



Software for Processing and Interpreting Remote Sensing Image Time Series

Felix Rembold, Carolien Tote, Herman Eerens, Dominique Haesen,
Sven Gilliams, Lieven Byderkerke

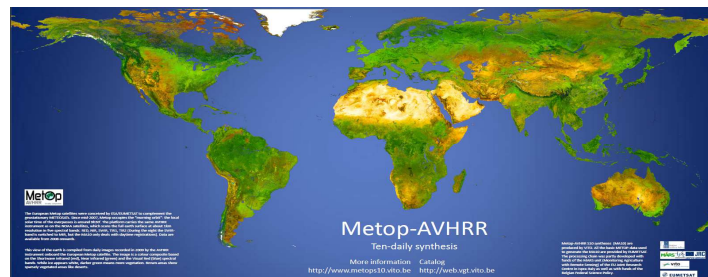
SPIRITS Launch

AfricaGIS 2013/GSDI 14, Addis Ababa, Ethiopia November 4-8, 2013



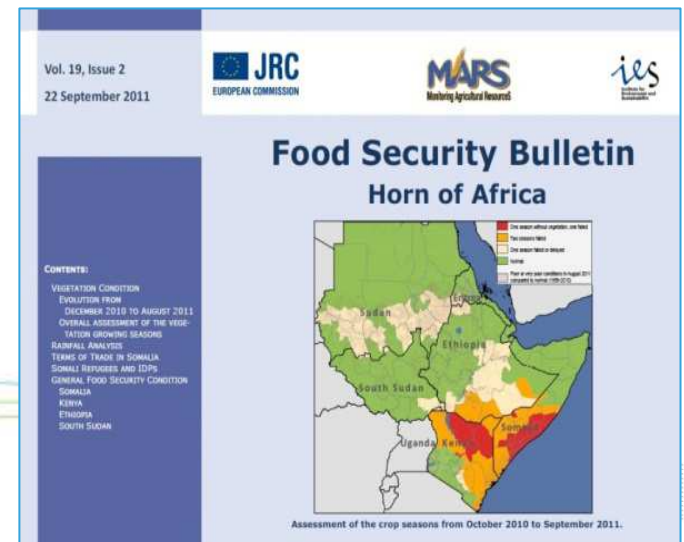
Why SPIRITS?

- » Large availability of free remote sensing data, but:
- » Remote sensing and processing software not specifically designed for time series processing
- » Food security analysts are usually not software programmers
- » Tools developed in the past are no longer updated (e.g. WINDISP)
- » Online platforms do not allow high degree of customization (e.g. Crop explorer, Decision Support Interface (DSI), MARS Viewer)



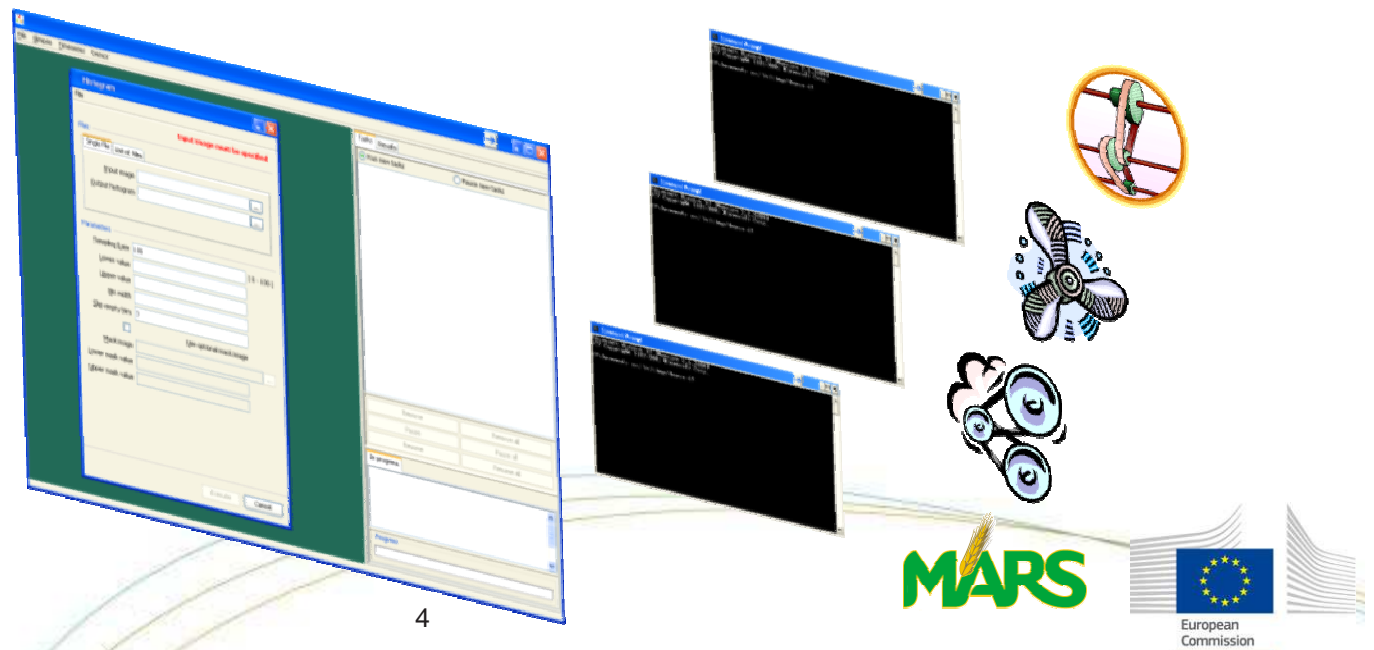
What is SPIRITS?

- » An integrated modular software for raster image time series processing for:
 - » producing information and facilitating analysis normally needed for **crop monitoring bulletins**
 - » strengthening **early warning systems** in food insecure countries
 - » automation of repetitive time series processing steps
 - » other uses like environmental monitoring
- » Complementary to other environmental analysis software (**E-station**) or drought monitoring systems (**ASIS**)



What is SPIRITS?

- » SPIRITS is a **Graphical User Interface** written in **Java** and based on GLIMPSE (previously developed set of C programs)
 - » controlling/using/launching/ in-built executables
 - » includes open source libraries (GDAL, HSQLDB...)
 - » can also run external executables
- » Software developed by VITO for the MARS Unit of the JRC



Who are the users?

- » Agricultural monitoring experts (e.g. Ministries of Agriculture and Forestry, Rural Development projects, FAO, WFP, etc...)
- » Remote sensing experts in research or government organizations
- » GIS experts with need to process remote sensing time series
- » E-station users focusing on agricultural monitoring
- » Other experts working with spatial data (food security, environment...)



<http://spirits.jrc.ec.europa.eu/>

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SPiRITS

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Software for the Processing and Interpretation of Remotely sensed Image Time Series



SPiRITS is an integrated and flexible **free software** environment for analyzing satellite derived **image time series** in **crop and vegetation monitoring**. With this toolbox, you can process and examine time series of low and medium resolution sensors such as SPOT-Vegetation and MODIS-Terra/Aqua. It can be used to perform and to automatize many spatial and temporal processing steps on time series and to extract spatially aggregated statistics. Vegetation indices and their anomalies can be rapidly mapped and statistics can be plotted and interpreted in seasonal graphs to be shared with analysts and decision makers.

[Download it](#) [See what you can do](#) [Get data](#)

See the **QUICK START** in the [Tutorial](#) (section 2) to **get started!**

News

23/04/2014 New ECMWF and Tamsat data (2nd dekad of April) now available

01/04/2014 ECMWF evapo-transpiration and solar radiation now available

01/04/2014 ECMWF data over Asia, Europe, America and Pacific area now available

30/12/2013 [Paper on SPiRITS](#) is the 6th most downloaded EMS Article

- » Currently Version 1.1.1
- » User's Manual
- » Scientific paper in «Environmental Modelling & Software» (03/2014)

A dedicated website to:

- » Disseminate Spirits
 - Download the latest release
 - Download the **tutorial** and the training data set
 - Download data in Spirits format
- » Support users
 - Wiki, FAQ, Video tutorial
- » Involve users
 - Wish list, Mailing list, Forum, News, Calendar



Software for the Processing and Interpretation
of Remotely sensed Image Time Series

USER'S MANUAL
Version: 1.1.0 - February 2013

Herman Eerens & Dominique Haesen (VITO)



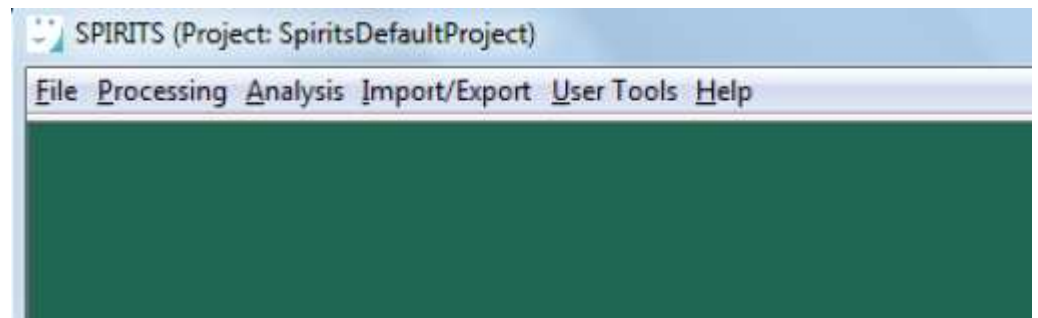
Tutorial
SPiRITS version: December 2012
Revised Draft - December 2012

Carolien Tote, Sven Gilliams, Dominique Haesen, Felix Rembold, Ferdinando Urbano

SPIRITS FUNCTIONALITIES

The SPIRITS menu

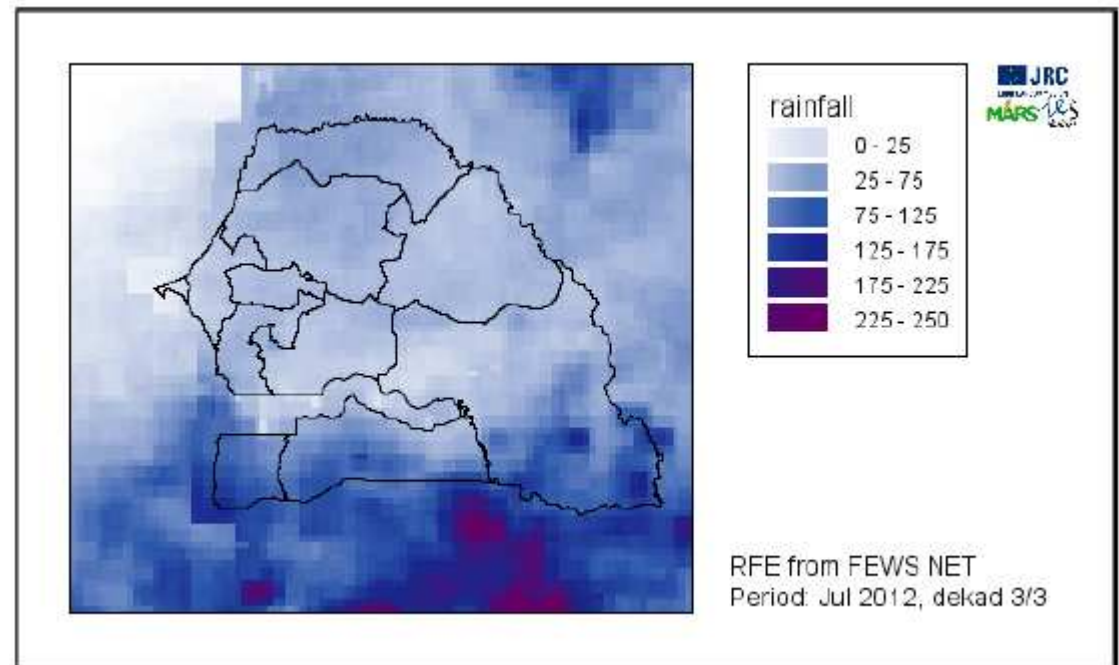
- » File
 - » File and project definitions, renaming etc...
- » Processing
 - » Image processing modules for single images (tools) or on a time-series of images
- » Analysis
 - » Produce maps, browse database, create charts... can be automated
- » Import/Export
 - » format conversions
 - » rasterization
- » User tools
 - » Runs external or internal executables on time series



Main functionalities (1/5)

