Technical Notes on TOPSAR Interferometry with Sentinel-1

1. Introduction to Interferometry

Interferometric Synthetic Aperture Radar (InSAR) is a remote sensing technique that utilizes the phase

difference between two SAR images to extract information about surface topography and displacement.

This is achieved by measuring the phase difference of backscattered radar signals acquired from slightly

different satellite positions.

2. Sentinel-1 IW Mode and TOPSAR

- Sentinel-1 uses Interferometric Wide Swath (IW) mode for land observations.
- IW mode applies Terrain Observation with Progressive Scans SAR (TOPSAR), which electronically

  steers the beam in the azimuth direction for each burst.
- It ensures uniform signal-to-noise ratio (SNR) and eliminates scalloping effects, making it optimal

  for interferometry.

3. Data Preparation

3.1. Downloading Data

- Data can be obtained from the Copernicus Open Access Hub.
- Sentinel-1 Single Look Complex (SLC) products are used for interferometry.
- For processing efficiency, an SSD is recommended for storage.

3.2. Installing Required Software

- The Sentinel-1 Toolbox (S1TBX) in SNAP is used for processing.
- snaphu (Statistical-cost Network-flow Algorithm for Phase Unwrapping) must be installed separately.

4. Processing Steps

4.1. Coregistration

- Aligns the two Sentinel-1 SLC images with sub-pixel accuracy.
- Uses S-1 TOPS Coregistration in SNAP.

- Involves splitting TOPSAR bursts, applying orbit files, and performing back geocoding.

4.2. Interferogram Formation & Coherence Estimation

- An interferogram is generated by multiplying one image with the complex conjugate of the other.
- The phase differences in the interferogram result from:
  - Topographic phase
  - Earth curvature (flat-earth phase)
  - Surface deformation
  - Atmospheric effects
  - Noise

4.3. Debursting and Filtering

- TOPS Deburst removes seamlines between bursts.
- Goldstein Phase Filtering improves the signal-to-noise ratio for better unwrapping results.

4.4. Phase Unwrapping with Snaphu

- Converts phase data from wrapped (modulo 2pi) to continuous values.
- SnaphuExport prepares data for snaphu processing.
- SnaphuUnwrapping performs unwrapping using cost-based algorithms.
- SnaphuImport brings the unwrapped phase data back into SNAP.

4.5. Phase to Displacement Conversion

- Converts phase data into metric surface displacement along the satellite's line of sight (LOS).
- Positive values indicate uplift; negative values indicate subsidence.

4.6. Terrain Correction & Geocoding

- Uses Range Doppler Terrain Correction to correct SAR distortions.
- Ensures displacement maps are georeferenced in a standard projection (e.g., WGS84 or UTM).

4.7. Masking Low Coherence Areas

- Areas with coherence <0.6 are masked to remove unreliable displacement values.

5. Multi-Temporal Analysis

- To improve accuracy and minimize atmospheric effects, multiple interferograms from different

dates can be averaged.

6. Visualization & Export

- Displacement results can be exported as KMZ files for visualization in Google Earth.
- Profile plots allow analysis of displacement trends over specific areas.

7. Applications of Sentinel-1 TOPSAR Interferometry

- Land Subsidence Monitoring
- Seismic Analysis
- Infrastructure Stability Assessment
- Volcanic Activity Monitoring

8. Conclusion

TOPSAR Interferometry with Sentinel-1 enables accurate surface deformation monitoring.
By following systematic processing steps in SNAP and applying phase unwrapping with snaphu, high-quality interferometric results can be obtained for various geospatial applications.