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
```

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

# 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, func, inspect
from sqlalchemy import text
```

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

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)
```

# Exploratory Climate Analysis

In [10]:
```
# Design a query to retrieve the last 12 months of precipitation data and plot th

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

# Perform a query to retrieve the data and precipitation scores

# Save the query results as a Pandas DataFrame and set the index to the date colu

# Sort the dataframe by date

# Use Pandas Plotting with Matplotlib to plot the data
```

In [11]:
```
# Create the inspector and connect it to the engine
inspector = inspect(engine)

# Collect the names of tables within the database
inspector.get_table_names()
```

Out[11]:
```
['measurement', 'station']
```

In [12]:
```
# Using the inspector to print the column names within the 'measurement' table an
columns = inspector.get_columns('measurement')
for column in columns:
    print(column["name"], column["type"])
```

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

In [13]:
```
# running out of time, using SQL to fetch the last date in the table.
# Using Textual SQL
# That’s why SQLAlchemy lets you just use strings, for those cases when the SQL
# https://docs.sqlalchemy.org/en/13/core/tutorial.html#sqlexpression-text
z = text('SELECT date FROM measurement order by date desc limit 1;''')
session.execute(z).fetchall()
```

Out[13]:
```
[('2017-08-23',)]
```

In [14]:
```
# http://localhost:8888/notebooks/10-Advanced-Data-Storage-and-Retrieval/3/Activ
# SELECT date as Date, prcp as Precipitation FROM measurement where date >= date
# https://stackoverflow.com/questions/8895208/sqlalchemy-how-to-filter-date-field
# Calculate the date 1 year ago from the last data point in the database

# Design a query to retrieve the last 12 months of precipitation data and plot th
s1 = session.query(Measurement.date,Measurement.prcp).filter(Measurement.date.bet
```

In [15]:
```
#type(session) sqlalchemy.orm.session.Session
```

In [16]:
```
# https://stackoverflow.com/questions/29525808/sqlalchemy-orm-conversion-to-pand

