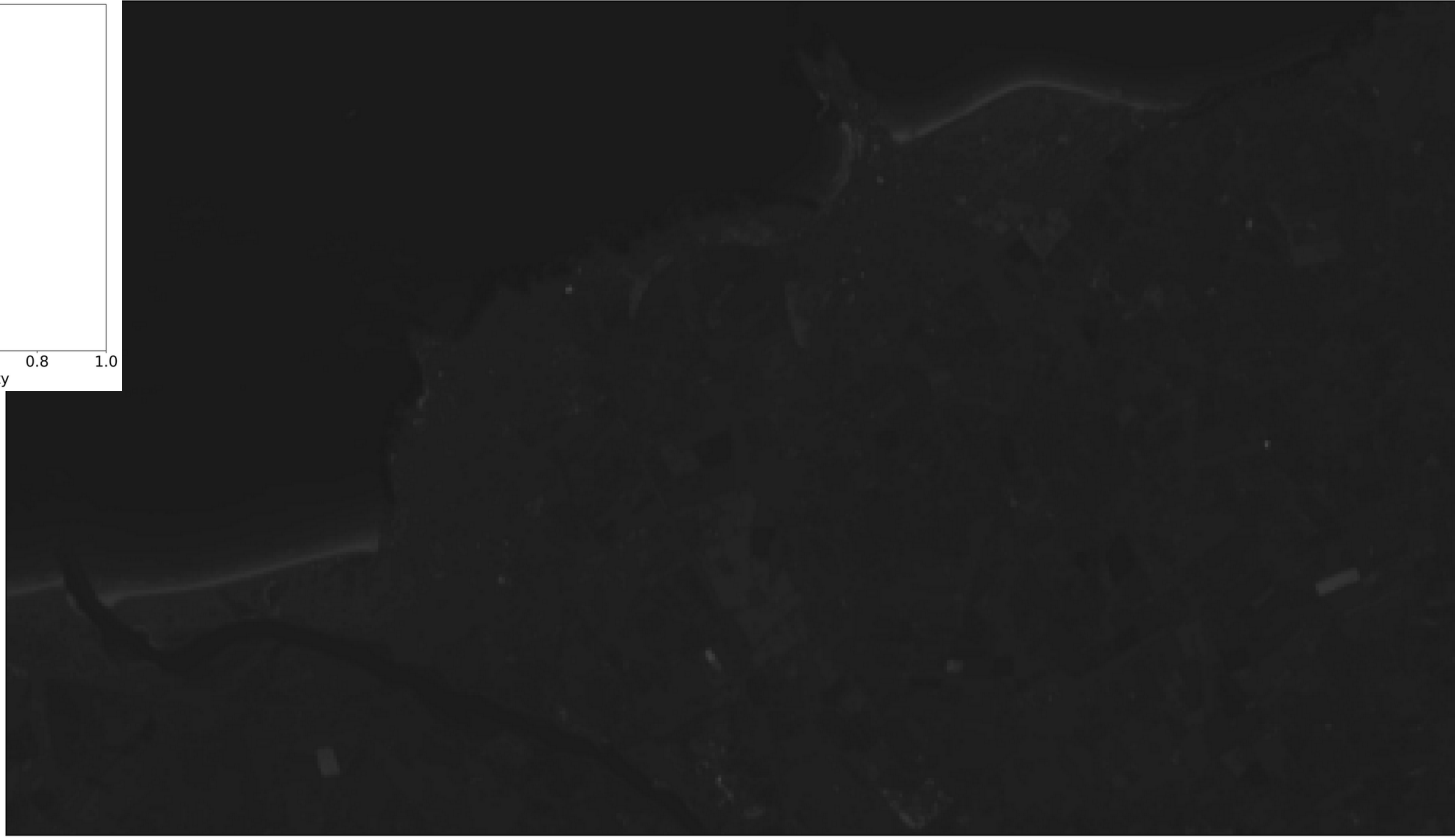
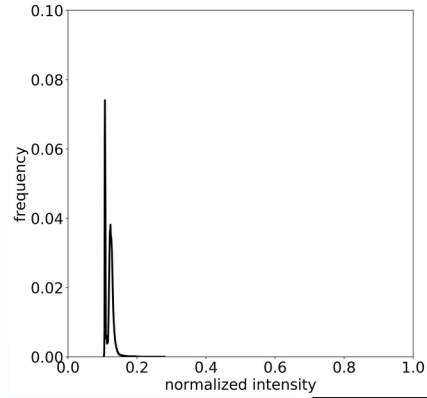


