InSAR

The Interferometric SAR (InSAR) package can be used to generate topographic products to characterize digital surface models (DSMs) or deformation products which identify subtle changes in surface elevation due to land subsidence.

Although it is possible to generate very high quality DSMs, the emphasis has been placed upon the generation of multiple layers of deformation products which can be easily co-registered into temporally ordered stacks for long term analysis of subsidence patterns.

The package has been developed to provide a commercial, end-to-end, interferometric processing, temporal analysis, and visualization capability designed to significantly reduce the processing requirements and operational constraints encountered by non-SAR experts.

Module Prerequisites

The InSAR package is an add-on module.

The minimum required pre-requisite packages include:
- Geomatica Core (GEO)
- Radar Ortho Suite (RAD)

The recommended packages, in order to make total use of all of the potential capabilities of the InSAR package are:
- Geomatica Prime (GTA)
- Radar Ortho Suite (RAD)
- Auto DEM (ODM)

Data Support

The InSAR package includes support for the following sensors/modes:

- ALOS-2 PALSAR - SLC strip map
- Cosmo-SkyMed – SLC strip map
- Kompsat-5 – SLC strip map
- RADARSAT-2 - SLP strip map and spotlight
- RISAT-1 – SLC strip map
- Sentinel-1 – SLC strip map
- TanDEM-X – SLC strip map, spotlight, and bistatic
- TerraSAR-X – SLC strip map, spotlight, and bistatic

NOTE: Strip map is acquired with the radar antenna pointing in a fixed direction (usually perpendicular to the flight direction). Each radar pulse generates a scan line in the range direction. The beam mode (i.e. swath width and incident angle range configuration) is selectable There are no spatial gaps in the azimuth direction.

The information in this document is subject to change without notice and should not be construed as a commitment by PCI Geomatics. PCI Geomatics assumes no responsibility for any errors that may appear in this document.

Page | 1

Interferometry

Radar interferometry is a technique that combines the coherent phase from a pair of synthetic aperture radar (SAR) signals to provide three-dimensional information about the Earth's surface. The technique requires the co-registration and processing of two SAR signals from very similar viewing geometries that have been acquired over the region of interest. By coherently combining the signals from the two acquisitions, the interferometric phase between the received signals can be determined for each imaged point.

The interferometric phase represents the difference in the path lengths to the imaged point. The interferometric phase is affected by topography, atmospheric effects, surface motion, and system noise. The effects of topography can be estimated and removed through the use of a (high-quality) digital elevation model (DEM) and knowledge of the radar characteristics (wavelength, range to target) and relative orbital positions (baseline length and drift).

After the effects of topographic, atmospheric and residual noise have been removed, the remaining phase differences are due to subsidence in the direction of the radar's line of sight (LOS). If multiple data sets are available, a long term temporal assessment of motion can be created for each target.

Workflow

The workflow sequence can be summarized as:

Creation of Interferograms

- SAR data ingest, extraction of metadata and geocoding information
- Automated image to image co-registration
- Generation of raw or filtered interferogram

Generation of Interferometric Products

- Removal of flat earth and topographic effects
- Removal of residual orbital errors
- Unwrapping the interferometric phase
- Interferometric Adjustment of Output Products
- Convert to Orthorectified Final Product

Temporal Analysis of Surface Subsidence

- Temporal parameter extraction from an unwrapped interferometric stack
- Enhanced visualization of temporal information.