#df_measurements_dt_prcp = pd.read_sql_query(session.statement, session.bind)
df_measurements_dt_prcp_sqlalchemy = pd.DataFrame(s1)
df_measurements_dt_prcp_sqlalchemy.columns = ['Date','Precipitation']
df_measurements_dt_prcp_sqlalchemy.sort_values(by=['Date'])
df_measurements_dt_prcp_sqlalchemy.set_index('Date',drop=True, inplace=True)
df_measurements_dt_prcp_sqlalchemy=df_measurements_dt_prcp_sqlalchemy.astype(flo
df_measurements_dt_prcp_sqlalchemy.groupby(['Date']).sum()
```

Out[16]:

| | Precipitation |
|---|---|
| **Date** | |
| **2016-08-23** | 2.71 |
| **2016-08-24** | 9.33 |
| **2016-08-25** | 0.54 |
| **2016-08-26** | 0.10 |
| **2016-08-27** | 0.32 |
| **2016-08-28** | 3.10 |
| **2016-08-29** | 1.46 |
| **2016-08-30** | 0.07 |
| **2016-08-31** | 3.18 |
| **2016-09-01** | 0.03 |
| **2016-09-02** | 0.25 |
| **2016-09-03** | 1.27 |
| **2016-09-04** | 1.38 |
| **2016-09-05** | 0.34 |
| **2016-09-06** | 1.23 |
| **2016-09-07** | 2.00 |
| **2016-09-08** | 0.46 |
| **2016-09-09** | 1.07 |
| **2016-09-10** | 1.40 |
| **2016-09-11** | 1.25 |
| **2016-09-12** | 1.54 |
| **2016-09-13** | 2.71 |
| **2016-09-14** | 14.28 |
| **2016-09-15** | 4.96 |
| **2016-09-16** | 0.82 |
| **2016-09-17** | 0.68 |
| **2016-09-18** | 0.53 |
| **2016-09-19** | 0.32 |

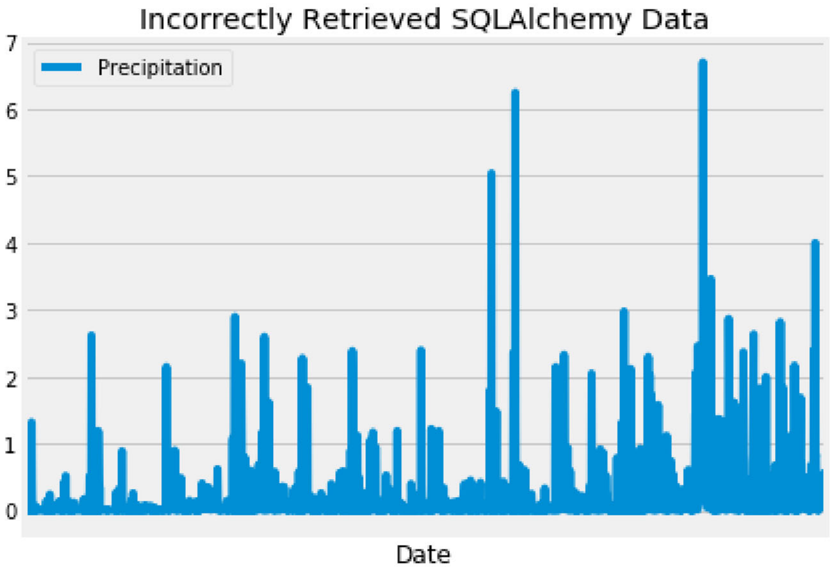
| | Precipitation |
|---|---|
| **Date** | |
| **2016-09-20** | 1.03 |
| **2016-09-21** | 1.17 |
| **...** | ... |
| **2017-07-25** | 0.61 |
| **2017-07-26** | 0.50 |
| **2017-07-27** | 0.01 |
| **2017-07-28** | 0.77 |
| **2017-07-29** | 0.61 |
| **2017-07-30** | 0.30 |
| **2017-07-31** | 0.00 |
| **2017-08-01** | 0.14 |
| **2017-08-02** | 0.30 |
| **2017-08-03** | 0.07 |
| **2017-08-04** | 0.06 |
| **2017-08-05** | 0.06 |
| **2017-08-06** | 0.00 |
| **2017-08-07** | 0.05 |
| **2017-08-08** | 0.44 |
| **2017-08-09** | 0.15 |
| **2017-08-10** | 0.07 |
| **2017-08-11** | 0.00 |
| **2017-08-12** | 0.14 |
| **2017-08-13** | 0.00 |
| **2017-08-14** | 0.31 |
| **2017-08-15** | 0.82 |
| **2017-08-16** | 0.61 |
| **2017-08-17** | 0.19 |
| **2017-08-18** | 0.06 |
| **2017-08-19** | 0.09 |
| **2017-08-20** | 0.01 |
| **2017-08-21** | 0.58 |
| **2017-08-22** | 0.50 |
| **2017-08-23** | 0.53 |

366 rows × 1 columns

```
In [17]: # Precipitation Analysis: From NoteBook: Use Pandas Plotting with Matplotlib to 
         # Precipitation Analysis: From Instructions: Plot the results using the DataFram
         # http://localhost:8889/notebooks/10-Advanced-Data-Storage-and-Retrieval/2/Activ

         # NOTE: my SQLALCHEMY GRAPH IS INCORRECT. USING SQL QUERY BELOW....

         df_measurements_dt_prcp_sqlalchemy.plot()
         plt.xticks([])
         plt.tight_layout()
         plt.title('Incorrectly Retrieved SQLAlchemy Data')
         plt.grid(b=True,axis='both')
```



In [18]:

```
# USING SQL VS SQLALCHEMY...
# Using Textual SQL
# That’s why SQLAlchemy lets you just use strings, for those cases when the SQL
# https://docs.sqlalchemy.org/en/13/core/tutorial.html#sqlexpression-text
s2 = text(
 "SELECT date as Date, prcp as Precipitation "
"FROM measurement "
 "where date >= date('2017-08-23','-365 days') "
"and prcp >=0 order by date")
session.execute(s2).fetchall()
# type(session) sqlalchemy.orm.session.Session
```

Out[18]:

```
[('2016-08-23', 0.0),
 ('2016-08-23', 0.15),
 ('2016-08-23', 0.05),
 ('2016-08-23', 0.02),
 ('2016-08-23', 1.79),
 ('2016-08-23', 0.7),
 ('2016-08-24', 0.08),
 ('2016-08-24', 2.15),
 ('2016-08-24', 2.28),
 ('2016-08-24', 1.22),
 ('2016-08-24', 2.15),
 ('2016-08-24', 1.45),
 ('2016-08-25', 0.08),
 ('2016-08-25', 0.08),
 ('2016-08-25', 0.0),
 ('2016-08-25', 0.0),
 ('2016-08-25', 0.21),
 ('2016-08-25', 0.06),
 ('2016-08-25', 0.11),
```

In [19]:

```
# https://stackoverflow.com/questions/29525808/sqlalchemy-orm-conversion-to-pand
# https://stackoverflow.com/questions/42593104/convert-list-into-a-pandas-data-fr
# https://stackoverflow.com/questions/11346283/renaming-columns-in-pandas
# https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.sor
# type(df_measurements_dt_prcp) # pandas.core.frame.DataFrame
# Precipitation Analysis: Load the query results into a Pandas DataFrame and set
# Precipitation Analysis: Sort the DataFrame values by date.

# SQL S2 returns 366 rows, versus SQLAlchemy S1 returning 366 rows.

df_measurements_dt_prcp_SQL = pd.read_sql_query(s2, engine)
df_measurements_dt_prcp_SQL.columns = ['Date','Precipitation']
df_measurements_dt_prcp_SQL.sort_values(by=['Date'])
df_measurements_dt_prcp_SQL.set_index('Date',drop=True, inplace=True)
df_measurements_dt_prcp_SQL=df_measurements_dt_prcp_SQL.astype(float)
df_measurements_dt_prcp_SQL.groupby(['Date']).sum()
```

Out[19]:

| | Precipitation |
|---|---|
| **Date** | |
| **2016-08-23** | 2.71 |
| **2016-08-24** | 9.33 |
| **2016-08-25** | 0.54 |
| **2016-08-26** | 0.10 |
| **2016-08-27** | 0.32 |
| **2016-08-28** | 3.10 |
| **2016-08-29** | 1.46 |
| **2016-08-30** | 0.07 |
| **2016-08-31** | 3.18 |
| **2016-09-01** | 0.03 |
| **2016-09-02** | 0.25 |
| **2016-09-03** | 1.27 |
| **2016-09-04** | 1.38 |
| **2016-09-05** | 0.34 |
| **2016-09-06** | 1.23 |
| **2016-09-07** | 2.00 |
| **2016-09-08** | 0.46 |
| **2016-09-09** | 1.07 |
| **2016-09-10** | 1.40 |
| **2016-09-11** | 1.25 |
| **2016-09-12** | 1.54 |
| **2016-09-13** | 2.71 |
| **2016-09-14** | 14.28 |

|  | Precipitation |
|---:|---:|
| **Date** |  |
| **2016-09-15** | 4.96 |
| **2016-09-16** | 0.82 |
| **2016-09-17** | 0.68 |
| **2016-09-18** | 0.53 |
| **2016-09-19** | 0.32 |
| **2016-09-20** | 1.03 |
| **2016-09-21** | 1.17 |
| **...** | ... |
| **2017-07-25** | 0.61 |
| **2017-07-26** | 0.50 |
| **2017-07-27** | 0.01 |
| **2017-07-28** | 0.77 |
| **2017-07-29** | 0.61 |
| **2017-07-30** | 0.30 |
| **2017-07-31** | 0.00 |
| **2017-08-01** | 0.14 |
| **2017-08-02** | 0.30 |
| **2017-08-03** | 0.07 |
| **2017-08-04** | 0.06 |
| **2017-08-05** | 0.06 |
| **2017-08-06** | 0.00 |
| **2017-08-07** | 0.05 |
| **2017-08-08** | 0.44 |
| **2017-08-09** | 0.15 |
| **2017-08-10** | 0.07 |
| **2017-08-11** | 0.00 |
| **2017-08-12** | 0.14 |
| **2017-08-13** | 0.00 |
| **2017-08-14** | 0.31 |
| **2017-08-15** | 0.82 |
| **2017-08-16** | 0.61 |
| **2017-08-17** | 0.19 |
| **2017-08-18** | 0.06 |
| **2017-08-19** | 0.09 |
| **2017-08-20** | 0.01 |

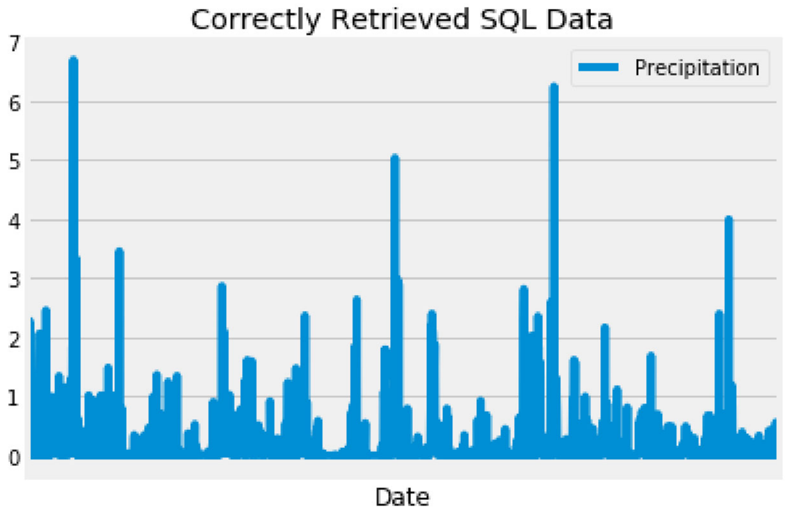
| | **Precipitation** |
|---|---|
| **Date** | |
| **2017-08-21** | 0.58 |
| **2017-08-22** | 0.50 |
| **2017-08-23** | 0.53 |

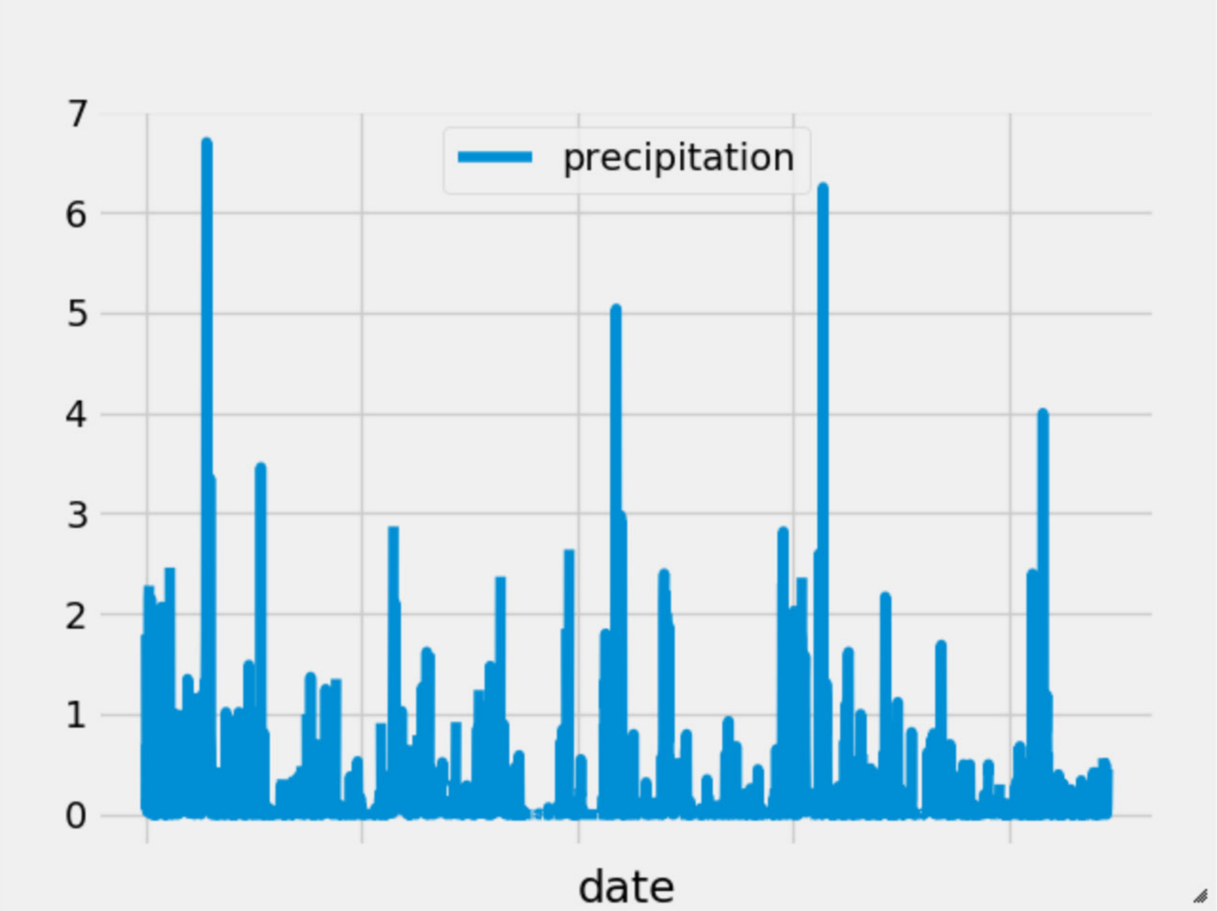
366 rows × 1 columns

In [20]:

```
# Precipitation Analysis: From NoteBook: Use Pandas Plotting with Matplotlib to p
# Precipitation Analysis: From Instructions: Plot the results using the DataFrame
# http://localhost:8889/notebooks/10-Advanced-Data-Storage-and-Retrieval/2/Activ

df_measurements_dt_prcp_SQL.plot()
plt.xticks([])
plt.title('Correctly Retrieved SQL Data')
plt.grid(b=True, which='minor', axis='both')
```





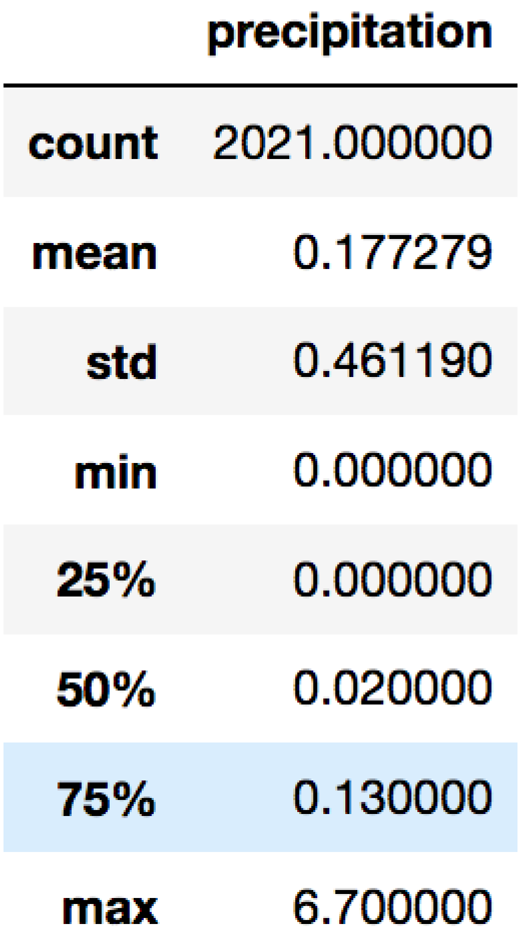
In [21]:

```
# Use Pandas to calcualte the summary statistics for the precipitation data
# https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.des

# Describe SQL retrieved correct data...
df_measurements_dt_prcp_SQL.describe()
```

Out[21]:

| | Precipitation |
|---|---|
| count | 2021.000000 |
| mean | 0.177279 |
| std | 0.461190 |
| min | 0.000000 |
| 25% | 0.000000 |
| 50% | 0.020000 |
| 75% | 0.130000 |
| max | 6.700000 |



| | precipitation |
|---|---|
| count | 2021.000000 |
| mean | 0.177279 |
| std | 0.461190 |
| min | 0.000000 |
| 25% | 0.000000 |
| 50% | 0.020000 |
| 75% | 0.130000 |
| max | 6.700000 |

In [22]:
```
# Describe SQLAlchemy retrieved incorrect data...
df_measurements_dt_prcp_sqlalchemy.describe()
```

Out[22]:

| | Precipitation |
|---|---|
| count | 2021.000000 |
| mean | 0.177279 |
| std | 0.461190 |
| min | 0.000000 |
| 25% | 0.000000 |
| 50% | 0.020000 |
| 75% | 0.130000 |
| max | 6.700000 |

In [23]:

```
# Using the inspector to print the column names within the 'station' table and i
columns = inspector.get_columns('station')
for column in columns:
    print(column["name"], column["type"])
```

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

In [24]:

```
# Design a query to show how many stations are available in this dataset?

stations = session.query(Station).group_by(Station.station).count()
print(stations)
type(stations)
```

```
9
```

Out[24]:

```
int
```

In [25]:

```
# What are the most active stations? (i.e. what stations have the most rows)?
# List the stations and the counts in descending order.

zzz = text(
" SELECT station.station as Station, count(measurement.station) as Observations"
" FROM measurement "
" JOIN station on station.station = measurement.station "
" GROUP BY station.name "
" ORDER BY Observations DESC ")
session.execute(zzz).fetchall()
# type(session) sqlalchemy.orm.session.Session
```

Out[25]:

```
[('USC00519281', 2772),
 ('USC00519397', 2724),
 ('USC00513117', 2709),
 ('USC00519523', 2669),
 ('USC00516128', 2612),
 ('USC00514830', 2202),
 ('USC00511918', 1979),
 ('USC00517948', 1372),
 ('USC00518838', 511)]
```

In [26]:

```
# Using the station id from the previous query, calculate the lowest temperature
# highest temperature recorded, and average temperature most active station?
# https://www.programcreek.com/python/example/88981/sqlalchemy.func.min

# can't get it to work. moving back to SQL...
session.query(Measurement, func.min(measurement.tobs), func.max(measurement.tobs
```

```
  File "<ipython-input-26-c9d47bc03b4c>", line 6
    session.query(Measurement, func.min(measurement.tobs), func.max(measuremen
t.tobs), func.avg(measurement.tobs), func.sum(measurement.tobs)/func.count(meas
urement.tobs)).filter(measurement.station = 'USC00519281')

^
SyntaxError: keyword can't be an expression
```

In [27]:

```
# Using the station id from the previous query, calculate the lowest temperature
# highest temperature recorded, and average temperature most active station?
sss = text(
 "SELECT min(tobs), max(tobs), avg(tobs)"
"FROM measurement "
 "where station = 'USC00519281'")
session.execute(sss).fetchall()
```

Out[27]:

```
[(54.0, 85.0, 71.66378066378067)]
```

In [28]:

```
# Choose the station with the highest number of temperature observations.
# Query the last 12 months of temperature observation data for this station and p
# http://localhost:8888/notebooks/10-Advanced-Data-Storage-and-Retrieval/3/Activ

# SELECT tobs, count(tobs) FROM measurement where station = 'USC00519281' and dat
# https://stackoverflow.com/questions/12941416/how-to-count-rows-with-select-coun

al1 =session.query(Measurement.tobs, func.count(Measurement.tobs)).group_by(Measu
```

In [29]:

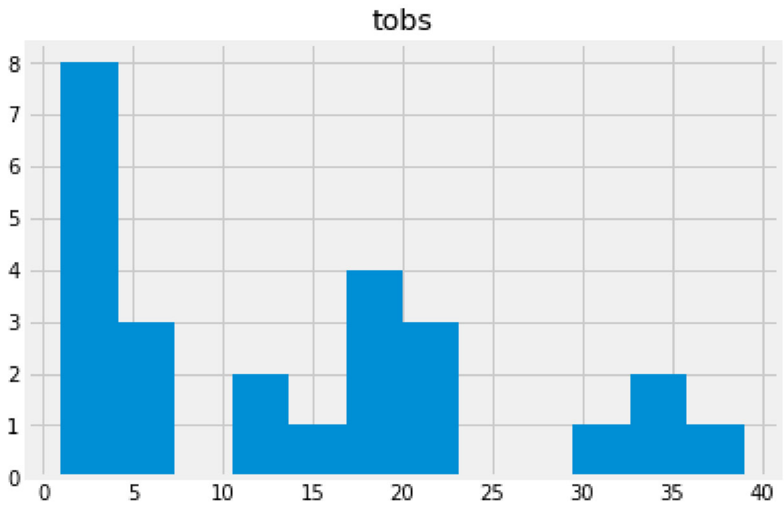
```
df_measurements_tobs_frequent_yr_sqlalchemy = pd.DataFrame(al1,columns = ['Frequ
df_measurements_tobs_frequent_yr_sqlalchemy.set_index('Frequency',drop=True, inpl
df_measurements_tobs_frequent_yr_sqlalchemy
```

Out[29]:

```
           tobs
Frequency
     59.0     3
     60.0     2
     61.0     1
     62.0     6
     63.0     4
     64.0     3
     65.0     7
     66.0     5
     67.0    15
     68.0    12
     69.0    19
     70.0    22
     71.0    18
     72.0    22
     73.0    18
     74.0    39
     75.0    33
     76.0    33
     77.0    31
     78.0    22
     79.0    18
     80.0    11
     81.0     4
     82.0     3
     83.0     1
```

In [30]:
```
df_measurements_tobs_frequent_yr_sqlalchemy.hist(bins=12)
#plt.xlim(55,80)
#plt.ylim(0,65)
```

Out[30]:
```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x00000235016C92E8>]],
      dtype=object)
```



In [31]:

```
# Using Textual SQL
# That’s why SQLAlchemy lets you just use strings, for those cases when the SQL
# https://docs.sqlalchemy.org/en/13/core/tutorial.html#sqlexpression-text
sss = text(
 "SELECT tobs, count(tobs)"
"FROM measurement "
 "where station = 'USC00519281' and date >= date('2017-08-23','-365 days') "
"GROUP BY tobs")
session.execute(sss).fetchall()
# type(session) sqlalchemy.orm.session.Session
```

Out[31]:

```
[(59.0, 3),
 (60.0, 2),
 (61.0, 1),
 (62.0, 6),
 (63.0, 4),
 (64.0, 3),
 (65.0, 7),
 (66.0, 5),
 (67.0, 15),
 (68.0, 12),
 (69.0, 19),
 (70.0, 22),
 (71.0, 18),
 (72.0, 22),
 (73.0, 18),
 (74.0, 39),
 (75.0, 33),
 (76.0, 33),
 (77.0, 31),
 (78.0, 22),
 (79.0, 18),
 (80.0, 11),
 (81.0, 4),
 (82.0, 3),
 (83.0, 1)]
```

In [32]:

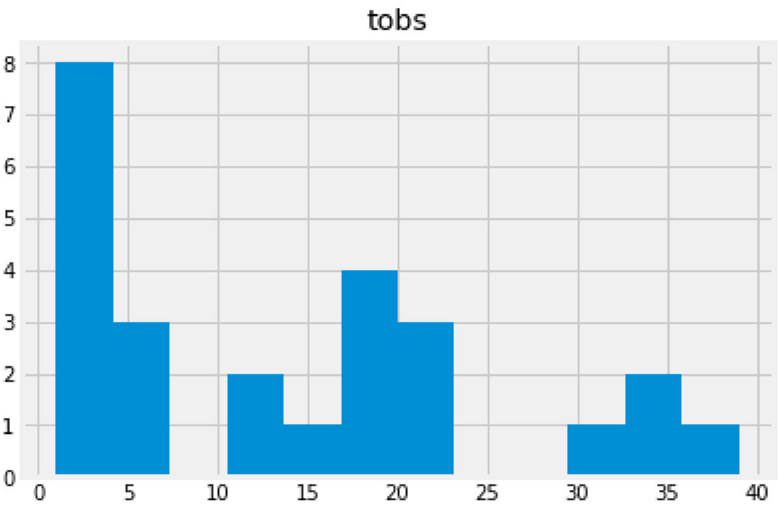
```
df_measurements_tobs_frequent_yr_SQL = pd.read_sql_query(sss, engine)
df_measurements_tobs_frequent_yr_SQL.columns = ['Frequency','tobs']
df_measurements_tobs_frequent_yr_SQL.set_index('Frequency',drop=True, inplace=Tr
df_measurements_tobs_frequent_yr_SQL
```

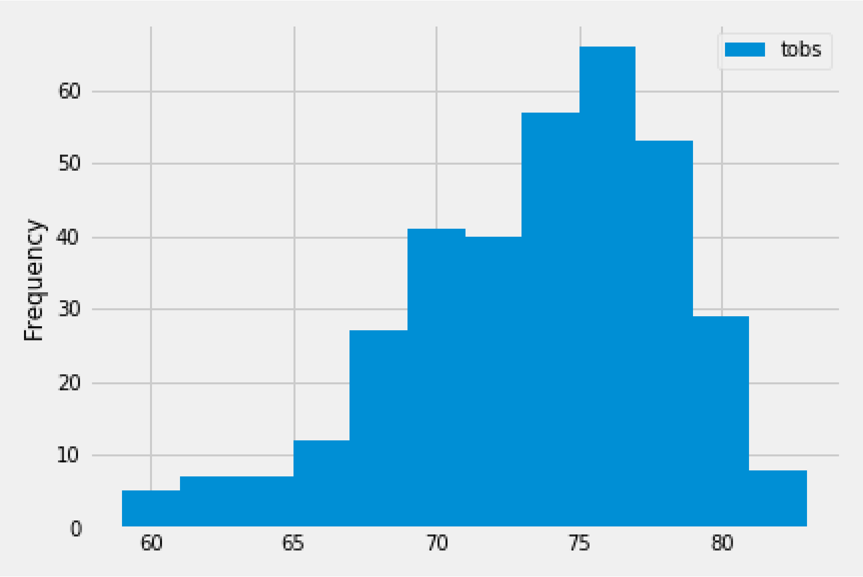
Out[32]:

```
            tobs
Frequency
     59.0      3
     60.0      2
     61.0      1
     62.0      6
     63.0      4
     64.0      3
     65.0      7
     66.0      5
     67.0     15
     68.0     12
     69.0     19
     70.0     22
     71.0     18
     72.0     22
     73.0     18
     74.0     39
     75.0     33
     76.0     33
     77.0     31
     78.0     22
     79.0     18
     80.0     11
     81.0      4
     82.0      3
     83.0      1
```

In [33]:
```
df_measurements_tobs_frequent_yr_SQL.hist(bins=12)
#plt.xlim(55,80)
#plt.ylim(0,65)
```

Out[33]:
```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000002350174FF60>]],
      dtype=object)
```





In [34]:

```
# This function called `calc_temps` will accept start date and end date in the fo
# and return the minimum, average, and maximum temperatures for that range of dat
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(Measurement.tobs),
        filter(Measurement.date >= start_date).filter(Measurement.date <= end_dat

# function usage example
print(calc_temps('2012-02-28', '2012-03-05'))
```

```
[(62.0, 69.57142857142857, 74.0)]
```

In [35]:

```
# Use your previous function `calc_temps` to calculate the tmin, tavg, and tmax
# for your trip using the previous year's data for those same dates.
print(calc_temps('2012-03-05', '2012-03-17'))
```

```
[(61.0, 68.71428571428571, 75.0)]
```

In [36]:

```
# 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)
```

In [37]:

```
# Calculate the total amount of rainfall per weather station for your trip dates
# Sort this in descending order by precipitation amount and list the station, nan
```

## Optional Challenge Assignment

In [38]:

```
# Create a query that will calculate the daily normals
# (i.e. the averages for tmin, tmax, and tavg for all historic data matching a sp

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 tmax

    """

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

daily_normals("01-01")
```

Out[38]:

```
[(62.0, 69.15384615384616, 77.0)]
```

In [39]:

```
# calculate the daily normals for your trip
# push each tuple of calculations into a list called `normals`

# Set the start and end date of the trip

# Use the start and end date to create a range of dates

# 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 each date
```

In [40]:

```
# Load the previous query results into a Pandas DataFrame and add the `trip_dates
```

In [41]:

```
# Plot the daily normals as an area plot with `stacked=False`
```

In [ ]:

In [ ]: