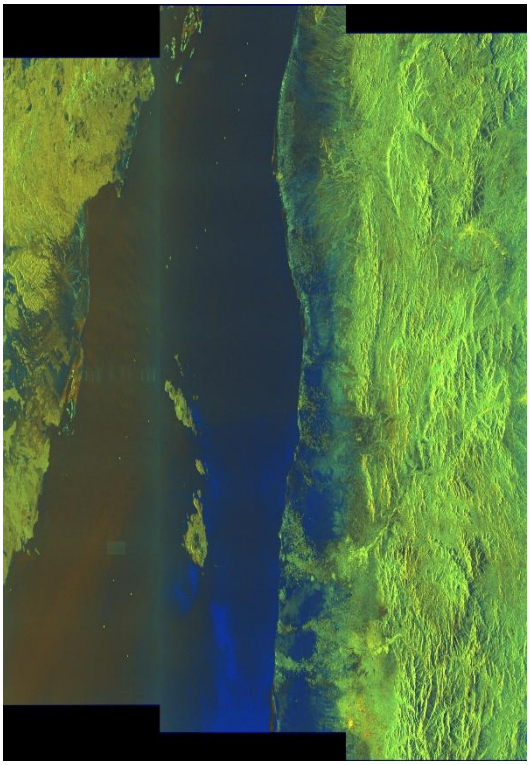
SAR ESSENTIALS TUTORIAL:
SAR SENTINEL-1 DATA DOWNLOAD



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1. INTRODUCTION

SAR Essentials provides a *SAR Download Sentinel-1* tool for querying and downloading SAR data from the Sentinel-1 satellite mission (Figure 1). This constellation is maintained by the European Space Agency (ESA) as a part of the Copernicus Sentinel series – a joint initiative between ESA and the European commission (EC). The constellation comprises two sun-synchronised near-polar orbiting satellites, separating the same orbital plane at 180°.

As of August 2026, the satellites Sentinel-1C (launched on December 5th, 2024) has been operational since 26th March 2025, and Sentinel-1D (launched on November 4th, 2025), has been collecting data since 17th April 2026. Since 24th June 2026 the two satellites have been in full operational constellation with six-day repeat-pass orbits, providing observation in C-band with central frequency of 5.405 GHz)[1]. Archive imagery collected from Sentinel-1A (6th October 2014 – 29th June 2026) and Sentinel-1B (26th September 2016 – 23rd December 2021) are also accessible.

Sentinel-1 SAR data are available on a free, full and open basis governed by the Legal Notice on the use of Copernicus Sentinel Data and Service[2].

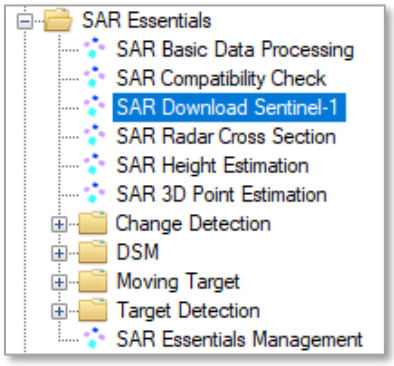


Figure 1. SAR Download Sentinel-1 tool in SAR Essentials toolbox

The tool allows to perform a query and download Sentinel-1 data from one of the following *Download Services*: ESA Data Space (https://dataspace.copernicus.eu/browser/) or Alaska Satellite Facility (ASF) (https://search.asf.alaska.edu) – see Figure 2. An account with login credentials is required for both platforms (see "Credentials"). To take advantage of the ASF data portal, the login should be done at least once on the ASF web browser portal and set a study area. The *Terms Of Service* for that account will also need to be accepted before using the *SAR Download Sentinel-1* tool.

Generally, the repository credentials can be set in the *SAR Essentials Management* tool (consult **SAR Essentials Getting Started** tutorial). In this way they will be saved for any further usage even after ENVI restart. To be applied, all the other *SAR Essentials tools* must be closed. The changes will take place when the tools are reopened. If the credentials are saved directly (and only) in *SAR Download Sentinel-1* tool they will be reset after the tool is closed.

Set your credentials for access to the Sentinel-1 data repositories in SAR Essentials Management tool – consult **Getting Started** tutorial and section Credentials for more details.

[1] https://sentiwiki.copernicus.eu/web/s1-mission
[2] https://sentinels.copernicus.eu/documents/247904/690755/Sentinel_Data_Legal_Notice

2. INPUT PARAMETERS

The time period and geographic area of interest should be known in advance. The terrain coverage can be set by coordinates or by a vector file. The tool will download *all* datasets that overlap the defined area of interest and time frame. See below for more details. In this exercise, manually set geographic coordinates for an area located in the Red Sea in November of 2023 will be applied.

2.1. TIME SPAN

The time span for the Sentinel-1 query can be defined in two ways. The first is by setting the *From* and *To* dates in the provided fields, respecting the format of Day-Month-Year (DD-MMM-YYYY, e.g., 01-Jan-2018) or using the Calendar button. These parameters are mandatory.

Choose the *Download Service* (Figure 2).

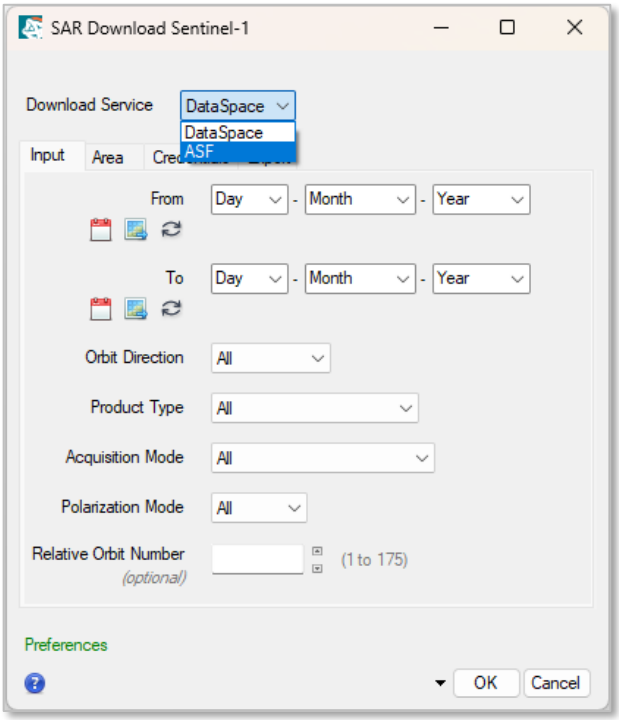


Figure 2. SAR Download Sentinel-1 Tool – selection of Download Service

Set the *From* date to 6th November 2023 and the *To* date to 8th November 2023 (Figure 3).

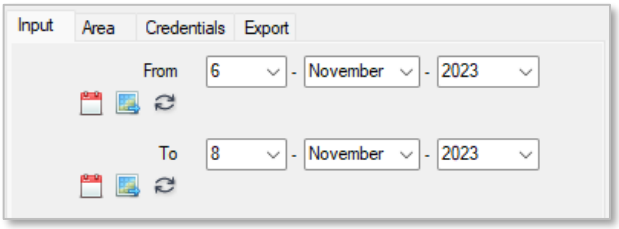


Figure 3. SAR Download Sentinel-1 Tool – defining the time span for the query in Input tab

Another option is to click the *From Dataset* button if a dataset covering the period of interest is already open in ENVI Data Selector (with option to browse for data). The *SAR Download Sentinel-1* tool will read the acquisition date/time from the dataset metadata.

2.2. ORBIT DIRECTION

The *Orbit Direction* field allows the selection between data acquired by *Ascending* or *Descending* Sentinel-1 satellite orbits, or to include both (*All,* Figure 4). This parameter is optional. By default, the data from both orbit passes will be downloaded.

Select *All* for the *Orbit Direction* (Figure 4).

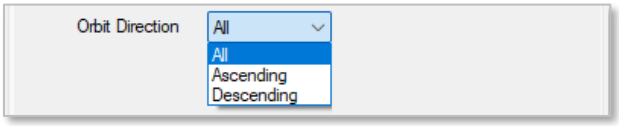


Figure 4. SAR Download Sentinel-1 Tool – choosing the Orbit Direction

2.3. PRODUCT TYPE

A filter for the type of Sentinel-1 product can be applied (Figure 5). The available product types are:

- *All* – by default, all available products will be downloaded,
- *Level-0* – unprocessed (**RAW**) radar measurements, containing amplitude and phase information[3],
- *Single Look Complex* (**SLC**) – Level 1 images in slant range in the imaging plane of the satellite data acquisition. Each image pixel contains amplitude and phase information.
- *Ground Range Detected* (**GRD**) – Level 1 focused SAR data that has been multilooked and projected to ground range using the Earth ellipsoid model WGS84. Ground range coordinates are the slant range coordinates projected onto the ellipsoid. Pixel values represent detected amplitude, while the phase information is not kept.
- *Ocean* (**OCN**) – Level 2 data for oceanographic applications.

Select *Single Look Complex* as the *Product Type* (Figure 5).

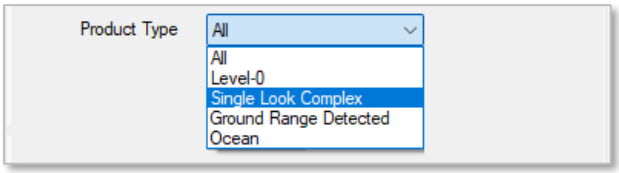


Figure 5. SAR Download Sentinel-1 Tool – selection of Product Type

2.4. ACQUISITION MODE

The Sentinel-1 sensor acquires data in several modes, depending on the product resolution and ground coverage (Figure 6), namely:

[3] https://documentation.dataspace.copernicus.eu/Data/SentinelMissions/Sentinel1.html

- *Stripmap* (**SM**) – high resolution data, acquired in 80-km swath (six overlapping swaths that cover a range of 375 km in total) at nearly 5 m by 5 m spatial resolution (single look)[4],
- *Interferometric Wide Swath* (**IW**) – high resolution data, acquired in 250-km swath at 5 m by 20 m spatial resolution (single look). Each swath consists of three sub-swaths (IW1, IW2 and IW3), which are further divided into 9 to 10 overlapping bursts (Figure 7). Data are generated with the Terrain Observation with Progressive Scans SAR (TOPSAR) system. This is the main acquisition mode over land.
- *Extra-Wide Swath* (**EW**) – medium resolution data generated with the TOPSAR system over a wider area (400-km swaths) using five sub-swaths at 20 m by 40 m spatial resolution. The EW mode is primarily used for sea ice, polar zones and specific maritime areas, oil spill monitoring and security services.
- Wave (**WV**) – acquires data in 20 by 20 km vignettes, at 5 m by 5 m spatial resolution, every 100 km along the orbit alternately from two different incidence angles. This is the default mode for acquiring data over open ocean.

The *Acquisition Mode* parameter is optional. By default, *All* available products will be downloaded.

Select *Interferometric Wide Swath* as the *Acquisition Mode* (Figure 6).

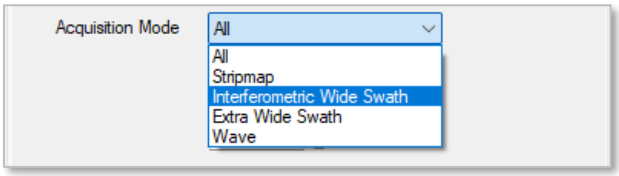


Figure 6. SAR Download Sentinel-1 Tool – selection of Acquisition Mode

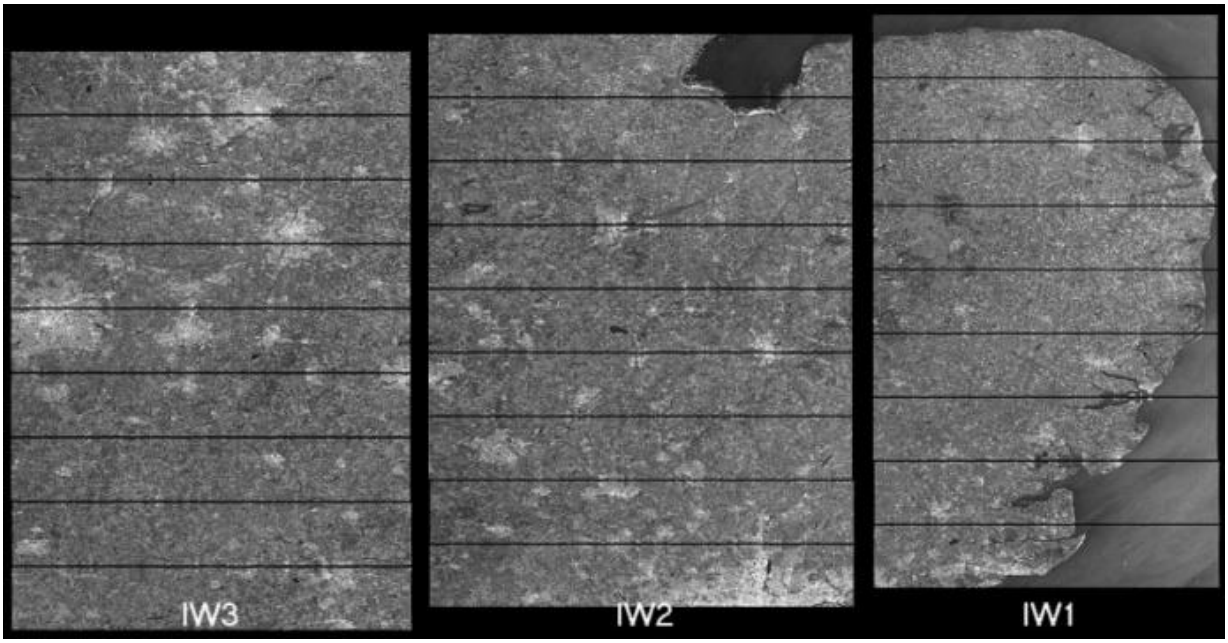


Figure 7. Example of Sentinel-1 IW SLC full image with three sub-swaths (IW1, IW2, and IW3) and their bursts (Source: ESA)

[4] https://sentiwiki.copernicus.eu/web/s1-mission

2.5. POLARIZATION MODE

Sentinel-1 data are distributed in the following polarization schemes and stored in different image bands (Figure 8):

- *VV* – single co-polarization, vertical transmit/vertical received radar signal
- *Dual VV* – partial dual co-polarization, vertical transmit/vertical received radar signal
- *HH* – single co-polarization, horizontal transmit/horizontal received signal
- *Dual HH* – partial dual co-polarization, horizontal transmit/horizontal received signal
- *VV + VH* – dual-band cross-polarization, one vertical transmit/dual vertical-horizontal received
- *HH + HV* – dual-band cross-polarization, one horizontal transmit/dual horizontal-vertical received
- *Dual HV* – partial dual-band HV cross-polarization
- *Dual VH* – partial dual-band VH cross-polarization[5]

The *Polarization Mode* parameter is optional. If the default option *All* is kept, all possible polarization modes will be downloaded.

Select *All* for the *Polarization Mode* (Figure 8).

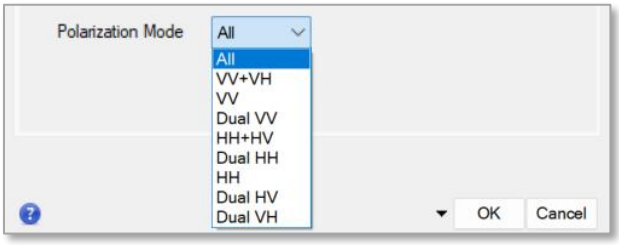


Figure 8. SAR Download Sentinel-1 Tool – selection of Polarization Mode

2.6. RELATIVE ORBIT NUMBER

Relative Orbit Number for the Sentinel-1 pass can be added as an additional option (Figure 9). The Relative orbit number is an identifier marking the position of each of the Sentinel-1 satellites within their 12-day repeat cycle, corresponding to 175-orbit repeat cycle, so the values are changing between 1 and 175. It indicates the acquisitions made over the same area (tracks) of the Earth's surface. The tracks have nearly the same viewing geometry.

Leave the *Relative Orbit Number* field unspecified (Figure 9).

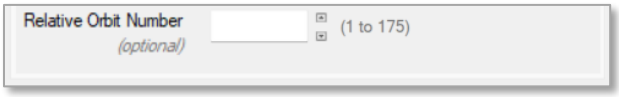


Figure 9. SAR Download Sentinel-1 Tool – optional parameter for selecting the Relative Orbit Number

[5] https://sentiwiki.copernicus.eu/web/s1-products

3. AREA PARAMETERS

A spatial criterion for the Area of Interest (AOI) can be defined by a vector file (*Geographical Region*) or a *Bounding box* given by geographic coordinates (Figure 10).

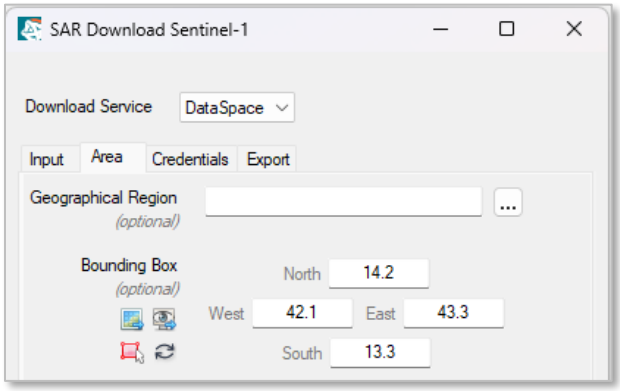


Figure 10. SAR Download Sentinel-1 Tool – Area tab for spatial definition of the AOI

3.1. GEOGRAPHICAL REGION

A vector file (.shp) or a Google Earth file (.kml or .kmz) can be uploaded to specify a region of interest. The AOI file must have at least 4 vertices. All acquisitions inside or intersecting this polygon are returned. The shapefile must be in Geographic Coordinate System (GEO-GLOBAL cartographic system, defining the coordinates by latitude and longitude).

3.2. BOUNDING BOX

The *Bounding Box* coordinates can be set by entering the values for the *North, South, East* and *West* coordinates (latitude and longitude). Decimal values must be entered using a dot (e.g. 29.30) and not a comma (e.g. 29,30) character. All acquisitions inside or intersecting this box will be selected. These fields must be left empty if a shapefile is used as spatial reference.

Alternatively, the coordinates may be obtained from a file that is already loaded in the *Data Manager* by selecting it *From Dataset*, *From the Current View* range in ENVI, or the User may draw the AOI by selecting the button *Draw Bounding Box*.

Add the following coordinates 14.2, 13.3, 42.1 and 43.3, in the fields *North, South, West* and *East*, respectively (Figure 10) in the ***Bounding Box*** section. These coordinates delineate the AOI over the Hanish Islands in the Red Sea (Figure 11). Alternatively, load the provided in the tutorial dataset file named *Hanish.kml* into the ***Geographical Region*** field (Figure 10) – use ... button.

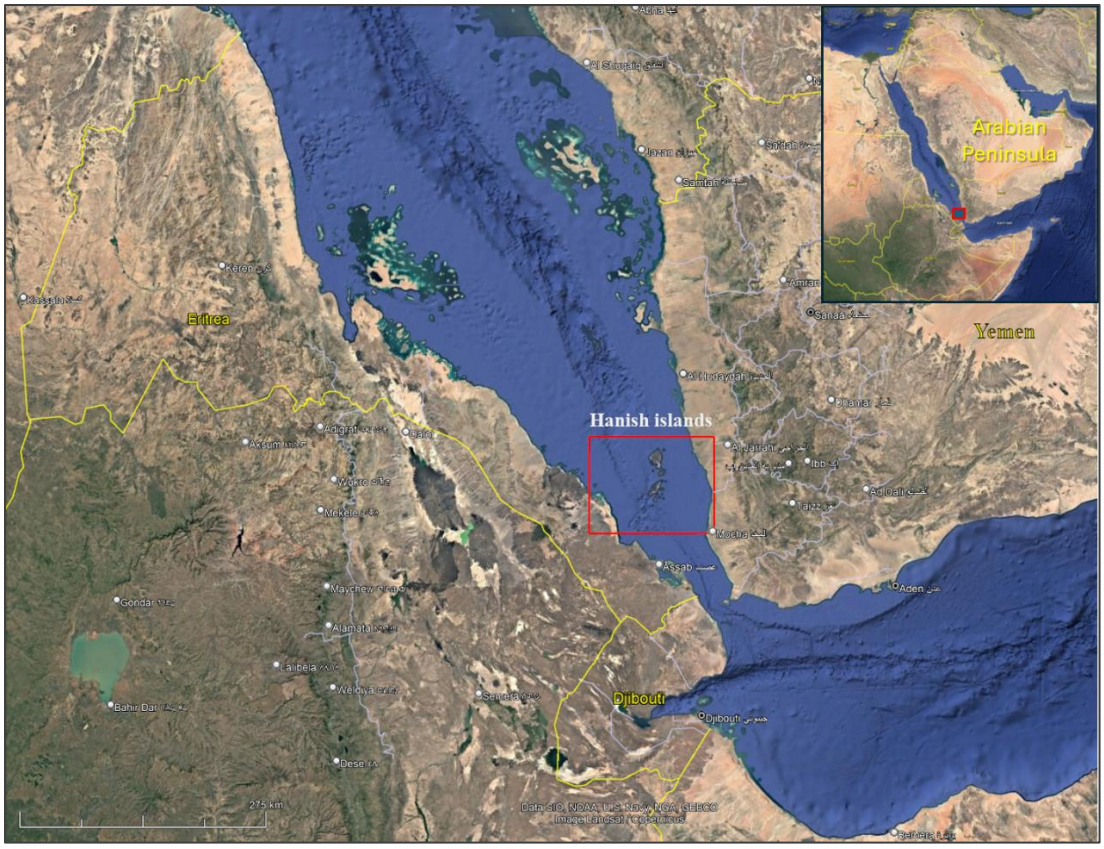


Figure 11. Coverage of the AOI used in the example over Google Earth – the red rectangle covering the Hanish Islands in the Red Sea

4. CREDENTIALS

Sentinel-1 data can be accessed through one of the two *Download services*:

- ESA Data Space: https://dataspace.copernicus.eu/browser/, or
- Alaska Satellite Facility (ASF): https://search.asf.alaska.edu.

An account with login credentials is required and the credentials should be added for at least one of two Sentinel-1 data repositories.

Both Sentinel-1 data providers, Data Space and ASF, require at least one special character in the password. The characters supported by SAR Essentials are:

$ + @ & ! #

Alternatively, the *Data Space* and *ASF* login credentials can be set in the *SAR Essentials Management Tool* and from there they will be automatically loaded in the current tool. In this way they will be kept for further processing sessions and will be loaded in the Downloader automatically. If the credentials are added only in the SAR Download Sentinel-1 tool they will be reset once the window is closed.

✍ Chose the relevant Download Service in the SAR Download Sentinel-1 window (Figure 12).

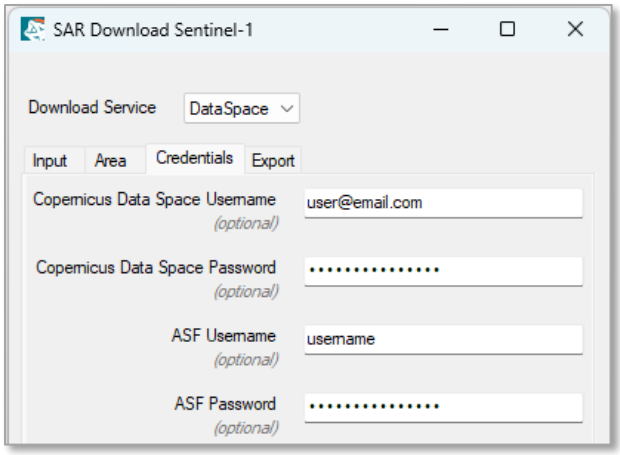


Figure 12. SAR Download Sentinel-1 Tool – Credentials tab

5. EXPORT PARAMETERS

The *Export* tab of the tool provides the opportunity to set the behaviour of the tool during the download process (Figure 13).

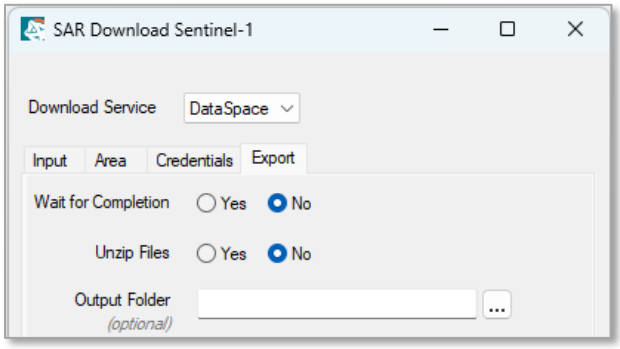


Figure 13. SAR Download Sentinel-1 Tool – Export tab

If *Wait for Completion* is set to *No*, once the downloading process starts, the license gets unlocked, and the panel can be closed. The downloader is executed as a stand-alone in DOS command prompt window and the download process runs in the background, while the User can continue using ENVI.

If the *Unzip Files* parameter is enabled, the downloaded files will be unzipped to the directory selected for *Output Folder*. The Output Folder may be defined here as an option or in the *ENVI Preferences* – panel *Directories* – field *Output Directory*.

Keep the two export parameters set to *No* (by default). Run the tool with the defined in the previous steps parameters – a sum up of the chosen settings is presented below in Figure 14.

The execution of the tool finds and downloads 1 SAR SCL IW image from the Sentinel-1 satellite over the area of the Hanish Islands in the Red Sea. The SAR Download Sentinel-1 window is closed, and the download is performed on the background. The progress of the download can be monitored via the automatically opened DOS command prompt window (Figure 15).

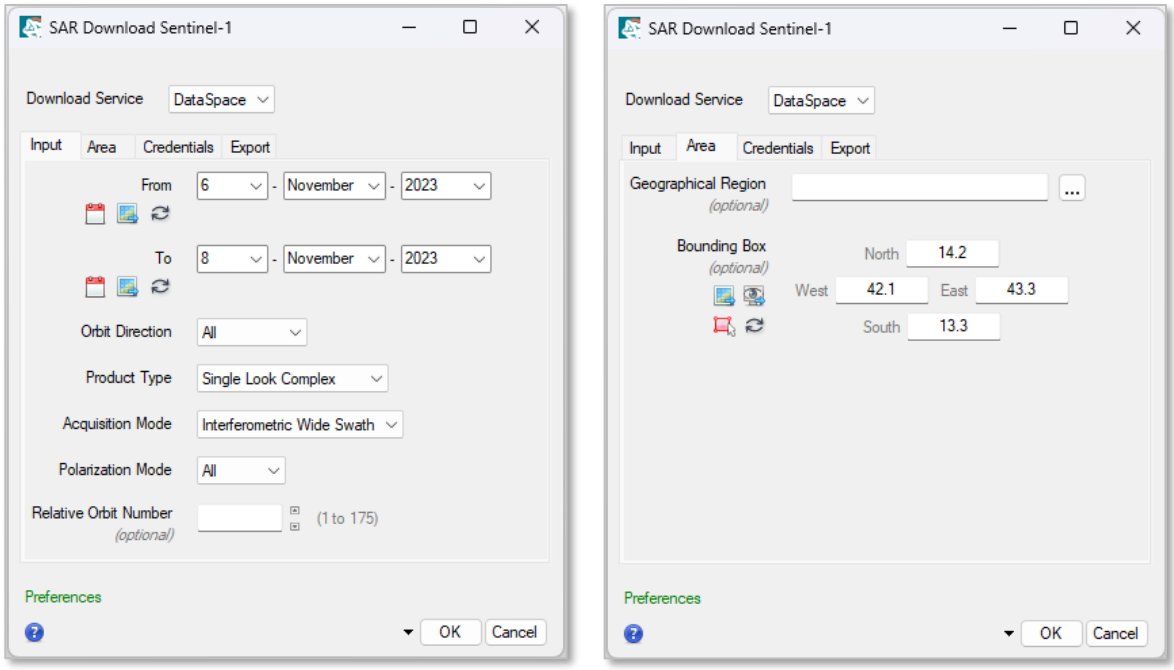


Figure 14. SAR Download Sentinel-1 Tool – tutorial settings

```
SciHub_download_plugin loaded succesfully!
1 Plugin(s) loaded successfully!
[?] Progress file 'D:\SAR_Essentials\progress' not found
[*] A new progress file 'D:\SAR_Essentials\progress' will be generated
Getting STAC items list from SciHub
Request URL: https://stac.dataspace.copernicus.eu/v1/search?collections=sentinel-1-slc&datetime=2023-11-06T00%3A00%3A00Z%2F202
3-11-08T23%3A59%3A59Z&limit=100&sortby=%2Bproperties.datetime&filter=sar%3Ainstrument_mode%20%3D%20%27IW%27%20AND%20sat%3Aorbi
t_state%20%3D%20%27ascending%27%20AND%20S_INTERSECTS%28geometry%2C%20POLYGON%28%2842.10000%2014.20000%2C42.10000%2013.30000%2C
43.30000%2013.30000%2C43.30000%2014.20000%2C42.10000%2014.20000%29%29%29

SciHub found 1 elements (STAC)

Found 1 unique frame(s)!

{1} SciHub added: 1 / 1 busy
{1} Validating file D:\SAR_Essentials\S1A_IW_SLC__1SDV_20231107T151938_20231107T152004_051113_062A09_4EFD.zip...
{1} [?] File not already present on disk, filename=D:\SAR_Essentials\S1A_IW_SLC__1SDV_20231107T151938_20231107T152004_051113_0
62A09_4EFD.zip_temp
{1} > Starting download 1 of 1...
{1} SciHub Downloading file S1A_IW_SLC__1SDV_20231107T151938_20231107T152004_051113_062A09_4EFD.SAFE...
Download request url : https://download.dataspace.copernicus.eu/odata/v1/Products(8d2bc5b5-95e3-4b29-a7f0-74e76c9b3e23)/$value
```

Figure 15. SAR Download Sentinel-1 Tool – download progress in DOS window

The download process takes several minutes to complete, depending on the number of found images. When the process is finished, the command window issues a "*Done…*" message.

When the download process is *Done* press ***ENTER*** from the keyboard to close the downloading prompt window (Figure 16).

```
Download recap:
Plugin ASF downloaded 1 file(s)
Done...
[<] SarsNT v1.5r for Win64 is down
press ENTER to quit
```

Figure 16. SAR Download Sentinel-1 Tool – message for download completed

The downloaded original images are archived separately *.zip[6] files (unless the option for *Unzip* was enabled) for each date. Each zip file contains a folder with the manifest.safe file which is used for reading the Sentinel-1 data. This file comprises links to the image data in a binary data format and the product metadata in XML files. The image data are systemised in the folder "measurements" by polarization and swaths, while the XML metadata files are stored in folder "annotation" (Figure 17). The folder "preview" contains a file, product-preview.html", which is listing the entire structure of the zip dataset and "map-overlay.kml" file that can visualise in Google Earth a thumbnail of the downloaded Sentinel-1 image.

Note: It is not necessary to unzip the original downloaded files.



Figure 17. An example of a Sentinel-1 data folder

As with any other data, the Sentinel-1 images must be imported in SAR Essentials, i.e. to be transformed into proper format for further processing. The SAR Essentials data format consists of a set of three mandatory files:

- **binary data** – raster data matrix (usually float, complex and byte)
- ***.sml** – SAR Essentials ASCII header file containing all mandatory information for the data processing
- ***.hdr** – ENVI header file for compatibility with ENVI tools

Note: For more details consult **SAR Essentials – Getting Started** tutorial.

For further processing, the original *.zip files can be directly imported into SAR Essentials using the *SAR Basic Data Processing* tool or ingested into SAR Essentials workflows. Consult the corresponding tutorials and help pages.

[6] File naming convention: https://sentiwiki.copernicus.eu/web/s1-products