A sample InSAR workflow sequence, including the interconnectivity of the modules is shown in Figure 1 on the next page.
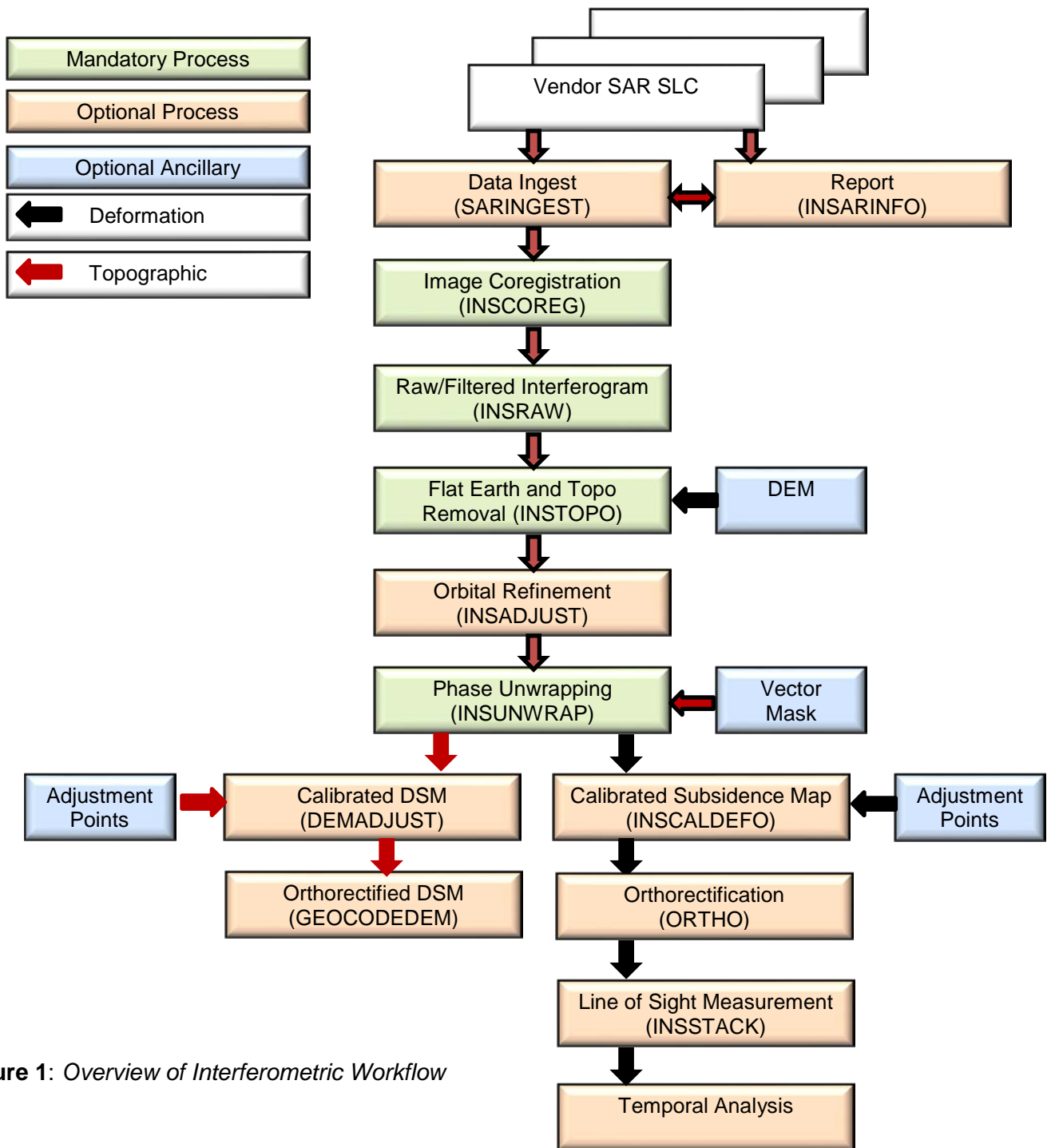
Legend:
- Mandatory Process
- Optional Process
- Optional Ancillary
- ← Deformation
- ← Topographic

Workflow:

Vendor SAR SLC

Data Ingest (SARINGEST) ↔ Report (INSARINFO)

Image Coregistration (INSCOREG)

Raw/Filtered Interferogram (INSRAW)

Flat Earth and Topo Removal (INSTOPO) ← DEM

Orbital Refinement (INSADJUST)

Phase Unwrapping (INSUNWRAP) ← Vector Mask

Adjustment Points → Calibrated DSM (DEMADJUST)

