```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split


df = pd.read_csv('dataset.csv');
df
```

	Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
0	1872	13.0	8.9	294.4	735.3	879.1	2632.7	3277.9	1359.9	2577.8	348.5	9.4	0.0
1	1873	5.3	105.2	290.8	455.7	339.3	2256.0	1804.4	1338.8	551.9	24.6	0.0	16.0
2	1874	27.2	118.4	278.6	719.6	2449.3	1632.5	2923.5	1152.1	1218.2	204.0	9.4	0.0
3	1875	70.4	20.1	176.3	1380.5	578.6	3407.7	2237.5	2128.5	365.8	12.7	0.0	0.0
4	1876	0.0	41.4	446.3	810.5	1368.0	4693.9	2016.0	1651.5	493.5	400.3	0.0	0.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...
132	2004	4.0	13.0	1234.0	1365.0	1678.0	4775.0	498.0	947.0	1917.0	28.0	NaN	NaN
133	2005	6.0	27.0	524.0	560.0	625.0	2205.0	2343.0	2262.0	314.0	490.0	0.0	0.0
134	2006	0.0	75.0	908.0	2120.0	2310.0	1341.0	699.0	986.0	21.0	27.0	7.0	NaN
135	2007	1.0	131.0	22.0	800.0	1081.0	2601.0	4133.0	974.0	1958.0	728.0	0.0	NaN
136	2008	48.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

137 rows × 13 columns

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
import math
import statsmodels.api as sm
import statsmodels.tsa.api as smt
import statsmodels.formula.api as smf
from statsmodels.tsa.stattools import adfuller
from sklearn.metrics import mean_squared_error

%matplotlib inline

import itertools
import warnings
warnings.filterwarnings('ignore')


df['Jan'].fillna((df['Jan'].mean()), inplace=True)
df['Feb'].fillna((df['Feb'].mean()), inplace=True)
df['March'].fillna((df['March'].mean()), inplace=True)
df['April'].fillna((df['April'].mean()), inplace=True)
df['May'].fillna((df['May'].mean()), inplace=True)
df['June'].fillna((df['June'].mean()), inplace=True)
df['July'].fillna((df['July'].mean()), inplace=True)
df['Aug'].fillna((df['Aug'].mean()), inplace=True)
df['Sep'].fillna((df['Sep'].mean()), inplace=True)
df['Oct'].fillna((df['Oct'].mean()), inplace=True)
df['Nov'].fillna((df['Nov'].mean()), inplace=True)
df['Dec'].fillna((df['Dec'].mean()), inplace=True)
```

Double-click (or enter) to edit

```
import six


def render_mpl_table(data, col_width=3.0, row_height=0.625, font_size=14,
                     header_color='#0000ff', row_colors=['#f1f1f2', 'w'], edge_color='w',
                     bbox=[0, 0, 1, 1], header_columns=0,
                     ax=None, **kwargs):
    if ax is None:
        size = (np.array(data.shape[::-1]) + np.array([0, 1])) * np.array([col_width, row_height])
        fig, ax = plt.subplots(figsize=size)
        ax.axis('off')

    mpl_table = ax.table(cellText=data.values, bbox=bbox, colLabels=data.columns, **kwargs)
```

```
    mpl_table.auto_set_font_size(False)
    mpl_table.set_fontsize(font_size)

    for k, cell in  six.iteritems(mpl_table._cells):
        cell.set_edgecolor(edge_color)
        if k[0] == 0 or k[1] < header_columns:
            cell.set_text_props(weight='bold', color='w')
            cell.set_facecolor(header_color)
        else:
            cell.set_facecolor(row_colors[k[0]%len(row_colors) ])
    return ax

