

# IST718 - Lab #6 - 9 May 2020

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## OVERVIEW

### Research Question

Can we predict which three zip codes provide the best investment opportunity for the Syracuse Real Estate Investment Trust (SREIT)?

### Summary Tables

Arkansas

Location/Data	Growth Calculation	Forecast % Inc. Price	Forecast 2018 Price	RMSE	Technique
Hot Springs - Zillow 97-17 monthly	17-18	1.4%	\$133,816	\$5285	ARIMA
Fayetteville - Zillow 97-17 monthl	17-18	2.5%	\$172,517	\$7132	ARIMA
Little Rock - Zillow 97-17 monthly	17-18	3.8%	\$145,683	\$5633	ARIMA
Searcy - Zillow 97-17 monthly	17-18	3.2%	\$95,435	\$8018	Prophet

USA

Location/Data	Growth Calculation	RECOMMENDED ZIP CODES	Forecast % inc. Price	Forecast % inc. GDP	RMSE % (rmse/actual)	Technique
USA - Zillow 97-17, GDP 01-07 annual	17-18	08401,08232, 08241	39-75%	3.7-6.7%	26-63%	Prophet
USA - Zillow 97-17, GDP 01-17 annual	97-18	90403, 90027, 90020	483-556%	93-147%	11-13%	Prophet

### Approach

- What technique/algorithm/decision process used?
  - After importing and processing the Zillow data, it contained 3.3 million observations. It was estimated that a time series models with monthly data would require over 50 hours of processing for 12,652 zip codes. The decision was made to group the data by years to reduce the processing time and a model could be run using Facebook's Prophet in about 4 hours for all 12,652 zip codes.
  - The time frame (short or long term), was another factor to consider when designing the models to forecast home prices. The research question did not state whether the REIT was interested in a short term or long term view. For this reason, the models were built with a short term view (forecast growth 2017-2018) and a long term view (forecast growth from 1997-2018).

### Conclusion

- What three zip codes provide the best investment opportunity for the SREIT?
  - The long term forecast using Zillow data identified 4 of the top 5 zip codes for % growth from 1997 to forecast 2018 in California (with one in New York). After using GDP data on the top Zillow zip codes, it was determined that 90403 (Santa Monica) and 90027/90020 (Los Angeles) provided the best long term potential.
  - The short term forecast using Zillow data provided more surprising and interesting results. The short term forecast for 2017 to forecast 2018 identified cities in the northeast that were impacted by Hurricane Sandy in 2012. The top zip codes for short term gains were 08401/08232 (Atlantic City) and 08241 (Galloway, NJ). Since this area was devastated by the 2012 storm, it is expected that the area will rebound in 2018. This rebuilding was also highlighted in the 2017 New York Times article, "Not Your Mother's Jersey Shore".
  - The RMSE percent error (RMSE/Actual) for the top zip codes ranged from 26-63% for the short term forecast and 11-13% for the long range forecast. The high RMSE values for the short term projections are concerning and additional evaluation of the New Jersey zip codes (with AtsPy) should be conducted to validate the Prophet forecasts.
  - Please see the table above and Section 3.0 for more details on the interpretation of the models.

### Data

- Zillow housing data from 1997-2018 (files.zillowstatic.com/research/public/Zip/Zip\_Zhvi\_SingleFamilyResidence.csv).
- Gross Domestic Product (GDP) data 2001-2018 is from the Bureau of Labor Statistics.

### Technology

- Facebook's Prophet was utilized for the high volume time series modeling.
- AtsPy (Automated Time Series Forecasting for Python) was used for the metro areas of Arkansas using ARIMA, Prophet and Gluonts techniques. More information on AtsPy can be found at <https://github.com/firmai/atspy>.

# 1.0 - OBTAIN - SCRUB - EXPLORE

## ▸ 1.1 - Arkansas Data - Obtain and Scrub

↳ 12 cells hidden

## ▾ 1.2 - Arkansas Explore

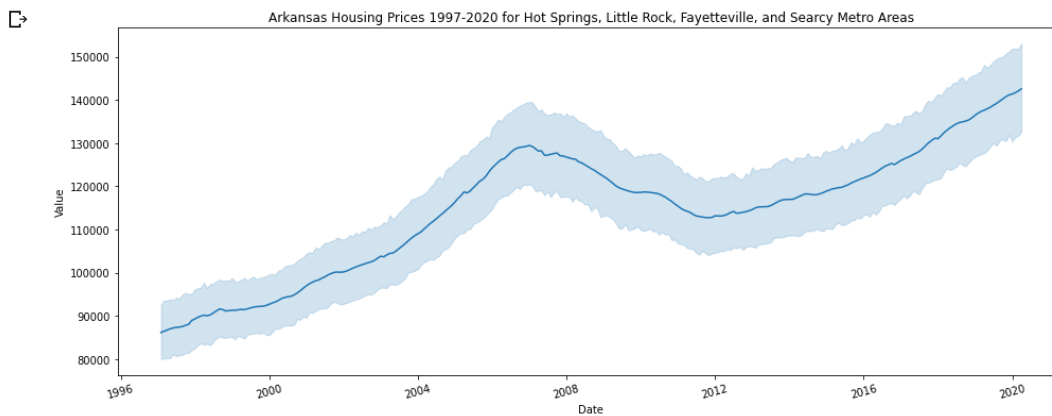
```
zillowARtrans.Metro.value_counts()
```

```
↳ Little Rock-North Little Rock-Conway    17298
   Fayetteville-Springdale-Rogers         13671
   Searcy                                  5022
   Hot Springs                             1953
   Name: Metro, dtype: int64
```

```
zillowARtrans.CountyName.value_counts()
```

```
↳ Pulaski County      6696
   White County       5022
   Benton County      4743
   Washington County  4464
   Lonoke County      3069
   Faulkner County    2790
   Saline County      2790
   McDonald County    2511
   Garland County     1953
   Madison County     1953
   Perry County       1116
   Grant County        837
   Name: CountyName, dtype: int64
```

```
plt.figure(figsize=(16, 6))
plt.clf()
sns.lineplot(x="Date", y="Value", data=zillowARtrans)
plt.xticks(rotation=15)
plt.title('Arkansas Housing Prices 1997-2020 for Hot Springs, Little Rock, Fayetteville, and Searcy Metro Areas')
plt.show()
```



```
plt.title('Arkansas Housing Prices 1997-2020 for Hot Springs, Little Rock, Fayetteville, and Searcy Metro Areas')
#plt.figure(figsize=(16, 6))
plt.xlabel('Average House Price')
plt.ylabel('Number of Houses')
plt.hist(zillowARtrans['Value'], alpha=0.5)
```

