Practical exercises Lesson 4: Import of (multi-temporal) VGT4Africa data (NDVI, FCOVER, LAI, PHENOKS), data quality assessment indicated by the status map and deriving (aggregated) statistics.

Introduction on import and processing of VGT4Africa products
As you have observed in lesson 3 the LSA SAF is also producing products related to Vegetation Parameters. These products are based on the MSG\SEVIRI instrument and are generated on a daily basis. The products you are going to work with now are based on the SPOT Vegetation instrument and are 10-day aggregated products. Further information is provided in the VGT User Guide (see theory lesson 4) and you can have access to the historical data using the following link: http://free.vgt.vito.be/.

Before starting to import the various products that are available in the GEONETCast data stream derived from the SPOT Vegetation Instrument you need to check the settings of the directories that contain the raw data. From the "*Geonetcast"* and *"Toolbox*" main menu select the option "*Configuration*" and "*Folder*" and select "*SPOT VGT4Africa*". Browse to the appropriate data input and output locations and in the case of VGT4Africa products note that the data is stored in the directory *"E:\GNC_data\VGT4Africa"*, where "*E:*" is the designated DVD drive location. Here as output location "*d:\GNC_out*" is used. Press "*Save*" to store the settings. Then press "*Close*".

1. Import of a 10-day NDVI product from VGT4Africa.
Note that the VGT4Africa products are a decadal product, in order to import the various products the "*Date*" format here should be specified as: yyyymmdecdec, where dec stand for decade. There are three decades, specified as 01, 11 and 21, for the first 10 days, the second series of 10 days and the remaining days for the last decade of the month respectively, so 20100121 as "Date" should be interpreted as: year = 2010, month = January, decade = 21 (third decade of the month).

Consult from the theory session of lesson 4 the "*Vegetation for Africa User Manual*" and read the S10-NDVI product description before you continue (pp 97- 105). The document can also be downloaded from:
http://www.vgt4africa.org/PublicDocuments/VGT4AFRICA_user_manual.pdf.

For the exercise use is made of the 20091201 S-10 NDVI. From the "*Geonetcast"* and *"Toolbox*" menu select "*SPOT VGT Products"* and *VGT4Africa*" and subsequently "*NDVI*". Import the VGT4Africa NDVI map, see also the specifications of figure 1. Also check the command window's information during the import.

Note that the import routine only allows you to import the VGT4Africa products that have a full continental coverage. If you are interested in subsets of the data it might be more convenient to use the VGT Extract Utility. This utility allows you to transform the data to an ILWIS raster format as well. I can be obtained from: http://free.vgt.vito.be/.

Upon completion of the import select the imported NDVI map, here "*ndvi20091201*", display the map using as "*Representation*" "*NDVI1"*. See also figure 2. Move the mouse

while keeping the left mouse button pressed over the active map display window. Note the scaling and offset values used in the heading of the active map display window as well. Also display the country boundaries (no info! and boundaries only).