render_mpl_table(df.head(10).round(3), header_columns=0, col_width=2.0)
```

<Axes: >

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1872.0	13.0	8.9	294.4	735.3	879.1	2632.7	3277.9	1359.9	2577.8	348.5	9.4	0.0
1873.0	5.3	105.2	290.8	455.7	339.3	2256.0	1804.4	1338.8	551.9	24.6	0.0	16.0
1874.0	27.2	118.4	278.6	719.6	2449.3	1632.5	2923.5	1152.1	1218.2	204.0	9.4	0.0
1875.0	70.4	20.1	176.3	1380.5	578.6	3407.7	2237.5	2128.5	365.8	12.7	0.0	0.0
1876.0	0.0	41.4	446.3	810.5	1368.0	4693.9	2016.0	1651.5	493.5	400.3	0.0	0.0
1877.0	29.5	29.0	281.9	298.7	893.8	1158.0	2821.2	998.2	3049.3	123.7	2.5	27.2
1878.0	52.1	96.0	255.8	514.1	483.4	3454.7	3855.0	3012.7	1947.7	211.6	136.4	0.0
1879.0	0.0	19.8	9.7	275.8	2151.1	3423.9	2715.0	2290.1	1149.1	293.9	0.0	44.5
1880.0	51.6	115.6	1277.6	1424.4	626.9	3091.9	2419.9	3046.0	630.4	206.2	3.6	17.3
1881.0	0.0	14.5	159.8	695.2	1275.1	2815.1	1682.8	1994.7	1804.4	80.3	34.3	0.5

```
df.set_index('Year', inplace=True)
df.head()
```

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1872	13.0	8.9	294.4	735.3	879.1	2632.7	3277.9	1359.9	2577.8	348.5	9.4	0.0
1873	5.3	105.2	290.8	455.7	339.3	2256.0	1804.4	1338.8	551.9	24.6	0.0	16.0
1874	27.2	118.4	278.6	719.6	2449.3	1632.5	2923.5	1152.1	1218.2	204.0	9.4	0.0
1875	70.4	20.1	176.3	1380.5	578.6	3407.7	2237.5	2128.5	365.8	12.7	0.0	0.0
1876	0.0	41.4	446.3	810.5	1368.0	4693.9	2016.0	1651.5	493.5	400.3	0.0	0.0

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
df=df.transpose()
df
```

Year	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	...	1999	2000	2001	2002
Jan	13.0	5.3	27.2	70.4	0.0	29.5	52.1	0.0	51.6	0.0	...	0.0	28.000000	27.000000	40.000000
Feb	8.9	105.2	118.4	20.1	41.4	29.0	96.0	19.8	115.6	14.5	...	0.0	1314.000000	2021.000000	1.000000
March	294.4	290.8	278.6	176.3	446.3	281.9	255.8	9.7	1277.6	159.8	...	44.0	1762.000000	2519.000000	316.000000
April	735.3	455.7	719.6	1380.5	810.5	298.7	514.1	275.8	1424.4	695.2	...	125.0	327.000000	1097.000000	3843.000000
May	879.1	339.3	2449.3	578.6	1368.0	893.8	483.4	2151.1	626.9	1275.1	...	1221.0	1638.000000	542.000000	3100.000000
June	2632.7	2256.0	1632.5	3407.7	4693.9	1158.0	3454.7	3423.9	3091.9	2815.1	...	1355.0	2731.000000	27.000000	1291.000000
July	3277.9	1804.4	2923.5	2237.5	2016.0	2821.2	3855.0	2715.0	2419.9	1682.8	...	2832.0	1040.000000	0.000000	947.000000
Aug	1359.9	1338.8	1152.1	2128.5	1651.5	998.2	3012.7	2290.1	3046.0	1994.7	...	1427.0	275.000000	1673.929032	69.000000
Sep	2577.8	551.9	1218.2	365.8	493.5	3049.3	1947.7	1149.1	630.4	1804.4	...	402.0	1059.699180	1059.699180	1.000000
Oct	348.5	24.6	204.0	12.7	400.3	123.7	211.6	293.9	206.2	80.3	...	627.0	400.368333	400.368333	400.368333
Nov	9.4	0.0	9.4	0.0	0.0	2.5	136.4	0.0	3.6	34.3	...	1.0	48.150427	48.150427	48.150427
Dec	0.0	16.0	0.0	0.0	0.0	27.2	0.0	44.5	17.3	0.5	...	3.0	12.470476	12.470476	12.470476

