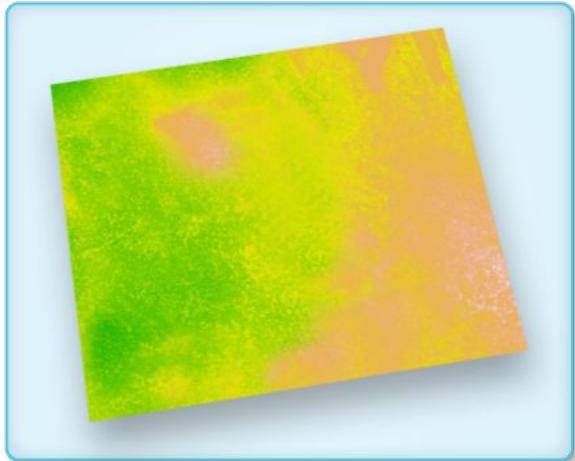
↑ Spectral or spatial resolution ↑ File size

Size of image = number of pixels \* bits per pixel



# Working with remote sensing data

Single Band Raster



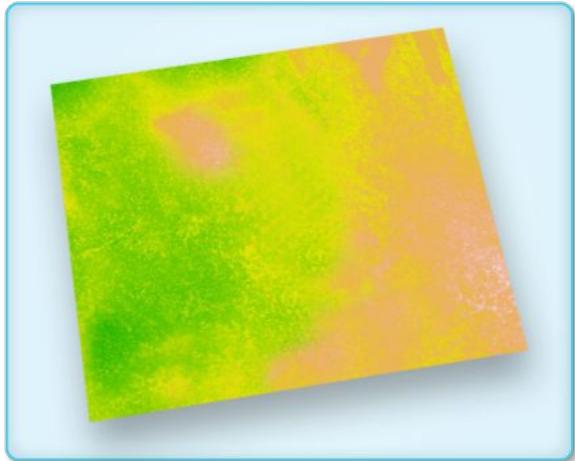
Multi Band Raster



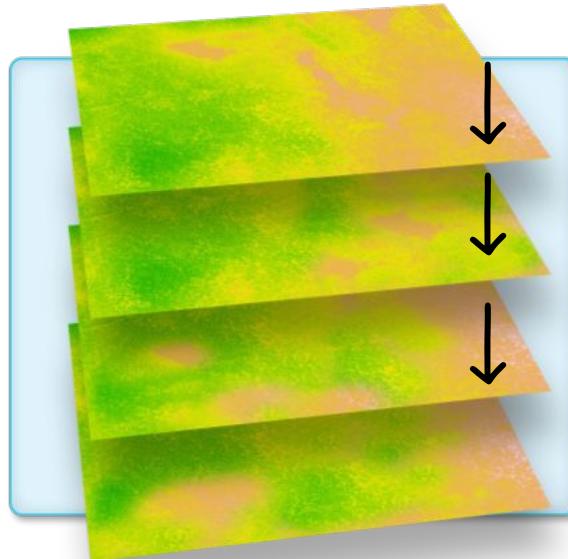
neon

# Working with remote sensing data

Single Band Raster

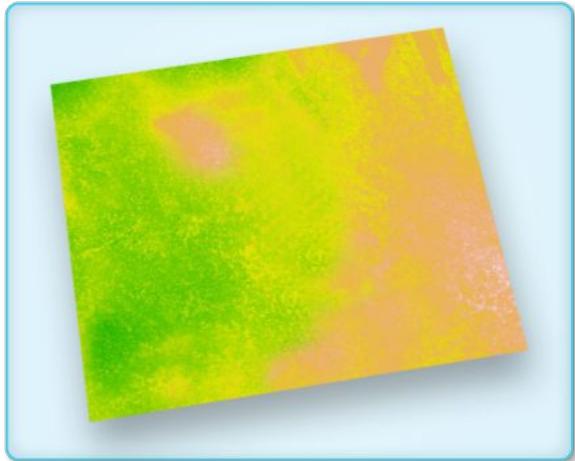


Multi Band Raster

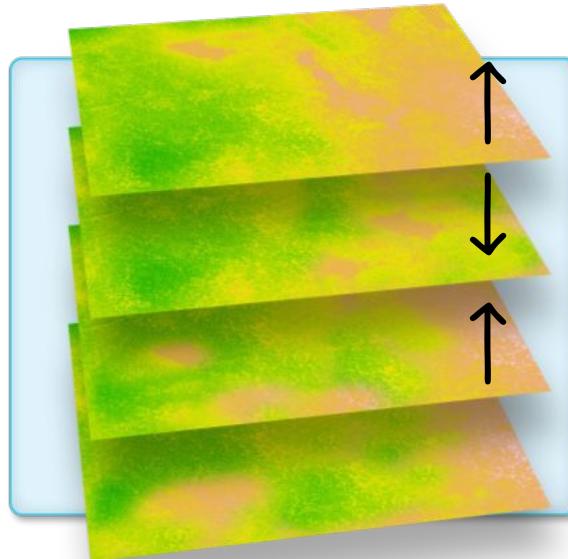


# Working with remote sensing data

Single Band Raster

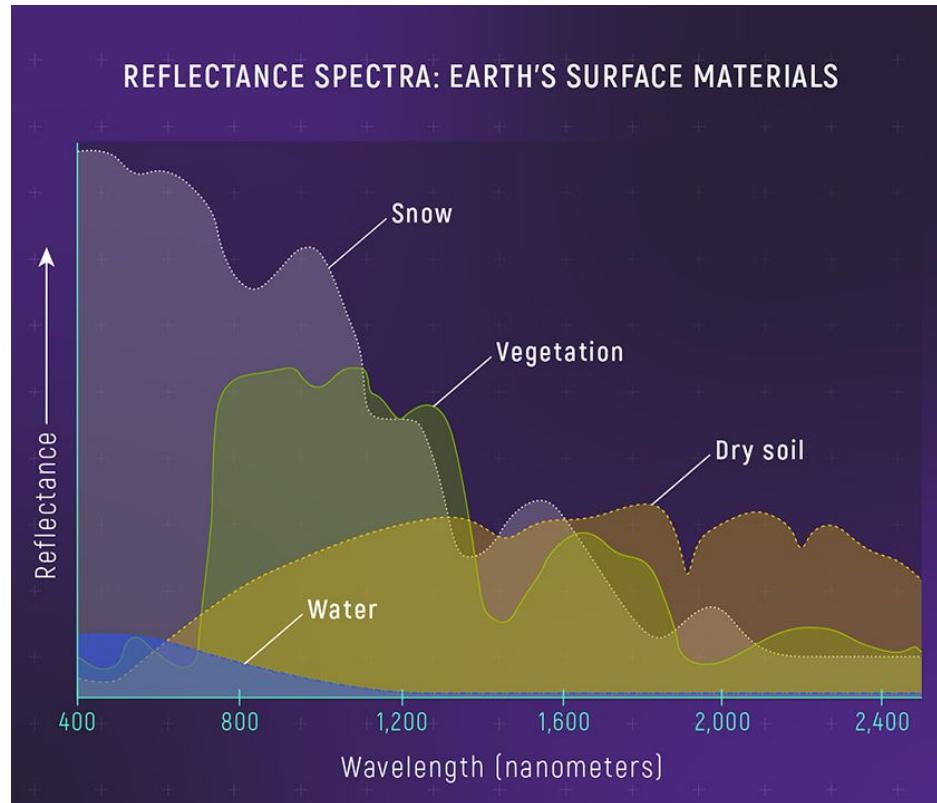


Multi Band Raster



neon

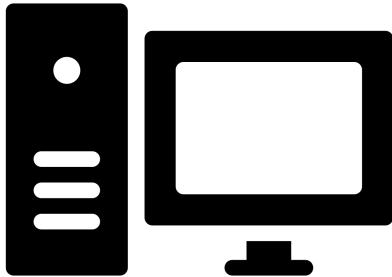
# Visualizing remote sensing data



# What is remote sensing?

“**the art, science, and technology** of obtaining reliable information about physical objects and the environment, through the process of recording, measuring, and interpreting imagery and digital representations of **energy** patterns derived from **non-contact sensor systems.**”  
(Colwell, 1997)

# Visualizing remote sensing data



# Visualizing remote sensing data

What you see..



Your computer sees..

