Innovative Postgraduate Education in The Field of Environment Protection: Methods and Tools
Final Conference – 5-7 October 2022 – Yerevan, Armenia

Quick Sentinel-2 MSI optical indices assessment exploiting the Google Earth Engine platform

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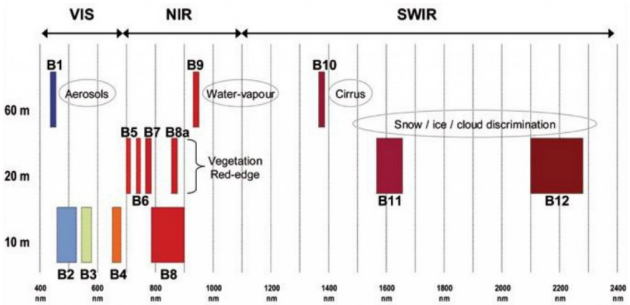
Why Sentinel-2 MSI Imagery?

Copernicus MultiSpectral Instrument Fact Sheet

The EU Copernicus Sentinel-2 satellite constellation offers free, **state-of-the-art imagery** for environmental sciences:

- Sun-synchronous orbit at about 800 km height
- 2 $\rightarrow$ 4 satellites constellation:
  - Sentinel-2A launched June 2015
  - Sentinel-2B launched March 2017
  - Sentinel-2C scheduled for 2024
  - Sentinel-2D scheduled for 2025
- 12 bands + meta info
- 5 days revisit time (10 days each)
- 10 metres ground resolution for VIS and NIR bands



The Sentinel-2 MultiSpectral Instrument bands.

The ground resolution of the Sentinel-2 satellites allows a fine-grained study of vegetation and landcover:
1 Landsat pixel = 9 Sentinel pixels: nearly 10x resolution.

The short revisit time provides optimal time series.

Complementary bands in the Level-2A (surface reflectance) data product offer scenes meta-info.

Working with Optical Indices

Remote optical imagery has a wide range of applications in environmental sciences.
Most applications involve the use of optical indices, deriver from surface reflectances, and the evaluation of indices time series, for monitoring changes.

An RGB image...

...the corresponding NDVI index...

...and the resulting trees.

A never-ending classic: the *NDVI*, i.e. **N**ormalized **D**ifferential **V**egetation **I**ndex, is an adimensional index related to the vegetation status and coverage.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

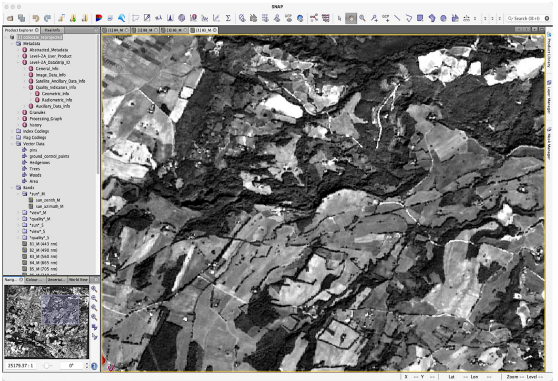
Remote Sensing

The traditional way

The standard workflow with optical imagery is time-consuming. It includes:

- Scene selection and images retrieval
- Images filtering (clouds...)
- Local image storage – **critical**
- Indices evaluation
- Time series evaluation – **critical**
- Indices classification and segmentation
- Scene or time series classification

These analyses can be conducted exploiting a bunch of specialized software. SNAP is a popular option, not just with Sentinel data, but it is hard to master, though.
Anything capable to shorten computation times and reduce storage needs is welcome.



The SNAP interface.

The EU Copernicus program provides a collection of tools grouped under a common interface, the **S**e**N**tinel **A**pplication **P**latform, commonly known as **SNAP**.

Open: distributed with a **GNU-GPLv3** license.

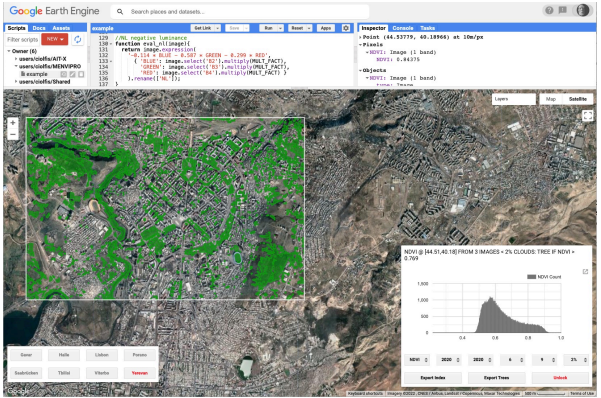
Remote Sensing

The Google Earth Engine alternative

Google Earth Engine is a cloud computing platform for remote sensing imagery.

