



**AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE**

GIS 4D

Wykład 1

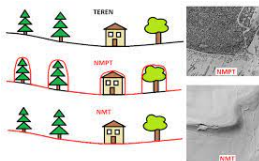
Beata Hejmanowska

<https://home.agh.edu.pl/~galia/>

Katedra Fotogrametrii Teledetekcji i Inżynierii Przestrzennej

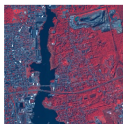
12 października 2022

- GIS 2D (x, y) statyczne płaskie dane
- GIS 3D (x, y, z) statyczne modele obiektów, opcjonalnie rozmieszczone na płaszczyźnie, powierzchni, powierzchni terenu
- GIS 2.5 (x, y, z) statyczne przestrzenne numeryczne modele terenu (NMT) i numeryczne modele powierzchni terenu NMPT



- satelity meteorologiczne, NOAA, MODIS, SENTINEL 3,4,5 (setki m, km)
- satelity do obserwacji Ziemi, LANDSAT 7 8, SENTINEL-1, 2 (m)
- satelity wysokorozdzielcze - komercyjne (cm)

Planet SkySat Public Ortho Imagery, Multispectral



Planet SkySat Public Ortho Imagery, RGB



NAIP: National Agriculture Imagery Program



- Google Earth Engine łączy wielopetabajtowy katalog zdjęć satelitarnych i zbiorów danych geoprzestrzennych z możliwościami analizy w skali planety. Naukowcy, badacze i programiści używają Earth Engine do wykrywania zmian, mapowania trendów i określania różnic na powierzchni Ziemi.
- Petabajt to miara pojemności pamięci lub przechowywania danych, która jest równa 2 do 50-tej potęgi bajtów. W petabajcie znajduje się 1024 terabajtów (TB) - lub 1 milion gigabajtów (GB) - a około 1024 PB tworzą jeden eksabajt.
- Jeden petabajt mieści 1000 terabajtów (TB) lub 1 000 000 000 000 bajtów. Duże organizacje używają petabajtów do przechowywania ogromnych ilości danych.

- GEE jest darmowy do użytku niekomercyjnego
- JavaScript
- oparta na chmurze platforma analizy geoprzestrzennej, która umożliwia użytkownikom wizualizację i analizę obrazów satelitarnych

- Introduction to Google Earth Engine
- End-to-End Google Earth Engine (Full Course Material)
-

Tutorial Contents

- [Earth Engine Explorer](#)
- [Data Catalog](#)
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 - [Opacity](#)
 - [Palette](#)
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- [Things to look out for](#)
- [What's Next](#)
- [Feedback for us?](#)

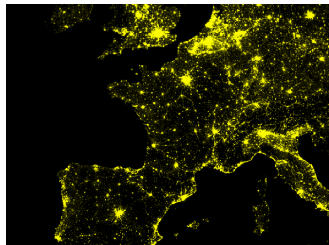


AGH

Earth Engine Data Catalog

dostępne dane źródłowe i produkty ich przetworzenia

- Klimat i prognozy pogody
(temperatura powierzchni Ziemi, klimat, atmosfera, pogoda)
- Obrazy (Landsat, Sentinel, MODIS, satelity wysokorozdzielcze)
- (NMT/NMPT, mapy pokrycia terenu (Land Cover), monitoring upraw rolnych, zobrazowania nocą)





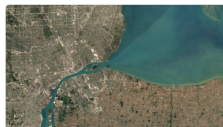
Landsat 9 OLI-2/TIRS-2

2021–Present



Landsat 8 OLI/TIRS

2013–Present



Landsat 7 ETM+

1999–2021



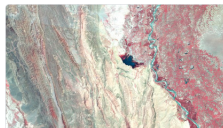
Landsat 5 TM

1984–2012



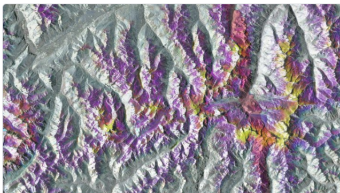
Landsat 4 TM

1982–1993



Landsat 1-5 MSS

1972–1999



Sentinel-1 SAR GRD: C-band Synthetic Aperture Radar

Data availability: 2014 – Present

The Sentinel-1 mission provides data from a dual-polarization C-band Synthetic Aperture Radar (SAR) instrument. SAR instruments are capable of acquiring meaningful data in all weather conditions (even clouds) during daytime and nighttime. Sentinel-1 data is used across many domains, including maritime activity, sea-ice mapping, humanitarian aid, crisis response, and forest management.

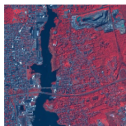


Sentinel-2 MSI: Multispectral Instrument

Data availability: 2015 – Present

The Sentinel-2 mission collects high-resolution multispectral imagery useful for a broad range of applications, including monitoring of vegetation, soil and water cover, land cover change, as well as humanitarian and disaster risk.

Planet SkySat Public Ortho
Imagery, Multispectral



This data from Planet labs Inc. SkySat satellites was collected for the experimental "Skybox for Good Beta" program in 2015, as well as for various crisis response events and a few other projects. The data is available in both a 5-band Multispectral/Pan collection, and a ...

Planet SkySat Public Ortho
Imagery, RGB



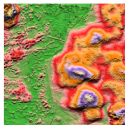
This data from Planet labs Inc. SkySat satellites was collected for the experimental "Skybox for Good Beta" program in 2015, as well as for various crisis response events and a few other projects. The data is available in both a 5-band Multispectral/Pan collection, and a ...

