Sen2Cor v 2.12.03: Installation, Configuration and Processing

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V 2.1.0

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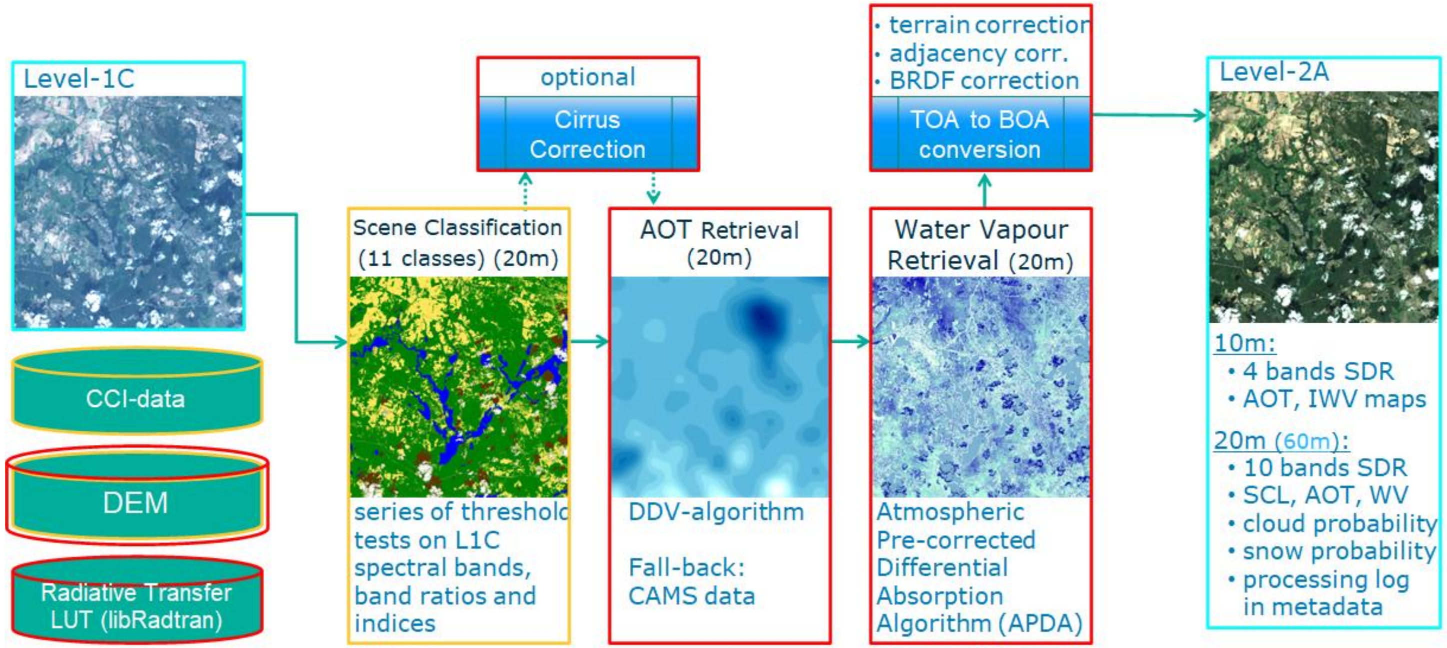
SUMMARY

Sen2Cor 2.12.03

What is Sen2Cor?

Sen2Cor is a **processor** for Sentinel-2 **Level 2A** product generation and formatting; it performs the atmospheric-, terrain- and cirrus correction of mono-temporal Top-Of-Atmosphere Level 1C input data. Sen2Cor creates Surface Reflectance (optionally terrain- and cirrus- corrected) images and, additionally, Aerosol Optical Thickness Map, Water Vapour Map, Scene Classification Map and Quality Indicators for cloud and snow probabilities. Its output product format is inherited from the Level 1C User Product: JPEG 2000 images, with three different resolutions, 60, 20 and 10 m.



Sen2Cor Overview © Bringfried Pflug (Optical MPC/DLR)

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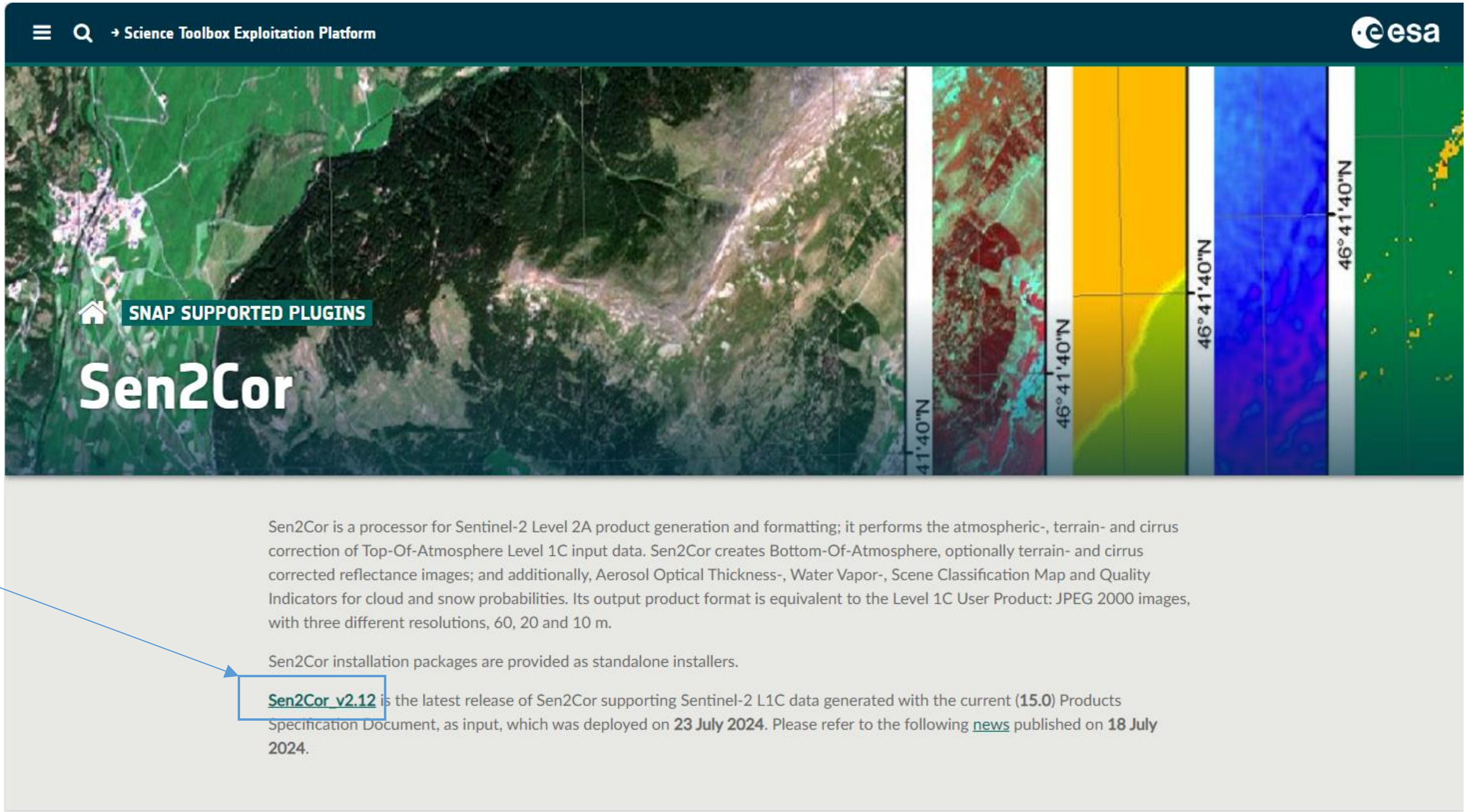
Download

`Sen2Cor` can be downloaded from [Sen2Cor – STEP (esa.int)] page where the latest version is available

Link to the Sen2Cor Download Page



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Download

The Sen2Cor v2.12 – Download Page contains a series of important information

- Information on new features within the latest release
- Link to necessary auxiliary files to be downloaded for a full configuration
  - DEM, ESA-CCI (see aux-files)
- Expected differences between L2A Core Products* and Sen2Cor Toolbox L2A Products:

Using the Copernicus DEM@90m, the only differences between L2A "Toolbox" and L2A "Core" Products are reported in the following table:

Category of Difference	Difference	L2A Toolbox	L2A Core Products
Product Format	HTML Folder	No	Yes
	Manifest	Same Set of Items but arranged in different order	
	Product Quality Metadata	Copied from L1C	Generated by L2A On-line Quality Check (OLQC)
	JPEG2000 encoding library	OpenJPEG	Kakadu
	Processing baseline	99.99	Official, e.g. **05.09**

- Installers:
  - Windows (link)
  - Linux (link)
- Documentation (see next page)

*Processed by the ESA Copernicus Sentinel-2 Productions Services and then disseminated via the official channels (see Slide 18)

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Documentation

The Sen2Cor v2.12 – Download Page contains a series of important information

- Documentation:
  - Software Release Notes: SRN
  - Software User Manual: SUM
  - Copernicus Sentinel-2 Product Definition Document: PSD
  - Copernicus Sentinel-2 Level 2A Input Output Data Definition: IODD
  - Copernicus Sentinel-2 Level 2A Algorithm Theoretical Baseline Document: ATBD

Note: `Sen2Cor` 2.12.03 introduces the possibility to process products from the Copernicus Sentinel-2C Satellite.
Users shall update their `Sen2Cor` version to this released 2.12.03 if they want to perform processing on the new Sentinel-2C L1C products.

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Installation (See also SUM, Section 3.1 and SRN Section 4)

The Python runtime packages of `Sen2Cor` will work fully autonomously and isolated and do not need any further installation of Anaconda, GDAL, OpenJPEG or any other python packages.

Example_1: **Windows (64 bit is mandatory).**
Package: **Sen2Cor-02.12.03**-win64.zip

- Extract the zipped archive with an unzip tool (in any desired location, best with short path)
- This will create a folder named: `Sen2Cor-02.12.03-win64`
- Change into the directory `Sen2Cor-02.12.03-win64` using the windows command line interpreter
- Call the command “`L2A_Process.bat --help`”

```
C:\Users\TEST\test_sen2Cor\Sen2Cor-02.12.03-win64\L2A_Process.bat --help
```

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Installation (See also SUM, Section 3.1 and SRN Section 4)

This will produce the following lines in case of first installation…

```
C:\Users\TEST\test_sen2Cor\Sen2Cor-02.12.03-win64\Lib\site-packages\sen2cor\cfg\L2A_GIPP.xml
-> C:\Users\TEST\Documents\sen2cor\2.12\cfg\L2A_GIPP.xml
1 File(s) copied
```

i.e. It will create a directory `\sen2cor\2.12\cfg` in the “Documents” folder,
where the installer will place the default `L2A_GIPP.xml`

N.B. In case of re-installation, the `L2A_GIPP.xml` will not be overwritten if present. A message similar to the following will be displayed:

```
File ‘C:\Users\TEST\test_sen2Cor\Sen2Cor-02.12.03-win64\Lib\site-packages\sen2cor\cfg\L2A_GIPP.xml’  already exists. So
we don’t change it! Please make sure its structure is in line with version installed
```

N.B. Please be sure to have the correct and more recent `L2A_GIPP.xml` within this folder as `Sen2Cor` 2.12.03 introduces the new PSD 15.0.

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Installation (See also SUM, Section 3.1 and SRN Section 4)

…followed by:

```
usage: L2A_Process.py [-h] [--mode MODE] [--resolution {10,20,60}]
                      [--datastrip DATASTRIP] [--tile TILE]
                      [--output_dir OUTPUT_DIR] [--work_dir WORK_DIR]
                      [--img_database_dir IMG_DATABASE_DIR]
                      [--res_database_dir RES_DATABASE_DIR]
                      [--processing_centre PROCESSING_CENTRE]
                      [--archiving_centre ARCHIVING_CENTRE]
                      [--processing_baseline PROCESSING_BASELINE] [--raw]
                      [--tif] [--sc_only] [--sc_classic] [--sc_cog]
                      [--cr_only] [--debug] [--GIP_L2A GIP_L2A]
                      [--GIP_L2A_SC GIP_L2A_SC] [--GIP_L2A_AC GIP_L2A_AC]
                      [--GIP_L2A_PB GIP_L2A_PB]
                      input_dir

Sen2Cor. Version: 02.12.03, created: 2024.09.09, supporting Level-1C product
version 14.2 – 15.0.

positional arguments:
  input_dir             Directory of Level-1C input
optional arguments:
  -h, --help            show this help message and exit
  --mode MODE           Mode: generate_datastrip, process_tile
  --resolution {10,20,60}
                        Target resolution, can be 10, 20 or 60m. If omitted,
                        only 20 and 10m resolutions will be processed
  --datastrip DATASTRIP
                        Datastrip folder
  --tile TILE           Tile folder
  --output_dir OUTPUT_DIR
                        Output directory
```

```
--work_dir WORK_DIR   Work directory
  --img_database_dir IMG_DATABASE_DIR
                        Database directory for L1C input images
  --res_database_dir RES_DATABASE_DIR
                        Database directory for results and temporary products
  --processing_centre PROCESSING_CENTRE
                        Processing centre as regex: ^[A-Z_]{4}$, e.g "SGS_"
  --archiving_centre ARCHIVING_CENTRE
                        Archiving centre as regex: ^[A-Z_]{4}$, e.g. "SGS_"
  --processing_baseline PROCESSING_BASELINE
                        Processing baseline in the format: "dd.dd", where
                        d=[0:9]
  --raw                 Export raw images in rawl format with ENVI hdr
  --tif                 Export raw images in TIFF format instead of JPEG-2000
  --sc_only             Performs only the scene classification at 60 or 20m
                        resolution
  --sc_classic          Performs scene classification in Sen2Cor 2.9 mode
  --sc_cog              Export SCL image in COG format instead of JPEG_2000
  --cr_only             Performs only the creation of the L2A product tree, no
                        processing
  --debug               Performs in debug mode
  --GIP_L2A GIP_L2A     Select the user GIPP
  --GIP_L2A_SC GIP_L2A_SC
                        Select the scene classification GIPP
  --GIP_L2A_AC GIP_L2A_AC
                        Select the atmospheric correction GIPP
  --GIP_L2A_PB GIP_L2A_PB
                        Select the processing baseline GIPP

C:\Users\TEST\test_sen2Cor\Sen2Cor-02.12.00-win64>
```

This output indicates a correct installation.

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Installation (See also SUM, Section 3.1 and SRN Section 4)

> The Python runtime packages of Sen2Cor will work fully autonomously and isolated and do not need any further installation of Anaconda, GDAL, OpenJPEG or any other python packages.

Example_2: **Linux (64 bit is mandatory).**
Package: **Sen2Cor-02.12.03**-Linux64.run

- Run in terminal: `sh Sen2Cor-02.12.03-Linux64.run`
- This will create a folder named: `Sen2Cor-02.12.03-Linux64`
- Change into the directory `Sen2Cor-02.12.03-Linux64`
- You can call the L2A Processor with the following:

```
C:/Users/TEST/test_sen2Cor/Sen2Cor-02.12.03-Linux64/bin/L2A_Process --help
```

- From here, in case of correct installation, the output will be similar to the Windows' output shown in the previous slides.

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Configuration: `L2A_GIPP.xml`

Calibration for Expert Users: `L2A_CAL_SC_GIPP.xml` and `L2A_CAL_AC_GIPP.xml`

The `L2A_GIPP.xml` file is the main configuration file for `Sen2Cor`.

Note: We recommend not to change the main parameters within the following sections:
1) <PSD_Version>DEFAULT</PSD_Version>
2) <Scene_Classification>…</Scene_Classification>
3) <Atmospheric_Correction>…</Atmospheric_Correction>

as the default configuration represents the configuration of the L2A Core Products.

The `L2A_CAL_SC_GIPP.xml` file is the calibration file for the Sen2Cor Scene Classification.
Note: We recommend **not** to modify the main parameters within the file as the default configuration represents the configuration of the L2A Core Product.

The `L2A_CAL_AC_GIPP.xml` file is the expert calibration file for the Sen2Cor Atmospheric Correction.
Note: We recommend **not** to modify the main parameters within the file as the default configuration represents the configuration of the L2A Core Product.

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Configuration: Digital Elevation Model, DEM (See also SUM, Section 2.2.8)

The usage of a DEM is not set by default. It has to be set manually.
The user can specify a DEM in the `L2A_GIPP.xml` configuration file by setting the parameter for <DEM_Directory> to a relative path inside the configuration directory, instead of `NONE`.
The DEM shall be located in the specified folder in the Sen2Cor home directory. Symbolic links are also allowed.
Example: <DEM_Directory>dem/dem_dir</DEM_Directory>

The `L2A_GIPP.xml` within `Sen2Cor` 2.12.03 Toolbox reports information and examples:

<DEM_Directory>None</DEM_Directory>
<!—
should be either a directory in the sen2cor home folder or 'NONE'.
1) To use **previously downloaded** CDSE DGED DEM, set <DEM_Directory> to the local path where the DEM files are stored (e.g. `dem/CopernicusDEM90_DGED`).
2) To use the Copernicus DEM hosted by AWS, set <DEM_Directory> to the local path where the DEM files are stored (e.g. `dem/CopernicusDEM90_AWS`).
3) If not DEM is used, <DEM_Directory> should be set to '`NONE`'.
-->
<DEM_Reference>None</DEM_Reference>
<!-- DEM_Reference is used to 1) reference the DEM in the L2A Metadata and, alternatively, 2) to set the url where DEM can be automatically downloaded.
1) To use **previously downloaded** CDSE DGED DEM, set <DEM_Reference> to '`CDSE-GLO-30`' or '`CDSE-GLO-90`' (resolution, 30/90, is mandatory).
2) To use the Copernicus DEM hosted by AWS, set for example <DEM_Reference>`https://copernicus-dem-90m.s3.eu-central-1.amazonaws.com/`</DEM_Reference>.
3) If no DEM is used, <DEM_Reference> should be set to '`NONE`'.

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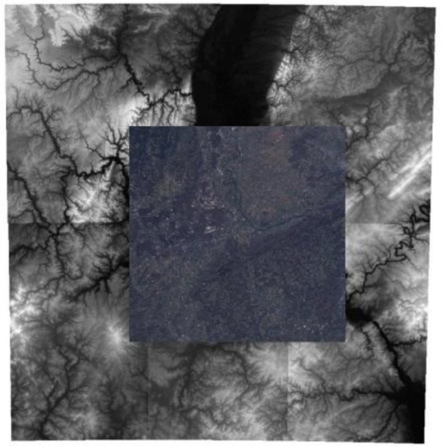
CDSE Copernicus DEM-Downloader (See also SUM, Section 2.2.8)

It is recommended to use the dedicated tool to retrieve for any L1C product the corresponding Copernicus DEM geocells from the Copernicus Data Space Ecosystem (CDSE). Those geocells can then directly be used by Sen2Cor software.

This tool can be accessed here: Senbox: CDSE-Copernicus-DEM-downloader

A quick guide explaining how to operate the tool is available here: CDSE_DEM_Downloader_v1_3.pdf

This tool is designed around Sen2Cor and provides a simple access to the official Copernicus DEM data.



Important Note:
To use downloaded CDSE DGED DEM, setting (in the `L2A_GIPP.xml`) `<DEM_Reference>` to '`CDSE-GLO-30`' or '`CDSE-GLO-90`' (resolution, 30/90) is mandatory.

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Configuration: Digital Elevation Model, DEM (See also SUM, Section 2.2.8)

As explained in previous slides, the DEM shall be located in the specified folder in the Sen2Cor home directory. Symbolic links are also allowed.
Example: <DEM_Directory>dem/dem_dir</DEM_Directory>

Automatic download:

If no appropriate DEM is found in this folder, the processor will try to automatically retrieve the necessary DEM files by downloading them from the address indicated in the <DEM_Reference> , e.g.:

<DEM_Reference>
http://website.dem/dem-folder/dem_files
</DEM_Reference>

If the necessary DEM files are found in the local folder defined by <DEM_Directory>, the download will not take place, and the local archive will be used instead.

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Configuration: Digital Elevation Model, DEM (See also SUM, Section 2.2.8)

`Sen2Cor` 2.12.03 Toolbox currently supports the **downloading** of the following DEMs:

- **Copernicus DEM (AWS)**:
  - Information on the Amazon Web Service (AWS) Copernicus DEM can be found at this link:
    - Amazon Web Service - Copernicus Digital Elevation Model
  - Example of links to be set in the `L2A_GIPP.xml` `<DEM_Reference>`:
    - AWS Copernicus DEM at 30m resolution:
      - `https://copernicus-dem-30m.s3.eu-central-1.amazonaws.com/`
    - AWS Copernicus DEM at 90m resolution:
      - `https://copernicus-dem-90m.s3.eu-central-1.amazonaws.com/`

- **SRTM (Legacy)**:
  - Information on the SRTM can be found at this link:
    - SRTM | Earthdata (nasa.gov)
  - Example of link to be set in the `L2A_GIPP.xml` `<DEM_Reference>`:
    - `http://srtm.csi.cgiar.org/wp-content/uploads/files/srtm_5x5/TIFF/`

If the download fails and no local DEM are found, the processor will continue **with a flat terrain calculation**.
In order to use the SRTM, the `<DEM_Reference>` has always to be set, even if the DEM files are already available.

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Configuration: [ESA Climate Change Initiative](), ESA CCI, Auxiliary Files (See also [SUM](), Section 3.1.2)

The *ESA CCI-LC* for `Sen2Cor` data package is prepared for users of `Sen2Cor` version ≥ 2.5 who want to benefit from the last improvements of `Sen2Cor` Cloud Screening and Classification module. This auxiliary data information is used in `Sen2Cor` to improve the accuracy of Sen2Cor classification over water, urban and bare areas and also to have a better handling of false detection of snow pixels.
`N.B.` a *Digital Elevation Model (DEM)* is a pre-requisite for using *ESACCI_LC* information in the Scene Classification algorithm.

Users of Sen2Cor version 2.10 (and up)
Download the new monthly snow condition files derived from ESACCI from this location:
https://earth.esa.int/eogateway/ftp/Sentinel-2/ESACCI-LC-L4-ALL-FOR-SEN2COR-2.10.tar.gz

The downloaded file shall then be extracted at this location of `Sen2Cor` installation: `$SEN2COR_BIN/aux_data/`

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Configuration: Use of L1C Quality Masks (See also SUM, Section 2.2.8, IODD Section 2.4)

Since version 2.10, `Sen2Cor` supports and handles L1C quality masks in raster format describing invalid pixels in the L1C input data. The `L2A_GIPP.xml` configuration file contains a new parameter:

```
<Handle_L1C_QLT_Mask>TRUE</Handle_L1C_QLT_Mask>
<!-- FALSE: no handling of L1C Quality Mask, TRUE: handling L1C Quality Mask -->
```

When this is set True, `Sen2Cor` reads from the file `GENERAL_QUALITY.xml` from the folder `L1C_product/GRANULE/tile_id/QI_DATA/` if loss of data is reported.

In the affirmative case, it reads the list of the affected bands.

`Sen2Cor` then checks within the:
`L1C_product/GRANULE/tile_id/QI_DATA/` that contains `MSK_QUALIT_BXX.jp2` (where `XX` is the ID of the bands) files.

The files with the affected bands are read and a mask is created.

L2A TCI image of a tile processed with a Quality Mask masking the defective pixels of different affected bands.

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Data access to Sen2Cor input data: Copernicus Sentinel-2 Level-1C Products

Sentinel-2 L1C Products can be retrieved either from:

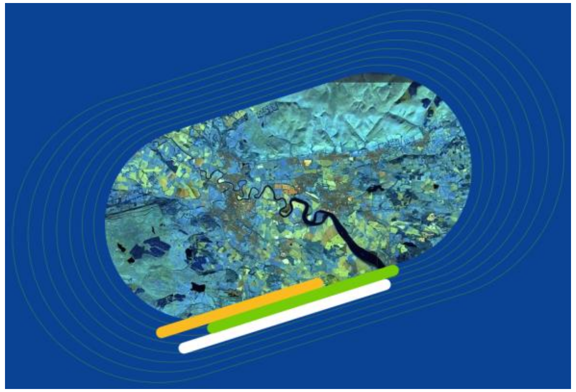
- Copernicus Data Space Ecosystem*

  Copernicus Data Space Ecosystem | Europe's eyes on Earth

- Copernicus Data and Information Access Services (DIAS)*

  Data and Information Access Services | Copernicus

  e.g.: https://creodias.eu, https://www.wekeo.eu/



Copernicus Browser

*N.B. Login may be required to access the data

Please note that the easiest way to get Level-2A files is to download them from the above data access services.
You only need to run `Sen2Cor` to get Level-2A files if you need to test a special configuration (e.g. no terrain correction)

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Processing: A quick guide to the Level-1C Products

S2A_MSIL1C_20240816T094031_N0511_R036_T33TXF_20240816T114129.SAFE

Mission ID (S2A/S2B/S2C)
MSIL1C indicates the Level-1C product level
Datatake sensing start time
NProcessing Baseline number
RRelative Orbit number (R001 - R143)
TTile Identification Number
Processing time
SAFE: Product Format (Standard Archive Format for Europe)

The **Level-1C** product is composed of 110x110 km^2 tiles (ortho-images in UTM/WGS84 projection). Earth is subdivided on a predefined set of tiles, defined in UTM/WGS84 projection and using a 100 km step. However, each tile has a surface of 110x110 km^2 in order to provide large overlap with the neighbouring.

The Sentinel 2 Tile system is described in detail at this link: Sentinel-2 UTM Tiling Grid
A KML file is also available at this link: Sentinel-2-KML-Tile_System

For general description of Copernicus Sentinel-2 Products: Products Overview
For detailed description of Copernicus Sentinel-2 L1C Products: L1C General Description & L1C Algorithms and Products

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Processing: A quick guide to the Level-2A Products

S2A_MSIL2A_20240816T094031_N0511_R036_T33TXF_20240816T141801.SAFE

Mission ID (S2A/S2B/S2C)
MSIL2A indicates the Level-2A product level
Datatake sensing start time
NProcessing Baseline number*
RRelative Orbit number (R001 - R143)
TTile Identification Number
Processing time
SAFE: Product Format (Standard Archive Format for Europe)

The **Level-2A** product provides atmospherically corrected Surface Reflectance (SR**) images, derived from the associated Level-1C products.

Detailed description on Copernicus Sentinel-2 L2A Core Products can be found at these links: L2A General Description, L2A Algorithms and Products, and in the Sen2Cor Documentations

*L2A Products processed with `Sen2Cor Toolbox` will have by default a processing baseline number **N9999** to distinguish them from operational products generated by the ground segment.

**SR corresponds to HDRF (Hemispherical Directional Reflectance Factor)

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Copernicus Sentinel 2: Useful References

- Sentinel-2 New Wiki Page: Sentinel-2 - SentiWiki
- Sentinel-2 Data Product Page: Sentinel-2 - Data Products
- Sentinel-2 Tiling System: Sentinel_2_Tiles.kml (more info on Sentinel-2 Data Product Page)
- Sentinel-2 Processing Baselines: L1C and L2A Processing Baselines

- Sentinel-2 Collection 1: Collection-1 Products generated from the reprocessing activity are tagged with Processing Baselines 05.00 and 5.10

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ESA STEP Forum Support

Since April 2023 the `Sen2Cor` Developers Team provides a support to the Sen2Cor Users within the ESA Step Forum that can be found here:

- Latest s2tbx/sen2cor topics - STEP Forum (esa.int)

Within the forum,

- A `Sen2Cor` Reference Page can be found at this link:
  - Sen2Cor reference page - s2tbx / sen2cor - STEP Forum (esa.int)
- A `Sen2Cor` Frequently Asked Questions can be found at this link:
  - Sen2Cor Frequently Asked Questions - s2tbx / sen2cor - STEP Forum (esa.int)

Please read these two pages before starting a new thread within the forum.

THANK **YOU**
FOR YOUR ATTENTION

telespazio.de