GeoGateway for Learning about Crustal Deformation, Data Analysis and Applications

Earth Educators Rendezvous 2021

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Abstract

Science gateways allow users to access shared data, software, and services. GeoGateway (http://geo-gateway.org) is a solid earth geoscience gateway that provides tools for scientific discovery, field use, and disaster response using Interferometric SAR (InSAR) and Global Navigation Satellite System (GNSS) integrated with earthquake faults, seismicity, and model data. GeoGateway was initially developed for researchers to analyze and model crustal deformation related to fault slip and earthquakes. Two highlights of GeoGateway are interactive map displays of global GNSS-based land deformation and thousands of radar images from the NASA airborne platform (UAVSAR). Applications have been expanded to include earthquake nowcasting, and analysis of wildfire burn areas and debris flows for disaster response. We are expanding GeoGateway to include educational applications. To make GeoGateway accessible to a broad audience, we developed a GeoGateway User Guide and example applications. Preliminary exercises and tutorials were tested in the classroom at CalPoly Pomona in 2018, and in workshops at the Seismological Society of America 2019 Meeting, and Geological Society of America 2020 Meeting. We are now developing additional example exercises for use as undergraduate class exercises or problem sets in a variety of geoscience and disaster response classes.

GeoGateway

The **purpose** of GeoGateway is to increase the value of existing geodetic imaging products from NASA as well as GNSS products from federally funded analysis centers to enable researchers to explore and integrate these data products. Geodetic imaging refers to mapped distributions of subcentimeter-level regional surface deformation due to crust-depth and shallower geologic processes including plate motion and earthquakes. Here we show examples of GeoGateway tools for data exploration and analysis.

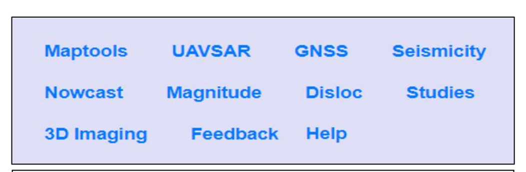


Figure 1: GeoGateway includes 11 tabs, which contain tools for scientific discovery, field use, and disaster response.

GeoGateway Goals:

- Bridge the gap between production and end-use of data products
- Simplify discovery of geodetic imaging and GPS data products
- Enable researchers to explore and integrate data products
- Allow researchers to easily share, publish, and collaborate

Locating Faults Using UAVSAR Interferograms

UAVSAR interferogram data is collected using radar instruments, providing detailed images of ground deformation.[2] Land features are imaged multiple times to assess changes over time.[3] The collected data assits in identifing deformation caused by earthquakes, glacier movements, landslides, and other factors. *Figure 2* shows how UAVSAR interferogram data can be used to view the San Andreas fault (SAF). *Figure 2(b)* shows the side-by-side view of selected interferograms, which form a linear feature between points **A** and **B**. This line is the SAF. Figure *2(a)* shows the Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) faults plotted as black lines overlain on the UAVSAR interferograms. The relatively high slip rate SAF is the most prominent fault imaged by UAVSAR interferograms in *Figure 2b*.

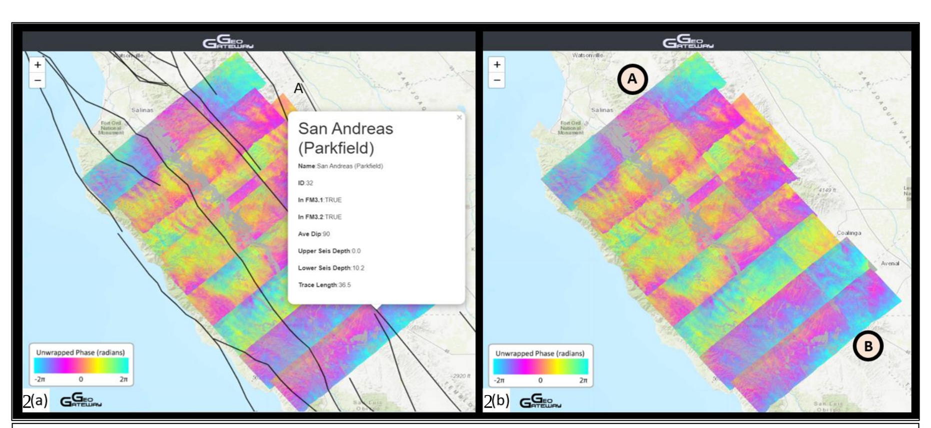


Figure 2(a): Interferogram overlayed on a segment of the SAF creeping section. The black lines represent UCERF3 faults.

