User Manual

Forest Canopy Density Mapping using Python

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Introduction

Forest Canopy Density (FCD) is an important biophysical parameter for forest management, vegetation health assessment and decision making. FCD model can describe the growing phenomenon of a forest. A remote sensing approach to estimate FCD was developed by Rikimaru (1996), and a semi-expert software package was designed by International Tropical Timber Organization (ITTO) in 2002 based on the methodology. The software was created to estimate FCD from Landsat TM imagery. However, the FCD Mapper software is no longer supported by the latest version of windows, and it is not able to calculate FCD from LANDSAT 8 imagery.

This python script is created in order to estimate FCD from Landsat 8 imagery using any computing platform that supports Python 3 and the required libraries mentioned below.

Requirements

To run the script, the user must install Python 3 on the computer. To download python, click here.

In addition to python, some python packages are also required to install. The text file named "*requirements.txt*" in the folder with script contains the list of packages needed to run the script. The required packages are: "***rasterio***", "***numpy***", and "***scikit-learn***". To install these packages using pip, use the following command:

$ pip install -r requirements.txt

Or, you can use the command to install individual packages:

$ pip install package_name

How to use the script

To run the script first user must install python and required packages. Then right-click on the "FCDMapper.py" file and select Open With > Python. If the script is opened with python, a Graphical User Interface (GUI) will pop up. The User Interface is described in the section below. If the script is run successfully and the GUI pops up, use the GUI to browse and select input bands, parameters, and output indices.

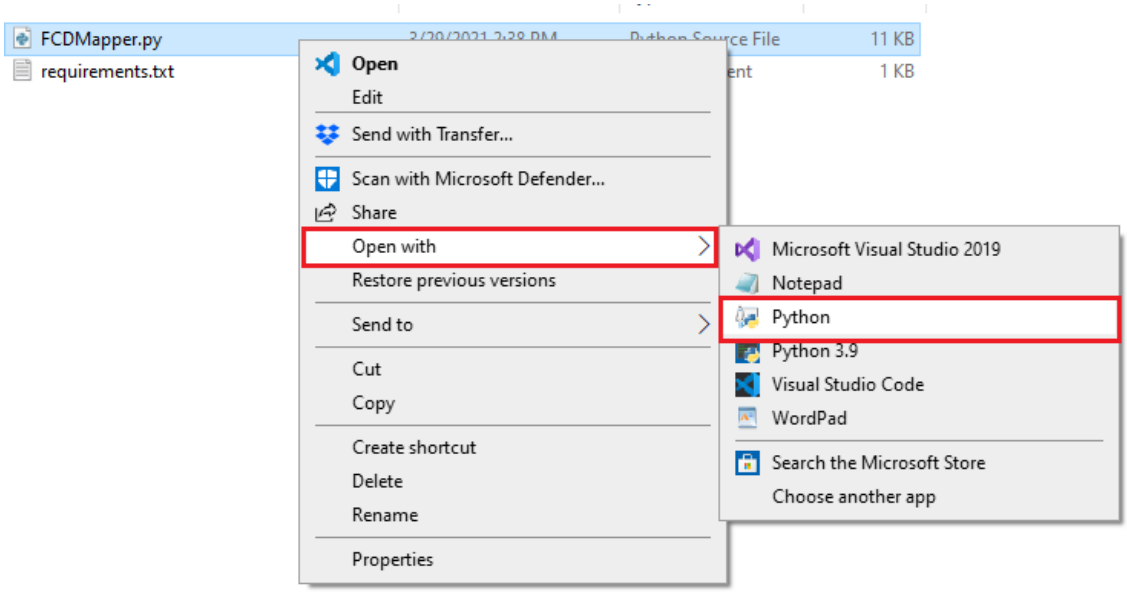

Figure 1: How to open the script using python.

Use any user-preferred text editor (e.g. Notepad++, Sublime Text, Visual Studio Code, or Notepad) to open the script for editing.