12 rows × 137 columns

```
render_mpl_table(df.iloc[:,0:12].head(10).round(3), header_columns=0, col_width=2.0)
```

<Axes: >

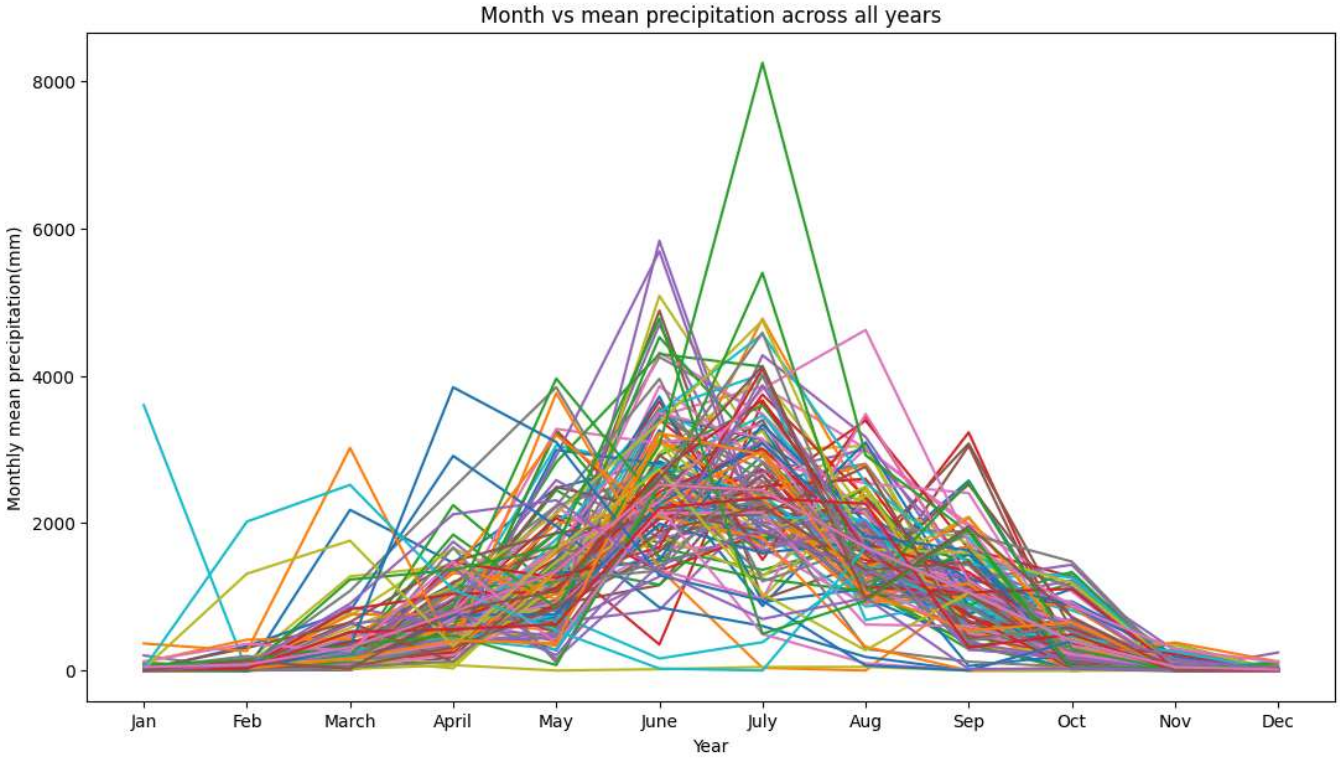
1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883
13.0	5.3	27.2	70.4	0.0	29.5	52.1	0.0	51.6	0.0	0.3	32.5
8.9	105.2	118.4	20.1	41.4	29.0	96.0	19.8	115.6	14.5	117.6	0.0
294.4	290.8	278.6	176.3	446.3	281.9	255.8	9.7	1277.6	159.8	396.0	112.5
735.3	455.7	719.6	1380.5	810.5	298.7	514.1	275.8	1424.4	695.2	574.0	365.5
879.1	339.3	2449.3	578.6	1368.0	893.8	483.4	2151.1	626.9	1275.1	952.8	1709.9
2632.7	2256.0	1632.5	3407.7	4693.9	1158.0	3454.7	3423.9	3091.9	2815.1	2654.0	2155.2
3277.9	1804.4	2923.5	2237.5	2016.0	2821.2	3855.0	2715.0	2419.9	1682.8	876.0	1714.2
1359.9	1338.8	1152.1	2128.5	1651.5	998.2	3012.7	2290.1	3046.0	1994.7	2347.5	1676.1
2577.8	551.9	1218.2	365.8	493.5	3049.3	1947.7	1149.1	630.4	1804.4	1140.7	1429.8
348.5	24.6	204.0	12.7	400.3	123.7	211.6	293.9	206.2	80.3	860.3	160.5

```
dates = pd.date_range(start='1872-01', freq='MS', periods=len(df.columns)*12)
len(dates)
```

