Lab Exercise II: SAR Interferometry – Generation of Digital Elevation Models

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Synthetic aperture radar interferometry is widely used for the generation of digital elevation models (DEM). The topographic information is derived by exploiting the phase differences of the coherent radar signal from 2 complex-valued SAR images (defined as Master and Slave image), which are acquired from slightly different orbit positions. Three essential steps are the main components of the standard InSAR processing (Fig. 1):

1) coregistration of the two complex images
2) interferogram generation and coherence estimation
3) phase unwrapping

The exercise will be split into three parts according to the above mentioned components.

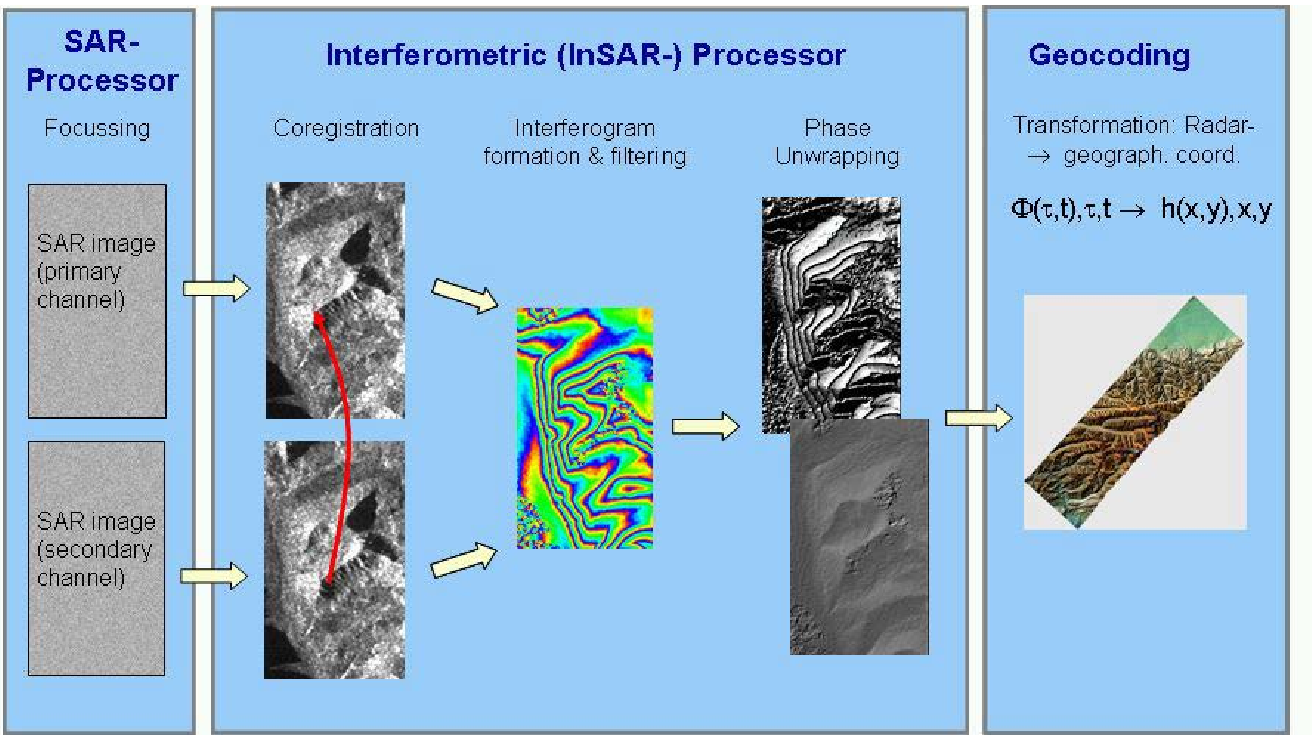

Figure 1: interferometric processing

Task 2: Interferogram generation and coherence estimation

The phase differences of two complex SAR images are related to the topographic elevation of the surface. To calculate these phase differences, the interferogram of the two complex images is generated. The fringes in an interferogram contain not only information about the surface topography, but also about the Earth's curvature (called flat earth phase or model phase) due to the acquisition geometry. In order to derive the topographic elevation, the flat earth phase has to be subtracted.
In an interferogram the coherence represents the correlation between the corresponding pixels of the two images, i.e. it is also a measure for the accuracy of the interferometric phase and has to be estimated.

Working steps:

5) Form interferogram: pixel-wise multiplication of the first image with the complex conjugate of the second one using the coregistered complex images from exercise 1 (or the provided coregistered data); visualize the interferogram
6) Subtract the model phase, then wrap the phase again; visualize the result
7) Estimate the coherence (on basis of original coregistered data): use a window of 5 pixels surrounding the pixel of interest; keep in mind to remove the flat earth phase!
   Hint: test your estimator on a small area, e.g., use the range [1540:2230, 390:650]
8) Visualize the coherence and the filtered interferogram from the estimated complex coherence results.
9) Identify regions with different qualities of coherence. Interpret the computed coherence based on the possible noise sources.
10) Propagation errors and temporal decorrelation decrease the quality of interferograms. Give ideas how to minimize these errors.

Data description: Model phase of the flat earth: MODELPHASE.mat, Master and Slave image data (coregistered): Master_fine.mat and Slave_fine.mat

Hints:

- Resolution of input data: 5 x 25 m (azimuth, range, i.e., rows, columns)

Useful Matlab functions:

- wrap: wrap the value to [-π, π]
- conj: complex conjugate