EGM702 – Photogrammetry and Advanced Image Analysis

Week 3, Part 2: Image Enhancement

- Sometimes, we want to improve the appearance of an image:
 - Aid visual interpretation
 - Aid other analysis
 - Presentation
- Broad classes we will discuss:
 - Linear vs nonlinear enhancement
 - Local vs global
 - Filtering

Low-contrast images

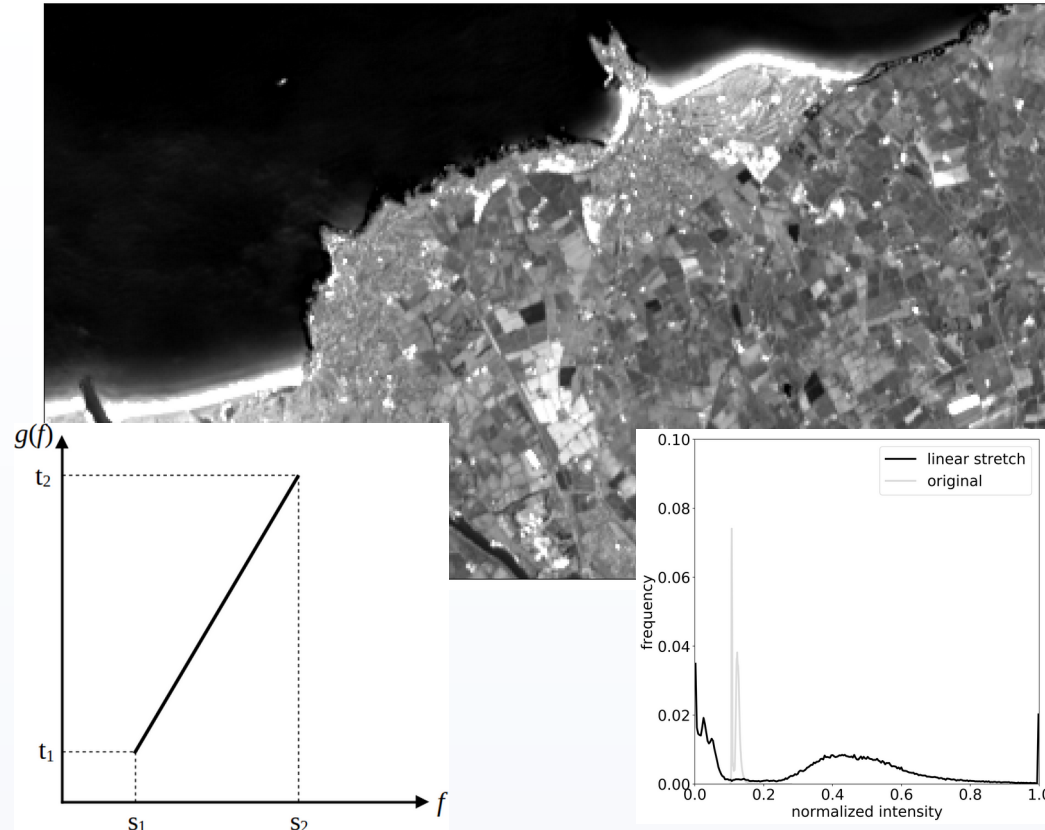


Linear contrast stretching

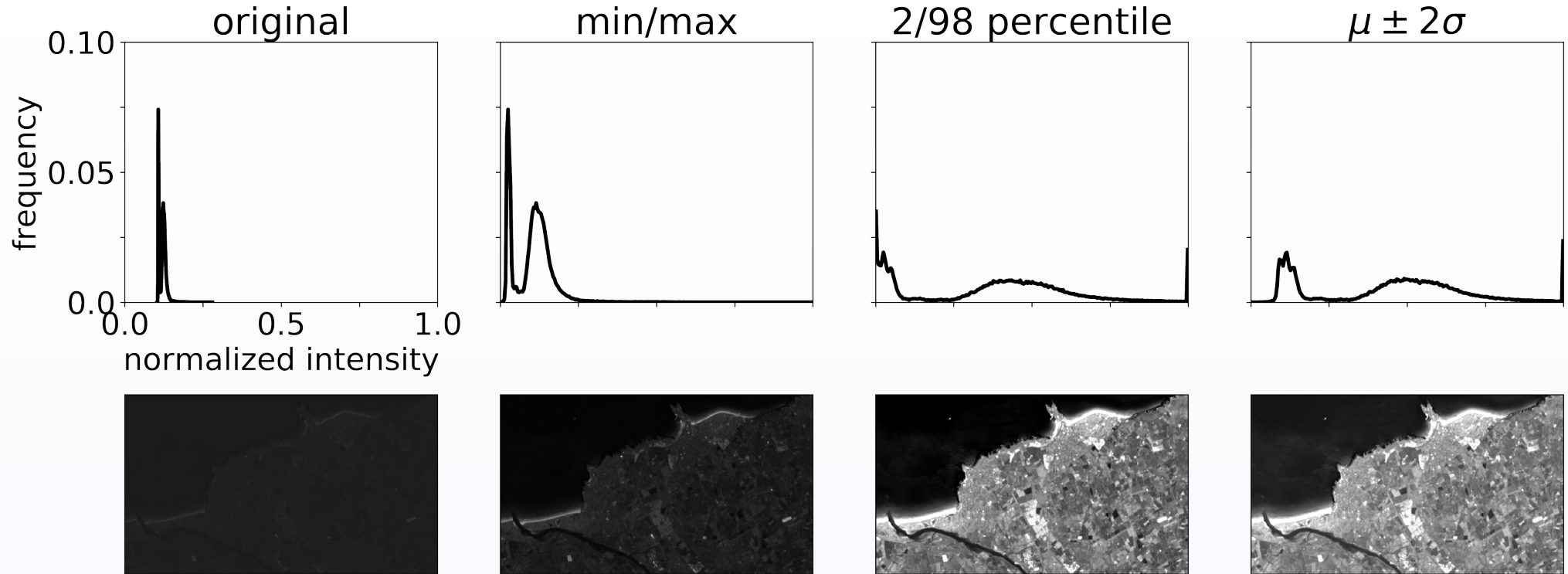
