SAR interferometric processing

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Outline

- Why InSAR processing?
- Processing chain
- Data sets
- Coregistration
- Interferogram generation
- Phase unwrapping
- Conversion from phase to height
- Geocoding
Why InSAR processing?

- extracting three-dimensional information out of a radar image pair covering the same area
  - digital elevation model
  - change detection
Processing chain

InSAR processing

Image co-registration

Master image, resampled in azimuth by factor 5

Slave image, resampled in azimuth by factor 5

Interferogram generation

Unchanged master image

Co-registered slave image

Complex interferogram

Coherence image
Processing chain

- Complex interferogram
- Phase unwrapping
- Unwrapped phase
- Conversion to height
- Coherence image

InSAR processing

Digital elevation mode
Data sets

- analog raw data on tape
- capture file
  - telemetry stripped off, digital $\rightarrow$ computer compatible
- level zero data
  - SKY telemetry format (STF)
  - CEOS raw format
- level one data
  - run through a SAR processor (e.g. AISP, PP, Focus)
  - CEOS single look complex
Data sets

- satellite data
  - ERS-1, ERS-2, RADARSAT-1, ENVISAT (C-band)
  - JERS-1 (L-band)

- airborne data
  - AirSAR, TOPSAR (research)
  - E-SAR, DOSAR, Star3i (commercial)

- shuttle
  - SIR-C / X-SAR mission (NASA + DLR)
  - Shuttle Radar Topography Mission (SRTM)
Coregistration

- alignment of master and slave image
- trade off between processing time and accuracy of technique applied
- coarse coregistration
  - matching images on a pixel level (shift in x and y)
- fine coregistration
  - sub-pixel alignment of images
  - large variety of techniques
Coregistration

- quality requirement to avoid phase errors
  → $\frac{1}{8}$ of a pixel

- interpolation method
  - nearest neighbor, bilinear, cubic splines, sinc

- quality measure: coherence
Interferogram generation

- complex multiplication of the two images
- corresponding amplitudes have to be averaged
- corresponding phases have to be differenced at each point in the image
  → phase difference related to height
- multilooking of interferogram
Phase unwrapping

- looking for the correct integer number of phase cycles that needs to be added to each phase measurement to obtain the correct slant range distance
- absolute phase is wrapped into the interval $(-\pi, +\pi] \rightarrow$ ambiguity problem
- solving ambiguity referred to as phase unwrapping
Phase unwrapping

- no standard procedure to solve the phase unwrapping problem
- large variety of algorithms developed
- generally trade off between accuracy of solution and computational requirements
- two types of strategy to solve the phase unwrapping problem
  - path-following methods (local approach)
  - minimum-norm methods (global approach)
Phase unwrapping

- ways of simplifying the problem
  - filtering the phase before unwrapping
  - removing topographic phase before unwrapping
    \(\rightarrow\) requires reference DEM
  - choice of geometry: short baseline
Conversion phase to height

- adding of topographic phase (in case removed before phase unwrapping)
- creation of the elevation map
- estimating an error map based on coherence image, baseline and unwrapped phase
- mapping from slant range to ground range geometry
Geocoding

• defines the transformation between local coordinate system and global Cartesian coordinates

• two different ways of implementation
  • Doppler frequency calculated on DEM positions and satellite orbit (requires reference DEM)
  • refinement of baseline and imaging geometry (no reference DEM required)
Questions