dsa

October 21, 2019

0.1 IOT Data Cleaning and Visualisation

0.1.1 Import required packages

```
In [34]: import pandas as pd
         import numpy as np
         import matplotlib.pyplot as plt
         %matplotlib inline
         import matplotlib.dates as mdates
         import re
         import os
         import datetime
         import seaborn as sn
```

0.1.2 Reading in data obtained from IOT Platform

- Download data as csv files and use load it using pandas
- Download json data through the API
- download the sample air quality data csv file from the session website (session 4). (https://airqo.net/dsa/)

```
In [35]: base_dir ='data'
         airquality_data = pd.read_csv(os.path.join(base_dir,'AQ_15_DSA.csv'), parse_dates = [
```

0.1.3 Data Inspection

```
In [36]: airquality_data.head()

Out[36]:             created_at  entry_id  field1  field2  field3  field4       field5  \
         0 2019-01-29 12:40:18         1   25.48   27.33   28.52   30.42     0.000000
         1 2019-01-29 12:41:34         2   24.87   25.83   31.00   32.65  1000.000000
         2 2019-01-29 12:47:33         3   28.52   31.03   29.80   31.35     0.000000
         3 2019-01-29 12:49:56         4   27.15   28.35   30.80   32.10  1000.000000
         4 2019-01-31 10:40:45         5   17.68   19.68   17.47   19.07     1.333921

                 field6  field7 field8  latitude  longitude  elevation  status
         0     0.000000    4.02    NaN       NaN        NaN        NaN     NaN
         1  1000.000000    3.79    NaN       NaN        NaN        NaN     NaN
         2     0.000000    4.02    NaN       NaN        NaN        NaN     NaN
```

```
        3  1000.000000    3.77    NaN       NaN        NaN        NaN     NaN
        4    34.372246    3.88    NaN       NaN        NaN        NaN     NaN
```

```
In [37]: airquality_data.tail()
```

```
Out[37]:                created_at  entry_id  field1  field2  field3  field4    field5  \
         93829 2019-10-02 14:40:36     93830   29.60   40.52   31.43   36.25  1.333871
         93830 2019-10-02 14:41:59     93831  101.13  116.60  105.43  112.90  1.333883
         93831 2019-10-02 14:43:29     93832  142.78  156.87  155.25  165.80  1.333903
         93832 2019-10-02 14:44:49     93833   35.65   42.58   34.17   39.97  1.333855
         93833 2019-10-02 14:46:11     93834   40.25   52.53   41.60   50.95  1.333859

                   field6  field7                                            field8  \
         93829  34.372238    3.71  1.333871,34.372238,1772.30,0.15,10.00,88.00,0...
         93830  34.372231    3.71  1.333883,34.372231,1774.10,0.05,10.00,84.00,0...
         93831  34.372280    3.70  1.333903,34.372280,1774.90,0.07,10.00,100.00,0...
         93832  34.372295    3.70  1.333855,34.372295,1764.10,0.08,11.00,83.00,0...
         93833  34.372288    3.70  1.333859,34.372288,1760.50,0.03,11.00,83.00,0...

                latitude  longitude  elevation  status
         93829       NaN        NaN        NaN     NaN
         93830       NaN        NaN        NaN     NaN
         93831       NaN        NaN        NaN     NaN
         93832       NaN        NaN        NaN     NaN
         93833       NaN        NaN        NaN     NaN
```

```
In [38]: print('shape of the data')
         print(airquality_data.shape)

         print('number of rows in the dataset')
         print(airquality_data.shape[0])
```

```
shape of the data
(93834, 14)
number of rows in the dataset
93834
```

```
In [39]: print(list(airquality_data.columns.values))
```

```
['created_at', 'entry_id', 'field1', 'field2', 'field3', 'field4', 'field5', 'field6', 'field7
```

```
In [40]: airquality_data.dtypes
```

```
Out[40]: created_at    datetime64[ns]
         entry_id               int64
         field1               float64
         field2               float64
         field3               float64
         field4               float64
         field5               float64
         field6               float64
         field7               float64
         field8                object
         latitude             float64
         longitude            float64
         elevation            float64
         status               float64
         dtype: object
```

```
In [41]: airquality_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 93834 entries, 0 to 93833
Data columns (total 14 columns):
created_at    93834 non-null datetime64[ns]
entry_id      93834 non-null int64
field1        93834 non-null float64
field2        93834 non-null float64
field3        93834 non-null float64
field4        93834 non-null float64
field5        93834 non-null float64
field6        93834 non-null float64
field7        93834 non-null float64
field8        82085 non-null object
latitude      0 non-null float64
longitude     0 non-null float64
elevation     0 non-null float64
status        0 non-null float64
dtypes: datetime64[ns](1), float64(11), int64(1), object(1)
memory usage: 10.0+ MB
```

