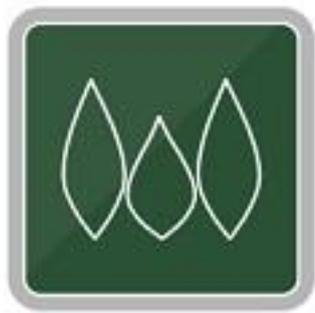


# Forestry Thematic Exploitation Platform



**forestry**  

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**tep**

## Service Portfolio

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**VTT**

**CGI**

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## 1 Introduction

### 1.1 Forestry TEP overview

Forestry Thematic Exploitation Platform is an online platform that enables users to efficiently access and process satellite data for forest monitoring purposes. It offers a wide range of readily available processing services and tools, and it enables users to create and share their own processing services, tools and products.

The Forestry TEP has been developed in a project funded by the European Space Agency (ESA). The platform is operated by VTT in Finland and CGI in UK, committed to maintain and develop the platform further and support the users. ESA continues to support the on-boarding activities on the platform financially.

More background and general information on the platform can be found on other sections of the platform website <https://f-tep.com/>. Particularly, the User Manual provides detailed guidance on how to access the platform, what are the core concepts and features and how they are used, how to use each individual processing service and tool, and how to develop new services.

### 1.2 Service portfolio overview

The F-TEP service portfolio covers thematic processing services (Table 1) and supporting processing services (Table 2), as well as interactive applications (Table 3).

In the tables below, services and tools that are listed as “Core Offering” are readily available to all platform users. The services listed as “by agreement” are also deployed on the platform, and they can be made available for use through a separate agreement. Interested users are encouraged to contact us for enquiries.

The later sections in this document give a brief overview on the services, while the User Manual on the platform website gives detailed guidance on how to use each service and tool.

Table 1. Thematic Processing Services

Provider	Availability	Title	Description	Input	Output
	Core Offering	<b>VegetationIndices</b>	Computation of radiometric indices (NDVI, TNDVI, RVI, SAVI, TSAVI, MSAVI, MSAVI2, GEMI, IPVI) <i>Note: supports batch processing</i>	<ul style="list-style-type: none"> <li>Sentinel-2 L1C</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	Core Offering	<b>ForestChangeS2</b>	Forest change mapping based on the ratio of red reflectance between two images	<ul style="list-style-type: none"> <li>2 x Sentinel-2 L1C</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	Core Offering	<b>LandCoverS2</b>	Land cover mapping with image classification trained by the Random Forest model, based on the algorithm implementation in the Orfeo ToolBox	<ul style="list-style-type: none"> <li>Sentinel-2 L1C</li> <li>Reference data (Shapefile)</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	Core Offering	<b>LandCoverS1</b>	Land cover mapping with image classification trained by the Random Forest model, based on the algorithm implementation in the Orfeo ToolBox	<ul style="list-style-type: none"> <li>Sentinel-1: time series of VV-polarized (SVV) data</li> <li>Reference data (Shapefile)</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	Core Offering	<b>LandCoverGeotiff</b>	Land cover mapping with image classification trained by the Random Forest model, based on the algorithm implementation in the Orfeo ToolBox	<ul style="list-style-type: none"> <li>GeoTiff</li> <li>Reference data (Shapefile)</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	Core Offering	<b>S1Biomass</b>	Biomass (stem volume) estimation using a fixed biomass model based on the water cloud model by Attema and Ulaby, 1978	<ul style="list-style-type: none"> <li>Sentinel-1: time series of VH-polarized GRD data</li> <li>Forest mask in GeoTiff</li> <li>DEM in GeoTiff</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>
	by agreement	<b>AutoChangeS2</b>	Change detection between two multispectral images from (preferably) the same satellite system; based on VTT-developed AutoChange methodology, which utilizes K-means clustering and subdivision of clusters of the first image	<ul style="list-style-type: none"> <li>2 x GeoTiff</li> </ul>	<ul style="list-style-type: none"> <li>GeoTiff</li> </ul>

	by agreement	<b>ProbaCluster</b>	Unsupervised K-means clustering <i>Part of the Probability classification and estimation chain</i>	<ul style="list-style-type: none"> <li>▪ GeoTiff or ERS image, or the Envimon output (zip)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ProbaCluster output (zip)</li> </ul>
	by agreement	<b>ProbaModel</b>	Associates ground reference data with the clusters from ProbaCluster, by producing variable (forest or other) spatial averages <i>Part of the Probability classification and estimation chain</i>	<ul style="list-style-type: none"> <li>▪ ProbaCluster output (zip)</li> <li>▪ Reference data (plot data, shapefile or an estimates image)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ProbaModel output (zip)</li> </ul>
	by agreement	<b>ProbaEstimates</b>	Produces a variable estimates output for (forest or other) spatial variables using clusters from ProbaCluster and cluster content data from ProbaModel <i>Part of the Probability classification and estimation chain</i>	<ul style="list-style-type: none"> <li>▪ GeoTiff or ERS image, or the Envimon output (zip)</li> <li>▪ ProbaModel output (zip)</li> </ul>	<ul style="list-style-type: none"> <li>▪ ProbaEstimates output (zip)</li> </ul>
	by agreement	<b>MaskProbaEstimates</b>	Masks the output from ProbaEstimates with cloud mask generated in the Envimon service and with an optional forest mask <i>Part of the Probability classification and estimation chain</i>	<ul style="list-style-type: none"> <li>▪ ProbaEstimates output (zip)</li> <li>▪ Envimon output (zip)</li> <li>▪ Forest mask (GeoTiff), optional</li> </ul>	<ul style="list-style-type: none"> <li>▪ ProbaEstimates output (zip)</li> </ul>
	by agreement	<b>ForestPropertyData Xml2Shape</b>	Converts ForestPropertyData from the Finnish <i>Forest Information Standard</i> to ESRI shapefiles	<ul style="list-style-type: none"> <li>▪ ForestPropertyData xml</li> </ul>	<ul style="list-style-type: none"> <li>▪ Shapefile</li> </ul>
	by agreement	<b>Estimate2Vector</b>	Appends existing forest stand data with forest variable estimates provided as a raster image; the vector formatted stand data can be GeoJSON, ESRI shapefile or ForestPropertyData from the Finnish <i>Forest Information Standard</i>	<ul style="list-style-type: none"> <li>▪ Estimate image in GDAL supported format</li> <li>▪ Stand data (ForestPropertyData xml, GeoJSON or Shapefile)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Updated stand data (XML, GeoJSON or Shapefile)</li> </ul>

Table 2. Supporting Processing Services

Provider	Availability	Title	Description	Input	Output
	Core Offering	<b>S1stack</b>	Mosaic Sentinel-1 images along the orbit, generating a separate image band per each acquisition day in the output product	<ul style="list-style-type: none"> <li>▪ Sentinel-1 GRD/SDV collection in the same geometry</li> </ul>	<ul style="list-style-type: none"> <li>▪ image stack (GeoTiff)</li> </ul>
	coming soon	<b>S1stackTempvar</b>	Mosaic Sentinel-1 images along the orbit, generating a separate image band per each acquisition day in the output product; additionally produces outputs with the interpolated stack and the temporal variability information	<ul style="list-style-type: none"> <li>▪ Sentinel-1 GRDH/SDV images in the same geometry</li> </ul>	<ul style="list-style-type: none"> <li>▪ image stack (GeoTiff)</li> <li>▪ image stack interpolated (GeoTiff)</li> <li>▪ temporal variability (GeoTiff)</li> </ul>
	coming soon	<b>CombS2granules</b>	Combines multiple Sentinel-2 tiles, belonging to the same full acquisition image, into a single output	<ul style="list-style-type: none"> <li>▪ N x Sentinel-2 L1C</li> </ul>	<ul style="list-style-type: none"> <li>▪ GeoTiff</li> </ul>
	coming soon	<b>CombS2granulesZ</b>	Combines multiple Sentinel-2 tiles, belonging to the same full acquisition image, into a single output; additionally performs projection to support tiles belonging to different UTM zones	<ul style="list-style-type: none"> <li>▪ N x Sentinel-2 L1C</li> </ul>	<ul style="list-style-type: none"> <li>▪ GeoTiff</li> </ul>
	coming soon	<b>MaskImage</b>	Masks an input image using the given mask file and values	<ul style="list-style-type: none"> <li>▪ GeoTiff or ERS image</li> </ul>	<ul style="list-style-type: none"> <li>▪ GeoTiff</li> </ul>
	coming soon	<b>MosaicImages</b>	Combines multiple input images into one output image using GDAL's gdalwarp tool	<ul style="list-style-type: none"> <li>▪ several input types</li> </ul>	<ul style="list-style-type: none"> <li>▪ e.g. GeoTiff</li> </ul>
	coming soon	<b>GdalTranslate</b>	Performs GDAL's gdaltranslate tool with user-provided parameters	<ul style="list-style-type: none"> <li>▪ several input types</li> </ul>	<ul style="list-style-type: none"> <li>▪ e.g. GeoTiff</li> </ul>
	by agreement	<b>Envimon</b>	Extracts Sentinel-2 data to a multi-band image, and performs cloud masking with a VTT in-house method; outputs the contained images and the generated cloud masks	<ul style="list-style-type: none"> <li>▪ Sentinel-2 L1C</li> </ul>	<ul style="list-style-type: none"> <li>▪ Envimon output (zip)</li> </ul>

Table 3. GUI Applications

Provider	Access	Title	Description	Input	Output
	Core Offering	<b>Monteverdi</b>	Satellite image viewer and analysis tool from the open source Orfeo ToolBox v5.8.0	<ul style="list-style-type: none"> <li>several input types</li> </ul>	[can export output]
	Core Offering	<b>QGIS 3</b>	QGIS v3.6, a free and open source Geographic Information System	<ul style="list-style-type: none"> <li>several input types, e.g. GeoTiff, Shapefile</li> </ul>	[can export output]
	Core Offering	<b>QGIS 2</b>	QGIS v2.18, a free and open source Geographic Information System	<ul style="list-style-type: none"> <li>several input types, e.g. GeoTiff, Shapefile</li> </ul>	[can export output]
	Core Offering	<b>SNAP</b>	Sentinel Applications Platform (SNAP) v6.0, an application for processing and analysis of Sentinel and other data - by Brockmann Consult, Array Systems Computing and C-S	<ul style="list-style-type: none"> <li>any Sentinel data</li> </ul>	[can export output]
	by agreement	<b>ProbaUI</b>	GUI for the Probability classification and estimation chain that consists of ProbaCluster, ProbaModel and ProbaEstimates	<ul style="list-style-type: none"> <li>image data</li> <li>reference data</li> </ul>	[can export output]

## 2 Thematic Processing Services

This section introduces the thematic processing services in the Forestry TEP Core Offering.

### 2.1 VegetationIndices

The measured reflectance in various parts of visible and infrared spectrum (*i.e.* in various spectral bands of the MSI instrument aboard Sentinel-2 satellites) correlates to properties of vegetation canopies. When applying ratios between spectral bands, indices with correlation to canopy properties and photosynthetic capacity can be derived. Using band ratios reduces the effects of potential inter-image variation (*e.g.* caused by atmospheric effects).

The most commonly used vegetation index is the Normalized Difference Vegetation Index (NDVI), which correlates very strongly with the proportion covered by leaves when the background is bare soil and when the proportion covered by leaves is not excessively high. Several other vegetation indices have also been developed. These newer indices make modifications to counter-act effects of soil properties or atmospheric effects.

The following vegetation indices can be calculated:

- **NDVI**, Normalized Difference Vegetation Index  $(\text{NIR}-\text{Red})/(\text{NIR}+\text{Red})$ ,
- **TNDVI**, Transformed Normalized Difference Vegetation Index  $(\text{sqrt}(\text{NDVI} + 0.5))$ ,
- **RVI**, Ratio Vegetation Index  $(\text{Red}/\text{NIR})$ ,
- **SAVI**, Soil Adjusted Vegetation Index  $(\text{NDVI}*(1+S))$ , S = soil adjustment factor),
- **TSAVI**, Transformed Soil Adjusted Vegetation Index,
- **MSAVI**, Modified Soil Adjusted Vegetation Index,
- **MSAVI2**, Modified Soil Adjusted Vegetation Index 2,
- **GEMI**, Global Environment Monitoring Index, and
- **IPVI**, Infrared Percentage Vegetation Index.

### 2.2 ForestChangeS2

Forest clearance causes substantial changes in visible and near infrared reflectance. This is evident when investigating the various spectral bands of Sentinel-2 satellite images. Due to the reduction of photosynthetically active vegetation in logging operations, especially if bare ground is exposed, red reflectance rises significantly. This increase in red reflectance can be used as a simple indicator for potential forest clearance.

The ForestChangeS2 service produces the ratio of red reflectance between two input images (*i.e.* “before” and “after” images). The service computes a red-reflectance ratio layer, which can then be further analysed *e.g.* in the QGIS application service together with other products (forest or land cover maps).

### 2.3 LandCoverS2

Land cover types (such as water, coniferous forest, or wheat field) reflect different amount of incoming sun radiation in different parts of the electromagnetic spectrum. This information can be used for land cover classification of satellite images.

Many land cover mapping or classification algorithms have been developed over the past decades. The LandCoverS2 service uses a random forest algorithm as implemented in the Orfeo toolbox (OTB). Based on samples of land cover classes, a set of decision trees are produced. For each tree, a random set of spectral bands at each decision node is chosen. The final land cover class is then chosen based on majority voting between the outputs of each decision tree.

The benefits of the random-forest algorithm include good adaptation to many different types of classification problems as well as independence of assumptions on statistical distribution of band-wise reflectance values within a (land-cover) class.

### 2.4 LandCoverS1

Persistently cloudy weather conditions complicate land cover mapping in many areas (e.g. in the humid tropics). Sentinel-1 C-band radar data penetrates cloud cover and allows regular observation even in areas with persistent cloud cover. The LandCoverS1 service allows land cover mapping into a few general land cover classes with Sentinel-1 time series.

Image time series (instead of a single image) allows utilization of the differences in variation of backscatter over time in various land cover types. For instance, mature forest has a very stable backscatter level while many agricultural areas show distinct variations depending on the crop type and crop calendar. When combining acquisitions from different parts of the year, these variations can be used to map land cover types. VV-polarized Sentinel-1 data are used in this algorithm because this is the most widely acquired data type globally (present in both dual and single-polarized scenes).

The service uses a random forest algorithm as implemented in the Orfeo ToolBox (OTB). Based on samples of land cover classes, a set of decision trees is produced. For each tree, a random set of spectral bands at each decision node is chosen. The final land cover class is then chosen based on majority voting between the outputs of each decision tree. The benefits of the random-forest algorithm include good adaptation to many different types of classification problems as well as independence of assumptions on statistical distribution of band-wise backscatter values within a (land-cover) class. The latter property is important for radar data since the distribution of radar backscatter data tends to differ from normal distribution.

### 2.5 LandCoverGeotiff

The LandCoverGeotiff service makes land cover classification using a random forest classifier as implemented in the Orfeo ToolBox. The service requires training data in the form of a shape file. The used earth observation data is not limited to any specific sensor.

## 2.6 S1Biomass

Radar signals can penetrate into forest canopy and scatter back from plant elements of various sizes. The greater biomass a forest has the higher the backscatter. L-band and longer wavelength radar data have been used successfully to map forest biomass for large areas. Even the C-band Sentinel-1 radar data can be used to estimate forest biomass, but note that it may saturate already at moderate forest biomass levels.

The S1Biomass service uses multi-temporal VH-polarized data from dual-polarized IW (Interferometric Wide swath) products. The biomass mapping is based on multi-temporal averaging combined with a fixed model relating radar backscatter to forest biomass. The model is based on the water cloud model introduced by Attema and Ulaby 1978 (Attema, E. and Ulaby, F. 1978. Vegetation modeled as a water cloud, Radio Science, vol. 13, no. 2, p. 357-364).

### 3 Supporting Processing Services

This section introduces the supporting processing services in the Forestry TEP Core Offering.

#### 3.1 S1Stack

The S1stack service mosaics dual-polarized Sentinel-1 GRD images along orbit and assigns acquisition dates as bands in a multi-temporal output image. This way, areas crossing scene boundaries can be used as input to e.g. the LandCoverGeotiff service.

#### 3.2 S1StackTempvar

The S1stack service mosaics dual-polarized Sentinel-1 GRD images along orbit and assigns acquisition dates as bands in a multi-temporal output image. This way, areas crossing scene boundaries can be used as input to e.g. the LandCoverGeotiff service. This service additionally produces outputs with the interpolated stack and the temporal variability information.

#### 3.3 CombS2granules and CombS2granulesZ

CombS2granules and CombS2granulesZ (if different UTM zones included) services mosaic neighbouring Sentinel-2 L1C products into a single geoTiff image. This way, a larger area can be processed in the LandCoverGeotiff service, which allows the training sites also to extend over larger area.

## 4 GUI Applications

This section introduces the GUI Applications in the Forestry TEP Core Offering.

### 4.1 Monteverdi

Monteverdi, provided within the Orfeo ToolBox v 5.8.0, is a GUI application that allows users to view, edit and analyse satellite imagery and data products. This service runs the Monteverdi application in a browser tab, using as input any image either produced inside the F-TEP system or resulting from a search query. Comprehensive advice about how to use Monteverdi within the Orfeo Toolbox is provided here: <https://www.orfeo-toolbox.org/CookBook/Monteverdi.html>

### 4.2 QGIS

QGIS (previously known as Quantum GIS) is a cross-platform free and open source desktop geographic information system (GIS) application that provides data viewing, editing, and analysis capabilities. This service runs the QGIS application in a browser tab, using as input any image either produced inside the F-TEP system or resulting from a search query. Further guidance on QGIS functionalities can be found here: <https://www.qgis.org/en/site/about/index.html>

### 4.3 SNAP

The Sentinel Application Platform (SNAP) consists of a rich set of visualisation, analysis and processing tools for the exploitation of Sentinel data. It also supports other ESA Earth Observation missions, such as Envisat (MERIS & AATSR), ERS (ATSR), as well as third party data from RapidEye, SPOT, MODIS (Aqua and Terra), Landsat (TM), ALOS (AVNIR & PRISM) and others. This service runs the SNAP application in a browser tab, using as input any image either produced inside the F-TEP system or resulting from a search query. Further guidance on SNAP functionalities can be found here: <http://step.esa.int/main/toolboxes/snap/>