How does global warming influence on vegetation?

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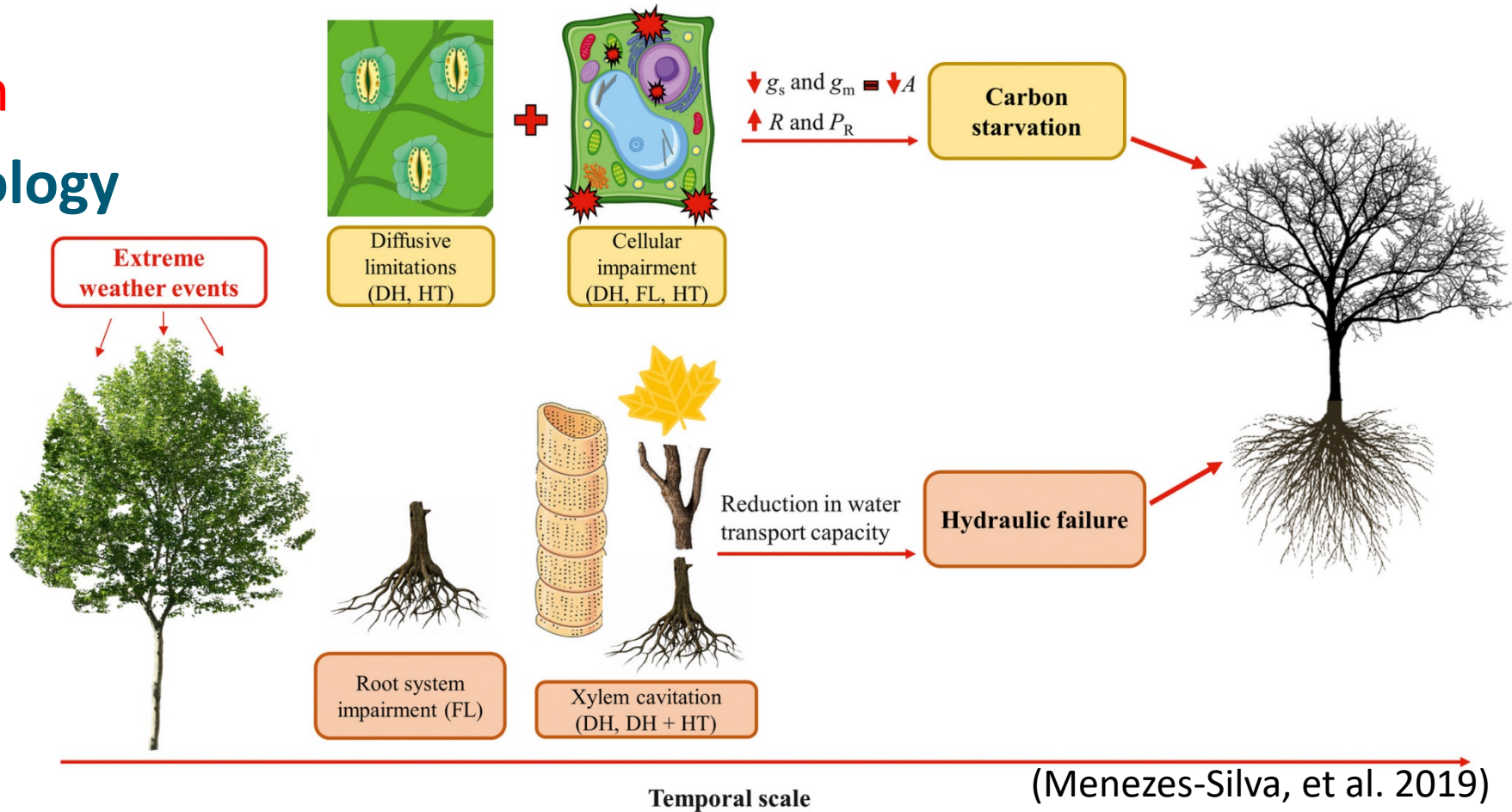
Climate change impacts on trees

Climate-related changes in:

- temperature,
- rainfall,
- nitrogen deposition

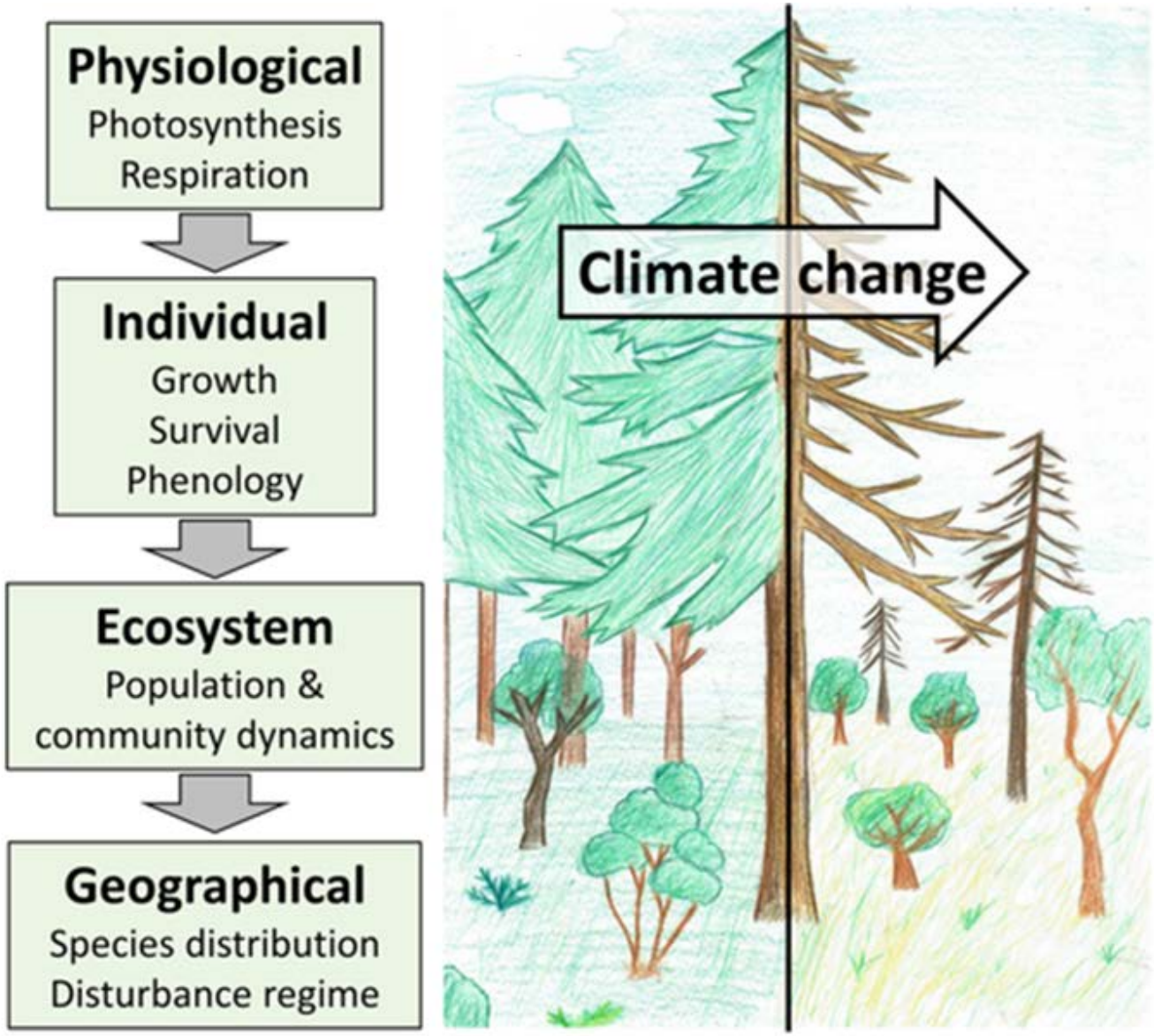
can affect **tree physiology**



(Menezes-Silva, et al. 2019)

Climate change impacts on forest ecosystems

Expected cascading effects
(direct and indirect)



(Kramer, et al. 2020)

Satellite images for vegetation monitoring

Land use and land cover

Cover

- foliage projective cover
- tree density
- coarse woody debris
- greenness
- vegetation health

Vegetation structure

- vertical forest structure
- above-ground biomass
- leaf area index
- basal area
- individual crowns and gap size

Vegetation chemistry and moisture

- foliar chemistry
- fraction of absorbed photosynthetically active radiation
- moisture content

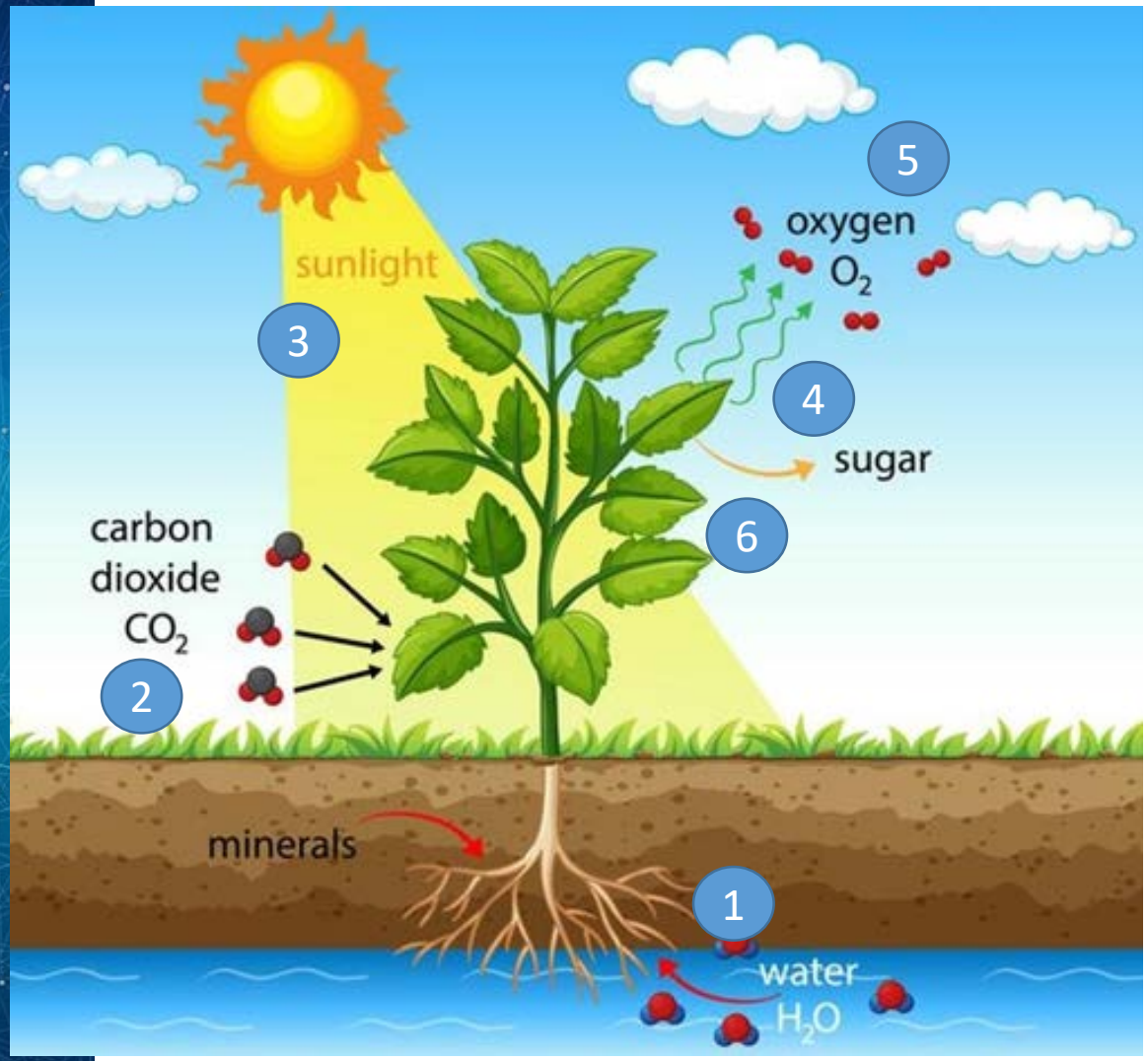
Biodiversity

- individual species identification
- biodiversity

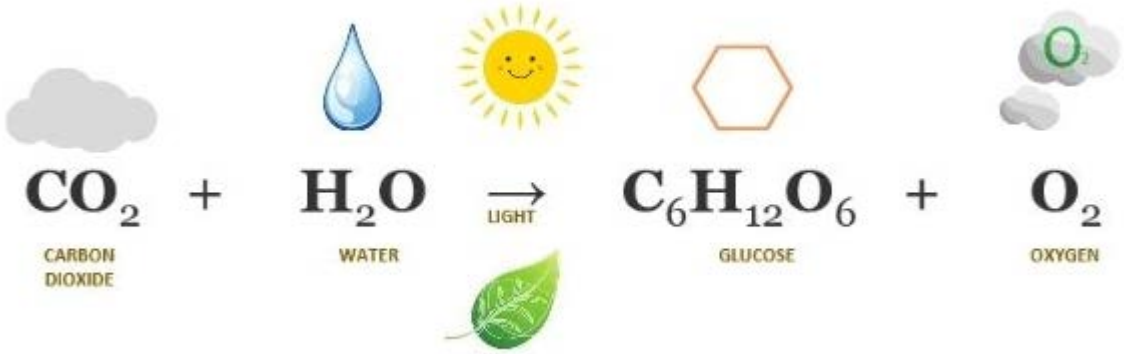
Disturbance

- detecting forest disturbance and recovery over long and multiple time periods
- fire scar mapping

Photosynthesis



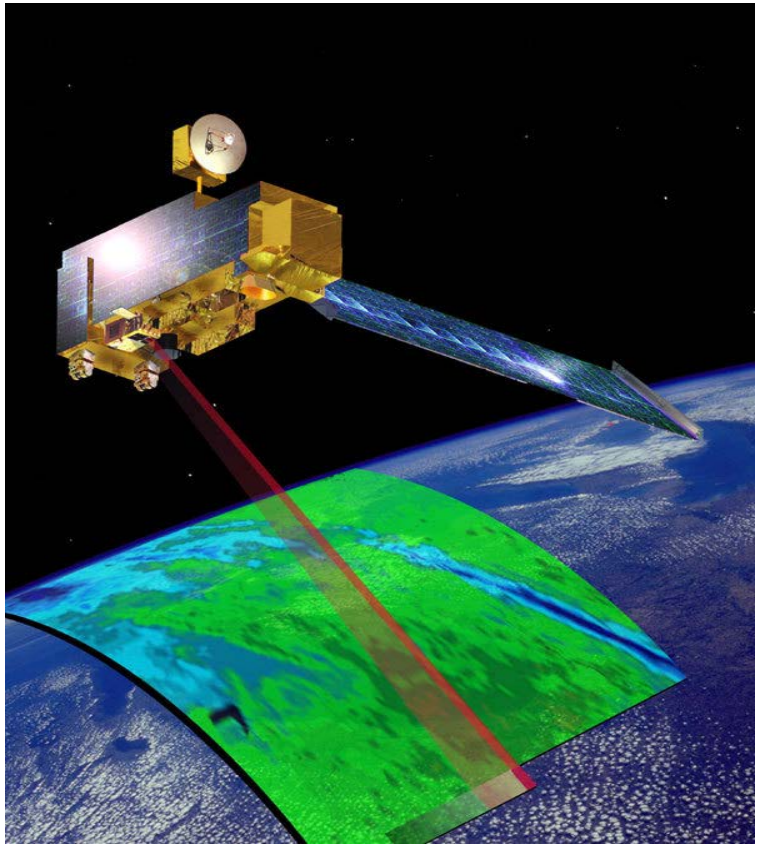
1. the plant absorbs water (H_2O) and mineral salts that are found in the soil through the roots
2. the leaves take carbon dioxide (CO_2) of the air through the small pores
3. the leaves trap energy from sunlight
4. the plant uses energy of sunlight to turn water (H2O) and carbon dioxide (CO_2) into sugars and oxygen (O_2)
5. the plant releases oxygen (O_2) into the air
6. the plant uses the sugars – glucose ($C_{16}H_{12}O_6$) - for growth