0.1.4 Rename column names

```
In [42]: airquality_data.rename(columns={'created_at':'TimeStamp','field1':'s1_pm2_5','field2'
                                              'field3':'s2_pm2_5', 'field4':'s2_pm10',
                                              'field5': 'Latitude', 'field6':'Longitude', 'fie
```

0.1.5 Drop the columns that we won't be using

```
In [43]: airquality_data_of_interest = airquality_data.drop(['entry_id','Battery Voltage','lat
                                                              'status','GpsData',], axis=1)
```

0.1.6 Show the summaries i.e mean, median, quaurtiles, count

```
In [44]: airquality_data_of_interest.describe()
```

```
Out[44]:           s1_pm2_5       s1_pm10      s2_pm2_5      s2_pm10      Latitude  \
         count  93834.000000  93834.000000  93834.000000  93834.00000  93834.000000
         mean      21.664234     27.359923     23.249641     26.12310    597.178577
         std       15.953107     20.357442     16.550017     19.46318    489.928987
         min        0.000000      0.000000      0.000000      0.00000      0.000000
         25%       12.220000     14.930000     13.170000     14.28000      1.333874
         50%       18.280000     22.830000     19.950000     21.53000   1000.000000
         75%       27.400000     34.580000     29.570000     32.50000   1000.000000
         max      891.520000   1490.320000    725.800000   1082.08000   1000.000000

                   Longitude
         count  93834.000000
         mean     610.290555
         std      473.989563
         min        0.000000
         25%       34.372250
         50%     1000.000000
         75%     1000.000000
         max     1000.000000
```

```
In [45]: airquality_data_of_interest.head()
```

```
Out[45]:            TimeStamp  s1_pm2_5  s1_pm10  s2_pm2_5  s2_pm10     Latitude  \
         0 2019-01-29 12:40:18     25.48    27.33     28.52    30.42     0.000000
         1 2019-01-29 12:41:34     24.87    25.83     31.00    32.65  1000.000000
         2 2019-01-29 12:47:33     28.52    31.03     29.80    31.35     0.000000
         3 2019-01-29 12:49:56     27.15    28.35     30.80    32.10  1000.000000
         4 2019-01-31 10:40:45     17.68    19.68     17.47    19.07     1.333921

              Longitude
         0     0.000000
         1  1000.000000
         2     0.000000
         3  1000.000000
         4    34.372246
```

0.1.7 Parsing the created_at field into a datetime object

This is important for indexing using datetime
localise timezone
In case of any duplicate timestamp, keep one of the duplicated records

```
In [46]: airquality_data_of_interest['TimeStamp'].dt.tz_localize('Africa/Kampala')
         airquality_data_of_interest = airquality_data_of_interest.drop_duplicates(subset='Time
         time_indexed_data = airquality_data_of_interest.set_index('TimeStamp')
         time_indexed_data.head()
```

```
Out[46]:                      s1_pm2_5  s1_pm10  s2_pm2_5  s2_pm10     Latitude  \
         TimeStamp
```

```
2019-01-29 12:40:18     25.48    27.33     28.52    30.42     0.000000
2019-01-29 12:41:34     24.87    25.83     31.00    32.65  1000.000000
2019-01-29 12:47:33     28.52    31.03     29.80    31.35     0.000000
2019-01-29 12:49:56     27.15    28.35     30.80    32.10  1000.000000
2019-01-31 10:40:45     17.68    19.68     17.47    19.07     1.333921

                       Longitude
TimeStamp
2019-01-29 12:40:18     0.000000
2019-01-29 12:41:34  1000.000000
2019-01-29 12:47:33     0.000000
2019-01-29 12:49:56  1000.000000
2019-01-31 10:40:45    34.372246
```

0.1.8 Get average values for both sensors

0.1.9 Deal with outliers

```
In [47]: # Finding out how many latitude or longitude entries have 0 or 1000
         bad_lat = []
         bad_long = []

         for lat in time_indexed_data['Latitude']:
             if ((lat==0) or (lat==1000)):
                 bad_lat.append(lat)
         print ('Bad latitudes are ', len(bad_lat))
         for long in time_indexed_data['Longitude']:
             if ((long==0) or (long==1000)):
                 bad_long.append(long)
         print ('Bad longitudes are ', len(bad_long))
```

```
Bad latitudes are  56594
Bad longitudes are  56594
```

```
In [48]: #Replacing latitude and longitude values of 0 and 1000 with Null
         time_indexed_data['Latitude'] = time_indexed_data['Latitude'].replace([0,1000], np.na
         time_indexed_data['Longitude'] =time_indexed_data['Longitude'].replace([0,1000], np.na
         time_indexed_data.head(5)
```

```
Out[48]:                      s1_pm2_5  s1_pm10  s2_pm2_5  s2_pm10  Latitude  Longitude
         TimeStamp
         2019-01-29 12:40:18     25.48    27.33     28.52    30.42       NaN        NaN
         2019-01-29 12:41:34     24.87    25.83     31.00    32.65       NaN        NaN
         2019-01-29 12:47:33     28.52    31.03     29.80    31.35       NaN        NaN
         2019-01-29 12:49:56     27.15    28.35     30.80    32.10       NaN        NaN
         2019-01-31 10:40:45     17.68    19.68     17.47    19.07  1.333921  34.372246
```

0.1.10 Show null values in each column

```
In [49]: time_indexed_data.isnull().sum()
```

```
Out[49]: s1_pm2_5         0
         s1_pm10          0
         s2_pm2_5         0
         s2_pm10          0
         Latitude     56594
         Longitude    56594
         dtype: int64
```

```
In [50]: time_indexed_data['Latitude'] = time_indexed_data['Latitude'].fillna(method = 'bfill'
         time_indexed_data['Longitude'] = time_indexed_data['Longitude'].fillna(method = 'bfil
         time_indexed_data.isnull().sum()
```

```
Out[50]: s1_pm2_5     0
         s1_pm10      0
         s2_pm2_5     0
         s2_pm10      0
         Latitude     0
         Longitude    0
         dtype: int64
```

```
In [51]: #Replacing values outside acceptable range with the other sensor's data

         time_indexed_data['s1_pm2_5'] = np.where(((time_indexed_data['s1_pm2_5']<=0) | (time_
                                                  time_indexed_data['s2_pm2_5'], time_indexed_da

         time_indexed_data['s2_pm2_5'] = np.where(((time_indexed_data['s2_pm2_5']<=0) | (time_
                                                  time_indexed_data['s1_pm2_5'], time_indexed_da
```

```
In [52]: #Dropping pm2.5 greater than 500.4 or less than or equal to 0 for both sensors
         outlier_indices = time_indexed_data[((time_indexed_data['s1_pm2_5'] > 500.4) & (time_
                                             ((time_indexed_data['s1_pm2_5'] <= 0) & (time_inde
         print(len(outlier_indices))
         time_indexed_data.drop(outlier_indices, inplace = True)
         time_indexed_data.info()
```

```
4
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 93830 entries, 2019-01-29 12:40:18 to 2019-10-02 14:46:11
Data columns (total 6 columns):
s1_pm2_5     93830 non-null float64
s1_pm10      93830 non-null float64
s2_pm2_5     93830 non-null float64
s2_pm10      93830 non-null float64
Latitude     93830 non-null float64
```

```
Longitude    93830 non-null float64
dtypes: float64(6)
memory usage: 5.0 MB
```

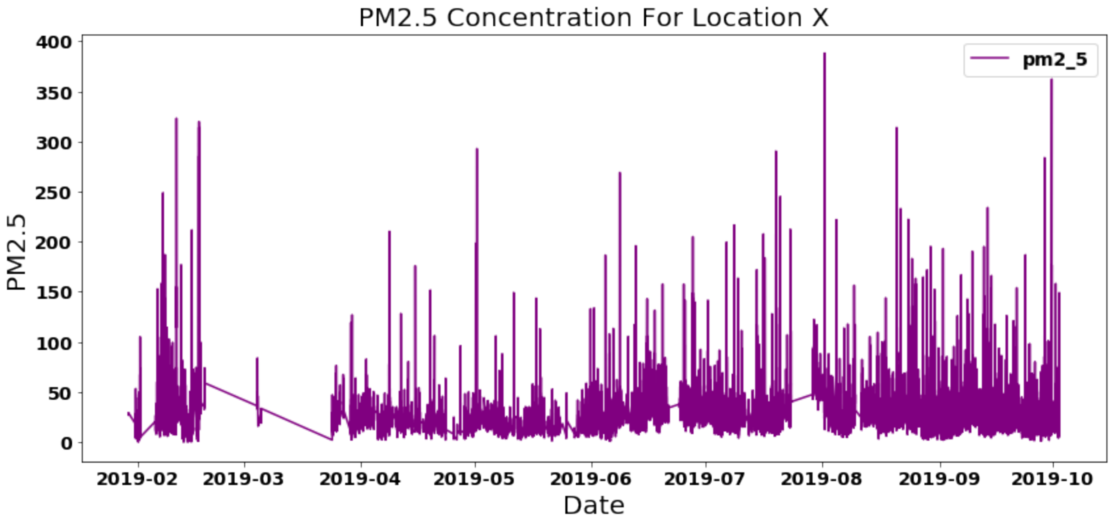
```
In [53]: time_indexed_data.head()
```

```
Out[53]:                      s1_pm2_5  s1_pm10  s2_pm2_5  s2_pm10  Latitude  Longitude
         TimeStamp
         2019-01-29 12:40:18     25.48    27.33     28.52    30.42  1.333921  34.372246
         2019-01-29 12:41:34     24.87    25.83     31.00    32.65  1.333921  34.372246
         2019-01-29 12:47:33     28.52    31.03     29.80    31.35  1.333921  34.372246
         2019-01-29 12:49:56     27.15    28.35     30.80    32.10  1.333921  34.372246
         2019-01-31 10:40:45     17.68    19.68     17.47    19.07  1.333921  34.372246
```

```
In [54]: ## obtaining the averages of sensor one and sensor two readings
         time_indexed_data['pm2_5'] =time_indexed_data[['s1_pm2_5', 's2_pm2_5']].mean(axis=1)
         time_indexed_data['pm10'] =time_indexed_data[['s1_pm10', 's2_pm10']].mean(axis=1)
```

0.1.11 Data Visualisation

```
In [55]:     fig = plt.figure(figsize=(14,6))
             plt.rcParams.update({'font.size':14, 'font.weight':'bold'})
             plt.plot(time_indexed_data.index,
                      time_indexed_data['pm2_5'], color='purple', linestyle='solid')

             chart_title =  'PM2.5 Concentration For Location X'
             plt.title(chart_title,fontsize=20)
             plt.ylabel('PM2.5', fontsize=20)
             plt.xlabel('Date', fontsize=20)
             plt.xticks(rotation=0)
             plt.legend()
             plt.show()
             plt.tight_layout()
             fig.savefig(os.path.join(base_dir,'pm25_concentration_for_location_x.png'))
```



```
<Figure size 432x288 with 0 Axes>
```

