Simulated_data_example_Poisson-MGWR

May 14, 2020

Notebook Outline:

Branch - gsco19
PR - https://github.com/pysal/mgwr/pull/60

0.0.1 Set up Cells

In [1]:
```
import sys
#change path here to point to your folder
sys.path.append("C:/Users/msachde1/Downloads/Research/Development/mgwr")
```

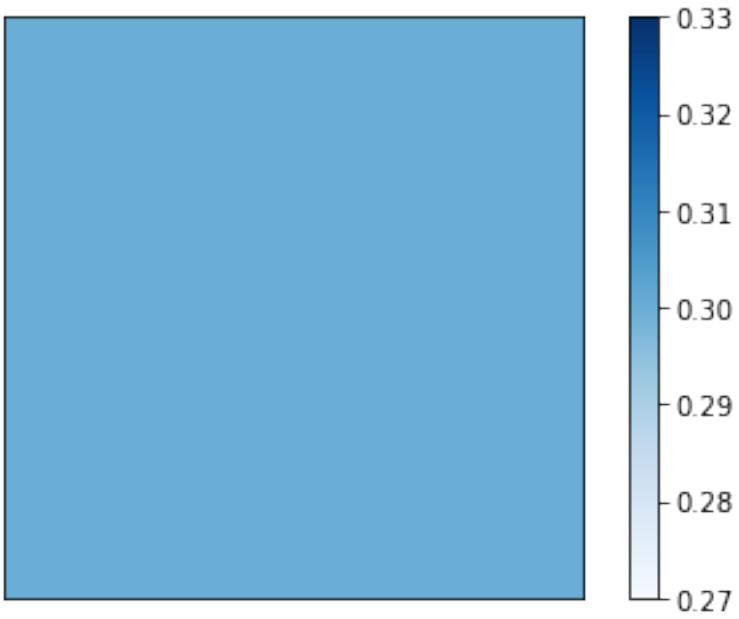
In [2]:
```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import numpy as np

from mgwr.gwr import GWR
from spglm.family import Gaussian, Binomial, Poisson
from mgwr.gwr import MGWR
from mgwr.sel_bw import Sel_BW
import multiprocessing as mp
pool = mp.Pool()
```

```
from scipy import linalg
import numpy.linalg as la
from scipy import sparse as sp
from scipy.sparse import linalg as spla
from spreg.utils import spdot, spmultiply
from scipy import special
import libpysal as ps
import seaborn as sns
import matplotlib.pyplot as plt
from copy import deepcopy
import copy
from collections import namedtuple
import spglm
```

0.0.2 Create Simulated Dataset

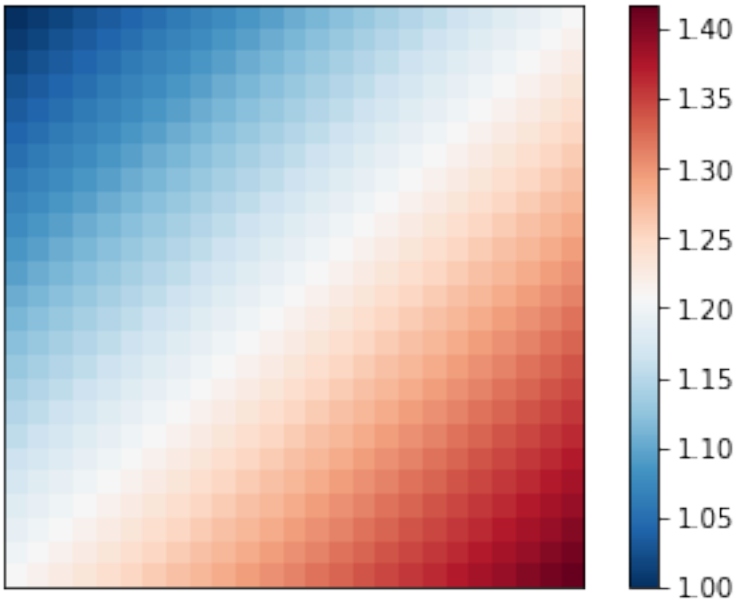
Forming independent variables

```
In [3]: def add(a,b):
            return 1+((1/120)*(a+b))

        def con(u,v):
            return (0*(u)*(v))+0.3

        def sp(u,v):
            return 1+1/3240*(36-(6-u/2)**2)*(36-(6-v/2)**2)

In [4]: x = np.linspace(0, 25, 25)
        y = np.linspace(25, 0, 25)
        X, Y = np.meshgrid(x, y)

In [5]: x1=np.random.normal(0,1,625)
        x2=np.random.normal(0,1,625)
        error = np.random.normal(0,0.1,625)

In [6]: B0=con(X,Y)
        B1=add(X,Y)
        B2=sp(X,Y)

In [7]: plt.imshow(B0, extent=[0,10, 0, 10], origin='lower',cmap='Blues')
        plt.colorbar()
        plt.axis(aspect='image')
        plt.xticks([])
        plt.yticks([])

Out[7]: ([], <a list of 0 Text yticklabel objects>)
```



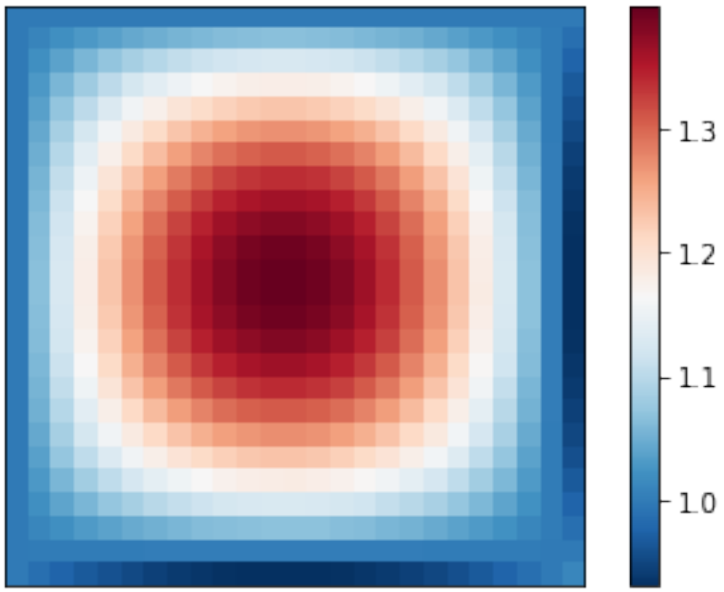

```
In [8]: plt.imshow(B1, extent=[0,10, 0, 10], origin='lower',cmap='RdBu_r')
        plt.colorbar()
        plt.axis(aspect='image')
        plt.xticks([])
        plt.yticks([])
```

```
Out[8]: ([], <a list of 0 Text yticklabel objects>)
```



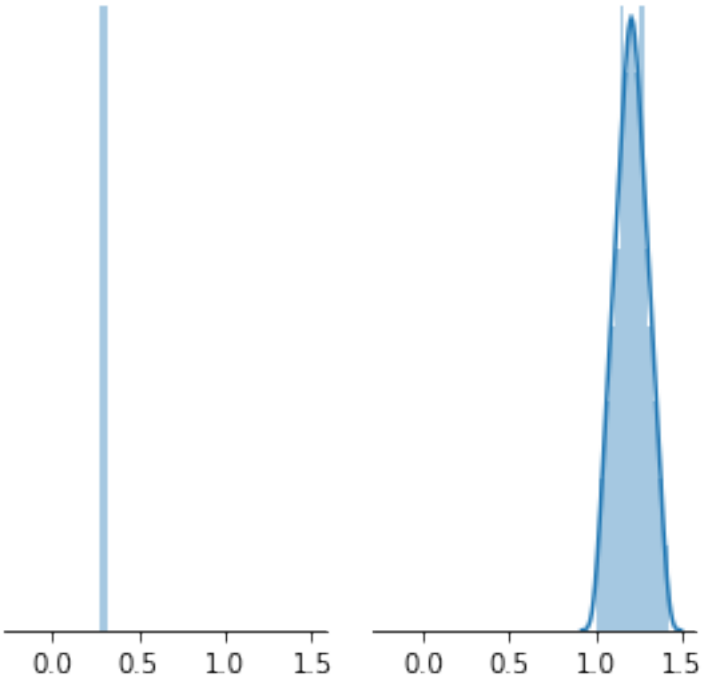
```
In [9]: plt.imshow(B2, extent=[0,25, 0, 25], origin='lower',cmap='RdBu_r')
        plt.colorbar()
        plt.axis(aspect='image')
        plt.xticks([])
        plt.yticks([])
```

```
Out[9]: ([], <a list of 0 Text yticklabel objects>)
```



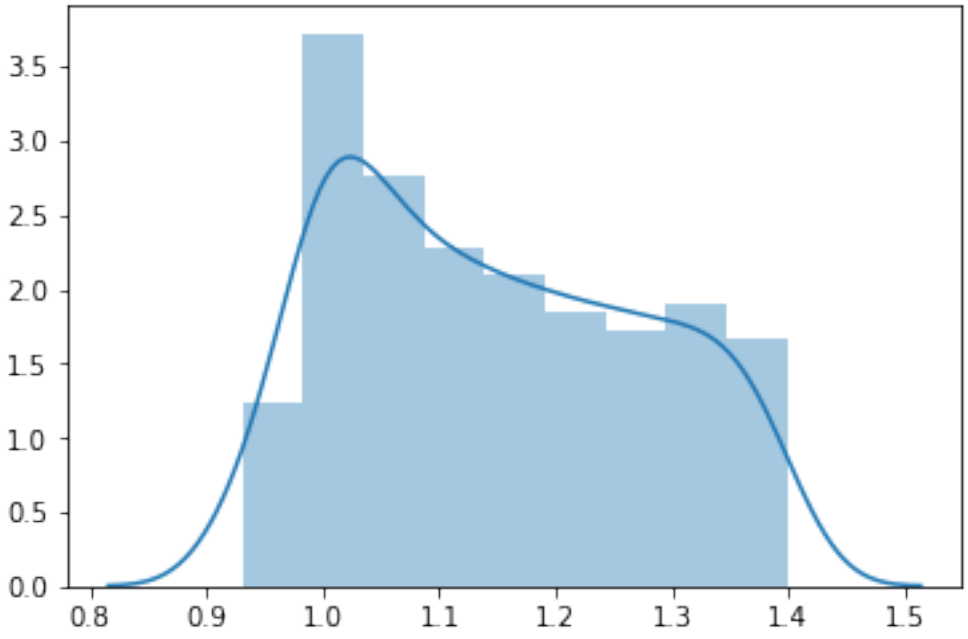

```
In [10]: B0=B0.reshape(-1,1)
         B1=B1.reshape(-1,1)
         B2=B2.reshape(-1,1)
```

```
In [11]: f, axes = plt.subplots(1, 2, figsize=(4, 4), sharex=True)
         sns.despine(left=True)
         sns.distplot(B0,ax=axes[0])
         sns.distplot(B1,ax=axes[1])

         plt.setp(axes, yticks=[])
         plt.tight_layout()
```




```
In [12]: sns.distplot(B2)
```

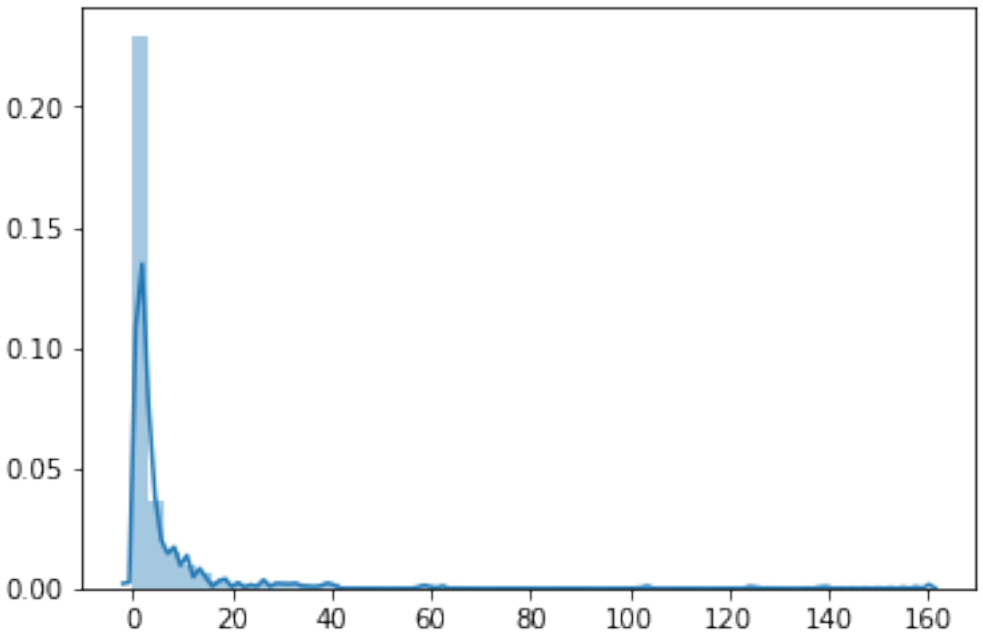
```
Out[12]: <matplotlib.axes._subplots.AxesSubplot at 0x24e1fcd0828>
```



```
In [13]: lat=Y.reshape(-1,1)
         lon=X.reshape(-1,1)

In [14]: x1=x1.reshape(-1,1)
         x2=x2.reshape(-1,1)

In [15]: param = np.hstack([B0,B1,B2])
         cons=np.ones_like(x1)
         X=np.hstack([cons,x1,x2])

In [16]: param.shape,X.shape

Out[16]: ((625, 3), (625, 3))
```

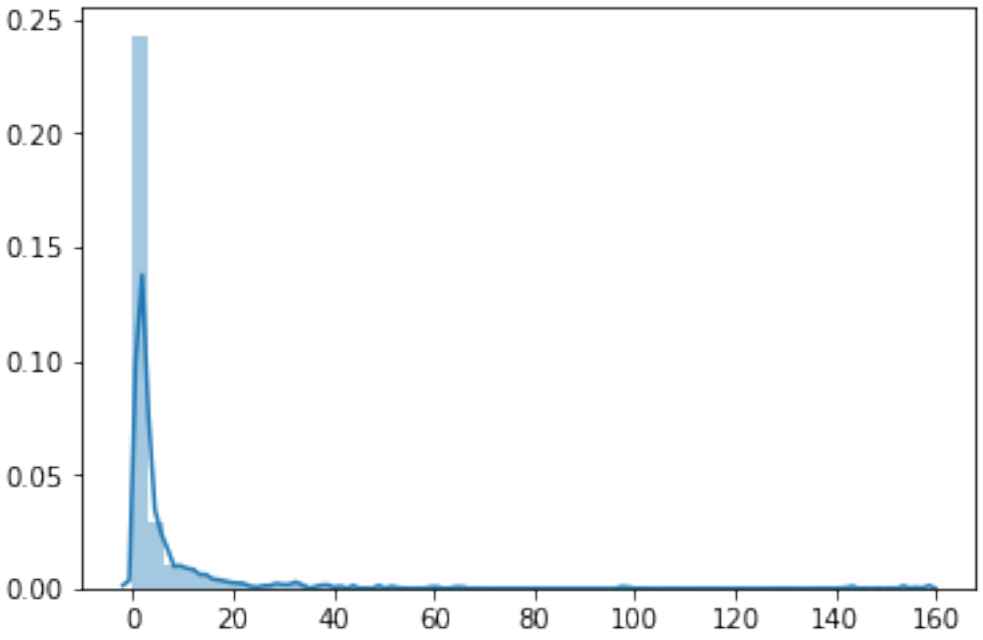
Creating y variable with Poisson distribution Incorporating step from - Chapter 6. Simulating Generalized Linear Models, p. 153

```
In [17]: #y
         y=(np.exp((np.sum(X * param, axis=1)+error).reshape(-1, 1)))
         y_new = np.random.poisson(y)

In [18]: y.shape

Out[18]: (625, 1)

In [19]: sns.distplot(y)

Out[19]: <matplotlib.axes._subplots.AxesSubplot at 0x24e1fdaaa90>
```



In [20]:
```
sns.distplot(y_new)
```

Out[20]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x24e1fef3828>
```



In [21]:
```
coords = np.array(list(zip(lon,lat)))
y = np.array(y_new).reshape((-1,1))
```

In [22]:
```
x=x1
x_std = (x-x.mean(axis=0))/x.std(axis=0)
X=np.hstack([x1,x2])
X_std = (X-X.mean(axis=0))/X.std(axis=0)
```

0.0.3 Univariate example

First example: checking GWR and MGWR models with one independent variable and constant = False

In [23]:
```
bw=Sel_BW(coords,y,x,family=Poisson(),offset=None,constant=False)
bw=bw.search()
gwr_model=GWR(coords,y,x,bw,family=Poisson(),offset=None,constant=False).fit()
bw
```

Out[23]:
```
43.0
```

```
In [24]: selector=Sel_BW(coords,y,x,multi=True,family=Poisson(),offset=None,constant=False)
         selector.search(verbose=True)
```

```
Current iteration: 1 ,SOC: 0.0
Bandwidths: 43.0
```

```
Out[24]: array([43.])
```

```
In [25]: mgwr_model=MGWR(coords,y,x,selector,family=Poisson(),offset=None,constant=False).fit()
```

```
HBox(children=(IntProgress(value=0, description='Inference', max=1), HTML(value='')))
```

Bandwidth: Random initialization check

```
In [26]: selector.search(verbose=True,init_multi=600)
```

```
Current iteration: 1 ,SOC: 0.0201116
Bandwidths: 43.0
Current iteration: 2 ,SOC: 0.0
Bandwidths: 43.0
```

```
Out[26]: array([43.])
```

Parameters check

```
In [27]: np.sum(((gwr_model.params-mgwr_model.params)==0.0)==True)
```

```
Out[27]: 625
```

```
In [28]: gwr_model.aic,mgwr_model.aic
```

```
Out[28]: (3458.604213385903, 3476.5331190431302)
```

```
In [29]: np.sum((gwr_model.predy-mgwr_model.predy==0)==True)
```

```
Out[29]: 625
```

0.0.4 Multivariate example

Second example for multiple bandwidths

```
In [30]: bw=Sel_BW(coords,y,X,family=Poisson(),offset=None)
         bw=bw.search()
         gwr_model=GWR(coords,y,X,bw,family=Poisson(),offset=None).fit()
         bw
```

```
Out[30]: 103.0

In [31]: selector=Sel_BW(coords,y,X,multi=True,family=Poisson(),offset=None)
         selector.search(verbose=True)

Current iteration: 1 ,SOC: 0.0056638
Bandwidths: 400.0, 43.0, 43.0
Current iteration: 2 ,SOC: 0.0011879
Bandwidths: 400.0, 48.0, 44.0
Current iteration: 3 ,SOC: 0.0001425
Bandwidths: 400.0, 48.0, 44.0
Current iteration: 4 ,SOC: 2.35e-05
Bandwidths: 400.0, 48.0, 44.0
Current iteration: 5 ,SOC: 6.6e-06
Bandwidths: 400.0, 48.0, 44.0


Out[31]: array([400.,  48.,  44.])
```

Bandwidths: Random initialization check

```
In [ ]: selector.search(verbose=True,init_multi=600)

In [32]: mgwr_model=MGWR(coords,y,X,selector,family=Poisson(),offset=None).fit()

HBox(children=(IntProgress(value=0, description='Inference', max=1), HTML(value='')))
```

Parameters check

```
In [34]: max(gwr_model.predy-mgwr_model.predy)[:10]

Out[34]: array([39.63245513])

In [35]: gwr_model.aic, mgwr_model.aic

Out[35]: (651.1442030497388, 838.3196815747232)
```

0.0.5 Global model parameter check

```
In [36]: import statsmodels.api as sma

In [37]: X_glob=sma.add_constant(X)

In [38]: poisson_mod = sma.Poisson(y, X_glob)

In [39]: poisson_res = poisson_mod.fit(method="newton")
         print(poisson_res.summary())
```

```
Optimization terminated successfully.
         Current function value: 1.604261
         Iterations 7
                          Poisson Regression Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  625
Model:                        Poisson   Df Residuals:                      622
Method:                           MLE   Df Model:                            2
Date:                Thu, 04 Jul 2019   Pseudo R-squ.:                  0.7832
Time:                        11:47:08   Log-Likelihood:                -1002.7
converged:                       True   LL-Null:                       -4624.4
                                        LLR p-value:                     0.000
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2894      0.036      7.972      0.000       0.218       0.361
x1             1.2009      0.019     62.905      0.000       1.163       1.238
x2             1.1628      0.021     54.264      0.000       1.121       1.205
==============================================================================
```

```
In [40]: selector=Sel_BW(coords,y,X,multi=True,family=Poisson(),offset=None)
```

```
In [41]: selector.search(verbose=True,multi_bw_min=[625,625,625], multi_bw_max=[625,625,625])
```

```
Current iteration: 1 ,SOC: 0.0067699
Bandwidths: 625.0, 625.0, 625.0
Current iteration: 2 ,SOC: 0.0006156
Bandwidths: 625.0, 625.0, 625.0
Current iteration: 3 ,SOC: 0.0001351
Bandwidths: 625.0, 625.0, 625.0
Current iteration: 4 ,SOC: 4.2e-06
Bandwidths: 625.0, 625.0, 625.0
```

```
Out[41]: array([625., 625., 625.])
```

```
In [42]: mgwr_model=MGWR(coords,y,X,selector,family=Poisson(),offset=None).fit()
```

```
HBox(children=(IntProgress(value=0, description='Inference', max=1), HTML(value='')))
```

```
In [43]: mgwr_model.params[:5]
```

```
Out[43]: array([[0.24911341, 1.22606055, 1.19712663],
                [0.25309895, 1.2283422 , 1.19713621],
                [0.25724177, 1.23072827, 1.19708916],
                [0.26154154, 1.23322148, 1.19697204],
                [0.26599496, 1.23582348, 1.19676824]])
```

parameters similar for global Poisson model and forced global MGWR Poisson model