Image processing for Earth observation

How to access geo-information?

Gaston Lenczner

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École polytechnique fédérale de Lausanne

Download data in remote sensing

- As in all fields of data science, a key step is to obtain the data
- Multiple platforms and sources provide aerial and satellite data
- Some are free, some are not, some provide a limited and/or conditional free offer
- For manual labelling of geospatial data and local visualization: QGIS (https://qgis.org/)

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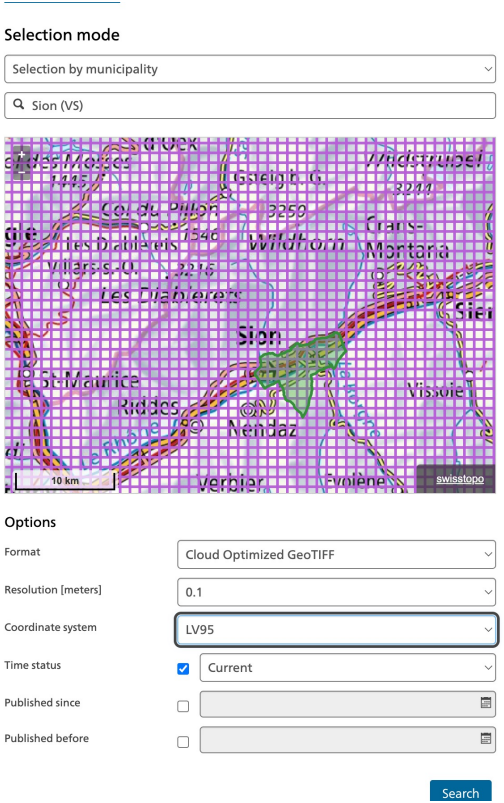
Swisstopo

https://www.swisstopo.admin.ch/en/orthoimage-swissimage-10

- RGB orthophotos at 10cm (or 25 cm depending on the area) of Switzerland
- One release per year since 2017: Free
- Upon request before (started in 1946)
- Digital Elevation Model available
- Maps: potential machine learning labels
- Extremely easy-to-download



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Copernicus browser – Overall

https://browser.dataspace.copernicus.eu/

- Free to use and publicly owned tool (ESA Project)
- Visualise, compare and analyse and download data
- Limited amount of freely available processing data
- Sentinel, Landsat, MODIS, Probas-V and GIBS products available
- Easily visualize pre-computed layers (NDVI, NDWI, …)
- Manual exporting method not suitable for large data sets

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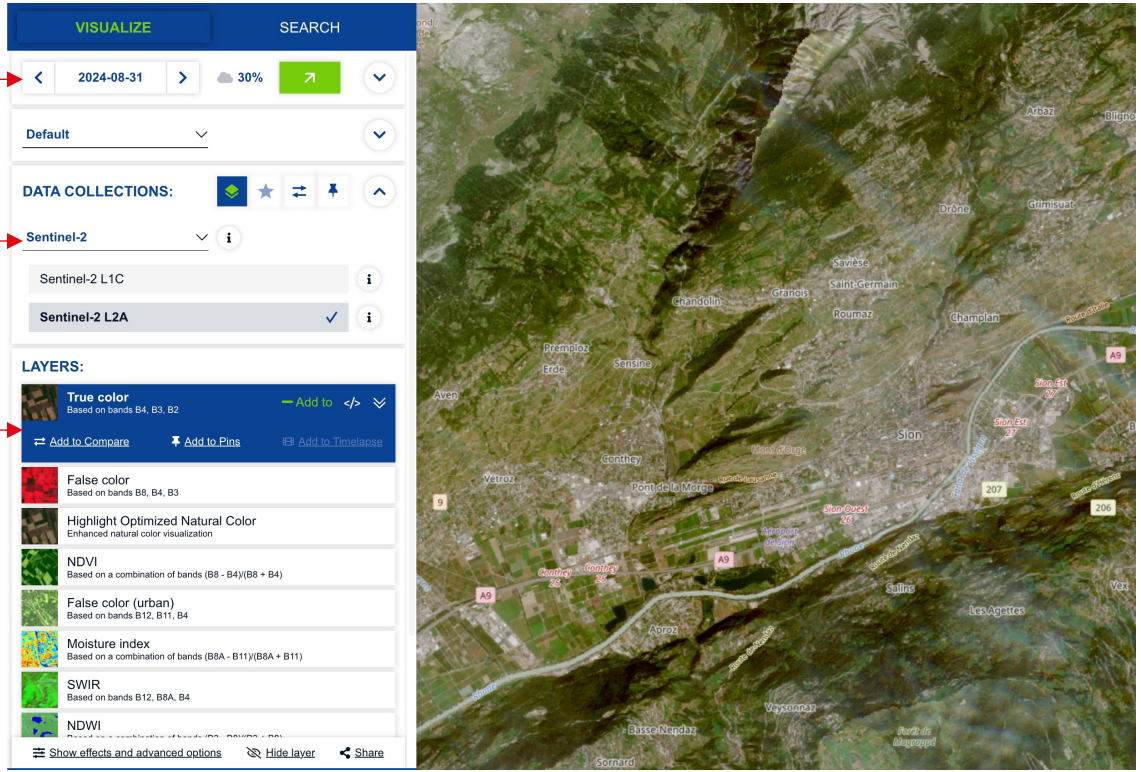
Copernicus browser – User interface

