

Open Foris SAR Toolkit

USER MANUAL

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Non-official DRAFT VERSION

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1 Introduction

1.1 About this manual

The user manual provides information on how to almost fully automatically pre-process Synthetic Aperture Radar (SAR) datasets using the Open Foris SAR Toolkit (OFST). It gives basic explanations of how OFST functions. It is not attempted to explain the theoretical background on how to use SAR remote sensing or GIS, but rather will guide you through **hands-on examples** for each tool, next to some general topics, such as the installation.

OFST is only available for Ubuntu 14.04. However, the user manual is written in a way that it can be understood by people who are experienced Windows or Mac users, but have not used Linux or OFST before. The same applies for SAR specific knowledge. While a basic understanding of product types and SAR missions is recommended, no detailed knowledge about processing of SAR images is needed at all.

1.2 What is Open Foris SAR Toolkit?

OFST - Open Foris SAR Toolkit is a collection of prototype command-line utilities for SAR related processing tasks such as data inventory and download as well as data preprocessing and some basic post-processing commands.

The processing commands follow standardized and highly automated workflows in order to provide ready-to-classify data stacks comparable to optical remote sensing data. The tools can be divided into stand-alone and bulk scripts and they have been tested on Ubuntu Linux 14.04 environment for now. We look forward to make it compatible with other Linux distributions as well as Mac OS and MS Windows.

For the actual processing, the scripts rely on other freely available software packages such as the Sentinel Application Platform (SNAP, <http://step.esa.int/main/toolboxes/snap/>) and geospatial FOSS software like the GDAL libraries and SAGA GIS.

The OFST project started under the UN-REDD initiative to develop, share and support software tools and methods for multi-purpose forest assessment, monitoring, verification and reporting. The Initiative develops and supports innovative, easy-to-use tools needed to produce reliable, timely information on the state of forest resources and their uses. The command-line tools aim to strongly simplify the complex process of transforming raw, or low level SAR imagery into higher level products that are ready for subsequent image processing tasks in order to produce value-added information.

1.3 The great potential of OFST

In the past, the use of SAR data required a specific expertise for creating useful datasets out of raw or low-level data. In addition, specialized software can be quite costly. The development of the OFST, on the contrary, provide rather ready-to-use, standardized workflows that do not need a fundamental knowledge of SAR data processing. It is based on already available GPL software such as ESA's SNAP toolbox and can therefore be used freely. The processing chains are realized in a bash environment. A minimum of easy-to-understand processing parameters has to be submitted in order to let the computer do the rest of the work.

1.4 First time users

First time users, the terminal is your friend: The Open Foris Geospatial Toolkit tutorial is aiming to provide straight forward guidelines and examples to help first time users to familiarise themselves with the Open Foris Geospatial Toolkit. This includes the installation of Ubuntu, various geospatial tools and, in particular, the installation and application of the Open Foris Geospatial Toolkit. You do not need to be an expert, we just would like you to be curious to try things out. Do not be afraid of using the command-line! We know that the terminal window is for many users a barrier of being afraid ruining everything and having to start from scratch. These days the terminal is not exclusively for advanced computer enthusiasts. Give it a try and just start playing around following the tutorials and instructions you can find in the wiki.

2 License

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The program will also download and install the official Oracle Java version. Please make sure you read and accept the terms and conditions of the Java binary code license which can be found here: <http://www.oracle.com/technetwork/java/javase/terms/license/index.html>

In addition the SNAP toolbox developed by the European Space Agency ESA will be downloaded and installed during the installation procedure. Note that SNAP is licensed under the same GNU GPL version 3 license as the Open Foris SAR Toolkit.

