



SNAP Microwave Toolbox

GSLC Terrain Correction

Geocoded, phase-preserving InSAR of the 2026 Venezuela earthquake



SkyWatch Space Applications October 2026

Scenario

On **24 June 2026** an earthquake **doublet** struck northern Venezuela: **Mw 7.2 at 18:04:33 local** (22:04:33 UTC), followed just **39 seconds later** by the **Mw 7.5 mainshock at 18:05:11 local** (22:05:11 UTC), on the right-lateral **San Sebastián fault**. To map the coseismic deformation with the **GSLC** (Geocoded SLC) approach we need an interferometric **pair** — one acquisition before the event and one after:

Role	Satellite	Acquisition (local / UTC)	Timing vs mainshock
Reference (pre-event)	Sentinel-1A	23 Jun 2026, 18:50:50 / 22:50:50	~23.2 h before
Secondary (post-event)	Sentinel-1C	24 Jun 2026, 18:49:58 / 22:49:58	~45 min after

***Two products, not three.** GSLC InSAR is ordinary pairwise interferometry: one reference + one secondary = one interferogram, so **two products** are enough. (This is the key difference from the Phase Linking tutorial, whose distributed-scatterer covariance needs ≥ 3 epochs.) The pair is chosen for the event timing, and the timing here is exceptional: S1C acquired the same track (**relative orbit 106** — shared by S1A, S1C and S1D) just **44 minutes 47 seconds after the mainshock**. S1A the evening before + S1C 45 minutes after therefore bracket the event about as tightly as Sentinel-1 permits: an almost purely **coseismic pair** with a **1-day temporal baseline**, which keeps coherence high even over the tropical vegetation of the epicentral region, and which captures the displacement field before any appreciable afterslip has accumulated. (The 30 Jun S1D acquisition makes a good optional **post-seismic pair** against S1C — see the note at the end.)*

Download the two products (free, by name) from the **Copernicus Data Space Ecosystem** (<<https://dataspace.copernicus.eu>>) or **ASF Vertex** (<<https://search.asf.alaska.edu>>) into a working folder. We process polarisation **VV**, subswath **IW3**. The full product names:

```
S1A_IW_SLC__1SDV_20260623T225050_20260623T225120_065103_0834C8_BAD5.SAFE
S1C_IW_SLC__1SDV_20260624T224958_20260624T225025_008254_010515_304A.SAFE
```

The pair brackets the earthquake by about a day before and 45 minutes after, so the interferometric phase carries essentially pure coseismic ground displacement, with only the first ~45 minutes of afterslip included. Much of the affected terrain is rural; GSLC's phase-preserving geocoding puts both scenes on a common map grid so the deformation fringes can be formed and interpreted directly.

***Where the scene sits relative to the rupture.** Read from the interferogram's own geocoding, the scene spans **lon -69.206 ... -68.156, lat 9.619 ... 11.443** (≈ 115 km E–W $\times$ 202 km N–S). The doublet's epicentre (**10.435° N, 68.472° W**) therefore falls **inside** the scene — about 34 km from the eastern edge and 80 km from the western one — so the epicentral zone is imaged directly. The rupture extends ~200 km along the San Sebastián fault, so it does run out of the scene to the east; the eastern part of the fault is not covered. Published finite-fault models (USGS, INGV, Peking University) put maximum slip at 3.6–4.5 m.*

What you will do

1. Generate the **reference GSLC** from S1A (IW3 / VV) — a phase-preserving, geocoded complex image, optionally **ETAD-corrected** first.
2. Feed the **raw secondary** (S1C) together with the reference GSLC to **`CreateStack`**, which auto-coregisters it onto the reference grid.
3. Form the **interferogram** (removing flat-earth **and** topographic phase) and filter it.
4. **Unwrap** with SNAPHU and convert to a coseismic displacement map — already geocoded, so no terrain correction is needed afterwards.

You will do it in the **SNAP Desktop** GUI and with `gpt` on the command line.

Why use it

Traditional terrain correction geocodes amplitude and discards phase, so the classical InSAR chain stays in slant range through a long pipeline (Back-Geocoding → ESD → Interferogram → Deburst → Merge → Terrain-Correction) and geocodes last. **GSLC geocodes up front, preserving phase**, so each acquisition becomes a phase-preserving complex product on a **common map grid**. It is the "geocode-first" architecture behind global-scale InSAR systems (NISAR GSLC, OPERA CSLC-S1).

What that buys you in practice:

	Classical chain	GSLC chain
Steps to a geocoded interferogram	Back-Geocoding → ESD → Interferogram → Deburst → Merge → Terrain-Correction	GSLC → CreateStack → Interferogram — already on the map
Unit of processing	the <i>pair</i> : every new pair re-runs coregistration in radar geometry	the <i>acquisition</i> : each scene is geocoded once, independently and in parallel, and reused in every pair it joins
Adding a new date to a stack	re-coregister against the reference	geocode the new scene onto the same standard grid — existing products are untouched
Combining overlapping scenes	tied to one radar geometry	every product with the same grid step is snapped to the same global lattice, so overlapping scenes line up on whole pixels
Wrapped phase resampled after filtering?	yes, by the final Terrain-Correction	never — the interferogram is born on the map grid
Downstream use	radar-geometry rasters need geocoding before GIS/ML	a GIS-ready complex raster, directly usable for time series, change detection and ML

It gives the same answer as the classical chain. Measured on three sites against a classical control processed from the same SLCs (see *How does it compare to the traditional chain?*): wrapped-phase agreement **0.92** raw and **0.96** after removing one fitted plane on Sentinel-1 TOPS (Venezuela); on Sentinel-1 stripmap (Napa) the two independently unwrapped displacement maps agree to a **median of 0.05 cm**. At Campi Flegrei both chains were also scored against a **published** P-SBAS time series: they match it comparably (identical over 72 days; classical slightly closer over one year) and are level at fine scale.

Prerequisites

- **SNAP 14+** with the SNAP Microwave Toolbox. Confirm the operator:

```
gpt GSLC-Terrain-Correction -h
```

- The two Sentinel-1 SLC products above, downloaded to a working folder. SNAP reads either the unzipped `.SAFE` folder or the `.zip` directly.
- **Sentinel-1 IW** input must be a **single subswath from 'TOPSAR-Split'** (burst-level). **Deburst** TOPS is **rejected**; **GRD** has no phase and is not usable. (Stripmap SLC — e.g. S-1 SM, ENVISAT ASAR IMS — is a direct input after `Apply-Orbit-File`.)
- Internet access for auto-downloaded precise orbits and the **Copernicus 30 m DEM**.

Part A — SNAP Desktop (GUI)

A1. Generate the reference GSLC (S1A, IW3 / VV)

1. **Prepare the input.** *File* ▶ *Open Product...* the S1A .SAFE, then **Radar** ▶ **Apply Orbit File**, then **Radar** ▶ **Sentinel-1 TOPS** ▶ **S-1 TOPS Split** and select **IW3 + VV**.
2. **(Optional but recommended) Apply ETAD.** Menu **Radar** ▶ **Sentinel-1 TOPS** ▶ **S-1 ETAD Correction**, with the split product as source. See *A1b* below — do this **before** geocoding.
3. **Launch GSLC.** Menu **Radar** ▶ **Geometric** ▶ **Terrain Correction** ▶ **Geocoded SLC Terrain Correction** (dialog title "*GSLC Terrain Correction*").
4. **I/O Parameters tab.** Source = the orbit-applied, split (and optionally ETAD-corrected) S1A product; target name gets suffix _GSLC; keep BEAM-DIMAP.
5. **Processing Parameters tab.** The fields that matter:

Field	Default	Notes
Digital Elevation Model	Copernicus 30m Global	Auto-download; or point <i>External DEM</i> at a local file
Image Resampling Method	BiSinc 5-point	Keep a sinc kernel for InSAR phase fidelity
Grid Spacing	NATIVE_ANISOTROPIC	How the grid step is chosen when Pixel Spacing is 0. NATIVE_ANISOTROPIC (default): rectangular cells at the native sampling step of each axis (S1 IW: slant-range step east, ~14 m azimuth step north). SQUARE_COARSEST : square cells at the coarser axis (~14 m for S1 IW) — smallest output, discards ~4× of range detail. SQUARE_FINEST : square at the finer axis, ~16× the pixels of SQUARE_COARSEST. Use the same setting for every product in a stack — each choice is a different lattice. For a north step finer than native azimuth (see the next row), set the pixel spacings explicitly
Pixel Spacing (m / deg)	0 (auto)	Set explicitly to lock resolution across the pair; becomes the east step when a north spacing is also set
Pixel Spacing North (m / deg)	0 (square)	Optional rectangular cells to preserve the SLC's anisotropic native resolution (S1 IW ≈ 3.4 m ground range × 14 m azimuth → set ≈ 3.4 m east × 7.5 m north; the north step must be finer than native azimuth because the orbit heading rotates the radar axes from the map axes). Leave 0 for square cells
Map Projection	WGS84(DD)	Any WKT CRS; use UTM for a metric grid
Output phase-flattened complex data	false	Leave false for InSAR. True only for amplitude/PolSAR

		single-date use
Restore TOPS azimuth carrier	false	Leave false. The carrier is acquisition-specific and does not cancel between acquisitions — restoring it corrupts cross-acquisition InSAR (~tens of spurious fringes per burst)
Output separable phase terms	✓ on (default)	Writes the removed deramp model as an <code>azimuthCarrierPhase</code> band (and the flattening phase). The Interferogram step then subtracts the two acquisitions' models exactly (their difference is the main reason a raw cross-acquisition GSLC interferogram shows extra fringes). The two phase bands are 64-bit, so they add about twice the size of the i/q data (~3× the product in total) — turn off only for pure backscatter work
Apply Solid Earth Tide / Tropospheric	off	Turn on for displacement-grade (sub-decimetre) InSAR

6. **Run.** The `S1A...GSLC` product is a phase-preserving complex image on the map grid.

A1b. ETAD correction (optional, recommended for displacement work)

ETAD supplies per-pixel range and azimuth timing corrections — tropospheric and ionospheric path delay, solid-Earth geodetic effects, bistatic and FM-mismatch azimuth shifts. It moves geolocation by centimetres to decimetres, which is small in amplitude terms but not in phase terms: one C-band range fringe is 2.77 cm.

Open **Radar** ► **Sentinel-1 TOPS** ► **S-1 ETAD Correction** with the **split** product as source (before GSLC — the corrections are defined in radar timing and must be applied in radar geometry).

Field	Setting	Notes
ETAD product	<i>(leave empty)</i>	Found and downloaded automatically (the search picks the candidate with maximum time overlap , so an adjacent slice of the same datatake is no longer selected by mistake). Requires Copernicus Data Space credentials stored in SNAP — see the note below. Browse to a local <code>S1*_ETA_*.SAFE</code> to override — it must be the same mission, date and slice as the input
Resampling Type	BiSinc 5-point	Match the kernel used for GSLC
Resampling Image	✓ on — required for GSLC	Off switches to the classical InSAR mode: the corrections are only <i>attached</i> as grids that the classical slant-range chain consumes downstream. A

		GSLC chain can never read those grids, so "off" is a silent no-op for this tutorial (measured: bit-identical output)
Output Phase Corrections	✓ ON for InSAR (default off)	Essential. See the note below — without it the atmospheric delay stays in the phase
Sum Of Range Corrections	✓ on (default)	The total range correction — tropospheric and ionospheric delay included
Sum Of Azimuth Corrections	✓ on (default)	The total azimuth correction
Individual layers (Tropospheric / Ionospheric / Geodetic / Doppler / Bistatic / FM Mismatch)	all off (default)	Only for isolating one contribution when studying it

Tick *Output Phase Corrections* — *resampling alone does not correct InSAR phase. An atmospheric delay Δr does two things: it makes the target appear at range $R + \Delta r$, and it adds $-4\pi\Delta r/\lambda$ to the phase the pixel carries. Resampling the image moves the pixel back to R but leaves that phase untouched, so the differential term survives into the interferogram in full. With Output Phase Corrections on, the range-delay phase is removed from the complex samples themselves, which is what you want for a geocoded chain — the correction is then baked in before geocoding and carried through automatically.*

This matters specifically for GSLC: InterferogramOp's ETAD handling runs only on the classical (slant-range) paths, so a geocoded stack cannot subtract ETAD grids downstream. The correction has to be applied to the complex data up front.

The defaults are not "no corrections". The two Sum Of... boxes are ticked by default and already contain the total correction. The seven individual checkboxes are unticked, which does **not** mean nothing is applied — they select a subset, and you would tick one only after unticking the sums.

Credentials for auto-download. The search authenticates against the Copernicus Data Space. Set them once under **Tools** ▶ **Options** ▶ **General** ▶ **Credentials** (the same ones the Product Library uses). Without them the operator reports *ETAD product not found* even when a product exists.

Keep the original product name. ETAD matches the SAR product to the ETAD product using the sensing start/stop timestamps in the product name. Renaming an intermediate to something short (*my_subset*) breaks the match; appending a suffix is fine — *S1A_IW_SLC__1SDV_20260623T225050_..._split* works.

"The selected ETAD product does not match the source product." The message prints both sensing windows — read them. The usual cause is the **adjacent slice** of the same datatake (same mission, same date, same orbit, but a window ~25 s off that only overlaps your scene by a couple of seconds) or a cross-date/cross-mission pick. Select the ETAD file whose window contains your scene's.

Apply to both acquisitions, or to neither. A stack mixing an ETAD-corrected reference with an uncorrected secondary puts the differential timing correction straight into the interferometric phase. Since *CreateStack* rebuilds a raw secondary from the reference's settings, the clean way to use ETAD is to correct and geocode **both** legs yourself, then stack two GSLCs.

Do not combine with GSLC's own tropospheric option. ETAD's tropospheric layer and GSLC's *Apply Tropospheric Correction* model the same delay — enabling both double-counts it. ETAD is

the measured estimate and is preferred where a product exists; the same applies to ETAD's geodetic layers versus Apply Solid Earth Tide.

A2. Build the coseismic interferogram (reference GSLC + raw secondary)

You only geocode the **reference** explicitly; CreateStack auto-coregisters the raw secondary.

1. **Prepare the secondary.** Apply-Orbit-File + TOPSAR-Split (**IW3, VV**) to **S1C**, but **do not** run GSLC on it.
2. **Create Stack** — Radar ▸ Coregistration ▸ Stack Tools ▸ Create Stack: add the **reference GSLC** (S1A) and the **raw split secondary** (S1C). CreateStack reads the reference's `gslc_source_slc_path` stamp, cross-correlates against the secondary to estimate the (Δ range, Δ azimuth) bias, rebuilds the secondary GSLC with that bias, and stacks the two on the reference grid.
3. **Interferogram Formation** — Radar ▸ Interferometric ▸ Products ▸ Interferogram Formation. In *Processing Parameters*:
 - Keep **Subtract flat-earth phase** ticked.
 - **✓ Tick "Subtract topographic phase"**. This simulates the topographic fringes from the DEM and removes them, so the interferogram shows **deformation + residual atmosphere** rather than topography — essential for reading the coseismic signal.
 - **There is no "Subtract Residual Ramp" checkbox any more.** Earlier drafts of this tutorial told you to tick it, because cross-acquisition GSLC interferograms showed a large smooth per-burst residual. That residual was a **bug**, not the annotations: the carrier-difference add-back had the wrong sign, leaving $2 \times (m_{ref} - m_{sec})$ in every GSLC TOPS interferogram. With the sign corrected, the same Venezuela pair agrees with the classical chain at a phase concentration of **0.96**, against **0.33** with the ramp estimator enabled — it was removing real signal. The data-driven ramp family has been removed (microwave-toolbox/docs/gslc-parity/etna-ramp-ab.md (<https://github.com/senbox-org/microwave-toolbox/blob/master/docs/gslc-parity/etna-ramp-ab.md>)). What runs automatically, and is what was doing the work all along: when both GSLCs carry the azimuthCarrierPhase band (*Output separable phase terms* in A1, on by default), the operator subtracts the two deramp models' **exact difference**. Watch the log for `GSLC carrier-difference: exact deramp-model subtraction active` — that is the line you want to see.
 - Keep **Include coherence** ticked, and set **Coherence Window (m)** to **100**. A window in metres is square on the ground in both geometries, so GSLC and radar-geometry coherence are directly comparable; a window in pixels means something different on a map grid than on an SLC.
4. **Goldstein Phase Filtering** → **SnaphuExport** → **SNAPHU** → **SnaphuImport** (unwrap) → **Phase to Displacement** (line-of-sight displacement in metres).

Because the GSLC pair is **already geocoded**, the displacement map is already in map coordinates — **no final Range-Doppler Terrain Correction is needed** (one fewer step than the traditional chain).

***Consistency rule:** reference and secondary must share the **same Output phase-flattened setting**, the same **Restore TOPS azimuth carrier setting** (leave it off — restoring the carrier corrupts cross-acquisition interferograms with tens of spurious fringes per burst), and the same **'Output separable phase terms' setting** (the exact model subtraction needs the band on both legs; with only one it logs a warning and applies no cross-acquisition correction at all). Mixing the first two conventions yields a meaningless (noise) interferogram. The CreateStack auto-coregister path enforces all three from the reference's metadata stamps and bands.*

Part B — Command line (gpt)

Run these from your working folder; the graphs take the input products as parameters, so no paths are hard-coded.

