VITO SENTINEL-2

PRODUCTS USER MANUAL

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<tr>
<th>Acronym</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
</tr>
<tr>
<td>DN</td>
<td>Digital Number Count</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>FAPAR</td>
<td>Fraction of Absorbed Photosynthetically Active Radiation</td>
</tr>
<tr>
<td>FCOVER</td>
<td>Fraction of green Vegetation Cover</td>
</tr>
<tr>
<td>FTP</td>
<td>File Transfer Protocol</td>
</tr>
<tr>
<td>GDAL</td>
<td>Geospatial Data Abstraction Layer</td>
</tr>
<tr>
<td>GeoTIFF</td>
<td>Geospatial Tagged Image File Format</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>HDFS</td>
<td>Hadoop Distributed File System</td>
</tr>
<tr>
<td>HTTP</td>
<td>HyperText Transfer Protocol</td>
</tr>
<tr>
<td>iCOR</td>
<td>An atmospheric correction algorithm</td>
</tr>
<tr>
<td>IDL</td>
<td>Interactive Data Language</td>
</tr>
<tr>
<td>INSPIRE</td>
<td>Infrastructure for spatial information in Europe</td>
</tr>
<tr>
<td>LAI</td>
<td>Leaf Area Index</td>
</tr>
<tr>
<td>LEVEL 1C</td>
<td>Radiometrically and geometrically calibrated Level-1 data</td>
</tr>
<tr>
<td>MEP</td>
<td>Mission Exploitation Platform</td>
</tr>
<tr>
<td>MSI</td>
<td>Multi-Spectral Instrument</td>
</tr>
<tr>
<td>MTDA</td>
<td>Mid Term Data Archive</td>
</tr>
<tr>
<td>NDVI</td>
<td>Normalized Difference Vegetation Index</td>
</tr>
<tr>
<td>NFS</td>
<td>Network File System</td>
</tr>
<tr>
<td>NIR</td>
<td>Near-Infrared</td>
</tr>
<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
</tr>
<tr>
<td>PDP</td>
<td>Product Distribution Portal</td>
</tr>
<tr>
<td>PROBA-V</td>
<td>Project for On-Board Autonomy - Vegetation</td>
</tr>
<tr>
<td>QGIS</td>
<td>Quantum GIS</td>
</tr>
<tr>
<td>RD</td>
<td>Reference Document</td>
</tr>
<tr>
<td>REST</td>
<td>Representational State Transfer</td>
</tr>
<tr>
<td>ROI</td>
<td>Region of Interest</td>
</tr>
<tr>
<td>SNAP</td>
<td>Sentinel Application Platform</td>
</tr>
<tr>
<td>SPOT-VGT</td>
<td>Satellite Pour l’Observation de la Terre – Végétation</td>
</tr>
<tr>
<td>SSH</td>
<td>Secure Shell</td>
</tr>
<tr>
<td>SWIR</td>
<td>Short-Wave Infrared</td>
</tr>
<tr>
<td>SZA</td>
<td>Solar Zenith Angle</td>
</tr>
<tr>
<td>TOA</td>
<td>Top-Of-Atmosphere</td>
</tr>
<tr>
<td>TOC</td>
<td>Top-Of-Canopy</td>
</tr>
<tr>
<td>UTC</td>
<td>Universal Time Coordinate</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>VITO</td>
<td>Vlaamse Instelling voor technologisch Onderzoek; Flemish Institute for Technological Research</td>
</tr>
<tr>
<td>VM</td>
<td>Virtual Machine</td>
</tr>
<tr>
<td>VNIR</td>
<td>Visible and Near-InfraRed</td>
</tr>
<tr>
<td>VZA</td>
<td>Viewing Zenith Angle</td>
</tr>
<tr>
<td>WGS84</td>
<td>World Geodetic System 1984</td>
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<tr>
<td>WCS</td>
<td>Web Coverage Service</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>WMS</td>
<td>Web Mapping Service</td>
</tr>
<tr>
<td>WMTS</td>
<td>Web Map Tile Service</td>
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OBJECTIVES AND REFERENCE DOCUMENTATION

VITO generates complementary Sentinel-2 products with specific tailoring for regional coverage and specific applications (vegetation monitoring) to extend the Sentinel-2 core product chains.

This document describes the VITO Sentinel-2 product work flows, the complementary products and the product distribution portal at which the products are disseminated. The objectives of this document are the following:

- To present a short overview of the Sentinel-2 mission
- To provide an overview of the VITO processing work flows of the various Sentinel products.
- To give a detailed overview of the various datasets and product file attributes.
- To guide the user through the registration and data ordering process
- To guide the user in the data viewing and handling

Reference documents


ToDo – Ref. to Future paper on iCOR atmospheric correction validation through the ACIX inter-comparison exercise

[RD5] ToDo – Ref. to BELCAM documents Isabelle Piccard
1. Introduction

The Sentinels are a fleet of satellites designed specifically to deliver the wealth of data and imagery that are central to the European Commission’s Copernicus programme. This unique environmental monitoring programme is making a step change in the way we manage our environment, understand and tackle the effects of climate change and safeguard everyday lives.

Sentinel-2 provides unprecedented views of Earth. The two identical satellites in the same orbit, 180° apart cover all Earth’s land surfaces, large islands, inland and coastal waters every five days at the equator.

The mission mainly provides information for agricultural and forestry practices and for helping manage food security. Satellite images can be used to determine various plant indices such as leaf area chlorophyll and water content indexes. This is particularly important for effective yield prediction and applications related to Earth’s vegetation.

Sentinel-2 data can be used to:
- monitor plant growth;
- map changes in land cover;
- monitor the world’s forests;
- provide information on pollution in lakes and coastal waters;
- contribute to disaster mapping (floods, volcanic eruptions and landslides);
- help humanitarian relief efforts.