- Linearly stretch original values to a new range
- With g the stretched image, f the original image:

$$g(f) = af + b$$

- Use desired min/max values (t) to determine a, b
- Can also use **piecewise linear** functions (i.e., segments with different a, b)
 - Want monotonically increasing segments

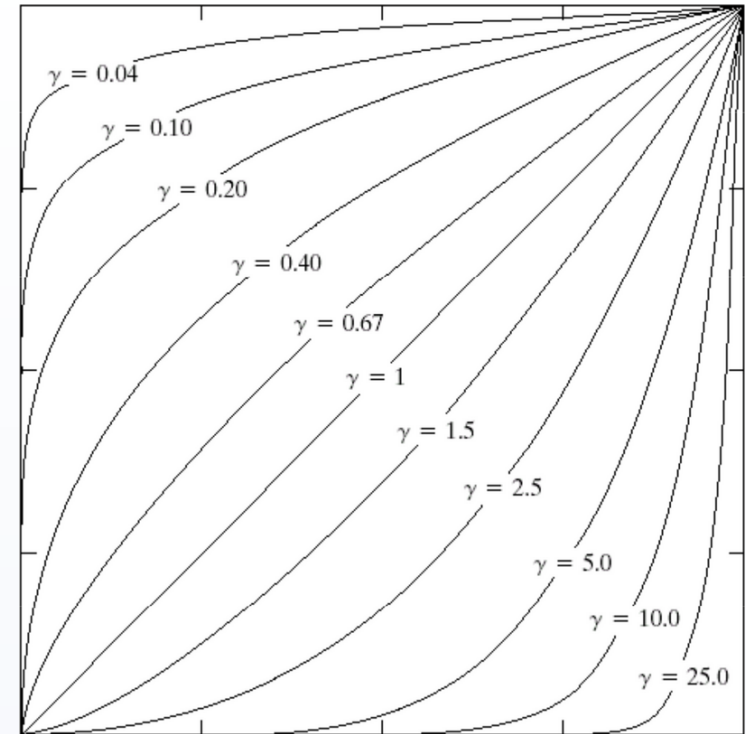


Linear contrast stretches

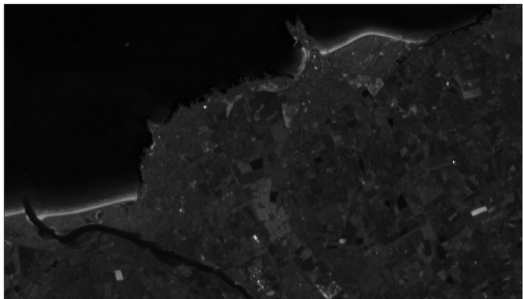
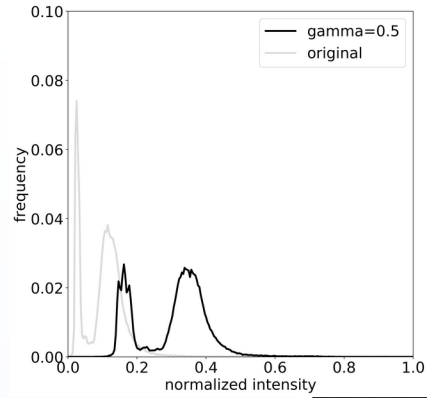


Nonlinear contrast stretching

- Stretched image $g(f)$ is **not** a linear function
- Examples:
 - Logarithmic: $g(f) = b \log(af + 1)$
 - Exponential: $g(f) = b(e^{af} - 1)$
 - Power law (gamma): $g(f) = cf^\gamma$
- Use to enhance dark regions, suppress bright areas

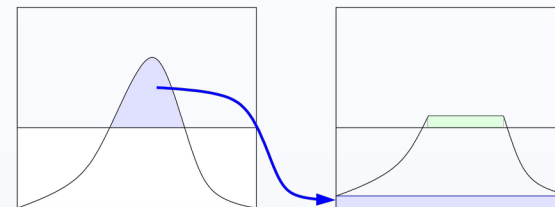
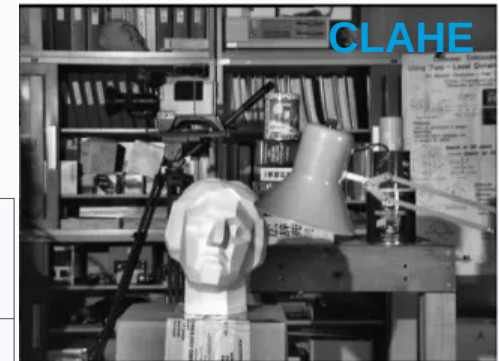
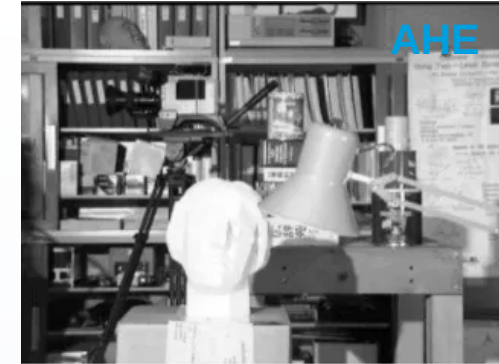


Gamma adjustment



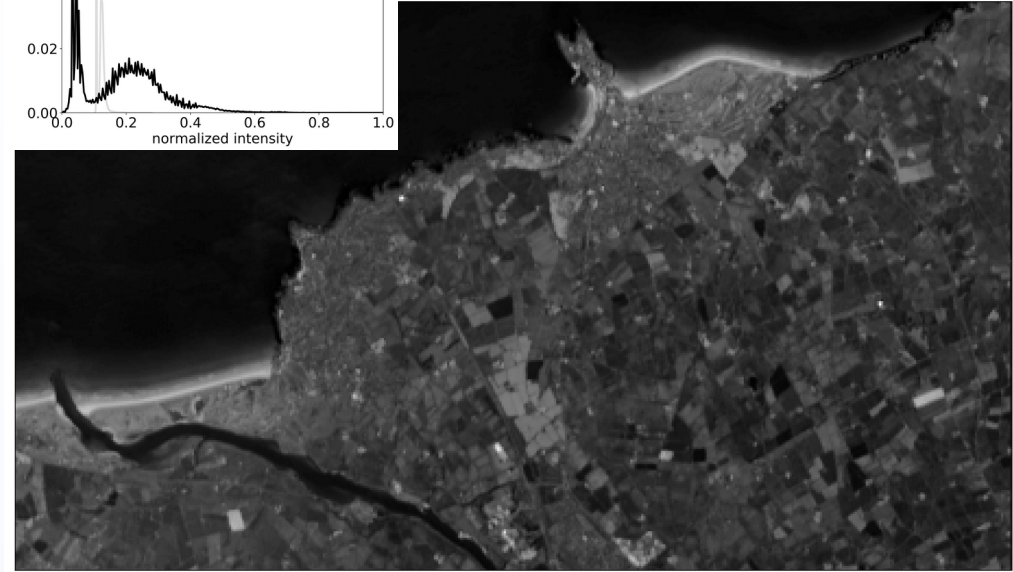
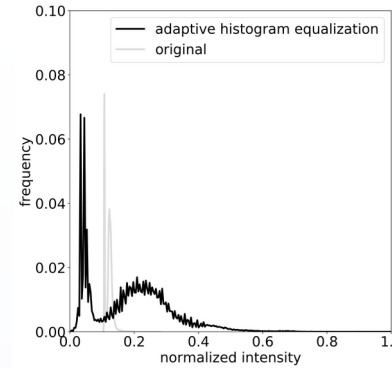
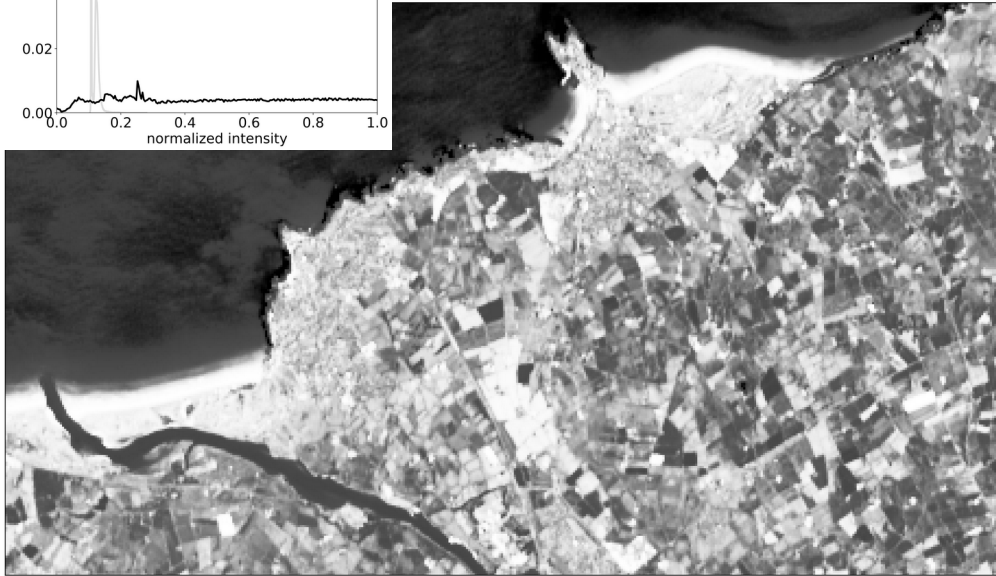
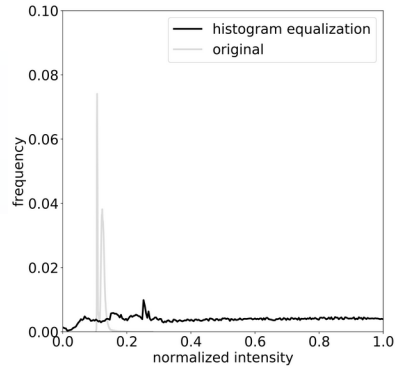
Local vs Global enhancement

