timeserieslab10-rohramehak-251524

May 14, 2024

[1]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[2]:
```
import pandas as pd
from matplotlib import pyplot as plt
import numpy as np
from statsmodels.tsa.statespace.sarimax import SARIMAX
from sklearn.metrics import mean_absolute_percentage_error
from sklearn.model_selection import train_test_split
from sklearn.model_selection import ParameterGrid
from sklearn.ensemble import RandomForestRegressor
import warnings
from statsmodels.tools.sm_exceptions import ConvergenceWarning
warnings.simplefilter('ignore', ConvergenceWarning)
```

[3]:
```
data = pd.read_csv('/content/drive/MyDrive/TSA_BDA_2024/Lab9/
 ↪monthly_in_situ_co2_mlo.csv', skiprows=61)
```

[4]:
```
data
```

[4]:
```
         Yr    Mn      Date         Date       CO2  seasonally          fit  \
0                                                     adjusted
1                     Excel                   [ppm]      [ppm]        [ppm]
2      1958    01     21200    1958.0411    -99.99      -99.99       -99.99
3      1958    02     21231    1958.1260    -99.99      -99.99       -99.99
4      1958    03     21259    1958.2027    315.71      314.44       316.20
..      …   …          …          …      …          …           …
801    2024    08     45519    2024.6230    -99.99      -99.99       -99.99
802    2024    09     45550    2024.7077    -99.99      -99.99       -99.99
803    2024    10     45580    2024.7896    -99.99      -99.99       -99.99
804    2024    11     45611    2024.8743    -99.99      -99.99       -99.99
805    2024    12     45641    2024.9563    -99.99      -99.99       -99.99

         seasonally          CO2       seasonally    Sta
0      adjusted fit       filled  adjusted filled    NaN
1             [ppm]        [ppm]            [ppm]    NaN
```

```
2          -99.99        -99.99            -99.99   MLO
3          -99.99        -99.99            -99.99   MLO
4          314.91        315.71            314.44   MLO
..            …             …             …    …
801        -99.99        -99.99            -99.99   MLO
802        -99.99        -99.99            -99.99   MLO
803        -99.99        -99.99            -99.99   MLO
804        -99.99        -99.99            -99.99   MLO
805        -99.99        -99.99            -99.99   MLO

[806 rows x 11 columns]
```

Preparing the data

[5]:
```
data.columns = data.columns.str.strip()
data.columns
data['Yr'] = data['Yr'].str.strip()
data['Mn'] = data['Mn'].str.strip()
```

[6]:
```
data.dropna(inplace=True)
data.drop(data.head(4).index, inplace=True)
data.drop(data.tail(9).index, inplace=True)
co2_data = data.loc[:,['Yr', 'Mn', 'CO2']]
co2_data['DateCons'] = co2_data['Yr'].astype(str) + '-' + co2_data['Mn'].
 ↪astype(str) + '-01'
```

[7]:
```
co2_data['DatePart'] = pd.to_datetime(co2_data['DateCons'], format='%Y-%m-%d',␣
 ↪errors='coerce')
co2_data.rename(columns = {"DatePart" : "Date"}, inplace=True)
co2_data.set_index("Date", inplace=True)
co2_data.drop(columns=["DateCons"], inplace=True)
```

