SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING
LRESE - Laboratory of Renewable Energy Sciences and Engineering

Solar Energy Conversion Devices and Plants: Exercise 1, solution

Solar Energy Potential in Switzerland
Utilize GIS data to estimate the potential of solar energy in Switzerland.

Computation of the solar energy for one day
These steps must be followed using the software QGIS

- Import the NetCDF file (.nc) for the first day of January, e.g. msg.SIS.D_ch02.lonlat_20140101000000.nc.
- Rename the previous file to "DIR01"
- The colors of the symbols (filling color) can be changed in the "Layer styling window" (press F7 to open the window).
- Change the "Single gray" color to "Singleband pseudocolor"
- Change the "Color ramp" to "Invert Color Ramp". The graph should show more intervals, see fig 1.
- Add the Swiss boundaries file TLM_LANDESGEBIET, it should be located inside the geodatabase called swissBOUNDARIES3D_1_3_LV95_LN02.gdb.
- Rename the previous file to "SwissBoundaries"
- Since we only need the solar irradiation for Switzerland, we have to remove the information from other countries. For doing that go to "Raster" → "Extraction" → "Clip Raster by Mask Layer".
- Select the DIR01 raster as input and the SwissBoundaries polygon as the Mask layer.
- Check that "Keep resolution of input raster" is selected.
- Save the clipped raster as "DIR01SB", the result should be like the one shown in figure 2.

Since extracting the data for every pixel in the figure would be expensive, we could reclassify the data, e.g. the values that are in the range from 0 to 10 W/m^2 will have a new value of 5 W/m^2.

- For reclassifying the data open the "Processing Toolbox" (Alt+Ctrl+T)
- Go to "Raster analysis" → "Reclassify by table".

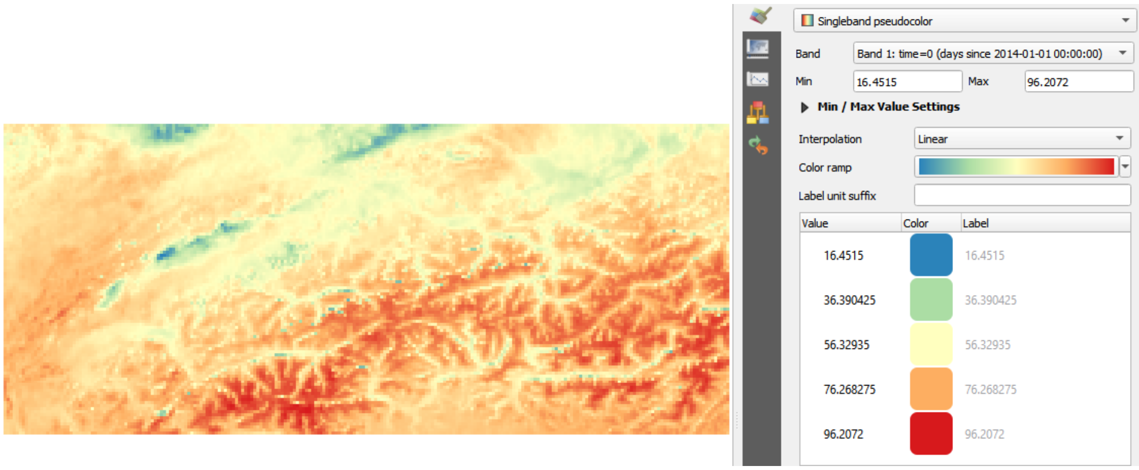

Figure 1: Initial figure after adding color ramp.

