bathymetric_stat

December 29, 2020

1 Calculate sea water volume from bathymetry

1.1 Data preparation

We use ETOPO1 data provided by NOAA.

Data is available from here and extract `.tiff` file to `data` directory.

tiff file were warped to Mollweide projection with the following command.

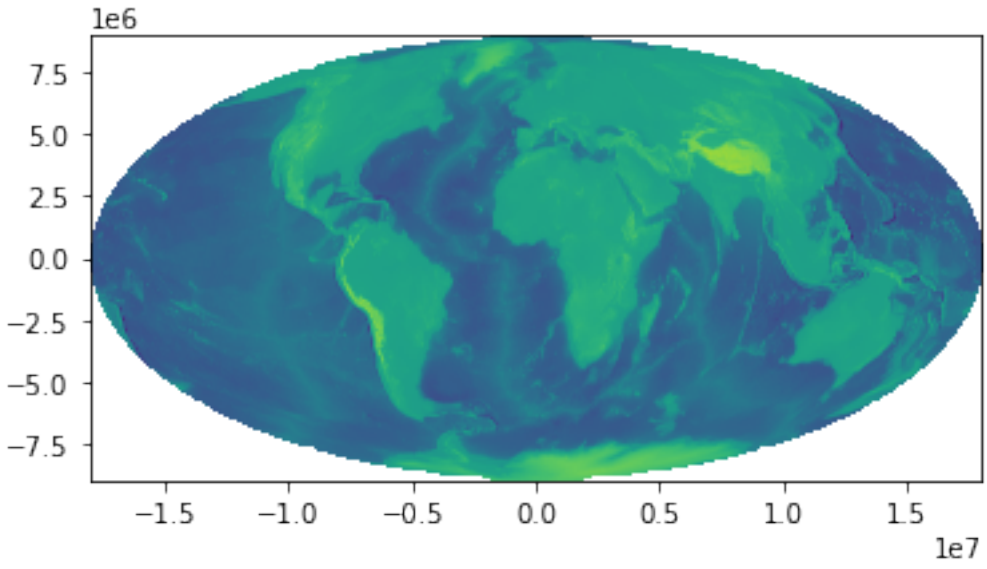
```
gdalwarp -s_srs EPSG:4326 -t_srs ESRI:54009 -dstnodata -32768.0 -r near -of GTiff ETOPO1_Ice_g
```

1.2 Import required libraries

[1]:
```
from rasterio.plot import show
import numpy as np
import rasterio
from rasterio.warp import (calculate_default_transform,
                           reproject,
                           Resampling)
import matplotlib.pyplot as plt
```

1.3 Read ETOPO data

[2]:
```
raster_path = 'data/ETOPO_mollweide.tif'
with rasterio.open(raster_path) as src:
    raster_array = src.read(1)
    raster_profile = src.profile
    raster_res = src.res
    show(src)
```

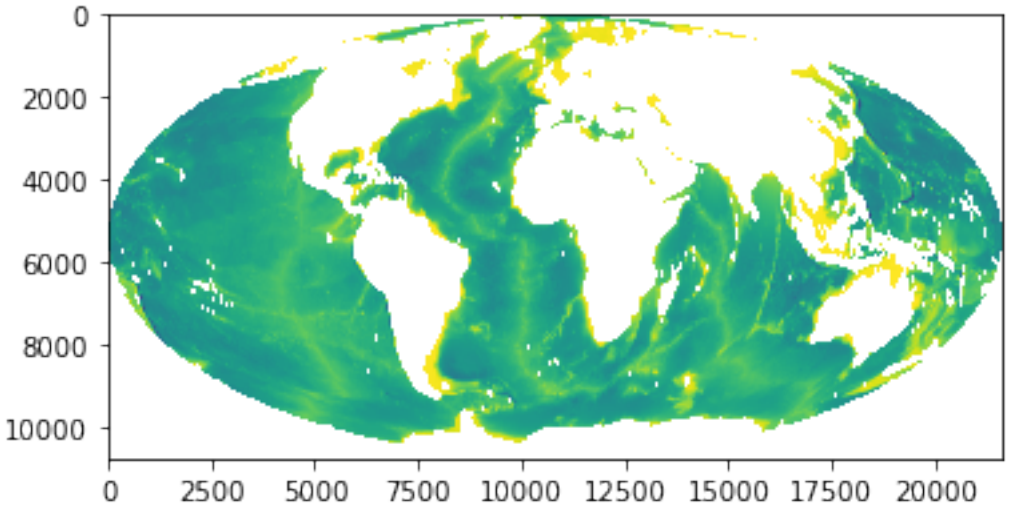


1.4 Remove land area

[3]:
```
raster_array = np.where(raster_array == raster_profile['nodata'],
                        np.nan, raster_array)

# Remove above 0m area. This will not remove inland low land area.
raster_array = np.where(raster_array >= 0, np.nan, raster_array)
plt.imshow(raster_array)
```

[3]: <matplotlib.image.AxesImage at 0x7f7d15c5dd30>



1.5 Calculate sea area and volume

[4]:
```
# pixel size in km^2
pixel_size = raster_res[0] * raster_res[1] / 1_000_000

sea_area = (~np.isnan(raster_array)).sum() * pixel_size
print('Total sea area is '
      f'{np.format_float_scientific(sea_area, precision=3)} km^2.')

# Total sea water volume
sea_volume = -np.nansum(raster_array) / 1000 * pixel_size
print('Total sea volume is'
      f'{np.format_float_scientific(sea_volume, precision=3)} km^3')
```

```
Total sea area is 3.622e+08 km^2.
Total sea volume is1.336e+09 km^3
```

[5]:
```
# volume above depth_bottom
def calc_water_volume_above_threshold(
    bathymetric_array: np.array,
    pixel_size: float,
    threshold: float = None) -> np.float64:

    """
    Args:
        bathymetric_array:
            negative values in meter
        threshold:
            negative value in meter
        pixel_size:
            km^2
    Return:
        Volume in km^3
    """

    if threshold is not None:
        if threshold > 0:
            raise ValueError('threshold should be negative value.')
        bathymetric_array = np.where(bathymetric_array < threshold,
                                     threshold, bathymetric_array)
    return -np.nansum(bathymetric_array) / 1000 * pixel_size
```

[6]:
```
depths = [-200, -1000, -4000, -6000, -10000]
volumes = []

for depth in depths:
```

```
    volume = calc_water_volume_above_threshold(raster_array,
                                               pixel_size,
                                               threshold=depth)
    volumes.append(volume)
```

[7]:
```
# print results
for depth, volume in zip(depths, volumes):
    print(f'Sea water volume above {depth}m is '
          f'{np.format_float_scientific(volume, 3)}')
    print(f'It\'s {np.format_float_positional((volume / sea_volume * 100), 1)} '
          '% of total sea water.\n')
```

```
Sea water volume above -200m is 6.880e+07
It's 5.2 % of total sea water.

Sea water volume above -1000m is 3.296e+08
It's 24.7 % of total sea water.

Sea water volume above -4000m is 1.169e+09
It's 87.5 % of total sea water.

Sea water volume above -6000m is 1.334e+09
It's 99.9 % of total sea water.

Sea water volume above -10000m is 1.336e+09
It's 100. % of total sea water.
```

1.6 Other stats

[8]:
```
# sea area which depth is deeper than 1000m.
(raster_array < -1000).sum() * pixel_size / sea_area
```

[8]:
```
0.8828970609869402
```