With its multispectral imager and wide swath coverage, the Sentinel-2 mission offers continuity and expands on the French Spot, US Landsat and also on the PROBA-V mission. Sentinel-2A was launched on 23 June 2015 and Sentinel-2B followed on 7 March 2017.

The availability of this new and magnificent Sentinel-2 data gives VITO the unique opportunity to generate complementary products with specific tailoring for regional coverage and specific applications (vegetation monitoring).

Since 1998 VITO operates the processing and dissemination facilities of the SPOT-VGT and later the PROBA-V satellite missions. This provides VITO the necessary know-how, expertise and resources to process the Sentinel-2 data. Therefore, VITO will be the enabler for the Belgian stakeholders by providing the Sentinel data products and derived information.

With the Belgian stakeholders we envision not only research institutes but also public authority, the industry and even individual users.
1.1. Sentinel-2 Mission Overview

Sentinel-2 Mission is an European earth polar-orbiting satellite constellation (Sentinel-2A and 2B) designed to feed the Copernicus system with continuous and operational high-resolution imagery for the global and sustained monitoring of Earth land and coastal areas.

The Sentinel-2 system is based on the concurrent operations of two identical satellites flying on a single orbit plane but phased at 180°, each hosting a Multi-Spectral Instrument (MSI) covering from the visible to the shortwave infrared spectral range and delivering high spatial resolution imagery at global scale and with a high revisit frequency.

The MSI aims at measuring the earth reflected radiance through the atmosphere in 13 spectral bands spanning from the Visible and Near Infra-Red (VNIR) to the Short Wave Infra-Red (SWIR):

- 4 bands at 10m: blue (490nm), green (560nm), red (665nm) and near infrared (842nm).
- 6 bands at 20m: 4 narrow bands for vegetation characterization (705nm, 740nm, 783nm and 865nm) and 2 larger SWIR bands (1610nm and 2190nm) for applications such as snow/ice/cloud detection or vegetation moisture stress assessment.
- 3 bands at 60m mainly for cloud screening and atmospheric corrections (443nm for aerosols, 945 for water vapor and 1375nm for cirrus detection).

Sentinel-2 mission objectives present a new challenge requiring space and ground segment resources in terms of:

- Temporal coverage, which translated into the need for a short orbit repeat cycle (10-days) and for a dual spacecraft operations in twin configuration providing a 5-days revisit frequency;
- Large spatial coverage and high coverage frequency, which translated into the need for a with wide swath coverage (290 km) with capabilities of global land masses acquisitions;
- High operation time during the daylight portion of the orbit;
- Wide spectrum optical range (visible to short-wave infrared) including 13 spectral bands;
- Data accessibility to the large Sentinel-2 data volume.

More information on the Sentinel-2 Mission and data products is on-line available at https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi.
1.2. Sentinel-2 Product Overview

Figure 1 shows the product overview of the Sentinel-2 products processed by VITO and described in detail in the current document in section 4. The figure includes an example for each product. The derived products are shown using a color map with different shades of grey.
Every Sentinel-2 user product is defined by a collection of data items (image, ancillary, auxiliary data) and metadata describing all elements composing the product.

The input products are the Sentinel-2 L1C products supplied by ESA. These Level-1C data products are Top-of atmosphere (TOA) reflectances in cartographic geometry.

In a first step the VITO Operational Atmospheric Correction processor generates the Sentinel-2 TOC products which are Level 2A surface reflectance products.

Starting from the Sentinel-2 TOC products, derived vegetation indicators are produced such as the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Fraction of green Vegetation Cover (FCOVER), Leaf Area Index (LAI) and Normalized Difference Vegetation index (NDVI).
2. Workflow and products description

This section describes the various VITO Sentinel-2 products. Initially VITO starts with the processing of the Sentinel-2 data over Belgium. First, the processing workflow with the various processing steps and applied algorithms are explained. Finally, for all product types an overview of the information content is given.

2.1. Sentinel-2 processing workflow

Figure 2 shows the high level diagram on the Sentinel-2 processing workflow performed in this context at VITO.
2.2. Input products

The input data for the VITO Sentinel-2 processing workflow are the Sentinel-2 Level-1C data products which are Top-of-atmosphere (TOA) reflectances in cartographic geometry.

The Level-1C products are a compilation of elementary granules of fixed size, along with a single orbit. A granule is the minimum indivisible partition of a product (containing all possible spectral bands).

The granules, also called tiles, are 100x100 km² ortho-images in UTM/WGS84 projection. The UTM (Universal Transverse Mercator) system divides the Earth's surface into 60 zones. Each UTM zone has a vertical width of 6° of longitude and horizontal width of 8° of latitude.

Initially, VITO will generate the Sentinel-2 products covering Belgium. The following grids represent the area of Belgium: 31UET, 31UFT, 31UDS, 31UES, 31UFS, 31UGS, 31UER, 31UFR, 31UGR, 31UFQ. Only those tiles will be downloaded and processed in the initial phase of the VITO Sentinel-2 project. Figure 3 shows, outlined in red, the grids covering Belgium which are downloaded and processed by VITO. The map is based on an OpenStreetMap layer.

Figure 3: Sentinel-2 grids covering Belgium
More info on the Sentinel-2 data products and tiling strategy is available on https://sentinel.esa.int/web/sentinel/missions/sentinel-2/data-products.

Detailed information on the Sentinel-2 L1C data products can be found in the [RD1].

2.3. Sen2Cor processing step

Sen2Cor is a processor for Sentinel-2 Level 2A product generation and formatting; it performs the atmospheric-, terrain and cirrus correction of Top-Of Atmosphere Level 1C input products. This Sen2Cor processor is freely on-line available from the ESA STEP (Science toolbox exploitation platform) portal. More information on this processor can be found at http://step.esa.int/main/third-party-plugins-2/sen2cor/.

Sen2Cor creates Bottom-Of-Atmosphere, optionally terrain- and cirrus corrected reflectance images; additional, Aerosol Optical Thickness-, Water Vapor-, Scene Classification Maps and Quality Indicators for cloud and snow probabilities. Its output product format is equivalent to the Level 1C User Product: JPEG 2000 images, three different resolutions, 60, 20 and 10 m. At VITO we reformat the data from JPEG 2000 into GeoTIFF files.

The two important processing modules in the Sen2Cor application are the SceneClass Module and the AtmCorr Module. In the VITO workflow, only the SceneClass Module is implemented to generate the Scene Classification Map and the cloud and shadow masks. The scene classification module allows to detect clouds, snow and cloud shadows and to generate a classification map, which consists of 4 different classes for clouds (including cirrus), together with six classifications for shadows, cloud shadows, vegetation, soil / desserts, water and snow.

The output of the at VITO implemented Sen2Cor processing step is the Scene Classification Map and the cloud/shadow mask covering images for the three resolutions.

The generated classification map is specified as follows:

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<tr>
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<td>NO_DATA</td>
</tr>
<tr>
<td>1</td>
<td>SATURATED_OR_DEFECTIVE</td>
</tr>
<tr>
<td>2</td>
<td>DARK_AREA_PIXELS</td>
</tr>
<tr>
<td>3</td>
<td>CLOUD_SHADOWS</td>
</tr>
<tr>
<td>4</td>
<td>VEGETATION</td>
</tr>
<tr>
<td>5</td>
<td>BARE_SOIL</td>
</tr>
<tr>
<td>6</td>
<td>WATER</td>
</tr>
<tr>
<td>7</td>
<td>CLOUD_LOW_PROBABILITY</td>
</tr>
<tr>
<td>8</td>
<td>CLOUD_MEDIUM_PROBABILITY</td>
</tr>
<tr>
<td>9</td>
<td>CLOUD_HIGH_PROBABILITY</td>
</tr>
<tr>
<td>10</td>
<td>THIN_CIRRUS</td>
</tr>
</tbody>
</table>
### 2.4. iCOR processing step

iCOR is an atmospheric correction algorithm which is scene and sensor generic. It can handle land and water targets (including optically complex waters) and is adaptable with minimal efforts to other hyper- or multi-spectral sensors. Through the use of a single atmospheric correction implementation, discontinuities in the resulting reflectance between land and the highly dynamic water areas are reduced. iCOR uses MODTRAN 5 (Berk et al., 2006) Look Up Tables (LUT) to perform the atmospheric correction and needs information about the solar and viewing angles (Sun Zenith Angle (SZA), View Zenith Angle (VZA) and Relative Azimuth Angle (RAA)) and a digital elevation model (DEM). In its GCS implementation, the aerosol optical thickness (AOT) is retrieved from the image, using a adapted version of the land-based AOT retrieval method developed by Guanter (2007).

Figure 4 represents the iCOR workflow implemented in the VITO processing chain.

---

<table>
<thead>
<tr>
<th>Label</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>SNOW</td>
</tr>
</tbody>
</table>

*Table 1: Classification map*

Associated quality indicators on snow and cloud probability are generated from the results. These quality indicators calculate the probability (0-100%) that the earth surface is obstructed by clouds or optically thick aerosol (ice or snow). More information can be found in the Sen2Cor Configuration and User Manual ([RD2]).

These scene classification map and cloud/shadow output images are included in all the other end user products (in the applicable resolution and in GeoTIFF format).
Due to issues in the input L1C data it is necessary to perform, in some cases, a geometric correction on the L2A products. This geometric correction is performed for each product and information on the applied geometric correction for each product is stored but is not delivered to the users.

2.5. BIOPAR processing step

Biophysical parameters (fAPAR, fCover and LAI) are calculated based on the methodology developed by INRA-EMMAH (see Figure 5). It mainly consists in generating a comprehensive data base of vegetation characteristics (fAPAR, fCover, LAI) and the associated top of canopy (TOC) reflectances. Thereby Radiative Transfer Models (RTM) are used. Artificial Neural Networks (ANN) are then trained to estimate the canopy characteristics from the TOC reflectances along with the corresponding angles defining the observational configuration. Once the ANN is trained it can be run in operational mode.
2.6. NDVI processing step

The Normalized Difference Vegetation Index (NDVI) is an indicator of the greenness of the biomes. As such, it is closely linked to the FAPAR. Even though it is not a physical property of the vegetation cover, its very simple formulation makes it widely used for ecosystems monitoring.

The NDVI is calculated from individual reflectance measurements as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

where NIR and RED are the spectral reflectances measured in the near infrared and red wavebands respectively. In case of Sentinel 2, the following formula is applied:

$$NDVI = \frac{B_{08_{TOC}} - B_{04_{TOC}}}{B_{08_{TOC}} + B_{04_{TOC}}}$$

Note after implementing the algorithm the data is converted (quantization) from floating point to integer mainly to reduce the size of the files and the data is compressed using the Deflate compression schema.
3. Product data access

VITO makes the Sentinel-2 data available for registered users. The data can be downloaded from the VITO Production Distribution Portal (see section 3.1) or can be accessed on the Mission Exploitation Platform where expert users can develop processing on demand tools or use the data within the virtual research environment (see section 3.2).

Furthermore VITO provides Sentinel Web Services for data viewing, discovery and access. The Sentinel Web Services are explained in section 3.3. An on-line Geo Viewer application allows the user to view the Sentinel-2 data in full resolution. The Geo Viewer application is explained in section 3.4.

3.1. VITO Product Distribution Portal (PDP)

Sentinel-2 products can be ordered and downloaded from the VITO EO DATA Product Distribution Portal (PDP) at http://www.vito-eodata.be/.

Figure 6 shows the portal’s main page.
3.1.1. Registration to the PDP

To order VITO EO data (PROBA-V, Sentinel, ...), registration to the PDP is required. Registration can proceed after clicking the ‘Register’ link in the portal main page’s upper-right corner.

After clicking the link, a form to be filled out by the user appears on top of the portal’s main page, see Figure 7. The user is requested to provide additional information and to accept the Terms and Conditions. After clicking the ‘Register’ button, an activation e-mail is sent to the user and registration is completed upon clicking the activation link in the e-mail. It is noted that in some occasions, the activation mail might end up in the junk e-mail folder.
3.1.2. Product catalogue and ordering

Sentinel-2 data can be searched in the catalogue. From the portal’s main page, the user can select the Sentinel-2 Syntheses image tiles that is linked to Sentinel-2 collections:

- Sentinel-2 TOC (L2A Surface Reflectance in cartographic geometry)
- Sentinel-2 FAPAR
- Sentinel-2 FCOVER
- Sentinel-2 LAI
- Sentinel-2 NDVI

Upon Sentinel-2 collections selection, a new screen is opened, with a map to the left and a catalogue search criteria window to the right (see Figure 8). In this example, the Sentinel-2 TOC product has been selected and data for the period of 1 – 31 January 2017 are requested.

After selection of one or more products, the user has the following options:

1. Back to search: go back and refine the search
2. Prepare order: proceed with the selected product(s), see

3. Figure 9 Further product customization options (reformatting, select bands, etc.) are currently not available for the Sentinel-2 products. Please contact the Helpdesk for further information and conditions.

4. Fast order by FTP: by clicking this button (order now), all selected products are ordered and are delivered via FTP pull.

After order preparation, the user needs to confirm the order by clicking the ‘submit’ button. The user will receive an e-mail with download information once the ordered data have been produced and delivered to the FTP location.
Figure 8: Map with a defined Region of Interest (RoI), the selected product type (S2 TOC) and the selected date range (1 – 31 January 2017)

Users have the option to download bulk data for a given region, time period, or a combination of both, using the so-called ‘Fast HTTP Access’ (see Figure 10). A short User Manual on this facility, which also contains explanations on how to use wget scripts, is available at http://www.vito-eodata.be/PDF/image/Data_pool_manual.pdf.
3.1.3. Further information


3.2. PROBA-V Mission Exploitation Platform (MEP)

The PROBA-V MEP (https://proba-v-mep.esa.int/) complements the Proba-V User Segment through an Exploitation Platform on the entire PROBA-V, SPOT-VGT and (VITO) Sentinel-2 (from the summer of 2017 onwards) data archive and provides the vegetation data user community with a wealth of computational resources and tools to fully explore and analyse the data and derived products in spatial, temporal, and combined extents. It enables users to apply various types of ancillary data, as well as their own set of tools/libraries/applications to carry out their analyses. The MEP was established to facilitate and ease usage of the continuously growing data amount through a paradigm shift that will bring the users to the data rather than the other way round.

The MEP includes several tools such as:
- Time Series Viewer on a limited set of PROBA-V data for a number of predefined regions;
- Full-resolution viewing application (Geo Viewer) on all PROBA-V product data resolutions;
- A first version of an N-daily compositor, to be applied to PROBA-V 1 km and 300 m data;
• ESA Cloud Toolbox, enriched with sample PROBA-V data and included with Python and the SNAP Toolbox support;
• Demonstrations of interactive notebooks;
• Provision of Virtual Machines (VMs) for beta users.

3.2.1. User Virtual Machine

Users can connect to a Virtual Research Environment, with further access to the complete PROBA-V data archive and the Sentinel-2 data (from the summer of 2017 onwards), as well as a wealth of tools and libraries to analyze the data, through a Virtual Machine (VM). The PROBA-V MEP VMs are provided in the OpenStack private cloud, hosted by VITO.

- The VM comes with pre-installed command line tools, desktop applications, and developer tools useful for PROBA-V data exploitation (e.g. GDAL, QGIS, GRASS GIS, SNAP, Python, etc.).
- Access to the full PROBA-V archive.
- Target users are scientists and developers that program applications involving PROBA-V data.

A VM can be requested upon MEP registration via this link: https://proba-v-mep.esa.int/proba-v-mep-toolset/user-virtual-machine.

Direct file access is possible on a VM by requesting access to the Sentinel data at ‘User VM’ request or later by contacting probav-mep@vgt.vito.be.

On the VM, Sentinel-2 data can be found in the folder: /data/MTDA, for instance:

- /data/MTDA/CGS_S2_FAPAR/
- /data/MTDA/CGS_S2_FAPAR/
- /data/MTDA/CGS_S2_RADIOMETRY/

3.3. Sentinel Web Services

VITO provides Web Services which can be used for Sentinel-2 data viewing, discovery and access. More information on the Sentinel Web Services are on-line available on https://proba-v-mep.esa.int/sentinel-web-services.

3.3.1. OGC WMTS

The Web Map Tile Service (WMTS) is a standard protocol for serving pre-rendered georeferenced map tiles over the internet. VITO applies to the OGC WMTS Implementation Standard (OGC 07-057r7).
It is possible to access the WMTS directly by using a simple web browser or desktop tools such as QGIS.