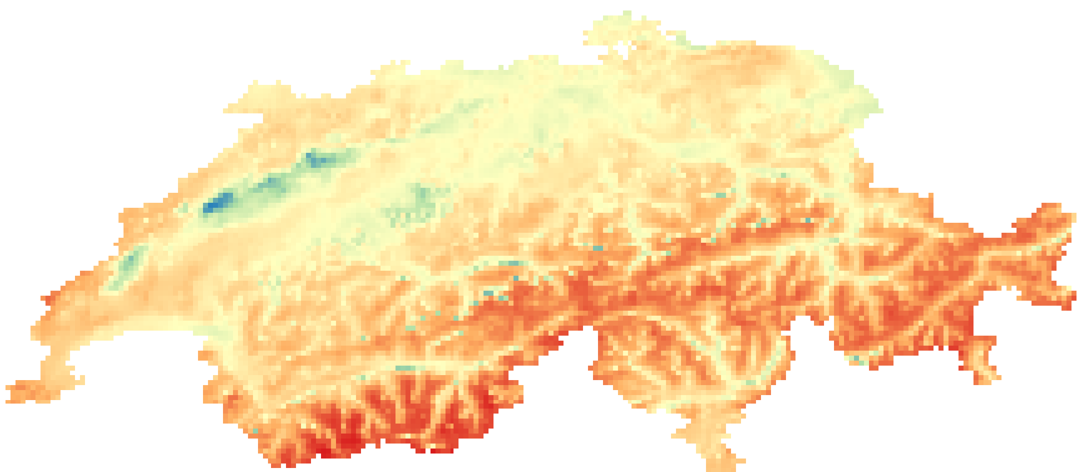

Figure 2: Extracted data for Switzerland only.

- Select "DIR01SB" for the raster layer, then set the reclassifying table with the new range of values as explained before.
- Save the new raster figure as "DIR01REC"
- Before extracting the numerical values, we need to convert the raster figure into a vector image. For that go to "Raster" → "Conversion" → "Polygonize (Raster to Vector)".

- For the input file select the "DIR01REC" raster, modidy the "Name of the field" to "DNI (W/m2)", and save the vector file as "DIR01VEC". The new vector image should look like the one shown in figure 3.
- To see the irradiation data, make right click in the "DIR01VEC" file in the "Layer" window and select "Open Attribute Table". The table will show only one column with the name "DNI (W/m2)".
- In order to know the area that corresponds to each data in the table, make click on the abacus icon called "Open field calculator".

- In the field calculator add the output field name "area (m2)", select the precision, in the "Expression" window type "$area", and finally press "OK". That should show the area corresponding to each row in the table.
- Finally we can export the data into a "csv" or a "xlsx" file for the post-processing. Make right click on "DIR01VEC" and select "Save features as...". Select the format, then give a name to the file and press "OK"

Python script
In order to avoid repeating all the previous steps 365 times, we wrote a "Python" script called "test_python2.py". In order to load the python code to QGIS press "Alt+Ctrl+P", next press

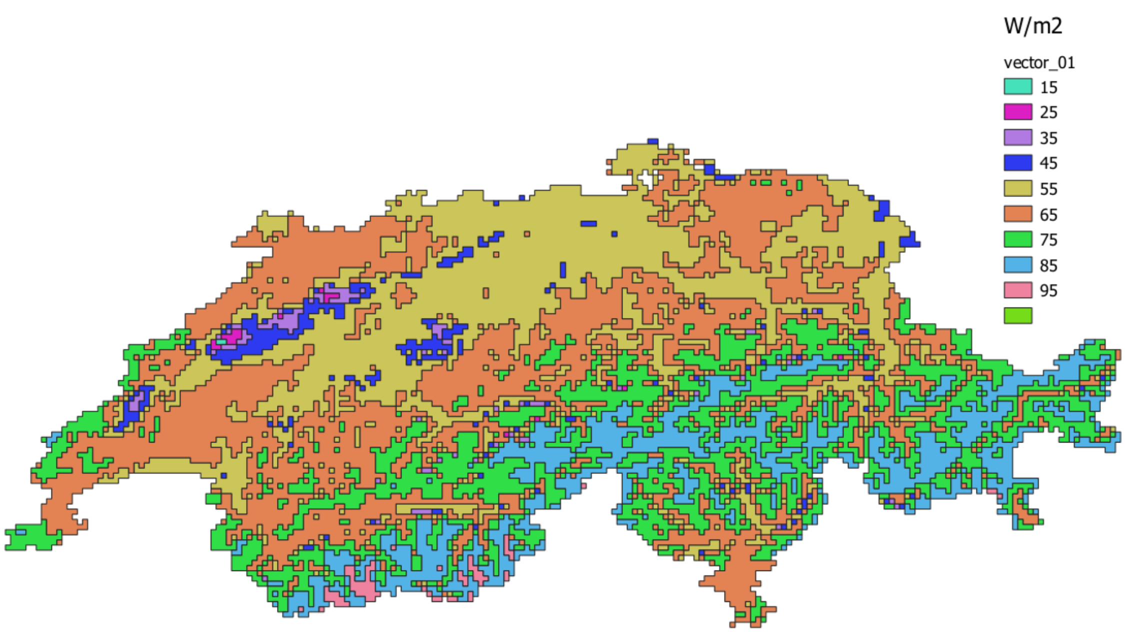

Figure 3: Vector layer with the after reclassification of the solar irradiation.

on the icon that says "Show Editor" and load the python script.
The next part is a description of the python's code:

1. The first part load some libraries to do some math or use some QGIS operations.
2. Next the variables "ini_d" and "tot_d" are used to set the initial and final day for the extraction of data, e.g. "ini_d = 1" and "tot_d = 365", for extracting the full year data into a csv file.
3. The first "for" loop is used to store the days for which we want to extract the irradiation data into a list called "numd".
4. The next part defines the path to the folders where the irradiation data is stored, the Swiss border is located, and the python folder where raster figures, vectors figures, and csv files will be stored.
5. The second "for" loop is used to extract the data for each day within the required range defined in step 2.
6. The rasters corresponding to the 13th and 20th days of the year for the irradiation don't have meaningful values, they go from -1e308 to 1e308, so we don't use them.
7. The variable "val1" contains the cumulative days for each month. This is used later in the function "search" to determine the month that correspond to the number of the day "j". This is useful to open the files and save the results.
8. In order to open the first raster we need to include the driver description which for .nc files is "NETCDF". Additionally, we also need to include the variable name which for GNI and DNI files is "SIS" and "SISDIR", respectively.
9. The next function called "QgsRasterLayer(path,name)" loads the raster and the inputs are the path of the file and the name of the file that we want to see in QGIS.
10. The function "QgsProject.instance().addMapLayer(name)" adds the raster to the "Map canvas".
11. Next the Swiss boundaries are added. In this case we need to add the layer name to the name of the geography database, e.g. "name.gdb+|layername=TLM_LANDESGEBIET".
12. In this case we used the "QgsVectorLayer(path,name,"ogr")" function to add the vector's layer, and "QgsProject.instance().addMapLayer(name)" to show it in the "Map canvas".
13. Next the area that is outside Switzerland is removed in the section called "CLIP MASK" and saved in the variable "rlayer2".

14. Before doing the reclassification it is necessary to know the upper and lower limits of the irradiation data from "rlayer2". This is made in the line that uses this expression "rlayer2.dataProvider().bandStatistics(1,QgsRasterBandStats.All)".

15. The new reclassification algorithm is in the section called "New classification of values [min, max, new values]" where the new values is saved in the list "tab_val".

16. The reclassification is made in the subsection called "Reclassify raster" where the inputs are the variables: "fcf_dir" (path of the clipped raster), "tab_val", and the path for the new reclassified raster "frf_dir".

17. The next section is for the conversion of the reclassified raster into a vector, where the main inputs are the path of the reclassified raster "frf_dir", the name of the field "DIN(W/m^2)", and the path for the new vector "vfn2_dir".

18. In the next section we added more fields to the vector figure, e.g. the area of each range, the total area, and the total irradiation. This is made by first defining the new fields and the type of values (e.g. pr.addAttributes([QgsField("Area(m2)", QVariant.Double)])), next define the expressions related to the new fields (e.g. QgsExpression("$area")), and finally add them to the vector.

19. The next step is the addition of the sum of irradiation for the whole area of Switzerland into the list called "sDIN" for each day "j".

20. The last step is the extraction of the results into single or multiple csv files for its comparison with the total energy consumed in Switzerland.