## COLD CLOUD DURATION MODEL

Combine each rainfall estimates method with its related characteristic.

1. It uses the Special Sensor Microwave/Imager (SSM/I), and the Advanced Microwave Sounding Unit (AMSU).

2. It uses historical rainfall data from stations for calibration.

3. It uses rainfall data from stations for the dekadal estimates.

RFE 1.0

RFE 2.0

TAMSAT

*Click each option, drag it and drop it in the corresponding box. When you have finished, click on "**Check Answer**".*

## RAINFALL ESTIMATES- DOWNLOADING DATA

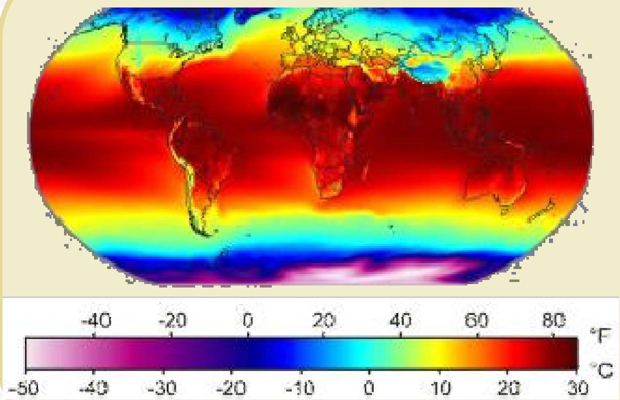
The following are some of the most common **sites for downloading rainfall estimates**:

| | |
|---|---|
| **Cold cloud duration data** | |
| TAMSAT Research Group, Department of Meteorology, University of Reading | www.met.reading.ac.uk/~tamsat/data |
| FEWS NET Data Portals | http://earlywarning.usgs.gov/adds/ |
| Africa Rainfall Estimates - Climate Prediction Center - NOAA | www.cpc.ncep.noaa.gov/products/fews/rfe.shtml |
| IRI/LDEO Climate Data Library | http://iridl.ldeo.columbia.edu/index.html* |
| **Interpolated rain-gauge data*** | |
| Earth System Research Laboratory- NOAA PSD : CPC Merged Analysis of Precipitation | www.esrl.noaa.gov/psd/data/gridded/data.cmap.html#detail |
| German Global Precipitation Climatology Centre (GPCC) | http://tinyurl.com/p2knnq9 |
| **Atmospherical models*** | |
| European Centre for Medium-Range Weather Forecasts | www.ecmwf.int/ |
| NOAA Climate.gov: Science & Services for Society | www.climate.gov/#dataServices/mapServices_global |
| JRC - FOODSEC Meteodata Distribution Page - Europa | http://spirits.jrc.ec.europa.eu/?page_id=184 |

## TEMPERATURE DATA FOR TEMPERATE AREAS AND MOUNTAINOUS CLIMATES

In temperate climates and in mountainous areas of tropical climates, **temperature data** can also play an important role in crop monitoring, since temperatures becomes an important additional factor to water availability for crop development.

Sowing only takes place when required temperatures for germination are reached and when the risk of cold shocks is low.




In many areas of the world measured temperatures are even more difficult to obtain than rainfall data. This is why again, **satellite derived temperatures can be of use**.