NAIP: National Agriculture
Imagery Program



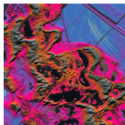
The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. NAIP projects are contracted each year based upon available funding and the imagery acquisition cycle. Beginning in 2003, NAIP was acquired on a 5-year cycle. 2008 was ...

AHN Netherlands 0.5m DEM, Interpolated



The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

AHN Netherlands 0.5m DEM, Non-Interpolated



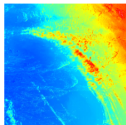
The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

AHN Netherlands 0.5m DEM, Raw Samples



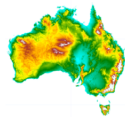
The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. This version contains both ground level samples and items above ground level (such as buildings, bridges, trees etc). The point cloud ...

Australian SM DEM



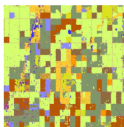
The Digital Elevation Model (DEM) 5 Metre Grid of Australia derived from LIDAR model represents a National 5 metre (bare earth) DEM which has been derived from some 236 individual LIDAR surveys between 2001 and 2015 covering an area in excess of 245,000 square kilometres. ...

DEM-H: Australian SRTM Hydrologically Enforced Digital Elevation Model



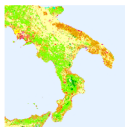
The Hydrologically Enforced Digital Elevation Model (DEM-H) was derived from the SRTM data acquired by NASA in February 2000. The model has been hydrologically conditioned and drainage enforced. The DEM-H captures flow paths based on SRTM elevations and mapped stream lines, and supports delineation of ...

Canada AAFC Annual Crop Inventory



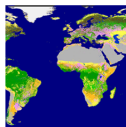
Starting in 2009, the Earth Observation Team of the Science and Technology Branch (STB) at Agriculture and Agri-Food Canada (AAFC) began the process of generating annual crop-type digital maps. Focusing on the Prairie Provinces in 2009 and 2010, a Decision Tree (DT) based methodology ...

Copernicus CORINE Land Cover



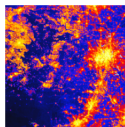
The CORINE (coordination of information on the environment) Land Cover (CLC) inventory was initiated in 1985 to standardize data collection on land in Europe to support environmental policy development. The project is coordinated by the European Environment Agency (EEA) in the frame of the EU ...

Copernicus Global Land Cover Layers: CGLS-LC100 Collection 3



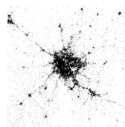
The Copernicus Global Land Service (CGLS) is earmarked as a component of the Land service to operate a multi-purpose service component that provides a series of bio-geophysical products on the status and evolution of land surface at global scale. The Dynamic Land Cover map at ...

CSP gHM: Global Human Modification



The global Human Modification dataset (gHM) provides a cumulative measure of human modification of terrestrial lands globally at 1 square-kilometer resolution. The gHM values range from 0.0-1.0 and are calculated by estimating the proportion of a given location (pixel) that is modified, the estimated intensity ...

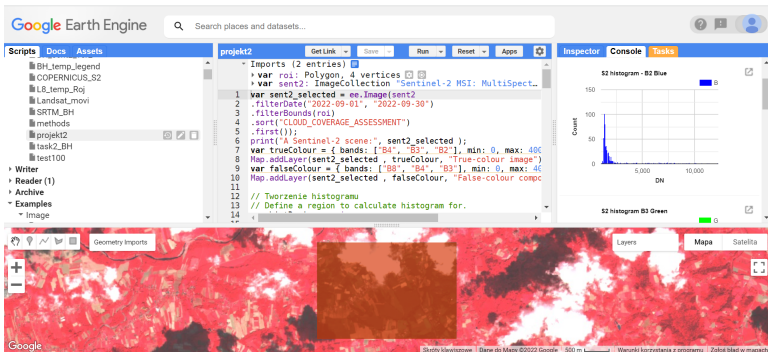
World Settlement Footprint 2015



The World Settlement Footprint (WSF) 2015 is a 10m resolution binary mask outlining the extent of human settlements globally derived by means of 2014-2015 multitemporal Landsat-8 and Sentinel-1 imagery (of which ~217,000 and ~107,000 scenes have been processed, respectively). The temporal dynamics of human settlements ...

Tworzenie własnego kodu z wykorzystaniem dokumentacji i dostępnych przypadków użycia (case studies)

- histogram
- wizualizacje
- wycinanie i eksport obrazów



The screenshot displays the Google Earth Engine web interface. The top navigation bar includes the Google Earth Engine logo, a search bar, and user profile icons. The left sidebar shows a project tree with folders like 'Scripts', 'Docs', and 'Assets', and a list of scripts including 'projekt2'. The main editor area shows the following code:

```

1 var sent2_selected = ee.Image(sent2)
2 .filterDate("2022-09-01", "2022-09-30")
3 .filterBounds(roi)
4 .sort("CLOUD_COVERAGE_ASSESSMENT")
5 .first();
6 print("A Sentinel-2 scene:", sent2_selected);
7 var trueColour = { bands: ["B4", "B3", "B2"], min: 0, max: 4000 };
8 Map.addLayer(sent2_selected, trueColour, "True-colour image");
9 var falseColour = { bands: ["B8", "B4", "B3"], min: 0, max: 4000 };
10 Map.addLayer(sent2_selected, falseColour, "False-colour compo");
11
12 // Tworzenie histogramu
13 // Define a region to calculate histogram for.
14

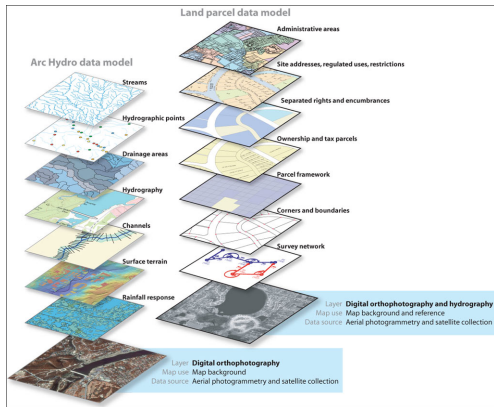
```

The right sidebar contains the 'Inspector' and 'Console' tabs. The 'Inspector' tab shows two histograms: 'S2 histogram - B2 Blue' and 'S2 histogram - B3 Green'. The 'S2 histogram - B2 Blue' histogram shows a distribution of pixel values for the B2 band, with a peak around 1000 DN and a tail extending to 10,000 DN. The 'S2 histogram - B3 Green' histogram shows a similar distribution for the B3 band.

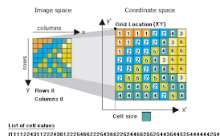
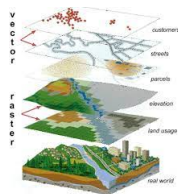
The bottom of the interface shows a map view with a red and blue false-color composite of the Sentinel-2 image. The map includes a 'Layers' panel, a 'Mapa' button, and a 'Satellite' button. The bottom status bar indicates the map is centered on a location in Poland, with a scale of 500 meters.

Różne typy kolekcji obrazów jedno kanałowe, wielokanałowe

- czym jest kanał obrazu?
- co może być zapisane w pikselu?
- co to są obrazy wielokanałowe?



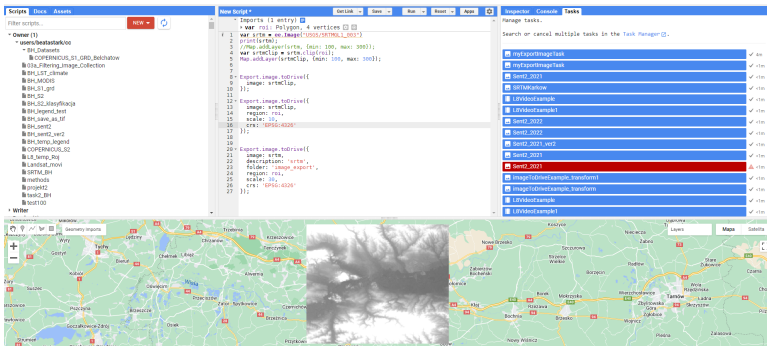
- czym jest kanał obrazu?
pojedyncza macierz (columns, rows)
- co może być zapisane w pikselu?
digital numbers (DN) - wysokość (H), identyfikator (ID) - kod mapy pokrycia użytkowania terenu (Land Use/Land Cover, np. Urban Atlas UA, współczynnik odbicia (obrazy teledetekcyjne) itd.)



- jednokanałowe: NMT (np. SRTM), mapy rastrowe pochodzące z wektorów (np. LULC UA)
- wielokanałowe jednoczasowe: pojedyncze obrazy satelitarne: Sentinel-2, Landsat
- wieloczasowe wielokanałowe: kolekcje obrazów satelitarnych obejmujące więcej niż jeden moment rejestracji (MODIS ale i kolekcja S2 lub Landsat z zadanego okresu, jeśli nie wybierzemy ostatecznie jednego, np. najmniej zachmurzonego `select.first()` Uwaga: łatwo można sprawdzić czy kolekcja jest wieloczasowa - nie da się wykonać `print(image)`;

Jednokanałowe, proste, wszystko da się zrobić łatwo ;-)

przykład SRTM



The screenshot displays the QGIS interface with three main panels:

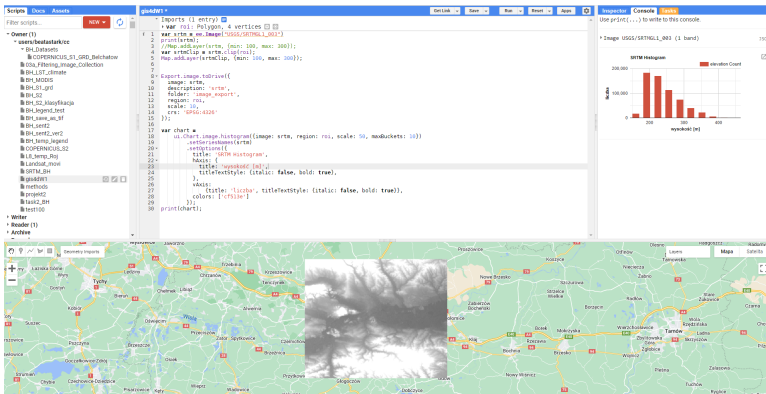
- Left Panel (Project Browser):** Shows a tree structure under 'Users/beatastark/oo'. The 'SRTM' folder is expanded, listing various processing results such as 'SRTM_clip', 'SRTM_clip_10m', 'SRTM_clip_10m_10m', and 'SRTM_clip_10m_10m_10m'.
- Center Panel (Processing Console):** Displays a Python script for SRTM processing:


```

      1 var rps = eo.image(1000,SRTM2_100)
      2 print(rps)
      3 rps = rps.clip(rps, false, 100, false, 3000)
      4 var srtmclip = rps.clip(rps)
      5 Map.addLayer(srtmclip, {name: 'SRTM', max: 3000})
      6
      7
      8 Export image to raster{
      9   image: srtmclip,
      10  }
      11
      12 Export image to raster{
      13   image: srtmclip,
      14   region: rps,
      15   scale: 10,
      16   crs: 'EPSG:4326'
      17 }
      18
      19
      20 Export image to raster{
      21   image: srtm,
      22   description: 'srtm',
      23   folder: 'image_export',
      24   region: rps,
      25   scale: 10,
      26   crs: 'EPSG:4326'
      27 }
      
```
- Right Panel (Task Manager):** Lists several processing tasks in a table:

