REMOTE SENSING
&
DIGITAL IMAGE PROCESSING

Beril Sirmacek, Dr. -Eng.

RAM. ROBOTICS AND MECHATRONICS

Content

- What is remote sensing?
- Common sensors
- Common applications
- Mathematical algorithms
- Doing some cool stuff

Goals

- You will know what remote sensing is and for which purposes this field gets attention
- You will know how to select data/sensor for a specific application
- You will know about the image processing algorithms which can help you to create these applications
- You will know about software platforms to perform these applications

What is remote sensing?

What is remote sensing?

What is remote sensing?

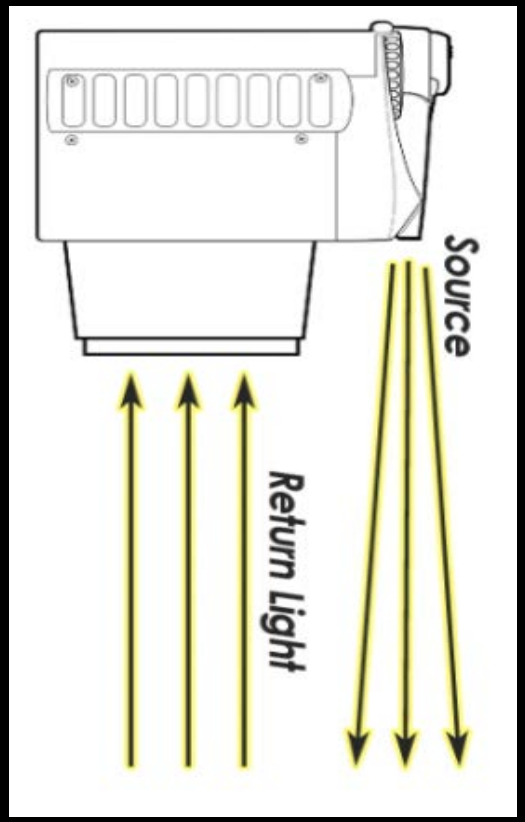
~1870

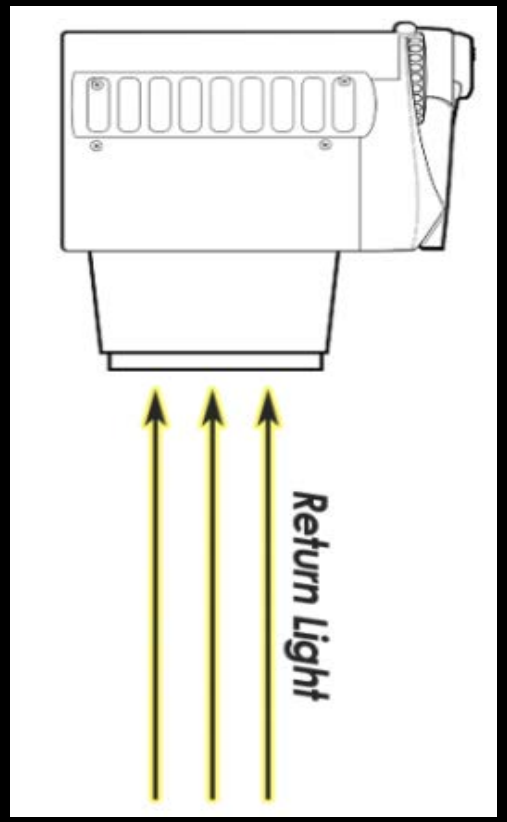
1906 San Francisco

http://www.oneonta.edu

What is remote sensing?

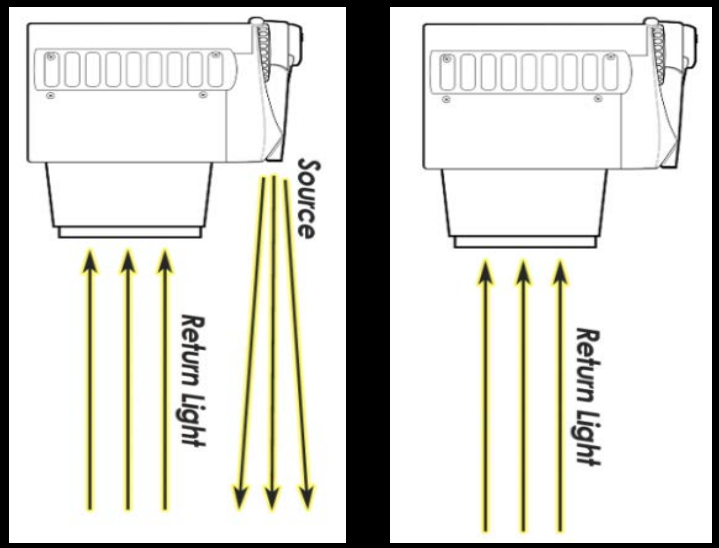
Common sensors

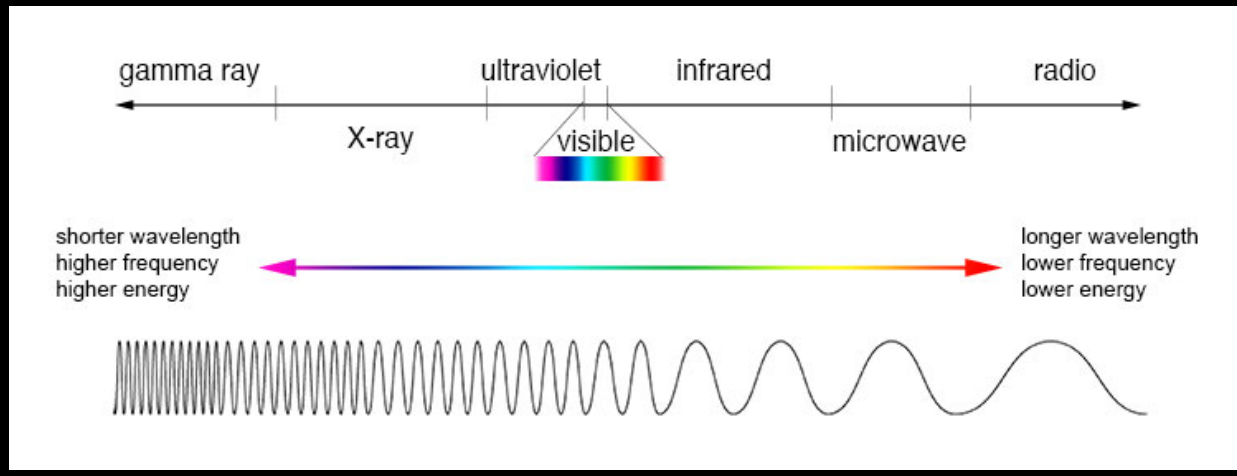




Active sensor

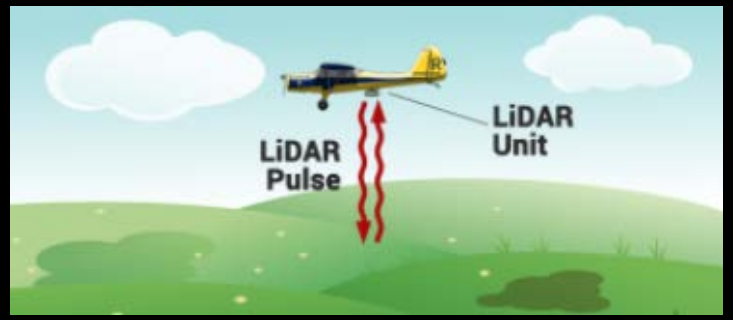
Common sensors



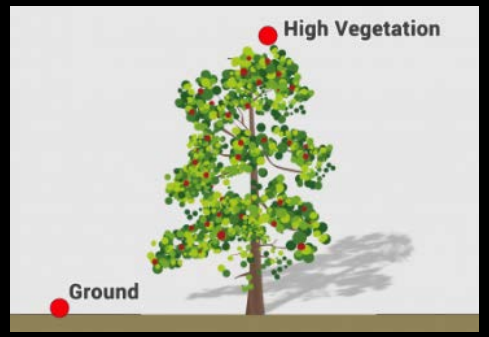


Common sensors *active*

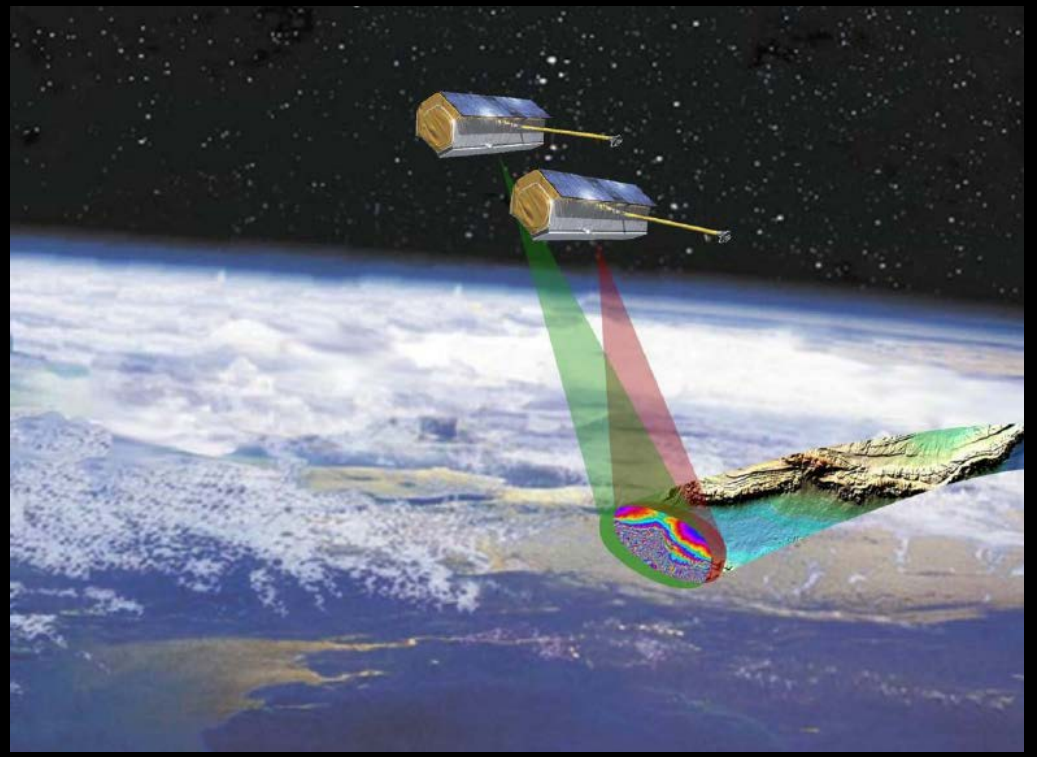
- RADAR (SAR)
- LiDAR (Light detection and Ranging)



