

FACULTY OF GEO-INFORMATION SCIENCE  
AND EARTH OBSERVATION

**ITC**

# CABO VERDE TOOLBOX

**INSTALLATION, CONFIGURATION AND  
USER GUIDE OF THE CABO VERDE  
TOOLBOX PLUG-IN FOR ILWIS 3.8.6**

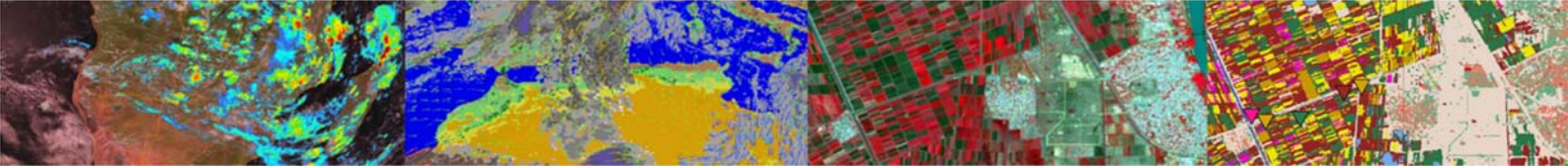
**XML version 1 or higher**

Ben Maathuis, Chris Mannaerts and Bas Retsios  
Department of Water Resources (WRS)

February 2021

**UNIVERSITY OF TWENTE.**





## Colofon:

University of Twente  
Faculty of Geo-information Science and Earth Observation  
Department of Water Resources

Date last modified:  
30 July 2020

Published version:  
Version 2.0, available at:  
Cabo Verde Toolbox: [http://filetransfer.itc.nl/pub/52n/ILWIS386/Toolbox\\_plugin/](http://filetransfer.itc.nl/pub/52n/ILWIS386/Toolbox_plugin/)  
ILWIS386 (latest release): <http://filetransfer.itc.nl/pub/52n/ILWIS386/Software/>  
Sample Data: [http://filetransfer.itc.nl/pub/52n/gnc\\_exercisedata/gnc\\_data/](http://filetransfer.itc.nl/pub/52n/gnc_exercisedata/gnc_data/)

E-mail corresponding author:  
[b.h.p.maathuis@utwente.nl](mailto:b.h.p.maathuis@utwente.nl)

Postal address:  
Hengelosestraat 99  
P.O. Box 217  
7500 AE Enschede  
The Netherlands

Website:  
<https://www.itc.nl>

Published by:  
University of Twente  
Faculty of Geo-Information Science and Earth Observation  
Departments of Water Resources and Geo-information Processing



© This work is licensed under the Creative Commons Attribution-NonCommercial 4.0 License. To view a copy of this license, visit <https://creativecommons.org/licenses/by-nc/4.0/> or send a letter to Creative Commons, 444 Castro Street, Suite 900, Mountain View, California, 94041, USA.



## List of acronyms and abbreviations

52North	52°North Initiative for Geospatial Open Source Software
AFIS	Advanced Fire Information System
AMESD	African Monitoring of the Environment for Sustainable Development
AMV	Atmospheric Motion Vector
AVHRR	Advanced Very High Resolution Radiometer
AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data
BRAT	Basic Radar Altimetry Toolbox
BUFR	Binary Universal Form for the Representation of meteorological data
CBERS	Chinese Brazilian Earth Resources Satellite
CCD	Charge Coupled Device
CLAI	Cloud Analysis Image
CTH	Cloud Top Height
DMP	Dry Matter Productivity
DN	Digital Number
DSLF	Down welling Surface Long-wave radiation Flux
DSSF	Down welling Surface Short-wave radiation Flux
DVB	Digital Video Broadcast
EAMNET	European African Marine Network
ESA	European Space Agency
ET	Evapotranspiration
EUMETCast	A satellite based data dissemination of various (mainly satellite based) data covering Europe and Africa
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FVC-FCOVER	Fraction of Vegetation Cover
GDAL	Geospatial Data Abstraction Library
GEO	Group on Earth Observation
GEONETCast	A global network of satellite based data dissemination systems
GEOSS	Global Earth Observation System of Systems
GNC	GEONETCast
GRIB	Gridded Binary data format
GSOD	NOAA's Global Summary of Day network
GUI	Graphical User Interface
HRIT	High Rate Image Transmission
HRV	High Resolution Visible
ILWIS	Integrated Land and Water Information System
INIDA	Instituto Nacional de Investigação e Desenvolvimento Agrário, Cabo Verde
ITC	Faculty of Geo-Information Science and Earth Observation
IR	Infra Red
ISD	Integrated Surface Data
JASON	The JASON altimeter program (named after the Greek mythological hero Jason)
LAI	Leaf Area Index
LSA	Land Surface Analysis
LST	Land Surface Temperature
METOP	Meteorological Operational satellite programme
MODIS	Moderate Resolution Imaging Spectrometer
MPE	Multi sensor Precipitation Estimate
MPEF	Meteorological Product Extraction Facility
MSG	Meteosat Second Generation
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NIR	Near Infra Red
NOAA	National Oceanic and Atmospheric Administration
PML	Plymouth Marine Laboratory
PROBA-V	Proba Vegetation Instrument



R	A language and environment for statistical computing and graphics
RFS	Rainfall Satellite
RGB	Red – Green – Blue colour assignment
SAF	Satellite Application Facilities
SAWS	South African Weather Service
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SST	Sea Surface Temperature
SWB	Small Water Bodies
TAMSAT	Tropical Applications of Meteorology using Satellite data and ground-based observations
TIR	Thermal Infra Red
VIS	Visible
VITO	Flemish Institute for Scientific Research
VPI	Vegetation Production Indicator
UCT	University of Cape Town, South Africa
USAF	United States Air Force
UTC	Universal Time Coordinated
WV	Water Vapour
XML	Extensible Markup Language

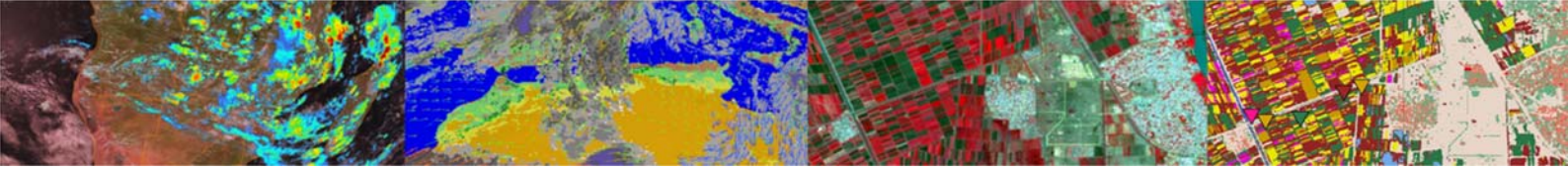


## Release notes

This Toolbox was developed in close collaboration with Instituto Nacional de Investigação e Desenvolvimento Agrário (INIDA), Cabo Verde

Following comments have to be taken into consideration with respect to the release of this Cabo Verde Toolbox, XML version 1:

1. This is an updated release and utmost care was taken to ensure appropriate operation of the routines developed but 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 GEONETCast received data sources used have been checked. For some data sources the data format or naming conventions have changed. Furthermore GEONETCast has a transient nature; some data might not be disseminated after some time. If any of such problems are encountered please report these to the corresponding author. On the other hand, some new data might be added to the data stream. If you need assistance building import routines please report them as well;
3. The Toolbox assumes a 64 bits Windows Operating System;
4. No liability can be accepted for use of the Cabo Verde Toolbox by the toolbox developers;
5. When using the Cabo Verde Toolbox you agree and comply with the conditions of the software utilities used as well as the terms and conditions stipulated by various GEONETCast (3<sup>rd</sup> party) data providers for the use or references to the source of the data;
6. Further license notes are described in the files '52N\_EO\_license.txt', 'CC-BY-NC-4.0.txt', 'About.txt' and 'Disclaimer.txt', situated in the root folder of the Cabo Verde Toolbox;
7. When not familiar with ILWIS386 a tutorial and a manual with exercises and exercise data is available at: <http://filetransfer.itc.nl/pub/52n/ILWIS386/Tutorial/>. It is strongly encouraged to consult these documents prior to start with the toolbox exercises described later within this manual. Here it is assumed that the user has a basic knowledge of GIS and remote sensing and ILWIS386 in particular.
8. Due to the transient nature of the internet some links provided in the document may no longer be active.

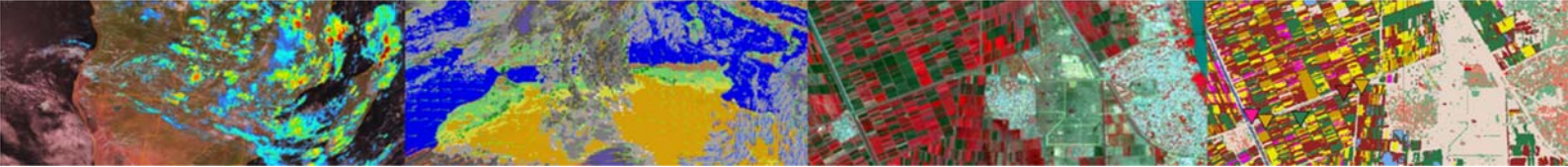


This page is blank



## Table of Contents

<b>1.</b>	<b>GENERAL INSTALLATION AND CONFIGURATION INSTRUCTIONS .....</b>	<b>11</b>
<b>1.1</b>	<b>Introduction .....</b>	<b>11</b>
1.1.1	Download and install ILWIS .....	11
1.1.2	Download the CaboVerde-Toolbox .....	11
1.1.3	Download Java Runtime Environment .....	13
1.1.4	Changing the ILWIS language settings, from English to French.....	13
1.1.5	Concluding remarks.....	13
<b>1.2</b>	<b>Configuration of the data stream using the GEONETCast Data Manager .....</b>	<b>14</b>
1.2.1	Introduction .....	14
1.2.2	General design considerations for development of the GEONETCast Data Manager .....	14
1.2.3	The GEONETCast Data Manager - "Rules" .....	15
1.2.4	Configuring the GEONETCast Data Manager.....	16
1.2.5	Making the GEONETCast data available within the organisation .....	19
1.2.6	Information on data disseminated through GEONETCast .....	20
<b>2.</b>	<b>OVERVIEW OF THE CABO VERDE TOOLBOX ARCHITECTURE .....</b>	<b>21</b>
<b>2.1</b>	<b>Introduction .....</b>	<b>21</b>
<b>2.2</b>	<b>Structure of the Cabo Verde Toolbox .....</b>	<b>22</b>
<b>2.3</b>	<b>Structure of the Config.xml.....</b>	<b>24</b>
<b>2.4</b>	<b>General Cabo Verde Toolbox Configuration - Folder settings .....</b>	<b>26</b>
<b>2.5</b>	<b>Configuring the data source of the MSG Data Retriever.....</b>	<b>26</b>
<b>2.6</b>	<b>Structure of the ILWIS Cabo Verde Toolbox scripts .....</b>	<b>29</b>
<b>2.7</b>	<b>Structure of the ILWIS CaboVerde-Toolbox batch routines .....</b>	<b>30</b>
<b>2.8</b>	<b>Changes and modifications .....</b>	<b>33</b>
<b>2.9</b>	<b>Advanced use.....</b>	<b>33</b>
<b>2.10</b>	<b>Concluding remark .....</b>	<b>33</b>
<b>3.</b>	<b>EXPLORING THE GEONETCAST DATA STREAM USING THE CABO VERDE TOOLBOX .....</b>	<b>35</b>
<b>3.1</b>	<b>Introduction .....</b>	<b>35</b>
<b>3.2</b>	<b>The CaboVerde-Toolbox functionality (XML Version 1.0).....</b>	<b>35</b>
3.2.1	Cabo Verde Toolbox General.....	35
3.2.1.1	Cabo Verde Toolbox Help .....	35
3.2.1.2	GEONETCast Product Navigator .....	35
3.2.1.3	GEONETCast Data Manager .....	36
3.2.2	Geostationary Satellites - Level 1.5 Data .....	36
3.2.2.1	Link to online resources.....	36
3.2.2.2	MSG Data Retriever .....	36
3.2.3	Real Time MSG Visualization.....	39
3.2.4	Automatic processing .....	42
3.2.5	Polar - Level 1.5 Data.....	45
3.2.6	Meteorological Products.....	46
3.2.7	Satellite Application Facilities (SAF).....	48
3.2.8	Other selected product - Global .....	49
3.2.8.1	MODIS Global Products .....	49
3.2.8.2	NPP Marine products.....	50
3.2.8.3	Global Precipitation Monitoring (GPM) mission.....	51
3.2.8.4	SMOS .....	52

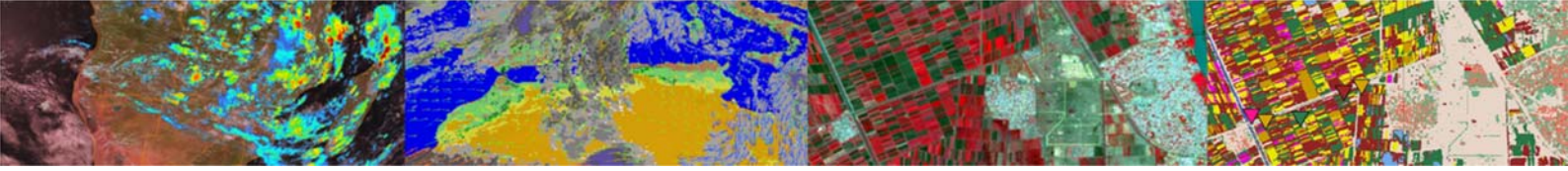


3.2.9	Other selected products - Regional.....	53
3.2.9.1	TAMSAT Rainfall Products.....	53
3.2.9.2	Sentinel 3 Land.....	53
3.2.9.3	Copernicus Regional NDVI.....	54
3.2.9.4	Copernicus Regional Soil Water Index.....	55
3.2.9.5	PROBA-Vegetation Products.....	55
3.2.9.6	AEMET Dust Forecasts.....	56
3.2.9.7	PML Marine Products.....	56
3.2.10	Other Routines.....	58
3.2.10.1	Polar Orbit Tracks.....	58
3.2.10.2	Earth Weather.....	58
3.2.10.3	GFS Agricultural Forecasts.....	58
3.2.10.4	H-SAF H05B rainfall on Google Earth.....	59
3.2.10.5	EUMETVIEW.....	59
3.2.10.6	METAR-Weather.....	60
3.2.10.7	Sentinel EO Browser.....	60
3.2.10.8	Display Julian Day Tables.....	61
3.2.10.9	Generic NetCDF-GRIB-HDF data visualization.....	61
3.2.10.10	Generic BUFR data visualization.....	62
3.2.10.11	JASON and AVISO.....	62
3.2.10.12	Generic GeoTif import.....	62
3.2.10.13	Calculate MSG angles.....	63
3.2.11	Other useful online resources.....	64
3.2.11.1	NCDC Integrated Surface Data (ISD).....	64
3.2.11.2	Global Land Data Assimilation System.....	64
3.2.11.3	GMAO - GEOS5 Land.....	65
3.2.11.4	C3S-CDS.....	66
3.2.11.5	GPM-IMERG.....	67
3.2.11.6	Latest NCEP GFS Precipitation Forecast.....	67
3.2.11.7	CHIRPS Rainfall.....	67
3.2.11.8	NASA POWER-Agro Climatology.....	68
3.2.11.9	NOAA – STAR.....	68
3.2.12	Configuration and folder settings.....	69
<b>3.3</b>	<b>Concluding remarks.....</b>	<b>70</b>
<b>4.</b>	<b>EXERCISES USING DATA FROM GEONETCAST, APPLYING ILWIS 386 AND THE CABO VERDE TOOLBOX.....</b>	<b>71</b>
<b>4.1</b>	<b>Import and visualization of Level 1.5 data from Geostationary Satellites.....</b>	<b>71</b>
4.1.1	Data import and visualization from Meteosat Second Generation (MSG).....	71
4.1.2	Construct a Daytime MicroPhysical (DMP) Colour Scheme composite.....	75
4.1.3	The MSG Water Vapour (WV_062) and Thermal (IR_108) channels.....	78
4.1.4	Multi temporal data import, processing and analysis.....	81
4.1.5	Import of the HRV channel.....	84
4.1.6	Import of the IODC and RSS MSG satellite observations.....	86
4.1.6.1	Indian Ocean Data Coverage (IODC).....	86
4.1.6.2	Rapid Scanning Service (RSS).....	87
4.1.7	Examples of other Geostationary satellites.....	89
4.1.7.1	GOES East and GOES West.....	89
4.1.7.2	Fengyun.....	93
4.1.7.3	Himawari.....	94
<b>4.2</b>	<b>Import of polar - level 1.5 data example METOP and NOAA.....</b>	<b>96</b>
4.2.1	Processing of METOP A, B and C AVHRR/3 and ASCAT.....	96
4.2.2	METOP AVHRR disseminated by EARS.....	102
4.2.3	NOAA GAC and LAC quick looks.....	103
<b>4.3</b>	<b>Import products from the Meteorological Product Extraction Facility.....</b>	<b>105</b>
4.3.1	Import and processing of MSG MPEF products.....	105
4.3.2	Import and processing of Fengyun MPEF products.....	112





4.3.3	Lightning detection .....	114
4.3.4	GFS Forecasts for Africa from NCEP .....	115
<b>4.4</b>	<b>Import products generated by the Satellite Application Facilities .....</b>	<b>116</b>
4.4.1	Import and processing of Land Surface Analysis SAF products .....	116
4.4.2	Import and processing of Ocean and Sea Ice SAF products .....	121
4.4.3	Import and processing of Hydrology SAF products.....	122
4.4.4	Import and processing of Now Casting SAF products .....	124
4.4.5	Import and processing of Climate Monitoring SAF products.....	126
<b>4.5</b>	<b>Import of other selected products – Global and Regional.....</b>	<b>127</b>
4.5.1	Selected products with a Global coverage .....	127
4.5.1.1	MODIS Global Products .....	127
4.5.1.2	NPP Marine Products .....	128
4.5.1.3	Global Precipitation Monitoring (GPM) Mission.....	129
4.5.1.4	SMOS .....	130
4.5.2	Other selected Regional Products.....	132
4.5.2.1	TAMSAT .....	132
4.5.2.2	Sentinel – 3 Land.....	134
4.5.2.3	Copernicus Global Soil Water Index.....	135
4.5.2.4	PROBA Vegetation Products.....	136
4.5.2.5	AEMET Dust Forecasts .....	137
4.5.2.6	PML Marine Products .....	138
4.5.2.7	EAMNET Marine Products.....	139
<b>4.6</b>	<b>Additional Exercises.....</b>	<b>141</b>
4.6.1	EUMETView .....	141
4.6.2	Sentinel EO Browser .....	142
4.6.3	Generic NetCDF-GRIB-HDF data visualization .....	143
4.6.4	Generic BUFR data visualization .....	144
4.6.5	Multi temporal data import using a batch looping procedure .....	146
4.6.6	Calculate MSG and solar zenith – azimuth angles .....	150
<b>APPENDICES</b>	<b>.....</b>	<b>152</b>
Appendix 1:	Other freeware utilities that can be used in conjunction with ILWIS 3.8.6 .....	152
Appendix 2:	Structure of the sample data on the ITC File Transfer server.....	153
Appendix 3:	MSG Data Retriever settings for exercise 4.1.....	154
Appendix 4:	Change logs for the various Cabo Verde Toolbox XML versions .....	156
Appendix 5:	Utilities available at the ITC GEONETCast web pages.....	157



This page is blank



## 1. GENERAL INSTALLATION AND CONFIGURATION INSTRUCTIONS

### 1.1 INTRODUCTION

Follow the instructions provided below to install ILWIS Version 3.8.6, the CaboVerde-Toolbox and a number of other free software utilities, in order to work with the data provided via EUMETCast - GEONETCast. Read the instructions provided below carefully and proceed with the installation of the various utilities. In case you want to use the CaboVerde-Toolbox, be aware that at this moment it is not running under LINUX-Ubuntu. Furthermore this CaboVerde-Toolbox version is not downwards compatible; you need to use at least (latest) ILWIS Version 3.8.6.



#### 1.1.1 Download and install ILWIS

Available from: <http://filetransfer.itc.nl/pub/52n/ILWIS386/Software/>

You can download the latest release by checking the date from the file name e.g. "ILWIS386\_20201116.zip", also a '\*.txt' file (using same prefix) is provided indicating the changes in the new release.

From: <http://filetransfer.itc.nl/pub/52n/ILWIS386/Tutorial/> download the installation instructions provided in the document "ILWIS\_installation\_instructions.pdf".

It is assumed here that the installation instructions are executed as described and ILWIS386 is installed on the root of the drive, e.g. in the folder "C:\ILWIS386".

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

- Don't use spaces in (sub-) directory or file names, instead use underscores;
- Do not only use numbers as file names, use at least one character preferably at the beginning of the file name;
- 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.

#### 1.1.2 Download the CaboVerde-Toolbox

Available from: [http://filetransfer.itc.nl/pub/52n/ILWIS386/Toolbox\\_plugin/](http://filetransfer.itc.nl/pub/52n/ILWIS386/Toolbox_plugin/)

Download the file "CaboVerde-Toolbox.zip". Also check the "readme.txt" file. The installation manual "CaboVerde\_TB\_install.pdf" is available from this link. Follow the installation instructions provided.

In short: After download is completed, copy the 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 sub-directory!*

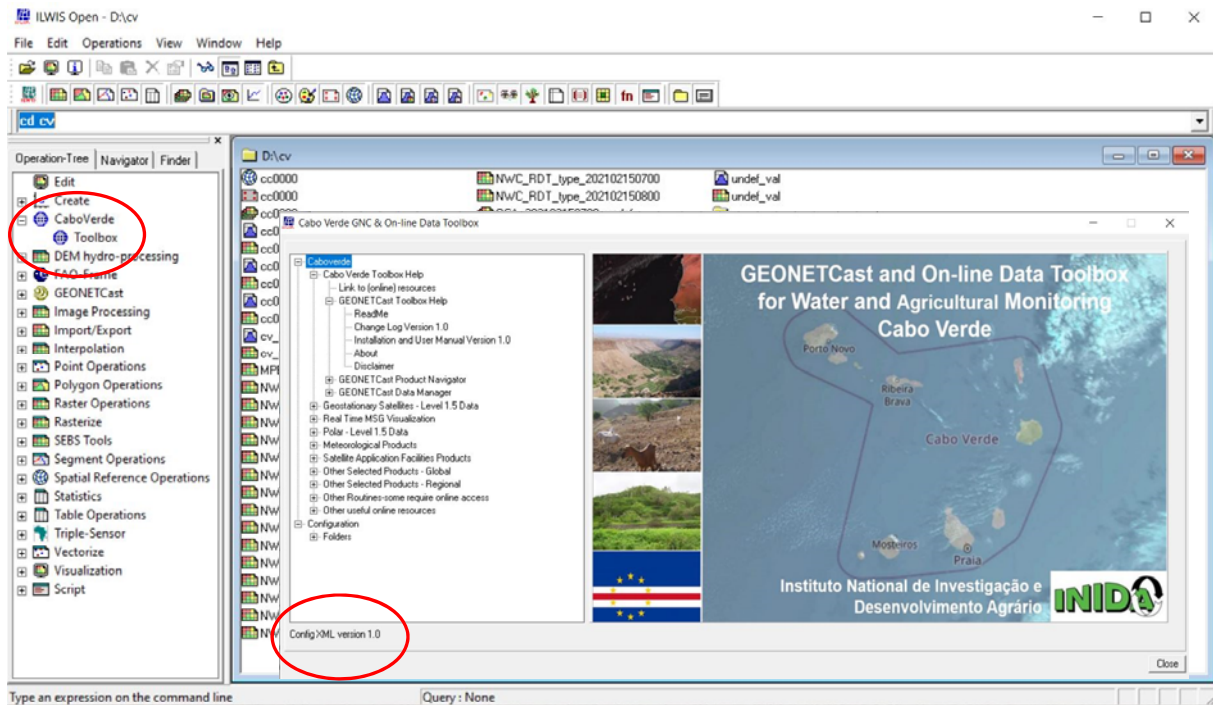
To check if it is properly installed, start ILWIS and in the Operation-Tree of ILWIS the "CaboVerde" tab will appear (see also figure 1.1). Double click the "CaboVerde" tab and the subsequent "Toolbox" tab and various (sub) menus are now at your disposal. These options can be used to import several image and data sources that are disseminated via EUMETCast-GEONETCast, a system that uses digital video broadcast (DVB-S2) to deliver environmental data worldwide.

Over 150 image and products disseminated are currently supported. As the dissemination system is constantly developing, keep checking the ITC website (<https://www.itc.nl/about-itc/organization/scientific-departments/water-resources/geonetcast/>) or the "Earth Observation" community webpage at <http://52north.org>, for new (toolbox) developments. Modifications and added functionality for the CaboVerde-Toolbox are made available here on an ad hoc basis, so check if you



are working with the latest version. The XML configuration number, currently version 1.0, is given on the lower left hand portion of the Cabo Verde Toolbox opening screen.

**Figure 1.1: The CaboVerde-Toolbox main and sub menu structure under ILWIS386**



Close ILWIS as you might need to install additional utilities. Check if you have already installed the Java runtime environment. If this is not the case, follow the additional installation instructions below.

Within the toolbox a number of utilities have been fully integrated. These are utilities freely available from the internet but for sake of convenience and the transient nature of the internet, these are now provided within the toolbox environment:

- 7Z (<https://www.7-zip.org/>): 7z command line utility supports several different data compression, encryption and pre-processing algorithms and used here for decompression.
- BUFRtool and BUFRdisplay (Available from: <http://www.elnath.org.uk/>). The BUFRtool command line utility is used to import selected BUFR encoded data into ILWIS. BUFRDisplay is used to visualize BUFR encoded data.
- Convsh. (retrieved from <http://badc.nerc.ac.uk/help/software/xconv/#convsh> , page no longer active). Convsh is used to import Grib format data and to reproject from a Gaussian grid to a 'normal' geographic latitude-longitude grid.
- GDAL (<http://www.gdal.org/>): Geospatial Data Abstraction Library, used for data translation, version downloaded from <http://www.gisinternals.com/release.php>.
- Gifsicle (<https://www.lcdf.org/gifsicle/>): a command-line tool for creating, editing, and getting information about GIF images and animations.
- Grep (<https://www.gnu.org/software/grep/grep.html>): a command-line utility for searching plain-text data sets for lines that match a regular expression.
- IrfanView (<http://www.irfanview.com/>): Utility is used to visualize pictures and animations which are not transformed into an ILWIS format, or is the result of a toolbox processing routine and visualized as a picture.
- Mweather (<http://www.nirsoft.net>): The MetarWeather utility decodes METAR weather reports from around the world, and displays them in a simple weather report table. You can save the weather report into text, HTML or XML files. MetarWeather can decode METAR reports from a text file, or download the latest reports directly from the Internet.
- PanoplyWin (<https://www.giss.nasa.gov/tools/panoply/>): Panoply plots geo-referenced and other arrays from netCDF, HDF, GRIB, and other datasets.



- Wget (<https://www.gnu.org/software/wget/>): Command line utility to retrieve files from FTP(S), HTTP(S), etc.
- Wgrib (<https://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/>). Utility used to read GRIB and GRIB2 formatted files.

### 1.1.3 Download Java Runtime Environment

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

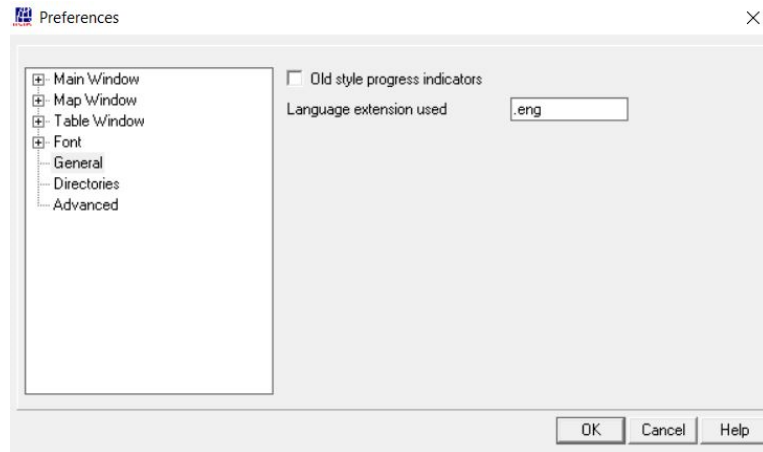
Some Cabo Verde Toolbox applications make use of JAVA. If the system does not have the JAVA Runtime Environment installed already, move to the website indicated above, select the “Java Download” button and install it. Accept the License Agreement to start and complete the installation (using default settings). It is recommended to use a recent JAVA release.

Java is required to operate the “GEONETCast Data Manager”, processing of the MPEF “FIRC” product (Active Fire Monitoring - Common Alert Protocol) and the “METOP-AVHRR Retriever”.

### 1.1.4 Changing the ILWIS language settings, from English to French

The ILWIS 3.8.6 version supports currently next to English, French and Spanish. It is envisaged to include Portuguese language in the near future as well. To switch languages start ILWIS, subsequently from the main ILWIS menu, select the option “File” and “Preferences”. Under “Font”, “General”, the language of the ILWIS menu can be defined. By default the English language is defined, using as Language extension “.eng” (for English). This can be changed to “.fr” (for French) or “.sp” (for Spanish) to show the menu of ILWIS in French and Spanish respectively. See also figure 1.2. After this modification press “OK”, close ILWIS and start ILWIS again. The menu will be shown in the language specified.

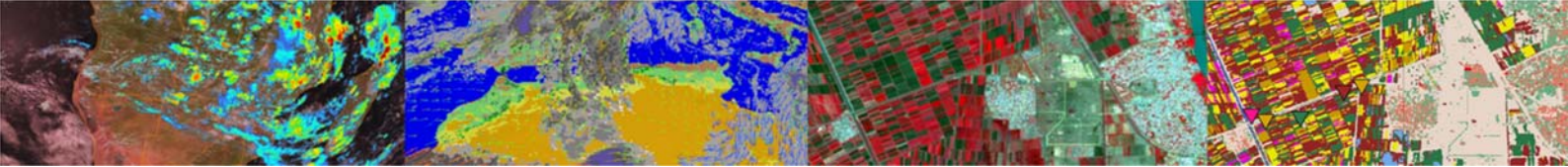
## 1.2 Changing the ILWIS menu language



### 1.1.5 Concluding remarks

With ILWIS, the Cabo Verde Toolbox plug-in and the other necessary utility-software installed you still need to continue with the CaboVerde-Toolbox configuration settings which are further described in the next chapter.

Note that also use can be made of other freeware utilities for pre or post processing of the data, such as BRAT, satellite tracking software, SNAP, etc. Links to these resources are provided in appendices. For other “EO” freeware utilities developed, like other Toolboxes developed, see also the references provided in the appendices.



## 1.2 CONFIGURATION OF THE DATA STREAM USING THE GEONETCAST DATA MANAGER

### 1.2.1 Introduction

Once having installed and configured a local GEONETCast ground receiving station the satellite and environmental data that is (re-) broadcasted via communication satellites can be received and stored on a storage device (server). As the data is received on a 24 hr – 7 days a week basis, the “GEONETCast Data Manager”, a data management system, has been developed that can be easily configured using a simple ascii text file. How to prepare or modify this ascii configuration file and to run the Data Manager is described below. This section is of special relevance to the system administrator that is operating the ground receiving station. By contacting the corresponding author a recent ascii “GEONETCast Data Manager” configuration file can be obtained, so new users don’t need to start from scratch constructing the ascii file. Within the Cabo Verde Toolbox an ascii configuration file is also available, see your ILWIS folder Extensions\CaboVerde-Toolbox\DataManager\ and open the file ‘GNCDataManager-Cband\_CaboVerde.txt’ using a text editor like notepad or notepad ++. Within this toolbox release an updated Data Manager (version 3) has been included, offering an auto-start and copy and for dated folders also the day-of-year option. Also check the “*Installation – User Manual*” (GEONETCast\_Data\_Manager\_Version3.pdf), available from your ILWIS folder “\Extensions\CaboVerde-Toolbox\util\manuals” .

### 1.2.2 General design considerations for development of the GEONETCast Data Manager

The GEONETCast Data Manager is a software application for Windows / Linux written in Java that - in short – examines computer files, and transfers them to a proper location, based on filename-patterns. It was developed at ITC (<https://www.itc.nl>).

The primary purpose for developing this application is to organize the large amount of data files received on a GEONETCast receiving station (a computer with a Digital Video Broadcast (DVB) card connected to a satellite dish, configured to receive the EUMETCast – GEONETCast data. The data that is received on the EUMETCast - GEONETCast receiving station must be transferred to computer storage that is independent of the receiving station's disk storage before users can access it. Users are not allowed to work directly with the data on the receiving station, because it should perform its primary task undisturbed, which is to be available all the time for storing the files captured by the (DVB-S2) device.

Main objectives of the GEONETCast Data Manager application:

- To organize all files in the "incoming" folder of the EUMETCast – GEONETCast receiving station, according to “rules” defined by the local system administrator.
- To detect and log "missing files". The application can be fed with knowledge about the files that are expected from a certain category (e.g. for MSG-HRV this would be 24 segments every 15 minutes). The "missing files" log is very helpful when users need to check data consistency prior to time-series analysis.
- Be extremely reliable to work continuously, 24 hours per day, 7 days per week, preferably unattended for several months, because if the application stops working unexpectedly (and nobody is available to solve the problem), after a couple of days, the files accumulated in the "incoming" folder on the EUMETCast - GEONETCast receiving station is likely to reach the maximum available disk capacity.
- Cause as little as possible disturbance to the EUMETCast – GEONETCast receiving station (lightweight activity), or otherwise the station will be too busy and occasionally miss the reception of files (fail to store some of the files captured by the DVB card).
- It must be easy to restore the configuration of the GEONETCast Data Manager after a software or hardware crash or a power failure, even by non-experts, as the local system administrator may not be available at all times.



- The GEONETCast Data Manager must be able to process a large number of files in a single folder at one time. Therefore it must be able to handle all files that have been accumulated in the "incoming" folder in case the application has not worked for a couple of days. This can be more than a million files!
- The type of files that the GEONETCast Data Manager can process must not be fixed to a specific type (e.g. satellite images). Therefore the application will only depend on the fact that EUMETCast files have specific filename-patterns. With this, the process of detecting a file's category can be kept lightweight, as the file does not need to be opened.
- The "rules" with which files are organized are kept simple in the initial implementation (transfer files to a new location, delete after a certain time period, delete immediately or keep forever, ignore specific files, etc.), which is sufficient for the primary objective of the application. However, it is not difficult to extend their capability if such demand exists.
- The system administrator must be able to easily adapt the configuration file, so that new data that is broadcasted can be easily handled, as the EUMETCast-GEONETCast system is further developing and it is expected that in the future more data will be broadcasted.
- The system manager should be able to fine-tune the storage of the data that is received to be tailored for a specific organization. Given the data load it is impossible to store all of the data. Each organization will have its own specific data storage requirements!

The GEONETCast Data Manager can run without problems on the EUMETCast-GEONETCast receiving station, but can also run on another computer, as long as all necessary folders can be accessed through the network connection. Note that the (sub-) directories assigned to store the various data files can be created manually prior to starting the Data Manager or can be automatically generated according to the directory names specified in the ascii configuration file.

Version-3 described here has a few added advantages, such as an automatic start option after system re-start and a copy option, leaving the data in the source folder of the ground receiving station to be available by other applications. This allows the construction of time series even if the other software routines running on the ground reception station are deleting the data from the source folder after some time. For further details also check the online installation and user manual.

### 1.2.3 The GEONETCast Data Manager - "Rules"

The local EUMETCast-GEONETCast system administrator creates the file-processing rules. This is initially done by editing a text-file (the configuration file that is used by the GEONETCast Data Manager). At a later stage, the rules are fine-tuned in the user-interface of the GEONETCast Data Manager. This was done to keep the user-interface simple and understandable. For example, file patterns or expected frequency of a category of files must be changed in the configuration file, using a text-editor. However, the destination location or the duration of storage of a category of files is changed in the user-interface, because it is considered a "last-minute" change: the administrator may frequently change his mind about this.

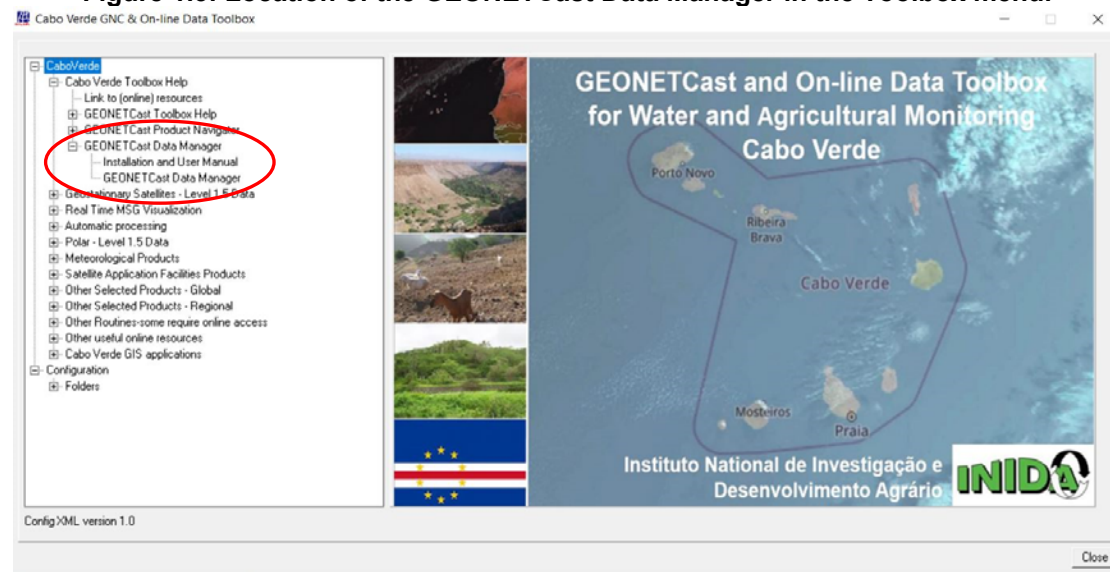
The user-interface of the GEONETCast Data Manager adapts itself to the rules that are defined. Rules are organized in "groups" and "items". Each group becomes a tab, and each item becomes a box within a tab.

## 1.2.4 Configuring the GEONETCast Data Manager

Open ILWIS and from the Operation-Tree select the “CaboVerde” and the “Toolbox” tab. Subsequently select the option “GEONETCast Data Manager” (see also the figure 1.3 below) and start the “Data Manager” by pressing the “Start Data Manager” button.

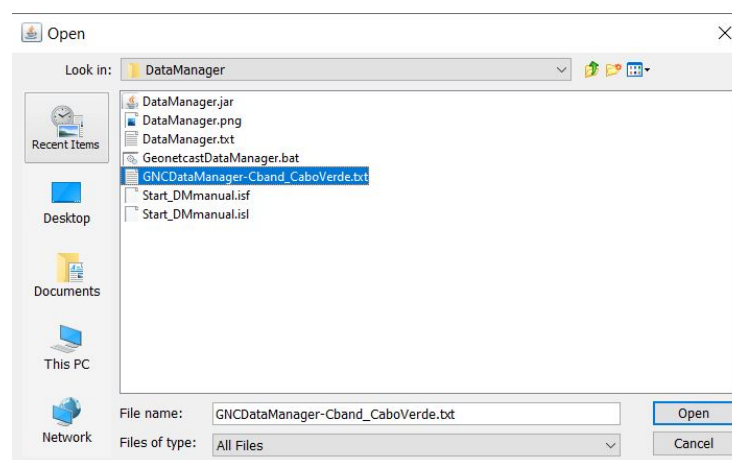
Once the GEONETCast Data Manager is activated an input configuration file needs to be specified as indicated in figure 1.4. A sample configuration file, pre-configured for C-band EUMETCast reception at INIDA, Cabo Verde is provided. This configuration file also incorporates the relevant services that are broadcasted via C-Band for Africa Service. Select the file “GNCDataManager-Cband\_CaboVerde.txt” and a menu will appear on the screen. A menu sample is shown in figure 1.5.

**Figure 1.3: Location of the GEONETCast Data Manager in the Toolbox menu.**



*Note that this utility only needs to be configured by the system manager-administrator to ensure that the data which is required by the organization – institute is properly stored and can be accessed by the other users within the organization – institute. There is no need to start the application as an instance of the GEONETCast Data Manager might already be running by the system administrator.*

**Figure 1.4: Selection of the input configuration file**







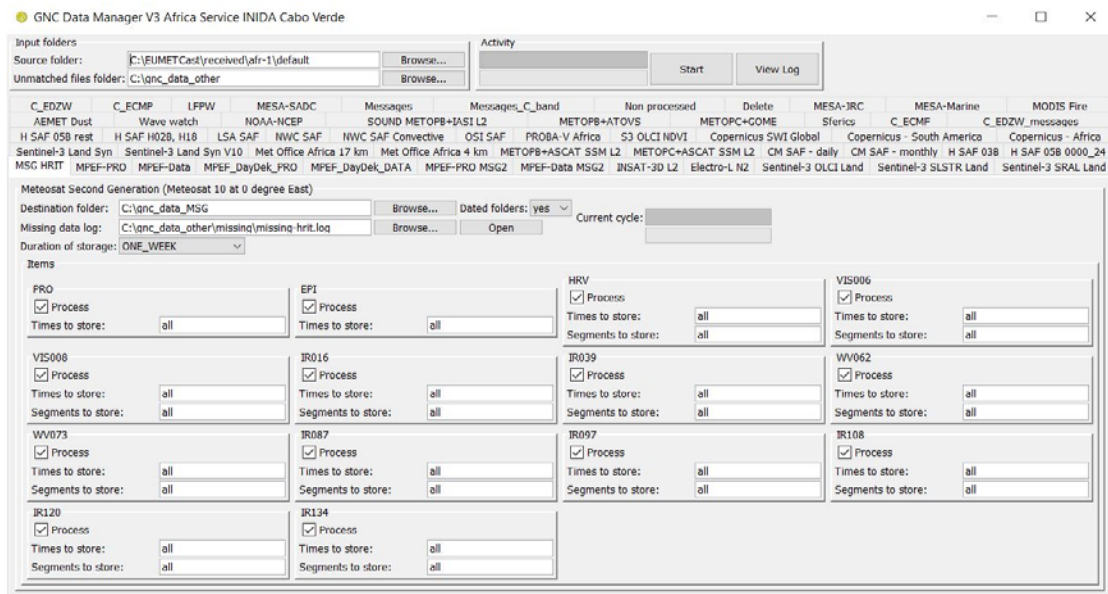
The menu that subsequently appears is based upon the settings that are provided in the “GNCDDataManager-Cband\_CaboVerde.txt” file. Examine the various tabs (“groups”) and look at the “items” within each of these groups (once more: don’t start the application!).

The User Interface allows the system administrator to define the “Source folder”, the directory where the newly incoming data arrive on the ground receiving station; the “Destination folder” is used to store the newly arrived data on the archiving system.

A location for the “Missing Data log” can be specified if for each “Item” the number of “Times per day” is specified (see also figure 1.6). Also “Duration of storage” can be interactively defined and how the data is stored, e.g. by a date formatted folder structure, activating the “Dated folders” option. Within this version also the option “doy” is available, next to “no” and “yes”. If “no” is used all data is transferred to the destination folder. If “yes” is used a dated folder structure will be created, for the ‘year’, for each ‘month’ within the year and ‘day’, for each day within the month. All files received will be transferred to the relevant sub-directory for each day. For MSG alone, on a daily basis 10.944 files, are received. For data sources having such a large number of files a dated folder structure is required, else the Windows Explorer is not able to display the folder content. The “doy” option creates a dated folder structure, with ‘year’ and ‘day of year’ within the year folder

This configuration file can also be opened using a text editor and can be modified according to the specific need of the user. The Data Manager can be closed by clicking the closing button in the top-right corner.

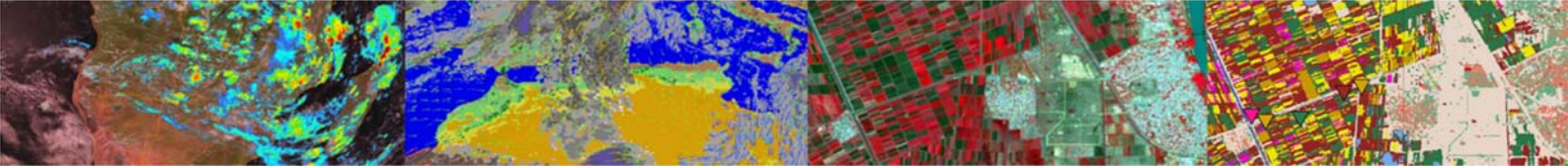
**Figure 1.5: The GEONETCast Data Manager, showing the menu as defined by the text file GNCDDataManager-Cband\_CaboVerde.txt**



Use the Windows Explorer, move to the ILWIS directory and move to the following sub-directory: \Extensions\CaboVerde-Toolbox\DataManager.

Select the file “DataManager.txt”, double click the file to open it using Notepad. This file is the default file that can be used to build your own data storage configuration file (see also figure 1.6).

As indicated in the application description before (chapter 1.2.3 GEONETCast Data Manager - “Rules”) you are able by adapting the “Group Name” and “Item Name” to modify the menu that will subsequently be generated when starting the application using the modified configuration file, which should be saved using a different name (else it will be overwritten when a new instance of the Data Manager is started using the default “DataManager.txt” file).



To ensure that the changes are implemented when a new event of the Data Manager is started the lines should be uncommented to let them take effect.

The GEONETCast Data Manager can also be used as a stand-alone application. All required files are situated in the ILWIS sub-directory \Extensions\CaboVerde-Toolbox\DataManager. This directory can be copied to the appropriate system with JAVA installed and the “DataManager.jar” can be directly started from there as well, also using LINUX.

Having the capability to easily adapt the menu and therefore also the storage of the incoming data stream any new modifications resulting from adaptations of the EUMETCast-GEONETCast system can be easily incorporated without the need to wait for software updates. This is important as the system continuously develops and broadcast more / other satellite and environmental data. Using simple copy and paste options the text file can be configured according to the need of the user, the system manager-administrator does not need to have any programming experience to conduct these type of modifications.

**Figure 1.6: Default GEONETCast Data Manager configuration file**

```
DataManager.txt - Notepad
File Edit Format View Help
|# This file will be automatically overwritten the next time you run the program!
|# You can make edits to this file when the program is not running
|# but it is no use to change the layout of this file or add your own comments.

# Uncomment lines to let them take effect

# Title:          Data Manager
# Source folder:  C:\source_folder
# Unmatched files folder:
# Copy files:    no
# Autostart delay:  10
# Columns:       2

Group Name:      Sample Group
# Description:    Sample Group
# Date position:  46
# File id position:  36
# Destination folder:
# Dated folders:  yes
# Missing data log:
# Duration of storage:  FOREVER

Item Name:       Sample Item
# Pattern:
# Process:       yes
# Times per day:  0
# Times to store:  all
# Expected segments:  0
# Segments to store:  all
```

Note that any data which is not assigned by the rules specified is stored in the Directory assigned under the “Unmatched files folder”. If this Directory is regularly checked the new data that has arrived can be easily captured in a set of new “rules” and stored if required relevant or deleted.

Carefully check the content of the text file “GNCDDataManager-Cband\_CaboVerde.txt” using Notepad to see how the full range of data broadcasted via GEONETCast is configured / handled and which data is stored (for various durations). Check also the various “Group and Item names”, “Pattern” and “Source and Destination folder” and that is used.

Wildcard characters, like \* and ? are allowed in the filename pattern (thus not full regular expressions). Expected pattern examples can therefore be:

```
*H-000-MSG? _-MSG? _____-HRV _____-*
*g2_BIOPAR*Africa* or *g2_BIOPAR*America*
```



The last example shows that the generic part of the centre of the file name string is maintained but the data for Africa and America can still be separated and moved to other folders. These wildcard options provide more flexibility to define the filename patterns.

Note that new GEONETCast user in Cabo Verde can use this configuration file to get going and adapt it to their local circumstances (using copy, paste and delete!).

### 1.2.5 Making the GEONETCast data available within the organisation

The data that is received via EUMETCast-GEONETCast is commonly stored on a file server that can be accessed by all users within the organization according to the Data Manager settings described above. When using the “GNCDataManager-Cband\_CaboVerde.txt” configuration file, two directories are relevant:

- GNC\_DATA\_MSG; a year, month, day formatted directory structure, which is storing the High Rate Image Transmitted data of Meteosat Second Generation at 0 degree (full spatial, spectral and temporal resolution data of MSG);
- GNC\_DATA\_OTHER; including a number of sub-directories as well as (undefined) data that might reside in the root of this directory, which still needs to be defined by new “rules”.

The directory “GNC\_DATA\_OTHER” is configured to contain all the other data, except the MSG HRIT data from the receiving computer, using the settings as specified by the GEONETCast Data Manager’s configuration file and is stored in various sub-directories in this archiving folder. Some relevant sub-directories in this folder are:

- AEMET: dust products for Europe and North Africa
- Copernicus: Biopar and soil water index data
- DevCoCast: Products produced by the DevCoCast partners, currently PML is distributing marine data for selected regions in Africa;
- EAMNET: EAMNET: Various marine products for several regions in Africa, produced by UCT;
- GPM: data from the global precipitation measurement mission;
- EUROCLIMA and MESA\_JRC: time series data provided by JRC
- JASON, SARAL\_OGDR and SARAL\_SSHA: data from (Jason) altimeter missions (sea surface height and sea level anomaly), Geophysical data records, coastal and hydrological products (licensed service).
- METOP: Data from the various instruments on-board of METOP;
- MPEF, MPEF\_daydek, MPEF\_IODC, MPEF\_IODC\_daydek: Meteorological Products (AMV, GII, CLM, CLAI) from MSG at 0 and 41.5 degree;
- MESA: marine products for Western Africa
- MODIS: MODIS global products like fires and chlorophyll;
- NPP and NPP\_AF: data from Suomi-NPP and marine products (SST and Windspeed)
- NOAA, NOAA\_AF, NOAA\_NCEP and NOAA\_SSMIS: data from NOAA, including GFS forecasts for Africa
- ProbaV: Dekadal processed data derived from PROBA Vegetation Instrument, like NDVI, NDWI, DMP, etc, for Africa and Latin America;
- S3\*: various images and products (Land and Marine) from Sentinel 3 (A/B)
- SAF\*: various products from the Satellite Application Facilities (CM, Hydro, LSA, NWC and OSI SAF’s)
- SMOS: soil moisture products
- Sounding\*: Level 2 data from various sounders, also soil moisture
- TAMSAT: Dekadal and monthly rainfall and rainfall anomaly products over the African continent;
- WW3: Wave products North Atlantic ocean

Restricted services, available only to National Meteorological Services and their Partner Organizations:



- ECMF: Analysis and forecasts from the ECMWF Integrated Forecast system;
- LFPW: Analysis and forecasts from the Meteo France Arpege model for Africa;
- Meteorological Data Dissemination Services:
  - METAR and TAF reports;
  - ECMF analysis and forecasts;
  - selected ECMWF products for ACMAD;
- Met. Office Exeter: NWP (Unified) model data for African National Meteorological & Hydrological Services

To get easy access to the data, as it is stored on a “distant” file server, it is convenient to map these directories as a Network Drive using the Windows Explorer ‘Network’ option.

When using WINDOWS-10 open Windows Explorer and from the left hand menu, right click with the mouse on the icon “Network” and select from the context sensitive menu the option: “Map Network Drive..”, specify a Drive letter, select the shared network folder from Windows and browse to the target folder. If you have configured your system using the “GNCDataManager-Cband\_CaboVerde.txt” file, specify two network mappings, one for the folder “GNC\_DATA\_MSG” (e.g. as drive Z:\) and another one for the folder “GNC\_DATA\_OTHER” (e.g. drive Y:\).

Folder settings will vary for different locations. You have to consult the system manager to get the details of how the data is stored in the archive. Note that there are differences with respect to the type of data disseminated by Ku (Europe) and C-Band (Africa) Services and a certain organization might not have requested all the services that are disseminated by EUMETCast-GEONETCast.

### 1.2.6 Information on data disseminated through GEONETCast

To obtain an overview of what is currently disseminated using the various services, browse to the Product Navigator from EUMETSAT, available at: <http://navigator.eumetsat.int/>. From there select: ‘Extended Search’. Use the ‘Access’ filter option from the left hand menu, select EUMETCast Europe or Africa / GEONETCast Americas, or CMACast, subsequently a listing of the products that are broadcasted is provided. EUMETSAT is maintaining and updating the ‘GEONETCast Product Navigator’ on a continuous basis.

The GEONETCast Product Navigator is also disseminated through EUMETCast and when having installed the Tellicast software using default settings, the ‘Product Navigator’ can be found in the “C:\EUMETSAT\EUMETCast\www\eametsat\product-navigator” folder on the ‘Ground Receiving Station’. The Navigator is activated by clicking on the file “indexer.html”. This folder can be copied to the archiving system to ensure that users within the organization are working with a recent version. As the Product Navigator is regularly updated it is advised to update it frequently so the end user is always using the latest version.

To accomplish this in an automated manner on a Window based system, a ‘Scheduled Task’ can be created. The Task to be created can be configured to execute automatically at the given system clock time, preferably to be invoked once a day. This task subsequently executes a batch file, which should have the following command line:

```
@echo off
xcopy /s /i /r /y \\pc\C:\EUMETSAT\EUMETCast\www\eametsat\product-navigator
\\archive\GNC_ProductNavigator
```

where:

\\pc\C:\EUMETSAT\EUMETCast\www\eametsat\product-navigator	the receiving computer source location of the Product Navigator
\\Archive\GNC_ProductNavigator	GNC Product Navigator target folder destination

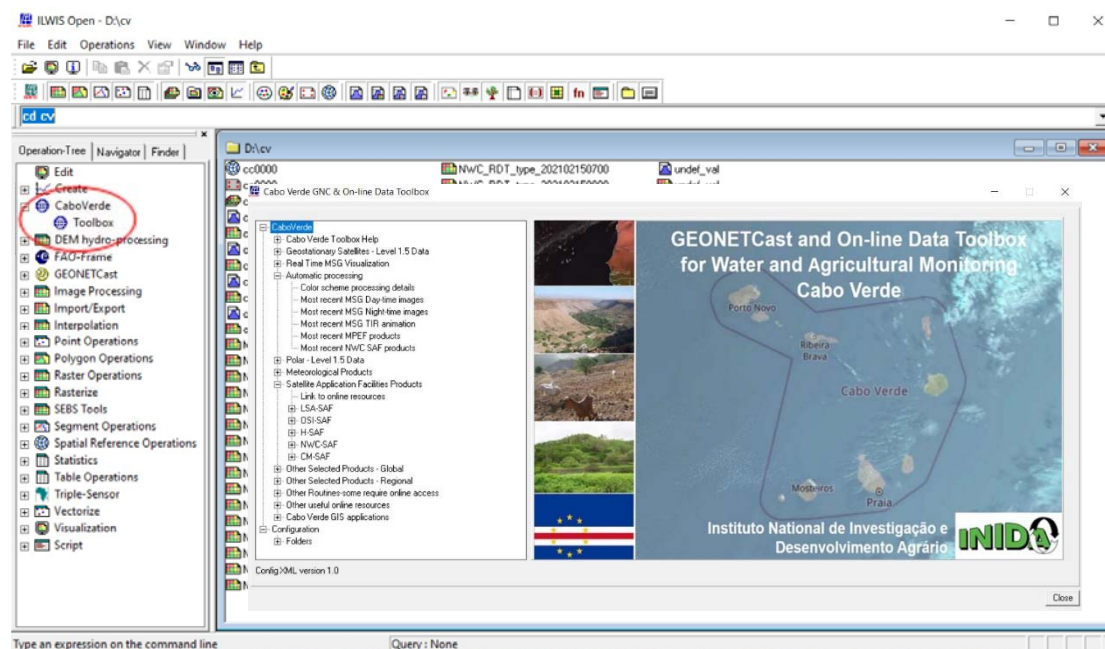
## 2. OVERVIEW OF THE CABO VERDE TOOLBOX ARCHITECTURE

### 2.1 INTRODUCTION

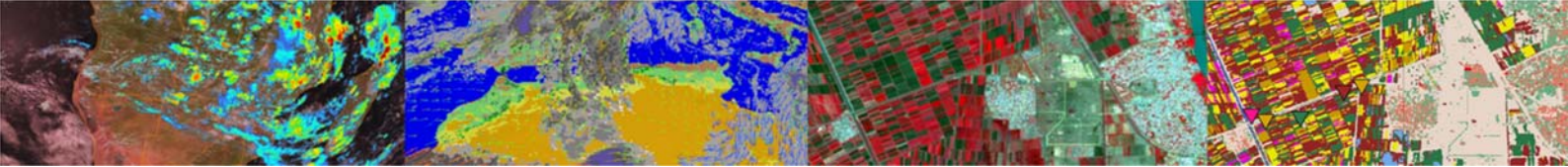
The Cabo Verde Toolbox is developed as a plug-in under ILWIS 3.8.6. The general installation instructions are described before. Note that this Toolbox version is not ILWIS downward compatible.

The main objective of the Toolbox is to allow the user, who operates a EUMETCast – GEONETCast ground receiving station to easily manage the incoming data stream and to import the data into a common freeware GIS-RS environment for further analysis, in this case using the functionality of ILWIS version 3.8.6. This toolbox version allows import of various data sources relevant for environmental monitoring 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 “Cabo Verde Toolbox” should appear as a menu item under the ILWIS Operation Tree (see figure 2.1).

**Figure 2.1: The Cabo Verde Toolbox plug-in Graphical User Interface**



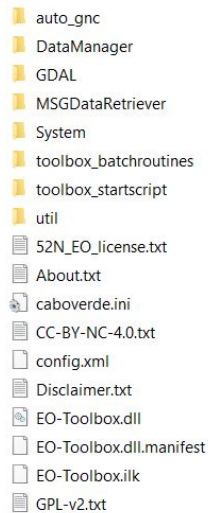
Next to the data received through EUMETCast – GEONETCast, within this toolbox also functionality has been added to retrieve data from free online resources relevant for water and agricultural monitoring. Those resources are provided under the menu heading “Other Routines” and “Other useful online resources”. The toolbox also includes some generic GIS operations, e.g. allowing the user to resample input data to common used geographic windows defined for the Cabo Verde region, at 3 km, 1 km and 100 meter spatial resolution. Next to this a generic translation between GEOTiff and ILWIS data format is provided allowing exchange between the data processed in ILWIS and other freeware RS and GIS tools like QGIS.



## 2.2 STRUCTURE OF THE CABO VERDE TOOLBOX

To operate the CaboVerde-Toolbox, the downloaded toolbox ZIP file is copied under the ILWIS sub-directory \Extensions. Once a new event of ILWIS386 is started this ZIP file is extracted and the content is stored in the sub-directory \CaboVerde-Toolbox within the same \Extensions sub-directory. Within the CaboVerde-Toolbox sub-directory a number of other sub-directories appear (see figure 2.2).

**Figure 2.2: Toolbox sub-directory structure**



The folder *auto\_gnc* contains the routines and within the sub directories the templates and background maps needed for the automatic visualizations of the latest MSG images, MPEF and Nowcasting products, as well as the MSG infrared enhanced animation. This directory contains a utility called “*DDEClient.exe*”. This is used for display of a map or mapview from the command prompt. It should be noted that ILWIS needs to be active!

The folder *DataManager* contains the “Geonetcast Data Manager”, a utility that allows automated archiving of the newly incoming data. This application requires the Java Runtime Environment. It is advised to run this utility as a stand-alone application if operated on a ground receiving station as it should be operated continuously. This utility is described in chapter 1.2 and also operates under the LINUX operating system.

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>). Here GDAL version 3.2.1, released on 29-12-2020, is used.

The folder *MSGDataRetriever* contains the utility that allows import of the HRIT MSG 8, 9, 10 and 11 Level 1.5 data. This utility can also be used as stand-alone. Further information is provided in chapter 2.5. Currently MSG-8 is providing the 41.5 degree service (Indian Ocean Data Coverage), MSG-10 the Rapid Scanning Service and MSG-11 the 0 degree service. MSG-9 is in stand-by mode.

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. Currently over 130 routines are available for accessing the various images and data products in the EUMETCast-GEONETCast data stream. Further information is provided in chapter 2.7.

The folder *Toolbox\_startscript* is containing various sub-directories containing ILWIS scripts. Upon selection of an import routine, from the Cabo Verde 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 2.6.

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. The folder is containing a number of sub-directories containing the additional utilities used by the toolbox as described in chapter 1.1.2., like `bufdisplay`, `bufextract`, `conv`, `gifsicle`, `grep`, `irfanview`, `panoplywin`, `wget`, and `wgrib2`. Next to these, the directory `\Maps` is containing a segment-polygon file of all countries and for Africa, a land mask for Africa (zipped) as well as a number of map views. The sub-directory `\MSG_time` contains the time stamps needed for the MSG real time visualization. A sub-directory `\Julian_Day` is containing 2 conversion tables to assist in transforming from calendar to Julian day, also for a leap year.

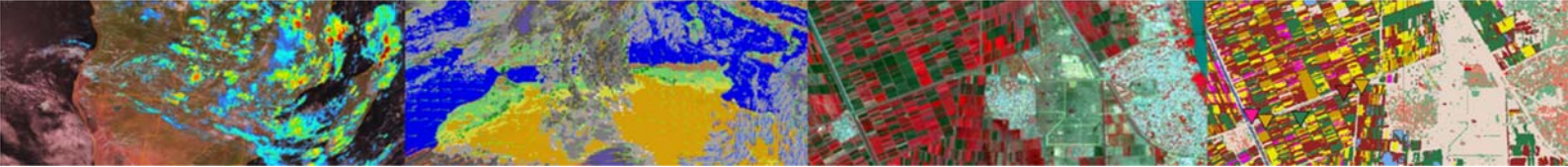
The folder `\Manuals` contains relevant documents, like this manual, the Data Manager manual, change log, BUFR Display and BUFR Extract manuals, as well as documents providing links to the source meta data from the Product Navigator.

Within the root of this folder also a number of files are available. The file `"config.xml"` contains the Cabo Verde-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 how to modify this XML files is provided in chapter 2.3.

The file `"caboverde.in"` 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: 'Configuration' and 'Folders'. Further information on the input and output folder settings is provided in chapter 2.4. These files can be opened and edited with Notepad or Wordpad.

The file `"EO-Toolbox.dll"` contains the layout of the User Interface of the Cabo Verde toolbox and generates the full ILWIS command string that executes the script, batch file and 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.

Furthermore included are an 'About.txt', a 'Disclaimer.txt' and a '52N\_EO\_license.txt', which can be opened using a text editor. These files provide relevant license and additional information on this toolbox release. The files 'CC-BY-NC-4.0.txt' and 'GLP-v2.txt' provide further details on the Creative Commons and GNU General Public License information applicable respectively.



## 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 persons with no programming background to make modifications in case new sensor data - products become available as the EUMETCast-GEONETCast data stream is continuously evolving and changing. 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 first few lines of the config.xml are:

```
1: < CaboVerde >  
2: <Version id="1.0"/>  
3: <UIInfo icon="earth" menu=" CaboVerde..Toolbox" title=" Cabo Verde GNC & On-  
   line Data Toolbox"/>  
4: <Path value="Extensions\CaboVerde-Toolbox" inifile="caboverde.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 CaboVerde-Toolbox menu, in the lower left hand corner. 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 “*caboverde.ini*” file, which provides the links to the input and output directories.

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 a different formats, in the example of figure 2.3 the “Date” stamp expected should have the format “yyyymmddhhmm” (y=year, m=month, d=day, h=hour and m=minute);
- *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 “CaboVerde-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: “ymdhm”;
- *Folderid*. This item generates a folder item in the “caboverde.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. As example a “folderid” of “H\_SAF\_H03B” is given. When opening the “caboverde.ini” file, using a text editor, an item [H\_SAF\_H03B] is added and the input and output folders can now be specified here as well by providing the relevant directory names, like:



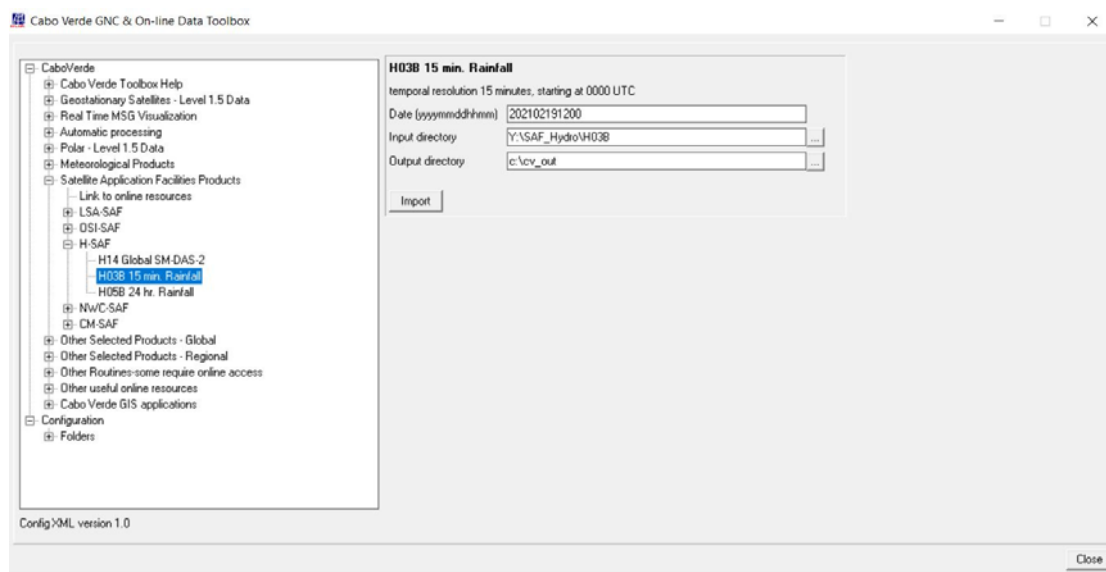


InputFolder= Y:\SAF\_Hydro\H03B  
OutputFolder= C:\cv\_out

Make use of a text editor (using find and replace) to quickly change the output directory for all “OutputFolder” settings in the “caboverde.ini”. Note that in a number of cases a ‘dated’ folder structure is used, so the ‘Date’ stamp for the year, month and day should coincide with the ‘folderid’ when importing a certain image or product!

- *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 temporal resolution of the H03B 15 minutes rainfall product and the starting time on a daily basis as produced by the Satellite Application Facility (SAF) on Hydrology.

**Figure 2.3: Popup menu for import, example HSAF – H03B rainfall product**

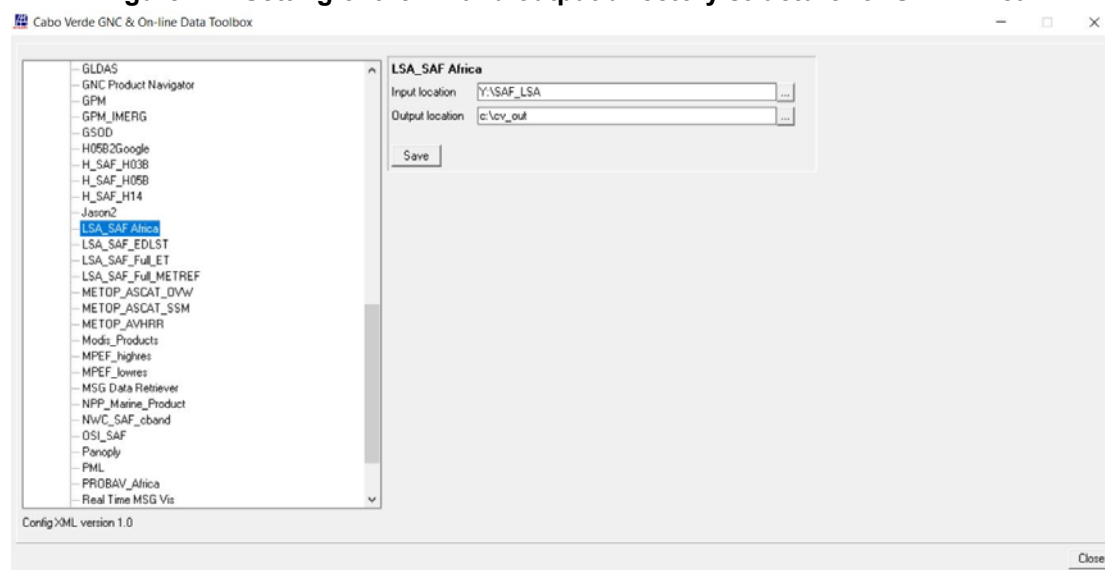


After changes are made to the config.xml the file should be saved and a new instance of the Toolbox should be started, showing the adaptations. Before modifying the file first make a backup!

## 2.4 GENERAL CABO VERDE TOOLBOX CONFIGURATION - FOLDER SETTINGS

For you to conveniently work with the Cabo Verde Toolbox the data sources (on your local area network) and the local system output (working) directories need to be defined. From the main Cabo Verde Toolbox menu, select “Configuration” and the sub-menu “Folders”. In figure 2.4 below the in- and output directory for the LSA\_SAF Africa is used as example (“Y:” is the “local area network drive” and “C:” is the local system hard disk). Note the use of a “Network Mapping” is described in chapter 1.2.5. Furthermore note that some input folders can be date formatted according to the specifications of the local system administrator. These directories are having a year, month and day structure.

**Figure 2.4: Setting of the in- and output directory structure for SAF Africa**



Configure the input directory “Folders” according to the settings given by the local system configuration. It might not be necessary to specify all folders as some of the data services are not received by the local ground reception infrastructure. The ‘Special Locations’ folder option is not used any longer within this toolbox version, as required utilities have now been fully integrated.

## 2.5 CONFIGURING THE DATA SOURCE OF THE MSG DATA RETRIEVER

The data source folder for the MSG Data Retriever can be specified from the main Cabo Verde Toolbox menu, select “Configuration” and the sub-menu “Folders”. Select the Folder “MSG Data Retriever” and specify the input location and press “Save”.

For advanced data source(s) configuration settings open the “Geostationary Satellites – Level 1.5 Data” >> “MSG Data Retriever” and activate the “Start MSG Data Retriever” option in the CaboVerde-Toolbox. The Meteosat Second Generation Data Retriever (MSG Data Retriever) window appears. This utility is a tool for converting raw Meteosat Second Generation (MSG) SERVIRI Level 1.5 files into a known raster-GIS or raster image file format. The MSG Data Retriever is used to extract the HRIT data recorded by MSG 8 – 11 (also referred to as MSG1 – MSG4 respectively prior to being declared operational).

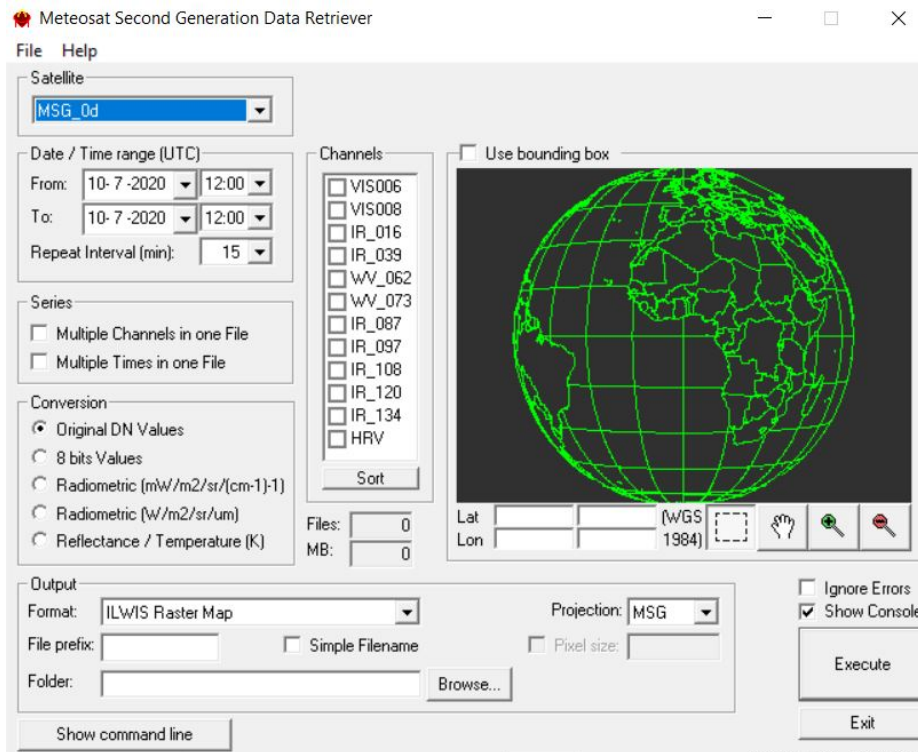
Note that the MSG data is licensed and therefore parts of MSG Data Retriever are licensed. Using the software means that you agree and comply to the conditions of use of the software as specified in the document provided under the main menu “Help” function. See here: “Limitation of use of MSG Data Retriever”. See also figure 2.5 below.

In the Satellite dropdown list, situated in the top left portion of the MSG Data Retriever window MSG\_0d, MSG\_41.5d and MSG\_RSS can be selected. These settings refer to MSG 11 situated at 0 degree, scanning the whole field of view of MSG at 15 minutes temporal



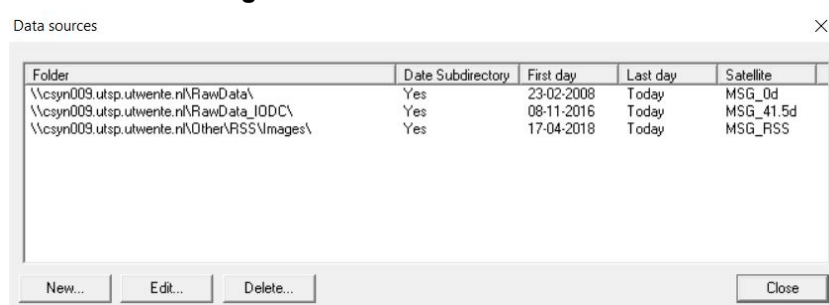
intervals, MSG 8 situated at 41.5 degree, also called the Indian Ocean Data Coverage (IODC), scanning the whole field of view of MSG at 15 minutes temporal intervals and MSG 10, the so-called Rapid Scanning Service (RSS) situated at 9.5 degree East, only scanning the northern 1/3 portion of the field of view of MSG at 5 minutes temporal intervals, respectively.

**Figure 2.5: Meteosat Second Generation Data Retriever**



The advanced settings of the data sources of the MSG data stream have to be configured separately. To configure the appropriate data source for the MSG\_0d satellite, select from the top left menu, the “File” Option and open the “Data Sources” menu.

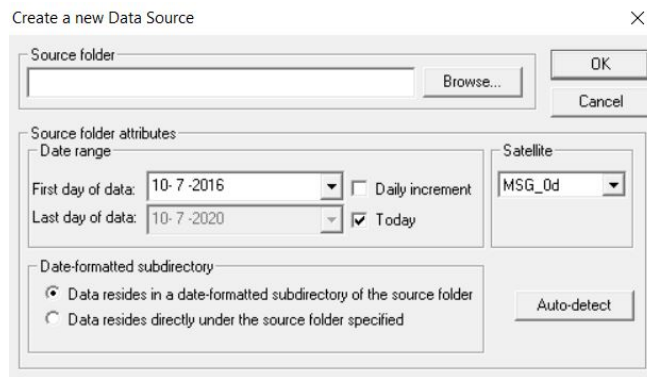
**Figure 2.6: Data Sources Menu**



In this submenu delete any folder that might appear, select “New”. In the “Create a new data source” menu, browse to your “drive:folder” that contains the raw MSG\_0d data (see also figure 2.7) and note that under the “Satellite” option the appropriate MSG satellite is selected. See also the description given in chapter 1.2.5 how a new network mapping has to be created.



**Figure 2.7: Create a new MSG data source folder**



When the source folder is provided, the “First day of data” should be specified. The “Last day of data” can be obtained using the option “Auto-detect” situated at the lower right portion of the “Create a new Data Source” Window. When using the “Auto-detect” option this is automatically detected. If “Last day of data” equals the current day it will automatically keep updating the “Last day of data” to be the present date.

If the data source is correctly specified the settings can be accepted by pressing “OK”. Note that when using the settings of the “GNCDDataManager-Cband\_CaboVerde.txt” (as discussed in chapter 1.2.4) use is made of a date-formatted sub-directory structure (each day a new sub directory is created storing the MSG data of that specific day). In this case the option “Data resides in a date-formatted subdirectory of the source folder” is activated. In case all the MSG data is situated directly under a source folder the other option can be activated (“Data is situated directly under a source folder specified”).

In a similar way also the source folder for the “MSG\_RSS” satellite (MSG 10, Rapid Scanning Service) and MSG 8 situated at 41.5 degree can be specified. The help function in the main MSG Data Retriever Window is providing additional information on the functionality offered by this utility.

Note that for Cabo Verde region the MSG at 0 degree is the only geostationary satellite required.



## 2.6 STRUCTURE OF THE ILWIS CABO VERDE TOOLBOX SCRIPTS

Most of the ILWIS scripts, situated within various sub-directories in the directory `\Toolbox_startscripts`, contain a single line which is identical. Below an example is given of an Atmospheric Motion Vector (AMV) import routine (the `MPEF_AMV` script is located in the sub-directory `\METEO\MPEF\`):

```
!%7\Extensions\CaboVerde-Toolbox\toolbox_batchroutines\MPEF_amvimport %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\CaboVerde-Toolbox\toolbox\_batchroutines\” and called “MPEF\_amvimport.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 time stamp entered for the specific product
%2	InputDrive	remark: input data drive, can also be a network mapping
%3	InputDir	remark: input data directory
%4	OutputDrive	remark: output data drive
%5	OutputDir	remark: output data directory
%6	GdalDir	remark: location of GDAL directory within toolbox
%7	IlwDir	remark: location of the ILWIS directory
%8	UtilDir	remark: location of the Util directory within toolbox

A number of these parameters are generated by the “CaboVerde-ToolboxUI.dll”, such as `GdalDir`, `IlwDir` 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 and the Date field provides the “Longfilename”, input and output directory for the “InputDrive”, “InputDir”, “OutputDrive” and “OutputDir” respectively.

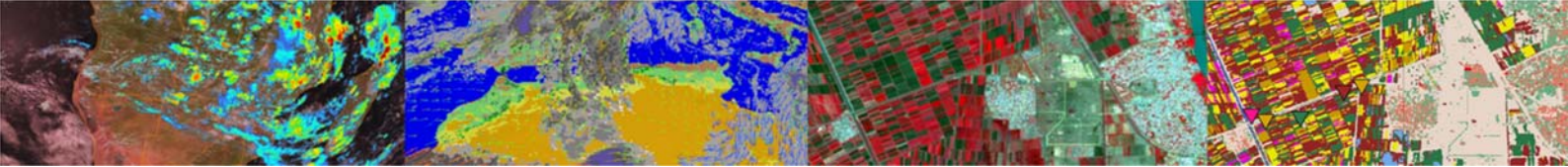
When pressing the “Import” button of the popup menu (see again figure 2.3) a command line is generated which is executed. Using the script example above of importing an Atmospheric Motion Vector (AMV) map, the following command line is generated and executed:

```
!C:\ilwis386\Extensions\CaboVerde-Toolbox\toolbox_batchroutines\MPEF_amvimport.bat 202007101145 Y: MPEF\2020\07\10 C: cv_out C:\ilwis386\Extensions\CaboVerde-Toolbox\GDAL C:\ilwis386 C:\ilwis386\Extensions\CaboVerde-Toolbox\util
```

The parameters are now defined as follows:

%1	Longfilename	202007101145
%2	InputDrive	Y:
%3	InputDir	MPEF\2020\07\10
%4	OutputDrive	C:
%5	OutputDir	cv_out
%6	GdalDir	C:\ilwis386\Extensions\CaboVerde-Toolbox\GDAL
%7	IlwDir	C:\ilwis386
%8	UtilDir	C:\ilwis386\Extensions\CaboVerde-Toolbox\util

Now with all parameters set the batch file “MPEF\_amvimport.bat”, situated in the ILWIS sub-directory `\Extensions\CaboVerde-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”, Windows Command Line Interpreter (CMD.exe) knows it has to execute this file using the Batch command line processor.



## 2.7 STRUCTURE OF THE ILWIS CABOVERDE-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 MPEF Cloud Top Height import routine is given below. The first 4 lines (see line numbers) are giving some remarks. The “echo” command shows or hides (echo off) the display of messages in the command line window. From line 5 to line 13 in the batch file, the parameters are passed, originating from the ILWIS script, to the batch file using the “SET” command. This command displays, sets, or removes Windows Environment Variables. Once these parameters are known the actual import routine can start. Special attention should be given to lines 5 and 6. The time stamp is defined as longfilename1 and is set in line 5. In line 6 this time stamp is used, starting from position 0, for 12 characters. In the example above a time stamp is used, like 201007021145 (as yyymmddhhmm), the whole time stamp will be set as “shortfilename1”, as this has a length of 12 characters. This allows flexibility in selections of portions of strings, but does not have any influence for this specific import routine, here longfilename and shortfilename1 are the same.

Lines 14 to 16 ensure that the application moves to the appropriate output directory. In line 17 a new variable is set, initially assuming MSG-2. Line 18 copies the requested input data for ‘MSG?’, note that this is currently either 2, 3 or 4, using the appropriate time stamp, note also the parameter %shortfilename1%, expressing the date stamp used. If the MSG2 data is subsequently locally available, see also line 19, jump in the batch file to the location given by ‘:START1’ (in line 23) else set the MSG\_number to 3 or repeat procedure and set MSG number to 4. This has been done to make the toolbox routines downward compatible, so also older products (e.g. from MSG2) or if a satellite is temporally replaced, can still be imported! If the data is locally available the routine is jumping from line 28, using the statement ‘:GOTO START’ to line 37, defined by ‘:START’

In line 22 a check is done if the data is locally available, note the variable ‘%MSG\_number:~0,1%’. This variable is either 2, 3 or 4. Based on what is available in the input drive-directory a statement is shown in the command line window that the data is copied from the source folder specified. If the data is not available goto to the section under ‘:MESSAGE’ (line 29) and subsequently, after having pressed the <enter> button of the keyboard, move to the section ‘:END’ (line 50) and in line 51 aborts the current ILWIS import process.

Images and products can consist of more than one file / segment. In line 18 note the portion of the file name string ‘\_\_-00000?\_\_’. Using the “?” allows copying all segments (from 0 to 9) of the same time stamp. For the reconstruction of the image or product the various segments have to be merged. This is done in line 38 and a new output file is created, file format is GRIB. This file is renamed in line 39, to obtain a shorter filename and imported into ILWIS format in line 40, using GDAL.

Once the file is in ILWIS format, ILWIS is executed from the command prompt in lines 41 and 42 (ilwis.exe -C) and a number of map calculations are performed. Lines 43 – 49 are deleting the files that have become obsolete, including the original data copied. Finally in line 51 the (second instance of) ILWIS routine is closed.

To make the processing routines more stable, in case for example a wrong date stamp is entered, the check on the data availability ensures that no unexpected processing routines are started and the import procedure is stopped in a normal manner.

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 1.1.1.



## Start of batch file listing: MPEF\_cthimport.bat

---

```
1: @echo off
2: echo MPEF CTH-import
3: echo Output-prefix: v value map
4: echo Output prefix: c class map, using elevclass.dom

5: set longfilename=%1
6: set shortfilename1=%longfilename:~0,12%
7: set InputDrive=%2
8: set InputDir=%3
9: set OutputDrive=%4
10: set OutputDir=%5
11: set gdalDir=%6
12: set llwDir=%7
13: set UtilDir=%8

14: cd\
15: %OutputDrive%
16: cd %OutputDir%

17: set MSG_number=2

18: copy "%InputDrive%\%InputDir%\L-000-MSG?__-MPEF_____-CTH_____-00000?__-_%shortfilename1%-
__.*"

19: if exist "%OutputDrive%\%OutputDir%\L-000-MSG2__-MPEF_____-CTH_____-00000?__-
_%shortfilename1%-__.*" GOTO START1

20: set MSG_number=3

21: if exist "%OutputDrive%\%OutputDir%\L-000-MSG3__-MPEF_____-CTH_____-00000?__-
_%shortfilename1%-__.*" GOTO START1

22: set MSG_number=4

23: :START1
24: if not exist "%InputDrive%\%InputDir%\L-000-MSG%MSG_number:~0,1%__-MPEF_____-CTH_____-
000001__-_%shortfilename1%-__" goto MESSAGE

25: echo The file(s) "%InputDrive%\%InputDir%\L-000-MSG%MSG_number:~0,1%__-MPEF_____-CTH_____-
00000?__-_%shortfilename1%-__" will be copied to your current working directory

26: echo.
27: echo.

28: GOTO START

29: :MESSAGE
30: echo The input file was not found.
31: echo Check your directory and date stamp settings
32: echo Your current date stamp used is %shortfilename1%
33: echo Check also if the data exists on your input directory - archive
34: echo Note the temporal resolution of your data

35: pause

36: GOTO END

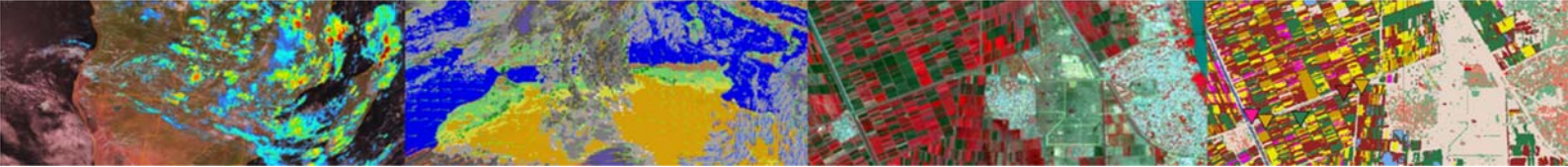
37: :START

38: "%UtilDir%\joinmsg.exe" "L-000-MSG%MSG_number:~0,1%__-MPEF_____-CTH_____-000001__-
_%shortfilename1%-__" %OutputDrive%\%OutputDir%\

39: rename "L-000-MSG?__-mpef_____-cth_____-000001__-_%shortfilename1%-__-_.grib"
TH%shortfilename1%.grib

40: "%gdalDir%\gdal_translate" -of ILWIS CTH%shortfilename1%.grib tCTH%shortfilename1%

41: "%llwDir%\ilwis.exe" -C %OutputDrive%\%OutputDir%\vCTH%shortfilename1%.mpr{dom=value;vr=-
100000.00:1000000.00:0.01}:=iff(%OutputDrive%\%OutputDir%\tCTH%shortfilename1%_band_1 ne
9999,%OutputDrive%\%OutputDir%\tCTH%shortfilename1%_band_1,?);
```



```

42: "%llwDir%\ilwis.exe" -C
    %OutputDrive%\%OutputDir%\cCTH%shortfilename1%.mpr{dom='%UtilDir%\elevclass'}:=
    MapSlicing(%OutputDrive%\%OutputDir%\vCTH%shortfilename1%.mpr,%UtilDir%\elevclass');

43: del "tCTH%shortfilename1%.mp*"
44: del "tCTH%shortfilename1%.aux*"
45: del "tCTH%shortfilename1%_band*.mp*"
46: del "tCTH%shortfilename1%.csy"
47: del "tCTH%shortfilename1%.grf"
48: del "tCTH%shortfilename1%.grib"
49: del "L-000-MSG?_-MPEF_____ -CTH_____ -00000?___-%shortfilename1%-_*.*"

50: :END
51: "%llwDir%\ilwis.exe" -C closeall

```

-----  
 End of Batch file listing.

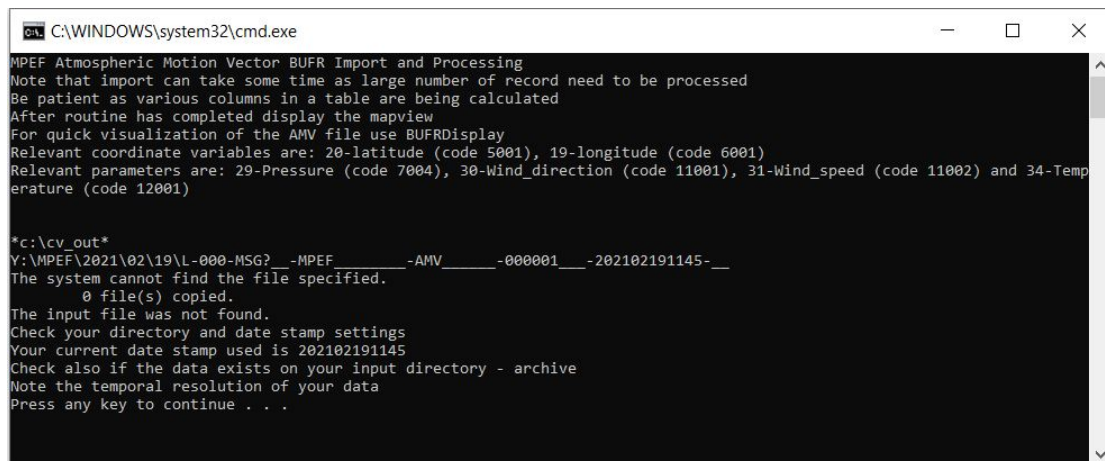
Although the content of the batch files vary significantly, the sequence of activities is mostly the same:

- Some remarks are given at the start of the batch file
- Setting of the environment variables, passing over the parameters from the ILWIS scripts
- Copy the original data to a local disk and check availability of the data, if data is not available then abort the routine
- Import of the data into ILWIS format
- Execute various ILWIS routines from the command prompt
- Delete obsolete files
- Close the import routine

Note that all batch routines show a command line window. Relevant information is contained in this window. It is advised that the content of the window 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 2.6.

In the example given for the Atmospheric Motion Vector import routine, a date stamp should have been entered like “202102191130” as the starting time on a daily basis of this product is at 00:30 UTC with a temporal interval of 1 hour. The actual time stamp used is “202102191145” which is resulting in the fact that the input data cannot be found and the routine, after pressing <Enter> can be aborted. When such an event occurs, carefully inspect the date stamp, the temporal resolution of the product or image (take note of the comment in the import window) and directory settings as indicated in the command line interpreter window as requested in the figure below. Can also be that due to system reception issues (part of) the data is not available, so it is always good to check in the source folders if the data is available.

**Figure 2.8: Resulting message when entering wrong date-time stamp**







## 2.8 CHANGES AND MODIFICATIONS

As the EUMETCast-GEONETCast data stream is continuously changing and further evolving, the user has the capability to easily modify or create new import routines and subsequently change the graphical user interface. For all these actions no programming experiences are required. New lines can be added in the “config.xml” file, and using the option “folderid” a new entry is created in the “caboverde.ini” file. When opening a new instance of the Cabo Verde Toolbox GUI, these changes are incorporated and using the option “Configuration” and “Folders” the appropriate input and output directories can be specified. A new script can be made, which in turn is executing a new batch file, to be created by the user. There are over 125 batch files within the ‘\toolbox\_batchroutines’ folder and portions of these files can be used as example how to create new ones.

It is advised to keep track of the changes using the XML version number. This version number can be modified in the “config.xml” file as well. The version number used for creation of this document is config.xml version 1.0. In the appendix the major changes of the Cabo Verde Toolbox versions are described.

## 2.9 ADVANCED USE

If certain operations have to be repeated on a continuous basis, e.g. import of a certain data type, e.g. for which basically only the time stamp has to be modified, it is advised 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.


Also 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.

Chapter 4.6.5 is describing how to execute batch looping routines. This is the most efficient way to import and pre-process the data needed, e.g. to construct time series.

## 2.10 CONCLUDING REMARK

With all the configuration settings provided you are now ready to utilize the Cabo Verde Toolbox and explore the (real time) data delivered via DVB-S2 broadcast. Note that services available in Europe (like the MSG-Rapid Scanning Service and some for METOP) are NOT available via e.g. the African turnaround service or GEONETCast Americas. Furthermore a number of routines are included facilitating the processing of data delivered through restricted services, which might require additional service registration prior to reception of the data.

The CaboVerde-Toolbox under ILWIS is able to import and process a multitude of data types delivered via EUMETCast-GEONETCast, but it depends on the service channels – PID’s activated which data is actually received at the various ground receiving stations located in the world. Check the services actually received by contacting the local ground receiving system administrator, eventually check the PID settings applied for the ‘Data Services’ from the DVB-S2 software. Further information on the data delivered can also be found in the EUMETSAT Product Navigator (<https://navigator.eumetsat.int/>) and check under ‘Access’ for the Distribution System, which ‘Channel’ is used. If registered to EUMETCast, also check the activated services at your EO-portal account and check if these Channels are included within the registered services.

A large number of products are contained in the various (multi-service) EUMETSAT Data Channels. To obtain an overview of the products per Service is a challenge and the easiest way to get an overview of the service product content is to use your browser and navigate to the EUMETSAT OSSI Service Status Indicator pages (<https://masif.eumetsat.int/ossi>), see also figure 2.9 (left). Now open the “0° Service” by clicking on the icon . Now within the new pop-up window open the link to the “Product Group Description” (figure 2.9, right).

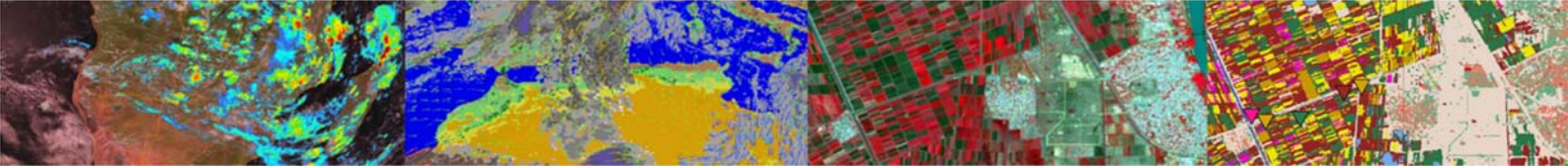


Figure 2.9: Service Status and Product Group Description

**SERVICE STATUS INDICATOR**

- 0° Service MET-11
- 9.5°E RSS MET-16
- 41.5°E IODC MET-8
- GDS-Metop-Metop-A
- GDS-Metop-Metop-B
- GDS-Metop-Metop-C
- GDS-NOAA-NOAA-19
- GDS-NOAA-NOAA-20
- GOES-16, GOES-17, Himawari-8
- 3rd Party
- Copernicus Sentinel-3A
- Copernicus Sentinel-3B
- EUMETCAST N/A

Valid for: 2021/02/22 08:29:32 UTC

**OSSI Level 2 - Product Group Overview**

The OSSI Level 2 report provides a summary of the availability status of Product Groups per service delivered via EUMETCast information is based upon the most recent Repeat Cycle/POU line and combines values for product completeness and product information. For a description of the product completeness, timeliness and threshold values please refer to the Product Group Description table.

Product Group Overview	EUMETCast Europe	EUMETCast Africa
Service Name: Copernicus SIC Name: Sentinel-3A		
OLCI Level 1B Full Resolution in NRT	<span style="color: green;">■</span>	<span style="color: green;">■</span>
OLCI Level 1B Reduced Resolution in NRT	<span style="color: green;">■</span>	<span style="color: green;">■</span>
OLCI Ocean Colour Reduced Resolution in NRT	<span style="color: green;">■</span>	<span style="color: green;">■</span>
SLSTR Sea Surface Temperature (SST) in NRT	<span style="color: green;">■</span>	<span style="color: green;">■</span>
SRAL Level 1B in NRT	<span style="color: green;">■</span>	<span style="color: green;">■</span>
SRAL Altimetry Global in NRT	<span style="color: red;">■</span>	<span style="color: red;">■</span>
SRAL Level 2 BUFR format	<span style="color: red;">■</span>	<span style="color: red;">■</span>

Product Group Definitions - 0° Service - Internet Explorer

https://www.eumetcast.net/.../0002/0001/Group.html

European Organisation for Meteorology and Hydrology

Service Name: 0° Service

Product Group Name	Channel/ Product	Seg	Format	EUMETCast			Thresholds		Product Navigator Reference
				Europe	Africa	Americas	C	T	
0° HR-SEVIRI Image Data				114 of 114	114 of 114	114 of 114	95%	30sec	ED/EUM/DAT/MSG/HRSEVIRI
HRV	PRO	180T	1.24	180T	✓	✓	✓		
OL_016	1.0	180T	✓	✓	✓				
OL_030	1.0	180T	✓	✓	✓				
OL_067	1.0	180T	✓	✓	✓				
OL_087	1.0	180T	✓	✓	✓				
OL_108	1.0	180T	✓	✓	✓				
OL_120	1.0	180T	✓	✓	✓				
OL_134	1.0	180T	✓	✓	✓				
VIS006	1.0	180T	✓	✓	✓				
VIS008	1.0	180T	✓	✓	✓				
WV_062	1.0	180T	✓	✓	✓				
WV_073	1.0	180T	✓	✓	✓				
EPN	180T	✓	✓	✓	✓				
0° Meteosat Meteorological Products				23 of 23	21 of 21	9 of 9	95%	30sec	ED/EUM/DAT/MSG/CLM
CLM	PRO	GR02	✓	✓	✓				ED/EUM/DAT/MSG/CLM
CLM	1.0	GR02	✓	✓	✓				ED/EUM/DAT/MSG/CLM
CI	PRO	BUFR	✓	✓	✓				ED/EUM/DAT/MSG/CI
CI	1	BUFR	✓	✓	✓				ED/EUM/DAT/MSG/CI
FRIC	PRO	CAF	✓	✓	✓				ED/EUM/DAT/MSG/FRIC

Note the listing of the “Channel/Product Acronyms” as well as the reference to the Product Navigator. Carefully inspect Product Group Description and use the information provided through the linkage with the Product Navigator. Repeat the procedure also for the 41.5° E IODC and the Global Data Services (GDS for METOP A, B and C and NOAA).

Double click on the link “Channel/Product Acronyms” and inspect the listing provided. This listing of Channel/Product Acronyms is very useful. It provides abbreviations for typical filenames used and these very often contain next to these abbreviations for satellite and product type the time stamp information and these are all standardized for each product or product collection.



### **3. EXPLORING THE GEONETCAST DATA STREAM USING THE CABO VERDE TOOLBOX**

#### **3.1 INTRODUCTION**

The CaboVerde-Toolbox provides an open and flexible integrated solution to manage the EUMETCast-GEONETCast data stream, import of the various image types and data products and bring them together in a common GIS and RS environment for further processing.

The data disseminated by EUMETCast-GEONETCast is consisting of various formats. Over time a number of utilities have been developed at ITC to be able to import these data types. Also other existing freeware utilities have been used and integrated in the toolbox, such as BUFR and GRIB (2) decoders. Also use can be made of other available software routines, such as SNAP, BRAT for pre-processing and Panoply for data visualization. Appendix 1 is providing the links to these additional useful utilities.

Also attention is given to use data that is made freely available through the World Wide Web and offers the capability to incorporate relevant (*in situ*) environmental and forecasting information. The Cabo Verde tools is extending the functionality beyond the 'real-time' EUMETCast-GEONETCast direct reception. To be able to use the functionality of these toolbox routines internet connectivity is required. The data is automatically retrieved if possible and pre-processed.

#### **3.2 THE CABOVERDE-TOOLBOX FUNCTIONALITY (XML VERSION 1.0)**

Below a short description with instructions to import the data / run a utility is provided of the main menu items that are available in the CaboVerde-Toolbox, XML version 1.0. The sequence followed is identical to the menu structure as given in figure 2.1.

##### **3.2.1 Cabo Verde Toolbox General**

###### **3.2.1.1 Cabo Verde Toolbox Help**

Under this menu item the 'About' and 'Disclaimer' are given which will be opened using a text editor, like Notepad. The change log for this XML version can be consulted as well as this 'Installation and User Manual'. These files require that a PDF Reader is available on your system. The PDF documents are situated in the ILWIS sub-directory 'Extensions\CaboVerde-Toolbox\util\manuals'

###### **3.2.1.2 GEONETCast Product Navigator**

The Product Navigator is developed and maintained by EUMETSAT. A link is provided to the online Product Navigator (<https://navigator.eumetsat.int/start>) as well as the Product Navigator as disseminated through EUMETCast-GEONETCast, see also chapter 1.2.6.

A regular Windows 'Scheduled Task' should be created to copy the files from this directory on the reception station to a central archive, so users always work with the latest 'Navigator' version. The location of this utility should be specified in the Toolbox using the options "Configuration" and "Folders". If this is done the button "Start GNC Product Navigator" can be pressed and a web browser is opened showing the details of the 'Product Navigator' available through EUMETCast. Also here, all kind of 'filter' settings a can be applied to find the data that might be of interest to the various users, although the appearance is different from the 'online' version. In general, this is a good starting point to discover the data that is currently disseminated for the various Services.



### 3.2.1.3 GEONETCast Data Manager

This utility allows the system administrator to transfer the newly incoming data on the ground receiving station to a central archive based on all kind of rules and decisions. This utility generates a graphical user interface based on an ascii text file. This file can be modified and adapted using a text editor (like Notepad) if new data has arrived or if the organization wants to maintain only a certain portion of the full data stream. This utility is described into more detail in chapter 1.2 and also the 'Data Manager Installation and User Manual' can be consulted. To view the manual a PDF reader needs to be installed. Furthermore note that Java is required to run this application.

Having selected from the menu the "Geonetcast Data Manager" the utility can be activated by pressing the "Start Data Manager" button and subsequently select the appropriate text file (\*.txt) and the graphical user interface will appear. As indicated before it is advised to run this utility as a stand-alone, only to be operated by the local system administrator.

## 3.2.2 Geostationary Satellites - Level 1.5 Data

### 3.2.2.1 Link to online resources

In each of the subsequent main menu levels a document with links to the online Product Navigator is provided for the respective satellite data or products that can be retrieved by the routines provided under the Toolbox under his level. For persons not familiar with the satellites or product details disseminated, further (online) information and references are provided. When checking the "Details" under "Access" > "by Distribution", e.g. for EUMETCast-Africa, also the typical file name is provided which can be used to check data availability in the local archive.

### 3.2.2.2 MSG Data Retriever

MSG-1 was launched on the 28<sup>th</sup> of August 2002 and after a testing period commenced routine operations on the 29<sup>th</sup> of January 2004. Then the satellite was renamed to Meteosat-8. On the 21<sup>st</sup> of December 2005, as a backup of Meteosat-8, MSG-2 was successfully launched and renamed Meteosat-9. On 05 July 2012 MSG-3 (Meteosat-10) was launched and was moved to the 0 degree position on 21 January 2013. Subsequently MSG-4 was launched on 15 July 2015 (Meteosat-11). Over time a number of modifications of the satellite operational status has occurred.

At this moment Meteosat-8 is situated at 41.5 degree East, scanning the Indian Ocean and the Middle East and Eastern part of Africa, the so called Indian Ocean Data Coverage (IODC). It is a replacement of Meteosat-7. Meteosat-9 is currently in a back-up status. Meteosat-10, situated at 9.5 degree East, has taken over the Rapid Scanning Service, only scanning the northernmost 1/3 portion of the full disk. Meteosat 11 is currently used as the prime geostationary satellite, providing full disc imagery every 15 minutes from the 0 degree position. This satellite coverage configuration will ensure continuous satellite observations till the launch of Meteosat Third Generation, which is composed of six new geostationary satellites, to be launched from 2021 onwards (4 Imaging Satellites and 2 Sounding Satellites).

The advanced SEVIRI radiometer on board the MSG series of geostationary satellites enables the Earth to be scanned in 12 spectral channels from visible to thermal infrared (including water vapour, ozone and carbon dioxide channels). The specifications of SEVIRI have been chosen carefully to match operational requirements. Each of the 12 channels (table 3.1) has one or more specific applications in mind, either when used alone or in conjunction with data from other channels. Each has a well-established heritage, ensuring that their characteristics are well understood so that the data can be used on an operational basis. The actual instrument includes a primary mirror with a diameter of 51 cm and infrared detectors. The raw images are generated through a combination of an east-west scan obtained from the spinning of the entire satellite at 100 revolutions per minute, together with a stepping of a telescope mirror from south to north after each scan line. The spatial resolution of the SEVIRI instrument has been slightly increased (at intervals of 3 km) compared to its



predecessors, the High Resolution Visible (HVR) channel even has a sampling distance interval of just 1 km.

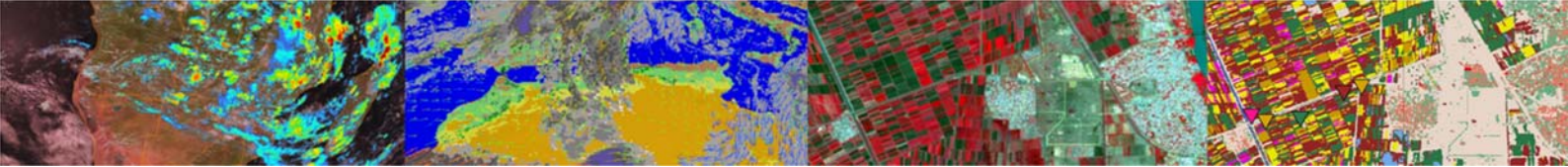
The problem with the MSG data is that the file format is not standard. None of the commonly used remote sensing packages is able to open or process the raw compressed images. Therefore a driver was developed for reading the images in the Geospatial Data Abstraction Library (GDAL, <http://www.gdal.org>). GDAL is a translation library for raster geospatial data formats that is released under an MIT style Open Source license. All source code is in C++, and great effort is put into keeping the code platform-independent. Drivers for writing files in popular RS formats (e.g. ENVI, ERDAS, ILWIS, GeoTiff) but also picture formats like JPEG, GIF and BMP have already been implemented by the community, so appending a driver for reading MSG image files to this driver was seen as the most appropriate solution.

**Table 3.1: SEVIRI channels and their applications**

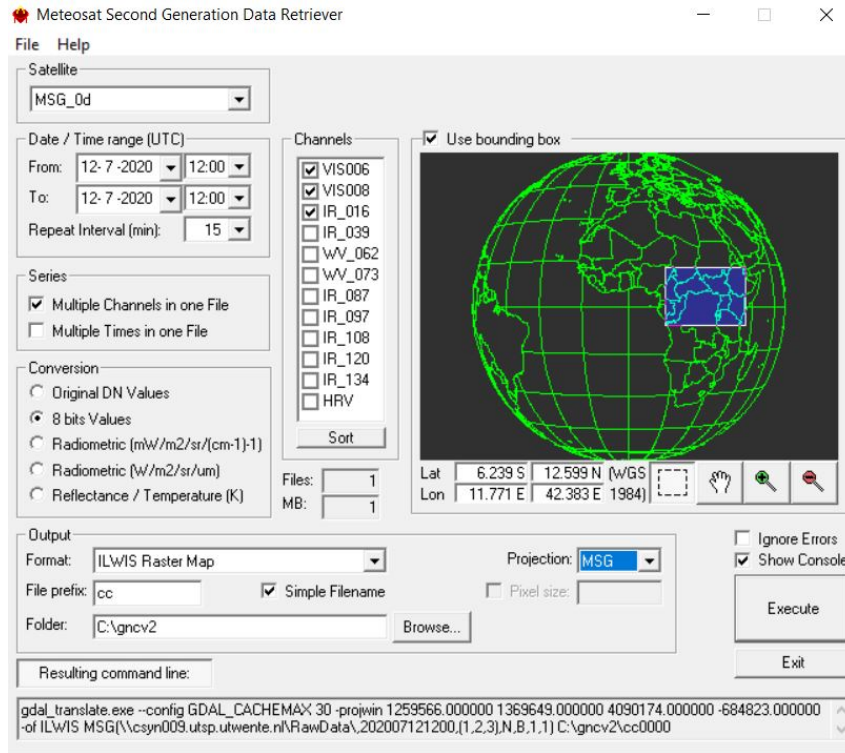
Band	Center	Min	Max	Nadir Res	Row x Cols	Repetition	Application
1	0.635	0.56	0.71	3000	3712 x 3712	15	Surface, clouds, windfield
2	0.81	0.74	0.88	3000	3712 x 3712	15	Surface, clouds, windfield
3	1.64	1.5	1.78	3000	3712 x 3712	15	Surface, cloud phase
4	3.9	3.48	4.36	3000	3712 x 3712	15	Surface, clouds, windfield
5	6.25	5.35	7.15	3000	3712 x 3712	15	Water vapor, high level clouds, atmospheric instability
6	7.35	6.85	7.85	3000	3712 x 3712	15	Water vapor, atmospheric instability
7	8.7	8.3	9.1	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
8	9.66	9.38	9.94	3000	3712 x 3712	15	Ozone
9	10.8	9.8	11.8	3000	3712 x 3712	15	Surface, clouds, windfield, atmospheric instability
10	12	11.00	13	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
11	13.4	12.4	14.4	3000	3712 x 3712	15	Cirrus cloud heights, atmospheric instability
12	-	0.4	1.1	1000	11136 x 7700	15	Surface, clouds

An algorithm developed is correctly re-composing the images from the multiple compressed data files / segments. According to the provided documentation the algorithm must take care of scan direction, image compression, bit-depth, image size and proper alignment of the image strips of the high resolution band. A second algorithm developed performs the radiometric calibration using the relevant header / footer (PRO / EPI) parameters and applying appropriate formulas that calculate the resulting pixel values into the required unit. A third algorithm determines the geo-location of each pixel. Automatic geo-location has the advantage that no manual steps are needed to transform the images to a known projection. This utility can be used to import the recordings from the SEVIRI instrument on board Meteosat-8, the 41.5 degree IODC service, the Meteosat-10 Rapid Scanning Service (RSS) and Meteosat 11, covering the 0 degree service. Also when there are changes, and Meteosat-9 is used given (maintenance) issues for the 0 degree or RSS service, the data retriever can be applied, irrespective of the actual satellite providing the service. Also downward compatibility is provided, e.g. the data from Meteosat-8, providing the initial 0 degree service, can still be retrieved, using the satellite settings for 'MSG-0d', etc.

The command-line utilities that come with GDAL facilitate the use of the library to transform MSG images into widely applied RS data formats. The GDAL version used supports 25 output formats in the library. In-house experiences with these command-line utilities revealed that composing such a command-line string is an error-prone process (given the many options available). Therefore a Microsoft Windows based user-interface was developed that generates the necessary command-line syntax (figure 3.1). The user only needs to express the "query" by making appropriate choices using checkboxes, radio buttons, list boxes, selection of area of interest, etc. Through the user interface all relevant parameters can be adjusted and a time series can be easily constructed. The user interface facilitates retrieval of original DN values (10 bit-depth), compressed DN values to 8 bit-depth, Top of Atmosphere radiances in 2 different units ( $W/m^2/sr/\mu m$  or  $mW/m^2/sr/cm-1$ )-1), computation of Top of Atmosphere reflectance for the visible channels or Top of Atmosphere temperature (in Kelvin) for the thermal channels. The geometric precision is within a pixel for the low resolution bands and Geographic coordinates and UTM projection conversion is possible (a pixel size dimension has to be entered).



**Figure 3.1: The MSG Data Retriever**



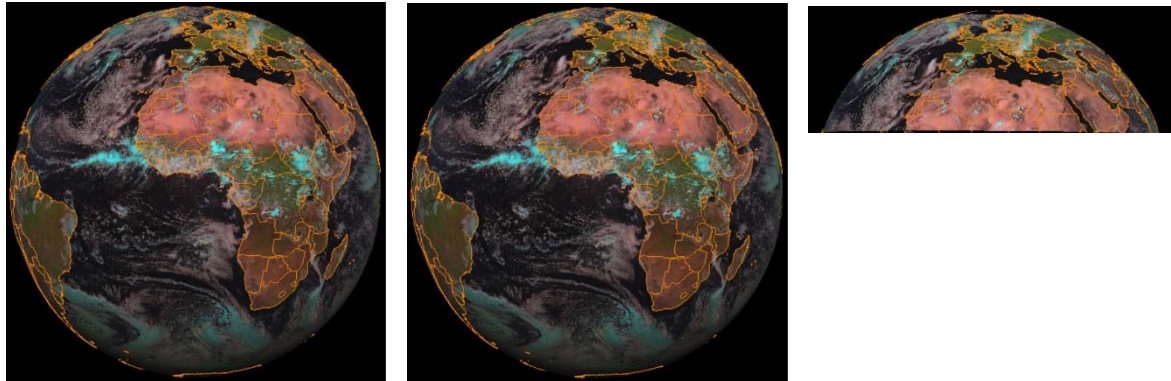
For more flexibility, showing the option “Resulting Command Line”, the corresponding command-line string for performing a certain import is revealed. This string can then be copied into a batch file which can be executed or called from within an ILWIS script in order to perform similar imports multiple times in a semi-automated manner. The GDAL-driver and windows based Data Retriever interface facilitate easy geometric and radiometric calibrated data retrieval of MSG into e.g. ILWIS format.

The MSG Data Retriever can be invoked when pressing the button “Start MSG Data Retriever” Using the option “File”, “Data Sources” the linkage can be established to the central archive, where the data is stored. Multiple data sources can be configured. More details on the configuration of the data sources can be found in chapter 2.5. Under the drop down menu of “Satellite” , 3 options are available to select the respective services. Also the map window changes, to allow for extraction of only a specific portion of the field of view of the satellite. Note should be taken furthermore that the temporal resolution of the RSS is set to 5 minutes.

A known issue is that on some new computers systems the Data Retriever does not start as some required resources are not locally available. The Microsoft Visual C++ redistributable packages, also known as VCredist, are runtime components in support of Windows applications and the “vcredist\_1\_x86.exe” and “vcredist\_2\_x86.exe”, available under the ILWIS folder \CaboVerde-Toolbox\MSGDataRetriever. These can be executed and required resource components are downloaded and installed. Ensure the system is online and after running the two executables, start the MSG Data Retriever again.



**Figure 3.2: MSG full disk from 0 and 41.5 degrees and RSS (left to right)**



### 3.2.3 Real Time MSG Visualization

Utilities are developed to automatically import a number of spectral channels (and band combinations) derived from the SEVIRI instrument. Once a real time visualization routine is selected and the appropriate input and output directories are specified, the utility automatically starts at a given system clock time, scheduled in such a way to ensure that the last recorded images have arrived at the ground reception station. The task is automatically repeated every 15 minutes, in sync with the temporal resolution of MSG. The current real time applications available are “Cabo Verde regional visible” and “Cabo Verde regional thermal” for day time and night time image visualization respectively.

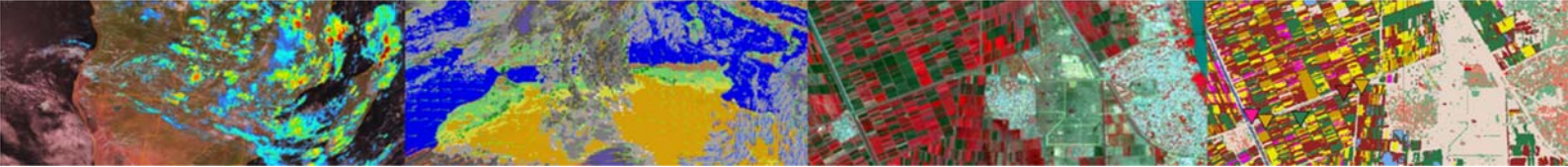
The utility starts a Windows Scheduled Task event. Once this is done, ILWIS can be closed as it will automatically run from the command prompt. To stop (and remove the Scheduled Task), the option “Stop ..... Visualization” (‘.....’ stands for “Visible” or “Thermal”) and subsequently the “Stop” button can be selected.

The procedure for automatic visualization is further explained below using as example the “Cabo Verde regional visible” option from the toolbox menu. Note that the other visualization routine works in a similar manner. When starting the routine “Cabo Verde regional visible” a batch file “ini\_ECOWAS.bat” is executed, situated within the toolbox sub directory \toolbox\_startscript\RealttimeMSGVisualization\AfricaECOWASWindow. This batch file sets a number of input parameters (like the in- and output drive\directory and the directory location of executables needed). It furthermore creates a Scheduled Task. In this example when a new event of a Scheduled Task is started a new file “st\_msgECOWAS.bat” is created. This file is stored in the same ILWIS sub-directory and the syntax line creating the Scheduled Task is given below:

```
schtasks /create /sc minute /mo 15 /st 08:01:00 /tn "MSG_visual" /tr
%4Extensions\Caboverde-Toolbox\toolbox_startscript\RealttimeMSGVisualization\AfricaECO
WASWindow\st_msgECOWAS.bat
```

where:

- schtasks Windows Scheduled Tasks application (schtasks /? is the help function)
- /create Create a scheduled task
- /sc Specifies the schedule frequency
- /mo Modifier, for more refined task tuning, as “/sc” is defined as “Minute”, “/mo” provides a repeat interval of 15 minutes
- /st Starting time, note this is your system time
- /tn Name that uniquely identifies the task
- /tr Task name, the batch file which is subsequently executed, containing the full path (here %4 defines the ILWIS directory)



The result is that a new Scheduled Task, named “MSG\_visual” is created, which now executes a batch file (“st\_msgECOWAS.bat”) every 15 minutes, starting from 08:01 hr (local time). Note that the file “ini\_ECOWAS.bat” can be modified if e.g. another starting time is required.

The applications access the newly arrived raw MSG data (at the end of the each scan) which is stored on a network resource. A dated folder structure is assumed here (see also chapter 2.5 and figures 2.6 and 2.7).

The thermal visualization routine applies a (similar) sequence of batch files which are located in the toolbox sub-directory “\toolbox\_startscript\RealtimeMSGVisualization\AfricaECOWAS Thermalc”. The sequence of batch routines is specified into more detail in figure 3.3.

The final image shown on the screen is visualized using IrfanView. Once a number of import sequences have passed the user can click with the left mouse button on the last displayed image (to activate the image display window) and use the scroll bar on the mouse to interactively move to the previous images and back to the last imported time interval.

The time stamp displayed on the upper left hand portion of the image is referring to the end of scan time for the whole field of view of MSG-11. The actual time when the northern most part of the Cabo Verde window is scanned by MSG is approximately 09:00 minutes after the start of scan time. So from 6 till 26 degree north latitude the actual time when the region is recorded is about 07:00 to 09:00 minutes after start of scan time respectively.

To get the appropriate end of scan time stamp in local time (but still applicable for the whole field of view of MSG) the system “date and time settings” should adhere to the appropriate time zone setting. It is advised to configure your system time stamp in a “HH:mm:ss” format, check your system “Region and Language” settings. The screen resolution to display the images should preferably be 1280 by 1024 pixels.

The “Cabo Verde regional thermal” imports the SEVIRI IR\_108 channel over the Cabo Verde region and is displaying the colder clouds in a colour scheme (using the routine “st\_msg\_thermal\_c.bat”). The imported data is transformed into Temperature. To obtain an inverse representation a coefficient of 400 is used from which the actual imported pixel values are subtracted (400-actual). Assume a non-clouded pixel with a Top of Atmosphere (ToA) temperature of 310 Kelvin (K) this algorithm will result in an output pixel value of 90. Now assume a cloud pixel with a top of the cloud temperature of 190 K, this will result in an output pixel value of 210. The resulting data range is mostly in the range of 0-255 (byte range), and if an inverted grey scale lookup table is used the white toned pixels now represent the cold clouds and the dark grey areas represent the non-clouded land and water surfaces. Thresholds are defined and the pixels falling in these threshold ranges are subsequently colour coded. The threshold actual temperature range and colour coding is given in table 3.2.

**Table 3.2: Thermal thresholds applied for temperature ranges and colour coding used**

Thresholds (Kelvin)	Grey scale values	Colour code (R,G,B)	Resulting colour
> 235	Inverted Grey scaling is applied for values less than 165		
220 - 235	165 - 180	255,136,0	orange
205 - 220	180 - 195	255,203,1	yellow
190 - 205	195 - 210	89,173,228	blue
< 190	> 210	255,93,255	pink

Within the batch file “st\_msg\_thermal\_c.bat” an ILWIS MAPCALC “color” operation is executed to create the output map “ccTOA\_Tinverse%workingtime%.mpr”, assigning the class ranges to the specified output colours. If more classes or different colour are required this expression can be modified to suit the need of the user.

If at a given moment required input files cannot be retrieved (from the archive) due to whatever reason the application stops the import of that given time event. A command box

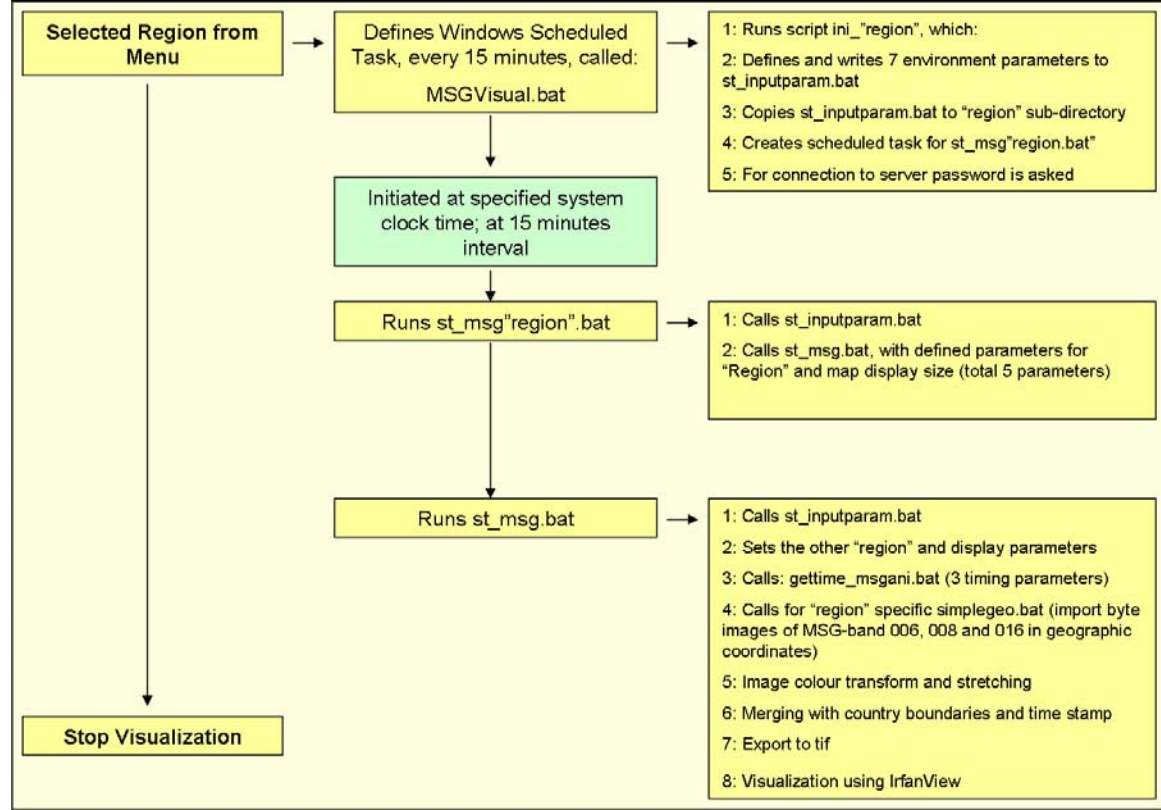




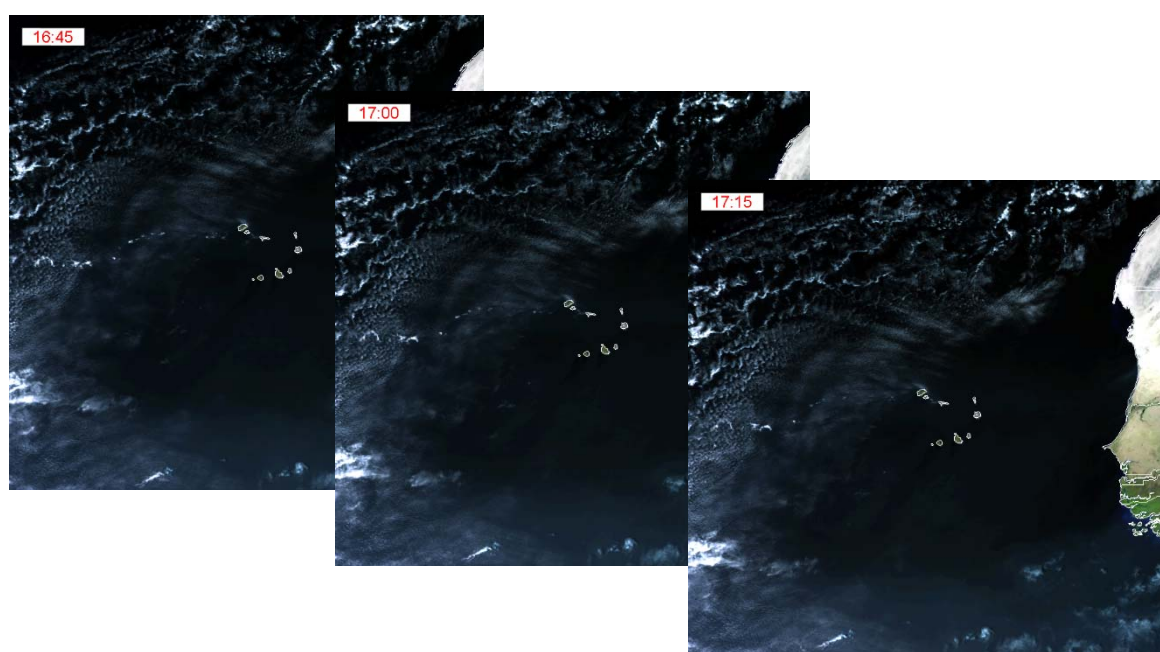
will appear on the screen. To continue press <enter> and check what the problem could be why you are not able to import the latest images!

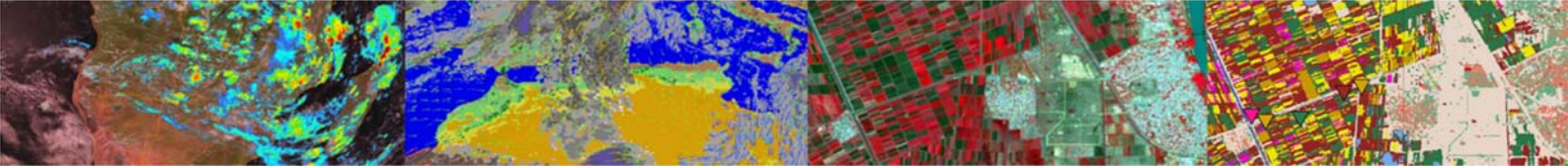
From the main Cabo Verde Toolbox menu, using the options "Configuration" and "Folders", the input "Real Time MSG VIS" and output directories can be specified. Also check the input folder settings for the folder "MSG Data Retriever".

**Figure 3.3: Layout of the various components for Real Time MSG visualization**



**Figure 3.4: Automated image visualization, Cabo Verde Window**





The output images are stored within the specified output drive\directory. The file name format is “cyyymmddhhmm.tif”. The first “hhmm” instance refers to the start of scan time in UTC, the second “hhmm” represents the local end of scan time (of the whole field of view of MSG) in hours and minutes, using a 24 hour format. Using IrfanView, and selecting the appropriate series of images, an animation can be easily created and can be saved as an executable (\*.exe). The created slideshow can be visualized just by double clicking the file using your mouse.

### 3.2.4 Automatic processing

To facilitate operational weather services a number of routines have been developed requiring minimal user interaction to retrieve and display in a map view a selected number of most recent MSG images and standard SEVIRI RGB composites as well as derived products. Figure 3.5 is showing the MPEF viewer, figure 3.6 shows the NWC SAF viewer and figure 3.7 is showing the MSG Day-time viewer. After the processing has been completed a map view is displayed showing the results over a standard background. The only user interaction required is to switch layers ‘on’ and ‘off’. Full GIS functionality is however provided, like zooming, panning, setting layers transparent, adding other layers, retrieving the image or product (pixel) values, etc. For image visualizations and RGB compositing the EUMETSAT ‘best practices’ are applied, see the menu item “Color scheme processing details”. Table 3.3 provides details on the products / images retrieved.

The routine determines for the selected images / products those which have been most recently received, retrieves the appropriate files, performs the processing, is creating and visualizing a map view. The date-time stamp attached to the map view is the (local) time when the routine started. For all products and images the actual file date-time stamp (in UTC) is used.

Figure 3.5: MPEF automatic generated map view

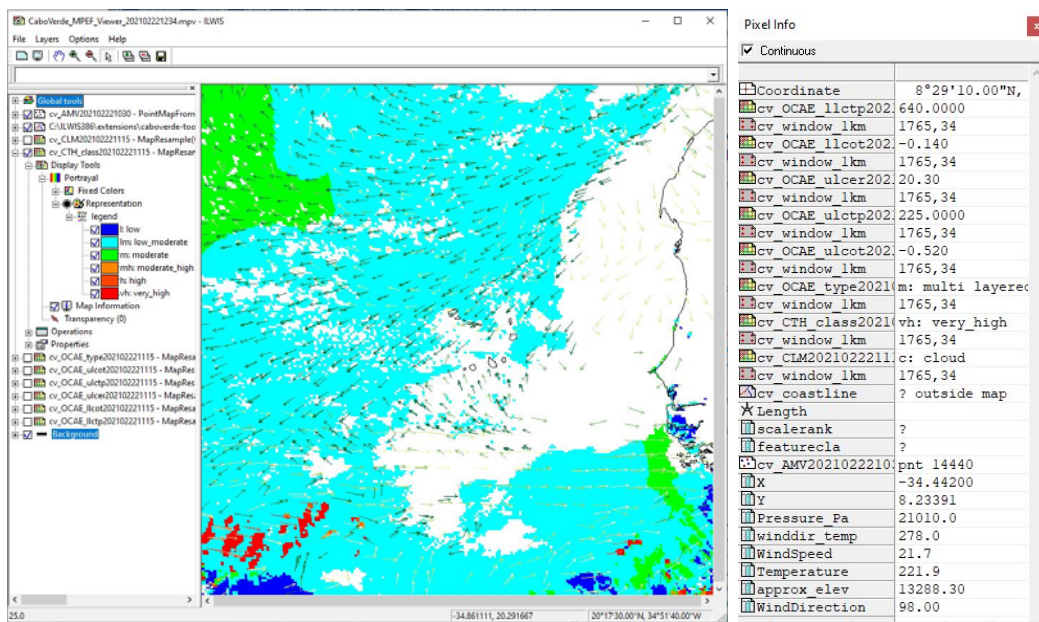




Figure 3.6: NWCSAF automatic generated map view

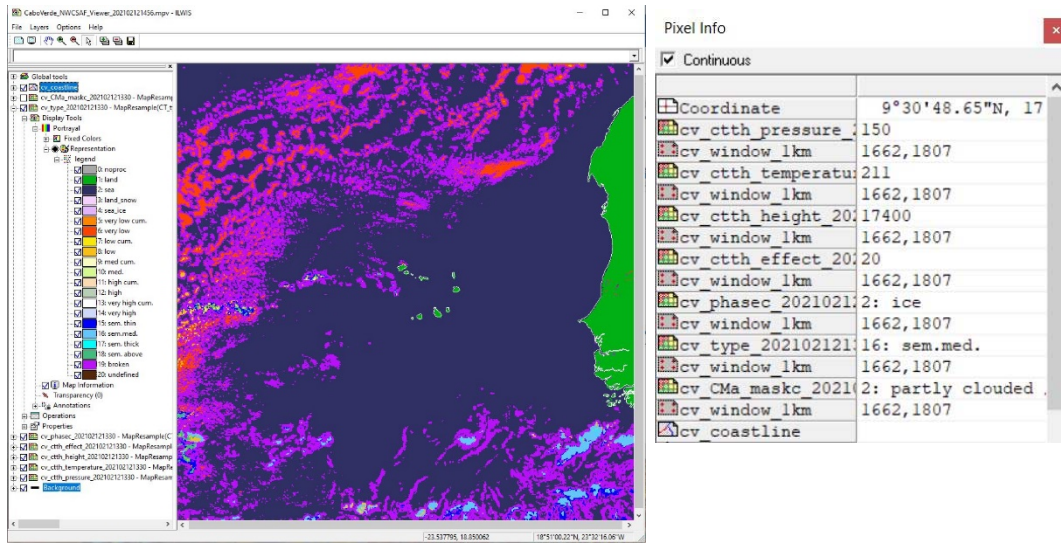
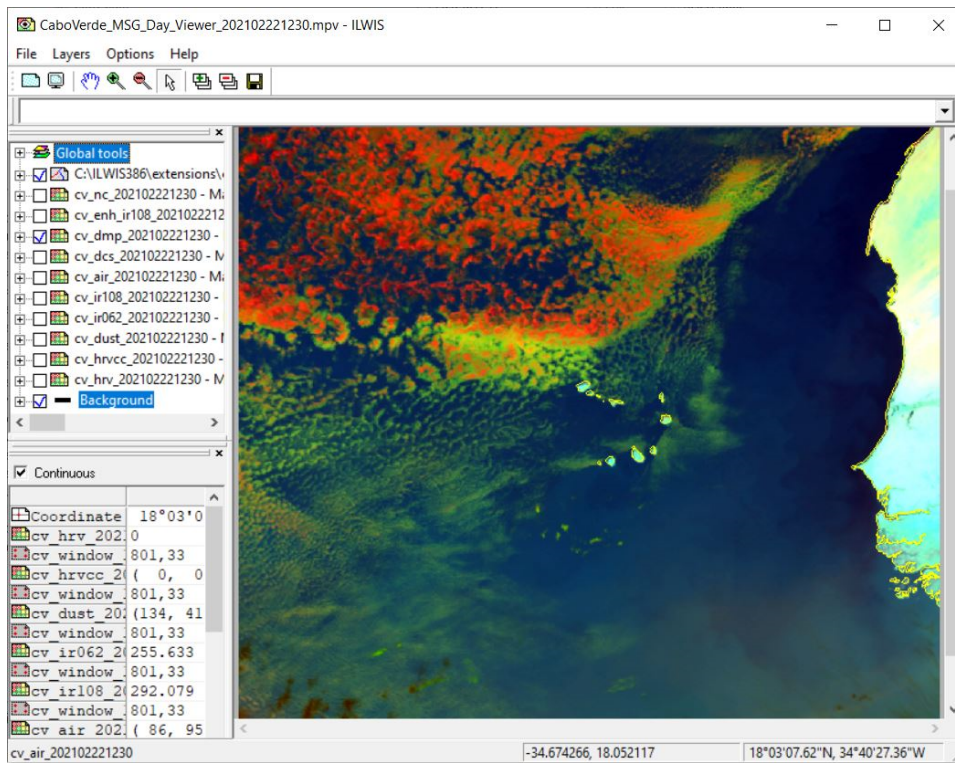


Figure 3.7: Example of MSG-Day-Viewer showing Day Micro Physics visualization



From the main Cabo Verde Toolbox menu, using the options “Configuration” and “Folders”, under “MPEF-highres”, “NWC\_SAF\_cband” and “MSG Data Manager” the input and output directories can be specified for the different viewers. The batch routine can be found under the ILWIS directory ‘\Extensions\CaboVerde-Toolbox\auto\_gnc’ and the batch filename convention used for this product is “begin\_\*.bat” which subsequently calls another batch routine “start\_\*.visualization.bat” (\* is used for the different product visualizations). The routine determines automatically if a dated folder structure is used and if this is the case, based on the actual system clock date-time, the appropriate year\month\day is determined. The routines can also be operated as a “Windows Scheduled Task”, fully automating the whole processing.



**Table 3.3: Automatic processed data layers**

Viewer	MSG-Day	MSG-Night	MPEF	NWC-SAF
<b>Image/products imported</b>	All MSG SEVIRI channels, converted to reflectance and temperature. Images are stretched and gamma function is applied.	All IR MSG SEVIRI channels, converted to temperature. Images are stretched and gamma function is applied.	Cloud Mask (CLM), Atmospheric Motion Vectors (AMV), Optimal Cloud Analysis (OCAE)	Cloud Mask (CMa), Cloud Type (CT), Cloud Temperature-Height (CTTH)
<b>Layers added to MapView visualization</b>	IR_10.8 (K) WV_6.2 (K) Enhanced IR_10.8 Airmass RGB Dust RGB Microphysics RGB Severe Storm RGB Natural RGB HighRes RGB	IR_10.8 (K) WV_6.2 (K) Enhanced IR_10.8 Airmass RGB Dust RGB Microphysics RGB	CLM Cloud Mask OCAE type, upper and lower level pressure, COT and upper level effective radius AMV Direction, Speed, Pressure, Temperature, approx. Elevation, Scaling for speed	CMa Cloud Mask CT Cloud Type and Phase CTTH Cloudiness (%), Temperature (K), Pressure (hPa), Height (m)
<b>Background layers used / at disposal</b>	Layers used: country boundary segment file			

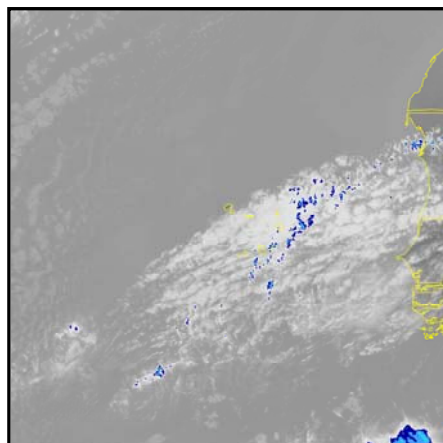
A routine has been added to create from the most recent 2 hr MSG IR\_10.8 images received at the reception station an animated gif. An enhanced TIR colour visualization is created, using the class intervals as given in table 3.4. For the TIR Animation an inverse grey scale is applied for the pixels having temperatures above 240 Kelvin. For the pixels below 240 K a colour scheme is adopted in 5 degree class intervals as given in the table below.

**Table 3.4: Temperature classes adopted for enhanced IR visualizations**

Temperature class (K)	Colour
>240	Inverted grey scale
240-235	Dark blue
234-230	Blue
229-225	Cyan
224-220	Green
219-215	Yellow
214-210	Orange
209-205	Red
< 205	Brown

An example of showing a single time step of such an animation is given in the figure below. The GIF file is automatically displayed and is stored in the working directory. The file name convention used is anim\_tir\_last2hrs\_yyyymmddhhmm.gif, where the date-time stamp refers to the start of the routine, local time! The animation shows the development – dissipation and movement of the colder clouds over the preceding 2 hours in 8 time steps.

**Figure 3.8: Single time step of the enhanced MSG TIR animation**





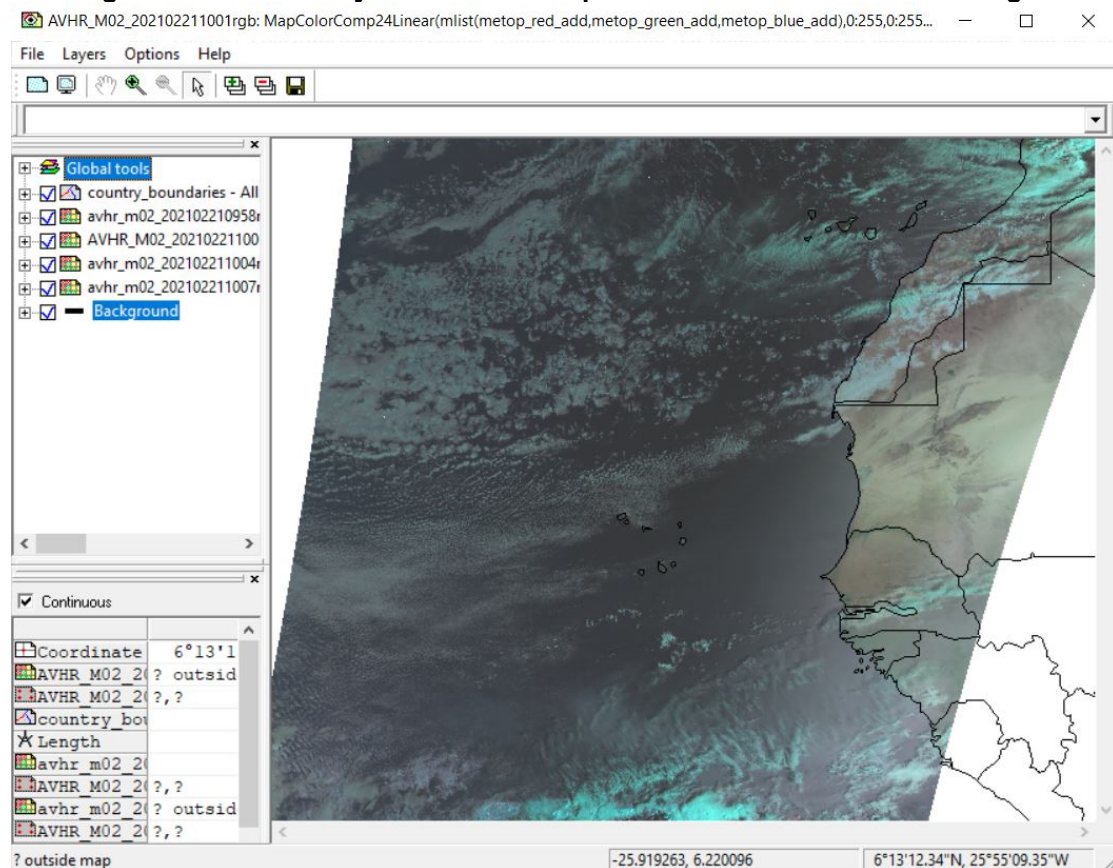
### 3.2.5 Polar - Level 1.5 Data

Within this submenu, routines are available to process recordings made by the AVHRR and ASCAT instruments on the METOP series of satellites, which supplement the observations from the geostationary satellites. A link is provided to relevant online resources and to determine the orbit position at a specific (UTC) time 'polar orbit tracks' can be used ([https://www.ssec.wisc.edu/datacenter/orbit\\_tracks.html](https://www.ssec.wisc.edu/datacenter/orbit_tracks.html)), also available from the Toolbox Menu option “Other Routines” > “Polar Orbit Tracks”.

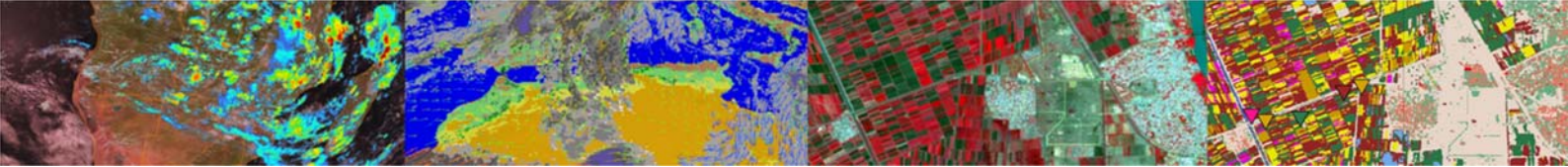
For METOP A, B and C an AVHRR data retriever is available, facilitating the import of each of the 3 minutes data files distributed through EUMETCast. The Advanced Very High Resolution Radiometer (AVHRR) is a multipurpose imaging instrument used for the global monitoring of cloud cover, sea surface temperature, ice, snow and vegetation characteristics. Data is extracted in ILWIS format and transformed to radiances for all channels, reflectances (for the visible channels; 1, 2 and 3a) and temperature (for the thermal channels; 3b, 4 and 5). Also (cloud) flags are extracted. Depending on day / night observation channel 3 is transformed into reflectance (during day time) or temperature (during night time). Upon import the full file name is expected, including the file name extension, here 'bz2'. Data is retrieved from the archive, decompressed and processed.

A routine has been developed to extract only the visible channels, to facilitate the computation of a day time colour composite, see also the figure below. Multiple files can be processed and added to a map display, to allow coverage of a whole continent.

**Figure 3.9: AVHRR day time colour composite of four 3 minutes scan images**



Also the data from the Advanced SCATterometer (ASCAT) instrument on METOP, used to derive the Ocean Vector Winds (OVW) and Surface Soil Moisture (SSM), both at a 12.5 km sampling distance in swath geometry, can be processed. The SSM product provides an estimate of the water saturation of the 5 cm topsoil layer, in relative units between 0 and 100 [%]. The expected average RMS error of the ASCAT soil moisture index is about 25%, which

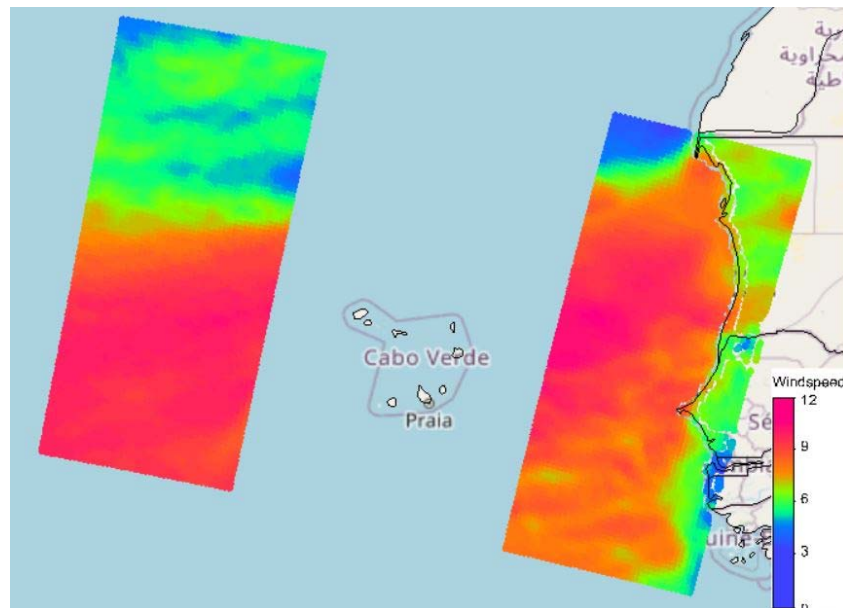


corresponds to about 0.03-0.07 m<sup>3</sup> water per m<sup>3</sup> soil, depending on soil type (ASCAT User Guide – EUMETSAT PDF\_DMT\_151558.pdf) .

The ASCAT Ocean Vector Winds product provides information about the wind speed (m/s) and wind direction (degree) at 10 metres above the sea surface. Consult also the ASCAT Wind Product User Manual ([http://projects.knmi.nl/scatterometer/publications/pdf/ASCAT\\_Product\\_Manual.pdf](http://projects.knmi.nl/scatterometer/publications/pdf/ASCAT_Product_Manual.pdf)) for further information.

All files are providing in a 3 minutes coverage as well. Upon import the full file name is expected, including the extension, here '.l2\_bufv'.

**Figure 3.10: A 3 minutes ASCAT derived Ocean Vector Winds product – wind speed**



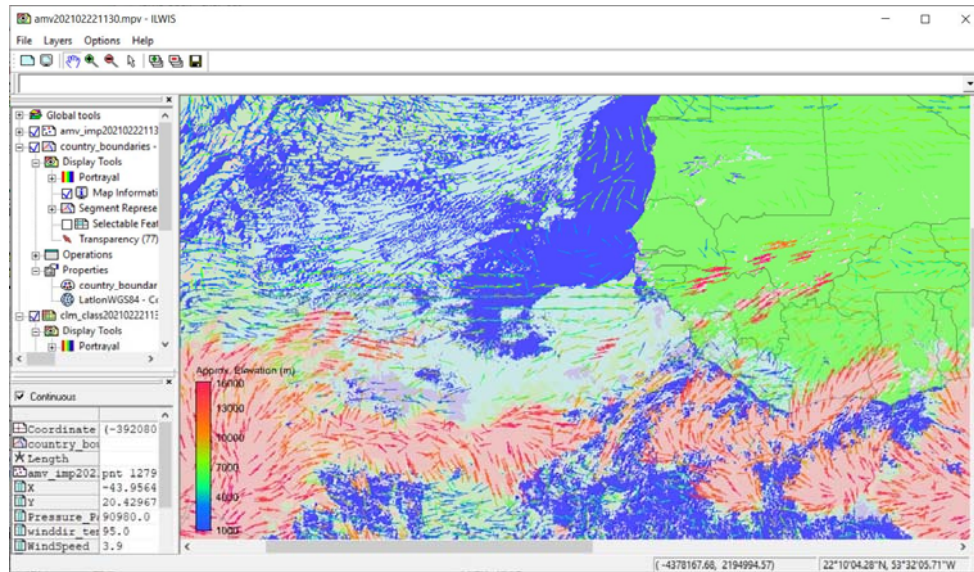
### 3.2.6 Meteorological Products

The Meteorological Products Extraction Facility (MPEF) is a part of the Ground Segment. The primary function is the generation of Meteorological Products from the Level 1.5 image data supplied by the Image Processing Facility (IMPF). The products are then quality controlled and encoded prior to being passed to the Data Acquisition and Dissemination Facility (DADF) for delivery to users. Currently MPEF product import routines are available for MSG at 0 degree.

Under the 'MSG 0-degree based' a number of routines are available to import the various products that are generated by the MPEF at EUMETSAT. For the "High Temporal Resolution MPEF Products" the time stamp required here should adhere to: yearmonthdayhourminute (12 digits), the temporal resolution changes for the various products; it is indicated in the comment line of the menu as well as the time of the first product generated on a given day. From the main CaboVerde-Toolbox menu, using the options "Configuration" and "Folders", the input "MPEF\_highres" and output directories can be specified. These products are generated using the full disk of MSG at 0. An example of AMVs, cloud mask and cloud top height classification image is given in the figure below.



**Figure 3.11: Sample products from MPEF**



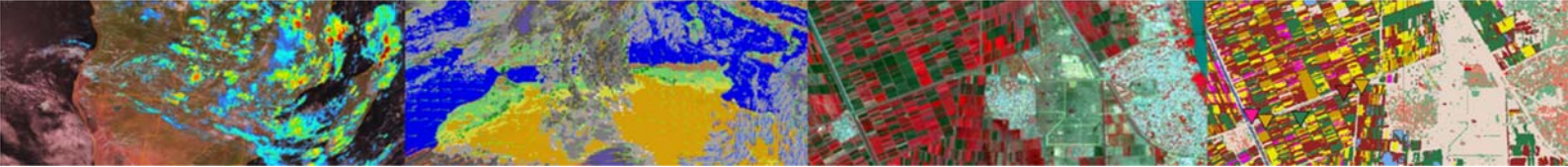
Also data with lower temporal resolution are generated by MSG-MPEF, such as a daily and dekadal NDVI. Import routines are available to process this information, the routines are situated under the sub menu “Low Temporal Resolution MPEF Products”, the input data directory is specified as “MPEF\_lowres”, using the options “Configuration” and “Folders”. The “hhmm” timestamp for these products is always “1200”.

To import some of the MPEF BUFR formatted products (like TOZ, GII and for the RSS service the RII) takes a long time as many records need to be processed. For the TOZ visualization and import the most recent software releases of BufrExtract and BufrDisplay are used.

Lightning Detection Data are provided through the ATDnet system, an automatic lightning location network capable of sensing lightning flashes over a wide and variable geographical area. The system locates lightning by timing the arrival of unique very low frequency radio waves (known as atmospheric, or simply 'sferics') generated by individual lightning strikes at the ATDnet stations. The differences in the arrival times of these strokes at the stations are used to calculate the lightning's location. Data are collected every minute and BUFR encoded using the 'Universal BUFR template for lightning data' with 15 minutes of data combined into one file which is then sent to EUMETSAT and disseminated (source: <http://navigator.eumetsat.int/>).

**Figure 3.12: ATDNET 15 minutes BUFR file plotted over MSG for the same time step**





The relationship between strong convective processes (cumulonimbus clouds) and occurrences of lightning can be clearly observed from the figure above. For further information see also <https://www.metoffice.gov.uk/learning/storms/thunder-and-lightning/lightning>.

Before starting to import the Sferics product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option “Configuration” and “Folder” and select “ATDNET”. As input string a “yyyymmddhhmm” timestamp is expected, note the temporal resolution of 15 minutes and the product is available with a timing offset of 3 minutes. After import of the file a point map and table is created using as file name convention “ATDNET\_sferics\_yyyyymmddhhmm”.

NOAA’s Climate Prediction Centre is providing forecasts on Weather and Climate Parameters for Africa, like Precipitation, Temperature, Winds, Heights, MSLP, Relative Vorticity, SST, etc. derived from the NOAA’s National Center for Environmental Prediction models: Global Forecast System (GFS), Global Ensemble Forecast System (GEFS), and Global Data Assimilation System (GDAS) for all the production cycles. The Global Forecast System (GFS) is a weather forecast model produced by the National Centres for Environmental Prediction (NCEP). Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration. The entire globe is covered by the GFS at a base horizontal resolution of 18 miles (28 kilometres) between grid points, which is used by the operational forecasters who predict weather out to 16 days in the future. Horizontal resolution drops to 44 miles (70 kilometres) between grid point for forecasts between one week and two weeks. The GFS model is a coupled model, composed of four separate models (an atmosphere model, an ocean model, a land/soil model, and a sea ice model), which work together to provide an accurate picture of weather conditions (source: <http://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forecast-system-gfs>).

The GFS output for the Africa region is disseminated through GEONETCast and is mostly available at 01:00 UTC at the local ground receiving station – next day . Model output is also online available at <http://www.cpc.ncep.noaa.gov/products/international/africa/africa.shtml>.

From the main Cabo Verde Toolbox menu, using the options “Configuration” and “Folders”, under “GFS” the input and output directories can be specified. A main menu template for Africa is displayed when running the import routine and from this main menu template links are provided to all the other product items.

### 3.2.7 Satellite Application Facilities (SAF)

Satellite Application Facilities (SAFs) are specialised development and processing centres within the EUMETSAT Applications Ground Segment. Utilising specialised expertise in Member States, they complement the production of standard meteorological products derived from satellite data at EUMETSATs Central Facilities.

The routines available here are grouped per SAF (like LSA, OSI, H, NWC, CM). Products are produced by the Satellite Application Facility (SAF) on Land Surface Analysis (LSA), Ocean and Sea Ice (OSI), SAF on Support to Operational Hydrology and Water Management (H-SAF), the SAF on Now-Casting (NWC-SAF) and the Climate Monitoring SAF (CM-SAF).

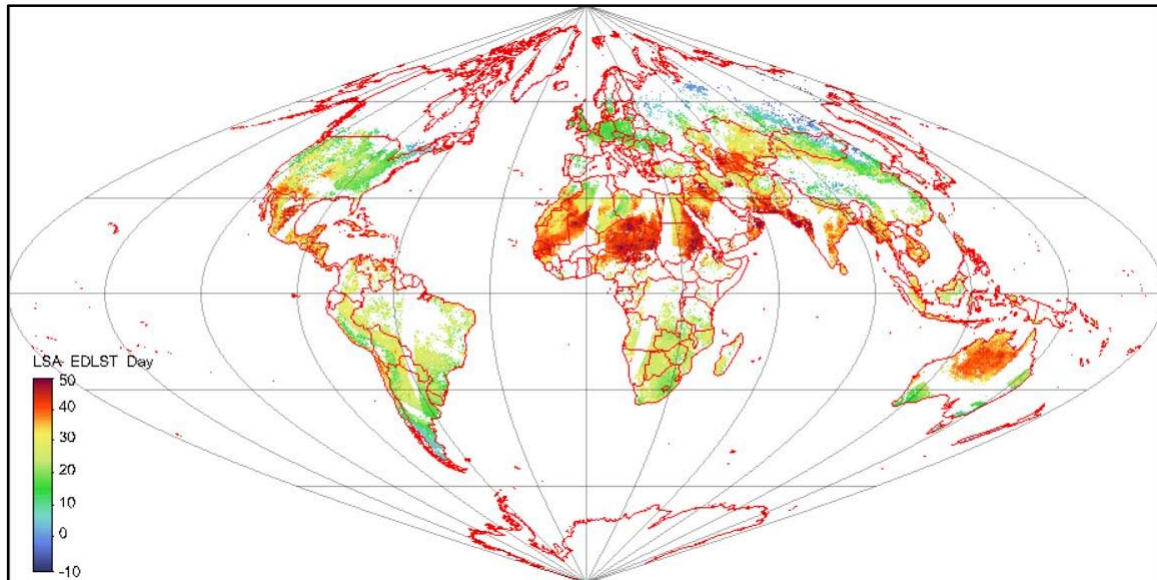
The LSA SAF provides various products on radiation budget and bio geophysical parameters, for various geographic windows, for the full MSG disk as well as global day and night time land surface temperature from METOP. The OSI SAF product extraction routine allows the import of a METOP derived global (twice daily) sea surface temperature product. The H-SAF provides daily global soil moisture index products, 15 minutes and 24 hours accumulated rainfall products. The NWC SAF is providing now-casting products derived from MSG, like various cloud parameters in full spatial and temporal resolution, convective rain rates and information on rapid developing thunderstorms. The CM-SAF provides monthly mean products on surface down welling shortwave radiation and the monthly mean cloud fraction.





The import routines available allow import of the various products. The time stamp required here should mostly adhere to: yearmonthdayhourminute (12 digits), the temporal resolution changes for the various products; it is indicated in the comment line of the menu as well as the time of the first product generated on a given day. From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input and output directories can be specified. For the LSA SAF products, select the LSA\_SAF Africa, LSA\_SAF\_EDLST, LSA\_SAF\_Full\_ET, LSA\_SAF\_Full\_METREF, depending on the product. For the OSI\_SAF, H\_SAF (for H03B, H05B and H14), CM\_SAF and NWC\_SAF\_cband the folders with corresponding names can be selected to specify the in- and output directories.

**Figure 3.13: Global day time Land Surface Temperature from METOP**

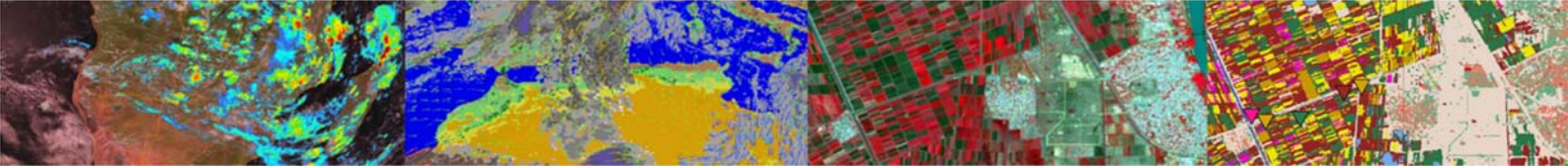


### 3.2.8 Other selected product - Global

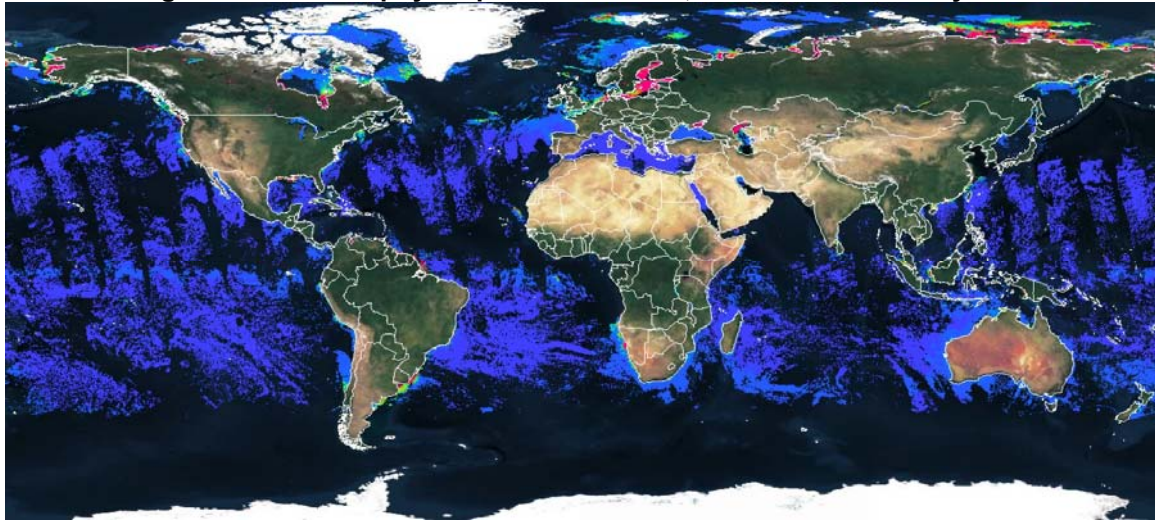
#### 3.2.8.1 MODIS Global Products

MODIS provides global marine products, such as the Chlorophyll Alpha, KD490, PAR and SST products, mapped at a spatial resolution of 4 km. MODIS provides the ability to measure chlorophyll fluorescence, which gives insight into the health of phytoplankton in the ocean. When phytoplankton is under stress, they no longer photosynthesise and begin to emit absorbed sunlight as fluorescence. Measurements of the chlorophyll fluorescence can be used to describe the physiological state of the phytoplankton, help to determine the cause of phytoplankton bloom collapses and help to make more robust estimates of primary productivity on a global scale (source: <http://navigator.eumetsat.int/>). An example is provided in figure 3.14. For visualization the map values can be stretched from 0.01 to 10, minimum and maximum respectively, using a logarithmic stretch function and pseudo representation for appropriate visualization.

From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input MODIS and output directories can be specified. Although the data files use a Julian Day date stamp, the import routine transforms calendar day to Julian day and retrieves the appropriate maps for that specific day of the year.



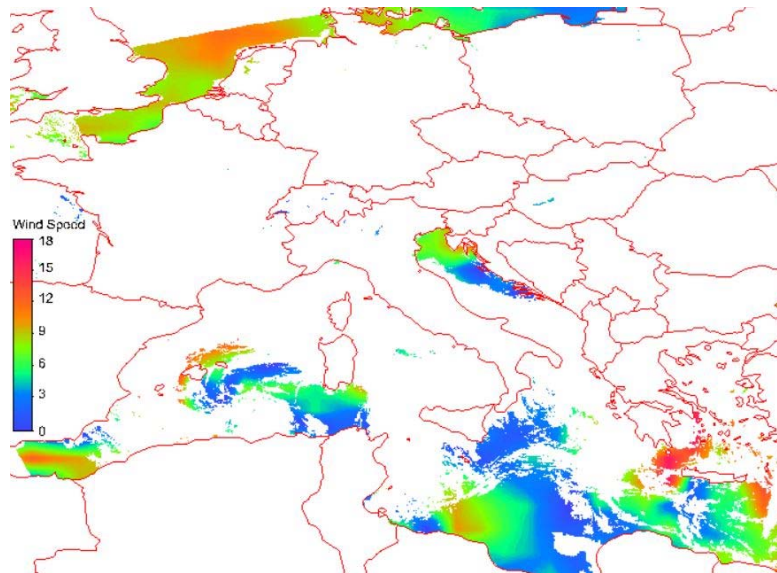
**Figure 3.14: Chlorophyll Alpha from MODIS, combination of 3 days**



### 3.2.8.2 NPP Marine products

Suomi NPP VIIRS SST and wind speed. The GHRSSST v2 Level 3U Global Skin Sea Surface Temperature from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite is created by the NOAA Advanced Clear-Sky Processor for Ocean (ACSP0). For more information see: [https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:GHRSSST-VIIRS\\_NPP-OSPO-L3U](https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:GHRSSST-VIIRS_NPP-OSPO-L3U). SST is obtained by regression with buoy measurements, sensitive to skin SST. The data also includes surface winds (10 meters above the sea surface) from NCEP GFS data, unit is in m/s. Spatial resolution of 1 km.

**Figure 3.15: NPP example showing wind speed**



From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input and output directories can be specified under the option “NPP\_Marine\_Product”.



### 3.2.8.3 Global Precipitation Monitoring (GPM) mission

The GPM mission is an international network of satellites that provide the next-generation global observations of rain and snow. Building upon the success of the Tropical Rainfall Measuring Mission (TRMM), the GPM concept centres on the deployment of a “Core” satellite carrying an advanced radar / radiometer system to measure precipitation from space and serve as a reference standard to unify precipitation measurements from a constellation of research and operational satellites.

The GPM Core Observatory operates a space-borne Ku/Ka-band Dual-frequency Precipitation Radar (DPR) and a multi-channel GPM Microwave Imager (GMI). The DPR instrument consists of a Ka-band precipitation radar (KaPR) operating at 35.5 GHz and a Ku-band precipitation radar (KuPR) operating at 13.6 GHz. Relative to the TRMM precipitation radar, the DPR is more sensitive to light rain rates and snowfall. In addition, simultaneous measurements by the overlapping of Ka/Ku-bands of the DPR provide new information on particle drop size distributions over moderate precipitation intensities. The GMI instrument is a conical-scanning multi-channel microwave radiometer with thirteen channels ranging in frequency from 10 GHz to 183 GHz. The GMI uses a set of frequencies that have been optimized to retrieve heavy, moderate and light precipitation using the polarization difference at each channel as an indicator of the optical thickness and water content. Further information is available at: [https://gpm1.gesdisc.eosdis.nasa.gov/data/doc/README\\_GPM.pdf](https://gpm1.gesdisc.eosdis.nasa.gov/data/doc/README_GPM.pdf).

The routine extracts 1 hr rainfall (composed of 12 files of 5 minutes each), in orbit geometry, creates a point map and raster map of those points experiencing rainfall.

For the GMI microwave radiometer, brightness temperature are extracted for the different frequencies at 10.6, 18.7, 23, 37, 89 GHz, with horizontal and vertical polarizations for S1 and 166 with horizontal and vertical polarizations and 183+3 and 183+7 GHz with vertical polarizations for S2. Further information is provided at: <https://gpm.nasa.gov/missions/GPM/GMI>. Files are processed for the 5 minutes duration files each. From the table a point map and a raster map is created.

**Figure 3.16: GPM derived precipitation in orbit configuration for 1 hr duration**



From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input and output directories can be specified under the option “GPM”.



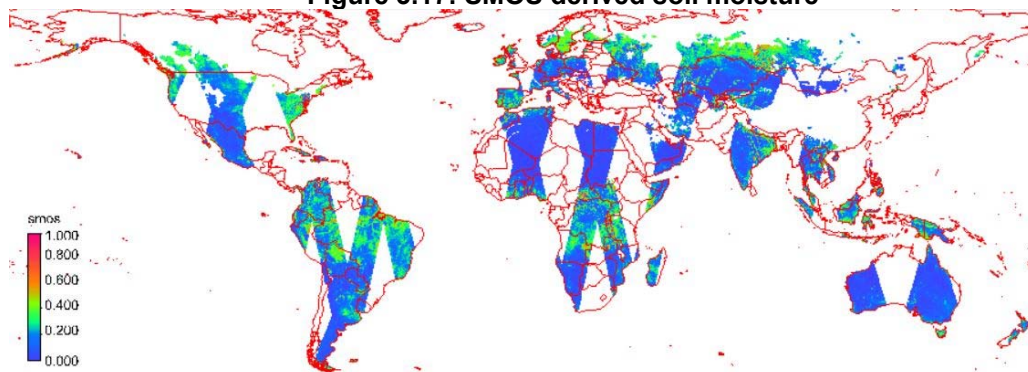
### 3.2.8.4 SMOS

The SMOS Level 2 Soil Moisture in near real time (NRT) product contains swath-based soil moisture. The product is derived from ESA L1C NRT product and based on the usage of a statistical algorithm, i.e. neural network trained on SMOS L2 soil moisture data. Further information on SMOS Level 2 data is available at:

[https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/content/-/asset\\_publisher/t5Py/content/data-types-levels-formats-7631](https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/content/-/asset_publisher/t5Py/content/data-types-levels-formats-7631).

First, the routine developed extracts all the SMOS level 2 files from the archive, then using a looping procedure, processes all files and from the tables extracted and point maps are created. These can be added to a new 'object collection' and displayed. An example is provided below.

**Figure 3.17: SMOS derived soil moisture**



From the main CaboVerde-Toolbox menu, using the options "Configuration" and "Folders", the input and output directories can be specified under the option "SMOS".



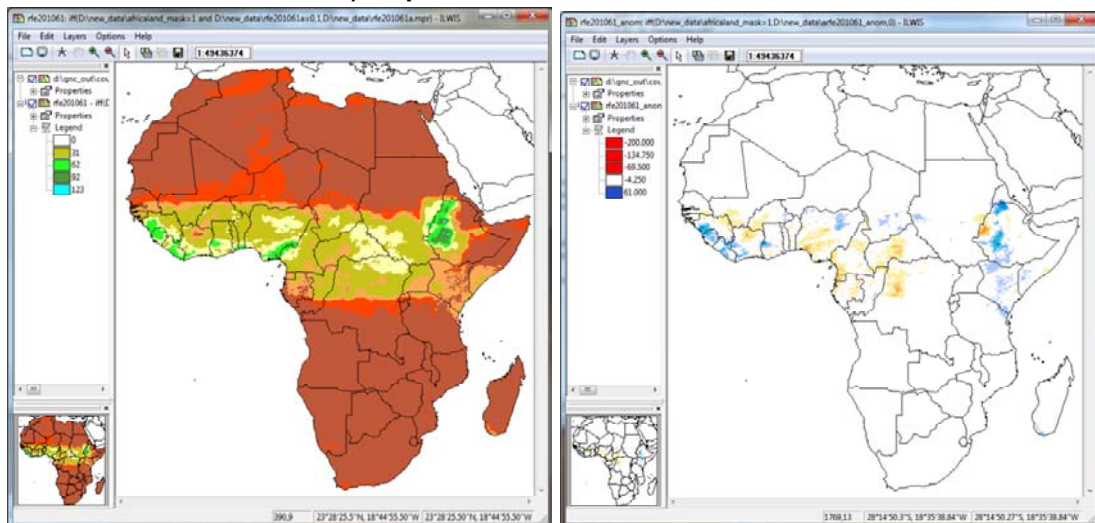
### 3.2.9 Other selected products - Regional

#### 3.2.9.1 TAMSAT Rainfall Products

Within the GEONETCast data stream also non-meteorological organizations contribute. An example is the rainfall product for Africa, produced by the TAMSAT group from the University of Reading, UK, which 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. Using this set of import routines the 10 day accumulated RFE rainfall product can be imported as well as a monthly accumulated rainfall product, which is calculated based upon the availability of 3 dekadal rainfall products for a given month. Furthermore a dekadal anomaly and monthly anomaly rainfall product can be imported. Note that the “Date” stamp required format is: `yyyymmdec` (which stands for yearmonthdekade), dekades are number 1 to 3 for the dekadal products and `yyyymm` (which stands for yearmonth) for the monthly products. As from the 1<sup>st</sup> decade of March 2011 the file format has changed, new import routines have been developed for import of the various TAMSAT rainfall (and anomaly) products of more recent date (Post March 2011).

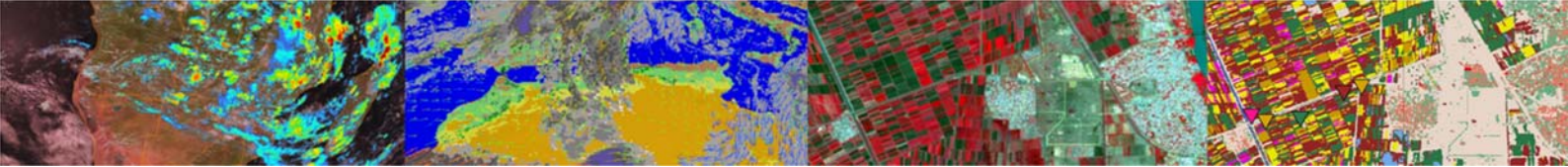
From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input TAMSAT and output directories can be specified. Standard representations for the various TAMSAT products for visualization are available, their names are starting with “`rfe_*`”. An example is provided in figure 3.18.

**Figure 3.18: Dekadal TAMSAT rainfall and rainfall anomaly (using climatology from 2000 - 2009) maps from 1<sup>st</sup> decade of June 2010**

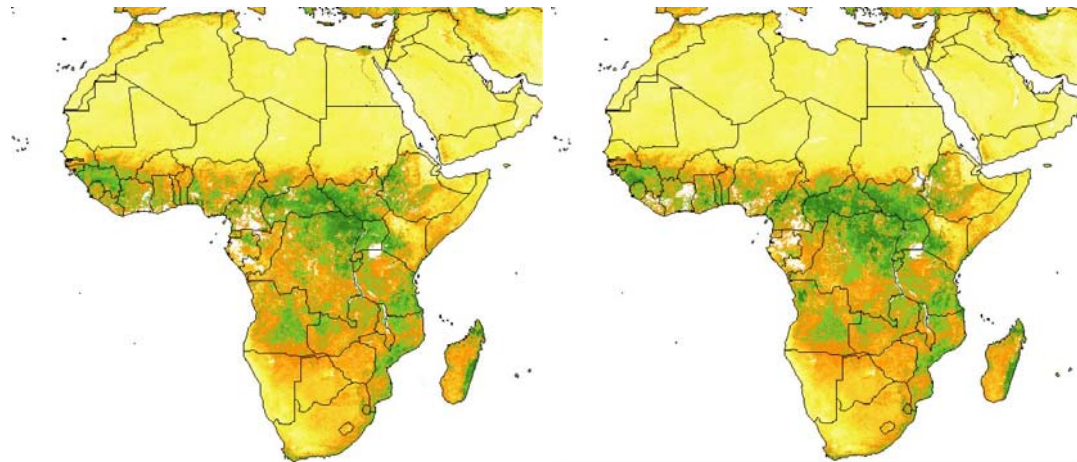


#### 3.2.9.2 Sentinel 3 Land

Sentinel 3 A and B Synergy ‘SY\_2\_V10 product’ is limited to the African continent and are a maximum Normalised Difference Vegetation Index (NDVI) value composite of ground reflectance measurements of all segments received during 10 days. These products have a Short-Time Critical (STC) timeliness and they are available in less than 3 days. Sentinel-3 is part of a series of Sentinel satellites, under the umbrella of the EU Copernicus programme. More information can be obtained from: <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy/product-types/level-2-vg1-v10>. These products are a continuation from the SPOT and PROBA Vegetation instruments. As from 20200511 the date format is referring to the 1<sup>st</sup> day, 11<sup>th</sup> day and 21<sup>st</sup> day of the month, representing the integration time of the first 10 days, days 11-20 and the remainder of the month. After import data is in byte format, to convert to the `ndvi` range -1 to 1, a scaling of 0.004 and an offset of -0.08 should be applied, e.g. ‘`scale*DN-offset`’.



**Figure 3.19: Sentinel 3 A and B Synergy NDVI of 20200611**



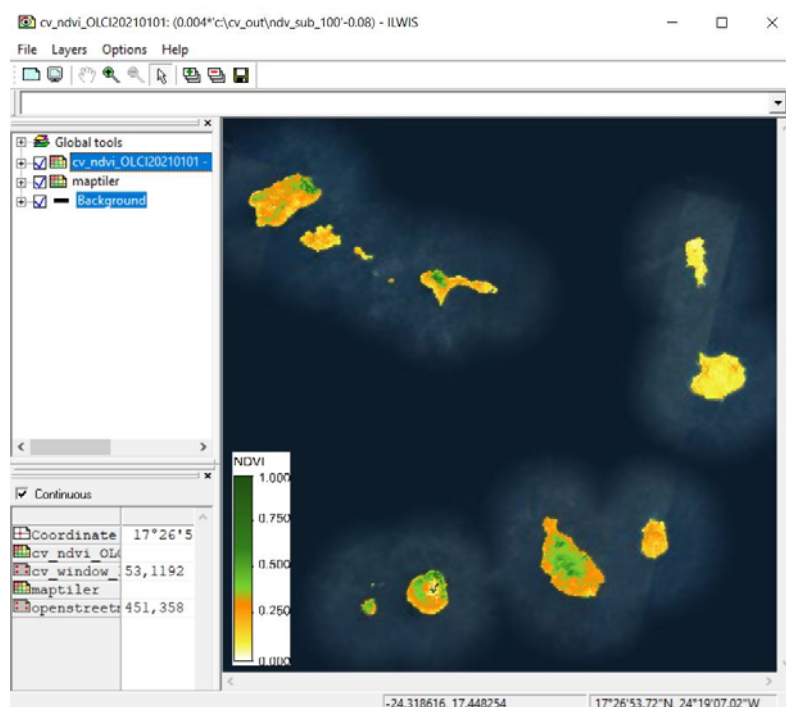
From the main CaboVerde-Toolbox menu, using the options “Configuration” and “Folders”, the input Sentinel folder “S3SYN” and output directories can be specified. Standard representation for the NDVI product (in byte range) for visualization is ‘ndv\_byte’.

### 3.2.9.3 Copernicus Regional NDVI

As from the beginning of 2021 the OLCI instrument on Sentinel-3 is used to generate a BDRF corrected NDVI. This product is a replacement of the Proba-V NDVI. The initial spatial resolution is 300 m and within the toolbox a subset is extracted and resampled to the Cabo Verde window with a spatial resolution of 100 m.

Before starting to import the NDVI product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option “Configuration” and “Folder” and select “Copernicus\_NDVI”. As input string a “yyyymmdekdek” timestamp is expected. The dekad stamp expected is 01, 11 and 21 respectively. The resulting NDVI image is given in the figure below.

**Figure 3.20: Sentinel 3 OLCI derived NDVI for the Cabo Verde Region**



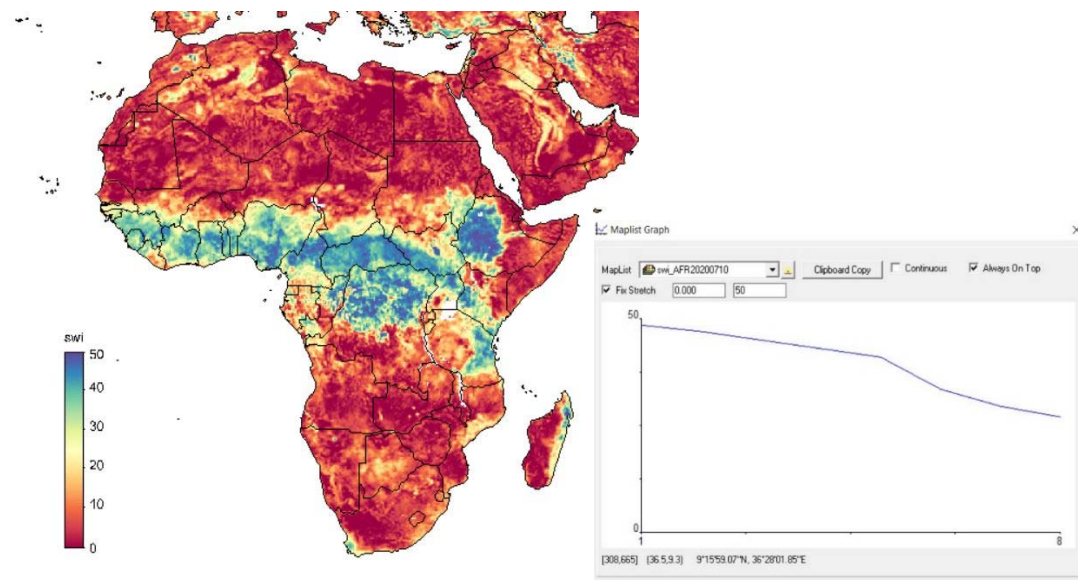


### 3.2.9.4 Copernicus Regional Soil Water Index

The Soil Water index (SWI) product provides global daily information about moisture conditions in different soil layers. SWI daily images are produced from EUMETSAT ASCAT-25km SSM product in orbit format and include a quality flag indicating the availability of SSM measurements for SWI calculations. Soil moisture is a key parameter in numerous environmental studies including hydrology, meteorology and agriculture. In addition to Surface Soil Moisture (SSM), information on the moisture condition within the underlying soil profile is of interest for different applications. Soil moisture in plant root zone can be estimated by an infiltration model using information on surface soil moisture and soil characteristics (source: <http://navigator.eumetsat.int/>). The Soil Water Index quantifies the moisture condition, also within the underlying soil profile in 8 different characteristic time lengths - T (where T is 1, 5, 10, 15, 20, 40, 60 and 100) (<https://land.copernicus.eu/global/products/swi>).

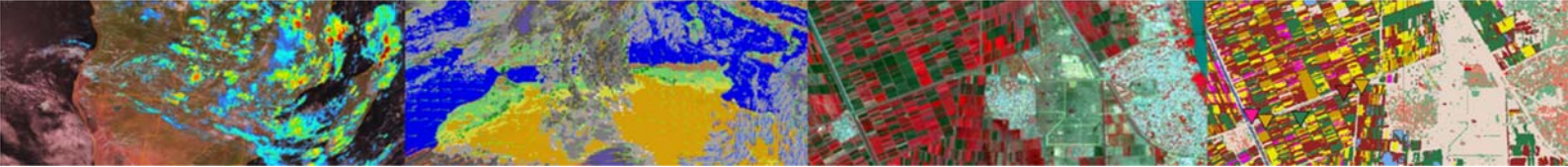
Before starting to import the SWI product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option "Configuration" and "Folder" and select "Copernicus\_SWI". As input string a "yyyymmdd" timestamp is expected. After import of the file a map list is created containing the 8 different characteristic time lengths (T), numbered from 1 to 8 (where T is 1, 5, 10, 15, 20, 40, 60 and 100 respectively), see the graph in the figure below taken from the highlands of Ethiopia.

**Figure 3.21: SWI over Africa from 20200710, with T=1, other integration times in graph**



### 3.2.9.5 PROBA-Vegetation Products

As from June 2014 the new Proba-Vegetation instrument took over the task of the SPOT-VGT instrument. See the Proba website for further instrument and mission details (<http://proba-v.vgt.vito.be/en>). Based on the data recorded by Proba, currently a number of derived products for Africa and Latin America are disseminated through GEONETCast to continue the legacy of its predecessor. Routines to import the products currently available have been included in this toolbox release, applying the calibration coefficients for the various products. It should be noted that the continental extend is different between the SPOT VGT and the Proba-V products, although their spatial resolution is the same (1 km). Proba is decommissioned in the mid of 2020, for more recent data the Sentinel-3 Synergy can be used. Routines to process the data from Proba-V have been maintained in this version of the toolbox.



Before starting to import the SWI product available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option “Configuration” and “Folder” and select “ProbaV\_Africa” or “ProbaV\_Latin America”, for the respective areas of interest. As input string a “yyyymmdekdek” timestamp is expected. The dekad time stamp expected is provided in the comment line, note that the routines are processing the latest product versions, also indicated in the command line.

### 3.2.9.6 AEMET Dust Forecasts

The Barcelona Dust Forecast Centre (<https://dust.aemet.es/>) provided a number of dust related forecasts (up to 72 hours, 6 hours interval) on optical depth, surface concentration, load, dry / wet deposition and surface extinction. These products are in a picture format and are therefore not imported into ILWIS, instead for visualization use is made of the animation option in IrfanView. Products cover the Northern Hemisphere, from 30W to 70E.

Before starting to import the AEMET products available in the GEONETCast data stream verify the settings of the directory containing the raw data. In order to do so, select from the main menu the option “Configuration” and “Folder” and select “AEMET\_dust”. As input string a “yyyymmdd” timestamp is expected. All forecast time steps are retrieved and an animated image sequence is shown. In Irfanview, available within the toolbox at \Extensions\CaboVerde-Toolbox\util\IrfanView and instance of “Irfanview” can be started and under the ‘Slideshow’ option the ‘slide advancement’ speed can be controlled, e.g. using the setting ‘Automatic after’ 0.75 seconds. Also the image display / screen size can be adapted.

### 3.2.9.7 PML Marine Products

PML produces and disseminates refined and 3-day composite ocean products based on MODIS-AQUA (chlorophyll-A, turbidity and water leaving radiances). The table below shows the current windows and the products. It is advised to check the raw data situated in the respective input directory to obtain the appropriate “Date” stamp as for the daily products it is related to the overpass time of the polar orbiting instrument used. Input “Date” stamp format is yyyymmddhhmm.

**Table 3.5: PML ocean product retrieval routines**

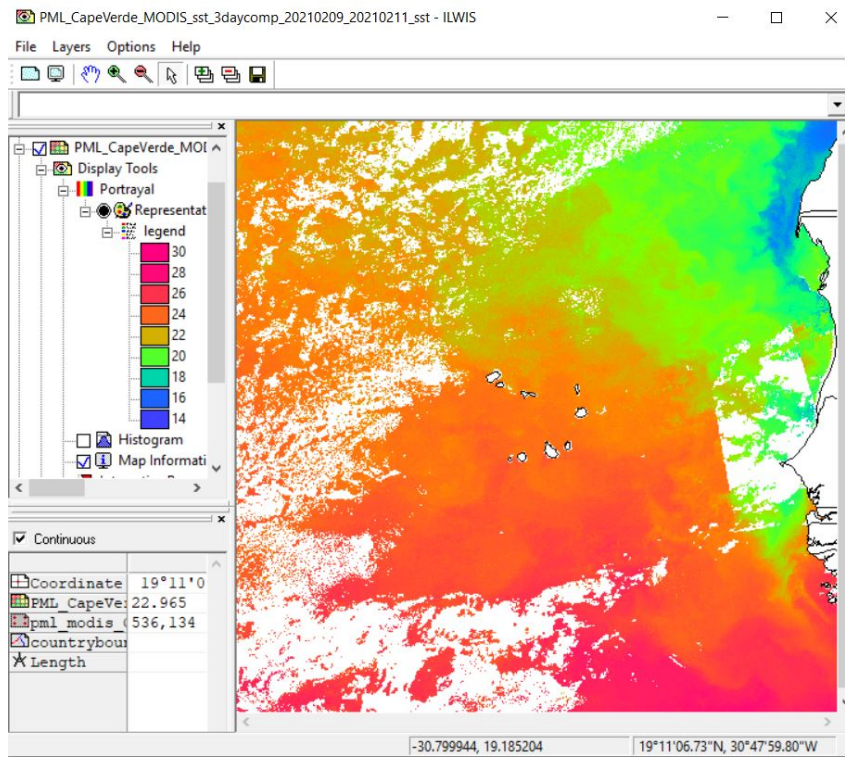
Region	OC Refined	SST Refined	OC 3day comp	SST 3day comp
Cape Verde	Chl-A, Kd-490, nLw	SST	Chl-A, Kd-490, nLw	SST

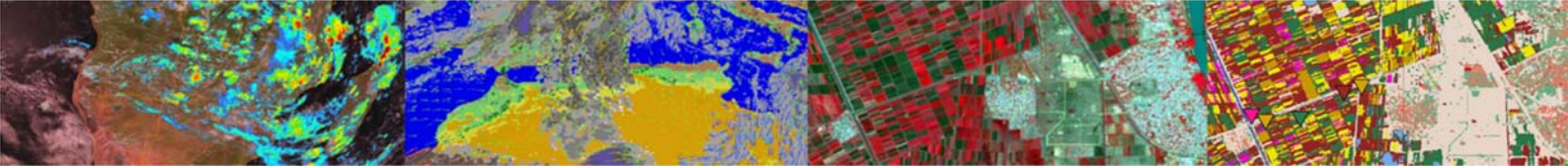
For the Near Real Time (NRT) products no processing routines are included. The normalized water leaving radiances are retrieved for 443, 448, 547 and 667 nm. PML advises to make a RGB composite using as band assignment, red=nLw\_547, green=nLw\_488 and blue=nLw\_443. To import the composite products the ‘start\_end’ time stamp is required, this can be obtained from the respective file name. A 3 day sst composite is given in the figure below for the Cabo Verde region.





**Figure 3.22 : 3-day SST composite for the Cabo Verde Region**





### 3.2.10 Other Routines

Some of the routines described below provide additional resources that can be used in conjunction with the data provided through GEONETCast-EUMETCast. Some of the utilities listed below require internet access.

#### 3.2.10.1 Polar Orbit Tracks

The Data Center at the University of Wisconsin-Madison Space Science and Engineering Center is providing links to polar orbit tracks for various satellites, also historical orbit tracks. The utility provides the link to: [https://www.ssec.wisc.edu/datacenter/polar\\_orbit\\_tracks/](https://www.ssec.wisc.edu/datacenter/polar_orbit_tracks/). Upon pressing “Import” Orbit Track links can be selected for the various satellites. Once a satellite is selected links are provided for current time, near future as well as a link to the historical archive. All times provided are in UTC.

#### 3.2.10.2 Earth Weather

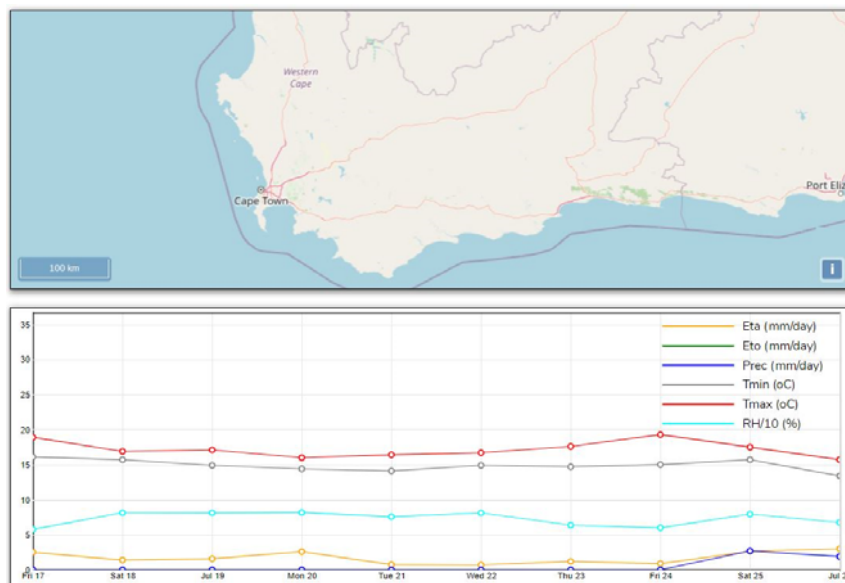
Earth Weather provides visualization of global weather conditions forecast updated every three hours, ocean surface current estimates are updated every five days, ocean surface temperatures and anomaly from daily average (1981-2011) are updated daily and ocean waves are updated every three hours. Extracted from <https://earth.nullschool.net>.

The interactive Weather Data visualization interface is using data derived from the Global Forecast System - GFS ([https://www.emc.ncep.noaa.gov/emc\\_new.php](https://www.emc.ncep.noaa.gov/emc_new.php)), Ocean Currents Data from Ocean Surface Current Analyses Real-time (<https://www.esr.org/research/oscar/>), Sea Surface Temperature from Operational Sea Surface Temperature and Sea Ice Analysis (<http://ghrsst-pp.metoffice.gov.uk/ostia-website/index.html>) and Ocean Waves are from WAVEWATCH III (<https://polar.ncep.noaa.gov/waves/>).

#### 3.2.10.3 GFS Agricultural Forecasts

GFS data for agricultural purposes can also be retrieved from <http://ut150436.ad.utwente.nl/gfs>. On a daily basis the data from GFS (Analysis from 00:00 UTC) is processed and the layers indicated above are extracted, aggregated at daily basis and the forecast for 10 days is derived. The graph shows the daily Maximum and Minimum Temperature, Rainfall, Relative Humidity and Potential and Actual Evapotranspiration Forecast for the future 10 days. A location on the map can be interactively selected. The data is refreshed daily at 08:00 UTC.

**Figure 3.23: 6 parameter agricultural forecast for Cape Town**



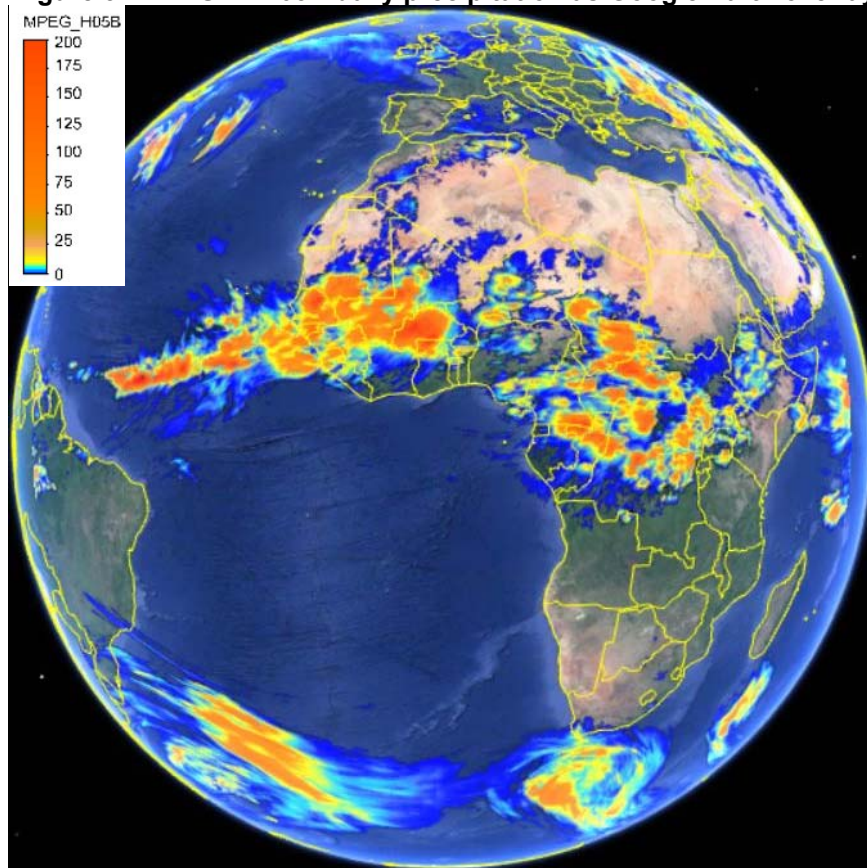


### 3.2.10.4 H-SAF H05B rainfall on Google Earth

At ITC MSG derived rainfall products are processed on a daily basis and transformed into an ILWIS file format containing the 24 hour accumulated precipitation from 00:00 to 23:45 UTC, in mm/24hr. These files are compressed and subsequently transferred to a HTTPS site ([https://filetransfer.itc.nl/pub/mpe/HSAF\\_H05B](https://filetransfer.itc.nl/pub/mpe/HSAF_H05B)).

The accumulated 24 hour precipitation map is retrieved, 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. The rainfall map extracted is also available in ILWIS format. The data is available from 20190701, when the SAF on Hydrology started operationally disseminating the H05B product, which replaced the MPEF – MPEG product. The data of MPEG, also aggregated to 24 hours, is available (in ILWIS format) at <https://filetransfer.itc.nl/pub/mpe/msg/> from 20100101. All files need to be unzipped before use in ILWIS.

**Figure 3.24: H-SAF H05B daily precipitation as Google Earth overlay**



### 3.2.10.5 EUMETVIEW

EUMETView is a visualisation service that allows users to view EUMETSAT imagery in a more interactive way through an online map viewer or Web Map Service (WMS). From the “Toolbox” main menu select the option “Other Routines” >> “EUMETVIEW”. Press “Import” and a Web Browser is opened at the following address:

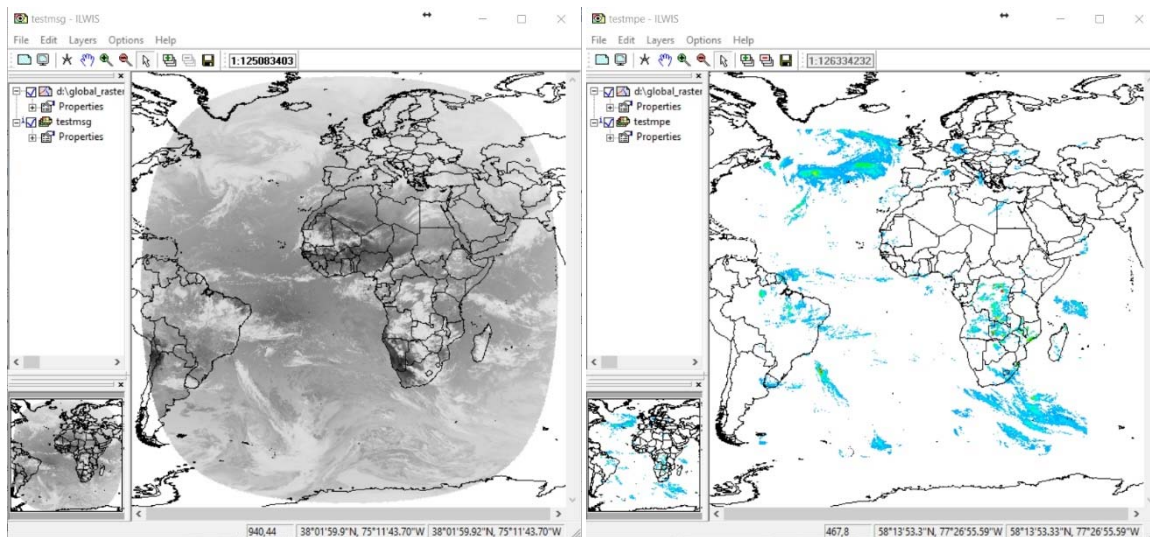
<https://eumetview.eumetsat.int/mapviewer/>



The browser is able to display Meteosat images, RGB composites and products at 0 and 41.5 degree, Metop B and C IR 10.8 images and RGB composites and various Sentinel-3 A/B RGB images and ocean colour, SST products.

Products can also be downloaded. When downloading, select the options “GEOTiff” and “Full Resolution”. The routine “Generic Geotif import” (further described in chapter 3.2.9.10) can be used to visualize the data in ILWIS. Subsequently in ILWIS display the downloaded product or image by selecting the map list created and assign the RGB colours to the appropriate bands. An example of the IR-039 channel and the H-SAF H03B product is provided in the figure below. If the EUMETCast reception station can't be operated, this is a good resource to continue providing services.

**Figure 3.25: Downloaded MSG IR-039 channel and H-SAF H03B product from EUMETVIEW**



### 3.2.10.6 METAR-Weather

To quickly visualize METAR and TAF information use is made of a freeware tool called “METAR-Weather” (currently use is made of MetarWeather Decoder version 1.78, Copyright (c) 2003 - 2018 by Nir Sofer). The Metar-Weather utility decodes METAR and TAF weather reports from around the world, and displays them in a simple weather report table. You can save the weather report into text, HTML or KML files. Metar-Weather can decode METAR reports from a text file, or download the latest reports directly from the Internet. Within the Toolbox this utility can also be used to display the METAR and TAF messages (for TAF only the first line of the message) disseminated through the GTS System, a restricted service of GEONETCast. This utility is available from: <http://www.nirsoft.net/utills/mweather.html>.

### 3.2.10.7 Sentinel EO Browser

The EO-Browser is a recent developed utility to view using a web browser data from Sentinel (1, 2, 3 and 5P) as well as Landsat. The portal is continuously updated and various selection criteria can be applied, like time range and cloud coverage. From the “Toolbox” main menu select the option “Other Routines” >> “Sentinel EO Browser”. Press “Import” and a Web Browser is opened at the following address:

<https://apps.sentinel-hub.com/eo-browser/>

EO Browser makes it possible to browse and compare full resolution images from all the data sources provided. Select the area of interest, select the desired time range and cloud

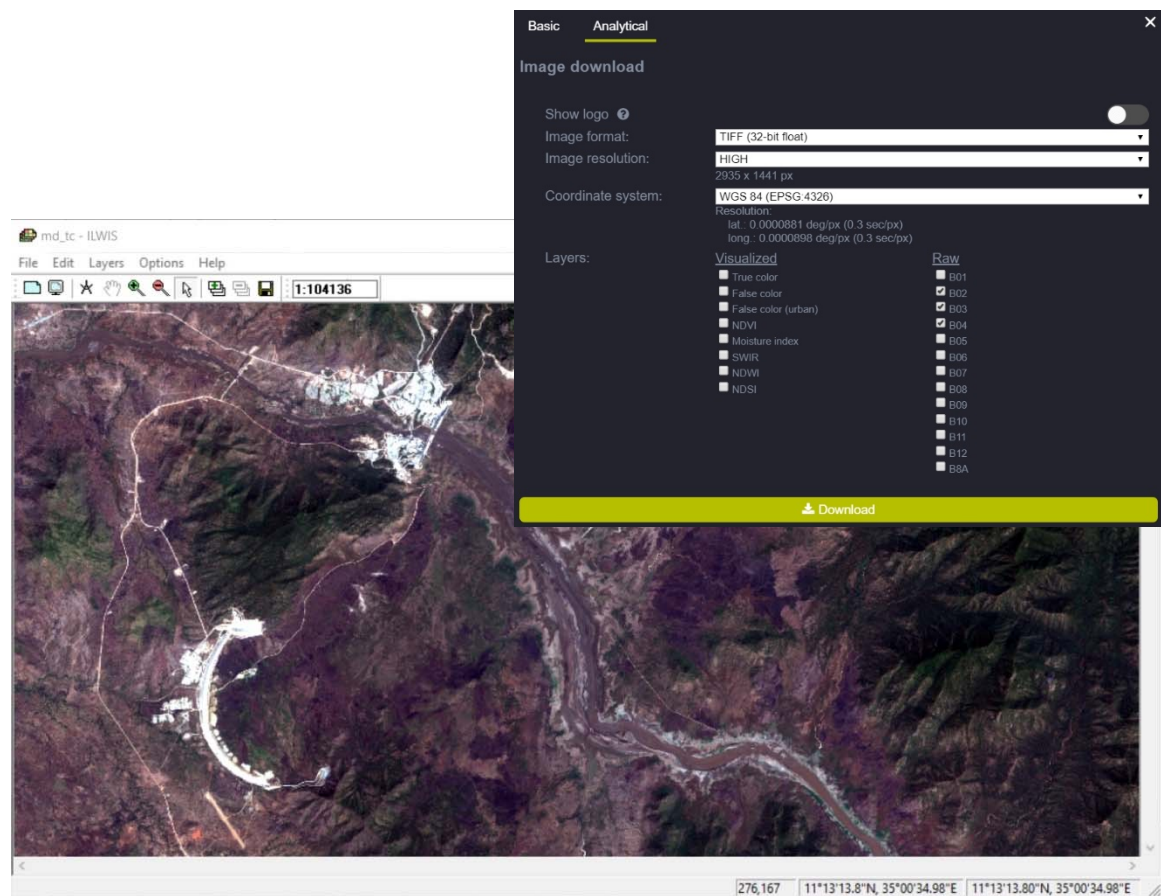


coverage, and inspect the resulting data in the browser. It is possible to create different visualizations, download high resolution images and create time lapses.

Once the browser is opened, first navigate to your area of interest. To make full use of the utility a free registration is required. After the selected image is visualized the view can be exported. The routine “Generic Geotif import” (further described in chapter 3.2.9.10) can be used to visualize the data in ILWIS.

The preferred settings to download a true colour image are given in the figure below as well as a recent Sentinel 2 level 1C image (2018-11-21) over the Millennium dam under construction in the Blue Nile, western part of Ethiopia using geographic coordinates.

**Figure 3.26: Sentinel data download settings and downloaded Sentinel 2 L1C True Colour image over the Millennium Dam**

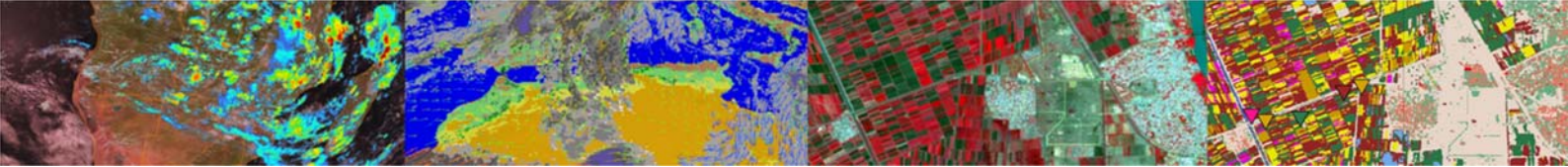


### 3.2.10.8 Display Julian Day Tables

As a number of products contained in the EUMETCast-GEONETCast data stream use the Julian Day convention two tables, one for a normal and one for a leap year, can be retrieved under this menu option. Select the appropriate “Show Julian Day table” option, press “Import” and the conversion table from Julian to Calendar day is given. This table can be closed and the operation is stopped.

### 3.2.10.9 Generic NetCDF-GRIB-HDF data visualization

Panoply (see also chapter 1.1.2) plots geo-referenced and other arrays from netCDF, HDF, GRIB, and other datasets. Panoply allows, without further import into ILWIS, quick visualization of:



- Slice and plot geo-referenced latitude-longitude, latitude-vertical, longitude-vertical, time-latitude or time-vertical arrays from larger multidimensional variables;
- Slice and plot "generic" 2D arrays from larger multidimensional variables;
- Slice 1D arrays from larger multidimensional variables and create line plots;
- Combine two geo-referenced arrays in one plot by differencing, summing or averaging;
- Plot lon-lat data on a global or regional map using any of over 100 map projections or make a zonal average line plot;
- Overlay continent outlines or masks on lon-lat map plots;
- Use any of numerous color tables for the scale colour bar;
- Save plots to disk GIF, JPEG, PNG or TIFF bitmap images or as PDF or PostScript graphics files;
- Export lon-lat map plots in KMZ format;
- Export animations as MP4 video or as a collection of individual frame images.

From the toolbox menu, select the option "Other Routines" >> "Generic NetCDF-GRIB-HDF data visualization" >> "Start Panoply". It should be noted that the routine requires Java, the batch file starting Panoply can be found under "Extensions\WFS\_E-Toolbox\toolbox\_batchroutines" and is called "panoply\_start.bat".

### 3.2.10.10 Generic BUFR data visualization

To visualize the various BUFR formatted products that are available in the EUMETCast-GEONETCast data stream you need to install the BUFRdisplay utility. See also chapter 1.1.2. From the main Cabo Verde Toolbox menu, using the options "Configuration" and "Folders", select "Bufdisplay". Browse to the appropriate data output directory and press "Save" to store the settings. Note that Bufdisplay is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the "GEONETCast" and "Toolbox" main menu select the option "Generic BUFR data Visualization" and "Show BUFR data using BUFRdisplay" sub menu items and if the output directory is properly assigned, press "Import". In the Command Line Interpreter (CMD.exe) window, acknowledge the copyright of Francis Breame by pressing <enter> and the BUFRdisplay utility is opened. From the BUFRdisplay window select "File" and "Open", navigate to the input data folder and select the appropriate file and press "Open". Under the "Data Selection" window the required attributes need to be specified, like latitude, longitude and the data field. Once this is done activate the option "Input/decode data" and subsequently "Generate map". Further information is provided in the BUFRdisplay User Guide by Francis Breame (BUFRdisplay\_User\_Guide\_v40.pdf).

### 3.2.10.11 JASON and AVISO

An import routine has also been made to use the data from the JASON-2 altimeter. In this case BRAT (see Appendix 1) is used as pre-processor. Also the ocean observation products from AVISO (licensed service, further information can be obtained from: <http://www.aviso.oceanobs.com>) like the Geophysical Data Records, coastal and hydrological products such as (corrected) Sea Surface Heights and Mean Sea Level, can be imported using the same pre-processing routines. The input file expected should be of a "NetCDF" format and the resolution (from 1/3 to 1/9 of a degree) should be specified as well upon import. The link to this directory has to be properly specified in the main CaboVerde-Toolbox menu, using the options "Configuration", "Folders" and Aviso.

### 3.2.10.12 Generic GeoTif import

To conveniently import some of the data in Geotif format, like LANDSAT (-8) data disseminated through GEONETCast for the central African region, this routine allows you to quickly transform the data format from TIF into ILWIS-format.



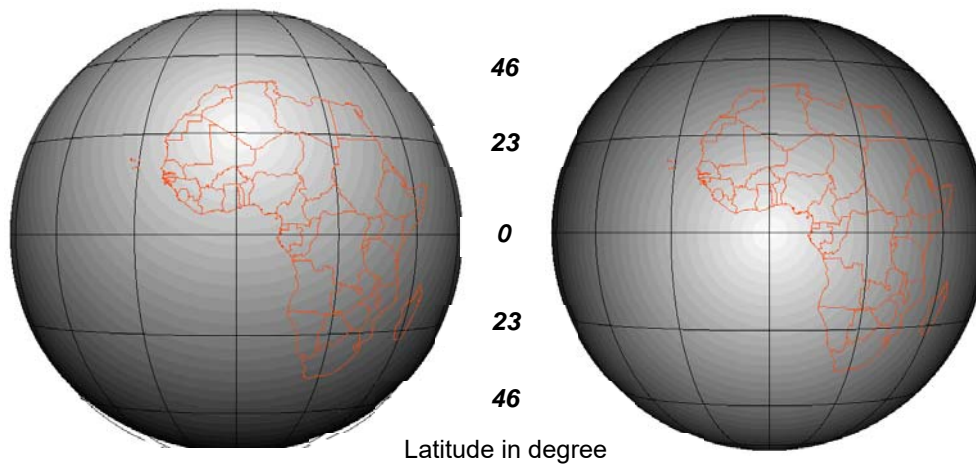
### 3.2.10.13 Calculate MSG angles

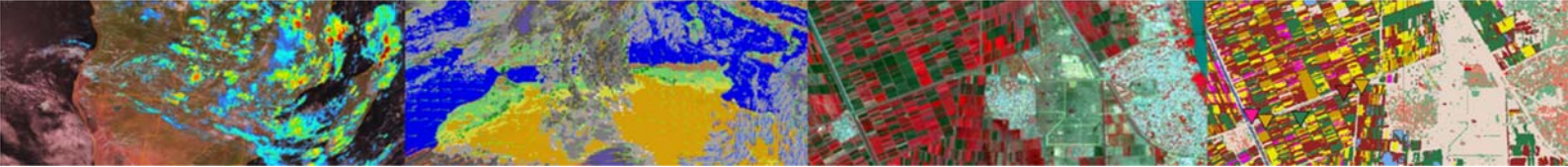
For many applications corrections to the pixels have to be applied based on satellite or sun azimuth and zenith angles. A Java applet has been created which allows computation of MSG satellite and sun azimuth and zenith angles based on date and time. This routine is called by an ILWIS script that allows the user to calculate the solar and MSG satellite solar / zenith angles for a certain time for the MSG field of view at 0 and 41.5 degree, using a simple user interface. Note that the minutes are expressed in decimals, e.g. 30 minutes is 0.5.

This utility is using ILWIS scripts which are situated in the ILWIS sub-directory \Extensions\CaboVerde-Toolbox\toolbox\_startscript\External\_routines\angle0. For the solar zenith angles also the sun elevation is calculated and the illumination conditions, as defined using thresholds from Meteo-France. The content of the scripts can be seen using ILWIS, using the Navigator option and move to the respective sub-directory. To open a script, double click the script using the left mouse button.

Once the Year, Month, Day and Time of day (in UTC) and output directory are specified the script can be started by pressing the "Create" button.

**Figure 3.28: Example of Sun (for 21 June 2020, 12.00 UTC) and MSG satellite zenith angles (for 0°N latitude and 0°E longitude, left and right hand picture respectively)**





### 3.2.11 Other useful online resources

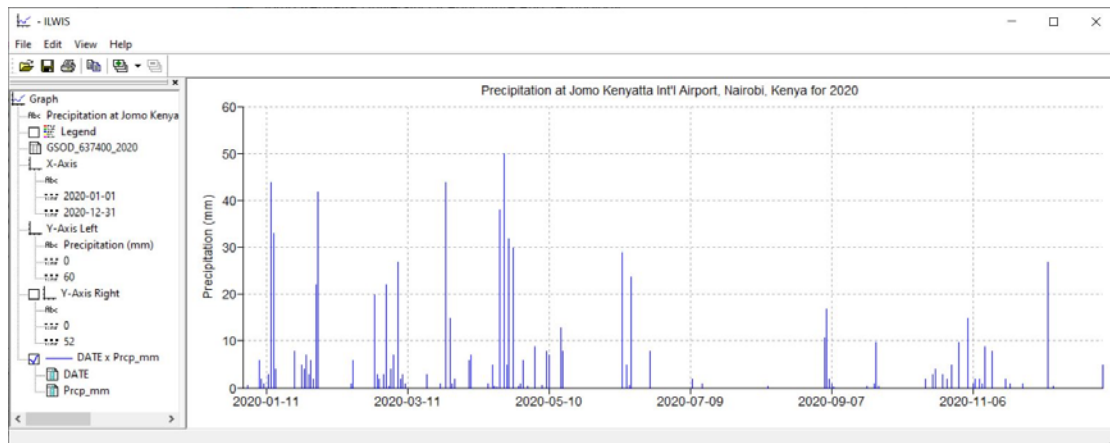
#### 3.2.11.1 NCDC Integrated Surface Data (ISD)

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 source is: <https://www.ncei.noaa.gov/data/global-summary-of-the-day/>.

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.

Two routines are available, firstly a station map to retrieve the USAF code for the respective station and secondly a routine which automatically retrieves the data set for the year of interest and upon import the data is converted to SI units. An example of this capability is given in the figure below, showing the precipitation over Jomo Kenyatta International Airport, Nairobi, Kenya for 2020.

**Figure 3.29: GSOD station data retrieved for USAF number 637400 (NAIROBI JKIA, KE)**



#### 3.2.11.2 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).

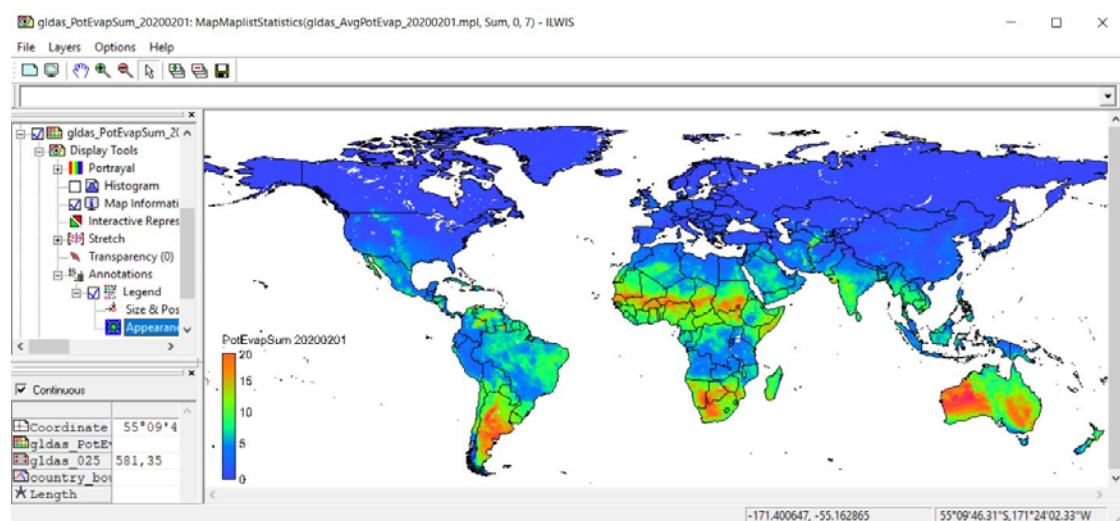




Currently, GLDAS drives four land surface models (LSMs): Mosaic, Noah, the Community Land Model (CLM), and the Variable Infiltration Capacity (VIC). More information is available at the Land Data Assimilation Systems (LDAS, <http://ldas.gsfc.nasa.gov/>) and Land Information System (LIS, <http://lis.gsfc.nasa.gov/>) websites. Further information is given in: [https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/README\\_GLDAS2.pdf](https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/README_GLDAS2.pdf).

The temporal resolution for the GLDAS products is 3-hourly. Output from the GLDAS-Noah model (currently GLDAS\_NOAH025\_3H.2.1), in NetCDF4 format, is retrieved using the routines developed. A number of 3 hourly products are extracted, like average actual and potential evapotranspiration, rainfall, surface temperature and soil moisture at 0-10 cm, 10-40 cm, 40-100 cm and 100-200 cm depth. Also daily accumulations are calculated for actual and potential evapotranspiration and rainfall. Also daily average, minimum and maximum surface temperature are calculated. Only full global extent is supported. Data is retrieved from [https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/GLDAS\\_NOAH025\\_3H.2.1/](https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/GLDAS_NOAH025_3H.2.1/) and access requires user registration and when starting the routine your User name and Password is required. An example is provided in the figure below.

**Figure 3.30: Accumulated potential evapotranspiration for 20200201**

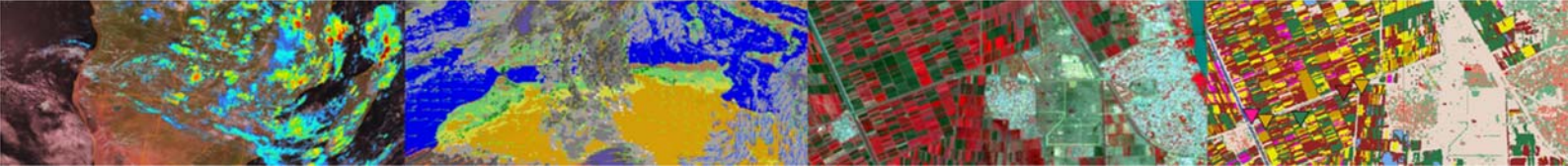


### 3.2.11.3 GMAO - GEOS5 Land

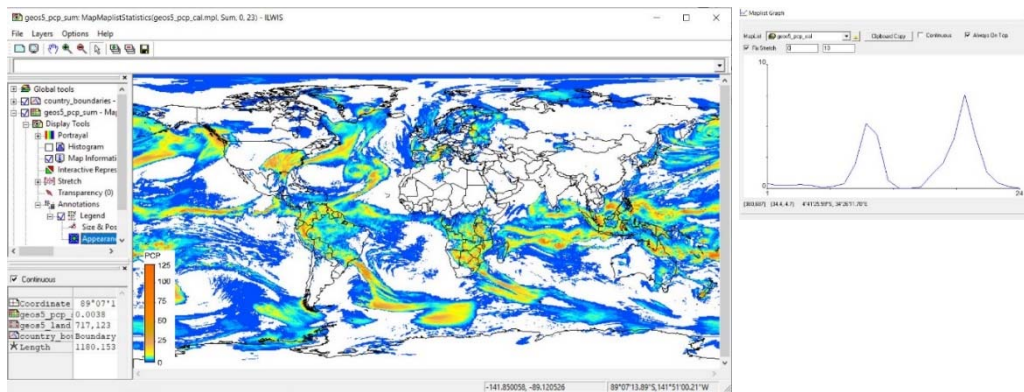
The Goddard Earth Observing System, Version 5 (GEOS-5) model consists of a group of model components that can be connected in a flexible manner in order to address questions related to different aspects of Earth Science. GMAO's work with GEOS-5 spans a large range of space and time scales and encompasses the representation of dynamical, physical, chemical and biological processes ([https://gmao.gsfc.nasa.gov/GEOS\\_systems/](https://gmao.gsfc.nasa.gov/GEOS_systems/)).

A routine has been added to import GEOS5 time-averaged land surface diagnostics from [https://portal.nccs.nasa.gov/cgi-lats4d/webform.cgi?&i=GEOS-5/fp/0.25\\_deg/assim/tavg1\\_2d\\_Lnd\\_Nx](https://portal.nccs.nasa.gov/cgi-lats4d/webform.cgi?&i=GEOS-5/fp/0.25_deg/assim/tavg1_2d_Lnd_Nx).

The meta data link is providing the GEOS-5 land layers description and units. Within the online portal the respective data layer and date – time range can be selected. The output format expected is NetCDF4. Once the selected data has been retrieved locally the GEOS5-Land data import routine can be applied to import the data in ILWIS. Data at hourly interval is available from 20171201 onwards. Only the full global extent is supported. An example of an accumulated precipitation product (derived from 24 hourly time steps) is provided in the figure below as well as a graph showing the hourly intensities. Note that the precipitation product (prectot) initial unit is kg m<sup>-2</sup> s<sup>-1</sup> and is converted at a later stage to mm/hour using a multiplication factor of 3600.



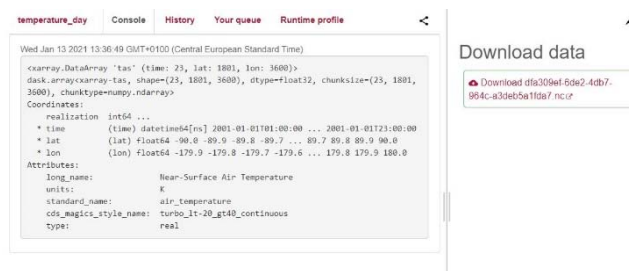
**Figure 3.31: GEOS5 daily accumulated precipitation and hourly graph over a pixel in Tanzania**



### 3.2.11.4 C3S-CDS

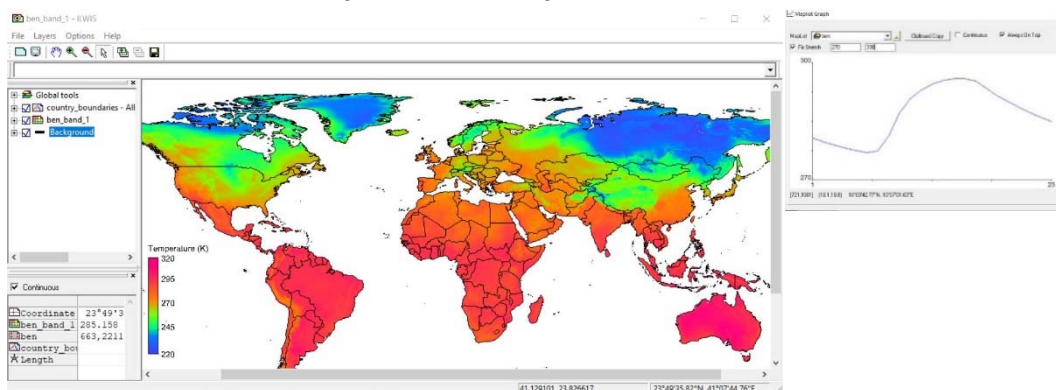
Using the Copernicus Climate Data Store (CDS) toolbox scripting capability provided the ERA-5 reanalysis data can be processed according to the user's requirement (<https://cds.climate.copernicus.eu/#!/home>) and applying the script option "return data" a link is created and the data can be downloaded locally in NetCDF4 format. Additional information after the script has been executed can be found under the tab "Console", see also the figure below.

**Figure 3.32: Climate Data Toolbox showing the console tab and the data download link created**



Once the data is locally available a routine is provided to process the data. Also here a global extent is required. Upon import of the time series data the user needs to provide information on the following items: the name of the data array to be processed, name of output file to be created and the data array resolution in degree (0.1 or 0.25 degree). This information is provided under the "Console", option as well as the unit used for the product. When the routine has imported time series data also a map list is created.

**Figure 3.33: Global hourly temperature at 00:00 from "reanalysis-era5-land" and graph of temperature over a pixel in Burkina Faso**

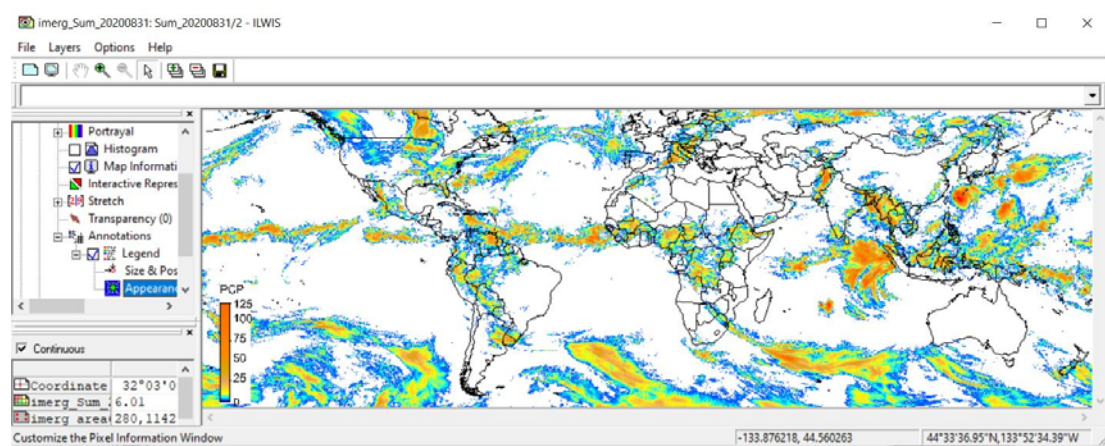




### 3.2.11.5 GPM-IMERG

GPM IMERG Final Precipitation L3 Half Hourly 0.1 degree x 0.1 degree V06 (GPM\_3IMERGHH) made available at GES DISC. The Integrated Multi-satellitE Retrievals for GPM (IMERG) is the unified U.S. algorithm that provides the multi-satellite precipitation product for the U.S. GPM team. Minor Version 06B is the current version of the data set. The precipitation estimates from the various precipitation-relevant satellite passive microwave (PMW) sensors comprising the GPM constellation are computed using the 2017 version of the Goddard Profiling Algorithm, then gridded, inter calibrated to the GPM Combined Ku Radar-Radiometer Algorithm product, and merged into half-hourly 0.1°x0.1° (roughly 10x10 km) fields from 60 degree North and South latitudes respectively. The final satellite-gauge product is applying both forward and backward morphing and including monthly gauge analyses. The current period of record is June 2000 to the present (delayed by about 3.5 months). The Integrated Multi-Satellite Retrievals for GPM (IMERG) algorithm is designed to leverage the international constellation of precipitation-relevant satellites to create a long record of uniformly global time/space gridded precipitation estimates ([https://disc.gsfc.nasa.gov/datasets/GPM\\_3IMERGHH\\_06/summary](https://disc.gsfc.nasa.gov/datasets/GPM_3IMERGHH_06/summary)). The data is extracted from [https://gpm1.gesdisc.eosdis.nasa.gov/data/GPM\\_L3/GPM\\_3IMERGHH.06/](https://gpm1.gesdisc.eosdis.nasa.gov/data/GPM_L3/GPM_3IMERGHH.06/) and access requires user registration and when starting the routine your User name and Password is required. An example is provided in the figure below. The routine provides the half hourly precipitation and is also calculating the daily sum.

**Figure 3.34: IMERG precipitation aggregated from half hourly to daily sum for 20200831**



### 3.2.11.6 Latest NCEP GFS Precipitation Forecast

This routine extracts the latest NCEP GFS Africa Precipitation, 850 Mb Temperature, Relative Humidity and Winds forecasts, up to 144 hours and shows these in an animated sequence. The pictures are extracted from <http://wxmaps.org/pix/af.vv.html> and <http://wxmaps.org/pix/af.850.html> respectively.

### 3.2.11.7 CHIRPS Rainfall

Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 30+ year quasi-global rainfall dataset. Spanning 50°S–50°N (and all longitudes), starting in 1981 to near-present, CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. As of February 12th, 2015, version 2.0 of CHIRPS is complete and available to the public. (source: <https://www.chc.ucsb.edu/data>). More detailed information can be obtained from <https://www.nature.com/articles/sdata201566>.

The daily and dekad rainfall products for Africa and global are retrieved from <https://data.chc.ucsb.edu/products/CHIRPS-2.0/> and routines are available to import the daily and dekad temporal intervals for Africa and at global level.



### 3.2.11.8 NASA POWER-Agro Climatology

NASA, through its Earth Science research program has long supported satellite systems and research providing data important to the study of climate and climate processes. These data include long-term climatologically averaged estimates of meteorological quantities and surface solar energy fluxes. Additionally, mean daily values of the based meteorological and solar data are provided in a time series format. These satellite and model-based products have been shown to be accurate enough to provide reliable solar and meteorological resource data over regions where surface measurements are sparse or non-existent. The products offer two unique features – the data is global and, in general, contiguous in time (<https://power.larc.nasa.gov/docs/methodology/>).

Climatology Resources for Agro climatology is extracted from <https://power.larc.nasa.gov/data-access-viewer> and select as 'User Community': Agroclimatology. All other parameters can be specified in the user interface provided in the POWER portal and point and area time series data can be retrieved.

### 3.2.11.9 NOAA – STAR

The Center for Satellite Applications and Research (<http://www.star.nesdis.noaa.gov/star/index.php>) creates satellite-based observations of the land, atmosphere, and ocean, and transfers them from scientific research and development into routine operations. The Vegetation Health Product (VHP) consists of gridded weekly global vegetation indices (VCI, TCI and VHI) derived from AVHRR GAC orbital data for the global area between latitude 55°S to 75°N. The projection of VHP is Plate Carree. The interval of grid is 0.144° (about 16km at equator). Noise is minimized by applying the time series smoothing technique and other correction algorithms. Further information on the algorithm and products is provided at [https://www.star.nesdis.noaa.gov/smcd/emb/vci/gvps/gvps\\_gvf\\_algorithm.php](https://www.star.nesdis.noaa.gov/smcd/emb/vci/gvps/gvps_gvf_algorithm.php). Products that can be retrieved, on a weekly basis, from 1981035 (weeks from 001 to 052) are:

- Normalized Difference Vegetation Index
- Brightness Temperature
- Temperature Condition Index
- Vegetation Condition Index
- Vegetative Health Index

The Vegetation Condition Index (VCI), Temperature Condition Index (TCI) and Vegetation Health Index (VHI) are designed to characterize moisture (VCI), thermal (TCI) and total vegetation health (VHI) conditions in response to weather impacts and are defined as:

- $VCI=100*(NDVI-NDVI_{min})/(NDVI_{max}-NDVI_{min})$
- $TCI=100*(BT_{max} - BT)/(BT_{max} - BT_{min})$
- $VHI = a*VCI + (1 - a)*TCI$

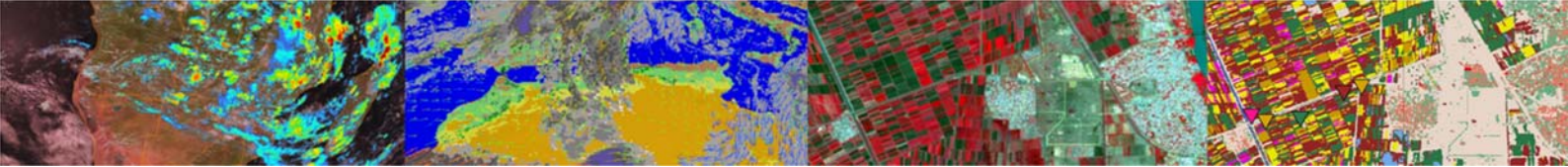
where NDVI, NDVI<sub>max</sub>, and NDVI<sub>min</sub> (BT, BT<sub>max</sub>, and BT<sub>min</sub>) are the smoothed weekly NDVI (BT), their multi-year absolute maximum, and minimum, respectively. The VCI, TCI and VHI approximate the weather component in NDVI, BT and their combination values. They fluctuate from 0 to 100, reflecting changes in vegetation conditions from extremely bad to optimal. The weighting factor (a) in the VHI equation was determined by experience, currently, a=0.5. Climatology is calculated over 24-years (from 1982 to 2005) using weekly maximum and minimum NDVI and channel 4 temperature fields ([http://www.star.nesdis.noaa.gov/smcd/emb/vci/gvps/gvps\\_climatology\\_data.php](http://www.star.nesdis.noaa.gov/smcd/emb/vci/gvps/gvps_climatology_data.php)).



### 3.2.12 Configuration and folder settings

For you to conveniently work with the Cabo Verde Toolbox the data sources (on your local area network) and the local system output (working) directories need to be defined. From the main Cabo Verde Toolbox menu, select “Configuration” and the sub-menu “Folders”. Further details have already been described in chapter 2.4. It is important to note that a “Folders” item can be set in the “config.xml”, using the “folderid” option.

In general the input and output folders are set over here and are subsequently used in the various import routines to pre-set the input and output folders over there. This prevents the need to specify the folder specifications time and again! This does not apply to ‘dated’ folders. Not only folders can be specified, also URL’s, using the folderid “urlpage”. Examples are the links to EUMETVIEW, etc. as described above.



### 3.3 CONCLUDING REMARKS

The description provided is showing the capabilities of the various routines that are currently implemented under the toolbox config XML version 1.0. Actual information on the various communication satellite based data dissemination streams can be obtained from EUMETSAT's Product Navigator, available at: <http://navigator.eumetsat.int>.

In case products or data is disseminated for which no import routines are available in the toolbox, chapter 2 is providing the necessary background information to add additional routines yourself. When you need assistance in building these scripts and batch routines don't hesitate to contact the corresponding author.

Chapter 4 contains a number of exercises that demonstrate the use of the data disseminated through GEONETCast. Not all toolbox routines are included as the sample data needed would become too bulky and is mainly focussing on Africa. The online data will be downloaded once the routines are executed.

Appendix 1 is providing links to other freeware utilities that can be used in conjunction with ILWIS. Having an operational ground receiving station, together with these utilities, allows you to process a multitude of environmental information, delivered near real time and free of charge. You can also register for licensed services like AVISO.

Appendix 2 is providing a description of how the sample and exercise data should be copied to / stored on your local system. Note that the sample and exercise data can be downloaded from: [http://filetransfer.itc.nl/pub/52n/gnc\\_exercisedata/](http://filetransfer.itc.nl/pub/52n/gnc_exercisedata/).

Appendix 3 is providing further information to configure the data source(s) for the MSG Data Retriever.

Appendix 4 is providing further details on the changes that have been implemented in the toolbox after the release of XML version 1.0.

Appendix 5 provides additional information on other utilities available at the ITC GEONETCast web pages.



## 4. EXERCISES USING DATA FROM GEONETCAST, APPLYING ILWIS 386 AND THE CABO VERDE TOOLBOX

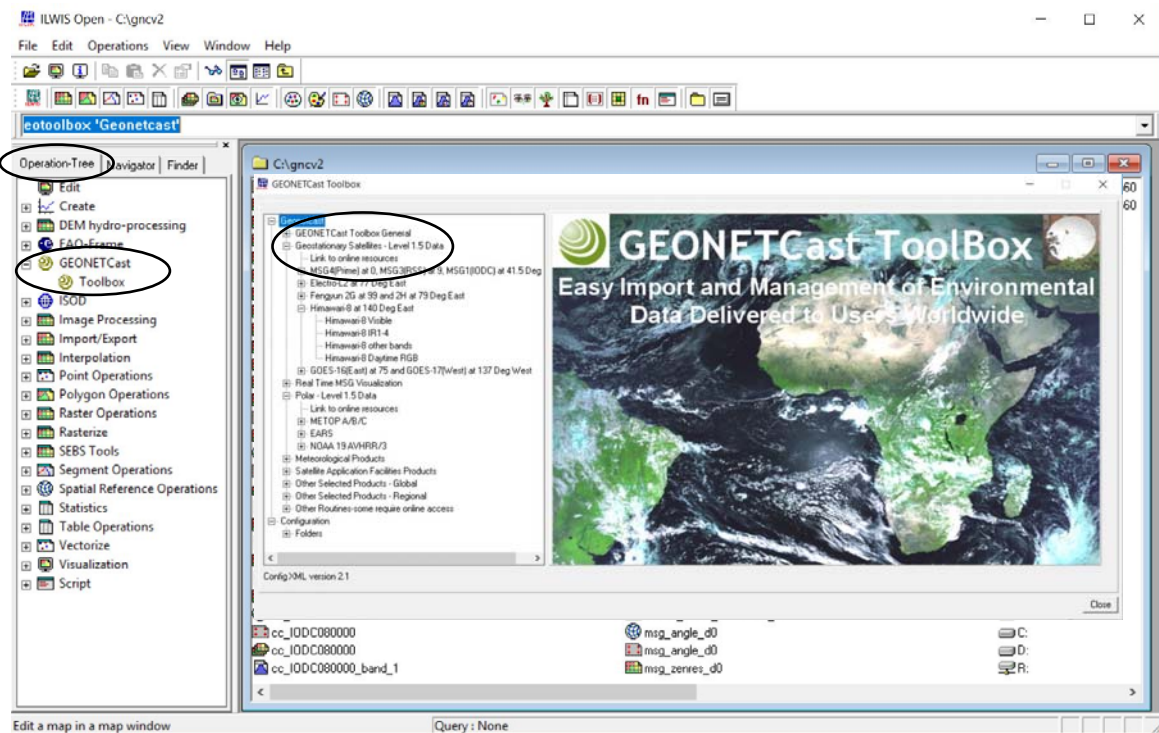
### 4.1 IMPORT AND VISUALIZATION OF LEVEL 1.5 DATA FROM GEOSTATIONARY SATELLITES

Download the sample data directory obtained from the ITC SFTP site ([http://filetransfer.itc.nl/pub/52n/gnc\\_exercisedata/gnc\\_data/](http://filetransfer.itc.nl/pub/52n/gnc_exercisedata/gnc_data/)) to your hard disk or copy them from the DVD(s). Preferably use the sub-directory structure as indicated in Appendix 2. Copy the folder “gnc\_out” to your C:\ drive.

#### 4.1.1 Data import and visualization from Meteosat Second Generation (MSG).

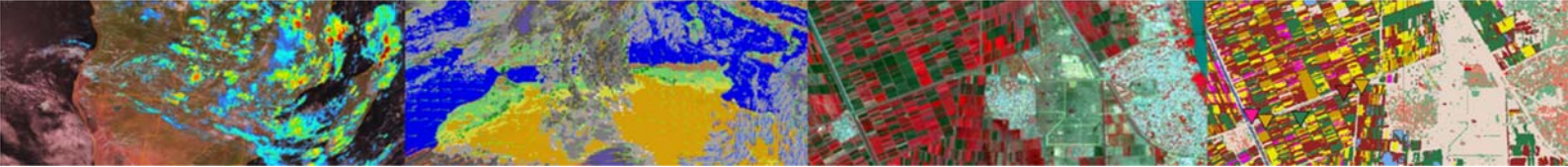
Open ILWIS386 and use the Navigator to select your working directory. See also ellipses indicated in the figure below pointing to the main menu items that will be used during this exercise. Note that in this figure the active working directory is “C:\GNC\_out”. Some ancillary files needed during the exercises are already located in this directory. Close ILWIS and open ILWIS again. It should now open in your working directory (C:\GNC\_out).

Figure 4.1.1: The main ILWIS menu and the active catalogue

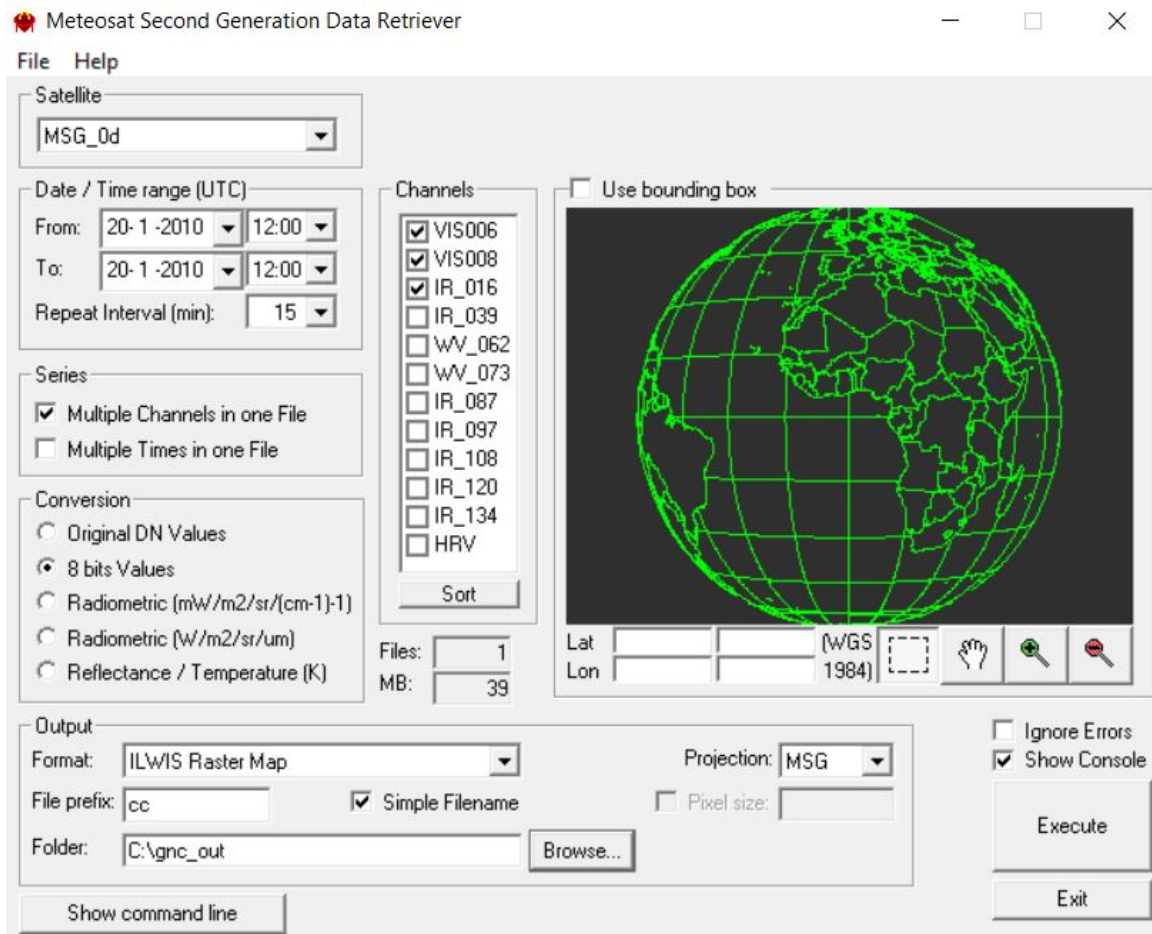


In order to import data from MSG open the “Geonetcast and Toolbox” tabs from the main menu and select “Geostationary Satellites – Level 1.5 Data” >> “MSG4(Prime)-0. MSG3(RSS)-9.5, MSG1(IODC)-41.5 De East” >> “MSG All” and “Start MSG Data Retriever”. The so-called MSG Data Retriever window will be activated which can be used to import the data recorded by MSG (the 0 degree, the 41.5 degree IODC and the Rapid Scanning Service). Specify the settings as indicated in figure 4.1.2, for the 12:00 UTC image.

If you did not configure the “Data Sources” of the MSG Data Retriever consult chapter 2.5 as well as Appendix 3, showing the settings to be used to conduct the exercises described below.






**Figure 4.1.2: Selection and import of MSG channels using the Data Retriever**



Note the following from these import settings: the “*Satellite*” selected is MSG\_0d, which refers to Meteosat Second Generation – at 0 degree. The “*Date / Time Range*” is 20 January 2010 and 12:00 UTC respectively. The three channels that have been selected are often used to generate a Daytime Standard Colour Scheme composite. The multiple imported channels, converted to 8 bits, are stored as “*Multiple Channels in one File*” with a “*File Prefix*” “cc” and the option “*Simple Filename*” is activated. As output format an ILWIS Raster Map is selected and the appropriate “*Folder*” is selected to store the output data generated. The “*Projection*” MSG allows you to look at the data from a geostationary perspective and in this case the whole disk as recorded by MSG is selected.

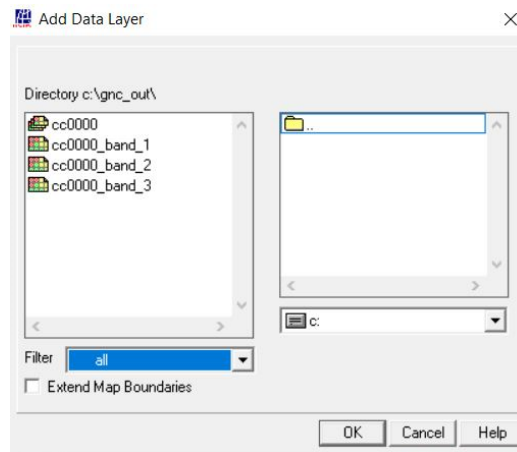
After you have specified the appropriate settings, press “*Execute*” to conduct the import. Close the Cabo Verde Toolbox window, note that in the tray bar the Meteosat Second Generation Data Retriever is still active, keep it as such as you will need it later.

Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the image double click the maplist icon  “cc0000” and in the Map List “cc0000” menu select the “*Open as ColorComposite*” option . Now activate from the map display window menu the option “*Add Data Layer*”  and from the new menu select as “*Filter*” the option “*Base maps*” and select the vector file “country\_boundaries” and press “OK”. In the left hand map legend the country\_boundaries are added. Double click the item “country\_boundaries” and under “*Display tools*” > “*Portrayal*” > “*Fixed Colors*” > “*Single Color*” you can modify the ‘*Draw Color*’ to “White” and press “Apply” and “Close”.



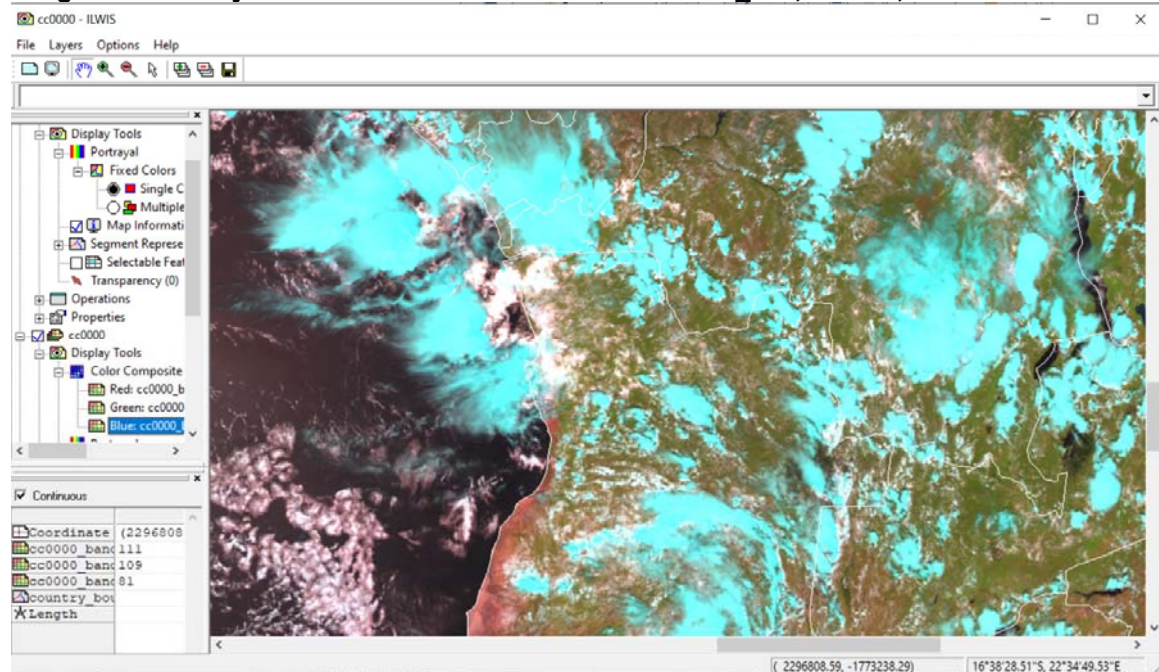


**Figure 4.1.3: Add Data Layer for visualization**



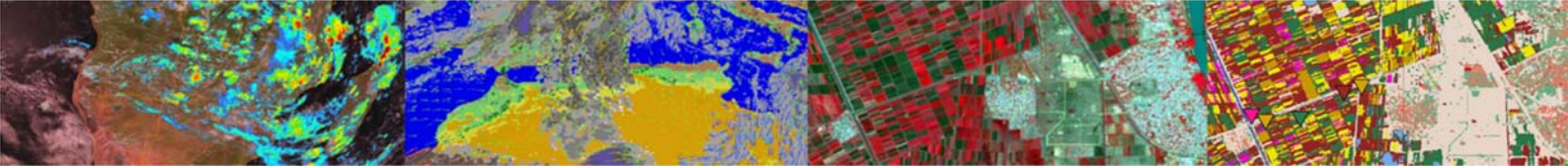
Note that using the “*Simple Filename*” option during import band\_1 now represents VIS006, band\_2 is VIS008 and band\_3 is the IR\_016 channel (see also figure 4.1.2). Figure 4.1.4 is showing a portion of the MSG disk, using a similar colour assignment for 20 January 2010 at 12:00 UTC.

**Figure 4.1.4: Day time standard colour scheme MSG: IR\_016, VIS008, VIS006 in RGB**



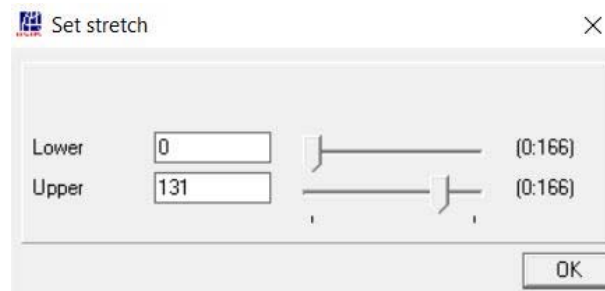
Check the features on the image, e.g. the water, (bare) land – vegetated surfaces and (various) clouds. With the vector layer active you can zoom to your area of interest, check the colour composite. Activate the “*Normal*” option from the active map display window. When you move the mouse cursor over the image and simultaneously press the left mouse button you can also see the values (note the unit: 8 bits values, see also the “*Conversion*” option as of figure 4.1.2) for RGB respectively. These pixel values can also be observed in the lower left hand corner of the map display window. From the active map menu, select also under the item “Options” >> “No Zoom”.


You also have the possibility to stretch the individual layers of the colour composite to improve the way the composite is displayed. From the left hand legend menu, double click on the layer ‘cc0000’ >> under “Color Composite” double click the “Red” layer and interactively the stretch per layer can be modified using the ‘Lower’ and ‘Upper’ limits of the all the bands.



To get the visualization as of figure 4.1.4 use the following stretch limits for Red: 0 – 131, Green: 0 – 163 and for Blue: 0 – 178.

**Figure 4.1.5: Stretching layers of a color composite**

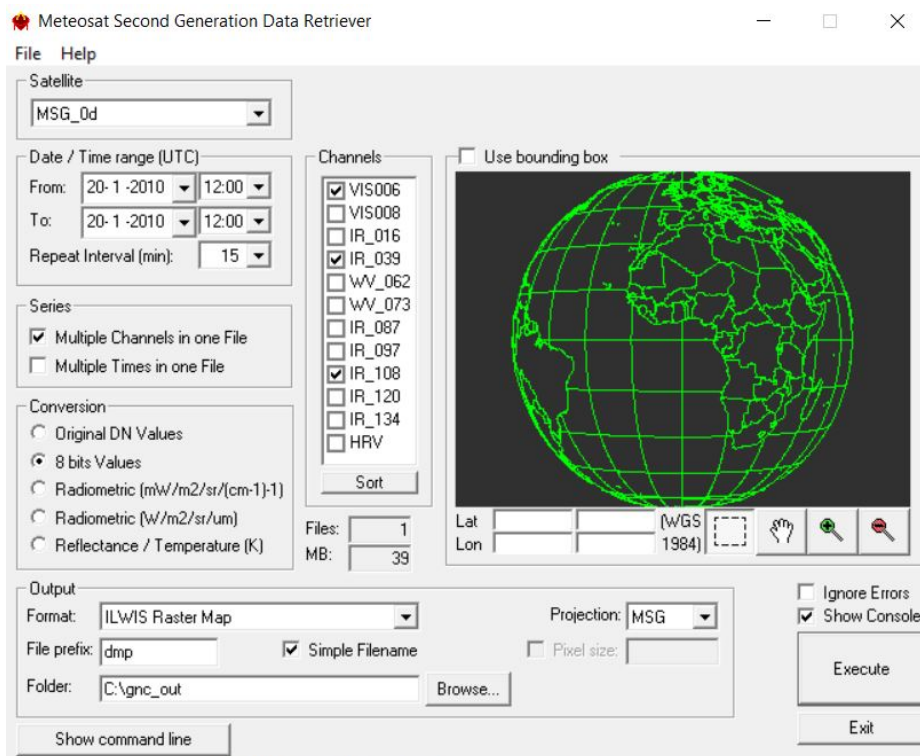


The stretch values have been obtained inspecting the histogram. From the ILWIS Catalogue to open the histogram, double click on the histogram (note the icon ) for "cc0000\_band\_3", and check the 1 % interval range, here from 0 to 131. Repeat this also for the other two bands. Eventually use the values as given under the 2 % interval range and note the display difference due to this new stretch. Upper stretch limits are now 125, 145 and 158 for R, G and B respectively.

#### 4.1.2 Construct a Daytime MicroPhysical (DMP) Colour Scheme composite

Once more open the “*Meteosat Second Generation Data Retriever*”. Now specify for the “*Date / Time range UTC*” the same date as used for the previous exercise. The other settings are indicated in figure 4.1.6. Once all relevant parameter are provided press “Execute”.

**Figure 4.1.6: Import settings to construct Daytime Microphysical Colour Scheme composite**



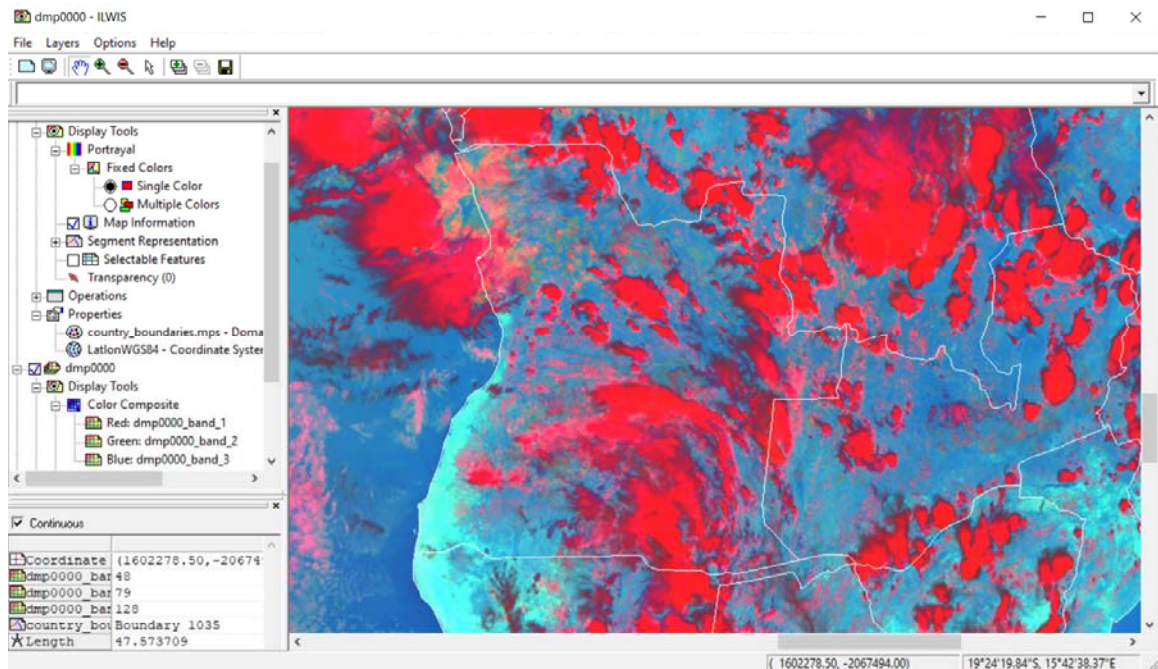
Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the new colour composite created, double click the map list called ‘*dmp0000*’ >> select from “*Display Tools*” >> and double click “*Color Composite*”, display band 1 (VIS006) as Red, band 2 (IR\_039) as Green and Band 3 (IR\_108) as Blue, app press “*Apply*” >> “*Close*”. Check the histograms for the 3 bands and use the 1% upper stretch values, here for red (band1): 178, for Green (band2): 143 and for Blue (band3): 179. Also display the country boundaries in ‘*White*’ and use the option “*no zoom*” in as well. Figure 4.1.7 is showing this visualization (for the identical time – part of MGS disk) of this MSG channel combination.

Note that this band combination can be used to determine in a qualitative manner some of the cloud properties. The VIS006 can be used to derive information about the optical thickness and the amount of cloud water and ice of the clouds, IR\_039 can be used to get an idea of the particle size and the phase of the clouds (e.g. consisting of water vapour, small ice, large ice) and the IR\_108 channel records the cloud top temperature.

Table 4.1 is showing the daytime convective development stages (I to IV) of clouds and the associated colouration that can be observed on a dmp colour composite. When using this colour scheme for the respective MSG channels, note that an increasing Red colour contribution is an indication of larger visible reflectance; an increased Green colour contribution indicates smaller cloud top particles and with an increased Blue colour contribution the cloud top are warmer.



**Figure 4.1.7: DayTime Microphysical Colour Scheme, VIS006, IR\_039 and IR\_108 in RGB**



**Table 4.1: Typical daytime convective development of clouds and related colour scheme**

	VIS006 (Red)	NIR016	IR_039 (Green)	IR_108 (Blue)	
<b>I. Very early stage</b> (low, warm water cloud)	White <i>opt thick</i>	White <i>water</i>	White <i>water</i>	Light Grey <i>warm</i>	<p>Related colour scheme for various stages of convective development</p> <p>Cb = Cumulonimbus</p>
<b>II. First convection</b> (first convective towers)	White <i>opt thick</i>	White <i>super cooled water</i>	White <i>super cooled water</i>	Dark Grey <i>cold</i>	
<b>III. First icing</b> (transformation into Cb)	White <i>opt thick</i>	Light Grey <i>small ice</i>	Grey <i>small ice</i>	Black <i>very cold</i>	
<b>IV. Large icing</b> (Cb anvils)	White <i>opt thick</i>	Dark Grey <i>large ice</i>	Black <i>large ice</i>	Black <i>very cold</i>	

Interaction of the solar radiation with clouds is presented in figures 4.1.8 and 4.1.9 for the various parts of the Electromagnetic Spectrum (EM). Figure 4.1.8 shows that at 1.6  $\mu\text{m}$  (NIR) much more solar radiation is absorbed by the clouds than in the visible (VIS) part of the EM, ice absorbs even more strongly than water in the NIR. At 3.9  $\mu\text{m}$  even more solar radiation is absorbed and here also ice is a stronger absorber compared to water. Figure 4.1.9 indicates the changes in reflectivity of snow clouds in the VIS and NIR part of the EM.



Figure 4.1.8: Absorption of water and ice by clouds for the various MSG channels (from: Daniel Rosenfeld, The Hebrew University of Jerusalem, HUJ)

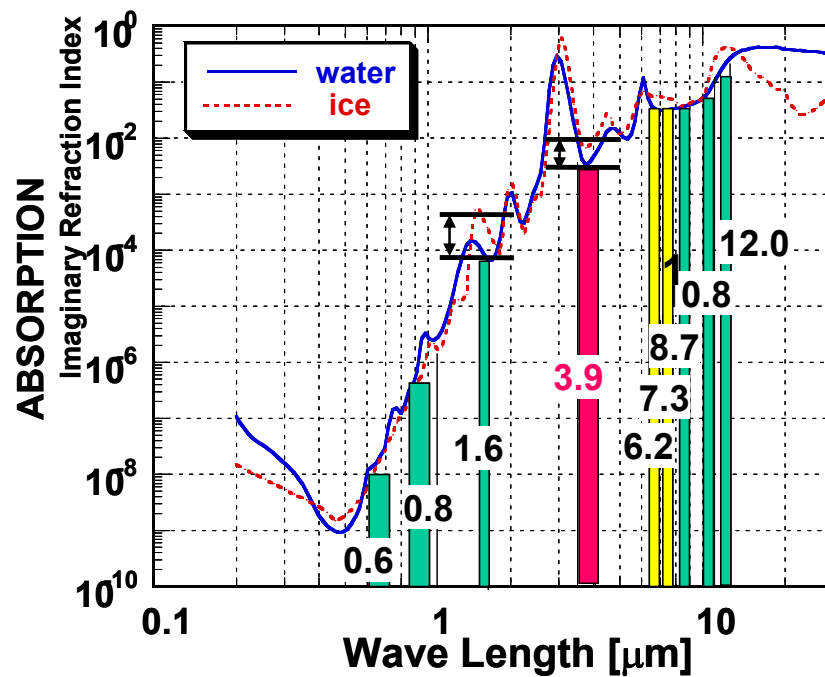
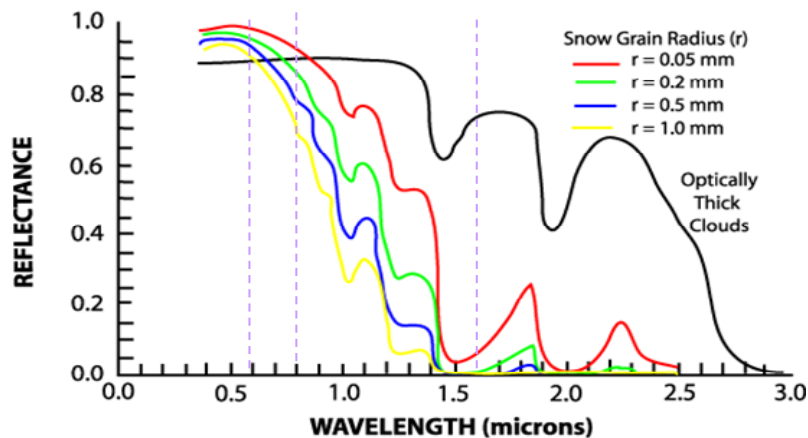


Figure 4.1.9: Different reflectivity of snow clouds at 0.6, 0.8 and 1.6 microns (from Rob Roebeling: Royal Netherlands Meteorological Institute, KNMI)

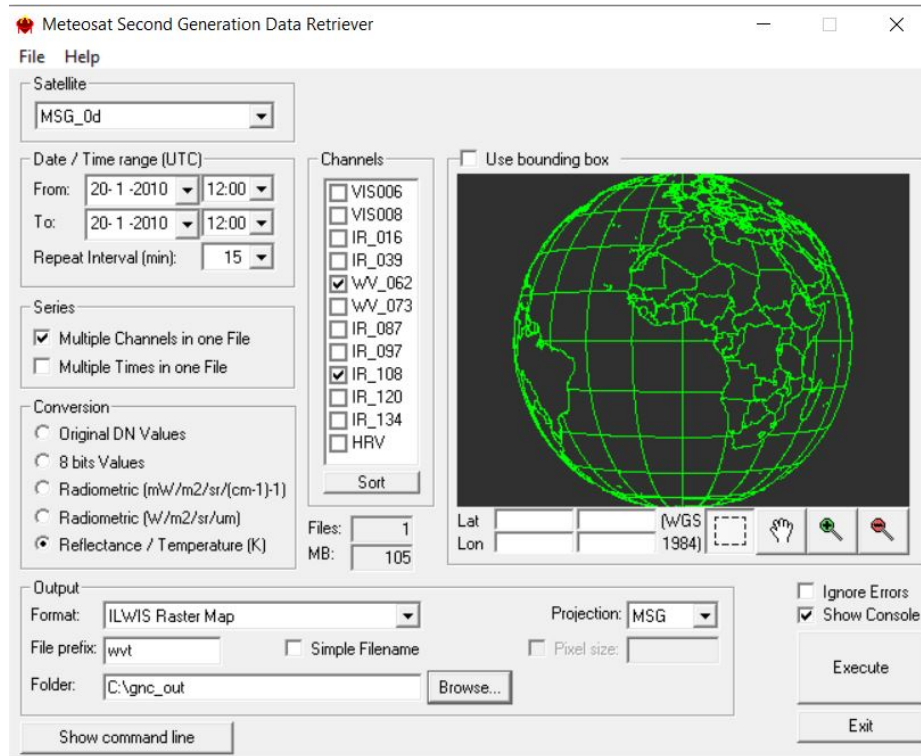


Explain using figures 4.1.8 and 4.1.9 why a daytime standard colour scheme (displayed as a colour composite, using as band assignments: IR\_016, VIS008 and VIS006 in RGB) snow and ice clouds will have a cyan appearance and water clouds will be white, see also the colour composite of figure 4.1.4.

### 4.1.3 The MSG Water Vapour (WV\_062) and Thermal (IR\_108) channels

MSG is recording the Visible to the Infrared region of the electromagnetic spectrum into a number of discrete channels. Import the WV\_062 and the IR\_108 channels for the same day as for the previous exercises and specify the other import options according to the specification given in figure 4.1.10.

Figure 4.1.10: Import of the MSG water vapour and thermal infrared channels



Note that the “*Conversion*” option used now is converting the WV and IR channels to Top of Atmosphere (TOA) brightness temperatures. The data is now converted to Kelvin, note the offset with Celsius of 273.15. After the import is completed, refresh the catalogue, press with the left mouse button on the catalogue and press F5.

Display the imported image; from the ILWIS catalogue select the imported water vapour channel raster layer directly by double clicking on the file: wvt0000\_band\_1, using under “Display Tools” >> “Representation” >> “Gray”. Right click with the mouse the filename “wvt0000\_band\_1” in the catalogue and from the context sensitive menu select “Statistics” >> “Histogram” >> “Show” and note the 1 percent stretch range. Double click under the display tools for this layer the option “Stretch”, and use 1 % stretch values (here 211 and 254 respectively). Also put a vector layer showing the country boundaries on top, use as boundary colour ‘red’. The image should be comparable with the left image of figure 4.1.11.

Check the values of the image and also check the patterns. What can you observe? Do you see any features from the Earth surface?

Also display the wvt0000\_band\_2 image, this is the thermal 10.8 micron IR image and calculate the histogram and note the 1 percent stretch values and use these stretch limits, add also the country boundaries, in an identical manner as done for the previous image. The IR\_108 image is given in figure 4.1.11 on the right hand side. Also compare the values of this image and note especially the differences between the clouded (the very dark toned pixels on both images) and the non-clouded areas, like those over the Sahara.



Figure 4.1.11: Imported WV channel (left) and TIR channel (right) for the same timestamp

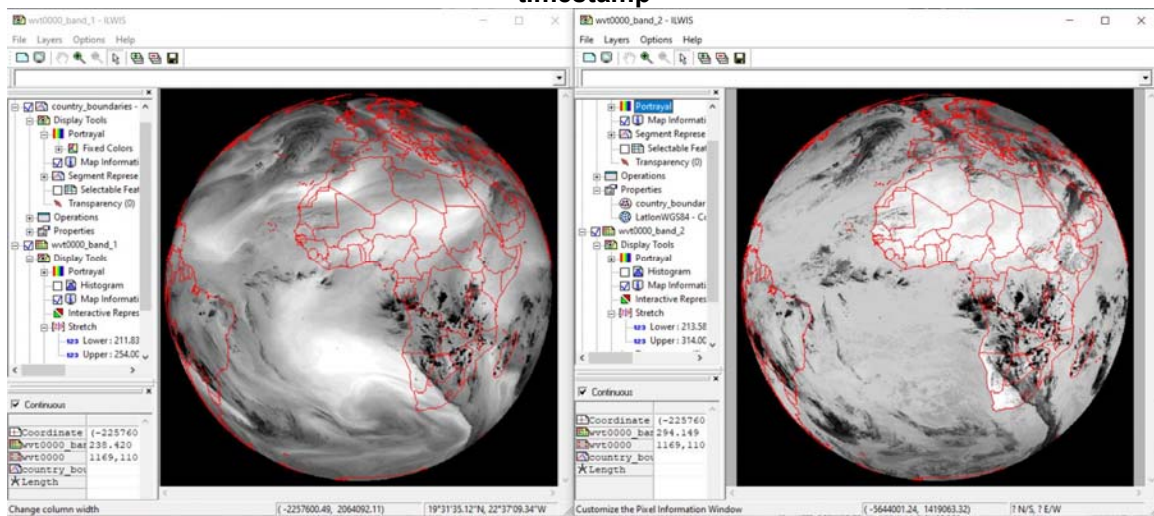
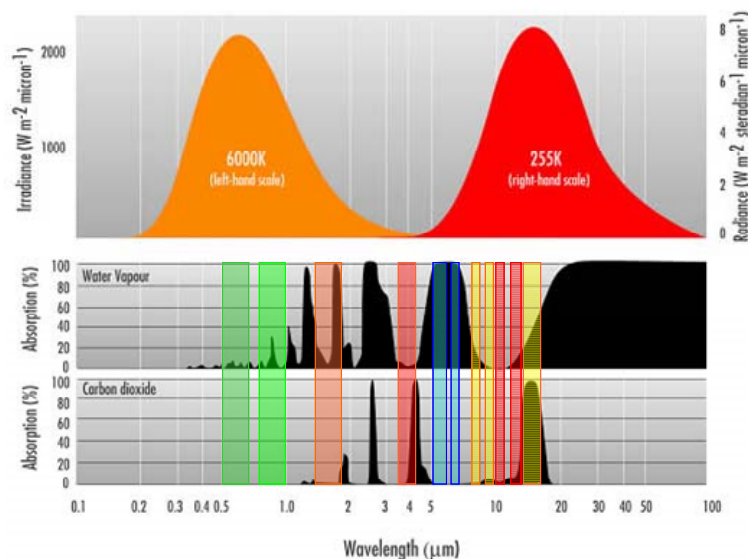
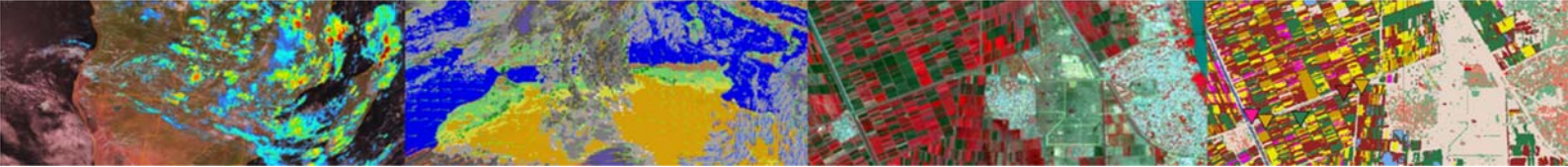


Figure 4.1.12: Irradiance and absorption for the various MSG channels (from: Rob Roebeling, Royal Netherlands Meteorological Institute, KNMI)

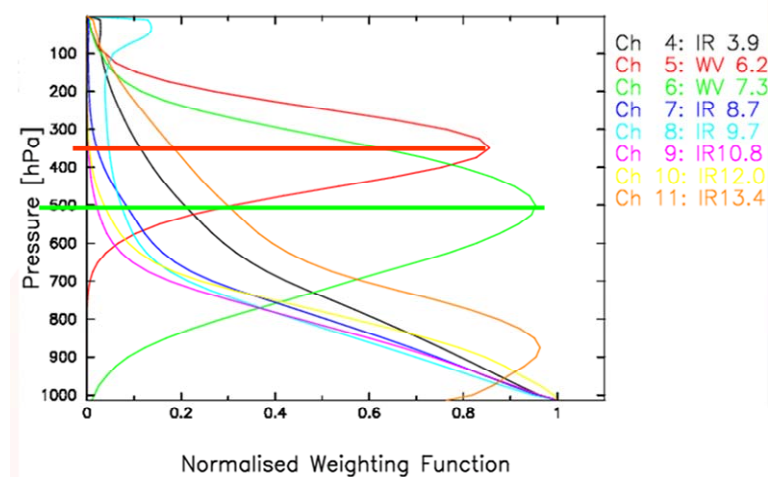


Note from figure 4.1.12 that the Water Vapour channels are strongly affected by absorption of the water vapour in the troposphere and therefore all radiation from the Earth itself is absorbed. The channels record the radiation that is emitted from certain layers within the troposphere. Therefore the water vapour channels are indicative of the water vapour content in the upper part of the troposphere. The maximum signal from WV\_062 is at 350 hPa, and for WV\_073 at 500 hPa (assuming normal pressure at sea level approximate elevation is at 8980 m and 5965 m amsl respectively), see also figure 4.1.13. If there would be no water vapour in the troposphere, radiation from far below can reach the satellite (source: Veronika Zwatz-Meise, ZAMG, available at: [http://oiswww.eumetsat.org/WEBOPS/msg\\_interpretation/PowerPoints/Channels/WVguide.ppt#283,1,Introduction into the Absorption Channels](http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/PowerPoints/Channels/WVguide.ppt#283,1,Introduction%20into%20the%20Absorption%20Channels)).

The IR\_108 channel has its maximum contribution from the ground surface. Note the effect of the carbon dioxide absorption in the IR\_134 channel.



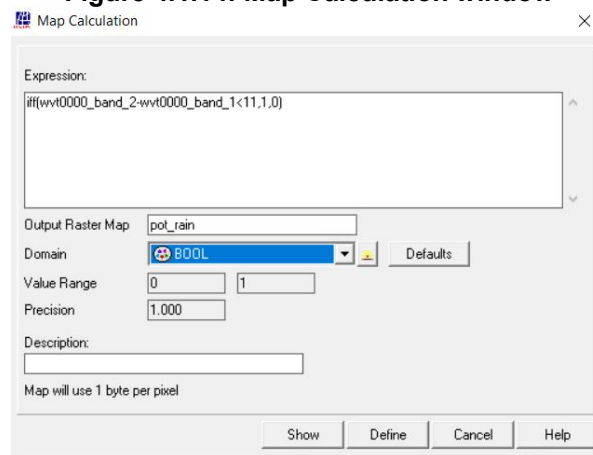
**Figure 4.1.13: Contributions to Water Vapour and IR channels**



The thermal channel records the emitted energy from the Earth surface itself. Based on a classification using MSG channel 108 and 062, applying a threshold on the temperature difference of less than 11 Kelvin (an empirically determined threshold by Kidder, et al, 2005) an approximation of the clouds that have a high likelihood of precipitation can be obtained (see also: Kidder, S., Kankiewicz, J.A., Eis, K. (2005): Meteosat Second Generation cloud algorithms for use in AFWA. In: BACIMO 2005, Monterey, CA.).

To calculate the potential precipitating clouds select from the ILWIS main menu the option “*Raster Operations*” and from the drop down menu “*Map Calculation*”. Type the indicated algorithm as indicated in figure 4.1.14 in the Expression window, specify an output map, select as Domain “*Bool*” and execute the command by pressing “*Show*”.

**Figure 4.1.14: Map Calculation window**



Display the map “*pot\_rain*” calculated, under “*Display Tools*”, for the “*Portrayal*” >> “*Boolean Colors*” for the “*True Color*” select “*Blue*” and for the “*False Color*” select “*White*”. Also add the country boundary layer and as boundary colour use “*Black*”.

From the menu of the map windows, select the option “*Add Layer*”, from the “*Filter*” option select “*Color Composite*” and select the map list “*dmp0000*” and press “*OK*”. Select “*Display Tools*” and double click “*Color Composite*”, display band 1 (VIS006) as Red, band 2 (IR\_039) as Green and Band 3 (IR\_108) as Blue, press “*Apply*” >> “*Close*”. Double click “*Red*” and use the 1% stretch values, here for red (band1): 0 - 178. Repeat this procedure also for Green (band2): 0 - 143 and for Blue (band3): 0 - 179. Also display the country boundaries in ‘*Yellow*’ and use the option “*no zoom*” as well. Under the Display Tools for the map “*dmp0000*”, double click the option “*Transparency*”, use the slide bar to change the transparency for the *dmp* image from 0 to 100%.





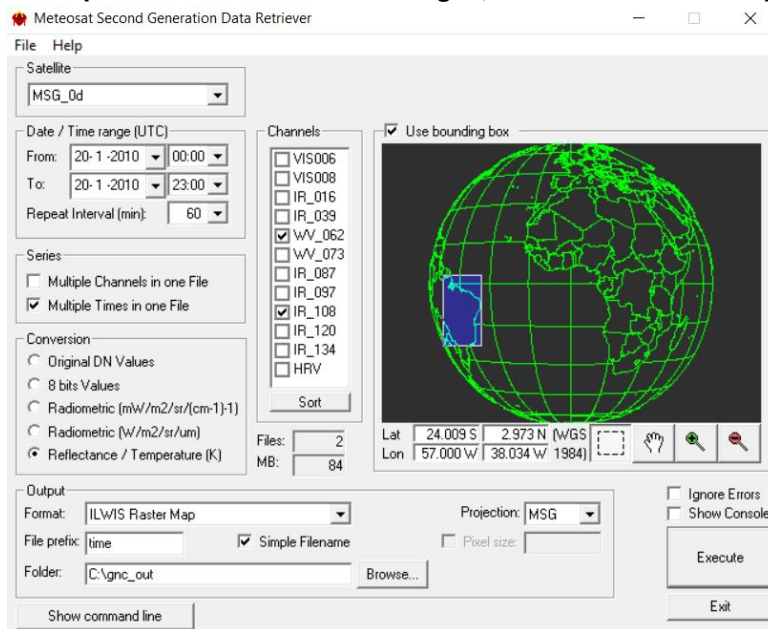
When you compare both images changing the transparency settings using the overlay of the dmp and the pot\_rain map what can you conclude? Take also note of table 4.1.



#### 4.1.4 Multi temporal data import, processing and analysis

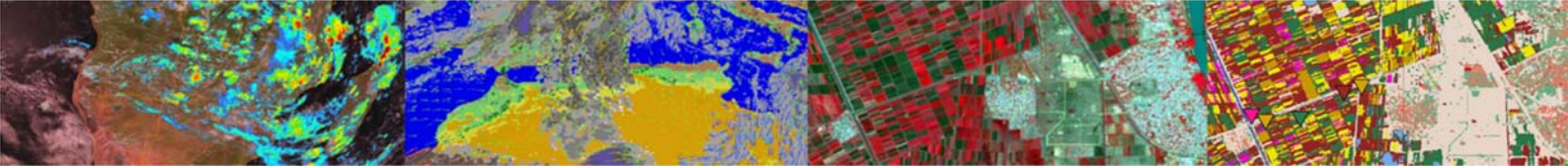
Within the ILWIS 3.8.6 additional tools are at your disposal to perform dedicated analysis using time series of e.g. Meteosat (15 minutes temporal interval) data. To deal with multi temporal image files ILWIS utilizes the concept of a map list, identical to the way a colour composite is handled. This list provides the temporal reference to a sequence of individual files in a time series. An algorithm can be entered (using a menu interface or through the command line) and is executed for all of the maps in the map list. Most of the regular Map calculation statements can be applied to map lists as well, making this a very powerful toolbox for data analysis. This map list can be created using the Data Retriever option: “multiple times in one file” and a co-registered image stack is created. The map list can be visualized using an animation, by right clicking the map list icon, Visualization / as Slide Show; the user can define the image refresh rate and select a suitable colour representation and stretch in the Display Options.


In order to import a time series of data from MSG open the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “MSG4(Prime)-0. MSG3(RSS)-9.5, MSG1(IODC)-41.5 De East” >> “MSG All” and “Start MSG Data Retriever”. The so-called MSG Data Retriever window will be activated which can be used to import the data recorded by MSG (the 0 degree, the 41.5 degree IODC and the Rapid Scanning service). You are now going to import the same bands as used during the previous exercise, but now an image for each hour. Specify the import settings as given in the figure below and execute the import. Given the time needed for import otherwise, here a subset of the field of view is selected; also try to select a subset, covering e.g. the Latin American region. Note the “Date / Time Range” settings!

Figure 4.1.15: Import time series of MSG images, transformed into temperature



Upon completion of the import, select from the ILWIS main menu, the option “Window” and from the drop down menu “Refresh F5”. To display the map list as an animated sequence double click the map list icon  “time0000” and in the Map List “time0000” menu select the “Open as SlideShow” option . Under “Display Tools” use as “Portrayal” >> “Representation” >> “Gray” and activate the option “Histogram” and now you have to wait a moment till all histograms are calculated. Close the maps display window, check the ILWIS catalogue and you will see that each image in the map list has a corresponding histogram.

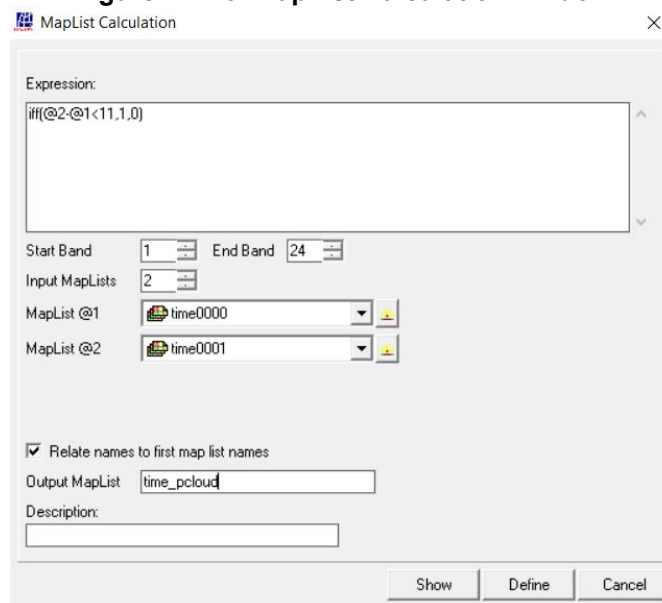


Right-click with the mouse the map list icon  "time0000", now select as option "Open as Animation", from "Portrayal" >> "Representation" >> select "Gray" and press "Run" and in the Animation Management window that appears, press the "Play" button. Stop the animation once the animation has looped a number of times, but don't close the map display window.

Open in a new map window the animation "time0001", representing the IR108 channel. Repeat the procedure as described above to calculate all the histograms, then close the map window and open the map list again as an animation and select "Gray" as Representation. Align the 2 map windows, on the left hand the WV\_062 and on the right hand the IR\_108 channels. Add the country boundaries to both map displays. Press from the left map window, under the display tools for the map list "time0000" the option "Run". Open the Tab "Synchronization" and as "Slave Animation" select "time0001" and press "Synchronize". Now open again the "Run" Tab in the Animation Management window, now press the "Play" button. To check the synchronization change the "Frame Rate" and note the 'index numbers'. Stop the animation once the animation has looped a number of times, but don't close the map display windows.

To calculate the potential precipitating clouds from this map list, select from the ILWIS main menu the option "Raster Operations" and from the drop down menu "Map List Calculation". Type the algorithm as indicated in figure 4.1.16: "iff(@2-@1<11,1,0)", in the Expression window, specify the appropriate Map Lists (time0000 is the WV; time0001 is the IR, as @1 and @2 respectively), activate the option "Relate names to first map list names" and specify an output map list. Execute the command by pressing "Show".

**Figure 4.1.16: MapList Calculation window**

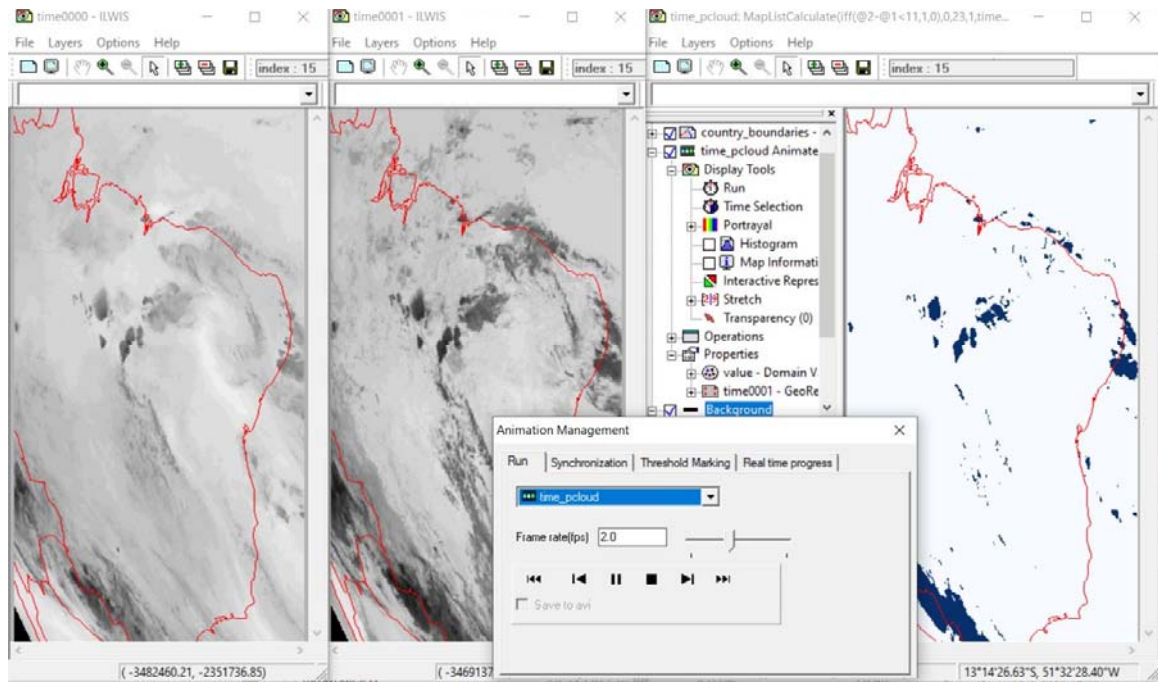


Note that a map list is defined by the "@" symbol. The syntax of the expression is the same as that of figure 4.1.14!

Upon completion of the calculation display the map list "time\_pcloud", under "Portrayal" >> "Representation" select "Blues" >> "Apply" >> "Close". Press from the left map window, under the display tools for the map list "time\_pcloud" the option "Run". Open the Tab "Synchronization" and as "Slave Animation" select "time0000" and press "Synchronize". Repeat this for "time0001" and press "Synchronize" again. Now open the "Run" Tab in the Animation Management window and press the "Play" button. To check the synchronization of the 3 map display windows change the "Frame Rate" and note the 'index numbers'. Stop the animation once the animation has looped a number of times.



**Figure 4.1.17: Synchronization of animations using time series MSG observations**



Note that the index number is referring to the sequential number within the map list, options exit to create a time column so the actual time is given. The procedure is described in the ILWIS 386 tutorial and exercise manual, available at <http://filetransfer.itc.nl/pub/52n/ILWIS386/Tutorial/>.

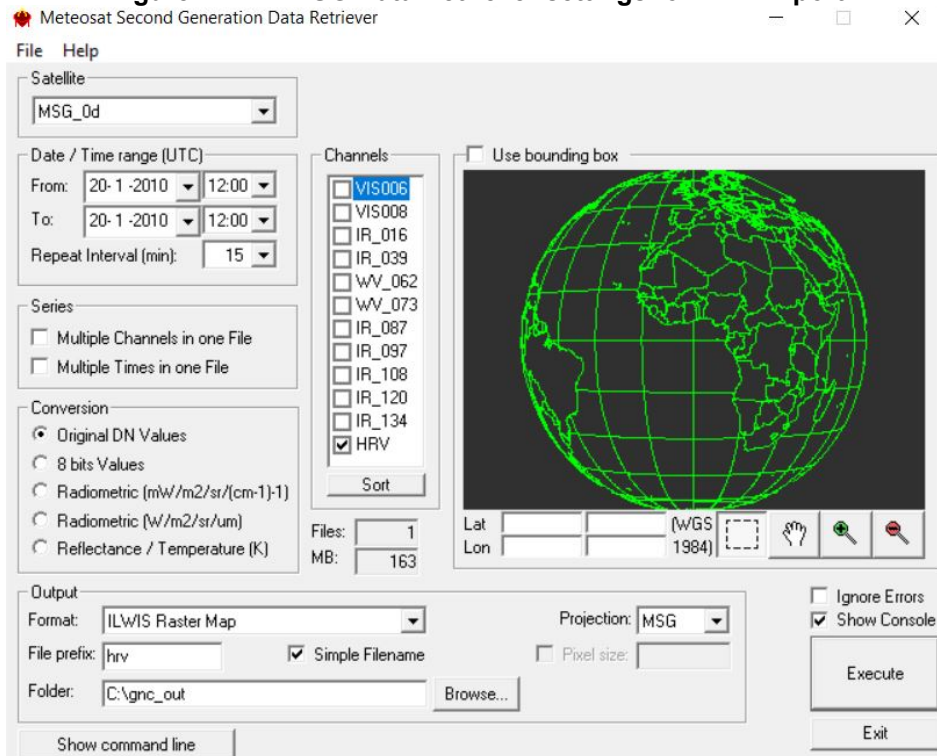


#### 4.1.5 Import of the HRV channel

One of the channels on MSG is the so-called High Resolution Visible channel. This is a broadband channel, recording the electromagnetic spectrum from 0.4 – 1.1  $\mu\text{m}$ , with a sub-satellite spatial resolution of 1 km. Its primary use is with respect to surface and clouds.

In order to import a HRV image from MSG open the “*Geonetcast and Toolbox*” tabs from the main-menu and select “*Geostationary Satellites – Level 1.5 Data*” >> “*MSG4(Prime)-0. MSG3(RSS)-9.5, MSG1(IOC)-41.5 De East*” >> “*MSG All*” and “*Start MSG Data Retriever*”. The MSG Data Retriever window will be activated which can be used to import the HRV channel. Specify the settings as given in the figure below. Note that the data is now imported as 10 bit, data range from 0 to 1023.

**Figure 4.1.17: MSG Data Retriever settings for HRV import**



Upon Completion of the import refresh the catalogue (press F5) double click the imported image “*hrv0000*”, as Representation use “*Gray*” and press Show to see the image. Under “*Display Tools*” >> “*Stretch*” modify the stretch upper limit from 1023 to about 425, to improve the image visualization. Also put a vector layer showing the country boundaries on top (boundary colour in red). Note that the image does not completely cover Africa and there is no coverage of South America at this UTC time selected. Zoom to the African region: from the active map window, select “*Options*” and “*No Zoom*” to see the image in the full resolution. Note that when another time is selected the southern part of the HRV image will move westward, e.g. for Western Africa a timestamp of 15:00 UTC and for Latin America 17:00 UTC can be used. An example of a HRV image over Latin America is provided in figure 4.1.18B for your reference.



Figure 4.1.18A: Imported HRV image

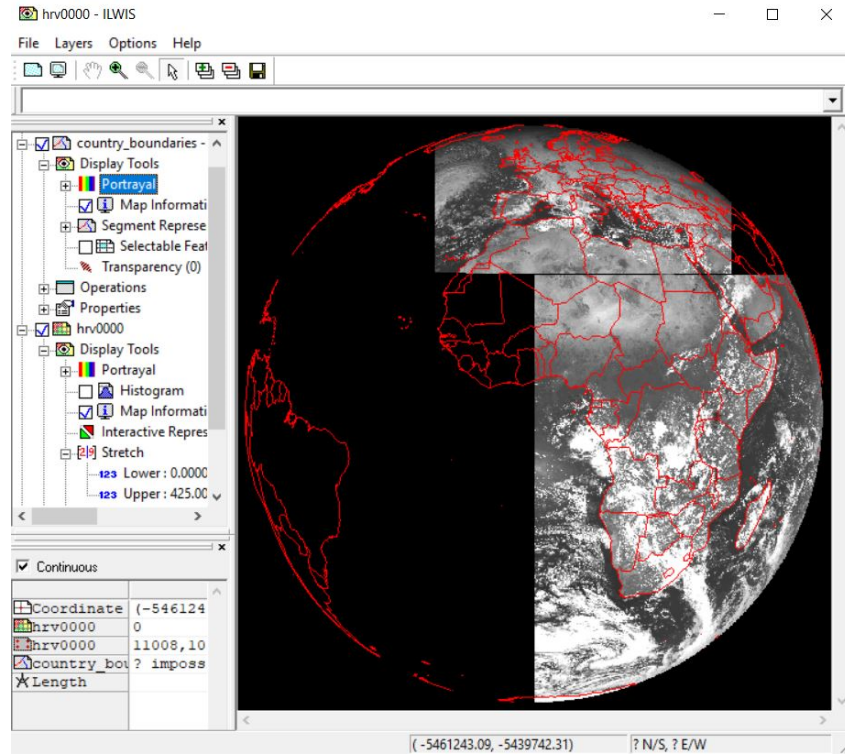
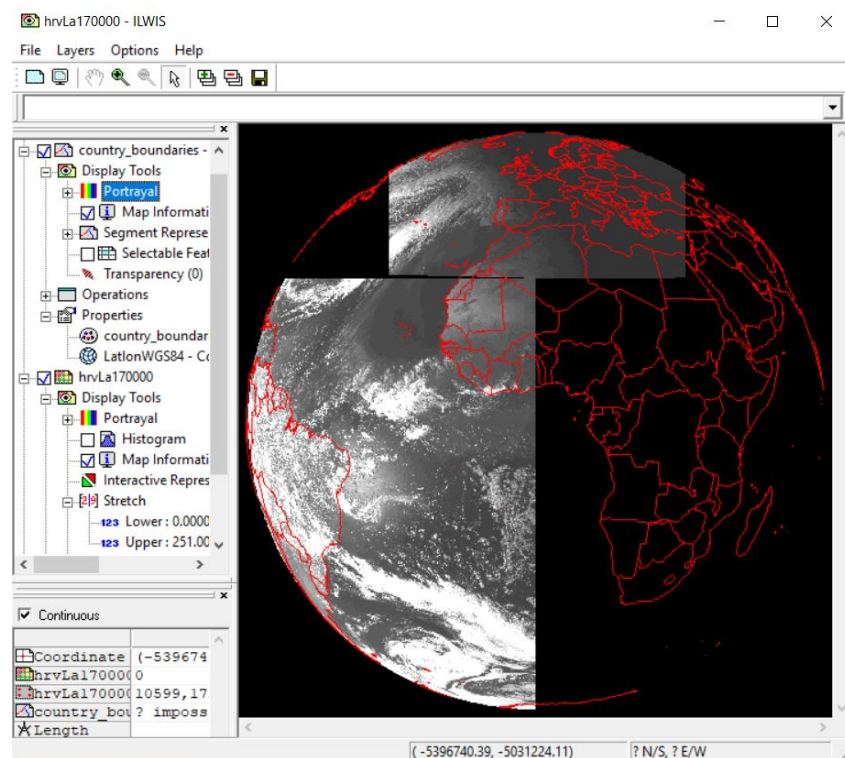


Figure 4.1.18B: Example of shift of the southern window of the HRV image



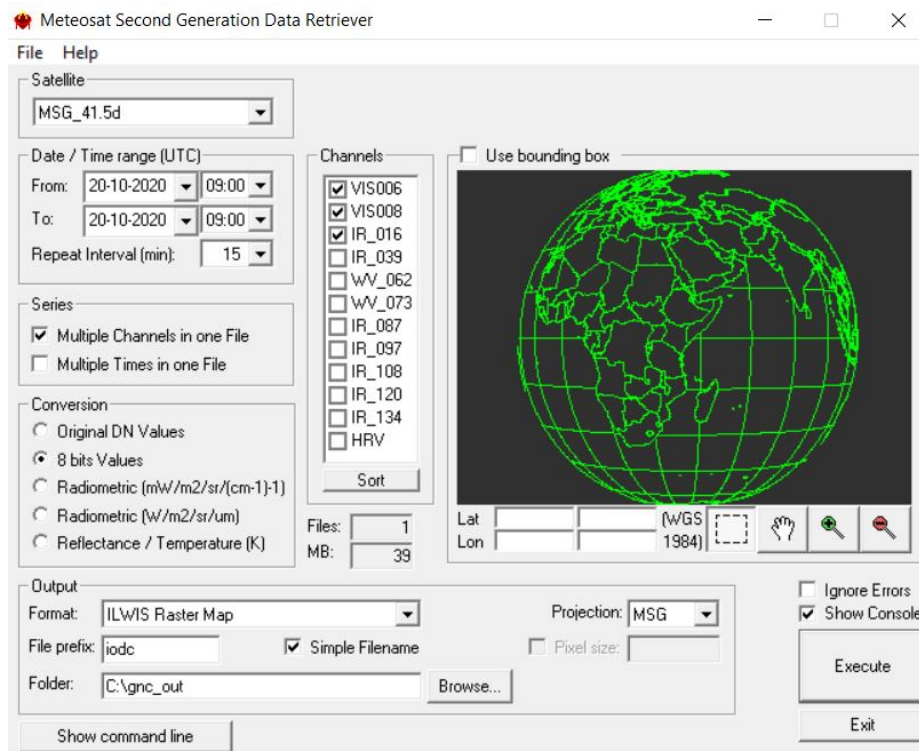
## 4.1.6 Import of the IODC and RSS MSG satellite observations

### 4.1.6.1 Indian Ocean Data Coverage (IODC)

Meteosat 7, the last first generation meteorological satellite was replaced by MSG, now situated at 41.5 degree East over the equator and the service is called the “Indian Ocean Data Coverage” (IODC). The satellite characteristics are identical as compared to MSG at 0 degree.

In order to import a IODC Daytime Standard Colour Scheme composite from MSG open the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “MSG4(Prime)-0. MSG3(RSS)-9.5, MSG1(IODC)-41.5 De East” >> “MSG All” and “Start MSG Data Retriever”. The MSG Data Retriever window will be activated which can be used to import MSG IODC data, situated at 41.5 degree. Specify the settings as given in the figure below. Note that the data is now imported for the “Satellite”: MSG\_41.5d. Note the change of the map window, compared to the import of the MSG satellite situated at 0 degree.

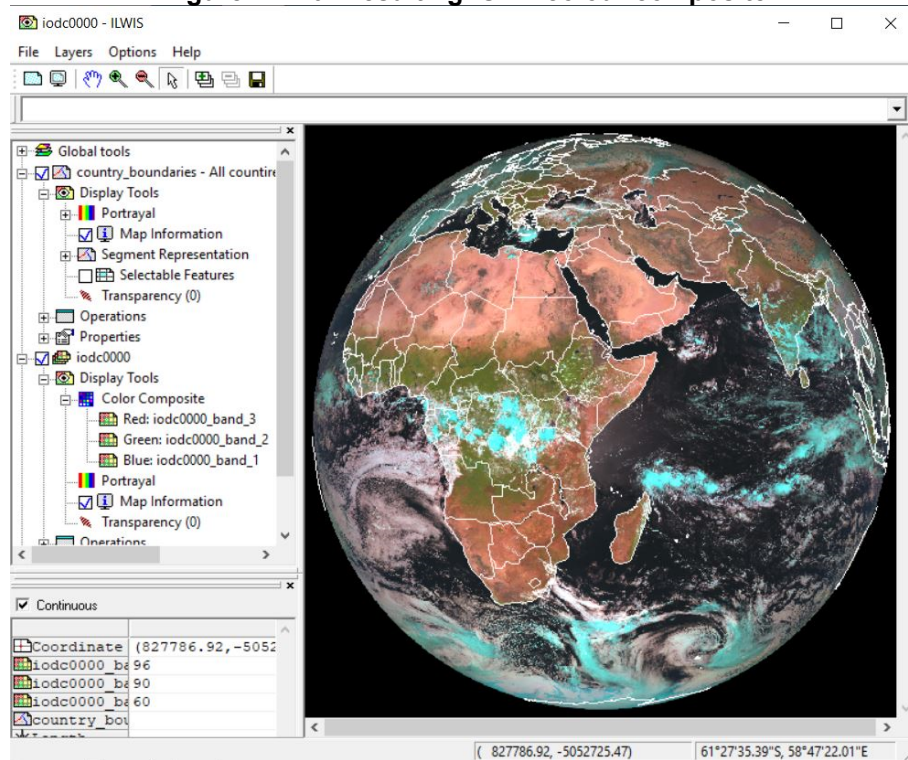
Figure 4.1.19: Import settings for MSG at 41.5 degree



Upon completion of the import, select from the ILWIS main menu, the option “Window” and from the drop down menu “Refresh F5”. To display the new colour composite created, double click the map list called “iodc0000” >> select from “Display Tools” >> and double click “Color Composite”, display band 3 (VIS016) as Red, band 2 (VIS008) as Green and Band 1 (VIS006) as Blue, and press “Apply” >> “Close”. Check the histograms for the 3 bands and use the 1% stretch values, here for red (band1): 132, for Green (band2): 128 and for Blue (band3): 140. Also display the country boundaries in ‘White’ and use the option “no zoom” in as well. Figure 4.1.20 is showing the visualization of this MSG channel combination for the whole field of view.



**Figure 4.1.20: Resulting IODC colour composite**

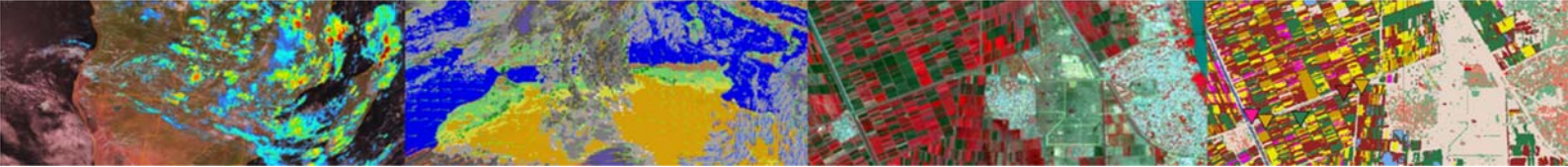


#### 4.1.6.2 Rapid Scanning Service (RSS)

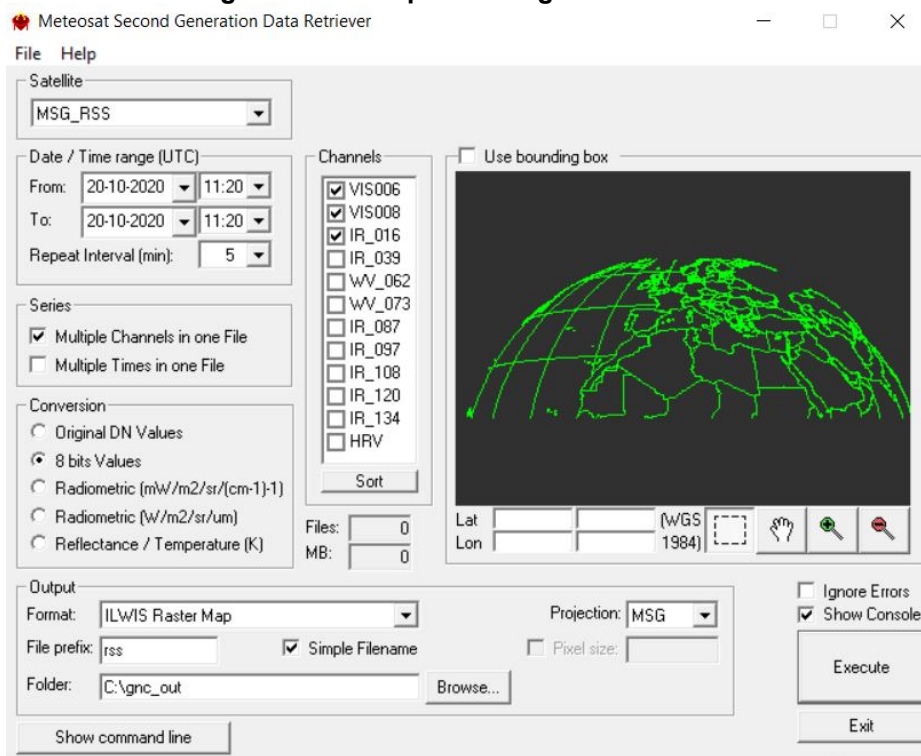
At the moment of writing this document, Meteosat 10 is used for the Rapid Scanning Service and the satellite is situated at 9.5 degree East over the equator. The satellite characteristics are identical as compared to the other MSG satellites, only the field of view is limited to the northern 1/3 of a nominal repeat cycle and therefore the temporal resolution is increased 3 fold, to 5 minutes. The rapid scan area for the MSG RSS covers a latitude range from approximately 15° to 70° in the northern hemisphere. Using a higher temporal resolution fast developments in the atmosphere can be monitored better, like thunderstorm development or spread of volcanic ash plumes.

In order to import a RSS Daytime Standard Colour Scheme composite from MSG open the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “MSG4(Prime)-0. MSG3(RSS)-9.5, MSG1(IODC)-41.5 De East” >> “MSG All” and “Start MSG Data Retriever”. The MSG Data Retriever window will be activated which can be used to import MSG RSS data, situated at 9.5 degree. Specify the settings as given in the figure below. Note that the data is now imported for the “Satellite”: MSG\_RSS. Note the change of the map window, compared to the import of the MSG satellite situated at 0 or 41.5 degree, now only covering the northern 1/3 portion of the whole field of view. Also note the increased temporal resolution under “Repeat Interval”.

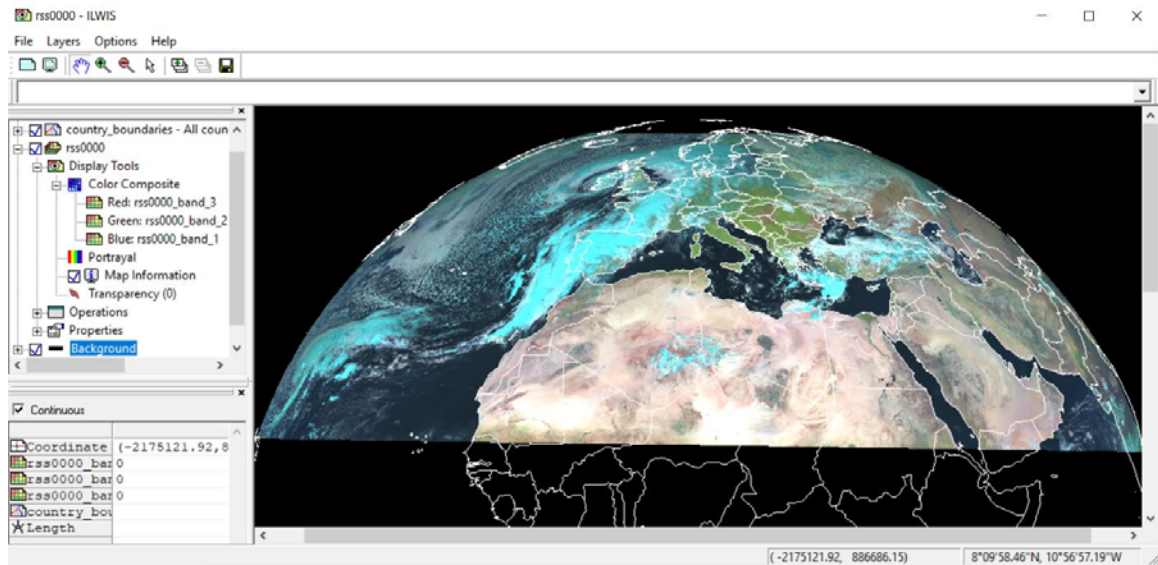
Upon completion of the import, select from the ILWIS main menu, the option “Window” and from the drop down menu “Refresh F5”. To display the new colour composite created, double click the map list called “rss0000” >> select from “Display Tools” >> and double click “Color Composite”, display band 3 (IR\_016) as Red, band 2 (VIS008) as Green and Band 1 (VIS006) as Blue, and press “Apply” >> “Close”. Check the histograms for the 3 bands and use the 1% upper stretch values, here for red (band1): 132, for Green (band2): 128 and for Blue (band3): 140. Also display the country boundaries in ‘White’ and use the option “no zoom” in as well. Figure 4.1.20 is showing the visualization of this MSG channel combination for the Rapid Scanning Service.



**Figure 4.1.19: Import settings for MSG RSS**



**Figure 4.1.20: Resulting RSS colour composite**





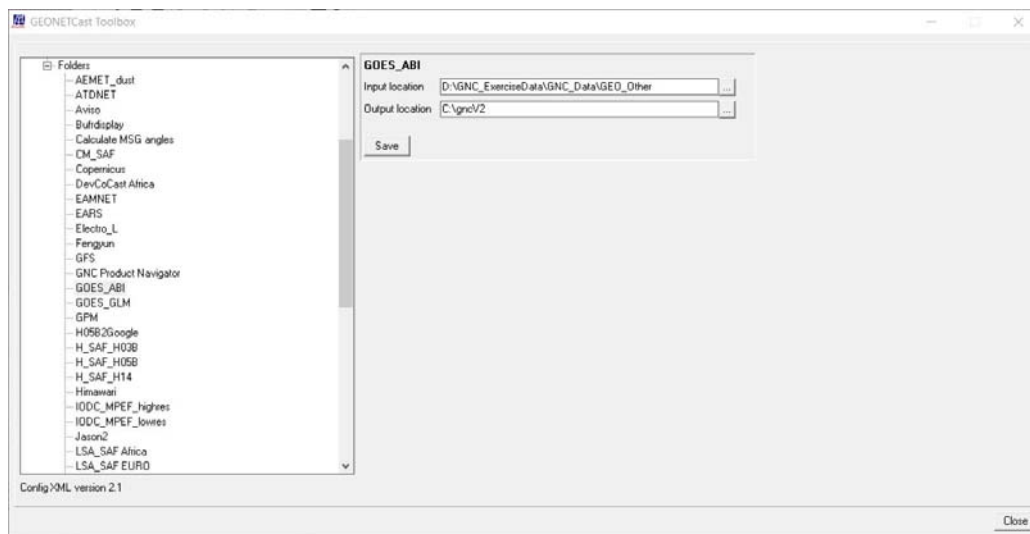


## 4.1.7 Examples of other Geostationary satellites

### 4.1.7.1 GOES East and GOES West

Before starting to import the various other data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “GOES\_ABI”. Browse to the appropriate data input and output locations and in the case of GOES\_ABI note that the data is stored in a different directory (here “D:\GNC\_ExerciseData\GNC\_Data\GEO\_Other”, where “D:” is the designated hard disk drive location). Here as output location “C:\gnc\_out” is used. Use the folder settings as given in the figure below. Press “Save” to store the settings. Use the same folder settings for “GOES\_GLM” which you will import later. Then press “Close”. Also have a look at Appendix 2 to see the directory structure details of the sample data provided.

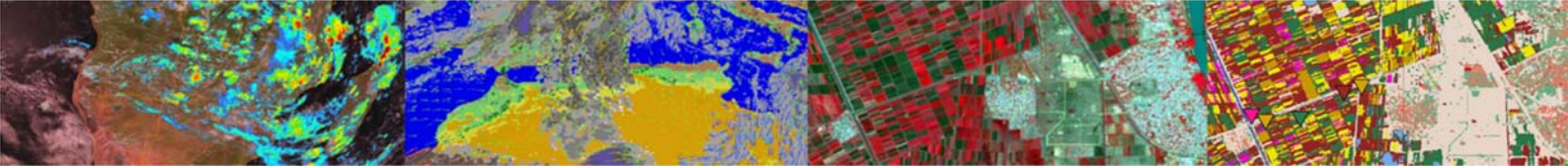
**Figure 4.1.21: Folder settings for the GEOS-ABI and GOES-GLM**



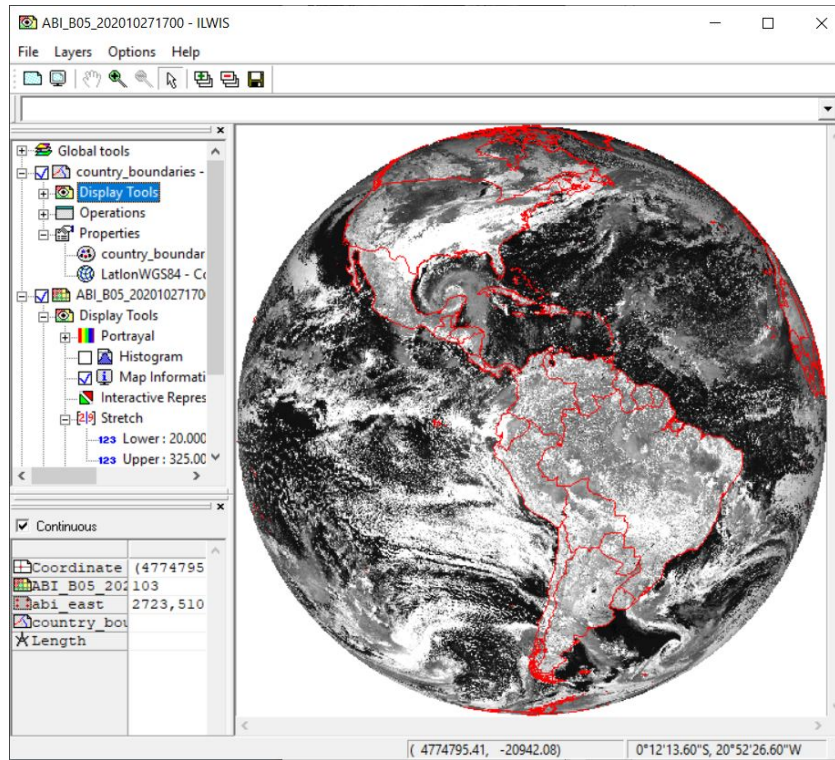
In order to import GOES-16 ABI the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “GOES-16(East) at 75 and GOES-17(West) at 137 Deg West” >> “GOES16 ABI (EAST)”. Specify the appropriate time stamp according to the format required: “202010271700”. Also note if the input and output directories are correctly defined.

After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file names of the newly imported images, e.g. “ABI\_”, followed by channel ID, year, month, day and time in UTC. Display the “ABI\_B05\_202010271700” image, use as “Representation” “gray”, use as stretch values: from 2 to 325. Also add the country boundaries in red. Check the coverage of the GOES East image. The results obtained should resemble those of figure 4.1.22. Also display a number of the other 16 imported channels and use an appropriate stretch.

For further information on the spectral characteristics, band name, primary use and RGB composites using the GOES EAST ABI channels see the ‘GOES-16 Band Reference Guide’, available at: [https://www.weather.gov/media/crp/GOES\\_16\\_Guides\\_FINALBIS.pdf](https://www.weather.gov/media/crp/GOES_16_Guides_FINALBIS.pdf). Note that this guide also applies to GOES West.



**Figure 4.1.22: GOES 15 (GOES-East) disk of 27 October 2020, at 17:00 UTC, Band 5**



As can be noted from the ‘GOES-16 Band Reference Guide’ the visible green spectral region is not recorded by GOES. An approach as described by Bah, Gunshor and Schmit is used, described in: “the Generation of GOES-16 True Color Imagery without a Green Band” ([https://aos.wisc.edu/aosjournal/Volume32/Bah\\_nonthesis\\_MS.pdf](https://aos.wisc.edu/aosjournal/Volume32/Bah_nonthesis_MS.pdf)) is applied when selecting the import option “GOES16 ABI (EAST)TC”.

To create a GOES-16 ABI True Colour Composite, from the “Geonetcast and Toolbox” tabs main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “GOES-16(East) at 75 and GOES-17(West) at 137 Deg West” >> “GOES16 ABI (EAST) TC”. Specify the appropriate time stamp according to the format required: “202010271700”. Also note if the input and output directories are correctly defined, as indicated before.

After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file names of the newly imported images, e.g. “ABI\_TC\_GE”, followed by year, month, day and time in UTC. Display the “ABI\_TC\_GE\_202010271700” image and add the country boundaries in red. Use the option “No Zoom” and inspect the image created.

For GOES-16 also the data recorded by the ‘Global Lighting Mapper’ (GLM) is available in Geonetcast. To import a GOES-16 GLM data file (temporal interval 5 minutes), from the “Geonetcast and Toolbox” tabs main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “GOES-16(East) at 75 and GOES-17(West) at 137 Deg West” >> “GOES16 GLM (EAST)”. Specify the appropriate time stamp according to the format required: “202010271700”. Also note if the input and output directories are correctly defined.

After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file name of the newly imported point file, e.g. “GOES16\_GML\_”, followed by year, month, day and time in UTC.

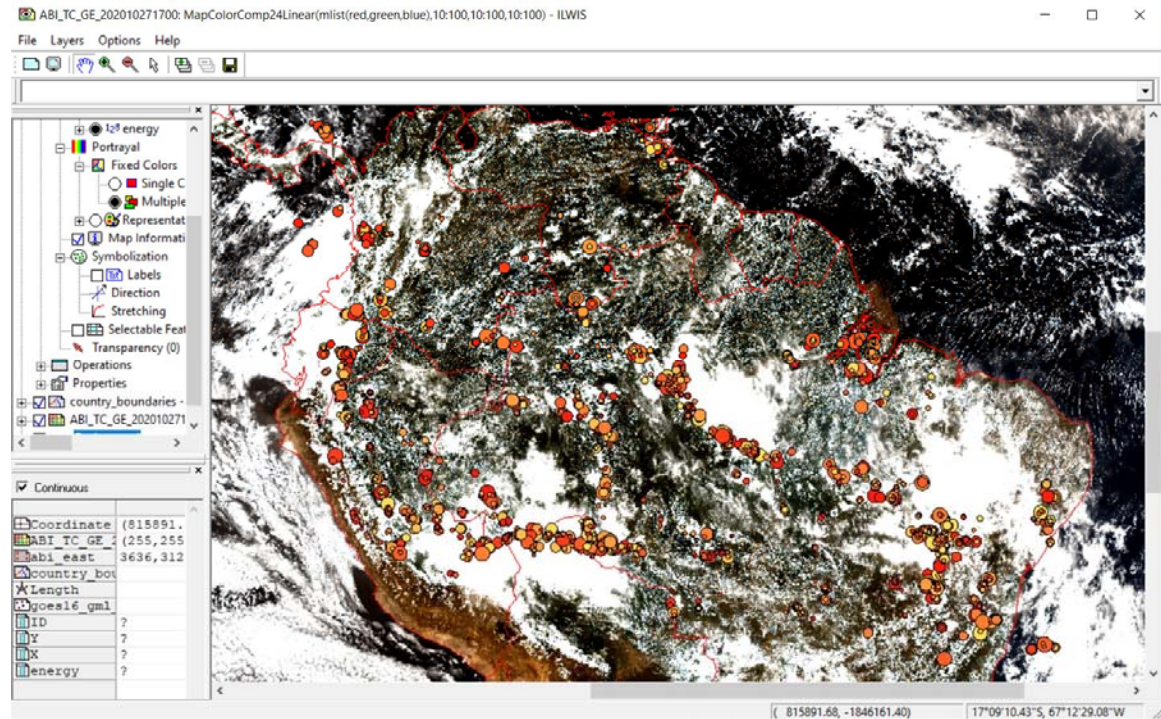
Open the map window display of the “ABI\_TC\_GE\_202010271700” image, use the option “Add Layer” and add the point file “GOES16\_GML\_202010271700”. In the left hand legend of the map display window, under the “Display Tools” of the point map open the tab “Display Attribute” and select “energy”, now under “Portrayal” use the option “Multiple Colours”. Double click “Symbolization”, use as Symbol “filled circle” and click “Apply” and “Close”. Double click



the “Stretching” option, use as Scale Exaggeration 8, active the option “Stretch”, select as Attribute Column “energy”, use as Range lower limit “3” and as Upper Limit “360” and press “Apply” and “Close”. Finally double click under “Portrayal” the option “Multiple Colors” and as colour scheme select “desert” and press “Apply” and “Close”. From the map display window select from the menu “Options” >> “No Zoom”.

Now check the occurrence of lightning strikes recorded with the appearance of clouds. Your results should resemble those on the figure below, showing the colour composite together with the global lightning mapper data, concatenated into a file of a 5 minutes time period during the time of image acquisition. To obtain all lighting strokes over the full image acquisition cycle a number of 5 minutes GLM files have to be processed!

**Figure 4.1.23: GOES 15 (GOES-East) Colour Composite and GLM overlay**



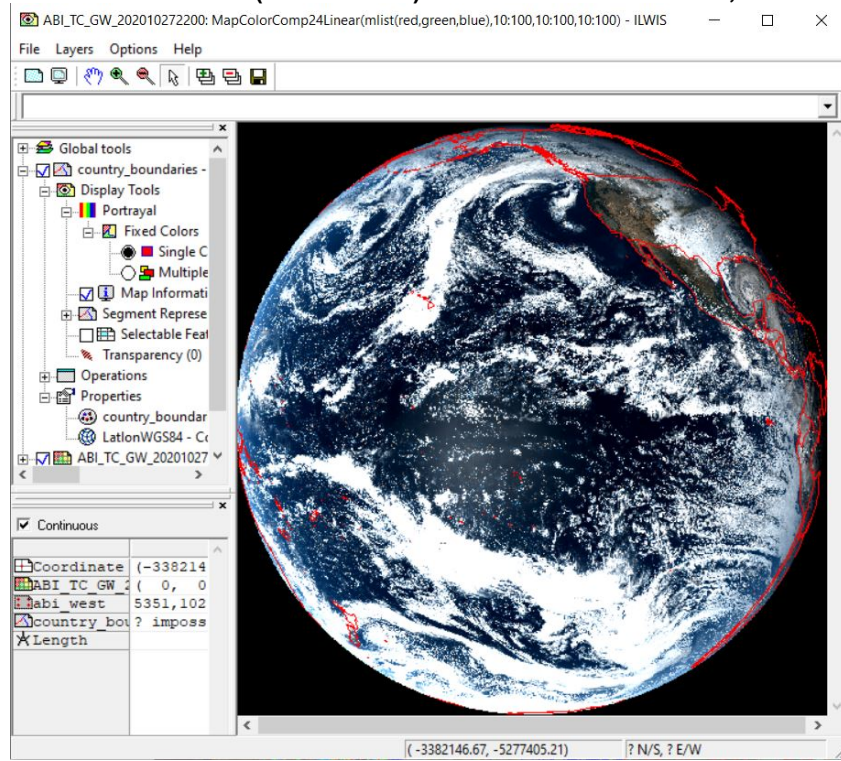
To import GOES West ABI the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “GOES-16(East) at 75 and GOES-17(West) at 137 Deg West” >> “GOES17 ABI (WEST) TC”. Specify the appropriate time stamp according to the format required: “202010272200”. Also note if the input and output directories are correctly defined.

After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file name of the newly imported image, e.g. “ABI\_TC\_GW\_”, followed by year, month, day and time in UTC. Display the “ABI\_TC\_GW\_ 202010272200” image, and add the country boundaries in red. Check the coverage of the GOES West image. The results obtained should resemble those of figure 4.1.24.

You can also import the individual channels of GOES West, using the import option “GOES17 ABI (WEST)” from the toolbox menu. Sample data for the same time step is provided in the data folder (here D:\GNC\_ExerciseData\GNC\_Data\GEO\_Other) and you can conduct the import in an identical manner as described for GOES East, using as time stamp 202010272200. Display the imported channels, use as Representation “Gray”, apply an appropriate stretch, using a lower upper limit.



**Figure 4.1.24: GOES 17 (GOES-West) disk of 27 October 2020, at 22:00 UTC**



Before you continue close all active layers.



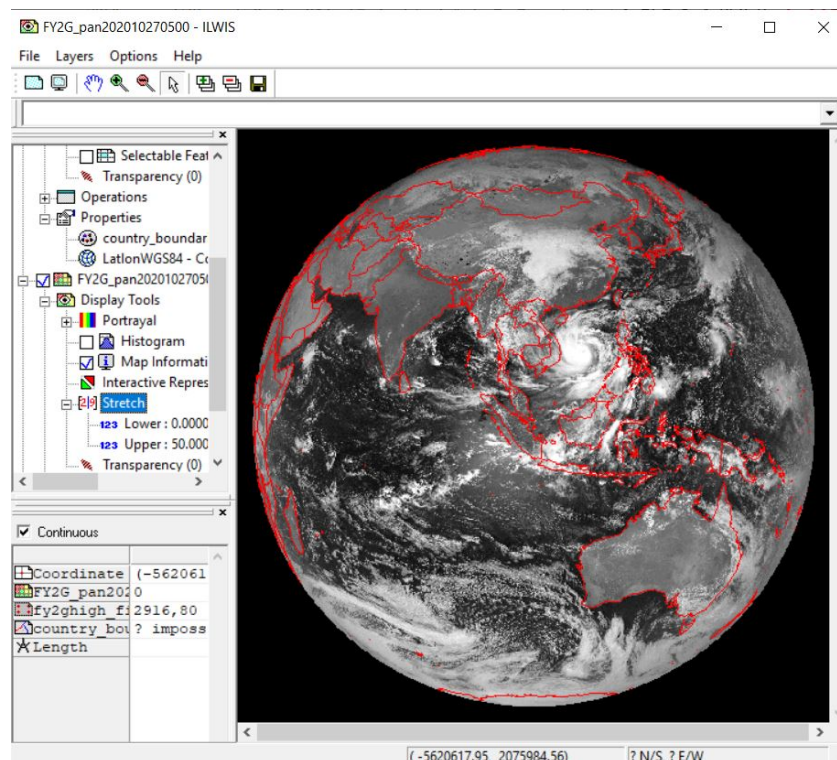
#### 4.1.7.2 Fengyun

Before starting to import the Fengyun data available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*Fengyun*”. Browse to the appropriate data input and output locations and in the case of Fengyun note that the data is stored in the following directory: “*D:\GNC\_ExerciseData\GNC\_Data\GEO\_Other*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings and then press “*Close*”. Also have a look at Appendix 2 to see the directory structure details of the sample data provided.

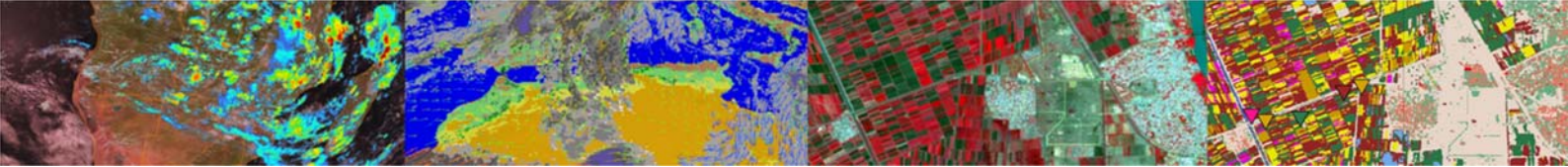
At the moment of writing this tutorial observations from two geostationary satellites operated by the Chinese Meteorological Agency (CMA) are provided through GEONETCast – EUMETCast: Fengyun 2G, situated at 99 and 2H at 79 Degree East. Sample data for both satellites is provided using the same time stamp, here the import procedure is described for Fengyun 2G only. The import for Fengyun 2H is identical.

In order to import Fengyun 2G activate the “*Geonetcast and Toolbox*” tabs from the main-menu and select “*Geostationary Satellites – Level 1.5 Data*” >> “*Fengyun 2G at 99 and 2H at 79 Deg East*” >> “*Fengyun 2G High*”. Specify the appropriate time stamp according to the format required: “*202010270500*”. Also note if the input and output directories are correctly defined. After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file names of the newly imported images, e.g. “*FY2G\_pan*”, followed by year, month, day and time in UTC. Display the “*FY2G\_pan202010270500*” image, use as “*Representation*” “*Gray*”, use as stretch values: 0 to 50. Also add the country boundaries in red. Check the coverage of the FY 2G image, use the option “*No Zoom*”. The results obtained should resemble those of figure 4.1.25.

**Figure 4.1.25: Fengyun 2G Panchromatic high resolution image**



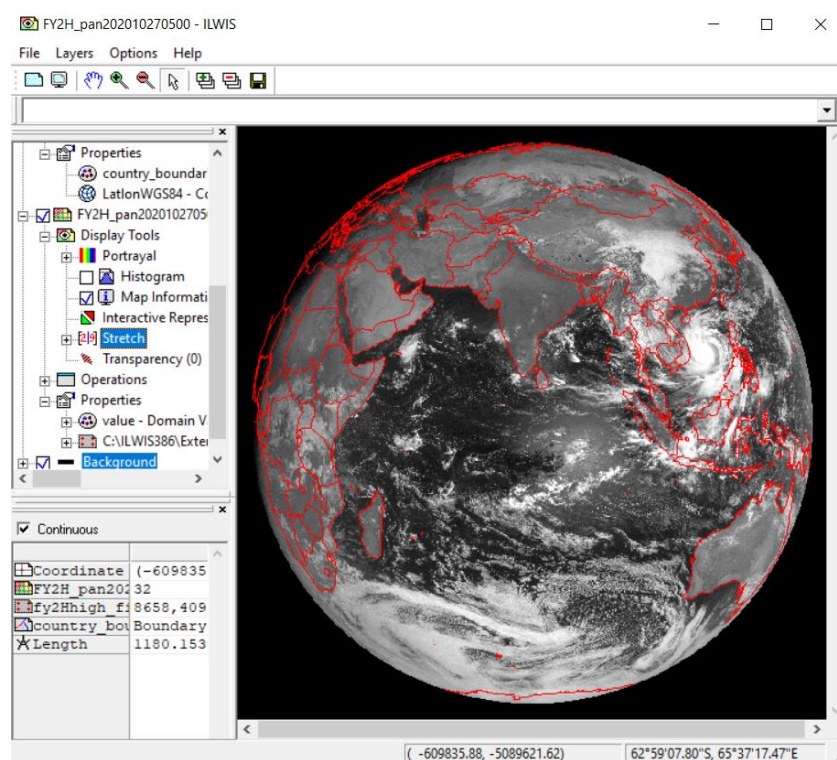
The Panchromatic image has a spatial resolution of 1.25 km. The FY 2G low has a spatial resolution of 5 km and has 5 spectral channels, IR 1 to 4 and a Visible channel. For further information see also [https://www.wmo-sat.info/oscar/instruments/view/s\\_vissr\\_fy\\_2f\\_g\\_h](https://www.wmo-sat.info/oscar/instruments/view/s_vissr_fy_2f_g_h).



Now proceed with importing the FY 2G Low images, use the same time stamp. After import is completed, update the ILWIS catalogue, and display the images “FY2Gir1\_202010270500” to “FY2Gir4\_202010270500” and “FY2Gvis\_202010270500”, use as Representation “Gray” and add the country boundaries in Red. Use lower upper limit stretch values to improve the visualization.

The FY 2H is an identical instrument, having the same spectral channels and spatial resolution, but recorded from another position along the equator (at 79 degree East). The import routine is similar. A high resolution sample image is provided in the figure below using an identical time stamp as for the FY 2G image. The image can be imported using the Fengyun 2H High and Low toolbox menu options.

**Figure 4.1.26: Fengyun 2H Panchromatic high resolution image**



### 4.1.7.3 Himawari

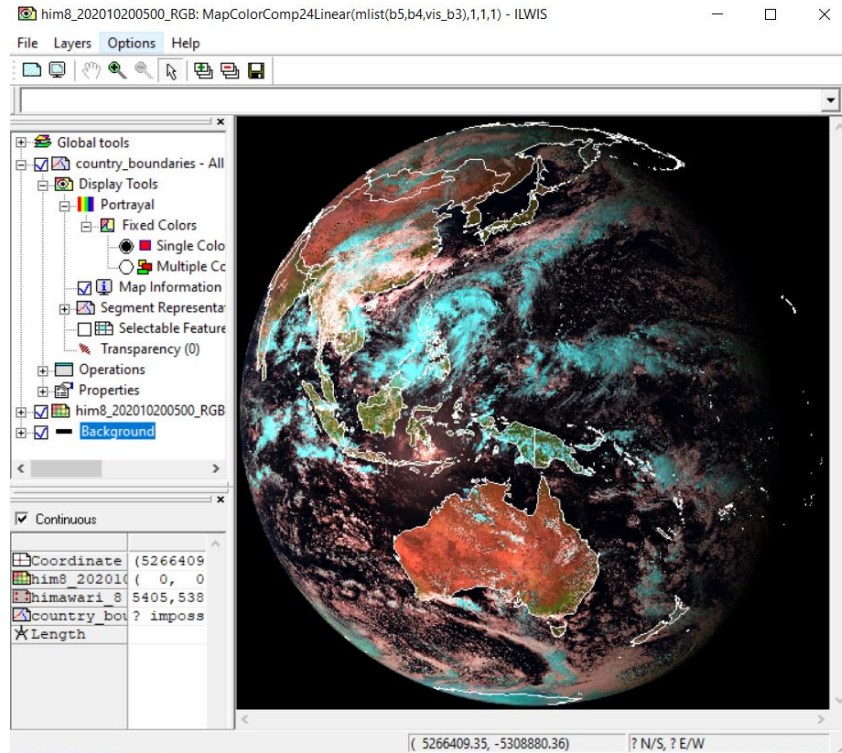
Before starting to import the Himawari data available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “Himawari”. Browse to the appropriate data input and output locations and in the case of Himawari note that the data is stored in the following directory: “D:\GNC\_ExerciseData\GNC\_Data\GEO\_Other”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings. Then press “Close”. Also have a look at Appendix 2 to see the directory structure details of the sample data provided.

In order to import a daytime Himawari colour composite open the “Geonetcast and Toolbox” tabs from the main-menu and select “Geostationary Satellites – Level 1.5 Data” >> “Himawari-8 at 140 Deg East” >> “Himawari-8 Daytime RGB”. Specify the appropriate time stamp according to the format required: “202010200500”. Also note if the input and output directories are correctly defined. After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file name of the newly imported image, e.g. “him8\_\*\_RGB”, followed by year, month, day and time in UTC and as suffix “\_RGB”. Display the



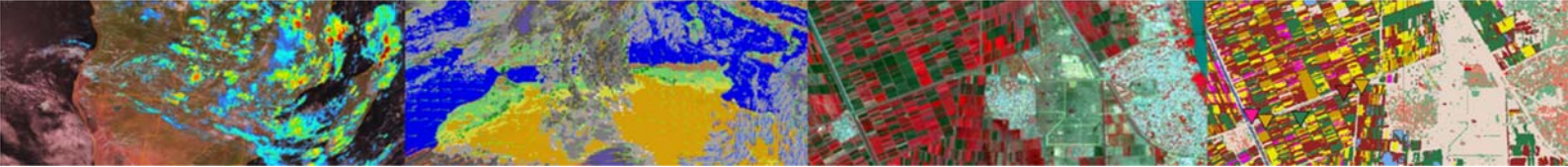
"him8\_202010200500\_RGB" image. Also add the country boundaries in White. Check the coverage of the Himawari image, use the option "No Zoom". The results obtained should resemble those of figure 4.1.27.

**Figure 4.1.27: Himawari-8 colour composite image**



Further details of the Advanced Himawari Imager (AHI) and the 16 spectral channels are provided at: <https://www.wmo-sat.info/oscar/instruments/view/ahi>. Sample data for the Visible, Infrared and other spectral channels is provided for the same time stamp. The respective import can be performed by selection of the toolbox menu options "Himawari-8 Visible", "Himawari-8 IR1-4" and "Himawari-8 other bands" respectively. The procedure is identical as to the one described above. For the thermal bands a polynomial function is used to transform the data into temperatures (Kelvin).

Before you continue close all active layers.



## 4.2 IMPORT OF POLAR - LEVEL 1.5 DATA EXAMPLE METOP AND NOAA

### 4.2.1 Processing of METOP A, B and C AVHRR/3 and ASCAT

The images collected by the AVHRR/3 sensor on METOP is not disseminated via the GEONETCast C-band turn around services (e.g. to Africa). Data can be obtained from the archive at EUMETSAT (<http://archive.eumetsat.int/umarf/>). To get an idea of the images an example is included in these exercises.

The table below shows the spectral channels of the AVHRR/3 sensor on METOP. It has six channels (three visible and three infra-red) but only five are transmitted. Channel 3 is the visible channel during daytime and the infra-red channel at night time.

**Table 4.2: AVHRR/3 spectral channel details and their primary use**

Channel	Spectral Bandpass (micrometers)	Primary Use
1 (Visible)	0.580 - 0.68	Daytime cloud/surface mapping
2 (Near IR)	0.725 - 1.00	Surface water delineation, ice and snow melt
3A (Near IR)	1.580 - 1.64	Snow / ice discrimination
3B (IR-Window)	3.550 - 3.93	Sea surface temperature, night time cloud mapping
4 (IR-Window)	10.300 - 11.3	Sea surface temperature, day and night cloud mapping
5 (IR-Window)	11.500 - 12.5	Sea surface temperature, day and night cloud mapping

AVHRR data files provided have a 3 minutes scan duration. MO1 in the filename refers to Metop B and MO2 refers to Metop A. Before starting to import the AVHRR data available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "Geonetcast" and "Toolbox" main menu select the option "Configuration" and "Folder" and select "METOP\_AVHRR". Browse to the appropriate data input and output locations and in the case of AVHRR note that the data is stored in the following directory: "D:\GNC\_ExerciseData\GNC\_Data\Polar\METOP\_AVHRR", where "D:" is the designated hard disk drive location. Here as output location "C:\gnc\_out" is used. Press "Save" to store the settings and then press "Close". Also have a look at Appendix 2 to see the directory structure details of the sample data provided.

If not already active, open ILWIS, from the "Geonetcast, Toolbox" tabs select the menu item "Polar - Level 1.5 Data" >> "METOP A/B/C" >> "AVHRR/3" >> "METOP AVHRR/3 daytime FCC". Specify the appropriate full file name (including extension), use here:

"AVHR\_xxx\_1B\_M01\_20201029105803Z\_20201029110103Z\_N\_O\_20201029113442Z.bz2"

Check the time stamp contained within the file name (here indicated in bold), the file contains data recorded from 10:58 to 11:01 UTC (start and end of scan time respectively) on 20201029. Also note if the input and output directories are correctly defined. Note the information displayed during import, e.g. those spectral channels indicated by an asterisks are not imported like channel 3B during daytime.

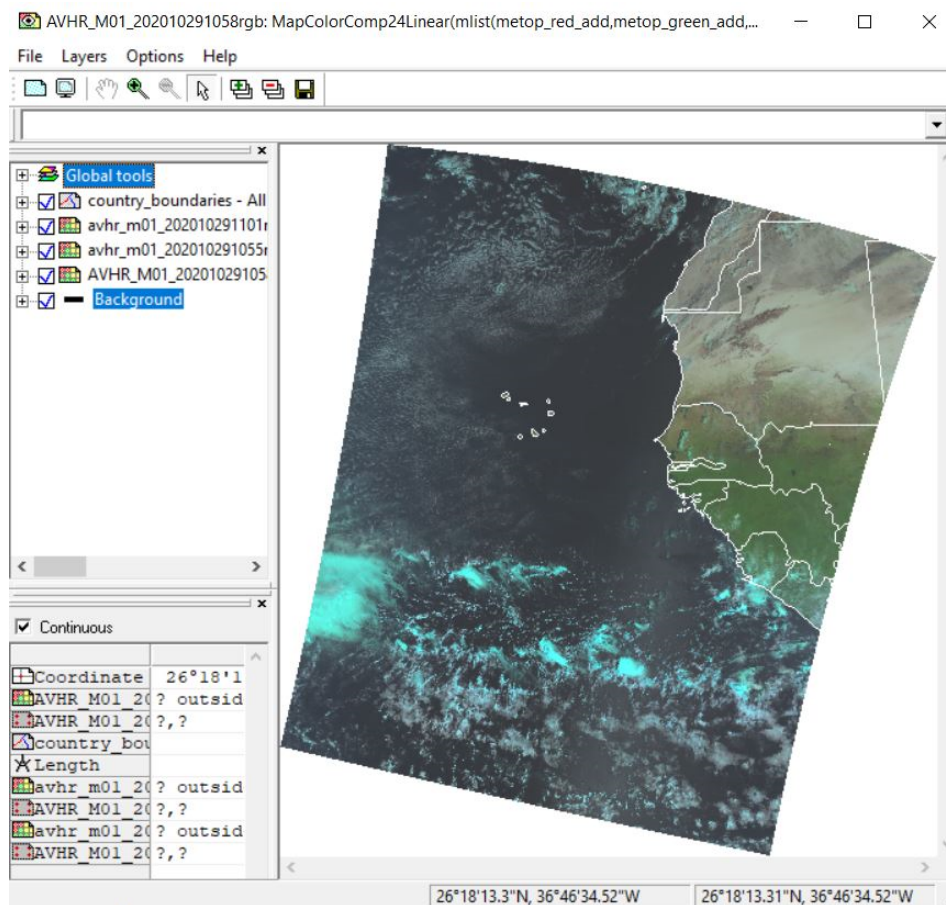
Given the fact that this is a daytime image, upon import a colour composite is created using channels 1, 2 and 3A and therefore the import routine takes a bit longer. After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file name of the newly imported image, e.g. "AVHR\_M01\_", followed by year, month, day and time in UTC. Display the "AVHR\_M01\_202010291058rgb" image and also add the country boundaries in white.





Check the coverage of the image, use the option “No Zoom”. Don’t close the map display window. Now also import the METOP B (MO1) AVHRR image as daytime colour composites of 10:55 and 11:01 (start of scan time). Upon completion of the import of both images, activate the map window which was used to display the 10:55 image. Press the “Add Data Layer” icon from the map window menu, select the image “AVHR\_M01\_202010291055rgb”, ensure that you have activated from the “Add Data Layer” menu the option “Extend Map Boundaries” and press “OK”. Repeat this procedure to add also the “AVHR\_M01\_202010291101rgb” image imported, again with the option activated for “Extend Map Boundaries”. Ensure that the vector file “country\_boundaries” appears at the top of the left hand legend. The results obtained should resemble those of figure 4.2.1. Note that except the colour composite all other input channels and intermediate files created after import are deleted and only the colour composite image is retained.

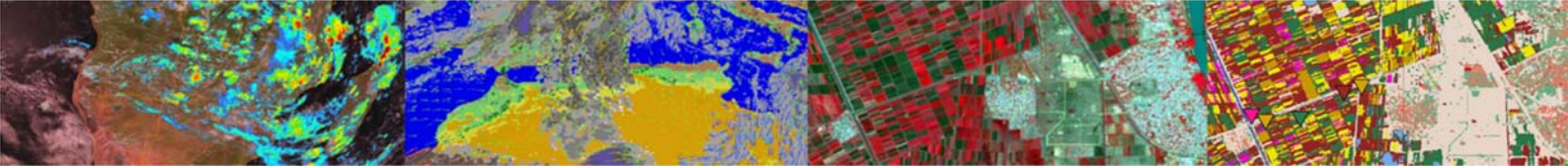
**Figure 4.2.1: METOP AVHRR 3 minutes scan over Western Africa / Cabo Verde**



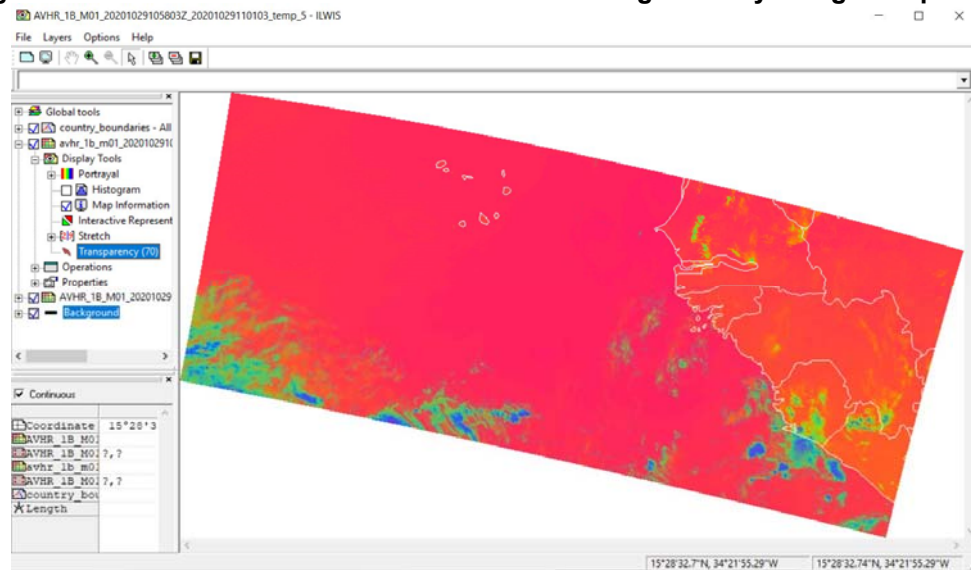
If not already active, open ILWIS, from the “Geonetcast, Toolbox” tabs select the menu item “Polar - Level 1.5 Data” >> “METOP A/B/C” >> “AVHRR/3” >> “METOP AVHRR Retriever”. Specify the appropriate full file name (including the .bz2 extension), here:

“AVHR\_xxx\_1B\_M01\_20201029105803Z\_20201029110103Z\_N\_O\_20201029113442Z.bz2”

Wait till the routine completes the import and refresh the ILWIS Catalogue. Now a number of files are at your disposal, e.g. the radiance and reflectance for channels 1, 2 and 3 and the temperature for channels 4 and 5, in the case of a daytime image. Also a cloud flag is available, note the suffix after “AVHR\_1B\_M01\_20201029105803Z\_20201029110103\_”. Display the imported channel 5 image “AVHR\_1B\_M01\_20201029105803Z\_20201029110103\_temp\_5” and add the cloud mask, now change the transparency setting for the cloud flags and inspect the temperatures for the clouded and non-clouded areas, both over sea and over land, see also the figure below.



**Figure 4.2.2: METOP AVHRR Channel 5 and cloud flags overlay using transparency**

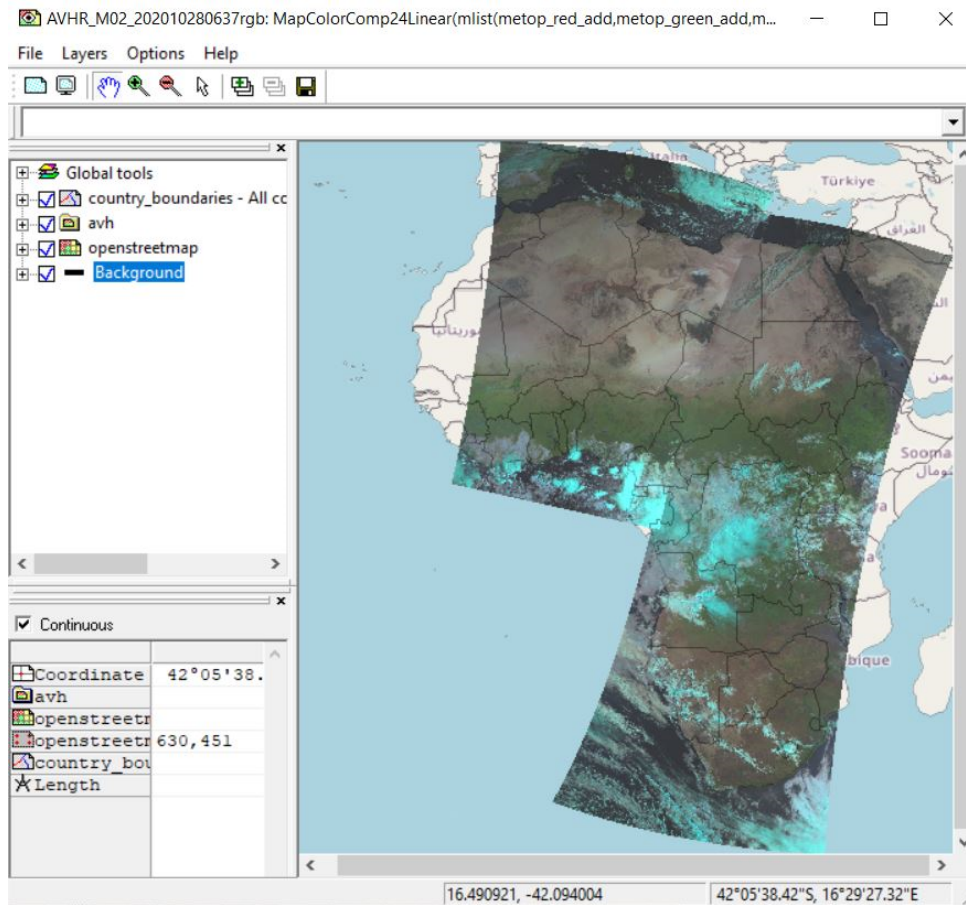


The other images in the METOP\_AVHRR directory are also recorded over Africa, but now by METOP A. Again, each of the images covers a recording time of 3 minutes. If interested you can import these as well and have a look at it. Note that the AVHRR instrument covers most of Africa in 3 overpasses of 15 to 18 minutes of scanning each of different overpasses.

For the 11 METOP AVHRR MO2 files use the import option “METOP AVHRR/3 daytime FCC” and copy / paste the full input file names available, including extension, in the data input folder and use this as the “Date”. Run the import operation for these 11 images. Once completed select all images from the ILWIS catalogue by clicking the filename and pressing simultaneously the “Shift” button on your keyboard. Once all images are selected (11), right click the mouse and from the context sensitive menu select “Selection to Object Collection”, specify an Object Collection name, here “AVH” and press “OK”. Right click with the mouse the object collection name “AVH” >> “Open as Layer”. Now you have to wait a few minutes for all resampling to be conducted, but then a visualization is created showing all images. Use the option “Add Layer” and add the country boundaries, as well as “OpenStreetMap”, ensure the country boundaries are placed as the top layer in the legend and drag the OpenStreetMap to the bottom of the legend. Your visualization should resemble the figure presented below.



**Figure 4.2.3: Coverage of the various 3 minutes AVHRR/3 images for 2 overpasses**



Also data from the ASCAT instrument on board of the METOP series of satellites is available. Import routines are created to retrieve the Ocean Vector Winds and the Surface Soil Moisture. Before starting to import the ASCAT data available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*METOP\_ASCAT\_OVW*”. Browse to the appropriate data input and output locations and in the case of AVHRR note that the data is stored in the following directory: “*D:\GNC\_ExerciseData\GNC\_Data\Polar\METOP\_ASCAT*”, where “*D:*” is the designated hard disk location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings and then press “*Close*”. Repeat the procedure and now select the folder “*METOP\_ASCAT\_SSM*”, use the same input data folder and output folder settings as specified for the OVW product. Also have a look at Appendix 2 to see the directory structure details of the sample data provided.

If not already active, open ILWIS, from the “*Geonetcast, Toolbox*” tabs select the menu item “*Polar - Level 1.5 Data*” >> “*METOP A/B/C*” >> “*ASCAT*” >> “*METOP-A/B/C ASCAT - Ocean Vector Winds (12.5 km)*”. Specify the appropriate Date stamp, use here: “*ascat\_20201104\_004800\_metopa\_72872\_eps\_o\_coa\_ovw.l2\_bufi*” and press “*Import*”. Note the bold section in the file name indicating the time.

Repeat the procedure for the other 2 OVW files, each file containing 3 minutes scan duration (like for the METOP AVHRR), import also the following files: “*ascat\_20201104\_005100\_metopa\_72872\_eps\_o\_coa\_ovw.l2\_bufi*” and “*ascat\_20201104\_005400\_metopa\_72872\_eps\_o\_coa\_ovw.l2\_bufi*”. Refresh the ILWIS catalogue and check the 3 point files “*ovw\_ascat\*\_metopa\_72872*” created. Left click using the mouse button the 3 *ovw\_ascat* point files, to select them, simultaneously press the <Ctrl> button on the keyboard. After selection of the 3 point files (note that once selected the file

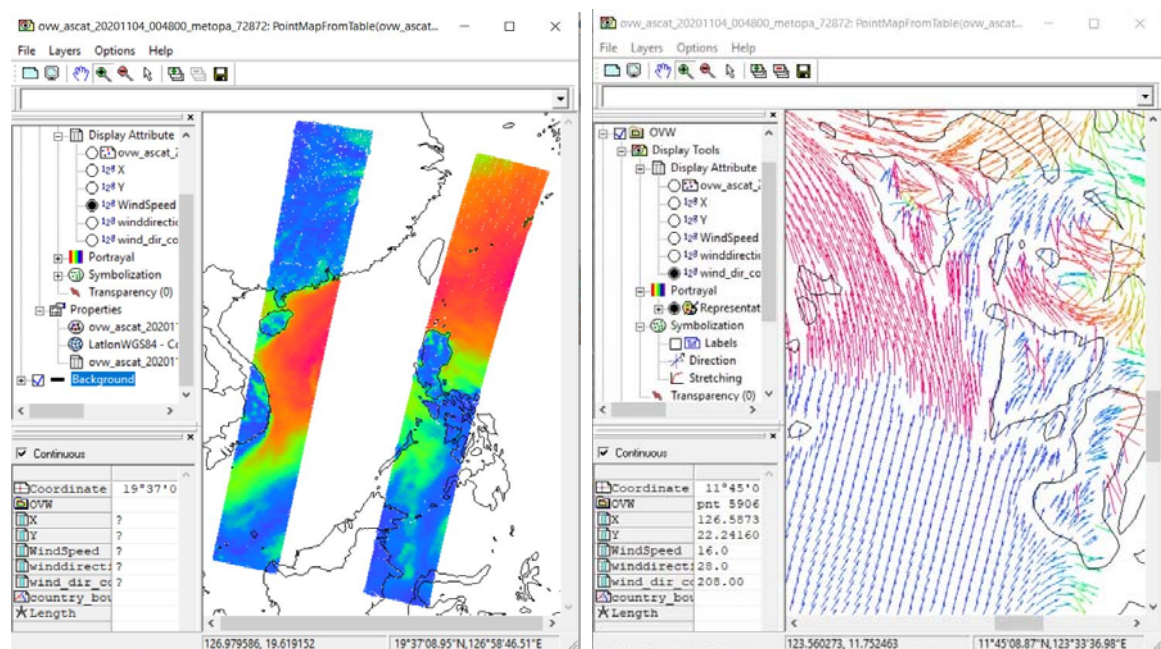


names get a blue colour), right click with the mouse and from the context sensitive menu select the option “*Selection to Object Collection*”, as name use “OVW” and press “OK”.

Right click with the mouse on the object collection “OVW” and use the option “Open as Layer”. Add the country boundaries. Open in the left hand legend the “OVW” layer and select “Display Attribute” and as Attribute select the “WindSpeed”. Eventually zoom in to see the point locations and note the values. Your visualization should look like the left figure below.

After review of the wind speed, select as ‘Display Attribute’ “wind\_dir\_cor”, double click “Symbolization” and as Symbol select “arrow-fixed-head-filled” and press “Apply” and “Close”. Now open the Symbolization tab, double click on “Direction”, activate the option “Rotate”, as Attribute column use “wind\_dir\_cor” and ensure that the option “Clockwise” is activated and press “Apply” and “Close”. Double click the option “Stretching”, as “Scale Exaggeration” use a value of “5”, activate the option “Stretch”, as Attribute column use “WindSpeed” and press “Apply” and “Close”. See also the right hand figure below, showing an enlargement over the Philippines.

**Figure 4.2.4 ASCAT Wind Speed and Ocean Vector Winds over the Philippines**



Note if you have correctly specified the input folder settings for the ASCAT SSM data, here: D:\GNC\_ExerciseData\GNC\_Data\Polar\METOP\_ASCAT. From the “*Geonetcast, Toolbox*” tabs select the menu item “Polar - Level 1.5 Data” >> “METOP A/B/C” >> “ASCAT” >> “METOP-A/B/C ASCAT - Surface Soil Moisture (12.5 km)”. Specify the appropriate Date stamp, use here:

**”W\_XX-EUMETSAT-  
Darmstadt,SOUNDING+SATELLITE,METOPA+ASCAT\_C\_EUMC\_202011  
04073300\_72876\_eps\_o\_125\_ssm\_l2.bin”**

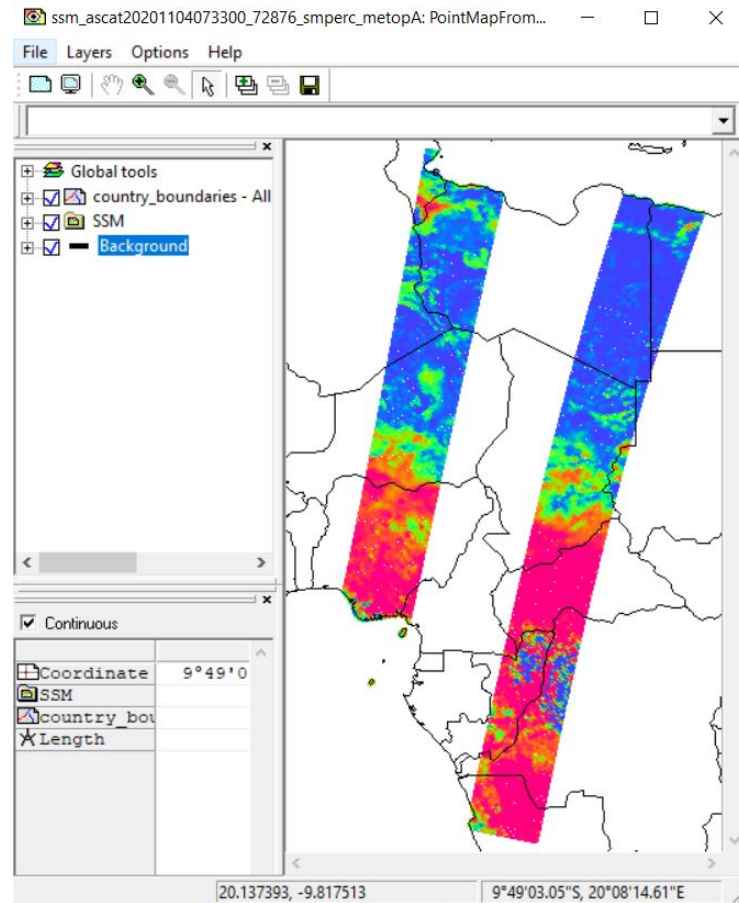
and press “Import”. Note the time stamp within the file name, here indicated in bold. Repeat the procedure for the other 3 SSM files, each file containing 3 minutes scan duration (like for the METOP AVHRR), import also the SSM files with the following time stamps, use the full file names upon import, including extension: “202011040736”, “202011040739” and “202011040742”. Refresh the ILWIS catalogue and check the 4 point files “ssm\_ascat\*\_smperc\_metopA” created. Left click using the mouse button the 4 ssm\_ascat point files, to select them, simultaneously press the <Ctrl> button on the keyboard. After selection of the 4 point files (note that once selected the file names get a blue colour), right

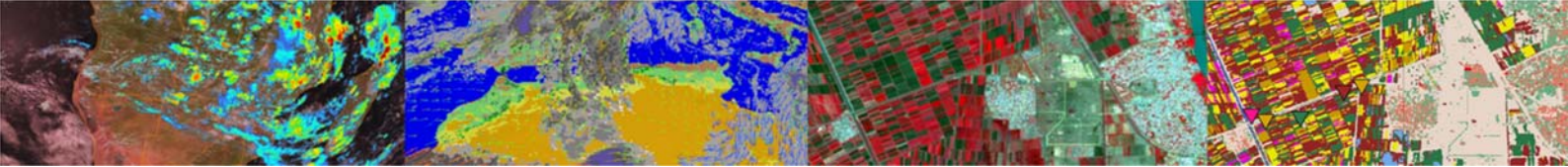


click with the mouse and from the context sensitive menu select the option “*Selection to Object Collection*”, as name use “SSM” and press “OK”.

Right click with the mouse on the object collection “SSM” and use the option “Open as Layer”. Add the country boundaries. Eventually zoom in to see the point locations and note the values. Also check the corresponding tables and note the values for the other columns imported. Your visualization should look like the figure below.

**Figure 4.2.4 ASCAT Surface Soil Moisture over Western Africa**





#### 4.2.2 METOP AVHRR disseminated by EARS

The Advanced Very High Resolution Radiometer (AVHRR) is a multipurpose imaging instrument used for the global monitoring of cloud cover, sea surface temperature, ice, snow and vegetation characteristics. The EUMETSAT Advanced Retransmission Service (EARS) provides instrument data from the METOP and NOAA satellites collected via a network of Direct Readout stations. Segments of one-minute duration are disseminated near real time to users via EUMETCast-GEONETCast and 6 of these segments are concatenated together to construct a regional pass. The high rate pictures (HRP) transmitted via EARS is not disseminated via the EUMETCast-GEONETCast C-band turn around services (e.g. to Africa) and basically covers the area over Europe and Northern Africa. To get an idea of the service some sample data are included to conduct the exercise described below.

From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “EARS”. Browse to the appropriate data input and output locations and in the case of EARS data note that the data is stored in a different directory (here “D:\GNC\_ExerciseData\GNC\_Data\Polar\EARS”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used and press “Save” to store the settings and then press “Close”.

If not already active, open ILWIS, from the “Geonetcast, Toolbox” tabs select the menu item “Polar - Level 1.5 Data” >> “EARS” >> “METOP-A (MO2) quicklook”. Specify the appropriate Date stamp, use here: “202011040915” and press “Import”.

Once the routine is ready a colour composite picture is displayed, using Irfanview, showing the full concatenated (6 minutes) part of the overpass based on the end time selected. In this case 6 pictures of 1 minute each are merged, with an end time (start of scan time) of 0915, including the previous 1 minute observations till 0909. The picture is transformed into a ‘tif’ format and is also available in the specified output folder used for visualization at a later moment. Using the ‘+’ and ‘-’ buttons from the keyboard the image can be enlarged or reduced respectively. To close the visualization, press <Esc>. This picture covers part of Northern Europe, but is quite clouded. Also check your output folder and display the tif file created using “Paint” or any other picture visualization tool available on your system. Note the picture has to be rotated by 180 degrees!

The colour composite created is using the AVHRR channels 1, 2 and 4 in RGB respectively. The imported data is also available as an ILWIS map list, right click using the mouse the map list also “EARS\_MetopA\_202011040915” and select the option “Open as Colour Composite”. Under “Display Tools” double click “Color Composite” as Red select “Vis006” channel, as Green select “Vis008” channel and as Blue the “IR\_108” and press “Apply”. Note the image still should be rotated. To perform a 180 degree rotation, right click the map list “EARS\_MetopA\_202011040915”, select “Spatial Reference Operations” >> “Mirror Rotate”, activate the option “Rotate 180 degrees clockwise” and specify an output map, here use: “EARS\_rot180” and press “Show”. Display the new colour composite using band 1 as red, band 2 as green and band 4 as blue and click “Apply”.

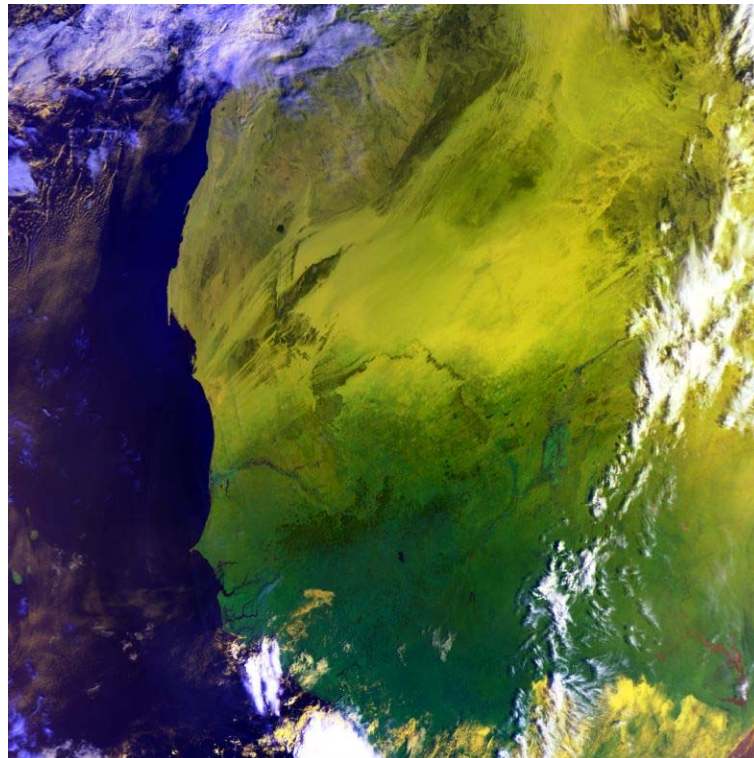
Repeat the procedure and now use as Date “202011040921” and have a look over Western Africa, see also the figure below.

In a similar manner also data from METOP B can be visualized, select as import routine “METOP-B (MO1) quicklook”. Specify the appropriate Date stamp, use here: “202011040852” and press “Import”. The image shows the Northern portion of part of Africa Also data using as “Date” stamp “202011040846” can be processed (Europe).

The same procedures are applicable to METOP-C, although currently is having a partial night time over pass (when in ascending orbit), then only the thermal channels are relevant.



**Figure 4.2.4: EARS METOP AVHRR HRP visualization**



#### 4.2.3 NOAA GAC and LAC quick looks

Also HRP pictures recorded by the AVHRR instrument on board the NOAA-19 satellite are disseminated through EUMETCast-GEONETCast in files containing 3 minutes and 1 minute of recording, in a global area coverage (GAC) and local area coverage (LAC) mode respectively.

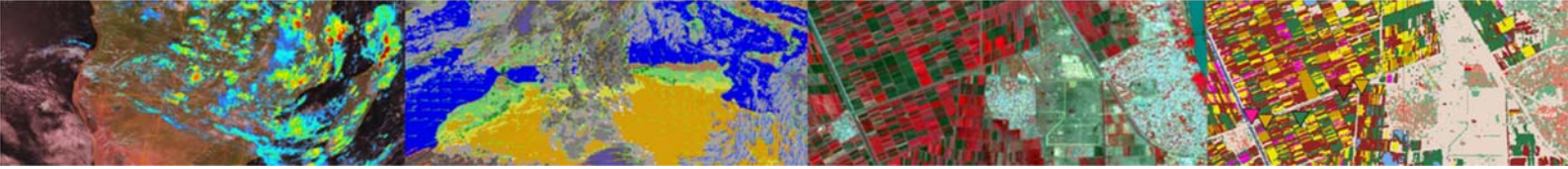
NOAA-19 at the moment of writing the manual has a (very) early morning overpass and therefore the thermal channels can be used to create a colour composite visualization, using channels 3B, 4 and 5.

From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “NOAA”. Browse to the appropriate data input and output locations and in the case of EARS data note that the data is stored in a different directory (here “D:\GNC\_ExerciseData\GNC\_Data\Polar\NOAA\_LAC\_GAC”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used and press “Save” to store the settings and then press “Close”.

If not already active, open ILWIS, from the “Geonetcast, Toolbox” tabs select the menu item “Polar - Level 1.5 Data” >> “NOAA 19 AVHRR/3” >> “NOAA19 GAC quicklook”. Specify the appropriate Date stamp, use here: “202011030240\_202011030243” and press “Import”.

Once the import is completed update the ILWIS catalogue and double click the new ILWIS map list “NOAA19\_G\_202011030240”. Under “Display Tools” double click “Color Composite” as Red select “IR\_039” channel, as Green select “IR\_108” channel and as Blue the “IR\_120” and press “Apply”. Note the image is covering the Gulf of Oman and the Persian Gulf region.

In a similar way also the NOAA 19 LAC (1 minute recordings) can be visualized. From this toolbox sub menu select “NOAA19 LAC quicklook” and specify the appropriate Date stamp, use here: “202011030427” and press “Import”. Next to the import of the channels, also a colour composite is created. Display the image “NOAA19\_l\_rgb\_202011030427” created using the two visible channels with a minor contribution of the IR-039 channel.



For appropriate orientation the image has to be rotated, first rotate the image using the mirror rotate option "Mirror Vertical" and save it as output file "N19\_L\_0327MV". Use this image and apply a new rotation "Mirror Horizontal", specify as output map "N19\_L\_0327MVH". Note the image is acquired over the Red Sea and covering a strip over Northern Ethiopia. As it is an early morning overpass, only features situated on the eastern section of the strip can be recognized applying a daytime visualization. You can also import a few other 1 minutes scans, use as time stamp "202011030426", "202011030425", "202011030424" and "202011030423". Note that these have to be rotated in an identical manner.

Also inspect the map lists created during import and create visualizations of the thermal channels, eventually a colour composite using the 3 thermal channels can be displayed. As these are pictures, the main use is quick visualization and the images are not suitable for further analysis.





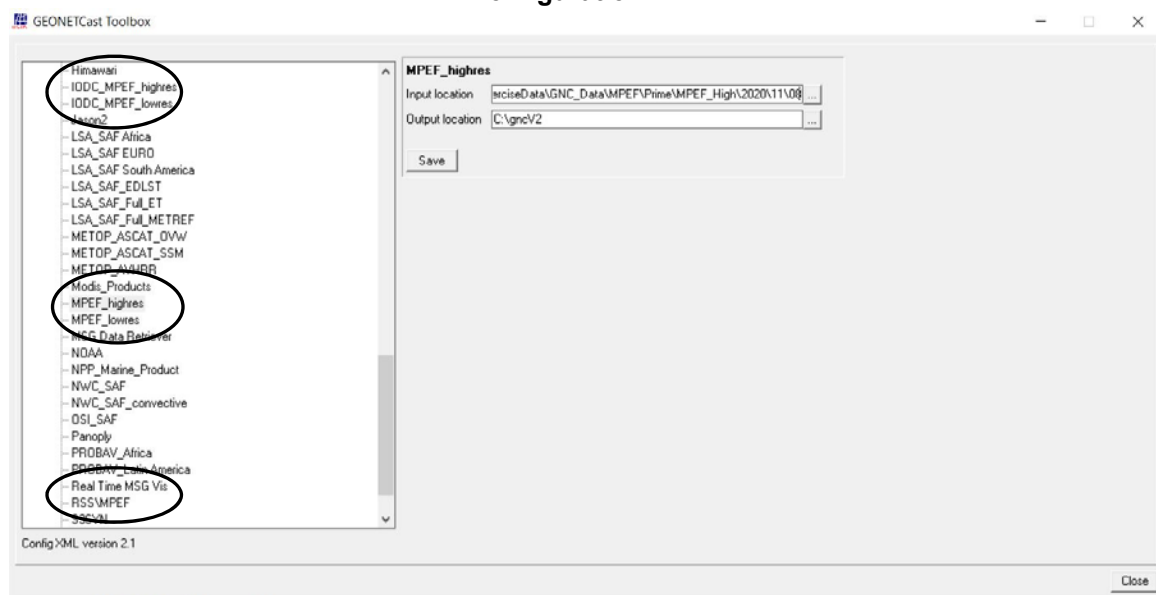
## 4.3 IMPORT PRODUCTS FROM THE METEOROLOGICAL PRODUCT EXTRACTION FACILITY

### 4.3.1 Import and processing of MSG MPEF products

Before starting to import the various other data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “MPEF\_highres”. Browse to the appropriate data input and output locations and in the case of MPEF note that the data is stored in a number of year-month-day specific directories (first use here “D:\GNC\_ExerciseData\GNC\_Data\MPEF\Prime\MPEF\_High\2020\11\08”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings. See also the figure below. Note that if other date settings are specified, the input folder settings need to be modified as well as a dated folder structure is applied here.

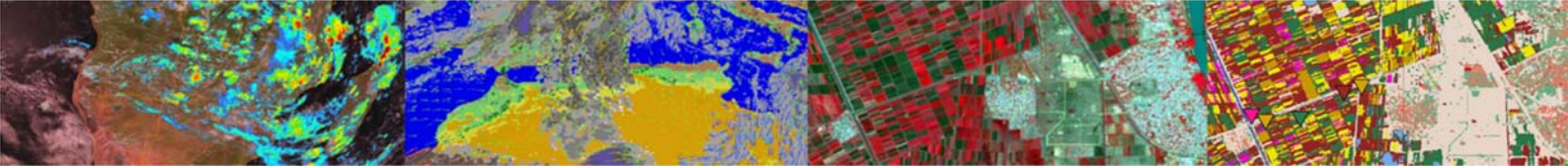
Also sample data is provided for MPEF-IODC and MPEF-RSS. See the folder structure under “D:\GNC\_ExerciseData\GNC\_Data\MPEF\IODC” and “D:\GNC\_ExerciseData\GNC\_Data\MPEF\RSS” respectively and use these to define the folder settings for “IODC\_MPEF\_highres” and “IODC\_MPEF\_lowres” and well as “RSS\MPEF” respectively.

**Figure 4.3.1: MPEF input and output directory specification using the Toolbox Folder Configuration**



From the “Geonetcast” and “Toolbox” main menu select “Meteorological Products” >> “Link to online resources” >> “Import”. A PDF document with “Links to Meteorological Product Extraction Facility (MPEF) Data Resources” is provided, for MSG for high temporal resolution and products with daily or dekad interval (for 0 degree, IODC and RSS service), Fengyun, the lightning detection and NCEP GFS Africa services. These links provide relevant information regarding the products. Review the documentation (e.g. user guides) provided through the links, e.g. for the CLM, CLAI, OCA and AMV products as these will be imported.

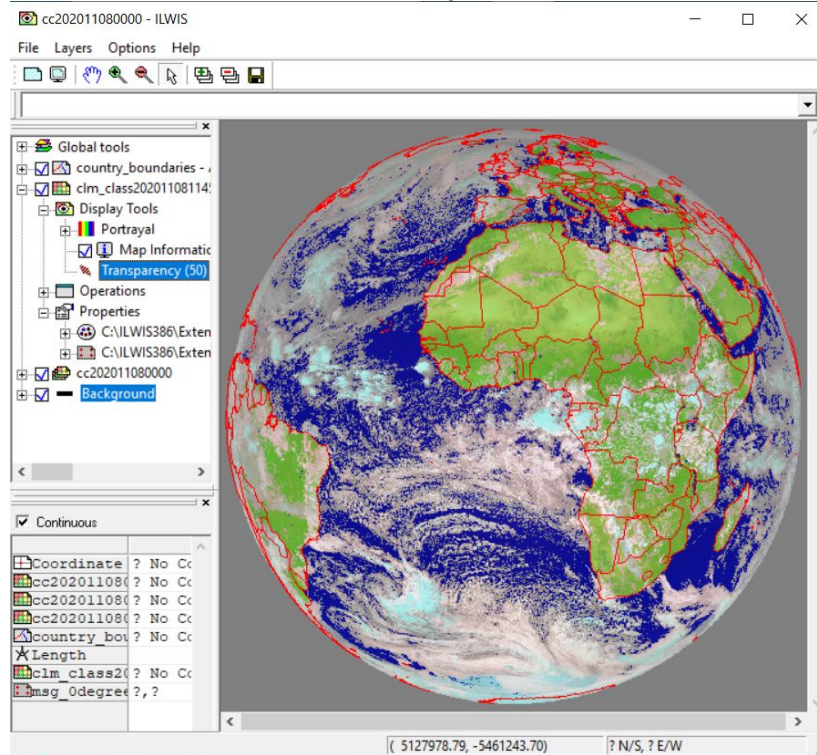
Before you continue open the MSG Data Retriever and first create a new colour composite of MSG at 0 degree, use as date – time stamp “202011081145” and import channels “VIS006”, “VIS008” and “IR\_016”, using the Series options “Multiple Channels in one file” and as Conversion use “8 bits Values”. Save the image in ILWIS format, using as File prefix “cc20201108”. Display the image as colour composite, display band 3 in red, band 2 in green and band 1 in blue, use the following stretch values: for red: 0 – 129, for green: 0 – 147 and use as stretch values for blue: 0 – 163. Also add the country boundaries in red. Keep the map display window open.



Now select from the toolbox menu the options "Meteorological Products" >> "MSG 0-degree based" >> "High Temporal Resolution MPEF Products" and "MPEF CLM" to import the Cloud Mask (CLM). Select for the "Date" the identical time as used when importing the MSG (prime) image, in this case 202011081145. Specify this time stamp according to the format required in the "Date" field ("yyyymmddhhmm" is in this case "202011081145"). Press "Import" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "Window" and "Refresh F5") and note that two new files have been created: CLM\_value\* and CLM\_class\* (\*=yyyymmddhhmm), a value and a classified cloud mask map respectively. Open both maps and check their values or class names. Close the maps again and open the map display window with the MSG image and add the map "clm\_class202011081145", use the transparency to check the cloud mask. The cloud mask class map overlaid on MSG is also given in figure 4.2.3.

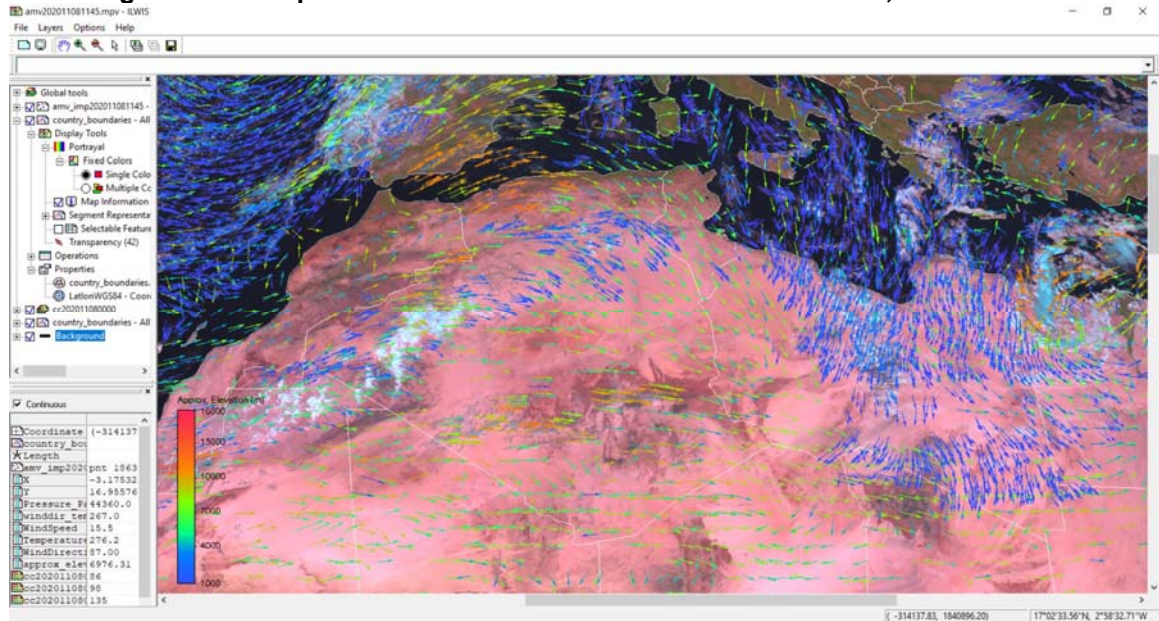
**Figure 4.3.2: Classified cloud mask map of 08 November 2020, 11:45 UTC**



Close all active layers before you continue. Now select as product from the menu "MPEF AMV" and as Date stamp "202011081145". Wait till the import is ready and a map view should appear on your screen. Use the option "Add Layer" >> under 'Filter' select "Color Composite" and select "cc202011080000" and press "OK", drag the colour composite layer below the AMV layer in the left hand map legend. Eventually use the stretch values as indicated above for the 3 channels, see also the figure below. Inspect the values and close the map view.



Figure 4.3.2: Map View of MSG and AMV on 08 November 2020, 11:45 UTC



Now import the "MPEF OCA" product, use as time stamp "202011081145". After import is completed update the ILWIS catalogue and check the map list "OCA\_202011081145\_undef", consisting of 12 map layers and open "OCA\_202011081145\_undef\_01"

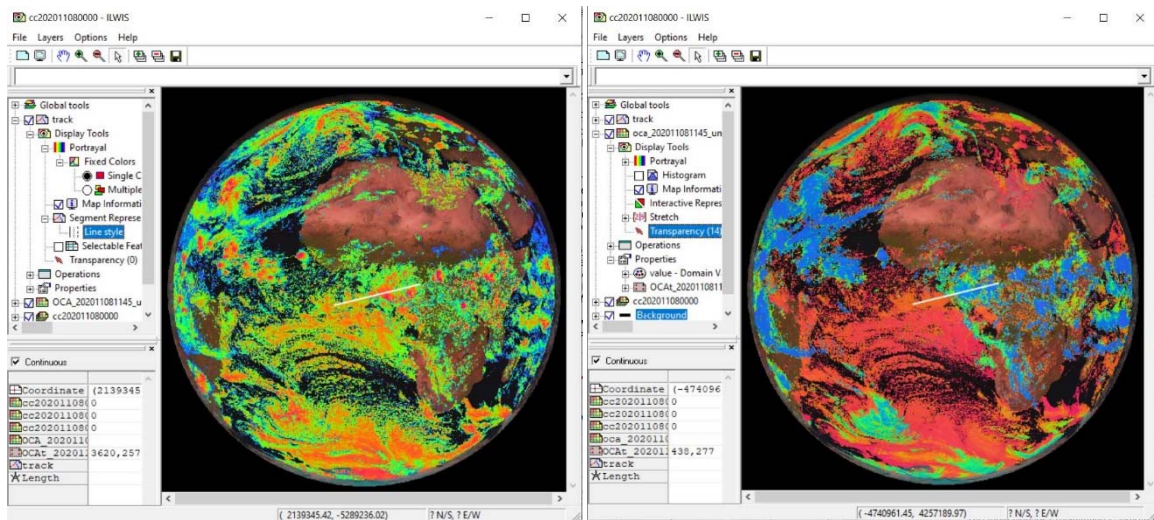
Layer 1, phase cloud type - 111 – single layer water cloud ,112 – single layer ice cloud and 113 – two - layer (ice over undetermined), Layer 3 is cloud optical thickness, Layer 4 is the cloud top pressure, etc, see also the product guide available through the meta data description from the Product Navigator, available under the menu item: with "[Links to Meteorological Product Extraction Facility \(MPEF\) Data Resources](#)" >> "OCA". Open the colour composite "cc202011080000", add the layer "oca\_202011081145\_undef\_04", change the transparency setting for this layer to check the appearance of the clouds on the colour composite. Note the cyan coloured clouds have low CTP's and the white coloured clouds are having higher pressure values (unit is Pa), so these are not so high in the atmosphere!

Right click with the mouse on the option "Display Tools" and activate the option "Track Profile" and activate the "Track Profile" item which has been added as a map legend item. A new Track profile graph window appears. Now screen digitize, using the mouse, by clicking on a starting position and clicking once more on another position in the image a line is appearing and in the graph window the corresponding pixel values appear, note the starting point is the "0" position in the graph, so digitize the line from West to East direction. Note the Y-axis values. Save the Track, use as file name "Track" and "Open Track as Table", use as table name "TrackProfile\_CTP". Note the column created "oca\_202011081145\_undef\_04". Remove the layer from the map display window, right click with the mouse the specified layer and select the option "Remove Layer". Now add the layer "oca\_202011081145\_undef\_03" which is the Cloud Optical Thickness. Again activate from the "Display Tools" the option "Track Profile". Load the Track "Track" and "Open Track as Table", use as table name "TrackProfile\_COT, and note the column "oca\_202011081145\_undef\_03".

Also add the vector file "Track", using a white colour and as "Segment Representation" select a "Line Thickness" of "2" and click "Apply" >> "Close".

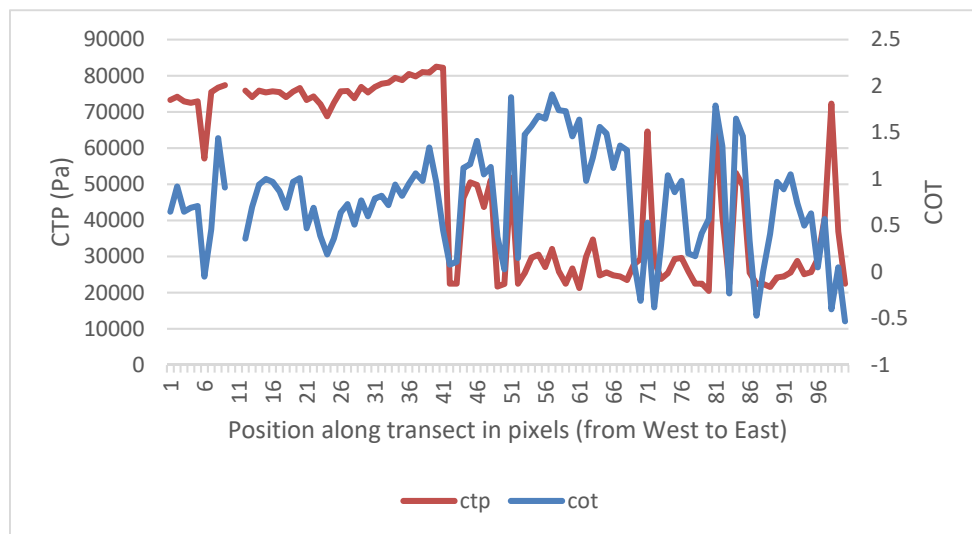


**Figure 4.3.3: MSG and OCA COT (left) – CTP (right) overlaid**



The columns from the Track Profile tables created can be copied via clipboard to e.g. Excel and a graphical representation can be created from the two OCA variables inspected. See a sample graph created below showing the COT and CTP over the track selected. The COT in general is higher with a lower CTP. Note also the corresponding features on the colour composite, e.g. the white (water) clouds and cyan (ice) clouds. Also inspect the other OCA layers. Once ready close all open (map) windows.

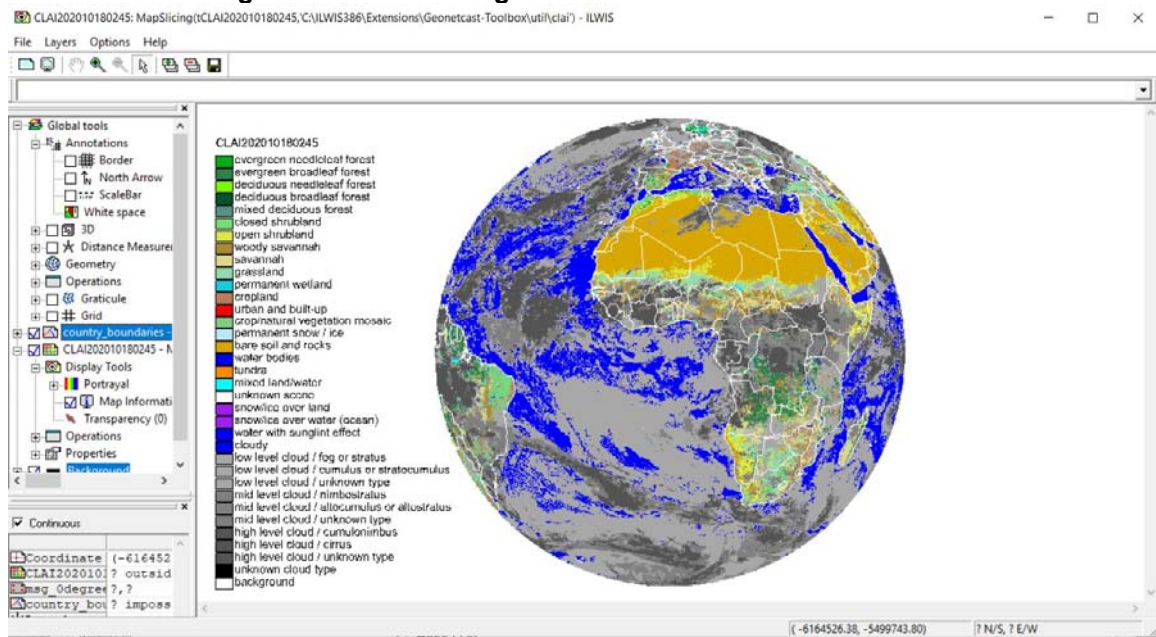
**Figure 4.3.4: Graphical representation of COT and CTP along the track**



Now change the folder settings to "D:\GNC\_ExerciseData\GNC\_Data\MPEF\Prime\MPEF\_High\2020\10\18" and from the toolbox menu select the options "Meteorological Products" >> "MSG 0-degree based" >> "High Temporal Resolution MPEF Products" and "MPEF CLAI" to import the Cloud Analysis Image (CLAI). Specify the time stamp according to the format required in the "Date" field ("yyyymmddhhmm" is in this case "202010180245". Press "Import" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window. Refresh the ILWIS catalogue and display the newly imported CLAI image "CLAI202010180245". Right click with the mouse the "Display Tools", select the option "Annotation" and activate the "Legend" option. In case the legend is overlaying the map, select from "Global tools" the option "Annotations" >> "White Space" and add 20 % to the Left and Right respectively and press "Apply" and "Close". Also add the country boundaries in white.



**Figure 4.3.5: CLAI image visualization of 202010180245**



Now press the right hand drop down button next to the ILWIS command line, check the expression used to import the product, the syntax is given below:

```
!C:\ILWIS386\Extensions\CaboVerde-Toolbox\toolbox_batchroutines\MPEF_claiimport.bat
202010180245 D: GNC_ExerciseData\GNC_Data\MPEF\Prime\MPEF_High\2020\10\18 C:
gncv2 C:\ILWIS386\Extensions\CaboVerde-Toolbox\GDAL C:\ILWIS386
C:\ILWIS386\Extensions\CaboVerde-Toolbox\util
```

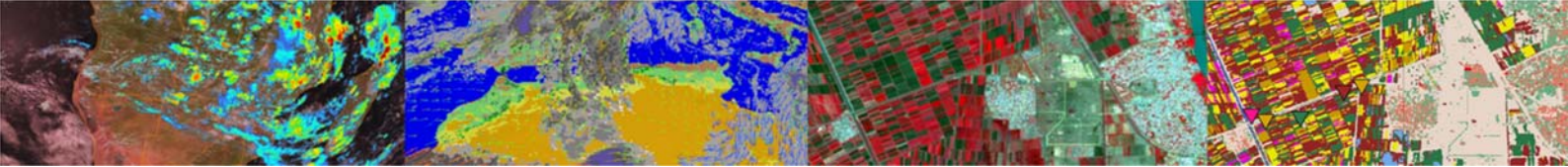
Now change the date stamp, indicated above in bold, to “202010200545” and press <Enter>, repeat this also for “202010180845”, “202010181145”, “202010181445”, “202010181745”, “202010182045” and “202010182345”.

Now from the main ILWIS menu select “File” >> “Create” >> “Map List” and specify as output Map List “CLAI”, select all 8 imported CLAI products and move them to the right hand window by pressing the “>” button and press “OK”. Right click the newly created map list “CLAI” >> “Open as Animation”. Under the CLAI Display Tools in the left hand legend, select the option “Run” and start the animation. Note the development of the high level clouds e.g. the Cumulonimbus clouds, during the daytime. Close the animation when it has looped a number of times.

In a similar manner also the other MPEF high resolution products can be imported. Note in the import window the starting time in UTC and the temporal resolution. These provide a key to the date – time settings required upon import. All raster maps can be animated by creating a map list, all vector information, like the AMV point files can also be animated, but then by creating “Object Collections”. To note temporal developments animations are important and by modifying only the time stamp in the import line from the ILWIS command line, import of time series data can be performed very efficiently. Some import routines, like for the GII take some time as a large number of points are retrieved and additional parameters are calculated, available in the associated point map tables.

The low temporal resolution products actually use the full 15 minutes temporal resolution, but integrate these over a daily cycle, e.g. to minimize the effect of cloud cover. In this way a NDVI on daily and dekad basis are created.

Now change the folder settings for “MPEF\_lowres” to “D:\GNC\_ExerciseData\GNC\_Data\MPEF\Prime\MPEF\_DayDeK” (note this folder does not have a dated structure!) and from the toolbox menu select the options “Meteorological Products” >> “MSG 0-degree based” >>



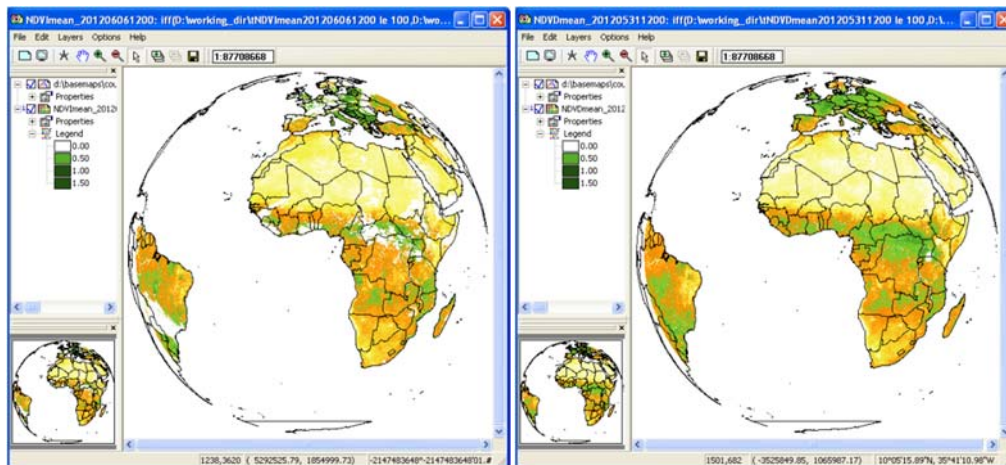
“Low Temporal Resolution MPEF Products” and “MPEF NDVI” to import the NDVI product. Specify the time stamp according to the format required in the “Date” field (“yyyymmddhhmm” is in this case “201206061200”). Note that there is 1 product on a daily basis, the ‘hhmm’ is always 1200. Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note that three new files have been created: NDVI<sub>max</sub>\*, NDVI<sub>mean</sub>\* and NDVI<sub>min</sub>\* (\*=yyyymmddhhmm), the daily maximum, mean and minimum NDVI of the various MGS observations respectively. Open the maps, using as representation “NDVI1” and check their values. The daily NDVI<sub>mean</sub> map of 201206061200 is also given in figure 4.3.6 (left).

From the “Geonetcast” and “Toolbox” main menu select the options “Meteorological Products” >> “MSG 0-degree based” >> “Low Temporal Resolution MPEF Products” and “MPEF NDVD” to import the Dekadal NDVI based on MSG (NDVD). Select for the “Date” the following date stamp: “201205311200”. Specify this time stamp according to the format required in the “Date” field (“yyyymmddhhmm”). Note that there are 3 products per month, the ‘hhmm’ is always 1200. Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note that three new files have been created: NDVD<sub>max</sub>\*, NDVD<sub>mean</sub>\* and NDVD<sub>min</sub>\* (\*=yyyymmddhhmm), the dekadal maximum, mean and minimum NDVI of the various daily MSG NDVI observations respectively. Open the maps, using as representation “NDVI1” and check their values. The daily NDVD<sub>mean</sub> map of 201205311200 is also given in figure 4.3.6 (right). Note the reduction of cloud contamination when comparing the daily and dekadal NDVI.

**Figure 4.3.6: MPEF NDVI day and dekadal map**



In a similar manner also MPEF products from the IODC and RSS can be visualized. Sample data is provided. Check the (dated) folders D:\GNC\_ExerciseData\GNC\_Data\MPEF\IODC and D:\GNC\_ExerciseData\GNC\_Data\MPEF\RSS. For the RSS the Multi Sensor Precipitation Estimate (MPEG) product is still being produced.

Import the following time step from MSG – RSS using the MSG Data Retriever: “202010181015”, using as Series options “Multiple Channels in one File”, as Conversion “8 bits Values”, as Output Format “ILWIS”, as File Prefix “cc\_rss202010181015”, note the output folder, here “C:\gnc\_out” and select the “VIS006”, “VIS008” and “IR\_016” channels and press “Execute”.

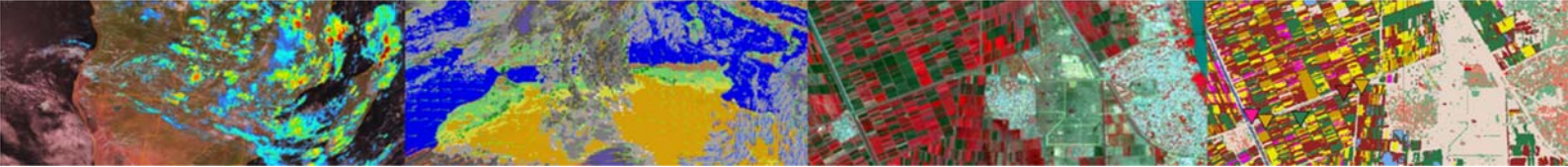


Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the new colour composite created, double click the map list called “*cc\_rss2020101810150000*” >> select from “*Display Tools*” >> and double click “*Color Composite*”, display band 3 (IR\_016) as Red, band 2 (VIS008) as Green and Band 1 (VIS006) as Blue, and press “*Apply*” >> “*Close*”. Check the histograms for the 3 bands and use the 1% upper stretch values, here for Red (band1): 134, for Green (band2): 97 and for Blue (band3): 95. Also display the country boundaries in ‘*White*’ and use the option “*no zoom*” as well. Keep the map display window open.

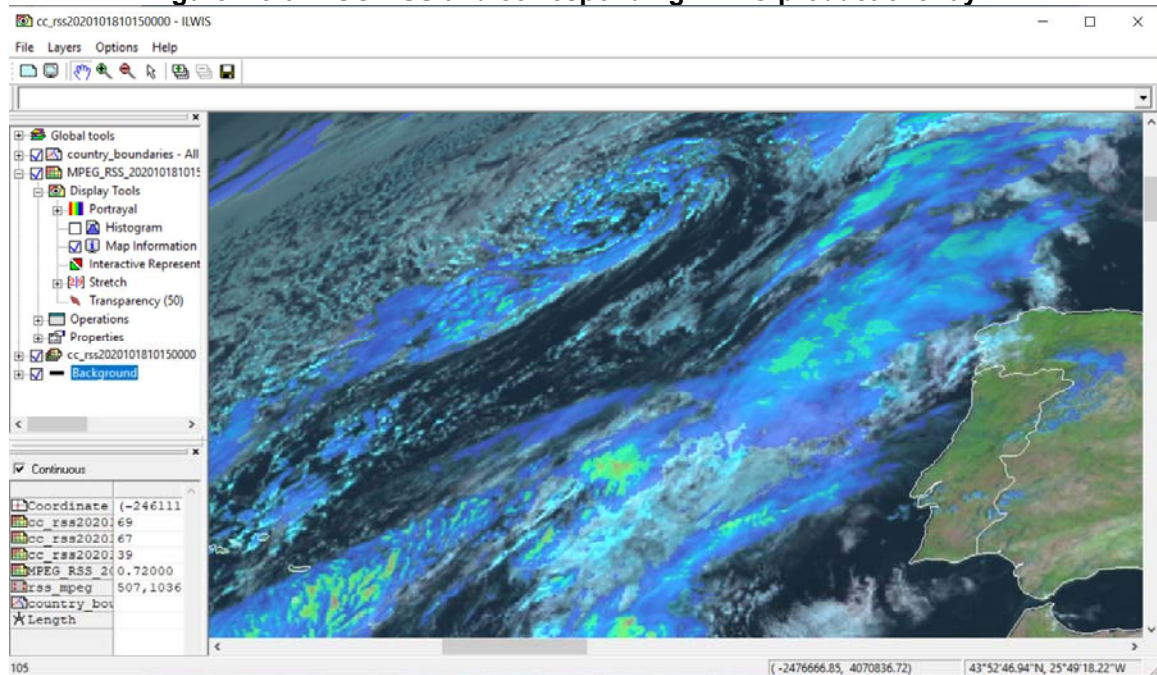
First check the settings of the directories that contain the raw RSS – MPEF data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*RSSMPEF*”. Browse to the appropriate data input and output locations and in the case of RSS MPEF note that the data is stored in a year-month-day specific directory, here “*D:\GNC\_ExerciseData\GNC\_Data\MPEF\RSS\2020\10\18*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings.

Now select from the toolbox menu the options “*Meteorological Products*” >> “*MSG-RSS based*” and “*MPEG*” to import the Multi Sensor Precipitation Estimate from Geostationary Satellites (MPEG). Select for the “*Date*” the identical time as used when importing the MSG RSS image, in this case “*202010181015*”. Specify this time stamp according to the format required in the “*Date*” field (“*yyyymmddhhmm*”). Press “*Import*” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “*Window*” and “*Refresh F5*”) and note the new file created: “*MPEG\_RSS\_202010181015*”. Drag the map to the open map display window showing the MSG RSS image. Under MPEG “*Display Tools*” select “*Transparency*”, activate the option “*Exclude range (full transparent)*” and as range specify as minimum “*0.0000*” and as maximum “*0.0001*”, press “*Apply*” and “*Close*”. Zoom into the map and change the transparency setting, also check the corresponding rainfall values and the cloud colouration, see also the figure below.



**Figure 4.3.6: MSG RSS and corresponding MPEG product overlay**



#### 4.3.2 Import and processing of Fengyun MPEF products

The Chinese Meteorological Agency is also disseminating a number of products derived from the FY2G and FY2H Geostationary satellites. To support ingestion of these products also import routines have been prepared but given lack of meta data description some deficiencies are still appearing, like for the precipitation product not providing intensities greater than 50 mm. Also the meta data is lacking for the atmospheric motion vectors. Taking these precautions into account you can start the processing of the MPEF data derived from Fengyun. Here we focus on FY2G, the procedures to import the products for FY2H are identical.

First check the settings of the directories that contain the raw Fengyun MPEF data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “Fengyun”. Browse to the appropriate data input and output locations and in the case of Fengyun MPEF data note that the data is stored in the following directory, here “D:\GNC\_ExerciseData\GNC\_Data\MPEF\Fengyun”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

Now select from the toolbox menu the options “Meteorological Products” >> “Fengyun based” >> “Fengyun 2G based Products” >> “Total Cloud Amount (CTA)”. Select as “Date” “20201110000”. Specify this time stamp according to the format required in the “Date” field (“yyyymmddhhmm”). Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the CTA import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note the new file created: “cma\_cta\_FY2G\_20201110000”. Display the map and note the values. Also display the country boundaries in red. Continue to import the Cloud Classification (CLT) product using the same time stamp and add the newly created map “cma\_clt\_cl\_FY2G\_20201110000” to the map display window showing the CTA map. Inspect the classes, also use the transparency setting to check the cloud amount for the various cloud classes.

Continue to use the toolbox FY 2G import option “Atmospheric Motion Vectors (AMV) from IR1 and IR3”, now use as time stamp “202011102330”. Upon completion of the import two tables have been created, check the table “cma\_amv\_ir1\_FY2G\_202011102330”, and note



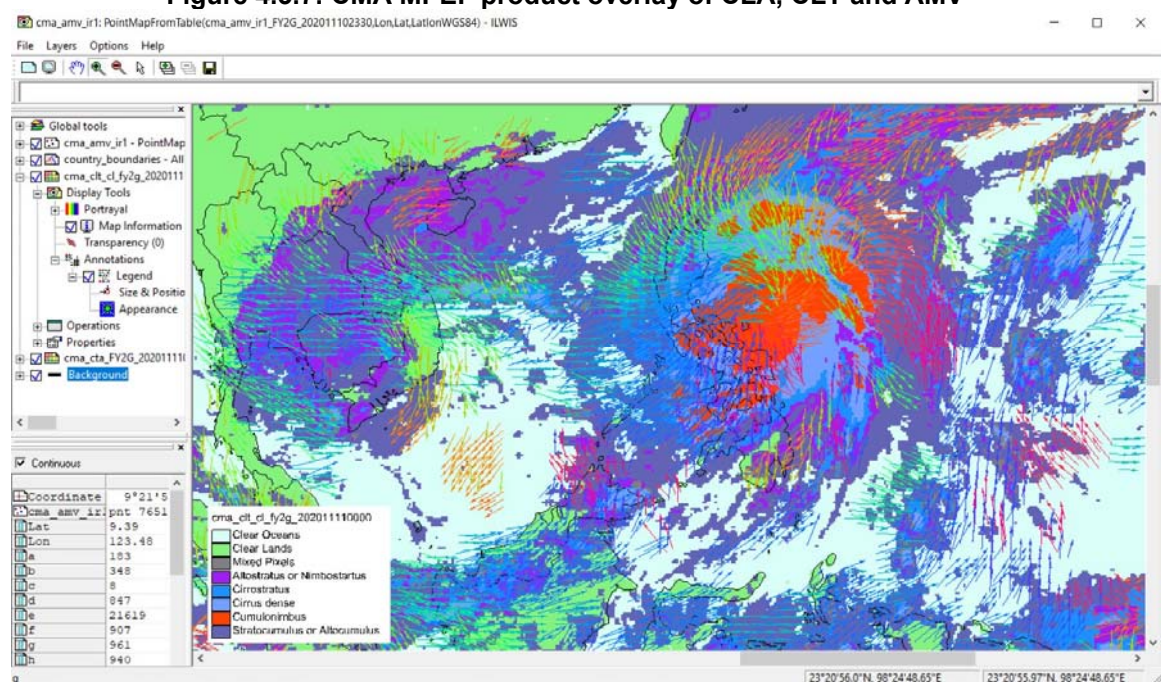


the content. The first two columns are latitude and longitude, other columns are named “a” to “r”. The actual attributes could not be confirmed but it is believed that column “b” is representing the wind direction and column “c” the wind speed. We can now transform the table to a point map. Close the table.

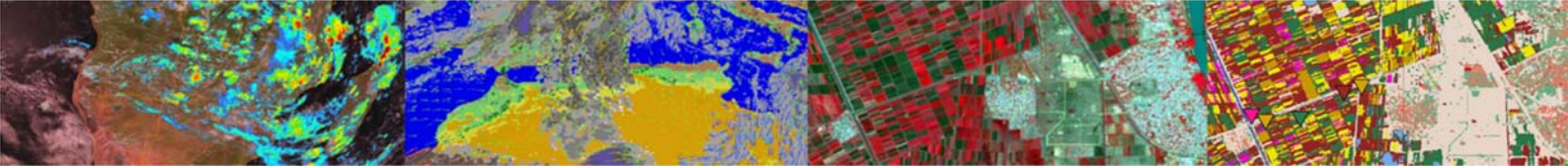
From the ILWIS catalogue right click with the mouse the table “cma\_amv\_ir1\_FY2G\_202011102330”, select from the context sensitive menu the option “Table Operations” >> “Table to Point Map”. As X Column select “Lon”, as Y Column select “Lat”, as Coordinate system select “LatLonWGS84”, specify as Output Point Map “cma\_amv\_ir1” and press “Show”. The point map is displayed in a new map window. From the left hand legend expand the content of the point map by clicking on the “+” sign in front of the map. Also open the “Display Tools” >> “Display Attribute” and select Attribute “b” (Wind Direction). Double click “Symbolization” and as Symbol select “arrow-fixed-head-filled” and press “Apply” and “Close”. Now open the Symbolization tab, double click on “Direction”, activate the option “Rotate”, as Attribute column use “b” and ensure that the option “Clockwise” is activated and press “Apply” and “Close”. Double click the option “Stretching”, as “Scale Exaggeration” use a value of “5”, activate the option “Stretch” and select as Attribute column “c” (wind speed), as upper Range value use “20” and press “Apply” and “Close”.

Now add the two other maps to the point map display, first add the CTA map, then the CTL class map, and also the country boundaries. Once more zoom in over the Philippines, change the transparency setting for the CTL class map so the cloud amount (CTA map) can be seen as well. Right click the option “Display Tools” for the CLT classified cloud map, activate the option “Annotation” and under “Annotation” activate the option “Legend”. Double click the Legend item, select “Appearance”, activate the option “Background color” as “White”, click “Apply” and “Close”. Your results should resemble those of the figure below.

**Figure 4.3.7: CMA MPEF product overlay of CLA, CLT and AMV**



Other CMA MPEF products can be imported using the appropriate date-time stamp. Check a few other import routines as well. Note not all products are provided in the sample data.



### 4.3.3 Lightning detection

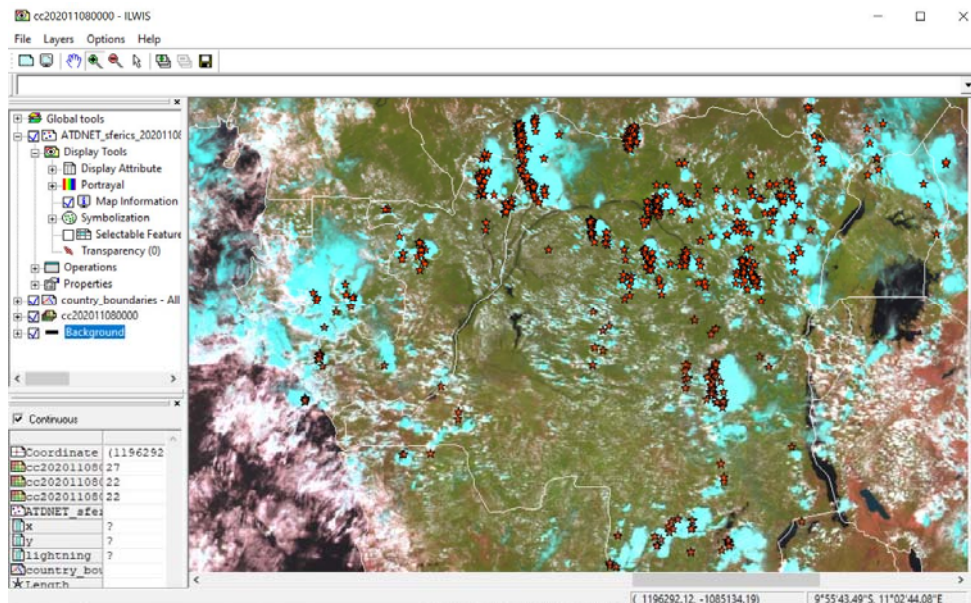
First check the settings of the directories that contain the raw ADTNET-Sferics data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “ADTNET”. Browse to the appropriate data input and output locations and in the case of lightning detection data note that the data is stored in the following directory, here “D:\GNC\_ExerciseData\GNC\_Data\MPEF\ADTNET”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

Now select from the toolbox menu the options “Meteorological Products” >> “Lightning Detection” >> “ADTNET Sferics”. Select as “Date” “202011081203”. Specify this time stamp according to the format required in the “Date” field (“yyyymmddhhmm”). Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

Once more display the MSG image of “202011081145” previously imported, if adhered to the instructions open the map list “cc202011080000” as colour composite, see also chapter 4.3.1. Note that the time refers to start of scan time. Display the image as colour composite, display band 3 in red, band 2 in green and band 1 in blue, use the following stretch values: for red: 0 – 129, for green: 0 – 147 and use as stretch values for blue: 0 – 163. Also add the country boundaries in white. Keep the map display window open.

After completion of the ADTNET import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note the new file created: “ADTNET\_sferics\_202011081203”. Drag the point map to the open map display window showing the MSG image. Under the point map “Display Tools” select “Symbolization” and as Symbol select “filled star” and press “Apply” >> “Close”. Note the occurrence of the lightning strikes in relation to mostly (cyan coloured – ice) convective Cumulonimbus clouds, see also the figure below. The time stamp of the ADTNET Sferics product is related to the 15 minutes concatenation duration (of 15 one minute observations) and therefore the data contained in the file have occurred over the previous 15 minutes.

**Figure 4.3.8: MSG and corresponding ADTNET Sferics lightning strike occurrences**





#### 4.3.4 GFS Forecasts for Africa from NCEP

Check the settings of the directories that contain the raw GFS Forecasts. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “GFS”. Browse to the appropriate data input and output locations and in the case of GFS forecast data note that the data is stored in the following directory, here “D:\GNC\_ExerciseData\GNC\_Data\MPEF\NCEP\_GFS”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

Now select from the toolbox menu the options “Meteorological Products” >> “NCEP GFS Africa” >> “GFS Forecasts”. Select as “Date” “20201107”. Specify this time stamp according to the format required in the “Date” field (“yyyymmdd”). Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

Once the import is completed a webpage is shown with active links to all information provided for continental Africa and the sub regions.

All extracted information is stored in a newly created folder in the output directory. Inspect, using your system’s explorer, the folder “ncep\_forecast\_20201107”. The web page can be opened once more by double clicking the page “ncep\_forecast\_20201107\_africa.html”. After inspection of the GFS forecasts, delete the folder as it is consuming a lot of disk space!



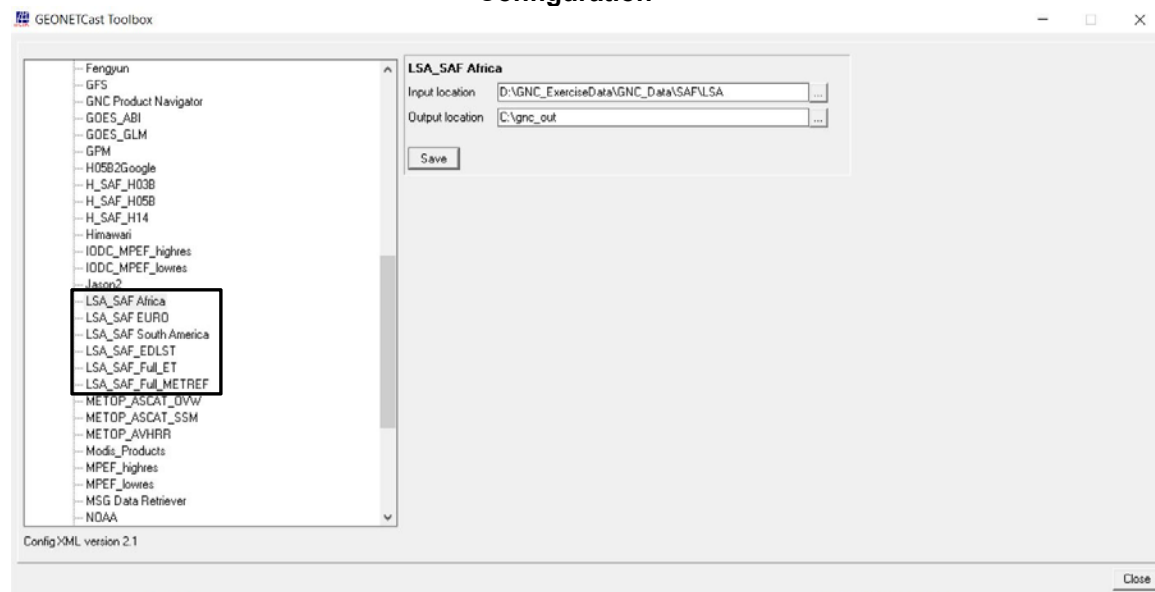
## 4.4 IMPORT PRODUCTS GENERATED BY THE SATELLITE APPLICATION FACILITIES

### 4.4.1 Import and processing of Land Surface Analysis SAF products

The aim of the Land Surface Analysis Satellite Application Facility (LSA SAF) is to take full advantage of remotely sensed data on land, land-atmosphere interactions and biosphere applications. A strong emphasis is put on developing and implementing algorithms allowing an operational use of data from the MSG and METOP satellites. The LSA SAF is part of the distributed EUMETSAT (European Organization for the Exploitation of Meteorological Satellites) Application Ground Segment. It is focused on the development and processing of satellite products that characterize the continental surfaces, such as radiation products, vegetation, evapotranspiration and wild fires. For further information also check <https://landsaf.ipma.pt/>. Also check, from “Geonetcast” and “Toolbox” main menu >> “Satellite Application Facilities Products” >> “Link to online resources” and press “Import”. Links to all products for which import routines have been prepared from each of the SAF’s is provided here.

Before starting to import the various other data types that are available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select for all “LSA\_SAF” entries (“Africa”, “Euro”, “South America”, “EDLST”, “Full\_ET” and “Full\_MetRef”) the appropriate data input and output locations and in the case of all the LSA SAF, the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\SAFLSA”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings. See also the figure below.

**Figure 4.4.1: Input and output directory specification using the Toolbox Folder Configuration**



Within the toolbox menu select “Satellite Application Facilities Products” >> “LSA-SAF”. Note the sub menu structure. First an example of a full MSG disk is provided, later some regional products and well as global products from METOP will be processed.

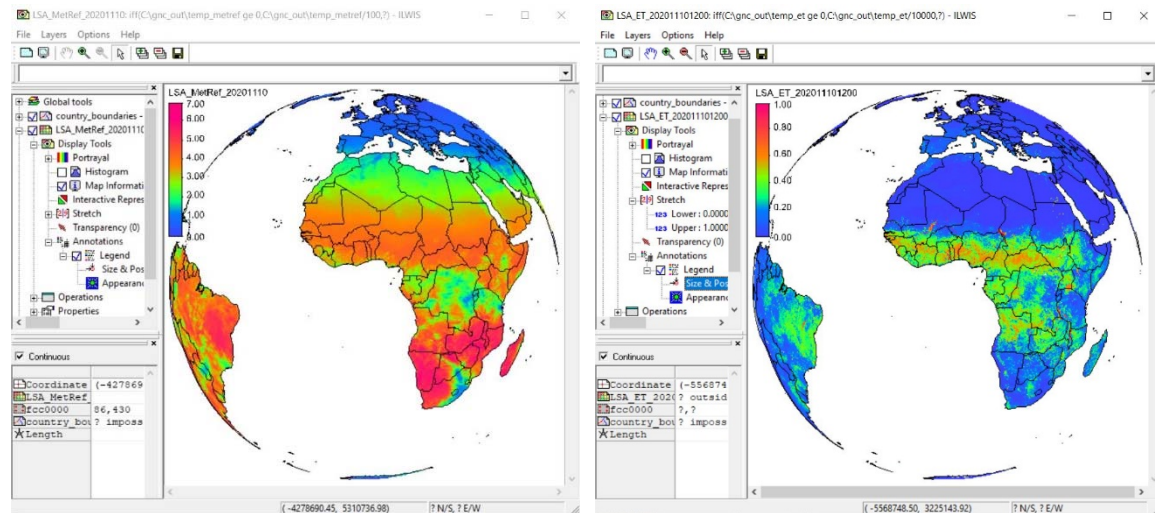
Continue and select from “Geonetcast” and “Toolbox” main menu >> “Satellite Application Facilities Products” >> “LSA-SAF” >> “Full MSG Disk” >> “Potential ET (ETo – METREF)”, specify the Date according to the format required, here “20201110” for yyymmdd and press “Import”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported “LSA\_MetRef\_20201110”.



Display this map, add the country boundaries and check the map values. Note the higher ETo values for Southern Africa, compared to Northern Africa – Southern Europe, for this period of the year.

In a similar manner also the Actual ET (ETa), Sensible Heat Flux (MH) and Latent Heat Flux (MLE) products can be imported. Use as Date – time stamp “202011101200”. Also note that these product have a temporal resolution of 30 minutes.

**Figure 4.4.2: Daily ETo (left) and half hourly ETa (right) products for full MSG Disk**



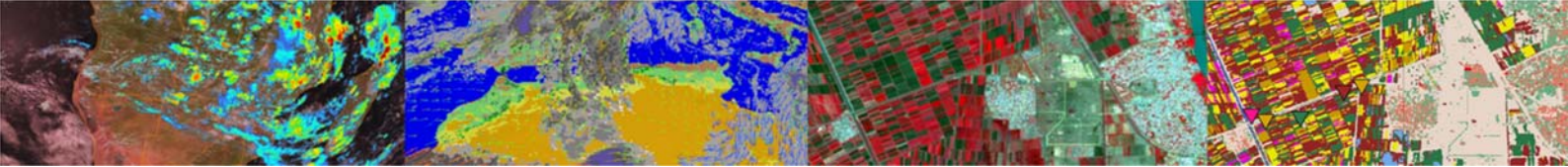
For Africa, Europe and South American windows, check the other products provided: "Albedo", "DSLRF", "DSSF", "FAPAR", "FVC", "LAI", "LST", "SNOW" and "FDeM" (for European window also "FRM"). Sample data is provided using for the daily temporal products "202011100000" and for the half hourly temporal products "202011101200" as Date stamp.

From the "Geonetcast" and "Toolbox" main menu select "Satellite Application Facility (SAF)" >> "Africa" >> "Albedo" to import the Surface Albedo product. Select for the "Date" the appropriate time stamp, here use is made of the data for 10 November 2020 and as time step "0000" is entered as the product is generated once a day. Specify the time stamp according to the format required in the "Date" field (e.g. "202011100000"). Press "Import" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "Window" and "Refresh F5") and note the file that has been created: "LSA\_albedo\_africa\*" (\*=yyyymmddhhmm). Display this map and also add the country boundaries using a black colour. Check the values obtained, note that these are in percentage. Your results should resemble those of figure 4.4.3 (left), close the map when finished.

To extract an example of the fluxes, from the "Geonetcast" and "Toolbox" main menu select "Satellite Application Facilities Products" >> "LSA-SAF" >> "Africa" >> "DSSF" to import the down-welling surface short-wave radiation flux product. Select for the "Date" the appropriate time stamp, here use is made of the product for 10 November 2020 and as time step "1200" UTC is entered. Specify the time stamp according to the format required in the "Date" field (e.g. "202011101200"). Also note if the input directory and output directory is correctly defined. Press "Import" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "Window" and "Refresh F5") and note the file that has been created: "LSA\_dssf\_africa\*" (\*=yyyymmddhhmm). Display this map and also add the country boundaries using a black colour. Check the values obtained, note that these are given in

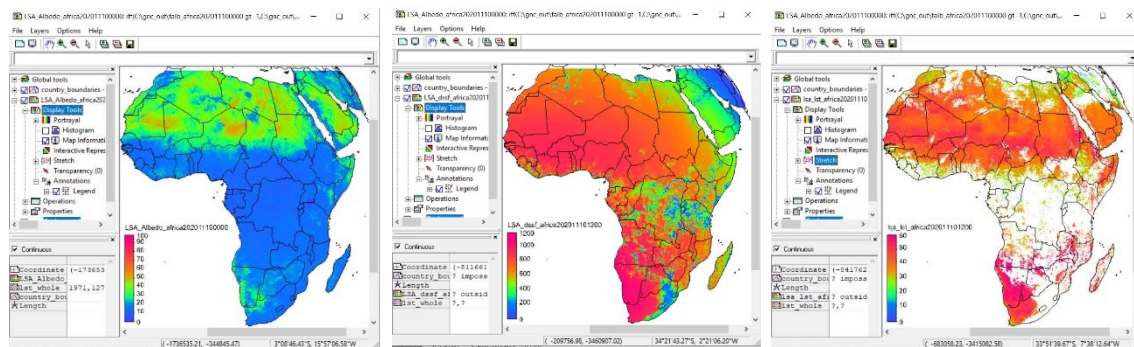


W/m<sup>2</sup>. Your results should resemble those of figure 4.4.3 (middle), close the map when finished.

Now select the “LST” to import the Land Surface Temperature product. Select for the “Date” the appropriate time stamp, here use is made of the data for 10 November 2020 and as time step “1200” UTC is entered. Specify the time stamp according to the format required in the “Date” field (“202011101200”). Also note if the input directory and output directory is correctly defined. Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note the file that has been created: “LSA\_1st\_africa” (\*=yyyymmddhhmm). Display this map and also add the country boundaries using a black colour. Check the values obtained, note that the temperature is in Celsius. Your results should resemble those of figure 4.4.3 (right), close the map when finished.

**Figure 4.4.3: LSA SAF products: Albedo (left) and DSSF (middle) and LST (right)**



You will now continue to import a number of Vegetation Parameters that are generated once a day by the LSA SAF, using the data collected by the SEVIRI instrument on board of MSG.

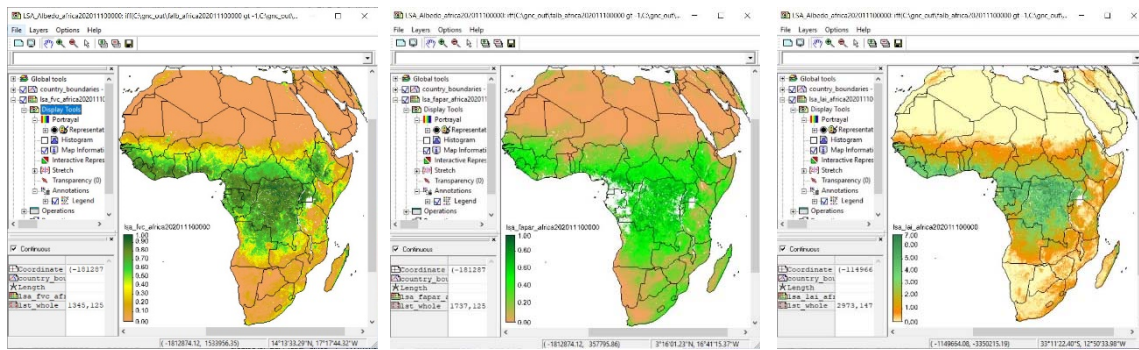
From the “Geonetcast” and “Toolbox” main menu select “Satellite Application Facility (SAF)” >> “Africa” >> and “FVC” to import the Fraction of Vegetation Cover product. Select for the “Date” the appropriate time stamp, here use is made of the data for 10 November 2020 and as time step “0000” is entered as the product is generated once a day. Specify the time stamp according to the format required in the “Date” field (e.g. “202011100000”). Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note the file that has been created: “LSA\_fvc\_africa” (\*=yyyymmddhhmm). Display this map, using as “Representation” “fvc”, also add the country boundaries Check the values obtained, note that these are in percentage (0 to 1 represents 0 to 100 percent). Your results should resemble those of figure 4.4.4 (left), close the map when finished.

In an identical manner also import the “LAI” - the Leaf Area Index product as well as the “FAPAR” - the Fraction of Absorbed Photosynthetically Active Radiation product. Use the same time stamp: “202011100000”. New maps are created. The first one is: “LSA\_lai\_africa” (\*=yyyymmddhhmm). Display this map, using as “Representation” “lai\_saf”, also add the country boundaries using a black colour. Check the values obtained, note these are m<sup>2</sup>/m<sup>2</sup>. Your results should resemble those of figure 4.4.4 (middle), close the map when finished. The other one created is: “LSA\_fapar\_africa” (\*=yyyymmddhhmm). Display this map, using as “Representation” “fapar”, also add the country boundaries using a black colour. Check the values obtained, note that the FAPAR unit is in percentage, 0 to 1, 1=100 percent. Your results should resemble those of figure 4.4.4 (right), close the map when finished.



**Figure 4.4.4: LSA SAF vegetation products FVC (left), LAI (middle) and FAPAR (right)**



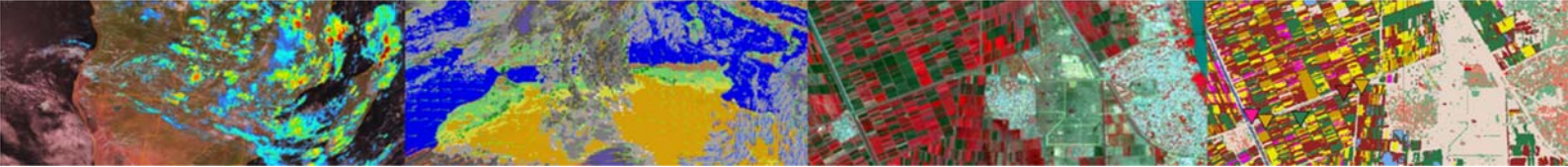
Note that the examples shown here only refer to Africa. Within the toolbox also routines are available to import the various SAF products over the European and Latin American part of the MSG field of view.

Finally import the fire related products, the Fire Detection and Monitoring (FDeM) product and for the European Window also the Fire Weather Index (FWI) and the Daily Severity Rating (DSR). Values represent levels of fire danger. Values below 10 can be considered low, above 10 up to 20 are moderate, above 20 are considered high and above 30 very high, respectively.

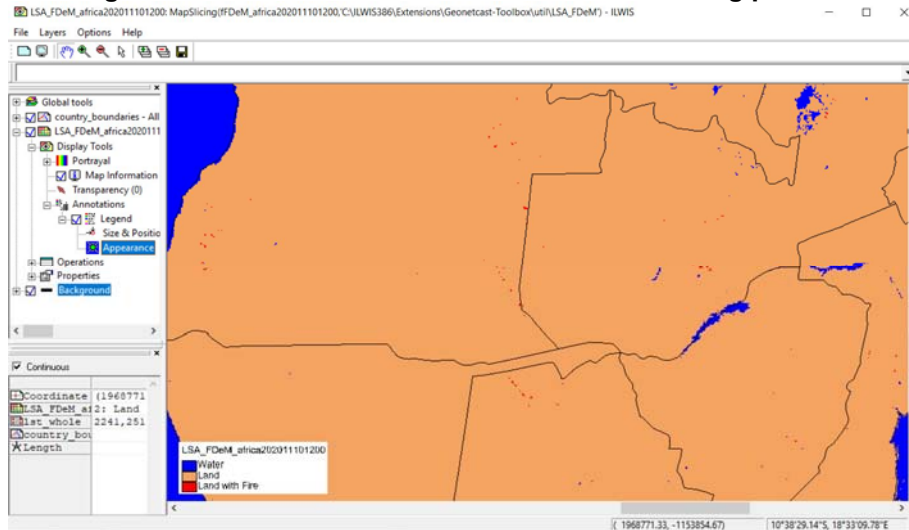
The forecasting time in the file name 'hhh' denotes the 24h, 48h or 72h forecasts and YYYY, MM, DD, HH and MM respectively, denote the year, the month, the day, the hour and the minute of data with respect to the forecast. It is worth stressing that YYYYMMDDHHMM indicates the date of the forecast and that Fhhh (where hhh is 024, 048, or 072) indicates that the forecast model started hhh hours before. For instance, if the name of the output file is FWI\_024\_euro\_20201110; it means that data refer to November 10, 2020 at 12:00 and are the result of a 24h forecast (i.e. the model run started at November 09, 2020 at 12:00).

From the "Geonetcast" and "Toolbox" main menu select "Satellite Application Facility (SAF)" >> "Africa" >> and "FDeM" to import the Fire Detection and Monitoring product. Select for the "Date" the appropriate time stamp, here use is made of the data for 10 November 2020 and as time step "1200" is entered as the product is generated every 15 minutes. Specify the time stamp according to the format required in the "Date" field (e.g. "202011101200"). Press "Import" to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select "Window" and "Refresh F5") and note the file that has been created: "LSA\_FDeM\_africa202011101200". Display this map also add the country boundaries and zoom in over central South Africa. Check the classes obtained, eventually add the legend. Your results should resemble those of figure 4.4.5, close the map when finished.



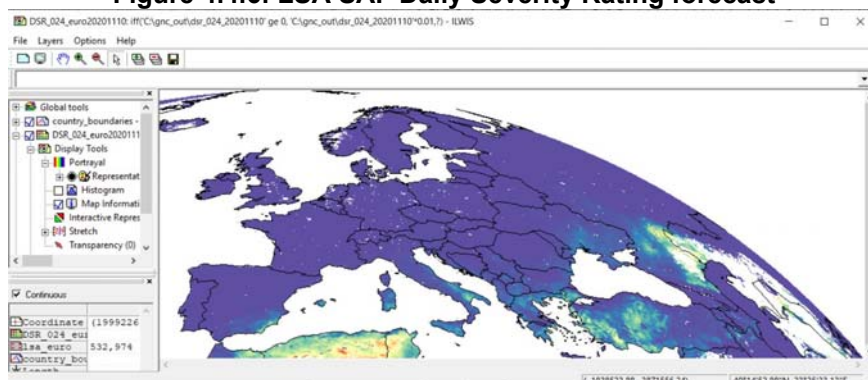
**Figure 4.4.5: LSA SAF Fire Detection and Monitoring product**



From the “Geonetcast” and “Toolbox” main menu select “Satellite Application Facility (SAF)” >> “Europe” >> “Fire” >> “FRM” to import the Fire Detection and Monitoring product. Select for the “Date” the appropriate time stamp, here use is made of the data for 10 November 2020. Specify the time stamp according to the format required in the “Date” field (e.g. “20201110”). Press “Import” to start the import. Note that during import a command window is activated, have also a look at what is displayed in this window.

After completion of the import, update the ILWIS catalogue (from the main ILWIS menu, select “Window” and “Refresh F5”) and note the 6 files that have been created: “DSR\_hhh\_euro20201110” and “FWI\_hhh\_euro20201110”, where ‘hhh’ denotes the forecasting time. Display one of these maps, use as Representation “Spectral\_inv” and also add the country boundaries. Check the values. Your results should resemble those of figure 4.4.6 for the ‘DSR\_024\_euro’ forecast product. Before you continue, close all active map windows.

**Figure 4.4.6: LSA SAF Daily Severity Rating forecast**



All other LSA-SAF import routines work on a similar manner for the different geographical windows (Africa, Europe and Latin America) specified. From the LSA-SAF toolbox menu open the menu item “LST-METOP Globe” >> “METOP LST - day (EDLST)” and import the day time LST using as Date stamp “20201110”, repeat the procedure also for the night time, using the menu option “METOP LST - night (EDLST)” for the same Date stamp (here: 20201110). After both import routines are completed, refresh the ILWIS catalogue and display the day time LST product “LSA\_EDLST\_Day20201110” and add to the map display window also the night time LST product “LSA\_EDLST\_Night20201110”. Also add the country boundaries. Note the ‘sinusoidal’ projection used. Move the cursor over the map display window and inspect the (difference between) the temperatures. Note the gaps between the successive METOP

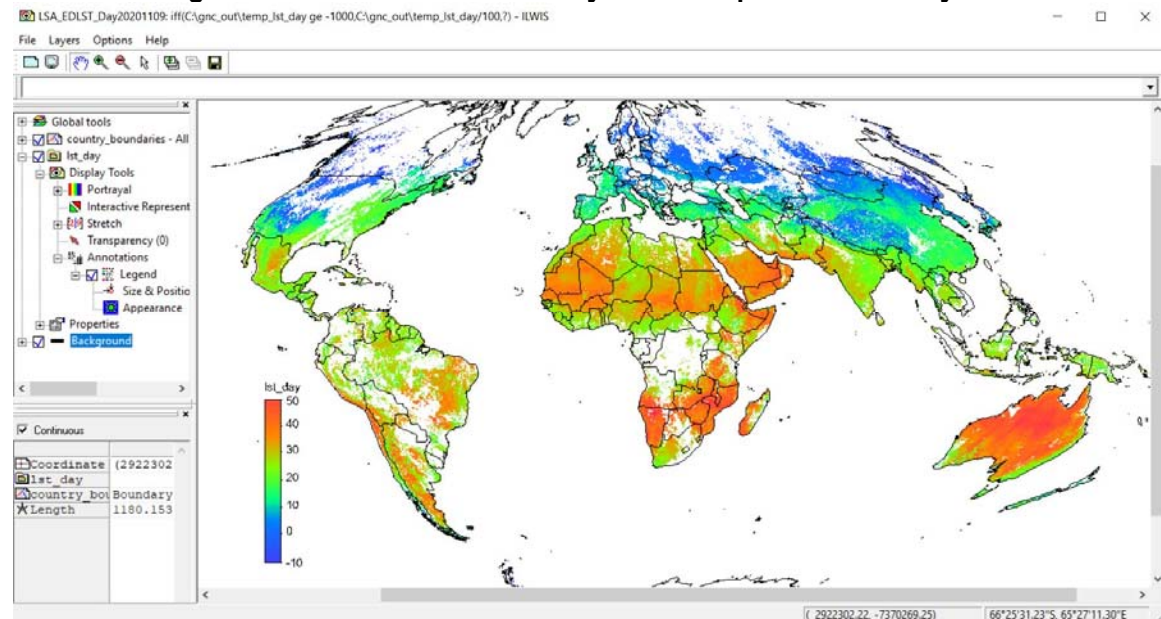




overpasses when you de-activate a layer in the map display window, especially towards the equator.

Continue to import the day time LST product for “20201109”. After completion of the import create an object collection using the “LSA\_EDLST\_Day20201109” and “LSA\_EDLST\_Day20201110” and save the collection as “LST\_day”. Open the “LST\_day” object collection as a layer and inspect the coverage and also note the cloud occurrences. The day time LST products for 09 and 10 November object collection is also given in the figure below.

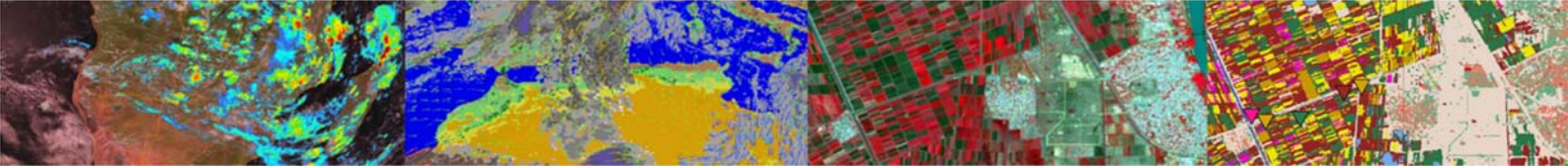
**Figure 4.4.7: LSA SAF METOP Day Time LST product for 2 days**



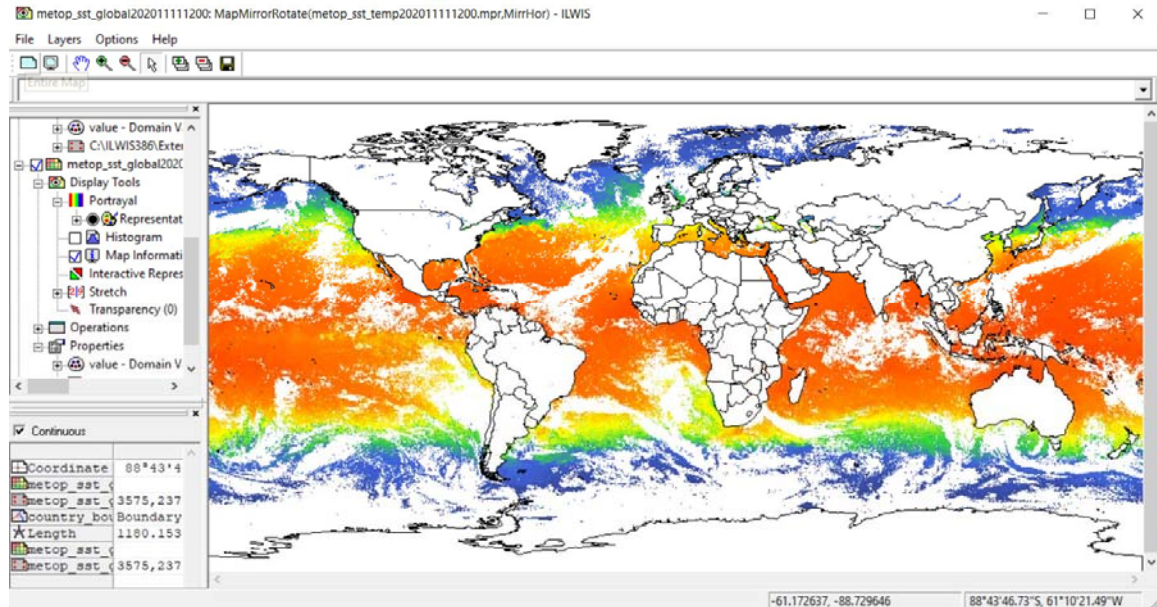
#### 4.4.2 Import and processing of Ocean and Sea Ice SAF products

First check the settings of the directory that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “OSI\_SAF”. The appropriate data input and output location in the case of the OSI SAF, note that the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\SAF\OSI”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

Continue and select from “Geonetcast” and “Toolbox” main menu >> “Satellite Application Facilities Products” >> “OSI-SAF” >> “Global SST METOP”, specify the Date according to the format required, here “20201111200” for yyyymmddhhmm and press “Import”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported “metop\_sst\_global20201111200” for the day time SST product. Display this map, use as Representation “sst”, add the country boundaries and check the map values. Repeat the import procedure also for the night time product, using as Date stamp “202011110000”. Add, after completion of the import this map (“metop\_sst\_global202011110000”) to the day time SST product, also using as Representation “sst”. Check the temperature differences between the daytime and night time sea surface temperature. The combined day and night time SST product is also given in the figure below.



**Figure 4.4.8: LSA OSI METOP Day - Night Time SST product**



### 4.4.3 Import and processing of Hydrology SAF products

Check the settings of the directory that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “H\_SAF\_H03B”, “H\_SAF\_H05B” and “H\_SAF\_H14”. Specify the appropriate data input and output locations in the case of the Hydrology SAF, note that the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\SAFH”, where “D:\” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings for the three folders.

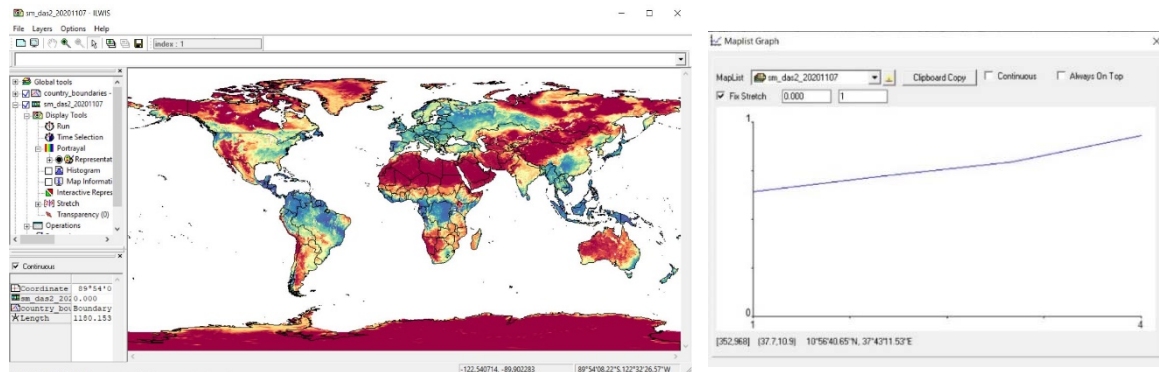
Continue and select from “Geonetcast” and “Toolbox” main menu >> “Satellite Application Facilities Products” >> “H-SAF” >> “H14 Global SM-DAS-2”, specify the Date according to the format required, here “20201107” for yyyymmdd and press “Import”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported as a map list: “sm\_das2\_20201107”. Right click with the mouse the Map List and select the option “Open as Animation”. Under “Display Tools” activate the option “Histogram”. Once all histograms are calculated close the map window and open it once more. Use as Representation “Spectral” and add the country boundaries, now “Run” the animation. Once the animation has looped a number of times, stop the animation. Note the changes. The SM-DAS-2 is providing the root zone soil moisture index and in the soil moisture assimilation system, the surface observation from ASCAT is propagated towards the roots region down to 2.89 m below surface, providing estimates for the 4 layers (thicknesses 0.07, 0.21, 0.72 and 1.89 m). Also check the Product User Manual for further details.

Now from the ILWIS main menu, select: “Operations”, “Statistics”, “MapList” and finally “MapList Graph”. Select as “MapList” “sm\_das2\_20201107”. Activate the option: “Fix Stretch”, select as minimum “0” (dry) and as maximum “1” (moist). Also activate the options “Continuous” and “Always On Top”. Note that the X-axis of the graph represents the 4 layers. Move the mouse cursor over the map (it might have disappeared under the main ILWIS window!) and check the corresponding Index values in the graph for a given pixel over the whole profile depth. Your results should resemble those of figure 4.4.9.

Note that with the “Clipboard Copy” option the time stack for a certain pixel can be copied to clipboard to be pasted into a spreadsheet. In order to do so it is necessary to uncheck the option “Continuous” and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner.



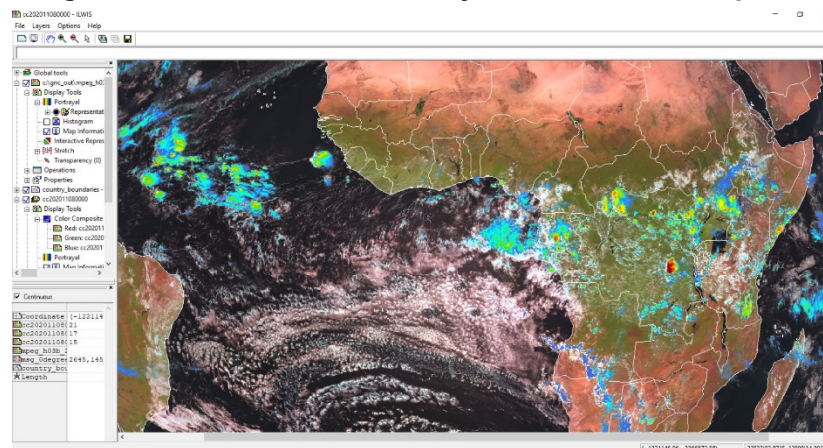
**Figure 4.4.9: H-SAF H14 Soil Moisture Index**



Now continue processing the rainfall products provided by the Hydrology SAF. From the Toolbox sub menu “*H-SAF*” select the option “*H03B 15 min. Rainfall*”, specify the Date according to the format required, here “*202011081145*” for *yyyymmddhhmm* and press “*Import*”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported as: “*MPEG\_H03B\_202011081145*”.

Once more display the MSG image of “*202011081145*” previously imported, if adhered to the instructions open the map list “*cc202011080000*” as colour composite, see also chapter 4.3.1. Note that the time refers to start of scan time. Display the image as colour composite, display band 3 in red, band 2 in green and band 1 in blue, use the following stretch values: for red: 0 – 129, for green: 0 – 147 and use as stretch values for blue: 0 – 163. Also add the country boundaries in white. Add the rainfall map “*MPEG\_H03B\_202011081145*” and use as Representation “*mpe\_single*”. Move the cursor over the map and inspect the rainfall intensities, also change the transparency settings of the H03B product to inspect the colours of the clouds. Note that the white coloured clouds do not produce any rainfall as these clouds are mainly consisting of water droplets. On the other hand, the cyan coloured clouds, due to the absorption of the electromagnetic radiation by the ice crystals (in the IR\_016 channel) are the rain producing clouds and from their appearance / circular shapes one can deduce the convective nature of the precipitation by cumulonimbus clouds in the tropical region and the more frontal appearance, given their elongated shapes (and lower rainfall intensities) at the higher latitudes.

**Figure 4.4.10: H-SAF H03B overlay on MSG colour composite**



Now also import the daily aggregated 24 hr. rainfall. From the Toolbox sub menu “*H-SAF*” select the option “*H05B 24 hr. Rainfall*”, specify the Date according to the format required, here “*20201110*” for *yyyymmdd* and press “*Import*”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported as: “*MPEG\_H05B\_20201110*”. Note the date stamp, the rainfall is



integrated over the previous 24 hrs. Display the map, use as representation “*mpe\_sum*” and also add the country boundaries. Check the map values.

#### 4.4.4 Import and processing of Now Casting SAF products

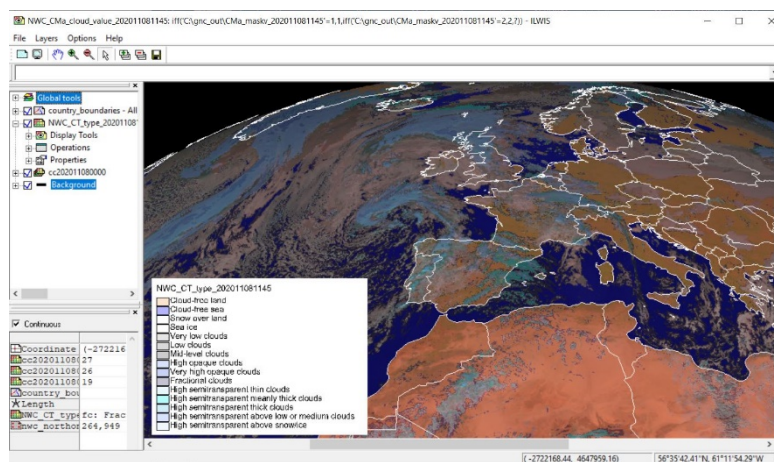
Check the settings of the directory that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*NWC\_SAF*” and “*NWC\_SAF\_Convective*”. Specify the appropriate data input and output locations in the case of the Now Casting SAF, note that the data is stored in the directory: “*D:\GNC\_ExerciseData\GNC\_Data\SAFNWC*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings for the three folders.

Continue and select from “*Geonetcast*” and “*Toolbox*” main menu >> “*Satellite Application Facilities Products*” >> “*NWC-SAF*” >> “*Cloud Mask*”, specify the Date according to the format required, here “*20201101145*” for *yyyymmddhhmm* and press “*Import*”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Display the new product imported: “*NWC\_CMa\_cloud\_value\_202011081145*”, use as Representation “*Clouds*”. Also a cloud class map, a dust and volcanic plume map is imported.

Add as colour composite the MSG image from the identical time period, here “*cc202011080000*”. Check the cloud mask against the MSG image by changing the transparency settings. Keep the map display window open.

Continue to import from the “*NWC-SAF*” sub menu the “*Cloud Type*” product, use as Date – time stamp “*202011081145*” and after import is completed add this product “*NWC\_CT\_type\_202011081145*” to the open map display window. Activate under “*Display Tools*” the option “*Annotation*” and under “*Annotation*” activate the option “*Legend*”. Double click the Legend item, select “*Appearance*”, activate the option “*Background color*” as “*White*”, click “*Apply*” and “*Close*”. Change the transparency setting to check the cloud type with the cloud mask layer. When done, remove the cloud mask from the map display window and check, by changing the transparency settings once more, the cloud type with the corresponding MSG image. Your results should resemble those of the figure below. Keep the map display window open.

**Figure 4.4.11: NWC-SAF Cloud Type overlay on MSG colour composite**

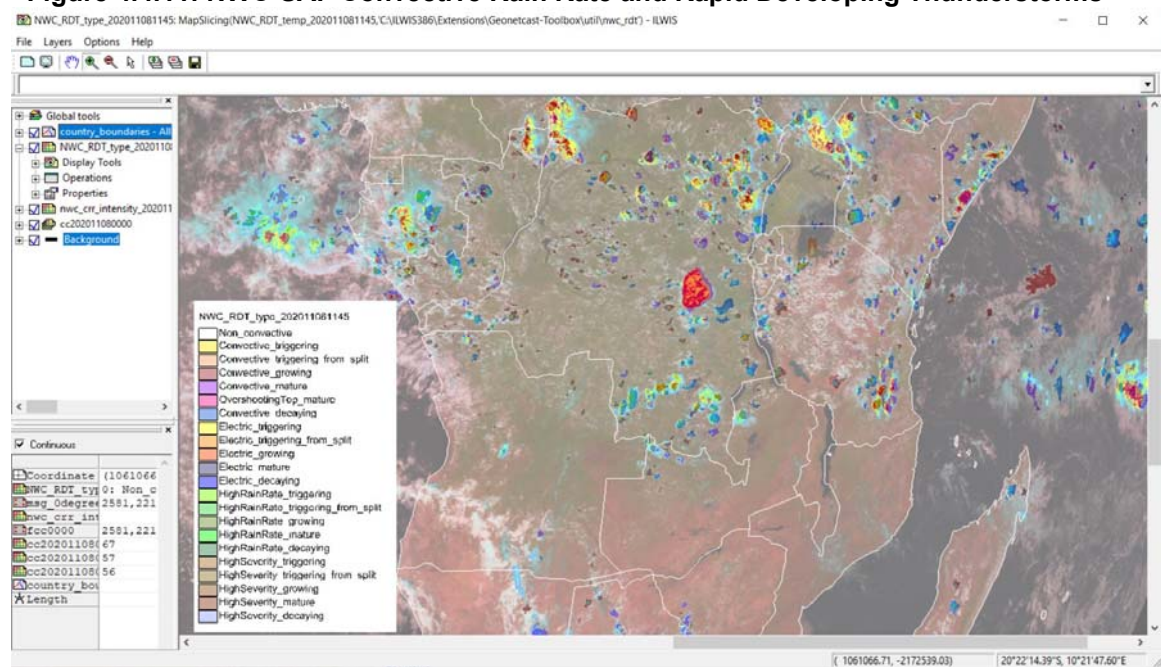


Continue to import from the “*NWC-SAF*” sub menu the “*Cloud Height/Temperature*” product, use as Date – time stamp “*202011081145*”. The parameters retrieved are: Cloudiness (%), Temperature (K), Pressure (hPa) and Height (m). After the import is completed add the maps “*NWC\_CTTH\_temperature\_20201108*” (air temperature at cloud top), “*NWC\_CTTH\_height\_202011081145*” (cloud top altitude) and “*NWC\_CTTH\_pressure\_202011081145*” (air pressure at cloud top) to the open map display window. Move the mouse cursor over the map and check the values for the different cloud types. Close the map window.



Now import from the “NWC-SAF” sub menu the “Convective Rain Rate” product, use as Date – time stamp “202011081145”. Continue to import from the “NWC-SAF” sub menu the “Rapid Developing Thunderstorms” product, use as Date – time stamp “202011081145”. After the import is completed display as colour composite the MSG image from the identical time period, here “cc202011080000”. Add the map “NWC\_CRR\_intensity\_202011081145” and the map “NWC\_RDT\_type\_202011081145”, also display the country boundaries in white. Zoom in to the central South African region. Under the NWC\_CRR\_intensity map “Display Tools” select “Transparency”, activate the option “Exclude range (full transparent)” and as range specify as minimum “0.000” and as maximum “0.001”, press “Apply” and “Close”. Use as Representation “mpe\_sum”. For the layer NWC\_RDT\_type under “Display Tools” activate the option “Annotation” and under “Annotation” activate the option “Legend”. Double click the Legend item, select “Appearance”, activate the option “Background color” as “White”, click “Apply” and “Close”. Change the transparency setting of this layer to check the rain rates with the Rapidly Developing Thunderclouds mask. Also check the underlying MSG image colours. Your results should resemble the figure below.

**Figure 4.4.11: NWC-SAF Convective Rain Rate and Rapid Developing Thunderstorms**



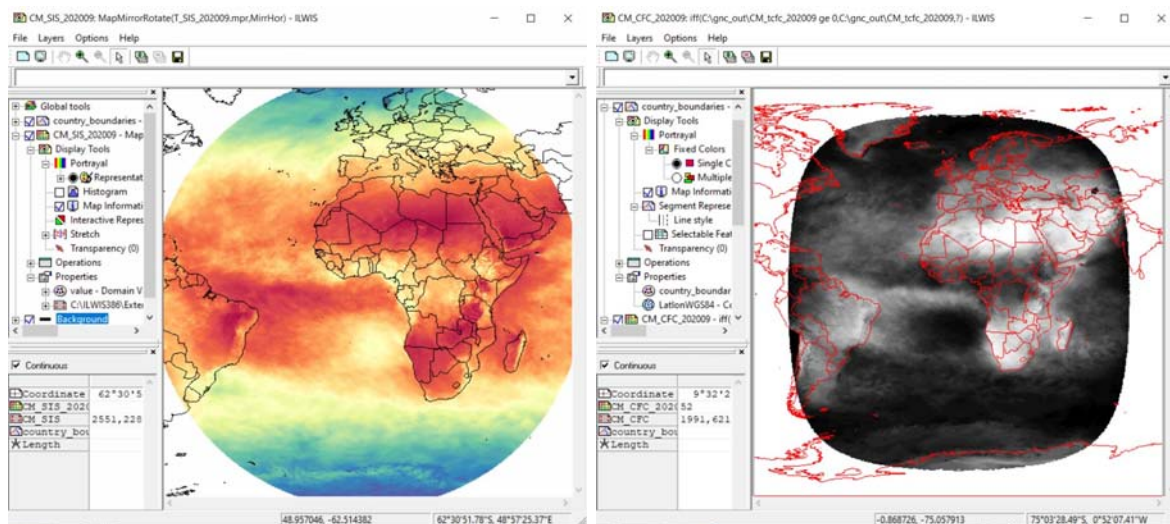
#### 4.4.5 Import and processing of Climate Monitoring SAF products

Check the settings of the directory that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “CM\_SAF”. Specify the appropriate data input and output locations in the case of the Climate Monitoring SAF, note that the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\SAFCM”, where “D:\” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings for the three folders.

Continue and select from “Geonetcast” and “Toolbox” main menu >> “Satellite Application Facilities Products” >> “CM-SAF” >> “Surface downwelling Shortwave Radiation”, specify the Date according to the format required, here “202009” for yyyy/mm and press “Import”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported as: “CM\_SIS\_202009”. Also import the “Cloud Fraction” and note the map “CM\_CFC\_202009” after completion of the import.

Display the map “CM\_SIS\_202009” using as Representation “Spectral\_inv” and display the cloud fraction map “CM\_CFC\_202009” using as Representation “Inverse”. Your results should resemble the figure below. Note the cloud cover impact on the shortwave radiation.

Figure 4.4.12: CM-SAF Surface downwelling Shortwave Radiation and Cloud Fraction





## 4.5 IMPORT OF OTHER SELECTED PRODUCTS – GLOBAL AND REGIONAL

### 4.5.1 Selected products with a Global coverage

#### 4.5.1.1 MODIS Global Products

At NASA, the Ocean Biology Processing Group (OBPG), is responsible for the processing of a number of Ocean related products derived from MODIS (– Aqua). Through GEONETCast – EUMETCast the following products are provided on a daily basis: Chlorophyll Alpha, KD-490, PAR and an SST product.

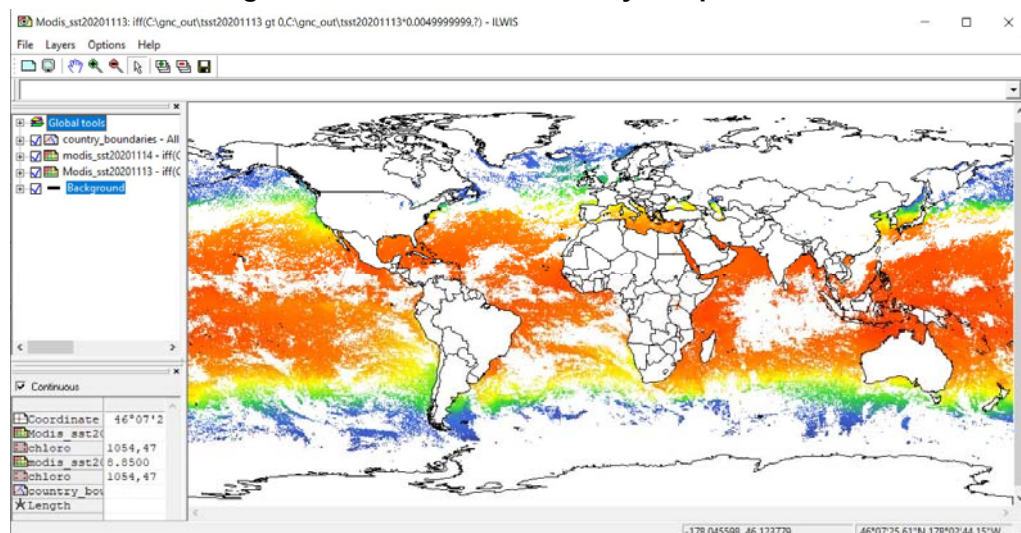
Check the settings of the directory that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*MODIS\_Products*”. Specify the appropriate data input and output locations in the case of the MODIS Products, note that the data is stored in the directory: “*D:\GNC\_ExerciseData\GNC\_Data\Other\_Global\MODIS*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings for this folder.

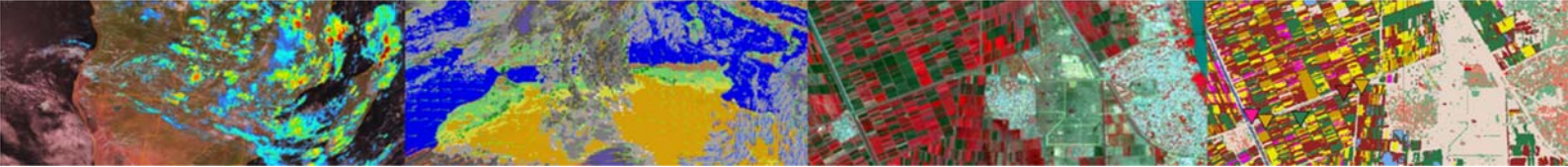
Continue and select from “*Geonetcast*” and “*Toolbox*” main menu >> “*Other Selected Products - Global*” >> “*MODIS Global Products*” >> “*MODIS-Aqua Chlorophyll Alpha*”, specify the Date according to the format required, here “*20201113*” for *yyyymmdd* and press “*Import*”. Check the information given in the command window and after the import is completed update the ILWIS Catalogue. Note the new product imported as: “*Modis\_chlora20201113*”. Also conduct the import for the next day, here “*20201114*”.

Display the map “*Modis\_chlora20201113*”, under “*Display Tools*”, double click the option “*Stretch*”. Activate the “*Logarithmic stretching*” option, and specify as Lower and Upper Stretch values: “*0*” and “*10*” respectively. Also add the map “*Modis\_chlora20201114*”, use the same stretch settings. Note the changes in Chlorophyll-A values along the coastal zones.

In a similar manner also import and display “*KD490*”, “*PAR*” and the “*SST*” products. For the “*SST*” product no logarithmic stretch is required, as Representation “*ssf*” can be used. See also the figure below.

**Figure 4.5.1: MODIS SST two day composite**





#### 4.5.1.2 NPP Marine Products

The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the key instruments on board the NOAA-20 spacecraft. It collects visible and infrared imagery and global observations of land, atmosphere, cryosphere and oceans.

Check the settings of the directory that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “NPP\_Marine\_Products”. Specify the appropriate data input and output locations in the case of the NPP Marine Products, note that the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\Other\_Global\NPP”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings for this folder.

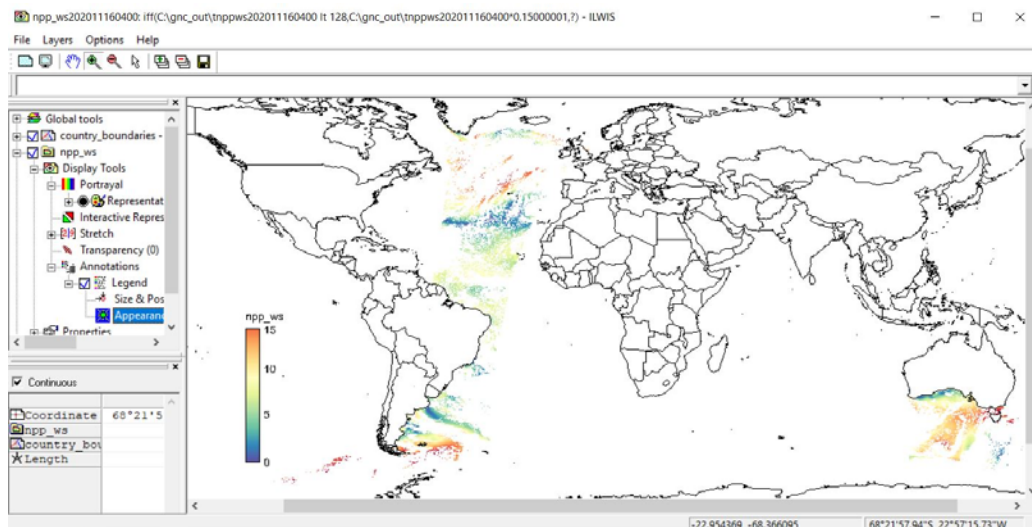
Continue and select from “Geonetcast” and “Toolbox” main menu >> “Other Selected Products - Global” >> “NPP Marine Products” >> “S-NPP VIIRS SST and Windspeed”, specify the Date according to the format required, here “202011160400” for yyyymmddhhmm and press “Import”.

After the import is completed, update the ILWIS catalogue and display the map “npp\_sst202011160400”, subsequently add the map “npp\_ws202011160400”. Also add the country boundaries and check the map extent as well as the values. As 1 hr of sample data is available from 202011160400 – 202011160450, as Date stamp continue the import with “202011160410” and repeat with 10 minutes increments, e.g. “202011160420”, “202011160430”, etc. until the full hour is completed.

After all products are imported, update the ILWIS catalogue select all NPP-SST maps from the ILWIS catalogue by clicking the filename and pressing simultaneously the “Shift” button on your keyboard. Once all maps are selected (6), right click the mouse and from the context sensitive menu select “Selection to Object Collection”, specify an Object Collection name, here “NPP\_SST” and press “OK”. Repeat the procedure for the wind speed product and create an Object collection “NPP\_WS”.

Right click with the mouse the object collection name “NPP\_SST” >> “Open as Layer”, add the country boundaries and check the map values. Repeat the procedure for the Wind Speed Object Collection, see also the figure below.

**Figure 4.5.2: Wind speed, concatenated as object collection, for 1 hr overpass**







### 4.5.1.3 Global Precipitation Monitoring (GPM) Mission

Rainfall data from GPM are provided in the GEONETCast - EUMETCast data stream. Each of the files provided cover 5 minutes of GPM observations.

Check the settings of the directory that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*GPM*”. Specify the appropriate data input and output locations in the case of the GPM products, note that the data is stored in the directory: “*D:\GNC\_ExerciseData\GNC\_Data\Other\_Global\GPM*”, where “*D:\*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings for this folder.

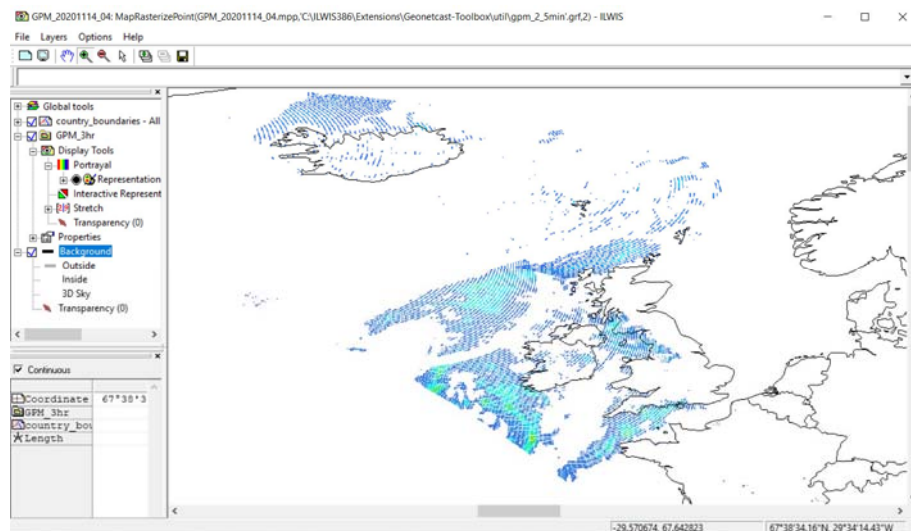
Continue and select from “*Geonetcast*” and “*Toolbox*” main menu >> “*Other Selected Products - Global*” >> “*GPM*” >> “*GPM Rainfall 1 hr orbit*”, specify the Date according to the format required, here “*202011140400*” for *yyyymmddhhmm* and press “*Import*”.

After the import is completed, update the ILWIS catalogue and display the raster map “*GPM\_20201114\_04*”, also add the country boundaries and check the map extent, the orbit configuration as well as the values. As 1 hr of sample data is available from 202011160400 – 202011160600, as Date stamp continue the import with “*202011160500*” and “*202011160600*”.

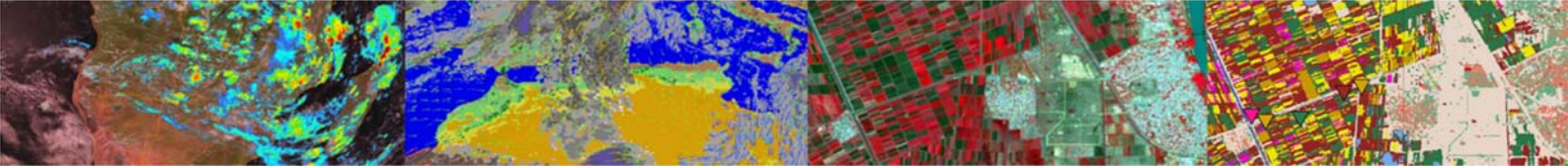
After all products are imported, update the ILWIS catalogue select the hourly GPM\_20201114 (\_04, \_05 and \_06) raster maps from the ILWIS catalogue by clicking the filename and pressing simultaneously the “*Shift*” button on your keyboard. Once all maps are selected (3), right click the mouse and from the context sensitive menu select “*Selection to Object Collection*”, specify an Object Collection name, here “*GPM\_3Hour*” and press “*OK*”.

Right click with the mouse the object collection name “*GPM\_3Hour*” >> “*Open as Layer*”, add the country boundaries and check the map values, see also the figure below over the UK and Iceland.

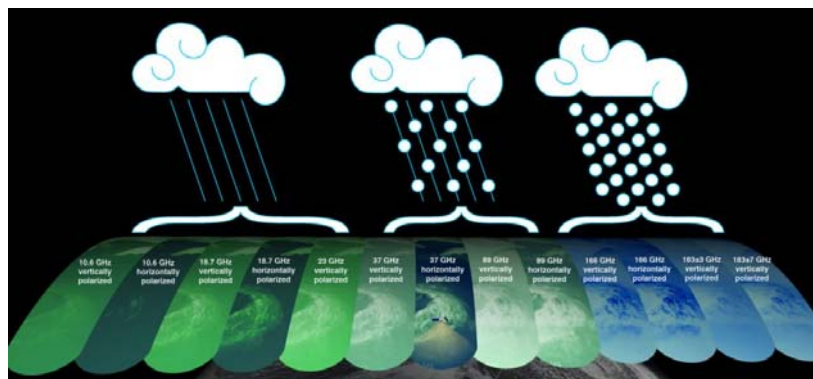
**Figure 4.5.3: GPM combination of several hourly overpasses in orbit configuration**



Continue to retrieve the brightness temperature for the various frequencies on the GPM Microwave Imager (GMI), the S1 product is providing the recordings from 10.6 to 89 GHz and the S2 product is providing the recordings from 166 to 183 GHz for the vertical and horizontal polarizations. See also the figure below (from: <https://gpm.nasa.gov/image-gallery/13-channels-gmi>) showing the sensitivity towards the different types of precipitation.



**Figure 4.5.4: GMI channels foot print, polarization and sensitivity to different types of precipitation**



Band [GHz]	Polarization	Spatial Resolution (3-dB footprint size) [km x km]
10.65	V,H	32 x 19
18.7	V,H	18 x 11
23.8	V	16 x 10
36.5	V,H	15 x 9
89.0	V,H	7 x 4
165.5	V,H	6 x 4
183.31+/-3	V	6 x 4
183.31+/-7	V	6 x 4

Open the table “GPM\_GMI\_S1\_202011140600” and “GPM\_GMI\_S2\_202011140600” and inspect the values, temperatures are given in Kelvin. Open the point map “GPM\_GMI\_S1\_202011140600\_BT1\_10\_7Ghz\_Ver”, showing the data for the first column in the table “GPM\_GMI\_S1\_202011140600”. Note the occurrence of the (difference in) temperatures in the various columns, representing the different channels – frequencies and polarizations. These brightness temperatures are used in algorithms and converted to rain rates (extracted before using the GPM 1 hr Rainfall Orbit product).

Other columns in the table can be converted to point maps as well, to conduct such an operation right click the table, use the options “Table Operations” >> “Table to PointMap”, specify the appropriate X and Y Columns, coordinate system (use here ‘LatlonWGS84’). If you want to keep the relationship with the table, use the Domain of Output map option “Use Record number as Identifiers”, else you can select a specific column using the option “Use Column of Table”. Specify an Output Point Map to complete the operation.

#### 4.5.1.4 SMOS

SMOS NRT-NN Soil Moisture product provides a Near Real Time soil moisture dataset based on statistical coefficients estimated by a Neural Network. It is provided in the SMOS Discrete Global Grid and only at the satellite track. It also provides an estimation of the uncertainty of the estimated soil moisture product and the probability that a soil moisture value is contaminated by Radio Frequency Interference.

Check the settings of the directory that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “SMOS”. Specify the appropriate data input and output locations in the case of the SMOS products, note that the data is stored in the directory: “D:\GNC\_ExerciseData\GNC\_Data\Other\_Global\SMOS”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings for this folder.

Continue and select from “Geonetcast” and “Toolbox” main menu >> “Other Selected Products - Global” >> “SMOS” >> “SMOS Soil Moisture”, specify the Date according to the format required, here “20201114” for yyyyymmdd and press “Import”.

After the import is completed, update the ILWIS catalogue and select all the point maps “smos\_20201114\*” (\*=hhmm) (18 in total) and save it as an Object Collection “SMOS\_20201114”. Open the Object Collection “SMOS\_20201114” as a Layer, also add the country boundaries and check the map extent, the orbit configuration as well as the values.

Change, under “Display Tools” the “Symbolization”, select as Symbols “filled-circle-only” and as Symbol scale “0.300”, press “Apply” and “Close”. Double click the Option “Stretch”, as lower limit specify “0.0” and as upper limit “0.5” and press “OK”. Zoom into the map and Pan over the different regions. Note the ascending and descending orbit configuration. Close the

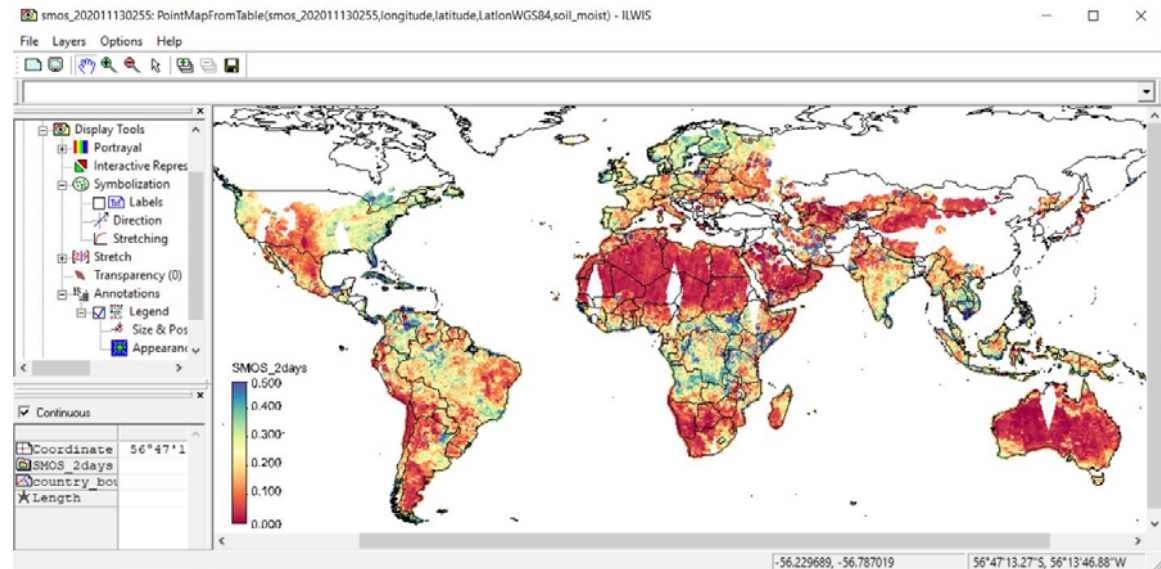


Object Collection “SMOS\_20201114”. Also open one of the SMOS product tables and check the content and note the information on ‘uncertainty’ and ‘probable RFI contamination’.

Delete the Object Collection “SMOS\_20201114”, confirm “Yes” under “Delete ObjectCollection SMOS\_20201114” and Press “No” when asked “Delete the contents of ObjectCollection SMOS\_20201114”.

Repeat the import procedure also for “20201113” and create an Object collection of all imported SMOS maps for the two days (42 maps) and as output collection specify “SMOS\_2days”. Now create a visualization using the same Display Tools settings as specified above. See also the figure below.

**Figure 4.5.5: SMOS Object Collection showing Soil Moisture product for 2 days.**



Also zoom into the map and check the point spacing. Use from the Legend the option “Global tools” and activate the “Distance measurer”. The point spacing of this product is 12.5 km.



## 4.5.2 Other selected Regional Products

### 4.5.2.1 TAMSAT

The TAMSAT RainFall Estimate (RFE) for Africa are 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. The products are currently disseminated via GEONETCast.

From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “TAMSAT”. Browse to the appropriate data input and output locations and in the case of the TAMSAT products note that the data is stored in the folder “D:\GNC\_ExerciseData\GNC\_Data\Other\_Regional\TAMSAT”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

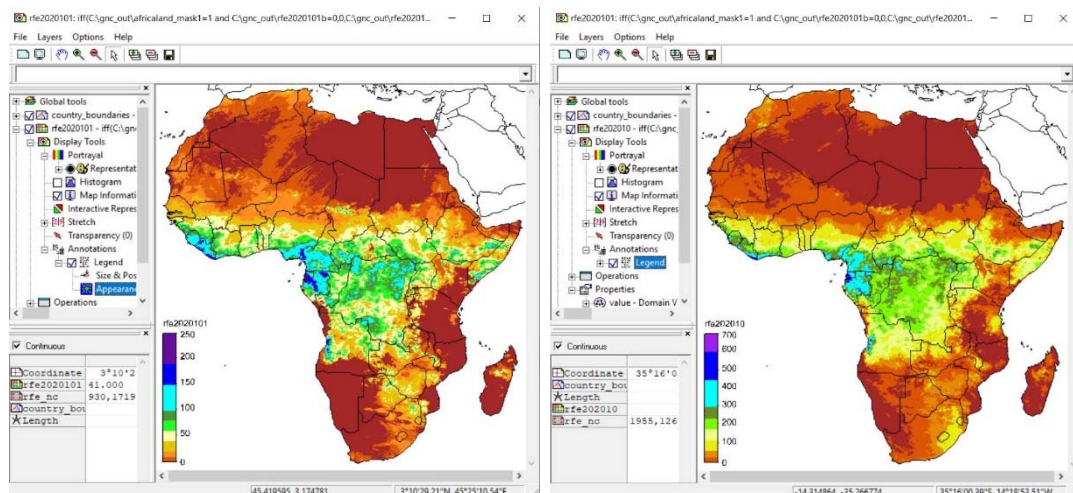
In order to import the dekadal RFE, from the “Geonetcast” and “Toolbox” main menu select the option “Other Selected Products - Regional” >> “TAMSAT Rainfall Products” >> “TAMSAT 10 day accumulated rainfall Africa”.

Import the dekadal rainfall map for the first dekad of October 2020, enter “2020101”. Note the format that is required for the Date stamp (yyyymmdek).

After import the import is completed, open the file “rfe2020101”, use as “Representation” “rfe\_dec”. Add the country boundaries using a black colour.

Conduct the import of the other 2 dekades of October 2020 (“2020102” and “2020103”) and optionally calculate the total monthly precipitation by adding the three dekadal maps to obtain the total monthly precipitation (in mm!). Display this map using as “Representation” “rfe\_month”. Browse with the left mouse button pressed over the map and note the values. Note that you can also use the “TAMSAT monthly accumulated rainfall Africa” import option available under “TAMSAT Rainfall Products”. As “Date” format yyyymm is expected, so enter for “Date”: “202010”. Conduct the import and display the map “rfe202010” using as “Representation” “rfe\_month”. The RFE map of the first dekad of October 2020 (right) and of the month of October 2020 (left) is also given in figure 4.5.6.

**Figure 4.5.6: RFE map of the first dekad of October 2020 and of the month of October 2020**



Compare your own calculated monthly RFE with the TAMSAT monthly RFE product, you can calculate the difference by subtracting the monthly precipitation maps or manually check some of the pixel values when both maps are added to the same Map Display Window.



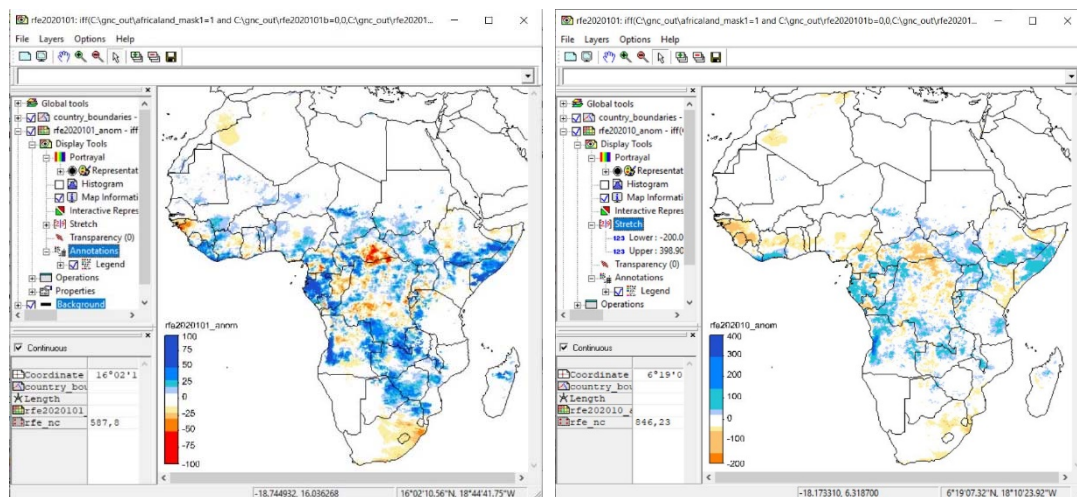
TAMSAT is also providing anomaly maps, using short term (10 years) climatology (from 2000-2009). In order to import the anomaly RFE for the 1<sup>st</sup> dekad of October 2020, select from the “Geonetcas” and “Toolbox” main menu the option “Other Selected Products - Regional” >> “TAMSAT Rainfall Products” >> “TAMSAT 10 day accumulated rainfall anomaly Africa”.

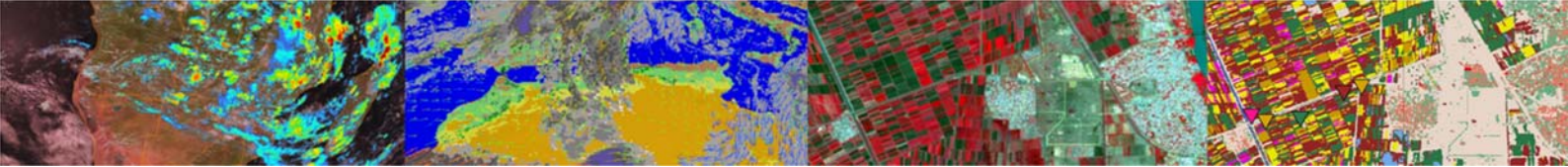
Import the dekadal anomaly rainfall map for the first dekad of October 2020, enter “2020101”. Note the format that is required for the Date stamp (yyyymmdek).

After import the import is completed open the file “rfe2020101\_anom”, use as “Representation” “rfe\_anom\_dec”. Add the country boundaries and use a black colour.

Repeat above procedure, but now select the import option “TAMSAT monthly accumulated rainfall anomaly Africa” and as Date stamp specify “202010” and press “Import”. After import the import is completed open the file “rfe202010\_anom”, use as “Representation” “rfe\_anom\_month”. Add the country boundaries and, use a black colour. Your results should be identical to those given in figure 4.5.7.

**Figure 4.5.7: RFE anomaly map for 1<sup>st</sup> dekad October 2020 (left) and the month of October 2020 (right)**





#### 4.5.2.2 Sentinel – 3 Land

Sentinel – 3 is replacing the Proba Vegetation Instrument which operated as an intermediate (or gap filler) mission to provide continuity with respect to the SPOT Vegetation instrument. A time series archive based on these instruments using a 10-day maximum value composition technique is now stretching back to 1998. Sentinel 3 is going to continue this heritage.

From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*S3SYN*”. Browse to the appropriate data input and output locations and in the case of the Sentinel 3 Synergy products note that the data is stored in the folder “*D:\GNC\_ExerciseData\GNC\_Data\Other\_Regional\S3\_LAND*”, where “*D:\*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings.

In order to import the 10 day NDVI maximum value composite derived from Sentinel 3A, from the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Other Selected Products - Regional*” >> “*Sentinel 3 Land*” >> “*S3A Synergy Products*”.

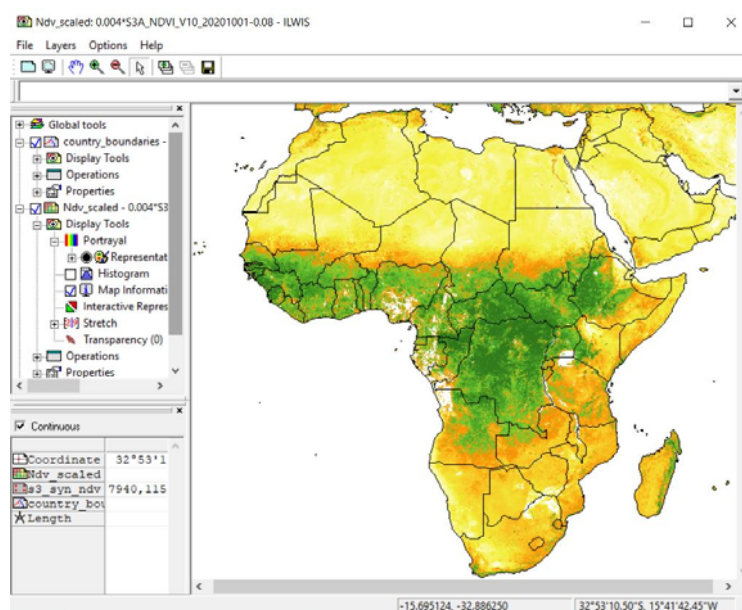
Import the dekadal NDVI map for the first dekad of October 2020, enter “*20201001* “. Note the format that is required for the Date stamp (yyyymmdd). The date convention is ‘01’ for the first dekad, ‘11’ for the second dekad and ‘21’ for the last dekad of the month.

After import the import is completed open the file “*S3A\_NDVI\_V10\_20201001*”, use as “*Representation*” “*ndv\_byte*”. Add the country boundaries using a black colour. To transform the product to and NDVI scaling from 0 to 1, type the expression given below in the command line in the main ILWIS menu and apply the following scaling and offset:

$Ndv\_scaled := 0.004 * S3A\_NDVI\_V10\_20201001 - 0.08$

Display the map “*Ndv\_scaled*” calculated, now use as Representation “*NDVI1*”. Note that the import for S3B is identical. You can use the same Date stamp to import the S3B NDVI product and use the same scaling and offset as well.

**Figure 4.5.8: Scaled NDVI for 1<sup>st</sup> dekad October 2020**





### 4.5.2.3 Copernicus Global Soil Water Index

The Copernicus global Soil Water Index product provides global daily information about moisture conditions in different soil layers. SWI daily images are produced from EUMETSAT ASCAT-25km SSM product in orbit format and include a quality flag indicating the availability of SSM measurements for SWI calculations. Soil moisture is a key parameter in numerous environmental studies including hydrology, meteorology and agriculture. In addition to Surface Soil Moisture (SSM), information on the moisture condition within the underlying soil profile is of interest for different applications. Soil moisture in plant root zone can be estimated by an infiltration model using information on surface soil moisture and soil characteristics (source: <http://navigator.eumetsat.int>).

The SWI algorithm uses an infiltration model describing the relation between surface soil moisture and profile soil moisture as a function of time. The algorithm is based on a two-layer water balance model proposed by Wagner et al. (1999) to estimate profile soil moisture from SSM retrieved from scatterometer data. A computational adaption of SWI algorithm has been made based on a recursive formulation proposed by Albergel (2008). The SWI retrieval method does not account for soil texture, which determines the relation between the characteristic time (T) value and the soil depth. Therefore 8 T values (T=1, 5, 10, 15, 20, 40, 60 and 100) are provided to give more possibility to the users for selecting the best matching data (source: <http://land.copernicus.eu/global/products/SWI>).

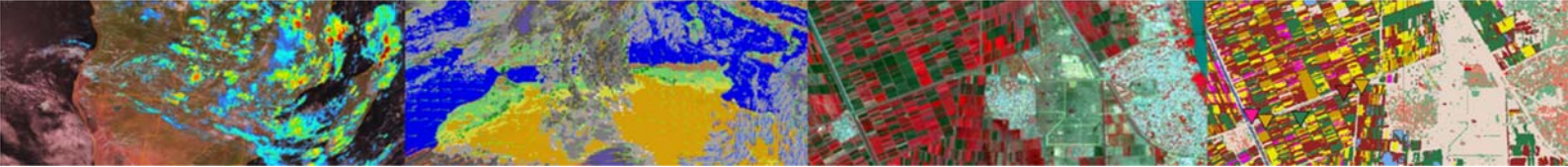
Before starting to import the SWI product available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*Copernicus*”. Browse to the appropriate data input and output locations and in the case of the SWI products note that the data is stored in the directory “*D:\GNC\_ExerciseData\GNC\_Data\Other\_Regional\Copernicus\_SWI*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings.

In the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Other Selected Products - Regional*” >> “*Copernicus Regional SWI*” >> “*Copernicus daily SWI-Africa*”. Note the specifications for the ‘Date’ stamp and specify here “*20201114*”, conduct the import by pressing “*Import*”.

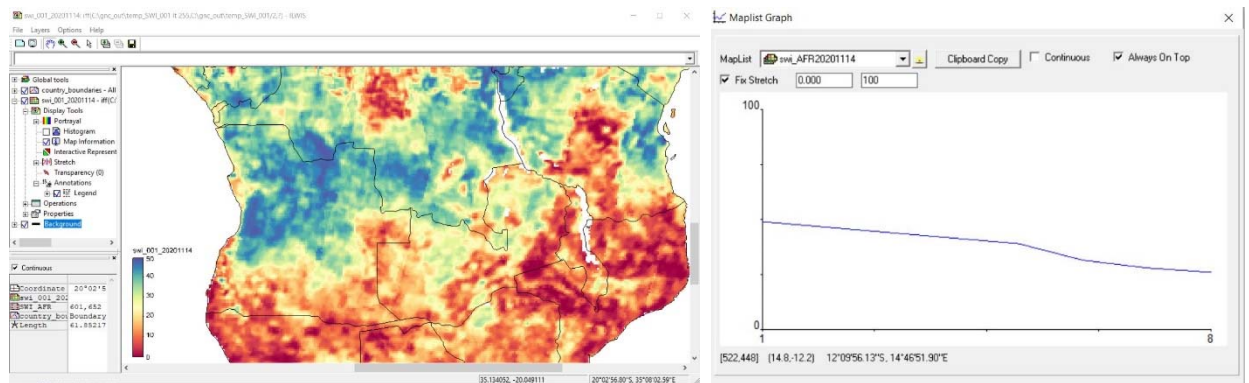
After the import is completed open the map list “*swi\_AFR20201114*” and from this map list select the layer “*swi\_001\_20201114*”, representing time step ‘1’, select as Representation “*Spectral*” and display the map. Browse with the mouse, keeping the left mouse button pressed over the map and inspect the values (in percentage).

Now from the ILWIS main menu, select: “*Operations*” >> “*Statistics*” >> “*MapList*” >> “*MapList Graph*”. Select as “*MapList*” “*swi\_AFR20201114*”. Activate the option: “*Fix Stretch*”, select as minimum “*0*” and as maximum “*100*”. Also activate the options “*Continuous*” and “*Always On Top*”. Note that the X-axis of the graph represents the time, here the time steps from T1 to T 100 and the Y axis is the WSI, in percentage. Move the mouse cursor over the map “*swi\_001\_20201114*” (it might have disappeared under the main ILWIS window!) and check the corresponding WSI values in the graph for a given pixel over the characteristic time range, in this case for 14 November 2020. Your results should resemble those of figure 4.5.9. Undefined pixels (not having a value) are represented by a dashed red line.

Note that with the “*Clipboard Copy*” option the time stack for a certain pixel can be copied to clipboard to be pasted into a spread sheet. In order to do so it is necessary to uncheck the option “*Continuous*” and click in the map on the desired location. The coordinate information / row-column number is provided in the Map List Graph window in the lower left hand corner.



**Figure 4.5.9: Imported SWI product of 2020114 and T graph zoomed in over Angola**



#### 4.5.2.4 PROBA Vegetation Products

A number of PROBA-Vegetation derived products are being disseminated through GEONETCast for Africa and Latin America. First the NDVI product for Africa will be retrieved. Further information can be obtained from <http://land.copernicus.eu/global/products/NDVI>.

Product user manuals are available from:

- [http://land.copernicus.eu/global/sites/default/files/products/GIO-GL1\\_PUM\\_NDVIV1\\_11.00.pdf](http://land.copernicus.eu/global/sites/default/files/products/GIO-GL1_PUM_NDVIV1_11.00.pdf)
- <http://land.copernicus.eu/global/sites/default/files/products/GIOGL1-ProductUserManual-NDVI-V2-I1.31.pdf>.

From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “PROBAV\_Africa”. Browse to the appropriate data input and output locations and in the case of PROBA note that the data is stored in “D:\GNC\_ExerciseData\GNC\_Data\ Other\_Regional\PROBA\_V”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings. Repeat the procedure and select the folder “PROBAV\_LatinAmerica”, use the same input and output folder settings.

In order to import the dekadal Proba-V NDVI, from the “Geonetcast” and “Toolbox” main menu select the options “Other Selected Products - Regional” >> “PROBA V Products” >> “PROBA V Africa” and “NDVI”.

Import the dekadal NDVI map for the last dekad of January 2020, enter “20200121 “. Note the format that is required for the Date stamp (yyyymmdekdek).

After the import is completed open the file “Proba\_ndvi20200121”, use as “Representation” “NDVI1”. Add the country boundaries and use a black colour for the boundaries. Note the cloud cover. In order to eliminate the occurrence of clouds a temporal filtering operation is required which is not further discussed here.

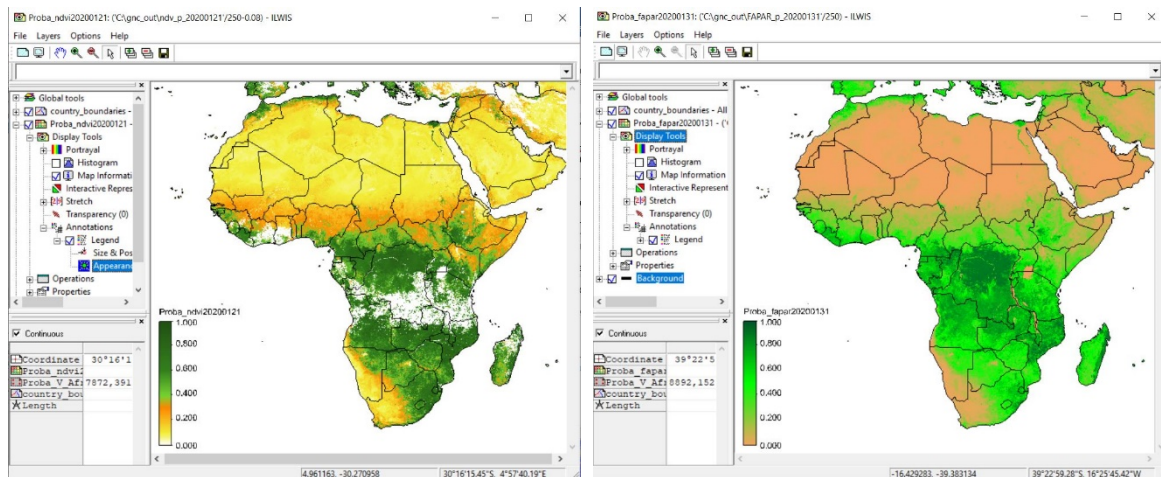
Continue to import another product, here the “FAPAR” is selected. Note the Date Stamp, now the last day of the month is required to import the 3<sup>rd</sup> dekad of January. As Date stamp use “20200131” and press “Import”.

After the import is completed open the file “Proba\_fapar20200131”, use as “Representation” “fapa”. Add the country boundaries using a black colour. See also the figure below.





**Figure 4.5.10: Proba-V NDVI (left) and FAPAR products (right)**



In a similar manner also the BA 300m, DMP, FCover, LAI, VCI and WB products can be retrieved. Note that for some of the products a different Date stamp is required. This information is provided in the 'comment line' of the Product Import menu. Continue to import some of the other products and use some of the standard Representations available, like "fvc" and "la", which can be used to visualize these products. Sample files for all PROBA Vegetation products for Africa are provided for the last dekad of January 2020.

Note that in order to import the PROBA-Vegetation products for Latin America the processing routines are operating in a similar manner and the file names have a suffix "\_LA". Sample files for all PROBA Vegetation products for Latin America are provided for the last dekad of February 2020.

#### 4.5.2.5 AEMET Dust Forecasts

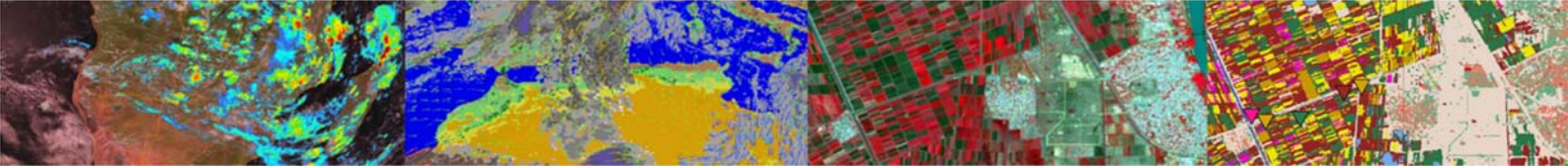
The Barcelona Dust Forecast Center produces and distributes dust forecasts, also available within GEONETCast. Further information is provided at: <https://dust.aemet.es/>.

Before starting to import the AEMET Dust Forecast product available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the "Geonetcast" and "Toolbox" main menu select the option "Configuration" and "Folder" and select "AEMET\_dust". Browse to the appropriate data input and output locations and in the case of the AEMET products note that the data is stored in the directory "D:\GNC\_ExerciseData\GNC\_Data\ Other\_Regional\AEMET", where "D:" is the designated hard disk drive location. Here as output location "C:\gnc\_out" is used. Press "Save" to store the settings.

In the "Geonetcast" and "Toolbox" main menu select the option "Other Selected Products - Regional" >> "AEMET Dust Forecasts" >> "Dust Surface Concentration". Note the specifications for the 'Date' stamp and specify here "20201115", conduct the import by pressing "Import".

After the import is completed an animation starts showing the 'Dust Surface Concentration' for the Northern Hemisphere, to stop the animation press the <Esc> button on the keyboard, else after a few loops the routine stops automatically. The animation uses "IrfanView", located in the ILWIS folder "\Extensions\CaboVerde-Toolbox\util\IrfanView". When changes are required for visualization and speed of animation, open "*i\_view32.exe*" and start an instance of IrfanView. From the 'Slideshow' menu the various parameters can be modified according to your preferences.

Also display some of the other forecast products, sample files for all products are available for "20201115".



#### 4.5.2.6 PML Marine Products

Plymouth Marine Laboratory – PML (<https://www.pml.ac.uk/>) produces daily near real time (NRT), refined and 3 day composites of a number of ocean colour and sea surface temperature products. The refined mode versions use accurate atmospheric measurements vs. estimates in the NRT and are produced after a week or two delay. Regional data is available for the east and north east of Madagascar, Cape Verde, Mozambique, Nigeria, South Somalia and Tanzania.

Before starting to import the Marine products by PML and provided through the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “PML”. Browse to the appropriate data input and output locations and in the case of the PML Marine products note that the data is stored in the directory “D:\GNC\_ExerciseData\GNC\_Data\Other\_Regional\PML”, where “D:” is the designated hard disk drive location. Here as output location “C:\gnc\_out” is used. Press “Save” to store the settings.

In the “Geonetcast” and “Toolbox” main menu select the option “Other Selected Products - Regional” >> “PML Marine Products” >> “Cape Verde” >> “Modis OC and SST 3 day composites” >> “MODIS 3 day SST”. Note the specifications for the ‘Date’ stamp and specify here “20201114\_20201116”, conduct the import by pressing “Import”. A longer accumulation period, here 3 days, reduces the effect of the clouds.

After the import is completed open the map “PML\_CapeVerde\_MODIS\_sst\_3daycomp\_20201114\_20201116\_sst”. Browse with the mouse, keeping the left mouse button pressed over the map and inspect the values (in Celsius). Use the same Date settings for retrieval of the other 3-day composite products; all products have as prefix “PML\_CapeVerde\_MODIS\_”, indicating the geographical region and as suffix the type of product, like “Chlor\_a”, “Kd\_490” and “nLw\_” for the normalized water leaving radiances for various wavelengths.

Also the refined Ocean Colour and Sea Surface Temperature products are available on a daily basis, select the option “Other Selected Products - Regional” >> “PML Marine Products” >> “Cape Verde” >> “Modis OC and SST day composites” >> “MODIS SST”. As date stamp use “202009301420” and after import is completed display the product: “PML\_CapeVerde\_MODIS\_sst\_refined\_202009301420\_sst”. Note that the refined products are produced with a certain time delay.

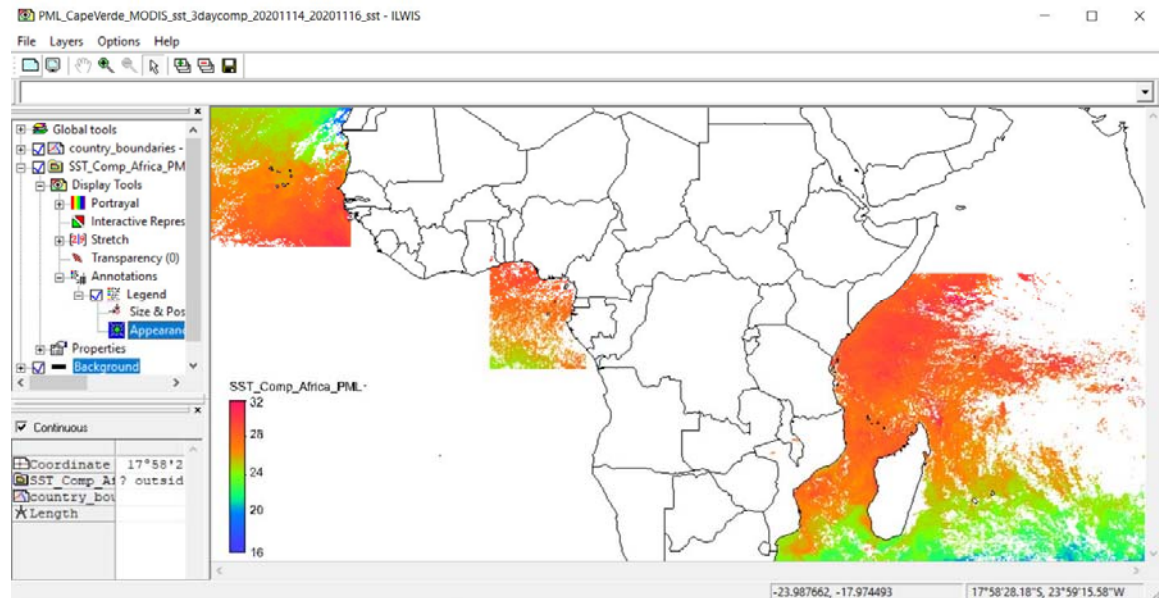
Also the other ‘refined’ ocean colour daily products can be imported, use as Date stamp “202011011420” for the MODIS Chlorophyll-A, Turbidity Kd\_490 and normalized Water Leaving Radiances. After completion of the import display “PML\_CapeVerde\_MODIS\_oc\_refined\_202011011420\_chlor\_a”. In order to get an appropriate visualization a logarithmic stretch should be applied. Note that the time is related to the satellite overpass time for these daily products.

In a similar manner also for the other geographical regions the daily refined and 3 day composite products can be visualized. To get an idea of the date – time stamp required, check the data input folder and inspect for the refined products the time stamp in the file name and use this time stamp for the Date specification in the product menu import interface window.

Continue to import the MODIS 3 day SST composite for the 7 regions and use as Date stamp “20201114\_20201116”. Upon completion of the import, select in the updated ILWIS catalogue the seven “\*\_MODIS\_sst\_3daycomp20201114\_20201116\_sst\*” created and copy the selection to a new “Object Collection” >> “SST\_Comp\_Africa\_PML”. Display the newly created Object Collection “SST\_Comp\_Africa\_PML” as a layer and add the country boundaries. See also the figure below.



**Figure 4.5.11: SST composites from PML for various regions displayed as object collection**



#### 4.5.2.7 EAMNET Marine Products

Also MODIS Aqua ocean colour products and sea surface temperature are provided by the Department of Oceanography, University of Cape Town (UCT), South African a daily basis at 1 km resolution. Next to SST, ocean colour products provided are: Chlorophyll-A, Kd490 and fluorescence line height. Regional data is available for Angola, South Africa (East), Namibia, Somalia (North), Senegal, South Africa (South) and South Africa (West).

Before starting to import the European-African Network Marine product available in the GEONETCast data stream you need to check the settings of the directories that contain the raw data. From the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Configuration*” and “*Folder*” and select “*EAMNET*”. Browse to the appropriate data input and output locations and in the case of the EAMNET products note that the data is stored in the directory “*D:\GNC\_ExerciseData\GNC\_Data\Other\_Regional\EAMNET*”, where “*D:*” is the designated hard disk drive location. Here as output location “*C:\gnc\_out*” is used. Press “*Save*” to store the settings.

In the “*Geonetcast*” and “*Toolbox*” main menu select the option “*Other Selected Products - Regional*” >> “*EAMNET Marine Products*” >> “*Angola*” >> “*MODIS SST*”. Note the specifications for the ‘Date’ stamp and specify here “*2020112*”, conduct the import by pressing “*Import*”.

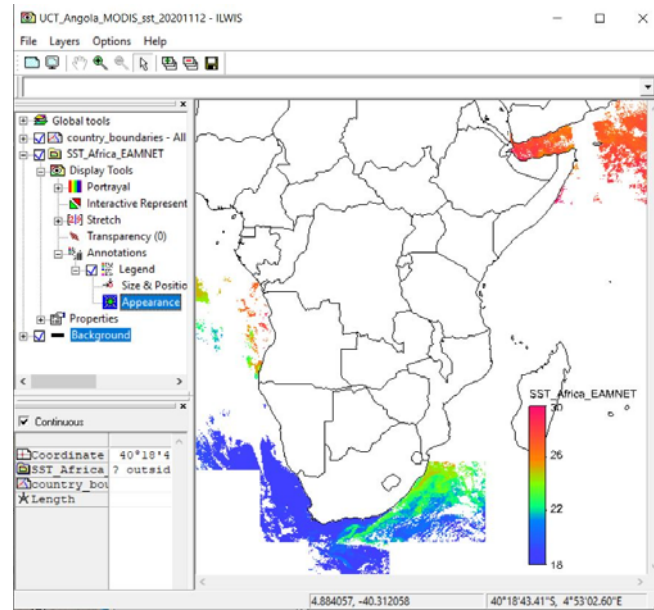
After the import is completed open the map “*UCT\_Angola\_MODIS\_sst\_2020112*” and display the map. Browse with the mouse, keeping the left mouse button pressed, over the map and inspect the values (in Celsius). Leave the map window open.

Repeat the import of the MODIS SST for the same geographical region, select from the menu once more “*EAMNET Marine Products*” >> “*Angola*” >> “*MODIS SST*” and now specify as input Date stamp “*2020110*”, “*2020111*” and “*2020113*” respectively. Add the newly created maps to the open map display window. Note that given persistent cloud cover even after 4 overpasses still no complete coverage is obtained.

Continue to import the MODIS day SST products for the other 5 regions for “*2020112*”. Upon completion of the import, select in the ILWIS catalogue the 6 “*UCT\_<Region>\_MODIS\_sst\_2020112*” maps and copy the selection to a new “*Object Collection*” >> “*SST\_Africa\_EAMNET*”. Display the newly created Object Collection as a layer and add the country boundaries. See also the figure below.



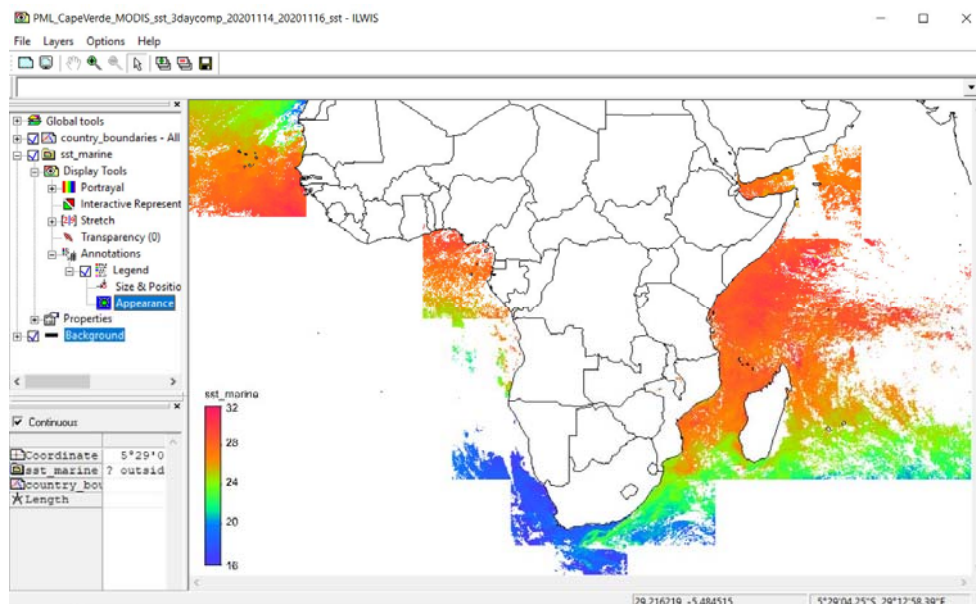
**Figure 4.5.12: SST maps for various regions combined in an object collection from UCT**



Also sample data is provided for the Chlorophyll-A product for the identical days as the SST for all the geographical regions. Continue to import some of the Chlorophyll-A products as well. Note that a logarithmic stretch might be required for appropriate visualization. Close all the open map windows when done. No sample data is provided for the other 2 products.

All products from the two Marine data suppliers can be added to a single Object Collection. The figure below shows the Object Collection of all the previously imported SST products for all geographical regions.

**Figure 4.5.13: SST Object Collection showing all PML and EAMNET geographical regions**





## 4.6 ADDITIONAL EXERCISES

### 4.6.1 EUMETView

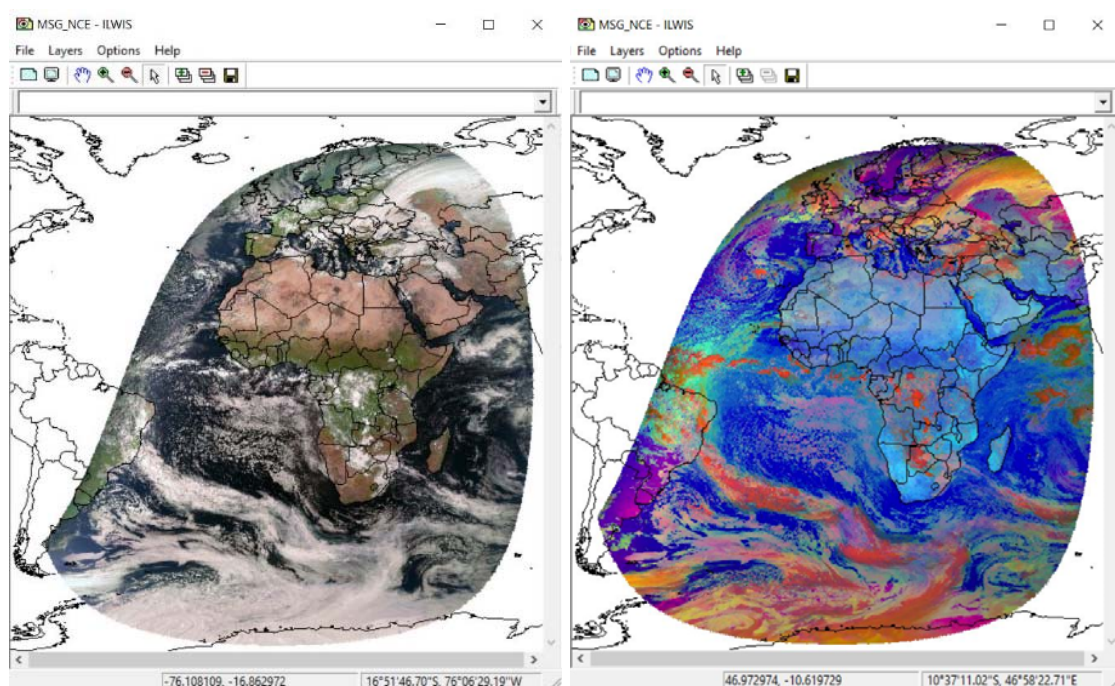
Assure you have internet access and subsequently from the “Geonetcast” and “Toolbox” main menu select the options “Other Routines” >> “EUMETView” >> “Latest EUMETSAT Images-Products” and press “Import”. Check the available near real time images and products. Review the different satellites, e.g. for Meteosat at 0 degree as RGB composite select the option ‘Natural Colour Enhanced’ and press the download button. As format select “GeoTIFF” and as extent the “full resolution product”. Uncheck the option “Overlay”. Download the image “meteosat-msg\_naturalenhncd.tif” copy it to the folder “c:\gnc\_out”.

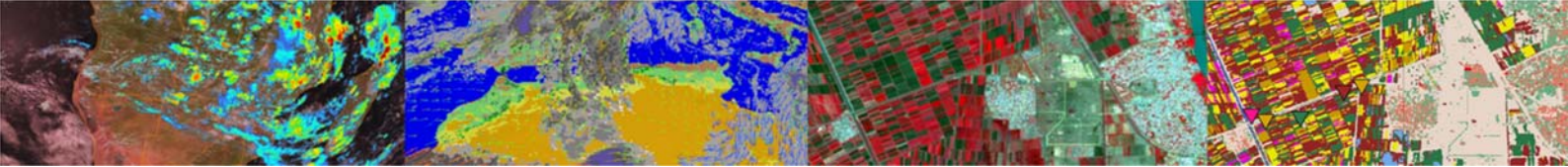
From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” >> “Folder” and specify the folder settings for “EUMETView”. Here the data is downloaded into a folder “c:\gnc\_out” and this folder is also used to store the output, so both input and output folders are identical. Press “Save” to store the settings.

In the “Geonetcast” and “Toolbox” main menu select the option “Other Routines” >> “EUMETView” >> “Import downloaded Images-Products”. Note the output directory specification and press “Import”. A script, called “EUMETView\_import” is retrieved. Study the content of the script and press the “Run Script” icon available from the menu bar. Two parameters are required and for the ‘input band name’ select the name of the downloaded file, including the extension. For the ‘output file name’ specify an appropriate name, e.g. “MSG\_NCE”, and press “OK” to execute the script.

Double click the map list icon “MSG\_NCE”, and show the map list as colour composite, “MSG\_NCE\_band\_1” as Red, “MSG\_NCE\_band\_2” as Green and “MSG\_NCE\_band\_3” as Blue and click “Apply” and “Close”. Note the coordinates and add the country boundaries. From the map window menu, select “Options” >> “No Zoom”. In a similar manner all EUMETVIEW products are at your disposal.

**Figure 4.6.1: Retrieval of EUMETView RGB Composites, examples are the Enhanced Natural Colour (left) and the Day Micro Physics (right)**





#### 4.6.2 Sentinel EO Browser

Assure you have internet access and subsequently from the “Geonetcast” and “Toolbox” main menu select the options “Other Routines” >> “Sentinel EO Browser” >> “Sentinel – Landsat, etc. Images-Products”. Press the option “Start Exploring” and navigate to your Area of Interest, select the appropriate satellite. Also other settings can be applied like cloud cover, time range, etc. Press the “Search” button. Check the available near real time images and products and make a selection of an image / product. The top left “Show Info” button provides access to the ‘Tutorial’.

Once logged in, the image / product can be downloaded, by pressing the “Download Image” button. Here a Sentinel 2 L2A image is selected. Use the options “Analytical”, uncheck the option “Show Logo”, as image format select “TIFF (32-bit float)”, image resolution is “High”, Coordinate System is “WGS 84 (EPSG:4326)”, as Layers under the option “Visualized” >> “True Color”, select from those listed under “Raw” the following layers: “B02”, “B03”, “B04” and “B08”. If all these criteria are correctly specified, press the “Download” button.

Once the image is downloaded, likely in your system ‘Downloads’ folder a file is available, called “EO\_Browser\_images.zip”. Copy this file to your output folder, here ‘c:\gnc\_out’ and unzip the file in this folder.

It is assumed that the same in - and output folders can be used. From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” >> “Folder” and specify the folder settings for “EO\_browser”. Here “c:\gnc\_out” is used for input and output folders. To store these settings press “Save”.

In the “Geonetcast” and “Toolbox” main menu select the option “Other Routines” >> “Sentinel EO-Browser” >> “Import downloaded Images-Products”. Note the output directory specification and press “Import”. A script, called “EO\_Browser\_import” is retrieved. Study the content of the script and press the “Run Script” icon available from the Script menu bar. Two parameters are required and for the ‘input band name’ select the name of the downloaded spectral band – here as example band 2, including the extension. For the ‘output file name’ specify an appropriate name, e.g. “S2\_L2A\_B2” (for band 2), and press “OK” to execute the script. Repeat the procedure for the other 3 spectral channels.

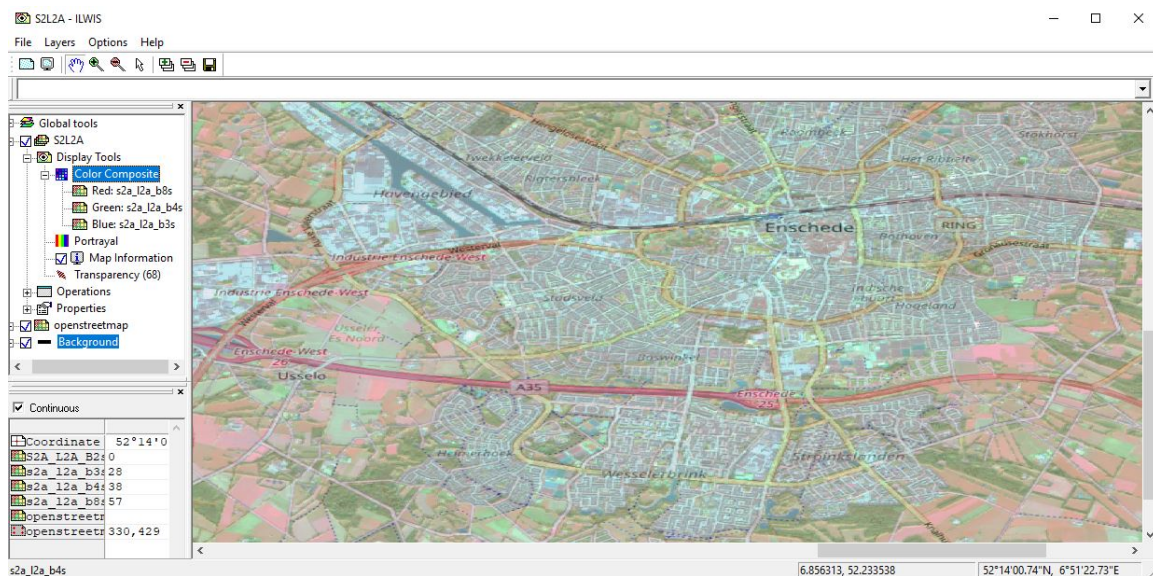
Double click the map “S2\_L2A\_B2”, and display the image using as Representation “Gray”. Move the cursor over the image and inspect the values. Note that the values represent ‘radiances’. Close the map window. In order to create an appropriate visualization, right click with the mouse button on the image “S2\_L2A\_B2” and from the context sensitive menu select the options “Image Processing” >> “Stretch”, as Output Raster Map specify “S2\_L2A\_B2s”, the other options can be kept using their default settings. Repeat above procedure for the other 3 spectral channels.

From the main ILWIS menu, select “File” >> “Create” and select “Map List”. Select the 4 stretched images in the left hand column and press “>” to move them to the right hand column. Note their sequence; band2, band 3, band 4 and band 8 from top to bottom respectively. Specify an appropriate output map list name, e.g. “S2L2A”. Double click on the newly created map list and use the “Open as ColorComposite” option. Under “Display Tools” >> “Color Composite”, select B4 as Red, B3 as Green and B2 as Blue” and press “OK” and check the true color composite. Change under “Display Tools” >> “Color Composite”, select B8 as Red, B4 as Green and B3 as Blue” and press “OK” to get a false colour composite.

From the map window menu, select “Options” >> “No Zoom”. Add the “OpenStreetMap”, use the “Add Data Layer” option from the map display window, use the drop down button next to the “Filter option” and select “Basemaps” >> “openstreetmap”. Under the left hand legend in the map display window drag the openstreetmap layer below the colour composite. Under the “Display Tools” of the colour composite, use the option “Transparency” and increase the transparency by moving the slide bar. Check the geometry of the imported image, see also the figure below.



Figure 4.6.2: Sentinel colour composite overlay on Open Street Map



### 4.6.3 Generic NetCDF-GRIB-HDF data visualization

Panoply is a Java application that allows the user to make plots of data from netCDF, HDF and GRIB datasets. Although its strength is in making longitude-latitude (map) plots, it can also make other types of georeferenced plots, including keograms and Hovmoeller diagrams; general 2D color plots; and line plots. Data arrays may be "sliced" from larger multidimensional arrays. A large selection of global map projections is available for lon-lat figures. Plot images may be saved to disk in bitmap graphic formats or in PDF.

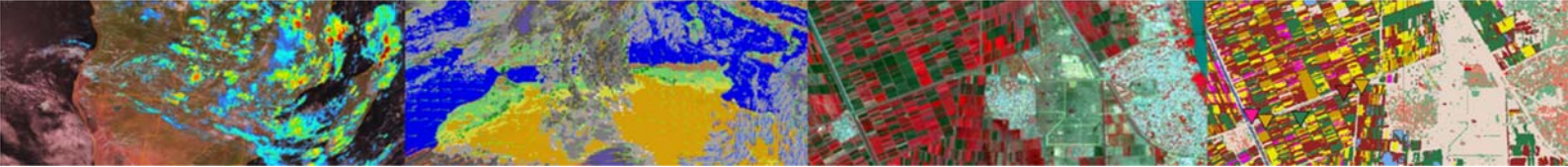
From the "Geonetcast" and "Toolbox" main menu select the option "Configuration" and "Folder" and select "Panoply". Browse to the appropriate data output directory. Here as output location "c:\gnc\_out" is used. Press "Save" to store the settings. Note that Panoply is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the "Geonetcast" and "Toolbox" main menu select the option "Other Routines" >> "Generic NetCDF-GRIB-HDF data visualization" and "Start Panoply" sub menu items and if the output directory is properly assigned, press "Import". In the Command Line Interpreter (CMD.exe) window, acknowledge the use of Panoply, developed by Robert B. Schmunk, NASA by pressing <enter> and the Panoply utility is opened.

From the main menu of Panoply, select the options "File" >> "Open", navigate to your input data folder. Use can be made here of the folder "D:\GNC\_ExerciseData\GNC\_Data\SAFWWC", under 'File name' provide the syntax "\*\*", so all entries in the folder are displayed, and now select the file "S\_NWC\_CTTH\_MSG4\_MSG-N-VISIR\_20201108T113000Z.nc". From the left hand legend, note the information provided under 'Name', 'Long name' and 'Type'. Select the layer "ctth\_alt", check the right hand meta data. Note that this file is having as 'Type' '2D', now double click the layer and "Create a 2D Plot using 'nx' for X axis and 'ny' for Y axis" and press "Create". Also make a plot of the layer "ctth\_pres", "ctth\_tempe" and "ctth\_effectiv".

Close this data set and from the folder "D:\GNC\_ExerciseData\GNC\_Data\Other\_Global\SMOS" open the file "W\_XX-ESA,SMOS,NRTNN\_C\_LEMM\_20201113002637\_20201112220158\_20201112233532\_o\_v200\_l2sm.nc". Once more check in detail the meta data provided. Visualize the data set by double clicking the layer "soil moisture" and "Create a georeferenced Trajectory Feature-Type plot". Also other plot options exist, like "Geo-2D", using the coordinate information provided.

In this way quickly different data types can be visualized which are provided within the EUMETCast data stream. For additional information on the use of Panoply, see also the help utilities available at: <https://www.giss.nasa.gov/tools/panoply/help/>.



#### 4.6.4 Generic BUFR data visualization

The Binary Universal Form for the Representation of meteorological data (BUFR) is a binary data format maintained by the World Meteorological Organization (WMO). BUFR was created in 1988 with the goal of replacing the WMO's dozens of meteorological formats, such as for surface observations, upper air soundings and monthly climatological data. BUFR was designed to be portable, compact, and universal. Any kind of data can be represented, along with its specific spatial/temporal context and any other associated metadata. In the WMO terminology, BUFR belongs to the category of table-driven code forms, where the meaning of data elements is determined by referring to a set of tables that are kept and maintained separately from the message itself.

From the “Geonetcast” and “Toolbox” main menu select the option “Configuration” and “Folder” and select “Bufdisplay”. Browse to the appropriate data output directory. Here as output location “c:\gnc\_out” is used. Press “Save” to store the settings. Note that BUFRdisplay is storing some temporary program files in the output directory, so ensure that you have the proper administration rights.

From the “Geonetcast” and “Toolbox” main menu select the option “Other Routines” >> “Generic BUFR data Visualization” and “BUFRdisplay User Guide V4.0” sub menu items and press “Import”. This ‘Help’ document provides additional information on BUFR encoded data, so if you are not familiar with this data type, consult the document carefully before you continue. Close the document.

From the “Geonetcast” and “Toolbox” main menu select the option “Other Routines” >> “Generic BUFR data Visualization” and “Start BUFRDisplay” sub menu items and if the output directory is properly assigned, press “Import”. In the Command Line Interpreter (CMD.exe) window, acknowledge the copyright of Francis Breame by pressing <enter> and the BUFR Display utility is opened.

From the BUFRdisplay window select “File” and “Open”, navigate to the GNC\_Exercise data folder “D:\GNC\_ExerciseData\GNC\_Data\MPEF\Prime\MPEF\_High\2020\11\108” and select the file: “L-000-MSG4\_-MPEF\_\_\_\_\_ -AMV\_\_\_\_\_ -000001\_\_\_\_ -202011081045-\_\_” and press “Open”. Check the various attributes that are contained within this Atmospheric Motion Vector (AMV) BUFR file under the “Data Selection” window. Note that to display the AMV data the following attributes need to be specified:

for the Latitude field:	12 Latitude (high accuracy)
for the Longitude field:	13 Longitude (high accuracy)
for Data field:	18 Wind Speed

Make sure that under “Options” >> “Display Mode” section the option: “Vector” is activated

now for Vector Direction field: 17 Wind Direction

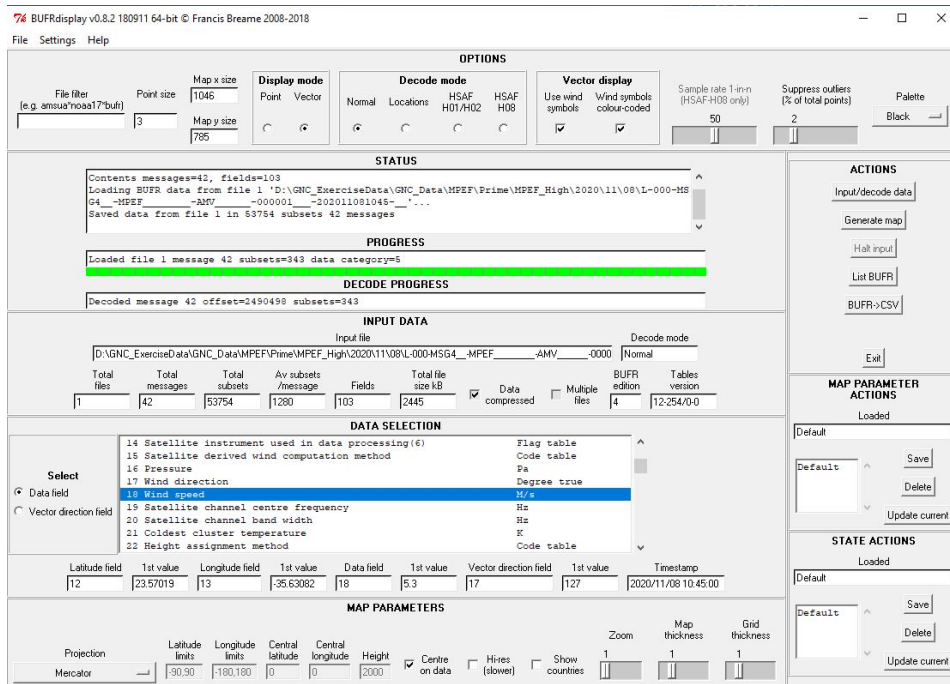
Now enter these values for the respective fields situated directly below the Data Attribute window: for Latitude field type “12”, for the Longitude field type “13”, for Data field type “18” and for Vector Direction field type “17” respectively. Note the values and the time stamp given. When the appropriate attributes are provided, press under “Actions” the option “Input/decode data” (situated on the mid-right hand side of the BUFR Display window). See also figure 4.6.3 below. After the data is decoded select again from the “Actions” the option “Generate Map” and the map window with the AMV's are displayed. Close the map and from the lower right hand part of the BUFR Display window select the option “Zoom” and enlarge the zoom factor to “5” by moving the slide bar to the right hand side using the mouse and activate the option “Show countries”, “Map thickness” of “2”. Press the option “Generate Map” again. Now use the slide bars at the right hand side and lower part of the map display window to navigate over the map. Close the map once more.

Select from the lower left hand part of the BUFR Display window the option “Projection” and now specify as projection “Stereographic”, also activate the option “Hi-res”, finally at the top right select as “Palette” “White” and press the option “Generate Map” again. Your results should resemble those presented in figure 4.6.4. After visualization close the map and to close BUFRdisplay, select from the menu “File” and “Exit”.





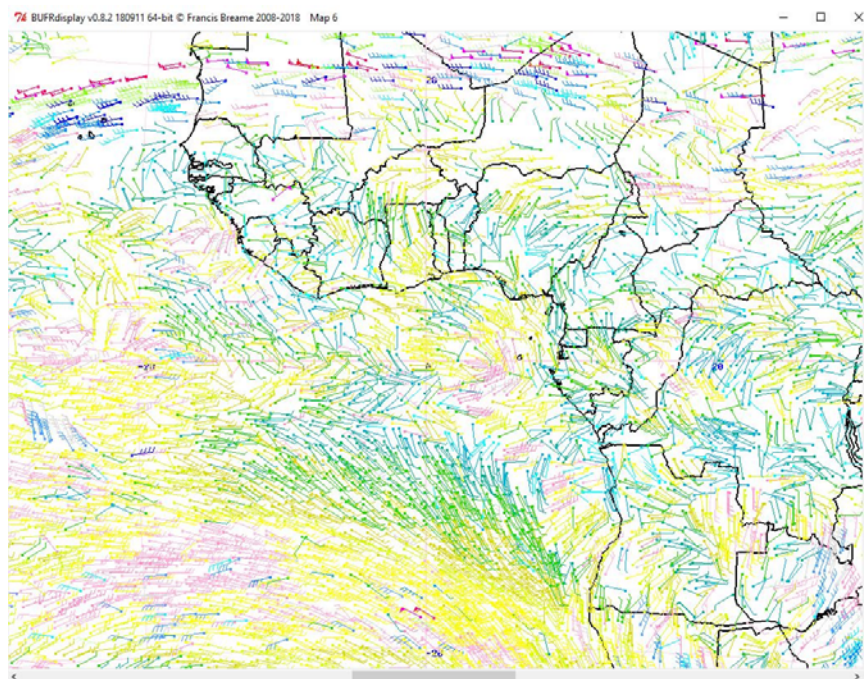
**Figure 4.6.3: BUFR Display main window using the settings to display AMV data**



Repeat the procedure and now use as input the Total Ozone product, available from the same directory. Select as input file: “L-000-MSG4\_-MPEF\_\_\_\_\_ -TOZ\_\_\_\_\_ -000001\_\_\_\_ -202011081045-\_\_” and for Latitude field type “12”, for the Longitude field type “13”, for Data field type “16”. Press under “Actions” the option “Input/decode data” and “Generate Map” respectively. Note the map displayed. Close BUFRdisplay.

In this way quickly different data layers contained in the BUFR files can be visualized which are provided within the GEONETCast-EUMETCast data stream.

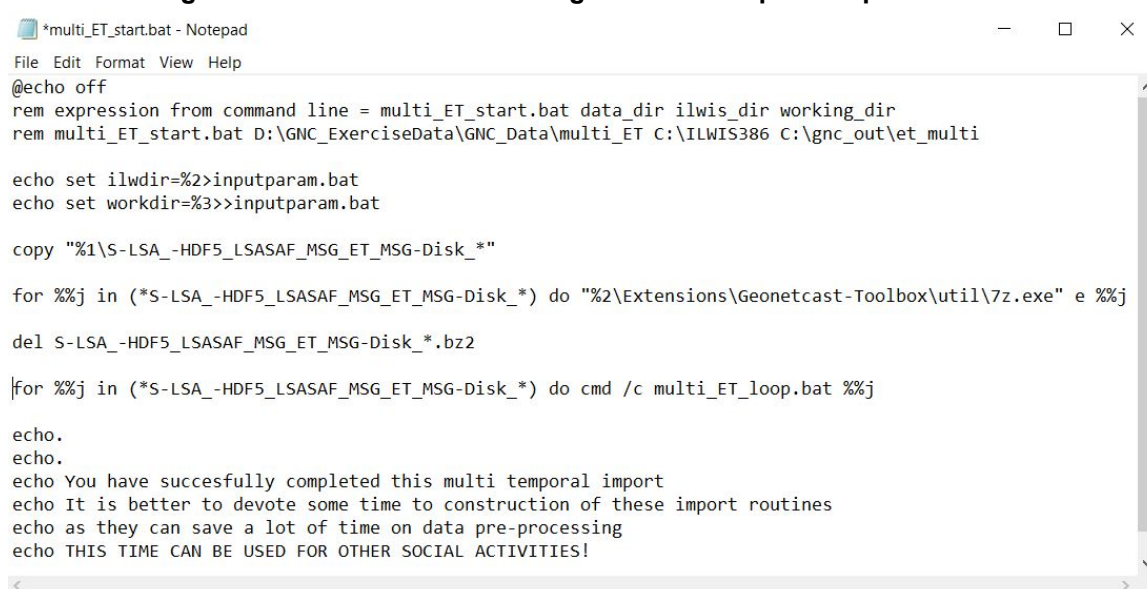
**Figure 4.6.4: AMV’s displayed in Stereographic projection over Western Africa**



#### 4.6.5 Multi temporal data import using a batch looping procedure

To import all necessary data to do a time series analysis using the Cabo Verde Toolbox menu can be cumbersome. Check the content of the folder “D:\GNC\_ExerciseData\GNC\_Data\multi\_ET” using your Windows Explorer. This folder is containing 48 half hourly ET files provided by the LSA SAF and 2 batch files, ‘multi\_ET\_start.bat’ and ‘multi\_ET\_loop.bat’. The content of these batch files is also provided in figure 4.6.5 and 4.6.6.

**Figure 4.6.5: Batch file 1 - starting the multi temporal import routine**



```
*multi_ET_start.bat - Notepad
File Edit Format View Help
@echo off
rem expression from command line = multi_ET_start.bat data_dir ilwis_dir working_dir
rem multi_ET_start.bat D:\GNC_ExerciseData\GNC_Data\multi_ET C:\ILWIS386 C:\gnc_out\et_multi

echo set ilwdir=%2>inputparam.bat
echo set workdir=%3>>inputparam.bat

copy "%1\S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_*"

for %%j in (*.S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_*) do "%2\Extensions\Geonetcast-Toolbox\util\7z.exe" e %%j

del S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_*.bz2

|for %%j in (*.S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_*) do cmd /c multi_ET_loop.bat %%j

echo.
echo.
echo You have succesfully completed this multi temporal import
echo It is better to devote some time to construction of these import routines
echo as they can save a lot of time on data pre-processing
echo THIS TIME CAN BE USED FOR OTHER SOCIAL ACTIVITIES!
```

The ‘start’ batch routine provides at the beginning, after the rem (remark) in line 2 and 3 how the batch file should be executed. It is expecting 3 parameters to execute the batch file: the Data directory, the ILWIS directory and the Working directory. Parameter 2 and 3 are stored in a new batch file that is created (parameter.bat). Subsequently the required input data is copied from the data directory specified. Next all data is unzipped using 7Z.exe (note the “for” and “do” expression) and the original zipped files are being deleted in the next command line. After this all remaining unzipped files are used as input for the second batch file (multi\_ET\_loop.bat) which is executed. The “cmd /c” is included to ensure that after all computations are finalized by the second batch file the process continues in the starting batch file. At the end a number of lines are displayed and the content is provided here.

The second batch file is given in figure 4.6.6. Note that for visualization purpose use is made here of the option “Word Wrap” of Notepad, actually if you open this batch file using Notepad you will see the expressions as single lines!

For each event which is meeting the file string criteria from the start\_batch file the loop\_batch file is executed. As we are working here with ET images having a 30 minutes temporal resolution and when processing a full day of data, the loop\_batch should be executed 48 times. Each ET input file is processed. From the file name the timestamp is extracted (having 12 digits), it is set as shortfilename1 and is displayed in the command line window. Then the parameter file, created by the batch\_start, which defines the ILWIS directory and Working directory is called and the directories are set. These are needed by the next three lines. Here the actual import of the data is done. Gdal\_translate extracts the ET layer from the HDF file and transforms it into an ILWIS format, the next line sets the georeference, taken from the Toolbox \Util subdirectory and finally a map calculation is performed to transform the data into the appropriate unit (here mm/hr). The obsolete files are then being deleted. Note that ILWIS is executed from the command prompt!



**Figure 4.6.6: Batch file 2, importing the multi temporal data**

```

multi_ET_loop.bat - Notepad
File Edit Format View Help
@echo off
echo Processing ET MSG Disk from LSA SAF in mm/hr
rem: sample file name expected = S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_202010210000

set longfilename=%1
set shortfilename1=%longfilename:~35,12%

echo.
echo Current time stamp processed = %shortfilename1%
echo.

call inputparam.bat

"%ilwdir%\Extensions\Geonetcast-Toolbox\GDAL\gdal_translate.exe" -of ilwis hdf5:"S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_
%shortfilename1%"::/ET temp_ET_%shortfilename1%

"%ilwdir%\ilwis.exe" -C setgrf '%workdir%\temp_ET_%shortfilename1%'.mpr '%ilwdir%\Extensions\Geonetcast-Toolbox\util\fcc0000'

"%ilwdir%\ilwis.exe" -C '%workdir%\MSG_ET_%shortfilename1%'.mpr{dom=value;vr=0.0000:10.0000:0.0001}:=iff('%workdir%\temp_ET_
%shortfilename1%' gt -1,'%workdir%\temp_ET_%shortfilename1%/10000,?)

del S-LSA_-HDF5_LSASAF_MSG_ET_MSG-Disk_%shortfilename1%
del temp_ET_%shortfilename1%.aux.xml
del temp_ET_%shortfilename1%.mp*
  
```

In order to start the multi temporal import, create a new folder in the directory “*c:\gnc\_out*” and use as sub-directory name “*et\_multi*”. Copy the 2 batch files (\*.bat) from the folder “*D:\GNC\_ExerciseData\GNC\_Data\multi\_ET*” into this newly created sub-directory.

Open “*ILWIS*” and navigate to the folder “*C:\gnc\_out\et\_multi*”. Close “*ILWIS*” and open “*ILWIS*” again, it should now open in the folder “*C:\gnc\_out\et\_multi*”. Leave *ILWIS* open.

You are going to use the Windows Operating System “*command.exe*” utility to run the batch files and to open the CMD command using the File Explorer to open Command Prompt Window, first navigate to your desired folder (here: “*c:\gnc\_out\et\_multi*”) and click on the location bar of Windows Explorer, then type “*cmd*” and press <enter> key. The command prompt will be opened in the folder “*c:\gnc\_out\et\_multi*”.

Check the directory content by typing “*dir*” (for directory content) and press <enter>. Verify if the two batch files are there. Now execute the ET import by typing the name of the ‘*start\_batch*’ and the three parameters on the command line (see also figure 4.6.7) and press <enter>. If the settings on your system are different then substitute these with the correct (sub-) directory names. Note the space between the batch file and the 3 parameters! Type the following expression and press <enter>:

*multi\_ET\_start.bat D:\GNC\_ExerciseData\GNC\_Data\multi\_ET C:\ILWIS386 C:\gnc\_out\et\_multi*

**Figure 4.6.7: Starting the batch processing from a CMD window**

```

Select C:\Windows\System32\cmd.exe
C:\gnc_out\et_multi>dir
Volume in drive C is System
Volume Serial Number is 7E82-DD60

Directory of C:\gnc_out\et_multi

23-11-2020 09:35 <DIR>      .
23-11-2020 09:35 <DIR>      ..
20-11-2020 16:43          948 multi_ET_loop.bat
20-11-2020 16:35          831 multi_ET_start.bat
                2 File(s)      1.779 bytes
                2 Dir(s)  56.908.505.088 bytes free

C:\gnc_out\et_multi>multi_ET_start.bat D:\GNC_ExerciseData\GNC_Data\multi_ET C:\ILWIS386 C:\gnc_out\et_multi
  
```

After the batch routines have started, keep following the messages displayed in the command line window, each time you will be notified that a new time step is being processed. When the batch routine has finished, activate *ILWIS* and update the *ILWIS* Catalogue. You will note that all 48 files are

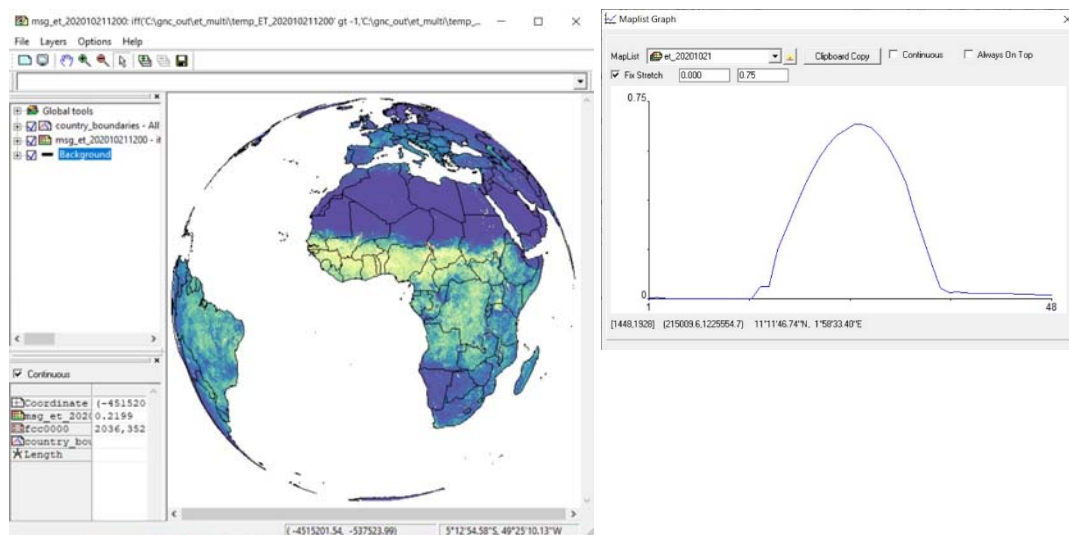


now available as raster maps. From the main ILWIS menu, select “File”, “Create” and select “Map List”. Select all 48 ET half hourly files in the left hand column and press “>” to move them to the right hand column. Specify an appropriate out map list name, e.g. “ET\_20201021” and press “OK”.

Right click with the mouse the Map List and select the option “Open as Animation”. Under “Display Tools” activate the option “Histogram”. Once all histograms are calculated close the map window and open it once more. Use as Representation “Spectral\_inv” and add the country boundaries, now “Run” the animation. Once the animation has looped a number of times, stop the animation. Note the changes in ET over the day and over the full MSG disk. Close the animation.

Eventually create a map list graph to get a better impression of the ET over the day at a number of locations. Open from the map list the layer “msg\_et\_202010211200”. Now from the ILWIS main menu, select: “Operations”, “Statistics”, “MapList” and finally “MapList Graph”. Select as “MapList” “ET\_20201021”. Activate the option: “Fix Stretch”, select as minimum “0” and as maximum “0.75”. Also activate the options “Continuous” and “Always On Top”. Note that the X-axis of the graph represents the 48 layers. Move the mouse cursor over the map (it might have disappeared under the main ILWIS window!) and check the corresponding Index values in the graph for a given pixel over the whole profile depth. Your results should resemble those of figure 4.6.8.

**Figure 4.6.8: ET layer of 12:00 UTC and changes of ET over the day for a pixel over Northern Ghana**



To compute the ET over the day, the map list has to be aggregated and the sum has to be calculated. As we have half hourly time steps and as unit mm/hr the obtained ‘sum’ map has to be divided by 2! Before you can perform this operation, first the ‘undefined’ or no data pixels have to be considered. There is an issue of a missing segment in one of the files and for some pixels, during the day no ET could be derived. These no-data pixels are going to be assigned to “0” first.

From the ILWIS main menu, select the options “Operations” >> “Raster Operations” >> “MapList Calculations”. Enter the following Expression: `ifundef(@1,0.00000)`, specify “1” Input MapList, and as MapList @1 select “ET\_20201021”, as Output MapList type: “et\_cor0” and press “Show”. Wait till the calculations are finished.

Now from the ILWIS main menu, select the options “Operations” >> “Statistics” >> “Maplist” >> “MapList Statistics”, as MapList select “et\_cor0”, as Statistics Function “Sum” and as Output Raster Map specify “et\_sum\_day” and press “Show”. Close the map.

As final step the oceans are going to be assigned “undefined” or no-data again and a unit correction is applied as the initial data is in mm/hr for each half hourly time step. Type the following expression on the command line in the main ILWIS menu and press “OK”:

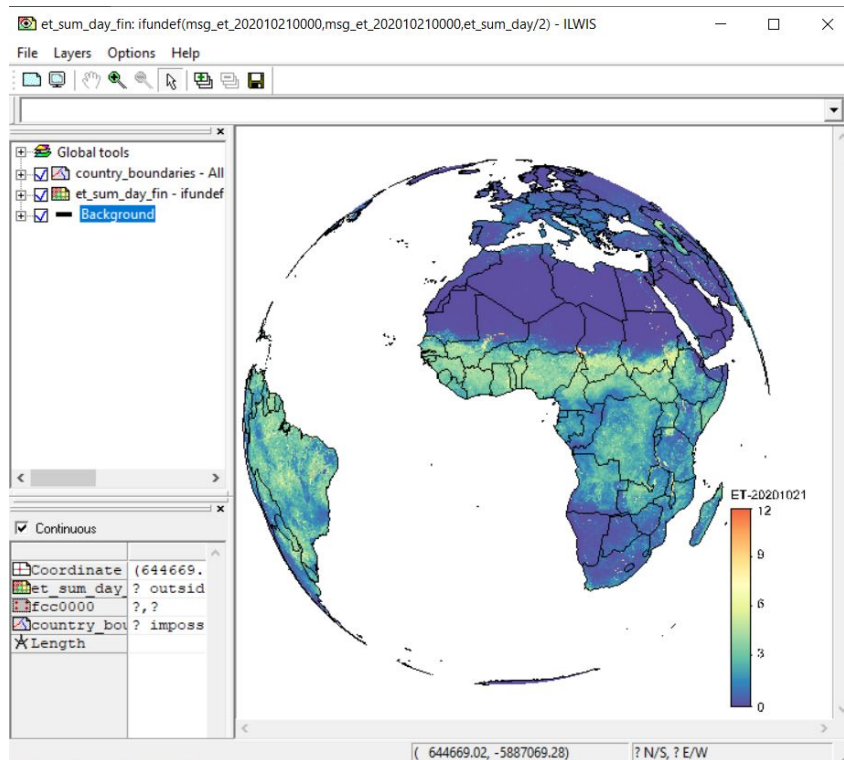


```
et_sum_day_fin:=ifundef(msg_et_202010210000,msg_et_202010210000,et_sum_day/2)
```

Display the map `et_sum_day_fin`, use as Representation “Spectral\_inv” and check the values. See also the figure below.

Note that the ILWIS map list calculator is a very efficient utility to perform calculations using time series. A single expression is executed over all the layers contained within the map list. The Map List Statistics function subsequently can be applied to aggregate the values using a number of functions, like ‘sum’, ‘avg’ or ‘std’ or select the ‘minimum’ or ‘maximum’ over the time series.

**Figure 4.6.9: Aggregated ET for 20201021 using the map list calculation – statistics functionality**

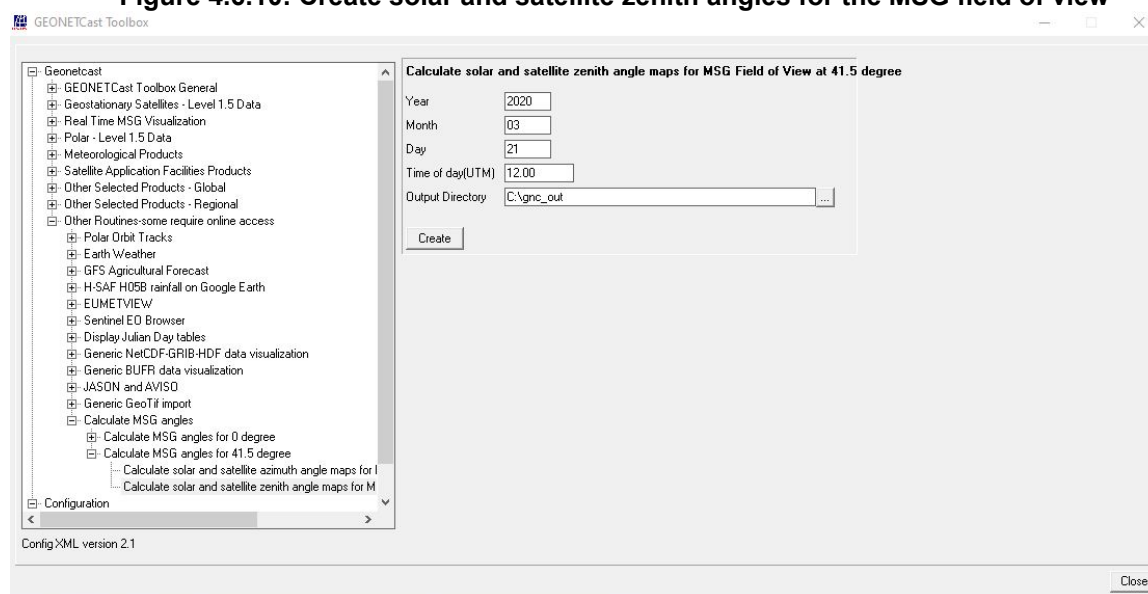


#### 4.6.6 Calculate MSG and solar zenith – azimuth angles

In order to derive the satellite viewing and solar angles for the MSG field of view select from the “Geonetcast” and “Toolbox” main menu the option “Configuration” and “Folder” and select “Calculate MSG angles”. Browse to the appropriate data output directory. Here as output location “c:\gnc\_out” is used. Press “Save” to store the settings. Satellite and solar zenith and azimuth angles can be obtained for the MSG field of view for MSG at 0 degree (or RSS) and at 41.5 degree.

From the “Geonetcast” and “Toolbox” main menu select the option “Other Routines” >> “Calculate MSG angles” >> “Calculate MSG angles for 41.5 degree” >> “Calculate solar and satellite zenith angle maps for the MSG Field of View” and specify the settings as given in the figure below for 21 March 2020 at 12:00 UTC, when the sun is above the equator and press “Create”.

Figure 4.6.10: Create solar and satellite zenith angles for the MSG field of view

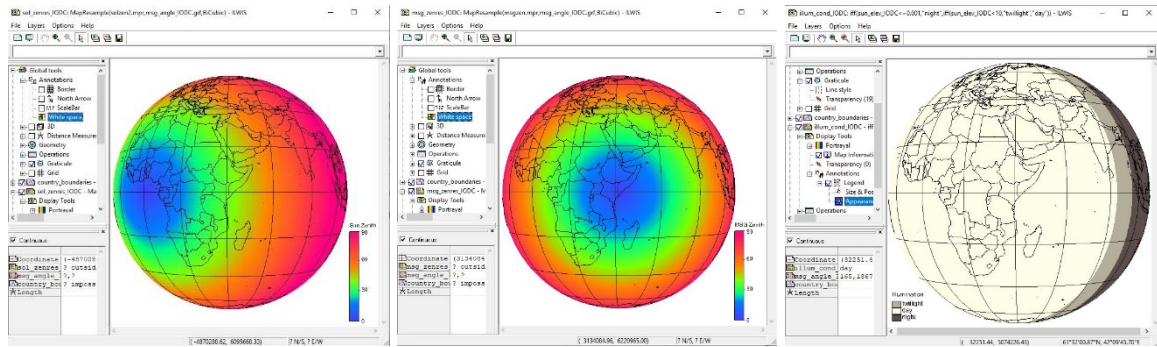


When the operation has completed, open the maps “msg\_zenres\_IODC” and “sol\_zenres\_IODC”. Note that also other maps are being created like “illum\_condition\_IODC” and “sun\_elev\_IODC”. Most maps can be displayed using a “Pseudo” Representation, as the “illum\_condition\_IODC” is a classified map, use the default Representation. From the “Global tools” under the map legend active the option “Graticule”, you can keep using a default Graticule distance of 20 degree, also add the country boundaries. Move the mouse, keeping the left mouse button pressed, over the map and inspect the values representing the respective angles. Also the secant of the MSG and sun angle are calculated, open the files “sec\_msgzen\_IODC” and “sec\_solzen\_IODC”, use again a “Pseudo” Representation.

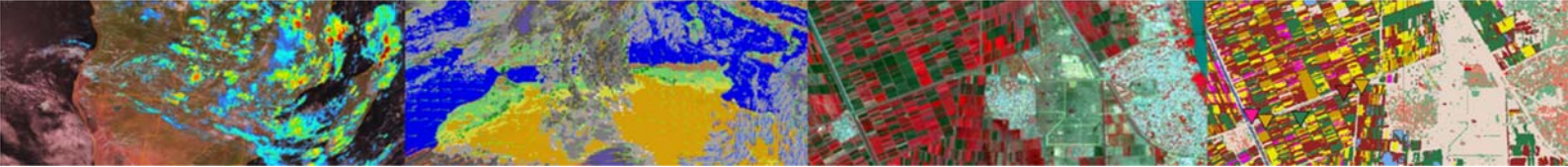
Your results should resemble those of figure 4.6.11. Note that also the azimuth angles of the sun and satellite can be derived using the other option from the menu.



**Figure 4.6.11: MSG at 41.5 degree zenith (left) and solar angles (middle) and illumination conditions (right) for 20200321 at 12:00 UTC**



MSG-IODC is situated over the equator at 41.5 degree and at this given moment the sun is also situated over the equator given the 12:00 UTC time stamp used.



## APPENDICES

### Appendix 1: Other freeware utilities that can be used in conjunction with ILWIS 3.8.6

#### For ILWIS:

Check eventual updates:

of software <http://filetransfer.itc.nl/pub/52n/ILWIS386/Software/>

and documentation: <http://filetransfer.itc.nl/pub/52n/ILWIS386/Tutorial/> or at:

<https://52north.org/software/software-projects/ilwis/>

#### For Altimeter Data:

Basic Radar Altimetry Toolbox: [http://www.altimetry.info/html/data/toolbox\\_en.html](http://www.altimetry.info/html/data/toolbox_en.html) or

[http://earth.esa.int/brat/html/data/toolbox\\_en.html](http://earth.esa.int/brat/html/data/toolbox_en.html)

#### For Satellite Tracking software:

Nova for Windows: <https://www.nlsa.com/>

WXTRACK (by D. Taylor): <http://www.satsignal.eu/software/wxtrack.htm#DownloadWXtrack>

#### For more Marine Applications and Processing:

BILKO, supported by UNESCO, BILKO is available from homepage:

<http://www.noc.soton.ac.uk/bilko/>

#### For Generic NetCDF-GRIB-HDF data visualization – Panoply:

For quick visualization of NetCDF-GRIB-HDF encoded files in the GEONETCast data stream, developed by Dr. R. Schmunk: <https://www.giss.nasa.gov/tools/panoply/>

#### For visualization and export of BUFR encoded data – BUFR Display:

For quick visualization of (multiple) BUFR encoded files in the GEONETCast data stream, developed by F. Bream: <http://www.vf0123.btinternet.co.uk/> or <http://www.elnath.org.uk/>

#### For statistical computing:

R is a language and environment for statistical computing and graphics and is available from the R-Project homepage: <http://www.r-project.org/>

#### For Picture visualization and animation:

Irfanview Graphic Viewer: <https://www.irfanview.com/>



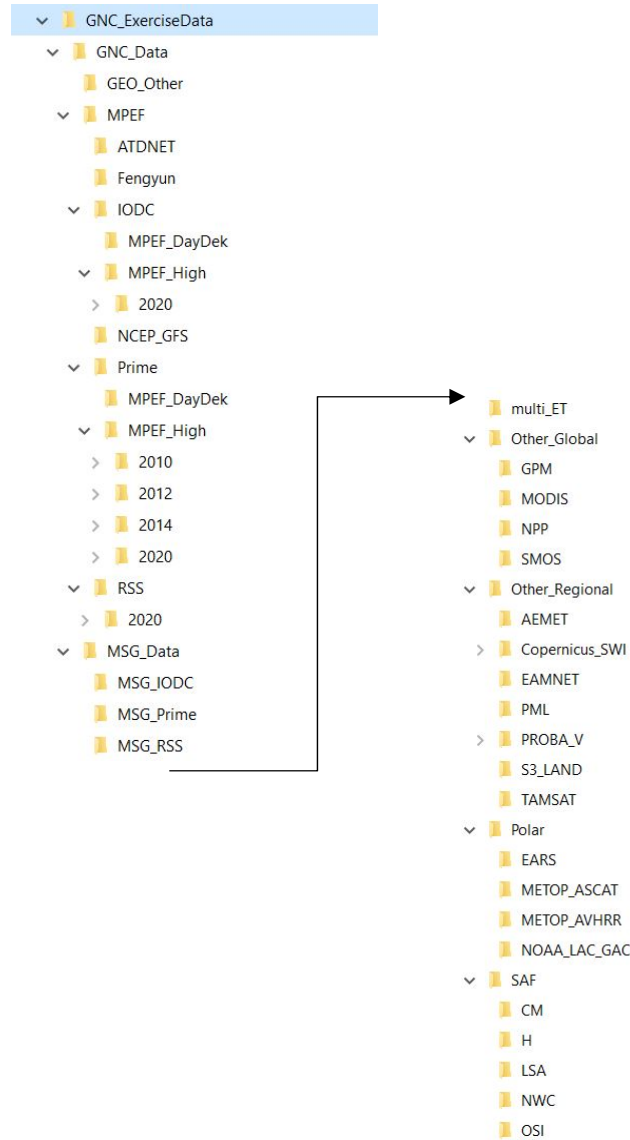


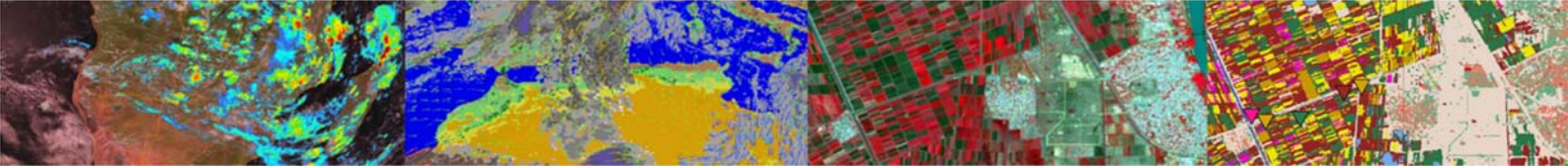
## Appendix 2: Structure of the sample data on the ITC File Transfer server

Note the sample data can be downloaded from: [http://filetransfer.itc.nl/pub/52n/gnc\\_exercisedata/](http://filetransfer.itc.nl/pub/52n/gnc_exercisedata/). Note that some zip files provided are large; you need appropriate bandwidth to download the files.

In the figure below the data directory structure is provided to execute the exercises according to the instructions provided. It is assumed that the data is stored on the D:\ drive.

**Figure: Directory structure for the exercises**





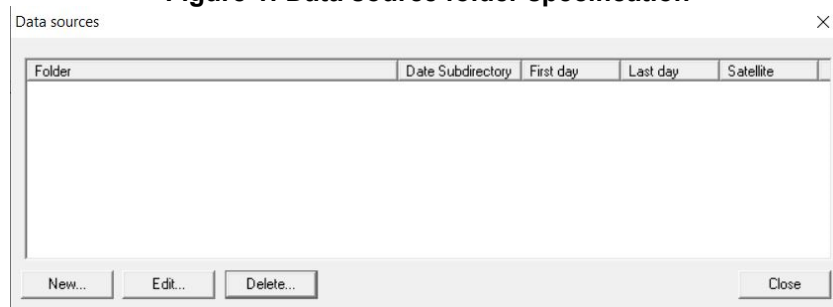
### Appendix 3: MSG Data Retriever settings for exercise 4.1

Follow the steps to set the appropriate source folder location for the MSG sample data provided for the exercises in chapter 4.

In order to import data from MSG, open the “*Geonetcast and Toolbox*” tabs from the main menu and select “*Geostationary Satellites – Level 1.5 Data*” >> “*MSG4(Prime)-0, MSG3(RSS)-9.5, MSG1(IODC)-41.5 Deg East*” >> “*MSG All*” and “*Start MSG Data Retriever*”.

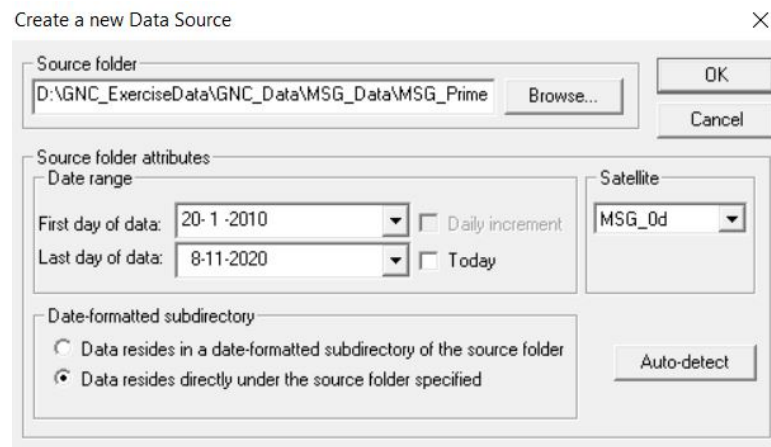
From the Data Retriever Menu, select the option “*File*” and from the popup menu the option “*Data Sources..*” The data sources menu is opened; see also figure 1. In case there are already data source folders specified delete these, using the “*Delete*” button.

**Figure 1: Data source folder specification**



To define the appropriate data source for the MSG-0 Degree sample data provided, select as Satellite “*MSG\_0d*”, press the “*Create*” button, to create a new data source. Use the browse button and move to the appropriate folder, here “*D:\GNC\_ExerciseData\GNC\_Data\MSG\_Data\MSG\_Prime*”. Note that the data is directly residing under the source folder, not in a date formatted structure as only a few sample images are provided. When pressing the “*Auto-detect*” button, the “*First day of data*” will be ‘20 January 2010’ and “*Last day of data*” will be assigned as ‘8 November 2020’. Check the specifications as given in figure 2 below.

**Figure 2: Create a new source folder to specify the location of the MSG-Prime sample data**



Repeat this procedure also for the other 2 ‘Satellites’, the “*MSG-IODC*” and the “*RSS*” to create the appropriate settings for the source folders. Note the source folders and the Date range for MSG-IODC is for 20201020 only and for the RSS from 20201018 to 20201020. See also the folder specifications in the figure 3 below.



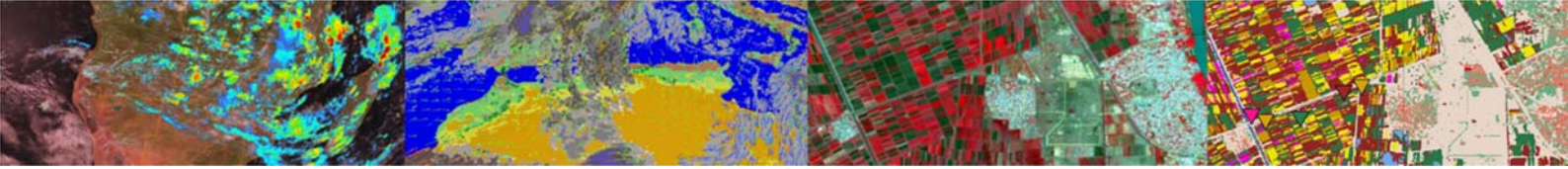
**Figure 3: Data Source folder specifications for the MSG satellites**

Data sources ×

Folder	Date Subdirectory	First day	Last day	Satellite
D:\GNC_ExerciseData\GNC_Data\MSG_Data\MSG_Prime\	No	20-01-2010	08-11-2020	MSG_0d
D:\GNC_ExerciseData\GNC_Data\MSG_Data\MSG_IDDC\	No	20-10-2020	20-10-2020	MSG_41.5d
D:\GNC_ExerciseData\GNC_Data\MSG_Data\MSG_RSS\	No	18-10-2020	20-10-2020	MSG_RSS

< >

New... Edit... Delete... Close



## **Appendix 4: Change logs for the various Cabo Verde Toolbox XML versions**

### **Change Log Cabo Verde Toolbox XML version 2.1**

As this is the first release of version 2 which is providing a major update as with respect to the previous XML 1.X versions, no log file is currently applicable.

### **Change Log Cabo Verde Toolbox XML version 2.2**

Routines have been added to import relevant environmental data from online archives, like GSOD in situ meteorological observations, climate data and model output from the Copernicus climate data store (ERA-5), GEOS-5 Land, GLDAS-Noah and Power – Agro climatology. Also a routine has been added to retrieve and process the GPM IMERG Final Precipitation product. Some of these online archive require free registration and the routines developed require User Name and Password before products are downloaded.



## **Appendix 5: Utilities available at the ITC GEONETCast web pages**

Further information and documents are posted on: <https://www.itc.nl/about-itc/organization/scientific-departments/water-resources/geonetcast/>.

Various documents and links are presented here providing further information on tools and utilities which can be consulted to establish a reception station and for geo-spatial data analysis and processing.