Step 1 — generate the reference GSLC (S1A)

Save as `gslc_reference.xml`:

```
<graph id="GSLC-Reference">
  <version>1.0</version>
  <node id="Read"><operator>Read</operator><sources/>
    <parameters><file>${s1a}</file></parameters>
  </node>
  <node id="Apply-Orbit-File"><operator>Apply-Orbit-File</operator>
    <sources><sourceProduct refid="Read"/></sources>
    <parameters><orbitType>Sentinel Precise (Auto
Download)</orbitType><continueOnFail>>false</continueOnFail></parameters>
  </node>
  <node id="TOPSAR-Split"><operator>TOPSAR-Split</operator>
    <sources><sourceProduct refid="Apply-Orbit-File"/></sources>

<parameters><subswath>IW3</subswath><selectedPolarisations>VV</selectedPolarisations></param
eters>
</node>
<node id="GSLC-Terrain-Correction"><operator>GSLC-Terrain-Correction</operator>
  <sources><sourceProduct refid="TOPSAR-Split"/></sources>
  <parameters>
    <demName>Copernicus 30m Global DEM</demName>
    <imgResamplingMethod>BISINC_5_POINT_INTERPOLATION</imgResamplingMethod>
    <pixelSpacingInMeter>0</pixelSpacingInMeter>
    <mapProjection>WGS84(DD)</mapProjection>
    <outputFlattened>>false</outputFlattened>
    <!-- writes the removed deramp model as a band; Interferogram then subtracts the two
        acquisitions' models exactly. Default true; shown for clarity -->
    <outputPhaseTerms>true</outputPhaseTerms>
    <applySolidEarthTide>>false</applySolidEarthTide>
    <applyTroposphericCorrection>>false</applyTroposphericCorrection>
  </parameters>
</node>
<node id="Write"><operator>Write</operator>
  <sources><sourceProduct refid="GSLC-Terrain-Correction"/></sources>
  <parameters><file>${output}</file><formatName>BEAM-DIMAP</formatName></parameters>
</node>
</graph>

gpt gslc_reference.xml ^
-Ps1a=S1A_IW_SLC__1SDV_20260623T225050_20260623T225120_065103_0834C8_BAD5.SAFE ^
-Poutput=S1A_GSLC.dim -c 12G -q 8
```

For **displacement-grade** work, add `-PapplySolidEarthTide=true -PapplyTroposphericCorrection=true` (and use the **same** setting for the secondary, which `CreateStack` rebuilds from the reference's stamp).

Step 1b (optional but recommended) — ETAD correction

ETAD (Extended Timing Annotation Dataset) is an auxiliary Sentinel-1 product that supplies per-pixel range and azimuth timing corrections — tropospheric and ionospheric path delay, solid-Earth geodetic

effects, bistatic and FM-mismatch azimuth shifts. Applying it moves geolocation by **centimetres to decimetres**, which is small in amplitude terms but *not* small in phase terms: at C-band one range fringe is only 2.77 cm of line-of-sight.

ETAD belongs **on the split SLC, before geocoding** — the corrections are defined in radar timing, so they must be applied while the product is still in radar geometry:

Read → Apply-Orbit-File → TOPSAR-Split → S1-ETAD-Correction → GSLC-Terrain-Correction

Insert this node between TOPSAR-Split and GSLC-Terrain-Correction in `gslc_reference.xml`:

```
<node id="S1-ETAD-Correction"><operator>S1-ETAD-Correction</operator>
  <sources><sourceProduct refid="TOPSAR-Split"/></sources>
  <parameters>
    <resamplingType>BISINC_5_POINT_INTERPOLATION</resamplingType>
    <resamplingImage>true</resamplingImage>
    <!-- essential for InSAR: removes the range-delay phase from the complex data.
        Without it, resampling fixes geolocation but leaves the atmospheric phase in
place. -->
    <outputPhaseCorrections>true</outputPhaseCorrections>
    <sumOfRangeCorrections>true</sumOfRangeCorrections>
    <sumOfAzimuthCorrections>true</sumOfAzimuthCorrections>
  </parameters>
</node>
```

then point GSLC-Terrain-Correction's source at S1-ETAD-Correction. That is the whole change — the command line is unchanged:

```
gpt gslc_reference.xml -Ps1a=...SAFE -Poutput=S1A_GSLC.dim -c 12G -q 8
```

The ETAD product is found and downloaded automatically. Leave `etadFile` unset and the operator searches the Copernicus Data Space for the ETAD product matching the acquisition and downloads it to SNAP's cache (`<cache>/etad`). This requires **Copernicus Data Space credentials stored in SNAP** (Tools → Manage External Tools / Product Library credentials — the same ones used for product download); without them the search cannot authenticate. If a product is genuinely unavailable the operator fails with *ETAD product not found*. You can still pass `etadFile` explicitly to use a local product.

What the defaults actually do. `sumOfRangeCorrections` and `sumOfAzimuthCorrections` default to `'true'`, while every individual layer (`troposphericCorrectionRg`, `ionosphericCorrectionRg`, `geodeticCorrectionRg`, `dopplerShiftCorrectionRg`, `geodeticCorrectionAz`, `bistaticShiftCorrectionAz`, `fmMismatchCorrectionAz`) defaults to `'false'`. That is not "no corrections applied" — the summed layers already contain the total range and azimuth correction, tropospheric and ionospheric delay included. The individual switches exist to apply a **subset**, which is what you want only when isolating one contribution for study.

Apply ETAD to both acquisitions, or to neither. A stack mixing an ETAD-corrected reference with an uncorrected secondary puts the differential timing correction straight into the interferometric phase. When `CreateStack` auto-geocodes a raw secondary it rebuilds it from the reference's stamps, so if you ETAD-correct the reference you should ETAD-correct the secondary and geocode it yourself, then stack two GSLCs (see the all-GSLC note in Next steps).

Do not use ETAD together with GSLC's own `'applyTroposphericCorrection'`. Both model the same tropospheric path delay, so enabling both double-counts it. Choose one: ETAD (measured, from the auxiliary product) or GSLC's Saastamoinen model (computed). ETAD is the better estimate

where an ETAD product exists. applySol idEarthTide overlaps with ETAD's geodetic layers in the same way.

Step 2 — GSLC interferogram, end to end

reference GSLC + raw secondary (S1C) → CreateStack (auto-coregister) → Interferogram (flat-earth + topo removed) → Goldstein → Write. Save as gslc_insar.xml:

```
<graph id="GSLC-InSAR">
  <version>1.0</version>
  <node id="ReadReference"><operator>Read</operator><sources/>
    <parameters><file>${reference_gslc}</file></parameters>
  </node>

  <!-- raw secondary: orbit + split only (NOT geocoded); CreateStack geocodes it -->
  <node id="ReadSecondary"><operator>Read</operator><sources/>
    <parameters><file>${secondary}</file></parameters>
  </node>
  <node id="OrbitSecondary"><operator>Apply-Orbit-File</operator>
    <sources><sourceProduct refid="ReadSecondary"/></sources>
    <parameters><orbitType>Sentinel Precise (Auto
Download)</orbitType><continueOnFail>>false</continueOnFail></parameters>
  </node>
  <node id="SplitSecondary"><operator>TOPSAR-Split</operator>
    <sources><sourceProduct refid="OrbitSecondary"/></sources>

<parameters><subswath>IW3</subswath><selectedPolarisations>VV</selectedPolarisations></parameters>
</node>

  <node id="CreateStack"><operator>CreateStack</operator>
    <sources>
      <sourceProduct refid="ReadReference"/>
      <sourceProduct.1 refid="SplitSecondary"/>
    </sources>
    <parameters><resamplingType>NONE</resamplingType></parameters>
  </node>
  <node id="Interferogram"><operator>Interferogram</operator>
    <sources><sourceProduct refid="CreateStack"/></sources>
    <parameters>
      <subtractFlatEarthPhase>true</subtractFlatEarthPhase>
      <subtractTopographicPhase>true</subtractTopographicPhase>
      <demName>Copernicus 30m Global DEM</demName>
      <includeCoherence>true</includeCoherence>
      <cohWinSizeMeters>100</cohWinSizeMeters>
    </parameters>
  </node>
  <node id="GoldsteinPhaseFiltering"><operator>GoldsteinPhaseFiltering</operator>
    <sources><sourceProduct refid="Interferogram"/></sources>
    <parameters/>
  </node>
  <node id="Write"><operator>Write</operator>
    <sources><sourceProduct refid="GoldsteinPhaseFiltering"/></sources>
    <parameters><file>${output}</file><formatName>BEAM-DIMAP</formatName></parameters>
  </node>
</graph>
```

```
gpt gslc_insar.xml ^
-Preference_gslc=S1A_GSLC.dim ^
-Psecondary=S1C_IW_SLC__1SDV_20260624T224958_20260624T225025_008254_010515_304A.SAFE ^
-Poutput=ifg_GSLC.dim -c 12G -q 8
```

The ``subtractTopographicPhase`` flag is the command-line equivalent of the *Subtract topographic phase* checkbox — it removes the DEM-simulated topographic fringes so the coseismic deformation signal remains. The exact deramp-model subtraction needs no flag: it activates whenever both GSLCs carry the azimuthCarrierPhase band (outputPhaseTerms=true in Step 1; look for GSLC carrier-difference: exact deramp-model subtraction active in the log). **`subtractResidualRamp` no longer exists** — see Step 2 and microwave-toolbox/docs/gslc-parity/etna-ramp-ab.md (<https://github.com/senbox-org/microwave-toolbox/blob/master/docs/gslc-parity/etna-ramp-ab.md>).

Step 3 — Unwrap to displacement (SNAPHU)

The interferogram phase is *wrapped* into $(-\pi, \pi]$. Converting it to displacement needs **unwrapping**, done by the external **SNAPHU** program via export → run → import. Because a GSLC interferogram is already geocoded, the unwrapped result is a displacement map in map coordinates with no further terrain correction.

1. Get the SNAPHU binary. Radar → Interferometric → Unwrapping → Batch Snaphu Unwrapping downloads it for you; the direct URLs are **Windows 64-bit: v2.0.4**

(step.esa.int/thirdparties/snaphu/2.0.4/snaphu-v2.0.4_win64.zip), Windows 32-bit and Linux/macOS: v1.4.2 (.../snaphu/1.4.2-2/...). Keep the extracted bin/ directory intact — on Windows snaphu.exe needs the msys-2.0.dll shipped beside it.

2. Export.

```
gpt SnaphuExport -Ssource=ifg_GSLC.dim -PtargetFolder=snaphu_out ^
-PstatCostMode=DEFO -PinitMethod=MST ^
-PnumberOfTileRows=6 -PnumberOfTileCols=4 -PnumberOfProcessors=8 ^
-ProwOverlap=400 -PcolOverlap=400 -PtileCostThreshold=500
```

`SnaphuExport` needs a band whose unit is `phase` — not i/q. It ignores the complex bands and looks for a phase band plus a coherence band, so a product carrying only $i_$, $q_$ and $coh_$ fails with wrapped phase band required. The interferogram written by Step 2 has the virtual Phase_ifg_... band and works as-is; the trap appears if you Subset first and select only the complex bands. Include the Phase_... band in the subset (its atan2(q, i) expression needs $i_$ / $q_$ present too).

3. Run SNAPHU from the created folder, using the command SNAP writes into line 7 of snaphu.conf (the last argument is the raster **width**):

```
cd snaphu_out/ifg_GSLC
snaphu -f snaphu.conf Phase_ifg_IW3_VV_23Jun2026_24Jun2026.snaphu.img 4000
```

4. Import the result, then convert to displacement:

```
gpt SnaphuImport -SsnaphuPhase=snaphu_out/ifg_GSLC/UnwPhase_...snaphu.hdr ^
-Swrapped=ifg_GSLC.dim -t unw_GSLC.dim
gpt PhaseToDisplacement -Ssource=unw_GSLC.dim -t disp_GSLC.dim
```

Practical limits worth knowing before you start

- **Multilook before unwrapping — it helps, substantially.** At single-look the interferogram is noise-dominated (median coherence 0.23 on this pair), and unwrapping low-coherence data is where SNAPHU goes wrong. Multilooking to roughly **8×8 (≈ 110 m cells)** on this scene raised the coherence estimate from **0.23 to 0.67**, made the field small enough to unwrap in **a single tile**, and

cut runtime from 19 minutes to 64 seconds. Verify the choice for your own scene by multilooking at several factors and measuring the block-to-block phase step: it *falls* while noise dominates and starts to *rise* once cells get large enough to smear real signal — take the minimum. Going too far (32×32 here) does begin to under-sample the deformation.

- **Tile overlap, or better, no tiles.** SNAPHU warns `Tile overlap is small` (may give bad results) when overlap is marginal relative to tile size — 200 px on 1000 px tiles triggers it. On this pair a 24-tile full-resolution unwrap produced a displacement field that disagreed with three independent multilooked solutions by ~ 18 cm over 93% of pixels; the multilooked solutions agreed with each other to 0.8–1.8 cm. **Multilooking enough to avoid tiling altogether is the more reliable route.** If you must tile, use generous overlap (≥ 400 px) and always re-run with a different tiling to confirm the field does not change.
- **Coherence sets the ceiling.** Unwrapping is a guess where coherence is low, and it fails *silently* — the output is always a smooth-looking raster. On this pair the median coherence over the epicentral subset is only ≈ 0.23 , with 14% nodata.
- **A GSLC-specific caveat.** `snaphu.conf` is populated with **radar-geometry** parameters (DR = slant-range spacing ≈ 2.33 m, DA = azimuth ≈ 15.6 m, and NCORRLOOKS derived from them), but a GSLC raster is in **map** geometry (13.89 m square for this pair with `gridSpacing=SQUARE_COARSEST`; rectangular with the default `NATIVE_ANISOTROPIC`). DEFO costs are generic enough to remain usable, but SNAPHU's statistical cost model is being given spacings that do not describe the grid it is working on. Treat the unwrapped amplitude as approximate until validated.

Check the unwrapped result rather than trusting it

An unwrapped raster always looks plausible. Four cheap tests:

1. **Re-wrap:** `wrap(unwrapped)` must reproduce the input wrapped phase wherever coherence is decent. This catches scaling, offset and byte-order errors in one shot. (Note the exported `.snaphu.img` files are **native/little-endian** float32, whereas BEAM-DIMAP `.img` files are big-endian.)
2. **Residue density** in the *wrapped* input — bounds how much of the field could be unwrapped unambiguously at all, independent of what SNAPHU returned.
3. **2π jumps** between adjacent pixels in high-coherence areas: these are unwrapping errors, not signal.
4. **Stratify by coherence:** report displacement statistics per coherence bin. If the "signal" exists only in the low-coherence bins, it is noise.

For the full worked example with figures, see the notebook ``snap-nb-sar-gslc-insar``.

How does it compare to the traditional chain?

The fair question is not "which picture looks nicer" but "do the two chains deliver the **same phase and the same coherence** from the same pair". Answering that needs a like-for-like comparison, and the rules for one are easy to break:

Comparing like with like.

- **Same filtering on both sides** — *both unfiltered, or both through the same filter. A Goldstein-filtered interferogram against an unfiltered one differs by the filter, not by the chain: on Napa, filtered classical against unfiltered GSLC scores 0.639, while both unfiltered score 0.785 and both filtered 0.892.*
- **Same coherence window in metres** (`cohWinSizeMeters`), *not in pixels* — *a 10×10 window covers a different patch of ground on an SLC than on a map grid.*

- **Compare complex values, never wrapped phase.** Resample i/q (or bin them), then take the angle of $GSLC \cdot \text{conj}(cLassical)$. Interpolating a wrapped phase raster manufactures errors at every $\pm\pi$ cut.

- **Score with phase concentration** $|\text{mean}(\exp(j\Delta\phi))|$: 1 means identical phase, 0 means unrelated. It ignores a constant offset and is robust to wrapping.

Measured that way on three sites, from the same SLCs and the same DEM (Copernicus 30 m):

Site	Mode	Phase agreement GSLC vs classical	Samples
Venezuela (S1A × S1C, 1 day)	IW TOPS	0.921 raw, 0.961 with one fitted plane removed	354 543 radar cells, nothing resampled
Napa (S1A, 7 × 31 Aug 2014)	Stripmap	0.785 , both single look and unfiltered	2.14 M map samples
Napa, filtered	Stripmap	0.892 , both Goldstein-filtered	2.14 M map samples
Napa, unwrapped	Stripmap	median $ \Delta $ 0.05 cm line-of-sight, correlation 0.905	400 949 map samples
Campi Flegrei, 72 d (S1A, 9 Aug × 20 Oct 2023)	IW TOPS	0.840 at 37 m (0.694 single look)	48 593 P-SBAS points
Campi Flegrei, 1 yr (S1A, 13 Oct 2022 × 20 Oct 2023)	IW TOPS	0.789 at 37 m (0.578 single look)	48 591 P-SBAS points

Coherence, both chains with a 100 m ground window (`cohWinSizeMeters`), on the same shared samples as the phase comparison (radar cells at Venezuela, map samples elsewhere):

Site	Classical / GSLC mean coherence	Difference, mean / median
Venezuela	0.280 / 0.285	+0.006 / +0.003
Napa	0.416 / 0.418	+0.002 / −0.001
Campi Flegrei, 72 d	0.238 / 0.245	+0.007 / +0.006
Campi Flegrei, 1 yr	0.227 / 0.232	+0.005 / −0.000

The chains agree on coherence to within ~3 %, with medians differing by under 0.01. The slightly higher GSLC means are consistent with its finer, oversampled map grid (neighbouring GSLC pixels are not fully independent looks), so they are not a quality claim.

