Assignment: Plotting Weather Patterns

The data for this assignment comes from a subset of The National Centers for Environmental Information (NCEI) Daily Global Historical Climatology Network (https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/readme.txt) (GHCN-Daily). The GHCN-Daily is comprised of daily climate records from thousands of land surface stations across the globe.

Each row in the assignment datafile corresponds to a single observation.

The following variables are provided:

- **id** : station identification code
- **date** : date in YYYY-MM-DD format (e.g. 2012-01-24 = January 24, 2012)
- **element** : indicator of element type
  - TMAX : Maximum temperature (tenths of degrees C)
  - TMIN : Minimum temperature (tenths of degrees C)
- **value** : data value for element (tenths of degrees C)

For this assignment, following instructions are must needed:

1. Read the documentation and familiarize yourself with the dataset, then write some python code which returns a line graph of the record high and record low temperatures by day of the year over the period 2005-2014. The area between the record high and record low temperatures for each day should be shaded.
2. Overlay a scatter of the 2015 data for any points (highs and lows) for which the ten year record (2005-2014) record high or record low was broken in 2015.
3. Watch out for leap days (i.e. February 29th), it is reasonable to remove these points from the dataset for the purpose of this visualization.
4. Make the visual nice! Leverage principles from the first module in this course when developing your solution. Consider issues such as legends, labels, and chart junk.

The data have been given is near **Ann Arbor, Michigan, United States**, and the stations the data comes from are shown on the map below.

Import Libraries

In [1]:
```
import matplotlib as mpl
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

Data Pre-processing

In [2]:
```
# read in csv file as dataframe
df_path = './data_temperature.csv'

df = pd.read_csv(df_path)
df.head()
```

Out[2]:

	ID	Date	Element	Data_Value
0	USW00094889	2014-11-12	TMAX	22
1	USC00208972	2009-04-29	TMIN	56
2	USC00200032	2008-05-26	TMAX	278
3	USC00205563	2005-11-11	TMAX	139
4	USC00200230	2014-02-27	TMAX	-106

In [3]:
```
# add datetime helpers to the dataframe to ultimately get to a DayOfYear field

df['DateTime'] = pd.to_datetime(df['Date'])
df['Year'] = pd.DatetimeIndex(df['Date']).year
df['Month'] = pd.DatetimeIndex(df['Date']).month
df['Day'] = pd.DatetimeIndex(df['Date']).day
df['Mon'] = df['DateTime'].apply(lambda x: x.strftime('%b'))
df['DayOfYear'] = df['Mon'] + "-" + df['Day'].map(str)
df.head()
```

Out[3]:

	ID	Date	Element	Data_Value	DateTime	Year	Month	Day	Mon	DayOfYear
0	USW00094889	2014-11-12	TMAX	22	2014-11-12	2014	11	12	Nov	Nov-12
1	USC00208972	2009-04-29	TMIN	56	2009-04-29	2009	4	29	Apr	Apr-29
2	USC00200032	2008-05-26	TMAX	278	2008-05-26	2008	5	26	May	May-26
3	USC00205563	2005-11-11	TMAX	139	2005-11-11	2005	11	11	Nov	Nov-11
4	USC00200230	2014-02-27	TMAX	-106	2014-02-27	2014	2	27	Feb	Feb-27

In [4]:
```
# prepare the dataframe to split by max and min and sorty by month and day to get

df_grp = df[['Month', 'Day', 'Year', 'DayOfYear', 'Element', 'Data_Value']]
df_grp = df_grp.sort_values(['Month', 'Day', 'Year'], axis=0, ascending=True)
df_grp = df_grp[df_grp['DayOfYear'] != 'Feb-29']
df_grp.head()
```

Out[4]:

	Month	Day	Year	DayOfYear	Element	Data_Value
1860	1	1	2005	Jan-1	TMAX	150
1906	1	1	2005	Jan-1	TMIN	-17
2035	1	1	2005	Jan-1	TMIN	-17
2073	1	1	2005	Jan-1	TMAX	144
2812	1	1	2005	Jan-1	TMIN	-50

In [5]:
```
# slice the TMAX data from the dataframe and group by max value

df_high = df_grp[df_grp['Element']=='TMAX']
df_high = (pd.DataFrame(df_high.groupby(['Month', 'Day', 'DayOfYear'])['Data_Valu
        .max())
        .reset_index())
df_high['DailyHigh'] = df_high['Data_Value'] / 10
df_high = df_high[['DayOfYear', 'DailyHigh']]

print(df_high.head())
print(df_high.shape)
```

```
  DayOfYear  DailyHigh
0     Jan-1       15.6
1     Jan-2       13.9
2     Jan-3       13.3
3     Jan-4       10.6
4     Jan-5       12.8
(365, 2)
```

In [6]:
```
# slice the TMIN data from the dataframe and group by max value

df_low = df_grp[df_grp['Element']=='TMIN']
df_low = (pd.DataFrame(df_low.groupby(['Month', 'Day', 'DayOfYear'])['Data_Value'
        .min())
        .reset_index())
df_low['DailyLow'] = df_low['Data_Value'] / 10
df_low = df_low[['DayOfYear', 'DailyLow']]

print(df_low.head())
print(df_low.shape)
```

```
  DayOfYear  DailyLow
0     Jan-1     -16.0
1     Jan-2     -26.7
2     Jan-3     -26.7
3     Jan-4     -26.1
4     Jan-5     -15.5
(365, 2)
```

In [7]:
```
# get max data for 2015 only

df_2015 = df_grp[df_grp['Year']==2015]

df_2015_high = df_2015[df_2015['Element']=='TMAX']
df_2015_high = (pd.DataFrame(
                df_2015_high.groupby(['Month', 'Day', 'DayOfYear'])
                ['Data_Value'].max())
               .reset_index())
df_2015_high['2015 High'] = df_2015_high['Data_Value'] / 10
df_2015_high = df_2015_high[['DayOfYear', '2015 High']]

df_2015_high.head()
```

Out[7]:

	DayOfYear	2015 High
0	Jan-1	1.1
1	Jan-2	3.9
2	Jan-3	3.9
3	Jan-4	4.4
4	Jan-5	2.8

In [8]:
```
# get min data for 2015 only

df_2015_low = df_2015[df_2015['Element']=='TMIN']
df_2015_low = (pd.DataFrame(
                df_2015_low.groupby(['Month', 'Day', 'DayOfYear'])
                ['Data_Value'].min())
               .reset_index())
df_2015_low['2015 Low'] = df_2015_low['Data_Value'] / 10
df_2015_low = df_2015_low[['DayOfYear', '2015 Low']]

df_2015_low.head()
```

Out[8]:

	DayOfYear	2015 Low
0	Jan-1	-13.3
1	Jan-2	-12.2
2	Jan-3	-6.7
3	Jan-4	-8.8
4	Jan-5	-15.5

In [9]:
```
# get max data for 2005-2015 period

df_pre2015 = df_grp[df_grp['Year'] < 2015]

df_pre2015_high = df_pre2015[df_pre2015['Element']=='TMAX']
df_pre2015_high = (pd.DataFrame(
                df_pre2015_high.groupby(['Month', 'Day', 'DayOfYear'])
                ['Data_Value'].max())
               .reset_index())
df_pre2015_high['Record High'] = df_pre2015_high['Data_Value'] / 10
df_pre2015_high = df_pre2015_high[['DayOfYear', 'Record High']]

df_pre2015_high.head()
```

Out[9]:

	DayOfYear	Record High
0	Jan-1	15.6
1	Jan-2	13.9
2	Jan-3	13.3
3	Jan-4	10.6
4	Jan-5	12.8

In [10]:
```
# get min data for 2005-2015 period

df_pre2015_low = df_pre2015[df_pre2015['Element']=='TMIN']
df_pre2015_low = (pd.DataFrame(
                df_pre2015_low.groupby(['Month', 'Day', 'DayOfYear'])
                ['Data_Value'].min())
               .reset_index())
df_pre2015_low['Record Low'] = df_pre2015_low['Data_Value'] / 10
df_pre2015_low = df_pre2015_low[['DayOfYear', 'Record Low']]

df_pre2015_low.head()
```

Out[10]:

	DayOfYear	Record Low
0	Jan-1	-16.0
1	Jan-2	-26.7
2	Jan-3	-26.7
3	Jan-4	-26.1
4	Jan-5	-15.0

In [11]:
```
# merge datframes on DayOfYear and flag record breaking temps

df_compare = df_2015_high.merge(df_2015_low, left_on='DayOfYear', right_on='DayOf
df_compare = df_compare.merge(df_pre2015_high, left_on='DayOfYear', right_on='Day
df_compare = df_compare.merge(df_pre2015_low, left_on='DayOfYear', right_on='DayO
df_compare = df_compare.merge(df_high, left_on='DayOfYear', right_on='DayOfYear')
df_compare = df_compare.merge(df_low, left_on='DayOfYear', right_on='DayOfYear')

# flag days the broke the Record High and Record Low Temps in 2015

df_compare['BrokeHigh'] = np.where(df_compare['2015 High'] > df_compare['Record H
df_compare['BrokeLow'] = np.where(df_compare['2015 Low'] < df_compare['Record Low

df_compare.head()
```

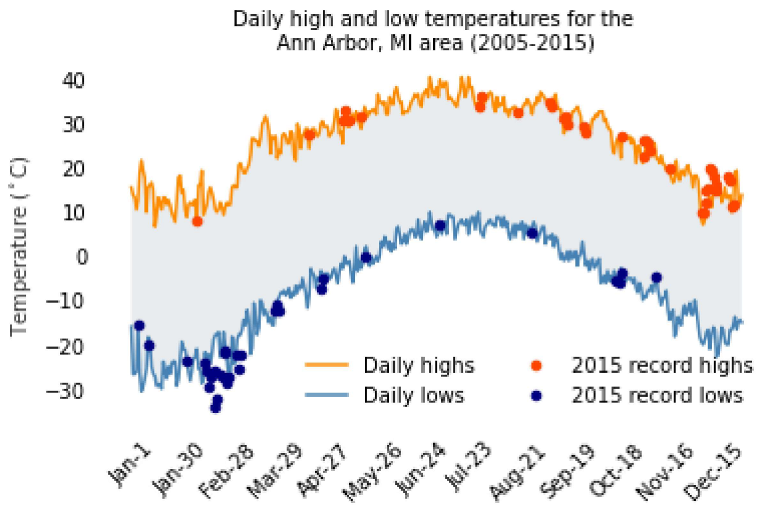
Out[11]:

	DayOfYear	2015 High	2015 Low	Record High	Record Low	DailyHigh	DailyLow	BrokeHigh	BrokeLow
0	Jan-1	1.1	-13.3	15.6	-16.0	15.6	-16.0	NaN	NaN
1	Jan-2	3.9	-12.2	13.9	-26.7	13.9	-26.7	NaN	NaN
2	Jan-3	3.9	-6.7	13.3	-26.7	13.3	-26.7	NaN	NaN
3	Jan-4	4.4	-8.8	10.6	-26.1	10.6	-26.1	NaN	NaN
4	Jan-5	2.8	-15.5	12.8	-15.0	12.8	-15.5	NaN	-15.5

In [12]:
```
# define plot series

days = df_compare['DayOfYear']
highs = df_compare['Record High']
lows = df_compare['Record Low']
record_highs = df_compare['BrokeHigh']
record_lows = df_compare['BrokeLow']
pos = np.arange(0, 364, 29)
days = days[pos]

days.head()
```

Out[12]:
```
0       Jan-1
29     Jan-30
58     Feb-28
87     Mar-29
116    Apr-27
Name: DayOfYear, dtype: object
```

In [13]:
```
#define plot and plot the four series by day of year

fig, ax1 = plt.subplots()

ax1.set_ylabel('Temperature ($^\circ$C)', alpha=0.8)
ax1.plot(highs, '-',
         label='Daily highs',
         color='darkorange')
ax1.plot(lows, '-',
         label='Daily lows',
         color='steelblue')
ax1.plot(record_highs, 'o',
         label='2015 record highs',
         color='orangered',
         markersize=4.5)
ax1.plot(record_lows, 'o',
         label='2015 record lows',
         color='navy',
         markersize=4.5)
ax1.set_xticks(pos)
ax1.set_xticklabels(days)

plt.title('Daily high and low temperatures for the \nAnn Arbor, MI area (2005-201
         fontsize=10)

# rotate the tick labels for the x axis
x = plt.gca().xaxis
for item in x.get_ticklabels():
    item.set_rotation(45)

plt.subplots_adjust(bottom=0.25)

# add and format legend
ax1.legend()
ax1.legend(loc='lower right', frameon=False, ncol=2)

# fill the area between the highs and lows
plt.gca().fill_between(range(len(highs)),
                       highs, lows,
                       facecolor='slategrey',
                       alpha=0.15)

# remove border and tick marks
plt.tick_params(top=False, bottom=False, left=False, right=False)

for spine in plt.gca().spines.values():
    spine.set_visible(False)

plt.show()
```


Daily high and low temperatures for the
Ann Arbor, MI area (2005-2015)
Temperature ($^\circ$C)
40
30
20
10
0
−10
−20
−30
Daily highs
Daily lows
2015 record highs
2015 record lows
Jan-1
Jan-30
Feb-28
Mar-29
Apr-27
May-26
Jun-24
Jul-23
Aug-21
Sep-19
Oct-18
Nov-16
Dec-15

```
In [ ]:
```