Modelling Vegetation Dynamics
An Assessment of Vegetation Change across Continental Africa

Introduction

One of the greatest benefits of satellite remote-sensing is the ability to monitor vegetation change across the globe. Change in vegetation is usually a response to numerous environmental conditions such as rainfall, temperature, soil type and human activities relating to land use change and agriculture.

Healthy canopies of green vegetation have a very distinctive interaction with energy in the visible and near infrared regions of the electromagnetic spectrum. In the visible regions, plant pigments (most notably chlorophyll) cause strong absorption of energy, primarily for the purpose of photosynthesis. This absorption peaks in the red and blue areas of the visible spectrum, thus leading to the characteristic green appearance of most leaves. In the near infrared, however, a very different interaction occurs. Energy in this region is not used in photosynthesis, and it is strongly scattered by the internal structure of most leaves, leading to a very high apparent reflectance in the near infrared. It is this strong contrast, then, most particularly between the amount of reflected energy in the red and near infrared regions of the electromagnetic spectrum, that has been the focus of a large variety of attempts to develop quantitative indices of vegetation condition using remotely sensed imagery (Thiam and Eastman 2009).

The Normalized Difference Vegetation Index (NDVI) was also introduced by Rouse et al. (1974) in order to produce a spectral vegetation index (VI) that separates green vegetation from its background soil brightness using Landsat MSS digital data. It is expressed as the difference between the near infrared and red (or visible) bands normalised by the sum of those bands, i.e.:

$$NDVI = \frac{NIR - VIS}{NIR + VIS}$$

This is the most commonly used VI as it retains the ability to minimize topographic effects while producing a linear measurement scale. In addition, division by zero errors are significantly reduced. Furthermore, the measurement scale has the desirable property of ranging from -1 to 1 with 0 representing the approximate value of no vegetation. Thus negative values represent non-vegetated surfaces.

Resources

- You should refer to the extensive list of **journals** published in the unit reader document (also available as a PDF from the unit webpage).
- **Text books** available from the All Saints library such as: Remote sensing and image interpretation by Thomas M. Lillesand and Ralph W. Kiefer
- Make use of the **Tutorial and Manual PDF documents** bundled with Idrisi and accessible from the HELP menu. Additional video tutorials can be found on the UKSCIENCE website.

Because this practical is assessed as part of your assignment mark, you must make every effort to show evidence of additional work and reading outside of the timetabled practical session

Initial Practical Tasks

There are **TWELVE** images – one for each month January to December. The images represent the **MEAN NDVI** for continental Africa – based on the processing of many years of data.

❶ First, you must **COPY** the data from the **J:** (Gaia) drive to **your own disk-space** (usually H: or I: drive). The data is kept in a folder at the following location:

J:\EG5503\VEGPRAC\

You will need at least **13 MB** of disk space to accommodate the above data. Included in the above folder is a vector map of Africa called **'africa'**.

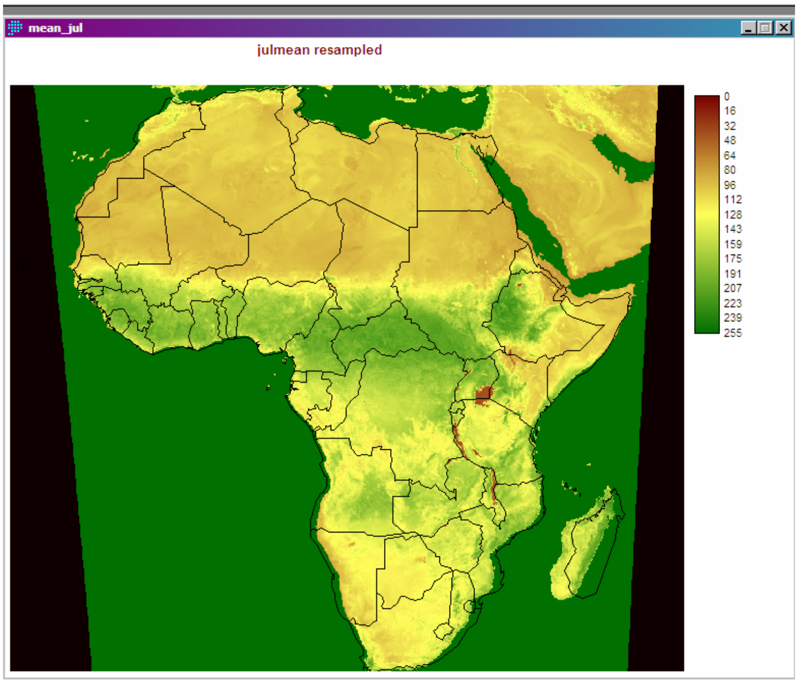
❷ Next you must set both your **MAIN WORKING FOLDER** (where all outputs created by Idrisi will be saved to) and the **RESOURCE FOLDER** (the location of the files you have copied from the J: drive). Make a note of these here so you don't forget:

Main Working Folder Location: ______________________________

Resource Folder Location: ______________________________

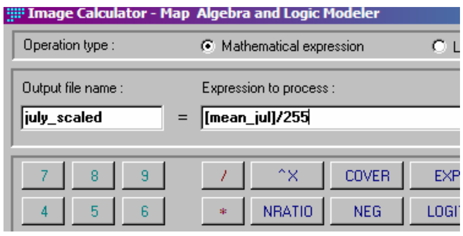
Hint: Try to keep the file path as short as possible and avoid spaces

❸ Now you can take a look at the images. Use the **DISPLAY** button ( )on the toolbar to open each image. Remember that since these are NDVI images you should select the built-in NDVI palette file. You should see something like this:



Notice that this raw data shows NDVI values scaled between zero and 255. That is because the raw data has not yet been scaled to the usual NDVI scale between 0 and 1. You can do this yourself by using the **Image Calculator** ( ). Create a new image for each month by taking the original image file and dividing it by 255:

NewImg = OldImg / 255



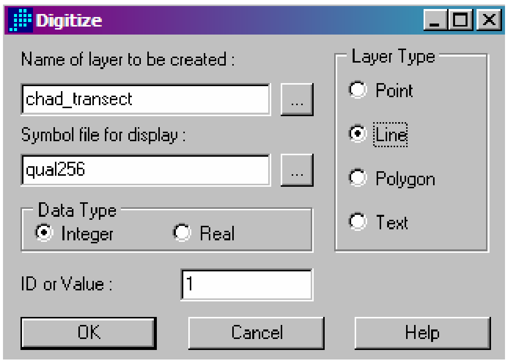
❹ Next, you should try and determine the *characteristics of vegetation change*. This is where you can pick up extra marks for the assignment. You should decide what questions to ask and carry out the relevant analysis of the data. Some examples might include:

- Where does most vegetation exist throughout the year?
- How does vegetation change geographically from one place to the next?
- Which month sees the lowest vegetation cover in the Sahel?
- What can you say about vegetation cover in mountainous areas?

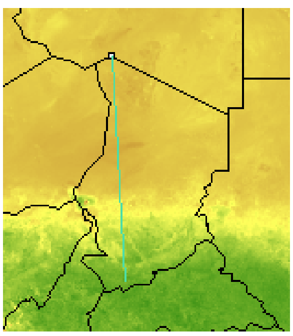
Some common techniques that allow you to visualise the spatial (geographical) change in vegetation and temporal variation include **transect analysis** and **cursor enquiry** tools.

❺ In order to help you start, the following procedure outlines a method used to determine vegetation change across a geographical region. This is known as a **transect analysis** method. Let's say we want to determine how vegetation varies from the northernmost border of **Chad** to its southern border – for the month of **July** (northern hemisphere Summer).