1644

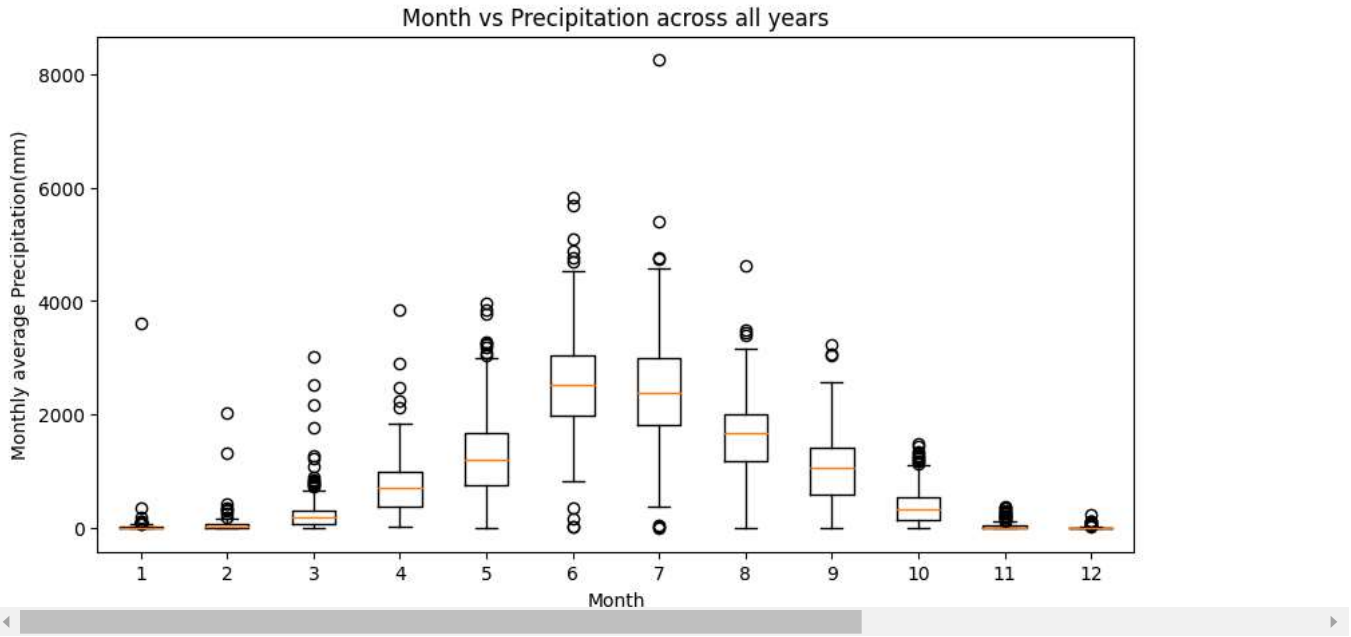
```
plt.figure(figsize=(13,7))
plt.plot(df)
plt.xlabel('Year')
plt.ylabel('Monthly mean precipitation(mm)')
plt.title('Month vs mean precipitation across all years')
```

```
Text(0.5, 1.0, 'Month vs mean precipitation across all years')
```




```
plt.figure(figsize=(10,5))
plt.boxplot(df.transpose())
plt.xlabel('Month')
plt.ylabel('Monthly average Precipitation(mm)')
plt.title('Month vs Precipitation across all years')
```

```
Text(0.5, 1.0, 'Month vs Precipitation across all years')
```




```
average_rainfall_year = pd.DataFrame({'average_rainfall_year': df.mean(axis=0)})
average_rainfall_year = average_rainfall_year.transpose()
average_rainfall_year.head()
```