http://gisgeography.com



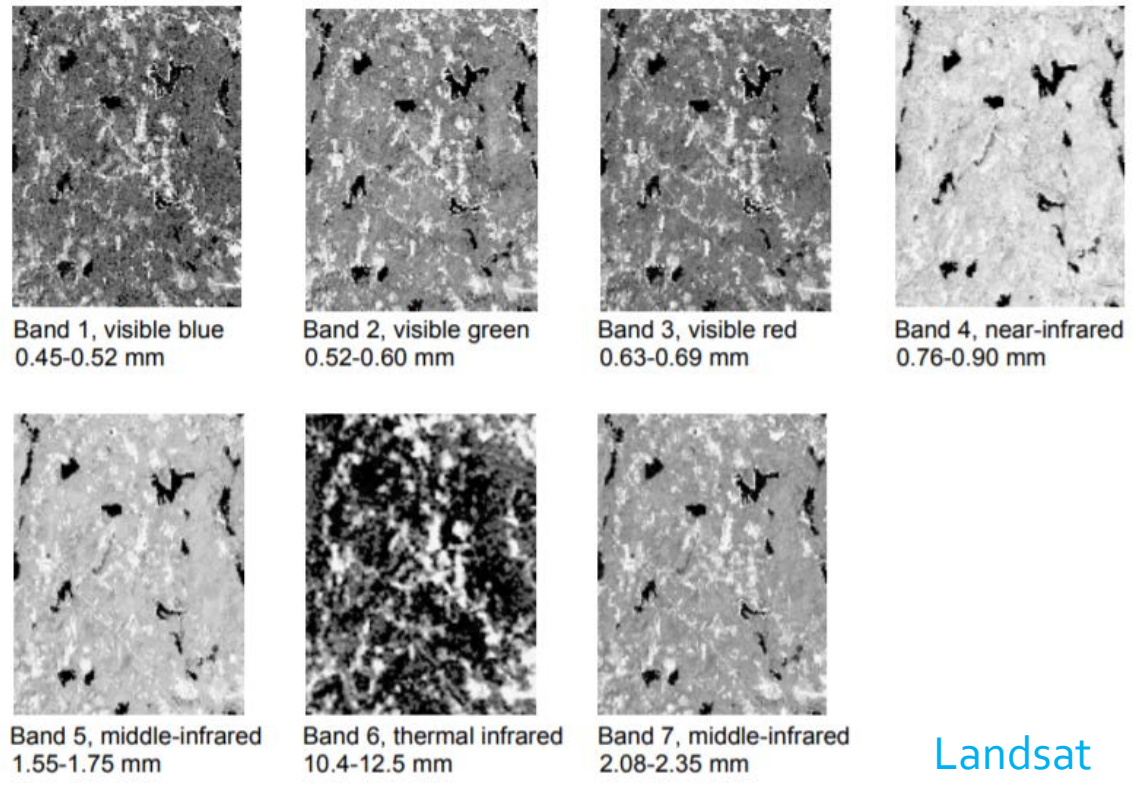
AHN = Actueel Hoogtebestand Nederland

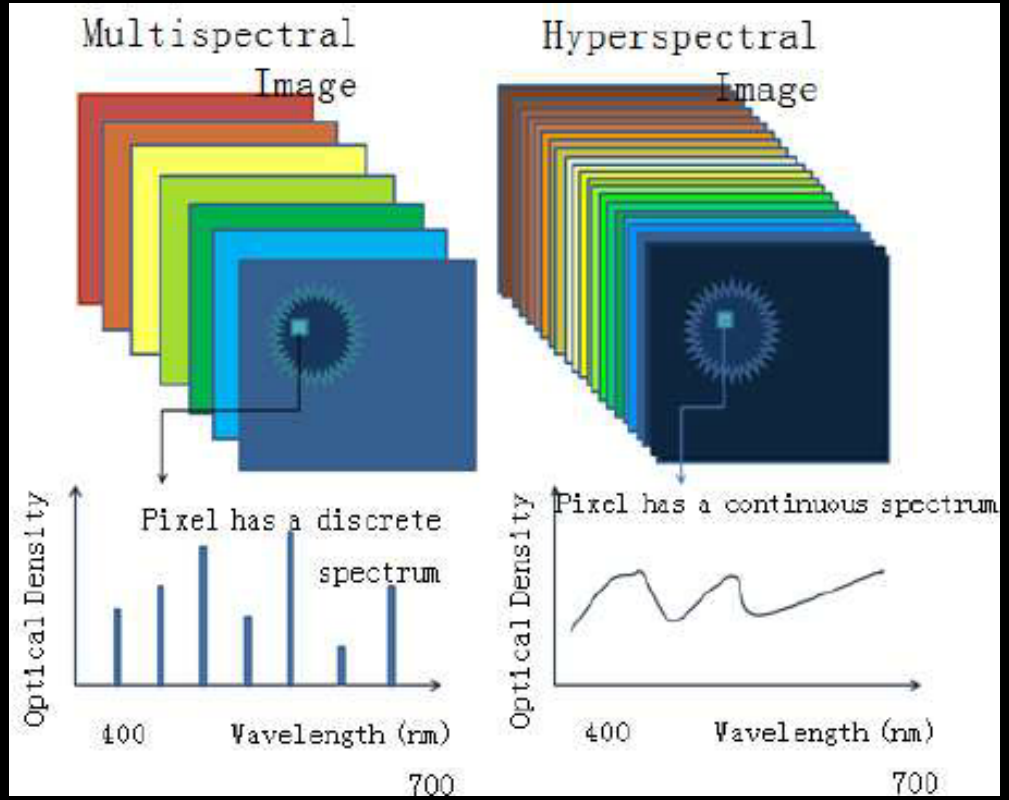


tandem satellites (DLR)

Common sensors passive

- RGB
- Multispectral
- Hyperspectral



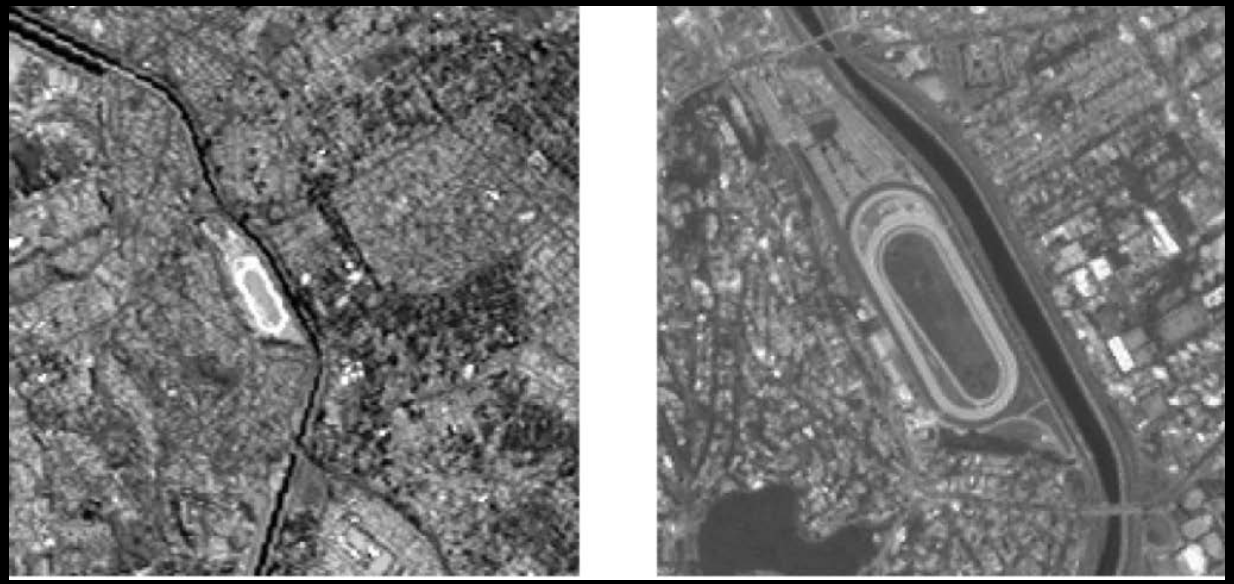


Ibraheem, Issa. (2015). Early detection of melanoma using multispectral imaging and artificial intelligence techniques.

