GlobWetland Africa Toolbox
Software User Manual

Version 2.0

Date: 24/04/2022

CHANGE RECORD

Date	Page(s)	Description of Change	Release
23-05-2017	17	Template	v1.00
08-06-2017	30	Release of first draft for GW-A Toolbox, version 1.2 (beta)	v1-1
20-02-2018	32	Final version for first official toolbox release, version 1.3	v1-2
-	32	Temporary working versions	v1-3, v1-4
20-03-2019	31	Version submitted with final toolbox release, version 1.5	v1-5
24-04-2022	25	Version for toolbox update to QGIS 3.16	v2-0

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Contents

1   Background

GlobWetland Africa is a large Earth Observation application project funded by the European Space Agency (ESA) in partnership with the African Team of the Ramsar convention on wetlands. The project is initiated to facilitate the exploitation of satellite observations for the conservation, wise-use and effective management of wetlands in Africa and to provide African stakeholders with the necessary Earth Observation (EO) methods and tools to better fulfil their commitments and obligations towards the Ramsar Convention on Wetlands.

As a principal objective GlobWetland Africa is developing and demonstrating an open source and free-of-charge software toolbox for the end-to-end processing of a large portfolio of EO products and the subsequent derivation of spatial and temporal indicators on wetland status and trends.

GlobWetland Africa (GW-A) is building on the legacy of its two GlobWetland precursors by further developing tools and products to effectively use the most up to date, open and free satellite data, primarily from the Sentinel missions, to address wetland conservation and management from a local, national and regional river basin perspective with a continental focus, being centered in Africa. The ultimate objective is to help African stakeholders (i.e. Ramsar Contracting Parties, Ramsar regional initiatives and African river basin authorities, etc.) and international/regional conservation agencies active in Africa to better assess the conditions of the wetlands under their areas of jurisdiction/study, and better monitor their trends over time.

1.1   Scope and objectives

The first part of this document provides the necessary information for installation and configuration of the GW-A Toolbox, while the second part of the document describes the system architecture and development including information on system customization and adaption/scalability. This document is accompanied by a Training Kit providing background presentations, a step-by-step tutorial and a tutorial data set designed to help the users become familiar with the features and capabilities of the GW-A Toolbox.

1.2   Development team

The GW-A Toolbox has been developed by a project consortium of Earth observation and ecosystem management experts including companies, research laboratories and universities that have hands-on experiences in EO satellite technology applied to ecosystem mapping and monitoring, development of related EO and GIS processing tools as well as a proven track record of successful projects related to EO applications in the field of wetland inventorying, mapping and monitoring in Africa. The project consortium consists of the following partners:

DHI GRAS is specialised in the development and provision of earth observation, satellite image processing and Geographic Information Systems technologies. DHI has a strong background in remote sensing for hydrology, water quality, environmental assessment and land cover mapping. DHI works closely with universities, research institutions and commercial partners in order to develop innovative and cost effective applications that can be applied in a range of different projects.

More information on DHI GRAS is available at the company's website: http://www.dhi-gras.com

GeoVille Information Systems is dedicated to the complete range of value added geographic information services in the land domain with special reference to environmental applications, including water related information solutions. The group provides products, services and consultancy in the field of digital information systems and 5pecializes in remote sensing and GIS applications.

More information on GeoVille is available at the company's website: http://www.geoville.com

Previous versions included input and support from:

The **Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente** is a multidisciplinary scientific institute specialising in research and education in earth observation and geo-information science for the understanding, monitoring, predicting and sustainable use and management of natural resources. The Department's mission is the sustainable management and meeting of societal needs from the green cover (biosphere) by applying and developing geo-information, earth observation and spatio-temporal analytical tools

More information on ITC is available at the institutes website: https://www.itc.nl/

Brockmann Consult GmbH (BC) has its expertise in turning environmental raw data into information products. Satellite observations, in-situ measurements and numerical model simulations are combined to provide status assessment and forecasts of physical or biogeochemical indicators. A wide range of applications is addressed and includes, for example, monitoring the eutrophication of national coastal waters, assessment of biodiversity in inland waters or mapping and monitoring of the UNESCO World Heritage Wadden Sea area.

More information on BC is available at the company´s website: http://www.brockmann-consult.de/

DTU ENVIRONMENT - The Department of Environmental Engineering, (ENV) is a department at the Technical University of Denmark (DTU ENV) aiming at developing technical and sustainable solutions to minimize the impact of society on the environment. The research agenda is focused on monitoring and modelling of large-scale water resources systems using ground based and space-borne geophysical sensors. Specific research interests are the use of geophysical and remote sensing methods for hydrological monitoring and modelling, as well as integrated water resources management.

More information on DTU ENV is available at the department's website: http://www.env.dtu.dk/

Getting Started

2 GW-A Toolbox Installation and Configuration

2.1 Introduction

The GW-A Toolbox is structured around a single GUI controlling a number of extension components that expand its core functionality. This allows the toolbox to cover the required capacity for integrated EO processing and GIS analysis to support wetland monitoring. QGIS has been chosen as the central integrating platform due to its clear and accessible GUI and strong development community. The integrated core components of the GW-A Toolbox are: GRASS GIS and SAGA GIS (large toolboxes of raster and vector analysis algorithms), SNAP Toolbox (processing of optical and radar ESA data products including Sentinel satellite data), Orfeo Toolbox (high resolution image processing) and R and Python scripts (advanced spatial statistical analysis). All of these Open Source (OS) software components have been integrated into QGIS using the Processing toolbox and provide the users with a unique diversity of functionalities for image processing and spatial analysis, including customized plugins and workflows that have been developed in response to the user requirements for products and tools to support wetland status and trends assessments.

2.2 System Requirements

There are no minimum system requirements for using the GW-A Toolbox. The software itself is compatible with 64-bit computers equipped with Windows operating system, from Windows 7 to Windows 10. However, the system performance depends on the size of the raster and vector data sets that are to be analysed and the computational complexity of the analysis tasks to be performed. Therefore, the following system specification (or better) is recommended for optimal use of the software:

CPU:	Intel Core i5-3570 Processor (Quad Core, 3.40GHz)
Memory:	16GB (2X4GB) 1600 MHz DDR3 Non-ECC
Disk Space:	1TB 3.5inch Serial ATA III (7.200 Rpm) Hard Drive
Display:	1024 x 768 resolution or higher, 24 bit colour depth
Video Card:	1GB AMD Radeon HD 7570
Operating System:	Windows 7 or higher (64 bit)

2.3 Semi-automatic installation

GW-A Toolbox version 2.0 comes with a wizard-like utility which will guide you through the installation process by starting the installers of the toolbox component software in the required order and automatically performing the post- and pre-installation tasks.

The installation utility is called **installer.exe** and is located in the same directory as this document. It is recommended to keep all the default settings throughout the installation process.

Please read the following points carefully in order to achieve smooth installation of the toolbox:

1. It is recommended to uninstall all components of previous toolbox software installations before installing a new version. Please see the next section for details. Note that old QGIS plugins will be removed during the installation (e.g. Processing and Processing Workflows). Therefore, take a backup of any customized models, scripts or workflows residing within those plugins' directories.

2. Some computers are configured with quite restrictive security settings which might cause problems when files are copied during installation. Therefore, it is strongly recommended to run installer.exe as an Administrator. To do this, right click on installer.exe and select "Run as administrator" from the drop-down menu.

3. Some error messages might pop-up during the first step of installation ("Install OSGeo4W"). They can be safely ignored and should not impact the functionality of the toolbox.

4. If some software components are missing or not working properly after the installation then please refer to section 3.1 *Troubleshooting*.

2.4   Uninstalling previous version of GW-A Toolbox

If you are updating from a previous version to GW-A Toolbox 2.0, or if you have some of the software components already installed, it is recommended to uninstall them in case they interfere with the installation or operation of GW-A Toolbox 2.0.

Uninstalling QGIS, GRASS, Orfeo Toolbox (OTB) and Python

QGIS, GRASS, OTB and Python are installed using the OSGeo4W installer and do not have an uninstallation utility. To uninstall those, simply delete the entire OSGeo4W folder, usually located in **C:\OSGeo4W** or **C:\OSGeo4W64**, any desktop icons related to the software or OSGeo4W and the OSGeo4W folder in the Windows Start Menu.

If you have previously installed QGIS 3.x then rename or delete folder **C:\Users\gwauser\AppData\Roaming\QGIS\QGIS3.** NB: any script and workflow customizations and installed plugins are contained in this folder, so consider making a backup.

Uninstalling other GW-A Toolbox software components

The other software can be uninstalled from the Windows Control Panel. In the Control Panel select Add or Remove Programs if you are using Windows XP or Programs and Features if you are using newer Windows versions. In the list of installed programs find and uninstall (if they are present) the following software:

QGIS 2.x / 3.x

SNAP

R

Uninstalling unused GW-A Toolbox software:

The software listed below were used by previous versions of GW-A Toolbox but since version 2.0 are no longer required. If you do not use this software for any other purpose apart from GW-A Toolbox then you can uninstall it to save disk space:

PostGIS

PostgreSql

SWATEditor

MWSWAT

MapWindow

TauDEM

BEAM

2.5 Manual installation

If for some reason you cannot use the semi-automatic installation utility (see section above), follow the instructions below to install the GW-A Toolbox manually. Read the instructions provided below carefully and proceed gradually with the installation of the various software components. All the software components are located in the following folder on the installer: GWA_InstallationPackage_x64_2.0\Installations_x64

Note: The GW-A Toolbox only installs on 64-bit computers.

Installing QGIS, GRASS, Orfeo Toolbox (OTB) and Python using OSGeo4W installer

- Run **osgeo4w-setup.bat**

- Reboot the computer if prompted

Installing SNAP Toolbox

- Run **esa-snap_sentinel_windows-x64_8_0** leaving all the default options.