Year	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	...	1999	
average_rainfall_year	1011.408333	599.0	894.4	864.841667	993.45	809.416667	1168.291667	1031.075	1075.95	879.725	...	669.75	886.3

1 rows × 137 columns

```
rainfall_data_matrix_np = df.transpose().values
```

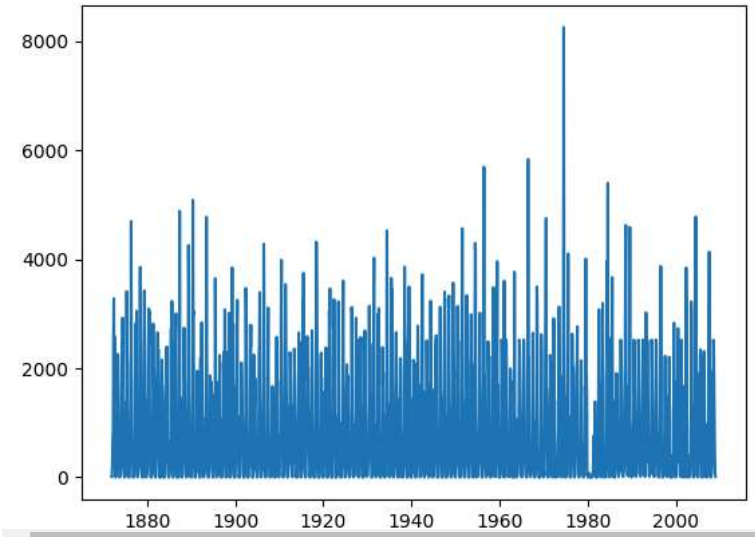
```
shape = rainfall_data_matrix_np.shape
rainfall_data_matrix_np = rainfall_data_matrix_np.reshape((shape[0] * shape[1], 1))


rainfall_data = pd.DataFrame({'Precipitation': rainfall_data_matrix_np[:,0]})
rainfall_data.set_index(dates, inplace=True)
rainfall_data.index.name = 'Month'
rainfall_data.head()
```

Month	Precipitation
1872-01-01	13.0
1872-02-01	8.9
1872-03-01	294.4
1872-04-01	735.3
1872-05-01	879.1