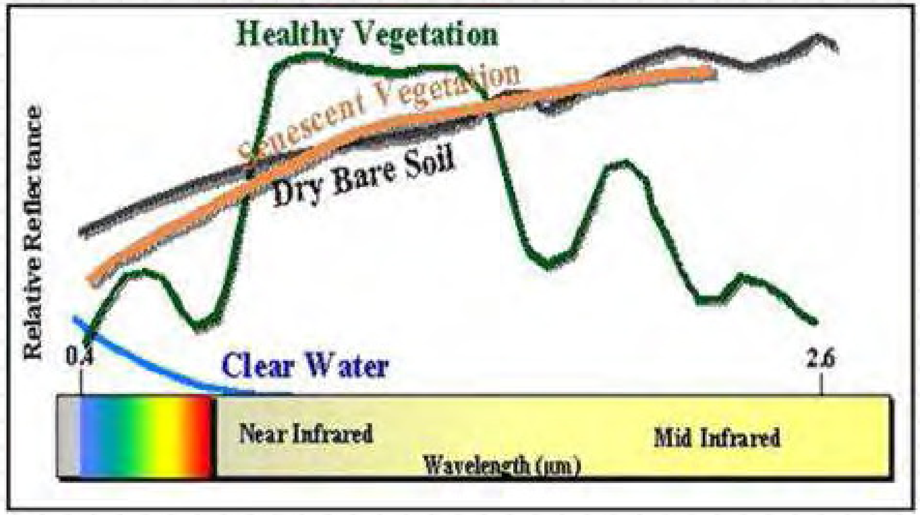
The NOAA AVHRR sensor for example has a **thermal band**, such as also the geostationary METEOSAT. Otherwise temperature data too are available from **global circulation models** such as the ECMWF.

There is a slight difference though: satellites measure surface temperature, while we usually need air temperatures.

## VEGETATION INDICES

**Vegetation indices** are mathematical transformations of the original multi-spectral data which are aimed at enhancing the information about vegetation properties while reducing the effect of external factors (mainly atmospheric and soil effects).

**Variation of reflectance for different ground targets (or spectral signature)**



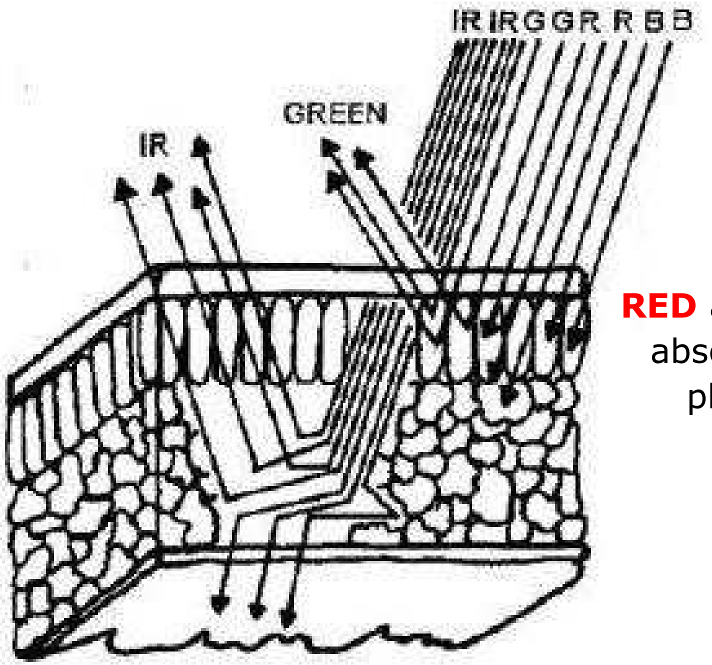

The basic principle of vegetation indices is the strong absorption of light by leaf pigments in the visible (mainly red) range of the spectrum and on the high reflectance of leaf mesophyll in the near infrared range.

This **strong reflectance difference** between the **red** and the **near infrared** channels is typical for vegetation and allows discrimination from other targets such as soil or water.

Vegetation indices are based on the large difference of green vegetation and soil reflectance between the red and near infrared wavelengths of electromagnetic radiation.

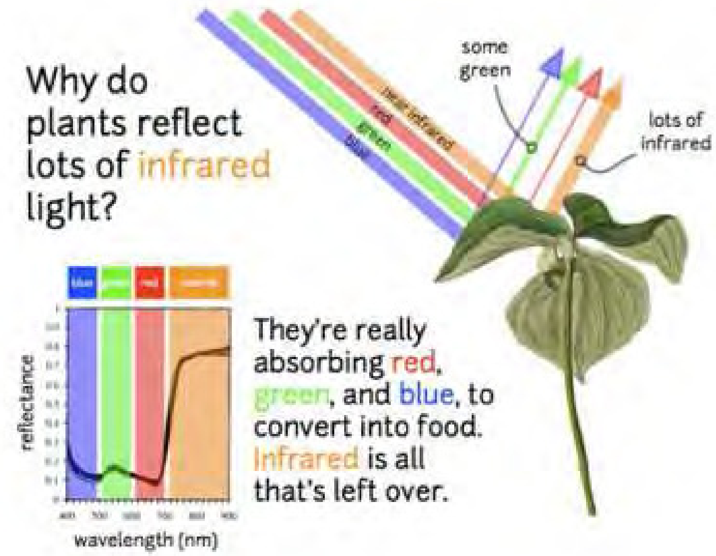
## VEGETATION INDICES

### Interaction of leaf structure with (visible and NIR) light




**RED** and **BLUE** largely absorbed for use in photosynthesis

While **blue** and **red** light is largely absorbed, NIR radiation is partially reflected.




As visible in this picture, the **red** and **blue** components of incoming radiation are absorbed by the surface of **green** leafs, while **near infrared** (**NIR**) radiation deeply penetrates the leaf but a significant portion of it is reflected backwards.

> Since this behaviour is only true for green and healthy leafs, vegetation indices are generally proportional to the photosynthetic efficiency of green vegetation.

## VEGETATION INDICES

Although a large number of vegetation indices has been developed, most of them are conceptually similar and partially redundant. The table below shows an overview of the commonly used simple **vegetation indices** (**VIs**).

NDVI

SR

EVI

SAVI

Click on the buttons to read more.

## VEGETATION INDICES

- **NDVI**
- SR
- EVI
- SAVI

**NDVI= (NIR-RED)/(NIR+RED)**

The **Normalized Difference Vegetation Index (NDVI)** is one of the oldest, best known, and most frequently used VIs. The normalized difference formulation makes it suitable for a wide range of conditions. It can, however, saturate in dense vegetation conditions when the Leaf Area Index (LAI) becomes high.

## VEGETATION INDICES

NDVI

**SR**

EVI

SAVI

**SR = NIR / RED**

The **Simple Ratio (SR)** index is another old and well known VI. The SR is simply the ratio between the near infrared and red reflectances. As the NDVI it is both easy to understand and effective over a wide range of conditions and it can saturate in dense vegetation when LAI becomes very high.

## VEGETATION INDICES

NDVI

SR

**EVI**

SAVI

**EVI = 2,5 [(NIR-RED)/(NIR+6RED-7,5BLUE+1)]**

The **Enhanced Vegetation Index (EVI)** was developed to improve the NDVI by optimizing the vegetation signal in high LAI regions by using the blue reflectance to correct for soil background signals and reduce atmospheric influences, including aerosol scattering. This VI is therefore most useful in high LAI regions, where the NDVI may saturate.

## VEGETATION INDICES

NDVI

SR

EVI

**SAVI**

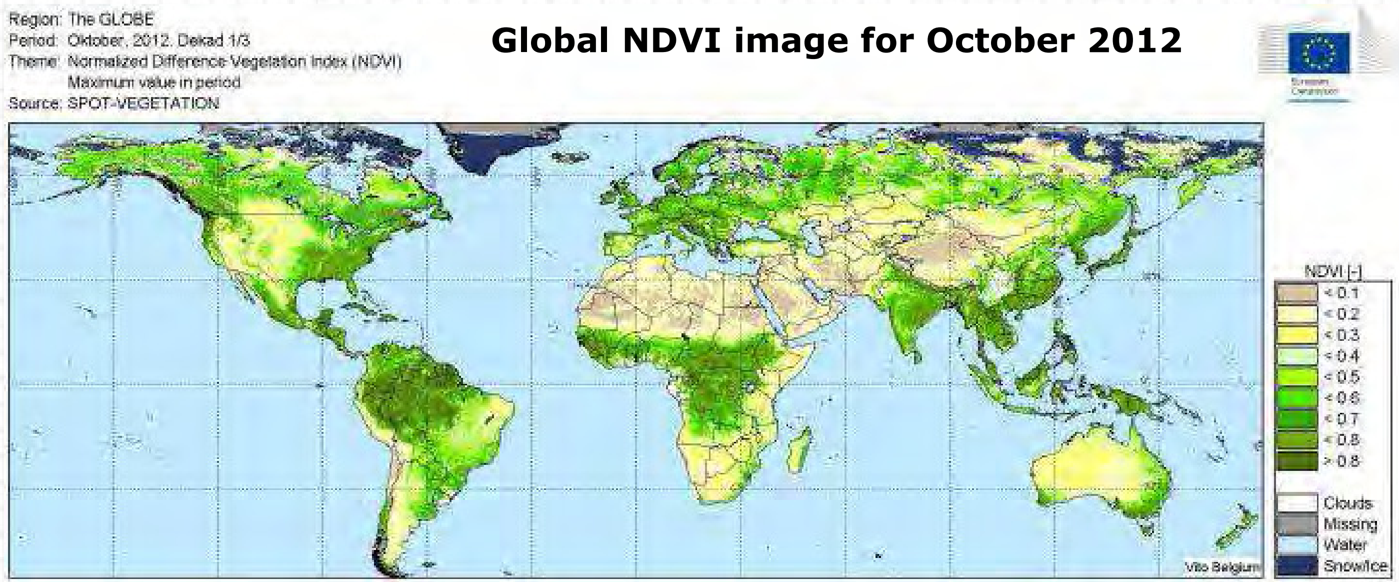
**SAVI = [(NIR-RED)/(NIR+RED+L)] * (1+L)**

The **Soil-Adjusted Vegetation Index (SAVI)** includes information on the soil properties. The factor L depends on the distance of RED and NIR from the so called “soil line” of bare soils. This information must be available. A development of the SAVI which minimizes soil noise is the so called TSAVI (Transformed SAVI).

## VEGETATION INDICES

Among the different vegetation indices based on the NIR and RED related behaviour of vegetation, it is the **NDVI the most popular indicator for studying vegetation health and crop production**. Research in vegetation monitoring has shown that NDVI is closely related to the **leaf area index** (**LAI**) and to the photosynthetic activity of green vegetation. NDVI is an indirect measure of primary productivity through its quasi-linear relation with the **fAPAR** (**Fraction of Absorbed Photosynthetically Active Radiation**).

**Global NDVI image for October 2012**




Cloudy areas (white) are visible in China and along the west coast of Central Africa.
Parts of Siberia and Canada are covered by snow (blue).

*Click on the image to enlarge it.*

## VEGETATION INDICES

Which of the following statements about Vegetation Indices is correct?

- ○ VI are the optimal input data for land cover classification.
- ○ VI are a direct measurement of crop yield.
- ○ VI are generally proportional to the photosynthetic efficiency of green vegetation.

*Please select the answer of your choice.*

## VEGETATION INDICES - ISSUES

All spectral devices operating in space are exposed to **orbital drift and sensor degradation**. Even with sophisticated radiometric calibration methods it is difficult to have satellite image time series of several decades that are perfectly **consistent in time**.

For data from the widely used **NOAA AVHHR** sensor the problem is further complicated by the fact that the images of the last 25 years belong to different sensors mounted on different satellites subject to different degradation scenarios.

The 2 sensors of the **SPOT-VGT** series (1 and 2) mark a clear progress in terms of improved consistency over time. However, the time series is only 14 years long so far.

## VEGETATION INDICES - ISSUES

Besides aerosol and water vapor related problems, **cloud contamination** remains the biggest problem for low resolution images.

For most applications **10-daily images** are used, where the daily images are composited in so called **Maximum Value Composites (MVC)** to eliminate at least the most perturbing atmospheric artifacts. The assumption here is that both clouds and atmospheric effects such as vapour and haze, are generally lowering NDVI, so by taking the maximum NDVI values during a time step of some days these effects are automatically reduced.

Although very helpful, MVC cannot fully eliminate all the atmospheric noise present in the images.

More on Compositing and MVC


A **ten-days time** step (or **dekad**) is also a reasonable period for monitoring changes in crop phenology and is widely used in agro-meteorology and crop monitoring.

## VEGETATION INDICES - ISSUES

Popup Window

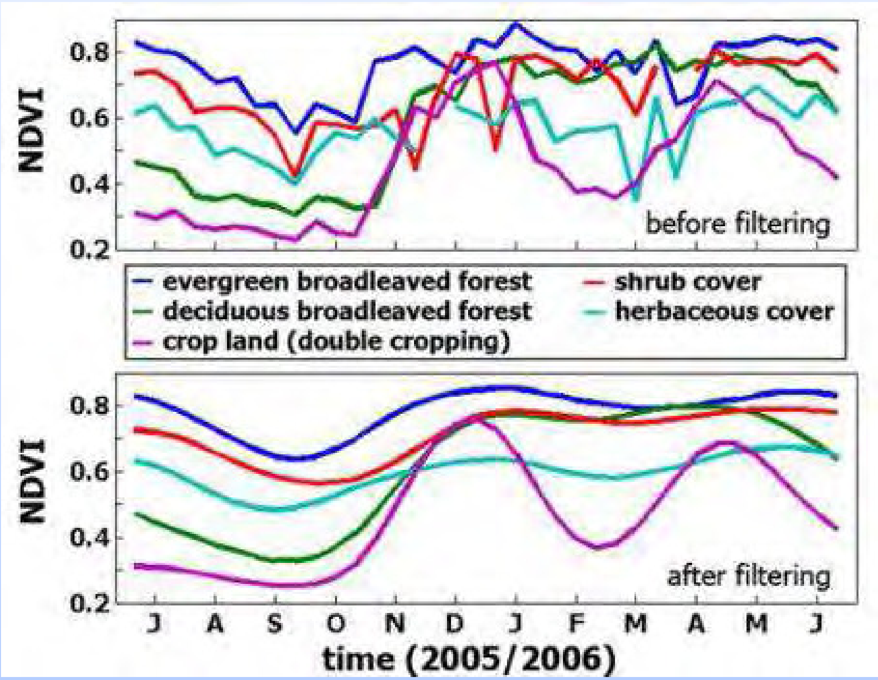
### Compositing and Maximum Value Composites (MVC)

Compositing is one of the procedures to get better land products. It consists of a combination of daily images to generate a single image that results in a cloud free land product over temporal intervals. MVC compares all the images taken by a sensor, such as MODIS, during a pre-defined period of time and selects the pixels with the highest vegetation index value since it is assume that contamination reduces the VI values [Viovy et. al. 1992].

Another approaches uses the mean value over the time period instead of the maximum. Although the method clearly improves the quality of land images it also has side effects:
1)adjacent pixels of an MVC image can belong to different days of the time period, e.g. in a 10-daily composite they can theoretically be 10 days apart; and
2)in vegetation monitoring, MVC's of the growing phase will select more pixels of the latest days of the time period while in senescence phases the opposite happens.

Finally MVC cannot eliminate all cloud problems especially in areas with nearly continuous cloud cover during the whole compositing period.

## VEGETATION INDICES - ISSUES




NDVI profiles from different land cover types before (top) and after (bottom) smoothing with the Whittaker filter.

**Temporal smoothing techniques** are commonly used in time series analysis and the number of different algorithms for temporal filtering continues to grow. The aim of the smoothing techniques is **to remove artefacts** related for example to undetected clouds and poor atmospheric conditions. Also, possibly occurring **data gaps** should be filled.

