Unwrapping with SNAPHU
≤ 100-m spatial perpendicular baseline
389 Sentinel-1 track A064 interferograms (Nov. 2018 - Jul. 2020)

Motivation

+ The July 2019 Mw 6.4 and Mw 7.1 Ridgecrest earthquakes are two of the most highly instrumented events to occur in California and were observed by Sentinel-1 SAR satellites in ideal conditions for InSAR analysis

Figure 1 (right). Unwrapped Sentinel-1 interferogram from track A064 showing LOS displacements from the Ridgecrest earthquake sequence.

Figure 2. InSAR time series example showing the effect of applying a linear smoothing constant when calculating coseismic displacement (grey line = time of earthquake).

+ InSAR time series analysis however, is hampered by the abrupt coseismic offset caused by the earthquake: this discontinuity prevents the use of common smoothing algorithms.

+ To move past the Ridgecrest events in time series analysis to study the interseismic, coseismic and postseismic observations, we need to correct the coseismic displacement

GOAL: Correct InSAR time series for observed earthquake offsets to:
1) enable common smoothing algorithms and
2) derive estimates of each period of the earthquake cycle

Method

InSAR Time Series Processing (via GMTSAR v6.1)
415 Sentinel-1 track D071 interferograms (Jul. 2018 - Jul. 2020)
389 Sentinel-1 track A064 interferograms (Nov. 2018 - Jul. 2020)

Low-pass filtered at 200 m wavelength ± 50-day temporal baseline ± 100-m spatial perpendicular baseline Unwrapping with SNAPHU (common points of low coherence removed) Time series processing with Small Baseline Subset (SBAS)

Cosmetic Correction

SBAS-based
Pixel-by-Pixel (PxP)
Remove that correction grid from the earthquake spanning unwrapped interferograms
Run SBAS on the “corrected” set of interferograms

Cosmetic Correction: Pinned InSAR Time Series

Figure 3 (below). Correction grids for each cosmetic correction method. (A) shows the result of the SBAS-based correction, while (B) and (C) show the result of the PxP correction. (B) and (D) show the 2019/04/01 09:17:16 corrected interferogram

Results

Incorporating a GNSS Displacement Data-correction

+ To improve estimates of the coseismic and postseismic periods of the earthquake cycle, we tie our interferograms to GNSS displacement data, which removes additional atmospheric noise and provides an underlying reference frame for the InSAR time series (Argus et al., 2005; Neely et al., 2020; Xu et al., in revision)

Postseismic Estimates At Any Time Period

Figure 10. We can use the postseismic amplitude grid estimated from our PnP method to calculate a cumulative postseismic displacement grid over any time period, with the assumption of a postseismic time series modeled term (decreasing or logarithmic) for the postseismic term (A) shows the estimated two year 07/2018 - 07/2020 interseismic velocity field, (B) shows the estimated coseismic displacement and (C) shows the cumulative estimated postseismic displacements for a 48 day following the event. White squares are the locations of GNSS stations, while changes in scales between panels.

Summary & Future Work

+ We have succeeded in correcting the coseismic offset present in both our ascending and descending Sentinel-1 InSAR time series using a Pixel-by-Pixel (PxP) estimation method

+ We tie our unwrapped interferograms to high-precision GNSS time series displacements which both helps correct additional atmospheric noise and provides an underlying reference frame for the InSAR time series

Both of these steps have enabled us to estimate displacements of pre-, co- and postseismic periods of the earthquake cycle around the 2019 Ridgecrest earthquake, which can be used in near- and far-field modeling of earthquake processes (and particularly decaying postseismic processes).

+ We plan on extending this analysis to a full GNSS-corrected Sentinel-1 InSAR time series from 2014 to the present day

InSAR-derived Earthquake Cycle Products

Postseismic
Amplitude
Cumulative Postseismic

References

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