MODIS

Moderate Resolution Imaging Spectroradiometer

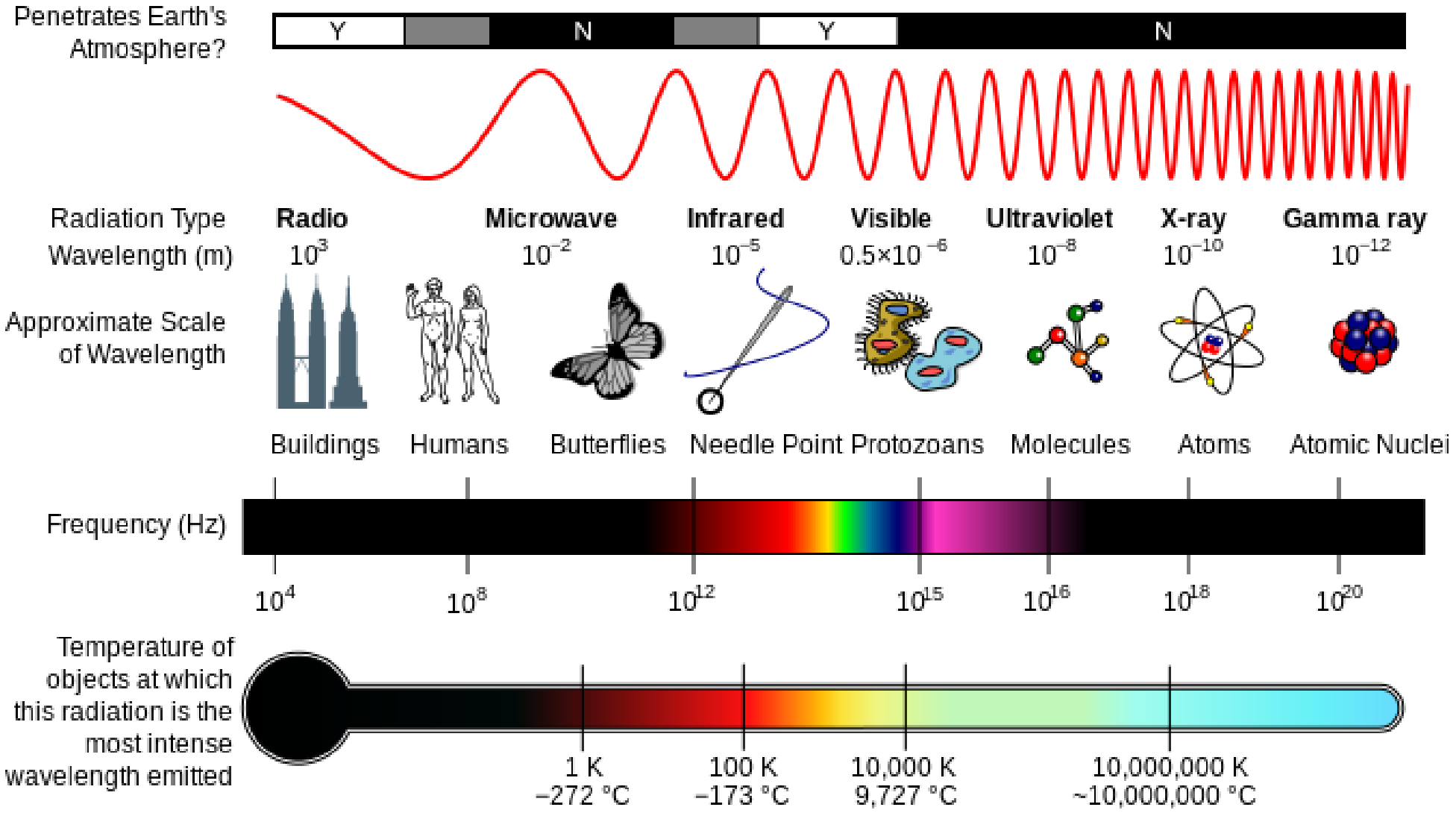
- MODIS satellites are viewing the entire Earth's surface every 1 to 2 days
- acquiring data in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm
- varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km)
- operating from 1999 (global products avaiable from spring 2000)



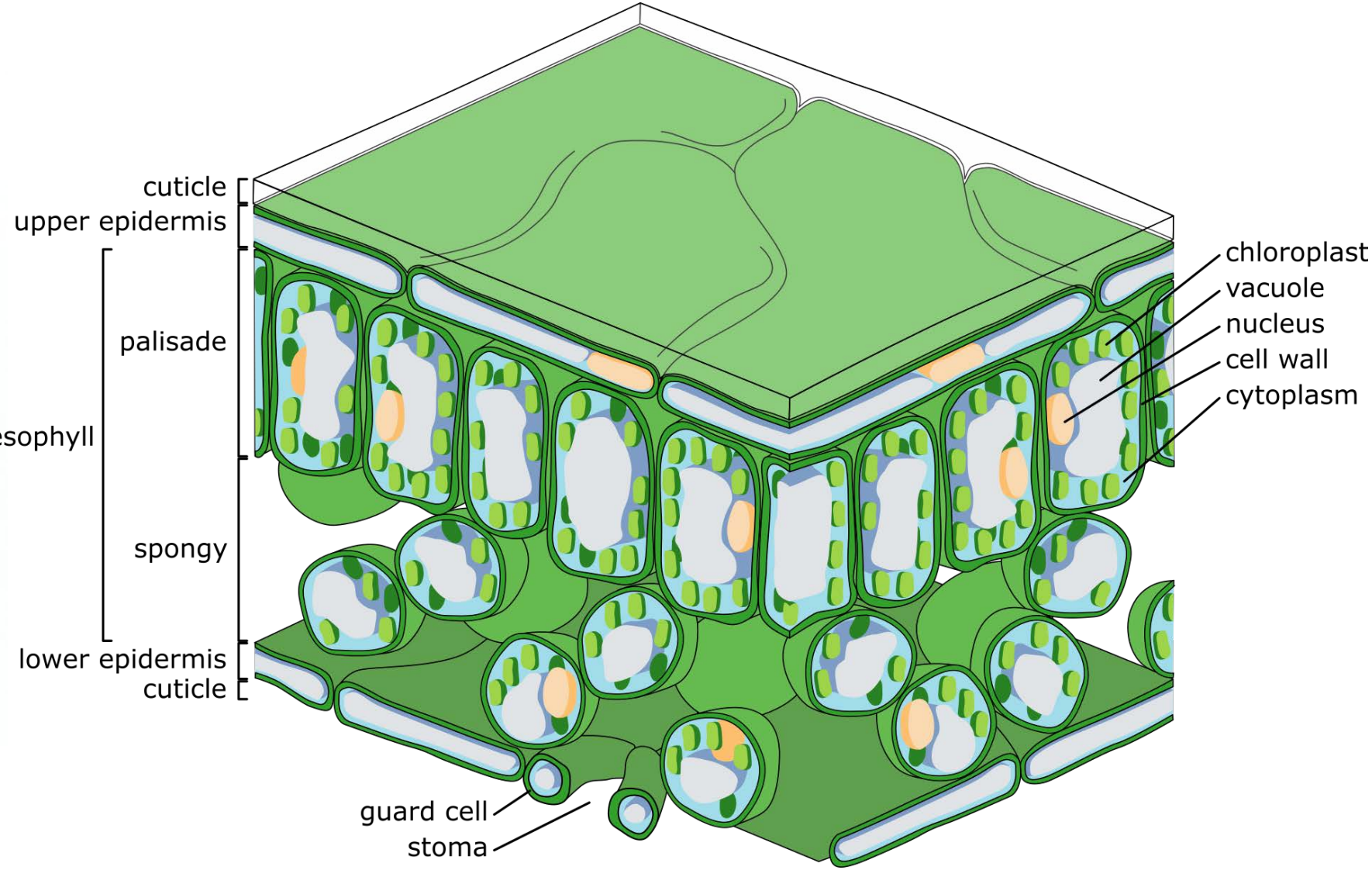
We will use:

- MOD09A1 reflectance product to calculate vegetation indices
- MOD13A1 vegetation indices product to analyse changes in growing season characteristics in the period 2000-2020

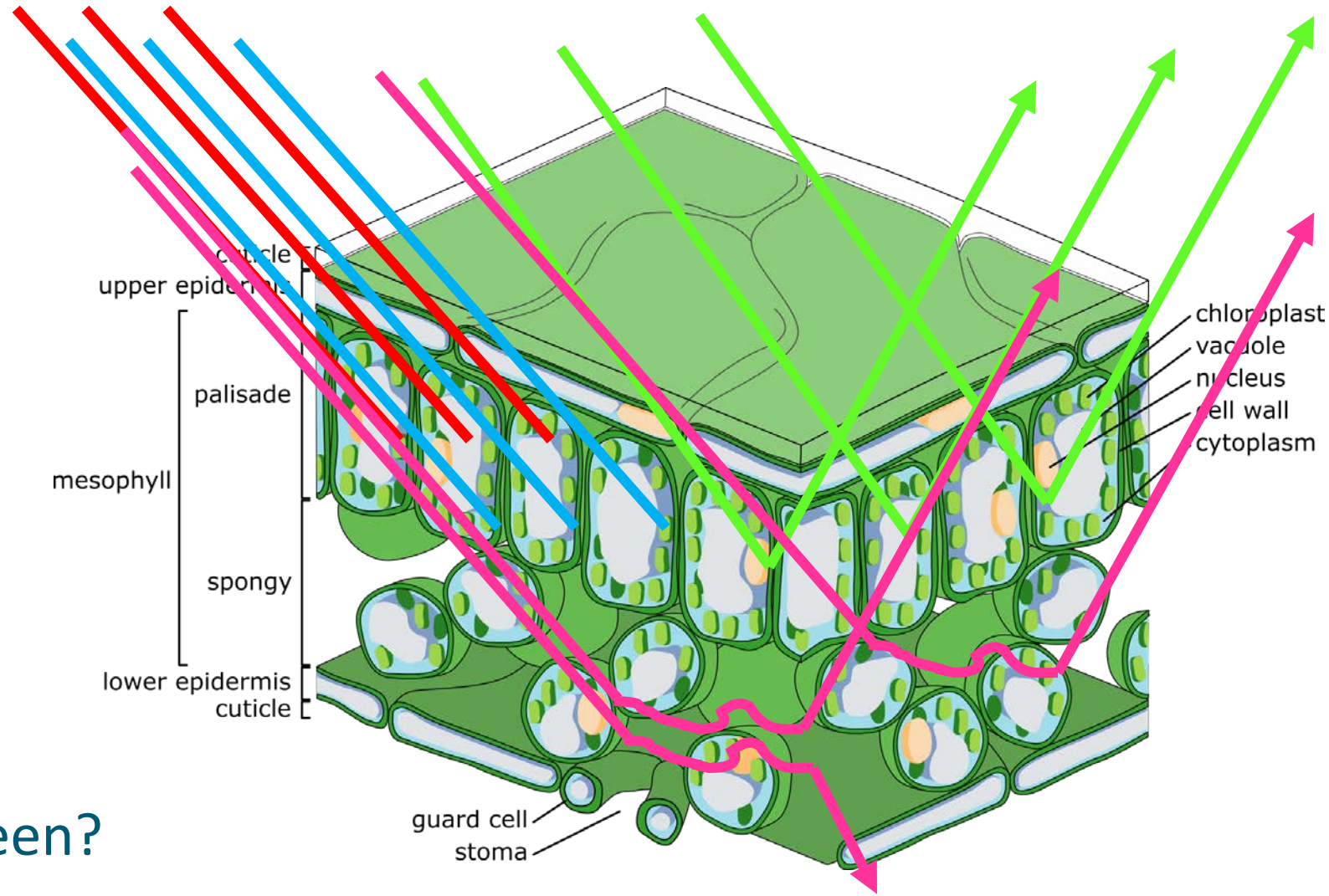
Remote sensing uses properties of electromagnetic spectrum for objects observation



Leaf anatomy and processes which take place in leaf have a footprint on satellite images



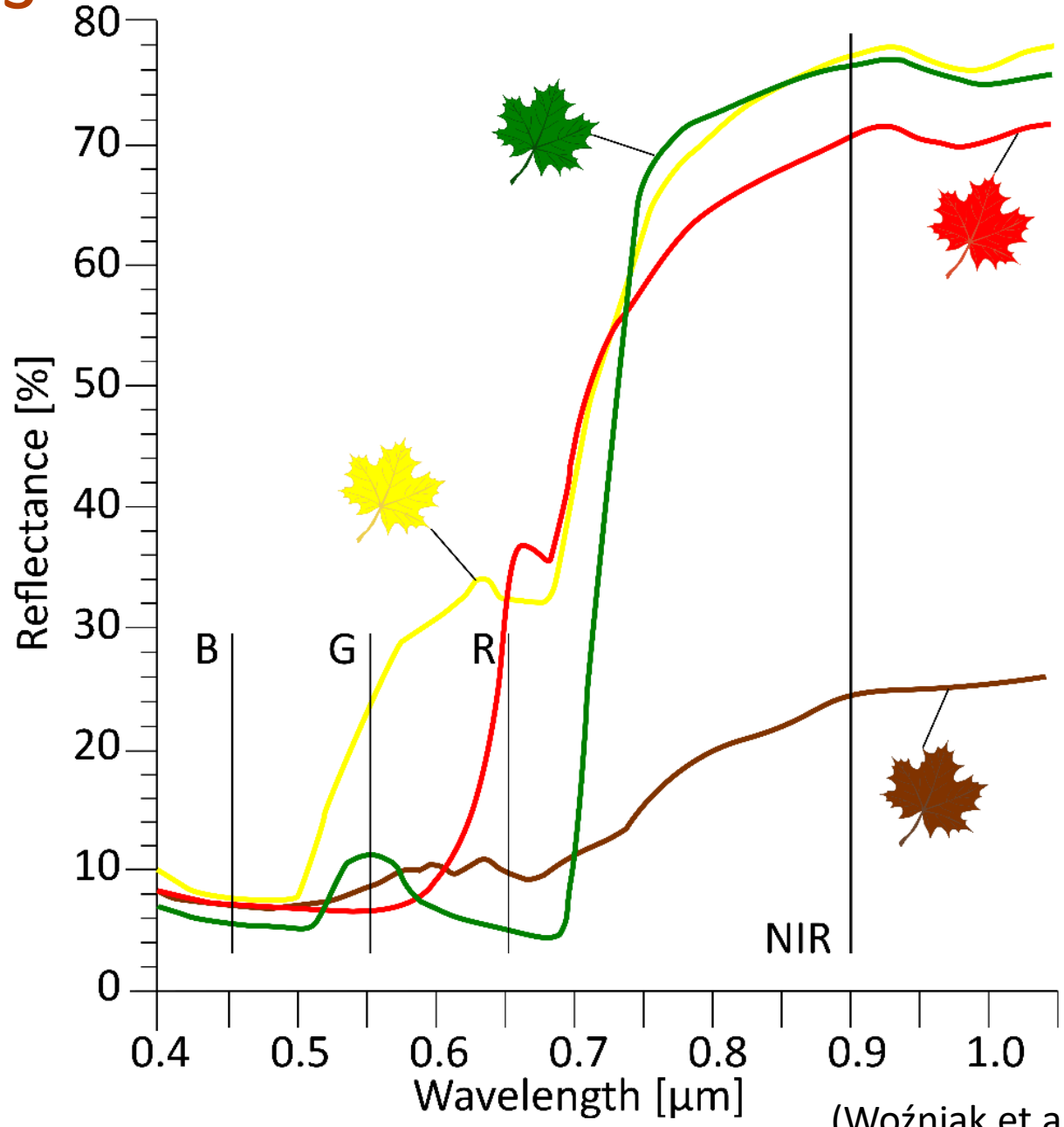
Interaction of electromagnetic wave with leaf: reflection, absorption, transmission



Why are leaves green?

