

# *REMOTE SENSING & DIGITAL IMAGE PROCESSING*

*Beril Sirmacek, Dr. -Eng.*

# *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

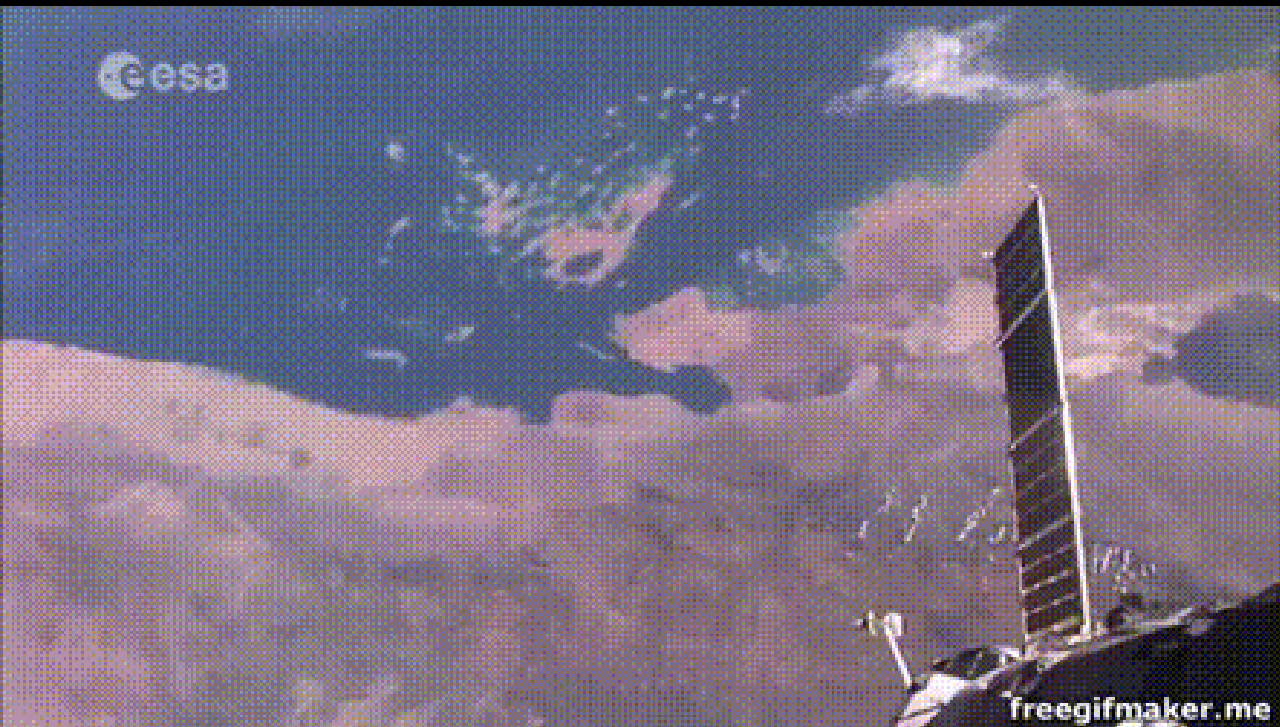


1906 San Francisco

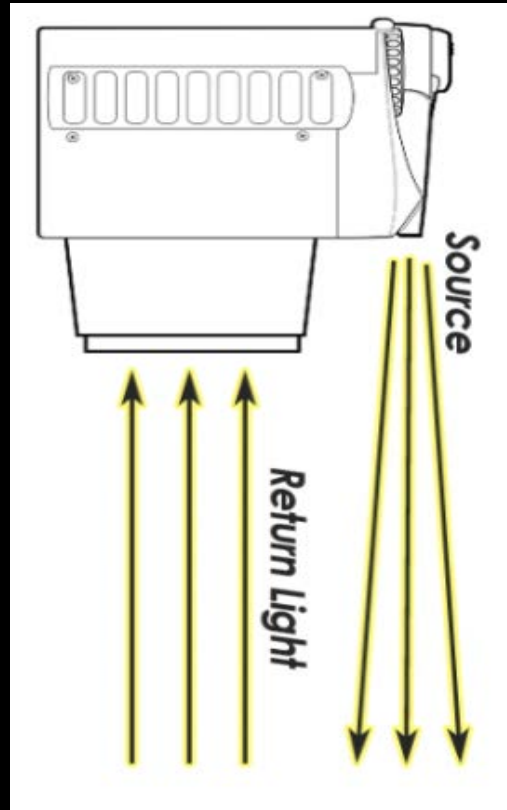
<http://www.oneonta.edu>



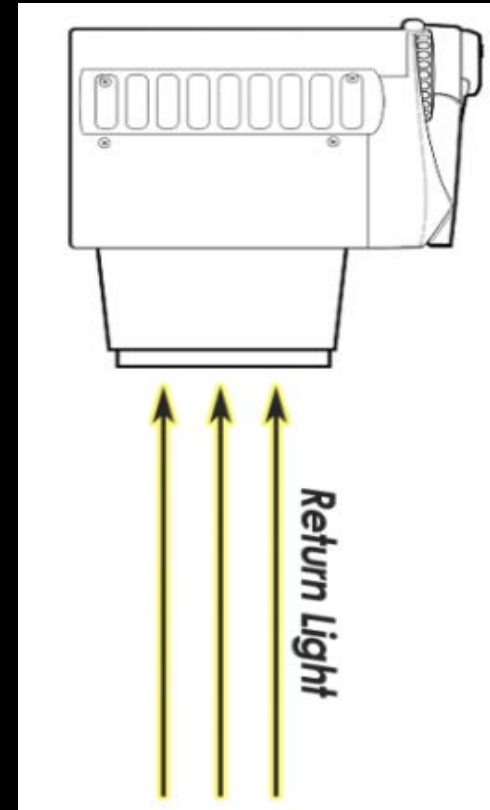
# *What is remote sensing?*



# Common sensors

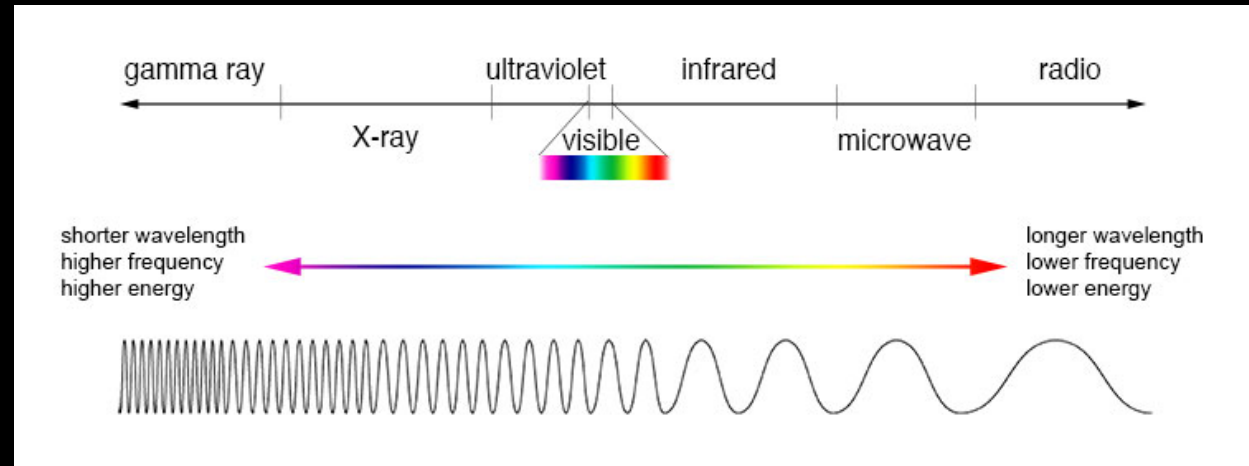
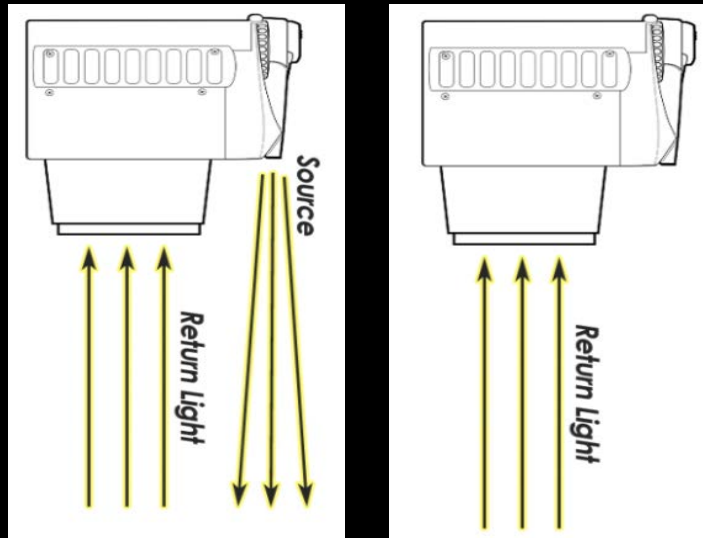


Active sensor



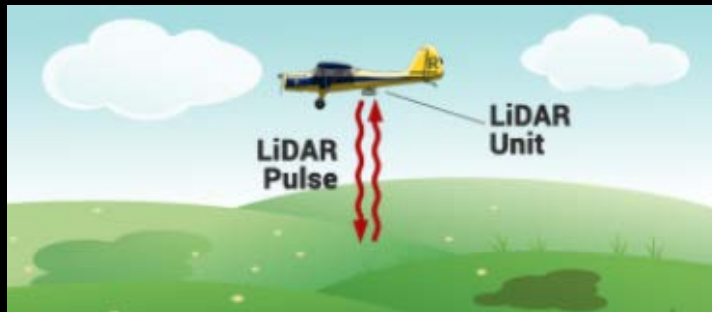


# Common sensors

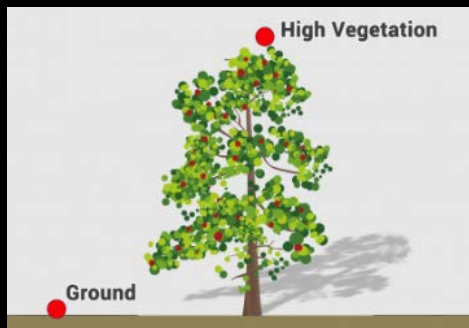


# Common sensors *active*

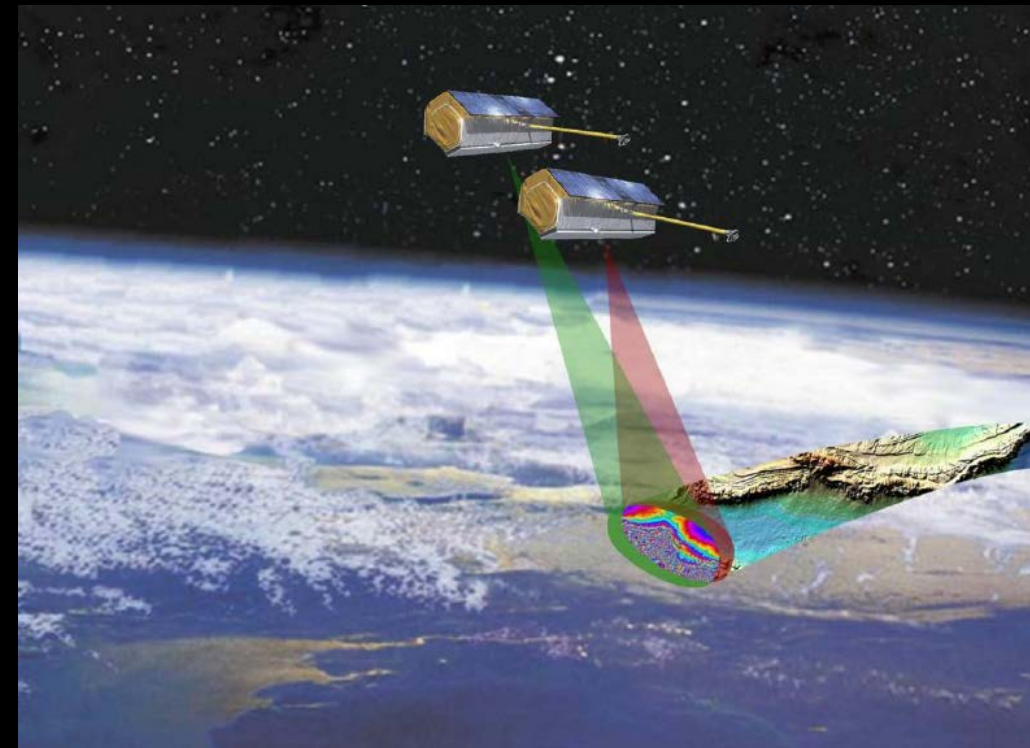
- RADAR (SAR)
- LiDAR (Light detection and Ranging)



<http://gisgeography.com>



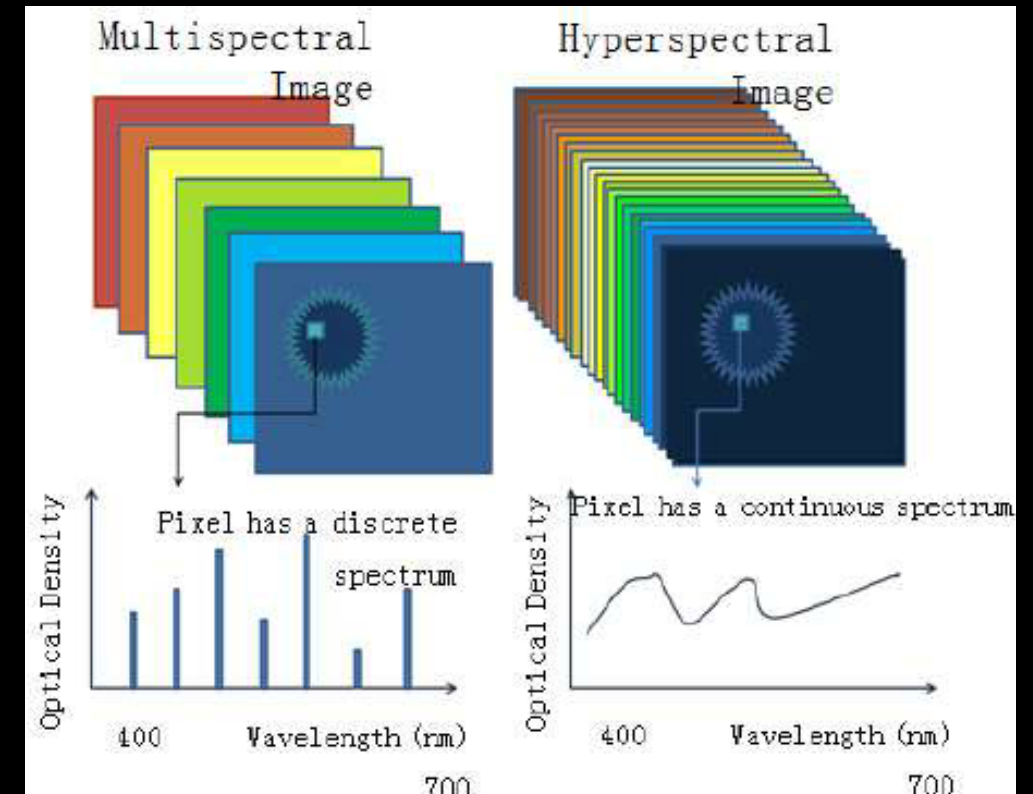
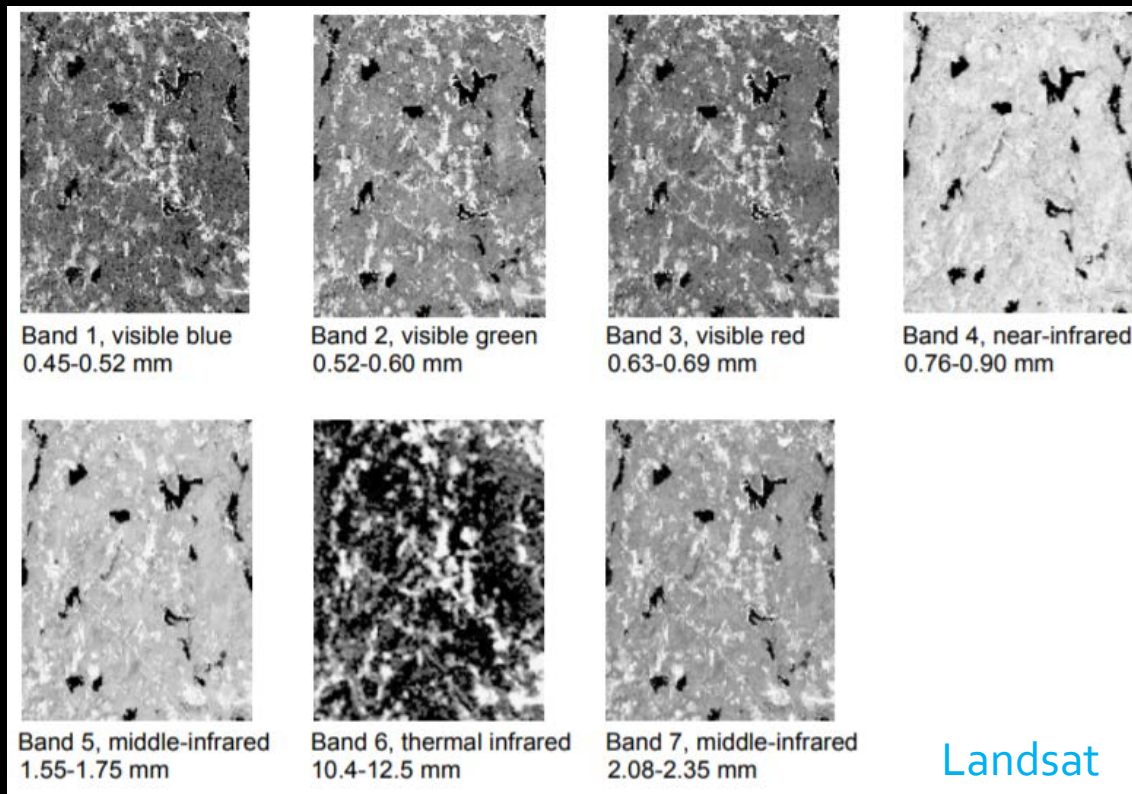
AHN = Actueel Hoogtebestand Nederland



tandem satellites (DLR)

# Common sensors *passive*

- RGB
- Multispectral
- Hyperspectral





# Common sensors

## Interesting specifications

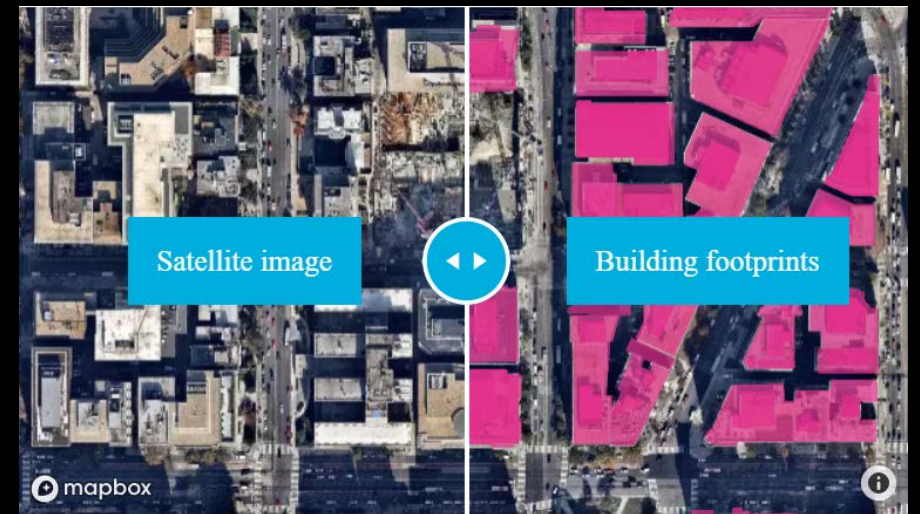
- Spatial resolution
- Spectral resolution
- Swath width
- Visiting frequency



30m resolution



10 m resolution



Digital globe

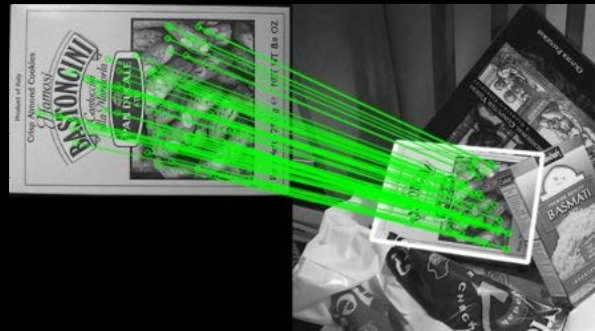
# *Common applications*

- DSM/DEM/DTM
- Hyperspectral signatures

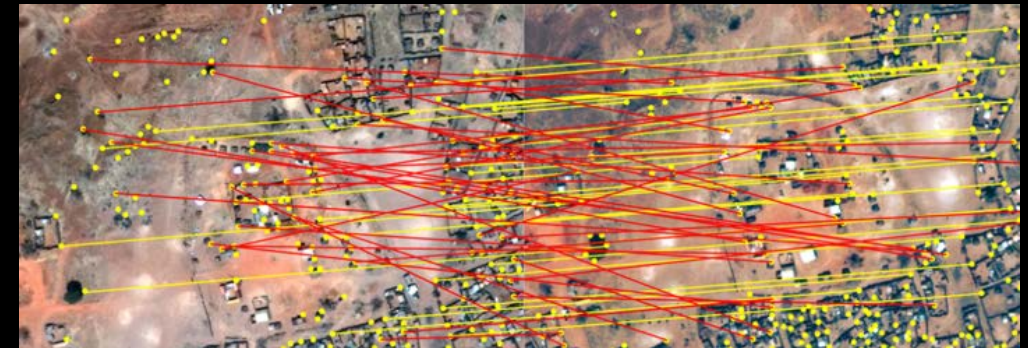
**What you can  
mathematically  
derive...**

# Common applications

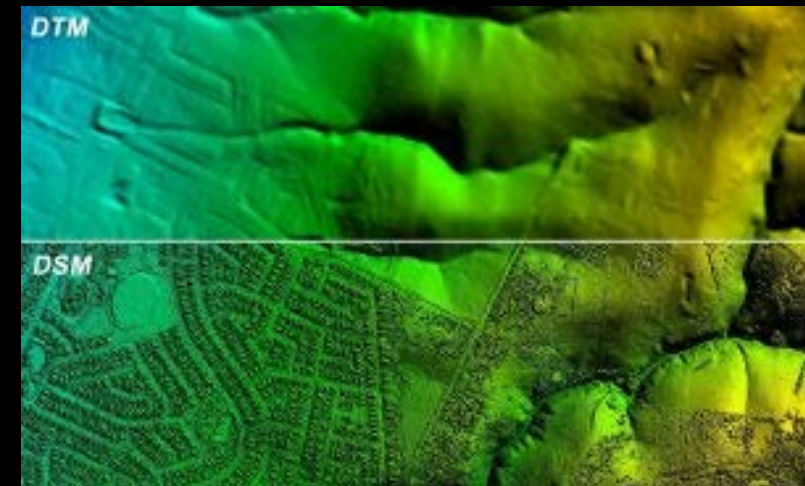
- DSM/DEM/DTM
- Hyperspectral signatures



SIFT features

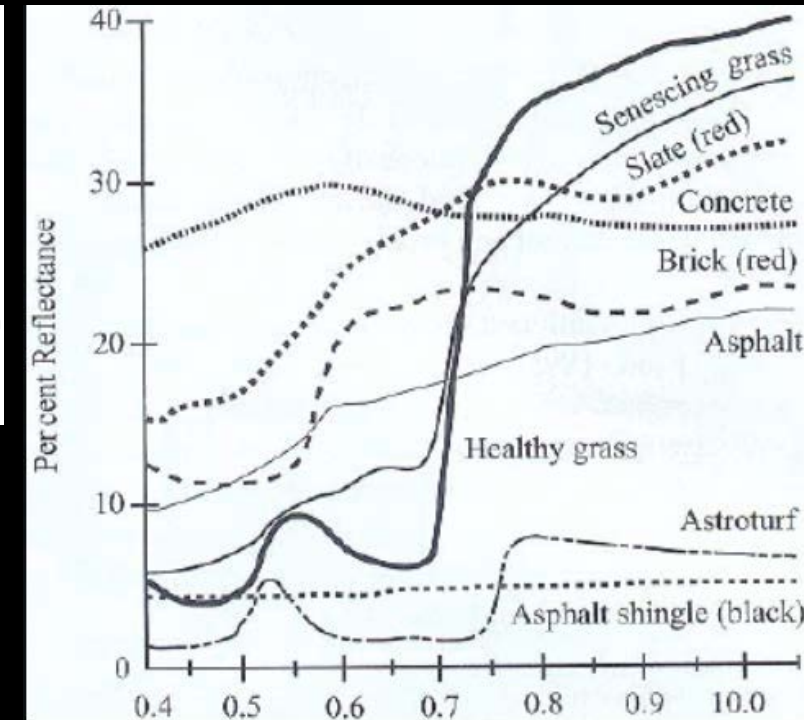
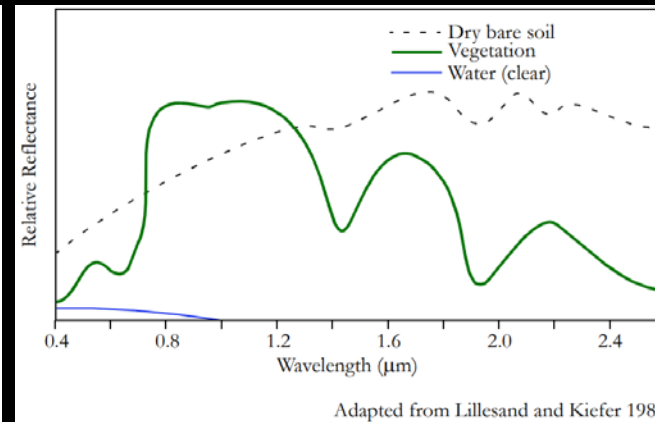
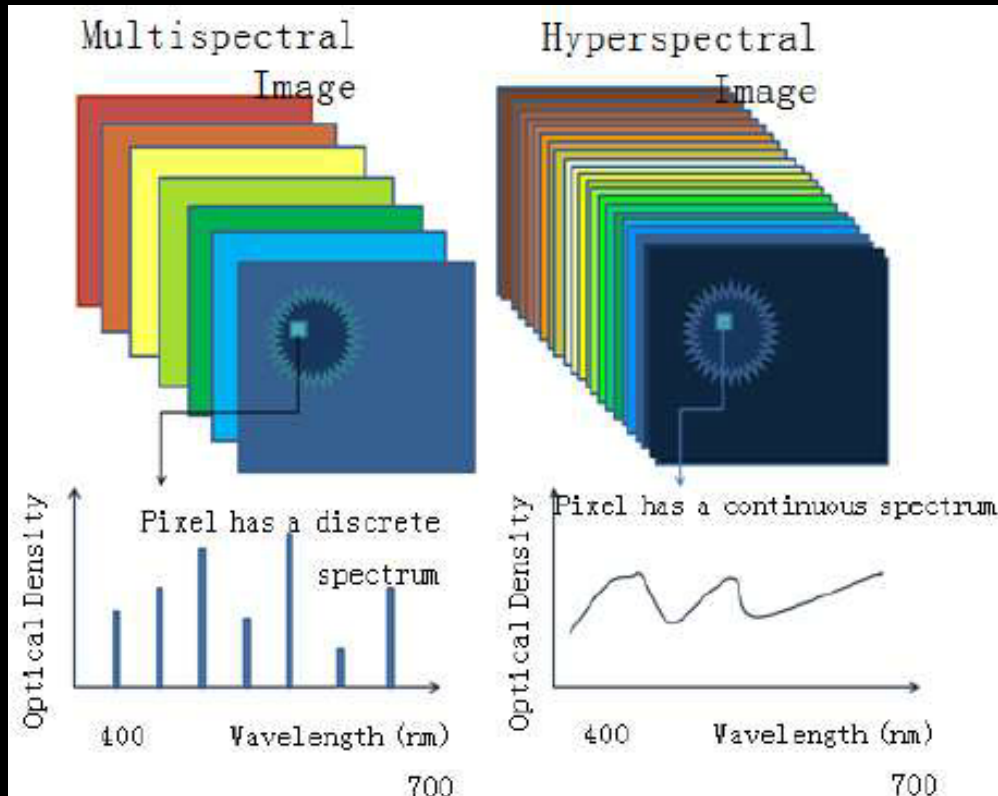


Point-matching method for remote sensing images with background variation Xiaolong Shi, Jie Jiang



# Common applications

- DSM/DEM/DTM
- Hyperspectral signatures



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



# *Common applications*

**Where you can  
apply...**

- Forests (logging, CO<sub>2</sub> 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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Where you can  
apply...



<https://www.bloomberg.com>



# *Common applications*

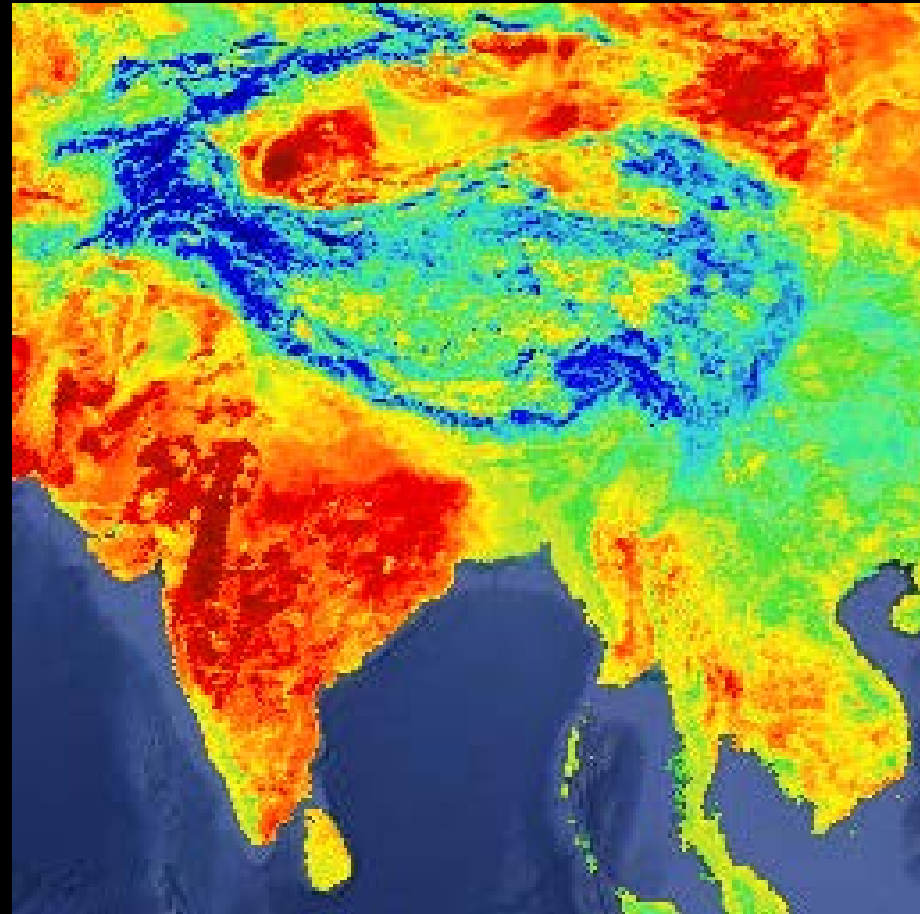
Where you can  
apply...



<https://www.bloomberg.com>

# *Common applications*

Where you can  
apply...



Surface heat map from Google earth engine

# *Common applications*

Where you can apply...



Economy indicators:

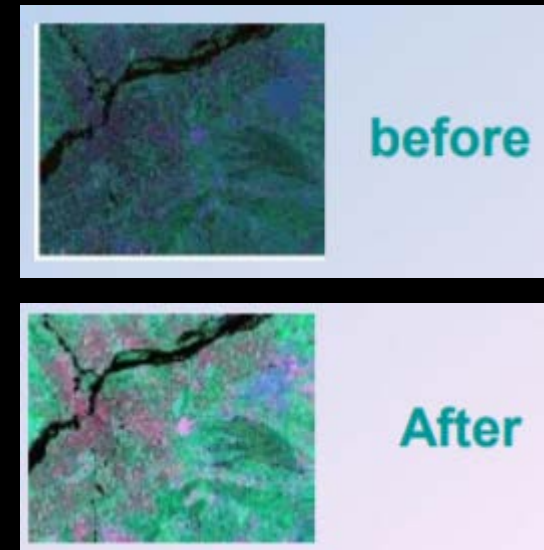
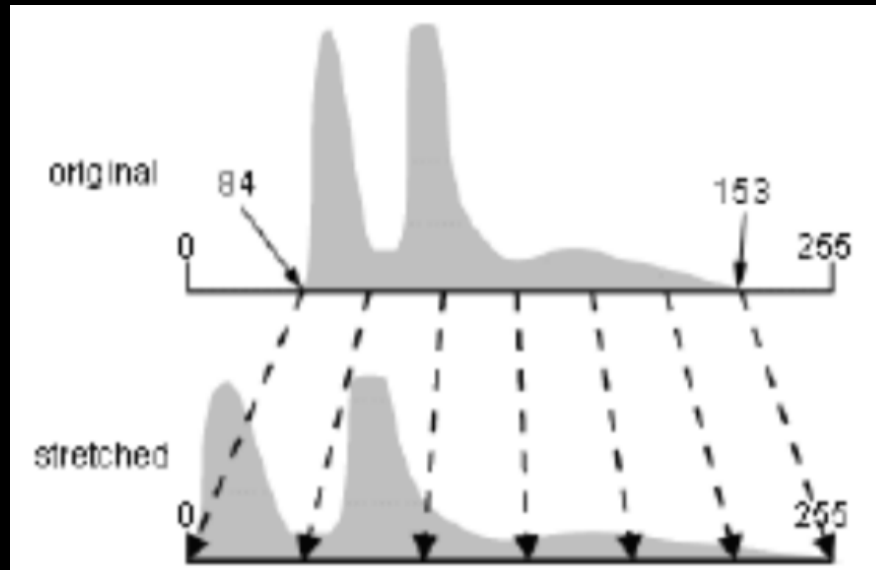
- Night lights
- Building heights / sizes / numbers
- Highway density
- Number of ports (air/sea)
- Size of the industrial areas
- Size of the agricultural areas

# *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*

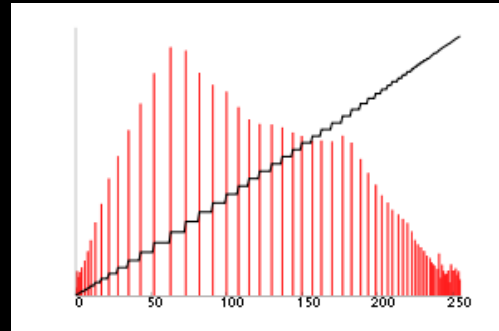
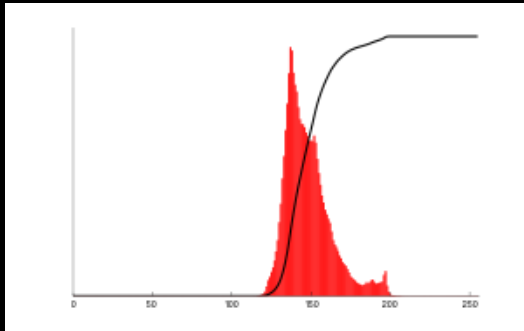
- Contrast stretching (= normalization)





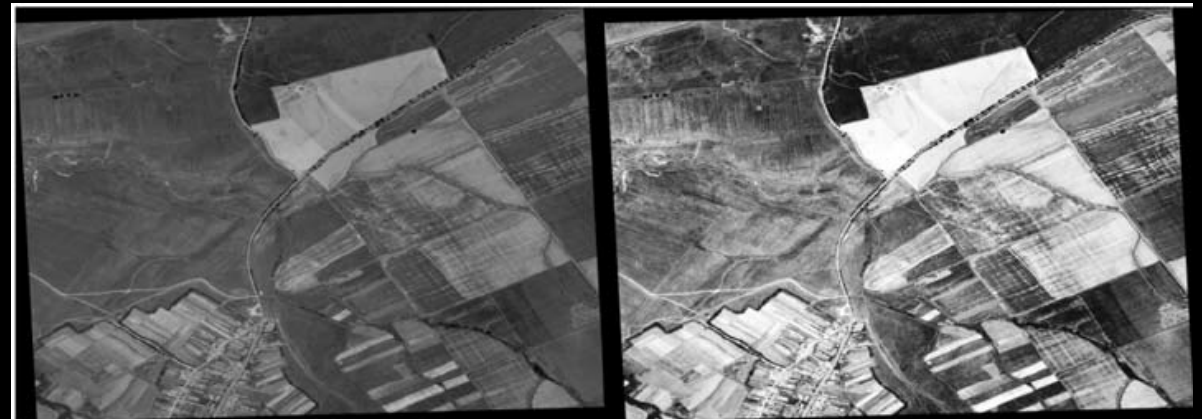
# Mathematical algorithms

- Contrast stretching (= normalization)



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

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





-1	0	1
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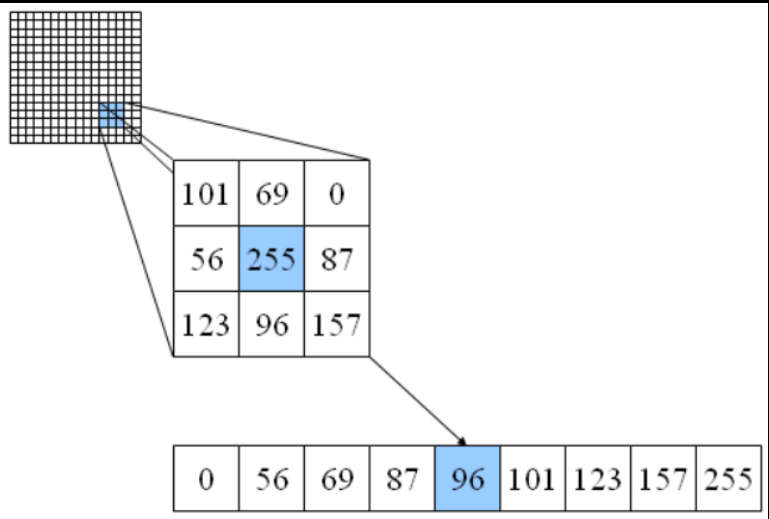
Horizontal

-1	-2	-1
----	----	----

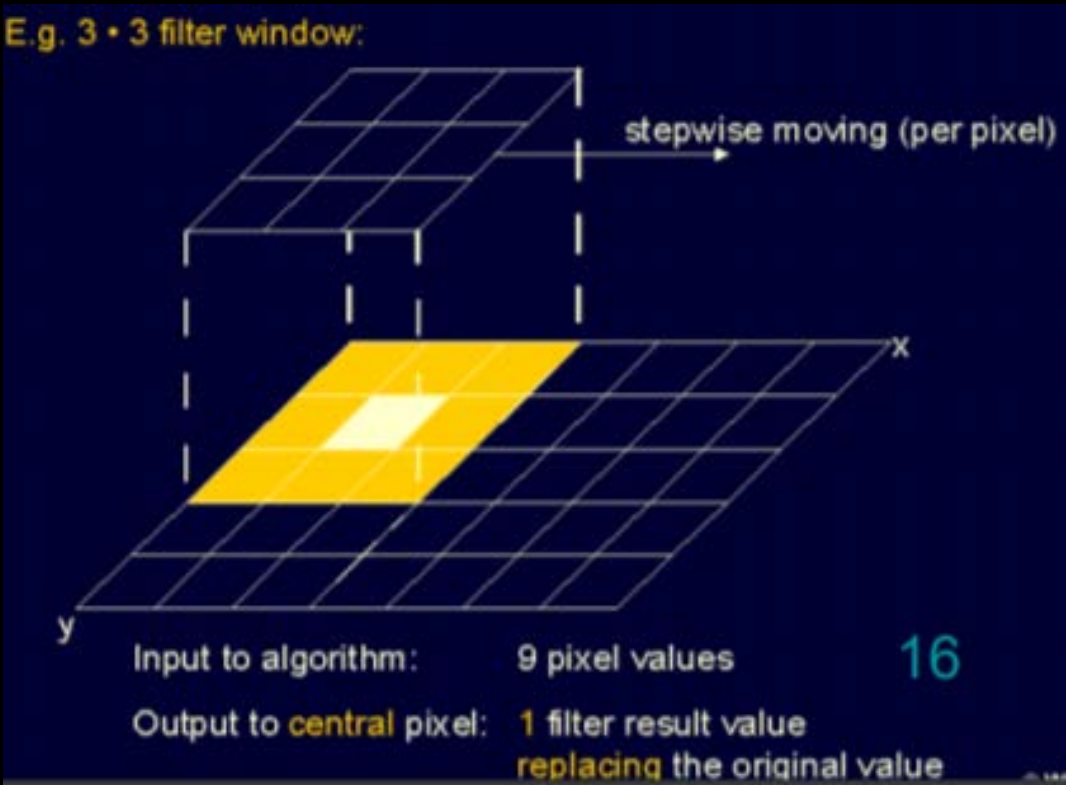
Vertical

# 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)

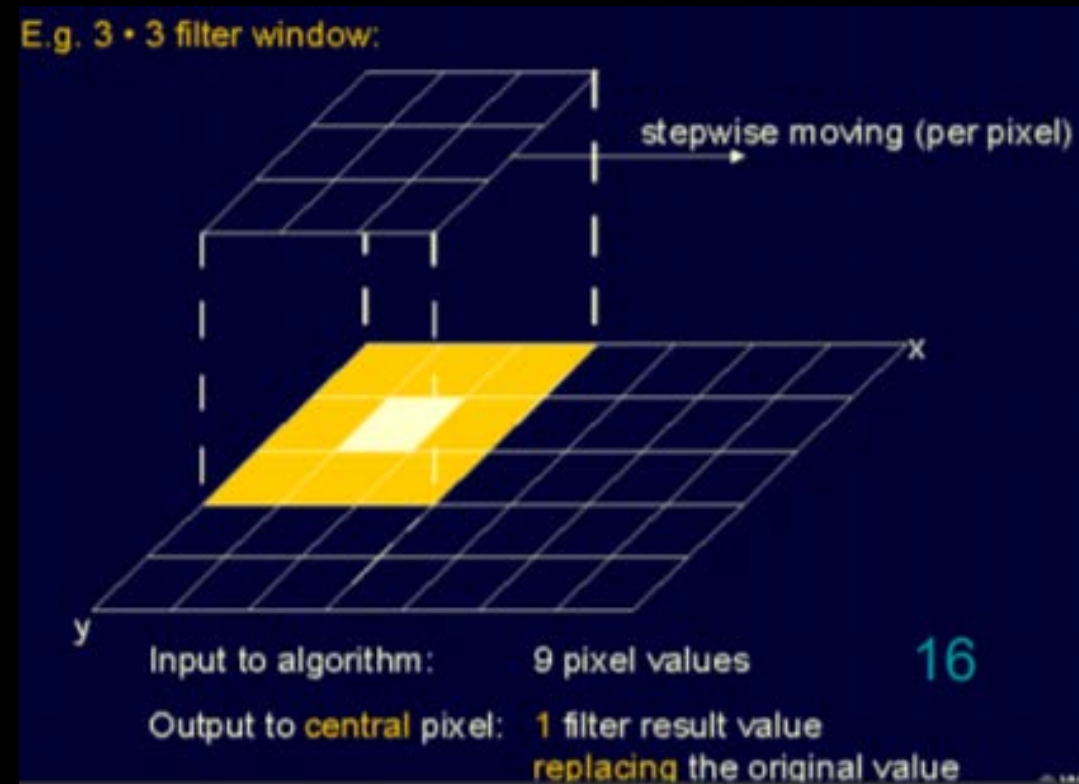
-1	0	1
-2	0	2
-1	0	1

Horizontal

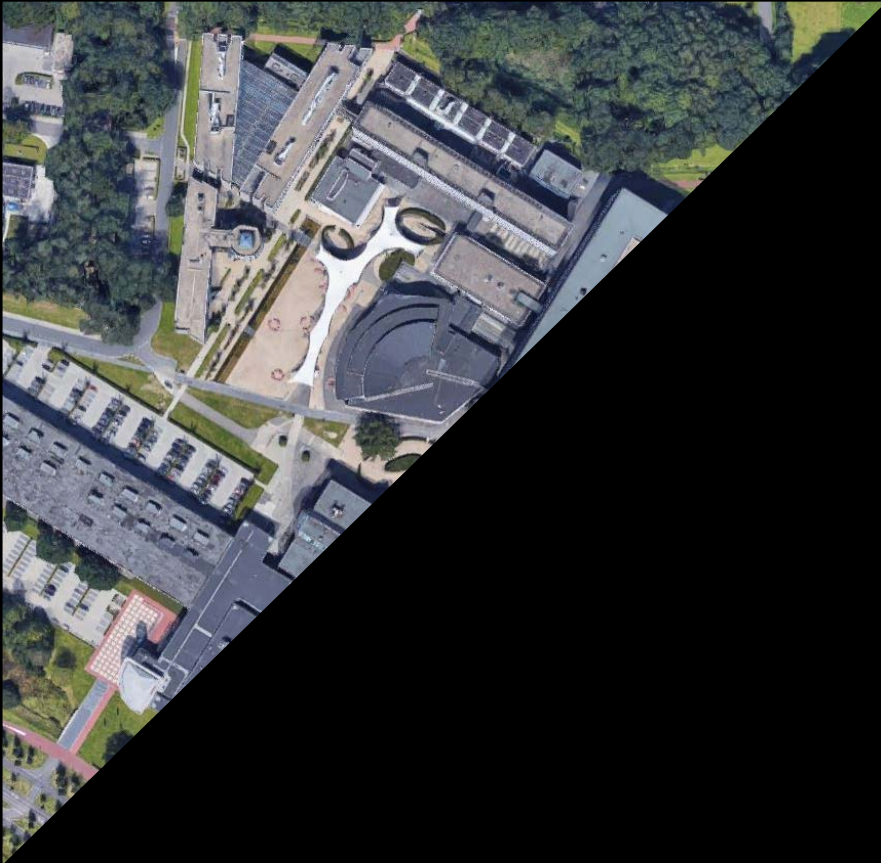
-1	-2	-1
0	0	0
-1	-2	-1

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)`





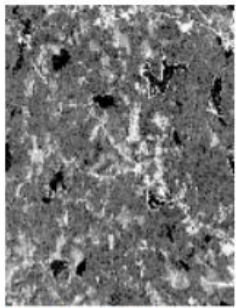
# *Mathematical algorithms*

- Band rationing

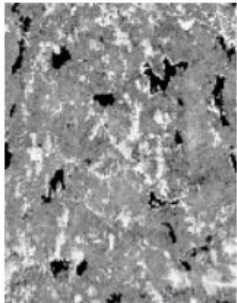
$$\text{NDVI} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R})$$

where NIR = Near Infrared

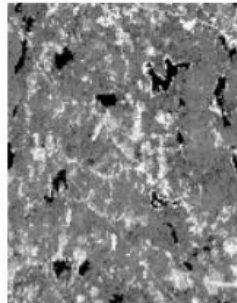
and R = Red



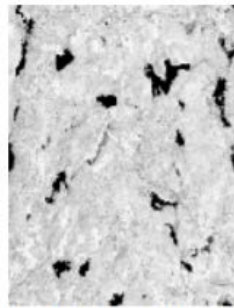
Band 1, visible blue  
0.45-0.52 mm



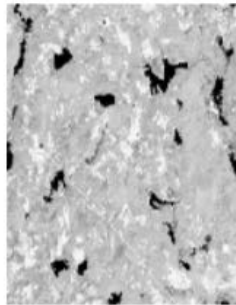
Band 2, visible green  
0.52-0.60 mm



Band 3, visible red  
0.63-0.69 mm



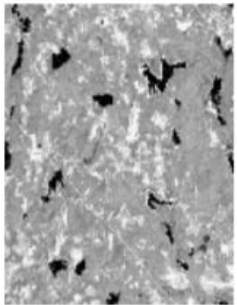
Band 4, near-infrared  
0.76-0.90 mm



Band 5, middle-infrared  
1.55-1.75 mm



Band 6, thermal infrared  
10.4-12.5 mm



Band 7, middle-infrared  
2.08-2.35 mm



gisgeography.com

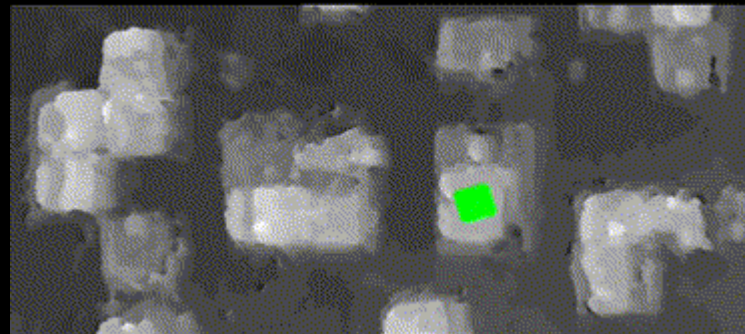


# Mathematical algorithms

- 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

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



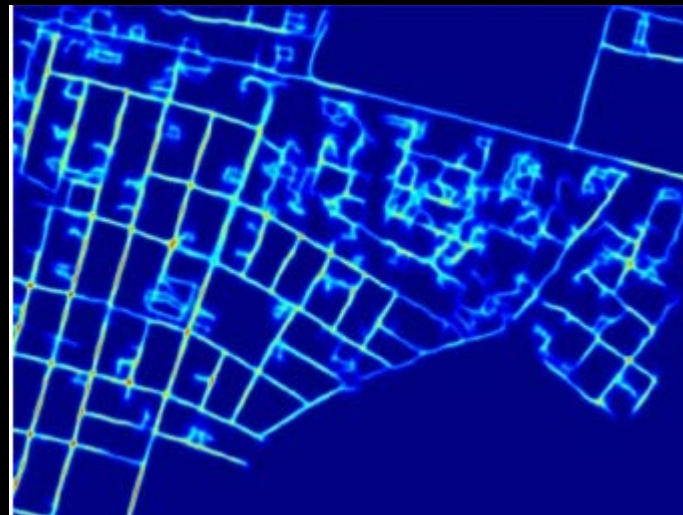
(a)



(b)



(c)



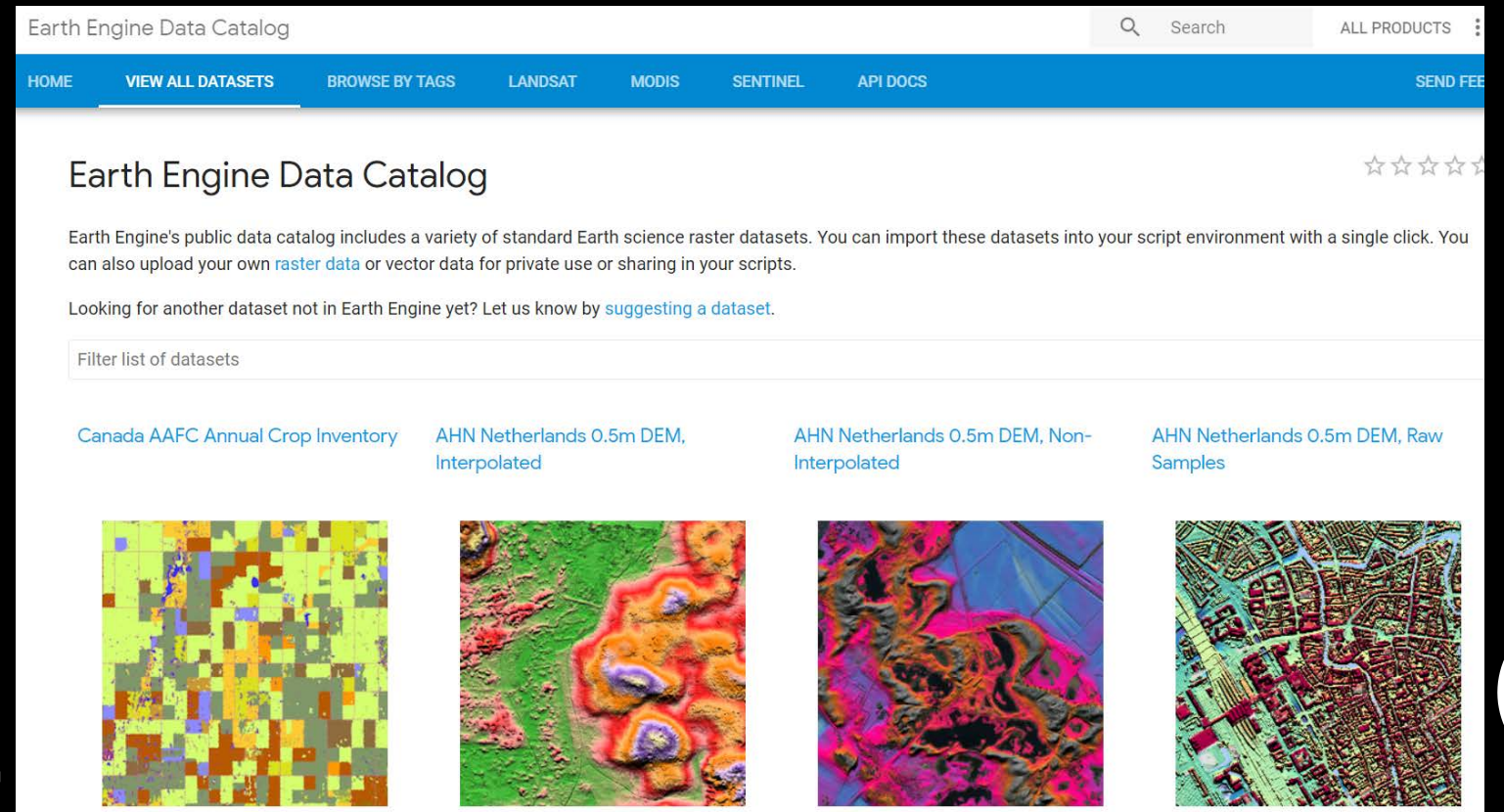
# *Doing cool stuff*

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



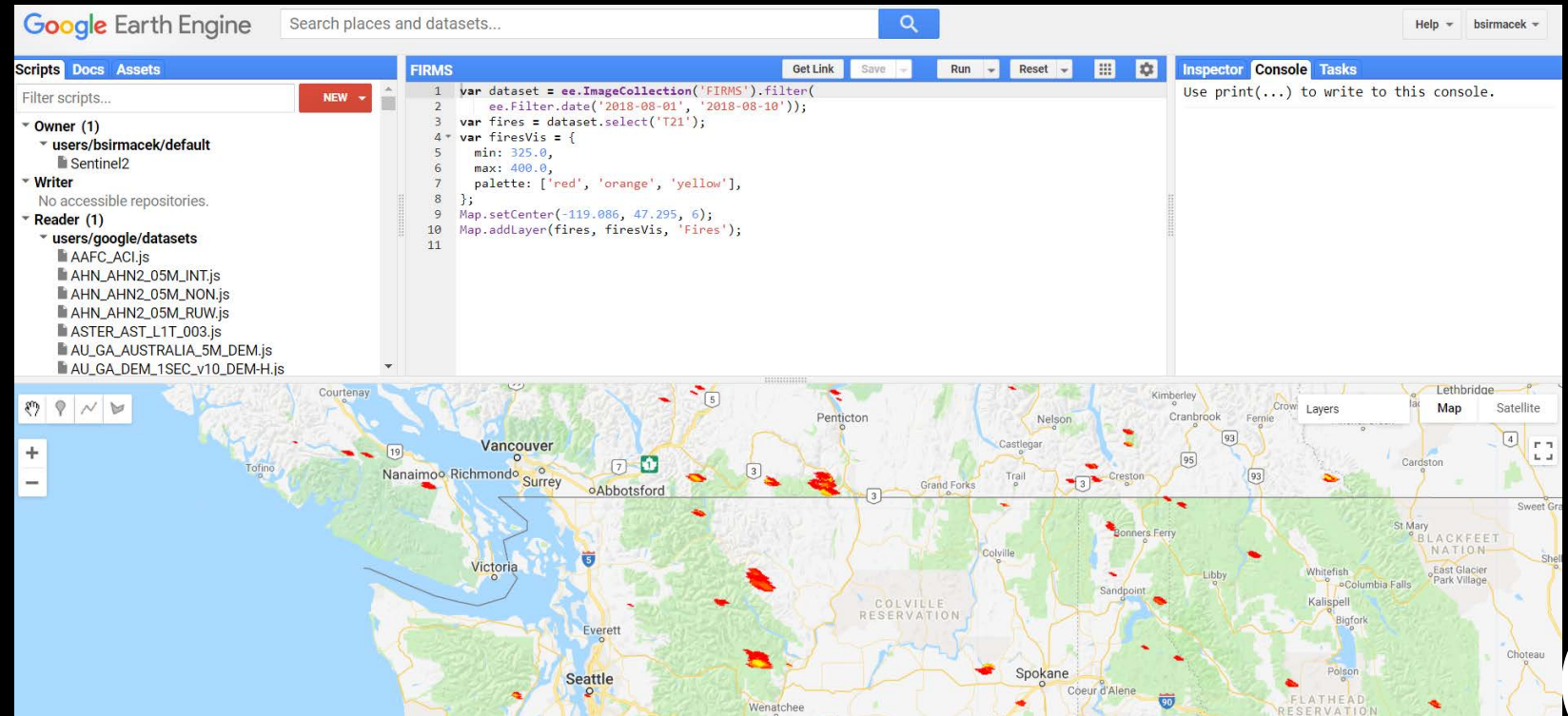
# Doing cool stuff

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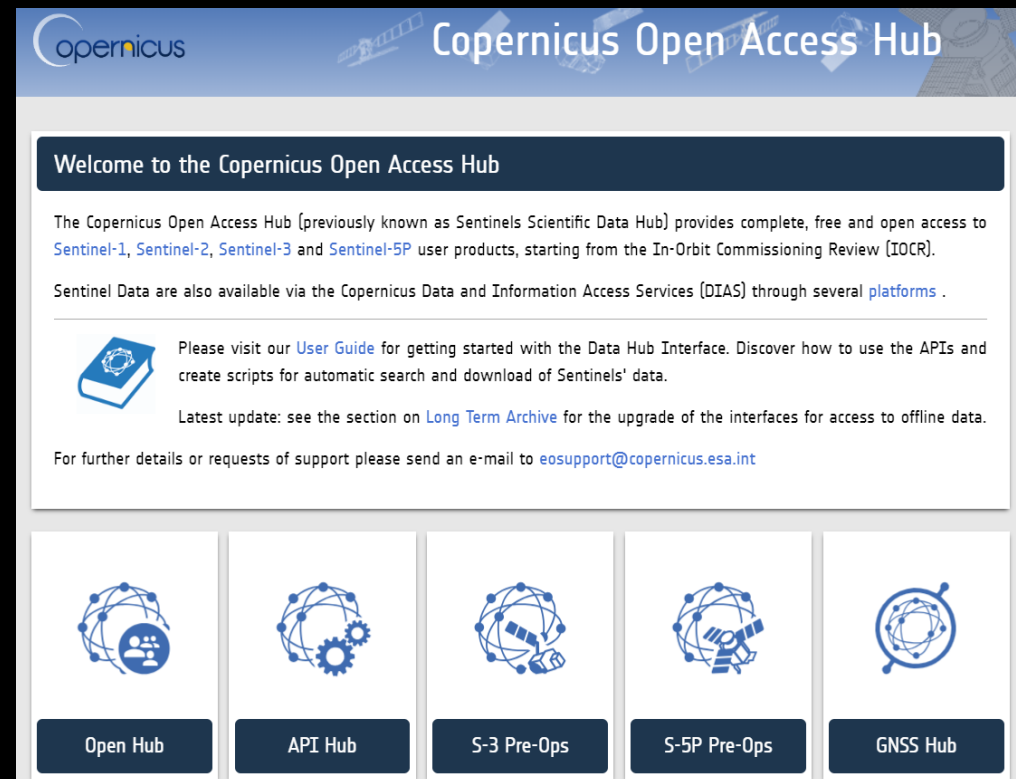
# Doing cool stuff

- Google earth engine
- ESA website
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# Doing cool stuff

- Google earth engine
- [ESA website](#)
- Openstreetmaps
- Code libraries



The screenshot shows the Copernicus Open Access Hub homepage. At the top, there's a header with the Copernicus logo and the text 'Copernicus Open Access Hub'. Below this is a dark blue banner with the text 'Welcome to the Copernicus Open Access Hub'. The main content area has a light blue background and contains a paragraph about the hub's purpose: 'The Copernicus Open Access Hub (previously known as Sentinels Scientific Data Hub) provides complete, free and open access to Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P user products, starting from the In-Orbit Commissioning Review (IOCR). Sentinel Data are also available via the Copernicus Data and Information Access Services (DIAS) through several platforms.' Below this is a blue icon of a book and a paragraph: 'Please visit our User Guide for getting started with the Data Hub Interface. Discover how to use the APIs and create scripts for automatic search and download of Sentinels' data. Latest update: see the section on Long Term Archive for the upgrade of the interfaces for access to offline data. For further details or requests of support please send an e-mail to eosupport@copernicus.esa.int'. At the bottom, there are five blue buttons with icons: 'Open Hub', 'API Hub', 'S-3 Pre-Ops', 'S-5P Pre-Ops', and 'GNSS Hub'.

Copernicus Open Access Hub

Welcome to the Copernicus Open Access Hub

The Copernicus Open Access Hub (previously known as Sentinels Scientific Data Hub) provides complete, free and open access to Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P user products, starting from the In-Orbit Commissioning Review (IOCR).

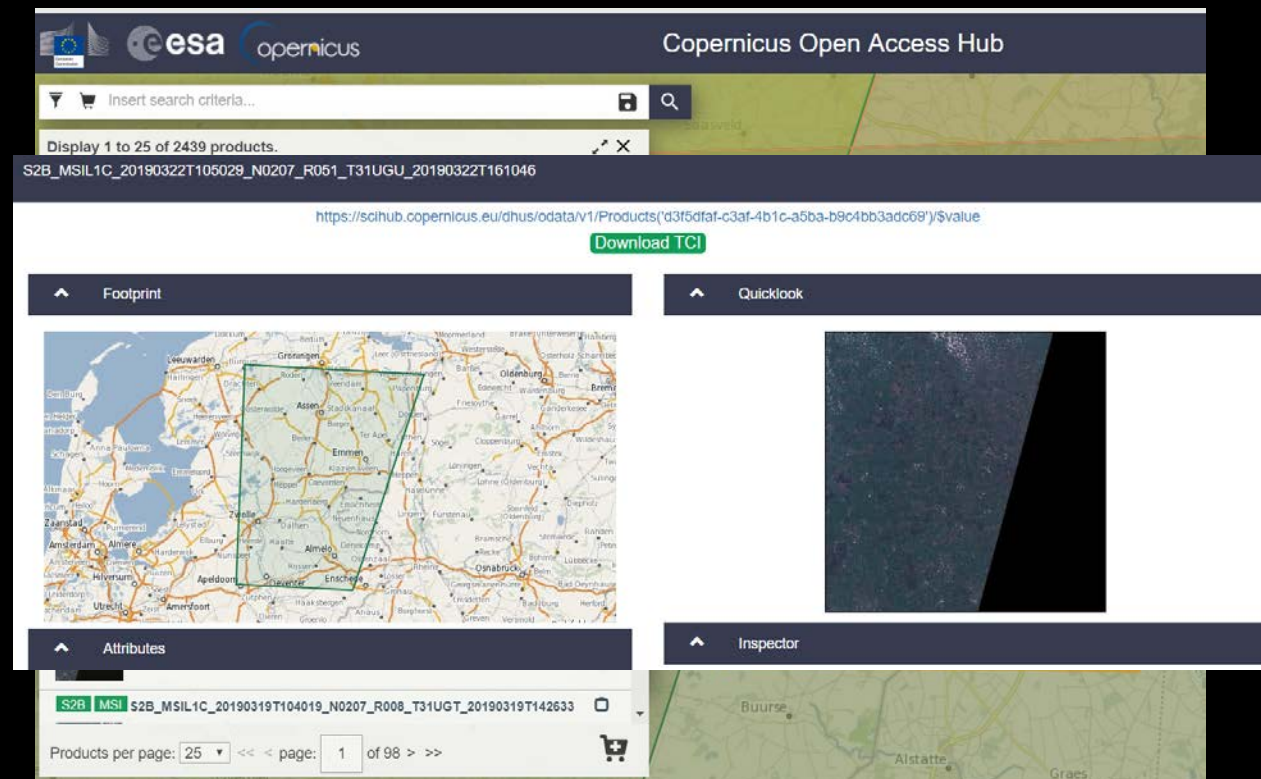
Sentinel Data are also available via the Copernicus Data and Information Access Services (DIAS) through several platforms .

Please visit our [User Guide](#) for getting started with the Data Hub Interface. Discover how to use the APIs and create scripts for automatic search and download of Sentinels' data.

Latest update: see the section on [Long Term Archive](#) for the upgrade of the interfaces for access to offline data.

For further details or requests of support please send an e-mail to [eosupport@copernicus.esa.int](mailto:eosupport@copernicus.esa.int)

Open Hub API Hub S-3 Pre-Ops S-5P Pre-Ops GNSS Hub



The screenshot shows the Copernicus Open Access Hub product search interface. At the top, there's a header with the ESA and Copernicus logos and the text 'Copernicus Open Access Hub'. Below this is a search bar with the text 'Insert search criteria...'. Below the search bar, it says 'Display 1 to 25 of 2439 products.' and shows a product ID: 'S2B\_MSIL1C\_20190322T105029\_N0207\_R061\_T31UGU\_20190322T161046'. Below this is a URL: 'https://schub.copernicus.eu/dhus/odata/v1/Products('d3f5daf-c3af-4b1c-a5ba-b9c4bb3adc68')/\$value' and a green button labeled 'Download TCI'. Below the URL, there are three panels: 'Footprint' showing a map of Europe with a green rectangle, 'Quicklook' showing a satellite image of the same area, and 'Inspector' showing a detailed view of the satellite image. At the bottom, there's a table with product details: 'S2B MSI S2B\_MSIL1C\_20190319T104019\_N0207\_R008\_T31UGT\_20190319T142633'. Below the table, it says 'Products per page: 25' and 'page: 1 of 98'.

Copernicus Open Access Hub

Insert search criteria...

Display 1 to 25 of 2439 products.

S2B\_MSIL1C\_20190322T105029\_N0207\_R061\_T31UGU\_20190322T161046

[https://schub.copernicus.eu/dhus/odata/v1/Products\('d3f5daf-c3af-4b1c-a5ba-b9c4bb3adc68'\)/\\$value](https://schub.copernicus.eu/dhus/odata/v1/Products('d3f5daf-c3af-4b1c-a5ba-b9c4bb3adc68')/$value)

Download TCI

Footprint Quicklook

Inspector

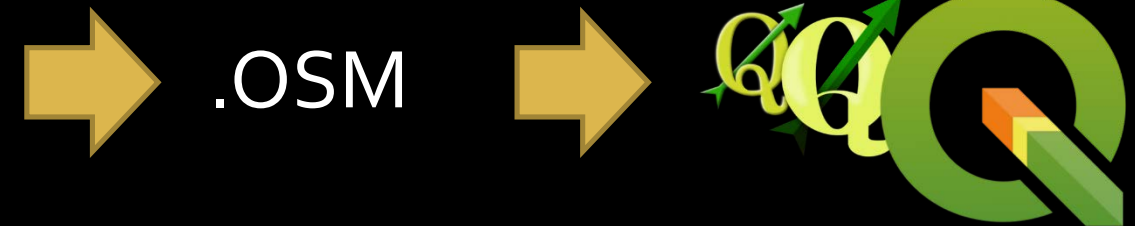
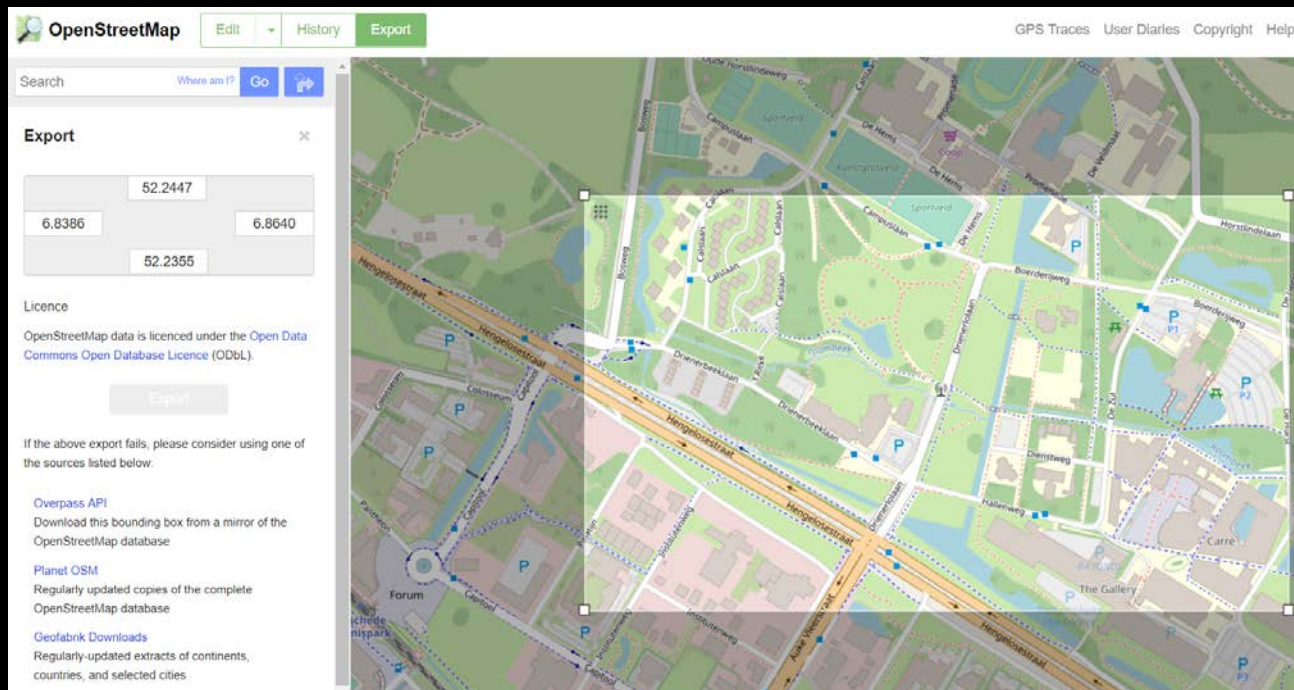
S2B MSI S2B\_MSIL1C\_20190319T104019\_N0207\_R008\_T31UGT\_20190319T142633

Products per page: 25 << < page: 1 of 98 > >>



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- ESA website
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<http://rscl-grss.org/>

Remote Sensing Code Library  
rscl-grss.org

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### Welcome to the RSCL

The Remote Sensing Code Library (RSCL) is a free online registry of software codes of interest to remote sensing scientists and engineers. The RSCL is indexed by IEEE and is citable by using the DOI assigned to each code. The DOI can be used to link to the code entry by prefacing the number with [https://doi.org](https://doi.org/10.21982/M8QP4B) (i.e., <https://doi.org/10.21982/M8QP4B>).

**Message to Code Contributors:** By submitting your code to RSCL or making it available for execution on your own server, you contribute to the advancement of remote sensing research and applications. In return, when other researchers use your code, they are expected to cite it, thereby contributing to your citation index.

**Message to Code Users:** When you use an RSCL code in support of your research, please make sure that you cite it in all publications that utilized that code. Below is a suggested citation format:

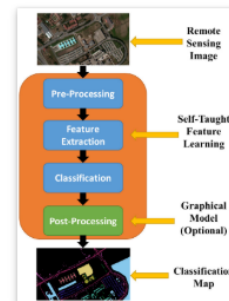
Author1\_last, Author1\_first, Author2\_last, Author2\_first, ... "The title of the code," RSCL:12245, June, 2017.

2018-11-13

[DOI: 10.21982/M8M05W] [RelDielConst\\_Vegetation.m](#)  
Ulabiy, Fawwaz  
Input: Microwave frequency, vegetation moisture content Output: Real part of dielectric, imaginary part of dielectric

<https://paperswithcode.com/>

Browse > Miscellaneous > Remote Sensing > The Semantic Segmentation Of Remote Sensing Imagery



## The Semantic Segmentation Of Remote Sensing Imagery

2 papers with code · Miscellaneous

Subtask of Remote Sensing

*Thank  
you!*

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*Questions?*