In [1]:
```
%matplotlib inline
from matplotlib import style
style.use('fivethirtyeight')
import matplotlib.pyplot as plt
```

In [2]:
```
import numpy as np
import pandas as pd
from scipy import stats
```

In [3]:
```
import datetime as dt
import dateutil as du
```

# Reflect Tables into SQLAlchemy ORM ¶

In [4]:
```
# Python SQL toolkit and Object Relational Mapper
import sqlalchemy
from sqlalchemy.ext.automap import automap_base
from sqlalchemy.orm import Session
from sqlalchemy import create_engine,inspect,func,desc
from sqlalchemy import Column, Integer, String, Float, Text
```

In [5]:
```
engine = create_engine("sqlite:///Resources/hawaii.sqlite")
conn = engine.connect()
```

In [6]:
```
# reflect an existing database into a new model
Base = automap_base()
# reflect the tables
Base.prepare(engine, reflect=True)
```

In [7]:
```
# We can view all of the classes that automap found
Base.classes.keys()
```

Out[7]:
```
['measurement', 'station']
```

In [8]:
```
# Save references to each table
Measurement = Base.classes.measurement
Station = Base.classes.station
```

In [9]:
```
# Create our session (link) from Python to the DB
session = Session(engine)
```

In [10]:
```
#inspect Measurement
inspector = inspect(engine)
columns = inspector.get_columns('Measurement')
for c in columns:
    print(c['name'], c["type"])
```

```
id INTEGER
station TEXT
date TEXT
prcp FLOAT
tobs FLOAT
```

In [81]:
```
#inspect Station
inspector = inspect(engine)
columns = inspector.get_columns('Station')
for c in columns:
    print(c['name'], c["type"])
```

```
id INTEGER
station TEXT
name TEXT
latitude FLOAT
longitude FLOAT
elevation FLOAT
```

# Step 1 - Climate Analysis and Exploration

## Precipitation Analysis

### Choose a start date and end date for your trip: 10/23/2015 to 10/30/2015

In [11]:
```
# Design a query to retrieve the last 12 months of precipitation data an
d plot the results

# Calculate the date 1 year ago from the last data point in the database

last_date = session.query(Measurement.date).order_by(Measurement.date.de
sc()).first()[0]
print("Latest Date:", last_date)

query_date= dt.date(2017, 8, 23) - dt.timedelta(days=365)
print("Query Date:", query_date)

precip = session.query(Measurement.date, Measurement.prcp).\
    filter(Measurement.date > query_date).\
    order_by(Measurement.date).all()

print(precip)
```

```
Latest Date: 2017-08-23
Query Date: 2016-08-23
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In [12]:
```
# Save the query results as a Pandas DataFrame and set the index to the
 date column
# Sort the dataframe by date
precip_df = pd.DataFrame(precip).fillna(0.00)
precip_df.head()
```

Out[12]:

| | date | prcp |
|---|---|---|
| 0 | 2016-08-24 | 0.08 |
| 1 | 2016-08-24 | 2.15 |
| 2 | 2016-08-24 | 2.28 |
| 3 | 2016-08-24 | 0.00 |
| 4 | 2016-08-24 | 1.22 |

In [85]:
```
# # Perform a query to retrieve the data and precipitation scores

# Save the query relts by USING READ_SQL as a Pandas DataFrame and set t
he index to the date column
df_prcp_scores = pd.read_sql("SELECT date, prcp FROM measurement WHERE d
ate >= '2016-08-24';", conn).set_index('date').\
fillna(0.00)
df_prcp_scores.head()

# # Sort the dataframe by date
```

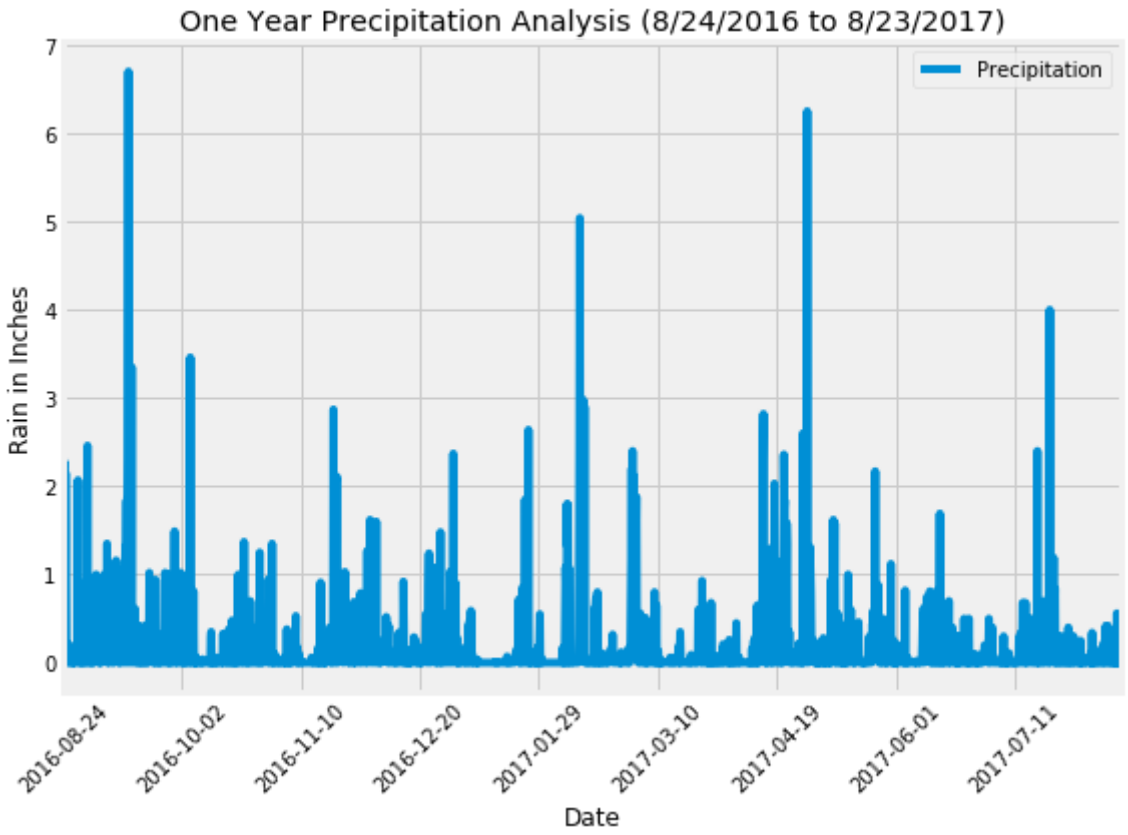
Out[85]:

| | prcp |
|---|---|
| date | |
| 2016-08-24 | 0.08 |
| 2016-08-25 | 0.08 |
| 2016-08-26 | 0.00 |
| 2016-08-27 | 0.00 |
| 2016-08-28 | 0.01 |

In [13]:
```
# Use Pandas Plotting with Matplotlib to plot the data
precip_df.plot('date', 'prcp', figsize=(8,6))
plt.xlabel("Date")
plt.ylabel("Rain in Inches")
plt.title("One Year Precipitation Analysis (8/24/2016 to 8/23/2017)")
plt.legend(["Precipitation"])
plt.xticks(rotation=45)
plt.tight_layout()

plt.savefig("Precipitation Analysis.png")

plt.show()
```




precipitation

In [42]:
```
# Use Pandas to calcualte the summary statistics for the precipitation data
precip_df.describe()
```

Out[42]:

| | prcp |
|---|---|
| count | 2223.000000 |
| mean | 0.159951 |
| std | 0.441220 |
| min | 0.000000 |
| 25% | 0.000000 |
| 50% | 0.010000 |
| 75% | 0.110000 |
| max | 6.700000 |

## Station Analysis

In [15]:
```
# Inspect
columns = inspector.get_columns('Station')
for c in columns:
    print(c['name'], c["type"])
```

```
id INTEGER
station TEXT
name TEXT
latitude FLOAT
longitude FLOAT
elevation FLOAT
```

In [16]:
```
# session.query(Measurement.station, Station.station).limit(50).all()
```

In [17]:
```
# same_station = session.query(Measurement, Station).filter(Measurement.station == Station.station).limit(10).all()
# for record in same_station:
#     (Measurement, Station) = record
#     print(Measurement.station)
#     print(Station.station)
```

In [18]:
```
# Design a query to show how many stations are available in this datase t?

# stations = session.query(func.count(Station.station)).all()[0]
stations = session.query(Station.station).count()
print(f'There are {stations} stations.')
```

```
There are 9 stations.
```

In [83]:
```
result_stations = session.query(Station.name).all()

result_stations
```

Out[83]:
```
[('WAIKIKI 717.2, HI US'),
 ('KANEOHE 838.1, HI US'),
 ('KUALOA RANCH HEADQUARTERS 886.9, HI US'),
 ('PEARL CITY, HI US'),
 ('UPPER WAHIAWA 874.3, HI US'),
 ('WAIMANALO EXPERIMENTAL FARM, HI US'),
 ('WAIHEE 837.5, HI US'),
 ('HONOLULU OBSERVATORY 702.2, HI US'),
 ('MANOA LYON ARBO 785.2, HI US')]
```

In [20]:
```
active_stations = [Measurement.station, func.count(Measurement.station)]
active_stations_query = session.query(*active_stations).\
    group_by(Measurement.station).\
    order_by(func.count(Measurement.station)).all()

most_active_station = active_stations_query[-1][0]
most_activity = active_stations_query[-1][-1]

print(f'Station Counts: {active_stations_query}')
print('--' *55)
print(f'The most active station is {most_active_station} with the highes
t number of temperature observations of {most_activity}.')
```

```
Station Counts: [('USC00518838', 511), ('USC00517948', 1372), ('USC0051
1918', 1979), ('USC00514830', 2202), ('USC00516128', 2612), ('USC005195
23', 2669), ('USC00513117', 2709), ('USC00519397', 2724), ('USC0051928
1', 2772)]
----------------------------------------------------------------------
----------------------------------------
The most active station is USC00519281 with the highest number of tempe
rature observations of 2772.
```

In [21]:
```
# Using the station id from the previous query, calculate the lowest tem
perature recorded,
# highest temperature recorded, and average temperature of the most acti
ve station?
station_id = engine.execute("SELECT min(tobs), max(tobs), avg(tobs) FROM
 Measurement WHERE station = 'USC00519281'").\
fetchall()
min = station_id[0][0]
max = station_id[0][1]
avg = round(station_id[0][2],1)
print(f' The minimum temperature on station USC00519281 is: {min}F;')
print(f' The maximum temperature on station USC00519281 is: {max}F; and'
)
print(f' The average temperature on station USC00519281 is: {avg}F.')
```

```
 The minimum temperature on station USC00519281 is: 54.0F;
 The maximum temperature on station USC00519281 is: 85.0F; and
 The average temperature on station USC00519281 is: 71.7F.
```

In [22]:
```
# Choose the station with the highest number of temperature observation
s.

# Query the last 12 months of temperature observation data for this stat
ion and plot the results as a histogram
USC_519281 = session.query(Measurement.date, Measurement.tobs).\
    filter(Measurement.date > query_date).\
    order_by(Measurement.date).all()
print(USC_519281)
```

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```

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0), ('2017-08-23', 82.0), ('2017-08-23', 76.0)]
```

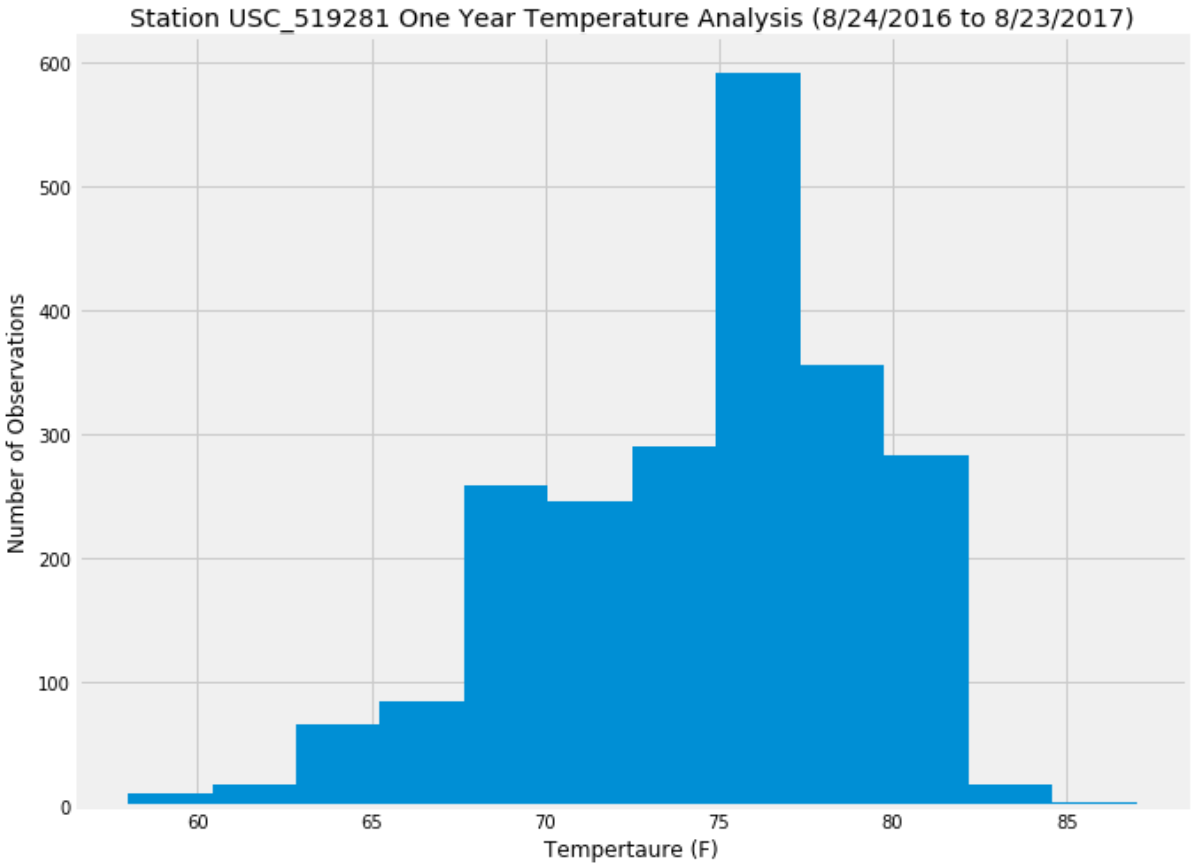
In [23]:
```
USC_519281_df = pd.DataFrame(USC_519281).fillna(0.00)
USC_519281_df.head(10)
```

Out[23]:

| | date | tobs |
|---|---|---|
| 0 | 2016-08-24 | 79.0 |
| 1 | 2016-08-24 | 76.0 |
| 2 | 2016-08-24 | 80.0 |
| 3 | 2016-08-24 | 78.0 |
| 4 | 2016-08-24 | 79.0 |
| 5 | 2016-08-24 | 77.0 |
| 6 | 2016-08-24 | 74.0 |
| 7 | 2016-08-25 | 80.0 |
| 8 | 2016-08-25 | 77.0 |
| 9 | 2016-08-25 | 81.0 |

In [24]:
```
USC_519281_df.hist(bins=12, figsize=(10,8))
plt.title("Station USC_519281 One Year Temperature Analysis (8/24/2016 t
o 8/23/2017)")
plt.xlabel("Tempertaure (F)")
plt.ylabel("Number of Observations")

plt.savefig("Station USC_519281 Temperature Analysis.png")
plt.show()
```




## Optional Challenge Assignment

## Temperature Analysis II

In [25]:
```
# This function called `calc_temps` will accept start date and end date
 in the format '%Y-%m-%d'
# and return the minimum, average, and maximum temperatures for that ran
ge of dates

def calc_temps(start_date, end_date):
    """TMIN, TAVG, and TMAX for a list of dates.

    Args:
        start_date (string): A date string in the format %Y-%m-%d
        end_date (string): A date string in the format %Y-%m-%d

    Returns:
        TMIN, TAVE, and TMAX
    """

    return session.query(func.min(Measurement.tobs), func.avg(Measuremen
t.tobs), func.max(Measurement.tobs)).\
        filter(Measurement.date >= start_date).filter(Measurement.date <
= end_date).all()

# function usage example
print(calc_temps('2012-02-28', '2012-03-05'))
# MY TRIP DATES: 10/23/2015 to 10/30/2015
print(calc_temps('2012-10-23', '2012-10-30'))
```

```
[(62.0, 69.57142857142857, 74.0)]
[(68.0, 74.41818181818182, 81.0)]
```

In [55]:
```
# Use your previous function `calc_temps` to calculate the tmin, tavg, a
nd tmax
# for your trip using the previous year's data for those same dates.
# MY TRIP DATES: 10/23/2015 to 10/30/2015

min = calc_temps('2014-10-23', '2014-10-30')[0][0]
avg = round(calc_temps('2014-10-23', '2014-10-30')[0][1],1)
max = round(calc_temps('2014-10-23', '2014-10-30')[0][2],1)


print('Previous Year Trip Dates: Oct.23 - Oct.30, 2014')
print('--'*18)
print(f' The minimum temperature was {min}')
print(f' The average temperature was {avg}')
print(f' The maximum temperature was {max}')
```

```
Previous Year Trip Dates: Oct.23 - Oct.30, 2014
------------------------------------
 The minimum temperature was 68.0
 The average temperature was 76.0
 The maximum temperature was 83.0
```

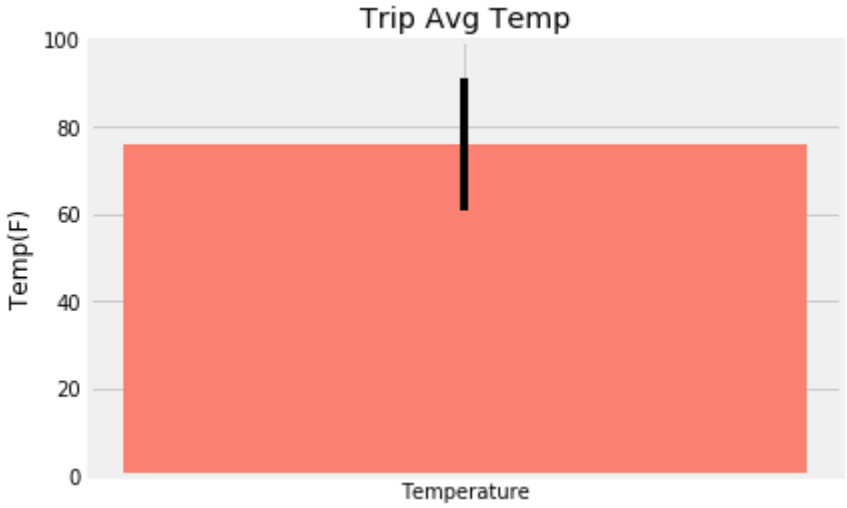
In [27]:
```
# Plot the results from your previous query as a bar chart.

# Use "Trip Avg Temp" as your Title
# Use the average temperature for the y value
# Use the peak-to-peak (tmax-tmin) value as the y error bar (yerr)

my_trip = calc_temps('2014-10-23', '2014-10-30')
error= [max - min]

plt.bar('Temperature', avg, yerr=error, color = 'salmon')
plt.title("Trip Avg Temp")
plt.ylabel("Temp(F)")
plt.yticks(np.arange(0, 120, 20))

plt.savefig("Trip Average Temperature.png")
plt.show()
```




In [28]:
```
# Calculate the total amount of rainfall per weather station for your tr
ip dates
# using the previous year's matching dates.
# Sort this in descending order by precipitation amount and list the sta
tion, name, latitude, longitude, and elevation

total_precip = session.query(Measurement.date, Measurement.tobs).\
    filter(Measurement.date > query_date).\
    order_by(Measurement.date).all()
```

# Temperature Analysis I

In [29]:
```
# Is there a meaningful difference between the temperature in, for examp
le, June and December?
# You may either use SQLAlchemy or pandas's read_csv() to perform this p
ortion.
# Identify the average temperature in June at all stations across all av
ailable years in the dataset.
# Do the same for December temperature.
# Use the t-test to determine whether the difference in the means, if an
y, is statistically significant.
# Will you use a paired t-test, or an unpaired t-test? Why?
```

In [30]:
```
sel = [Measurement.station,
       func.avg(Measurement.tobs)]
june_averages = session.query(*sel).\
                filter(func.strftime('%m', Measurement.date) =="06").\
                group_by(Measurement.station).\
                order_by(Measurement.station).all()

dec_averages = session.query(*sel).\
                filter(func.strftime('%m', Measurement.date) =="12").\
                group_by(Measurement.station).\
                order_by(Measurement.station).all()

print(' Average temperature in June at each of the nine station:')
print('--'*28)
print(f'{june_averages}')
print('')
print('Average temperature in December at each of the nine station:')
print('--'*28)
print(f'{dec_averages}')
```

```
 Average temperature in June at each of the nine station:
------------------------------------------------------------
[('USC00511918', 74.13939393939394), ('USC00513117', 74.0508474576271
1), ('USC00514830', 76.00537634408602), ('USC00516128', 71.937219730941
7), ('USC00517948', 76.6554054054054), ('USC00518838', 73.3947368421052
6), ('USC00519281', 73.27118644067797), ('USC00519397', 77.559322033898
31), ('USC00519523', 76.66810344827586)]

Average temperature in December at each of the nine station:
------------------------------------------------------------
[('USC00511918', 69.6842105263158), ('USC00513117', 71.06944444444444),
('USC00514830', 73.2247191011236), ('USC00516128', 69.29126213592232),
('USC00517948', 71.8348623853211), ('USC00518838', 72.42105263157895),
('USC00519281', 69.90322580645162), ('USC00519397', 71.10952380952381),
('USC00519523', 72.43333333333334)]
```

In [31]:
```
june_averages_df =pd.DataFrame(june_averages,columns=['Station','Avg_June_Temps'])
dec_averages_df = pd.DataFrame(dec_averages,columns=['Station','Avg_Dec_Temps'])
june_averages_df.set_index('Station', inplace=True)
dec_averages_df.set_index('Station', inplace=True)
print(round(june_averages_df,1))
print(round(dec_averages_df,1))
```

```
             Avg_June_Temps
Station
USC00511918            74.1
USC00513117            74.1
USC00514830            76.0
USC00516128            71.9
USC00517948            76.7
USC00518838            73.4
USC00519281            73.3
USC00519397            77.6
USC00519523            76.7
             Avg_Dec_Temps
Station
USC00511918           69.7
USC00513117           71.1
USC00514830           73.2
USC00516128           69.3
USC00517948           71.8
USC00518838           72.4
USC00519281           69.9
USC00519397           71.1
USC00519523           72.4
```

In [32]:
```
concact_df = pd.concat([june_averages_df,dec_averages_df], axis=1)
june = concact_df.iloc[:,[0]]
june
dec = concact_df.iloc[:,[1]]
dec
```

Out[32]:

| Station | Avg_Dec_Temps |
|---|---|
| USC00511918 | 69.684211 |
| USC00513117 | 71.069444 |
| USC00514830 | 73.224719 |
| USC00516128 | 69.291262 |
| USC00517948 | 71.834862 |
| USC00518838 | 72.421053 |
| USC00519281 | 69.903226 |
| USC00519397 | 71.109524 |
| USC00519523 | 72.433333 |

In [33]:
```
# Use the t-test to determine whether the difference in the means, if an
y, is statistically significant.
# Will you use a paired t-test, or an unpaired t-test? Why?
(t_stat, p) = stats.ttest_ind(june, dec, equal_var=False)

print("The mean temperature in June across all station is {}.".format(ju
ne.mean()))
print("The mean temperature in December across all station is {}.".forma
t(dec.mean()))
print("p is {}.".format(p[0]))
if p < 0.05:
    print("The difference in sample means is significant.")
else:
    print("The difference in sample means is not significant.")
```

```
The mean temperature in June across all station is Avg_June_Temps    7
4.85351
dtype: float64.
The mean temperature in December across all station is Avg_Dec_Temps
71.21907
dtype: float64.
p is 0.0003657335214469917.
The difference in sample means is significant.
```

## Daily Rainfall Average

In [75]:
```
# Create a query that will calculate the daily normals
# (i.e. the averages for tmin, tmax, and tavg for all historic data matc
hing a specific month and day)

def daily_normals(date):
    """Daily Normals.

    Args:
        date (str): A date string in the format '%m-%d'

    Returns:
        A list of tuples containing the daily normals, tmin, tavg, and t
max

    """

    sel = [func.min(Measurement.prcp), func.avg(Measurement.prcp), func.
max(Measurement.prcp)]
    return session.query(*sel).filter(func.strftime("%m-%d", Measurement
.date) == date).all()

print(daily_normals("10-24"))
```

```
[(0.0, 0.2379999999999999, 4.47)]
```

In [73]:
```
# calculate the daily normals for your trip
# MY TRIP DATES: 10/23/2015 to 10/30/2015

normals= daily_normals("10-23"), daily_normals("10-24"), daily_normals(
"10-25"),daily_normals("10-26"),daily_normals("10-27"), daily_normals("1
0-28"),daily_normals("10-29"),daily_normals("10-30")
print('Oct.23 to Oct.30 Rainfall: Min., Avg., Max')
print('--'*23)
normals
```

```
Oct.23 to Oct.30 Rainfall: Min., Avg., Max
-----------------------------------------------
```

Out[73]:
```
([(0.0, 0.18181818181818182, 2.31)],
 [(0.0, 0.2379999999999999, 4.47)],
 [(0.0, 0.12333333333333334, 1.6)],
 [(0.0, 0.0795833333333333, 1.1)],
 [(0.0, 0.1490909090909091, 2.0)],
 [(0.0, 0.12244444444444444, 0.7)],
 [(0.0, 0.11239999999999999, 1.05)],
 [(0.0, 0.14265306122448979, 1.9)])
```

In [79]:
```
trip_df = pd.DataFrame(trip_dates, columns = ['Min', 'Avg', 'Max'])
trip_df
```

Out[79]:

| | Min | Avg | Max |
|---|---|---|---|
| 0 | 0.0 | 0.109623 | 2.0 |

In [80]:
```
# Stip off the year and save a list of %m-%d strings
# Loop through the list of %m-%d strings and calculate the normals for e
ach date

min = calc_prcp('2015-10-23', '2015-10-30')[0][0]
avg = round(calc_prcp('2015-10-23', '2015-10-30')[0][1],1)
max = round(calc_prcp('2015-10-23', '2015-10-30')[0][2],1)


print('Trip Dates: Oct.23 - Oct.30, 2015')
print('--'*16)
print(f' The minimum rainfall was {min}')
print(f' The average rainfall was {avg}')
print(f' The maximum rainfall was {max}')
```

```
Trip Dates: Oct.23 - Oct.30, 2015
--------------------------------
 The minimum rainfall was 0.0
 The average rainfall was 0.1
 The maximum rainfall was 2.0
```

In [56]:
```
# Load the previous query results into a Pandas DataFrame and add the `t
rip_dates` range as the `date` index
# Plot the daily normals as an area plot with `stacked=False`
```

In [ ]: