SAR Processing, Interferometry, Differential Interferometry and Geocoding Software

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Abstract

The overall design of Gamma Remote Sensing's SAR processing, interferometry, differential interferometry and geocoding software, the algorithms used, the special features implemented, and some typical processing sequences are presented. For data examples and results achieved it is referred to the interactive presentation and [7].

1. Introduction

During the past years SAR data of an increasing number of space- and airborne sensors became available. This, together with the technical development in single- and repeat-pass SAR interferometry, lead to a significant improvement of the potential of SAR for a wide variety of applications. In order to support the application of SAR data we developed the Modular SAR Processor (MSP), the Interferometric SAR Processor (ISP), and the Differential Interferometry and Geocoding Software (DIFF&GEO). Up to the present time, processing has been performed using data of the space-borne SAR on ERS-1/2, JERS-1, RADARSAT and SIR-C/X-SAR and the air-borne Dornier DOSAR radar.

Advanced, up to date, algorithms were implemented in order to achieve accurate processing of the data while permitting timely analysis of large data sets on a workstation computer. The modular software was written in ANSI-C language guaranteeing a high portability and efficient processing. User-friendly display tools and full documentation in HTML language complement the software.

2. Modular SAR Processor (MSP)

The main modules of the MSP are pre-processing, range compression with optional azimuth prefiltering, autofocus, azimuth compression, and multi-look post processing. A flow chart for the MSP is shown in Figure 1. 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 prefiltering for quick-look image processing. The azimuth processor uses the range-Doppler algorithm with optional secondary range migration as required for RADARSAT data. The output geometry of the images can be selected 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. The good interferometric results achieved demonstrated that the SAR processor is phase preserving. Multilook images are produced by time-domain averaging of the single look complex image samples. An advanced motion compensation module is also available for processing of airborne SAR data. Efficient automated processing is realized using shell scripts. Further discussion on the MSP was presented in [5].

3. Interferometric SAR Processor (ISP)

The ISP encompasses a full range of algorithms required for the generation of interferograms, height maps, coherence maps, and differential interferometric products. These steps (for an ISP flow chart see Figure 2) include baseline estimation from orbit data, precision

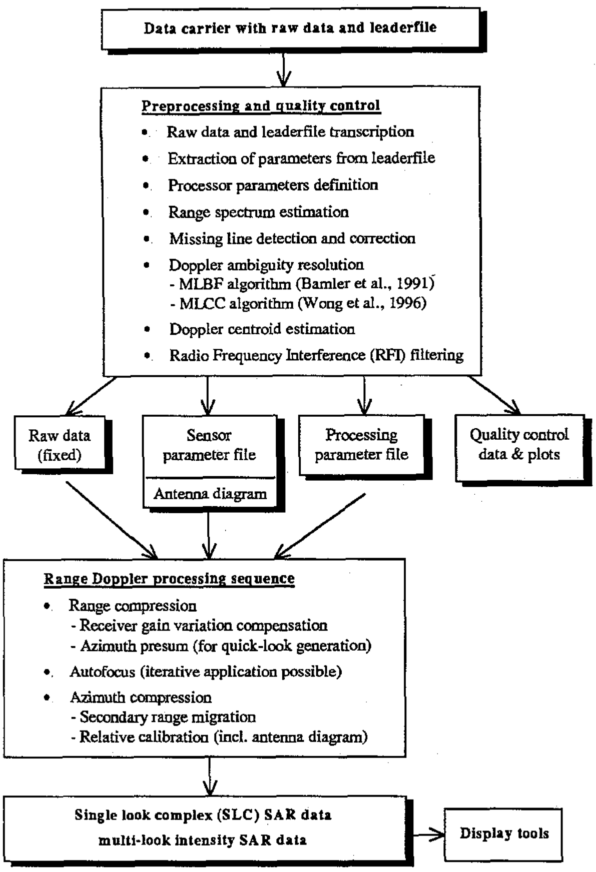

Figure 1: Modular SAR Processor (MSP): flow chart.

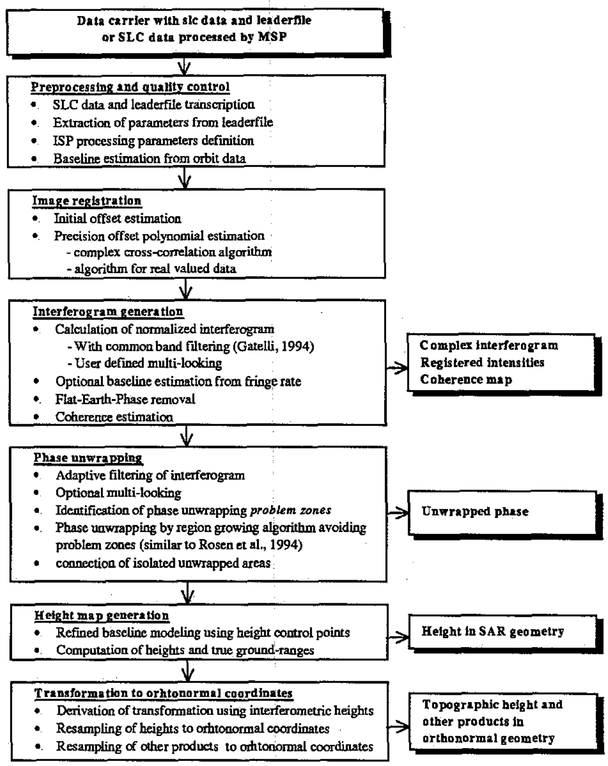

Figure 2: Interferometric SAR Processor (ISP): flow chart.

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 a branch cut algorithm, precision estimation of interferometric baselines from ground control points, generation of topographic height, and image rectification and interpolation of interferometric height and slope maps. The display of the intermediate and final products is supported with display programs and programs to generate easily portable images in SUN rasterfile format. Quality control programs complement the main processing sequence. Further discussion on the ISP was presented in [5].

4. Differential SAR Interferometry and Geocoding (DIFF&GEO)

The DIFF&GEO is a collection of programs designed to support the differential interferometric processing of SAR data as well as geocoding between range-Doppler coordinates and map projections. The reason for inclusion of these quite different processes into one module is that geocoding capability is required for 2-pass differential interferometry.

Geocoding is the coordinate transformation between the coordinates of an imaging system, in this case range-Doppler coordinates of the SAR, and orthonormal map coordinates. Geocoding is necessary to combine information retrieved by the imaging system (e.g. the SAR image and products derived from it) with information in map coordinates (e.g. a digital elevation model, a landuse inventory, geocoded information from optical remote sensing, etc.). In addition inverse geocoding, i.e. the coordinate transformation from orthonormal map coordinates to the range-Doppler coordinates, is required for 2-pass differential interferometry, namely for the simulation of the interferometric phase (in range-Doppler coordinates) from the DEM in map coordinates. Figure 3 shows the flow chart of the geocoding part of the DIFF&GEO. The selected approach is very flexible as it allows to calculate the geocoding lookup table based on a DEM in map coordinates as well as based on an interferometric height estimate (in range-Doppler coordinates).

The interferometric phase is sensitive to both surface topography and coherent displacement in between the acquisition of an image pair. The basic idea of differential interferometric processing is to separate the two effects, allowing, in particular, to retrieve a differential displacement map. This goal is achieved by subtracting the topography related phase. The topography related phase can either be calculated from a conventional DEM (2-pass differential interferometry) or from an independent interferometric pair without phase component from differential displacement (3 or 4-pass differential interferometry). A variety of supported approaches of 2-, 3-, and 4-pass differential interferometry and the corresponding processing flow charts are presented in [6].

5. Summary and conclusions

A software for SAR processing, interferometry, differential interferometry and geocoding was presented. The software supports the processing of data of the current space-borne SAR using up-to-date algorithms. This software enables users whose main competence is not in SAR processing but in a specific application science, such as seismology, geology, forestry, glaciology, urban planning, to take advantage of the great potential of SAR, INSAR and differential interferometry.

6. References

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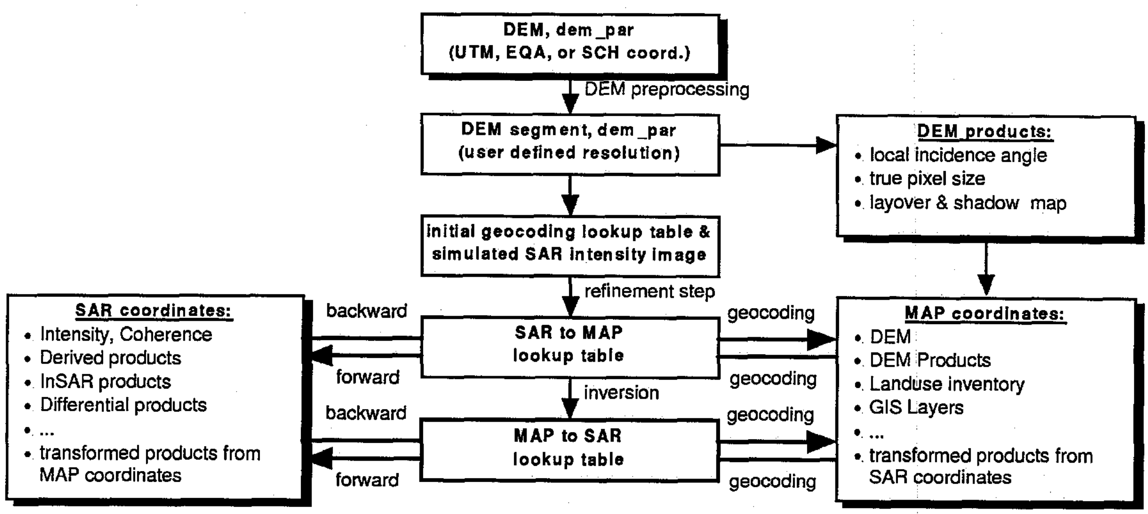

Figure 3. Flow chart for terrain corrected geocoding. The topography may either be known in map or range-Doppler coordinates.