PROCESSING OF BISTATIC TANDEM-X DATA

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ABSTRACT

In 2010, the German radar satellite TanDEM-X will be launched and flown in close formation with the TerraSAR-X satellite, launched in 2007. Together, they establish the first bi-static single pass interferometer in space. The primary TanDEM-X mission goal is to generate a global Digital Elevation Model (DEM) with a relative point-to-point height accuracy of 2 meters for moderate terrain at 12 m posting [1]. For that purpose interferometric SAR data will be acquired over a period of 3 years in parallel to the operational running TerraSAR-X mission. Systematic processing of SAR raw data to so-called raw DEMs is performed by one single processing system, the Integrated TanDEM Processor (ITP). The final global DEM is then calibrated and mosaicked by a second system, the Calibration and Mosaicking Processor (MCP). The scope of this paper is to present an overview of the ITP functionalities and to summarize the first processing results. Detailed presentations on specific ITP processing aspects and related results will be given in [10]-[13].

Index Terms— TanDEM-X, Bistatic SAR, Digital Elevation Model (DEM), SAR Interferometry

1. INTRODUCTION

The unique bi-static satellite formation in space is complemented by a complex ground segment. Therein, the world-wide network of receiving stations and the central processing and archiving facility (PAF) in Oberpfaffenhofen are the principal components of the SAR data workflow [9].

The tasks of SAR data quality analysis, interferometric processing and DEM generation are performed by the Integrated TanDEM-X processor (ITP) operated at the central PAF. A dedicated ITP-Screener version is installed at the receiving stations as well. Here, a first quality assessment of the SAR data is performed immediately after each downlink and the results are transferred to the PAF. Based on the combined screening results the ITP performs the so called interferometric quality pre-check (IQPC) scenario to provide a fast feedback on the success of the satellites' joint acquisition.

After transfer of the SAR raw data to the PAF and the availability of all required auxiliary data - particularly a calibrated baseline product – the ITP is invoked for its main task; the Raw DEM generation scenario.

In comparison to repeat pass interferometry, the requirements on instrument accuracy are much more demanding for bi-static operations. The oscillators of the two instruments are running independently and may drift [5]. Other instrument characteristics, namely, antenna phase patterns, electronic delays, and calibration networks effects have to be precisely compensated. Timing and phase synchronization as well as instrument corrections are the first of the challenging tasks of the ITP [3], [5]. Further key elements of the interferometric processing chain are the approximation of the bi-static acquisition geometry for focusing [4], high resolution image co-registration, spectral matching of time variant azimuth spectra, unwrapping of steep phase gradients on small scales, and finally consistent geocoding of all product layers.

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2. PROCESSING FUNCTIONALITIES

The ITP processing scenarios Screening, IQPC, and Raw DEM Generation are organized as sequences of single ITP processing steps. Bistatic SAR processing comprises:

- Synchronization pulse analysis and evaluation resulting in timing and phase corrections to be applied to the SAR data [5], [10].
- Generation of a bistatic focusing replica from calibration-pulses of both channels
- Calculation of time variant bi-static acquisition geometry and focusing parameters [4].
- Determination and analysis of common ground coverage and beam illumination overlap.
- Mutual Doppler centroid deviation analysis.
- SAR data focusing by an enhanced version of the TerraSAR Multimode SAR Processor (TMSP) [7]

Interferometric processing is detailed in [14] and consists of

- Filtering of both interferometric channels to common spectra.
- High resolution image co-registration, fusing a coherent and incoherent correlation approach supported by geometrical predictions [11] and resampling.
- Single and dual baseline phase unwrapping including the calculation of cost-functions controlling the underlying minimum cost flow algorithm [6], [12], [15].
- The actual generation of the raw DEM, based on the unwrapped interferometric phase, together with a set of maps assessing the quality of estimated terrain height [13].

A schematic overview of the bistatic processing workflow for raw DEM generation is illustrated in Figure 1. The diagram depicts the SAR data input the essential bistatic processing steps and the output consisting of a pair of co-registered SSCs (CoSSC) and the actual raw DEM. The dashed arrow indicates that CoSSCs acquired with a different baseline configuration may serve as additional inputs to the phase unwrapping step supporting the dual

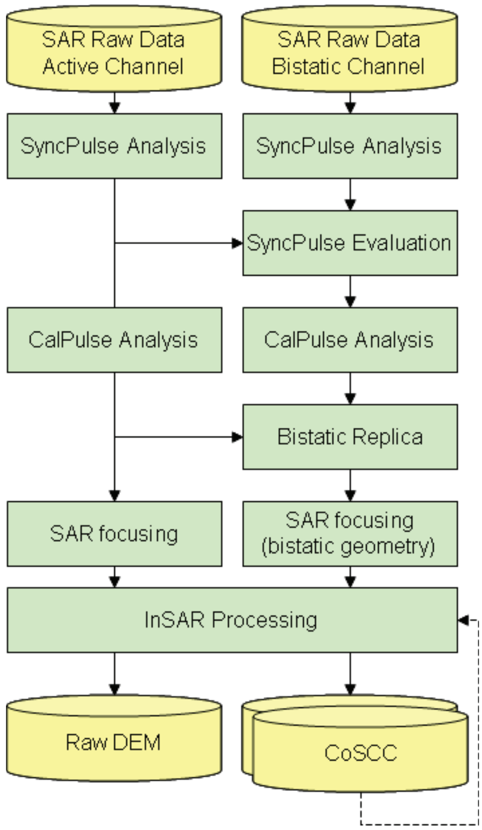

Figure 1: Schematic overview of the bistatic processing scenario for interferometric raw DEM generation

baseline option. In order to reduce the diagram's complexity other external interfaces and the inherent flow of processing parameters from step to step are not shown.

3. PROCESSING RESULTS

The processing results to be presented within this chapter will be either based on simulated bi-static point target SAR raw data including simulated oscillator phase drifts and on TerraSAR-X repeat pass interferometry or - if available at the time of writing - on pursuit monostatic and bi-static TanDEM-X data giving a first estimate of the quality to be expected.

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