Introduction to SAR interferometry

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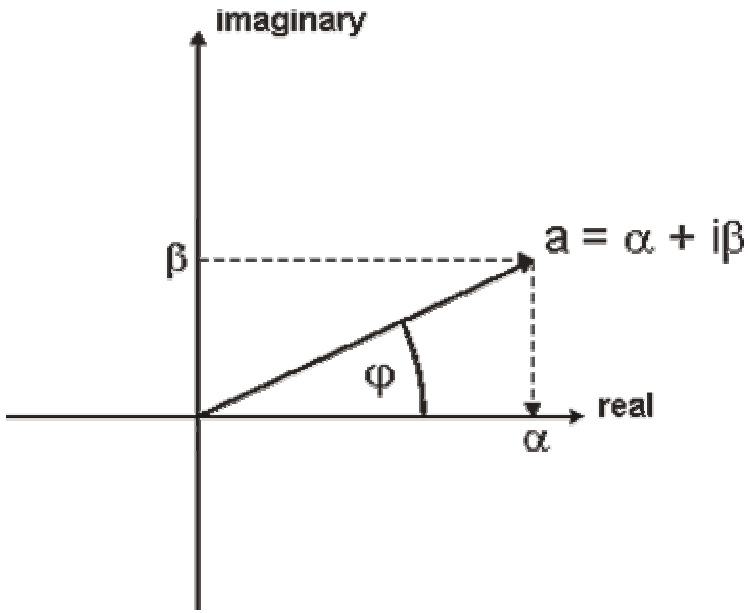
ASF

Outline

- Relevant terms
- Geometry
- Why does InSAR work?
- Techniques
- Products
- Applications
- Error sources
- Trends and challenges

Relevant terms



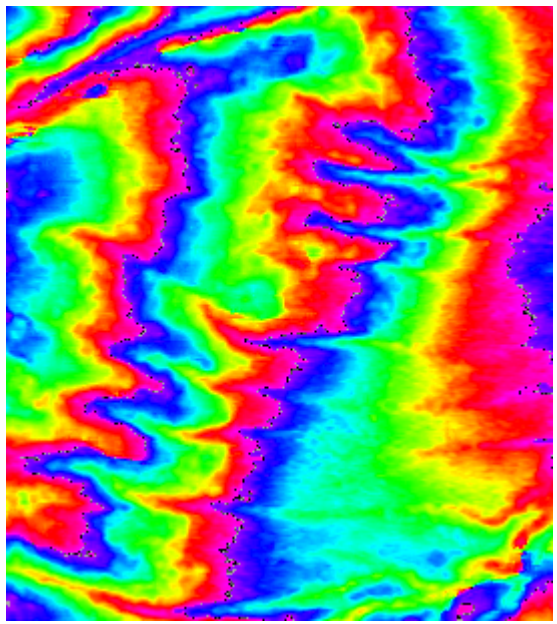
- amplitude
  - measure of the strength of the signal
- phase
  - angle of a complex number

Relevant terms

- baseline
  - separation between the two antenna positions either mounted on an aircraft or realized by two repeating satellite orbits

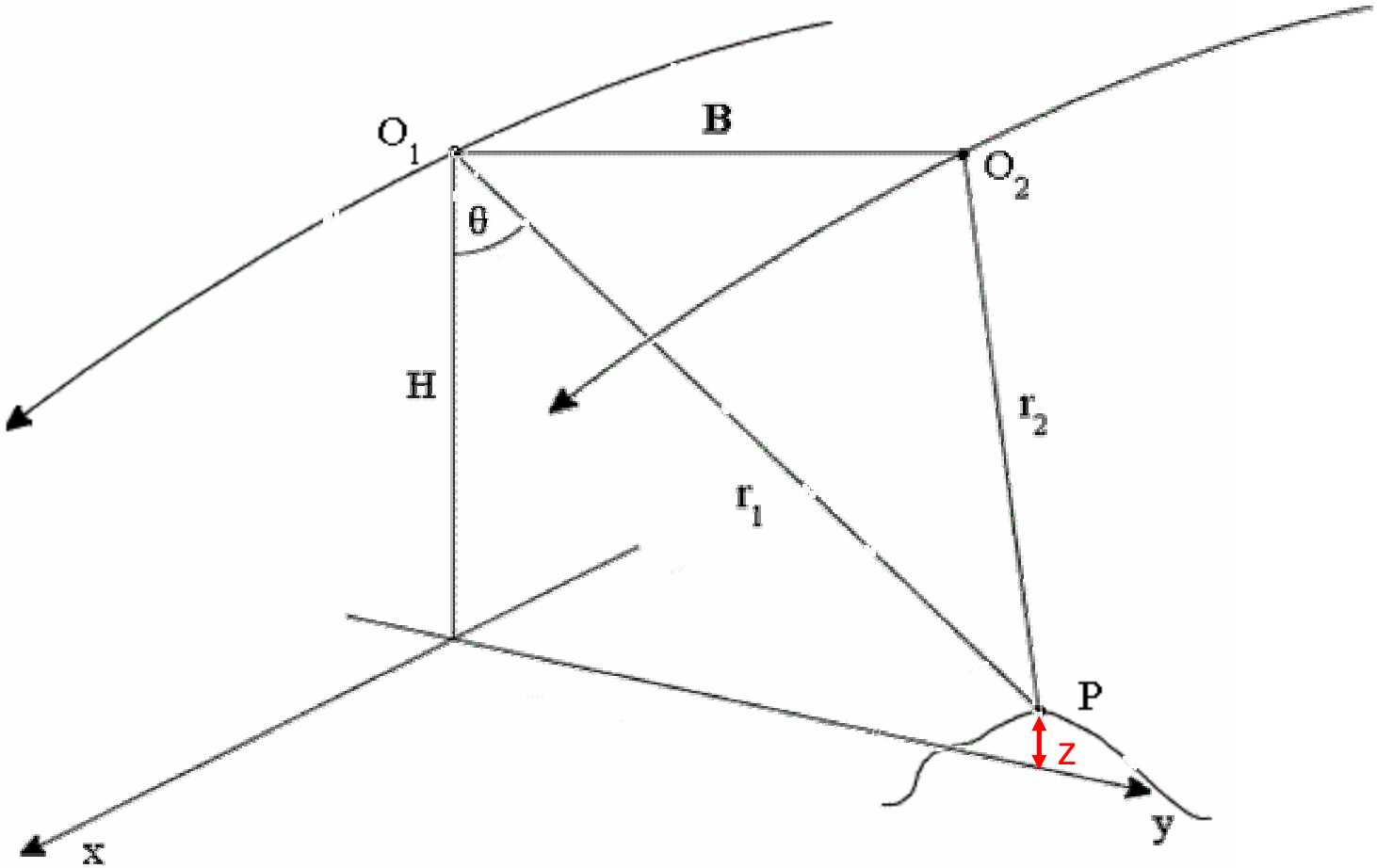
Source: Gens and van Genderen, IJRS, 1996

Relevant terms



- fringe
  - represents the whole range of the phase in an interferogram from 0 to 2π in a full colour cycle

Geometry of SAR interferometry



Why does InSAR work?

- coherent signal
  - single frequency
- same geometry covering the same area from slightly different position in space

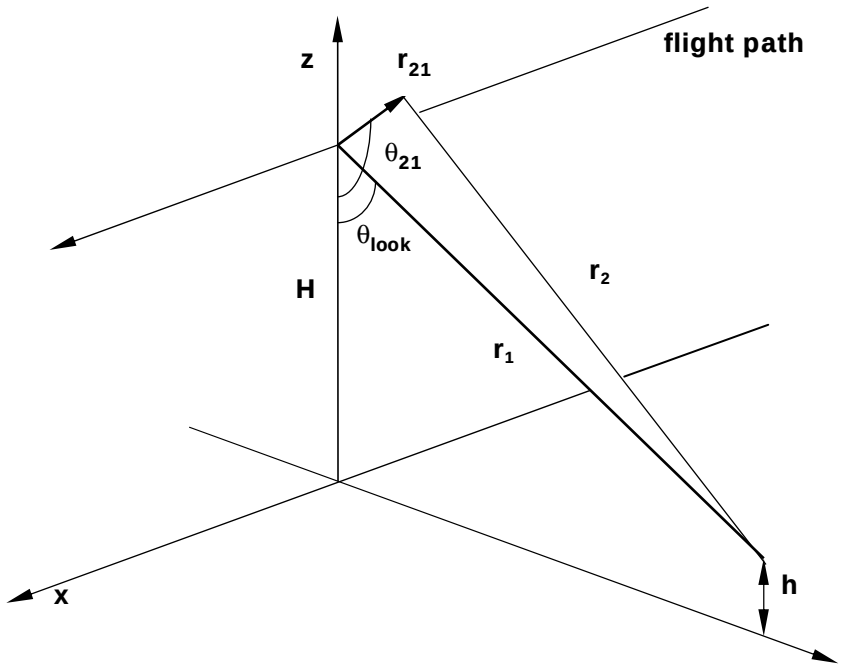
Does optical interferometry work? yes

- coherent light source: laser
- application: holography

Interferometric techniques

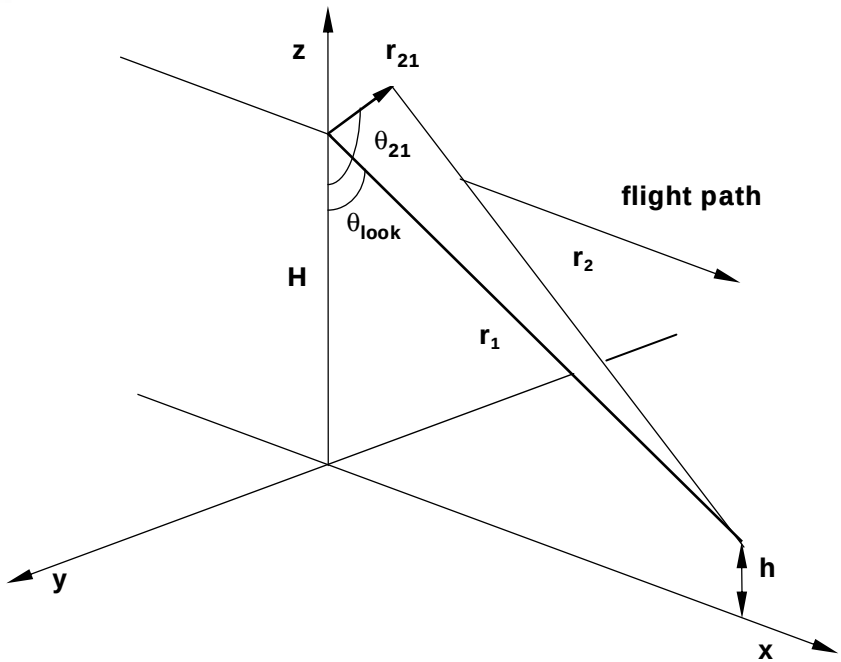
- across-track interferometry
  - regular airborne geometry
- along-track interferometry
  - airborne geometry
  - monitoring ocean currents or other moving objects
- repeat-pass interferometry
  - usually spaceborne
- differential interferometry
  - change detection

Across-track interferometry



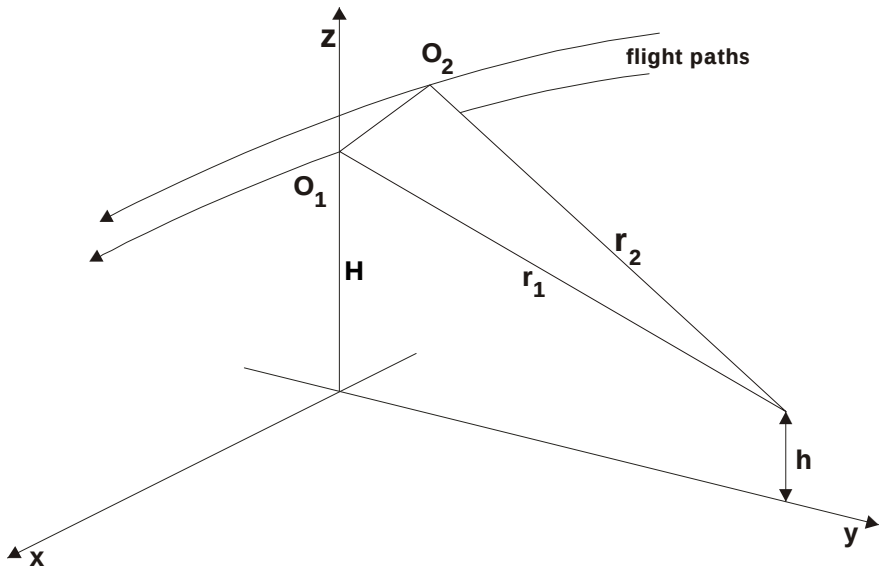
- presently only employed on airborne system
- two SAR antenna systems to be mounted simultaneously on the platform perpendicular to the flight direction
- distinction between errors caused by the aircraft roll and the influence of the terrain slope is not possible.

Along-track interferometry



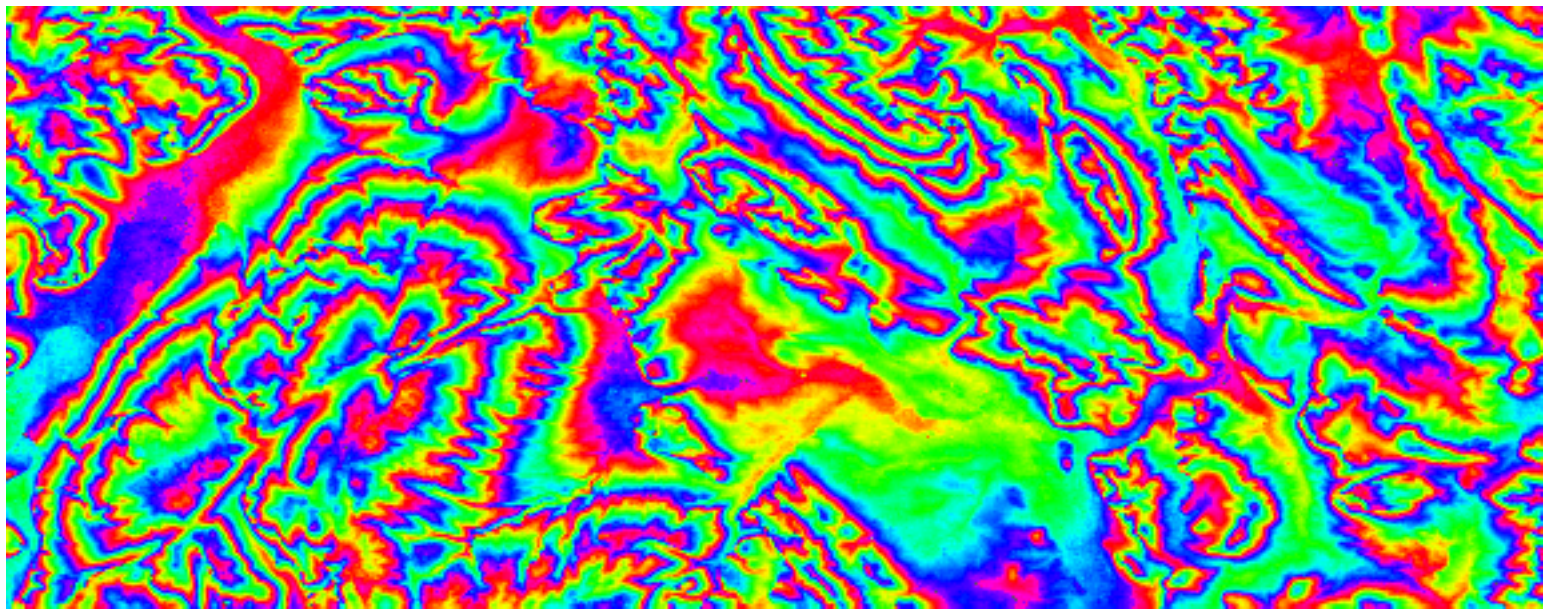
- only applicable to airborne SAR systems
- yaw and pitch cause baseline components in y- and z-direction which produce additional phase differences.
- calibration of the phase difference is necessary before absolute velocity measurements are possible

Repeat-pass interferometry



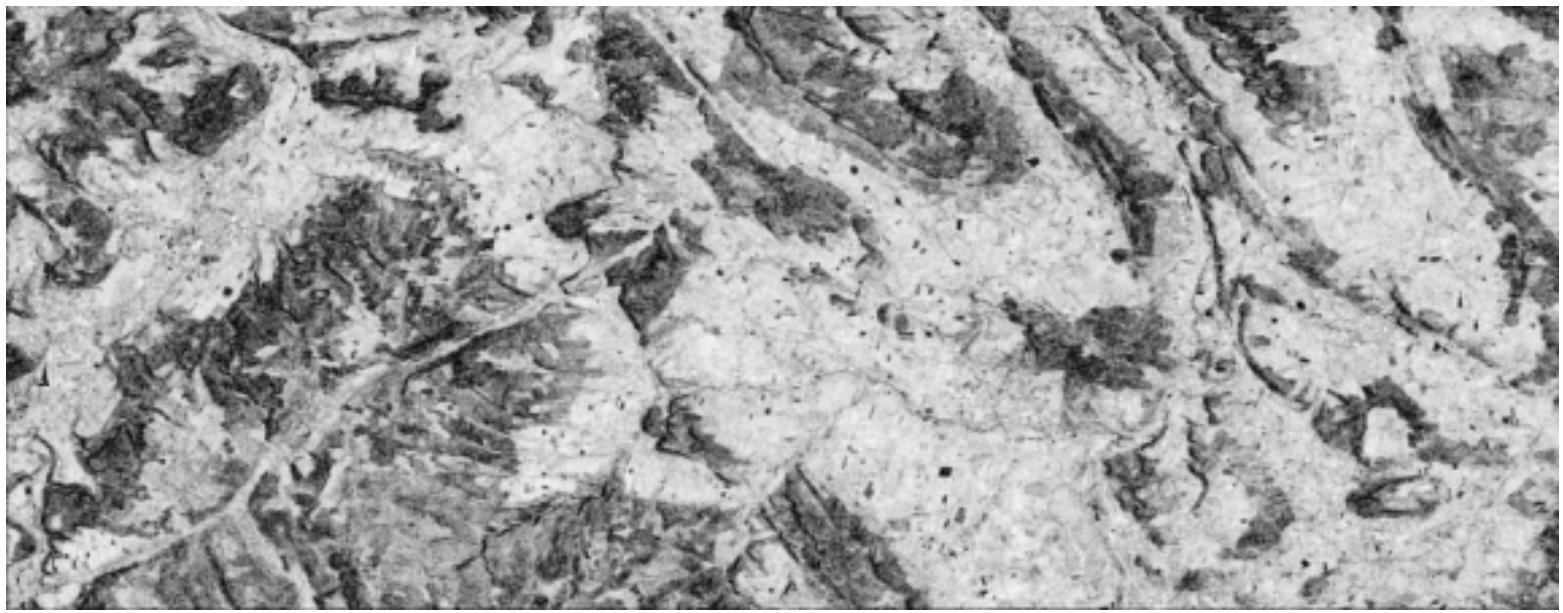
- requires only one antenna
- most suited to spaceborne sensors
- precise location of the flight path is required
- satellite passing nearly the same orbit to cover an area twice with a slightly different viewing geometry.

Interferogram



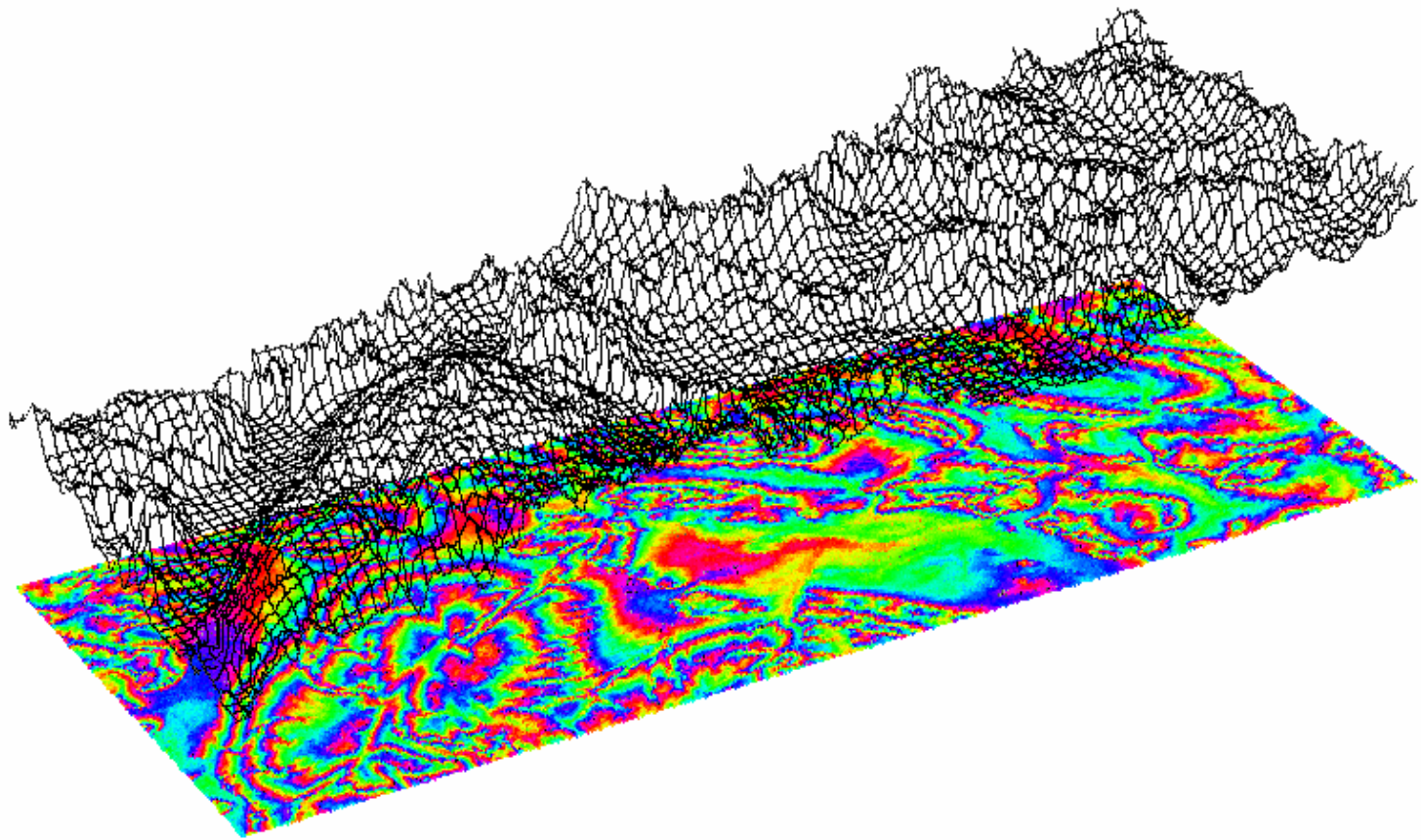
complex multiplication of the two images; i.e. the corresponding amplitudes have to be averaged and the corresponding phases have to be differenced at each point in the image

Coherence image

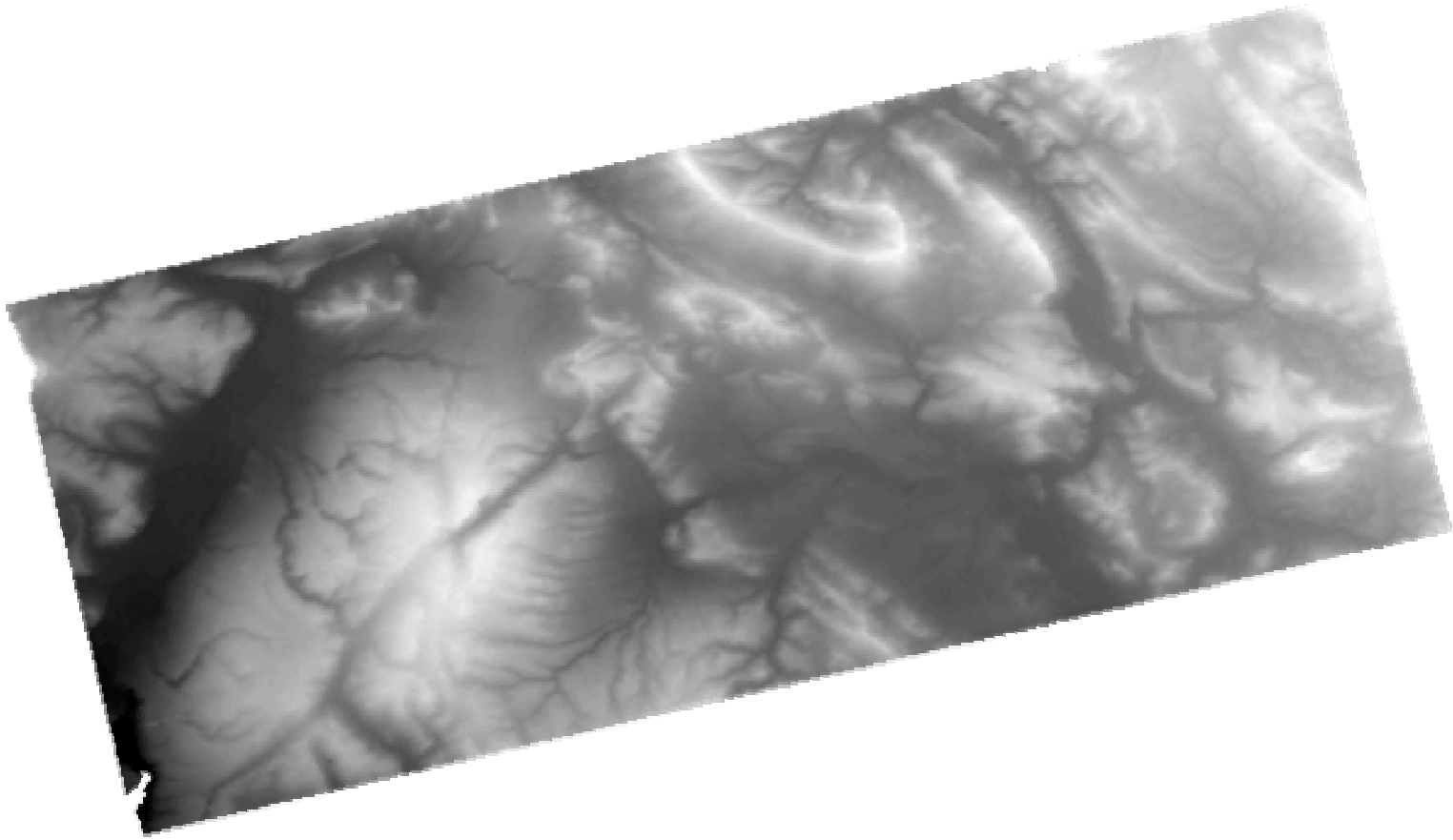


- measure for the correlation of corresponding signals
- ranges from 0 to 1

Digital elevation model



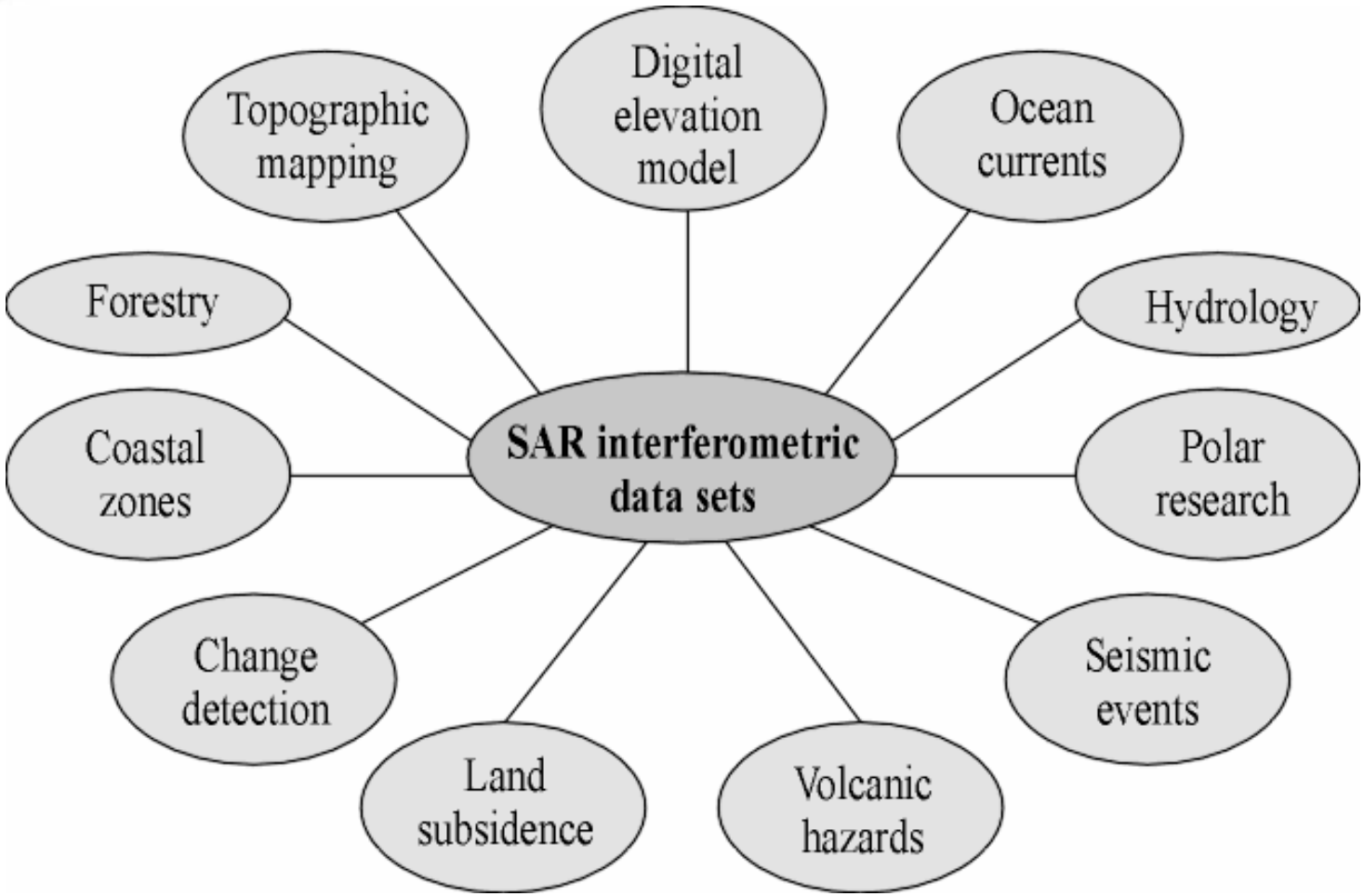
Digital elevation model



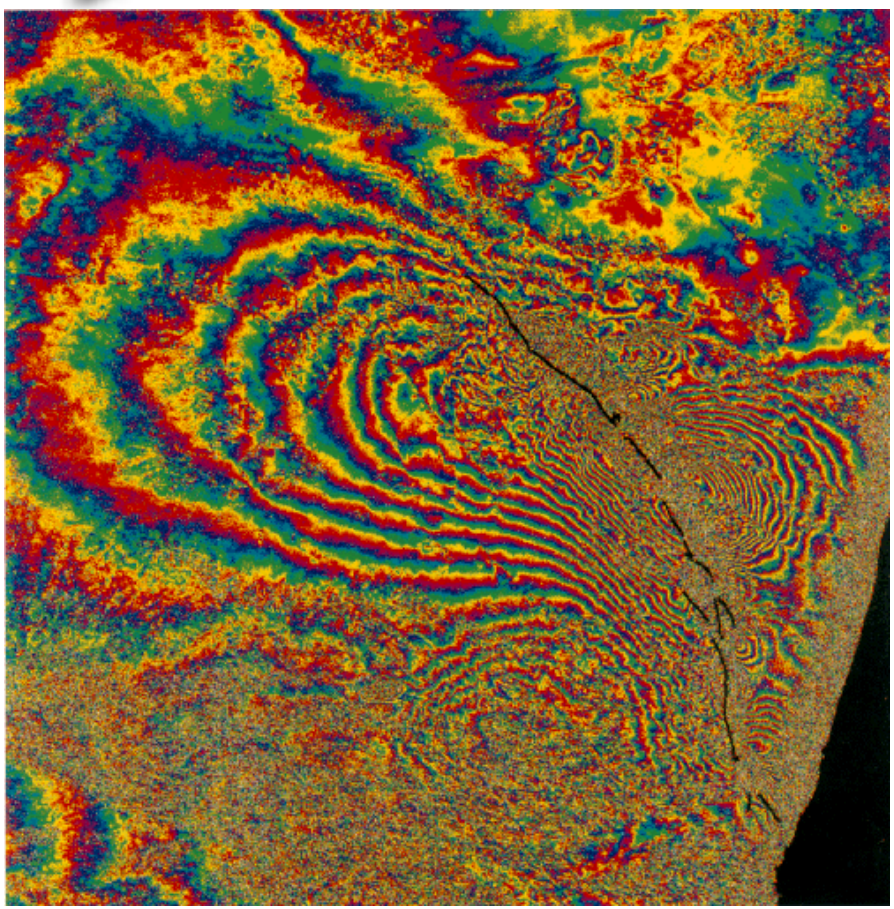
Differential interferogram

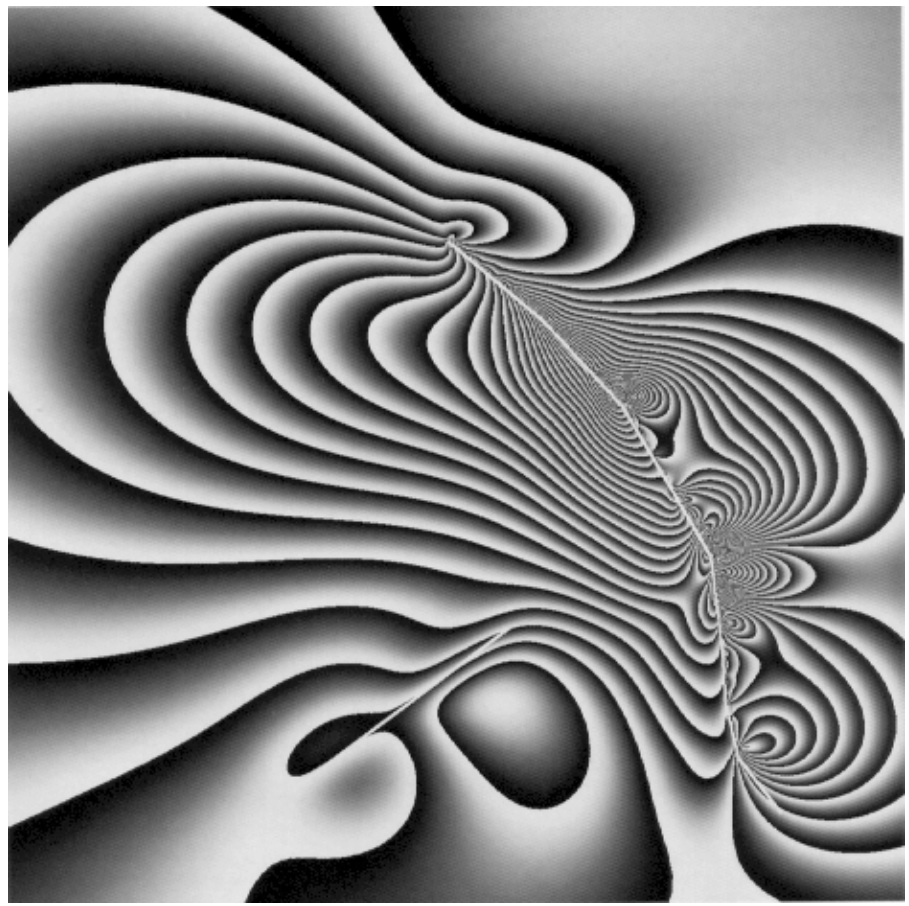
- change detection: measurement of small-scale movements in the vertical direction
- displacement measured is not vertical, but along the viewing direction
- relative accuracy of the order of a few centimetres or even less vs. absolute accuracy of digital elevation models of about 10-15 meters (for ERS data)

Interferometric applications



Seismic events





Source: Massonnet et al. (1993)

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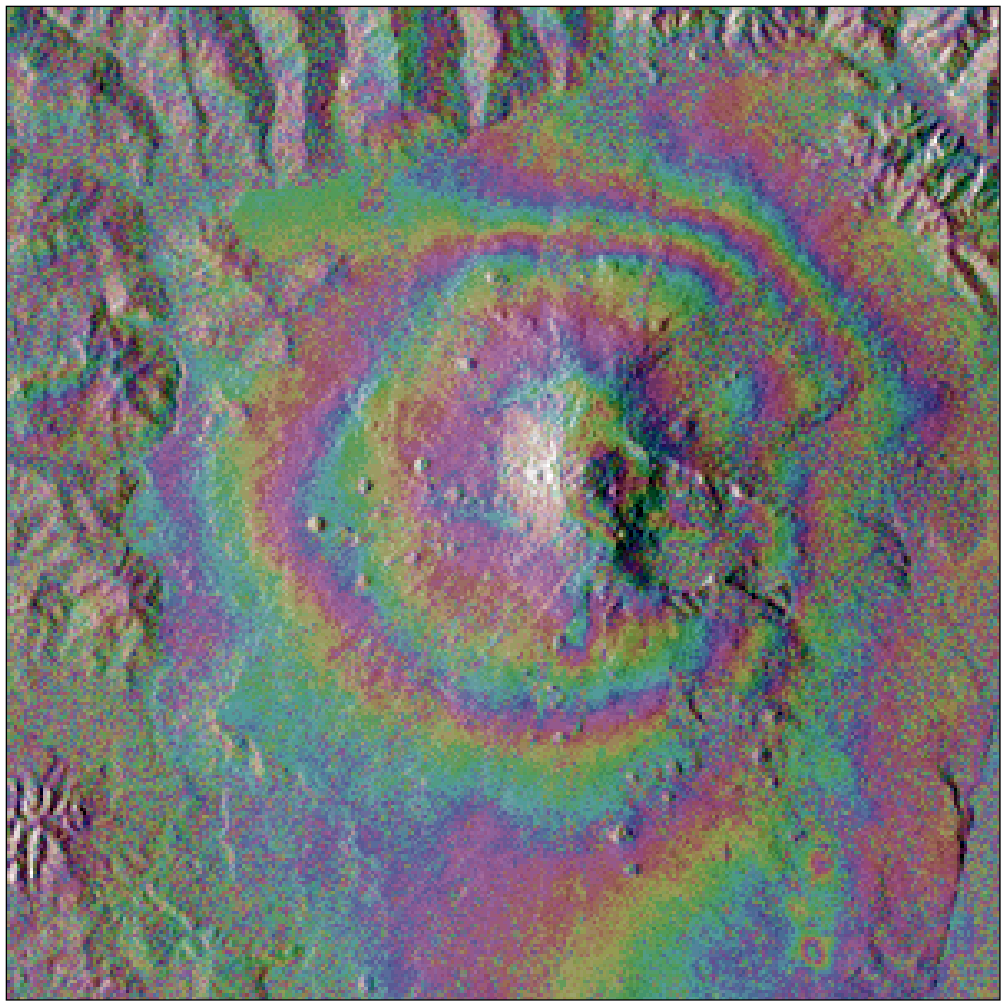
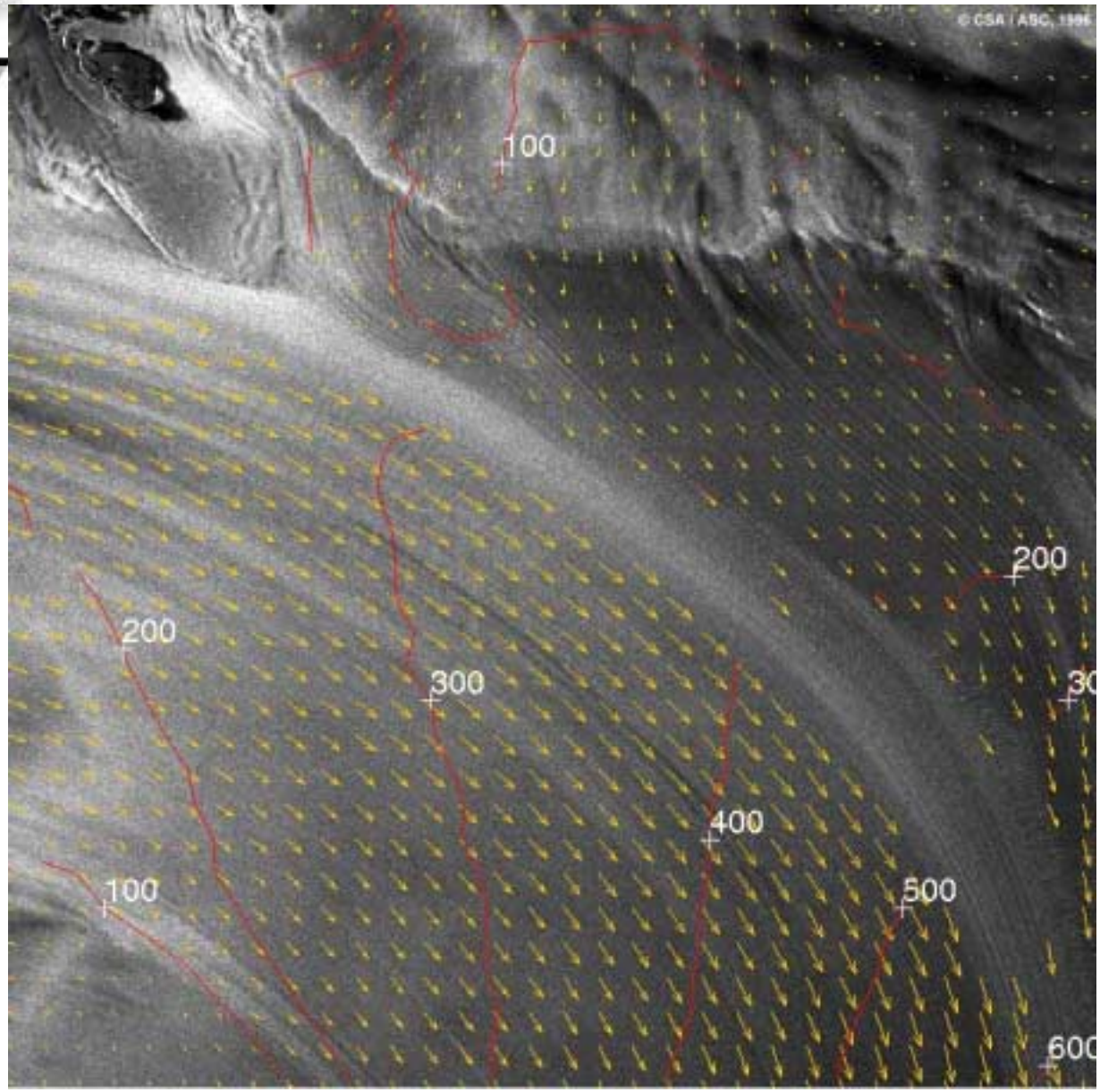
Volcanic hazards



Source: Massonnet (1997)

Glacier research



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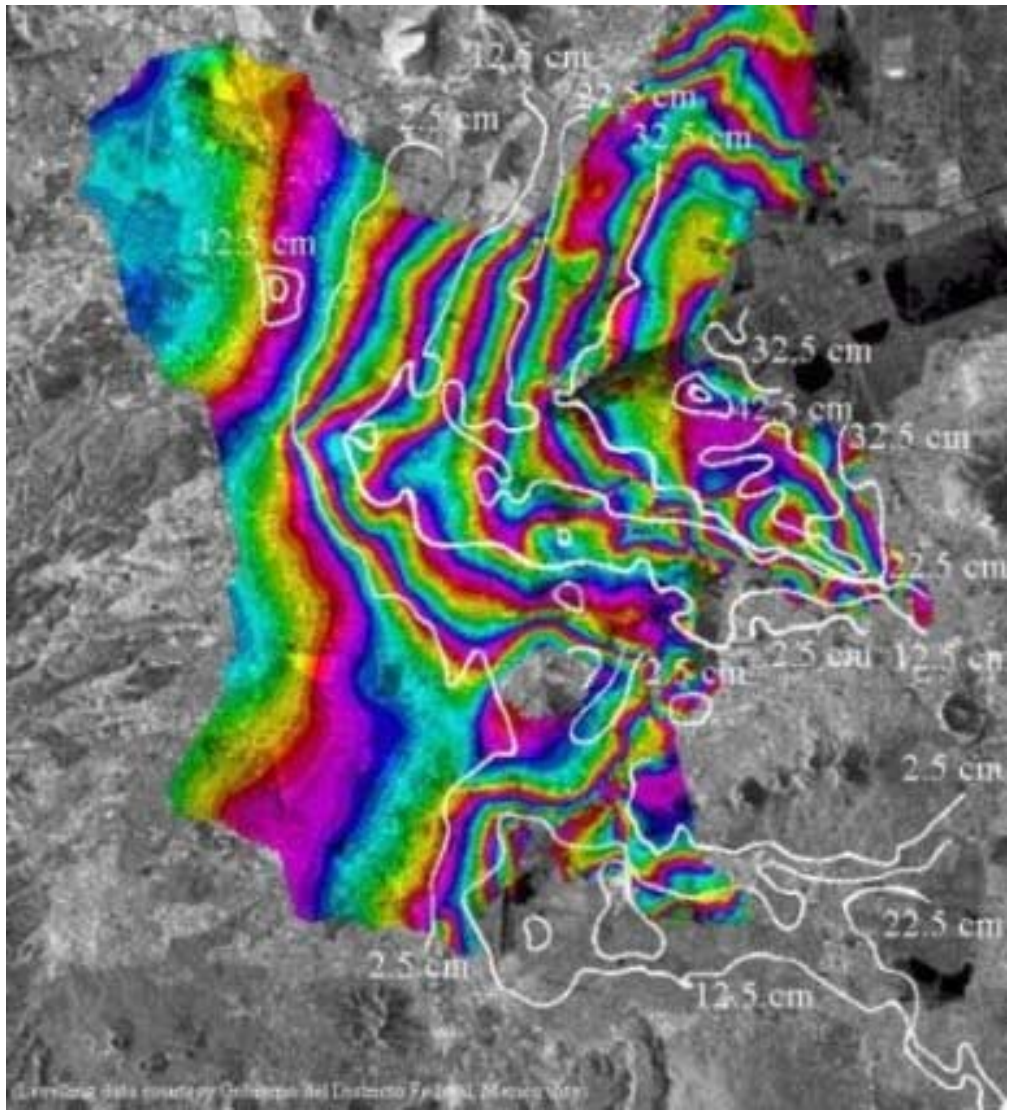
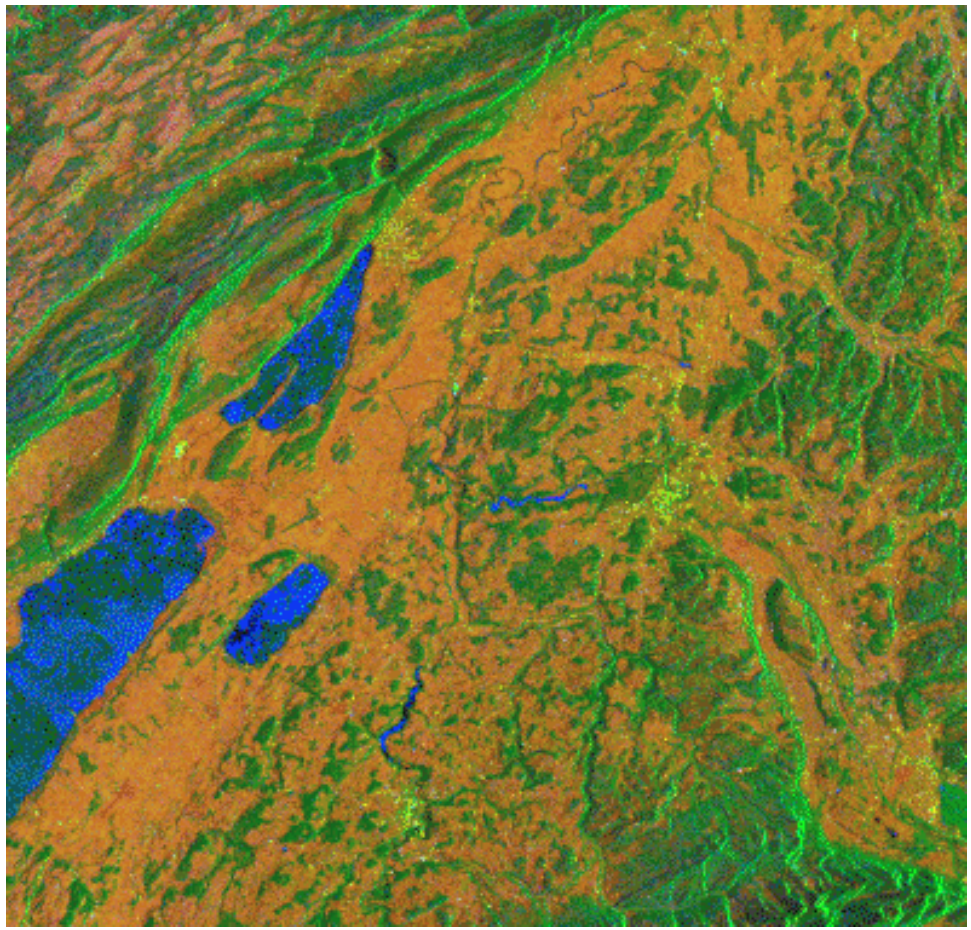
Land subsidence



Source: http://www.gamma-rs.ch/research/mexico.html

Forestry



- interferometric correlation
- backscatter intensity
- backscatter change

Source: Strozzi and Wegmüller (1997)

Error sources

- atmospheric effects
  - maybe most limiting factor for differential InSAR
  - delays signal return
  - can be heterogeneous and very local
    $\rightarrow$ difficult to determine
  - change the tropospheric water vapor content
  - new research field for studying of tropospheric turbulences and ionospheric phenomena

Error sources

- orbits
  - *predicted* vs. *restituted* vs. *precise orbits*
- temporal decorrelation
  - caused by physical changes in the surface over the time period between observations
- baseline decorrelation
  - higher noise level with increasing length of baseline

    $\rightarrow$ decorrelation of radar signal
- processing

Trends and challenges

- Shuttle Radar Topography Mission (SRTM)
  - flown in February 2000
- swath processing
  - data volume
  - Doppler frequency issues
- DEM production for larger areas
  - SRTM
  - AKDEM project

Questions

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