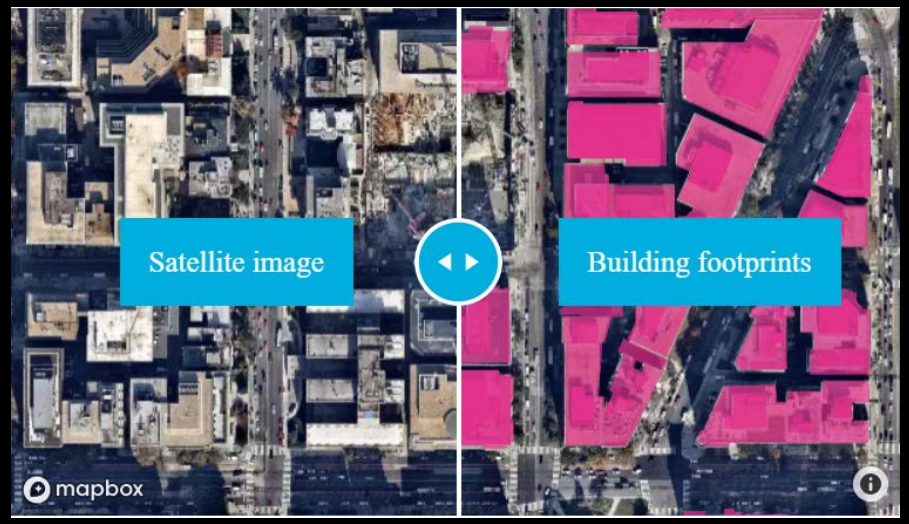
Common sensors

Interesting specifications

- Spatial resolution
- Spectral resolution
- Swath width
- Visiting frequency



30m resolution 10 m resolution



Digital globe

Common applications

- DSM/DEM/DTM
- Hyperspectral signatures

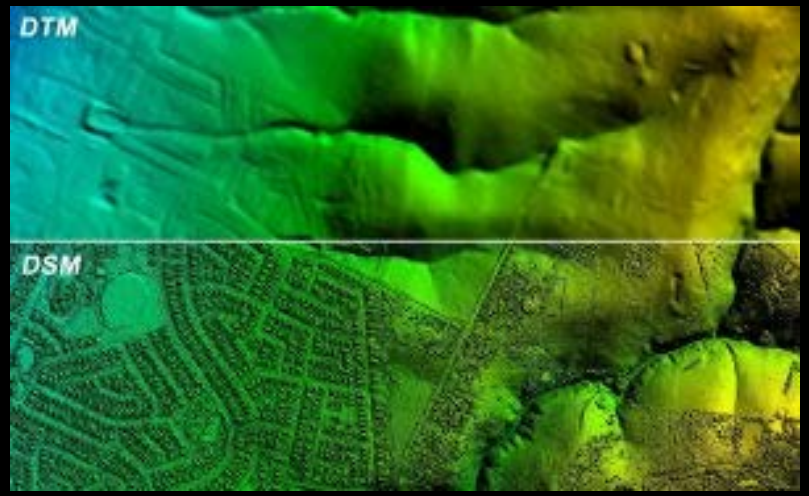
What you can mathematically derive…

Common applications

- DSM/DEM/DTM
- Hyperspectral signatures

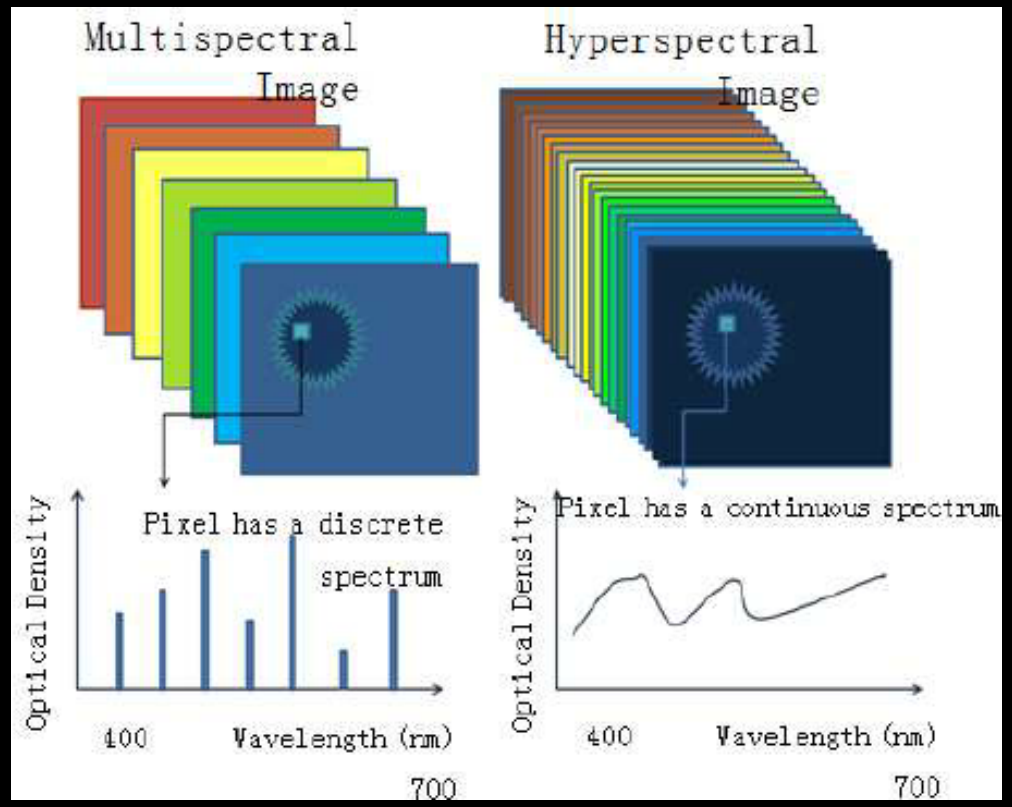
SIFT features

Point-matching method for remote sensing images with background variation Xiaolong Shi, Jie Jiang



Common applications

- DSM/DEM/DTM
- Hyperspectral signatures



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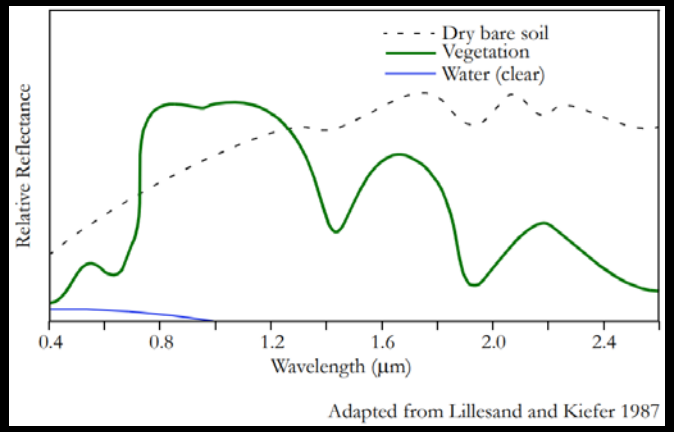

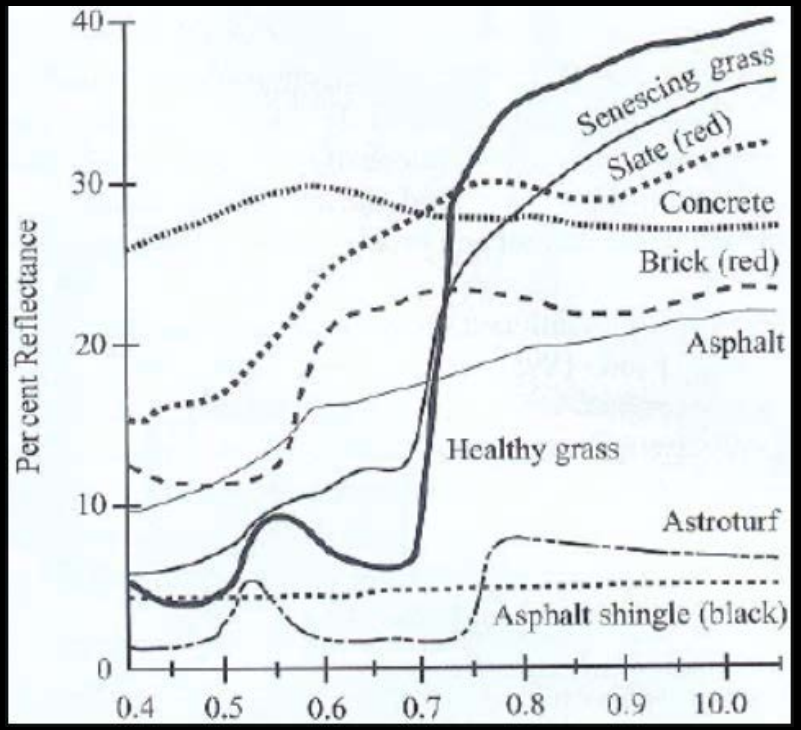

Common applications

Where you can apply…

- Forests (logging, CO_2 absorption volume)
- Oceans (security, climate change)
- Wild animals (environmental sciences)
- Water contamination
- Agriculture
- Disease (plants, soil, water, air)
- Soil content (minerals, fertilizers, moisture)
- Early fires
- Predicting Earthquakes / Avalanches
- Social/Economical/population growth
- Meteorology (predicting hurricanes, rain etc.)

Common applications

Where you can apply…

https://www.bloomberg.com

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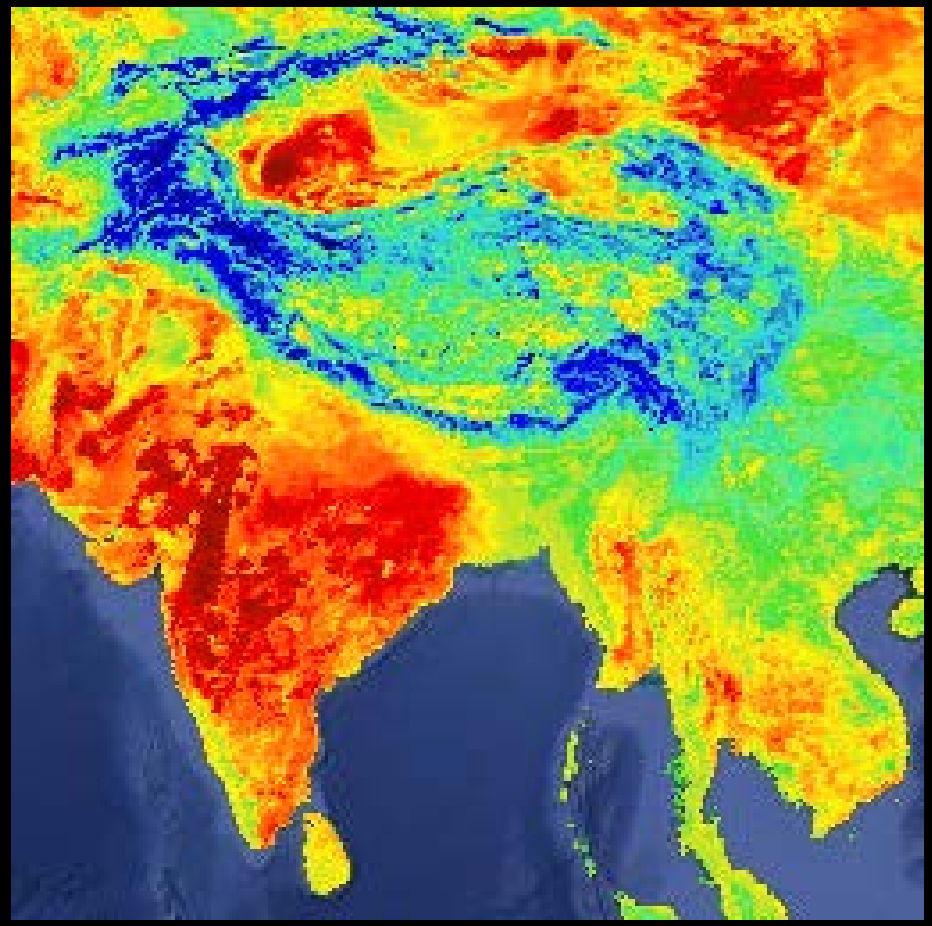
Common applications