User Interface (GUI)

If the script is run successfully, the GUI in Figure 2 will be on the screen. On the left side of GUI, all are the fields for required inputs. To calculate the FCD index, six spectral bands of Landsat 8 (Red, Green, Blue, NIR, SWIR, and TIR) is used. In addition to these raster bands, K1 and K2 parameters have to be added manually for the Temperature Index (TI) calculation. How to prepare the inputs for FCD calculation is discussed in the input section below.

To add a raster band, click on the "**Browse**" button corresponding to the band and select the file (raster band) from the explorer.

To save an index, browse the directory where to save and choose a filename.

Once all the inputs are added and the output location and names are entered, press the "Calculate FCD" button to calculate the FCD index. The script will perform all the calculations inside and save the four indices and FCD indices automatically.

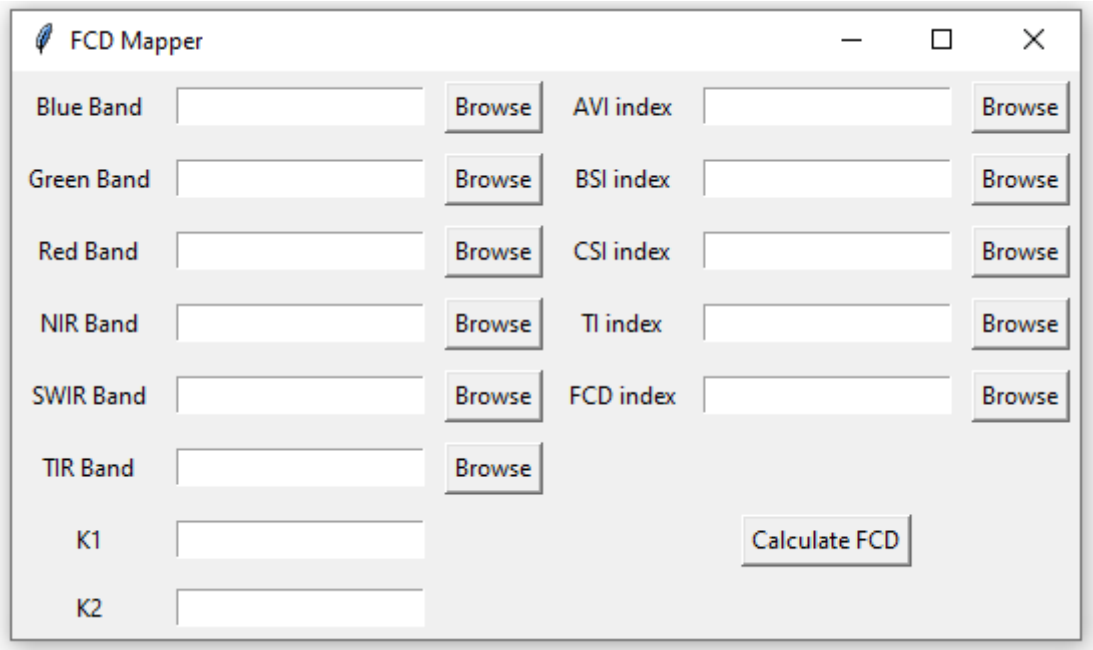

Figure 2: The Graphical User Interface of the script

Input

In the methodology of Forest Canopy Density mapping, they used Top of Atmosphere product of Landsat TM. This python script to estimate FCD was created based on Landsat Collection 1 Level 1 data products (Top of Atmosphere) of Landsat 8. The definition of Landsat Collection 1 Level 1 data can be found here.

The image should be cloud free. If the image has cloud and cloud shadow, they should be masked prior to using in the analysis. It is also suggested that waterbody should be masked before using the image in FCD calculation.

The script require all the bands (Blue, Green, Red, NIR, SWIR, TIR) to be added separately to the GUI. A composite of all bands will not work! Moreover, each band should be added to it's correct path field otherwise the calculated FCD index will be inaccurate. In the case of SWIR, use either SWIR-1 (Band 6) or SWIR-2 (Band 7) of Landsat 8.

For TIR, either of Band 10 or Band 11 can be used. However, additional parameters e.g. K1 and K2 constants corresponding to the selected bands have to be added in the K1 and K2 field of GUI. These parameters are

required for Temperature Index (TI) calculation. The value of K1 and K2 for band 10 and band 11 can be found in the metadata file (MTL.txt) provided with the image. The highlighted text in the Figure 3 shows the values for K1 and K2 constants corresponding to band 10 and band 11.

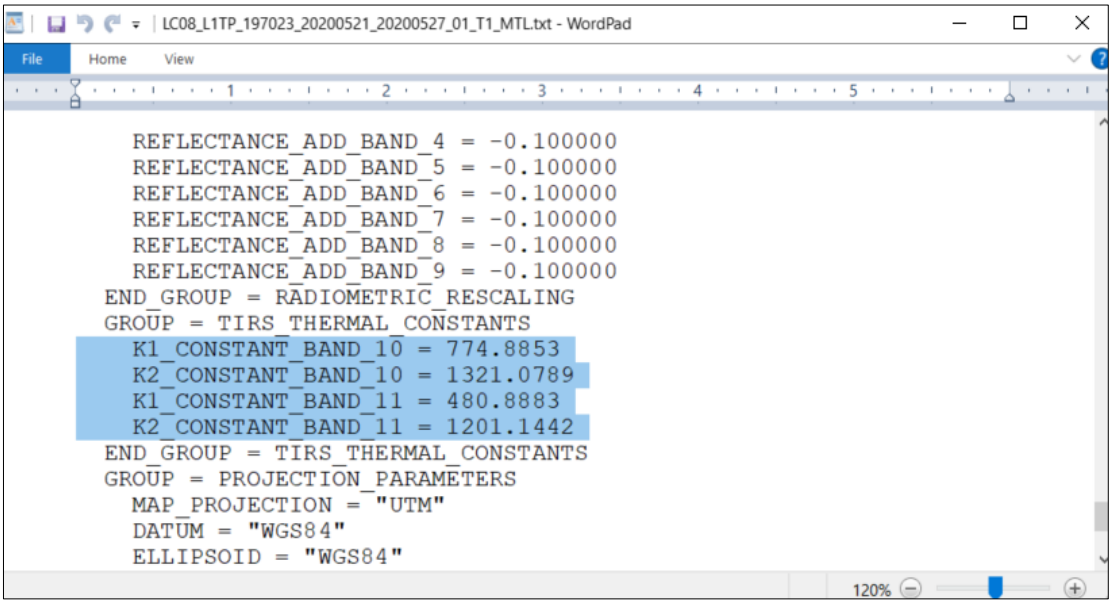

Figure 3: Metadata file containing K1 and K2 constant values for TIR

Table 1: Landsat 8 Spectral Bands used in FCD calculation.

Input Band Name	Band No of Landsat 8 Image	Spectral Range (µm)	Data Type
Blue	Band 2	0.452 – 0.512	16-bit unsigned integer
Green	Band 3	0.533 – 0.590	16-bit unsigned integer
Red	Band 4	0.636 – 0.673	16-bit unsigned integer
NIR	Band 5	0.851 – 0.879	16-bit unsigned integer
SWIR	Band 6 Band 7	1.566 – 1.651 2.107 – 2.294	16-bit unsigned integer
TIR	Band 10 Band 11	10.60 – 11.19 11.50 – 12.51	16-bit unsigned integer

The range of values for each bands have to be normalized prior to use in FCD calculation. The equations to calculate AVI, BSI, CSI used in the script is for 16 bit image. Therefore, the TOA reflectance values have to be normalized in 0 – 63335 range. Landsat Collection 1 Level 1 products downloaded from USGS are typically normalized in 0 – 65535 value range.

Outputs

The script will save five indices as output such as AVI, BSI, CSI, TI, and FCD index. The indices are saved in "*GeoTiff*" format (.tif).

Output indices can be open in any GIS software such as ArcGIS, QGIS and use for further analysis, for example, forest classification based on FCD value (high, medium, low density).