1	11	155
4	20	174
6	55	202
23	72	33
37	90	41



Low values

High values

# Visualizing remote sensing data



Low values

High values



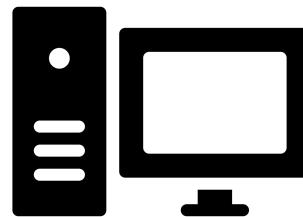
8 bit image:  $2^8 = 256$  values per band



RGB display:  $256 * 256 * 256 =$   
more than 16 million color  
combinations



# Visualizing remote sensing data



Low values

High values

Red channel



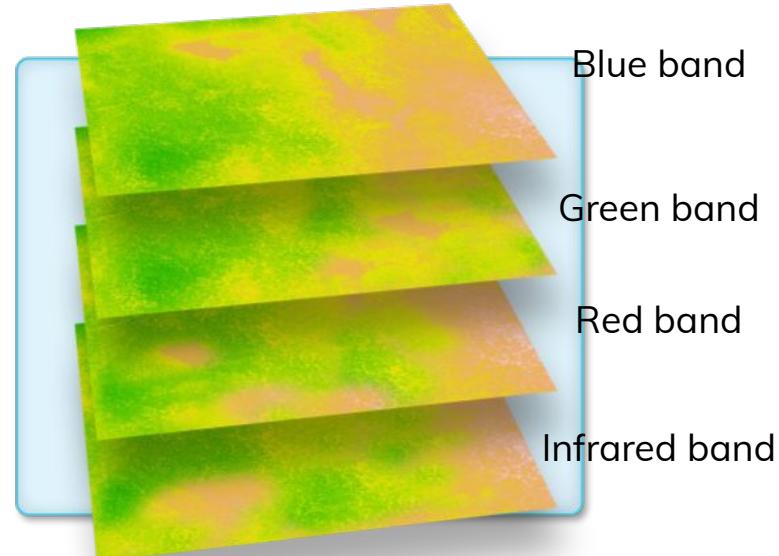
Green channel



Blue channel



Multi Band Raster



# Visualizing remote sensing data



Low values

High values



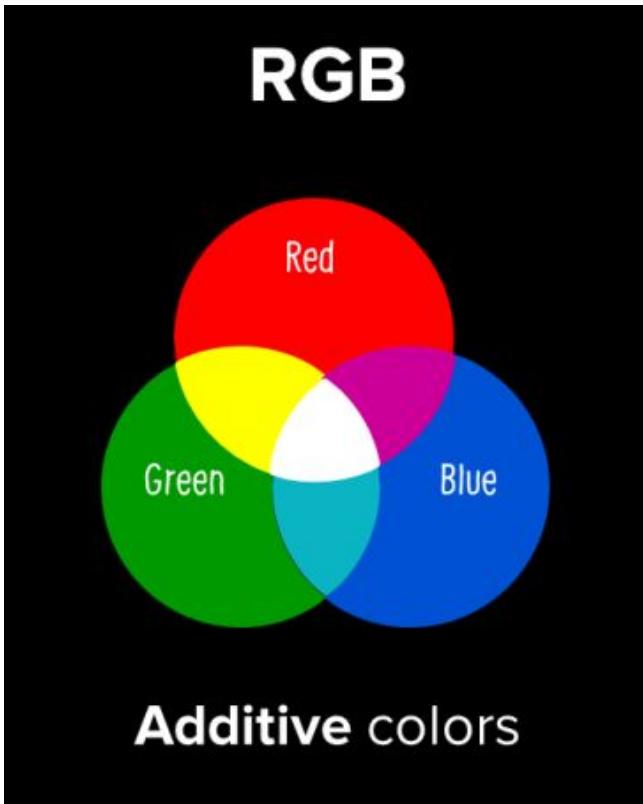
8 bit image:  $2^8 = 256$  values per band



RGB display:  $256 * 256 * 256 =$   
**more than 16 million color  
combinations**



# Color mixing: RGB



- Red, Green, Blue color model
- Additive color model
- Start with black and “add” colors to make white
- Primary colors
  - Red
  - Green
  - Blue
- Secondary colors
  - Magenta
  - Yellow
  - Cyan
- Purpose: digital display
- How light actually works!

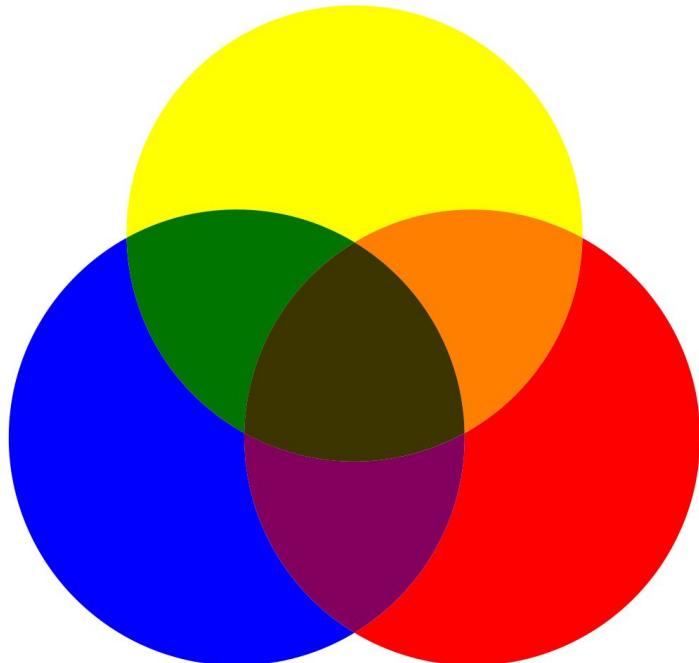
# Color mixing: CMYK



- Cyan, Magenta, Yellow, Key (black) color model
- Subtractive color model
- Start with white and “subtract” colors to make black
- Primary colors
  - Magenta
  - Yellow
  - Cyan
- Secondary colors
  - Red
  - Green
  - Blue
- Purpose: paints

**Subtractive** colors

# Wait.... What about RYB?



- Red, Yellow, Blue color model
- Subtractive color model
- Predates modern color theory

# True and False color imagery



Low values

High values

Red channel



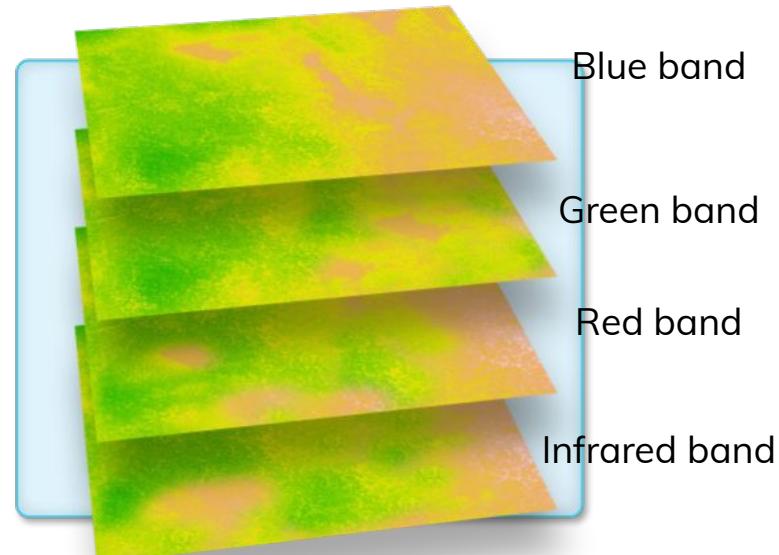
Green channel



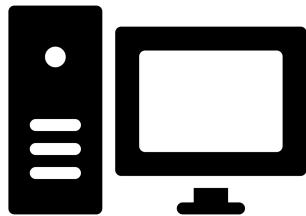
Blue channel



Multi Band Raster



# True and False color imagery



Red channel



Red band

Green channel



Green band

Blue channel

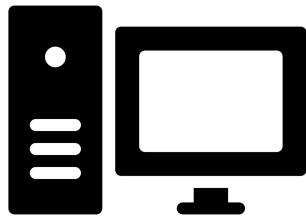


Blue band



True color image

# True and False color imagery



Red channel



Green band

Green channel



Red band

Blue channel



Infrared band

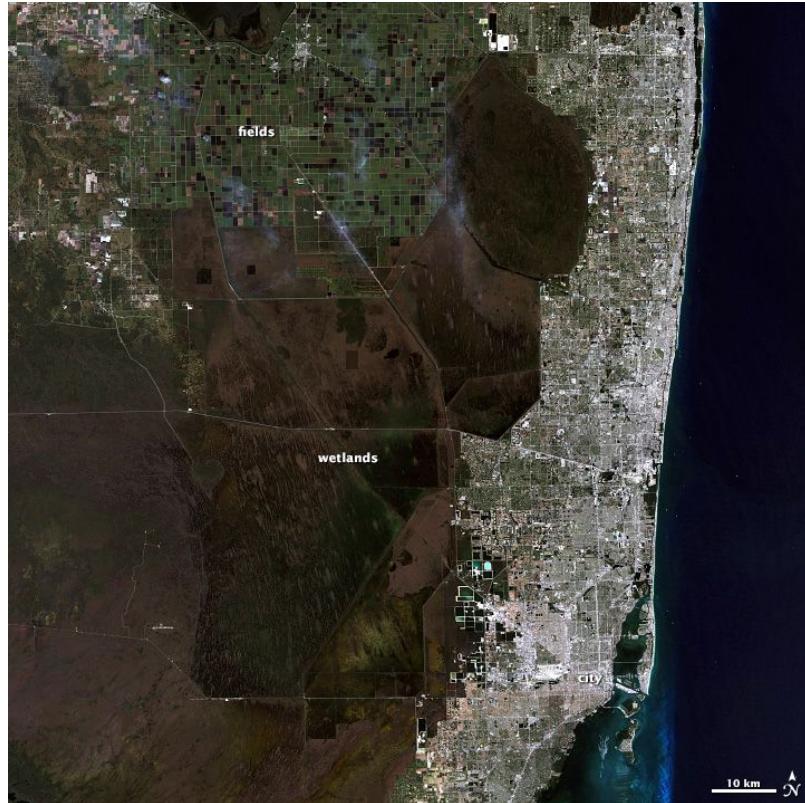


False color image

## True and False color imagery

YELLOW	BLUE	ORANGE
BLACK	RED	GREEN
PURPLE	YELLOW	RED
ORANGE	GREEN	BLACK
BLUE	RED	PURPLE
GREEN	BLUE	ORANGE

# True and False color imagery



Red channel



Red band

Green channel

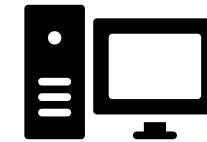
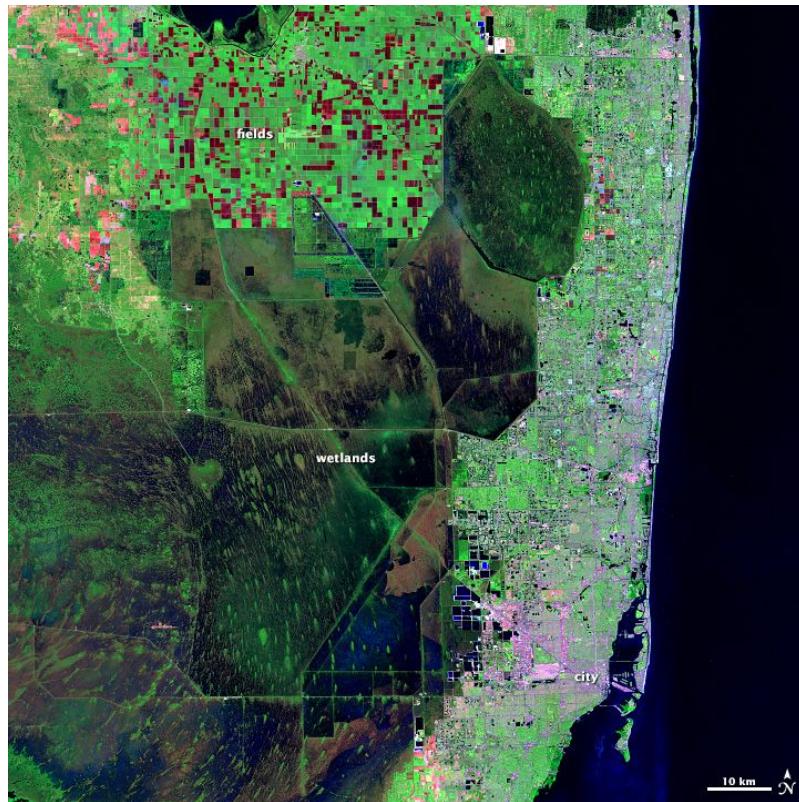


Blue channel



True color image

# True and False color imagery



Red channel

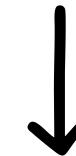


Green band

Green channel

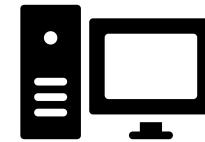
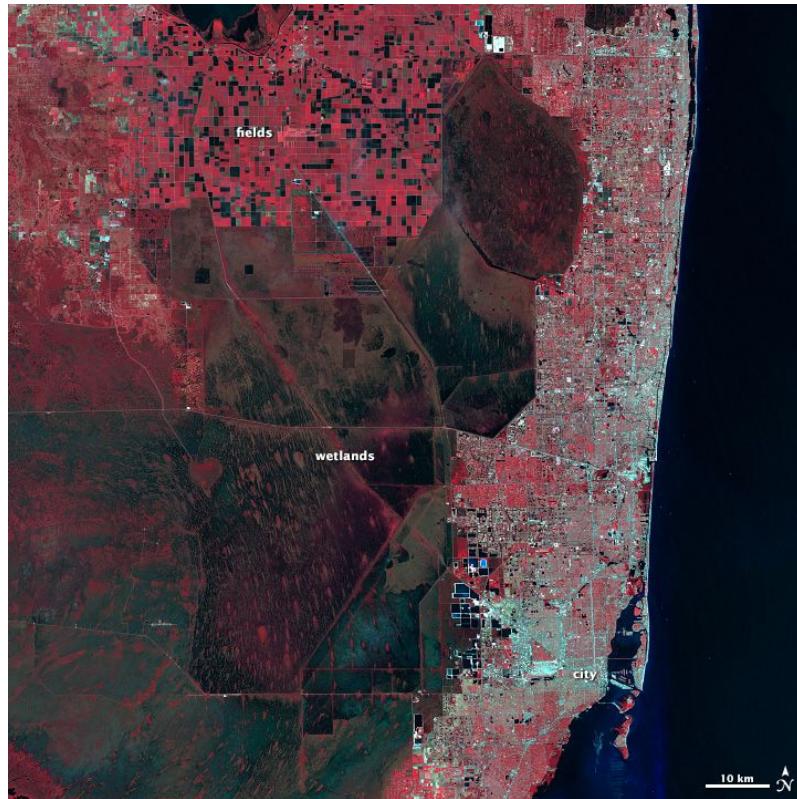


Blue channel



False color image

# True and False color imagery



Red channel



Green band

Green channel



Blue channel

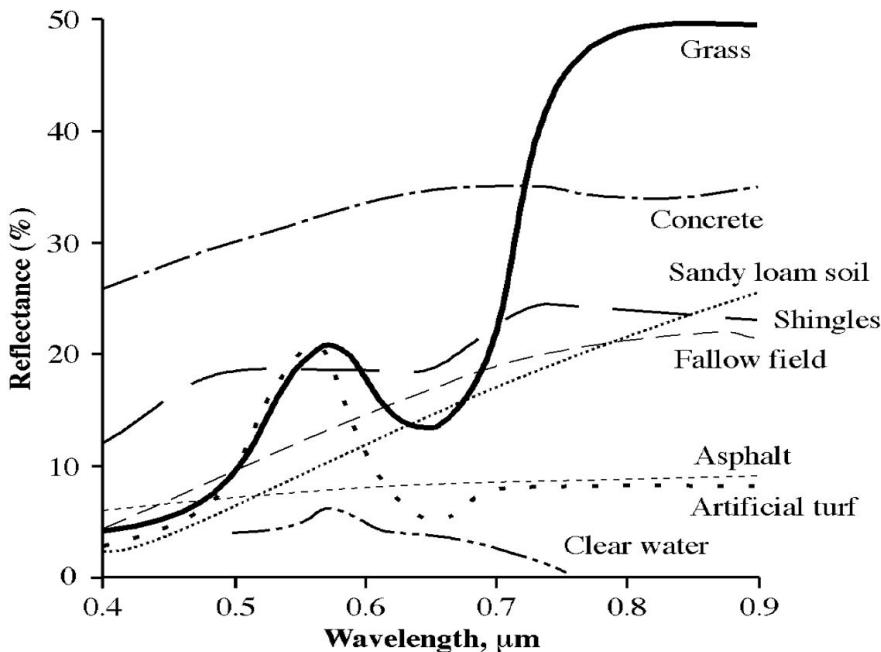


Near infrared  
band



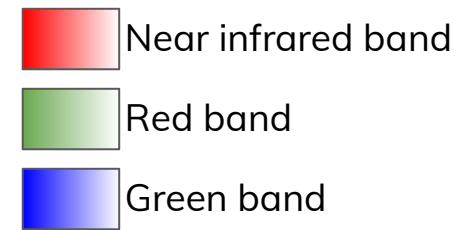
False color image

# True and False color imagery



- **Blue light (450-490 nm)**
  - Reflects:
    - Water
    - Manmade features
- **Green light (490-580 nm)**
  - Reflects:
    - Chlorophyll
    - Sediment in water
- **Red light (620-780 nm)**
  - Reflects:
    - Iron and iron oxides
  - Absorbs:
    - Healthy vegetation
- **Near infrared (700-1100 nm)**
  - Absorbs:
    - Water
- **Shortwave infrared (1100-3000 nm)**
  - Reflects:
    - Fire, newly burned area
  - Absorbs:
    - Water

# False color imagery



- Plants reflect more infrared than green → appear red
- Useful for seeing changes in plant health

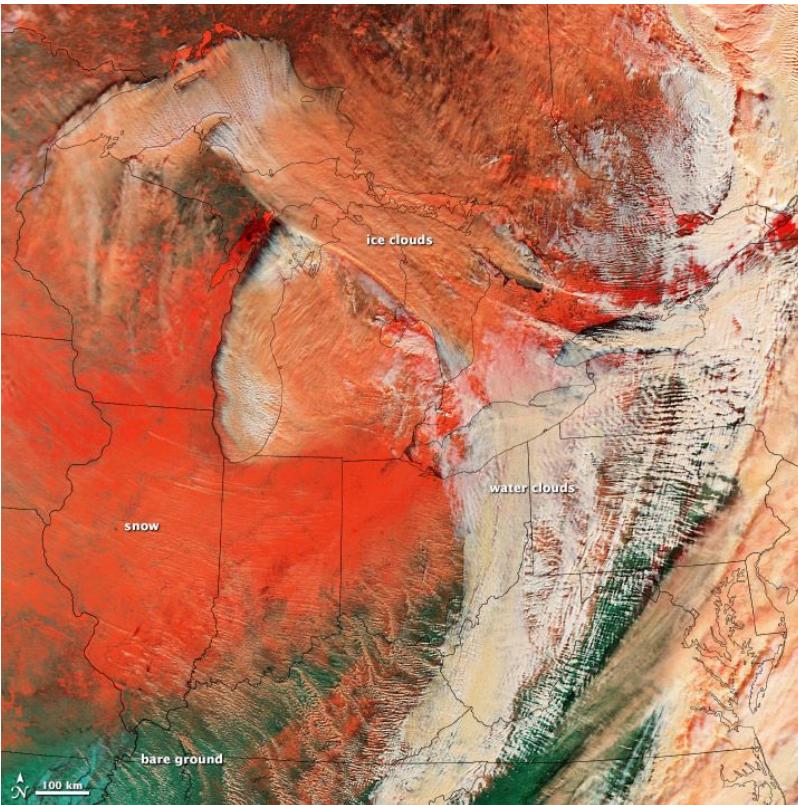
# False color imagery



- Shortwave infrared band
- Near infrared band
- Green band

- Water absorbs all 3 bands, so typically appears black
- Useful for seeing floods or newly burned land

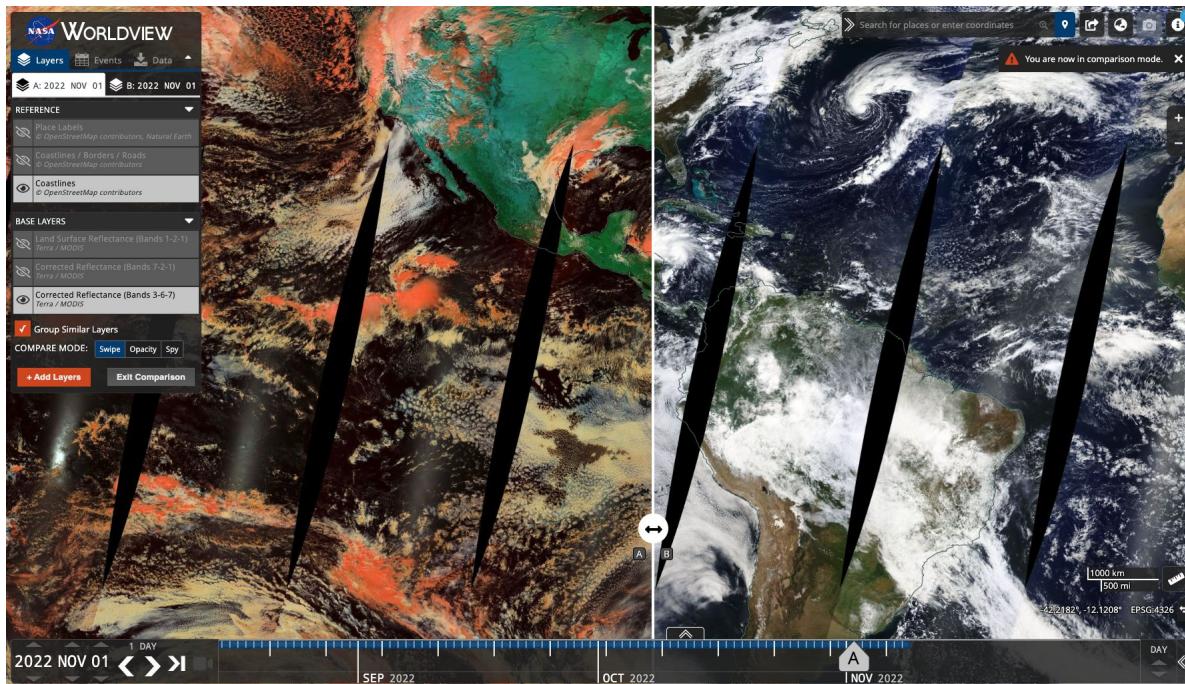
# False color imagery



- Blue band
- Shortwave infrared band
- Shortwave infrared band

- Ice reflects more blue light than snow or ice clouds
- Useful for distinguishing snow, ice, and clouds

# False color imagery



- Select an image
- Determine which bands are being displayed in which channels
  - What wavelengths correspond to RGB display?
- Discuss what patterns this band combination reveals

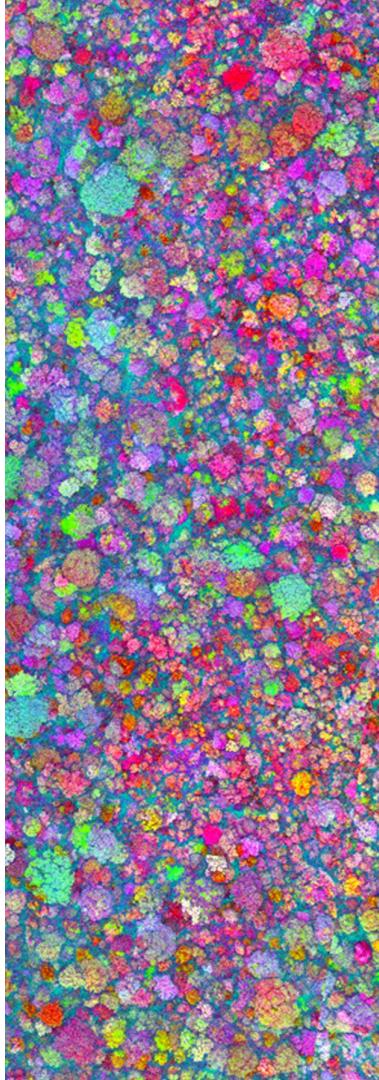
# Expert panel



Dr. Dana Chadwick  
NASA Jet Propulsion Laboratory



Dr. Anabelle Cardoso  
University at Buffalo  
University of Cape Town



# EDS 223: Geospatial Analysis & Remote Sensing

## Week 7



USGS via Unsplash