RandomForestRegressor_v1_seg_2

November 24, 2022

1 Random Forest regressor

[ ]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split, RandomizedSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import Pipeline
from sklearn.neural_network import MLPRegressor
from sklearn.feature_selection import SelectFromModel
from sklearn.metrics import r2_score, mean_absolute_percentage_error,␣
↪mean_absolute_error, mean_squared_error

from sklearn.ensemble import RandomForestRegressor


from statsmodels.tools.eval_measures import stde
```

1.1 Read the etl info results

[ ]:
```
df_info = pd.read_csv('../dataset_clean/options_csv_v1_etl.csv')
df_info
```

[ ]:
```
   remove_time_features  generic_features  remove_atypical_values  \
0                 False              True                   False

   feature_combination  remove_feature_selection  \
0                False                     False

   remove_invalid_correlated_features
0                               False
```

1.2 Read the dataset

[ ]:
```
df = pd.read_csv('../dataset_clean/PlatteRiverWeir_features_v1_clean.csv')
df
```

[ ]:
```
                SensorTime          CaptureTime  Stage  Discharge    grayMean  \
0      2012-06-09 13:15:00  2012-06-09T13:09:07   2.99      916.0   97.405096
1      2012-06-09 13:15:00  2012-06-09T13:10:29   2.99      916.0  104.066757
2      2012-06-09 13:45:00  2012-06-09T13:44:01   2.96      873.0  105.636831
3      2012-06-09 14:45:00  2012-06-09T14:44:30   2.94      846.0  104.418949
4      2012-06-09 15:45:00  2012-06-09T15:44:59   2.94      846.0  106.763541
…                      …                    …      …          …           …
42054  2019-10-11 09:00:00  2019-10-11T08:59:53   2.54      434.0   82.872720
42055  2019-10-11 10:00:00  2019-10-11T09:59:52   2.54      434.0   89.028383
42056  2019-10-11 11:00:00  2019-10-11T10:59:52   2.54      434.0   94.722097
42057  2019-10-11 12:00:00  2019-10-11T11:59:53   2.54      434.0   96.693270
42058  2019-10-11 12:45:00  2019-10-11T12:59:52   2.54      434.0   98.738399

       graySigma  entropyMean  entropySigma       hMean     hSigma  \
0      39.623303     0.203417      0.979825  105.368375  41.572939
1      40.179745     0.206835      1.002624  112.399458  41.795584
2      40.533218     0.204756      0.994246  114.021526  42.145582
3      41.752678     0.202428      0.983170  112.612830  43.575351
4      44.442097     0.202661      0.989625  114.839424  46.302008
…              …            …             …           …          …
42054  57.702652     0.221708      1.076393   87.260572  61.485334
42055  55.840861     0.233168      1.124774   94.175906  59.006132
42056  54.355753     0.240722      1.151833  100.534577  56.921028
42057  52.787629     0.244789      1.171987  102.891159  55.083532
42058  52.025453     0.252812      1.213278  105.292067  53.994155

            sMean    sSigma       vMean     vSigma
0      124.520218  4.111846  132.405971  14.983367
1      124.317679  4.270429  133.070221  15.334166
2      124.304621  4.310293  133.294541  15.502448
3      124.369736  4.120586  133.458381  15.190064
4      124.283191  4.088480  133.573595  14.801143
…               …         …           …          …
42054  127.807813  2.564157  124.073149  13.757842
42055  127.336000  2.585121  124.882812  13.234735
42056  126.958768  2.774867  126.145409  13.408480
42057  126.679956  2.998683  127.508063  13.863205
42058  126.328075  3.258103  128.788256  14.353808

[42059 rows x 14 columns]
```

[ ]:
```
df['SensorTime'] = pd.to_datetime(df['SensorTime'])
df['Year'] = df['SensorTime'].dt.year
df['Month'] = df['SensorTime'].dt.month
```

[ ]:
```
df.dtypes
```

[ ]:
```
SensorTime      datetime64[ns]
CaptureTime             object
Stage                  float64
Discharge              float64
grayMean               float64
graySigma              float64
entropyMean            float64
entropySigma           float64
hMean                  float64
hSigma                 float64
sMean                  float64
sSigma                 float64
vMean                  float64
vSigma                 float64
Year                     int64
Month                    int64
dtype: object
```

[ ]:
```
df = df[(df.Stage > 0) & (df.Discharge > 0)]
```

[ ]:
```
df.isna().sum()
```

[ ]:
```
SensorTime      0
CaptureTime     0
Stage           0
Discharge       0
grayMean        0
graySigma       0
entropyMean     0
entropySigma    0
hMean           0
hSigma          0
sMean           0
sSigma          0
vMean           0
vSigma          0
Year            0
Month           0
dtype: int64
```

1.3 Divide dataset to X and Y

[ ]:
```
np.random.seed(0)