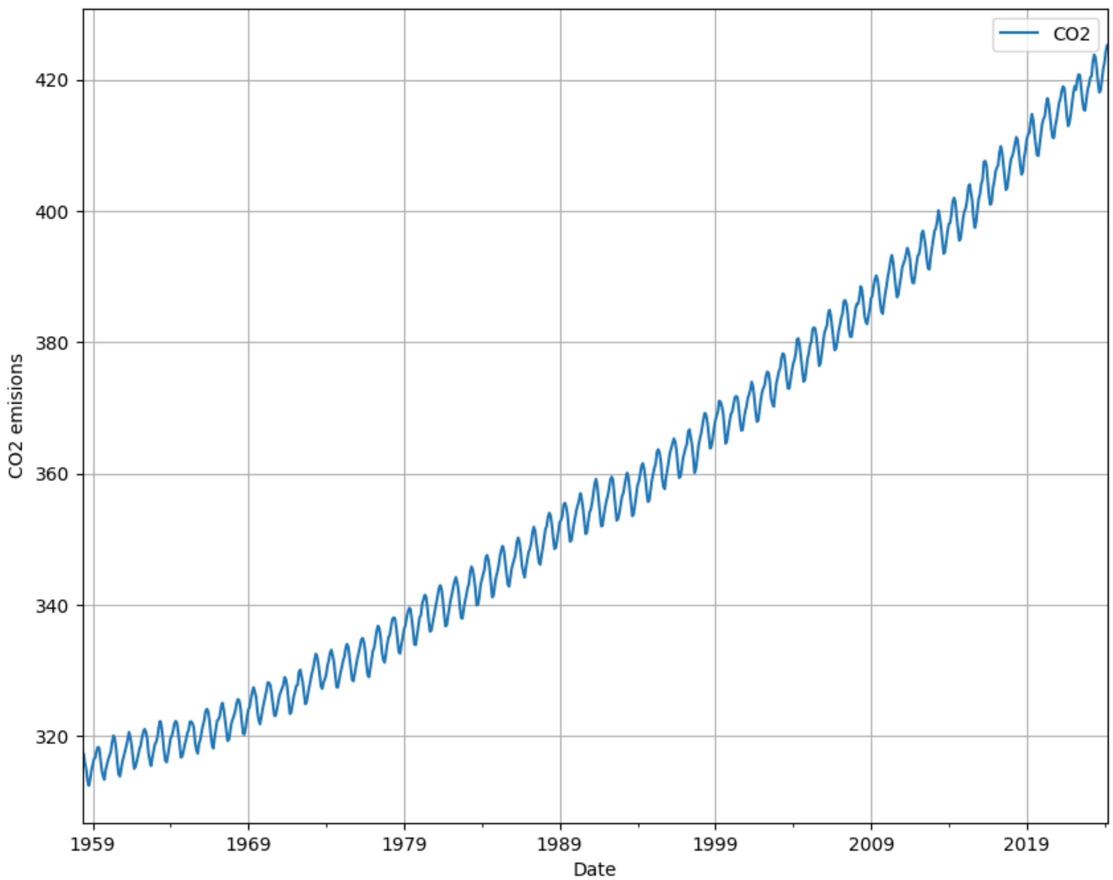
[8]:
```
co2_data = co2_data.iloc[:, [3]]
co2_data ['CO2'] = co2_data ['CO2'].astype(float)
```

```
<ipython-input-8-74b60c3e6da4>:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  co2_data ['CO2'] = co2_data ['CO2'].astype(float)
```

CO2 Emissions Time series

[9]:
```
co2_data.plot(figsize=(10,8), grid=True)
plt.ylabel("CO2 emisions")
plt.show()
```



[10]:
```
co2_data.sort_index(inplace=True)
```

[11]:
```
co2_data.index.freq='MS'
```

[12]:
```
df = co2_data.copy()
```

[13]:
```
df['CO2'].shift(0)
```

[13]:
```
Date
1958-05-01    317.51
1958-06-01    317.27
1958-07-01    315.87
1958-08-01    314.93
1958-09-01    313.21
                …
2023-11-01    420.12
2023-12-01    421.65
2024-01-01    422.62
2024-02-01    424.35
```

```
2024-03-01    425.22
Freq: MS, Name: CO2, Length: 791, dtype: float64
```

[14]:

```python
for i in range(12,0,-1):
    print(i)
    df['t= ' + str(i)] =df['CO2'].shift(i)
```

```
12
11
10
9
8
7
6
5
4
3
2
1
```

Preparing time series for prediction

[15]:

```python
df
```

[15]:

```
               CO2   t= 12   t= 11   t= 10    t= 9    t= 8    t= 7    t= 6  \
Date
1958-05-01  317.51     NaN     NaN     NaN     NaN     NaN     NaN     NaN
1958-06-01  317.27     NaN     NaN     NaN     NaN     NaN     NaN     NaN
1958-07-01  315.87     NaN     NaN     NaN     NaN     NaN     NaN     NaN
1958-08-01  314.93     NaN     NaN     NaN     NaN     NaN     NaN     NaN
1958-09-01  313.21     NaN     NaN     NaN     NaN     NaN     NaN     NaN
…             …      …      …       …      …       …      …       …
2023-11-01  420.12  417.03  418.48  419.23  420.33  420.51  422.73  423.78
2023-12-01  421.65  418.48  419.23  420.33  420.51  422.73  423.78  423.39
2024-01-01  422.62  419.23  420.33  420.51  422.73  423.78  423.39  421.62
2024-02-01  424.35  420.33  420.51  422.73  423.78  423.39  421.62  419.56
2024-03-01  425.22  420.51  422.73  423.78  423.39  421.62  419.56  418.06

              t= 5    t= 4    t= 3    t= 2    t= 1
Date
1958-05-01     NaN     NaN     NaN     NaN     NaN
1958-06-01     NaN     NaN     NaN     NaN  317.51
1958-07-01     NaN     NaN     NaN  317.51  317.27
1958-08-01     NaN     NaN  317.51  317.27  315.87
1958-09-01     NaN  317.51  317.27  315.87  314.93
…             …      …      …       …      …
2023-11-01  423.39  421.62  419.56  418.06  418.40
2023-12-01  421.62  419.56  418.06  418.40  420.12
```

```
2024-01-01  419.56  418.06  418.40  420.12  421.65
2024-02-01  418.06  418.40  420.12  421.65  422.62
2024-03-01  418.40  420.12  421.65  422.62  424.35

[791 rows x 13 columns]
```

