Week 10 - Plotting with the Plotly API

Plotting Options in Python

1. `matplotlib` - The classic library, with options to change just about everything. Creates static images
2. `seaborn` - A stats-focused wrapper for `matplotlib`
3. `pygal` - For SVG-based graphics, interactive plots
4. `plotly` - Based on D3.js, allows for dynamic plotting and data dashboards hosted online
5. `bokeh` - Also based on D3.js functions
6. `plotnine/ggplot` - uses the Grammar of Graphics structure to mimic R's ggplot2

Why Use Plotly?

Plotly is a good choice for several reasons:

- It allows for easy interactive plotting
- Interactive plots can be embedded in notebooks
- Can be run on a server
- Plotly has developed a dashboard API to complement their plotting library (similar to Shiny for R)
- It also has a shorthand library `plotly_express` for rapid exploration

Getting Started

```
from plotly.offline import iplot
import plotly.graph_objs as go
```

First, we want to import `iplot`, which is needed to generate plots offline, and render them inline within our notebook. We don't want to use the Plotly servers at the moment.

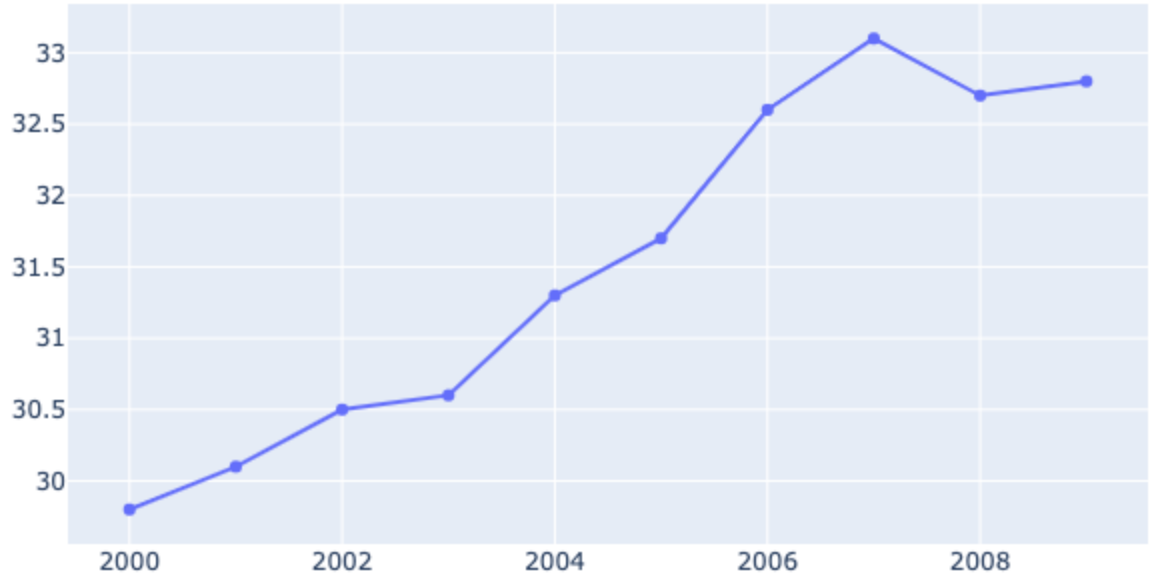
If you would prefer plots be rendered in a separate browser tab, import `plot` instead.

Next, we import the graphing objects, which include things like Scatter plots and Histograms, and allow us to construct our visualization.

Creating Plot Objects

```
trace = go.Scatter( # initialize scatter object
  x = list(range(2000,2010)), # pass x, y values
  y = [29.8,30.1,30.5,30.6,31.3,31.7,32.6,33.1,32.7,32.8])

plotdata=go.Data([trace]) # Process the plots

iplot(plotdata) # Render the plots
```

In this (very) simple example, we plot some time series data. Our plot is provided as an html page opened in the default browser.



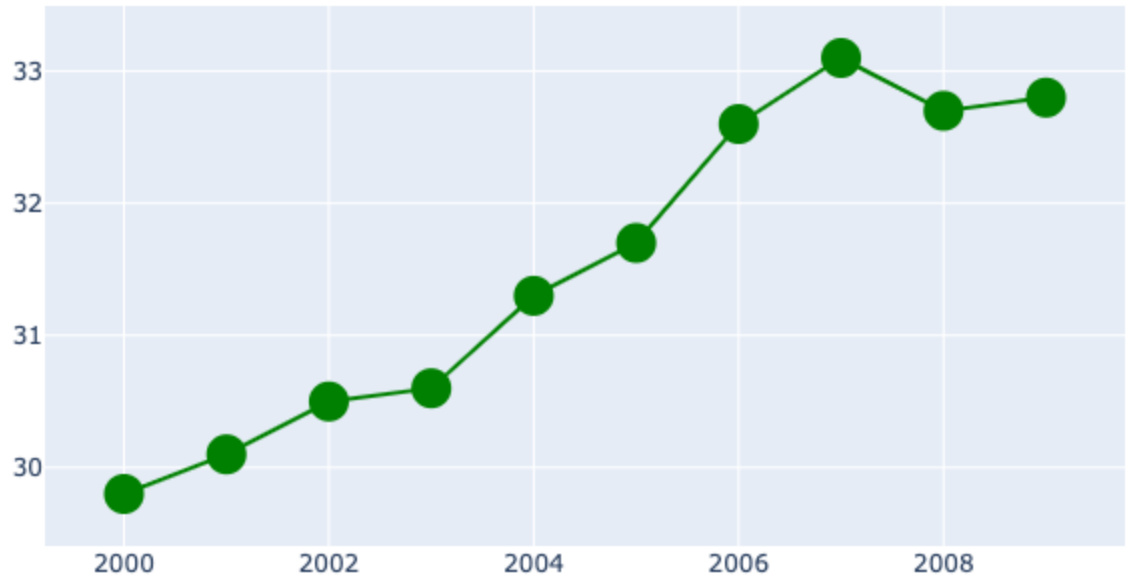
In this (very) simple example, we plot some time series data. Our plot is provided as an html page opened in the default browser.