Task Name	Status
myExportImageTask	✓ 4s
myExportImageTask	✓ 11s
Srtm2_2021	✓ 11s
SRTMKarlow	✓ 11s
LRVtk001example	✓ 11s
LRVtk001example1	✓ 11s
Srtm2_2022	✓ 11s
Srtm2_2022	✓ 11s
Srtm2_2021_vert	✓ 11s
Srtm2_2021	✓ 11s
Srtm2_2021	✓ 11s
ImageToRasterExample.Transform1	✓ 11s
ImageToRasterExample.Transform	✓ 11s
LRVtk001example	✓ 11s
LRVtk001example1	✓ 11s
- Bottom Panel (Map):** Shows a satellite view of a mountainous region with a semi-transparent SRTM elevation overlay. The map includes labels for various locations and a scale bar.

Jednokanałowe, proste, wszystko da się zrobić łatwo ;-) przykład SRTM



The screenshot displays a web-based GIS application interface. The top navigation bar includes 'Scripts', 'Data', and 'Assets'. The left sidebar shows a 'Filter scripts...' section with a 'NEW' button and a tree view of folders and scripts, including 'Owner (1)', 'waven-testastarkice', 'BH_Datasets', 'COOPERNICUS_S1_GRD_Pielchatow', 'Gis_StreamingImage_Collection', 'BH_LIST_climate', 'BH_LIST_MODIS', 'BH_LIST_gpd', 'BH_LIST', 'BH_LIST_klasyfikacja', 'BH_Listing_test', 'BH_list_an_MF', 'BH_list2', 'BH_LIST_LAND', 'BH_list_Legend', 'COOPERNICUS_S2', 'L1_Sensor_Map', 'Landsat_shov', 'SRTM_BH', 'globeSRTM', 'methods', 'proj4M2', 'srtm_BH', and 'test100'. Below this is a 'Writer' section with 'Reader (1)' and 'Archive'.

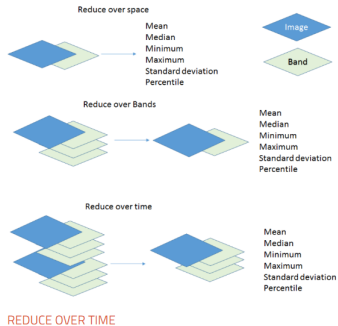
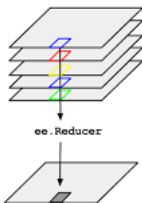
The main area is a script editor for a file named 'globeSRTM'. The script is as follows:

```

1 Imports (1 entry)
2   * var roi: Polygon, 4 vertices
3
4   1 var srtm = ee.Image("USGS/SRTMGL1_003")
5   2 //Map.addLayer(srtm, {min: 100, max: 200});
6   3 var srtmClip = srtm.clip(roi);
7   4 Map.addLayer(srtmClip, {min: 100, max: 200});
8
9
10  5 Export.image.toDrive({
11    6 image: srtm,
12    7 description: 'srtm',
13    8 folder: 'image_export',
14    9 region: roi,
15    10 scale: 10,
16    11 crs: 'EPSG:4326'
17  });
18
19  12 var chart =
20  13 us.Chart.image.histogram({image: srtm, region: roi, scale: 50, madducolors: 10})
21  14 .setOptions({
22  15   title: 'SRTM Histogram',
23  16   radius: {
24  17     title: 'radius [m]',
25  18     titleTextStyle: {italic: false, bold: true},
26  19     vAxis: {
27  20       title: 'Liczba', titleTextStyle: {italic: false, bold: true},
28  21       colors: ['cf933f']
29  22     }
30  23   })
31  24 );
32  25 print(chart);
  
```

The right sidebar shows the 'Inspector' and 'Console' tabs. The 'Inspector' displays 'Image USGS/SRTMGL1_003 (1 band)' with a 'SRTM Histogram' chart. The chart is a bar graph with 'Liczba' on the y-axis (0 to 200,000) and 'mynickod [m]' on the x-axis (0 to 600). The chart shows a distribution of values with a peak around 200m. The 'Console' tab is empty.

The bottom part of the screenshot shows a map of a region in Poland, with a central inset showing a grayscale SRTM elevation map of the same area. The map includes various geographical features like rivers, roads, and place names.