- Global: same function for the whole image
 - With especially bright/dark regions, not ideal
- Local: function derived from neighborhood
- Example: adaptive histogram equalization (AHE)
 - Equalize (flatten) histogram using subsets of image
 - In 'flat' areas, can amplify noise: Contrast-Limited AHE (CLAHE)

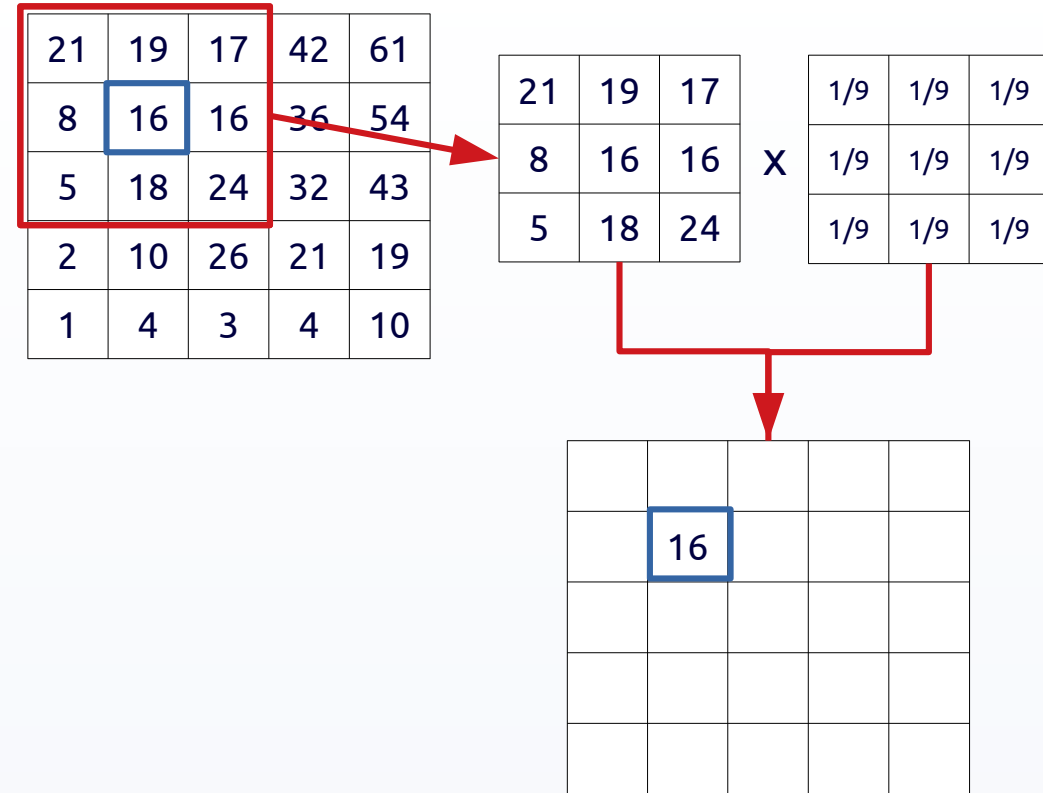


[wikimedia.org](https://commons.wikimedia.org/wiki/File:CLAHE_demo.jpg)

