Better estimates of creep rate along the Hayward Fault, CA through High-Resolution DEM's and InSAR

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Introduction

The Hayward, Calaveras, and San Andreas are the major faults in California releasing the strain from the sliding motion between the North American and Pacific plates. Strain is relieved quickly through earthquakes or slowly through creep, the small aseismic sliding across a fault. The Hayward fault releases strain through both earthquakes and creep.

The last major rupture was a magnitude 6.8 to 7.0 quake in 1868. As the most urbanized earthquake zone in the US, the Bay Area is estimated to bear upwards of 100 billion dollars in damage from a magnitude 6.7 to 7.0 quake (USGS, 2018).

Data

We used SSARA and ASF Vertex online databases to access SAR data spanning the Hayward fault area. The data availability is represented by Figure 1 and Table 1 below.

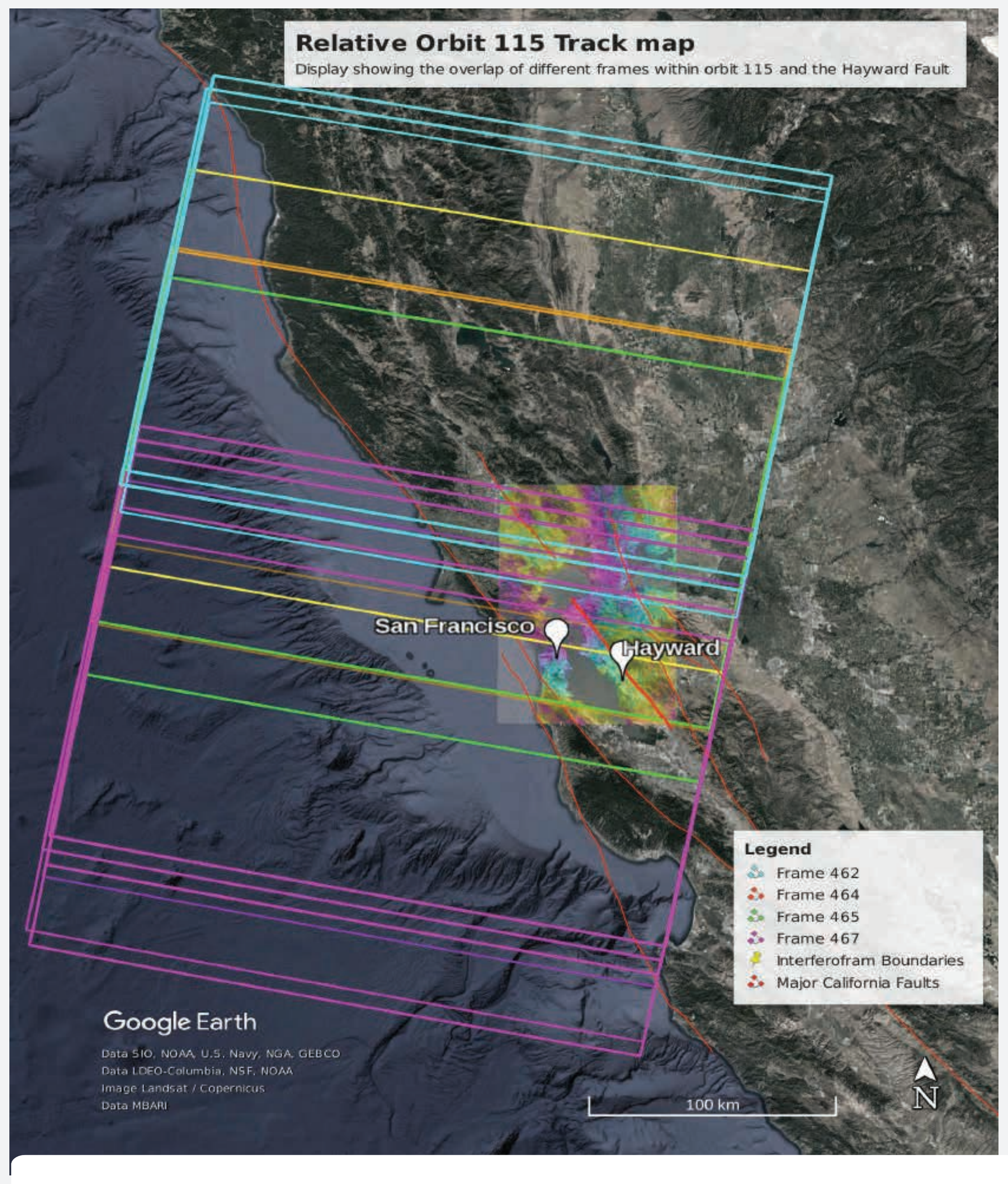

Figure 1: Relative orbit 115, with frames from 462-467 had the best coverage of the Hayward fault.

