Workbook

Satellite Imagery Processing for AgroMeteorological Assessments MODIS Vegetation time series analysis for the Nile Basin

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Information Products for Nile Basin Water Resources Management
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Preface

Vegetation growth indirectly represents a significant consumptive component in the water balance. Analysis of vegetation growth therefore holds important information on the hydrological cycle and hydrological response functions of a watershed.

Modern satellites produce information with an ever increasing spatial and temporal detail. Meanwhile becoming more and more useful for various water resources interests. In this training module an elementary introduction to remote sensing is combined with a hands-on training exercise. The purpose of this training is;

- To make participants more conversant with multi-spectral information recorded by satellites.
- To expand the participant's GIS capacities with an understanding of time series image processing.
- To interactively analyze vegetation dynamics for the participants home countries.
- To enable participants to present their own spatial time series results in video mode.
- To calculate and assess Agro-Meteorological factors in relation to observed vegetation dynamics.
- To correlate vegetation dynamics more quantitatively with surface hydrological functions.

Table of Contents

Elements of Remote Sensing: a short introduction to fundamental theory

1.1 Components of an ideal remote sensing information system

Remote sensing studies the earth surface and it's direct environment from the air or from space, by the registration of electromagnetic radiation.

Electromagnetic radiation is one form of energy present at the earth surface, besides other forms of energy as e.g. heat, chemical, electrical or kinetic energy. Electromagnetic radiation is primarily emitted by the sun and to a lesser extent by objects at the earth surface themselves. The most recognizable form of electromagnetic radiation in our daily life is light.

Electromagnetic radiation is transmitted by the earth's atmosphere and in interaction with the earth surface it is either absorbed or reflected. In short we can distinguish four principle components in remote sensing;

(1) Light or radiation emission sources
(2) The atmosphere as transmission medium
(3) The earth surface interaction
(4) A sensor to register variable radiation levels

When these four principle components are complemented by a data handling system (5) and user groups (6), we can describe the ideal remote sensing information system as indicated in figure 1 below.

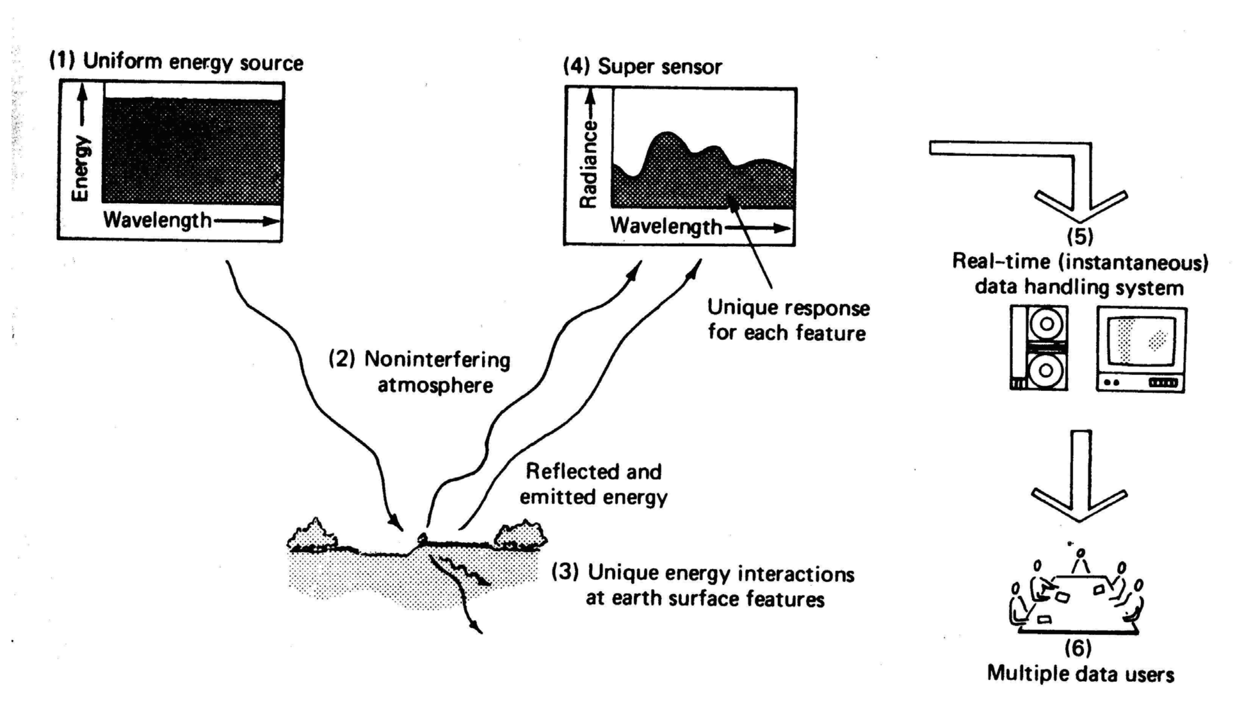


Fig 1. Components of an ideal remote sensing information system (source: Lillesand and Kiefer,1987)charging unit.

In reality the ideal remote sensing system does not exist and actual registration of electromagnetic radiation is influenced by a multitude of time, space and technology dependent factors. Some factors which compromise the ideal system are given below;

- Where besides the sun every object at the earth surface itself is an energy source, energy sources are far from uniform. The emitted energy is not only dependent on the physical properties of the object's material, but also on space and time dependent factors as temperature. For example, more energy is radiated when an object is warmer and also the wavelengths in which this radiation is emitted will be different.

- The atmosphere is not an ideal transmitter and transforms some of the radiation on its way. The degree of transformation largely depends on the distance that the radiation travels and its wavelengths. Basically some of the radiation energy is lost to the atmosphere through absorption. Other parts of the radiation may be lost in different directions through scattering. Both absorption and scatter affect typical wavelengths more severely than others. While also largely dependent on the composition of the atmosphere, which makes it weather specific and thereby variable in time.

- Objects at the earth surface both emit and reflect incoming radiation. Hence the total outgoing radiation is the sum of these two. Reflection behavior is typically not unique, where an object can either absorb, transmit or reflect incoming radiation, this will depend on; the wavelength of the radiation, physio-chemical properties of the object and its surface roughness. These factors can easily change over time as e.g. a soil may be either wet or dry, or can be seasonably covered with more or less vegetation.

- Finally are sensors not always able to record unique responses for each feature. Where the measured radiation energy in a sensor is converted to an electrical pulse, this process is a function of wavelength, time, space, flight geometry, angle and polarization. No sensor can optimally combine all these factors and is therefore always a best compromise for a specific purpose.

1.2 Properties of the electromagnetic spectrum

From the limitation to the ideal remote sensing system as described in paragraph 1.1, it is apparent that optimization of remote sensing results requires knowledgable skills. It requires a set of considerate decisions for each specific question. Good knowledge of the electromagnetic spectrum and its responses with respect to the earth surface and atmospheric interaction are of key importance in this process.

The spectrum of electromagnetic radiation is much broader than what is seen by the human eye. In remote sensing this spectrum is described by wavelength ranges, which are also referred to as bands. An overview of wavelengths/ bands and their common names in remote sensing is shown in figure 2.

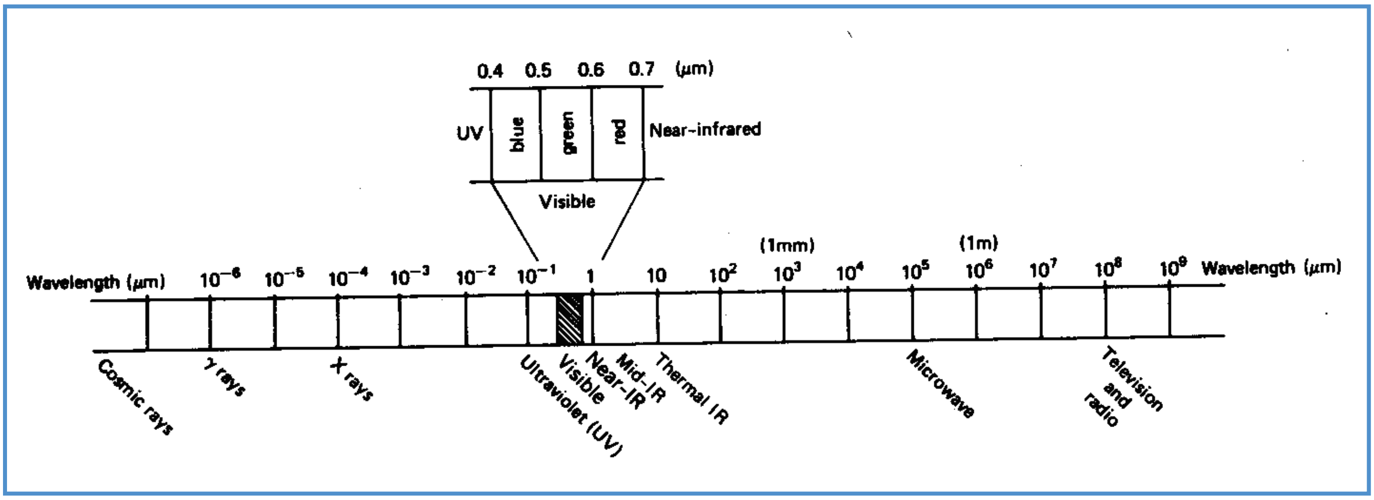


Figure 2. Overview of wavelengths for visible light and the rest of the electromagnetic spectrum. (source: Lillesand and Kiefer,1987)

Remote sensing most commonly uses radiation in the wavelengths ranges from visible light to microwave, which is also referred to as radar. However not all radiation energy in all wavelengths is equally present. Some wavelengths, as e.g. in the microwave range, are not naturally transmitted by common energy sources as the sun. While upon transmission through the atmosphere, various other wavelengths suffer energy absorption and hence any information is blocked. As a consequence a set of practical "atmospheric windows" or wavelength combinations remain, in which information for remote sensing is contained. An overview of such windows is provided in figure 3.

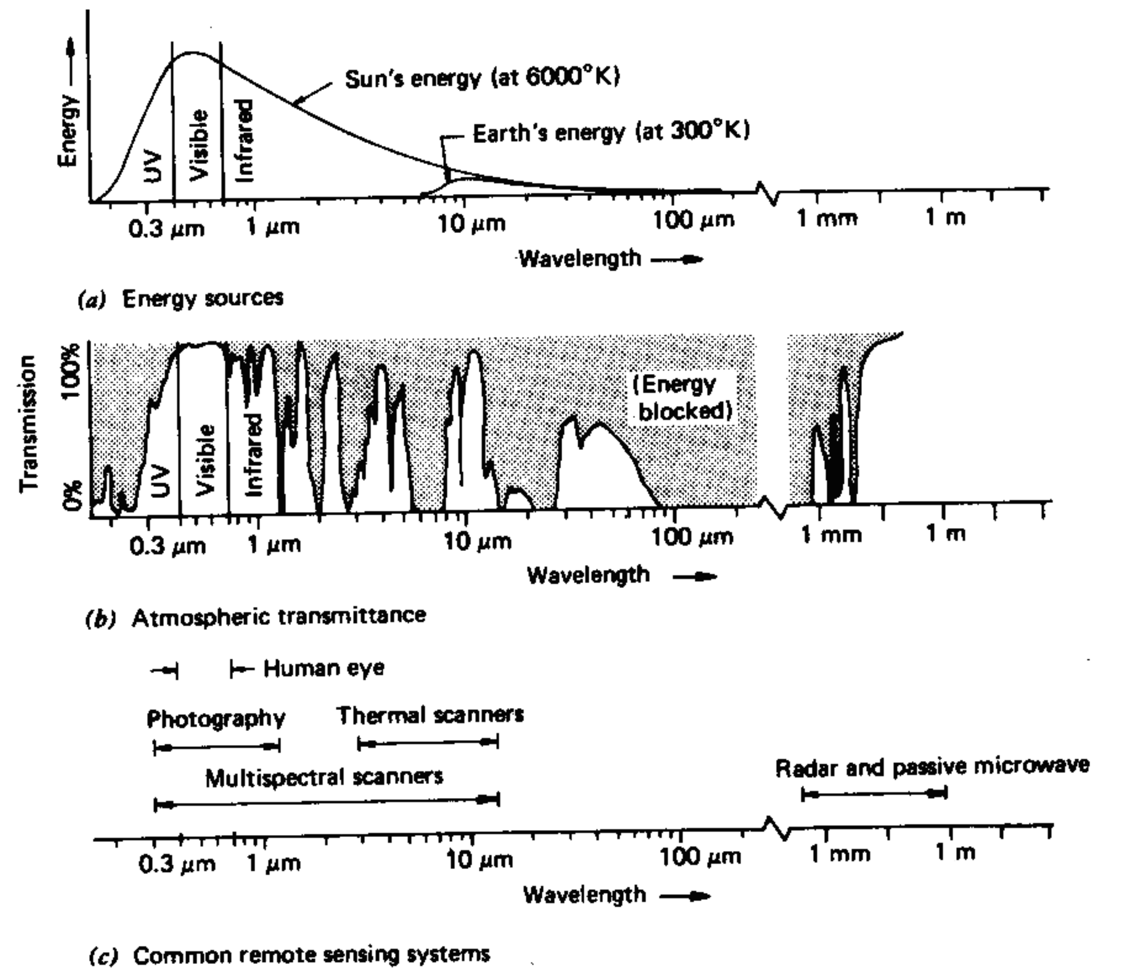


Figure 3 Emitted and transmitted wavelengths creating atmospheric windows for remote sensing. (source: Lillesand and Kiefer,1987)

In addition to considerations on typical radiation from energy sources and the effect of atmospheric windows, comes a unique reflection response from different objects at the earth surface. Reflection is measured as a percentage of the incoming radiation energy per wavelength. Depending on the earth surface interaction, unique reflection is observed as a function of the wavelength. Figure 4 shows an example of such typical reflection functions for some characteristic land cover types. Suitable wavelength for analysis are those where the differences in reflection between objects are large and atmospheric interference is minimal.

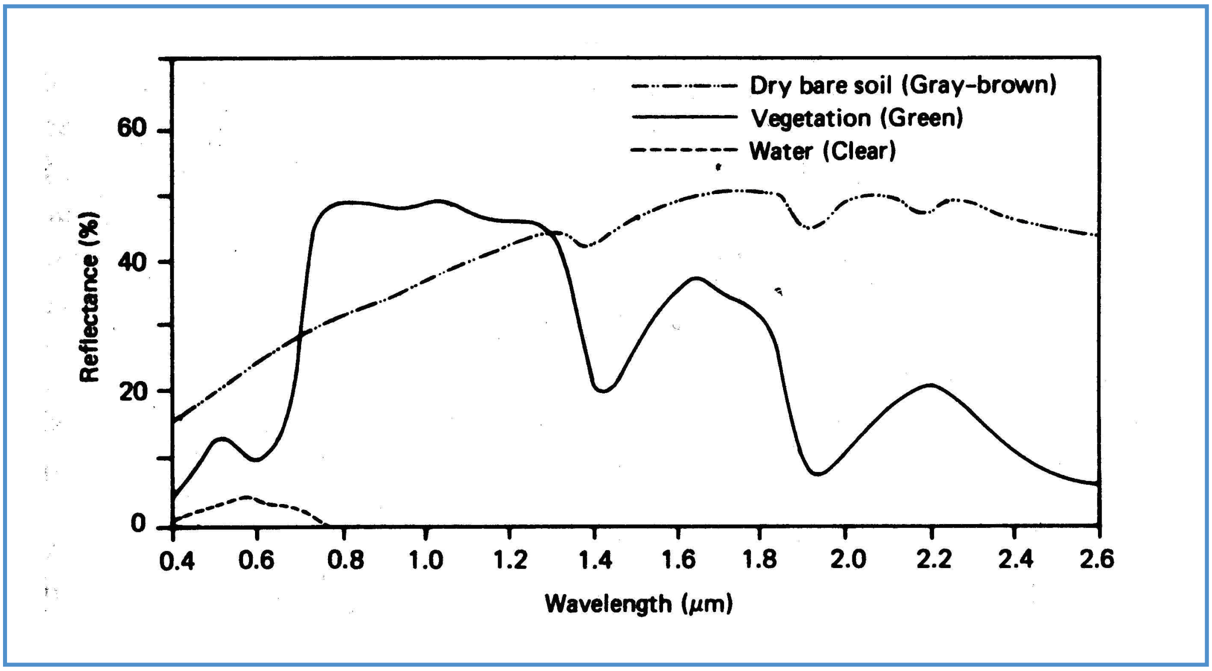


Figure 4. Energy interactions with earth surface features (source: Lillesand and Kiefer,1987)

Vegetation Indices and Agro-Meteorology

2.1 Using reflection responses to study vegetation growth

Vegetation growth at the earth surface almost always represents the development of a leafy biomass. This growth is in many cases seasonal and dependent on favorable temperatures and sufficient water to sustain abundant growth.

Pigments in plant leaves as chlorophyll make leaves to appear green for the human eye. However chlorophyll also causes energy absorption in the visible red wavelength range. When observed from an airplane, vegetation surfaces and water bodies appear as relatively dark, while bare soil areas come out as relatively light colored. This can also be seen from the reflection response functions as shown in figure 4 and 5.

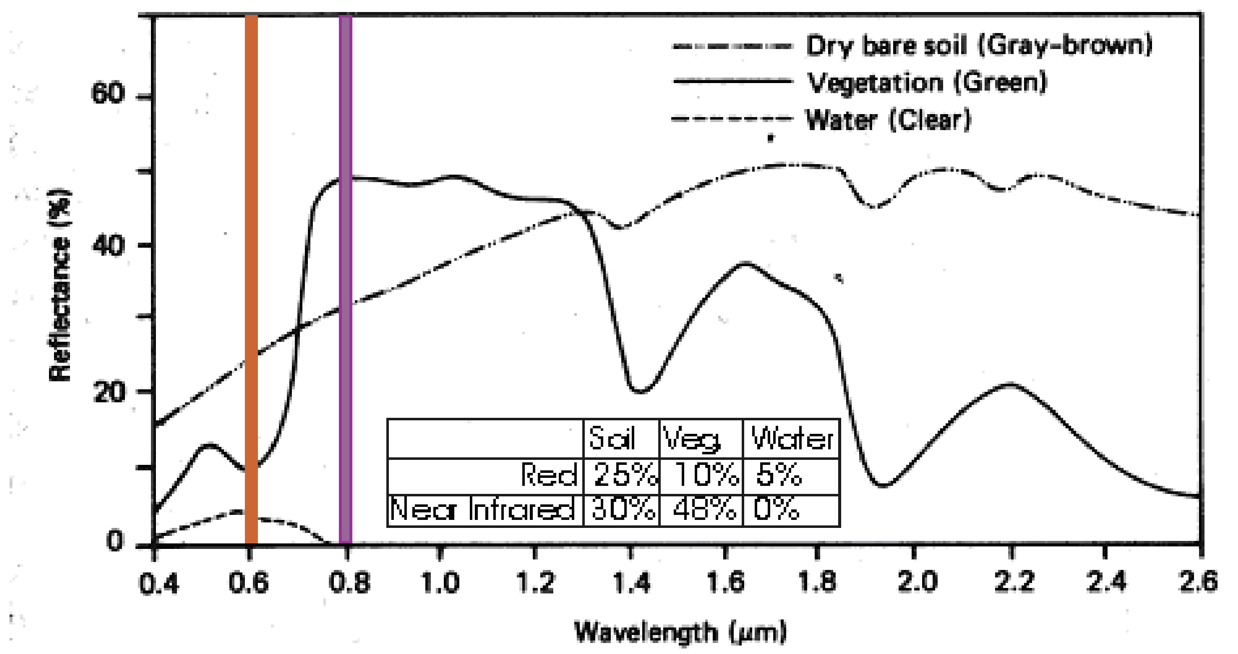


Figure 5. Reflection differences between red (0.6) and near infrared (0.8) bands, for soil vegetation and water. (modified from: Lillesand and Kiefer,1987)

It can be seen from figure 3, that both visible red and near infrared wavelengths are emitted by the sun and are relatively undisturbed during atmospheric transmission. The contrast in reflection responses for vegetation and bare soil if compared between red and near infrared can even be enhanced by a simple arithmetic calculation. Where soil reflects highly and vegetation fairly low in the red wavelength (R), this is reversed for near infrared wavelengths (NIR). A simple normalization ratio is therefore also often used to take maximum advantage of these properties, by contrasting this through the following equation;

2.1.1 Normalized Difference Vegetation Index, NDVI = (NIR-R)/(NIR+R)

Through such a simple calculation all land objects can be rated in terms of "greenness" by a number ranging from –1 to +1. Low numbers represent non vegetated areas and numbers towards the +1 value represent highly vegetated areas. Naturally the NDVI value does not distinguish between vegetation types, nor does it represent a measure of vegetation quality. Most commonly different types of vegetation jointly compose a single "greenness" value. For non homogeneous pixels sometimes also referred to as mixels the combined presence of scattered vegetation and bare soil will give an average response. As a consequence identical NDVI scores can for example be reached by either a homogenous light vegetation cover or a patchy thick vegetation intermixed with bare soil. It may be clear that satellite data with smaller pixel sizes or larger spatial resolutions will largely reduce such mixed effects.

NDVI research over the last two decades has gone a long way in trying to derive physical meaning from NDVI values and dynamics. As a result a wide range of alternative, modified NDVI equations exists, as well as many times series and trend analysis techniques. A full discussion of these techniques is beyond the scope of this training manual, however reference is made below for possible further reading into this subject (Eklundh, L., 1996).

In order to demonstrate how different wavelengths can be used to detect vegetation cover, it can simply be visualized as a photograph. However it should be noted that for example near infrared wavelengths (NIR), as used in the NDVI calculation, can not be seen by the human eye. In order to visualize this radiation, other colors are used to represent them. Photographs or imagery that use substitute colors (red, green or blue) to visualize one or more wavelengths outside the visual spectrum (see fig 2), are generally referred to as false colour photos. A typical example of a normal color photo compared to a false color photo used to enhance visibility of vegetation, is shown below;

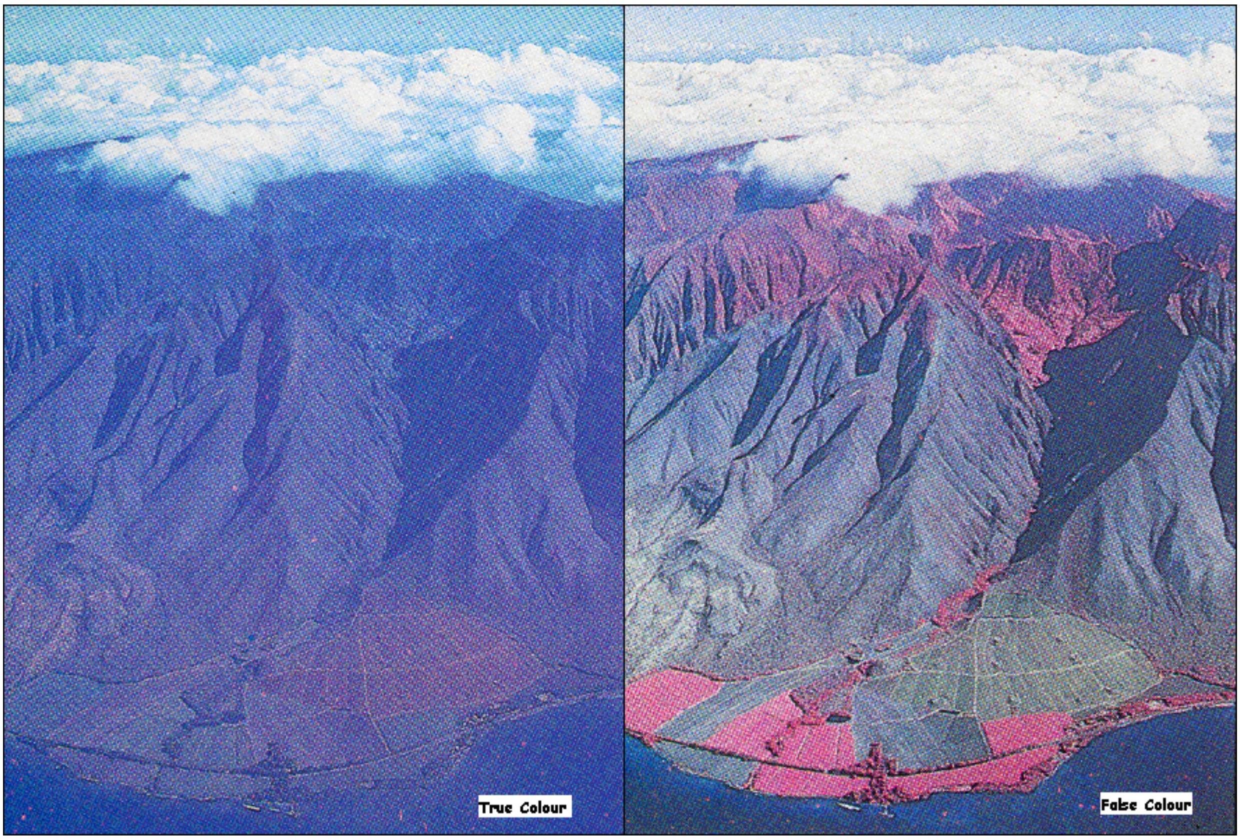


Figure 6. Normal and false colour photographs, showing enhanced vegetation detection (in red) (source: Lillesand and Kiefer,1987)

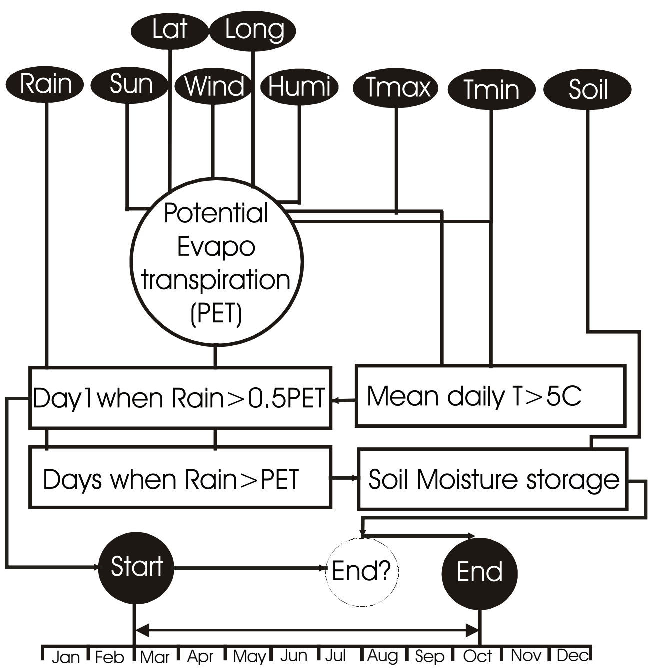
In conclusion, we can say that much value on vegetation cover can be revealed by remote sensing. Both calculated vegetation indexes as well as false color display can reveal information which is otherwise impossible to obtain. NDVI, generally does not judge vegetation types or quality and is most useful in dynamic studies of temporal and spatial change comparison. Times series analysis forms a crucial link between greening responses and agro-meteorology.

2.2 Combining vegetation growth, greening up responses and agro-meteorology

Where favorable moisture and temperature conditions for plant growth are naturally derived from local weather conditions, vegetation growth responses will generally coincide well with seasonal weather events, as e.g. arrival of monsoon rains, or the fall of night frost periods. Vegetation responses to the agro-meteorological conditions will be more explicit when hard limitations, as e.g. water stress, are faced during other parts of the year.

Agricultural crop growth seasonality is generally determined by its reference growing period (RGP) (FAO,1981). The RGP is observed by the combined occurrence of favorable conditions in the thermal and moisture regimes. A simple model is used to establish the RGP start and ending dates, as well as to identify characteristic sub-periods as start of rains (BEG), intermediate growth (I) , humid period (BH) , end of rains, soil moisture extension period and the end of the growing season(END). Figure 7 shows a schematic representation of this simple model. Inputs and example results are given for the Kitale area in western Kenya.

Kitale	Latitude= 1.01	Longitude: 35.0	Altitude:1875	Climate A		
	Precip.	Tmin	Tmax	Sun n/N	Wind	Humidity
JAN	30	10	27.3	0.065	2	56
FEB	26	10.3	27.7	0.06	2	59
MAR	74	11.5	27.2	0.31	2	62
APR	145	12.6	26	0.29	2	72
MAY	156	12.3	24.8	0.35	2	74
JUN	124	11.3	24	0.39	1.8	68
JUL	161	11.5	22.8	0.34	1.8	73
AUG	164	11.1	23.5	0.32	2	73
SEP	115	10.6	24.7	0.36	2	67
OCT	105	11	25.5	0.31	2	64
NOV	82	10.6	25.2	0.39	2	63
DEC	59	10.5	25.6	0.63	2	59



Description:	**normal**	*rains with temperatures*	**unconstrained**	***Moisture Regime 1***	***Start***	***End***	***Length***
Duration:	**314** *<----- days*			*Pr.exceeds PET --->*	**7 / 4**	**9 / 9**	**155** *days*
BEG	**11-Mar**	*beginning of growing period*		*Pr.exceeds 0.5PET ->*	**11 / 3**	**11 / 12**	**275** *days*
BH	**7 / 4**	*beginning of humid period*					
EH	**9 / 9**	*end of humid period*		***Period 1 rainfall surplus:***		**185** *mm*	
ER	**11 / 12**	*end of rains*		***Maximum soil moisture storage:***		***100*** *mm <--- change here*	
END	**19-Jan**	*end of growing period*	**next year**	***Actual soil moisture recharge:***		**100** *mm*	
				Stored moisture depleted after:			**39** *days*

Figure 7. Schematic overview and example on the calculation of reference growing periods.

Kitale area is characterized by a single extended moisture regime, without absolute temperature limitations. Sufficient rains to start agricultural growth begin on 11 March. From 7 April to 9 September there is commonly abundant rainfall, this rainfall exceeds the potential evapotranspiration with 185 mm. By the end of the rainy period on 11 December, soils contain sufficient moisture to sustain crop growth beyond the rainy season for an approximate 39 days. From 19 January to 11 March Kitale is facing a short dry season.

While this broadly described seasonality for rainfed agriculture lacks in many important agro-hydrological details as runoff-runon effects, shallow groundwater or the difference between farmers actual planting dates and these theoretical results, such calculation is nevertheless useful as a quick assessment of general, regional growing conditions. Especially where the NDVI analysis equally represents generalized greening trends, the comparison of NDVI greening responses with this agro-meteorological calculation shows important similarities (see fig. 8)

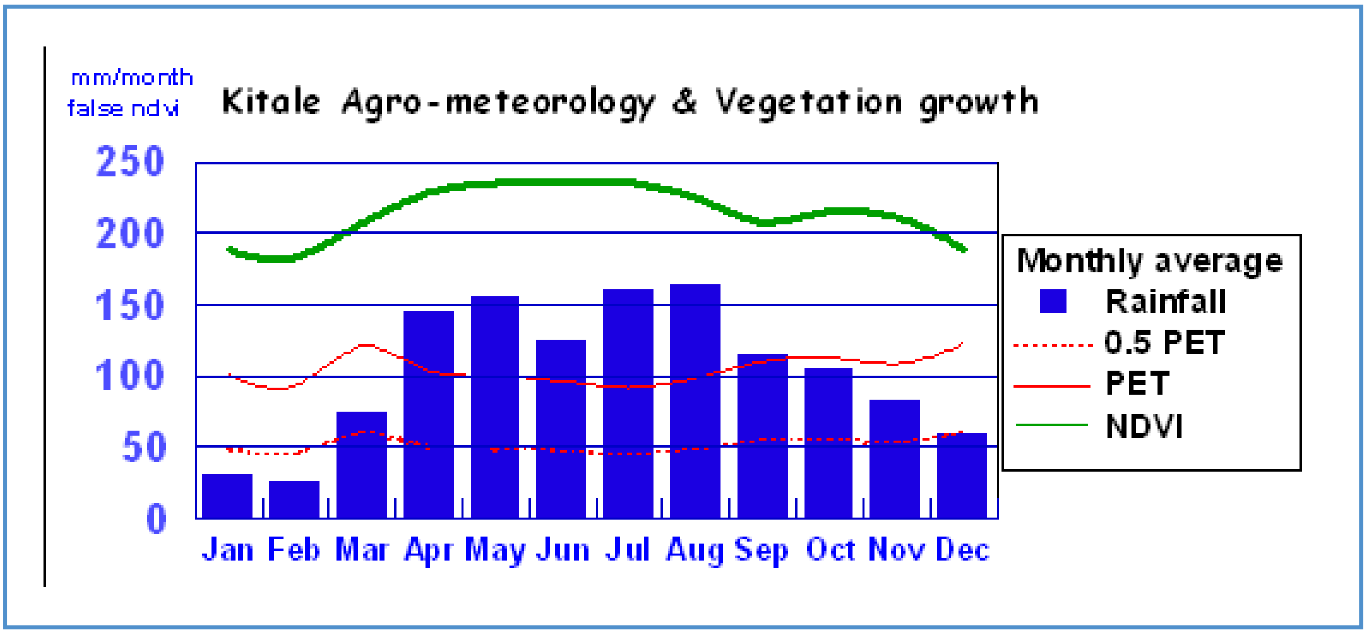


Figure 8. Observed MODIS NDVI response for 1500 hectares of maize crop land near Kitale.

During the theoretical start of the growing season around 11 March, a sharp increase in NDVI values is observed. NDVI values are high throughout the humid period from April to August and remain at relatively high levels until the end of November. A significant drop in the NDVI is however observed in September. This is most likely the result of the maturing of the maize crop. Kitale at 1875 meters altitude meets no absolute temperature constraints, however the modest temperatures do result in relatively longer periods for maize to mature. For altitudes at around 2000 meters this is reported to be 7 months (FAO Ecocrop). This 7 months cycle coincides well with the NDVI dip in September. The slight increase until December probably reflects the growth of additional vegetable crops.

The above example clearly shows how meteorological station data can be used to provide a more quantitative physical background to the NDVI values. While at the same time the NDVI holds valuable spatial and temporal information about cropping cycles, which can not be obtained from meteorological station data.

Literature and Further Reading

Eklundh, Lund, 1996.	AVHRR NDVI for monitoring and mapping of vegetation and drought in East African environments. Meddelan fran Lunds Universitets Geografiska Instituioner Avhandlingar 126. (Lund: Lund University Press)
FAO, 1981	FAO Agro-Ecological Zones project.
FAO, 1994	Crop production systems of the IGADD subregion., FAO agrometeorological working paper series N.10.
FAO, 1999	FAO Ecocrop cd-rom
Gommes, R.	FAO publication on pocket computers in Agro-meteorology
Lillesand, T. and Kiefer R., 1987	Remote Sensing and image interpretation. Second edition. Wiley.

Computer Exercises

* Modis NDVI image sourcing and processing

* Agro-meteorological correlation

Introduction to the exercises

In the following exercise you are going to study vegetation dynamics for your country over the period 2000 to 2004. You will be asked to combine time series image processing with an agro-meteorological assessment for four distinct agricultural areas in your country. In the first day you will generate a typical temporal overview of vegetation growth which you will learn to present for your country in the form of a dynamic video message.

During the second day you will be asked to make a more quantitative assessment on the physical meaning behind the greening responses in your video. This involves correlating greening responses to meteorological station data to arrive at a set of more quantitative conclusions and relations with regards to surface hydrological conditions in space and time.

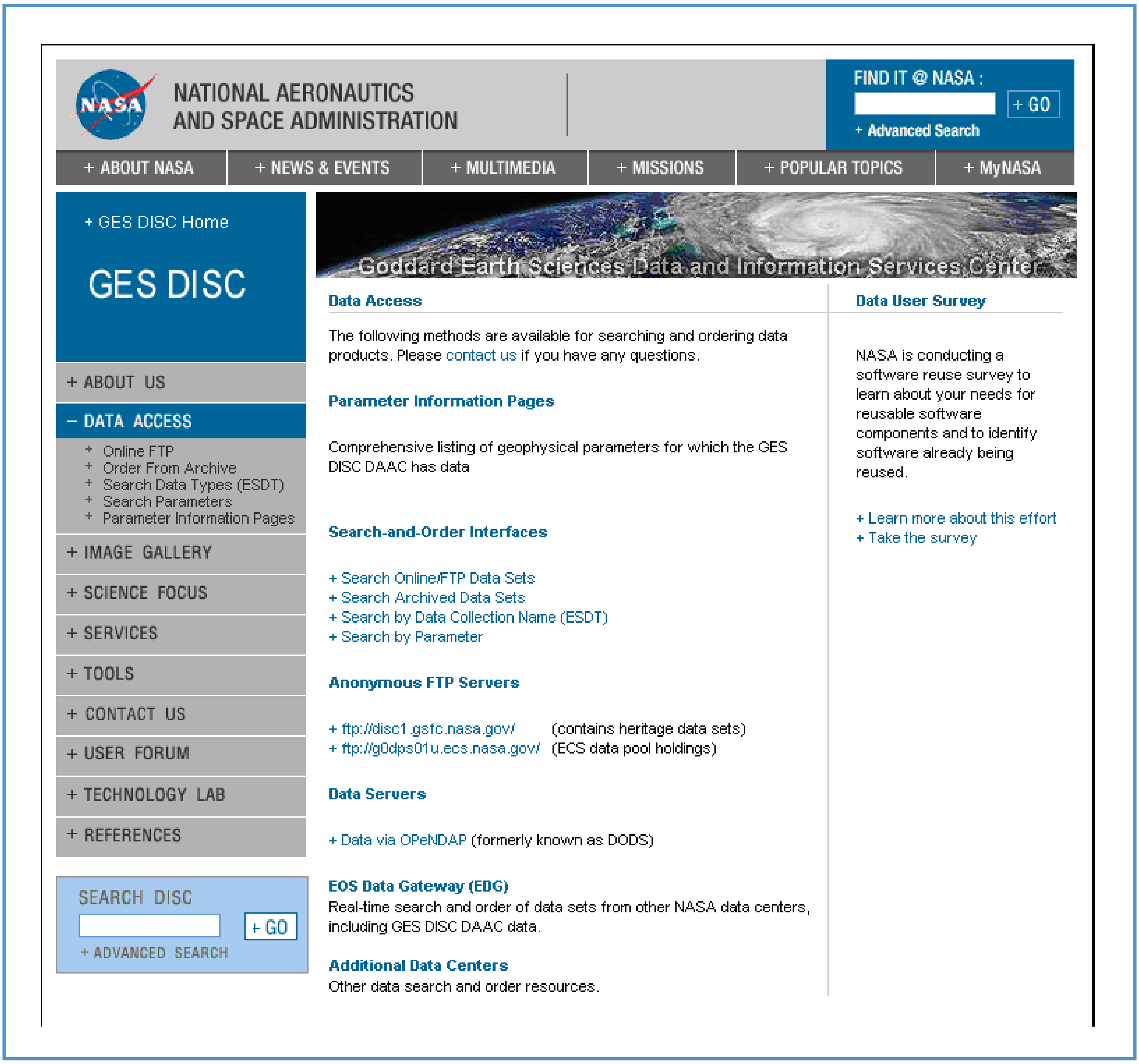
In the exercise you will learn how to source and obtain MODIS imagery from the internet. You will further expand your knowledge of using IDRISI, to run time series analysis. The GIF animator software will be introduced to you to enable simple and more complex video compilation. You will obtain insight in the calculation of Agricultural Reference Growing Periods (RGP's) and use it to try and give a quantitative insight to the hydrological information contained in the NDVI time series data.

Start of Practical Exercise; "Modis NDVI image sourcing and processing"

In order to source MODIS data on the internet, we start the exercise with exploring different places on the internet, through which data can be obtained free of cost. While looking for MODIS data on the internet, it is important to realize that many different MODIS products are being offered on various websites. In the MODIS background information included in the appendices of this manual you can read that MODIS sensors are hosted by two different satellites, generally distinguished as "terra" and "aqua". In this exercise we are concerned with the terrestrial information from "terra". The vegetation indices can be calculated from MODIS bands 1(R) and 2 (NIR) at 250m spatial resolution. These data are being offered primarily through NASA and NASA related web data portals.

- To have a look at this primary location for MODIS data, open the internet explorer and open the following site http://daac.gsfc.nasa.gov. (this looks like the page shown below)

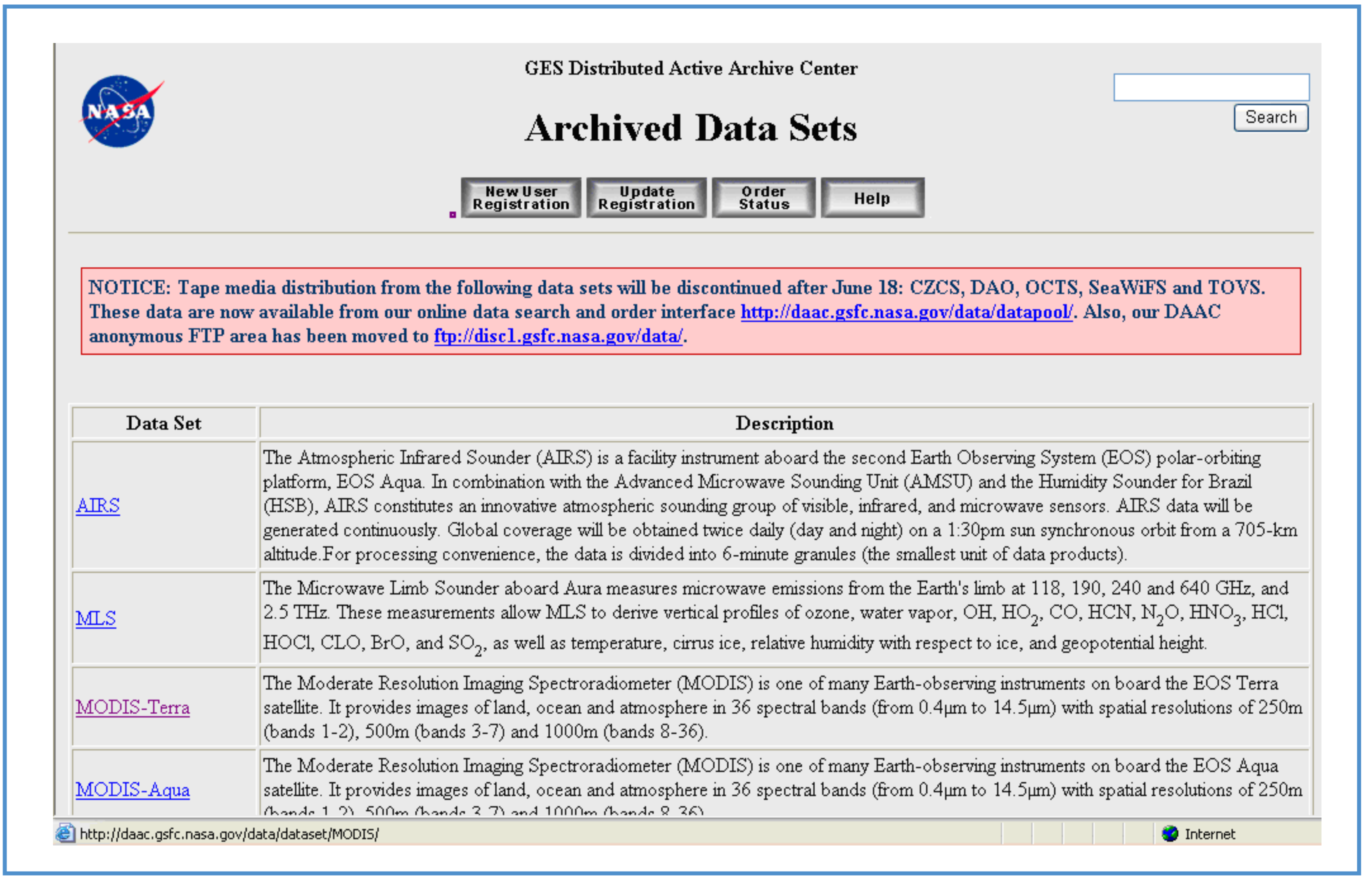
- Double click the “Data Access” as indicated on the previous page and open the next location http://daac.gsfc.nasa.gov/get_data.shtml (this looks like the page shown below)



On this page you get a first overview and various links to other websites where data are stored and distributed via the internet. Some locations as e.g. the "EOS Gateway" are strictly for ordering larger collections from the archives. This requires some more time and registration as a user. You will have to wait for e-mail response from the data center. Where the data are also here free of charge, there might be minor charges for recording materials and post-age. Best is to request for FTP data transfer as this requires no storage media or postage. Where this ordering and ftp transfer process is a slightly longer process, it falls beyond the scope of this training.

