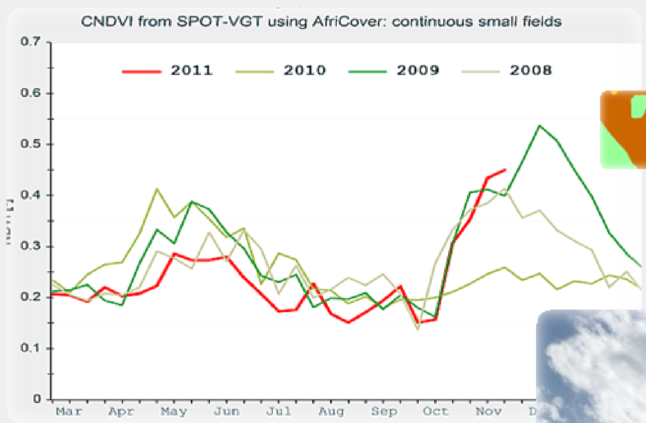
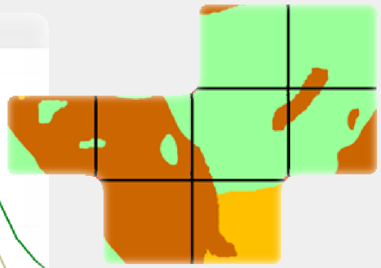
LEARNING OBJECTIVES

Lesson 4
Methods and Analysis 2: Rainfall and NDVI Seasonal Graphs

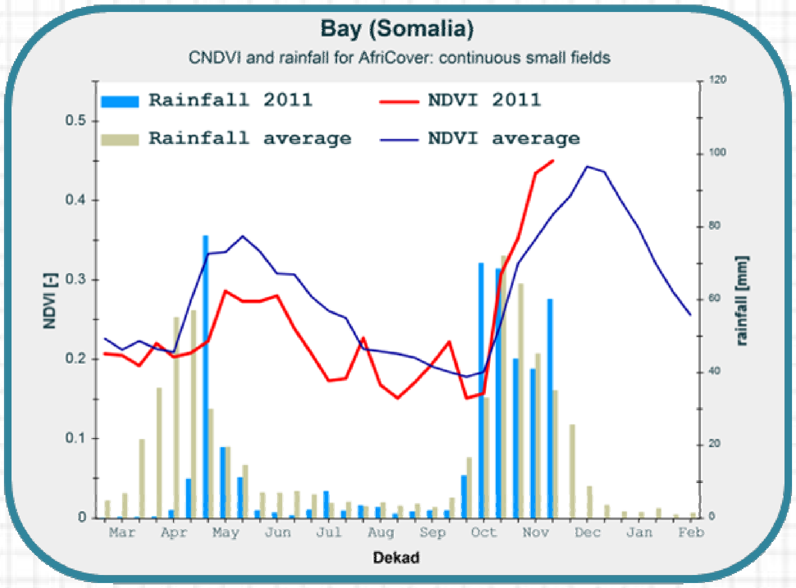
At the end of the lesson, you will be able to:

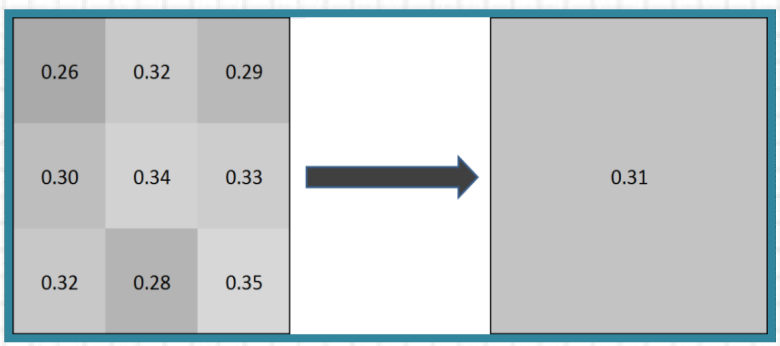
- understand **seasonal graphs for rainfall and NDVI;**
- describe the concept of and rationale for **spatial aggregation**;
- identify significant differences from long term average, reference years and historical maximum and minimum; and
- recognize relationships between rainfall and NDVI during the crop season.





INTRODUCTION





This lesson explains how **seasonal graphs of rainfall and NDVI** are constructed. Particularly attention is paid to **spatial aggregation**.

The aim of this lesson is to provide you the knowledge required to understand and **analyse** these seasonal graphs and **identify the timing of anomalies**.

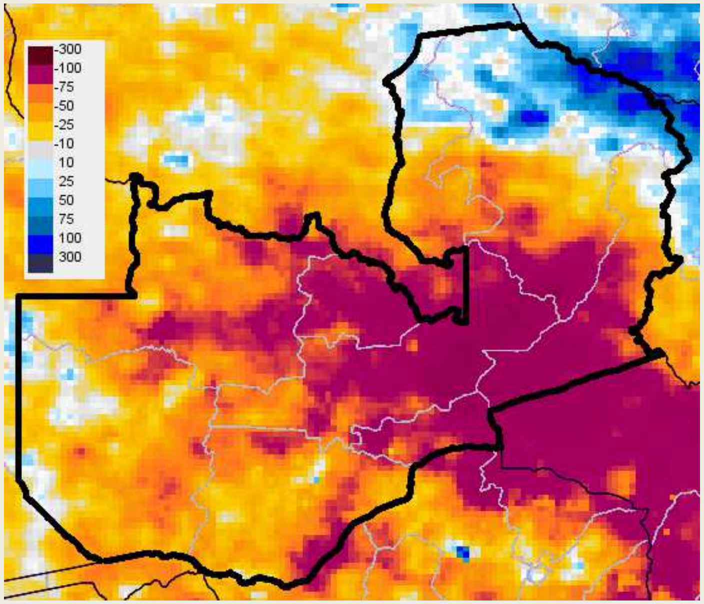
The lesson first focuses on NDVI, then on rainfall, and finally on the combined analysis of both.

INTRODUCTION

Anomalies are deviations from normal behaviour. Rainfall and NDVI anomalies can be represented in maps, which identify how and where rainfall and vegetation development are different from normal.

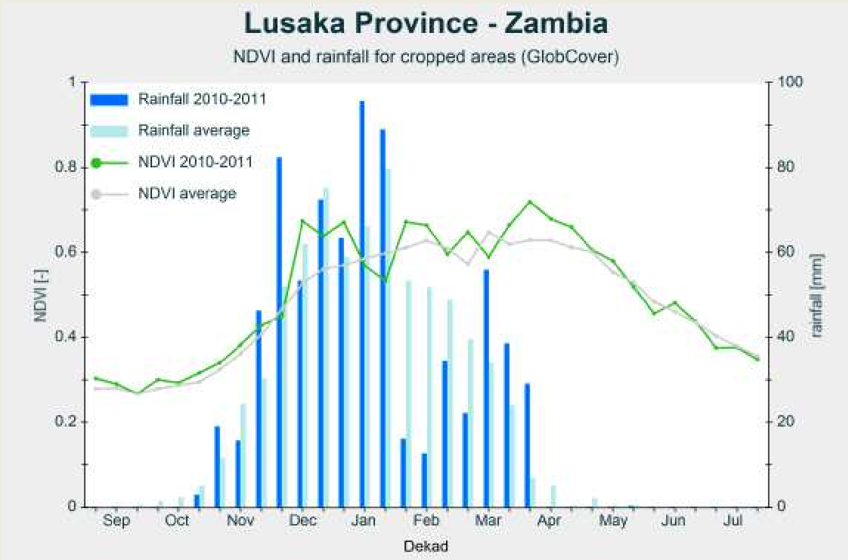
The **anomaly maps relate to one specific time** (dekad, month, or season). However, a single map contains little information about temporal aspects of anomalies.

Rainfall absolute anomaly map Feb. 2011, Zambia



Source: Early Warning Explorer

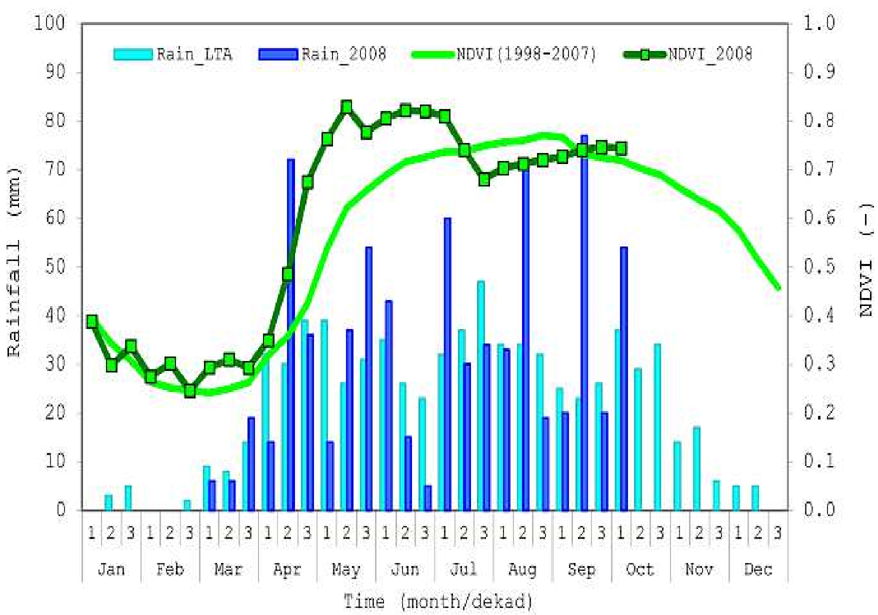
Seasonal graphs show **how rainfall and NDVI behave during a** specific **season**.



Source: MARS Viewer

INTRODUCTION

Seasonal Graph Pochalla (South Sudan)



Typical example of a seasonal graph as used in crop monitoring.

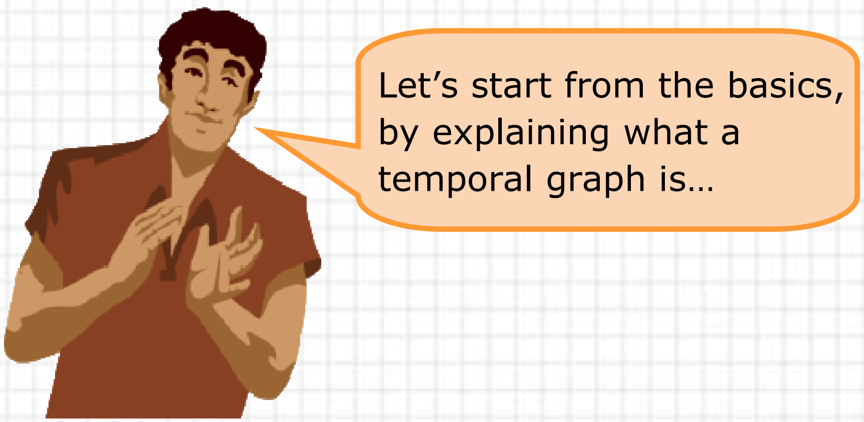
Seasonal graphs are **temporal plots** (also called **profiles**) that show how rainfall and NDVI behave during a specific season.

Plotting also other years (or averages of years) in the same graph, **anomalies and their timing** can be identified.

For example a seasonal graph shows that vegetation green-up started earlier than normal, due to abundant rain in April. However, in July NDVI is slightly below normal.

Graphs combining rainfall and NDVI are particularly useful for early warning purposes. Combined graphs show possible stress situations and indicate whether evidence from both independent data sources regarding such situations converges. The interpretation of such graphs allows to draw qualitative conclusions on possible crop yield reductions.

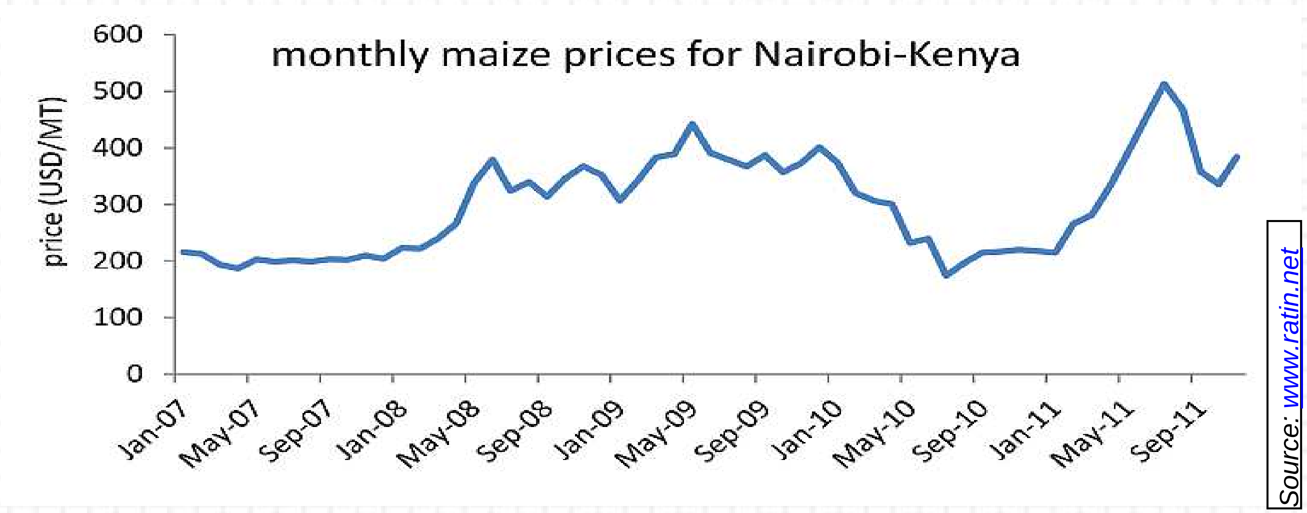
TEMPORAL GRAPHS



A temporal graph (also called temporal profile or time plot) shows how a certain **variable behaves through time**.