Figure 2(b): The side-by-side strips of interferograms displays the SAF. The figure displays the SAF running prominently through all the interferograms.

Locating Fault Creep Using UAVSAR Interferograms

The creeping section of the SAF is located between Juan Bautista and Parkfield. UAVSAR interferogram swaths allow users to image the creeping section and measure creep. In *Figure 3(a)*, an interferogram swath numbered 23015 with timeframe October 27, 2009 - November 18, 2010, is displayed between King City, CA and Coalinga, CA. Overlaying the UCERF3 faults shown in black allows users to validate the location of the SAF. The line-of-sight (LOS)[3] tool shows a change in distance within the selected swath spanning the SAF. This example shows 6.1 cm of LOS slip across the fault. *Figure 3(b)* displays the same swath without UCERF3 faults overlayed. The location where the darker and lighter green join is where the SAF is located.

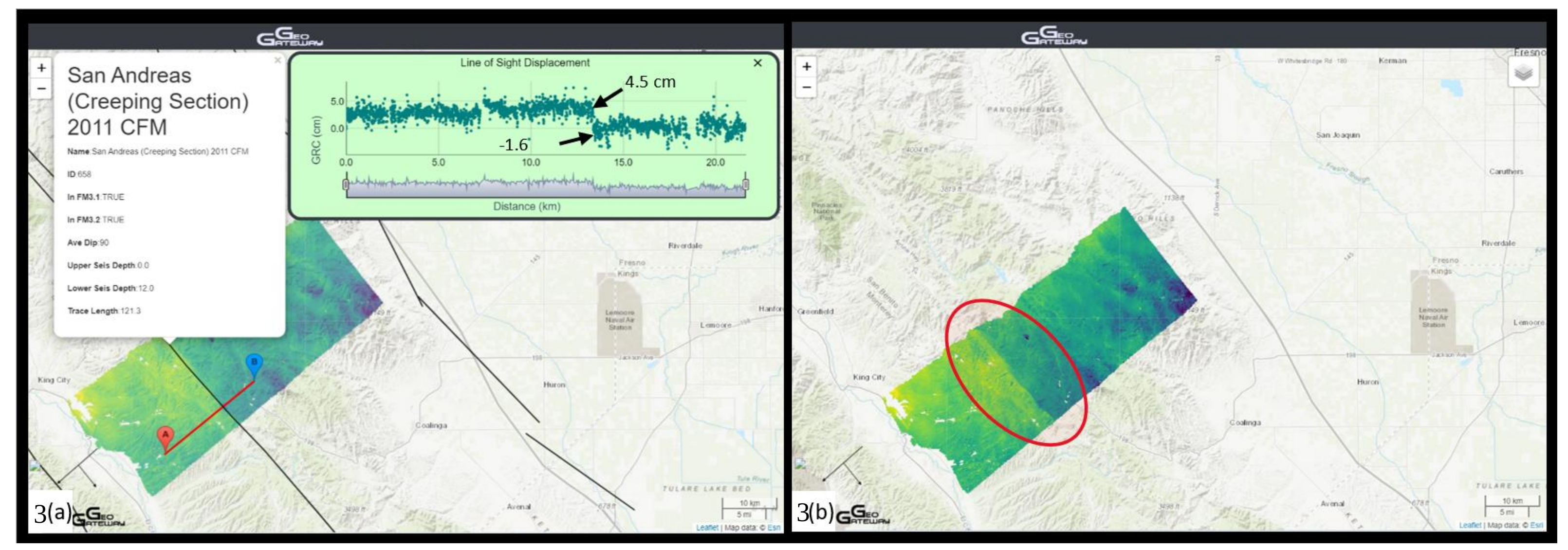


Figure 3(a): Interferogram overlayed on the creeping section of the SAF. The black lines represent UCERF3 faults. The SAF runs through the interferogram where there is a line-of -sight (LOS) change. The LOS tool displays surface displacement for the period between flights.

Figure 3(b): Interferogram displays surface change (displacement) within the red circle where the dark green and light green meet.

Analyzing Coseismic Slip with UAVSAR Interferograms

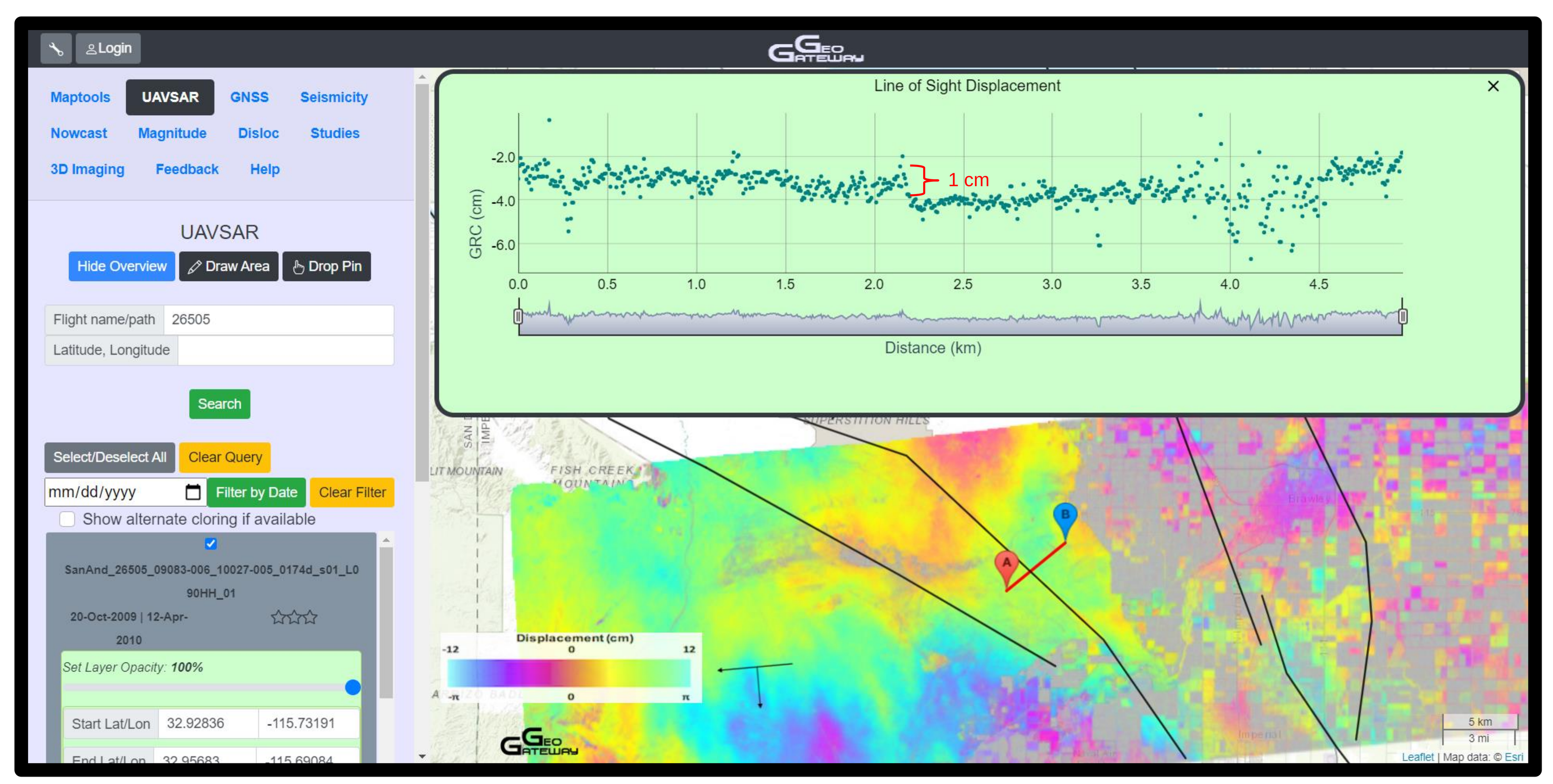


Figure 4: UAVSAR interferogram used to visualize coseismic slip at the Superstition Hills fault (SHF) north of the California and Mexico border. The line-of-sight (LOS) indicated as a red line crosses over the SHF.

The use of UAVSAR provides information about crustal deformation that is useful in analyzing earthquake cycles.[1] UAVSAR interferograms reveal surface slip on multiple faults in the Imperial Valley triggered by the April 4, 2010, Mw 7.2 El Mayor-Cucapah (EMC) earthquake.[3,4,5,7] *Figure 4* shows coseismic creep observed on the Superstition Hills fault (SHF) with 1 cm of LOS displacement across the fault which corresponds to 2 cm creep on the SHF if the slip is horizontal and parallel to the slip lineation.[4]

Global Navigation Satellite System (GNSS) Tool

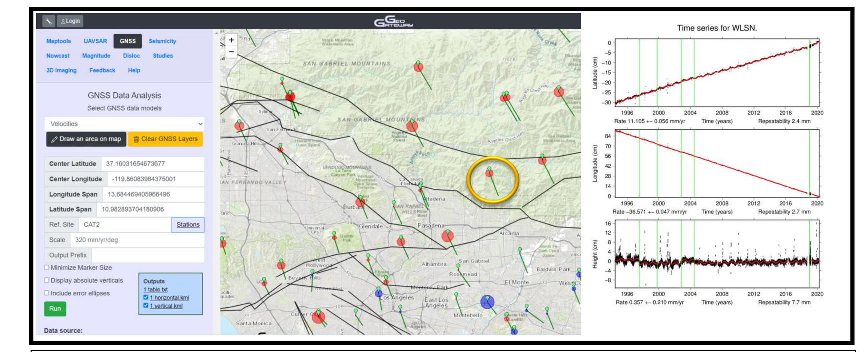


Figure 5(a): GNSS stations movement relative to Catalina Island, CA

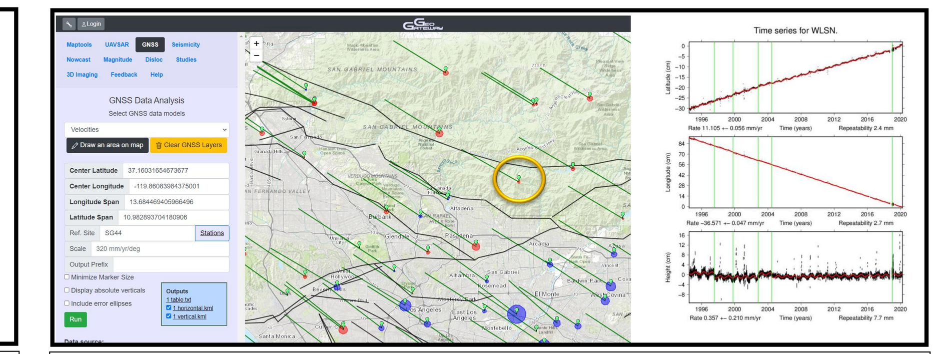


Figure 5(b): GNSS stations movement in reference to the state of Kansas

GeoGateway's GNSS tool can be used to measure plate motion and detect strain accumulation across faults using data from different GNSS stations (station data sourced by Jet Propulsion Laboratory and the Nevada Geodetic Laboratory).[1 2 7] Station movement is displayed as vectors on a map or within plots. *Figure 5(a)* illustrates motion of stations in southern California with respect to Catalina Island (CAT2 station) on the Pacific Plate, and with respect to the North American Plate (station SG44 in Kansas) as shown in *Figure 5(b).* Horizontal displacement is indicated by green vectors. The GNSS station pinpoint is the tail of the vector, and the vector length shows how fast the station is moving.[7] Upward motions are shown by red circles, downward motion by blue circles. Three-component line plots display movement of the GNSS station selected. The graphs indicate that station WLSN is moving Northwest. On the top graph for both *figure 5(a)* and *figure 5(b)*, the dots display Northward movement, and in the middle graph, the dots display Westward movement.

Analyzing Coseismic and Postseismic Slip Using GNSS

Figure 6(a), shows El Mayor-Cucapah (EMC) earthquake coseismic displacement. Most stations moved South and upward (red circles) and two stations moved downward (blue circles).

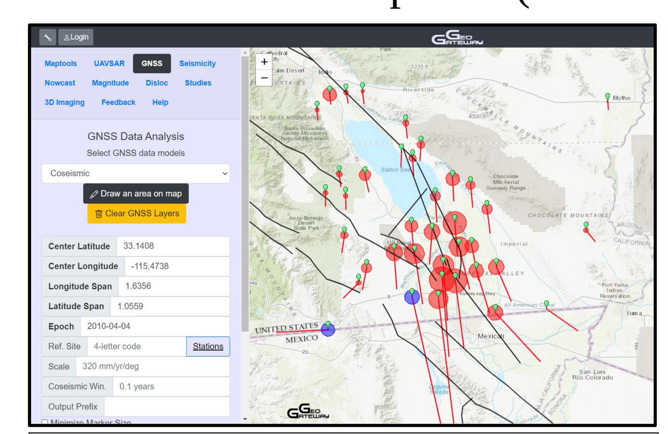


Figure 6(a): Coseismic displacement

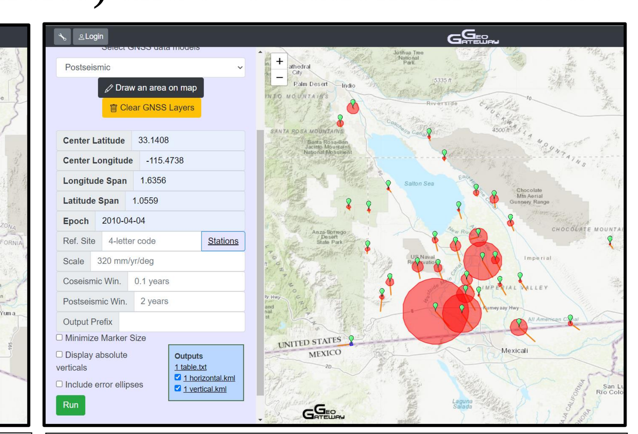
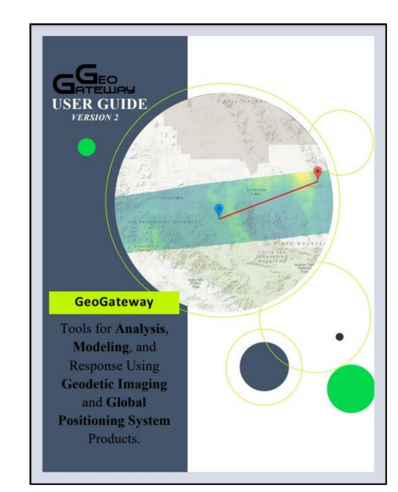
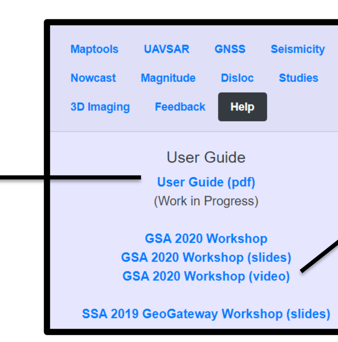


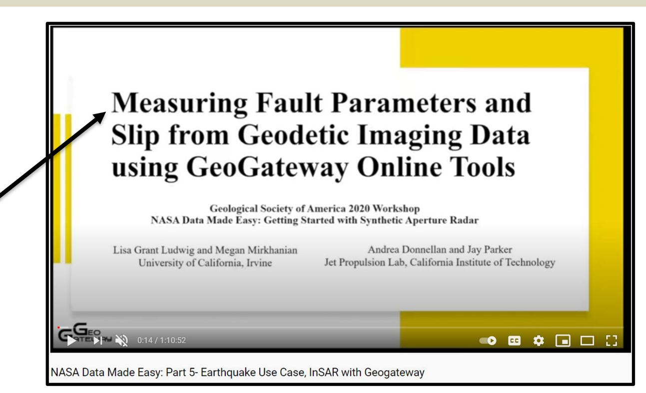
Figure 6(b): Postseismic displacement

Figure 6(b) displays the EMC earthquake's postseismic displacement. Here stations are also moving to the South, but at shorter distances, with all stations displaying movement upward.[4,7]

GeoGateway User Resources







The **Help** tab describes GeoGateway hosted datasets and tools. Resources include a User Guide, links to past workshops, exercises, and tutorial videos (currently under development).

Work Cited

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