3 Installation of Open Foris SAR Toolkit

The Open Foris SAR Toolkit comes with an install script which automatically downloads all of its software dependencies automatically. It is named **install_osk.sh**. To run the installer please follow the steps:

1. Open the terminal (CTRL+ALT+T) and download the script from the github repository by copying the following line into the terminal:

```
wget https://raw.githubusercontent.com/BuddyVolly/\nOpenSARKit/master/bins/install_scripts/install_osk.sh
```

*Note: the **wget** command allows you to download files from the internet directly from the command line just as you can do from your browser. Since you will be in your home folder after opening the terminal, the installation script will be placed there. There are advanced options available as well (e.g. defining an output directory).*

2. Run the script as **Superuser** on the command line of the opened terminal window in order to install everything:

```
sudo bash install_osk.sh [optional installation directory]
```

Note I: The installation directory argument is optionally. If no input is given, OFST will be automatically installed into **/usr/local/lib/osk**.

Note II: This script has to be run as Superuser (i.e. use of the **sudo** command) since it will install additional software packages where administrative permission is needed. After launching the script it will ask for your Superuser password, which in most of the cases is the same as your normal user password. If you are a secondary user of the PC where you want to install OFST, contact the administrator of the PC for assistance.

3. Source the commands (optionally) by typing:

```
source /etc/profile.d/OpenSARKit.sh
```

*Note: Within the File **/etc/profile.d/OpenSARKit.sh** all the paths to the OFST scripts are defined. By adding them to the global PATH variable they will be available for execution on the command line. Since the file itself acts as a script by launching a new terminal it will be only necessary to source the file the first time. Opening a new terminal window will from now on include all OFST commands .*

4 OFST - Tools documented

4.1 ALOS Kyoto & Carbon workflow

4.1.1 Dataset Description

Kyoto & Carbon initiative

Global 25m resolution PALSAR-2/PALSAR mosaic and forest/non-forest map are free and open datasets generated by applying JAXA's sophisticated processing and analysis method/technique to a lot of images obtained with Japanese L-band Synthetic Aperture Radars (PALSAR and PALSAR-2) on Advanced Land Observing Satellite (ALOS) and Advanced Land Observing Satellite-2 (ALOS-2).

The global 25m resolution PALSAR/PALSAR-2 mosaic is a seamless global SAR image created by mosaicking SAR images of backscattering coefficient measured by PALSAR/PALSAR-2, where all the path within 10x10 degrees in latitude and longitude are path processed and mosaicked for the sake of processing efficiency. Correction of geometric distortion specific to SAR (ortho-rectification) and topographic effects on image intensity (slope correction) are applied to make forest classification easy. The size of one pixel is approximately 25 meter by 25 meter. The temporal interval of the mosaic is generally 1 year.

The global forest/non-forest map (FNF) is generated by classifying the SAR image (backscattering coefficient) in the global 25m resolution PALSAR-2/PALSAR mosaic so that strong and low backscatter pixels are assigned as forest (colored in green) and non-forest (colored in yellow), respectively. Here, the forest is defined as the natural forest with the area larger than 0.5ha and forest cover over 90%, as same to the FAO definition. Since the radar backscatter from the forest depends on the region (climate zone), the classification of 2 Forest/Non-forest is conducted by using the region dependent threshold of backscatter. The classification accuracy is checked by using in-situ photos and high-resolution optical satellite images. *(taken from the official document at http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/DatasetDescription_PALSAR2_Mosaic_FNF_v1.pdf)*

Data Distribution by JAXA

In order to retrieve data, the user has to register at http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/registration.htm. Note that the datasets are provided free of charge, but are available for research and educational purposes only. It is prohibited to use the datasets for commercial, profit-making purposes without JAXA's consent. If users wish to use the datasets for such purposes, please make contact to JAXA. Anyone wishing to publish any results using the datasets should clearly acknowledge the ownership of the data in the publication. JAXA retains

ownership of the dataset. JAXA cannot guarantee any problem caused by or possibly caused by using the datasets.

4.1.2 Overview of the workflow

The workflow of the ALOS Palsar Kyoto & Carbon mosaics consists of 2 scripts, one for the data download and one for the subsequent processing (Figure 1). The only input which needs to be given is either a polygon shapefile, bounding the area of interest, or one ISO3 country code, in case the data should be processed for a whole country.