VITO Sentinel WMTS URL:

http://sentineldata.vito.be/wmts?service=WMTS&request=GetCapabilities

The available layers are:

- CGS_S2_NDVI
- CGS_S2_FAPAR
- CGS_S2_RADIOMETRY

Examples:

http://sentineldata.vito.be/mapcache/wmts?layer=CGS_S2_NDVI&style=default&tilematrixset=g3857&Service=WMTS&Request=GetTile&Version=1.0.0&Format=image%2Fpng&TileMatrix=8&TileCol=131&TileRow=85&TIME=2015-07-16T08%3A50%3A24.00Z

http://sentineldata.vito.be/mapcache/wmts?layer=CGS_S2_RADIOMETRY&style=default&tilematrixset=g3857&Service=WMTS&Request=GetTile&Version=1.0.0&Format=image%2Fpng&TileMatrix=13&TileCol=4136&TileRow=2744&TIME=2017-05-19T09%3A05%3A30.00Z

3.3.2. OGC WMS

The Web Map Service (WMS) is a standard protocol for serving pre-rendered georeferenced map images over the internet. VITO applies to the OGC WMTS Implementation Standard (OGC 06-042).

It is possible to access the WMS directly by using a simple web browser or desktop tools such as QGIS.

VITO Sentinel WMS URL:

http://sentineldata.vito.be/ows?service=WMS&request=GetCapabilities

The available layers are:

- CGS_S2_NDVI
- CGS_S2_FAPAR
- CGS_S2_RADIOMETRY_BROWSE

Example:
3.3.3. OGC WCS

The OGC Web Coverage Service (WCS) standard defines Web-based retrieval of coverages – that is, digital geospatial information representing space/time-varying phenomena.

The VITO Sentinel WCS URL:
http://sentineldata.vito.be/ows?service=WCS&request=GetCapabilities

The available layers are:

- CGS__CGS_S2_NDVI
- CGS__CGS_S2_FAPAR
- CGS__CGS_S2_RADIOMETRY_BROWSE

Login is required for requests that download the data.

Example:

3.3.4. Time series REST service

VITO provides the time series REST service, to retrieve a time series for a given point or polygon. The response contains total and valid pixel counts, so you can easily detect dates with no or very little data for your area.

This curl request:

3.4. Sentinel-2 Geo Viewer

The on-line Geo Viewer application allows the user to view the Sentinel-2 data in full resolution. The Geo Viewer is backed by the OGC standard based web services WMS and WMTS as described above. The sentinel-2 Geo Viewer is available at [http://sentineldata.vito.be/viewer/#](http://sentineldata.vito.be/viewer/#).

![Sentinel-2 GeoViewer](image)

*Figure 11: Sentinel-2 GeoViewer*

The user can easily scroll within the available date ranges and data layers.

From the Geo Viewer, the user can generate an image (via WMS) or download the image as a GeoTIFF (via WCS) by using the ‘Generate image’ / ‘Download as Geotiff’ features as shown in the figure below.
3.5. User contact

User questions (technical and scientific), on both the Product Distribution Portal and the Mission Exploitation Portal can be addressed to the VITO Remote Sensing Helpdesk:

helpdeskticket@vgt.vito.be / probav-mep@vgt.vito.be

Please note that it can take up to two working days upon receiving an answer.
4. Data and metadata formats

4.1. Sentinel-2 file format

All Sentinel-2 image files (including the products and the browse images or quicklooks) generated by VITO are delivered in the GeoTIFF format. The accompanied metadata file is in XML format following the INSPIRE metadata standard.

4.1.1. GeoTIFF format

The GeoTagged Image File Format (GeoTIFF) is a metadata standard that allows for including georeferencing information (ellipsoids, projection, datums, etc.) to a TIFF raster file. The GeoTIFF format has become the standard format for most GIS applications, including Quantum GIS, ArcGIS, ERDAS Imagine, etc. GeoTIFF images can be properly read by any program/script that is built on the Geospatial Data Abstraction Library (GDAL) [RD3].

All the GeoTIFF image data has been compressed using the Deflate compression scheme. The quicklooks which are the browse images, are down-sampled to 160m resolution.

4.1.2. Metadata format

The Sentinel-2 data products are presented together with a metadata xml describing the data. The INSPIRE metadata file accompanying the product data files, applies to ISO/TS 19139 (2007) which defines geographic metadata xml encoding for the implementation of ISO 19115 (Geographic Information Metadata).

Examples of the INSPIRE metadata files are included in the Annexes.

4.1.3. Product Version Information

The Sentinel-2 product version number in the filename has three digits, which consists of two parts: the first digit indicates the collection number, which is ‘1’ for Collection 1 and will be incremented to ‘1’ for the upcoming reprocessed data (Collection 2). The second and third digit together represent a processing counter for the number of iterations a certain collection has taken till completion. These numbers will thus not change once a collection has been completed.
The various algorithms within the processing chain can have an irregular change in versioning.

4.2. Sentinel-2 Products File Description

4.2.1. General Conventions

Naming conventions:

<MISSION>_<DATE>T<UTC>_Z_<GRIDID>_<CONTENT>_V<VERSION>_</OP>

- **<MISSION>** Mission ID (S2A/S2B)
- **<DATE>** Start date of the segment identifier (format: YYYYMMDD)
- **<TIME>** Start time (UTC) of the segment (format: hhmmss)
- **<GRIDID>** ID of the granule/tile in UTM/WGS84 projection
- **<CONTENT>** Content of the file. For details see the table below.
- **<RESOLUTION>** Resolution of the product/file (not always available).
- **<VERSION>** Version identifier, three digits starting from ‘101’ for the first operational version
- **<OP>** Optional, only used for the QuickLook (QL).

Example: S2A_20160908T105416Z_31UFS_FAPAR_10M_V101

<table>
<thead>
<tr>
<th>Content</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOC</td>
<td>Top Of Canopy total product</td>
</tr>
<tr>
<td>TOC-B01</td>
<td>Top of Canopy B01</td>
</tr>
<tr>
<td>TOC-B02</td>
<td>Top of Canopy B02</td>
</tr>
<tr>
<td>TOC-B03</td>
<td>Top of Canopy B03</td>
</tr>
<tr>
<td>TOC-B04</td>
<td>Top of Canopy B04</td>
</tr>
<tr>
<td>TOC-B05</td>
<td>Top of Canopy B05</td>
</tr>
<tr>
<td>TOC-B06</td>
<td>Top of Canopy B06</td>
</tr>
<tr>
<td>TOC-B07</td>
<td>Top of Canopy B07</td>
</tr>
<tr>
<td>TOC-B08</td>
<td>Top of Canopy B08</td>
</tr>
<tr>
<td>TOC-B08A</td>
<td>Top of Canopy B08A</td>
</tr>
<tr>
<td>TOC-B11</td>
<td>Top of Canopy B11</td>
</tr>
<tr>
<td>CLOUDMASK</td>
<td>Cloumask file</td>
</tr>
<tr>
<td>SHADOWMASK</td>
<td>Shadowmask file</td>
</tr>
<tr>
<td>SCENECCLASSIFICATION</td>
<td>Scene Classification file</td>
</tr>
<tr>
<td>FAPAR</td>
<td>Fraction of Absorbed Photosynthetically Active Radiation</td>
</tr>
<tr>
<td>FCOVER</td>
<td>Fraction of green Vegetation Cover</td>
</tr>
<tr>
<td>LAI</td>
<td>Leaf Area Index</td>
</tr>
</tbody>
</table>
4.2.2. **S2 TOC product**

The Sentinel-2 TOC products generated and distributed by VITO include several files which are the output of the iCOR processor for the atmospheric correction and of the Sen2Cor processor for the masks (Cloud/Shadow) and the Scene Classification.

Figure 13 shows the files included in the S2 TOC product.

```
Data Files:
- TOC-B01_60M_Vxxx.tif
- TOC-B02_10M_Vxxx.tif
- TOC-B03_10M_Vxxx.tif
- TOC-B04_10M_Vxxx.tif
- TOC-B05_20M_Vxxx.tif
- TOC-B06_20M_Vxxx.tif
- TOC-B07_20M_Vxxx.tif
- TOC-B08_10M_Vxxx.tif
- TOC-B08A_20M_Vxxx.tif
- TOC-B11_20M_Vxxx.tif
- TOC-B12_20M_Vxxx.tif
- CLOUDMASK_10M_Vxxx.tif
- CLOUDMASK_20M_Vxxx.tif
- CLOUDMASK_60M_Vxxx.tif
- SHADOWMASK_10M_Vxxx.tif
- SHADOWMASK_20M_Vxxx.tif
- SHADOWMASK_60M_Vxxx.tif
- SCENECLASSIFICATION_20M_Vxxx.tif

Metadata Files:
- TOC_Vxxx.xml

Quicklook Image:
- TOC_Vxxx_QL.tif
```

*Figure 13: S2 TOC product file list*

The S2 TOC Spectral Bands span from the visible and the Near Infra-Red to the Short Wave Infra-Red in different resolutions:
- 4 bands at 10m;
- 6 bands at 20m;
- 1 bands at 60m.
Note that B09 and B10 are not delivered as these contain respectively the water vapor and cirrus bands.

Table 3 depicts the Spectral bands together with their resolution and Central Wavelength.

<table>
<thead>
<tr>
<th>Physical band</th>
<th>Pixel resolution (m)</th>
<th>Central Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B01</td>
<td>60</td>
<td>443</td>
</tr>
<tr>
<td>B02</td>
<td>10</td>
<td>490</td>
</tr>
<tr>
<td>B03</td>
<td>10</td>
<td>560</td>
</tr>
<tr>
<td>B04</td>
<td>10</td>
<td>665</td>
</tr>
<tr>
<td>B05</td>
<td>20</td>
<td>705</td>
</tr>
<tr>
<td>B06</td>
<td>20</td>
<td>740</td>
</tr>
<tr>
<td>B07</td>
<td>20</td>
<td>783</td>
</tr>
<tr>
<td>B08</td>
<td>10</td>
<td>842</td>
</tr>
<tr>
<td>B08A</td>
<td>20</td>
<td>865</td>
</tr>
<tr>
<td>B11</td>
<td>20</td>
<td>1610</td>
</tr>
<tr>
<td>B12</td>
<td>20</td>
<td>2190</td>
</tr>
</tbody>
</table>

*Table 3: List of the S2 TOC Spectral bands*

The physical pixel values in the S2 TOC files are converted from floating point values into integers, mainly to reduce the size of the files. Table 4 lists the technical information of the Sentinel-2 TOC product with information necessary to calculate the physical values from the digital numbers available in the files. The physical number can be defined by using the following formula:

Physical Number= Scaling * Digital Number + offset.

<table>
<thead>
<tr>
<th>Technical information on the S2 TOC values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical min</td>
</tr>
<tr>
<td>Physical max</td>
</tr>
<tr>
<td>Digital number min</td>
</tr>
<tr>
<td>Digital number max</td>
</tr>
<tr>
<td>Scaling</td>
</tr>
<tr>
<td>Offset</td>
</tr>
<tr>
<td>No data</td>
</tr>
<tr>
<td>Data type</td>
</tr>
</tbody>
</table>

*Table 4: Sentinel-2 TOC technical information*
4.2.3. **S2 Vegetation Indices**

VITO offers 4 Sentinel-2 vegetation indices or biophysical parameters: fAPAR, fCover, LAI and NDVI. All the products of these vegetation indices contain 6 files. Four datafiles (including the CloudMask ShadowMask and the Scene Classification), a metadata file describing the data (INSPIRE format) and a Quicklook image. All the files, except the Scene classification files (20meter resolution), have a spatial resolution of 10 meter.

Table 5 lists the technical information of the Sentinel-2 derived products providing information on how to calculate the physical values from the digital numbers available in the files. The physical number can be defined by using the following formula:

\[
\text{Physical Number} = \text{Scaling} \times \text{Digital Number} + \text{offset}. \]

<table>
<thead>
<tr>
<th></th>
<th>FAPAR</th>
<th>fCOVER</th>
<th>LAI</th>
<th>NDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical min</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.08</td>
</tr>
<tr>
<td>Physical max</td>
<td>1.0</td>
<td>1.0</td>
<td>10.0</td>
<td>0.92</td>
</tr>
<tr>
<td>Digital number min</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Digital number max</td>
<td>200</td>
<td>200</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Scaling</td>
<td>1/200</td>
<td>1/200</td>
<td>10/250</td>
<td>1/250</td>
</tr>
<tr>
<td>Offset</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.08</td>
</tr>
<tr>
<td>No data</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Data type</td>
<td>Byte</td>
<td>Byte</td>
<td>Byte</td>
<td>Byte</td>
</tr>
<tr>
<td>Saturation min*</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>-1.0</td>
</tr>
<tr>
<td>Saturation max**</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Table 5: Sentinel-2 derived vegetation products technical information*

*Values between saturation min and physical min will be set to physical min before quantization is applied.

** Values between saturation max and physical max will be set to physical max before quantization is applied.

4.2.3.1. **FAPAR**

The **Fraction of Absorbed Photosynthetically Active Radiation** quantifies the fraction of the solar radiation absorbed by live leaves for the photosynthesis activity. Then, it refers only to the green and alive elements of the canopy. The FAPAR depends on the canopy structure, vegetation element optical properties, atmospheric conditions, and angular configuration. To overcome this latter dependency, a daily integrated FAPAR value is assessed.
4.2.3.2. LAI

The **Leaf Area Index** is defined as half the total area of green elements of the canopy per unit horizontal ground area. The satellite-derived value corresponds to the total green LAI of all the canopy layers, including the understory which may represent a very significant contribution, particularly for forests. Practically, the LAI quantifies the thickness of the vegetation cover.

Figure 15 shows the files included in the S2 LAI product.
4.2.3.3. FCOVER

The Fraction of Vegetation Cover corresponds to the fraction of ground covered by green vegetation. Practically, it quantifies the spatial extent of the vegetation. Because it is independent from the illumination direction and it is sensitive to the vegetation amount, fCover is a very good candidate for the replacement of classical vegetation indices for the monitoring of ecosystems.

Figure 16 shows the files included in the S2 fCover product.

4.2.3.4. NDVI

The Normalized Difference Vegetation Index is an indicator of the greenness of the biomes. As such, it is closely linked to the FAPAR. More information on the NDVI can be found in section 2.6.
Figure 17 shows the files included in the S2 NDVI product.

**Data Files:**
- NDVI_10M_Vxxx.tif
- CLOUDMASK_10M_Vxxx.tif
- SHADOWMASK_10M_Vxxx.tif
- SCENECLASSIFICATION_20M_Vxxx.tif

**Metadata Files:**
- NDVI_10M_Vxxx.xml

**Quicklook Image:**
- NDVI_Vxxx_QL.tif

*Figure 17: S2 NDVI product file list*
5. Quality assurance

All products are delivered together with the classification map which gives an indicating on the pixel quality of the delivered product. iCOR atmospheric correction is validated through the ACIX inter-comparison exercise and has been one of the top performers for atmospheric correction. ([RD4]). BIOPAR processing step to generate the different vegetation indices (FAPAR, FCover, LAI) has been validated in the BELCAM validation campaign ([RD5]).

5.1. Classification map

The pixel quality for all Sentinel-2 data is provided in the classification map, the values and their meaning are given in Table 6.

<table>
<thead>
<tr>
<th>Label</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NO_DATA</td>
</tr>
<tr>
<td>1</td>
<td>SATURATED_OR_DEFECTIVE</td>
</tr>
<tr>
<td>2</td>
<td>DARK_AREA_PIXELS</td>
</tr>
<tr>
<td>3</td>
<td>CLOUD_SHADOWS</td>
</tr>
<tr>
<td>4</td>
<td>VEGETATION</td>
</tr>
<tr>
<td>5</td>
<td>BARE_SOIL</td>
</tr>
<tr>
<td>6</td>
<td>WATER</td>
</tr>
<tr>
<td>7</td>
<td>CLOUD_LOW_PROBABILITY</td>
</tr>
<tr>
<td>8</td>
<td>CLOUD_MEDIUM_PROBABILITY</td>
</tr>
<tr>
<td>9</td>
<td>CLOUD_HIGH_PROBABILITY</td>
</tr>
<tr>
<td>10</td>
<td>THIN_CIRRUS</td>
</tr>
<tr>
<td>11</td>
<td>SNOW</td>
</tr>
</tbody>
</table>

Table 6: Pixel quality classification map
Annex 1: Inspire Metadata File

The example below shows the S2A_20170126T105612Z_31UFS_LAI_10M_V100.xml metadata file.

```xml
<?xml version="1.0" encoding="UTF-8"?>
  <gmd:fileIdentifier>
    <gco:CharacterString>urn:eop:VITO:CGS_S2_LAI:S2A_20170126T105612Z_31UFS_LAI_10M_V100</gco:CharacterString>
  </gmd:fileIdentifier>
  <gmd:parentIdentifier>
    <gco:CharacterString>urn:eop:VITO:CGS_S2_LAI:S2A_20170126T105612Z_31UFS_LAI_10M_V100</gco:CharacterString>
  </gmd:parentIdentifier>
  <gmd:contact>
    <gmd:CI_ResponsibleParty>
      <gmd:organisationName>Flemish Institute for Technological Research (VITO)</gmd:organisationName>
      <gmd:contactInfo>
        <gmd:CI_Contact id="VITO">
          <gmd:address>
            <gmd:CI_Address>
              <gmd:deliveryPoint>Boeretang 200</gmd:deliveryPoint>
              <gmd:city>Mol</gmd:city>
              <gmd:country>Belgium</gmd:country>
              <gmd:electronicMailAddress>sales@vgt.vito.be</gmd:electronicMailAddress>
            </gmd:CI_Address>
          </gmd:address>
        </gmd:CI_Contact>
      </gmd:contactInfo>
    </gmd:CI_ResponsibleParty>
  </gmd:contact>
</gmd:MD_Metadata>
```
LAI was defined by CEOS as half the developed area of the convex hull wrapping the green canopy elements per unit horizontal ground. This definition allows accounting for elements which are not flat such as needles or stems. LAI is strongly non-linearly related to reflectance. Therefore, its estimation from remote sensing observations will be scale dependent over heterogeneous landscapes. When observing a canopy made of different layers of vegetation, it is therefore mandatory to consider all the green layers. This is particularly important for forest canopies where the understory may represent a very significant contribution to the total canopy LAI. The derived LAI corresponds therefore to the total green LAI, including the contribution of the green elements of the understory. The resulting GEOV1 LAI products are relatively consistent with the actual LAI for low LAI values and ‘non-forest’ surfaces; while for forests, particularly for needle leaf types, significant departures with the true LAI are expected.

The SENTINEL 2 LAI product can be also useful for all applications related to the environment monitoring.

This product is provided by the VITO CVB Project funded by BELSPO (Belgian Science Policy).

This product is provided by the VITO CVB Project funded by BELSPO (Belgian Science Policy).
Quicklook at 16 times reduced resolution of LAI dataset.

(d) the confidentiality of commercial or industrial information, where such confidentiality is provided for by national or community law to protect a legitimate economic interest, including the public interest in maintaining statistical confidentiality and tax secrecy.
VITO Sentinel-2

Annexes

<gmd:MD_DataIdentification>
  <gmd:identificationInfo>
    <gmd:MD_InformationContent>
      <gmd:MD(Content)>
        <gmd:MD_ImageDescription id="S2-LAI">
          <gmd:attributeDescription>
            <gco:RecordType>LAI</gco:RecordType>
          </gmd:attributeDescription>
          <gmd:contentType>
            <gmd:MD_CoverageContentTypeCode>
              <gco:RecordType codeList="http://www.isotc211.org/2005/resources/codelist/gmxCodelists.xml#MD_CoverageContentTypeCode">
                <gmd:MD_CoverageContentTypeCode codeListValue="image"/>
          </gmd:MD_CoverageContentTypeCode>
          <gmd:dimension>
            <gmd:MD_Band>
              <gmd:maxValue><gco:Real>250</gco:Real></gmd:maxValue>
              <gmd:minValue><gco:Real>0</gco:Real></gmd:minValue>
            </gmd:MD_Band>
          </gmd:dimension>
          <gmd:cloudCoverPercentage><gco:Real>21.423</gco:Real></gmd:cloudCoverPercentage>
          <gmd:processingLevelCode>
            <gmd:MD_Identifier>
              <gmd:code>
                <gco:CharacterString>L3</gco:CharacterString>
              </gmd:code>
            </gmd:MD_Identifier>
          </gmd:processingLevelCode>
        </gmd:MD_ImageDescription>
      </gmd:contentInfo>
      <gmd:distributionInfo>
        <gmd:MD_Distribution>
          <gmd:distributionFormat>
            <gmd:MD_Format>
              <gmd:name>
                <gco:CharacterString>geoTIFF</gco:CharacterString>
              </gmd:name>
              <gmd:version>
                <gco:CharacterString>v1</gco:CharacterString>
              </gmd:version>
            </gmd:MD_Format>
          </gmd:distributionFormat>
          <gmd:distributorContact>
            <gmd:CI_ResponsibleParty>
              <gmd:organisationName>
                <gco:CharacterString>VITO</gco:CharacterString>
              </gmd:organisationName>
              <gmd:positionName>
                <gco:CharacterString>VITO Helpdesk</gco:CharacterString>
              </gmd:positionName>
              <gmd:contactInfo xlink:title="VITO" xlink:href="#VITO"/>
            </gmd:CI_ResponsibleParty>
          </gmd:distributorContact>
          <gmd:MD_Distributor>
            <gmd:distributorContact>
              <gmd:CI_ResponsibleParty>
                <gmd:organisationName>
                  <gco:CharacterString>VITO</gco:CharacterString>
                </gmd:organisationName>
                <gmd:positionName>
                  <gco:CharacterString>VITO Helpdesk</gco:CharacterString>
                </gmd:positionName>
              </gmd:CI_ResponsibleParty>
            </gmd:distributorContact>
          </gmd:MD_Distributor>
        </gmd:MD_Distribution>
      </gmd:distributionInfo>
    </gmd:MD_InformationContent>
  </gmd:MD_InformationContent>
</gmd:MD_DataIdentification>
Products can be downloaded from www.vito-eodata.be after registration.

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This LAI product is produced from SENTINEL 2 data using the VITO processing chain. Please contact VITO for more details.

LAI computation based on radiometric bands.

Source:
S2A_20170126T105612Z_31UFS_TOC_V100

Metadata maintenance:
- Maintenance and Update Frequency: as Needed
- Maintenance Information:
  - Code List: https://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/ML_gmxCodes.xml#MD_MaintenanceFrequencyCode

Code List: https://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/ML_gmxCodes.xml#CI_DateTypeCode