Variables could be anything that changes in time.

For example…

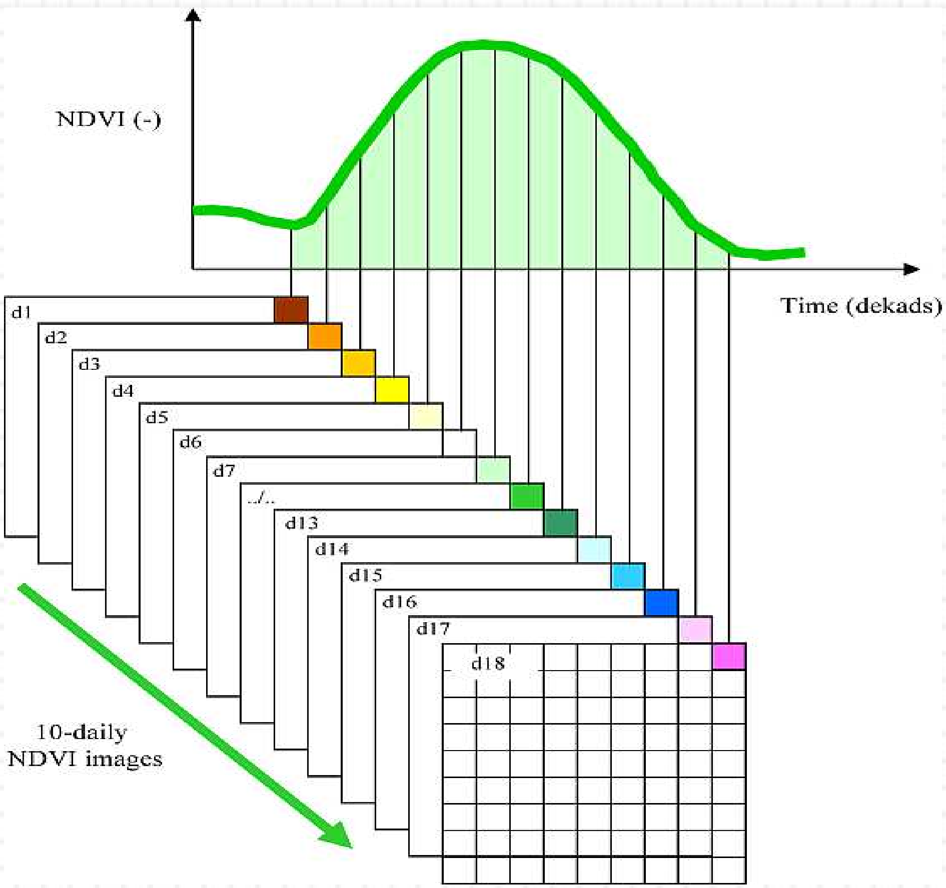


Source: www.ratin.net

In this temporal graph the variable is maize price, reported on a monthly basis.

TEMPORAL GRAPHS

Extract a pixel from images to get time plot



For crop monitoring, variables of interest include rainfall and NDVI. You get them mostly from **multi-temporal image data** that often have a **10-daily time step** (dekad). However, you can also use other sources, for example rainfall from rain gauge measurements.

In temporal graphs this time step is normally preserved, i.e. no further temporal aggregation is performed.

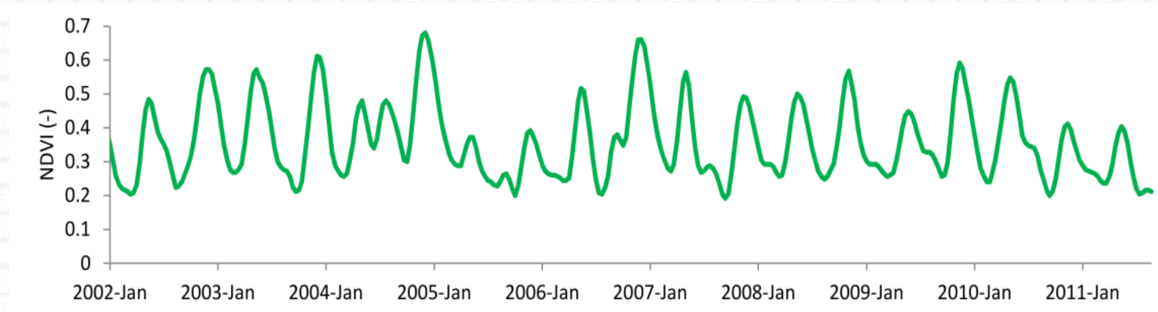
You can plot the temporal behaviour of NDVI for a single location (pixel) by retrieving that pixel's value from each 10-daily image. For example…

This diagram illustrates how for one pixel location the value from each image (dekad) is plotted in a temporal graph.

TEMPORAL GRAPHS

If you continue plotting 10-daily NDVI for several years you can obtain a graph like this...

NDVI series for one pixel



To some extent this graph allows **identifying good** (***more vegetation***) and **bad years** (***little vegetation***).

However, in such **temporal graphs** detailed comparison of the current year with previous years is difficult.

≠

Seasonal graphs are a specific type of temporal graphs. They show the NDVI (or rainfall) development of the current year, also plotting the NDVI for previous years for comparison.

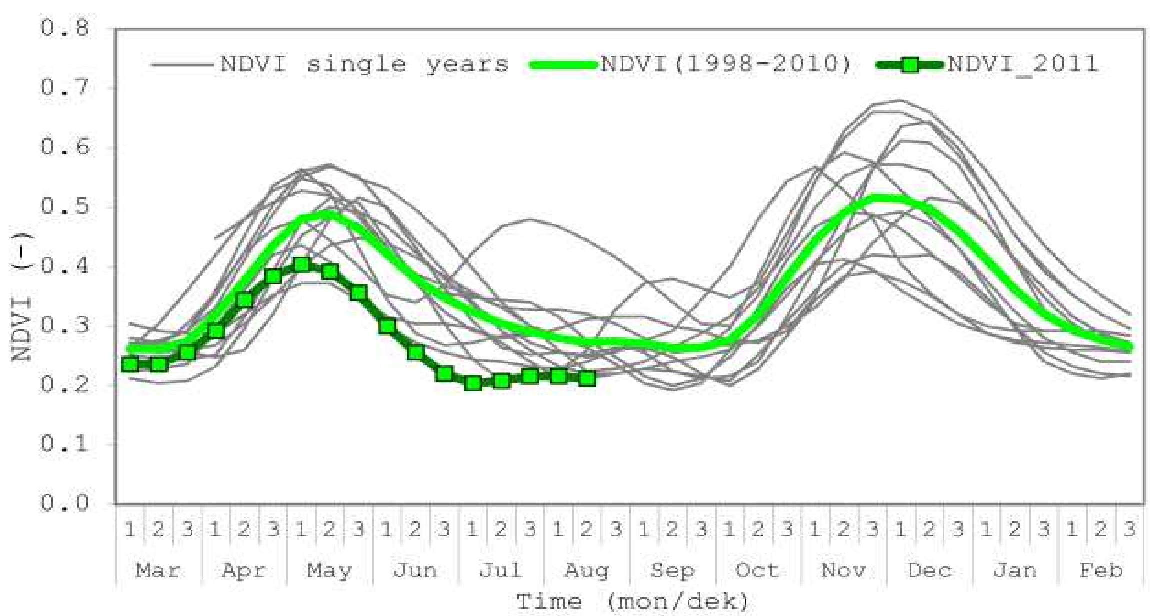
Let's go more in depth...

SEASONAL GRAPHS

Seasonal graphs show in detail the NDVI (and/or rainfall) development of the current year. In the same graph the NDVI for previous years is plotted for comparison. This could also be an average of previous years, such as LTA/STA .

The **start of x-axis** (time) is normally chosen in a relatively **dry period** such that the vegetation development during the season is not interrupted (i.e. seasons do not always end by December).

Seasonal graph NDVI for one pixel



This is the seasonal graph for the same pixel as the temporal graph in the previous screen.

View the graph’s explanation

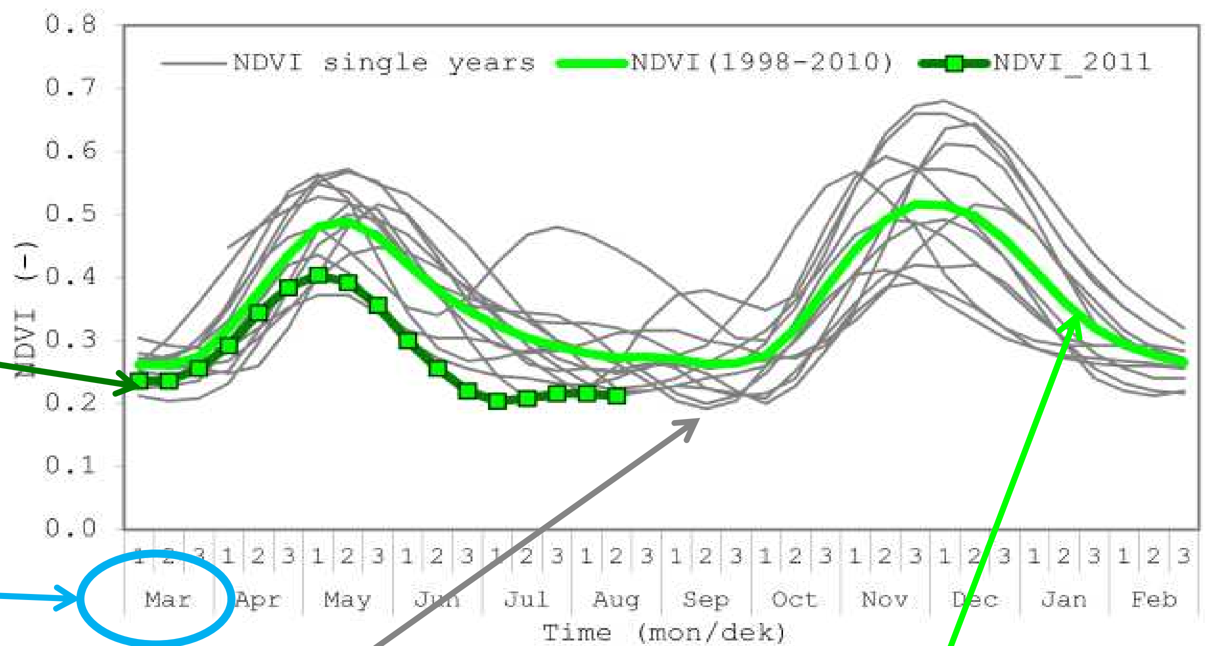
SEASO

Popup Window

Seasonal NDVI graph for one pixel

The **2011 NDVI values for each dekad** are the bright green points connected by the dark green line.

The **x-axis** starts at March to optimally represent both growing seasons.

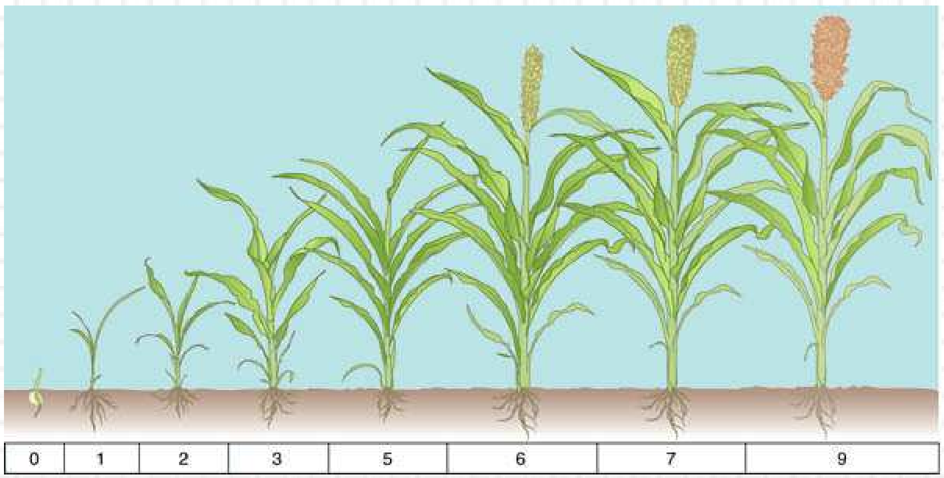


The small gray lines show the graphs for all **previous years** of data (1998 to 2010).

The bright green line gives the average of all **previous years** of data (1998 to 2010).

SEASONAL GRAPHS

As a measure of the green vegetation abundance in a pixel, annual NDVI variation follows the crop phenology.



When interpreting the signal you must however realize that:

•**multiple land covers can be present in one pixel** (each of which affects NDVI); and

•**between different years** , not only crop performance but also **crop areas could change**.

The term "**phenology**" relates to the timing of recurrent biological events.
Crop phenology is therefore the **timing of main crop stages during the season**.
In the same area crop stages and their timing can show large differences depending on the crop and variety. In addition climatic variability strongly influences this timing.