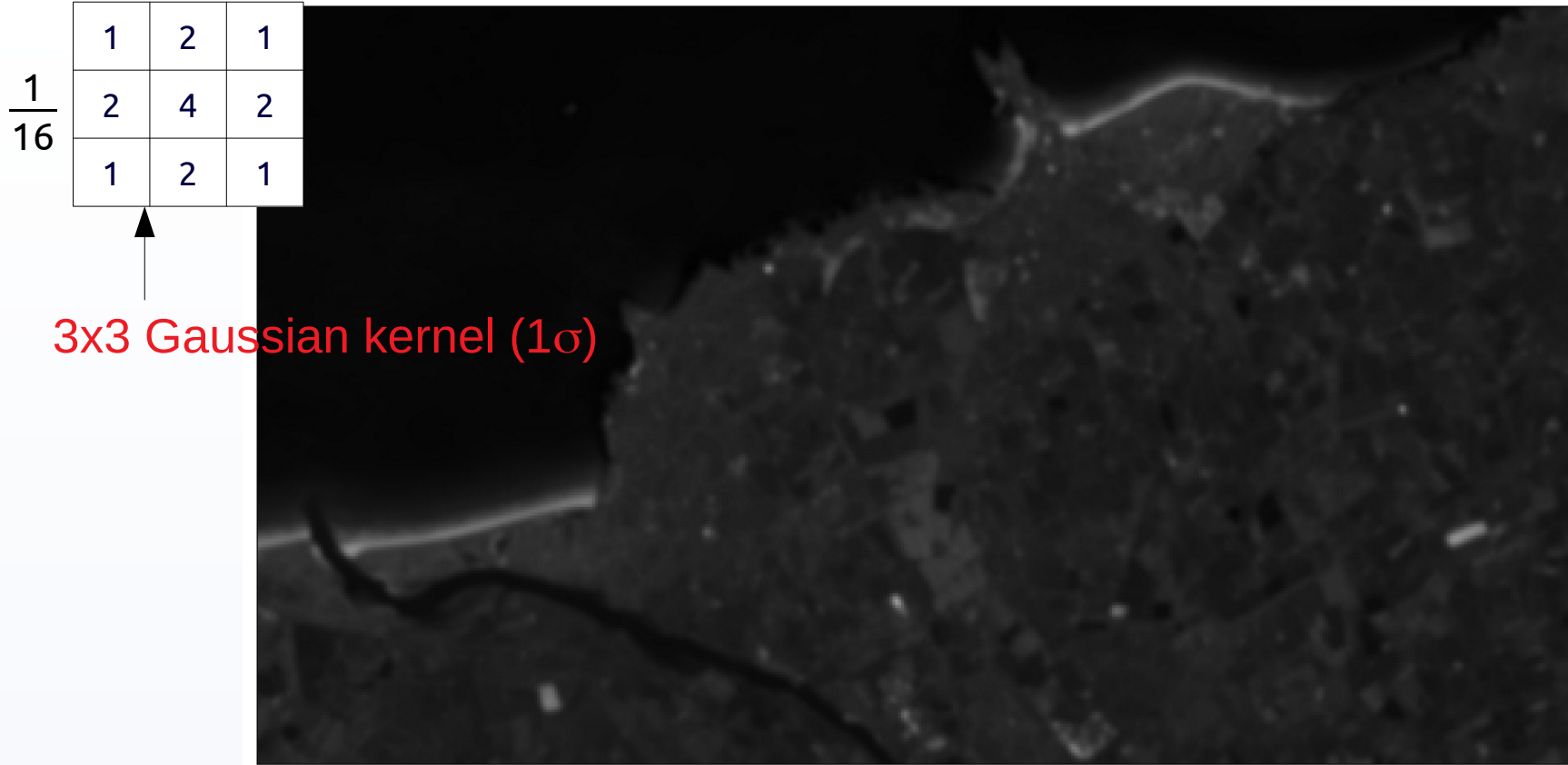
Histogram equalization



- Filters enhance or smooth image data
- Can highlight certain features, suppress other ones
- Uses:
 - Edge detection
 - Sharpening
 - Noise reduction
- Can operate in spatial or frequency domains
- Convolve a kernel (window) with the image
 - For each pixel, calculate the new value using the values that fall within the window
 - Example: 3x3 mean filter