Date

Satellite source

Product



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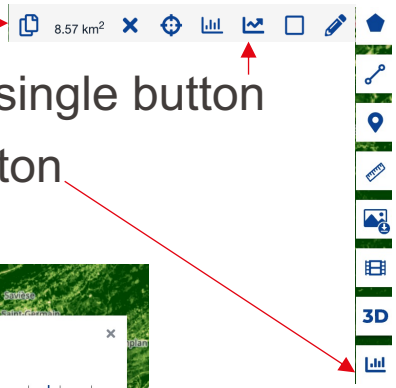
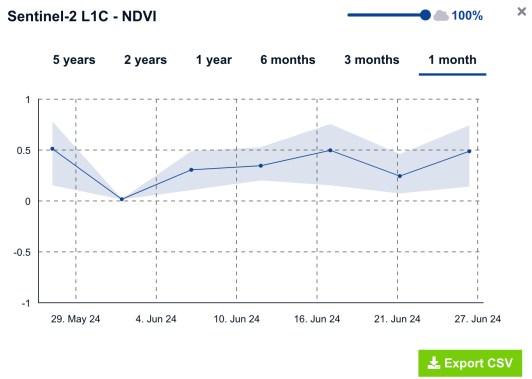
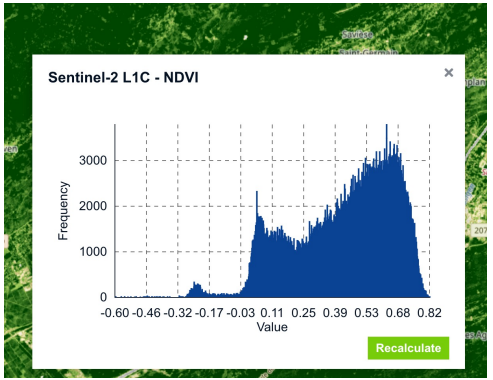
Copernicus browser – Easy statistics

- Draw or import an region of interest
- Get the time serie of an index in a selected area with a single button
- Get the histogram of the selected area with a single button