SPATIAL AGGREGATION - WHAT IS

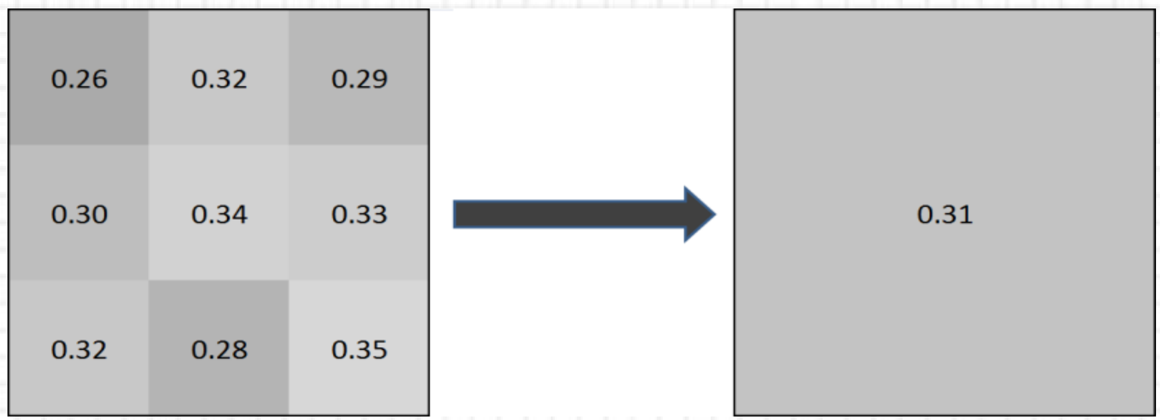
What is spatial aggregation?

Instead of plotting values for **single pixels**, seasonal graphs in crop monitoring bulletins normally use **spatial averages**.

For each 10-day image the NDVI (or rainfall) values of multiple pixels are averaged.

This process is called spatial aggregation.

An example of spatial aggregation



A single NDVI value (average) is obtained from 9 NDVI pixel values.

SPATIAL AGGREGATION - WHY

Why do we spatially aggregate when making seasonal graphs?

- It would be impossible and undesirable to present seasonal graphs for all pixels (in a country or region).
- Spatial aggregation is a way of **summarizing information** by providing values representative **for a larger region**.
- Dry or wet conditions (anomalies) are usually similar in a wider region.
- Food security in a region is at stake when large parts of that region experience anomalous conditions (such as drought).
- Additional data that could be used for comparison (such as official crop production statistics) are often only available at an aggregated scale.

The aim of spatial aggregation is to obtain a seasonal graph that is representative for a specific geographic area.

SPATIAL AGGREGATION - PURPOSE

A possible common form of spatial aggregation is the transformation of an image from high-resolution (let’s say 30x30 m pixels) to lower resolution (for example 90x90 m).

True-colour Landsat-5 TM image of Flevoland (the Netherlands) 26 June 2010, original 30m resolution, and aggregated to 90m resolution.

However, **spatial units** of interest in crop monitoring can have **various shapes**.

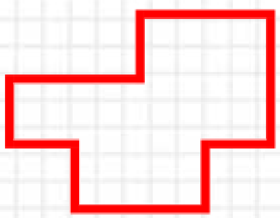
Our purpose is to obtain a representative NDVI or rainfall value for that spatial unit.

Let’s see how...

SPATIAL AGGREGATION - HOW

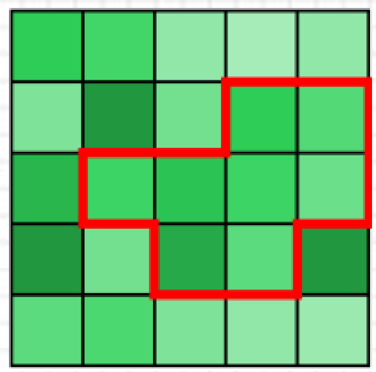
OBTAINING A REPRESENTATIVE NDVI (OR RAINFALL) VALUE FOR A SPATIAL UNIT

Consider an **irregularly shaped unit of interest**...



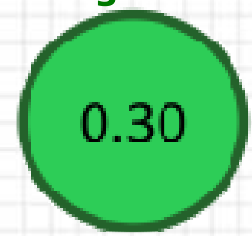
...we can put this unit on top of an NDVI image...

NDVI image June dekad 1

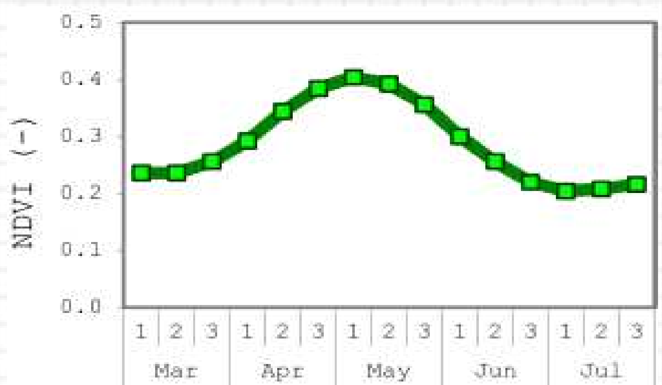


...averaging the NDVI values of the 8 pixels falling within the unit, gives you the aggregated NDVI value...

Average NDVI



Seasonal NDVI graph for dekad 1



...that value is put into our seasonal NDVI graph for the indicated dekad.

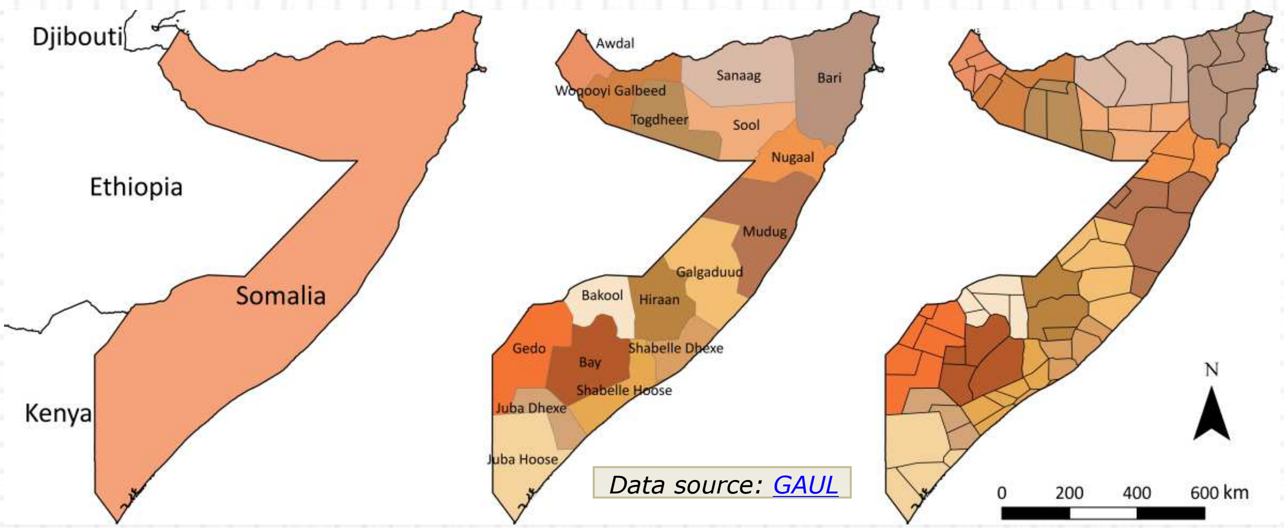
Following the same process (spatial aggregation within the red area) for the other 10-daily images gives us the entire seasonal graph.

SPATIAL AGGREGATION - COMMON UNITS

Which spatial units should I use for seasonal graphs?

This largely depends on what you as an analyst consider relevant thematic units for summarizing information.

Example of administrative areas for Somalia



Here administrative areas go from country, regions, to districts.

Click on the image to enlarge it.

Possible **units** include:

a. **livelihood zones** or **soil units** that may be obtained from existing geographic data; and

b. **administrative areas**, the most common aggregation units for crop monitoring bulletins.

Global Administrative Unit Layers (GAUL)

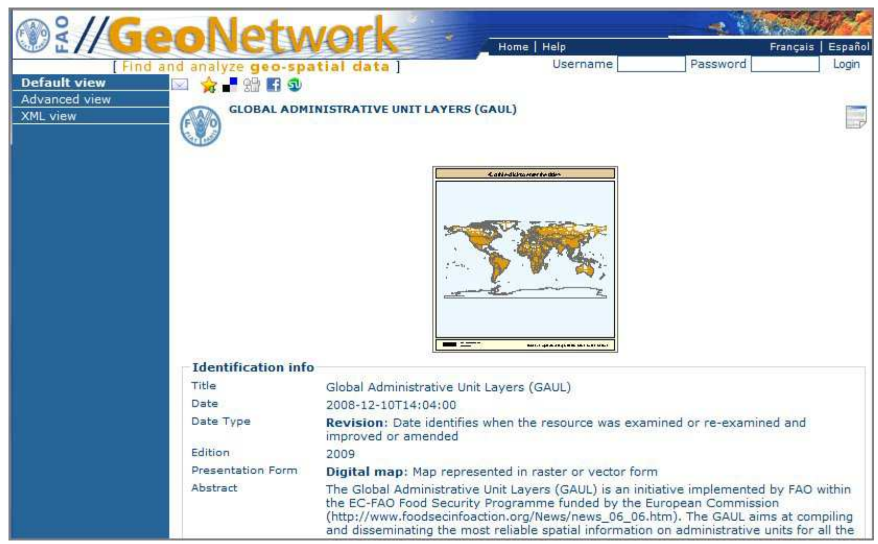
SPATIAL AGGREGATION - COMMON UNITS

Administrative areas could be **countries**, but mostly sub-national units such as **states**, **provinces**, **regions** or **departments**. The choice of a unit size (or level) is a compromise between maintaining spatial detail and homogeneity (using smaller units) and the need for generalization

Popup Window

GAUL (Global Administrative Unit Layers)

The Global Administrative Unit Layers (GAUL) is an initiative implemented by FAO within the EC-FAO Food Security Programme funded by the European Commission. The GAUL aims at compiling and disseminating the most reliable spatial information on administrative units for all the countries in the world, providing a contribution to the standardization of the spatial dataset representing administrative units.



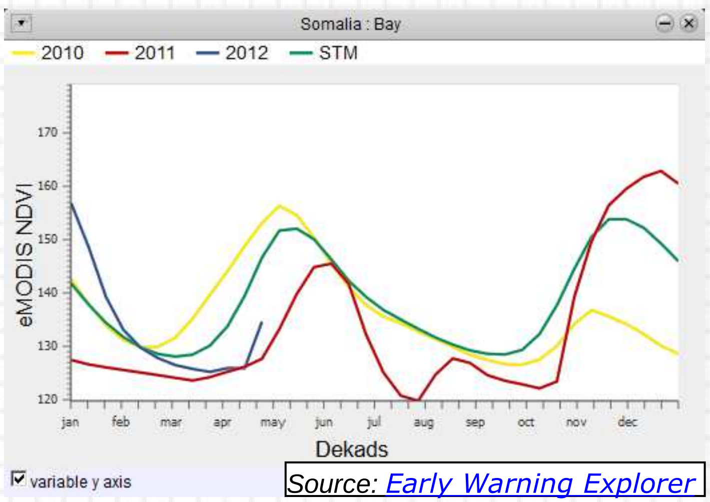
http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

SPATIAL AGGREGATION - COMMON UNITS

Using **administrative units** for aggregation has some **advantages**...

- Administrative **boundaries** are always **available**.
- Agricultural **statistics** (crop areas, production, yield) are commonly aggregated for administrative units and can be used to compare with the seasonal graphs.

NDVI seasonal graph



Source: *Early Warning Explorer*

Click on the image to enlarge it.

For example, FEWS-NET provides an online tool (the Early Warning Explorer) to extract eMODIS NDVI for sub-national administrative regions.

This figure shows an example for the Bay region of Somalia, comparing 2012 with previous years and the short term average (STM: 2000-2011).

SPATIAL AGGREGATION - COMMON UNITS

Within a single **administrative unit**, **land cover is not uniform**.

You may find for example that part of the area is covered by deserts, forests, or inland lakes. The **NDVI measured** in those areas **does NOT give information** about the status of **crops or pastures** in the administrative unit.

Therefore, it makes sense to **mask out** such areas: i.e. you aggregate the NDVI only for areas (pixels) in the administrative unit that have the land use of your interest.

To do that you need crop masks or land land cover maps.

View an example

Land use in Somalia.

SPATIAL AGGREGATION - COMMON UNITS

Popup Window

Crop mask

A crop mask is a map that shows where crops are grown and where no crops are grown. Such masks can be crop-specific (for example only indicating the presence of maize).

Popup Window

Land cover map

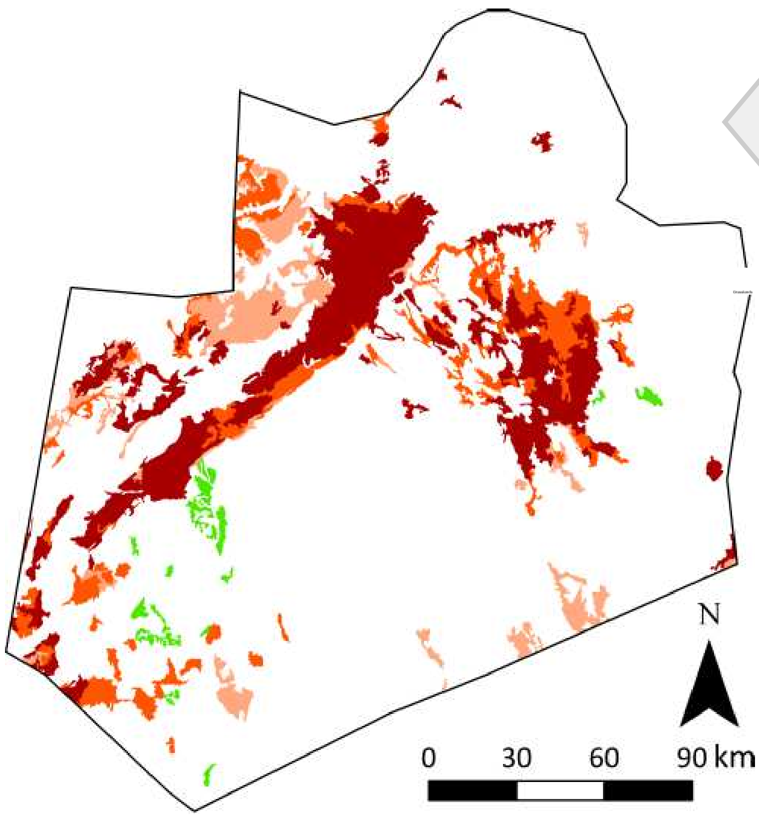
A land cover map is a thematic map that shows the main land cover for each pixel or polygon. AfriCover is an example of a land cover map.

