Release Notes GAMMA Software, 20250701

Urs Wegmüller, Christophe Magnard, Charles Werner, Othmar Frey,
Andreas Wiesmann, Philipp Bernhard
Gamma Remote Sensing AG
Worbstrasse 225, CH-3073 Gümligen
http://www.gamma-rs.ch
1-Jul-2025

Introduction

This information is provided to users of the GAMMA software. It is also available online at https://www.gamma-rs.ch/uploads/media/GAMMA_Software_upgrade_information.pdf.

This release of the Gamma software includes new programs that provide new capability, additional features to existing programs and bug fixes.

Gamma Software on Linux, macOS, and Windows

The Gamma software has been compiled and tested on Linux (different distributions), Apple macOS Sonoma (15.5) for both Intel and Apple Silicon processors, and Windows 10 and 11. Computationally intensive programs such as used in co-registration and resampling and geocoding have been parallelized using the OpenMP API built into the GCC compiler. Processing speed on Linux, macOS, and Windows systems is comparable.

Linux Distribution:

The Gamma software is developed on Ubuntu 22.04 LTS 64-bit Linux and is tested extensively with this distribution. The Gamma software is also available for Ubuntu 24.04 LTS.

Versions of the Software will also be uploaded for RHEL8 based on Rocky Linux 8, and RHEL9 based on Rocky Linux 9.

Note that Red Hat has ended support for CentOS8 at the end of 2021. Consequently, the Gamma software built for RHEL8 is now built on Rocky Linux 8.

For installation instructions for the binary LINUX distributions see the HTML file INSTALL_linux.html (found in two places: the download directory of the distribution and the main directory of the distribution).

Apple MacOS Distribution:

The software in this version has been compiled using macOS Sequoia (15.5). You will need to install libraries such as GDAL using MacPorts. The build uses GCC 15 compiler. Version are available for Apple Silicon (M1/M2) and Intel x86_64 processors. This may be the last time that a version for Intel is provided.

For installation instructions for the binary macOS distributions see the HTML file INSTALL_macOS.html (found in two places: the download directory of the distribution and the main directory of the distribution).

Windows Distribution:

The Windows version of the Gamma software is compiled with 64-bit support and multi-threaded. The build uses the MINGW64 GCC 15 compiler.

For installation instructions for the binary Windows distributions see the HTML file INSTALL_win64.html (found in two places: the download directory of the distribution and the main directory of the distribution).

The Gamma Software and its environment are now provided through two installers:

- Gamma Software Installer – Includes the Gamma Software. Its filename follows the pattern: GAMMA_SOFTWARE-YYYYMMDD_GEO_LAT.mingw64_msys2.exe
- Gamma Environment Installer – Provides shared libraries and support files for the Gamma Software, including MSYS2 (Linux-like environment), the current Gamma Local version, WinPython, 7-Zip, and Gnuplot. Its filename follows the pattern: GAMMA_ENV_YYYYMMDD.exe

Alternatively, the method previously used to install the Gamma Software and Gamma Local is still available and is also documented in INSTALL_win64.html.

Notice that installing the latest Gamma Local is mandatory because a new GCC compiler and new libraries were used to build the software. Furthermore, the .bashrc file needs to be updated following the installation instructions.

The Gamma Plugin for ArcGIS is available in all Gamma Software distributions for Windows that include the *GEO* or *ISP/DIFF&GEO* modules. Full functionality requires access to the *LAT* module.

On both Windows 10 and 11, it is also possible to install the Windows Subsystem for Linux (WSL2) and run a Linux distribution of the Gamma software on that environment. Instructions for this setup are available in the HTML file INSTALL_wsl.html located in the main directory of the distribution. With Windows 10 reaching end-of-support in October 2025, the Windows distribution is now tested exclusively on Windows 11.

Documentation and Program List

The Gamma documentation browser is an HTML based system for viewing the web pages and pdf documents. The documentation browser includes for each module a Contents sidebar on the right side of the screen and a search functionality. The main Gamma documentation browser page *Gamma_documentation.html* is found in the main software directory.

The program *gamma_doc* facilitates the access to the documentation related to a given module or program:

gamma_doc	Opens the main page of the Gamma documentation browser and shows the program list.
gamma_doc DIFF	Opens the DIFF&GEO documentation.
gamma_doc gc_map2	Opens the reference manual web page for *gc_map2*.

Further information related to the GAMMA Software is available online:

General information:
gamma-rs.ch/uploads/media/GAMMA_Software_information.pdf
Technical reports, conference and journal papers:
gamma-rs.ch/uploads/media/GAMMA_Software_references.pdf
Release notes / upgrade information:
gamma-rs.ch/uploads/media/GAMMA_Software_upgrade_information.pdf

In case the program list is incomplete, run the python script program_list.py after successful installation of the Gamma Software in the main folder of the Gamma Software distribution:

```
./program_list.py Gamma_documentation_base.html Gamma_documentation_contents_sidebar.html -a
```

Python and Matlab wrappers

The Gamma Software is integrated into Python and Matlab through wrappers. Gamma Software program calls become Python / Matlab function calls where command line arguments can be used as function arguments, and system outputs can be stored in variables or written to log files. Binary images, point lists and data, parameter files, tab files, can be easily read, inspected, and written using additional functions provided with the wrappers.

The *py_gamma* Python module permits a smooth usage of the Gamma Software within Python scripts as well as within a Python Interactive Development Environment (IDE) such as Spyder or PyCharm or using Jupyter Notebooks. Using *py_gamma*, function arguments can be entered either as positional arguments or as keyword arguments, with the Gamma command line parameter names becoming the keyword names.

In the same way, the Matlab (and Octave) wrapper, composed of *mat_gamma* and *par_file* classes, permits a smooth usage of the Gamma Software within an interactive use of Matlab as well as within Matlab scripts.

Gamma plugin for ArcGIS

The Gamma plugin for ArcGIS permits using some Gamma software functionalities (tools) from ArcGIS Pro (Windows only) using a convenient interface. The Gamma plugin allows to perform the following operations:

- Reading SAR data from various sensors / formats
- Detection, radiometric calibration and geocoding of SAR data
- Co-registration of SLC and MLI SAR images in slant range / azimuth geometry
- Adaptive interferometric coherence estimation
- Multi-temporal processing and filters
- Spatial filtering of 2D SAR images
- Change detection in SAR images
- Polarimetric decompositions

Using ArcGIS ModelBuilder, it is possible to generate dedicated processing chains using the Gamma tools as building blocks. It is also possible to use each Gamma tool as a Python function (ArcGIS Pro is required). Note that the LAT module is required to be able to use all the tools; without the LAT module, only a subset of the tools is available.

See also gamma-rs.ch/uploads/media/2024-1_Gamma_Plugin_for_ArcGIS_presentation.pdf.

Hardware Recommendations

Using multi-core processors (8 or more cores) will bring substantial improvement in processing speed due to parallelization of the code base. There should be at least 8 GB RAM available for each processor core with 16 GB per core recommended. Disk storage requirements for using the Gamma Software effectively depend on the amount of input data and data products that will be produced. Based on our experience we recommend considering at least 16 TB space, especially when working with stacks of Sentinel-1 or very high-resolution data (TerraSAR-X, Cosmo-Skymed) data. The current trend towards larger data products requires substantially increased storage capacities.

GAMMA Software Training Courses

A SAR/INSAR (MSP/ISP/DIFF&GEO/LAT) training at GAMMA (near Bern, Switzerland) is planned for 1. – 5. Dec 2025.

A PSI (IPTA) training at GAMMA (near Bern, Switzerland) is planned for 21. – 24. Oct. 2025. See also https://www.gamma-rs.ch/software/training.

Significant Changes in the Gamma Software Modules since the Dec. 2024 Release

Support for Sentinel-1 ETAD data

Sentinel-1 Extended Timing Annotation Dataset (ETAD) [1] data are now supported by the Gamma Software. These range and azimuth timing corrections compensate for multiple individual effects arising from physical phenomena and assumptions made during data focusing. The corrections can be applied to Sentinel-1 SLC data acquired in either TOPS or Stripmap mode. ETAD can be downloaded from https://dataspace.copernicus.eu/

As described in "S1-ETAD Project - Product Definition Document" [3], Sentinel-1 ETAD contains the following timing corrections:

- ***Tropospheric delay in range***: the 4D operational analysis weather model data provided by ECMWF at discrete positions and time steps are interpolated to obtain the refractivity along the sensor to ground line-of-sight, which is then integrated to derive the tropospheric path delay in range. Impact can vary between 0.5m and 4.5m, depending on geographic location and atmospheric conditions.
- ***Ionospheric delay in range***: the delay caused by the dispersive ionosphere is derived from total electron content (TEC) maps containing the integrated free electrons inferred from global GNSS observations. Impact can vary between 0m and 2m, depending on geographic location and solar activity.
- ***Solid Earth tidal displacements in range and azimuth***: the tidal deformation of the Earth's crust by Sun and Moon is computed by the conventional geodynamic model associated with the geodetic reference frames and converted into timing corrections of range and azimuth. Impact can vary between ±0.2m in range and ±0.05m in azimuth, depending on geographic location and the Sun and Moon constellation.
- ***Bistatic azimuth shifts***: the corrections for the residual bistatic effects in azimuth stemming from the change of position of the satellite during the SAR acquisition are computed using the annotations of S-1 Single Look Complex (SLC) products. Impact is in the order of -5m to 0.5m, depending on the S-1 beam.
- ***Doppler-induced range shifts***: the corrections for the range shifts caused by the focusing of Doppler-shifted radar pulses in Sentinel-1 TOPS modes are computed based on the annotations of S-1 SLC products. Impact varies between ±0.5m along the TOPS bursts.
- ***FM-rate mismatch azimuth shifts***: the corrections for the azimuth shifts due to the mismatch of azimuth FM-rate, which is derived by the S-1 SAR IPF applying topographic assumptions, are computed using the accurate Copernicus 90m DEM and the annotations of the S-1 SLC products. Impact can reach up to 6m at the border of TOPS bursts if the scene contains large topographic height variation.

In addition to the corrections mentioned above, constant timing corrections in range and azimuth from instrument calibration are also provided.

ETAD corrections achieve high geolocation accuracy, but only when precision orbit data are used. These data are also included in the ETAD product.

ETAD corrections can be applied using the program ***S1_ETAD_SLC***, where the different corrections can be individually selected. They can also be applied using the script ***read_S1_TOPS_SLC.py*** or the ***Gamma Plugin for ArcGIS Pro***; in that case, a default selection of corrections is performed. The precision orbit data included in the ETAD data can also be applied using these programs.

Phase corrections corresponding to the timing corrections can also be applied to the SLC data, as these can be useful for interferometric processing.

ETAD corrections are particularly useful when co-registration refinement is complicated or impossible. Examples include regions with snow and ice cover (such as the Arctic and Antarctic), areas affected by a large earthquake, and images that mostly include forested areas.

Additional information is available in the Gamma Software documentation.

[1] C. Gisinger et al., "The Extended Timing Annotation Dataset for Sentinel-1—Product Description and First Evaluation Results," in IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1-22, 2022, Art no. 5232622, doi: 10.1109/TGRS.2022.3194216.
[2] ETAD-DLR-DD-0008, "S1-ETAD - Algorithm Technical Baseline Document", 2024. (link)
[3] ETAD-DLR-PS-0002, "S1-ETAD Project - Product Definition Document", 2024. (link)
[4] ETAD-DLR-PS-0014, "S1-ETAD - Product Format Specification Document", 2023. (link)

Gamma Time-Series Viewers for QGIS and ArcGIS Pro

With the current distribution, the new additional module *TS_DISP* is included. All the users with a valid license and running maintenance for the *IPTA* module now obtain the module *TS_DISP*. This module provides comprehensive visualization and analysis tools for time-series data from Interferometric Point Target Analysis (IPTA) and general InSAR processing results.

