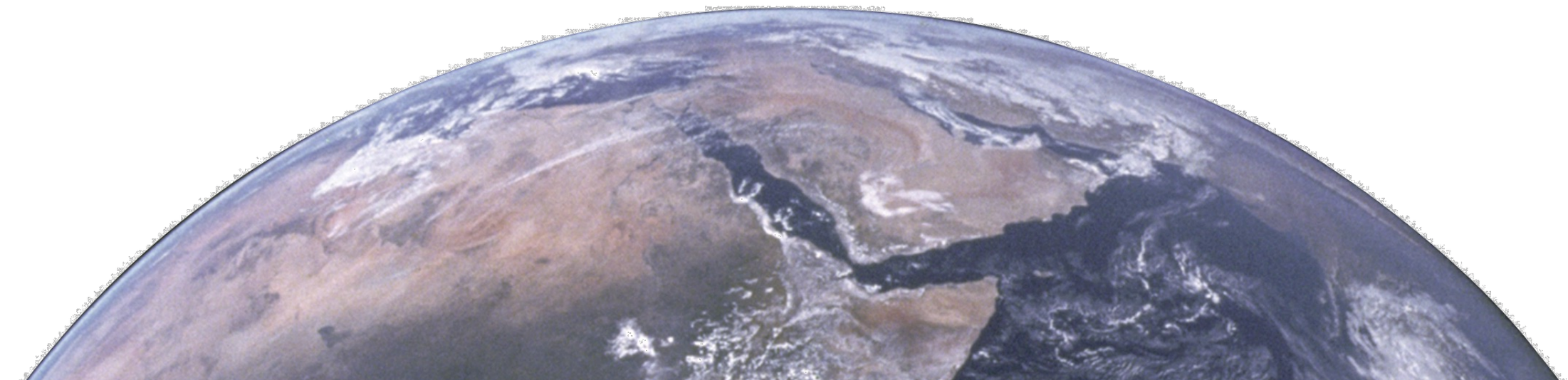
The University of Texas at Austin
Aerospace Engineering
and Engineering Mechanics
Cockrell School of Engineering

Interferogram formation

Ann Chen



InSAR processing steps

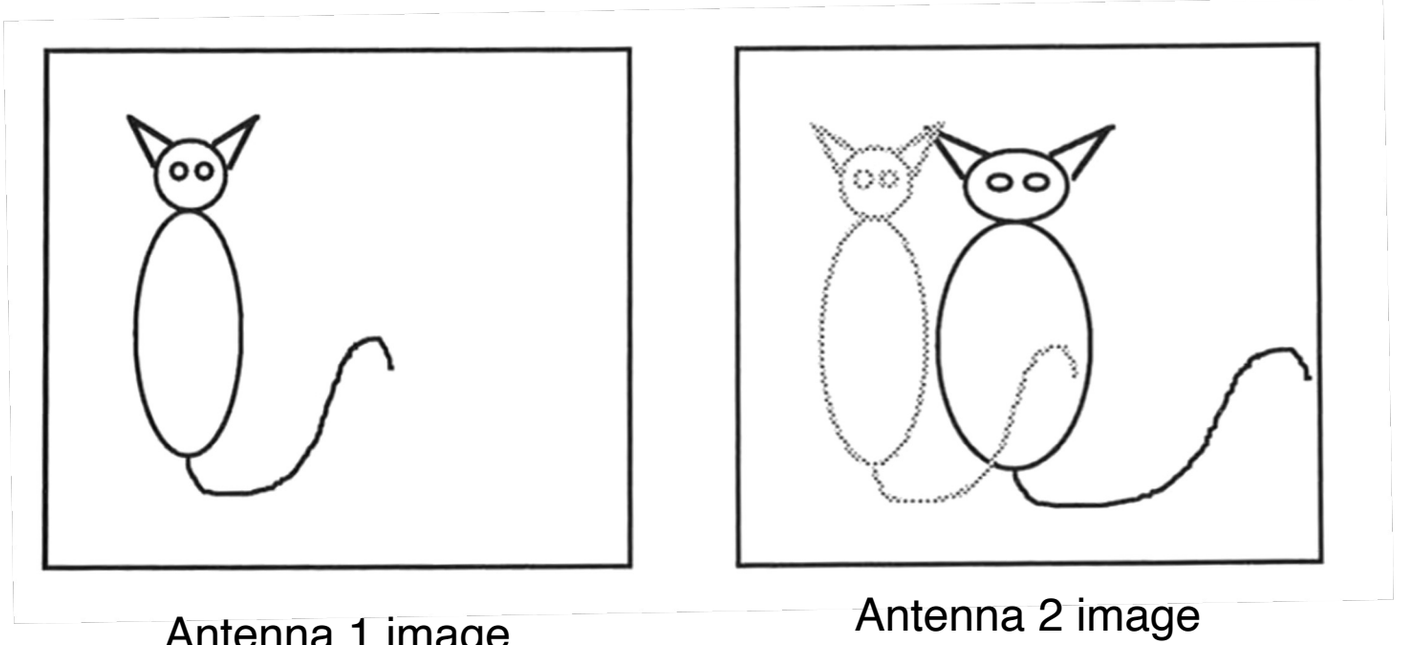
A typical processing chain has multiple steps, although not always in the exactly this order:

1. Matching, or coregistering, the SLCs.
2. Difference the image phases to form the interferogram.
3. Remove the effects of orbit positions and Earth curvature (Flattening).
4. Register the interferogram to a DEM to remove topography.
5. Filter and unwrap the interferogram.

Reference: https://www.cambridge.org/core/books/satellite-radar-interferometry/1F8951EFC610A352837B95E4DAEFBAEB

Image coregistration

- Forming the interferogram means relating the phase of a pixel in image 1 to the phase of the same pixel in image 2. Thus it is necessary to identify each pixel in image2 in terms of its location in image 1 (e.g. using 2D cross correlation techniques or orbit information).



Antenna 1 image

Antenna 2 image
Shifted and stretched

Interferogram formation

- The next step is to resample SAR image 2 to SAR image 1 coordinates using $\delta(dr)$. In addition, if there is an azimuth shift due to timing consideration, we can correct for it at this time as well:

$$image1(x, y) * conj\ (image2(x + \delta, y + azoffset))$$

where the complex conjugate multiplication results in a phase differencing operation as desired.

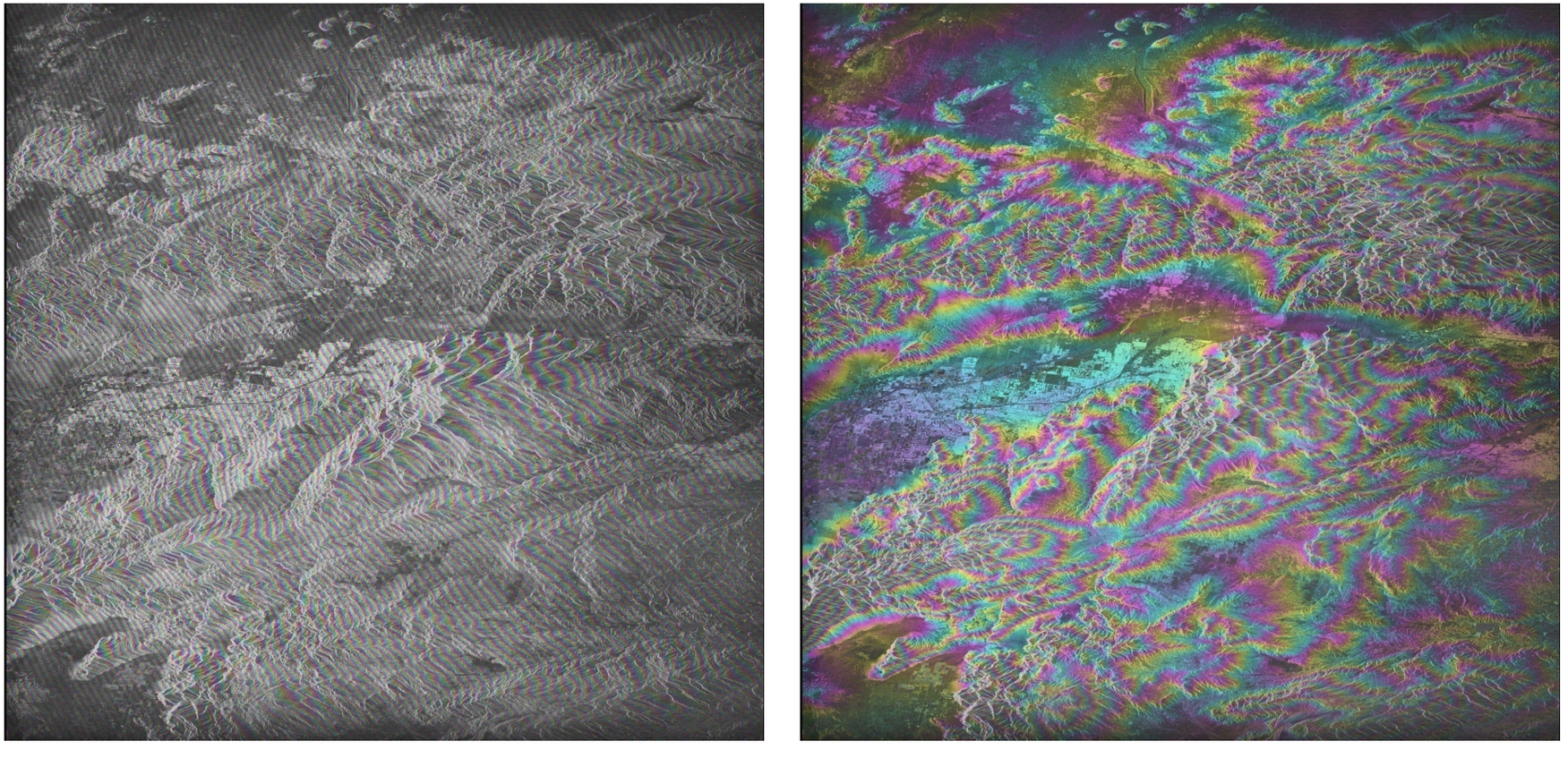
Multi-looking

- Once we generated the interferogram, we often want to multi-look in order to improve our phase estimate accuracy at the expanse of reducing spatial resolution. This also reduces the required data volume for storage.

- For the SAR data, we average signal powers rather than complex values. But for the interferogram, we need to average phase, so we need to average the complex values.

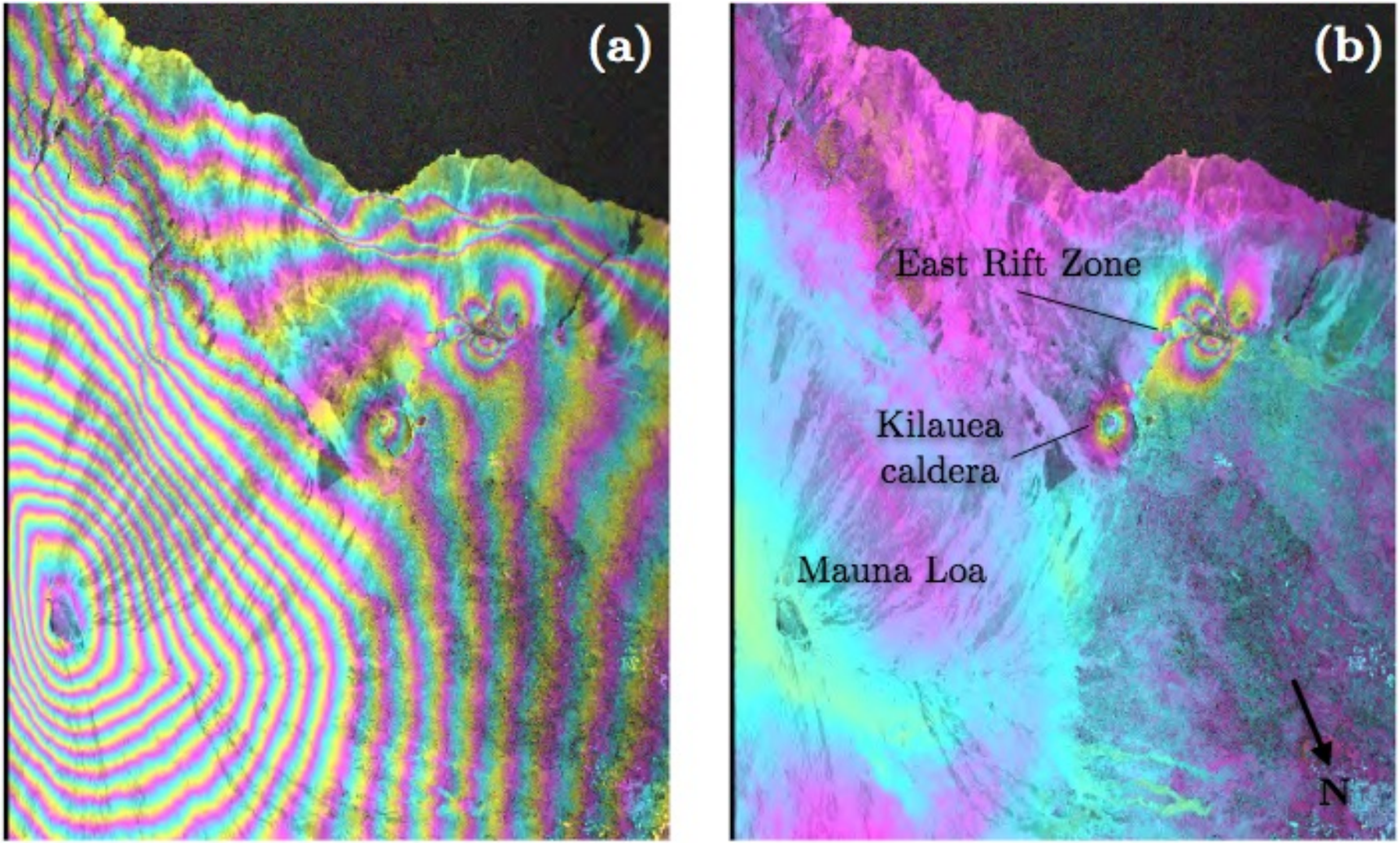
Flattening

Because the satellite is in different orbit positions for the two acquisitions, the distance between satellite and ground will vary across the image.



Before (Left) and After (Right) flattening.

Topographic correction



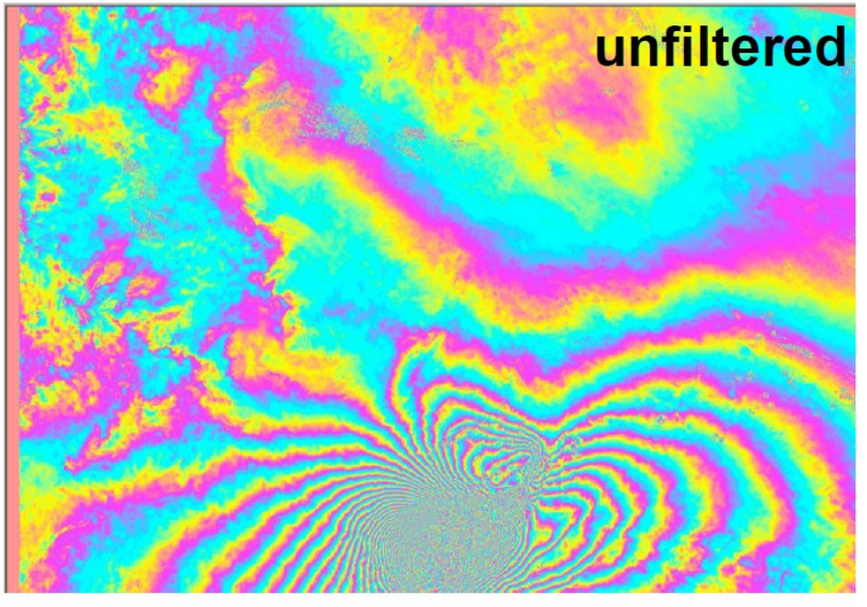
From (a) to (b), topographic phases are estimated and removed based on SRTM data.

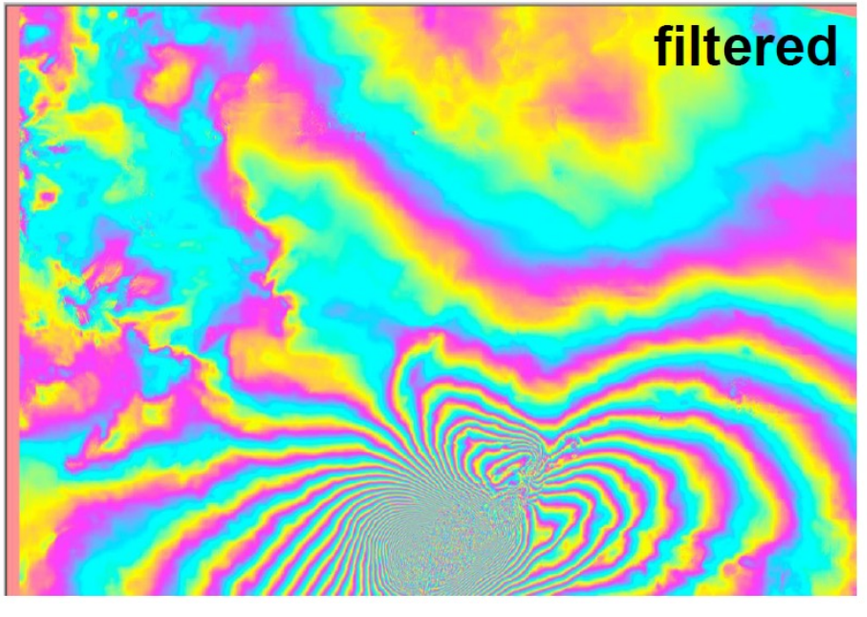
Filtering

- To boost the signal-to-noise ratio, a power spectrum filter is applied that increases the power of the most coherent information in the interferogram.
- Two methods:

  - Static methods involve low-pass filters (Gaussian, boxcar, etc.).

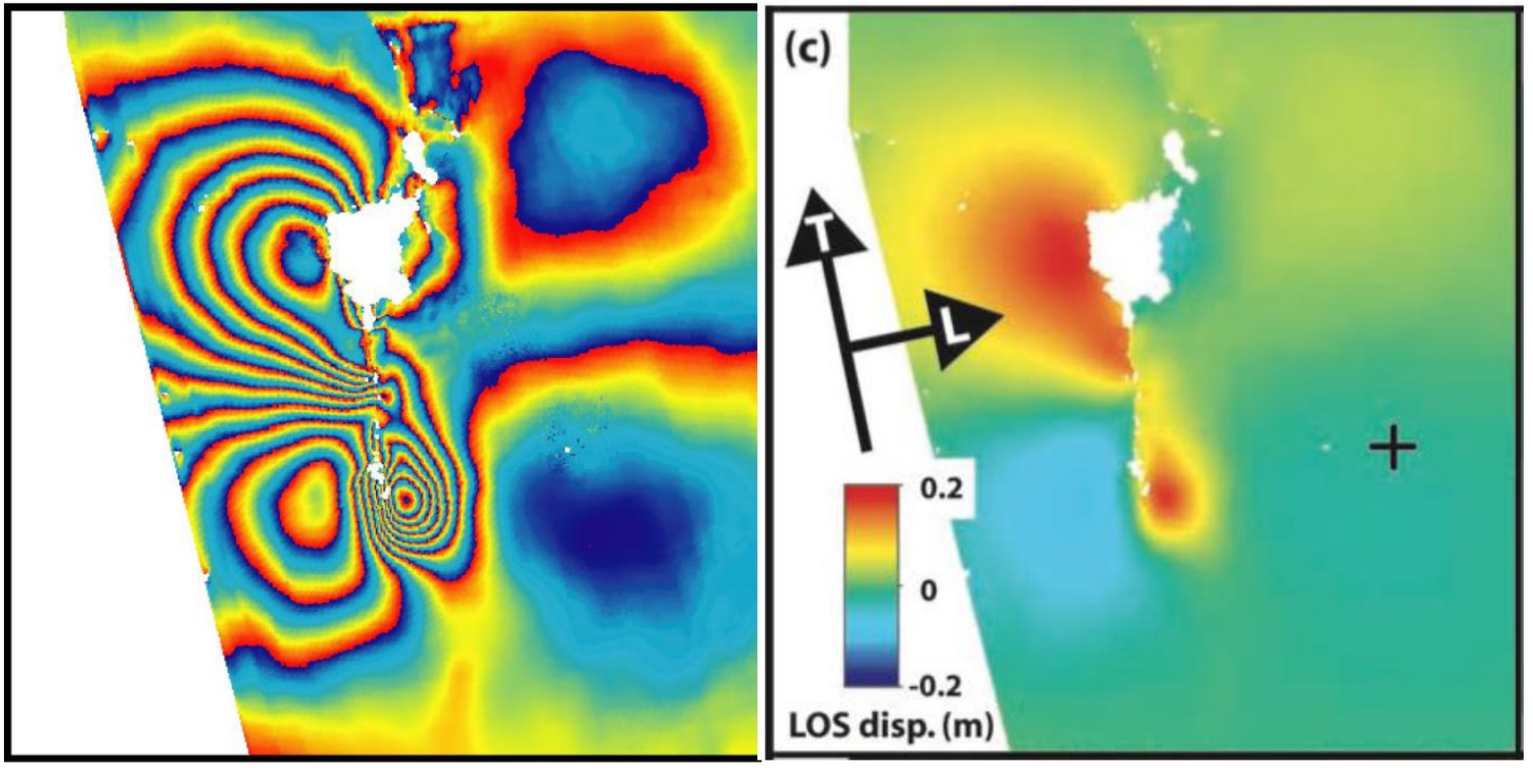
  - Adaptive filters are spectral filters [Goldstein and Werner, 1998].





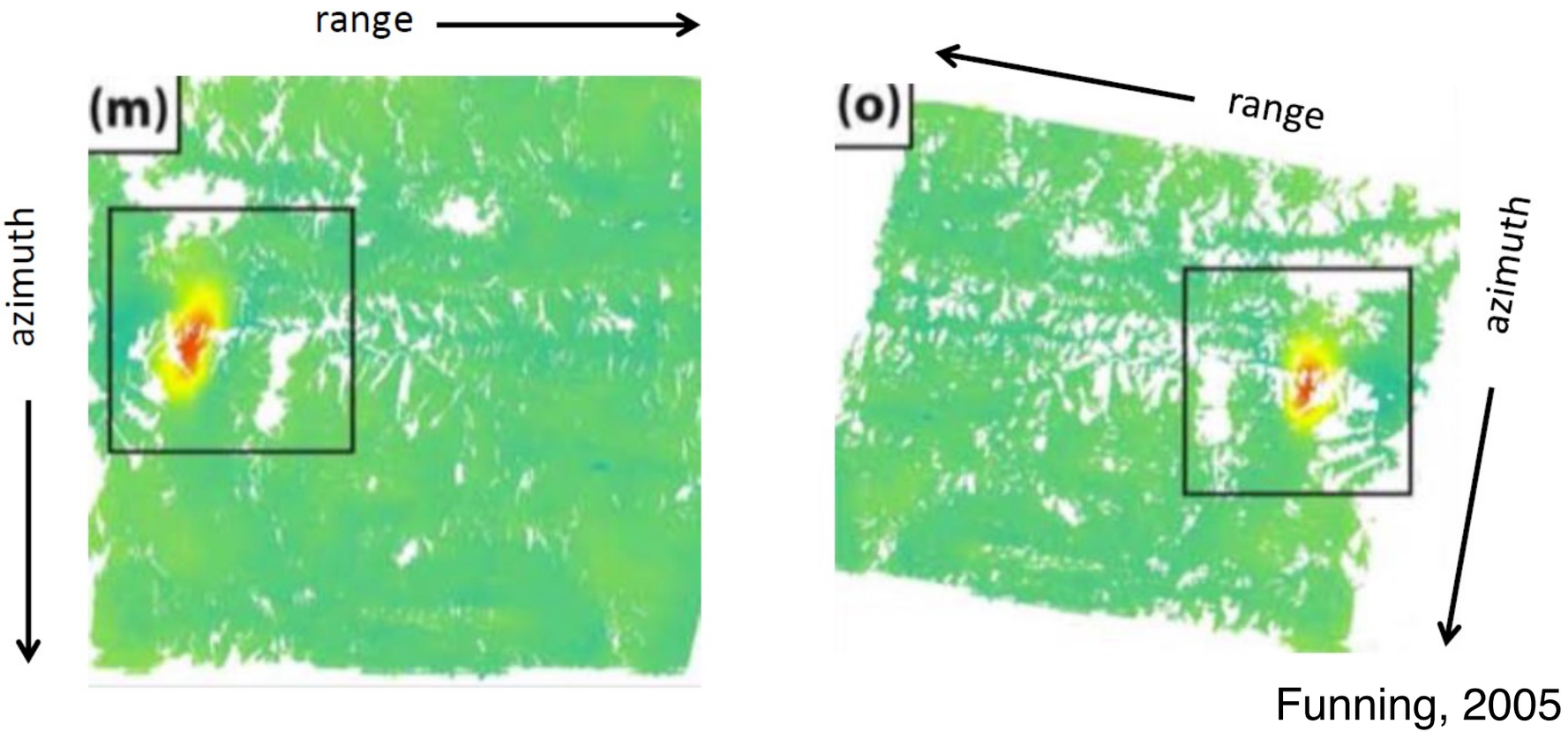
Phase unwrapping

Wrapped **Unwrapped**



- Unwrapping is the process of converting the cyclical (modulo 2π) phase signal from the interferogram into a smooth deformation signal.
- Masking can be done to remove decorrelated areas, prior to unwrapping.

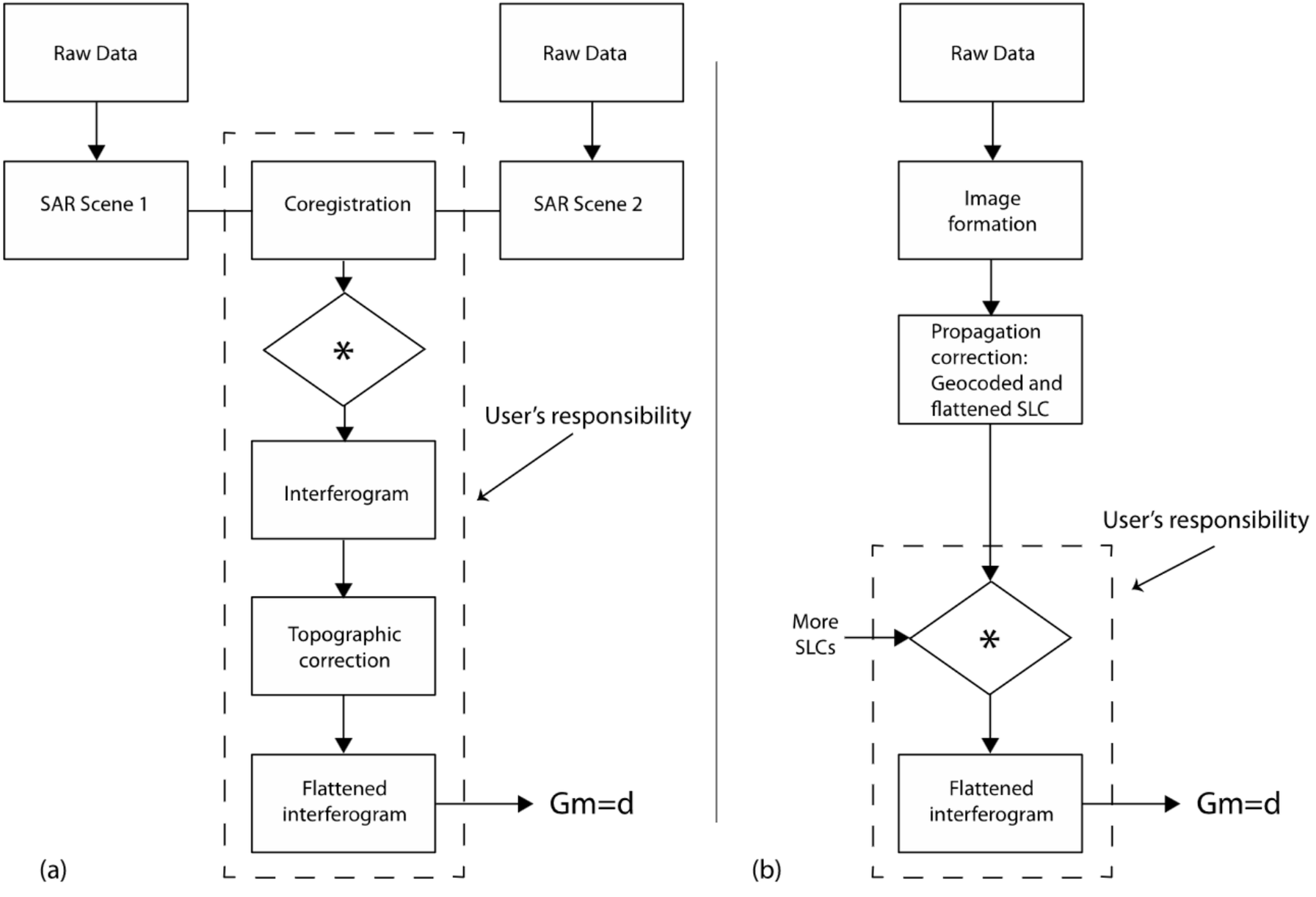
Geocoding



Funning, 2005

Final processing stage, converts the data from radar coordinates (range and azimuth), left, to geographic coordinates, right.

User Friendly InSAR data products



[Zebker, 2017]