↳

```
/usr/local/lib/python3.6/dist-packages/numpy/lib/histograms.py:839: RuntimeWarning:
```

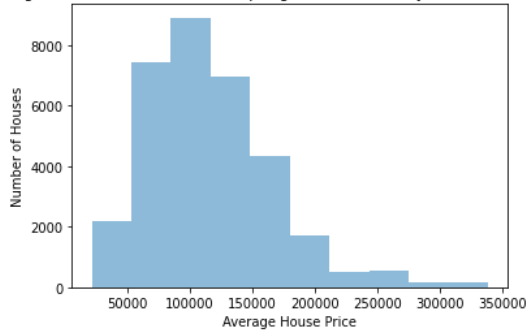
```
invalid value encountered in greater_equal
```

```
/usr/local/lib/python3.6/dist-packages/numpy/lib/histograms.py:840: RuntimeWarning:
```

```
invalid value encountered in less_equal
```

```
(array([2194., 7454., 8913., 6982., 4344., 1720., 528., 549., 175.,  
       185.]),  
 array([ 21450., 53192.1, 84934.2, 116676.3, 148418.4, 180160.5,  
       211902.6, 243644.7, 275386.8, 307128.9, 338871. ]),  
<a list of 10 Patch objects>)
```

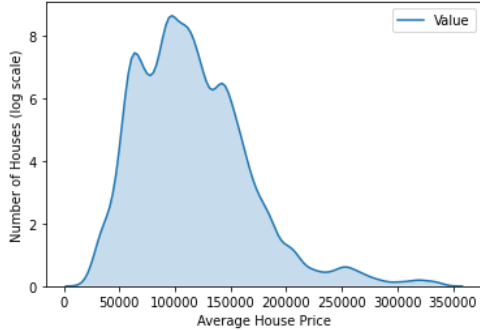
Arkansas Housing Prices 1997-2020 for Hot Springs, Little Rock, Fayetteville, and Searcy Metro Areas



```
plt.title('AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas')  
#plt.figure(figsize=(20,1))  
plt.xlabel('Average House Price')  
plt.ylabel('Number of Houses (log scale)')  
sns.kdeplot(zillowARtrans['Value'], shade=True)
```

```
↳ <matplotlib.axes._subplots.AxesSubplot at 0x7f4930f03ba8>
```

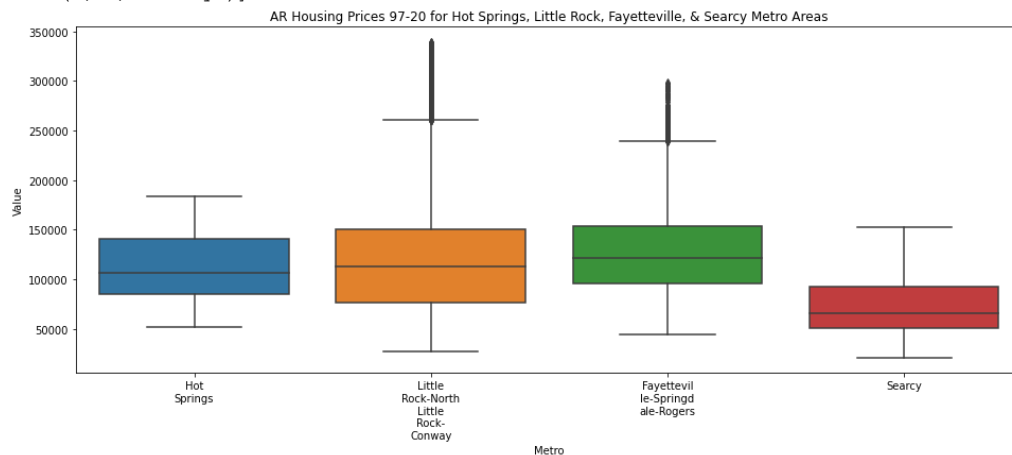
AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas



```
import textwrap  
plt.figure(figsize=(16, 6))  
plt.title('AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas')  
ax = sns.boxplot(data=zillowARtrans, x='Metro', y='Value')  
ax.set_xticklabels([textwrap.fill(t.get_text(), 10) for t in ax.get_xticklabels()])
```

```
↳
```

```
[Text(0, 0, 'Hot\nSprings'),
Text(0, 0, 'Little\nRock-North\nLittle\nRock-\nConway'),
Text(0, 0, 'Fayettevil\nle-Springd\nale-Rogers'),
Text(0, 0, 'Searcy')]
```

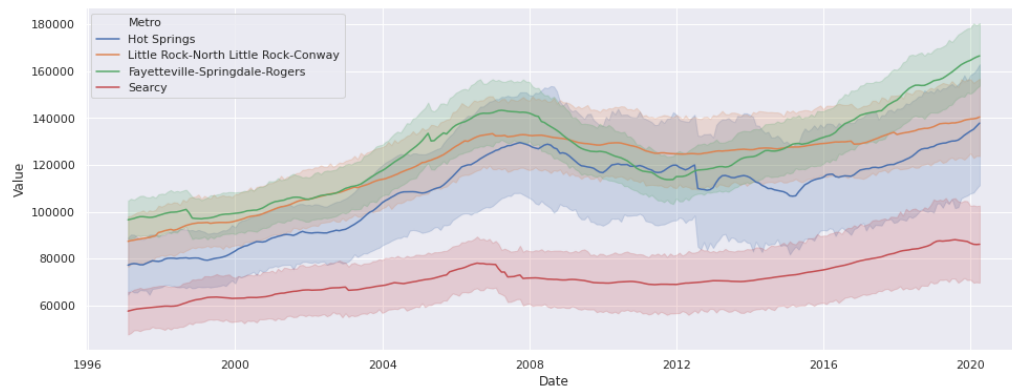


```
import seaborn as sns
plt.figure(figsize=(16, 6))
sns.set(style="darkgrid")

# Load an example dataset with long-form data
#fmri = sns.load_dataset("zillowARtrans")

# Plot the responses for different events and regions
sns.lineplot(x="Date", y="Value",
             hue="Metro",
             data=zillowARtrans)
```

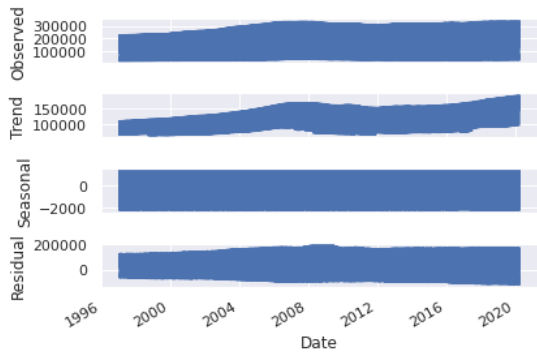
↳ <matplotlib.axes.\_subplots.AxesSubplot at 0x7f49308d4ac8>



```
from pylab import rcParams
zillowARtrans = zillowARtrans.dropna() #remove missing values for this plot
res = sm.tsa.seasonal_decompose(zillowARtrans.Value,
                               freq=12,
                               model='additive')

resplot = res.plot()
resplot.savefig('Seasonal_Decompose.png', dpi=150)
```

↳

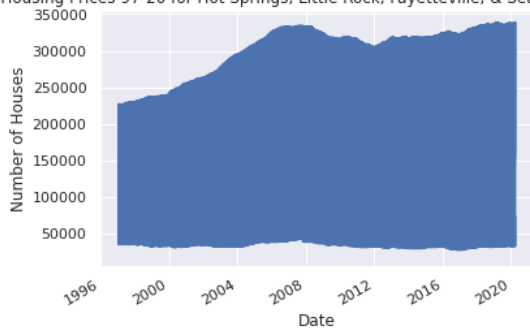


```

from matplotlib import pyplot
zillowARseries.plot()
plt.title('AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas')
plt.ylabel('Number of Houses')
pyplot.show()

```

AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas

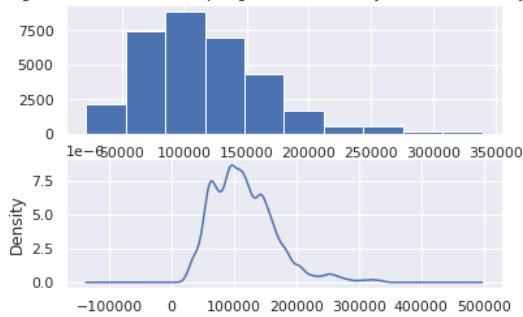


```

pyplot.figure(1)
pyplot.subplot(211)
zillowARseries.hist()
plt.title('AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas')
pyplot.subplot(212)
zillowARseries.plot(kind='kde')

```

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f492af3e908>  
AR Housing Prices 97-20 for Hot Springs, Little Rock, Fayetteville, & Searcy Metro Areas



### 1.3 - GDP Data - Obtain and Scrub

Sources:

Crosswalk table for FIPS to Zip Codes

<https://data.world/nrippner/fips-to-zip-code-crosswalk>

Real GDP (thousands of chained 2012 dollars) 2001\_2018

<https://apps.bea.gov/regional/Downloadzip.cfm>

↳ 6 cells hidden

## ▸ 1.4 - Zillow USA Data - Obtain and Scrub

## ▸ 1.5 - Prophet Data- Obtain and Scrub

In this section, the Zillow USA data is formatted prior to feeding to the Prophet models.

↳ 3 cells hidden

## ▾ 1.6 - Prophet Output- Obtain and Scrub

The output of the Prophet models was saved to csv files and then imported in this section for processing and the calculation of forecasted growth.

### ▸ 1.6.1 - Zillow Data

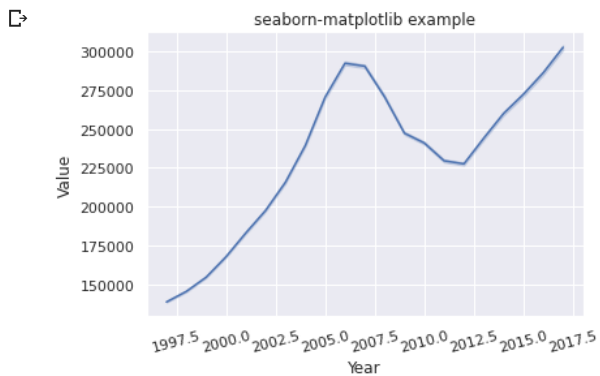
↳ 11 cells hidden

### ▸ 1.6.2 - GDP Data

↳ 7 cells hidden

## ▾ 1.7 - USA Explore

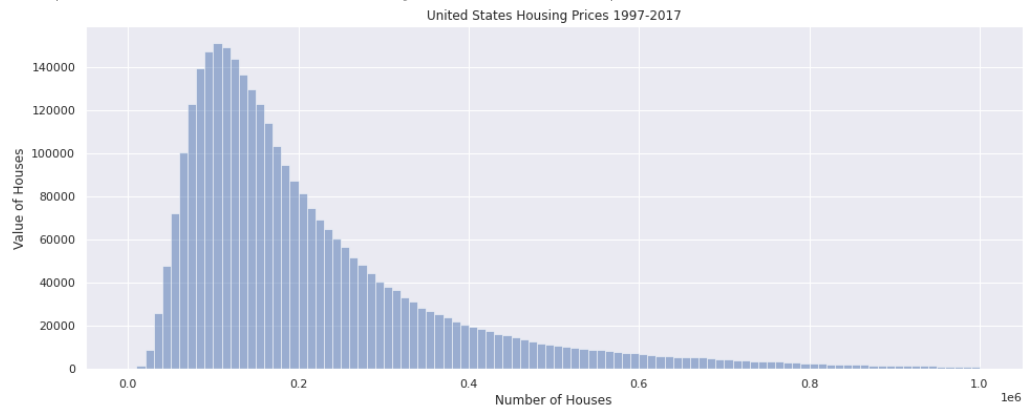
```
plt.clf()
sns.lineplot(x="Year", y="Value", data=zillowUSA97to17)
plt.xticks(rotation=15)
plt.title('seaborn-matplotlib example')
plt.show()
```



```
#Plot of Values
plt.figure(figsize=(16, 6))
plt.hist(zillowUSA97to17['Value'], alpha=0.5, bins=100, range=[0, 1000000])
plt.xlabel('Number of Houses')
plt.ylabel('Value of Houses')
plt.title('United States Housing Prices 1997-2017')
```

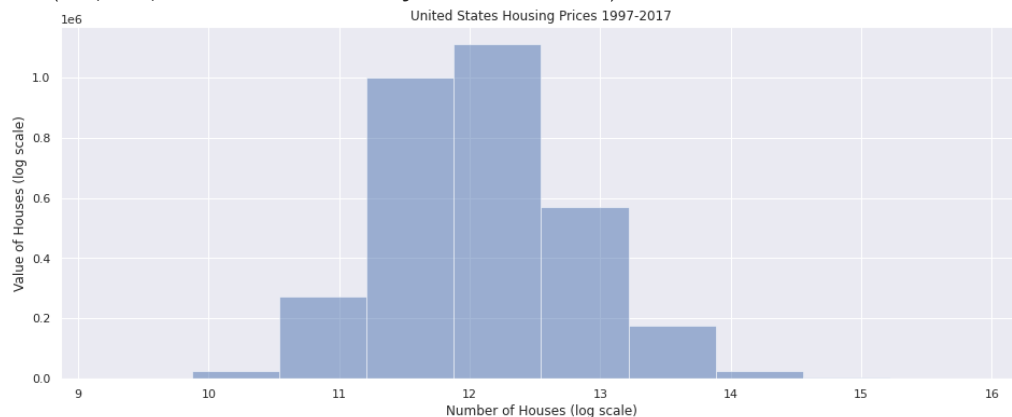
↳

```
Text(0.5, 1.0, 'United States Housing Prices 1997-2017')
```



```
#Plot of Log Values  
plt.figure(figsize=(16, 6))  
plt.hist(zillowUSA97to17['LogValue'], alpha=0.5)  
plt.xlabel('Number of Houses (log scale)')  
plt.ylabel('Value of Houses (log scale)')  
plt.title('United States Housing Prices 1997-2017')
```

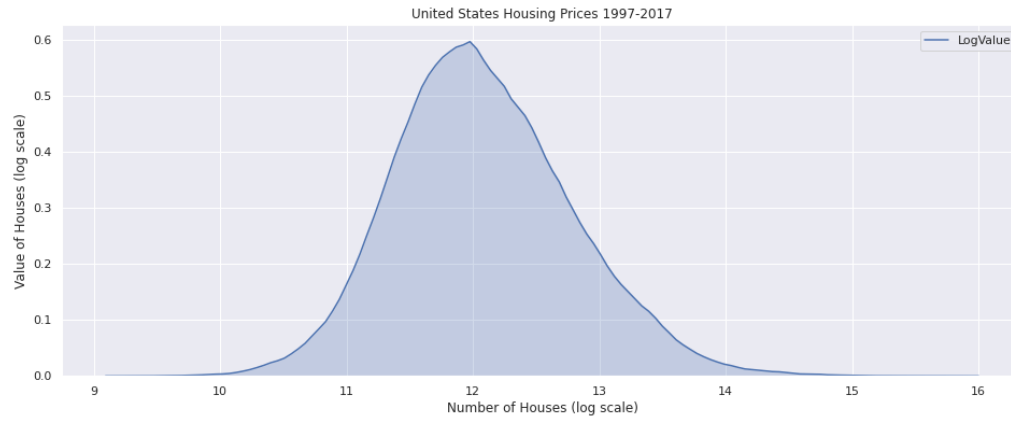
```
↳ Text(0.5, 1.0, 'United States Housing Prices 1997-2017')
```



```
plt.figure(figsize=(16, 6))  
sns.kdeplot(zillowUSA97to17['LogValue'], shade=True)  
plt.xlabel('Number of Houses (log scale)')  
plt.ylabel('Value of Houses (log scale)')  
plt.title('United States Housing Prices 1997-2017')
```

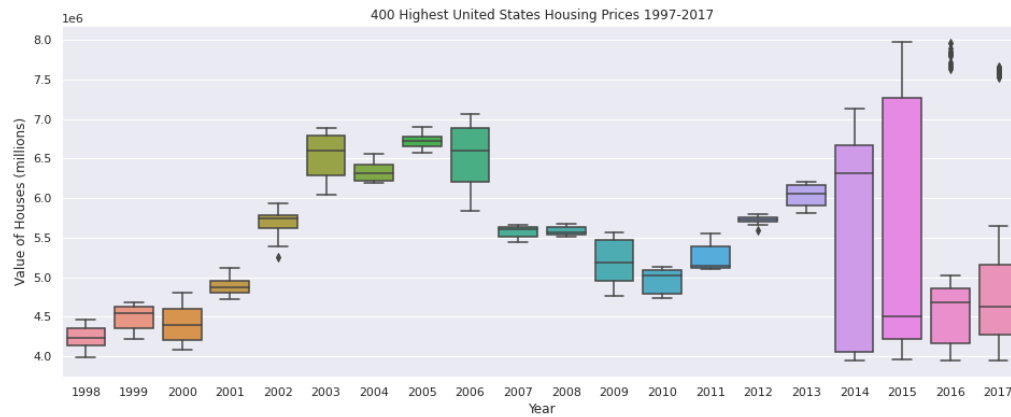
```
↳
```

```
Text(0.5, 1.0, 'United States Housing Prices 1997-2017')
```



```
plt.figure(figsize=(16, 6))  
zillowUSATop400 = zillowUSA97to17.nlargest(400, ['Value'])  
sns.boxplot(data=zillowUSATop400, x='Year', y='Value');  
plt.ylabel('Value of Houses (millions)')  
plt.title('400 Highest United States Housing Prices 1997-2017')
```

```
Text(0.5, 1.0, '400 Highest United States Housing Prices 1997-2017')
```



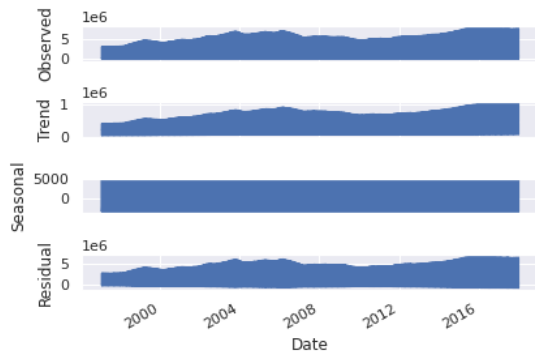
```
plt.figure(figsize=(16, 6))  
plt.title('400 Lowest United States Housing Prices 1997-2017')  
zillowUSABottom400 = zillowUSA97to17.nsmallest(400, ['Value'])  
sns.boxplot(data=zillowUSABottom400, x='Year', y='Value');
```

```
Text(0.5, 1.0, '400 Lowest United States Housing Prices 1997-2017')
```

## 2.0 - MODEL

```
#Look at Residuals, Seasonal and Trend for the Zillow USA data.  
#Since there is no noticeable patterns, no additional transformations are needed.  
from pylab import rcParams  
plt.figure(figsize=(16, 6))  
plt.figure(figsize=(16, 6))  
res = sm.tsa.seasonal_decompose(zillowUSA97to17.Value,  
                               freq=12,  
                               model='additive')  
  
resplot = res.plot()  
resplot.savefig('Seasonal_Decompose.png', dpi=150)
```

<Figure size 1152x432 with 0 Axes>  
<Figure size 1152x432 with 0 Axes>



## 2.1 - Prophet - Analyze All Zip Codes By Year

### 2.1.1 - GDP Functions

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### 2.1.2 - Zillow Functions

↳ 3 cells hidden

## 2.2 - AtsPy - Analyze Arkansas Metro Areas By Month

### 2.2.1 - Install AtsPy Packages

NOTE: After installing the AtsPy packages you will need to restart the runtime.

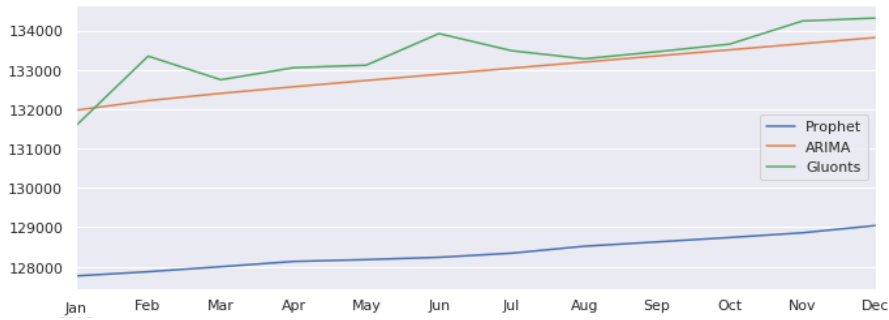
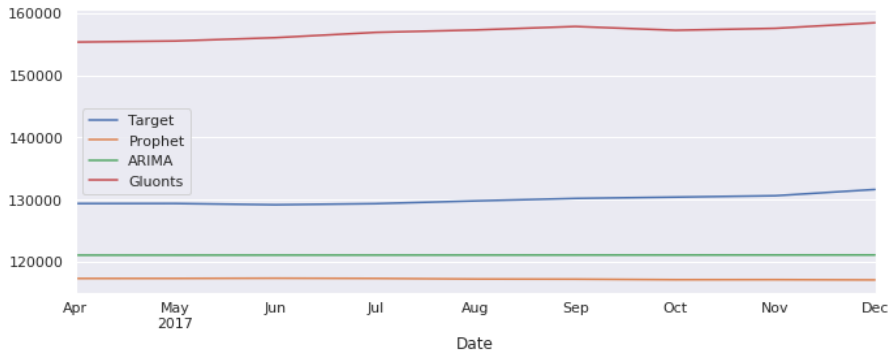
↳ 1 cell hidden

### 2.2.2.- Zillow Functions

Date	ARIMA	Gluonts	Prophet
2018-01-31	131969.149750	131566.187500	127761.860957
2018-02-28	132215.424970	133345.078125	127869.769228
2018-03-31	132399.298620	132744.703125	127997.531953
2018-04-30	132566.452711	133051.843750	128130.147863
2018-05-31	132726.068365	133115.453125	128177.084656
2018-06-30	132883.096459	133917.718750	128235.378970
2018-07-31	133039.108485	133482.875000	128340.203224
2018-08-31	133194.748009	133277.250000	128516.998139
2018-09-30	133350.246175	133456.843750	128626.546025
2018-10-31	133505.691629	133650.718750	128738.339398
2018-11-30	133661.117251	134237.921875	128858.073741
2018-12-31	133816.535446	134311.984375	129041.051826

	Target	ARIMA	Gluonts	Prophet
rmse	0.000000	5.284589e+03	2.185493e+04	7.534903e+03
mse	0.000000	2.792688e+07	4.776382e+08	5.677476e+07
mean	124765.136508	1.210010e+05	1.454516e+05	1.185070e+05

AtsPy Forecast for: Hot Springs



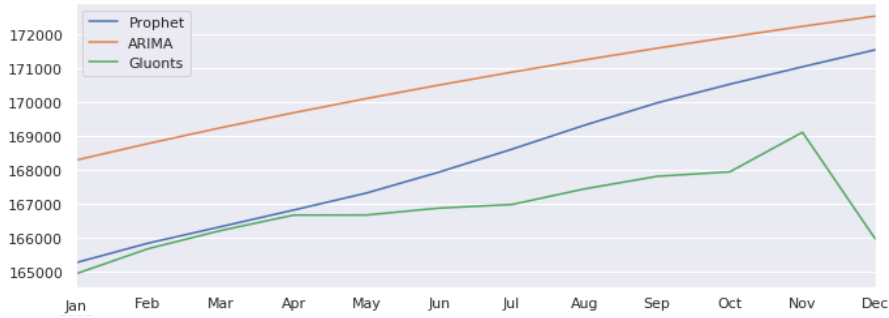
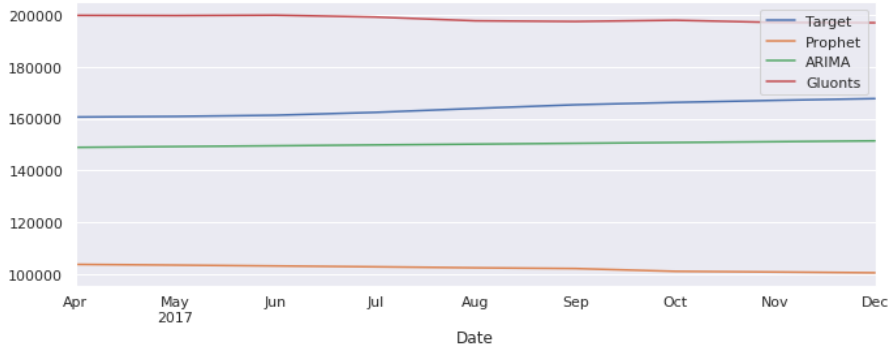
Note: Bottom chart is Forecast 2018.



Date	ARIMA	Gluonts	Prophet
2018-01-31	168270.524773	164922.796875	165251.042149
2018-02-28	168763.685814	165666.562500	165829.623626
2018-03-31	169228.819205	166201.968750	166315.154901
2018-04-30	169669.535696	166656.109375	166805.095418
2018-05-31	170087.866236	166658.156250	167304.253508
2018-06-30	170485.528644	166862.343750	167921.268371
2018-07-31	170864.091196	166967.281250	168594.787179
2018-08-31	171225.001003	167426.765625	169301.503902
2018-09-30	171569.595274	167797.781250	169960.301758
2018-10-31	171899.109889	167929.359375	170510.716065
2018-11-30	172214.687107	169094.953125	171023.864231
2018-12-31	172517.382665	165957.921875	171522.961604

	Target	ARIMA	Gluonts	Prophet
rmse	0.000000	7.132396e+03	4.244133e+04	3.853849e+04
mse	0.000000	5.087107e+07	1.801266e+09	1.485215e+09
mean	147081.066564	1.416891e+05	1.891813e+05	1.125520e+05

AtsPy Forecast for: Fayetteville-Springdale-Rogers



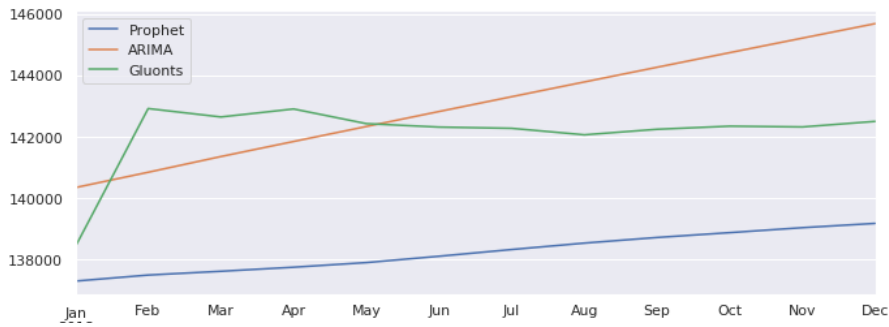
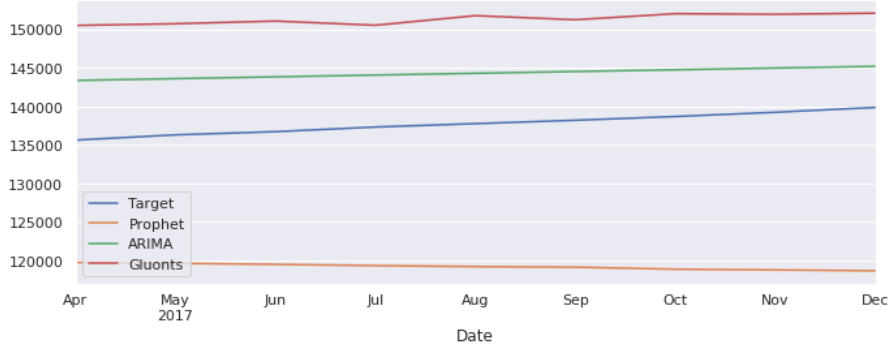
Note: Bottom chart is Forecast 2018.



Date	ARIMA	Gluonts	Prophet
2018-01-31	140346.687120	138430.906250	137302.297017
2018-02-28	140845.190957	142919.375000	137499.193881
2018-03-31	141356.899845	142645.265625	137621.883345
2018-04-30	141846.756771	142905.468750	137754.100633
2018-05-31	142334.354435	142428.218750	137904.827816
2018-06-30	142822.389083	142315.968750	138111.197741
2018-07-31	143304.821234	142275.593750	138330.206603
2018-08-31	143785.111192	142064.359375	138539.260350
2018-09-30	144263.548321	142244.718750	138722.235081
2018-10-31	144739.182097	142345.687500	138879.804418
2018-11-30	145212.517133	142320.765625	139041.508606
2018-12-31	145683.674776	142501.562500	139181.134570

	Target	ARIMA	Gluonts	Prophet
rmse	0.000000	5.632812e+03	1.426510e+04	1.079240e+04
mse	0.000000	3.172858e+07	2.034931e+08	1.164759e+08
mean	132261.164885	1.373579e+05	1.464196e+05	1.228433e+05

AtsPy Forecast for: Little Rock-North Little Rock-Conway



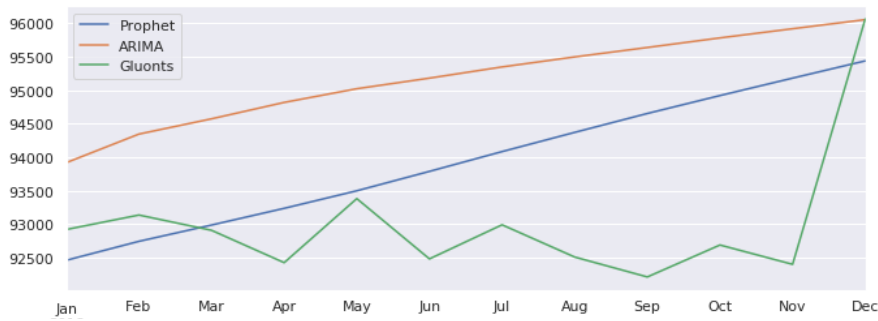
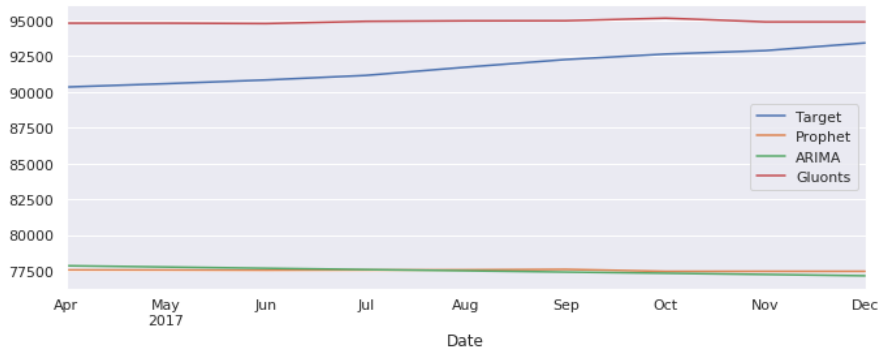
Note: Bottom chart is Forecast 2018.



Date	ARIMA	Gluonts	Prophet
2018-01-31	93916.778110	92919.609375	92460.610077
2018-02-28	94343.250049	93135.710938	92743.435010
2018-03-31	94571.188799	92907.687500	92986.424555
2018-04-30	94815.624544	92425.460938	93235.684713
2018-05-31	95019.929158	93380.609375	93497.449265
2018-06-30	95177.980954	92481.539062	93786.868335
2018-07-31	95345.045826	92990.031250	94082.149855
2018-08-31	95494.398223	92509.093750	94368.762373
2018-09-30	95635.069638	92212.039062	94650.629380
2018-10-31	95778.021471	92688.593750	94917.850270
2018-11-30	95914.696793	92400.210938	95178.016325
2018-12-31	96050.353122	96059.210938	95435.160274

	Target	ARIMA	Gluonts	Prophet
rmse	0.000000	7.462463e+03	9.561997e+03	8.017737e+03
mse	0.000000	5.568836e+07	9.143178e+07	6.428411e+07
mean	84340.759259	7.896259e+04	9.329532e+04	7.773234e+04

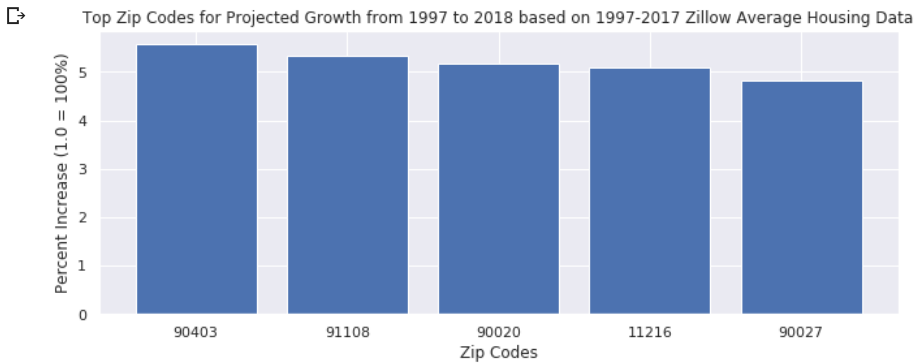
AtsPy Forecast for: Searcy



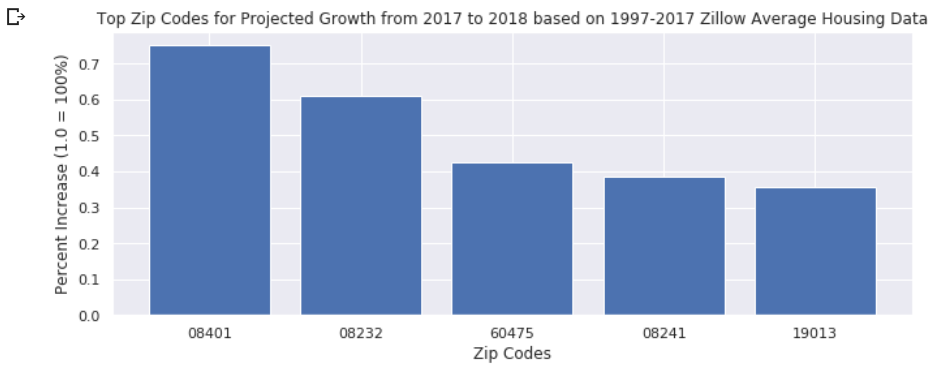
Note: Bottom chart is Forecast 2018.

### 3.0 - INTERPRET

```
#Bar plot of Forecast growth using Zillow data from 1997-2017 data and predicting 2018
height = Z_Top5_97_18.Growth97_18.sort_values(ascending=False)
bars = Z_Top5_97_18.RegionName
y_pos = np.arange(len(bars))
# Create bars
plt.bar(y_pos, height)
# Create names on the x-axis
plt.xticks(y_pos, bars)
# Add title and axis names
plt.title('Top Zip Codes for Projected Growth from 1997 to 2018 based on 1997-2017 Zillow Average Housing Data')
plt.xlabel('Zip Codes')
plt.ylabel('Percent Increase (1.0 = 100%)')
# Show graphic
plt.show()
```

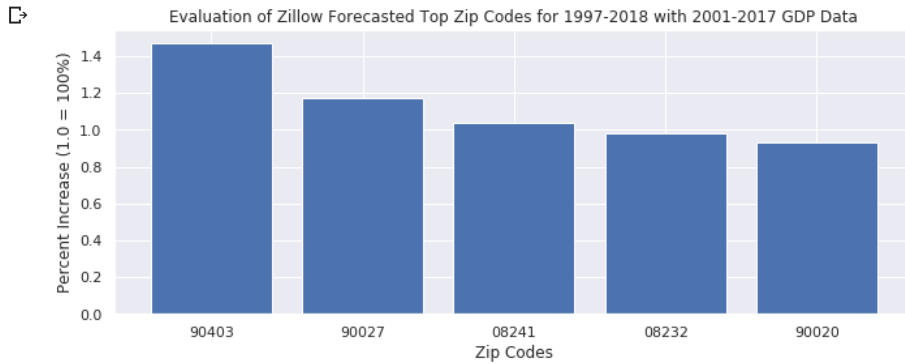


```
#Bar plot of Forecast growth using Zillow data from 1997-2017 data and predicting 2018
height = Z_Top5_17_18.Growth17_18.sort_values(ascending=False)
bars = Z_Top5_17_18.RegionName
y_pos = np.arange(len(bars))
# Create bars
plt.bar(y_pos, height)
# Create names on the x-axis
plt.xticks(y_pos, bars)
# Add title and axis names
plt.title('Top Zip Codes for Projected Growth from 2017 to 2018 based on 1997-2017 Zillow Average Housing Data')
plt.xlabel('Zip Codes')
plt.ylabel('Percent Increase (1.0 = 100%)')
# Show graphic
plt.show()
```

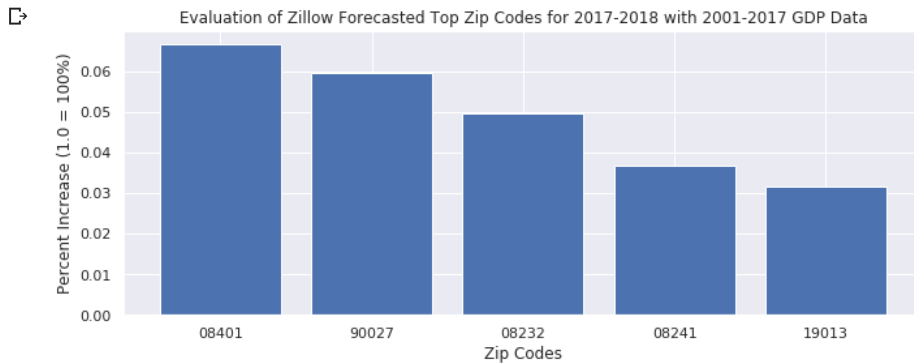


```
#Bar plot of Forecast GDP growth using 2001-2017 data and predicting 2018
height = G_Top5_01_18.Growth01_18.sort_values(ascending=False)
bars = G_Top5_01_18.ZIP_x
y_pos = np.arange(len(bars))
# Create bars
plt.bar(y_pos, height)
# Create names on the x-axis
plt.xticks(y_pos, bars)
# Add title and axis names
plt.title('Evaluation of Zillow Forecasted Top Zip Codes for 1997-2018 with 2001-2017 GDP Data')
plt.xlabel('Zip Codes')
plt.ylabel('Percent Increase (1.0 = 100%)')
```

```
plt.ylabel('Percent Increase (1.0 = 100%)')
# Show graphic
plt.show()
```



```
#Bar plot of Forecast GDP growth using 2001-2017 data and predicting 2018
height = G_Top5_17_18.Growth17_18.sort_values(ascending=False)
bars = G_Top5_17_18.ZIP_x
y_pos = np.arange(len(bars))
# Create bars
plt.bar(y_pos, height)
# Create names on the x-axis
plt.xticks(y_pos, bars)
# Add title and axis names
plt.title('Evaluation of Zillow Forecasted Top Zip Codes for 2017-2018 with 2001-2017 GDP Data')
plt.xlabel('Zip Codes')
plt.ylabel('Percent Increase (1.0 = 100%)')
# Show graphic
plt.show()
```



## 4.0 - MAPPING

### 4.1 - Code

↳ 5 cells hidden

### 4.2 - California Map

```
# THIS IS AN INTERACTIVE GRAPHIC. CLICK THE LEGEND BUBBLES TO SHOW/HIDE DIFFERENT GROUPS.
```

```
#Geographic view of Housing Prices by Forecast Growth fo California. Code Source: https://plotly.com/python/bubble-maps/
#df['text'] = df['Zip']# + " " + (df['TotalComp']/1e6).astype(str)+' million'
limits = [(1,55),(55,180),(180,305),(305,430),(430,560)]
colors = ["royalblue","crimson","lightseagreen","orange","lightgrey"]
#cities = []
scale = 5000

fig = go.Figure()

for i in range(len(limits)):
    lim = limits[i]
    dfCA_sub = dfCA[lim[0]:lim[1]]
    fig.add_trace(go.Scattergeo(
```

```

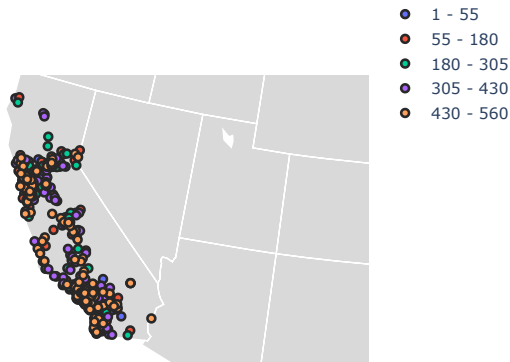
locationmode = 'USA-states',
lon = dfCA_sub['Longitude'],
lat = dfCA_sub['Latitude'],
#text = df_sub['School'],
#text = df_sub['text'],
marker = dict(
    #size = df_sub['Growth97_18'],
    #color = colors[i],
    line_color='rgb(40,40,40)',
    line_width=2,
    sizemode = 'area'
    #sizemin=4
),
name = '{0} - {1}'.format(lim[0],lim[1]))

fig.update_layout(
    title_text = 'California 2018 Forecast Percent Increase in Housing Prices Based on 1997-2017 Zillow Data',\
    showlegend = True,
    geo = dict(
        scope = 'usa',
        landcolor = 'rgb(217, 217, 217)',
    )
)
fig.show()

```



California 2018 Forecast Percent Increase in Housing Prices Based on



### 4.3 - New Jersey Map

# THIS IS AN INTERACTIVE GRAPHIC. CLICK THE LEGEND BUBBLES TO SHOW/HIDE DIFFERENT GROUPS.

#Geographic view of Housing Prices by Forecast Growth for New Jersey. Code Source: <https://plotly.com/python/bubble-maps/>

```

#df['text'] = df['Zip']# + " " + (df['TotalComp']/1e6).astype(str)+' million'
limits = [(1,55),(55,180),(180,305),(305,430),(430,560)]
colors = ["royalblue","crimson","lightseagreen","orange","lightgrey"]
#cities = []
scale = 5000

```

```
fig = go.Figure()
```

```

for i in range(len(limits)):
    lim = limits[i]
    dfNJ_sub = dfNJ[lim[0]:lim[1]]
    fig.add_trace(go.Scattergeo(
        locationmode = 'USA-states',
        lon = dfNJ_sub['Longitude'],
        lat = dfNJ_sub['Latitude'],
        #text = df_sub['School'],
        #text = df_sub['text'],
        marker = dict(
            #size = df_sub['Growth97_18']

```

```

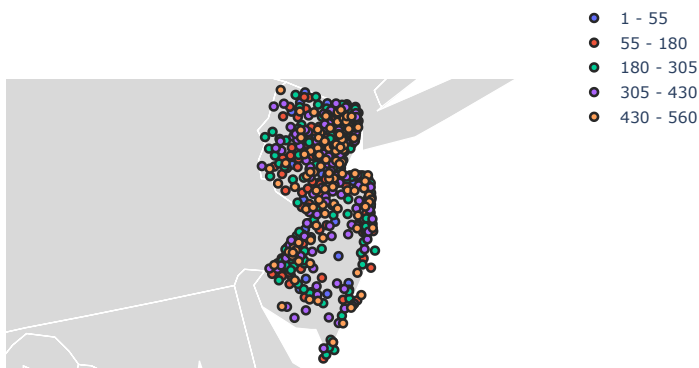
        #size = size_sub[GROWTH97_18 ],
        #color = colors[i],
        line_color='rgb(40,40,40)',
        line_width=2,
        sizemode = 'area'
        #sizemin=4
    ),
    name = '{0} - {1}'.format(lim[0],lim[1]))

fig.update_layout(
    title_text = 'New Jersey 2018 Forecast Percent Increase in Housing Prices Based on 1997-2017 Zillow Data',\
    showlegend = True,
    geo = dict(
        scope = 'usa',
        landcolor = 'rgb(217, 217, 217)',
    )
)
fig.show()

```



New Jersey 2018 Forecast Percent Increase in Housing Prices Based o



▸ Time Series Code from "Modeling Techniques in Predictive Analytics"

↳ 18 cells hidden

▸ Arima Tutorial Code

↳ 2 cells hidden