Interferometric processing

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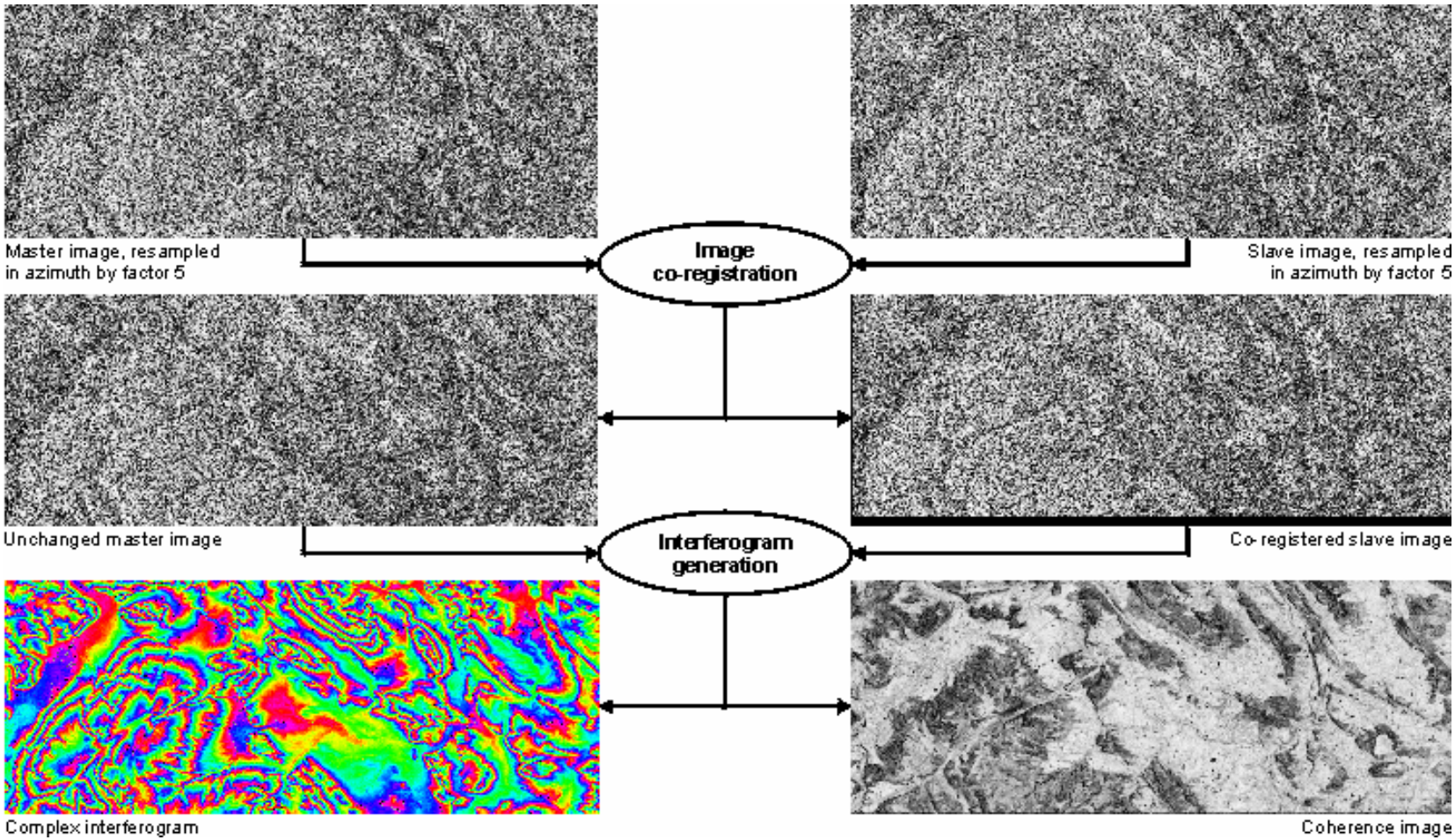
ASF

Why InSAR processing?

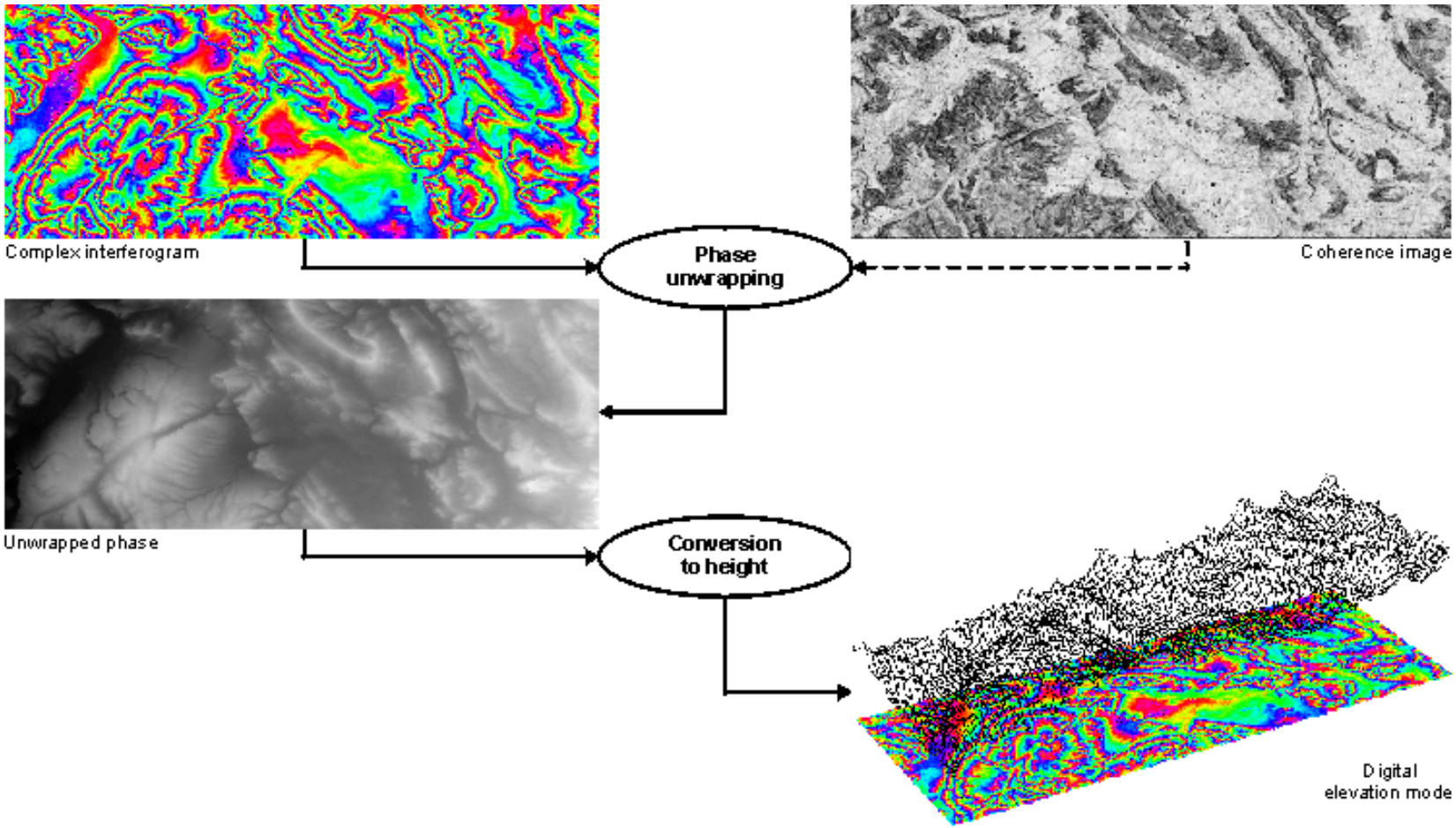
- extracting three-dimensional information out of a radar image pair covering the same area
  - digital elevation model
  - change detection

Processing chain

Interferometric processing



Processing chain



Interferometric processing

Data sets

- analog raw data on tape
- capture file
  - telemetry stripped off, digital → 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
  → ⅛ of a pixel
- interpolation method
  - nearest neighbor, bilinear, cubic splines, sinc
- quality measure: coherence

Parameters influencing coregistration

- topography
  - different vantage point cause different overlay
  - shift in azimuth direction for non-parallel orbits
- deformation
  - local deformation perpendicular to the slant range vector cause geometric differences
- atmosphere
  - different conditions cause different degrees of refraction and delay of radar signals

Parameters influencing coregistration

- antenna
  - malfunctioning of antenna during one acquisition results in geometric differences

Coarse coregistration techniques

- satellite orbits
  - good for 1-2 pixels
- tie points
  - common tie points in both images
  - last alternative
- multi-resolution sequence
  - also referred to as pyramid construction
  - low resolution to high resolution

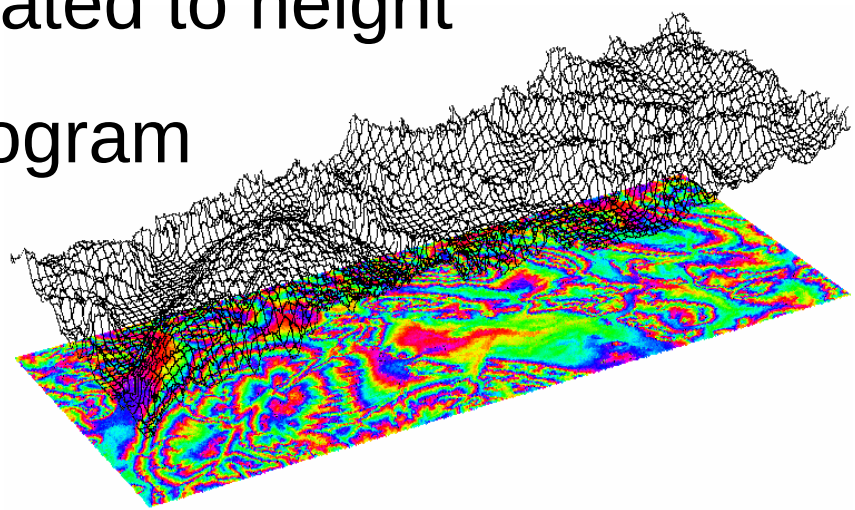
Fine coregistration techniques

- maximum coherence
- least-squares intensity
- signal-to-noise ratio
- average fluctuation
- fast Fourier transformation

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

  $\rightarrow$ phase difference related to height
- multilooking of interferogram



Coherence

- measure for the correlation of the phase information of corresponding signals
- ranges from 0 to 1
- quality measure for coregistration

$$\gamma = \frac{\left|\left\langle s_1 s_2^* \right\rangle\right|}{\sqrt{\left\langle s_1 s_1^* \right\rangle \left\langle s_2 s_2^* \right\rangle}}$$

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)