datasets-example

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1 Functions and classes to load and manipulate datasets

This notebook shows how to use the functions and classes in datasets.py to load and manipulate the data used in this project.

1.1 Package imports

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

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

```
In [3]: from datasets import fetch_crust1, fetch_assumpcao_moho_points
```

1.2 Crustal thickness

Function fetch_assumpcao_moho_points loads the seismic crustal thickness dataset of Assumpção et al. (2012). The data are provided in the Moho_Map_SAm2013_data.tar.gz archive in the data folder. These are point estimates of crustal thickness derived from various seismic sources.

```
In [4]: data = fetch_assumpcao_moho_points('../data/Moho_Map_SAm2013_data.tar.gz',
                                           todepth=True)
        # todepth=True will convert crustal thickness to Moho depth
        lat, lon, height, moho_depth, error = data
```

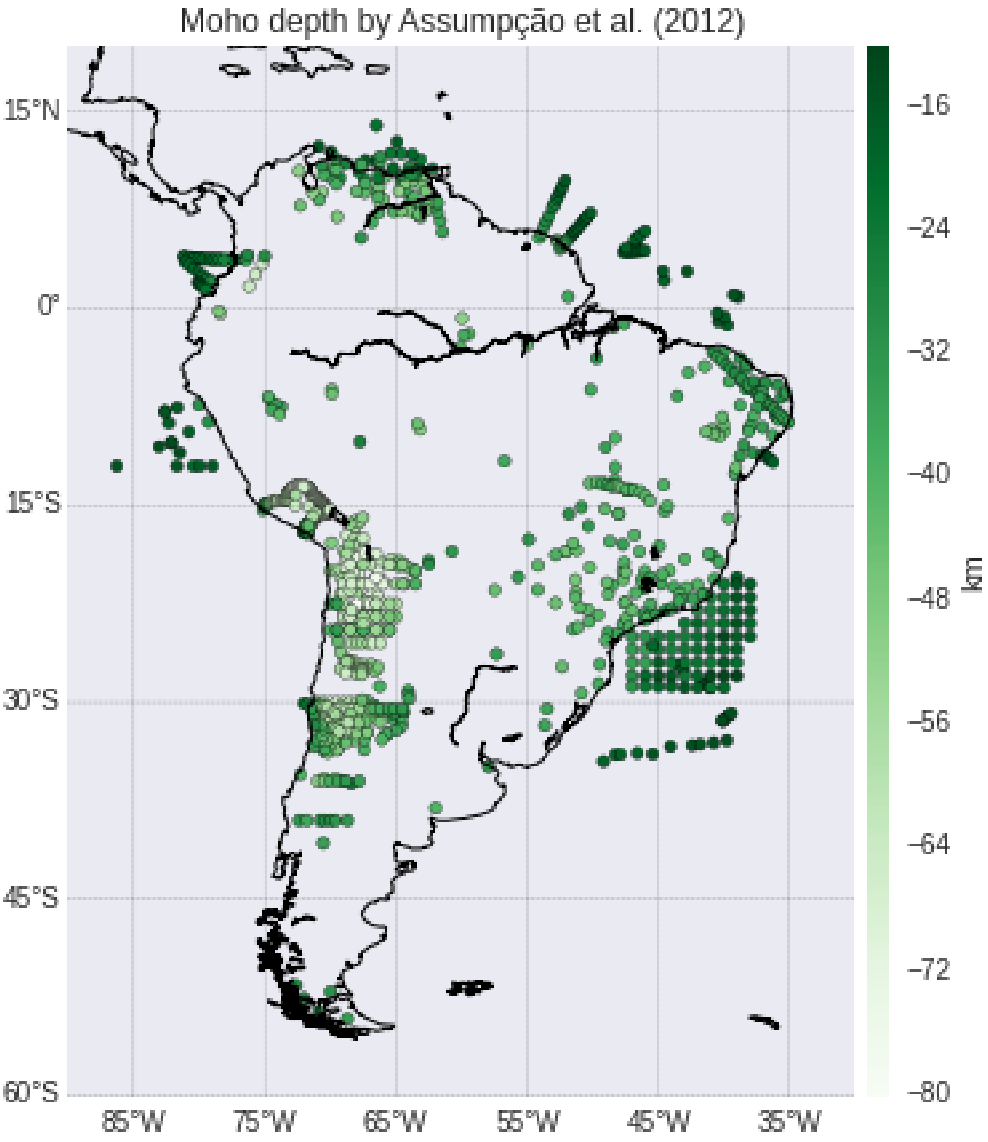
Lets make a plot of the dataset.

```
In [5]: area = (-60, 20, -90, -30)
        bm = Basemap(projection='cyl',
                     llcrnrlon=area[2], urcrnrlon=area[3],
                     llcrnrlat=area[0], urcrnrlat=area[1],
                     lon_0=0.5*(area[2] + area[3]), lat_0=0.5*(area[1] + area[0]),
                     resolution='l')
```

```
In [6]: x, y = bm(lon, lat)

        plt.figure(figsize=(7, 6))
        plt.title(u'Moho depth by Assumpção et al. (2012)')
        bm.scatter(x, y, c=0.001*moho_depth, cmap='Greens')
        plt.colorbar(pad=0.01, aspect=50).set_label('km')
```

```
bm.drawmeridians(np.arange(-85, -20, 10), labels=[0, 0, 0, 1], linewidth=0.2)
bm.drawparallels(np.arange(-60, 30, 15), labels=[1, 0, 0, 0], linewidth=0.2)
bm.drawcoastlines()
plt.tight_layout()
```



