The FTEP service **GAMMAS1geocoding** allows for processing Sentinel-1 Interferometric Wide-Swath (IW) images in Ground-range Detected (GRD) format to radiometric terrain-corrected level with the commercial software developed by GAMMA Remote Sensing AG (www.gamma-rs.ch). The pre-processing includes:

1) 2 x 2 multi-looking in range and azimuth to obtain pixels with 20 x 20 m^2 pixel posting,
2) compensation for the noise equivalent sigma zero (NESZ),
3) updating of orbit state vectors with precision orbit vectors provided by ESA within 20 days past the image acquisition or, for images acquired more recently, the restituted orbits (https://dataspace.copernicus.eu/),
4) topographic correction accounting for varying pixel scattering areas dependent on topography as with Frey et al. (2013) to produce "terrain-flattened" γ^0 backscatter intensity images,
5) geocoding and orthorectification based on the Copernicus 1-arcsecond Digital Elevation Model (DEM) to the target UTM map grid with 20 x 20 m^2 pixel size.

Each individual Sentinel-1 GRD image is geocoded to the same MGRS/UTM tiling grid to which ESA processes Sentinel-2 data to allow for a joint use/inter-comparison of Sentinel-1 and Sentinel-2 imagery. Since covering an area of ~250 x 160 km^2, a processed IW GRD image will be stored in a variable number of 110 x 110 km^2 large tiles, each containing a subset of the entire GRD image (Figure 1). For each tile, the processing produces the terrain-corrected and geocoded subset of the backscatter acquired at either single (VV or VH) or dual-polarizations (VV/VH or HH/HV) as well as maps of the local incidence angle and a layover/shadow mask. As of now, processing of Sentinel-1 GRD imagery is supported for 746 tiles covering Europe (Figure 2). The data format and filenaming conventions are summarized in Table 1.

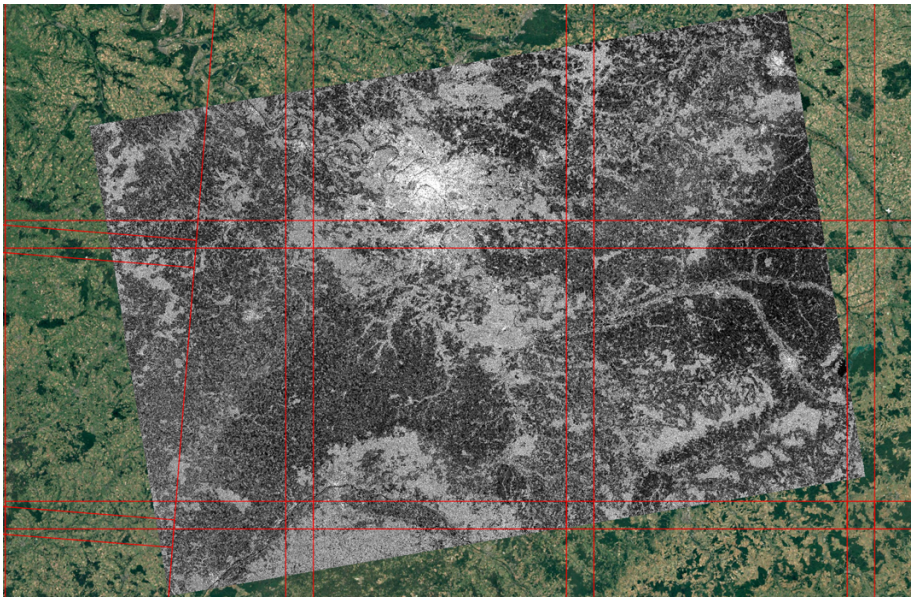

Figure 1. Terrain-corrected and geocoded Sentinel-1 IW image acquired in VH polarization over Paris, France. The polygons show the corresponding S2 tiling grid.

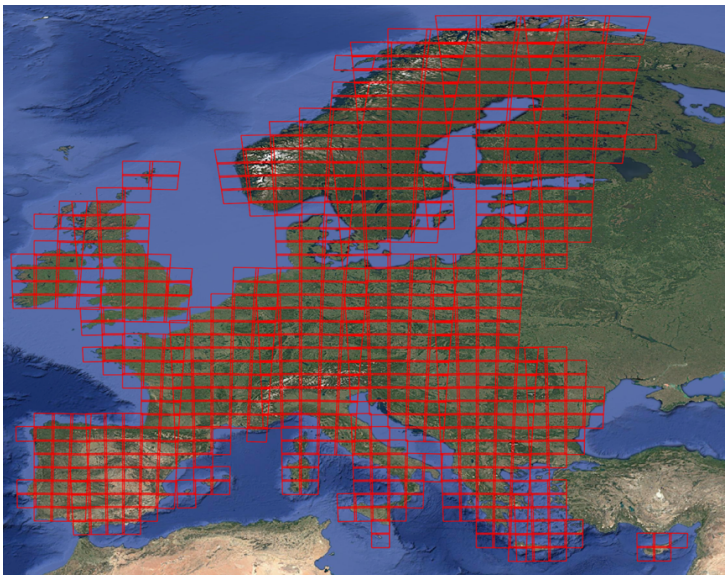

Figure 2. 746 UTM tiles for which Sentinel-1 data can be processed.

Metric	Format	Values/Scaling	**Filename convention**
Backscatter	16-bit integer	$DN = 10^{0.5*log_{10}(\gamma^0)+4.15}$ $\gamma^0[dB] = 10 * log_{10}(DN^2) - 83.0$	<**TileID**>_<**Date**>T<**Time**>_<**RELORB**> <**METRIC**>.tif **TileID**: UTM Tile ID, e.g., 31UEQ **Date**: Acquisition date in format "YYYYMMDD" **Time**: UTC time of acquisition start in format "HHMMSS" **RELORB**: Orbital track/relative orbit from which the S1 image was acquired **METRIC**: 1. "<VV/VH/HH/HV>_AMP": γ^0 backscatter coefficient in one polarization 2. "INC": Local incidence angle image 3. "LSMAP": Processing mask information image
Local incidence angle map	8-bit integer	*DN = Degrees*	
Layover/shadow mask	8-bit integer	DN = 1: Valid DN = 5: Layover DN = 17: Shadow DN = 21: Layover in Shadow	

***Table 1**. List of GeoTIFF image products and data conversion rules for the 8- or 16-bit integer digital numbers (DN). No data value for all products is zero (0).*

The only input required to start the processing is the Sentinel-1 GRD image to be processed. The FTEP Explorer may be used to identify and select Sentinel-1 scenes available in the archive (Figure 3). Parallel processing of multiple S1 GRDs is supported. Once the processing is completed, the processed data is stored in the Users' FTEP storage.

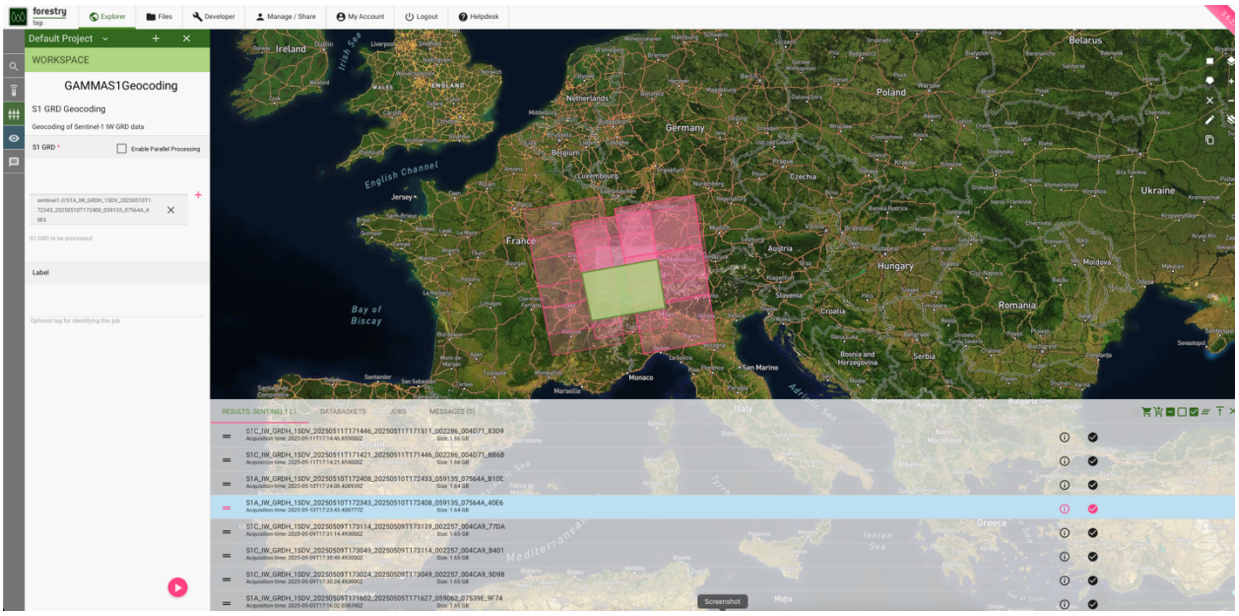

Figure 3. FTEP interface for the GAMMAS1geocoding service.

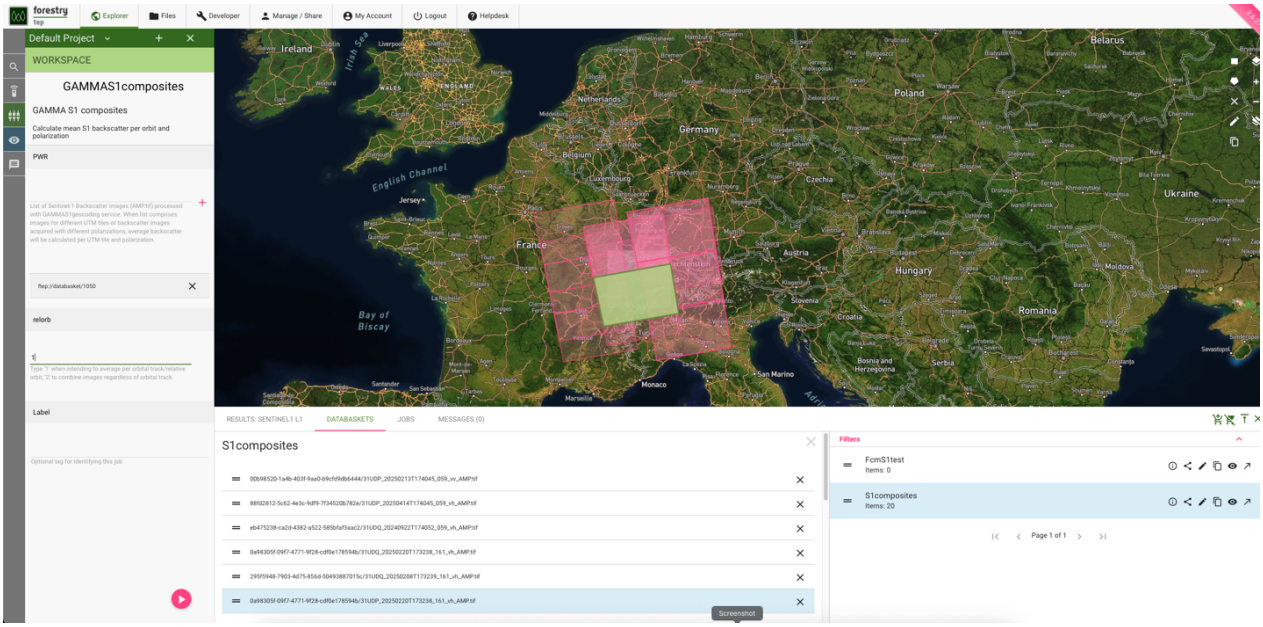

Figure 4. FTEP interface for the GAMMAS1compositing service.

A second FTEP service **GAMMAS1composites** is available, which calculates the average multi-temporal backscatter from S1 data processed with FTEP service GAMMAS1geocoding. The FTEP Explorer may as well be used to select images for which to calculate the multitemporal average (Figure 4). The input of FTEP data baskets which contain all selected imagery is supported; note that the maximum size of such baskets is 100 images.

The averaging will be performed across all selected images, per S2 TileID and polarization in case the selected images include multiple polarizations and cover more than one Tile. An example is

illustrated in Figure 5 where three S1 images acquired between September 22nd, 2024, and April 14th, 2025, from relative orbit 59 were averaged. The user may choose to perform the averaging per orbital track/relative orbit or across all images in the selected image stack regardless of the orbit. In case, averaging is performed per orbital track, the filename convention for the output images is:

<**TileID**>_<**RELORB**>_<**FirstDate**>_<**LastDate**>_< **Polarization** >_AMP_mean.tif

In case images are averaged regardless of the orbit, the convention is:

<**TileID**>_<**FirstDate**>_<**LastDate**>_< **Polarization** >_AMP_mean.tif

"FirstDate" and "LastDate" denote the acquisition date of the first and last S1 acquisition considered in the averaging. The output imagery is as well stored as 16-bit GeoTiffs in amplitude scale (cf. Table 1).

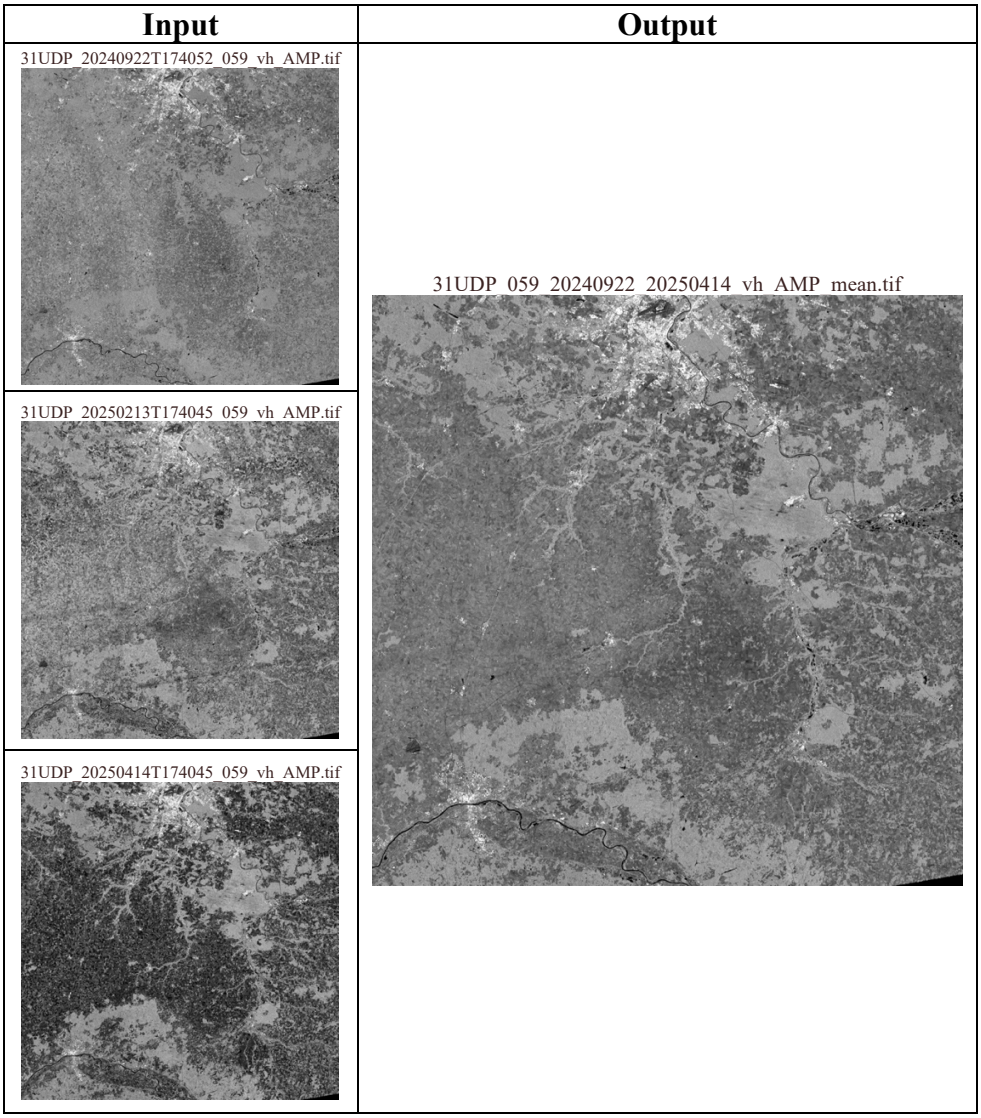

Figure 5. Multitemporal backscatter image (right) calculated from three S1 acquisitions (left).