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Wielokanałowe

jednoczasowe, wieloczasowe

Poniżej przykład kolekcji Sentinel-2 (patrz również MODIS Projekt 1)

The screenshot displays the QGIS interface with a script editor and a map view. The script editor shows the following code:

```
Imports (2 entries)
var roi: Polygon, 4 vertices
var sent2: ImageCollection "Sentinel-2 MSI: Multispectral Instrument, Level-2A"
var sent2_selected = ee.Image(sent2
  .filterDate("2022-09-01", "2022-09-30")
  .filterBounds(roi)
  .sort("-CLOUD_COVERAGE_ASSESSMENT")
  .first());
print("A Sentinel-2 scene:", sent2_selected);
var trueColour = { bands: ["B4", "B3", "B2"], min: 0, max: 4000 };
Map.addLayer(sent2_selected, trueColour, "True-colour image");
var falseColour = { bands: ["B8", "B4", "B1"], min: 0, max: 4000 };
Map.addLayer(sent2_selected, falseColour, "False-colour composite");

// Tworzenie histogramu
// Define a region to calculate histogram for.
var histRegion = roi;
// Define the chart and print it to the console.
var chart =
  ui.Chart.image.histogram([image: sent2_selected.select(['B2']), region: histRegion, scale: 100])
  .setSeriesNames(['B2'])
  .setOptions({
    title: 'S2 histogram - B2 Blue',
    hAxis: {
      title: 'DN',
      titleTextStyle: {italic: false, bold: true},
    },
    vAxis: {
      title: 'Count', titleTextStyle: {italic: false, bold: true},
      colors: ['0000FF']
    }
  });
print(chart);

var chart =
  ui.Chart.image.histogram([image: sent2_selected.select(['B1']), region: histRegion, scale: 100])
```

The map view shows a false-color composite of Sentinel-2 data, with a region of interest (ROI) highlighted in orange. The ROI is a polygon with four vertices. The map is titled "Geometry Imports".

On the right side of the interface, there are two histograms:

- S2 histogram - B2 Blue:** A blue histogram showing the distribution of pixel values for the B2 band. The x-axis is labeled "DN" and ranges from 0 to 5,000. The y-axis is labeled "Count" and ranges from 0 to 150.
- S2 histogram B2 Blue:** A green histogram showing the distribution of pixel values for the B2 band. The x-axis is labeled "DN" and ranges from 0 to 5,000. The y-axis is labeled "Count" and ranges from 0 to 75.



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Wielokanałowe

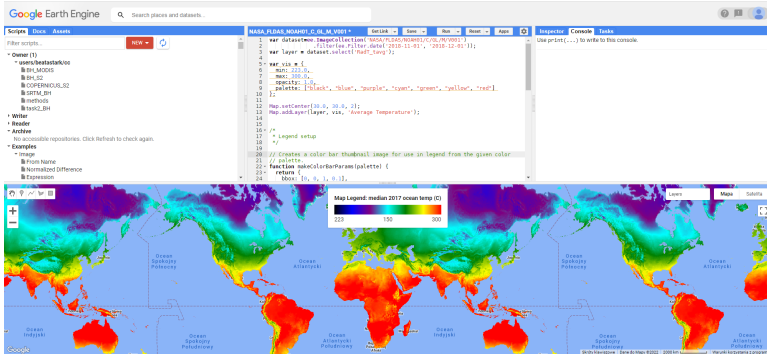
jednoczasowe, wieloczasowe

Poniżej przykład kolekcji Sentinel-2 (patrz również MODIS Projekt 1)

```
projekt2
81  .setOptions({'width': 100, 'height': 100, 'width': 100})
82  .setOptions({
83    title: 'S2 histogram B, G, R, NIR',
84    hAxis: {
85      title: 'DN',
86      titleTextStyle: {italic: false, bold: true},
87    },
88    vAxis: {
89      title: 'Count', titleTextStyle: {italic: false, bold: true},
90      colors: ['0000FF', '00FF00', 'FF0000', '000000']
91    });
92  print(chart);
93
94  // Docieć do roi
95  var sent2_clip = sent2_selected.clip(roi);
96  Map.addLayer(sent2_clip, trueColour, "True-colour image sent2_clip");
97
98  //Eksportownie do formatu tif
99  // Wybór kanałów o rozdzielczości 10m; nie da się zapisać do formatu tif kanałów o różnej rozdzielczości w różnych rozmiarów, róż
100 var sent2_selected_bands = ee.Image(sent2_selected.select(['B2', 'B3', 'B4', 'B8']));
101 var projection = sent2_selected.select('B2').projection().getInfo();
102 print(projection);
103 // Export the image, specifying the CRS, transform, and region.
104 Export.image.toDrive({
105   image: sent2_selected_bands,
106   description: 'Sent2_2021',
107   crs: projection.crs,
108   crsTransform: projection.transform,
109   region: roi
110 });
111 Map.centerObject(roi, 13);
112
113
```

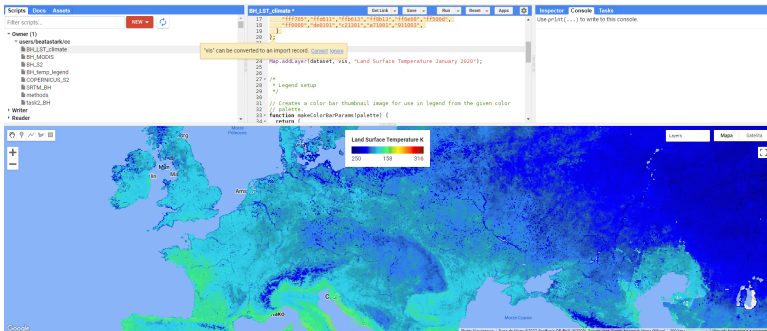


- Information on many climate-related variables including moisture content, humidity, evapotranspiration, average soil temperature, total precipitation rate, etc.
- How to add color-map scale in Google Earth Engine?





