

FACULTY OF GEO-INFORMATION SCIENCE
AND EARTH OBSERVATION

ITC

In Situ and Online Data Toolbox
Installation, Configuration and
User Guide

XML Version 1.3

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Abstract

Currently large amounts of environmental data are delivered through “GEONETCast-EUMETCast”. ILWIS plug-ins are developed to import various data types delivered via these telecommunication based systems. The generic RS and GIS capability offered by ILWIS can be used for further processing of the data.

These systems disseminate real and near real-time environmental data which can be received using a low cost ground receiving station. On the other hand, various environmental data resources, especially time series of data, are currently available through the internet. The “***In Situ and Online Data Toolbox***” (ISOD) is developed to easily ingest these data sources. The data supplements the information delivered through the data dissemination systems mentioned above, but requires internet connectivity.

The toolbox is identical in design as compared to the other toolbox plug-ins, like the GEONETCast Toolbox. This document is providing a description where to download all the freeware utilities, how to install and configure them. The ISOD Toolbox developed is an open utility. It can be easily modified and tuned to fit the specific user needs without programming skills. Next to this description also an overview is presented on the various data resources that can be automatically retrieved and processed. Finally the document provides hands-on exercises how to use the utilities offered. The exercises provided are focusing on near real-time climatological *in situ* observations, gauge and satellite derived precipitation products, weather and pressure forecasts, potential evapotranspiration, normalized difference vegetation indices, ocean and elevation information.

The utilities provided are extensively tested using various operating systems, such as Windows Vista, XP (various service packages) and Windows-7 and have found to be performing in a stable manner. The toolbox currently does not work under LINUX. In case unexpected behaviour or bugs are observed, additions to the functionality are required or if you have developed new utilities which you want to share, please contact the EO Community Contact (<http://52north.org/communities/earth-observation/community-contact>).

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LIST OF ACRONYMS AND ABBREVIATIONS

52North-----	52°North Initiative for Geospatial Open Source Software
AMESD-----	African Monitoring of the Environment for Sustainable Development
ARC-----	Africa Rainfall estimate Climatology
ASTER-----	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR-----	Advanced Very High Resolution Radiometer
BDMS-----	Botswana Department of Meteorological Services
CMORPH-----	Climate Prediction Centre Morphing Technique for rainfall estimation
CPC-----	Climate Prediction Centre
EO-----	Earth Observation
ECMWF-----	European Centre for Medium-Range Weather Forecast
eMODIS-----	Expedited MODIS
ESA-----	European Space Agency
EUMETCast-----	Telecommunication based data dissemination system
EUMETSAT-----	European Organisation for the Exploitation of Meteorological Satellites
FTP-----	File Transfer Protocol
FEWSNET-----	United States Agency for International Development (USAID) Famine Early Warning System
GDAL-----	Geospatial Data Abstraction Library
GDEM-----	Global Digital Elevation Model
GLDAS-----	Global Land Data Assimilation System
GEONETCast-----	Telecommunication based data dissemination system
GMTED-----	Global Multi-resolution Terrain Elevation Data
GRIB-----	GRIdded Binary
GSOD-----	Global Summary of Day Data
GTS-----	Global Telecommunication System
HDF-----	Hierarchical Data Format
ILWIS-----	Integrated Land and Water Information System (GIS-RS software)
ISOD Toolbox-----	In Situ and Online Data Toolbox
IrfanView-----	Software tool for visualization of pictures
ITC-----	Faculty of Geo-Information Science and Earth Observation, University of Twente, the Netherlands
ITF or ITCZ-----	Intertropical Convergence Zone
ISD-----	Integrated Surface Data
MEaSure-----	NASA project to develop Vegetation Phenology and Vegetation Index Products from Multiple Long Term Satellite Data Records
MOD16-----	MODIS Evapotranspiration product
MODIS-----	Moderate Resolution Imaging Spectrometer
MPE-----	Multi sensor Precipitation Estimate
NDVI-----	Normalized Difference Vegetation Index
NASA-----	National Aeronautics and Space Administration
NetCDF-----	Network Common Data Form
NOAA-----	National Oceanic and Atmospheric Administration
NOAH-----	National Centres for Environmental Prediction / Oregon State University / Air Force / Hydrologic Research Lab Model
OS-----	Open Source
PET-----	Potential EvapoTranspiration
QMORPH-----	Identical to CMORPH but without Infra-red propagation rainfall estimate
RFE-----	Rainfall Estimate
RFS-----	Rainfall Satellite for Latin America
SPOT-----	Système Probatoire d'Observation de la Terre ou Satellite Pour l'Observation de la Terre
SRTM-----	Shuttle Radar Topographic Mission
SST-----	Sea Surface Temperature
TAF-----	Terminal Aerodrome Forecast
TAMSAT-----	Tropical Applications of Meteorology using Satellite data and ground-based observations
USAF-----	United States Air Force

TRMM----- Tropical Rainfall Monitoring Mission
UTC----- Universal Time Coordinated
XML----- Extensible Markup Language

RELEASE NOTES

Following comments have to be taken into consideration with respect to the release of this ISOD Toolbox, XML version 1.3:

1. This is the third release and utmost care was taken to ensure appropriate operation of the routines developed but at this stage some defects might still be included and should be reported to the corresponding author to be included in a new release;
2. For the release of this toolbox version all data sources used have been checked. For some data sources the data format or naming conventions have changed. It was also noted some data has been re-processed. Furthermore Internet has a transient nature; some links might not be active after some time. If any of such a problems are encountered please report these to the corresponding author;
3. No liability can be accepted for use of the ISOD Toolbox by the toolbox developers;
4. When using the ISOD Toolbox you agree and comply with the conditions of the software utilities used as well as the terms and conditions stipulated by various online data providers for the use or references to the source of the data;
5. When using ILWIS 3.8 Open or higher some functionality has changed and is not downwards compatible. When not familiar with ILWIS it is advised to use ILWIS 372 for the purpose of learning how to apply this toolbox in conjunction with other ILWIS functionality. When running the toolbox under ILWIS 372 and you want to use ILWIS 38 for visualization – animation, copy the ILWIS service objects, available under your ILWIS 372 sub-directory “\Extensions\ISOD-Toolbox\System” into the ILWIS 38 sub-directory “\system”.

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1. GENERAL INSTALLATION AND CONFIGURATION INSTRUCTIONS

1.1 INTRODUCTION

Follow the instructions provided below to install ILWIS Version 3.7.2, the ISOD Toolbox and a number of other free software utilities, in order to work with the data provided via open internet resources. Read the instructions provided below carefully and proceed with the installation of the various utilities. In case you want to use the ISOD Toolbox, be aware that at this moment it is not running under LINUX-Ubuntu. Furthermore this ISOD Toolbox version is not downwards compatible; you need to use at least ILWIS Version 3.7.2.

1.2 DOWNLOAD ILWIS

Available from: <http://52north.org/>

From this location select the navigation tab: “Downloads” or directly select “<http://52North.org/downloads/ILWIS>”. Select the latest (multiple file) ILWIS372 version (“*ILWIS 3.07.02*”) and download the ZIP file(s), save the file(s) in a temporary directory on your hard disk. Unzip the file and run the ILWIS setup. When you intend to use the ISOD Toolbox **do not install ILWIS372 under the default installation directory “C:\Program Files”** as this might cause problems with respect to administration rights (especially under Windows 7) when creating temporary files and because the toolbox is utilizing DOS batch routines, which can be affected by the space in the directory file name “*Program Files*”. Select as your installation “*drive:\directory*” a location where you have the proper administrative rights (e.g. “*D:\ILWIS372*”). In the “*ILWIS372*” directory a shortcut to the “*ILWIS.exe*” can be created, you can copy this shortcut to the desktop of your system.

Please take into consideration, straight from the start, the following golden rules when using ILWIS:

- Don't use spaces in directory or file names, instead use underscores;
- Do not only use numbers as file names;
- Do not work in multiple output directories;
- Start ILWIS, navigate to your working directory and close ILWIS. Open ILWIS again to ensure that your current working directory is also the actual ILWIS working directory.

1.3 DOWNLOAD THE ISOD TOOLBOX

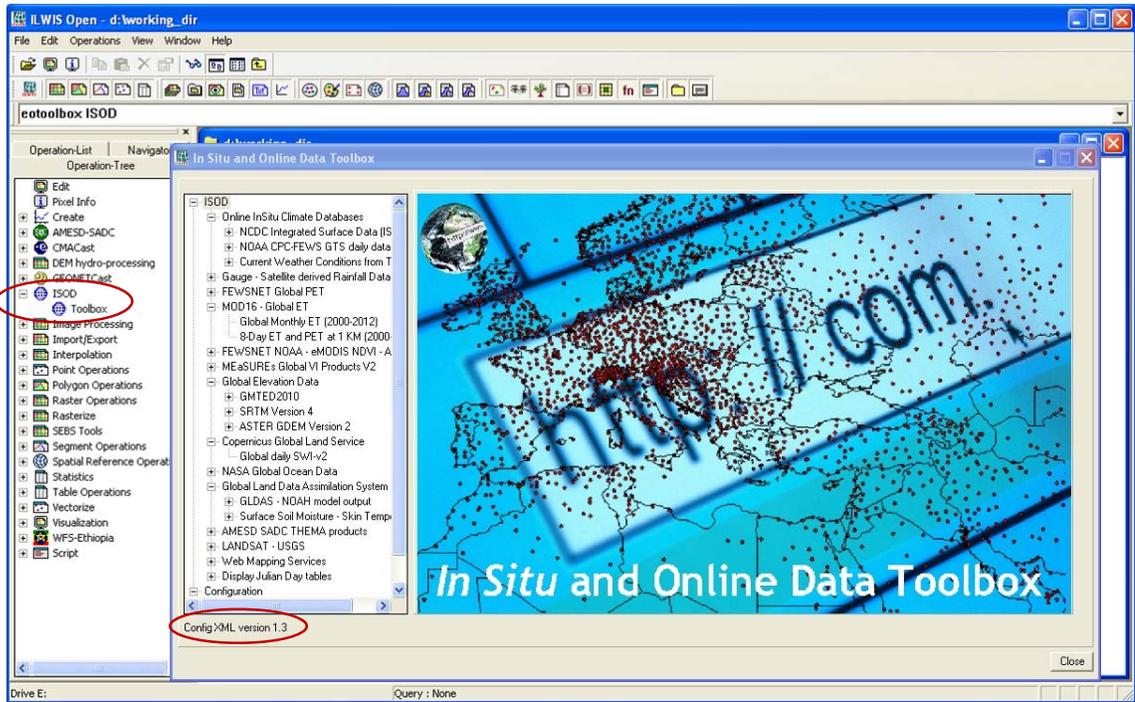
Available from: <http://52north.org/>

To download the ISOD Toolbox from the 52North website: Select from the 52north.org website the navigation tab: “*Earth Observation*”. Additional information is provided over there as well as the link to the download area. You can also directly download the Toolbox from <http://52north.org/downloads/earth-observation>, select “*ISOD*”. Download the Zip file: “*52n-ee-isod-toolbox-1.3*” available over there and store it in a temporary directory. Eventually download other resources provided over there.

After the download is completed, copy this ZIP file in the ILWIS sub-directory “\Extensions”. There is no need to unzip the file! ILWIS automatically detects the ZIP file in this directory then unzips the file and installs the plug-in when a new instance of ILWIS is started. Afterwards the ZIP file is deleted in this “\Extensions” sub-directory!

Start ILWIS and in the Operation-Tree of ILWIS the “ISOD” tab will appear (see also figure 1.1). Double click the “ISOD” tab and the subsequent “Toolbox” tab and various (sub) menus are now at your disposal. These options can be used to import open internet environmental data sets. Keep checking the “*Earth Observation*” community web pages (<http://52north.org/communities/earth-observation/>) for new (toolbox) developments. Modifications and added functionality for the ISOD Toolbox are made available on these websites on an ad hoc basis, so check if you are working with the latest version. The XML configuration number, currently 1.3, is given on the lower left hand portion of the ISOD Toolbox opening screen.

Figure 1.1: The ISOD main and sub menu structure under ILWIS372



Close ILWIS as you might need to install additional utilities. Check if you have already installed IrfanView. If this is not case use the link below and follow the additional installation instructions.

1.4 DOWNLOAD JAVA RUNTIME ENVIRONMENT

Available from: <http://www.java.com/en/download/index.jsp>

Some ISOD toolbox applications make use of JAVA. If the system does not have the JAVA Runtime Environment installed already, move to the website indicated above, select the “Free Java Download” button and install it. Accept the License Agreement to start and complete the installation (using default settings).

1.5 DOWNLOAD IRFANVIEW

Available from: <http://www.irfanview.com/>

For some data visualizations and animation that do not require import into an ILWIS data format, use is made of IrfanView. Download the setup executable and save it in a temporary directory on your hard disk.

After the download has been completed run the setup, there is no need to create shortcuts, use the option: “For all users” and select the default Installation folder. Click “Next” three times, just use the default settings, “Don’t install Google Desktop Search”, click “Next” two times and after the installation has been completed, press “Done”.

An instance of IrfanView can be started to check if the installation has been successful, the program can be stopped.

1.6 DOWNLOAD NOTEPAD++

Available from: <http://notepad-plus-plus.org/download>

Download the 'Notepad++ 7z package' and store it in a temporary directory. Unzip the file "*npp*.bin.7z*". Rename the sub-directory which is created during unzipping, called "unicode" into "npp". Copy this sub-directory into the ILWIS sub-directory "\Extensions\ISOD-Toolbox\util". Notepad++ is used for visualization of some of the meta-data.

1.7 DOWNLOAD PANOPLY

Available from: <http://www.giss.nasa.gov/tools/panoply/>

Currently data retrieved from ECMWF are visualized using Panoply, developed by Robert B. Schmunk, NASA Goddard Institute for Space Studies. The Panoply package for Windows comes as a zipped archive. Manually extract this archive in the ILWIS sub-directory "\Extensions\ISOD-Toolbox\util\Panoply". This sub-directory, after decompression, should include the following items: Panoply.exe (application), application code files in a folder called "jars", colour tables in a folder called "colorbars", continent masks and outlines in a folder called "overlays". You can check to run Panoply by double-clicking on the Panoply.exe application.

1.8 CONCLUDING REMARKS

With ILWIS, the ISOD Toolbox plug-in and the other necessary utility-software installed you still need to continue with the ISOD Toolbox configuration settings which are further described in the next chapter, next to additional information with regard to the overall toolbox architecture.

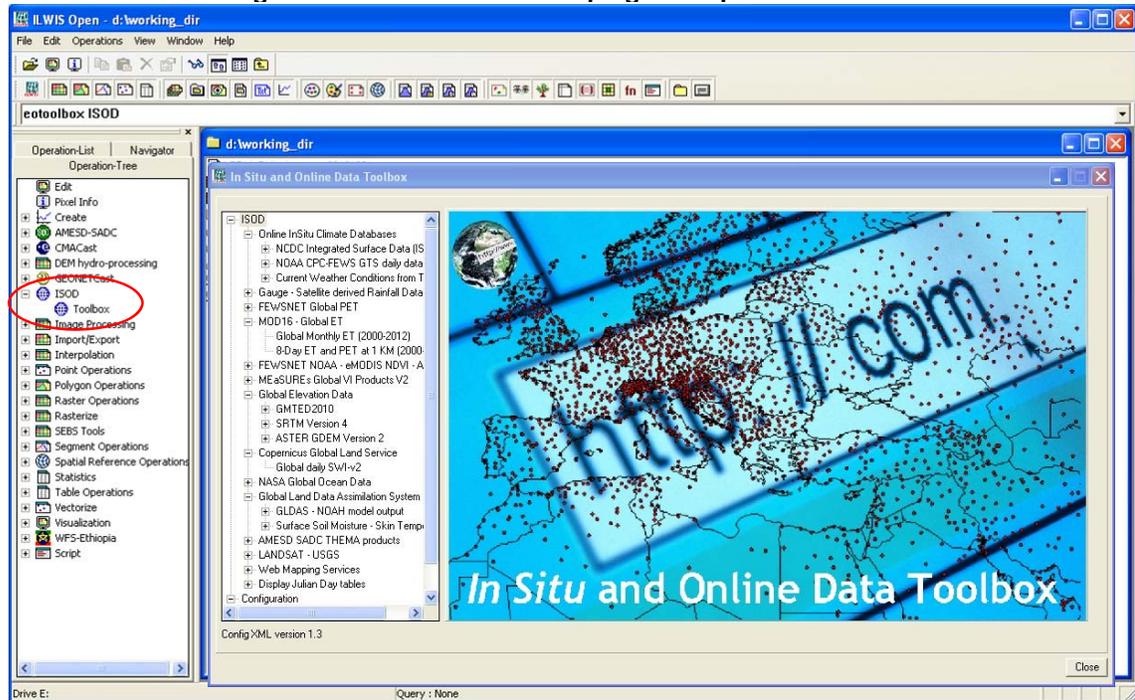
This page is blank

2. OVERVIEW OF THE ISOD TOOLBOX ARCHITECTURE

2.1 INTRODUCTION

The ISOD Toolbox Config XML version 1.3 allows import of various web based environmental data resources through a Graphical User Interface (GUI). Here the toolbox architecture is described into more detail. Once the toolbox is installed and ILWIS is newly started the “ISOD Toolbox” should appear as a menu item under the ILWIS Operation Tree (see figure 2.1).

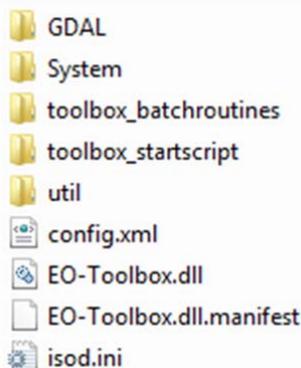
Figure 2.1: The ISOD Toolbox plug-in Graphical User Interface



2.2 STRUCTURE OF THE ISOD TOOLBOX

To operate the ISOD toolbox, the Zip file “52n-eo-isod-toolbox-1.3” is copied under the ILWIS sub-directory “\Extensions”. Once a new event of ILWIS372 is started this ZIP file is extracted and the content is stored in the sub-directory “ISOD-Toolbox” within the same “\Extensions” sub-directory. Within the “ISOD-Toolbox” sub-directory a number of other sub-directories appear (see figure 2.2).

Figure 2.2: Toolbox sub-directory structure



The folder “\GDAL” (Geospatial Data Abstraction Library) contains a translator library for raster geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation (<http://www.gdal.org>).

The folder “\System” is storing the ILWIS service objects. Service objects are used by data objects; they contain accessories required by data objects besides the data itself. Upon installation of the toolbox, these objects are copied to the main ILWIS directory \System.

The folder “\Toolbox_batchroutines” provides the batch files that are used to execute most of the actual operations. These files can be opened and modified using a text editor. Further information is provided in chapter 2.6. Before you modify a routine, first make a backup!

The folder “\Toolbox_startscript” contains a number of sub-directories which contain the ILWIS scripts. Upon selection of an import routine, from the ISOD Toolbox User Interface a script is called and this script subsequently calls a batch file which executes the operation. The scripts can also be opened and modified using ILWIS. Further information is provided in chapter 2.5.

In the root of the “\Util” folder ILWIS service objects are stored, like lookup tables, georeferences, domains, etc. Furthermore a number of executables are stored here that are used by various toolbox batch routines, such as the “7z” executable. The sub-directory “\Maps” is containing a segment-polygon file of all countries and for Africa. The sub-directory “\wget” is storing the utility used to extract the selected data from the internet http or ftp location. The sub-directory “\metadata” contains a number of files that provide ancillary information describing the nature of the data to be retrieved. A sub-directory “\Panoply” should be created by the user and the “Panoply” utility should be stored there (see also chapter 1.5 for installation instructions). Furthermore to read the meta-data from the downloaded GLDAS-NOAH GRIB files the Notepad++ package should be included in the sub-directory “\npp”, Julian day tables, for leap and normal year, are provided in the sub-directory “\JulianDay”.

The file “config.xml” contains the ISOD Toolbox GUI menu structure. This file can be edited using a text editor. In case the user wants to add new routines, this XML file can be adapted and modified. The resulting menu will be adapted accordingly when a new instance of the Toolbox is started. This allows users that do not have programming experiences to adapt the toolbox to their own preferences. A more detailed description is provided below in chapter 2.3.

The file “isod.ini” contains the settings of the input and output directories for each “folderid” that is defined in the “Config.xml”. This file is storing the settings as defined from the Toolbox menu options “Configuration” >> “Folders”. Further information on the folder settings is provided in chapter 2.4.

The file “EO-Toolbox.dll” contains the layout of the User Interface of the ISOD Toolbox and generates the full ILWIS command string that executes the script, batch file, defines and passes the parameters that are used, like the time stamp, input drive, input directory, output drive, output directory, ILWIS directory, etc. Up to 9 parameters are used to execute a Toolbox operation.

The file “EO-Toolbox.dll.manifest” is used by the operating system for certification of the appropriate DLL.

NOTE: As from ILWIS38 a new version of the “EO-Toolbox.dll” has to be used. This file can be downloaded from the “Earth Observation Downloads Area” (<http://52north.org/communities/earth-observation/>). When using ILWIS38, copy this file into the ILWIS directory “\Extensions\ISOD-Toolbox”. Eventually overwrite the existing “EO-Toolbox.dll”. The ISOD Toolbox plug-in should now appear in the Operation-Tree, identical to figure 2.1 when activating ILWIS38.

2.3 STRUCTURE OF THE CONFIG XML

One of the main criteria during the development of this utility was to make the toolbox as open as possible, allowing users with no programming experiences to make modifications. As indicated before, all scripts and batch routines used can be adapted by the user. Next to this, the user can also modify the menu of the Toolbox GUI. The file that generates the user interface, “Config.xml”, can be opened using a text editor.

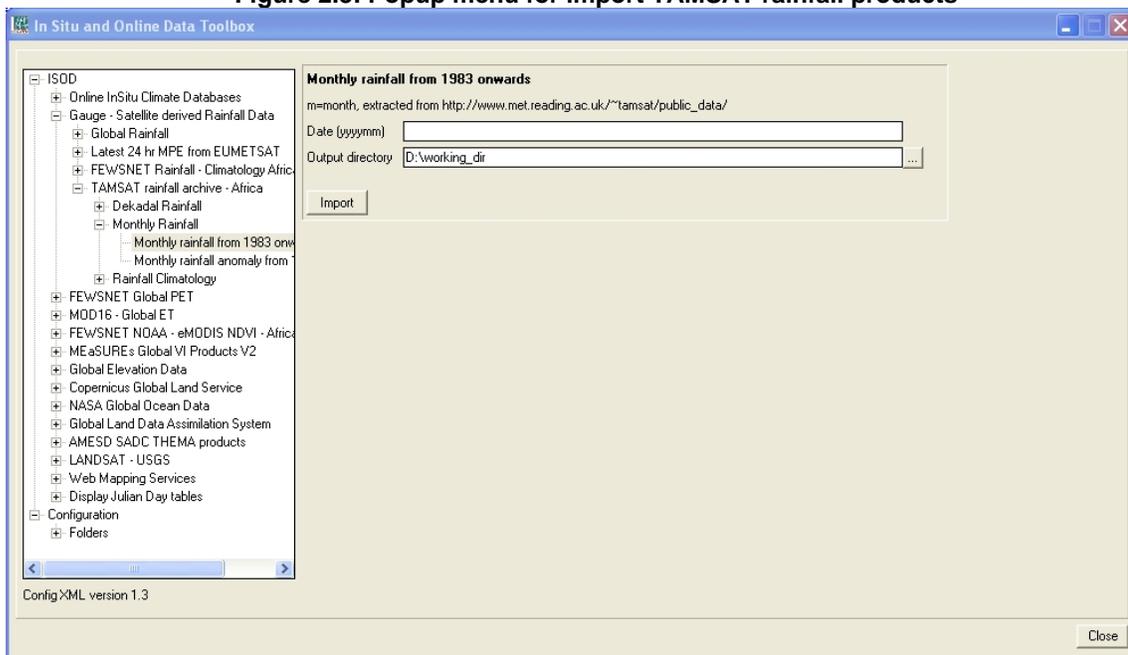
The structure of the file is kept as simple as possible. The “Level” is defining the main (Level1) and sub menu structure (Level2 – Level “N”). For the “Level value=” a menu name can be defined. Within a certain Level a “Product value=” can be specified, which will generate the name of the respective (sub) menu.

The string starting with “Product value=” contains mostly a number of other items, like “script”, “format”, “type”, “folderid” and “comment”.

- Script: The item script defines the sub-directory where the respective ILWIS script is located and the name of the script that should be executed;

- **Format:** The text string that can be entered here will appear in the popup window when importing a certain image or product. It is used to ensure that e.g. the appropriate “time stamp” is entered on the user interface (see the “Date” on figure 2.3). For the various images and products these can have different formats, in the example of figure 2.3 the “Date” stamp expected should have the format “yyyymm” (yyy=year, mm=month). Also jji=Julian day, dek=Dekade are used, e.g. “yyyymmdekdek”;
- **Type:** This is the only part of the toolbox that does not allow user modification without programming experiences. Various forms, that generate the pop-up windows are available within the “EO-ToolboxUI.dll” and are called by their specific names given. These forms generate the appearance of the popup windows when importing a specific product. The popup menu that is given in figure 2.3 is generated from a “type” called: “ymdhmo”;
- **Folderid:** This item generates a folder item in the “isod.ini” file. From the main Toolbox menu, “Configuration” and “Folders” option, this Folder item is now available and can now be further specified by defining the appropriate input and output directories.
- **Comment:** Additional information (one line of text) can be provided in the popup menu to notify the user on any specific information that might be relevant. In figure 2.3 a comment string is added showing the “Date” format expected (m=month) and the location the data is extracted from.

Figure 2.3: Popup menu for import TAMSAT rainfall products



Other syntax used in the config.xml is:

- < Start of a new line
- /> End of a line
- <Level... Start of a new level
- </Level"n"> End of level "n"

Note that all the text should be entered between quotation marks "".

The first few lines of the config.xml are:

- 1: < ISOD >
- 2: <Version id="1.2" finder="false"/>
- 3: <UIInfo icon="earth" menu="ISOD..Toolbox" title="In Situ and Online Data Toolbox"/>
- 4: <Path value="Extensions\ISOD-Toolbox" inifile="isod.ini"/>

Line 1 provides the link to the plug-in and the menu name, note that this is also the last line of the XML. Line 2 provides the opportunity to indicate a version number, useful if modifications are done to the original XML. The version number is also shown in the main ISOD Toolbox menu, in the lower left hand corner.

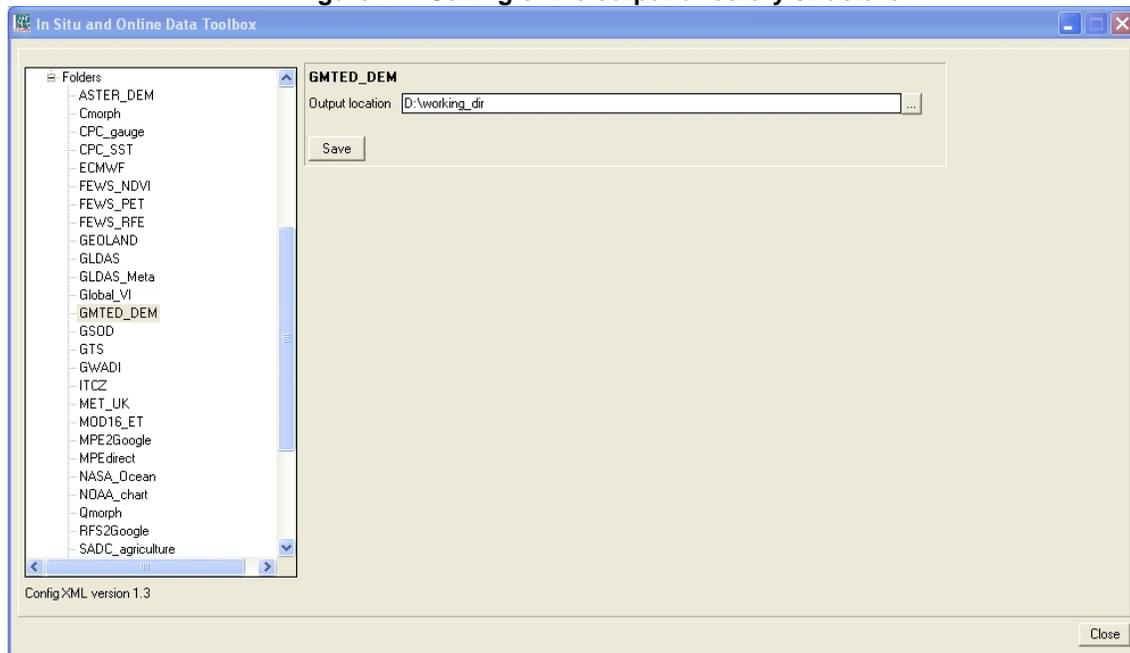
The “*Finder*” is a utility under development, allowing a search using keywords. The “*UIInfo Icon*” in line 3 refers to the toolbox logo used in the ILWIS Operation Tree, the “*menu*” provides the name, the “..” indicates that the menu consists of two levels, and the heading used in the toolbox user interface is defined by the “*title*”. In Line 4 the “*path*” defines the location of the toolbox in ILWIS and the “*inifile*” here refers to the “*isod.ini*” file, which provides the links to the input and output directories.

After changes are made to the config.xml the file should be saved and a new instance of the Toolbox should be started, showing the adaptations. Before modifying the file first make a backup!

