# Estimating LAI
# Using Red Edge Position

## Quantitative remote sensing of biophysical parameters (part III)

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## Preparation

In this exercise, we will use a software system for technical computations called Matlab. If you have not yet installed Matlab on your computer, please do so.

## Data

*You may copy the folder "measured" from the network on your computer. Needed files for this exercise are:*

samples.mat
lai.mat
wl.mat

For further information, please see the articles which are provided on the network by Darvishzadeh et al. 2011, Darvishzadeh et al. 2009, and of course the Matlab help.

# Outline

Developments in the field of remote sensing and imaging spectrometry have promoted a new group of vegetation indices based on the shape and relative position of the spectral reflectance curve. These include the red edge of the vegetation spectrum, which is the sharp slope between the low reflectance in the visible region and the higher reflectance in the near-infrared region, around 670-780 nm. The red edge inflection point (REIP), that is the wavelength that has a maximal slope in the red edge, and the shape of the red edge has been investigated in several studies and have demonstrated a good correlation with biophysical parameters such as LAI. The aim of this exercise is to calculate the REIP using two methods and examine its relationship with LAI.

**Data Exploration**

Start MATLAB software through the MATLAB-Icon. MATLAB contains five windows: usually command window in the center, workspace, and command history on the left side of the screen and on the right side of the screen folders, and the details of files are demonstrated.

Change your current directory to where you have copied the data by browsing it from the menu bar on top.

The folder contains three files. "samples.mat" contains spectral reflectance data measured in 584 wavelengths by a hyperspectral sensor for 60 grassland plots. These spectral data are presented in the form of a matrix (584*60).
"wl.mat" is an array with the wavelengths names of the hyperspectral sensor.
"lai.mat" contains the measured field LAI for each plot.

Load the matrices by entering the "load" command in the command window or by double-clicking the matrices in the current folders windows

Load samples
Load lai
Load wl

In Matlab always a matrix is defined by its row and columns. In our case, the matrix of reflectance is a 584* 60. This means that the reflectance data is measured in 584 wavelengths (as rows) for 60 grass plots (as columns).
The matrix of LAI is a one-dimensional array and is called a vector. It contains the measured LAI of 60 grassland plots.

**Calculation of REIP**

Studies performed on the relationship between REIP and LAI have shown contradictory results. While in serval studies strong relationships have been observed between REIP and LAI, in some others REIP has poorly related to LAI. Therefore, in this exercise, you will examine the LAI and REIP relationships. For this, the REIP will be calculated using two different approaches which are widely used in the literature, namely linear interpolation (Guyot and Baret 1988) and linear extrapolation techniques (Cho and Skidmore, 2006).
Linear interpolation assumes that the spectral reflectance at the red edge can be simplified to a straight line centered around a midpoint between a) the reflectance in the near-infrared shoulder at about **780 nm** and b) the reflectance minimum of the chlorophyll absorption feature at about **670 nm**. The reflectance value is estimated at the inflection point. It applies a linear interpolation procedure for the measurements at **700** nm and **740 nm** estimating the wavelength corresponding to the estimated reflectance value at the inflection point.

☞ Remove the unnecessary data and limit the spectral data and their corresponding wavelength to only contain the red edge region (670-800 nm). For this open the matrix of wavelengths by double-clicking it in the workspace window and write down the corresponding index (row number) for the wavelengths 670 and 800. In this case, these wavelengths are in rows 189 and 277, respectively.

The commands below make the wavelength file and the reflectance file smaller and limit them to the red edge region.

```
REPWL=wl(189:277,:);
REPPOOL=samples(189:277,:);
```

☞ In the main Menu bar on the top under the HOME click on the new script icon. A new page will be open now. Type the formula for the calculation of the REIP using linear interpolation.

$$R_{red\text{-}edge}=(R_{670}+R_{780})/2$$

$$REIP_{linear} = 700 + 40\left[\frac{R_{red-edge} - R_{700}}{R_{740} - R_{700}}\right]$$

where the constants 700 and 40 result from interpolation between the 700 nm to 740 nm intervals, and $R_{670}$, $R_{700}$, $R_{740}$, and $R_{780}$ are, respectively, the reflectance values at 670 nm, 700 nm, 740 nm and 780 nm.

☞ open the new matrix of wavelengths (REPWL) by double-clicking it in the workspace window and write down the corresponding index (row number) for the wavelengths 670, 780, 700, and 740. In this case, these wavelengths are in rows 1, 75, 21 and 48, respectively.

☞ Now rewrite the above formulas by replacing the appropriate name (index) for the corresponding wavelengths to calculate the red edge using linear interpolation.

REIPBARET= ….

> Note that in Matlab by writing the division like "**./**" , Matlab will calculate the division for each element in the first vector by the corresponding element in the second vector. As a result, you will have the answer as a vector.
>
> You can use the "**%**" sign to make the earlier formulas as comments. Therefore, they will be there as info.

Run your commands step by step to make sure there is no error in your calculation. A window will appear to save your script first. Give your script a name and save it in the corresponding directory.

**LAI and REIP relationships**

In order to see how the calculated REIP is related to LAI data, calculate the coefficient of determination ($R^2$). This is something you have performed in the first exercise in part one. If you have forgotten the command look at the instructions in the first exercise.

☞Challenge (optional)

☞Now calculate the REIP using the linear extrapolation method. Recall that the *linear extrapolation method (LEM)* (Cho and Skidmore, 2006) is based on the linear extrapolation of two straight lines through two points on the far-red (680 nm to 700 nm) and two points on the NIR (725 nm to 760 nm) flanks of the first derivative reflectance spectrum (D) of the red edge region. The REIP is then defined by the wavelength value at the intersection of the straight lines.

*Far-red line*: D= $m_1.\lambda+c_1$

*NIR line*: D= $m_2.\lambda+c_2$

where *m* and *c* represent the slope and intercept of the straight lines, respectively. At the intersection, the two lines have equal wavelengths and D values. Therefore, the REIP, which is the wavelength at the intersection, can be written as

$$RIEP_{LEM} = \frac{-(c_1 - c_2)}{(m_1 - m_2)}$$

Note you need to first calculate the first derivative of the reflectance here!

☞Compare the two coefficients of determinations obtained using LAI and the two REIP.

Which one is higher? can we explain this?