Low-pass (smoothing) filter

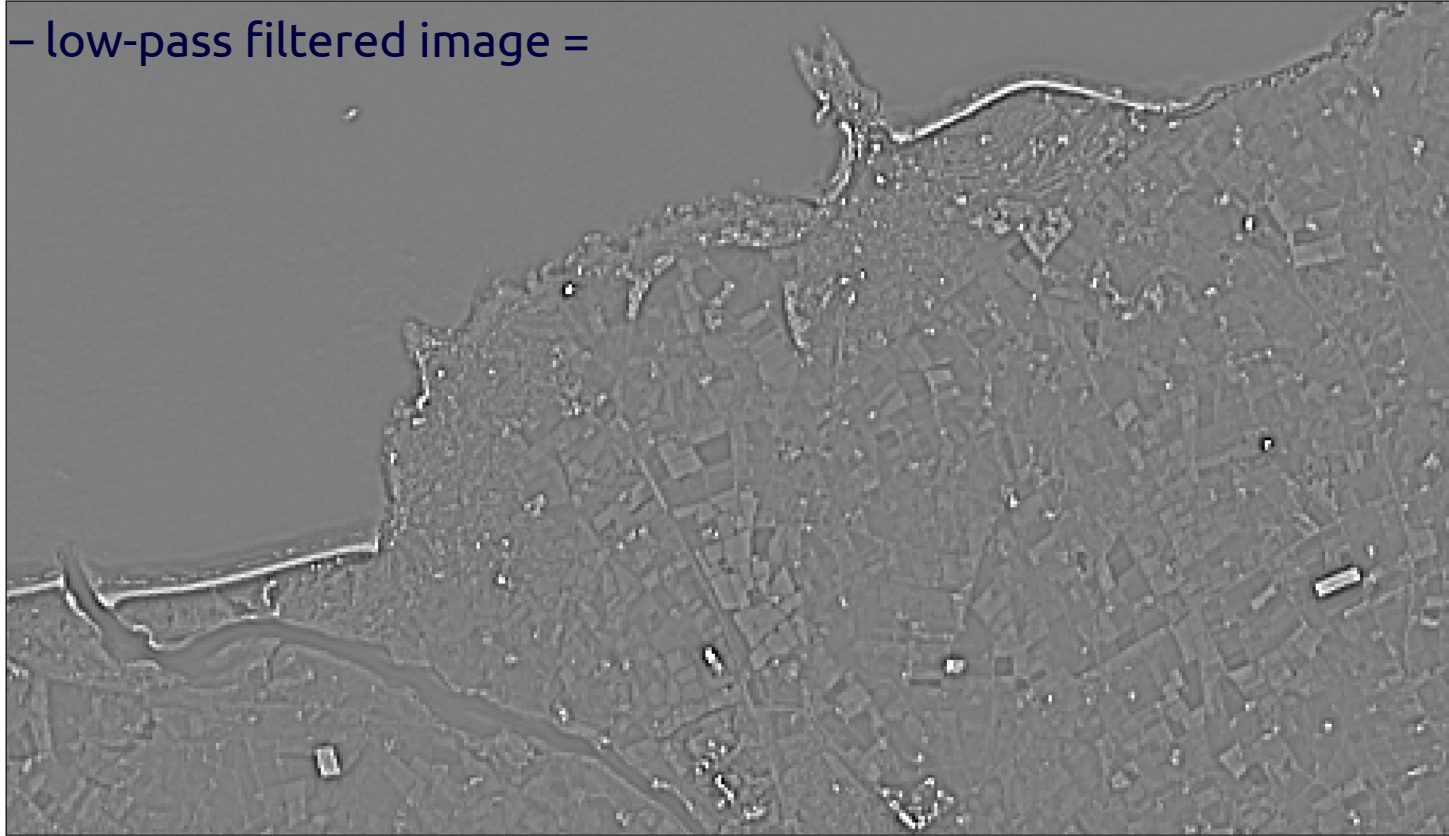


Example: noise reduction



High-pass (sharpening) filter

original image – low-pass filtered image =



Edge filters

-1	0	1
-2	0	2
-1	0	1

← horizontal (x)