A metadata fix these numbers depend on. Before 26 Sep 2026 the GSLC product recorded its east–west pixel spacing converted at the equator instead of at the scene's latitude. A metre-based coherence window was therefore too small east–west at mid latitudes: ~79 m instead of 100 m at Napa, ~76 m at Campi Flegrei (negligible at Venezuela's 10° N). A smaller window biases coherence upwards, and it had roughly doubled the apparent GSLC lead at Campi Flegrei (ratio 1.06 → 1.03 after the fix). The Napa and Campi Flegrei values above are re-measured with the fix. If you rely on `cohWinSizeMeters` with GSLC products made before that date, re-run `GSLC-Terrain-Correction`.

Venezuela — Sentinel-1 IW TOPS

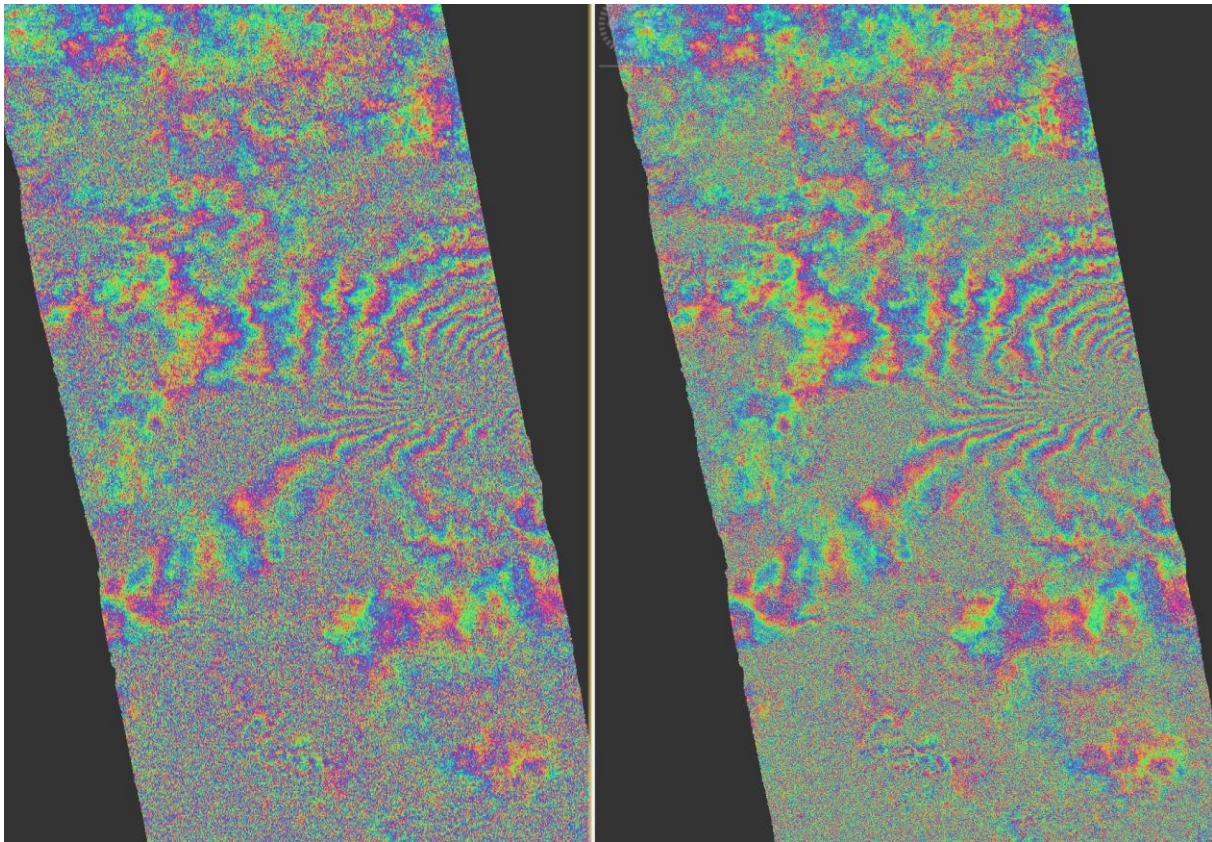


Figure 1. Venezuela coseismic pair (S1A 23 Jun × S1C 24 Jun 2026) in SNAP 14.0.2. Left: classical chain, terrain-corrected. Right: GSLC chain, Goldstein-filtered. Same fringe field, same fault trace. (A visual comparison: the quantitative one below uses both chains unfiltered.)

Here the GSLC records, for every map pixel, the source range/azimuth index it was read from, so both chains can be binned into the same ~100 m radar cells **without resampling either one**. That is the cleanest comparison possible: both unfiltered, it gives 0.961 after removing a single plane. The gap to the raw 0.921 is a faint scene-scale gradient, the only systematic difference left between the chains.

Napa — Sentinel-1 stripmap

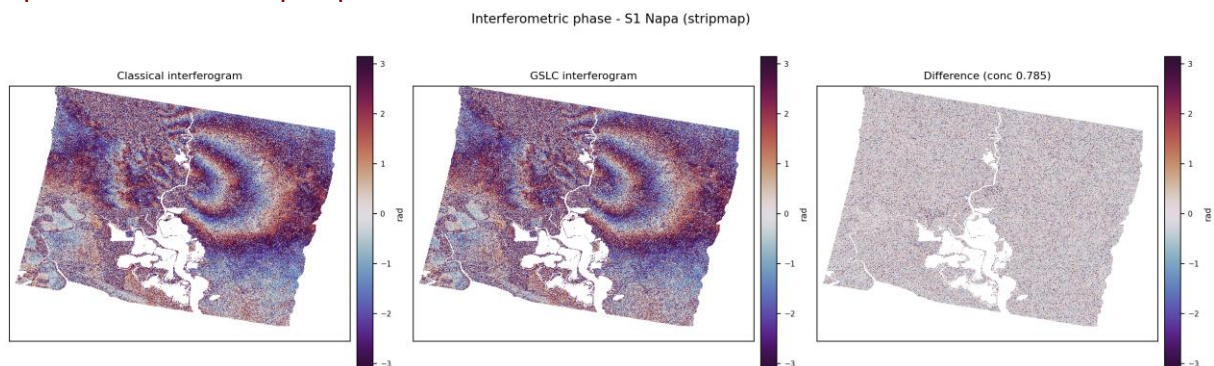


Figure 2. South Napa 2014 earthquake, both chains single look and unfiltered, on the classical product's map grid. Left to right: classical, GSLC, and the wrapped difference GSLC minus classical (concentration 0.785). No fringe structure survives in the difference — only speckle-scale noise from the two independent resamplings onto the shared grid.

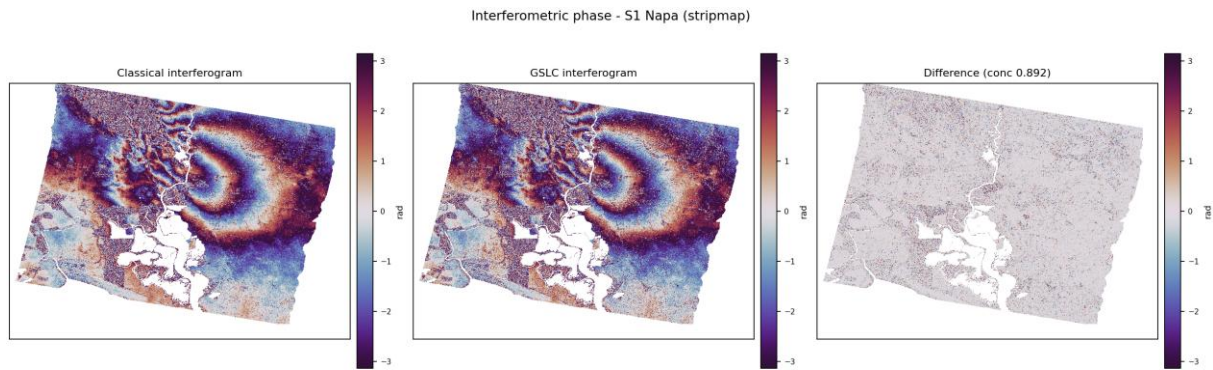


Figure 3. The same comparison with both chains Goldstein-filtered (concentration 0.892): the classical filtered in radar geometry then terrain-corrected, the GSLC filtered on its map grid. The filter windows cover different ground areas in the two geometries, so this view is for reading the fringes; the unfiltered comparison above is the quantitative one.