STEP 1: Create a **transect line** from one location to another using the on-screen digitize function. Select the on-screen digitize button ( ) from the toolbar. Give the name of your transect as **'chad_transect'** and select **'Line'** for the Layer Type:

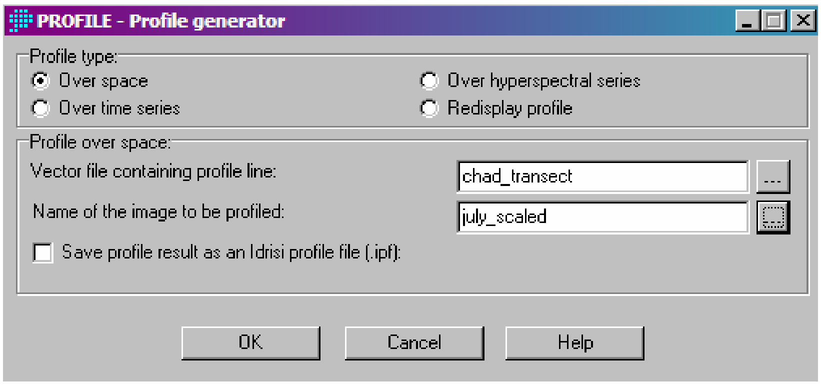


The mouse cursor will turn into a crosshair and you should position it on the **northern edge of Chad's border with Libya**. This will anchor your *starting point* of the transect. Now click on the **southern border of Chad** – on the border with Central African Republic – the **end point** of the transect. Ideally, the line should be as straight as possible. Once you make your second click a feint line appears. To finish, click on the image with the **RIGHT HAND** mouse button and close the image by clicking on the '**X**' on the upper right corner of its window – you will be asked if you want to save the transect line – you click on YES.

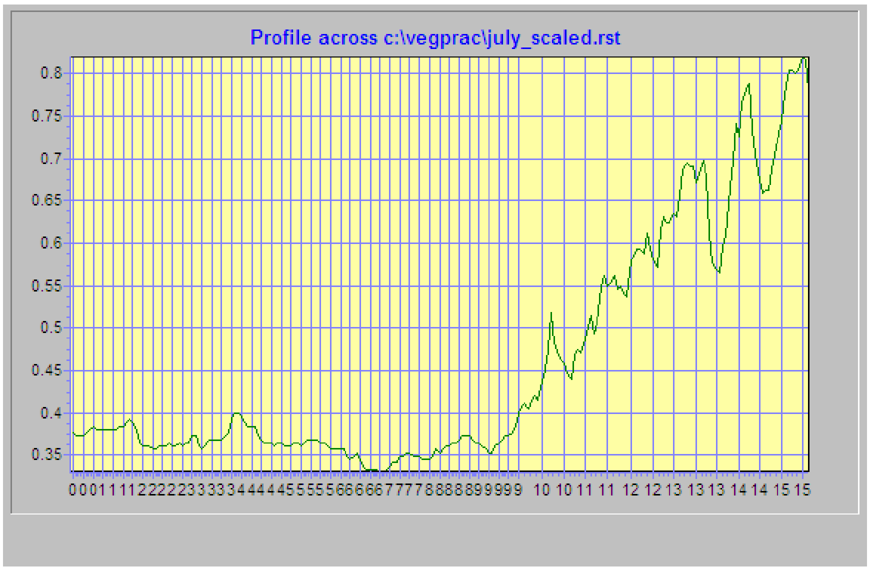


Above: transect line (feint blue line) from north of Chad to south.

STEP 2: Now we have created a transect line, we can get Idrisi to sample the NDVI across it – for every pixel. This is achieved by selecting **PROFILE** (GIS Analysis ➔ Change / Time Series):



Make sure you select **'Over space'** as the Profile Type. Select the transect line you just created (**chad_transect**) and choose the **July NDVI image**. **NOTE**: you have the option to output the results to a text file that can be opened in Excel so you can create your own graph – to do this, just click on the optional **'Save profile result as an Idrisi profile file (.ipf)'**. For now though, just click on **OK**. You will see a graph of NDVI values across Chad (from the north to the south along your transect line):



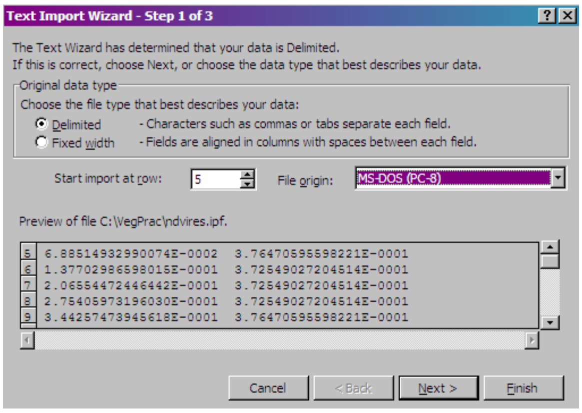
As you can see, the graph (above) shows the NDVI value (vegetation) increasing as you move from the north to the south of the country. You can also see how poor the basic quality of the Idrisi graph is. You cannot adequately see the values on the 'X' axis. This is one reason why you should use the optional export function to create your own graph in Excel.

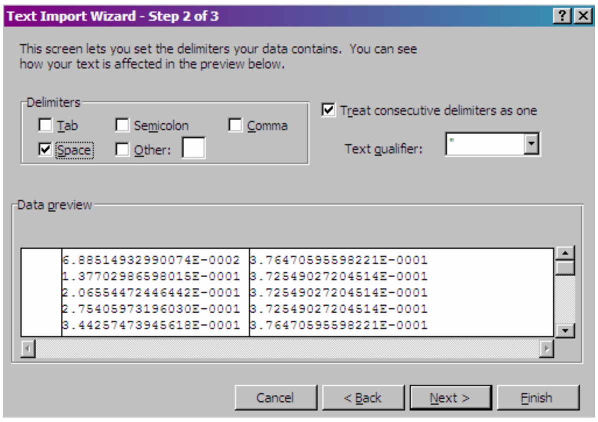
TIP: By default, the **'X'** axis value (distance along the transect) is just a sequentially increasing pixel number. If you create your own graph in Excel, you will want to replace this with a true distance in **kilometres**. In order to do this, you will need to know the distance along the transect. You can determine this by writing down the **latitude** and **longitude** of the start and end points of your transect. You can do this by moving the mouse to both locations and noting down the **x:** value (longitude) and **y:** value (latitude) that is shown on the bottom of the screen when you overlay the **chad_transect** vector line on the **July NDVI** image. In this example, the coordinates of this line is:
NORTH (LAT: 23. 496 / LON: 16.081) to SOUTH (LAT: 8.157 / LON: 16.976). In order to calculate the distance along this transect line you can either download a Windows/Macintosh program called **LLPDC** from http://www.ukscience.org/software.html.

Alternatively you can visit http://www.gpsvisualizer.com/calculators to perform the calculation via an online calculator.

In this example, the distance is 1,700km. Once in Excel (imported as a XXX) you simply divide the distance (1700) by the number of pixels sampled to determine how to scale your 'X' axis.

TIP: Open the Idrisi Profile File (.JPF) in Excel and it will automatically open the Text Import Wizard. Start the import at **LINE 5** and then choose **SPACE** delimited:





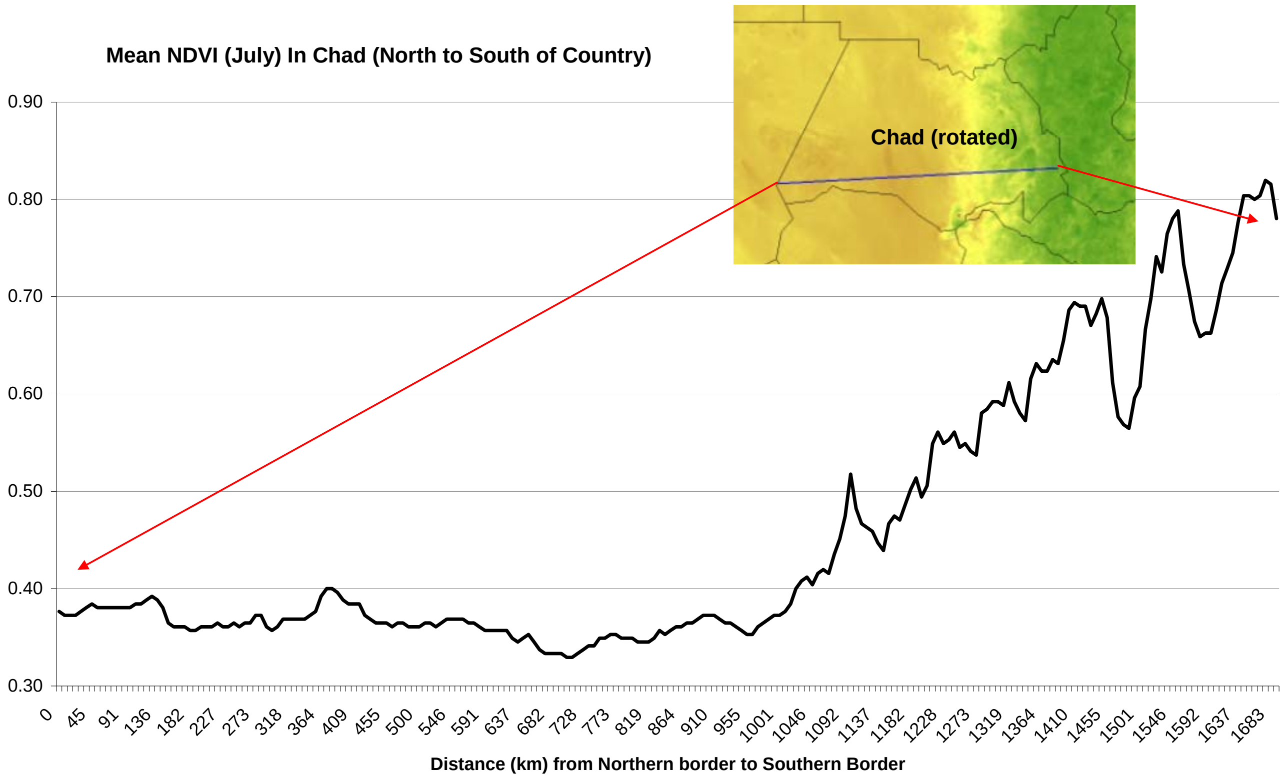
The data is stored as **scientific notation**. You can transform this into normal decimal values by highlighting the two columns of data – then **Right Click** with the mouse and choose **Format Cells** and change the type to **number** (2 decimal places).

The first column of data is **distance** and the second column is our **NDVI** value. If we know the distance along the transect, we can replace the first column data with actual distance values. In this example, the distance is **1,700km** and there are **224** pixels…..so each pixel is **1700/224** which is **7.58km** per pixel. Now we can give the first distance value as zero and simply add 7.58 to every row that follows in Excel

TIP: If you put zero in the first row in Excel, you can add the formula **=A1+7.58** in the second row and use AUTOFILL to drag the formula all the way to the last row. You can now create a proper graph – and add data (using the same transect line) for the other months or selected months.

You should try and create graphs that illustrate what you are trying to show from your analysis. Remember to make the titles and axis labels as clear as possible

EXAMPLE:



The transect analysis method is just one of several types of analysis you will need to undertake. Do **NOT** just print off a sheaf of graphs and screenshots and hand this in. Much of the work you are being assessed for is demonstrating how you can use a systematic approach in a GIS to analyse relevant data to address a question: in this case to describe and analyse vegetation dynamics in Africa. Much of the effort you will expend will be the analysis and discussion of your results.

ASSIGNMENT COMPONENTS REQUIRED:

1) An annotated WORKFLOW DIAGRAM showing the sequence of operations you undertook in order to complete your various analysis tasks in Idrisi (no more than TWO sides of A4)
2) A brief graphical analysis section showing any graphs, tables or other outputs generated as a result of your Idrisi data analysis. Only show graphs and screenshots that are essential to support the written commentary
3) A written commentary – with a suitable structure (introduction, main discussion and final conclusions) where you are expected to discuss the analysis in the context of vegetation dynamics across Africa. You should make FULL USE of relevant peer review scientific journal articles. All literature must be cited correctly (according to the Harvard system) and you should include a suitably formatted Reference List.

All three components (above) will form the basis of your first practical report. This, together with the second Term 1 assessed practical (completed in consolidation week) will form the Assignment 1a submission due on 18th December. Do not submit this practical report separately. It must be handed in with the later second assessed practical also part of assignment 1a, via the usual coursework submission bins.