Temporal smoothing also follows the principle of MVC that high NDVI values are generally good measurements, while sudden dips in NDVI are mainly due to cloud contamination and atmospheric perturbation. Differently from MVC it looks at good quality data before and after the current composite, while MVC operates inside the compositing period.

A large number of algorithms has been proposed for smoothing out the bad dekads and **smoothed images** are usually appearing much **cleaner than the original ones**.

## VEGETATION INDICES - ISSUES

Which among the following factors affect the quality of vegetation indices for low-res images?

- [ ] Sensor degradation
- [ ] Aerosol and water vapor
- [ ] Cloud contamination
- [ ] Sensor temperature
- [ ] Senescent vegetation

*Please select the option of your choice (2 or more) and press "**Check Answer**".*

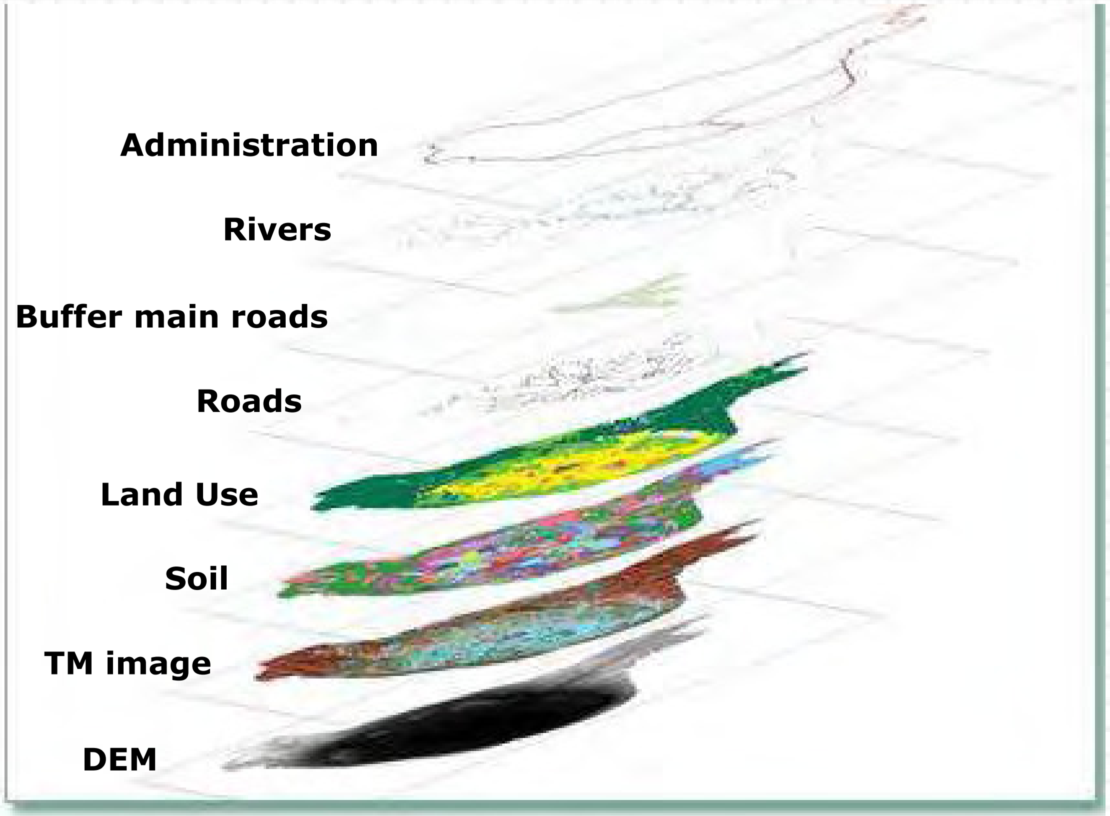
## VEGETATION INDICES - DOWNLOADING DATA

The following are some of the most common **sites for downloading low and high resolution data**:

| | |
|---|---|
| USGS FEWS NET Data Portal - | http://earlywarning.usgs.gov/adds/ |
| DevCoCast project website | http://www.devcocast.eu |
| LP DAAC: ASTER and MODIS Data Products | https://lpdaac.usgs.gov |
| Reverb / ECHO – Nasa | http://reverb.echo.nasa.gov/reverb |
| Global - BOKU IVFL University of Natural Resources and Life Science | http://ivfl-info.boku.ac.at/index.php/eo-data-processing/dataprocess-global |
| MetopS10-AVHRR – Vito | http://www.metops10.vito.be/index.html |
| SPOT-VEGETATION programme webpages | http://www.spot-vegetation.com/ |
| STAR - Global Vegetation Health Products | http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php |
| COPERNICUS - Global Land Service Products | http://land.copernicus.eu/global/products |

## COMMONLY USED ANCILLARY DATA

**Example of secondary data layers**




While time series of remote sensing data provide information on the status of agricultural vegetation, **additional data layers** are needed to contextualize this information.

**Ancillary data**

Data derived from existing sources (other than remote sensing) used to assist in classification and analysis of remotely sensed data. These data have been collected for other purposes, often independent from crop monitoring. Examples: topographic, demographic or socio-economic data.

## COMMONLY USED ANCILLARY DATA

For mapping purposes but also for possible spatial aggregation **administrative unit layers** (1) and **topographic information** (2) are needed. This is important also because other data that can be used for comparison such as **agricultural statistics** (3) are generally aggregated by administrative units.

Furthermore it is important to distinguish agricultural vegetation from natural vegetation which has a different behaviour for example in terms of spectral signature, and **crop masks** (7) can be helpful in knowing the spatial distribution of crops.

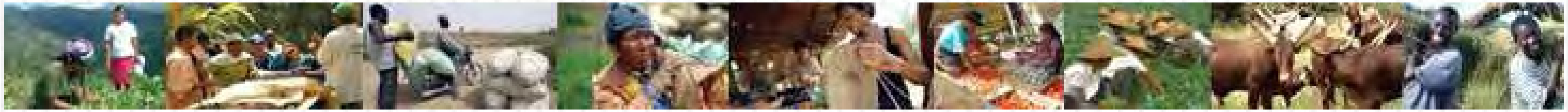
Any other thematic layers on the studied areas are also helpful in crop monitoring, such as for example **soil and land use maps** (6), **geomorphology and hydrology** (4).

Since the ultimate goal of crop monitoring in semi-arid countries is often to contribute relevant information to food security analysis, **socio-economic data** (5) also play an important role. This can be for example information on livelihood groups, vulnerability information, food consumption and nutrition data.

In the temporal domain, **crop calendars** (8) are extremely important to understand the seasonal patterns and distribution of crop cycles.

1. Administrative boundaries
2. Topographic information
3. Agricultural statistics
4. Geomorphology and hydrology
5. Socio-economic data
6. Land use, land cover and soils
7. Crop masks
8. Crop calendars

## IF YOU WANT TO KNOW MORE



### Additional reading

**About TAMSAT:**
Grimes, D. I. F., E. Pardo-Igúzquiza, and R. Bonifacio, 1999: Optimal areal rainfall estimation using raingauges and satellite data. *Journal of Hydrology*, *222*(1-4), 93–108.

**RFE rainfall**
**RFE2**
Xie, P. and Arkin, P. A. 1997, A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. Bulletin of the American Meteorological Society 78(11): 2539-58"

**Rainfall estimates validation and comparison:**
Dinku, T., P. Ceccato, E. Grover - Kopec, M. Lemma, S. J. Connor, and C. F. Ropelewski, 2007: Validation of satellite rainfall products over East Africa's complex topography. *International Journal of Remote Sensing*, *28*(7), 1503–1526.

**About NDVI:**
http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_1.php
http://en.wikipedia.org/wiki/Normalized_Difference_Vegetation_Index