The real test of a deformation product is the displacement map. Each chain was multilooked to ~20 m, Goldstein-filtered and unwrapped **independently** with SNAPHU:

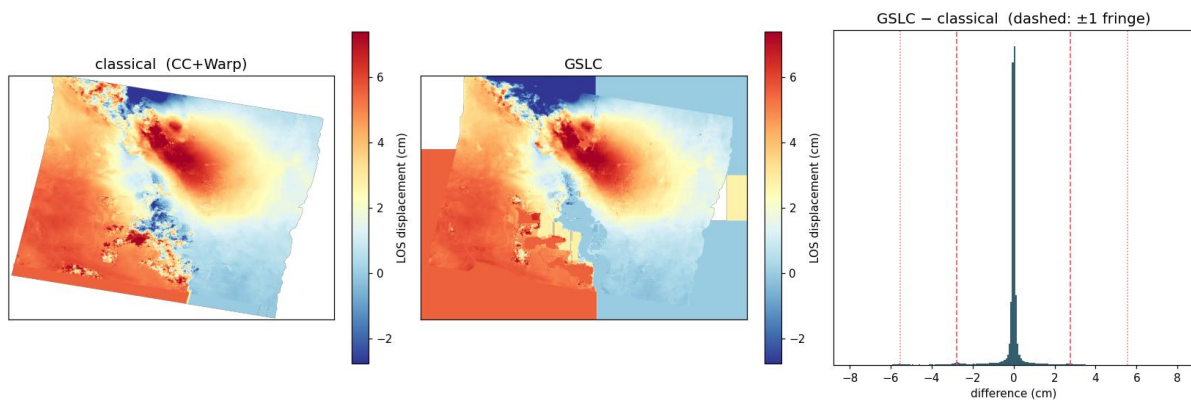


Figure 4. Line-of-sight displacement from the classical chain (left) and the GSLC chain (middle), and the histogram of their difference (right). The histogram spikes at zero; the small side peaks sit exactly at ± 1 fringe (2.77 cm) — places where the two independent unwrapping runs chose a different cycle in decorrelated patches. The flat patches in the GSLC panel are SNAPHU assigning a constant to disconnected, decorrelated islands: an unwrapping artefact, not a chain one.

Median absolute difference **0.05 cm**. The RMS (1.04 cm) is not a chain difference: most of the 9 % of samples that differ by more than 1 cm sit on whole fringes of $\lambda/2 = 2.77$ cm, the signature of unwrapping choices, not of phase error.

Campi Flegrei — small-scale volcanic uplift, against a published reference

Venezuela and Napa compare the two chains with each other. Campi Flegrei adds a **third party**: the caldera west of Naples has been rising since 2005 (at the peak, about 1.4 cm per month of line-of-sight motion over the year used here, per the P-SBAS series below), and CNR-IREA and INGV published their Sentinel-1 **P-SBAS** displacement time series for it openly (Giudicepietro et al. 2024, *Int. J. Appl. Earth Obs. Geoinf.* 132:104060; data on Zenodo, doi:10.5281/zenodo.10781496, CC-BY 4.0). Differencing two epochs of that series gives the published displacement for exactly our pair, so each chain can be scored against it.

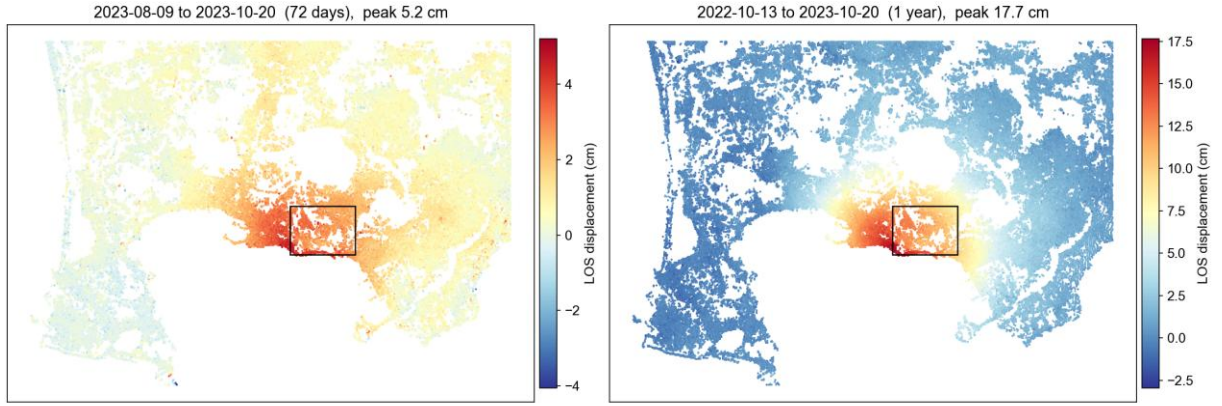


Figure 5. The published P-SBAS line-of-sight displacement (descending track 22) for the two pairs used here: 5.2 cm peak over 72 days, 17.7 cm over one year. The box marks the Mt Olibano–Accademia area, where Giudicepietro et al. report a $\sim 1.3 \text{ km}^2$ zone that has lagged the surrounding uplift by $\sim 9 \text{ cm}$ since 2021 (box position approximate).

Setup. S1A descending track 22, IW1, the two bursts over the caldera (burst IDs 45938/45939), split with a WKT area of interest so every date covers the same ground. Both chains use the same auto-downloaded Copernicus 30 m DEM, with no filtering and no ETAD on either side. Each chain's interferogram is averaged to the P-SBAS 37 m resolution and scored against the phase predicted from the published displacement. No unwrapping is needed, and the unknown constant between the two references cancels. The P-SBAS product is itself multilooked (2×10) and Goldstein-filtered, so the absolute scores against it are floor-limited; they are for comparing the two chains with each other, not with other sites.

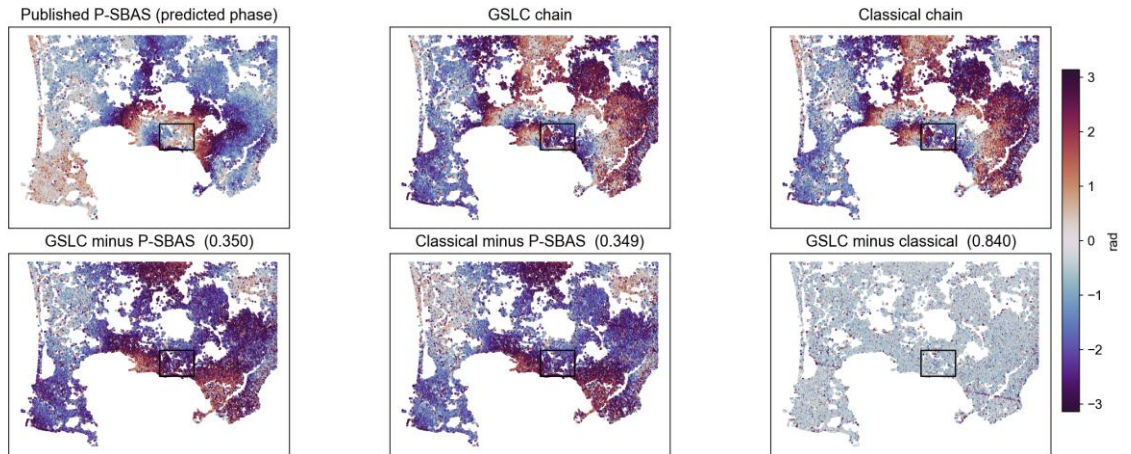


Figure 6. 72-day pair, 9 Aug $\rightarrow$ 20 Oct 2023. Top: the phase predicted from the published P-SBAS, the GSLC chain and the classical chain. Bottom: each chain minus P-SBAS, and GSLC minus classical. The two chains agree with each other at 0.840; against P-SBAS they score 0.350 and 0.349 and leave the same smooth, km-scale residual.

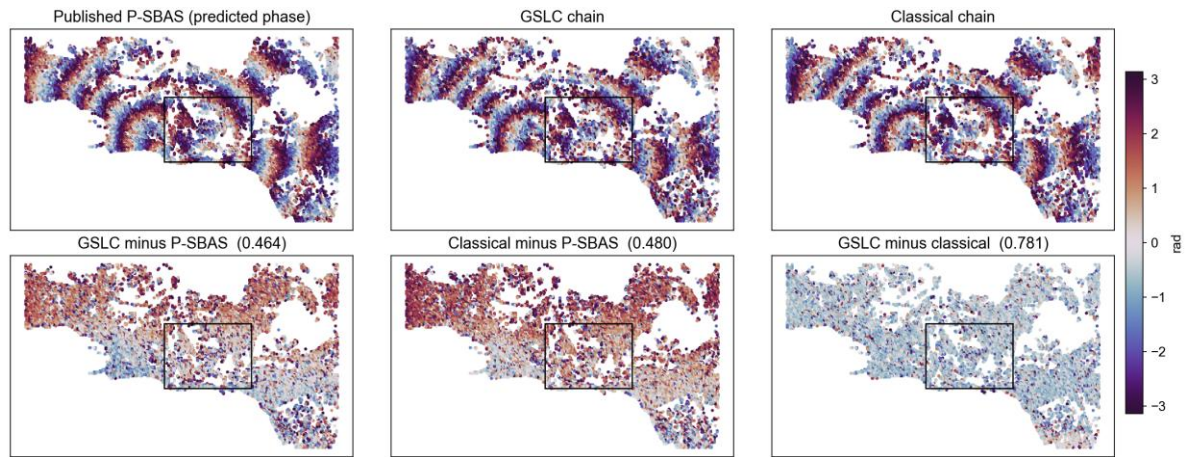


Figure 7. One-year pair, 13 Oct 2022 → 20 Oct 2023 (~18 cm), zoomed on the caldera centre (about 8×4 km). All ~6 concentric fringes, and the distortion inside the Olibano–Accademia box, appear in both chains.

Campi Flegrei (48 593 / 48 591 P-SBAS points)	72 days	1 year
Published P-SBAS peak displacement	5.2 cm	17.7 cm
GSLC vs classical	0.840	0.789
GSLC vs published P-SBAS	0.350	0.336
Classical vs published P-SBAS	0.349	0.358
Fine scale (residual high-passed at 2 km), caldera centre: GSLC / classical	0.595 / 0.591	0.548 / 0.556

Two things stand out:

- **Both chains match the published result comparably.** Over 72 days they are identical (0.350 vs 0.349); over one year classical is slightly closer (0.358 vs 0.336). At fine scale — the residual high-passed at 2 km, averaged over 50 placements of the block grid — they are level on both pairs: the difference never exceeds ± 0.03 in either direction. One pair each, so read these as one data point per interval, not a rule.
- **The residual against P-SBAS is most likely atmosphere, and both chains carry it equally.** It repeats in both pairs (block-scale agreement 0.73, against 0.30 for random), and the two pairs share only one date, 20 Oct 2023. The P-SBAS series departs from its own local trend by only ~0.26 cm per epoch, so it carries little per-date atmosphere, while a single interferogram keeps all of it. The ETAD tropospheric delay, an independent weather-model estimate, raises the agreement from 0.349 to 0.382 (GSLC) and 0.378 (classical) with the physically expected sign, and trims the km-scale residual by ~12 % on average — equally for both chains. Most of the residual is left: consistent with small-scale atmosphere a weather model cannot resolve, but not proven.

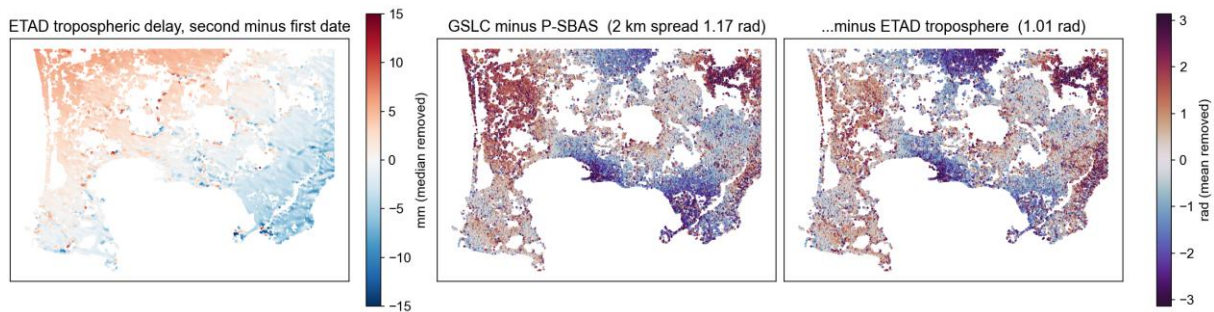


Figure 8. ETAD check on the 72-day pair. Left: ETAD tropospheric delay difference between the two dates. Middle: GSLC minus P-SBAS. Right: the same after subtracting the ETAD troposphere; the 2 km residual spread falls from 1.17 to 1.01 rad (means over 50 block-grid placements; constants removed for display).

What this means for your own processing. A single GSLC pair measures deformation plus the atmospheric delay of its two dates, typically a few millimetres at km scale, as here. For centimetre-level uplift this is small; for millimetre-level signals, use ETAD (see A1b) and consider several pairs or a time series.

What to take from it

- **Same phase.** On all three sites the GSLC chain reproduces the classical interferogram — while being shorter, per-acquisition and already geocoded.
- **Checked against a published result, not just against itself.** At Campi Flegrei both chains match an independent, published P-SBAS time series comparably, and are level at fine scale.
- **GSLC never resamples wrapped phase.** The interferogram is born on the map grid, filtered there, and is final. A classical displacement product should be unwrapped in radar geometry *before* terrain correction; GSLC sidesteps that ordering issue entirely. (Terrain-Correction now detects an InSAR source and geocodes the complex pair as *complex*, re-deriving Phase — so a default TC of an interferogram no longer interpolates wrapped phase.)
- **Phase-agreement numbers are not comparable across sites.** Venezuela is binned with nothing resampled; Napa resamples both sides onto one grid; Campi Flegrei is scored on P-SBAS points at 37 m. Compare within a row, not across rows.

Variant — Sentinel-1 stripmap (the Napa pair above). The same workflow runs on stripmap with one step fewer: there are no bursts, so **skip TOPSAR-Split** and go straight from **Apply-Orbit-File** to **GSLC-Terrain-Correction**. The pair used above is

`S1A_S1_SLC__1SSV_20140807T142342_20140807T142411_001835_001BC1_05AA` (reference) and `S1A_S1_SLC__1SSV_20140831T142335_20140831T142403_002185_002356_C2E5` (secondary), VV, bracketing the M6.0 South Napa earthquake of 24 Aug 2014. A full stripmap frame is large (~53 000 lines); a Subset around the epicentre (38.215° N, 122.312° W), followed by **Apply-Orbit-File**, keeps the run to minutes — that is the order used for the results above. Leave the subset's copy metadata on — GSLC needs the orbit and geolocation grid.

Optional extension — post-seismic pair. The 30 Jun **S1D** acquisition (same track, `S1D_IW_SLC__1SDV_20260630T225009_20260630T225040_003472_006226_2543.SAFE`) pairs with **S1C** (24 Jun) to image the **first six days of post-seismic motion**: repeat the same workflow with **S1C** as reference and **S1D** as secondary. Comparing the coseismic and post-seismic interferograms is a compact demonstration of why acquisition timing matters as much as processing.

Reading / validating the output

- The S1A_GSLC product is a geocoded complex image (i_/q_ bands) plus any diagnostic bands you enabled (DEM, lat/lon, incidence, layover-shadow, simulated phase).
- After *Interferogram*, inspect the **coherence** band and the **wrapped phase** (fringes). Over stable terrain coherence should be high and fringes smooth; the fringes that crowd toward the fault trace are the coseismic deformation. Sanity-check against a traditional-pipeline interferogram of the same S1A/S1C pair. Because this is a long right-lateral strike-slip rupture, expect **fault-parallel, elongated** fringe bands whose spacing tightens toward the fault (each fringe = 2.8 cm of line-of-sight displacement) — not concentric lobes about a point — with narrow decorrelated strips where the near-field gradient exceeds one fringe per pixel.

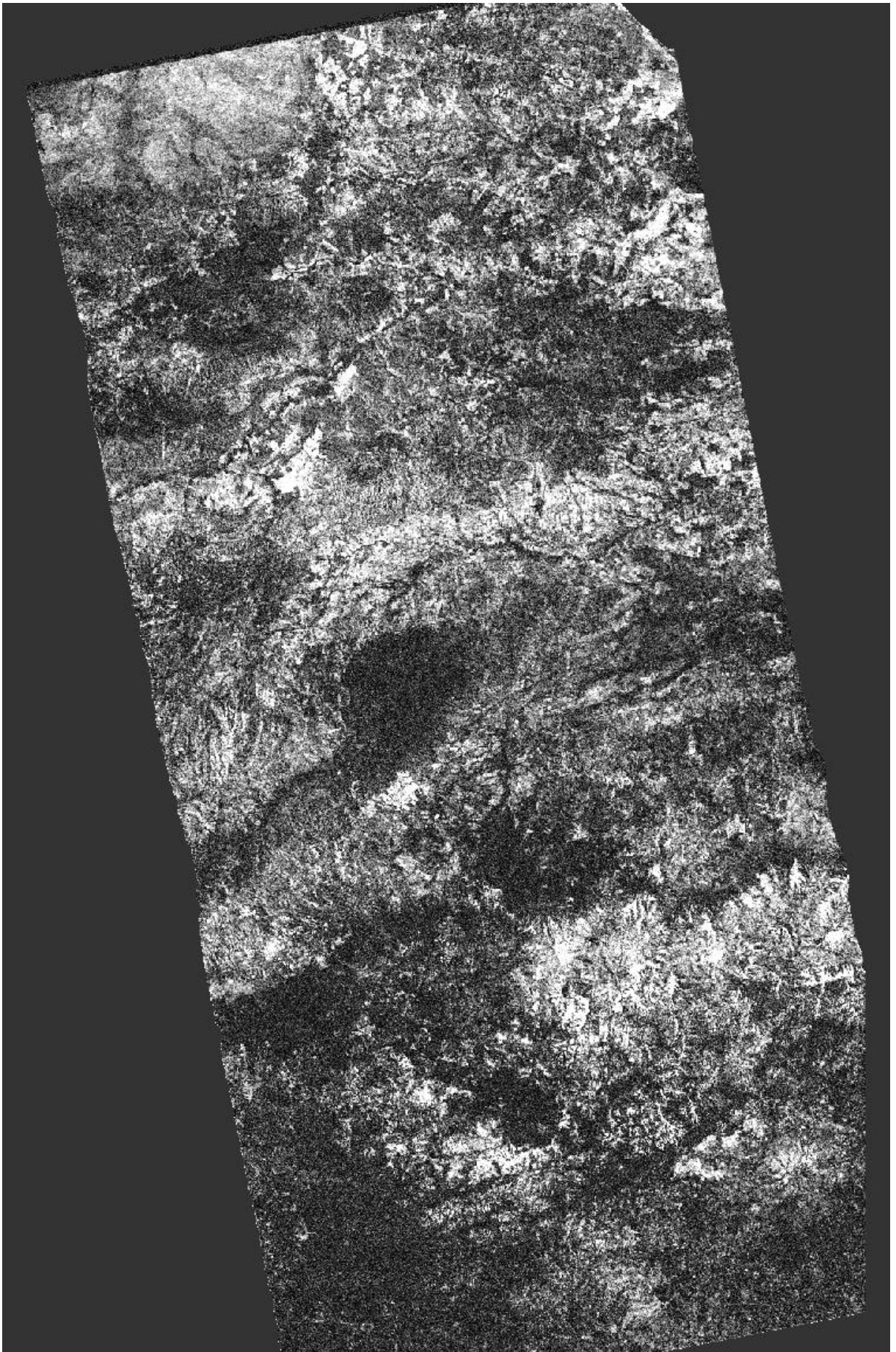


Figure 9. GSLC coherence of the S1A 23 Jun × S1C 24 Jun coseismic pair (IW3, VV). The 1-day temporal baseline keeps coherence high across most of the scene; dark patches are water, dense vegetation and steep slopes.

- **Judge the phase after filtering or multilooking, not at full resolution.** A single-look interferogram at realistic coherence ($\gamma \approx 0.2$ over vegetation) looks like noise on screen even when it is perfectly correct — and a terrain-corrected comparison image has been implicitly smoothed by its resampling. Apply Goldstein filtering or a 4×4 multilook before deciding whether the interferogram "worked".
- **Write the stack to disk before running `Interferogram` on large scenes** (as the graphs in this tutorial do). Chaining Interferogram directly onto an in-memory CreateStack→GSLC graph recomputes geocoding tiles many times over and can appear to hang.

Troubleshooting

Symptom	Cause / fix
Operator rejects a debursteds TOPS product	GSLC needs a split (burst-level) TOPS product or a Stripmap SLC; debursteds TOPS is explicitly rejected. GRD has no phase — it isn't blocked but yields a degenerate product, so don't use it.
Interferogram is pure noise	(1) outputFlattened mismatched between reference and secondary — must be identical; (2) large residual misregistration — use the CreateStack auto-coregister path.
Coherence lower than expected	Check DEM quality; for displacement scenes enable SET + troposphere; verify like-for-like comparison (same multilook, same area). Note S1A↔S1C is a cross-platform constellation pair — confirm they share the relative orbit/track (this pair: both on relative orbit 106).
Reference and secondary don't align	Ensure both use the same pixel spacing (GSLC always snaps to the shared standard grid automatically); let CreateStack set the sub-pixel rangeOffsetPixels/azimuthOffsetPixels.
Topographic fringes still dominate the interferogram	Enable Subtract topographic phase (subtractTopographicPhase=true) with a valid DEM.
Regular fringes / wavy "fringe packets" that the traditional interferogram doesn't show — possibly only over <i>part</i> of the scene	Before the carrier-sign fix this was the inverted add-back leaving $2 \times (m_{\text{ref}} - m_{\text{sec}})$, and the advice was to enable the (now removed) residual ramp. Now: check the log for GSLC carrier-difference: exact deramp-model subtraction active. If it is missing, one of the GSLCs was built with Output separable phase terms switched off (outputPhaseTerms=false) — rebuild it, rather than reaching for subtractResidualRamp. (A decimated screen zoom of a fine GSLC grid also aliases dense correct fringes into wavy packets; judge multilooked.)
A sharp phase-jump line near one edge of the scene, bounding a noisy band that fades toward far range	The two TOPSAR-Splits framed different burst windows (e.g. 10 vs 9 bursts): in the extra-burst region the legs used to pair <i>adjacent</i> bursts — disjoint Doppler bands, inherently incoherent. Fixed by the burst-boundary lock: the secondary now stays on the burst the reference frames and masks what cannot pair (log: edge seam(s) pushed to the matched burst's extent).

	Rebuild the stack with the CreateStack auto-coregister path; if stacking two prebuilt GSLCs by hand, pass the reference's <code>gslc_burst_valid_times</code> stamp as <code>refBurstValidTimes</code> on the secondary's GSLC step.
Elongated bands / subtle phase breaks along burst seams, strongest over part of the range swath, at several seams	A residual discontinuity at the burst seams, range-varying (so it can look strong at near range and invisible mid-swath). Tick Subtract Burst Seam Steps (GSLC) (<code>subtractSeamSteps=true</code>): the Interferogram step measures each seam's step directly and subtracts it (log: <code>GSLC seam steps (pair N): [s0 ... rad @near/mid/far]</code>). This is safe to use on its own — across-seam differencing cannot absorb deformation or atmosphere, which are continuous across seams — and it no longer requires <code>subtractResidualRamp</code> . Seams inside heavily decorrelated areas are left untouched (unmeasurable — and invisible there anyway).
ETAD: The selected ETAD product does not match the source product	The message prints both sensing windows. Usual cause: the adjacent slice of the same datatake (window ~25 s off, overlaps your scene by seconds) or a cross-date/mission file. Pick the ETAD whose window contains the scene's; the auto-search now selects by maximum overlap.
ETAD ran but changed nothing in the GSLC chain	Resampling Image was off (classical grid mode — a silent no-op for GSLC). Set <code>resamplingImage=true</code> and <code>outputPhaseCorrections=true</code> , and apply to both acquisitions.
Slow / huge output over sea	Keep <i>Mask out areas with no elevation</i> (<code>nodataValueAtSea=true</code>) on.

Next steps

- **Jupyter notebooks** — full, runnable SAR/InSAR workflows: <<https://github.com/senbox-org/snap-jupyter-notebooks>>. See `snap-nb-sar-gslc-insar` for the complete GSLC-InSAR example with figures.
- Algorithm, parameters, and the coregistration model: `GSLC-Geocoding-Explained.md`.
- Operator parameter reference: in-app Help (F1 in the dialog) → *GSLC Terrain Correction*.

For more tutorials visit the Sentinel Toolboxes website

<http://step.esa.int/main/doc/tutorials/>

Send comments to the SNAP Forum

<http://forum.step.esa.int/>

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