1. Introduction

This package enables the joint inversion or single data inversion of rupture processes combining any array of teleseismic data, near-field strong motion data, GPS data, and InSAR data. The scripts required to run this package include joint\_invt.m, view\_tele.m, and view\_sm.m, with joint\_invt.m being the main script for joint inversion. The core program was written by Zhang Yong, packaged by Wang Pingchuan, and updated by Hua Sibo.

2. Preparation of the Green's Function Library

Please refer to the document "compute gfunc lib.docx".

3. Data Preparation

3.1 Teleseismic Data

Download GSN broadband SACASC format data from IRIS.

3.2 Strong Motion Data

Organize into a mat file containing 4 variables:

loca: represents the latitude and longitude of stations, size(loca) = [numbers\_of\_stations, 2]; for any station i, loca(i,:) = [latitude, longitude];

mm: represents the station names, size(mm) = [numbers\_of\_stations, 4];

ob: represents the three-component velocity data recorded by the stations, size(ob) = [length\_of\_record, 3, numbers\_of\_stations], with components in order: E, N, U;

srate: represents the sampling rate of the record, i.e., how many samples per second, size(srate) = [1,1].

3.3 GPS Data

Organized into a mat file containing 1 variable:

gps: represents GPS data, size(gps) = [numbers\_of\_sampling, 5]; for any sampling point i, gps(i,:) = [latitude, longitude, eastward\_displacement, northward\_displacement, upward\_displacement].

3.4 InSAR Data

Organized into a mat file containing 2 (or 3) variables:

insar: represents InSAR data, size(insar) = [numbers\_of\_sampling, 6]; for any sampling point i, insar(i,:) = [latitude, longitude, displacement (line-of-sight displacement), cosines of the angles between the line-of-sight displacement direction and three directions for the 4th, 5th, 6th elements].

nsar: represents the number of sampling points for each InSAR scene, size(nsar) = [numbers\_of\_sampling\_of\_each\_photo,1].

(Optional) dr: represents the scale of each InSAR data sampling point (half the length of a square side), size(dr) = [numbers\_of\_sampling,1].

4. How to Use the Package

4.1 Preparation and Selection of Stations for Teleseismic Data (if using teleseismic data)

Open view\_tele.m. This script selects teleseismic stations with appropriate epicentral distances, intervals, and signal-to-noise ratios, and further filters stations by viewing waveforms. Follow the comments in the script to set parameters, and after setting, run the program to generate and save teleseismic waveform files for joint inversion.

4.2 Preparation and Selection of Stations for Strong Motion Data (if using strong motion data)

Open view\_sm.m. This script selects stations by viewing waveforms and station distribution. Follow the comments in the script to set parameters, and after setting, run the program to generate and save strong motion waveform files for joint inversion.

4.3 Performing Inversion

Open joint\_invt.m, follow the comments in the file to set parameters, and after setting, run the program to start the calculation and save the inversion result files. Points to note include:

(2.4)(2.10) When setting the path to the Green's function library, the last level path should be '/green\_func/'.

(2.1)(2.7)(2.13)(2.15) The four weightings cannot be 0 simultaneously; when a weight is 0, the parameter settings below it can be ignored. The larger the weight value, the greater its influence on the results, and for different types of seismic wave data, equal weights will be weighted to the same sum of squares for each record.

(2.5)(2.11) These items allow for a time shift of the waveform to maximize the correlation coefficient with the synthetic waveform after the initial inversion and to perform a second inversion, thereby achieving a higher waveform fitting correlation coefficient. However, allowing a shift means losing the arrival time information of the waveform. For teleseismic waveforms, we generally do not fit the arrival time, so teleseismic waveform shifting is recommended; for strong motion waveforms, which contain good arrival time information, it is suggested not to shift the waveform if the strong motion data is not too poor. The program allows shifting if it does not exceed 5 seconds.

(2.6)(2.12) When adjusting related parameters or when the Green's function changes, it is necessary to recalculate the Green's function.

Note: (2.1) teletp is the method for using teleseismic Green's functions for inversion, where teletp=1 calculates the Green's functions from each subfault to each station, and teletp=0 obtains the Green's functions for each subfault by time-shifting the Green's functions from the source location. If teletp=1, it is necessary to calculate Green's functions for multiple sufficient depths when calculating the Green's function library; if teletp=0, only the Green's function library for the source depth is needed. The parameter Ifastf is whether to invert for the apparent source time function, 1 for yes, 0 for no, and weight\_astf is the weight for the apparent source time function inversion. Since the apparent source time function inversion is less stable than waveform inversion, it is generally not used for rupture process inversion, i.e., usually set ifastf=0. If performing apparent source time function inversion, the slip angle will not be changeable, i.e., rakevar must be 0. If you just want to see the apparent source time functions at different stations without affecting the inversion results, you can set ifastf=1; give weight\_astf a very small value like 0.001.

4.4 Correction of Inversion Results

Based on the fitting of the inversion results, exclude stations with poor or much better fitting than other stations through view\_tele.m and view\_sm.m, and appropriately adjust other parameters that need to be adjusted, and repeat the process 3.1-3.3 until satisfactory inversion results are obtained.

5. Viewing Inversion Results

The run time of the inversion program may vary from tens of seconds to several minutes depending on the parameter settings. After the calculation is completed, up to twelve (if the corresponding data is used) inversion result windows will pop up, including:

1) Subfault source time functions

2) Distribution of teleseismic stations;

3) Distribution of strong motion stations;

4) Total slip distribution on the fault plane;

5) Source time functions

6) Teleseismic record waveform fitting

7) Strong motion record waveform fitting

8) GPS data fitting

9) and 10) InSAR data fitting.

11) Cumulative slip distribution within every n1 seconds time period (this figure can be set n1, n2, n3 see program lines 317~319)

12) Cumulative slip distribution up to different n1 seconds time periods (this figure can be set n1, n2, n3 see program lines 317~319)

13) and 14) Apparent source time function inversion waveforms and stf fitting.

The moment magnitude of the inversion will be displayed in the Matlab workspace.

7. Example

You can try using the data files and Green's functions of the November 13, 2016, M7.8 earthquake in New Zealand in the example-2016NZ folder.

8. Note:

Before inversion, whether for strong motion or teleseismic, the default input data is velocity. If it is displacement or acceleration, it needs to be converted to velocity before input (i.e., it must be ensured that the data ob in ob\_tele.mat and ob\_sm.mat is velocity).