The *TS_DISP* module consists of two complementary platform-specific implementations, each contained in separate folders: the ***Gamma Time-Series Viewer ArcGIS Toolbox*** (ArcGIS Pro, Windows only) and the ***Gamma Time-Series Viewer QGIS Plugin*** (cross-platform, requires QGIS version 3+), along with auxiliary documentation including User Guides, installation instructions, and change log files.

Both plugins support geospatial vector layer files containing point attributes with numerical values and provide two visualization tools:

- ***Vector Layer Visualization***: Rapid application of scientific color schemes to point datasets with customizable styling options, automated statistical range calculations (min/max, mean ± standard deviations), and specialized features including symmetric scaling around zero values for deformation velocity data. The tool provides optimized color ramps specifically suited for InSAR data visualization and supports both sequential and diverging color schemes.

- ***Time-Series Visualization***: Interactive exploration capabilities with multiple point selection methods, plotting window with analysis tools including linear/polynomial fitting, seasonal decomposition, and several other features.

For the time-series visualization, date-formatted field/attribute names are needed that can follow various temporal patterns (e.g., D%Y%m%d format for GAMMA software output, %Y-%m-%d for ISO dates, or other custom date formats). The tools are specifically optimized for InSAR time-series analysis results and provide capabilities for temporal pattern analysis in geospatial point datasets, including deformation trend identification, coherence-based quality assessment, and spatial clustering of similar temporal behaviors. The QGIS plugin offers additional interactive features such as real-time point highlighting with hoverable plot elements and supports enhanced customizable color schemes and predefined visualization settings.

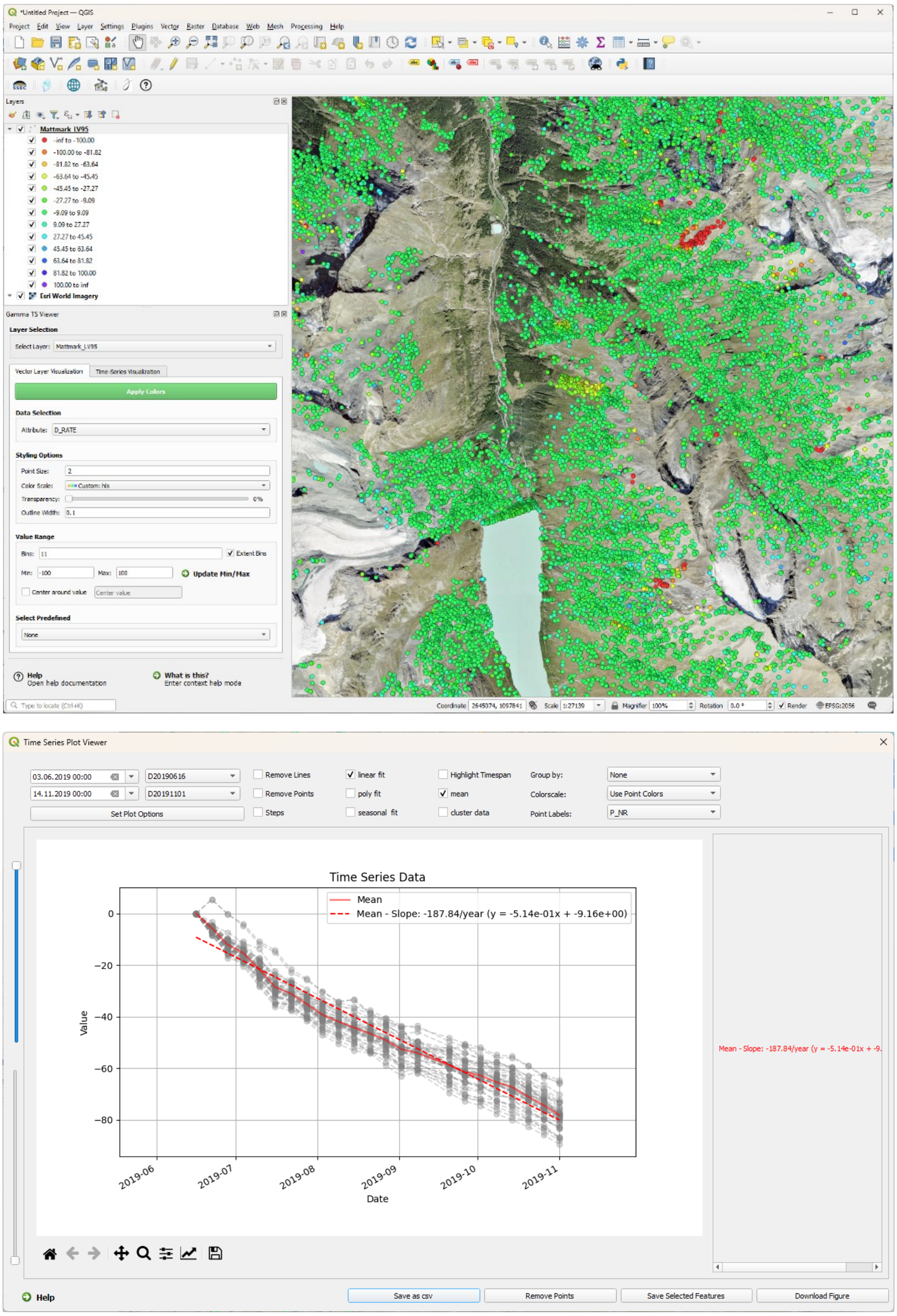


Figure 1 Interface of the Gamma Time-Series Viewer QGIS Plugin for Vector Layer Visualization (top) and Time-Series plot window (bottom). The data shown are from an IPTA processing example using Sentinel-1 data over an alpine area centered on the Mattmark artificial lake in Switzerland. The area includes several landslides. Background image: Esri World Imagery (accessed June 2025), including data from Esri, Maxar, Earthstar Geographics, and others.

New tool to extract an area of interest from an image based on geospatial data

A new Python script named ***crop_image.py*** has been implemented to enable the straightforward extraction of an area of interest from an MLI, SLC, or geocoded image, based on geospatial data. The area of interest can be defined in the following ways:

- Using a file: The file can be a DEM parameter file or any GDAL/OGR-supported format (e.g., GeoTIFF, KML, ESRI Shapefile, GPKG). The file's extent determines the area of interest.
- Specifying the extent: The extent is provided in WGS84 latitude/longitude (decimal degrees) as: "lon_upper_left lat_upper_left lon_lower_right lat_lower_right"
- Defining a point and a buffer: The extent is calculated from a center point in WGS84 lat/lon coordinates (decimal degrees) and a buffer (in meters): "lon lat buffer"

When extracting an area of interest from MLI or SLC data, *crop_image.py* performs a backwards geocoding to determine the area of interest in slant range/azimuth coordinates by converting a subset of points from map coordinates to radar coordinates. The minimum and maximum values in slant range and azimuth define a "generous" area of interest to extract.

The height of the area in map coordinates significantly affects slant range values in radar coordinates. A binary DEM file (FLOAT format) or a constant height can be specified: if a DEM file is provided, its minimum and maximum heights are used for geocoding; if a constant height is given, it replaces the default value (0.0 m).

ScanSAR / TOPS SLC mosaic files require careful cropping to prevent multi-looking from combining pixels from different bursts. For such files, the multi-look factors specified when generating the ScanSAR / TOPS SLC mosaic should be provided using a script option. The script ensures that the selected area of interest aligns with the specified multi-look factors, avoiding data mixing.

When extracting an area of interest from a file in map coordinates, the data type can be specified. This option is necessary if the input data is not in FLOAT format. This option does not apply to MLI and SLC data, as their data type is read from the associated parameter file.

PALSAR-3

The SLC reader program *par_EORC_PALSAR* was further tested using real PALSAR-3 stripmap data (obtained through a ALOS-4 Cal/Val project of GAMMA). We were able to make initial tests with PALSAR-3 DInSAR (Figure 2), PALSAR-2 – PALSAR-3 DInSAR (Figure 3) and PALSAR-3 Polarimetry (Figure 4).

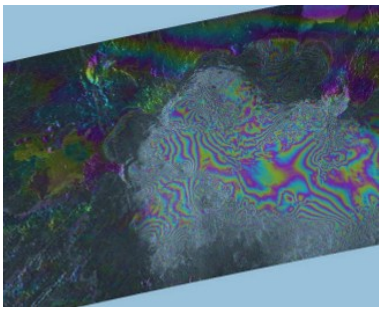


Figure 2 PALSAR3-PALSAR3 stripmap mode differential interferogram over Iceland.

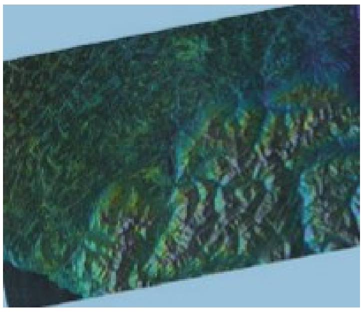


Figure 3 PALSAR3 stripmap - PALSAR2 ScanSAR differential interferogram over Switzerland.

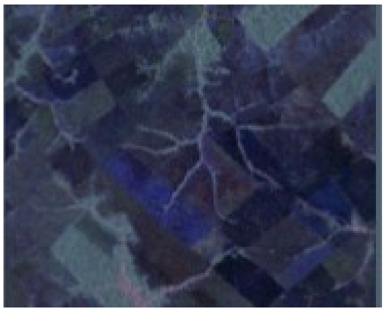


Figure 4 Pauli decomposition for PALSAR3 quad-pol. data over the Rio Branco.

Capella time-series

A stack of 18 Capella scenes acquired with approximately 3-day time intervals and reasonably short spatial baselines (mostly < 500m relative to a centered spatial reference) over a section of Mexico City, was used to assess the possibility of interferometric time-series analysis with Capella data. Here some characteristics for the CAPELLA-C14 X-band HH-pol. SLC stripmap mode data stack over Mexico City:

- satellite orbit type: mid-inclination
- range pixel spacing: 0.62 m
- azimuth pixel spacing: 1.06 m
- heading angle: 44 deg
- incidence angle: 41 deg
- Doppler Centroid values between -452 Hz and -266 Hz.

Figure 5 shows the time-baseline plots for the single reference stack and a multi-reference stack with baselines < 500m. It shows that the orbital control supports acquiring interferometric pairs with short baselines as well as stacks suited for interferometric time-series analysis.

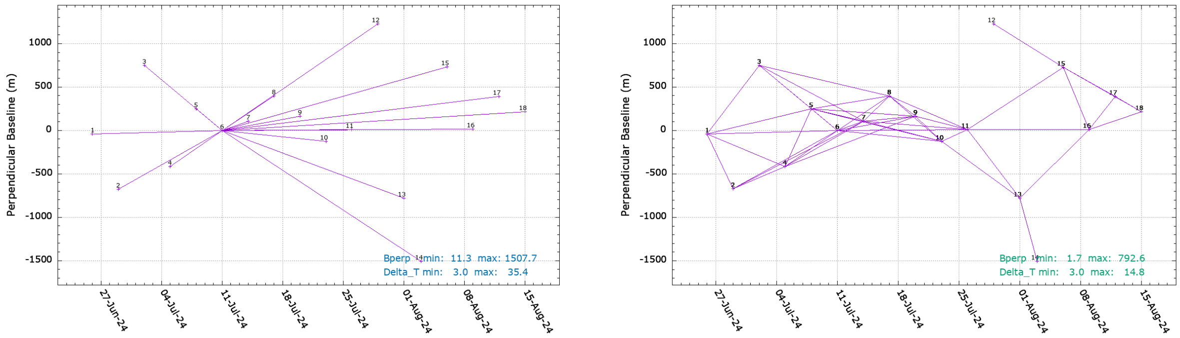


Figure 5 Time-baseline plots for single reference stack over Mexico City (left, reference 20240711) and a multi-reference stack with Δt<15days and $B_{\perp}$< 800m.

Different types of interferometric time-series analyses can be used. Important characteristics include if a single reference stack or a multi-reference stack is considered and if single pixel phases or multi-look interferometric phases are considered. We tested two different approaches:

(a) an approach using multi-look interferometric phases with a multi-reference stack,
(b) a "Persistent Scatterer Interferometry" approach considering single pixel phases of "point scatterer candidates" with a single reference stack.

The average deformation rate determined with the first approach, using a threshold of 0.8 radian for the phase standard deviation, is shown for a section of the scene in Figure 6. Very high line-of-sight (LOS) rates, with maximum values above 70cm/year, corresponding to assumed vertical displacements above 90cm/year, are observed. The average deformation rate determined with the second approach, a single reference persistent scatterer method on single pixel phases, is shown in Figure 7. Figure 8 shows a small section of the PSI result in greater detail, Figure 9 a coherence product generated based on the multi-temporal Capella data set.

For a more detailed description of the processing done and the results generated see https://www.gamma-rs.ch/uploads/media/2025-1_TR_Capella_PSI_Mexico.pdf.

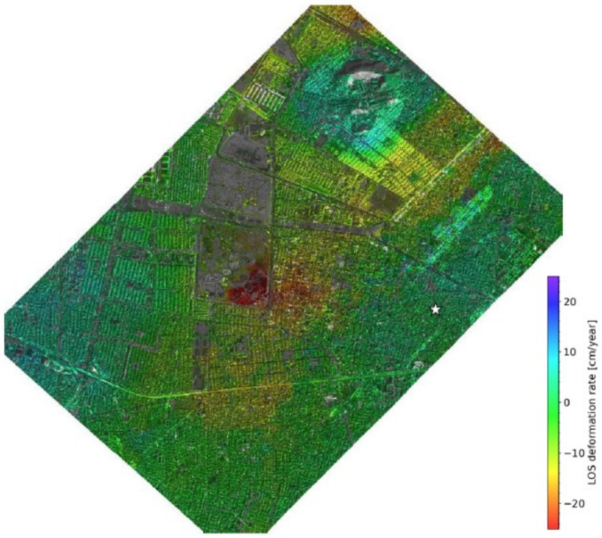


Figure 6 Average line-of-sight deformation rate determined using multi-look phases and a multi-reference stack. In the red area near the center maximum LOS rates above 70cm/year are observed.

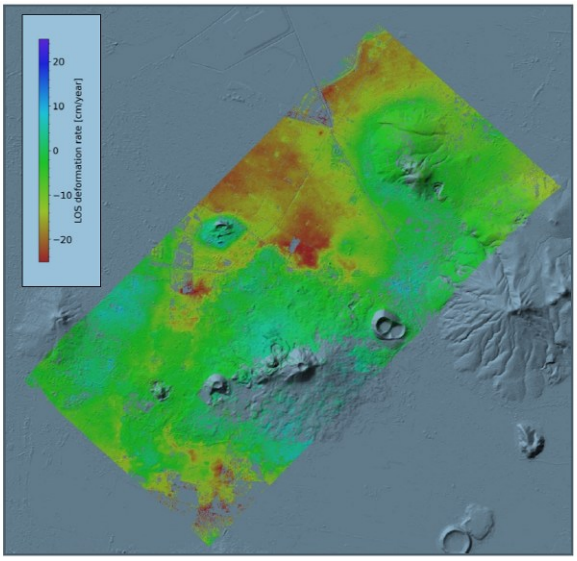


Figure 7 Average line-of-sight displacement rate determined in the single reference stack PSI analysis for the 18 Capella acquisitions between 26-Jun-2024 and 15-Aug-2024.

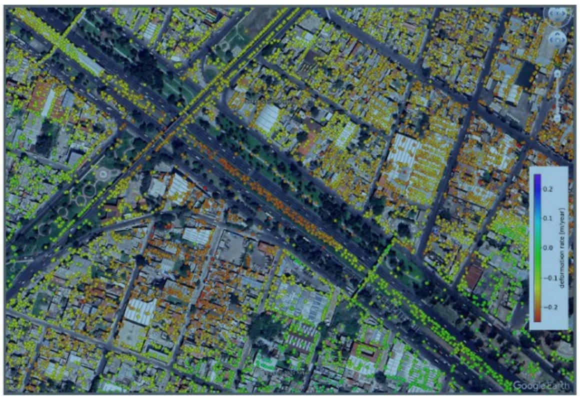


Figure 8 Detailed view of average line-of-sight displacement rate determined in the single reference stack PSI analysis (visualized in Google Earth). The corrected point height was considered in the geocoding.

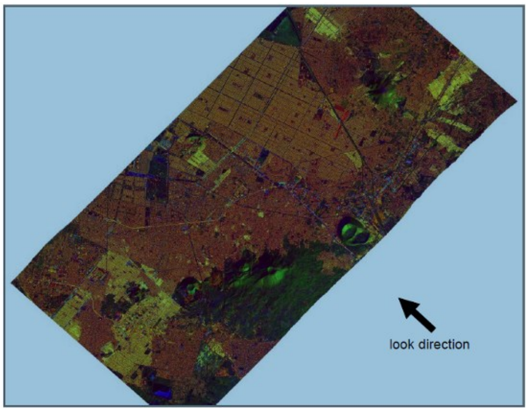


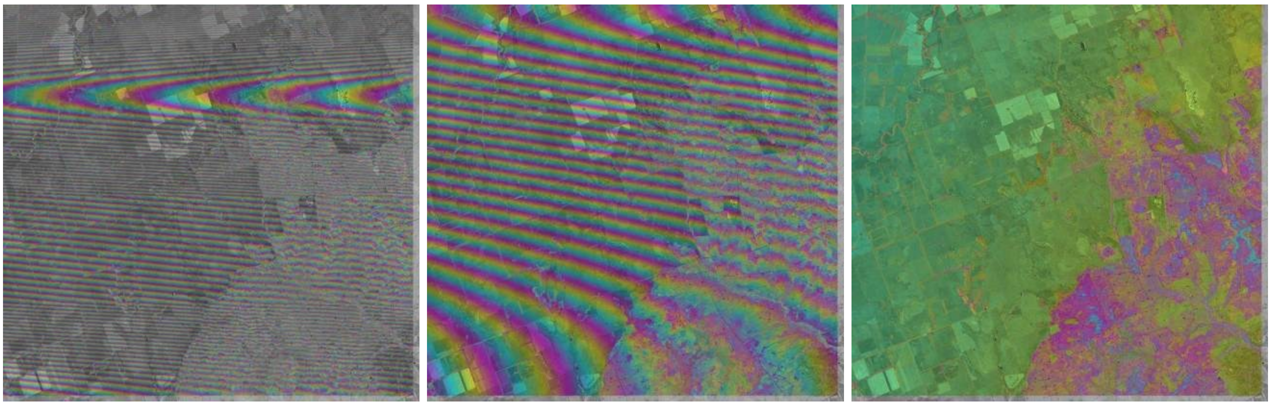
Figure 9 RGB composite of average coherence, average backscatter and backscatter temporal variability calculated for the Capella X-band stack over Mexico City. The arrow indicates the radar look direction (at 40.5 deg. incidence angle).

SuperView Neo2-03/04

In late 2023 the reader program *par_SV2_SLC* was written to support reading Superview Neo2 01 and Superview Neo2 01 data. Now this program was updated and tested with Superview Neo2 03 and Superview Neo2 04 data. Superview Neo2 01/02 and Superview Neo2 03/04 are X-band Tandem constellations, similar to TerraSAR-X / Tandem-X.

Using Superview Neo2 03/04 data we tested using the precision orbits available (Figure 10), RFI filtering (Figure 11), repeat-pass differential interferometry (Figure 12) and single-pass bistatic differential interferometry (Figure 13).

For a more detailed description of the processing done and the results generated see https://www.gamma-rs.ch/uploads/media/2025-2_TR_China_SV2_Support_in_GAMMA.pdf.



unfiltered state vectors | filtered state vectors | precision state vectors

Figure 10 Differential interferograms for a bistatic (Tandem) acquisition (using SVN2-03 and SVN2-04) on 20250208 calculated using the unfiltered state vectors from the meta data (left), the filtered stated vectors (center) or the precision state vectors (right). One color cycle corresponds to one phase cycle. The subtracted topographic phase was estimated based on the 30m Copernicus DEM.

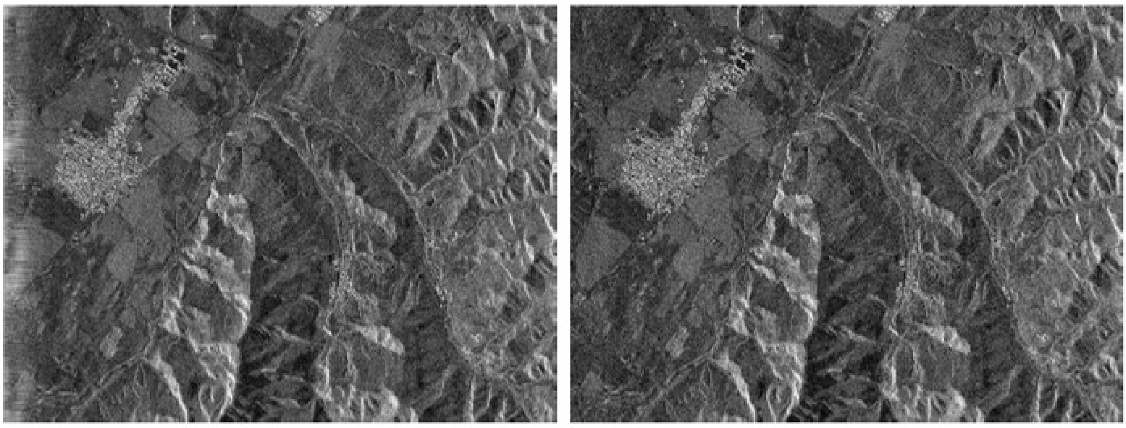


Figure 11 Original (left) and RFI-filtered (right) backscatter image (RFI in the near range is removed).

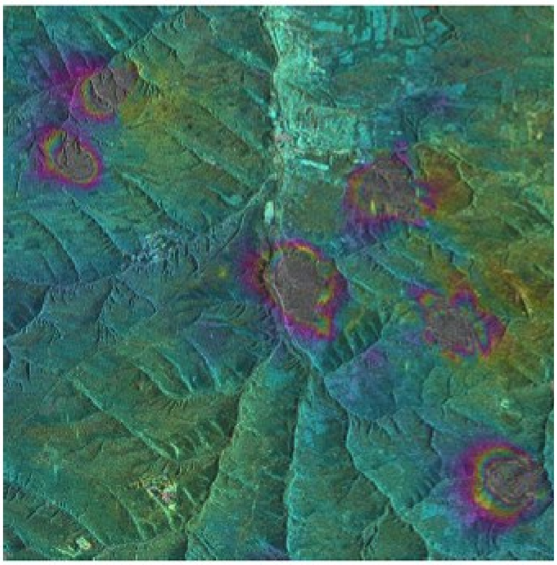


Figure 12 Superview Neo2-03 repeat-pass differential interferogram over Yanya Mining area (20241225_20250110, $B_\perp$ 6m, dt 16 days), shown with a cyclic color scale with one phase cycle per color cycle.

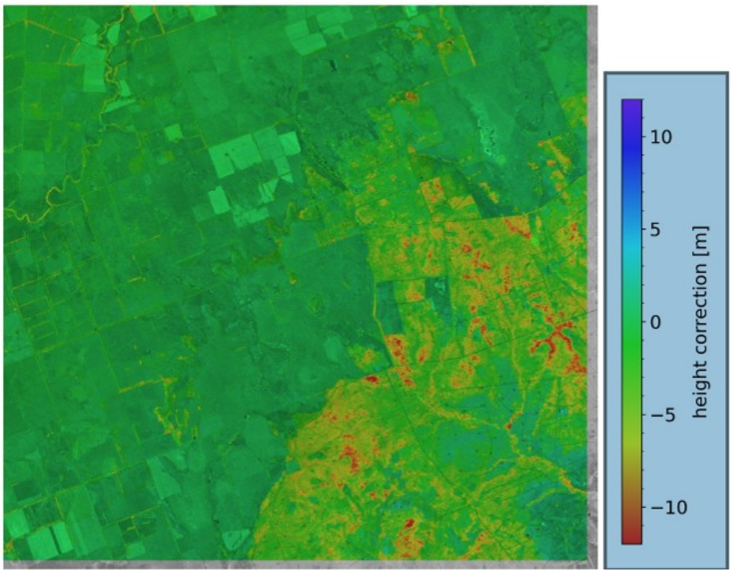


Figure 13 Height corrections (relative to the Copernicus 30m DEM heights) estimated with a single-pass Tandem SVN2-03/04 acquisition (20250224, $B_\perp$ 634m) over Condamine, Australia.

New and updated SAR data readers

New / updated SAR data reader	**Short description**
par_EORC_PALSAR	For ALOS-2 PALSAR-2 acquisitions in SM2, SM3, and WD modes, the radar center frequency specified in the parameter file is now based on predefined values. Previously, it was calculated from the wavelength value provided in the CEOS leader file. When reading these data, both the predefined and calculated center frequency values are displayed at the end of the program run. The reader program was also further tested using real PALSAR-3 stripmap data.
S1_ETAD_SLC	New program to read and apply Sentinel-1 Extended Timing Annotation Dataset (ETAD) to correct range and azimuth timings of Sentinel-1 SLC images.
read_S1_TOPS_SLC.py	New --ETAD option to read and apply Sentinel-1 Extended Timing Annotation Dataset (ETAD) to correct range and azimuth timings of Sentinel-1 SLC images.
par_SAOCOM_GRD	New program to generate MLI parameter and image files for SAOCOM L1B Ground Range Detected Images.
par_UAVSAR_SLC	Updated to support reading of SLC and MLC data from UAVSAR PolSAR Annotation File Version Number 2.4.
par_SICD_SLC	Reduced memory usage, new warning message when image size doesn't correspond to size indicated in metadata. Improved geolocation accuracy of data in PFA geometry.
par_Capella_SLC	Now includes a reramping of Capella spotlight data processed using backprojection. This reramping avoids azimuth phase ramps in interferograms. Improved geolocation accuracy of data in PFA geometry.
par_SV2_SLC	Now includes an option to specify the output radiometric calibration. Reader was tested for Superview Neo2-01/02 and Superview Neo2-03/04.
SV2_precision_orbit.py	New script to extract SuperView Neo-2 / SuperView-2 / Gaojing-2 precision state vectors and write them to an SLC/MLI parameter file.
par_NISAR_RSLC	New option [noise] to perform noise subtraction using the noise equivalent backscatter look-up tables.

Gamma Software Demo examples

The access to the Gamma Software Demo examples is limited to Gamma Software users with a valid license. The access information is provided with the software delivery. A list of the Demo examples is available here:

https://gamma-rs.ch/uploads/media/README_Gamma_Software_demo.html.

New / modified demo example:	Contents

MSP

ERS_proc_*, create_proc_par, create_sar_par: replaced calls to gets() with g_fgets(...), gets() is removed from strlib.c

ISP

ionosphere_check: New [use_existing] option to use files generated in a previous run and speed up processing. The option is turned off by default.

par_SAOCOM_GRD: New program to generate MLI parameter and image files for SAOCOM L1B Ground Range Detected Images.

SLC_mosaic_range: New program to calculate a mosaic of Stripmap SLC data provided in multiple pieces in range direction (e.g. PALSAR-3)

S1_ETAD_SLC: New program to read and apply Sentinel-1 Extended Timing Annotation Dataset (ETAD) to correct range and azimuth timings of Sentinel-1 SLC images.

read_S1_TOPS_SLC.py: New --ETAD option to read and apply Sentinel-1 Extended Timing Annotation Dataset (ETAD) to correct range and azimuth timings of Sentinel-1 SLC images.

S1_burstloc: Updated to support Sentinel-1C.

S1_path_number: Updated to support Sentinel-1C.

S1_BURST_tab_from_zipfile.py, SLC_cat_list.py, ScanSAR_ovr.py: Temporary directories now use shorter names.

par_UAVSAR_SLC: Updated to support reading of SLC and MLC data from UAVSAR PolSAR Annotation File Version Number 2.4.

fspf: New options [interp_mode] and [order] to select the interpolation method for resampling the downsampled and filtered data back to the original grid.

par_SICD_SLC: Reduced memory usage, new warning message when image size doesn't correspond to size indicated in metadata. Improved geolocation accuracy of data in PFA geometry.

par_Capella_SLC: Now includes a reramping of Capella spotlight data processed using backprojection. This reramping avoids azimuth phase ramps in interferograms. Improved geolocation accuracy of data in PFA geometry.

par_SV2_SLC: Now includes an option to specify the output radiometric calibration.

SV2_precision_orbit.py: New script to extract SuperView Neo-2 / SuperView-2 / Gaojing-2 precision state vectors and write them to an SLC/MLI parameter file.

par_NISAR_RSLC: New option [noise] to perform noise subtraction using the noise equivalent backscatter look-up tables.

par_EORC_PALSAR: For ALOS-2 PALSAR-2 acquisitions in SM2, SM3, and WD modes, the radar center frequency specified in the parameter file is now based on predefined values. Previously, it was calculated from the wavelength value provided in the CEOS leader file. When reading these data, both the predefined and calculated center frequency values are displayed at the end of the program run.

DIFF&GEO

MLI_coreg.py, MLI_coreg_refine.py, SLC_coreg.py, SLC_coreg_refine.py, ScanSAR_coreg.py, ScanSAR_coreg_check.py, ScanSAR_coreg_overlap.py, ScanSAR_coreg_pol.py, gc_map2_large.py, gp_geo_fit.py, radcal.py, rg_sens.py: Temporary directories now use shorter names.

crop_image.py: New tool to extract an area of interest from an image based on geospatial data. Supports MLI and SLC files, as well as geocoded data as input. The definition of the extent of the area to be extracted can be defined by specifying the edge coordinates, a center point with a buffer around it, or by using a file (DEM parameter, KML, GeoTIFF, ESRI Shapefile, GPKG, ...).

LAT

compact_pol_decomposition.py, quad_pol_decomposition.py: Temporary directories now use shorter names.

DISP

kml_pt: New option [pts_tile] permits specifying the maximum number of points per tile. The default directory name for the KML tiles is now the root name of the output KML file name.

data2geotiff: The size of the tiles is now set to 512 and overviews are now generated when producing a cloud-optimized GeoTIFF using option [COGflg] = 1.

IPTA

unw_correction_mb_pt.py: Temporary directory now uses a shorter name.

kml_ts_pt: New option [pts_tile] permits specifying the maximum number of points per tile. The default directory name for the KML tiles and images is now the root name of the output KML/KMZ file name.

pt2geo, disp_prt, disp_tab2gis, pdata2gis: In case the slant-range / azimuth pixel coordinates can't be converted into map pixel coordinates (e.g. for points outside of area defined in DEM parameter file), their map pixel coordinates are now set to (-1, -1) instead of (0, 0). A (0, 0) pixel coordinate is now considered as valid when exporting the data.

data2pt, d2pt: The data values are now interpolated from the 2D image data file using the selected interpolation method (using the new options [interp_mode] and [order]). If the geometry is the same for both the image and the point list, the values are picked directly from the image (no interpolation). For images in BYTE and SUN/BMP/TIFF raster formats, the nearest neighbor interpolation method is always used. Log and sqrt interpolation modes should only be used with non-negative data. To get the same results as using the previous version, select nearest-neighbor interpolation.

TS_DISP

The module *TS_DISP* has been added with the mid-2025 distribution. This module includes the Gamma Time-Series Viewers for QGIS and ArcGIS Pro. All the users with a valid license and running maintenance for the *IPTA* module now obtain the module *TS_DISP*.

Gamma_TS_Viewer_QGIS: Initial version

Gamma_TS_Viewer_ArcGIS: Initial version

TDBP (Time-Domain Back-Projection)

The TDBP programs are available for Ubuntu 22.04 Linux and Windows 11 WSL2 with Ubuntu 22.04 Linux (and legacy 20.04 Ubuntu Linux and Windows 11 WSL2 versions).

The time-domain back-projection focusing program *az_proc_tdbp_gpu* employs parallelized TDBP imaging implemented in C/CUDA and therefore requires an Ubuntu Linux computer equipped with an NVIDIA GPU.

The TDBP module supports image focusing of SAR data from airborne platforms, UAVs, and mobile-mapping platforms such as cars, or trains, with high-quality 3-D geometry/motion compensation. Subsequent interferometric/tomographic processing and value-adding is supported. The TDBP module supports SAR image focusing of pulsed and FMCW SAR data with a generic sensor-agnostic data interface. In particular, SAR image focusing of FMCW SAR data acquired with our in-house Gamma SAR systems is also supported. See also the Gamma L-band SAR demo examples and our publications on ground motion/slope stability retrieval plus other SAR imaging examples obtained with Gamma SAR systems mounted on a car or a UAV and processed with the TDBP module: https://www.gamma-rs.ch/L-band-specific-Publications.

Python wrapper

py_gamma.py: Now also supports paths defined using pathlib.

Matlab wrapper

-

GIS

With the end-of-2023 distribution the additional module *GIS* has been included. All the users with a valid license and running maintenance for the *GEO* or a combination of modules that includes the *ISP/DIFF&GEO* obtain the module *GIS*. Notice that many of the programs of the *GIS* module require access to the *LAT*. Users without the *LAT* will not see the tools requiring *LAT* programs.

The *GIS* programs compose the "***Gamma Plugin for ArcGIS Pro***". This plugin supports running SAR data specific tools in the ArcGIS Pro environment (Windows only). The GIS module consists of several text files (README file, Change log file) and Python programs. The text files are in the main GIS directory, the Python programs and the related documentation (xml files that can be accessed within ArcGIS Pro) are located in the subdirectory scripts. The text file README_GIS is a listing of the contents of the GIS module.

arc_read_data.py: Support for SAOCOM L1B Ground Range Detected Images has been added.

arc_ScanSAR_mosaic.py, arc_change_detection.py, arc_coreg.py, arc_crop_image.py, arc_geocoding.py, arc_linear_to_dB.py, arc_multi_look.py, arc_multi_temp.py, arc_read_data.py, arc_spatial_filter.py: Temporary directories now use shorter names.

arc_read_data.py: Now supports Sentinel-1 Extended Timing Annotation Dataset (ETAD).

arc_read_data.py: The "beta0" and "gamma0 ellipsoid" radiometric calibrations are now available when reading SuperView Neo-2/SuperView-2/Gaojing-2 data. Support for SuperView Neo-2/ SuperView-2/Gaojing-2 precision orbit data has been added.

All packages

-