FAO Training in Crop Yield Forecasting

- Remote Sensing -

Method for Crop Yield Forecasting System (CYFS) from spatial Remote Sensing for **Tajikistan**. Integration of PROBA-V NDVI images.

BELGIUM - Arlon Campus Environment

January 2015

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Foreword

This manual has been written for the "Training for strengthening crop yield forecasting capacity of the State Administration for Hydrometeorology (Hydromet) of Tajikistan" that occurred between 12nd January and 7th February 2015 in Arlon – Belgium in the framework of the Food and Agriculture Organization (FAO) of the United Nations Project (GCP/TAJ/007/EC) "Support to Strengthening the National Food Security Information System in Tajikistan".

This manual is intended to cover the **Remote Sensing** part only of the general Crop Yield Forecasting System (CYFS). Data and software related to this manual are all provided in the training package. Despite written for the **Tajik** context this manual can serve as an example for all other countries.

This manual follows on from the 2 manuals entitled:

- "FAO Training in Crop Yield Forecasting ARMENIA - Erevan – May 2011 – Remote Sensing".
- "FAO Training in Crop Yield Forecasting. Improvement of the Crop Yield Forecasting System (CYFS) in Armenia: a new approach for satellite data integration. ARMENIA - Yerevan - January 2013."

This manual, in addition to adapt the method to Tajik context, integrates for the first time the NDVI images of **PROBA-V satellite**. These images continue the stopped SPOT-VEGETATION time's series, from 2014 to undefined future.

Currently, the efficiency of the explanatory variables produced by the method presented in this manual to predict crop yields of Tajikistan has not been assessed yet. Consequently the user should take an experimental approach of this method.

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Cover images (from the top down): PROBA-V satellite, satellite image of Tajikistan, Tajikistan's mountains and lake, fodder harvesters, cotton growers, cotton bolls, Statue of Ismail Samani (Ismoili Somoni) in Dushanbe.

Table of contents

List of Figures

List of tables

List of abbreviations & definition

AVHRR	Advanced Very High Resolution Radiometer
CMD	Code for Missing Data
CYFS	Crop Yield Forecasting System
EC	European Community
ENP	European Neighbourhood Policy
ESA	European Space Agency
FAO	Food and Agriculture Organization
FAQ	Frequently Asked Questions
GMFS	Global Monitoring for Food Security (project)
GUI	Graphical User Interface
MA10	METOP-AVHRR 10-daily composites
MVC	Maximum Value Compositing (algorithm for image processing)
NDVI	Normalized Difference Vegetation Index
NIR	Near Infra-Red
NOAA	National Oceanic and Atmospheric Administration
PDP	Products Distribution Portal (website for satellite images access)
PPT	PROBA-V ProductCustomization Tool
PROBA-V	PROBA Vegetation
PV	Physical value
ROI	Region Of Interest
RS	Remote Sensing
S10	Synthesis 10 days (refers to decadal synthesis of NDVI images)
SPOT VGT	SPOT VEGETATION
TOC	Top Of Canopy (refers to atmospherically corrected reflectance)
ULg	University of Liège
VAST	Vegetation Analysis in Space and Time (software)
VDR	Valid Data Range

1 Introduction

The ongoing global population growth is leading to food security question. Currently 800 millions of persons worldwide are undernourished.

Given this situation, some international organizations, such as the FAO, are working on the development of early warning systems for food security tools. In this context and with such tools, the University of Liège (ULg) has elaborated its own Crop Yield Forecasting (CYF) methodology. This method aims at forecasting crop yield from meteorological, agrometeorological and Remote Sensed (NDVI) data with different software.*

This method has already been applied in different context, for examples:

- In Senegal for **millet,** sorghum, maize, cowpea and peanuts (Tychon et Rosillon, 2006 et Kouadio, 2007)
- In Burkina **Faso for coton** (Bronne, 2009)
- In Armenia for wheat, potato and grape (2013)

This manual focuses on the **Remote Sensing** (RS) part of the model only. It is divided in **4 chapters**:

I. **Database production for the first time**
First the general CYF methodology is explained and software used are presented. Then the main part of this manual is devoted to the detailed and illustrated description of the application of the method to Tajikistan, i.e. where to find satellite NDVI images and how to process them to produce desired crop yield explanatory variables.

II. **Database updates and modifications**
How to quickly update the database.

III. **Real time crop yield forecasting**
How to make a real time CYF (during the cropping season with an incomplete NDVI images time-series).

IV. **Complementary information for CYFS (optional)**
Some methods are given to produce complementary information that can be used as support to the CYF itself. How to create graphs, stress maps, where to find complementary information, etc.

Data and software presented in this manual are provided in the training package.

* Source : adapted from the manual « Prévision des rendements agricoles Guide d'utilisation, C.E. Bronne, M. Diakité, J. Wellens & B. Tychon, GEEAU project.

The **main updates** compared to the previous manuals (confer Foreword) are:

General:

- New illustrations of the method and concepts for better understanding

NDVI images:

- Use of the NDVI images from the new sensor **PROBA-V** (available since 21st November 2013) in addition and continuity to SPOT VEGETATION NDVI images. No METOP AVHRR NDVI image is used anymore in the proposed CYFS. Access to and process of these new data is presented.
- All satellite images (SPOT-VEGETATION, PROBA-V (and also METOP AVHRR)) have now to be downloaded from a single website: http://www.vito-eodata.be
- The website that previously distributed the SPOT VEGETATION images (http://free.vgt.vito.be/) doesn't exist anymore and is replaced by the website mentioned above.

Software:

- The new version of the software **VGT EXTRACT** has to be used (version 2.1.0) to process the SPOT VEGETATION images from the new website.
- The new software "**PROBA-V ProductCustomization Tool**" (PPT) has to be used to prepare PROBA-V images for TIMESAT.
- Use of **TIMESAT** software, instead of VAST, for the temporal smoothing of NDVI images and the season parameters extraction.
- Some debug solution for TIMESAT in case of installation problem on some computer

2 General methodology of the Crop Yield Forecasting

The basis of the proposed CYF model is simple and consists in studying the **correlation between historical yields of a given crop and selected explanatory variables**. The most correlated variables will then be used as predictive variables for yield of the current year.

These explanatory variables are of 3 types:

- **Meteorological:** cumuli of meteorological parameters (rain, evapotranspiration, solar radiation,…)
- **Agrometeorological:** outputs of AgrometShell software
- Computed from **remote sensed NDVI** : phenological (season) parameters computed by TIMESAT and cumuli of NDVI values on identified phenological periods

The development of this **multivariate model** can be divided in **3 main parts** (Figure 1 and Figure 2):

- The **identification** of quantitative variables correlated with crop yields (Inputs)
- The **production** of explanatory variables
- The **statistical study** of the correlation between the generated explanatory variables and the historical yields.

This manual focuses on the production of the Remote Sensed NDVI derived explanatory variables only.

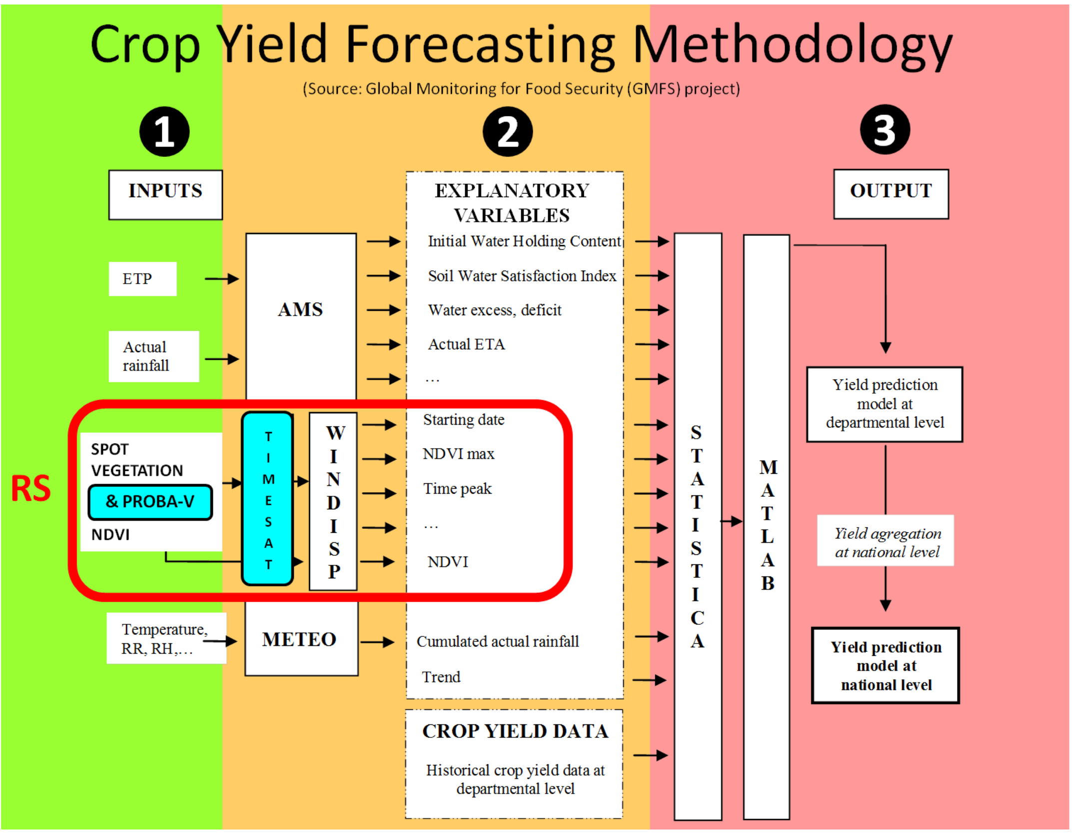


Figure 1 : General methodology of the Crop Yield Forecasting. Surrounded in red: the Remote Sensing part of the methodology. In blue, the main methodology updates.

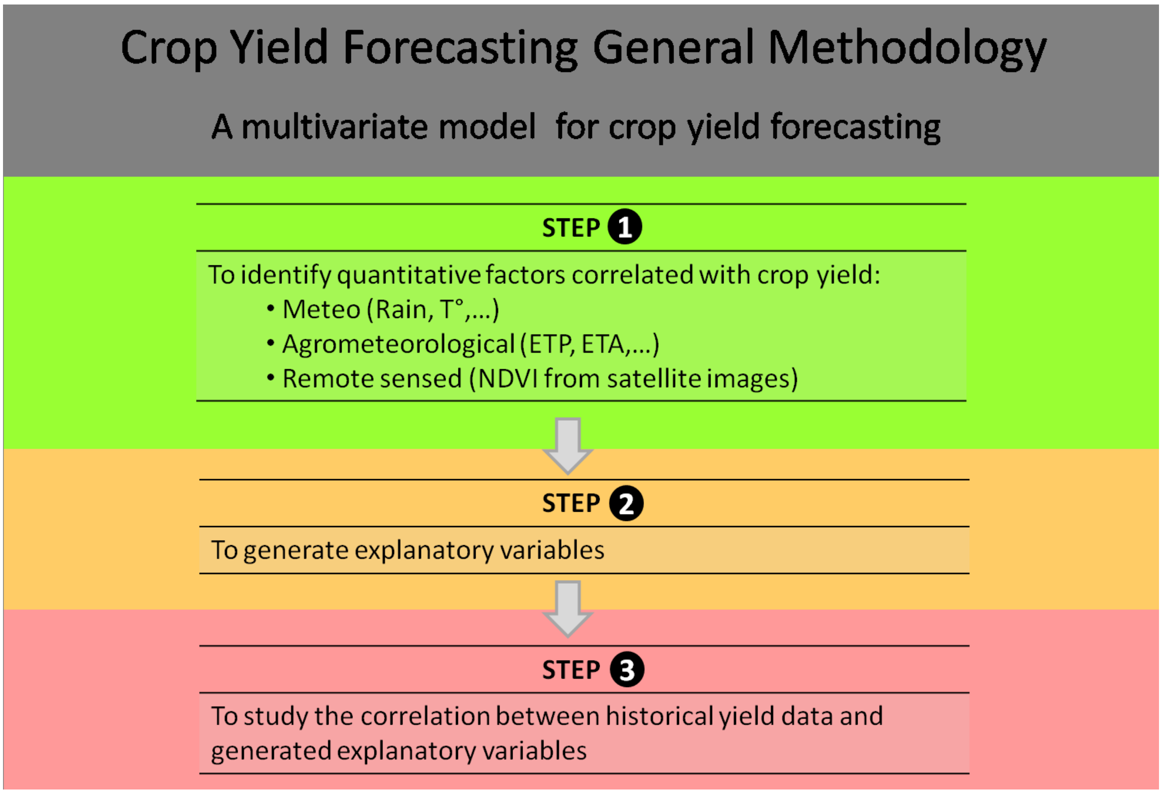


Figure 2: the 3 main steps of the Crop Yield Forecasting Methodology

CHAPTER I. DATABASE PRODUCTION

This first chapter describes **in details the whole process to produce NDVI derived explanatory variables**, from software download to variables verification. Software, NDVI images, and methodology are presented, and each parameter value is justified.

Once the detailed methodology is understood and mastered by the operator, **process automation, by the use of batch files,** has to be envisaged in order to reduce considerably the time used to produce the RS derived database.

Typically, this first chapter will be useful when producing the database for the first time and to understand deeply the methodology.

3 General methodology of the RS part of the CYFS

The general methodology of the RS part of the CYFS can be divided in **5 parts** according to the working environment (purple boxes) of each step, as illustrated at the Figure 3:

1. **Download** of the NDVI images from the **web**
2. **Extraction** of the NDVI images in the desired **format and area** (Tajikistan extent)
    - With **VGT Extract** software for SPOT VEGETATION images
    - With **PPT** for PROBA-V images
3. Temporal **smoothing** of the NDVI images series and **season parameters extraction** with **TIMESAT**
4. Computation of **variables statistics** per provinces, time step (year / decade) and crops with **WinDisp**
5. Computation of additional variables (**cumulated NDVI** per phenological period) with **Excel**

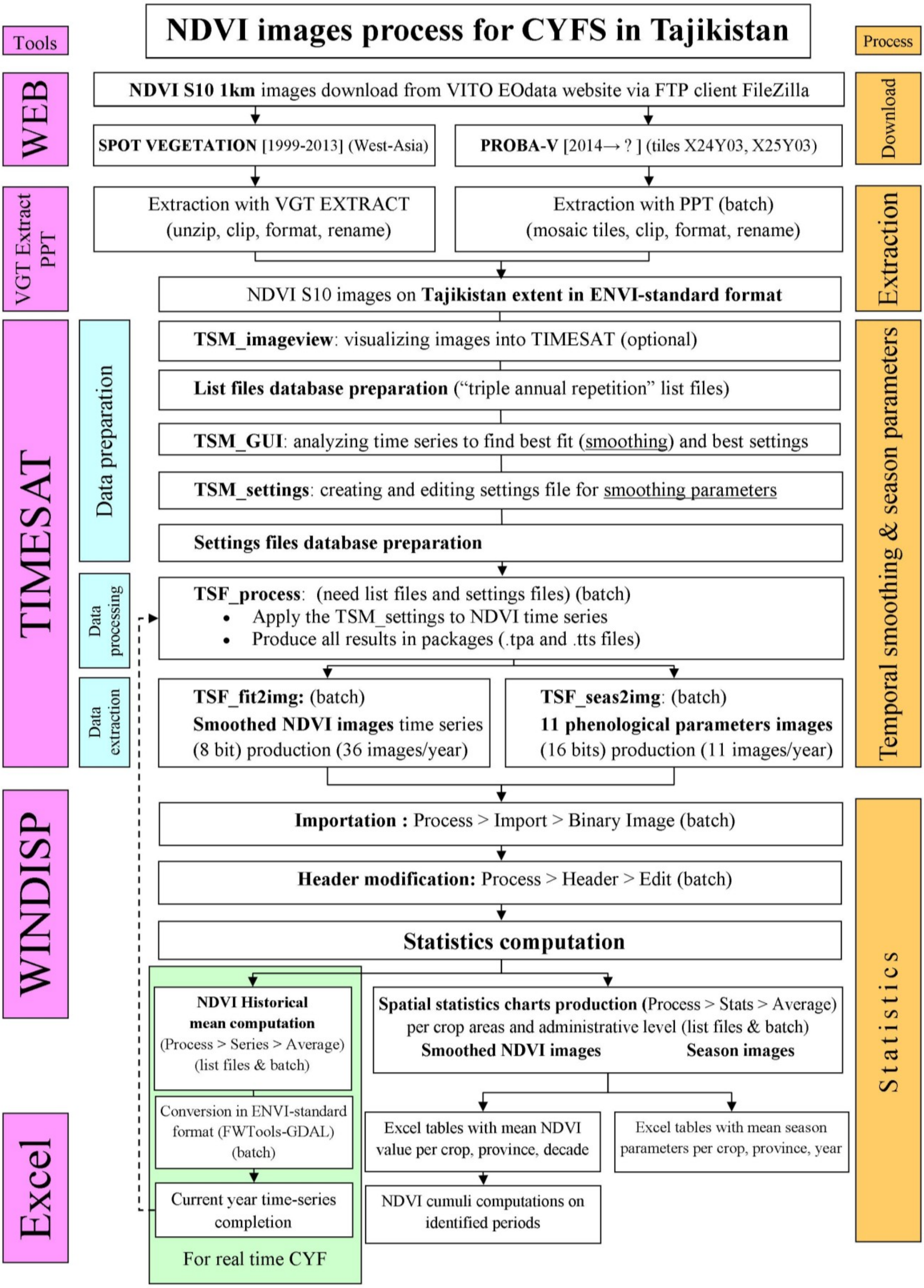


Figure 3: general methodology of the Remote Sensing part of the CYFS

4 Check list for NDVI images process

Below is the **list of all the steps** to follow for the preparation of the remote sensing explanatory variables for the CYF model. Each data production step has to be followed by a careful **data check**.

Ensure to have the correct computer directories organisation on your computer (page 23)

Ensure to have the necessary software (page 26)

- VGT Extract 2.1.0. or newer version
- PROBA-V ProductCustomization Tool" (PPT) 1.2.1 or newer version
- FWTools 2.4.7 that uses GDAL library.
- 7-zip
- TIMESAT 3.1.1.
- WinDisp 5.1
- Microsoft Office Excel
- Notepad++
- QuantumGIS or ArcGIS (optional)

NDVI images preparation (section 8, page34)

- Download all available NDVI images (SPOT VEGETATION and PROBA-V) from internet and stored them in right directory
- Extract NDVI images (extraction = unzip, spatial subset, format conversion) with
    - "**VGT Extract**" software for SPOT VEGETATION NDVI images
    - "**PPT**" software for PROBA-V NDVI images, with the batch file "ProductCustomization_batch.bat."
- Complete the current year image database with the "historical mean" NDVI images (confer page 158). If the "historical mean" NDVI images time-series is not available, you will have to compute it as indicated in the section "Operations for real-time CYF" below, after the complete process has been executed once, and then restart the complete process for the current year.

TIMESAT process (page 69)

- Establish the right **settings** for NDVI smoothing and seasons parameters computation with **TSM_GUI**
- Make **settings files**, 1 per year and sensor (to be used in the "TSF_process")
- Make **list files**, 1 per year and sensor (to be used in the "TSF_process")
- Create and execute **batch files** for
  - "TSF_process": produces the ".tpa" and ".tts" files (approximately 30 minutes per year for Tajikistan)
  - "TSF_fit2img": produces the smoothed NDVI images
  - "TSF_seas2img": produces the season parameter images
- **Delete** useless smoothed NDVI images produced by "TSF_fit2img" process (images of the decades 1 to 36 and 73 to 108 of each year) (with the batch file "...\DATA\NDVI IMAGES\RESULTS\BATCH_DELETE_SUPERFLUOUS_FITTED_IMAGES.bat")

WinDisp process (page 105)

- Ensure to have necessary **boundary files** in ".bna" format for the crop of interest: wheat, potato, cotton,... These files have to respect the recommendations given in section 11.4 at page 136.
- Create **list files**
  - 1 list file per year (17 years in 2015) and sensor, listing all smoothed NDVI images in the year (36 decades in a year)
  - 1 list file per season parameter images (11 season parameters) and sensor, listing images of all years of a given season parameter
- Create and execute **batch files** for:
  - Importing images and modifying image headers
  - Computing spatial statistics

Operations for real-time CYF (page 158)

- Create an "historical mean" SPOT VEGETATION NDVI images time-series (confer page 159) with the batch file "...\DATA\WINDISP DATA\BATCH FILES\MEAN_YEAR_1999_2013_SPOT_VGT.cmd"
- Convert the "historical mean" SPOT VEGETATION NDVI images time-series from "IDA" format to "ENVI-standard" format with the batch file "...\DATA\NDVI IMAGES\WINDISP\MEAN_1999_2013_SPOT_VGT\BATCH_FORMAT_CONVERSION_MEAN_1999_2013_SPOT_VGT.bat"

- Complete the current year image database with the “historical mean” NDVI images (confer page 158).
- Restart the complete process for the current year time-series completed with the “historical mean” time-series

Post processings (optional) (in Excel or programming software) (pages 156 and 163)

- Select right explanatory variables (section 12.2, page 163) (for real time CYF)
- Compute NDVI cumuli on defined periods (phenological periods or others) (page 156)
- Compute additional phenology parameters (section 12.2, page 163)

5 Overview of the variables to compute

NDVI-derived explanatory variables to produce are numerous and of 2 types:

- **NDVI values**, mainly **cumulated NDVI** values on identified periods
- **Season parameters**, related to crop phenology

Here is an overview of the potential number of NDVI-derived explanatory variables to produce in the case of Tajikistan for 2015.

List of parameters defining the number of explanatory variables

- **17 years**. Years: 1999 – 2015 = (1999 is the start of SPOT VEGETATION NDVI images series)
- **36 decades** per year
- **3 Crops**. Currently, crop yield forecast in Tajikistan is done for:
  - Winter wheat
  - Potato
  - Cotton
- **4 Provinces**. Tajikistan is composed of 4 provinces.
- **11 season parameters:** season parameters computed in TIMESAT. However, depending on the forecast date, not all parameters are usable (confer section 12.2, page 163).
- **2 sensors**. SPOT VEGETATION [1999-2013] and PROBA-V [2014-...].

Number of true NDVI variables

The mean NDVI value is computed per year, decade, crop and Province, which totals up:

17 years * 36 decades * 3 crops * 4 provinces = **7 344 NDVI values** distributed into **51 Excel files** (1 Excel file summarize NDVI values for all decades and provinces).

In addition, **cumulated NDVI** variables on identified phenological periods have to be added to this.

Number of season parameters

The 11 season parameters are computed per year, crop and province, which total up:

11 season parameters * 17 years * 3 crops * 4 provinces = **2 244 season values** distributed into **33 Excel files** (1 Excel file summarize season parameters for all years and provinces).

In addition some complementary season parameters can be computed later in programming software as described in section 12.2, page 163).

6 Computer directories organisation

Figure 4 presents the directory organisation for the database of the remote sensing part of the CYFS. It is **recommended to the user to respect this directory organisation** as this manual often refers to particular directory and that the proper functioning of many furnished process (especially the **batch files** and the TIMESAT and WinDisp dependent files) depends on that directory organisation.

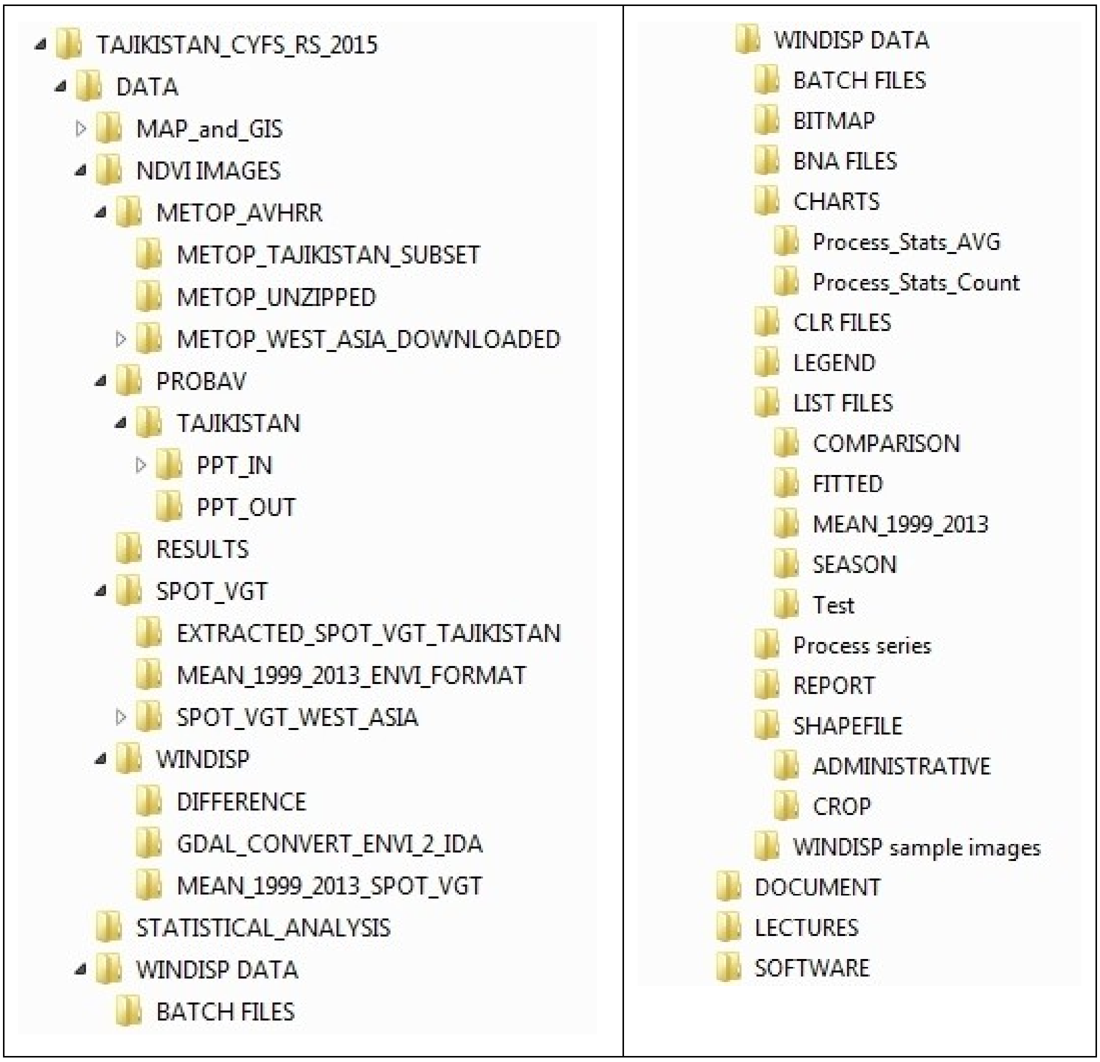


Figure 4: Directory organization for the database of the remote sensing part of the CYFS

The complete directory used when producing the training data was "**D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\ TAJIKISTAN_CYFS_RS_2015\...**". **It is recommended to the user to place the training package "TAJIKISTAN_CYFS_RS_2015" in the same directory**. However, if the user places the training package in another directory, he will have to modify accordingly the files referring to this directory, mainly list files and batch files.

In this manual the **directories will be abbreviated**, omitting the "D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\ TAJIKISTAN_CYFS_RS_2015\..." part that will be replace by "...", e.g. **"...\DATA\NDVI IMAGES\RESULTS\".** (Note that "space" or "blank" in directory names may sometimes lead to some problem on some "unstable" computers when using or building list files or batch files with some programs... in case of problem when working with list and batch files on your computer, you may investigate this potential source of problem.)

All the data mentioned in this manual are available in the training package in the "...\DATA" folder. In particular, the **images** for each processing level are given in the "**NDVI IMAGES**" folder which is described in the Figure 5 below.

"...\DATA\NDVI IMAGES\PROBAV\" contains:

- The PROBA-V images as downloaded from the website http://www.vito-eodata.be/ for the period [2014 – January 2015] for the 2 tiles X24Y03 and X25Y03 (PPT_IN folder)
- The PROBA-V images on TAJIKISTAN extent, in ENVI format (".img" image files with ".hdr" header files), 1 image per decade (2 tiles mosaicked), (extracted with PPT software) (PPT_OUT folder)
- The batch file "ProductCustomization_batch.bat" for the spatial subsetting, mosaicking and format conversion of the PROBA-V images.

"...\DATA\NDVI IMAGES**SPOT_VGT**\" contains:

- The SPOT VEGETATION images on WEST ASIA extent as downloaded from the website http://www.vito-eodata.be/ for 3 sample images (folder "SPOT_VGT_WEST_ASIA")
- The SPOT VEGETATION images for the period [1999 – 2013], on TAJIKISTAN extent, in ENVI format (".img" image files with ".hdr" header files) (extracted with "VGT EXTRACT" software) (folder "EXTRACTED_SPOT_VGT_TAJIKISTAN")
- The "MEAN_1999_2013_ENVI_FORMAT" folder contains the historical mean time-series in ENVI standard format.

"...\DATA\NDVI IMAGES**METOP_AVHRR**\" contains:

- The METOP AVHRR images on WEST ASIA extent as downloaded from the website http://www.vito-eodata.be/ for 3 sample images (folder "METOP_WEST_ASIA_DOWNLOADED")
- The METOP AVHRR sample images, on TAJIKISTAN extent, in ENVI format (".img" image files with ".hdr" header files) (extracted with "7ZIP" and "FWTools" software) (folder "METOP_TAJIKISTAN_SUBSET")

"...\DATA\NDVI IMAGES**RESULTS**\" contains:

- The list files, settings files and batch files necessary for TIMESAT processes.
- The TIMESAT outputs from the 3 processes “TSF_process” (“.tpa” and “.tts” files), “TSF_fit2img” (smoothed NDVI images) and “TSF_seas2img” (season parameters images)

“...\DATA\NDVI IMAGES**WINDISP**\” contains:

- The smoothed NDVI images and season parameter images in correct WinDisp format
- The folder “MEAN_1999_2013_SPOT_VGT” contains the historical mean time-series of SPOT VEGETATION in WinDisp format

Figure 5: Description of the content of the “…\DATA\NDVI IMAGES\” directory

7 Presentation of the main software

5 main specialized software are used in the Remote Sensing part of the CYF system:

- VGT Extract 2.1.0.
- PROBA-V ProductCustomization Tool (PPT) 1.2.1.
- FWTools 2.4.7 that uses GDAL library.
- TIMESAT 3.1.1.
- WinDisp 5.1

All software and user guides are provided in the training package.

7.1 VGT EXTRACT 2.1.0 (for SPOT VEGETATION)

(Source: VGT EXTRACT Software User Guide (VGTExtract_SUG_EN, 2010-12-16))

The primary aim of VGTExtract is to facilitate the integration of SPOT-VEGETATION products (VGT) into commonly used end-user software, such as GIS and Remote Sensing software for further analysis & post-processing, or visualization software. These products are distributed by VITO and its partners under license from CNES and SPOT IMAGE (for basic products like NDVI) […].

VGT products are usually distributed in the form of zipped archives that consist of one or more data files in HDF (4 or 5) file format, […]

VGTExtract can automatically perform the following actions on the zipped archives data files:

- **Unpack** (uncompress) the product
- Extract a given **geographic bounding box** or Region of Interest (ROI);
- Convert to other **file formats**;
- Change **data type** as may be required by the output format;
- Apply a **linear encoding** of the form output = (scale * input) + offset) to all values except one (and only one) special value for missing data.

Availability: VGT Exctract can be downloaded for free from the “Free VEGETATION distribution site” at the following address: http://free.vgt.vito.be/. It is advised to download the following version: “For Windows: VGTExtract version with the Java virtual machine”. The VGT EXTRACT Software User Guide can be downloaded at the following address: http://www.vgt4africa.org/VGTExtract.do.

Installation: once downloaded, the installation of VGT EXTRACT is made by execution of the setup "setupVGTExtract_VM.exe". More information on the installation procedure can be found in the VGT EXTRACT Software User Guide. **Update of VGT EXTRACT** from an old version to the newest version under Windows7 may result in **bug** when using VGT EXTRACT as explained in the "VGT Extract Software User Guide" in section "2.2 Upgrading to a new version". This may be due to the previous settings of VGT EXTRACT that are not suppressed when uninstalling an old version. In that case, to bypass this problem, install VGT Extract in another directory than the one of the previous version (the default directory is "C:\Program Files (x86)"), e.g. "C:\VGTEXTRACT".

7.2 PROBA-V ProductCustomization Tool (PPT) 1.2.1.

(Source: http://www.vito-eodata.be/PDF/image/news/PROBA-V_Product_Customization_Tool.html)

For PROBA-V, a "PROBA-V ProductCustomization Tool" (PPT) is available. The PPT software facilitates the use of PROBA-V products by providing following customization operations:

- File format conversion (ENVI - HDF5 - HDF4 - GEOTIFF)
- Map projections
- Mosaicking
- Band extraction
- Clipping

The PPT software is compiled for use on multiple operating systems (Unix and Windows) and in 32 and 64 bit.

Availability: PPT can be downloaded for free at the following address: http://www.vito-eodata.be/PDF/image/news/PROBA-V_Product_Customization_Tool.html) http://free.vgt.vito.be/ or from the upper right corner of website http://www.vito-eodata.be/ (Figure 6). Download the version compatible with your computer and the release notes.

Figure 6: Access to "PROBA-V ProductCustomization Tool" from http://www.vito-eodata.be/

Once downloaded, you will find the "**UserManual.pdf**" of the PPT in the folder "…\SOFTWARE\PPT\probav_ppt_v1.2.1_windows64\probav_ppt_v1.2.1_windows64\doc\". This manual has the following sections:

- Tool Capabilities
- Tool Installation
- Tool Command-Line Interface
- Tool Graphical User Interface

Installation:

In the PPT user manual, the section "PROBA-V ProductCustomization Tool Installation" will indicate you how to install the PPT.

Here are some explanations to simplify and clarify the one of the user manual:

- Unzip the zip folder "probav_ppt_v1.2.1_windows64.zip" to get the folder "probav_ppt_v1.2.1_windows64"
- Create a "PPT" directory on the C (for example) disc of your computer as: "C:\PPT"
- Copy the "bin, doc, etc, gui, lib" folders of the "probav_ppt_v1.2.1_windows64" folder into "C:\PPT"
- Create and modify **environment variables** of your computer for PPT: follow the instructions on page 17 section 2 ("Installation Instructions for Windows Platforms") of the user manual.

- Don't use command line to set the PATH environment variable but rather do it directly through "Advanced System Settings" panel (i.e. Start – Control Panel – System – Advanced System Settings - environment variables).
- In the "system variable" panel, create a new environment variable called PPT_INSTALL_DIR by clicking the "New" – button. The value of the variable should hold the full path to where the PPT – tool has been installed (e.g. "C:\PPT").
- In the "system variable" panel, edit the "PATH" variable (Figure 7) by selecting the "PATH" (case insensitive) variable in the "Environment Variables" panel, click the "Edit" button and append the following paths to the to the variable values, separated by a ";" character:
  - C:\PPT\bin
  - C:\PPT \lib
- It is **strongly advised to user to update you Java Runtime Environment** (JVE) as indicated in the PPT user manual for the PPT GUI to work properly. Download the JVE appropriated for your computer at the following address: http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html. And install it.

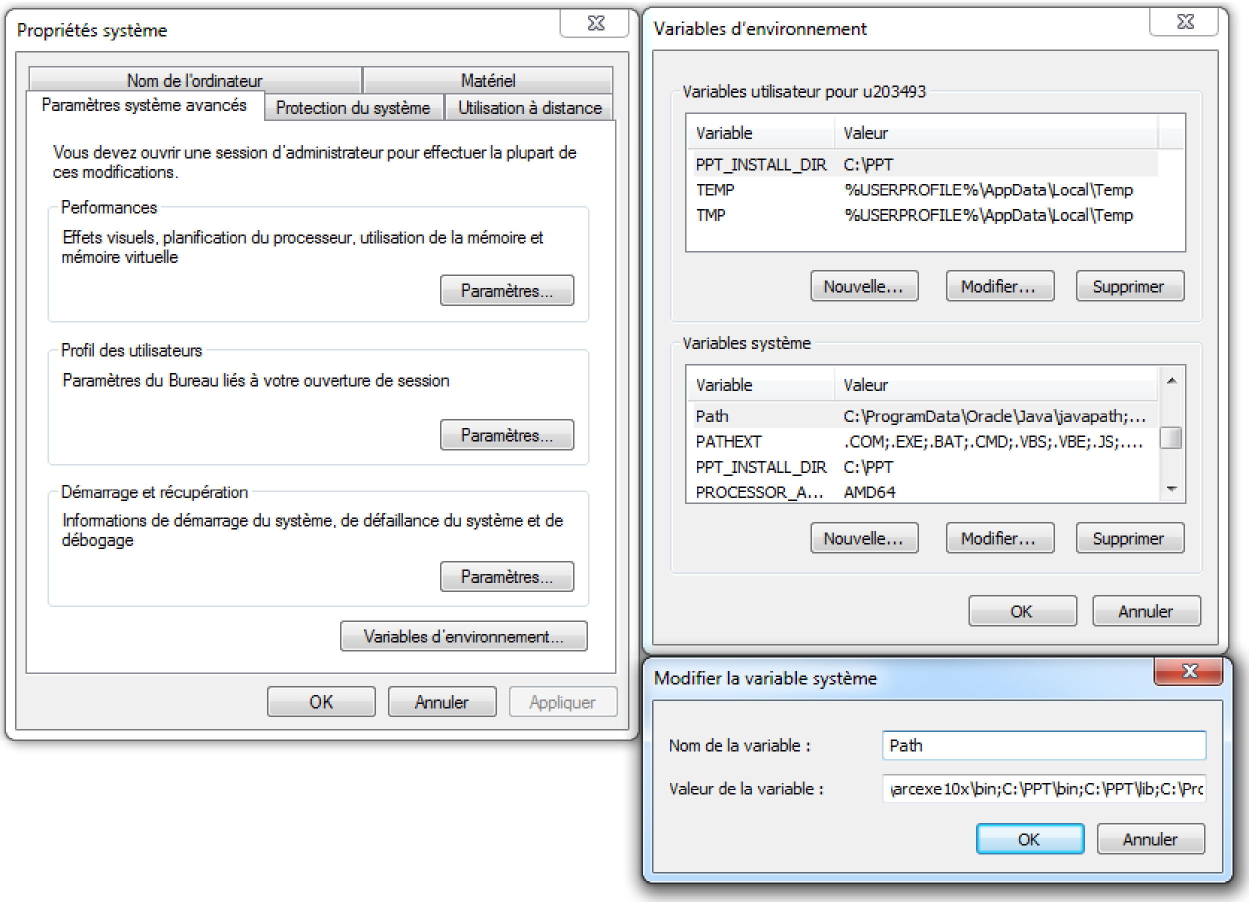


Figure 7: Installation of PPT: editing the "PATH" environment variable

7.3 FWTools 2.4.7 (for METOP AVHRR)

FWTools is a set of Open Source GIS binaries for Windows (win32) and Linux (x86 32bit) systems produced by Frank Warmerdam (ie. FW) (Source: http://fwtools.maptools.org/). It includes, among other, the GDAL library, needed for this methodology. FWTools is used in order to facilitate the call of GDAL library from DOS command line.

GDAL is a **translator library for raster geospatial data formats**. As a library, it presents a single abstract data model to the calling application for all supported formats. (Source: GDAL website http://www.gdal.org/)

In this case, GDAL is used to clip (subset / window) METOP AVHRR NDVI images on Tajikistan extent and to convert images format.

Availability: FWTools can be downloaded for free from http://fwtools.maptools.org/.

Installation and use: confer section 8.5.3.3 at page 56.

7.4 TIMESAT 3.1.1.

(Source: TIMESAT website http://www.nateko.lu.se/timesat/timesat.asp)

TIMESAT is a software package for **analysing time-series of satellite sensor data**, typically time series of NDVI images.

Output from the program is a set of files containing **seasonality parameters** (beginning of season, end of season, amplitude, integrated values, derivatives, etc.), as well as **fitted (temporally smoothed)** function files containing smooth renditions of the original data.

TIMESAT operates in **3 steps**:

- Definition of the number of seasons and their approximate timing
- Fitting of smoothing functions to the data (Savitzky-Golay filter, or least-squares fitted assymetric Gaussian or double logistic smoothing functions).
- Computation of the seasonality parameters

TIMESAT runs from a **graphical user interface**. For large images or long time-series **FORTRAN executables ensure fast processing**. Matlab is the default running environment but is no longer required.

Availability: downloadable for free, for non-commercial academic research (see distribution policy), after registration, at: http://www.nateko.lu.se/timesat/timesat.asp?cat=4. Note that the retrieval of the login that will give you access to the download can take several days. For detailed information confer section 10.1.

Installation: for information on the installation refer to section 10.2 of this manual and to pages 36 and 37 (section 7) of "TIMESAT 3.1 Software Manual" that comes with the download. In this case, unzip TIMESAT zipped folder into "...\SOFTWARE\TIMESAT\" directory.

TIMESAT may sometimes not install properly on some computers. Here are some tips to debug TIMESAT.

- Some installation file of TIMESAT may be blocked by some **antivirus** (AVAST,...) when copying the TIMESAT files to computer or during installation. In this case, deactivate the antivirus temporally while needed (copying and installation of TIMESAT). Don't forget to reactivate it after!
- Be sure to have installed the "**Microsoft Visual C++ 2010 Redistributable Package**" or newer version, version adapted to your computer. This is available through Google search. This should normally be installed when installing the TIMESAT "MCRinstaller.exe"
- A problem that can arise with TIMESAT installation is the following. The "MCRInstaller.exe" installation can install successfully, but when launching "TIMESAT.exe", nothing happen except a DOS window that opens and closes quickly. When launching the "TIMESAT.exe" through command lines interface, the following error message appears: "**Could not access the MCR component cache**" (Figure 8).

Figure 8: TIMESAT error

This indicates a problem with the "MCR component cache", which is a folder that is created when installing "MCRInstaller.exe" and launching "TIMESAT.exe". For unknown reason this "MCR component cache" seems to be corrupted.

This "MCR component cache" is located in a directory like: "C:\Users\username\AppData\Local\Temp\username\ mcrCache7.14".

A solution to this problem can be:

- Go to the directory "C:\Users\username\AppData\Local\Temp\username\ mcrCache7.14".

- Simply give a new name to the “mcrCache7.14” folder like “old_mcrCache7.14”
- Launch “TIMESAT.exe” by clicking on it (in the folder “...\SOFTWARE\TIMESAT\timesat311_standalone_windows32\timesat311\compiled\Win32”)
- This will recreate automatically the good “mcrCache7.14” folder in the directory “C:\Users\username\AppData\Local\Temp\username\ mcrCache7.14”.
- TIMESAT should now open normally.

7.5 WinDisp 5.1

WinDisp is a public domain, easy to use software package for the d**isplay and analysis of satellite images, maps and associated databases**, with an emphasis on early warning for food security. WinDisp was originally developed for the FAO Global Information and Early Warning System. It allows users to:

- **Display and analyse** satellite images
- Compare two images and analyse trends in a **time-series** of images
- Extract and **graph** trends from a number of satellite images such as during the growing season for comparison with other years
- Compute new images from a series of images
- Display tabular data in map format
- Build custom products combining images, maps and specialised legends
- Write and execute **batch** files to automate routine and tedious tasks
- Build a customized project interface for providing users with detailed menus of available data for a country or a specific area

Availability: **WinDisp** can be downloaded for free at the following address: http://www.fao.org/giews/english/windisp/windisp.htm.

Installation: once downloaded, the installation of WinDisp is made by execution of the setup “windisp51_setup.exe “. More information on the installation procedure can be found in the WinDisp Software User Guide.

Important remarques

1. Note that this manual don't describe thoroughly all the software used but rather presents only the functions of the software that are of interest for the training in crop yield forecasting.

   For more information on the software, refer to the user guides provided with them.

2. Before manipulating data (especially in WinDisp) beware of having proper computer settings. **For proper use (at least with WinDisp) the decimal separator of the computer has to be the point and not the coma!**

8 NDVI images: database creation

8.1 NDVI concept and NDVI images

NDVI stands for **Normalized Difference Vegetation Index**. It is a spectral index particularly appropriate for the study of vegetation. It combines radiation in the Red and Near Infra Red (NIR) spectral region (Figure 9) according to the following formula:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Where:

- NIR is the Near Infra Red spectral region: 0,79 - 0,89 µm
- RED is the Red spectral region: 0,61 - 0,68 µm

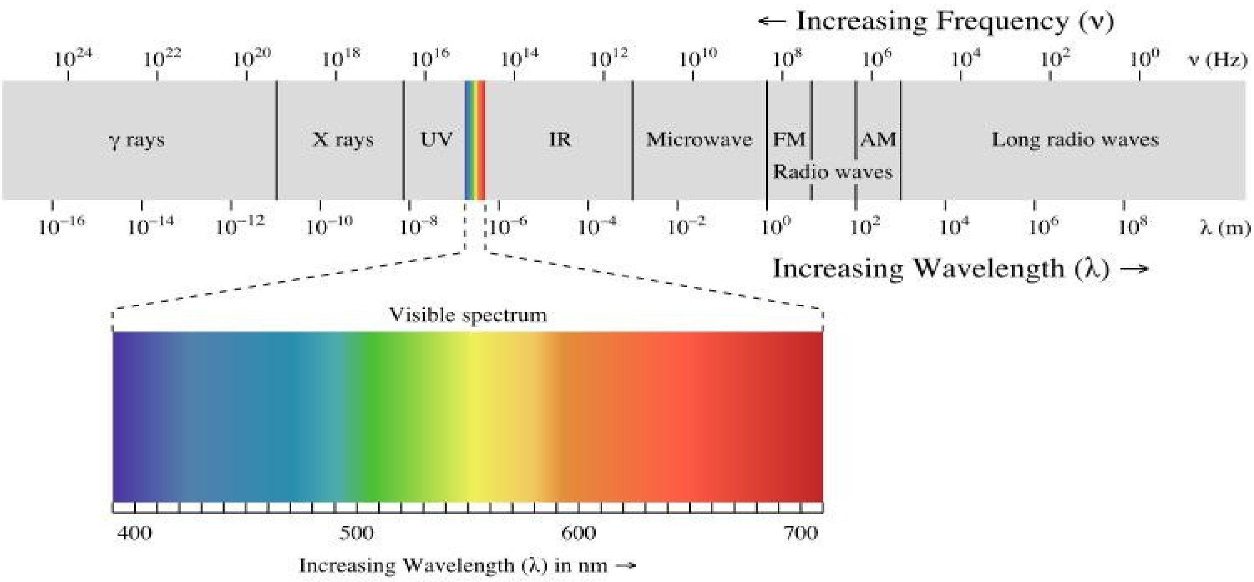


Figure 9: electromagnetic spectrum and spectral region

Generally (Figure 10)

- Dense vegetation in good phytosanitary condition will absorb a lot the electromagnetic spectrum in the RED spectral region. This results in a **HIGH NDVI** value.
- Sparse vegetation and/or in bad phytosanitary condition will not absorb a lot the electromagnetic spectrum in the RED spectral region. This results in **LOW NDVI** value.

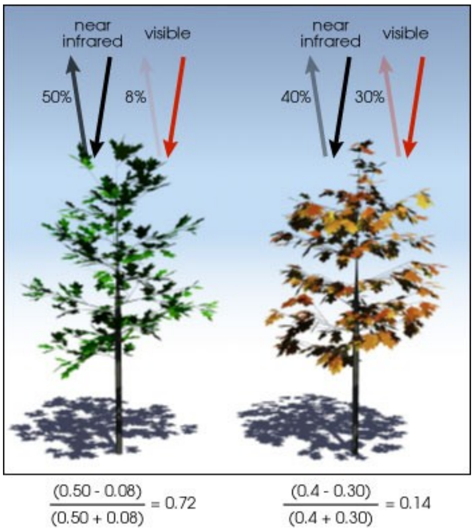


Figure 10: reflection of the NIR and visible part of the electromagnetic spectrum by green-healthy and brown-sick plants.

RED and NIR radiation information are collected everyday all over the world thanks to a series of sensors disposed on satellites. This spectral information is then used to compute NDVI images (Figure 1 and Figure 16) which are then distributed through internet. This index is then used for the assessment of the vegetation status all over the world. Well-known examples of NDVI application are:

- The monitoring of crops evolution during the cropping season
- The monitoring of the green vegetation evolution in the Sahel region

8.2 NDVI images encoding

In NDVI satellite images, NDVI values, i.e. the Physical Value (PV) of the NDVI indicator, vary between [0-1] and are associated to the image pixels under the form of a numeric value often called "Digital Number" (DN). The value of the DN is often proportional to the NDVI through a linear mathematic relation of type "PV(NDVI) = SCALE * DN + OFFSET" where the "SCALE" parameter is the slope of the straight line linking NDVI and DN, and the "OFFSET" is the intercept of this line with the NDVI axis when DN is equal to 0 (Figure 11). In an image coded with 8 bit, there are 2^8 i.e. 256 possible values for each pixel, comprised in the interval [0-255].

PV(NDVI)	SCALE or SLOPE	DN	OFFSET or INTERCEPT
-0.08	0.004	0	-0.08
0	0.004	20	-0.08
0.1	0.004	45	-0.08
0.2	0.004	70	-0.08
0.3	0.004	95	-0.08
0.4	0.004	120	-0.08
0.5	0.004	145	-0.08
0.6	0.004	170	-0.08
0.7	0.004	195	-0.08
0.8	0.004	220	-0.08
0.9	0.004	245	-0.08
0.94	0.004	255	-0.08
1	0.004	270	-0.08

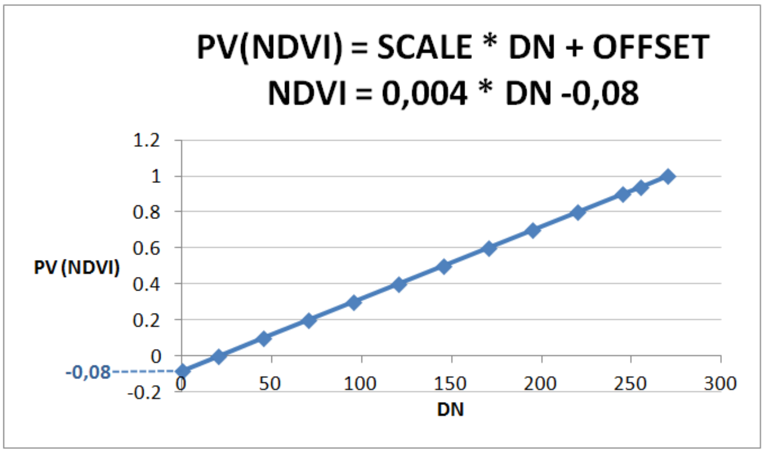


Figure 11: Relation between NDVI and DN for PROBA-V

8.3 SPOT VEGETATION, METOP AVHRR and PROBA-V sensors and NDVI images presentation and comparison

The method presented in this manual proposes to use only NDVI products coming from 2 sensors:

- **SPOT VEGETATION** for the period [1999 - 2013]
- **PROBA-V** for the period [2014 - ...]

Nevertheless another sensor produces very similar NDVI products:

- **METOP AVHRR** for the period [2008 - ...]

