CGFD3D-elastic
User Manual

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Contents

Chapter 1

Media

run_test.sh

```
"media_input" : {
    "#import" : "$MEDIA_DIR",
    "#code_generate" : 1,
    "#in_3lay_file" : "${IN_MEDIA_3LAY_FILE}", # *.md3lay
    "in_3grd_file" : "${IN_MEDIA_3GRD_FILE}",  # *.md3grd
    "equivalent_medium_method" : "har",       # default: "loc"
},
"is_export_media" : 1,                        # if export media
"media_export_dir"  : "$MEDIA_DIR",
```

In the configuration of media, if `in_3lay_file` is selected, there need to be a .md3lay file, and the file format is shown in Section 1.1. If `in_3grd_file` is selected, there need to be a .md3grd file, and the file format is shown in Section 1.2.

1.1 Layer to Model

The **media_el_iso_layer2model** function is used to discretize the given layer model to the grid model. It provides two medium parameterization method: using the local point values (`loc`), and volume arithmetic and harmonic averaging method (`har`) [Moczo et al., 2002, 2014].

1.1.1 File Format (.md3lay)

3D Layer Velocity Model File (`.md3lay`)

The following description ignores comment lines and blank lines.

- The first line is the number of interface (`NI`).
- The second line is the information of the given interface mesh:

  `NX   NY   MIN_X   MIN_Y   SPACING_X   SPACING_Y`

  `NX` and `NY` are the number of points along x and y direction;

  `MIN_X` and `MIN_Y` are the minimal x and y coordinates;

  `SPACING_X` and `SPACING_Y` are spacing between points along x and y.
- After then, the elevation, velocity and density are given as:

```
for (ni=0; ni<NI; ni++)
  for (iy=0; iy<NY; iy++) {
    for (ix=0; ix<NX; ix++) {
      fscanf(layer_file, "%f %f %f %f %f %f %f",
             &elevation[ni][iy][ix],
             &vp[ni][iy][ix], &vp_grad[ni][iy][ix],
             &vs[ni][iy][ix], &vs_grad[ni][iy][ix],
             &rho[ni][iy][ix], &rho_grad[ni][iy][ix]);
    }
  }
}
```

For each interface (from the free surface to bottom), a set of elevation values (elevation), v_p (vp), the gradient of v_p (vp_grad), v_s (vs), the gradient of v_s (vs_grad), ρ (rho) and the gradient of ρ (rho_grad) on the regular 2D grid is required.

The velocities and density below interface(x, y, elevation) are calculated by

$$v_p^{grid\ point} = vp + (elevation - z^{grid\ point}) * vp\_grad.$$

1.1.2 Example

A model with a horizontal interface can be given as:

test.md3lay

```
# NI
  2
# NX    NY    MIN_X    MIN_Y    SPACING_X    SPACING_Y
  2     2     0.0      0.0      2000.0       2000.0
# elevation   vp   vp_grad   vs   vs_grad   rho   rho_grad
# interface #1 free surface
    0.0     2500.0  0.0  1500.0  0.0  1500.0  0.0
    0.0     2500.0  0.0  1500.0  0.0  1500.0  0.0
    0.0     2500.0  0.0  1500.0  0.0  1500.0  0.0
    0.0     2500.0  0.0  1500.0  0.0  1500.0  0.0
# interface #2
 -1000.0    4000.0  0.0  2400.0  0.0  2400.0  0.0
 -1000.0    4000.0  0.0  2400.0  0.0  2400.0  0.0
 -1000.0    4000.0  0.0  2400.0  0.0  2400.0  0.0
 -1000.0    4000.0  0.0  2400.0  0.0  2400.0  0.0
```

We provide a more complex model in the `test/` directory.

1.2 Grid to Model

The **media_el_iso_grid2model** function is used to discretize the given grid model to the grid model. It also provides two medium parameterization method: using the local point values (`loc`), and volume arithmetic and harmonic averaging method (`har` in) [Moczo et al., 2002, 2014].

1.2.1 File Format (.md3grd)

The following description ignores comment lines and blank lines.

- The first line is the number of layer (`NL`), if `NL` > 1, there is a designated interface.
- the next `NL` lines are the number of grids in the z-direction of each layer

- The third line is the information of the given interface mesh:

  `NX NY MIN_X MIN_Y SPACING_X SPACING_Y`

  `NX` and `NY` are the number of points along x and y direction;

  `MIN_X` and `MIN_Y` are the minimal x and y coordinates;

  `SPACING_X` and `SPACING_Y` are spacing between points along x and y.

- After then, the elevation, velocity and density are given in every grid points:

```
for (ig=0; ig<ng_z; ig++)
  for (iy=0; iy<NY; iy++) {
    for (ix=0; ix<NX; ix++) {
      fscanf(grid_file, "%f %f %f %f", &elevation[ig][iy][ix],
            &vp[ig][iy][ix], &vs[ig][iy][ix], &rho[ig][iy][ix]);
    }
  }
}
```

The velocities and density are calculated by interpolation of the values at the given grid points.

1.2.2 Example

A model with a horizontal interface can be given as:

test.md3lay

```
# NL
  2
# How many z-grids are in each layer
  2
  2

# NX    NY    MIN_X    MIN_Y    SPACING_X    SPACING_Y
  2     2     0.0      0.0      2000.0       2000.0
# elevation    vp       vs      rho
# z-grid #1: Top - free surface
    0.0     2500.0  1500.0  1500.0
    0.0     2500.0  1500.0  1500.0
    0.0     2500.0  1500.0  1500.0
    0.0     2500.0  1500.0  1500.0
# z-grid #2
 -1000.0    2500.0  1500.0  2400.0
 -1000.0    2500.0  1500.0  2400.0
 -1000.0    2500.0  1500.0  2400.0
 -1000.0    2500.0  1500.0  2400.0
# z-grid #3 (the elevation needs to be the same as #2)
 -1000.0    4000.0  2400.0  2400.0
 -1000.0    4000.0  2400.0  2400.0
 -1000.0    4000.0  2400.0  2400.0
 -1000.0    4000.0  2400.0  2400.0
# z-grid #4
 -2000.0    4000.0  2400.0  2400.0
 -2000.0    4000.0  2400.0  2400.0
 -2000.0    4000.0  2400.0  2400.0
 -2000.0    4000.0  2400.0  2400.0
```

if `NL` > 1, there is a designated interface; and the elevation of the ng[il]+1 needs to be the same as ng[il]. The equivalent medium parameterization method can be applied on this interface. We provide a more complex model in the `test/` directory.

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Main historical authors:

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Evolution of the code:

Bibliography

P. Moczo, J. Kristek, V. Vavrycuk, R. J. Archuleta, and L. Halada. 3D heterogeneous staggered-grid finite-difference modeling of seismic motion with volume harmonic and arithmetic averaging of elastic moduli and densities. *Bulletin of the Seismological Society of America*, 92(8):3042–3066, 2002.

P. Moczo, J. Kristek, and M. GÃąlis. *The finite-difference modelling of earthquake motions: waves and ruptures*. Cambridge University Press, New York, 2014. ISBN 978-1-107-02881-4.