Figure 1: VGT4Africa NDVI import window

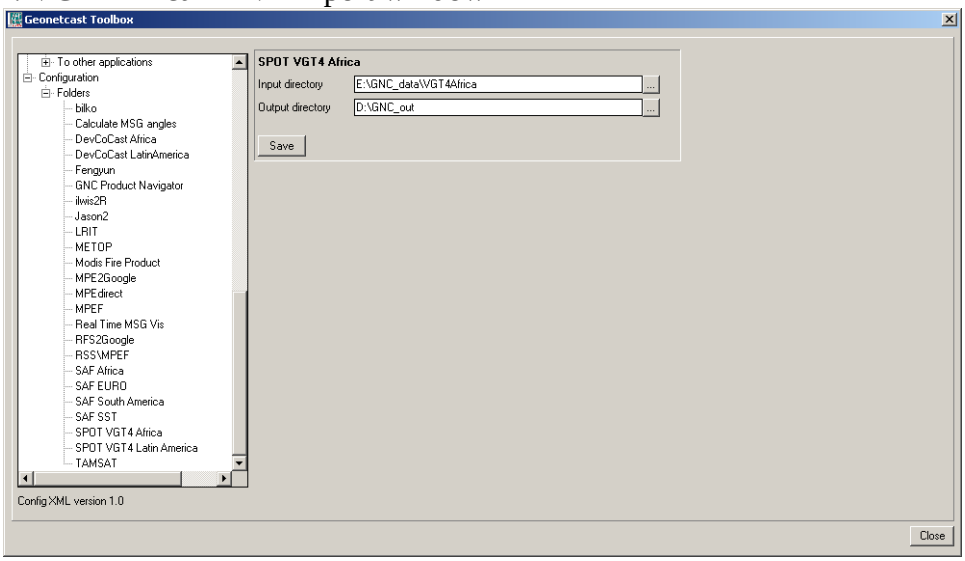
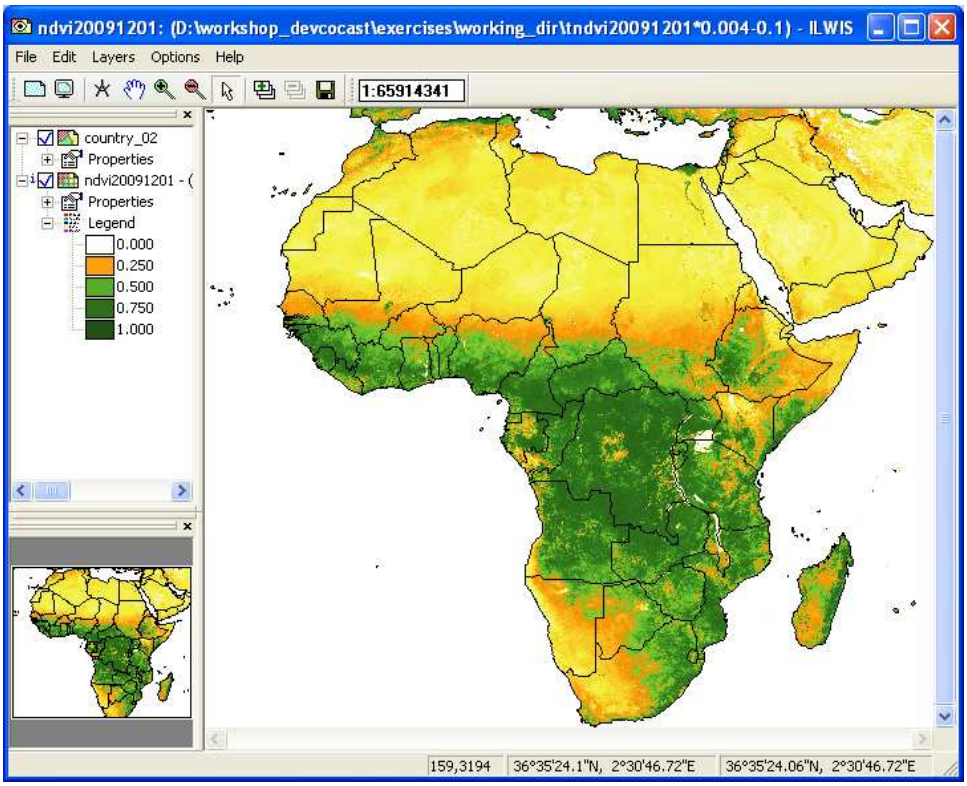


Figure 2: The imported NDVI map



In a similar way the other products disseminated via VGT4Africa can be imported. Continue to import a few other products that have been described during lesson 4, e.g the Leaf Area Index (LAI), the Fraction of Vegetation Cover (FCOVER) and PHENOKS.

Use the same date / decade for these products as the NDVI map imported previously. In order to conduct the import select from the "*Geonetcast*" and "*Toolbox*" menu "*SPOT VGT Products*", *VGT4Africa*" and subsequently the required import routine for the product you want to import (LAI, FCover, PHENOX). Use the appropriate Representations for the products, e.g. for the NDVI :"*NDVI1*", for the FCOVER: "*fvc*", for the LAI: "*lai*" and for PHENOKS products (phstart, phhalf, phlength) a "*pseudo*" Representation can be used.

Further information on the products can be obtained in the relevant sections of the "*VGT4Africa User Manual*". Upon completion of the import check the values of the maps created. The results should resemble those of figure 3.

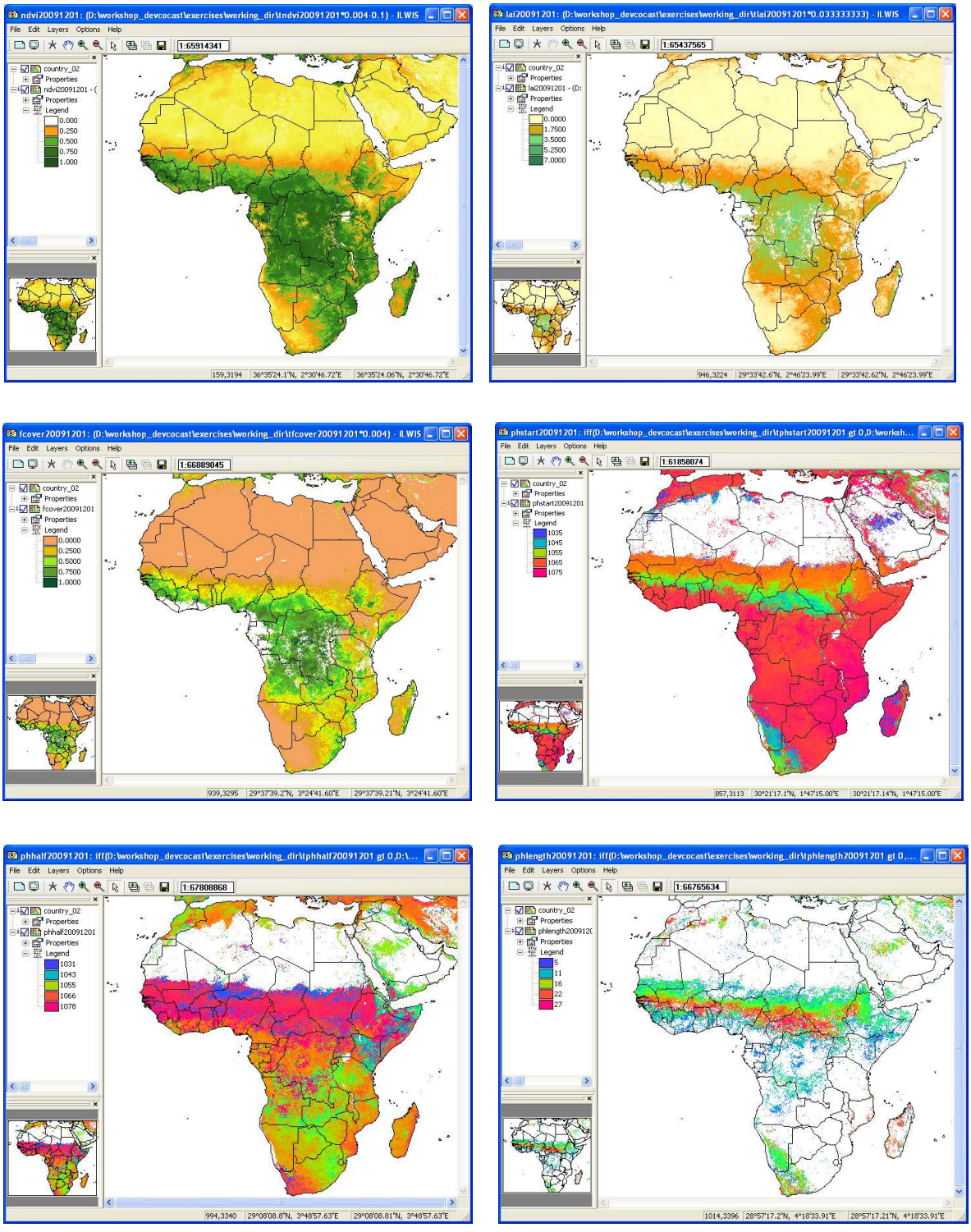
Some of the VGT4Africa products come with a status map which can be used to filter the values on their quality. Display the Status Map, using the default settings, that was created when importing the NDVI map, having the same name as the NDVI map but with a file name extension "*_SM*". Check the values of this map as well. Note that a byte range is used for this map. The status map needs to be interpreted on a bitwise basis. The status map flag filter matrix for the NDVI product is shown in figure 4.

Figure 4: The NDVI Status Map flag filter matrix

Bit Sequence	Meaning
X X X X X X 0 0	Clear (cloud-free) pixel
X X X X X X 0 1	Shadow detected
X X X X X X 1 0	Shadow/cloud detection is uncertain
X X X X X X 1 1	Cloud detected
X X X X X 0 X X	No ice/snow
X X X X X 1 X X	Ice/snow detected
X X X X 0 X X X	Sea/water pixel
X X X X 1 X X X	Land pixel
X X X 0 X X X X	Bad radiometric quality of SWIR band (interpolated value)
X X X 1 X X X X	Good radiometric quality of SWIR band
X X 0 X X X X X	Bad radiometric quality of NIR band (interpolated value)
X X 1 X X X X X	Good radiometric quality of NIR band
X 0 X X X X X X	Bad radiometric quality of red band (interpolated value)
X 1 X X X X X X	Good radiometric quality of red band
0 X X X X X X X	Bad radiometric quality of blue band (interpolated value)
1 X X X X X X X	Good radiometric quality of blue band

The red circles in figure 4 define the criteria that can be used to select only the good NDVI quality pixels for further analysis. Information can be provided to use the "*Status Map*" in conjunction with NDVI map but it is not further elaborated here.

Figure 3: Imported NDVI, LAI, FCOVER and PHENOKS (phstart, phhalf and phlength) VGT4Africa products of 20091201



Check also the other training materials of lesson 4 providing further information on the various products as shown in figure 3.

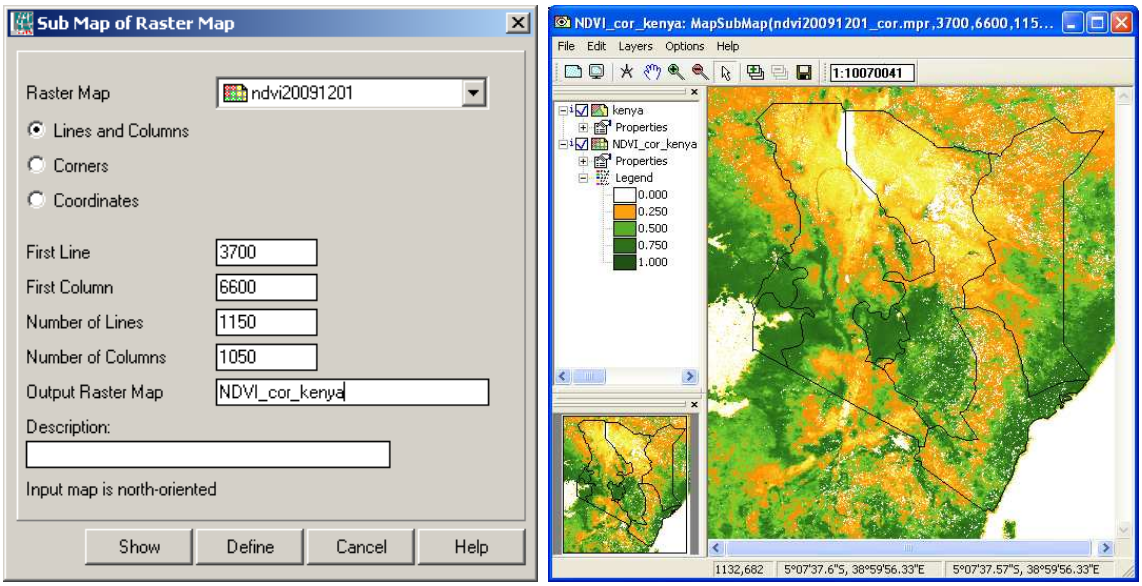
2. Deriving statistical information, aggregated per province, using the NDVI map for Kenya

Display once more the "*NDVI20091201*" map created during the previous exercise, using the "*Representation*" "*NDVI1*". Now add to this map the vector layer "*Kenya*". To do so open from the active map display window menu the option "*Layers*" and from the context sensitive menu "*Add Layer*", leave the option "*Info*" active and display "*Boundaries only*". Zoom to the country Kenya on the map, activate the  "*Normal*" option from the active map display window. When you move the mouse cursor over the vector layer and simultaneously press the left mouse button you can see the values from the vector layer.

From the active map display window select from the menu "*File*" and from the drop down menu select "*Open Pixel Information*". Move the mouse cursor over the vector layer and check the changing values in the Pixel Information table. After having checked the table content for the different provinces in Kenya, close all active layers.

As we are doing this analysis only for Kenya, we can make a of the corrected NDVI map. In order to do so, open from the main ILWIS menu "*Operations*", "*Spatial Reference Operation*" and subsequently "*Raster Operations*" and "*SubMap of Raster Map*". As raster input map select the NDVI20091201 map. See also figure 8 for the other settings. Display the NDVI sub map, here called "*NDVI_cor_kenya*", as well as the vector layer Kenya. Your results should resemble those of figure 5.

Figure 5: Create Sub Map of Kenya, sub map details and output map created.



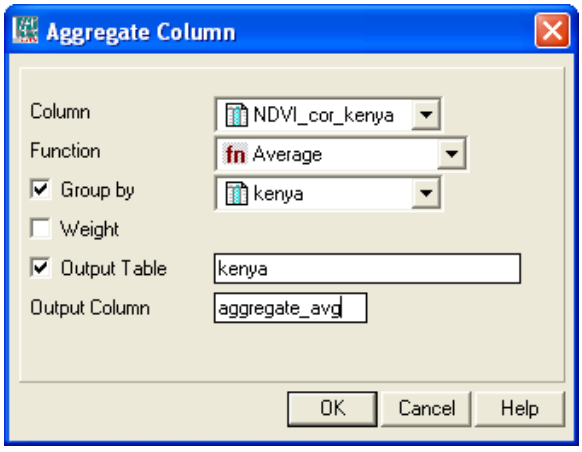
The next step is to convert the Polygon map "Kenya" to a Raster format, using the georeference of the sub map created. Open from the main ILWIS menu "*Operations*", subsequently "*Rasterize*" and "*Polygon to Raster*". Select as polygon map the vector map "Kenya" and as output map you can specify the same name: "*Kenya*" (a new raster layer will be obtained) and select the georeference that belongs to the sub map, in this case the

one that belong to the sub map as given in figure 5: “NDVI_cor_Kenya”. When the vector to raster conversion is completed, select from the menu “*Display Options*” the option “*Multiple colors*” and select “*15*”, press *OK* to show the raster map of Kenya. Move the mouse cursor over the map and check the values. Once more open from the active map display window the menu item “*File*” and from the drop down menu select “*Open Pixel Information*”. Check the relationship between the map and the table.

Now you can cross both maps. Open from the main ILWIS menu “*Operations*”, subsequently “*Raster Operations*” and “*Cross*”. Specify as first map: “*Kenya*” and as second map the (sub) map: “*NDVI_cor_kenya*”. Specify as output cross table: “ndvi_kenya”, all other options can be left as default, like “*Ignore Undefined*” and don’t “*Create an Output Map*”. Execute the map crossing by pressing “Show”. After the crossing is completed the cross table will appear on your screen. Check the content of the table.

Note that for the column “Kenya” in the cross table the left alignment of the numbers, these are identifiers (ID’s) and not values! Select from the Table menu the option: “*Columns*” and from the drop down menu: “*Aggregation*”. Specify other settings according to figure 6 and press OK to calculate the average NDVI per province. Note that a new column in the output table: “*kenya*” is being created by this operation.

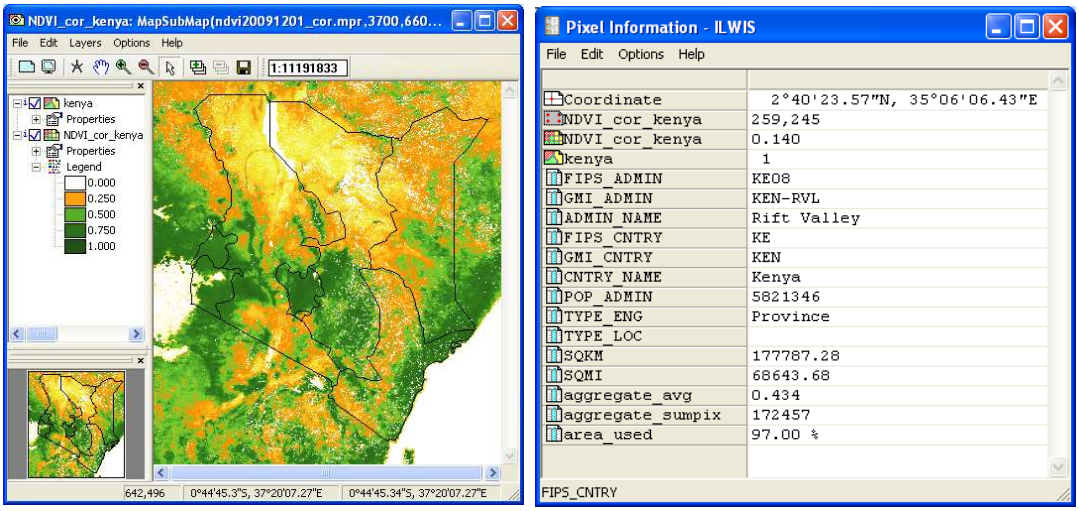
Figure 6: Create new output column table with aggregated statistics, grouped per province, using the function average for the NDVI



Close the cross table “ndvi_kenya” and open the table called: “Kenya”, which belongs to the raster map “Kenya” and check all the values in this table. Note once more that a new column has been added to this table according to the aggregated information from the cross table.

Display the sub map "*NDVI_cor_kenya*" and add the vector layer "*Kenya*", select boundaries only. Open from the active map display window "*File*" and "*Open Pixel Information*". Inspect your results. They should resemble those of Figure 7.

Figure 7: NDVI sub map of Kenya and aggregated statistics appended to map table



3. Deriving pixel based and aggregated time series information using a NDVI map list

To continue the exercises use ILWIS to navigate to the sub directory: "*NDVI_timeseries*" as the data needed are situated there. To save time some pre-processing was done to prepare the time series needed, identical to the correction procedures described in figure 4 as well as the creation of sub maps as given above (see figure 5) for each of the decades of 2009. The following pre-processing steps have been conducted:

1. Import of the 36 NDVI decades for 2009;
2. Corrected all 36 NDVI maps using the status flags, identical criteria have been adopted as described before, see also figure 4;
3. Preparation of sub maps for each of the NDVI maps;
4. Construction of a map list, containing all 36 NDVI sub maps of 2009.

The final map list to be used for this exercise is: "*kenya_2009ndvi_cor*"

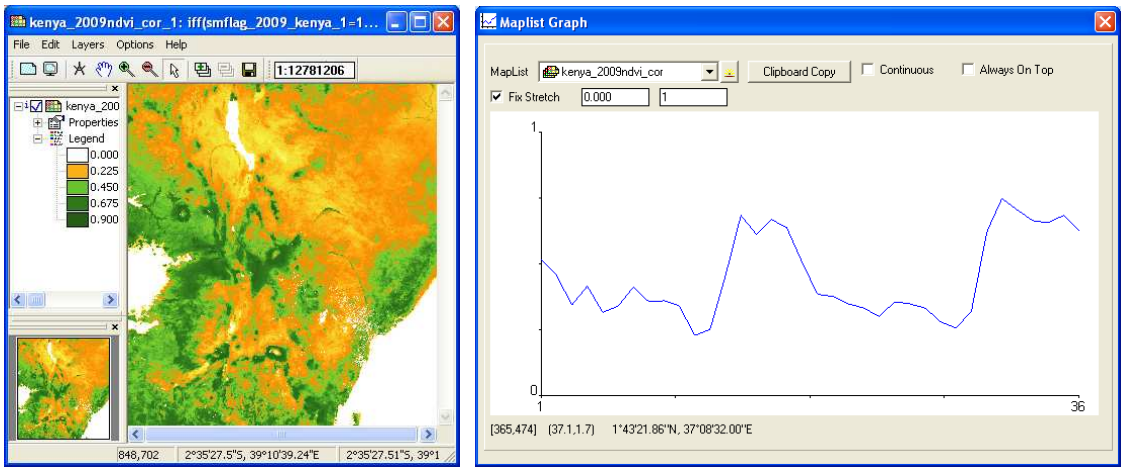
Open the "*Map List*" "*kenya_2009ndvi_cor*" by double clicking with the left mouse button on the file name, note the different icon  , such an icon belongs to a map list. Note the content of the maplist, ndvi maps from 1 to 36 represent the 36 decades of 2009. To display the map list, select as visualization option "*Open as Slide Show*", by clicking on the  icon in the map list display window. For the "*Display Options*" select as "*Representation*" "*NDVI1"* and press "*OK*", for the new window showing more "*Display Options*", like "*Refresh rate*", the defaults can be accepted, continue by pressing OK.

Visually inspect the changes that have occurred over the year 2009, also note the occurrence of the "not a value"/ undefined pixels. After you have inspected the map list, close the map list display window.

Open the map list "*kenya_2009ndvi_cor*" once more and now select the layer "*Kenya_2009ndvi_cor_1"*, double click on this layer with the left mouse button and as "*Representation*" select "*NDVI1*", press "*OK*" to display the map showing the first decade of 2009. Now from the ILWIS main menu, select: "*Operations*", "*Statistics*", "*MapList*" and finally "*MapList Graph*". Select as "*MapList*" "*kenya_2009ndvi_cor*". Activate the option: "Fix Stretch", select as minimum "*0"* and as maximum "*1"*. Also activate the options "*Continuous*" and "*Always On Top*". Note that the X-axis of the graph represents the time, here the decades from 1 to 36. Move the mouse cursor over the map and check the corresponding NDVI values in the graph for a given pixel over the whole time range, in this case for each of the decades in 2009. Your results should resemble those of figure 8.

Note that with the "*Clipboard Copy*" option the time stack for a certain pixel can be copied to clipboard to be pasted into a spreadsheet. In order to do so it is necessary to uncheck the option "*Continuous*" and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner.

Figure 8: NDVI sub map of decade 1, 2009 (left) and the map list graph for the whole time series for a selected pixel location (right)



Close all active map windows before you continue. Now from the ILWIS main menu, select: "*Operations*", "*Statistics*", "*MapList*" and finally "*MapList Statistics*". Select as "*MapList*" "*kenya_2009ndvi_cor*", as "*Statistical Function*": "*Minimum*" and as "*Output Raster Map*": "*ndvi_min*" and press "*Show*". As "*Representation*" use "*NDVI1*" and press "*OK*" to show the map.

Repeat this procedure to calculate also the maps: "*ndvi_max*" using the "*Statistical Function*": "*Maximum*" and "*ndvi_count*" using the "*Statistical Function*" "*count*". Note that the map "ndvi_count" gives for each pixel the number of events that in the input time series there contained a data value. Note that due to the status flag criteria applied the poor quality pixels have been removed resulting in pixels with "*not a value / undefined*". The map "*ndvi_count*" should be displayed with a Representation" "*Pseudo*", for the map "*ndiv_max*" the Representation" "*NDVI1*" can be used.

Due to the occurrence of "*not a value / undefined*" the "*Statistical Function*" "*sum*" and "*average*" should be treated differently. First the NDVI map list will be adapted for these undefined pixels, they will be assigned 0, prior to the use of the '*Statistical Function*" "*sum*". The average can than be calculated as: sum / count.

To assign 0 values to the undefined pixels in the map list, open from the main ILWIS menu "*Operations*", "*Raster Operations*" and "*MapList Calculation*" and type the expression:

ifnotundef(@1,@1,0)

Specify only 1 input map list, select "*kenya_2009ndvi_cor*" and specify as output map list "*ndvi_0*", press "*Show*" to execute the operation. After the computation is finished the map list can be displayed "*as a slide show*", using as "*Representation*" "*NDVI1*", accept all other settings as default. Click with the left mouse button pressed on the active map

display window and move to the white toned areas, inspect the values, you will note that these have become 0.

Now from the ILWIS main menu, select: "*Operations*", "*Statistics*", "*MapList*" and finally "*MapList Statistics*". Select as "*MapList*" "*ndvi_0*", as "*Statistical Function*": "*Sum*" and as "*Output Raster Map*": "*ndvi_sum*" and press "*Show*". As "*Representation*" use "*Pseudo*" and press "*OK*" to show the map.

To calculate the Average NDVI, open from the main ILWIS menu "*Operations*", "*Raster Operations*" and "*Map Calculation*" and type the following expression:

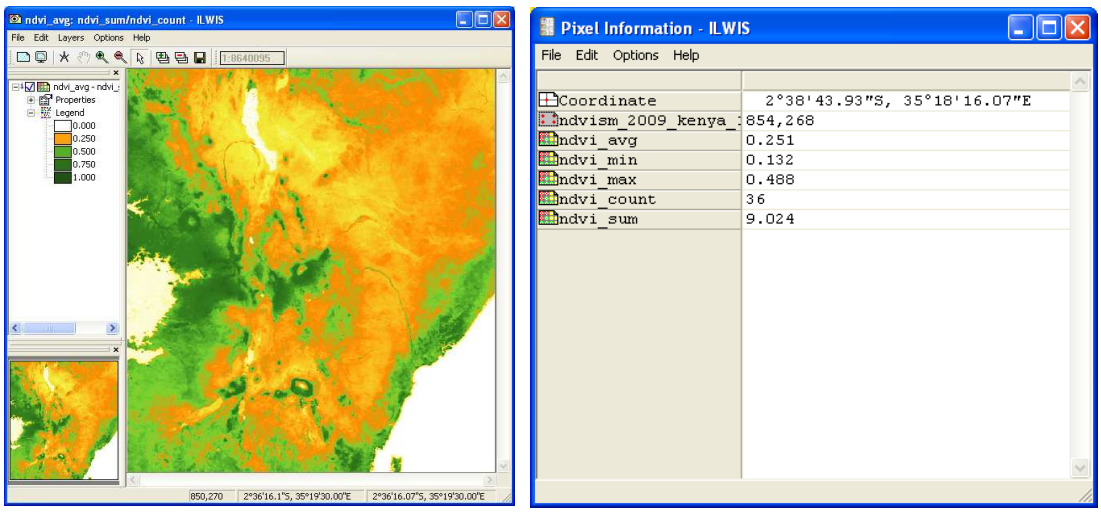
Ndvi_sum/ndvi_count

Specify as output map: "*ndvi_avg*", as "*Domain*" select "*Value*", the "*Value Range*" can be specified from "*0*" to "*1*", use as "*Precision*" "*0.001*". Press "*Show*" to calculate the map. This map can be displayed using as "*Representation*" "*NDVI1*".

From the active map display window select "*File*" and "*Open Pixel Information*". Now from the Pixel Information Window, select: "*File*" and "*Add Map*" and select the maps computed: "*ndvi_min*", "*ndvi_max*", "*ndvi_count*" and "*ndvi_sum*"

Move the mouse cursor over the map and inspect the resulting statistics. You will get a good idea of the variability of the 2009 ndvi changes on a pixel basis. Your results should resemble those of figure 9.

Figure 9: Average NDVI for 2009 and pixel information window with other statistics



Before you continue, close all active layers. You have now concentrated on the variations of the NDVI that have occurred over the year 2009. During the start of this exercise you imported the NDVI map of the 1st decade of December 2009. Also this map is available in the map list.

Open the map list "*kenya_2009ndvi_cor*" and select layer "*Kenya_2009ndvi_cor_34*", double click on this layer with the left mouse button and as "*Representation*" select "*NDVI1*", press "*OK*" to display this map which is showing the first decade of December 2009.

Open also the map "*ndvi_avg1201_from03_08*". This map represents the average of the same decade (12_01) for the years 2003 – 2008, computed in an identical manner as how the average was derived above. Now it is possible to compare the actual NDVI of the first decade of December 2009 with a longer term mean of the same decade, but of the 6 years before. This is a good way to see if the NDVI for a given moment is performing worse or better compared to average of the previous years.

To do so we can simply calculate the difference. Open from the main ILWIS menu "*Operations*", "*Raster Operations*" and "*Map Calculation*" and type the following expression:

Kenya_2009ndvi_cor_34-ndvi_avg1201_from03_08

Specify as output map: "*ndvi_dif*", as "*Domain*" select "*Value*", the "*Value Range*" can be specified from "*-1*" to "*1*", use as "*Precision*" "*0.001*". Press "*Show*" to calculate the map. This map can be displayed using as "*Representation*" "*Pseudo*".

The map indicates by its negative values those pixels that have lower actual (1st decade December 2009) NDVI values compared to the previous 6 years average. For the positive values it is the other way around, values around 0 have identical NDVI values compared to the longer term average. To get a better impression the continuous data can be grouped into discrete classes. To do so a domain has been created, called dif_cl, having the following icon:  . Double click with the left mouse button the domain "*dif_cl*" and check the class intervals and corresponding class names.

To use this domain to classify a map, open from the main ILWIS menu "*Operations*", "*Image Processing*" and "*Slicing*". Specify as "*Raster Map*" "*ndvi_dif*", as "output Raster Map" "*ndvi_dif_class*" and as "*Domain*" "*dif_cl*", press "*Show*" to execute the operation.

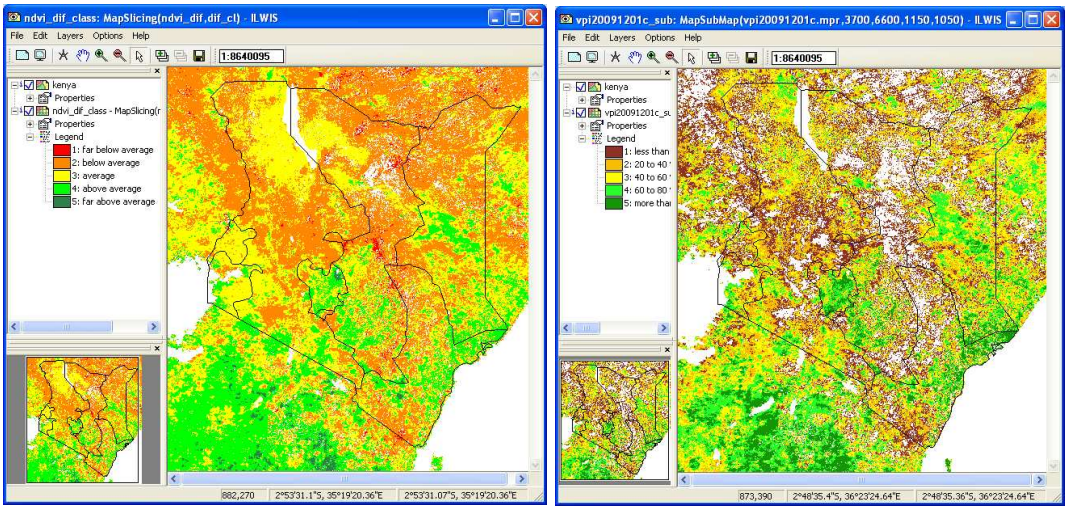
Form the active map display window, select "*Layer*", "*Add Layer*" and select the vector map "*Kenya*". Once more from the active map window, select "*File*" and "*Open Pixel Information*". From the Pixel Information Window select "*File*" and "*Add Map*" and select the map "*ndvi_dif*". Move the mouse cursor over the map display and check your results. Your results should resemble those as presented in figure 13 (left hand figure).

A VGT4Africa product that also compares the actual decadal situation with respect to a long term average is the so called Vegetation Production Indicator (VPI). Further information on the VPI product is given in the VGT4Africa User Manual and other workshop documentation.

From the "*Geonetcast"* and "*Toolbox*" menu select "*SPOT VGT Products"* and *VGT4Africa*" and subsequently "*VPI*" (note the settings of the input and output directory). Select the same decade as the one used to produce the classified NDVI map (20091201). Press "*Import*" to conduct the import. After completion of the import, show the VPI maps, note that file name extension "*c*" indicates that the output map is a class map and the "*v*" indicates that the map is having values.

A sub map should still be created to be able to compare it. The sub map settings as provided in figure 5 (left hand) should be used. Make a sub map of the VPI class map, call it VPI20091201c_sub and display the map. Also display the classified ndvi difference map created by you. The results should resemble those of figure 10.

Figure 10: Classified NDVI difference map and VPI class map of 20091201



To complete this part of the exercises we will once more have another look at the so called Fractional Cover. The cover fraction (fCover) is the fraction of green vegetation covering a unit area of horizontal soil. fCover can be used as a substitution of the classical vegetation indices that have been used throughout these exercises. fCover varies from 0 (bare soil) to 1 (full vegetation cover).

From the "*Geonetcast"* and "*Toolbox*" menu select "*SPOT VGT Products"* and *VGT4Africa*" and subsequently "*FCOVER*" (note the settings of the input and output directory). Select the same decade as the one used to produce the NDVI map (20091201). Display the new fCOVER output map created using as "*Representation*" "*fvc*". Also display the "*errfcover..*" map using as "*Representation*" "*pseudo*", showing the parameter uncertainty of the derived fCOVER.

A sub map should still be created to be able to compare the NDVI and the fCover map over Kenya. Specify the sub map settings as provided in figure 5 (left hand). Make a sub map of the fCOVER map, call it fcover20091201_sub and display the map using as "*Representation*" "*fvc*". Also display the ndvi map created before (see also figure 5: NDVI_cor_Kenya). Compare both maps. The results should resemble those of figure 11.

Figure 11: the NDVI (left) and fCover (right) maps over Kenya, for 20091201