2.4 GENERAL ISOD TOOLBOX CONFIGURATION - FOLDER SETTINGS

For you to conveniently work with the ISOD Toolbox the local system output (working) directories need to be defined. From the main ISOD Toolbox menu, select “*Configuration*” and the sub-menu “*Folders*”. In figure 2.4 below the output directory for the Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) is used as example (“D” is the local system hard disk). If the folders are correctly specified the “*Save*” button should be pressed to store the ‘drive:\folder’ settings.

Figure 2.4: Setting of the output directory structure



The “*isod.ini*” file can also be edited using a text editor to change using the “find and replace” option e.g. the drive for all directory entries in the file. Also the full directory settings can be specified, as example a “*folderid*” of “*GMTED_DEM*” is given. When opening the “*isod.ini*” file, using a text editor, an item “[*GMTED_DEM*]” is given and the output folder can now be changed by providing the relevant directory names, like:

```
[GMTED_DEM]
OutputFolder=D:\working_dir
```

There is a “*Special locations*” folder to select the location of an executable. Currently the location of “*IrfanView*” and “*i_view32.exe*” (or newer version) needs to be specified. This freeware utility is used for visualization and animation of pictures that are not transformed into an ILWIS data format. Make sure that this folder and executable are always correctly specified. Installation instructions are given in chapter 1.4.

2.5 STRUCTURE OF THE ISOD TOOLBOX SCRIPTS

Most of the ILWIS scripts, situated within the sub-directories within the “\Toolbox_startscripts\” directory contain a single line having an identical structure. Below an example is given of the extraction of the “SRTM Version4 elevation data” script:

```
!%7\Extensions\ISOD-Toolbox\toolbox_batchroutines\SRTM4_import.bat %1 %2 %3 %4 %5 %6 %7 %8
```

The command line starts with: ! This syntax (!) instructs ILWIS to start an external application. The application that should be started is situated in “%7\Extensions\ISOD-Toolbox\ toolbox_batchroutines\” and calls “SRTM4_import.bat”. This is a DOS batch routine which should be executed. The parameters required to execute the batch routine are given as %1 to %8:

%1 Longfilename	remark: the lower left corner coordinates for the specific elevation tile
%2 InputDrive	remark: input data drive, not used here
%3 InputDir	remark: input data directory, not used here
%4 OutputDrive	remark: output data drive
%5 OutputDir	remark: output data directory
%6 gdalDir	remark: location of GDAL directory within the toolbox
%7 llwDir	remark: location of the ILWIS directory
%8 UtilDir	remark: location of the Util directory within the toolbox

A number of these parameters are generated by the “EO-Toolbox.dll”, such as gdalDir, llwDir and UtilDir as these are fixed locations within the toolbox. Other parameters require user interaction, such as longfilename, InputDrive, InputDir, OutputDrive, OutputDir, as these change based on the user preferences. These parameters can be interactively provided in the popup menu when importing an image or product, see e.g. figure 2.3 above. The “Date” field provides the “Longfilename”, input and output drive and directory for the “InputDrive”, “InputDir”, “OutputDrive” and “OutputDir” respectively.

When pressing the “Import” button of the popup menu (see again figure 2.3) an ILWIS command line is generated which is executed. Using the script example above for import of an SRTM elevation tile for Long=E030 and Lat=S20, the following command line is generated and executed:

```
!D:\Ilwis372 \Extensions\ISOD-Toolbox\toolbox_batchroutines\SRTM4_import.bat E030S20 x x D: working_dir D:\Ilwis372\Extensions\ISOD-Toolbox\GDAL\bin D:\Ilwis372 D:\Ilwis372 \Extensions\ISOD-Toolbox\util
```

The parameters are now defined as follows:

%1 Longfilename	E030S20 (note that this is a modification of the “Date” stamp)
%2 InputDrive	x (not used here)
%3 InputDir	x (not used here)
%4 OutputDrive	D:
%5 OutputDir	working_dir
%6 gdalDir	C:\Ilwis372\Extensions\AMESD-SADC-Toolbox\GDAL\bin
%7 llwDir	C:\Ilwis372
%8 UtilDir	C:\Ilwis372\Extensions\AMESD-SADC-Toolbox\util

Now with all parameters set the batch file “SRTM4_import.bat”, situated in the ILWIS subdirectory “\Extensions\ISOD-Toolbox\toolbox_batchroutines\” can be executed. Starting the command with the “!”, ILWIS knows it has to execute an external command, given the fact that the extension is “.bat”, the Windows operating system knows it has to execute this file using the Windows Command Line Processor (CMD.exe).

For a number of visualization and animation routines to view picture products (in png, gif or jpg formats) “IrfanView” is used. In these cases an additional parameter is defined as %9, called “IrfanViewDir”. This parameter defines the location of the IrfanView directory and executable. It can be specified under “Configuration” >> “Folders” and “Special locations” options from the ISOD Toolbox User Interface.

2.6 STRUCTURE OF THE ISOD TOOLBOX BATCH ROUTINES

As is the case with the ILWIS scripts, also most of the batch files follow a similar structure. As an example a retrieval of the “FEWSNET – eMODIS NDVI for South Africa” import routine is given below. The first 9 lines (see line numbers) are giving some general remarks and these are shown in the command line window, see figure 2.5. The command “echo.” results in an empty line in the command line window, which is used to improve the readability of the text given in the command line window.

From line 10 to line 19 in the batch file the “Date” stamp, here defined as “*longfilename*” is passed, originating from the ILWIS script, to the batch file using the “SET” command. This command displays, sets or removes Windows Environment Variables.

When starting this import operation for the Date field the appropriate NDVI map date should be entered, here defined as “*perperyyyy*” (see also line 6 and 7, per = period). Two digits are needed to define the period, from 01 up to 72. As the period stamp in the archive for the first 9 periods per year only uses one digit (from 1 up to 9), for the periods 01 up to 09 the zero value (0) is removed in lines 12 to 15 and passed as a parameter called %mnrthtif%. For the year only the last two digits are retained and passed as %shortfilename3% in lines 16 to 19. The result of this operation is that when entering a string like “022012” it is modified into a string “212”, which is needed to correctly recompose the filename in the archive (see also line 6).

From lines 20 to 26 the other parameters are passed, originating from the ILWIS script, to the batch file. Once all these parameters are known the actual import routine can start. Lines 27 to 29 ensure that the application moves to the appropriate output directory. Line 30 displays the selected output directory in the command line window (see figure 2.5). The items “echo.” in lines 31 and 32 creates two empty lines in the command line window.

Once in the output directory line 33 starts the “Wget” utility which retrieves the requested input data from the specified internet location, using the appropriate file name, partially derived from the “Date” stamp, note “%mnrthtif%%shortfilename3%”. Line 34 sets the display of subsequent messages off.

In line 35 a check is performed if the input file exists, if this file does not exist the batch routine jumps to the section starting with “:MESSAGE”. If the input file exists line 36 is displayed in the command line window, followed by 2 empty lines and then jumps to the start of the actual import routine, which begins at the “:START” section (line 39).

If the input file does not exist (in line 35) the batch routine jumps to line 40 “:MESSAGE”, the section below (lines 41 to 46) are displayed, see also figure 2.5. In line 47 a “pause” command is used and the user has to press <enter> in order to continue. Once this is done the “GOTO END” command in line 48 causes the routine to jump to line 60.

If the data is located in the specified input drive-directory, the copied file is unzipped in line 50, renamed in line 51 and imported into ILWIS format in line 52, using GDAL. Once the file is in ILWIS format, ILWIS is executed from the command prompt in line 53 and the radiometry of the data is changed using an expression: (NDVI_in-100)/100. In line 54 the coordinate system is appended (ilwis.exe -C setgrf) to set the georeference of the final NDVI map. Lines 55 – 59 are deleting the files that have become obsolete.

Line 60 marks the “:END” section. With or without the required input data line 61 is always executed, this line closes instances of ILWIS which have started using this batch routine.

Start of batch file listing: *fews_emodis_ndvi_sa.bat*

```
-----
1: @echo off
2: echo Extract FEWS eMODIS NDVI
3: echo From 012010 - to 1 month before present
4: echo eMODIS 10-day maximum-value composite NDVI images at 250m spatial resolution
5: echo Note periods (odd and even periods)
6: echo File name format sa3711.zip (sa=south africa, 37=period 37 and 11=year 2011)
7: echo Time string entered for example 012010
8: echo.
9: echo.
10: set longfilename=%1
```

```

11: set shortfilename1=%longfilename:~2,4%
12: set period=%longfilename:~0,2%
13: set mnthtif=%period%
14: set deccounter=%mnthtif:~0,1%
15: if %deccounter% EQU 0 (set mnthtif=%mnthtif:~1,1%)

16: rem input year 4 digits
17: set shortfilename2=%longfilename:~2,4%
18: rem input input year 2 digits
19: set shortfilename3=%longfilename:~4,2%

20: set InputDrive=%2
21: set InputDir=%3
22: set OutputDrive=%4
23: set OutputDir=%5
24: set gdalDir=%6
25: set llwDir=%7
26: set UtilDir=%8

27: cd\
28: %OutputDrive%
29: cd %OutputDir%

30: echo your current working directory = %OutputDrive%\%OutputDir%
31: echo.
32: echo.

33: "%UtilDir%\wget\wget.exe" http://igskmncngs600.cr.usgs.gov/ftp2/africa/emodis/sa%mnthtif%%shortfilename3%.zip

34: echo off
35: if not exist "%OutputDrive%\%OutputDir%\sa%mnthtif%%shortfilename3%.zip" goto MESSAGE
36: echo The file(s) "sa%mnthtif%%shortfilename3%.zip" has been retrieved and transferred to your current working directory
37: echo.
38: echo.

39: GOTO START

40: :MESSAGE
41: echo The input file was not found in the archive.
42: echo Check your Date stamp settings
43: echo Your current Date stamp used is %longfilename%
44: echo Data is retrieved from http://igskmncngs600.cr.usgs.gov/ftp2/africa/emodis/
45: echo Check also manually if the data exists on ftp archive (see link above)
46: echo Internet has a transient nature - addresses might not be valid or has changed after some time!

47: pause

48: GOTO END

49: :START

50: "%UtilDir%\7z.exe" e sa%mnthtif%%shortfilename3%.zip

51: ren sa%mnthtif%%shortfilename3%.tif emodis_ndvi%shortfilename2%%period%.tif

52: "%gdalDir%\gdal_translate" -of ilwis emodis_ndvi%shortfilename2%%period%.tif temodis_ndvi%shortfilename2%%period%.mpr

53: "%llwDir%\ilwis.exe" -C %OutputDrive%\%OutputDir%\emodis_sa_ndvi%shortfilename2%%period%.mpr{dom=value;vr=-1.000:1.000:0.0001};=(%OutputDrive%\%OutputDir%\temodis_ndvi%shortfilename2%%period%-100)/100

54: "%llwDir%\ilwis.exe" -C setgrf %OutputDrive%\%OutputDir%\emodis_sa_ndvi%shortfilename2%%period%.mpr %UtilDir%\emodis_sa

55: del sa%mnthtif%%shortfilename3%.tfw
56: del emodis_ndvi%shortfilename2%%period%.tif
57: del sa%mnthtif%%shortfilename3%.zip
58: del temodis_ndvi%shortfilename2%%period%.mpr*
59: del temodis_ndvi%shortfilename2%%period%.grf

60: :END
61: "%llwDir%\ilwis.exe" -C closeall

```

End of Batch file listing

Although the content of the batch files can vary significantly, the sequence of activities is mostly the same:

- Some remarks are given at the start of the batch file
- Setting of the environment variables, passing over the parameters from the ILWIS scripts
- Check if input data is available, if not go to the end of the batch routine
- Copy the original data to a local disk
- Import of the data into ILWIS format
- Execute various ILWIS routines from the command prompt
- Delete obsolete files
- Close ILWIS tasks created by the batch routine

Note that all batch routines show a command line window. Relevant information is contained in these windows. It is advised that the content of these windows is critically checked while waiting for the batch routine to finish. The batch files can be opened using a text editor. The name of the batch file executed can be obtained from the ILWIS command line string as given in chapter 2.5. Some import routines download time series of data (e.g. daily data for a month or year). Upon extraction of the file all data contained is imported using a batch looping procedure. For further information on how these procedures operate see also the reference given in chapter 2.7. Some files are large so adequate bandwidth is required for smooth operations.

In the example given in the batch file listing a date stamp should have been entered as "022012". The actual time stamp used is "022013" which is resulting in the fact that the input data cannot be found (as it is not available at this moment!) and the routine, after pressing <Enter> is aborted. Carefully inspect the date stamp and directory settings as indicated in the command line interpreter window as given in the figure below.

Figure 2.5: Resulting message when entering wrong date-time stamp

```

Wget http://igskmncngs600.cr.usgs.gov/ftp2/africa/emodis/sa213.zip
Extract FEWS eMODIS NDVI
From 012010 - to 1 month before present
eMODIS 10-day maximum-value composite NDVI images at 250m spatial resolution
Note periods (odd and even periods)
File name format sa3711.zip (sa=south africa, 37=period 37 and 11=year)
Time string entered for example 012010

your current working directory = D:\working_dir

SYSTEM_WGETRC = c:/progra~1/wget/etc/wgetrc
syswgetrc = c:/progra~1/wget/etc/wgetrc
--2012-10-17 11:55:40-- http://igskmncngs600.cr.usgs.gov/ftp2/africa/emodis/sa2
13.zip
Resolving igskmncngs600.cr.usgs.gov... 152.61.136.147
Connecting to igskmncngs600.cr.usgs.gov[152.61.136.147]:80... connected.
HTTP request sent, awaiting response... 404 Not Found
2012-10-17 11:55:43 ERROR 404: Not Found.

The input file was not found in the archive.
Check your Date stamp settings
Your current Date stamp used is 022013
Data is retrieved from http://igskmncngs600.cr.usgs.gov/ftp2/africa/emodis/
Check also manually if the data exists on ftp archive (see link above)
Internet has a transient nature - addresses might not be valid or has changed af
ter some time!
Press any key to continue . . .

```

When appropriate, "quotation marks" are used to specify the location of a 'directory\executable' as well as for the input original file names to ensure that batch routines keep working if encountered spaces in (sub-) directory names and to process input files with complex file names. To ensure proper operation of the batch routines stick to the golden rules as given in chapter 1.2.

Some routines also use PowerShell scripts. This utility is used to create interactive pop-up menus for easy data entry. The PowerShell *.ps1 is activated through the batch file and is creating, based on the user input a text file, which is subsequently called by the next line in the batch routine. This text file contains the user entries and these are set as environment variables.

2.7 ADVANCED USE

If certain operations have to be repeated on a continuous basis, e.g. import of certain products for which basically only the time stamp has to be modified the use of the ISOD toolbox menu might be cumbersome. From the main menu of ILWIS, the command line history can be checked. Select the appropriate string generated through the graphical user interface, modify the time stamp and execute the expression again by pressing <Enter>.

It is advised however, to copy the command line string that is generated through the graphical user interface, available from the command line in the main menu of ILWIS, to the WINDOWS command line processor (CMD.exe). Delete the "!" from the start of the string and execute the expression. Within the string the date stamp can be easily modified. Eventually this line can be copied into a new text file and the file can be given an extension ".bat". This file can then be executed from the DOS Command prompt as well. With multiple lines in such a batch file only having different "Date" stamps, time series can be created very efficiently. Additional information on how to conduct these procedures is described in the "GEONETCast – DevCoCast Application Manual", online available at: <http://www.itc.nl/Pub/WRS/WRS-GEONETCast/Application-manual.html>. Also within this document an example demonstrating automated data retrieval and processing is presented (see chapter 4.2.4).

2.8 CONCLUDING REMARK

With all the configuration settings provided you are now ready to utilize the ISOD Toolbox and explore the data that is freely available from the Internet. The main objective of this toolbox is to integrate these resources in an efficient manner into the Geographic Information System ILWIS. With the other toolboxes, allowing efficient import of the data disseminated through satellite based telecommunication systems, a multitude of archive and real time information is now at the disposal of the User Community. If you have links to other free internet resources and want to be able to use these also within the ISOD toolbox, please contact the EO Community contact (at: <http://52north.org/communities/earth-observation/community-contact>) so new applications can be integrated in an updated version / new release of the toolbox and others can make use of it as well.

This document is providing links to various online metadata and background reference resources, next to the data archives itself (within the toolbox pop-up menu). It should be noted that due to the transient nature of the internet some of these links might not be up to date anymore. In case this is noted please provide your observations to the EO Community contact as well, using the link given above.

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3. EXPLORING THE INTERNET RESOURCES USING THE ISOD TOOLBOX

3.1 INTRODUCTION

Various environmental (time series) data resources are currently available on the internet relevant for a multitude of applications. Users are often not aware of these resources and if so, they might find it difficult to import the (multi-temporal) data into a GIS. In order to overcome these bottlenecks, the “*In Situ* and Online Data” Toolbox has been developed. When operating the toolbox, the data is in most cases automatically retrieved (when possible!) and ingested into an ILWIS format. The data exchange library within ILWIS allows the user to export the data to other formats; furthermore the extensive image, vector and thematic data processing capability of ILWIS can be used for further data analysis.

Within this chapter attention is given to the various data resources which can be retrieved using the toolbox. Additional relevant background information is presented here to obtain a better understanding of the data which is needed if further analysis is envisaged. References to (online) documentation are provided as well. In the following chapter a number of practical exercises are presented using the toolbox to become familiar with its functionality.

The toolbox menu (XML Version 1.3) as presented in figure 2.1 has a number of main menu items. This menu sequence is followed below as well to present the relevant background details.

3.2 ONLINE *IN SITU* CLIMATE DATABASES

3.2.1 *NCDC Integrated Surface Data (ISD)*

The data summaries provided here are based on data exchanged under the World Meteorological Organization (WMO) World Weather Watch Program according to WMO Resolution 40. This allows WMO member countries to place restrictions on the use or re-export of their data for commercial purposes outside of the receiving country. Data for selected countries may, at times, not be available through this system.

Those countries' data summaries and products which are available here are intended for free and unrestricted use in research, education and other non-commercial activities. The data are available via <http://www.ncdc.noaa.gov/cgi-bin/res40.pl?page=gsod.html> and <ftp://ftp.ncdc.noaa.gov/pub/data/gcod>.

The input data used in building these daily summaries are the Integrated Surface Data (ISD), which includes global data obtained from the USAF Climatology Centre. The latest daily summary data are normally available 1-2 days after the date-time of the observations used in the daily summaries. The online data files begin with 1929, and over 9000 stations' data are typically available.

The daily elements included in the dataset (available for each station) are: mean temperature, mean dew point, mean sea level pressure, mean station pressure, mean visibility, mean wind speed, maximum sustained wind speed, maximum wind gust, maximum temperature, minimum temperature, precipitation amount, snow depth and indicator for the occurrence of: fog, rain or drizzle, snow or ice pellets, hail, thunder and tornado/funnel cloud. Upon import the data is converted to SI units.

3.2.2 *NOAA CPC-FEWS GTS Data*

One important source of information used by NOAA/CPC and many other meteorological agencies for weather and climate applications is the gauge-observed precipitation reports transmitted through the Global Telecommunications System (GTS). Together with station reports from other national and international sources, the GTS gauge data are used to monitor and assess the climate at station locations and as inputs to define analysed fields of global and regional precipitation.

The Global Telecommunication System (GTS) is the coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange, and distribution of observed and processed meteorological information within the framework of the World Weather Watch (WWW). Station reports of precipitation, together with those of many other physical variables, are exchanged routinely among the World Meteorological Organization (WMO) member countries through the GTS network. At NOAA / CPC,

these precipitation reports are received and processed to form a database of GTS gauge-based daily precipitation. Starting from October 1977, the GTS daily gauge database is updated on a real-time basis. On average, daily reports are available from about 6000 GTS stations. The GTS gauge network is relatively dense over United States, Western Europe, and east coasts of Australia and China, while it is very sparse over several regions including equatorial Africa and Amazon (source: Quality Control of Daily Precipitation Reports at NOAA/CPC by Mingyue Chen, Pingping Xie and CPC Quality Control Working Group, Climate Prediction Center, CPC/NCEP/ NOAA, available at <http://ams.confex.com/ams/pdfpapers/131381.pdf>).

The rainfall and temperature (minimum and maximum) up to a year before present can be obtained online from <ftp://ftp.cpc.ncep.noaa.gov/fews/gts>.

3.2.3 **Current Weather Conditions from TAF**

In meteorology and aviation, TAF is a format for reporting weather forecast information, particularly as it relates to aviation. "TAF" is an acronym of Terminal Aerodrome Forecast or, in some countries, Terminal Area Forecast. TAFs apply to a five statute mile radius from the center of the airport runway complex. Generally, TAFs can apply to a 9- or 12-hour forecast; some TAFs cover an 18- or 24-hour period; and as of November 5, 2008, TAFs for some major airports cover 30 hours periods. The date/time group reflects the new 30 hour period in Coordinated Universal Time (UTC), as always. TAFs complement and use similar encoding to METAR reports. They are produced by a human forecaster based on the ground. For this reason there are fewer TAF locations than there are METARs. TAFs can be more accurate than Numerical Weather Forecasts, since they take into account local, small-scale, geographic effects (source: Wikipedia).

Terminal Aerodrome Forecasts are routinely issued every 6 hours, and are valid 24 hours from issuance time. The product provides a forecast of cloud heights and ceilings, wind direction and speed and associated wind shear, visibilities, and prevailing weather conditions. An explanation on the various codes used can be found at <http://www.spacearchive.info/taf.htm> and individual reports, in meteorological code, can also be retrieved from <http://weather.noaa.gov/weather/taf.shtml> when entering the four-character ICAO Location Indicator. Here the current weather reports from the TAF reports are processed.

3.3 GAUGE BASED AND SATELLITE DERIVED RAINFALL DATA

Routines have been developed to integrate the online (satellite derived) precipitation products from the NOAA Climate Prediction Centre, EUMETSAT, NASA and FEWS NET RFE for Africa. Further details are presented below on the various products that can be retrieved.

3.3.1 **CPC Gauge-Based Analysis of Global Daily Precipitation**

This data set is the first product of the CPC Unified Precipitation Project that is underway at NOAA Climate Prediction Centre (CPC). The primary goal of the project is to create a suite of unified precipitation products with consistent quantity and improved quality by combining all information sources available at CPC and by taking advantage of the optimal interpolation (OI) objective analysis technique.

The coverage is global (land only) at 0.5 degree spatial resolution. The temporal resolution is daily and the data is available from the 1st of January 1979 – Present:

1979 – 2005:	Retrospective Version (30K+ gauges) ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/V1.0/
2006 - Present:	Real-time version (~17K gauges) ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/RT/

Other relevant background documents are:

- On the Interpolation algorithm:
Xie, P., A. Yatagai, M. Chen, T. Hayasaka, Y. Fukushima, C. Liu and S. Yang (2007): A gauge-based analysis of daily precipitation over East Asia, *J. Hydrometeorol.*, 8, 607. 626.
ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/DOCU/Xie_et_al_2007_JHM_EAG.pdf
- On the Gauge Algorithm Evaluation:

Chen, M., W. Shi, P. Xie, V. B. S. Silva, V E. Kousky, R. Wayne Higgins and J. E. Janowiak (2008): Assessing objective techniques for gauge-based analyses of global daily precipitation, *J. Geophys. Res.*, 113, D04110, doi:10.1029/2007JD009132.

ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/DOCU/Chen_et_al_2008_JGR_Gauge_Algo.pdf

- On the Construction of the Daily Gauge Analysis:
Chen, M., P. Xie, and Co-authors (2008), CPC Unified Gauge-based Analysis of Global Daily Precipitation, Western Pacific Geophysics Meeting, Cairns, Australia, 29 July - 1 August, 2008.
ftp://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_GLB/DOCU/Chen_et_al_2008_Daily_Gauge_Anal.pdf

3.3.2 **CMORPH**

CMORPH (CPC MORPHing technique) produces global precipitation analyses at very high spatial and temporal resolution. This technique uses precipitation estimates that have been derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data. At present it is incorporating precipitation estimates derived from the passive microwaves aboard the DMSP 13, 14 & 15 (SSM/I), the NOAA-15, 16, 17 & 18 (AMSU-B), and AMSR-E and TMI aboard NASA's Aqua and TRMM spacecraft, respectively. These estimates are generated by algorithms of Ferraro (1997) for SSM/I, Ferraro et al. (2000) for AMSU-B and Kummerow et al. (2001) for TMI. Note that this technique is not a precipitation estimation algorithm but a means by which estimates from existing microwave rainfall algorithms can be combined. Therefore, this method is extremely flexible such that any precipitation estimates from any microwave satellite source can be incorporated.

With regard to spatial resolution, although the precipitation estimates are available on a grid with a spacing of 8 km (at the equator), the resolution of the individual satellite-derived estimates is coarser than that - more on the order of 12 x 15 km or so. The finer "resolution" is obtained via interpolation.

In effect, IR data are used as a means to transport the microwave-derived precipitation features during periods when microwave data are not available at a location. Propagation vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR which are then used to propagate the microwave derived precipitation estimates. This process governs the movement of the precipitation features only. At a given location, the shape and intensity of the precipitation features in the intervening half hour periods between microwave scans are determined by performing a time-weighting interpolation between microwave-derived features that have been propagated forward in time from the previous microwave observation and those that have been propagated backward in time from the following microwave scan. This latter step is referred to as "morphing" of the features (source: http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html).

The 8-km 30 minute CMORPH data sets can be found on the <ftp.cpc.ncep.noaa.gov> server in the "precip/global_CMORPH/30min_8km" directory. The CMORPH 0.25 degree – 3 hours product is undergoing reprocessing as from the last quarter of 2012. Currently there is version "0.x" of CMORPH that CPC has been generating since CMORPH became operational in December 2002, the data set is generated using an improving algorithm and with inputs of evolving versions (ftp://ftp.cpc.ncep.noaa.gov/precip/CMORPH_V0.x). To avoid confusion the reprocessed CMORPH is called Version 1.0 (ftp.cpc.ncep.noaa.gov/precip/CMORPH_V1.0).

Once finished releasing the reprocessed CMORPH the entire data period is from Jan.1998 to Dec.2012, CPC will terminate the production of the Version 0.x. However, since the fixed algorithm used to generate the Version 1.0 is very close to the currently operational algorithm being used to produce the CMORPH Version 0.x for recent years, the differences between the Version 0.x and Version 1.0 will be minor. The major differences include:

- The Version 1.0 covers the entire TRMM/GPM era from Jan.1998 to the present, while the Version 0.x started from Dec.2002;
- The Version 1.0 is generated using a fixed algorithm and inputs of fixed versions to ensure best possible homogeneity, while the Version 0.x has been produced using an evolving algorithm and inputs of changing versions and therefore presents substantial inhomogeneities especially over the earlier years of its operations (2003-2006);

- The Version 1.0 include the raw, satellite only precipitation estimates as well as bias corrected and gauge-satellite blended precipitation products; while the Version 0.x only has the satellite-only products.

Therefore note that the 'global_CMORPH 3-hourly_025deg' products availability is undergoing changes. The units are mm/3hr. Version 0.x data is currently available from 20060101 onwards; version 1.0 data is available from 19980101 to 20051231 (as of 04 January 2013).

The CMORPH daily and weekly aggregated rainfall estimates are retrieved from <ftp://ftp.cpc.ncep.noaa.gov/fews/CMORPH/GIS/>, units are mm per time step (day or week).

3.3.3 **QMORPH**

Because the CMORPH estimates are available about 18 hours after real-time, users that require more timely estimates may be interested in "QMORPH" estimates, which are similar to CMORPH estimates, except that the passive microwave precipitation features are propagated via IR data forward in time only with no morphing. QMORPH estimates are available within 3 hours of real time, and the past one week of QMORPH data are available online.

3.3.4 **TRMM MERGED HQ/INFRARED PRECIPITATION**

The Tropical Rainfall Measuring Mission (TRMM) is a joint U.S.-Japan satellite mission to monitor tropical and subtropical precipitation and to estimate its associated latent heating. The rainfall measuring instruments on the TRMM satellite include the Precipitation Radar (PR), an electronically scanning radar operating at 13.8 GHz; TRMM Microwave Image (TMI), a nine-channel passive microwave radiometer; and Visible and Infrared Scanner (VIRS), a five-channel visible/infrared radiometer (Source: http://gcmd.gsfc.nasa.gov/records/GCMD_GES_DISC_TRMM_3B42_daily_V7.html).

The purpose of the 3B42 algorithm is to produce TRMM-adjusted merged-infrared (IR) precipitation and root-mean-square (RMS) precipitation-error estimates. The algorithm consists of two separate steps. The first step uses the TRMM VIRS and TMI orbit data (TRMM products 1B01 and 2A12) and the monthly TMI/TRMM Combined Instrument (TCI) calibration parameters (from TRMM product 3B31) to produce monthly IR calibration parameters. The second step uses these derived monthly IR calibration parameters to adjust the merged-IR precipitation data, which consists of GMS, GOES-E, GOES-W, Meteosat and NOAA data. The final gridded, adjusted merged-IR precipitation (mm/hr) and RMS precipitation-error estimates have a 3-hourly temporal resolution and a 0.25-degree by 0.25-degree spatial resolution. Spatial coverage extends from 50 degrees south to 50 degrees north latitude. The daily accumulated (beginning at 00Z and ending at 21Z; unit: mm) rainfall product is derived from this 3-hourly product.

The daily and weekly data from TRMM are based on algorithm 3B-42. For further information consult <http://trmm.gsfc.nasa.gov/3b42.html>. The 3B-42 estimates are produced in four stages; (1) the microwave estimates precipitation are calibrated and combined, (2) infrared precipitation estimates are created using the calibrated microwave precipitation, (3) the microwave and IR estimates are combined, and (4) rescaling to monthly data is applied. Each precipitation field is best interpreted as the precipitation rate effective at the nominal observation time.

