GAMMA Software information:

GAMMA Software supports the entire processing from SAR raw data to products such as digital elevation models, displacement maps and landuse maps. The software is grouped into five packages:

- Modular SAR Processor (MSP)
- Interferometric SAR Processor (ISP)
- Differential Interferometry and Geocoding (DIFF&GEO)
- Land Application Tools (LAT)
- Interferometric Point Target Analysis (IPTA)

In addition, the image registration and geocoding functionality is also available as a separate GEO package.

A special motion compensation package (MOCOM) is also available for advanced processing of airborne data (acquired with less stable platforms).

Each of the packages is very modular and can therefore be used in the way the user prefers. On the other hand shell scripts permit running often used processing sequences in a more operational and efficient way.

The software is written in ANSI-C. Standard binary distributions are available for:

- UNIX workstations with Solaris Operation System
- PCs with LINUX operation system (with versions for 32- and 6-bit processors)
- PCs with NT operation system and CYGWIN emulation

Distributions for other platforms may be provided on demand.

The software was used to process data of spaceborne and airborne SAR data, including data of the following spaceborne SAR:

- ERS-1/2
- JERS
- RADARSAT
- SIR-C
- ENVISAT ASAR

The software is fully compatible with the data provided by the different space agencies.

The main processing sequence is complemented by quality control and display programs. The display of the final and intermediate products is supported with display programs and programs to generate easily portable images in SUN rasterfile or BMP format.

<u>Modular SAR Processor (MSP):</u>

The main modules of the Modular SAR Processor (MSP) are pre-processing, range compression with optional azimuth pre-filtering, autofocus, azimuth compression, and multi-look post processing.

In the pre-processing step processing parameters are determined from the CEOS leader files and extracted from the raw data. During range compression, data may be decimated in azimuth by pre-filtering for quick-look image processing. The azimuth processor uses the range-Doppler algorithm with optional secondary range migration as required for

RADARSAT data. The user can select the output geometry of the images to be either deskewed or non-deskewed in azimuth. The autofocus algorithm refines the along-track platform velocity estimate. The processed images are radiometrically normalized for the antenna pattern, along track gain variations of the radar, length of the azimuth and range reference functions, and slant range. Absolute calibration constants were determined for ERS-1, ERS-2, and JERS with active transponders and by cross-validation with ESA and NASDA processed calibrated data. It has been demonstrated that the Gamma processor is phase preserving from interferometric processing. Multi-look images are produced by time-domain averaging of the single look complex image samples. Processing related parameters and data characteristics are saved as text files that can be displayed using commercial plotting packages. For ERS-1/2, and ENVISAT ASAR the use of precision orbits ("Delft", PRC, DORIS) is supported. ASAR Alternative Polarization (AP) raw data processing is supported.

An advanced motion compensation module is also available for processing of airborne SAR data.

<u>Interferometric SAR Processing Software (ISP):</u>

The Gamma Interferometric SAR Processor (ISP) encompasses a full range of algorithms required for generation of interferograms, height and coherence maps. The processing steps include baseline estimation from orbit data, precision registration of interferometric image pairs, interferogram generation (including common spectral band filtering), estimation of interferometric correlation, removal of flat Earth phase trend, adaptive filtering of interferograms, phase unwrapping using either a branch cut algorithm or an approach based on a triangular irregular network with a minimum cost flow optimization technique, precision estimation of interferometric baselines from ground control points, generation of topographic height, and image rectification and interpolation of interferometric height and slope maps. Absolute radiometric calibration of ESA PAF processed SLC and PRI data is also supported. Offset tracking techniques starting from SLC pairs are also supported by the ISP.

The ISP is also the base for the differential interferometry software.

<u>Differential Interferometry and Geocoding (DIFF&GEO):</u>

The differential interferometry module (DIFF&GEO) is designed to be very flexible with respect to separating topographic and displacement effects. If you have a DEM available from another source you can use this to simulate an interferogram and use that to subtract the topographic phase effects (that's probably the best solution in this case). The precision registration between the simulated interferogram and the true interferogram (due to uncertainties in the orbit data for example) can be done automatically.

Other approaches, which are independent of a DEM, are 3 and 4-pass interferometry. In this case an interferogram, preferably one without differential effects, is used as reference to subtract the topographic phase effects. It is necessary to unwrap this reference interferogram (putting some limitations with respect of steep terrain and low coherence over forests and water).

The optimum scaling of the phase (between the two interferograms) can be estimated from the ratio of the baselines. In practice it turns out, nevertheless, that the baselines may not be accurate enough. Therefore, we included the option to determine optimum scaling parameters based on the best fit of the reference interferogram to the interferogram with the differential effects. This gives a lot of flexibility to optimize the result for a specific case.

In addition the DIFF&GEO package provides a complete set of programs for precision geocoding. Terrain and ellipsoid corrected geocoding from range-Doppler to map coordinates and vise versa are supported. Interpolation algorithms are applied for the resampling step. Due to inaccurate orbit information the geocoding requires a fine registration step. In order to automate this step a SAR image is simulated (based on the DEM) and used to automatically determine the fine registration using cross correlation analyses. The geocoding of images in ground-range geometry is also supported.

The DIFF&GEO also supports SLC co-registration considering terrain topography effects. Furthermore, offset tracking techniques starting from detected images are supported.

Land Application Tools (LAT):

The land application tools support filtering, parameter extraction, simple classification schemes, mosaicing, and additional data display tools.

Filtering tools include spatial filters (moving average, median, Frost, Lee, Enhanced Lee, Gamma Map) as well as multi-temporal filtering tools (based on Quegan et al). Data of specified polygon regions and lines can be extracted and investigated (mean values, standard deviations, histograms). Adaptive coherence, texture, and effective number of looks estimation programs as well as programs to conduct simple calculations with image data are included. Single or multiple classes can be classified based on one or several registered input data sets using a hierarchic thresholding scheme. Mosaicing of multiple data sets in map geometry is supported. Tools to generate RGB and HIS composites and tools to exchange the image intensity of one image with that of another image are included.

Geocoding Module (GEO):

The SAR data geocoding and image co-registration functionality is also available in the stand-alone GEO module. This module is of interest for people requiring advanced SAR geocoding and image co-registration functionality but without interest in interferometric analysis.

Terrain and ellipsoid corrected geocoding from range-Doppler to map coordinates and vise versa are supported. Interpolation algorithms are applied for the resampling step. Due to inaccurate orbit information the geocoding requires a fine registration step. In order to automate this step a SAR image is simulated (based on the DEM) and used to automatically determine the fine registration using cross correlation analyses. The geocoding of images in ground-range geometry and image co-registration in SAR or in map geometry are also supported.

The functionality of the GEO is fully covered by the ISP and DIFF&GEO.

Interferometric Point Target Analysis (IPTA):

Instead of a full two-dimensional analysis of a stack of interferograms only the phases of selected points are analyzed. For points which correspond to point targets the geometric decorrelation observed for distributed targets does not occur, permitting to interpret interferometric phases even for pairs with baselines above the critical baseline. Consequently, a more complete interpretation of the SAR data becomes possible. More interferometric pairs can be included in the analysis, leading to an increase of the accuracy and temporal coverage achieved.

In the IPTA much of the data are kept in vector data format, in so-called point data stacks, which permits to dramatically increase the processing efficiency and reduce the disk and memory requirements. Another important element are programs for a systematic use of the temporal dimension of the data.

A typical IPTA processing sequence starts by co-registering multiple repeat-pass SLCs. Then, an important step is the identification of point targets. For the selected point targets the interferometric phases are further investigated. The physical models describing the dependence of the interferometric phase on system and target parameters are exactly the same as used in conventional interferometry. An iteration concept is used for the optimization of the information retrieval from the multi-temporal set. Parameters that are improved include the topographic heights of the scatterers, the deformations, the atmospheric path delays, and the baselines. Different phase terms can be discriminated based on its differing spatial, temporal, and baseline dependencies. The atmospheric phase delay, for example, is relatively smooth in the spatial dimension, but uncorrelated in the temporal dimension. The topographic phase shows a linear dependence on the perpendicular baseline component and the deformation can in many cases be assumed to be relatively smooth (or low-pass) in the spatial and temporal dimensions.

The main results derived with the IPTA are topographic heights, average deformation rates, deformation histories, and relative atmospheric path delays.

The IPTA is fully compatible with the other GAMMA software. Programs for conversion between the vector data used in the IPTA and the normal 2D raster formats used are included. For a convenient use of the IPTA access to the GAMMA ISP and DIFF&GEO modules is required.

Recent developments:

Recent developments include:

- GEO stand-alone module
- ENVISAT ASAR adaptations
- New IPTA module
- Enhanced offset tracking functionality
- SLC co-registration considering terrain height effects

ALOS PALSAR:

Near future upgrades will include adaptations for ALOS PALSAR (which will be provided as "normal upgrade" as part of our maintenance; i.e. if you purchase the software now, the ALOS PALSAR upgrades will be delivered during the one year of maintenance included with the purchase).

Maintenance and support:

Gamma uses it's software for it's own research and development activities, which also means that the software is kept up-to-date with the newest developments. Your contacts for the support are those persons who developed the software and who use it regularly for their own work!

Further information:

Additional information is also available at GAMMA's homepage http://www.gamma-rs.ch.