Access Geodata from the Web

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- Exercise 1 - Download DEM and analyse terrain surface height values.
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The following handout gives instructions on how to access and download geospatial data from the web with different means:

1. Downloading data in your computer
2. Web Services WMS[1] / WFS / TMS
3. OpenStreetmap Data[2]

The objective is to be able to hunt for geospatial data for your future projects, including the project required for passing the exam.

Downloading geospatial data from web providers

[1] Check tutorial *Working with WMS Data*
[2] Check tutorial *Searching and Downloading OpenStreetMap Data*

An internet portal that provides several geospatial datasets for downloading is usually called a “Catalogue”. Finding catalogues can be as easy as search using a search engine (e.g. Google), but sometimes require further investigation. In the next session some examples of web portals providing geospatial data with global, national and regional scales.

2 Global Datasets

2.1 GENERAL COLLECTIONS

2.1.1 Natural Earth Data

Free vector and raster map data at 1:10m, 1:50m, and 1:110m scales

https://www.naturalearthdata.com/

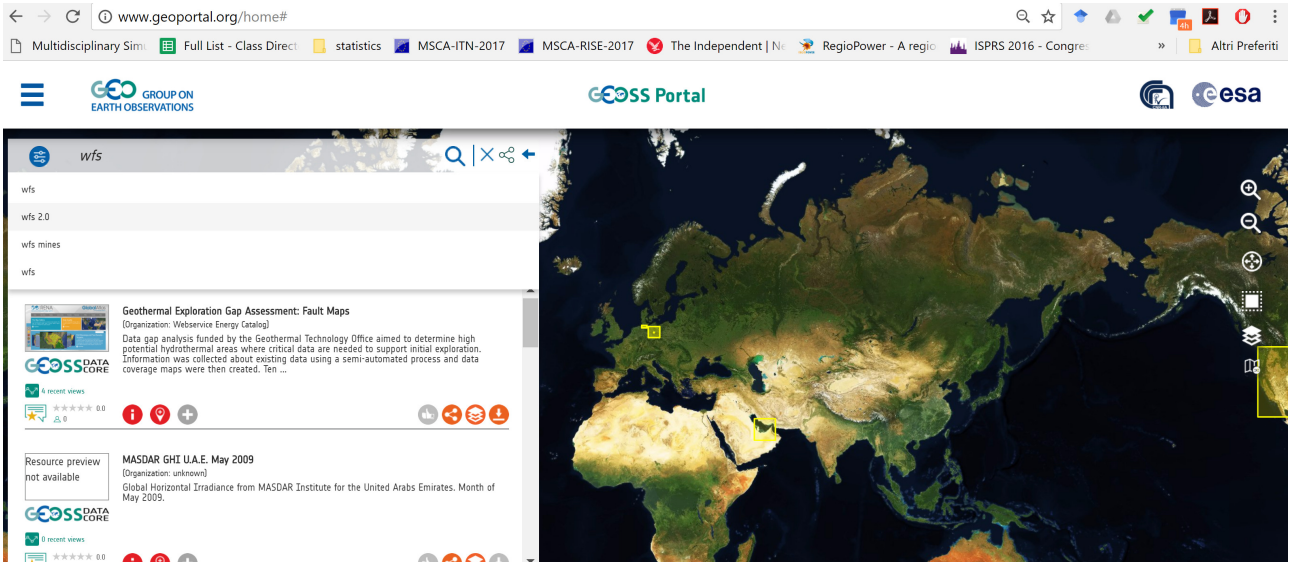
2.1.2 Essential Climate Variables

GCOS Essential Climate Variables (ECV) Data Access Matrix

https://www.ncdc.noaa.gov/gosic/gcos-essential-climate-variable-ecv-data-access-matrix/

2.1.3 GEOSS portal

http://www.geoportal.org/ Geoportal allows to search for both downloads and W(FCM)S services (see section “Online web mapping services WMS / WCS / WFS”)



There are many options for filtering data. Not all data links are “live”, some links do not work, so it requires some searching for data.

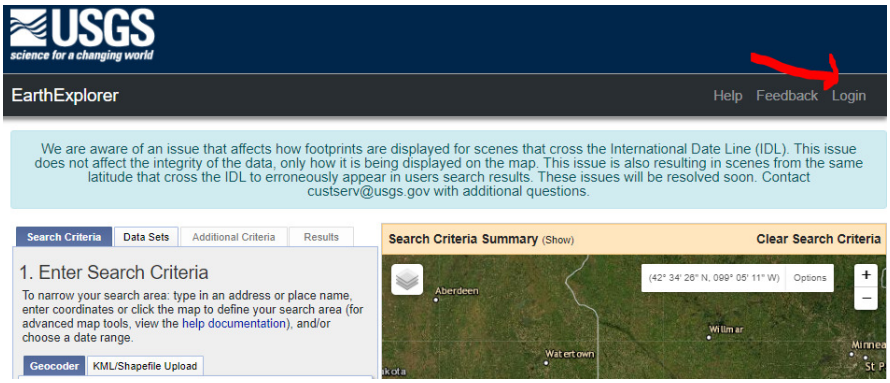
2.1.4 USGS: EarthExplorer

USGS EarthExplorer https://earthexplorer.usgs.gov/ provides **raster** data from satellite and airborne missions. Some missions provide a raster of **height values** (**DEM** - digital elevation model). In the following

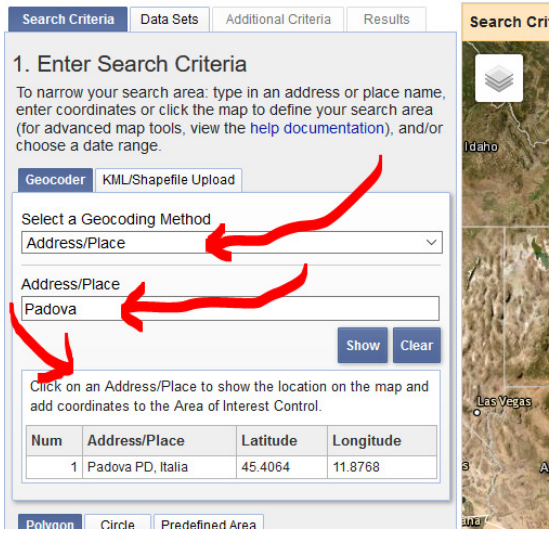
tutorial we will learn how to download a digital surface model (**DSM**) from the SRTM which differs from a digital terrain model (**DTM**) as the DSM values include heights of buildings and trees, whereas the DTM values are of the bare terrain.

In the following exercise we will learn how to get two DSM rasters from two different sensors,

1. Create a user profile by registering from https://earthexplorer.usgs.gov/



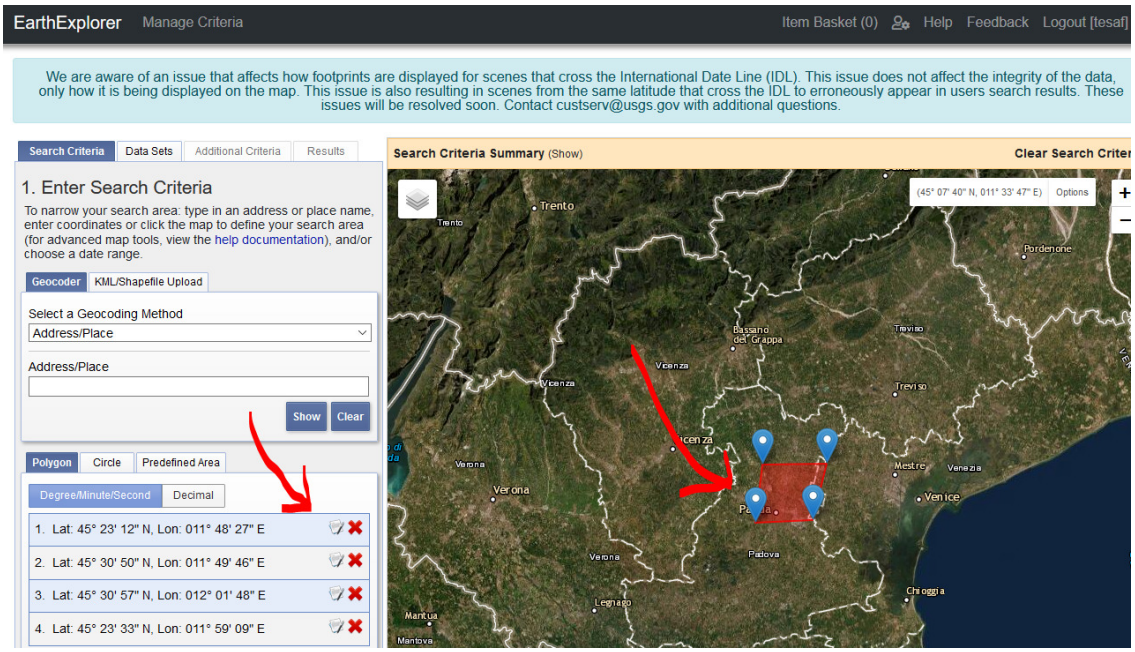
2. After registration proceed to login https://earthexplorer.usgs.gov/ with your registration credentials (username and password) by clicking "login" (see image above)

3. 

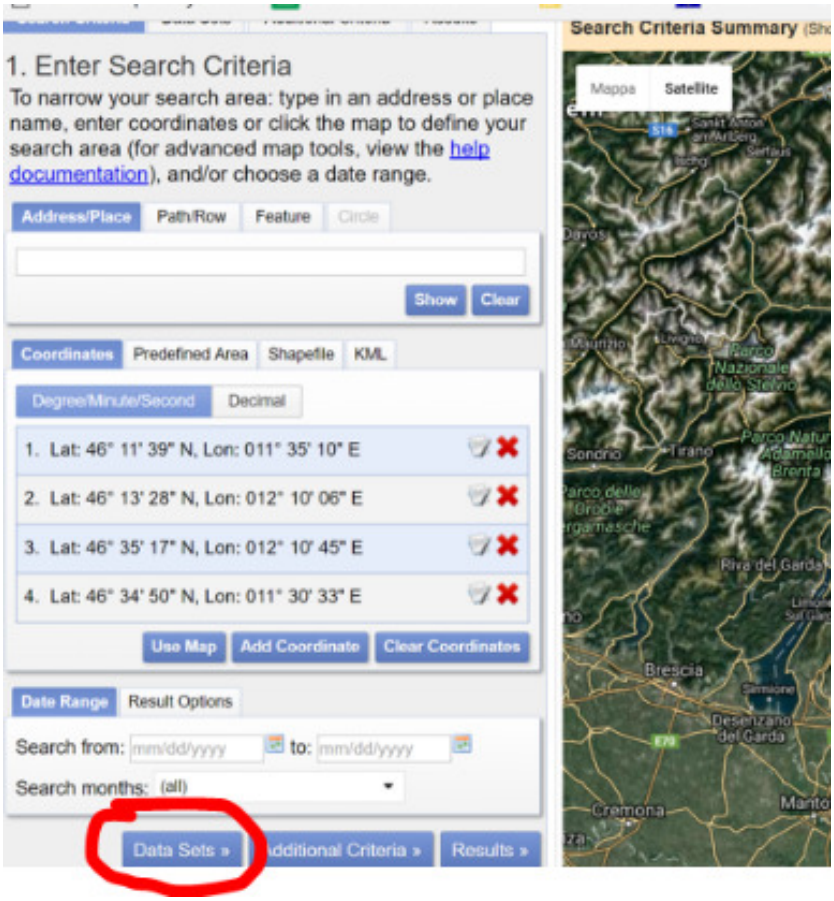
Identify your area in the map. There are several ways to do this:

a. Search by address / place (e.g. select "AddressPlace" and select Padova like the image on the right) **NB this is available only if you are logged in!**