As from 22 May 2012 Version 7 of TRMM product 3B42 has been implemented, which supersedes all previous versions. As of November 2012 processing issues were discovered with both series of data and it was decided to re-do the retrospective processing to correct the issues. In general the original Version 7 data sets are considered an improvement over Version 6, but this additional processing is considered important to meet the goals of the project. It was discovered that AMSU data were neglected in the first retrospective processing of both the Version 7 TMPA (3B42/43) and TMPA-RT (3B40/41/42RT) data series, which creates an important shortcoming in the inventory of microwave precipitation estimates used during 2000-2010. In addition, a coding error in the TMPA-RT replaced the occasional missings in product 3B42RT with zeros. Accordingly, both product series are being retrospectively processed again. The main impact in both series should be to improve the fine-scale patterns of precipitation during 2000-2010 (and for 3B4xRT into late 2012). Averages over progressively larger time/space scales should be progressively less affected. Further information is provided on <http://disc.sci.gsfc.nasa.gov/alerts/technical-details-about-retrospective-processing-for-version-7-tmpa-tmpa-rt>.

The import routine has been adapted to retrieve the 3 hourly data for both the original V.7 3B42 and reprocessed data (using a suffix "7A.HDF", currently for January 2000 - September 2010). Next to the 3 hours products the import routine aggregates the 8 maps to a daily total (unit is mm/day).

Other relevant background documents are:

- Huffman, G.J., R.F. Adler, B. Rudolph, U. Schneider, and P. Keehn, 1995: Global Precipitation Estimates Based on a Technique for Combining Satellite-Based Estimates, Rain Gauge Analysis, and NWP Model Precipitation Information, *J. Clim.*, 8, 1284-1295.
- Huffman, G.J., 1997: Estimates of Root-Mean-Square Random Error for Finite Samples of Estimated Precipitation, *J. Appl. Meteor.*, 1191-1201.
- Huffman, G.J., R.F. Adler, P. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolph, and U. Schneider, 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Dataset, *Bul. Amer. Meteor. Soc.*, 78, 5-20.
- Huffman, G.J., R.F. Adler, D.T. Bolvin, G. Gu, E.J. Nelkin, K.P. Bowman, Y. Hong, E.F. Stocker, D.B. Wolff, 2007: The TRMM Multi-satellite Precipitation Analysis: Quasi-Global, Multi-Year, Combined-Sensor Precipitation Estimates at Fine Scale. *J. Hydrometeor.*, 8(1), 38-55.
- Huffman, G.J., R.F. Adler, M. Morrissey, D.T. Bolvin, S. Curtis, R. Joyce, B. McGavock, J. Susskind, 2001: Global Precipitation at One-Degree Daily Resolution from Multi-Satellite Observations. *J. Hydrometeor.*, 2(1), 36-50.

3.3.5 **GWADI- PERSIANN Global**

This bias corrected PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) precipitation product maintains total monthly precipitation estimates, consistent with GPCP (Global Precipitation Climatology Project) product. The released data set retains the spatial and temporal features of precipitation estimates provided by the original PERSIANN algorithm at 0.25-degree spatial and 3 as well as 6 hourly temporal resolution. Data is provided covering a monthly period, from March 2000 onwards. Currently for the 3 hourly monthly product up to April 2012 and for the 6 hourly product up to November 2012. The current availability can be obtained from <ftp://hydis8.eng.uci.edu/pub/PERSIANN> and subsequently navigate to the sub-directory "/tar_3hr/" or "/tar_6hr/".

PERSIANN precipitation estimation relies on cloud texture information from longwave infrared images (~10.2-11.2 μm) obtained from geostationary satellites and updated using the higher quality rainfall estimates from low-orbit passive microwave sensors (Hsu et al., 2007; Soroosh et al., 2000). To reduce bias while preserving spatial and temporal patterns in high resolution, PERSIANN precipitation is adjusted based on GPCP rainfall (Version 2.1) at 2.5° monthly resolution (Adler et al., 2003; Huffman et al., 2009). Before applying bias adjustment, missing data in PERSIANN estimation is filled with passive microwave rainfall estimation at each 30 minutes time step. In the subsequent step, the data is aggregated to 2.5° monthly scale and a correction factor is computed based on the ratio of GPCP rainfall and PERSIANN rainfall at a grid of 2.5° monthly scale. This ratio is then used to calculate the PERSIANN rainfall fine spatial (0.25°) and temporal scale (hourly) within the 2.5° coverage. Full monthly archives of PERSIANN's final 0.25° are available at 3 and 6 hourly temporal resolution (source: <http://chrs.web.uci.edu/persiann/data.html>). Intensity is given in mm per time interval, giving the precipitation accumulation period for the duration indicated by the start of the time interval to the end. For example a 6 hourly event starting at hour stamp 12, provides the 6 hour accumulated rainfall from 12:00 to 18:00.

Other relevant background documents are:

- Adler, R.F., G.J. Huffman, A. Chang, R. Ferraro, P. Xie, J. Janowiak, B. Rudolf, U. Schneider, S. Curtis, D. Bolvin, A. Gruber, J. Susskind, and P. Arkin, 2003: The Version 2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979-Present). *J. Hydrometeor.*, 4, 1147-1167.
- George J. Huffman, Robert F. Adler, David T. Bolvin, Guojun Gu. (2009) Improving the global precipitation record: GPCP Version 2.1. *Geophysical Research Letters* 36:17.

- Hsu, K., X. Gao, S. Sorooshian, and H.V. Gupta, Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks, *Journal of Applied Meteorology*, 36(9), 1176-1190, 1997.
- Sorooshian, S., K. Hsu, X. Gao, H.V. Gupta, B. Imam, and Dan Braithwaite, Evaluation of PERSIANN System Satellite-Based Estimates of Tropical Rainfall, *Bulletin of the American Meteorological Society*, 81(9), 2035-2046, 2000.

3.3.6 **Last 24 hour MPE from EUMETSAT**

This utility automatically extracts to a specific output directory the Multi Sensor Precipitation Estimates (MPE) produced by EUMETSAT, made available about 1 hour after satellite recording on their 24 hour rolling archive (available at: <http://oiswww.eumetsat.org/SDDI/html/grib.html>). The user can select the MPE derived from METEOSAT-7 and MSG. Once all data is downloaded, the files are imported into an ILWIS format. A loop processing routine is applied to import the various rainfall instances. This routine needs a fast internet connection as a lot of files are transferred (48 for MET-7 and 96 from MSG). Rainfall intensities are given in mm per hour. Using generic GIS functionality the various rainfall instances can be aggregated.

3.3.7 **FEWSNET RAINFALL AND CLIMATOLOGY FOR AFRICA**

These rainfall estimates are created by the Climate Prediction Center for the United States Agency for International Development (USAID) Famine Early Warning System (FEWS) project to assist in drought monitoring and flood forecasting efforts throughout Africa.

The rainfall algorithm called RFE1.0 uses infrared temperature satellite data, rain gauge data, modeled wind and relative humidity data to compute ten day rainfall estimates. Meteosat-5 IR temperature data is first used to compute estimated rainfall via the GOES Precipitation Algorithm (GPI). Modeled relative humidity and wind data is then compared to topographical data to estimate cross-terrain flow as orographic precipitation. These two estimates are then compared to Global Telecommunications System (GTS) rain gauge measurements, and ground truthing is performed to remove bias and create the final rainfall estimate. RFE Version 1.0 data is available from 1995-2000. The algorithm used to create these estimates was replaced on January 1, 2001 and is no longer operational. From 1995-2000, each 10-day rainfall estimate covers the domain from 20W-55E and 40S-20N with a resolution of 0.1 degree.

The RFE Version 2.0 algorithm is based on the Xie method and is currently employed to create the RFE as operational product at the NOAA/Climate Prediction Center in association with USAID/FEWS-NET. The spatial resolution is 0.1 degree and the bounding coordinates are from 40S to 40N in latitude, and 20W to 55E in longitude, covering the whole African continent. Data is available from 2000 onwards. Maps of daily, dekadal, and monthly rainfall estimates, as well as documentation on the RFE algorithm methodology can be consulted at <http://www.cpc.ncep.noaa.gov/products/fews/rfe.shtml>. Longer duration products are created by accumulation of the daily data.

Also RFE based climatology data is produced by the Climate Prediction Center. Daily, dekadal and monthly means in mm per respective time interval are currently based on a climatological record from 1983 till 2011. The files contain climatological rainfall estimates over the African continent utilizing the Africa Rainfall Estimate Climatology Version 2 (CPC-ARC2) - method, see also http://www.cpc.ncep.noaa.gov/products/fews/AFR_CLIM/afr_clim.shtml. Also further information on the ARC2 dataset is provided there. The geographical extent is identical compared to the RFE2 rainfall estimate. Also check http://www.cpc.ncep.noaa.gov/products/fews/AFR_CLIM/AMS_ARC2a.pdf.

References:

- Xie, P. and P.A. Arkin, 1996: Analyses of Global Monthly Precipitation Using Gauge Observations, Satellite Estimates, and Numerical Model Predictions. *J. Climate*: 9, 840-858.

Comparison of satellite derived precipitation products:

- T. Cohen Liechti, J. P. Matos, J.-L. Boillat and A. J. Schleiss (2012): Comparison and evaluation of satellite derived precipitation products for hydrological modeling of the Zambezi River Basin. *Hydrol.*

Earth Syst. Sci., 16, 489-500, 2012. <http://www.hydrol-earth-syst-sci.net/16/489/2012/hess-16-489-2012.html>

- D.A. Hughes. Comparison of satellite rainfall data with observations from gauging station networks http://eprints.ru.ac.za/470/1/Hughes_Comparison_of_satellite_rainfall.pdf
- Nick Novella and Wassila Thiaw (2009): Validation of Satellite-Derived Rainfall Products over the Sahel 2009 EUMETSAT Meteorological Satellite Conference, Bath, United Kingdom 21 - 25 September 2009 (http://www.eumetsat.int/Home/Main/AboutEUMETSAT/Publications/ConferenceandWorkshopProceedings/2009/SP_201001515267179?l=en)

3.3.8 TAMSAT Rainfall archive for Africa

The TAMSAT group from the University of Reading, UK, are producing ten-daily (dekadal) and monthly rainfall estimates and anomalies derived from Meteosat Thermal Infra-Red (TIR) channels based on the recognition of storm clouds and calibration against ground-based rain gauge data (see also <http://www.met.reading.ac.uk/tamsat/about/>). Using this set of retrieval routines the 10 day accumulated RFE rainfall product can be retrieved as well as the monthly accumulated rainfall products. Furthermore decadal anomaly and monthly anomaly rainfall products can be retrieved. The online archive currently contains 10 day and monthly rainfall data from 1983 onwards. Also 30-year rainfall climatology (from 1983-2012) is available from here. The data covers Africa and has a spatial resolution of 0.0375 degree; geographic coordinates in lat-lon. The seasonal rainfall totals are not used within the ISOD Toolbox; these can be easily constructed by the user applying an aggregation function.

3.4 FEWSNET Global Potential Evapotranspiration

The daily global potential evapotranspiration (PET) is calculated from climate parameter data that is extracted from Global Data Assimilation System (GDAS) analysis fields. The GDAS data are generated every 6 hours by the National Oceanic and Atmospheric Administration (NOAA). The GDAS fields used as input to the PET calculation include air temperature, atmospheric pressure, wind speed, relative humidity, and solar radiation (long wave, short wave, outgoing and incoming). PET is computed for each 6 hour period and then summed to obtain daily totals. A day is defined as beginning at 00 hours GMT.

The daily PET is calculated on a spatial basis using the Penman-Monteith equation (the formulation of Shuttleworth (1992) for reference crop evaporation is used). These equations were standardized in accordance with the FAO publication 56 for the 6-hourly calculations (Allen et al, 1998).

The daily PET values are scaled up (i.e. multiplied) by a factor of 100 to preserve the precision to .01 mm. The PET data have a 1 degree ground resolution and are global in spatial extent (i.e. -180 to +180 longitude by -90 to +90 latitude) (source: <http://earlywarning.usgs.gov/fews/global/web/readme.php?symbol=pt>).

The Year Collection of daily PET images are ~25 Mb per file (year). The naming convention is pet_YYYY.tar.gz where YYYY is the 4 digit year. These files are containing a year of daily (365 or 366 in leap year) data files.

The Month Collection of daily PET images are ~ 2 Mb per file (month). The naming convention is pet_YYYYMM.tar.gz where YYYY is the 4 digit year and MM is the 2 digit month of year. These files are containing a month of daily (28-31) data files. For the individual day PET images also retrieval and processing routines are developed.

Yearly global PET data is available from 2001 onwards up to the last full year. Monthly data can also be extracted from 2001 onwards. Daily global PET data can be retrieved up to a year before present. Further information can be obtained from <http://earlywarning.usgs.gov/fews/global/web/dwnglobalpet.php>. Upon retrieval / import the data is converted to mm / per day.

References for Calculations:

- Allen, R.G., L. Pereira, D. Raes, and M. Smith, 1998. Crop Evapotranspiration, Food and Agriculture Organization of the United Nations, Rome, Italy. *FAO publication 56*. ISBN 92-5-104219-5. 290p.
- Shuttleworth, W.J., 1992. Evaporation. In D. Maidment, *Handbook of Hydrology*. McGraw-Hill

- Smith, M. 1992. Expert consultation on the revision of FAO methodologies for crop water requirements. FAO, Rome, Italy. 60pp.

3.5 MOD16 – GLOBAL PET AND ET

The MOD16 ET datasets are estimated using Mu et al.'s improved ET algorithm (2011) over previous Mu et al.'s paper (2007a). The ET algorithm is based on the Penman-Monteith equation (Monteith, 1965). Surface resistance is an effective resistance to evaporation from land surface and transpiration from the plant canopy (see also: ftp://ftp.nts.gov.umt.edu/pub/MODIS/NTSG_Products/MOD16/ and <http://www.nts.gov.umt.edu/project/mod16>).

The MOD16 monthly global evapotranspiration (ET) dataset at 0.05° degree resolution (5600 meters at the equator), using geographic coordinates, and the 8-day ET and potential ET (PET) datasets at 1-km² spatial resolution. The dataset currently covers the time period 2000 – 2012 and future years will be produced and posted periodically, but not in near-real time. For the high spatial resolution product the data is posted using the h and v grid system (see: http://modis-land.gsfc.nasa.gov/MODLAND_grid.html). The import routine developed is automatically assigning the h and v numbers based on the latitude and longitude assigned for the top-left geographic coordinates of the 10 by 10 degree tile selected.

In case after import the user wants to integrate the 8-day ET-PET data with e.g. vector information, use should be made of the LATLON coordinate system or else the map should be resampled (from Sinusoidal) to the target projection (e.g. to LATLON using a pixel size of 32.14 seconds).

The 8-day ET (0.1mm/8days) is the sum of ET during these 8-day time periods (5 days for 361 composite data in 2001, 2002, 2003, 2005, 2006, 2007, 2009, 2010, 2011, 6 days for 361 in 2000, 2004, 2008 and 2012). The monthly ET (0.1mm/month) is the sum of monthly ET. For February, there are 29 days in a leap year and 28 days in normal years.

References

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- Mu, Q., M. Zhao, S.W. Running (2011). Improvements to a MODIS Global Terrestrial Evapotranspiration Algorithm. *Remote Sensing of Environment*.

3.6 FEWSNET NOAA - eMODIS NDVI for Africa

3.6.1 FEWSNET NOAA DERIVED NDVI FOR AFRICA

Introduction: The Normalized Difference Vegetation Index (NDVI) provides a measure of the amount and vigour of vegetation at the land surface. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general, higher values of NDVI indicate greater vigour and amounts of vegetation. NDVI is derived from data collected by National Oceanic and Atmospheric Administration (NOAA) satellites, and processed by the Global Inventory Monitoring and Modelling Studies group (GIMMS) at the National Aeronautical and Space Administration (NASA).

The NOAA-Advanced Very High Resolution Radiometer (AVHRR) collects the data that are used to produce the NDVI. The scanning radiometer (comprised of five channels) is used primarily for weather forecasting; however, there are an increasing number of other applications, e.g., drought monitoring. NDVI is calculated from two channels of the AVHRR sensor, the near-infrared (NIR) and visible (VIS) wavelengths, using the following algorithm:

$$NDVI = (NIR - VIS)/(NIR + VIS)$$

NDVI is a nonlinear function that varies between -1 and +1 (undefined when NIR and VIS are zero).

Values of NDVI for vegetated land generally range from about 0.1 to 0.7, with values greater than 0.5 indicating dense vegetation.

Since the late 1980's, the Famine Early Warning System (FEWS) has used AVHRR data to produce dekadal (10-day) composite NDVI images of Africa and has built a valuable archive of these data from mid-1981 to present.

NDVI-g data background: EROS processes and archives a dekadal (i.e. ~10 days, 36/year) Africa NDVI product from the NASA GIMMS group called NDVI-g. The dataset is inter-calibrated with SPOT Vegetation NDVI, and uses NOAA-17 data since January 2004. The NOAA-17 NDVI data have also been inter-calibrated with NOAA-16 and previous NDVI products. These data are available from the African Data Dissemination Service server (<http://earlywarning.usgs.gov/fews/>). Note that the NDVI data from July dekad 1, 1981 through December dekad 3, 2008 are NDVI-g. The data from January dekad 1, 2008 to present are NDVI-rg. NASA has stated that the NDVI-rg data will be updated to the archival NDVI-g product approximately every 6-12 months.

FEWS-NET NDVI data originates from the NASA GIMMS group. For more information about AVHRR data, NDVI processing and for proper acknowledgement of these data in any report or publication, see the references at the end of this section.

NDVI-g data characteristics: Data source is the NASA - GIMMS group, time step of the data is 10-day (dekadal), and spatial resolution is 8km. The projection used is Albers equal area conic, using the Clarke ellipsoid, the applied temperature threshold for cloud screening is 285 Kelvin and the file format is byte (8 bit). The satellite that acquired the data for any given period is provided below:

NOAA 7 periods	(Jul 81 - Feb 85)
NOAA 9 periods	(Feb 85 - Nov 88)
NOAA 11 periods	(Nov 88 - Sep 94)
NOAA 9 periods (descend)	(Sep 94 - Jan 95)
NOAA 14 periods	(Jan 95 - Oct 00)
NOAA 16 periods	(Nov 00 - Dec 03)
NOAA 17 periods	(Jan 04 - present)

Processing Details: No correction has been applied to correct for atmospheric effects due to water vapor, Rayleigh scattering or stratospheric ozone. Maximum value compositing has been used, with a forward binning procedure method implemented. A stratospheric aerosol correction has been applied during April 82-Dec 84 and June 91-Dec 93 to correct for stratospheric aerosols due to volcanic eruptions (Tanre, Holben and Kaufman 91). The corrections use a hybrid of retrieved optical thicknesses (Vermott et al. 95) and modelled thicknesses from GISS.

Artefacts in the NDVI due to satellite drift have been corrected using the empirical mode decomposition (EMD) procedure. The correction is especially important in tropical regions. For details see the paper of Pinzon et al 2004, referenced below. The VIg correction has been applied to the GIMMS VIid data that has had the desert calibration applied for NOAA 7-14 (Los 1998).

Scaling Info: NDVI is archived as byte data files. In the formula below, the data, once imported, is referred to as the 'raw' data. To recover the -1 to 1 range of NDVI, use the following formula:

$$\text{NDVI} = \text{raw}/250$$

After conversion, Water pixels have a value of 1.0200, and 1.0160 are masked pixels, and missing are 1.0120 (source: <http://earlywarning.usgs.gov/fews/africa/web/readme.php?symbol=nd>). This algorithm is applied when processing the data using the ISOD toolbox.

The AVHRR sensor (the sensor used to derive the Africa dekadal AVHRR NDVI) onboard the NOAA-17 satellite has been encountering major degradation problems. The NDVI data derived from the NOAA-17 AVHRR sensor are no longer valid and are no longer staged or distributed until further notice.

NASA is currently in the process of converting from the NOAA-17 AVHRR sensor to the NOAA-18 AVHRR sensor. NASA intends to calibrate and reprocess the AVHRR NDVI using the NOAA-18 sensor data back

to the beginning of 2010. When this transition has been completed and production using the NOAA-18 sensor is established, NASA will continue staging and distributing the AVHRR NDVI product. For more recent products the eMODIS derived NDVI can be applied, for further information see the next section.

References:

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- Vermote, E. and Y. J. Kaufman (1995). "Absolute calibration of AVHRR visible and near-infrared channels using ocean and cloud views." *International Journal of Remote Sensing* 16(13): 2317-2340.

3.6.2 FEWSNET EMODIS DERIVED NDVI, ANOMALY AND HISTORICAL DATA FOR AFRICA

Expedited MODIS (eMODIS) is a process for creating a community-specific suite of vegetation monitoring products based on the National Aeronautics and Space Administration's (NASA) Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) and produced at the U.S. Geological Survey's (USGS) Earth Resources Observation and Science (EROS) Centre. Real-time and historical Normalized Difference Vegetation Index (NDVI) products are composited in 10-day intervals every 5 days on a Geographic mapping grid.

eMODIS 10-day maximum-value composite NDVI images at 250m spatial resolution are used to monitor vegetation condition. NDVI is a measure of the density of chlorophyll contained in vegetative cover and is defined as $(NIR - RED) / (NIR + RED)$, where NIR is the near-infrared reflectance and RED is the visible-red reflectance. This vegetation product is calculated from MODIS L1B Terra surface reflectances, corrected for molecular scattering, ozone absorption, and aerosols (source: <http://earlywarning.usgs.gov/fews/africa/index.php>).

The NDVI and NDVI Anomaly maps are the product of a temporally smoothed 250m NDVI data set. A time series smoothing technique developed by Swets and others (1999) was used to smooth NDVI composites for the years 2001 through 2010. The technique uses a weighted least squares linear regression approach to "correct" observations that are of poor quality due to clouds or other atmospheric contamination. This smoothed time series was used to derive a 10-year mean NDVI on a pixel-by-pixel basis for each of the 72 composite periods per year. As current-year composites become available, they are added to the time series and smoothed, resulting in a smoothed composite comparable to the historical mean for a given 10-day period.

Reference:

- Swets, D.L., Reed, B.C., Rowland, J.D. & Marko, S.E. (1999): A weighted least-squares approach temporal NDVI smoothing. In: 1999 ASPRS Annual Conference: From Image to Information, Portland, Oregon, May 17-21. Proceedings: Bethesda, Maryland, *American Society for Photogrammetry and Remote Sensing*.

The following products can be retrieved:

- *Temporally Smoothed NDVI* – Smoothed 10-day NDVI composite.

- *Short-term Mean Anomaly* - Anomalies represent a subtraction of the mean NDVI values (2001-2010) for a 10-day period from current-year values for the same period, rendering an image where negative values portray less vigorous vegetation than average, and positive values represent areas that are more vigorous in the current year.
- *Previous Year Difference* – The difference image is a subtraction of the current year NDVI values from those of the previous year.
- *Short-term Mean* – mean per period derived for a time series from 2001-2010.

Other relevant parameters are:

- MODIS NDVI data are stretched (mapped) linearly (to byte values) as follows:
Data range: [-1.0, 1.0] -> [0, 255], Invalid Values: 201 – 255, formula applied:
NDVI = (value – 100) / 100; example: [(150 – 100) / 100 = 0.5 NDVI]
- Anomaly / Difference Classification: The absolute difference and anomaly images are stretched from - 0.3 to 0.3 NDVI. The area of relatively no difference is approximately -0.05 – 0.05. The original data is provided in GeoTIFF format and transformed to ILWIS format.
- The coordinate system used is Geographic, the units are in decimal degrees, and spheroid used is WGS84. Pixel size in x and y direction is 0.002 degree.

All parameters above are implemented during the product extraction – processing routines when using the ISOD toolbox. The routines allow retrieval and processing of the recent 2 years data as well as the historical NDVI data from 2001 onwards and the short term mean.

3.7 MEASURES GLOBAL VI PRODUCTS V2

VIP – Vegetation Phenology and Vegetation Index Products from Multiple Long Term Satellite Data Records. Kamel Didan at the University of Arizona has developed a consistent 30-year record of Enhanced Vegetation Index and Phenology products using the Advanced Very High Resolution Radiometer (AVHRR), the Systeme Pour l’Observation de la Terre (SPOT) Vegetation instrument, and the Moderate Resolution Imaging Spectroradiometer (MODIS) to create a 30-year record that can be extended into future missions (currently from 1981_001-2010_365, year_julian day).

In July 2012, the VIP project released version 2 of its vegetation index products. The product suite is comprised of daily, 7-day, 15-day, and monthly temporal intervals covering the period start 1981 to end 2010. (Source: https://lpdaac.usgs.gov/user_community/nasa_measures). Resolution of the product is 0.05 degrees (5600 meters). Import routines for the Phenology set of products still have to be developed. Further information can be obtained from the documents tab at the “viplab”, available at: http://measures.arizona.edu/viplab_data_explorer.php#. Conventions used to calculate NDVI and EVI2 are presented below:

$$\text{NDVI (Normalized Vegetation Index):} \quad \text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}$$

$$\text{EVI2 (Enhanced Vegetation Index):} \quad \text{EVI2} = 2.5 \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + 2.4 \text{RED} + 1)}$$

3.8 GLOBAL ELEVATION DATA

3.8.1 GMTED 2010

The USGS and the NGA have collaborated on the development of a notably enhanced global elevation model named the GMTED2010 that replaces GTOPO30 as the elevation dataset of choice for global and continental scale applications. The new model has been generated at three separate resolutions (horizontal post spacing) of 30 arc-seconds (about 1 kilometer), 15 arc-seconds (about 500 meters), and 7.5 arc-seconds (about 250 meters). This new product suite provides global coverage of all land areas from lat 84°N to 56°S for most products, and coverage from 84°N to 90°S for several products. GMTED2010 is based on data derived from 11 raster based elevation sources.

The new elevation products have been produced using the following aggregation methods: minimum elevation, maximum elevation, mean elevation, median elevation, standard deviation of elevation, systematic subsample and breakline emphasis. Metadata have also been produced to identify the source and attributes of all the input elevation data used to derive the output products. Many of these products will be suitable for various regional and continental applications, such as climate modeling, continental-scale land cover mapping, extraction of drainage features for hydrologic modeling, and geometric and radiometric correction of medium and coarse resolution satellite image data. The global aggregated vertical accuracy of GMTED2010 can be summarized in terms of the resolution and RMSE of the products with respect to a global set of control points (estimated global accuracy of 6 m RMSE) provided by NGA. At 30 arc-seconds, the GMTED2010 RMSE range is between 25 and 42 meters; at 15 arc-seconds, the RMSE range is between 29 and 32 meters; and at 7.5 arc-seconds, the RMSE range is between 26 and 30 meters. GMTED2010 is a major improvement in consistency and vertical accuracy over GTOPO30, which has a 66 m RMSE globally compared to the same NGA control points. In areas where new sources of higher resolution data were available, the GMTED2010 products are substantially better than the aggregated global statistics; however, large areas still exist, particularly above 60 degrees North latitude that lack good elevation data. As new data become available, especially in areas that have poor coverage in the current model, it is hoped that new versions of GMTED2010 might be generated and thus gradually improve the global model (source: <http://pubs.usgs.gov/of/2011/1073/pdf/of2011-1073.pdf>). The routines within the ISOD toolbox retrieve the breakline emphasis elevation products for the various resolutions.

3.8.2 **SRTM Version 4**

The SRTM digital elevation data, produced by NASA originally, was a major breakthrough in digital mapping of the world, and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world. The SRTM digital elevation data provided by CGIAR has been processed to fill data voids. The data is provided in an effort to promote the use of geospatial science and applications for sustainable development and resource conservation in the developing world. Digital elevation models (DEM) for the entire globe, covering all of the countries of the world, are available. The SRTM 90m DEM's have a resolution of 90m at the equator, and are provided in mosaiced 5 by 5 degree tiles. All are produced from a seamless dataset to allow easy mosaicking (source: <http://srtm.csi.cgiar.org/>). The data is projected in a Geographic (Lat/Long) projection, with the WGS84 horizontal datum and the EGM96 vertical datum. For further information on the SRTM Version 4 details and the product history consult the CGIAR website given above.

The toolbox routine calculates the corresponding index number from the lower left hand Latitude and Longitude coordinate pair and subsequently extracts the elevation tile. The data is currently downloaded from http://droppr.org/srtm/v4.1/6_5x5_TIFs/. The addresses for the other mirror sites are included in the batch file (SRTM4_import.bat). It was found that the selected address was facilitating faster downloads. The SRTM data is retrieved in GeoTIFF format and transformed into ILWIS.

3.8.3 **ASTER GDEM Version 2**

In 2009, NASA and the Ministry of Economy, Trade and Industry (METI) of Japan released a Global Digital Elevation Model (GDEM) to users worldwide at no charge as a contribution to the Global Earth Observing System of Systems (GEOSS). Version 1 ASTER GDEM (GDEM1) was compiled from over 1.2 million scene based DEMs covering land surfaces between 83°N and 83°S latitudes. The GDEM1 was found to have an overall accuracy of around 20 meters at the 95% confidence level. Several artifacts associated with poor stereo coverage at high latitudes, cloud contamination, water masking issues and the stacking process used to produce the GDEM1 from individual scene-based DEMs were noted. A second version of the ASTER GDEM (GDEM2) was released by NASA and METI in 2011. Improvements in the GDEM2 result from acquiring 260,000 additional scenes to improve coverage, a smaller correlation kernel to yield higher spatial resolution and improved water masking.