df_train = df[(df.Year >= 2012) & (df.Year <= 2017)]
df_train = df_train.iloc[np.random.permutation(len(df_train))]

df_test = df[(df.Year >= 2018) & (df.Year <= 2019)]
```

[ ]:
```
df_train = df_train.drop(columns=["Year", "SensorTime", "CaptureTime"])
#df_val = df_val.drop(columns=["Year", "SensorTime", "CaptureTime"])
df_test = df_test.drop(columns=["Year", "SensorTime", "CaptureTime"])
```

[ ]:
```
y_train = df_train["Stage"]
X_train = df_train.drop(columns=["Stage", "Discharge"])

y_test = df_test["Stage"]
X_test = df_test.drop(columns=["Stage", "Discharge"])
```

[ ]:
```
print(X_train.shape)
print(y_train.shape)
```

```
(27421, 11)
(27421,)
```

[ ]:
```
input_shape = X_train.shape
output_shape = y_train.shape

print(input_shape, output_shape)
```

```
(27421, 11) (27421,)
```

1.4 Train model

[ ]:
```
pipeline = Pipeline([
    ('scaler', StandardScaler()),
    ('clf', RandomForestRegressor(random_state=0))
])

param_grid = {'clf__n_estimators': np.arange(50, 300, 1), 'clf__max_features':␣
↪["sqrt", 1.0, "log2"]}

clf = RandomizedSearchCV(pipeline, param_distributions=param_grid, n_iter=20,␣
↪n_jobs=8, verbose=3, scoring="neg_mean_squared_error")
```

[ ]:
```
clf.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 20 candidates, totalling 100 fits
```

```
[CV 4/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.206 total
time=  11.7s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.190 total
time=  11.7s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.186 total
time=  11.8s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.201 total
time=  12.0s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.187 total
time=  12.2s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.187 total
time=  12.6s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.190 total
time=  13.0s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.201 total
time=  13.3s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.188 total
time=   7.0s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.201 total
time=   7.2s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.190 total
time=   7.3s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.206 total
time=   7.3s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.187 total
time=   7.0s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.206 total
time=  12.5s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.186 total
time=  13.0s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.201 total
time=   5.7s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.191 total
time=   5.1s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.188 total
time=   6.1s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.208 total
time=   5.1s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.186 total
time=   5.1s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.187 total
time=  11.4s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.201 total
time=  12.3s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.195 total
time=  29.4s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.190 total
time=  10.6s
```

```
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.185 total
time=  31.0s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.186 total
time=  31.4s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.182 total
time=  30.9s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.202 total
time=  32.0s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.186 total
time=  10.8s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.206 total
time=  11.4s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.195 total
time=  26.4s
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.185 total
time=  28.6s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.195 total
time=  22.9s
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.186 total
time=  22.5s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.186 total
time=  26.8s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.186 total
time=  23.3s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.202 total
time=  28.4s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.182 total
time=  28.3s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.201 total
time=  10.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.187 total
time=  10.4s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.190 total
time=  10.2s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.206 total
time=  10.4s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.186 total
time=  10.2s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.203 total
time=  21.4s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.201 total
time=  13.0s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.183 total
time=  21.5s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.201 total
time=   8.2s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.187 total
time=  12.9s
```

```
[CV 2/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.187 total
time=   8.4s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.190 total
time=  13.2s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.206 total
time=  12.8s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.186 total
time=  12.7s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.190 total
time=   8.8s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.206 total
time=   8.7s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.202 total
time=   4.1s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.186 total
time=   8.3s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.188 total
time=   4.3s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.192 total
time=   4.5s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.208 total
time=   4.2s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.188 total
time=   4.2s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.204 total
time=   3.2s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.189 total
time=   3.2s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.186 total
time=  16.3s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.201 total
time=  17.6s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.193 total
time=   2.9s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.190 total
time=   2.9s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.209 total
time=   3.2s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.185 total
time=  17.3s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.189 total
time=  18.3s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.206 total
time=  18.2s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.201 total
time=   5.3s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.188 total
time=   5.5s
```