- Temperatura powierzchni Ziemi
- Zmiana tytułu legendy i centrowania



Deklaracja zmiennych



```

Klasyfikacja_Przyklad
Get Link Save Run Reset Apps
Imports (10 entries)
var CZEHPIN: Polygon, 4 vertices
var Las: FeatureCollection (13 elements)
var Zabudowa: FeatureCollection (18 elements)
var GlebaOdkryta: FeatureCollection (17 elements)
var Uprawy: FeatureCollection (16 elements)
var Woda: FeatureCollection (12 elements)
var S22A: ImageCollection "Sentinel-2 MSI: MultiSpectral Instrument, Level-2A"
var KLASYFIK: classification from 0 to 4
var PARAM: B4, B3 and B2 from -181.75883640227067 to 1187.8778263012607
var zakres: Polygon, 4 vertices
  
```

Filtracja obrazów

```

1 var filtracja = ee.Image(ee.ImageCollection('COPERNICUS/S2_SR')
2   .filterDate('2018-05-01', '2018-05-28')
3   .filterBounds(CZEHPIN)
4   .filterMetadata('CLOUDY_PIXEL_PERCENTAGE', 'less_than', 5)
5   .first())
6   .clip(zakres);
7 Map.setCenter(16.75,52.15,11)
  
```

Przypadek użycia - Case study

Wynik filtracji obrazów

Inspector	Console	Tasks
		2500
	zbiór obrazów Sentinel-2 ZA 0508071	2500
	Liczba obrazów ograniczonych przez wskazany zakres 209	2500
	Liczba obrazów ograniczonych przez wskazany % zachmurzenia 34	2500
	Liczba obrazów ograniczonych okresem czasu w 2017 r. 1	2500
	Liczba obrazów ograniczonych okresem czasu w 2018 r. 4	2500
	Liczba obrazów ograniczonych okresem czasu w 2019 r. 2	2500

```
Sortowanie obrazów z 2018 r.celem wybrania obrazu o najmniejszym zachmurzeniu 2500
▼ ImageCollection COPERNICUS/S2_SR (4 elements) 2500
  type: ImageCollection
  id: COPERNICUS/S2_SR
  version: 1593695733578980
  bands: []
  ▼ features: List (4 elements)
    ▶ 0: Image COPERNICUS/S2_SR/20180506T100031_20180506T100214_T33LXT (23 bands)
    ▶ 1: Image COPERNICUS/S2_SR/20180531T100029_20180531T100410_T33LXT (23 bands)
    ▶ 2: Image COPERNICUS/S2_SR/20180521T100029_20180521T100024_T33LXT (23 bands)
    ▶ 3: Image COPERNICUS/S2_SR/20180526T100031_20180526T100553_T33LXT (23 bands)
  ▼ properties: Object (20 properties)

Obraz z 2018 r. 2500
▼ Image COPERNICUS/S2_SR/20180506T100031_20180506T100214_T33LXT (23 bands) 2500
  type: Image
  id: COPERNICUS/S2_SR/20180506T100031_20180506T100214_T33LXT
  version: 1557772726534878
  ▼ bands: List (23 elements)
  ▼ properties: Object (81 properties)
```

```
37 var nir = obraz2017.select('B0');
38 var red = obraz2017.select('B4');
39 var NDVI2017 = obraz2017.expression('(nir-red)/(nir+red)', {'nir': nir, 'red': red}).rename('NDVI')
40 .clip(obszar);
41 Map.addLayer(NDVI2017, PARAMETRY_NDVI, 'NDVI2017');
```

2017 RGB



2017 NDVI



2018 RGB



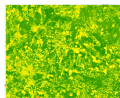
2018 NDVI



2019 RGB



2019 NDVI



Przypadek użycia - Case study

Zmienność NDVI w czasie



```

56 var NDVI_k = kolekcja.map(function(image) {
57   var ndvi = image.normalizedDifference(['B8', 'B4']).rename('NDVI');
58   return image.addBands(ndvi);
59 });
60
61 var chart1 = ui.Chart.image.series({
62   imageCollection: NDVI_k.select('NDVI'),
63   region: ROI1,
64   reducer: ee.Reducer.first(),
65   scale: 30

```



```

122 = }).setOptions({title: 'Zmiany wartości indeksu NDVI we wskazanym punkcie ROI1 w 2018 r.',
123 = hAxis: {
124 =     title: 'Miesiąc',
125 = },
126 = vAxis: {
127 =     title: 'NDVI'
128 = },
129 =     lineWidth: 2,
130 = });

```

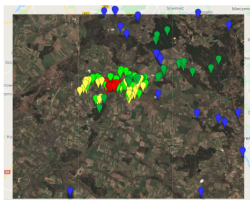
Rys. 28 Fragment skryptu, konfiguracja parametrów wyświetlania wykresu



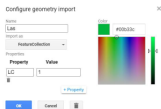
Rys. 29 Wykres we wskazanym punkcie na podstawie kolekcji obrazów z 2018 r.