Creating Plot Objects

Let's add some formatting. First, we can change the marker size and the color of our plot:

```
trace = go.Scatter( # initialize scatter object
  x = list(range(2000,2010)), # pass x, y values
  y = [29.8,30.1,30.5,30.6,31.3,31.7,32.6,33.1,32.7,32.8],
  marker =  {'color': 'green', # choose the marker color
    'symbol': 0, # choose a shape
    'size': 20}, # choose a size
    )

plotdata=go.Data([trace]) # Process the plots

iplot(plotdata) # Render the plots
```

Let's add some formatting. First, we can change the marker size and the color of our plot:

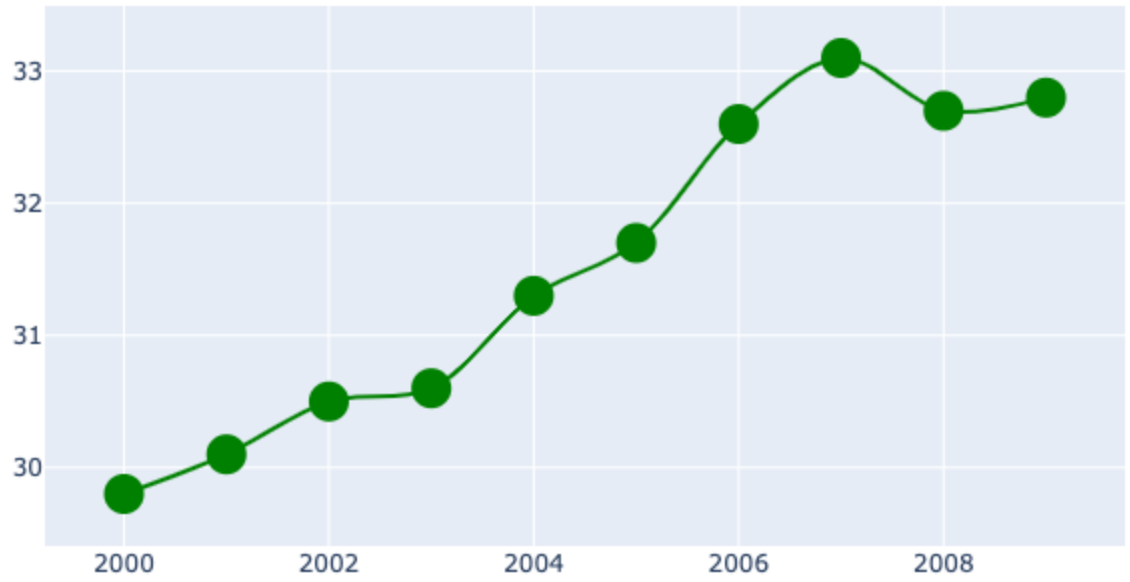


Creating Plot Objects

Next, we can smooth our line between markers:

```
trace = go.Scatter( # initialize scatter object
  x = list(range(2000,2010)), # pass x, y values
  y = [29.8,30.1,30.5,30.6,31.3,31.7,32.6,33.1,32.7,32.8],
  marker =  {'color': 'green', # choose the marker color
    'symbol': 0, # choose a shape
    'size': 20}, # choose a size
    line=dict(
        shape='spline' # spline smoothing
    ))

plotdata=go.Data([trace]) # Process the plots

iplot(plotdata) # Render the plots
```

Next, we can smooth our line between markers:



Creating Plot Objects

We can add text to our markers that can be seen when mousing over the points:

```
trace = go.Scatter( # initialize scatter object
  x = list(range(2000,2010)), # pass x, y values
  y = [29.8,30.1,30.5,30.6,31.3,31.7,32.6,33.1,32.7,32.8],
  marker =  {'color': 'green', # choose the marker color
    'symbol': 0, # choose a shape
    'size': 20}, # choose a size
    line=dict(
        shape='spline' # spline smoothing
    ),
    text=['Year: ' + str(i) for i in list(range(2000,2010))], # hover text
    name='PCC') # name for legends

plotdata=go.Data([trace]) # Process the plots

iplot(plotdata) # Render the plots
```