SPATIAL A

Popup Window

Masking out areas of interest

JRC (Joint Research Centre) frequently uses AfriCover for Eastern Africa.



This figure shows AfriCover classes related to agriculture for the Bay region in Somalia.

Note that these classes cover a relatively small area of the region.

JRC still combines these maps with other sources of information to identify which crops can be expected in each region.

Continuous small agricultural fields
Clustered small agricultural fields
Isolated small agricultural fields
Grasslands

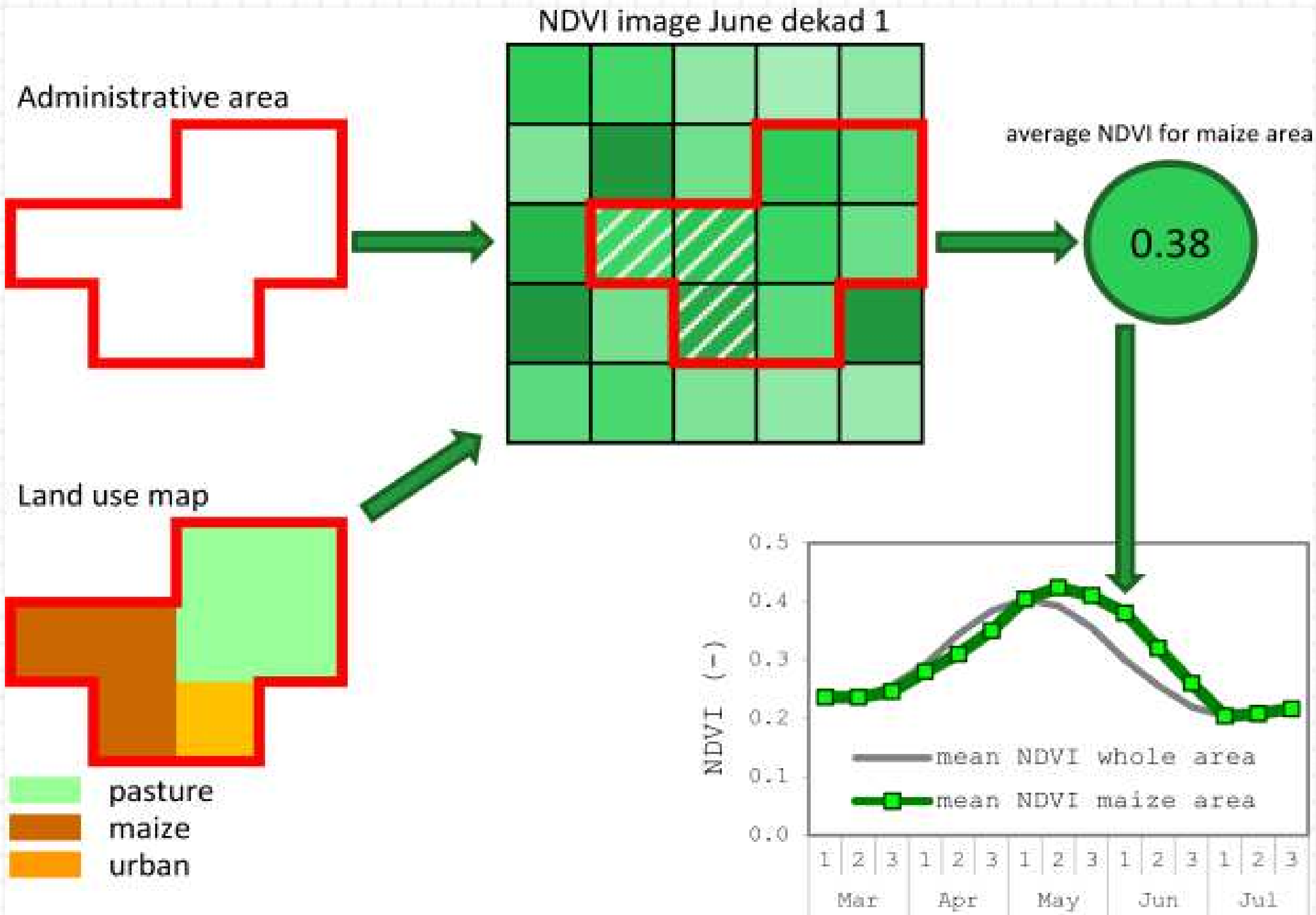
SPATIAL AGGREGATION - COMMON UNITS

Which map should I use for masking?

This is a decision to be made by you as an analyst, and will **depend on the availability and accuracy of existing maps** for the country.

This figure schematically shows how the average NDVI for a maize area within an administrative unit (hatched cells in the NDVI image) is derived and put into a seasonal graph.

Spatial aggregation using a crop mask



LAND COVER MAPS AND NDVI DATA

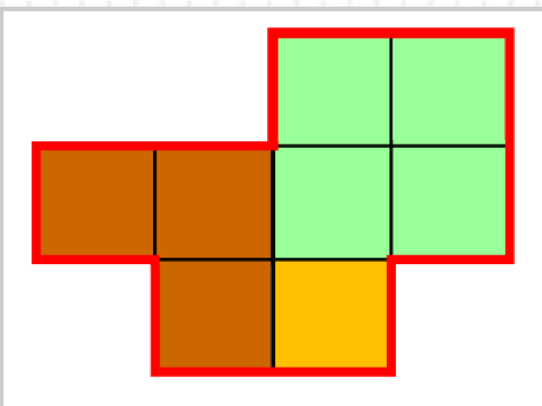
In the previous screen's example we assumed that each **NDVI pixel** corresponds to one **land cover class**. If our land cover map has a similar spatial resolution as our NDVI data, this is a fair assumption.

However, in reality land cover often has a high spatial variability and many **land cover maps** have **a higher resolution than available temporal NDVI data**.

For example...

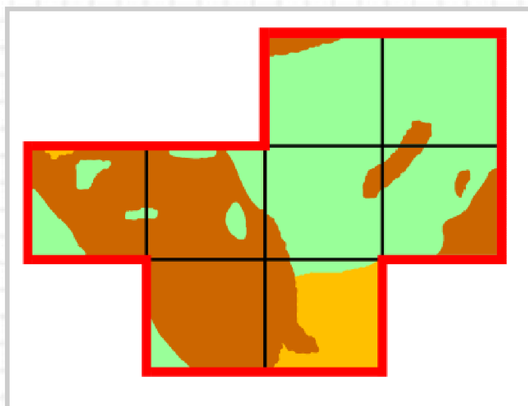
- **AfriCover** is based on [Landsat] images with **30m** resolution; while
- **MODIS** imagery has **250m** resolution; and
- [SPOT VEGETATION] has a **1-km** resolution.

Ideal land cover map



VS

Real land cover map



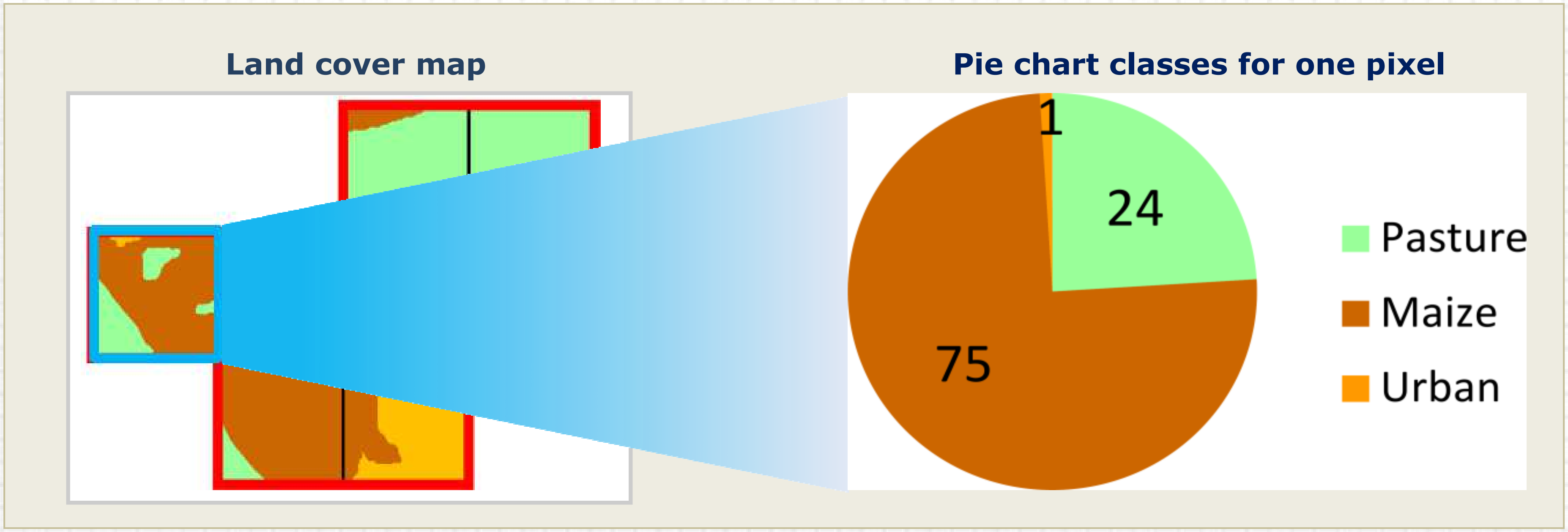
Following the previous example these maps illustrate how real land cover could be distributed for our eight NDVI pixels.

Each NDVI pixel thus contains multiple land covers.

LAND COVER MAPS AND NDVI DATA

Since each NDVI pixel corresponds to multiple land covers, it is useful to evaluate what the abundance of each land cover is within a specific NDVI pixel.

For example the **percentage abundance of land cover** in the left-most pixel can be summarized as follows:



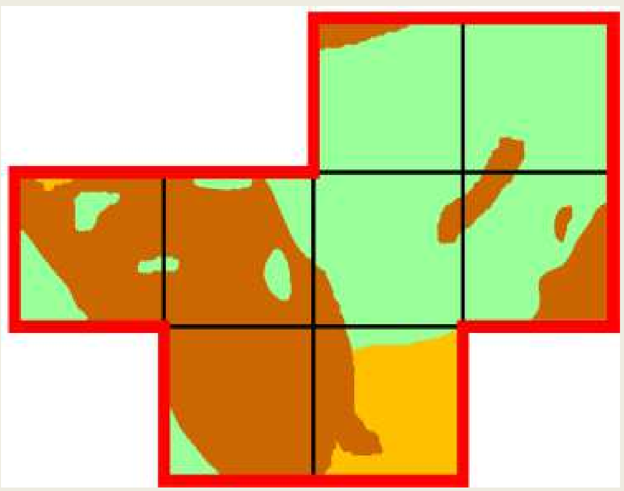
You can do the same for the other pixels....

LAND COVER MAPS AND NDVI DATA

The following shows for each NDVI pixel which percentage of its area is covered by maize and pasture.

LAND COVER PERCENTAGE PER PIXEL

Land cover map



Maize

		7	5
75	82	9	33
	93	28	

Pasture

		93	95
24	18	91	67
	7	7	

On the next screens you will see how you can use these percentages to calculate a **weighted average** of NDVI values (instead of the normal average)....

WEIGHTED AVERAGE NDVI OR CNDVI

Popup Window

The CNDVI concept

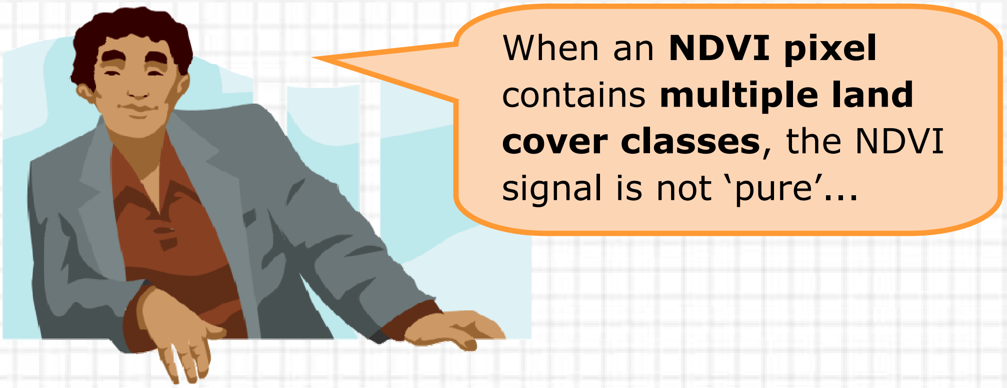
The CNDVI concept was introduced for Europe in 2001.

CNDVI originally stands for “CORINE NDVI”, where **CORINE** (**CO**-ordination of **IN**formation on the **E**nvironment) refers to the European programme that generated a European land use map at 100 m resolution. It was used in combination with 4.4 km resolution NOAA-AVHRR NDVI images for calculating CNDVI.

In analogy the term AFRICNDVI has been used when having AfriCover land use maps as input.

Nowadays CNDVI is generally referred to as “**Crop-specific NDVI**” and can thus be used with any crop or land use map.