[16]:
```
df.dropna(inplace=True)
```

prepared time series for prediction

[17]:
```
df
```

[17]:
```
               CO2   t= 12   t= 11   t= 10    t= 9    t= 8    t= 7    t= 6  \
Date
1959-05-01  318.29  317.51  317.27  315.87  314.93  313.21  312.42  313.33
1959-06-01  318.15  317.27  315.87  314.93  313.21  312.42  313.33  314.67
1959-07-01  316.54  315.87  314.93  313.21  312.42  313.33  314.67  315.58
1959-08-01  314.80  314.93  313.21  312.42  313.33  314.67  315.58  316.49
1959-09-01  313.84  313.21  312.42  313.33  314.67  315.58  316.49  316.65
…              …      …      …      …      …      …      …      …
2023-11-01  420.12  417.03  418.48  419.23  420.33  420.51  422.73  423.78
2023-12-01  421.65  418.48  419.23  420.33  420.51  422.73  423.78  423.39
2024-01-01  422.62  419.23  420.33  420.51  422.73  423.78  423.39  421.62
2024-02-01  424.35  420.33  420.51  422.73  423.78  423.39  421.62  419.56
2024-03-01  425.22  420.51  422.73  423.78  423.39  421.62  419.56  418.06

              t= 5    t= 4    t= 3    t= 2    t= 1
Date
1959-05-01  314.67  315.58  316.49  316.65  317.72
1959-06-01  315.58  316.49  316.65  317.72  318.29
1959-07-01  316.49  316.65  317.72  318.29  318.15
1959-08-01  316.65  317.72  318.29  318.15  316.54
1959-09-01  317.72  318.29  318.15  316.54  314.80
…              …      …      …      …      …
2023-11-01  423.39  421.62  419.56  418.06  418.40
2023-12-01  421.62  419.56  418.06  418.40  420.12
2024-01-01  419.56  418.06  418.40  420.12  421.65
2024-02-01  418.06  418.40  420.12  421.65  422.62
2024-03-01  418.40  420.12  421.65  422.62  424.35

[779 rows x 13 columns]
```

[18]:
```
X = df.iloc[:,1:].values
```

[19]:
```
y = df.iloc[:, 0].values
```

[20]:
```
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.
↪2,random_state=42)
```

GRID Search for best params of Random Forest Regressor

[ ]:
```
parameters = {
     'max_features': [3,4,5],
     'n_estimators': [100, 200, 500]

}
clf_gbm = GridSearchCV(RandomForestRegressor(), parameters, cv=8)
clf_gbm.fit(X_train, y_train)
print("Best parameters:", clf_gbm.best_params_)
print("Best score:", clf_gbm.best_score_)
```

```
Best parameters: {'max_features': 5, 'n_estimators': 500}
Best score: 0.9995718760856878
```