- Configure snappy (the SNAP Python interface) by running snappy_conf.bat and passing to it the paths to the OSGeo4W Python installation and OSGeo4W Python libraries. If you left the default options, then the command should be as follows: *C:\Program Files\snap\bin\snappy-conf.bat C:\OSGeo4W64\bin\python-qgis-ltr.bat C:\OSGeo4W64\apps\Python37\lib\site-packages*

- The amount of heap space (RAM memory) available to SNAP Toolbox can be set by editing the *gpt.vmoptions* file. If you left the default options it should be in the *C:\Program Files\snap\bin* directory. Right click on the file, select edit and set the –*Xmx* option to the desired number (e.g. for 6000 megabytes of RAM set the option to –*Xmx6000M*). Sometimes, due to Windows security settings, it is not possible to save the modified *gpt.vmoptions* file. In this case make a copy of *gpt.vmoptions* on the desktop, modify it there and then copy back to the original folder overwriting the existing *gpt.vmoptions*. Also, you need to modify snappy.ini file and set java_max_mem field. If you left the default option, then it should be in the *C:\OSGeo4W64\apps\Python37\lib\site-packages\snappy* directory.

- Copy all the directories from "**SNAP additional modules**" to the SNAP installation directory. If you left the default option, then it should be *C:\Program Files\snap.*

- Start SNAP, in the main menu select *Tools > Options, go to S3TBX tab* and tick the box next to *Read Sentinel-3 OLCI products with per-pixel geo-coding instead of using tie-points.*

Installing R

- Run **R-3.3.3-win.exe** leaving all the default options.

Installing and setting up QGIS plugins

- Extract the zip archives *models_and_workflows, rlibs* and *scripts* in "**QGIS additional software**" directory into
  "*C:\Users\your_users_name\AppData\Roaming\QGIS\QGIS3\profiles\default\processing*" directory, remembering to change *your_user_name* in the path to the actual user name. If the directory does not exist, create it. Otherwise overwrite any files and directories already present if asked.

- Extract the zip archive *python_packages* in "**QGIS additional software**" directory into
  "*C:\OSGeo4W64\apps\Python37\lib\site-packages*" directory. Overwrite any files and directories already present if asked.

- Copy the content of *plugins* folder in "**QGIS additional software**" directory into
  "*C:\Users\your_user_name\AppData\Roaming\QGIS\QGIS3\profiles\default\python\plugins*" directory, remembering to change *your_user_name* in the path to the actual user name. If the directory does not exist, create it. Otherwise overwrite any files and directories already present if asked.

- Start QGIS Desktop

- Select *Plugins > Manage Plugins…*from the main menu, find the *QuickMapServices Plugin, Processing, Processing BEAM and SNAP algorithm Provider, Processing R Provider*, *Processing Workflows, LecoS* and *ThRasE* plugins in the list and tick the boxes next to them – when finished click Close.
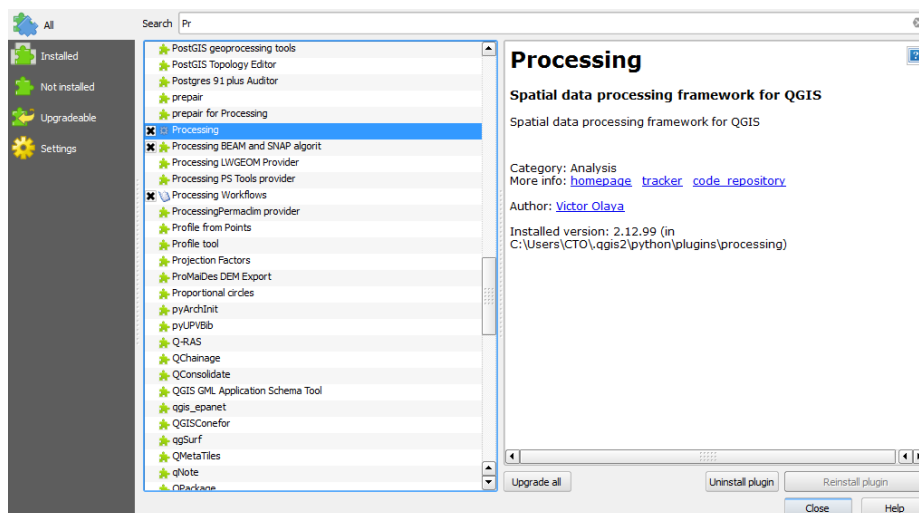
- If you need to modify any Processing options they can be accessed from the main menu: *Settings > Options > Processing.* Under the *Providers* section you need to activate GRASS, OTB, SAGA, R, SNAP, and GWA TBX collection under Workflows providers. You also need to set the path to the OTB, SNAP and R and installation directories.

- Restart QGIS

3   Basic usage instructions

Regardless of the installation method QGIS provides the user interface to all of the GW-A Toolbox software components. Clicking the GlobWetland Africa icon on the main QGIS task bar will open toolbox dialog containing all the processing workflows. Individual software components' functions can be accessed by opening the *Processing Toolbox*. It is accessible from the QGIS main menu under *Processing > Toolbox.*
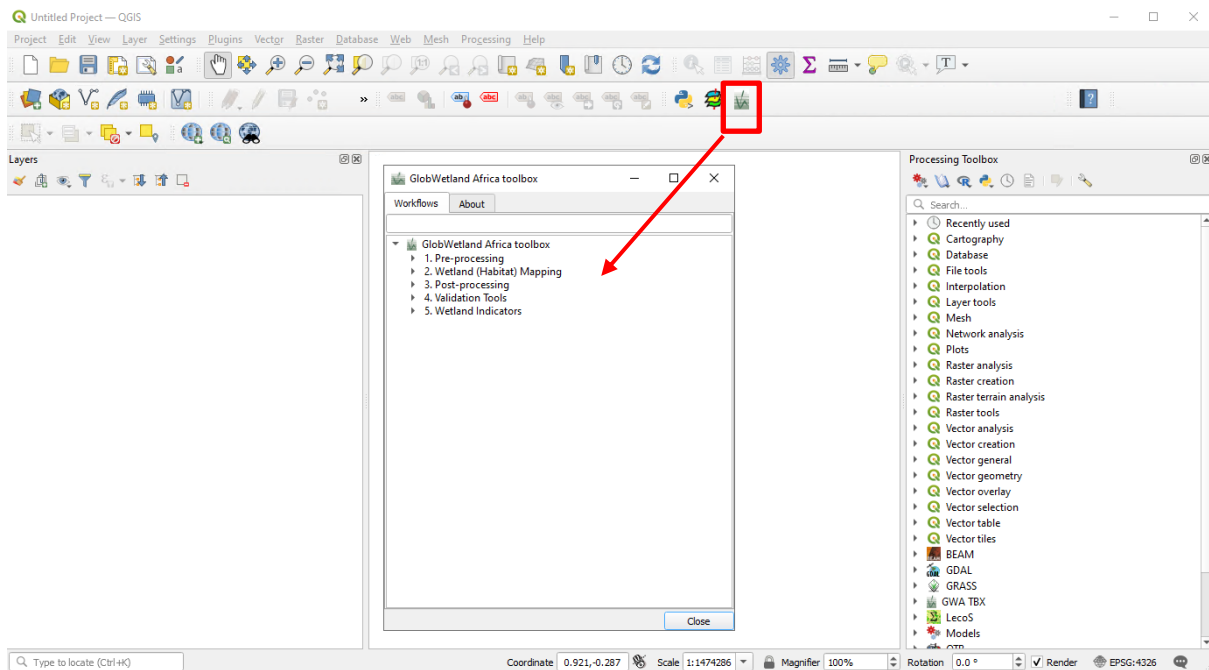
A workflow can be started by selecting it from the list and double clicking:
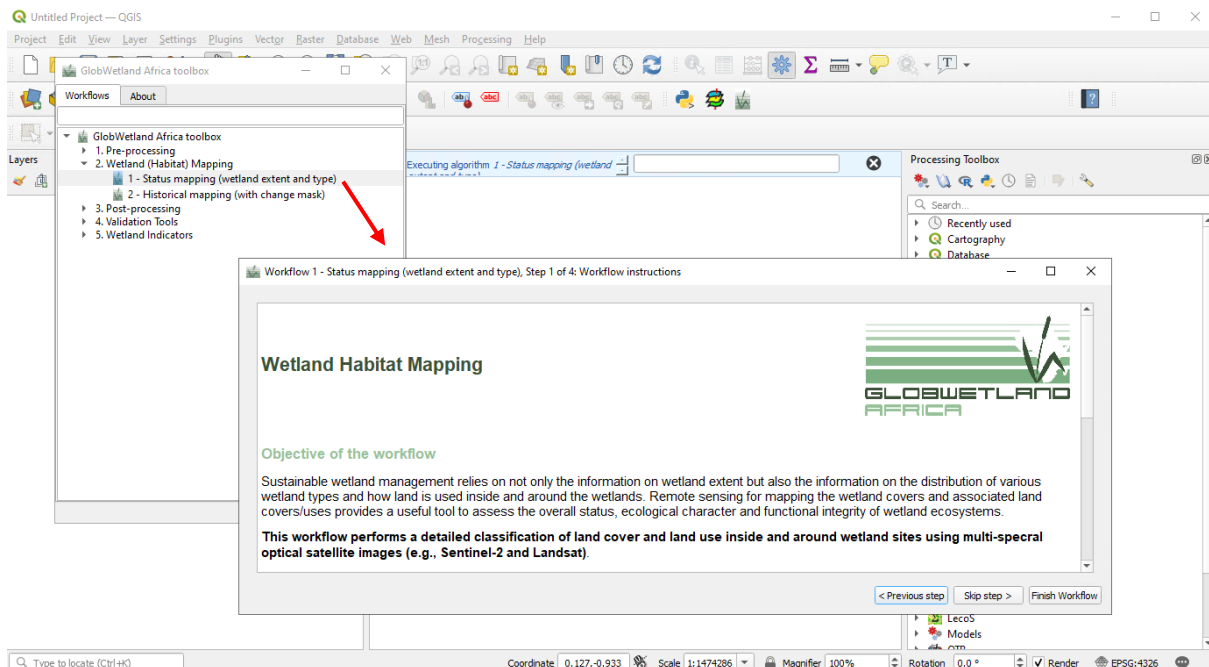
Any encountered errors will be available from the Log Messages Panel. In QGIS Go to:

View > Panels > Log Messages or simply click on the 🗨 icon in the lower right corner:
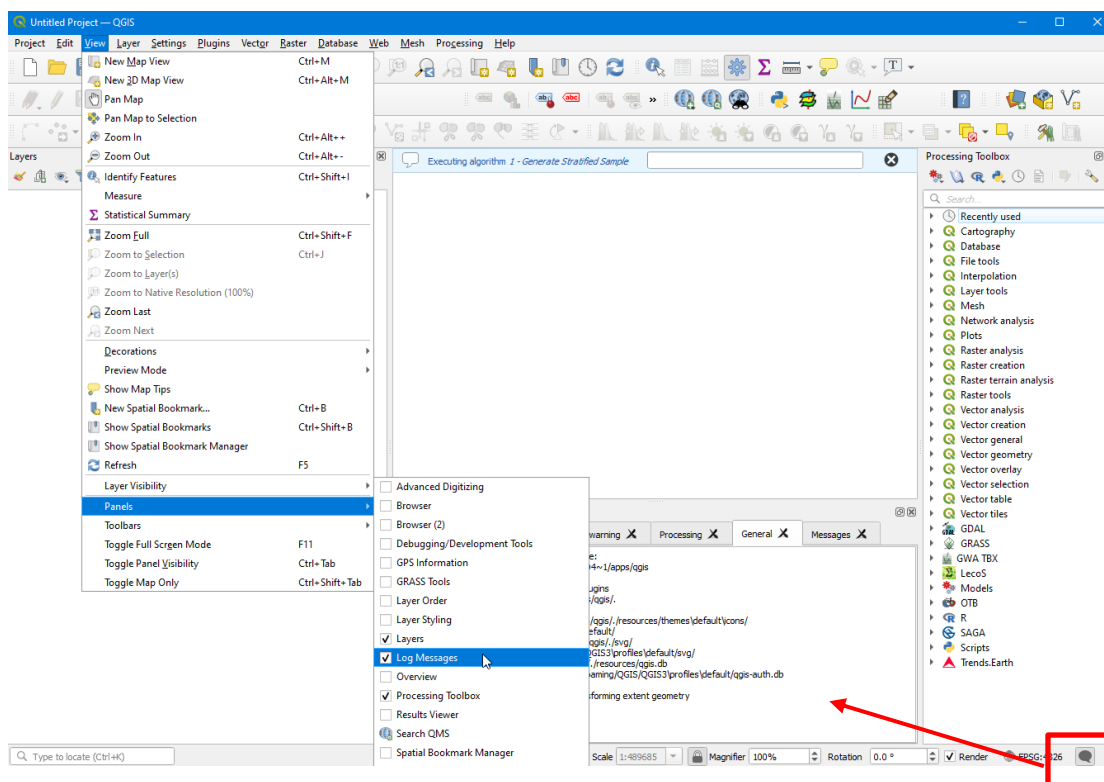
3.1 Troubleshooting

Issue	Solution
Installation failure	Make sure to run the installation as administrator. Also be aware that usernames can't have spaces or special characters.
Missing components	Make sure that all the instructions from section 2.3 (if semi-automatic installation was used) or section 2.5 (if manual installation was used) were followed. If it is discovered that some instructions were not followed, uninstall the toolbox as described in section 2.4 and perform the installation again.
QGIS Processing Toolbox crashes when starting QGIS	Some QGIS plugins could clash with QGIS Processing Toolbox and make it (or QGIS) crash when starting QGIS. Plugins which are included with the GlobWetland-Africa Toolbox have been tested and are known to work well. If you have installed other plugins and notice this issue then try updating them to the latest version and if that does not help then uninstall them or remove from

	C:\Users\user_name\AppData\Roaming\QGIS\QGIS3\profiles\default\python\plugins directory.
Bugs encountered in GW-A Toolbox	If you encounter software bugs in the toolbox please report them through the GlobWetland Africa GitHub web page: https://github.com/GlobWetlandAfrica . At the main page select the repository which you think is the most relevant to the encountered issue and then click the *Issues* link on the right side to the page. Read through any existing issues before creating a new one using the *New issue* button.

System Overview

4 Toolbox Overview

This section provides a high-level view of the GW-A Toolbox through a conceptual model (cf. Figure 1). The conceptual model seeks to illustrate the different elements and functions of the system. The more detailed system structure including the software building blocks and their interaction as well as the main principles of system and workflow development are provided in subsequent chapters.

The GW-A Toolbox can be seen as a multipurpose system consisting of functionality for semi-automated processing and analysis of the EO data through customized processing facilities, and decision support tools for mapping and reporting (cf. Figure 1).

Figure 1. The GW-A Toolbox is developed as a customisation of the 'Platform' which is a complete suite of open source software for managing, processing and analysing Earth Obser-vation data and building customised workflows to cover multiple needs, from those of wetland specialists and engineers to managers and policy makers

4.1 Software Architecture

The GW-A Toolbox development is based on a modular software architecture framework, which is structured around a central component controlling a number of extension

components that expand its core functionality. The central component of the GW-A toolbox is an open source geographic information system (GIS) software, QGIS, which provides the basic functions and features for working with geospatial data and an easy to use graphical user interface (GUI). The other confirmed components of the GW-A toolbox are: GRASS GIS and SAGA GIS (large toolboxes of raster and vector analysis algorithms), Sentinel Application Platform - SNAP (processing of visible, thermal and radar ESA data products), Orfeo Toolbox (high resolution image processing), Python and R-scripts (advanced analysis).

Figure 2. Open source software packages providing the required functionality for the GW-A toolbox.

4.2   Graphical User Interface

QGIS was chosen as the central integrating platform, due to its clear and accessible GUI, strong development community, ease of implementing additional functionalities through Python plugins and its high level of interoperability with major GIS data formats through the use of the Geospatial Data Abstraction Library (GDAL/OGR) library.

Figure 3. Schematics of the graphical user interface (GUI) for the GW-A Toolbox. The GUI is based on QGIS, but modified to include a GW-A Toolbox button on the menu ribbon. This button loads the Toolbox from where the user can select and run the customized end-to-end processing workflows for the entire suite of GW-A products and indicators.

All the software components to be used for EO processing (i.e. GRASS, Orfeo Toolbox, SNAP, R and Python scripts) are seamlessly integrated into QGIS via the Processing framework.

4.3   Workflow, Scripts and Models

A QGIS plugin has been developed that enables the creation of workflows from individual Processing algorithms. The Processing workflow plugin comes with a workflow creator tool which provides a simple GUI for creating new workflows and modifying the existing ones (see Figure 4). Once a workflow is saved it appears in the Processing toolbox among all the other tools, and also under an icon on the main QGIS toolbar. The saved workflows do not contain

any information on the internal workings of the algorithms used within the workflow steps, making them robust in case there are any changes to those algorithms.
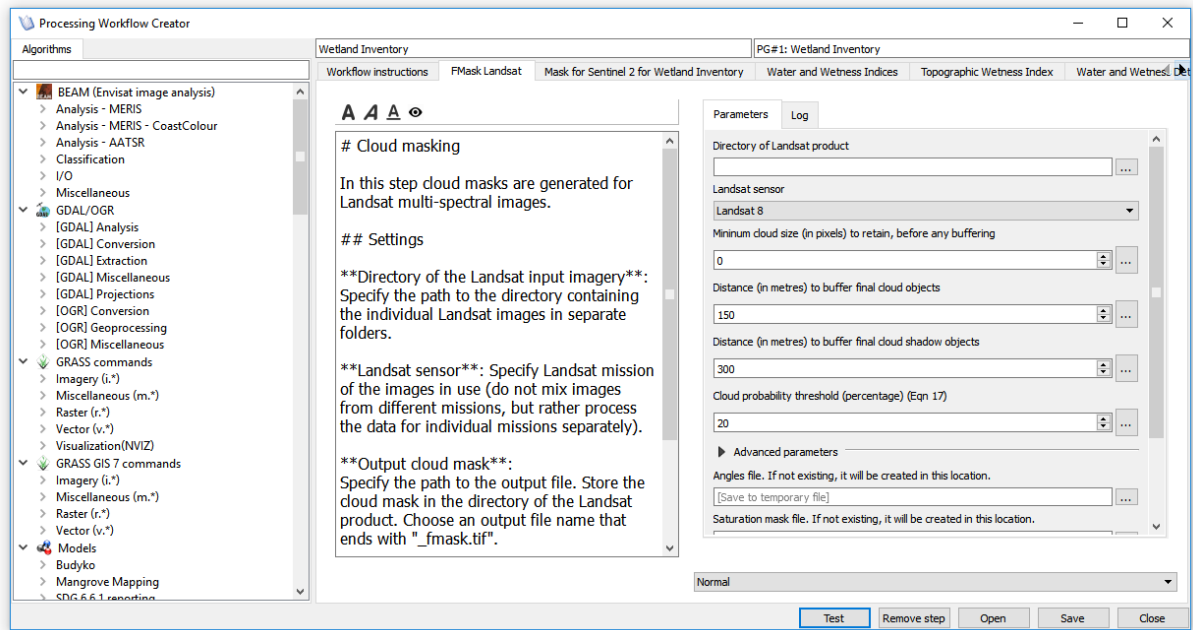

Figure 4. Illustration of the graphical user interface for creating step-by-step processing wizards.

The workflows provide a step-by-step guidance through more complex GIS processes, such as wetland classification, with the output of earlier steps being used as the input to the later ones. Once an algorithm has been integrated into the Processing toolbox it can be used inside workflows without any restrictions. The workflows can contain steps with tools from different algorithm providers, allowing the workflow creator to exploit the strengths of all the providers available within Processing.

