

# Binomial\_MGWR\_MonteCarlo\_Results

May 14, 2020

## Notebook Outline:

- Section 0.0.1
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- Section 0.0.4
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- Section 0.0.6
  - Section 0.0.6
- Section 0.0.7

Monte Carlo experiment code can be found in path mgwr/notebooks/Binomial\_MC\_script/  
(branch - gsoc19)

## 0.0.1 Set up Cell

```
In [1]: import warnings
        warnings.filterwarnings("ignore")
        import pickle
        import sys
        import seaborn as sns
        import numpy as np
        sys.path.append("C:/Users/msachde1/Downloads/Research/Development/mgwr/notebooks/Binom")
        import model_mc
        import matplotlib.pyplot as plt
        import pandas as pd
        from mpl_toolkits.axes_grid1 import make_axes_locatable

C:\Users\msachde1\AppData\Local\Continuum\anaconda3\envs\gwrenv\lib\site-packages\libpysal\io\
warnings.warn('SQLAlchemy and Geomet not installed, database I/O disabled')
```

## 0.0.2 List bandwidths from pickles

```
In [2]: mgwr_bw0=[]
        mgwr_bw1=[]
        mgwr_bw2=[]
        gwr_bw=[]
```

```
In [3]: for i in range(0,1000,50):
        p1 = pickle.load( open( "C:/Users/msachde1/Downloads/Research/Development/mgwr/notes/p1.pkl" ))
        for j in range(50):
            mgwr_bw0.append(p1[j].mgwr_bw[0][0])
            mgwr_bw1.append(p1[j].mgwr_bw[0][1])
            mgwr_bw2.append(p1[j].mgwr_bw[0][2])
            gwr_bw.append(p1[j].gwr_bw[0])
```

### 0.0.3 Parameter functions

```
In [4]: 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)

        def med(u,v):
            B = np.zeros((25,25))
            for i in range(25):
                for j in range(25):

                    if u[i][j]<=8:
                        B[i][j]=0.2
                    elif u[i][j]>17:
                        B[i][j]=0.7
                    else:
                        B[i][j]=0.5
            return B
```

```
In [5]: x = np.linspace(0, 25, 25)
        y = np.linspace(25, 0, 25)
        X, Y = np.meshgrid(x, y)
```

```
B0=con(X,Y)
#B1=add(X,Y)
B1=sp(X,Y)
B2=med(X,Y)
```

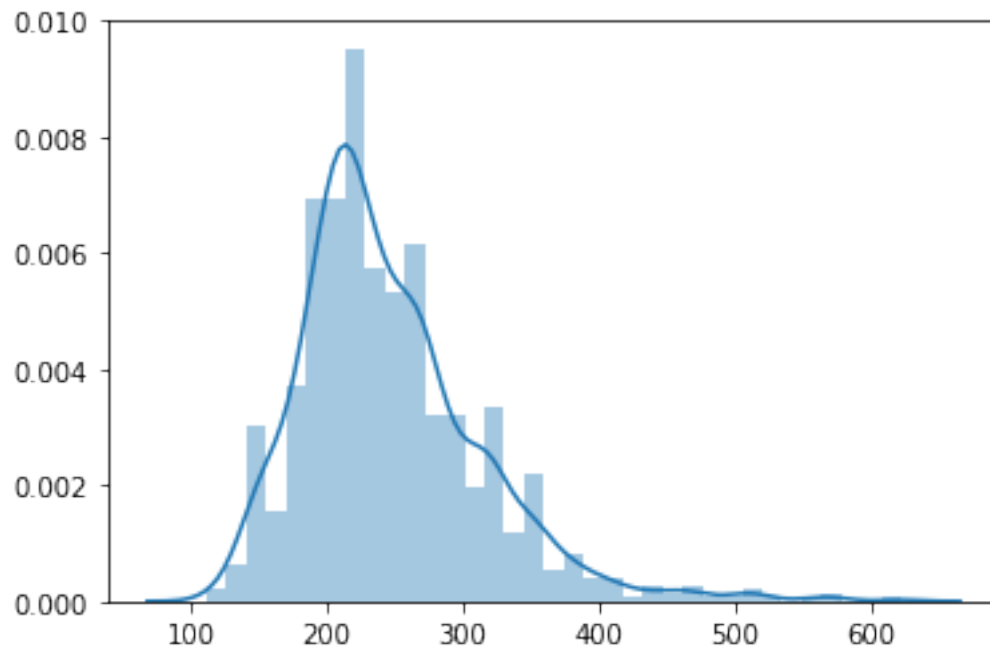
```
In [6]: x = np.linspace(0, 25, 25)
        y = np.linspace(25, 0, 25)
```

```
In [7]: x = np.linspace(0, 25, 25)
        y = np.linspace(25, 0, 25)
```

### 0.0.4 GWR bandwidth

```
In [8]: sns.distplot(gwr_bw)
```

Out[8]: <matplotlib.axes.\_subplots.AxesSubplot at 0x1460f35f470>



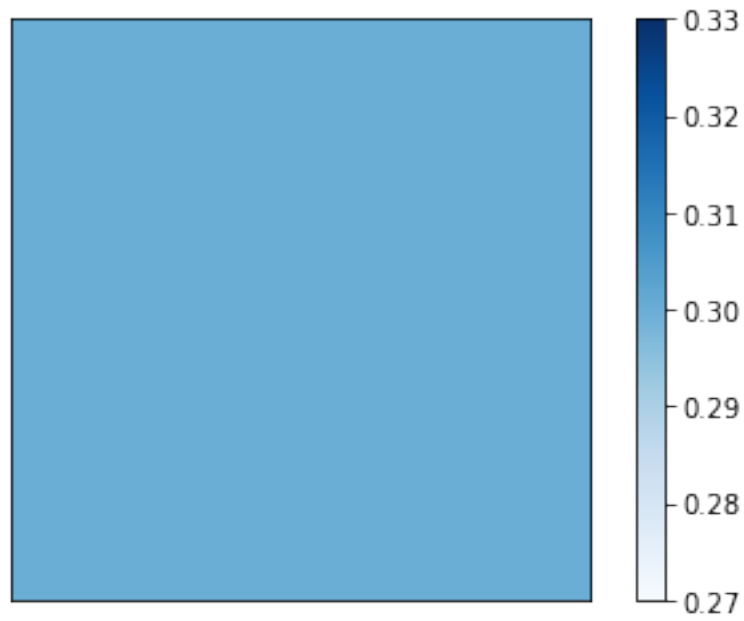
In [9]: `np.mean(gwr_bw)`

Out[9]: 246.295

### 0.05 MGWR bandwidths

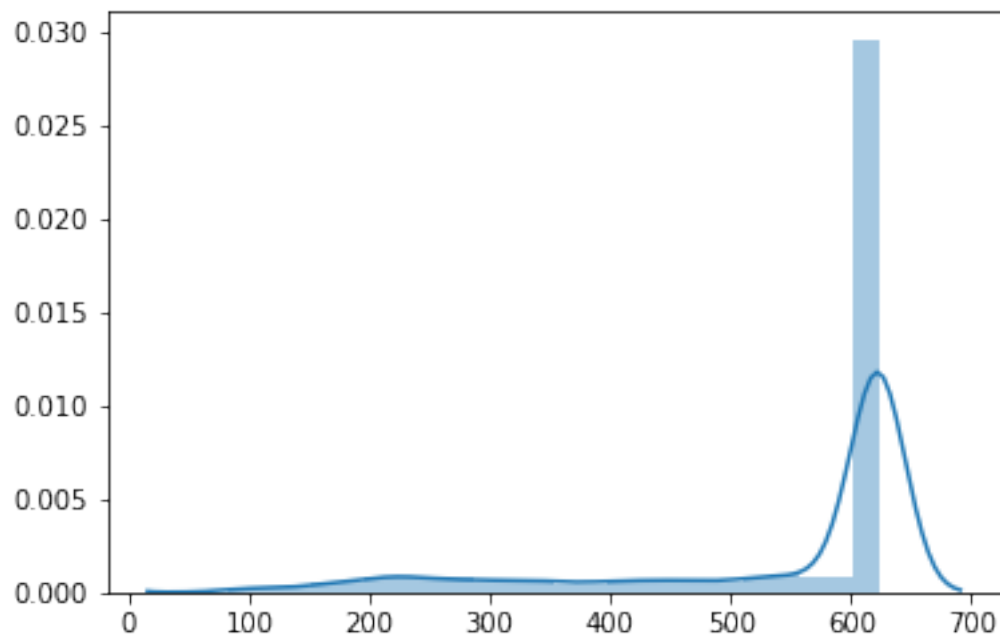
In [10]: `plt.imshow(B0, extent=[0,10, 0, 10], origin='lower', cmap='Blues')  
plt.colorbar()  
plt.axis(aspect='image')  
plt.xticks([])  
plt.yticks([])`