Import and export external data formats

- » Image importer: all formats supported by GDAL
- » Vector to raster conversion
- » File renamer
- » Image exporter



Main functionalities (2/5)

Spatial processing operations

- » Region of interest (ROI) extraction
- » Resampling
- » Area fraction image generation
- » Low pass filters



input IMG: map info = {Geographic Lat/Lon, 1.5, 1.5,
-180, 90, 2.7778e-003, 2.7778e-003}

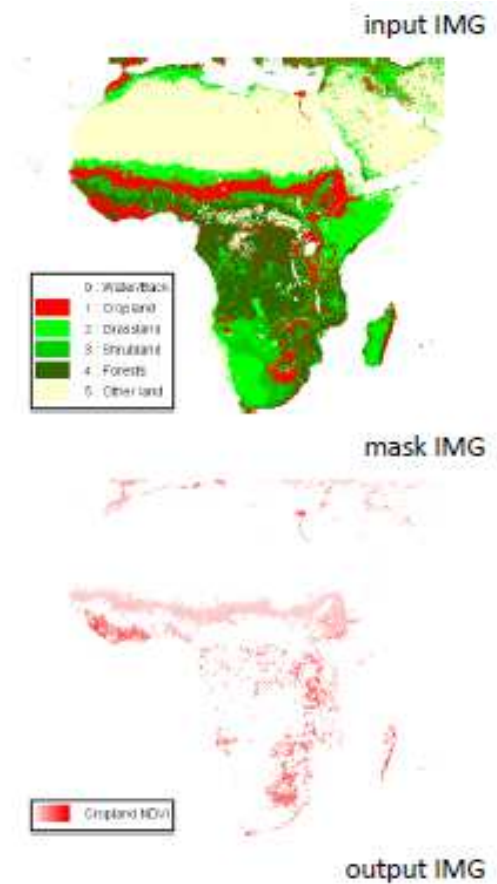


output IMG: map info = {Geographic Lat/Lon, 1, 1,
-26.066964, 38.0669643, 0.1875, 0.1875}

Main functionalities (3/5)

Thematic processing operations

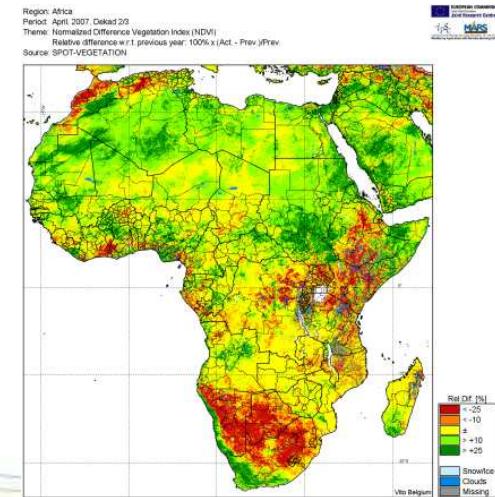
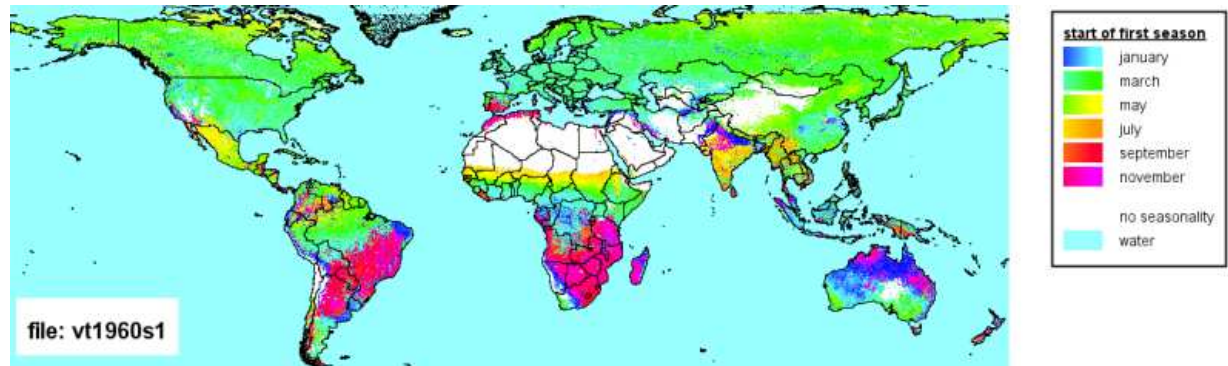
- » Rescaling
- » Index
- » Masking
- » Flagging
- » DMP (Dry matter production)
- » Clustering



Main functionalities (4/5)

Temporal processing operations

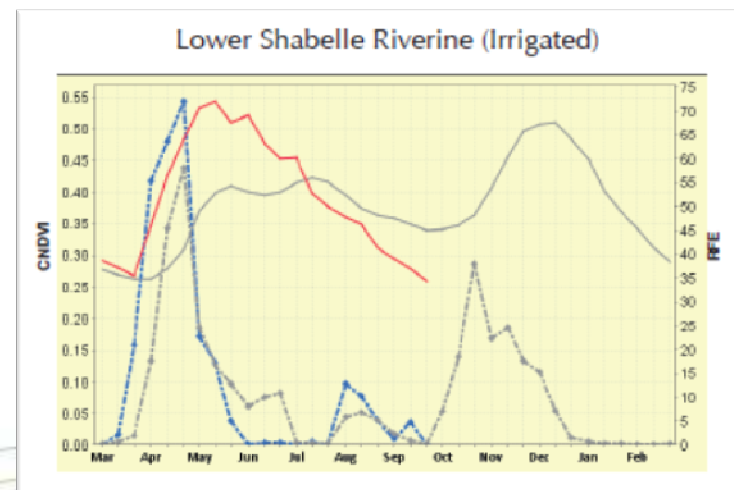
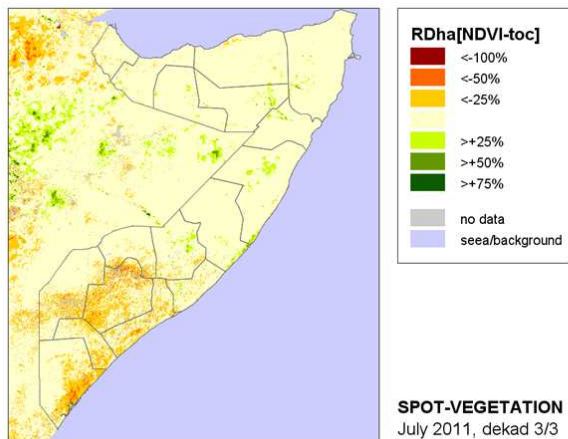
- »Smoothing
- »Compositing
- »Averaging
- »Cumulating
- »Phenology
- »Phenological averaging or cumulating
- »Long term statistics
- »Anomalies
- »Similarity analysis
- »Similarity based yield assessment



Main functionalities (5/5)

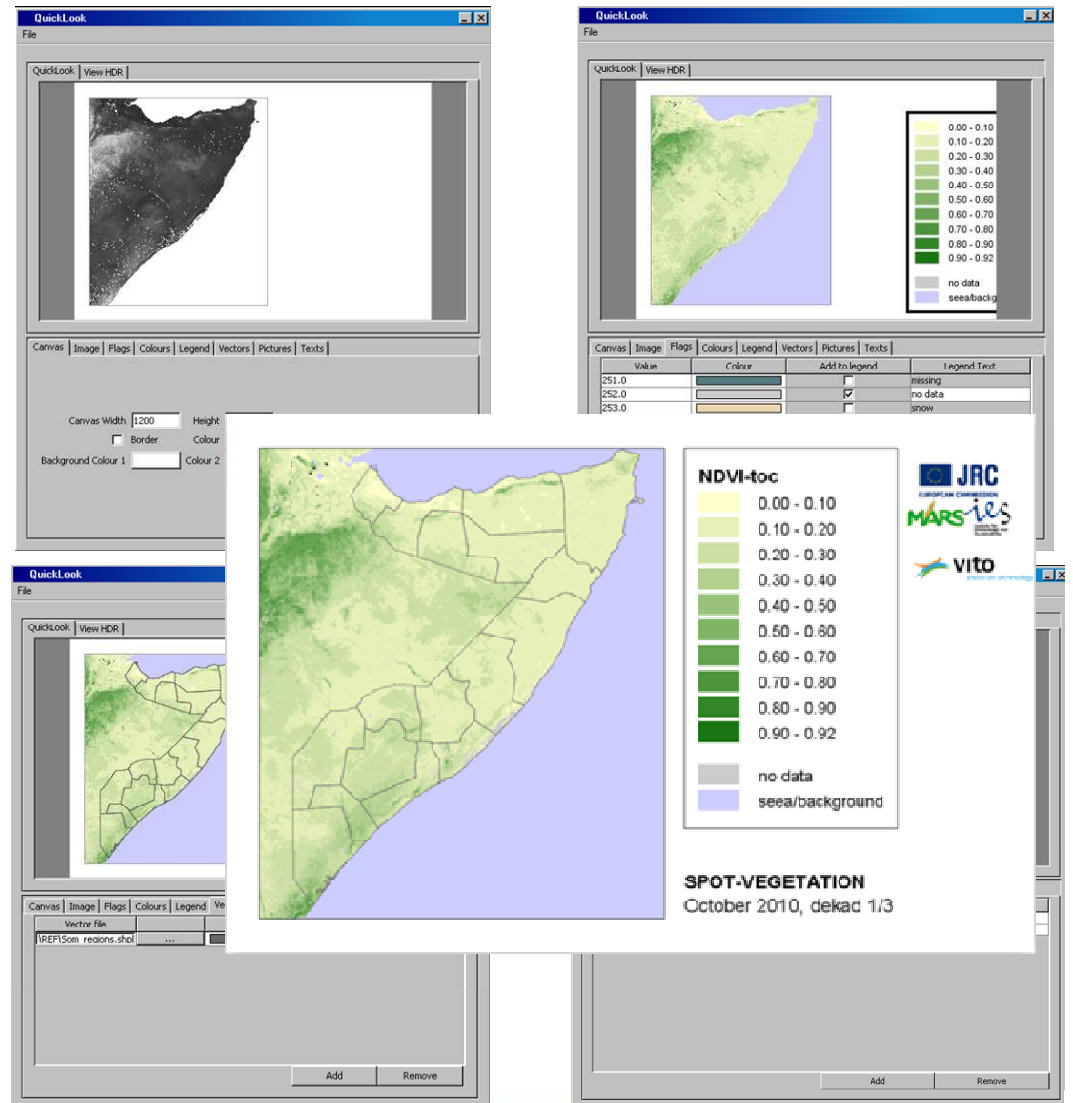
Analysis tools

- » Map composer
- » Database with regionally and thematically aggregated statistics
- » Graph composer
- » User tool



Map composer

- » Create image maps
 - » Choose frame and background extension and properties
 - » Overlay vector files
 - » Edit legends
 - » Label features
 - » Add logos
 - » Copy directly into a report
 - » Export as PNG



Maps – Time Series

The image shows a 'Create Quick Looks' dialog box overlaid on a file explorer window. The dialog box is titled 'Create Quick Looks' and has a blue title bar. It contains several sections:

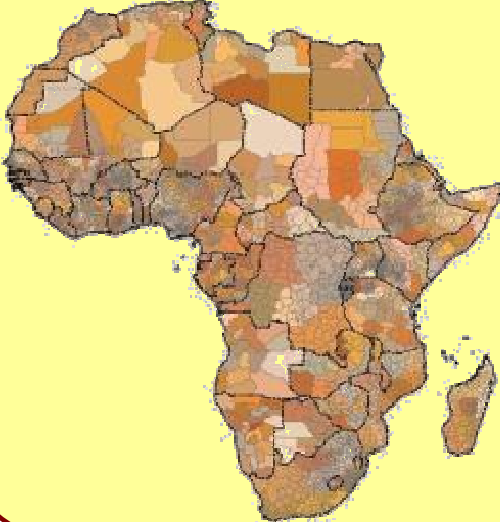
- File**: Quick Look template: QNQ template . Buttons: ..., New, View, Edit.
- Files**: Input directory: . Periodicity: Dekad. Input filenames: prefix , date , suffix . Output directory: . Output filenames: prefix , date , suffix .
- Time Series**: Start date: (format YYYYMMDD). End date: (format YYYYMMDD).

Buttons: Cancel, Execute.

The background window is a file explorer showing a grid of map files. The files are named FAPAR9813a.png through FAPAR9901a.png. A tooltip is visible over one of the files, showing: Dimensions: 600 x 400, Type: PNG Image, Size: 22,2 KB. The status bar at the bottom of the file explorer shows '373 objects (Disk free space: 18,6 GB)' and '8,04 MB My Computer'.

Aggregated statistics extraction and visualization

Administrative boundaries



SPOT-VGT images



Landcover



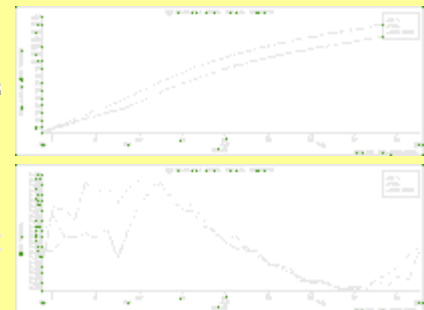
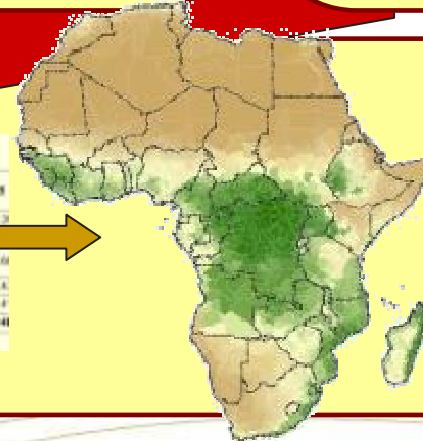
“RUM” database – regional unmixed

Maplebox for 2002, 2004, 2006

Figures indicate the dry matter productivity in kg/ha/decade. Column 1: 30 estimates decade 1 to decade 30.

Centre	Area LEVEL 1	Area LEVEL 2	Area LEVEL 3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
Malawi	Northern	CH200		0.60	0.97	0.84	0.84	0.60	0.70	0.74	0.84	0.81	0.62	0.95	0.52	0.83	0.86	0.80	0.89	0.48	0.42	0.51	0.84	0.88	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	
Malawi	Northern	Maranga		0.95	0.70	0.88	0.80	0.88	0.72	0.72	0.83	0.60	0.62	0.90	0.98	0.84	0.64	0.81	0.95	0.62	0.46	0.49	0.85	0.88	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	
Malawi	Northern	Maloti	Bar	0.62	0.74	0.83	0.48	0.71	0.73	0.74	0.83	0.86	0.84	0.95	0.82	0.78	0.74	0.83	0.74	0.47	0.58	0.60	0.52	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Malawi	Northern	Mtendere		0.47	0.89	0.88	0.88	0.68	0.75	0.78	0.88	0.67	0.70	0.82	0.88	0.70	0.70	0.86	0.87	0.48	0.58	0.57	0.87	0.83	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	
Malawi	Northern	Mtenda		0.43	0.83	0.58	0.47	0.63	0.67	0.87	0.53	0.81	0.65	0.81	0.82	0.83	0.83	0.99	0.59	0.44	0.44	0.45	0.83	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	
Mean				0.51	0.80	0.82	0.58	0.64	0.70	0.73	0.83	0.57	0.64	0.50	0.82	0.67	0.68	0.61	0.65	0.47	0.48	0.49	0.80	0.52	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48		

* 1 decade is a ten-days synthesis of the dry matter productivity values.



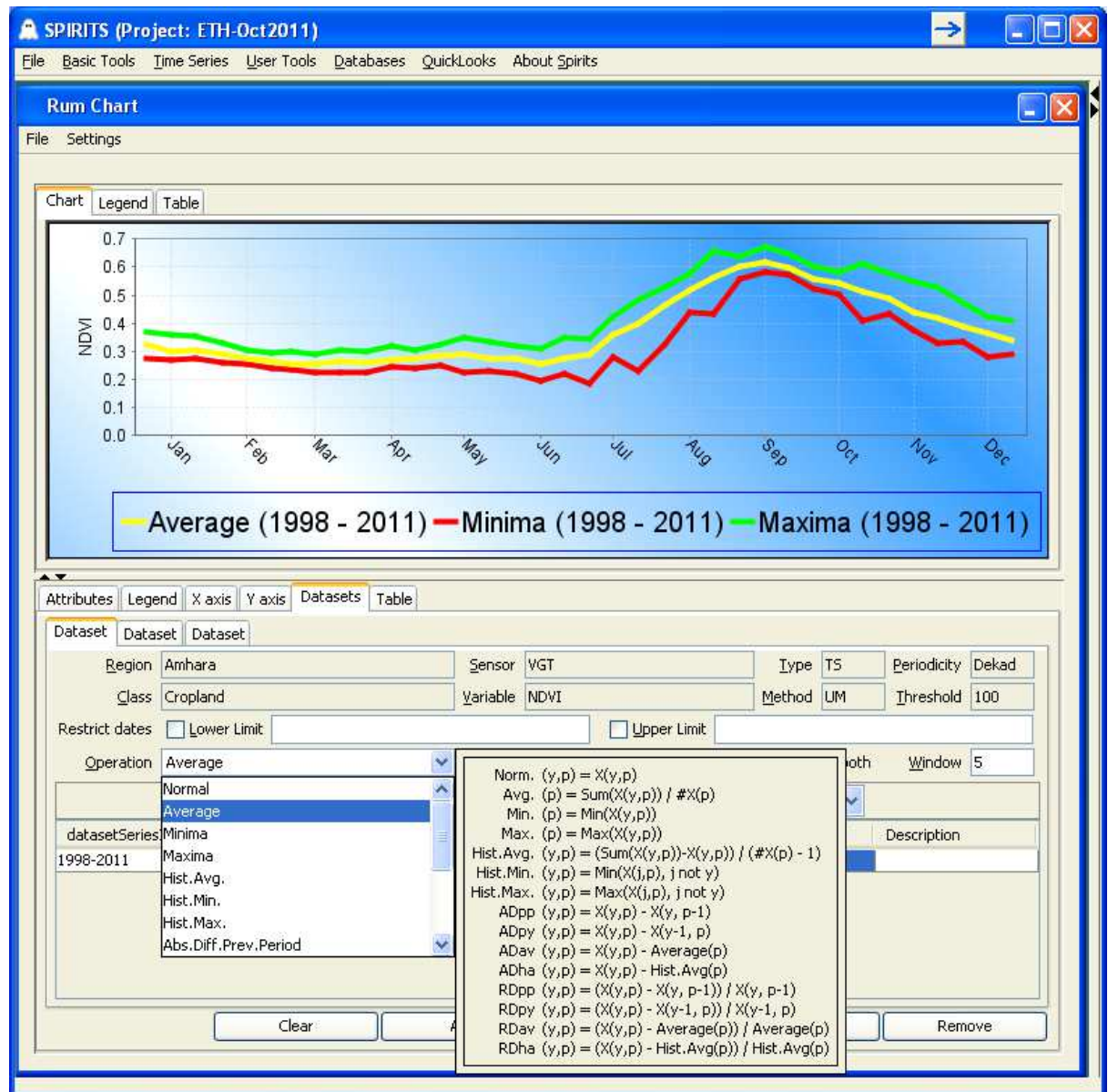
Time series analysis charts

*Database browser:
selected series
can be sent to
a chart*

The screenshot displays the SPIRITS (Project: NewMarch) software interface. The main window is titled "Browse RUM database" and contains several dropdown menus for "Regions Set" (GLD), "Region" (*ALL*), "Classes Set" (GLC2000), "Class" (*ALL*), "Sensor" (SPOT-VGT), "Variable" (FAPAR), "Periodicity" (*ALL*), and "Method" (ALL). Below these is a table listing data series with columns for Type, Region, Class, Method, Threshold, Sensor, and Variable. A red box highlights the "Values" column in a preview table below, which shows a list of dates and mean values for FAPAR. A red arrow points from this table to a small chart window titled "table preview" showing a time series plot of FAPAR values from 1999 to 2007. A green arrow points from the "Variable" dropdown in the main window to the "Example of SPIRITS Graph" window, which displays a multi-line chart of FAPAR values for various years (1999-2007) from January to October. On the right side, a task list window shows a list of tasks such as "Id: 788 Extract RUM 060211" and "Id: 1102 Extract RUM DONE 100% Ste".

Chart operations

- » Normal
- » Average
- » Minimum
- » Maximum
- » Historical Average
- » Historical Minimum
- » Historical Maximum
- » Absolute Difference
 - » previous period
 - » previous year
 - » average
 - » historical average
- » Relative Difference
 - » previous period
 - » previous year
 - » average
 - » historical average



Charts – time series

RUM Chart series

File Task submitted

RUM Chart template

CNC template: M:\Bay_rainfed.cnc ... New View Edit

Regions

Select Regions Ref. Region: BAY - Set: Reg

Select	Id	Abbreviation	Name
<input checked="" type="checkbox"/>	16	L_SHABELLE	L_SHABELLE
<input type="checkbox"/>	9	MUDUG	MUDUG
<input type="checkbox"/>	18	M_JUBA	M_JUBA
<input checked="" type="checkbox"/>	14	M_SHABELLE	M_SHABELLE
<input type="checkbox"/>	7	NUGAL	NUGAL
<input type="checkbox"/>	2	SANAG	SANAG
<input type="checkbox"/>	6	SOOI	SOOI

Classes

Select Classes Ref. Class: cont - Set: AFRI

Select	Id	Abbreviation	Name
<input type="checkbox"/>	0	CA_0	CN_0
<input type="checkbox"/>	4	clus_s	clus_s
<input checked="" type="checkbox"/>	1	cont	cont
<input type="checkbox"/>	3	f_irrig	f_irrig
<input type="checkbox"/>	6	herb_som	herb_som
<input type="checkbox"/>	2	irr_s	irr_s
<input type="checkbox"/>	8	onsh_som	onsh_som

Output files

Output directory: C:\X_Data\SOM\Graphs ...

Filename pattern: Region_%0_Class_%3 .png Filename Parameters

Cancel Execute

(C:) \> X_Data \SOM \Graphs Search Graphs

are with Slide show Burn New folder

The figure displays six time series charts arranged in a 3x2 grid. Each chart is titled 'Bay rainfed' and shows multiple data series over time. The x-axis is labeled 'Time' and the y-axis is labeled 'LSDM'. The charts are labeled as follows:

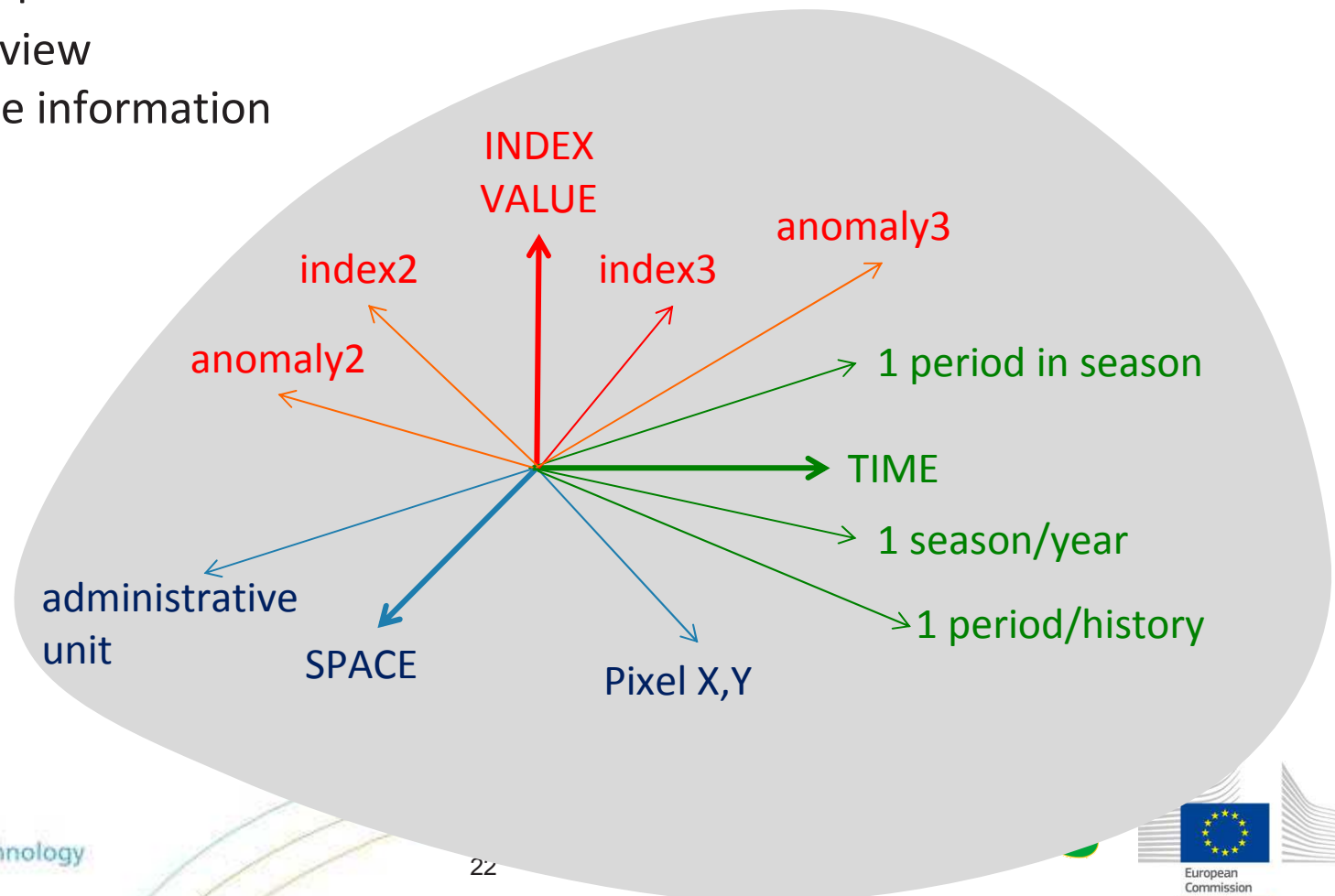
- Region_11_Class_1.png
- Region_12_Class_1.png
- Region_14_Class_1.png
- Region_15_Class_1.png

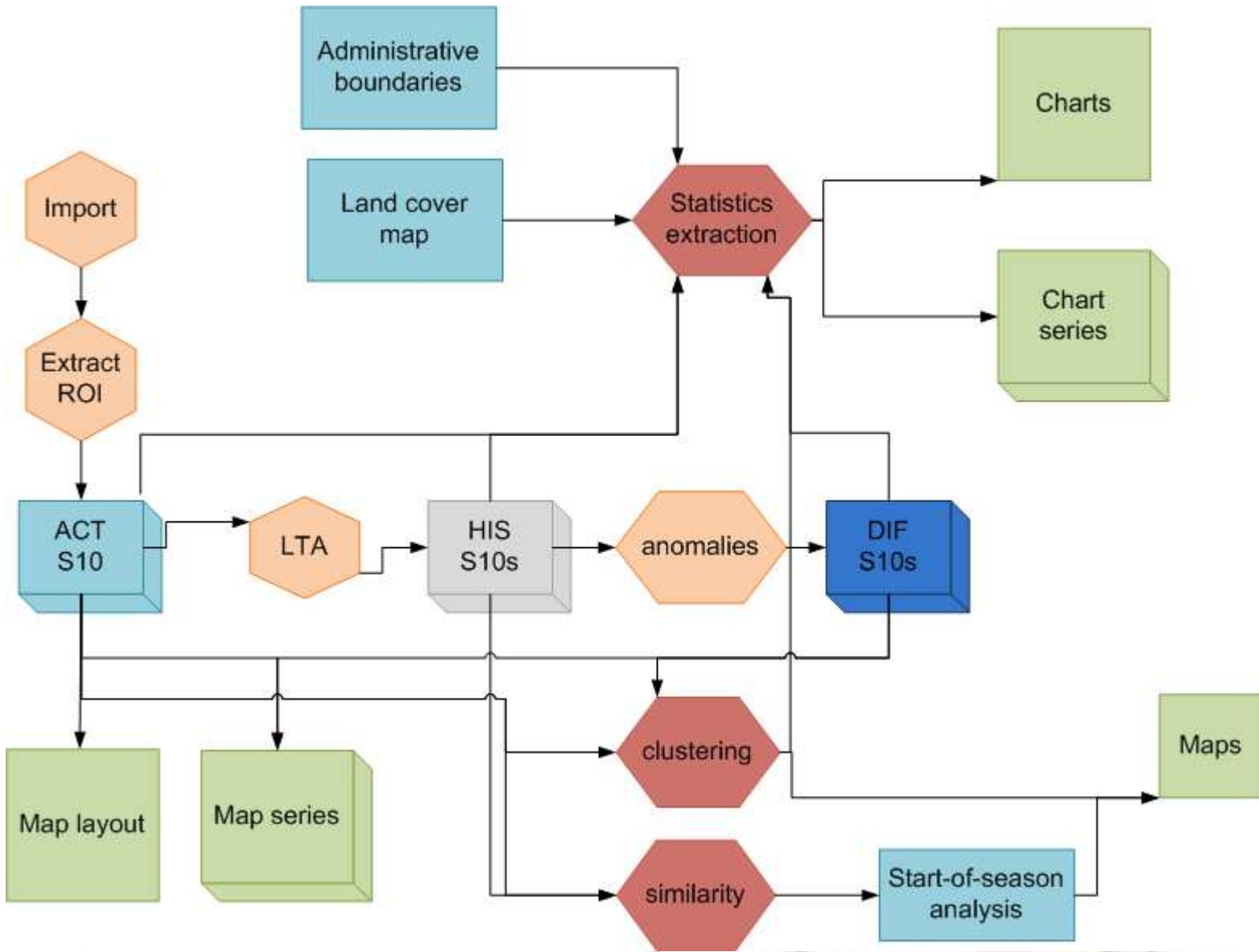
Each chart shows a blue line with sharp peaks and a red line with smoother curves, representing different data series over time.

SPIRITS ANALYSIS METHODS

The challenge of information analysis

- » A lot of information to analyze in space and time!
- » How to interpret multi dimensions?
- » Get an overview and combine information

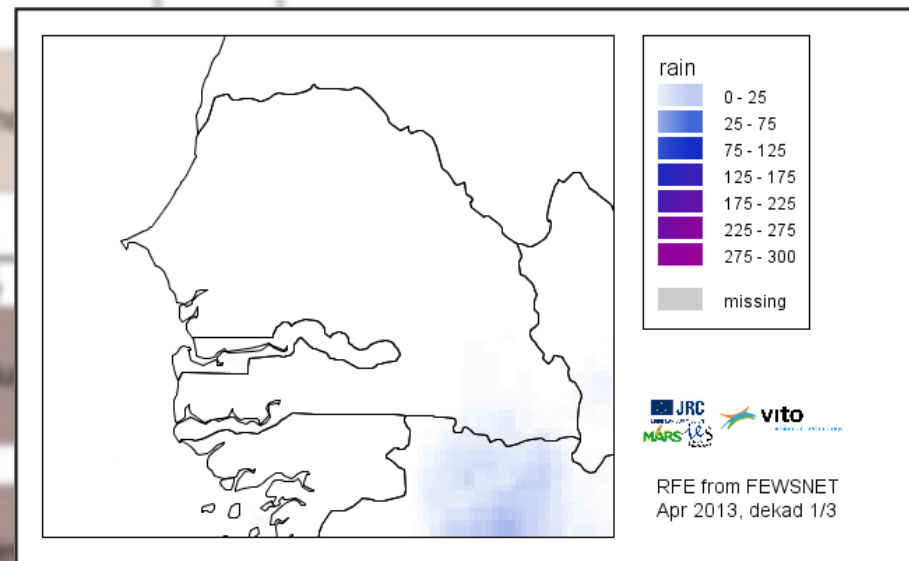
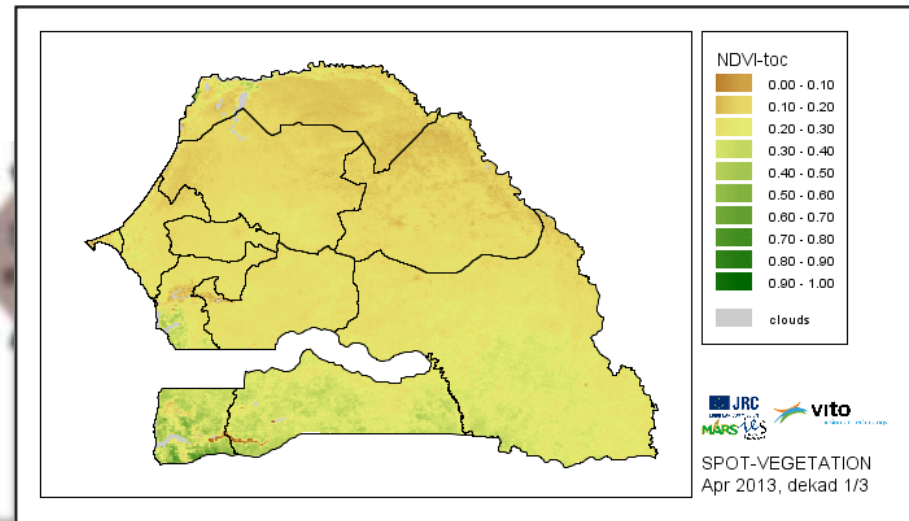
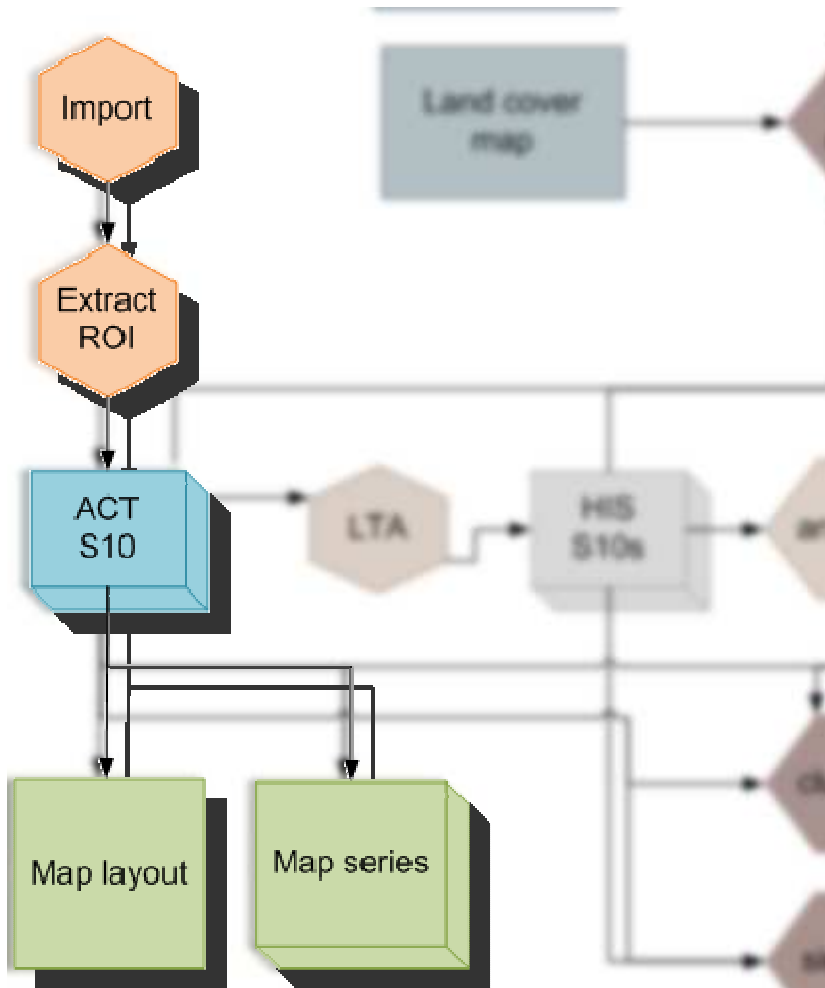




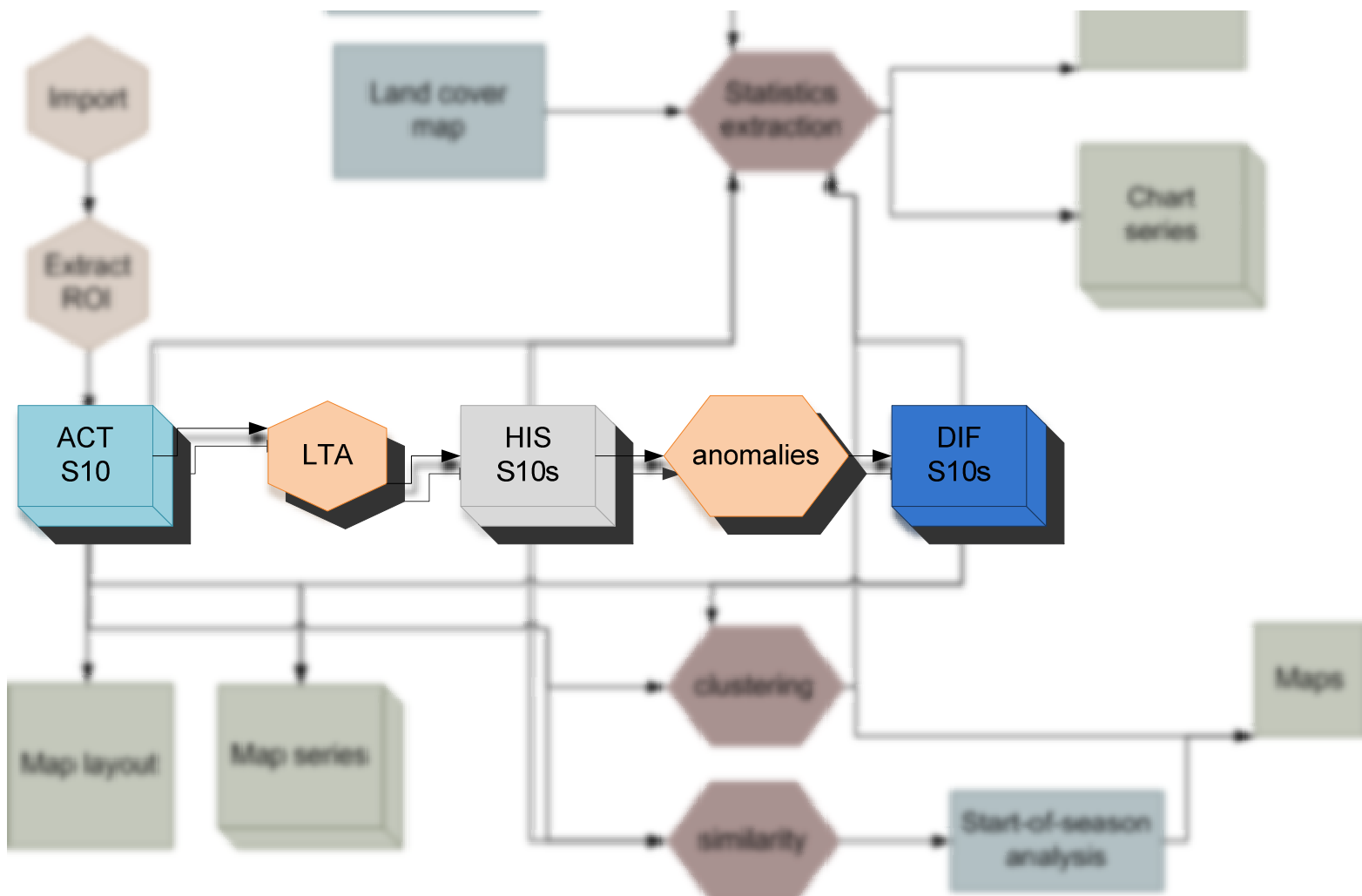
SPIRITS OUTPUT

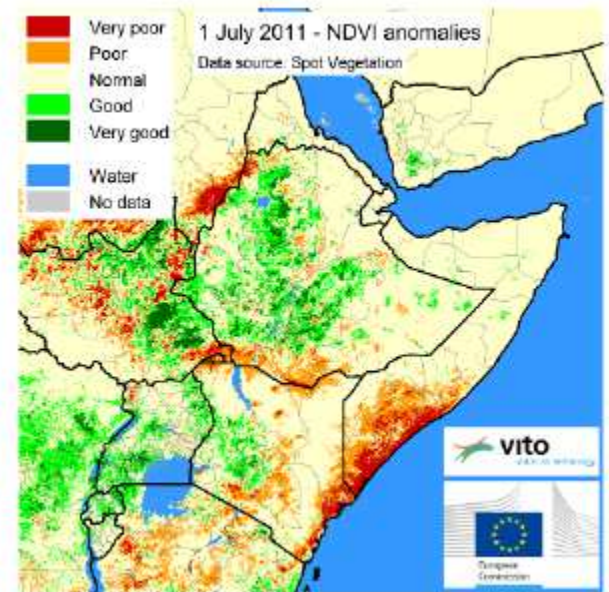
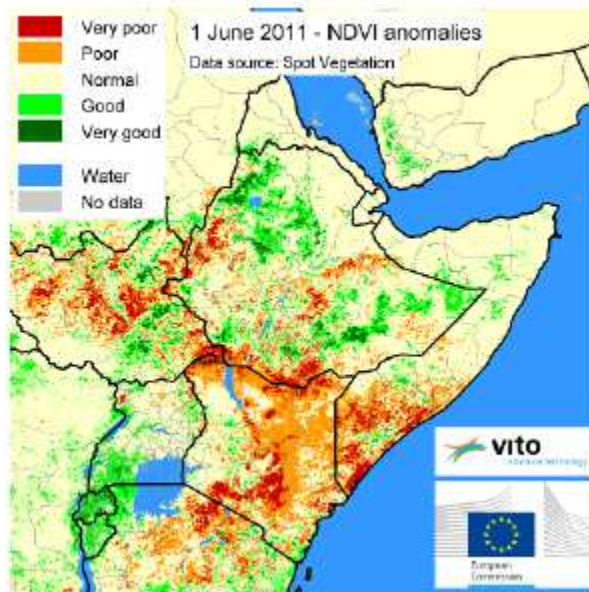
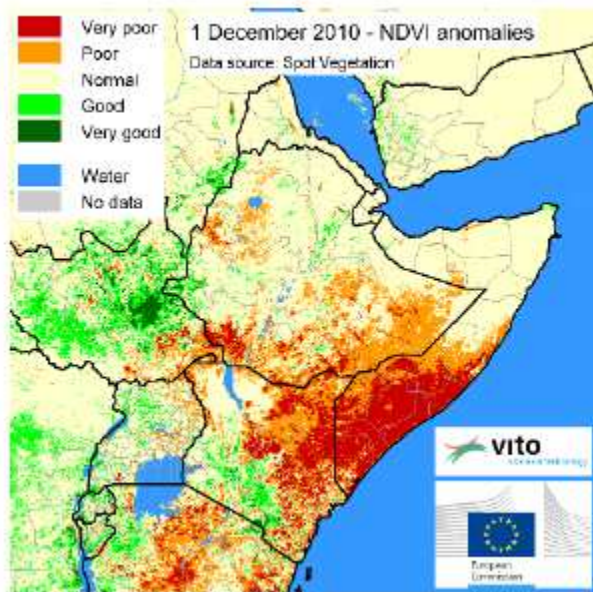
- » Map series based on a layout
- » Long term averages
- » Anomalies
- » Graphs for multiple variables
- » Clustering
- » Start-of-season shift
- » ...

Map series



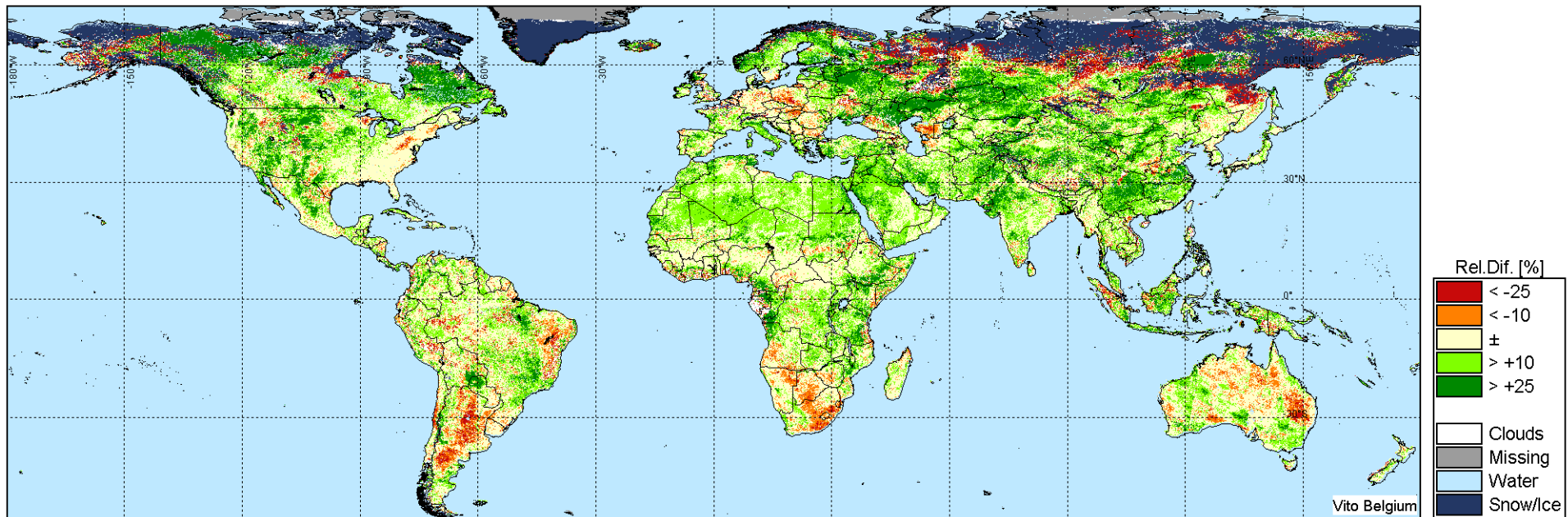
Long term averages and anomalies



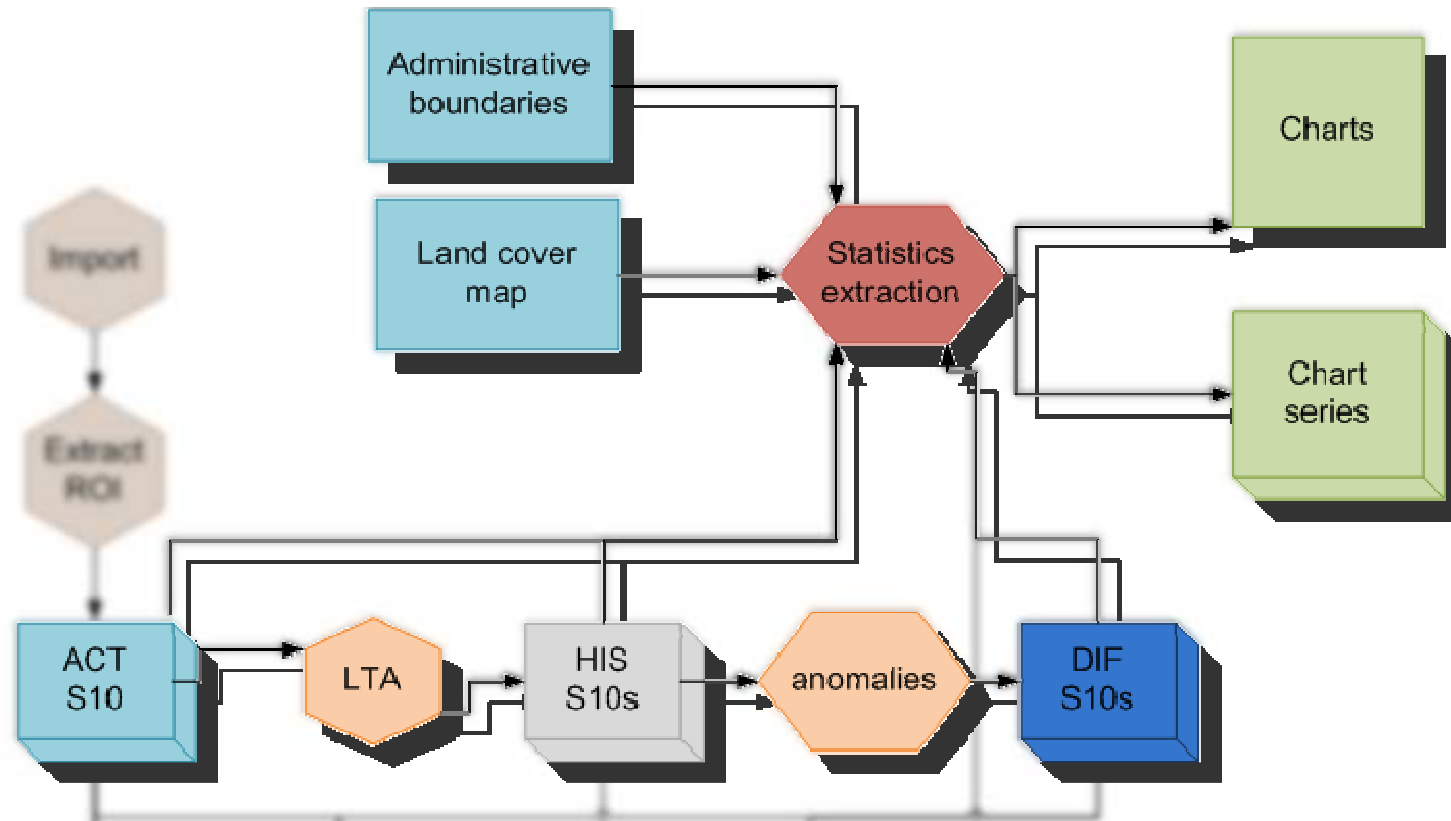


2010/2011 drought, Horn of Africa

Region: The GLOBE
 Period: Oktober, 2013, Dekad 2/3
 Theme: Normalized Difference Vegetation Index (NDVI)
 Relative difference w.r.t. historical mean: $100\% \times (\text{Act.} - \text{Hist.})/\text{Hist.}$
 Source: SPOT-VEGETATION

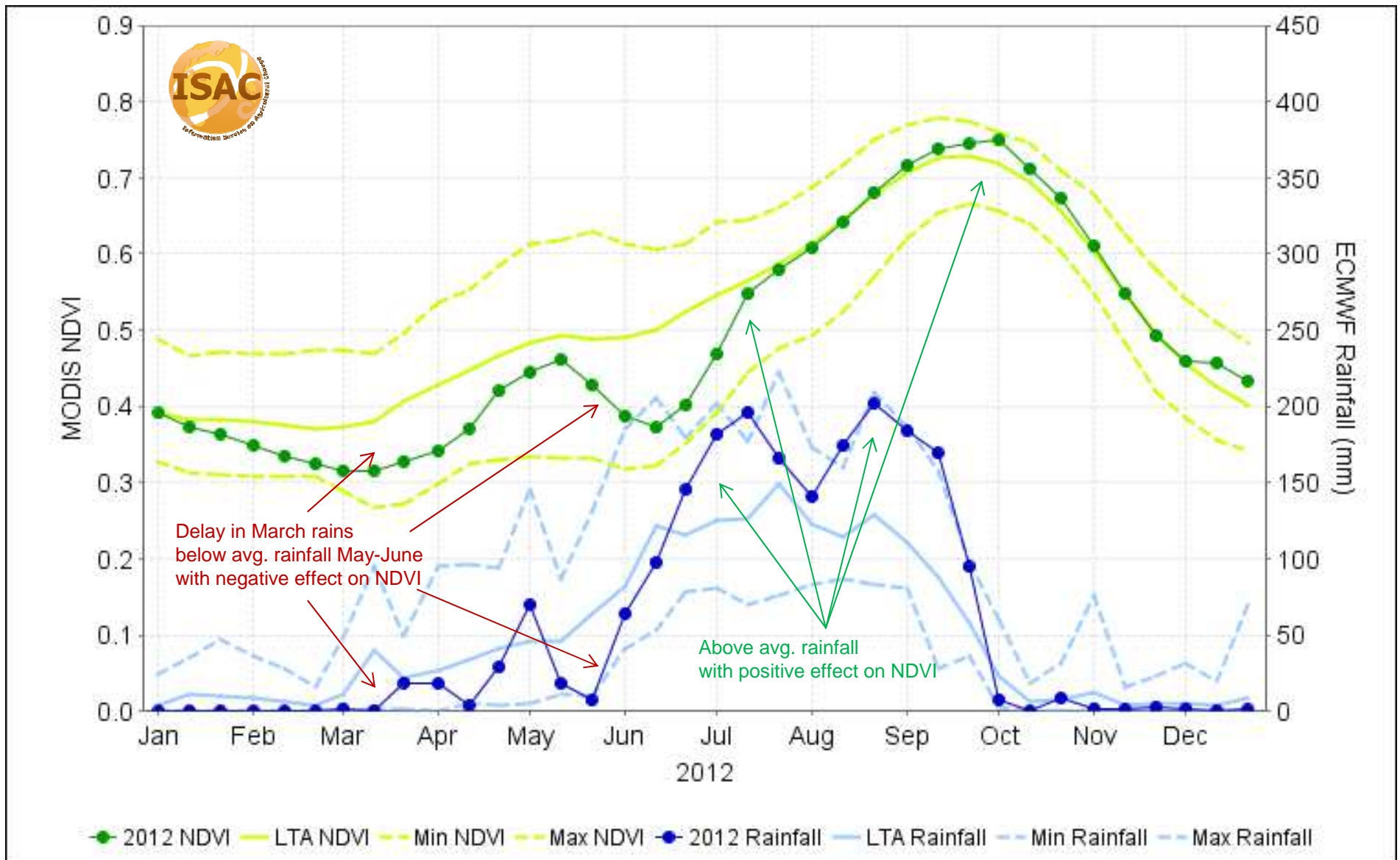


Current global situation



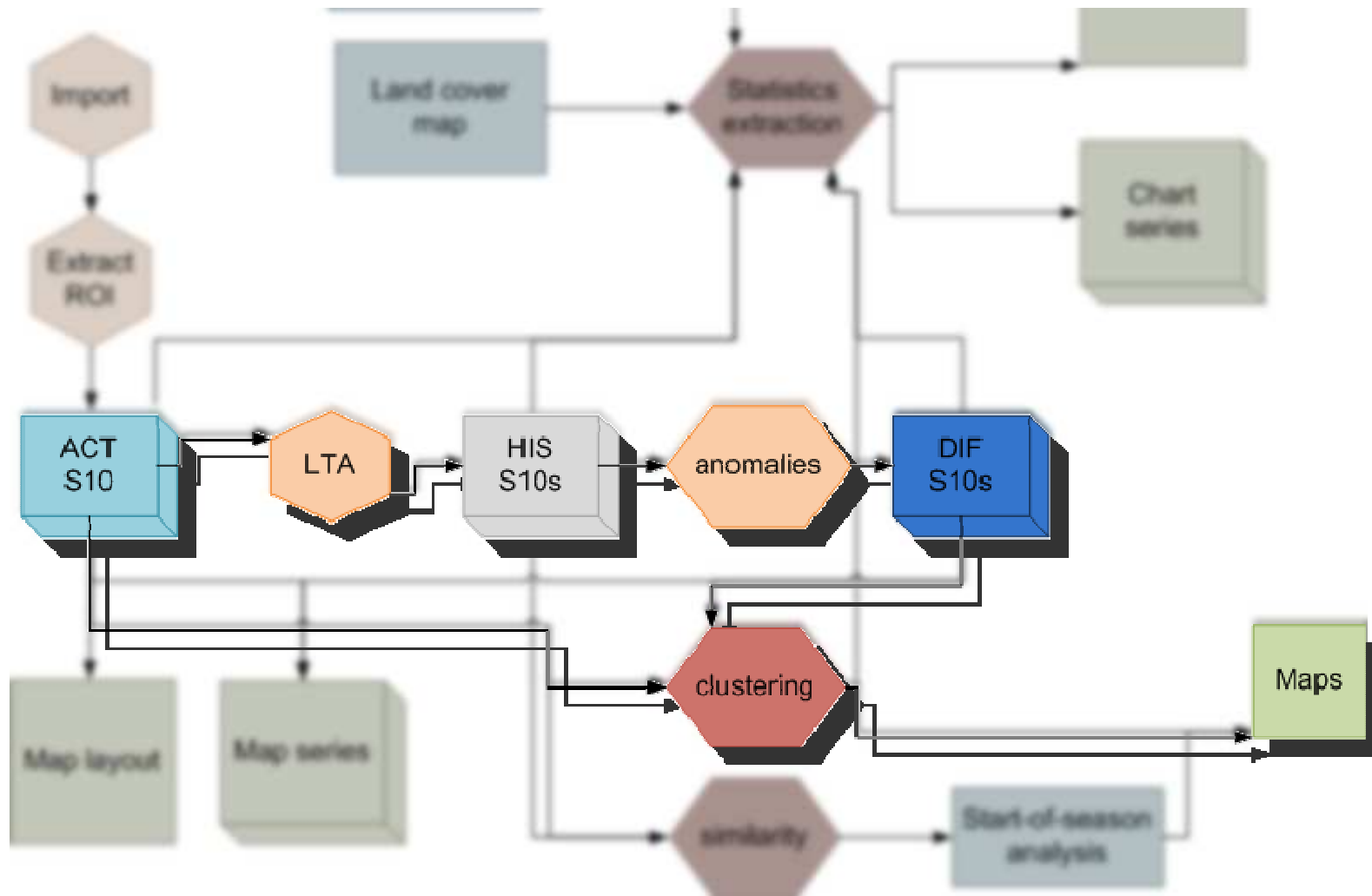
Statistics extraction and graphs



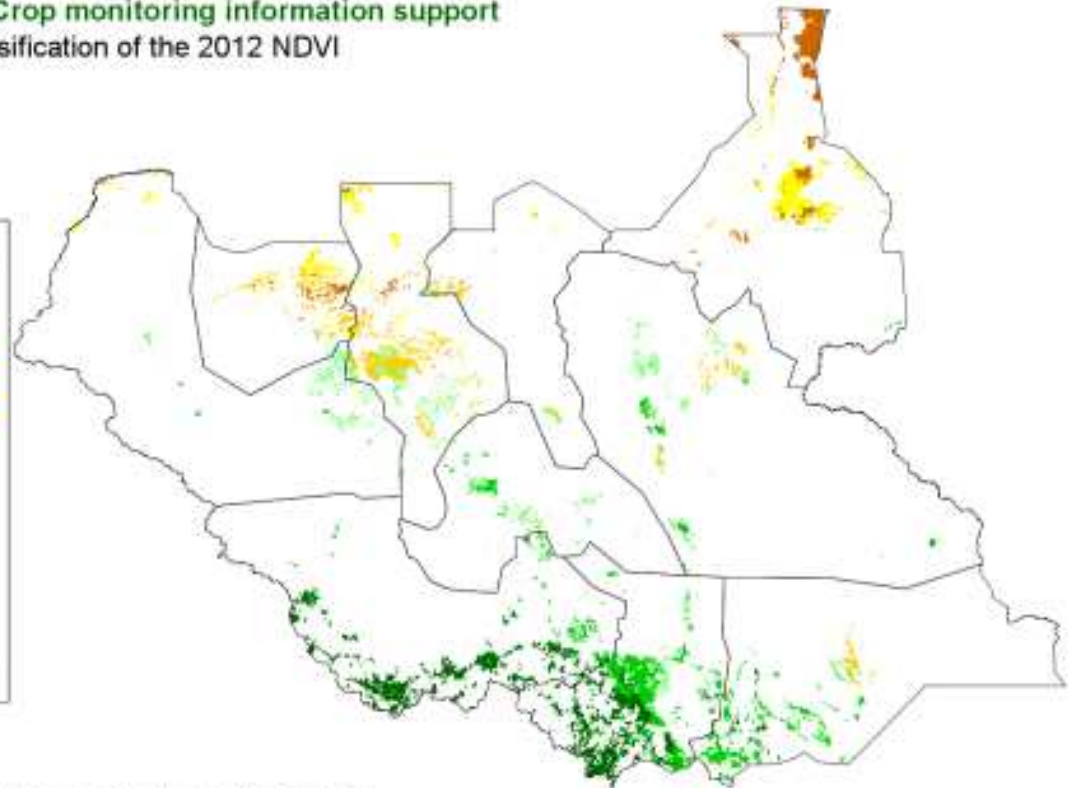
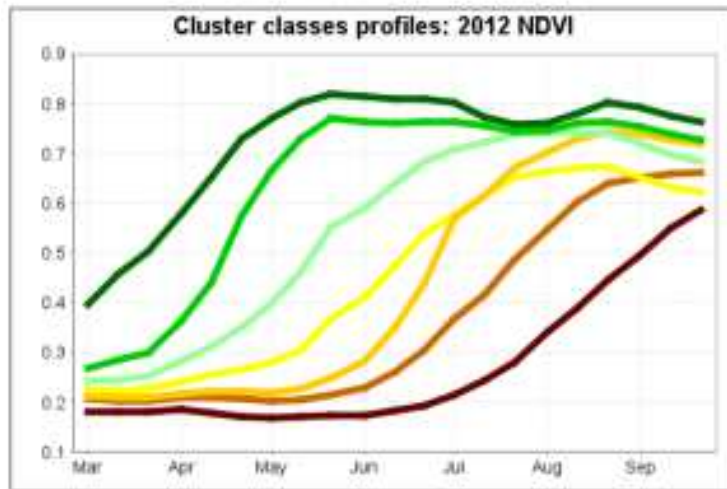


2012 Meher season, West-Shewa, Ethiopia

Clustering



SOUTH SUDAN - Crop monitoring information support
Cluster classification of the 2012 NDVI



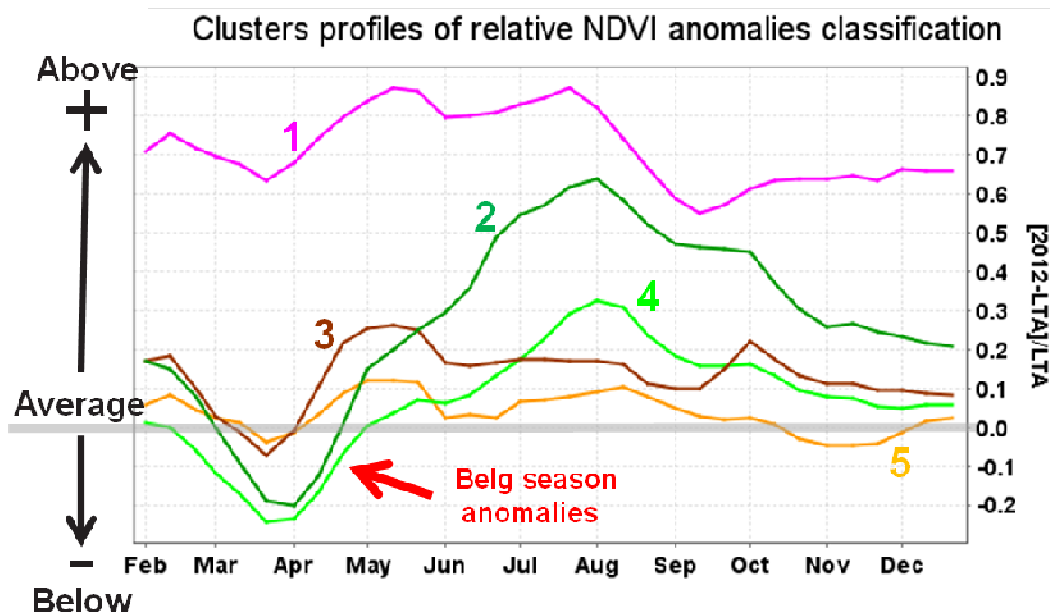
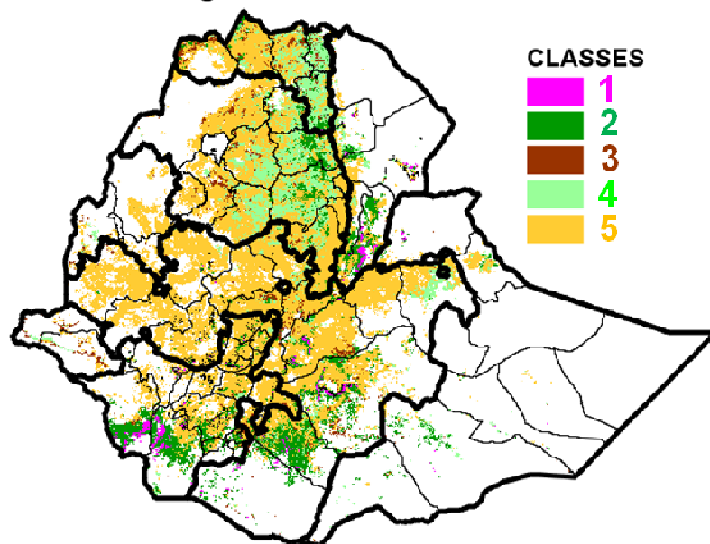
Sources: 1) CLASmas - 2) Vectors from FAO-GAUL, level 2 - 3) Produced per FAO GEWS/GMPS
Projection: Geographic LatLon - Resolution: 1km

2012 crop season, South Sudan

ETH - Relative NDVI anomalies classification

Period: February to December 2012

Focus on main agriculture area



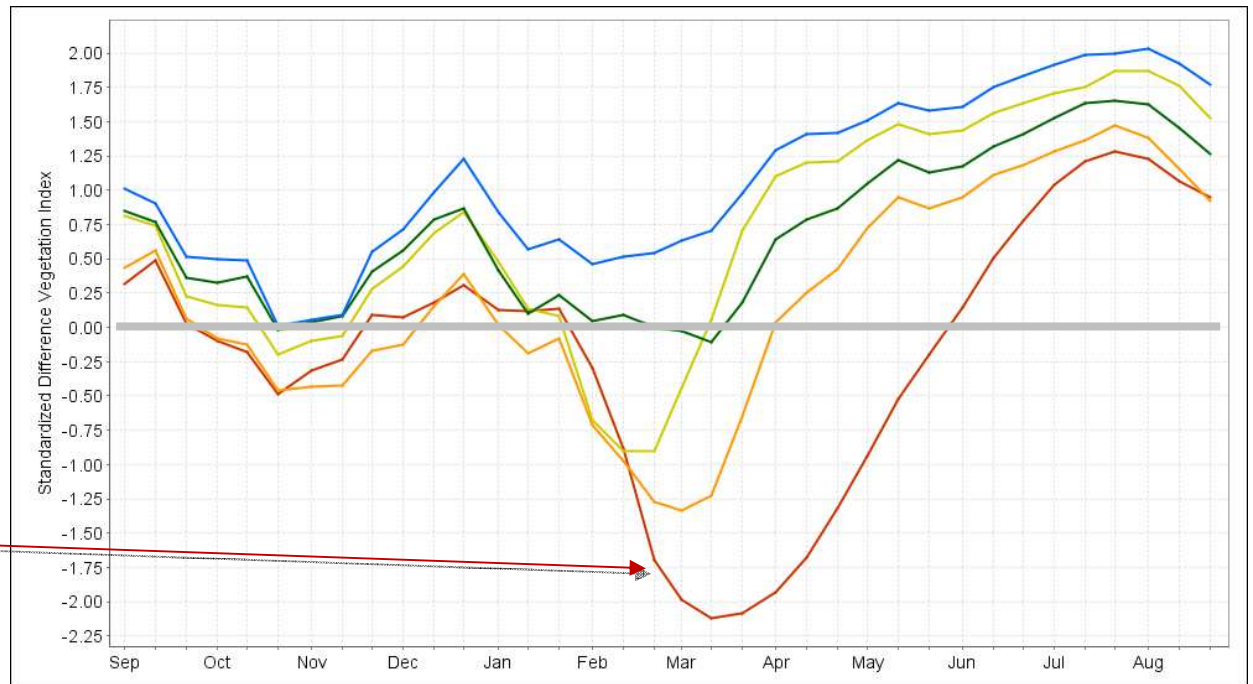
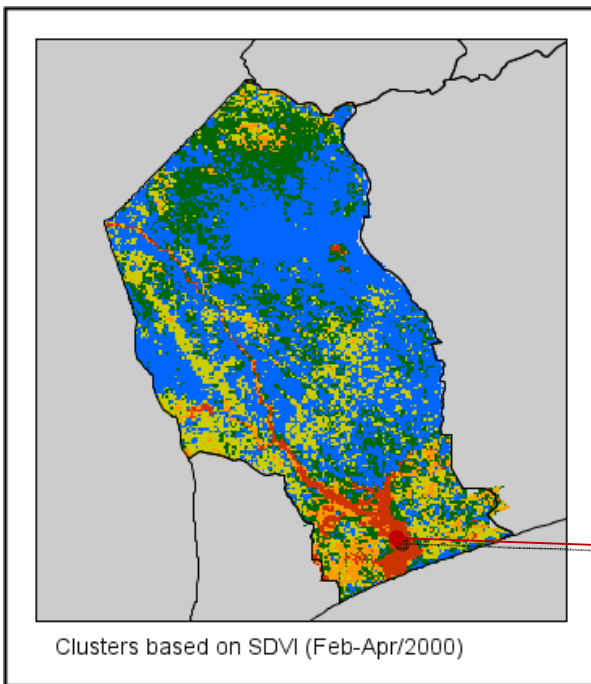
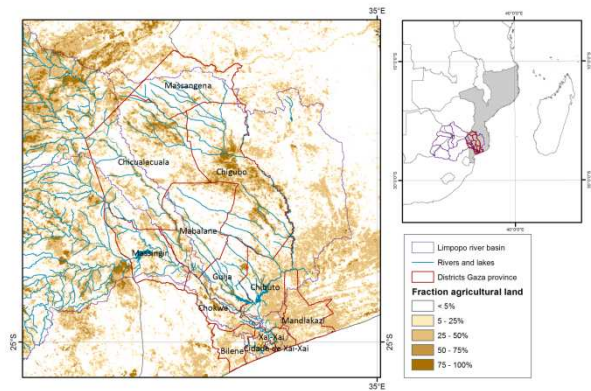
*LTA: Long Term Average 1999-2011

Map: Geographic, WGS 84 - Resolution: 1km

Images : SPOT/VGT - Vectors from FAO Gaul



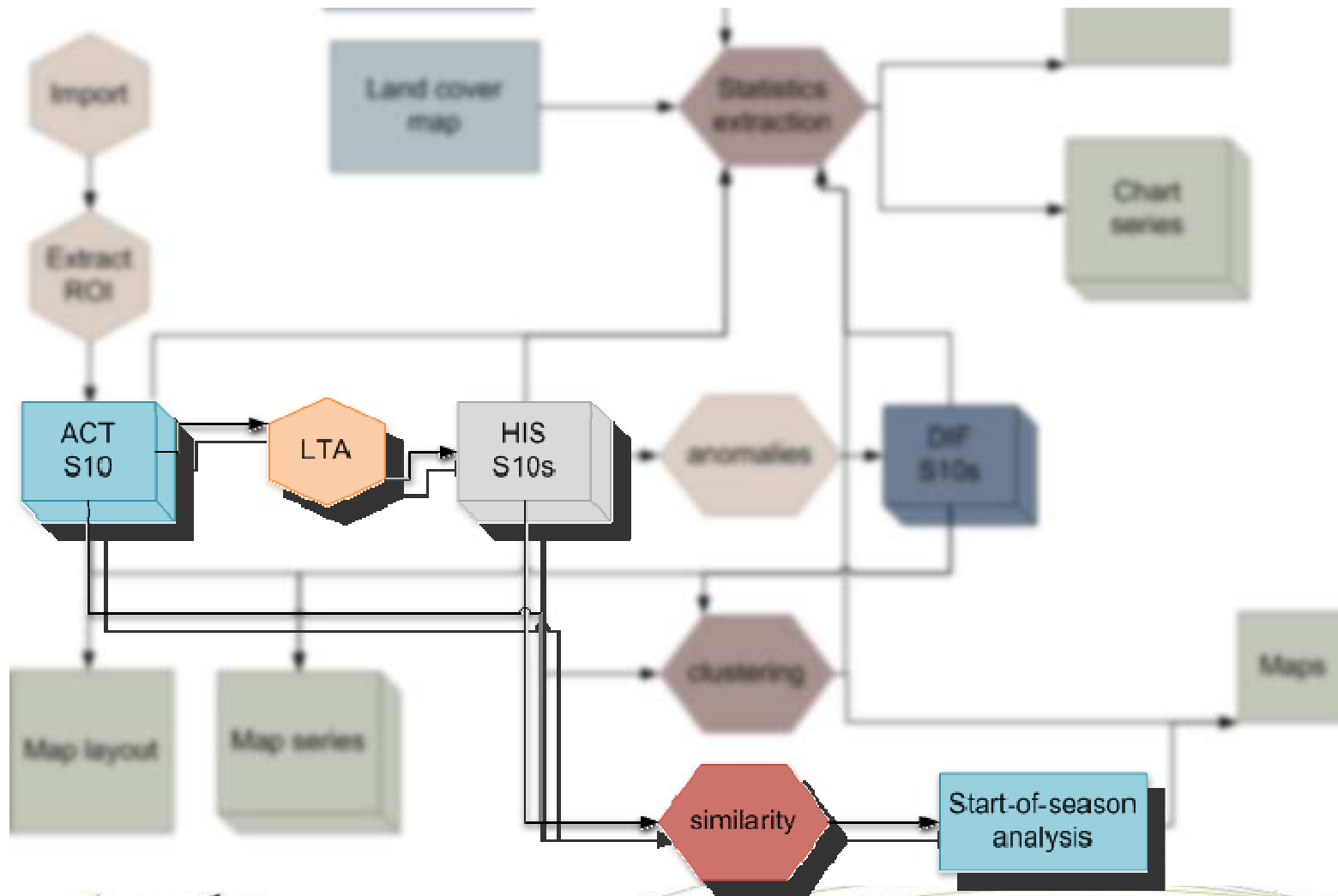
2012 Belg - Meher crop seasons, Ethiopia



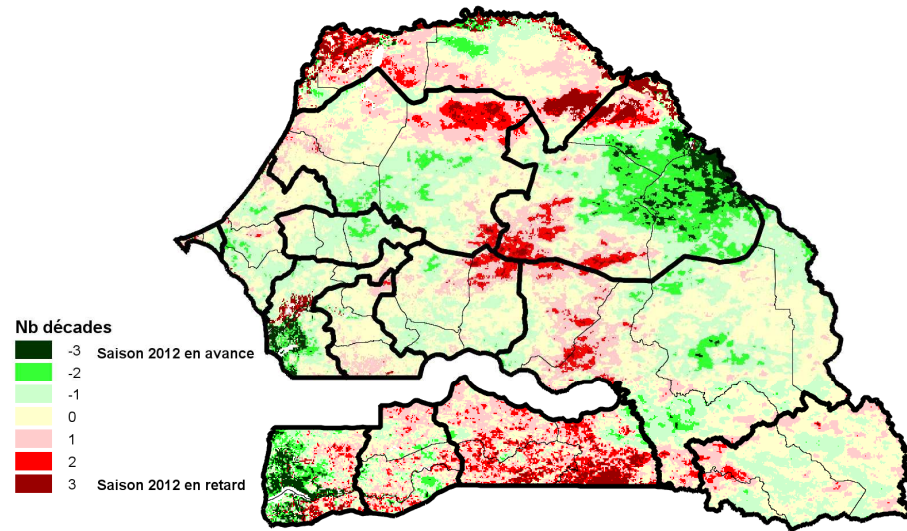
2000 Flood of Limpopo River, Gaza, Mozambique



Similarity for start-of-season analysis

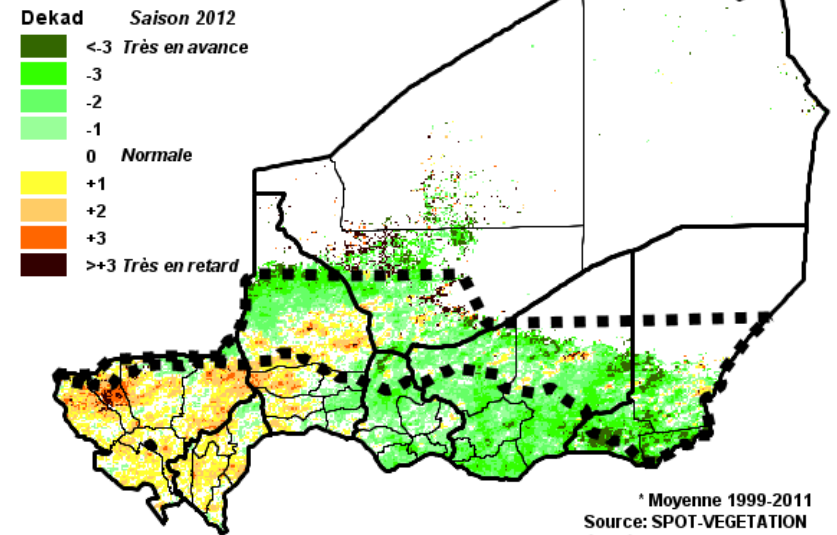


SENEGAL - Elements d'analyse de la campagne agro-pastorale
Anomalies de démarrage de la saison du 01/05/2012 à 31/07/2012
Comparaison des profils NDVI: 2012 avec la moyenne 1999-2011



Projection: Geographic Lat/Lon - Grid size: 1km
Sources: 1)Analyse de données SPOT VGT- 2) Vecteurs de FAO-GAUL level 2 - 3) Produit par GMFS

Début de la saison 2012 par rapport à la moyenne*
Période d'avril à juillet 2012



* Moyenne 1999-2011
Source: SPOT-VEGETATION
Réalisé par AGRHYMET/GMFS

2012 Start-of-season shift compared to long term average (Senegal, Niger)

Growing user community

SPIRITS users/contributors

CENTRE DE SUIVI ECOLOGIQUE **CSEF**
Suivi de la campagne agro-pastorale 2013
BILAN A MI-PAROURS DE LA SAISON DES PLUIES
BULLETIN N°30 SEPTEMBRE 2013 - BILAN A MI-PAROURS



Suivi des cultures et des pâturages au Niger bilan à la fin du mois de septembre 2012

Dans les autres pages :

Prévision des rendements du mil et du sorgho	2
Profils comparés	3
Validation	5
Protocoles d'analyse GMFS	6

La situation agro-pastorale, telle qu'elle se présente en fin septembre 2012, laisse présager des meilleures conditions de vie au cours des mois à venir pour les agriculteurs et les pasteurs nigériens. Plus de 90% des zones agricoles et pastorales présenteront des productions comparables ou supérieures à la moyenne des 14 dernières années, moins de 10% des surfaces sont déficitaires. Il faut signaler qu'en plus des conditions de mauvais déroulement de la campagne (Pause pluviométrique et retard d'installation) les inondations dans la vallée du fleuve ont causé beaucoup de dommages ayant entraîné une diminution voire la perte totale des productions envisagées sur les 3/5 des zones traversées par le fleuve niger au Niger (figure1).

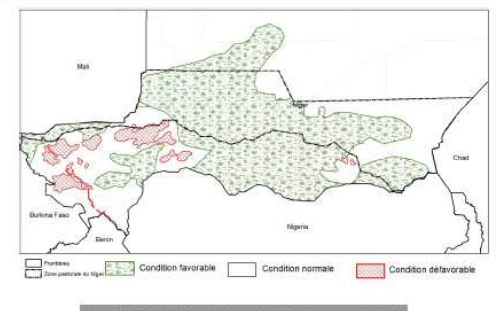


Figure 1 : Situation de la campagne agropastorale au 30 septembre 2012

Le Rouge montre les zones à situation défavorable. C'est-à-dire les zones dans lesquelles les conditions pluviométriques n'ont pas été du tout propices à une bonne croissance et à un développement important de la végétation laissant craindre des mauvaises à très mauvaises perspectives de production agropastorale.

Le Blanc se rapporte aux zones à situation moyenne car comparable à la moyenne enregistrée au cours des 14 dernières années. On peut espérer une production agropastorale tout au moins égale à la moyenne de 1998 à 2011.

Le Vert représente les zones à situation favorable. C'est-à-dire les zones dans lesquelles les conditions pluviométriques ont permis une bonne croissance ainsi qu'un développement favorable de la végétation, laissant espérer une bonne à très bonne production agropastorale.



RÉSUMÉ

Sommaire

Le bilan à mi-parcours de la campagne agro-pastorale fait l'état des lieux sur le comportement de la végétation au niveau des différentes zones agro-écologiques du Sénégal de mai à août. Pour cette année 2013, le mois de septembre a été inclus dans le bilan à mi-parcours pour mieux ressortir l'incidence des pluies de la troisième décennie du mois d'août, souvent très pluvieuses, sur le comportement des cultures.

La campagne agro-pastorale 2013-2014 est marquée, à l'échelle nationale, par un retard quasi global, du début de croissance de la végétation, sauf au niveau des régions de Ziguinchor et de Sédhiou qui ont enregistré une avance de plus de 3 décades par rapport à la moyenne 1998-2012. Ces régions ont bénéficié d'un début de saison des pluies précoce mais ont par la suite connu une situation similaire au reste du pays.

À la première décennie du mois de septembre 2013, les conditions de croissance de la végétation (VCI) ont été défavorables dans les départements de Fatick, Matam, Kaolack, Louga, Fatick, Sédhiou et le nord de Vélingara. Certaines zones ont aussi été classées à risque en attendant les missions de terrain du Groupe de Travail pluridisciplinaire (GTP) qui pourra mieux cibler les zones à visiter avec l'aide du VCI.

Cette situation par endroit défavorable laisse présager une baisse des rendements des cultures et de la production herbacée pour l'alimentation animale si les pluies du mois de septembre ne permettent pas de combler le déficit de croissance de la végétation dans les zones à risque.

SENEGAL - Indice de Condition de la Végétation (VCI) Décennie du 10/2013
 VCI (%)
 0-10
 11-20
 21-30
 41-50
 61-70
 81-90
 91-100
 Moy 100

Figure 1 : Anomalies de croissance de la végétation (VCI) à la première décennie de septembre 2013

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Strengths

- » Advanced TS processing, unique tool for crop monitoring
- » Modular structure
- » Fast computation
- » Automation of complex data processes
- » Automation of outputs on multiple time/space objects
- » Freely available
- » Growing community of practice (website and training)
- » Complete documentation: manual and tutorial

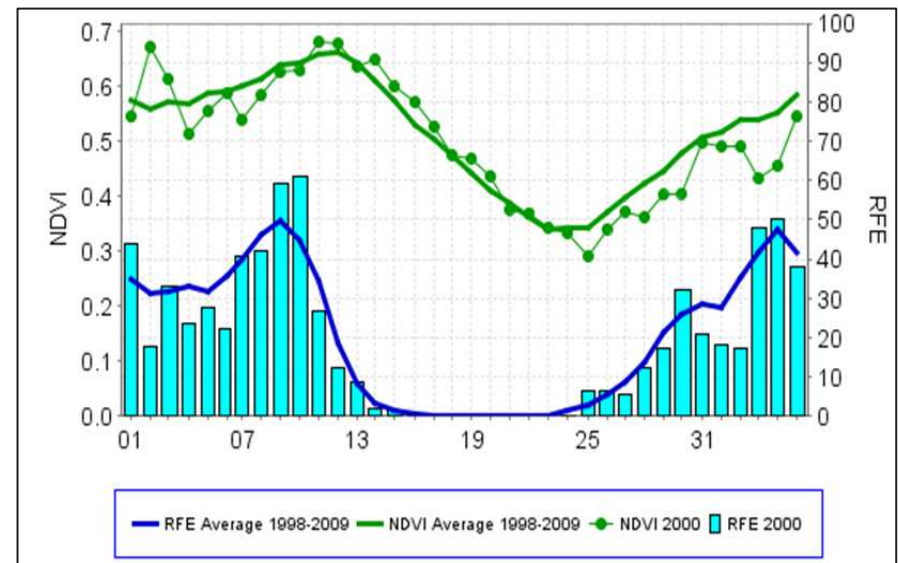


Weaknesses

- » SPIRITS-specific standards
 - » File format (modified ENVI)
 - » Contents of HDR file
 - » File name structure
 - » Flagging of no data values
- » Not open source
- » No real user support service yet
- » Initial steep learning curve

Future activities

- » **Technical developments** planned for 2014
 - » Import/export: HDF5 format
 - » Smoothing: Witthaker smoother
 - » Anomaly indicators: SPI (Standard precipitation index)
 - » Database operations: Standard deviation and Z-scores
 - » Projection: reprojection from other projections to Geographic Lat/Long
- » Finalization of the **website** and **user forum** for better user support
- » **Training workshops** planned in 2014
 - » AGRICAB regional workshops and follow up training workshops
 - » MARS trainings follow up: South Sudan, Kenya, Botswana
 - » Others to be identified, e.g. China



Summary: in a nutshell...



“SPIRITS is a tool that simplifies and speeds up a growing number of time series data processing and analysis steps”

Remote sensing background required and initial training recommended

Powerful and complete solution for working with time series when no programming skills are available