So, in addition to describe the method for SPOT VEGETATION and PROBA-V, this manual will also, most of the time, for information, describe it for METOP AVHRR NDVI products. It is advised to the user to focus on SPOT VEGETATION and PROBA-V only.

Figure 12 presents an artist's impression of these 3 satellites and Figure 13 their timeline.

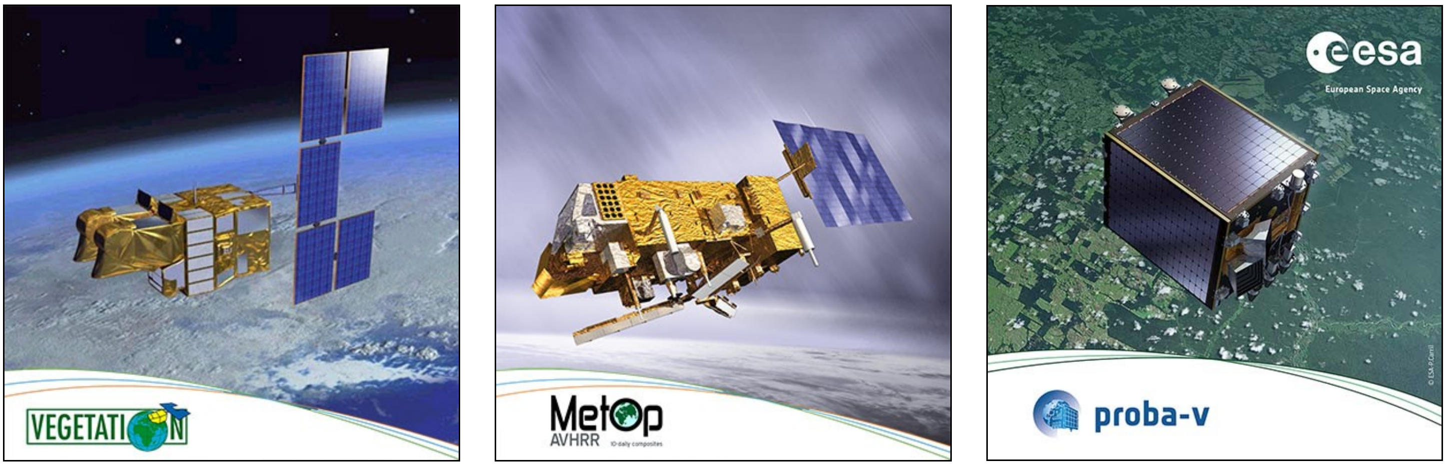


Figure 12: Artist's impression of the 3 satellites SPOT VEGETATION, METOP AVHRR and PROBA-V

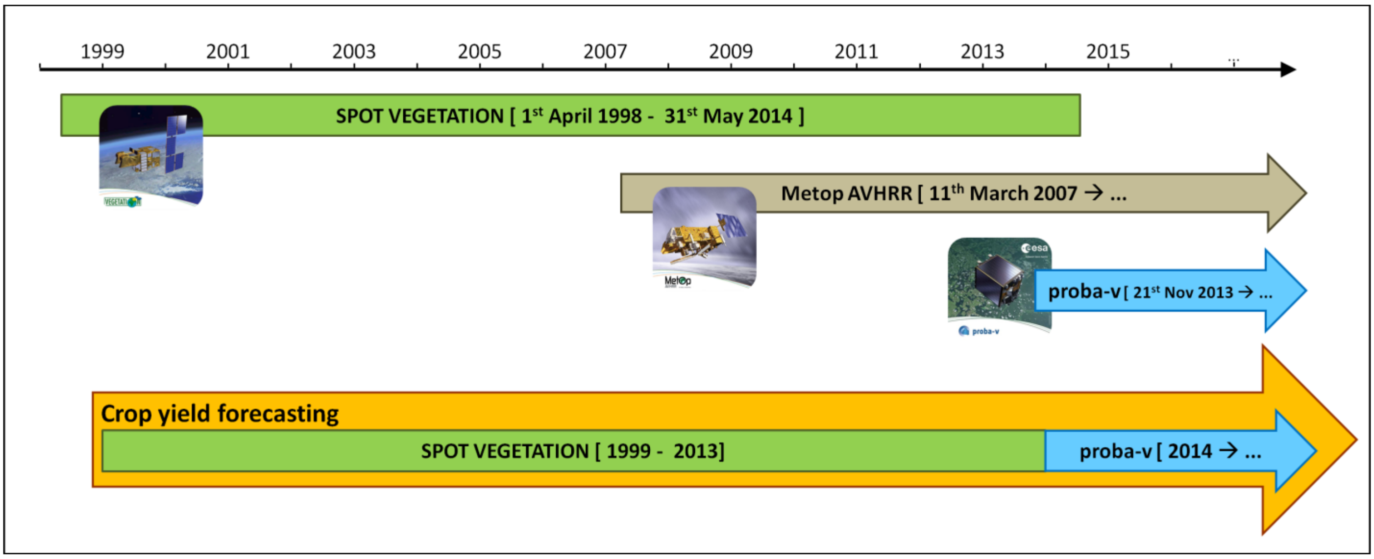


Figure 13: Timeline of three sensors SPOT VEGETATION, Metop AVHRR and PROBA-V and their use in the CYFS.

SPOT VEGETATION, METOP AVHRR and PROBA-V NDVI images are really similar on a technical point of view, which **should** allow using METOP AVHRR and PROBA-V images in the continuity of the SPOT VEGETATION series that provided its last complete year of images in end of 2013. For more information on the compatibility of these 3 sensor's series, confer section 11.3.3.2** Explanation of "Slope" and "Intercept" parameters values., page 126.

Note also that other NDVI products coming from other sensors exist. The most widely distributed is probably the one coming from the Advanced Very High Resolution Radiometer (AVHRR) sensor on the National Oceanic and Atmospheric Administration (NOAA) satellite (http://phenology.cr.usgs.gov/ndvi_avhrr.php).

Table 1 presents a comparison on the main technical features of these 3 sensor's images when downloaded from PDP. Examples of NDVI S10 images for West-Asia and Tajikistan extents are given in Figure 15 and Figure 16 respectively.

Satellite common name	**SPOT VEGETATION**	**Metop AVHRR**	**PROBA-V**
Satellite platform	SPOT 4 SPOT 5	Metop	PROBA-1
Instrument sensor	VEGETATION 1 VEGETATION 2	AVHRR	VEGETATION
Spectral bands	BLUE, **RED, NIR,** SWIR	**RED, NIR**, SWIR, TIR1, TIR2	BLUE, **RED, NIR**, SWIR
Spatial resolution	1 km	1 km	1 Km
Temporal resolution	1 day	1 day	1 day
Decadal synthesis process	MVC*	MVC*	MVC*
Number of S10 images per year	36	36	36
Period of availability	1st April 1998 to 31st May 2014	11th March 2007 to...	21st November 2013 to...

Years of complete availability in early 2015	15 years [1999 – 2013]	7 years [2008 – 2022]	1 year [2014 – ...]
Number of useful images for the period [1/1/1999 – 31/12/2014]	540	252	36
Size of 1 NDVI product at download extent	~21 Mo	~40 Mo	~1.36 Mo for the 2 tiles
Size of 1 NDVI product on Tajikistan extent	437 Ko	437 Ko	437 Ko
Size of useful images time series for the period [1/1/1999 – 31/12/2014] (NDVI products) at download extent	~12 GO (West-Asia extent)	~10 GO (West-Asia extent)	~ 50 Mo (for the 2 tiles)
Size of useful images time series for the period [1/1/1999 – 31/12/2014] (NDVi products) on Tajikistan extent	234 Mo	110 Mo	16 Mo
Real time acquisition?	Time series finished	Yes	Yes
Real time access? **	/	Yes**	Yes
Real time price?	/	Free	Free
Delivery package	ZIP folder	ZIP folder	Simple folder
Data type	8-bit unsigned integer	8-bit unsigned byte	8-bit unsigned integer
Image format	HDF (.HDF)	flat binary*** (.IMG)	HDF5 (.HDF5)
Download extent	West-Asia	West-Asia	Tiles X24Y03, X25Y03
Download extent coordinates (North, South, West, East) (Degree)	50, 5, 25, 98 Coordinates of the centre of the edge pixels	50, 5, 25, 98	45, 35, 60, 80 (Edges of the 2 tiles)
N° of rows	5041****	5040	1120 for each tile
N° of columns	8177****	8176	1120 for each tile
Pixel spatial resolution (degree)	0.0089285714 = 1°/112 = ± **1 km** along the great circle	0.0089285714	0.0089285714
Valid data range: **Valid DN range** **Flags value(s)** **Flag for aberrant states** (Sea, NoData, NoValidData, Error)	[1-255] 0 /	[0-250] [251-254] 255	[0-254] 255
Formula linking DN and NDVI	**NDVI = - 0.1 + 0.004 * DN**	**NDVI = - 0.08 + 0.004 * DN**	**NDVI = - 0.08 + 0.004 * DN**
Coordinate system	Geographic latitude longitude	Geographic latitude longitude	Geographic latitude longitude
Cost	**Free**	**Free**	**Free**

Table 1 : SPOT VEGETATION, METOP AVHRR and PROBA-V NDVI images features for the downloaded images extent used for Tajikistan

*** Maximum Value Compositing**

MVC stands for "**Maximum Value Compositing**". This is the name of the algorithm that is used for the production of the 10 days NDVI synthesis from daily NDVI images. This process merge segments (data strips) acquired in a ten days period. All the segments of this period are compared again pixel by pixel to pick out the 'best' ground reflectance values. The "best" reflectance is computed by the MVC process which consists in retaining the highest reflectance.

**** Near-real time acquisition**

To get near-real time METOP AVHRR images, send an e-mail to the Metop helpdesk as indicated on the METOP website http://www.metops10.vito.be/metop-S10_pages/main.html#distribution.

***** "Flat binary" format**

The **images** are distributed in "**flat binary" format without header**/trailer bytes. "Flat" means that each layer of a certain composite is stored in a separate image file. These files have the fixed extension ***.IMG**. All layers have the **byte data type (1 pixel = 1 byte).**

Associated to each image file is a small **ASCII-formatted annotation file ("header file"**, which has the same base name as the image but extension ***.HDR**. It provides all the basic ancillary information to import the imagery directly into the **ENVI** software. When having the image and its header file in a same directory, the image can be opened easily in ENVI software.

Figure 14 is an example of the header file of the NDVI image of West Asia window extracted from the MA10 of the second decade of December 2008. The sequence "1.5, 1.5, 25.0, 50.0" in "map info" specifies that the centre of the top-left pixel (Col=1.5, Rec=1.5) is located at the geographical position with Lon=25°, Lat=50°.

```
ENVI
description = {METOP-AVHRR, 10-daily synthesis, 20081211-20081220, NDVI, processing by VITO-Belgium }
samples = 8176
lines = 5040
bands = 1
interleave = BSQ
file type = ENVI Standard
data type = 1
sensor type = METOP-AVHRR
map info = { Geographic Lat/Lon, 1.5, 1.5, 25.0, 50.0,  0.0089285714,  0.0089285714, WGS-84, units=Degrees }
```

Figure 14: METOP AVHRR NDVI WEST ASIA image header file content

****** Image size**

SPOT VEGETATION images are 1 pixel bigger than METOP AVHRR images on WEST-ASIA extent in longitude and latitude. SPOT VEGETATION images extend one column further to the East and one line further to the South compared to METOP AVHRR images.

8.3.1 NDVI products online resources

8.3.1.1 SPOT VEGETATION online resources

Main website	http://www.spot-vegetation.com/index.html
FAQ	http://www.spot-vegetation.com/faqnew/index.html
Product metadata	http://www.vito-eodata.be/collections/srv/eng/main.home?uuid=0ce4e2fe-183f-4c04-928c-e1f770fa5b34

8.3.1.2 METOP AVHRR online ressources

Main website	http://www.metops10.vito.be/index.html
FAQ	http://www.metops10.vito.be/metop-S10_pages/FAQ.html
Product metadata	http://www.vito-eodata.be/collections/srv/eng/main.home?any=95c6d610-ba36-11de-8a39-0800200c9a66

8.3.1.3 PROBA-V online ressources

Main website	http://proba-v.vgt.vito.be/
FAQ	http://www.vito-eodata.be/PDF/image/faq_help/Faq.html
Product metadata	http://www.vito-eodata.be/collections/srv/eng/main.home?uuid=2dc3d0e3-a731-11e2-9e96-0800200c9a66
User manual	http://www.vito-eodata.be/PDF/image/PROBAV-Products_User_Manual_v1.1.pdf
PROBA-V on ESA website	https://earth.esa.int/web/guest/data-access/browse-data-products/-/asset_publisher/y8Qb/content/proba-v-1km-synthesis-products-s1-toa-s1-toc-and-s10-toc https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/proba-v

Figure 15 and Figure 16 present SPOT VEGETATION NDVI S10 image for West-Asia and Tajikistan extent respectively (1st decade of May 1999).

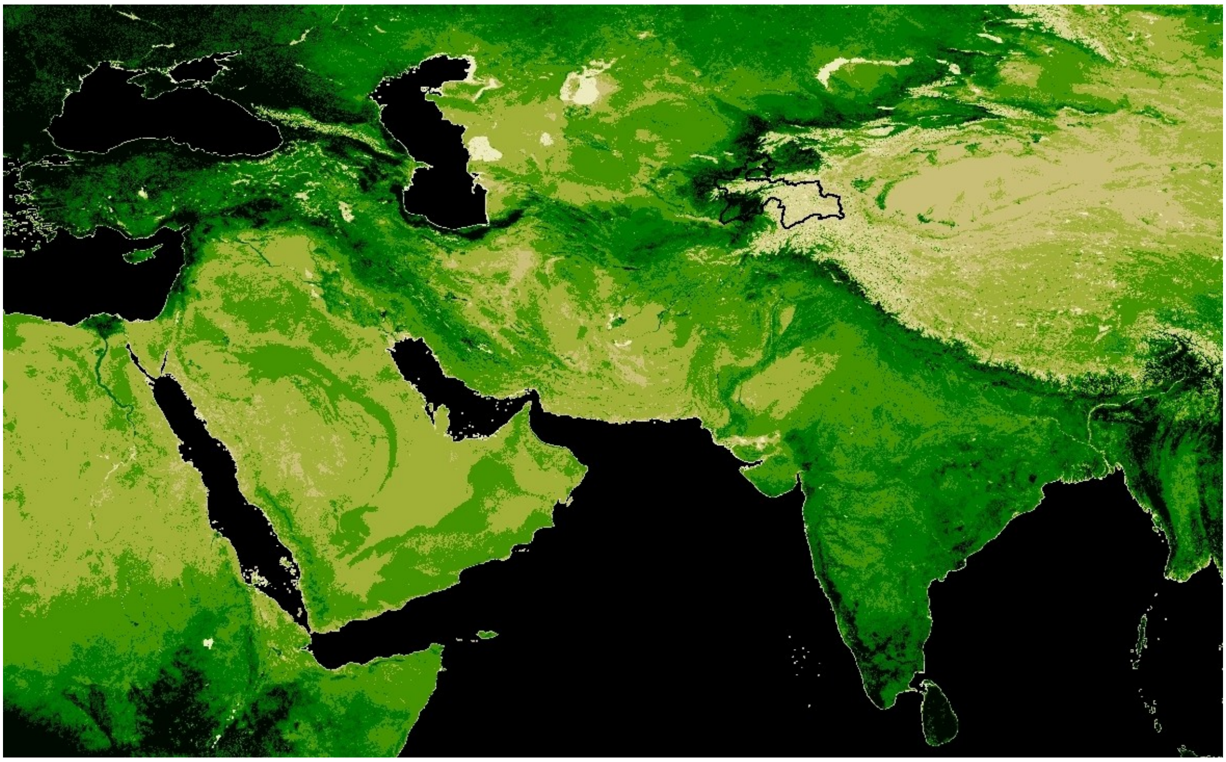


Figure 15: SPOT VEGETATION NDVI S10 image for West-Asia (1st decade of May 1999). Tajikistan boundaries appear in black.

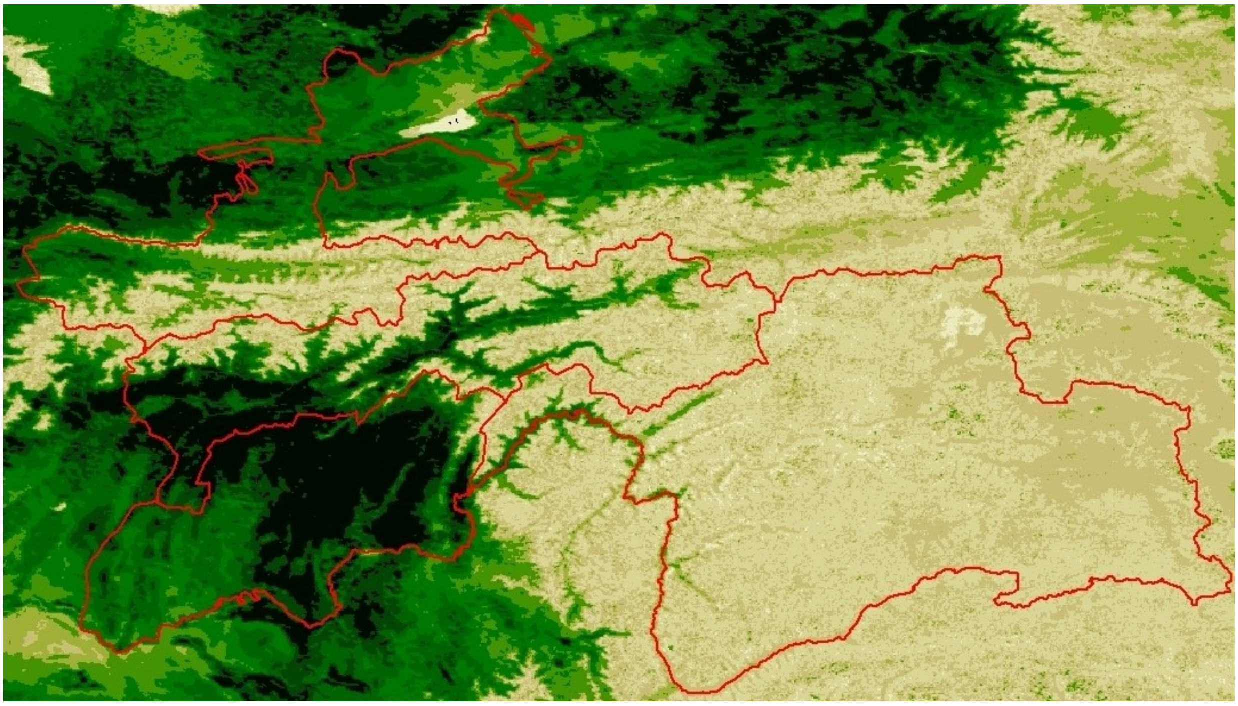


Figure 16 : SPOT VEGETATION NDVI S10 image for TAJIKISTAN (1st decade of May 1999). Tajikistan provinces boundaries appear in red.

8.4 NDVI images access and download

The S10 NDVI images for SPOT VEGETATION, METOP AVHRR and PROBA-V can all be downloaded for free on the VITO "Product Distribution Portal" (PDP) web page: http://www.vito-eodata.be/ (Figure 17). Some images have already been downloaded and are available in the training package under the directory "...\DATA\NDVI IMAGES\".

8.4.1 Registration and login for the PDP

To be able to download the different products, you have to "register" and then "login" with the menus in the upper right corner of the PDP web page (arrow 1 in Figure 17).

Figure 17: Home page of the Product Distribution Portal http://www.vito-eodata.be/ with the SPOT VEGETATION, METOP AVHRR and PROBA-V products of interest highlighted

1. **Register:**
    - Click on the "register" button.
    - Complete the form (Figure 18) and write somewhere your login and password.
    - Accept the terms of use and privacy policy.
    - Click on register.

- You should soon receive an email. Go to your email box and click on the activation link in the email you received.

2. **Login:**
   - Once activation is done, go back to the PDP.
   - Login (arrow 1 in Figure 17) with your user name and password.
   - Once your are "login", there will be the message "Welcome First name Last name" appearing in the upper right corner of the (PDP)

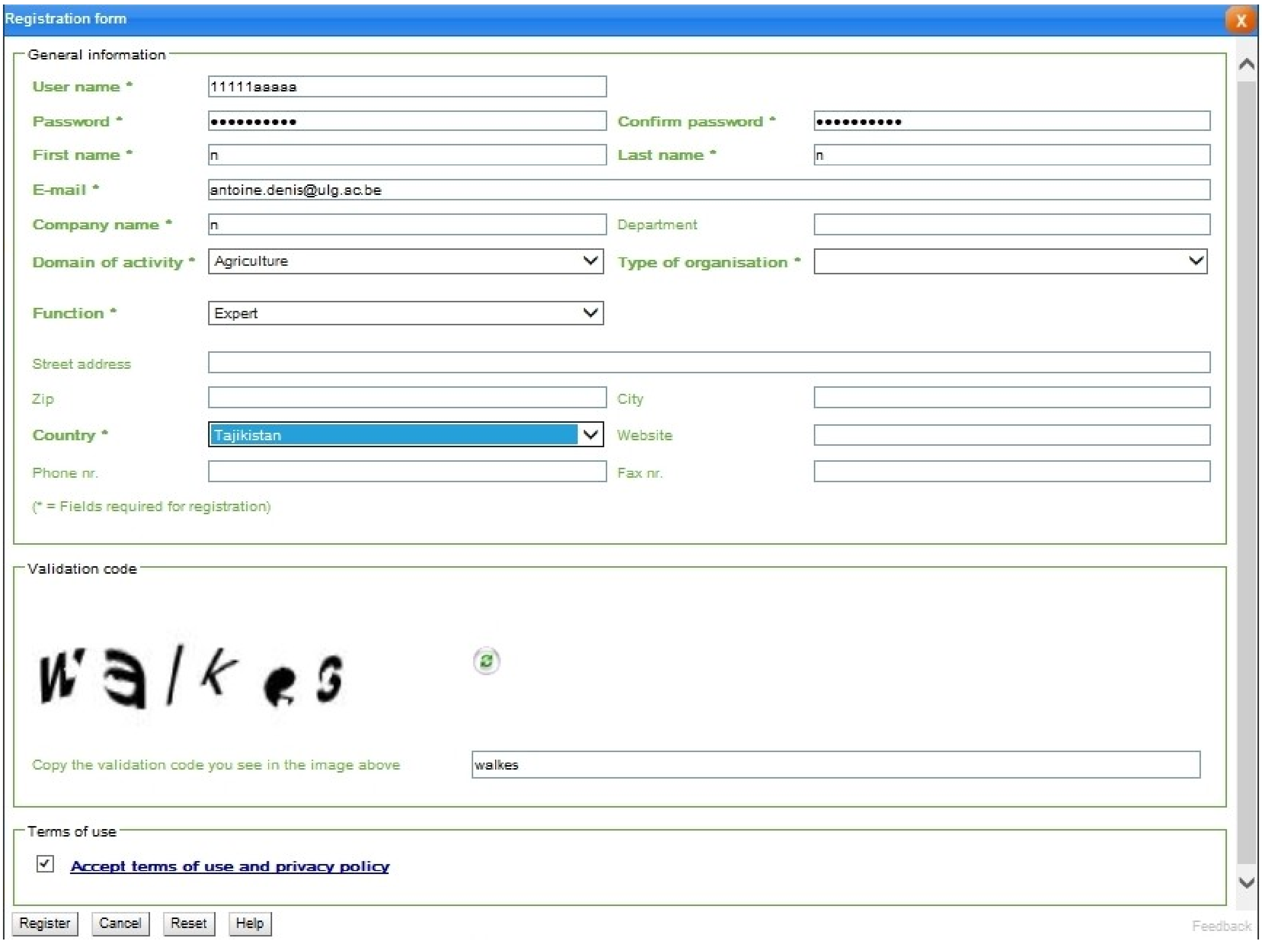


Figure 18: Registration form of the Product Distribution Portal http://www.vito-eodata.be/

A video explaining how to order and download images from the PDP is available in the upper right part of the PDP home page by clicking on link "View the PDF instruction movie" http://www.vito-eodata.be/PDF/image/movie/pdf_instruction_movie.html. Note that there have been some changes in the PDP since the video was made.

8.4.2 Supplementary registration for PROBA-V NDVI

VITO distributes the PROBA-V S10 TOC NDVI collection on behalf of ESA. Therefore you will need to apply for this data by a supplementary registration on Earthnet online https://earth.esa.int/web/guest/home.

A manual **explaining "How to register for the PROBA-V 1km data?"** is available here: http://www.vito-eodata.be/PDF/image/faq_help/Manual_PROBA-V1km_data.pdf.

To have access to this new registration, follow the indications in the manual mentioned above or go directly to https://eo-sso-idp.eo.esa.int/idp/AuthnEngine and then follow the instructions of the manual.

In the subscription process to ESA you will need to give a project summary. You can use this (for the case of Tajikistan):

> ***Project:*** *EU/FAO project "Support to Strengthening of the National Food Security Information System". GCP/TAJ/007/EC PROJECT.*
> ***Funding:*** *EU FAO*
> ***Objectives:*** *This project has been designed to strengthen the information system in Tajikistan. More specifically, the project will focus on ensuring that decision makers have access to the quality information required for designing, implementing and monitoring agricultural interventions to reduce poverty and malnutrition. In this respect, improving agro-meteorological information and crop forecasting is very important.*
> *PROBA V NDVI S10 images want to be used in a crop yield forecasting system in continuation of SPOT VEGETATION NDVI S10 images.*
> ***Method:*** *crop yield are forecasted by models using NDVI, meteo and agrometeo data, at regional scale, during the cropping season.*
> ***Deliverable:*** *no deliverable is foreseen for the time. The data will be used for the training only.*

After the subscription to ESA is complete, you should receive an email from "ESA Earth Observation Helpdesk" that informs you that you can now access to PROBA-V data.

After you got the authorization from ESA, you should be able to download the PROBA-V images from the PDP (Figure 17) **Erreur ! Référence de lien hypertexte non valide.**by the process described below.

8.4.3 Summary of NDVI products download

Figure 19 present the summary of information on format, size, extent and processing tool for SPOT-VGT, METOP AVHRR and PROBA-V NDVI products after download, for Tajikistan.

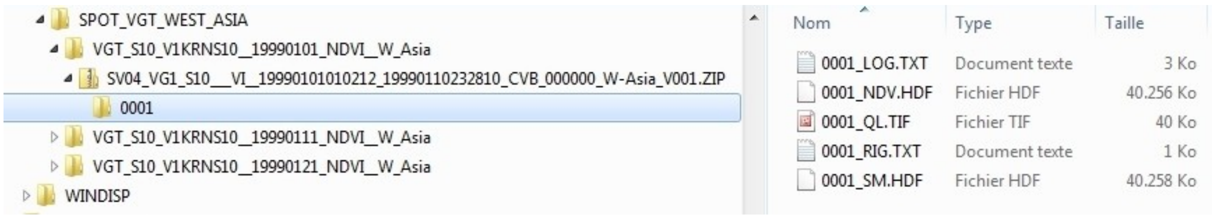
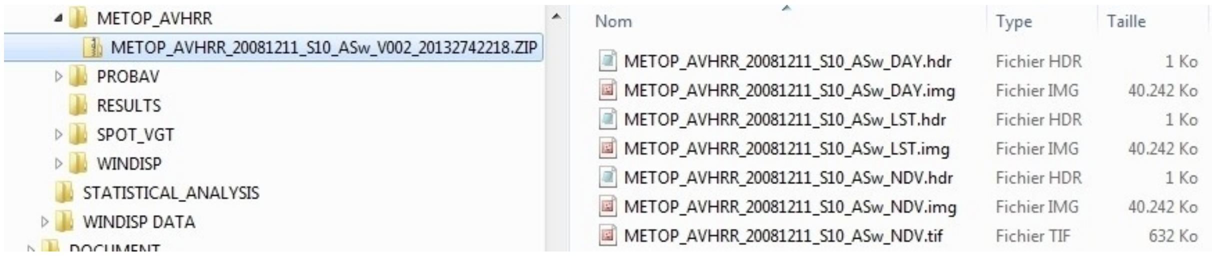
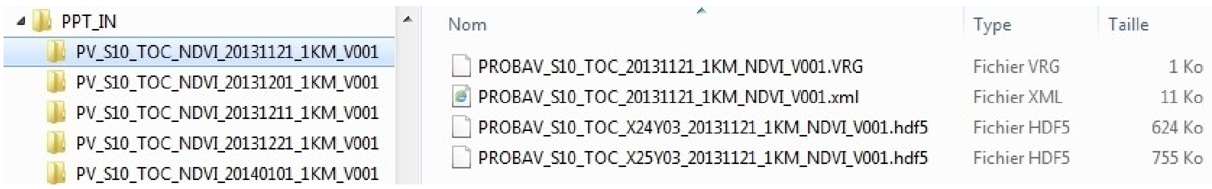
<table>
<tr><th></th><th>Package</th><th>Format</th><th>Size (NDVI product)</th><th>Extent</th><th>Processing tool</th></tr>
<tr><td rowspan="2">SPOT-VGT</td><td colspan="5">
</td></tr>
<tr><td>ZIP folder</td><td>.HDF</td><td>21 Mo</td><td>West Asia</td><td>VGT EXTRACT</td></tr>
<tr><td rowspan="2">METOP AVHRR</td><td colspan="5">
</td></tr>
<tr><td>ZIP folder*</td><td>.IMG</td><td>40 Mo</td><td>West Asia</td><td>7-ZIP and FWTools (GDAL library)</td></tr>
<tr><td rowspan="2">PROBA-V</td><td colspan="5">
</td></tr>
<tr><td>Simple folder</td><td>.HDF5</td><td>1.4 Mo</td><td>2 tiles X24Y03, X25Y03</td><td>PPT</td></tr>
</table>

Figure 19: Summary of format, size, extent and processing tool for SPOT-VGT, METOP AVHRR and PROBA-V NDVI products after download for Tajikistan

*** METOP AVHRR ZIP folder**

Each METOP AVHRR ZIP folder contains 26 files among which only the ones with the extension **"…NDV.img"** and **"….NDV.hdr"** are of interest for this application. These are the NDVI images on West-Asia extent and its header file in "ENVI" format.

8.4.4 NDVI images access, order and download

Once registered and login on the http://www.vito-eodata.be/ website, to access, order and download the images, the process is similar for the 3 NDVI products (SPOT VEGETATION, (METOP AVHRR) or PROBA-V) with however some small difference for PROBA-V. Do the followings:

1. Click on the icon of the PDP for the product you want to download (Figure 17) and this will drive you to the image catalog portal with a geographic interface.
    a. **SPOT-VEGETATION**: “SPOT-VEGETATION” window
    b. **METOP AVHRR**: “METOP-AVHRR S10 syntheses” window
    c. **PROBA-V**: “PROBA-V 1 KM SYNTHESES NEAR REAL-TIME” window. (No S10 images are available in the module “PROBA-V TILES (OLDER THAN 1 MONTH)”.

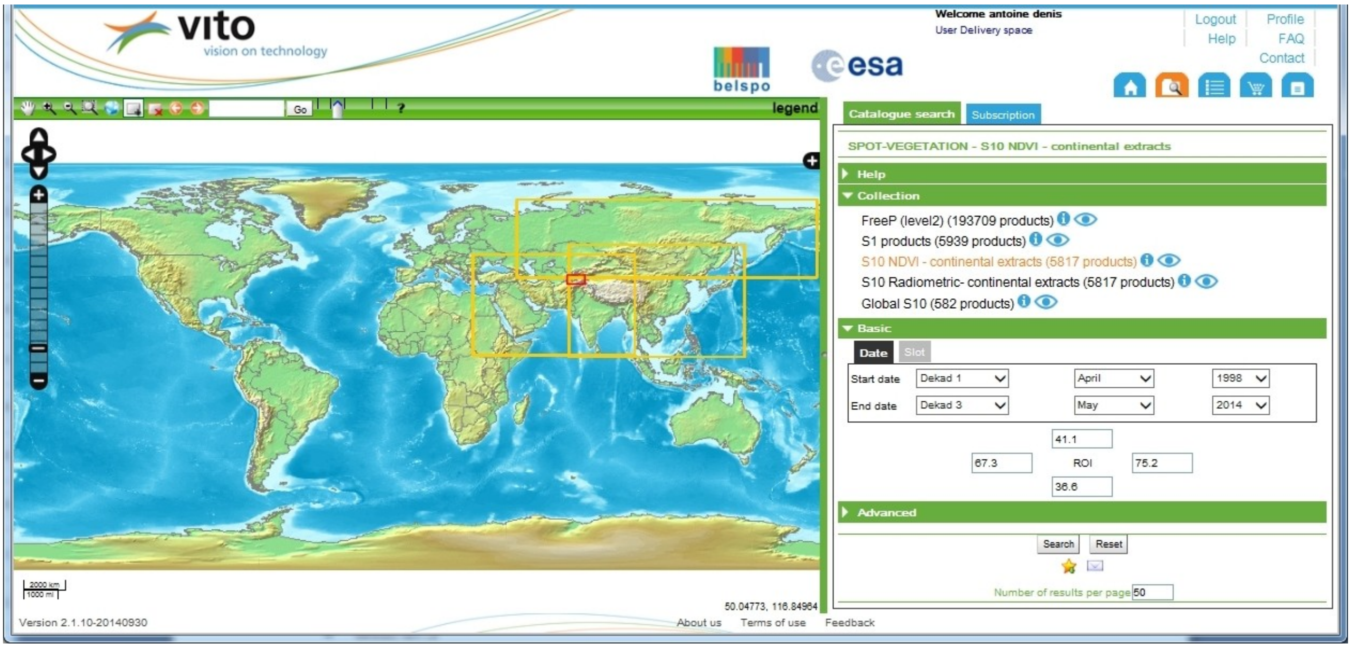


Figure 20: search criteria settings in the geographic interface of the PDP. E.g. of SPOT VEGETATION.

2. Select the desired **product** in the “Collection” menu:
    a. SPOT-VGT: “S10 NDVI - continental extracts”
    b. METOP AVHRR: “ENDVI10 products”
    c. PROBA-V: “S10 TOC NDVI - 1 km” (TOC = Top Of Canopy = atmospherically corrected)
3. Select the **period** for which you want to download the data
4. Indicate the desired **extent**
    a. Indicate the extent coordinates of the area of interest (ROI). The Tajikistan extent that will be considered in this manual is: North: 41.1, South: 36.6, West: 67.3, East: 75.2 (Figure 21).

b. Alternatively, in the geographic interface, you can interactively set to the region of interest. Countries' borders don't appear clearly in the current portal version.

c. For **SPOT VEGETATION and METOP AVHRR**:

    i. SPOT VEGETATION and METOP AVHRR products are presented under the form of predefined ROI corresponding to continental extracts. In the case of Tajikistan, the zone **"W-Asia" (West-Asia)** has to be selected. The other two regions intersecting Tajikistan don't cover it completely.

    ii. → Alternatively and in order to select only the images of "W-Asia, use an "extent" that is included only in the predefined ROI "W-Asia", even if this extent is not in Tajikistan. This way, you will not have to select again between the different predefined ROI in the "Results" window (confer below).

d. For **PROBA-V**:

    i. The PROBA-V products are not presented under the form of predefined ROI corresponding to continental extracts but rather on global extent that is organized under the form of tiles **of 10° by 10°.**

    ii. For PROBA-V you have to define the ROI "North: 41.1, South: 36.6, West: 67.3, East: 75.2". This will enable the selection of the 2 tiles intersecting Tajikistan: **X24Y03 and X25Y03**.

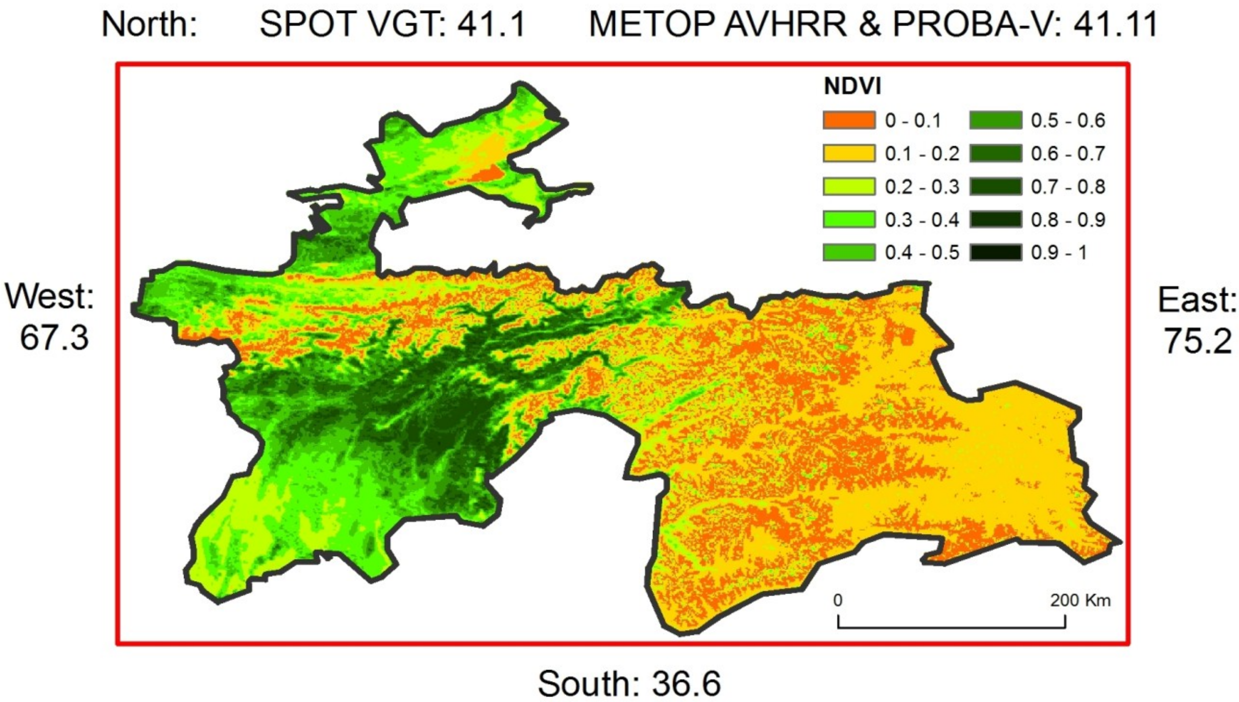


Figure 21: Tajikistan extent with extent borders coordinates in decimal degree. Background is the SPOT VEGETATION NDVI of 1st decade of June 1999.

5. Click on the “Search” button and this will drive you to the “Results” page of the PDP (Figure 22) with some information on the products: region, dates, size, Quicklook.

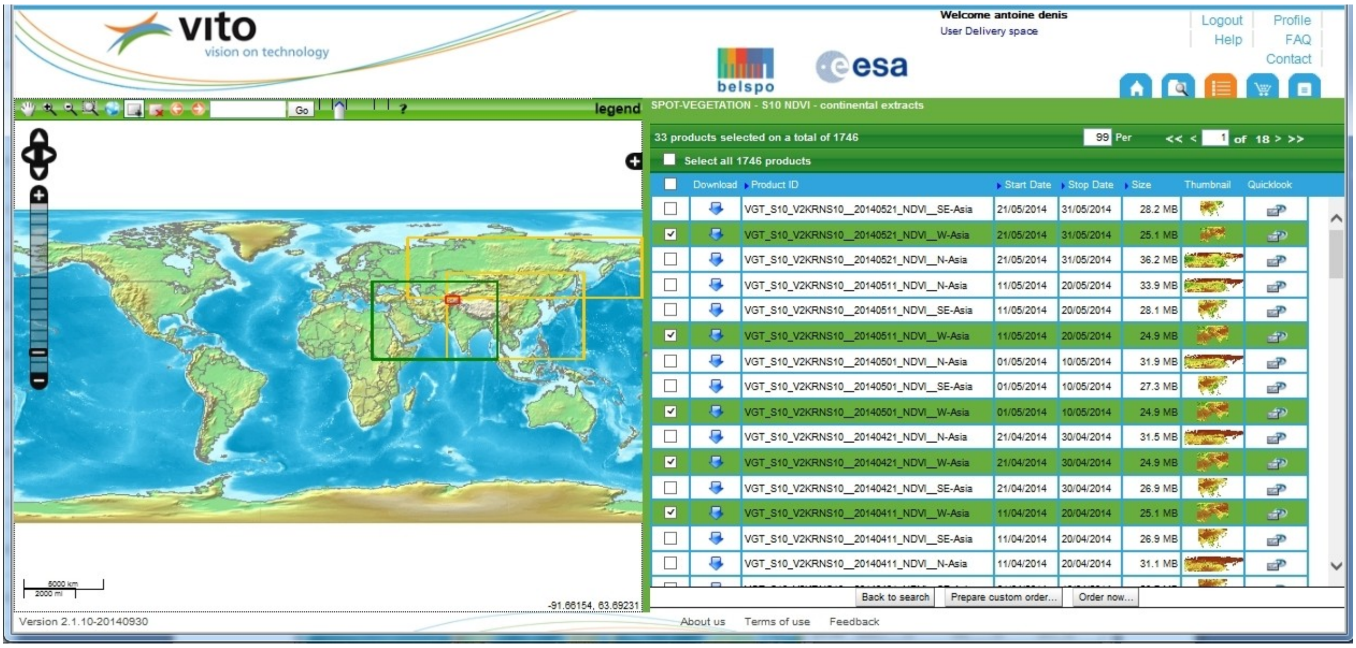


Figure 22: Results interface of the PDP. E.g. of SPOT VEGETATION

6. Select the desired products in the right panel.
    a. Select only the products that correspond to the desired extent.
        i. You can select the desired products manually in the list, or
        ii. You can select all products of a given ROI by selecting this ROI in the geographic interface.
    b. You can modify the number of products per page to display
    c. (Note that it is possible to download directly the images one by one by clicking on the blue arrow. As this may take a long time for downloading a time series, you will not use this option. In order to fasten the process and to download group of images quickly, you can use a “ftp client” like “FileZilla”. Confer below).
    d. Don’t use the “select all n products” function. This function, in the current portal version, will result in very slow data preparation.
7. Click on “Order now” button and this will drive you to the “Order follow-up” PDP page (Figure 23) that summaries your orders information and their status (“In production” or “Completed”, “Cancelled”, “Archived”, etc). (Don’t use the “Prepare Custom order…” option. This would cause the application not take into account the desired extent for PROBA-V and produce global data instead. This is probably a bug.)

Figure 23: "Order follow-up" page of the PDP.

8. The preparation of your order, depending of its size, may take from a few seconds (e.g. 30 seconds for 36 images) to several tens of minutes. You can refresh the table with the double arrow button to update the production status.
9. You can navigate through the different PDP windows with the upper right menu-buttons  .
10. Once your order is "Completed", you should receive an email in your email box with the name of the order, the order description, and the instructions to download it. One possibility to download the prepared images is to use a client FTP program like FileZilla.
11. Download, install and configure FileZilla
    a. Download FileZilla for your computer version from the web, for example from http://www.clubic.com/lancer-le-telechargement-428669-0-filezilla.html
    b. Install FileZilla
    c. Open FileZilla (Figure 24)

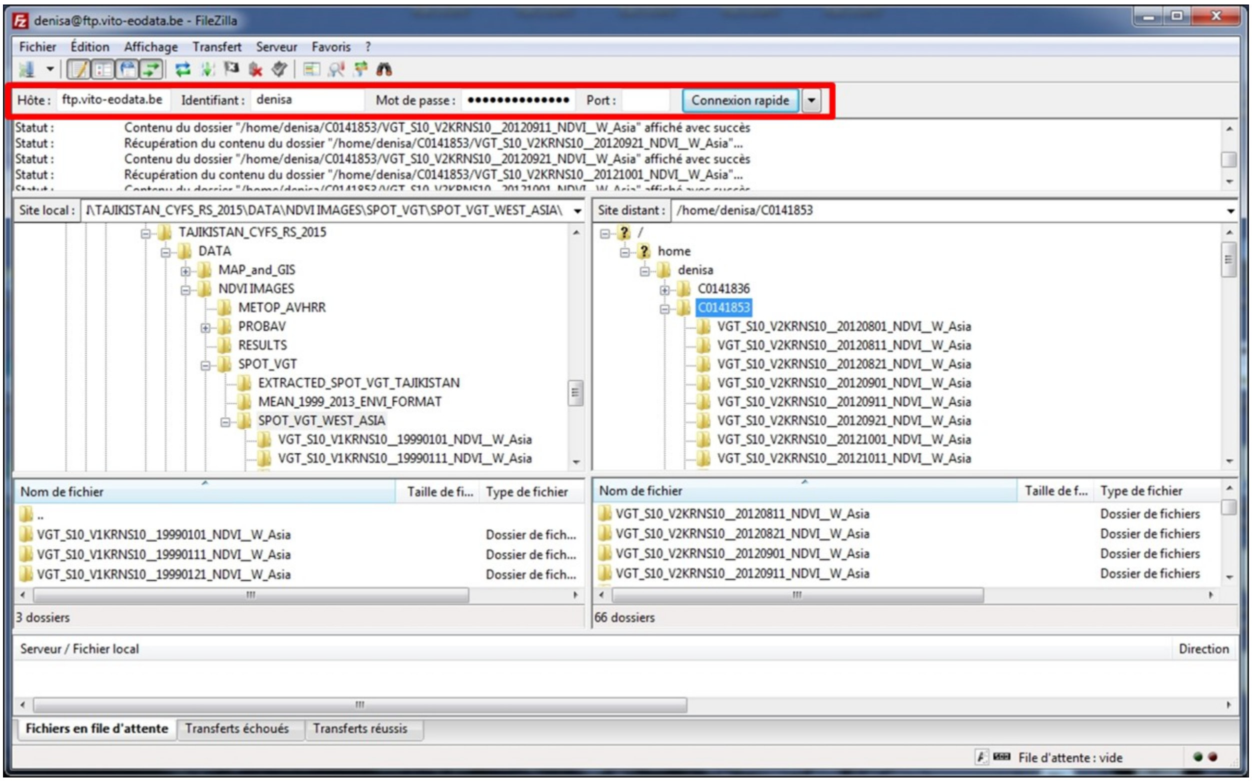


Figure 24: File Zilla interface

d. Create a connection to the ftp web site that will deliver you the images you have ordered. For this, fill in the following boxes in FileZilla (red rectangle in Figure 24):

   i. Host: ftp.vito-eodata.be
   ii. Login : your login for the PDP
   iii. Password : your password for the PDP

e. And then click on "connexion". This will connect you to your folder on the ftp site where you can download the ordered images.

f. In the left panel of FileZilla, corresponding to your computer, browse to the directory where you want to record the images

g. In the right panel of FileZilla, corresponding to the ftp server, browse to the folder containing the images you want to download.

h. Then simply "Drag and drop" or "Copy/paste" the desired data from the ftp server to your computer target directory. It is advised to record all the images of a given sensor in a **unique directory** in order for the extraction process to go faster (cf. next section). VGT-S10 NDVI images for WEST-ASIA should be stored in the folder "...\DATA\NDVI IMAGES\SPOT_VGT\SPOT_VGT_WEST_ASIA\" of the training package. SPOT-VGT images of 1998 and 2014 are useless for this methodology (complete year is needed).

8.5 NDVI images preparation for TIMESAT

Once downloaded, satellite images need to be prepared to be readable into TIMESAT.

SPOT VEGETATION, METOP AVHRR and PROBA-V are not provided in the same format. Specific process has to be applied on each image type.

8.5.1 SPOT VEGETATION NDVI images preparation with VGT Extract

Downloaded NDVI SPOT VEGETATION products cover WEST-ASIA and are recorded in ZIP files in a particuliar format. In order to be used in TIMESAT, these images will have to be converrted with the VGT Extract software. This operation will enable to:

- **Extract** the NDVI images from the ZIP files
- To **subset** the WEST-ASIA images to Tajikistan extent
- To **convert** the images into "ENVI standard" format compatible with TIMESAT

Note that this processing has already been done for the period 1999-2013 and that the **540 resulting images** are available in the training package in the directory "...\DATA\NDVI IMAGES\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN". These images totalise a size of approximately **230 Mo**.

8.5.1.1 Extracting the NDVI images from the ZIP files

Launch VGT Extract software. In the main interface of VGT Extract (Figure 25) you have to:

- Define the **"Input"** directory: browse on your computer to the folder containing the zipped NDVI SPOT VGT folders. In the training package, it is the folder "DATA\NDVI IMAGES\SPOT_VGT \SPOT_VGT_WEST_ASIA\".
- Define the **"Output"** directory: browse on your computer to the folder that will receive the extracted NDVI SPOT VGT. In the training package, it is the folder "...\DATA\NDVI IMAGES\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN\"
- Define a new **"Processing Settings"** for Tajikistan: clic on "New" and call it "SPOT_VGT_TAJIKISTAN_TIMESAT" for example. A new window (Figure 26) appears: confer next section.

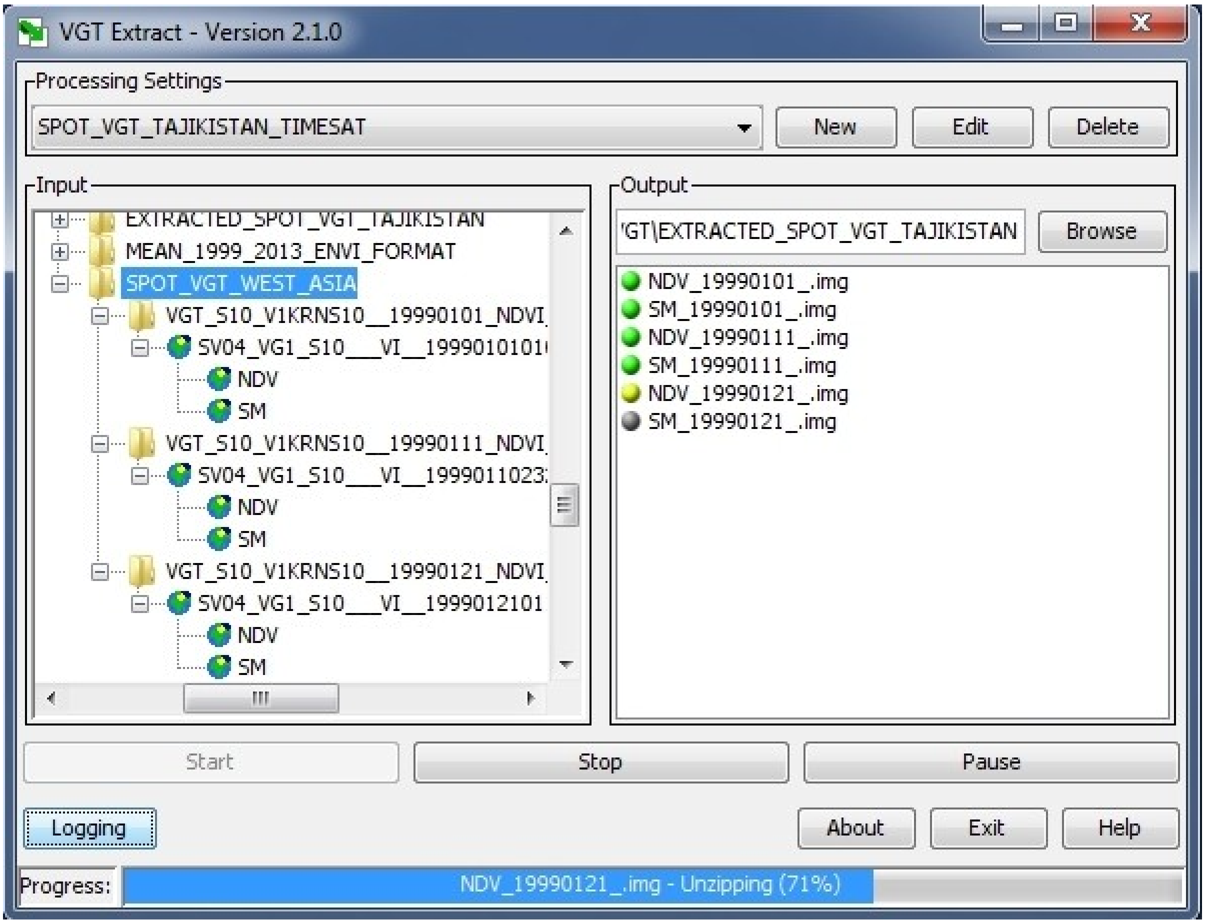


Figure 25: VGT Extract main interface (process is executing).

8.5.1.2 Subsetting the WEST-ASIA images to TAJIKISTAN extent

In the appearing “ROI” interface of VGT Extract (Figure 26):

- Choose the **“Manual Input”** mode (no predifined ROI are defined for Tajikistan)
- Enter manually the following coordinates (in decimal degree) which surround completely Tajikistan (Figure 21): **North = 41.1°, South = 36.6°, West = 67.3°, East = 75.2°.**

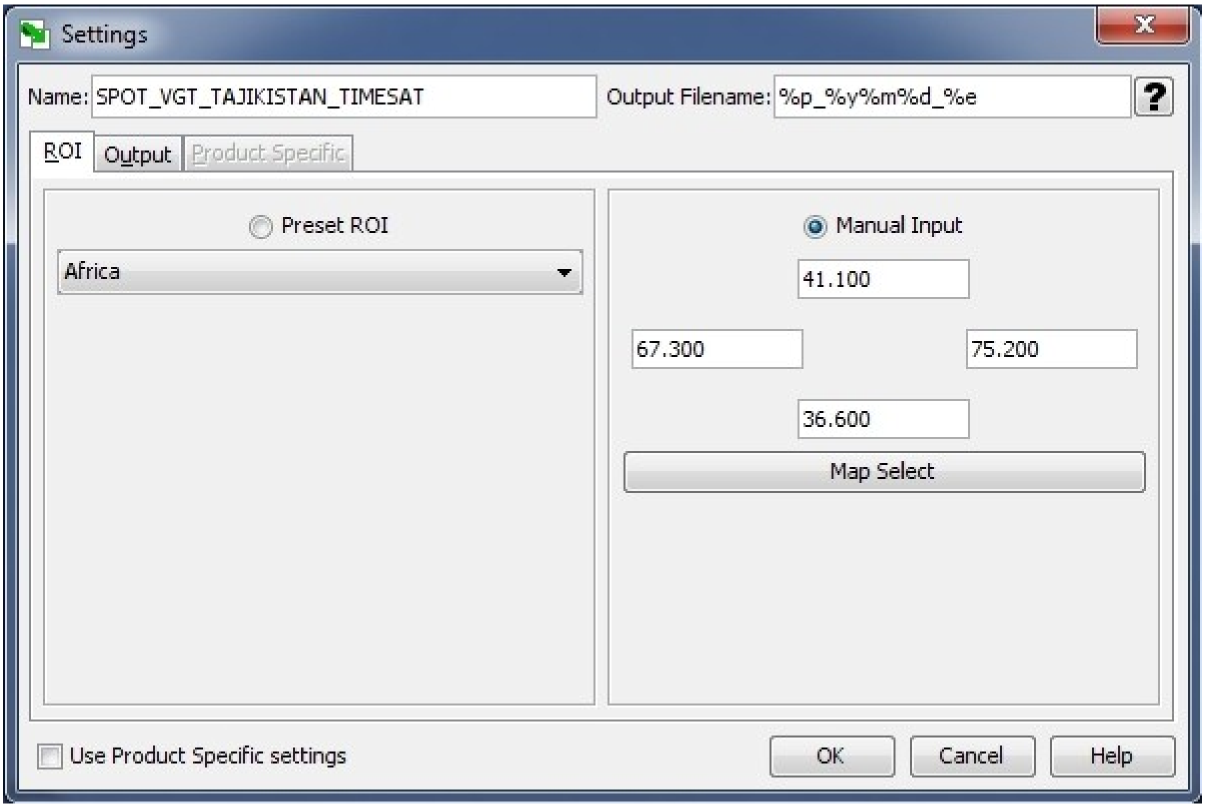


Figure 26: VGT Extract interface for ROI settings

8.5.1.3 Converting the images into a format compatible with TIMESAT

Then click on the "Output" tab of VGT Extract (Figure 27) and:

- Choose **"ENVI"** as "Output format" and **"Unsigned Byte"** as "Data Type" (format compatible with TIMESAT)
- Let the other parameter to default ("Scaling" of 1.0, "Offset" of 0.0 and "**Missing Data Value" of 0.0**).
- Set the **"Output Filename"** to "%p_%y%m%d_%e which will result in filename such as, for example, "NDV_19990101_.img"

See the **"VGT Extract Software User Guide"** for more information. In particular, the sections 3.3 chips 6 and 7, section 3.6.3 and section 4.3 give explanations regarding the scaling, offset, missing data value and "Use product specific settings" box (leave it unchecked).

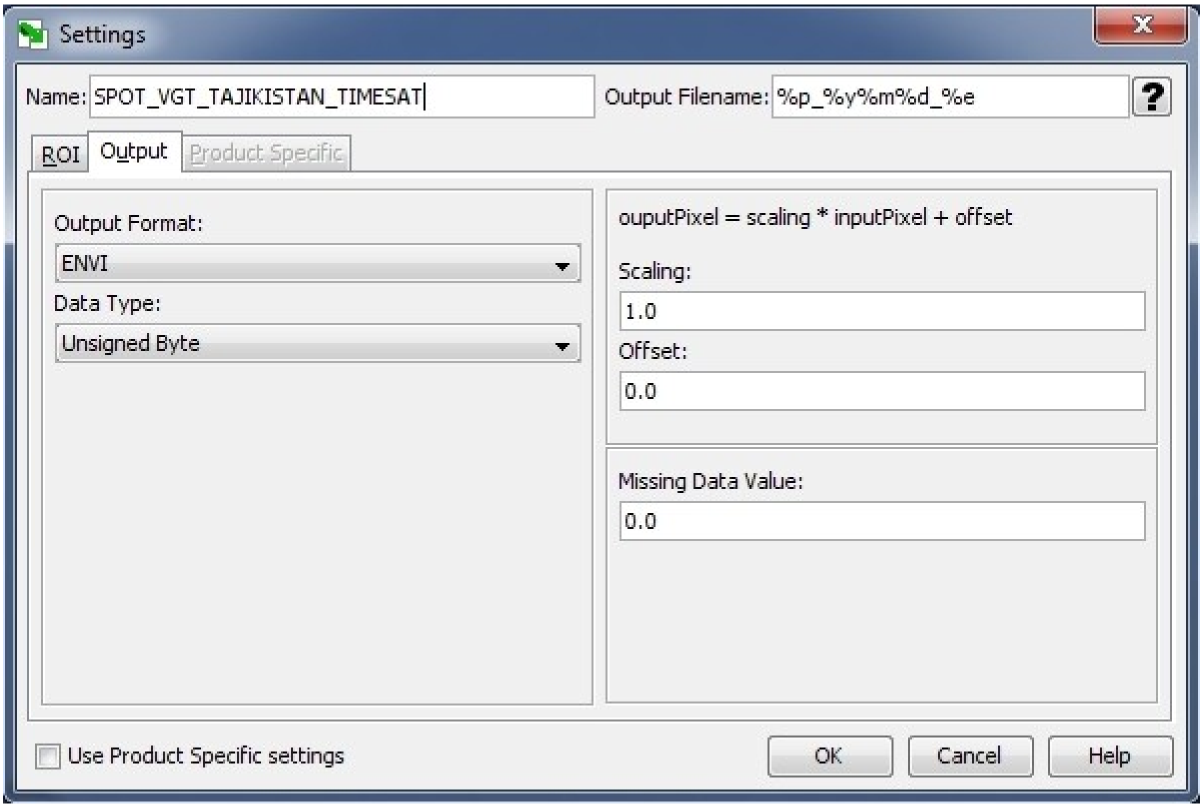


Figure 27: VGT Extract interface for Output format settings

Launch the processing of the files by clicking on the "**start**" button of the main interface of VGT Extract. 2 types of files are produced (Figure 25):

- **"NDV_19990101_.img"**, which are the NDVI images of interest
- "SM_ 19990101_.img", which are not of interest for this training. So they have to be deleted to spare disc place.

The "ENVI" format will create for each image 2 files:

- One containing the image itself with the extension "**.img**"
- The other being the "header" file with the extension "**.hdr**" containing some metadata (coordinates system etc). This file can be opened with a text editor such as "Notepad++" for example.

One image is composed of **885 columns** ("samples") **and 505 lines**. This information is available in the header file.

8.5.2 METOP AVHRR NDVI images preparation with 7-zip and FWTools

8.5.3 Extraction and subset

In order to be used in the model:

- NDVI images and associated header files have to be **extracted** from the zipped folder
- NDVI images have to be **spatially subsetted** on Tajikistan extent

The sections below describe:

- First, in details, the **manual operations** to realise these 2 tasks (time consuming)
- Then the **process automation** by the use of a **batch file** used in command line (very fast)

8.5.3.1 Extraction

The extraction can be done with, for example, "7-zip" software. 7-zip can be downloaded from the following website http://www.7-zip.org/ and easily installed.

After installation, all files can be extracted from the zipped folders, in one click, by:

- Selecting all zipped folder
- Right clicking and choosing "Extract here"

All files will be extracted to the current directory. In order to spare disc space, non "…NDV.img" or "….NDV.hdr" can be deleted.

8.5.3.2 Adding an information in the header files

The spatial subset operation using GDAL (described in the next section) requires, beforehand, the addition, at the end of each header file, of the text line: "interleave = bsq", as explained at the end of Question 7 of the FAQ of Metop Website, here http://www.metops10.vito.be/metop-S10_pages/FAQ.html. This can be done manually for example, for each file.

8.5.3.3 Subset and format selection

The spatial subset on Tajikistan extent can be done with the free software "FWTools" that contains the GDAL library itself containing the "gdal_translate » utility that enables the raster subsetting. For more information on the subset process confer to the Question 7 of the FAQ of Metop Website here http://www.metops10.vito.be/metop-S10_pages/FAQ.html. GDAL_translate tool is fully described here: http://www.gdal.org/gdal_translate.html. More information on the spatial subsetting process can be found here: http://trac.osgeo.org/gdal/wiki/FAQRaster#HowdoIusegdal_translatetoextractorclipasub-sectionofaraster.

In order to **spatially subset** the images,

- Download FWTools here http://fwtools.maptools.org/ under the section "download". Choose "FWTools 2.4.7 (Windows 32bit)" if your computer is using Windows. This version is compatible with Windows 7 64 bits. This software is provided in the training package in the "SOFTWARE" folder.
- Install FWTools by clicking on "FWTools247.exe" and follow the normal installation process.

Once installed, this tool can be called via the command line window. Rather than using the command line window directly, it is easier to **write the commands in a "batch file" (a text file with the extension ".bat" or ".cmd")**. This can be done with "Notepad++" software for example, by creating a new file and saving it as "batch file" with the extension ".bat". The elements of the command in the batch file are:

- Directory and name of the command to execute with " " signs if there is space in the directory name. This indicates where the "gdal_translate.exe" has been installed. For example: "C:\Program Files (x86)\FWTools2.4.7\bin**gdal_translate.exe**"
- The gdal_translate function arguments: "-**projwin *ulx uly lrx lry***" to identify the "subwindow" (spatial subset) coordinates in terms of geographic coordinates ("ul" stands for "upper left", "lr" for "lower right", "x" for "longitude", and "y" for "latitude"). In the case of Tajikistan the subwindow coordinates used in "VGT EXTRACT" software for SPOT VEGETATION images are North = 41.1°, South = 36.6°, West = 67.3°, East = 75.2°. However the use of these coordinates on METOP AVHRR images with "GDAL_translate" results in an image of 504 lines and 885 columns, whereas the extracted SPOT VEGETATION images have 505 lines and 885 columns. This is not explain but is probably related to the fact that the SPOT VEGETATION images are 1 pixel bigger in longitude and latitude than METOP AVHRR images on WEST-ASIA extent as presented in the Table 1 page 39. In order to produce METOP AVHRR images of same size than SPOT VEGETATION images, the window North coordinate is extended a little (of 0.01 degree) as indicated below (Figure 21). This produces images with 505 lines and 885 columns.
    - ***ulx :*** the upper left longitude: 67.3 (degree)

    - ***uly** :* the upper left latitude: 41.11 (degree)
    - ***lrx** :* the lower right longitude: 75.2 (degree)
    - ***lry:*** the lower right latitude: 36.6 (degree)
    - which results in the **function**: -projwin 67.3 41.1 75.2 36.6
- Name of the **input file**, the image to subset, for example: METOP_AVHRR_20080101_S10_ASw_NDV.img
- Name of the **output file**, the subsetted image to create, for example: METOP_20080101_TAJIKISTAN.img
- The command "**-of ENVI**", indicating that the output format will be of "ENVI standard" type, the format needed for TIMESAT, has to be added just after "gdal_translate.exe"", otherwise the output format will be the default one i.e. "GeoTIFF", and the image won't be correctly read in TIMESAT.
- The use of the command "**pause**" at the next text line prevent the automatic closing of the command line window after the operation and enable to check the right command execution.

The final command should look like the following, on 2 lines:

- "C:\Program Files (x86)\FWTools2.4.7\bin\gdal_translate.exe" -of ENVI -projwin 43 67.3 41.11 75.2 36.6 "D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\METOP_AVHRR\METOP_UNZIPPED\ METOP_AVHRR_20800101_S10_ASw_NDV.img" "D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\METOP_AVHRR\METOP_TAJIKISTAN_SUBSET\ METOP_20080101_TAJIKISTAN.img"
- Pause

A similar command has to be written for each image to extract, which is fastidious (confer next section for automation). Once the batch file has been written, it has to be saved and closed. When double-clicking on that file, the process will automatically be launched. To open or edit the batch file, right-click on the file and choose "Notepad++" for example to open it.

8.5.3.4 Extraction and subset automation with command line

In order to speed up the process extraction from the zip folder, header file modification and spatial subsetting can be done automatically by the use of a batch file used in the command line.

The **batch file** to be used (and slightly adapted according to your working directory) can be found in "...\DATA\NDVI IMAGES\METOP_AVHRR**METOP_EXTRACT.bat**". This batch file can be open with "Notepad++" software by right clicking on it and choosing "Open with Notepad++".

Before using the batch:

- The "**7zip**" software in command line version (available here http://www.7-zip.org/download.html) has to be placed in the folder "... \TAJIKISTAN_CYFS_RS_2015 \SOFTWARE\7zip_command_line\7za920\7za.exe".
- The "**FWTools**" software (available here http://fwtools.maptools.org/) has to be installed on your computer. After installation, check that the installation directory is the same than the one mentioned in the batch file. If not, modify the batch file accordingly.
- Metop WEST-ASIA NDVI images have to be downloaded in the folder "...\ DATA\NDVI IMAGES\METOP_AVHRR\METOP_WEST_ASIA_DOWNLOADED\"
- The directory "...\ DATA\NDVI IMAGES\METOP_AVHRR\METOP_TAJIKISTAN_SUBSET\" has to exist

Above the signs "..." represent the beginning of your working directory. If yours differs from the one used in the script file, you have to change it in the script file at the line beginning by "SET" by editing the file with a software such as "Notepad++" for example.

The script is divided in 3 sections:

- The first section enables the operator to set the working directory
- The **second section** enables the **extraction**, with the "7-zip" software of the files "...NDV.img" and "...NDV.hdr" from downloaded zipped folders. The commands are:
    - The full path to 7-zip executable
    - The command "e" that stands for "extraction from the zip"
    - The directory containing the zipped folder containing the files of interest ending with "*.zip" to take into account all zip folders of that directory.
    - The output directory where extracted files will be recorded
    - The names of the files to be extracted, in this case, only the files "…NDV.img" and "…NDV.hdr".

  - Note that “” signs are used for indicating directories when there are some spaces in directory names.
- The **third section** enables the **spatial subset** of WEST-ASIA images on Tajikistan extent. The commands are organized in a 3 loop “FOR” to iterate the command on the images filenames containing 3 variables: the year, the month and the decade. In details, the commands are:
  - “for /L” enables to make an iteration by using a start value, a constant increment, and a end value. “for /L %%y in (2008,1,2015)” stands for “variable year from 2008 to 2015 by step of 1”, meaning 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015.
  - “(for %%d in (01 11 21)” stands for: value 01, 11, 21.
  - “echo interleave = bsq >> "%Directory%...NDV.hdr" enables to add the text “interleave = bsq” at the last line of each header file
  - The code containing the “gdal_translate.exe" enables to spatially subset the NDVI image to Tajikistan extent
  - The script is repeated twice, one for month from 1 to 9, then for month from 10 to 12.

To **run the batch** file, simply double click on it.

1 METOP AVHRR NDVI image has already been extracted on Tajikistan extent and is provided as example in the training package under the directory “...\DATA\NDVI IMAGES\METOP_AVHRR\METOP_TAJIKISTAN_SUBSET\”. This image is ready to be used in TIMESAT for the following of the process. **METOP AVHRR image name structure** is organized like this “METOP_20080111_TAJIKISTAN.img” (in this case, the second decade of January 2008).

8.5.4 PROBA-V NDVI images preparation with PPT

PPT can be used with a **Graphical User Interface** (GUI) or through **command lines**. In this manual, first the GUI is briefly presented and secondly the use of PPT through command line and batch file is presented.

The **PPT user manual** is available in the folder “doc” of the PPT installation package. This user manual indicates how to use PPT with GUI and with command line.

8.5.4.1 PPT GUI

This section presents a summary of the indications given in the PPT user manual at the section “PROBA-V ProductCustomization Tool Graphical User Interface”.

To start PPT:

- Double click on the file “start.bat” in the folder “C:\PPT\gui\bin\”. A DOS consol should open briefly before the PPT GUI automatically opens (Figure 28).
- Optionally you can create a “start.bat” shortcut on your desktop by right-clicking the “start.bat” file and select “send to > desktop”.

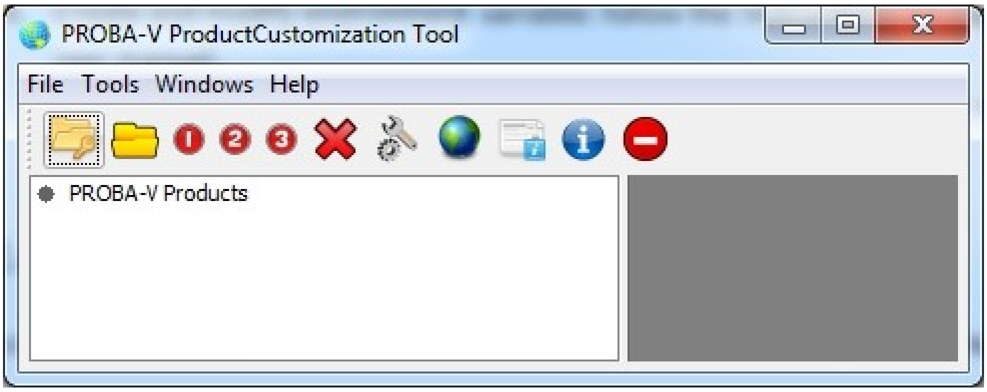


Figure 28: PROBA-V ProductCustomization Tool (PPT) Graphical User Interface (GUI)

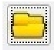
In case of problem, if nothing happens, this may due to a problem with the installation of JAVA. You can try to uninstall and reinstall JAVA, available here: https://www.java.com/fr/download/manual.jsp. Double check that you respected the installation instruction and/or refer to the user manual.

The operations to carry out on the downloaded PROBA-V images to prepare them for TIMESAT are:

- Mosaic the 2 tiles of Tajikistan extent of each decade into 1 single image
- Clip the images on the Tajikistan extent
- Transform the images format into ENVI format, for compatibility with TIMESAT

To prepare PROBA-V images for TIMESAT:

1. To open a PROBA-V product,

   - Click on the import button 
   - Select a ".VRG" file in your data directory, e.g., "...\DATA\NDVI IMAGES\PROBAV\TAJIKISTAN\PPT_IN\PROBAV_S10_TOC_20131121_1KM_NDVI_V001.VRG" and open it
   - It should appear in the PPT left panel (Figure 30).
   - If the image cannot be added in the left panel of PPT, check the DOS consol and the error message, and check the section "Installation of Java Runtime Environment" of the user manual for error documentation. Maybe you will have to reinstall the Java version suited for your computer.
   - You can then optionally display the tiles location by selecting the file of interest and clicking on the display button  (Figure 29)

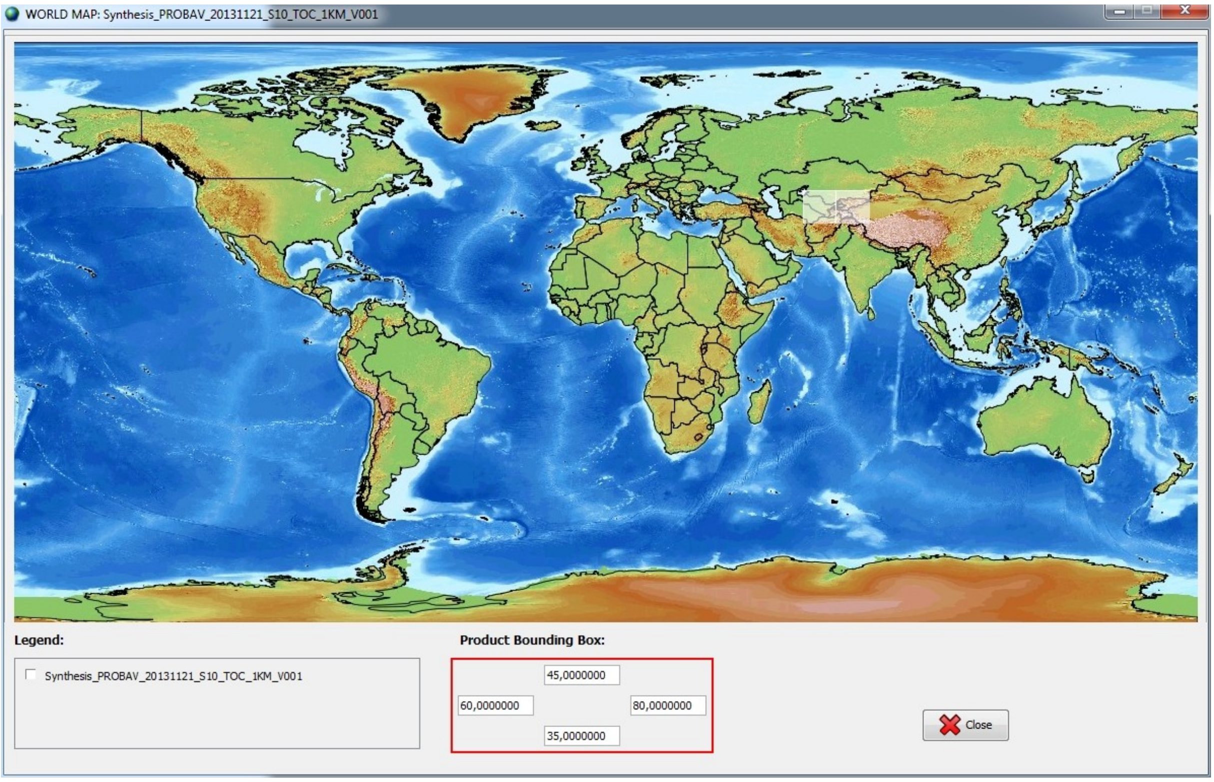


Figure 29: Tajikistan PROBA-V tiles on the PPT WORLD MAP.

2. To customize (process) the PROBA-V product:

   - Click on "Product customization" (Figure 30) button and fill the "I/O parameters" and "Customization parameters" as follow:

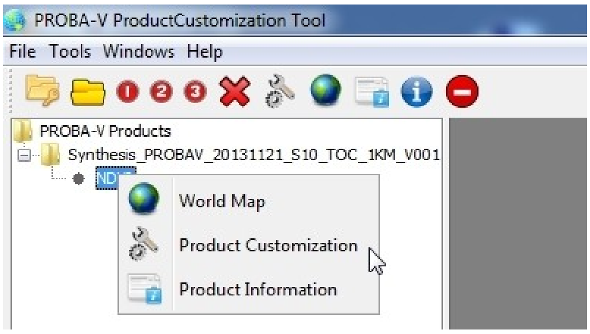


Figure 30: PPT left panel with 1 PROBA-V image open

- Fill the "I/O parameters" (Figure 31):
  - Output File: the output filename has to contain the %DATASET% token because the selected output format is ENVI, e.g.: "20131121%DATASET%.img".
  - Input file must be a ".VRG" file that indicates to PPT the tiles to use.
  - Creation of logging file is optional.

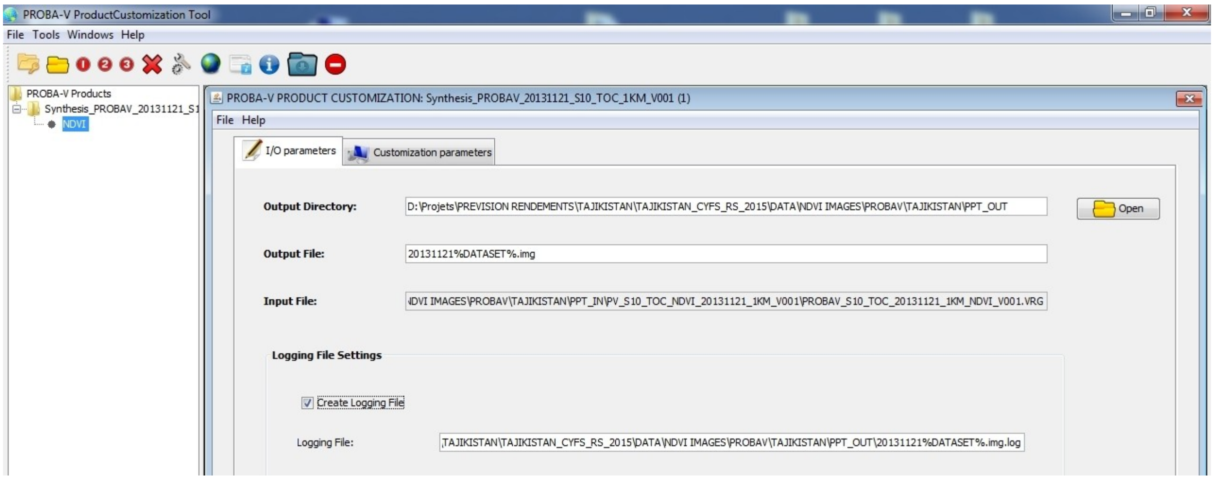


Figure 31: PPT "I/O parameters" window

- Customization parameters (Figure 32):
  - Output file format: ENVI format
  - Region of interest: Tajikistan extent (confer above and Figure 32). Check the 2 boxes:
    - <u>**Perform clipping**</u> (cut the image on the desired extent). !! <u>**The North extent limit is set to 41,11.**</u> In order to have SPOT VEGETATION and PROBA-V NDVI images of same size (number of rows = 505 and number of columns = 885), which is more convenient for further process, the North extent limit (arbitrarily) has to be set to 41,11 in PPT extent setting. A value of 41,1 (as in VGT EXTRACT for SPOT VEGETATION) results in an image of 504 lines only.

- **Perform mosaicking** (merge the 2 tiles in 1 image)
  - Output projection: no reprojection. Don't check the box.
  - Output dataset: no band extraction. Don't check the box.

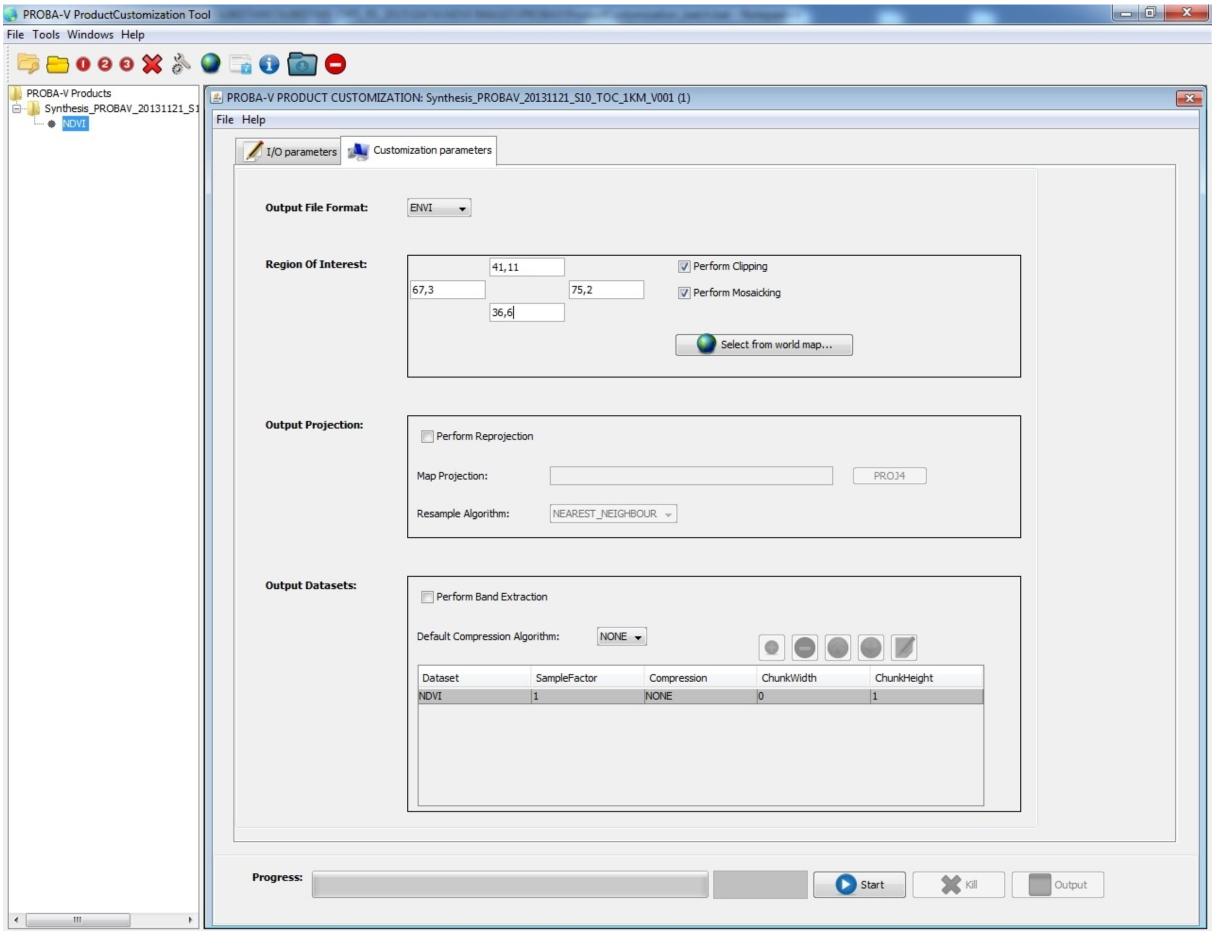


Figure 32: PPT "Customization parameters" window

3. Save the parameters file to your directory "…\DATA\NDVI IMAGES\PROBAV\" with the menu "File > Save as" of the customization window and call it "ProductCustomization_parameters.cfg" (Figure 33).

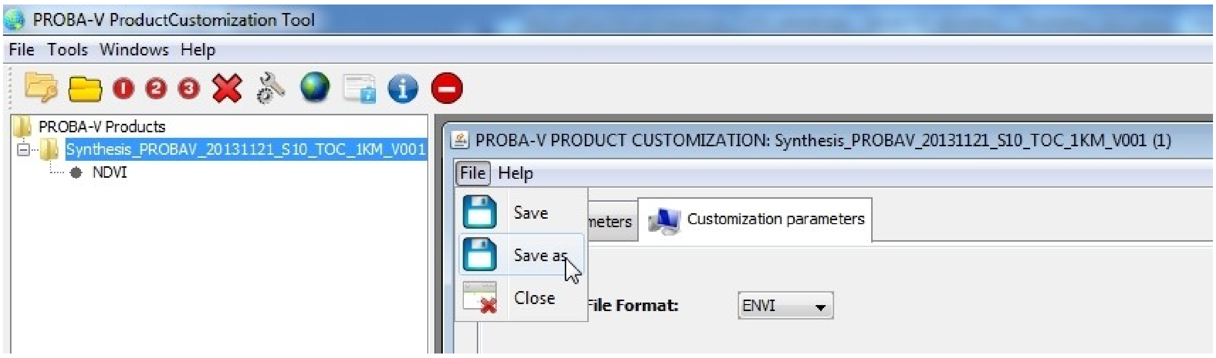


Figure 33: PPT menu to save configuration file

4. Click on the "Start" button to start the process (Figure 34)

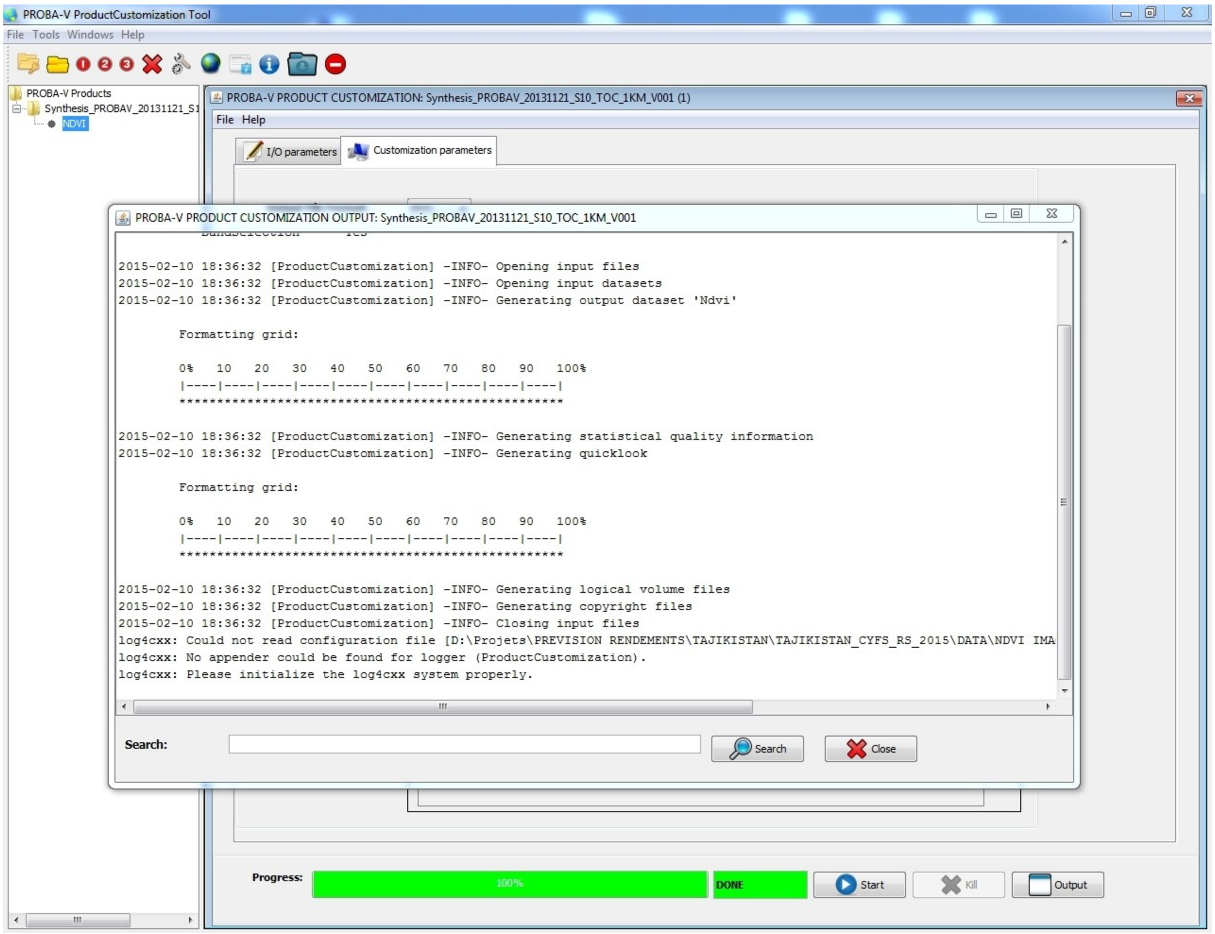
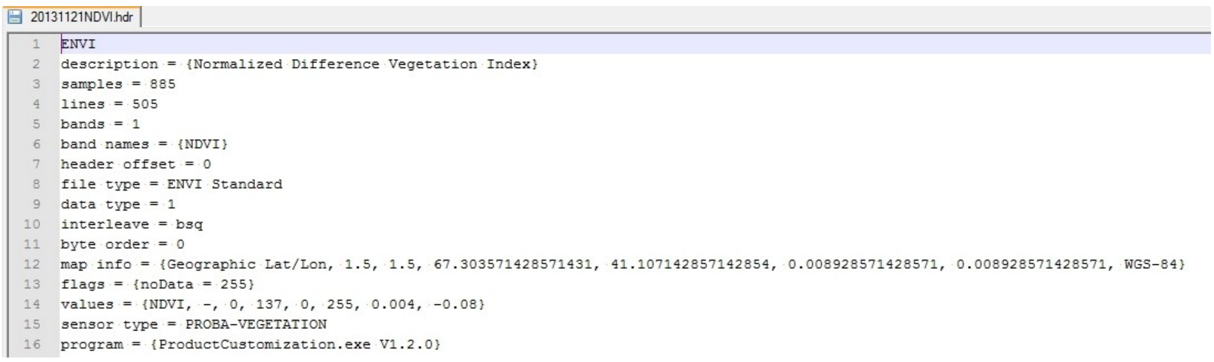


Figure 34: PPT popup window when starting and finishing a process.

This process results in NDVI image in ENVI format (.img and .hdr files (Figure 35)) mosaicked and clipped on Tajikistan with:

- Number of rows/lines : 505
- Numbers of columns/samples : 885



20131121NDVI.hdr

```
ENVI
description = {Normalized Difference Vegetation Index}
samples = 885
lines = 505
bands = 1
band names = {NDVI}
header offset = 0
file type = ENVI Standard
data type = 1
interleave = bsq
byte order = 0
map info = {Geographic Lat/Lon, 1.5, 1.5, 67.303571428571431, 41.107142857142854, 0.008928571428571, 0.008928571428571, WGS-84}
flags = {noData = 255}
values = {NDVI, -, 0, 137, 0, 255, 0.004, -0.08}
sensor type = PROBA-VEGETATION
program = {ProductCustomization.exe V1.2.0}
```

Figure 35: header file of an PROBA-V image processed with PPT

The PROBA-V images resulting from this PPT process can be used in TIMESAT!

8.5.4.2 Use PPT with command line

This section presents **a summary of the indications given in the PPT user manual** at the section “PROBA-V ProductCustomization Tool Command-Line Interface” and “commanding”.

The process above can be repeated manually for all images. However in order to process the series of images faster, the **process can be automated with the help of a batch file** that can be executed in command line.

Based on the indications of the “commanding” section of the “PPT user manual”, a batch file has been created to enable to:

- **Create and use configuration files** needed for PPT for a series of PROBA-V images defined by the 3 variables "y" (year), "m" (month), "d" (decade). This .cfg file, called "ProductCustomization_parameters_batch.cfg", is overwritten for each combination of these 3 variables. Consequently, only the last requested .cfg file is kept on the hard drive when using the batch.
- **Apply the "ProductCustomization.exe"** tool for each combination of these 3 variables by using the configuration files created in the first step.

This batch file is:

- Available in the directory “…\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\PROBAV\”
- Called “**ProductCustomization_batch.bat**”.

This batch file is a simple text file of which the extension “.txt” has been modified to “.bat” which transforms this file in an executable file.

To access to the content of this file:

- Right-click on the file and open it with “Notepad++”.

Some explanations on this file are given inside the file. The lines beginning by “rem” are comments lines and the other ones are command lines.

Before to use the batch:

- Adapt the directories of the batch file according to your computer and save the file.
- Make sure you have the input data in the right directory and the PPT tool is installed and functioning properly before to launch the batch file.

To launch the batch file:

- Double click on the batch file.

This will:

- open a DOS window
- process all images of the input directory
- produce desired images in the output directory (good format (ENVI), good extent (clip on Tajikistan extent), 1 image per decade (mosaicking the 2 tiles per decade))

After you used the batch:

- Check that the images are produced in the output directory.

Optionally you can check the content of the “ProductCustomization_parameters_batch.cfg” file produced by the batch in the folder “…TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\PROBAV\” by opening it with Notepad++. It should contain the right parameterization for a given PROBA-V image.

The PROBA-V images resulting from PPT process can be used in TIMESAT!

For some supplementary information on the PROBA-V images processing possibilities, refer to the following FAQ website http://www.vito-eodata.be/PDF/image/faq_help/Faq.html.

9 Valid data range during the process

The “Valid Data Range” (VDR) and the “Code for Missing Data” (CMD) of the images will vary during the process when images are produced or transformed. In order to have a clear view of this evolution, their values are presented in the Table 2 below.

Note that even if the CMD is set to “0” in TIMESAT processes, the VDR of the images produced by TIMESAT is always [0 - 255] for 8 bit images (smoothed NDVI images) and [-32768 - 32767] for 16 bit images (season parameter images).

In WinDisp it was decided to define the VDR as [1 - 255] in order not to overlap the CMD which is set to “0”.

	WEB		EXTRACTION		TIMESAT					WinDisp	
	Image download		VGT EXTRACT, FWTools, PPT		TSF_process	TSF_fit2img Smoothed NDVI		TSF_seas2img Season image		Importation and header modification	
	VDR	CMD	VDR	CMD	VDR	VDR	CMD	VDR	CMD	VDR	CMD
SPOT VGT*	[1-255]	0	[1-255]	0	[1-255]	[0-255] (8 bit)	0	[-32768 -32767] (16 bit)	0	[1-255] fitted [1-255] season	0
METOP AVHRR**	[0-250]	[251-254] [255]	[0-250]	[251-254] [255]	[0-250]	[0-255] (8 bit)	0	[-32768 -32767] (16 bit)	0	[1-255] fitted [1-255] season	0
PROBA-V***	[0-254?]	255	[0-254?]	255	[0-254?]	[0-255] (8 bit)	0	[-32768 -32767] (16 bit)	0	[1-255] fitted [1-255] season	0

Table 2 : Chronological modification of Valid Data Range (VDR) and Code for Missing Data (or flag) (CMD) during the CYF methodology process.

*** SPOT VEGETATION VDR and CMD**: VDR is [1-255]. This information can be found in the « VGT Extract » user guide issue 1.4.2 at page 20, section “An example: … NDVI datasets are stored as eight bits per pixel (or Byte) values, between 0 and 255, with 0 as flag value for missing data.”

**** METOP AVHRR VDR and CMD**: this information can be found on the METOP website (http://www.metops10.vito.be/metop-S10_pages/main.html) in the section « Products > Spectral Aspects > in the table, at the line “NDV” and at the column “Digital Values V”.

- [0-250]= Significant V-range. The scaling only holds for this range. Values beyond [0-250] are flags.
- [255] Per image, there is only one flag to indicate all "aberrant" states (Sea, NoData, NoValidData, Error). The Status Map image provides more information.

***** PROBA-V VDR and CMD:**

- No information was found on the PROBA-V VDR but it is supposed to be [0-254] as the only information found was for the CDM which is 255 (information available in the header file of ENVI format PROBA-V image (after extraction with PPT)).

10 TIMESAT - NDVI images temporal smoothing and season parameters extraction

Foreword. Note that the mention **"(optional)"** is written at the right of sections that doesn't need to be executed for the CYFS methodology but that are however interesting to present to new TIMESAT user.

TIMESAT (http://www.nateko.lu.se/timesat/timesat.asp) software is used, in this methodology, for (Figure 36):

- Smoothing temporally the NDVI images
- Extracting season (pheneology) parameters from images

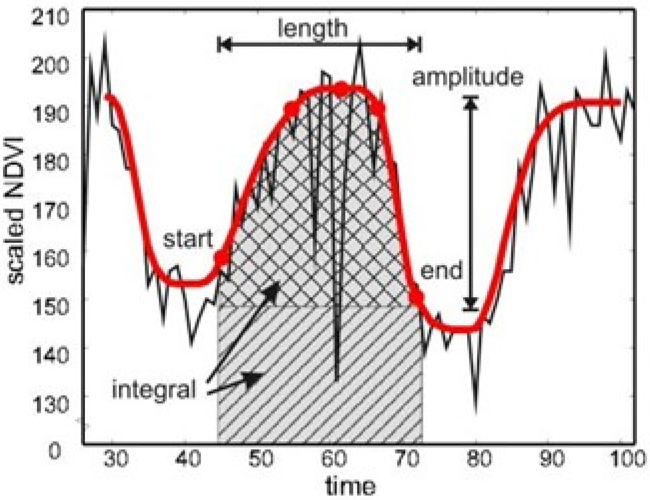


Figure 36: Illustration of TIMESAT process on NDVI temporal signal: smoothing (red) and season parameter extraction (start, end, etc).

TIMESAT short presentation is given at the section 7.4 above.

The **11 seasons parameters** produced by TIMESAT are described at the page 23 of the "Timesat 3.1 Software Manual" (confer section 10.2 below).

Note. Previously (with the old CYF methodology), the season parameters were extracted with the **VAST3.0** software (FEWS – 1993). TIMESAT replaces VAST for the following reasons:

- No or very little documentation was available for VAST (eg. No detailed information on the smoothing algorithm) and no maintenance was realised. On the contrary TIMESAT is well documented and maintained will possible help staff.
- TIMESAT probably provide a better temporal smoothing method and smoothed images are produced and available for cumuli computation whereas it was not the case with VAST.
- Consequently the season parameters extraction is probably better with TIMESAT.

10.1 TIMESAT download

TIMESAT can be downloaded for free, for non-commercial academic research (see distribution policy), after registration, at: http://www.nateko.lu.se/timesat/timesat.asp?cat=4. Note that the retrieval of the login that will give you access to the download can take several days.

Once logged, **download**

- The **software package** version adapted to your situation. In this manual, the following situation will be considered: "*TIMESAT standalone version 3.1.1 for Windows users without Matlab* (zip archive, 2012-11-22, 181 Mb)". The downloaded folder is "timesat311_standalone_windows32.zip"
- You may also want to download some **sample data** under the section "Additional test data for TIMESAT" (Useless for this methodology).

10.2 TIMESAT installation

For detailed information on the installation refer to **pages 36 and 37** (section 7) **of "TIMESAT 3.1 Software Manual"** that comes with the download. The following section gives a summary of the installation steps:

- **Unzip** the software package "timesat311_standalone_windows32.zip" in the directory "...\TAJIKISTAN_CYFS_RS_2015\SOFTWARE\TIMESAT\". The **software manual** "timesat3_1_1_SoftwareManual.pdf" can be found in the directory "timesat311_standalone_windows32\timesat311\documentation\".
- If Matlab is not available on the computer it is necessary to first install a runtime engine called the **Matlab Compiler Runtime (MCR).** For Windows users, double click on the file **MCRinstaller.exe** stored in the directory "timesat311_standalone_windows32\timesat311\compiled\Win32\". You might

receive the following message ".NET Framework is not installed. If you require it, select Cancel and install ".NET framework" (available on internet through Google search) first, then start again the installation process. Otherwise select OK to continue". You can just continue the installation by pressing OK. See also section 7.4 page 30 of this manual for more installation information (bugs and solution).

- TIMESAT itself doesn't need to be installed.

10.3 Starting TIMESAT

- To start TIMESAT **double click** on the file **"TIMESAT.exe"** in the "timesat311_standalone_windows32\timesat311\compiled\Win32\" folder. If the computer asks you if you want to execute the file, say yes.
- Note that you may want to create a **shortcut on the desktop** for "TIMESAT.exe". For this, right click on the executable file and choose "create a shortcut on the desktop" or "send to desktop".
- After double-clicking, a DOS command line window will appear. Wait a few seconds and then you will be asked to indicate the "TIMESAT installation folder". **Browse to the folder called "timesat311"** as illustrated in the Figure 37 and click "OK". This step is very important!!

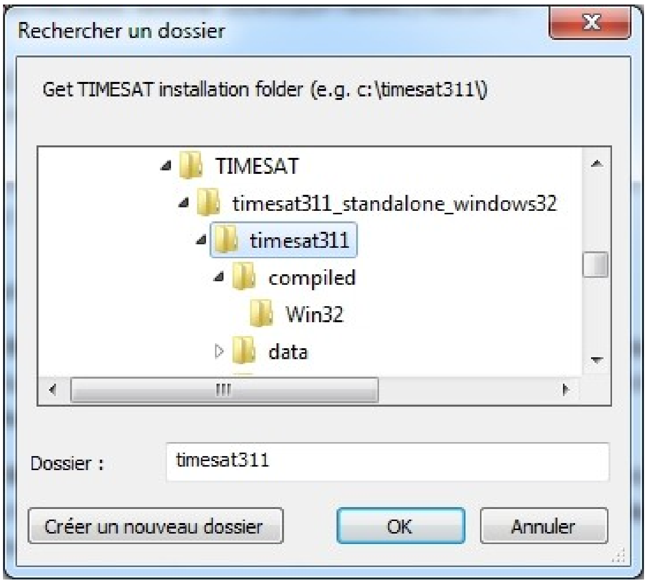


Figure 37: Indicating the TIMESAT installation folder when launching TIMESAT.

- Then the "Timesat menu system", which is the TIMESAT main interface, will open (Figure 38).

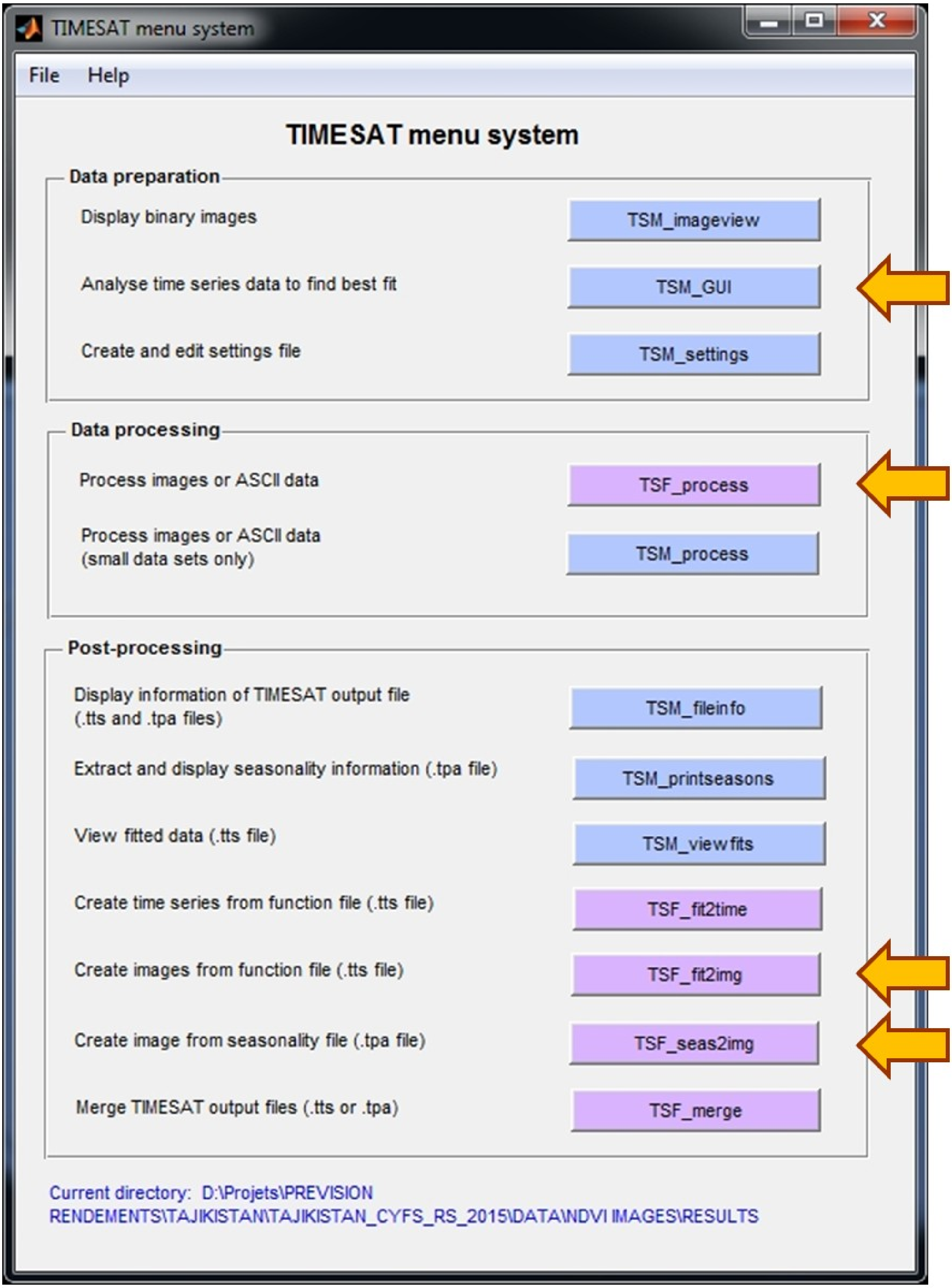


Figure 38: TIMESAT menu system

- In the “Timesat menu system” you have to **indicate your working directory** (Figure 39 and Figure 40) (p. 37 and p. 43 of the “TIMESAT 3.1 Software Manual”). **This step is really important and the rest of the methodology will repose on the definition of that working directory!!!** The working directory is the directory where the TIMESAT RESULTS will be stored. This will also be the directory containing the batch files for TIMESAT process automation. The proper functioning of the provided batch files depends on that definition of the working directory (otherwise batch files have to be adapted). The provided TIMESAT list files are constructed relatively to this working directory (confer section 10.7.2).
  - Go in “TIMESAT menu system > File > Preferences” and browse to your working directory, in this case: “...\DATA\NDVI IMAGES\RESULTS\.

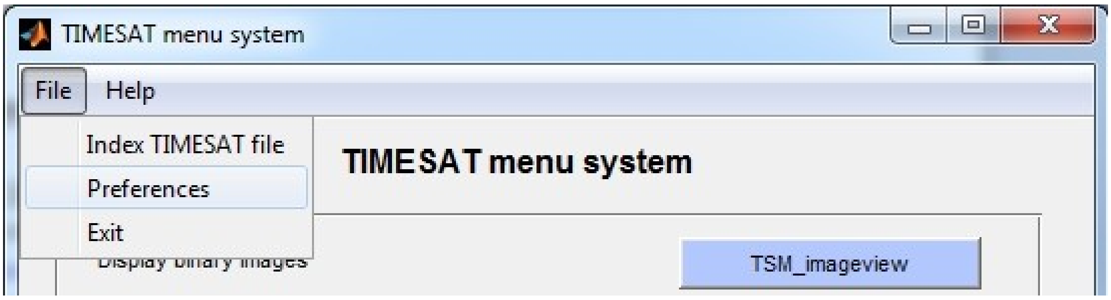


Figure 39: way to set the correct working directory when starting TIMESAT.

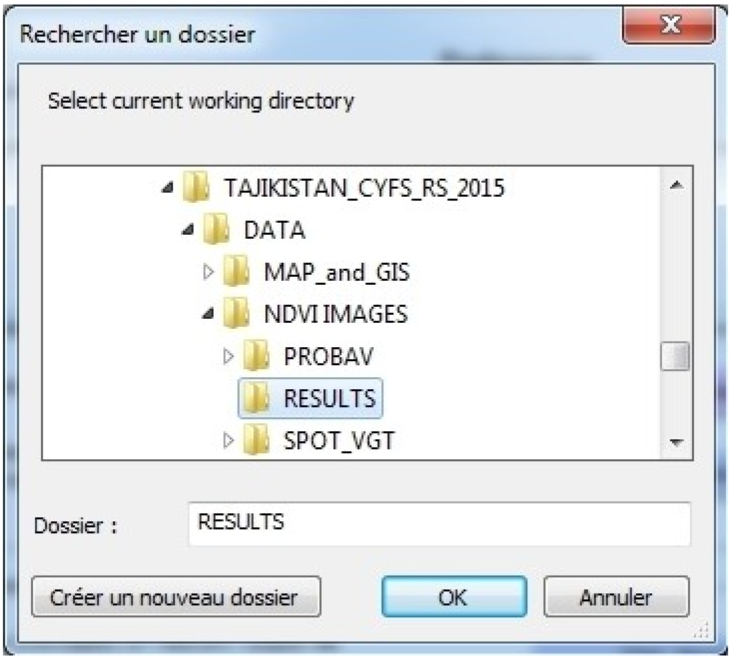


Figure 40: Defining the working directory in TIMESAT (in this case, the folder “RESULTS”).

10.4 Opening an image with TIMESAT (optional)

NDVI images can be opened and visualized in TIMESAT with the menu "TSM_imageview". This can be done to check that the images are correctly read by TIMESAT and to have an overview of them. This can also be used to visualize the output images of TIMESAT. To open and visualize one image:

- Go in "File > Open Image File" and browse to the image to be opened (stored in the folders "...\DATA\NDVI IMAGES\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN" or "...\DATA\NDVI IMAGES\PROBAV\TAJIKISTAN\PPT_OUT").
- Indicate the following settings into the "Format" rectangle (Figure 41)
    - **Image file type:** 8-bit unsigned integer
    - **Byte order:** Little endian
    - **No of rows in image:** 505
    - **No of columns:** 885
- Click on "Draw" button

The image should draw in the visualizing window as presented in the Figure 42.

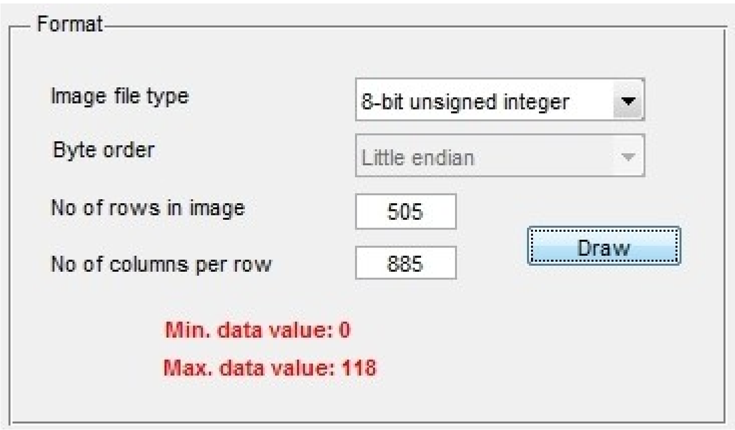


Figure 41: TIMESAT image viewer "format" window

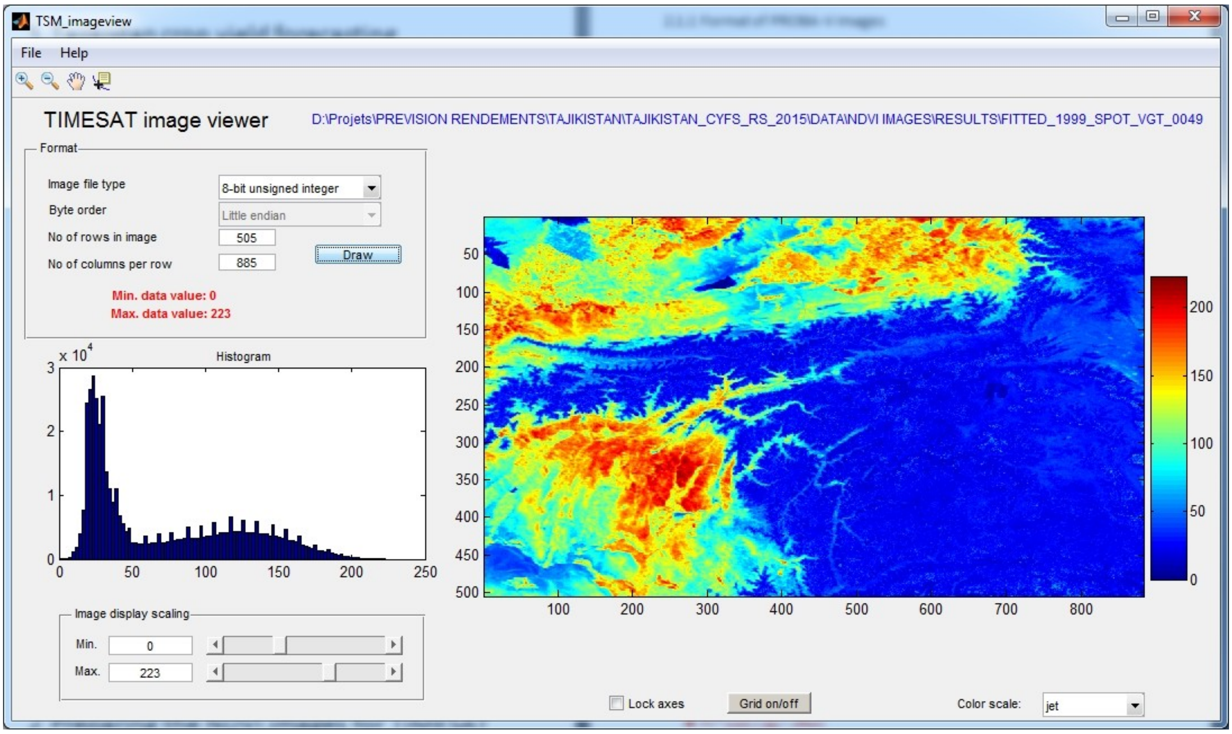


Figure 42: SPOT VEGETATION NDVI image of the first decade of May 1999 on Tajikistan in TIMESAT image viewer.

Zoom and colour scale can possibly be changed.

10.5 File names convention in TIMESAT

In TIMESAT, several file types are used regularly. In order to facilitate the database organization, it is suggested in this methodology (this is not compulsory for TIMESAT proper use) to respect a certain structure in the file names. A file name convention for the different file types of TIMESAT is proposed in the Table 3 below.

Type of file	E.g. for the 1999 SPOT_VGT images	E.g. for the 2008 METOP images	E.g. for the 2014 PROBA-V images
List file	LIST_FILE_1999_SPOT_VGT.txt	LIST_FILE_2008_METOP.txt	LIST_FILE_2014_PROBAV.txt
Settings file	SETTINGS_1999_SPOT_VGT.set	SETTINGS_2008_METOP.set	SETTINGS_2014_PROBAV.set
Job name in a settings file	1999_SPOT_VGT	2008_METOP	2014_PROBAV
.tts file	1999_SPOT_VGT_fit.tts	2008_METOP_fit.tts	2014_PROBAV_fit.tts
.tpa file	1999_SPOT_VGT_TS.tpa	2008_METOP_TS.tpa	2014_PROBAV _TS.tpa
Fitted (smoothed) NDVI images	FITTED_1999_SPOT_VGT	FITTED_2008_METOP	FITTED_2014_PROBAV
Season parameter images (e.g.: start)	start_1999_SPOT_VGT	start_2008_METOP	start_2014_PROBAV
Batch file (optional)	BATCH_TSF_process_SPOT_VGT_1999_2013.bat BATCH_TSF_fit2img_SPOT_VGT_1999_2013.bat BATCH_TSF_seas2img_SPOT_VGT_1999_2013.bat	BATCH_TSF_process_METOP_2008_2015.bat BATCH_TSF_fit2img_METOP_2008_2015.bat BATCH_TSF_seas2img_METOP_2008_2015.bat	BATCH_TSF_process_PROBAV_2014_2015.bat BATCH_TSF_fit2img_PROBAV_2014_2015.bat BATCH_TSF_seas2img_PROBAV_2014_2015.bat

Table 3: File names convention in TIMESAT

10.6 Opening an image using a list file (optional)

An image can also be opened by choosing it into a pre-built list file (page 44 of "TIMESAT 3.1 Software Manual"). The construction of a list file is presented in the next section. To open an image from a list file:

- Go in "File > Open File List > Open File List > browse to the list file of interest > click "open" > **select** in the list the image you want to open > click on "Close" > click on "Draw".

10.7 Creation of list files

10.7.1 Introduction to the list files

List file are used by TIMESAT to **find where the image series are stored**. List files are needed in TIMESAT for several things:

- Viewing an image by selection of the image in a list (confer section 10.6 above – optional).
- To use the **TSM_GUI** menu (mandatory)
- To use the **TSF_process** menu (mandatory)

List files are text files with the first line indicating the number of images in the list and the next ones indicating the directory to each of the images (confer page 41 and 74 of "TIMESAT 3.1 Software Manual" for more information on list files).

A list file can be created manually from a blank text file or by modification of an existing file, which is faster. In this case, some list files have already been created and are provided in the training package in the "RESULTS" folder under the name "LIST_FILE_...". It is advised to open these list files with "Notepad++".

10.7.2 Absolute and relative list files

Absolute list file

A list file can be "**Absolute**", meaning that each of his lines indicates the full directory (starting at directory's root) to the image (e.g.: "D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN\name_of_the_image.img").

Relative list file

A list file can be "**Relative**", meaning that the directories to the images are written **relatively to the TIMESAT working directory.** That's one of the reasons why it is **<u>very important to properly set the working directory</u>** when starting TIMESAT (cf. Section 10.3 for setting the working directory in TIMESAT).

For **example**,

- if the NDVI images are stored in the directory " D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN\", and that
- the TIMESAT working directory is "D:\Projets\PREVISION RENDEMENTS\TAJIKISTAN\TAJIKISTAN_CYFS_RS_2015\DATA\NDVI IMAGES\RESULTS\",
- the path to a given SPOT VEGETATION image in the list file will be "..\SPOT_VGT\EXTRACTED_SPOT_VGT_TAJIKISTAN\SPOT_VEGETATION_19990101_TAJIKISTAN.img".

Using a relative path has the **advantage** that you can move your "DATA" folder (to another computer for example) and the path to your images indicated in the list file will remain right provided that you choose the correct working directory when starting TIMESAT.

Figure 43 gives an example of a relative list file for METOP AVHRR NDVI images of 2008 with a triple annual repetition as explained in next section.

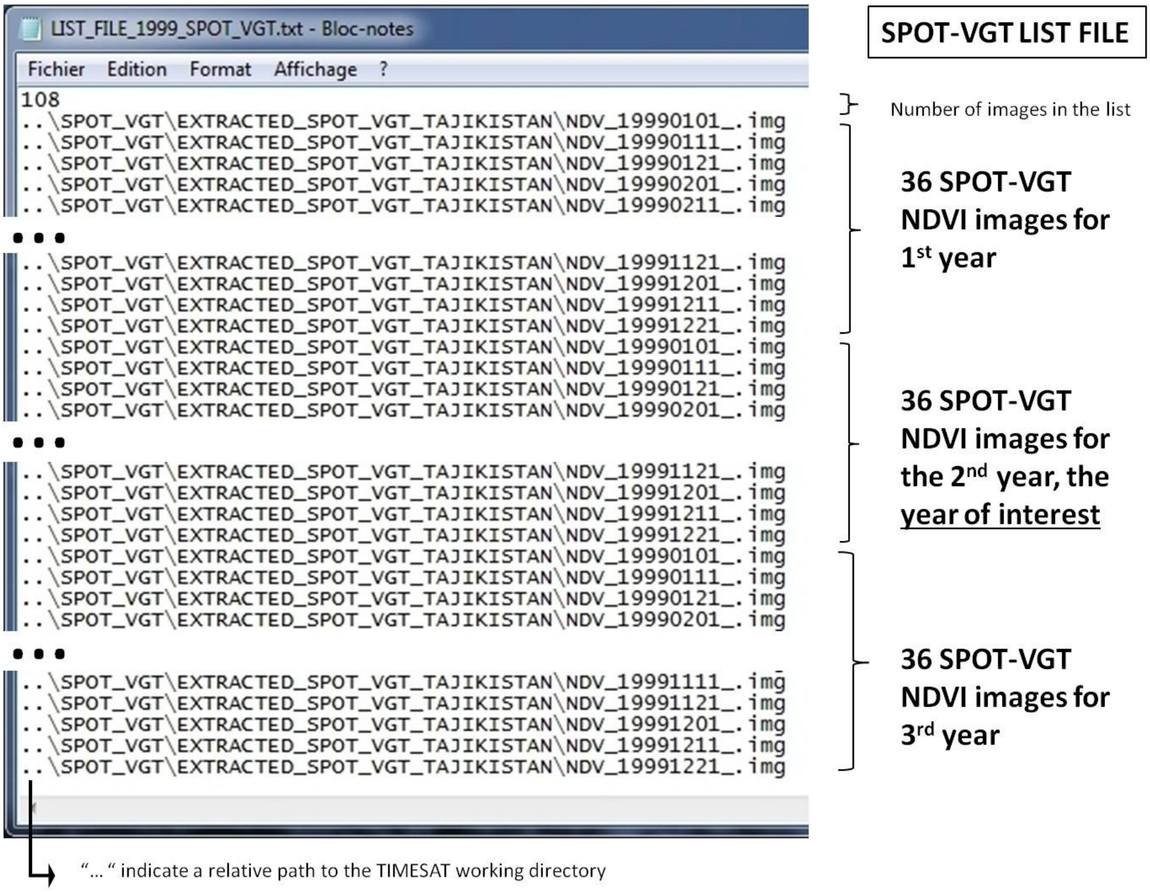


Figure 43: Example of TIMESAT list file for 108 SPOT VEGETATION images (triple annual repetition) with relative path

10.7.3 List file to process one year data with triple repetition

As indicated in the "TIMESAT3.1 Software Manual" at page 21, the extraction of seasonality parameters from one year data, when vegetation season peaks around the middle of the year, which is the case for Tajikistan, require the creation and use **of 2 artificial time series** to be placed **before and after the time series (year) of interest** (Figure 44).

The creation of 2 new time series by duplicating images can be avoided by the simple replication of 3 times the same 36 (in the case of decadal images) paths in the list file, as illustrated in Figure 43.

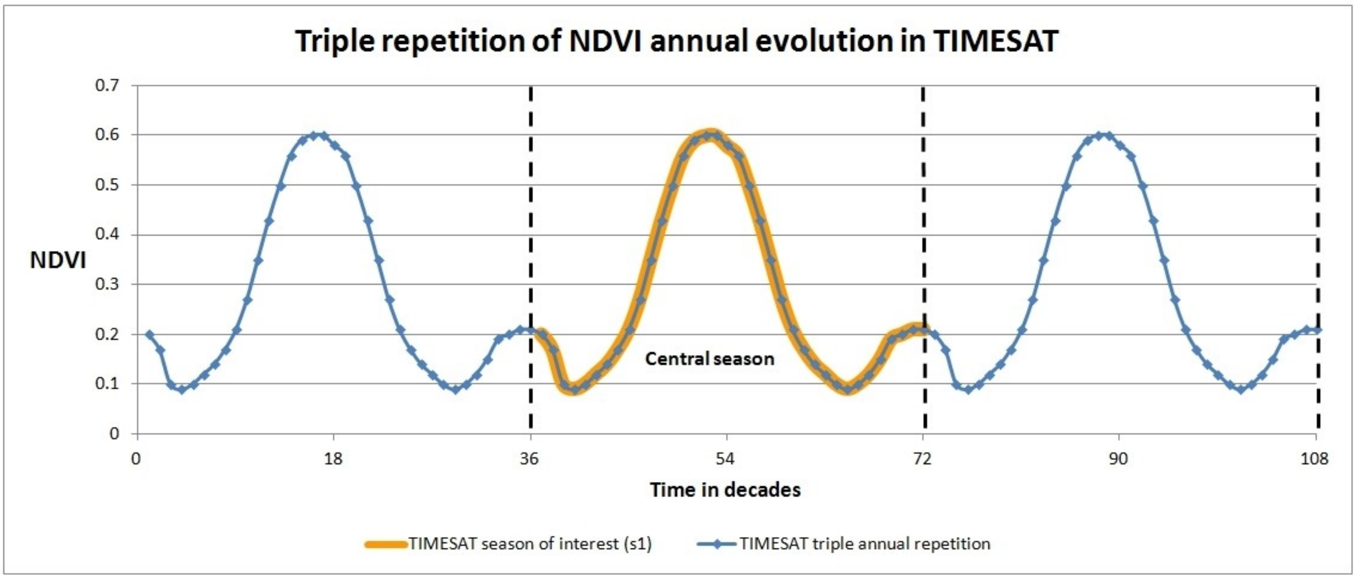


Figure 44: triple repetition of one annual NDVI evolution time series

10.7.4 Preparation of a list file database

In this case, relative list files (with triple annual repetition) have to be created for each year and stored in the “RESULTS” folder. Different list files can be created by duplication of existing list files and modification of their name and content. It is recommended to use the “replace” function of Notepad++ to modify their content. It is important to respect the filename convention presented in Table 3.

These list files will be used by the “TSF_process” (confer section 10.9).

Relative list file for long time series (e.g. 1999-2013) can also be created (without the annual triple repetition) in order to visualize the complete time series with “TSM_GUI” TIMESAT interface (confer section 10.8 below).

A set of relative list files is provided in the training package in the “RESULTS” folder under the name “LIST_FILE_....txt”.

10.8 TSM_GUI

10.8.1 TSM_GUI presentation

Several **inputs parameters** need to be set before TIMESAT can process NDVI images series by running the "TSF_process". These input parameters can be estimated optimally thanks to the program "TSM_GUI".

These parameters are described at the pages 24 to 30 and 74 to 77 of the "Timesat 3.1 Software Manual" and define, among other, the **NDVI smoothing method** and the method to compute **season parameters**. The "**TSM_GUI**" interface enables to visually adapt the settings to the situation analyzed by presenting the effect of the settings on the smoothed NDVI curve and season parameters values. Once found, optimal settings can then be recorded in "**Settings files**", which are small text files, listing the settings, and needed for the "**TSF_process**" application of TIMESAT.

Note:

- For detailed **description of the smoothing algorithms** refer to the section 3 of the "Timesat 3.1 Software Manual"
- TIMESAT enables to work with **land cover map** and **auxiliary quality data** as described in the "Timesat 3.1 Software Manual". The use of a land cover map can be useful to apply different settings to different land cover / areas. However, these options won't be used in this methodology and the same settings will be applied on the whole Tajikistan. A possible enhancement of the methodology could be to apply different settings to different crops or areas (depending on the climatic conditions for example). It is not sure however that such method would give better results in terms of CYF.

10.8.2 TSM_GUI utilization for settings definition

The detailed use of TSM_GUI is described at the pages 45 to 52 of the "Timesat 3.1 Software Manual".

10.8.2.1 TSM_GUI utilization for a long time series (optional)

In a first time (optional), TSM_GUI can be used to visualise the multi-annual NDVI evolution, for example for the period 1999-2013 for SPOT VEGETATION NDVI. To do that:

- In "TIMESAT menu system", click on TSM_GUI button. The TSM_GUI interface opens.

- Go in “Files > Open list of image files”. The “image_files_input” window opens (Figure 45).

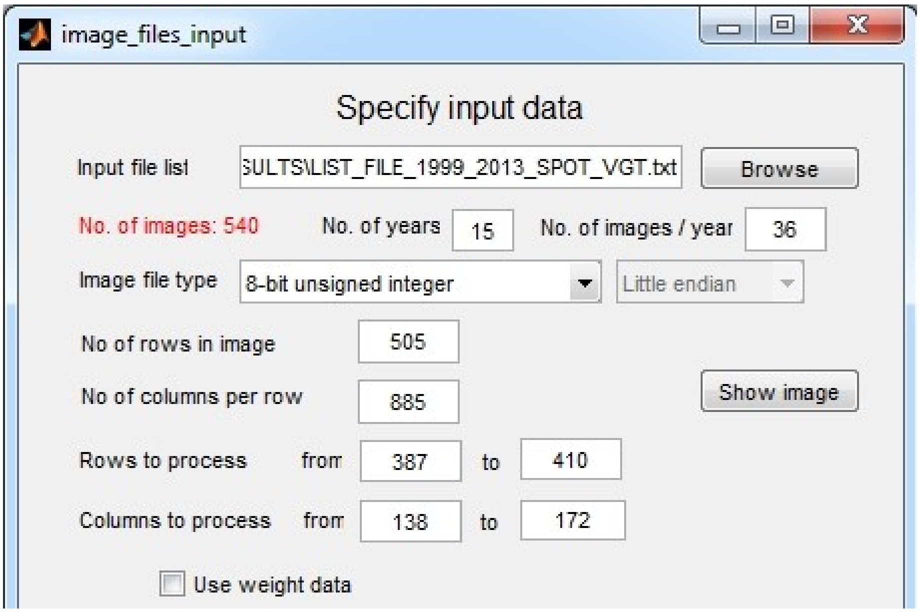


Figure 45: The “image_files_input” window of TSM_GUI with some parameters, in this case for the 15 years (1999 – 2013) of the SPOT_VGT images series

- In the “image_files_input” window, open the **list file** you want to visualize in TSM_GUI.
- Indicate the number of years and images per year, in this case, 15 years with 36 images per year
- The image file type is “**8-bit unsigned integer**”
- The number of rows is **505** and the number of columns is 885.
- Click on “**Show image**” button and the “**Figure Window**” opens as in the Figure 46.

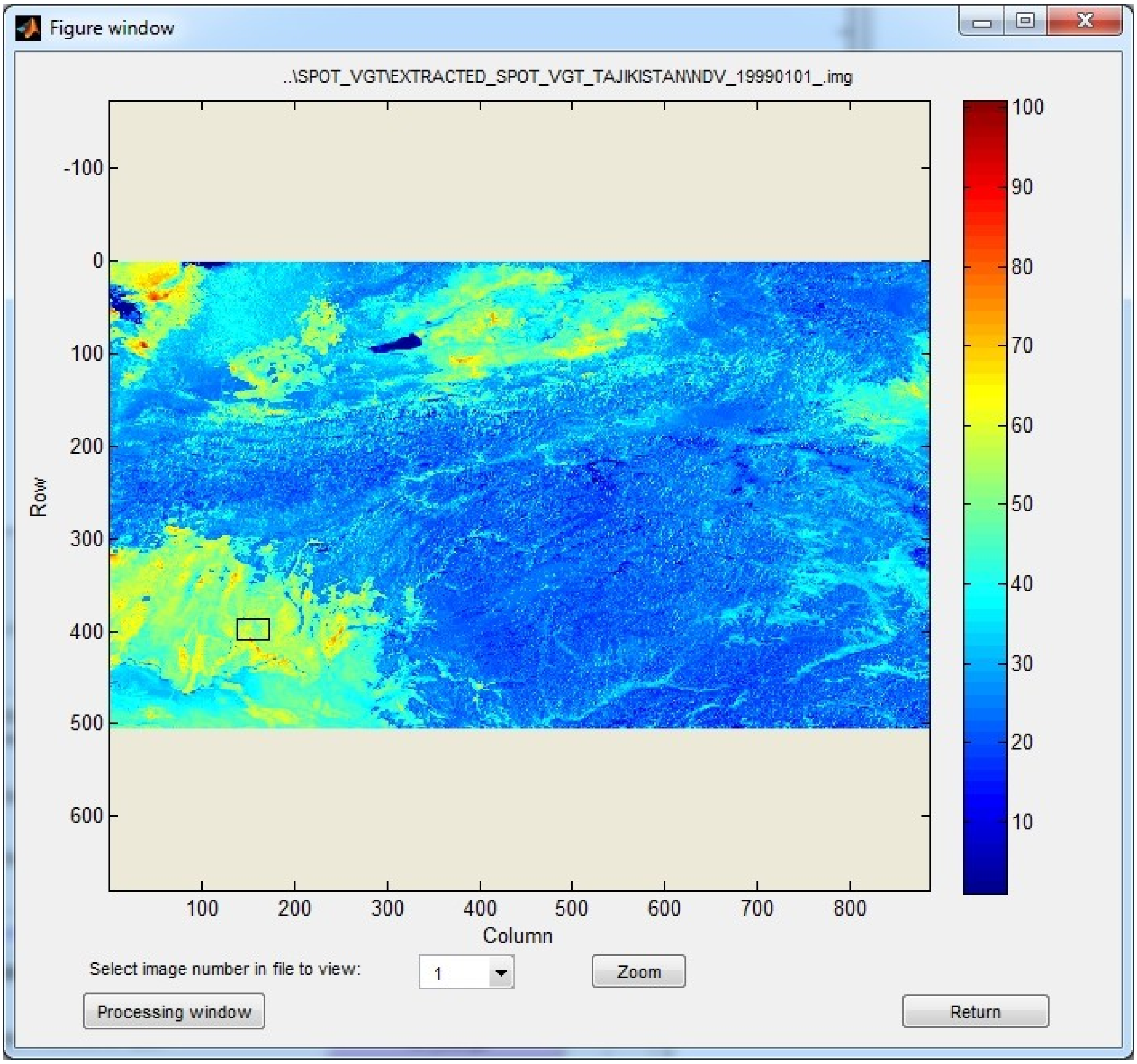


Figure 46: Figure window of TSM_GUI

- The "**Processing window**" button enables to define a subwindow that identifies the pixels that will be the base for the settings definition in TSM_GUI main interface. Select a small pixels window that is representative of the crop areas of Tajikistan.
- Click on the "**Return**" button. You come back to the "image_files_input" window.
- The "**Rows and columns to process**" values are added in the interface according to the window you defined in the "Figure Window".
- Don't use "**Weight data**" (leave the box unchecked).
- Click on the "**Load data**" button. The TSM_GUI interface will present the complete NDVI time series (199-2012) for the first pixel of the window identified in the "Figure Window" above (Figure 47).

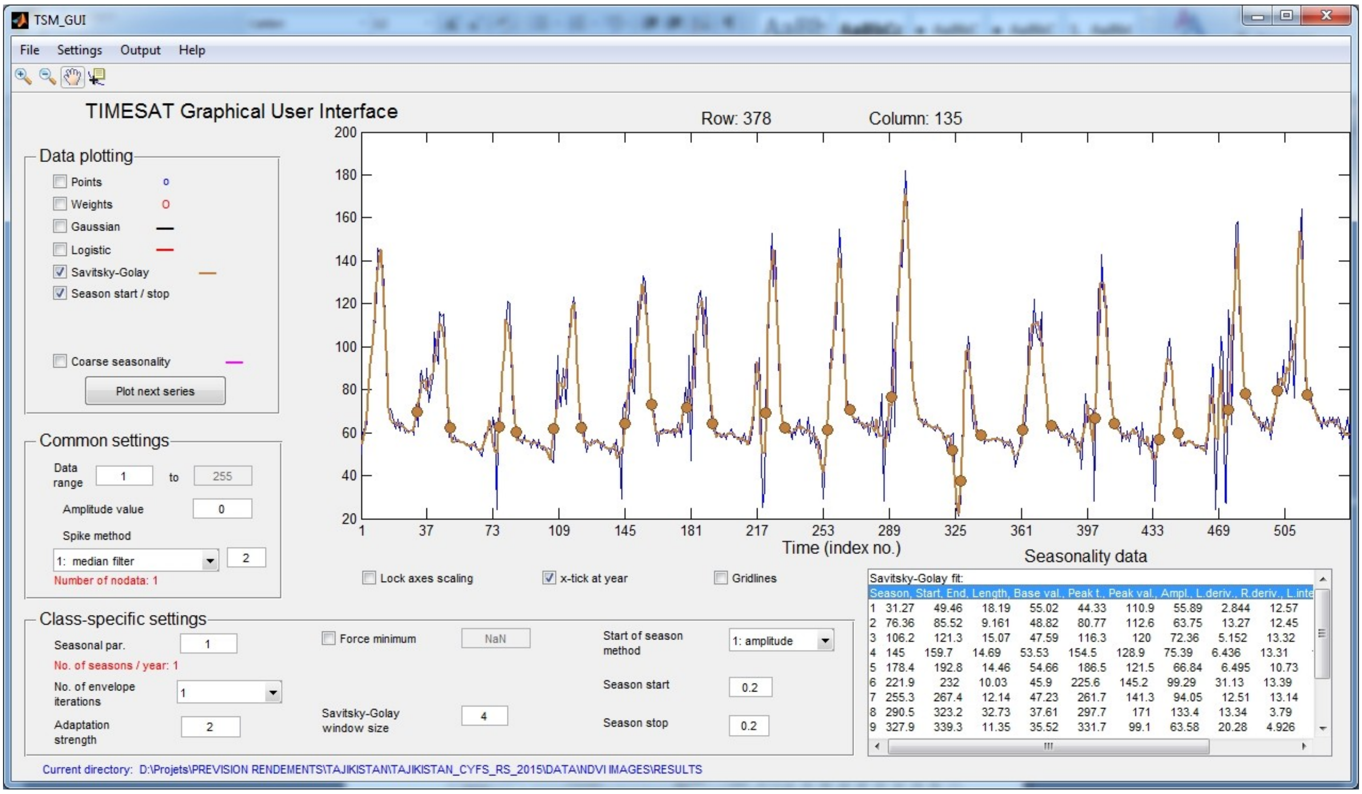


Figure 47 : SPOT VEGETATION NDVI evolution for the period 1999-2013 in TSM_GUI for a given pixel in Tajikistan.

- Click on the "**Plot next series**" button to visualise the NDVI evolution for the next pixel in the window defined previously.
- Note that the **season parameters**, for the considered pixel, for each year, are presented in the lower-right corner of the interface.

For other options of the TSM_GUI window, confer the next section.

10.8.2.2 TSM_GUI utilization for one year series (mandatory)

In a second time (mandatory), TSM_GUI can be used on **one year data** to **define the right settings** for NDVI temporal smoothing and season parameters extraction.

With the same process than the one described in the previous section, open, this time, a **one year data** list file that contains a **triple repetition of one year** (108 images = 3 * 36 decadal images). The number of year will thus be 3 and the graph window will present 3 times the same curve (Figure 48).

Adapt the different settings in order to find the best fit (smoothing) to the NDVI raw data and to extract at best the season parameters. There is no general rule for identifying the best settings and the operators is encouraged to take an **experimental approach** by testing different settings. Note that it is really important that the pixels used in TSM_GUI to define the settings have to be representative of all the pixels that will be considered by the TSF_process using these settings (confer section 10.8.2.3 for a settings suggestion).

For "**recommended" settings for Tajikistan, confer next section**.

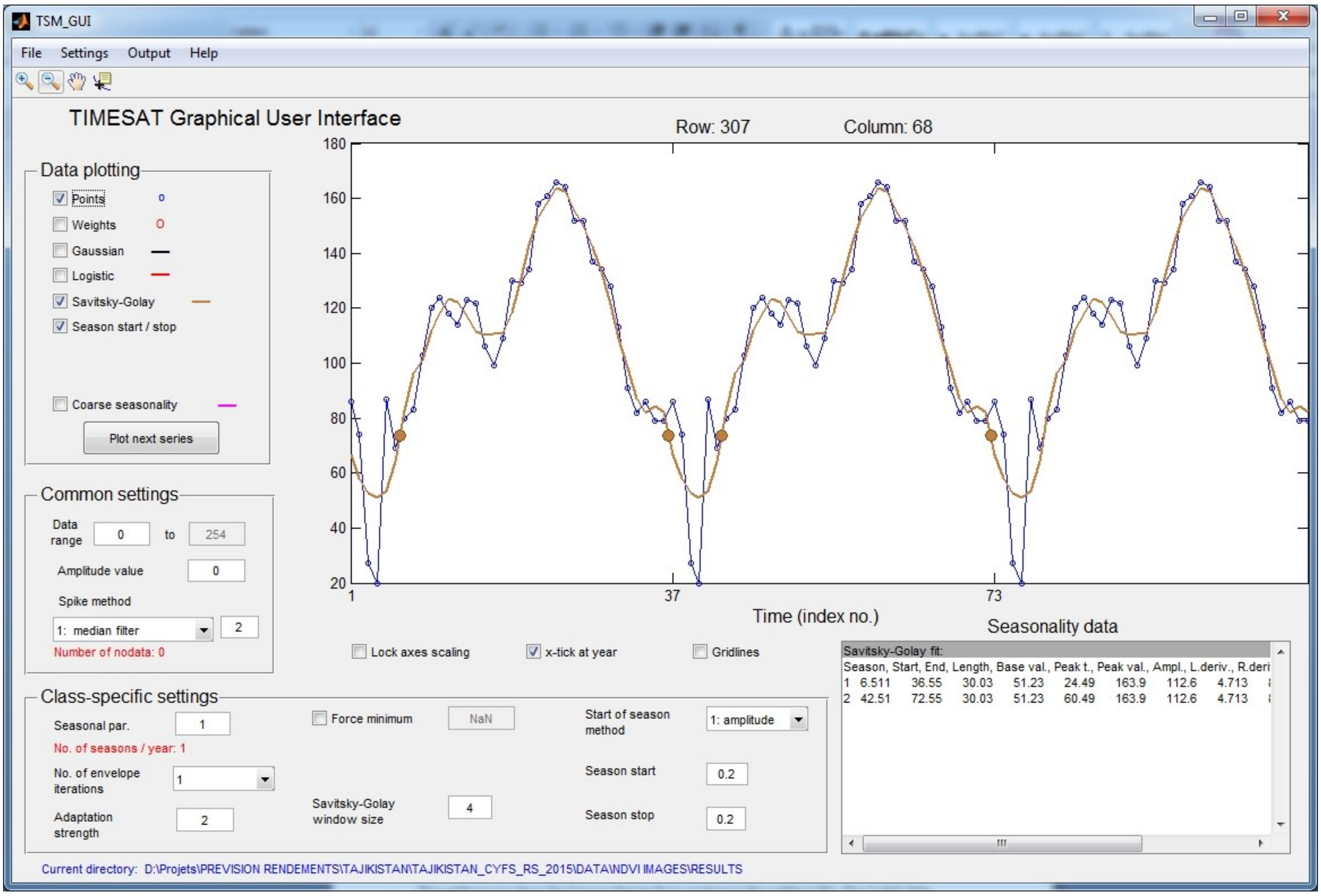


Figure 48: TSM_GUI settings for Tajikistan for PROBA-V images for a triple repetition of a 1 year time-series.

Once the operator has adjusted the right settings in the TSM_GUI, the settings have to be saved into a "**settings file**". To save the settings in a settings file:

- Go in "Settings > Save to settings file". And the "TIMESAT input settings tool" opens (Figure 49).
- The settings defined in the TSM_GUI are already present in the "TIMESAT input settings tool". **Complementary settings**, not present in the TSM_GUI, have to be adjusted. These are described in the next section 10.8.2.3.

Once all the settings are completed,

- Go in "File > **Save settings file as**" and browse to the "RESULTS" folder (which is the working directory) and name the settings file according to the **file name convention** presented in the Table 3 above (e.g.: "SETTINGS_1999_SPOT_VGT.set").

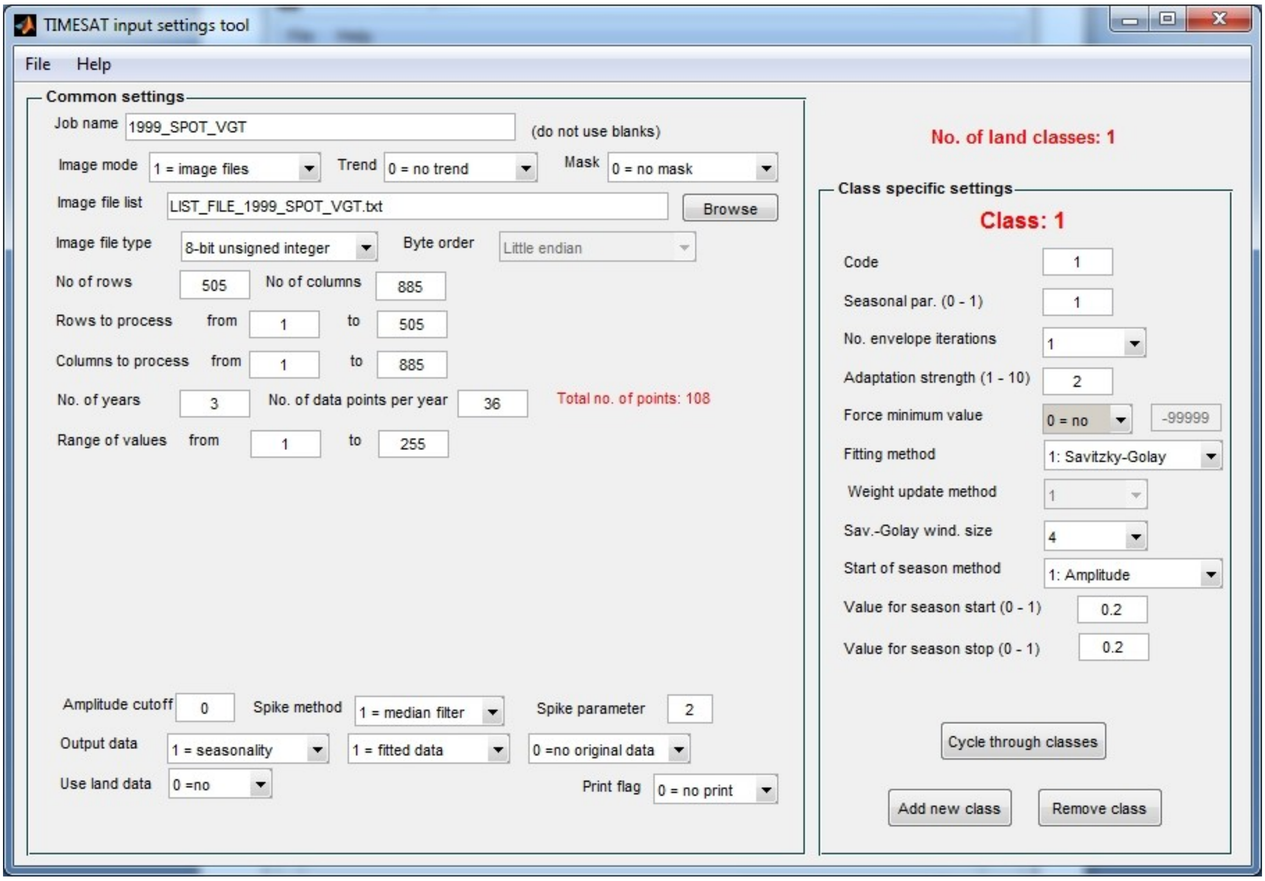


Figure 49: TIMESAT input settings tool with proposed parameters value for Tajikistan for SPOT VEGETATION images

The settings file is a simple text file that can be opened and modified with software such as “Notepad++” (Figure 50).

SETTINGS_1999_SPOT_VGT.set

```
1999_SPOT_VGT  %Job_name (no blanks)
1                %Image /series mode (1/0)
0                %Trend (1/0)
0                %Use mask data (1/0)
LIST_FILE_1999_SPOT_VGT.txt  %Data file list/name
dummy  %Mask file list/name
1                %Image file type
0                %Byte order (1/0)
505 885       %File dimension (nrow ncol)
1 505 1 885  %Processing window (start row stop row start col stop col)
3 36             %No. years and no. points per year
1 255       %Valid data range (lower upper)
-1e+006 1e+006 1         %Mask range 1 and weight
-1e+006 1e+006 1         %Mask range 2 and weight
-1e+006 1e+006 1         %Mask range 3 and weight
0                %Amplitude cutoff value
0                %Print functions and weights (1/0)
1 1 0            %Output files (1/0 1/0 1/0)
0                %Use land cover (1/0)
  %Name of landcover file
1                %Spike method
2                %Spike value
1                %No. of landcover classes
************
1                %Land cover code for class  1
1                %Season parameter
1                %No. of envelope iterations (1-3)
2                %Adaptation strength (1-10)
0 NaN            %Force minimum (1/0) and value
1                %Fitting method (1-3)
1                %Weight update method
4                %Window size for Sav-Gol.
1                %Season start method
0.2 0.2          %Season start / stop values
```

Figure 50: a settings file as opened with Notepad++ for the 1999 SPOT VEGETATION series

10.8.2.3 Settings proposal for Tajikistan (description of the settings file)

Some very quick and rough tests have already been carried out on NDVI time series for Tajikistan and **settings for Tajikistan are proposed and justified in the Table 4 below**. However, note that this is the result of a very quick and rough tests and that some settings could maybe be enhanced through further study. No sensitivity study of these settings on the CYF accuracy has been carried out yet.

The settings are described according to their ranking in the settings file. The “valid data range setting” is different for **SPOT VEGETATION** and **METOP AVHRR** images, as explained in the Table 4. Settings are described at the page 24 to 31 and 74 to 77 of the “Timesat 3.1 Software Manual”.

Row	Parameter	Parameter value			Justification
		SPOT_VGT	METOP	PROBA-V	
1	Job name	1999_SPOT_VGT	2008_METOP	2014_PROBAV	Confer the “file name convention” in Table 3, page 76
2	Image/series mode (1/0)	1	1	1	This method uses images
3	Trend (1/0)	0	0	0	Option not in use. Confer the “Timesat 3.1 Software Manual”
4	Use mask/quality data (1/0)	0	0	0	This method doesn’t use mask or quality data
5	Data file list/name	LIST_FILE_1999_SPOT_VGT.txt	LIST_FILE_2008_METOP.txt	LIST_FILE_2014_PROBAV.txt	Confer the “file name convention” in Table 3*
6	Mask/Quality file list/name	dummy	dummy	dummy	As this method doesn’t use mask or quality data, any dummy name can be set
7	Image file type	1	1	1	Images are 8-bit unsigned integer
8	Byte order (1/0)	0	0	0	Images are in little endian byte order
9	Image dimension	**505 885**	**505 885**	**505 885**	Dimension of the images for Tajikistan
10	Processing window	**1 505 1 885**	**1 505 1 885**	**1 505 1 885**	The whole image has to be processed
11	Years and points per year	**3 36**	**3 36**	**3 36**	**Years**: always “3” as 3 times the same annual time series has to be used in TIMESAT list files in order to process an individual year (Confer the “Timesat 3.1 Software Manual” at page 21.) **Points per year**: 36 as this method uses decadal images.
12	**Valid Data Range (VDR)**	**1 255**	**0 250**	**0 254**	**Confer section “9. Valid data range during the process”**
13	Mask/Quality range 1 and weight	-1e+006 1e+006 1	-1e+006 1e+006 1	-1e+006 1e+006 1	This is the default value when no mask / quality data is used
14	Mask/Quality range 2 and weight	-1e+006 1e+006 1	-1e+006 1e+006 1	-1e+006 1e+006 1	This is the default value when no mask / quality data is used
15	Mask/Quality range 3 and weight	-1e+006 1e+006 1	-1e+006 1e+006 1	-1e+006 1e+006 1	This is the default value when no mask / quality data is used
16	Amplitude cutoff value	0	0	0	As no study has been carried out to decide if some low amplitude series should not be

					processed, 0 is used in order to process all series
17	Print functions and weights / Debug (1/0)	0	0	0	In order not to print debug data (recommended)
18	Output files (1/0 1/0 1/0)	1 1 0	1 1 0	1 1 0	In order to print seasonality data and fitted function but not the original time-series.
19	Use land cover (1/0)	0	0	0	As this method doesn't use any land cover file
20	Name of land cover file				Empty as this method doesn't use any no land cover file
21	Spike method (3/2/1/0)	1	1	1	The median filter seems to be an appropriate method
22	Spike value	2	2	2	2 seems to be an appropriate value
23	No. of land cover classes	1	1	1	As this method doesn't use any land cover map
24	Separator	********	********	********	The separator
25	Land cover code for class 1	1	1	1	As this method doesn't use any land cover map
26	Seasonality parameter	1	1	1	As there is just one season per year in Tajikistan**
27	No. of envelope iterations 1,2,3	1	1	1	If a value higher than 1 is used it seems that the small "second" season* is completely smoothed**
28	Adaptation strength (1-10)	2	2	2	Value of 2 is normal. It seems that this value is acceptable
29	Force to minimum (1/0) and value of minimum	0	NaN	NaN	No apparent reason for forcing a minimum value
30	Fitting method (3/2/1)	1	1	1	The Savitzky-Golay filtering method seems the most appropriate***
31	Weight update method	1	1	1	As indicated in the "Timesat 3.1 Software Manual"
32	Window for Savitzky-Golay	4	4	4	4 seems to be an appropriate value
33	Season start method (2/1)	1	1	1	The proportional method seems to be the most appropriate
34	Season start / end values	0.2 0.2	0.2 0.2	0.2 0.2	0.2 seems to be an appropriate value
35 – 45	Data for class 2				Empty as this method doesn't use any land cover map
…	…				

Table 4: settings proposal and justification for SPOT VEGETATION, METOP AVHRR and PROBA-V images for Tajikistan

Comments on some settings

* **Data file list/name:** the default "data file list/name" (when recorded by TSM_GUI) is a full (absolute) path (from the disc root to the list file). However this long path can be shortened to the "file list name" only without any directory before, at the condition that the list file is stored in the working directory, in this case the folder "RESULTS". It is advised to the user to follow this technique (Figure 50).

** **Number of season per year in Tajikistan:** observation of annual NDVI evolution curve in Tajikistan revealed, for a non negligible proportion of pixels, the presence of a secondary NDVI maximum before or after the main maximum in the central season (Figure 48) depending on the areas. For some pixels a very small 2nd season is also sometimes observed after the central season, just before the winter. Hypothesis for explanation is a possible re-growth of the vegetation after crop harvest and before bad season. These features are however not considered as real second vegetation season for TIMESAT processing.

*** **Fitting method:** the Savitzky-Golay filtering method seems the most appropriate as it is the method that best fit the data. The 2 other methods seem to smooth too much the NDVI profile and consequently reduce the accuracy of the season parameter computed from the NDVI curve.

Notes on the use of TSM_GUI

- It is primordial **to keep, for a given region, the same settings for all the years**. Settings could possibly vary according to region. This option is possible in TIMESAT by using a land cover file, but won't be used in this method (confer section 10.8.1).
- In a "triple annual repetition" time-series, TSM_GUI identifies the 2 "center-most" seasons only (Figure 48). Depending on the pixels, it can be year 1 and 2 or year 2 and 3.

10.8.2.4 Preparation of the settings files database

One settings file has to be created for each year to process. Rather than to create them with TSM_GUI, it is easier to **duplicate** an existing settings file (copy/paste) and to **edit** the copy. The modifications to apply to each settings file are:

- The name of the settings file itself (confer the file names convention in Table 3)
- The "Job name" (confer the file names convention in Table 3)
- The "Data file list/name" (confer the file names convention in Table 3)
- The "Valid data range (lower upper)", depending on the sensor type, SPOT VEGETATION or METOP AVHRR (confer the Table 4)

The settings files have to be placed in the "**RESULTS**" folder.

A set of settings files is provided in the training package in the "RESULTS" folder under the name "SETTINGS_....set".

10.9 TSF_process (Data processing)

The TSF_process is the **central application** of TIMESAT. It computes:

1. the **smoothed NDVI**
2. the **season parameters**

To **execute the TSF_process** (one execution per year to process),

- Click on the "TSF_process" button of "TIMESAT menu system"
- Browse to the settings file for the year you want to process.

TIMESAT will then launch the TSF_process.

- **Inputs** of the TSF_process are the **settings files**. Note that the settings files call, in turn, the **list files**. When using relative path, list files and settings files have to be in the working directory, in this case the "RESULTS" folder.
- **Outputs** of the TSF_process are the 2 packages:
    - **"jobname_fit.tts" :** file containing the time-series constructed from the fitted functions (for the smoothed NDVI images)
    - **"jobname_TS.tpa":** file containing the season parameters

The TSF_process can take quite a **long time** to execute, depending on the size of the area to process and on your computer power (e.g.: 30 minutes for 1 year of images on the whole Tajikistan extent with a good computer, i.e.8h30 for 17 years data).

Files "jobname_fit.tts" and "jobname_TS.tpa" are described in detailed at the page 31 of the "Timesat 3.1 Software Manual". These files are not directly readable and TIMESAT propose a series of tools to have access to the information contained in these 2 files packages. These tools are presented in the next sections. Only 2 of these tools are necessary for this method:

- "**TSF_fit2img**": produces the temporally smoothed images (needed for the NDVI cumuli computation)
- "**TSF_seas2img**": produces the season parameters images

Non necessary tools have the mention "(optional)" in their respective section titles below and are given as information.

10.10 TSM_fileinfo (optional)

The "TSM_fileinfo" tool provides some basic information on the TIMESAT ".tts" and ".tpa" files. To use the "TSM_fileinfo" tool,

- Click on the "TSM_fileinfo" button of the "TIMESAT menu system
- Browse to the ".tts" or ".tpa" file that you want information on

The "fileinfo" window will open as illustrated at Figure 51 and Figure 52 below. On METOP AVHRR images some water bodies are identified. On SPOT VEGETATION images these water bodies are not identified. This depends of the valid data range of both sensors which differs.

☞ For more information on the "TSM_fileinfo" tool confer the pages 52 and 69 of the "Timesat 3.1 Software Manual".

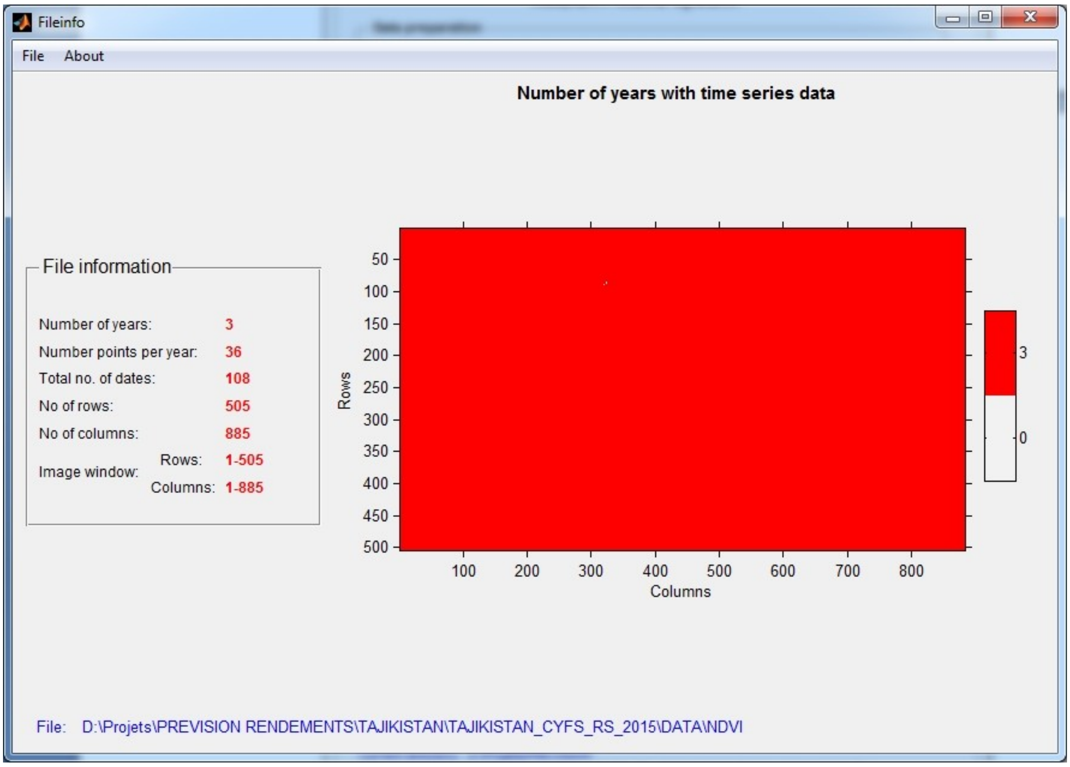


Figure 51: Fileinfo window for a ".tts" file for a SPOT VEGETATION image

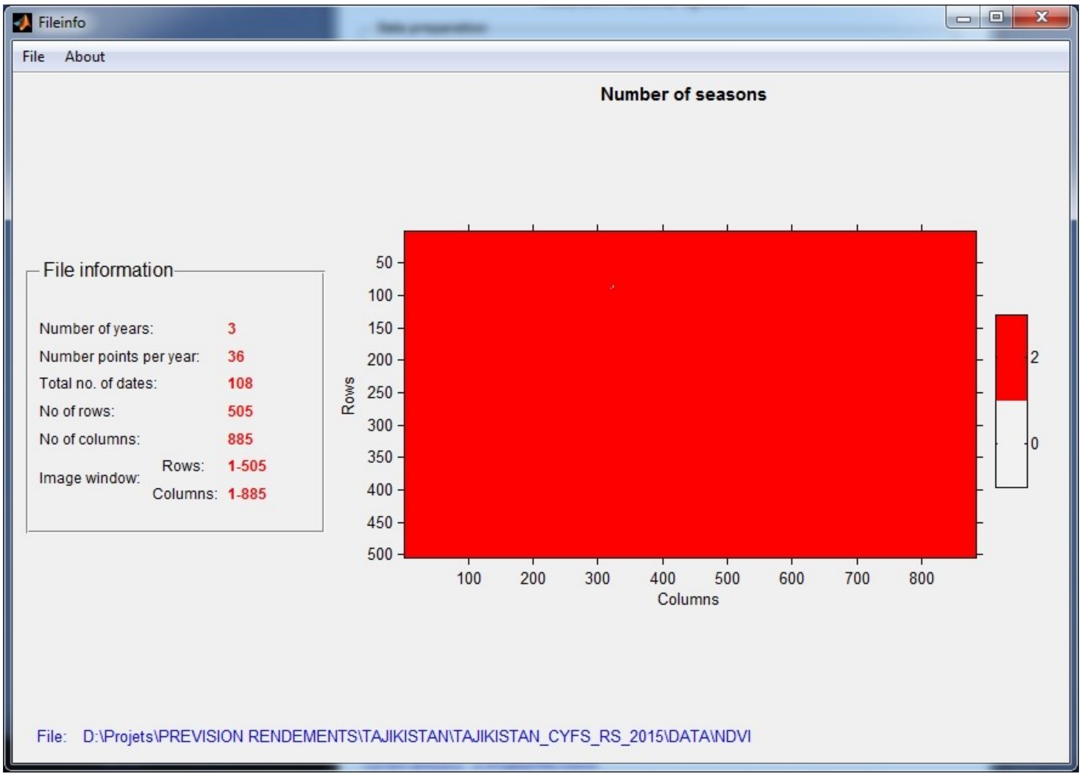


Figure 52: Fileinfo window for a ".tpa" file for a SPOT VEGETATION image

10.11 TSM_printseasons (optional)

The "TSM_printseasons" tool enables to view the **season parameters values** for selected pixels. To use the "TSM_fileinfo" tool,

- Click on the "TSM_printseasons" button of the TIMESAT menu system
- Browse to the ".tpa" file you are interested in
- Go to the command line window and follow the indications.

At the end of the process the "TSM_printseasons" tool will provide the season's parameters values for the founded seasons of selected pixels as illustrated at Figure 53 below.

☞ For more information on the "TSM_printseasons" tool confer the pages 52 and 70 of the "Timesat 3.1 Software Manual".

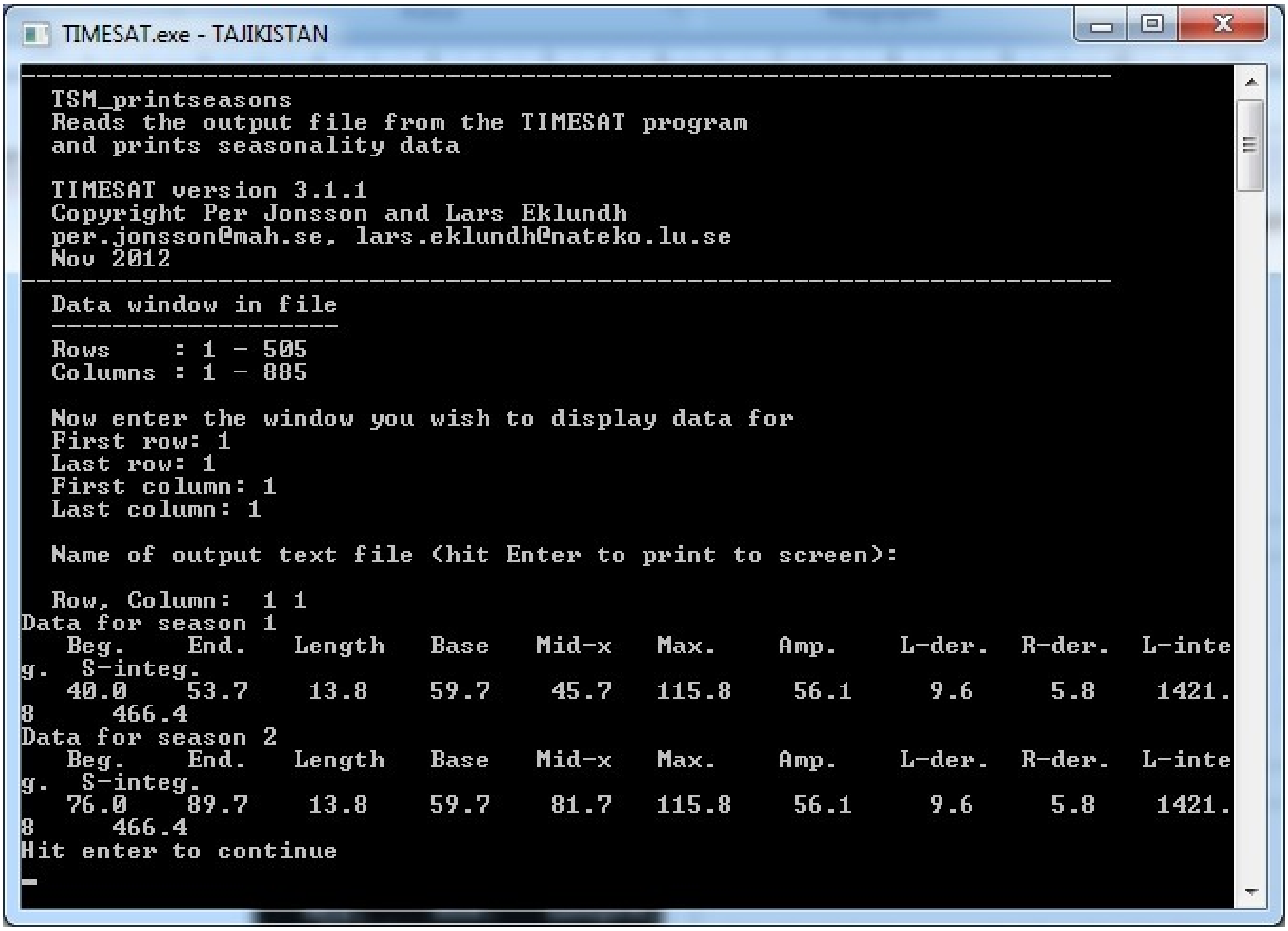


Figure 53: TSM_printseasons command line window with season parameters values for the founded seasons of a selected pixel.

10.12 TSM_viewfits (optional)

The “TSM_viewfits” tool enables to view the **original and smoothed (fitted) NDVI curve** for selected pixels. To use the “TSM_fileinfo” tool,

- Click on the “TSM_viewfits” button of the TIMESAT menu system
- Go to the command line window and follow the indications.

At the end of the process the “TSM_viewfits” tool will display a graph illustrating the NDVI evolution curve for the selected period and pixels as illustrated at Figure 53 below.

☞ For more information on the “TSM_viewfits” tool confer the pages 54 and 70 of the “Timesat 3.1 Software Manual”.

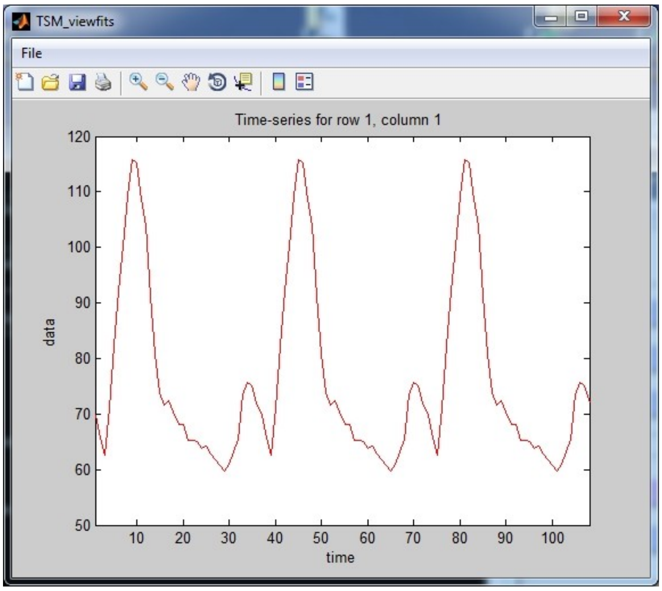


Figure 54: TSM_viewfits window presenting the NDVI temporal evolution curve of a given pixel for the “triple repetition” of one year NDVI time-series

10.13 TSF_fit2img

The "TSF_fit2img" tool generates the **temporally smoothed NDVI images**. To use the "TSF_fit2img" tool,

- Click on the "TSF_fit2img" button of the TIMESAT menu system
- Browse to the ".tts" file you are interested in and click "Open"
- Go to the command line window and follow the indications. The Table 5 below indicates the parameter value to use with the "TSF_fit2img".

Parameters	Parameter values and justification
Fitted data file name (".tts")	E.g.: 1999_SPOT_VGT_fit.tts **Confer** the filename convention presented in Table 3
Code **to give** to missing pixels	0 Propose to use 0 as 0 is the flag value in the SPOT_VGT images. Although 0 is a valid value for METOP AVHRR and PROBA-V, it seems better to indicate the same code for both SPOT_VGT and METOP in order to have comparable output files. Beside there is probably no / few pixel with 0 value in NDVI images.
Name of output files (no extension!)	E.g.: FITTED_1999_SPOT_VGT **Confer** the filename convention presented in Table 3
File type for the output image	1 1 = 8-bit binary type. This type is selected because it is the data type of the original NDVI SPOT VEGETATION and METOP input images and output smoothed images will have to be imported in WinDisp that reads 8-bit binary image only
Image no. to map	-1 This will creates smoothed images for all images of the ".tts" file. Note that currently it is not possible in TIMESAT to select a range of images to process. Operator has to choose between 1 or all images.

Table 5: "TSF_fit2img" parameters values and justification

- The "TSF_fit2img" process is really fast and all 108 smoothed images will be recorded in the working directory for each year processed.
- Only images of the second season, images from 37 to 72, have to be kept. All other images (1 to 36 and 73 to 108) have to be deleted (manually) to free disc space.

☞ For more information on the "TSF_fit2img" process confer the pages 56 and 71 of the "Timesat 3.1 Software Manual".

"TSF_fit2img" process has to be run for each year. However it can also be run in **command line with a batch file**. Here is an example of command line instruction to use for Tajikistan (confer the section 10.16 about batch file in TIMESAT):

- …\TSF_fit2img.exe 1999_SPOT_VGT_fit.tts 0 FITTED_1999_SPOT_VGT 1 -1

10.14 TSF_seas2img

The "TSF_seas2img" tool generates the **season parameters images, i.e. 11 images per year**. To use the "TSF_seas2img" tool,

- Click on the "TSF_seas2img" button of the TIMESAT menu system
- Browse to the ".tpa" file you are interested in and click "Open"
- Go to the command line window and follow the indications. The Table 6 below indicates the parameter value to use with the "TSF_seas2img".

Parameter	Parameter value and justification
Season data file name (".tpa")	E.g.: 1999_SPOT_VGT_TS.tpa **Confer** the filename convention presented in Table 3
Seasonal parameter to output	E.g.: 1 This will produce the "start of the season" image. "TSF_seas2img" process has to be repeated for 11 season parameters, from 1 to 11.
Somewhat wider interval than the dates between which the season of interest is expected to occur.	25,80 These values seem to fully encompass the second season (the one of interest) in the "triple annual repetition" time-series (108 images).
Code to put if season is not found between min and max dates	0
Code for missing pixel for other reason	0
Name to append to the output files	E.g.: start Give a name corresponding to the season parameter being processed (proposed names are given in Table 8, column 1, below)

Specify the file type for the output image files (2 or 3)	2 2 = 16-bit signed integer (values will be rounded to nearest integer). 8-bit format is not available. 16-bit season images will have to be converted to 8-bit during the importation in WinDisp. 32-bit format is not supported by WinDisp.

Table 6: "TSF_seas2img" parameters values and justification

- The "TSF_seas2img" process is really fast and 2 "start season images" will be recorded in the working directory for each year processed (section "TSF_seas2img: Creating an image from the seasonality data" of TIMESAT manual, page 58):
  - **Image with "s1"** extension for the **1st season of the central year** (year 2 in the triple annual repetition (Figure 44)), which is the image to be considered in this methodology
  - **Image with "s2"** extension for the **2nd season of the central year** (year 2 in the triple annual repetition(Figure 44)). In the case of Tajikistan, as there is only 1 season per year, the "s2" image will be mainly composed of pixel with the code for missing season, i.e. 0 in this manual. This images "s2" is useless.

Remarque on the season number as identified in TIMESAT When considering a "triple annual repetition" NDVI time-series in Tajikistan, • In **TSM_GUI and TSM_print_seasons**, the 2 identified seasons (among the triple annual repetition) are the 2 "center most" seasons (confer TIMESAT manual section 4.1). Depending of the pixels and vegetation behaviour in these locations, and in the case of 1 season per year, it can be during year 1 and 2 OR year 2 and 3.

Table 7: Remarque about the season's number as identified in TIMESAT

☞ For more information on the "TSF_seas2img" process confer the pages 57-58 and 71-72 of the "Timesat 3.1 Software Manual".

"TSF_seas2img" process has to be run for each year and season parameter. However it can also be run in **command line with batch file**. Here is an example of command line instruction to use for Tajikistan (confer the section 10.16 about batch file in TIMESAT):

… \TSF_seas2img.exe 1999_SPOT_VGT_TS.tpa 1 25 80 0 0 start_1999_SPOT_VGT 2

Table 8 presents the range of season parameters values as observed on "TSF_seas2img" outputs for 1999 SPOT VEGETATION time series on Tajikistan. It is useful to know these value ranges in order to know what conversion factor to apply when importing in WinDisp which handle only 8-bits data, i.e. data in the [0-255] value range (confer section 11.3.2.1). Note that some (very few) negative values are observed for the 2 parameters “Increase” and “Decrease”, which is not explained. “Large” and “Small” season parameters are the only 2 season parameter to have values higher than 255.

Season parameter	Value range for 1999 SPOT VEGETATION images on Tajikistan
Start	0 to 67
End	0 to 80
Length	0 to 35
Base	0 to 94
Middle	0 to 81
Max	0 to 242
Ampli	0 to 235
Increase	-15 to 61 (but mostly positive)
Decrease	-11 to 41 (but mostly positive)
Large	0 to 4512
Small	0 to 3480

Table 8: Range of season parameters values as observed on “TSF_seas2img” outputs from 1999 SPOT VEGETATION images on Tajikistan

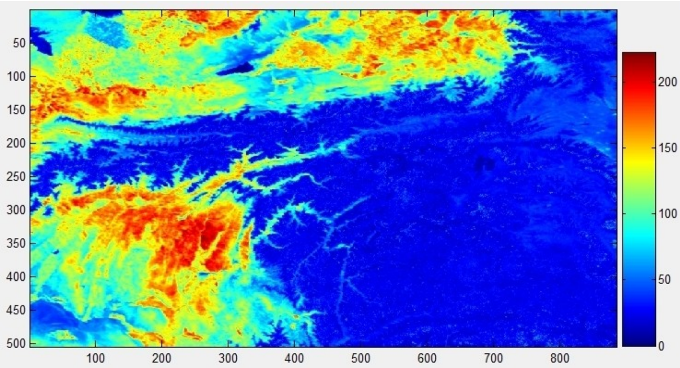
10.15 Viewing smoothed NDVI and season parameters images with “TSM_imageview” (optional)

The smoothed NDVI images and the season parameters images can be visualized in TIMESAT with the “TSM_imageview” tool. Figure 55 gives an overview of TIMESAT output images for **SPOT VEGETATION 1999** time-series.

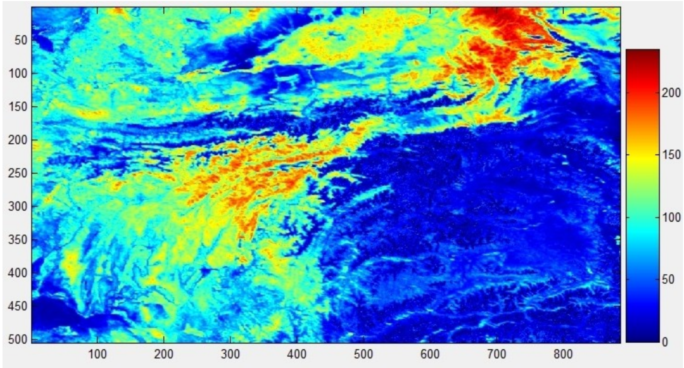
Note that some histogram graph present unexplained shape for certain parameters:

- “Ampli” and “Maximum” season parameters graphs have a jagged behaviour
- “Middle” and “Start” season parameters graphs have some gaps (missing columns)
- “Increase” and “Decrease” season parameters graphs have some negative values

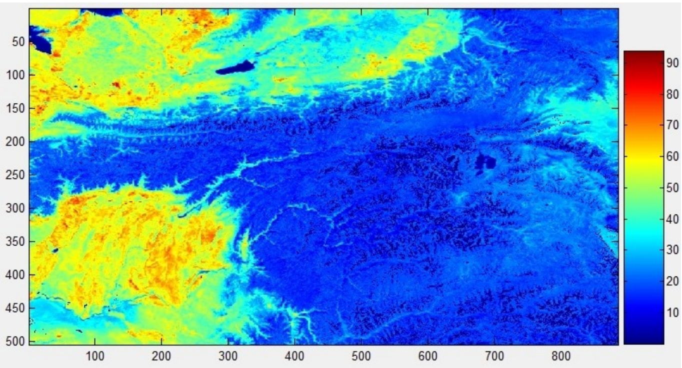
Smoothed NDVI 1st decade of May 1999



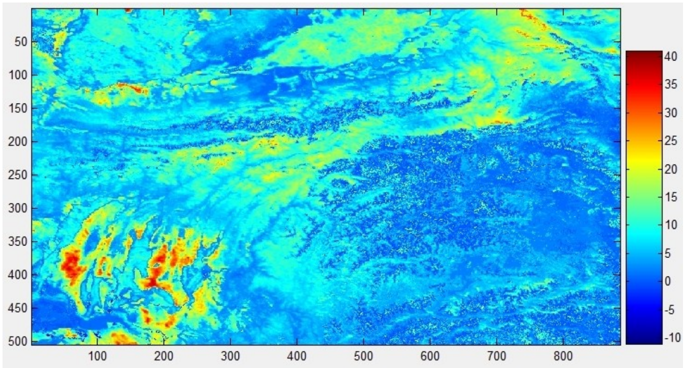
Ampli



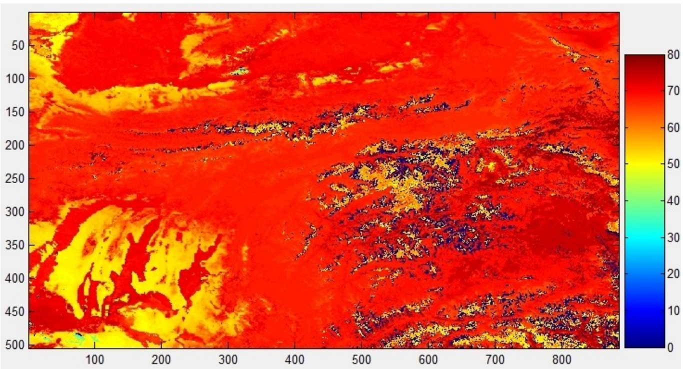
Base



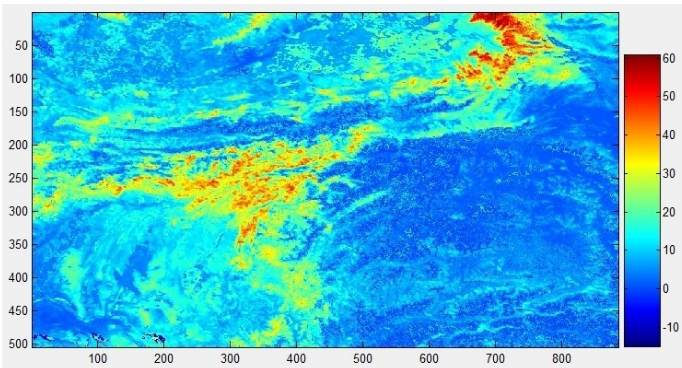
Decrease



End



Increase



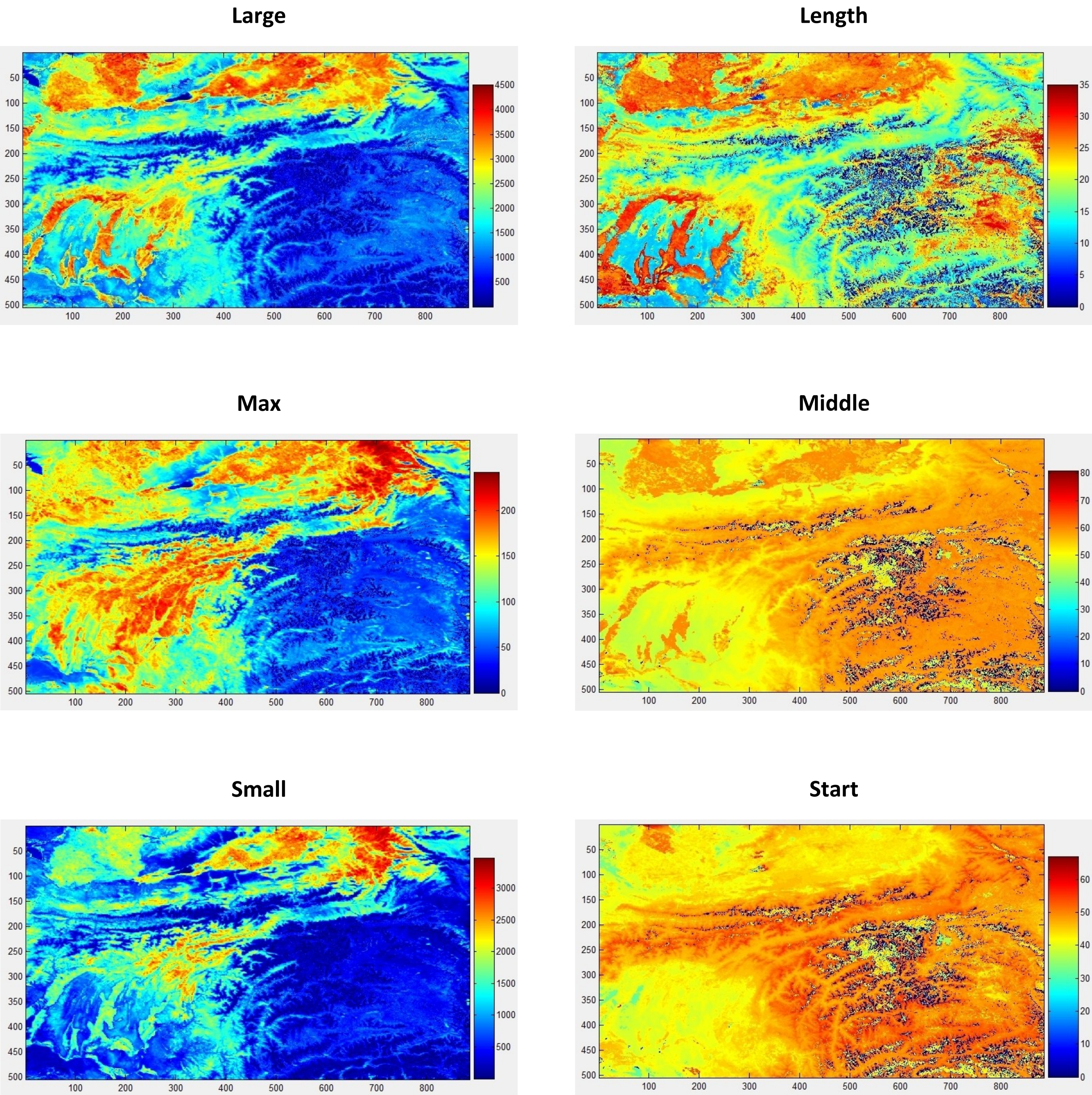


Figure 55: Overview of TIMESAT output images for SPOT VEGETATION 1999 time-series on Tajikistan extent

10.16 Using Batch file in TIMESAT

Many operations in TIMESAT are **repetitive and time consuming** if the operator has to manually repeat all operations. The use of the interactive command line window is particularly time-consuming, for example for:

- "TSF_fit2img" process, that has to be repeated for each year (1999-2015) (i.e.: 17 times)
- "TSF_seas2img" process, that has to be repeated for each year (1999-2015) and each of the 11 season parameters (i.e.: 187 times).
- "TSF_process" process has to be repeated for each year (1999-2015) (i.e.: 17 times)

The use of **batch files** (a simple text file with the ".bat" extension) enables to execute all the repetitions of a given process in just one click by writing in the batch file the commands to execute. TIMESAT doesn't need to be opened to run the batch files since the batch file will automatically call the ".exe" files of TIMESAT. To run the batch, double-click on it. Table 9 presents examples of commands to be written in batch file for the 3 TIMESAT processes "TSF_process", "TSF_fit2img" and "TSF_seas2img". Each command has to be written on one line and is composed of:

- The directory indicating the ".exe" file directing the command, followed by
- The arguments of the command

In order to ensure the execution of all the desired processes (for all years and/or season parameters), command lines have to be duplicated in the batch file, written each on one line and adapted. The variation between command lines will be, for:

- "TSF_process": the names of the settings files
- "TSF_fit2img": the names of the ".tts" files and output files
- "TSF_seas2img": the names of the ".tpa" files, the number identifying the season parameters (1-11) and the names of the output files ("start", "end", etc).

Process	Command to be written in the batch files
TSF_process	..\..\..\SOFTWARE\TIMESAT\timesat311_standalone_windows32\timesat311\timesat_fortran\main\TSF_process.exe SETTINGS_1999_SPOT_VEGETATION.set
TSF_fit2img	..\..\..\SOFTWARE\TIMESAT\timesat311_standalone_windows32\timesat311\timesat_fortran\tools\TSF_fit2img.exe 1999_SPOT_VEGETATION _fit.tts 0 FITTED_1999_SPOT_VEGETATION 1 -1
TSF_seas2img	..\..\..\SOFTWARE\TIMESAT\timesat311_standalone_windows32\timesat311\ti

	mesat_fortran\tools\TSF_seas2img.exe 1999_SPOT_VEGETATION _TS.tpa 1 25 80 0 0 start_1999_SPOT_VEGETATION 2

Table 9: Examples of commands to be written in batch file for the 3 TIMESAT processes “TSF_process”, “TSF_fit2img” and “TSF_seas2img”

Batch files needed in TIMESAT for the 3 processes “TSF_process”, “TSF_fit2img” and “TSF_seas2img” are provided in the training package in the **folder “RESULTS”,** where the batch files have to be placed in this methodology. The directory to the “.exe” files is given as “relative path” (confer section 10.7.2) compared to the working directory. Consequently the folders organization given in the training package has to be respected or the directory to the “.exe” files has to be adapted in the batch file (confer also next section). The execution of these batch files, provided that the suggested directories organisation is respected and that depend files (images, list files, settings files) are also in the right directories and correctly written, will produce all TIMESAT outputs necessary for the CYFS.

The next section gives some general considerations to have in mind when working with batch files in TIMESAT.

☞ Some information on how to use batch file in TIMESAT are given at the pages 61 and 73 of the “Timesat 3.1 Software Manual”.

The “TSF_fit2img” batch file will produce for each year images from 1 to 108, corresponding to the 3 annual repetitions used in the TIMESAT list files. Only images from 37 to 72 have to be kept and **fitted images 1 to 36 and 73 to 108 can be deleted**. This can be done automatically with the provided batch file “...\DATA\NDVI IMAGES\RESULTS \BATCH_DELETE_SUPERFLUOUS_FITTED_IMAGES.bat”.

10.16.1 General considerations for working with batch files in TIMESAT

When using batch files the operator will have to pay attention to the following points:

- A batch file has to be written in a **text file** with the **“.bat”** (or “.cmd”) extension
- TIMESAT doesn’t need to be open before executing the batch file.
- The folder containing the batch file:
    - Defines the “Working Directory” (WD) of the process called by the batch file (which can be different than the WD set in the “Preferences” menu of TIMESAT). The WD of a process is the folder containing the batch file calling that process.
    - Will be the folder where all results are stored

  - In this methodology, it will be the folder “**RESULTS**”
  - In this methodology, the WD has also to contain the settings files and the list files (see explanation hereafter):
    - The batch files:
      - Use a relative path to the TIMESAT “.exe files”
      - Use no path to the settings files, so the settings files have to be in the same folder than the batch files
    - The settings files:
      - Use no path to the list files, so the list files have to be in the same folder than the batch files. (The settings files could be somewhere else if, in the batch, a full directory is used to indicate where the settings files are)
      - (Note that the path to the list file can have space and can be relative).
    - The list files:
      - Use a relative path (relative to the WD) to the image files

- Take care of having the files called by the process ready, for example, for the:
  - **TSF_process.exe**: the “settings files” and the “list files” of each year to be processed.
  - **TSF_fit2img.exe**, the “.tts” files of each year to be processed.
  - **TSF_seas2img.exe**, the “.tpa” files of each year to be processed.
- The directory pointing to TSF_process.exe can be written in relative mode if there is no space in the written directory (there can be space if they are included in the “..\..\” and so not “written”). “” signs have to be added when there are written spaces in the directory pointing to the “.exe” file.
- (Note: when working on big countries or with not powerful computer, for testing batch file, it can be good to work on small processing window in order to fasten the process)

11 WinDisp – computing statistics by zones

! In this section, some examples use Armenian data! Same principles are valid for Tajikistan.

11.1 Introduction

WinDisp is mainly used in the CYFS to **compute spatial statistics on smoothed NDVI images and season's parameters images** computed in TIMESAT. These statistics are mainly the **average** of the pixels values by spatial zones that correspond to the **intersection of a given crop location with the Marzes** (administrative unit) of Armenia. The **3 crops** considered in this case are **wheat, cotton and potato**.

The **images process for CYFS in WinDisp** consists in **3 steps**:

1. Importation of images
2. Modification of image header
3. Spatial statistics computation

These operations can be speeded up with the use of **batch file** (as for TIMESAT). The statistics are recorded in **charts** that will be used in the statistical part of the CYFS.

WinDisp can also be used for **complementary operations** that can be useful for the CYFS, such as:

- **Visualizing** NDVI images
- Visualizing the **NDVI temporal evolution curve** for selected pixels and realizing various **graphs**
- Realizing **maps** (e.g.: NDVI stress maps)

The **next sections** are organised as follow:

1. First an **introduction to WinDisp** that will give the basics (and a bit more) to beginner users to correctly handle WinDisp for CYFS.
2. The use of WinDisp for the **CYFS**
3. The methodology for building **boundary files**
4. The **process automation** by the use of **batch files**
5. **Computation of cumulated NDVI values per phenological period in Excel**

Data needed to work in WinDisp are provided in the training package in the directory "...\DATA\WINDISP DATA\". In particular, a sample **images** ready to be used in WinDisp (correct format) is provided in the training package in the directory: "...\DATA\WINDISP DATA\WINDISP sample images\". These images correspond to the SPOT VEGETATION NDVI images for 1999, on Tajikistan, smoothed by TIMESAT.

11.2 Introduction to WinDisp

A short introduction to WinDisp software, download and installation process is described in section 7.5.

Data mentioned in the introduction above can be used to follow the indication in this section.

11.2.1 Displaying information

This section introduces to the WinDisp interface and basic manipulations to visualize data.

To **start WinDisp**,

- Double click on the WinDisp icon appearing on your computer's desktop after WinDisp installation

To **open an image**,

- Click on « File > Open >Image » (Figure 56).

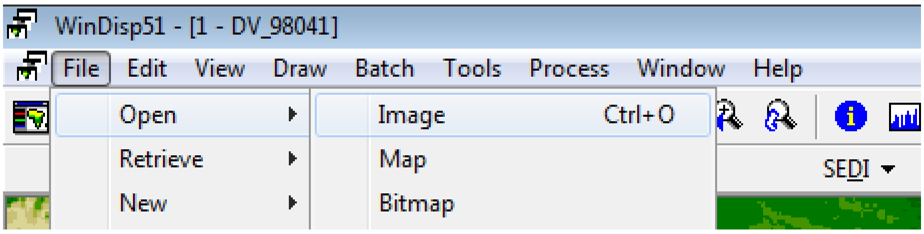


Figure 56: opening an image in WinDisp

- Open, for example, the provided NDVI image "FITTED_1999_SPOT_VGT_58".
- In the field « Color table », open the file «…\ DATA\WINDISP DATA\CLR FILES\NDVI.CLR».

Color tables are used to transpose the values of the image pixels (DNs – Digital Numbers) to specific colors when displaying an image.

- Keep default value unchanged for other parameters, and then click OK. The NDVI Spot-Vegetation image opens (Figure 60).

To **add a map** of the Armenian provinces (Marzes) to this image,

- Go to « File > Retrieve > Map » (Figure 57).

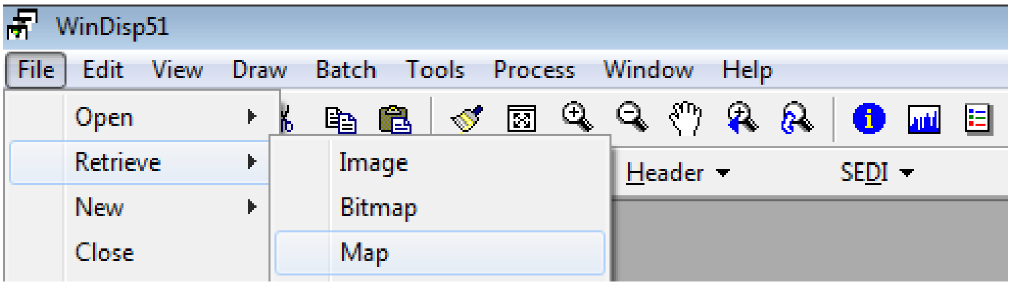


Figure 57: adding a map in WinDisp (1)

The following box displays Figure 58:

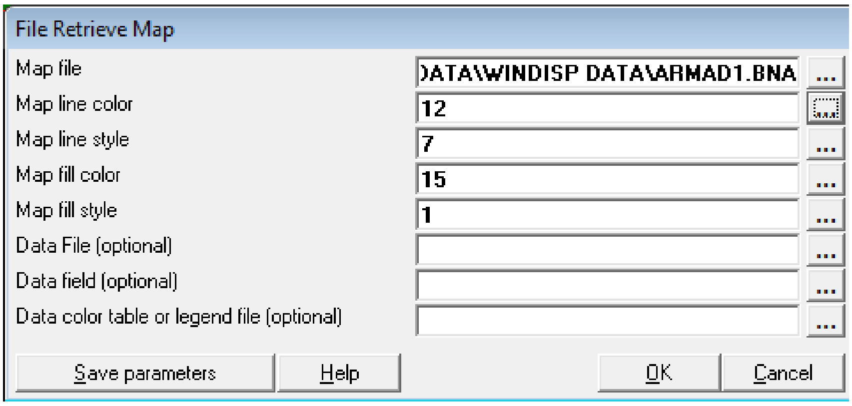


Figure 58: adding a map in WinDisp (2)

- In "Map file" (first line), browse to the file "...\DATA\WINDISP DATA\BNA FILES\ARMENIA_MARZES.BNA » in order to open it. This is a map file of the first administrative level of Armenia.
- The others parameters relate to the layout (keep their default values unchanged).

The administrative units appear on the NDVI image (Figure 60).

In order to easily identify what are the **names of these geographic-administrative units**,

- Click on "Draw\Labels" in the main toolbar. Then for the "Map File", browse to "ARMENIA_MARZES.BNA " (same as above). Keep the default parameters for the other fields as indicated in Figure 59. Then click OK.

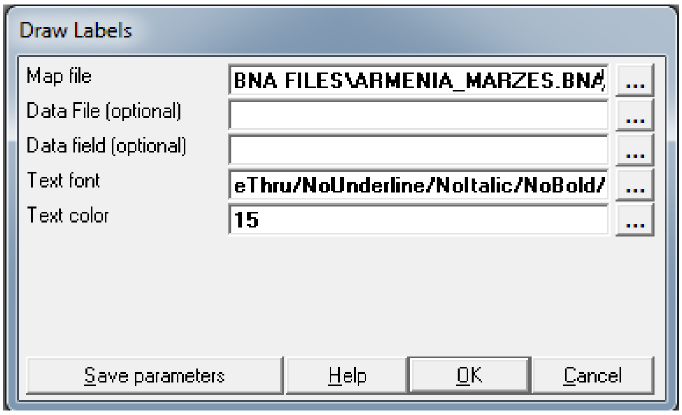


Figure 59: drawing labels in WinDisp

You should now get the names of the administrative area on each unit (Figure 60). Figure 60 illustrates the visualization of spatial information in WinDisp (image, map, labels).

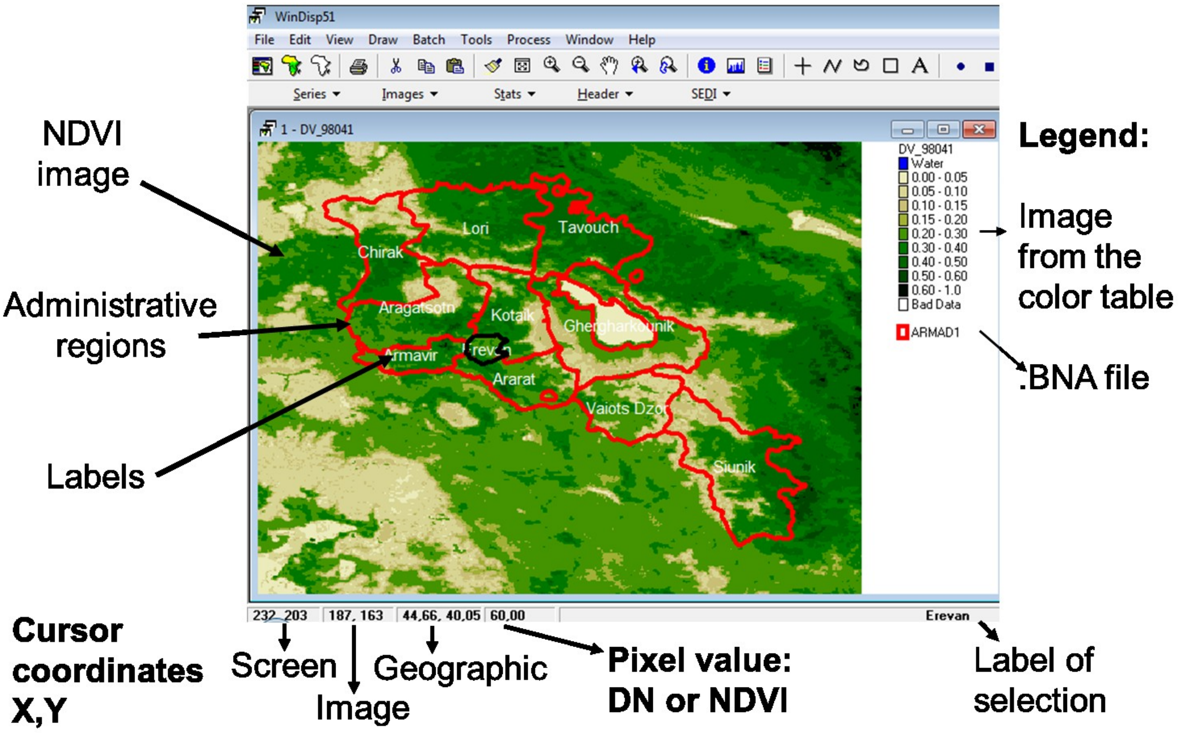


Figure 60: Visualizing spatial data in WinDisp: image, map, label, coordinates, and legend. Image is NDVI SPOT VEGETATION 10 days Synthesis. The map is the first administrative level of Armenia.

The icons  give you the possibility to choose the display that best suits you. You can zoom on Erevan province for example.

If you move the cursor around the image, some information appears at the bottom of the screen (Figure 61):

- The first pair of numbers on the left (outlined in red) is the cursor position on the screen in « **screen pixel** » (depending on the screen resolution).
- The second pair of numbers (in green) is the cursor position on the image in « **image pixel** ».
- The third pair (in yellow) represents the cursor position in **geographic coordinates** (longitude, latitude).
- The last number (in black) is the **pixel value**, NDVI value in this case.
- If you click on a cartographic feature (selected in black in the image bellow) the **name of the administrative unit** selected will appear in the last box (outlined in brown in the Figure 61).

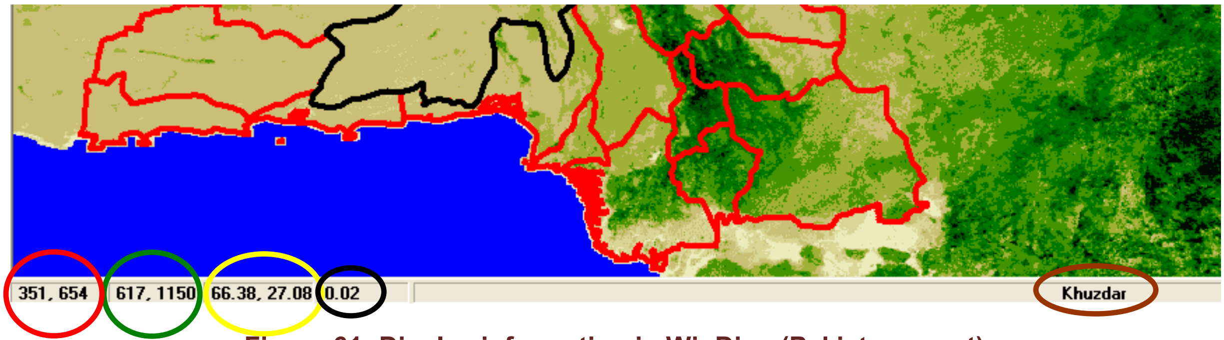


Figure 61: Display information in WinDisp (Pakistan coast)

11.2.2 Making list files and NDVI temporal evolution graphs

Spatial statistics computation in WinDisp requires the creation of list files specific to WinDisp. The following section explains how to **create list file** and how list files can be used to visualize **NDVI temporal evolution in graphs** for selected pixels.

The function « View > Graph > Image Series" is used to display a graph of the temporal evolution in a series of images, of the values of a designated pixel.

To evaluate the NDVI evolution during the year 1999 on the basis of a series of 36 Spot Vegetation images of 1999.

To **create a list file** (« .lst » file) **in WinDisp**,

- Open an NDVI image, e.g. the image of the 1st decade of January 1999 with the NDVI color table. Click OK. The NDVI image appears.
- Go in "View > Graph > Image Series" menu (Figure 62). The "View graph image series" window opens.

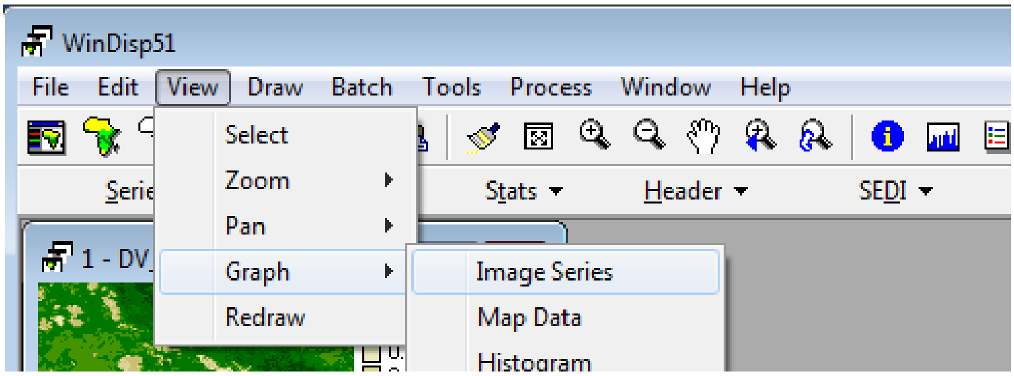


Figure 62: building of an image list in WinDisp (1)

- Click on the browse button ... . An empty “List Builder” window appears.
- Click on « File > New » and enter the number of lines (36 since there are 36 SPOT Vegetation images for 1 year) and columns (1 since we want to view one images time-series at a time only. 2 columns would graph 2 time-series in parallel).
- Click on « Files > add » and browse to the decadal Spot Vegetation NDVI images for 1999 in the “...\DATA\WINDISP DATA\WINDISP sample images\” directory. While holding the « shift » key (or “ctrl” key) pressed, click on the first and then the last images of the wanted series. Click OK. When creating the list file, be careful and check that the images are in the chronological order.

The window « List Builder » should now contain all the images sorted (from the first decade of January to the last decade of December) as shown for example in Figure 63.

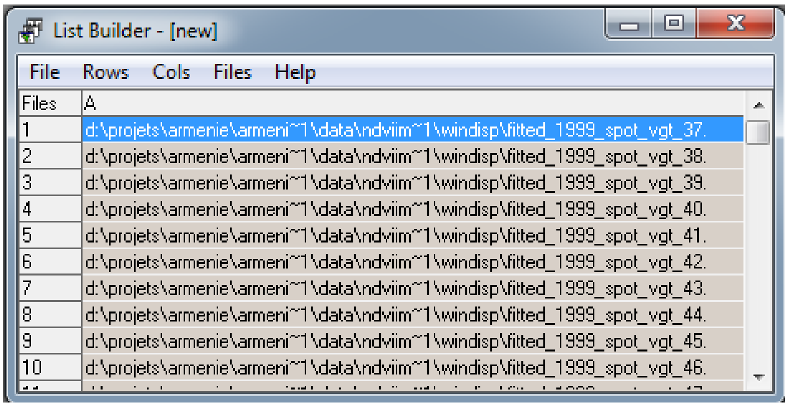


Figure 63: building of an image list in WinDisp (2)

- Click on « File > Save As » and save this list in the directory “...\DATA\WINDISP DATA\LIST FILES\Test\” and call it “test_FITTED_1999_SPOT_VGT.lst”.
- Close the window « List Builder » and click OK.

The list file is created. As list file are text file, **similar list files, for other years for example, can be created by duplicating existing list file and editing them with the software “Notepad++”** for example (confer section 10.8.2.4).

When closing the window « List Builder », in addition to the NDVI image, a «graph window» opens.

To **visualize the NDVI temporal evolution during the time-series of the list file in a graph,**

- Click on a given pixel of the image, and the graph appears in the « graph window» (Figure 64 to Figure 66).

Note that the unit of the Y-axis of the "Graph – Image Series" function is DN [0-255].

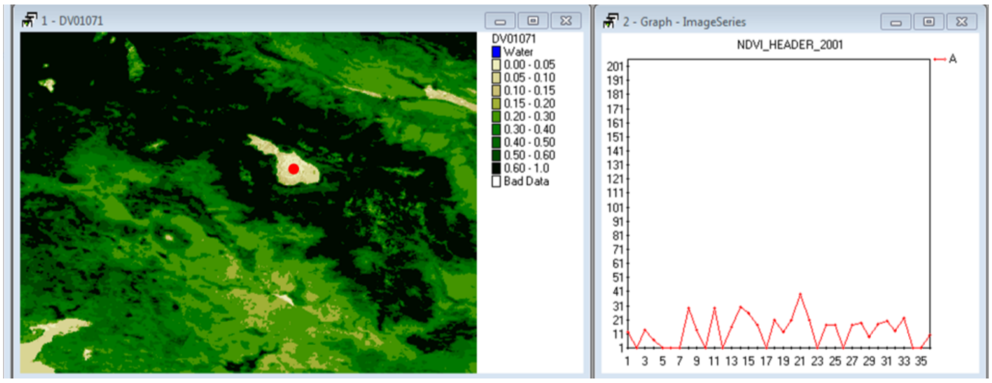


Figure 64: SPOT VEGETATION NDVI evolution in 2001 on Lake Sevan (red point)

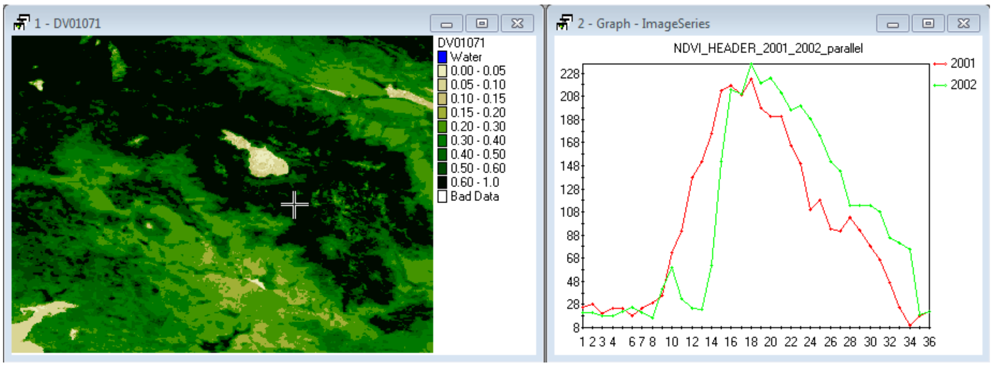


Figure 65: SPOT VEGETATION NDVI evolution in 2001 and 2002 in pasture (cross) (list file with 2 columns, one column per year)

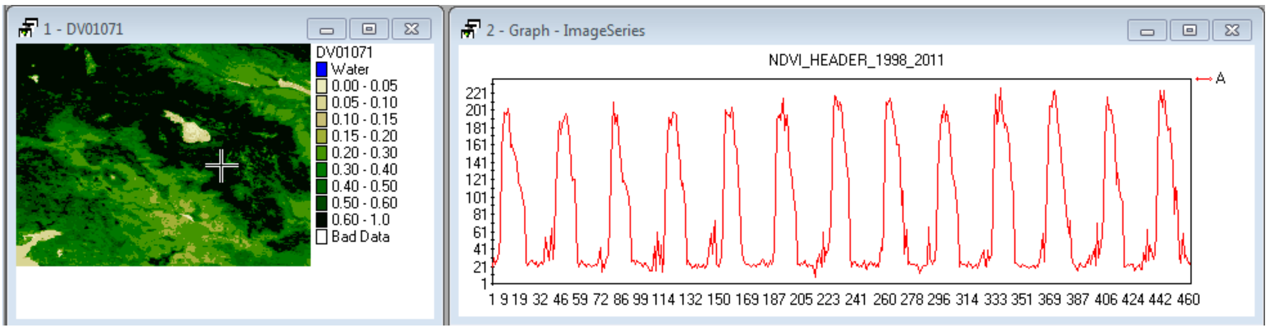
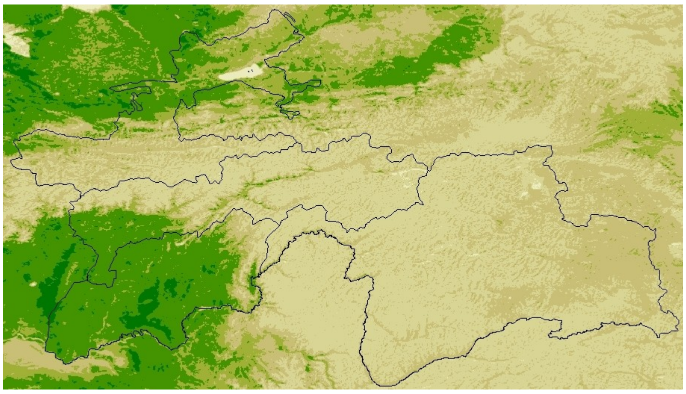


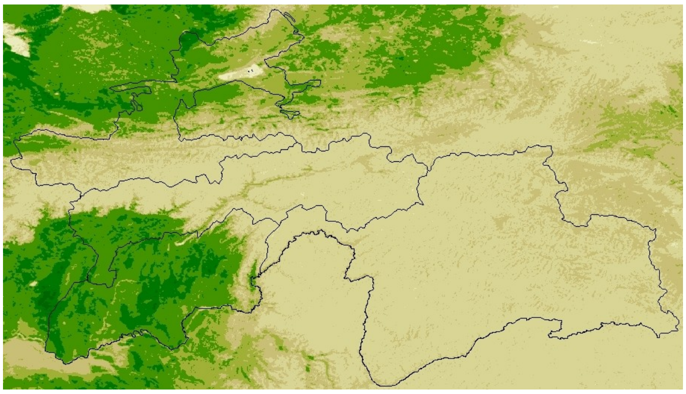
Figure 66: SPOT VEGETATION NDVI evolution from April 1998 to January 2011 in pasture (cross)

Figure 67 illustrates the annual NDVI evolution on Tajikistan for the 1999 SPOT VEGETATION time series.

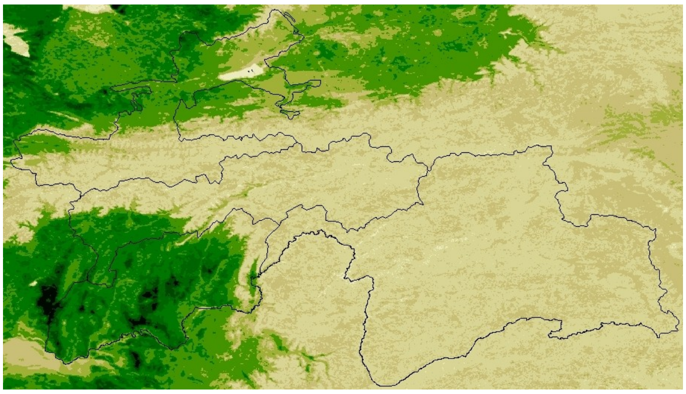
January



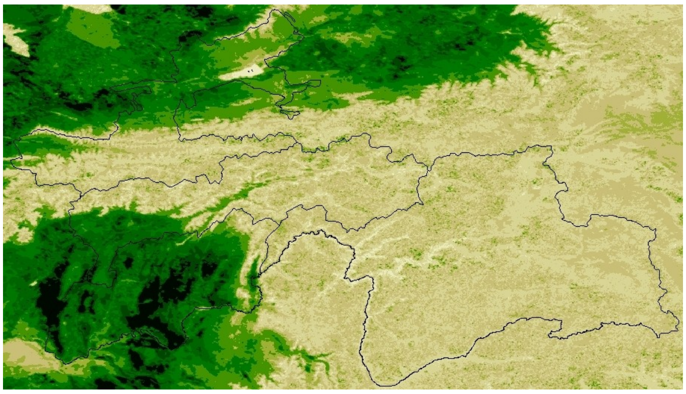
February



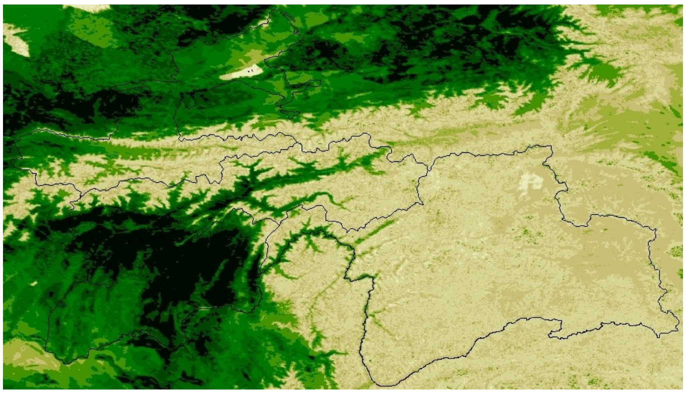
March



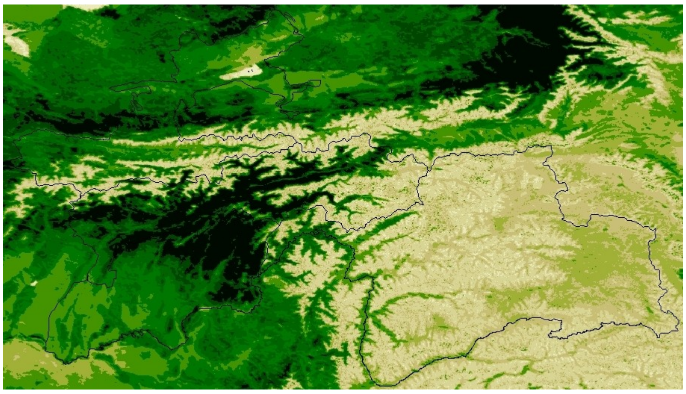
April



May



June



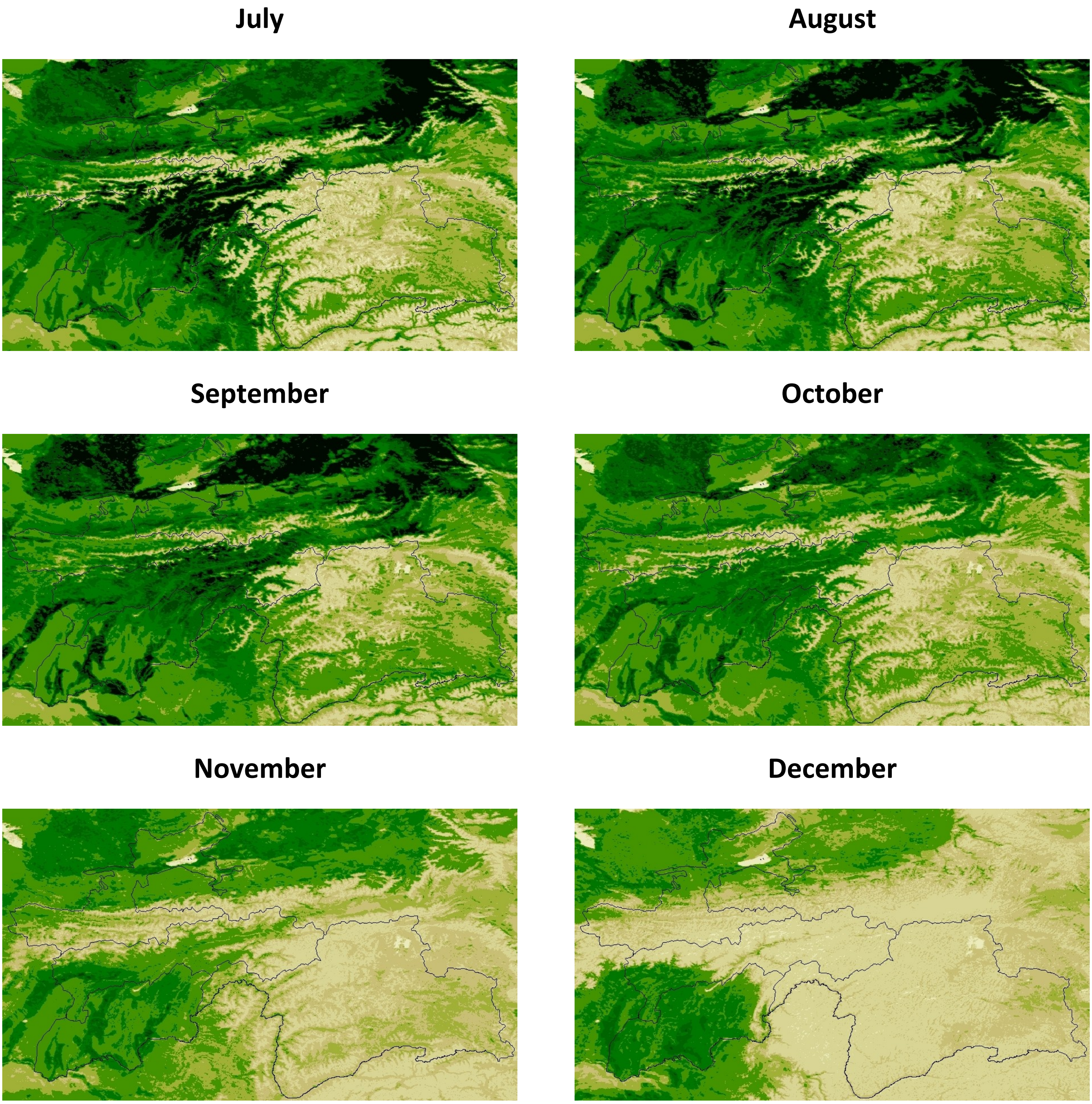


Figure 67; SPOT VEGETATION NDVI evolution in Tajikistan in 1999 (1st decade of each month)

11.2.3 Computing statistics

11.2.3.1 Process of images series (input: images series, output: 1 image) (optional)

(This section is given as indication and is not useful for the CYF methodology.)

The set of commands located in **« Process \ Series** », give the possibility to calculate **temporal statistics by pixel**. Some of these processes are **similar to the ones of TIMESAT**.

- The **input** is a list file identifying a **series of images** (e.g.: image series of 1999).
- The **output** is an **image** of which each pixel represents the result of the process implemented to the corresponding pixels of the chosen images series (e.g.: the maximum image value encountered during 1999).

The following statistics are available:

Max	Maximum value
Min	Minimum value
Avg	Average value
Median	Median value
Range	Range of values
Sum	Sum of values
Count	Number of valid pixels
Stddev	Standard deviation of values
Decloud	Temporal smoothing technique
Slope	Slope of trend-line of values
MaxDate	When the maximum value occurs
MinDate	When the minimum value occurs

To evaluate the date when NDVI is maximal during the year 1999,

- Click on « Process > Series > MaxDate ». The empty "Process Series MaxDate" window opens (Figure 68).

Figure 68: the "MaxDate" process of WinDisp

- Click on the browse button  located next to « File list of image names ». The "List builder" window appears.

- Go in “File > Open” and browse to the list file you’ve created previously “...\DATA\WINDISP DATA\LIST FILES\Test\test_FITTED_1999_SPOT_VGT.lst”. This selects the images series you want to compute statistics for.
- Then close the “List Builder” window.
- In the “Image to create” box, browse where you want to place your resulting file (for example in “…\DATA\WINDISP DATA\Process series\) and give it a name and extension (e.g.: “MAX DATE 1999.arm”).
- Click OK.

The “statistics image” is now recorded in your repertory. To visualize it (Figure 69),

- Open it as a normal image (confer above) but
- Use a **color table** adapted to the “statistic image” values. “…\DATA\WINDISP DATA\CLR FILES\36_DATES.clr”. This color table is adapted to visualize values ranging from 1 to 36 which is the value range of the “MAX DATE” parameter (36 decades in a year).

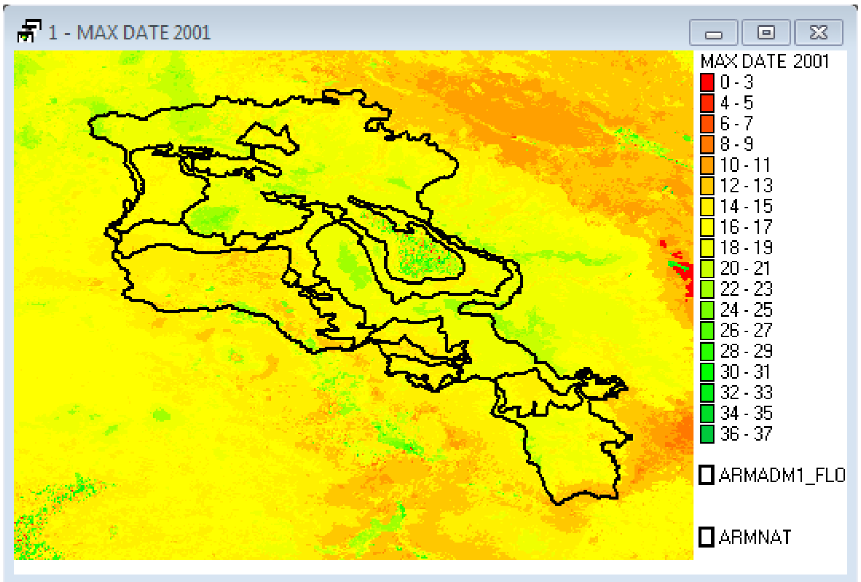


Figure 69: spatial representation of the “MaxDate” parameter of the “Process Series” function of WinDisp for 2001.

11.2.3.2 Process Statistics.

This process is the main one used in WinDisp for CYFS.

The commands situated in **“Process\Stats\...”** enables to calculate temporal and regional statistics for certain area represented in a map.

- The **inputs** are a list file of “smoothed NDVI images” or “season parameters images”, and a map identifying the areas for which to compute the statistics.

- The **output** is an **ASCII chart containing the statistic values per date (columns) and areas (lines)**.

The following statistics are available.

Max	Maximum value
Min	Minimum value
Average	**Average value**
Median	**Median value**
Stddev	Standard deviation of values
Range	Range of values
Count	Number of valid pixels (between the maximum and minimum thresholds) in a polygon

To **compute statistics with "Process\Stats\...",** e.g. for the average value,

- The first thing is to have or to create a **list file** which contains the image series to be processed (confer section 11.2.2). A list file may contain for example the 36 images of a given year or the 15 (15 years time series) images of a given season parameters.
- Go in "Process > Stats > Avg" (Figure 70). The "Process Stats Avg" window opens.

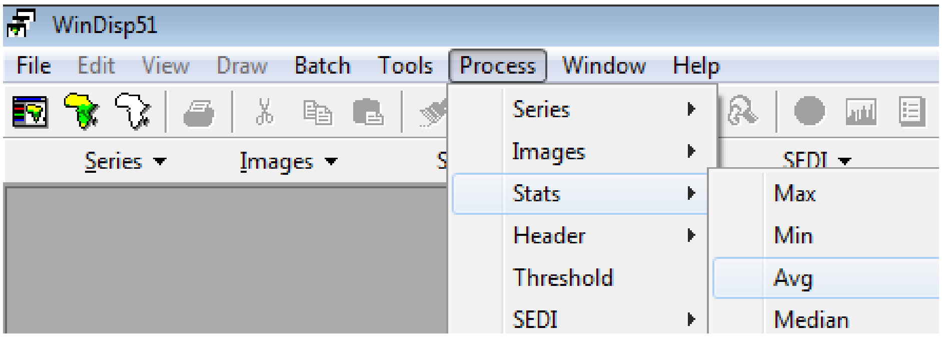


Figure 70: "Process\Stats\..." function of WinDisp

- Select the list file of interest (e.g.: list file of 1999 NDVI images series, or list file of all "starting decade" images series)
- Select the map file (".bna" file) of interest, in the box **"Map file",** for example the "...\DATA\WINDISP DATA\BNA FILES\WHEAT_ARMENIA_MONOPART.BNA" file if you want to compute statistics for wheat areas in Armenian Marze. **Remarque that** if the information on the localization of the specific crop targeted by the model is available, it is better to use **one specific ".bna" file per crop**. Using a **shapefile (*.shp)** is also possible but you will get number instead of administrative names (eg. Provinces names) in the first column of the output statistics chart. Using a "*.bna" file will provide administrative names in the statistics chart, which is better.

- Browse and give a name for your output file with the extension ".xls". The use of the ".xls" extension produce Excel chart, which is important in this methodology.
- In the box **"Window around point",** keep default value. This parameter is used to define the area around a pixel (for example a meteorological station) which can be included in the analysis of the pixel. In the case of analysis linked to polygons this parameter is not used, so its value by default is equal to **1**.
- **Important remark:** by default, if more than half of the polygon (half of the pixels in a polygon) contains pixels outside the relevant thresholds, a value of -9999 is returned. Both the thresholds and the percentage of the polygon that needs to be valid can be modified with the "Process > Thresholds > command".

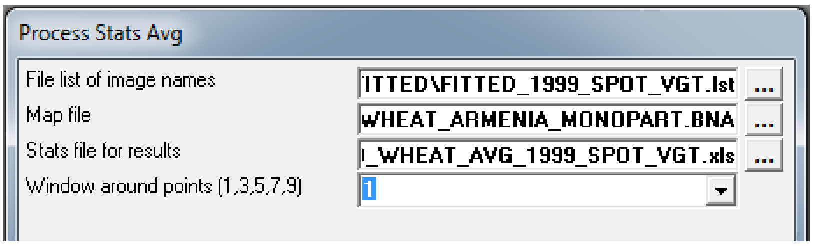


Figure 71: "Process Stats Avg" function in WinDisp

- Click "Ok".

Excel will open automatically and the results will be displayed as in the table presented in Figure 72. Wait a little if you do not get results directly. If Excel does not open automatically, browse to your output folder and open the **output file** (Figure 72).

	A	B	C	D	E	F	G	H	I
1	stats	code	1	2	3	4	5	6	7
2	Aragatsotn	1	0.15	0.14	0.14	0.15	0.17	0.16	0.16
3	Ararat	2	0.15	0.15	0.14	0.15	0.15	0.15	0.14
4	Gegharkunik	5	0.13	0.14	0.14	0.14	0.14	0.13	0.11
5	Kotayk	6	0.15	0.14	0.13	0.15	0.16	0.15	0.14
6	Syunik	10	0.25	0.25	0.23	0.22	0.21	0.18	0.16
7	Vayots_Dzor	12	0.13	0.14	0.13	0.13	0.13	0.11	0.1
8	Lori	8	0.22	0.19	0.18	0.19	0.2	0.19	0.17
9	Shirak	9	0.11	0.1	0.09	0.09	0.12	0.12	0.12
10	Armavir	3	0.17	0.18	0.18	0.19	0.19	0.19	0.19
11	Erevan	4	0.14	0.14	0.14	0.15	0.17	0.17	0.16
12									

...

Figure 72: Statistics chart in Excel for the Average value of "CUMM" VAST parameter by area identified in a ".BNA" file.

In this chart, the two first columns correspond to the 2 attribute fields of your BNA file. There is one line per geographic unit of your BNA file, here, one line per province. The column 3 and the following one's identify the images which were processed, for examples:

- If you computed the **average statistics for the 36 NDVI images of a given year**, you will get 36 columns, each corresponding to the average NDVI of 1 decade, by areas.

For example, the first column will be the average NDVI of the 1st decade for the given year by areas.

- If you computed the **average statistics for the 15 TIMESAT outputs images** “start” (start of the season) from 1999 to 2013, you will get 15 columns, each corresponding to the average, by areas, of the “start of the season” for one year. For example, the first column will be the average “start of the season” for 1999 by area.

The **Excel table will contain as many lines as there are of spatially distinct areas in the “.BNA” file** used in the statistic process. Consequently, if for example there are “n” crop areas in the administrative area named “x”, the Excel table will contain “n” lines corresponding to the administrative area “x”. The aggregation of this information by Marz is quite fastidious as described in section 11.3.4.1 and 11.4. That’s why it is recommended to **use a simplified map file with a single crop area per administrative area** (confer sections 11.3.4.1 and 11.4).

The code “-9999” will be set for areas/dates where no data could be computed. These have to be treated as “no data” or replaced with the mean value of all the Marzes for the considered period. This can be done in the statistical part of the CYFS.

When re-computing with WinDisp statistical charts that already exist, existing statistical charts will not be overwritten but new statistical information will be added next to the existing information in the existing file (in new columns). Besides if existing charts files are not deleted and new statistics are computed with a new bna file that does not respect the same administrative areas names, number and order, WinDisp batch will bug. **So when re-computing statistical charts in WinDisp, existing charts have to be preventively deleted.**

11.3 WinDisp for Crop Yield Forecasting System

11.3.1 WinDisp filenames convention

In order to better organize the files to be produced in WinDisp, a file name convention is proposed in Table 10.

Type of file	**GENERIC_EXAMPLE** • **REAL_EXAMPLE**
Imported fitted images	TYPE_YEAR_SENSOR_DECADE • FITTED_1999_SPOT_VGT_37 • FITTED_2008_METOP_37 • FITTED_2014_PROBAV_37
Imported season images	PARAM_YEAR_SENSOR • ampli_1999_SPOT_VGT • large_2008_METOP • start_2014_PROBAV
List file for fitted images	TYPE_YEAR_SENSOR.lst • FITTED_1999_SPOT_VGT.lst • FITTED_2008_METOP.lst • FITTED_2014_PROBAV.lst
List file for season parameters	SENSOR_PARAM.lst • SPOT_VGT_ampli.lst • METOP_start.lst • PROBAV_end.lst
Statistic output files (Process > Stats > Average) for fitted images	TYPE_CROP_STAT_YEAR_SENSOR.xls • FITTED_GRAIN_AVG_1999_SPOT_VGT.xls • FITTED_COTTON_AVG_2008_METOP.xls • FITTED_WHEAT_AVG_2014_PROBAV.xls
Statistic output files (Process > Stats > Average) for season images	TYPE_BNATYPE_CROP_PARAM_STAT_SENSOR.xls • SEASON_MONO_GRAIN_ampli_AVG_SPOT_VGT.xls • SEASON_MONO_COTTON_start_AVG_METOP.xls • SEASON_MONO_WHEAT_end_AVG_PROBAV.xls

Table 10: File names convention in WinDisp

11.3.1.1 List of values for the filenames parameters

The list below presents the possible values for the filenames parameters.

TYPE: type of image:

- **FITTED**: the smoothed NDVI images extracted with TSF_fit2img.exe of TIMESAT
- **SEASON**: the seasons parameters extracted with TSF_seas2img.exe of TIMESAT

BNATYPE

- **MONO**: monopart ".bna" file
- **MULTI**: multipart ".bna" file

YEAR: the year

- **1999 to 2015** and next

SENSOR: the type of sensor

- **SPOT_VGT**: SPOT VEGETATION
- **METOP**: METOP AVHRR
- **PROBAV**: PROBA-V

DECADE: the decade as produced from TIMESAT

- **37 to 72**

PARAM: the 11 season parameters from TIMESAT

- **start**: start of the season
- **end**: end of the season
- …

CROP: the crop identified in the ".BNA" file used during the "Process > Stats > Average" process of WinDisp:

- **WHEAT**
- **COTTON**
- **POTATO**
- **...**

STAT: the type of statistic computed

- **AVG**: average
- **MEDIAN**: median

11.3.2 Importation of images into WinDisp

The images to import into WinDisp, which are the output images from TIMESAT (stored in the “RESULTS” folder), are of 2 types:

- The **NDVI smoothed** images, in **8-bit** binary image format
- The **seasons parameters** images, in **16-bits** binary image format

In this case, the importation has to be done in the folder “...\DATA\NDVI IMAGES\WINDISP\”. The user may test the importation process with an image of his choice.

The importation in WinDisp can be done with the WinDisp function:

- **“Process > Import > Binary Image”.**

This function enables to import 8 or 16 bit binary images. The importation of one image can be done manually by using this function. The importation of a high number of images, as it is the case in this methodology, requires the process automation by the use of **batch file**, as described in sections 11.5 and 11.5.3.

11.3.2.1 Parameters values of the “Import” function of WinDisp

Note that WinDisp operates ONLY with 8-bit images and care must be taken when users are importing 16-bit images from other systems when using the “Process Import Binary Image” function. When importing 16-bit images, the correct **slope** and **intercept** (offset) values must be applied, **if necessary**, in order to **scale the 16-bit pixel values** (that ranges from – 32767 to 32767) **to the 8-bit pixel values** (that ranges from 0 to 255). This scaling is illustrated by the function below:

Slope * DN [16-bit image] + **Intercept** => DN [8-bit image]

In this case, the season parameters, except the 2 integral parameters, have values in the range [0-255] so no conversion or scaling has to be done.

For the 2 season parameters with pixel value higher than 255, the **<u>large and small integrals</u>**, a **scaling** has to be applied in order for these images to be correctly readable in WinDisp. Their values in the 16-bit images range between [0 – 10 000]. (The maximum value for a given decade is 255, so the theoretical maximum integral value on 1 year is: 36 * 255 = 9180 ~ 10 000). The maximum value that can be expressed in a 16-bit integer image is 32 767. In that latter case a scaling factor of 0.0075 would enable to obtain values not over 255 (maximum value in 8-bit image) (32 767 * 0.0075 = 254.7). However if we consider 10 000 as the largest possible value for the large integral, **a scaling factor of 0.025** can be used as 0.025 * 10 000 = 250.

Based on that, the parameters to use with the "import" function, in this case, are summarized in the Table 11 below.

Type of image to import	**FITTED images**	**SEASON images (all except the 2 integral)**	**SEASON images (for the 2 integral)**
Width of image	885	885	885
Height of image	505	505	505
Header size	0	0	0
Scale factor	1	1	**0.025**
Offset	0	0	0
Swap bytes	N	N	N

Table 11: parameters values to use with the "import" function of WinDisp for Tajikistan

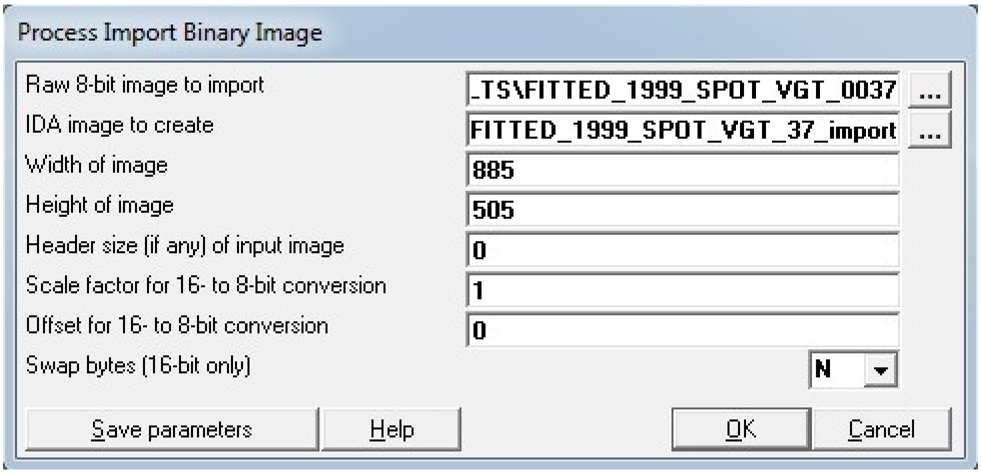


Figure 73: "Process Import Binary Image" window for Tajikistan in WinDisp for Tajikistan

11.3.3 Modification of image header

The **image header** contains some information that enables WinDisp to display correctly the images (coordinates system, size and position in space of the image, size of the pixels, code for missing values, parameters values for the transformation of DN to real values (NDVI, phenology)). After the importation of the images into WinDisp, header values are not the right ones and consequently have to be modified. This will among other enable to:

- Position correctly images in space.
- Apply the right conversion of DN into NDVI or phenology values

To **access and modify** the parameters values of an image header:

- Go in the menu "Header > Edit" or "Process > Edit > Header"

- Browse to the image you want to modify the header (in this case the image that have imported into WinDisp in the previous section).

The “header window” opens with (wrong) default values (Figure 74). Header values can be changed interactively in this window.

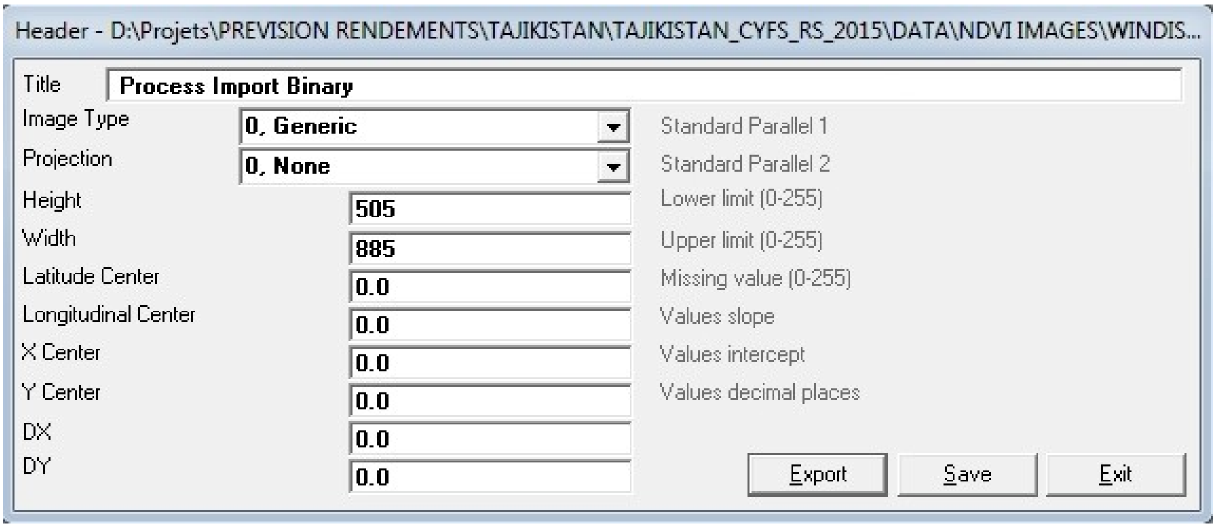


Figure 74: default header values of a NDVI image after importation in WinDisp from TIMESAT output for Tajikistan

The right header parameters values to be used in this case are presented in the Table 12, with some difference according to the sensor (SPOT-VGT, METOP AVHRR, PROBA-V) and the type of images (fitted NDVI vs season parameters) (Figure 75).

Parameter	**Value**	**Comment**
Image Type	200, user-defined	Non-predefined Image type. Parameters values have to be entered by the user
Projection	3, Geographic	Images are in geographic coordinate system
Height	505	Size of the Tajikistan subset
Width	885	Size of the Tajikistan subset
Latitude Center	0.0	“These values identify the center of the projection in decimal degrees” (cf. “WinDisp4 User’s Manual”)
Longitudinal Center	0.0	
X Center*	**SPOT_VGT** -7537.5000241175	See the explanations in the section below *
	METOP -7537.5000089556	
	PROBA-V -7537.5	
Y Center*	**SPOT_VGT** 4603.5000147224	
	METOP 4604.5000179187	

	PROBA-V 4604.5	
DX	0.0089285714	The size of the pixel in decimal degree (1 km) (METOP website information and images header file)
DY	0.0089285714	
Standard Parallel 1	0	This parameter are not activated in manual edition of the header file for "Projection = 3, Geographic". But there values must be "0" in the batch file.
Standard Parallel 2	0	
Lower limit [0-255]	1	Smoothed and seasons images from TIMESAT have the 0 code for missing values
Upper limit [0-255]	255	Confer section "9. Valid data range during the process" 255 is the theoretical maximum value of 8-bit season image
Missing value [0-255]	**0**	0 is the code given to missing values for both fitted and seasons images in TIMESAT
Values slope**	**0.004** **for the NDVI images (the fitted images and the 2 season images "base" and "max")**	Season images "base" and "max" express NDVI values and DN have consequently to be transformed into NDVI values. See explanations in the section 11.3.3.2 below ** **!! These values may have to be adapted in some circumstances (e.g. use of METOP AVHRR in continuity of SPOT-VGT): confer section 11.3.3.2.2 below****
	1 **For other season images**	
Values intercept**	**-0.1 for SPOT-VGT** **-0.08 for PROBA-V** **-0.08 for METOP** **for the NDVI images (the fitted images and the 2 season images "base" and "max")**	
	0 **For other season images**	
Values decimal places	2	The number of decimal places to use in the "Process/Stats" function of WinDisp. 2 decimals for dealing with NDVI values seem to be enough. (Source: "WinDisp4 User's Manual", page 100)

Table 12: header parameters values to be used in WINDISP for NDVI and season images and justification

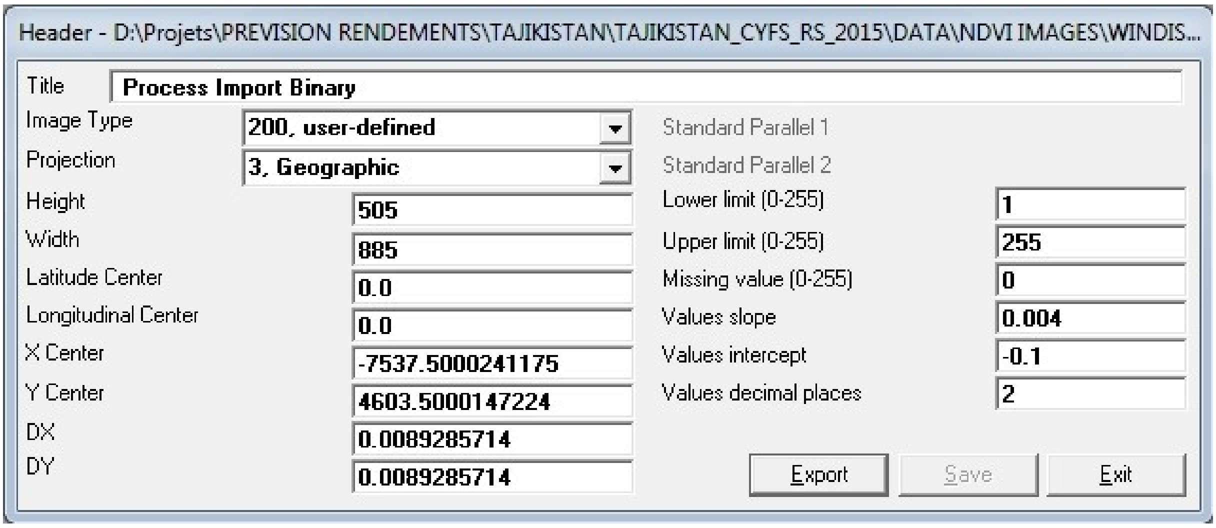


Figure 75: example of right header file after modification in WINDISP, the case of a smoothed SPOT VEGETATION NDVI image

After the header modification,

- Click on "Save", which saves the modifications.
- Possibly reopen the header to ensure that the modification has been done.
- Possibly open the image of which you have modified the header and **note that, in the case of NDVI image, the pixel values displayed at the bottom of WinDisp display window are NDVI values and no more DN value**.

The header modification has to be done for each image. To do that manually would be a huge work. Fortunately this operation (as others) can be **automated** by the use of a batch files. The creation and use of batch files is presented at the end of the manual in section 11.5.2.

Images for the period 1999-2012 (NDVI and season parameters) have already been imported into WinDisp and their header modified. These images are stored in the training package under the directory "...\DATA\NDVI IMAGES\WINDISP\".

The **batch files** used for the images importation and header modification are available in the folder "...\DATA\WINDISP DATA\BATCH FILES **...**".

11.3.3.1 * X Center and Y Center of a subset image

In order to find the right "X Center" and "Y Center" header information for IDA format, the WinDisp image format, it is advised to use the "FWTools/GDAL_translate" function to convert the SPOT VEGETATION, METOP AVHRR and PROBA-V NDVI images as extracted on Tajikistan, respectively with VGT EXTRACT, FWTools/GDAL_translate, and PPT from the ENVI-standard format to IDA format. This can be done only for 3 images, 1 SPOT VEGETATION, 1

METOP AVHRR and 1 PROBA-V, as the “X Center” and “Y Center” will be the same for all images of a same sensor (same geographic properties). Once produced, the header files of these 2 images opened in WinDisp give their X Center and Y Center for WinDisp format, as presented in Table 13. This conversion can be done with the batch file “CONVERT_ENVI_2_IDA_FORMAT.bat” provided in the training package under the directory “...\DATA\NDVI IMAGES\WINDISP\GDAL_CONVERT_ENVI_2_IDA\” where the 2 converted images are stored as well. The X and Y Centers slightly differ between the 2 sensors, which is probably due to the fact that the original images on Europe extent present 1 pixel difference (confer Table 1 page 39).

	SPOT VEGETATION	METOP AVHRR	PROBA-V
X Center	-7537.5000241175	-7537.5000089556	-7537.5
Y Center	4603.5000147224	4604.5000179187	4604.5

Table 13: X Center and Y Center values for SPOT VEGETATION, METOP AVHRR and PROBA-V images header for Tajikistan extent in WinDisp

11.3.3.2 ** Explanation of “Slope” and “Intercept” parameters values.

The Digital Numbers (DN) of the pixels of the images imported in WinDisp are in the range [0-255] as it is 8-bits images. In order to convert the DN values [0-255] to NDVI values [0-1], a formula needs to be applied. This formula uses a “slope” and “intercept” parameter as illustrated in the generic formula below:

Slope * DN + Intercept = NDVI

See also section “**8.2.**

NDVI images encoding" and Figure 11, page 36 for more information on NDVI images encoding.

The header modification of "value slope" and "intercept" parameters concerns only the images of which pixels represent NDVI values, i.e.:

- The smoothed NDVI images
- The seasons parameters "base" and "Max".

The "value slope" and "intercept" parameters of the other season parameter images have to be set to "1" and "0" respectively in order not to apply any conversion.

Rem: the transformation of the "base" parameter into real NDVI value can be important if the user would like to make a subsequent filter to suppress all pixels that would not reach a certain NDVI value threshold. This filter isn't however applied in this methodology.

11.3.3.2.1 Original header "value slope" and "intercept" values for the 3 sensors

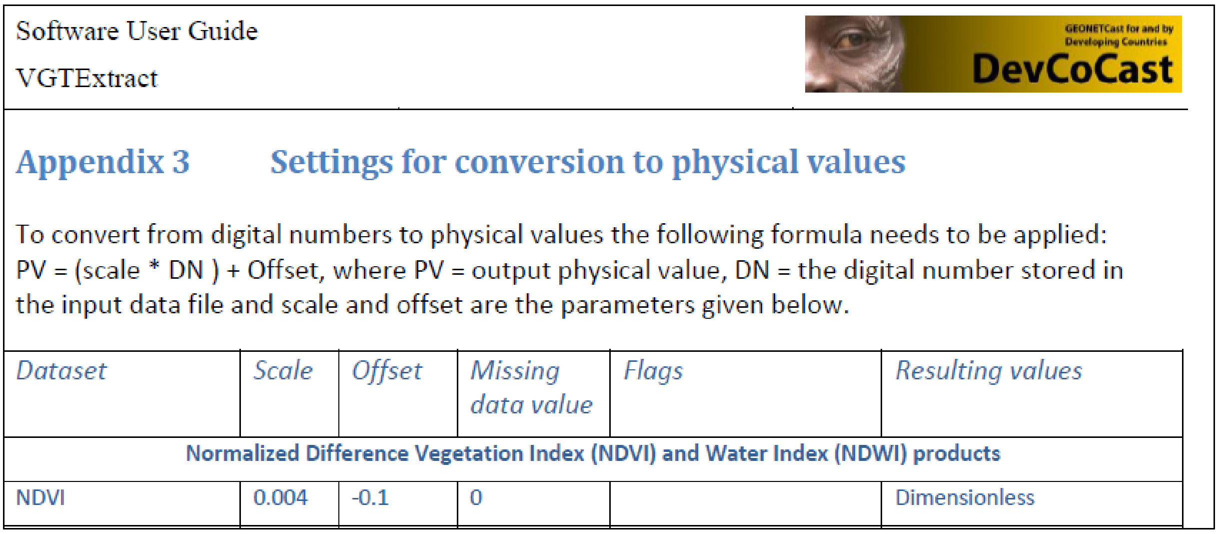
The original "value slope" and "intercept" parameter values for the 3 sensors are presented in the Table 14. Note that NDVI images from METOP AVHRR and PROBA-V have the same intercept whereas SPOT VEGETATION's one differs.

	SPOT VEGETATION	METOP AVHRR	PROBA-V
Value slope	0.004	0.004	0.004
Intercept	**-0.1**	-0.08	-0.08

Table 14: Original "value slope" and "intercept" parameters values for the 3 sensors

These values are coming from:

- For **SPOT VEGEATION:** the "VGT Extract software User Guide". (Figure 76)



Software User Guide

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Appendix 3 Settings for conversion to physical values

To convert from digital numbers to physical values the following formula needs to be applied: PV = (scale * DN) + Offset, where PV = output physical value, DN = the digital number stored in the input data file and scale and offset are the parameters given below.

Dataset	*Scale*	*Offset*	*Missing data value*	*Flags*	*Resulting values*
Normalized Difference Vegetation Index (NDVI) and Water Index (NDWI) products					
NDVI	0.004	-0.1	0		Dimensionless

Figure 76: Conversion value to convert Digital Number (DN) to physical NDVI value (source: VGT Extract User Guide)

- For **METOP AVHRR**: the METOP AVHRR website (http://www.metops10.vito.be/metop-S10_pages/main.html) in the technical description of the spectral aspects of the images.
- For **PROBA-V**: these values can be found in the header file (at the line "values", the 2 last numbers) of a PROBA-V NDVI image extracted with PPT in ENVI format.

11.3.3.2.2 Inter-calibration of SPOT VEGETATION and METOP AVHRR NDVI products for time series continuity: impact on header "value slope" and "intercept" values.

☞ *This section may be outdated as it was written in January 2013 and no update has been made in 2015.*

Regarding SPOT VEGETATION and METOP AVHRR, due to "problems" of inter-calibrations between the different sensors and/or NDVI products, the application of the original "value slope" and "intercept" parameters values mentioned above results in NDVI values that may differ between SPOT VEGETATION and METOP AVHRR image. As the METOP AVHRR NDVI images have to ensure the continuity [2014-2022] of the SPOT VEGETATION series [1999-2013], NDVI values derived from these 2 sources should be **identical** for a given area at a given time. In order to ensure this compatibility the 2 types of NDVI images have to be inter-calibrated. This can be done since the period 2008-2012 is covered by the 2 sensors. In this manual, it was chosen to adapt the SPOT VEGETATION NDVI values to the one of METOP AVHRR, so that modification will have to be made for SPOT VEGEATTION images database once and METOP AVHRR NDVI images won't have to be modified for the future acquisitions.

IF ONE WANTS TO USE METOP AVHRR INSTEAD OF PROBA-V FOR TIME SERIES CONTINUITY, the "value slope" and "intercept" parameters values to be used in this methodology for **SPOT VEGETATION** NDVI images, can be derived from a study comparing the Digital Number (DN) and NDVI physical values of the 2 considered sensors. This study has been realized by Herman Eerens from VITO and was available on the METOP AVHRR website at http://www.metops10.vito.be/metop-S10_pages/info.html, is provided in the training package in the "LECTURES" folder and is called "Comparison_NDVI_METOP_VGT_Trial2.docx". A small difference is observed by Herman Eerens between the 2 sensors. The author proposes a mathematical relation between NDVI values of SPOT VEGETATION ($NDVI_{VGT}$) and METOP AVHRR ($NDVI_{METOP}$) sensors as presented hereafter.

In this case, it is necessary to transform the DN of SPOT VEGETATION images (DN_{VGT}) into NDVI values comparable to the NDVI values of METOP AVHRR. Based on the 3 following equations obtained by Herman Eerens:

- $NDVI_{METOP} = -0.08 + 0.004 * DN_{METOP}$
- $NDVI_{VGT} = -0.10 + 0.004 * DN_{VGT}$
- $NDVI_{VGT} = -0.0585 + NDVI_{METOP}$

It is easy to obtain the following relation (Figure 77):

- $- 0.0585 + NDVI_{METOP} = - 0.10 + 0.004 * DN_{VGT}$
- $NDVI_{METOP} = 0.0585 - 0.10 + 0.004 * DN_{VGT} = - 0.0415 + 0.004 * DN_{VGT}$

$$\mathbf{NDVI_{METOP} = - 0.0415 + 0.004 * DN_{SPOT\_VGT}}$$

Figure 77: equation for the conversion of DN of SPOT VEGETATION NDVI image into NDVI values comparable to the METOP AVHRR NDVI images

If one wants to use METOP AVHRR for SPOT VEGETATION time series continuity, the "value slope" and "intercept" parameters values for SPOT VEGETATION to be used in WINDISP are 0.004 and -0.0415 respectively.

The user should note however that the comparison of the NDVI values of the 2 sensors for a given area and a given time, after that inter-calibration, shows that **these values are not perfectly identical** as presented in the next section 11.3.3.2.3.

11.3.3.2.3 Comparison of SPOT VEGETATION and METOP AVHRR NDVI values after inter-calibration for Armenia

☞ *This section may be outdated as it was written in January 2013 and no update has been made in 2015.*

The comparison of the NDVI values of SPOT VEGETATION and METOP AVHRR for a given area and a given time, after the inter-calibration mentioned above, shows that these NDVI values are not perfectly identical. Figure 78 presents the comparison of the NDVI values of the SPOT VEGETATION and METOP AVHRR sensors for Aragatsotn marz (province) of Armenia in 2008 for potato areas, after the sensors inter-calibration mentioned above. It is observed that, broadly speaking, METOP AVHRR NDVI values are lower than the SPOT VEGETATION ones for decades 1 to 22 and higher for the last decades of the year. The same comparisons for other marzes or for wheat result in similar difference between the 2 sensors.

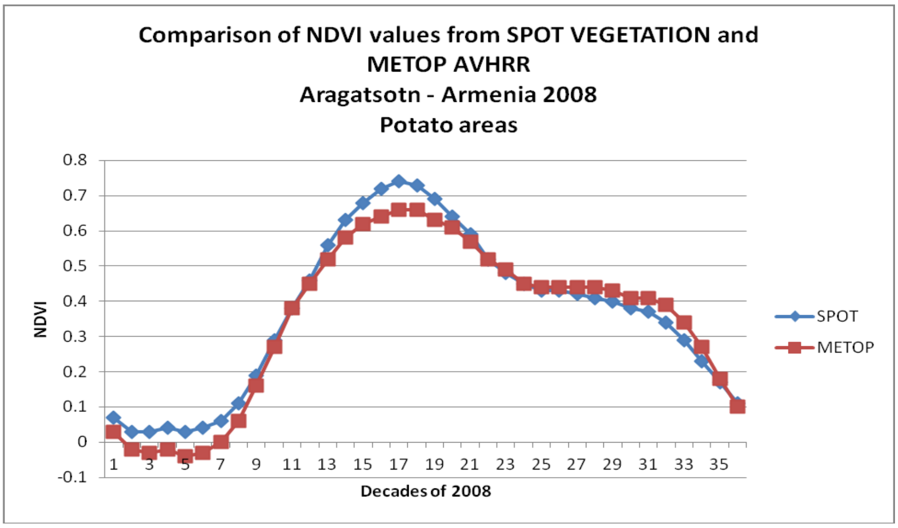


Figure 78: Comparison of the NDVI values of the SPOT VEGETATION and METOP AVHRR sensors for Aragatsotn marz of Armenia in 2008 for potato areas, after the sensors inter-calibration mentioned above.

This systematic non linear difference cannot be corrected by the modification of the "value slope" and "intercept" parameters values which can only linearly modify the NDVI values. This difference is not explained yet and **prevent the direct use of METOP AVHRR derived NDVI values to complete the SPOT VEGETATION time series**. **This problem has been reported to VITO and is currently under investigation by VITO experts…** (January 2013)

11.3.3.2.4 Comparison of SPOT VEGETATION and METOP AVHRR season parameters values after inter-calibration for Armenia

☞ *This section may be outdated as it was written in January 2013 and no update has been made in 2015.*

The season parameters values computed in TIMESAT and summarized in WinDisp by Marz (province) seem to show a **small systematic difference** between the ones computed from SPOT VEGETATION and the ones computed from METOP AVHRR NDVI. For example, the start of the season is either egal (often) or earlier of 1 (often) or 2 (very rare) decades when computed from SPOT VEGETATION images compared to the ones of METOP AVHRR.

However this topic has not been more deeply studied yet. **This should be the object of a future study.**

11.3.3.2.5 Comparison of SPOT VEGETATION and PROBA-V NDVI values for Tajikistan

Considering the mean S10 NDVI values for each of the 4 provinces of Tajikistan, for the period 2013 11 21 to 2014 05 21, for the 2 sensors SPOT VGT and PROBA-V (Figure 79), SPOT-VGT NDVI values seems to be often/systematically higher than PROBA-V, especially for higher NDVI values (using the following scale and offset: NDVI = 0.004 DN SPOT-VGT - 0.1 and NDVI = 0.004 DN PROBA-V - 0.08).

Currently we don't know how to consider this difference. Is this due to a local phenomenon due to the study area or other local factor? Will this cause a problem for the continuity of SPOT VEGETATION time series by PROBA-V? Further investigations should be carried out on this topic. Currently it is proposed to used the original slope and intercept parameter values for PROBA-V.

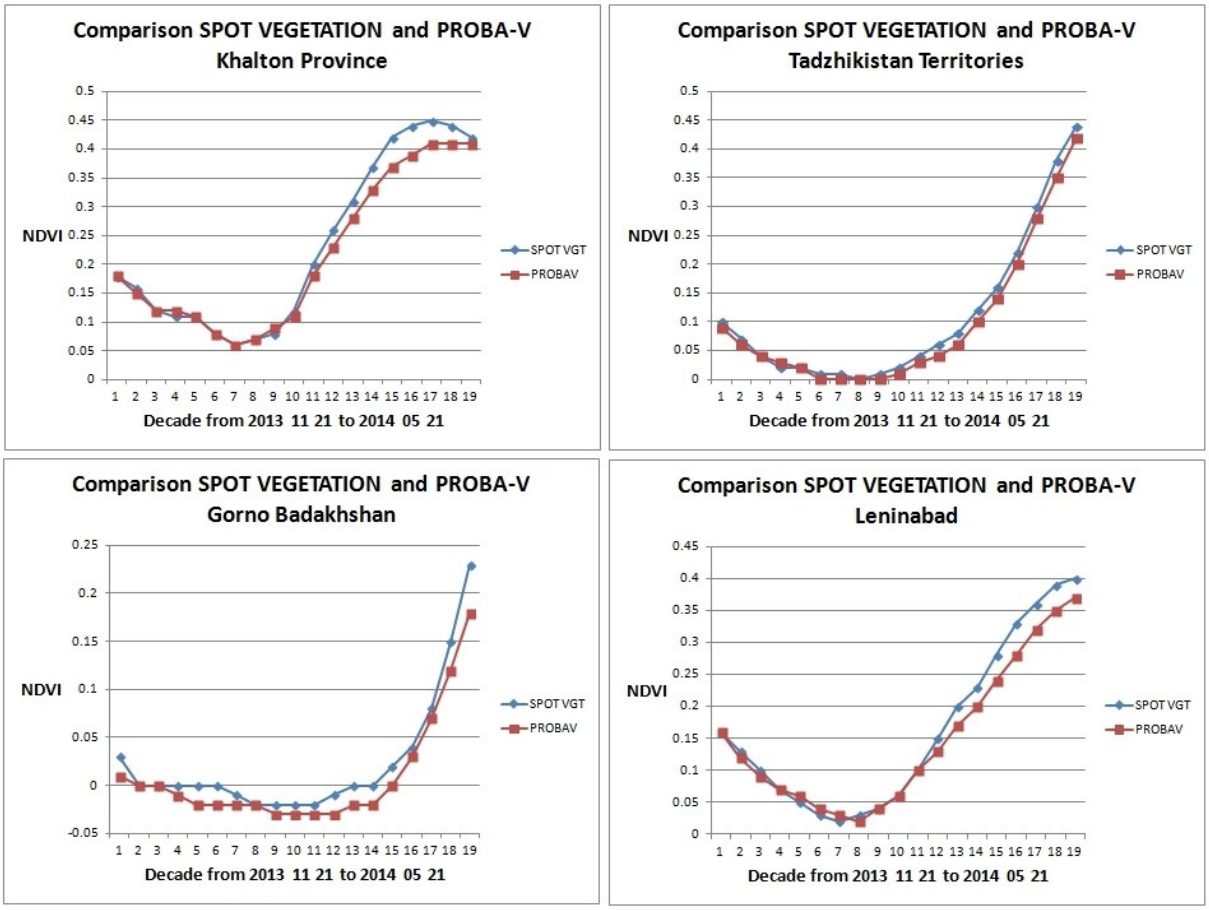


Figure 79: Comparison of mean NDVI values of SPOT VEGETATION and PROBA-V per Tajikistan province for the common time period from 2013 11 21 to 2014 05 21.

11.3.4 Spatial statistics computation

Once the images are imported and their header has been modified, spatial statistics can be computed. This operation consists in computing the mean (or median) of pixels values by areas identifying the crop location by administrative unit (Armenian marzes, Tajik provinces).

This can be done with the "**Process > Stats > Average (or Median)**" WinDisp function as described in the section 11.2.3.2 at page 115.

In the framework of the CYF model, this statistic process has to be done for the followings:

- **All 11 season parameters images**: in this case, it is necessary to create **11 list files**. One list file will contain the 15 images (1999-2013) of a given season parameter for the 15 studied years. And 11 list files for the period [2014-2015] for PROBA-V.
- **All NDVI images**: in this case, it is necessary to create **17 list files**, one for each of the 17 studied years (1999-2015). One list file will contain the 36 images of a given year.

This could also be done on series of **outputs of the "Process Series"** function of WinDisp (list of "MaxDate" for example). But this will be redundant with the TIMESAToutputs.

The **list files** to be used are provided in the training package under the directories "...\DATA\WINDISP DATA\LIST FILES\FITTED\" and "...\DATA\WINDISP DATA\LIST FILES\SEASON\". These list files don't contain "relative directory" as WinDisp don't support that. Consequently, the directories mentioned in these list files have to be adapted to the user's computer. This can be done with software such as "Notepad++" for example. The season images list files are made separately for SPOT VEGETATION images, METOP AVHRR and PROBA-V images (confer also the last section of section 11.5.3 at page 154).

The **boundary files** to be used in the case of Tajikistan are described in the next section.

The **statistics charts** resulting from this operation are the one to be used in the statistical part of the CYFS.

11.3.4.1 Boundary files to use in the current CYFS for spatial statistics computation

Boundary files are used for the delimitation of areas of interest for the **computation of statistics** into WinDisp on NDVI and season parameters images. One boundary file identifies a given crop location for each province where it is present. 3 crops are studied in this case: **wheat, potato and cotton**.

3 boundary files have been realized and are presented in Figure 80:

- COTTON_TAJIKISTAN_MONOPART.BNA

- WHEAT_TAJIKISTAN_MONOPART.BNA
- POTATO_TAJIKISTAN_MONOPART.BNA

These 3 boundary files are identical (except their names) as no information for each particular crop was available. These boundary files were roughly realised in GIS based on the observation of NDVI images. Up to the user to enhance them (confer next section).

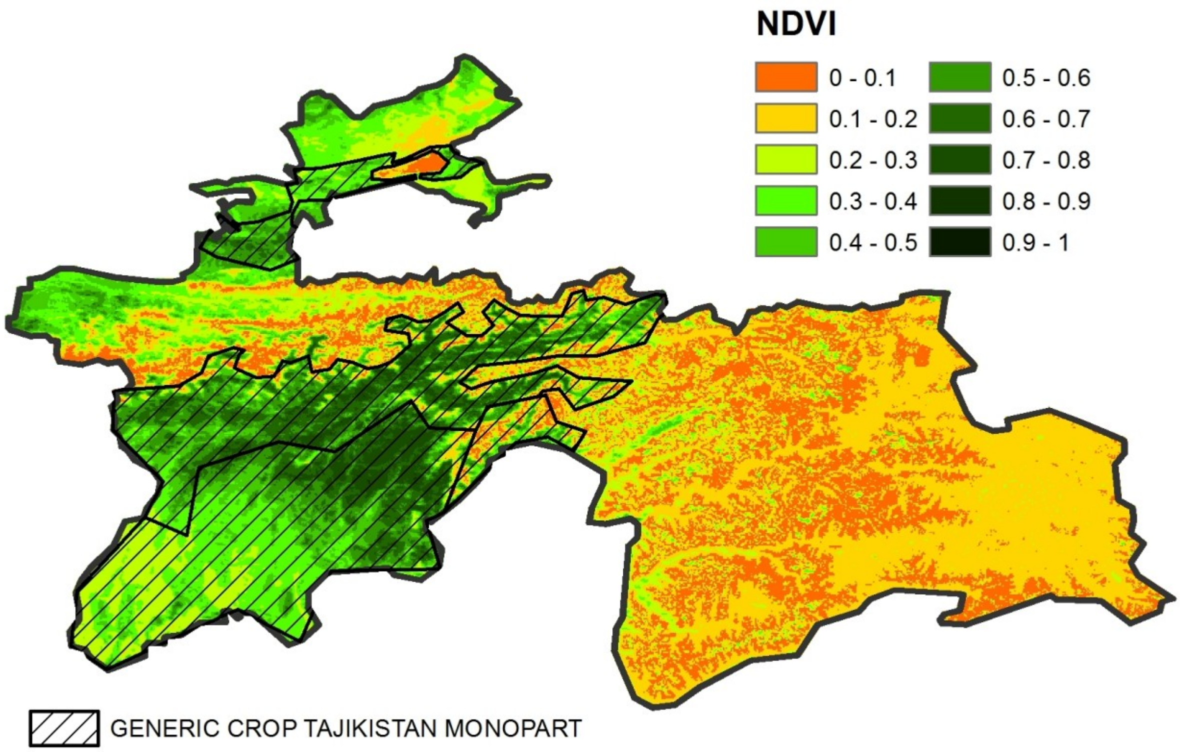


Figure 80: illustration of the boundary files currently used in Tajikistan for all crops. In thick black are the provinces boundaries. Background is the SPOT VEGETATION NDVI of 1st decade of June 1999.

Boundary files have to be in ".bna" format for compatibility with WinDisp. Methodology and constraints to respect when building boundary files for use in WinDisp with the current methodology are explained the next section.

Despite possible enhancement of these files and methodology, described below, it is recommended to work with these file for the time.

11.4 Building boundary files and possible enhancement

11.4.1 Building of the boundary files

The methodology and constraints to respect when building boundary files for use in WinDisp with the current CYF methodology is explained here.

11.4.1.1 Constraints to be respected for boundary files

First, for ease of data handling in the proposed CYFS methodology it is recommended to use boundary files that present **one single crop polygon per administrative level of interest** ("**MONOPART**" boundary files) (Marz in the case of Armenia, province in the case of Tajikistan). Indeed, the charts resulting from the computation with the "Process > Stats > Average" WinDisp function are composed of as many lines as there are spatially distinct areas in the boundary file used for the computation. If a "**MULTIPART**" boundary file is used, file where an area of interest is composed of several spatially distinct polygons, the resulting chart has to be post processed. This **post processing** consists in computing the mean parameter value per area of interest by weighting the mean parameter value of each spatially distinct polygon by its surface. This post-processing is **fastidious** in the current state of development of the methodology (in Excel). Possible methodology developments are mentioned in sections 11.4.2 and 11.4.3.

Secondly, the boundary **file format** has to be **".bna"** for better compatibility with WinDisp. Using a shapefile (*.shp) is also possible but this will result, in the **first column** of the output statistics chart, in a number instead of **administrative names** (eg. names of Marzes or provinces). Using a "*.bna" file will provide administrative names in the first column of the statistics chart, which is more convenient for post processing. The production of ".bna" file from shapefile is described below in section 11.4.1.2.2.

11.4.1.2 Methodology for building boundary files

The building of boundary files for use in WinDisp is made in 2 steps:

1. Building boundary file in "**shapefile**" format in **ArcGIS or QuantumGIS**
2. Conversion of the shapefile into a **".bna"** file format for better compatibility with WinDisp

If you don’t have neither shapefile, “.bna” file nor ArcGIS, you can draw the boundary file in WinDisp and then create a «.bna» file from your drawing. See “On-screen digitizing », page 46 of « Windips 4 User’s manual » for more information.

11.4.1.2.1 Building boundary file in "shapefile" format in ArcGIS

It is recommended to build boundary files in **ArcGIS or QuantumGIS** in the **shapefile** format because shapefile creation and edition is easily done with these software.

In this methodology, ideally, the boundary file to produce would have to represent the areas of a given crop for each Tajik province. The following steps can be followed:

- Producing one shapefile per crop of interest. If the different crops are all presents in a same shapefile, the crop of interest can be selected and exported to a new shapefile.
- Having one boundary shapefile of the administrative level of interest. For Tajikistan such shapefile can be downloaded for example from http://www.gadm.org.
- Use of the function "**intersect**" of ArcGIS or QuantumGIS on the 2 shapefiles representing the crop location and the Tajik provinces.
- Use the editing tools of ArcGIS to produce a "monopart" (confer section 11.4.1.1) boundary files. Pay attention to:
    - In the case that several spatially distinct crop areas are identified per administrative area and that the user wants to use the "monopart" approach, a solution is the construction of artificial thin (as thin as possible) "links" between crop areas of a given administrative area. However this solution is not elegant at all. Better (but more difficult to implement) solution is proposed in section 11.4.3.
    - "**Hole**" in polygon (inner part of a polygon that doesn't belong to the polygon) is considered in WinDisp as an independent polygon. So it is important to avoid them and they have to be fulfilled.
    - **Artefacts,** very small polygons that can result from the "intersect" function because of none perfect overlap between intersected shapefiles, have to be deleted.
- The **attribute table** of the resulting shapefile has to contain a column (called "province") with the names of the provinces.
- The coordinates system to be used is the Geographic coordinate system WGS84.

The **accuracy** of the shapefile can be checked by exporting the shapefile to Google Earth (function "Layer To KML (conversion)") and comparing the areas identified in the shapefile with the very high resolution images where available (confer section 11.4.2).

11.4.1.2.2 Conversion of the shapefile into a ".bna" file format for better compatibility with WinDisp

Although shapefile can be used for spatial statistics computation in WinDisp, it is recommended to convert them into ".bna" files for better compatibility with WinDisp (confer section 11.4.1.1).

The conversion from shapefile to ".bna" can be down with the FAO freeware "SHP2BNA" available on the following internet website: http://www.hoefsloot.com/agrometshell.htm. After you downloaded "SHP2BNA" freeware to your computer, unzip it and then click on the "shp2bna.exe" file. The interface shown below (Figure 81) will appear. You just have to:

- Select the shapefile you want to convert
- Select the output directory and name (explicitly) the ".bna" file you want to create.
- Select which attribute field (information) of the shapefile you want to be copied in the ".bna" file as the first and second ID of the «.bna» file. It is recommend to select the "province" column as the one giving the attribute to the first column of the «.bna» file and no attribute is selected for the 2nd column of the «.bna» file.
- Click on "Convert" to convert your shapefile to a «.bna» file.

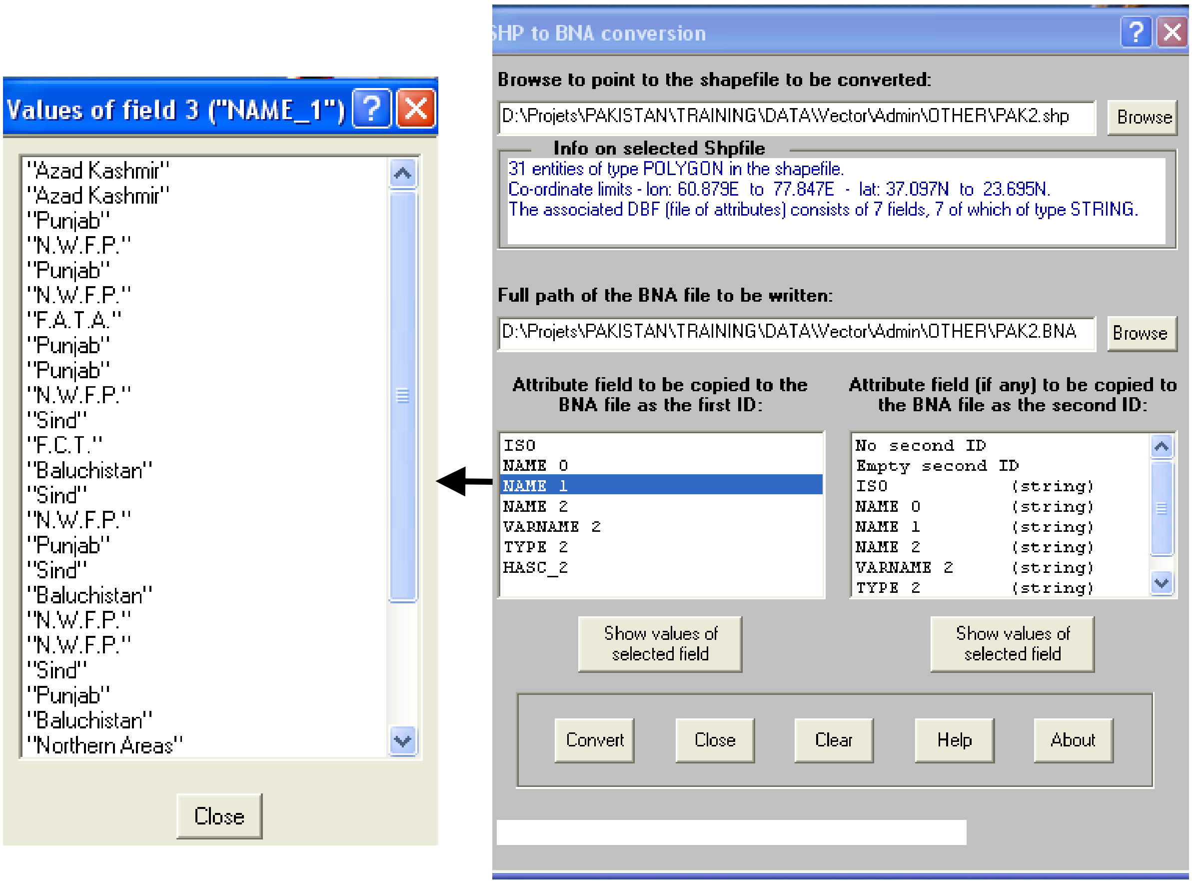


Figure 81: « SHP2BNA » FAO freeware for conversion of shapefile to «.bna» file (the case of Pakistan shapefile).

11.4.2 Enhancement of the boundary files to foresee

Both the boundary files and the method using them in the current CYFS in Tajikistan could be enhanced. **2 enhancements** are foreseen:

1. **Using more accurate crop boundaries**

The current crop boundaries are not very accurate. Indeed these boundaries don't delimit correctly crop areas. Many non crop (mountain, forest, built up, etc) areas are included in the current boundaries. This can be seen by overlaying the boundaries in Google Earth, as explained and shown below.*

*** Quick study of the accuracy of the boundary files in Google Earth**

The correspondence between boundary files and real land cover can be studied by overlaying the boundary files to satellite images in Google Earth. This can be done by doing the following:

- Transforming the shapefile of interest into "KMZ" or "KML" file format for compatibility with Google Earth (ArcGIS function "Layer To KML (conversion)", Quantum GIS function "Save vector layer as\KML")
- In Google Earth, comparing the shapefile boundaries and the land cover where very high resolution images are available.
- Edition of the shapefile can be realized in Google Earth in order to produce more accurate boundaries
- The Google Earth KML file can then be converted in shapefile in ArcGIS or QuantumGIS

Figure 82 shows an example for the potato shapefile of Armenia, where many inaccuracies and discordance between the boundaries and the land cover can be seen (forest and mountain areas are included in potato boundaries).

Figure 82: comparison in Google earth of the current potato boundaries used for Armenia and the very high resolution images

Note that it would be interesting to study the sensitivity of the general CYF model to the use of different boundary files for a given crop (crop boundary vs general province boundaries).

2. Using “multipart” boundary files

The creation of artificial thin tubes for “monopart” boundary file will inevitably negatively impact the quality of the statistics computation in WinDisp. An easy methodology should be developed to enable the use of multipart boundary files. That way, the mean of NDVI values and other season parameters per province should be computed by weighting each value area by its surface. Given the high number of value to handle (one value per year, crop, province, decade and season parameter), this would have to be done by programming, and for sure not manually, the later being subject to making quantity of errors.

The use of free software such as “**QGIS**” (www.qgis.org/) or “**R**” (www.r-project.org/) should be studied in the purpose of finding a better methodology than the one available in WinDisp, and enabling the use of “multipart” boundary files. The next section gives however a (fastidious) solution to handle multipart shapefiles in WinDisp.

11.4.3 Computing parameter value by Marz (province) from multipart polygon in WinDisp.

When using a **"multipart" boundary file** to compute spatial statistics with the "**Process > Stats > Average**" of WinDisp, the resulting chart will contain the **parameter values** organized in several lines per area of interest as illustrated in Figure 83, in this case several lines for a given Marz (columns from "C" indicate the decades).

	A	B	C	D	E	F	G	H	I	J
1	stats	code	1	2	3	4	5	6	7	8
2	Lori	1	0.29	0.27	0.25	0.26	0.27	0.24	0.21	0.19
3	Lori	2	0.41	0.4	0.39	0.39	0.39	0.34	0.3	0.28
4	Lori	3	0.35	0.33	0.33	0.33	0.34	0.32	0.29	0.28
5	Lori	4	0.37	0.33	0.31	0.3	0.31	0.27	0.23	0.22
6	Lori	5	0.21	0.19	0.16	0.16	0.17	0.15	0.12	0.11
7	Tavush	6	0.35	0.33	0.32	0.33	0.33	0.32	0.29	0.3
8	Tavush	7	0.33	0.31	0.3	0.3	0.31	0.29	0.26	0.25
9	Tavush	8	0.41	0.37	0.37	0.37	0.39	0.36	0.31	0.29
10	Tavush	9	0.35	0.33	0.33	0.33	0.34	0.31	0.27	0.26
11	Tavush	10	0.34	0.31	0.3	0.3	0.3	0.28	0.25	0.25

Figure 83: example of Excel chart resulting from the "Process > Stats > Average" function of WinDisp when using a "multipart" boundary file.

In order to use this information in the statistical part of the CYFS, it has to be summarized by Marz by taking into account the relative surface of each polygon, through a **sum weighted by area**.

The **area** of each spatially distinct polygon of a given boundary file can be computed in WinDisp by using the function "**Process > Stats > count**" with this boundary file. This gives the number of valid pixels (situated between the maximum threshold and the minimum threshold in a polygon) of each polygon (proportional to the area) (confer WinDisp 4.0 User's manual, page 33) (Figure 84). A batch file to count the pixels from multipart bna file is provided under the directory "...\DATA\WINDISP DATA\BATCH FILES" and is called "COUNT_PIXELS_MULTIPARTS_BNA.cmd".

	A	B	C	D	E	F	G	H	I	J
1	stats	code	1	2	3	4	5	6	7	8
2	Lori	1	1590	1590	1590	1590	1590	1590	1590	1590
3	Lori	2	19	19	19	19	19	19	19	19
4	Lori	3	127	127	127	127	127	127	127	127
5	Lori	4	25	25	25	25	25	25	25	25
6	Lori	5	33	33	33	33	33	33	33	33
7	Tavush	6	18	18	18	18	18	18	18	18
8	Tavush	7	63	63	63	63	63	63	63	63
9	Tavush	8	7	7	7	7	7	7	7	7
10	Tavush	9	34	34	34	34	34	34	34	34
11	Tavush	10	532	532	532	532	532	532	532	532
12	Tavush	11	187	187	187	187	187	187	187	187
13	Tavush	12	52	52	52	52	52	52	52	52
14	Lori	13	99	99	99	99	99	99	99	99

Figure 84: example of Excel chart resulting from the "Process > Stats > Count" function of WinDisp when using a "multipart" boundary file

In both charts resulting from “Process > Stats > Average” and “Process > Stats > Count”, the second column **“code”** contains the numeric code that WinDisp give to each spatially distinct polygon. This code can be used to make the junction between these 2 tables and give to each spatial entity its area.

From this information it is now possible to compute the average parameter value by Marz by taking into account the relative surface of each spatially distinct polygon inside a Marz. The **equation** below presents the formula to be applied to compute the mean parameter value per Marz“V_M” from the “n” units “i” of an area “A_i”, of a value V_{i_M} for a Marz “M”.

$$V_M = \sum_{i=1}^{n} \left(V_{i\_M} * \frac{A_{i\_M}}{A_{TOTAL\_M}} \right)$$

- V_M, the average parameter value to be computed by Marz
- i, a spatially distinct unit corresponding to one polygon
- n, the number of spatially distinct units i in a given Marz M
- M, a given Marz
- V_{i_M}, the parameter mean value for a polygon i in a Marz M
- $A_{i\_M,}$ the area for a polygon i in a Marz M
- ATOTAL_M, the total area of all polygons i in a Marz M

This computation can be realised in Excel but is fastidious. Therefore it is recommended to do that computation with programming software such as “R”.

Note: the “code” produced by WinDisp doesn’t correspond to the shapefile “objectid” information.

Table 15: example of final statistics file structure for indicators derived from satellite images. D stands for "Decade" and C for "Cumul".

1 file per province and per crop																				
	TIMESAT season parameters											TIMESAT NDVI Decade					NDVI cumuli			Others
Year	ampli	base	decrease	end	increase	large	length	max	middle	small	start	D1	D2	…	D35	D36	C_D1_D5	C_D1_D10	…	…
1999																				
2000																				
2001																				
2002																				
2003																				
2004																				
2005																				
2006																				
2007																				
2008																				
2009																				
2010																				
2011																				
2012																				
2013																				
2014																				
2015																				
…																				

Note: if the same shapefile is used for the different crops, the statistic file for only 1 crop has to be prepared and it will be duplicated afterward.

Origin of the different variables:

1. TIMESAT season parameters: TIMESAT seas2img process
2. TIMESAT NDVI Decade: TIMESAT fit2img
3. NDVI cumuli: NDVI cumuli can easily be computed into Excel for example
4. Others: others parameters can be computed in Excel for example. This can be the increase between given decades, etc

11.5 Process automation in WinDisp – batch files

11.5.1 Introduction

Many operations in WinDisp are **repetitive**, for example the importation of each of the images of a given time series (36 decades * 15 years (1999-2013) = 540 images to import). Doing each of these operations manually would take a very long time. The use of "**batch**" files enables the **automation** of such process, among other by introducing variables and looping process on these variables.

In the case of the CYFS, **image importation, header modification and statistics computation** have to be done for all images in a few "click" thanks to the use of a batch file.

The next sections are organised as follow:

1. An **introduction** to the use of batch files (how to build and use them)
2. The presentation of the batch files to be used in the **CYFS**

!! Note !! When working with batch files you have to modify the settings of your computer in order for the **point "." to be the decimal symbol**. !!

11.5.2 How to build and use "batch" files in WinDisp (optional)

Note: most of the indications in this section are extracted from the "WinDisp User's Manual 4.0". This section was written and illustrated for data on Pakistan and was not updated for Tajikistan. Illustrations are not always in line with the indications in the text.

11.5.2.1 Batch files

Batch processing is an effective way to automate repetitive tasks. All of the main display and processing functions can be saved in a batch file to be used later. The batch file is written in ASCII text format, and can be easily edited. Variables, if-then statements, for-next loops, and goto-label jumps can be used in a batch file.

11.5.2.2 Creating and using batch files

To create a batch file, select "Batch > Record" from the menu. You will be asked to give a filename to the batch file. After this, each WinDisp 4.0 command that you execute will be saved to the batch file. When you are finished recording, select Batch Stop in the menu. These commands can now be executed again by selecting Batch Play and specifying the name of the file. To see what the batch file looks like, and to make changes to it, use Batch Edit. If you want to execute the commands one at a time, use Batch Debug; with this option you can also change parameters in each step before executing them.

11.5.2.3 Batch file format

The basic format for a command in a batch file is:

Function, "Parameters"

Where Function is the menu command and "Parameters" are the parameters associated with this command. The "Parameters" are listed, separated by commas, in the same order as in the dialog box corresponding to the menu command.

For example, a command to display an image might look like this:

File Open Image, " c:\ccd_af\1997\Dc97073.af,,c:\data\projects\c.clr, 88,174,341,401"

It is important to note:

- The option Function is effected by the case of the letters used.
- Blank lines can be used to separate groups of commands and do not have an effect on the execution.
- Spaces and tabs at the beginning of a line are ignored and can be used to separate groups of commands.
- Long commands can be written on several lines. The beginning and end of a command is designated by quotation marks.
- Comments can be added in a batch files by denoting it as a comment line by starting the comment string with a # sign.
- Variables are delimited on each side by % symbols. If the users wishes to use the % symbol for other than denoting a batch variable, a pair of %% symbols must be used.

11.5.2.4 Using variables

Repetitive tasks can be simplified by using variables in a batch file. For example, decade images (every 10 days) can be given file names with similar structure such as “DV02011”, “DV02012”, etc. It is possible to substitute the year, month and decade values by variables. It is also possible to use command (“prompt”) so the user will be prompted to enter the number of the month and dekad for the image desired. The responses will be read into the batch file to identify the image to display. The dialog would look like this:

Batch Variable Prompt, "Month, Enter month desired, 7"

Batch Variable Prompt, "Dekad, Enter dekad desired, 3"

File Open Image, "c:\ccd_af\1997\Dc97%Month%%Dekad%.af,,c:\data\projects\c.clr, 0,0,0,0"

After replacing the variables by the values attributed to them, (%Month% by 07 and %Dekad% by 3), the command line becomes:

File Open Image, "c:\ccd_af\1997\Dc97073.af,,c:\data\projects\c.clr, 0,0,0,0"

The open file can now be used to display the desired image. Note that value entered by the user is 7 rather that 07 in the %Month% field.

It is important to note:

- If you include variables in a parameter during Batch Record, the command is saved to the batch file.
- Variables can be assigned values within the batch file using Batch Variables Set and with Batch For Begin.
- If you include a variable in a batch but do not set its value, you will automatically be asked for a value during execution.
- With Batch Variable Set you can use algebraic expressions and include other variables in the expression.

11.5.2.5 Batch file exercises (not adapted to Tajik data)

! Note that in this section, data mentioned and illustrations are not adapted to the Armenian case. The user should consequently adapt that by itself. !

Batch to open series of image.

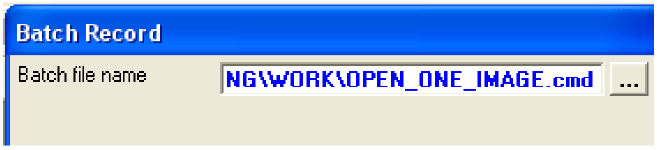
The problem is the following: you would like to open the 36 images of each year from 1999 to 2012 in WinDisp. So you will have to open “36 decadal images * 14 years =504 images”. Of course you can do that manually but this will take you a long time. It is possible to create a file which enables to automate this.

We will thus create a “batch file” which will be able to open automatically series of 36 decadal images of a given year. The purpose is thus to create a file which automates the operation “OPEN IMAGE”.

As an introduction, we will first create a batch file that allows opening automatically one image only.

The first step is to create the batch file itself. To do that, in WinDisp, in the main toolbar, go to “Batch > Record”. Browse to the following directory where you will record the batch file:

"…\DATA\WINDISP DATA\batch FILES\" and name your batch file "OPEN_ONE_IMAGE.cmd" as indicated in the figure bellow. Do not forget the "cmd" extension. Then clic OK.



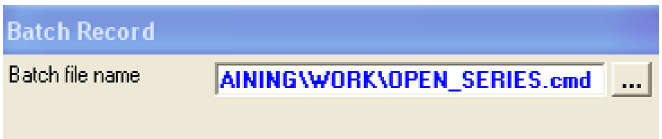
You've just created an empty batch file. Now, we will have to "write" in this empty batch file. Be CAREFUL!, now, all the operation you will do in WinDisp (open an image, or else…) will be recorded in the batch file ! So DO NOT do others operation than the one you want to automate. Open the first image of year 1999. For this, go to "File > Open > image" and open the image "DV92011.pak" in the directory "D:\VAST\in" with the NDVIE.clr color table as indicated in the figure below. Then click OK. The image displays. Remember this is the operation you want to automate. This operation has been recorded in the batch file. Then, go to "Batch > Stop" to stop the recording of your batch file.

Now you can check the batch file you have created. Go to "Batch > Edit" and select the batch file "OPEN_ONE_IMAGE.cmd". Then click OK. The following text file should appear:

File Open Image, "D:\VAST\in\DV92011.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"

This is your first batch file. First is the name of the process, then the directory of the image you want to open, then the directory of the CLR table you used to open the image.

Then, close the batch file and close the image. Now you will test your first batch file. Go to "batch > Play" and browse to the batch file you created in "…\PAKISTAN\TRAINING\WORK\OPEN_ONE_IMAGE.cmd" and clic OK.



The image "DV92011.pak" automatically opens.

Now, you will create **a batch file to open series of 18 images of year 1992**. Close all the images in windisp. Again go to "Batch > Record" and create a new batch file:

“…\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd” and clic OK. Go to “Batch > For > Begin”. The following window appears:

Complete the window as indicated in the figure above. You are creating a “variable” called “Month” which starts from January (1) to September (9) by increment step of 1 month (each month between month 1 and 9 is considered). Do the same for a new variable called “decade” starting at 1 (first fifteen days of a month) to 2 (second fifteen days). Remember that for GIMM-GLCF images, there are 24 images a year, thus 2 images per month only.

Then, open the first image of year 1992. For this, go to “File > Open > image” and open the image “DV92011.pak” in the directory “D:\VAST\in\” with the NDVIE.clr color table. Then clic OK. The image displays.

Then go to “Batch > for > end” to close the “for” of “decade” and again go to “Batch > for > end” to close the “for” of “month”. Then, go to “Batch > Stop” to stop the recording of your batch file.

Now you can check the batch file you have created. Go to “Batch > Edit” and select the batch file “OPEN_ONE_IMAGE.cmd”. Then clic OK. The following text file should appear:

Batch For Begin, "Month, 1, 9, 1"
Batch For Begin, "decade, 1, 2, 1"
File Open Image, "D:\VAST\in\DV92011.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"
Batch For End, ""
Batch For End, ""

Close the batch file. Then go to “Batch > play > “and browse to the new batch file“…\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd”. Clic OK.

Before to read the following section, try to understand what happened? Why? Can you comment?

The image **“DV92011.pak » opened 18 times**, this because you asked windisp to open 18 times the same image. For month = 1 and Decade = 1, WinDisp opened the image, the same for month = 1 and Decade = 2, then for month = 2 and Decade = 1, etc.

In fact WinDisp should open the image “DV92011.pak” when month = 1 and Decade = 1, open the image “DV92012.pak when month = 1 and Decade = 2, open the image “DV92021.pak when month = 2 and Decade = 1, etc. So WinDisp should open the 18 images from January to September 1992.

In order to do that, you have to modify your batch file. You have to **enter the variables (“month” and “decade”)** into the process command of the batch file. You will have thus to modify the line

> *File Open Image, "D:\VAST\in\DV92011.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*

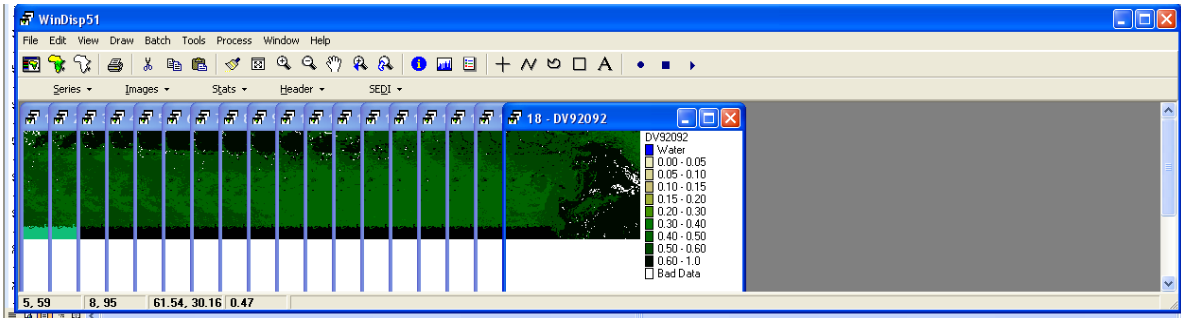
Of the batch file “OPEN_SERIES_IMAGE.cmd”

First close all the images with the tool “File > close All” in the main menu. Then, go to “Batch > edit” and browse to your batch file “…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd” and clic OK. Now you will replace the “month” part of the image name “DV920**1**1.pak” by the variable “Month” and replace the “decade” part of the image name “DV9201**1**.pak” by the variable “decade” as indicated below with %% around each variable.

> *Batch For Begin, "Month, 1, 9, 1"*
> *Batch For Begin, "decade, 1, 2, 1"*
> *File Open Image, "D:\VAST\in\DV920**%Month%%decade%.**pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
> *Batch For End, ""*
> *Batch For End, ""*

Then close your batch file. WinDisp will ask you if you want to save changes. Say Yes (OUI). In the “File Save Text” window, clic OK. And say Yes (oui) for overwriting. Check if your new batch file has been recorded correctly: go to “batch > edit “ and browse to “…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd” and clic OK. After checking, close the batch file.

Then you will play the new batch file which should **open the 18 first images of 1992**. Go to “Batch > play” and browse to “…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd” and clic OK. The 18 images should open as presented in the figure above:



To see all the opened images, go to “Window” and try successively “tile vertically” “tile horizontally” and “cascade”.

Then go to “file > close all”.

With this batch we opened 18 images only. You will now modify your batch file in order to open the **24 images of 1992**.

Try to do it before reading the following section!!

In order to modify your batch file, go to “Batch > edit” and browse to “…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_IMAGE.cmd” and clic OK. You can now modify the batch file.

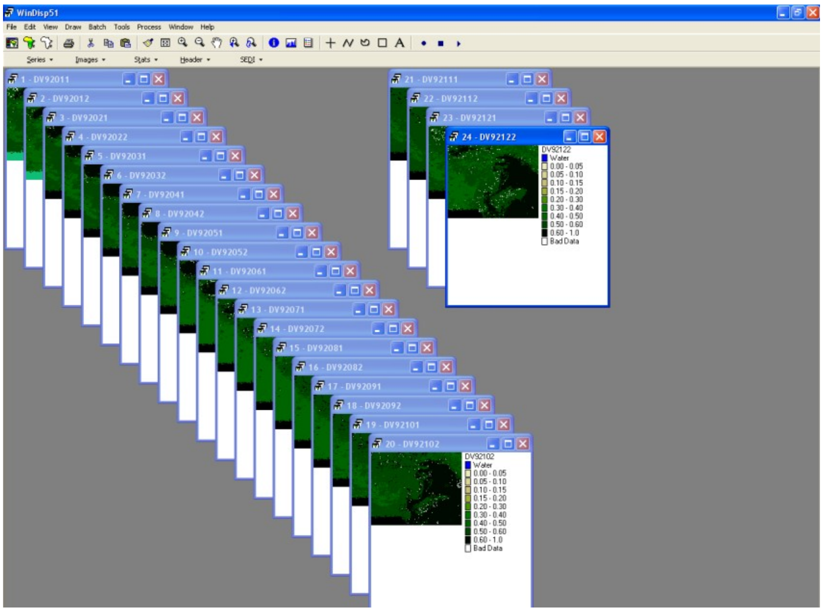
Here is the solution to open the 24 images of the year 1992:

Batch For Begin, "Month, 1, 9, 1"
Batch For Begin, "decade, 1, 2, 1"
File Open Image, "D:\VAST\in\DV920%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"
Batch For End, ""
Batch For End, ""

Batch For Begin, "Month, ***10, 12,*** *1"*
Batch For Begin, "decade, 1, 2, 1"
*File Open Image, "D:\VAST\in\DV92**%M**onth%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
Batch For End, ""
Batch For End, ""

You just had to copy and past the text already created and modify the month of interest (10 to 12: October to December). Be careful! You also have to modify the name of the image file: you have to suppress the “0” standing before the %month% variable. Indeed, here, we use month from 10 to 12 and no “0” is necessary anymore (not “010” to “012”). For month 1 to 9, the “0” before the month variable was necessary because the month reference in the NDVI image is composed of two numbers, “01” for January for example, and the variable is starting from “1” to “9” and not from “01” to “09”.

Once this is done, save your new batch file as "…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_24IMAGEs.cmd". Then play the batch file "OPEN_SERIES_24IMAGEs.cmd".



Now imagine that you want to open images for the year 1993 the same way. What do you have to do ?

You simply have to modify the year reference in your batch file as indicated below:

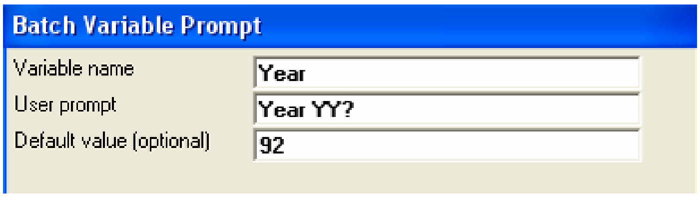
Batch For Begin, "Month, 1, 9, 1"
Batch For Begin, "decade, 1, 2, 1"
*File Open Image, "D:\VAST\in\DV**93**0%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
Batch For End, ""
Batch For End, ""

Batch For Begin, "Month, 10, 12, 1"
Batch For Begin, "decade, 1, 2, 1"
*File Open Image, "D:\VAST\in\DV**93**%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
Batch For End, ""
Batch For End, ""

To do that go to "Batch > edit" and browse to "…\Projets\PAKISTAN\TRAINING\WORK\OPEN_SERIES_24IMAGEs.cmd". Then modify your batch and save it as "…\PAKISTAN\TRAINING\WORK\OPEN_SERIES_24_IMAGE_93.cmd". Then play this new batch to check if it works!

As it is not really practical to edit the batch file each time you want to execute it for a different year**, WinDisp enables to change the year without editing the batch file**. This is possible with the "Batch > Variable > Prompt" tool.

Close all your images. Then go to “Batch > record” and save a new batch file as following: “…\PAKISTAN\TRAINING\WORK\OPEN_SERIES_24_IMAGE_92_98.cmd”. Then go to “Batch > Variable > Prompt” and complete the window as below and clic OK.



Then stop the recording with “Batch > Stop” and open the new batch file with the single line containing the “Prompt” command which look like the following: “***Batch Variable Prompt, "Year, Year YY?, 92"***”

You created a new variable which is called « Year ». The User prompt means that the question “Year YY?” will appear to the user he will play the batch file. The user will then have to enter “93” if he want to open the 24 images for 1993. If he does not change anything the default value of 92 will open the 24 images of 1992.

You have then to create a new batch file containing both the “prompt command” and the commands to open the images from January to December. Save this new batch file as following: “…\PAKISTAN\TRAINING\WORK\OPEN_SERIES_24_IMAGE_92_98.cmd”. it should looks like the following:

Batch Variable Prompt, "YY, Year YY?, 92"

Batch For Begin, "Month, 1, 9, 1"
Batch For Begin, "decade, 1, 2, 1"
*File Open Image, "D:\VAST\in\DV**%YY%**0%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
Batch For End, ""
Batch For End, ""

Batch For Begin, "Month, 10, 12, 1"
Batch For Begin, "decade, 1, 2, 1"
*File Open Image, "D:\VAST\in\DV**%YY%**%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"*
Batch For End, ""
Batch For End, ""

It would be even better to be able to say to WinDisp what are the years we want to open images for. For example: “I would like to open all the images from 1992 to 1998 in just one command”. This is also possible.

Try to find a solution before reading the following section.

The following batch file “OPEN_SERIES_24_IMAGE_92_98_Choose.cmd”will enables you to open in 1 clic 168 images from 1992 to 1998. You could also open images for a certain period included in 1992 to 1998.

Batch Variable Prompt, "SY, Starting Year YY?, 92"
Batch Variable Prompt, "EY, Ending Year YY?, 98"
Batch For Begin, "YY, %SY%, %EY%, 1"

Batch For Begin, "Month, 1, 9, 1"
Batch For Begin, "decade, 1, 2, 1"
File Open Image, "D:\VAST\in\DV%YY%0%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"
Batch For End, ""
Batch For End, ""

Batch For Begin, "Month, 10, 12, 1"
Batch For Begin, "decade, 1, 2, 1"
File Open Image, "D:\VAST\in\DV%YY%%Month%%decade%.pak, , D:\Projets\GMFS\Données de base\NDVI Afrique NOAA\NOAA ARTEMIS\NDVIE.CLR"
Batch For End, ""
Batch For End, ""

Batch For End, ""

Now, try to do a batch **file which enables to Window** (parameters of the clip : X1 = 15, Y1=20, X2=100, Y2=100) the images from 1992 to 1998 (and to save the result in the following folder “…\PAKISTAN\TRAINING\WORK\ window\” and to display the resulting windowed file in WinDisp

11.5.2.6 Comment on batch files

If the batch file commands a process that creates or modifies images and that the images called by the batch don’t exist, the batch will **create empty images** as output. For example if you apply the batch to modify the header to the year 1998 on SPOT VEGETATION images where there are images from April only, the execution of the batch file will create empty images from January to April.

11.5.3 Batch files for images importation, headers modification and computation of statistics in the CYFS

For the CYFS in Armenia batch files for WinDisp have already been created for **images importation, headers modification and computation of statistics**. These are stored in the directory “...\DATA\WINDISP DATA\BATCH FILES\” and are:

- IMPORT_HEADER_METOP_FITTED.cmd
- IMPORT_HEADER_METOP_SEASON.cmd
- IMPORT_HEADER_SPOT_VGT_FITTED.cmd
- IMPORT_HEADER_ SPOT_VGT _SEASON.cmd
- STATS_AVG_FITTED_MONOPART.cmd
- STATS_AVG_FITTED_MULTIPARTS.cmd (optional)
- STATS_AVG_SEASON_MONOPART_METOP.cmd
- STATS_AVG_SEASON_MONOPART_SPOT_VGT.cmd
- STATS_AVG_SEASON_MULTIPARTS_METOP.cmd (optional)
- STATS_AVG_SEASON_MULTIPARTS_SPOT_VGT.cmd (optional)

Batch files can be adapted according to user's need. This can be done by simple editing of the batch files with "Notepad++" for example.

These batch files have to be **launched from WinDisp** interface through the menu "Batch > Play". Be careful, when executing the batch: at the "Batch > Variable > Prompt" "Input Directory?" question, **check that the input directory default value is the right one**. It has to be the one mentioned at the 1st line of the batch file, in this case: "D:\Projets\ARMENIE\ARMENIA_CYFS_RS_2013\DATA\". This can be adapted according to your computer directories organisation.

The **batch files for statistics computation** call **list files** that are stored in the folder "...\DATA\WINDISP DATA\LIST FILES\". If you don't use the same directories organisation than the one proposed in this manual, adapt the directories of these list files.

Statistics on season parameters has to be computed with different batch for SPOT VEGETATION and METOP AVHRR images since their header information (geographic features) are not exactly the same (confer section 11.3.3).

11.6 Excel - Computation of cumulated NDVI values per phenological period

It has been showed in the literature that the cumulated (sum) values of NDVI on crop phenological periods (flowering,…) or other periods can be highly correlated to crop yields. NDVI cumuli computation can be down in 2 steps:

- Identification of the phenological periods (or other periods of interest) of the studied crop
- Computation of the cumulated (sum) NDVI values for these periods. This computation can be easily done in the Excel charts resulting from the "Process> Stast > Average" WinDisp function. However it is probably easier to handle these computations in programming software such as "R".

These NDVI cumuli can then be used in the statistical part of the CYFS as the other crop yield explanatory variables.

CHAPTER II. DATABASE UPDATES AND MODIFICATIONS

Sometimes it can be necessary to make some database updates, for example in the case that the users want to change a computation parameter (e.g.: the start of the season threshold value, the missing data code, the smoothing parameters, etc). In this case the users will simply have to **modify the desired settings in the settings files or batch files of TIMESAT and/or WinDisp** and launch the modified process and downstream processes with the **batch files**. Except for the "TSF_process" of TIMESAT that takes approximately 30 minutes per year for Tajikistan extent, all other processes can be executed in a few seconds. Database updates and modification can thus be done **very rapidly**.

CHAPTER III. REAL TIME CROP YIELD FORECASTING

12 Strategy to handle real time crop yield forecasting

Crop yield forecasting has to be done in time, typically before harvest takes place and, most of the time, before the end of the vegetation season. In that case the NDVI curve of the current vegetation season is not yet completed which prevents the derivation of season parameters in TIMESAT. To overcome that problem, the current year NDVI time-series has to be **artificially completed**. The proposed solution is to artificially complete the current time-series with the **historical mean time series computed from the past year** (confer section 12.1 below) (Figure 85).

The completion of the time-series enables the season parameters derivation in TIMESAT. However only **parameters not affected by this artificial season ending** should be taken into account for the selection of the explanatory variables of the crop yield model as explained in section 12.2 below. Beside **complementary variables** can be computed in programming software such "R".

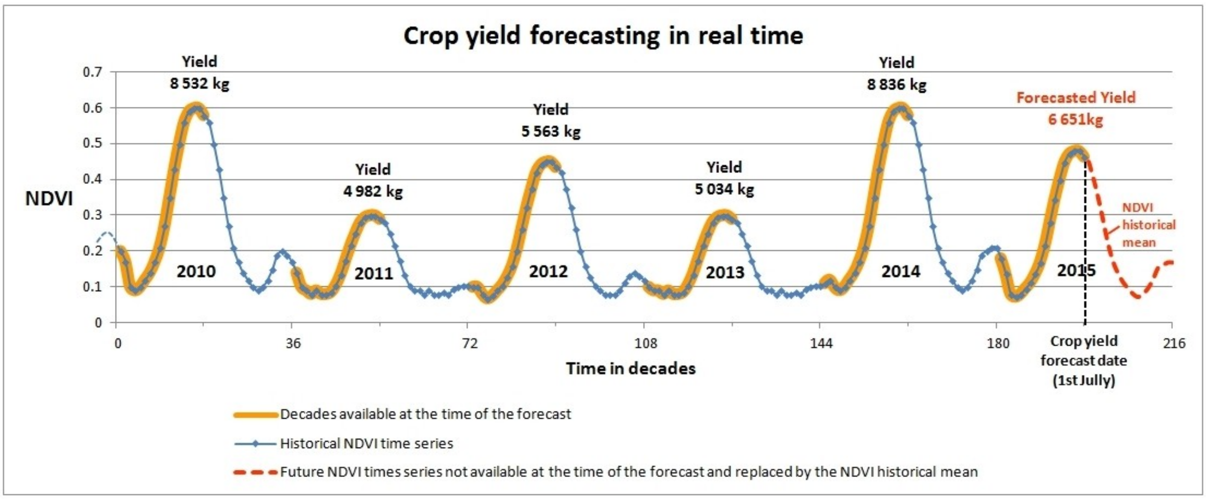


Figure 85: Concept of the real time crop yield forecasting from NDVI time series

12.1 Preparing a "historical mean" NDVI time-series

The proposed methodology for the preparation of the "historical mean" time-series has to be done in 2 steps:

1. Computation of the "historical mean" time-series in WinDisp.
2. Conversion of the resulting images format for compatibility with TIMESAT in ENVI standard format, with the "GDAL_translate" function of "FWTools 2.4.7". So these images can be used to complete the current year time-series and to process it TIMESAT.

12.1.1 Computation of a “historical mean year” in WinDisp

The “historical mean” time-series can be computed in WinDisp, although it is a fastidious work. A method to compute it in programming software such “R” should be developed in the future.

That computation can be done with the “**Process > Series > Average**” function of WinDisp. It has to be done from **SPOT VEGETATION** images only. This computation has to be done on images already processed in TIMESAT (smoothed) and imported into WinDisp.

The “historical mean” images time-series computation requires:

- The realisation of as many **list files** as decades for which to compute the “historical mean” time-series (maximum of 36 list files). For example, the list file for the decade 25 will contain the 15 (in the case of past years = [1999-2013]) NDVI images of the decades 25 of the 15 SPOT-VGT years. These list files have to be made in WinDisp or by copy/past/edit in Notepad++.
- The execution of the “**Process > Series > Average**” function of WinDisp as many times as there are decades for which to compute the “historical mean” time-series (maximum of 36 times). This can be done with a **batch file**.

The 36 list files and the batch file have already been made and are available in the following directories:

- **List files**: “...\DATA\WINDISP DATA\LIST FILES\MEAN_1999_2013\...”
- **Batch file**: “...\DATA\WINDISP DATA\BATCH FILES\MEAN_YEAR_1999_2013_SPOT_VGT.cmd”

Note that, for unexplained raison, this batch file may need to be launched several times to properly work!

The resulting “**historical mean” NDVI images in WinDisp format** are stored in the directory:

- “...\DATA\NDVI IMAGES\WINDISP\ MEAN_1999_2013_SPOT_VGT\...”

Figure 86 presents the comparison between the historical mean of SPOT VEGETATION NDVI temporal evolution for the years 1999 to 2012 (red) and the one of the year 2012 (green), for 3 pixels in Armenia. Note that the historical mean spectra present a little inflection at the decade 19. This inflection is not obvious when visualizing each of the 14 years individually (Figure 91).

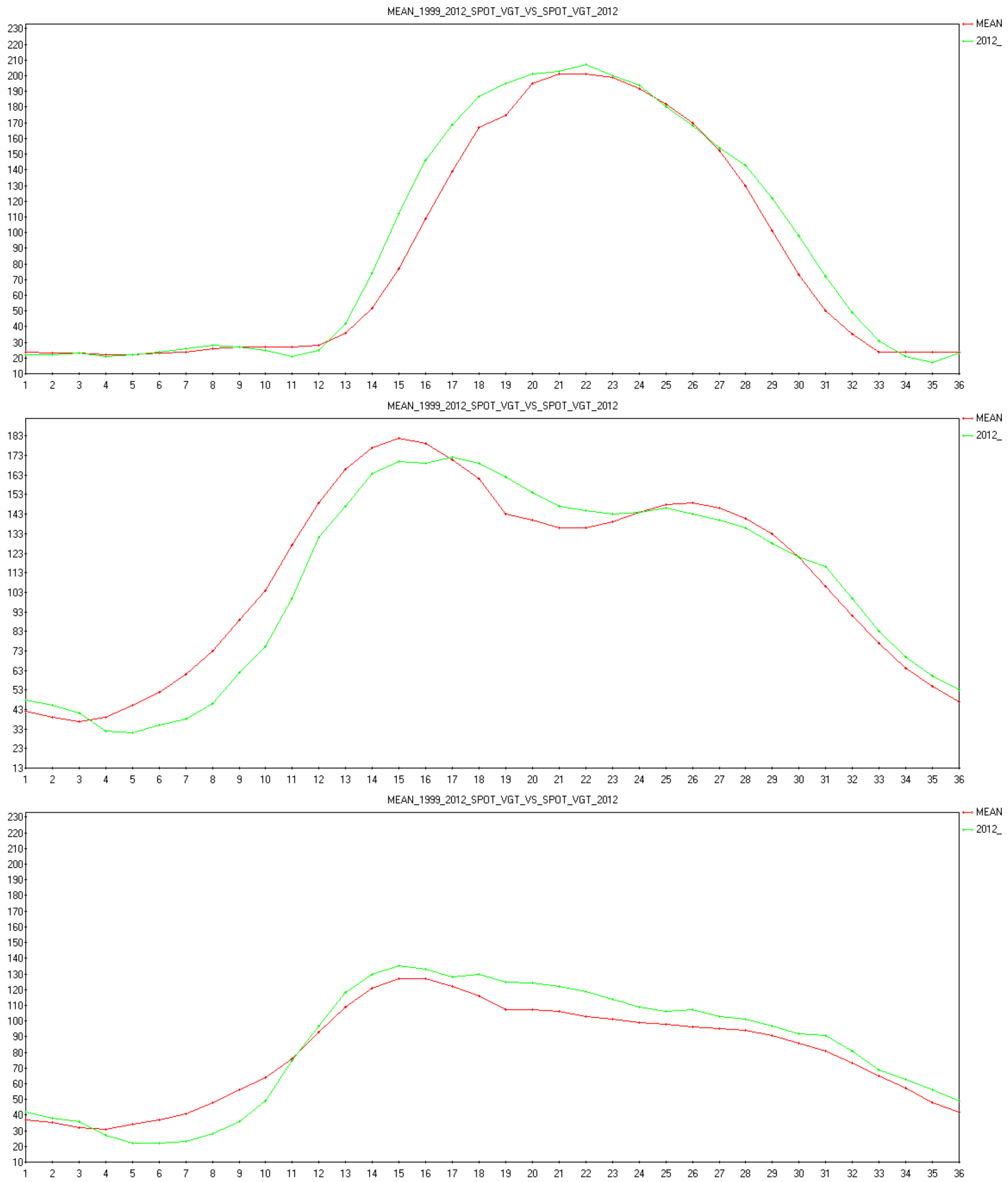


Figure 86: Comparison between the mean SPOT VEGETATION NDVI temporal evolution for the years 1999 to 2012 (red) and the one of the year 2012 (green), for 3 pixels in Armenia

12.1.2 Format conversion of the "historical mean year"

As the "historical mean" time-series has to be used in **TIMESAT** for season parameters extraction, images have to be **converted in TIMESAT compatible format** (ENVI standard format). This can be done with the "GDAL_translate" function of "FWTools 2.4.7".

A **batch file** has been created in this purpose and is in the directory:

- “...\DATA\NDVI IMAGES\WINDISP\MEAN_1999_2013_SPOT_VGT\BATCH_FORMAT_CONVERSION_MEAN_1999_2013_SPOT_VGT.bat”

In this batch file, input files have a filename structure such as “MEAN_FITTED_1999_2013_SPOT_VGT_0037”, and an output filename structure such as

“20150101NDVI.img”. The year of the output filenames (“2015” in this case) is the year of the current year (the time-series to be completed). The output filename structure has to respect the one of the current year NDVI images found in the directory “...\DATA\NDVI IMAGES\ PROBAV\TAJIKISTAN\PPT_OUT\”.

Resulting images from the execution of this batch file are stored in the directory:

- “...\DATA\NDVI IMAGES\SPOT_VGT\MEAN_1999_2012_ENVI_FORMAT\”

12.1.3 Completion of the current year time-series with the “historical mean” time-series

When real time CYF has to be done, for example for 2015:

1. First all available images from 2015 have to be downloaded and the database completed
2. Secondly, the 2015 time-series has to be completed with the images of the “historical mean” time-series (1999-2013) in the directory containing the current year NDVI images, i.e. in the directory “...\DATA\NDVI IMAGES\ PROBAV\TAJIKISTAN\PPT_OUT\” (if PROBA-V images are the one used for the current year).

Then the TIMESAT and WinDisp processes can be executed for the “artificially completed” 2015 time-series.

12.2 Explanatory variables selection for CYF before the end of the vegetation season

Given the configuration of the annual NDVI evolution in Armenia (or Tajikistan), with a vegetation season ending late in December (e.g. in Figure 87), numerous TIMESAT seasons parameters are not usable for real time CYF before the end of the vegetation season as their computation depends on the real end of the vegetation season.

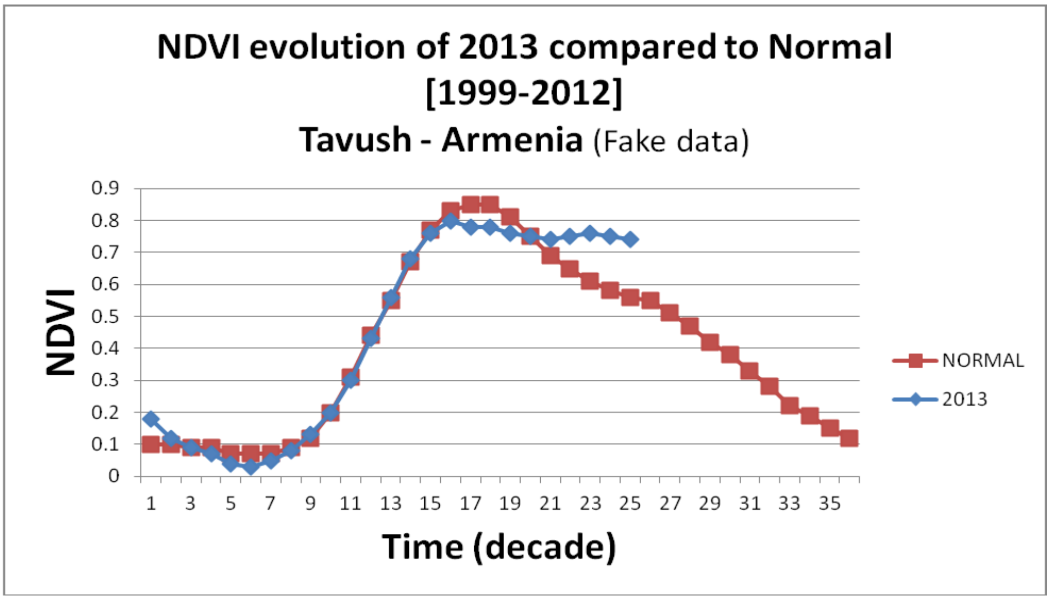


Figure 87: comparison of the current NDVI values at the first decade of September 2013 with the historical mean ones (mean on 1999-2012) for Tavush Marz in Armenia (fake data).

The Table 16 presents a classification of the NDVI-derived explanatory variables depending on their availability for real time CYF before the end of the vegetation season.

Type of explanatory variables	Variables allowed in a model realised before the end of the vegetation season	Variables NOT allowed in a model realised before the end of the vegetation season
TIMESAT season parameters	Start date , maximum value, increase rate	End date, season length, base level, middle time, amplitude, decrease rate, large integral, small integral
NDVI cumuli	All cumuli that can be made before the date of the CYF.	All cumuli that would include data after the date of the CYF
Other parameters to be computed	Date of the maximum NDVI value Decrease rate between the date	

	of maximum NDVI value and a later date (e.g.: maximum date + 3 decades)	

Table 16: NDVI-derived explanatory variables classification depending on their availability for real time CYF before the end of the vegetation season.

Only few **TIMESAT season parameters** (3) are available before the end of the vegetation season.

NDVI cumuli can be computed on identified crop phenological period as explained in section 11.6. These cumuli periods can for example start at the start of the season identified by TIMESAT and cover different periods till the date of the CYF.

Complementary season parameter can be computed, e.g. the date of the maximum NDVI value, the NDVI decrease rate between the date of the maximum NDVI value and a later date (e.g.: maximum date + 3 decades). This can be easily done in programming software such as "R".

Note that a strategy to overcome the "end of the season" problem could be (to be tested) to use of a fixed NDVI value threshold as method to identify the end of the season in TIMESAT, rather than the currently used "amplitude (relative) method". This would allow identifying the end of the season before the minimum NDVI value at the end of the season is reached.

12.3 The similarity approach

Another strategy, that doesn't require the artificial completion of the current time series, is the **"similarity" approach**. This consists in identifying for each pixel the most resembling NDVI curve (regarding its shape and absolute NDVI values at the time of the forecast) in the past years. The crop yield at the administrative level of interest (Marz, department, etc) of the past year resembling the most to the current year will be attributed to each pixel of the image for the current year. Then the mean yield is computed at the administrative level of interest (Marz, department, etc).

This methodology isn't presented here. The free software "**SPIRITS**" (foreseen release in November 2013) will contain tools for applying this methodology.

CHAPTER IV. COMPLEMENTARY INFORMATION FOR CYFS (OPTIONAL)

Beside the crop yield forecasting itself, satellite imagery can be used to derive complementary information that can be useful for monitoring vegetation seasons or that are interesting to present in an agrometeorological bulletin.

The next sections present some methodologies to produce this information and some websites providing satellite derived information relevant in this context.

13 NDVI temporal evolution graph

Section 11.2.2 presents a methodology to produce in WinDisp graphs expressing the NDVI temporal evolution. These graphs can concern one year (Figure 88) or several years, in series or in parallel (Figure 89 to Figure 91). This can be used to:

- Compare the NDVI profile of a given pixel for several **years**
- Compare NDVI profiles according to **regions / land cover**.

To produce a graph of **several years in series**, the list file has to be composed of 1 column and as many lines as decades to be represented. To produce a graph of **several years in parallel**, the list file has to be composed of as many columns as there are of years to be represented and 36 lines (in the case of decadal images for 1 year) (Figure 89). A particular case of the later is the comparison of the NDVI values of the current year with the historical mean computed as explained in the section 12.1.

WinDisp will draw graphs for pixels interactively selected in the image.

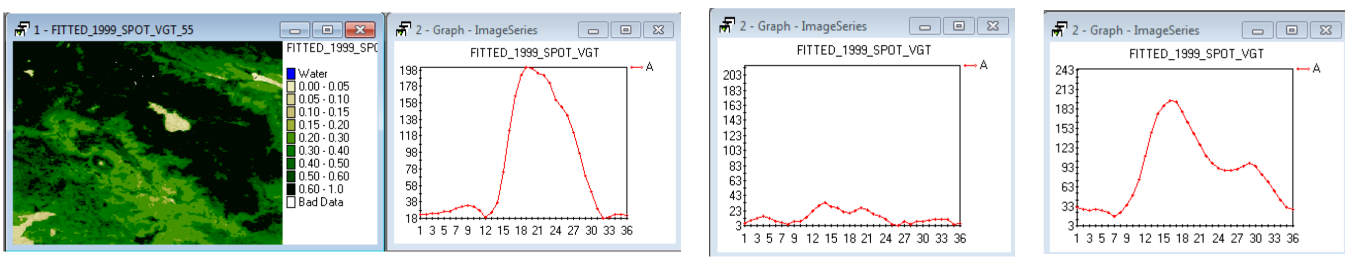


Figure 88: examples of annual NDVI evolution for some pixels of Armenia

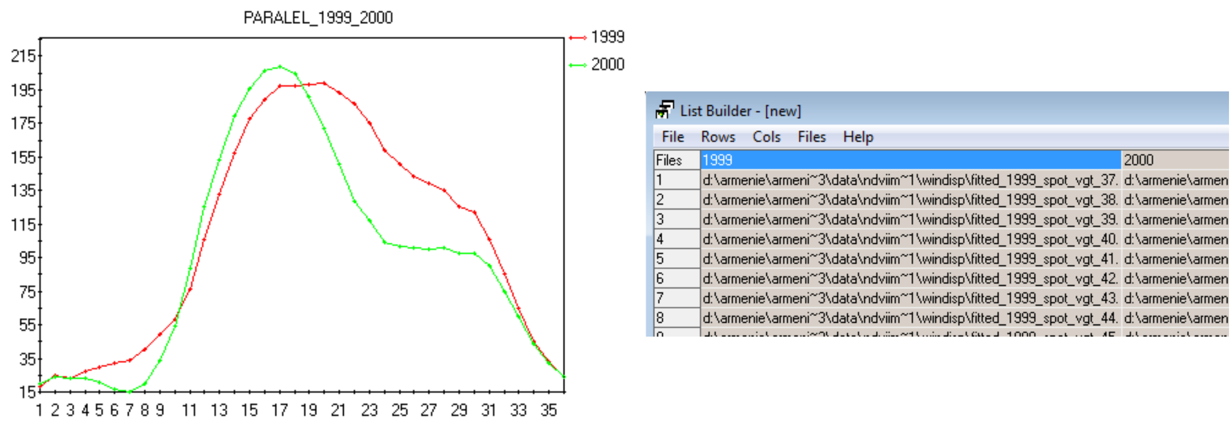


Figure 89: example of a graph representing the annual NDVI evolution of a given pixel in Armenia for 2 years in parallel, and the corresponding list file (part of it)

Figure 90 presents an example of the NDVI temporal evolution for a “pasture pixel” in Armenia, for the years 2007 to 2010 from non smoothed SPOT VEGETATION images.

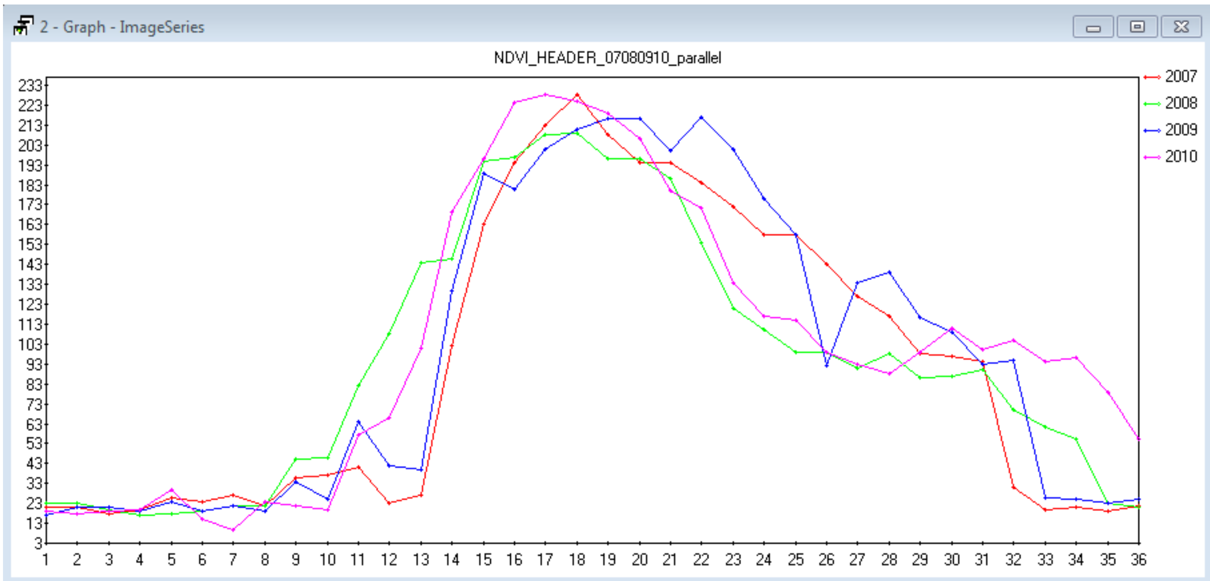


Figure 90: SPOT VEGETATION NDVI temporal evolution (before smoothing) for the years 2007 to 2010 for 1 pasture pixel in Armenia

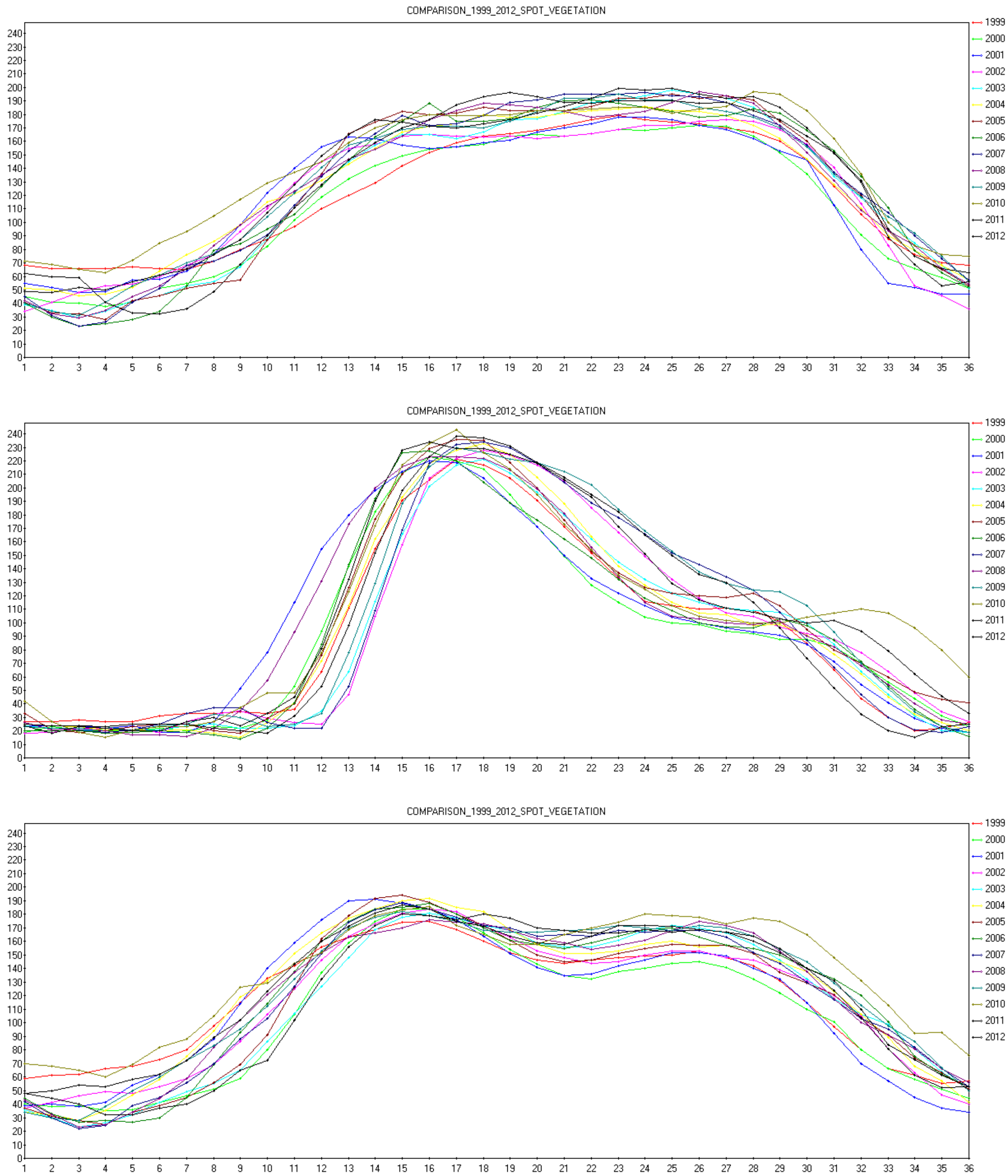


Figure 91: SPOT VEGETATION NDVI temporal evolution for the years 1999 to 2012 for 3 pixels in Armenia

Some other NDVI temporal evolution graphs are presented for different areas of Pakistan in Annex 1.

14 Stress maps

"Stress" maps are used to highlight areas where vegetation (in this case) presents unusual behaviour, in particular stressed status, i.e. lower biomass development than usual, at a given date.

A stress map results from the comparison of the current situation image to a reference "normal" situation image. This reference "normal" situation image is usually obtained by the computation of the historical mean of the data of interest.

To realise a stress map for a given decade,

1. Compute the "**normal**" image (historical mean), for the decade of interest. Methodology to compute such image is explained in the section 12.1.
   a. Create a file list of all images of the decade of interest from 1999 to 2012 for (14 lines = 14 years)
   b. Compute the normal image of the decade of interest for 1999-2012 with the function "Process > Series > Average" and chose the list file created above.
   c. Give an explicit name to the output "normal" image (e.g.: SPOT_VGT_NORMAL_1999_2012_DECADE_55)
   d. Visualize the output in WinDisp

   Note that "**historical mean" NDVI images in WinDisp format** are stored in the directory: "...\DATA\NDVI IMAGES\WINDISP\ MEAN_1999_2012_SPOT_VGT\..."

2. Use the "**Process > Image > Difference**" to produce the stress maps. Confer the remarque* below to understand better what this function does. Choose as function parameters:
   i. A image: the "normal" image created above
   ii. B image: the current year image for the decade of interest

   a. Name the result explicitly (e.g.: **DIFF_**DECADE_55_NORAML_2012_SPOT_VGT)
3. Display the image
4. Modify the header value with slope of 1 and intercept of 0 in order to get [0-255] values range (or keep the NDVI transformation)
5. Create a **new colour table** expressing the normal situation, the situation lower and higher than normal, in the example below for the [0-255] value range, with
   i. Normal situation: values around 128
   ii. Stress situation: values below 128
   iii. "Better" situation than normal: values higher than 128

6. Save image as “bitmap” file for exportation in report

Note that “stress maps” can also be realized on NDVI values or seasons parameters.

*** Remarque:** explanation of the “Difference” WinDisp function. Subtracting one image from another is a very useful way to compare two images. For instance, you can compare current vegetation conditions with previous conditions. This function subtracts the second image from the first image and rescales the result to fit in 8-bits (0-255) according to the equation (256+A-B)/2. In the output image, if count = 128 there is no difference, if count > 128 then the first image has a higher value than the second image, and vice versa. (Source: “WinDisp 4.0 User’s Manual”).

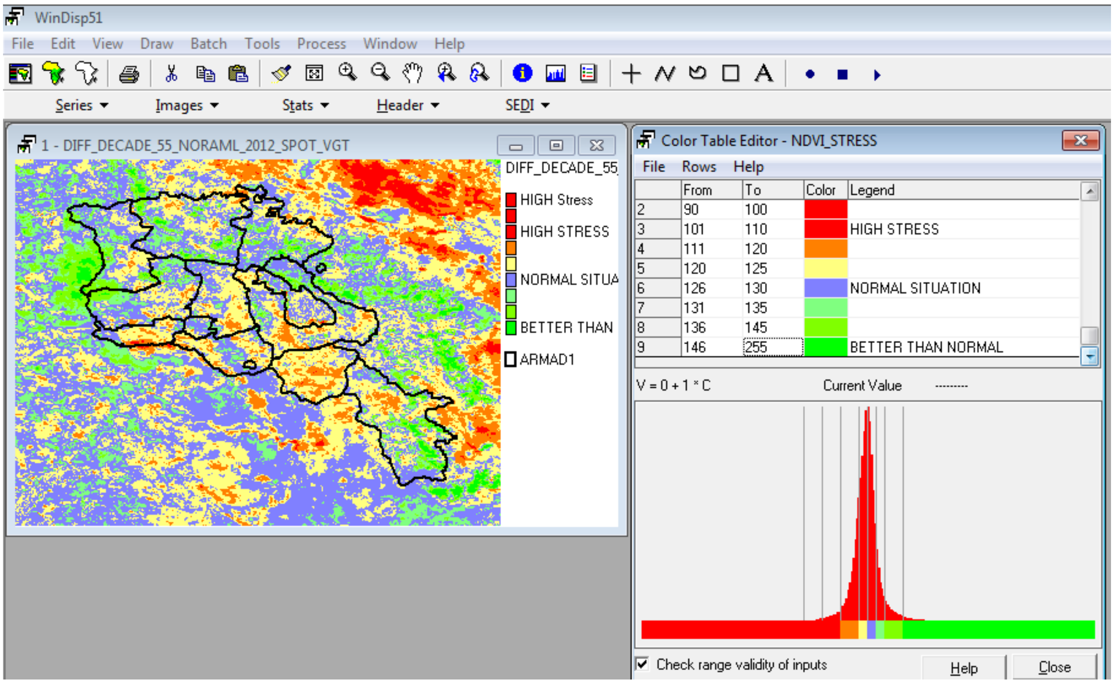


Figure 92: example of a stress maps realized for the decade 55 of 2012 on Armenia with the “Color Table Editor” WinDisp tool.

15 Realisation of animated images

Animated GIF images can be used to show, for example, the evolution of the NDVI values for a given year, in Tajikistan. This consists in an animated image that displays in a short time interval (e.g.: 3 seconds) the 36 NDVI images of a given area. That kind of animated image is not really rich in information but looks good on a website. An example is provided in the directory "...\DOCUMENT\ANIMATED GIF IMAGE\". It can be read with an internet browser for example.

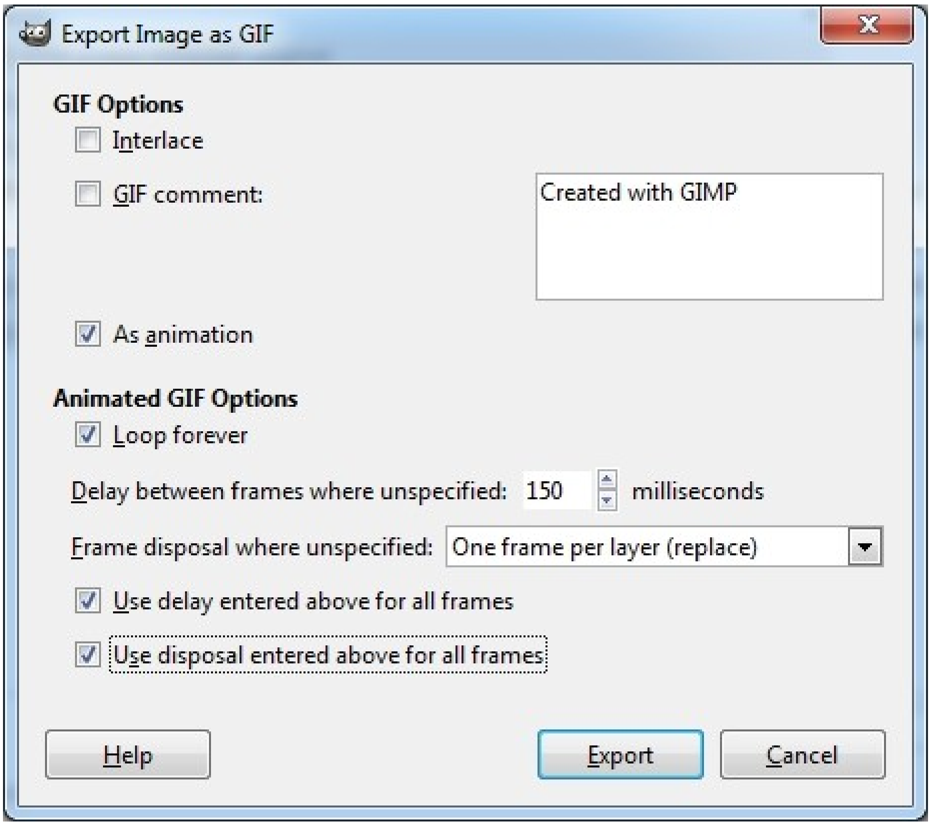
Animated GIF can be realised with software such as "**GIMP**" (freely available here: http://www.gimp.org/).

The **steps** to follow to realise an animated GIF images from a series of images are the following (in this case, the series of images are the 36 NDVI images of a given year in Tajikistan):

1. To produce the images that will compose the animation by:
    i. Opening the images in WinDisp (potentially with a batch file if the number of images is important)
    ii. Optionally overlay some boundary file (e.g.: Tajikistan boundary)
    iii. Saving these images as ".bmp" file with the function "File > Save > Bitmap"
2. With a software such as Microsoft Office Picture Manager for example, (optional):
    i. Trim the images to keep only the part of the image to be used in the animation (same trim to apply to all images)
    ii. Compress the images in order to reduce the size of the animation (and consequently to enhance the display of the animation on a website)
3. Realise the animation in GIMP:
    i. Open GIMP
    ii. Open the first image of the animation (File > Open)
    iii. Open all the other images composing the animation as "layers" (File > Open as layers)
    iv. Arrange the images by chronological order in the "Layers – Brushes" window: the last image above, the first image below.
    v. Save the group of images as an animation with the function "File > Export", give a name and use the file extension **".gif**", and click on "Export"

vi. In the appearing window, complete the options as indicated in the figure below, among other:

1. Uncheck “Interlace” and “GIF comment”
2. Check “As animation” and “Loop forever”
3. Select a animation speed by giving a delay between frames of your chose, for example 150 milliseconds
4. Check the 2 last options
5. And finally export



i. Save your GIMP project (File > Save as > and choose the “.xcf” extension)

16 Access to complementary information

Some websites provide freely satellite derived information relevant in this context. 2 websites are presented hereafter.

16.1 Land Surface Analysis - Satellite Application Facility (LSA-SAF)

The “Land Surface Analysis - Satellite Application Facility (LSA-SAF)” website, http://landsaf.meteo.pt/, provides many data derived from the **EUMETSAT Satellite** (MSG and EPS).

The interested user shall have a look on that website, in particular at the “Product description” section. The **available products** are, among other:

- SMA: Soil Moisture Availability
- ET: Evapo-Transpiration
- Vegetation stress
- FVC: Fraction Vegetation Cover
- LST: Land Surface Temperature

Note that these products are only available for the **last 3-4 years** and are consequently not usable in the CYFS model itself.

16.2 GEOLAND

The Biogeophysical Parameters (BioPar) Service of the “Geoland” website, http://www.geoland2.eu/portal/service/ListService.do?serviceCategoryId=CA80C981, provides in near real time and off-line a series of bio-geophysical parameters describing the continental vegetation state, the energy budget and the water cycle. Examples of data available are:

- LAI: Leaf Area Index
- FAPAR: Fraction of Absorbed Photosynthetically Active Radiation
- FCOVER: Fraction of vegetation cover
- NDVI: Normalized Difference Vegetation Index
- DMP: Dry Matter Productivity

Annex

Annex 1 - NDVI temporal evolution in different region of Pakistan with SPOT VEGETATION images of 1999 – 2006

NDVI evolution extracted with WinDisp from a time serie of 288 NDVI SPOT-Vegetation NDVI images from 1999 to 2006

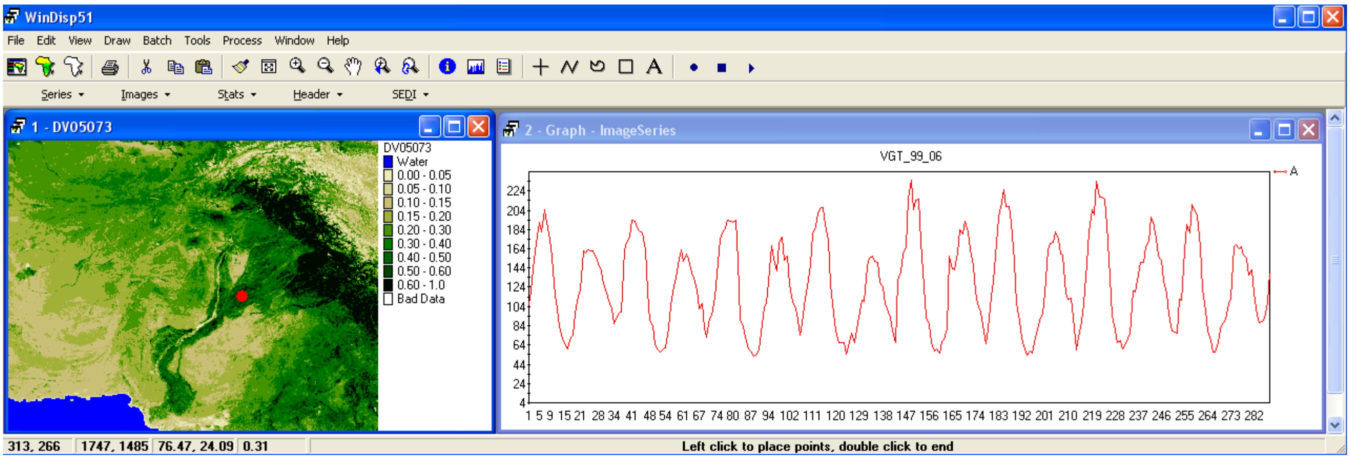


Figure 93 : NDVI evolution curve for year 1999 to 2006 in the central valley of Pakistan.

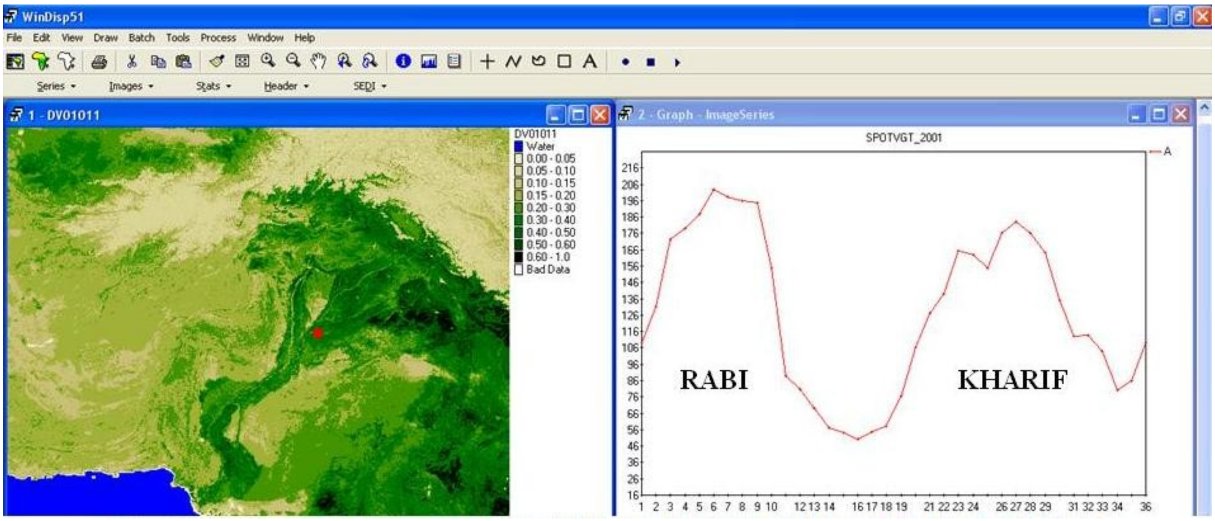
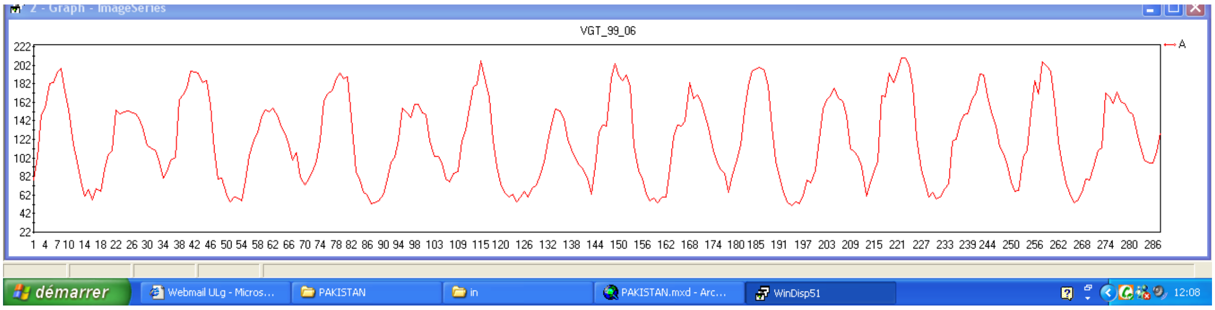
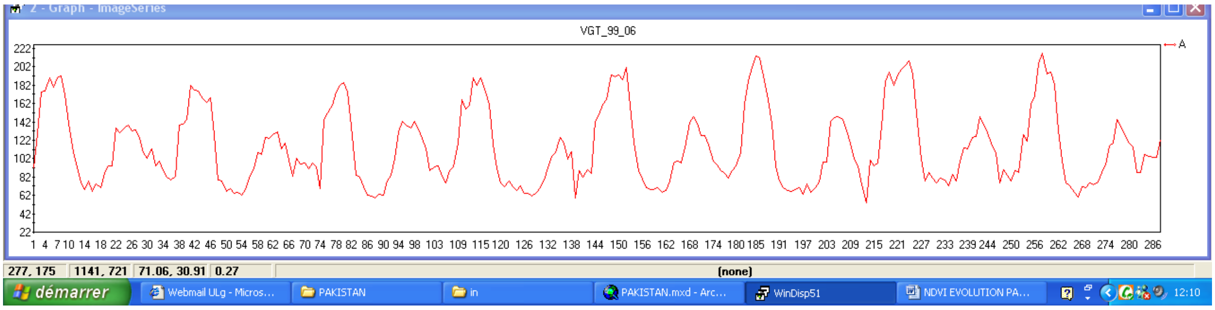


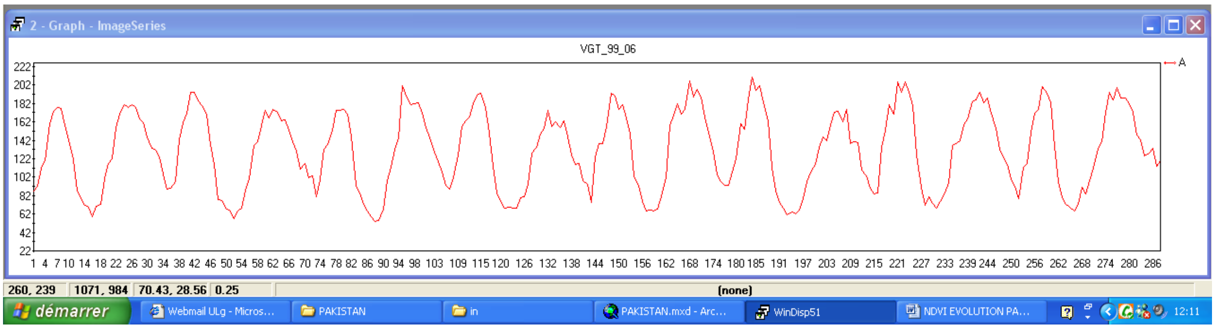
Figure 94: NDVI evolution curve for year 2001 in the central valley of Pakistan: the 2 growing seasons RABI and KHARIF are identified.



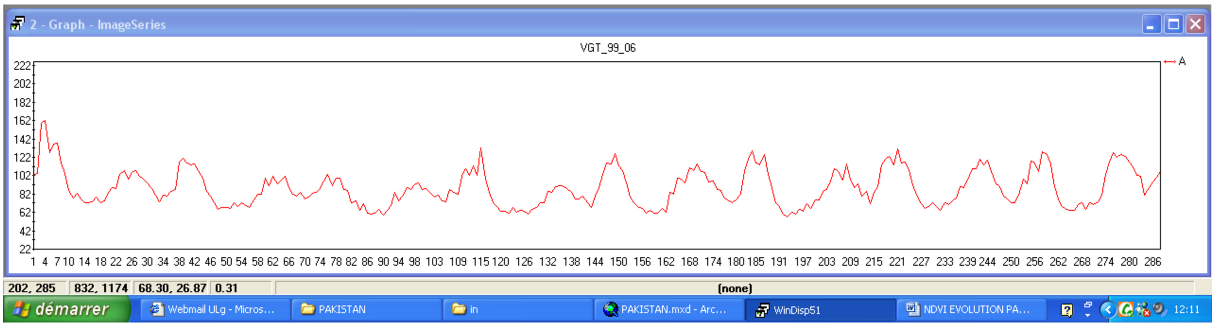
North East



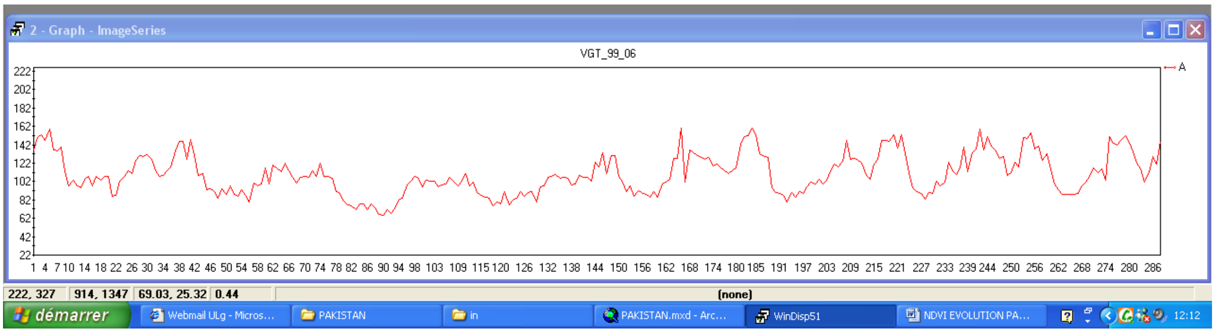
North West



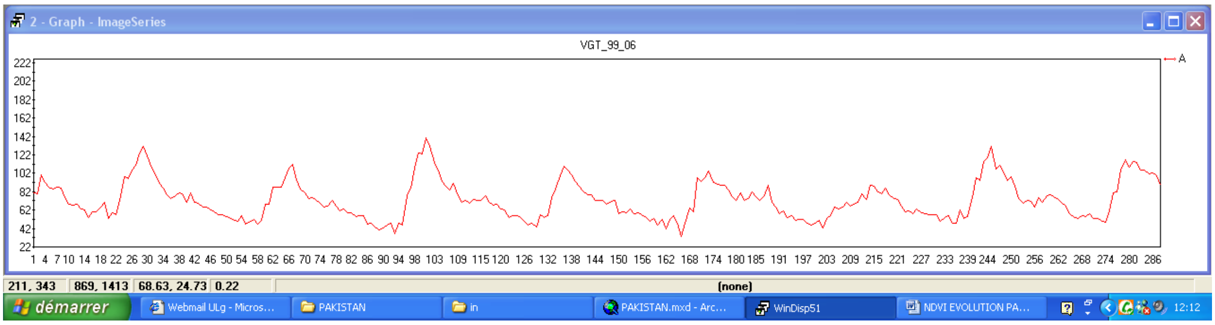
Center



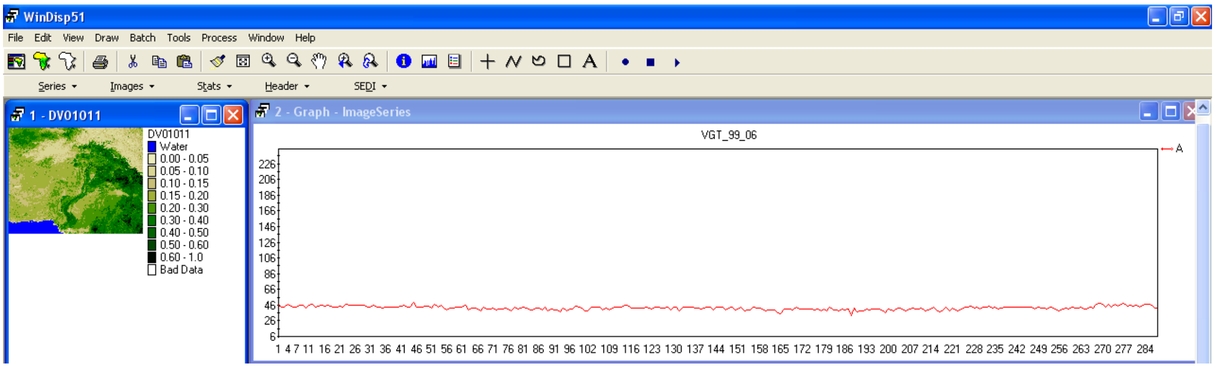
Central South



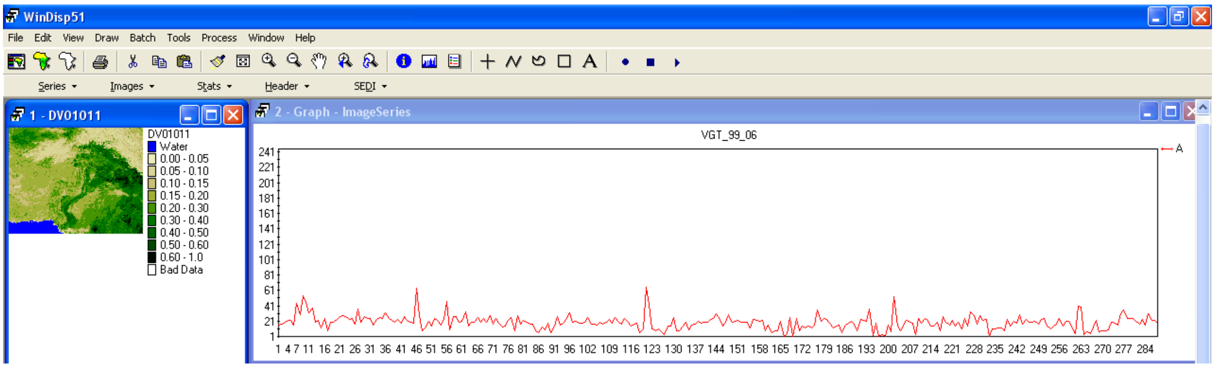
Central South



Extreme South



Extreme West



Extreme North (mountain)