Results

Running pg_tileserv

A Mapbox vector tile server can be set up to access the database. In this example we used pg_tileserv, a PostGIS only tile server written in the GO language. The easiest way to set up pg_tileserv is to download the binaries for your operating system. An explanation on how to do this is at:

https://access.crunchydata.com/documentation/pg_tileserv/1.0.1/installation/

After you have downloaded the appropriate zip file and unzipped it, you will need to edit the config file pg_tileserv.toml.example, which is in the config directory, and rename it pg_tileserv.toml. When editing this file you will need make the following changes:

```
# pg_tileserv

# Database connection
# postgresql://username:password@host/dbname
DbConnection = "postgresql://postgres:postgres@localhost/reg3sim"
#It will default to port 5432. If you are using a different port for your database you can specify the port in the following way.
#DbConnection = "postgresql://postgres:postgres@localhost:5434/reg3sim"

# Close pooled connections after this interval
# 1d, 1h, 1m, 1s, see https://golang.org/pkg/time/#ParseDuration
DbPoolMaxConnLifeTime = "1h"

# Hold no more than this number of connections in the database pool
DbPoolMaxConns = 4

# Cancel a tile request if a tile can't be rendered in this time (seconds)
# DbTimeout = 10

# Look to read html templates from this directory
# AssetsPath = "/usr/share/pg_tileserv/assets"

# Accept connections on this subnet (default accepts on all)
```

```
HttpHost = "0.0.0.0"

# Accept connections on this port
HttpPort = 7800

# Advertise URLs relative to this server name
# default is to look this up from incoming request headers
UrlBase = "http://localhost/"

# Resolution to quantize vector tiles to
DefaultResolution = 4096

# Padding to add to vector tiles
DefaultBuffer = 256

# Limit number of features requested (-1 = no limit)
MaxFeaturesPerTile = 50000

# Advertise this minimum zoom level
DefaultMinZoom = 0

# Advertise this maximum zoom level
DefaultMaxZoom = 22

# Allow any page to consume these tiles
#CORSOrigins = *

# Output extra logging information?
Debug = true
```

After these changes have been made, and have the region3db_container container running, with the database started, you can start the server on a linux machine simply by using the following command:

```
./pg_tileserv
```

Demo

After you have pg_tileserv running you can run the Demo.ipynb notebook. You need need to install Jupyter Notebooks, and Python module being imported by Demo.ipynb. Below is the content of Demo.ipynb, for a cleaner view you can also look at Demo.pdf or run Demo.ipynb.

ADCIRC Region 3 Simulation Database

The ADCIRC Region 3 Simulation database size is currently 22 TB. It is a PostgreSQL database, that uses TimescaleDB, and PostGIS extensions. TimescaleDB enables storing large amounts of data in PostgreSQL, by using hypertables, which are comprised of many interlinked sub-tables called chunks. Chunks are created by partitioning the hypertable's data into one or multiple dimensions: All hypertables are partitioned by a time interval, and can additionally be partitioned by a key such as device ID, location, user id, etc.

Each storm from the Region 3 Simulation data is stored in it's own table, which are partitioned into chunks by a 2 hour time interval. The geometry data are stored in a separate PostGIS table that can be linked to the storm tables in a query.

We serve the data using pg_tileserv, which is a vector tile data server.

In [1]:

```
# To download, read and display the data, first import these Python module
import requests, subprocess
from ast import literal_eval
from vt2geojson.tools import vt_bytes_to_geojson
import pandas as pd
import geopandas as gpd
import numpy as np
from scipy.interpolate import griddata
from mpl_toolkits.basemap import Basemap
import matplotlib.pyplot as plt
```

