Disloc

Elastic dislocation models are commonly used to analyze inversion on faults following the event of an earthquake (Chen et al., 2020). In 1985, Yoshimitsu Okada (Ph.D.) proposed a formula which calculated displacement in an isotropic, uniform elastic half space. The formula can calculate coseismic deformation caused by any fault within the elastic half space (Okada, 1985). Okada's dislocation theory, which is the most commonly used dislocation theory, is often used with InSAR. InSAR monitors the surface coseismic deformation field, and subsequently, Okada's theory is used to conduct fault slip inversion, calculating the coseismic strain stress field (Chen et al., 2020). Elastic dislocation models generated by Disloc can be used to geodetically measure deformation of an elastic medium due to slip from active faults (Avouac, n.d.).

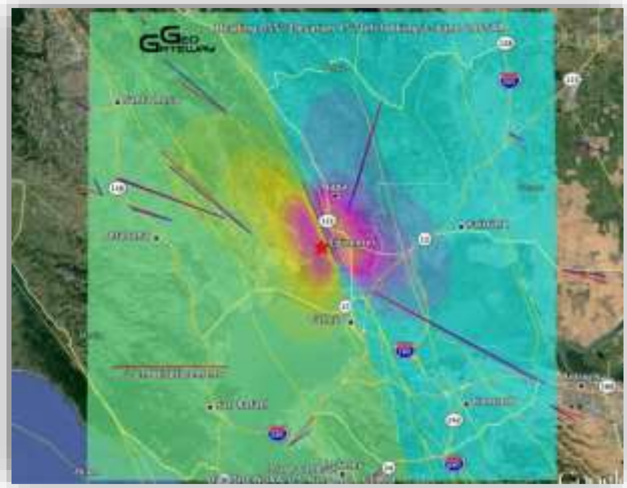


Figure 1: Example of Okada's dislocation in an elastic half space (figure adapted from NASA's GeoGateway team).

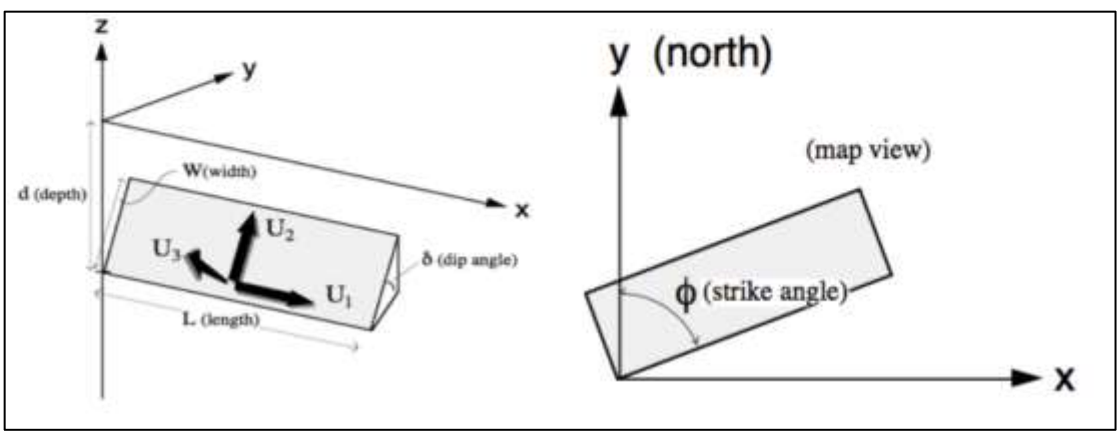


Figure 2: Elastic Dislocation Fault Parameters (figure adapted from Harvey Mudd College)

In *figure 2*, the ***location*** of the fault is defined as the surface projection of the lower-left corner of the fault plane. The ***depth*** is represented as the z-coordinate of the fault's bottom edge. The depth is the absolute value of the z-coordinate. The ***dip*** angle is measured from horizontal (Harvey Mudd College, n.d.).