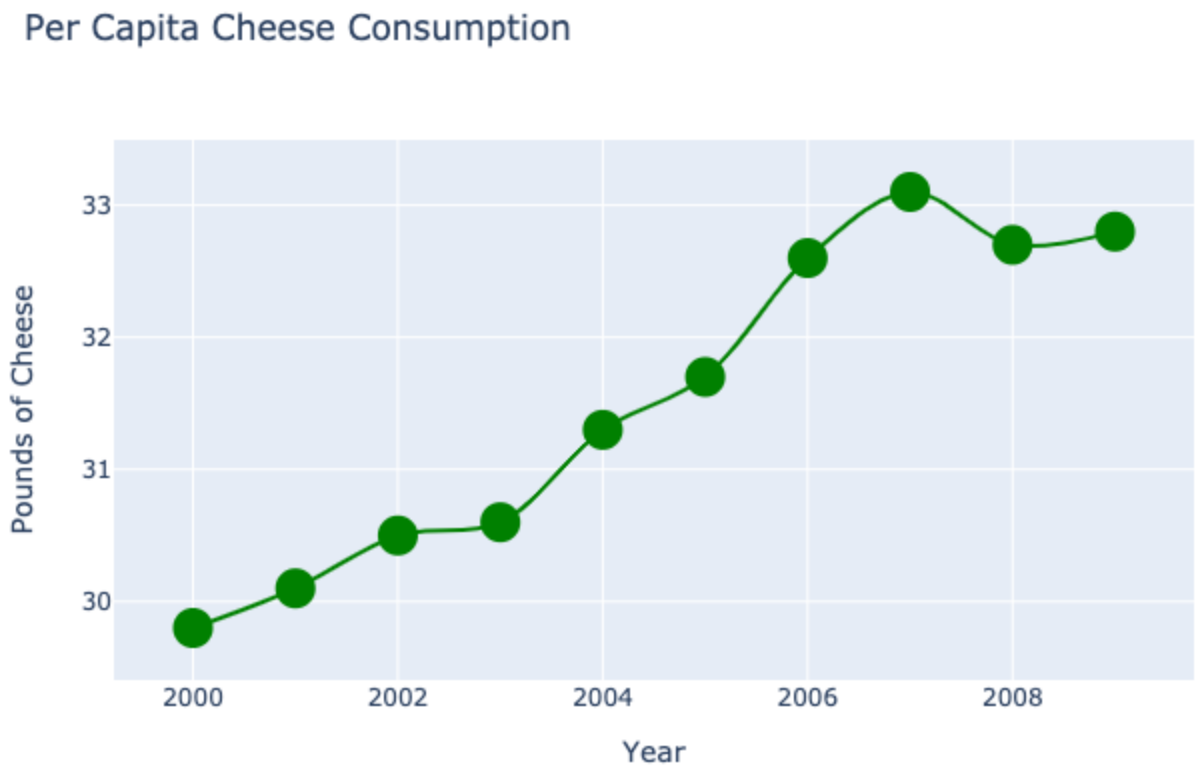
Creating Plot Objects

We can add information to our plot by adding `Layout` and `Figure` objects:

```
plotdata=go.Data([trace]) # Process the plots

layout=go.Layout(title="Per Capita Cheese Consumption",
                 # configure the plot
  xaxis={'title':'Year'},  # layout and name
  yaxis={'title':'Pounds of Cheese'})  # the axes.

figure=go.Figure(data=plotdata,layout=layout)
# combine data and layout code

iplot(figure) # Render the plots
```

Note: this code should be used with the code from the previous slide.

We can add information to our plot by adding `Layout` and `Figure` objects:



Creating Plot Objects

Let's add a second series:

```
trace2 = go.Scatter( # initialize scatter object
  x = list(range(2000,2010)), # pass x, y values
  y = [327,456,509,497,596,573,661,741,809,717],
  marker =  {'color': 'grey', # choose the marker color
    'symbol': 0, # choose a shape
    'size': 20}, # choose a size
    line=dict(
        shape='spline' # spline smoothing
    ),
    text=['Year: ' + str(i) for i in list(range(2000,2010))], # hover text
    name='DIB',
    yaxis='y2') # name for legends
```

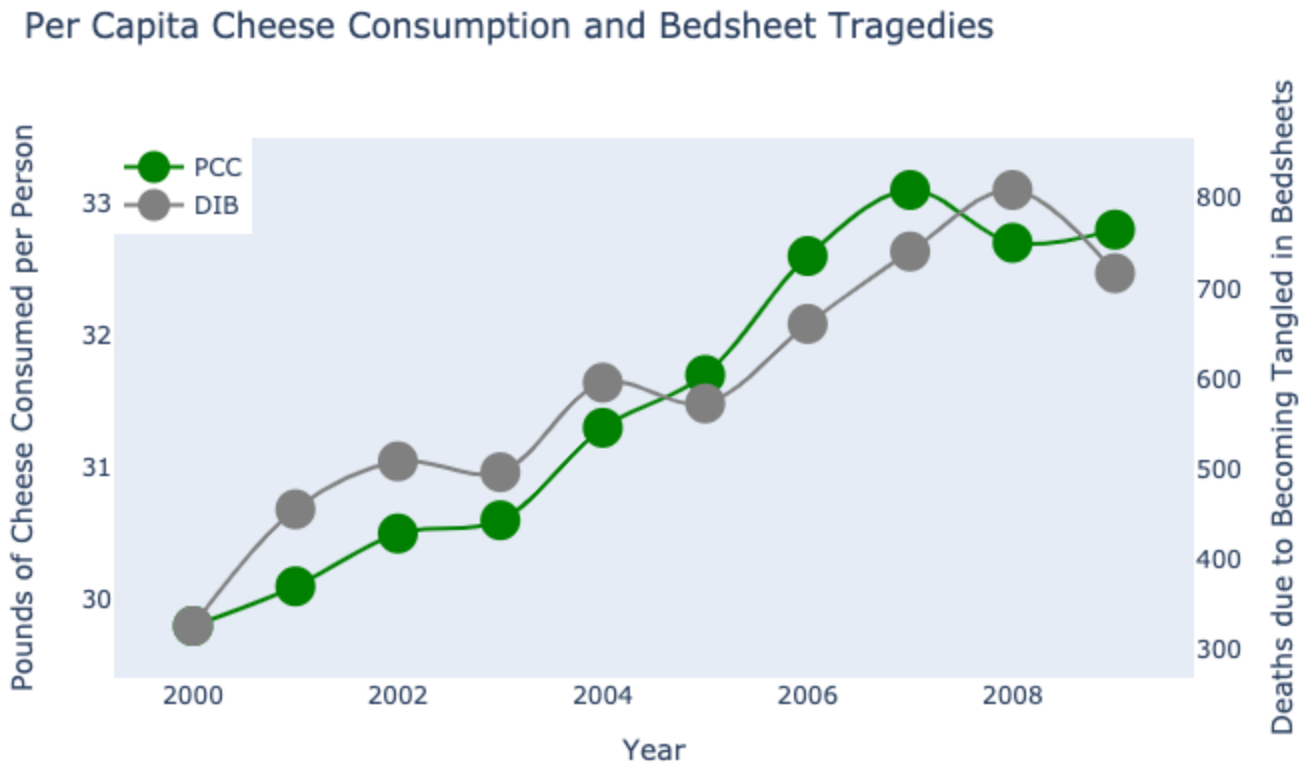
Creating Plot Objects

We also need to update our data and layout objects AND add a secondary y axis:

```
plotdata=go.Data([trace, trace2]) # Process the plots

layout=go.Layout(title="Per Capita Cheese Consumption and Bedsheet Tragedies",
                 # configure the plot
  xaxis={'title':'Year',
         'showgrid':False},  # layout and name
  yaxis={'title':'Pounds of Cheese Consumed per Person',
         'showgrid':False},
  yaxis2={'title':"Deaths due to Becoming Tangled in Bedsheets",
          'overlaying': 'y',
          'side':'right',
          'showgrid':False})  # the axes.

figure=go.Figure(data=plotdata,layout=layout)
# combine data and layout code

figure.update_layout(legend=dict(x=0, y=1)) # Make Legend Readable by relocating

iplot(figure) # Render the plots
```

Creating Plot Objects

Our plot now looks something like this:



Using Existing Data

Let's import average household income data for Nebraska using the ACS data at dadata.cba.edu (accessible through VPN connection to Mammel Hall):

```
from sqlalchemy import create_engine
import pandas as pd

SELECT = """SELECT AVG(hhincome) AS hhincome, year
  FROM ACS
  WHERE statefip=31
  GROUP BY year
  ORDER BY year"""
conn = create_engine(
  'mysql+mysqlconnector://viewer:@dadata.cba.edu:3306/ACS'
  )

data = pd.read_sql(SELECT, conn)
```

Using Existing Data

```
trace = go.Scatter( # initialize scatter object
  x = data['year'],
  y = data['hhincome'],
  marker =  {'color': 'green',
    'symbol': 0,
    'size': 12},
  mode="markers+lines",
  name='Household Income Over Time')

plotdata=go.Data([trace])
layout=go.Layout(title="Household Income",
  xaxis={'title':'Year'},
  yaxis={'title':'Income ($)'})

figure=go.Figure(data=plotdata,layout=layout)
plot(figure)
```

Let's Use More States!

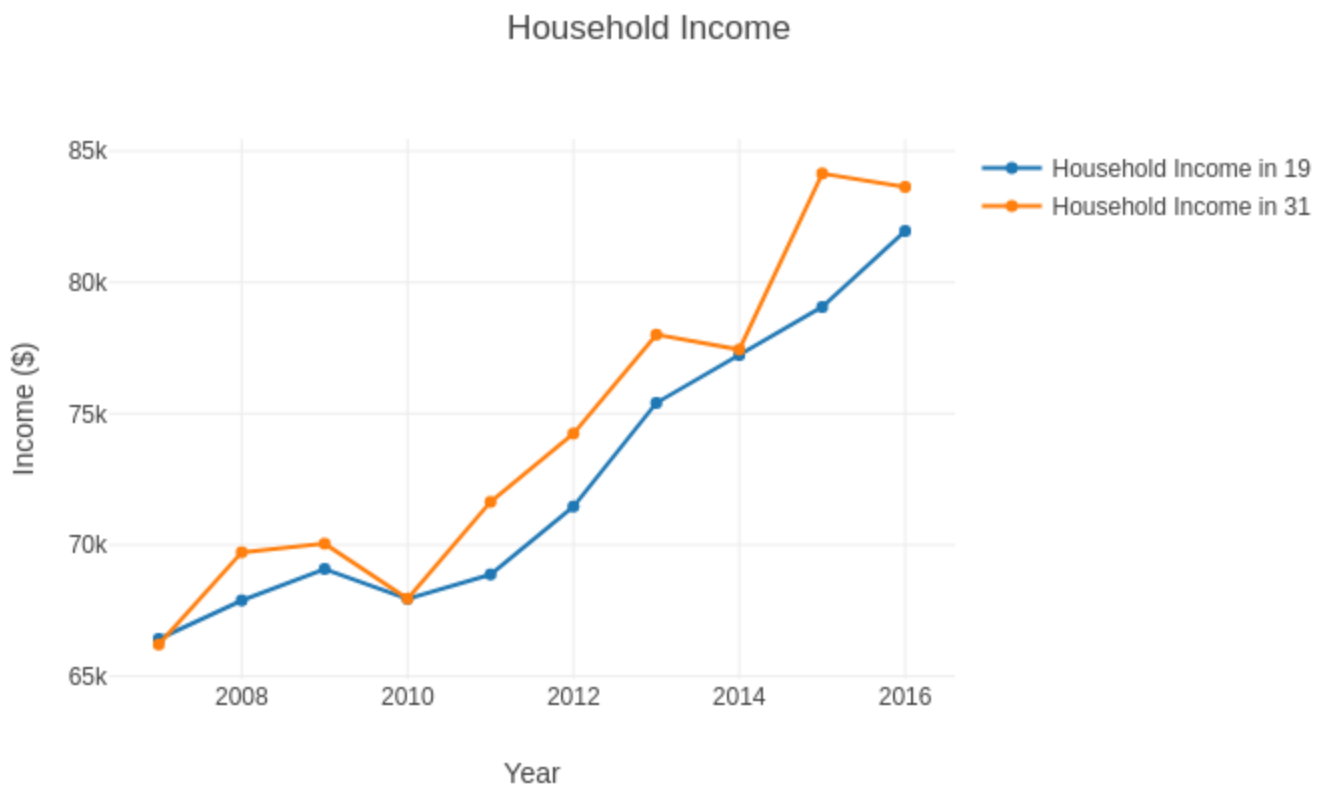
First, update our dataset:

```
SELECT = """SELECT AVG(hhincome) AS hhincome, year,
    statefip
  FROM ACS
  WHERE statefip=31 or statefip=19
  GROUP BY year, statefip
  ORDER BY year, statefip"""
conn = create_engine(
  'mysql+mysqlconnector://viewer:@dadata.cba.edu:3306/ACS'
  )

data = pd.read_sql(SELECT, conn)
```

