tesseroid-relief-example

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1 A mesh class for a tesseroid relief

There is a `PrismRelief` mesh class in Fatiando a Terra but we still need a `TesseroidRelief` for this inversion. This is a mesh of tesseroids distributed along an area. They undulate below and above a reference level, describing the relief of an interface. Tesseroids have either the top of bottom fixed to a reference height. The other end undulates along a relief. The `TesseroidRelief` class is defined in the `mohoinv.py` module. This notebook will show some of the features of the mesh and how to use it.

1.1 Package imports

```
In [1]: # Insert plots into the notebook
        %matplotlib inline
```

```
In [2]: from __future__ import division, unicode_literals
        import numpy as np
        import matplotlib.pyplot as plt
        from IPython.display import Image
        import multiprocessing
        import seaborn  # Makes the default style of the plots nicer
```

```
/home/leo/bin/anaconda/envs/moho/lib/python2.7/site-packages/matplotlib/__init__.py:872: UserWarning: axe
  warnings.warn(self.msg_depr % (key, alt_key))
```

Load the required modules from Fatiando a Terra and show the specific version of the library used.

```
In [3]: from fatiando import gridder, utils
        from fatiando.vis import myv
        from fatiando.gravmag import tesseroid
        import fatiando
```

```
In [4]: print("Using Fatiando a Terra version: {}".format(fatiando.__version__))
```

```
Using Fatiando a Terra version: 3c4953c170e1e9d964325ccd133a5ef28e319e89
```

```
In [5]: from mohoinv import TesseroidRelief
```

1.2 Create some synthetic relief

Define a regular grid.

```
In [6]: # shape is nlat, nlon = the number of points in the grid
        shape = (41, 31)
        # Make a regular grid inside an area = (s, n, w, e)
        area = (20, 60, -40, 40)
        lat, lon, h = gridder.regular(area, shape, z=250e3)
```

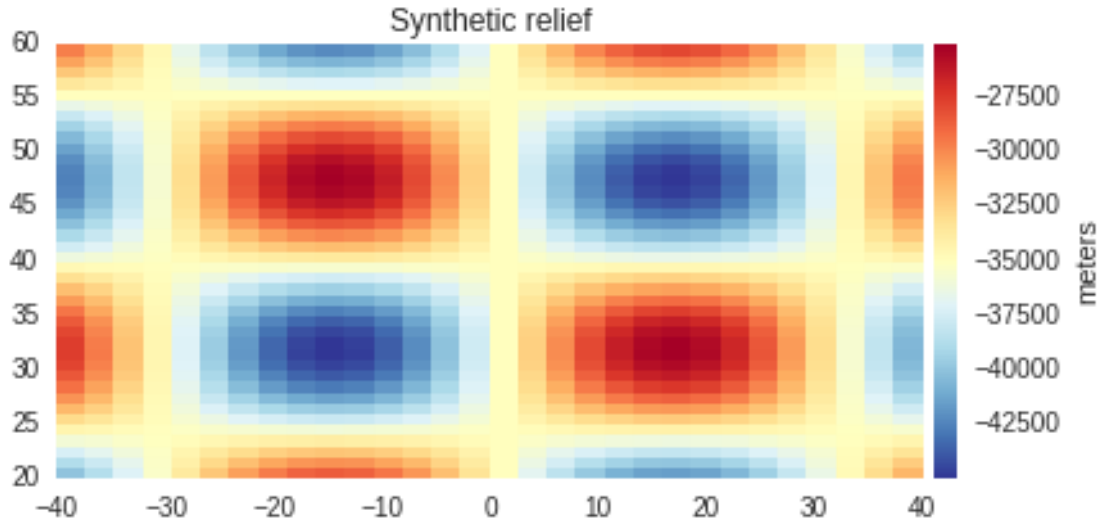
The model area is slightly larger because the points generated above are in the center of each cell.

```
In [7]: dlat, dlon = gridder.spacing(area, shape)
        s, n, w, e = area
        modelarea = (s - dlat/2, n + dlat/2, w - dlon/2, e + dlon/2)
```

Make a checker board relief undulating along a specified height reference.

```
In [8]: f = 0.2
        reference = -35e3
        relief = 10e3*np.sin(0.5*f*lon)*np.cos(f*lat) + reference
```

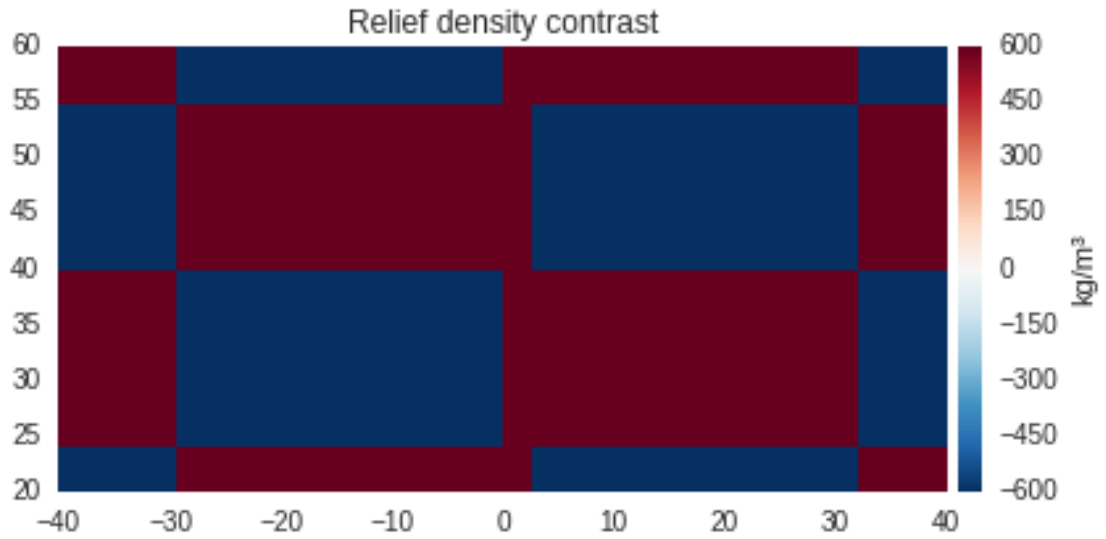
```
In [9]: plt.figure(figsize=(7, 3))
        plt.title('Synthetic relief')
        plt.axis('scaled')
        plt.pcolormesh(lon.reshape(shape), lat.reshape(shape), relief.reshape(shape),
                       cmap="RdYlBu_r")
        plt.colorbar(pad=0.01).set_label('meters')
        plt.xlim(lon.min(), lon.max())
        plt.ylim(lat.min(), lat.max())
        plt.tight_layout()
```



Set a density contrast for the relief. The density contrast is negative if the relief is below the reference and positive otherwise.

```
In [10]: density = 600*np.ones_like(relief)
         density[relief < reference] *= -1
```

```
In [11]: plt.figure(figsize=(7, 3))
         plt.title('Relief density contrast')
         plt.axis('scaled')
         plt.pcolormesh(lon.reshape(shape), lat.reshape(shape), density.reshape(shape),
                        cmap="RdBu_r")
         plt.colorbar(pad=0.01).set_label(u'kg/m$^3$')
         plt.xlim(lon.min(), lon.max())
         plt.ylim(lat.min(), lat.max())
         plt.tight_layout()
```



Now we can create a mesh and make a 3D plot of it.

```
In [12]: sample_mesh = TesseroidRelief(modelarea, shape, relief, reference, {'density': density})
```

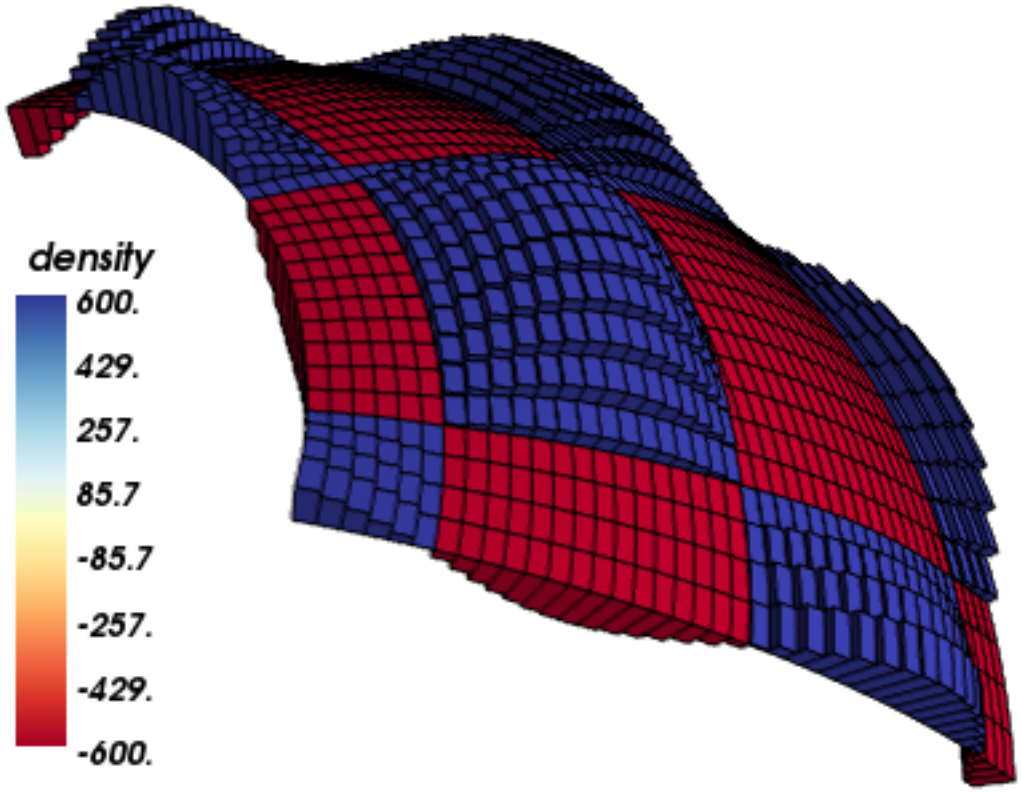
```
In [13]: def plot_result_3d(moho, fname):
             bounds = modelarea + (-20e3, -60e3)
             scale = (1, 1, 40) # Exaggerate the radial dimension
             datarange = np.abs([moho.props['density'].max(),
                                 moho.props['density'].min()]).max()
             scene = myv.figure(zdown=False)
             plot = myv.tesseroids(moho, 'density', scale=scale)
             plot.module_manager.scalar_lut_manager.show_legend = True
             plot.module_manager.scalar_lut_manager.lut_mode = 'RdYlBu'
             plot.module_manager.scalar_lut_manager.data_range = [-datarange, datarange]
             plot.module_manager.scalar_lut_manager.scalar_bar_representation.minimum_size = \
                 np.array([1, 1])
             plot.module_manager.scalar_lut_manager.scalar_bar_representation.position2 = \
                 np.array([ 0.13741855,  0.64385382])
             plot.module_manager.scalar_lut_manager.scalar_bar_representation.position = \
                 np.array([ 0.03303258,  0.07342193])
             plot.module_manager.scalar_lut_manager.scalar_bar_representation.maximum_size = \
                 np.array([100000, 100000])
             plot.module_manager.scalar_lut_manager.label_text_property.color = (0, 0, 0)
             plot.module_manager.scalar_lut_manager.title_text_property.color = (0, 0, 0)
             scene.scene.camera.position = [2252864.9143914036, -5202911.2574882135,
                                            8495162.9722945951]
             scene.scene.camera.focal_point = [3135763.9476126051, 1056258.4985192744,
                                               829277.18542720564]
             scene.scene.camera.view_angle = 30.0
             scene.scene.camera.view_up = [0.6164057832087273, 0.57367112225287575,
                                           0.53939350563383837]
             scene.scene.camera.clipping_range = [783483.44437851617, 16078402.004277557]
             scene.scene.camera.compute_view_plane_normal()
             scene.scene.render()
```

```
        myv.savefig(fname)
        #myv.show()
        myv.mlab.close()
        return Image(filename=fname)
```

```
In [14]: plot_result_3d(sample_mesh, 'example-mesh.png')
```

```
WARNING:traits.has_traits:DEPRECATED: traits.has_traits.wrapped_class, 'the 'implements' class advisor h
```

Out[14]:



1.3 Calculate the gravitational effect of this mesh

The mesh behaves like a list of `Tesseroid` objects. So we can pass it to any function in Fatiando a Terra that takes such list as input.

Below, we'll show an example of using the forward modeling functions in Fatiando to calculate the gravitational effect of the above relief.

```
In [15]: ncpu = multiprocessing.cpu_count()
         print('Number of cores: {}'.format(ncpu))
```

```
Number of cores: 4
```

Forward model the data on the grid generated above using all available cores of the processor.

```
In [16]: data = tesseroid.gz(lon, lat, h, sample_mesh, njobs=ncpu)
```

```
/home/leo/bin/anaconda/envs/moho/lib/python2.7/site-packages/fatiando/gravmag/tesseroid.py:282: RuntimeW
  warnings.warn(msg, RuntimeWarning)
/home/leo/bin/anaconda/envs/moho/lib/python2.7/site-packages/fatiando/gravmag/tesseroid.py:282: RuntimeW
  warnings.warn(msg, RuntimeWarning)
/home/leo/bin/anaconda/envs/moho/lib/python2.7/site-packages/fatiando/gravmag/tesseroid.py:282: RuntimeW
  warnings.warn(msg, RuntimeWarning)
/home/leo/bin/anaconda/envs/moho/lib/python2.7/site-packages/fatiando/gravmag/tesseroid.py:282: RuntimeW
  warnings.warn(msg, RuntimeWarning)
```

The warnings above are because some small tesseroids (below 10 cm dimensions) are ignored to avoid numerical issues.

In [17]:
```
plt.figure(figsize=(7, 3))
plt.title('Relief gravity anomaly')
plt.axis('scaled')
plt.tricontourf(lon, lat, data, 40, cmap="RdBu_r")
plt.colorbar(pad=0.01).set_label(u'mGal')
plt.xlim(lon.min(), lon.max())
plt.ylim(lat.min(), lat.max())
plt.tight_layout()
```