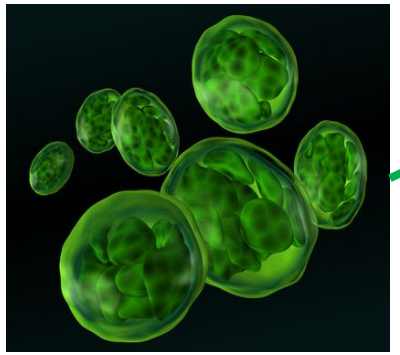
Spectral curves of leaves at different state

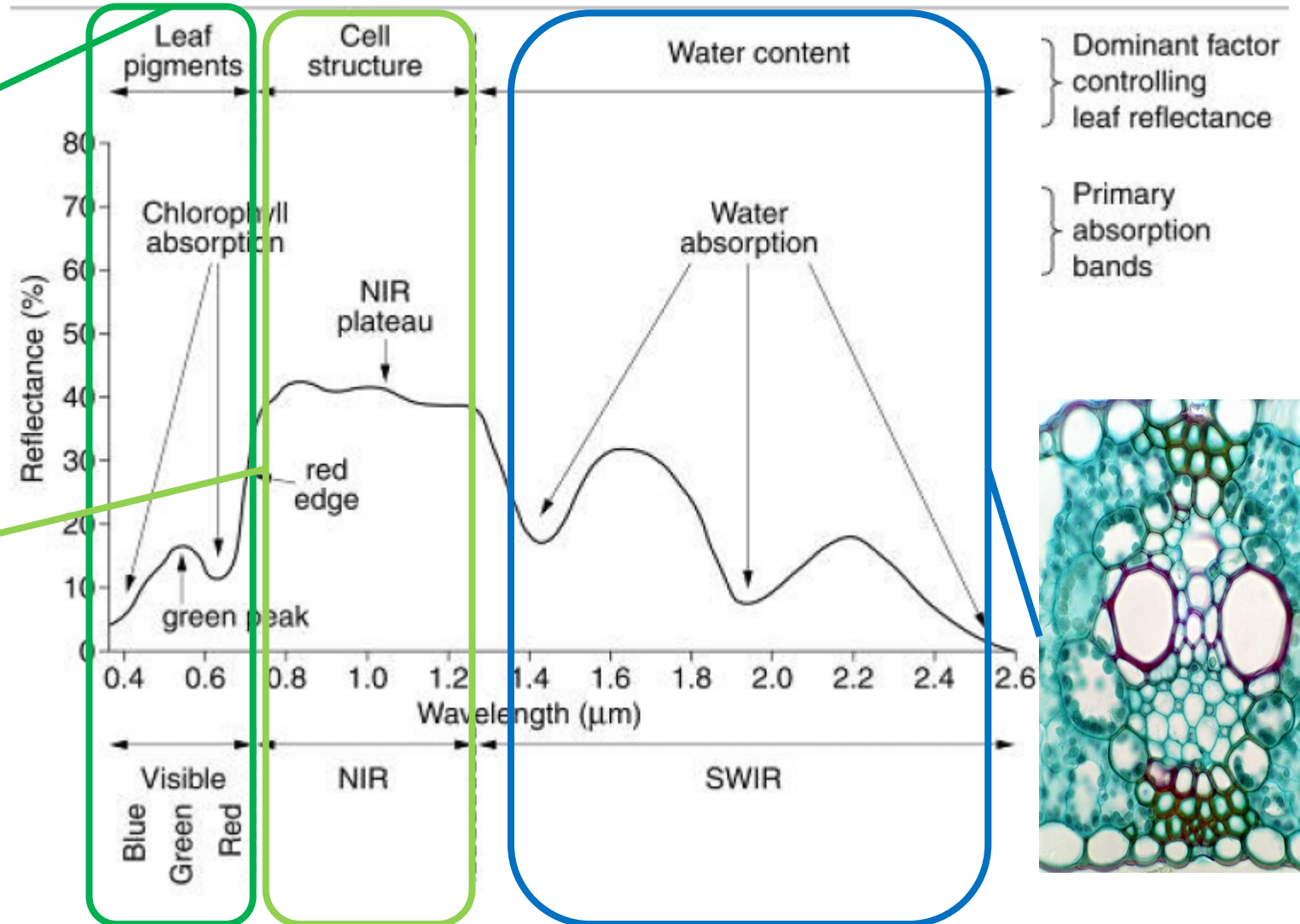
Reflectance of various wavelength depends strongly on leaf state



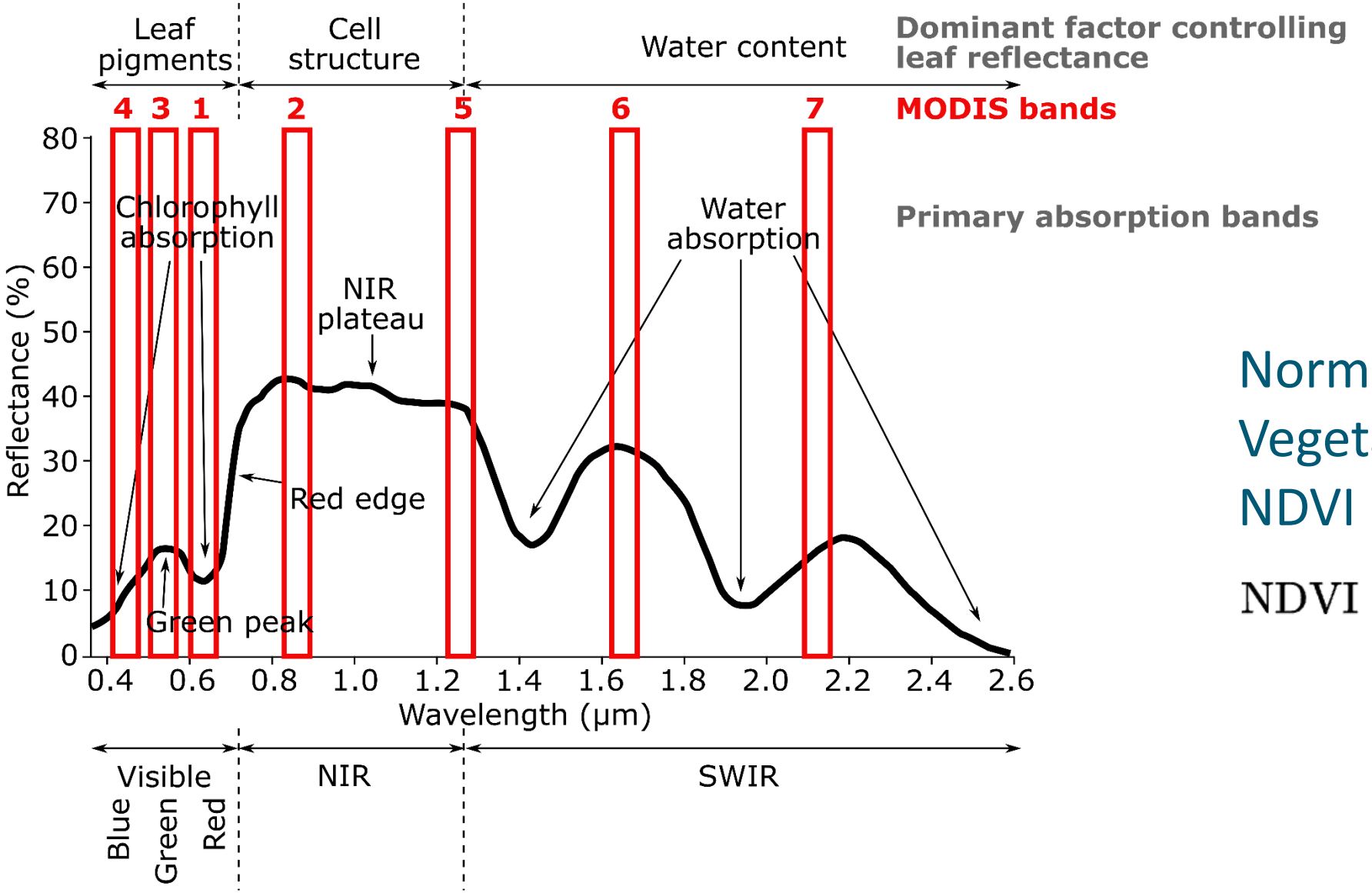
(Woźniak et al. 2020)

Vegetation spectral curve – dominant factors controlling leaf reflectance





MODIS bands and vegetation index



Normalized Difference Vegetation Index NDVI

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$

(Rouse et al. 1973)

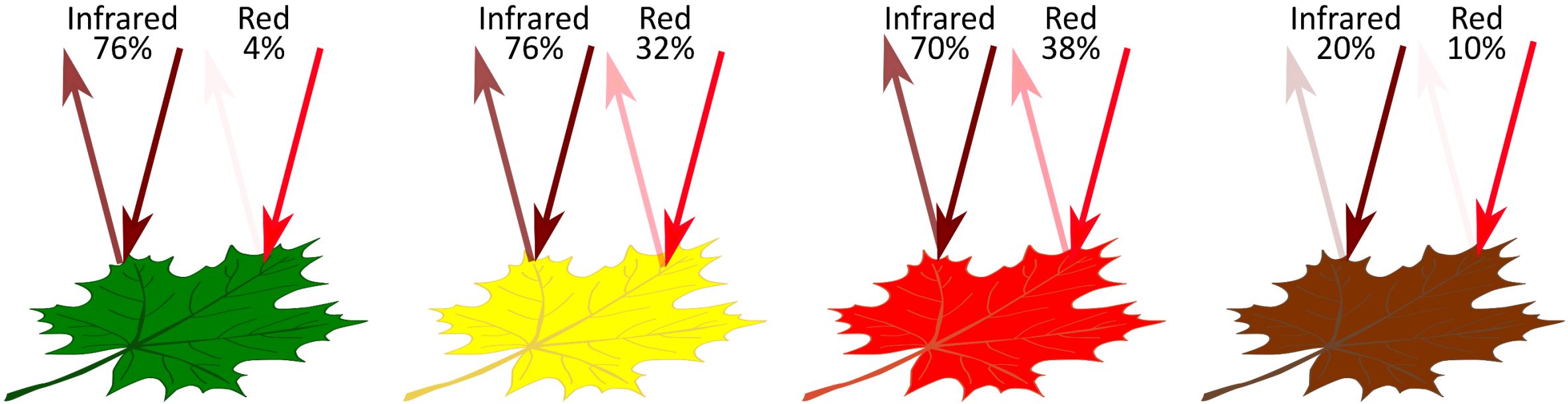
Normalized Difference Vegetation Index - NDVI

MAX = 1

intensive photosynthesis

MIN = -1

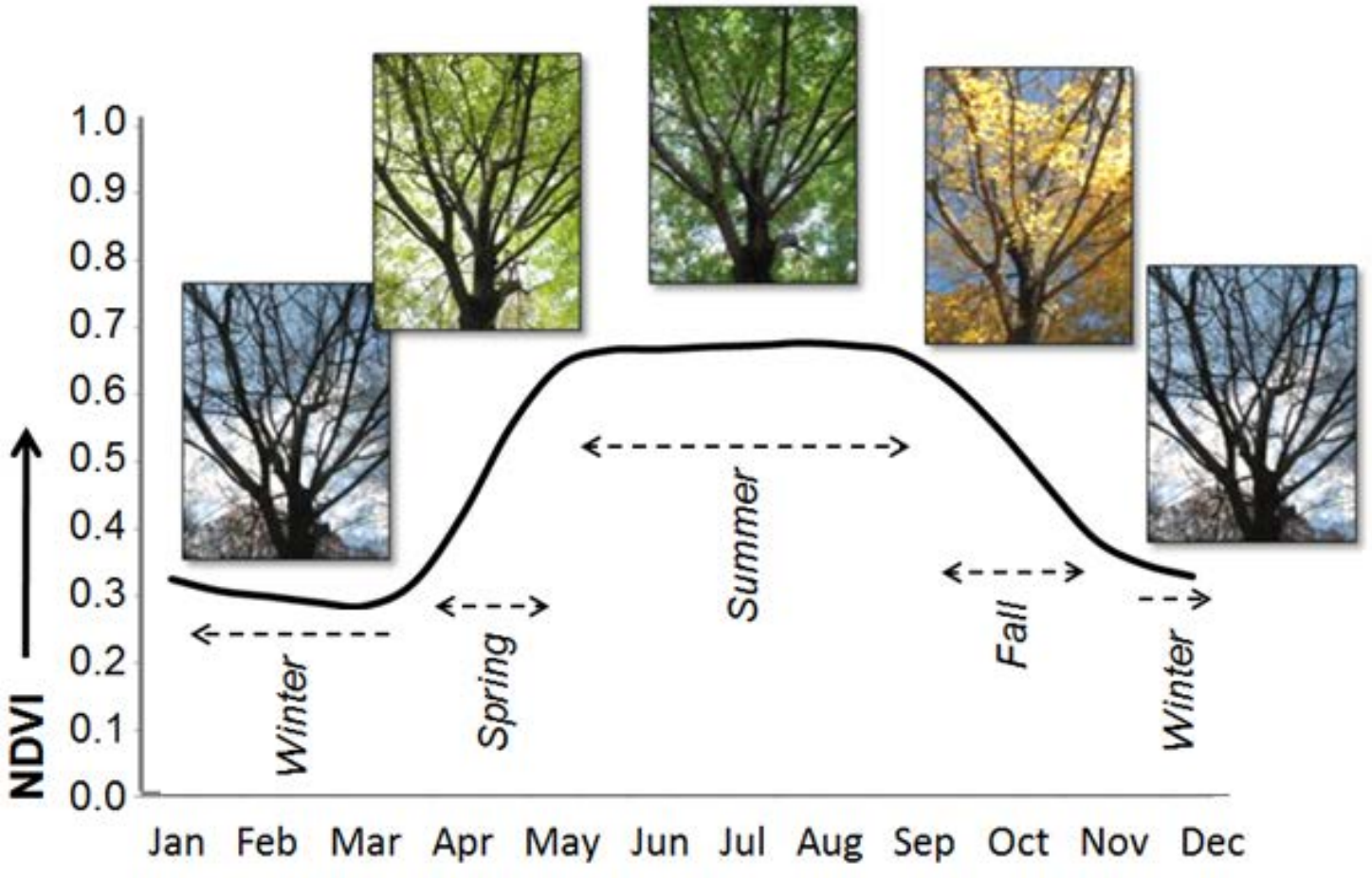
lack of photosynthesis



(Woźniak et al. 2020)

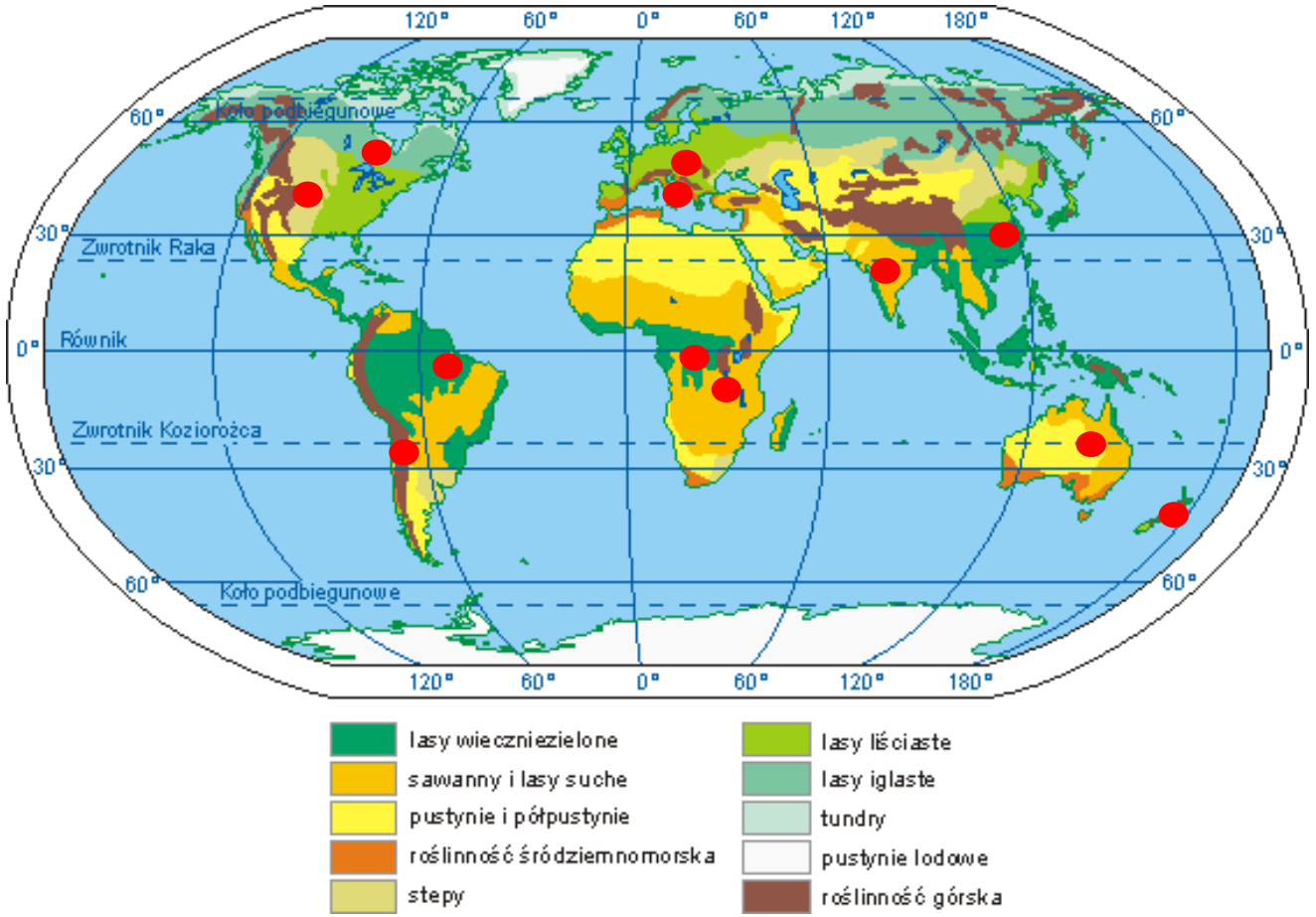
Research questions

- Has a phenological cycle changed from 2000 to 2020 (length of growing season, its intensity, its maximum period)?
- What could be the possible drivers of changes?



Practice

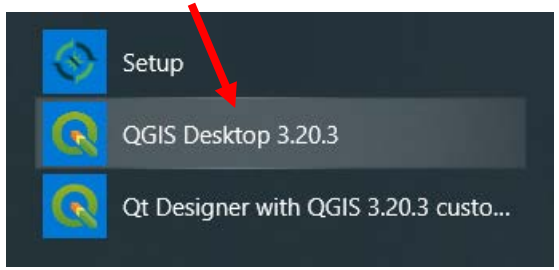
1. To calculate NDVI using MODIS reflectance images (MOD09) and to compare the values of indices for different land covers
2. To analyse changes in photosynthesis cycle from 2000 to 2020 in different regions

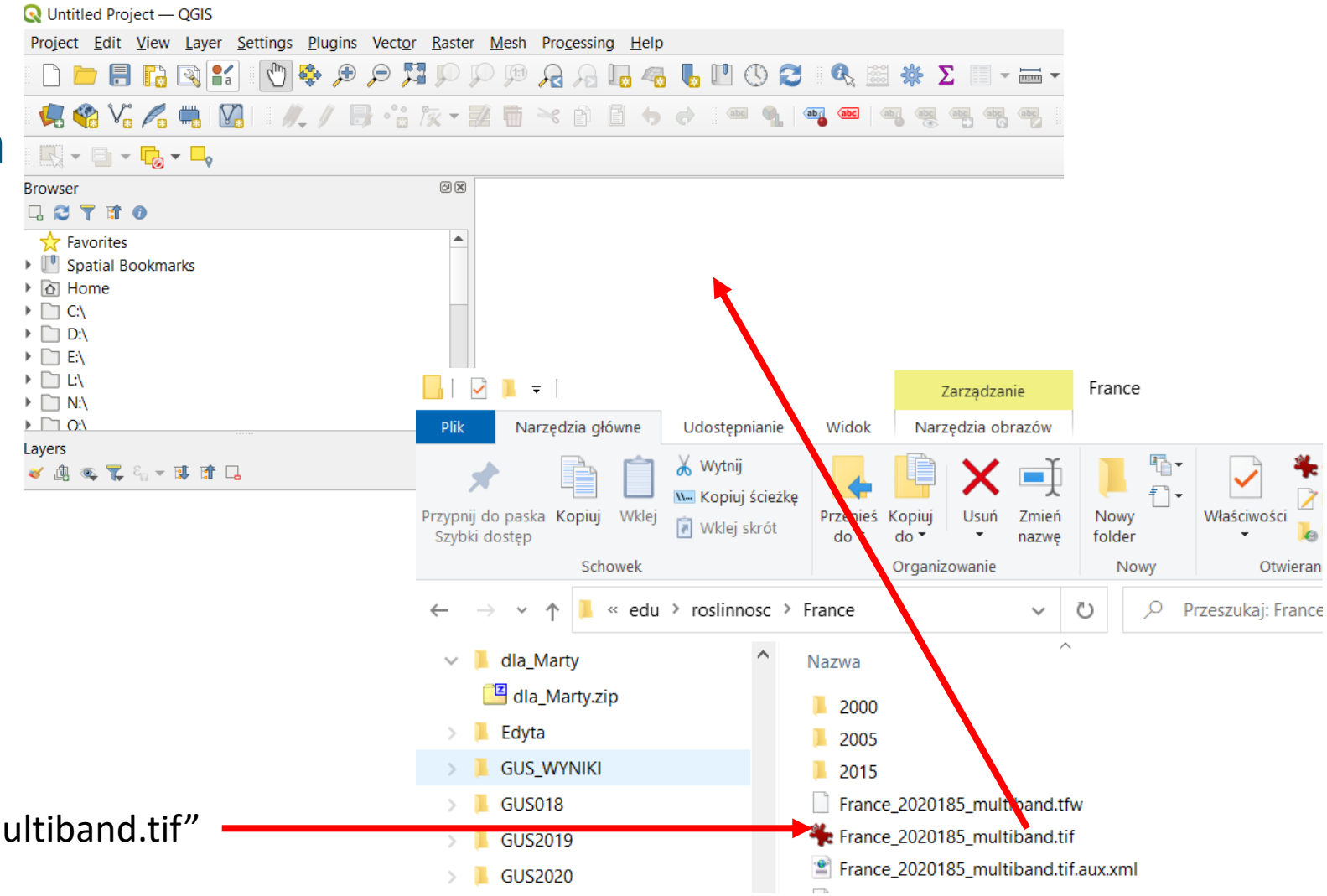


Instruction – part 1.
Calculation of vegetation index NDVI

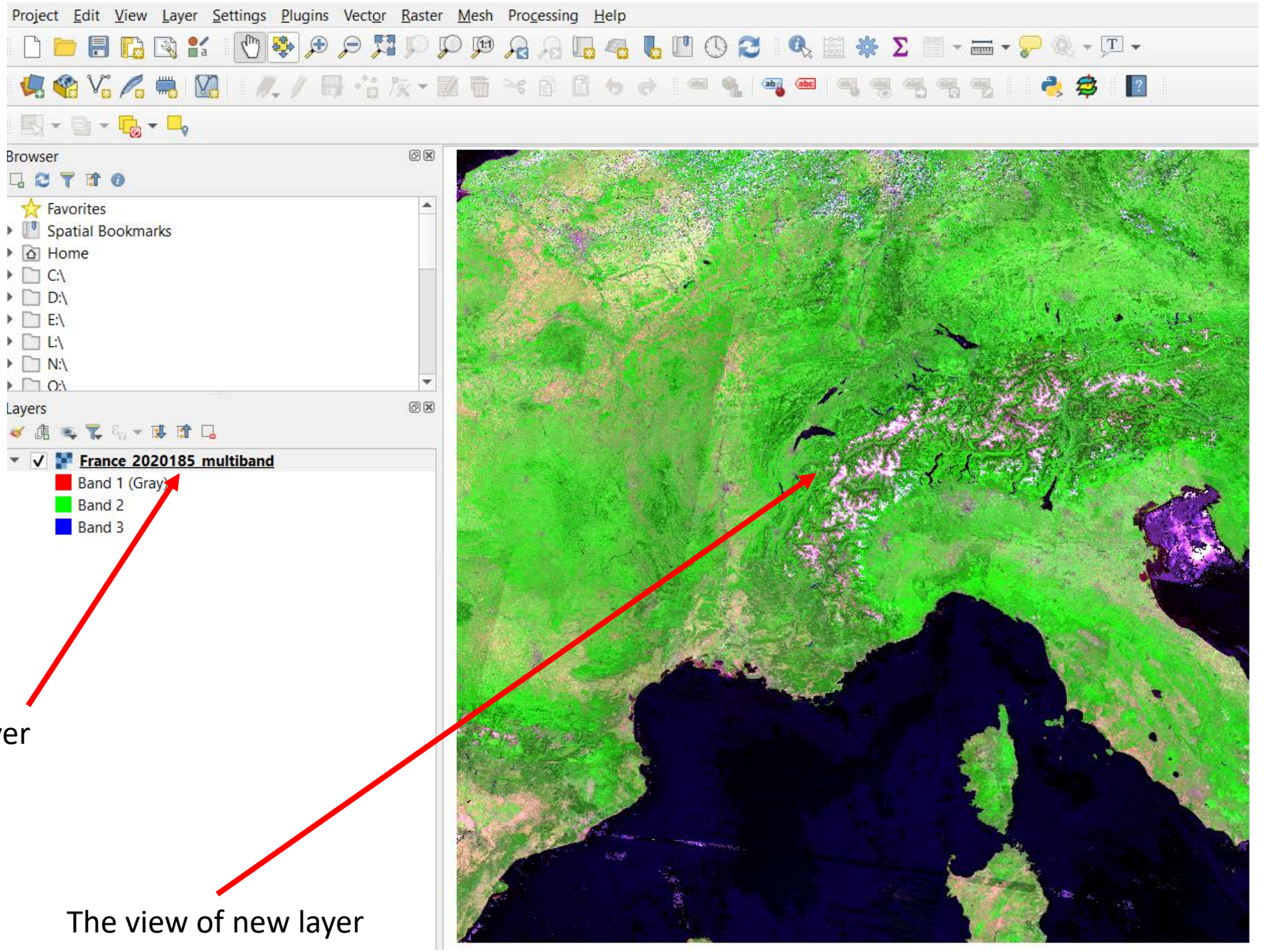
Opening software and data

1. Open QGIS





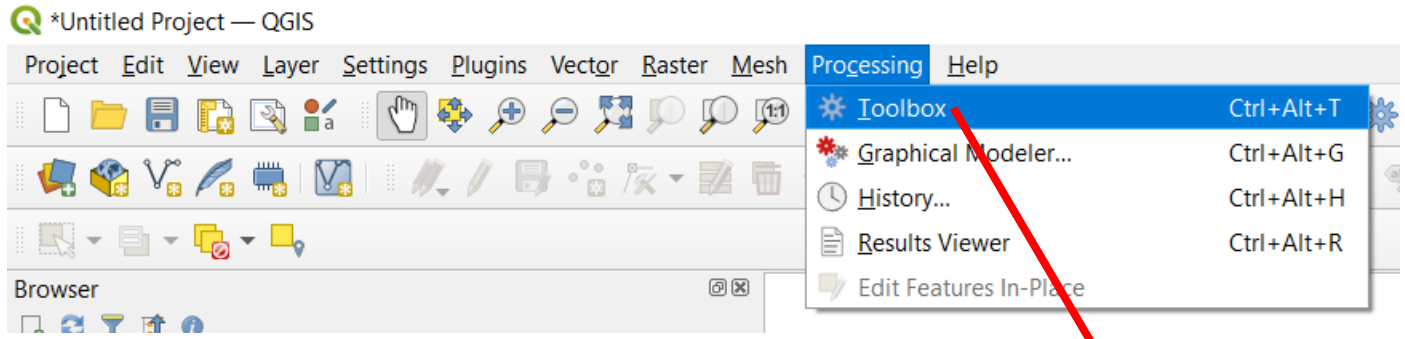
2. Drag an image „*region_date*_multiband.tif”