CNDVI WITH AREA THRESHOLDS

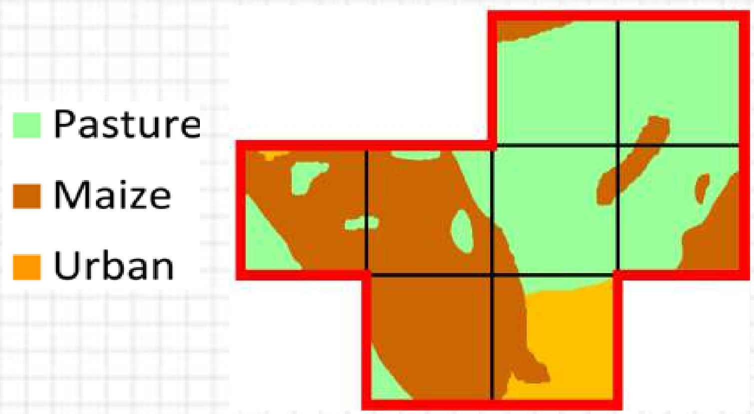


When more land cover classes occur within a pixel, the NDVI value itself is a mix (of for example maize NDVI and pasture NDVI).

This phenomenon is referred to as the **mixed pixel** or **mixel**.

When the abundance of one class (e.g. maize) in a mixed pixel is low, the resulting NDVI value is not representative for maize. Therefore you may decide to **exclude** such **non-representative values** in your calculation of CNDVI for the administrative unit.

Mixed pixels



So in practice you can set a **threshold** on the **minimal abundance** you want **for a specific class in any pixel**.

Let's see an example...

CNDVI WITH AREA THRESHOLDS

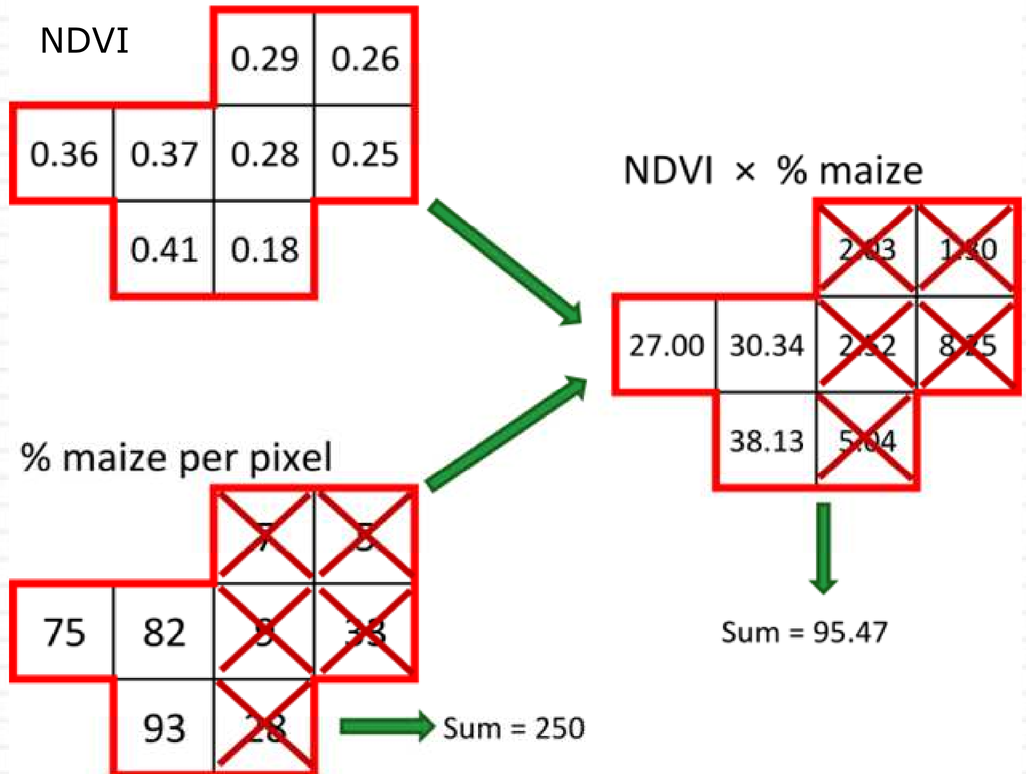
This example refers to the mixed pixels map of the previous screen, and shows a CNDVI calculation for maize applying a **threshold of 50%.**

The **threshold choice** is subjective.

A **general guideline** used by JRC is:

- 80% when an administrative area contains many pure pixels for the class of interest.
- 20% in areas with fragmented land cover classes where contributions of low area fractions are needed.

CNDVI with area thresholds



weighted average NDVI = 95.47 / 250 = 0.38

CNDVI WITH AREA THRESHOLDS

Let's consider again the administrative unit of screen **XX**. The left table gives for a specific dekad the NDVI values for each pixel. The right table gives the abundance (in percentage) of pasture within each pixel.

NDVI

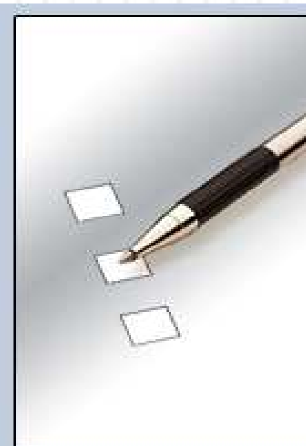
		0.51	0.48
0.25	0.27	0.54	0.41
	0.42	0.21	

Pasture

		93	95
24	18	91	67
	7	7	

Can you calculate the CNDVI using a threshold of minimal abundance of 80%?

- 0.46
- 0.51
- 0.49



Please select the answer of your choice.

CNDVI – OTHER CONSIDERATIONS

When using CNDVI you should take note of the following things…

Spatial resolution of NDVI

The benefit of CNDVI as compared to normal average pixel NDVI (per land cover class) becomes less when:

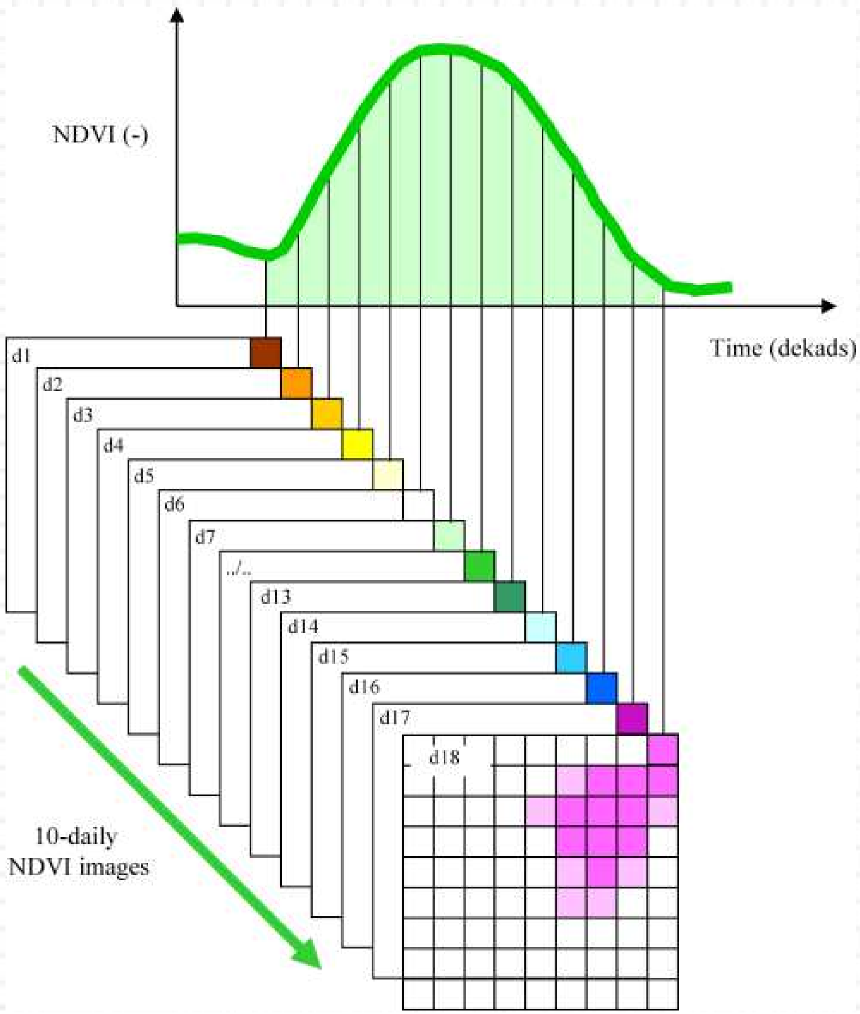
•spatial resolution of the NDVI time series increases (smaller pixel sizes); and

•land cover is more homogeneous in a region (many pure land cover pixels are present in the region)

Land cover change

Land cover is not static, but can change from year to year. **Accurate crop maps** are often **not available** on an **annual** basis: therefore CNDVI normally uses a **single crop map** for the **entire time series**. As a result, both **changes** in **crop performance** (crop NDVI) and **crop areas** **could explain differences in CNDVI between years**.

SEASONAL NDVI GRAPHS



Using NDVI images for each dekad, you can obtain a **time series of CNDVI**.

This time series can then be presented in a seasonal graph, as shown earlier in this lesson.

SEASONAL NDVI GRAPHS

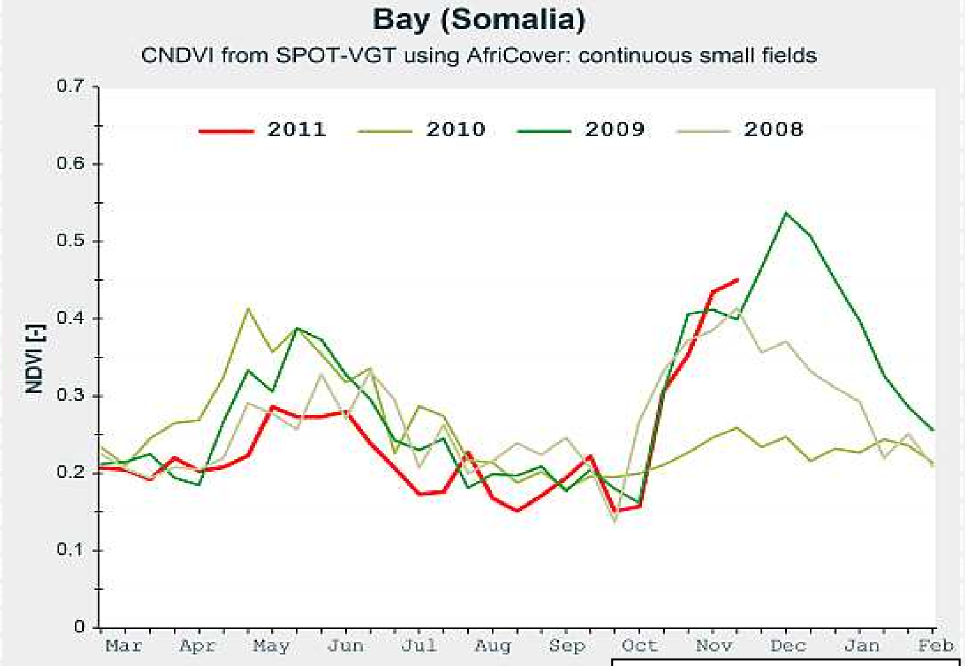
Why do we use seasonal graphs of CNDVI?

The answer is:

To compare vegetation status throughout the season with other years and evaluate how the current season behaves in comparison.

This graph shows the CNDVI for continuous small fields for the Bay region in Somalia for 2008-2011.

Note that CNDVI was relatively low (poor crop performance) during the 2011 *Gu* season (April-June). The CNDVI for the second season (*Deyr*: October-January) develops similar to 2008 and 2009, while for 2010 CNDVI was particularly low.



Adapted from MARS Viewer

Click on the graph to enlarge it.

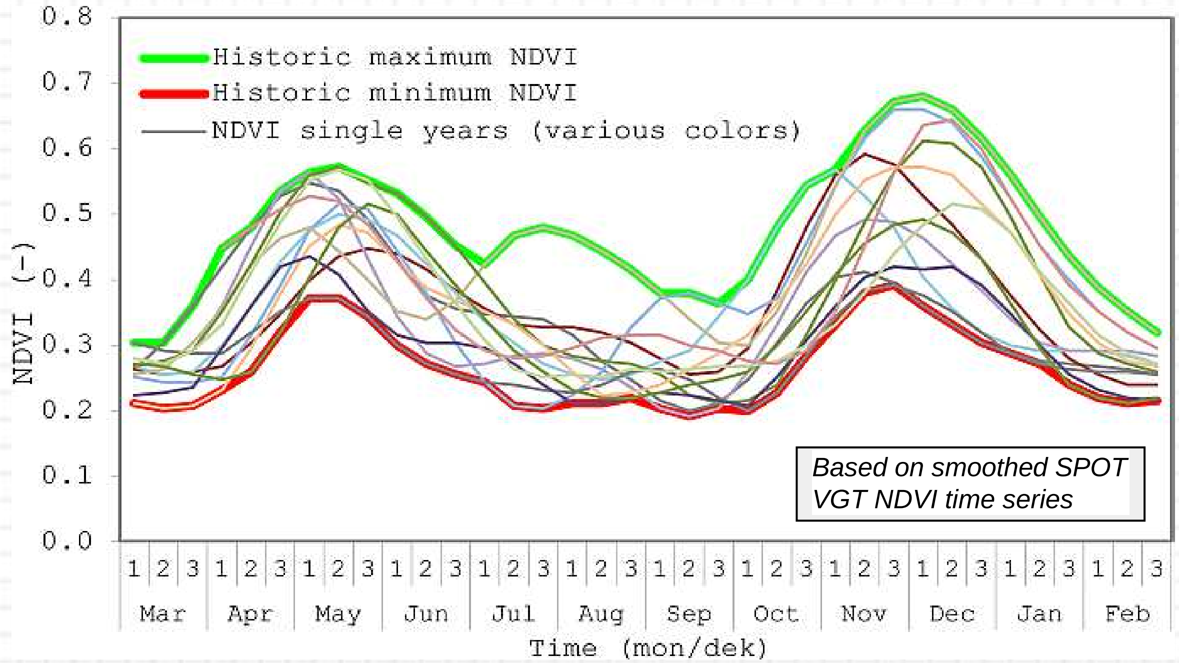
SEASONAL NDVI GRAPHS

To avoid overloading your graphs, you may not want to include each individual year. Instead, you could plot the current year CNDVI values with:

- **long-term average** or LTA (30 years or full time series);
- **short-term average** or STA (5 or 10 years)
- **single reference years**, commonly last year or a known good and/or bad year
- **historical maximum or minimum**, this shows for each dekad the highest and lowest CNDVI value in the time series.

The graph illustrates this last concept for NDVI (individual years are 1998-2010 for SPOT VGT).

Historical maximum and minimum NDVI for a random pixel in Bay (Somalia)



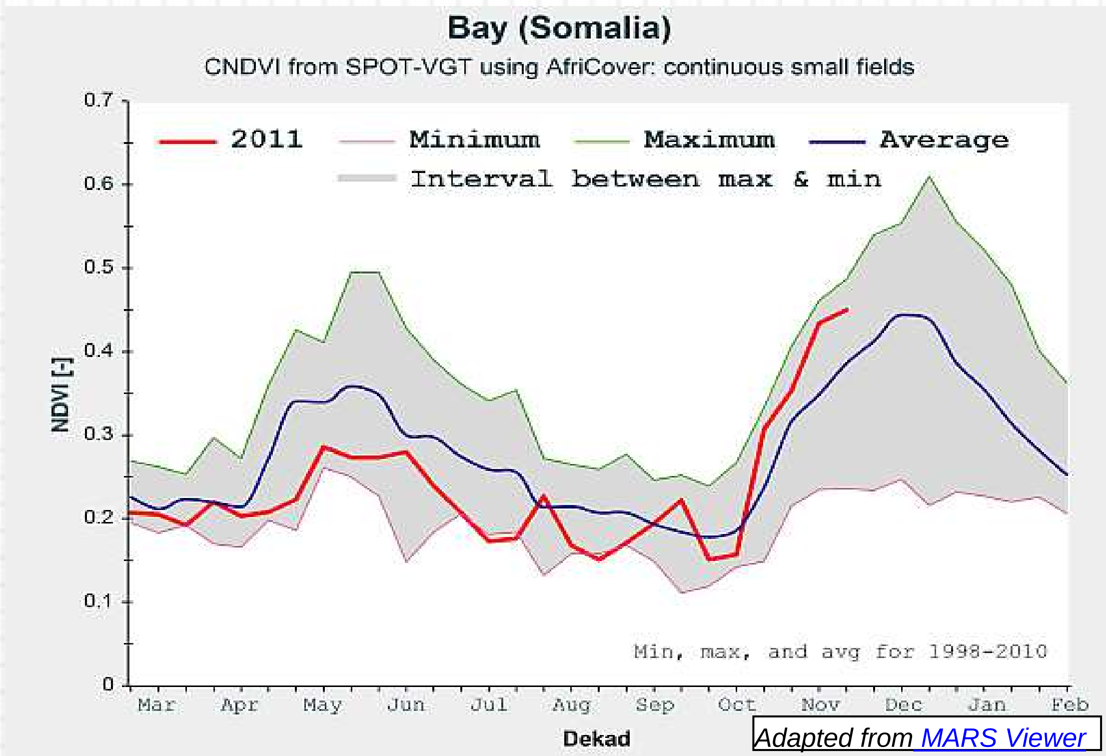
Click on the graph to enlarge it.

SEASONAL NDVI GRAPHS

Let's now merge the info provided by the last two graphs into a new one, showing the CNDVI for continuous small fields for Bay (Somalia), together with the average and historical maximum and minimum.

The area between minimum and maximum is colored grey: this indicates the range of existing CNDVI for each dekad in the time series.

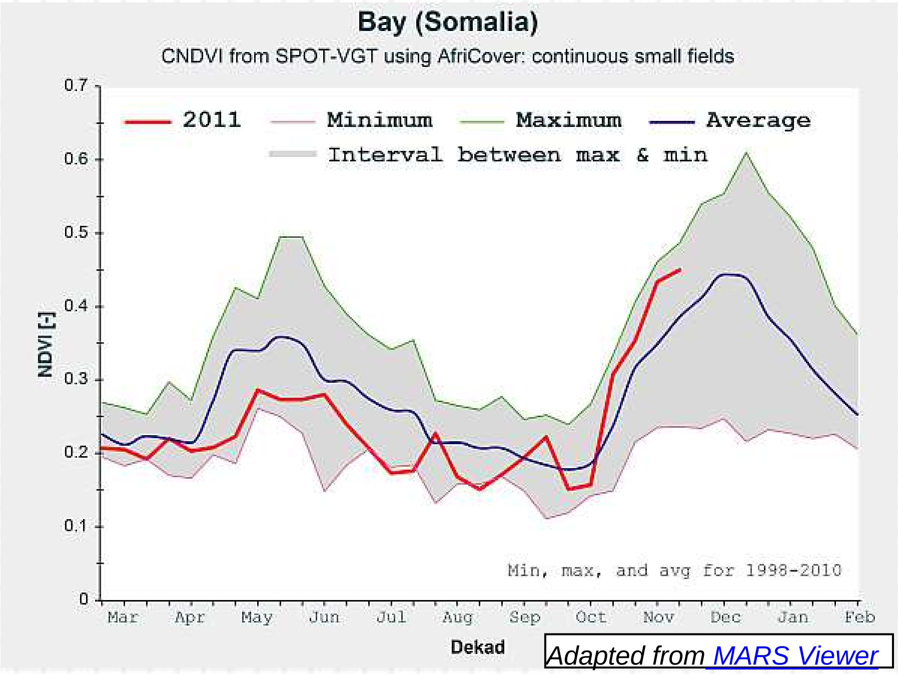
Note that the current year is not included in this range: the red 2011 line is in some occasions (July-August) slightly below the minimum.



Click on the graph to enlarge it.

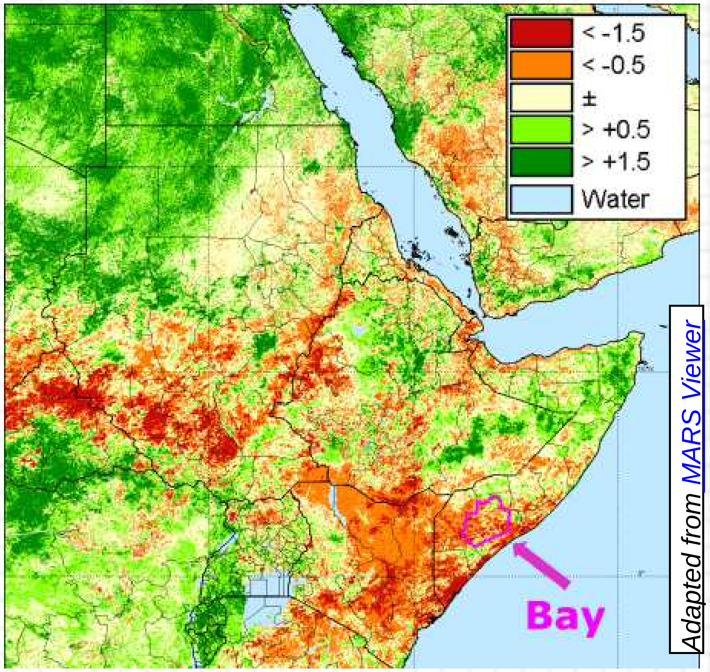
SEASONAL NDVI GRAPHS

Let's now compare the relatively low CNDVI of the *Gu* season for Bay (southern Somalia) to the following June NDVI anomaly maps.



Click on the graph to enlarge it.

NDVI June2011 anomaly maps



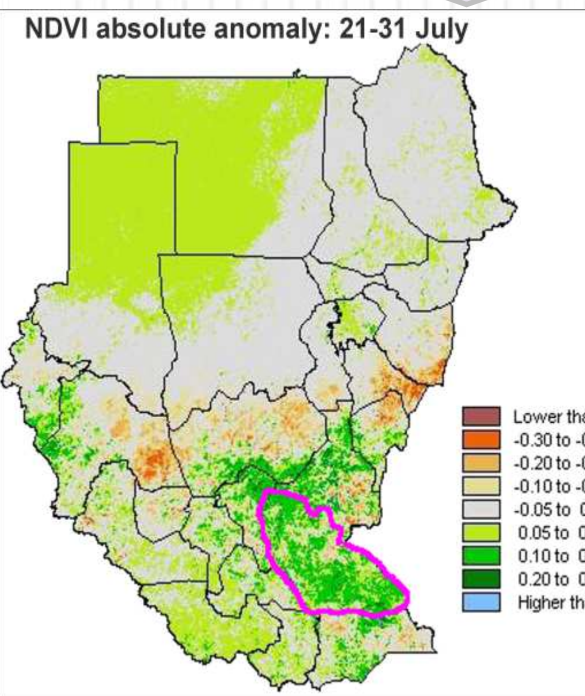
Click on the image to enlarge it.

Note that the anomaly maps show mostly red and orange colors in southern Somalia, which corresponds to the seasonal CNDVI graph, which is below-average for June 2011.

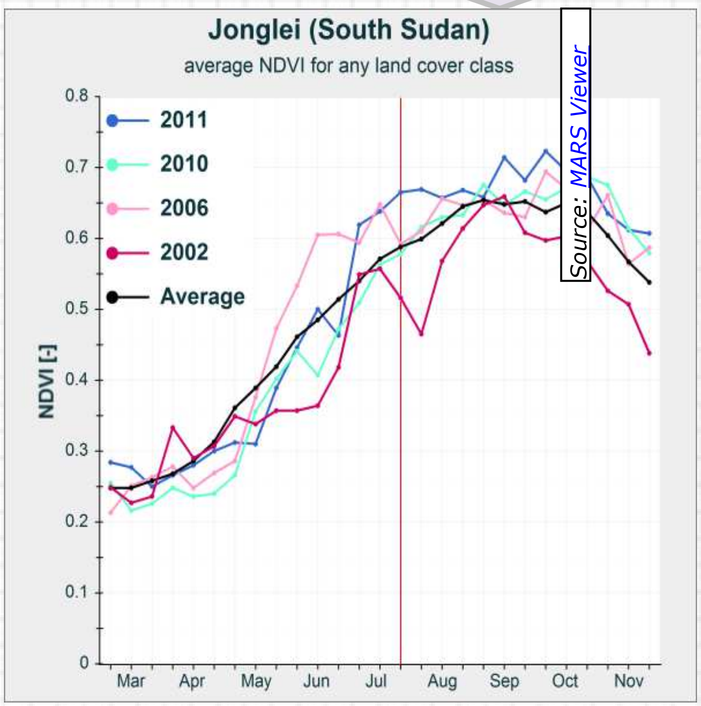
SEASONAL NDVI GRAPHS

This is a an **NDVI anomaly map** of the 3rd dekad of July for the former Sudan. The outline of the state of Jonglei is shown in pink. Since 9 July 2011 it is part of South Sudan.

This is a **seasonal NDVI graph** for Jonglei, including 4 individual years and the average profile (1998-2010). Here the graph presents a simple average of all NDVI cover class in Jonglei for the months March-November. The vertical red line indicates the 3rd dekad of July.



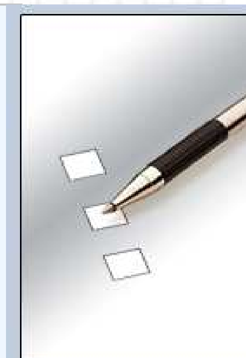
Source: Sudan Seasonal Monitor August 2011



Source: MARS Viewer

What is the corresponding year for the NDVI anomaly map?

- ○ 2002
- ○ 2006
- ○ 2010
- ○ 2011

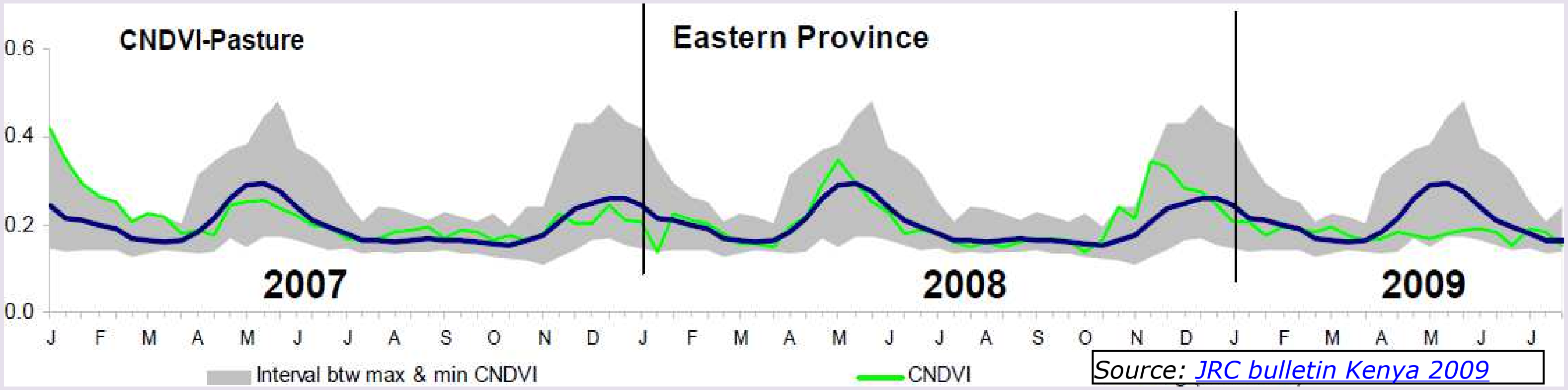


Please select the answer of your choice.

SEASONAL NDVI GRAPHS

This graph shows the **CNDVI** for the Kenyan Eastern Province for 2007-2009 in comparison to the **historical average**, **minimum and maximum**.

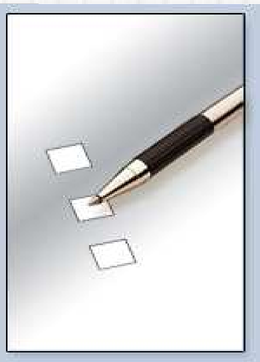
JRC crop monitoring bulletin for Kenya



Source: JRC bulletin Kenya 2009

During which of the indicated months the vegetation greenness was higher than normal?

- May 2007
- December 2007
- March 2008
- November 2008
- May 2009



Please select the answer of your choice.

SPATIAL AGGREGATION OF RAINFALL

Spatial aggregation of rainfall estimates can be done in the same way as for NDVI.

- FEWS-NET generally averages all pixels within an administrative unit or a crop mask.

- JRC uses a weighted average in analogy to the CNDVI concept.

You could refer to this as a **crop-specific aggregated rainfall estimate**.

The same concept may be applied to **other meteorological indicators**, such as temperature and radiation. We can therefore call these aggregated indicators **C-indicators**.

SEASONAL RAINFALL GRAPHS

Using rainfall estimate images for each 10-day period, you can construct **seasonal rainfall graphs**. The spatial aggregation and temporal plotting can be done in the same way as for NDVI.

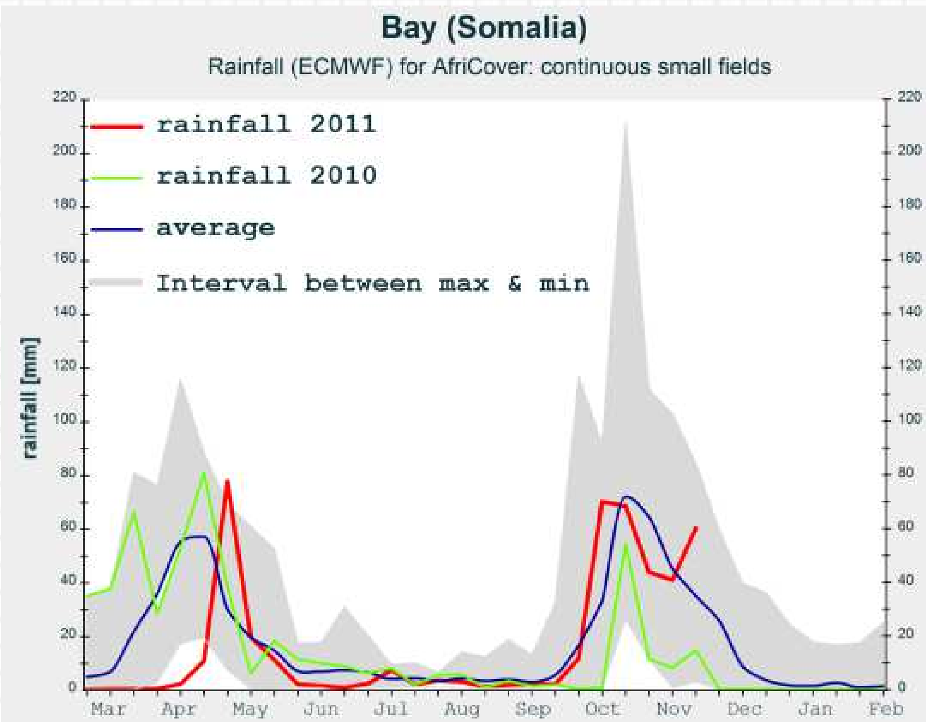
You can make **comparisons** with:

- individual years;
- historical minimum and maximum; and
- average rainfall.

Depending on the rainfall estimate product, 30 years or more of data may be available. This permits also extracting **seasonal profiles for the long-term average** (LTA).

SEASONAL RAINFALL GRAPHS

Let's consider the following example...



Adapted from MARS Viewer

This graph shows the rainfall estimate from the ECMWF (European Centre for Medium-Range Weather Forecasts) model aggregated for continuous small fields in the Bay region, Somalia.

The year 2011 is **compared to the previous year** (2010), LTA. The grey region shows the interval between historic maximum and minimum (as determined for past 30 years, i.e. 1981-2010).

Note that despite one high rainfall during the first dekad of May, rainfall amounts were well below average in the *Gu* season (Apr-Jun). The *Deyr* season (Oct-Jan) however received close to average rainfall.

Click on the graph to enlarge it.

A similar seasonal rainfall graph could also be made using **rain gauge data**.

SEASONAL RAINFALL GRAPHS – CUMULATED RAINFALL

Besides a graph containing the amount of rain received during each dekad, you can also **present for each dekad the rain amount since the start of the season** (or year). This is called cumulative rainfall.

How do I calculate cumulative rainfall?

Let's shortly illustrate this concept with an example....

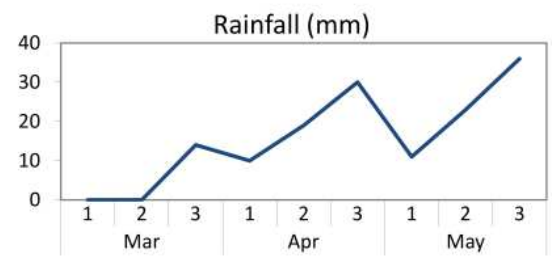
Example of cumulative rainfall calculation

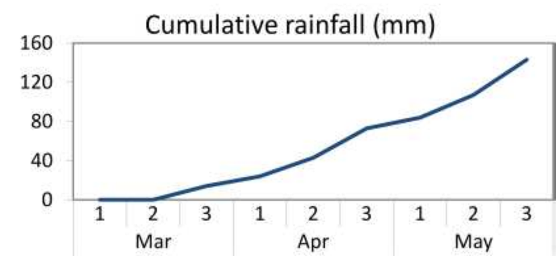
Let's assume a season starting in March. The table gives rainfall amount per dekad.

The cumulative rainfall can be calculated by adding the cumulative rainfall of the previous dekad with the rain received in the current dekad, for example:

Rainfall during the 3rd dekad of April was ***30 mm,*** and until then ***43 mm*** had fallen: ***43+30*** =***73 mm*** for the cumulated rainfall for that dekad.

	March			*April*			*May*		
	1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Rainfall	0	0	14	10	19	30	11	23	36
Cumulative rainfall	0	0	14	24	43	73	84	107	143





Adapted from MARS Viewer

SEASONAL RAINFALL GRAPHS – CUMULATED RAINFALL

You can compare the cumulative rainfall with previous years, like for 'normal' seasonal rainfall graphs. This **comparison** indicates whether this season (until a specific dekad) has received more or less rainfall than other years or multi-year averages.

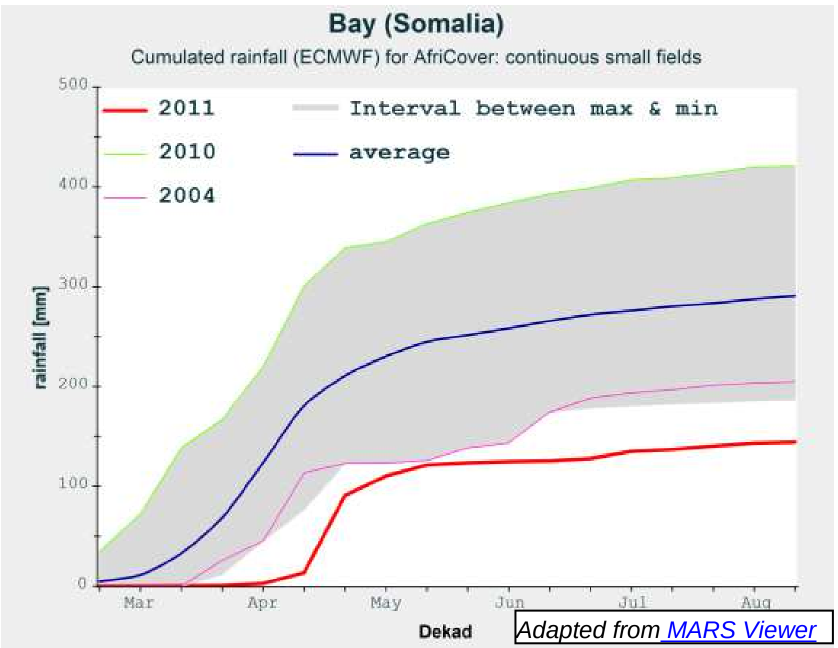
Total rainfall for a season gives important information for **water availability** to crops or pasture. However, interpretation needs to be done with care: for example run-off could diminish water availability when large quantities of rain fall during a short period.

Let's view an example of cumulated rainfall seasonal rainfall graphs…

SEASONAL RAINFALL GRAPHS – CUMULATED RAINFALL

Example: Cumulative rainfall seasonal graph

This graph shows the cumulative rainfall for the *Gu* season in the Bay region.



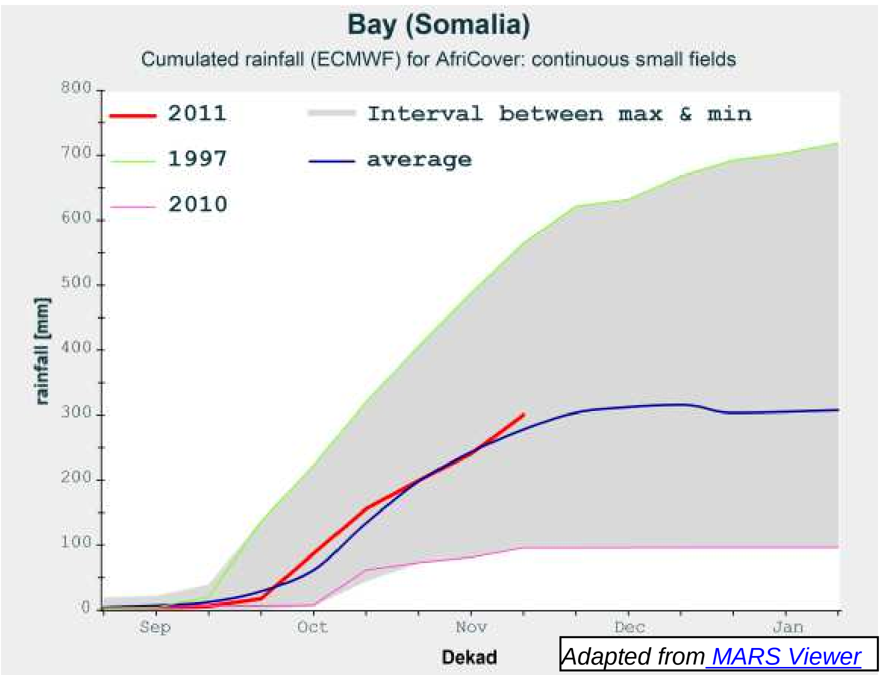
Click on the graph to enlarge it.

- The grey area gives the interval between ***historic minimum and maximum***.
- The dark blue line is the ***LTA***.
- The green line shows the ***wettest Gu season*** in history (2010: coinciding fully with the historic maximum).
- The pink line shows **one of the driest *Gu* seasons** (2004).
- The red line shows ***the 2011 Gu season*** of the 30 years in the LTA (2011).

The 2011 *Gu* season is drier than any of the 30 years in the LTA. In fact a famine struck southern Somalia shortly after the 2011 *Gu* season. This famine resulted partly also from the previous season that had failed, i.e. the 2010 *Deyr* season.

SEASONAL RAINFALL GRAPHS – CUMULATED RAINFALL

Example: Cumulative rainfall seasonal graph



Click on the graph to enlarge it.

This graph shows that 2010 had the driest *Deyr* season in 30 years.

The 2011 *Deyr* season is however proceeding well with about average rainfall (red line).

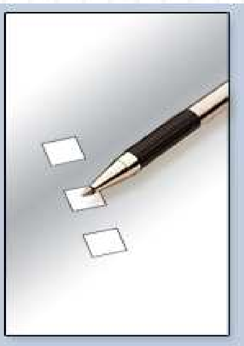
For effective analysis of the season performance, the graph should start with the (relatively) dry period just before that season.

For regions with two seasons per year, it is recommended to make separate graphs for each season.

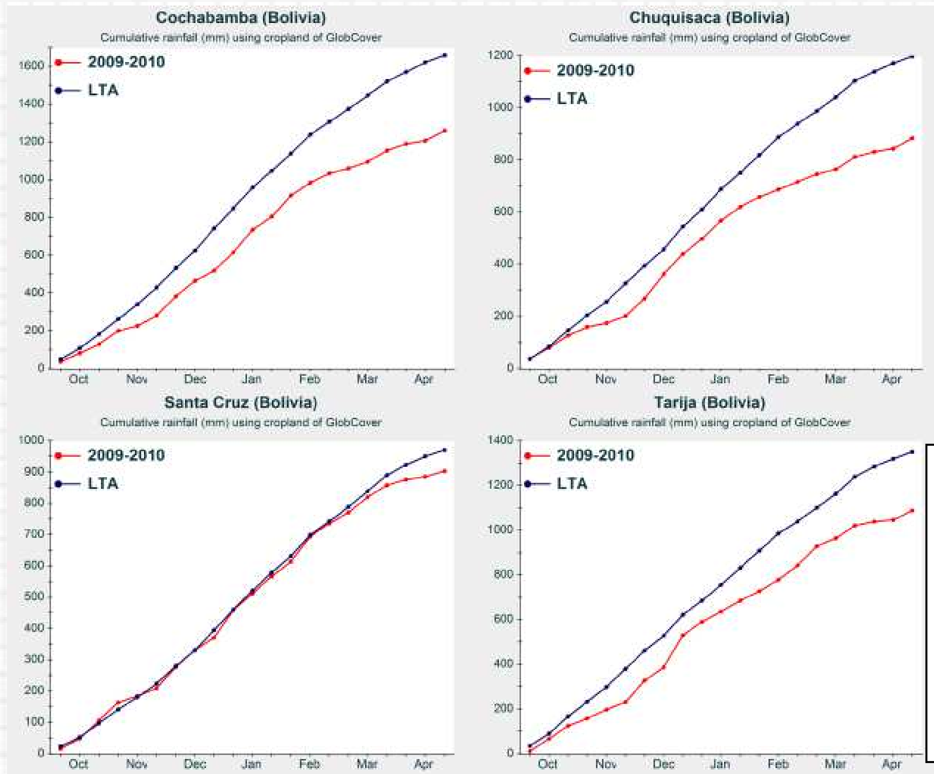
SEASONAL RAINFALL GRAPHS – CUMULATED RAINFALL

These graphs show Bolivian four major cropping areas' cumulative rainfall for the October-April season (2009-2010) against the LTA.

Which region had closest to normal rainfall?



- Cochabamba
- Chuquisaca
- Santa Cruz
- Tarija



Adapted from MARS Viewer

Click on the image to enlarge it.

Please select the answer of your choice.

SEASONAL COMPOSITE GRAPHS

For early warning purposes **graphs showing at the same time** the development of vegetation (through **NDVI**) and **rainfall** (on 2 axes) are very helpful.

In fact, they provide information on:

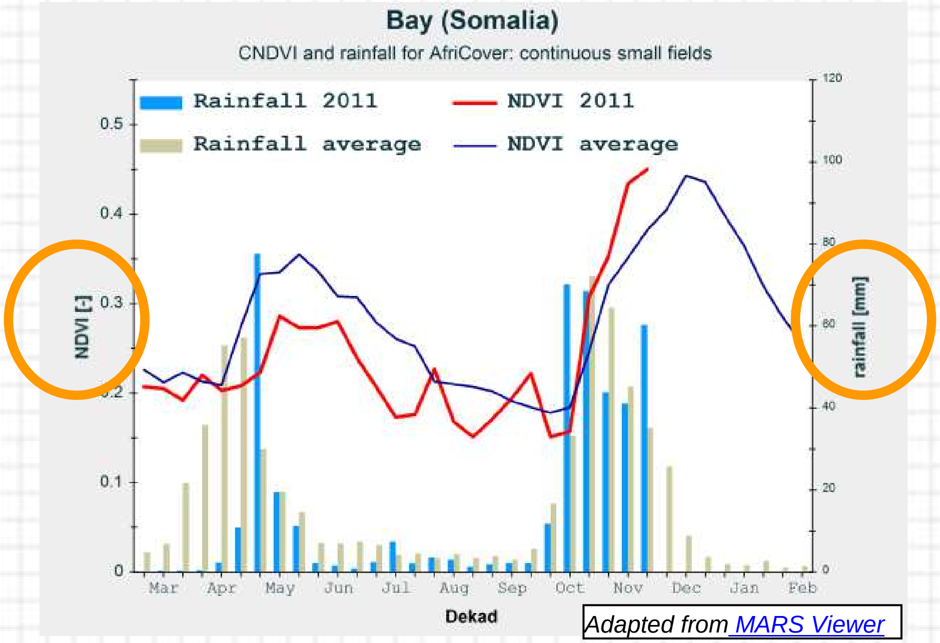
- possible stress situations as compared to normal; and
- relationship between rainfall and vegetation greenness.

In principle it is possible to **combine** all the ingredients shown in this lesson (*LTA, historic maximum and minimum, known good/bad years, cumulative rainfall*, etc.) into a single graph.

For readability however it makes sense to **present only key information**.

Often this will come down to showing:

- the **current year rainfall and NDVI**; against
- a **multi-year average**.



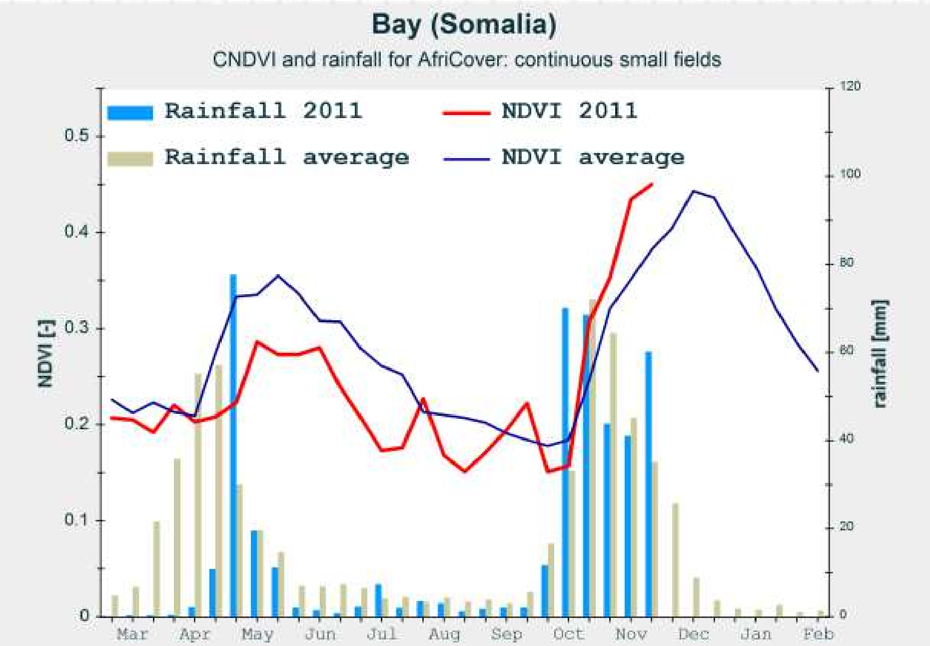
Adapted from MARS Viewer

As an example, let's examine this graphs in detail...

SEASONAL COMPOSITE GRAPHS

All information contained in this graph has previously been presented in this lesson.

Here **rainfall** and **NDVI** for 2011 are plotted against their **historic averages**. To better separate rainfall and NDVI, rainfall is presented in bars.



Adapted from MARS Viewer

Click on the graph to enlarge it.

- Until the end of April 2011, almost no rain was received, causing NDVI to stay at very low levels.
- The high amount of rainfall during the first dekad of May did not make up for the poor vegetation development: NDVI remained far below normal during the whole *Gu* season.
- The 2011 *Deyr* season started good with a high amount of rainfall in mid-October causing a steep rise in NDVI.
- Given the above-average rainfall during the 3rd dekad of November (last dekad in the analyzed series), NDVI can be expected to rise further and reach above-average levels.

CONVERGENCE OF EVIDENCE

NDVI and rainfall estimates are two independent data sources.

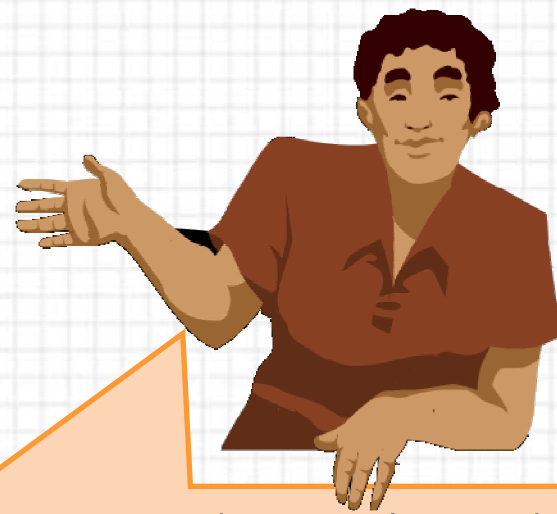
If NDVI and rainfall show the same type of anomaly, we say that the evidence for such an anomaly (positive or negative) converges.

The previous example showed that 2011 NDVI and rainfall anomalies tell a similar story for the Bay region:

•less than normal rainfall in the *Gu* season leads to lower NDVI; while

•above normal rainfall in the *Deyr* season leads to higher NDVI values.

In this case, the information from both data sources **converges.**



But **convergence** does not always take place! If only one data source shows an anomaly while the other is close to normal, more attention is needed for interpretation....

CONVERGENCE OF EVIDENCE

When interpreting NDVI and rainfall anomalies, **data quality may be an issue**, for example:

•**poor rainfall estimates** because important processes are not well represented;

•persistent **cloud cover** resulting in low NDVI values not matching with real vegetation greenness.

Besides 'technical' reasons, processes on the ground could well be the cause of the **divergence**.

Explaining **divergence in anomalies** between both data sources thus requires additional field knowledge.

Popup Window

Important processes

One example of important processes that may be ill-represented in rainfall estimate products is **orographic rainfall**: in mountainous terrain, clouds can develop following a lifting of moist air. This can result in rainfall although the cloud top is still relatively warm. Rainfall estimate products that use satellite-derived cloud temperature as a main input cannot effectively account for this rainfall process. Similar problems can affect rainfall estimates in coastal regions.

Popup Window

Processes on the ground

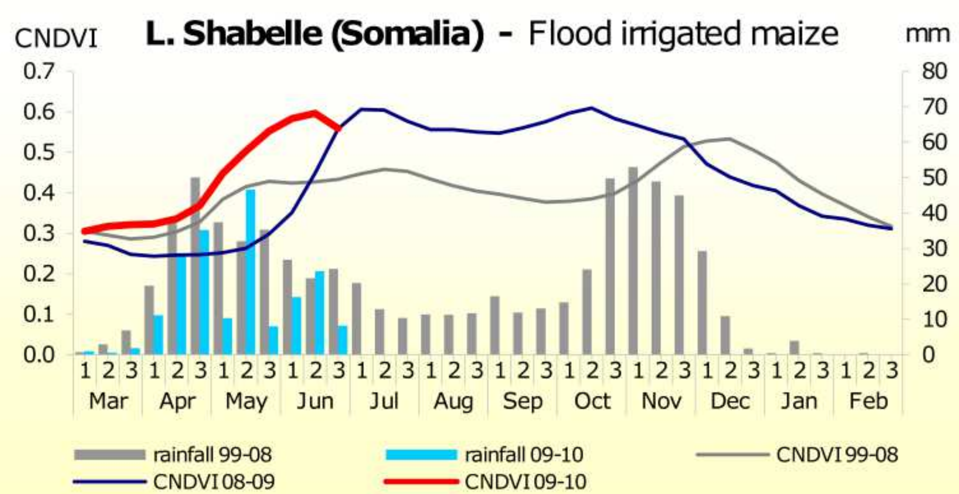
You can think of processes like:

- land use / crop area change;
- increased water extraction for irrigation;
- introduction of earlier crop varieties;
- Floods...

CONVERGENCE OF EVIDENCE

Example of non-convergence

This is a combined graph for flood irrigated maize in the Lower Shabelle region of Somalia. Despite below-average rainfall during March-June 2009, **NDVI increased** much earlier to high levels.



Source: JRC bulletin 06-2009

Click on the graph to enlarge it.

To explain this you should look at other factors than rainfall:

Ground reports indicate **a large area increase** due to high maize prices, while **access to irrigation water** improved because of **canal rehabilitation** and temporarily **improved security**.

This example stresses again that if two sources give contrasting information, additional data collection and analysis are required.

SUMMARY

Seasonal graphs show how rainfall and/or NDVI behave during a specific season.

To provide representative information in seasonal graphs, rainfall and NDVI are **spatially aggregated** (mostly within administrative regions).

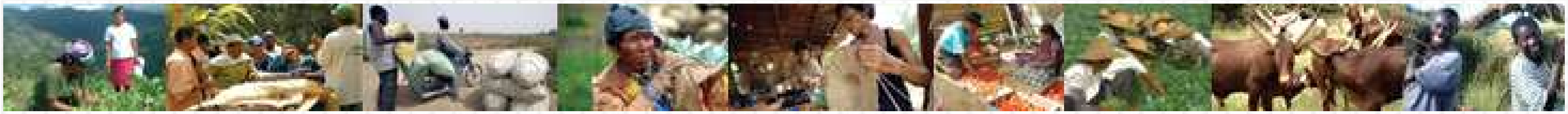
CNDVI is a method to create a weighted average NDVI value for a region which only represents a specific land cover class: this method can also be applied to rainfall estimates.

Anomalies can be identified from seasonal graphs by **comparing** the **current year with previous years**: for that purpose historic average and minimum/maximum values are useful to include in these graphs.

If NDVI and rainfall show the same type of anomaly, we say that the evidence for such an anomaly (positive or negative) **converges**. If not, interpretation should be done with care and additional analysis may be needed.

Flash
File \Images\CWD\swf\Summary.jpg.swf

IF YOU WANT TO KNOW MORE



Online resources

AfriCover - http://www.africover.org/

FAO GAUL: Global Administrative Unit Layers - http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

FAO GIEWS seasonal graphs for rainfall - http://www.fao.org/giews/english/ierf/index.htm

Famine Early Warning Systems Network (FEWS-NET) Early Warning Explore (EWX) - http://earlywarning.usgs.gov:8080/EWX/index.html

JRC MARS Crop bulletins - http://mars.jrc.it/mars/Bulletins-Publications

MARS Web Viewer for spatial and temporal analysis using MARS data (registration needed) - http://www.marsop.info/marsop3/ (website to be updated as MARSOP contract is being renewed)

First article on CNDVI - Genovese, G., C. Vignolles, T. Nègre, and G. Passera. 2001. A methodology for a combined use of normalised difference vegetation index and CORINE land cover data for crop yield monitoring and forecasting. A case study on Spain. Agronomie 21: 91-111. http://www.agronomy-journal.org/index.php?option=com_article&access=doi&doi=10.1051/agro:2001111&Itemid=129