0.1.12 Compute average, minimum and maximum hourly, daily, monthly concentration values

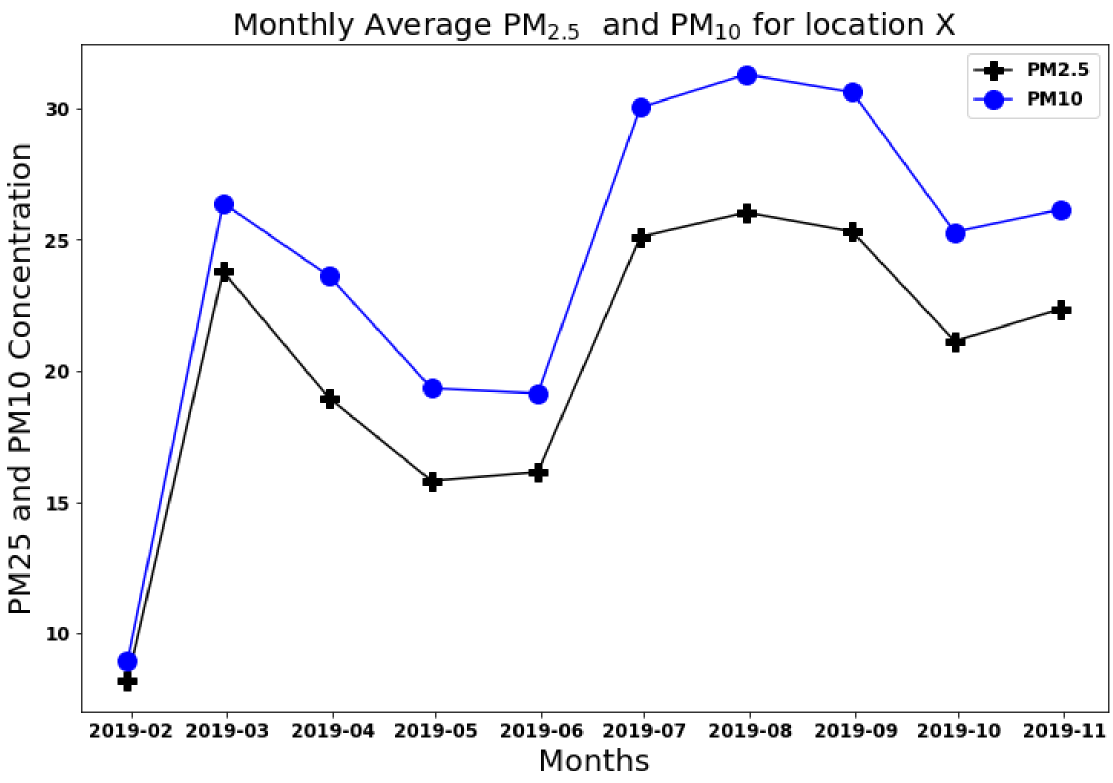
- calculate the corresponding averages for hourly, daily and monthly observations

```
In [56]: hourly_average_airquality_data_concentrations = time_indexed_data.resample('H').mean(
         hourly_maximum_airquality_data_concentrations  = time_indexed_data.resample('H').max(
         hourly_minimum_airquality_data_concentrations  = time_indexed_data.resample('H').min(

         daily_average_airquality_data_concentrations  = time_indexed_data.resample('D').mean(
         daily_maximum_airquality_data_concentrations  = time_indexed_data.resample('D').max()
         daily_minimum_airquality_data_concentrations  = time_indexed_data.resample('D').min()

         monthly_average_airquality_data_concentrations  = time_indexed_data.resample('M').mea
         monthly_maximum_airquality_data_concentrations  = time_indexed_data.resample('M').max
         monthly_minimum_airquality_data_concentrations  = time_indexed_data.resample('M').min

         hourly_average_airquality_data_concentrations.head()
```

```
Out[56]:                      s1_pm2_5  s1_pm10  s2_pm2_5  s2_pm10  Latitude  \
         TimeStamp
         2019-01-29 12:00:00     26.51    28.14     30.03    31.63      1.33
         2019-01-31 10:00:00     18.47    21.23     18.91    21.35      1.33
         2019-01-31 11:00:00      7.02     7.95      8.14     8.74      1.33
         2019-01-31 12:00:00      9.70    10.25     11.01    11.47      1.33
         2019-01-31 13:00:00      7.81     8.56      8.65     9.14      1.33

                              Longitude  pm2_5   pm10
```

```
TimeStamp
2019-01-29 12:00:00      34.37  28.27  29.88
2019-01-31 10:00:00      34.37  18.69  21.29
2019-01-31 11:00:00      34.37   7.58   8.34
2019-01-31 12:00:00      34.37  10.35  10.86
2019-01-31 13:00:00      34.37   8.23   8.85
```

```
In [57]:    plt.rcParams.update({'font.size':14, 'font.weight':'bold','mathtext.default':  're
            x_axis_label = 'Months'
            y_axis_label =  'PM25 and PM10 Concentration'
            chart_title  =  'Monthly Average $PM_{2.5}$  and $PM_{10}$ for location X'
            file_path_no_aqi_color   =   os.path.join(base_dir , 'average_pm25_foreach_month_


            fig = plt.figure(figsize=(12,8))
            plt.rcParams.update({'font.size':12, 'font.weight':'bold', 'mathtext.default':  '
            ax = fig.add_subplot(111)

            plt.plot(monthly_average_airquality_data_concentrations.index,
                     monthly_average_airquality_data_concentrations['pm2_5'].values,
                     color='black', marker='P', linestyle='solid',  label='PM2.5', linewidth=

            plt.plot(monthly_average_airquality_data_concentrations.index,
                     monthly_average_airquality_data_concentrations['pm10'].values,
                     color='blue', marker='o', linestyle='solid',  label='PM10', linewidth=1.


            plt.title(chart_title, fontsize=20)
            plt.ylabel(y_axis_label, fontsize=20)
            plt.xlabel(x_axis_label,fontsize=20)

            plt.legend(loc='upper right')
            plt.show()
            fig.savefig(file_path_no_aqi_color)
```

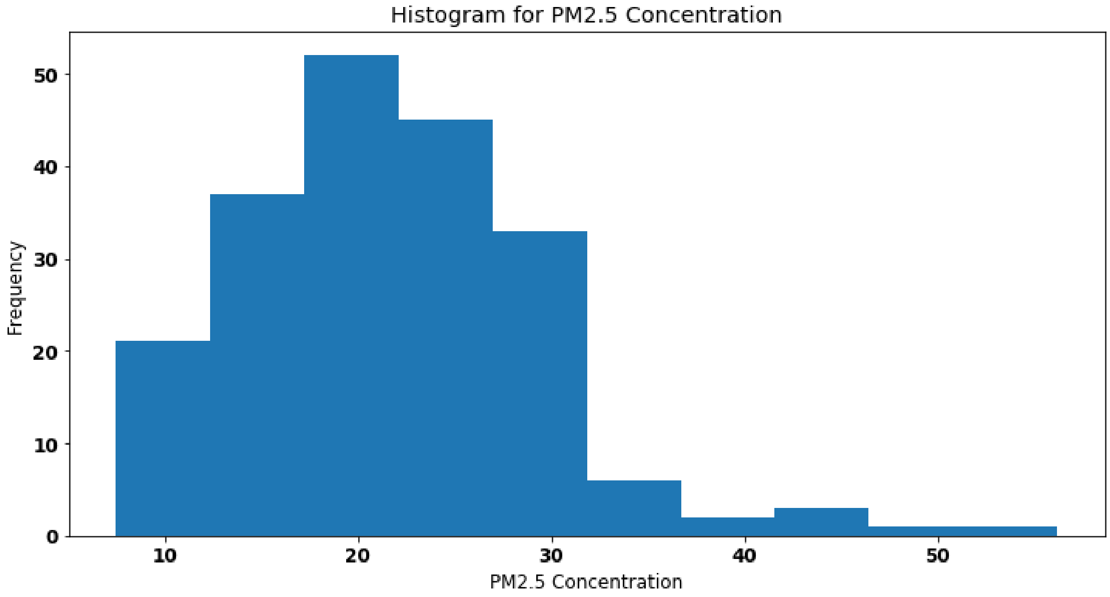


0.1.13 Daily Summaries

```
In [58]: print(daily_average_airquality_data_concentrations.shape) #shape of dataframe
         print(daily_average_airquality_data_concentrations.max()) #max values in dataframe
```

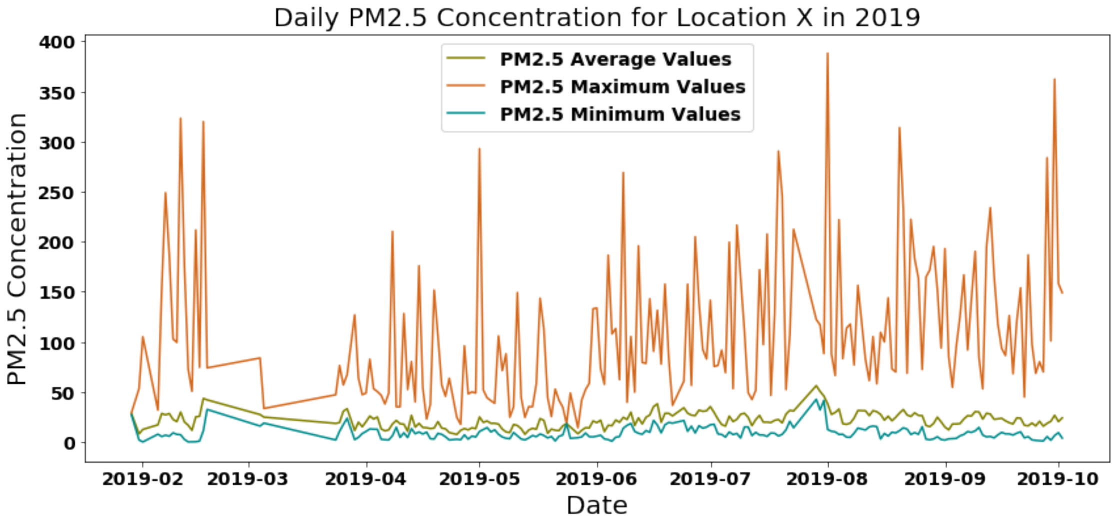
```
(201, 8)
s1_pm2_5     55.21
s1_pm10      69.79
s2_pm2_5     57.14
s2_pm10      67.31
Latitude      1.33
Longitude    34.37
pm2_5        56.18
pm10         68.55
dtype: float64
```

```
In [59]: plt.rc('figure', figsize=(12,6))
         plt.hist(daily_average_airquality_data_concentrations['pm2_5'], 10)
         plt.ylabel('Frequency')
         plt.xlabel('PM2.5 Concentration')
         plt.title('Histogram for PM2.5 Concentration')
         plt.show()
```



In [60]:

```
fig = plt.figure(figsize=(14,6))

plt.rcParams.update({'font.size':14, 'font.weight':'bold'})

plt.plot(daily_average_airquality_data_concentrations.index,
         daily_average_airquality_data_concentrations['pm2_5'],
         color='olive',  linestyle='solid', label='PM2.5 Average Values')

plt.plot(daily_maximum_airquality_data_concentrations.index,
         daily_maximum_airquality_data_concentrations['pm2_5'],
         color='chocolate',  linestyle='solid', label='PM2.5 Maximum Values')

plt.plot(daily_minimum_airquality_data_concentrations.index,
         daily_minimum_airquality_data_concentrations['pm2_5'],
         color='darkcyan', linestyle='solid', label='PM2.5 Minimum Values')

chart_title =  'Daily PM2.5 Concentration for Location X in 2019'
plt.title(chart_title,fontsize=20)
plt.ylabel('PM2.5 Concentration', fontsize=20)
plt.xlabel('Date', fontsize=20)
plt.xticks(rotation=0)
plt.legend()
plt.show()
fig.savefig(os.path.join(base_dir,'daily_pm25_concentration_location_x_2019.png'))
```



```
In [61]: ind = np.arange(len(monthly_average_airquality_data_concentrations))
         width = 0.36
         #0.525
         fig = plt.figure(figsize=(13,4))
         ax = fig.add_subplot(111)
         rects1 = ax.bar(ind- width/2, monthly_minimum_airquality_data_concentrations['pm2_5']
         rects3 = ax.bar(ind + width, monthly_average_airquality_data_concentrations['pm2_5'],
         rects2 = ax.bar(ind+ width/4,  monthly_maximum_airquality_data_concentrations['pm2_5'

         ax.set_ylabel('PM2.5 Concentration',fontsize=16)
         ax.set_title(' Monthly PM2.5 Concentration For 2019', fontsize=16)
         ax.set_xlabel('Date', fontsize=16)
         ax.set_xticks(ind)
         x_tick_labels = pd.to_datetime(monthly_average_airquality_data_concentrations.index)
         final_labels= []
         for x in x_tick_labels:
             final_labels.append(x.strftime('%b'))
         ax.set_xticklabels(final_labels, fontsize=14)
         ax.legend()


         plt.show()
         fig.savefig( 'monthly_pm25_concentration_bargraph.png')
```