Let's Use More States!

```
traces = []
for i in data['statefip'].unique():
  small_data = data.loc[data['statefip']==i, :]
  traces.append(go.Scatter( # initialize scatter object
    x = small_data['year'],
    y = small_data['hhincome'],
    mode="markers+lines",
    name='Household Income in {}'.format(i)))

plotdata=go.Data(traces)
layout=go.Layout(title="Household Income",
  xaxis={'title':'Year'},
  yaxis={'title':'Income ($)'})

figure=go.Figure(data=plotdata,layout=layout)
plot(figure)
```

Let's Use More States!



Other Plot Types

We can do a LOT more than scatter plots!

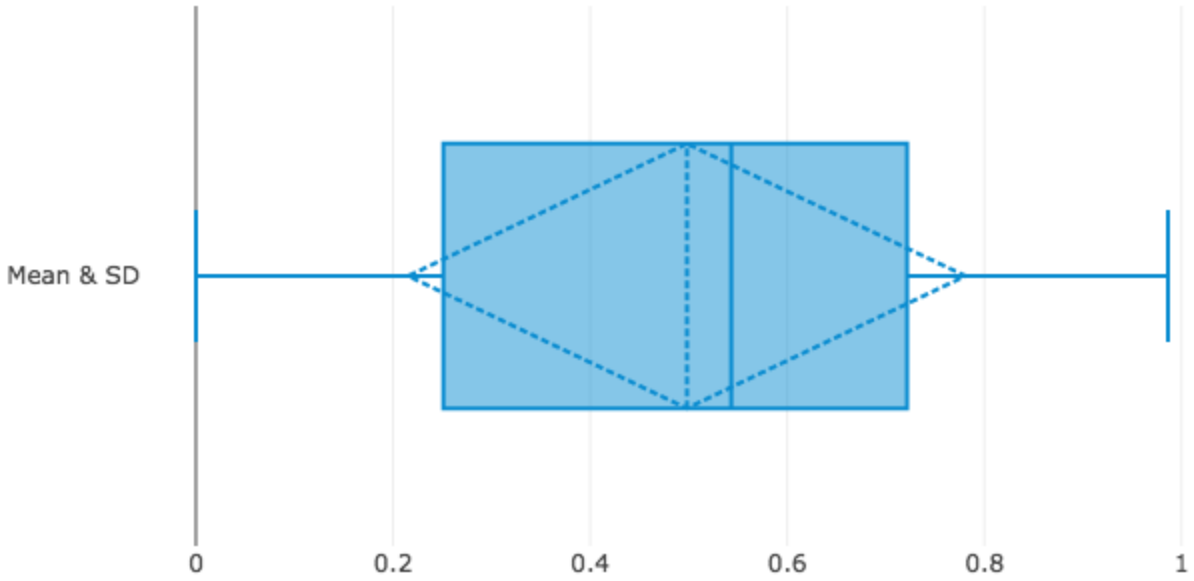
- Box Plots
- Histograms, with distribution stats
- Heatmaps
- Choropleth, Line, and Bubble Maps

among many others.

Box Plots

```
trace1 = go.Box(
  y=np.random.rand(100),
  name='Mean & SD',
  marker=dict(
    color='rgb(10, 140, 208)',
  ),
  boxmean='sd' # Shows quartiles AND Std Dev on plot
)

plotdata = go.Data([trace1])
figure = go.Figure(data=plotdata)
plot(figure)
```

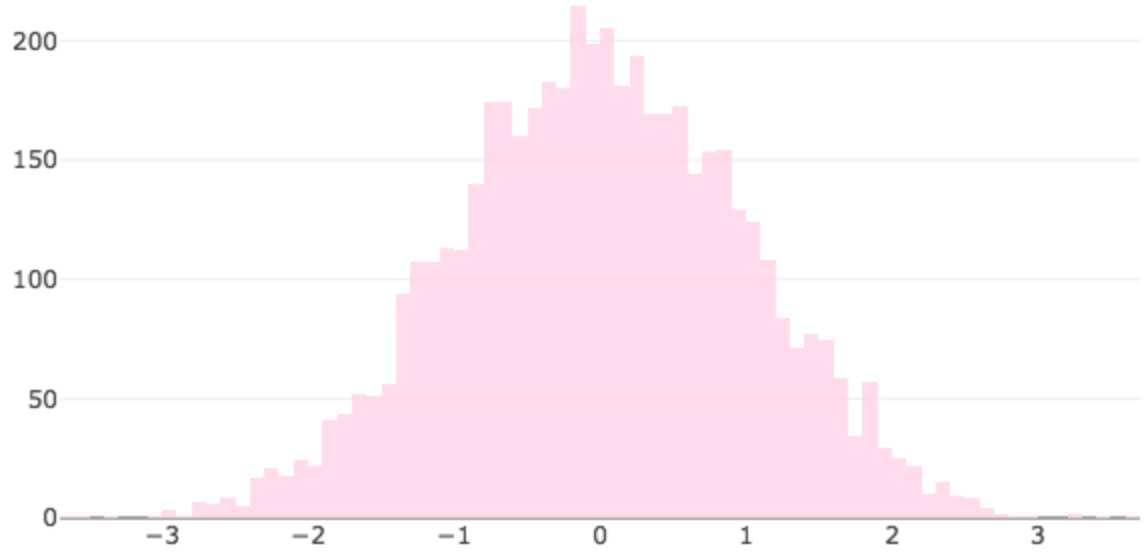
Box Plots



Histograms

```
trace1 = go.Histogram(
  x=np.random.randn(5000),
  histnorm='density',
  xbins=dict( # Declare bin size
    start=-4.0,
    end=4.0,
    size=0.1
  ),
  marker=dict( # Customize markers
    color='#FFD7E9',
  ),
  opacity=0.9
)

plotdata = go.Data([trace1])
figure = go.Figure(data=plotdata)
plot(figure)
```

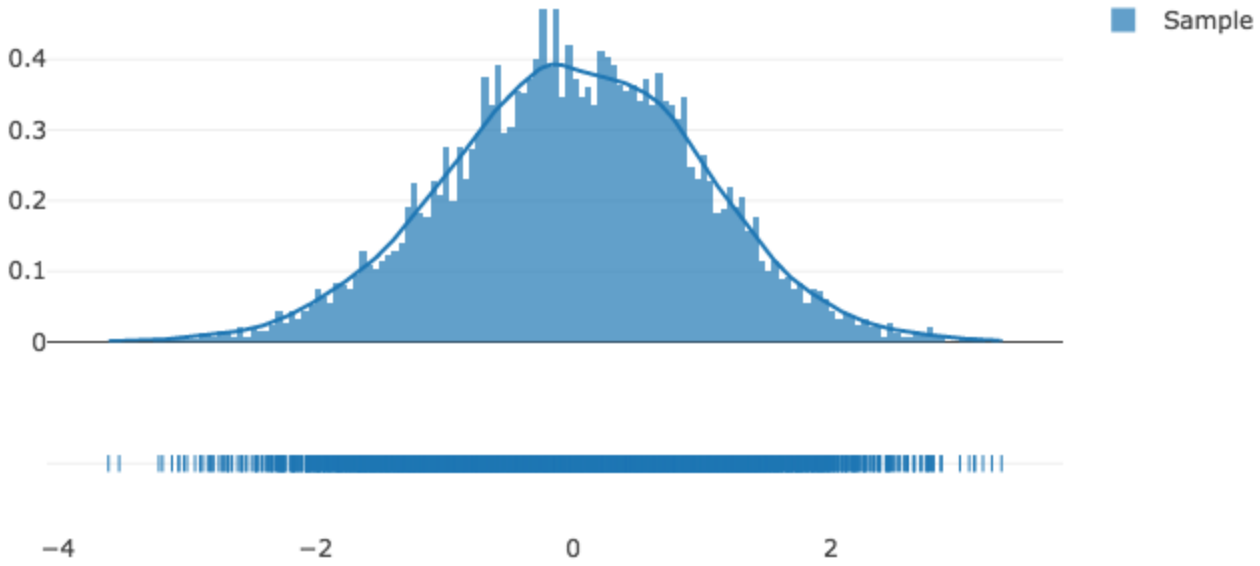
Histograms



Histograms and Distributions

```
import plotly.figure_factory as ff

x = np.random.randn(5000)
hist_data = [x]
group_labels = ['Sample'] # Labels our 'rug' plot

fig = ff.create_distplot(hist_data,
  group_labels,
  bin_size=0.05,
  show_hist=True,  # Toggle histogram
  show_curve=True, # Toggle smoothed distribution
  show_rug=True    # Toggle rug plot
  )

plot(fig)
```

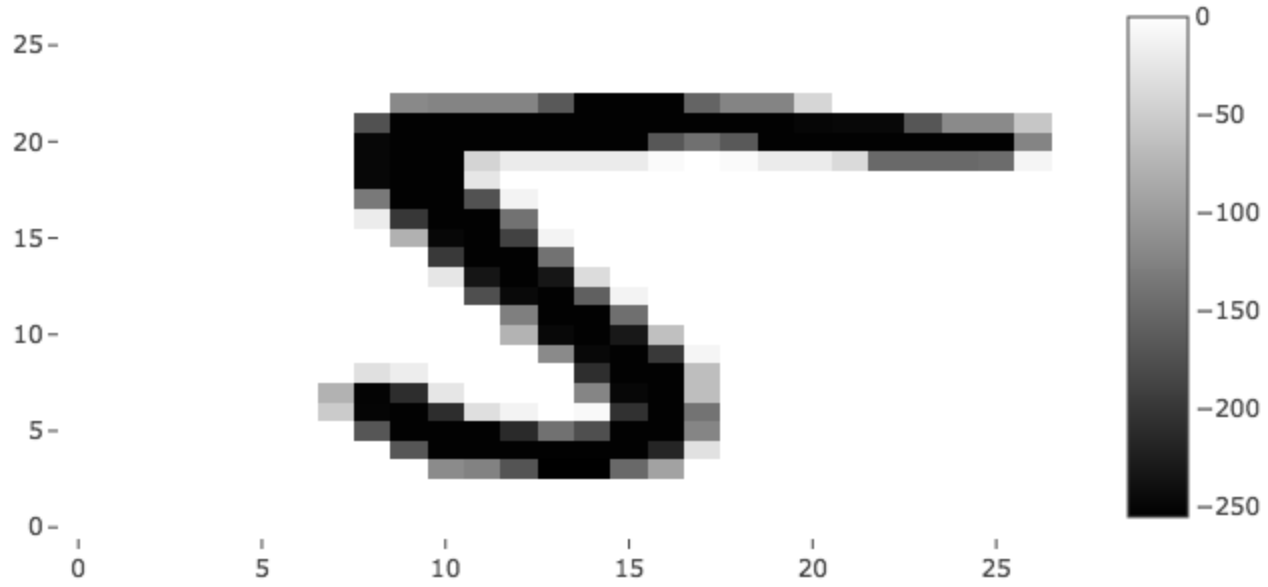
Histograms and Distributions



Heatmaps

```
# Create an array of data (its from MNIST)
# x = list of 784 elements between 0 and 255,
#     indicating the pixel's darkness

x = - np.array(x).reshape(28,28)

trace = go.Heatmap(z = x, colorscale = "Greys")
plotdata=[trace]
plot(plotdata)
```

Heatmaps

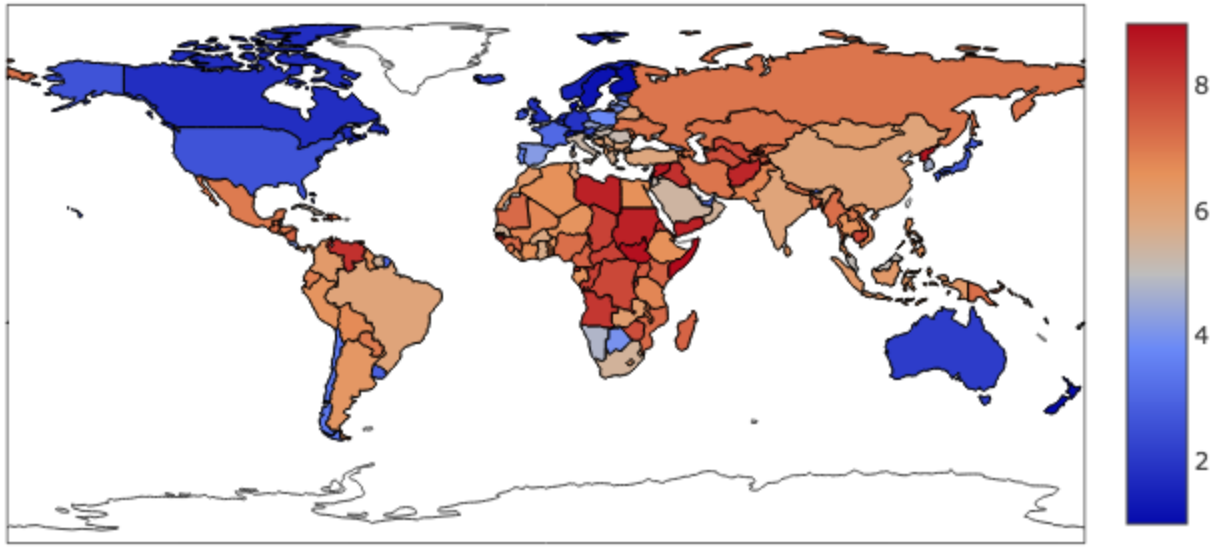


Choropleth Maps

```
data = pd.read_csv(
  "https://raw.githubusercontent.com/dustywhite7/Econ8320/master/LabCode/corruption2018.csv")

plotdata = go.Choropleth(
        locations = data['Abbr'],
        z = data['Index'],
        text = (data['Name'], data['Index']),
        autocolorscale = False,
        colorscale = 'Picnic',
        showscale = True,
    )


figure = go.Figure(data=[plotdata])
plot(figure)
```

Map data from the INFORM Index

Choropleth Maps



Mapping Options: Layout->Geo

We have many additional options that we can pass to the layout of our plot when dealing with geographic data.

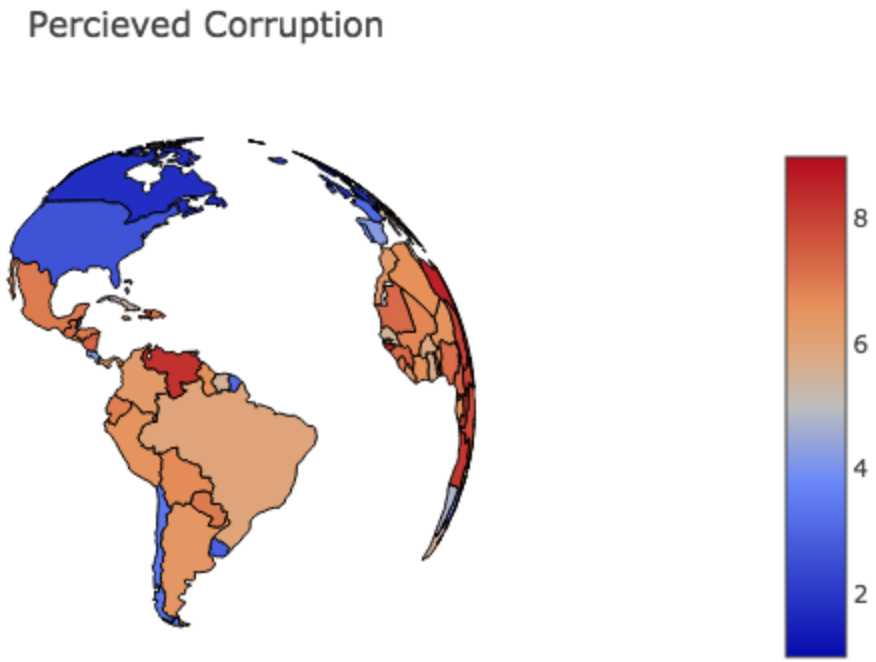
- Map projection
- Map scope
- Country lines
- Lots more

Here is a link to the full documentation

Choropleth Maps - Layout

```
layout = go.Layout(
    title = "Percieved Corruption",
    geo = dict(projection = dict(type='orthographic'),
               showcoastlines=False,
               showcountries = False,
               showframe = False,
               showrivers=False,
               scope = 'world'
        )
    )

figure = go.Figure(data=[plotdata], layout=layout)
plot(figure)
```

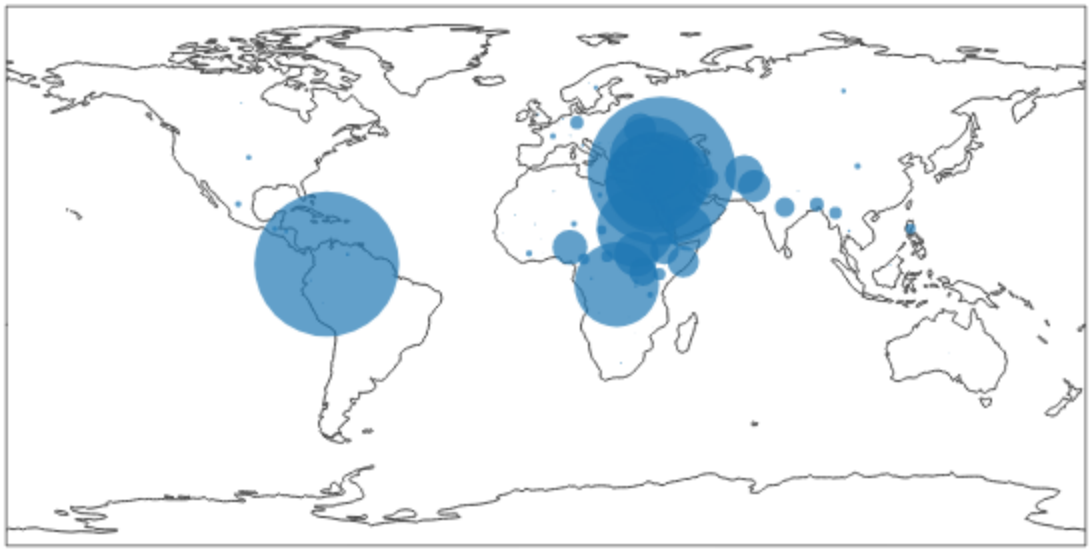
Choropleth Maps



Bubble Maps

```
data = pd.read_csv(
  "https://raw.githubusercontent.com/dustywhite7/Econ8320/master/LabCode/displaced2018.csv")

plotdata = go.Scattergeo(
            locationmode = 'country names',
            locations = data['Name'],
            marker = dict(
                size = data['Displaced']/100000,
                line = dict(width = 0)
            ),
            text = data['Displaced']
            )

figure = go.Figure(data=[plotdata])
plot(figure)
```

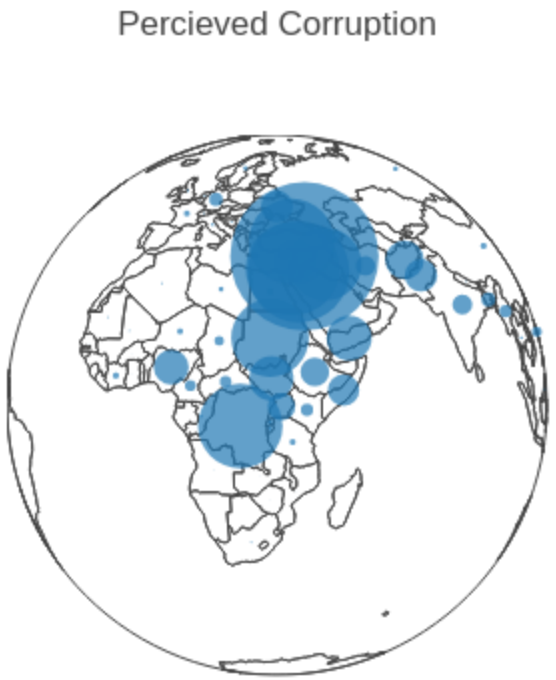
Bubble Maps



Bubble Maps

```
...
layout = go.Layout(
    title = "Percieved Corruption",
    geo = dict(projection = dict(type='orthographic'),
                showcountries = True,
        )
    )

figure = go.Figure(data=[pdata], layout=layout)
plot(figure)
```

Bubble Maps



For Lab Tonight

Let's make use of this week's and last week's data together!

- Draw data from any dataset
- Generate three plots that you find interesting **using Plotly**
- Try to use a different kind of plot for each figure, just to get more practice