Platform	Relative Orbit	Flight Direction	Frame	First Image	Last Image	Potential Images
Sentinel-1A	115	Descending	462	20151125	20180712	47
Sentinel-1A	115	Descending	463	20150610	20151101	7
Sentinel-1A	115	Descending	464	20150222	20170518	8
Sentinel-1A	115	Descending	465	20161002	20170506	15
Sentinel-1A	115	Descending	466	20161219	20161219	1
Sentinel-1A	115	Descending	467	20151113	20180712	64

Table 1: Information on the available images used to create a time series.

Methods

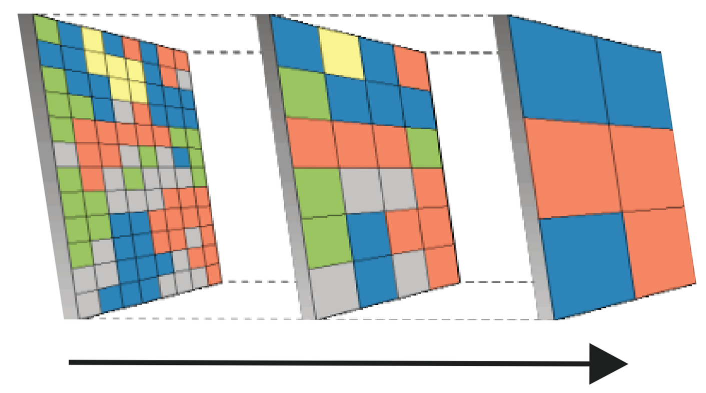

Figure 2: Example of an High-Resolution DEM being upsampled to create a lower resolution.

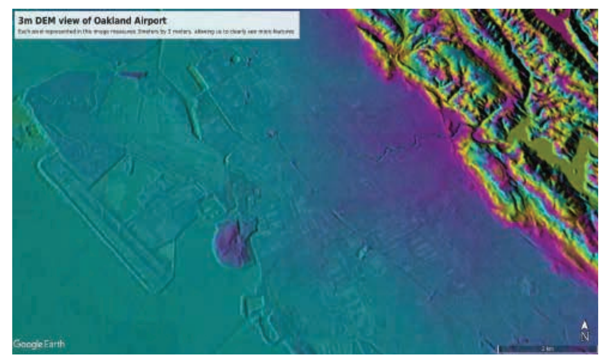

Figure 3: View of Oakland Airport and nearby hills with a 3m DEM. Notice how streams, runways and topography are better represented

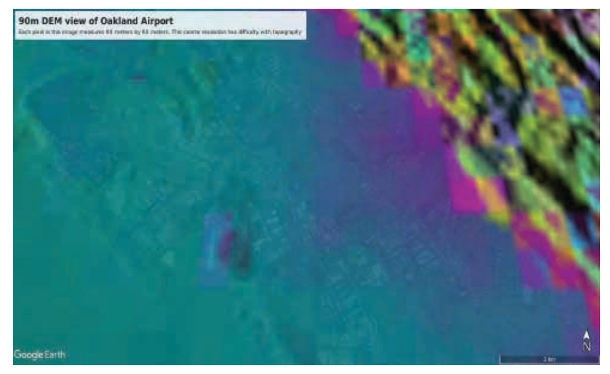

Figure 4: View of the Oakland Airport and nearby hills with a 90m DEM. This coarse resolution has trouble showing topography and other features

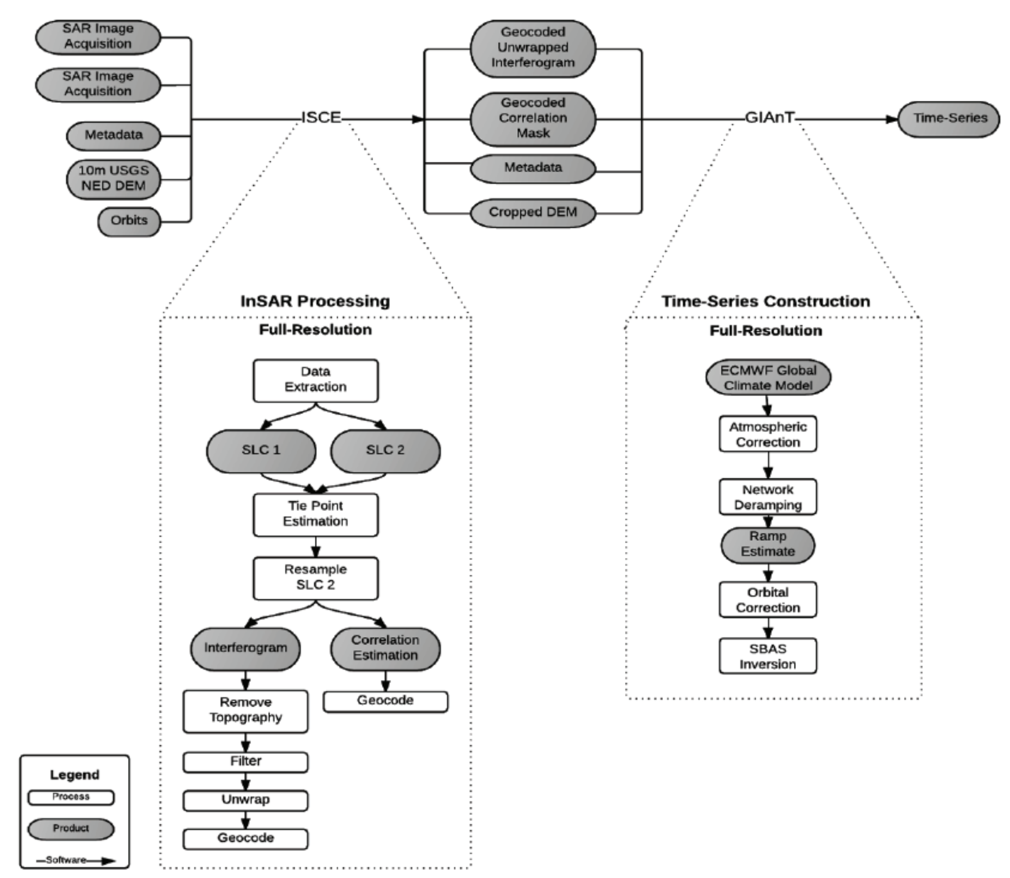

Figure 5: Flowchart of InSAR data processing using JPL ISCE and GIAnT software for creating interferograms

We performed InSAR processing using the Caltech/JPL ISCE and GIAnT software (Gurrola et al., 2010). We used the USGS National Map platform to acquire the National Elevation Data (NED) 1/9 arc second DEM for the topographic correction. The DEM was downsampled to common resolutions including 3 m, 5 m,10 m, 30 m, and 90 m.

Compared DEM Results

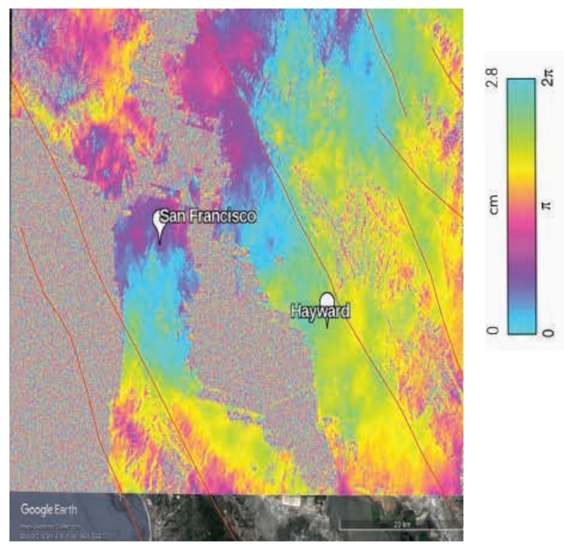

Figure 6: Interferogram created from 3 meter DEM

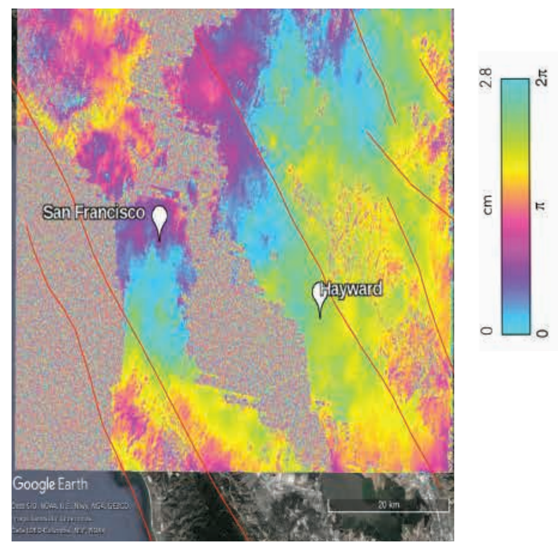

Figure 7: Interferogram created from upsampled 30 meter DEM

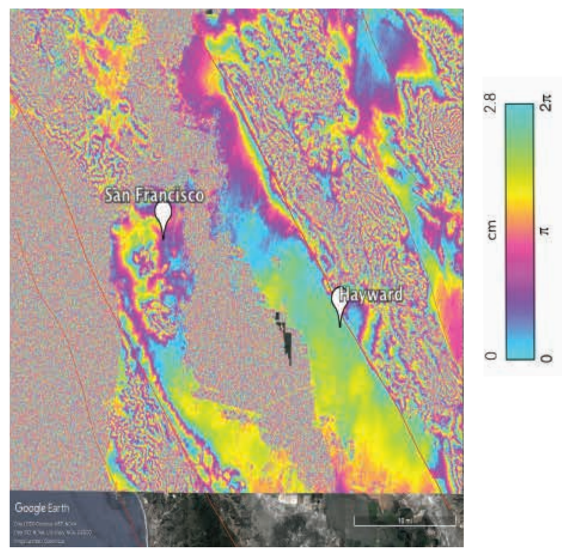

Figure 8: Interferogram created from 30 meter SRTM DEM

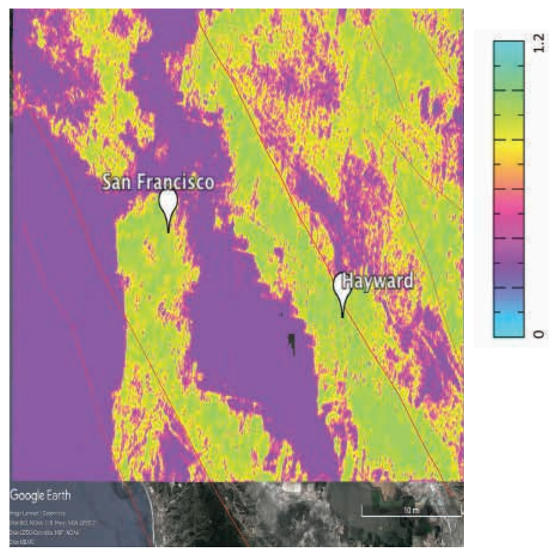

Figure 9: Phase variance created from 3 meter DEM

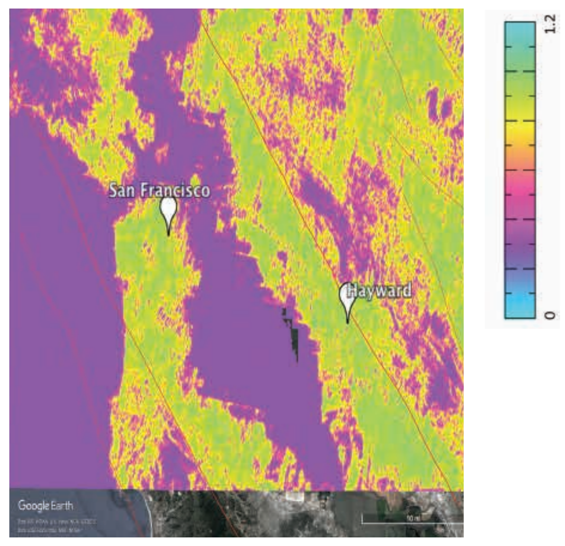

Figure 10: Phase variance created from upsampled 30 meter DEM

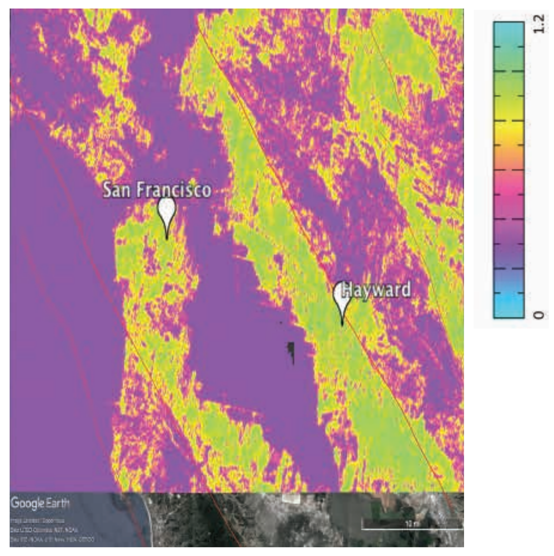

Figure 11: Phase variance created from 30 meter SRTM DEM

Time Series Results

Our time series focuses on Sentinel-1A SAR images. We process 19 pairs, with 12-day repeat intervals, spanning from February 23, 2017 to October 09, 2017

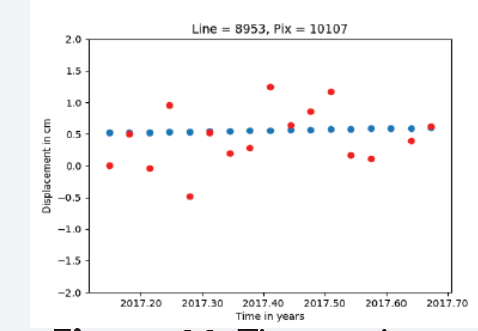

Figure 11: Time series showing individual LOS decrease for a pixel from Figure 14 below

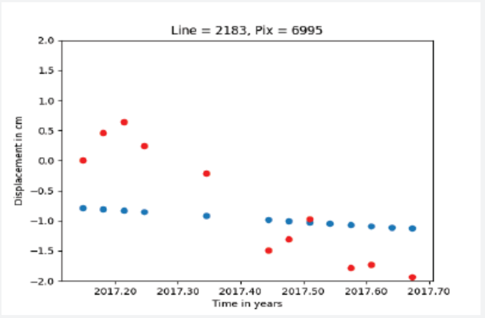

Figure 11: Time series showing individual LOS increase for a pixel from Figure 14 below

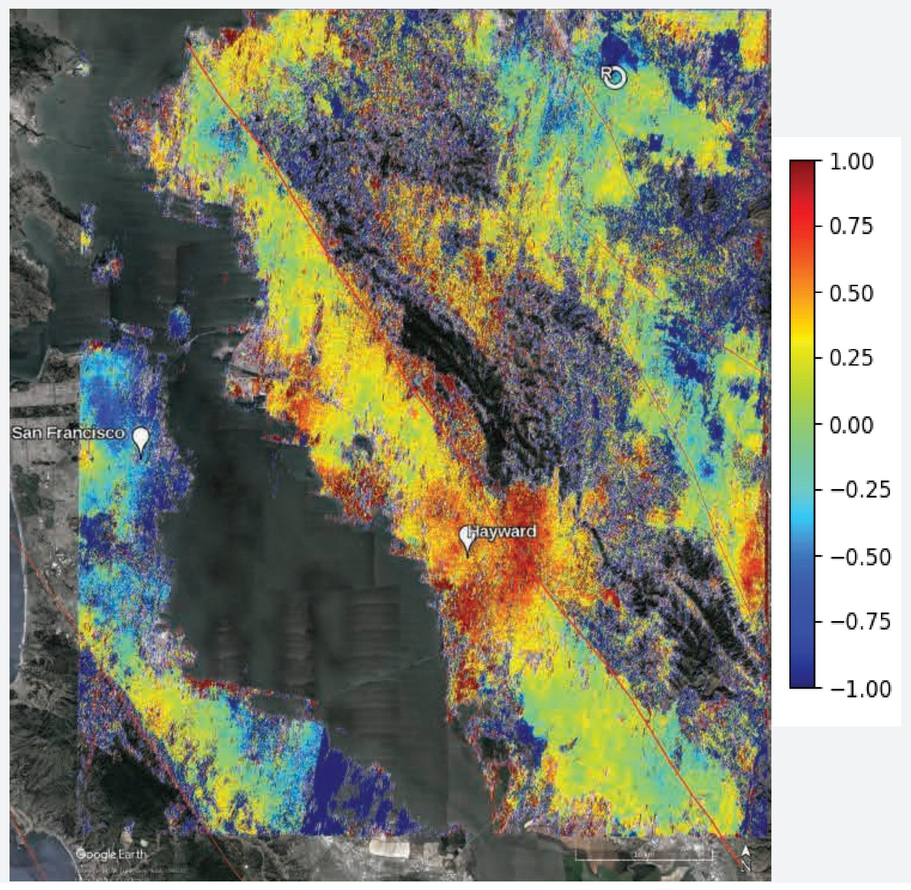

Figure 14: Cumulative displacement map showing LOS deformation over the Hayward Fault area.

Conclusions

Our results so far show that Sentinel-1A/1B can produce high coherence cumulative displacement maps of the Hayward Fault over a short time period. The next step is a more complete time series consisting of 3 or 4 years of data. We also found a stark contrast in coherence between the results with SRTM provided DEM's and our own upsampled DEM's. Our findings support a case for reprocessing previous research with higher resolution DEM's to improve results and coherence. Future work will involve looking at pixel coherence statistics over slope variations to better quantify our recovery.

Acknowledgements

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