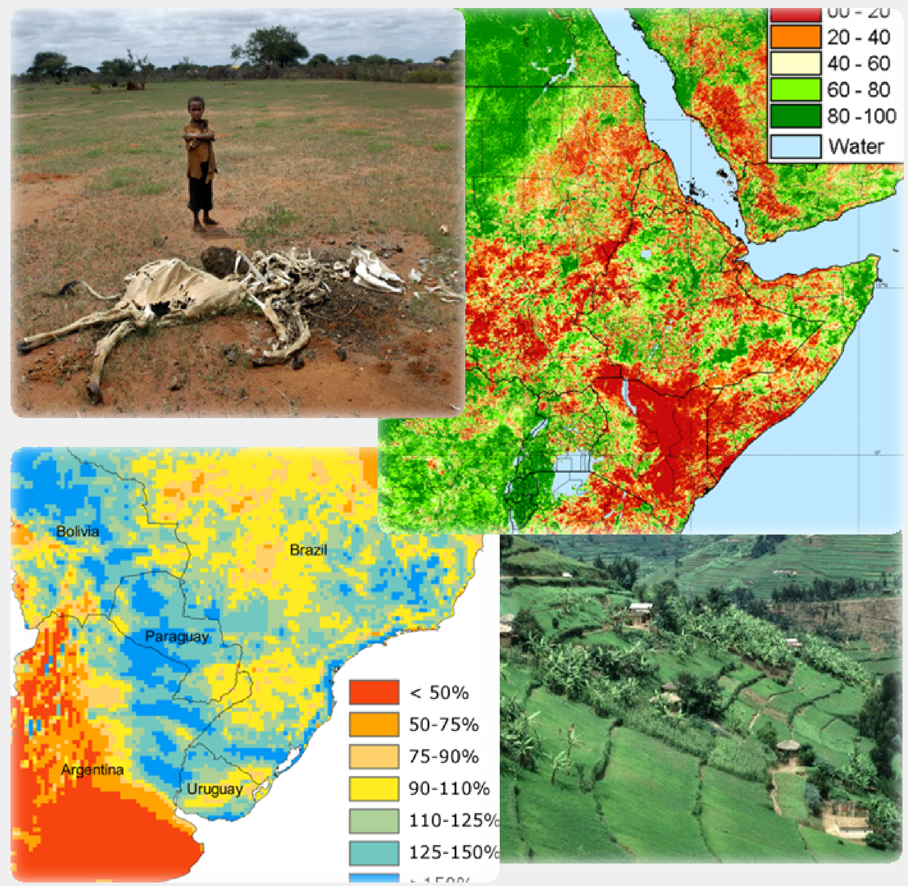
LEARNING OBJECTIVES

Lesson 3
Methods and Analysis: Rainfall and NDVI Anomaly Maps

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

- interpret maps of rainfall estimates and derived **rainfall anomaly maps**;
- understand NDVI and **NDVI anomaly maps**; and
- geographically localize dry spells and vegetation stress at specific times during the crop season.



WHAT IS AN ANOMALY?

Let's start defining what an anomaly is:

Anomaly

A deviation from normal behaviour. In crop monitoring, a quantitative measure that expresses how different a variable at a certain place and time (e.g. rainfall, NDVI) is from reference conditions.

So, in crop monitoring the **deviation** relates to the difference from reference years or form multi-annual **average conditions**, which are considered as the norm.

ANOMALY MAPS

Rainfall estimates (RFE) and vegetation indices are key data sources for crop monitoring. Anomaly maps can identify how and where **rainfall** and **vegetation** development are **different from normal**.

Below-normal conditions relate to **drought** (water stress) conditions. These may have implications for crop yields and pasture availability, potentially affecting human lives and livelihoods.

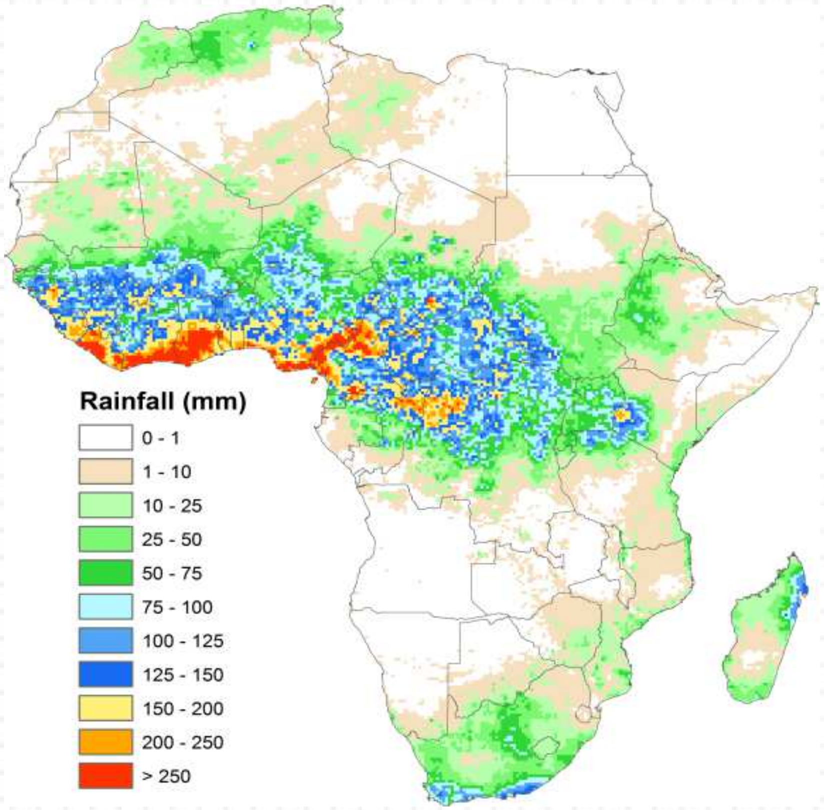
Above-normal conditions could imply **good vegetation development**, but in the case of rainfall could also relate to problems like **flooding**.

Therefore it is **good to look at more indicators**, i.e. not only at rainfall. Rainfall is a necessary condition for crop development, while vegetation indices observe actual vegetation growth.

Anomaly maps give an indication about the location and extent of areas of potential concern regarding reduced crop or pasture availability. They thus form an important input to food security analysis and the planning of potential relief measures.

RAINFALL ESTIMATES

June 2011 monthly rainfall map



Click on the map to enlarge it

Rainfall estimates provide a spatial and temporal overview of the amount of rainfall based on a variety of input data.

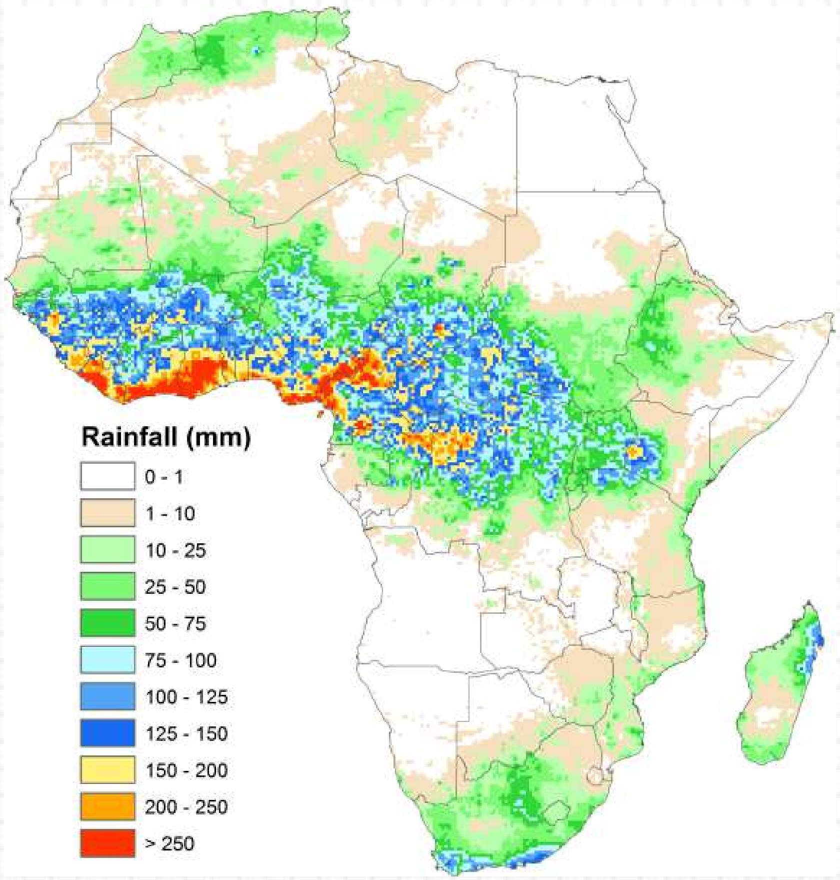
In this module we will use the term ***rainfall*** as a synonym for ***rainfall estimate***, although all data and maps presented are estimates.

The figure shows a monthly rainfall map for June 2011 (in this case the rainfall estimate of the TRMM 3B43 product). It provides spatial information on the amount of rainfall received during June 2011.

(Colour scale taken from FEWS-NET)

RAINFALL ESTIMATES

June 2011 monthly rainfall map



Click on the map to enlarge it

Why could I be interested in rainfall anomalies?

You can observe that highest rainfall amounts were received along the coast of West Africa, and also western Kenya had a wet month.

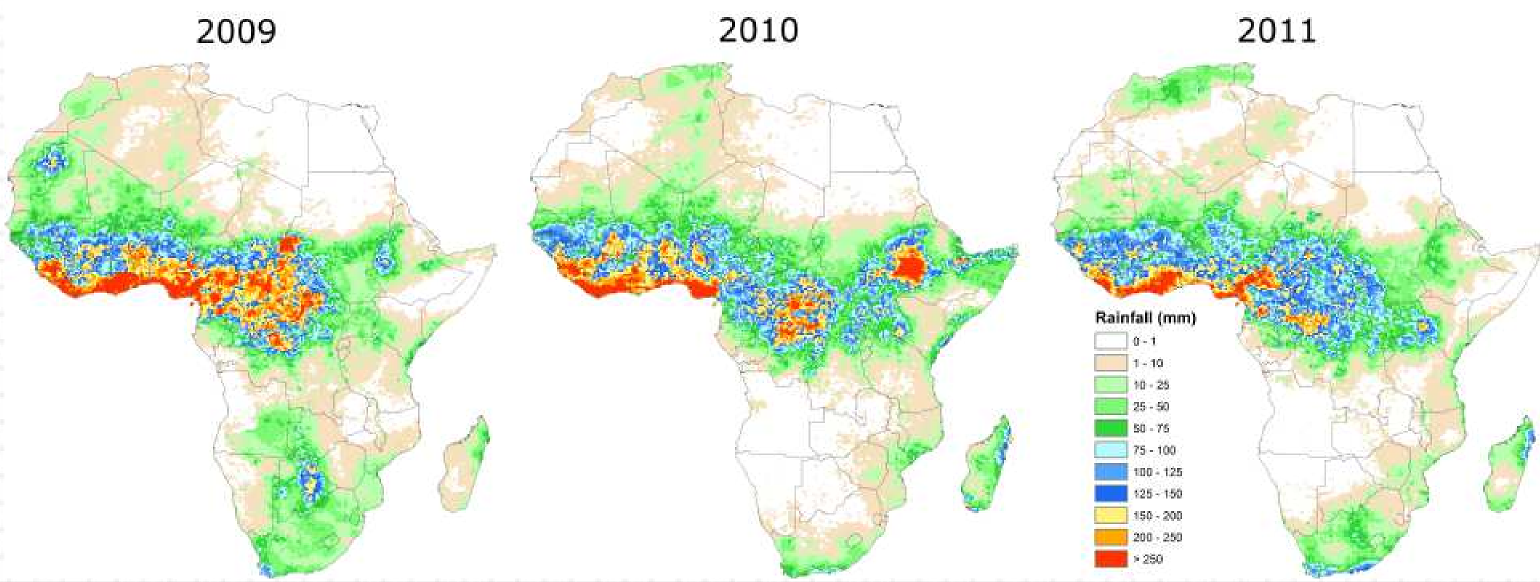
Angola, Namibia, and Zambia hardly received any rainfall. However, can you say that there was a drought in those countries? The answer is no, unless we have a reference level to compare these rainfall amounts to.

A number of drought definitions exists, but most refer to below-average conditions. Hence in this case a **June reference level is needed**.

COMPARING WITH HISTORICAL REFERENCE

Reference rainfall can be obtained from data of previous years. You could simply compare your June 2011 map with June rainfall maps of other years.

Rainfall June 2009-2011



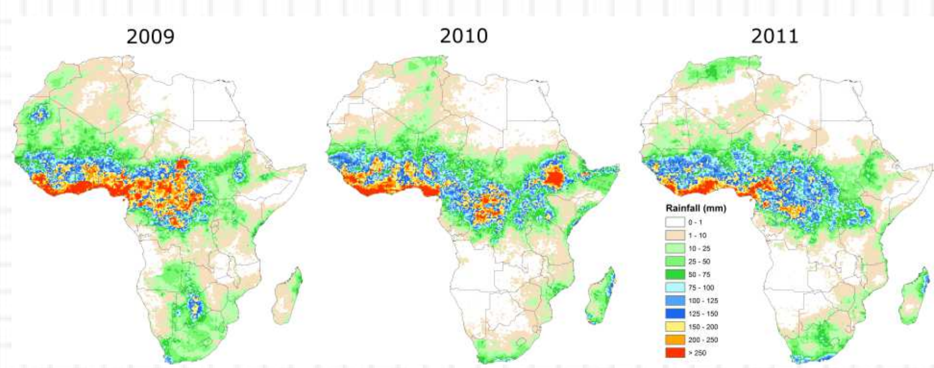
Click on the map to enlarge it

Here is a comparison of 2011 with rainfall in June 2009 and 2010. You can quickly observe that the coast of West Africa generally receives high quantities of rain in June. At the same time other parts are always dry in this month (such as Egypt). Careful visual inspection also allows finding differences. For example wet conditions are apparent in Botswana and west Sudan (2009), in western Ethiopia (2010) and in northern Algeria (2011).

ANOMALIES BASED ON A REFERENCE YEAR

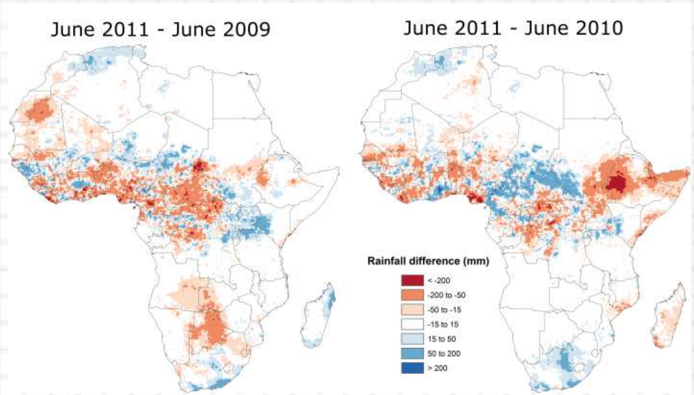
Comparing two or more rainfall maps requires careful visual inspection. You can facilitate this process by presenting the information of two maps in one.

Let's consider again the June rainfall maps.



You can subtract the two images from each other, i.e. calculate for each pixel:

Difference = rainfall (June2011) – rainfall (June2010)



Click on the map to enlarge it

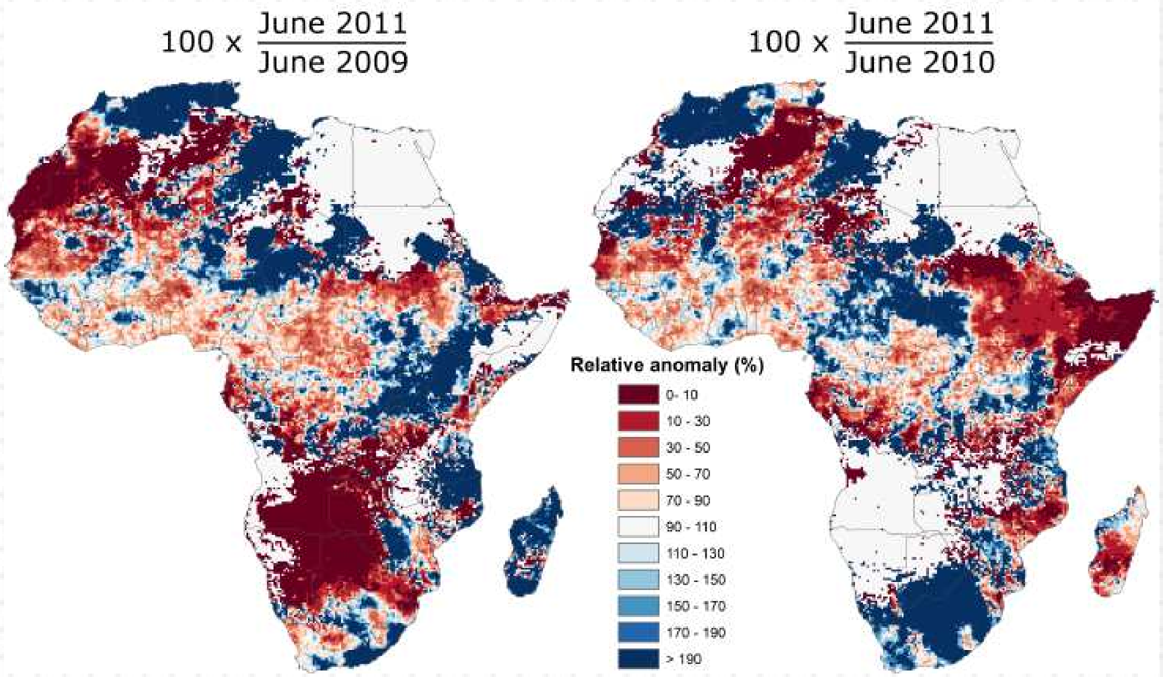
Difference values below 0 imply that rainfall in June 2011 was less than in June 2010 (i.e. drier conditions). Note that **different reference years can give very different results**.

The best reference year depends largely on the analyst and whether he wants to compare to dry, average, or wet years. Of course for large regions (such as Africa) the same year could be wet in one part and dry in others.

ANOMALIES BASED ON A REFERENCE YEAR

A **relative** representation of the **difference between two years** is also possible.

Rainfall difference June 2011 compared to previous years



Click on the map to enlarge it

Following the example, the June 2011 rainfall is expressed as a percentage of the June 2010 (and 2009) rainfall for each pixel. A value below 100% means that June 2011 is drier than June 2010 (or 2009). **Note that small absolute difference can translate in large relative anomalies.**

MULTI-ANNUAL AVERAGE CONDITIONS

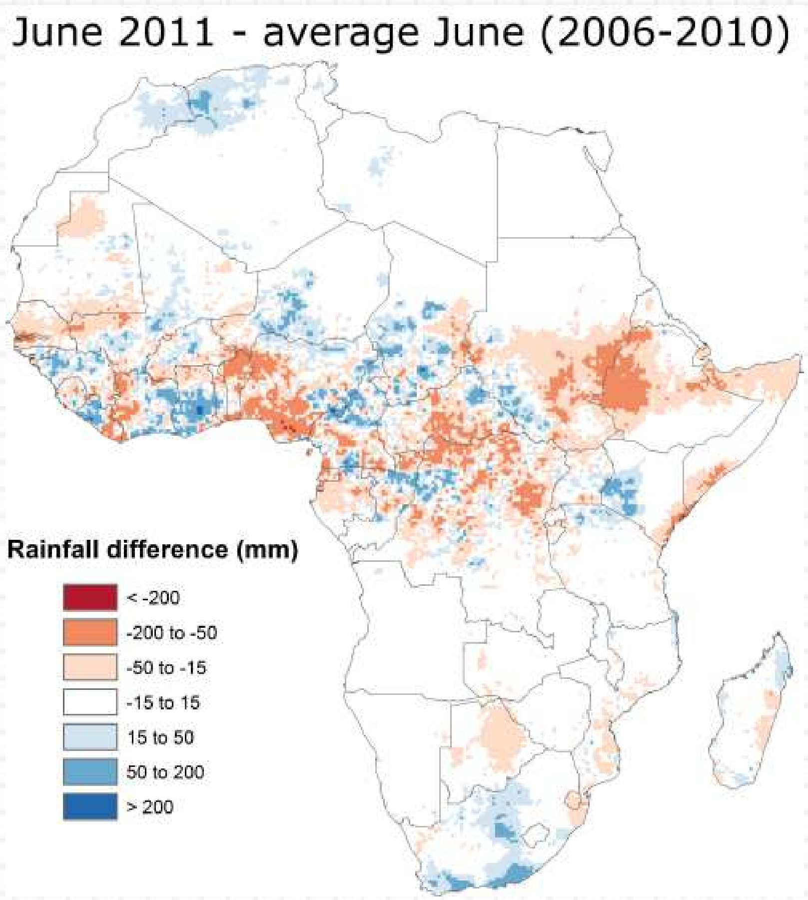
As alternative to single reference years, **multi-annual averages** can be used as the reference. These are then assumed to be the normal condition.

How do I get a multi-annual average?

Let’s consider an example...

MULTI-ANNUAL AVERAGE CONDITIONS

As an example, let’s calculate a **5-year average June rainfall**.



Click on the map to enlarge it.

Simply add all June rainfall (*P*) values between 2006 and 2010, and divide by 5.

$$\overline{P\,June} = \sum_{i=2006}^{2010} P_i^{June} \Big/ 5$$

You could do this of course for any other month. These calculations can be made in Excel for a single location.

	A	B	C	D	E	F	G
1		2006	2007	2008	2009	2010	Average
2	January	3.0	52.9	3.9	5.5	34.2	19.9
3	February	26.4	12.7	0.4	1.6	9.2	10.1
4	March	38.4	5.6	3.5	12.2	18.7	15.7
5	April	73.3	15.7	26.5	19.4	8.6	28.7
6	May	172.3	110.4	43.0	11.8	40.7	75.6
7	June	43.2	79.8	106.8	34.2	301.0	113.0
8	July	285.5	78.6	108.4	179.9	43.5	139.2
9	August	124.3	70.7	150.9	85.0	46.5	95.5
10	September	181.0	31.3	56.2	83.6	151.2	100.7
11	October	76.8	16.1	68.0	82.5	8.6	50.4
12	November	27.4	10.0	14.6	1.1	44.6	19.5
13	December	27.4	0.0	2.1	29.5	1.3	12.1

Open the spreadsheet

MULTI-ANNUAL AVERAGE CONDITIONS

In order to calculate a multi-annual average, you can also use different **base periods**.

Two main conventions exist:

Long-term average (LTA)

Usually 30 years.

Short-term average (STA) or Recent average

Usually 5 or 10 years.

In **climatology**, climate normals (**LTA's**) are calculated for fixed 30-year periods, i.e. 1961-1990, 1971-2000, 1981-2010.

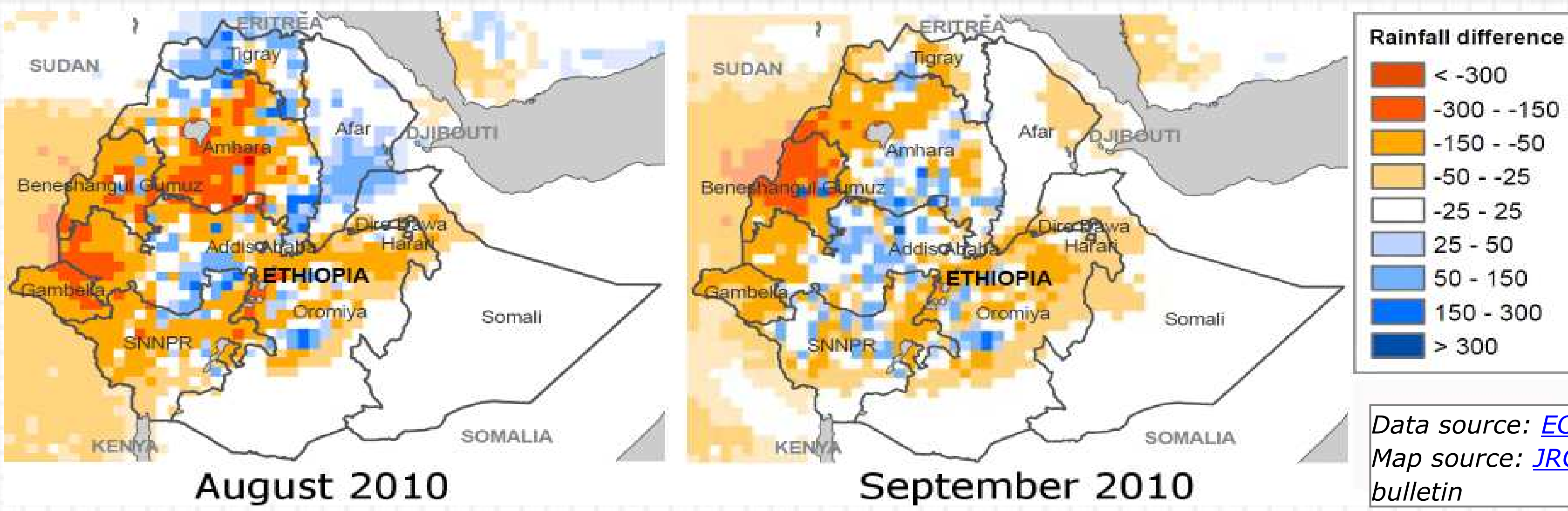
For **crop monitoring** this can be different: for example the Joint Research Centre recalculates and updates **LTA** and **STA** at the start of each calendar year.

MULTI-ANNUAL AVERAGE CONDITIONS

You will not always find 30 years of available data for rainfall or NDVI products, especially for products derived from remote sensing sources. Therefore, instead of 5 or 10 years, an alternative is to use all years available. **Which base period to use**, thus **depends on data availability**.

In addition you should make your own judgment whether it is **more relevant** to compare to climate normals (LTA) or recent conditions.

Difference with average rainfall of the previous 10 years



Data source: ECMWF.
Map source: JRC bulletin Ethiopia Nov2010

Click on the map to enlarge it.

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

How can I calculate anomalies?

Anomalies can be calculated and presented in different ways. The most common are:

- **Absolute**
- **Relative**
- **Standardized**

Click on the buttons for more information

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

- Absolute
- Relative
- Standardized

Absolute

Simple difference between current value and the average of previous years. The difference is expressed in the physical units of the variable (e.g. mm for RFE).

current value − *average previous years*

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

Absolute

Relative

Standardized

Relative

The current value is expressed as a percentage of the average. A value below 100% means that rainfall (NDVI) is lower compared to normal conditions.

100* values ÷ ***average***

Sometimes the difference between current and average is expressed as a percentage of the average!

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

Absolute

Relative

Standardized

Standardized (or **z-score**)

Difference between current value and the average of previous years, divided by the standard deviation calculated from all previous year values.
For example, for rainfall negative z-scores indicate drier than normal conditions.

(*current value* − *average*) ÷ *Stddev*

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

Do you think the following sentence is true?

Another common name for standardized anomaly is z-score.

- Yes
- No

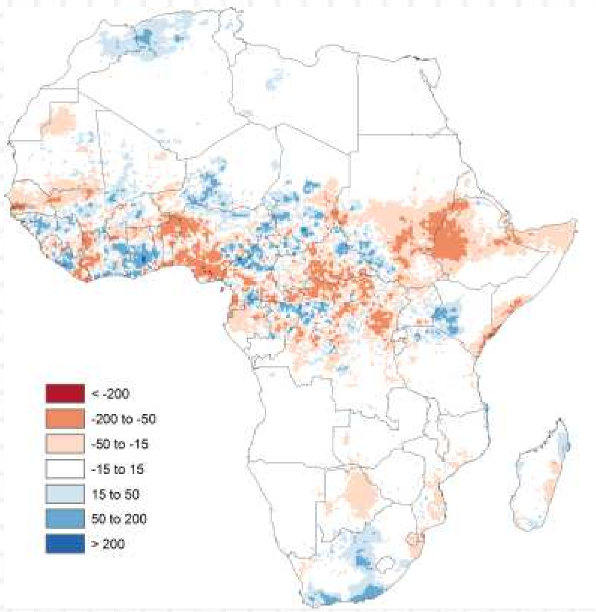
Please select the answer of your choice.

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

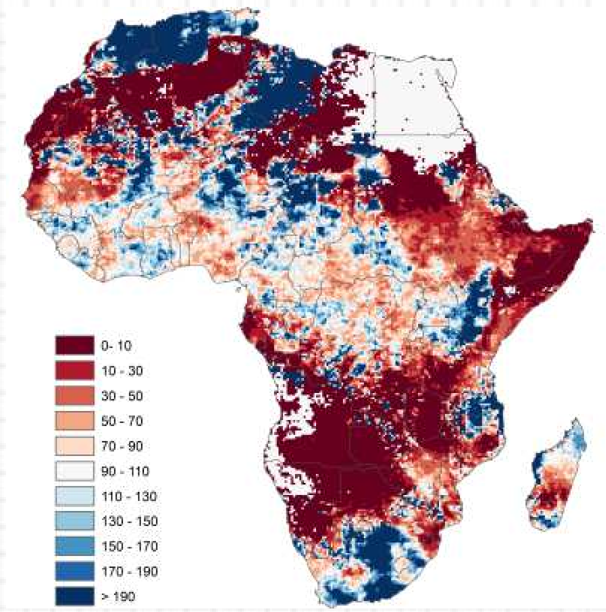
Let's compare different anomaly maps relating rainfall of June 2011 to June of 2006-2010.

The relative anomaly shows **large dark red areas** and **some dark blue areas**, invisible on the absolute anomaly map. This is largely an artifact of **low normal levels of precipitation** during that month. Let's see an example...

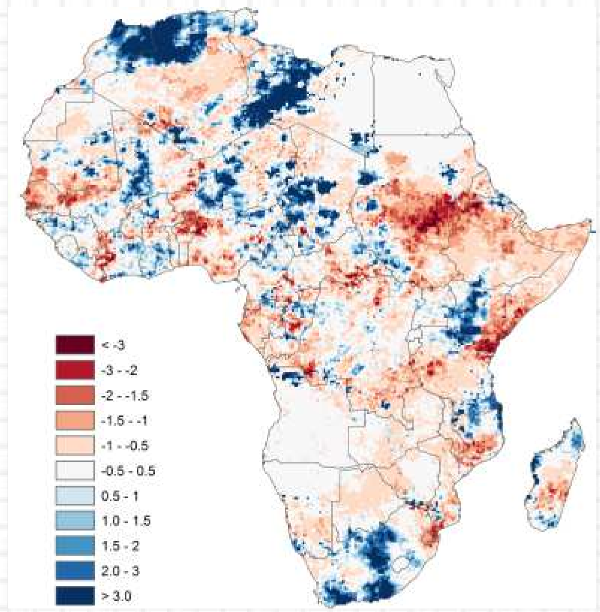
Absolute (mm)



Relative (% of 5-yr mean)



Standardized (z-score)

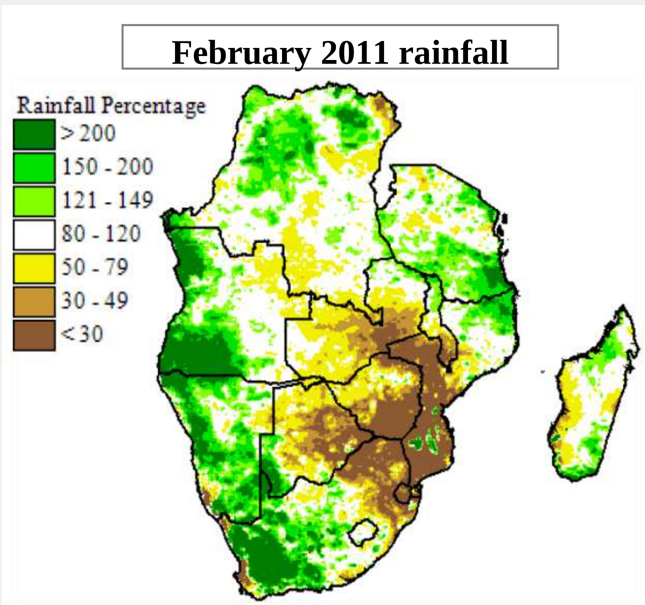


Click on each map to enlarge it.

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

Most organizations consistently use one type of anomaly in agro-meteorological and food security bulletins. For example, JRC FOODSEC and FEWS-NET (Famine Early Warning Systems Network) mostly present **absolute anomalies** (for vegetation indices).

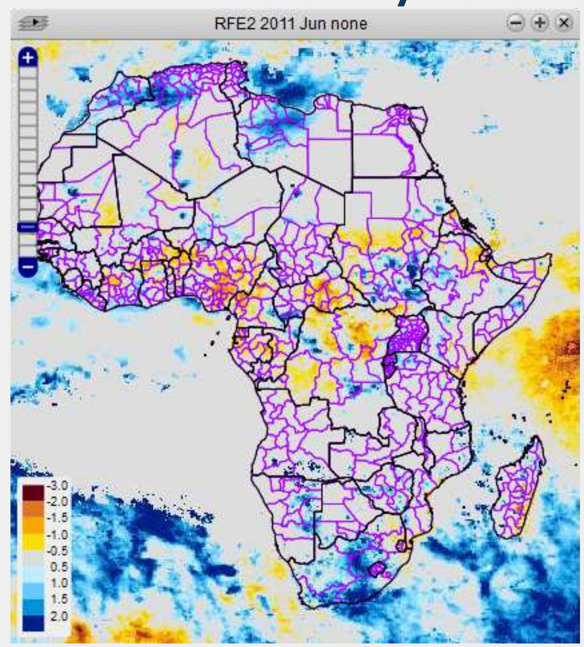
Relative anomaly from SADC



The Southern African Development Community (SADC) generally uses **relative anomalies**.

Click on each map to enlarge it

Standardized anomaly from RFE2



Online tools such as the Early Warning Explorer also allow calculating and mapping **standardized anomalies**.

MULTI-ANNUAL AVERAGE – HOW TO CALCULATE ANOMALIES

The following table summarizes the characteristics of each anomaly and highlight the respective advantages and disadvantages.

Anomaly	Unit	Expresses	Advantages	Disadvantages
Absolute	mm	Absolute difference between current and normal.	Easy to interpret.	Not apparent how anomaly relates to normal rainfall.
Relative	%	Current as percentage of normal.	Easy to interpret.	Gives extreme results in areas that normally receive little rainfall during specific month.
Standardized	-	Number of standard deviations current is above/below normal level.	Takes into account the variability between years.	Interpretation is a bit more complex (unitless).

RAINFALL ANOMALIES: DEKAD, MONTH, SEASON

Rainfall anomaly maps can be made for different time periods. **The most common integration periods** are:

dekad

month

season

Dekad = 10 days . A 10-day time step is widely used in agro-meteorology and crop monitoring.

In practice **three periods per month** are used (for day 1-10, 11-20, and 21- end of month), where the 3rd dekad of the month can range from 8 to 11 days.

Dekadal data give a good account of current conditions. However, rainfall during one dekad says little about the longer term conditions. Therefore ideally a 10-day anomaly map is presented together with neighbouring 10-day periods, or to show up-to-date data on continuing trends (e.g. present dekad after a month with known droughts).

Not to be confused with ***decade*** (=decennium) which indicates a period of 10 years.

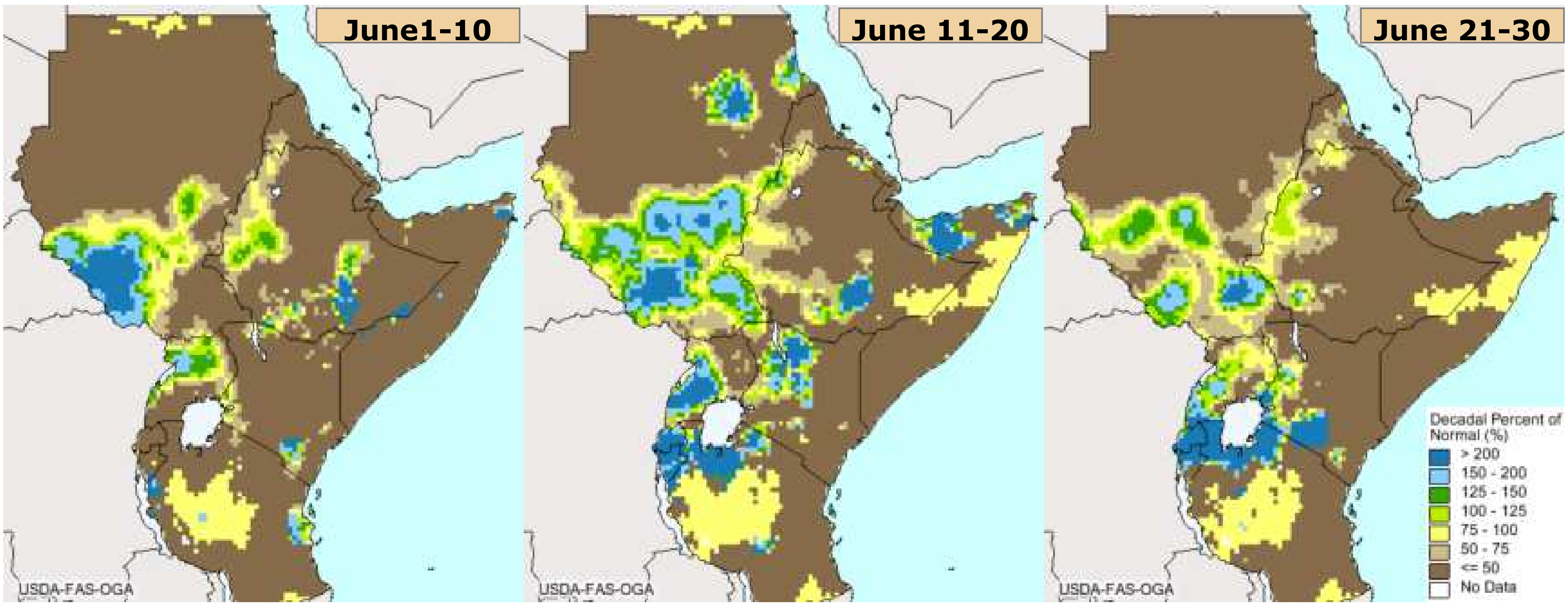
View an example

Popup Window

Dekadal anomaly maps

This map shows three dekadal anomaly maps for June 2011. Some areas (e.g. South Somalia, Eastern Kenya) persistently show below-average rainfall.

Dekadal relative anomaly maps East Africa



Click on the map to enlarge it.

Map source: Crop Explorer USDA FAS
Data source: AFWA LIS

RAINFALL ANOMALIES: DEKAD, MONTH, SEASON

dekad

month

season

Monthly rainfall equals the accumulation of rainfall during three dekads. A longer integration time averages out much of the short-term rainfall variability.

In other words, a dry anomaly during one month is more indicative of potential drought-related problems as compared to the anomaly for a single dekad.

RAINFALL ANOMALIES: DEKAD, MONTH, SEASON

dekad

month

season

Seasonal rainfall is the accumulation of rainfall during multiple dekads or months. One dry month can often be compensated for by a wet month, and crop production may still attain good levels. However, below-average rainfall during the season is strongly linked to below-average crop productivity for water-limited production systems.

Two options exist for anomaly mapping:

•**entire season**, can only be completed at the end of the growing season; and

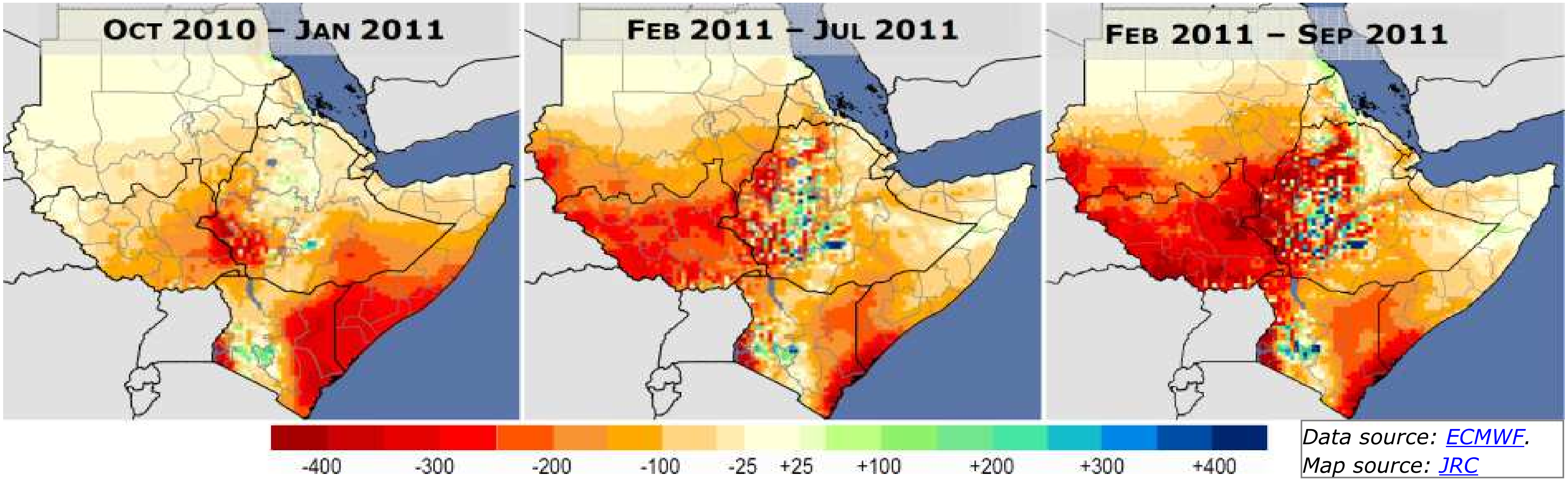
•**cumulative rainfall for the season until present**, includes the most recent rainfall data to give the status of the ongoing season.

View an example

Popup Window

Seasonal rainfall anomaly map

The maps show seasonal rainfall anomalies (mm). The middle map (July bulletin) was updated for a longer period in the right-hand map (September bulletin) when more data were available.
The choice of start and end of season should normally depend on the crop calendar. For large regions (such as dekadal example map) crop calendars can vary much within the region, making the choice for start and end date somewhat subjective (i.e. dependent on dominant crop calendar in the region).

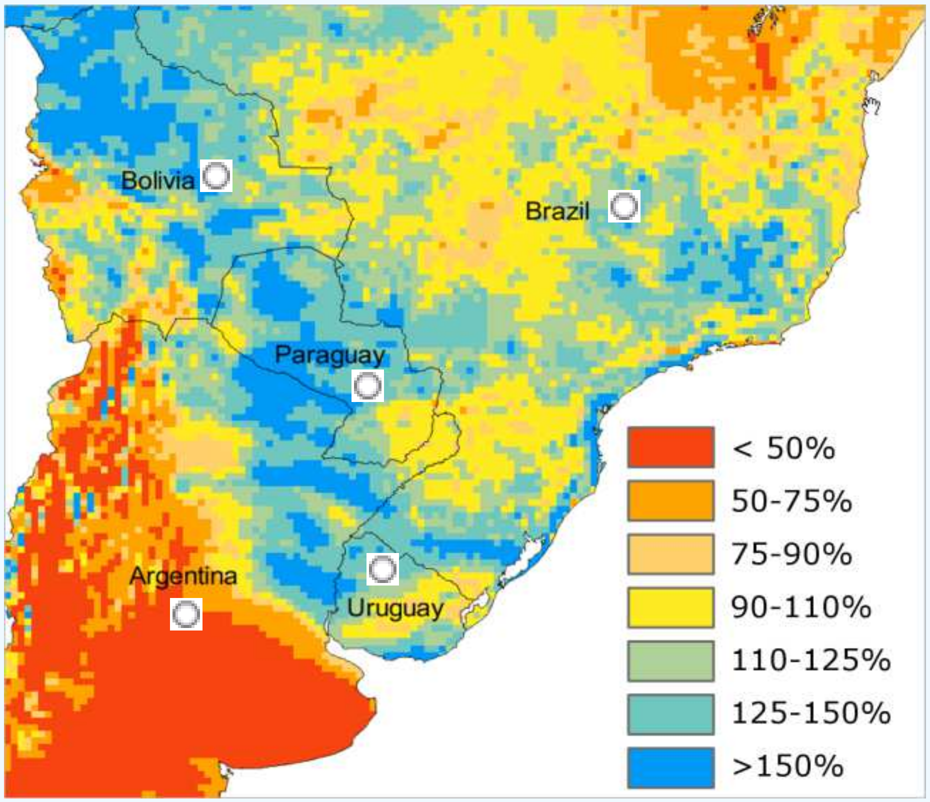


Data source: ECMWF. Map source: JRC bulletin

Click on the map to enlarge it.

RAINFALL ANOMALIES - EXERCISE

Relative rainfall anomaly

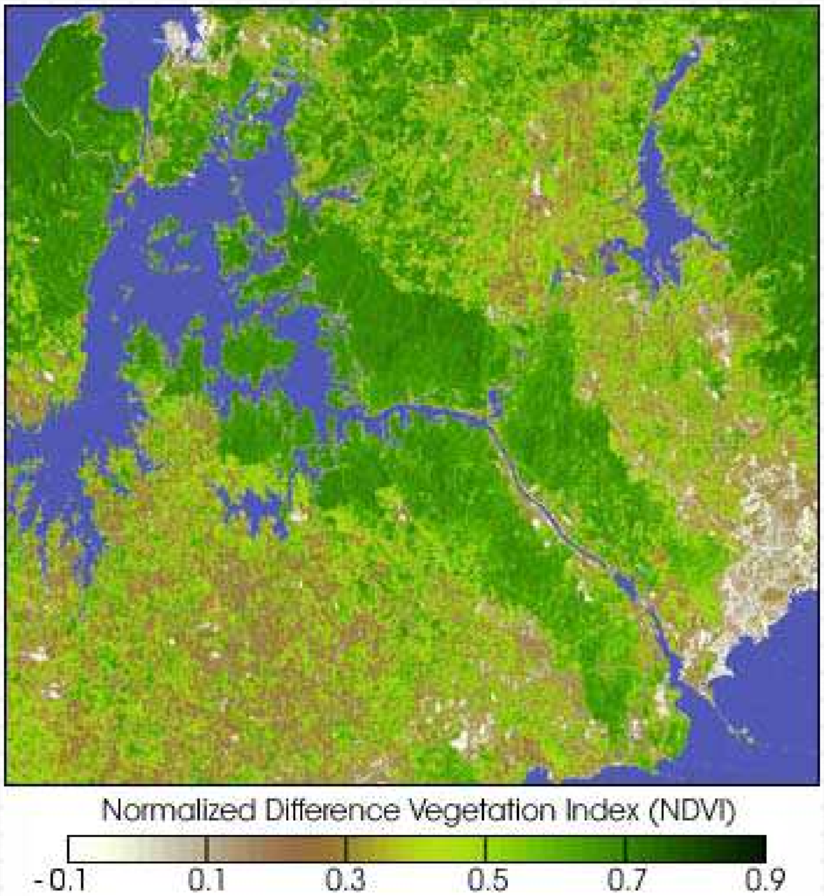


The map shows the relative anomaly of 2009 January-February rainfall in relation to the long term average for a part of South America.

Based on this map, which country faced most serious drought problems?

Please click on the country of your choice.

NDVI MAPS



http://earthobservatory.nasa.gov/Experiments/ICE/panama/panama_ex2.php

The Normalized Difference Vegetation Index (**NDVI**) is a **measure of vegetation performance** and depends on the climatic conditions prior to the date of observation.

In semi-arid systems NDVI strongly **relates to the rainfall** received.

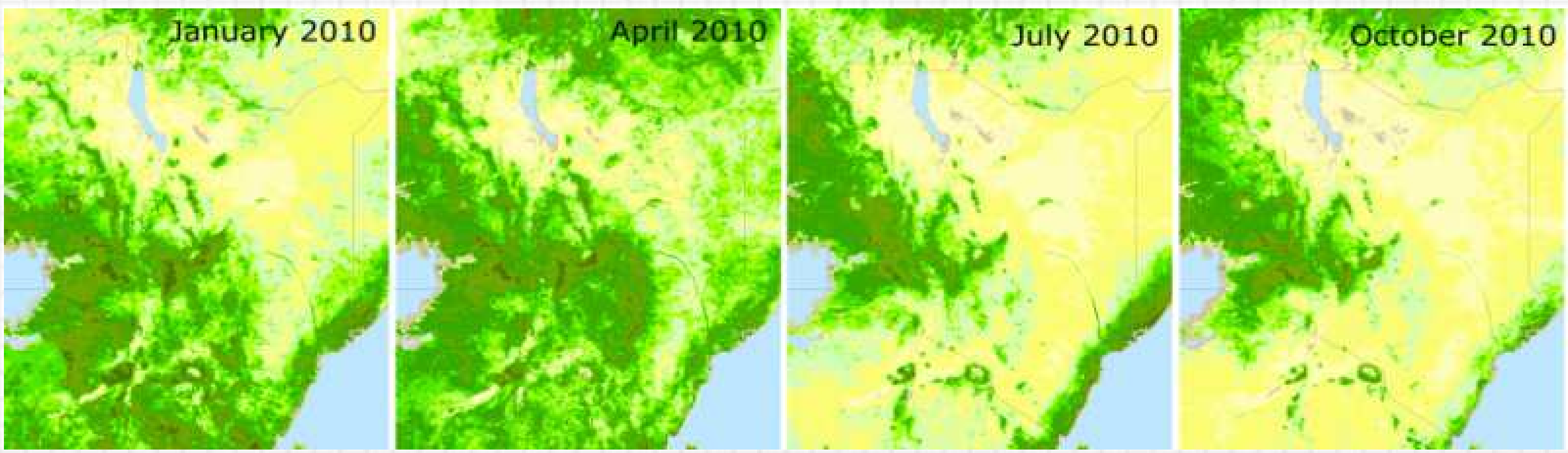
High values of NDVI indicate a high amount of life green vegetation.

NDVI MAPS

Let's look at this map:

- **high NDVI** is in darker **green** colors; and
- **low NDVI** in **yellow** and **brown**.

NDVI from SPOT VEGETATION for Kenya and surrounding areas

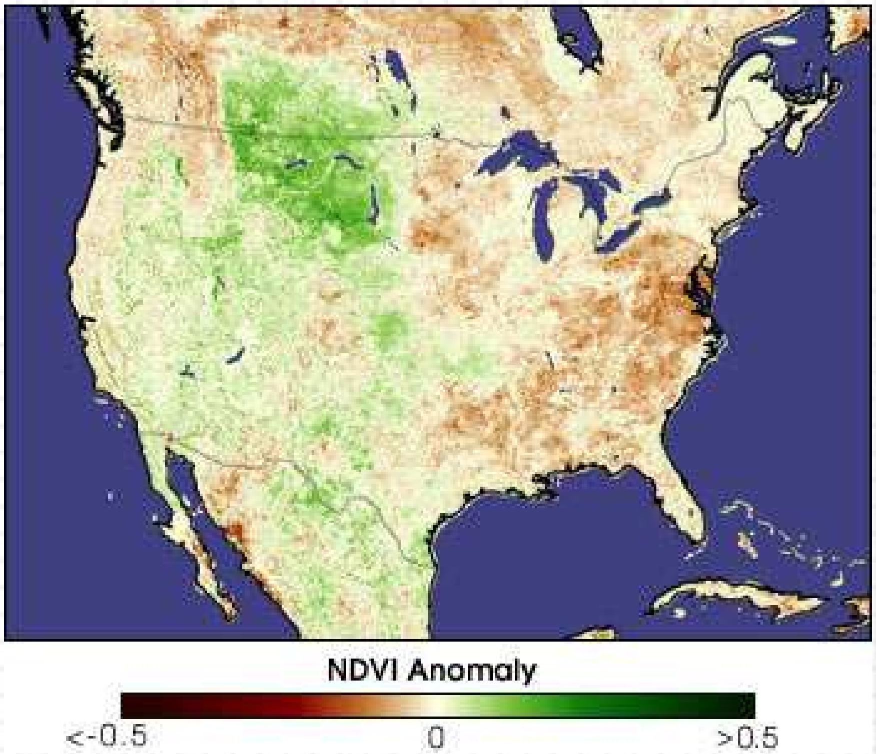


SPOT VEGETATION

Click on the map to enlarge it.

For Kenya, the **variability of NDVI** during the year, **relates to the variability of rainfall** during the year.

NDVI ANOMALIES



Example of an absolute NDVI anomaly map for August 1993, as compared to a 20-year average. Heavy rain in the Northern Great Plains resulted in positive anomalies (green), while drought conditions in the Eastern U.S. gave negative anomalies (red).

NDVI anomalies are complementary to rainfall anomalies. Their calculation follows the same principles of rainfall.

This implies that also NDVI anomalies can be represented as:

- **Absolute**
- **Relative**
- **Standardized**

NDVI VS RAINFALL ANOMALIES

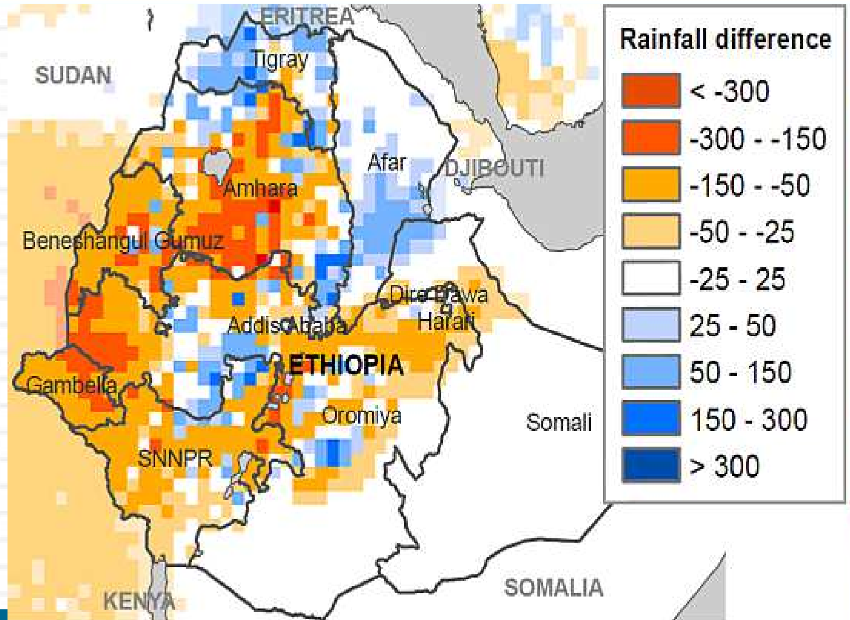
The table below presents some of the main differences between rainfall and NDVI products.

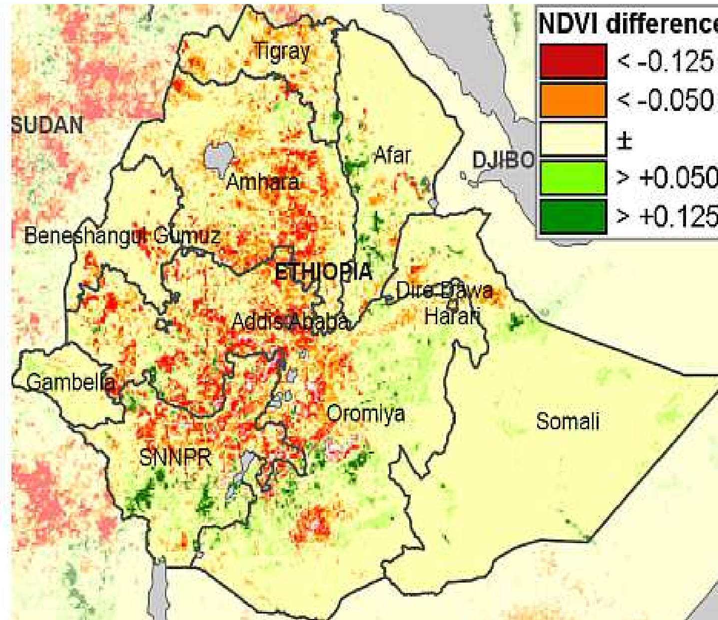
What are the differences between rainfall and NDVI?

Products	Rainfall	NDVI
Construction	Accumulation over time.	Composite: best (cloud-free) pixel with maximum NDVI is selected.
Gives indication of	Precipitation received.	Amount of green vegetation.
Anomaly maps commonly used	Dekad, month, season.	Dekad, month (*although seasonal measures such as cumulated or maximum NDVI could be derived*).

NDVI VS RAINFALL ANOMALIES

Absolute rainfall and NDVI anomaly maps for Ethiopia for August 2010 compared to a 10-year average.





Popup Window

Clear **rainfall deficits** (**red** colours) are apparent in most regions (except Tigray and Afar). **NDVI anomalies** also show below-average conditions in large parts of Ethiopia (**red** colours). To a certain extent this matches with the rainfall anomalies.

Still, **differences** can be observed (for example: Tigray is below-average for NDVI and above-average for rainfall).

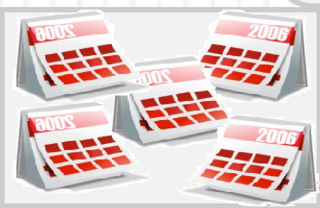
This stresses that vegetation condition not only depends on rainfall during the same period, but also rainfall of prior periods affect the vegetation condition.

NDVI ANOMALIES: REFERENCE LEVEL

Long term averages usually span 30-years. For NDVI only one source currently reaches 30-years (NOAA AVHRR). However, higher quality NDVI products currently exist with among others an improved spatial resolution. **The base period is thus limited by data availability**.

Spatial comparison of NDVI is mostly done based on the following **references**:

- **one year**, i.e. the same period (dekad, month) of another year:
  - a ***previous*** *year*;
  - a ***good*** *year*, when high crop yields were obtained, i.e. in semi-arid systems this is usually a wet year;
  - a ***bad*** *year*, when crop yields were low, i.e. dry years;



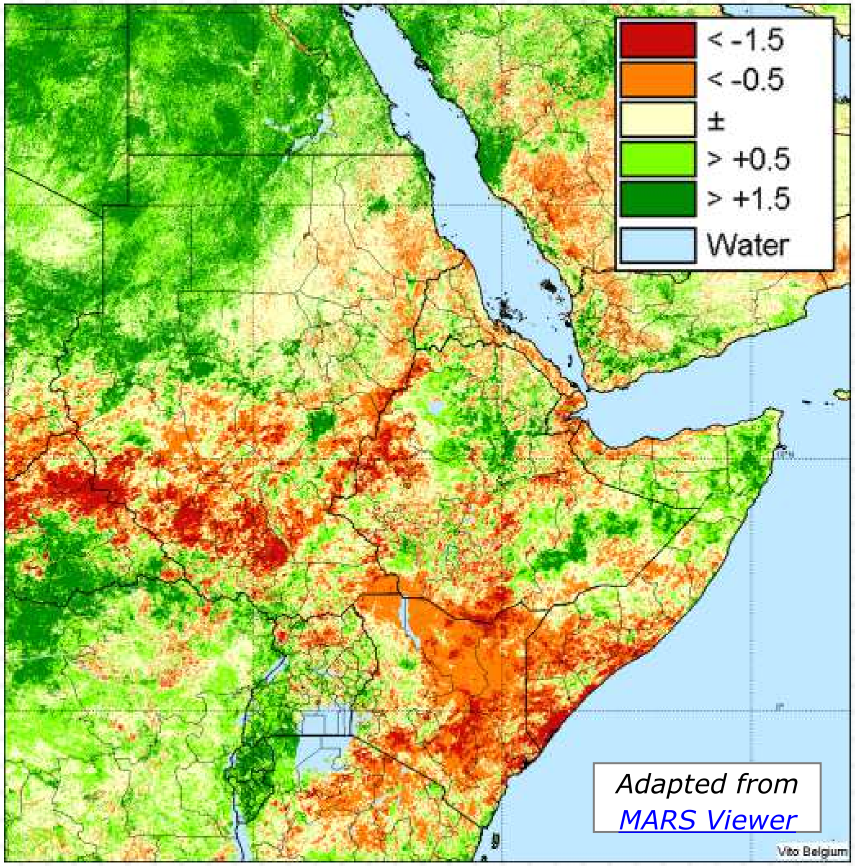
- **five or ten years**, as for rainfall this can be called STA (Short Term Average); and

- **available archive**, for example the SPOT VEGETATION NDVI series starts in April 1998. To compare 2012 NDVI values, 1998-2013 could thus be used (15-16 years).

Let's see an example of the **standardized NDVI anomaly** (z-score)...

NDVI ANOMALIES: REFERENCE LEVEL

Standardized NDVI anomaly

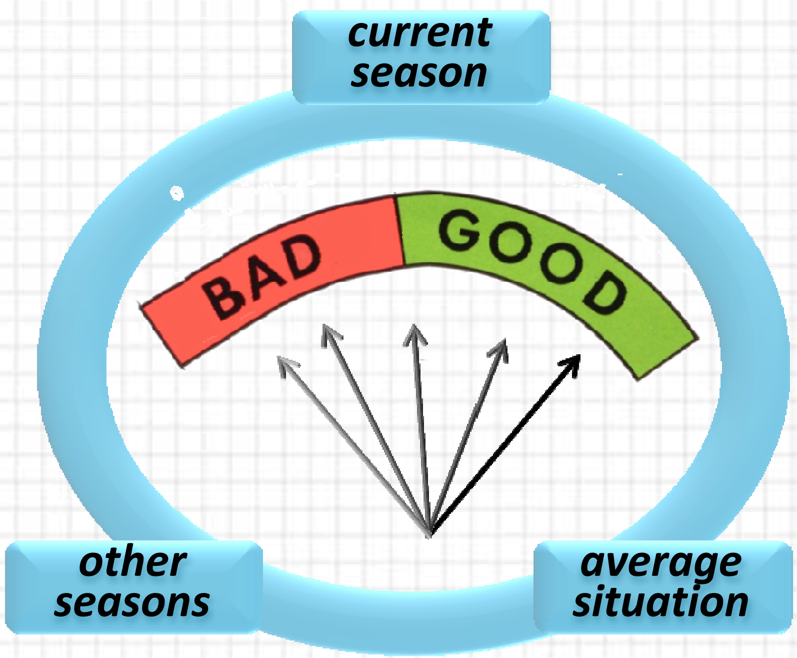


The map shows a **z-score** for June 2011, compared to the 1998-2010 June period (using SPOT VEGETATION), for the Horn of Africa.

Vegetation activity was poor in large parts of Kenya, Somalia, and South Sudan (**red** colours).

NDVI ANOMALIES: INFORMATION CONTENT

What can NDVI anomalies tell me?

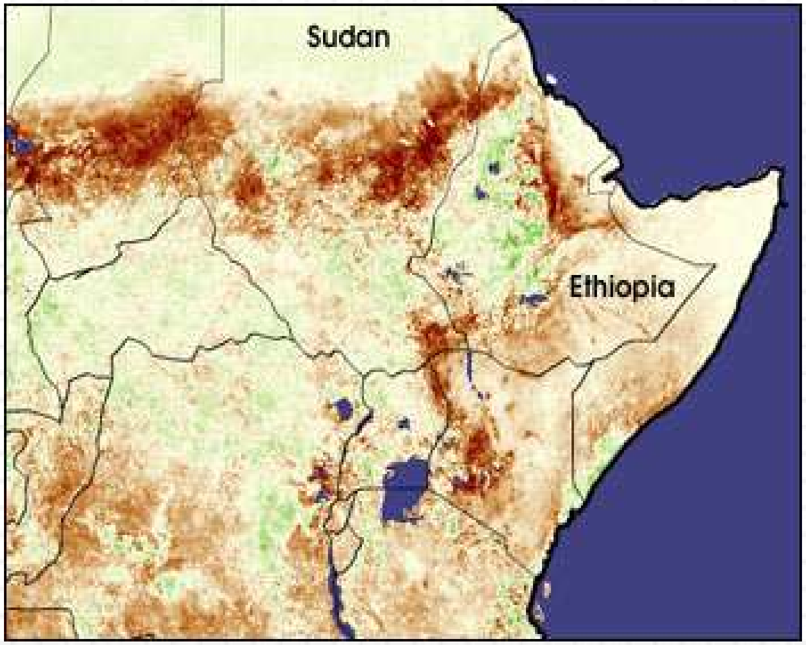


As for rainfall, NDVI anomalies basically give a **qualitative indication** of how '**good**' or '**bad**' the **current season** is when compared with other seasons or with the average situation.

Furthermore....

NDVI ANOMALIES: INFORMATION CONTENT

NDVI anomaly August 1984 - Horn of Africa



Dark red indicates the most severe drought, light yellow areas are normal, and green areas have denser than normal vegetation.

NDVI anomalies highlight **deviations** from normal vegetation development (either positive or negative).

Quality of NDVI anomaly maps

Large areas with **negative NDVI anomalies** are of concern, especially if:

•these anomalies are **persistent**, i.e. continue for many dekads/months;
•these anomalies **occur in a critical moment** of crop development (for example when grain is formed); and
•**people** living in the region largely **depend on vegetation productivity** (pasture, crops) for their livelihoods.

NB: Persistent cloud or haze may affect NDVI and resulting NDVI anomalies (particularly in the humid tropics.

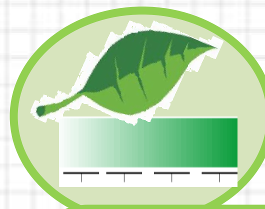
NDVI anomalies can thus be used as an **indirect evidence for food security**.

NDVI ANOMALIES: OTHER ANOMALY MEASURES

Besides the absolute, relative and standardized anomalies, two other measures are commonly used to **compare current NDVI to historical values**.

Vegetation Condition Index (VCI)

The VCI linearly scales a pixel's NDVI value between the historic minimum and maximum value for that dekad/month. Its values range from 0 to 100. VCI values below 35 are usually considered to indicate drought conditions.



Vegetation Productivity Indicator (VPI)

The VPI is similar to the VCI. Instead of using only the pixel's historic minimum and maximum value, the VPI uses the full range of historic dekadal/monthly NDVI values. The VPI also ranges from 0 to 100 with low values indicating poor vegetation growth (drought)."

These two measures consider the **historic range** instead of historic average and/or standard deviation. Let's see how to calculate them....

NDVI ANOMALIES: VEGETATION CONDITION INDEX (VCI)

How do I calculate the VCI?

The VCI is calculated as:

$$VCI = 100\left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)$$

Where...

- ***NDVI*** is the NDVI value for the current dekad/month under consideration; and
- ***$NDVI_{max}$*** and ***$NDVI_{min}$*** are the maximum and minimum dekadal (or monthly) NDVI values in the time series i.e. the max and min for a given dekad (or month).

The **VCI** thus scales the current NDVI value based on the historical range of recorded NDVI values for a specific pixel and dekad/month.

Let's see an example...

NDVI ANOMALIES: VEGETATION CONDITION INDEX (VCI)

Example: Calculation of the VCI

Let's consider the NDVI anomaly based on June 2011 and 1998-2010 June values, for the Horn of Africa. The calculation shows NDVI values for one pixel for the first dekad of June.

1998	1999	2000	2001	2002	2003	2004
0.21	0.34	0.19	0.22	0.30	0.26	0.20
2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
0.36	0.24	0.28	0.18	0.25	0.26	0.23
Minimum (1998-2010)			0.18			
Maximum (1998-2010)			0.36			
VCI June1-10 2011			28			

Open the spreadsheet

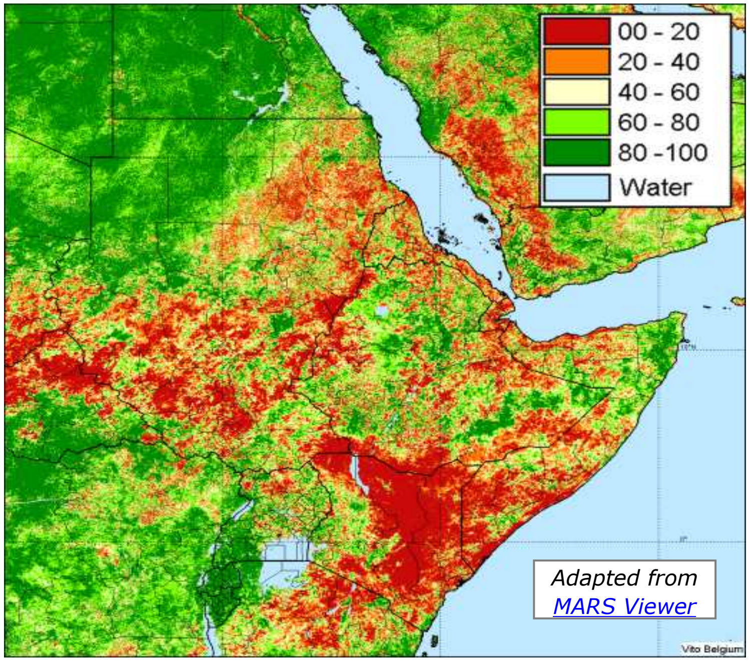
Minimum and ***maximum*** are derived from the 1998-2010 values. The **VCI for the first dekad** of June for that pixel is then:

100*(0.23-0.18)/(0.36-0.18) = 28%

This low value implies vegetation performs quite poor as compared to the historic range of values.

A VCI of 50% would mean that NDVI is exactly between minimum and maximum.

VCI for June 2011 for the Horn of Africa



Click on the map to enlarge it.

NDVI ANOMALIES: VEGETATION PRODUCTIVITY INDICATOR (VPI)

The VPI assesses the probability of getting a lower NDVI value than the current value. This probability is derived from the historic NDVI values for that pixel and dekad/month.

For example…

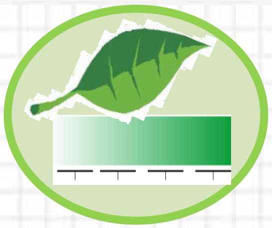
Compared to the historical value range, a **20% probability level** indicates:

•a **20% chance** of getting a **lower NDVI value;** therefore

•an **80% chance** of getting a **higher NDVI value**.

This implies **poor vegetation performance**.

NDVI ANOMALIES: VEGETATION PRODUCTIVITY INDICATOR (VPI)



How do I calculate the VPI?

The VPI can be calculated as:

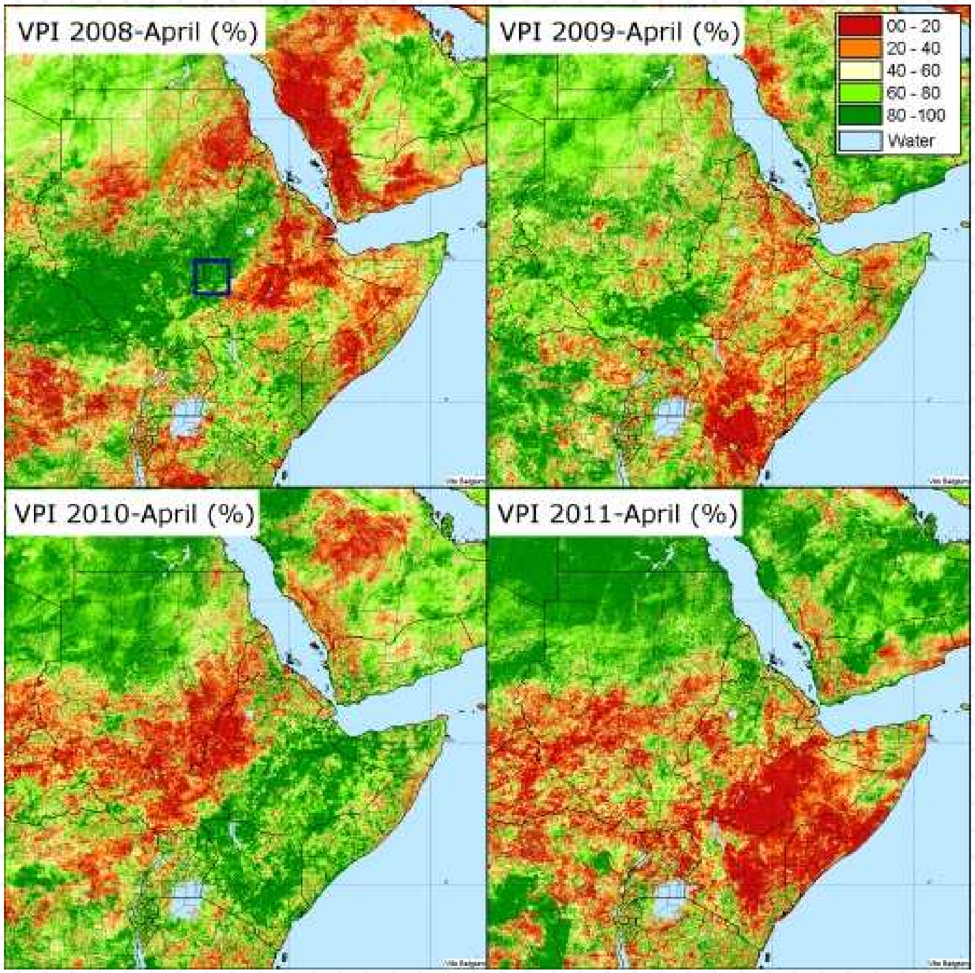
$$p = \frac{m}{n+1}$$

Where....

- ***p*** is the probability of having an NDVI value less or equal to a given value (for food security monitoring the given value is normally the NDVI value for the current dekad/month);
- ***m*** is the rank when ordering the historical data in ascending order; and
- ***n*** is the number of years of historical data that are used.

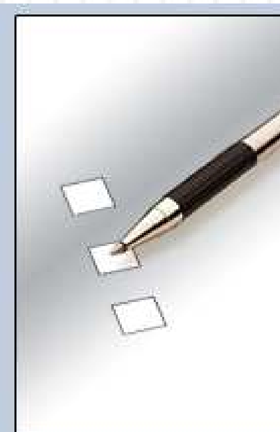
Let's see an example...

NDVI ANOMALIES: VEGETATION PRODUCTIVITY INDICATOR (VPI)



The four maps show the **VPI for April 2008, 2009, 2010, and 2011**. For the area indicated in the 2008 map by the square box (Eastern Ethiopia) indicate the years during which the vegetation development of April was best and worst.

	best	worst
2008	○	○
2009	○	○
2010	○	○
2011	○	○



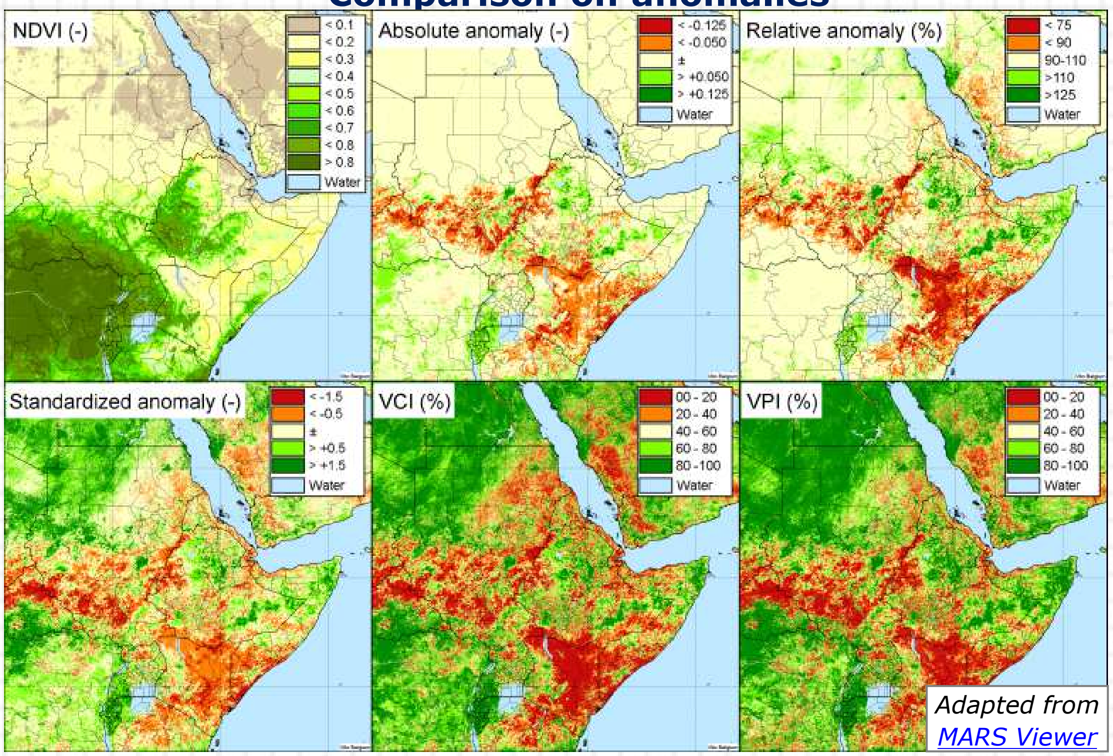
*Please select the answers of your choice. When you have finished, click on "**Check Answer**".*

VISUAL COMPARISON OF NDVI ANOMALIES

Let's now visually compare the different NDVI anomalies described so far, again using the June 2011 NDVI in relation to the June 1998-2010 NDVI for the Horn of Africa.

Which anomaly measure is presented often largely depends on personal preferences.

Comparison on anomalies



Adapted from [MARS Viewer]

Click on the image to enlarge it.

- **Strong anomalous situations are apparent in all maps** and the main anomalies are well identified by all methods.

- The **largest deviations between maps** are found in **areas** that normally have **low NDVI** values during that time of the year (or little rainfall). More...
- For any map a red (or green) color can have different meanings, depending on the time and location. It is therefore wise not to draw conclusions based on only one anomaly map.
- Always be aware of what type of anomaly map you are looking at: this requires a careful inspection of the legend.

ANOMALY MAPPING AND LEGENDS

Map display always involves **making choices**. Let's see what are the main choices you need to take...

When creating an anomaly map display, the main choices to be made involve deciding about the following:

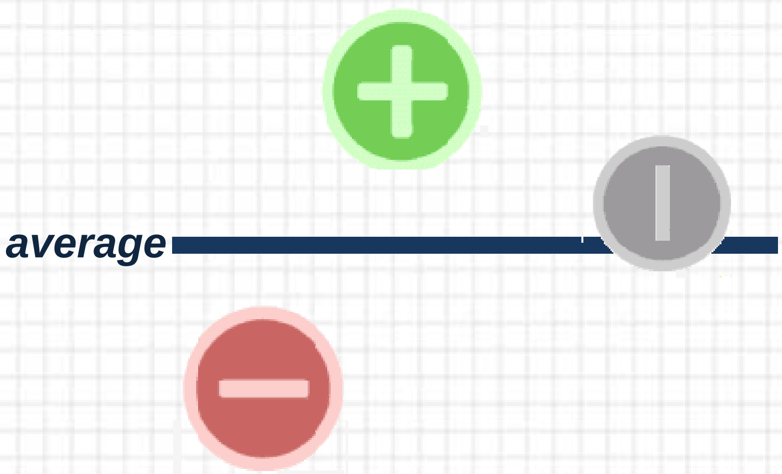
- **Which data** (rain, NDVI, others… dekad, month, season…. timing) do I consider?
- **What reference** level (one year, STA, LTA) do I set?
- **Which anomaly type** (absolute, relative, standardized, VHI…) do I use?
- **How many classes** do I show on the map?
- **What are the class limits** (i.e. cut-off values between classes)?
- **What colors do I give each class**?

ANOMALY MAPPING AND LEGENDS

There are many **software** and **online tools** that can make the map display choices for you.

View some software and online tools

If you would make maps yourself, bear in mind that **anomalies** are always:



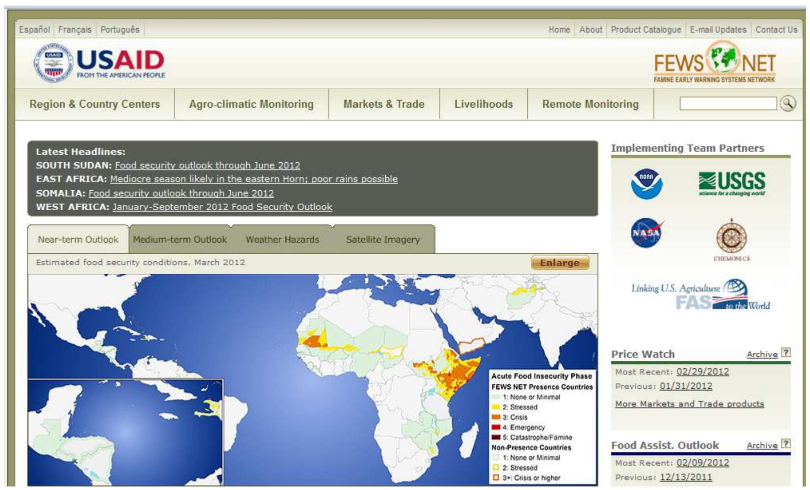
- **positive** (above-average);
- **neutral** (close to average); and
- **negative** (below-average).

Therefore a **diverging color scheme** should be used. A good online tool for selecting colour schemes is ColorBrewer.

CROP MONITORING BULLETINS - EXAMPLE

This brief example focuses on the 2011 drought that struck a large part of the Horn of Africa. It concentrates on the *Gu* season (April-June) in Somalia.

Example of anomaly maps presented and interpreted in bulletins



First let's look at early indications of the drought based on the [Regional Rain Watch from FEWS-NET, issued on 1 April 2011], which presents an absolute rainfall anomaly map for the month of March 2011…

http://www.fews.net/Pages/default.aspx

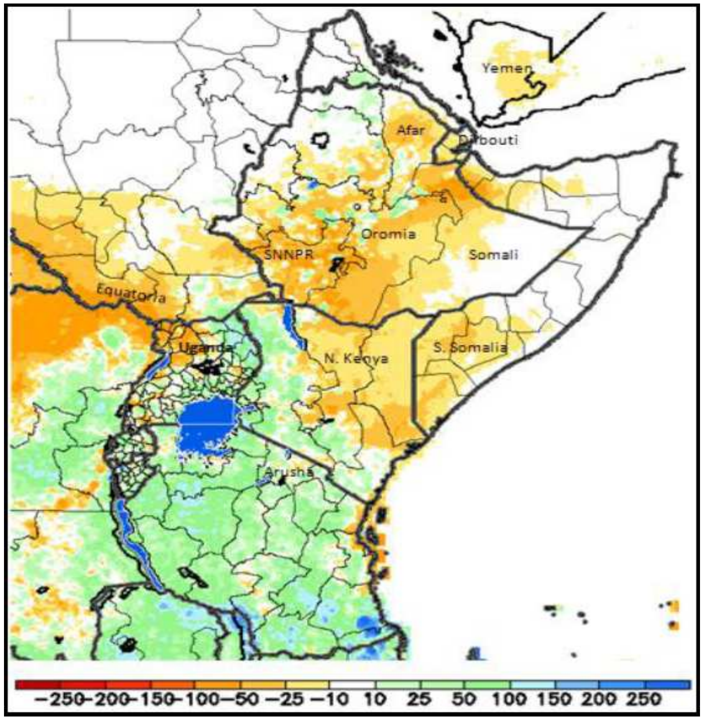
Example

Click the forward arrow to see how the case study unfolds or click on the PDF icon to read it and print it

CROP MONITORING BULLETINS - EXAMPLE

Example of anomaly maps presented and interpreted in bulletins

Absolute rainfall anomaly March 2011



The bulletin describes that the main (*Gu*) season is yet to start in Somalia, but already deficits from 10-50mm are found across the country. Such deficits reduce soil moisture availability, hence delaying vegetation emergence.

Every 10 days (after a new 10-day RFE is ready) FEWS-NET presented an update of the Regional Rain Watch, allowing close monitoring of the season performance.

Click on the map to enlarge it.

nn of nn

SUMMARY

Anomalies compare **current rainfall or NDVI to historical reference levels**. They indicate **below- or above-average rainfall or vegetation development**.

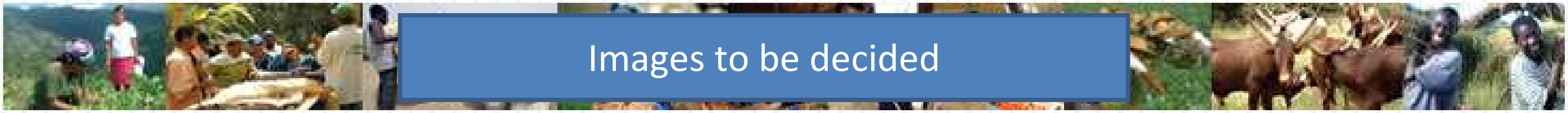
Historical reference levels can be a **dekad**, **month**, or **season** of a single year or the average condition of multiple years.

Anomalies can be presented as **absolute, relative, or standardized**. In addition for NDVI two common additional anomaly measures exist: **VCI** (Vegetation Condition Index) and VPI (Vegetation Productivity Indicator).

Although major anomalies will be detected by all measures, important differences exist between anomaly measures.

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

IF YOU WANT TO KNOW MORE



Online resources

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

Famine Early Warning Systems Network (FEWS-NET) Early Warning Explorer (EWX) -http://earlywarning.usgs.gov/fews/ewxindex.php

USDA Foreign Agricultural Service (FAS) Crop Explorer - http://www.pecad.fas.usda.gov/cropexplorer/

Southern African Development Community (SADC) Regional Early Warning System (REWS): http://www.sadc.int/fanr/aims/rews/index.php

VPI calculation in GMFS - http://www.gmfs.info/uk/publications/documents/GMFS_S5_ProductSheet_VPI.pdf

Color schemes - http://colorbrewer2.org/

http://www.ipcinfo.org/attachments/RemoteSensedData_IPC_JRC_guidelines.pdf

Additional reading

Rojas, O., A. Vrieling, and F. Rembold. 2011. Assessing drought probability for agricultural areas in Africa with coarse resolution remote sensing imagery. Remote Sensing of Environment 115(2): 343-352.

Kogan, F. N. 1990. Remote sensing of weather impacts on vegetation in non-homogeneous areas. International Journal of Remote Sensing 11: 1405-1419.

Sannier, C. A. D., J. C. Taylor, W. Du Plessis, and K. Campbell. 1998. Real-time vegetation monitoring with NOAA-AVHRR in southern Africa for wildlife management and food security assessment. International Journal of Remote Sensing 19: 621-639.

Rembold, F., Atzberger, C., Savin, I. and Rojas, O. 2010 Using low resolution satellite imagery for crop monitoring and yield prediction at the regional scale. In "Remote Sensing Optical Observations of Vegetation Properties", pp. 81 – 113. ISBN: 978-81-308-0421-7