Where you can apply…



Surface heat map from Google earth engine

Common applications

Where you can apply…

Economy indicators:

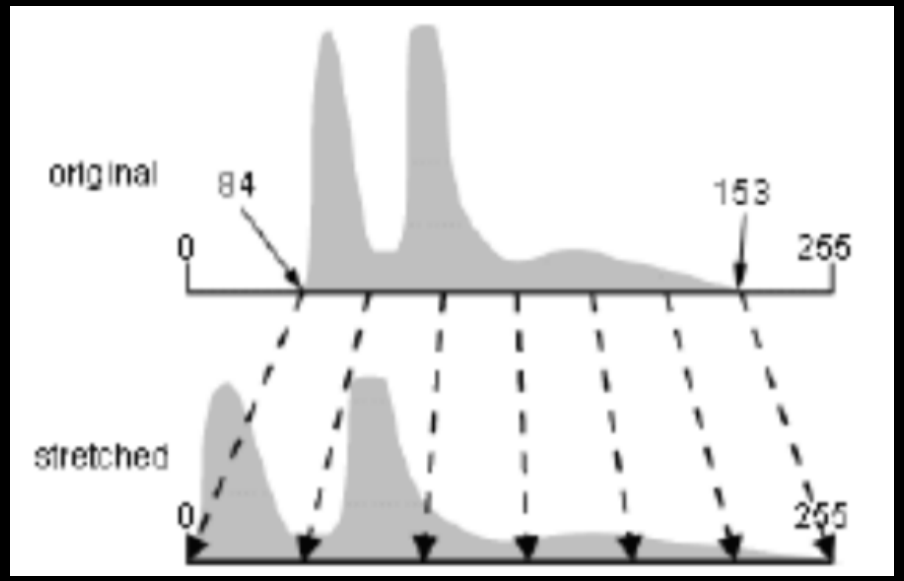
- Night lights
- Building heights / sizes / numbers
- Highway density
- Number of ports (air/sea)
- Size of the industrial areas
- Size of the agricultural areas

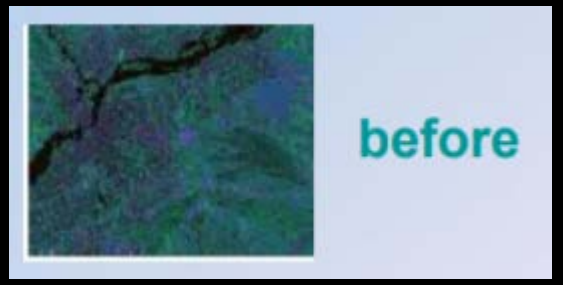
Mathematical algorithms

- Image enhancement / de-noising/ sharpening
- Edge detection
- Feature extraction & Matching
- Shape recognition
- Template matching
- Region growing (active shape algorithms)
- Classification (SVM, decision trees etc.)
- Neural networks (deep learning & AI)

Mathematical algorithms

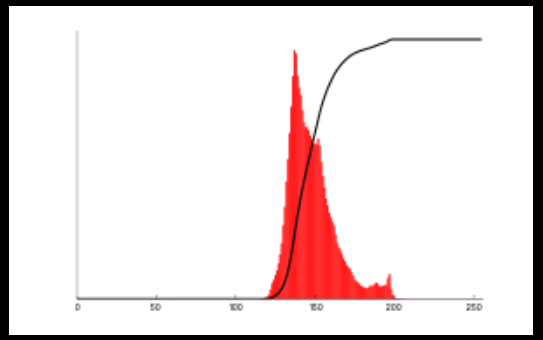
- Contrast stretching (= normalization)

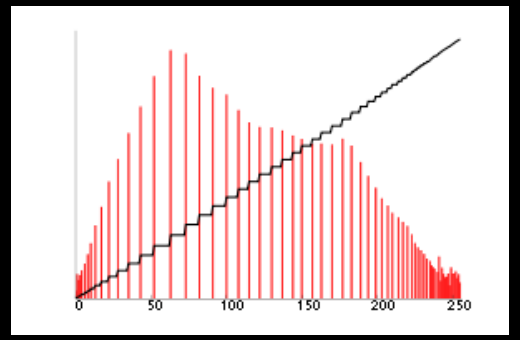




Mathematical algorithms

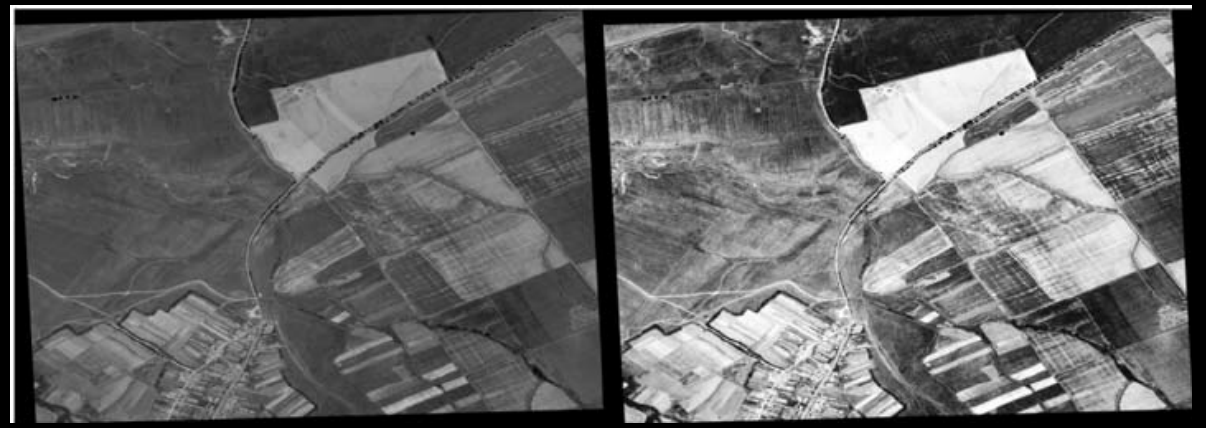
- Contrast stretching (= normalization)



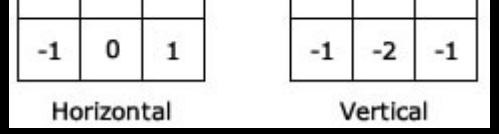


Histogram equalization (making the cumulative function *cdf* linear while stretching)

$$cdf_x(i) = \sum_{j=0}^{i} p_x(j)$$

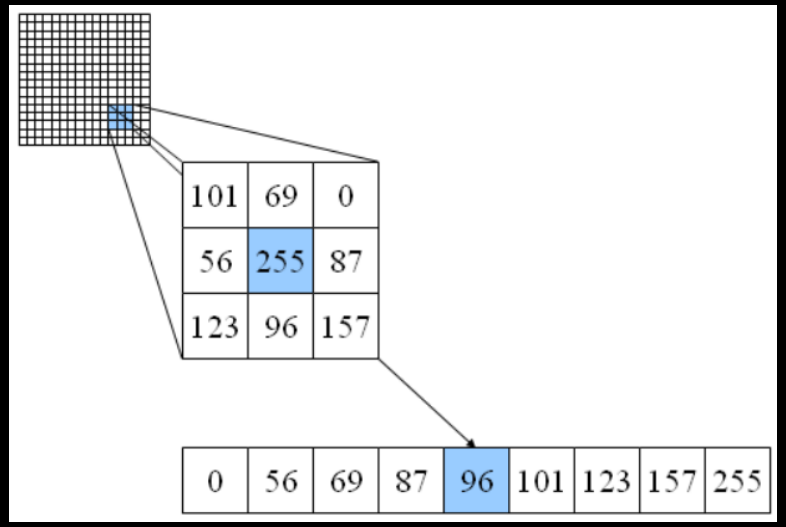


Petcu, Dana & Zaharie, Daniela & Neagul, Marian & Panica, Silviu & Frincu, Marc & Gorgan, Dorian & Stefanut, Teodor & Bacu, Victor. (2009). Remote Sensed Image Processing on Grids for Training in Earth Observation.

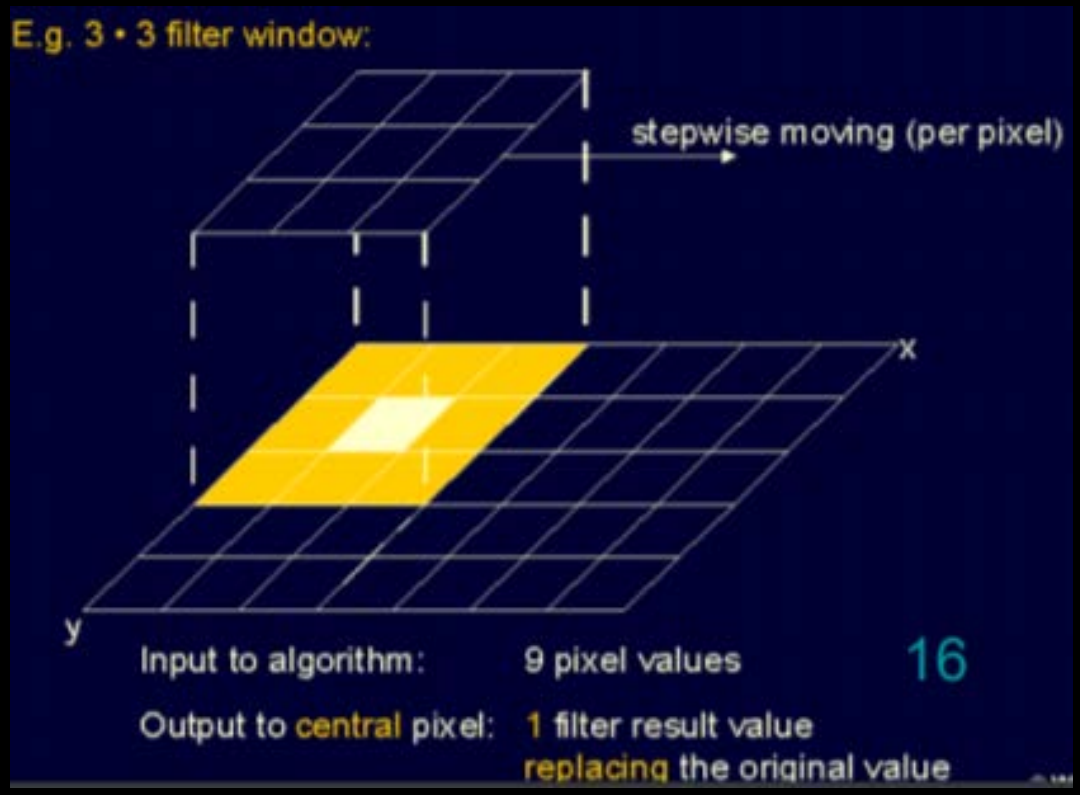


Mathematical algorithms

- Spatial filtering (sharpening, cloud filtering, denoising, edge detection)



If it is a median filter…



Mathematical algorithms

- Spatial filtering (sharpening, cloud filtering, denoising, edge detection)

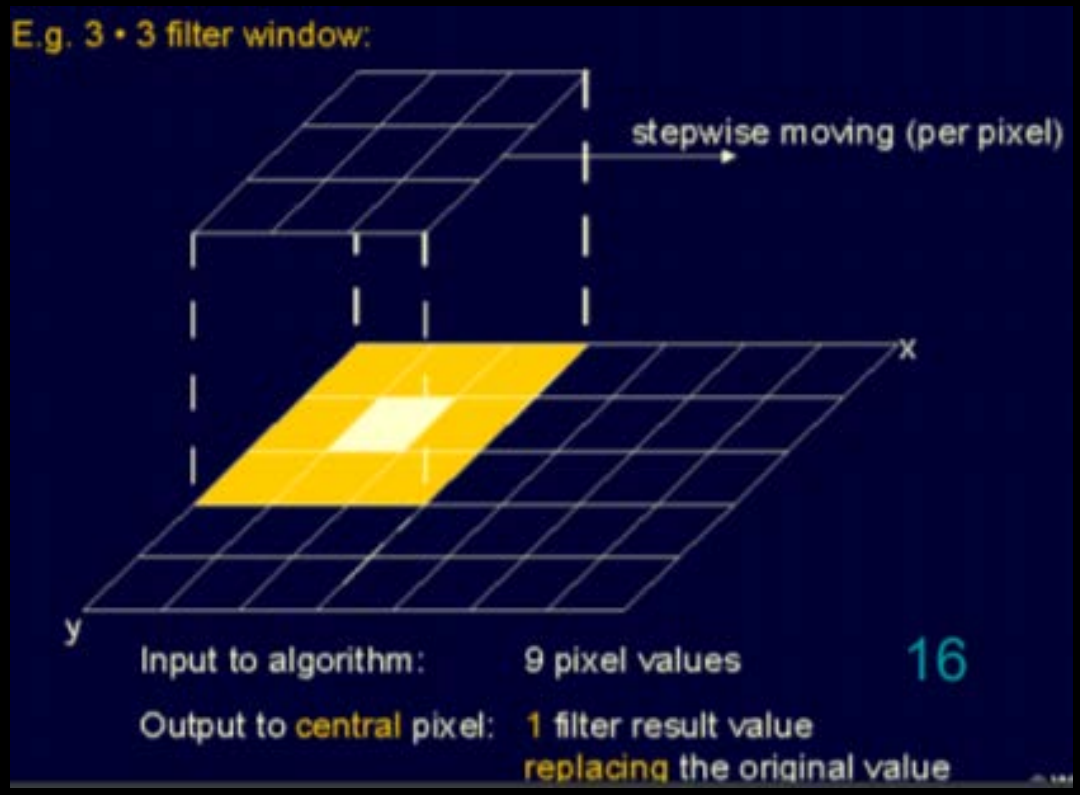
-1	0	1
-2	0	2
-1	0	1

Horizontal

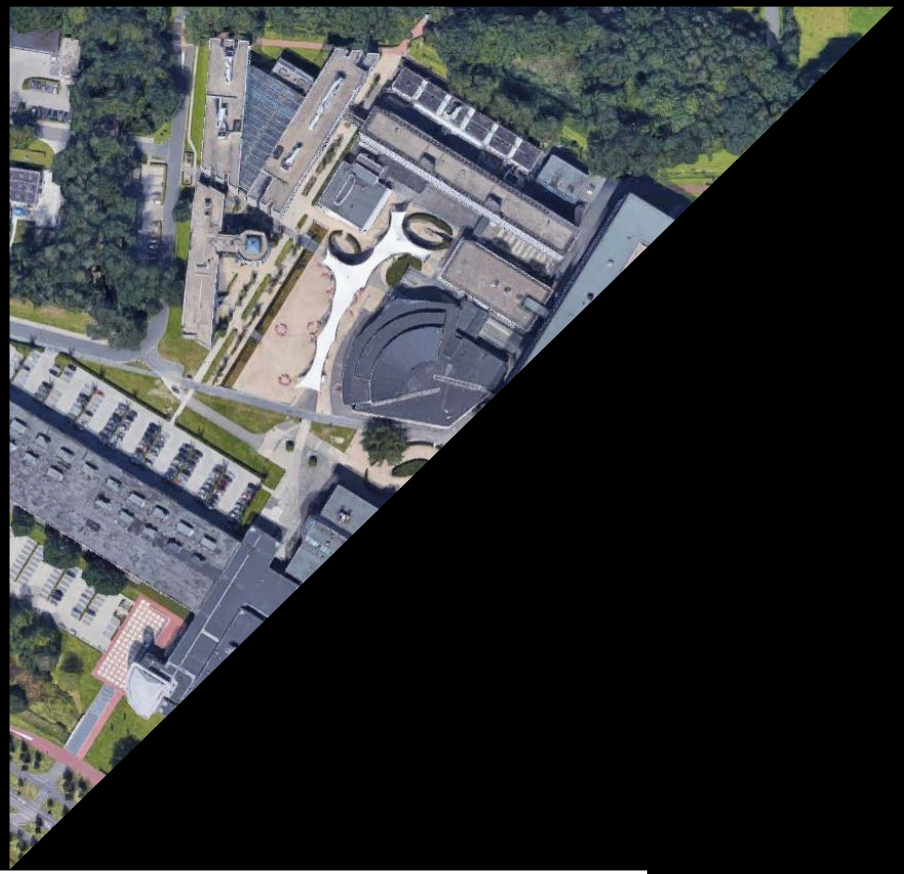
-1	-2	-1
0	0	0
-1	-2	-1

Vertical

Sobel filter…

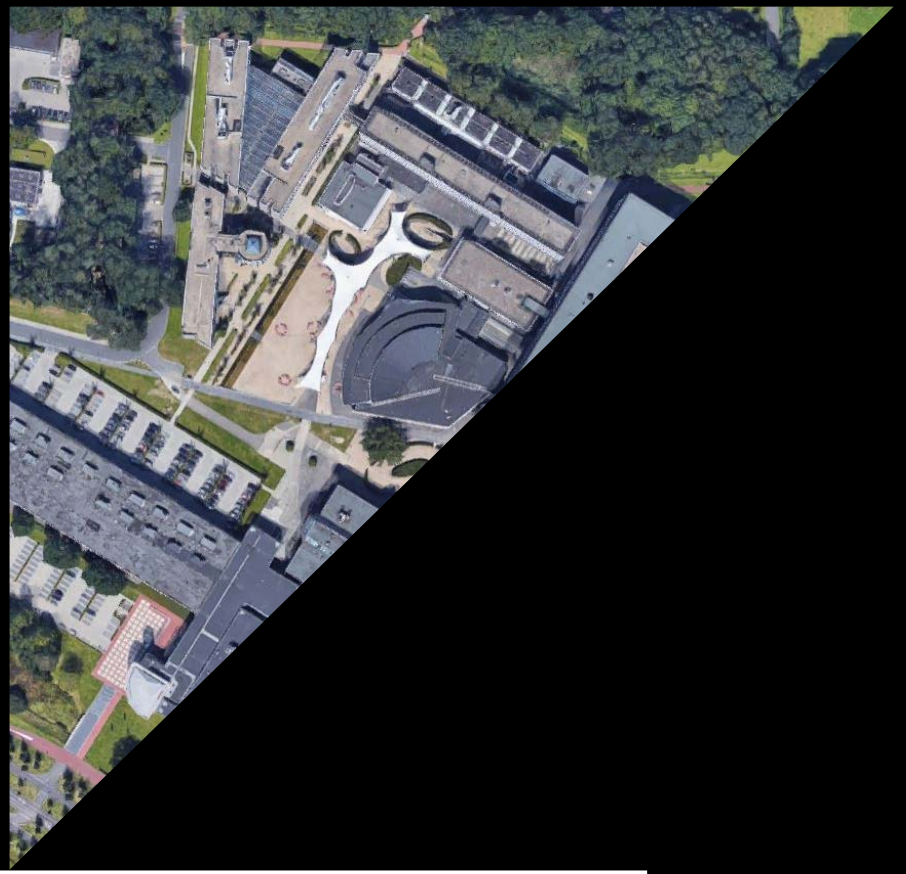


Mathematical algorithms

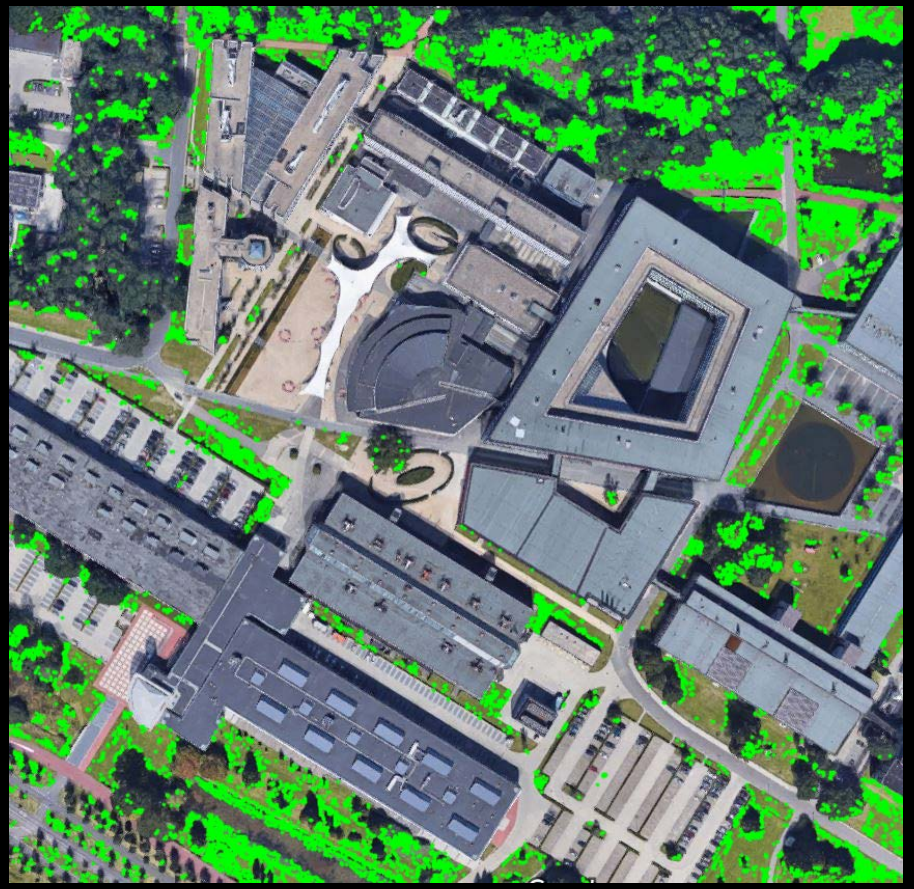


bw = edge(img, 'Sobel')

Mathematical algorithms



if(im(i,j,1)<100 && im(i,j,2)>100 && im(i,j,3)<100)



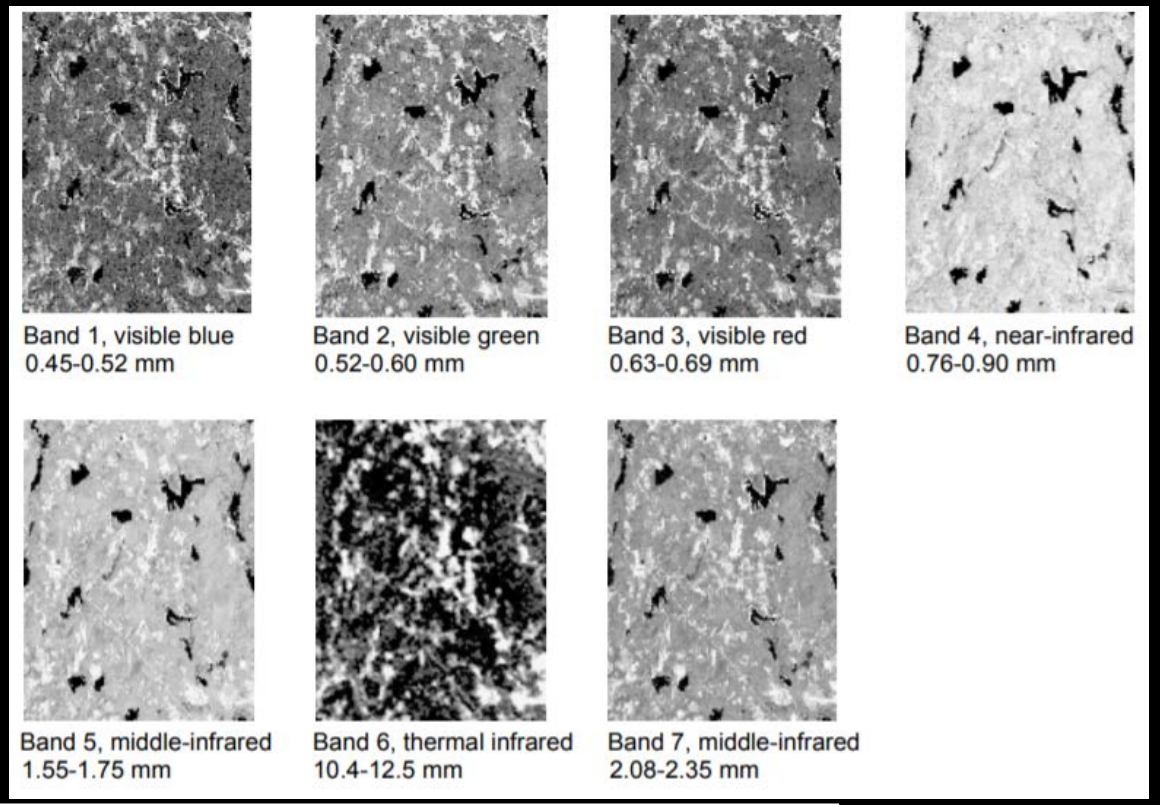
Mathematical algorithms

- Band rationing

$$NDVI = (NIR - R) / (NIR + R)$$

where NIR = Near Infrared

and R = Red

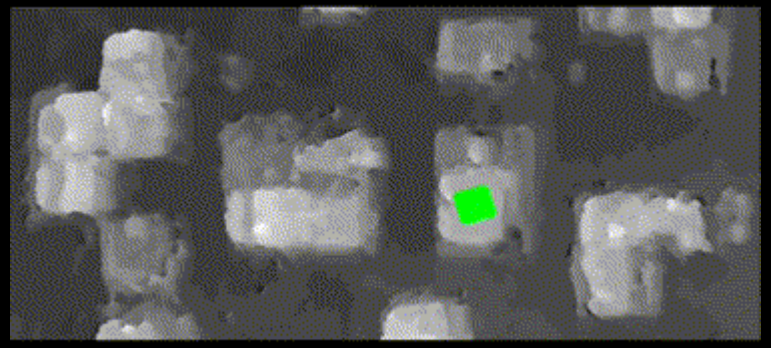


gisgeography.com

Mathematical algorithms

- Region growing (active shape algorithms)

$$E = \sum_{i=1}^{n} min(\sqrt{(x_v(i) - x_e(j))^2 - (y_v(i) - y_e(j))^2})$$



Mathematical algorithms

- Region growing (active shape algorithms)

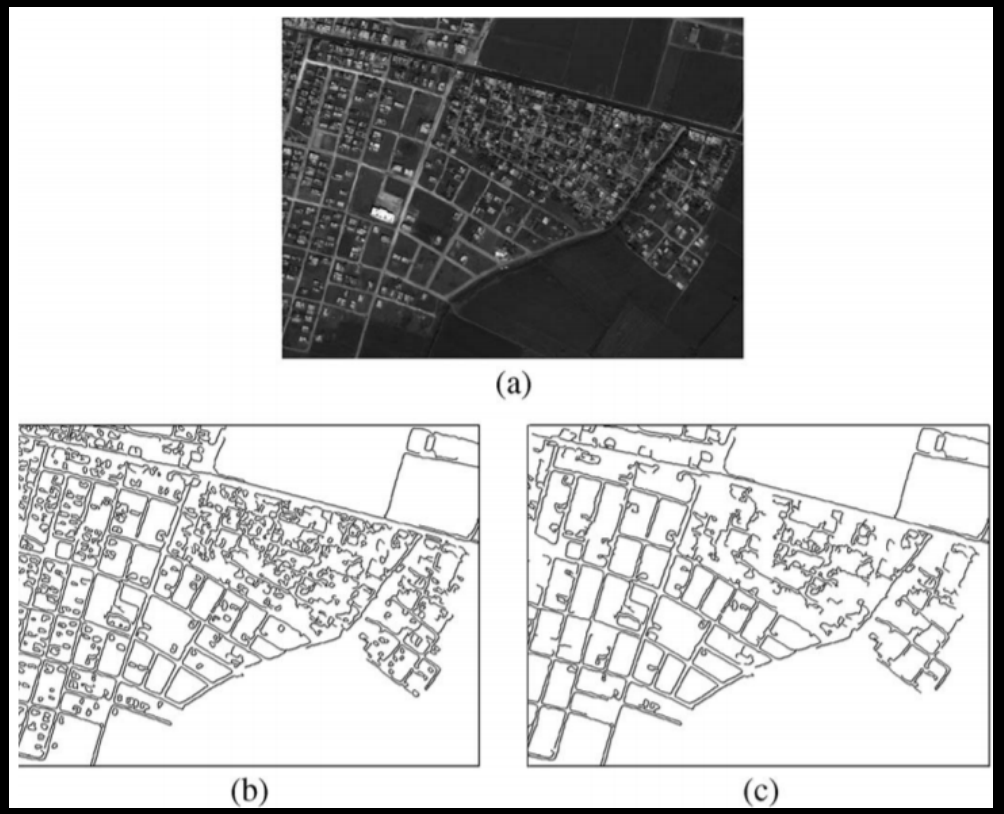
Directional kernel:

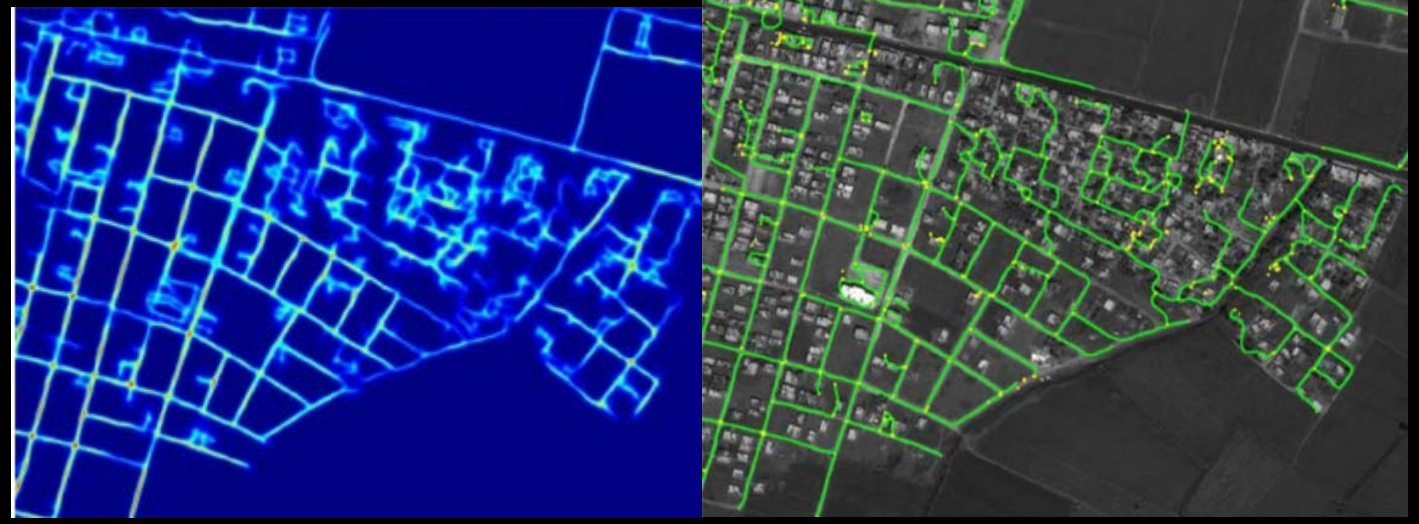
$$N_i(x,y) = \frac{1}{\kappa}\exp(A^T A)$$

$$A = \begin{bmatrix} w_i/2 & 0 \\ 0 & w_i/10 \end{bmatrix} \begin{bmatrix} \cos(\theta_i) & -\sin(\theta_i) \\ \sin(\theta_i) & \cos(\theta_i) \end{bmatrix} \begin{bmatrix} x - x_i \\ y - y_i \end{bmatrix}$$