It solves some problems in everyday's image manipulation:

- No need for local storage
- Works seamless with huge amount of data
- Outputs results as raster (geotiff) or vector (shapefile) datasets
- It is unbelivably fast
- Users can configure a set of widgets and interactive tools
- Coordinates and projections can be mixed freely



The GEE interface.

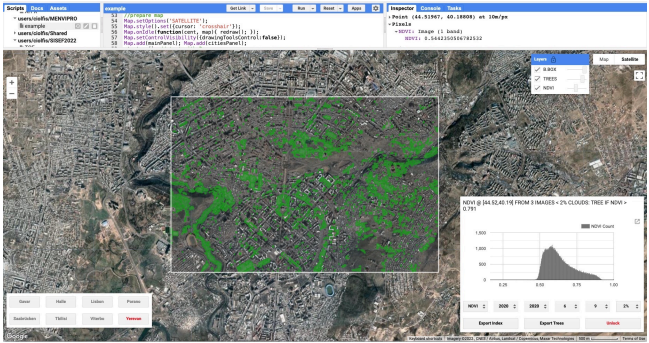
GEE is operated by Javascript programming via a dedicated web interface.

In order to use GEE, a potential user should enrol as a Google Developer (for free, but needs registration).

GEE is free, but it is not open!

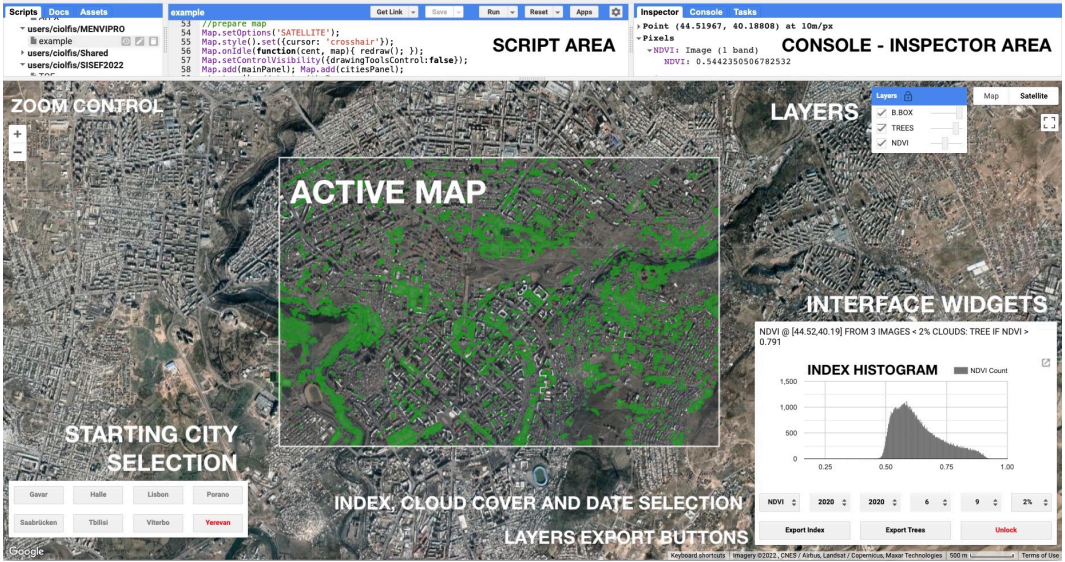
Sentinel-2 on GEE – A Working Example: Finding Trees

This is a naïve working example. The script finds a median index over a period of time and evaluates its histogram, form which the user selects a threshold values for trees identification. All parameter can be configured via a graphical user interface.



