

# 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.).

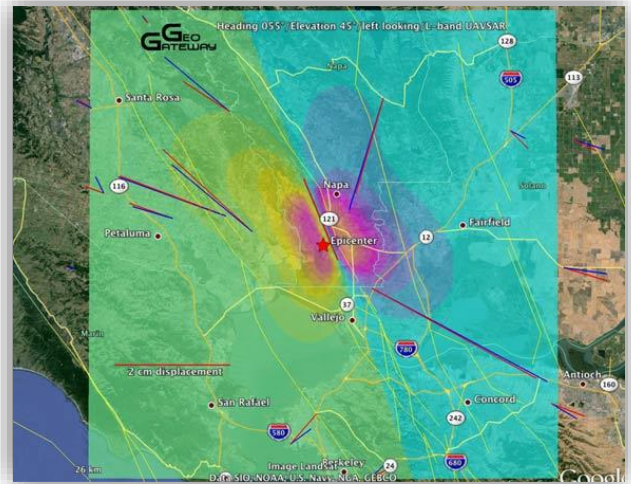


Figure 1: Example of Okada's dislocation in an elastic half space (figure adapted from NASA's GeoGateway team).

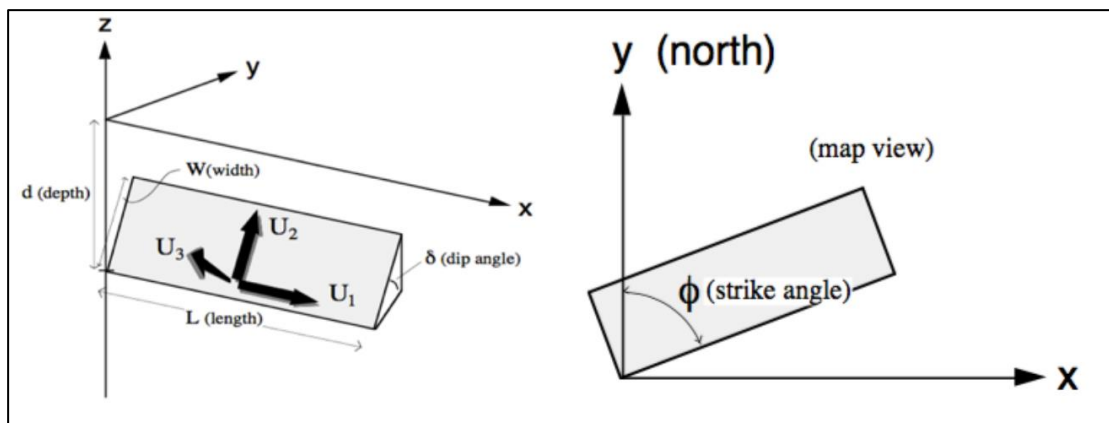


Figure 2: Elastic Dislocation Fault Parameters (figure adapted from Harvey Mudd College)

In *figure 3*, 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 **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).

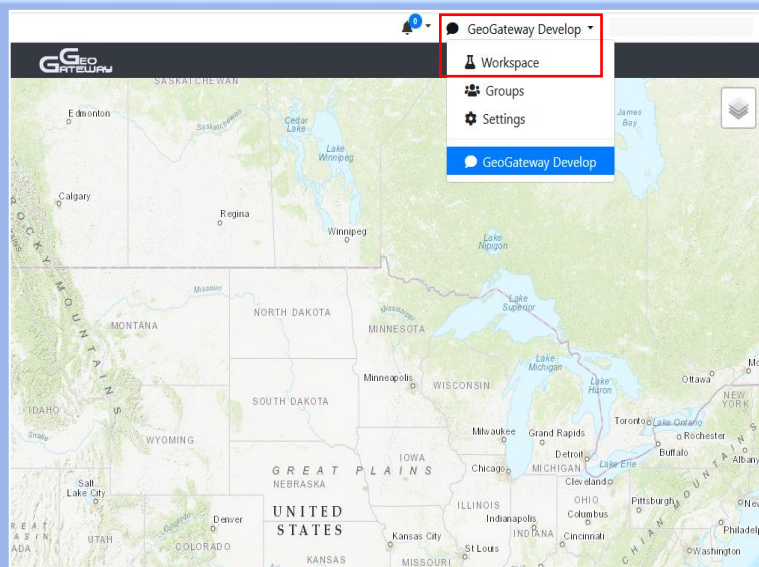
To run Disloc, visit the Disloc tab on GeoGateway and follow the following steps.

Step 1: Create an account on GeoGateway by visiting

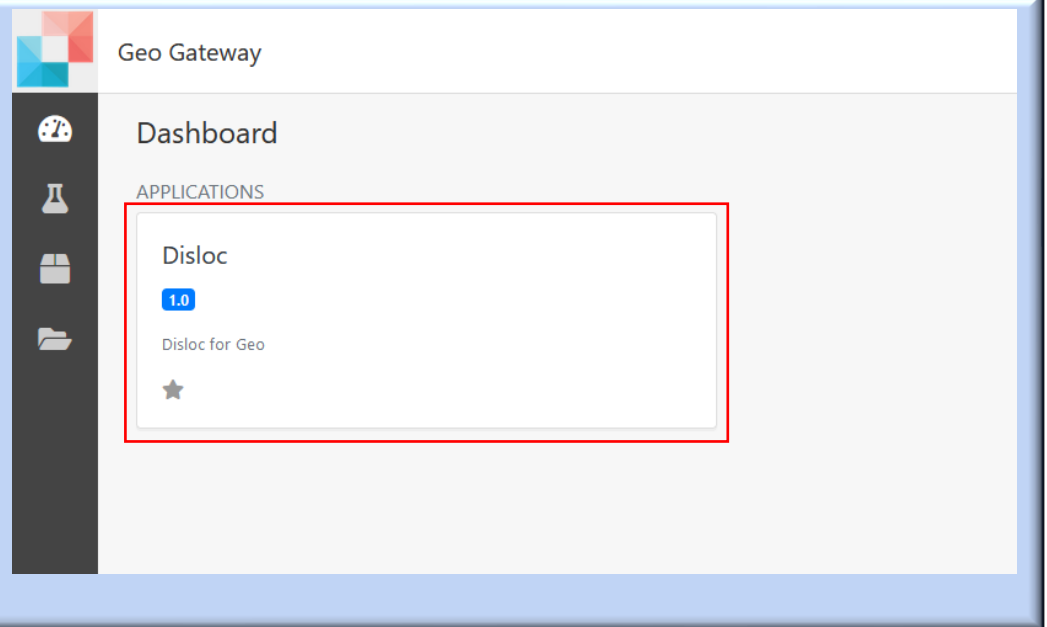
<https://geo-gateway.org/auth/create-account>

Step 2: Log into GeoGateway by clicking on the “ Login” 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.

The screenshot shows the 'Create a New Experiment' form in the Disloc application. The form includes several sections: 'Experiment Name' with a text input field, 'Add a description' with a text area, 'Project' with a dropdown menu, 'Application Configuration' with 'Application Inputs' and 'Disloc Input File' (a file upload area with a red box around it), 'Elevation' (60), 'Azimuth' (0), 'Radar Frequency' (1.26), 'Allocation' (Geo Default), 'Compute Resource' (geogateway-vc-jetstream-cloud.org), and 'Settings for queue cloud' (1 NODE COUNT, 0 CORE COUNT, 10 minutes TIME LIMIT). A green 'Save and Launch' button is at the bottom right. Red arrows point from the text in Step 5 to the 'Experiment Name', 'Add a description', 'Elevation', 'Azimuth', 'Radar Frequency', and 'Save and Launch' button.

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.

Browse Experiments

Search Experiments    Select an attribute to search by    Select an experiment status to filter by    Reset    Search

Select a date range to filter by

| Name                            | Application | Creation Time      | Status    | Actions |
|---------------------------------|-------------|--------------------|-----------|---------|
| Disloc on May 12, 2021 11:49 AM | Disloc      | a day ago          | COMPLETED | Clone   |
| Disloc on May 12, 2021 10:23 AM | Disloc      | a day ago          | COMPLETED | Clone   |
| Disloc on May 12, 2021 9:57 AM  | Disloc      | mmirkhan a day ago | COMPLETED | Clone   |

Showing 1 - 3

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

Geo Gateway    Workspace

Experiment Summary    Share    Clone

Disloc Output  
output.csv

Disloc-Standard-Error  
Disloc.stderr

Disloc-Standard-Out  
Disloc.stdout

KMZ Output File  
output.csv.insar.kmz

User Input Copy  
4fault.txt  
input.txt



|    | A   | B | C |
|----|---|---|---|
| 1  | 201 101 32.705002 -115.911331   |   |   |
| 2  | 69.11097717285156 -60.93335342407227 -5                               |   |   |
| 3  | 14 45 1 1 -450 -600 0 33 14   |   |   |
| 4  | x y ux uy uz exx exy eyy  |   |   |
| 5  | -100.000002 -10.000000 -2.311e+00 6.078e-01 -3.776e-01 -2.695e-02 6.8 |   |   |
| 6  | -99.000002 -10.000000 -2.338e+00 6.166e-01 -3.813e-01 -2.741e-02 6.99 |   |   |
| 7  | -98.000000 -10.000000 -2.366e+00 6.256e-01 -3.850e-01 -2.787e-02 7.17 |   |   |
| 8  | -97.000000 -10.000000 -2.394e+00 6.348e-01 -3.887e-01 -2.835e-02 7.36 |   |   |
| 9  | -96.000002 -10.000000 -2.422e+00 6.442e-01 -3.925e-01 -2.884e-02 7.55 |   |   |
| 10 | -95.000002 -10.000000 -2.451e+00 6.538e-01 -3.963e-01 -2.933e-02 7.74 |   |   |
| 11 | -94.000002 -10.000000 -2.481e+00 6.635e-01 -4.002e-01 -2.984e-02 7.94 |   |   |
| 12 | -93.000000 -10.000000 -2.511e+00 6.735e-01 -4.041e-01 -3.036e-02 8.15 |   |   |
| 13 | -92.000002 -10.000000 -2.542e+00 6.837e-01 -4.081e-01 -3.089e-02 8.37 |   |   |
| 14 | -91.000000 -10.000000 -2.573e+00 6.942e-01 -4.121e-01 -3.143e-02 8.59 |   |   |
| 15 | -90.000000 -10.000000 -2.605e+00 7.048e-01 -4.162e-01 -3.199e-02 8.82 |   |   |

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:**  $x_0$   $x_\Delta$   $x_\Delta$   $y_0$   $y_\Delta$   $y_\Delta$  (Represents the grid: This consists of starting  $x$ -coordinate, increment in  $x$ -direction, number of steps in  $x$ -direction, starting  $y$ -coordinate, increment in  $y$ -direction, 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, depth, dip (degrees),  $\lambda$  ( $\mu$ ),  $u_1$ ,  $u_2$ ,  $u_3$ , length, width  
(Provide the vertical depth to the *bottom* of the fault, followed by the dip angle in degrees (zero for horizontal; 90° for vertical). The  $\lambda$  and  $\mu$  are the Lamé elastic parameters, their absolute values are not important, only their ratio.  $\lambda = \mu$  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

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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

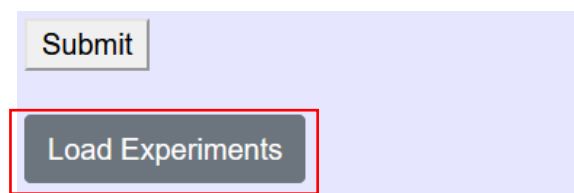
**Example of line 8 (same format as line 4):** 1 14 60 1 1 -830 0 0 60 14

**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





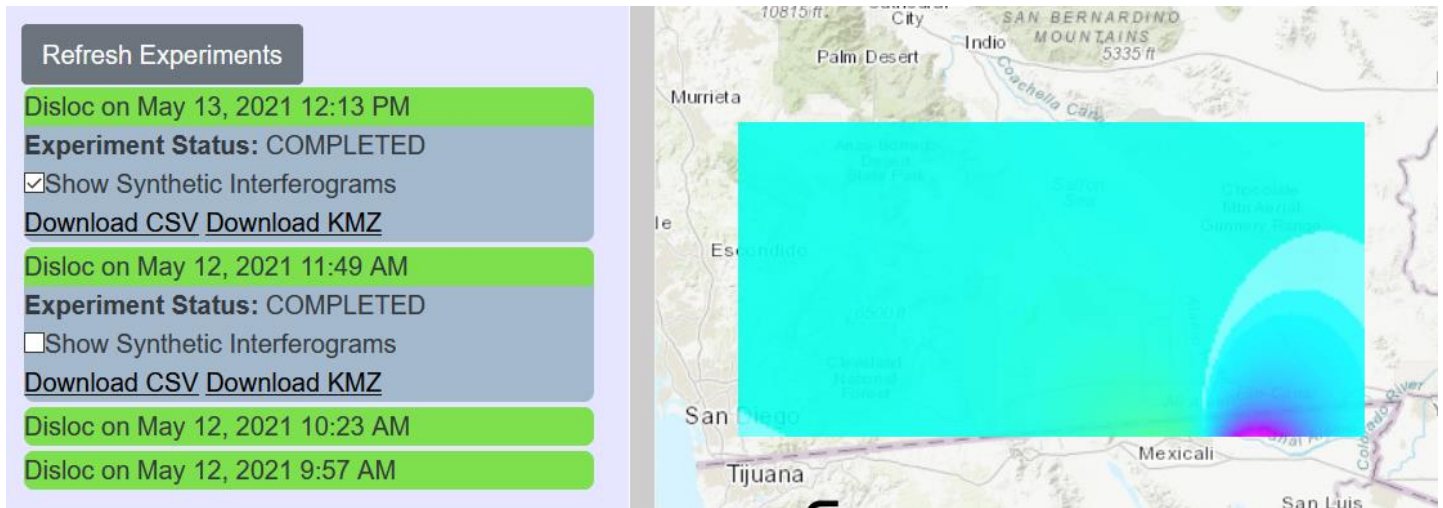


Figure 5: Dislocation output data displayed on map on GeoGateway. The image is in correspondence to line's 1-4 from figure 4.

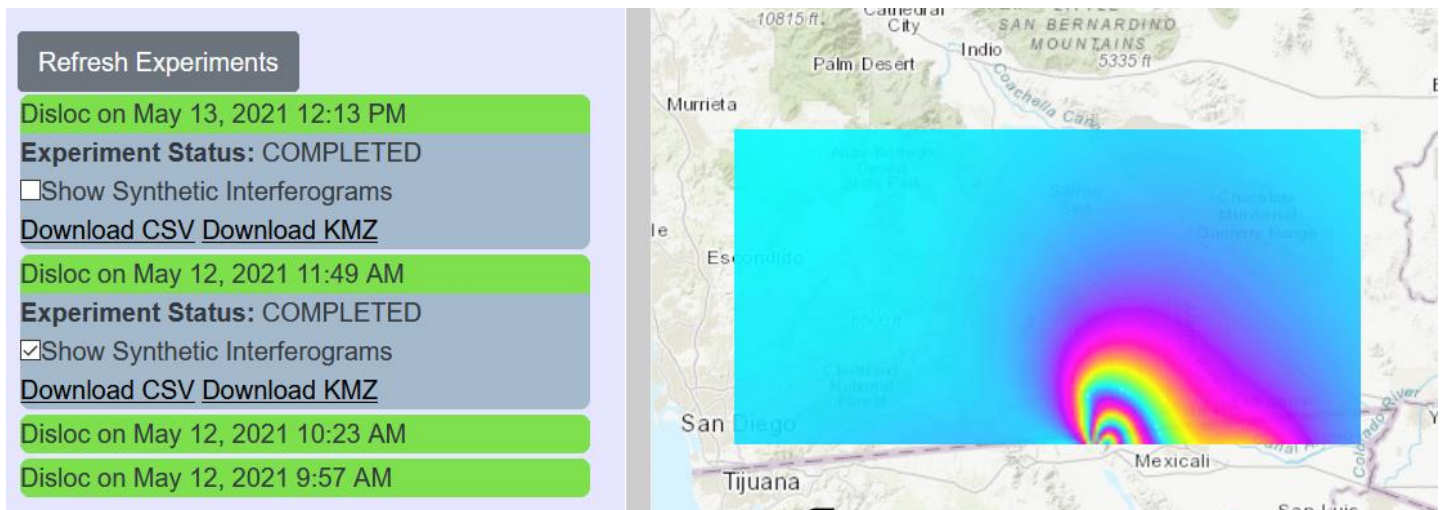


Figure 6: Dislocation output data displayed on map on GeoGateway. The image is in correspondence to line's 1-10 from figure 4.