Within the given project folder the download script (oft-sar-ALOS-KC-download) will create a ZIP folder, where all downloaded archives will be stored. If the download script is run more than once for different years, again, all archives are stored therein, independent of the year.

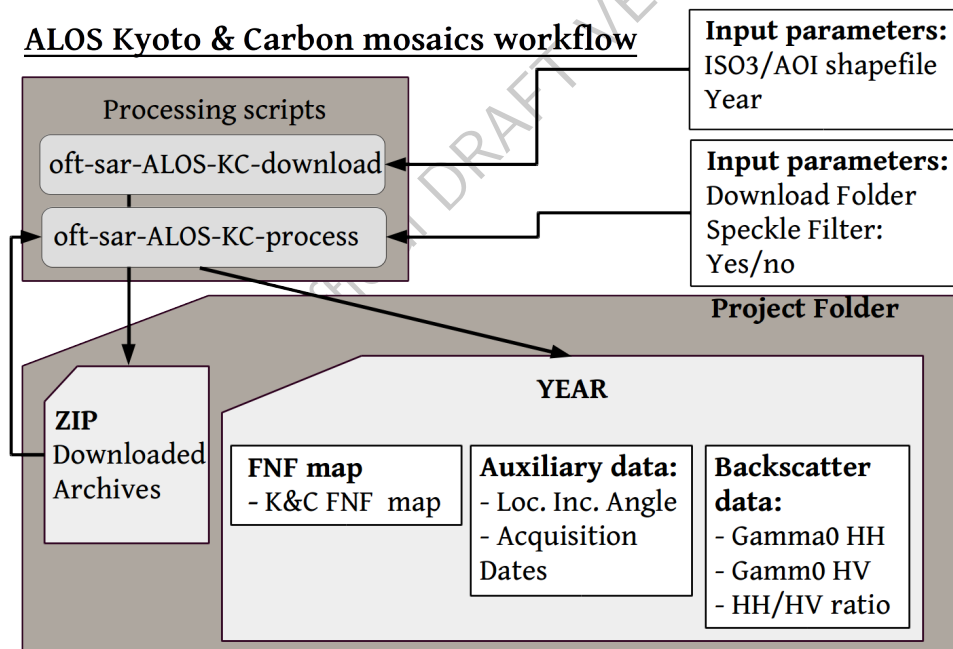


Figure 1: Overview of the ALOS Kyoto & Carbon workflow.

After the download is completed, the process script (oft-sar-ALOS-KC-process) can be run. The Project folder should be the same as for the download script, i.e. the one where the Zip folder is stored. Next to the Zip folder, a folder named

after the year will be created within the project folder.

Inside this year folder, 4 additional folders will be created. The first one is called FNF and contains the forest/non-forest map created by Jaxa for the area of interest. The second one is called AUX and contains a GeoTiff file with the local incidence angle of the acquisitions and another one containing the acquisition dates. The backscatter data is stored in the MOS folder. Within this folder 4 files are placed. 2 files correspond to the Gamma0 HH- and HV polarized bands. In addition the script creates a ratio band out of the HH and HV polarized data. In order to visualize the data, a virtual raster file (vrt) is added as well. Band 1,2 and 3 correspond to Gamma0 HH, HV and HH/HV ratio, respectively.

4.1.3 Script manuals

oft-sar-ALOS-KC-download

oft-sar-ALOS-KC-process

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4.2 ALOS ASF data processing

4.2.1 Dataset Description

Mission

From 2006 to 2011, PALSAR's L-band SAR yielded detailed, all-weather, day-and-night observation, as well as repeat-pass interferometry. PALSAR data are from multiple observation modes with variable polarization, resolution, swath width, and off-nadir angle.

PALSAR was one of three instruments on the Advanced Land Observing Satellite-1 (ALOS-1), also known as DAICHI, developed to contribute to the fields of mapping, precise regional land-coverage observation, disaster monitoring, and resource surveying. ALOS-1 was a mission of the Japan Aerospace Exploration Agency (JAXA). (<https://www.asf.alaska.edu/sar-data/palsar/about-palsar/>)

Technical specifications

4.2.2 Data Distribution by Alaska Space Facility

ASF provides data free-of-charge after signing the EULA terms & conditions (<https://www.asf.alaska.edu/data-tools/submit-a-proposal/alos-end-user-license-agreement/>), which fundamentally allows for the use of the available ALOS data for non-commercial use. Even though ASF holds a considerable amount of imagery, it does not contain the full archive. Most of data is limited to the regions of the Americas, Africa and South-East Asia.

4.2.3 Overview of the workflow

In order to preprocess ALOS data from the Alaska Space Facility site, 3 scripts are needed. At the moment OFST only supports the already radiometrically, terrain corrected products that are provided by (i.e. RTC_HI_RES, RTC_LOW_RES), which should be respected during data inventory by choosing the corresponding processing level.

The inventory script will create a shapefile within a newly created Inventory folder containing the footprints and additional metadata information like acquisition date etc. This shapefile can be edited in order to refine the data selection.

Based on the inventory shapefile, the download script will retrieve all scenes. In order to allow an immediate bulk processing, the data is already sorted in a predefined structure under the newly created folder named after acquisition mode (e.g. FBD).

From within the acquisition mode folder, the oft-sar-ALOS-ASF-bulk-preprocess script can be run. This script will apply a Refined Speckle Filter to all scenes and merge the scenes of the same track acquired at the same date into one swath product. All swath products are stored inside a newly created folder called PATH.

4.2.4 Script manuals

oft-sar-ALOS-ASF-inventory - data inventory script for ALOS PALSAR data from the Alaska Space Facility

OFST VERSION

0.1

SYNOPSIS

oft-sar-ALOS-ASF-inventory <output folder> <area of interest> <start date> <end date> <mode> <processing level> <script Mode>

- output folder: (output) folder where the downloaded data will be saved
- area of interest: (input) shapefile of your area of interest (AOI)
- start date: start date of search in format YYYY-MM-DD
- end date: end date of search in format YYYY-MM-DD
- mode: acquisition mode of the PALSAR instrument
 - available choices:
 - FBS (Fine-Beam Single Polarization)
 - FBD (Fine-Beam Dual Polarization)
 - PLR (Polarimetric Mode)
 - WB1 (Wide-swath Mode)
- processing level: choose the product level
 - available choices
 - L1.0 (RAW - Level 1.0)
 - L1.1 (SLC - Level 1.1)
 - L1.5 (GRD - Level 1.5)
 - RTC_HI_RES (12.5m High-resolution Terrain Corrected)
 - RTC_LOW_RES (30m Low-resolution Terrain Corrected)

- script mode
 - available choices
 - 0 (only do the data inventory)
 - 1 (data inventory + direct data download)

DESCRIPTION

This command will create a folder called Inventory inside the given Project folder. This new directory contains a shape-file with the footprints of the scenes and additional information in its attribute table based on the search criteria given. The direct download option (script mode has to be 1) will download all resulting scenes. In case of script mode 0, a refined manual selection of the desired scenes is possible based on the created shape-file. You can then download the selected scenes using the oft-sar-ALOS-ASF-download script.

Note I: The Alaska Space Facility provides unrestricted access to ALOS PAL-SAR data for major regions in the world (i.e. Americas, Africa, Asia). Apart from the standard SAR products (RAW,SLC,GRD), already preprocessed imagery (RTC) is available at 2 resolutions (12.5m, 30m) and it is highly recommended to use those. For more information you can visit:

<https://www.asf.alaska.edu/sar-data/palsar/terrain-corrected-rtc/>

NOTE II: Even though the scripts supports different acquisition modes, it is recommended to use the Fine-Beam-Dual (FBD) mode, especially if you work on large regions or nations. The predefined observation strategy implemented by JAXA assured a consistent coverage for the whole world and the cross-polarized channel (i.e. HV) is well-suited for forestry applications.

oft-sar-ALOS-ASF-download - download script for ALOS PALSAR data from the Alaska Space Facility based on a OFST inventory shapefile

OFST VERSION

0.1

SYNOPSIS

`oft-sar-ALOS-ASF-download <output folder> <inventory shapefile>`

- output folder: (output) folder where the downloaded data will be saved
- inventory shapefile: Shapefile created by the `osk_ALOS_ASF_inventory` script

DESCRIPTION

This command will download ALOS data that is listed in an inventory shapefile created by the `oft-sar-ALOS-ASF-inventory`. The shapefile can be edited beforehand (i.e. selection of a subset of scenes instead of all scenes available on the server).

oft-sar-ALOS-ASF-RTC-bulk-process - data inventory script for ALOS PALSAR data from the Alaska Space

OFST VERSION

0.1

SYNOPSIS

`oft-sar-ALOS-ASF-RTC-bulk-process <project path> <resolution>`

- project path: pathname, where the ASF downloaded zips are located
- resolution: output resolution in degree (- for original resolution)

DESCRIPTION

This command will process all scenes contained in the project path which corresponds to the folder of the acquisition mode created by the download script (e.g. /path/to/FBD). Resolution should be set in degrees, since the data is in Lat/Long projection.

4.3 Sentinel-1 data processing

4.3.1 Dataset Description

Mission

http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-1/Facts_and_figures

Technical specifications

http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-1/Instrument

4.3.2 Data Distribution by Copernicus program

In line with its data and information policy, the Copernicus programme provides users with free, full and open access to environmental data.

Depending on their needs, users can obtain these data either from the Copernicus services or directly from the Copernicus satellites. No registration is required for discovery and view services while it is a prerequisite to download Sentinel data. Registration is free of charge and can be done at <https://scihub.copernicus.eu/dhus/#/self-registration>

4.3.3 Overview of the multi-temporal workflow

In order to preprocess Sentinel-1 GRD data 3 scripts are needed. The first one does the data inventory and creates a shapefile containing the footprints and metadata on the single acquisitions. This file can be edited and then used for the download script, which will download the data in a predefined folder structure. This allows for the immediate processing using the multi-temporal bulk processing script. As a result, radiometrically, terrain corrected datasets are available for every swath. Optionally multi-temporal metrics can be derived by image swath.

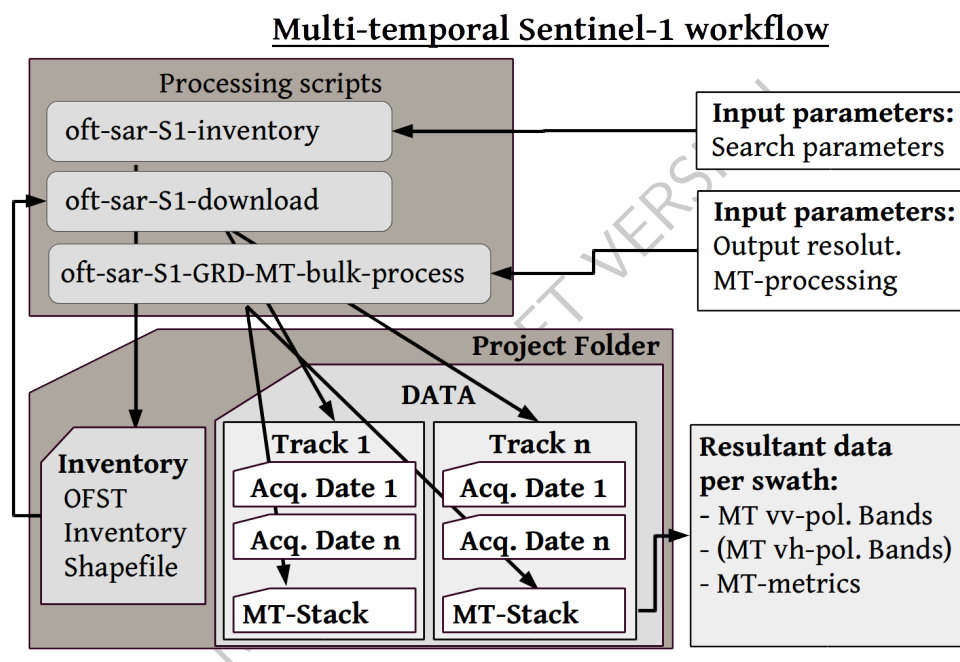


Figure 2: Overview of the multi-temporal Sentinel-1 GRD workflow.

4.3.4 Script manuals

oft-sar-S1-inventory - data inventory script for Sentinel-1 data on the Copernicus scihub server

OFST VERSION

0.1

SYNOPSIS

oft-sar-S1-inventory <output folder> <area of interest> <start date>
<end date> <product type> <polarization mode> <script mode>

- output folder: (output) folder where the downloaded data will be saved
- area of interest: (input) shapefile of your area of interest (AOI)
- start date: start date of search in format YYYY-MM-DD
- end date: end date of search in format YYYY-MM-DD
- product type: acquisition mode of the PALSAR instrument
available choices:
 - SLC (L1.1 - Single-look complex)
 - GRD (L1.5 - Ground Range Detected)
- polarization mode: acquisition Mode of Sentinel-1 instrument
available choices
 - VV (for IWS Mode VV & VV/VH)
 - VH (for IWS Mode VV/VH)
 - HH (for IWS Mode HH & HH/HV)
 - HV (for IWS Mode HH/HV)
- script mode
available choices
 - 0 (only do the data inventory)
 - 1 (data inventory + direct data download)

DESCRIPTION

This command will create a folder called Inventory inside the given Project folder. This new directory contains a shape-file with the footprints of the scenes and additional information in its attribute table based on the search criteria given. The direct download option (script mode has to be 1) will download all resulting scenes. In case of script mode 0, a refined manual selection of the desired scenes is possible based on the created shape-file. You can then download the selected scenes using the oft-sar-S1-download script.

Note 1: At the moment OFST is only able to handle GRD data. The corresponding product type should therefore be set appropriately.

oft-sar-S1-download - download script for ALOS PALSAR data from the Alaska Space Facility based on a OFST inventory shapefile

OFST VERSION

0.1

SYNOPSIS

`oft-sar-S1-download <output folder> <inventory shapefile>`

- output folder: (output) folder where the downloaded data will be saved
- inventory shapefile: Shapefile created by the oft-sar-S1-inventory script

DESCRIPTION

This command will download ALOS data that is listed in an inventory shapefile created by the oft-sar-ALOS-ASF-inventory. The shapefile can be edited beforehand (i.e. selection of a subset of scenes instead of all scenes available on the server).

oft-sar-ALOS-ASF-RTC-bulk-process - data inventory script for ALOS PALSAR data from the Alaska Space

OFST VERSION

0.1

SYNOPSIS

```
oft-sar-S1-GRD-MT-bulk-preprocess <input directory> <resolution>  
<MT metrics>
```

- input directory: (input) higher-level directory of the downloaded zip file (i.e. DATA folder created by oft-sar-S1-download)
- output resolution:
 - available choices:
 - HI_RES (10m output)
 - MED_RES (30m output)
- MT-metrics: calculate multi-temporal metrics
 - available choices:
 - 0: does not calculate the MT-metrics
 - 1: calculates the MT-metrics

DESCRIPTION

This command will process all scenes contained in the input which corresponds to the DATA folder by the download script (e.g. /path/to/Project/DATA).

If the MT metrics are not calculated, all scenes will be assembled to the whole swath (i.e. if more than 1 scene per swath), will be radiometrically terrain corrected and an additional vv/vh ratio channel will be created for the dual-polarized products.

the multi-temporal mode, instead, will create a MT-metrics folder for every swath. Within this folder a coregistered stack of each polarization and of the multi-mtemporal metrics calculated for every polarization will be stored.