Regression with Random Forest

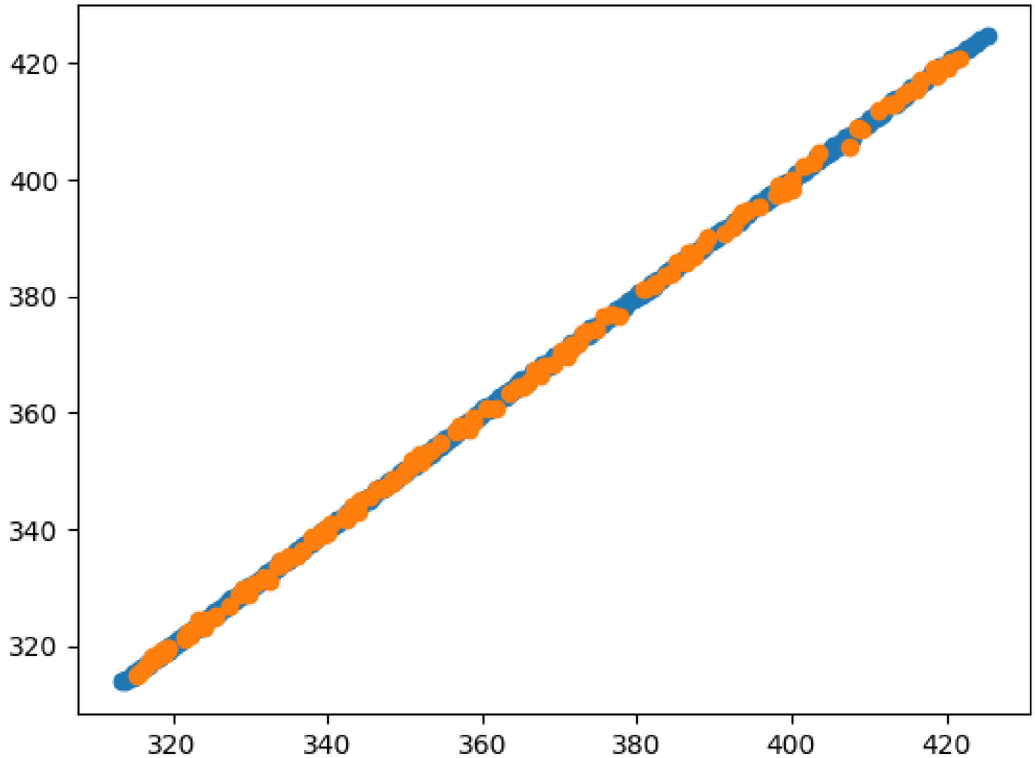
[21]:
```
rfr =RandomForestRegressor(random_state=42,n_estimators=500,max_features=5)
rfr.fit(X_train, y_train)
```

[21]:
```
RandomForestRegressor(max_features=5, n_estimators=500, random_state=42)
```

[22]:
```
train_prediction = rfr.predict(X_train)
test_prediction = rfr.predict(X_test)
```

[23]:
```
plt.scatter(y_train,train_prediction)
plt.scatter(y_test,test_prediction)
```

[23]:
```
<matplotlib.collections.PathCollection at 0x78e704f2ca30>
```



[24]:
```
mean_absolute_percentage_error(y_train, train_prediction)*100
```

[24]: 0.04918088070645875

[25]:
```
mean_absolute_percentage_error(y_test, test_prediction)*100
```

[25]: 0.12741933601819283

[26]:
```
def get_first_eval_batch(data, n):
    return data[-n:].reshape(-1,n)
```

[27]:
```
train = co2_data[:-12]
test = co2_data[-12:]
```

[28]:
```
n_lag = 12
test_prediction_rfr = []
current_batch = get_first_eval_batch(train['CO2'].values, n_lag)
for i in range(len(test)):
    current_pred = rfr.predict(current_batch)[0]
    test_prediction_rfr.append(current_pred)
    current_batch = np.append(current_batch[:,1:], current_pred).reshape(-1,␣
 ↪n_lag)
```

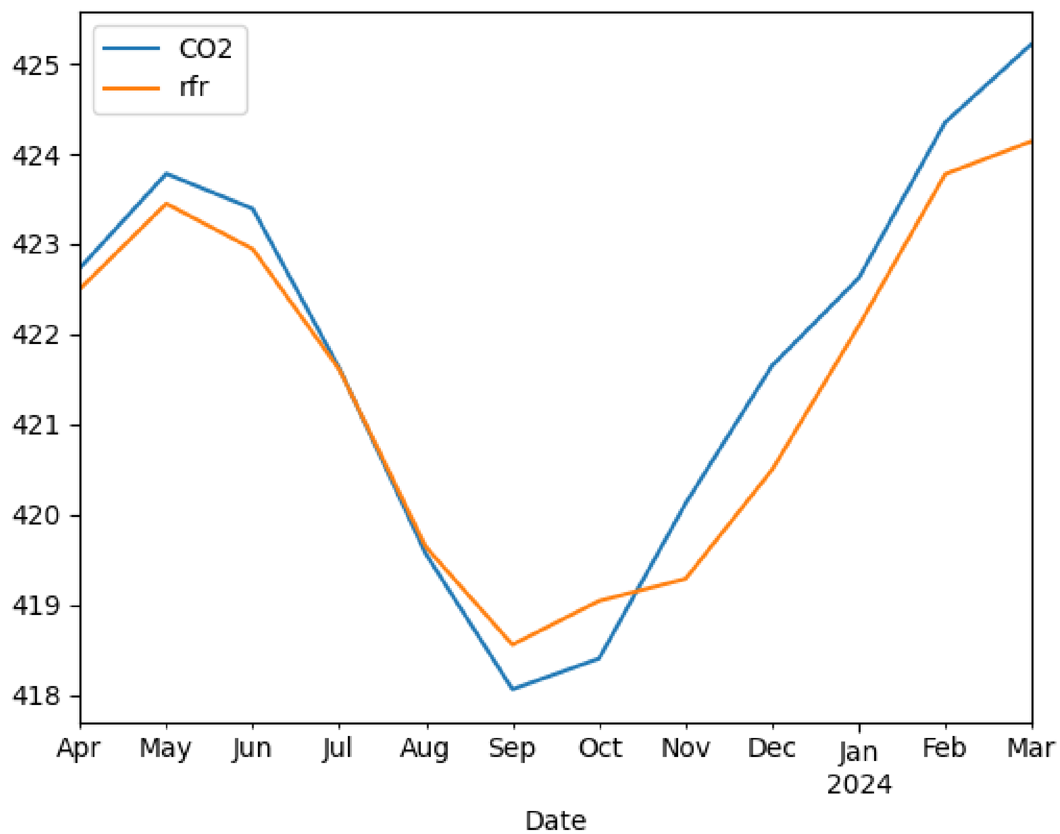
[29]:
```
test_prediction_rfr
```

[29]:
```
[422.49870000000215,
 423.4473400000001,
 422.94332000000264,
 421.60557999999827,
 419.63795999999905,
 418.5546199999989,
 419.0403400000003,
 419.2844600000012,
 420.4948200000006,
 422.0894599999997,
 423.7748000000014,
 424.1403400000014]
```

Actual vs Predicted values using RandomForest Regression

[30]:
```
df_comp =test['CO2'].to_frame()
df_comp['rfr'] = test_prediction_rfr
df_comp.plot()
```

[30]:
```
<Axes: xlabel='Date'>
```



[31]:
```
mean_absolute_percentage_error(df_comp['CO2'], df_comp['rfr'])*100
```

[31]:
```
0.1266594143067228
```

Gradient Boost Regression

[ ]:
```
from sklearn.ensemble import GradientBoostingRegressor
```

Running Grid Search to look for best params

[ ]:
```
from sklearn.model_selection import GridSearchCV

parameters = {
    'learning_rate': [0.01, 0.05, 0.1],
    'max_depth': [3, 4, 5],
    'n_estimators': [100, 200, 500],
    'max_features' : [3,4,5]

}
clf_gbm = GridSearchCV(GradientBoostingRegressor(), parameters, cv=8)
clf_gbm.fit(X_train, y_train)

print("Best parameters:", clf_gbm.best_params_)
print("Best score:", clf_gbm.best_score_)
```

```
Best parameters: {'learning_rate': 0.05, 'max_depth': 5, 'max_features': 5,
'n_estimators': 500}
Best score: 0.9995220285574494
```

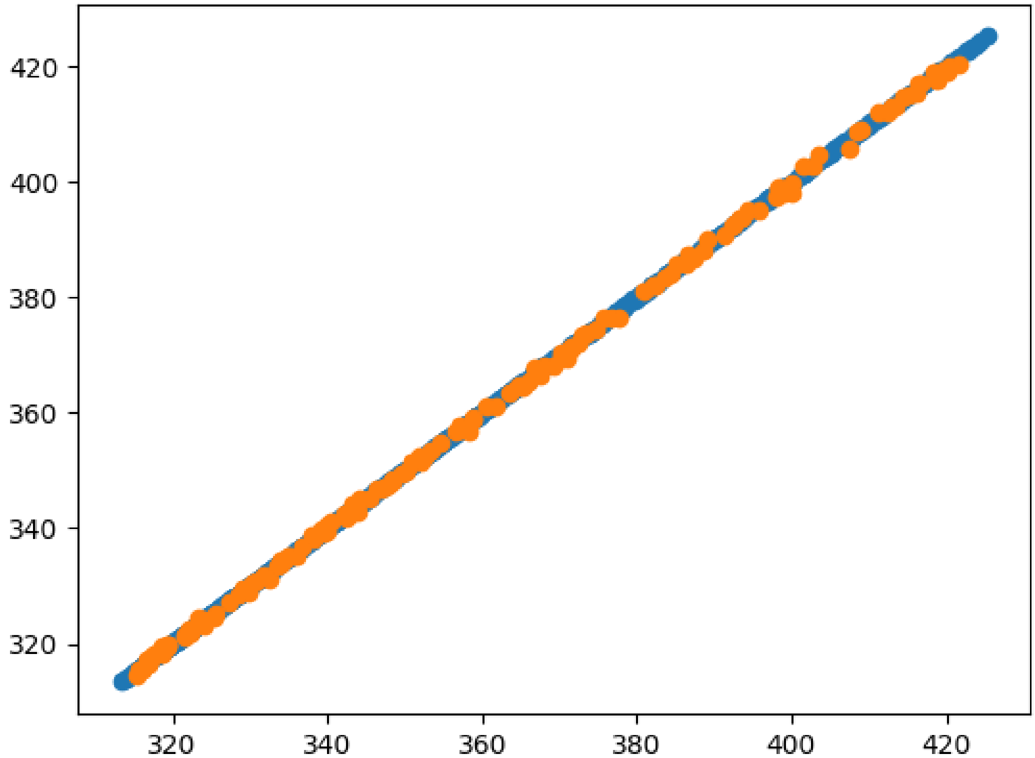
[ ]:
```
gbr =
 ↪GradientBoostingRegressor(random_state=42,n_estimators=500,max_features=5,
 ↪learning_rate=0.05, max_depth=5)
gbr.fit(X_train, y_train)
```