vertical (y) →

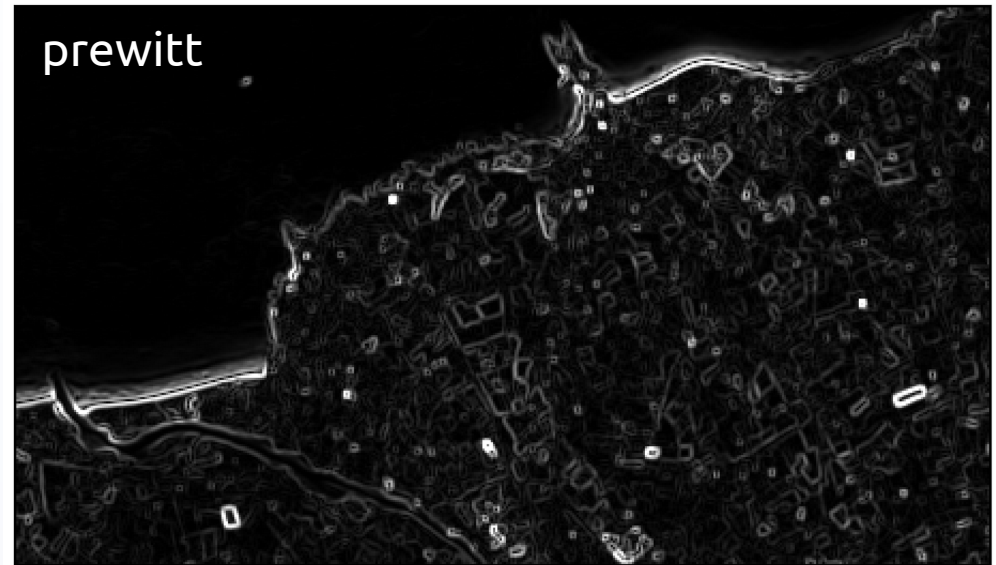
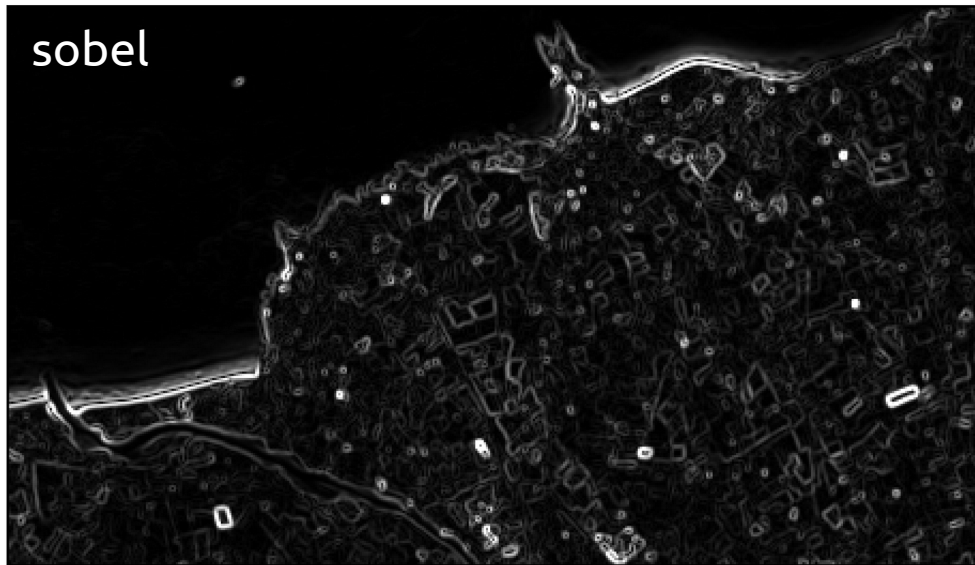
-1	-2	-1
0	0	0
1	2	1

-1	0	1
-1	0	1
-1	0	1

← horizontal

vertical →

-1	-1	-1
0	0	0
1	1	1



- Enhancements help us visually interpret images
- Can also help reduce noise in images
- Contrast stretching helps utilize more range
- Global enhancement not always best
- Filtering can reduce/enhance noise, find edges

- Lillesand, Kiefer & Chipman – Chapter 7
- Tempfli et al. – Chapter 5.4
- Natural Resources Canada [Remote Sensing Tutorials](#)
- How Blurs & Filters Work [[computerphile](#)]
- Finding the Edges (Sobel Operator) [[computerphile](#)]
- Contrast Stretching in ArcGIS [[Karen Joyce](#)]