Time serie



Histogram

Copernicus browser – Download data

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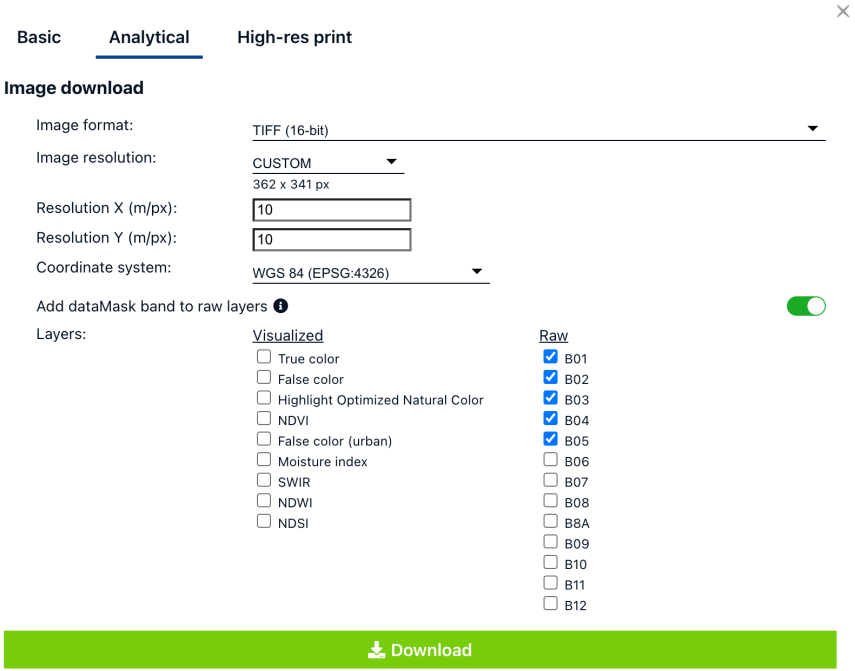
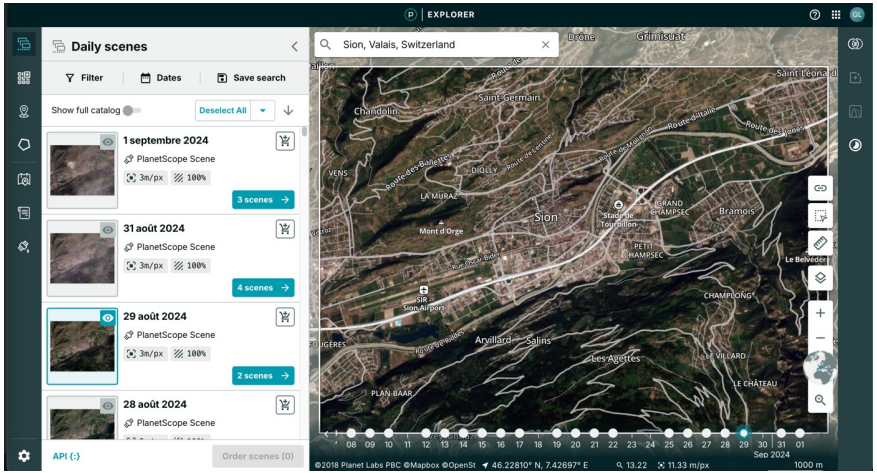


Planet explorer

https://www.planet.com/explorer/

- Education and Research Standard Plan: free to download 5000km²/month.
- High resolution imagery (3m)
- Manual exporting method not suitable for large data sets
- User friendly interface to specify the area of interest, the dates and deal with parameters like cloud coverage



Google Earth Engine – What is it?

https://code.earthengine.google.com

- **Cloud-based platform** for processing vast amounts of satellite imagery and geospatial data.
- **Programming interface**: Uses JavaScript and Python APIs
- **Large-scale data processing**: Can analyze large amounts of data without needing local infrastructure.
- **Support machine learning**

Google Earth Engine - Pros

- Large catalog of remote sensing datasets
  - Imagery (e.g. Sentinel, Landsat)
  - Climate (e.g. ERA5)
  - Surface temperature (e.g. MODIS)
  - Digital Elevation Models (e.g. SRTM)
  - Land Cover (e.g. ESA World Cover)
- Real-time data availability: Many datasets are updated regularly.
- Web-based Javascript interface and Python API
  - Easy to share results and scripts with others
- Free for non-commercial use
- Usable to download big amounts of data with coding scripts

Google Earth Engine - Cons

- Requires a Google account.
- Requires some coding knowledge.
- **Impractical to export data outside the platform:**
  - Through Google drive with the Javascript API
    - Natively supported, easy-to-do
    - Manual method not suitable for large data sets
    - A file size limit
  - Through Python API
    - A file size limit that can be bypassed by splitting the data into smaller parts
- Commercial use restrictions (not our concern)
- Google can change the way it works at any time.
- Need to be careful when downloading a new dataset:
  - SAR data are log transformed, normalized and thresholded.

Google Earth Engine – Visualize data

```
var sion = ee.Geometry.Point([7.3606, 46.2331]); // Define the location of Sion, Switzerland
var region = sion.buffer(10000).bounds(); // 10 km buffer around Sion as a bounding box

// Load S2 image collection
var s2 = ee.ImageCollection('COPERNICUS/S2').filterBounds(sion).filterDate('2024-07-01', '2024-08-31');
// Take most recent image
var s2_first = s2.sort('system:time_start', false).first()
// Select the RGB bands (Red, Green, Blue)
var rgb = s2_first.select(['B4', 'B3', 'B2']);

// Center the map on Sion and display the RGB image
Map.centerObject(region, 10);
Map.addLayer(rgb, {min: 0, max: 5000}, 'S2 RGB');

// Highlight the region on the map
Map.addLayer(region, {color: 'red'}, 'Region of Interest');

// Export the image to Google Drive
Export.image.toDrive({
  image: rgb,
  region: region,
  description: 'Sion_S2_RGB_Summer2024',
  scale: 10, // S2 has 10m resolution for RGB bands
});
```

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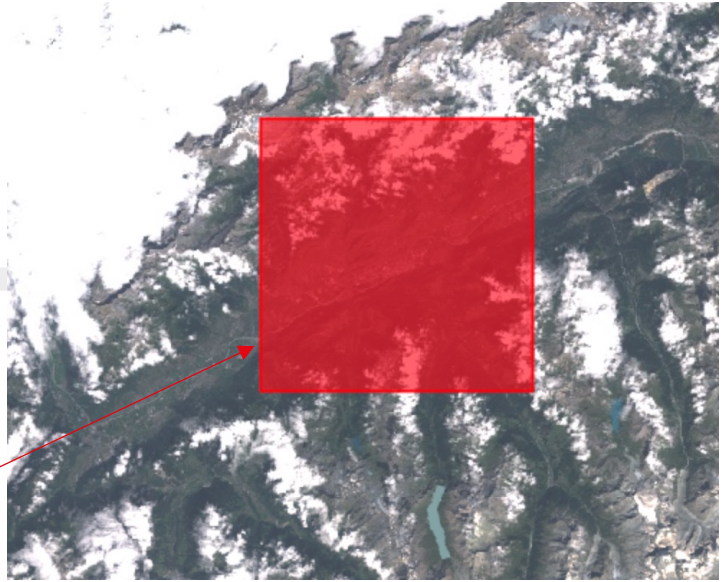

Target area to download

Google Earth Engine – Visualize data

Possible to add customized pre processing:
here, we compute the median over July and August and remove clouded images

```
// Mask clouds
var MAX_CLOUD_PROBABILITY = 20;
function maskClouds(s2, s2Clouds){
  var s2EdgdesMasked = s2.map(function(img){
    return img.updateMask(img.select('B8A').mask().updateMask(img.select('B9').mask()))
  })
  var s2SrWithCloudMask = ee.Join.saveFirst('cloud_mask').apply({
    primary: s2EdgdesMasked, secondary: s2Clouds,
    condition: ee.Filter.equals({leftField: 'system:index', rightField: 'system:index'})
  })
  var s2CloudMasked = ee.ImageCollection(s2SrWithCloudMask).map(function(img){
    return img.updateMask(ee.Image(img.get('cloud_mask')).select('probability').lt(MAX_CLOUD_PROBABILITY))
  })
  return s2CloudMasked
}


var sion = ee.Geometry.Point([7.3606, 46.2331]); // Define the location of Sion, Switzerland
var region = sion.buffer(10000).bounds(); // 10 km buffer around Sion as a bounding box

// Load S2 image collection
var s2 = ee.ImageCollection('COPERNICUS/S2').filterBounds(sion).filterDate('2024-07-01', '2024-08-31');
// Load associated cloud probability
var s2Clouds = ee.ImageCollection('COPERNICUS/S2_CLOUD_PROBABILITY').filterDate('2024-07-01', '2024-08-31').filterBounds(sion);
// Take median over all images that do not contain clouds
var s2_median = maskClouds(s2, s2Clouds).median()
// Select the RGB bands (Red, Green, Blue)
var rgb = s2_median.select(['B4', 'B3', 'B2']);

// Center the map on Sion and display the RGB image
Map.centerObject(region, 10);
Map.addLayer(rgb, {min: 0, max: 5000}, 'S2 RGB');
```

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Google Earth Engine – Visualize data

S2 image without preprocessing on one date

Median S2 image with cloud masking over July and August 2024

QGIS – Visualize and annotate locally

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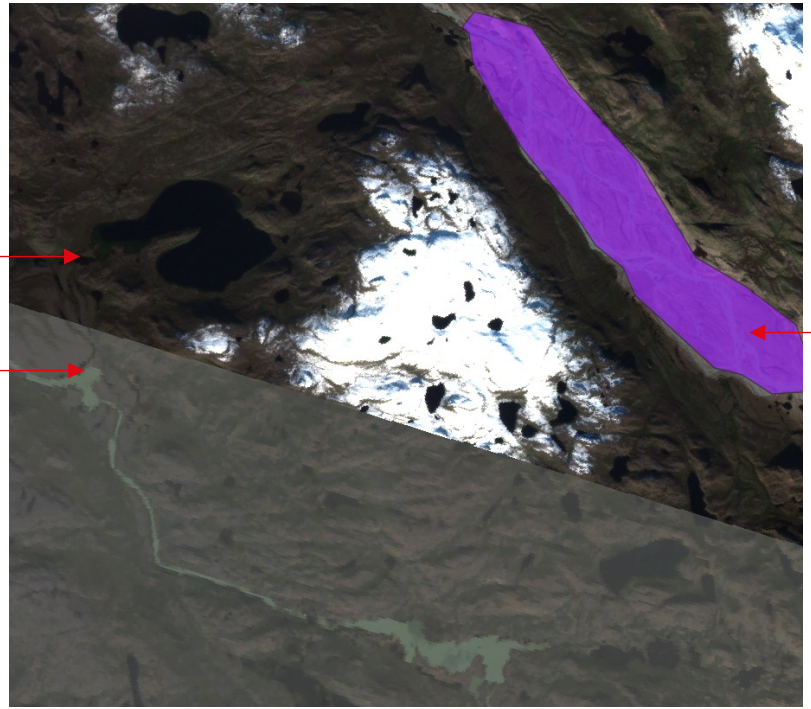

Landsat RGB imagery overlayed with Planet RGB imagery and outwash plain annotation in Greenland

Take-home message

- No *easy* and *free* way to download large amounts of remote sensing images
  - Through Planet explore and Copernicus browser: Good for visualization and downloading small datasets.
  - Through Google Earth Engine: Many datasets and possible large files exports but with some coding tricks.
  - Swisstopo for Switzerland
- Labels can be available depending on the country policy
  - Switzerland: Swisstopo, France: IGN, …
- Many other platforms exist (PEPS by CNES, USGS.gov, …)
- QGIS to work locally with GIS data.
- Dedicated geospatial Python libraries
  - Rasterio, fiona, shapely, geopandas, …

Bonus: Find your name in Landsat

https://landsat.gsfc.nasa.gov/apps/YourNameInLandsat-main/