```
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.207 total
time=   5.4s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.190 total
time=   5.8s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.186 total
time=   6.0s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.201 total
time=   5.0s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.188 total
time=   5.7s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.191 total
time=   5.4s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.208 total
time=   5.3s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.187 total
time=   5.4s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.201 total
time=   8.7s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.187 total
time=   9.2s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.190 total
time=   9.0s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.206 total
time=   8.5s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.186 total
time=   8.1s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.195 total
time=  32.3s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.186 total
time=  34.0s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.202 total
time=  31.8s
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.185 total
time=  34.8s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.182 total
time=  33.2s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.202 total
time=   3.4s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.188 total
time=   3.4s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.192 total
time=   3.8s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.188 total
time=   3.4s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.207 total
time=   3.4s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.195 total
time=  29.6s
```

```
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.185 total
time=  29.2s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.186 total
time=  29.1s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.202 total
time=  28.6s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.182 total
time=  27.6s
```

[ ]:
```
RandomizedSearchCV(estimator=Pipeline(steps=[('scaler', StandardScaler()),
                                             ('clf',
RandomForestRegressor(random_state=0))]),
                   n_iter=20, n_jobs=8,
                   param_distributions={'clf__max_features': ['sqrt', 1.0,
                                                              'log2'],
                                        'clf__n_estimators': array([ 50,  51,
52,  53,  54,  55,  56,  57,  58,  59,  60,  61,  62,
        63,  64,  65,  66,  67,  68,  69,  70,  71,  72,  73,  74,  75,
        76,  77,  78,  79,  80,  81,  82,  83,  84,  85,  86,  87,  88,
        89,  90…
       219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231,
       232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244,
       245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257,
       258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270,
       271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283,
       284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296,
       297, 298, 299])},
                   scoring='neg_mean_squared_error', verbose=3)
```

1.5 Test model

[ ]:
```
clf.best_score_
```

[ ]:
```
-0.18974709842322832
```

[ ]:
```
clf.best_params_
```

[ ]:
```
{'clf__n_estimators': 177, 'clf__max_features': 1.0}
```

[ ]:
```
clf.score(X_test, y_test)
```

[ ]:
```
-0.346428887134744
```

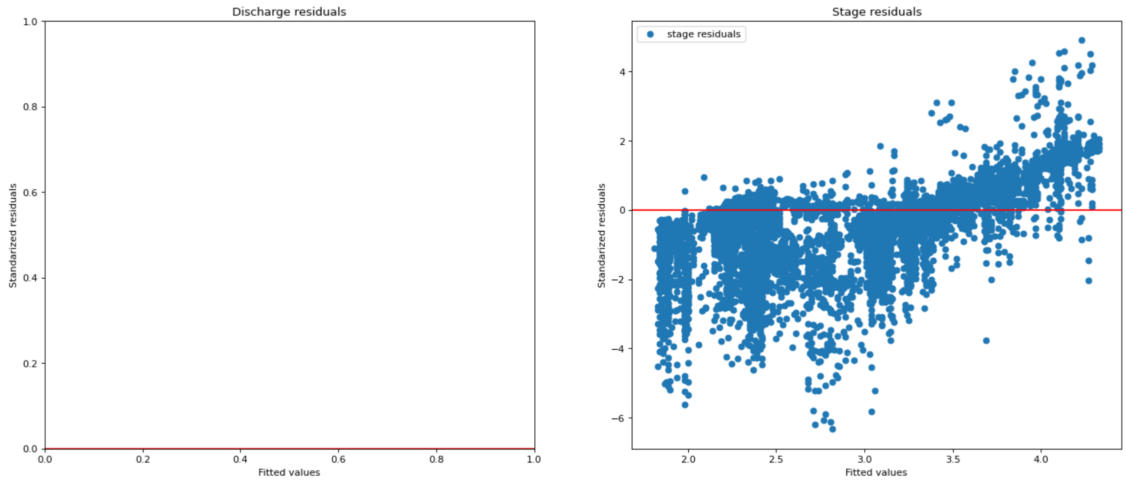
[ ]:
```
y_pred = clf.predict(X_test)
```

[ ]:
```
print("R^2: ", r2_score(y_test, y_pred))
print("mse: ", mean_squared_error(y_test, y_pred))
```