Processing also provides functionality to call the different algorithms inside simple Python scripts and thus to create new tools. This is useful, for example, when it comes to processing time-series data. Instead of the user having to repeat the same operation multiple times on a large number of time-series images, the script can automate the process. Saved scripts appear in the Processing toolbox along with all the other algorithms, and they are presented to the user with the standardized GUI and can be included in workflows.

Finally, the Processing models can be used, similarly to scripts, for automatizing algorithm execution. However, unlike scripts, the models can be created using a drag-and-drop GUI interface thus making them easier to create and modify for non-technical users (cf. Figure 5).
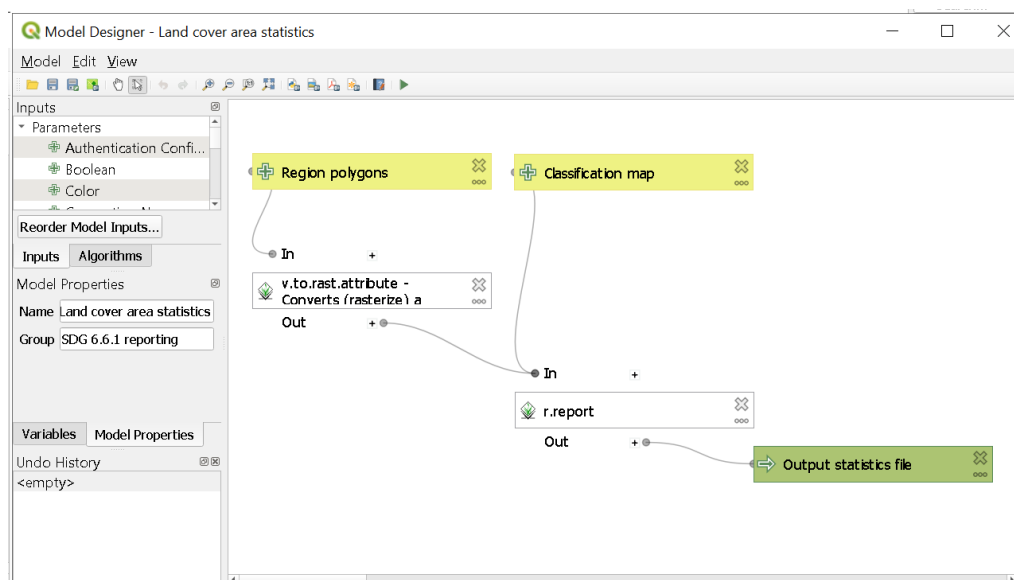
Figure 5. The QGIS drag-and-drop model builder

4.4   GW-A Toolbox workflows

In addition to the ability for users to develop their own image processing workflows the GW-A Toolbox also comes with a number of processing workflows that have been developed in response to the user requirements for products and tools to support mapping of wetland extent and condition. The embedded workflows in the current GW-A Toolbox version are as follows:

1. **Pre-processing**
   - These processing workflows allow users to perform the necessary pre-processing steps of Sentinel-1, sentinel-2 and Landsat 8/9 to prepare data for subsequent analysis and classification.
2. **Wetland (Habitat) Mapping**
   - The Wetland Habitat Mapping workflows provides the needed functionality to perform a detailed classification of the state and change in land cover and land use in wetland sites and their surrounding areas.

3. **Post-processing**
   - The post-processing workflow provide the users with the opportunity to perform manual post-classification editing.
4. **Validation tools**
   - The validation workflows can be used to generate sample locations and used them to perform Accuracy Assessment i.e. an independent verification of map outputs.
5. **Wetland indicators**
   - The wetland indicator workflows allow users to generate wetland status and trend indicators from the wetland information products. It also contains a workflow for Sustainable Development Goal (SDG) indicator 6.6.1 reporting.

For each of the workflows a small training kit has been prepared that consist of background presentations, a step-by-step tutorial and a tutorial data set designed to help the users become familiar with the features and capabilities of the GW-A Toolbox. The training kit is distributed as separate appendix to this document.

5   Updates

This section will include notifications of important updates for future releases of the GlobWetland Africa Toolbox

Version 1.2

General bug fix and updating of software components to latest versions. This version also includes new validation tools including functionality for generating stratified random samples:

- Creation of sampling unit polygons to match raster resolution
- Option for 3 x 3 pixel sampling unit
- easy creation of .kml files for Google Earth

Accuracy assessment now done by one single tool

- Class value extraction done in same script as error matrix and statistics

Now supports weighted accuracy assessments and unbiased area Statistics.