Direct download of original reflectance data, without any registration and time delay are available from the "Datapool".

- Double click the "Search Archived Dataset" as indicated on the previous page and open the next location http://daac.gsfc.nasa.gov/get_data.shtml (this looks like the page shown on the next page)



GES Distributed Active Archive Center

Archived Data Sets

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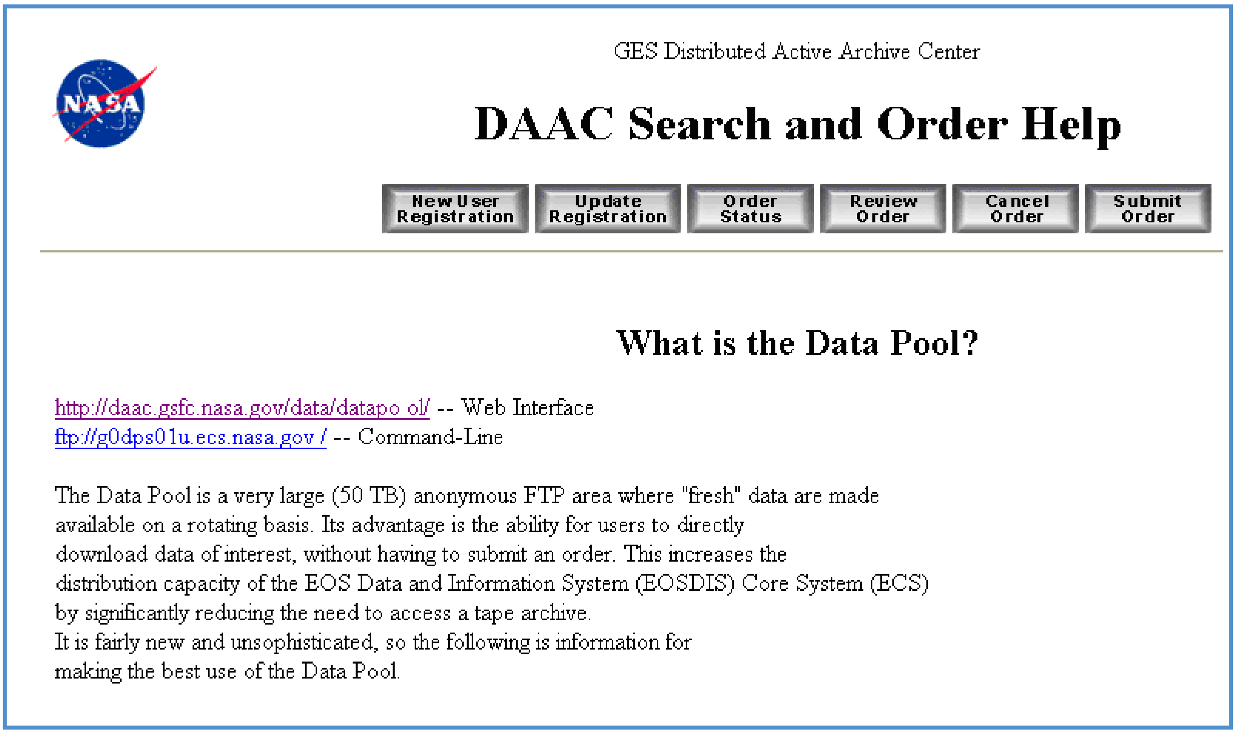
Search

NOTICE: Tape media distribution from the following data sets will be discontinued after June 18: CZCS, DAO, OCTS, SeaWiFS and TOVS. These data are now available from our online data search and order interface http://daac.gsfc.nasa.gov/data/datapool/. Also, our DAAC anonymous FTP area has been moved to ftp://disc1.gsfc.nasa.gov/data/.

Data Set	Description
AIRS	The Atmospheric Infrared Sounder (AIRS) is a facility instrument aboard the second Earth Observing System (EOS) polar-orbiting platform, EOS Aqua. In combination with the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB), AIRS constitutes an innovative atmospheric sounding group of visible, infrared, and microwave sensors. AIRS data will be generated continuously. Global coverage will be obtained twice daily (day and night) on a 1:30pm sun synchronous orbit from a 705-km altitude.For processing convenience, the data is divided into 6-minute granules (the smallest unit of data products).
MLS	The Microwave Limb Sounder aboard Aura measures microwave emissions from the Earth's limb at 118, 190, 240 and 640 GHz, and 2.5 THz. These measurements allow MLS to derive vertical profiles of ozone, water vapor, OH, HO_2, CO, HCN, N_2O, HNO_3, HCl, HOCl, CLO, BrO, and SO_2, as well as temperature, cirrus ice, relative humidity with respect to ice, and geopotential height.
MODIS-Terra	The Moderate Resolution Imaging Spectroradiometer (MODIS) is one of many Earth-observing instruments on board the EOS Terra satellite. It provides images of land, ocean and atmosphere in 36 spectral bands (from 0.4µm to 14.5µm) with spatial resolutions of 250m (bands 1-2), 500m (bands 3-7) and 1000m (bands 8-36).
MODIS-Aqua	The Moderate Resolution Imaging Spectroradiometer (MODIS) is one of many Earth-observing instruments on board the EOS Aqua satellite. It provides images of land, ocean and atmosphere in 36 spectral bands (from 0.4µm to 14.5µm) with spatial resolutions of 250m (bands 1-2), 500m (bands 3-7) and 1000m (bands 8-36).

http://daac.gsfc.nasa.gov/data/dataset/MODIS/ Internet

In the above screen you can find a reference to the data pool at http://daac.gsfc.nasa.gov/data/datapool/. The data pool stores data from various satellites, including Modis-terra as is seen above. A description of the datapool is given below. The datapool holds relatively recent data, through the webinterface you can find and download scenes for your area. Single scenes for MODIS terra 250 meter resolution are around 274 Mb in size. A single scene is likely the cover a whole country or more. Detailed instructions and tips for using the "data pool" are included in appendix III of this manual. If however you need a mosaic of scenes or time series data, the datapool will not be suitable for you and it is best to use the EOS Gateway as mentioned above.



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DAAC Search and Order Help

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What is the Data Pool?

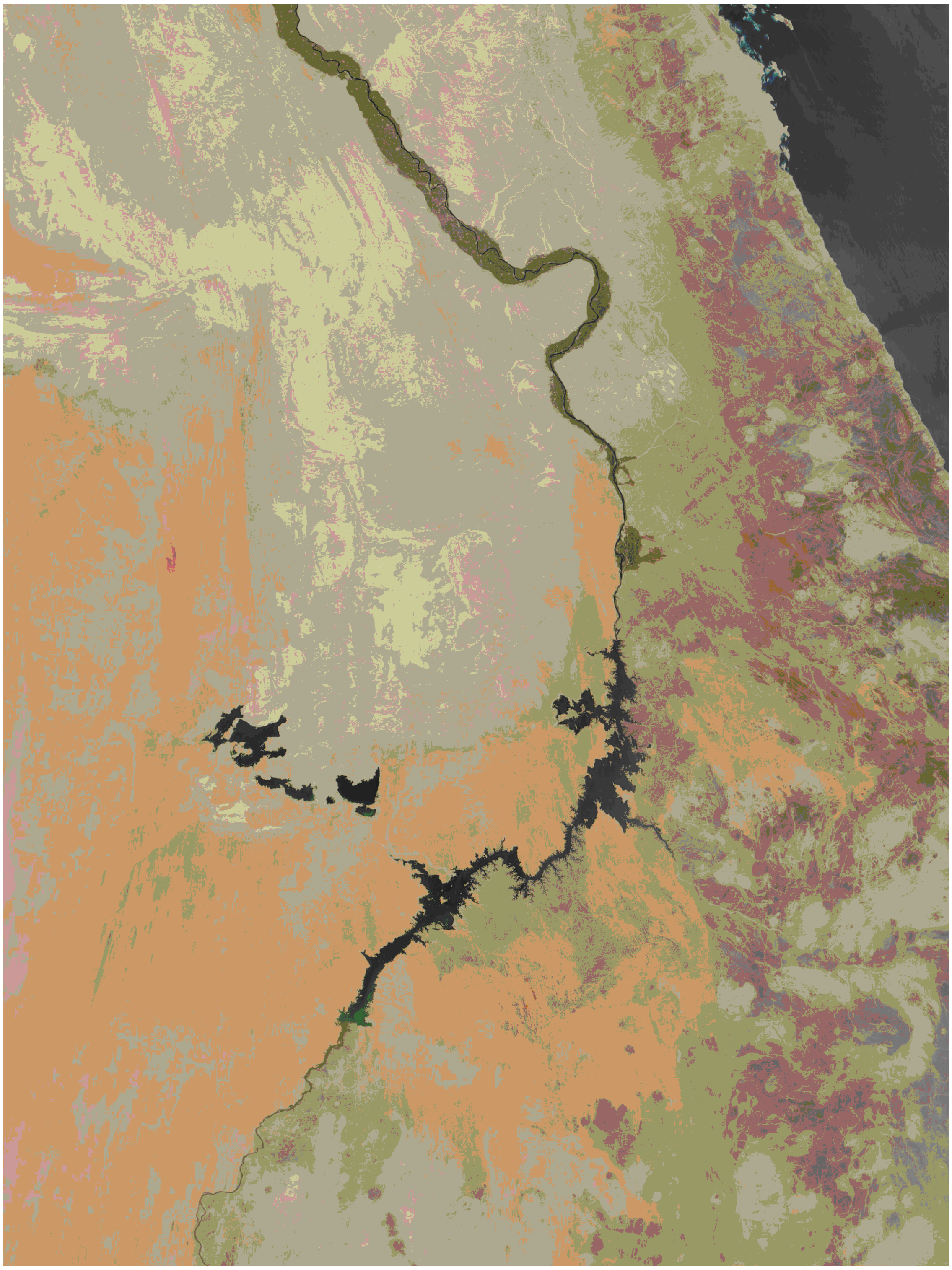
http://daac.gsfc.nasa.gov/data/datapo ol/ -- Web Interface
ftp://g0dps01u.ecs.nasa.gov / -- Command-Line

The Data Pool is a very large (50 TB) anonymous FTP area where "fresh" data are made available on a rotating basis. Its advantage is the ability for users to directly download data of interest, without having to submit an order. This increases the distribution capacity of the EOS Data and Information System (EOSDIS) Core System (ECS) by significantly reducing the need to access a tape archive. It is fairly new and unsophisticated, so the following is information for making the best use of the Data Pool.

So far we have looked at web-sources providing multi-spectral reflectance data for analytical interests. However for presentation purposes you may also be interested in good quality natural color display. For this purpose please have a look at an attractive image gallery under;

Http://rapidfire.sci.gsfc.nasa.gov/gallery/

An example of a "JPG", graphics file image for the Nile basin from the "rapidfire gallery" is shown below



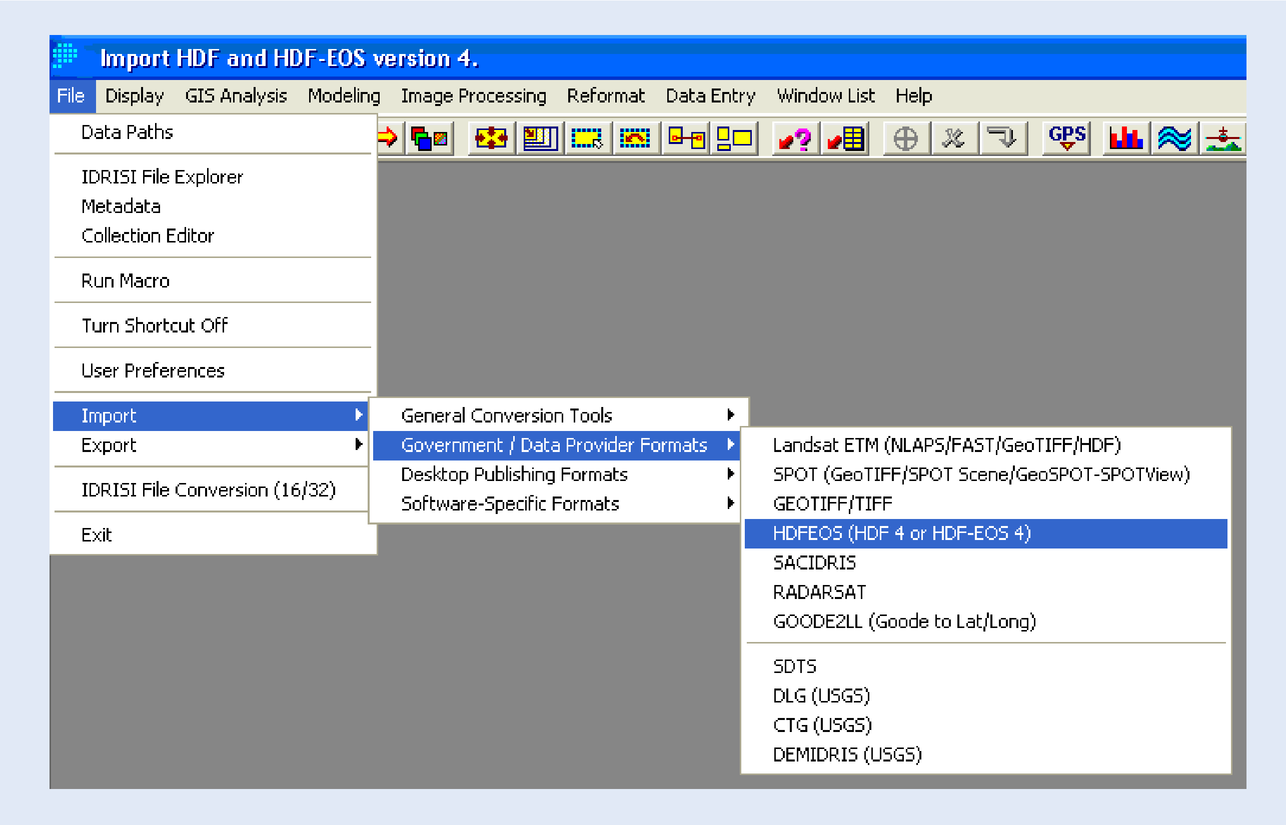
Modis natural color 250 meter resolution graphics for presentations at the "rapidfire gallery".

In this first part of the exercise you have learned where to search, source, browse and download MODIS data on the internet. In the continued exercises, you will now learn how to open a typical download file from the "Data pool" for analytical purposes and image processing in a GIS.

An unprocessed recent image of the Nile Basin was downloaded from the data pool for you. The typical NASA EOS files come in an HDF format, which stands for hierarchical data format. This format usually holds multiple bands in a single file and can be unpacked or read by various modern GIS softwares, including ArcView and IDRISI. For the purpose of automated time series processing we will use IDRISI in this exercise.

- Open the IDRISI GIS software set the Data Path to" C:\Modis training\Rsdata" under the File option on the main menu. (see upper left corner of the screen, also visible in the screen below)

- Open the IDRISI GIS software and select from the File menu Import Government/ Data Provider Fomats HDFEOS. (as shown below)



- Click on the square box behind "HDF file", browse to C:\modis training\rsdata and select the file MOD02QKM. A2005228.0820.005.2005229100028.hdf for opening.

After selecting, please note in the information window that IDRISI specifies 4 different types of information in this HDF file and that these will be represented in four separate IDRISI images. The first two images, listed as band 1 and 2 respectively represent the red and near infrared reflection values not % but in energy/m2. The second two images contain uncertainty statistics for each pixel in each band.

- Use the "tick selection boxes", in front of the file names, to set the first two images to "yes" and the last two images to "no".

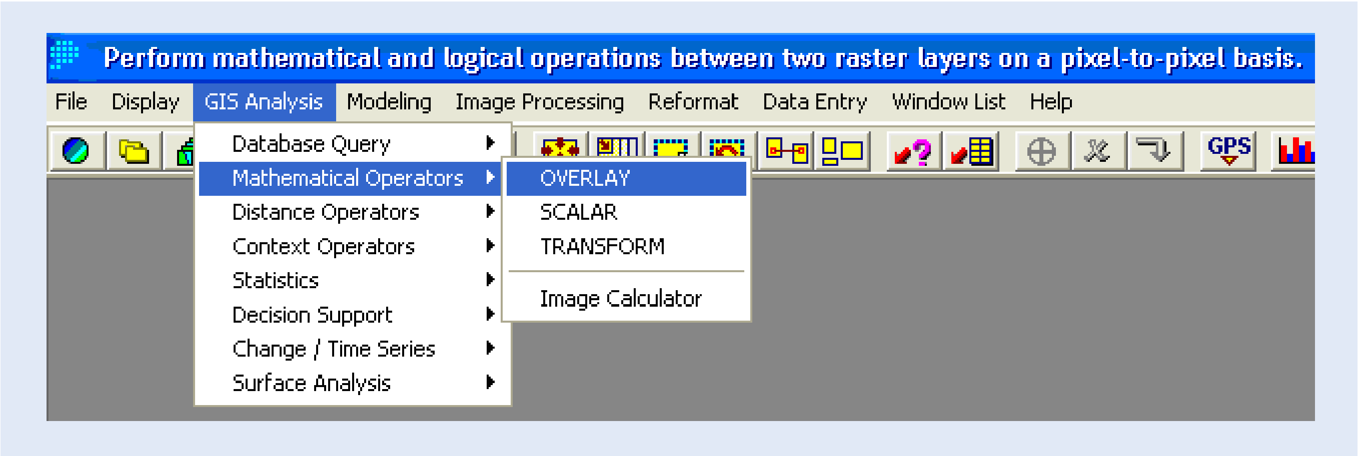
- Change the systems default files names respectively to "Nilemodisaug05B2.rst" and "Nilemodisaug05B1.rst". Then press"run".

- For the EV_250_REFSB image which has meanwhile appeared on your screen, click on layer properties in the composer window, change the palette file name to "terrain" and click apply.

After changing the color appearance on the screen you will easily be able to recognize the course of the Nile riverbed. The fairly low processing status of the image is easily noticed by the lack of proper georeferencing. The map coordinates are identical to the row and column positions. Image artifacts as random and structural missing pixel values can be noticed in some places, due to different rotation speeds of the earth surface at changing latitudes. Smaller horizontal shifts can be seen in a few locations. Nevertheless despite such smaller shortcomings, great spatial detailed is obtained that can help to reveal very recent major changes anywhere in the basin, for all concerned and free of cost.

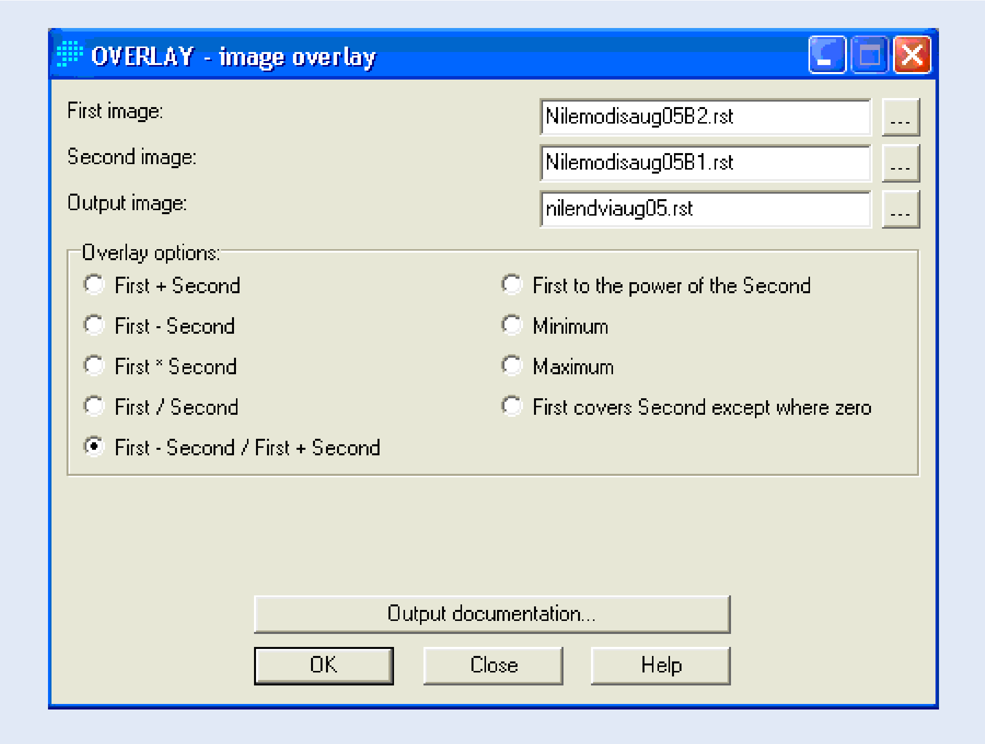
- Zoom in to the image and visually explore any places of your particular interest.

- A visually enhanced image on the vegetation characteristics can now be made by doing an NDVI calculation. For this purpose select "GIS analysis". "Mathematical Operators" "Overlay" from the main menu. A window as displayed below will appear.



In the overlay communication window as show below, a range of arithmetic option between two images are available. The option for NDVI calculation is represented here by "first-second/first+second".

- Load your band2(NIR) as the first image and band1 (Red) as the second image. Select the correct overlay option as shown below and press OK.



- Load the "nilendviaug05" image with the ndvi256 palette and zoom in to your areas of interest

Note that in the "nilendviaug05" image as now on your screen, vegetated areas come out as dark green and barren lands as yellow-greenish. The riverbed and open water surfaces come out clearly in the NDVI. While contrasts in the image have been enhanced, even infrastructural patterns as canals and villages have started to become recognizable.

Where you have now created just one single NDVI image, it is clear that it requires many images to capture characteristic seasonal trends. There are three main considerations in this;

1 Cloud contamination and sometimes technical errors can cause single scenes to have missing values. Such missing values may easily be corrected for by the next image that follows in time, when clouds or errors have passed or cover other areas.

2 Greening responses aggregated over longer periods of weekly, 10 daily or monthly data, are generally more consistent as very time dependant dynamic factors as e.g. flooding or dust-storm influences can be compensated for.

3 Interannual variation of rainfall can cause different greening trends and erratic years or areas with abnormal droughts, can be adequately compensated for.

The dataset that you are going to work with in the rest of this exercise represents 75% of the full current "modis terra archiving period, from November 2000 to April 2004. These data are already aggregated on a 32 day interval for you and generalized to 500 meter spatial resolution. The data are in Goode projection and were obtained from the EOS gateway. As the images already represent 32 periods, considerations of the first and second type, as described above, have been largely catered for. Your task of time series processing of this data set, largely deals with removing residual cloud contamination and correcting for interannual variation.

Where your dataset comes in 32 day periods, the year has 11 images per year per band. This involves a total of 76 images over this period, with a total of 9.1GB of data. It may be apparent that such large data sets require some form of automated processing. This as compared to the single overlay as you have just done or as to what you could handle in the ArcView map calculator. In the next part of the exercise you will learn how to automate such bulk processing needs in the IDRISI Macro Modeller.

- Go to the display launcher and first open one of the 76 reflectance files to explore the appearance of the monthly 500m files as compared to the 250m unprocessed download from 16 August 2005. For this purpose navigate to C:\modis training\rsdata and load any of the 76 files (b2 images recommended for sharper objects)

Please note that this image is georeferenced using the Goode project with coordinate units in meters. (see for parameters in appendix IV) Reflectance values have been scaled from 0 to 255 to allow for compact "byte binary" storage.

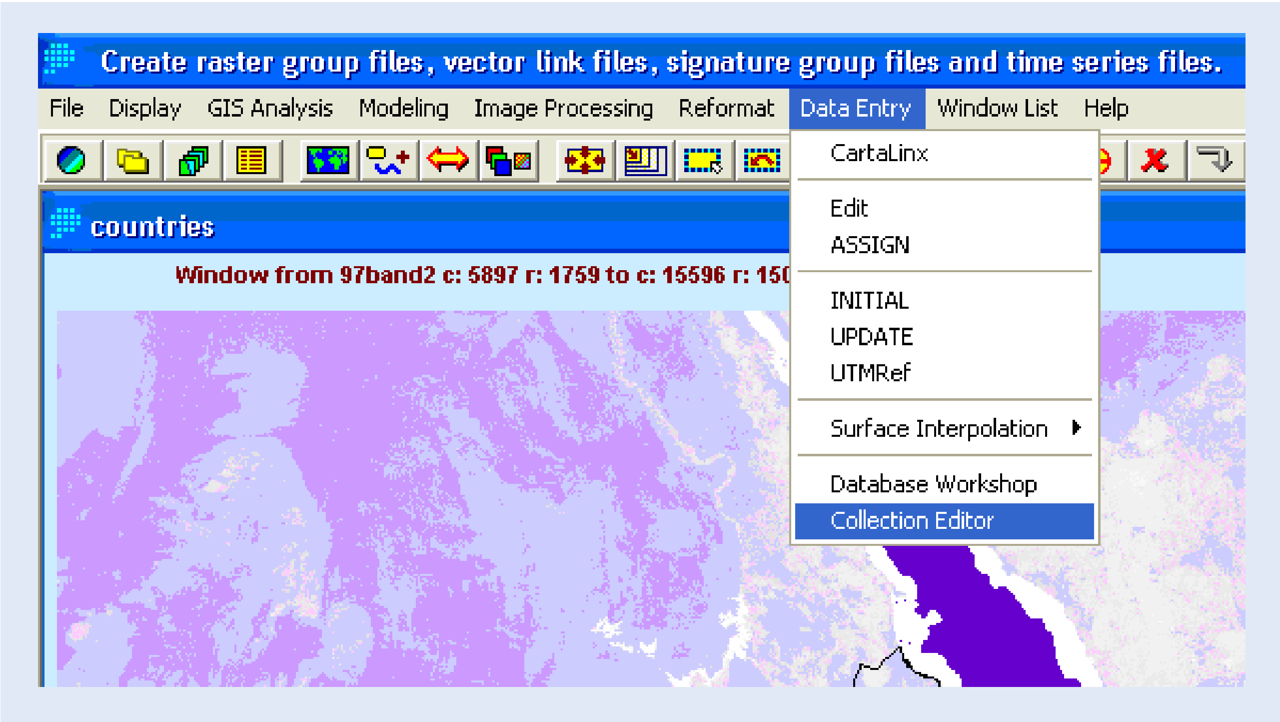
- Load any additional vector layers available under the same path to assist in recognizing your country boundary.

- Use the cursor and the column and row positions indicated at the bottom of the screen to describe a box or window. This window will be used to cut out your area and reduce your database size.

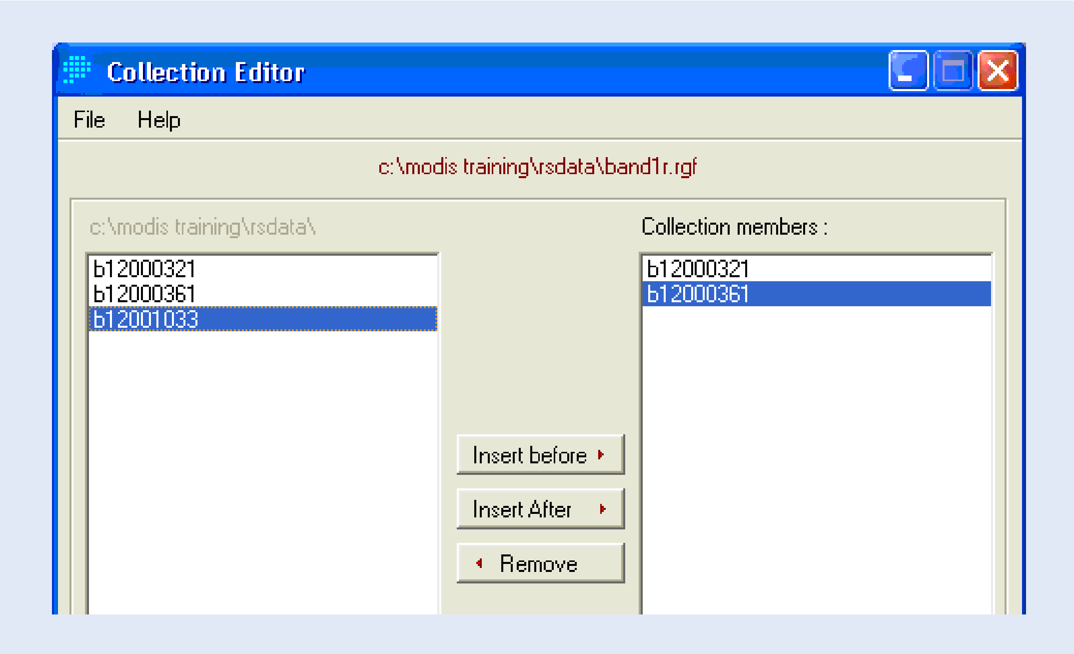
Note down Min Column: Min Row:
Max Column: Max Row:

Now that you have defined the size of your area, you first need to organize your image collection in raster group files for automated processing.

- Select "Data Entry" , "Collection Editor" from the main menu, as shown below.



- Create a new raster group file called "band1R.rgf" under C:/modis training/ and select all the band 1 images one by one to be included in this file, in the correct time sequence. (see example below).

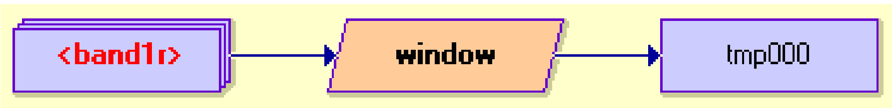


- Create in a similar way the rastergroup file C:/modis training/rsdata/band2NIR.rgf

- Now open the macro modeler tool under the modeling option from the main menu. A subwindow will appear with it's own main menu option. Click on the dynagroup button , select rastergroup file and double click on the file band1R to add its visual display to the screen.

- Click on the module button and select the "Window" module from the list.

- Click on the connection button , then click on the dynagroup display for "band1r", keep the left mouse button pressed and drag it to the "window" module to establish a link as displayed below;



- Give a right mouse click on the window box to get to the parameter setting and set the row and column boundaries for your area, which you noted down earlier in this exercise. Click OK to confirm.

- Give a right mouse click on the outpout box called "tmp000". Here you should specify an automated way of giving output names. In the "Help" file is described how you can assign pre or postfix combinations to existing names in various ways. In this case you can type; cut+<band1r> and confirm by pressing OK. This prefix will add the three letters cut in front of the original file names included in the raster group file band1r.rgf. Without the plus sign it will replace the first three letter by cut, equally you can write this as a postfix. Important is that data references in original file names are not overwritten!

- When you are confident all details of your macro routine are correct, press the run button . The system will warn you that it will overwrite possibly files with identical names if they exist, this is just a warning, please continue. The number of maps involved is indicated, please do not select to display results for all maps. Just press OK.

When looking at your results, please note that not only for every map a "cut map" was automatically generated, but that for this new group also automatically a new "cutband1r.rgf" raster group file was formed. This new group file maintains the same sequence as the input group file, the way you entered it. It can be directly used in further processing.

- Make and repeat an identical macro modeling routine to cut band2 files to the same window.

After reducing the database size that you are going to work with and having learned how to compose and run spatial macro's in the Macro modeler, you can now calculate the 38 NDVI times series maps.

- Think of an automated way for calculating 38 NDVI maps for your window. List below which raster group files you are going to use, which module and which naming syntax you will use for processing of the NDVI maps.
  Raster group files: modules: syntax:

- If you are confident of what to do under the macro modeler, please compile the macro and run it. Otherwise ask for some assistance.

- Verify the success of your operation by displaying one of the resulting maps on your screen. Check if the naming convention you thought of worked well and whether your map files are lying between –1 and +1?

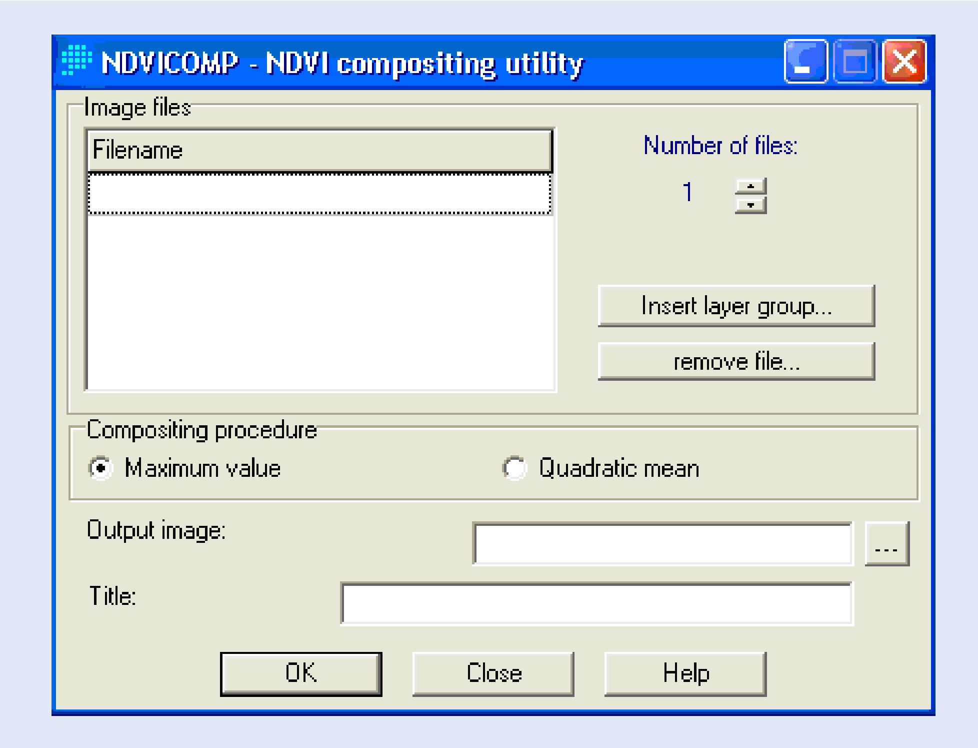
In NDVI it is a common practice to convert decimal NDVI scores from –1 to plus 1 to a binary scale of integers from 0-254. This makes further processing much faster and storage space more efficient. Without loss of significant information a rounding of (NDVI+1)*127, can be used to calculate false integer NDVI images.

- Use the macro modeler and the "Scalar" module to convert your newly created raster group files to false ndvi's as per the equation above and use the "Convert" module to convert the new file formats to "byte binary". Please note that this can all be done in one long interconnected macro!

When your false NDVI maps are correct, you can now proceed with making the summary that reduces the annual trends to just 11 NDVI maps at approximately 1 map per 32 days. This involves the filtering of remaining residual cloud cover as well as non-seasonal, non-structural, erratic drought phenomena. In IDRISI this can be done with the image processing module "NDVIcomp". Essentially any cloud cover or erratic drought will be reflected by abnormally low NDVI. Non clouds and normal growth will have a higher NDVI. So by comparing pixel values for the same period over time and by taking and average or maximum value, problems with clouds and erratic droughts can be taken out. If your time series are long enough, probably it is best to take an average. If the time series are relatively short, you may want to take the maximum instead. Even though that may not be fully representative either, as this might give a bias by including erratic wet periods instead.

- Where the composite processing is done between images that all represent the same time in the year, you will first need to construct 11 new raster group files in which ndvi images are placed together by the last 3 digits of the file name. So all with 033 together and all with 321 together. This will generally give you around 4 images per collection. Open the collection editor and make these new files. Give them a name that somewhere includes the same last three digits for these respective 32 day periods.

- After having completed the new raster group files go to " Image Processing", "Restoration" , "NDVIcomp" at the main menu. A window as shown below will appear.



- Insert your first 32day period raster group, select maximum value and give an output name.
- Press OK to run the composite operation.
- Repeat this in a similar way for the other 10 raster groups.
- Use the display launcher to show one of the composite results on your screen. Select layer properties from the composer window and load the "modisndvi.smp" palette file from C:\modis training\rsdata. Verify the map in appearance as well as in pixel values to assure correctness of your processing.
- If you don't like the modisndvi.smp color palette, you can modify it in the symbol workshop. To do this click on the symbol workshop button and open the modisndvi palette by file open.

When you open the palette file you directly see the color range used. The upper left corner colors are used for the lowest colors in a range the lower right corners for the highest values in a range. Any of the 256 colors represented in the grid can be modified by clicking on it and selecting a new color. The blend tool can be used to extend gradual color transitions between any two hand picked colors anywhere in this flexible color spectrum.

- Try to use the symbol workshop tools, as e.g. manual color picking and blending to make a palette that appeals to you and presents a natural understanding of vegetation dynamics. To judge it, you can save and display it for an image. Then come back to it for re-editing and improve it in an iterative way.
- Now that you have completed the image processing part and master the color display of your images, you will now proceed with the more graphical tasks for the video compilation. Think of any vector layers available under |rsdata that you want to display on top and add them to the display and composer window.
- Use the maximize display button and then press the save button in the composer window. Select copy to clipboard and press OK.
- Open the windows paint program under "programmes" "accessories". Select "Edit" from the main menu and press "Paste". Your complete map display will now appear in the paste program. Here you can further edit

it to take edges of or remove the legend box, as you wish. Important is however that for all the next 10 images each pixel gets exactly the same place. All results also need to get the same row and column numbers, which you can set under "Image" "Attributes" and then be saved.

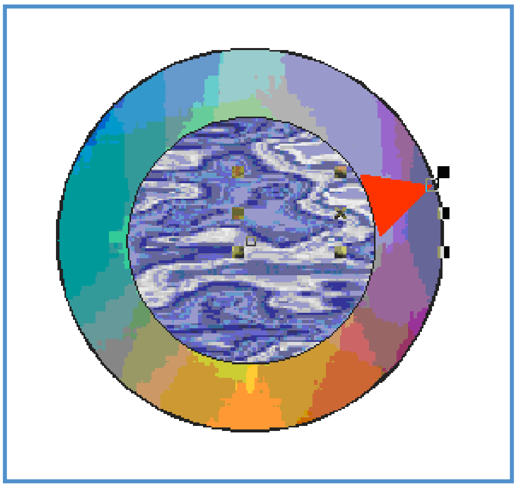
- Edit your first image and save it as a 24bit bitmap file. Do the other 10 images in exactly the same way! Note that any shifts will result in a "wobbly" video.

- If you have solved all your final 11 images in bitmap form, then open the Coreldraw video template file C:\modis training\videotemplate.cdr. This template will help you to add some more advanced graphics, including text and a dynamic clock to your eventual video display.

If you are not familiar with Coreldraw, this is an advanced graphical programme that can handle both raster and vector graphics. You will find easily modifiable text blocs and additional graphics elements that can be visually placed over the stored image bitmaps and then saved as a completely new graphics. Each new graphics file saved from here will serve as one single display scene in your video.

- Go to File Import in the Coreldraw main menu and import the first out of 11 bitmaps that you prepared. After importing click somewhere on the screen to place it. This bitmap graphics now serves as the background layer to the other graphics and the box and other graphics items now need to be moved and possibly resized to make it to combine well with your imported background image. Please take care when selecting any graphic objects to select it as a whole and not as subsections. In order to do this draw a larger select box around it so that everything you want to move is completely included, but nothing else. You may have to pull the black box on the side and put it back at the end. Ask for assistance if you need help.

- One special item added to the video is the clock. There is little editing to it besides placing it at a suitable location on the image and setting the time. In order to set the time, select the coreldraw pick tool on the left side of the screen and click on the tip of the red arrow and keep it placed exactly over this tip. An open square box will appear at the tip as a sign that it is ready to rotate. See the following example;



Keep the left mouse button pressed and drag to rotate the clock arrow to the desired position. Note that you have 11 images to display over the year and that a full circle represents a full year. You can plan approximately for 11 equal intervals for the arrow to move.

- When you are satisfied about the overall layout, including text boxes and clock timing, then go to "File" "Export" on the coreldraw main menu. Give a filename, select save as type "Windows Bitmap" and press "Export".

- In the next window set the resolution at 100 or 150 DPI and set the row and column sizes for your window. Row and columns should not be much larger than 800*600, otherwise the video will be too large to be shown on your screen at once.

- After you have saved the first complete bitmap from Coreldraw, save the coreldraw file in order to maintain all your settings. The next step is to delete the imported background image and to import the next 32 day period image. This needs to be place in the same location as the old one. The black box can give you guidance. Make very sure that you don't move any of the additional graphics items added in Coreldraw, including the black box outline. When things are moved, your eventual video display will be wobbly. Repeat editing and saving the other 10 images with successive clock arrow movement. If you need assistance please call for help.

- The last and final step is to compose and compile your video for display. You need to use a video editing software for this purpose. In this exercise you will be using the GIF animator 5 software, of which a trial version is included on your training cd-rom. To open the GIF animator, go to your desktop screen and double click on the GIF animator shortcut as shown below.

- Where this is a trial version, select"Try now" at the next window.

- After the software has opened select "Animation Wizard" from the pop up screen.

- The animation wizard starts with asking you for the desired canvas size. Enter here the row and column numbers with which you exported your bitmaps from Coreldraw. Then click "Next".

- Next the Animator asks you to select files to be added to the video. To do this click on the "Add Image" button, navigate to the location where you stored the bitmap results from coreldraw and select image 1 to 11 in the correct sequence. Then press "Open" and "Next" on the select file window.

- In the "frame duration" window that has appeared now you can set the display speed. You can either do that by specifying a "Frame rate" or a "Delay time". As these two are interrelated you only need to fill in one of the two. The Demo window show you the speed of display that you have selected. Generally a "delay time" of 300 is very suitable. Select your speed, click "Next" and "Finish" on the final screen to complete the wizard start.

- In the GIF animator software you will now see at the bottom of your screen, 11 frames representing your imported images. You can click on each of these frames to see the image in large in the center part of the screen. Please check that the images were loaded in the correct time sequence according to the clock. Select and drag any frames to their correct sequential position in case the sequence was not correct.

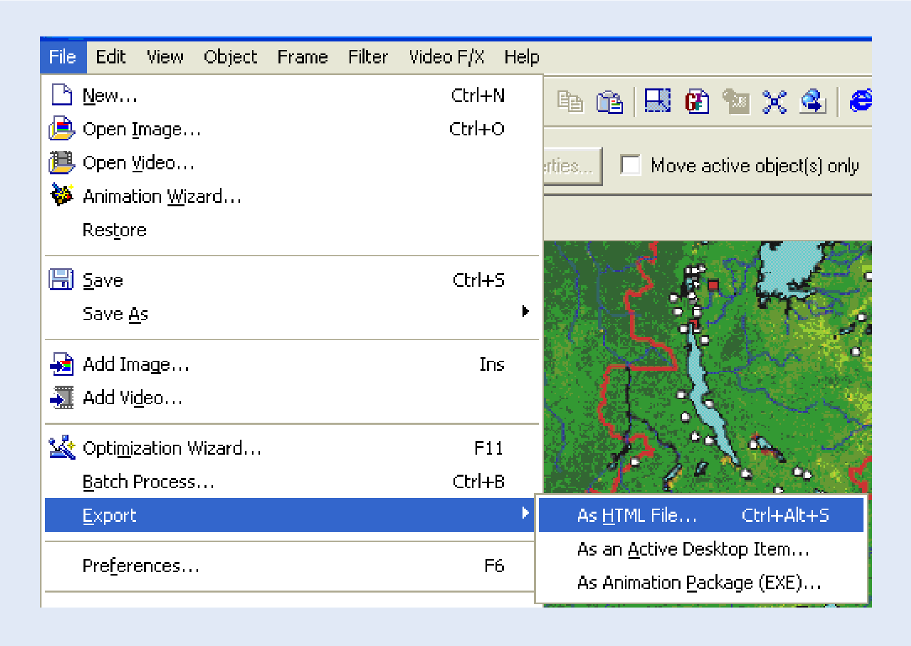
- Click on "Preview" to see the first video display of your time series.

- If your preview is satisfactory, you can consider to add some dynamic text banners to each frame. To do this select the first frame, give a "Right mouse click" and select Add Banner Text...

- The resulting window features a text entry area in the lower left part of the screen. Any text typed here will be displayed with the image through the graphical window in the top. In this graphical window the text position can be changed by dragging the text over the image. Please try typing a text, dragging the location and various layout options being offered to improve your video. When you are confident with this, add sequentially the following dates besides the clock on the 11 images; 2Feb, 6Mar, 7Apr, 19May, 20Jun, 24Jul, 25Aug, 27Sep, 28Oct, 29Nov, 27Dec

- Have a look at the preview for the last time and save the file.

- While GIF Animator can store your video compilation in many formats, a most convenient and compact format to compile your video is in HTML. The advantage is that file sizes are very reasonable, it is very easy to display using the internet explorer, it plays continuous and it can be directly used with hyperlinks to be included in a web page if that would be of any interest. To save your video as HTML, select"File" "Export" "HTML" as shown below. Give a filename and press "Save". Congratulations with compiling this remote sensing video!



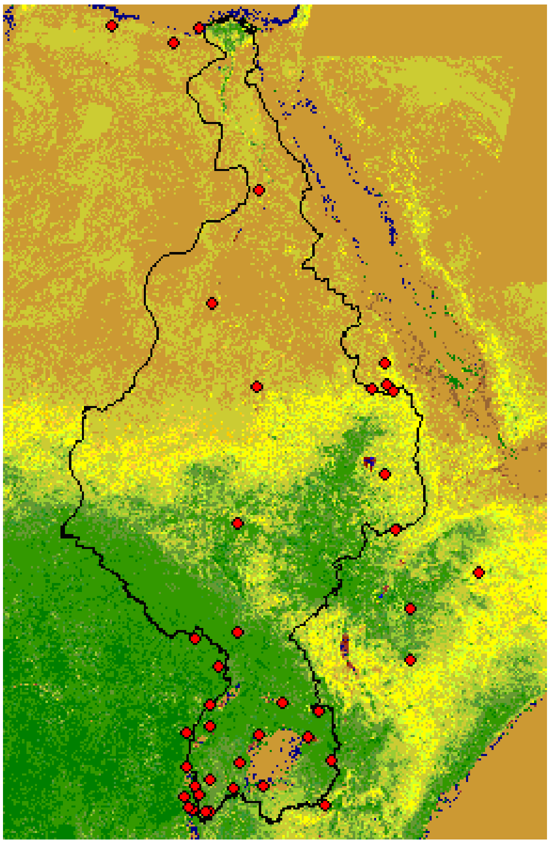
Start of Practical Exercise; "Agro-Meteorological Correlation"

In the first part of the exercise you have learned how to find and obtain MODIS data on the internet. By processing these data in a suitable way, you have been able to provide an insightful understanding of seasonal vegetation dynamics over your country. What remains however is the question on how such greening trends relate in a more quantitative way to the water balance?

In order to try and correlate the NDVI response to general soil moisture conditions for plant growth, a simple surface water balance function will be used as a next step to establish a quantitative framework to understand crop growth seasonality. A comparison will be made between the theoretically calculated length of the growing season and the observed greening responses as observed by MODIS terra.

- Open your 11 false NDVI images in the display launcher and then add the vector file" nilemstat".

- With the "Nilemstat" map selected in the composer window, click on layer properties and click on "Advanced palette/Symbol selection". Select symbol size 8, color red and press OK. You should now see the 40 meteorological stations over the Nile Basin which will be used to correlate the seasonal surface water balance. This involves 4 stations per country as also displayed below.



The meteorological stations do not all fall within the Nile Basin, as they were also selected to represent variable conditions for agriculture. With some pre-knowledge, stations were selected at variable altitudes and under different rainfall regimes. Where the meteorological station coordinates come from a general database without specification of an exact georeferencing system, the station locations as indicated on the map must be considered as approximate locations.

In order to compare greening patterns of strictly agricultural lands in the direct neighbourhood of the meteorological stations, the use of land cover maps is required. For this purpose the national FAO Africover databases will be used. For Ethiopia an attempt will be made to distinguish and on-screen digitize an area of cropland from digital navigation chart in combination with a regional farming systems map.

- Minimize IDRISI and open Arcview, select "open an existing project file", navigate to "C:\modis training\" and open the project file called "selecting cropland areas for agro-meteorological correlation".

- For all countries other then Ethiopia open the "Africover" view. For Ethiopia open the "Farming systems & navigation charts" view.

---------------- (Non Ethiopia instructions)--

- Open the windows explorer and navigate to the folder "C:\modis training\africover. Select the relevant africover zip files for cultivated land and unzip the map layers that you need, to identify the cultivated areas.

- Zoom in to the area that contains your four meteorological stations and switch on the display for the pre-selected cropland areas, called"sampleareas". This sampleareas vector file is also available in IDRISI and can be overlaid to extract NDVI value statistics.

- Look at the areas that were preselected and try to explore which specific land cover types they represent. Use the map legends and possibly the africover PDF national legend files to do this.

- Note down below, station names and the statcor value in the sampleareas shapefile, corresponding to each station. Then note down what type of landcover or cropland was selected to correspond with each station;

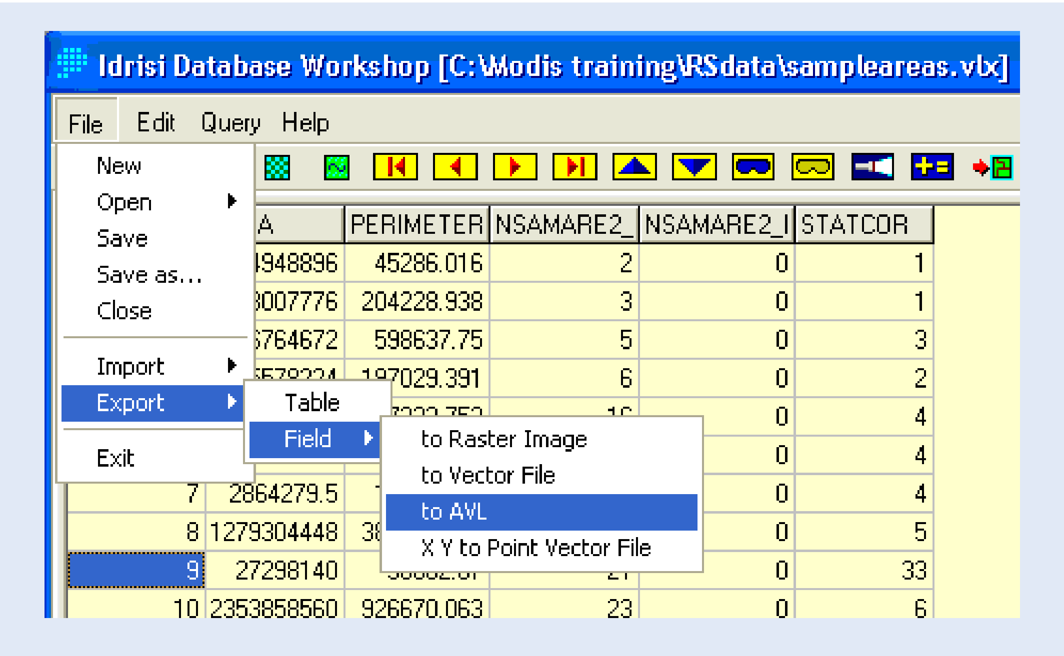
Station 1:	Statcor:	Land Cover class:
Station 2:	Statcor:	Land Cover class:
Station 3:	Statcor:	Land Cover class:
Station 4:	Statcor:	Land Cover class:

- Maximize the IDRISI display. Select "File" "Import" "Software Specific formats" "ESRI formats" "ShapeIDR".

- Select the option"Shapefile to Idrisi" and click on the square box behind "input file" and browse to select the "sampleareas.shp". Specify the outfile name as "sampleareas" and leave the reference information as " plane" and click "OK".

- Go to "Data entry" on the IDRISI main menu and select "Database workshop". In the workshop window go to "File open" and select the file"sampleareas.vlx". This vlx file contains all the attributes of the orginal sampleareas shapefile. Upon importing shapefiles in IDRISI, the resulting vector file with be labeled with orginal polygon id's. If we wish to change them to the "Statcor" numbers we need to run an "Assign" operation, using an IDRISI attribute values file. We will first make this attribute value file in the data base workshop.

- In the database workshop go to "File" "export" "field" "to AVL" as shown below.



- Use IDR_ID as link field and "Statcor" as data field name. Give the attribute value filename as "sampleareas" and click "OK".

- Now go back to data entry and click "Assign". Select the vector file option, give "samplearesa" as the feature definition file and attribute value file. Give "Areas" as output file name and click OK. A new vector file has now been created where the polygon values are equal to the statcor values. The next step is to start extracting the NDVI statistics.

--------------(Ethiopia instructions)--

- In the "Farming systems & navigation charts" view, zoom in to the most northern station called "Debre Tabor". Keep the station in the center of the screen and set the map display scale to; Scale 1: 500,000

After this switch on the display of the map layer "DebreAddis.img". You will now see a detailed topography layer appearing on your screen.

- Select the cropzones raster map layer as the active theme and use the information button to click over your screen and find out which characteristic cropping systems are reported for this area.

- Discuss together, based on the knowledge of your country where on the screen you could draw a polygon that would most likely represent cropland.

- When you know where to select your cropland, click on the digitize button  on the Arcview toolbar. Start digitizing with a single clicks of the mouse and close with a double click. Save the new shapefile as "ETHsel1.shp".

- Switch off the "DebreAddis.img" display before you zoom out otherwise it will slow your machine and clog your view. Then zoom out and zoom in again to the next station. Repeat setting scales to Scale 1: 500,000 and display the corresponding "*.img" to look at the topography.

- In this way digitize in total four polygons for likely cropland, relating to the direct environment of each meteorological station.

- When you saved the shapefiles "ETHsel1-4", call assistance from the training supervisor for projection to the correct Goode parameters and further use in IDRISI. When ready please continue as given below with theprojected shapefile received from the training supervisor.

- Maximize the IDRISI display. Select "File" "Import" "Software Specific formats" "ESRI formats" "ShapeIDR".

- Select the option"Shapefile to Idrisi" and click on the square box behind "input file" and browse to select the projected file from the suprvisor. Specify the outfile name as "ETHsampleareas" and leave the reference information as " plane" and click "OK".

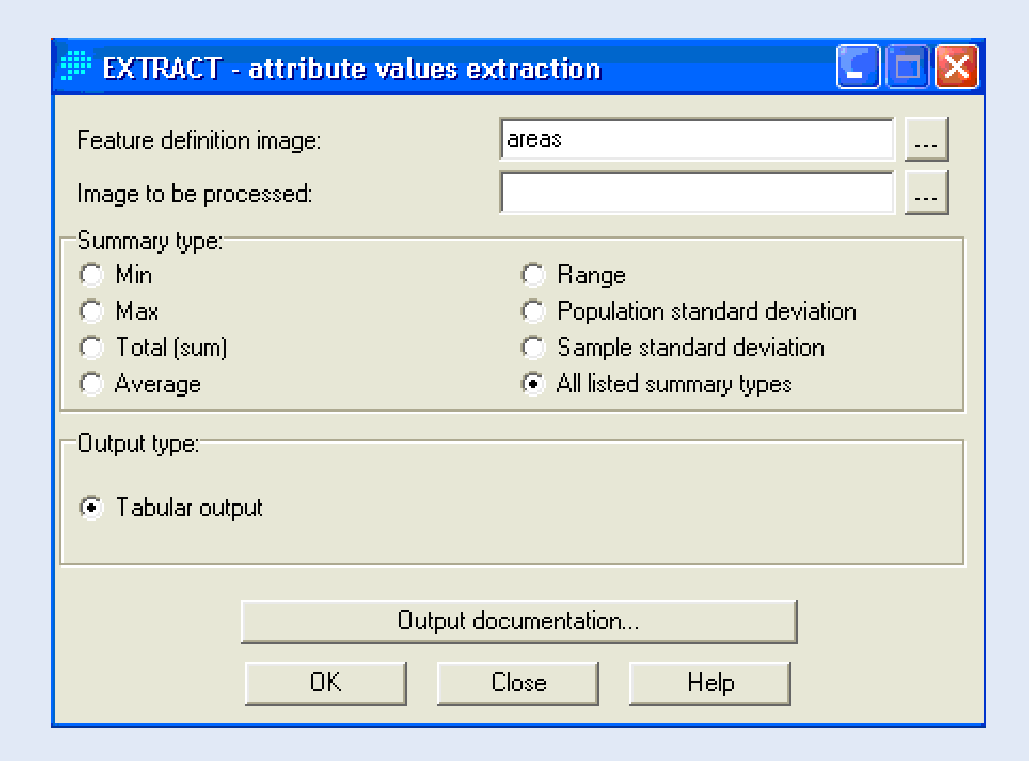
------------ (Continued instruction for all countries)--

In order to extract a range of spatial statistics for subareas in an image you will use the statistical GIS analysis function called "Extract". Extract required two images as input to the operation, one image with the data to be analyzed, in this case the monthly NDVI's . The other image is the feature definition image, in this case your sample areas. As your sample areas are still in vector format you first need to convert this to raster.

- Make an empty raster file through "Data Entry" "Initial". Select "copy the spatial parameters from another image. Give the raster output filename "Areas". Use one of your cutout NDVI images as the image to copy parameters from. Choose data type "byte" and initial value "0". Then press OK.

- Select "Reformat" "RASTERVECTOR" via the main menu. Select "Vector to raster" and "Polygon to raster". Give "Areas" as the image file to be updated and "Areas" or "ETHsampleareas" as the vector polygon file. Then press OK. Your rasterized areas will be shown on the screen.

- Now go to "GIS analysis" at the main menu, from there select "Statistics" "Extract".Give "Areas" as the feature definition image and select the first out of 11 false NDVI images as the image to be processed. Further select "all listed summary types" and " tabular output" as shown in the window below. Then press OK.



- Module results will be shown in a new window on your screen, as shown below. The ID number correlates with the area polygon and Statcor number that you noted earlier for each meteorological station. The next 6 columns represent statistics for the subareas, except column 5, which holds standard deviation statistics for the image as a whole.

ID	Minimum	Maximum	Total	Average	Range	Population_SD	Sample_SD
0	0	254	5.62927E7	225.5172	254	30.37748	30.37754
1	-9999	-9999	0	0	-9999	0	0
2	-9999	-9999	0	0	-9999	0	0
3	-9999	-9999	0	0	-9999	0	0
4	-9999	-9999	0	0	-9999	0	0
5	-9999	-9999	0	0	-9999	0	0
6	-9999	-9999	0	0	-9999	0	0
7	-9999	-9999	0	0	-9999	0	0
8	-9999	-9999	0	0	-9999	0	0
9	-9999	-9999	0	0	-9999	0	0
10	-9999	-9999	0	0	-9999	0	0
11	190	240	12250	226.8519	50	9.98593	10.0797
12	185	234	32150	218.7075	49	11.47918	11.51843
13	178	241	256609	216.7306	63	10.46992	10.47434

- Repeat this extract operation for the 10 other remaining NDVI periods and fill in the following four correlation tables, one for each of the 4 meteorological stations..

Table 1:				
Station4. Name:		**Lancover type:**		
Date:	Minimum NDVI	Maximum NDVI	Average NDVI	Sample standard deviation
2 Feb				
6 Mar				
7 Apr				
19 May				
20 Jun				
24 Jul				
25 Aug				
27 Sep				
28 Oct				
29 Nov				
27 Dec				

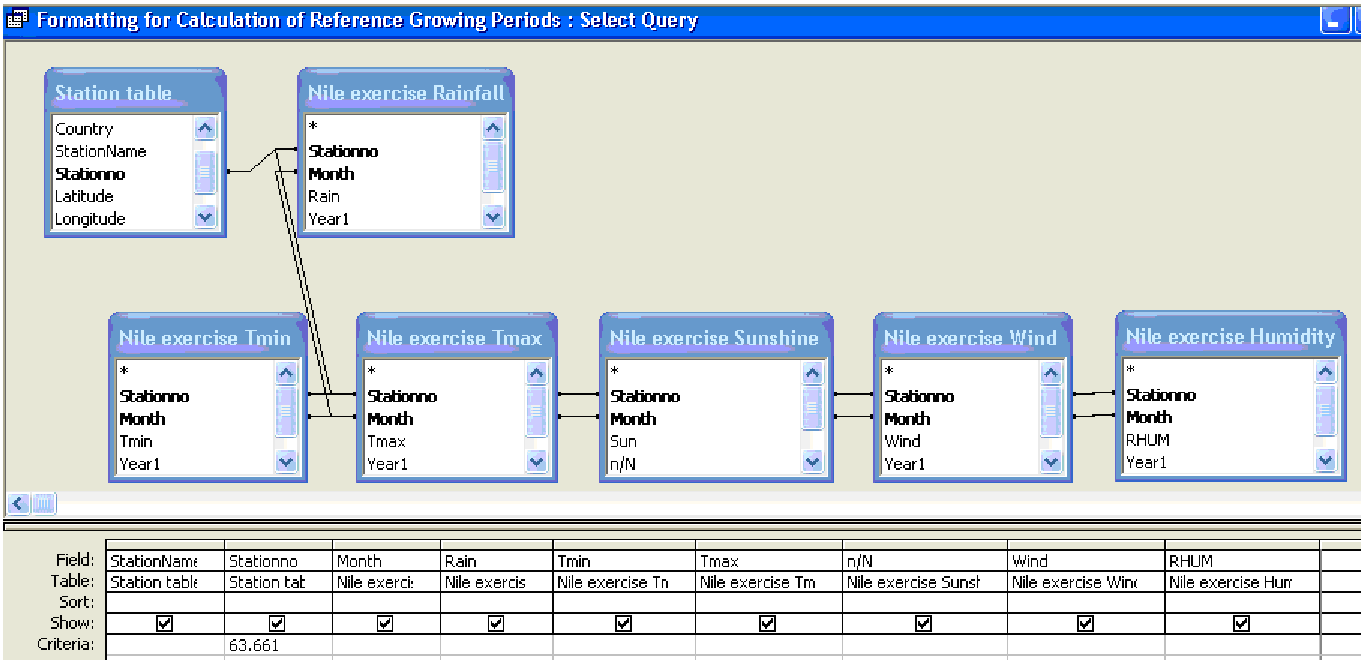
Table 2:				
Station3. Name:		**Lancover type:**		
Date:	Minimum NDVI	Maximum NDVI	Average NDVI	Sample standard deviation
2 Feb				
6 Mar				
7 Apr				
19 May				
20 Jun				
24 Jul				
25 Aug				
27 Sep				
28 Oct				
29 Nov				
27 Dec				

Table 3:				
Station2. Name:		**Lancover type:**		
Date:	Minimum NDVI	Maximum NDVI	Average NDVI	Sample standard deviation
2 Feb				
6 Mar				
7 Apr				
19 May				
20 Jun				
24 Jul				
25 Aug				
27 Sep				
28 Oct				
29 Nov				
27 Dec				

Table 4:				
Station1. Name:		**Lancover type:**		
Date:	Minimum NDVI	Maximum NDVI	Average NDVI	Sample standard deviation
2 Feb				
6 Mar				
7 Apr				
19 May				
20 Jun				
24 Jul				
25 Aug				
27 Sep				
28 Oct				
29 Nov				
27 Dec				

As the image processing and NDVI analysis part has now been completed, next is to organize the meteorological station data for calculation of the reference growing periods through a simple water balance function as decribed on page 9 of this manual. For the calculation there is an MsAcces file available which contains all your required meteorological parameters on rainfall, temperatures, sunshine, wind and humidities. Spreadsheet tools that calculate the water balance, growing seasons and visual graphs for you, will be further used to summarize your finding and make some conclusions.

- Open the MsAcces file called "Climatological Monthly Station Data" stored under C:\modis training\Agrometeo. You will find six data tables and one station table.
- Click the query tab and select "New".Select design view and add all seven tables to the query.
- Arrange the tables and relation links in a similar way as shown on the next page. Set all query joins to "type 1 equal". Add to the field selection sequentially the; StationName, Stationnumber, Month, Rain, Tmin, Tmax, n/N, Wind and Rhum. Toggle back and forth between "Design View" and "Datasheet View" to see the result. Finally save the query as "Formatting for calculation of reference growing periods".



- Type any of your station numbers as can be found in the station table under "Criteria" for the Stationno field.

This will give you all monthly data that you need on a single station basis.

- Minimize your MsAcces screen and now open the MsExcell, spreadsheet file called "Ecoregional Growing Seasons" in the folder C:\Modis Training\Agrometeo.

The spreadsheet that you have just opened is fairly complex and contains various functions for the calculation of the annual solar cycle, calculation of Penman potential evapotranspiration as well as simple water balance functions to calculate the number of moisture seasons with their durations and dates. For this exercise only make changes to add your own meteorological station data to the green areas in the worksheet called "Growing Season".

- Choose the first meteorological station that you want to assess and modify in the "Growing Season" worksheet the data on Name, Latitude, Longitude and Altitude. An example of where to change this precisely is shown below.

3	***Station:***		Kitale	
4	***latitude:***		1.01	*degrees*
5	***longitude:***		35	*degrees*
6	***altitude:***		1875	*meters*
7	***Koppen climate:***		A	

- Now scroll down to approximately row 40 in the same worksheet to find the locations where the the meteorological data can be changed.

- From the Access query that you have created previously, select the correct station number and select the first data block of "Rain-Tmin-Tmax" as shown on the next page below. Use Copy and paste to transfer these numbers into the correct green colored area of the spreadsheet. To do this click on cell B41 Precip., give a right mouse click and select "Paste".

eference Growing Periods : Select Query

Month	Rain	Tmin	Tmax	n/N
1	30	10	27	0.75
2	26	10	28	0.74
3	74	12	27	0.68
4	145	13	26	0.63
5	156	12	25	0.65
6	124	11	24	0.62
7	161	12	23	0.49
8	164	11	24	0.49
9	115	11	25	0.6
10	105	11	26	0.6
11	82	11	25	0.62
12	59	10	26	0.67

- Follow the same copy and paste procedure to add" Sun-Wind-Humidity" data.

- Read your instant agro-meteorological summary results from the top of the "Growing Season" worksheet. This looks like as is shown below.

3	*Station:*		Kitale				*Thermal Regime*		*Start*	*End*	*Length*	
4	*latitude:*		1.01	*degrees*			*Tday >*	25	0	0	0	*days*
5	*longitude:*		35	*degrees*			*Tday >*	20	22 / 9	28 / 6	279	*days*
6	*altitude:*		1875	*meters*			*Tday >*	15	N.A.	N.A.	365	*days*
7	*Koppen climate:*		A				*Tmean<*	5	0-Jan	0	0	*days*
8	*Number of reference growing periods:*			1	totalling 314 days		*Tmin <*	0	0-Jan	0	0	*days*
9							*Tmax>*	25	26 / 9	10 / 5	226	*days*
10												
11	*MOISTURE SEASON I*											
12	*Description:*	normal	*rains with temperatures*		unconstrained		*Moisture Regime 1*		*Start*	*End*	*Length*	
13	*Duration:*	314	*<----- days*				*Pr.exceeds PET --->*		7 / 4	9 / 9	155	*days*
14	*BEG*	11-Mar	*beginning of growing period*				*Pr.exceeds 0.5PET ->*		11 / 3	11 / 12	275	*days*
15	*BH*	7 / 4	*beginning of humid period*									
16	*EH*	9 / 9	*end of humid period*				*Period 1 rainfall surplus:*			185	*mm*	
17	*ER*	11 / 12	*end of rains*				*Maximum soil moisture storage:*			100	*mm <--- change here*	
18	*END*	19-Jan	*end of growing period*		next year		*Actual soil moisture recharge:*			100	*mm*	
19							*Stored moisture theoretically depleted after:*				39	*days*
20	*MOISTURE SEASON II*											
21	*Description:*	no	*rains with temperatures*		unassessed		*Moisture Regime 2*		Start	End	*Length*	
22	*Duration:*	0	*<----- days*				*Pr.exceeds PET --->*		none	none	0	days
23	*BEG*	none	*beginning of growing period*				*Pr.exceeds 0.5PET ->*		none	none	0	days
24	*BH*	none	*beginning of humid period*									
25	*EH*	none	*end of humid period*				*Period 2 rainfall surplus:*			0	*mm*	
26	*ER*	none	*end of rains*				*Maximum soil moisture storage:*			100	*mm*	
27	*END*	none	*end of growing period*				*Actual soil moisture recharge:*			0		
28							*Stored moisture theoretically depleted after:*				#DIV/0!	days

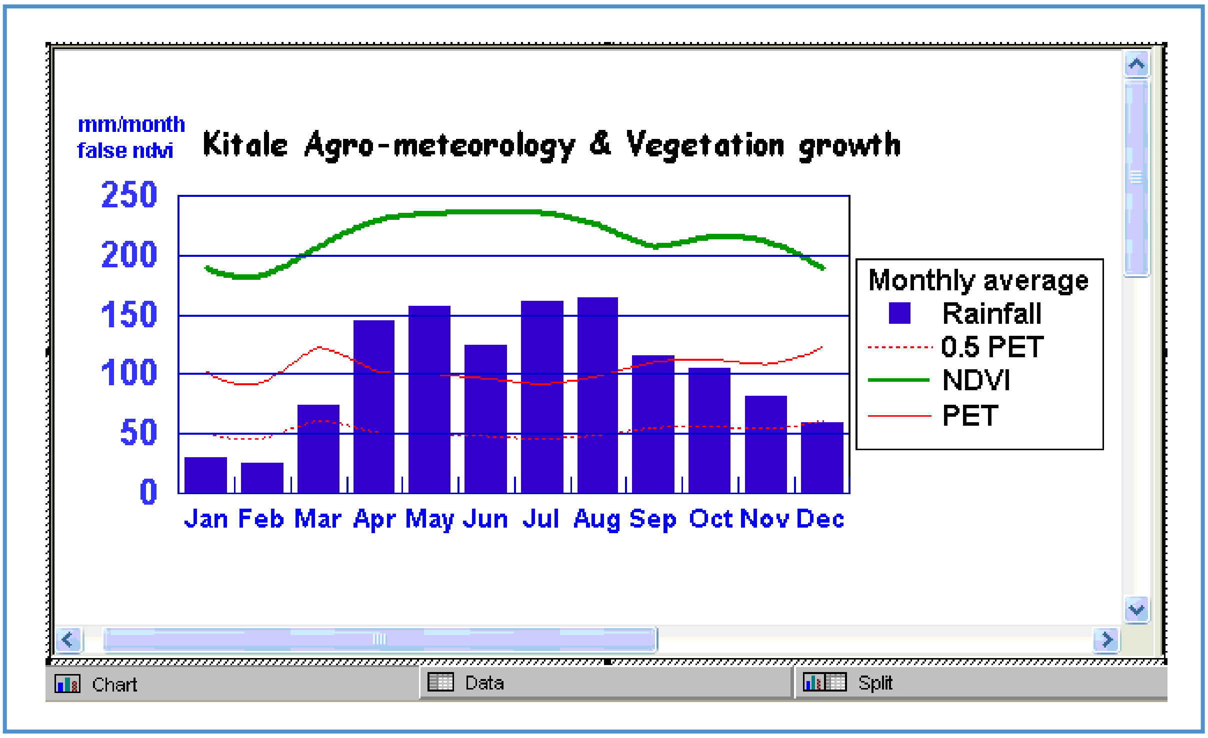
The Agro-meteorological result can be read as follows; One long moisture season has been assessed for Kitale without periods where temperatures become a serious constraint. Rains start exceeding half of the potential evapo-transpiration by 11 March and by 7 April rains are in excess of evapotranspiration until 9 September. In this humid period an excess rainfall of 185 mm is received and soil moisture will have been recharged. Rains continue to be above half evapotranspiration until 11 December, by which rains are becoming sparse. However soils are generally sufficiently wet to support plant growth until 19 January of the next year. From 19 January until 11 March there is an approximate period of 7 weeks relative drought. The reference growing period, RGP, during which plants prosper to grow is relatively long, with a total of 314 days.

- To summarize your results in an insightful graphical way, now open the "Agro-Summary" spreadsheet which is also stored under C:\Modis training\Agrometeo. In this spreadsheet you will see a simple table and a graph. The data in the yellow parts of the spreadsheet are linked and thereby directly read from the "Ecoregional growing season" calculation spreadsheet.

- Type in the green part your average false NDVI values as you wrote down for this particular station in one of the earlier tables. Repeat the first and the last to get to 12 numbers. In the red field on the left this is directly converted back to original NDVI values in the scale from –1 to +1.

- The graphics display is not a standard MsExcell tool but uses an Harvard Graphics add in. The link of the data to the graph is not automatic and needs to be updated by copy and paste. In order to do this, select the complete data block in the upper part of the spreadsheet however excluding the text part. Give a right mouse click and select "Copy".

- Now double click on the graphics part so that it becomes activated for editing. You will see that at the bottom of the graphic subscreen 3 tabs will appear, one for "Chart", one for"Data" and one called "Split". See for an example screen on the next page.(If you don't see it, try to scroll down)



- Click on the "Data" tab and you will see the same "data block" as in the spreadsheet which you have just copied. Put your cursor on cell B2, give a right mouse click and select "paste". Click on the "Chart" tab to go back to the graphics, which has now been updated with new data.

- Double click on the title of the Graph and change "Kitale" to any other station name to which your results apply. Now have a careful look whether the trends in bars and curves correspond with your numbers and assess whether the outcomes make any sense to you?

- When you are ready leave the graphic editor, by just clicking anywhere in the Excell spreadsheet part. Now give a single click on the graphics and with a right mouse click select "copy".

- Open a new MsPowerpoint file for your presentation, insert a blank slide and paste your graphical result from the agro-meteorological assessment in this slide.

- Note down in a second slide, the results from the growing season calculations.

- Repeat the general procedure of calculating growing seasons and making combined graphics for the other three meteorological stations and all results to the powerpoint slides.

Congratulations with completing all this analytical work! The last task remaining is to prepare your results for a short 10 minute presentation. Use the powerpoint presentation already made to add a view more sheets on observations and conclusions. In the last sheet, write down in a few scentences, what you know about the four agricultural areas in terms of farming and crops and wether you thing your results have brought you additional useful information and understanding?

Ingredients of your 10 minute presentation should contain;
* Your video presentation
* A Powerpoint presentation discussing sequentially by agricultural area;
    1 Analysis results
    2 NDVI Correlation and possible explanation of discrepencies
    3 A description of what you know about farming in the area
    4 Special remarks