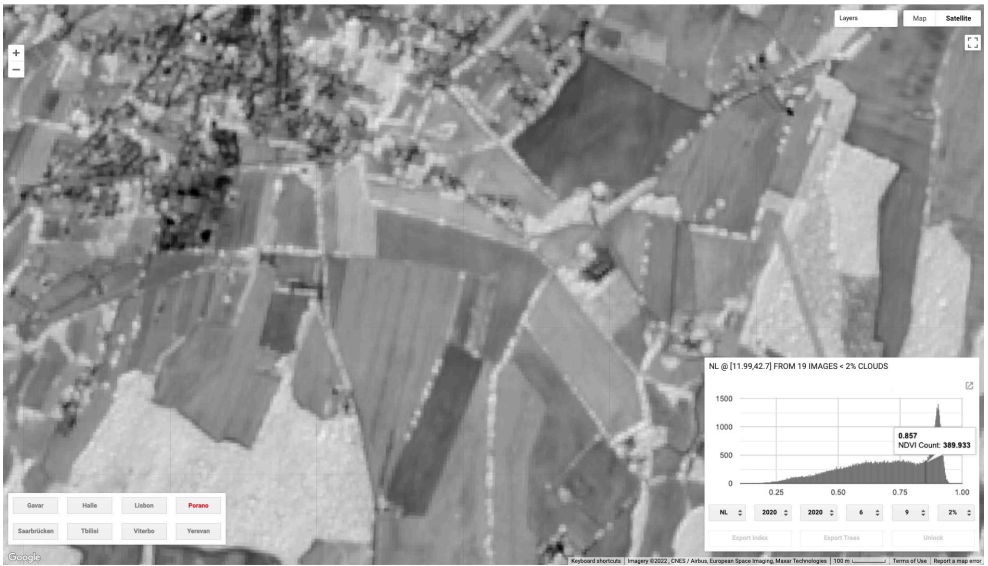
Code shared @ https://code.earthengine.google.com/?accept_repo=users/mciolfi/menvipro
Suggestion: make your own copy of the script and feel free to experiment.

Sentinel-2 on GEE – The interface



Running the Code – 1.Find an area of interest

Running the Code – 2.Evaluate an index and pick a threshold



Running the Code – 3.Check and export the resulting trees

GEE Data Catalog

The Google Earth Engine platform also acts as a proxy for the entire MODIS, Landsat and Sentinel imagery catalog. These images can also be accessed via their respective interfaces and web services, but GEE provides a unified, seamless interface for data retrieval.

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.

Sentinel-3 OLCI EFR: Ocean and Land Color Instrument

Data availability: 2016 – Present

The Sentinel-3 instrument provides systematic measurements of the planet's oceans, land, ice, and atmosphere, including the temperature, color and height of the sea surface as well as the thickness of sea ice.

Sentinel-5P TROPOMI: TROPOspheric Monitoring Instrument

Data availability: 2018 – Present

The Sentinel-5 Precursor mission collects data useful for assessing air quality, including concentrations of: ozone, methane, formaldehyde, aerosol, carbon monoxide, nitrogen oxide, and sulphur dioxide.

Landsat 9 OLI-2/TIRS-2

2021–Present

Landsat 8 OLI/TIRS

2013–Present

Landsat 7 ETM+

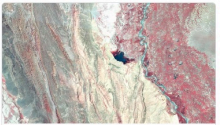
1999–2021

Landsat 5 TM

1984–2012

Landsat 4 TM

1982–1993



Landsat 1-5 MSS

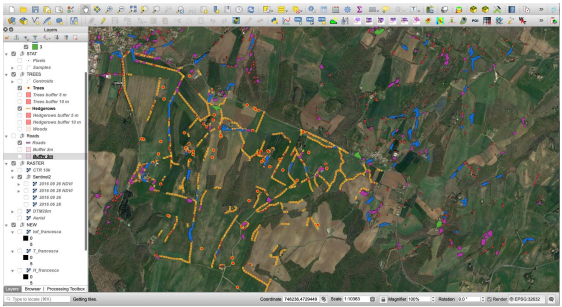
1972–1999

The full catalog can be accessed @ https://developers.google.com/earth-engine/datasets

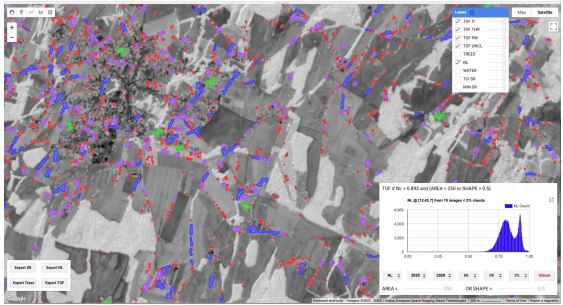
Is GEE the ultimate tool?

GEE yields quick access to satellite imagery with an unprecedented ease, but is it the tool for all possible remote sensing needs in environmental sciences? Should we dismiss the old tools?

Traditional craftsmaship



GEE cloud computing



✗ Steep learning curve
✗ Images must be stored locally
✓ Finest control on processing algorithms
✓ Unrivaled GIS and imagery toolbox

✓ No need for ultra-fast network connection
✓ Zero load on local storage and CPU
✗ Server/client interaction quirky
✗ *Quick* often rhymes with *dirty*

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