Understanding Interferogram and Coherence in InSAR

1. What is an Interferogram?

An interferogram is an image that represents the phase difference between two Synthetic Aperture Radar (SAR) images taken at different times from slightly different satellite positions. It is used in Interferometric Synthetic Aperture Radar (InSAR) to detect surface movements, terrain elevations, and structural deformations.

Key Concept:

- Phase Difference (phi): Each SAR image records the phase (phi) of the reflected radar signal.
- When two images are combined, their phase difference creates an interferogram.
- The resulting image shows interference patterns ("fringes"), representing small displacements in the Earth's surface.

Applications:

- Earthquake monitoring (detecting ground displacement).
- Land subsidence analysis (due to mining or groundwater extraction).
- Glacier and volcanic activity monitoring.

Example of an Interferogram:

- Bright/Dark Fringes: Represent areas of different phase shifts.
- Closer fringes: Indicate rapid surface deformation.
- Wider fringes: Show slow or minimal displacement.

2. What is Coherence?

Coherence is a measure of how similar two SAR images are in terms of phase stability. It is used to evaluate the quality of interferometric results.

Key Concept:

- Coherence values range from 0 to 1:
  - 1 (High Coherence): The two images are very similar -> Stable terrain (urban areas, dry ground).
  - 0 (Low Coherence): The images are different -> Unstable terrain (vegetation, water, snow).

Factors Affecting Coherence:

- Temporal Decorrelation: Changes in the ground surface (e.g., vegetation growth) reduce coherence.
- Geometric Decorrelation: A large difference in satellite positions decreases coherence.
- Volume Scattering: Objects like forests cause phase randomness, lowering coherence.

Example of a Coherence Map:
- Bright Areas: High coherence (good for interferometry).
- Dark Areas: Low coherence (not suitable for deformation analysis).

3. Relation Between Interferogram & Coherence
- The interferogram provides phase difference information but includes noise.
- The coherence map helps identify areas where the interferogram is reliable.
- Low coherence areas should be masked out to avoid incorrect deformation results.

By understanding both interferograms and coherence, InSAR users can ensure accurate analysis of ground displacement and topographic changes.