**Purpose:** The program RUPTURE\_BIEM is designed for computation of the earthquake rupture process.

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**Reference to the program:**

The user is asked to make reference to

Xu, J. K., Zhang, H. M. & Chen, X. F. Rupture phase diagrams for a planar fault in 3-D full-space and half-space. Geophys J Int 202, 2194-2206 (2015).

Zhang, H. M. & Chen, X. F. Dynamic rupture on a planar fault in three-dimensional half space - I. Theory. Geophys J Int 164, 633-652 (2006).

Zhang, H. M. & Chen, X. F. Dynamic rupture on a planar fault in three-dimensional half-space - II. Validations and numerical experiments. Geophys J Int 167, 917-932 (2006).

**Basic information:**

The whole package contains two programs: kernel\_full\_z and para\_rupture. The first program calculates the Green's function of the medium, and the second program simulates the rupture process. The result of the first program is the input of the second program.

**Installation guide:**

The program runs on Linux system (Program has been tested successfully on Linux CentOS 7 ). For package kernel\_full\_z, modify the “FC” in Makefile to Intel FORTRAN compiler on your computer and compile directly with the “make” instruction. For package para\_rupture, modify the “Compiler” in Makefile to “GNU” or “Intel”, modify the “FC” in Makefile to Intel or GNU FORTRAN compiler on your computer and compile directly with the “make” instruction. The installation processes take time less than 1 minute.

**Running guide:**

For program kernel\_full\_z, use ”. / FZ.out” to run the program.

For program para\_rupture, use parallel code “mpirun -np {number of cores} ./bin/rupture ” to run the program. You can also run the code by submitting scripts.

**Input for kernel\_full\_z:**

The input file is input\_z.dat. There are 17 rows of inputs. The current version is to calculate the full media version. Therefore, several inputs are not used in the program. See the table below.

|  |  |  |
| --- | --- | --- |
| The line number of the variable | Unit | Description |
| 1 | km/s | Vp |
| 2 | km/s | Vs |
| 3 | / | Not used |
| 4 | / | Space interval ds (ds has been dimensionless processed in this program. Therefore, it’s not used. ) |
| 5 | / | CFL  (CFL determines the time interval dt; CFL=vp\*dt/ds) |
| 6 | / | Not used |
| 7 | / | Not used |
| 8 | / | Not used |
| 9 | / | Not used |
| 10 | Points | Grid start point in x direction  (default 0) |
| 11 | Points | Grid end point in x direction |
| 12 | Points | Grid start point in y direction  (default 0) |
| 13 | Points | Grid end point in y direction |
| 14 | / | Not used |
| 15 | / | Time steps |
| 16 | / | Kernel directory path |
| 17 | / | Saved kernel name |

**Output for kernel\_full\_z:**

The outputs of kernel\_full\_z are saved directly in the folder specified in the input. And the para\_rupture program will read in this output.

**Calculation time kernel\_full\_z:**

The calculation of Green’s function is fast. The time of calculating a 200\*200 grid points and 2000 time steps Green’s function on a core takes half a minute. The smaller the grid points and time steps, the less the calculation time.

**Input for para\_rupture:**

The input file is input\_rup\_z. There are 32 rows of inputs.

|  |  |  |
| --- | --- | --- |
| The line number of the variable | Unit | Description |
| 1 | / | Full space(1) or free surface(2) ( free surface is not available for this version ) |
| 2 | Points | Length of the calculation area |
| 3 | points | width of the calculation area |
| 4 | Km/s | Vp |
| 5 | Km/s | Vs |
| 6 | Km/s | Rupture velocity (The model is in Supplementary material) |
| 7 | / | CFL |
| 8 |  | D0 |
| 9 | / | Ti (Normalized stress) |
| 10 | / | Te (Normalized stress) |
| 11 | Points | Nucleation zone diameter |
| 12 | / | Strike slip fault is 1; Dip slip fault is 2 |
| 13 | Points | Max time step |
| 14 | Points | Max time step of the kernel |
| 15 | Points | X grid point of the center of nucleation zone |
| 16 | Points | Y grid point of the center of nucleation zone |
| 17 | s | Break occurs at this time |
| 18 | Points | Time step that controls the calculation stop. Assuming that the value is 15, the calculation will be terminated if the slip rate of 15 consecutive time step faults changes very little. |
| 19 | / | Kernel directory path |
| 20 | / | Transformed directory |
| 21 | / | Output directory path |
| 22 | / | Time smoothing filter parameter |
| 23 | / | Time smoothing filter parameter |
| 24 | / | Dc (Normalized stress) |
| 25 | / | Not used |
| 26 | / | Te (Normalized stress) |
| 27 | / | Not used |
| 28 | Points | Maximum grid points in X direction |
| 29 | Points | Maximum grid points in X direction |
| 30 | Points | Maximum grid points in Y direction |
| 31 | Points | Maximum grid points in Y direction |
| 32 | Points | Diameter of the barrier boundary |

**Output for para\_rupture:**

The outputs of para\_rupture are saved directly in the folder specified in the input.

Program para\_rupture generates three kinds of output files:

**Output file: “ flag1\_{k}.dat ”**

The output is the flag of the kth time step. The file is N \* M size data, where N is the number of maximum grid points in X direction and M is the number of maximum grid points in Y direction. The data of each point is 0, which means it has not ruptured, and 1, which means it has ruptured.

**Output file: “ rate1\_{k}.dat ”**

The output is the slip rate of the kth time step. The file is N \* M size data, where N is the number of maximum grid points in X direction and M is the number of maximum grid points in Y direction. The data of each point is the dimensionless slip rate. The dimensional slip rate is equal to the dimensionless stress multiplied by 2\*Tu\*vs/Miu, where Tu is the breakdown shear stress drop and Miu is the shear modulus.

**Output file: “ stress1\_{k}.dat ”**

The output is the stress of the kth time step. The file is N \* M size data, where N is the number of maximum grid points in X direction and M is the number of maximum grid points in Y direction. The data of each point is the dimensionless stress. The dimensional stress is equal to the dimensionless stress multiplied by 2\*Tu\*vs/Miu, where Tu is the breakdown shear stress drop and Miu is the shear modulus.

**Calculation time para\_rupture:**

The speed of program calculation varies obviously with the amount of calculation. Using a 100\*100 grid and a rupture process with a time step of about 700 steps, it takes about 15 minutes to calculate in parallel with 100 nodes. Using a 200\*200 grid and a rupture process with a time step of about 700, it takes about one and a half hours for parallel computing with 100 nodes.