The ***strike*** angle is the orientation (measured clockwise from north) of the surface projection of the fault's horizontal edges. The ***length*** and ***width*** are the dimensions of the rectangular fault (Harvey Mudd College, n.d.).

U_1 is the strike slip component of fault slip (strike-slip dislocation U_1 greater than 0 identifies a right lateral motion).
U_2 is the dip slip component of fault slip (dip-slip dislocation U_2 greater than 0 identifies a reverse motion).
U_3 is the tensile component of fault slip (tensile dislocation U_3 greater than 0 identifies a tensile opening).

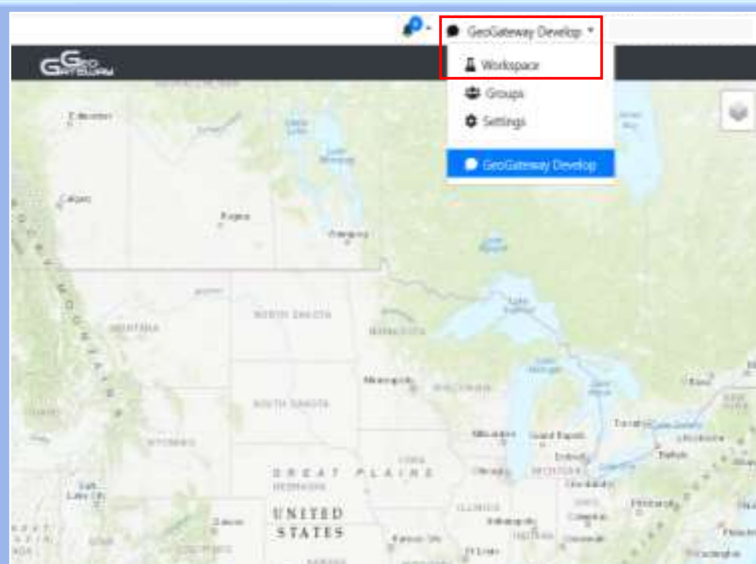
To run Disloc, visit the Disloc tab on GeoGateway and follow the following steps.

Step 1: Create an account on GeoGateway by visiting https://geo-gateway.org/auth/create-account

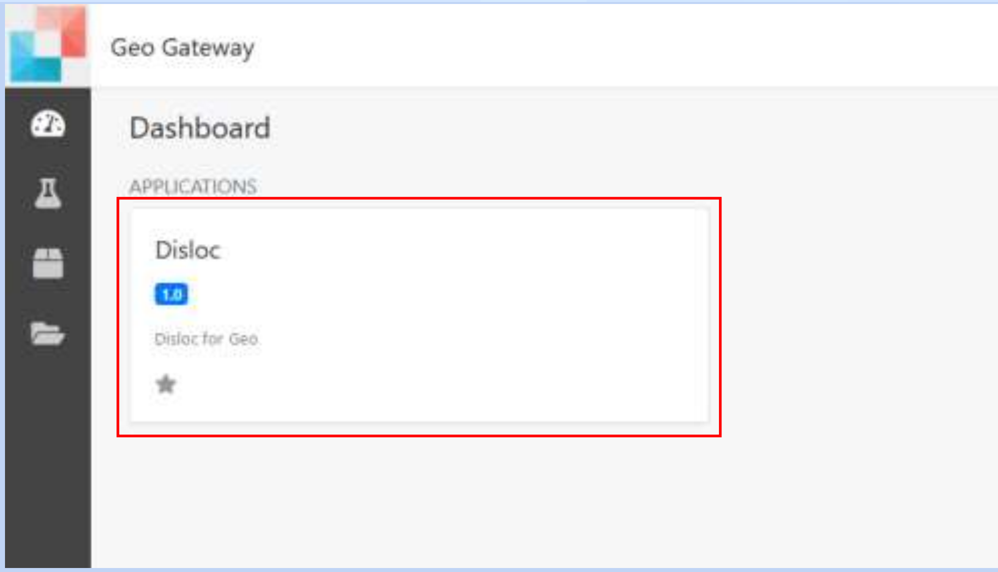
Step 2: Log into GeoGateway by clicking on the "

" button on the left corner found on GeoGateway's homepage.

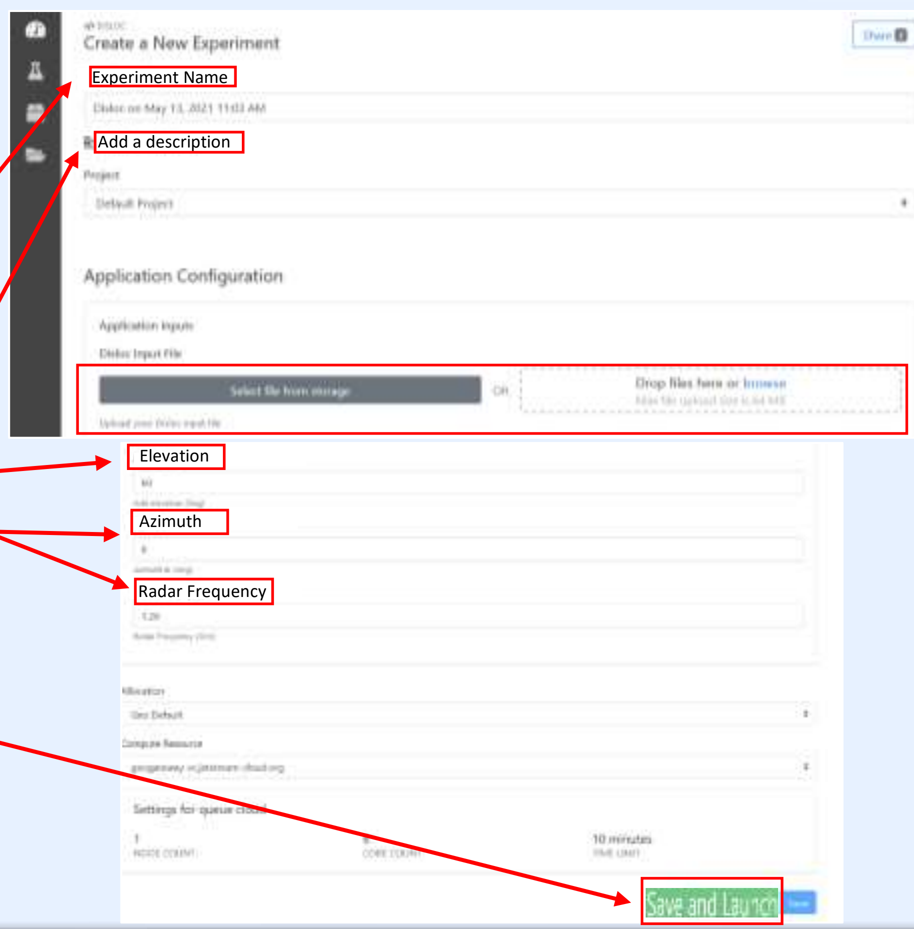
Step 3: On the upper right corner on GeoGateway's homepage, click on "GeoGateway Develop," and then click on "Workspace."



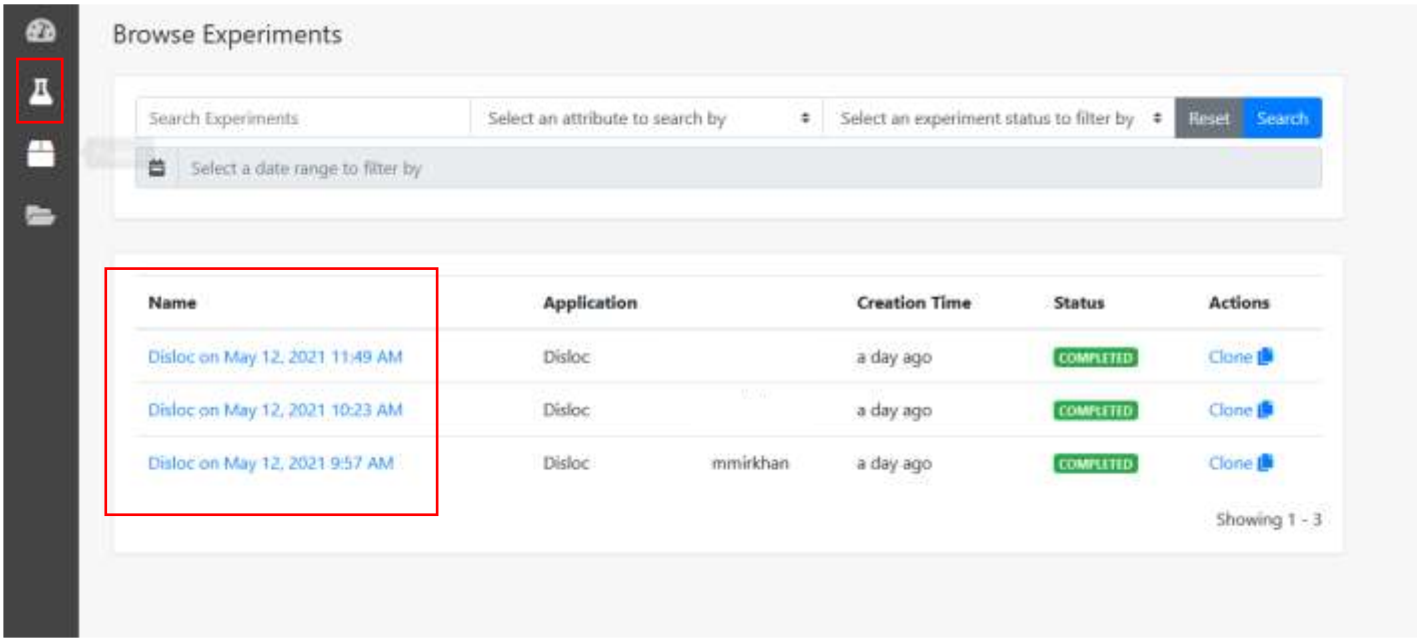
Step 4: Click on the “Disloc” application as shown within the red box.