[ ]:
```
GradientBoostingRegressor(learning_rate=0.05, max_depth=5, max_features=5,
                          n_estimators=500, random_state=42)
```

[ ]:
```
train_prediction = gbr.predict(X_train)
test_prediction = gbr.predict(X_test)
```

[ ]:
```
plt.scatter(y_train,train_prediction)
plt.scatter(y_test,test_prediction)
```

[ ]:
```
<matplotlib.collections.PathCollection at 0x7bdffe2305b0>
```



[ ]:
```
mean_absolute_percentage_error(y_train, train_prediction)*100
```

[ ]: 0.012278367102289058

[ ]:
```
mean_absolute_percentage_error(y_test, test_prediction)*100
```

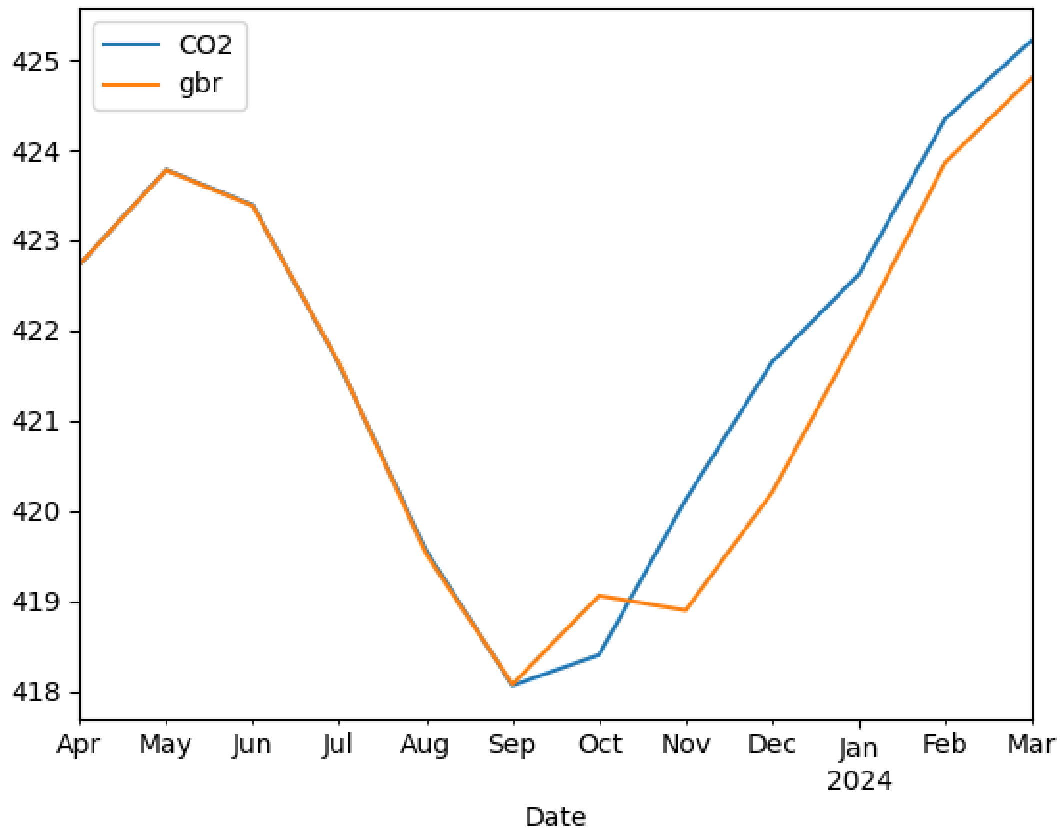
[ ]: 0.13256530777559283

[ ]:
```
n_lag = 12
test_prediction_gbr = []
current_batch = get_first_eval_batch(train['CO2'].values, n_lag)
for i in range(len(test)):
    current_pred = gbr.predict(current_batch)[0]
    test_prediction_gbr.append(current_pred)
    current_batch = np.append(current_batch[:,1:], current_pred).reshape(-1,␣
 ↪n_lag)
```

Actual vs Predicted values for Gradient Boost

[ ]:
```
df_comp =test['CO2'].to_frame()
df_comp['gbr'] = test_prediction_gbr
df_comp.plot()
```

[ ]: <Axes: xlabel='Date'>



[ ]:
```
mean_absolute_percentage_error(df_comp['CO2'], df_comp['gbr'])*100
```

[ ]: 0.0976487544068113

Xtreme Gradient Boosting Regression

[ ]:
```
!pip install xgboost
```

```
Requirement already satisfied: xgboost in /usr/local/lib/python3.10/dist-
packages (2.0.3)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages
(from xgboost) (1.25.2)
Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages
(from xgboost) (1.11.4)
```

[ ]:
```
import xgboost as xgb
```

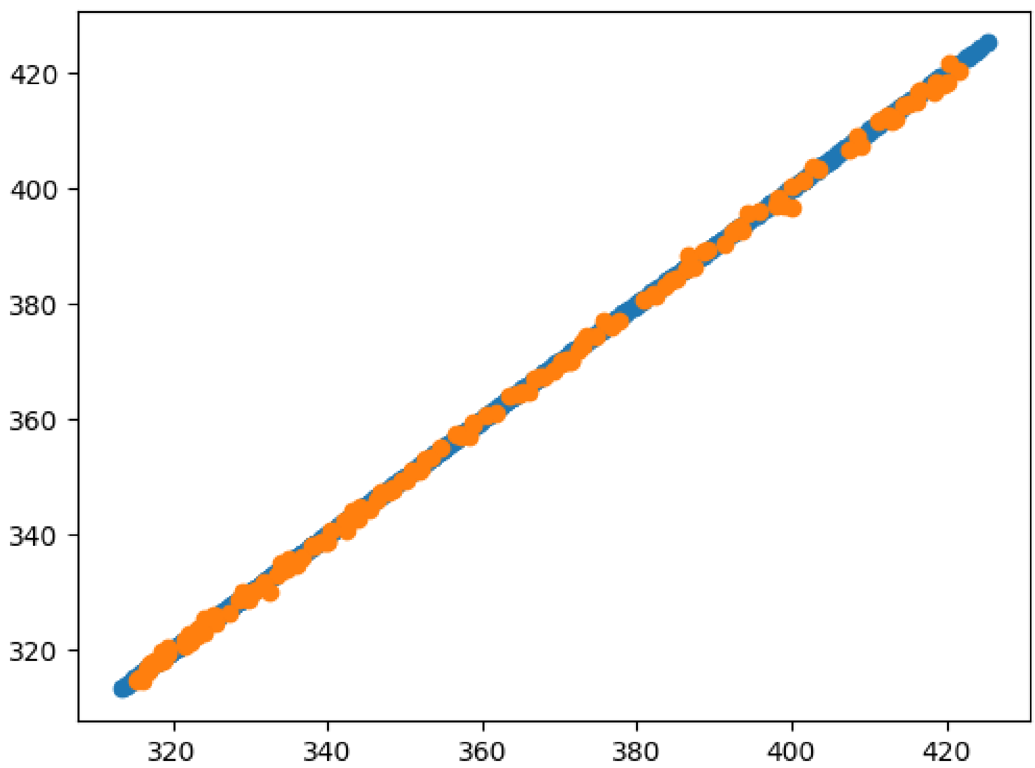
[ ]:
```
xgbr= xgb.XGBRegressor(objective='reg:squarederror', n_estimators=200)
xgbr.fit(X_train, y_train)
```

[ ]: XGBRegressor(base_score=None, booster=None, callbacks=None,
                 colsample_bylevel=None, colsample_bynode=None,
                 colsample_bytree=None, device=None, early_stopping_rounds=None,
                 enable_categorical=False, eval_metric=None, feature_types=None,
                 gamma=None, grow_policy=None, importance_type=None,
                 interaction_constraints=None, learning_rate=None, max_bin=None,
                 max_cat_threshold=None, max_cat_to_onehot=None,
                 max_delta_step=None, max_depth=None, max_leaves=None,
                 min_child_weight=None, missing=nan, monotone_constraints=None,
                 multi_strategy=None, n_estimators=200, n_jobs=None,
                 num_parallel_tree=None, random_state=None, …)

[ ]:
```
train_prediction = xgbr.predict(X_train)
test_prediction = xgbr.predict(X_test)
```

[ ]:
```
plt.scatter(y_train,train_prediction)
plt.scatter(y_test,test_prediction)
```

[ ]: <matplotlib.collections.PathCollection at 0x7be0179de470>



[ ]:
```
mean_absolute_percentage_error(y_train, train_prediction)*100
```

[ ]: 0.0014265072449335934

```
[ ]: mean_absolute_percentage_error(y_test, test_prediction)*100
```

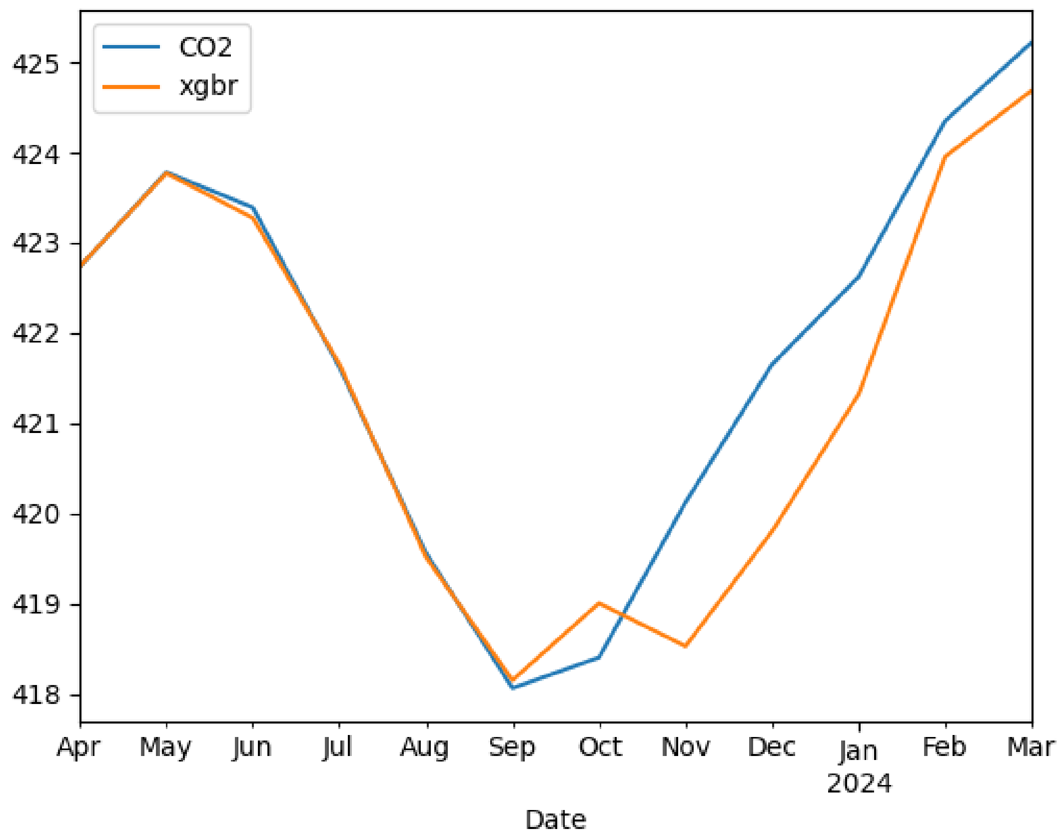
[ ]: 0.1755306919523586

```
[ ]: n_lag = 12
test_prediction_xgbr = []
current_batch = get_first_eval_batch(train['CO2'].values, n_lag)
for i in range(len(test)):
    current_pred = xgbr.predict(current_batch)[0]
    test_prediction_xgbr.append(current_pred)
    current_batch = np.append(current_batch[:,1:], current_pred).reshape(-1,␣
 ↪n_lag)
```

Actual vs Predicted Values for XGBoost Regression

```
[ ]: df_comp =test['CO2'].to_frame()
df_comp['xgbr'] = test_prediction_gbr
df_comp.plot()
```

[ ]: <Axes: xlabel='Date'>



[ ]:
```
mean_absolute_percentage_error(df_comp['CO2'], df_comp['xgbr'])*100
```

[ ]: 0.1299934183045117

Gradient Booster yielded the best results out of the three regressions models with mean absolute percentage error being ~ 0.09