In [2]:

```
# This is a python function that retrieves the data from the database server.
# It's inputs are  storm  table  name,  timestamp,  and  region  of  interest  (roi) file # which containes
the bounding box coordinates. The vector tiles are downloaded       # and stiched together.
def getData(stormtable, timestamp, roi):
    # Geodex calculates the tiles in the bounding box roi
    std_result = subprocess.run(['geodex', roi, str(13), '--output-format', '({z}, {x}, {y})'],
                                stdout=subprocess.PIPE)
    tile_inds_string = std_result.stdout.decode('utf-8').split('\n')
    tile_inds_tuple = [literal_eval(ti) for ti in tile_inds_string if len(ti) > 0]

    gdfall = gpd.GeoDataFrame()

    for tile in tile_inds_tuple:
```

```python
        # region3_sim_storms_bufopt is a PLSQL function that tackes zoom level, x and y
        # tile coordinates, buffer size, storm table, and timestamp as input. The function # links the storm table
        with the geometry table and outputs a vector tile.
        tileURL = "http://localhost:7800/public.region3_sim_storms_bufopt/"+ \
                    str(tile[0])+"/"+str(tile[1])+"/"+str(tile[2])+".pbf?buffer=0&stormtable="+ \
                    stormtable+"&timestep="+timestamp+"&properties=node,zeta,bathymetry"
        r = requests.get(tileURL)

        assert r.status_code == 200, r.content
        vt_content = r.content

        features = vt_bytes_to_geojson(vt_content, tile[1], tile[2], tile[0])
        gdf = gpd.GeoDataFrame.from_features(features)
        gdfall = pd.concat([gdfall,gdf])

    gdfall = gdfall.sort_values(by=['node'], ascending=True)
    gdfall = gdfall.reset_index(drop=True)
    duplicateRowGDF = gdfall[gdfall.duplicated(['node'])]

    if len(duplicateRowGDF) > 0:
        print(len(duplicateRowGDF))

    return(gdfall)
```

In [3]:

```python
# When you run the getData funciton with the required input, it outputs a geopandas dataframe.
stormtable = 'var_dp3r3b1c1h1l1_fort63'
timestep = '2000-09-03T20:30:00'

# The roi is of the central chesapeake Bay
roi = 'roi.geojson'
gdf = getData(stormtable, timestep, roi)
gdf.head()
```

Out[3]:

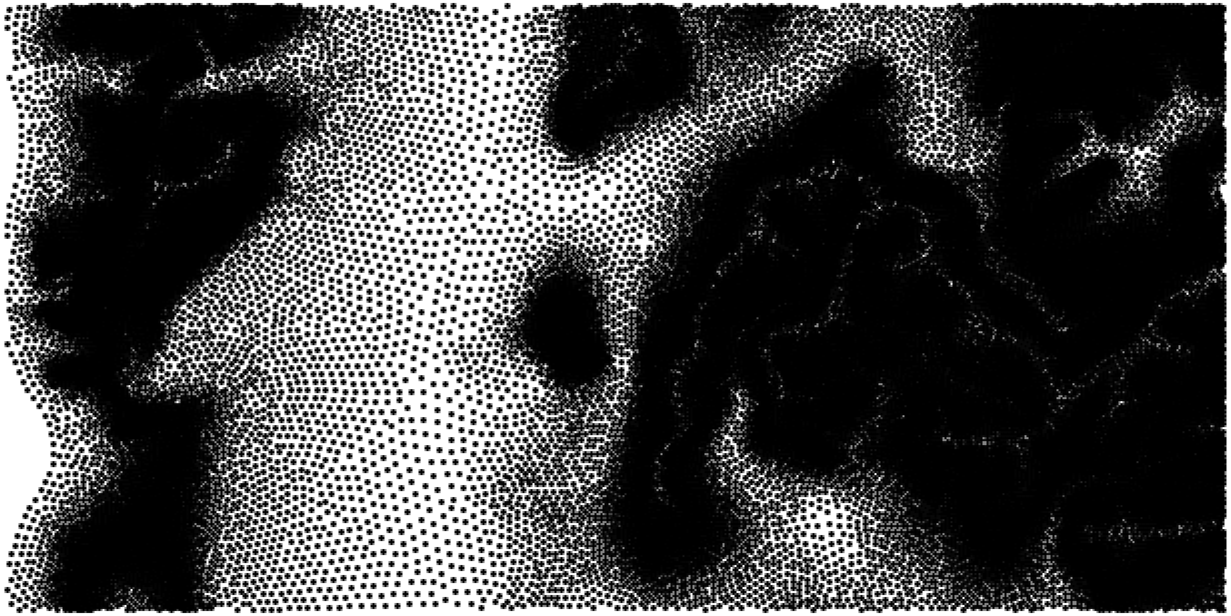
	geometry	node	bathymetry	zeta
0	POINT (-76.11368 38.82117)	153814	-4.2484112	NaN
1	POINT (-76.11448 38.82387)	153815	-4.837077	NaN
2	POINT (-76.11329 38.82603)	153816	-4.9151185	NaN

3	POINT (-76.11369 38.78163)	156471	-3.9950436	NaN

	geometry	node	bathymetry	zeta
4	POINT (-76.11347 38.78365)	156472	-4.682347	NaN

In [4]:

```
# The display the points using MatPlotLib fig, ax
= plt.subplots(figsize=(12, 10))
gdf.plot(ax=ax, markersize=3.5,
color='black') ax.axis('off')
plt.axis('equal')
plt.show()
```



In [5]:
```
# One way of displaying the data is to regrid it and display it as an image
# This can be done by first defining the region, and then createing a basemap
lllon = min(gdf.geometry.bounds.minx)
lllat = min(gdf.geometry.bounds.miny)
urlon = max(gdf.geometry.bounds.maxx)
urlat =max(gdf.geometry.bounds.maxy)
```

```
# set up basemap chose projection!
m = Basemap(projection = 'merc', resolution='c',llcrnrlon = lllon, llcrnrlat = lllat, urcrnrlon = urlon, urcrnrlat =
```

In [6]:

```
 # Then pull out pull out the variables
lon = gdf.geometry.x.to_numpy()
 lat = gdf.geometry.y.to_numpy()

 # The Region 3 Simulation depth data is depth below geoid, which means the land values are negative.       # So here we
 rescale the data so the the land values are positive
bathymetry = gdf.bathymetry.to_numpy().astype(np.float) minusones =
 np.ones(54448,) - 2
bathymetry = bathymetry * minusones

 # Zeta is water surface elevation above geoid
zeta =  gdf.zeta.to_numpy().astype(np.float)

 # transform coordinates to map projection m
m_lon, m_lat = m(*(lon, lat))
```

In [7]:

```
 # generate grid data
numcols, numrows = 240, 240
xi  = np.linspace(m_lon.min(), m_lon.max(), numcols)
```

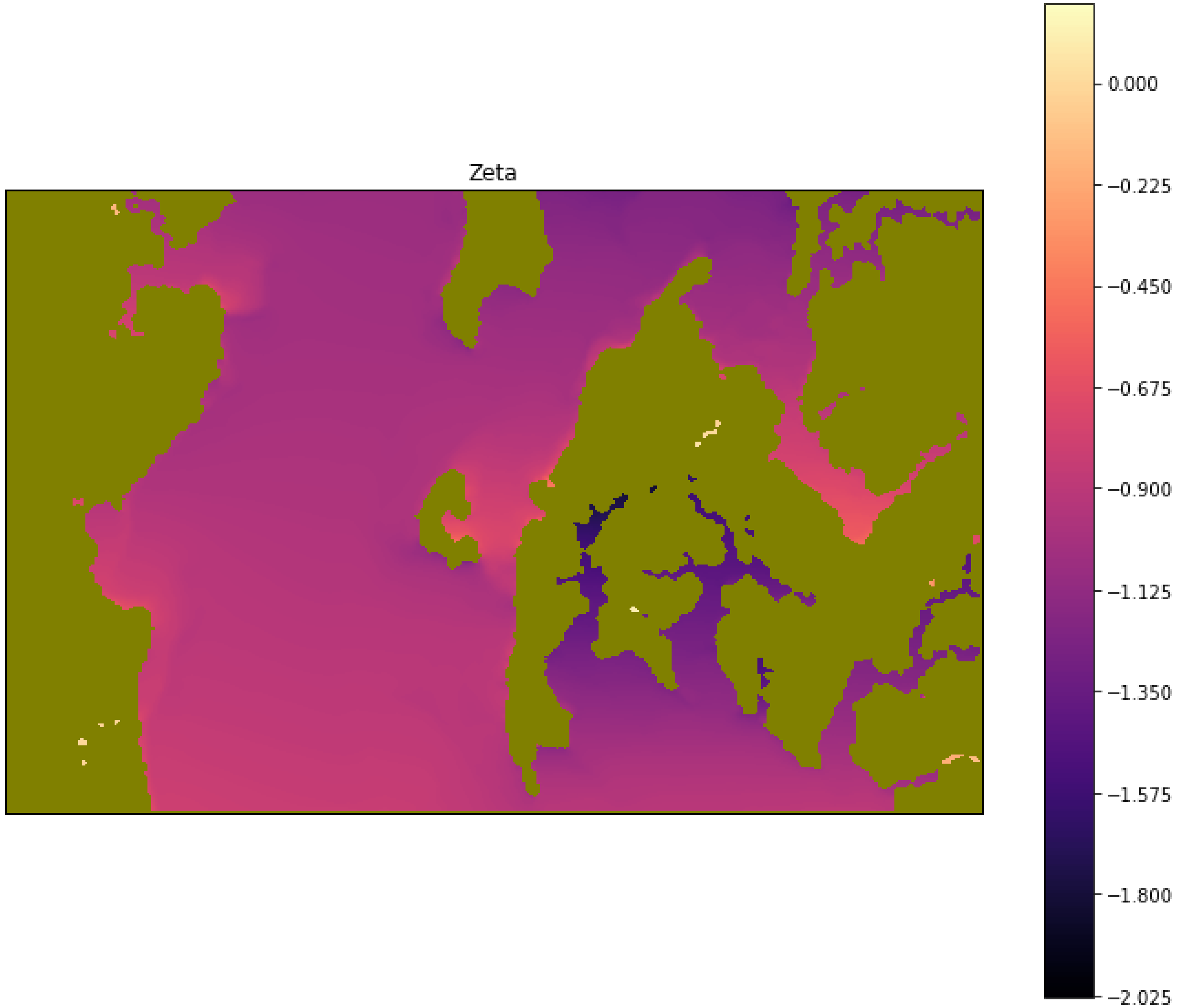
In [8]:

```
# Plot the zeta data
fig, ax = plt.subplots(figsize=(12, 10))

# draw map details
m.drawmapboundary(fill_color = 'olive', zorder = 1)

# Plot interpolated bathymetry
m.contourf(xi, yi, zi, 500, cmap='magma', zorder = 2)

cbar = plt.colorbar()
plt.title('Zeta')
plt.show()
```



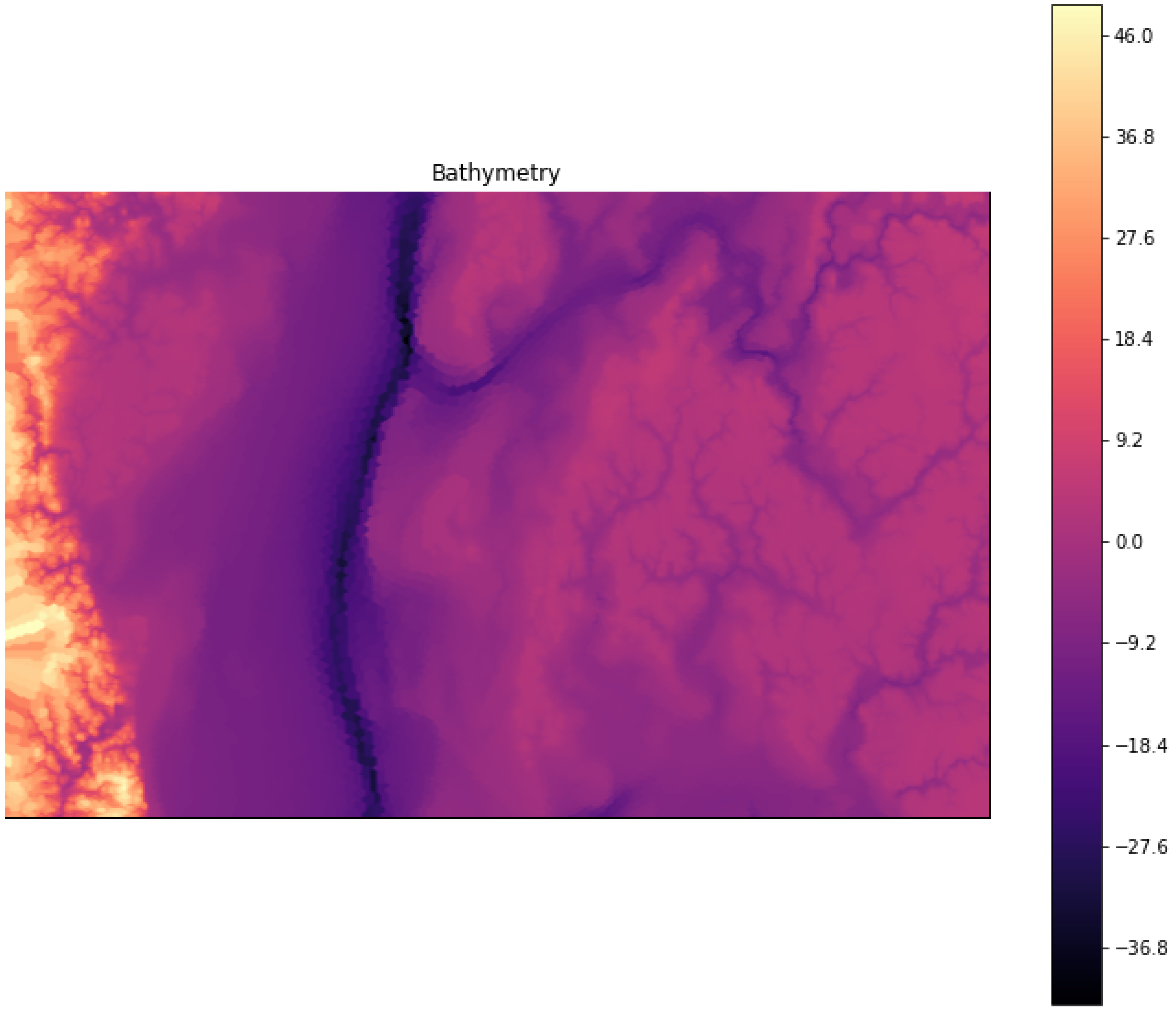
In [9]:
```
# interpolate the bathymetry data
zi = griddata((m_lon,m_lat),bathymetry,(xi,yi),method='nearest',fill_value=np.nan)

# Plot the bathymetry data
fig, ax = plt.subplots(figsize=(12, 10))
```

```python
# draw map details
m.drawmapboundary(fill_color = 'olive', zorder = 1)

# Plot interpolated bathymetry
m.contourf(xi, yi, zi, 500, cmap='magma', zorder = 2)

cbar = plt.colorbar()
plt.title('Bathymetry')
plt.show()
```



In [10]:
```
# When you run the getData funciton with the required input, it outputs a geopandas dataframe.
stormtable = 'var_dp3r3b1c1h1l1_swan63'
timestep = '2000-09-03T20:30:00'

# The roi is of the central chesapeake Bay
roi = 'roi.geojson'
```

```
gdf = getData(stormtable, timestep, roi)
gdf.head()
```

Out[10]:

	geometry	node	bathymetry	hs	tps	dir
0	POINT (-76.11368 38.82117)	153814	-4.2484112	NaN	NaN	NaN
1	POINT (-76.11448 38.82387)	153815	-4.837077	NaN	NaN	NaN
2	POINT (-76.11329 38.82603)	153816	-4.9151185	NaN	NaN	NaN
3	POINT (-76.11369 38.78163)	156471	-3.9950436	NaN	NaN	NaN
4	POINT (-76.11347 38.78365)	156472	-4.682347	NaN	NaN	NaN

In [11]:

```
hs = gdf.hs.to_numpy().astype(np.float)
 # interpolate the hs data
zi = griddata((m_lon, m_lat), hs, (xi, yi), method='linear', fill_value=np.nan, rescale=False)
```