1.3 The CRUST1.0 model

The fetch_crust1 function loads the model from the tar.gz archive. It returns a Crust1 class that allows us to manipulate the CRUST1.0 model by getting different physical properties as numpy arrays and providing some combinations of properties (like total sediment thickness, Moho depth, slicing the model, etc).

```
In [7]: model = fetch_crust1('../data/crust1.0.tar.gz')
```

Lets see what layer the model makes available to us.

```
In [8]: model.layers
```

```
Out[8]: [’water’,
         ’ice’,
         ’upper_sediments’,
         ’middle_sediments’,
         ’lower_sediments’,
         ’upper_crust’,
         ’middle_crust’,
         ’lower_crust’,
         ’mantle’]
```

Each layer has the `density`, `vp`, and `vs` attributes that return 2D numpy arrays of the corresponding physical property.

```
In [9]: model.water.density
```

```
Out[9]: array([[ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
               [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
               [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
               ...,
               [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
               [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
               [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.]])
```

```
In [10]: model.upper_crust.vp
```

```
Out[10]: array([[ 5900.,  5900.,  5900., ...,  5900.,  5900.,  5900.],
                [ 5900.,  5900.,  5900., ...,  5900.,  5900.,  5900.],
                [ 5900.,  5900.,  5900., ...,  5900.,  5900.,  5900.],
                ...,
                [ 5000.,  5000.,  5000., ...,  5000.,  5000.,  5000.],
                [ 5000.,  5000.,  5000., ...,  5000.,  5000.,  5000.],
                [ 5000.,  5000.,  5000., ...,  5000.,  5000.,  5000.]])
```

You can also access the physical properties directly from the model object to get a 3D array of the property of all layers.

```
In [11]: model.density
```

```
Out[11]: array([[[ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
                 [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
                 [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
                 ...,
                 [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
                 [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.],
                 [ 1020.,  1020.,  1020., ...,  1020.,  1020.,  1020.]],

                [[  920.,   920.,   920., ...,   920.,   920.,   920.],
                 [  920.,   920.,   920., ...,   920.,   920.,   920.],
                 [  920.,   920.,   920., ...,   920.,   920.,   920.],
                 ...,
                 [  920.,   920.,   920., ...,   920.,   920.,   920.],
                 [  920.,   920.,   920., ...,   920.,   920.,   920.],
                 [  920.,   920.,   920., ...,   920.,   920.,   920.]],
                [[ 2260.,  2260.,  2260., ...,  2260.,  2260.,  2260.],
                 [ 2260.,  2260.,  2260., ...,  2260.,  2260.,  2260.],
                 [ 2260.,  2260.,  2260., ...,  2260.,  2260.,  2260.],
                 ...,
                 [ 1930.,  1930.,  1930., ...,  1930.,  1930.,  1930.],
                 [ 1930.,  1930.,  1930., ...,  1930.,  1930.,  1930.],
                 [ 1930.,  1930.,  1930., ...,  1930.,  1930.,  1930.]],

                ...,
                [[ 2740.,  2740.,  2740., ...,  2740.,  2740.,  2740.],
                 [ 2740.,  2740.,  2740., ...,  2740.,  2740.,  2740.],
                 [ 2740.,  2740.,  2740., ...,  2740.,  2740.,  2740.],
                 ...,
                 [ 2850.,  2850.,  2850., ...,  2850.,  2850.,  2850.],
                 [ 2850.,  2850.,  2850., ...,  2850.,  2850.,  2850.],
                 [ 2850.,  2850.,  2850., ...,  2850.,  2850.,  2850.]],

                [[ 2910.,  2910.,  2910., ...,  2910.,  2910.,  2910.],
                 [ 2910.,  2910.,  2910., ...,  2910.,  2910.,  2910.],
                 [ 2910.,  2910.,  2910., ...,  2910.,  2910.,  2910.],
                 ...,
                 [ 3050.,  3050.,  3050., ...,  3050.,  3050.,  3050.],
                 [ 3050.,  3050.,  3050., ...,  3050.,  3050.,  3050.],
                 [ 3050.,  3050.,  3050., ...,  3050.,  3050.,  3050.]],

                [[ 3360.,  3360.,  3360., ...,  3360.,  3360.,  3360.],
                 [ 3360.,  3360.,  3360., ...,  3360.,  3360.,  3360.],
                 [ 3340.,  3340.,  3340., ...,  3360.,  3360.,  3360.],
                 ...,
                 [ 3350.,  3350.,  3350., ...,  3340.,  3340.,  3340.],
                 [ 3340.,  3340.,  3340., ...,  3340.,  3340.,  3340.],
                 [ 3340.,  3340.,  3340., ...,  3340.,  3340.,  3340.]]])
```

A use of this feature is to calculate things across all layers, like the mean crustal density (layers 5-7):

```
In [12]: model.density[5:8].mean(0)
```

```
Out[12]: array([[ 2773.33333333,  2773.33333333,  2773.33333333, ...,
                  2773.33333333,  2773.33333333,  2773.33333333],
                [ 2773.33333333,  2773.33333333,  2773.33333333, ...,
                  2773.33333333,  2773.33333333,  2773.33333333],
                [ 2773.33333333,  2773.33333333,  2773.33333333, ...,
                  2773.33333333,  2773.33333333,  2773.33333333],
                ...,
                [ 2816.66666667,  2816.66666667,  2816.66666667, ...,
                  2816.66666667,  2816.66666667,  2816.66666667],
                [ 2816.66666667,  2816.66666667,  2816.66666667, ...,
                  2816.66666667,  2816.66666667,  2816.66666667],
                [ 2816.66666667,  2816.66666667,  2816.66666667, ...,
                  2816.66666667,  2816.66666667,  2816.66666667]])
```

The `Crust1` class also provides some other attributes that are derived from the model layers, like total sediment thickness and Moho depth.

```
In [13]: model.sediment_thickness
```

```
Out[13]: array([[ 1500.,  1500.,  1500., ...,  1500.,  1500.,  1500.],
               [  400.,   400.,   400., ...,   300.,   300.,   300.],
               [  300.,   300.,   300., ...,   400.,   400.,   300.],
               ...,
               [ 1800.,  1800.,  1800., ...,  1800.,  1800.,  1800.],
               [ 1000.,  1000.,  1000., ...,  1000.,  1000.,  1000.],
               [ 1300.,  1300.,  1300., ...,  1500.,  1500.,  1500.]])
```

```
In [14]: model.moho_depth
```

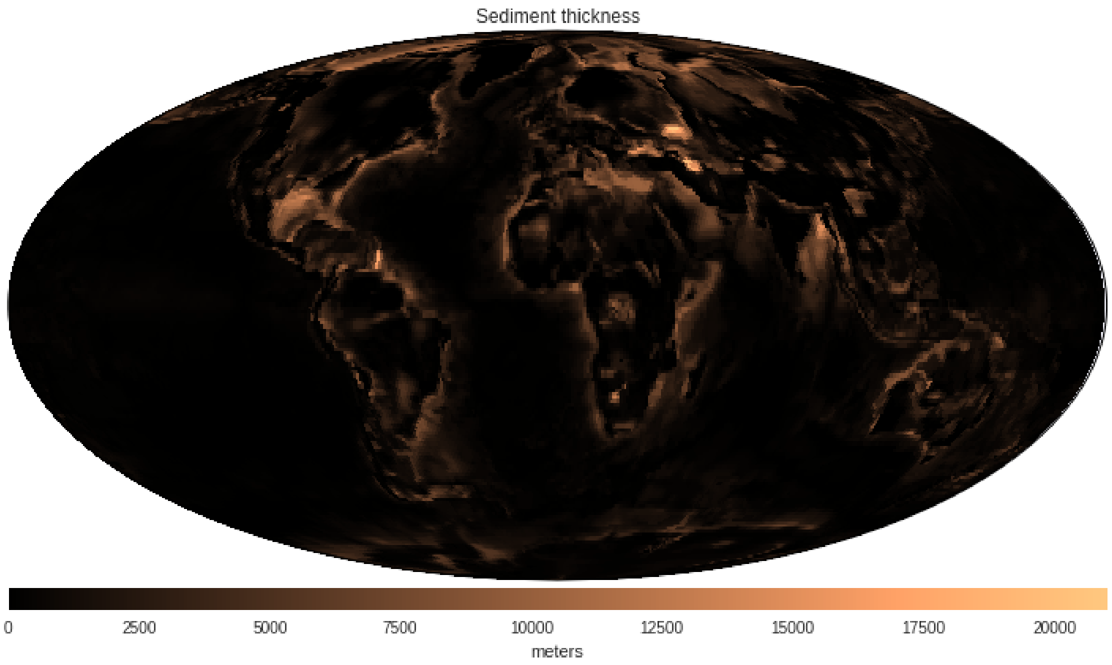
```
Out[14]: array([[ 36150.,  36150.,  36150., ...,  36130.,  36130.,  36140.],
               [ 37910.,  37910.,  37910., ...,  37930.,  37930.,  37930.],
               [ 39950.,  39950.,  39960., ...,  39980.,  39980.,  39980.],
               ...,
               [ 12650.,  12650.,  12640., ...,  12740.,  12690.,  17000.],
               [ 11380.,  11400.,  11410., ...,  11300.,  11330.,  15930.],
               [ 11750.,  11740.,  11720., ...,  12760.,  12750.,  16230.]])
```

Lets make plots of these two properties for the entire Earth.

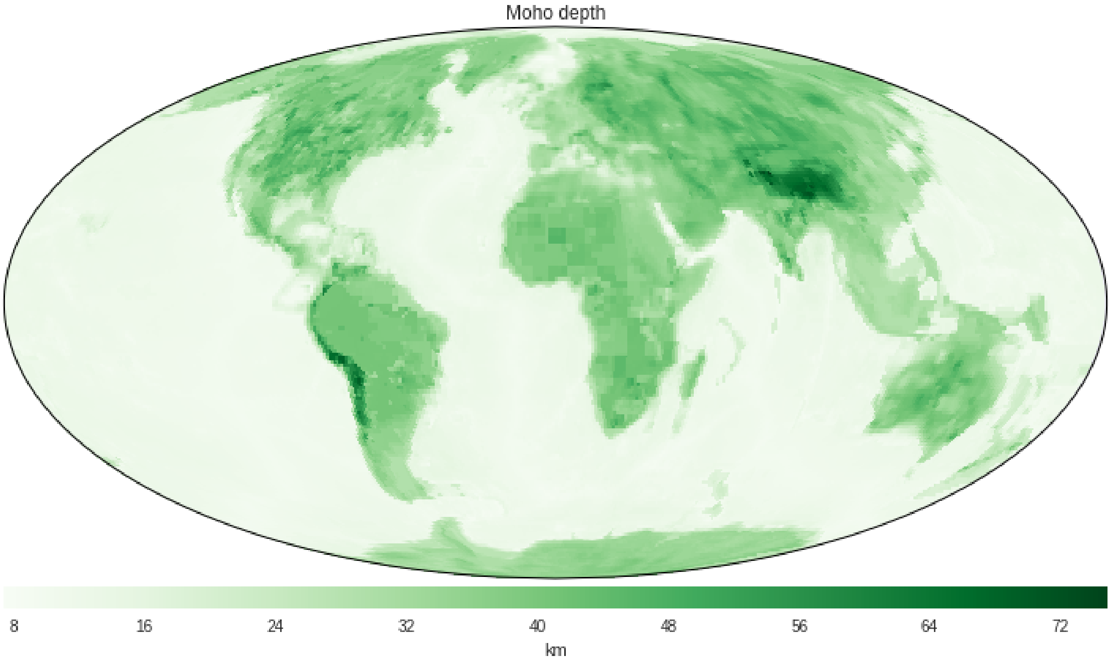
```
In [15]: bm = Basemap(projection='moll', lon_0=0, resolution='c')
```

```
In [16]: x, y = bm(model.lon, model.lat)

         plt.figure(figsize=(10, 7))
         plt.title('Sediment thickness')
         bm.pcolormesh(x, y, model.sediment_thickness, cmap='copper')
         plt.colorbar(pad=0.01, orientation='horizontal', aspect=50).set_label('meters')
         plt.tight_layout()
```



```
In [17]: plt.figure(figsize=(10, 7))
         plt.title('Moho depth')
         bm.pcolormesh(x, y, 0.001*model.moho_depth, cmap='Greens')
         plt.colorbar(pad=0.01, orientation='horizontal', aspect=50).set_label('km')
         plt.tight_layout()
```



We can cut the model to get only parts that we want. For example, let's get only South America.

```
In [18]: sa = model.cut((-65, 20, -90, -30))
```

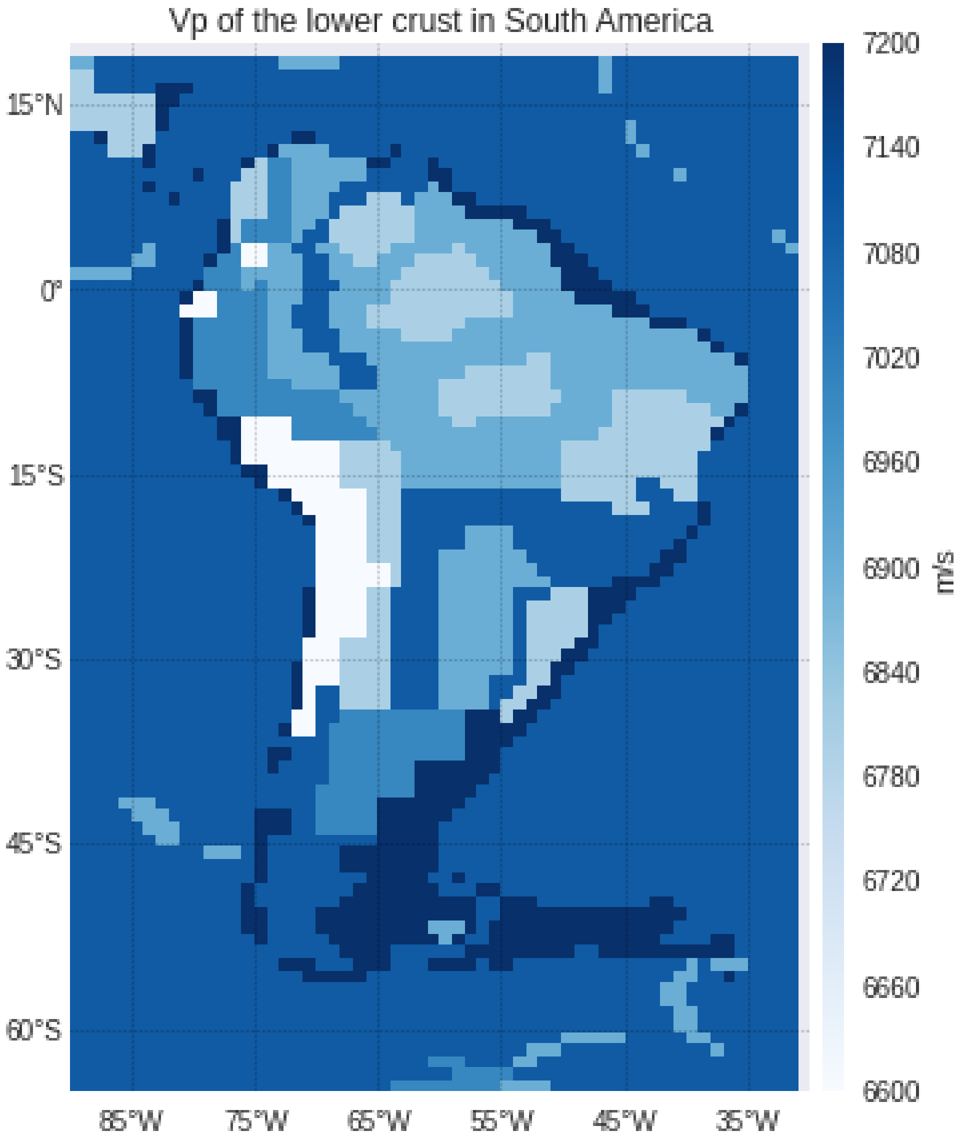
The cut part is also a `Crust1` object, so you can do all of the above with it as well.

```
In [19]: sa.lower_crust.vs

Out[19]: array([[ 4050.,  4050.,  4050., ...,  4050.,  4050.,  4050.],
                [ 4050.,  4050.,  4050., ...,  4050.,  4050.,  4050.],
                [ 4050.,  4050.,  4050., ...,  4050.,  4050.,  4050.],
                ...,
                [ 3870.,  3870.,  4050., ...,  4050.,  4050.,  4050.],
                [ 3870.,  3870.,  3900., ...,  4050.,  4050.,  4050.],
                [ 3870.,  3870.,  4100., ...,  4050.,  4050.,  4050.]])

In [20]: area = sa.area
         bm = Basemap(projection='cyl',
                      llcrnrlon=area[2], urcrnrlon=area[3],
                      llcrnrlat=area[0], urcrnrlat=area[1],
                      lon_0=0.5*(area[2] + area[3]), lat_0=0.5*(area[1] + area[0]),
                      resolution='l')

In [21]: x, y = bm(sa.lon, sa.lat)
         plt.figure(figsize=(7, 6))
         plt.title('Vp of the lower crust in South America')
         bm.pcolormesh(x, y, sa.lower_crust.vp, cmap='Blues')
         plt.colorbar(pad=0.01, aspect=50).set_label(u'm/s')
         bm.drawmeridians(np.arange(-85, -20, 10), labels=[0, 0, 0, 1], linewidth=0.2)
         bm.drawparallels(np.arange(-60, 30, 15), labels=[1, 0, 0, 0], linewidth=0.2)
         plt.tight_layout()
```


Vp of the lower crust in South America
15°N
0°
15°S
30°S
45°S
60°S
85°W
75°W
65°W
55°W
45°W
35°W
7200
7140
7080
7020
6960
6900
6840
6780
6720
6660
6600
m/s