Przypadek użycia - Case study

Wybór pól referencyjnych



Rys. 32 Wybór pól treningowych



Rys. 33 Menu konfiguracyjne geometrii

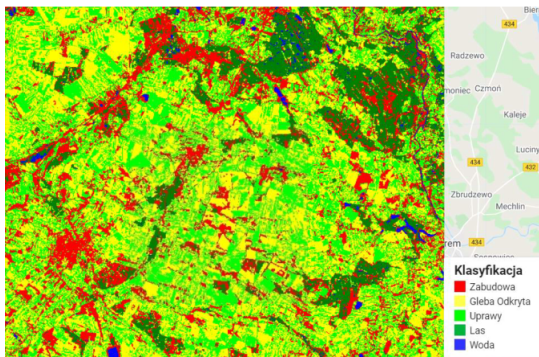
```

11 var classNames = Las.merge(Zabudowa).merge(GlebaOdkryta).merge(Uprawy).merge(Woda);
12 print('Punky Treningowe', classNames);
13
14 var bands = ['B2', 'B3', 'B4', 'B5', 'B6', 'B7', 'B8'];
15 var training = image.select(bands).sampleRegions({
16   collection: classNames,
17   properties: ['LC'],
18   scale: 20
19 });
20
21 var classifier = ee.Classifier.smileCart().train({
22   features: training,
23   classProperty: 'LC',
24   inputProperties: bands
25 });
26
27 var classified = image.select(bands).classify(classifier);
28
29 Map.addLayer(classified,
30   {min: 0, max: 4, palette: ['blue', 'green', 'red', '00FF00', 'yellow']},
31   'classification');

```

Przypadek użycia - Case study

Wynik klasyfikacji





AGH

Przypadek użycia - Case study

Analiza dokładności

Confusion matrix

```
33 var valNames = vlas.merge(vzabud).merge(vgleba).merge(vvoage).merge(vvoda);
34
35 var validation = classified.sampleRegions({
36   collection: valNames,
37   properties: ['LC'],
38   scale: 20,
39 });
40 print('Punky Kontrolne', validation);
41
42
43 var testAccuracy = validation.errorMatrix('LC', 'classification');
44 print('Macierz Błędów walidacji: ', testAccuracy);
45 print('Dokładność walidacji: ', testAccuracy.accuracy());
46
47 var CA = testAccuracy.consumersAccuracy();
48 var Kappa = testAccuracy.kappa();
49 var PA = testAccuracy.producersAccuracy();
50
51 print(CA, 'Dokładność Konsumenta');
52 print(Kappa, 'Kappa');
53 print(PA, 'Dokładność Producenta');
```

```
Punky Treningowe 250N
+ FeatureCollection (75 elements, 2 columns) 250N

Punky Kontrolne 250N
+ FeatureCollection (51 elements, 0 columns) 250N

Macierz Błędów walidacji: 250N
+ List (5 elements) 250N
+ 0: [8,1,0,0,0]
+ 1: [1,8,1,0,0]
+ 2: [0,0,12,1,0]
+ 3: [0,0,0,5,4]
+ 4: [0,0,1,2,7]

Dokładność walidacji: 250N
0.7843137254901961

Punky Treningowe 250N
+ FeatureCollection (75 elements, 2 columns) 250N

Punky Kontrolne 250N
+ FeatureCollection (51 elements, 0 columns) 250N

Macierz Błędów walidacji: 250N
+ List (5 elements) 250N
+ 0: [8,1,0,0,0]
+ 1: [1,8,1,0,0]
+ 2: [0,0,12,1,0]
+ 3: [0,0,0,5,4]
+ 4: [0,0,1,2,7]

Dokładność walidacji: 250N
0.7843137254901961
```

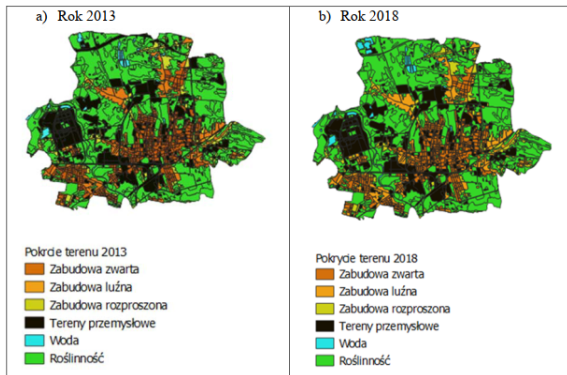

Landsat 8

Parametry orbity satelity Landsat 8:

- Światowy system odniesienia (WRS-2).
- Orbita heliosynchroniczna (biegunowa), na wysokości 705 km,
- 233 okrążeń w cyklu, czas rewizyty, co 16 dni,
- Pochylona 98,2°,
- Czas obiegu 98,9 minuty,
- Przekroczenie równika: 10: 00 +/- 15 minut.
- Rozmiar sceny: 170 km x 185 km
- Żywotność minimum 5 lat [8]

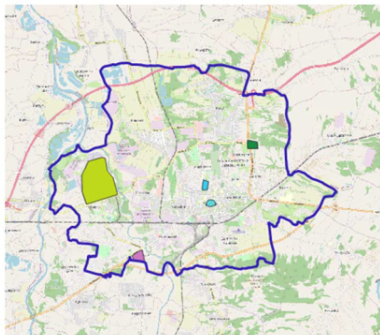
Tabela 1. Zestawienie wszystkich kanałów spektralnych satelity Landsat 8 [13].

Kanał	Długość fali (µm)	Rozdzielczość przestrzenna [m]
Band 1 - Coastal aerosol	0.43-0.45	30
Band 2 - Blue	0.45-0.51	30
Band 3 - Green	0.53-0.59	30
Band 4 - Red	0.64-0.67	30
Band 5 - Near Infrared (NIR)	0.85-0.88	30
Band 6 - SWIR 1	1.57-1.65	30
Band 7 - SWIR 2	2.11-2.29	30
Band 8 - Panchromatic	0.50-0.68	15
Band 9 - Cirrus	1.36-1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.6-11.19	100
Band 11 - Thermal Infrared (TIRS) 2	11.50-12.51	100



Przypadek użycia - Case study

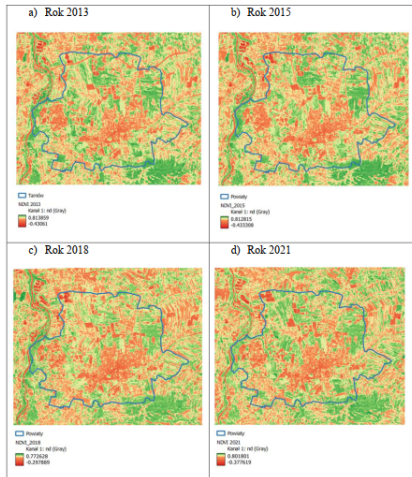
Tarnów Open Street Map OSM



- Tarnów
 - Wybrane lokalizacje Tarnów
 - Zakłady Azotowe
 - Osiedle Koszyckie
 - Rondo Niepodległość
 - Park Strzelecki
 - Ścisłe centrum Tarnowa
- OpenStreetMap

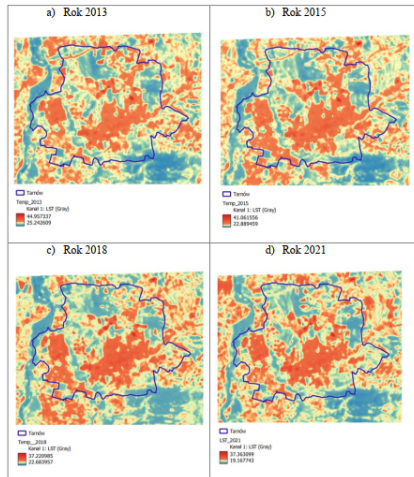
Przypadek użycia - Case study

Tarnów NDVI w czasie



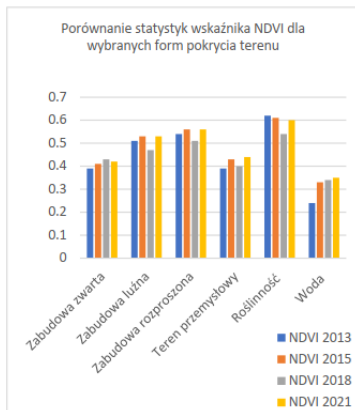
Przypadek użycia - Case study

Tarnów temperatura w czasie



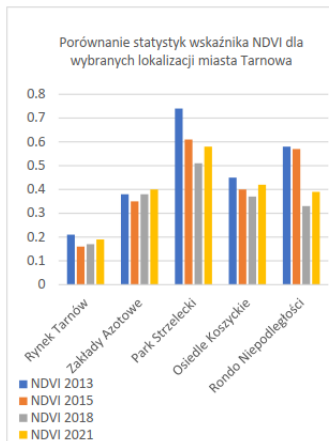
Przypadek użycia - Case study

Tarnów NDVI dla różnych form pokrycia terenu w czasie



Przypadek użycia - Case study

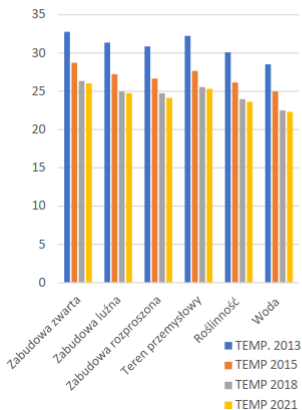
Tarnów NDVI dla wybranych obiektów w czasie



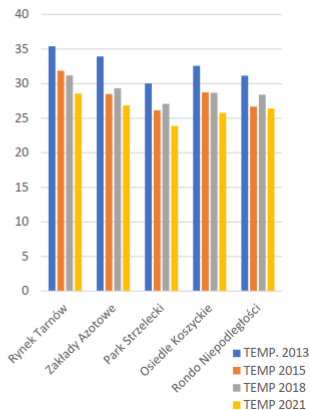
Przypadek użycia - Case study

Tarnów porównanie zmienności temperatury

Porównanie wartości temperatury powierzchni dla wybranych form pokrycia terenu

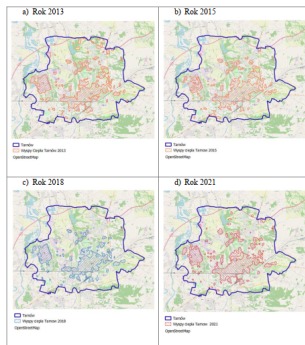


Porównanie wartości średniej temperatury powierzchni dla wybranych lokalizacji miasta Tarnowa



Przypadek użycia - Case study

Tarnów wyspy ciepła



Rysunek 14. Graficzne przedstawienie „wysp ciepła” na obszarze Tarnowa a) 2013, b) 2015, c) 2018, d) 2021.

Tabela 5. Zmierzanie powierzchni „wysp ciepła” dla obszaru Tarnowa podczas czterech badań.

Rok	Srednia temperatura powierzchni [°C]	Graniczna temperatury „wyspy ciepła” [°C]	Powierzchnia „wyspy ciepła” [ha]	Procentowy udział w powierzchni miasta [%]
2013	30,58	32,88	1206	16,7
2015	26,67	28,67	1067	14,7
2018	26,93	28,93	974	13,5
2021	24,18	26,18	1153	15,9