Vertical accuracy assessments included a comparison of the GDEM2 against absolute geodetic references over the Conterminous US (CONUS), against national elevation grids over the US and Japan, against the Shuttle Radar Topography Mission (SRTM) 1 arc-second elevation grids over the US and 20 sites around the globe, and against space borne laser altimeter data globally. Horizontal accuracy assessments were conducted as part of the Japan and the global SRTM studies, and horizontal resolution studies were conducted in both Japan and the US. The absolute vertical accuracy study found the GDEM2 to be within -0.20 meters on average when compared against 18,000 geodetic control points over the CONUS, with an

accuracy of 17 meters at the 95% confidence level. The Japan study noted the GDEM2 differed from the 10-meter national elevation grid by -0.7 meters over bare areas, and by 7.4 meters over forested areas. Similarly, the CONUS study noted the GDEM2 to be about 8 meters above the 1 arc-second NED over most forested areas, and more than a meter below NED over bare areas. The global altimeter study found the GDEM2 to be on average within 3 meters of altimeter-derived control, and also documented sensitivity to tree canopy height. The Japan study noted that the horizontal displacement in GDEM1 of 0.95 pixels was reduced to 0.23 pixels in GDEM2. Both teams noted improvements in horizontal resolution, between 71 and 82 meters, comparable to the SRTM 1 arc second elevation model, but at the cost of some increased noise. The number of voids and artifacts noted in GDEM1 were substantially reduced in GDEM2, and in some areas virtually eliminated.

GDEM2, while vastly improved, still contains some artifacts which could affect its utility in certain applications (source: http://www.jspacesystems.or.jp/ersdac/GDEM/ver2Validation/Summary_GDEM2_validation_report_final.pdf).

The original files are in GeoTIFF format (signed 16 bits) using geographic coordinates and the spatial resolution is 1 arc-second. Each tile is 1 by 1 degree (3601 lines by 3601 columns). Due to the fact that Users have to register prior to be able to obtain the data, in order to ingest the data, the User has to download the ASTER-GDEM tiles first to a user defined location and start the extraction procedure specifying the appropriate input directory on the local system used.

3.9 COPERNICUS GLOBAL LAND SERVICE

The overall objective of the Copernicus Global Land Service is the creation of a Global Land Component in the framework of GMES Initial Operations (GIO) and is earmarked as a component of the Land service to operate “a multi-purpose service component” that will provide a series bio-geophysical products on the status and evolution of land surface at global scale. Production and delivery of the parameters are to take place in a timely manner and are complemented by the constitution of long term time series (<http://land.copernicus.eu/global/?q=index.html>). Within the toolbox a routine has been added to import the Soil Water Index (SWI). The SWI quantifies the moisture condition within the underlying soil profile. It is mainly driven by the precipitation via the process of infiltration. Soil moisture is a very heterogeneous variable and varies on small scales with soil properties and drainage patterns. Satellite measurements integrate over relative large-scale areas, with the presence of vegetation adding complexity to the interpretation. From <http://land.copernicus.eu/global/?q=products/swi> also the product user manual can be retrieved. To access the data one has to register. The data (for version 2) is assumed to be available locally before the SWI can be processed using the toolbox. In total 8 layers are retrieved, representing 8 different characteristic time lengths - T (for T = 1, 5, 10, 20, 40, 60 and 100).

3.10 NASA GLOBAL OCEAN DATA

The following routines are developed to extract the data from the ocean data archive at NASA: SST (sea surface temperature), SSTN (night time sea surface temperature), temperature in degree C., and Chlor_a (chlorophyll a concentration (mg m⁻³)). Other data ocean sets are available from there as well, also using other sensors. The link to the online archive is <http://oceandata.sci.gsfc.nasa.gov/>. The Level 3 Standard Mapped Image (SMI) products are image representations of binned data products. The image is typically a scaled value (16bit), two-dimensional array of an Equidistant Cylindrical projection of the globe. The original SMI definition was a 9.2km (at the equator) resolution product, resampled to 4.6 km for the products used here (source: <http://oceancolor.gsfc.nasa.gov/>).

The long-wave SST algorithm makes use of MODIS bands 31 and 32 at 11 and 12 um. The brightness temperatures are derived from the observed radiances by inversion (in linear space) of the radiance versus blackbody temperature relationship. For msl12, these relationships were precomputed for the spectral response of each MODIS channel, and the tables were then stored in HDF files to be loaded at run-time. In modsst, the radiance versus blackbody temperature relationship was computed at run-time. The nonlinear SST algorithm was tuned for two different regimes based on brightness temperature difference. The algorithm for computing long-wave SST (sst) from observed brightness temperatures is shown below:

$$dBT \leq 0.5$$

$$sst = a00 + a01*BT11 + a02*dBT*bsst + a03*dBT*(1.0/mu-1.0)$$

dBT >= 0.9
 sst = a10 + a11*BT11 + a12*dBT*bsst + a13*dBT*(1.0/mu-1.0)

0.5 < dBt < 0.9
 sstlo = a00 + a01*BT11 + a02*dBT*bsst + a03*dBT*(1.0/mu-1.0)
 ssthi = a10 + a11*BT11 + a12*dBT*bsst + a13*dBT*(1.0/mu-1.0)
 sst = sstlo + (dBT-0.5)/(0.9-0.5)*(ssthi-sstlo)

where:

dBT = BT11 - BT12

BT11 = brightness temperature at 11 um, in deg-C

BT12 = brightness temperature at 12 um, in deg-C

bsst = baseline SST, which is either sst4 (if valid) or sstref (from oisst)

mu = cosine of sensor zenith angle

At night, where sst4 retrieval is reliable, the algorithm uses sst4 (SST derived at 4 micron) for the bsst value. For daytime SST, the algorithm uses a reference SST source (sstref) for bsst, where sstref is operationally derived from the weekly Reynolds oisst product, bilinearly interpolated to the pixel location. The coefficients a00, a01, a02, and a03 and a10, a11, a12, and a13 are derived and continuously verified by RSMAS based on match-ups between the satellite retrievals of brightness temperature and field measurements of sea surface temperature. As currently implemented, these coefficients can be time-dependent. The coefficients are provided to msl12 through external files, which are in a columnated ascii format of "sensor start-date end-date ai0 ai1 ai2 ai3", with each pair of lines corresponding to low and high dBT difference cases, respectively.

For the MODIS instrument on Terra, the retrieved long-wave SST is further augmented by a time-dependent, mirror-side specific bias. The adjustment varies from -0.2 deg-C to 0.1 deg-C over the mission lifespan, and it is applied to mirror-side 1 only. The mirror-side correction was developed by RSMAS. Source: http://oceancolor.gsfc.nasa.gov/DOCS/modis_sst/.

The Ocean Color (OC) suite of chlorophyll a (Ca, mg/m3) algorithms describe the polynomial best fits that relate log-transformed Ca to log-transformed ratios of remote-sensing reflectances (Rrs, 1/sr).

Currently, all have the form:

$$Ca = 10^{(a_0 + a_1*x + a_2*x^2 + a_3*x^3 + a_4*x^4)}$$

where x = log10(Rrs[blue wl] / Rrs[green wl])

The wavelengths and polynomial coefficients (a0...a4) used in operational MSI12 processing are provided below for MODIS.

sensor	blue wl*	green wl	a0	a1	a2	a3	a4
MODIS	443>488	551	0.2830	-2.7530	1.4570	0.6590	-1.4030
HMODIS(500-m)	469	555	0.1543	-1.9764	1.0704	-0.2327	-1.1404

(* the greatest Rrs[blue wl] is used when multiple blue wl are specified)

3.11 GLOBAL LAND DATA ASSIMILATION SYSTEM

The data used in this toolbox-routine are acquired as part of the mission of NASA's Earth Science Division and archived and distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC), the so called 0.25 Degree 3-Hourly Data from the Noah Model. This model provides basic information on the land surface state (e.g., soil moisture and surface temperature) and flux (e.g., evaporation and sensible heat flux) parameters generated by the Global Land Data Assimilation System (GLDAS). GLDAS drives multiple, offline (not coupled to the atmosphere) land surface models, integrates a huge quantity of observation based data, and executes globally at high resolutions (2.5° to 1 km),

enabled by the Land Information System (LIS) (Kumar et al., 2006). Currently, GLDAS drives four land surface models (LSMs): Mosaic, Noah, the Community Land Model (CLM), and the Variable Infiltration Capacity (VIC). More information is available at the Land Data Assimilation Systems (LDAS, <http://ldas.gsfc.nasa.gov/>) and Land Information System (LIS, <http://lis.gsfc.nasa.gov/>) websites. Further information is given in: ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/GLDAS_V1/README.GLDAS.pdf.

The temporal resolution for the GLDAS products is 3-hourly. Monthly products are also generated through temporal averaging of the 3-hourly products. Output from the GLDAS-Noah model (GLDAS_NOAH025SUBP_3H), in original GRIB format, is retrieved using the routines developed within the ISOD toolbox. Only the 3 hourly products are extracted. Other model output can be found at <http://disc.sci.gsfc.nasa.gov/services/grads-gds/gldas> and the Noah model data is retrieved from ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/GLDAS_V1/GLDAS_NOAH025SUBP_3H.

The listing below provided a summary of the data available within each 3 hourly GRIB file. All the 8 files for a single day are automatically retrieved and processed. During processing all pixels with a value of 9999 are assigned 'no data'.

Summary of the data layers as well as their unit, available at 3 hourly temporal intervals; from day of the year 055 – 2000 up to 274 – 2012 are currently available (as from February 2013, check the ftp link above for the actual status), is given below. It has been noted that temperature is most likely given in Celsius and needs to be further confirmed.

avgsurft: average surface temperature k
canopint: total canopy water storage kg/m²
evap : total evapotranspiration kg/m²/s
lwdown : surface incident longwave radiation w/m²
lwnet : net longwave radiation w/m²
psurf : surface pressure pa
qair : near surface specific humidity kg/kg
qg : ground heat flux w/m²
qh : sensible heat flux w/m²
qle : latent heat flux w/m²
qs : surface runoff kg/m²/s
qsb : subsurface runoff kg/m²/s
qsm : snowmelt kg/m²/s
rainf : rainfall rate kg/m²/s
swe : snow water equivalent kg/m²
swdown: surface incident shortwave radiation w/m²
swnet : net shortwave radiation w/m²
snowf : snowfall rate kg/m²/s
soilm1 : 0-10 cm average layer 1 soil moisture kg/m²
soilm2 : 10-40 cm average layer 2 soil moisture kg/m²
soilm3 : 40-100 cm average layer 3 soil moisture kg/m²
soilm4 : 100-200 cm average layer 4 soil moisture kg/m²
tsoil1 : 0-10 cm average layer 1 soil temperature k
tsoil2 : 10-40 cm average layer 2 soil temperature k
tsoil3 : 40-100 cm average layer 3 soil temperature k
tsoil4 : 100-200 cm average layer 4 soil temperature k
tair : near surface air temperature k
wind : near surface wind magnitude m/s

Also the meta-data from each of the GRIB files can be retrieved. A routine is available to obtain the corresponding day of year for leap and normal years to deal with the Julian day format. To extract the meta-data the GRIB file first has to be imported.

Relevant references are:

- Berg, A. A., J. S. Famiglietti, J. P. Walker, and P. R. Houser, 2003. Impact of bias correction to reanalysis products on simulations of North American soil moisture and hydrological fluxes, J. of Geo. Res., 108(D16), 4490.

- Derber, J. C., D. F. Parrish, and S. J. Lord, 1991. The new global operational analysis system at the National Meteorological Center. *Weather Forecasting*, 6, 538-547.
- Kumar, S. V., C. D. Peters-Lidard, Y. Tian, P. R. Houser, J. Geiger, S. Olden, L. Lighty, J. L. Eastman, B. Doty, P. Dirmeyer, J. Adams, K. Mitchell, E. F. Wood, and J. Sheffield, 2006: Land Information System - An interoperable framework for high resolution land surface modeling, *Environ. Modeling and Software*, 21, 1402-1415.
- Rodell, M. and P. R. Houser, 2004. Updating a land surface model with MODIS derived snow cover, *J. Hydromet.*, 5(6), 1064-1075.
- Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2004. The Global Land Data Assimilation System, *Bull. Amer. Meteor. Soc.*, 85(3): 381-394.

Next to the GLDAS-NOAH model data, the Level 3 (gridded) data set's land surface parameters, surface soil moisture, land surface (skin) temperature, and vegetation water content, derived from passive microwave sensor of the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI), using the Land Parameter Retrieval Model (LPRM), are provided. There are two files per day, one day and one night, archived as two different products. The data set covers the period from December 1997 to present, at a spatial resolution of 0.25 degree from 40 degree north to 40 degree south, 180 degree west to 180 degree east. The data is stored in netCDF format.

The LPRM is based on a forward radiative transfer model to retrieve surface soil moisture and vegetation optical depth. The land surface temperature is derived separately from TMI's Ka-band (37 GHz). A unique feature of this method is that it can be applied at any microwave frequency, making it very suitable to exploit all the available passive microwave data from various satellites.

Input data are from the TMI Brightness Temperatures (1B-11) product, daytime and night time passes and processed using LPRM (source: <http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings/>).

Here the Surface Soil Moisture and the Skin Temperature are retrieved. Skin temperature refers to the effective radiating temperature of the soil plus canopy surface. It is inferred from satellites in the 8-12 um window region. In climate models, it is the temperature used to determine upward thermal emission. The skin temperature usually shows a larger diurnal variation than the surface air temperature, a factor that needs to be considered when evaluating data/model comparisons (source: R. E. Dickinson. Land surface. In K. E. Trenberth, editor, *Climate System Modeling*, pages 149-171. Cambridge Univ. Press, 1992]. The SSM is expressed as volumetric soil moisture (volume of water in relation to total volume – soil volume + water volume + air space).

3.12 AMESD-SADC THEMA ONLINE PRODUCTS

The AMESD program addresses the need for improved environmental monitoring towards sustainable management of natural resources in five regions of sub-Saharan Africa, namely CEMAC, ECOWAS, IGAD, IOC and SADC Regional Economic communities (RECs). The program is implemented under the coordination of the African Union Commission with the support of the European Union. In the SADC region, the theme is "*Agricultural and Environmental Resource Management*". The SADC thematic action is developing three information services namely Agriculture, Drought and Fire in order to address the already prioritized decision needs for the SADC region. The Agricultural Service monitors the state of the crops and rangeland. The Drought Service monitors drought during the whole year and provide drought outlooks. The Fire Service provides a daily fire risk indication, detection and follow-up of active fires (in real time) and burnt area assessments during the fire season.

As from July 2011 environmental data relevant for agricultural, drought and fire analysis from the SADC region are operationally produced and disseminated to the global user community using GEONETCast. A separate toolbox plug-in for import of these products is also available, see appendix 1. An online archive, containing at least the latest three decades of most products, is available to the User Community as well. The data can be obtained from <http://www.amesd.co.bw/products/>.

Most of the products, except those from the fire service, adhere to the map extent details presented below and cover the SADC Region.

Lat/Long - WGS 84 (pixel size: 1x1km)

Corner Coordinates (degrees):

ulx = 11

uly = 6

lrx = 41

lry = -35

The data for the SADC region is mainly dekadal data and after the end of each 10 day period, the products are available online. The majority of the products are produced at BDMS but for the drought, fire and the seasonal weather forecasts services other organizations are collaborating within the AMESD SADC programme, such as ARC, CSIR and SAWS from South Africa. Further details on the products are provided at: http://www.amesdsadc.org/data/documents/manuals/Products_and_Services/SADC_THEMA_products_services_users_guide_R18_bis_v1.2.pdf.

3.13 LANDSAT – USGS

Data collected by the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) onboard the Landsat 8 satellite are available to download at no charge from GloVis, EarthExplorer, or via the LandsatLook Viewer (<http://landsatlook.usgs.gov/>).

Orbiting the Earth every 99 minutes, Landsat 8 images the entire Earth every 16 days in the same orbit previously used by Landsat 5. Data products are available within 24 hours of reception. OLI and TIRS data from Landsat 8 is processed to be consistent with the already archived Landsat 1 through 7 data products. Processing details of Landsat 8 Level 1 Products are described on http://landsat.usgs.gov/LDCM_DataProduct.php.

The data is assumed to be locally available, unzipped and in Tif format. The routine transforms the Tif file in an ILWIS data format. For conversion from Digital Number to radiance, reflectance or brightness temperature, consult the link above. The coefficients required are provided when downloading the data in an accompanied meta-data file.

3.14 WEB MAPPING SERVICES

3.14.1 *MPE and RFS to Google*

These two services make use of the 15 minutes precipitation products, the MPE derived from MSG and the RFS derived from GOES. The Multi-Sensor Precipitation Estimate (MPE) product consists of the near-real-time rain rates in mm/hr for each METEOSAT image in original pixel resolution. The algorithm is based on the combination of polar orbiter microwave measurements and images of the Meteosat IR channel by a so-called blending technique. The MPE is most suitable for convective precipitation. The RFS product comprises the instantaneous and the accumulated convective rainfall estimates, based on GOES images, for the South America region. The estimation is based on the adjusted hydro-estimator methodology from South America, using INPE information about precipitated water, relative humidity and winds. At ITC these 15 minutes products are aggregated to obtain the 24 hr precipitation (from 00:00 to 23:45 UTC). These files (in ILWIS format) are compressed and subsequently transferred to FTP (<ftp://ftp.itc.nl/pub/mpe/>). After specifying an output directory the application can be started, the accumulated 24 hr precipitation map is downloaded, decompressed and transformed into a PNG format (with a transparent layer for the areas that have not received precipitation). A "KML" file is created and executed which invokes Google Earth to start and display the results. These applications assume that Google Earth is locally available. It has been noted recently that Google Earth shows some strange behaviour when displaying the map overlay of the MSG based MPE using Window-7.

At any given day the aggregated rainfall from the previous day is processed; for the MPE product at 08:00 UTC and for the RFS product at 11:00 UTC. Daily aggregated data is available from the FTP location provided above approximately half an hour and 10 minutes later for the MPE and RFS products respectively.

3.14.2 *Surface Pressure Forecast Europe*

This application automatically downloads the surface pressure forecast over Europe prepared by the UK Met-Office. New forecasts become available at 07:30 UTC. Forecasts are downloaded and visualized using IrfanView as an animation with maps showing the surface pressure from T+0 to T+84. Further information can be obtained from: http://www.metoffice.gov.uk/weather/europe/surface_pressure.html, like the description of the weather chart symbols used.

3.14.3 *Current Position of the Africa ITF*

This application automatically downloads the latest image showing the current position of the Inter Tropical Convergence Zone (ITCZ), also called the Inter Tropical Front, produced by NOAA, available from: <http://www.cpc.noaa.gov/products/fews/ITCZ>. Data is available, updated on a decadal basis, when the ITCZ is situated over the Northern Hemisphere. IrfanView is used to display the downloaded image. By pressing the escape key the visualization is aborted.

3.14.4 *NOAA Weather Charts*

The NWS Gateway provides access to the latest version of the weather facsimile chart they operationally distribute. The charts are not altered or enhanced and are in the original black-and-white form used by NWS offices, available from: <ftp://tgftp.nws.noaa.gov/fax/>. The utilities provided download and animate, using IrfanView, the NOAA weather charts for the Northern Hemisphere, Europe and Africa, Africa and Asia and Latin America and Africa, showing the forecast up to 36 hours.

The Flight level selected is FL050, meaning the situation at 5000 feet, or at a standardized barometric pressure of 850 millibar (roughly 33 feet per millibar, $1013.25 - 850 = 163.25$ millibar * 33feet = 5387.25 feet * 0.304 = 1637 meter). Note that this assumes standard pressure (1013.25 mb at sea level - using standard datum) and does not include local topography! It is the lowest level provided and in many cases corresponds to the ground surface phenomena (temperature and wind speed - direction). See also figure 3.11.1 for the wind speed symbols used and conversions from knots to miles/hour and to meters/second (source: <http://www.theweatherprediction.com/basic/conversions/>).

Figure 3.11.1: Wind speed and direction symbols and wind speed conversions

Wind Speed & Direction

- Calm
- 5 knots
- 10 knots
- 15 knots
- 20 knots
- 50 knots
- 65 knots

Points to direction wind is coming from.
Small barbs indicate wind speed.
(1 Knot = 1.15 mph)

Example Wind Barb

Read as:
Northwest Wind
at 25 Knots

On analysis charts and weather reporting observations, wind is most commonly given in one of three units: Miles per hour, knots, or meters per second. To find miles per hour, multiply the knots value by 1.15. To find knots, divide the miles per hour value by 1.15.

1 knot = 1.15 miles per hour
1 mile per hour = 0.87 knots
100 knots = 115 mph

Metric unit wind speeds are often expressed as meters per second. The conversion below shows the change from miles per hour to meters per second.

$$(1 \text{ mi/hr}) * (1 \text{ hour}/3,600 \text{ sec}) * (1.61 \text{ km}/1 \text{ mile}) * (1000 \text{ meters}/1 \text{ km}) = 0.45 \text{ m/s}$$

3.14.5 NOAA-CPC SST and SST Anomaly

To get some idea with respect to the possible occurrence of El Niño – Southern Oscillation (ENSO) an SST and SST Anomaly animation can be retrieved from the Climate Prediction Centre. More information is available at: <http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml>.

The ENSO cycle refers to the coherent and sometimes very strong year-to-year variations in sea-surface temperatures, convective rainfall, surface air pressure, and atmospheric circulation that occur across the equatorial Pacific Ocean. El Niño and La Niña represent opposite extremes in the ENSO cycle. El Niño refers to the above-average sea-surface temperatures that periodically develop across the east-central equatorial Pacific. It represents the warm phase of the ENSO cycle, and is sometimes referred to as a Pacific warm episode. La Niña refers to the periodic cooling of sea-surface temperatures across the east-central equatorial Pacific. It represents the cold phase of the ENSO cycle, and is sometimes referred to as a Pacific cold episode. The animation shows the SST (and anomaly) conditions over the 12 weeks before present.

3.14.6 ECMWF Re-Analysis data

The European Centre for Medium-Range Weather Forecasts has made available the ERA-Interim. ERA-Interim is the latest ECMWF global atmospheric reanalysis of the period 1979-01-01 to present. Reanalyses of multi-decadal series of past observations have become an important and widely utilized resource for the study of atmospheric and oceanic processes and predictability. Since reanalyses are produced using fixed, modern versions of the data assimilation systems developed for numerical weather prediction, they are more suitable than operational analyses for use in studies of long-term variability in climate. Reanalysis products are used increasingly in many fields that require an observational record of the state of either the atmosphere or its underlying land and ocean surfaces (source: <http://www.ecmwf.int/research/era/do/get/ Reanalysis ECMWF>). ERA-Interim data can now be downloaded from the internet at full resolution from http://data-portal.ecmwf.int/data/d/ interim_full_daily. A large number of parameters can be retrieved from here and can be quickly visualized using the “Panoply” utility, including preparation of animated sequences.

3.14.7 Online Maps

A number of utilities are added for display of online (high resolution) maps, like Google maps and Microsoft ‘Virtual Earth’. The first option is showing Google maps, when zooming into the region of interest higher resolution topographical information is presented. The second option can be used to search Google maps, by entering location name and country. By default use is made of Internet Explorer, initiated through a HTML file.

The last routine displays ‘Virtual Earth’, a high resolution satellite backdrop image together with labels. In a pop-up screen you can specify the centre of your map and the zoom factor and based on these three parameters the window is retrieved and displayed. In the map window you can interactively uncheck the labels, aerial view, zoom in and out, etc.

3.15 DISPLAY JULIAN DAY TABLES

To conveniently retrieve the corresponding calendar date from a Julian day stamp, for normal and leap years, tables are included for quick reference. Note for the year selected if it is a normal year or leap year and display the table. For each calendar day the corresponding Julian day is given.

4. PRACTICAL EXERCISES USING THE ISOD TOOLBOX

4.1 ONLINE CLIMATIC DATA RETRIEVAL

4.1.1 Introduction

After installation of ILWIS and the ISOD Toolbox (XML version 1.2), start ILWIS and open the “ISOD” > “Toolbox” options from the left hand menu tree. Inspect the menu strings of the Toolbox and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “InSitu”. For the Folder items under CPC_gauge, GSOD, GTS, TAF, specify the appropriate directory and press “Save” to store the drive:\directory settings. Close the Toolbox and use the ILWIS Navigator to move to the directory “C:\InSitu”. Close ILWIS and start ILWIS again, ensure that the location of your catalogue is now “C:\InSitu”. Select from the menu the “ISOD” and “Toolbox” options and you are ready to start the exercises. Note that if you have changed working directory during an active ILWIS session, it is advised to close ILWIS and start it again. The catalogue should now open in the correct working directory. Also note the other “golden rules” when working with ILWIS (see also Chapter 1.2)

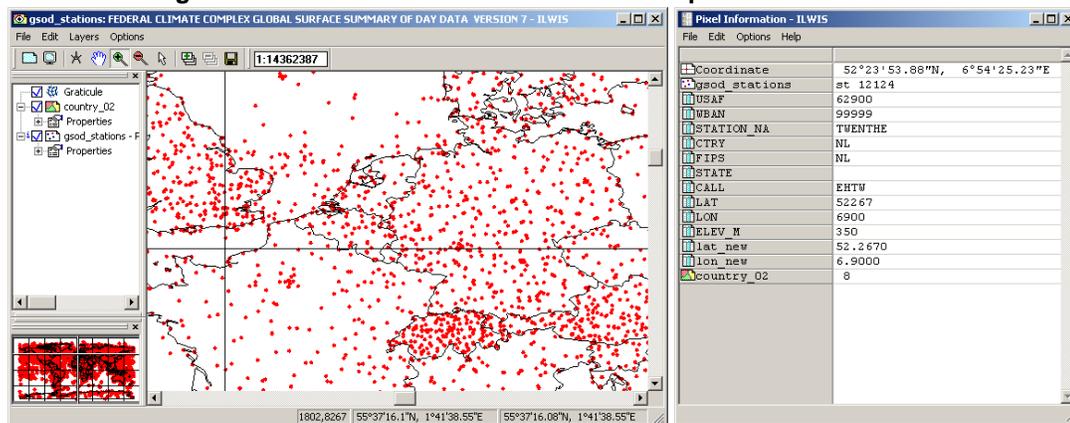
4.1.2 Global Surface Summary of Day Data (GSOD)

Within the ISOD toolbox utilities are available to incorporate the archive maintained and updated by the NCDC, providing a global surface summary of daily data on various climatological parameters as indicated in Chapter 3.2.1. First a map will be visualized showing the locations and the station numbers of the climatological stations (over 27750 records).

From the “ISOD” and “Toolbox” main menu select the “Online InSitu Climate Database” > “NCDC Integrated Surface Data (ISD)” > “Stations map of Global surface summary of day product produced by the NCDC” sub menu. Note that the “Output Directory” here is “C:\InSitu” and press “Import”.

After import a map view will be shown, indicating the locations of the stations. Moving the mouse over the active map window, keeping the left mouse button pressed is providing information on the station number. To get additional information, select from the menu of the active map window the option “File” and “Open Pixel Information”. Zoom into the area of interest and move the mouse over a station. In the Pixel Information window additional details are shown, such as station name, USAF number, coordinates and elevation. The USAF number should be noted as this is used during the subsequent extraction of the daily summary data. Furthermore note that the record “CALL” provides the ICAO Code, which will also be used in one of the next exercises (chapter 4.1.4: TAF import).

Figure 4.1.1: GSOD station locations and the pixel information window



To

extract the station data, from the “ISOD” and “Toolbox” main menu select the “Online InSitu Climate Database” > “NCDC Integrated Surface Data (ISD)” > “Import GSOD station data” sub menu. Specify the “Year”, USAF “Station”, check the settings for the “Output Directory” and press “Import”. Here use is made of the station “Twenthe”, year is “2009” and USAF station number is “062900”. Note that a 6 digit station

code is required; in case the station has only a 5 digit code (like in the example presented here) the station number coding should always precede with a zero (0).

Additional information on the data is provided when selecting the “*Metadata*” option. Note that this file is retrieved from your ILWIS sub-directory “\Extensions\ISOD-Toolbox\util\metadata”. When using the import routine the data will be extracted and processed, additional columns are calculated providing the data in SI units, like temperature (also minimum and maximum), dew point, visibility, wind speed and maximum wind speed, precipitation. Note that if during import an error message appear that ILWIS cannot find table, close ILWIS, start ILWIS again and repeat the import. This error occurs due to the fact that you changed to another output directory during an active ILWIS session.

To visualize the imported station data, open the imported table, starting with “*st_USAFno_year*”, in this case “*st_062900_2009*”. Inspect the table content. In the menu of the active table window, select the graph icon, in the subsequent popup window, don't select an X-axis, for the Y-axis select the attribute to be visualized, here “*Prcp_mm*” and press “*OK*”.

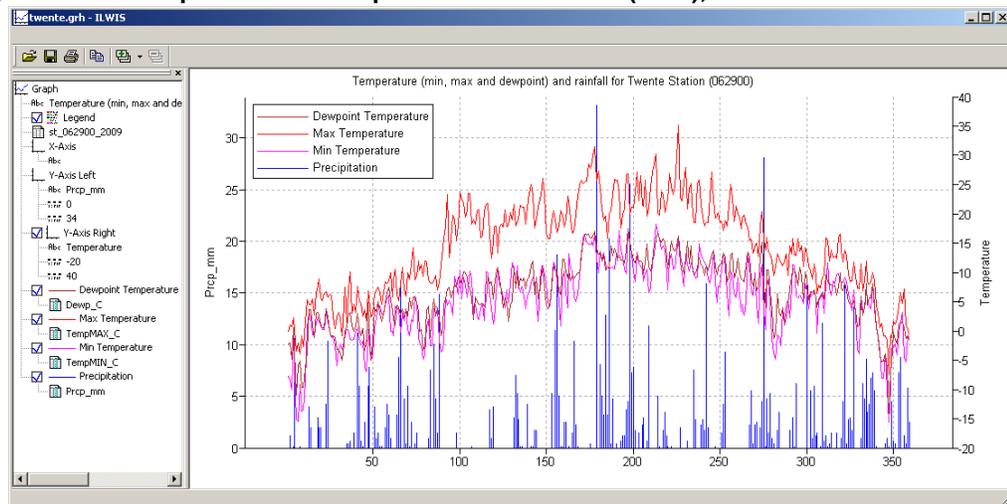
Now from the left hand graph menu the visualization properties can be changed. Double click the layer “*Prcp_mm*”. In the Graph options, change the name to “*Precipitation*”, select a “*Needle*” representation, instead of a point, and eventually change the colour to “*Blue*” and press “*OK*”.

Now select from the graph menu the option “*Edit*” > “*Add Graph*” > “*from Columns*” and select for the Y-Axis the table attribute “*TempMIN_C*” and press “*OK*”. Double click the layer “*TempMIN_C*”. In the Graph options, change the name to “*Min Temperature*”, select a “*Line*” representation, instead of a point, and eventually change the colour to “*Magenta*”. Now select “*Use Y-Axis*” the “*Right*” Axis, unselect the option “*Show Grid*” and press “*OK*”.

From the graph menu, select the option “*Y-Axis Right*” , as Axis Text “*Temperature*” and set the Min-Max Interval to “*-25*” and “*40*” respectively and press “*OK*”. Note that the data range required can be obtained from the statistics pane from the (bottom) of the table!

Repeat the procedure for the attribute “*tempMAX_C*” and “*Dewp_C*”, call these “*Max Temperature*” and “*Dewpoint Temperature*” respectively, select as representation “*line*” and select appropriate colours. Ensure that the Y-Axis Right is used! In the graph window itself the title can be modified. Double click on the title in the Graph and consult figure 4.1.2 for a sample title.

Figure 4.1.2: Precipitation and temperature for Twente (2009), USAF station number 062900



As additional exercise you can repeat above described procedure using a station / year of your preference.

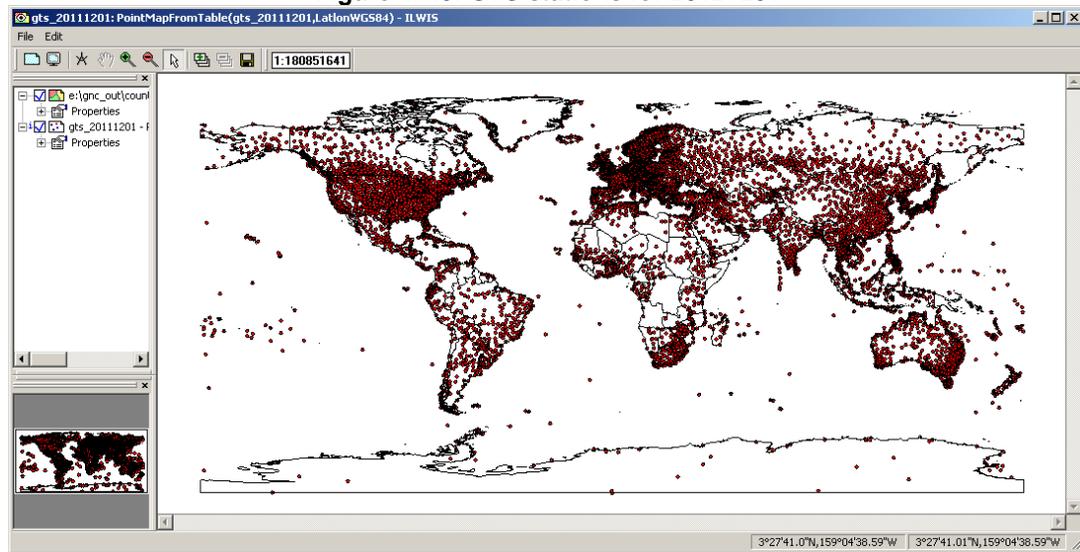
4.1.3 **GTS station data on precipitation and temperature**

Within the ISOD toolbox utilities are available to incorporate the rolling yearly GTS archive maintained by NOAA/CPC. To extract the station data, from the “*ISOD*” and “*Toolbox*” main menu select the “*Online*

InSitu Climate Database" > "NOAA CPC-FEWS GTS daily data" > "Import global GTS station data" sub menu. Specify the "Date" stamp in the required format (yyyymmdd), here "20121201" is used, note the "Output Directory" and press "Import".

Select from the catalogue the table "gts_20121201" and inspect the content. Note that typically over 8000 stations are available. Close the table. From the catalogue, right click with the mouse on the table "gts_20111201" and from the context sensitive menu select the option "Table operations" > "Table to Pointmap". From the table to point map menu, specify as Coordinate System "LatLonWGS84" and as output map "gts_20121201". Press "Show" to create the point map. In the Display Options – Point Map click the "Symbol" button and as Size, specify "3" and as fill colour select "Red" and press "OK" twice. From the active point map display window select the option "Add Data Layer" and browse to your ILWIS directory, select the polygon map "Country_02" from the subdirectory "Extensions\ISOD-Toolbox\util\maps". As display option unselect the item "Info" and specify the option "Boundaries Only". Press "OK" to display the map. Your results should resemble those of figure 4.1.3 and note the distribution of the stations.

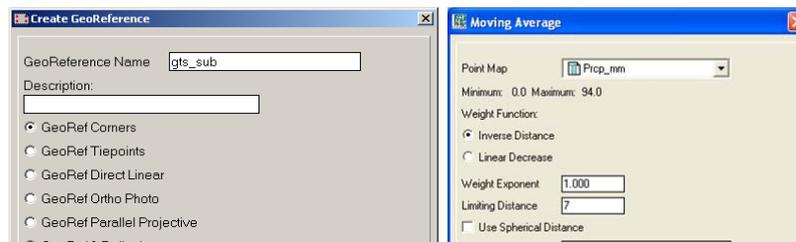
Figure 4.1.3: GTS stations for 20121201



From the ILWIS main menu select the option "File" > "Create" > "Georeference". Specify the settings as given in figure 4.1.4 (left) and press "OK" to create the Georeference. From the main ILWIS menu select the option "Operations" > "Interpolation" > "Point Interpolation" > "Moving Average". As Point map select from the point map "gts_20121201" the table attribute "Prpc_mm" (press the + sign in front of the point map name to see the various table attributes!!), select the Georeference "gts_sub", use other settings as given by their default and press "Show". See also right hand picture of figure 4.1.4.

Upon completion of the interpolation display the map and check your results obtained. Use as Representation "mpe_single". To add the country boundaries to the map display, select the option "Layers" > "Add Layer" and select the polygon map "Country_02". As display option unselect the item "Info" and specify the option "Boundaries Only". Press "OK" to display the map. Also add the "gts_20121201" point map to the active map display. In the Display Options – Point Map click the "Symbol" button and as Size, specify "3" and as fill colour select "Red" and press "OK" twice.

Figure 4.1.4: Georeference details and moving average parameter settings



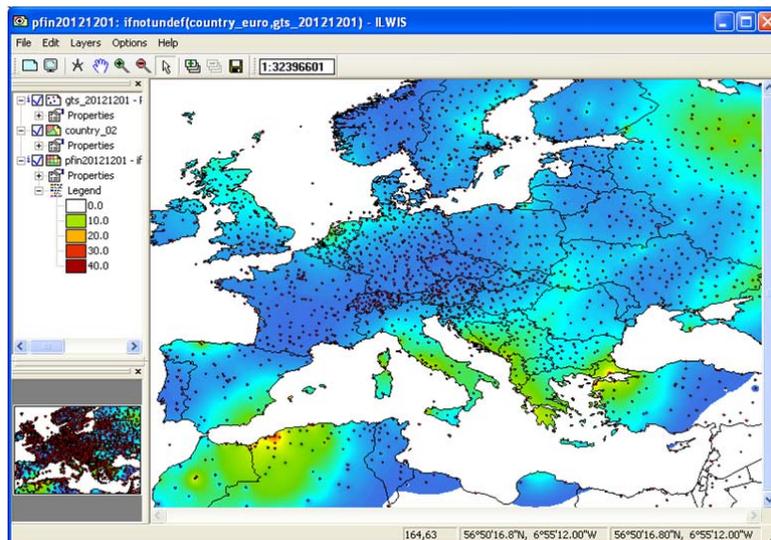
Note that there are hardly measurements from the sea and ocean surface. To obtain the rainfall only over the land use can be made of the polygon map "country_02". Select from the main ILWIS menu the option "Operations" > "Rasterize" > "Polygon to Raster". As Polygon map use "country_02", as output raster map specify "country_euro" and as Georeference select "gts_sub". Press "Show" to conduct the operation. Have a look at the ("values"!!! of the) map obtained.

To retrieve only the rainfall over land from the raster map "gts_20121201", type the following expression in the command line of the main ILWIS menu:

```
p_fin20121201:=ifnotundef(country_euro,gts_20121201)
```

Keep the other settings default and press "OK" to execute the operation. Use as Representation "mpe_single". Add the country boundaries and gts station locations as well. Your results should resemble those of figure 4.1.5. From the active map display window select "File" > "Open Pixel Information". Move the cursor over the map and check the results obtained using the pixel information table and check the interpolation results against the gts input data.

Figure 4.1.5: Resulting interpolated rainfall map of 20111201 using GTS station input



As additional exercise repeat above described procedure and use the minimum or maximum temperature as provided by GTS daily data. Use the same geographical window and same interpolation procedure. Furthermore you can specify another geographic window by creating another georeference and retrieve the rainfall for this newly defined region; eventually specify another date.

4.1.4 **Current Weather Conditions using Terminal Aerodrome Forecast (TAF) data**

From the "ISOD" and "Toolbox" menu, select the following options: "Online InSitu Climate Databases" > "Current Weather Conditions from TAF" > "Terminal Aerodrome Forecast station data" and press the option "Load code file" and try to find the appropriate ICAO code. Type "Amsterdam" in the second "Key" field (case sensitive!) and note the code for Amsterdam/Schiphol. Enter the ICAO code (here "EHAM", again Case Sensitive) for the "CODE" stamp and press "Import".

The report is showing the Current Weather Conditions and a summary of the last 24 hours for Amsterdam Airport Schiphol, Netherlands. This document is stored on your output "drive:\directory" as well (using airport code and time format given as: "ICAOcode_yyyymmddhhmm.html"). The time format is obtained from the time settings of your system when extracting the file. If you are interested in obtaining regular information from certain stations you can create a "Scheduled Task" in the Operating System to automate the extraction procedure!

Close the ICAO html report retrieved. Use the "Windows" Explorer and check the content of your working directory and open the file: "EHAM_yyyymmddhhmm.html" and check once more the content of the report.

Select from the Code File table another country or airport, e.g. Cape Town, South Africa ("FACT") and repeat the procedure to extract the TAF data.

Note: For the code file use is made of the document "Location Indicators by State" (r4cdlocationindicatorsbystate.pdf), available from <http://legacy.icao.int/anb/aig/taxonomy/r4cdlocationindicatorsbystate.pdf>, which is providing all ICAO codes. The Toolbox Code File table is stored under the main ILWIS directory "Extensions\ISOD-Toolbox\util\metadata". This file only provides the ICAO code per city / country. For presenting the html file currently Windows Internet Explorer is used. Furthermore the system regional setting format assumed is "English (United States)", as short date format "M/d/yyyy" and short time format "h:mm tt" are expected. If you use another default web browser or your system uses different "Region and Language" settings the results might appear different!

4.2 **GAUGE BASED AND SATELLITE DERIVED RAINFALL DATA**

4.2.1 **Introduction**

Routines have been developed to integrate the online (satellite derived) precipitation products from the NOAA Climate Prediction Centre, EUMETSAT, NASA and FEWS NET RFE for Africa. A number of exercises are presented below on the various products that can be retrieved. In the ISOD Toolbox, version 1.1, various import routines have been created to retrieve some online precipitation resources. Routines are available to import global precipitation products like CPC gauge based analysis of global daily precipitation, Cmorph, Qmorph, TRMM, latest rainfall from the EUMETSAT as well as RFE version 1 and 2 rainfall products for Africa and climatology, produced by FEWS-NET and TAMSAT.

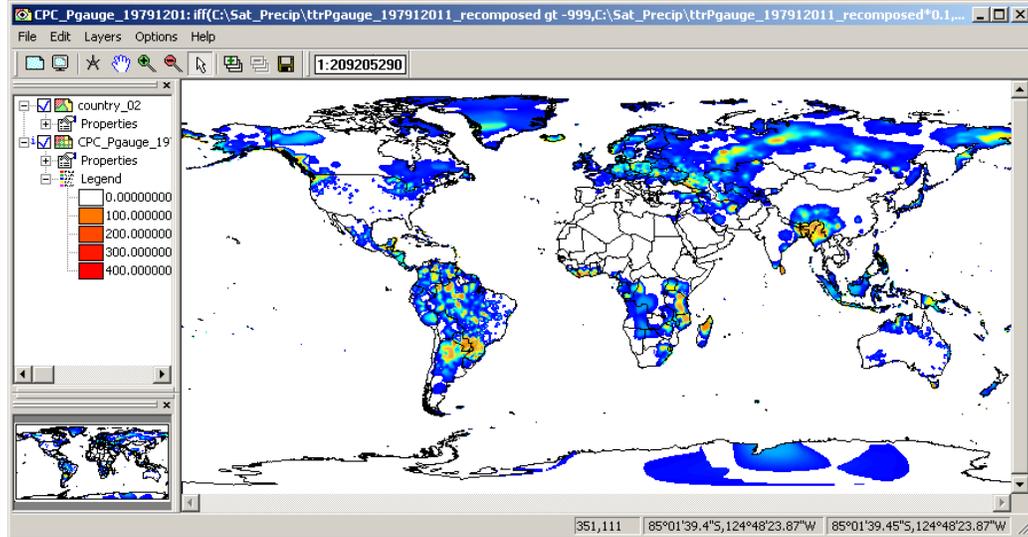
After installation of ILWIS and the ISOD Toolbox (XML version 1.2), start ILWIS and open the "ISOD" > "Toolbox" options from the left hand Operation-Tree (see also figure 2.1). Inspect the menu items of the Toolbox and open the item "Configuration" > "Folders". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "Sat_Precip". For the Folder items under CPC_gauge, Cmorph, FEWS_RFE, MPEdirect, Qmorph, TAMSAT_archive, TRMM_3B42 and TRMM specify the appropriate directory and press "Save" to store the output drive:\directory settings. Use the ILWIS Navigator to move to the specific working directory, close ILWIS and open it again. ILWIS should now open using the selected directory.

4.2.2 **CPC unified Gauge-Based analysis of Global Daily Precipitation**

Within the ISOD toolbox utilities are available to incorporate the CPC unified Gauge-Based analysis of Global Daily Precipitation. To extract retrospective version global interpolated precipitation data, from the "ISOD" and "Toolbox" main menu select the "Gauge – Satellite derived Rainfall Data" > "Global Rainfall" > "CPC Gauge-Based Analysis of Global Daily Precipitation" > "Retrospective version daily data - 0.5 degree" sub menu. This option allows import of daily interpolated gauge based precipitation from 1979 to 2005. Specify the "Date" stamp in the required format (yyyymmdd), here "19791201" is used, note the "Output Directory" and press "Import".

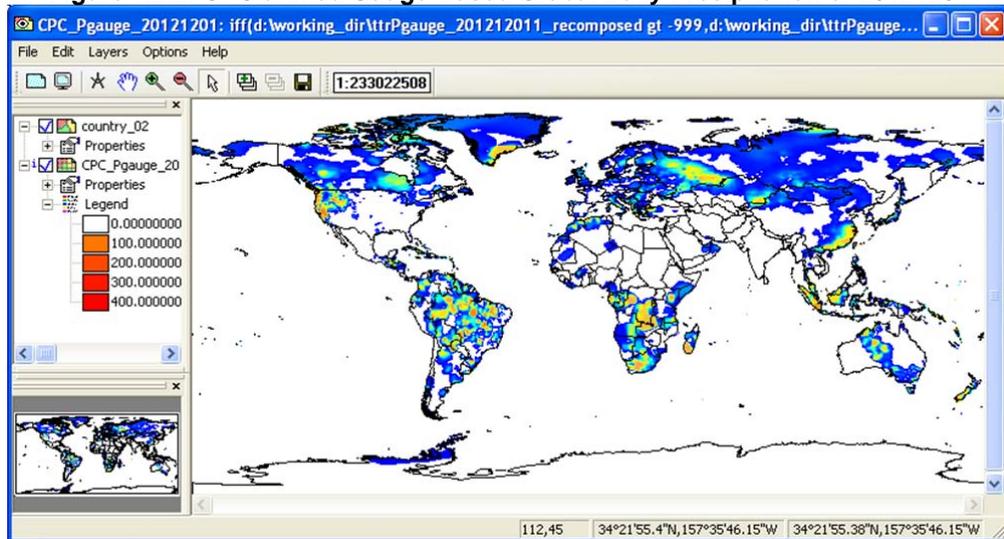
Upon completion of the import, display the map “CPC_Pgauge_19791201” using as Representation “MPE_sum”. Add the country boundaries, unchecking the display option “Info” and activating the option “Boundaries only”. Your results should resemble those of figure 4.2.1.

Figure 4.2.1: CPC unified Gauge-Based Global Daily Precipitation of 19791201



To extract the recent real-time version global interpolated precipitation data, from the “ISOD” and “Toolbox” main menu select the “Gauge – Satellite derived Rainfall Data” > “Global Rainfall” >> “CPC Gauge-Based Analysis of Global Daily Precipitation” > “Real-time version daily data - 0.5 degree 20090101” sub menu. This option allows import of daily interpolated gauge based precipitation starting from 2009. Specify the “Date” stamp in the required format (yyyymmdd), here “20121201” is used, note the “Output Directory” and press “Import”. Note that the data for the intermediate period (20060101-20081231) can be retrieved using the toolbox option “Real-time version daily data - 0.5 degree 2006 to 2008”. Upon completion of the import, display the map “CPC_Pgauge_20121201” using as representation “MPE_sum”. Add the country boundaries, unchecking the display option “Info” and activating the option “Boundaries only”. Your results should resemble those of figure 4.2.2.

Figure 4.2.2: CPC unified Gauge-Based Global Daily Precipitation of 20121201



4.2.3 NOAA CPC, NASA, EUMETSAT, FEWS NET and TAMSAT online precipitation products

Various satellite derived rainfall products and time series are available online. Open the “ISOD” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “Sat_Precip”. For the Folder items under Cmorph, FEWS_RFE, Qmorph, TRMM_3B42, TRMM, GWADI, MPEdirect and TAMSAT_archive specify the appropriate output directory and press “Save” to store the drive:\directory settings. If you started from chapter 4.2 the settings are already specified. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again, remember the “golden rules” as indicated in Chapter 1.2.

4.2.3.1 CMORPH

From the “ISOD” > “Toolbox” main menu select the “Gauge – Satellite derived Rainfall Data” > “Global Rainfall” > > “CMORPH – Global” > “CMORPH 8 km - 30 min” sub menu. In this case only the “Date” field and the “Output Directory” need to be specified, note that the “Date” stamp also requires the hour time stamp! Enter a suitable date which is more recent than two weeks as the data is extracted from a rolling archive of about two weeks up to present. Upon completion of the import two files are available, the “cmorph8km30min_yyyymmddhhlater” map represents the next half hour after the time stamp and the “cmorph8km30min_yyyymmddhhbefore” is the previous half hour precipitation with regard to the time stamp. The unit is in mm/hr. Display both maps, using as representation “mpe_single”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

The reprocessed CMORPH 0.25 degree – 3 hours products can be obtained from the <ftp.cpc.ncep.noaa.gov> server. The version 0.x is extracted from “precip/CMORPH_V0.x” and version 1.0 from the “precip/CMORPH_V1.0” directory. All units are mm/3hr. Data is available from 19980101 onwards. From the “ISOD” > “Toolbox” main menu select the “Gauge – Satellite derived Rainfall Data” > “Global Rainfall” > “CMORPH – Global” > “CMORPH 0.25 degree - 3 hour V1.0” sub menu. In this case only the “Date” field and the “Output Directory” need to be specified. As Date stamp select “20051001” and press “Import”. For the specified day 8 three hour precipitation maps are imported.

Select from the main ILWIS menu “File” > “Create” > “Map List”, as Map List name enter “Cmorph_3hr20051001”, select all cmorph025d3hr_yyyymmdd_hhUTC” maps (8 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the “>” sign to add them to the right hand Create MapList window and press “OK” to save the new maplist. Double click with the mouse the newly created Maplist “Cmorph_3hr20051001”. In the MapList window select as display option “Open as Slide Show”, as Representation select “mpe_single” and press “OK” twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Close the maplist “Cmorph_3hr20051001” window, click with the right mouse button pressed on the map list icon “Cmorph_3hr20051001” and select from the context sensitive menu the options “Statistics” > “MapList Statistics”, as statistical function select “Sum” and as Output Raster map specify “cmorph20051001_sum” and press “Show”. Display the map using as Representation “mpe_sum”. Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values. Close the open map windows.

From the “ISOD” > “Toolbox” main menu select the “Gauge – Satellite derived Rainfall Data” > “Global Rainfall” > “CMORPH – Global” > “CMORPH 0.25 degree - 3 hour V0.x” sub menu. In this case only the “Date” field and the “Output Directory” need to be specified. As Date stamp select “20121001” and press “Import”. For the specified day 8 three hour precipitation maps are imported.

Select from the main ILWIS menu “File” > “Create” > “Map List”, as Map List name enter “Cmorph_3hr20121001”, select all cmorph025d3hr_yyyymmdd_hhUTC” maps (8 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the “>” sign to add them to the right hand Create MapList window and press “OK” to save the new maplist. Double click with the mouse the newly created Maplist “Cmorph_3hr20121001”.

Close the maplist "*Cmorph_3hr20121001*" window, click with the right mouse button pressed on the map list icon "*Cmorph_3hr20121001*" and select from the context sensitive menu the options "*Statistics*" > "*MapList Statistics*", as statistical function select "*Sum*" and as Output Raster map specify "*cmorph20121001_sum*" and press "*Show*". Display the map using as Representation "*mpe_sum*". Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values.

Leave the map display window open and now from the "*ISOD*" > "*Toolbox*" main menu select the "*Gauge – Satellite derived Rainfall Data*" > "*Global Rainfall*" > "*CMORPH – Global*" > "*CMORPH 0.25 degree - daily*" sub menu. In this case only the "*Date*" field and the "*Output Directory*" need to be specified. As Date stamp select "*20121001*" and press "*Import*". For the specified day the 24 hour precipitation map is imported. Add this map, "*cmorph_d20121001*", to your active map display (using as Representation "*mpe_sum*") and use pixel information once more to inspect the values. Close the map display window (s).

Finally import the weekly precipitation map; totalled across the week ending on the date as given by the file name. From the "*ISOD*" > "*Toolbox*" main menu select the "*Gauge – Satellite derived Rainfall Data*" > "*Global Rainfall*" > "*CMORPH – Global*" > "*CMORPH 0.25 degree -weekly*" sub menu. In this case only the "*Date*" field and the "*Output Directory*" need to be specified. As Date stamp select "*20121001*" and press "*Import*". Display the imported map "*cmorph_w20121001*", as Representation use "*mpe_sum*". Note that the date in the file name represents the final day of the week long time period, using 00:00 UTC as the starting and ending times.

4.2.3.2 QMORPH

From the "*ISOD*" > "*Toolbox*" main menu select the "*Gauge – Satellite derived Rainfall Data*" > "*Global Rainfall*" > "*QMORPH – Global*" > "*QMORPH 8 km 30 min*" sub menu. In this case only the "*Date*" field and the "*Output Directory*" need to be specified. Enter a suitable date which is more recent than one week as the data is extracted from a rolling archive of about two weeks. Upon completion of the import two files are available, the "*qmorph8km30min_yyyymmddhhlater*" map represents the next half hour after the time stamp and the "*qmorph8km30min_yyyymmddhhbefore*" is the previous half hour precipitation with regard to the time stamp. The unit is in mm/hr. Display both maps, using as Representation "*mpe_single*", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

4.2.3.3 TRMM

To import the daily global precipitation data select from the "*ISOD*" > "*Toolbox*" main menu the "*Gauge – Satellite derived Rainfall Data*" > "*Global Rainfall*" > "*TRMM – Global*" > "*TRMM 0.25 degree - daily*" sub menu. In this case only the "*Date*" field and the "*Output Directory*" need to be specified. As Date stamp select "*20121001*" and press "*Import*". For the specified day the 24 hour precipitation map is imported. Display this map, "*trmm_20121001*", using as Representation "*mpe_sum*", add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values. Note the regions between 50-60 degree north and south latitudes, these do not contain valid data!

Also display the map "*cmorph_d20121001*" using as Representation "*mpe_sum*" and compare both precipitation products. What can be noted!

To import the data from the reprocessed TRMM 3B42 3-hourly (Julian day) archive, select from the "*ISOD*" > "*Toolbox*" main menu, select the item "*Gauge – Satellite derived Rainfall Data*" > "*Global Rainfall*" > "*TRMM – Global*" > "*TRMM 3B42 day archive*" sub menu. In this case only the "*Date*" field and the "*Output Directory*" need to be specified. As Date stamp select "*20051001*" and press "*Import*". During import all 3 hour events are extracted and processed, a map list is created and an aggregate statistics function "sum" is executed, resulting in the daily total precipitation map. Note that the 3 hour events are given in mm/hr and the day sum map is given in mm/day!

Display the imported maplist "*trmm_3B42_20051001*" as an animated sequence, Double click on the map list and in the MapList window select as display option "*Open as Slide Show*", as representation select "*mpe_single*", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Display also the imported map "*trmm_3B42_20051001_day*" using as representation "*mpe_sum*". From the map window showing the map "*trmm_3B42_20051001_day*"

select from the menu "File" > "Open Pixel Information". From the Pixel Information menu select "File" > "Add Map" and now select the map list "trmm_3B42_20051001" and press "OK". Move the mouse over the map display and check the resulting values. Once more note that the 3 hour rainfall events are giving the rainfall intensity in mm/hr.

4.2.3.4 WGADI-PERSIANN

To import the data from the GWADI-PERSIANN 3-hourly precipitation archive (on a monthly basis), select from the "ISOD" > "Toolbox" main menu the item "Gauge – Satellite derived Rainfall Data" > "Global Rainfall" > "GWADI-PERSIANN – Global" > "GWADI 0.25 degree 3 hour" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. As Date stamp select "200502" and press "Import". During import all 3 hour events on a monthly basis are extracted and processed. Note that the routine takes a long time to complete, as for this month there are 28 days and 8 timestamps per day (total of 224 global rainfall maps). Note furthermore that the intensity is given in mm/time step, in this case mm/3hr. Display the output map created with the name "gwadi_3hr0503200", using as representation "gwadi", eventually display the country boundaries (using option "info off"). The filename has to be interpreted following: "gwadi_3hr" is the product name_timestep, "05" is the year, "032" is the day of the year (for a normal year this is 01 February) and "00" is the time step.

In case calendar day and Julian day (or day of the year) conversion is needed, a utility has been added for easy conversion. Select from the "ISOD" > "Toolbox" main menu the menu item "Display Julian Day tables" and subsequently select the normal or leap year routine and press "Import". A table will be shown indicating for each calendar day the corresponding day of year – Julian day number.

Select from the main ILWIS menu "File" > "Create" > "Map List", as Map List name enter "gwadi_3hr200502", select all gwadi_3hr0503200 maps (224 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "OK" to save the new maplist. Double click with the mouse the newly created Maplist "gwadi_3hr200502" and display the first map layer "gwadi_3hr0503200", using as representation "gwadi", eventually display the country boundaries (using option "info off").

Now from the main ILWIS menu, select "Operations" > "Statistics" > "MapList" > "MapList Graph". In the maplist graph window, select as MapList "gwadi_3hr200502", use a fixed stretch of "0 to 50", activate the options "Continuous" and "Always on top". Activate the map window showing the previously opened map layer "gwadi_3hr0503200". Browse with the mouse cursor over the map, e.g. the eastern part of the Democratic Republic of Congo. Note the precipitation time series values in the graph window, the X-axis shows the time (from the first 3 hr time stamp of February 2005 as time step 1 to the last time step of 28 February as time step 224) and the Y-Axis the amount of precipitation (in mm) during each 3 hr period for the respective pixel. When done close all layers.

Also total monthly rainfall can be derived. To do this, select from the main ILWIS menu the option "Operations" > "Statistics" > "MapList" > "MapList Statistics". As Statistics function select "Sum" and as Output Map specify "gwadi_sum200502" and press "Show". Display the map using as Representation "Pseudo". Move the mouse cursor, keeping the left mouse button pressed, over the map. Note the white toned regions, here 'no data' is given. This is due to the fact that within some of the layers no rainfall retrieval could be accomplished! It is not possible to make a sum for a pixel including 'no data'. If you want to do so, you first have to re-assign the 'no data' to a value, e.g. "0", assuming no precipitation for such an event. This type of further processing is beyond the scope of this manual.

4.2.3.5 MPE

Select "ISOD" > "Toolbox" > "Gauge – Satellite derived Rainfall Data" > "Latest 24 hr MPE from EUMETSAT" > "MPE MSG based". Note the output directory and press "Import". The latest 96 rainfall products are retrieved from the EUMETSAT website and are imported in ILWIS. The files are retrieved from an online EUMETSAT website, located at: <http://oiswww.eumetsat.org/SDDI/html/grib.html>. The data provided there is deleted after 24 hours. This routine needs a fast internet connection as a lot of files are transferred (96 from MSG, one file for each 15 minutes interval). Rainfall intensities are given in mm per hour per time interval.

After the import of all 96 images has been completed, select from the main ILWIS menu "File" > "Create" > "Map List", as Map List name enter "MPE_recent", select all msgmpeyyyyymmddhhmm maps (96 in total) in

the left hand maplist window (selected maps are now indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "OK" to save the new maplist. Double click with the mouse the newly created Maplist "MPE_recent". In the MapList window select as display option "Open as Slide Show", as Representation select "mpe_single" and press "OK" twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values.

Eventually import also the MPE derived from Meteosat-7 and repeat the procedure as indicated above, note that the temporal resolution of MET-7 is half hourly, therefore 48 files are retrieved and processed. Here also the rainfall is in mm/hr per instance. Note the occurrence of blocks with high precipitation values, these areas should be disregarded, might be the result from a processing problem.

4.2.3.6 Africa Rainfall Estimate (RFE) and Climatology Version 2 (ARC2)

To import the RFE version1 10 day satellite derived precipitation estimates, select from the "ISOD" > "Toolbox" main menu the "Gauge – Satellite derived Rainfall Data" > "FEWSNET Rainfall - Climatology Africa" > "Rainfall RFE – Africa" > "RFE version1 10 day estimates" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. As Date stamp select "1999121" and press "Import". For the specified decade the precipitation map is imported. Display the map, "rfe1_1999121" using as Representation "rfe-dec", add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values.

Now import the daily and dekadal RFE Version2 precipitation maps; from the "ISOD" > "Toolbox" main menu first select the "Gauge – Satellite derived Rainfall Data" > "FEWSNET Rainfall - Climatology Africa" > "Rainfall RFE – Africa" > "RFE version2 daily estimates" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. As Date stamp select "20101031" and press "Import".

Repeat the procedure using as Date stamp "2010103", now using the menu option "RFE version2 10 day estimates". Display the two imported maps, "rfe2_20101031", using as Representation "mpe_sum" and "rfe2_2010103", using as Representation "rfe-dec". Add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values. Also note the difference in geographical extent between the RFE1 and RFE2 versions.

To derive appropriate rainfall climatology the procedure as described above can be applied. Recently the ARC2 data set became available, providing the mean monthly, dekadal and daily precipitation, currently derived from rainfall estimates of 1983 up to 2011. To import the monthly ARC2 data select from the "ISOD" > "Toolbox" main menu the "Gauge – Satellite derived Rainfall Data" > "FEWSNET Rainfall - Climatology Africa" > "RFE ARC2 – Climatology Africa" > "RFE monthly mean climatology" sub menu. In this case only "Output Directory" needs to be specified and press "Import".

After the data has been retrieved and imported using a looping procedure, click with the mouse on the ILWIS catalogue and press "F5" or select from the ILWIS main menu "Window" > "Refresh". Now create a maplist of the 12 newly created RFE mean dekadal rainfall maps (rfe_clim_month01 to rfe_clim_month12) and show this as an animation. Select from the main ILWIS menu "File" > "Create" > "Map List", as Map List name enter "RFE_clim_month", select all "rfe_clim_month" maps (12 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "OK" to save the new maplist. Double click with the mouse the newly created Maplist "RFE_clim_month". In the MapList window select as display option "Open as Slide Show", as Representation select "rfe_month" and press "OK" twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Note the temporal change of the rainfall patterns over Africa.

Repeat the procedure but now process the dekadal ARC2 rainfall maps. Select from the "ISOD" > "Toolbox" main menu the "Gauge – Satellite derived Rainfall Data" > "FEWSNET Rainfall - Climatology Africa" > "RFE ARC2 – Climatology Africa" > "RFE dekadal mean climatology" sub menu. In this case only "Output Directory" needs to be specified and press "Import".

After the data has been retrieved and imported, click with the mouse on the ILWIS catalogue and press "F5" or select from the ILWIS main menu "Window" > "Refresh". The name convention used for the output files created is "rfe_clim_dekad011" to "rfe_clim_dekad123". Now create a maplist of the 36 imported RFE mean dekadal rainfall maps and show this as an animation, using the procedure as described above.

Display the maps using as Representation "*rfe_dek*". Add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values.

In a similar manner also the daily mean ARC2 rainfall data can be retrieved and processed. Note that 365 days (excluding 29 February) are available when the routine has completed the processing. To conduct this routine select from the "*ISOD*" > "*Toolbox*" main menu the "*Gauge – Satellite derived Rainfall Data*" > "*FEWSNET Rainfall - Climatology Africa*" > "*RFE ARC2 – Climatology Africa*" > "*RFE daily mean climatology*" sub menu. In this case only "*Output Directory*" needs to be specified and press "*Import*". Note that given the large number of files the routine takes some time! The name convention used for the output files created is "*rfe_clim_day0101*" to "*rfe_clim_day1231*".

4.2.3.7 TAMSAT

Dekadal (every 10 days) and monthly rainfall estimates and anomalies derived from Meteosat Thermal Infra-Red (TIR) channels are based on the recognition of storm clouds and calibration against ground-based rain gauge data. This rainfall estimate is produced by the University of Reading, Meteorology Department, UK.

A number of products are available, like the dekadal and monthly accumulated rainfall products for Africa, the dekadal and monthly accumulated rainfall anomaly products for Africa. Select "*ISOD*" > "*Toolbox*" > "*Gauge – Satellite derived Rainfall Data*" > "*TAMSAT Rainfall archive - Africa*" > "*Dekadal Rainfall*" > "*Dekadal Rainfall from 1983 onwards*". As date stamp specify: "*201110*". Upon completion of the import display the map "*rfe2011101*" and as Representation use "*rfe_dek*". Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed note the map values.

To import the monthly accumulated rainfall map of October 2011, select the menu options "*Gauge – Satellite derived Rainfall Data*" > "*TAMSAT Rainfall archive - Africa*" > "*Monthly Rainfall*" > "*Monthly Rainfall from 1983 onwards*" and specify as date stamp "*201110*". Upon completion of the import display the map "*rfe201110*" and as Representation use "*rfe_month*". Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Also import the 10 day and monthly rainfall anomalies for October 2011 and use as Representations "*rfe_anom_dek*" and "*rfe_anom_month*" for the imported "*rfe2011101_anom*" and "*rfe_201110_anom*" maps respectively. Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values.

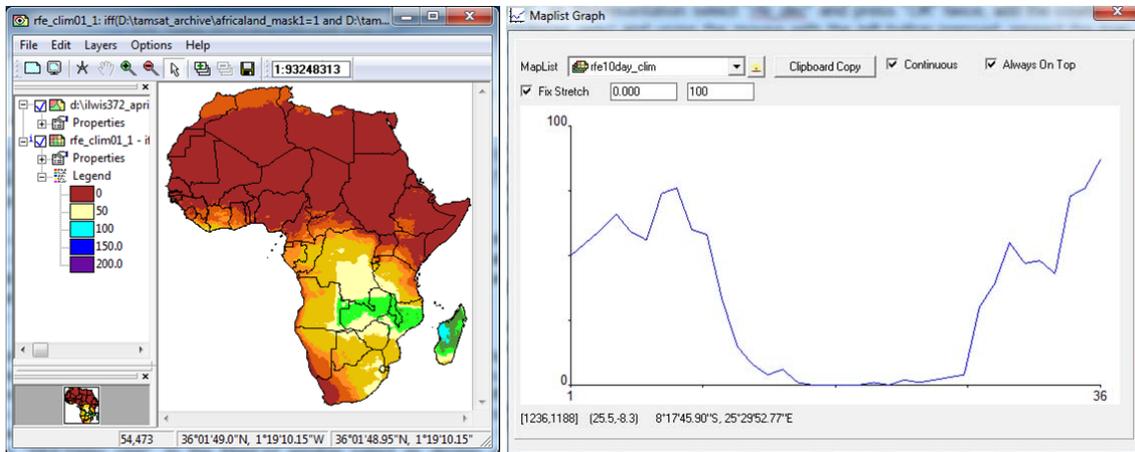
To get an idea of the distribution of the rainfall over a longer time period the rainfall climatology (derived from 1983-2012) can be used, but you can also compare your actual rainfall against the rainfall climatology. To import the Dekadal Climatology rainfall, select the menu options "*Gauge – Satellite derived Rainfall Data*" > "*TAMSAT Rainfall archive - Africa*" > "*Rainfall Climatology*" > "*Dekadal rainfall 1983-2012*", note the output directory and press the "*Import*" button. After extraction of the file a looping routine imports all 36 dekades. From the main ILWIS menu, select "*Window*" > "*Refresh*" to see the updated content of the catalogue.

After the import of all 36 rainfall climatology maps (*rfe_clim01_1* up to *rfe_clim12_3*) has been completed, select from the main ILWIS menu "*File*" > "*Create*" > "*Map List*", as Map List name enter "*RFE10day_clim*", select all *rfe_clim_month_dekade* maps (36 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "*OK*" to save the new maplist. Double click with the mouse the newly created Maplist "*RFE10day_clim*". In the MapList window select as display option "*Open as Slide Show*", as Representation select "*rfe_dek*" and press "*OK*" twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values. Close the animation window when finished.

Once more open the maplist "*RFE10day_clim*" and display the map "*rfe_clim01_1*". Add to this map the vector layer showing the country boundaries and use the option boundaries only for display of this vector layer. Now from the main ILWIS menu, select "*Operations*" > "*Statistics*" > "*MapList*" > "*MapList Graph*". In the maplist graph window, select as MapList "*RFE10day_clim*", use a fixed stretch of "*0 to 100*", activate the options "*Continuous*" and "*Always on top*". Activate the map window showing the previously opened map layer "*rfe_clim01_1*". Browse with the mouse cursor over the map. Note the precipitation time series

values in the graph window, the X-axis shows the time (from the first decade of January as time step 1 to the last decade of December as time step 36) and the Y-Axis the average amount of precipitation (in mm) during each 10 day period for the respective pixel. See also figure 4.2.3.

Figure 4.2.3 TAMSAT time series rainfall climatology over Africa



4.2.4 Data extraction and import automation for generation of time series precipitation data

In the previous exercises you have imported a variety of precipitation products using the ISOD Toolbox menu. You can keep using this procedure to import the other events from the same products by changing the Date stamp, e.g. each time selecting the next temporal interval. This is a cumbersome activity that needs user intervention. This procedure can be easily automated by copying the ILWIS command line string that is created each time you conduct an ISOD toolbox routine.

From the Main ILWIS menu, press the “drop down” button on the right hand side of the command line. You will now see the “history”. A typical command line string that is generated when using the ISOD Toolbox is given below using as example the import routine used for the ‘FEWSNET 10 day RFE2’-import (note that the command line string is given as a single line, the location of your ILWIS directory might be different!):

```
!d:\ilwis372\Extensions\ISOD-toolbox\toolbox_batchroutines\fews_rfe2_10day.bat 2010103 x x c: Sat_Precip d:\ilwis372\Extensions\ISOD-Toolbox\GDAL\bin d:\ilwis372 d:\ilwis372\Extensions\ISOD-Toolbox\util
```

Have a look at the command line above and note that “!” is used in ILWIS to call an external routine, in this case “fews_rfe2_10day.bat”. This batch file is executed for the time stamp “2010103” (for the 3rd decade of October 2010). The “x” indicates that here no input drive and input directory is used. All other strings define the parameters that specify the locations of the required software utilities to conduct the operation. In your case the location of ILWIS might be in a different ‘drive:directory’ and therefore your command line string might look different, but the string will have the same number of “items / parameters”. See also chapter 2.6 for further details.

Once more execute this operation from the toolbox menu and subsequently copy this command line to clipboard, open ‘Notepad’ and paste the command line string as a single line into Notepad (Check from the Notepad menu > Format > Word Wrap off!). Delete the “!” at the start of the line and add the following syntax: cmd /c instead. The line now becomes:

```
cmd /c d:\ilwis372\Extensions\ISOD-toolbox\toolbox_batchroutines\fews_rfe2_10day.bat 2010103 x x c: Sat_Precip d:\ilwis372\Extensions\ISOD-Toolbox\GDAL\bin d:\ilwis372 d:\ilwis372\Extensions\ISOD-Toolbox\util
```

Now copy this modified line and paste it 2 more times. Modify for the 3 lines the date stamp, instead of “2010103”, enter as new date stamps: “2010111”, “2010112” and “2010113” respectively. Your final results (as 3 lines) should look like the example below:

```
cmd /c d:\llwis372\Extensions\ISOD-toolbox\toolbox_batchroutines\fewes_rfe2_10day.bat 2010111 x x
c: Sat_Precip d:\llwis372\Extensions\ISOD-Toolbox\GDAL\bin d:\llwis372 d:\llwis372\Extensions\ISOD-
Toolbox\util
```

```
cmd /c d:\llwis372\Extensions\ISOD-toolbox\toolbox_batchroutines\fewes_rfe2_10day.bat 2010112 x x
c: Sat_Precip d:\llwis372\Extensions\ISOD-Toolbox\GDAL\bin d:\llwis372 d:\llwis372\Extensions\ISOD-
Toolbox\util
```

```
cmd /c d:\llwis372\Extensions\ISOD-toolbox\toolbox_batchroutines\fewes_rfe2_10day.bat 2010113 x x
c: Sat_Precip d:\llwis372\Extensions\ISOD-Toolbox\GDAL\bin d:\llwis372 d:\llwis372\Extensions\ISOD-
Toolbox\util
```

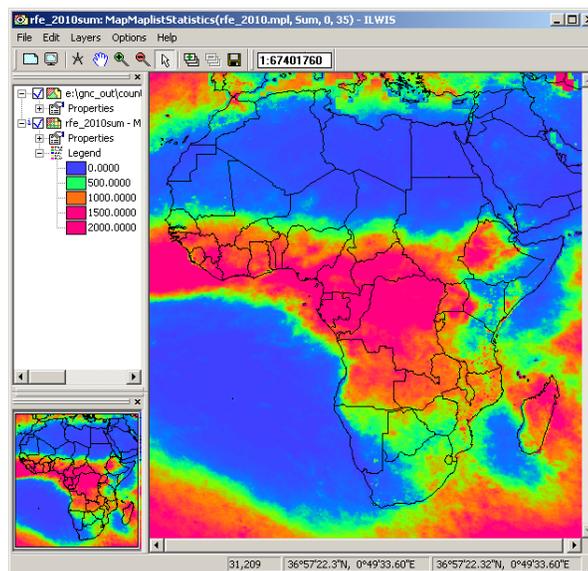
 Save this file in your active working directory, use as file name “*rfe2_nov10_import.bat*”.

Now use the Windows Explorer, browse to your active working directory and double click with the mouse on the new batch file created “*rfe2_nov10_import.bat*”. The RFE2 maps are now automatically retrieved and processed in ILWIS. When the operation has been completed, click with the mouse on the ILWIS catalogue and press “F5” or select from the ILWIS main menu “Window” > “Refresh”. Now create a maplist of the 3 imported dekadal images and show this as an animation. Also use maplist statistics, and the “sum” option, to calculate the monthly precipitation of November 2010. Display the map using as Representation “*rfe_month*”. Add the country boundaries (no Info, boundaries only) and use pixel information to inspect the values.

Repeat this procedure, now prepare a batch file to import all RFE2 10 day rainfall products for 2010 (36 events) and calculate the sum, min, max and mean yearly precipitation for 2010.

Your final results (for the sum) should resemble those provided in figure 4.2.4, using a “Pseudo” Representation and a stretch from 0 to 1500. Note that more advanced batch procedures can be developed, using a so called “looping” procedure, identical to the import of the Climatology products. You can find various examples in the “*toolbox_batchroutines*” sub-directory.

Figure 4.2.4: RFE2 based total precipitation over Africa for 2010



4.3 MOD 16 –GLOBAL ET AND PET

Open the “ISOD” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “MOD16_ET”. For the Folder items under MOD16_ET specify the appropriate directory and press “Save” to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

From the "ISOD" > "Toolbox" main menu select the "MOD16 - ET" > "Global monthly ET (2000-2012)" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. Enter a suitable date string, here as example "201204" is used to process the data from April 2012. Press "Import".

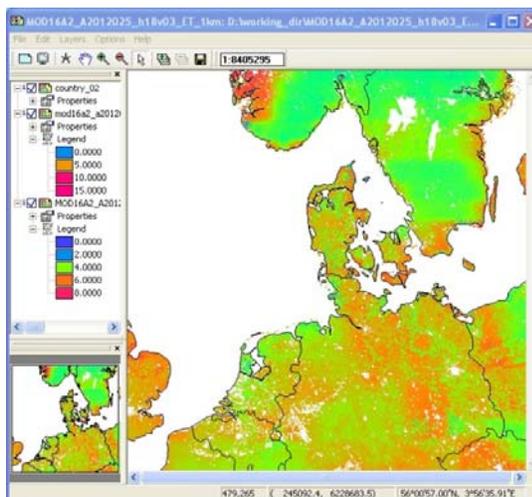
Upon completion of the import display the map "MOD16_ET_201204" and as Representation use "Pseudo". Add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed and inspect the map values. Note the ET is given in mm/month. The spatial resolution is 3 minutes (0.05 degree) or 5600 mtr at the equator.

Now from the "ISOD" > "Toolbox" main menu select the "MOD16 - ET" > "8-Day ET and PET at 1 km (2000-2012)" sub menu. Also here the "Date" field and the "Output Directory" need to be specified. Enter a suitable date string, here as example "2012025" (Julian Day!) is used to process the data from 25 January, 2012. Note for the time stamp, you have to use multiples of 8. A Julian day stamp of 1 represents the accumulation period from 01 to 08 January. The date stamp of 025 represents the time from 25 January to 01 February. Note whether you are dealing with a leap year! Press "Import".

Subsequently a new pop-up menu appears, enter the suitable upper left latitude – longitude coordinate pair, in 10 degree intervals, and press "OK". Here as example for longitude "0" and latitude "60" is used to retrieve the window over Western Europe. Inspect the command line window for further information as well.

Upon completion of the import display the map "MOD16A2_A2012025_h18v03_ET_1km" and as Representation use "Pseudo". Add to this map window the map "MOD16A2_A2012025_h18v03_PET_1km" and also use as Representation "Pseudo". Subsequently add the country boundaries (no Info, boundaries only). Now use "Pixel Information" to inspect the ET and PET values. Note the values are given in mm/8-day. The projection is still 'Sinusoidal'. If your vector layer has as coordinate system "LATLON" the vector information is properly displayed over the map. If your vector coordinate system is "LATLON-WGS84" then there is a displacement.

Figure 4.3.1: MOD16 ET and PET



To resample e.g. the ET map from a Sinusoidal projection to LATLON, create a new Georeference. Select from the main ILWIS menu the option "File" > "Create" > "Georeference". Your GeoReference Name is "ET_latlon", use the option "GeoRef Corners", as Coordinate System select "LATLON" from the drop down list, as pixel size "32.14" seconds (= 1 km at the equator), the min and max Lat – Lon according to the window extracted, here "50N" and "60N" for min and max Lat respectively and "0E" and "10E" for min and max Lon respectively. Uncheck the option "Center of Corner Pixel" and press "OK".

Now from the ILWIS main menu select the option "Operations" > "Spatial Reference Operations" > "Raster" > "Resample". In the Resample Map window select as Raster Map

"MOD16A2_A2012025_h18v03_ET_1km", as resampling method "Nearest Neighbour", as output map "mod16ET_latlon" and finally as georeference "ET_latlon", keep the other values as default and press "Show" and "OK". Display the map using a "Pseudo" Representation. Now you can overlay vector files with a 'latlon' coordinate system as well as with a 'latlon-wgs84' coordinate system.

4.4 FEWSNET GLOBAL PET

Open the "ISOD" > "Toolbox" options from the left hand menu tree and open the item "Configuration" > "Folders". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "FEWS_PET". For the Folder items under FEWS_PET specify the appropriate directory and press "Save" to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

From the "ISOD" > "Toolbox" main menu select the "FEWSNET Global PET" > "PET 1 degree - daily per month" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. Enter a suitable date string, here as example "201104" is used to process the data from April 2011.

Upon retrieval of the file a looping procedure is started which imports all the daily data of April 2011. When the import has been completed refresh the catalogue (from the main ILWIS menu, select "Window" and "Refresh"), open the map "pet20110401" using a "Pseudo" Representation and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Select from the main ILWIS menu "File" > "Create" > "Map List", as Map List name enter "PET_201104", select all "pet_yyyymmdd" maps (30 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "OK" to save the new maplist. Double click with the mouse the newly created Maplist "PET_201104". In the MapList window select as display option "Open as Slide Show", as Representation select "Pseudo" and press "OK" twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Eventually select from the "ISOD" > "Toolbox" main menu select the "FEWSNET Global PET" > "PET 1 degree - daily per year" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. Enter a suitable Date string, here as example 2010 can be used to process the data for the whole year of 2010. For visualization create a maplist, use a similar procedure as indicated above using all daily PET maps of 2010.

To process a recent Global PET event, select a day during the current month. From the "ISOD" > "Toolbox" main menu select the "FEWSNET Global PET" > "PET 1 degree - daily" sub menu. In this case the "Date" and the "Output Directory" needs to be specified. Enter a suitable date string (note that you can take a recent day of the current month as the full month data is not available!), here as example the date stamp of the day before present is used to retrieve the PET data from 'yesterday'. Display the map, use as Representation "Pseudo" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

4.5 FEWSNET NOAA – EMODIS NDVI FOR AFRICA

4.5.1 FEWSNET NOAA16 and 17 derived NDVI

Open the "ISOD" > "Toolbox" options from the left hand menu tree and open the item "Configuration" > "Folders". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "FEWS_NDVI". For the Folder item under FEWS_NDVI specify the appropriate directory and press "Save" to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

From the "ISOD" > "Toolbox" main menu select the "FEWSNET NOAA – eMODIS NDVI - Africa" > "NOAA NDVI (current processing suspended)" > "NDVI-N16 bulk download (NOAA-16 Calibration)" sub menu. In this case only the "Date" field and the "Output Directory" need to be specified. Enter a suitable date string, here as example "1995" is used to process the NOAA-16 derived NDVI data from 1995.

Upon retrieval of the file a looping procedure is started which imports all the dekadal NDVI data of 1995. When the import has been completed refresh the catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh*”), open the map “*fewsndvi_950101*” using a “*NDVI1*” Representation and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Select from the main ILWIS menu “*File*” > “*Create*” > “*Map List*”, as Map List name enter “*FEWS_NDVI_1995*”, select all *fewsndvi_yyyyymmdecdec* maps (36 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the “>” sign to add them to the right hand Create MapList window and press “*OK*” to save the new maplist. Double click with the mouse the newly created Maplist “*FEWS_NDVI_1995*”. In the MapList window select as display option “*Open as Slide Show*”, as Representation select “*NDVI1*” and press “*OK*” twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

In a similar manner also the “*NDVI-N16 Long term mean*”, “*NDVI-N16 Short term mean*”, “*NDVI-N17 bulk download (NOAA-17 Calibration)*” and “*NDVI-N17 Short term mean*” can be retrieved and processed. Note that the Long Term Mean was calculated from data for the period 1982 to 2008. The Short Term Mean was calculated from data for the period 2004 to 2008. For NDVI-17 the Short Term Mean was calculated from data for the period 2003 to 2008. There is no Long Term Mean for the NDVI-17 product.

4.5.2 **FEWSNET eMODIS derived NDVI**

Before starting to retrieve the data first some general remarks on the conventions used for the eMODIS products. Recent dekadal data is available for 012010 onwards; each year is consisting of 72 periods. Note the period’s definition: period 1 is from Dec26-Jan5 for a given year, period 2 is from Jan1-Jan10 for a given year, period 71 is from Dec16-Dec25 for a given year and period 72 is from Dec21-Dec31 for a given year. The older data, organized per month (6 files for the 6 decades) is available from 2001 onwards as well as a short term mean per period (from 2001-2010). First a recent Temporally Smoothed NDVI, Mean Anomaly and Previous Year Difference map is going to be retrieved for the eastern African region.

Open the “*ISOD*” > “*Toolbox*” options from the left hand menu tree and open the item “*Configuration*” > “*Folders*”. Note that here the assumption is made that you have created on your local system, using drive “*C*”, a directory called “*FEWS_NDVI*”. For the Folder item under FEWS_NDVI specify the appropriate directory and press “*Save*” to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

To import a recent eMODIS NDVI images, from the “*ISOD*” > “*Toolbox*” main menu select the “*FEWSNET NOAA – eMODIS NDVI - Africa*” > “*eMODIS NDVI and anomaly (from 012010 - to 1 month before present)*” > “*East Africa*” > “*Temporally Smoothed NDVI*” sub menu. You can also select another African window. In either case only the “*Date*” field and the “*Output Directory*” needs to be specified. Enter a suitable Date string (per = period), here as example “*022012*” is used to retrieve the eMODIS NDVI data from the second period of 2012, from 1-10 January. Note that the whole procedure can take quite some time depending on your internet bandwidth as each of the four windows cover an extensive area and having a spatial resolution of 250 meter / pixel the files have considerable volume!

When the import has been completed refresh the catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh*”), open the map “*emodis_ea_ndvi201202*” using a “*NDVI1*” Representation and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

To import a recent eMODIS Mean Anomaly map, from the “*ISOD*” > “*Toolbox*” main menu select the “*FEWSNET NOAA – eMODIS NDVI - Africa*” > “*eMODIS NDVI and anomaly (from 012010 - to 1 month before present)*” > “*East Africa*” > “*Mean Anomaly*” sub menu. You can also select another African window. In either case only the “*Date*” field and the “*Output Directory*” needs to be specified. Enter a suitable Date string (per = period), here as example also “*022012*” is used to retrieve the eMODIS Mean Anomaly NDVI data from the second period of 2012, from 1-10 January.

When the import has been completed refresh the catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh*”), open the map “*emodis_ea_ndvi201202stm*” using a “*Pseudo*” Representation and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button

pressed inspect the map values. Note that the anomalies represent a subtraction of the mean NDVI values (2001-2010) for a given 10-day period from current-year values for the same period, rendering an image where negative values portray less vigorous vegetation than average, and positive values represent areas that are more vigorous in the current year.

To import a recent eMODIS Previous Year Difference, from the "ISOD" > "Toolbox" main menu select the "FEWSNET NOAA – eMODIS NDVI - Africa" > "eMODIS NDVI and anomaly (from 012010 - to 1 month before present)" > "East Africa" > "Previous Year Difference" sub menu. You can also select another African window. In either case only the "Date" field and the "Output Directory" needs to be specified. Enter a suitable Date string (per = period), here as example also "022012" is used to retrieve the eMODIS Previous Year Difference.

When the import has been completed refresh the catalogue (from the main ILWIS menu, select "Window" and "Refresh"), open the map "emodis_ea_ndvi201202dif" using a "Pseudo" Representation and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the positive and negative map values.

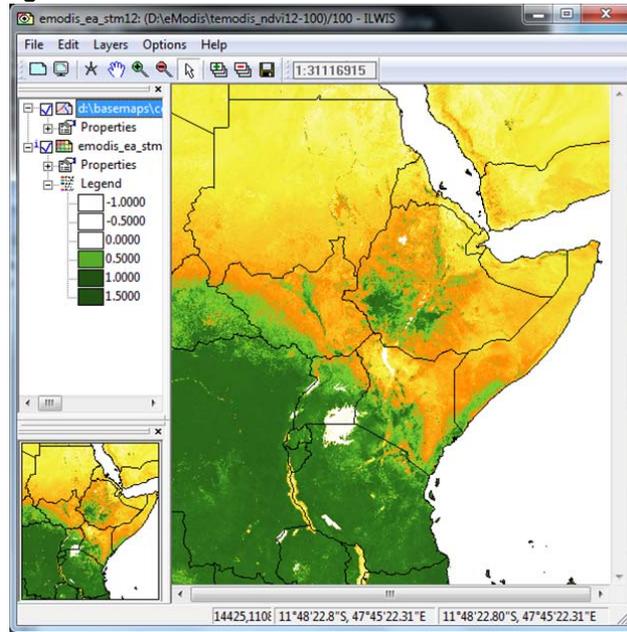
To import historical eMODIS NDVI images, from the "ISOD" > "Toolbox" main menu select the "FEWSNET NOAA – eMODIS NDVI - Africa" > "eMODIS NDVI historical data (2001-2011)" > "East Africa" > "Monthly NDVI" sub menu. You can also select another African window. In either case only the "Date" field and the "Output Directory" needs to be specified. Enter a suitable Date string (m = month), here as example "022001" is used to retrieve the eMODIS historical NDVI data from February 2001. Note that the whole procedure can take quite some time depending on your internet bandwidth as each of the four windows cover an extensive area and having a spatial resolution of 250 meter / pixel the files have considerable volume! Furthermore 6 files per month are being processed, covering the dekades defined by the eMODIS team. Note once more that the even periods are from 01-10, 11-20 and 21 till the end of the month. The odd periods are from 26 of the previous month to 5 (of the current month), 6-15 and 16-25, etc.

Upon retrieval of the file a looping procedure is started which imports all the dekadal NDVI data of the selected month. When the import has been completed refresh the catalogue (from the main ILWIS menu, select "Window" and "Refresh"), open the map "emodis_ea_ndvi0801" using a "NDVI1" Representation and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Note that period 08 represents the data from 01-10 February 2001!

To import the short term mean eMODIS NDVI images, from the "ISOD" > "Toolbox" main menu select the "FEWSNET NOAA – eMODIS NDVI - Africa" > "eMODIS NDVI historical data (2001-2011)" > "East Africa" > "East Africa" > "Short Term Mean NDVI" sub menu. You can also select another African window. In either case only the "Date" field and the "Output Directory" needs to be specified. Enter a suitable Date string (m = month), here as example "02" is used to retrieve the eMODIS Short Term Mean NDVI data for February.

Upon retrieval of the file a looping procedure is started which imports all the short term mean NDVI data of the selected month. When the import has been completed refresh the catalogue (from the main ILWIS menu, select "Window" and "Refresh"), open the map "emodis_ea_stm08" using a "NDVI1" Representation and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Note that period 08 represents the short term mean of 01-10 February! The short term mean is currently derived for NDVI data for the period 2001-2010. The retrieved short term mean NDVI is presented in figure 4.4.1.

Figure 4.4.1. eMODIS short term mean for 01-10 February



4.6 MEASURES GLOBAL VI PRODUCTS V2

Open the "ISOD" > "Toolbox" options from the left hand menu tree and open the item "Configuration" > "Folders". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "VIP". For the Folder item under "Global_VI" specify the appropriate directory and press "Save" to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

From the "ISOD" > "Toolbox" main menu select the "MEaSURES Global VI Products V2" > "Global Vegetation Indices" > "Daily NDVI-EVI2" sub menu. Note that the routine expects a year – Julian date input, e.g. specify for 31 January 2010 the following time stamp: "2010031". Check the output folder and press "Import".

After the import has been completed (can take some time as these are large files), display the new map created: "VIP01NDVI_2010031", use as Representation "NDVI1" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Also display the map "VIP01EVI2_2010031" and use as Representation "NDVI1" and press "OK". Here VIP01 indicates that this is the daily product.

You can repeat the procedure and import the 7-day, 15-day or monthly NDVI-EVI2 products. Note that to obtain the appropriate date stamp, for the 7-day product use a multiple of 7 + 1, e.g. for the second week of January 2010, use as Date stamp: "2010015". Use an identical procedure to get the 15-day or monthly product (multiple of 15 + 1 or multiple of days of month + 1). Take normal or leap year occurrence into consideration! Note that the output file names start with the temporal interval selected, like VIP07, VIP15, VIP30, for 7-days, 15-days and monthly temporal resolution respectively. When displaying the retrieved maps, use as Representation "NDVI1", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

4.7 COPERNICUS GLOBAL LAND SERVICE – SWI

To import the Soil Water Index product from the Copernicus Global Land Service, first Open the "ISOD" > "Toolbox" options from the left hand menu tree and open the item "Configuration" > "Folders". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "GEOLAND". For the Folder item under "GEOLAND" specify the appropriate directory and press "Save" to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

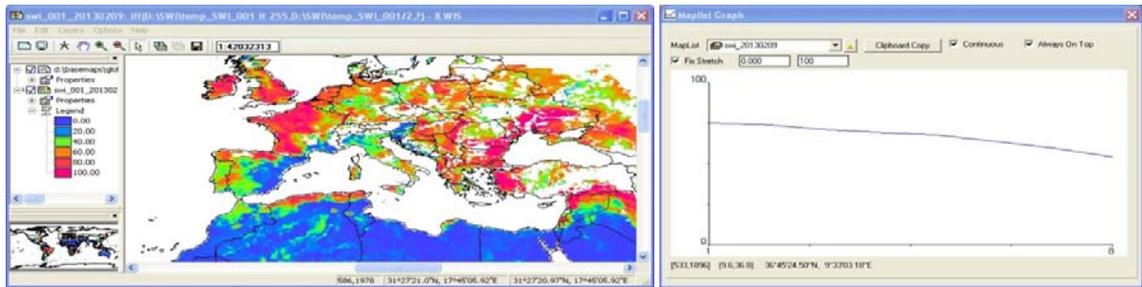
Note that given the registration no anonymous access is provided. You have to download the data first using your own registration specifications (from: <http://land.copernicus.eu/global/?q=index.html>). Here as example a SWI file is retrieved, called "g2_BIOPAR_SWI_201302090000_GLOBE_ASCAT_V2.0.0.zip" and has been copied into the folder C:\GEOLAND\SWI_data.

From the "ISOD" > "Toolbox" main menu select the "Copernicus Global Land Service" > "Global daily SWI – v2" sub menu. Note that the routine expects a yyyyymmdd date input, therefore specify the following time stamp: "20130209". Check once more the output folder and press "Import".

Open the maplist "swi_20130209" and display the map "swi_001_20130209" using a "Pseudo" Representation. This layer represents the T=1 characteristic time length layer. Add to this map the vector layer showing the country boundaries and use the option boundaries only for display of this vector layer. Now from the main ILWIS menu, select "Operations" > "Statistics" > "MapList" > "MapList Graph". In the maplist graph window, select as MapList "swi_20130209", use a fixed stretch of "0 to 100", activate the options "Continuous" and "Always on top". Activate the map window showing the previously opened map layer "swi_001_20130209". Browse with the mouse cursor over the map. Note the soil water index values in the graph window, the X-axis shows the characteristic time length layers (T = 1 for layer 1 up to the last layer, 8, for T = 100) and on the Y-Axis the soil water index (in %) for the respective pixel. See also figure 4.7.1. For an interpretation of 'T' consult the product user manual from the Service provider.

Most other products are also disseminated through GEONETCast. Use can be made of the GEONETCast-Toolbox for further pre-processing.

Figure 4.7.1: Soil Water Index map and profile for a selected pixel in North Tunisia



4.8 GLOBAL ELEVATION DATA

4.8.1 GMTED 2010

Open the “ISOD” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “DEM”. For the Folder items under GMTED_DEM, SRTM_DEM and ASTER_DEM specify the appropriate directory and press “Save” to store the drive:\directory settings. Note that for the ASTER_DEM folder settings also a local input directory has to be specified. Also create this temporary directory. Move to the new working directory using the ILWIS Navigator. Close ILWIS and open it again.

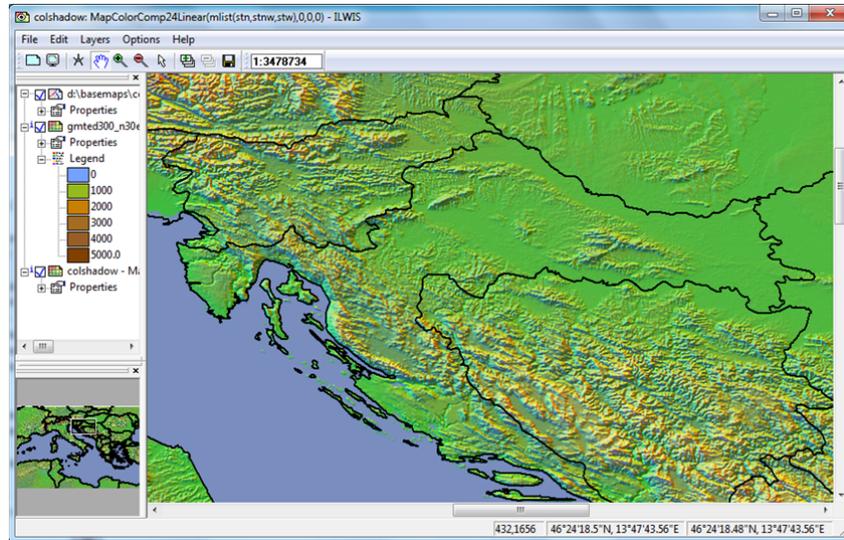
From the “ISOD” > “Toolbox” main menu select the “Global Elevation Data”, “GMTED2010” > “GMTED 30 Arc Sec / 1 km” sub menu. In this case the Lower Left Latitude and Longitude Corner coordinates have to be specified. Note that the Latitude interval is 20 degrees (from N90 to S70) and the longitude interval is 30 degrees (from W180 to E150) Enter a suitable lower left corner coordinate pair; N, S, W and E are case sensitive, enter them as capital. In this example for Lat: “N30” and Long: “E000” are used. Check the output folder and press “Import”.

After the import has been completed, display the new map created: “gmted300_N30E000”, use as Representation “Elevation3”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. Do not close the map windows at this moment.

In ILWIS a whole suite of DEM processing routines are available. Open from the Operation-Tree, the tab “DEM hydro-processing” > “Dem Visualization”. As input DEM select the newly imported elevation model, here “gmted300_N30E000” is used. The default Output Map name can be used and press “OK”. Further information on these routines is provided under the ILWIS Help function. Close the map “colshadow”. Now add the newly created map “colshadow” to the map window of the “gmted300_N30E000”. To do this, select from the active map window displaying the map “gmted300_N30E000” the option “Layers” > “Add Layer”, select the map “colshadow” and press “OK”. Select the “colshadow” map from the left hand legend menu of the active map display window and drag the map below the map “gmted300_N30E000”. Double click the map layer “gmted300_N30E000” and from the Map Display options menu activate the option “Transparent”, set the transparency to 50 % and press “OK”. From the active map display window, select from the menu “Options” > “No Zoom”. Use the “Pan” Function to scroll over the map window. Your results should resemble those given in figure 4.6.1. Close the map when finished.

In an identical manner the “GMTED 15 Arc Sec / 500 m” and “GMTED 7.5 Arc Sec / 250 m” can be retrieved and processed. Note that due to the increased spatial resolution the file sizes increase. Note that the output file name is indicating the spatial resolution selected, e.g. “gmted150_*.shp” and “gmted075_*.shp”.

Figure 4.6.1. GMTED 30 Arc Seconds visualization



4.8.2 SRTM Version 4

From the “ISOD” > “Toolbox” main menu select the “Global Elevation Data” > “SRTM Version 4” > “SRTM 3 Arc Sec / 90 m 5 X 5 degree tiles” sub menu. In this case Lower Left Latitude and Longitude Corner coordinates have to be specified. Note that the Latitude interval is 5 degrees (up to 60 degrees north and south) and the longitude interval is also 5 degrees (from W180 to E180) Enter a suitable lower left corner coordinate pair; N, S, W and E are case sensitive, enter them as capital. In this example for Lat: “S20” and Long: “E010” are used. Check the output folder and press “Import”.

Note that the coordinate pair used is transformed into the corresponding SRTM tile index number. The GeoTIFF file is retrieved from the selected FTP location and converted into an ILWIS format. Note that in the batch file additional locations for retrieval are given.

After the import has been completed, display the new map created: “srtm_S20E010”, use as Representation “Elevation3”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values. You can use the DEM hydro-processing tools to further process the elevation model. Note that if you want to combine multiple tiles you can use the generic ILWIS option “GlueRas”, available from the main ILWIS menu under “Operations” > “Raster Operations” > “Glue Maps”.

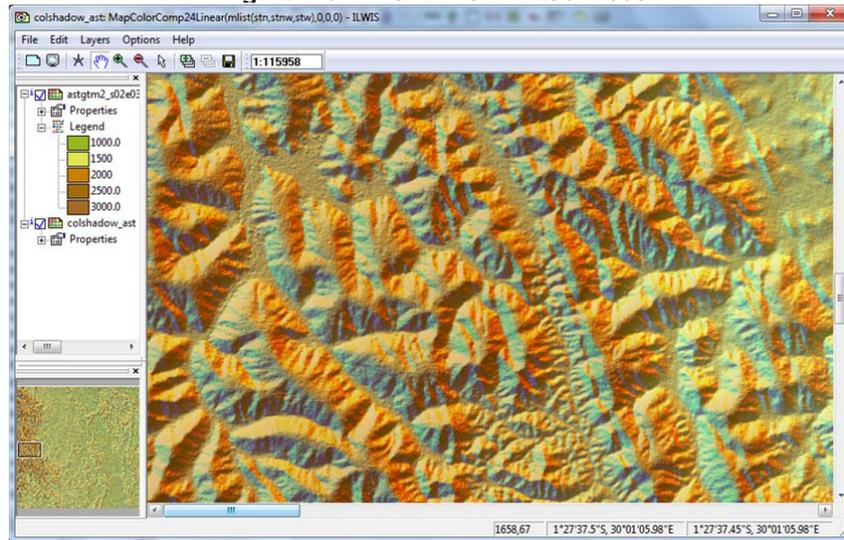
4.8.3 ASTER GDEM Version 2

One has to register to get access to the GDEM data. Therefore the import routine can’t automatically retrieve the data. Eventually register and login to obtain the GDEM data (from: <http://gdem.ersdac.jspacesystems.or.jp/>). Select the required elevation data and download it first onto a local storage device in the temporary directory created.

Once the selected elevation information is downloaded open from the “ISOD” > “Toolbox” main menu select the “Global Elevation Data” > “ASTER GDEM Verion 2” > “ASTER GDEM 1 Arc Sec / 30 m 1 X 1 degree tiles” sub menu. In this case Lower Left Latitude and Longitude Corner coordinates have to be specified. Note that the Latitude interval is 1 degree (up to 83 degrees north and south) and the longitude interval is also 1 degree (from W180 to E180). Enter a suitable lower left corner coordinate pair; N, S, W and E are case sensitive, enter them as capital. In this example the ZIP file “ASTGTM2_S02E030” was manually downloaded and stored into the input folder (note that the file was not unzipped) specified under the “Configuration” and “Folders” options of the ISOD Toolbox main menu. Now the following coordinates are applied in the import window: for Lat: “S02” and Long: “E030”. Check the output folder and press “Import”.

After the import has been completed, display the new map created: “ASTGTM2_S02E030”, use as Representation “*Elevation3*” and using the mouse with the left button pressed inspect the map values. You can use the DEM hydro-processing tools to further process the elevation model. Note that if you want to combine multiple tiles you can use the generic ILWIS option “*GlueRas*”, available from the main ILWIS menu under “*Operations*” > “*Raster Operations*” > “*Glue Maps*”. Your results should resemble those of figure 4.6.2, using the option “*No Zoom*” available from the active map display window menu “*Options*”.

Figure 4.6.2. ASTER GDEM S02E030



4.9 NASA GLOBAL OCEAN DATA

Open the “*ISOD*” > “*Toolbox*” options from the left hand menu tree and open the item “*Configuration*” > “*Folders*”. Note that here the assumption is made that you have created on your local system, using drive “*C*”, a directory called “*Ocean*”. For the Folder item under “*NASA_Ocean*” specify the appropriate directory and press “*Save*” to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

From the “*ISOD*” > “*Toolbox*” main menu select the options “*NASA Global Ocean Data*” > “*Ocean SST*” > “*ModisT-SST daily*”. Note that the routine expects a year – Julian date input, e.g. specify for 31 January 2010 the following time stamp: “*2010031*”. Check the output folder and press “*Import*”.

After the import has been completed display the new map created: “*sst_T2010031*”, use as Representation “*ssf*” and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values for example along the coast of Namibia. Note the unit is in degree Celsius.

From the “*ISOD*” > “*Toolbox*” main menu select the options “*NASA Global Ocean Data*” > “*Ocean SST*” > “*ModisT-NSST daily*”. Note that the routine expects a year – Julian date input, e.g. specify for 31 January 2010 the following time stamp: “*2010031*”. Check the output folder and press “*Import*”.

After the import has been completed display the new map created: “*nsst_T2010031*”, use as Representation “*ssf*” and press “*OK*”, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

From the “*ISOD*” > “*Toolbox*” main menu select the options “*NASA Global Ocean Data*” > “*Ocean Chlor-A*” > “*ModisT-Chlor-A daily*”. Note that the routine expects a year – Julian date input, e.g. specify for 31 January 2010 the following time stamp: “*2010031*”. Check the output folder and press “*Import*”.

After the import has been completed display the new map created: "*chlorA_T2010031*", use as Representation "*Pseudo*" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values (unit in mg m^{-3}).

In a similar manner also the products derived from the MODIS Aqua sensor can be retrieved and processed.

4.10 GLOBAL LAND DATA ASSIMILATION SYSTEM

4.10.1 GLDAS-Noah model

To retrieve the data from GLDAS open the "*ISOD*" > "*Toolbox*" options from the left hand menu tree and open the item "*Configuration*" > "*Folders*". Note that here the assumption is made that you have created on your local system, using drive "C", a directory called "GLDAS". For the Folder item under "GLDAS" and "GLDAS_Meta" specify the appropriate directory and press "Save" to store the drive:\directory settings. Move to the working directory using the ILWIS Navigator. Close ILWIS and open it again.

For import of the GLDAS-Noah model output, select from the "*ISOD*" > "*Toolbox*" main menu the options "*Global Land Data Assimilation System*" > "*GLDAS NOAH model output*" > "*GLDAS-HOAH 0.25 degree 3 hr*". Specify the appropriate year and day of year number. Here as example the "2005300" is used and press "Import". Note that 8 files are extracted providing the output for each 3 hourly time step.

If you want to know the actual calendar day, select from the "*ISOD*" > "*Toolbox*" main menu the menu item "*Display Julian Day tables*" and subsequently select the normal year routine and press "Import". A table will be shown indicating for each calendar day the corresponding day of year, here for day 300 this is 27 October.

After import is completed note that 8 map lists are created. Open the map list "GLDAS_NOAH025_3H_A2005300_00", giving the model output for the first 3 hours of 27 October 2005. Note that within the map list after to time stamp indicator (here "00") also a layer number is given, e.g for the first layer in this map list given a suffix "_1". Display this map ("*GLDAS_NOAH025_3H_A2005300_00_1*"), use as Representation "*Pseudo*" and also add the country boundaries, using option "*info off*". From the active map window, select from the menu the option "*File*" > "*Open Pixel Information*" and from the Pixel Information window select "*File*" > "*Add Map*" (eventually navigate to your working directory) and select the map list "GLDAS_NOAH025_3H_A2005300_00" and press "OK". Now move the cursor of the mouse over Australia and inspect the values of the 28 attributes – map layers.

To get an idea of what you are looking at and what the values represent, open from the "*ISOD*" > "*Toolbox*" main menu the options "*Global Land Data Assimilation System*" > "*GLDAS NOAH model output*" > "*GLDAS-HOAH 0.25 degree 3 hr meta data*". Specify the appropriate year, day of year number and time step. Here as example "200530000" (for time step 00) is used and press "Import". The meta data is extracted for the given time step and displayed. Note that the file is stored using the settings as provided under the ISOD Toolbox options "*Configuration*" > "*Folders*" > "*GLDAS_Meta*" settings, so these can be reviewed at any time. The figure below is showing the meta-data extracted from the GRIB file for this time step and is displayed using 'Notepad++' (for appropriate operations see installation instructions in chapter 1!).

The layer numbering of the meta-data file is identical to the suffix used in the map list name. In order to display the wind speed select layer "23", using as Representation "*Pseudo*", note the unit is in m/s.

Figure 4.8.1: Meta data of the GLDAS-Hoah model for time step 200530000

```

1 1:0:D=2005102621:NSWRS:sfc:kpds=111,1,0:0-3hr ave:winds are N/S:"Net short wave (surface) [W/m^2]
2 2:594096:D=2005102621:NLWRS:sfc:kpds=112,1,0:0-3hr ave:winds are N/S:"Net long wave (surface) [W/m^2]
3 3:1157816:D=2005102621:LHTFL:sfc:kpds=121,1,0:0-3hr ave:winds are N/S:"Latent heat flux [W/m^2]
4 4:1751912:D=2005102621:SHTFL:sfc:kpds=122,1,0:0-3hr ave:winds are N/S:"Sensible heat flux [W/m^2]
5 5:2346008:D=2005102621:GFLUX:sfc:kpds=155,1,0:0-3hr ave:winds are N/S:"Ground heat flux [W/m^2]
6 6:2909728:D=2005102700:LFTX:sfc:kpds=131,1,0:anl:winds are N/S:"Surface lifted index [K]
7 7:3503824:D=2005102700:4LFTX:sfc:kpds=132,1,0:anl:winds are N/S:"Best (4-layer) lifted index [K]
8 8:4097920:D=2005102700:EVP:sfc:kpds=57,1,0:anl:winds are N/S:"Evaporation [kg/m^2]
9 9:4661640:D=2005102700:SSRUN:sfc:kpds=235,1,0:anl:winds are N/S:"Storm surface runoff [kg/m^2]
10 10:5255736:D=2005102700:BGRUN:sfc:kpds=234,1,0:anl:winds are N/S:"Baseflow-groundwater runoff [kg/m^2]
11 11:5849832:D=2005102621:SNOM:sfc:kpds=99,1,0:0-3hr ave:winds are N/S:"Snow melt [kg/m^2]
12 12:6322426:D=2005102700:BVF2:sfc:kpds=138,1,0:anl:winds are N/S:"Brunt-Vaisala frequency^2 [1/s^2]
13 13:6855772:D=2005102700:WEASD:sfc:kpds=65,1,0:anl:winds are N/S:"Accum. snow [kg/m^2]
14 14:7449868:D=2005102700:TSOIL:0-4 cm down:kpds=85,112,4:anl:winds are N/S:"Soil temp. [K]
15 15:7983214:D=2005102700:TSOIL:0-3 cm down:kpds=85,112,3:anl:winds are N/S:"Soil temp. [K]
16 16:8516560:D=2005102700:TSOIL:0-2 cm down:kpds=85,112,2:anl:winds are N/S:"Soil temp. [K]
17 17:9049906:D=2005102700:TSOIL:0-1 cm down:kpds=85,112,1:anl:winds are N/S:"Soil temp. [K]
18 18:9583252:D=2005102700:SOILM:0-4 cm down:kpds=86,112,4:anl:winds are N/S:"Soil moisture content [kg/m^2]
19 19:10177348:D=2005102700:SOILM:0-3 cm down:kpds=86,112,3:anl:winds are N/S:"Soil moisture content [kg/m^2]
20 20:10771444:D=2005102700:SOILM:0-2 cm down:kpds=86,112,2:anl:winds are N/S:"Soil moisture content [kg/m^2]
21 21:11365540:D=2005102700:SOILM:0-1 cm down:kpds=86,112,1:anl:winds are N/S:"Soil moisture content [kg/m^2]
22 22:11959636:D=2005102700:TCDC:sfc:kpds=71,1,0:anl:winds are N/S:"Total cloud cover [%]
23 23:12462606:D=2005102700:WIND:sfc:kpds=32,1,0:anl:winds are N/S:"Wind speed [m/s]
24 24:12904826:D=2005102700:TMP:sfc:kpds=11,1,0:anl:winds are N/S:"Temp. [K]
25 25:13407796:D=2005102700:SPFH:sfc:kpds=51,1,0:anl:winds are N/S:"Specific humidity [kg/kg]
26 26:13667762:D=2005102700:PRES:sfc:kpds=1,1,0:anl:winds are N/S:"Pressure [Pa]
27 27:14261858:D=2005102621:DSWRF:sfc:kpds=204,1,0:0-3hr ave:winds are N/S:"Downward short wave flux [W/m^2]
28 28:14855954:D=2005102621:DLWRF:sfc:kpds=205,1,0:0-3hr ave:winds are N/S:"Downward long wave flux [W/m^2]
29

```

As various map lists are at your disposal, one for each 3 hour time step, it is also possible to create daily integrated maps. As example here the Evaporation (layer 8) is used. Select from the main ILWIS menu "File" > "Create" > "Map List", as Map List name enter "ET", select all GLDAS_NOAH025_3H_A2005300_??_8" maps (note that ?? stands for each 3 hourly time step, 00, 03, 06, 09, 12, 15, 18; 8 in total) in the left hand maplist window (selected maps are indicated by a blue colour), press the ">" sign to add them to the right hand Create MapList window and press "OK" to save the new maplist. Double click with the mouse the newly created Maplist "ET". In the MapList window select as display option "Open as Slide Show", as Representation select "Pseudo" and press "OK" twice, add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed, inspect the map values. Note that also over the land surface there are 'no data' pixels and negative values. Furthermore note that the unit is still in kg/m^2. Close the animation window when finished.

To get the aggregated 24 hr ET in mm/day, select from the main ILWIS menu the option "Operations" > "Raster Operations" > "Map List Calculation". Enter the following expression:

```
iff(@1>=0,@1,?)
```

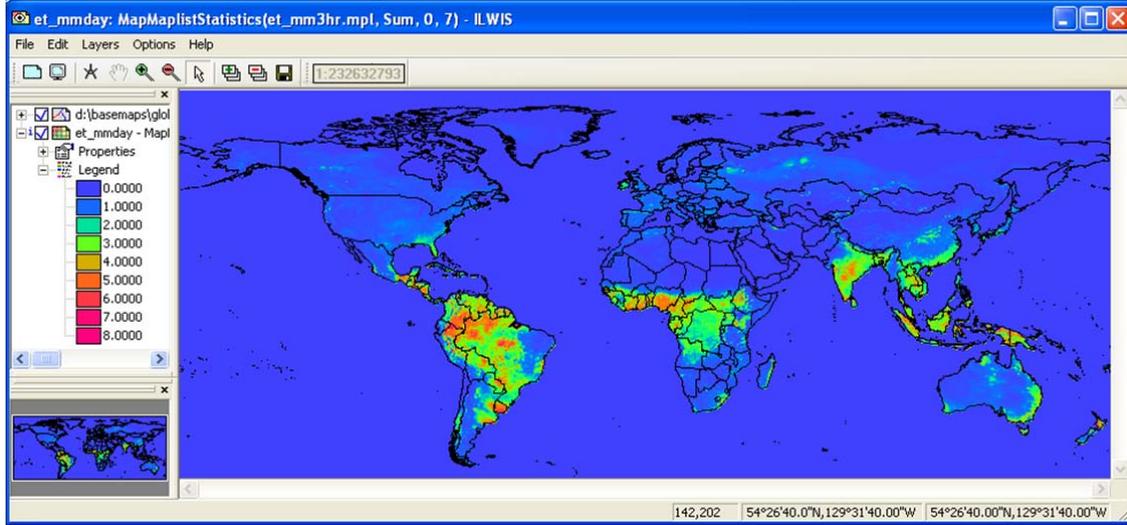
Select as MapList @1 "ET" and as Output MapList "ET_notnegative" and press "Show" and display the newly created maplist using a "Pseudo" Representation. Note that all negative values are now assigned 'no data'.

To convert the data to mm per time step (here mm/3 hr) for those pixels that are assigned a positive value and for the pixels that are assigned 'no data' a value of '0' is assumed, enter the following expression in the Map List Calculation window:

```
ifnotundef(@1,@1*3*3600,0)
```

Select as MapList @1 "ET_notnegative" and as Output MapList "ET_mm3hr" and press "Show". Also display this map list. Now all 3 hourly maps can be added to derive the daily total ET. Now from the main ILWIS menu, select "Operations" > "Statistics" > "MapList" > "MapList Statistics". As Maplist select "ET_mm3hr", as function specify "Sum", as output raster map "ET_mmday" and press "Show". Display this map using a "Pseudo" Representation. Note that the given procedure is neglecting the negative and no data pixels per time step! Your results should resemble those of the figure below.

Figure 4.8.2: GLDAS-Hoah model daily ET



4.10.2 GLDAS Soil Surface Moisture - Skin Temperature

To retrieve the GLDAS day and night time soil moisture products, select from the "ISOD" > "Toolbox" main menu the options "Global Land Data Assimilation System" > "Surface Soil Moisture – Skin Temperature" > "Day time LPRM TMI/TRMM SSM and Skin Temperature". Enter a suitable Date string, here as example "20120425" is used. Check the output folder and press "Import".

After the import has been completed two new maps have been created, first display the map created: "LPRM_TMI_day_sm_x20120425", use as Representation "Pseudo" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

Display also the map "LPRM_TMI_day_ts20120425" use as Representation "Pseudo" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

From the "ISOD" > "Toolbox" main menu select the options "Global Land Data Assimilation System" > "Hydrology" > "Night time LPRM TMI/TRMM SSM and Skin Temperature" and use the same date stamp. Display both the retrieved "night_sm" and "night_ts" products using as Representation "Pseudo" and press "OK", add the country boundaries (no Info, boundaries only) and using the mouse with the left button pressed inspect the map values.

4.11 AMESD-SADC ONLINE PRODUCTS

4.11.1 Introduction to the AMESD-SADC online products

AMESD-SADC products are created by a number of organizations from the SADC region. Further info on the partners in this program can be found at: <http://www.amesdsadc.org/partners>. To retrieve the online data from the AMESD-SADC program open the “ISOD” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “AMESD”. For the Folder item under “SADC_agriculture”, “SADC_drought”, “SADC_fire” and “SADC_forecasting” specify the appropriate directory and press “Save” to store the drive:\directory settings. Note that for the visualization also use is made of IrfanView. Therefore check under the Folder item “Special locations” if the location to “iview*.exe” is properly specified as a Fire Danger Index Forecast product is using Irfanview for visualization. Move to your working directory using the ILWIS Navigator. Close ILWIS and open it again.

Note that the DBMS server has a few decades of data online; check the AMESD online products currently available from <http://www.amesdsadc.org/data/products/>. Within the various sub-directories the relevant date-time stamps for the products can be obtained which are currently online. Further details on the various products can be obtained from the reference provided in chapter 3.9 and from http://www.amesdsadc.org/data/documents/manuals/Products_and_Services/. Retrieve the document: SADC_THEMA_products_services_users_guide_v2.pdf for a more detailed description of the product generation and the use. Details with respect to the product file name conventions used are presented in the table below.

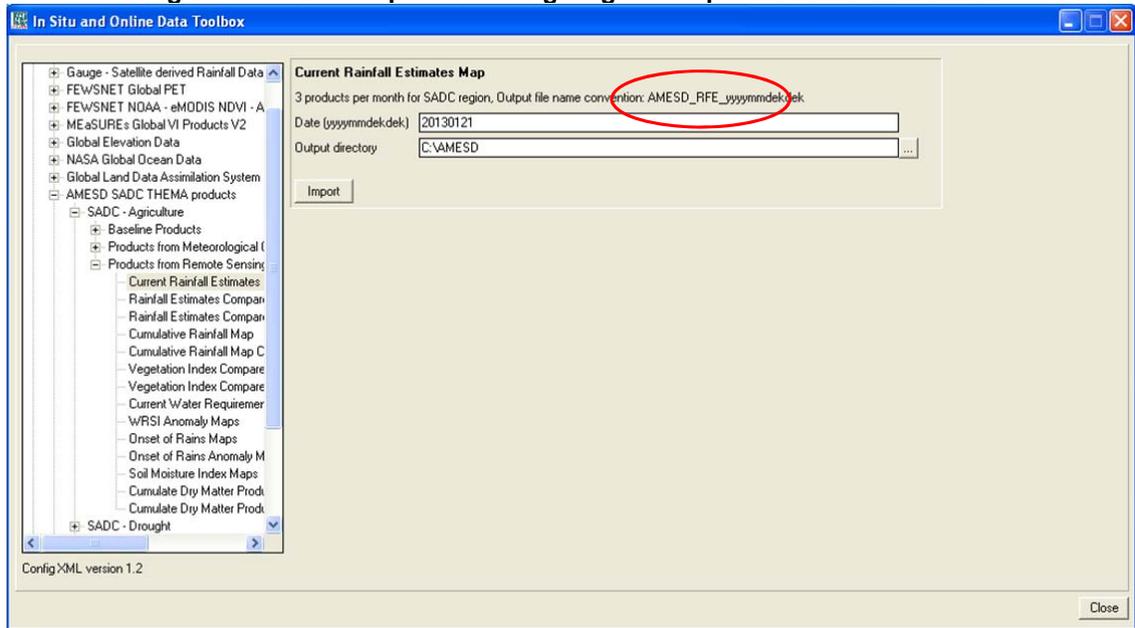
Table 4.9.1: AMESD-SADC product abbreviations used

Abbreviation	Full name
<i>T</i>	<i>Temperature</i>
<i>RFE</i>	<i>Rain</i>
<i>c</i>	<i>Cumulative</i>
<i>P</i>	<i>Percentage</i>
<i>avg</i>	<i>Average</i>
<i>d</i>	<i>Difference</i>
<i>max</i>	<i>Maximum</i>
<i>min</i>	<i>Minimum</i>
<i>An</i>	<i>Anomaly</i>
<i>an</i>	<i>Above normal</i>
<i>bn</i>	<i>Below normal</i>
<i>n</i>	<i>Normal</i>
<i>on</i>	<i>Onset of Rains</i>
<i>LRF3</i>	<i>Long range forecast over three months</i>
<i>Lt</i>	<i>Long term</i>
<i>sd</i>	<i>Standard deviation</i>
<i>Ss</i>	<i>Seasonal</i>
<i>DR</i>	<i>Drought</i>
<i>b</i>	<i>Boolean</i>
<i>gd</i>	<i>Graded</i>
<i>g (prefix)</i>	<i>Ground</i>
<i>g (suffix)</i>	<i>Graph</i>
<i>Speci</i>	<i>Specific</i>
<i>CFWI</i>	<i>Canadian Fire Danger Index</i>
<i>FDI</i>	<i>Fire Danger Index</i>

Last but not least, given the large number of products available, per item also the output file name convention is provided. In the example below (see figure 4.9.1) the output file name convention is given for the current rainfall estimates map: “AMESD-RFE_yyyymmdekdek”. Note that for most of the products for the agriculture and drought service the temporal resolution is on decade (10 day) basis, the decade convention used is 01, 11 and 21 for the 1st 10 day period, 2nd 10 day period and last part of the month respectively. In the example the date stamp format given is ‘20130121’, indicating the last decade of January, 2013. Currently not all Agriculture Baseline products are online, there is an agricultural mask, having as date stamp “20110101”. The agriculture mask its almost static and only changes as soon as new improved products comes in. The date on the product just reflects the date on which the product was generated. At this moment for the crop statistics and crop specific maps input from SADC member states is required which needs further data collection. For the ‘Fire’ and ‘Forecasting’ products other temporal

resolutions and Regions of Interest are used. The date-time stamp format required is specified for each of the products. Below a number of examples are given showing how the data can be retrieved and imported for the various services. Note that the time stamp you are going to use is likely different from the one used below!

Figure 4.9.1: Data import window giving the output file name convention



4.11.2 SADC-Agriculture

First a number of SADC-Agriculture products are going to be retrieved. These products are mainly created by BDMS. All products have a spatial resolution of 1km and are referenced to the Geographic Lat/Long projection, WGS84. Open from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Agriculture" > "Products from Remote Sensing" > "Cumulative Rainfall Map". Specify an appropriate Date stamp, note the Output directory defined and press "Import". Display the map "AMESD_RFEc_yyyymmdekdek", use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off").

This map shows the progressive sum of dekadal rainfall estimates since the start of season and is updated every 10 days. The rainfall is cumulated from the start of season up to the end of season. The start of season and end of season for the SADC has been defined as from September to April. The product is created by summing up the rainfall estimates from the start of season up to the current period.

Open from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Agriculture" > "Products from Meteorological Ground Measurements" > "Current Conditions Air Temperature Map". Specify an appropriate Date stamp, note the Output directory defined and press "Import". Display the map "AMESD_gT_yyyymmdekdek", use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off").

The ground measurement products use data obtained from [ftp://ftp.ncdc.noaa.gov/pub/data/g sod](http://ftp.ncdc.noaa.gov/pub/data/g sod). This product is generated by interpolation of daily air temperature measurements. At the end of the ten days the daily air temperature are averaged to come up with a 10 day average temperature map. Air temperature is one of the weather elements which determine plant growth and development during the ploughing season. Very high temperatures immediately after ploughing may cause crop germination failure and plant wilting during the development stage due to high evaporation and transpiration while very low temperatures at harvesting period may cause frost bite to crops thus causing poor yield.

4.11.3 SADC-Drought

Some of the SADC-Drought products are created by the Agricultural Research Council from South Africa. For some of the products a resampling is performed to ensure that these products have the same georeference as those from the agricultural service.

Open from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Drought" > "Vegetation Performance Maps" > "Long Term Average NDVI". Specify an appropriate Date stamp, note the Output directory defined and press "Import". Display the map "AMESD_LtavgNDVI_yyyymmdekdek", use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off").

This product is calculated as $(NDVI_{A1} + \dots + NDVI_{Ax})/x$, where 'x' is the number of years considered and 'A' is a specific 10-day period. Furthermore you will note that the data is scaled in a byte range. To convert to real NDVI values a scaling (0.004) and offset (-0.1) (according to the VGT4Africa User Guide – Manual, 2006) have to be applied.

Type the following expression on the ILWIS command line:

```
NDVI_LtavgReal:=(0.004*AMESD_LtavgNDVI_yyyymmdekdek)-0.1
```

Where: NDVI_LtavgReal is the new output map calculated

AMESD_LtavgNDVI_yyyymmdekdek is your imported Long Term Average NDVI map

In the Raster Map Definition window accept the defaults and press "OK". Display the map "NDVI_LtavgReal", using as Representation "NDVI" and press "OK", eventually add the country boundaries (using as display options "boundaries only" and info "off").

Open from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Drought" > "Vegetation Performance Maps" > "Long Term PASG". Specify an appropriate Date stamp, note the Output directory defined and press "Import". Display the map "AMESD_PASG_yyyymmdekdek", use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off"). Move the mouse cursor over the map display window keeping the left mouse button pressed to inspect the map values.

PASG measures the relationship (expressed as a percentage) of the vegetation condition for portions of the growing season to historical average conditions for comparable time periods. The PASG is one of the key spectral indices used in Vegetation Drought Response Index (VegDRI) models. PASG is based on time-series NDVI and is useful for monitoring crop condition. It is computed as:

$$PASG_{PnYn} = \left(\frac{SG_{PnYn}}{xSG_{Pn}} \right) \times 100$$

Where: SGPnYn refers to the seasonal greenness (SG) for a ten-day period (Pn) of a specific year (Yn) and xSGPn is the historical average for the same ten-day. PASG values range from 0 to 250 percent of the seasonal greenness range for each pixel. The data are truncated at 250 percent so that PASG can be delivered as byte data.

PASG values less than 100 percent occur when the accumulated SG for a period is less than the historical average. Low PASG values indicate poor vegetation conditions while PASG values greater than 100 percent occur when the accumulated SG is greater than the historical average and indicate vegetation conditions better than those typically found during that time period. This product is directly applicable for monitoring of vegetation condition over time and in particular of the on-going growing season. It can be used to get a quick assessment of how well the current growing season is doing and what regions might need particular attention. It is further useful in agricultural monitoring where it has a 'flag' function, identifying possible zones at risks for low agricultural production (source: SADC_THEMA_products_services_users_guide_v2.pdf).

Another product is the Drought Risk map, to import such a map, select from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Drought" > "Drought Maps" > "Drought Risk Map (Graded Type)". Specify an appropriate Date stamp, note the Output directory defined and press "Import". Display the map "AMESD_DRrisk_gd_yyyymmdekdek", use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off"). Move the mouse cursor over the map display window keeping the left mouse button pressed to inspect the map values.

This map is showing varying risk of drought occurring currently and into the near future (3-months) based on current conditions (PASG or percentage of cumulative rainfall) and the three month outlook product provided by the SAWS (see also below, chapter 4.9.5). Inputs are the 3-month rainfall outlook and either percentage of long-term average rainfall for a recent period or PASG for a recent period. The advantage is that this product also represents the intensity of the drought in different shades which is not apparent in the 'Drought Risk Map (Boolean type)'.

The algorithm applied is: $\text{Drought risk}_{\text{graded}} = (A) * (1 - B)$

Where: A = 3-month chance for rainfall below 33rd percentile expressed as factor ranging between 0 and 1

B = PASG expressed as factor ranging between 0 and 1 or B = Rainfall as a percentage of average expressed as a factor ranging between 0 and 1

4.11.4 SADC-Fire

The products are mainly created by the Council for Scientific and Industrial Research (CSIR Meraka) in South Africa, apart from the MSG WildFire_Automated Biomass Burning Algorithm product. Data are transferred to the BDMS online server. These products come with a different georeference and if they need to be integrated with other data from the agricultural or drought service, the raster maps have to be resampled.

To import Fire products, select from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Fire" > "Canadian Forest Fire Danger Index". Specify an appropriate Date stamp, now defined as 'yyyymmdd', note the Output directory defined and press "Import". Display the map "CSIR_cfw_i_yyyymmdd1200_c", use the default Representation, eventually add the country boundaries (using as display options "boundaries only" and info "off"). Move the mouse cursor over the map display window keeping the left mouse button pressed to inspect the map classes. Also note that a map "CSIR_cfw_i_yyyymmdd1200_val" is created, this map is containing the values (without classification!).

The Fire Danger Index (LFDI) is a forecast product. As Date stamp the actual day needs to be provided and the forecast period, e.g. '2013021372'. The LFDI is retrieved for 13 February 2013 and the forecasting period is 72 hours. Note that this product is displayed using IrfanView, check under "Configuration" > "Folders" > "Special Locations" if the 'Iview' executable is properly defined. Specify an appropriate date stamp, press "Import" and the LFDI map is shown. To close the map press <Esc>.

To retrieve a Burned Area Product the start and end time stamps in 'Day of the Year – format' are required. To see the online products use Internet Explorer and navigate to <http://www.amesdsadc.org/fire-products>, select the Fire Service and subsequently select the MODIS Burnt Area Product and note the date stamp of the product you want to import. For conversion between Julian day and calendar day select from the ISOD Toolbox menu the option "Display Julian Day tables"! Here as example the BA product having a date stamp of "2012275_2012305" is extracted (note the underscore between the starting date and ending date!), representing the period from 1st to 31st October 2012 (leap year!). Display the map "CSIR_ba_2012275_2012305" using a "Pseudo" Representation and inspect the map values. Also add the country boundaries (using as display options "boundaries only" and info "off"). The MODIS active fire product detects fires in 1km pixels that are burning at the time of overpass under relatively cloud-free conditions using a contextual algorithm.

The MSG WildFire_Automated Burned Biomass Algorithm (ABBA) product is also using a Julian day format. Select an appropriate date and import a product. This product is available at hourly temporal resolution (1 minute after each full hour!) and provides location and instantaneous fire temperature.

To import MSG-ABBA Fire product, select from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SADC - Fire" > "MSG-ABBA Fire Product". Specify an appropriate Date stamp, now defined as 'yyyjjjhhmm', note the Output directory defined and press "Import". Display the point map "MSG_ABBA_yyyjjjhhmm", use "single symbol", as symbol select for Size "3" and as Fill Color "Red" and press "OK" twice. Add the country boundaries (using as display options "boundaries only" and info "off"). From the active map window select from the menu the option "File" > "Open Pixel Information". Move the mouse cursor to a fire location on the map and note the content of the attribute table.

4.11.5 SADC-Forecasting

Seasonal forecasting products with respect to rainfall, minimum and maximum temperature are created by SAWS and transferred to the BDMS online server. Open from the "ISOD" > "Toolbox" main menu the options "AMESD SADC THEMA products" > "SAWS – Seasonal Forecast" > "Seasonal Rainfall Forecast" > "SADC rainfall forecast Above Normal". Specify an appropriate Date stamp, note as import stamp the actual month is required and the months for which the forecast period is valid, e.g. 'feb_mam' should be interpreted as 'feb': moment the forecast was produced and 'mam': MarchAprilMay being the forecast period. Enter an appropriate Date stamp, check the Output directory defined and press "Import". Display the map "SAWSRAIN_ANxxx_abc" (where xxx=actual month, abc=predicted period), use as Representation "Pseudo", eventually add the country boundaries (using as display options "boundaries only" and info "off").

Import also the Below Normal and the Normal Rainfall Forecast for the same period. From the active map window displaying the map "SAWSRAIN_ANxxx_abc" select from the menu the option "File" > "Open Pixel Information". From the Pixel Information window select "File" > "Add Map" and select the other two imported rainfall forecast products ("SAWSRAIN_BNxxx_abc" and "SAWSRAIN_NNxxx_abc"). Move the mouse cursor over the map and note the probabilities for normal, below and above normal rainfall forecast. The sum of the 3 maps is 100!

The procedure to import the seasonal minimum and maximum temperature forecasts are identical as for the seasonal rainfall forecast.

4.10 WEB MAPPING SERVICES

4.10.1 Introduction

In the toolbox a number of routines have been included to retrieve information from various online resources that are currently not converted into an ILWIS data format, but use is made of the files as retrieved and these are visualized using IrfanView and Panoply. Open the “ISOD” > “Toolbox” options from the left hand menu tree and open the item “Configuration” > “Folders”. Note that here the assumption is made that you have created on your local system, using drive “C”, a directory called “WMS”. For the Folder items under CPC_SST, ECMWF, ITCZ, MET_UK, MPE2Google, NOAA_chart and RFS2Google specify the appropriate directory and press “Save” to store the drive:\directory settings. Note that for the visualization use is made of IrfanView, Also check under the Folder item “Special locations” if the location to “iview*.exe” is properly specified. Move to the new working directory using the ILWIS Navigator. Close ILWIS and open it again.

4.10.2 MPE and RFS to Google

These two services make use of the 15 minutes precipitation products, the MPE derived from MSG and the RFS derived from GOES. At ITC these 15 minutes products are aggregated to obtain the 24 hour precipitation amount in mm (from 00:00 to 23:45 UTC). These files are compressed and subsequently transferred to a FTP site (<ftp://ftp.itc.nl/pub/mpe/>). After specifying an output directory the application can be started, the accumulated 24 hour precipitation map is downloaded, decompressed and transformed into a PNG format (with a transparent layer for the areas that have not received precipitation). A “KML” file is created and executed which invokes Google Earth to start and display the results. These applications assume that Google Earth is locally available.

From the “ISOD” > “Toolbox” main menu select the “Web Mapping Services”, “MPE to Google” > “Aggregated 24 hour MPE to Google Earth” sub menu. In this case only the “Date” field and the “Output Directory” need to be specified. Enter a suitable date, e.g. “20111101” to extract the 24 hour aggregated Multi Sensor Precipitation Estimate from the ITC-FTP site and press “Import”. Note that in order to produce this map, 96 events over a 24 hour period have been processed, and you extract the sum of all these 15 minutes events. The unit is in mm / 24 hours, from 00:00 to 23:45 UTC for a given day. During UTC noon the precipitation map of the previous day is available from this FTP site. The map is shown in Google Earth and after inspection the application is closed. The original data (in ILWIS format) is not deleted and can be displayed using ILWIS (having as file name “fsummsgmpeyyymmdd”), using as Representation “mpe_sum”. Display also this map using ILWIS and add the country boundaries (no Info, boundaries only) and check the map values.

Also select the option “Web Mapping Services” > “RFS to Google” > “Aggregated 24 hour RFS to Google Earth”, note the output directory and specify an appropriate Date stamp, e.g. “20111101” and press “Import”. The unit is in mm / 24 hrs, from 00:00 to 23:45 UTC for a given day. During UTC noon the precipitation map of the previous day is available from this FTP site. The map is shown and then the Google Earth application can be closed. The original data (in ILWIS format) is not deleted and can be displayed (having as file name “fsumrfsyyymmdd”), using as Representation “mpe_sum”. Display also this map using ILWIS and add the country boundaries (no Info, boundaries only) and check the map values.

4.10.3 Surface Pressure Forecast Europe

Once more, before you start this routine check under the options “Configuration” > “Folders” > “Special locations” if the IrfanView directory and “i_view” executable is correctly specified, see also chapter 2.4. In the “Configuration” > “Folders” subsequently select “MET_UK”. Ensure that the drive:\output directory settings are correctly specified as well. Use the ILWIS navigator to move to the drive:\directory specified.

From the “ISOD” > “Toolbox” main menu select the “Web Mapping Services”, “Surface Pressure Forecast Europe” > “UK MET Office surface pressure (T+0) to 84-hour (T+84) forecast”, note the output drive:\directory and press “Import”. An animation is showing the pressure forecast.

Note that if the slide advancement is not appropriate; open an instance of IrfanView yourself. From the menu select “File” > “Slideshow”. Modify the timing of the “Slide advancement”, specify for “Automatic after” “1.00” seconds and activate the option “Play in full screen mode (current monitor)”. Close IrfanView

and start the retrieval procedure once more. You can also modify other settings in IrfanView according to your preferences. For further assistance using IrfanView consult the "Help" function from the menu of the software.

4.10.4 **Current Position of the Africa ITCF**

From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services", "Current Position of the Africa ITCF" > "Latest Current Position of the ITCF-ITCZ (NOAA)" and press "Import". To terminate the image visualization press <Escape>. Note that only the current ITCZ dekadal image is given when it is situated over the Northern Hemisphere!

4.10.5 **NOAA Weather Charts**

From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services", "NOAA Weather Charts" and select your region of interest, here "Europe-Africa" is used as example. Select "NWS forecast for FL050 (5000 ft, using int. pressure datum of 1013.25 hPa)" and press "Import". After retrieval of the files an animation is repeated a couple of times, note the change of the time stamp of the forecast. For details on the Flight Level used and image symbols consult also chapter 3.10.1.

4.10.6 **NOAA-CPC SST and SST Anomaly**

Before you start this routine first check under the options "Configuration" > "Folders" > "Special locations" if the IrfanView directory and "i_view" executable is correctly specified, see also chapter 2.4. In the "Configuration" > "Folders" subsequently select "CPC_SST". Ensure that the drive:\output directory settings are correctly specified as well. Use the ILWIS navigator to move to the drive:\directory specified.

From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services" > "NOAA-CPC SST-SST Anomaly" > "Latest 12 weeks SST and Anomaly animation" and press "Import". After retrieval of the files the SST and anomaly animation shown. You can stop the animation by pressing the <Esc> button of your keyboard. Note the change of the weekly time stamp of the SST and Anomaly in the animation (12 weeks before present).

4.10.7 **ECMWF Re-Analysis**

Before you start this routine first check under the options "Configuration" > "Folders" and subsequently select "ECMWF". Ensure that the drive:\output directory settings are correctly specified. Use the ILWIS navigator to move to the drive:\directory specified. Note that this option is making use of the Panoply utility for visualization of the downloaded data. Check the description in chapter 1.5 if you have correctly installed "Panoply" (the "Panoply.exe" and associated sub-directories should be available in root of the ILWIS sub-directory "Extensions\ISOD-Toolbox\util\Panoply").

This routine expects that the data is locally available, retrieved in NetCDF format. Before you start the routine first download manually the data which you want to visualize from http://data-portal.ecmwf.int/data/d/interim_daily/. Here as an example the data for the month of "June 2012", Time: "12:00:00", Step: "12" and Parameter: "Sunshine Duration" is selected and downloaded. The file ("output.nc") is stored locally in the specified working directory.

From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services" > "ECMWF Re-Analysis data" > "Show ERA Interim Daily Fields" and press "Import". After acknowledgement of the copyright press "<enter>" to start the application. After Panoply has started, browse to your working directory and select the file "output.nc" and press "Open". Double click on the layer "sund", select as Plot type "Lon-La" to see the resulting Sunshine Duration global plot of "2012-06-02 00:00". From the menu you can always consult the "Help" function to get further information on the functionality of this utility. You can close the application when finished inspecting the data.

4.10.8 **Online Maps**

For this collection of routines no input or output folders need to be specified. From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services" > "Online Maps" > "Show Google Maps" and press "Import". Might be that your Internet Explorer browser is blocking the display of the content; in that case

select from the browser "Allow blocked content". A world zoom is presented and you can zoom in to see additional details. Close the browser window.

From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services" > "Online Maps" > "Search in Google Maps", provide the 'Location+Country', as example "Paris+France" can be used and press "Import". A map showing the Paris municipal area is retrieved and you can zoom, pan, etc. according to your requirements.

Another option is provided by 'Virtual Earth'. From the "ISOD" > "Toolbox" main menu select the "Web Mapping Services" > "Online Maps" > "Show MS - Virtual Earth" and press "Import". In the new popup window set your map latitude and longitude coordinate as well as zoom factor. Enter here for latitude "52.308" and as longitude "4.758", zoom factor of "12" and press "OK". You should see 'Schiphol International Airport', situated on the south western fringe of Amsterdam, the Netherlands. Eventually unselect "Labels", pan and zoom according to your preference.

4.11 DISPLAY JULIAN DAY TABLES

This application was inserted for easy reference. As a number of products use Julian Day format for their date stamps, the tables can be consulted to quickly transform a calendar date to a Julian Day. Two tables are available, one for normal and one for leap years.

To start the routine, select from the "ISOD" > "Toolbox" main menu the option "Display Julian Day Tables" and subsequently select the Normal or Leap year table and press "Import". The table is displayed and for each Julian day the corresponding calendar date is given.

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5. CONCLUSIONS

This manual is mainly focussing on data retrieval and visualization of the various free environmental data sources residing on the internet. Other documents demonstrating how to further process the data can be found under the links indicated in appendix 2.

Various environmental data resources, especially time series of data, are currently freely available through the internet but the potential User Community is likely not aware of its existence. The "***In Situ and Online Data Toolbox***" (ISOD) is therefore developed to easily ingest these data sources. To operate the toolbox, internet connectivity is required. Some of the data sources are having high data volumes and therefore a reasonable bandwidth is required to smoothly operate some of the toolbox routines, especially for import of time series data.

The archived time series of data supplement the near real-time data currently disseminated through telecommunication based data dissemination systems like GEONETCast. It is hoped that when using the toolbox routines developed the various data sources are used for appropriate assessment of the environment. Currently a focus was given to global data sets and data provision for Africa. If toolbox users have links to other resources they would like to have included in a next version of the ISOD toolbox contact the EO-Community Contact at: <http://52north.org/communities/earth-observation/community-contact>. This link can also be used if other remarks or comments do arise.

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APPENDICES

Appendix 1: Other utilities available at the EO Community web pages at 52North.org

Various other software utilities have been developed over time are released via the 52North.org web portal, through the Earth Observation Community, available at: <http://52north.org/communities/earth-observation/overview>. A short overview of the freely available ILWIS plug-ins is presented below. Also dedicated ILWIS scripts are available to import the Culture MERIS, MERIS Reduced Resolution S10 and METOP AVHRR-S10 data (under data bases) as well as various documents and useful links.

ILWIS plug-ins to handle free Environmental data sources



Current data dissemination systems, like GEONETCast, provide free, near real-time Environmental and Earth Observation data together with derived products to a worldwide user community. The environmental data is delivered on a global scale via communication satellites. Next to this, a multitude of environmental relevant data is residing in online archives. To integrate this information toolbox plug-ins have been developed, also dealing with specific geographic regions only upon user request, like the AMESD-SADC Toolbox and the Water and Food Security Toolbox for Ethiopia.

The toolbox plug-ins, coupled with the existing ILWIS processing utilities, facilitate easy integration of large amounts of environmental data into various applications related to weather, atmosphere, oceans, land, vegetation, water and environment.

General Key Features:

- open design and easy user configuration
- GEONETCast automated data management system for dedicated storage of data

Features GEONETCast Toolbox Version 1.4

- import routines for various satellites, Meteorological Product Extraction facility (MPEF), Satellite Application Facilities (SAF's), Chinese Meteorological Administration and 3rd party data providers such as TAMSAT, DevCoCast, MODIS, SPOT Vegetation
- integration of METOP-AVHRR and JASON-2 data
- export routines to BILKO and R
- calculation of solar and MSG zenith and azimuth angles
- real time METEOSAT Second Generation visualization

Features Water and Food Security-Ethiopia Toolbox Version 1.0

- processing selected GEONETCast data relevant for water and food security monitoring and analysis for Ethiopia, including Meteorological Data Dissemination Service routines

Features ISOD Toolbox Version 1.3

- retrieval and import of data from various free online archives related to in situ climatological observations, gauge and satellite derived rainfall estimates, weather and pressure forecasts, potential evapotranspiration, normalized difference vegetation indices, ocean and elevation information

Features AMESD-SADC Toolbox Version 1.2

- import and pre-processing of all products disseminated by the AMESD-SADC program for southern Africa, related to agriculture, drought and fire

Appendix 2: Utilities available at the ITC GEONETCast web pages

For access to the Capacity Building utilities use can be made of the information and documents posted on: <http://www.itc.nl/Pub/WRS/WRS-GEONETCast>. Various documents are presented here providing further information on data dissemination systems providing a multitude of free environmental information, without the need for internet access but using a local ground receiving station for reception of the data.

For more advanced use of the environmental information in ILWIS use can be made of the so-called "GEONETCast-DevCoCast Application manual", providing various exercises, including description, exercise data and powerpoint presentation. Also other training materials are available from the ILWIS community at <http://52North.org> as well as from <http://www.itc.nl/ilwis/downloads/ilwis33.asp>, check the left hand "*Documentation*" and "*Applications*" tabs.

Also a Moodle based Capacity Building portal, the "Earth Observation Capacity Building Portal" is under construction, providing a lot course materials provided during various workshops conducted. The link to this resource is <http://130.89.212.208:100/>. It requires a password; you can contact the corresponding author for access.

Finally various resources, like scripts, base maps, sample data, etc. are also posted at <ftp://ftp.itc.nl/pub/52n/> for easy access by the user community.

Appendix 3: Changelog

ISOD Toolbox version 1.3

In this release some new resources have been added. All internet links have been checked and modified when the URL's or the products have changed, to assure proper operation.

Changes

In the XML version 1.3 of the ISOD toolbox a number of additional routines are added, like the MOD16 ET and PET products, the Soil Water Index from the Copernicus Global Land Service, a Geotif import routine to quickly import the Landsat-8 images and retrieval of online maps from Google and Virtual Earth. The TAMSAT climatology has been modified to represent the 30 years climatology currently provided.

ISOD Toolbox version 1.2

The ISOD toolbox XML version 1.2 menu structure has been modified to reflect the changes due to the reprocessing of the CMORPH and TRMM rainfall data. Also some new resources have been added. All internet links have been checked and modified when these have changed to assure proper operation.

Changes

In the XML version 1.2 of the ISOD toolbox the import routines of the CMORPH and TRMM 3B42 have been adapted to incorporate the changes due to reprocessing of the rainfall estimates. The TRMM extraction routine makes use of a small Java based utility; this requires installation of JAVA RTE. Next to this, routines have been added to display Julian Day tables for normal and leap years, 3 and 6 hourly precipitation estimates from the GWADI server, GLDAS-Noah model data (28 parameters) for 3 hour intervals on a daily basis, online rolling archive of AMESD-SADC products (these routines are developed by Masego Rachel Nkepu, BDMS-Botswana).

ISOD Toolbox version 1.1

The ISOD toolbox v1.1 menu structure has been modified substantially and a number of new data retrieval – import routines have been added. The menu structure, also due to the addition of routines, required modification. The Web Mapping Services now focus on retrieval of data sets that are not imported into an ILWIS data format, the data is visualized using IrfanView or Panoply. All other routines extract (multi-temporal) data which is subsequently transformed into an ILWIS data format for further analysis. Next to this for all routines first a check is done if the data is available from the archives, if this is not the case the user is informed about the missing data and can abort the import procedure. The Installation and User Guide has been updated to reflect the changes incorporated.

Changes

In the XML version 1.1 of the ISOD toolbox various changes have been implemented. The most important are:

Modification of the menu, the web mapping services are now retrieving the data and do not convert these into ILWIS data format, the data is visualized using IrfanView and Panoply.

All routines have been checked and in case data sources have been modified (e.g. re-processed) or if links to these data sources have changed the import routines have been adapted. Some bugs in import routines have been corrected.

All routines now first check if data is downloaded before further processing is done, if no data can be retrieved the routine can be aborted.

New routines have been added, like retrieval of:

TRMM 3B42 global daily rainfall archive;

MEaSURES Global Vegetation Products (NDVI and Enhanced Vegetation Index) for various data integration periods, like daily, 7-days, 15-days and monthly time intervals;

NASA Global Ocean Data (day and night time SST and Chlorophyl-a from MODIS Terra and Aqua);

Daily Surface Soil Moisture from TRMM-TMI (day and night time overpasses) from the Global Land Data Assimilation System;

Web Mapping Services, added visualization of data from the ECMWF (using Panoply) and NOAA-CPC SST and SST anomaly animations.

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