Calibrated Subsidence Map (INSCALDEFO) ← Adjustment Points

Orthorectified DSM (GEOCODEDEM)

Orthorectification (ORTHO)

Line of Sight Measurement (INSSTACK)

Temporal Analysis

Figure 1: *Overview of Interferometric Workflow*

Data Visualization

For the InSAR work there are a few specific data visualization tools in Geomatica Focus that should be mentioned:

- Viewing a layer as amplitude and phase
- Viewing properties of an amplitude and phase layer
- Viewing an InSAR temporal chart

Viewing a layer as amplitude and phase

Focus allows users to visualize complex SAR data as amplitude and phase. The amplitude of the complex layer is displayed in black and white while the phase information is displayed as a semi-transparent (30%) color ramp. This allows the user to examine the coherence (i.e. amplitude) and phase patterns to assess the quality of the data.

Viewing properties of an amplitude and phase layer

Once an amplitude and phase layer is loaded to the Focus view users can view the properties and control the various views by right-clicking on the layer and selecting the "Properties" option.

Viewing an InSAR temporal chart

The InSAR temporal chart can be found under the "Analysis" menu in Focus. This tool allows users to analyze interferometric stacks produced with the INSSTACK function by viewing an interactive InSAR temporal chart.
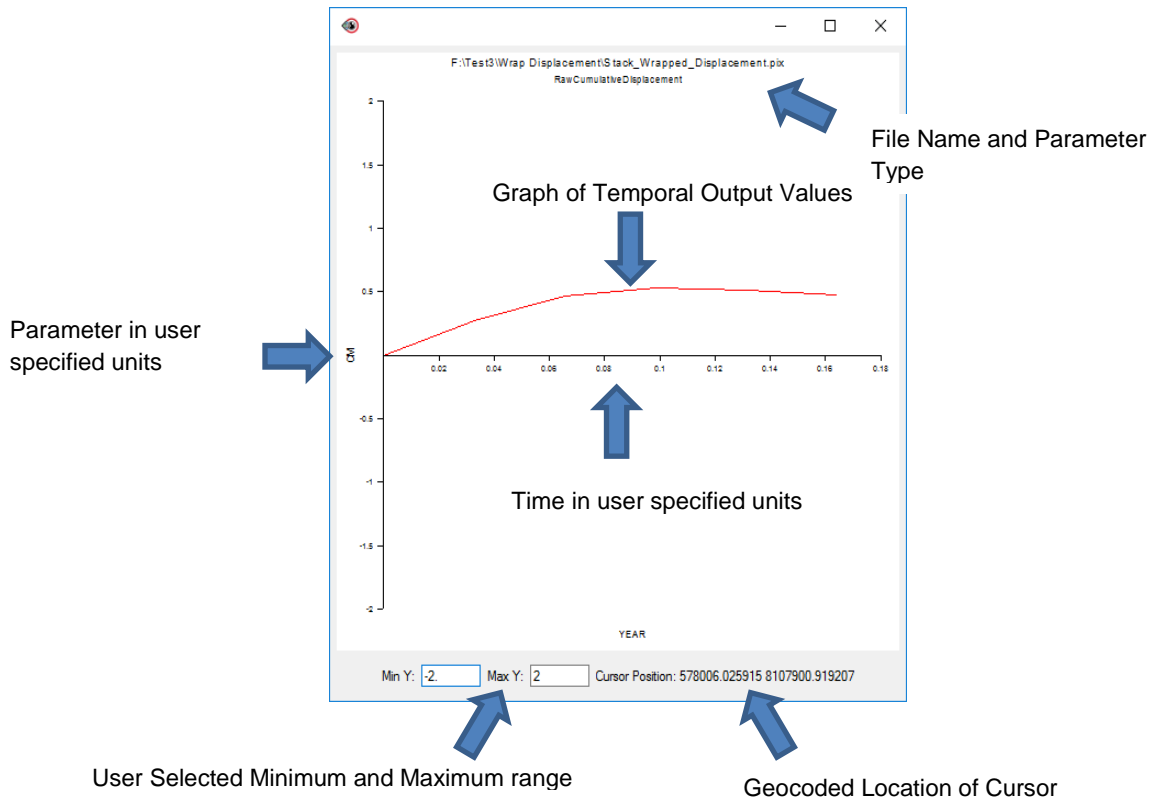

Figure 2: *InSAR Temporal Chart*

Functions

The following functions are activated with the InSAR package. These modules can be executed either independently or sequentially via an EASI™ or Python™ script. They may also be available in the Algorithm Librarian in Geomatica Focus and the PCI Modeler.

The following programs are included in the InSAR package:

- INSADJUST – Module that automatically removes low frequency residual phase caused by orbital drift and/or baseline errors. The module iteratively estimates both the horizontal and vertical spectral residuals and applies the correction based upon the viewing geometry for the interferometric pair.
  Note: INSADJUST uses large amounts of memory; systems with limited memory may perform poorly when processing large images

- INSCALDEFO – This function is used to adjust unwrapped displacement values to be zero at all points held in a vector layer or text file.

- INSCOREG – Module designed to automatically resample and co-register the dependent file to the reference file. The module automatically acquires control points, removes outliers, and resamples the dependent file to match one-to-one with the reference file.

- INSINFO – This module is designed to provide pertinent interferometric parameters such as acquisition dates, baseline distances, incident angles for the reference file and the dependent file(s). If multiple dependent files are to be evaluated, the file names can be listed in a text file.

- INSMODGOLD – This function applies a sliding 3x3 spatial boxcar filter to prefilter the data prior to estimating the fringe frequency. It is normally applied after the topographic phase correction (INSTOPO) or after the orbit adjustment (INDSADJUS) to enhanced interferometric fringes and speed up the following phase unwrapping (INSUNWRAP).

- INSRAW – module required to produce the raw interferogram using the specified reference file and resampled dependent file generated by the INSCOREG module.

- INSSTACK – Converts a number of co-registered SAR interferograms into a time ordered stack of phase values, accumulative displacements or velocities. It also produces a file of statistical values including average coherence and best fit linear velocity. The stacks can be produced from slant range interferograms or orthorectified interferograms. The input interferograms must be coregistered on a one-to-one basis and in the same projection.

- INSTOPO – This module extracts the reference and dependent file orbit data and calculates the required phase adjustments to correct for systematic flat earth effects projected to the specified earth model (which is generally the WGS-84 ellipsoid). Variations in phase caused by topography are also corrected if a digital elevation model is supplied.

- INSUNWRAP – This module unwraps the interferometric phase by performing a two dimensional integration of the wrapped phase values to generate the unambiguous phase. The unwrapping is based upon the Statistical cost, Network flow, Algorithm for Phase Unwrapping algorithm as described in Ref [1]. The algorithm computes the most likely unwrapped solution based upon the observable data (coherence).

The information in this document is subject to change without notice and should not be construed as a commitment by PCI Geomatics. PCI Geomatics assumes no responsibility for any errors that may appear in this document.

Page | 5

[1] C. W. Chen, H. A. Zebker, "Two-dimensional phase unwrapping with use of statistical models for cost functions in nonlinear optimization," *Journal of the Optical Society of America A, vol. 18, pp. 338-351 (2001).*

For more information, contact

PCI Geomatics
90 Allstate Parkway, Suite 501
Markham, ON L3R 6H3
Canada

Phone: 1 905 764 0614
Fax: 1 905 764 9604
Email: info@pcigeomatics.com
Web: www.pcigeomatics.com

株式会社 インフォサーブ

〒 101-0021
東京都千代田区外神田6丁目2番8号 松本ビル
TEL： 03-3833-8201　　FAX： 03-3833-8203
E-mail： product_info@infoserve.co.jp
URL： http://www.infoserve.co.jp

The information in this document is subject to change without notice and should not be construed as a commitment by PCI Geomatics. PCI Geomatics assumes no responsibility for any errors that may appear in this document.

Page | 6