Next steps: Generate code with rainfall_data | View recommended plots | New interactive sheet

```
plt.plot(rainfall_data)
```

```
[<matplotlib.lines.Line2D at 0x79cd75180b80>]
```




```
len(rainfall_data)
```

```
1644
```

```
train=rainfall_data.iloc[:1632]
test=rainfall_data.iloc[1632:]


from sklearn.preprocessing import MinMaxScaler
scalar=MinMaxScaler()


rainfall_data.head(),rainfall_data.tail()
```

```
(            Precipitation
Month
1872-01-01           13.0
1872-02-01            8.9
1872-03-01          294.4
1872-04-01          735.3
1872-05-01          879.1,
             Precipitation
Month
2008-08-01    1673.929032
2008-09-01    1059.699180
2008-10-01     400.368333
2008-11-01      48.150427
2008-12-01      12.470476)
```

```
scalar.fit(train)
scaled_train = scalar.transform(train)
scaled_test = scalar.transform(test)
```

```
scaled_train[:10]
```

```
array([[0.00157637],
       [0.00107921],
       [0.0356987 ],
       [0.08916186],
       [0.10659892],
       [0.31923898],
       [0.39747538],
       [0.16490032],
       [0.31258185],
       [0.04225882]])
```

```
from tensorflow.keras.preprocessing.sequence import TimeseriesGenerator


n_input = 12
generator = TimeseriesGenerator(scaled_train, scaled_train, length=n_input, batch_size=1)


from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, LSTM


n_features = 1
model = Sequential()
model.add(LSTM(100, activation='relu', input_shape=(n_input, n_features)))
model.add(Dense(1))
model.compile(optimizer='adam', loss='mse')


model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
lstm (LSTM)	(None, 100)	40,800
dense (Dense)	(None, 1)	101

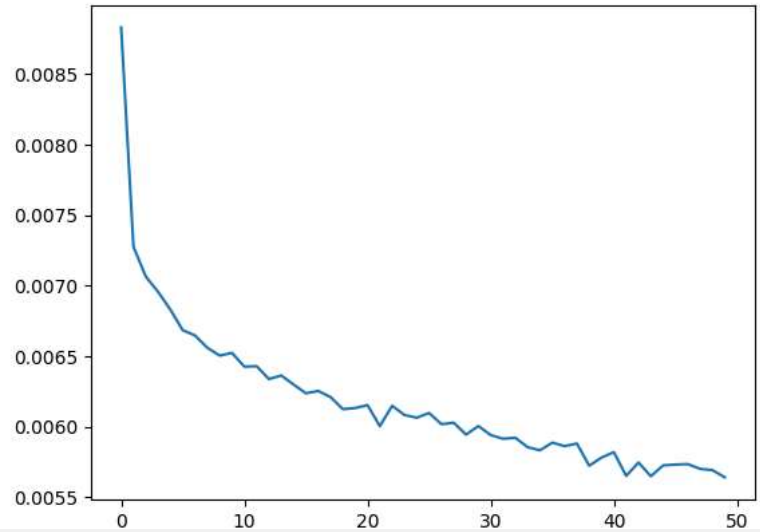
Total params: 40,901 (159.77 KB)
Trainable params: 40,901 (159.77 KB)

```
model.fit(generator,epochs=50)
```

```
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 19s 11ms/step - loss: 0.0060
Epoch 43/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 17s 10ms/step - loss: 0.0059
Epoch 44/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 21s 10ms/step - loss: 0.0058
Epoch 45/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 18s 11ms/step - loss: 0.0050
Epoch 46/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 19s 10ms/step - loss: 0.0053
Epoch 47/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 17s 10ms/step - loss: 0.0056
Epoch 48/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 22s 11ms/step - loss: 0.0054
Epoch 49/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 17s 10ms/step - loss: 0.0058
Epoch 50/50
1620/1620 ━━━━━━━━━━━━━━━━━━━━ 17s 10ms/step - loss: 0.0048
<keras.src.callbacks.history.History at 0x79cd153d88e0>
```

```
loss_per_epoch = model.history.history['loss']
plt.plot(range(len(loss_per_epoch)),loss_per_epoch)
```

```
[<matplotlib.lines.Line2D at 0x79cd0c440280>]
```




```
last_train_batch = scaled_train[-12:]
```

```
last_train_batch = last_train_batch.reshape((1, n_input, n_features))
```

```
model.predict(last_train_batch)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 691ms/step
array([[0.01774772]], dtype=float32)
```