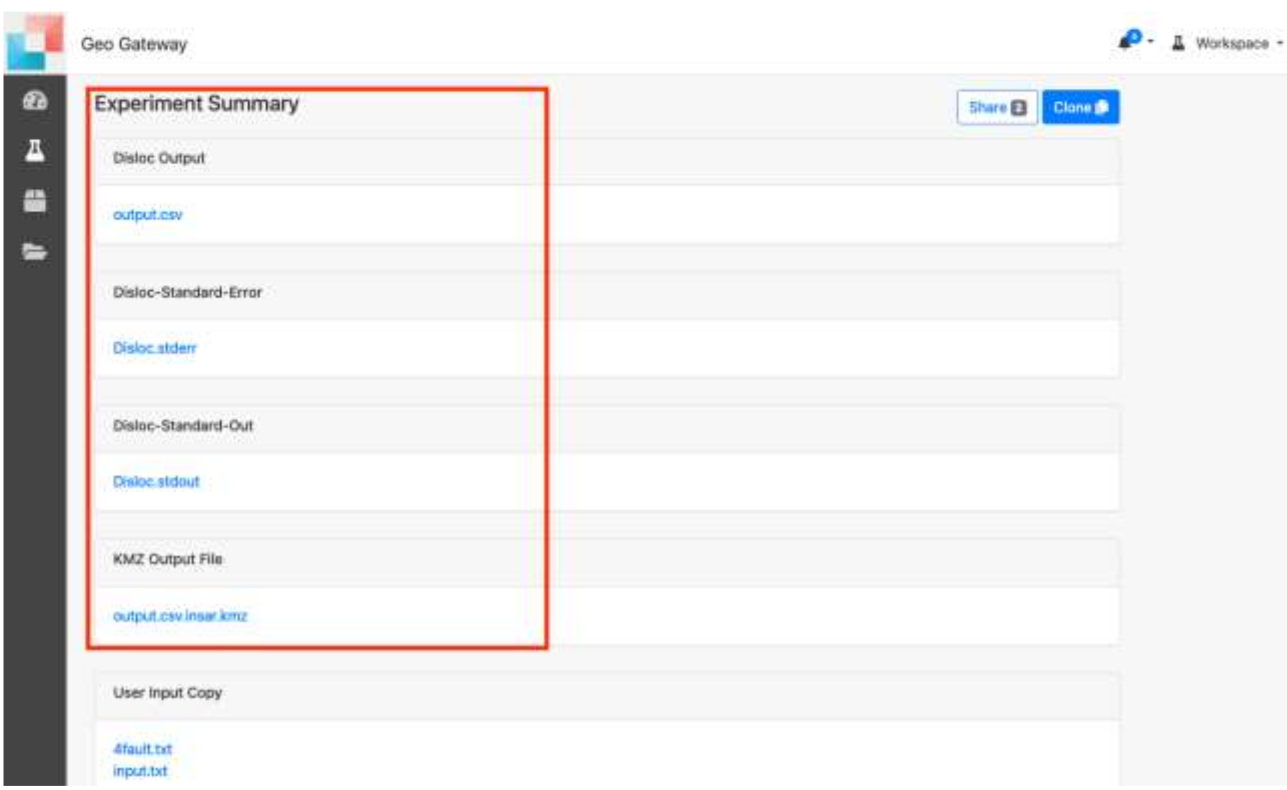
Step 5: Users must upload their Disloc files into the area shown in the red box. Users have the option to change the experiment name and add a description by clicking on “Add a description.” Users may also change the “elevation,” “azimuth,” and “radar frequency,” of their choice as shown in the image to the right. Lastly, click on the green button, “Save and Launch.” Note the data might take a couple of minutes to load.



To find the output files, click on the Erlenmeyer flask found on the left side of the page. There the output file name will be displayed. To view the output files, click on the experiment of interest.



In the image below, the experiment summary and output files are displayed. Now, users may download each of these files.



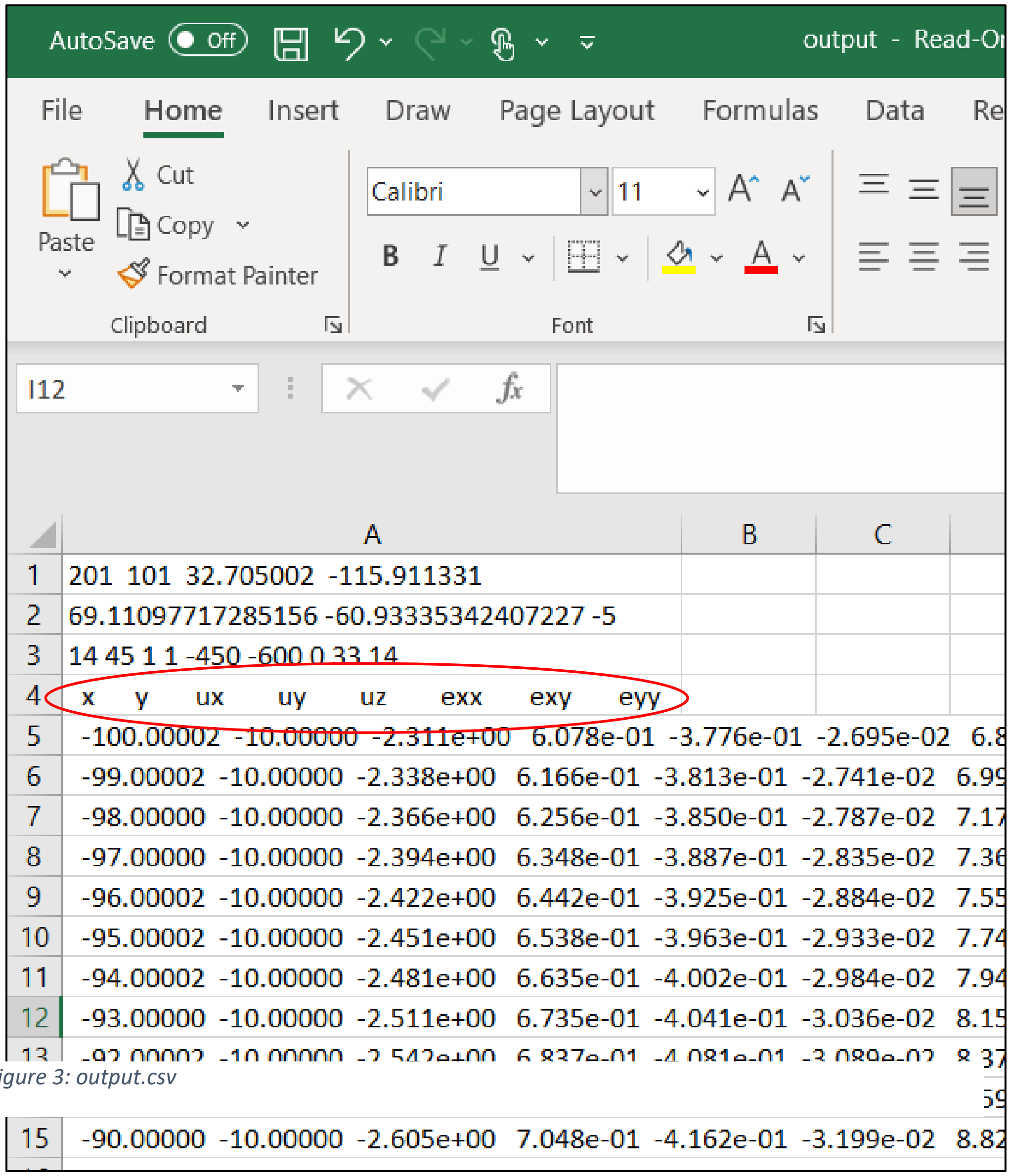


Figure 3: output.csv

Figure 3 displays the output.csv file which shows the x, y, U_1, U_2, and U_3 (refer to *figure 2*), and exx, exy, and eyy (components of the surface strain) factors. For more information regarding the parameters used please refer to (Okada, 1985).

Referring to Step 5, users must upload a text file. The figure below shows what the text file must include.

Line 1: Latitude Longitude # (The latitude and longitude are the model origin location, corresponding to x = 0, y = 0. The # represents the generation parameter. This tells how you will specify the points at which you want calculated displacements. If it is 0, this means you will be giving it a list of arbitrary x, y points (good for irregularly distributed sites). If it is 1, this means you are asking for output at regularly spaced points on a rectangular grid

Example of line 1: 32.705000 -115.911333 1

Line 2: x_0 x_Δ $x_\#$ y_0 y_Δ $y_\#$ (Represents the grid: This consists of starting x-coordinate (km), increment in x-direction (km), number of steps in x-direction, starting y-coordinate (km), increment in y-direction (km), number of steps in y-direction).

Example of line 2: -100 1 201 -10 1 101

Line 3: x, y (km) from origin and strike (degrees) (x coordinate and y coordinate of the first fault and the strike angle of the fault, measured clockwise from north)

Example of line 3: 69.110979 -60.933355 -5

Line 4: fault type 0 for point dislocation and 1 for rectangular plane dislocation, depth, dip (degrees), lambda (λ), mu (μ), u_1, u_2, u_3, length (km), width (km)

(Provide the vertical depth to the *bottom* of the fault, followed by the dip angle in degrees (zero for horizontal; 90° for vertical). The λ and μ are the Lamé elastic parameters, their absolute values are not important, only their ratio. For both lambda and mu, units are nominally Pascals (Pa), but in disloc, only their ratio is used, therefore the units cancel out. It is practical to set both to the value "1". Disloc then models the earth as an isotropic elastic solid with a Poisson Ratio of 0.25. λ=μ is the most common assumption for typical rocks. U_1, U_2, and U_3 are the amounts of relative slip to apply to the fault surface in the strike-slip, dip-slip, and tensile directions, respectively. Positive U_1 corresponds to *left-lateral motion* (opposite in sense to the San Andreas fault for example. Positive U_2 corresponds to *thrusting motion* with the hanging wall riding up over the foot wall (like the San Gabriel mountains for example). U_3 will not normally be used since ordinary earthquake faults involve motion only tangential to the fault plane. Finally, the length and width of the rectangular fault surface.)

Example of line 4: 1 14 45 1 1 -450 -600 0 33 14

Repeat the formatting from line 3 and line 4 for each additional fault.

Example of line 5 (same format as line 3): 56.877979 -45.030355 -48

Example of line 6 (same format as line 4): 1 15 75 1 1 -830 0 0 51 15

Example of line 7 (same format as line 3): 46.475979 -56.538355 132

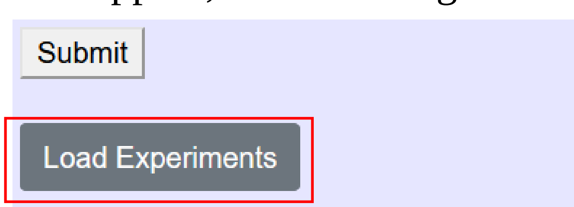
Example of line 8 (same format as line 4): 1 14 60 1 1 -830 0 0 60 14

Example of line 9 (same format as line 3): 25.940979 -9.411355 -25

Example of line 10 (same format as line 4): 1 12 50 1 1 -100 0 0 18 12

Figure 4: Dislocation input data

To allow the output file to be shown on GeoGateway, return to the Disloc tab on the GeoGateway website and click on "Load Experiments" as shown in the image below. Once the experiments appear, click on the green highlighted text



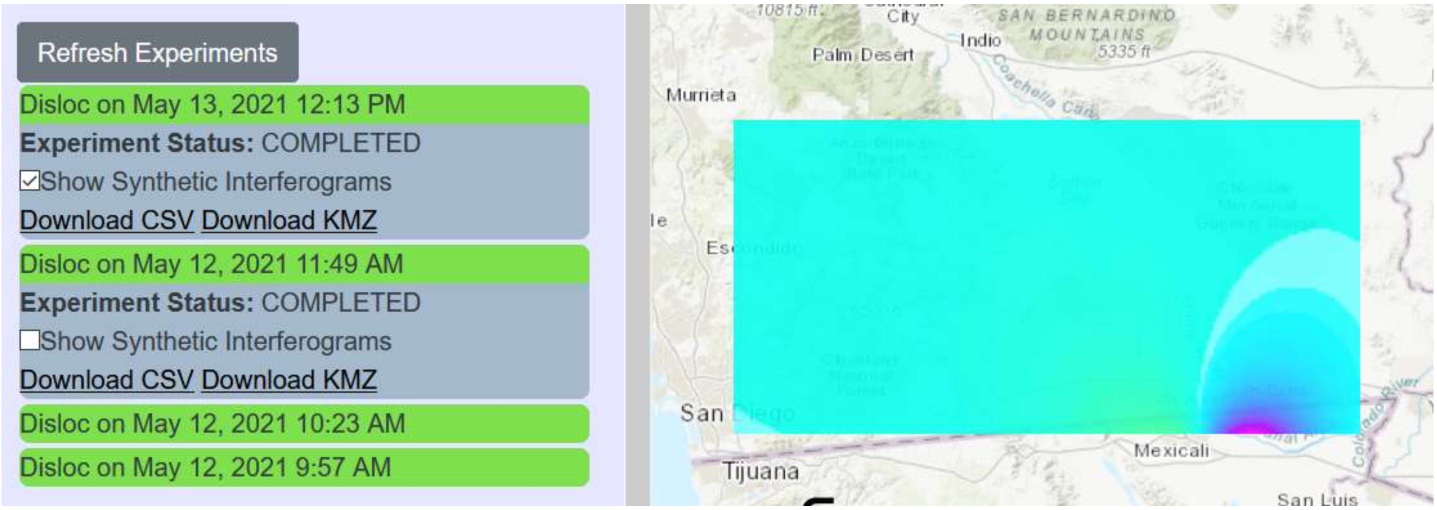


Figure 5: Dislocation output data displayed on map on GeoGateway. The image is in correspondence to lines 1-4 from figure 4.

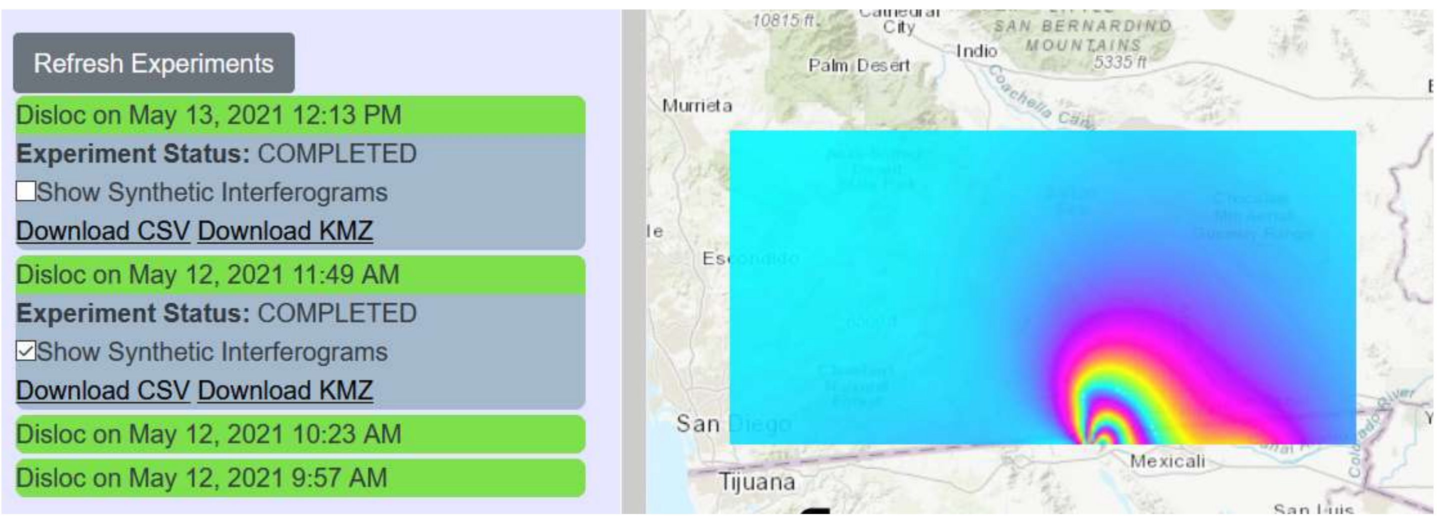


Figure 6: Dislocation output data displayed on map on GeoGateway. The image is in correspondence to lines 1-10 from figure 4.