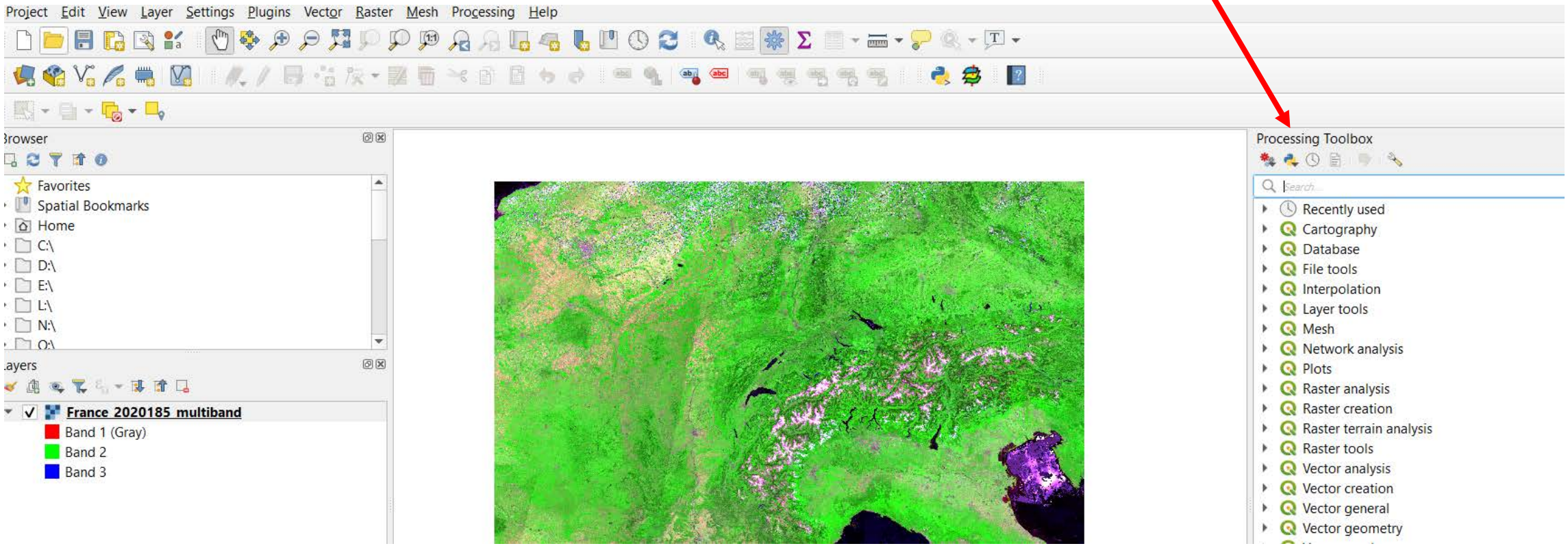


New layer

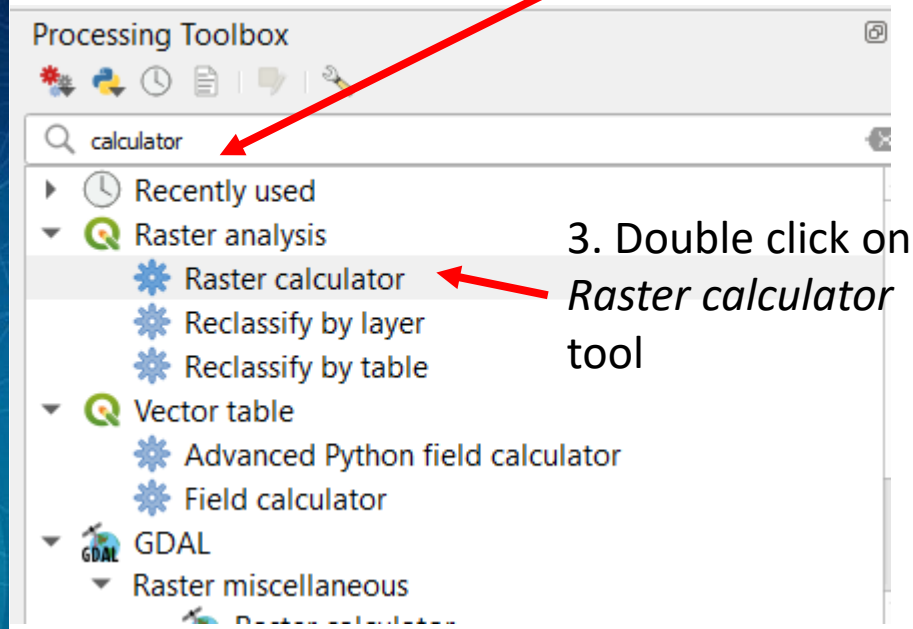
The view of new layer

3. Open toolbox

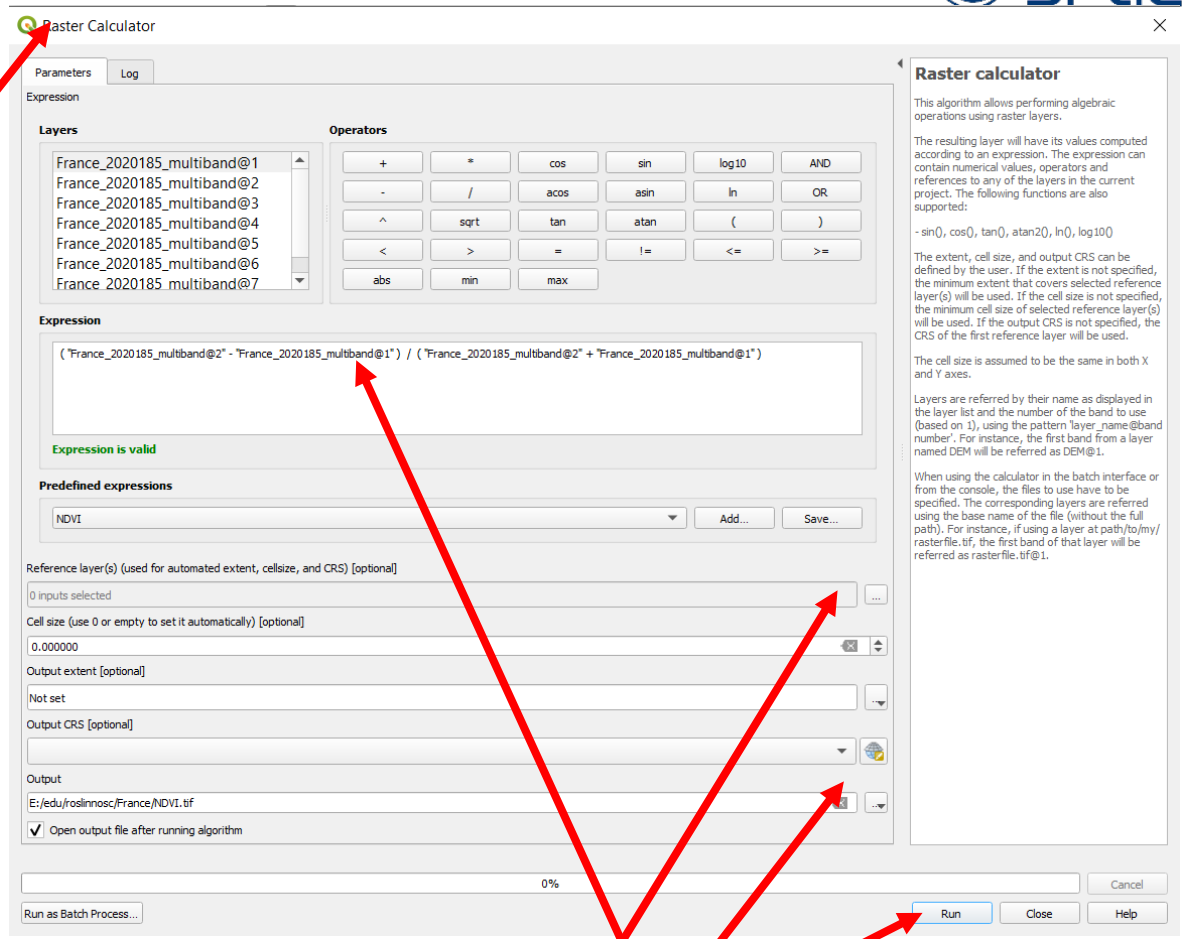


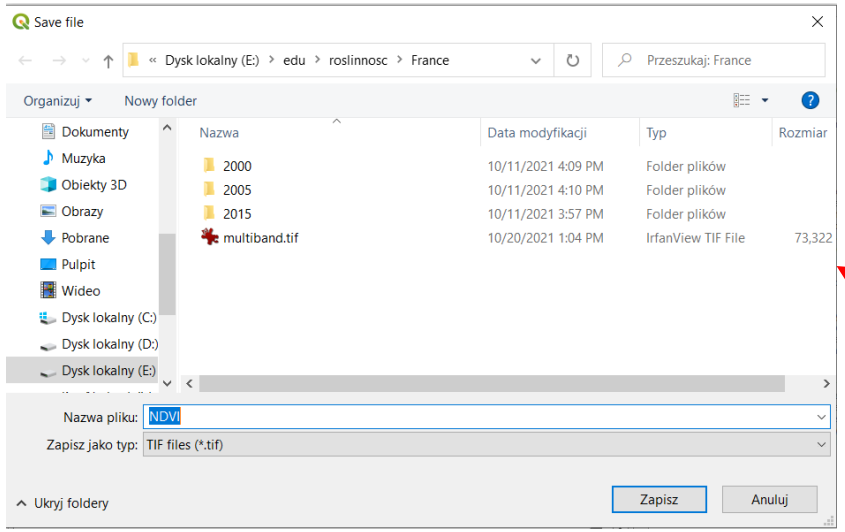


4. Write **calculator** in the *Processing Toolbox Search* window



3. Double click on *Raster calculator* tool





5. Insert the equation based on ***multiband*** file (b2-b1)/(b2+b1) to calculate NDVI

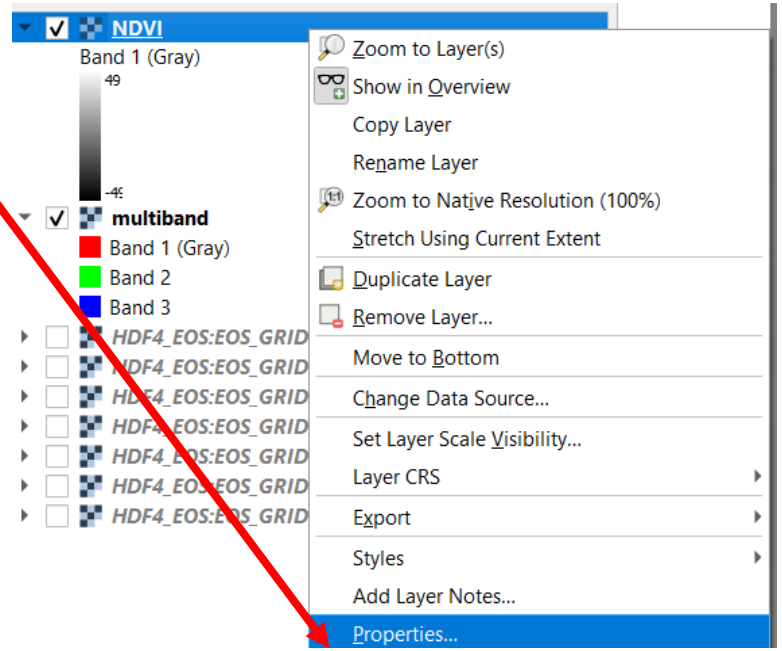
6. Select ***multiband*** file to define new layer extend

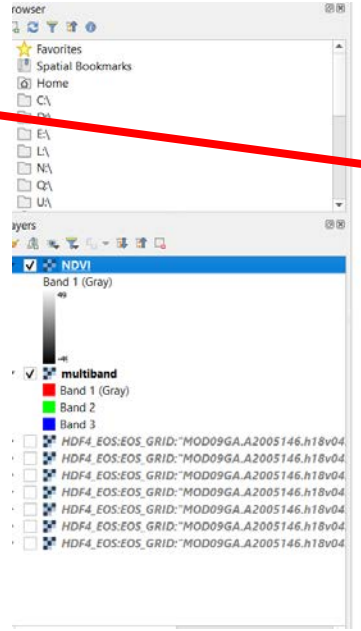
7. Define the name of the output layer ***NDVI***

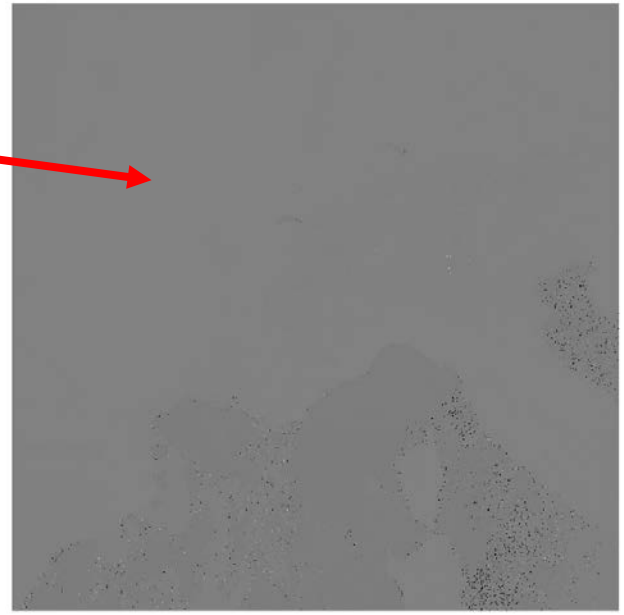
8. Run

The NDVI layer will appear in your project. However due to erroneous value at the Edge of clouds it will be little visible. To make it visible do the following:

a) click right button of the mouse on NDVI layer and choose *Properties* option

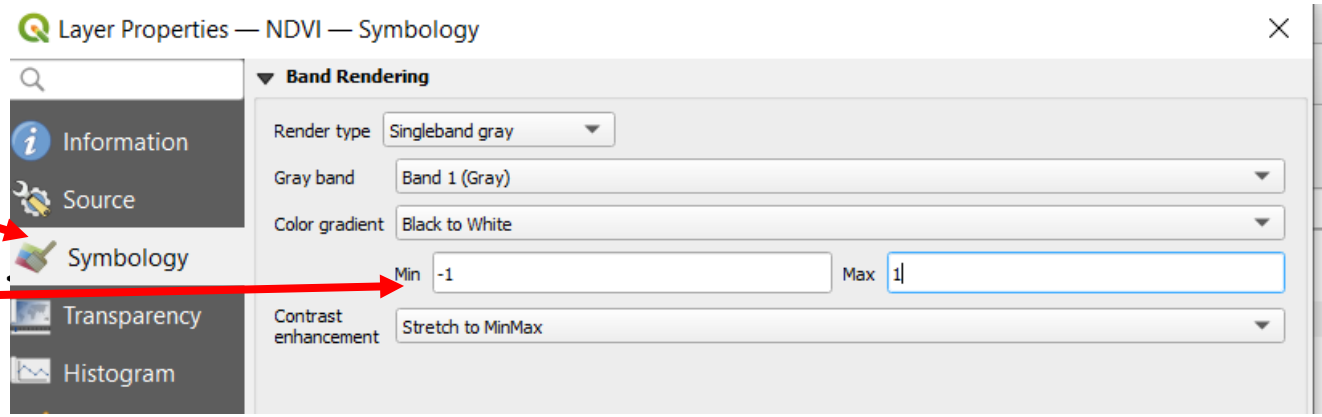




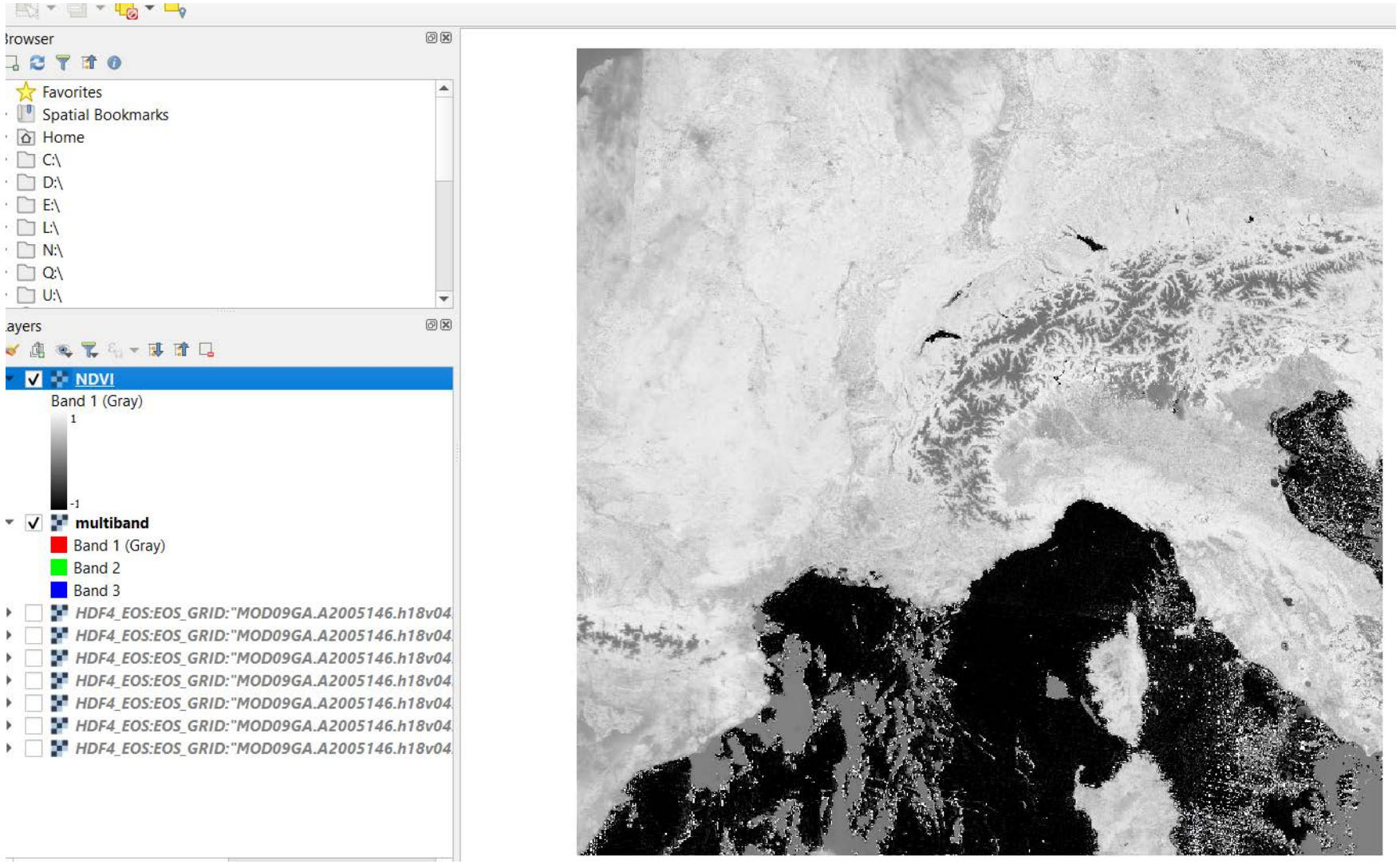


b) open Symbology

c) change min and max to the range value of the NDVI <-1 1> and press OK

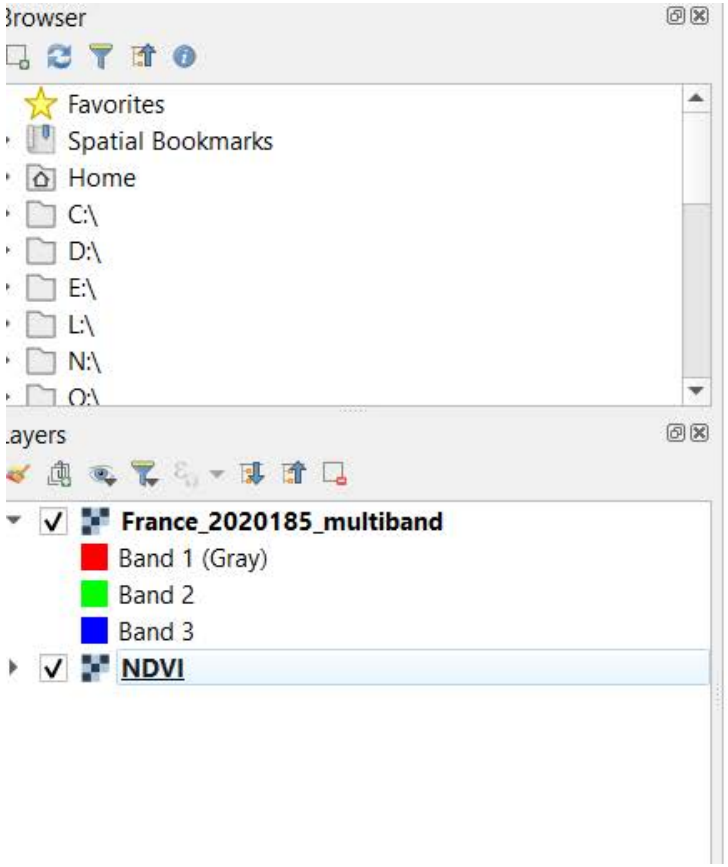


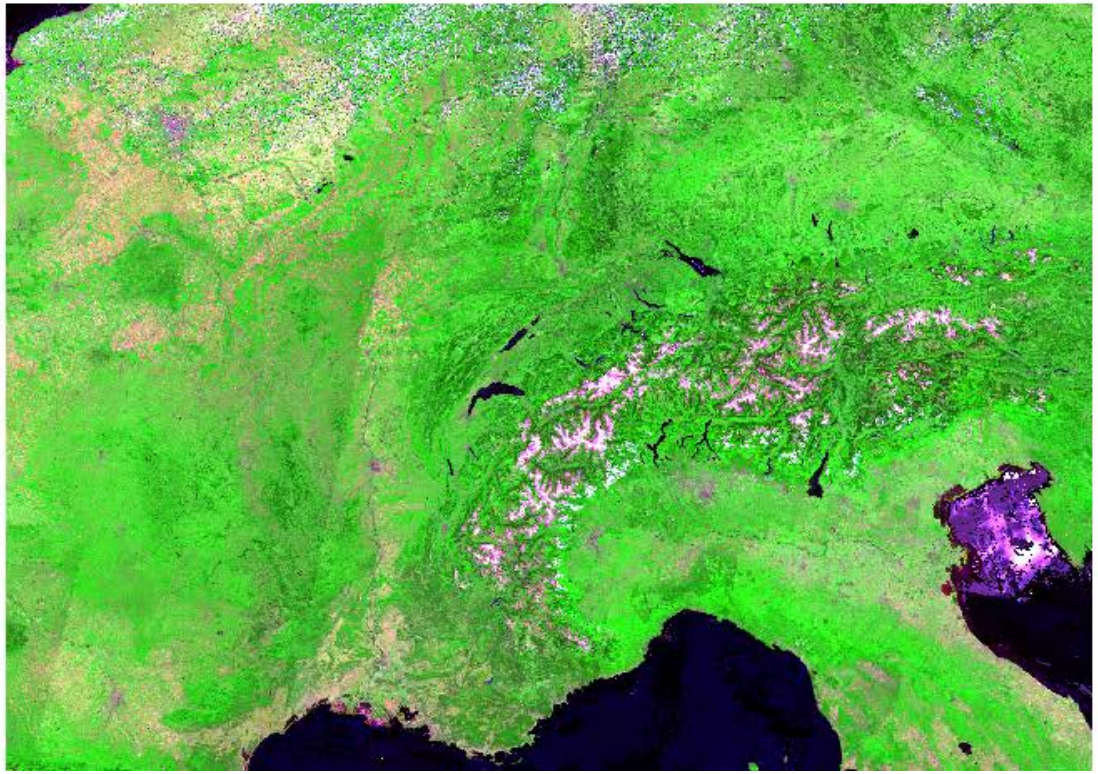
You will obtain a similar image.
White colour means that the photosynthesis within the area is very high, black that it is very low.



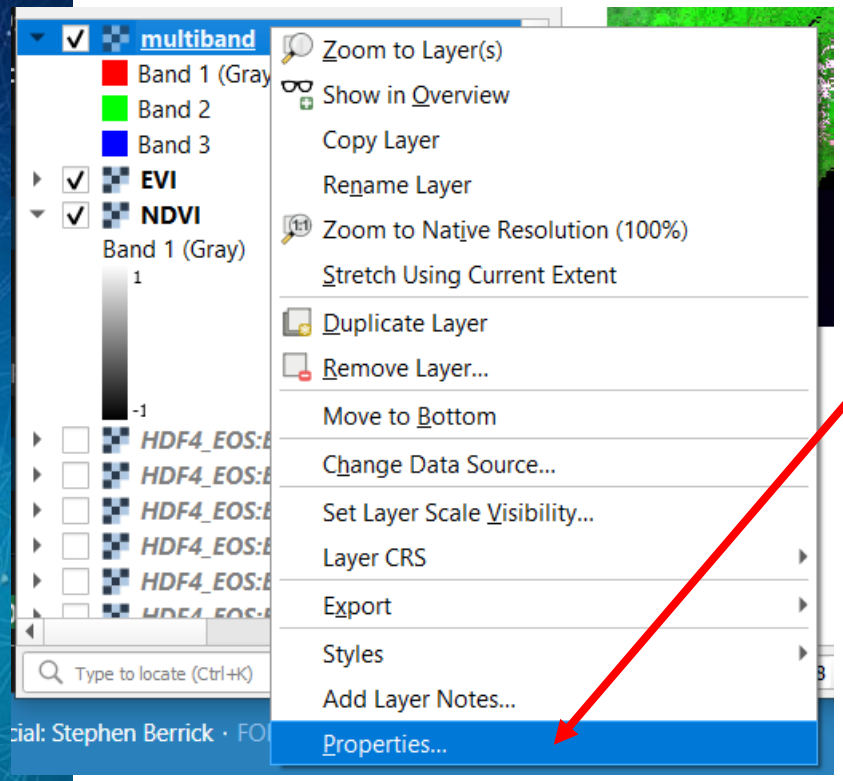
Comparison of the values of NDVI for different land covers

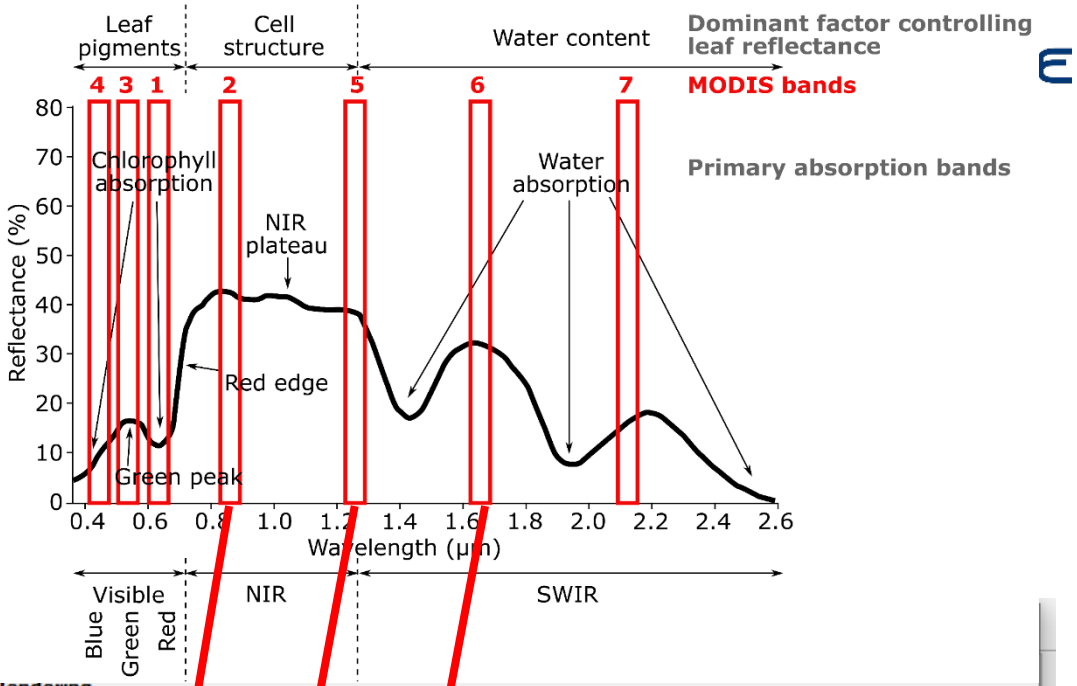
1. Drag ***multiband*** image to the top of the list

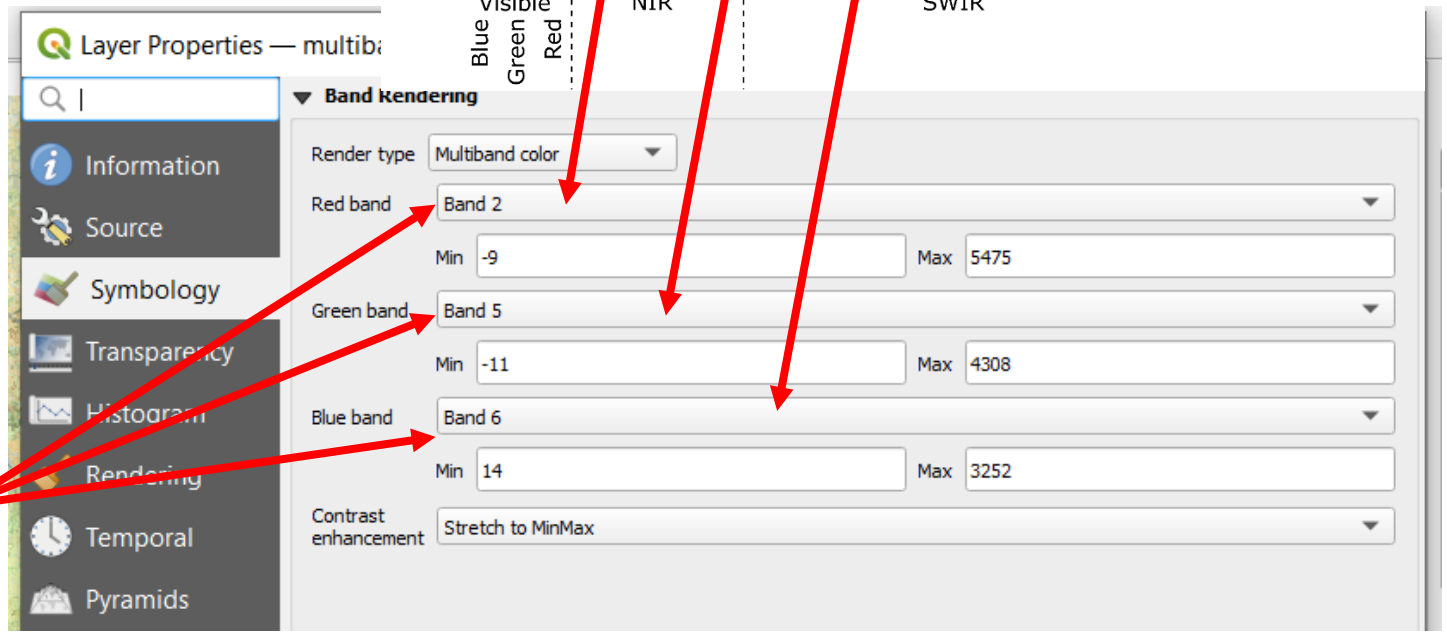




2. Click right button of the mouse on ***multiband*** layer to open *Properties*

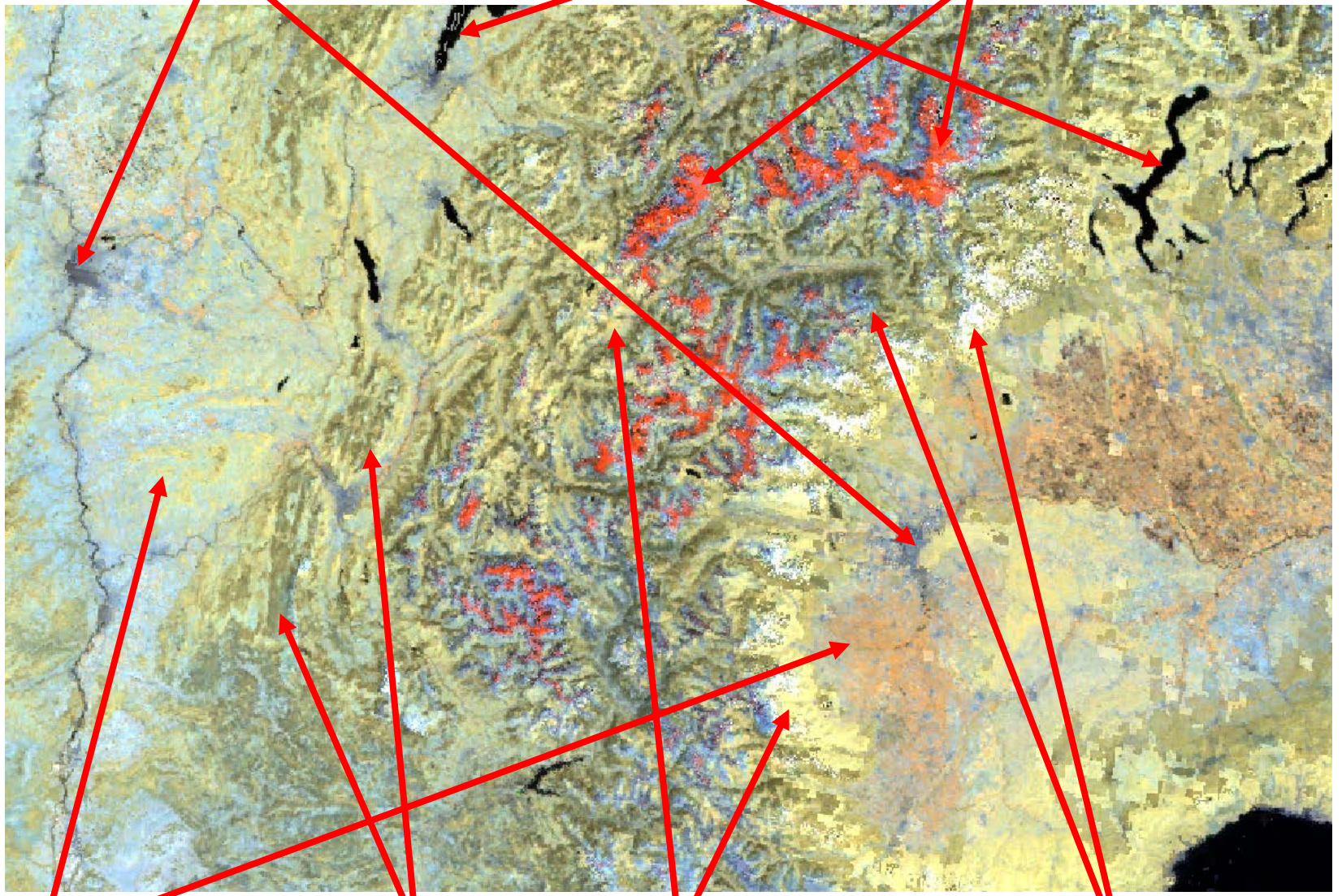






3. Change *Multiband colour* composition to see better differences among different land covers

Image interpretation



Global land cover map will help you in the interpretation https://esa-worldcover.org/en

Checking vegetation indices for different land cover and their interpretation

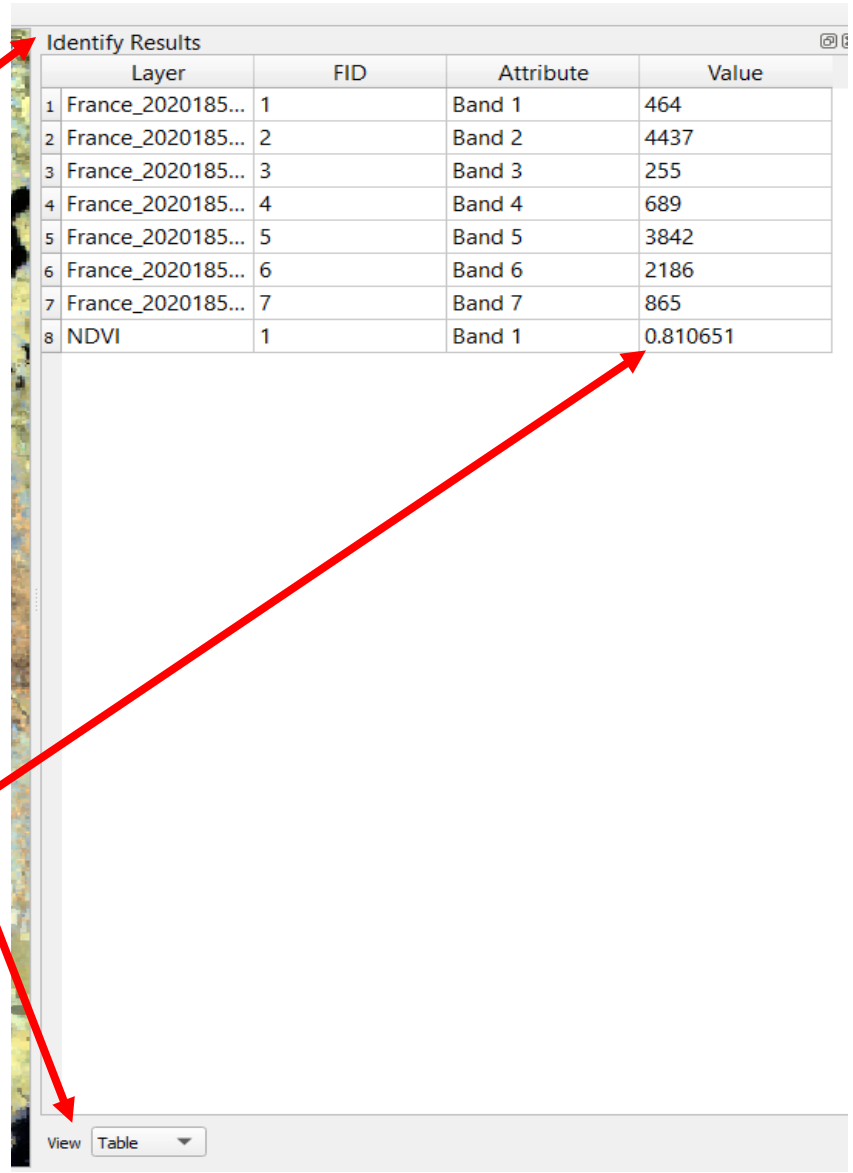
4. Choose *Feature Identification* tool and click on the image 

Identification Results window will appear and Values of all layers

5. Change *View* to *Table*

6. Click on different types of land cover and check NDVI values

7. Elaborate table with NDVI for different land cover discuss and draw conclusions about photosynthesis activity, where is the most/less intensive and why.