PDF: showing possible road centers

$$p(x,y) = \frac{1}{\kappa}\sum_{i=1}^{I} N_i(x,y)$$





Road network detection, Sirmacek & Unsalan 2011

Doing cool stuff

- Google earth engine
- ESA website
- Openstreetmaps
- Code libraries

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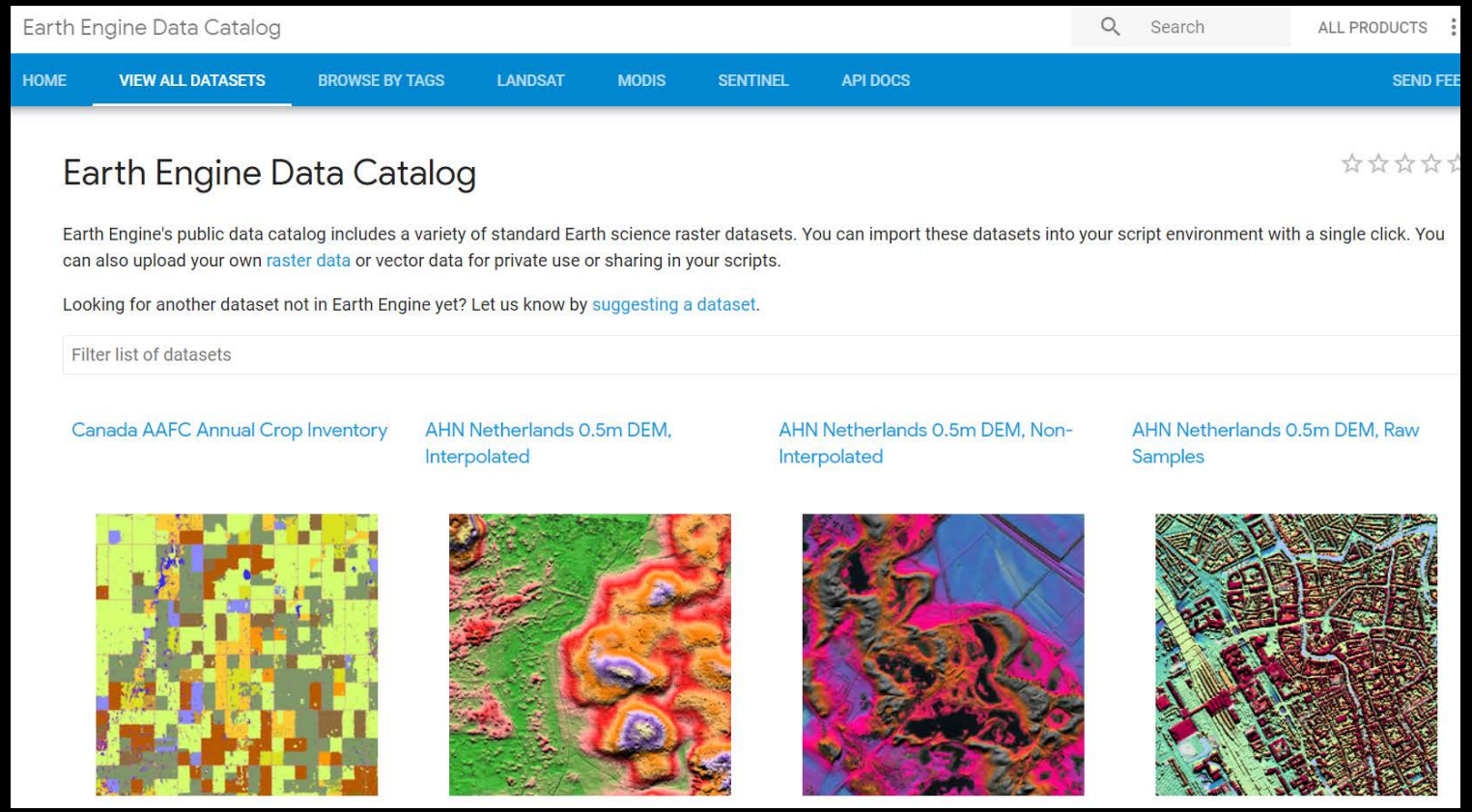

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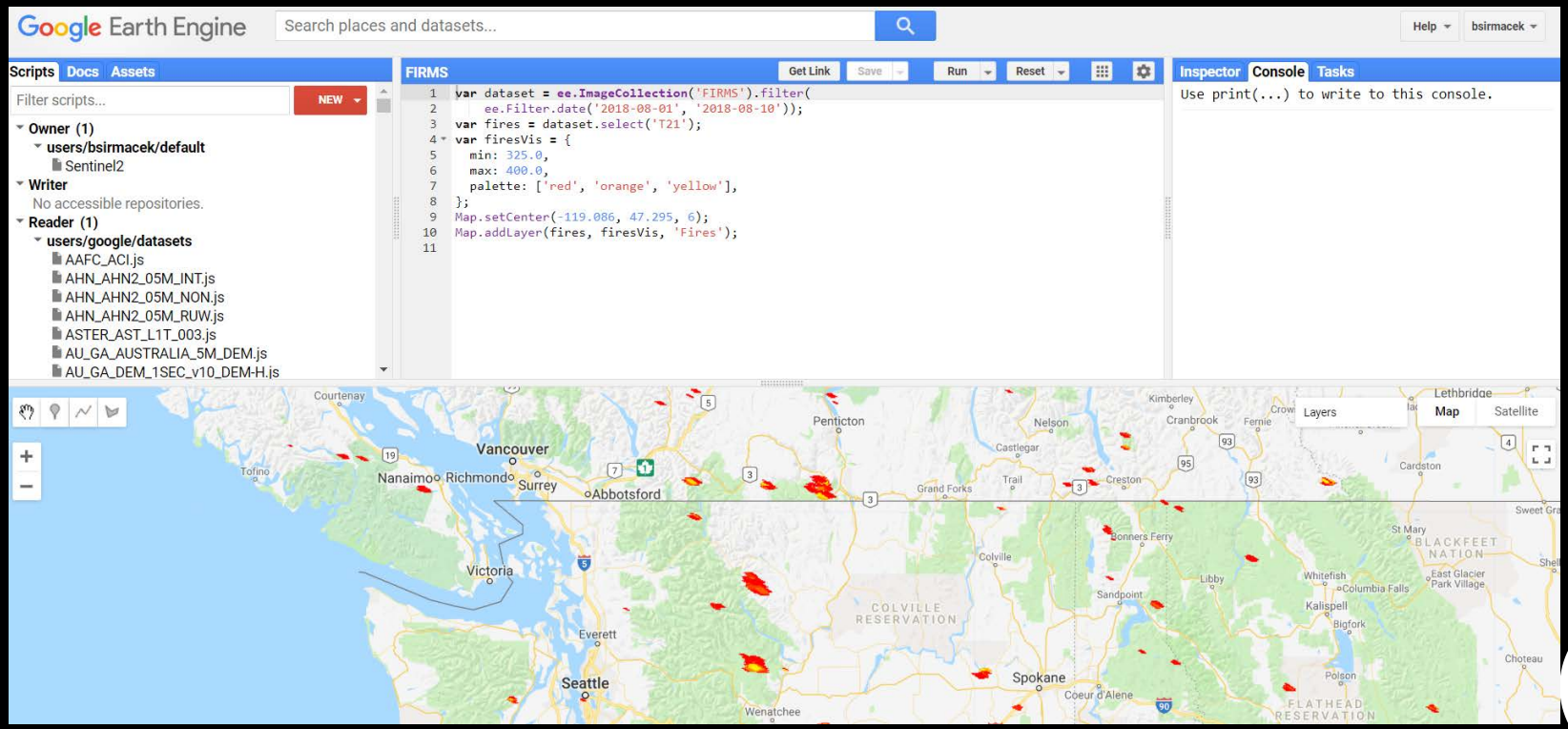

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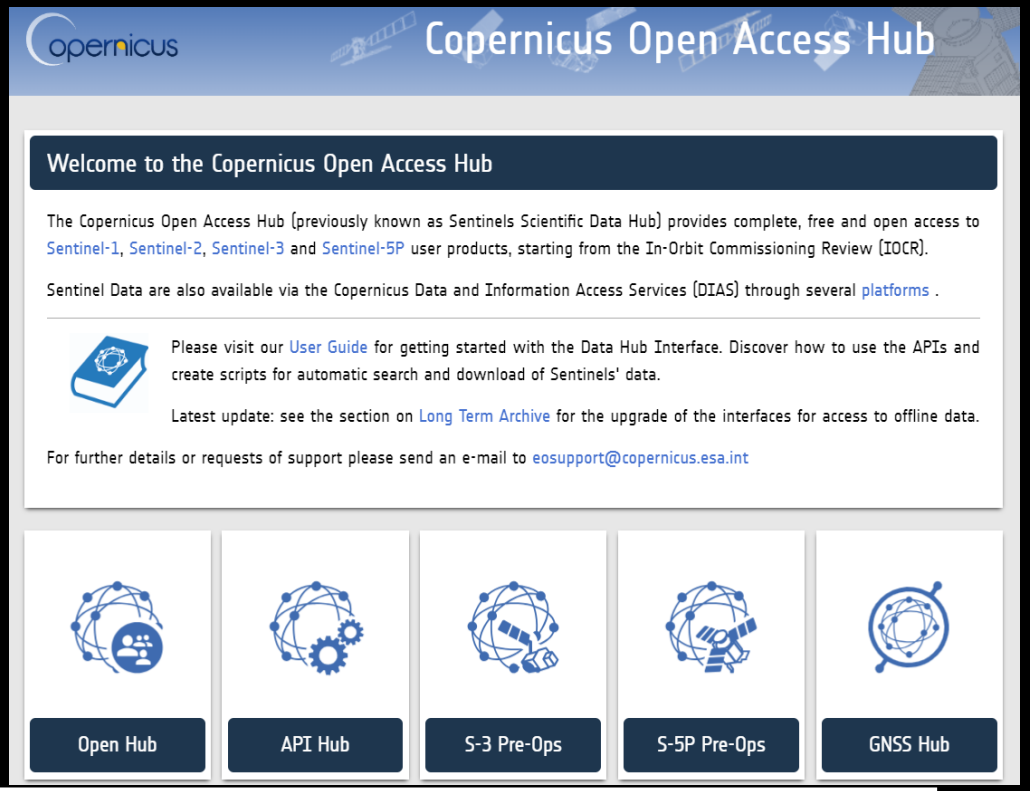

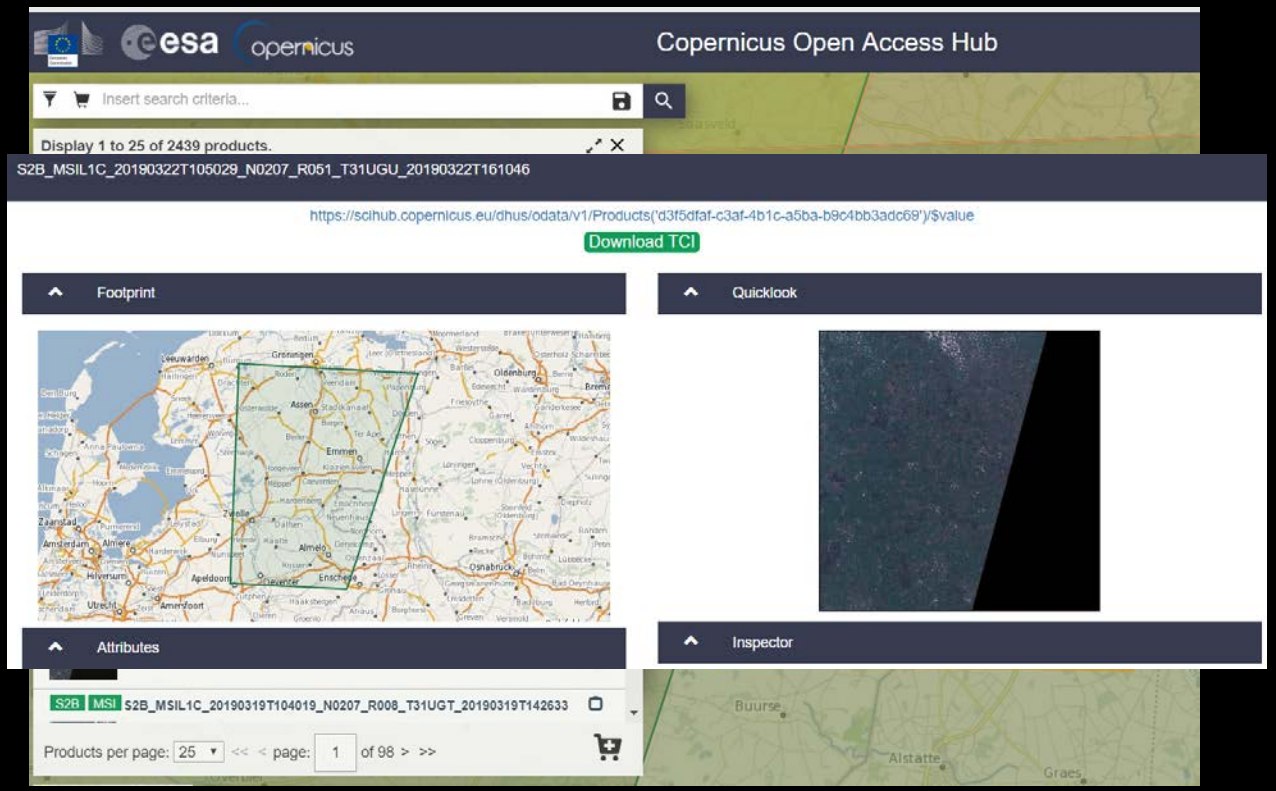

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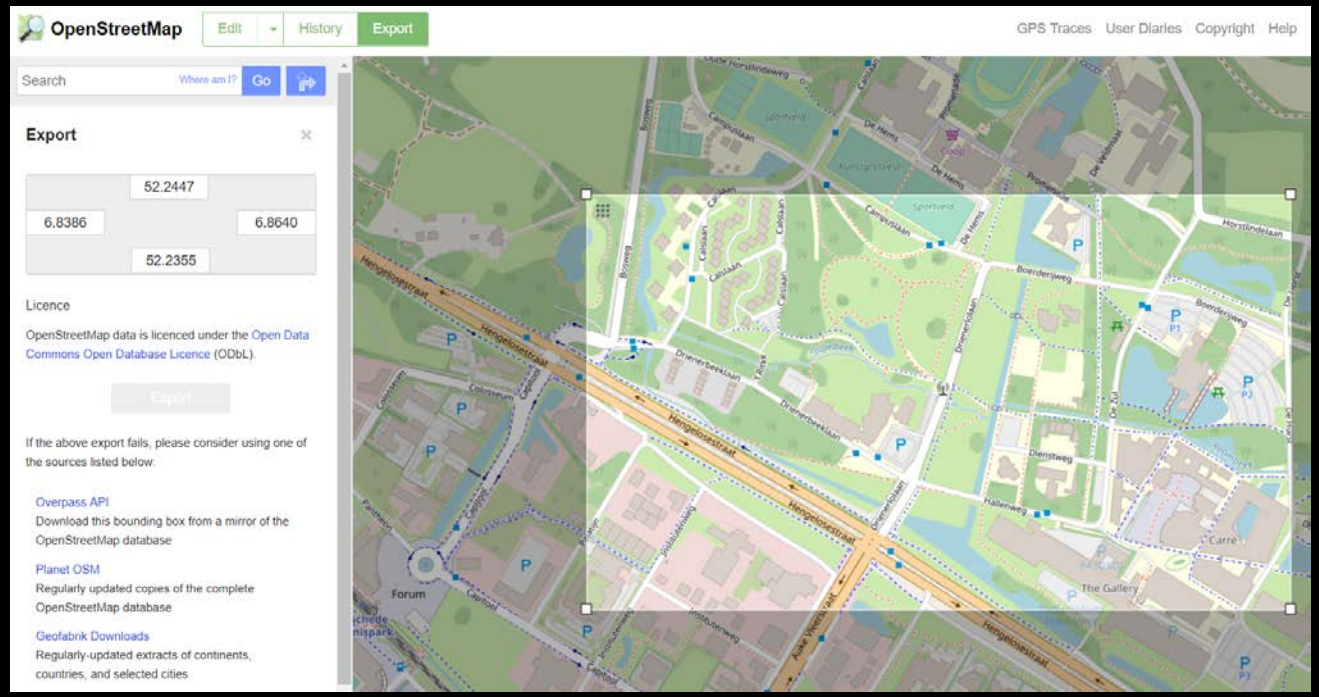

.OSM

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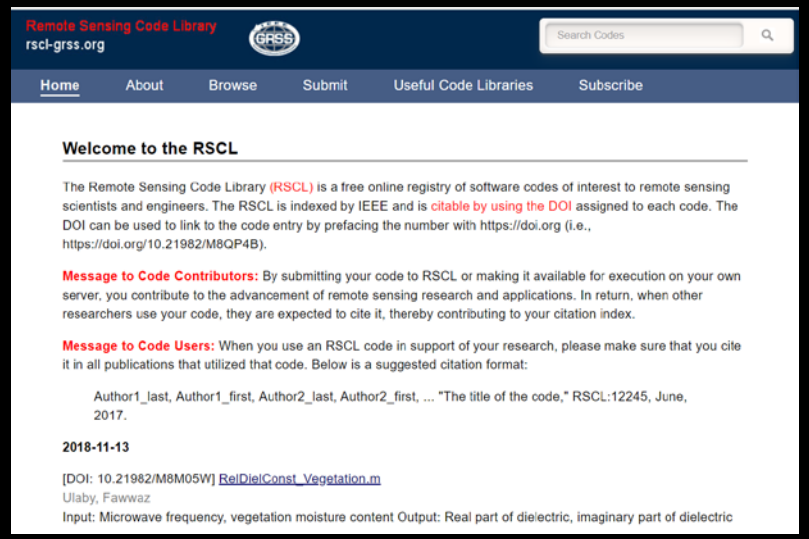
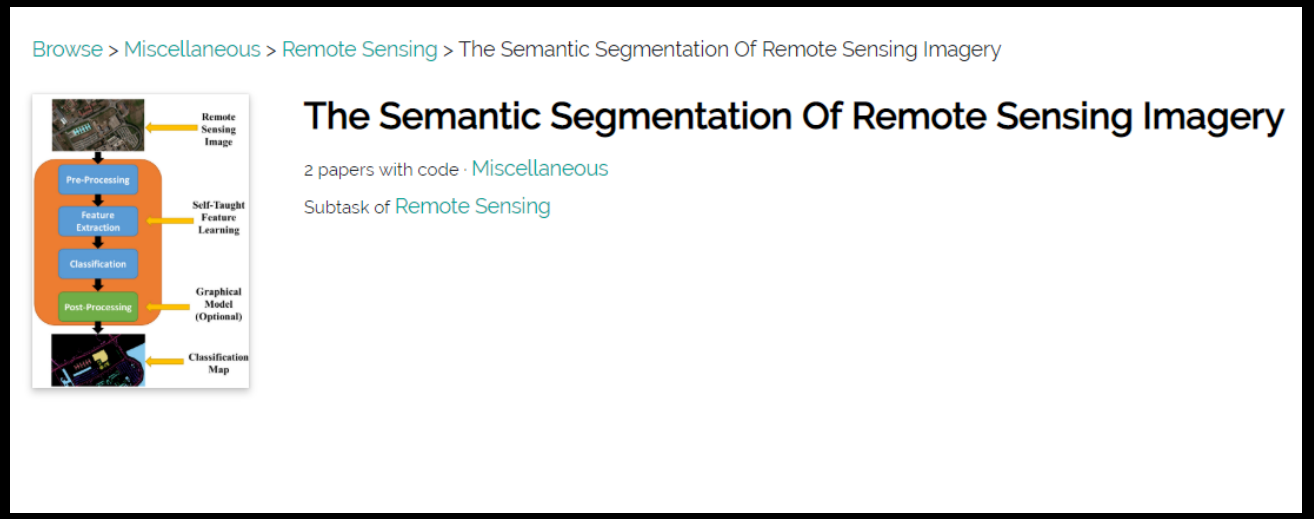
http://rscl-grss.org/



https://paperswithcode.com/



Thank you!

Questions?

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