```
scaled_test[0]
```

```
array([0.00582044])
```

```
test_predictions = []

first_eval_batch = scaled_train[-n_input:]
current_batch = first_eval_batch.reshape((1, n_input, n_features))

for i in range(len(test)):
    current_pred = model.predict(current_batch)[0]
    test_predictions.append(current_pred)
    current_batch = np.append(current_batch[:,1:,:],[[current_pred]],axis=1)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 40ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 36ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 41ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 29ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 24ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 24ms/step
```

```
test_predictions
```

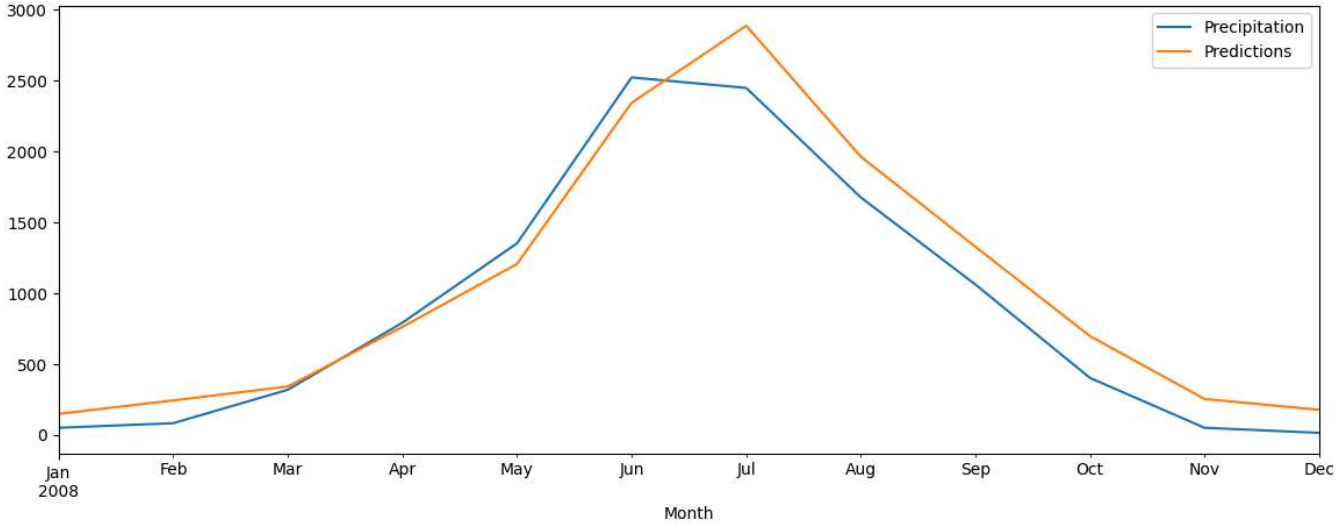
```
[array([0.01774772], dtype=float32),
 array([0.02922243], dtype=float32),
 array([0.04115302], dtype=float32),
 array([0.09217337], dtype=float32),
 array([0.14603642], dtype=float32),
 array([0.28390035], dtype=float32),
 array([0.34986514], dtype=float32),
 array([0.23789892], dtype=float32),
 array([0.16079293], dtype=float32),
 array([0.08431326], dtype=float32),
 array([0.03047311], dtype=float32),
 array([0.02122235], dtype=float32)]
```

```
true_predictions = scalar.inverse_transform(test_predictions)
```

```
test['Predictions'] = true_predictions
```

```
test.plot(figsize=(14,5))
```

```
<Axes: xlabel='Month'>
```




```
from sklearn.metrics import mean_squared_error
from math import sqrt
rmse=sqrt(mean_squared_error(test['Precipitation'],test['Predictions']))
print(rmse)
```

```
221.95117061002873
```

```
Start coding or generate with AI.
```