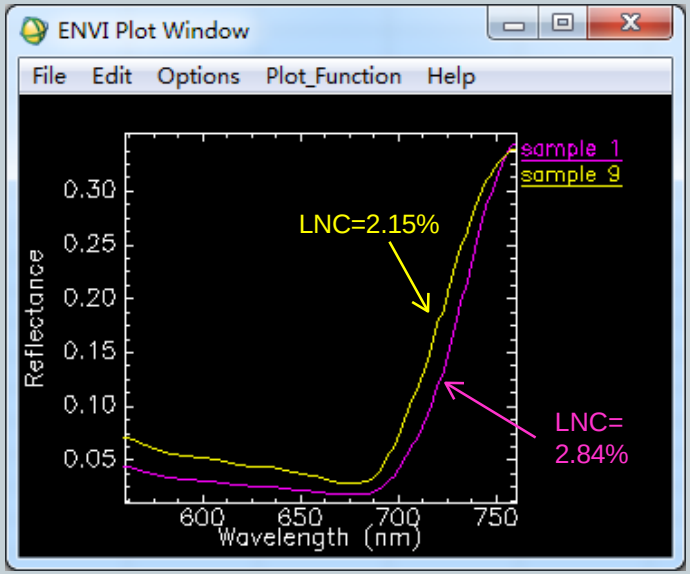
Instructor: Prof. Tao Cheng (tcheng@njau.edu.cn), Nanjing Agricultural University.

Lab 3: Spectral Analysis



December 24, 2023

Outline

- Transfer raw data from ViewSpec to ENVI
  - Export data using ViewSpec
  - Display data using ENVI

- Plot function
  - Open plot window
  - Set up plotting parameters
  - Set up data parameters
  - Save data as ENVI spectral library

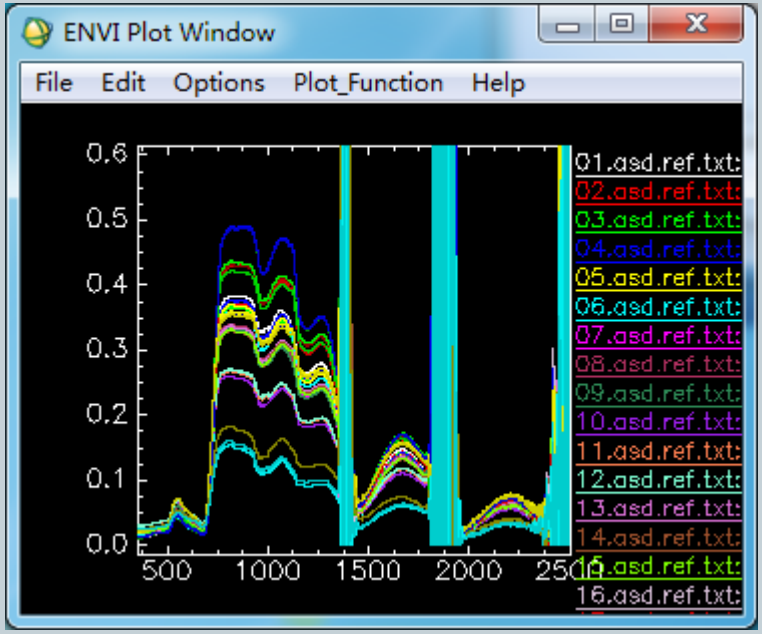
- Spectral math
- Calculation of Spectral indices
- Continuum removal analysis
- Lab project:
  - *Estimation of rice leaf nitrogen content from canopy reflectance spectra*

Example data

- Start with ASD data
  - Binary format
  - *.asd or *.asd.ref files

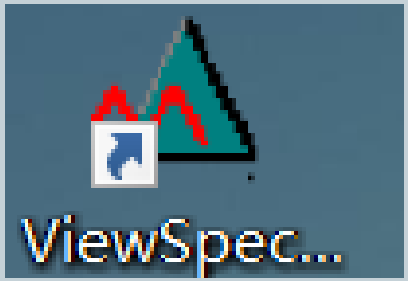
ASD FieldSpec 4

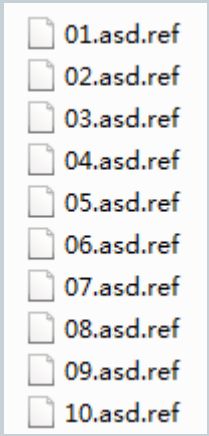
- ASD reflectance spectra
  - Corresponding to 10 samples (10 values of leaf nitrogen content)
  - Three spectra per sample



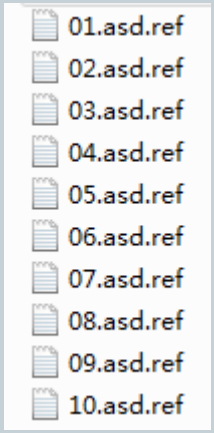
ASCII Export using ViewSpec Pro

- Start *ViewSpec Pro* Version 6.0
- Go to *Setup->Output directory*
- Go to *File->Open* and select the ASD spectra files (*.asd)
- Go to View->Graph data to browse the spectral data
- Go to *Process->ASCII Export*, choose *Reflectance* if that's the data you have collected. Select *Print Header Information* as that will give you really useful information on the instrument. Then click *OK* to proceed.





Input files

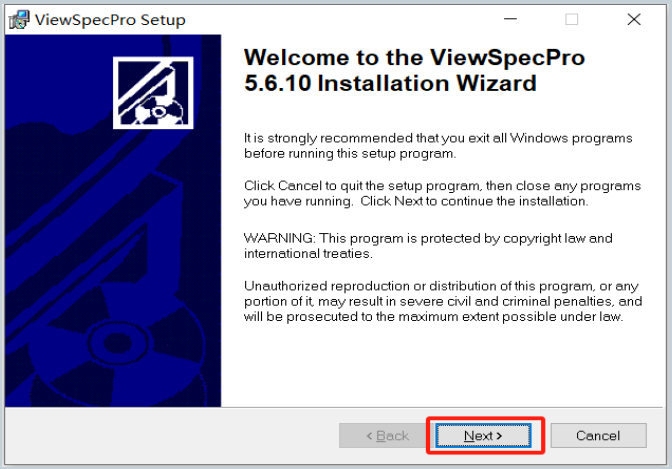


Output files

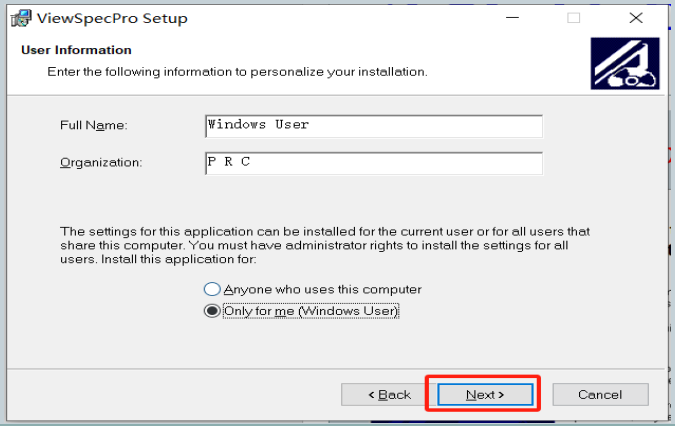
ASCII Export using ViewSpec Pro

1. Install *ViewSpec Pro* Version 6.0

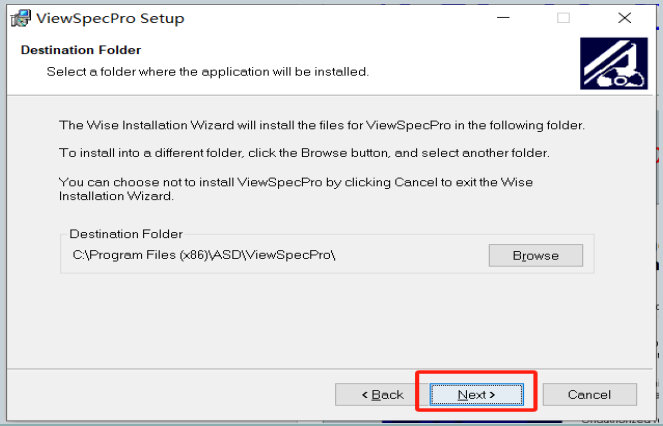
1



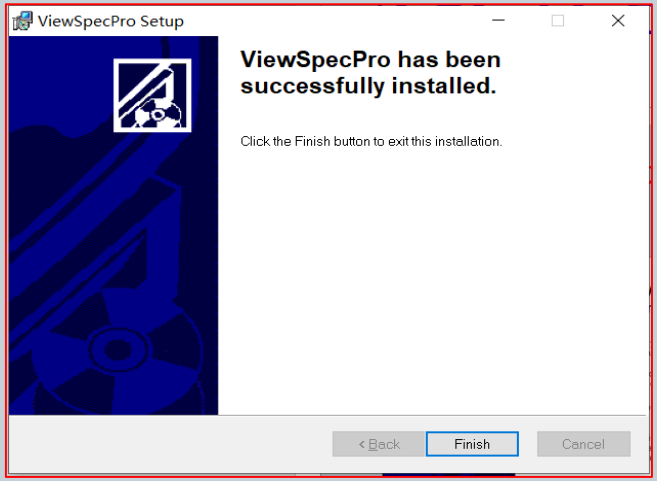
2



3

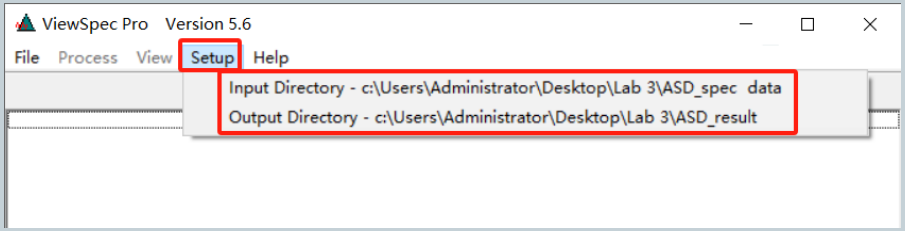


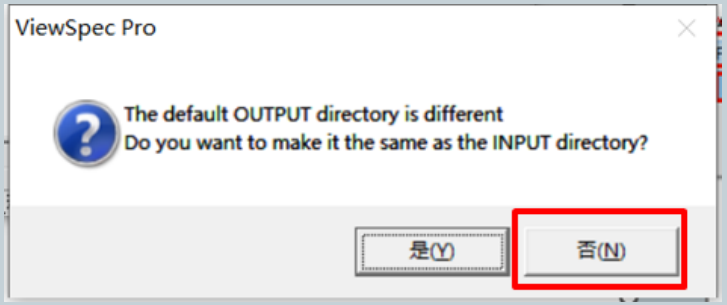
4



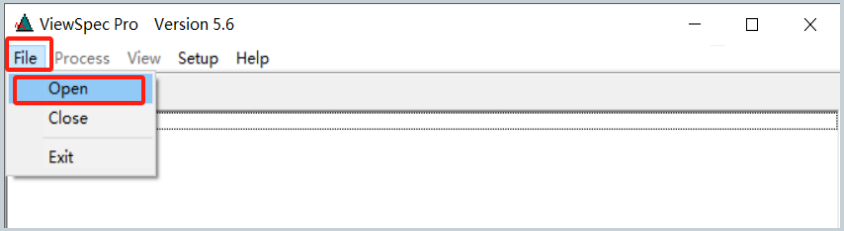
ASCII Export using ViewSpec Pro

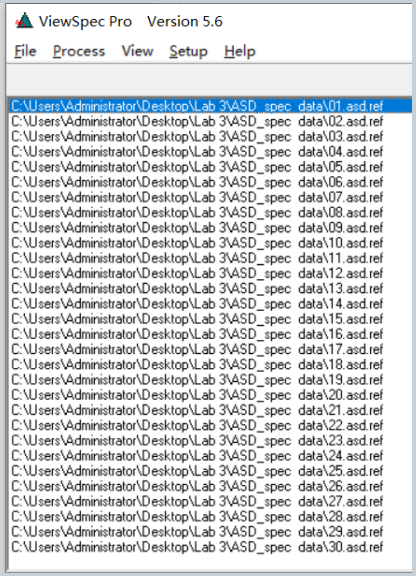
2. Go to *Setup->Output directory*





3. Go to *File->Open* and select the ASD spectra files (*.asd)

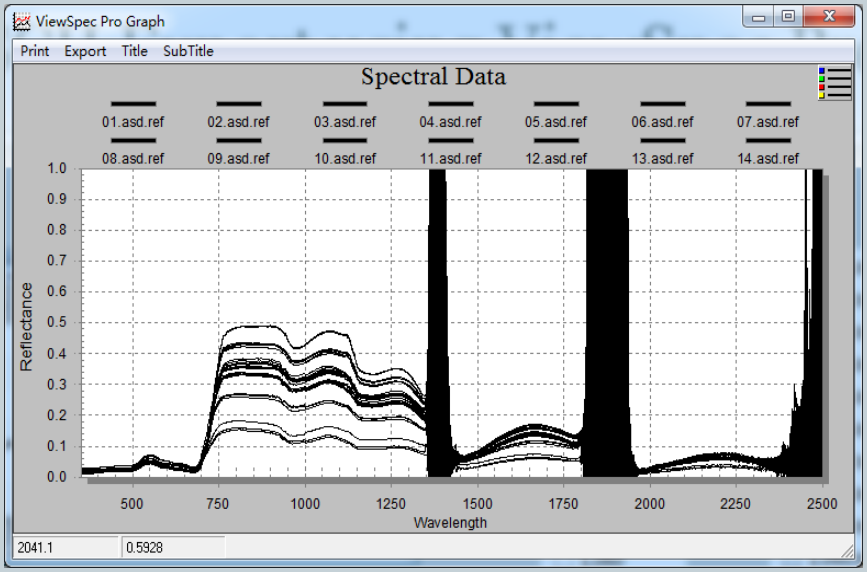




display

ASCII Export using ViewSpec Pro

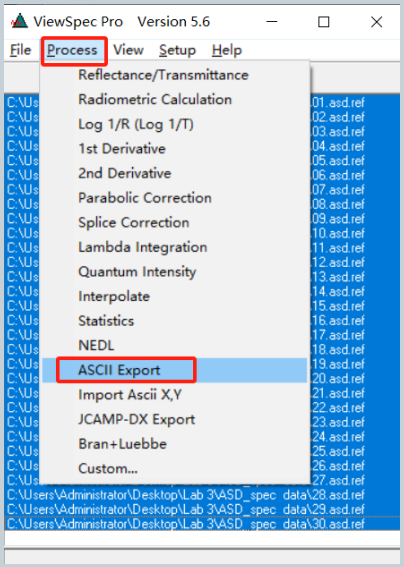
4. Go to View->Graph data to browse the spectral data

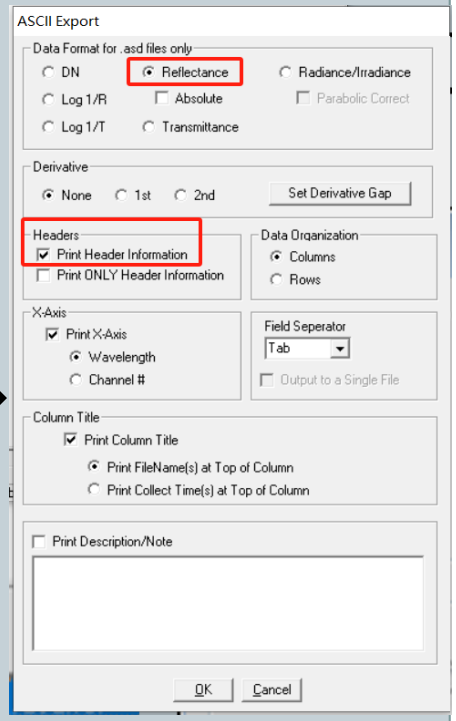


Spectra displayed in ViewSpec Pro

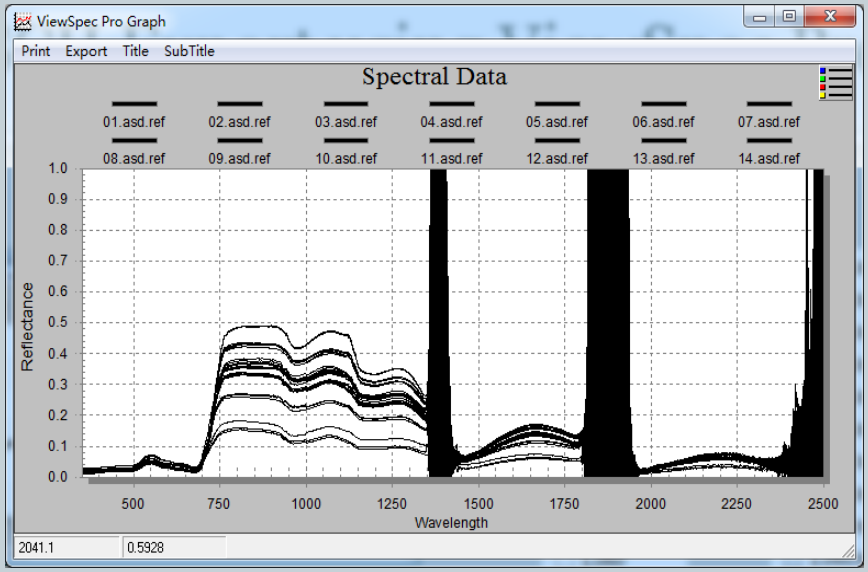
5. Go to *Process->ASCII Export*, choose *Reflectance* if that's the data you have collected.

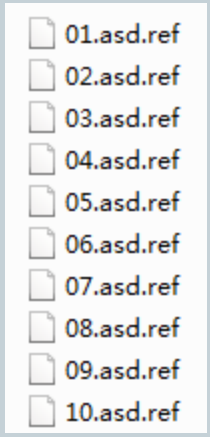
Select *Print Header*-> click *OK* to proceed.



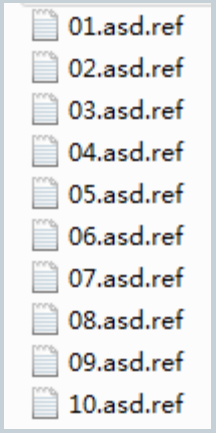


ASCII Export using ViewSpec Pro





Input files



Output files

ViewSpec Pro is only used for exporting ASCII files.
We use ENVI for spectral analysis!

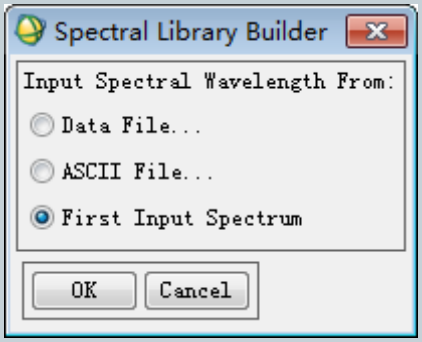
Working with your spectra in ENVI

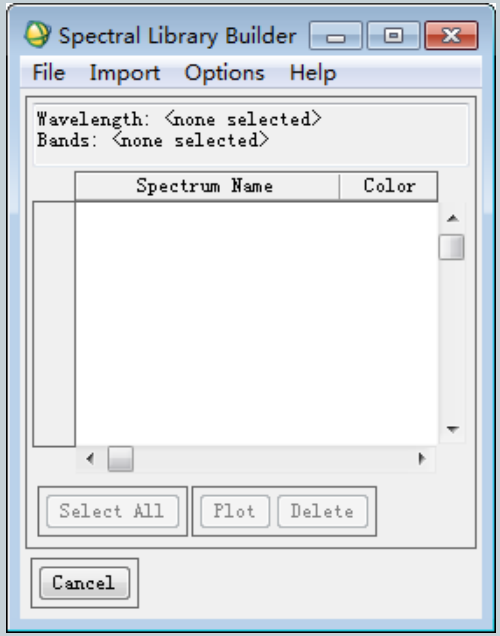
Now your data are ready for spectral analysis in ENVI!

- Import ASCII files in ENVI
- Save and open the spectra
- Configure plot and data parameters
- Mask bad bands
- Derive mean spectra
- Perform continuum removal analysis
- Calculate spectral indices

Import ASCII files in ENVI

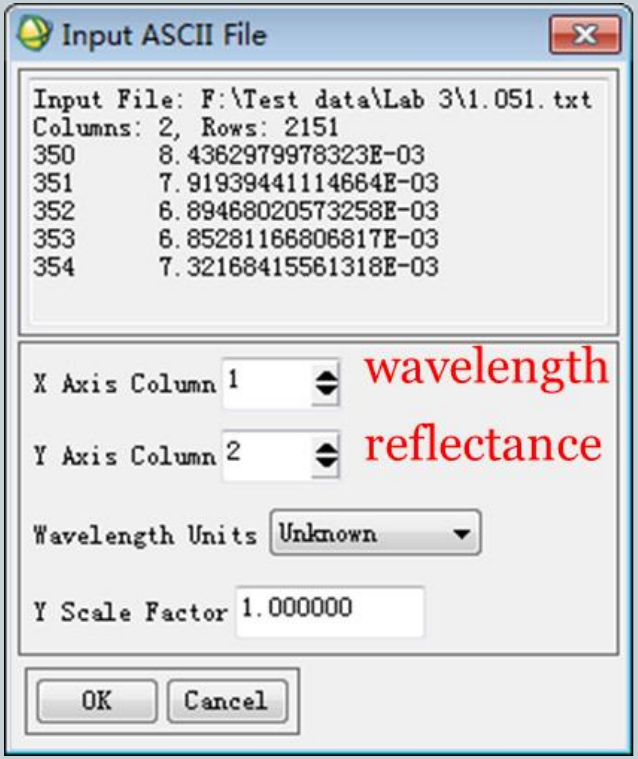
- Start *ENVI*
- Go to *main Menu* -> *Spectral* -> *Spectral Libraries* -> *Spectral Library Builder*, choose *First Input Spectrum* to proceed. Click OK.
- In the *Spectral Library Builder* window, go to Import -> *from ASCII file…* and select all the text files you want to analyze.



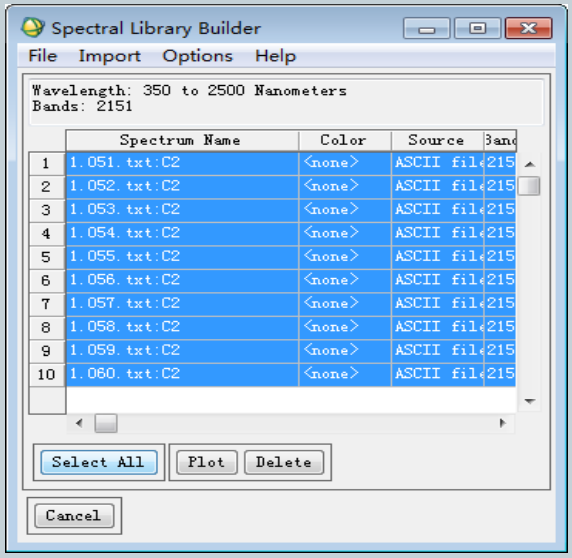


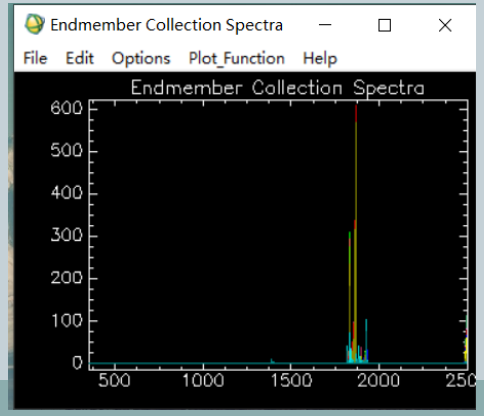
Input ASCII File

- In the dialog *Input ASCII File*, check the text files that are being read by ENVI. Click OK.



- **Select all** and click *Plot*

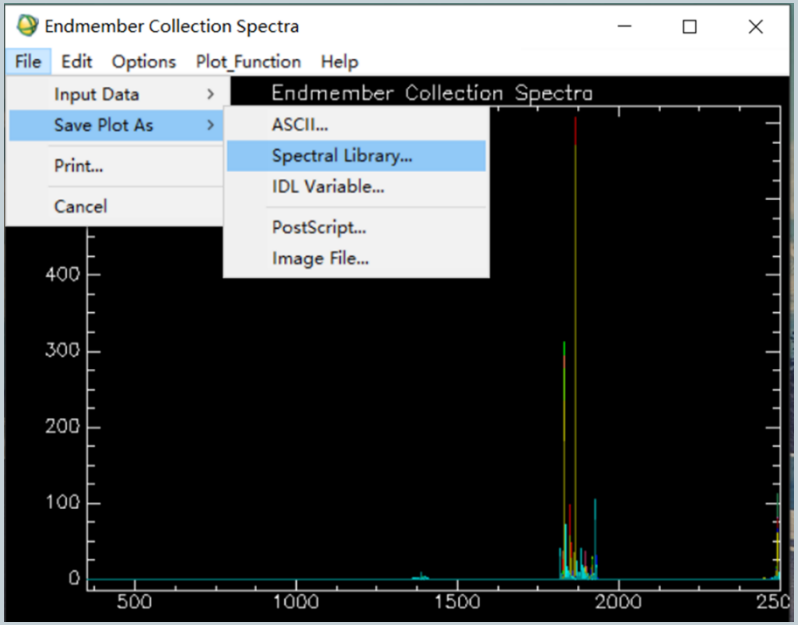


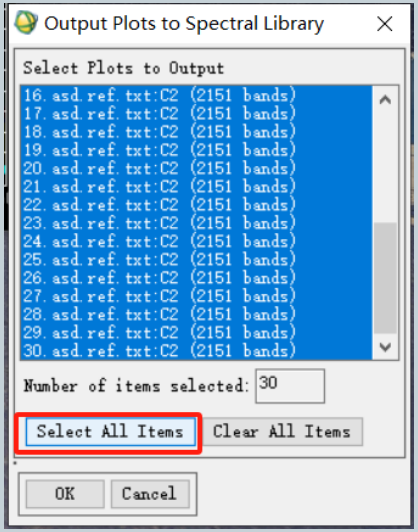


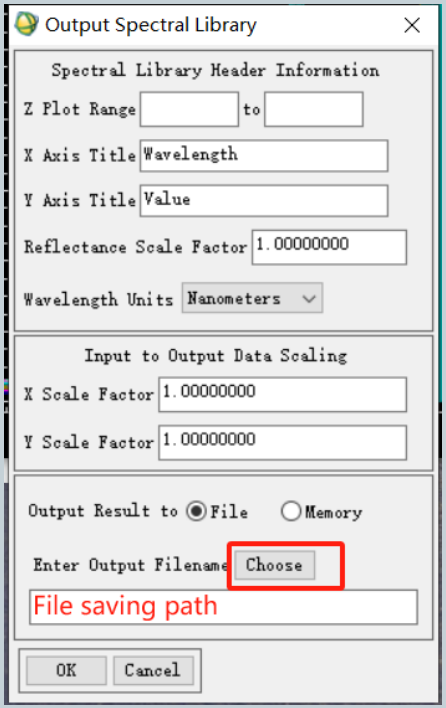
Save your spectra

Endmember Collection Spectra interface:

- File-> Save Plot as-> *Spectral Library*.

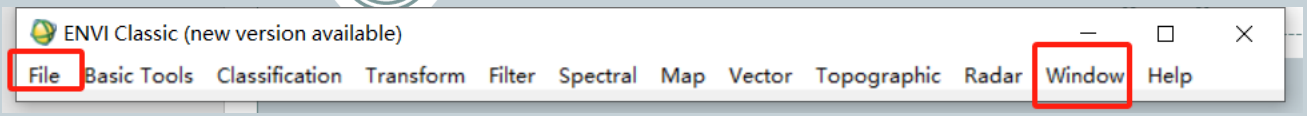




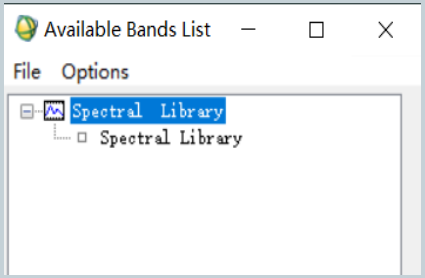


Then you can reload the spectra easily in ENVI.

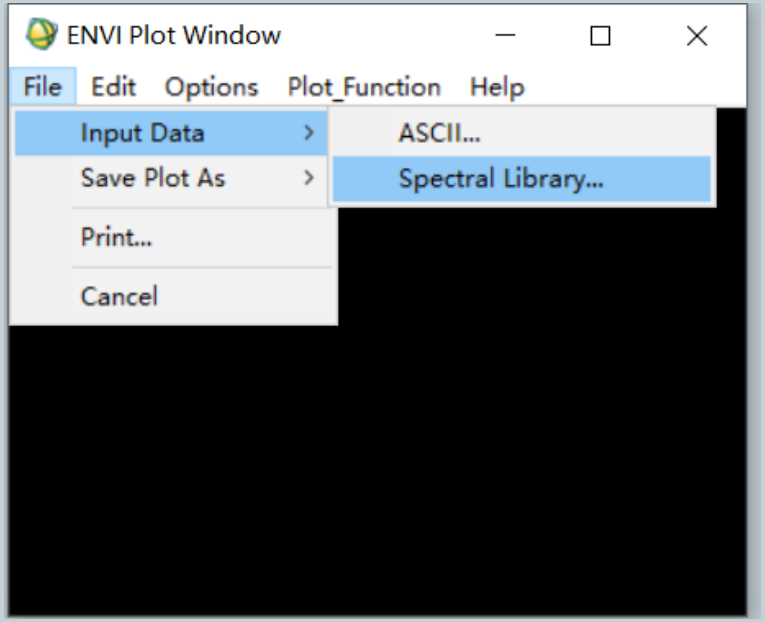
Open your spectra



- ENVI main menu: File-> Open Image File.



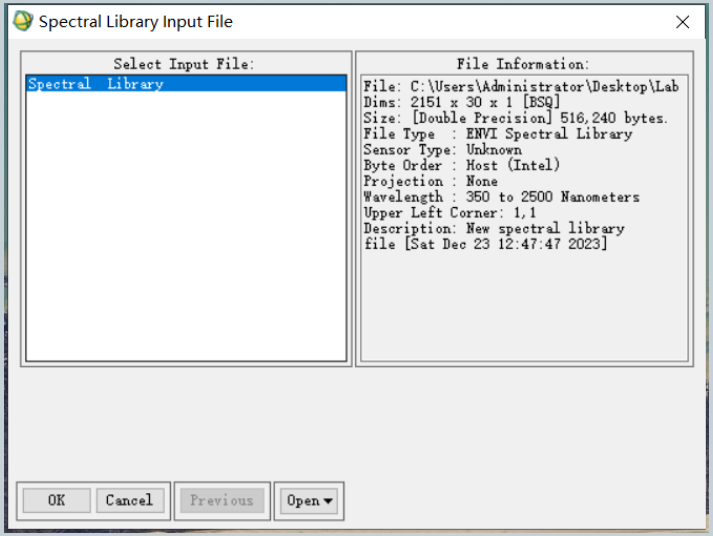
- ENVI main menu: Window-> Start New Plot Window

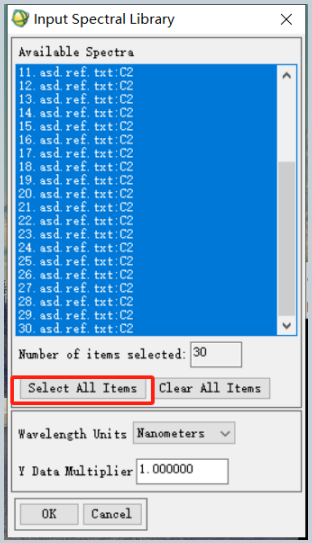


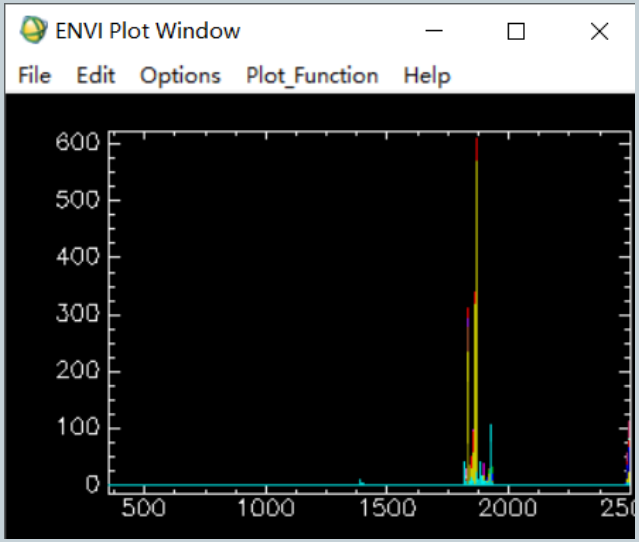
- In the 'ENVI Plot Window' interface:
  File->Input Data-> Spectral Library

Open your spectra

- In the ‘Spectral Library Input File’ interface, select your file.
- In the ‘Input Spectral Library’ interface, select all items and Click ‘OK’ button.



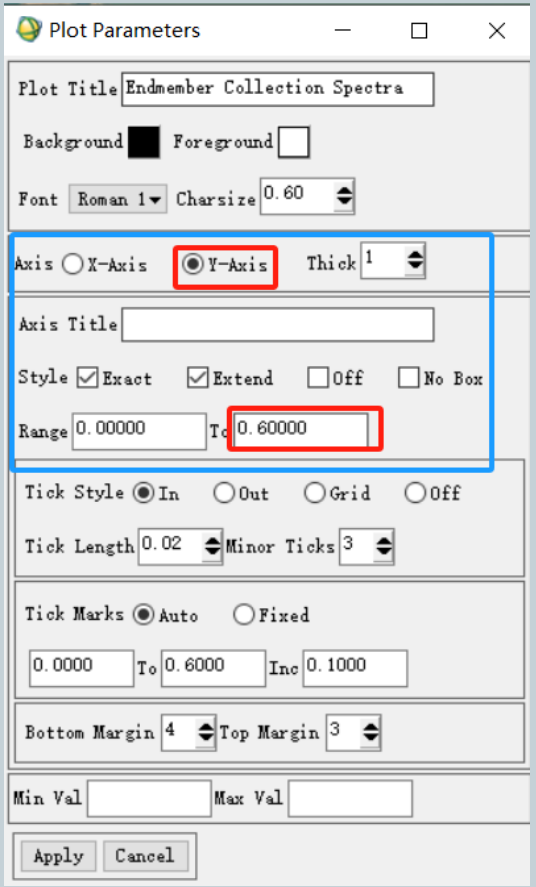




Configure plot parameters

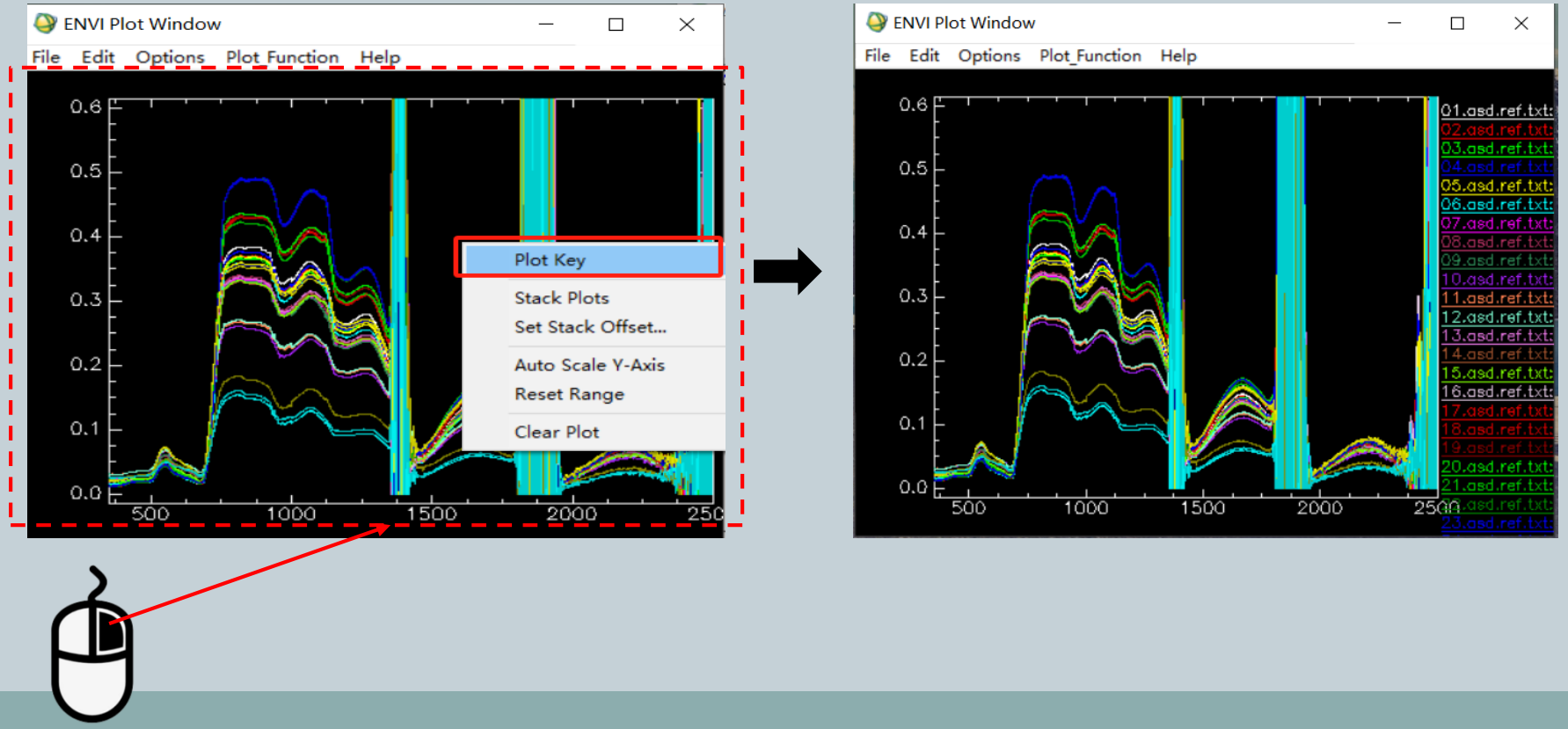
'ENVI Plot Window' interface: Edit-> Plot parameters

- Plot Title
- Axis Title
- Range (**y**range = 0-0.6
  xrange = 350-2500 nm)
- Left Margin, Right Margin
- Note: plot parameters **will not be saved** to the *spectral library* file. You will have to set them up again when you reload the spectra next time.



Display spectrum names

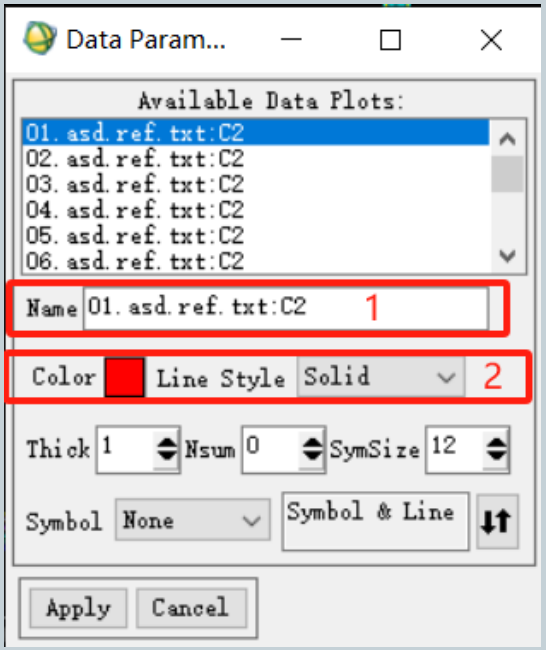
- **Right click** in the 'ENVI Plot Window' interface and select Plot Key to display spectrum names.



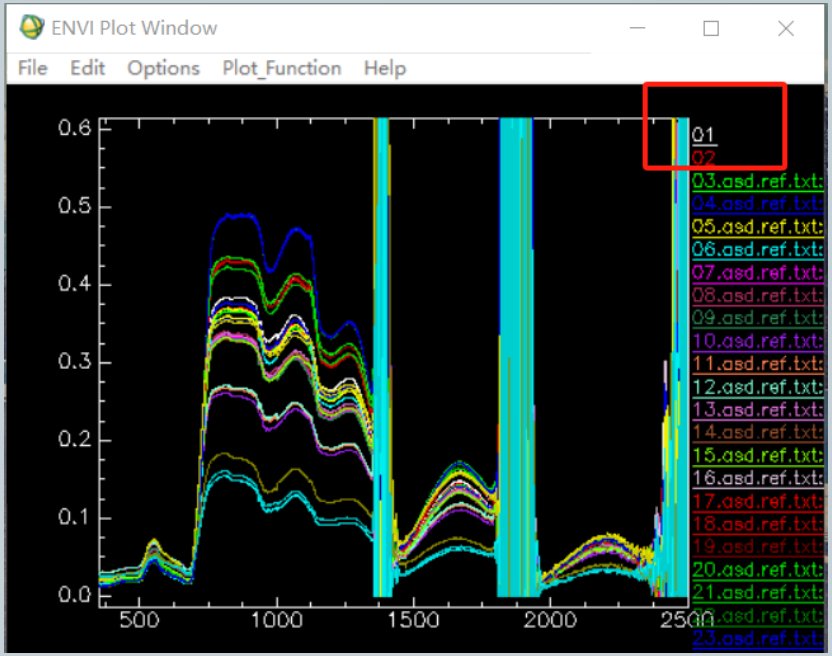
Configure data parameters

'ENVI Plot Window' interface: Edit-> Plot parameters

- Change spectrum names



- Change spectrum color and style.



Note: only name changes could be saved in the spectral library file. But name changes do not save automatically in the spectral library file**!**

Mask bad bands

- **Method 1:** Manually set up the Bad Bands Lists to mask them out
- **Method 2:** Edit spectral library file's Header file (recommended)

Noisy wavelength range: corresponding band range

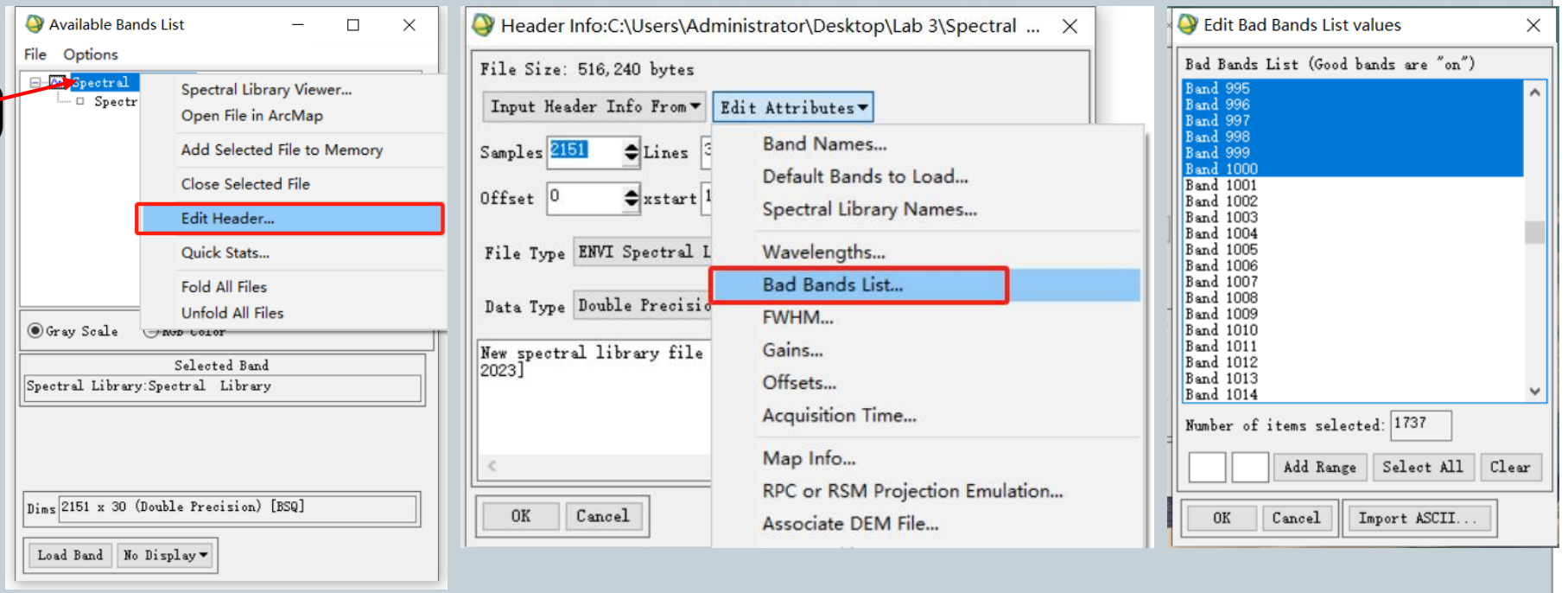
Range 1
Wavelength: 1350-1450 nm, Band: 1001-1101,
Range 2
Wavelength: 1800-1960 nm, Band: 1451-1611,
Range 3
Wavelength: 2350-2500 nm, Band: 2000-2151.

Mask bad bands

- **Method 1:** Manually set up the Bad Bands List
  - In the Available Bands list Window, right click the spectral library file.
  - Choose Edit Header … to bring up the Header Info Window.
  - Click Edit Attributes and select Bad Bands List…
  - Deselect Bad Bands: band 1001-1101,
  - Hold the Ctrl key and use the Shift key to deselect ranges.

Mask bad bands

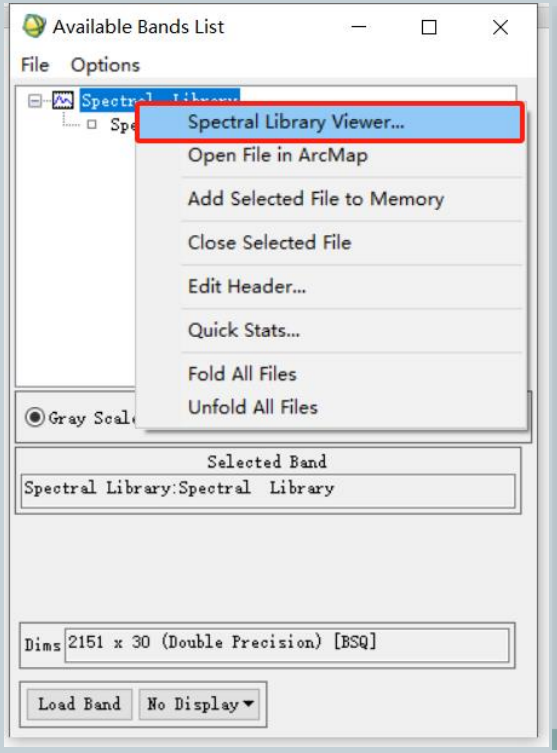
- **Method 1 :** Manually set up the Bad Bands List

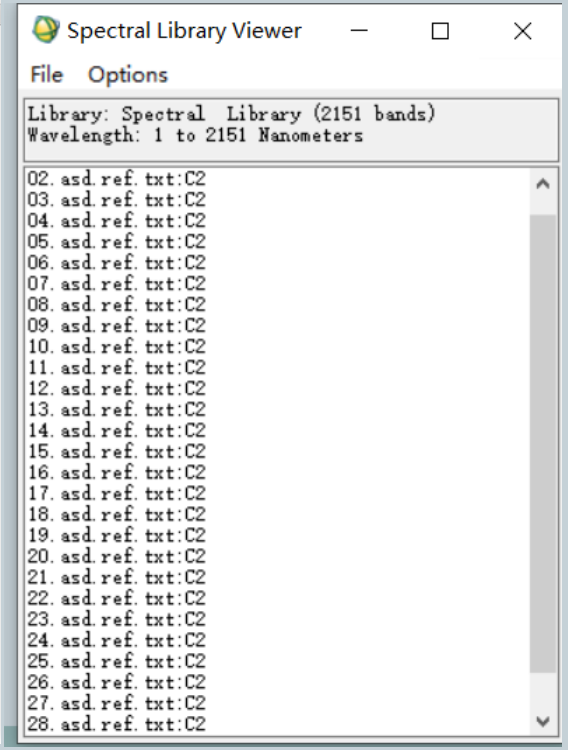


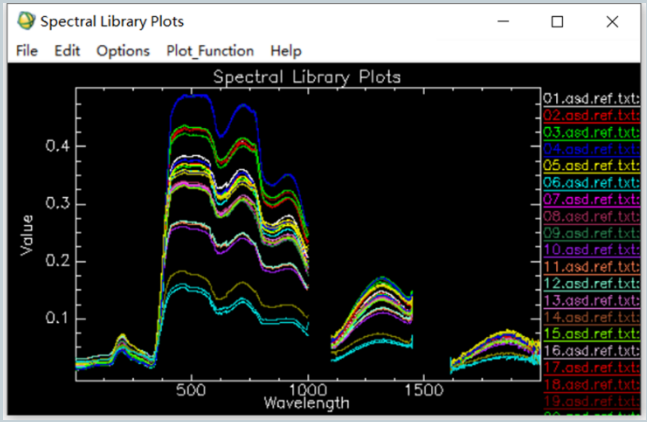
Note: Do not delete these bands in the source file. Just close bad bands for plot view!

Mask bad bands

- **Method 1:** Manually set up the Bad Bands List
- In the Available Bands list Window, right click the spectral library file-> Spectral Library Viewer.







Click and select one by one

Mask bad bands

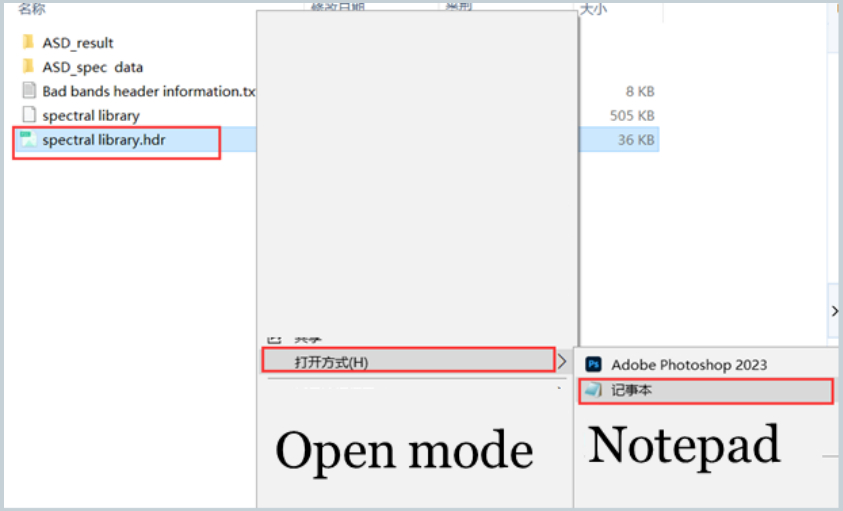
- **Method 2:** Edit spectral library file's Header file

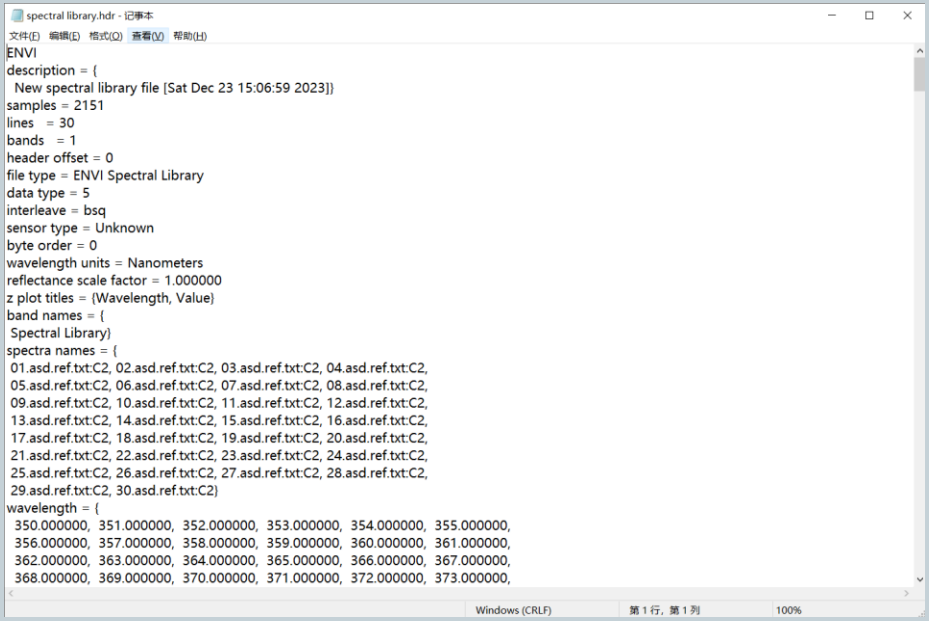
  - Step 1: Open the header file by Notepad
    - Close ENVI
    - Find your spectral library files
    - Select and Right Click the " **(your file name).hdr" file
    - Choose 'Open mode' and select 'Notepad'.

  - Step 2: Edit the header file
    - Add the bad bands information from the provided .txt file to the end of the header file
    - Save the .hdr file in Notepad, then close Notepad
    - Start ENVI and open your spectral library again!

Mask bad bands

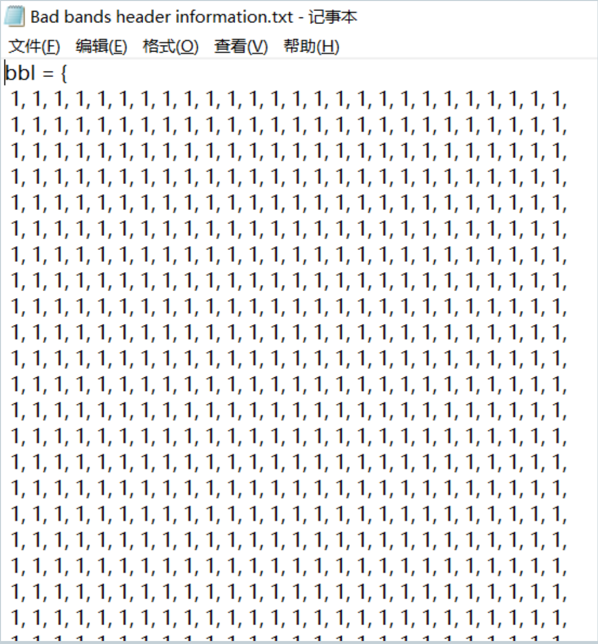
- **Method 2:** Edit spectral library file's Header file





Mask bad bands

- **Method 2:** Edit spectral library file's Header file



```
Bad bands header information.txt - 记事本
文件(F)  编辑(E)  格式(O)  查看(V)  帮助(H)
bbl = {
 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
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```

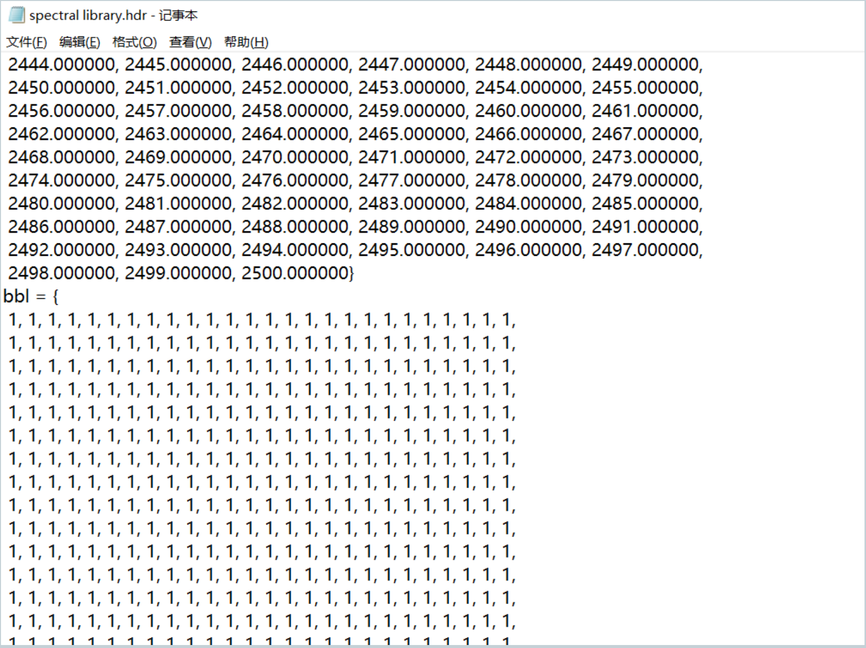

```
spectral library.hdr - 记事本
文件(F)  编辑(E)  格式(O)  查看(V)  帮助(H)
 2444.000000, 2445.000000, 2446.000000, 2447.000000, 2448.000000, 2449.000000,
 2450.000000, 2451.000000, 2452.000000, 2453.000000, 2454.000000, 2455.000000,
 2456.000000, 2457.000000, 2458.000000, 2459.000000, 2460.000000, 2461.000000,
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 2468.000000, 2469.000000, 2470.000000, 2471.000000, 2472.000000, 2473.000000,
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 2486.000000, 2487.000000, 2488.000000, 2489.000000, 2490.000000, 2491.000000,
 2492.000000, 2493.000000, 2494.000000, 2495.000000, 2496.000000, 2497.000000,
 2498.000000, 2499.000000, 2500.000000}
bbl = {
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```
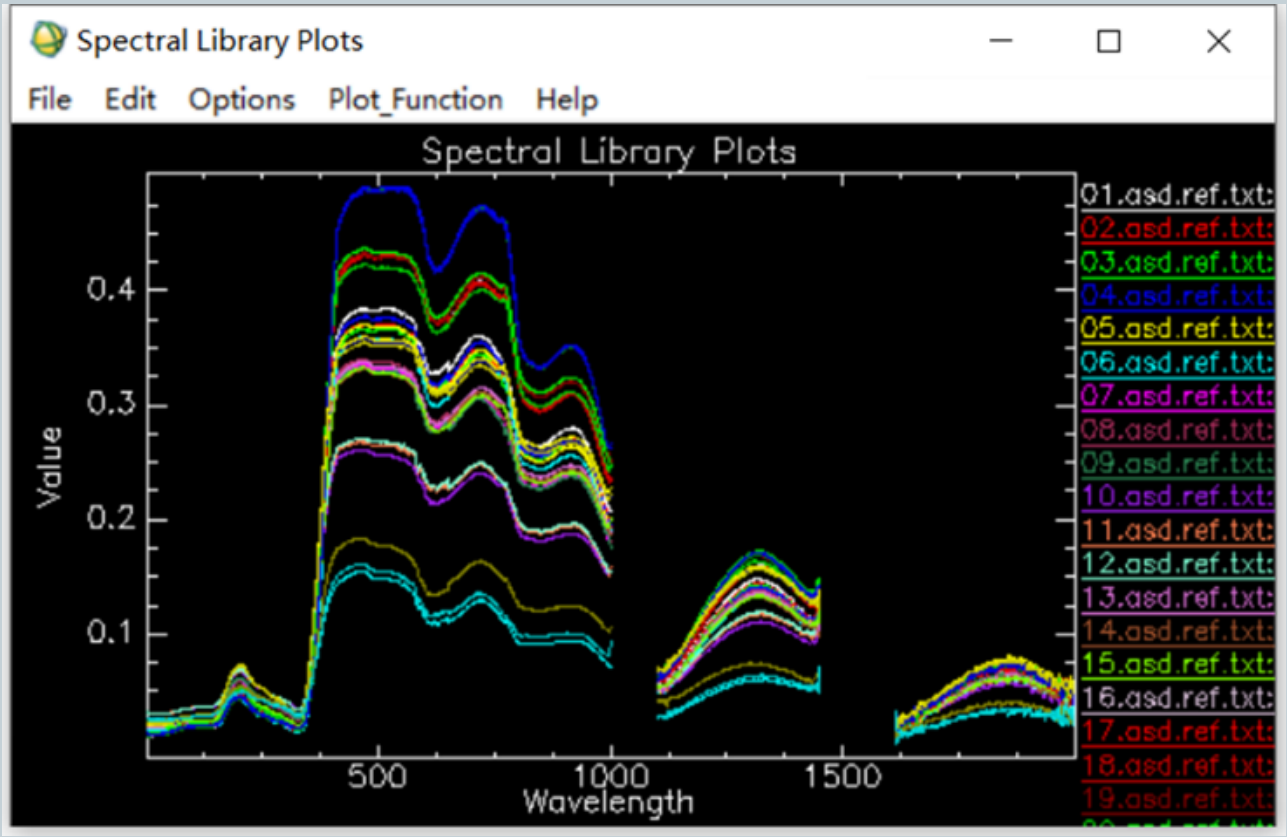

Ctrl+A then Ctrl+C :
select and copy all the information

Add bad bands information and Save (Ctrl+S)

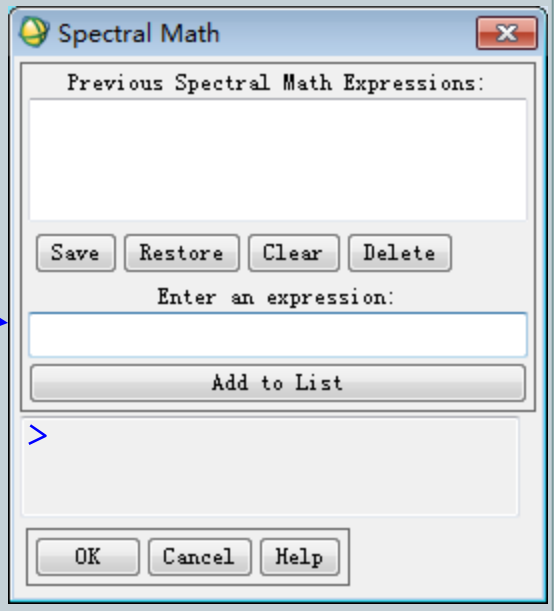
Mask bad bands

- **Method 2:** Edit spectral library file's Header file



Derive mean spectra

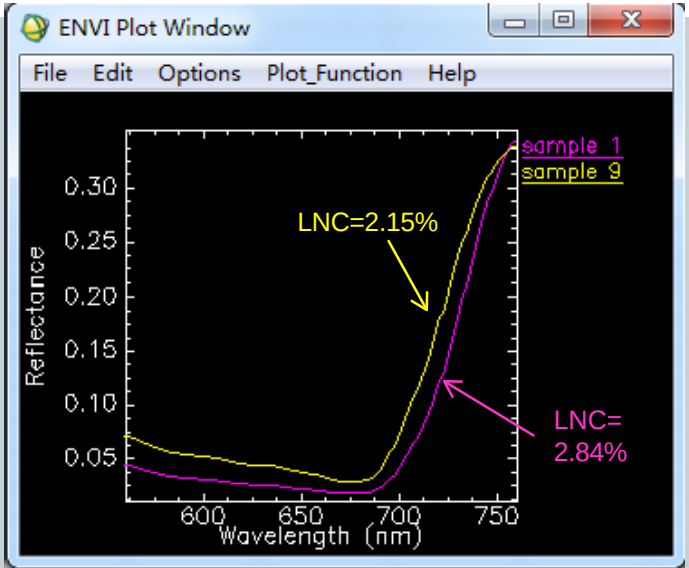
- Main menu: Spectral -> Spectral Math
- Get the average of three spectra
  - float(s1+s2+s3)/3
- Note: variable names must begin with "s" or "S" and contain up to 5 numbers.

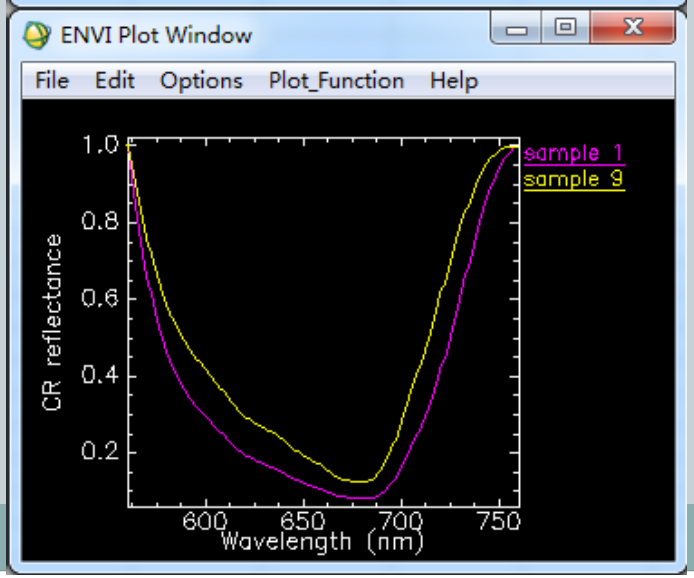


Here, we have 30 ASD spectra for a total of 10 samples.

Continuum removal analysis

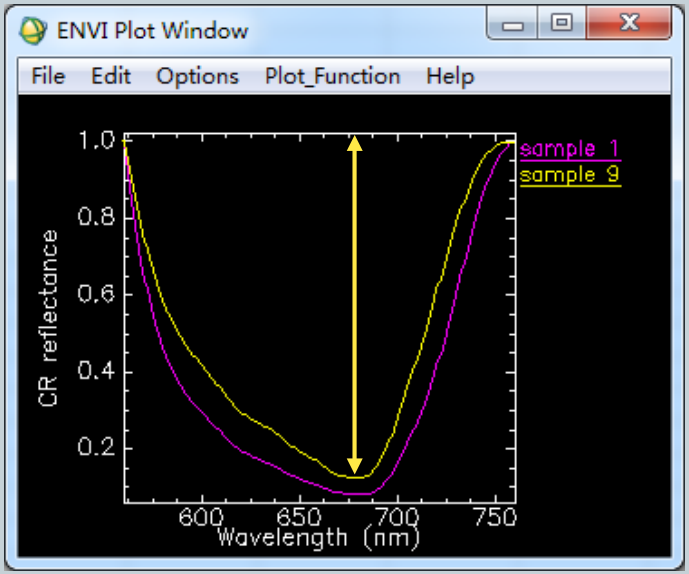
- Determine the start and end wavelengths of the absorption feature (chlorophyll 560-760 nm)
- Select Plot_Function->Continuum Removed
- Go to File->Save Plot As -> Spectral Library…





Estimation of LNC using continuum removal analysis

- Estimation of LNC using absorption depth at the band center (680 nm) Dc:
  - $Dc = 1 - R_c'$
  - R' is continuum removed reflectance.



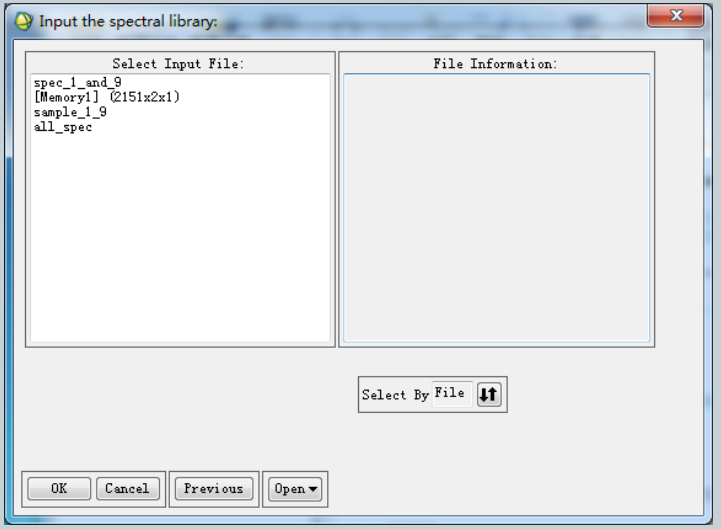
(Kokaly & Clark, 1999, RSE, 67, 267-287.)

Calculate spectral indices

- Use my IDL script *calc_spec_index_from_refl.pro*. Note: The file path cannot contain Chinese characters.
- Insert ";" at the beginning of a line to comment a command line.
- Open the *pro* file in IDL and click Run.
- Input: a Spectral Library file.
- Output: a csv file with spectral index values in columns.

calc_spec_index_from_refl.pro

```
PRO calc_spec_index_from_refl

  ENVI_SELECT, TITLE = 'Input the spectral library:', FID = fid, DIMS = dims, FILE_TYPE = 4, POS = pos
  IF (fid EQ -1) THEN RETURN
  ENVI_FILE_QUERY, fid, FNAME = spec_fname, NS = ns, NL = nl, WL = wl

  vi1 = DBLARR(nl)  ; Vegetation index 1
  vi2 = DBLARR(nl)  ; Vegetation index 2.

  spec = ENVI_GET_DATA(FID = fid, DIMS = dims, POS = pos) ; Read in spectral library.

;-------------------------------------------
; Calcuation of spectral indices

 FOR i=0, nl-1 DO BEGIN

;;     VIopt=  (1+0.45)*((R800)^2+1)/(R670+0.45). Reyniers et al. (2006):
      b1 = WHERE(wl EQ 800)
      b2 = WHERE(wl EQ 670)
      r1 = FLOAT(spec[b1,i])
      r2 = FLOAT(spec[b2,i])
      vi1[i] = FLOAT(1+0.45)*((r1)^2+1)/(r2+0.45)

 ENDFOR

 output = [TRANSPOSE(vi1), TRANSPOSE(vi2)]

 WRITE_CSV, spec_fname + '_indices.csv', vi1, HEADER = ['VI-1']

 PRINT, 'DONE :) ^_^...'

END
```



Lab project

1. **Make a plot to display the mean spectra of ten samples. Please follow the criterion below: (10%)**
   - Display the ten mean spectra in one plot window
   - Configure these plot and data parameters:
     - X-axis, Y-axis, xrange = 350-2500 nm, yrange = 0-0.6
     - Spectrum names = [Sample 1, Sample 2, …, Sample 10]
     - Spectrum colors should be different between samples
     - Hide the bad bands
2. **From the ten mean spectra, choose two that correspond to the min and max LNC. Plot them in reflectance and continuum removed reflectance, respectively. (20%)**
   - Make two plots with one for reflectance and the other for continuum removed reflectance. Set the spectral range for plots as 560-760 nm
   - For other plot and data parameters, refer to Ex. 1

Lab project

3. Estimation of leaf nitrogen content (LNC) from canopy reflectance (30%)

- Build regressions using two methods, spectral indices & continuum removal analysis
  - X-axis: predictor variable; Y-axis: LNC
  - Add trend lines and regression equations
  - Spectral index: LICI (Li et al., 2020)
  - Continuum removal: band depth at the center (Kokaly & Clark, 1999)

$$LICI = \frac{R_{735}}{R_{720}} - \frac{(R_{573} - R_{680})}{R_{573} + R_{680}}$$

Li et al. (2020), RSE, 248, 111985.

Lab project

- Answer questions

1. **The absorption feature centered at 680 nm is not directly related to nitrogen absorption. Why can we still predict LNC using continuum removal analysis? (20%)**

2. **The spectral index and continuum removal analysis techniques are well studied in the community for quantifying vegetation parameters. Of the two spectral techniques, which one do you prefer to use? What are the disadvantages and advantages of each technique? (20%)**

Notes

- **Lab report:** Submit a **PDF** report with your answers.
- **Naming convention:** Student Number + Name.
- **Email:** 2022201004@stu.njau.edu.cn
- **Deadline:** December 31, 2023, 7:00 p.m.