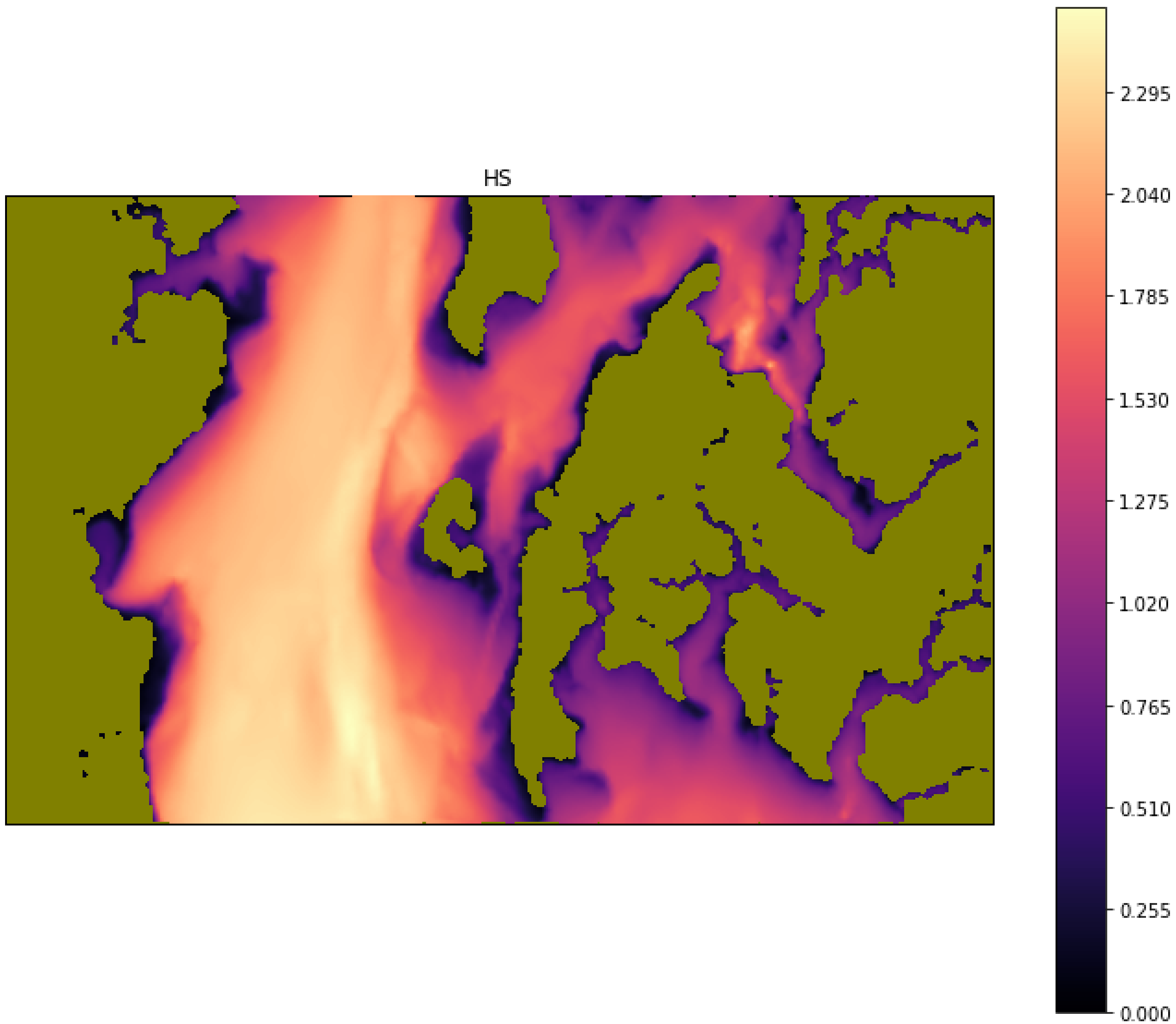
In [12]:

```
 # Plot the hs data
fig, ax = plt.subplots(figsize=(12, 10))

 # draw map details
m.drawmapboundary(fill_color = 'olive', zorder = 1)

 # Plot interpolated bathymetry
m.contourf(xi, yi, zi, 500, cmap='magma', zorder = 2)

cbar = plt.colorbar()
 plt.title('HS')
 plt.show()
```



In [ ]: