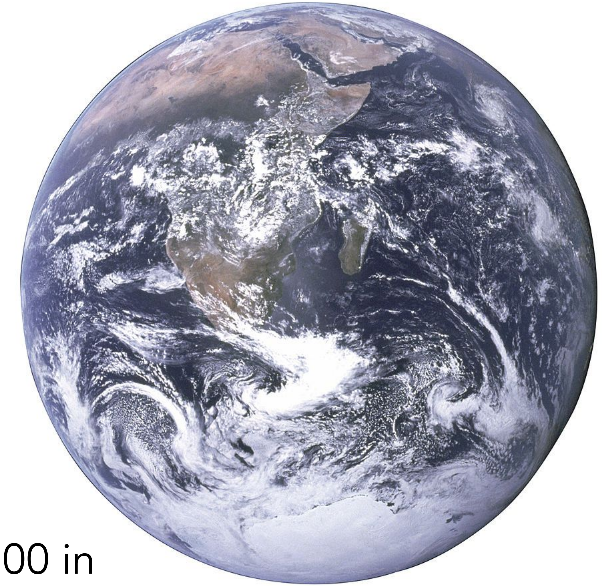
Remote Sensing 1: GEOG 4/585

Lecture 1.2.

Basic concepts



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165 Condon Hall

Welcome

Shelby Weiss (SSIL Liaison)

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- Office hours: Monday 13:00-15:30, Tuesday and Thursday 13:00-16:45

Overview

- Interpreting satellite imagery
  - Scale, patterns, color, prior knowledge
- Some more basic concepts
  - Data formats, image visualization, enhancements etc.
  - Differences between bands
- Introduction to Lab 1

Interpreting satellite imagery

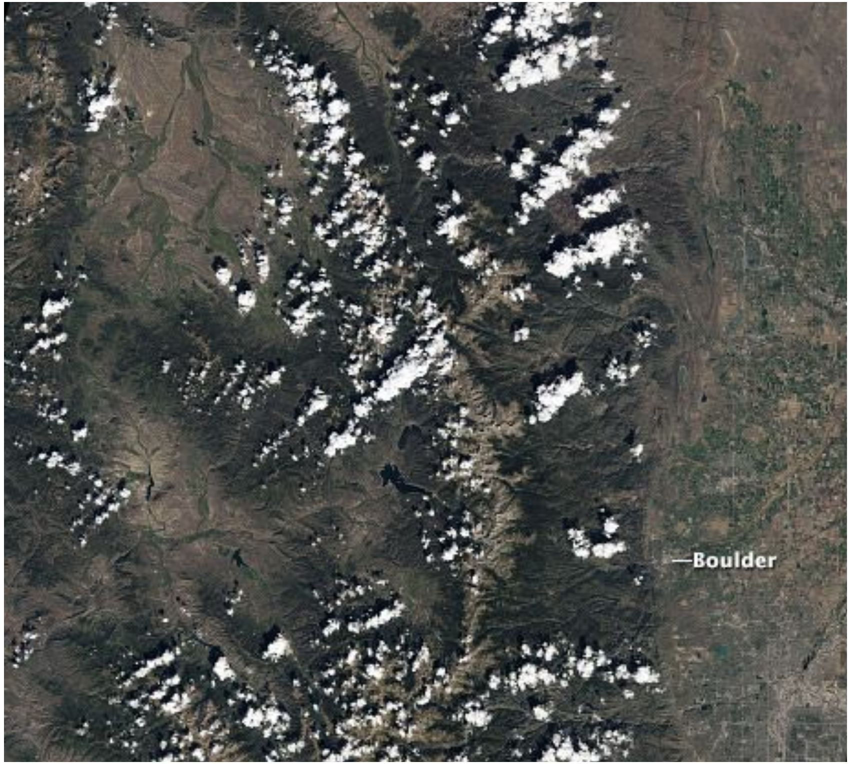
- Scale
- Patterns, shapes, and textures
- Colors
- Prior knowledge

Scale

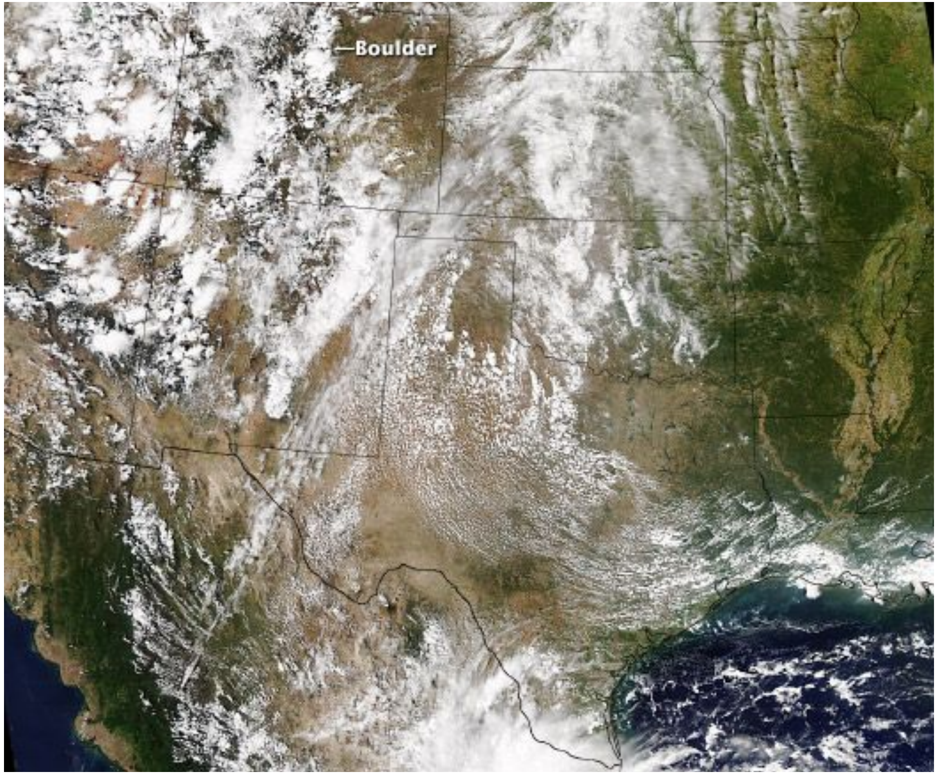
WorldView-2 satellite image
Pixel represents 50 x 50 cm

Landsat 8 satellite image
Pixel represents 30 x 30 m

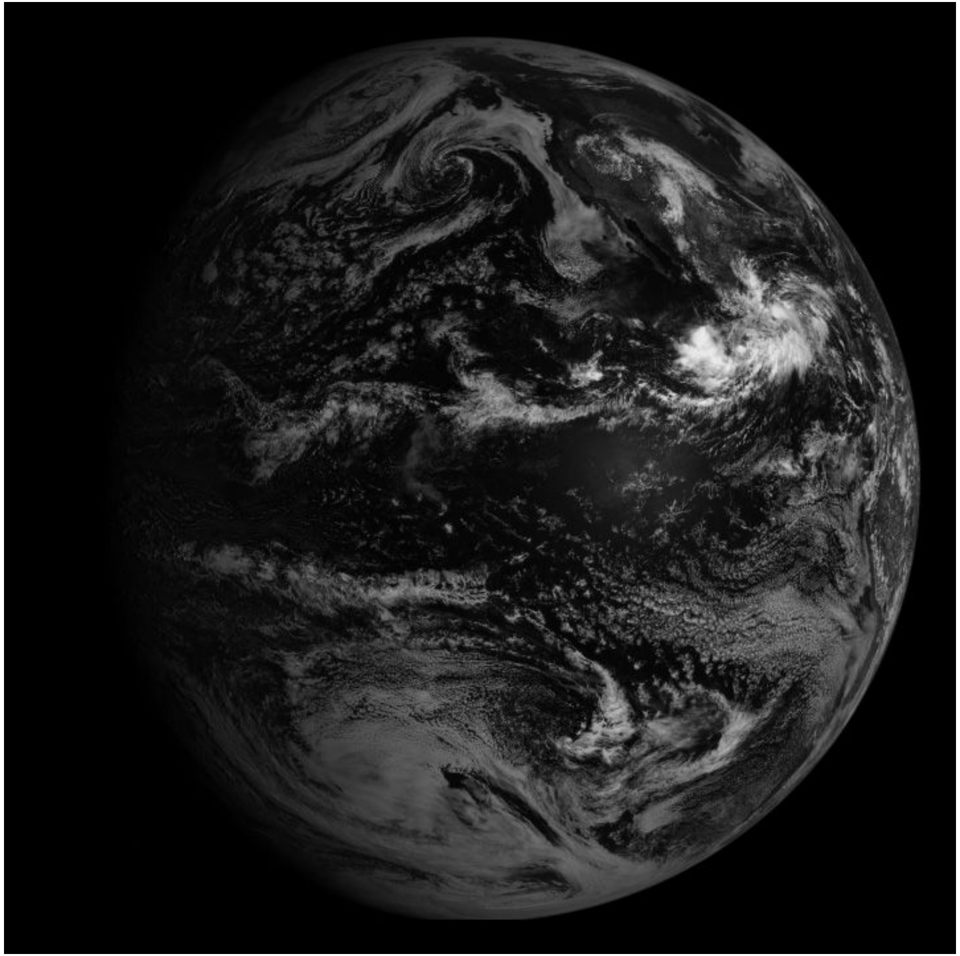
Scale



Landsat 8 image (30 x 30 m)



MODIS image (500 x 500 m)



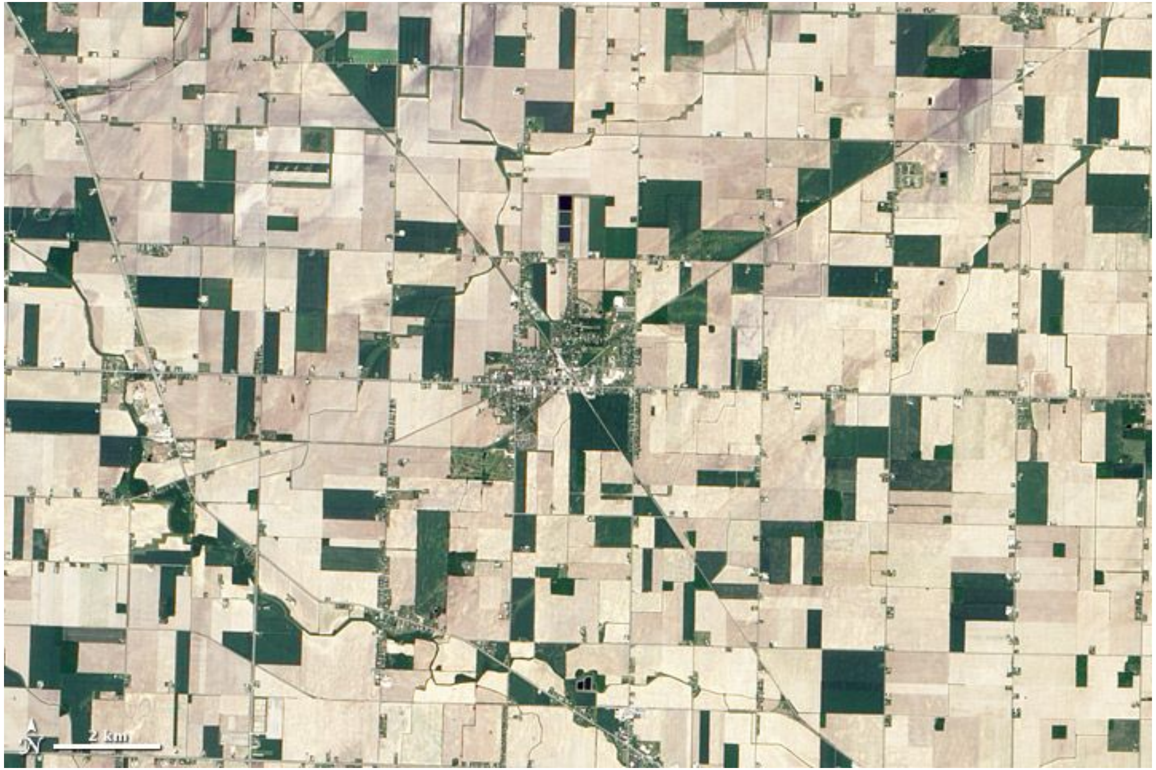
GEOS satellite image (4 x 4 km)

Scale

- Geostationary weather satellites observe a whole hemisphere at a time
- But are much less detailed
- Support weather forecasting, severe storm tracking, and meteorology research

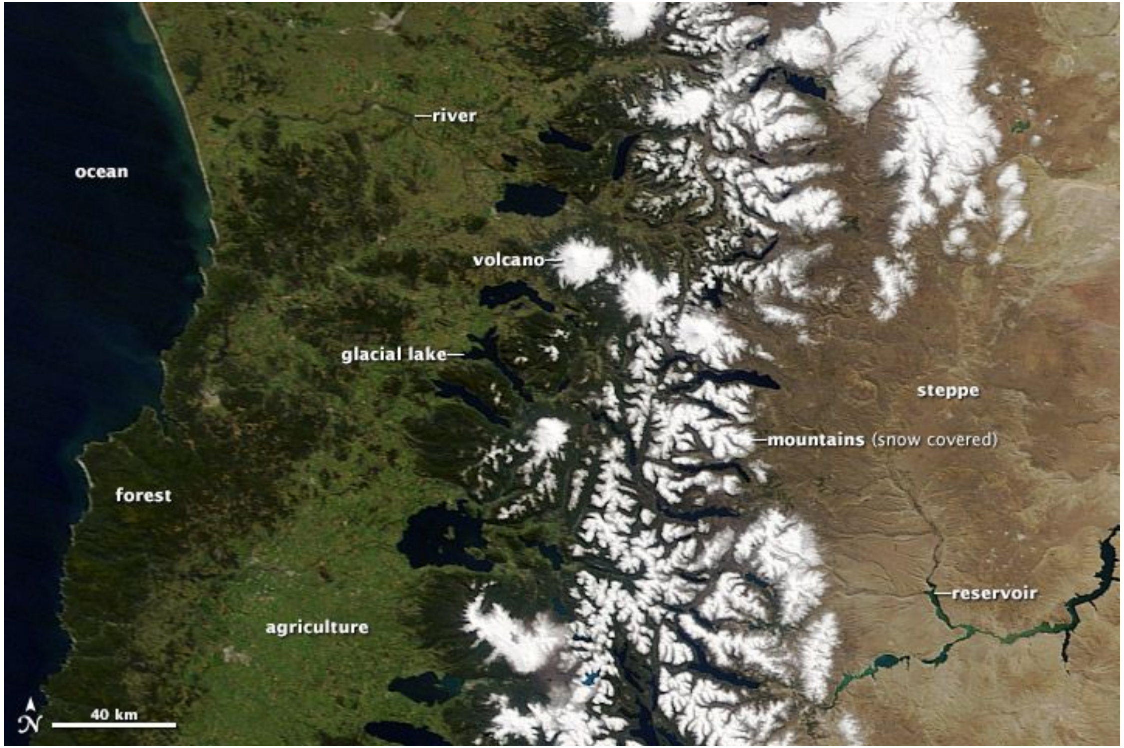
Patterns, shapes, and textures

- The human brain is very good at identifying patterns
- Distinctive patterns in satellite imagery can be used to investigate human impacts on the environment



Human land use in Reese, Michigan from Landsat 8

Patterns, shapes, and textures



Central Chile and Argentina from Landsat 8

- Geology shapes the landscape in ways that are often easier to see in a satellite image.

Patterns, shapes, and textures

- Water bodies are often the simplest features to identify because they have unique shapes and textures.

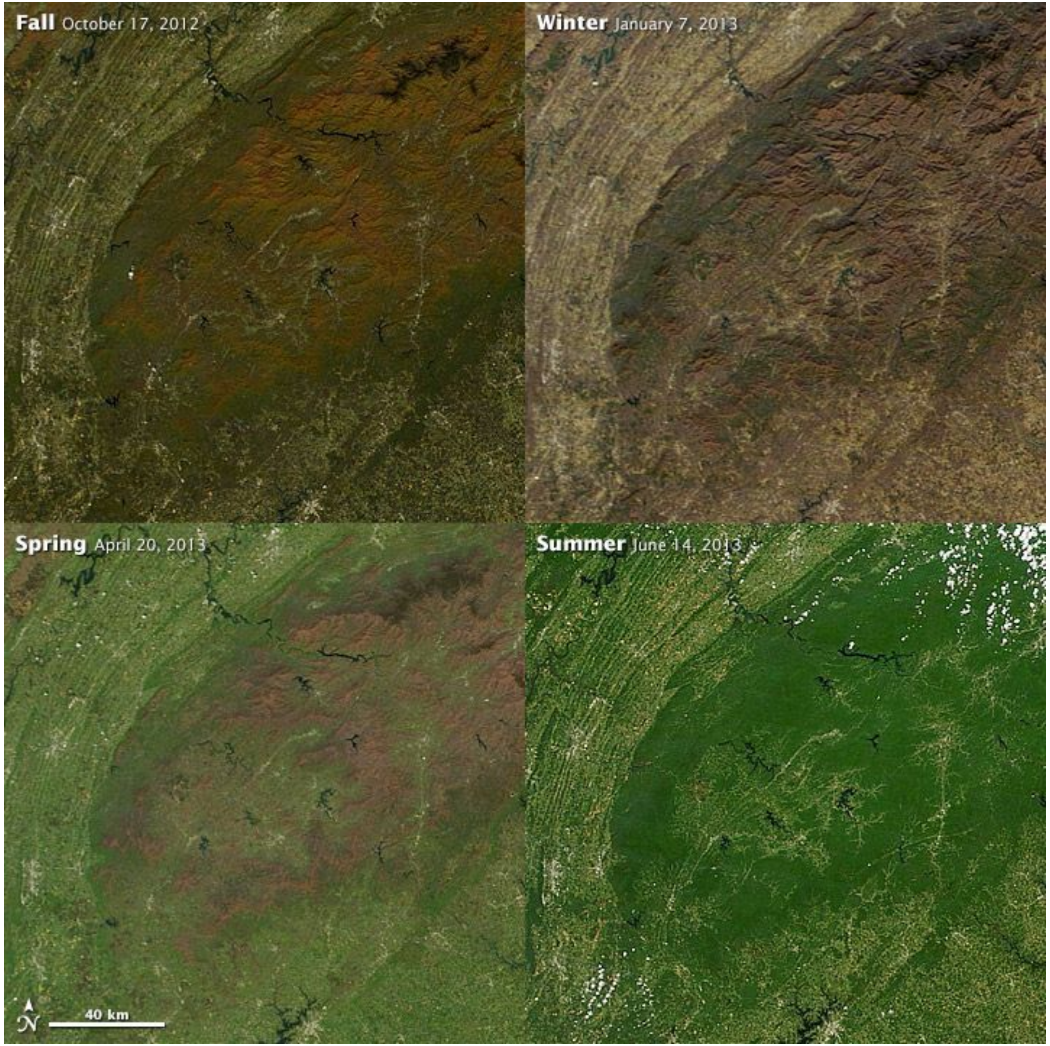
Lake Powell NZ/AZ from Landsat 5, 1985

Colors

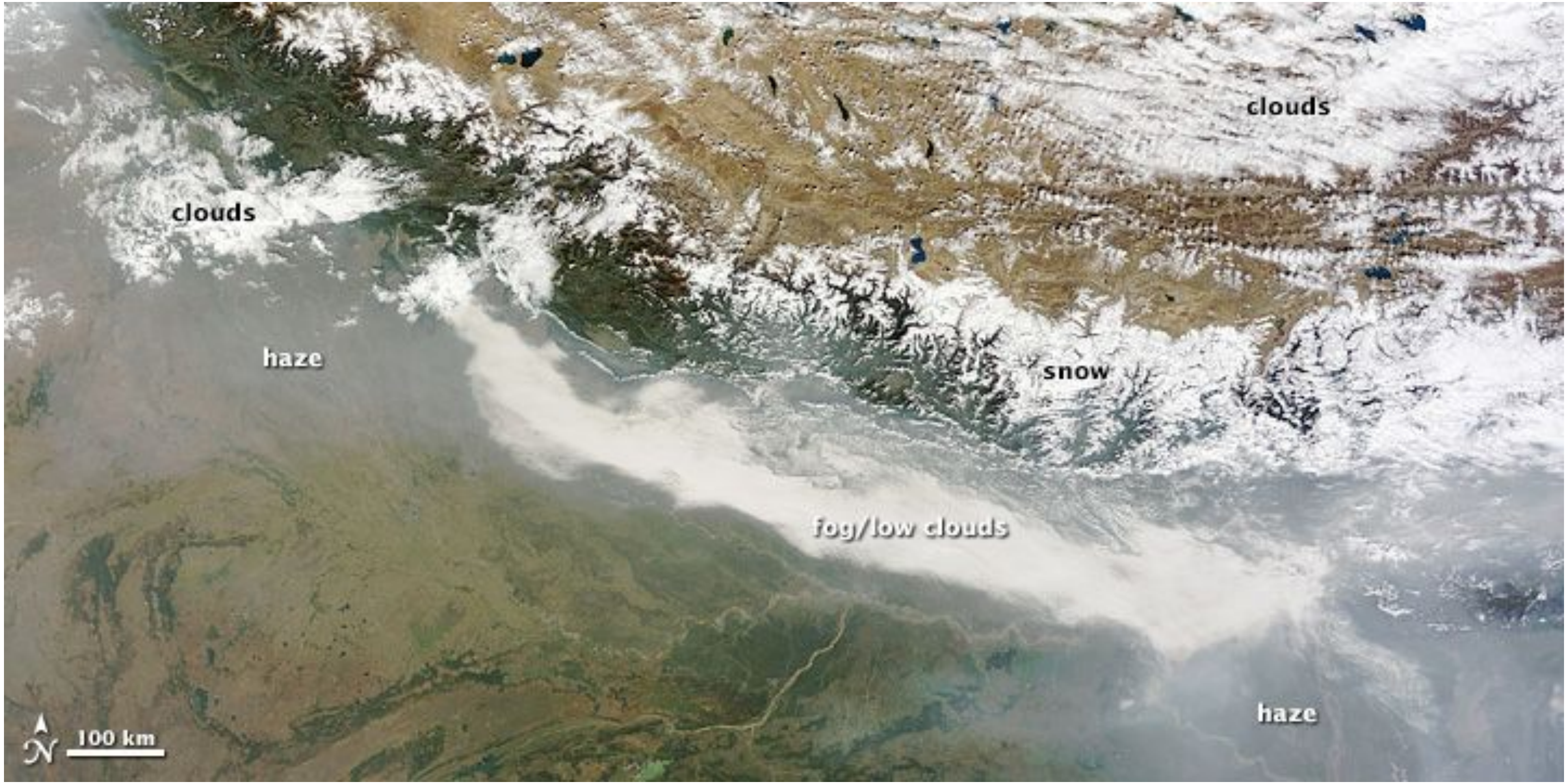
Mouth of the Zambezi River from Landsat 8

Colors

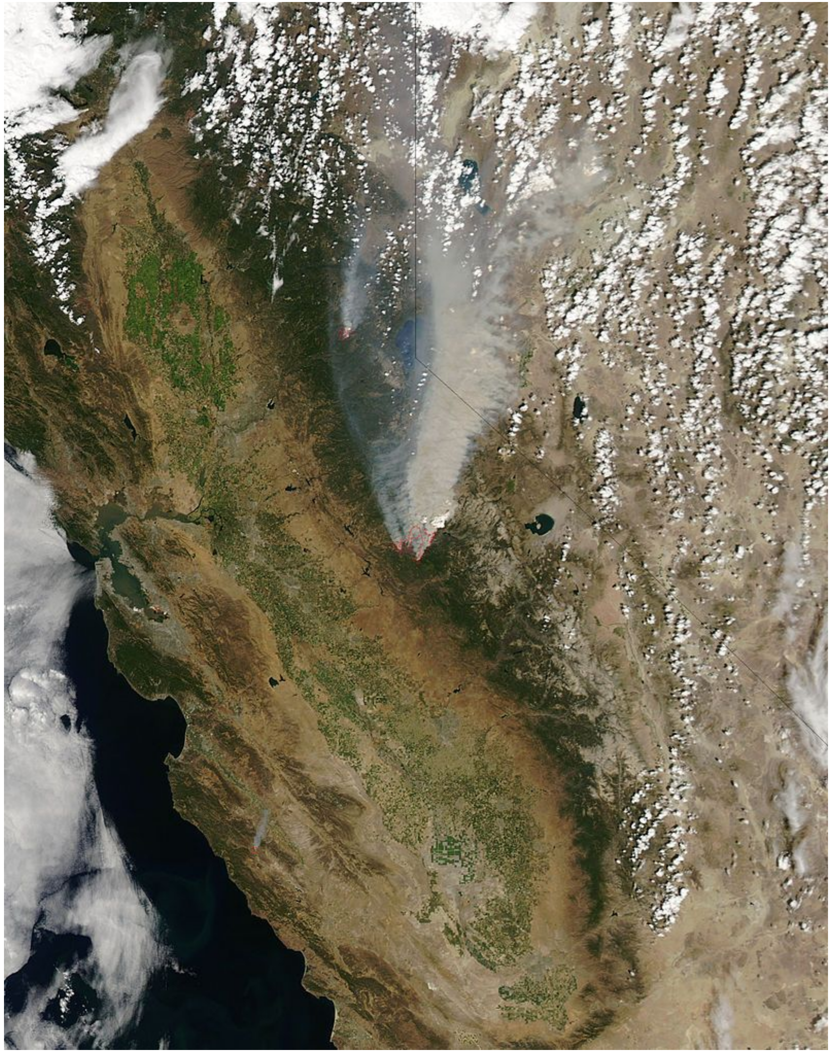
- Great Smoky Mountains of the Southeastern United States from MODIS.



Colors



Himalaya from MODIS

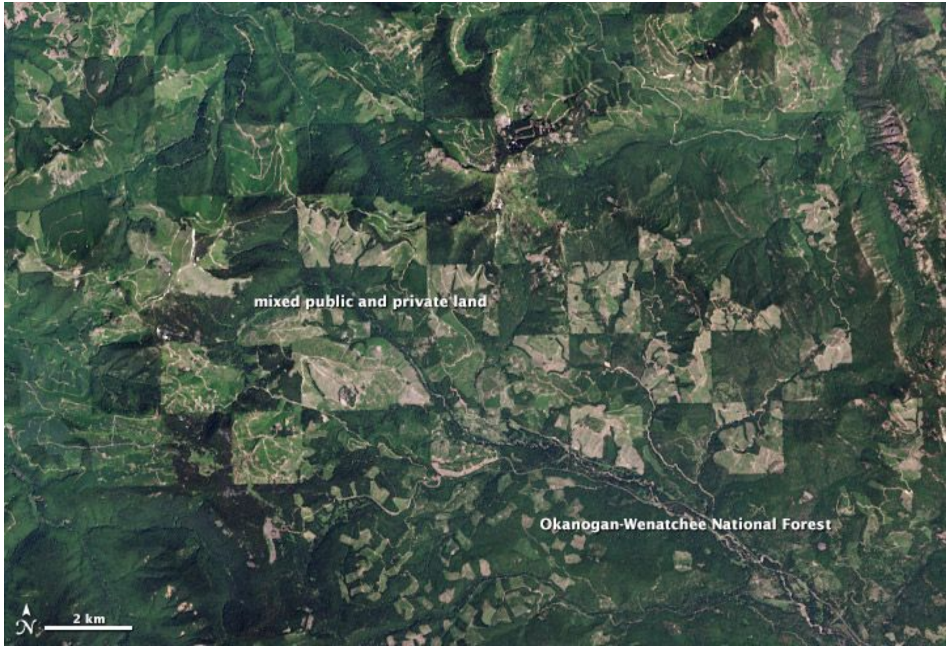


Work with a partner to describe what is going on in this image

California from MODIS

Warsaw, Poland from Landsat

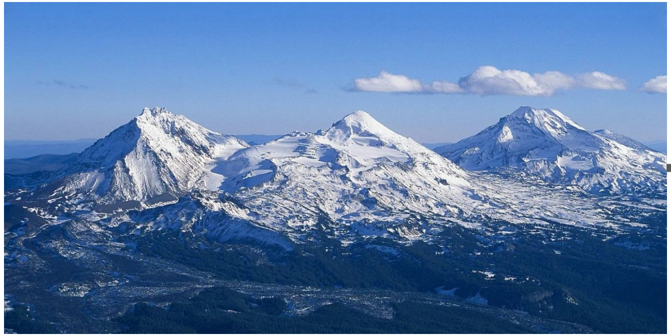
Sierra Nevada, CA from Landsat 8



Poland (left) and the U.S. state of Washington (right).

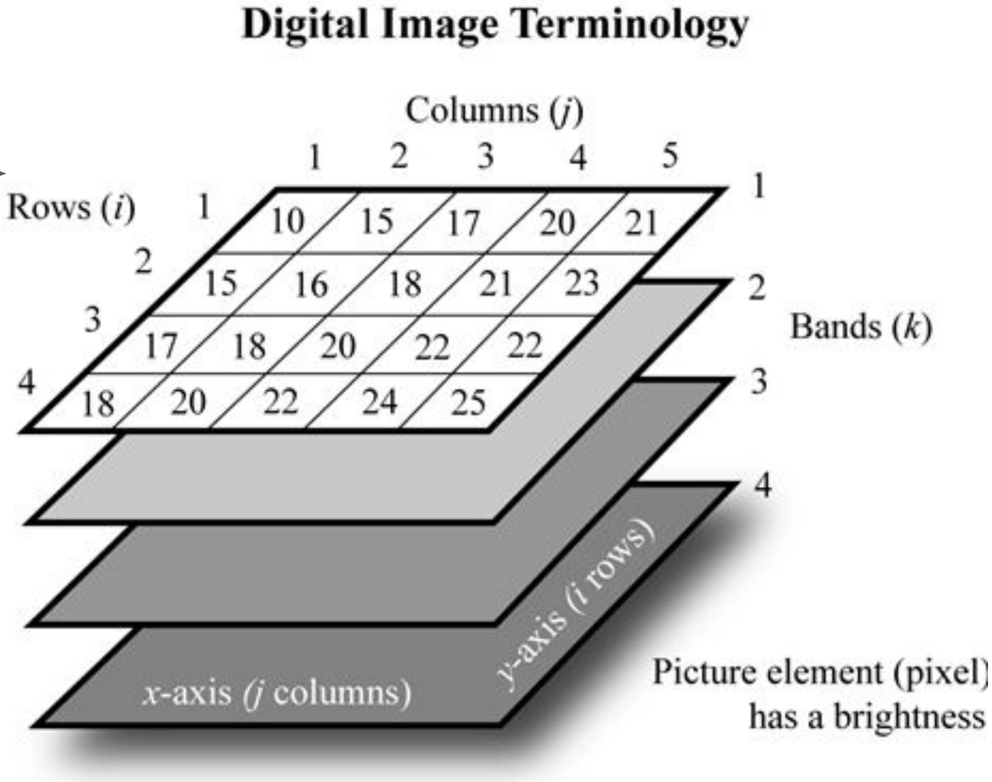
Basic remote sensing concepts

Basic remote sensing concepts

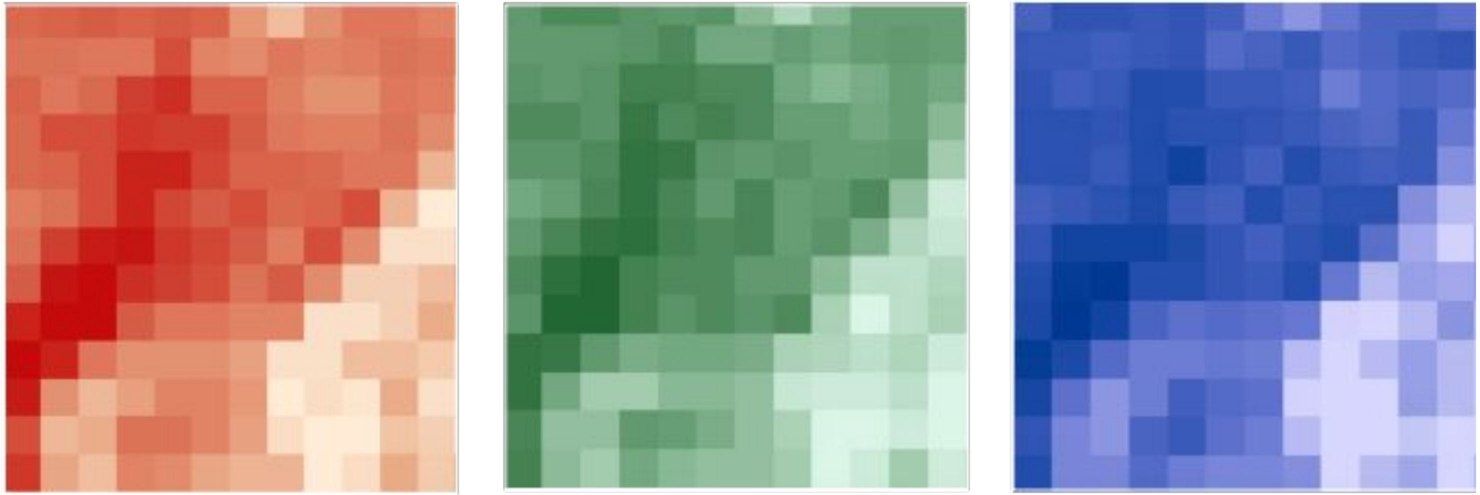


The computer, at a minimum, has to know several things to open an image:

columns
rows
bands
data type
(bits, bytes…)



Digital image and digital numbers (DNs)



RGB ("Red", "Green", "Blue") images can display 3 bands, corresponding to the intensities in the red, green, and blue. Computer monitor colors are additive, meaning "true" red + green + blue = white.

Typically, lower pixel values (brightness values) are displayed as "dark" and higher pixel values are displayed as "bright".

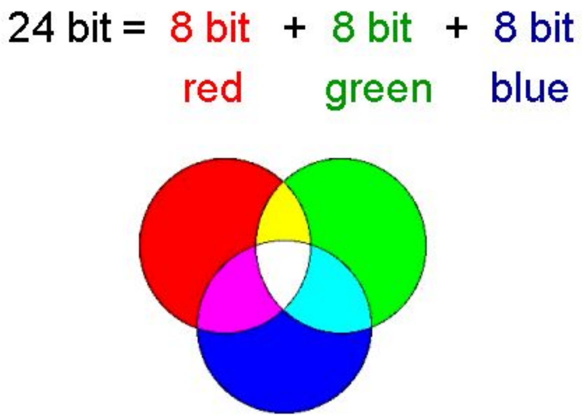
Primary and secondary colors

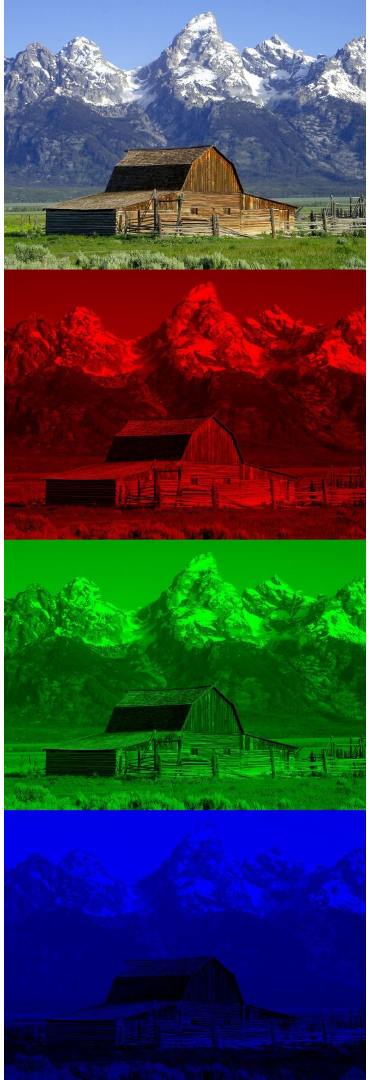
RGB can be combined in pairs to make secondary colors

- R+B = magenta (M)
- R+G = yellow (Y)
- B+G = cyan (C)
- R+G+B = white

8-bit image – 256 (2^8) values per band

Therefore, RGB display can have 256 x 256 x 256 color combos, or more than 16 million (2^{24})



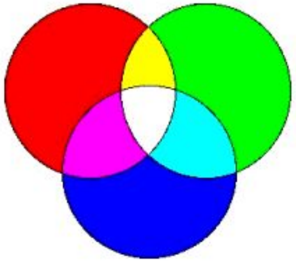


Color mixing - RGB

RGB color model: additive color model. Combination of three primary colors of red, green, and blue in appropriate intensities makes white.

- Start with black, “add” colors to make white

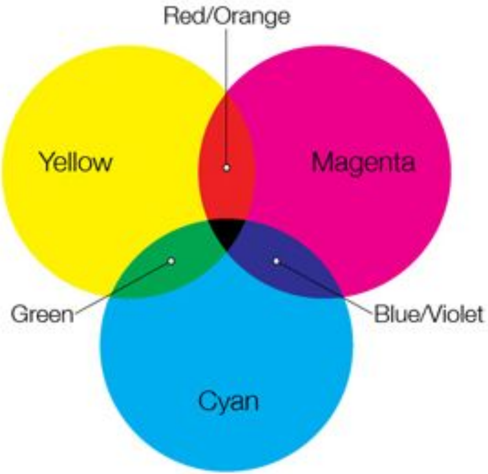
- Main purpose is for display of images in electronic systems (TV, computer screen)



Color mixing - CMYK

CMYK (short for cyan, magenta, yellow, and key/black) is a subtractive color model. It works by partially or entirely masking certain colors on the typically white background (that is, absorbing particular wavelengths of light).

- Start with white, “subtract” colors to make black
- White is the natural color of the paper, black results from a full combination of colored inks
- Main purpose is for printing, painting



Subrtactive Color Model
(pigment, CMYK)

True and false color imagery

- True color is when the RGB image bands are loaded to the screen on that order

- A false color image is one in which the R,G, and B values do not correspond to the true colors of red, green and blue.

Example: a false color infrared:
- Red channel: NIR band
- Green channel: Red band
- Blue channel: Green band

This false color infrared combination is useful for detecting:
- Stressed vegetation
- Moist areas in fields
- Plant species

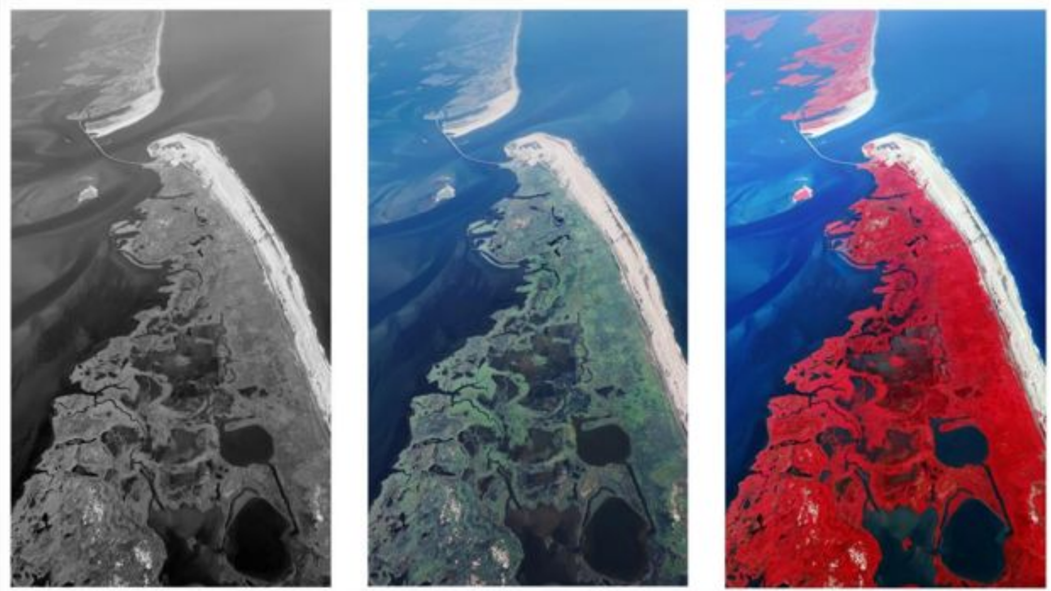
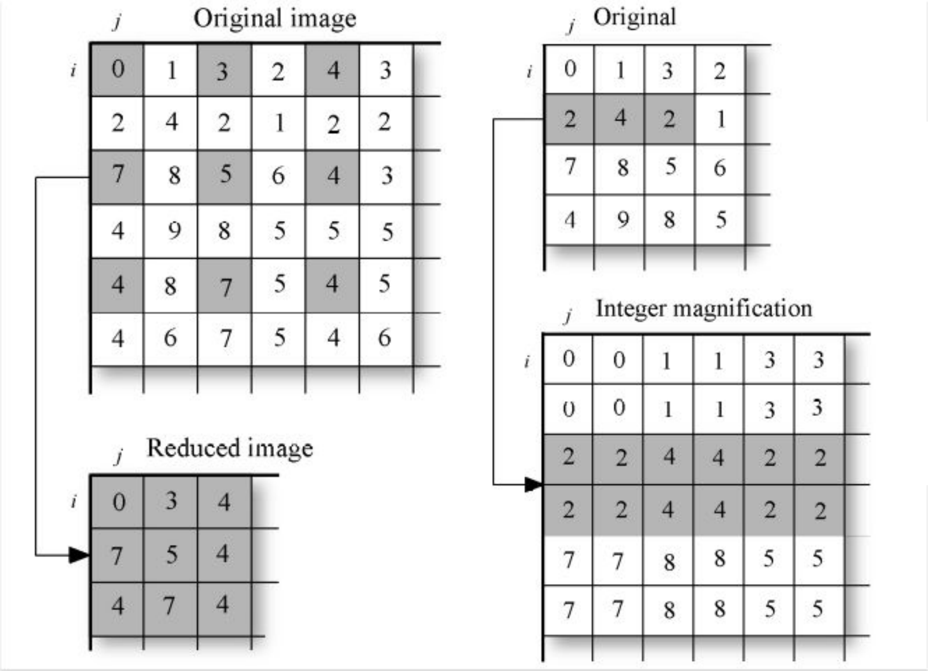


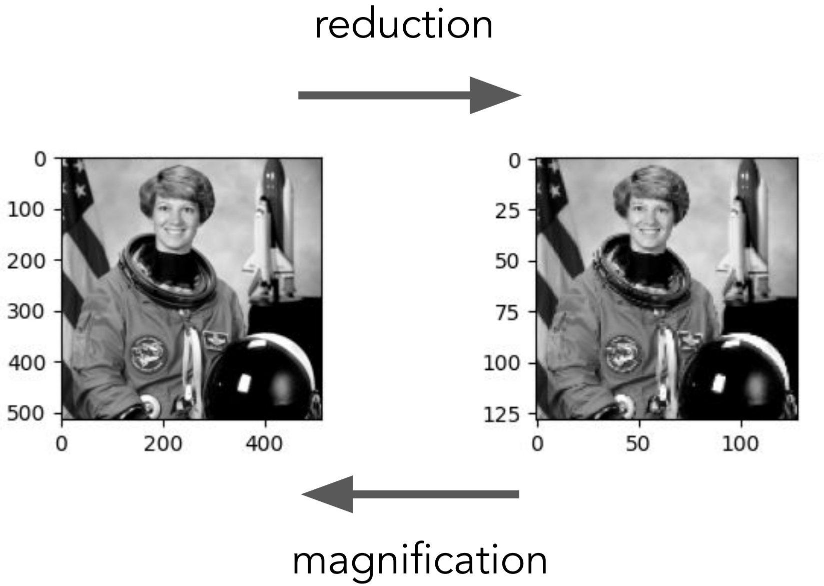
Image processing

- Image processing is used to make it easier for visual interpretation and understanding of imagery
    - Image reduction/magnification/resampling
    - Contrast enhancements (stretching, filtering)
    - Image transformations/band ratios

Reduction and magnification

- Most often used to change pixel size/spatial resolution; collectively called “resampling”





Contrast enhancements

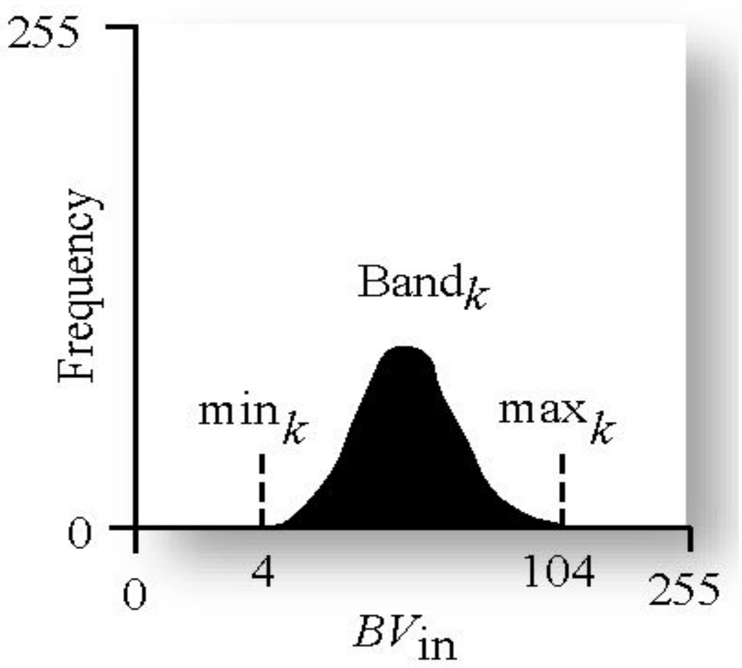
- In raw imagery, the useful data often populates only a small portion of the available range of digital values (commonly 8 bits or 256 levels).

- Contrast enhancement involves changing the original values so that more of the available range is used, thereby increasing the contrast between targets and their backgrounds.

Contrast enhancements - histograms

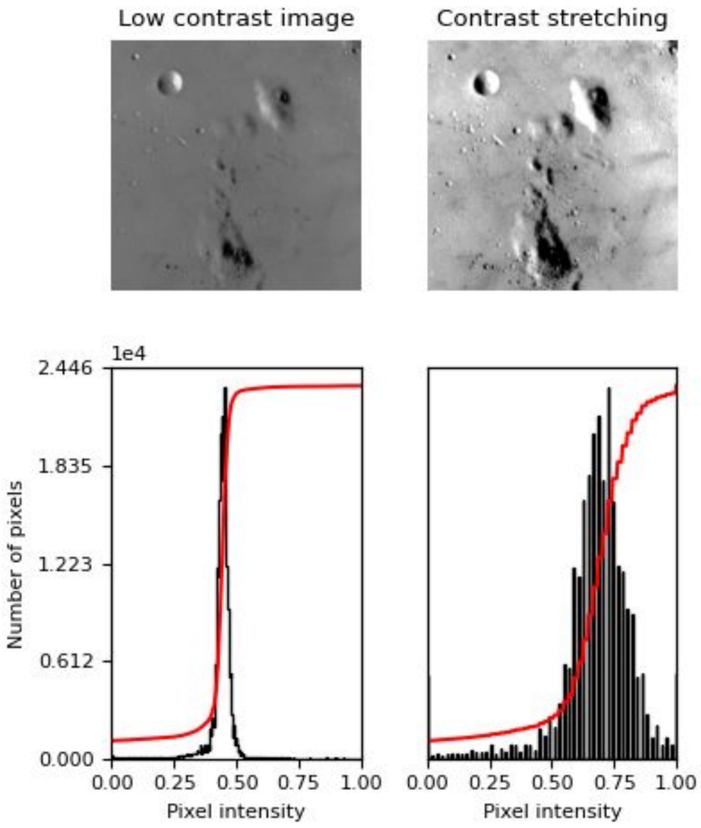
- The key to understanding contrast enhancements is to understand the concept of an image histogram.

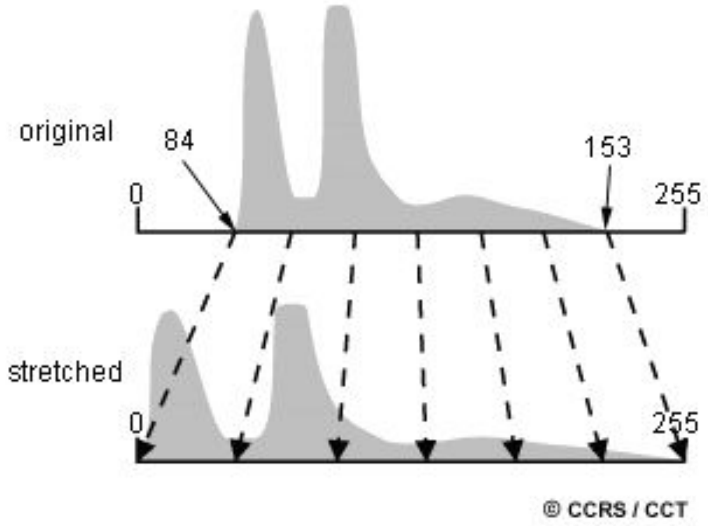
- A histogram is a graphical representation of the brightness values that comprise an image. The brightness values (i.e., 0-255) are displayed along the x-axis of the graph.



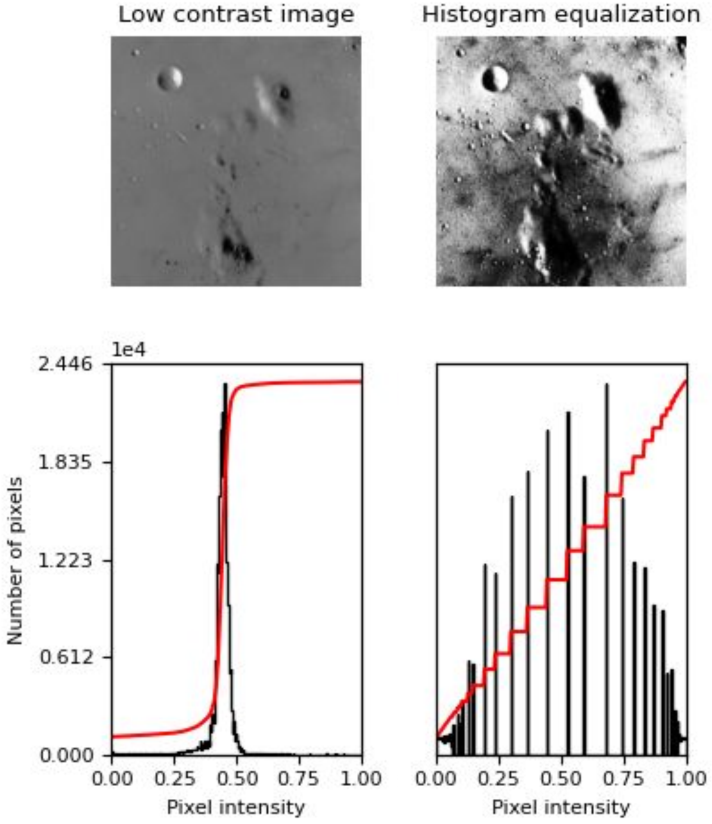
Low contrast image

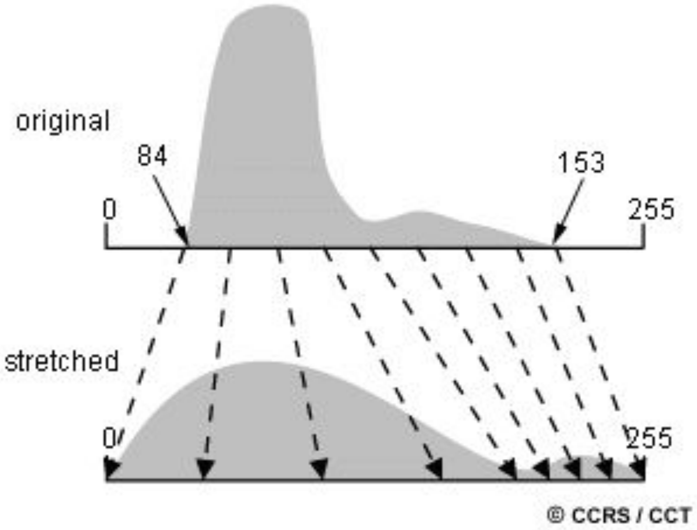
Contrast enhancements - linear stretch





Contrast enhancements - histogram equalized





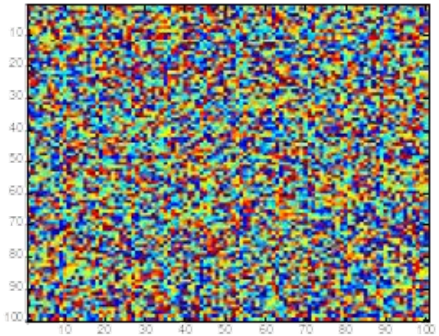
More weight (display values) to the frequently occurring portions of the histogram

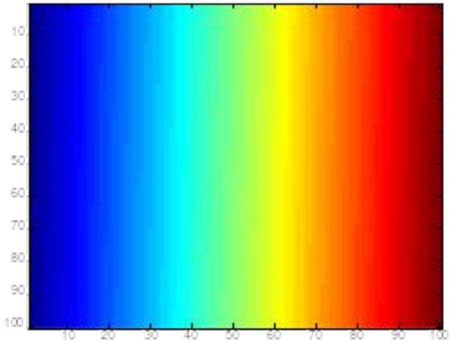
Contrast enhancements - filtering

Spatial filters highlight or suppress specific features in an image based on their spatial frequency (the number of changes in brightness value per unit distance for any part of the image)

- "Rough" textured areas of an image, where the changes in tone are abrupt over a small area, have <u>high spatial frequencies</u>

- “Smooth" areas with little variation in tone over several pixels, have <u>low spatial frequencies</u>

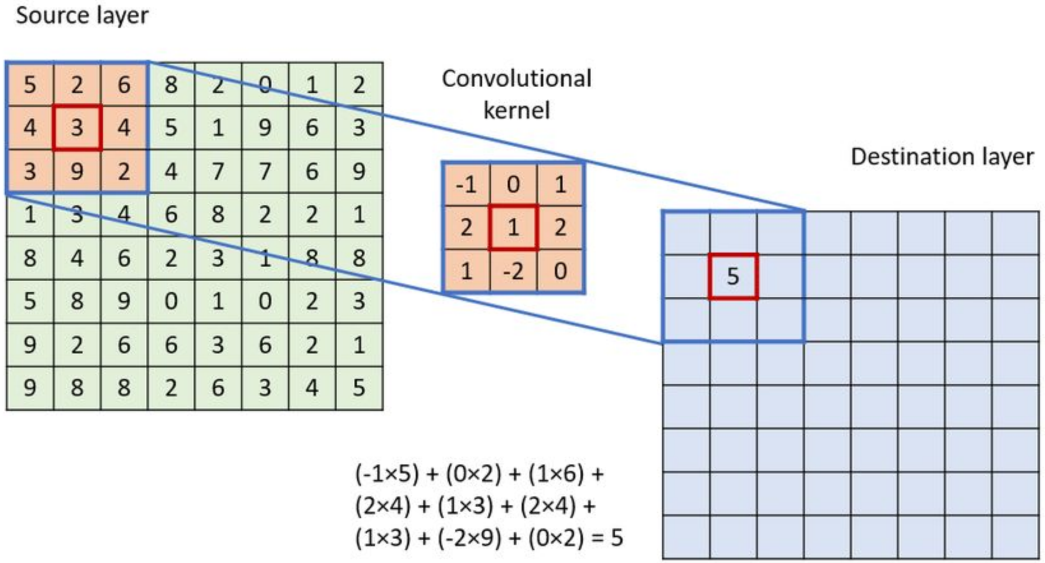




Contrast enhancements - kernel convolution

- A common filtering procedure involves moving a 'window' of a few pixels in dimension (e.g. 3x3, 5x5, etc.) over each pixel in the image, applying a mathematical calculation using the pixel values under that window, and replacing the central pixel with the new value.

- A moving window with a mathematical calculation is also called a ‘kernel convolution’



Contrast enhancements - filtering

A low-pass filter is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image.

- It generally serves to smooth the appearance of an image
- Average (median, mean) filters are examples of low-pass filters

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

High-pass filters do the opposite and serve to sharpen the appearance of fine detail in an image.

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Contrast enhancements - different kernels

1	1	1
1	1	1
1	1	1

Unweighted 3x3 smoothing kernel

0	1	0
1	4	1
0	1	0

Weighted 3x3 smoothing kernel with Gaussian blur

0	-1	0
-1	5	-1
0	-1	0

Kernel to make image sharper

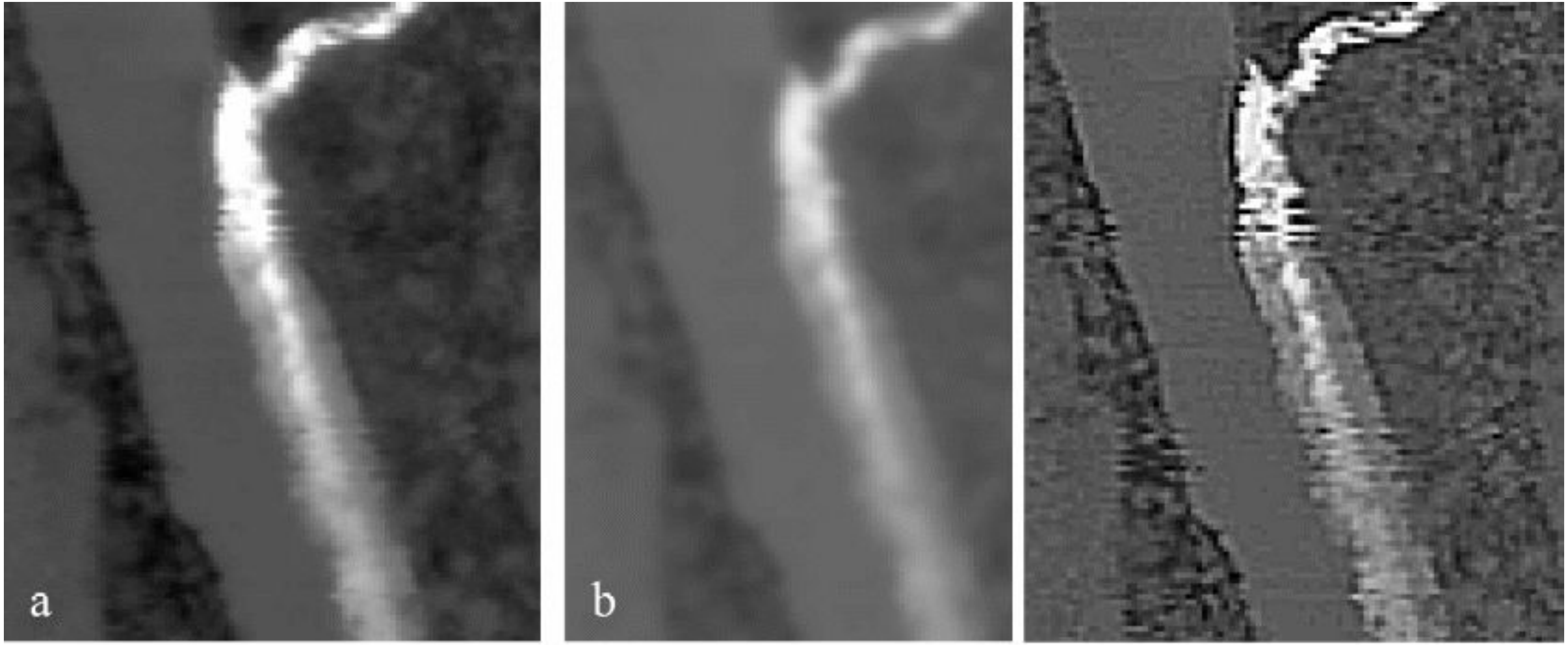
-1	-1	-1
-1	9	-1
-1	-1	-1

Intensified sharper image

Gaussian Blur

Sharpened image

Contrast enhancements - filtering



Original contrast stretched Low frequency High frequency

Image transformation

- Image division or spectral ratioing is one of the most common transformations applied to image data.
- By ratioing the data from two different spectral bands, the resultant image enhances subtle variations in the spectral reflectance of the two different spectral ranges that may otherwise be masked by the pixel brightness variations in each of the bands.

Band ratios

Red, green, blue

Band ratios

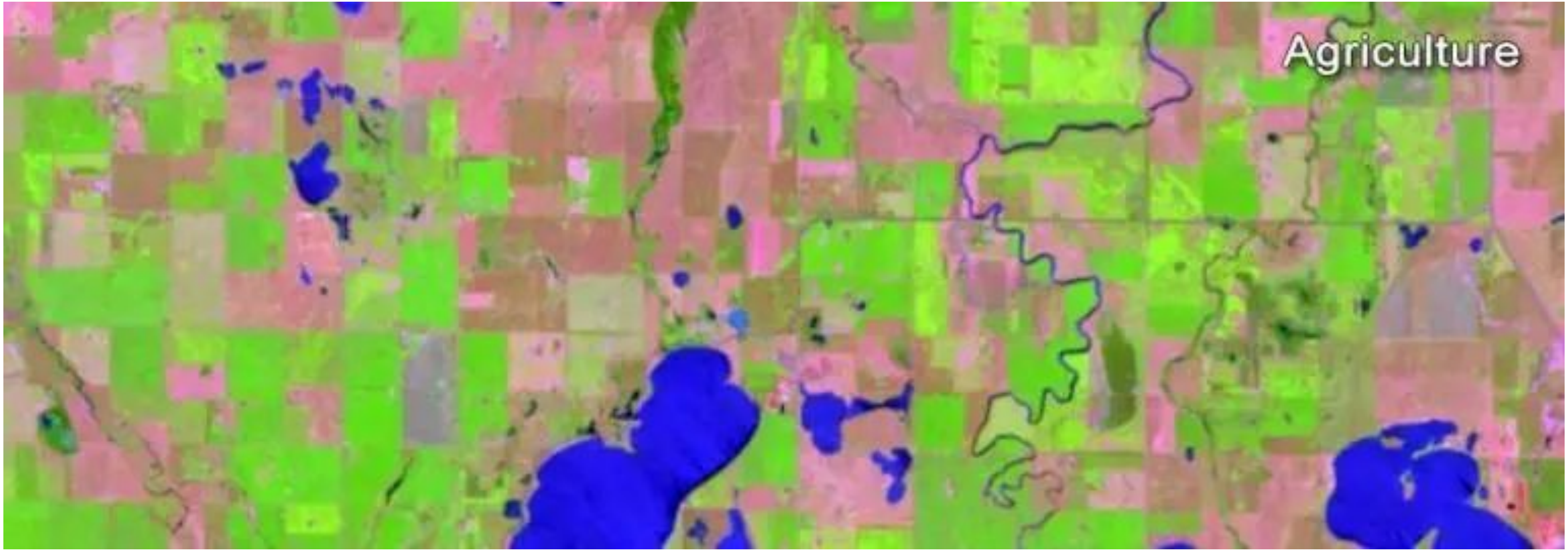
Near-infrared, red, green

Band ratios

SWIR-2, SWIR-1, red

Band ratios

SWIR-1, near-infrared, blue



Band ratios

SWIR-2, SWIR-1, blue

Band ratios

Red, green, coastal band

Today’s lab

Lab Assignment #1: Resolution and scale

Objectives:

- Learn the basic functions of QGIS
- Become familiarized with some of the multiple resolutions and scales encountered in remote sensing

Deadline: October 5 Tuesday 11:59 pm