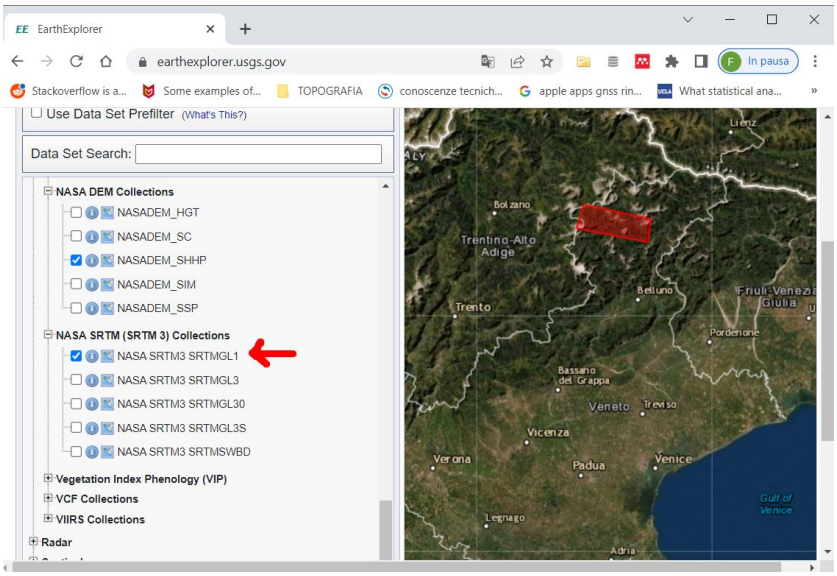
b. Click the map directly to create a polygon or a point defining your area of interest like in the image below. You can **remove polygon points** on the table that appears or you can drag the points with the mouse to change the area.



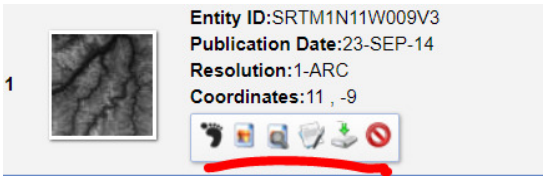
4. At the bottom of the page, click on "**datasets**" (in some cases you can choose to select a certain time window – that's in case of multitemporal datasets)



5. In the input space of "Data Sets Search" type "**SRTM**" – you will see the product that you can select by clicking the checkbox



6. All SRTM products intersecting your area will appear – for each product you can select from the toolbar the following (from left to right – see image below)



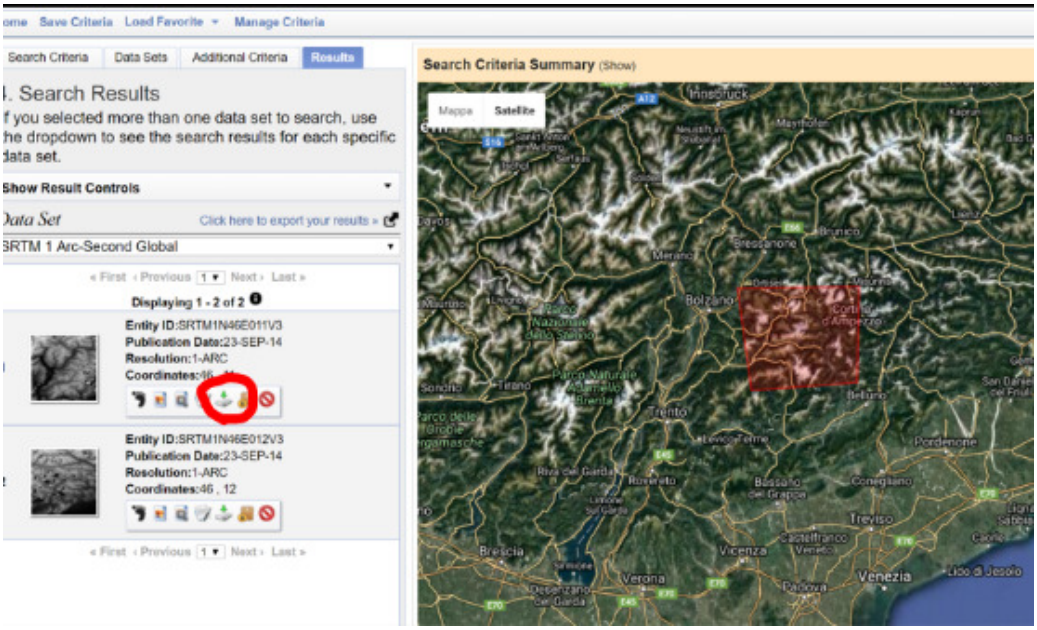
a. Show footprint

b. Show preview on map

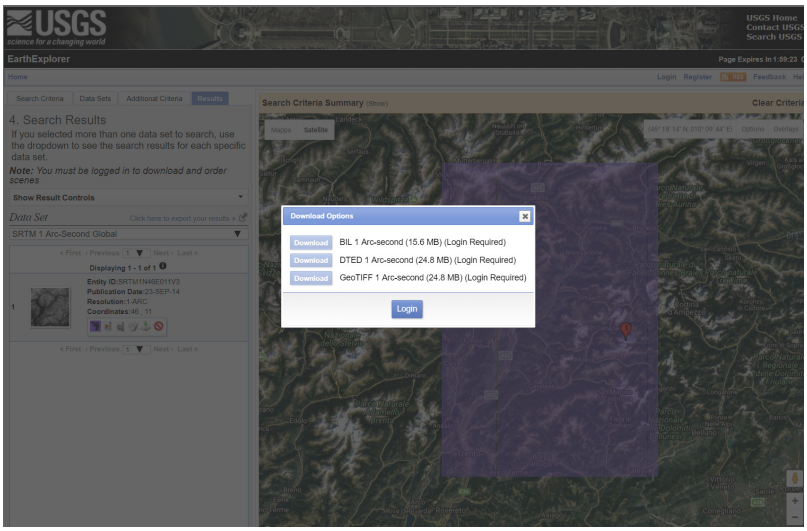
c. Browse data

d. Show metadata

e. Download.



7. You can choose from three different raster formats, QGIS is able to read all of them (more on Raster Formats @ http://www.gdal.org/formats_list.html)



8. Load the file in your QGIS project –CRS of this file is 4326 (geographic latitude and longitude) – check handout on coordinate reference systems for more info in CRS.

2.1.4.1 Exercise 1 Exercise: download DEMs and analyse differences: with the procedures above download any two elevation datasets from the EarthExplorer portal and self-assess if you know how to answer the following two questions: - what are the two spatial resolutions? - compare differences in elevations of the two DEMs using the raster calculator in QGIS and style the map. What are the minimum and maximum values of the differences?

2.1.5 FAO: GeoNetwork

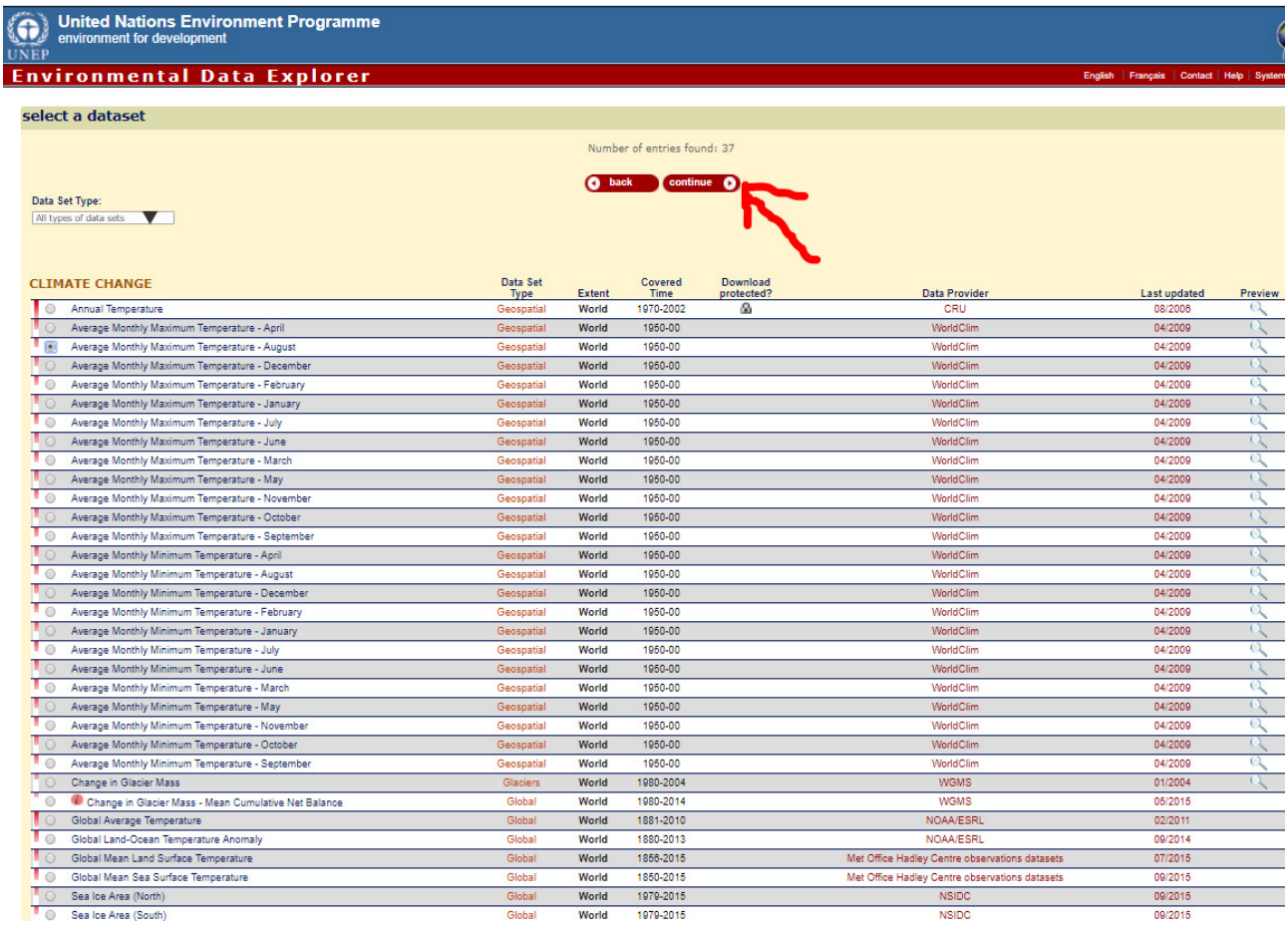
http://www.fao.org/geonetwork/srv/en/main.home

Excellent source of global and agricultural and environmental data

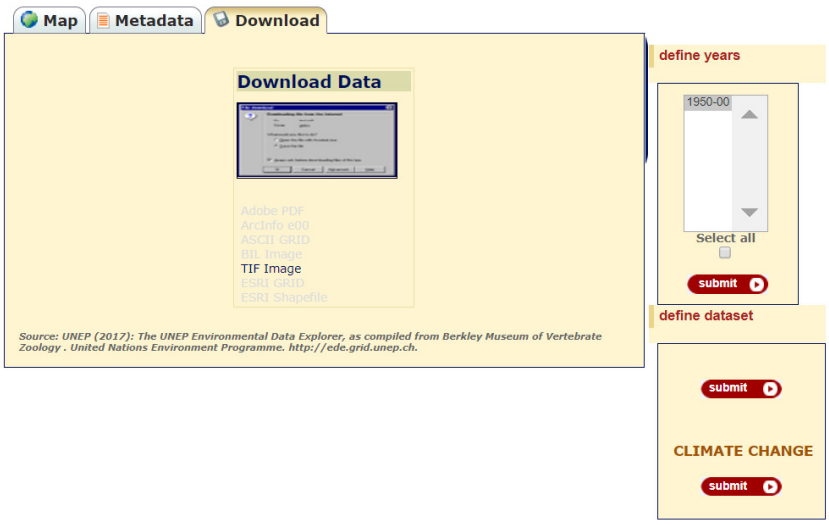
2.1.5.1 Exercise 2 Search for "rainfall African Water Resource Database" keywords and download rainfall data for Africa in two time windows, e.g. "APRIL 1ST-DECADAL SHORT MEAN RAINFALL". This is Arc/Info Binary Grid.adf format (click link for more info). Style the map using QGIS. NB: the CRS (coordinate reference system) of this map is not known. Apply the same color scale to compare the two rasters.

2.1.6 United Nations - UNEP

http://geodata.grid.unep.ch/



CLIMATE CHANGE	Data Set Type	Extent	Covered Time	Download protected?	Data Provider	Last updated	Preview
Annual Temperature	Geospatial	World	1970-2002		CRU	08/2006	
Average Monthly Maximum Temperature - April	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - August	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - December	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - February	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - January	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - July	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - June	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - March	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - May	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - November	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - October	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Maximum Temperature - September	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - April	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - August	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - December	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - February	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - January	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - July	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - June	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - March	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - May	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - November	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - October	Geospatial	World	1950-00		WorldClim	04/2009	
Average Monthly Minimum Temperature - September	Geospatial	World	1950-00		WorldClim	04/2009	
Change in Glacier Mass	Glaciers	World	1980-2004		WGMS	01/2004	
Change in Glacier Mass - Mean Cumulative Net Balance	Global	World	1980-2014		WGMS	05/2015	
Global Average Temperature	Global	World	1881-2010		NOAA/ESRL	02/2011	
Global Land-Ocean Temperature Anomaly	Global	World	1880-2013		NOAA/ESRL	09/2014	
Global Mean Land Surface Temperature	Global	World	1856-2015		Met Office Hadley Centre observations datasets	07/2015	
Global Mean Sea Surface Temperature	Global	World	1850-2015		Met Office Hadley Centre observations datasets	09/2015	
Sea Ice Area (North)	Global	World	1979-2015		NSIDC	09/2015	
Sea Ice Area (South)	Global	World	1979-2015		NSIDC	09/2015	



2.1.6.1 Exercise 3 Find new human settlements using lighting visible from space. The Landsat satellite records (also) night-time imagery allowing to monitor human settlements using visible lights from space (~700 km from the Earth surface). Search and download "Nightlights" from two dates and use raster calculator to detect new human settlements in the most recent date. Try to come-up with mathematical expression to reach that objective. You can find a hint here - but try yourself first!

2.1.7 Google Earth Engine

Google Earth Engine is and advanced portal for processing satellite imagery and other geospatial big-data online through their map-reduce paradigm. You can put your hands on many datasets, process them and even download results or any intermediate data your produce – with limitations on the size of the data you can download. **Coding** is required (Javascript language through their online https://code.earthengine.google.com/ or Python through Jupyter notebooks). Welcome to coding/programming if you want to dive deeper in more advanced GIS.

2.2 SPECIFIC topics

2.2.1 Night lights map

https://eogdata.mines.edu/products/dmsp/ in this page you can download maps of night lights.

2.2.2 USGS: Land-cover

https://landcover.usgs.gov/ at link "Global Land Cover" (see image below) you will find a link to European Space Agency (ESA) datasets, see next section.

At link "30 meter Global Land Cover" also an interesting set of data for further GIS analyses (https://landcover.usgs.gov/glc/).

2.2.3 ESA: Land-cover

https://www.esa-landcover-cci.org/

https://land.copernicus.eu/

2.2.3.1 Exercise 4 Styling exercise with ESA GlobCover

When you open with QGIS the GeoTIFF file, you only see numeric values of the single cells. Each cell value corresponds to a legend
label. The label is found in the MS Excel file that is distributed
with the dataset. In this exercise you will learn how to create a
legend file to style the layer automatically.

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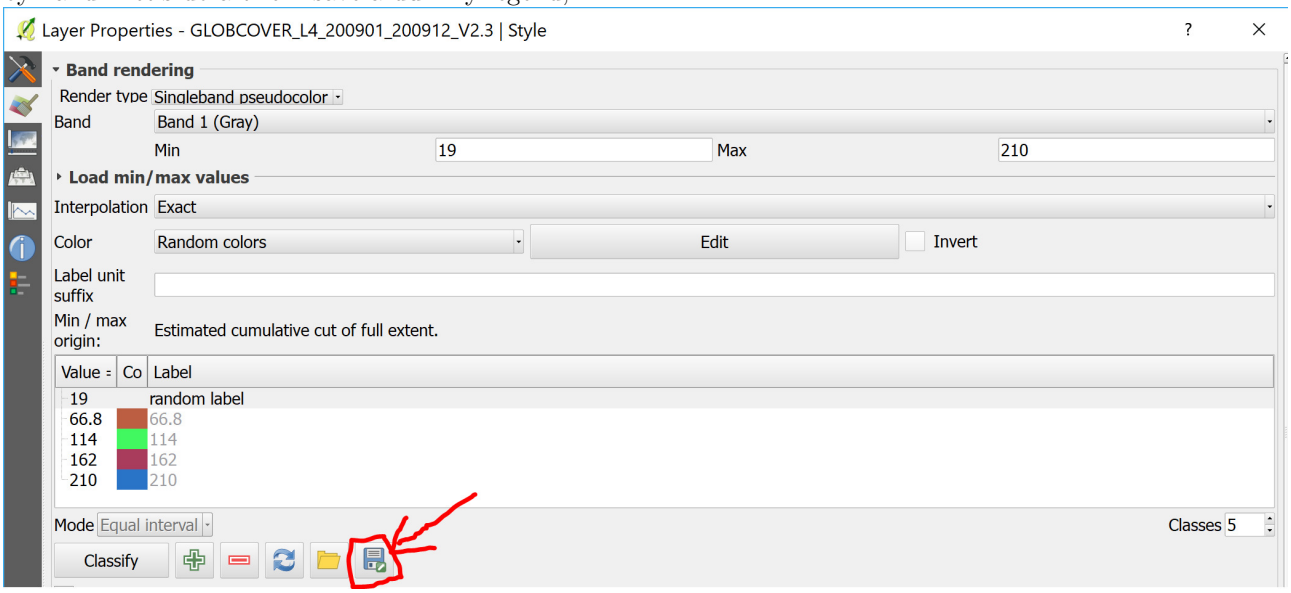
324 fx No data (burnt are

	A	B	C	D	E
	Value	Label	Red	Green	Blue
	11	Post-flooding or irrigated croplands (or aquatic)	170	240	240
	14	Rainfed croplands	255	255	100
	20	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	220	240	100
	30	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	205	205	102
	40	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	0	100	0
	50	Closed (>40%) broadleaved deciduous forest (>5m)	0	160	0
	60	Open (15-40%) broadleaved deciduous forest/woodland (>5m)	170	200	0
	70	Closed (>40%) needleleaved evergreen forest (>5m)	0	60	0
	90	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	40	100	0
	100	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	120	130	0
	110	Mosaic forest or shrubland (50-70%) / grassland (20-50%)	140	160	0
	120	Mosaic grassland (50-70%) / forest or shrubland (20-50%)	190	150	0
	130	Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	150	100	0
	140	Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	255	180	50
	150	Sparse (<15%) vegetation	255	235	175
	160	Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	0	120	90
	170	Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	0	150	120
	180	Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline water	0	220	130
	190	Artificial surfaces and associated areas (Urban areas >50%)	195	20	0
	200	Bare areas	255	245	215
	210	Water bodies	0	70	200
	220	Permanent snow and ice	255	255	255
	230	No data (burnt areas, clouds,...)	0	0	0

We can style the layer by right-click “Properties” and go the the “style” dialogue, but it would take a long time to enter all values by hand. Let’s do a trick: save a dummy legend,



and then use a text editor to check format

dummy.txt

```
# QGIS Generated Color Map Export File
INTERPOLATION:EXACT
19,221,169,57,255,random label
66.8,187,94,65,255,66.8
114,66,248,96,255,114
162,169,59,92,255,162
210,42,116,200,255,210

```

Steps:

1. In MS Excel in the legend file information change columns to mirror the above table

Value	Red	Green	Blue	alpha	Label
11	170	240	240	255	Post-flooding or irrigated croplands (or aquatic)
14	255	255	100	255	Rainfed croplands
20	220	240	100	255	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)
30	205	205	102	255	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
40	0	100	0	255	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
50	0	160	0	255	Closed (>40%) broadleaved deciduous forest (>5m)
60	170	200	0	255	Open (15-40%) broadleaved deciduous forest/woodland (>5m)
70	0	60	0	255	Closed (>40%) needleleaved evergreen forest (>5m)
90	40	100	0	255	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
100	120	130	0	255	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
110	140	160	0	255	Mosaic forest or shrubland (50-70%) / grassland (20-50%)
120	190	150	0	255	Mosaic grassland (50-70%) / forest or shrubland (20-50%)
130	150	100	0	255	Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)
140	255	180	50	255	Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)
150	255	235	175	255	Sparse (<15%) vegetation
160	0	120	90	255	Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water
170	0	150	120	255	Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water
180	0	220	130	255	Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline water
190	195	20	0	255	Artificial surfaces and associated areas (Urban areas >50%)
200	255	245	215	255	Bare areas
210	0	70	200	255	Water bodies
220	255	255	255	255	Permanent snow and ice
230	0	0	0	255	No data (burnt areas, clouds,...)

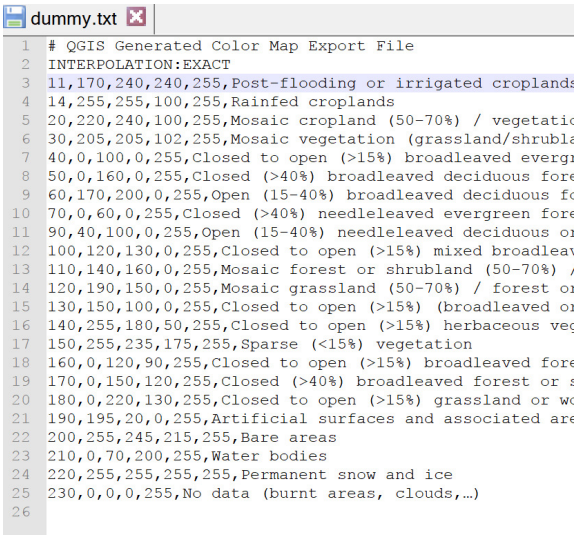
2. Select (as image above) and copy/paste to the text file

dummy.txt

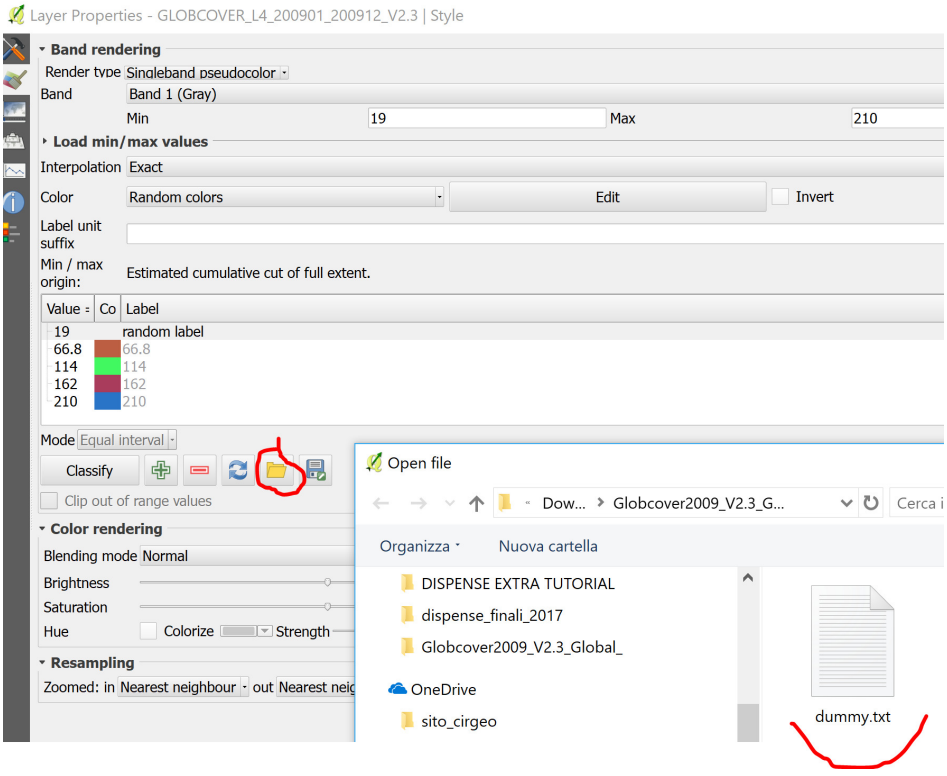
```
# QGIS Generated Color Map Export File
INTERPOLATION:EXACT
19,221,169,57,255,random label
66.8,187,94,65,255,66.8
114,66,248,96,255,114
162,169,59,92,255,162
210,42,116,200,255,210


11      170 240 240 255 Post-flooding or irrigated cropl
14      255 255 100 255 Rainfed croplands
20      220 240 100 255 Mosaic cropland (50-70%) / veget
30      205 205 102 255 Mosaic vegetation (grassland/shr
40      0   100 0   255 Closed to open (>15%) broadleave
50      0   160 0   255 Closed (>40%) broadleaved decidu
60      170 200 0   255 Open (15-40%) broadleaved decidu
70      0   60  0   255 Closed (>40%) needleleaved everg
90      40  100 0   255 Open (15-40%) needleleaved decid
100     120 130 0   255 Closed to open (>15%) mixed broa
110     140 160 0   255 Mosaic forest or shrubland (50-7
120     190 150 0   255 Mosaic grassland (50-70%) / fore
130     150 100 0   255 Closed to open (>15%) (broadleav
140     255 180 50  255 Closed to open (>15%) herbaceous
150     255 235 175 255 Sparse (<15%) vegetation
160     0   120 90  255 Closed to open (>15%) broadleave
170     0   150 120 255 Closed (>40%) broadleaved forest
180     0   220 130 255 Closed to open (>15%) grassland
190     195 20  0   255 Artificial surfaces and associat
200     255 245 215 255 Bare areas
210     0   70  200 255 Water bodies
220     255 255 255 255 Permanent snow and ice
230     0   0   0   255 No data (burnt areas, clouds,...)
```

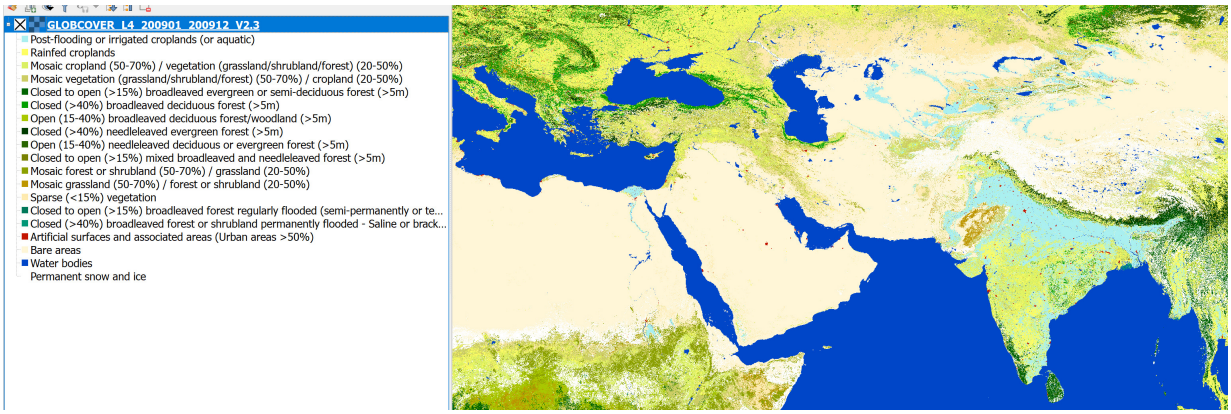
3. Make sure to change column separators to correct ones (commas) – a "find and replace" should work on any text editor. The final result should be like the image below.



4. Open the style dummy.txt that you modified



5. You will get a correct legend



2.2.4 Forest Global Maps

University of Maryland's Global Land Analysis and Discovery lab has two interesting datasets.

1. **Forest Cover** (with Gain and Loss from 2000) LINK HERE!!
2. **Forest height** - this is and estimation using remote sensing and GEDI laser altimeters data LINK HERE!!

2.2.5 Climate WC v1

WorldClim is a set of global climate layers (gridded climate data) with a spatial resolution of about 1 km^2. These data can be used for mapping and spatial modelling, and multi-criteria analysis (see the dedicated tutorial). http://worldclim.org

From the Google Earth Engine Catalogue description:

WorldClim V1 Bioclim provides bioclimatic variables that are derived from the monthly temperature and rainfall in order to generate more biologically meaningful values.

The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation), seasonality (e.g., annual range in temperature and precipitation), and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters).

WorldClim version 1 was developed by Robert J. Hijmans, Susan Cameron, and Juan Parra, at the Museum of Vertebrate Zoology, University of California, Berkeley, in collaboration with Peter Jones and Andrew Jarvis (CIAT), and with Karen Richardson (Rainforest CRC).

2.2.6 Climate WC v2

WorldClim version 2 is a set of global climate layers (gridded climate data) with a spatial resolution of about 1 km^2. These data can be used for mapping and spatial modelling, and multi-criteria analysis (see the dedicated tutorial). https://worldclim.org/data/worldclim21.html

For the GIS courses, the bioclimatic variables have been added to a Web Coverage Service (WCS - see dedicated section on how to load WCS services in your GIS here)

Right click this link and "copy link" to get the WCS address for WorldClim2 to add to your QGIS.

NB as readme.txt file states "
This is WorldClim 2.1 (January 2020) downloaded from http://worldclim.org They represent average monthly climate data for 1970-2000.

The data were created by Steve Fick and Robert Hijmans
You are not allowed to redistribute these data
" Therefore please only use them for educational purposes and do not redistribute data in any way.

2.2.7 Soil Carbon

From the website: "SoilGrids and WoSIS Soilgrids is a system for digital soil mapping based on a global compilation of soil profile data (WoSIS) and environmental layers. Read about the SoilGrids and WoSIS projects on isric.org" https://www.isric.org/explore/soilgrids

2.2.8 Precipitation: CHIRP

Researchers at Climate Hazard Center at University of California at Santa Barbara provide grid of 0.05° (around 5 km at the equator) with daily rainfall data https://chc.ucsb.edu/data/chirps

3 Regional datasets (Europe)

3.1 European Statistical (EUROSTAT)

https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data

Provides vector data of boundaries and other important information at European and global level.

Example: https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/countries#countries20 and download boundaries in TopoJSON format. You can drag and drop the whole downloaded ZIP-file to QGIS! You will see that you can choose which files to open.

3.2 European Environmental Agency (EEA)

https://discomap.eea.europa.eu/Index/

Provides mostly WMS services (see section "Online web mapping services WMS / WCS / WFS")

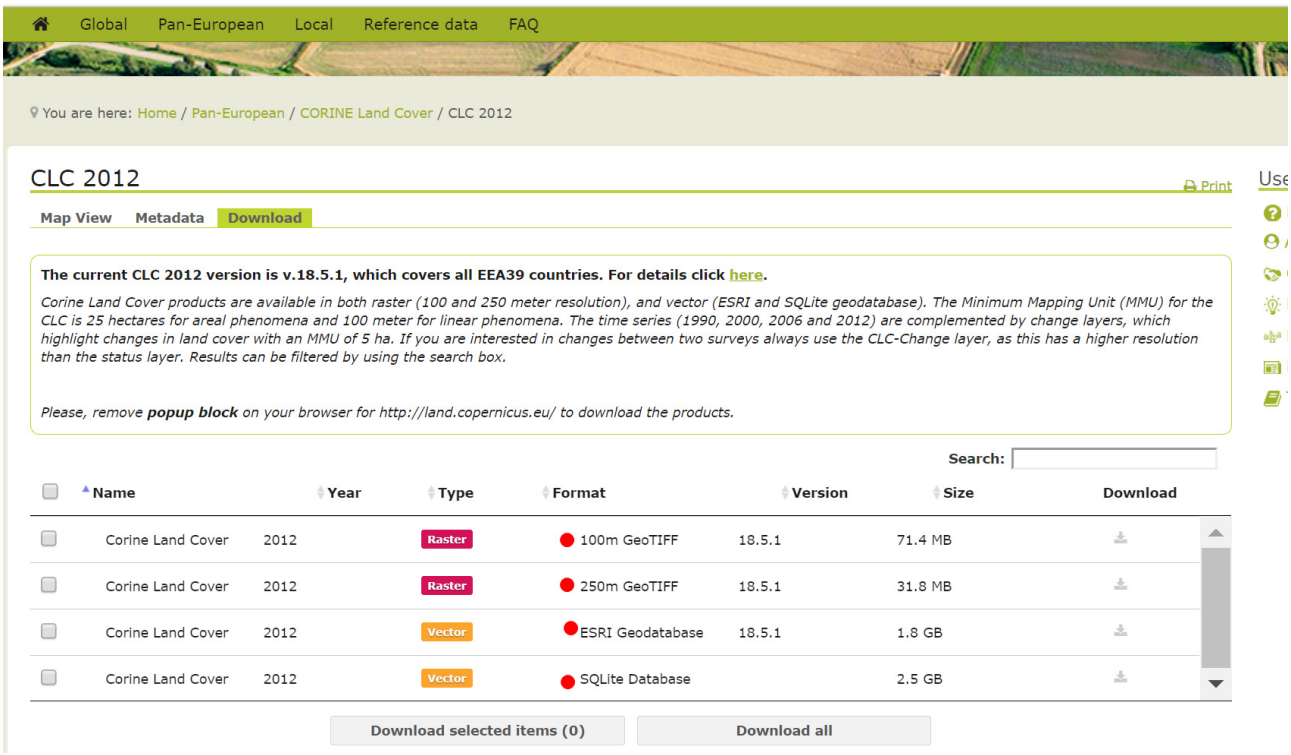
3.3 CORINE Land Cover

https://land.copernicus.eu/

"*An inventory of land cover in 44 classes, and presented as a cartographic product, at a scale of 1:100 000. This database is operationally available for most areas of Europe.*"

You have 4 options for download

1. Raster (GeoTIFF) 100 m cell size
2. Raster (GeoTIFF) 250 m cell size
3. Vector model (ESRI Shapefile)
4. Vector model (SQLite Database).



3.4 Copernicus CORINE

The service below provides viewer and download capabilities, but you must register and login.

https://land.copernicus.vgt.vito.be/PDF/portal/Application.html

There is also a OGC services! (WMS/WFS/WCS)! You have to use the url

https://viewer.globalland.vgt.vito.be/geoserver/ows

and use the username and password in the credentials of QGIS. (see dedicated section on how to load OGC services in your GIS here)

4 Regional datasets (Italy)

4.1 ISTAT boundaries

Municipal boundaries updated every two years in ESRI shapefile at different detail. https://www.istat.it/it/archivio/222527

4.2 Lombardy Region

http://www.geoportale.regione.lombardia.it/download-dati

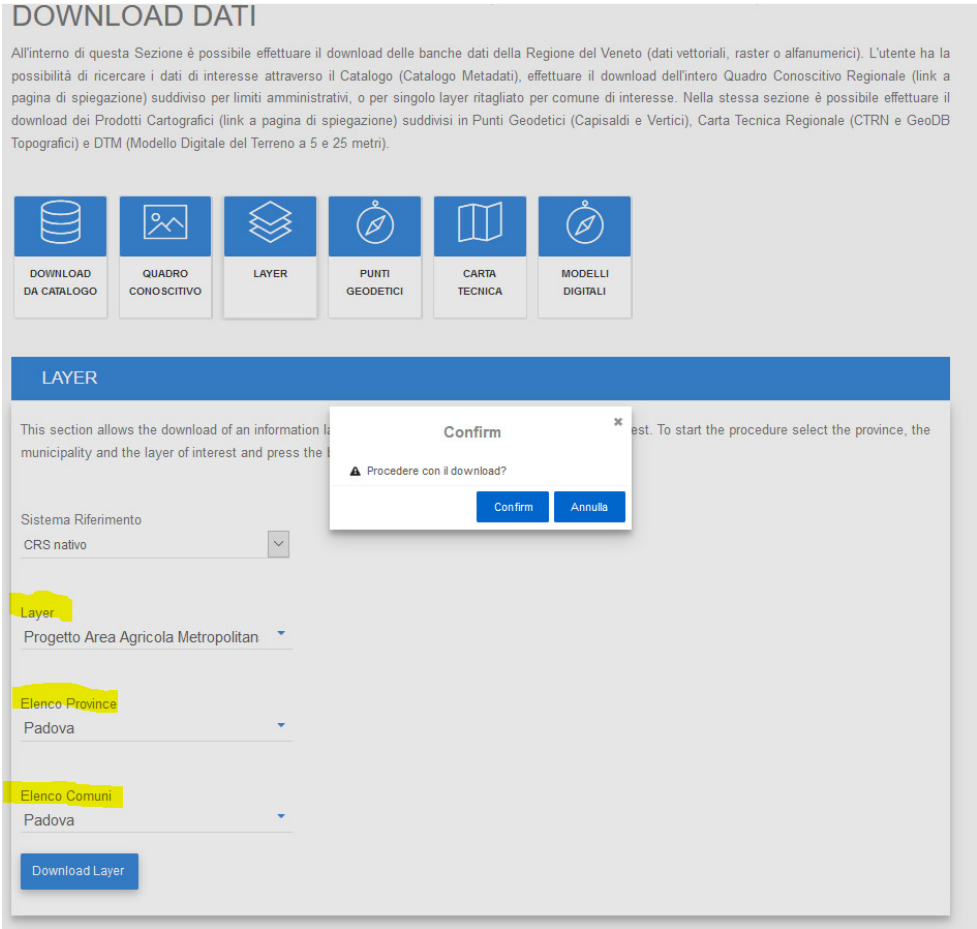
4.3 Veneto Region

The Veneto Region portal - https://idt2.regione.veneto.it - provides downloading capabilities and also services (see chapter **Online web mapping services WMS / WCS / WFS**).

For downloading raster and vector datasets:

https://idt2.regione.veneto.it/idt/downloader/download

You can choose the CRS (see the handout on coordinate reference systems), and filter using the province and municipality of interest (e.g. Padova) – below and example for downloading the Urban Agricultural Areas.

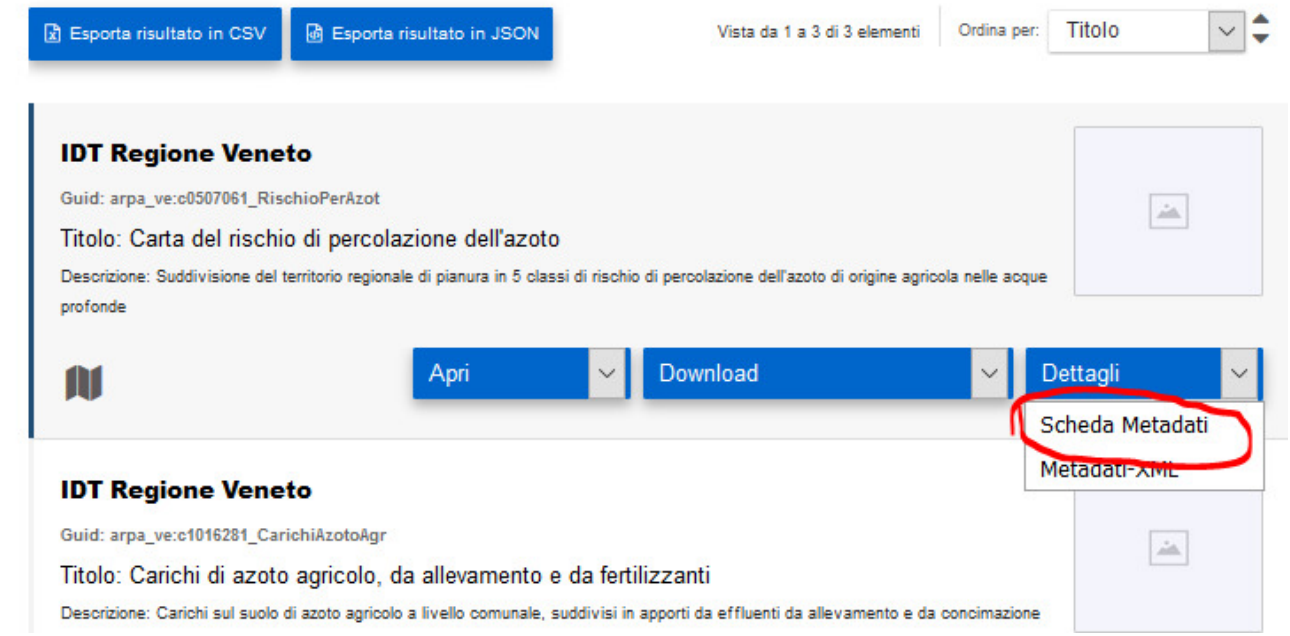


If you want to mine for data using key-words, you can use the Catalog

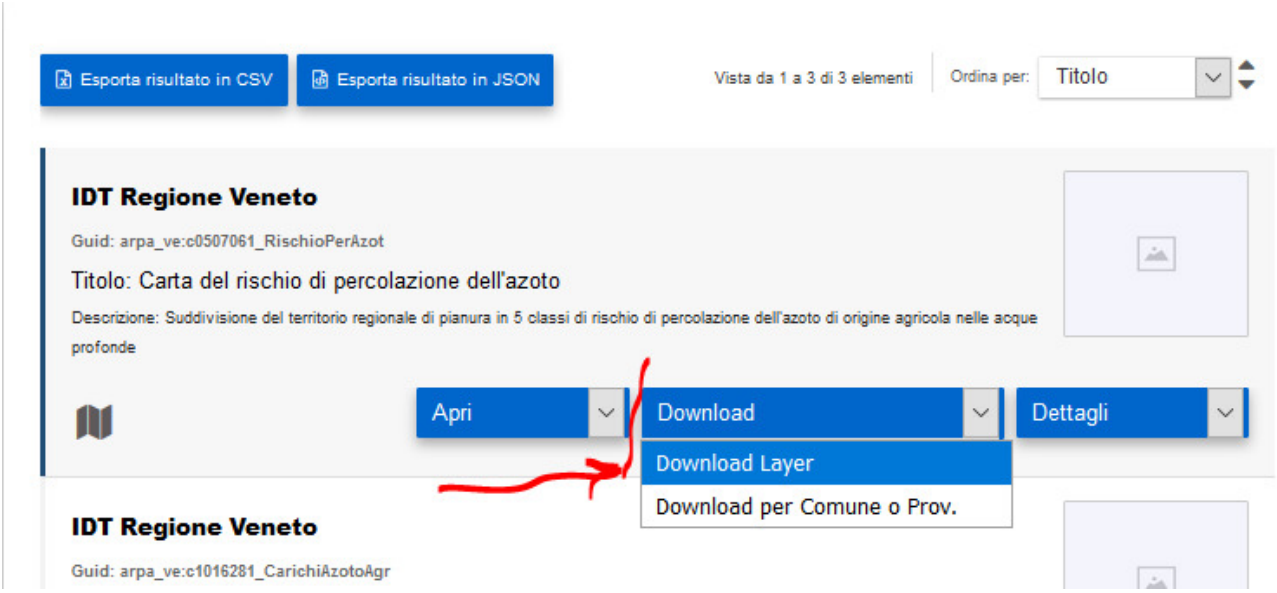
With key-words you can find both geospatial data and documents. If you want only geospatial data you can filter using only “Layers”

From results you can:

1. Read metadata. Metadata keep all information that are not directly in the data – for example who is the owner, the date that data were acquired, copyright etc. . .



2. You can download the layer for all the Region or for only a municipality or province.



3. Almost all data are available also via web services, check Online web mapping services WMS / WCS / WFS section below.

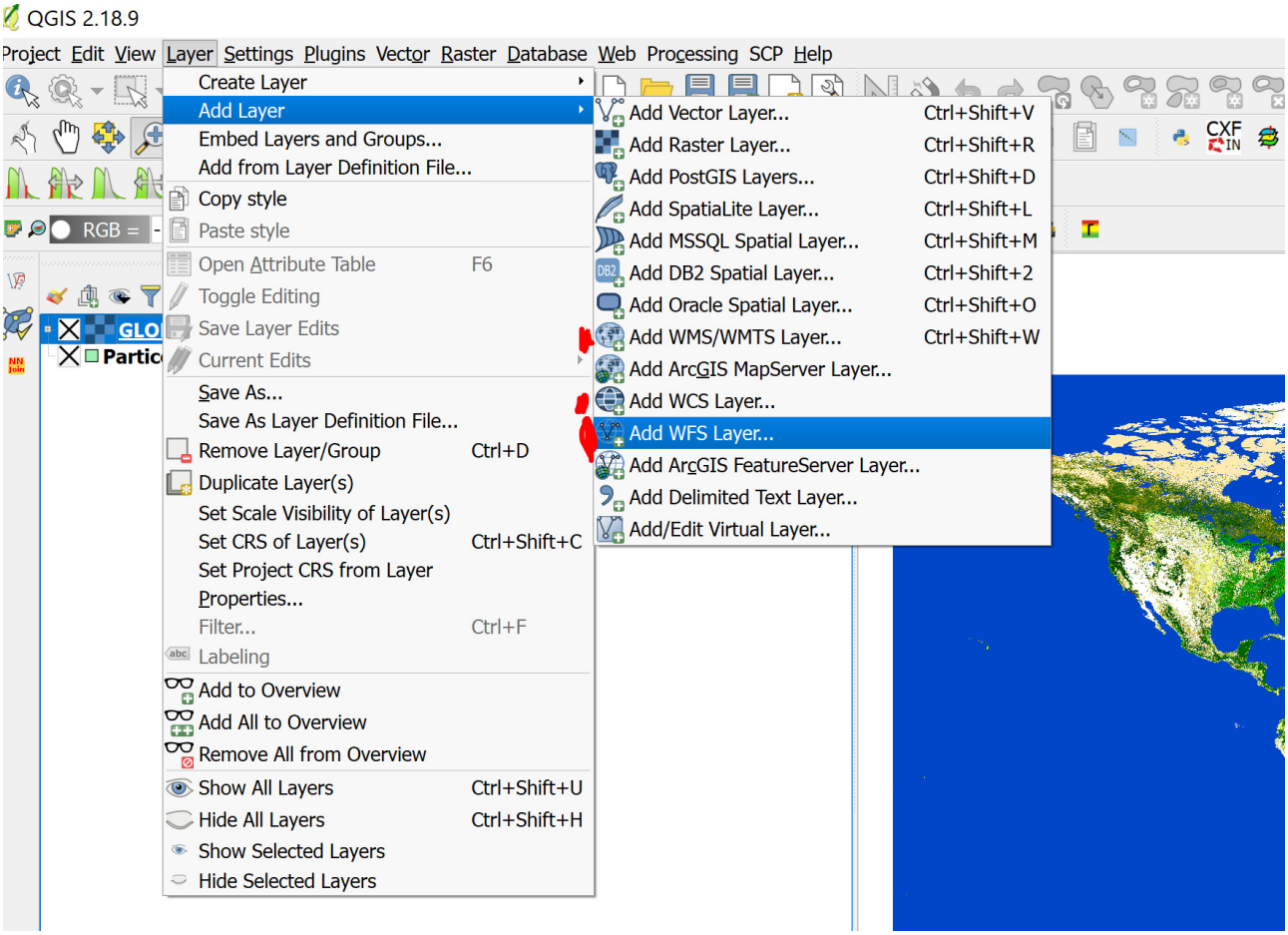
5 Online services WMS / WCS / WFS

These are online services providing access to the data for download or visualization. WMS is only for visualization, WCS and WFS are respectively for downloading data as well, for raster (grid) data and vector data respectively.

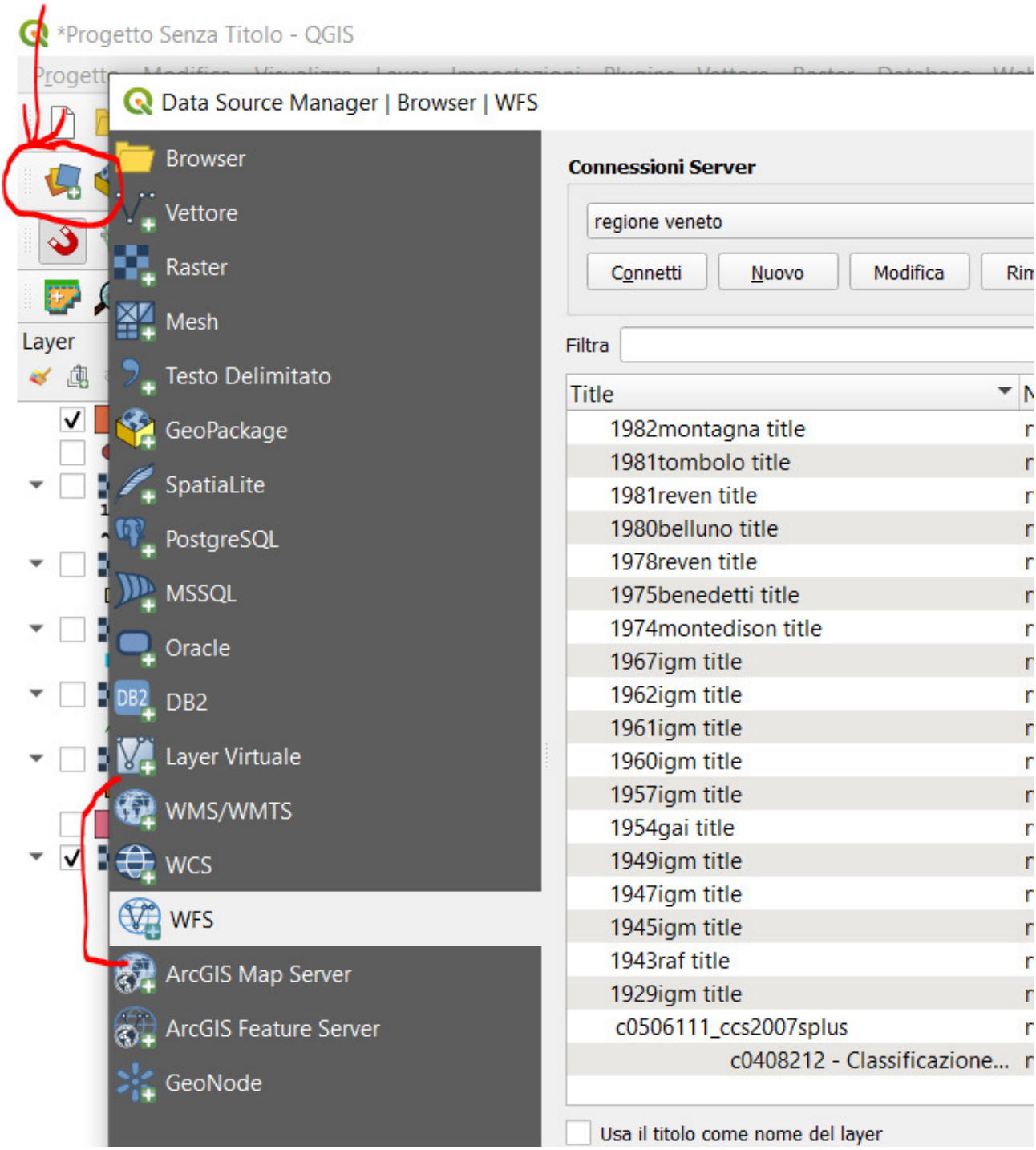
1. WMS – Web Mapping Services – see also tutorial
2. WCS – Web Coverage Services
3. WFS – Web Feature Services

There are many more services, which are standards defined by user community of the Open Geospatial Consortium (https://en.wikipedia.org/wiki/Open_Geospatial_Consortium) - OGC. As a matter of fact these services have been recently referred to the term: **OWS** – **O**pen Geospatial Consortium (OGC) **W**eb **S**ervices.

You access these data either from the menu bar, "Layer""Add layer"



. . . or you can use the Data source manager by clicking the icon in the toolbar (see figure below).



In all cases you will need to add a web address (URL) to the dialogue window. See next example and bottom of next section for some URL sources.

5.1 National Geo Portal – WFS services

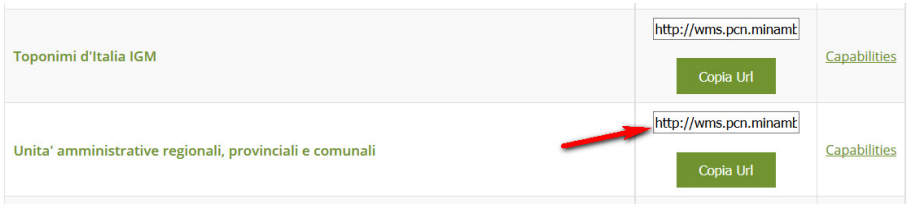
http://www.pcn.minambiente.it/mattm/en/

Click “Services”Network Services - OGC”.

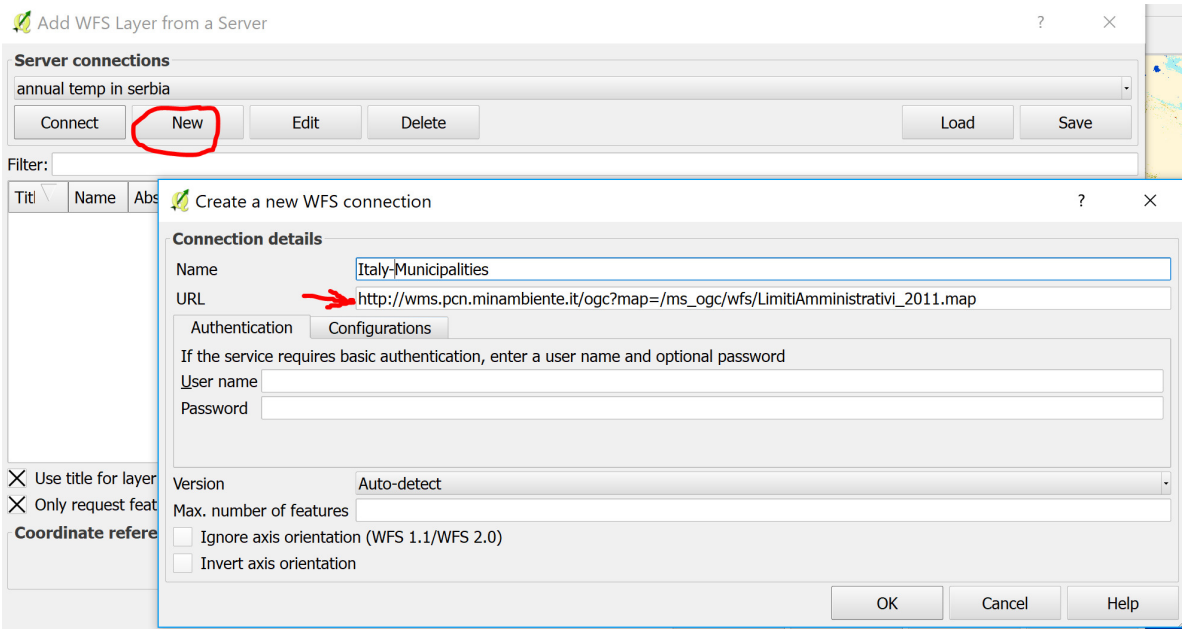
Select in the next page WFS Services

You will see a list of datasets, all have a URL address – we will "Copy URL" of the data we want. For

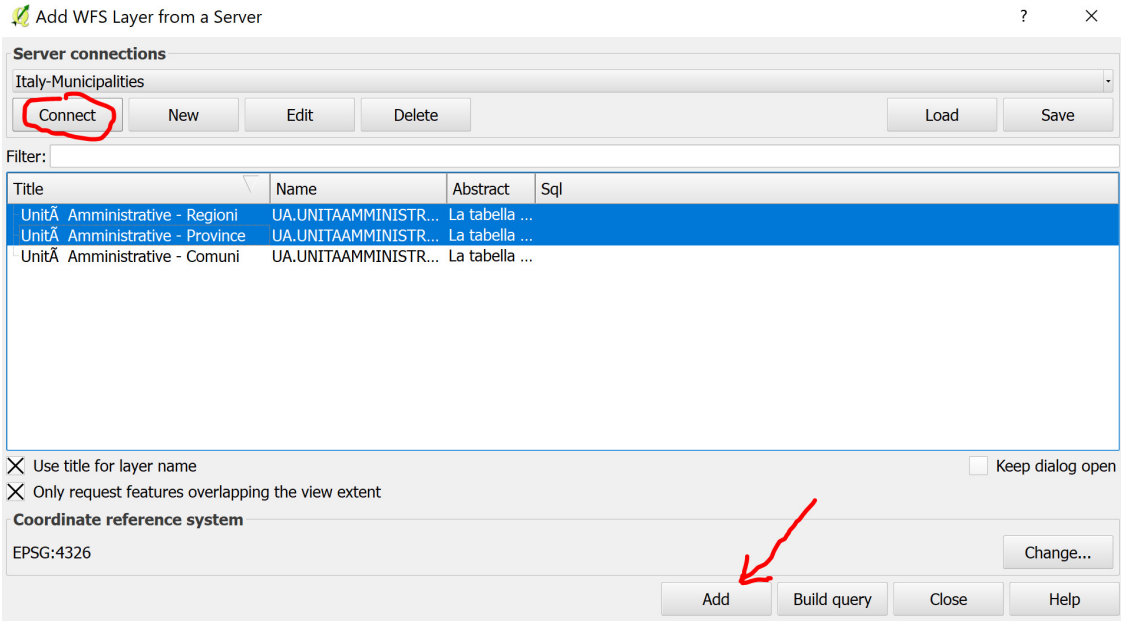
example “Unità amministrative” is the border of municipalities in Italy (layer names are only in Italian).



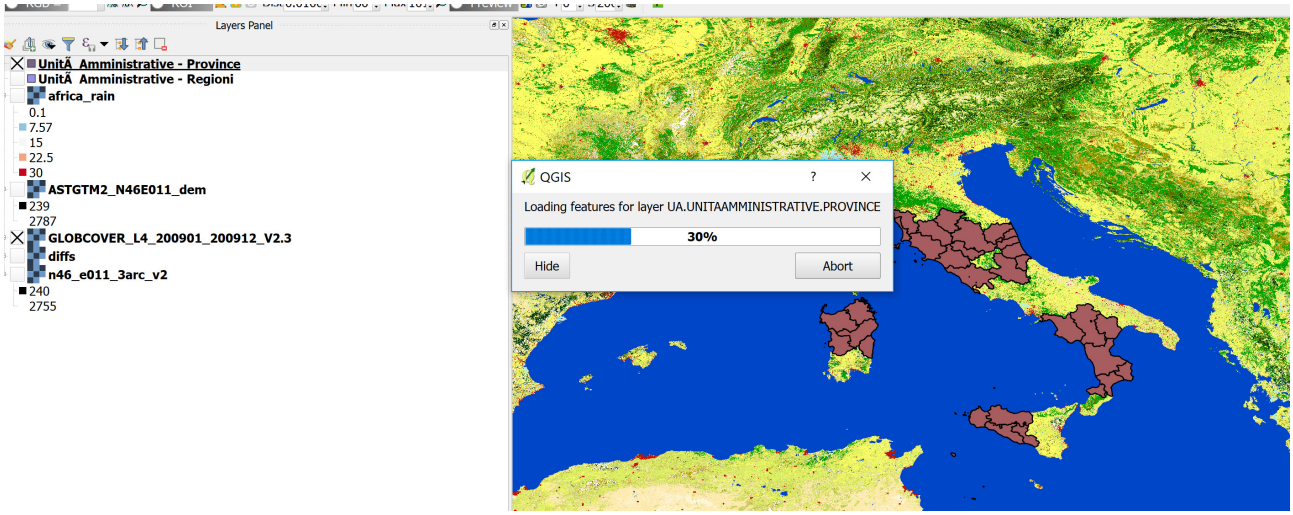
In the QGIS menu “Layer”“Add Layer”“Add WFS layer” you will get a dialogue window, click “New” and copy the URL in the input area, and give a Name to the layer



After click “ok” and “connect” from the main window. You will get three sub-layers: regions, provinces and towns – you can choose one ore more layers and then “Add” to add to project:



The layers will load: it might take some time depending on the size of the data, on internet connection speed and on the speed of the server providing the WFS service



NB: the same identical procedure can be used to add WMS or WCS service layers, which add raster data: QGIS menu "Layer""Add Layer""Add WCS layer" or "Add WMS layer"

5.2 Other OGC OWS services

https://www.qgistutorials.com/en/docs/working_with_wms.html

WMS

https://mrdata.usgs.gov/wms.html - USGS OGC Web Mapping Services

https://idt2-geoserver.regione.veneto.it/geoserver/ows - Veneto Region Styled raster

https://idt2.regione.veneto.it/gwc/service/wmts - Veneto Region orthophotos

WFS

https://mrdata.usgs.gov/wfs.html - USGS OGC Web Feature Services

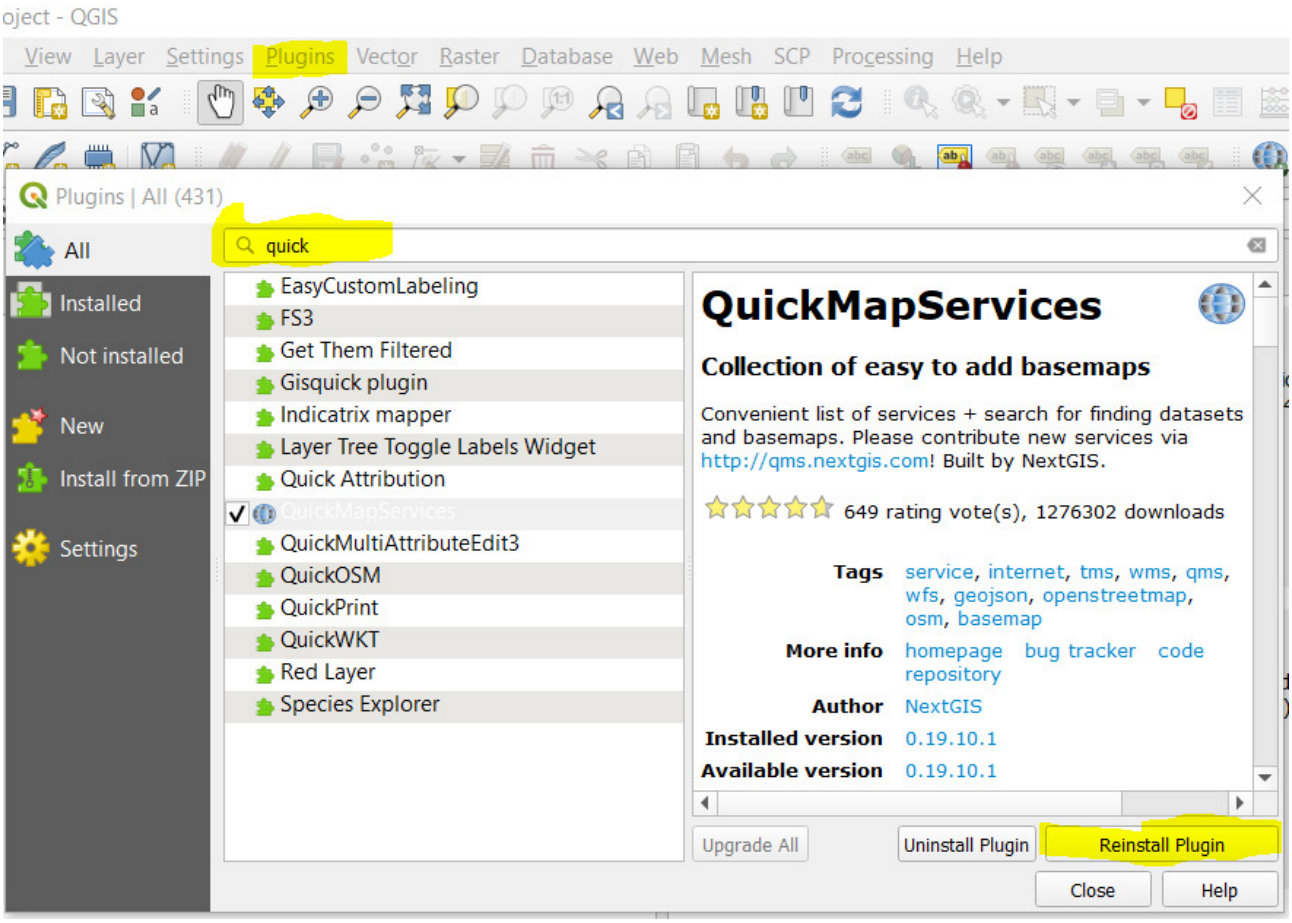
https://idt2-geoserver.regione.veneto.it/geoserver/ows - Veneto Region

5.3 TMS services (OpenStreetMap)

TMS Services are a particular type of online services that provide visual maps, usually styled maps and aerial imagery (e.g. Google Maps). They are very fast to load and are used as base maps to view study area extents and provide visual information of your area.

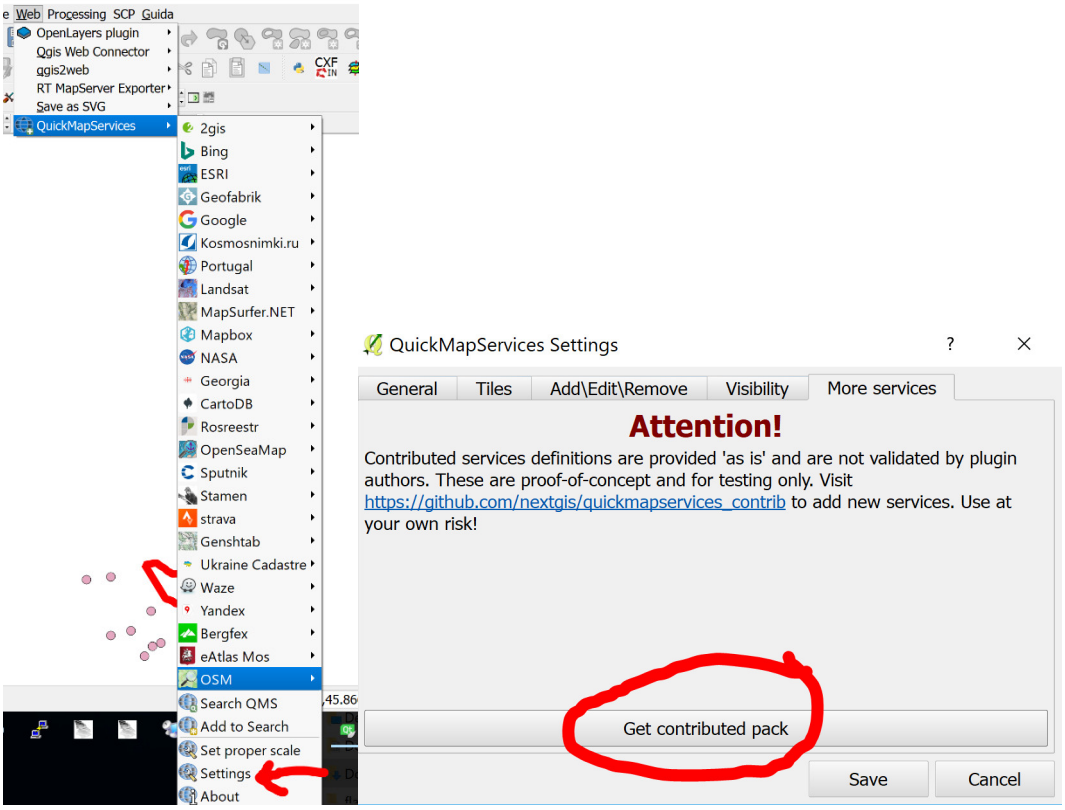
QGIS provides two plugins to access TMS data, OpenLayers and QuickMapServices. We will use "QuickMapServices" as it is more robust. The procedure to install the plugin is the following:

1. Download the plugin "QuickMapServices" (menu "Plugins""Manage and install plugins"). NB is you do NOT see a large list of plugins, you might not be connected to the internet or maybe QGIS has trouble connecting – to solve (i) check that internet is working (ii) close and reopen the Plugin panel window (iii) if still no plugins, restart QGIS.

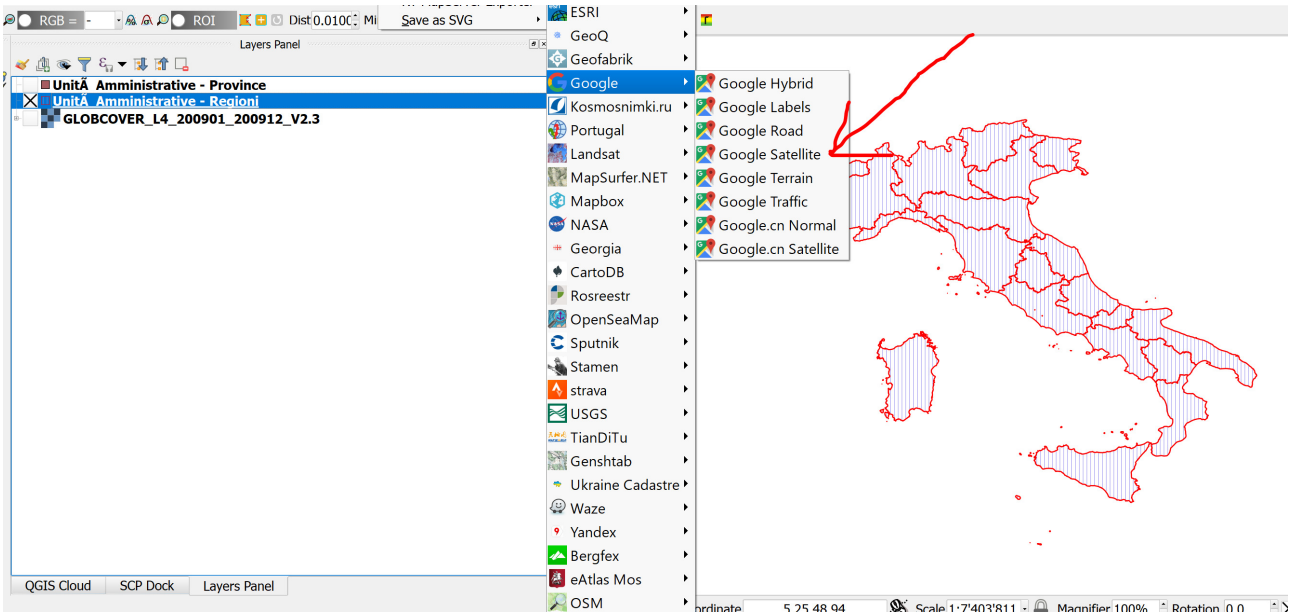


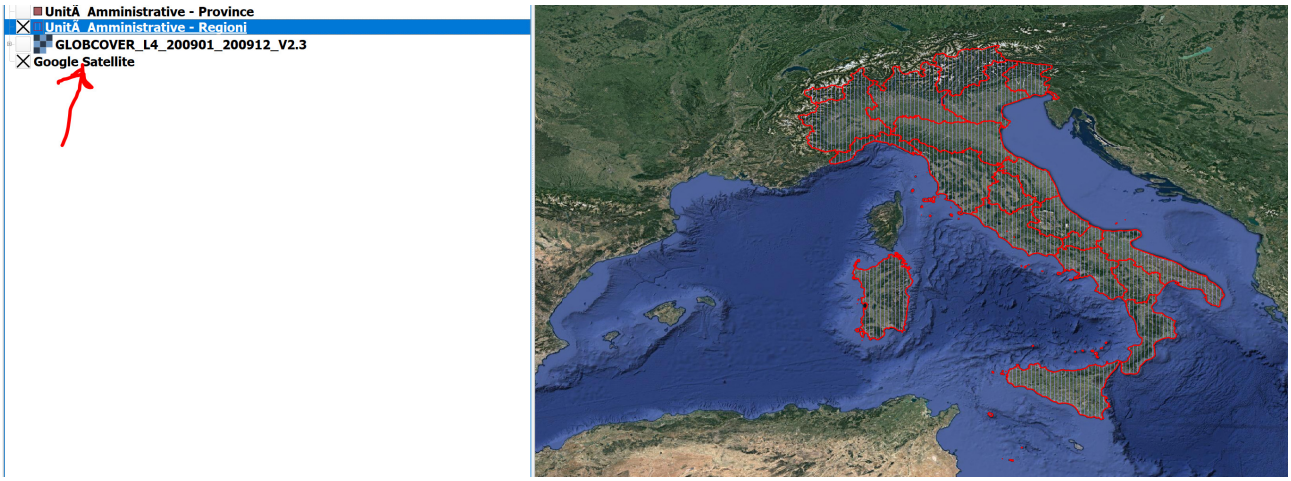
2. Once installed, you will see the plugin in the menu at "Web" "QuickMapServices" – you will see many available map services that can be loaded, **but not all**

3. to load all services go to menu "Web""QuickMapServices""Settings": from dialogue window click "More Services" "Get Contributed Pack"



4. Now from menu “Web” “QuickMapServices” you will see all available services: select “Google”“Google Satellite” you will have access to Google image database up to a resolution below 1 m in almost all of the Earth surface!!





5.4 Open Streetmap

Open StreetMap is a special type of service providing access to their data also for download. Check online tutorial Searching and Downloading OpenStreetMap Data

Exercies 3 hint: formula can be - ("Nightlights_1993@1" = 0) * "Nightlights_2003@1" - the first part creates a 0/1 result called "mask" that is then multiplied by the values from the recent image. Thus areas without lights in 1993 but with lights in 2003 will have a values > 1, whereas areas already having lights in 1993 (settlements already present) will have value 0 (we are only interested in **new** settlements)