Out[10]: (`[]`, <a list of 0 Text yticklabel objects>)



```
In [11]: sns.distplot(mgwr_bw0)
```

```
Out[11]: <matplotlib.axes._subplots.AxesSubplot at 0x1460f778438>
```

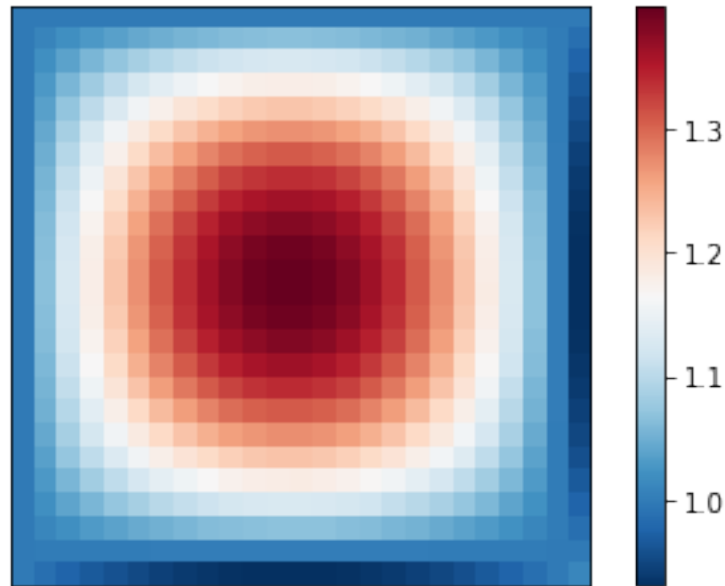


```
In [12]: np.mean(mgwr_bw0)
```

Out[12]: 538.887

```
In [13]: plt.imshow(B1, extent=[0,25, 0, 25], origin='lower',cmap='RdBu_r')
plt.colorbar()
plt.axis(aspect='image')
plt.xticks([])
plt.yticks([])
```

Out[13]: ([], <a list of 0 Text yticklabel objects>)

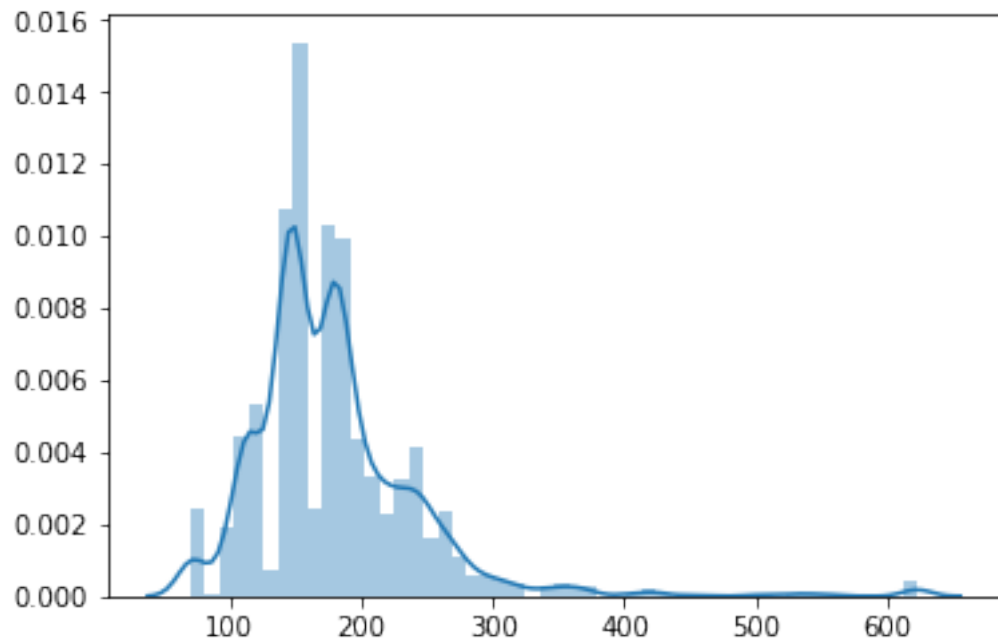


```
In [14]: np.mean(mgwr_bw1)
```

Out[14]: 179.233

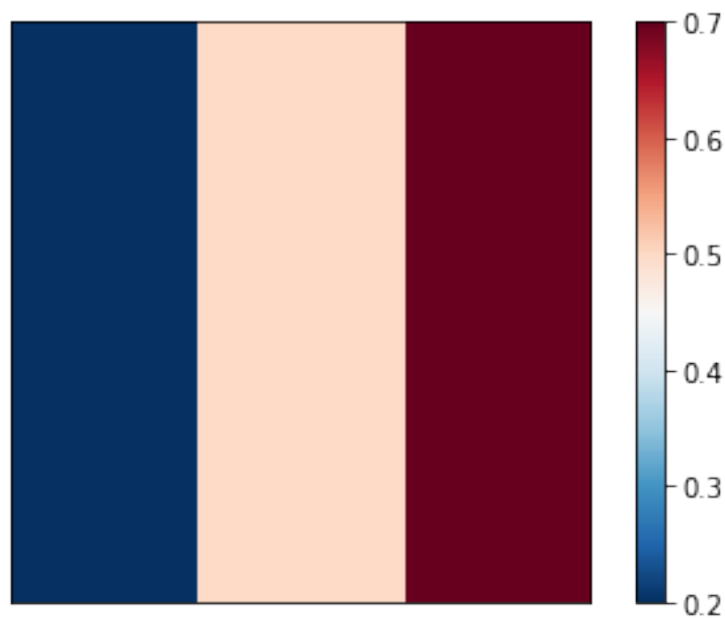
```
In [15]: sns.distplot(mgwr_bw1)
```

Out[15]: <matplotlib.axes.\_subplots.AxesSubplot at 0x1460f81a2e8>



```
In [16]: plt.imshow(B2, extent=[0,25, 0, 25], origin='lower',cmap='RdBu_r')
plt.colorbar()
plt.axis(aspect='image')
plt.xticks([])
plt.yticks([])
```

```
Out[16]: ([], <a list of 0 Text yticklabel objects>)
```

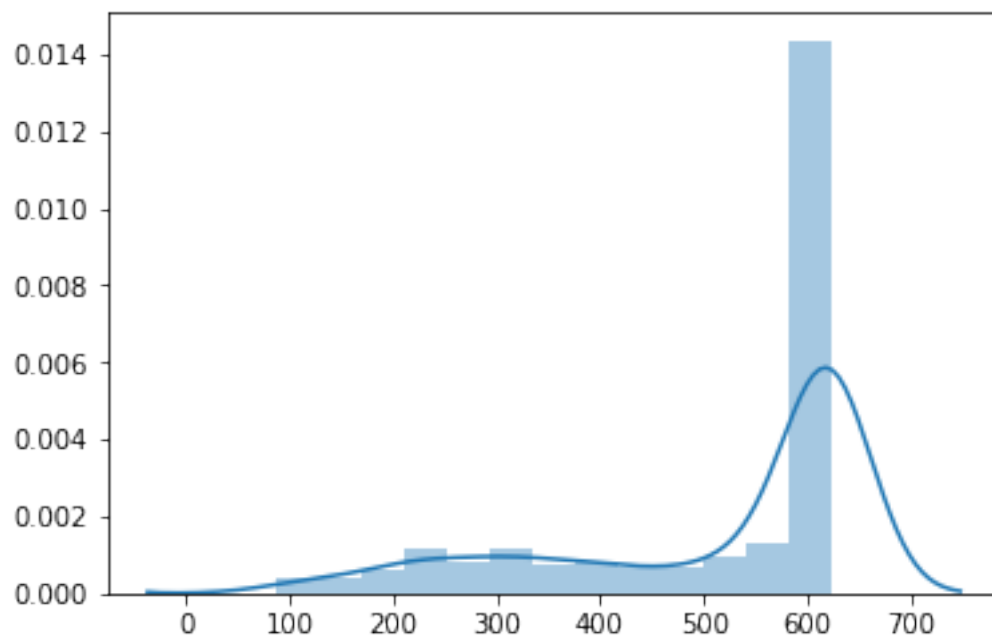


```
In [17]: np.mean(mgwr_bw2)
```

```
Out[17]: 514.968
```

```
In [18]: sns.distplot(mgwr_bw2)
```

```
Out[18]: <matplotlib.axes._subplots.AxesSubplot at 0x1460f963128>
```



```
In [19]: np.mean(mgwr_bw0), np.mean(mgwr_bw1), np.mean(mgwr_bw2)
```

```
Out[19]: (538.887, 179.233, 514.968)
```

## 0.0.6 AIC, AICc, BIC check

```
In [20]: mgwr_aicc=[]  
         gwr_aicc=[]  
         mgwr_bic=[]  
         gwr_bic=[]  
         mgwr_aic=[]  
         gwr_aic=[]  
         mgwr_params=[]  
         gwr_params=[]  
         mgwr_predy=[]  
         gwr_predy=[]
```

```

In [21]: for i in range(0,1000,50):
          p1 = pickle.load( open( "C:/Users/msachde1/Downloads/Research/Development/mgwr/no
          for j in range(50):
              mgwr_aicc.append(p1[j].mgwr_aicc[0])
              gwr_aicc.append(p1[j].gwr_aicc[0])

              mgwr_bic.append(p1[j].mgwr_bic[0])
              gwr_bic.append(p1[j].gwr_bic[0])

              mgwr_aic.append(p1[j].mgwr_aic[0])
              gwr_aic.append(p1[j].gwr_aic[0])

              mgwr_params.append(p1[j].mgwr_params[0])
              gwr_params.append(p1[j].gwr_params[0])

              mgwr_predy.append(p1[j].mgwr_predy[0])
              gwr_predy.append(p1[j].gwr_predy[0])

```

```

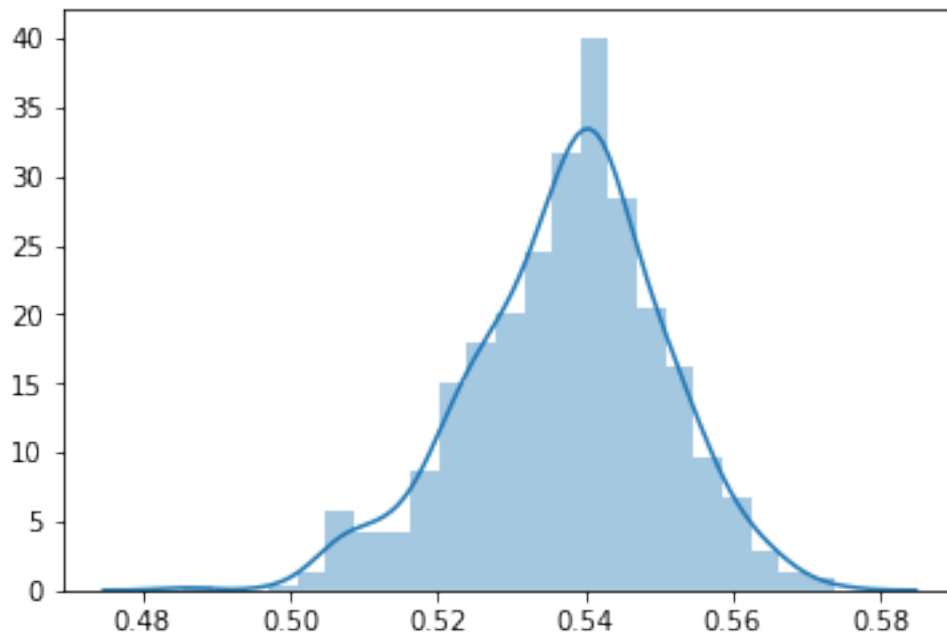
In [22]: sns.distplot(np.mean(gwr_predy,axis=0))

```

```

Out[22]: <matplotlib.axes._subplots.AxesSubplot at 0x146109b99b0>

```



```

In [23]: sns.distplot(np.mean(mgwr_predy,axis=0))

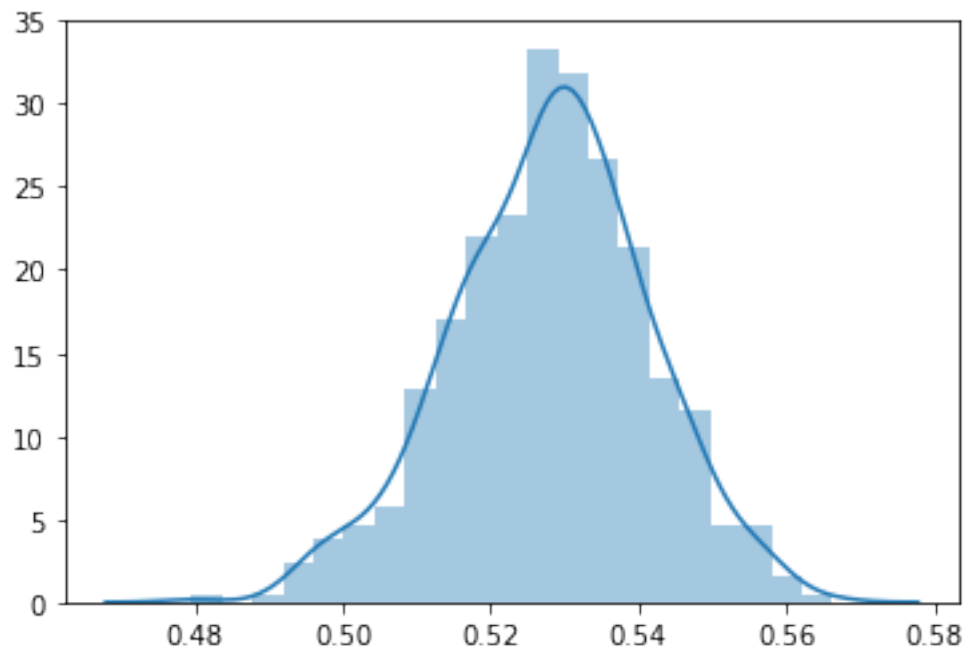
```

```

Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x14612a449b0>

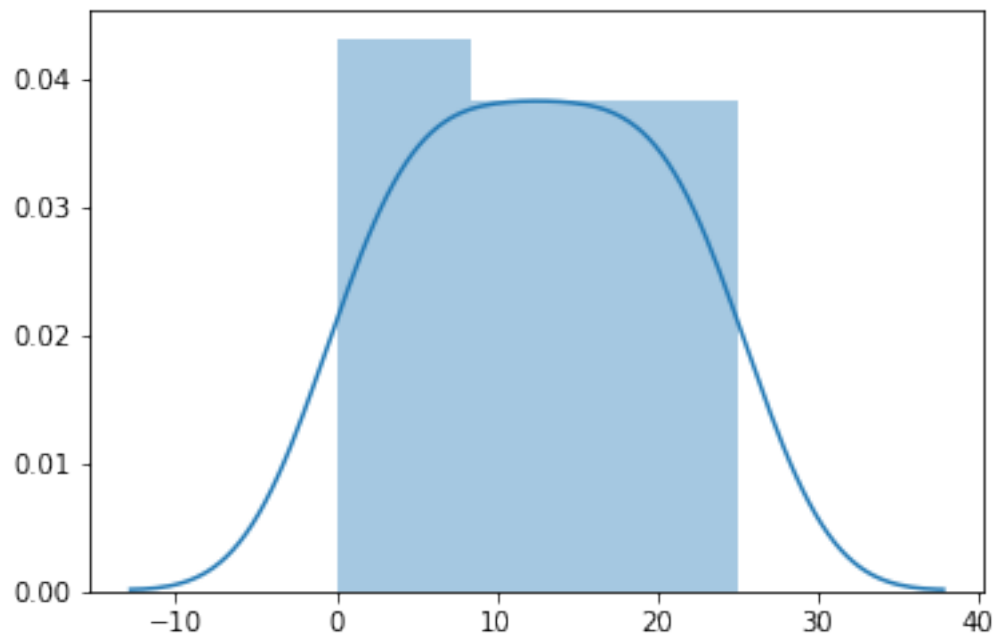
```





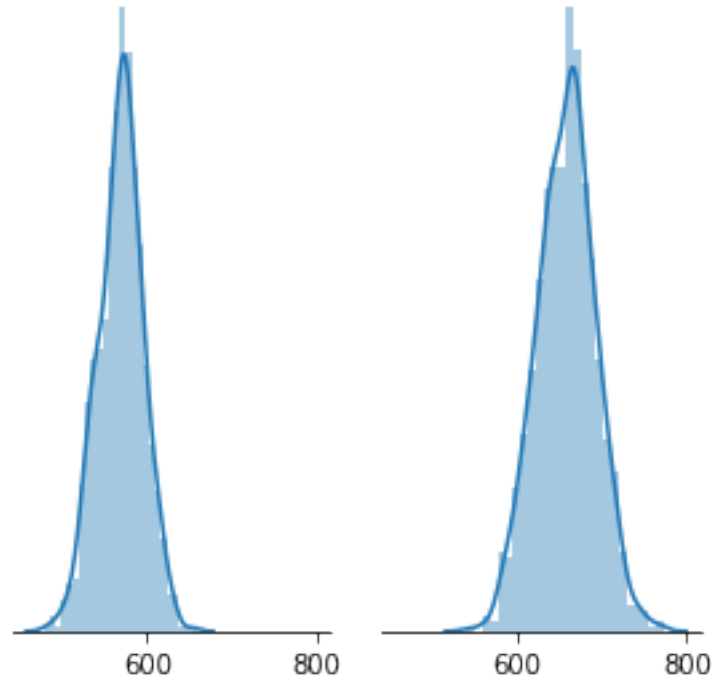
```
In [24]: sns.distplot(y)
```

```
Out[24]: <matplotlib.axes._subplots.AxesSubplot at 0x1460f8deb70>
```



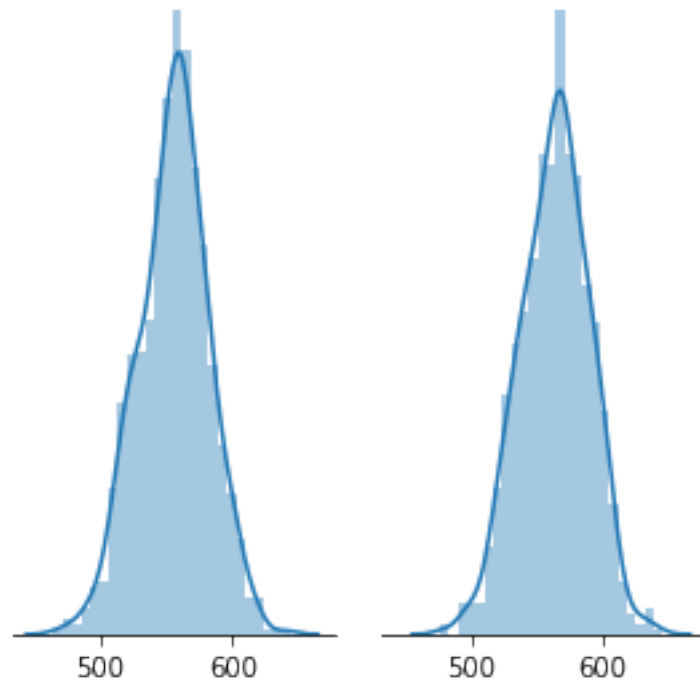
```
In [25]: f, axes = plt.subplots(1, 2, figsize=(4, 4), sharex=True)
sns.despine(left=True)
sns.distplot(mgwr_bic, ax=axes[0])
sns.distplot(gwr_bic, ax=axes[1])

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



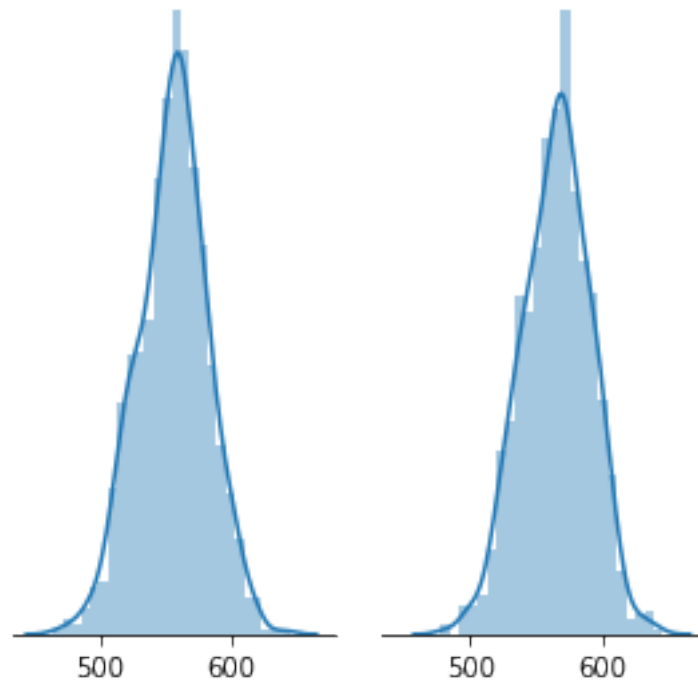
```
In [26]: f, axes = plt.subplots(1, 2, figsize=(4, 4), sharex=True)
sns.despine(left=True)
sns.distplot(mgwr_aic, ax=axes[0])
sns.distplot(gwr_aic, ax=axes[1])

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



```
In [27]: f, axes = plt.subplots(1, 2, figsize=(4, 4), sharex=True)
sns.despine(left=True)
sns.distplot(mgwr_aicc, ax=axes[0])
sns.distplot(gwr_aicc, ax=axes[1])

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



```
In [28]: np.mean(mgwr_aicc), np.mean(gwr_aicc)
```

```
Out[28]: (555.2930310559196, 565.2171303944737)
```

```
In [29]: np.mean(mgwr_aic), np.mean(gwr_aic)
```

```
Out[29]: (555.2543525109128, 563.542676896326)
```

```
In [30]: np.mean(mgwr_bic), np.mean(gwr_bic)
```

```
Out[30]: (568.5736137906213, 657.6378243512686)
```

### AIC, AICc, BIC Boxplots for comparison

```
In [32]: model=[]
         model = ['gwr']*1000
         model2 = ['mgwr']*1000
         model=model+model2
```

```
In [33]: aic=[]
         aic=gwr_aic
         aic=aic+mgwr_aic
```

```
In [34]: aicc=[]
         aicc=gwr_aicc
         aicc=aicc+mgwr_aicc
```

```

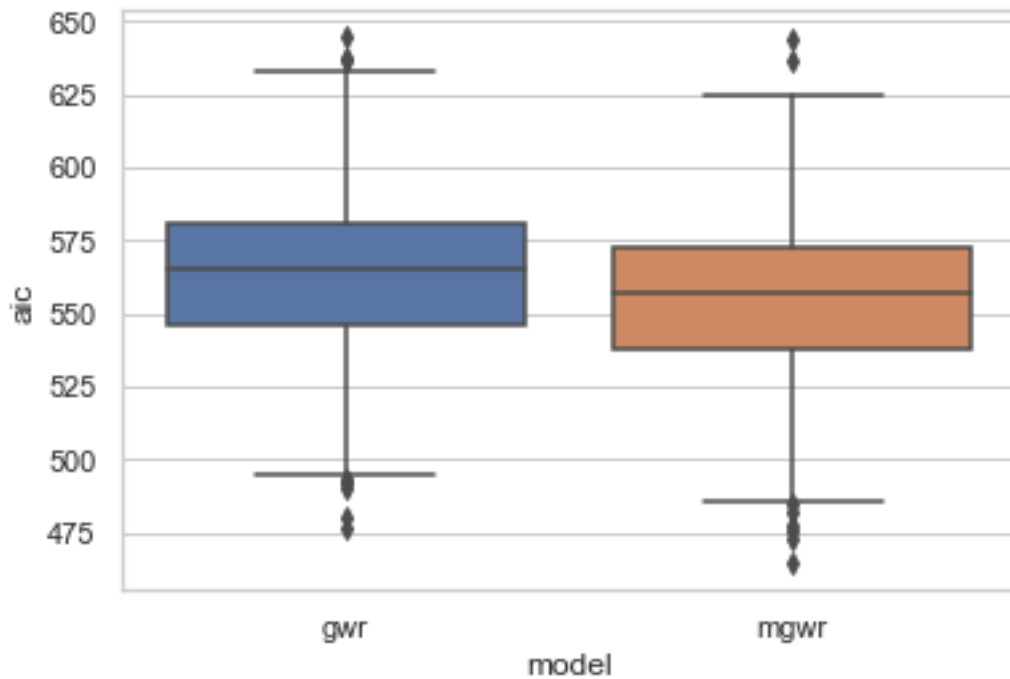
In [35]: bic=[]
         bic=gwr_bic
         bic=bic+mgwr_bic

In [36]: d = {'aic':aic,'bic':bic,'aicc':aicc,'model':model}

In [37]: df=pd.DataFrame(data=d)

In [38]: sns.set(style="whitegrid")
         ax = sns.boxplot(y=df['aic'],x=df['model'])

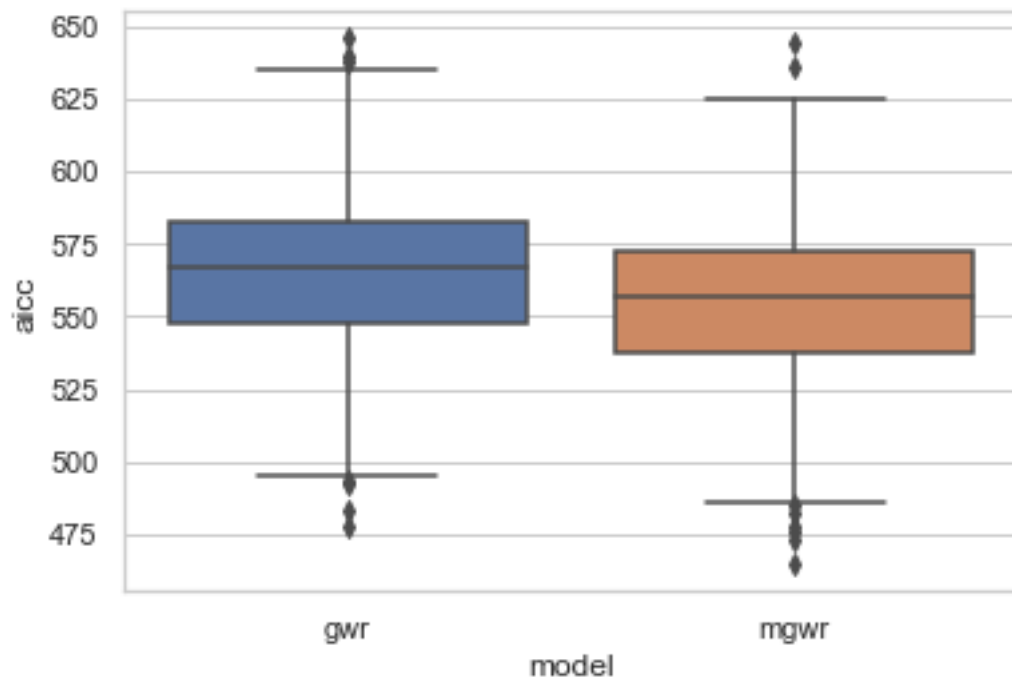
```



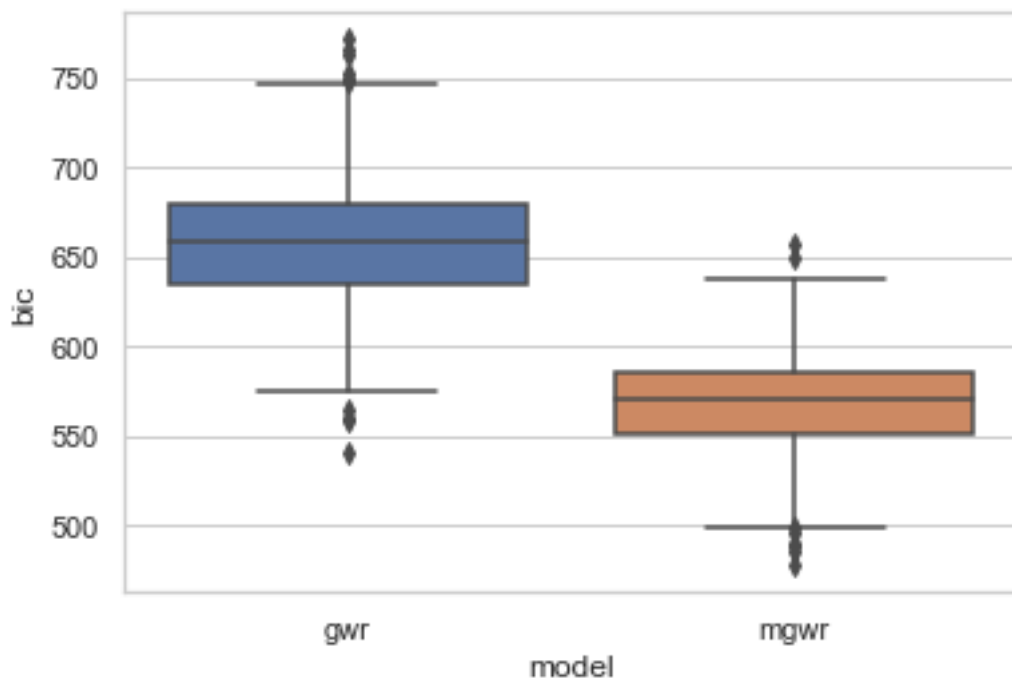
```

In [39]: sns.set(style="whitegrid")
         ax = sns.boxplot(y=df['aicc'],x=df['model'])

```



```
In [40]: sns.set(style="whitegrid")
         ax = sns.boxplot(y=df['bic'],x=df['model'])
```



### 0.0.7 Parameter comparison from MGWR and GWR

```
In [41]: mgwr_params_mean=np.mean(mgwr_params,axis=0)
        gwr_params_mean=np.mean(gwr_params,axis=0)

In [42]: gwr_params_mean

Out[42]: array([[0.2846917 , 1.60675938, 0.25596671],
               [0.28371941, 1.60712877, 0.26163037],
               [0.28254898, 1.60802699, 0.26836111],
               ...,
               [0.28030459, 1.7171863 , 0.64758872],
               [0.27994884, 1.68247975, 0.6534747 ],
               [0.27958057, 1.65168921, 0.65852034]])

In [43]: B0_mgwr=np.hsplitt(mgwr_params_mean,3)[0]
        B1_mgwr=np.hsplitt(mgwr_params_mean,3)[1]
        B2_mgwr=np.hsplitt(mgwr_params_mean,3)[2]

In [44]: B0_gwr=np.hsplitt(gwr_params_mean,3)[0]
        B1_gwr=np.hsplitt(gwr_params_mean,3)[1]
        B2_gwr=np.hsplitt(gwr_params_mean,3)[2]

In [45]: B0_mgwr=B0_mgwr.reshape(25,25)
        B1_mgwr=B1_mgwr.reshape(25,25)
        B2_mgwr=B2_mgwr.reshape(25,25)

In [46]: np.mean(B1_mgwr),np.mean(B1_gwr),np.mean(B1)

Out[46]: (2.5987313746451686, 2.452124883320957, 1.147104517676957)

In [47]: B0_gwr=B0_gwr.reshape(25,25)
        B1_gwr=B1_gwr.reshape(25,25)
        B2_gwr=B2_gwr.reshape(25,25)

In [48]: fig, (ax, ax2,ax3, cax) = plt.subplots(ncols=4,figsize=(10,6),
        gridspec_kw={"width_ratios":[1,1,1, 0.1],"height_ratios":[1]})
        fig.subplots_adjust(wspace=0.3)
        im = ax.imshow(B0, extent=[0,10, 0, 10], origin='lower',cmap='Blues')
        ax.text(3, -2, 'Original B0')
        im2 = ax2.imshow(B0_mgwr, extent=[0,10, 0, 10], origin='lower',cmap='Blues')
        ax2.text(3, -2, 'MGWR B0')
        im3 = ax3.imshow(B0_gwr, extent=[0,10, 0, 10], origin='lower',cmap='Blues')
        ax3.text(3, -2, 'GWR B0')

        divider = make_axes_locatable(ax3)
```

```
fig.colorbar(im, cax=cax)
```

```
ax.set_xticks([])
```

```
ax.set_yticks([])
```

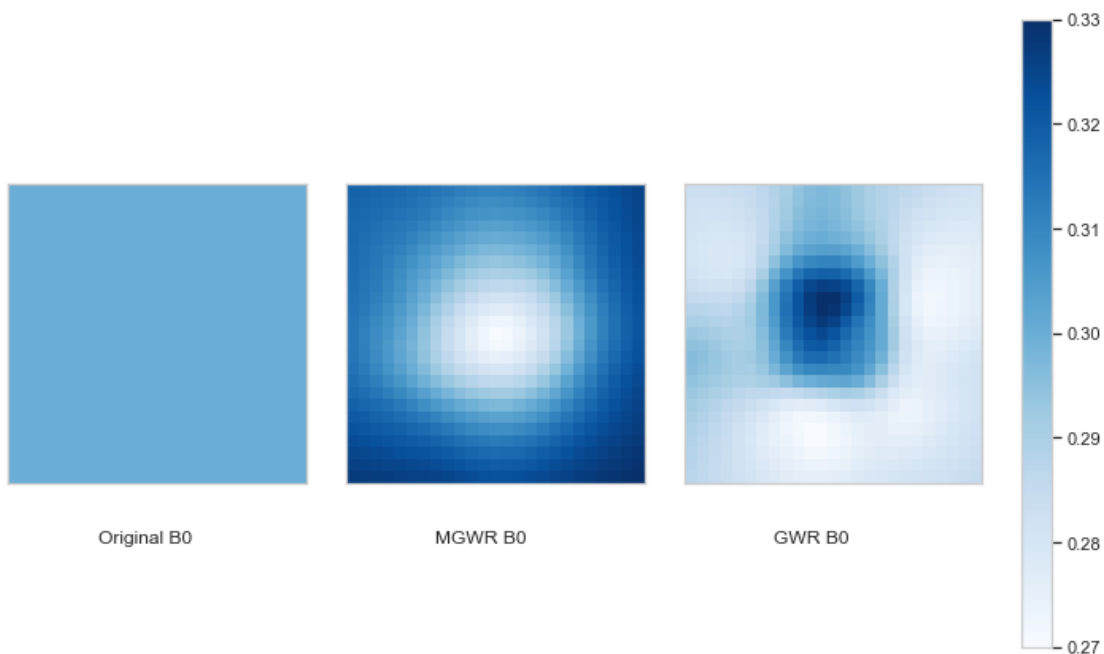
```
ax2.set_xticks([])
```

```
ax2.set_yticks([])
```

```
ax3.set_xticks([])
```

```
ax3.set_yticks([])
```

```
plt.tight_layout()
```



```
In [49]: fig, (ax, ax2, ax3, cax) = plt.subplots(ncols=4, figsize=(10,6),
                                                gridspec_kw={"width_ratios": [1,1,1, 0.1], "height_ratios": [1]})
fig.subplots_adjust(wspace=0.3)
im = ax.imshow(B1, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax.text(3, -2, 'Original B1')
im2 = ax2.imshow(B1_mgwr, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax2.text(3, -2, 'MGWR B1')
im3 = ax3.imshow(B1_gwr, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax3.text(3, -2, 'GWR B1')

divider = make_axes_locatable(ax3)
```



```

fig.colorbar(im, cax=cax)

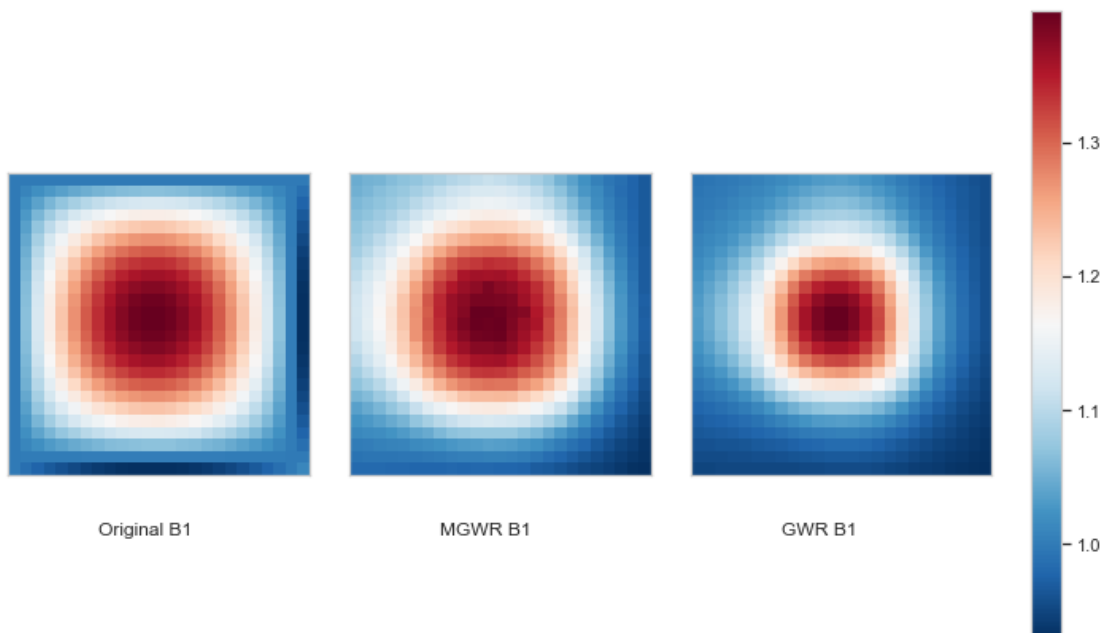
ax.set_xticks([])
ax.set_yticks([])

ax2.set_xticks([])
ax2.set_yticks([])

ax3.set_xticks([])
ax3.set_yticks([])

plt.tight_layout()

```



```

In [50]: fig, (ax, ax2, ax3, cax) = plt.subplots(ncols=4, figsize=(10,6),
                                                gridspec_kw={"width_ratios": [1,1,1, 0.1], "height_ratios": [1]})
fig.subplots_adjust(wspace=0.3)
im = ax.imshow(B2, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax.text(3, -2, 'Original B2')
im2 = ax2.imshow(B2_mgwr, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax2.text(3, -2, 'MGWR B2')
im3 = ax3.imshow(B2_gwr, extent=[0,10, 0, 10], origin='lower', cmap='RdBu_r')
ax3.text(3, -2, 'GWR B2')

divider = make_axes_locatable(ax3)

fig.colorbar(im, cax=cax)

```

```

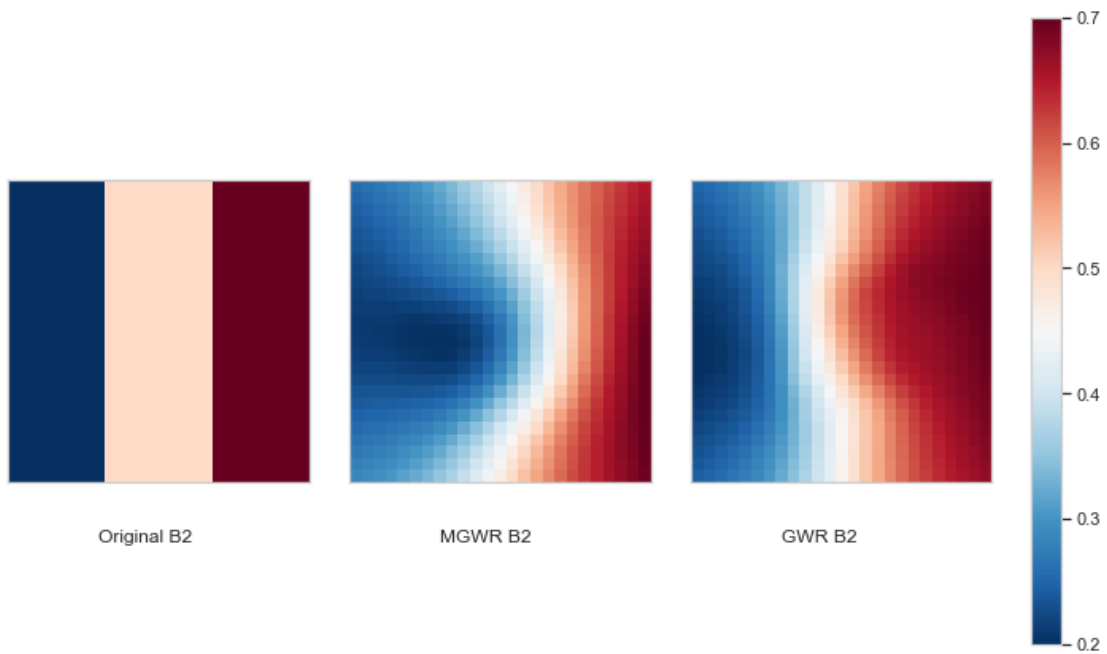
ax.set_xticks([])
ax.set_yticks([])

ax2.set_xticks([])
ax2.set_yticks([])

ax3.set_xticks([])
ax3.set_yticks([])

plt.tight_layout()

```



### 0.08 Comparing parameters (MGWR and GWR)

$$RMSE_j = \sqrt{1/n \sum (\beta_j(u_i, v_i) - \hat{\beta}(u_i, v_i))^2}$$

```

In [51]: B0_g=np.hsplitt(gwr_params_mean,3)[0]
          B1_g=np.hsplitt(gwr_params_mean,3)[1]
          B2_g=np.hsplitt(gwr_params_mean,3)[2]

In [52]: B0_m=np.hsplitt(mgwr_params_mean,3)[0]
          B1_m=np.hsplitt(mgwr_params_mean,3)[1]
          B2_m=np.hsplitt(mgwr_params_mean,3)[2]

In [53]: b0 = B0.reshape(-1,1)
          b1 = B1.reshape(-1,1)
          b2 = B2.reshape(-1,1)

```

### 0.0.9 $B_0$

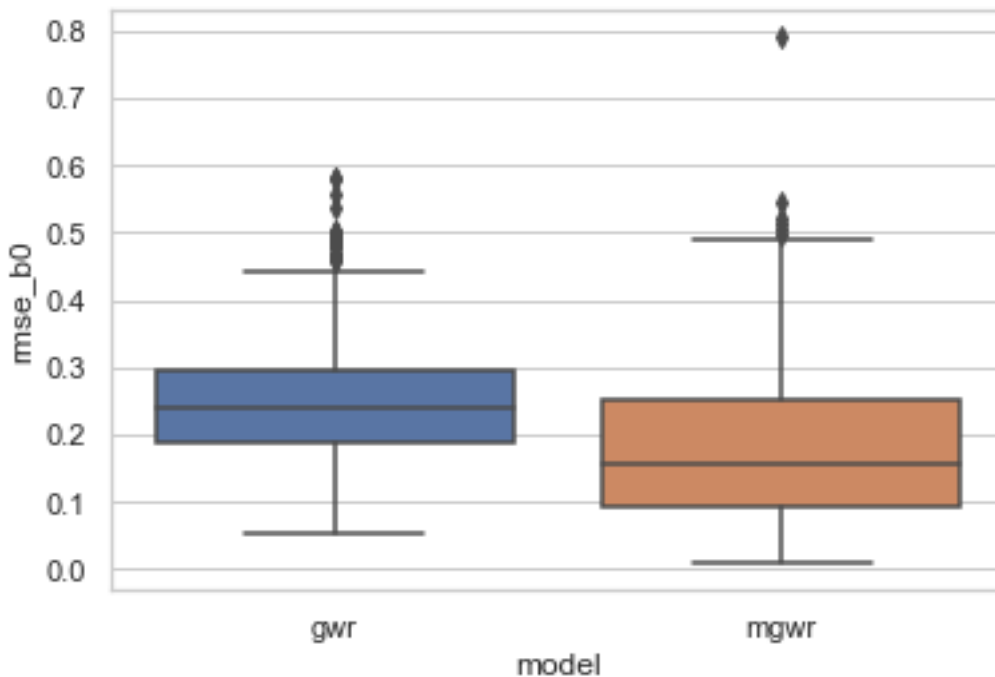
```
In [55]: rmse_b0_m=[]
        for i in range(1000):
            rmse_b0_m.append(np.sqrt((np.sum((b0 - (np.hsplit(mgwr_params[i],3)[0]))**2))/625))

        rmse_b0_g=[]
        for i in range(1000):
            rmse_b0_g.append(np.sqrt((np.sum((b0 - (np.hsplit(gwr_params[i],3)[0]))**2))/625))

In [56]: model=[]
        model = ['gwr']*1000
        model2 = ['mgwr']*1000
        model=model+model2

        rmse_b0 = rmse_b0_g+rmse_b0_m
        d = {"model":model,"rmse_b0":rmse_b0}
        df = pd.DataFrame(data=d)

In [57]: sns.set(style="whitegrid")
        ax = sns.boxplot(y=df['rmse_b0'],x=df['model'])
```



### 0.0.10 $B_1$

```
In [58]: rmse_b1_m=[]
        for i in range(1000):
```

```

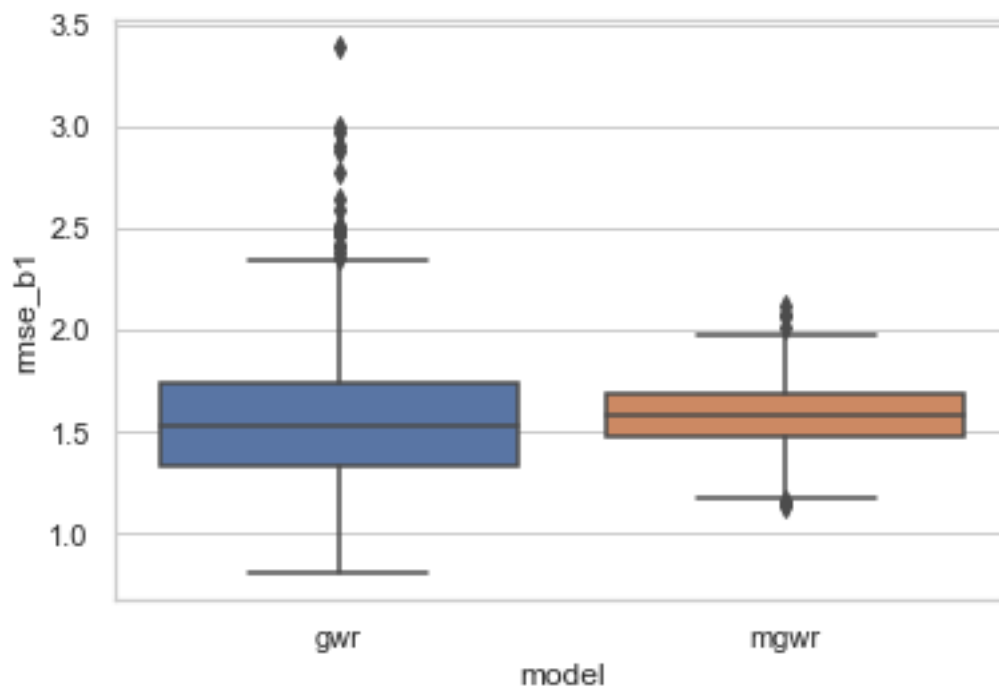
rmse_b1_m.append(np.sqrt((np.sum((b1 - (np.hsplit(mgwr_params[i],3)[1]))**2))/625))

In [59]: rmse_b1_g=[]
         for i in range(1000):
             rmse_b1_g.append(np.sqrt((np.sum((b1 - (np.hsplit(gwr_params[i],3)[1]))**2))/625))

In [60]: model=[]
         model = ['gwr']*1000
         model2 = ['mgwr']*1000
         model=model+model2
         rmse_b1=[]
         rmse_b1 = rmse_b1_g+rmse_b1_m
         d = {"model":model,"rmse_b1":rmse_b1}
         df = pd.DataFrame(data=d)

In [61]: sns.set(style="whitegrid")
         ax = sns.boxplot(x=df['model'],y=df['rmse_b1'])

```



```

In [62]: np.sqrt((np.sum((b1 - (np.hsplit(mgwr_params_mean,3)[1]))**2))/625)

Out [62]: 1.5218558005607021

In [63]: np.sqrt((np.sum((b1 - (np.hsplit(gwr_params_mean,3)[1]))**2))/625)

Out [63]: 1.487375751104697

```

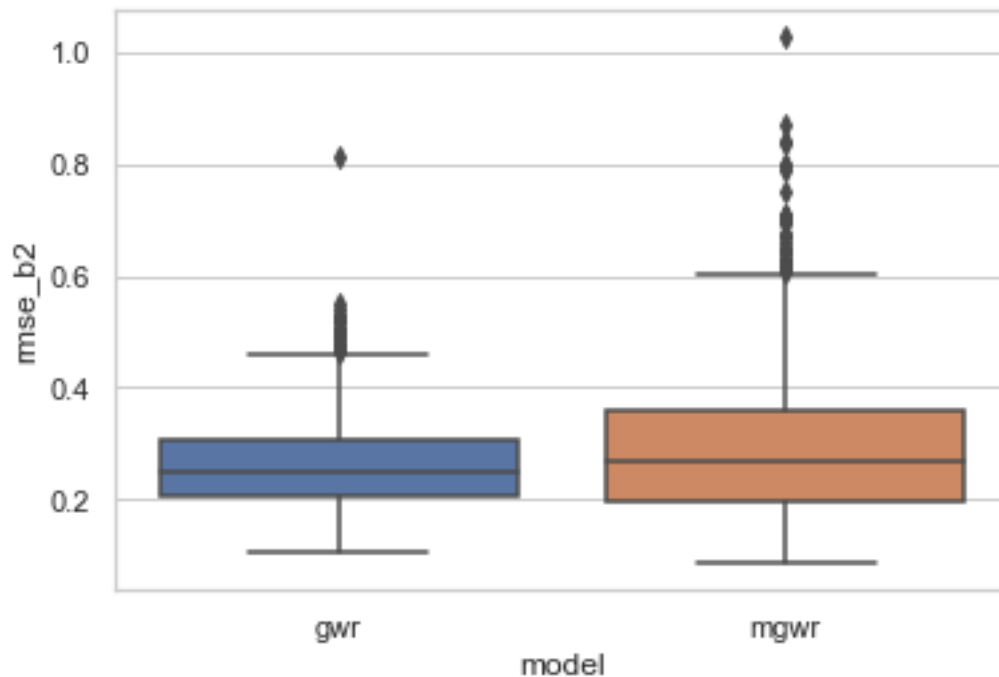
### 0.0.11 $B_2$

```
In [65]: rmse_b2_m=[]
        for i in range(1000):
            rmse_b2_m.append(np.sqrt((np.sum((b2 - np.hsplit(mgwr_params[i],3)[2])**2))/625))

        rmse_b2_g=[]
        for i in range(1000):
            rmse_b2_g.append(np.sqrt((np.sum((b2 - np.hsplit(gwr_params[i],3)[2])**2))/625))

In [66]: model=[]
        model = ['gwr']*1000
        model2 = ['mgwr']*1000
        model=model+model2
        rmse_b2=[]
        rmse_b2 = rmse_b2_g+rmse_b2_m
        d = {"model":model,"rmse_b2":rmse_b2}
        df = pd.DataFrame(data=d)

In [67]: sns.set(style="whitegrid")
        ax = sns.boxplot(y=df['rmse_b2'],x=df['model'])
```



```
In [68]: np.sqrt((np.sum((b2 - (np.hsplit(mgwr_params_mean,3)[2]))**2))/625)
```

```
Out [68]: 0.16342922217077274
```

```
In [69]: np.sqrt((np.sum((b2 - (np.hsplit(gwr_params_mean,3)[2]))**2))/625)
```

```
Out[69]: 0.07374405903986679
```