- Implementation of methods from Olofsson et al. 2013 & Card 1982
- Proportional weighted accuracy estimators
- Unbiased area estimates (corrections applied using error matrix)

- Confidence intervals (95%) supplied with all statistics

Version 1.3

General bug fix and updating of software components to latest versions. This version also includes a new placeholder for indicator workflows, including:

- SDG 6.6.1.a reporting
  - This workflow allows users to report on SDG 6.6.1.a "spatial extent of water related ecosystems" by returning area statistics on vegetated wetlands and open water respectively within a user defined region (e.g. a country mask)
- Wetland area statistics
  - Calculates the area present in each of the categories of a user-selected map
- Wetland change (post-classification comparison)
  - A detailed tabulation of changes between two maps
- Wetland fragmentation
  - Supports generation of both landscape and patch level fragmentation indices
- Wetland time-series analysis
  - Makes each pixel value a function of the values assigned to the corresponding pixels in the input image time-series (e.g. min, max, mean, median, quartile, percentile)

Version 1.4 (beta release)

This release focused on improving the workflow design, both from functionality and visualization perspectives:

- Standardized the look of all workflows and improved the user experience. This was facilitated by new functionality in the Workfows plugin allowing for the usage or Markdown syntax and cascading style sheets (CSS) when styling workflow instructions.
- Addition of workflow for national-scale Sustainable Development Goal (SDG) indicator 6.6.1 reporting.
- Various fine-tuning of workflow steps and associated R and Python scripts and Processing models.

Version 1.5

This is the final release of the toolbox as part of the GlobWetland-Africa project. It sets the scene for long-term exploitation of the toolbox and for possible future developments.

- Replacement of SWAT hydrological modelling framework by TauDEM-Budyko modelling framework. This removes a lot of software dependencies (e.g. MapWindow) thus simplifying the installation and future maintenance. It also removes the last major obstacle to cross-platform (Windows and Linux) toolbox usage. The hydrological outputs are still of high accuracy[1].
- Update of toolbox software components to:
  - QGIS 2.18.28 – this is the last QGIS release of the 2.x series and has been in long-term support for over a year
  - SNAP 6.0.6
  - GRAS 7.4.4
  - OrfeoToolbox 5.0.0
  - Python 2.7.14
  - TauDEM 5.3
- Removal of PostGIS which was not utilized within the toolbox.
- Various fine-tuning of workflow steps and associated R and Python scripts and Processing models.

Version 2.0

This is the latest major update to the GWA toolbox to ensure align it with the latest developments of the underlying software components, namely QGIS 3.x, GRASS GIS, Orfeo Toolbox and SNAP. This release is also simplifying the backend to ease the installation, operation and maintenance of the toolbox.

- Update of toolbox software components to:
  - QGIS 3.16 – this is a long-term support release
  - SNAP 8.0.8
  - GRAS 7.8
  - OrfeoToolbox 7.3.0
  - Python 3.7
  - R 3.3.3
  - TauDEM (removed)

The simplification also means that certain previously supported product groups is no longer supported including wetland inventory, inundation regime, water quality, hydrological modelling and mangroves mapping. User still interested in wetland, mangroves and

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[1] Kittel, C. M. M., Nielsen, K., Tøttrup, C., and Bauer-Gottwein, P.: Informing a hydrological model of the Ogooué with multi-mission remote sensing data, Hydrol. Earth Syst. Sci., 22, 1453-1472, https://doi.org/10.5194/hess-22-1453-2018, 2018.

inundation mapping can still do this for limited areas using the Wetland (Habitat) Mapping workflows, while users interested in Hydrological Modelling can still access the Python implementation of the Budyko hydrological modelling scheme and its QGIS integration here: https://github.com/DHI-GRAS/budyko-qgis

6   Software references

The software components included as part of the GW-A Toolbox are all established open source/public domain packages with a long history, a very strong user community and extensive online documentation. The following table briefly describes the included software components and provides links to their respective webpages for further reading.

QGIS (formerly known as Quantum GIS) is a powerful and user friendly Open Source Geographic Information System licensed under the GNU General Public License (GPL).

For more information see www.qgis.org

Geographic Resources Analysis Support System, commonly referred to as GRASS-GIS, is an advanced open source GIS and image processing software, which is licensed under GNU GPL.

For more information see http://grass.osgeo.org/

Orfeo Tool Box (OTB) is an Open source library of advanced image processing algorithms for high resolution images. OTB is distributed under a free software license CeCILL (similar to GPL)

For more information see http://www.orfeo-toolbox.org

Sentinel Application Platform is an open source (GNU GPL) toolbox for reading, post-processing, analysing and visualising the large archive of data from ESA SAR missions including ERS-1 & 2, ENVISAT and Sentinel 1, 2 and 3.

For more information see http://step.esa.int/main/toolboxes/snap/

R is a statistical software package which can be applied for statistical analysis (e.g. linear and nonlinear modeling, classical statistical tests, time-series analysis, classification, clustering.) and graphical techniques. R is available as Free Software under the GNU GPL.

For more information see http://www.r-project.org/

Python is a scripting language, very popular with scientific and geographic communities. It includes numerous packages for GIS analysis, advanced modelling and data processing. Python is available as Free Software under Python Software Foundation license.

For more information see https://www.python.org/

Acknowledgement

The GlobWetland Africa Toolbox has been developed under the GlobWetland Africa project which is a large Earth Observation application project funded by the European Space Agency (ESA) in partnership with the African Team of the Ramsar convention on wetlands.

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