Instruction – part 2.
Analysis of changes in photosynthesis cycle from 2000 to 2020 in different regions

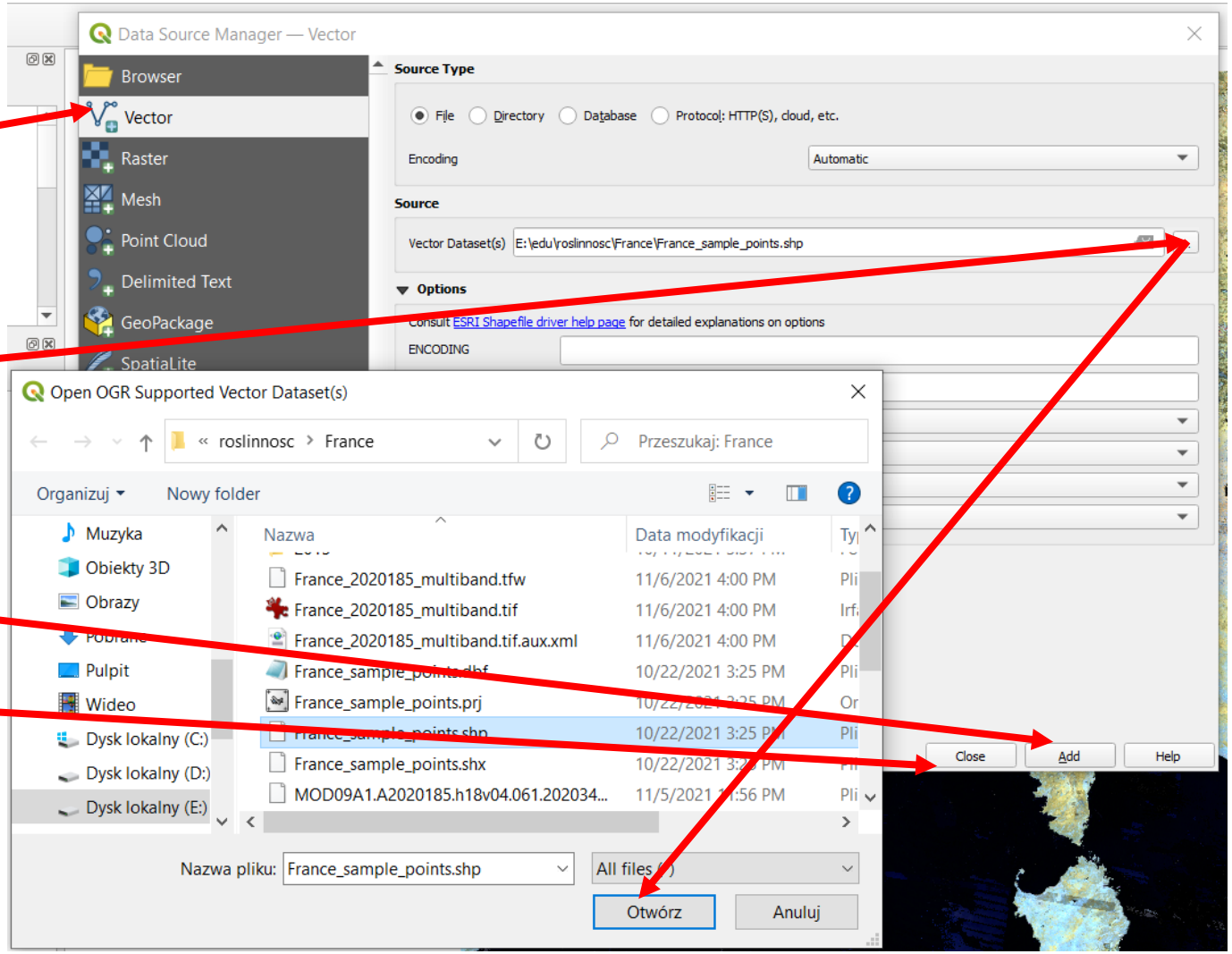
1. Load sample points using *Open data source manager*

2. Select *vector*

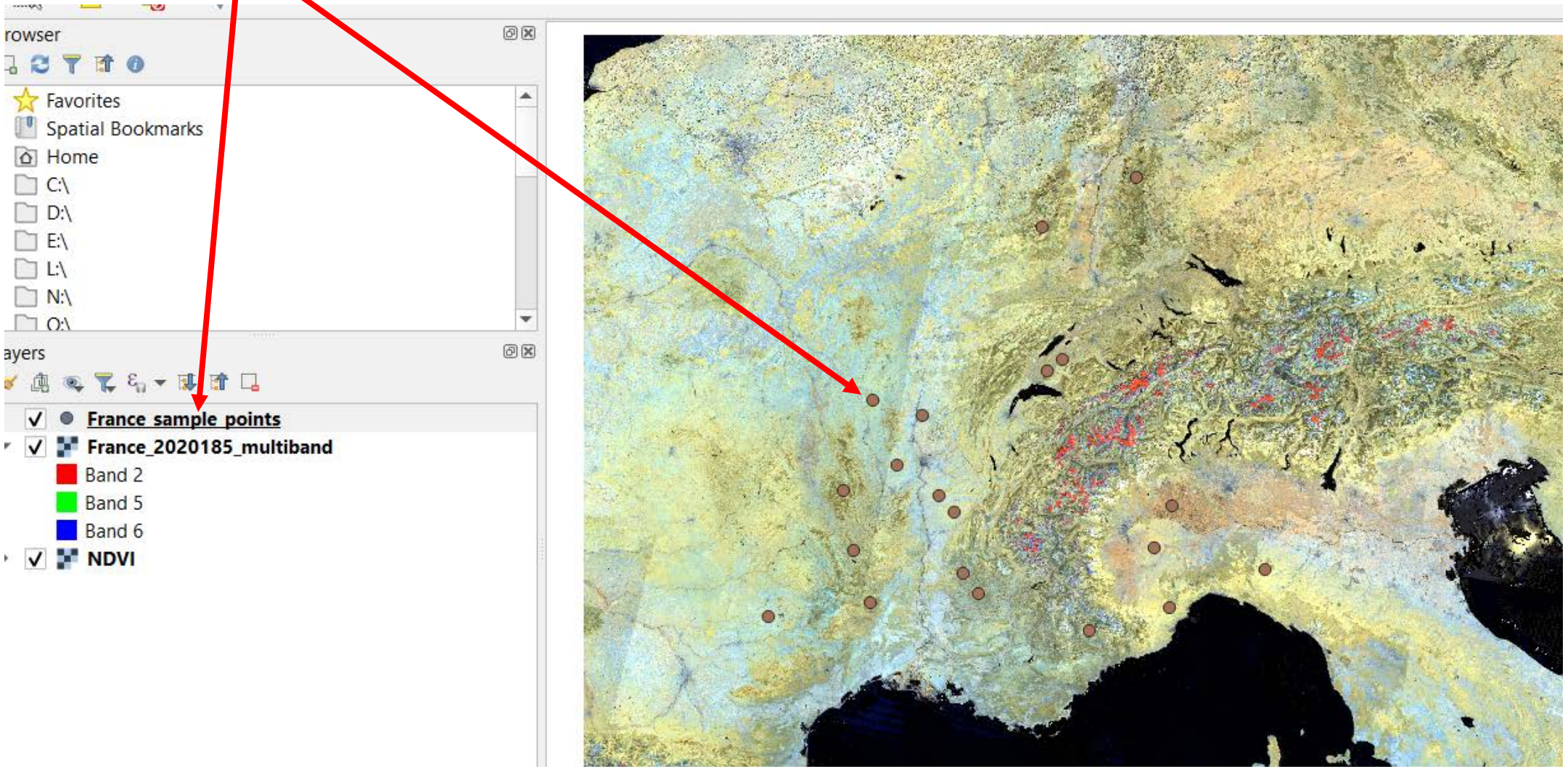
3. Select ***region_sample_points.shp*** file

4. Add

5. Close

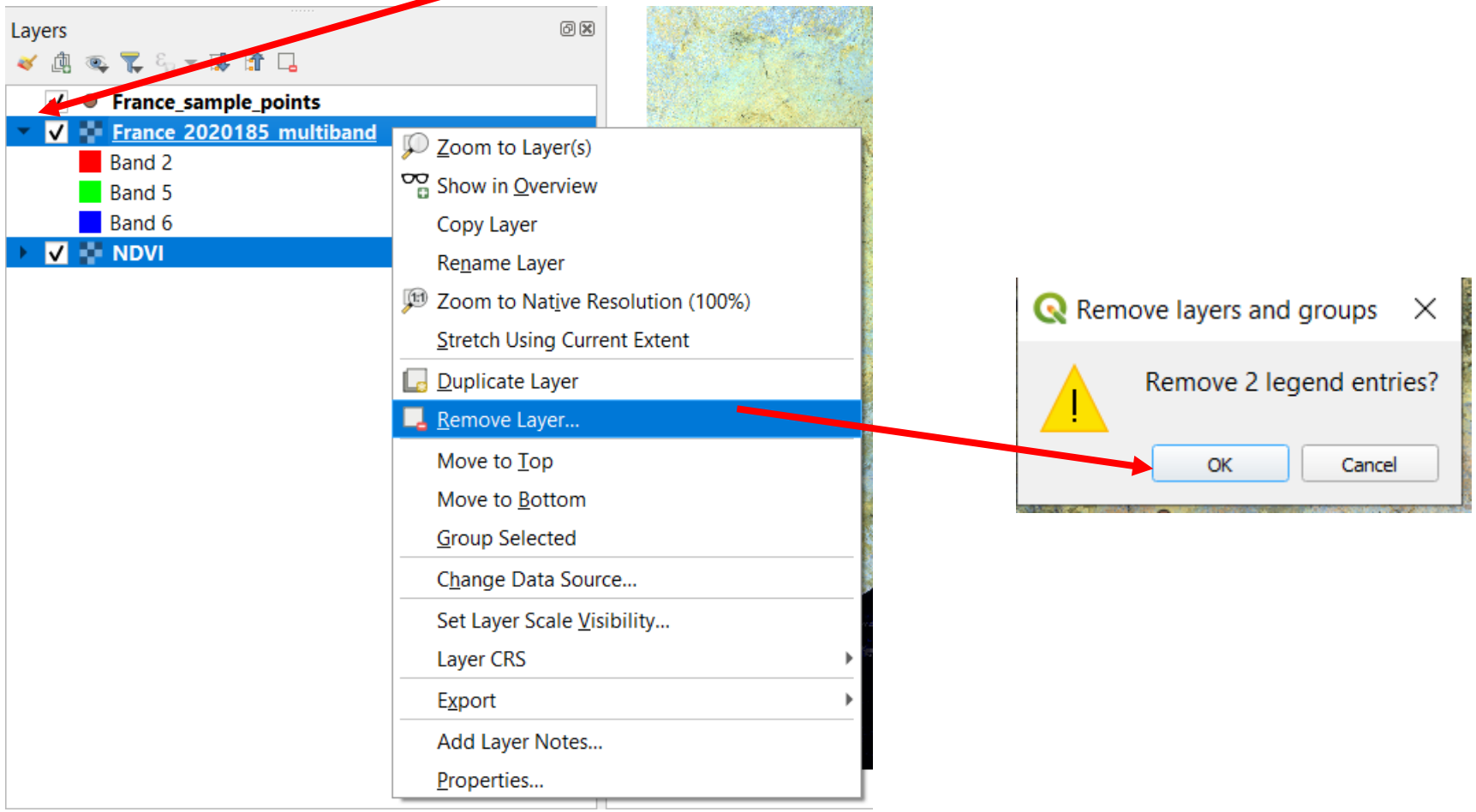


New layer will appear

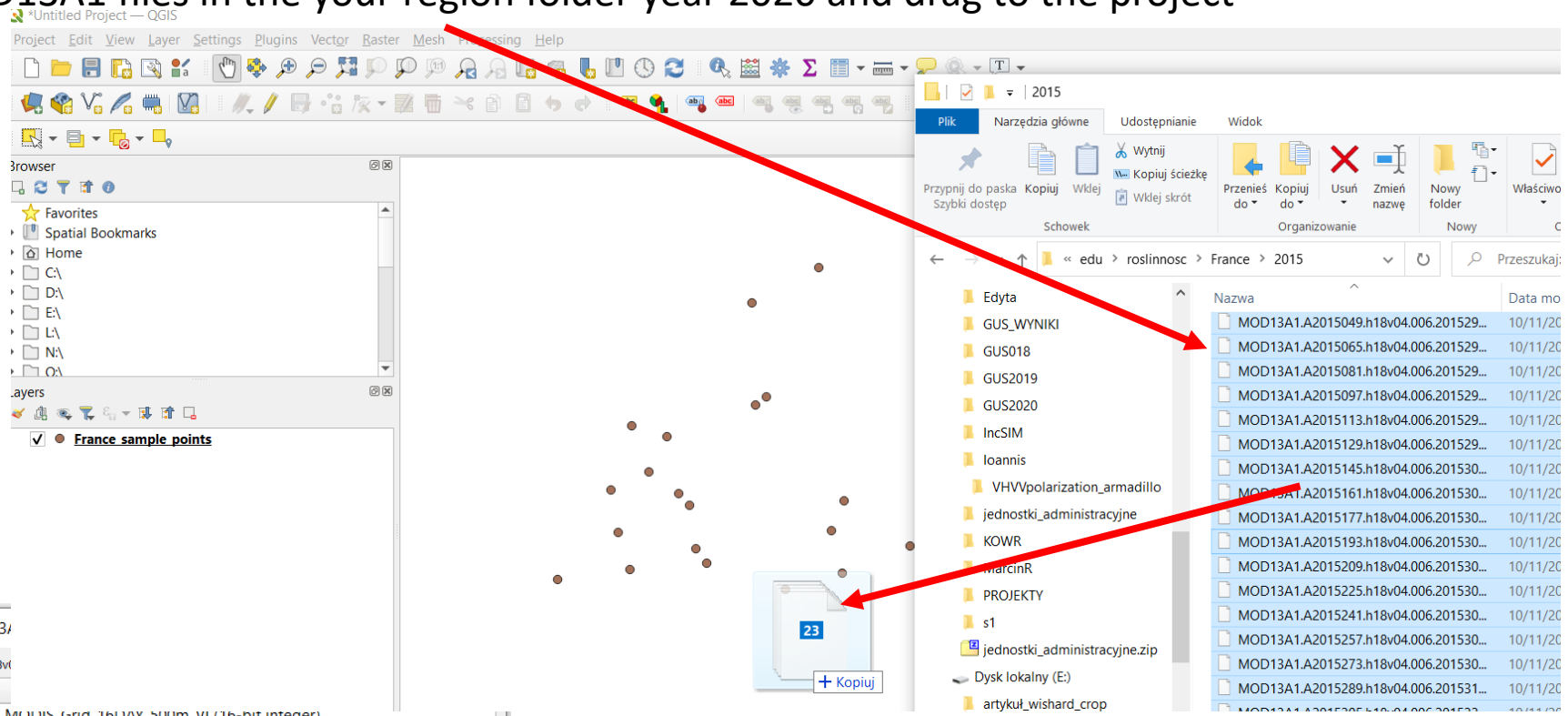


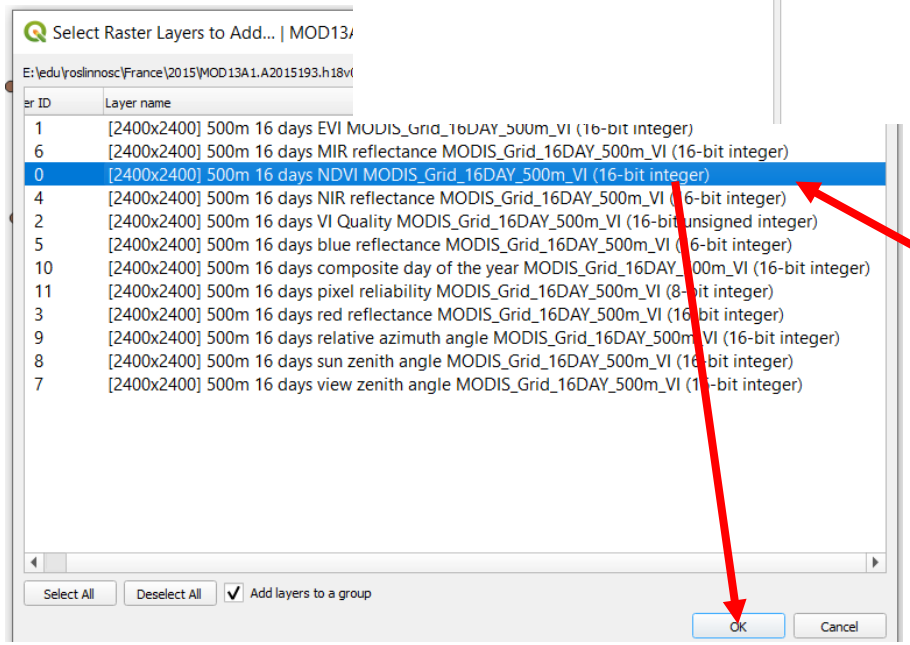
Extraction of NDVI values within growing season

6. Remove all the layers except region_sample_points .shp. Select layers clicking on them and pressing ***Crtl***. Press right button of the mouse and select *Remove Later …* from the list



7. Select all MOD13A1 files in the your region folder year 2020 and drag to the project



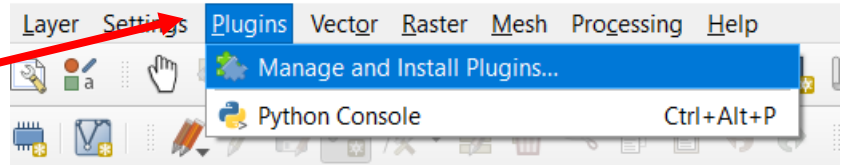


8. Select only NDVI layer (number 0)

Repeat until all images are loaded

Preparation of tool for the automatic extraction of values from layers to point

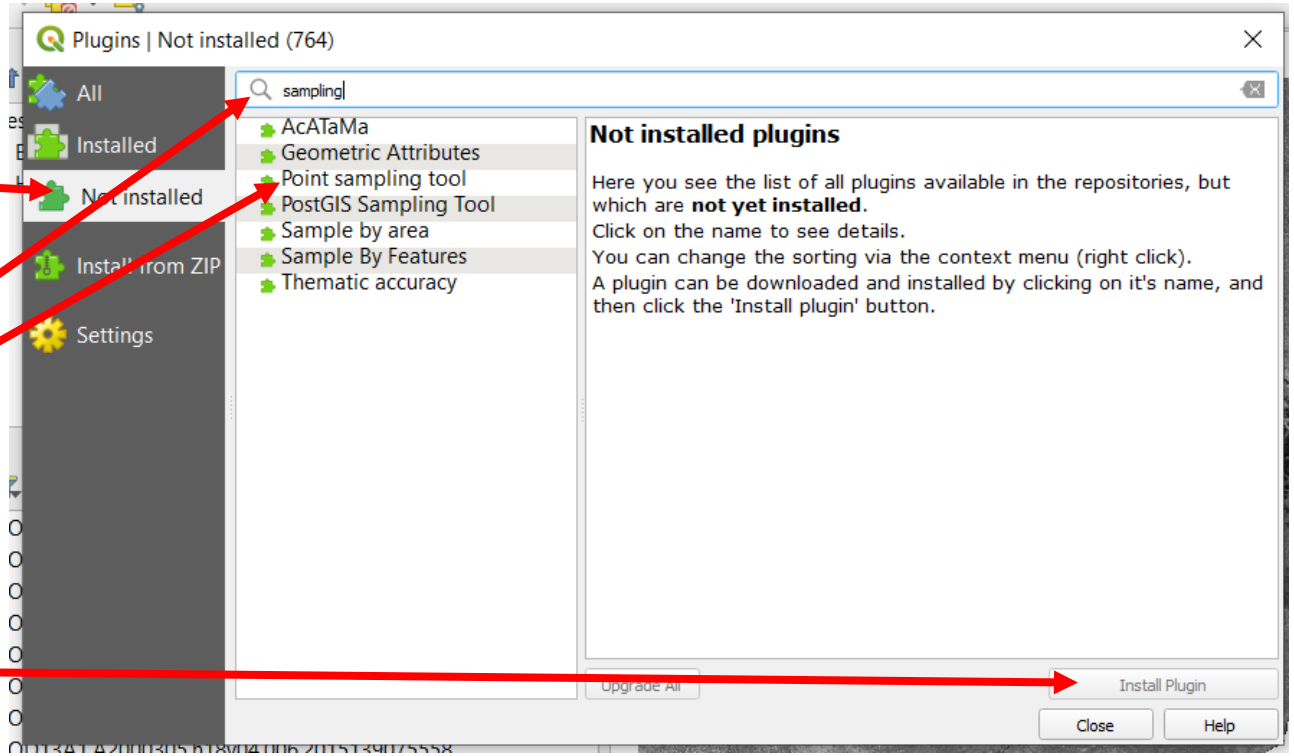
9. Go to *Plugins -> Manage and Install Plugins*



10. Go to *Not Installed* plugins

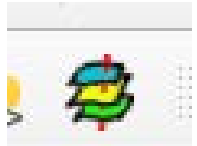
11. Write ***sampling*** in the search window

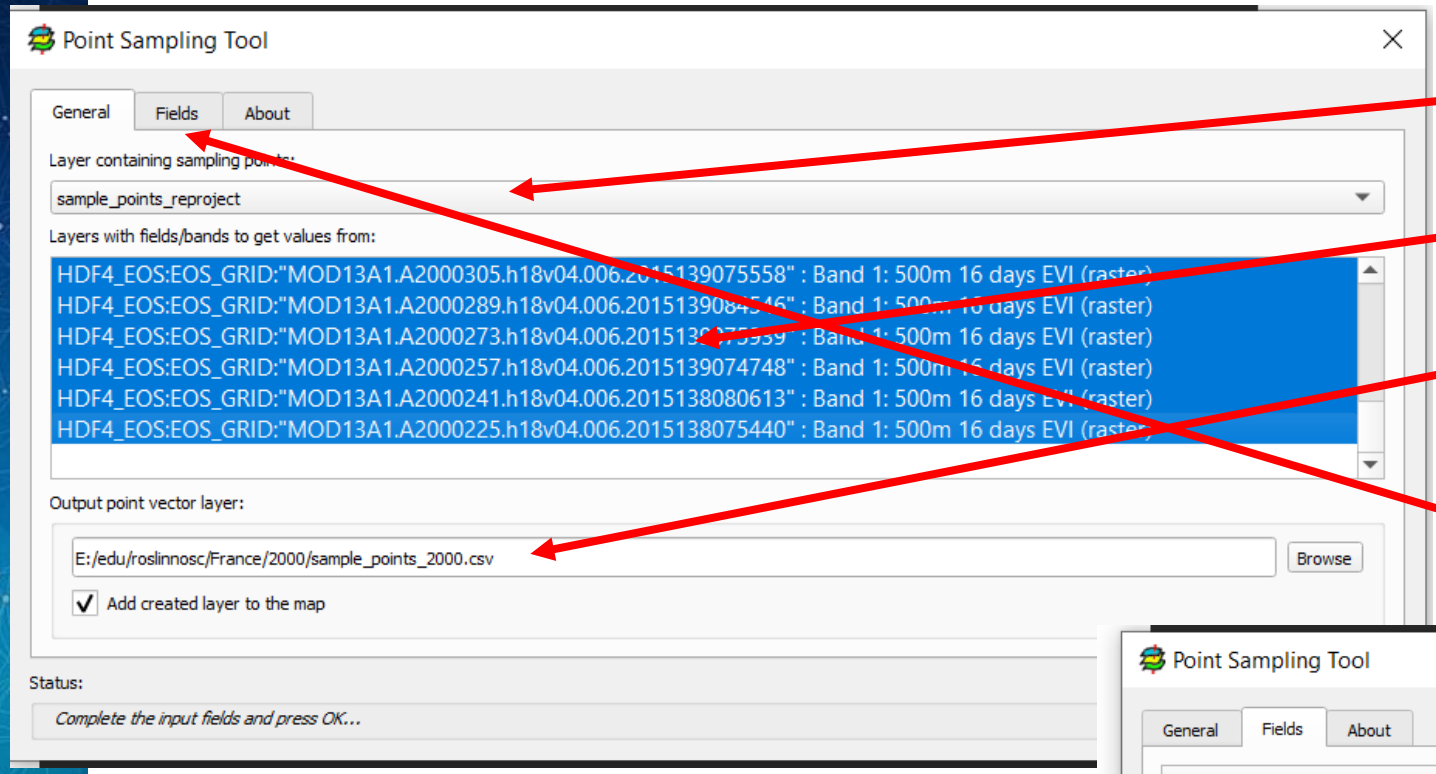
12. Choose *Point sampling tool*



13. Install plugin

New icon will appear 14. Press it to open the tool window



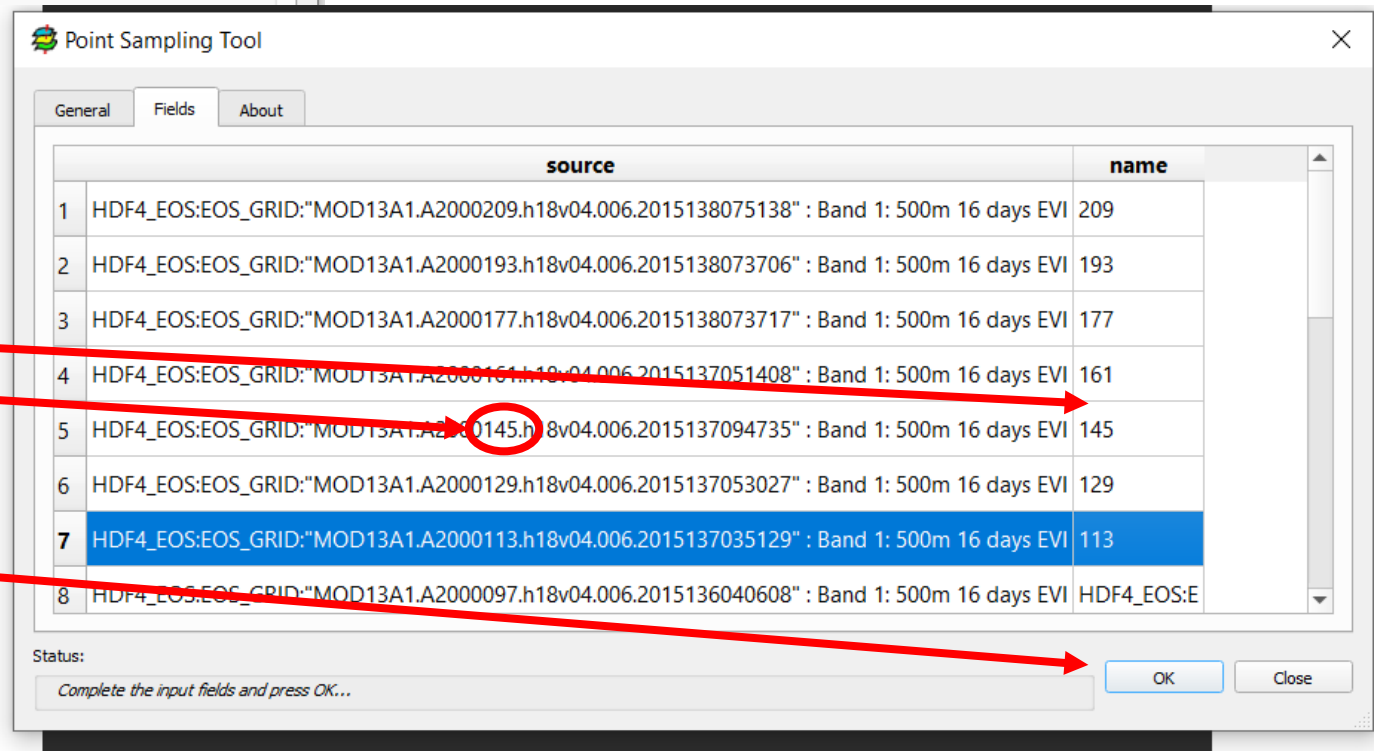


15. Select point layer

16. Using Shift and mouse select all layers

17. Set output layer name, select csv format

18. Go to *fields* tab



19. Change the names of the fields from default to the number of the day of the year (last 3 digits before ***.h***)

20. Press *OK*.

The file .csv will de obtained

21. Close QGIS

Statistical analysis of NDVI values within growing season

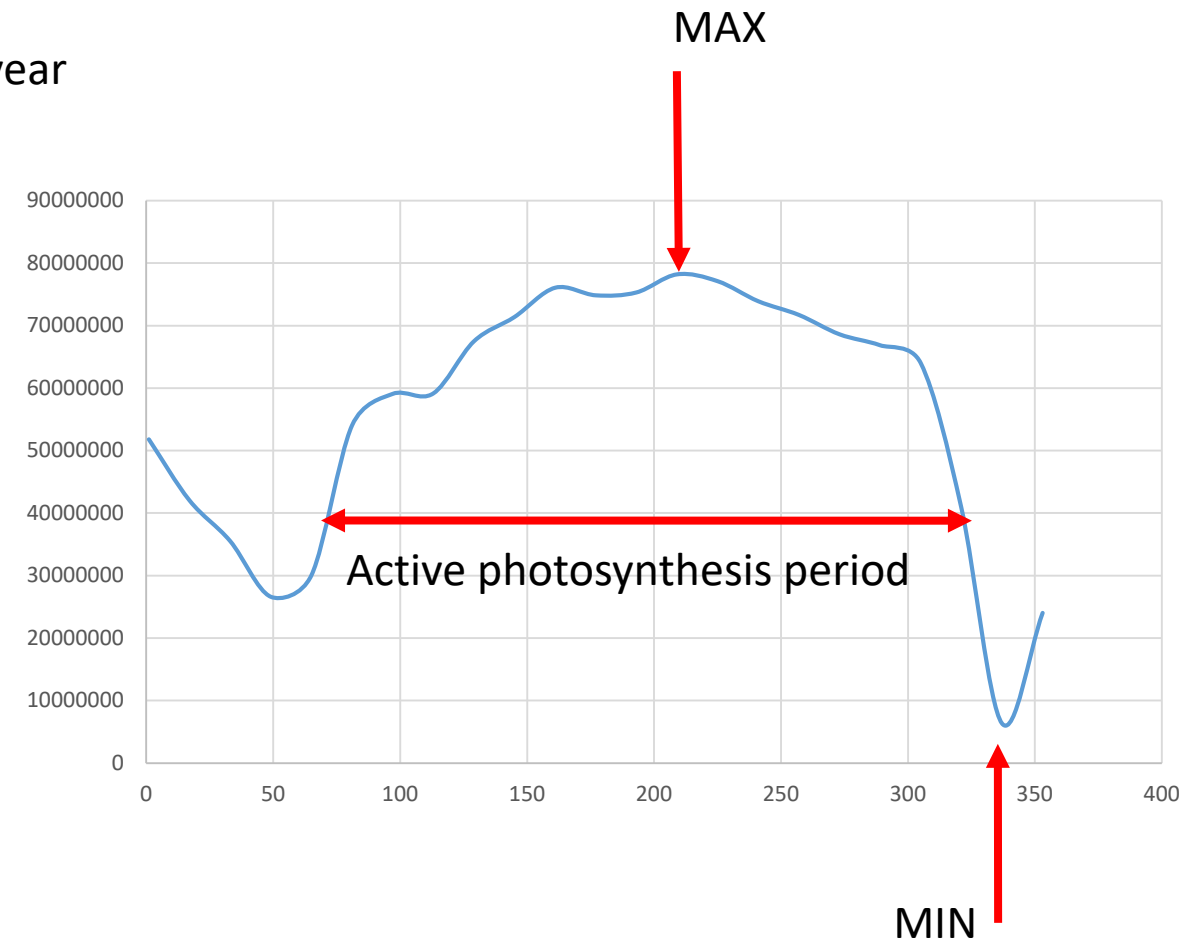
1. Open .csv file in excel

2. Order columns from the first to the last day of the year

3. Calculate mean value per day

4. Create a graph of changes of NDVI values during the year, find maximum and minimum values and when they take place, calculate numbers of day with NDVI > 0,4

5. Compare it for all years for your region



Discussion and conclusions

- Individual groups present their conclusions regarding the changes in vegetation in the region in the period 2000 – 2020.
- They will discuss how different if growing season within areas
- If there are regional trends of changes? If yes, if they are similar for all regions?
- What factors influence in they opinion of changes
- What should be done to ensure that the concussions are correct?
- etc.