```python
print("rmse: ", mean_squared_error(y_test, y_pred, squared=False))
print("mae: ", mean_absolute_error(y_test, y_pred))
print("mape: ", mean_absolute_percentage_error(y_test, y_pred))
print("Error estandar: ", stde(y_test.squeeze(),
      y_pred.squeeze(), ddof=2))
```

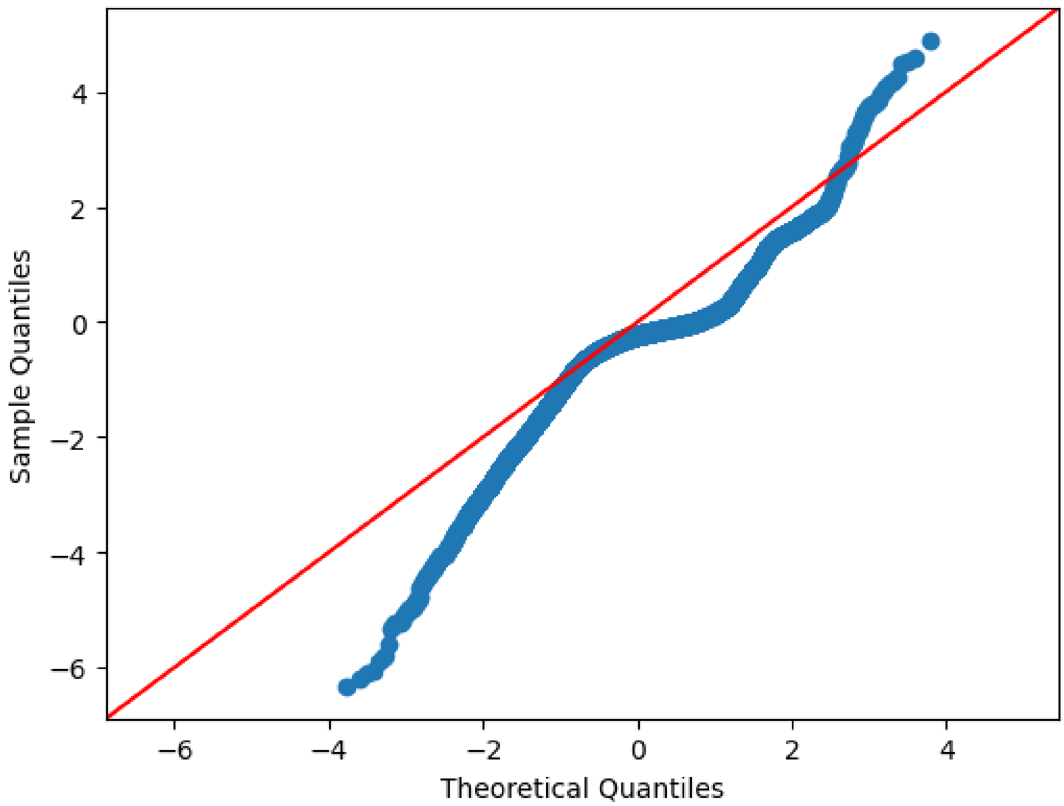
```
R^2:  0.11294665850022367
mse:  0.346428887134744
rmse:  0.5885820988908378
mae:  0.38203317916134527
mape:  0.14412078605527165
Error estandar:  0.5452671219668532
```

[ ]:
```python
residuals = y_test - y_pred
residuals_std = residuals / residuals.std()

y_real_stage = y_test
residual_stage = residuals

#y_real_discharge = np.array([i[-1] for i in y_test])
#residual_discharge = np.array([i[-1] for i in residuals])


figure, ax = plt.subplots(ncols=2, figsize=(20, 8), dpi=80)

ax[1].scatter(y_real_stage, residual_stage / residual_stage.std(), label="stage␣
 ↪residuals")
#ax[0].scatter(y_real_discharge, residual_discharge / residual_discharge.std(),␣
 ↪label="discharge residuals")
ax[1].axhline(y=0.0, color='r', linestyle='-')
ax[0].axhline(y=0.0, color='r', linestyle='-')

ax[1].set_title("Stage residuals")
ax[0].set_title("Discharge residuals")

ax[1].set_xlabel("Fitted values")
ax[0].set_xlabel("Fitted values")
ax[1].set_ylabel("Standarized residuals")
ax[0].set_ylabel("Standarized residuals")

plt.legend()
plt.show()
```

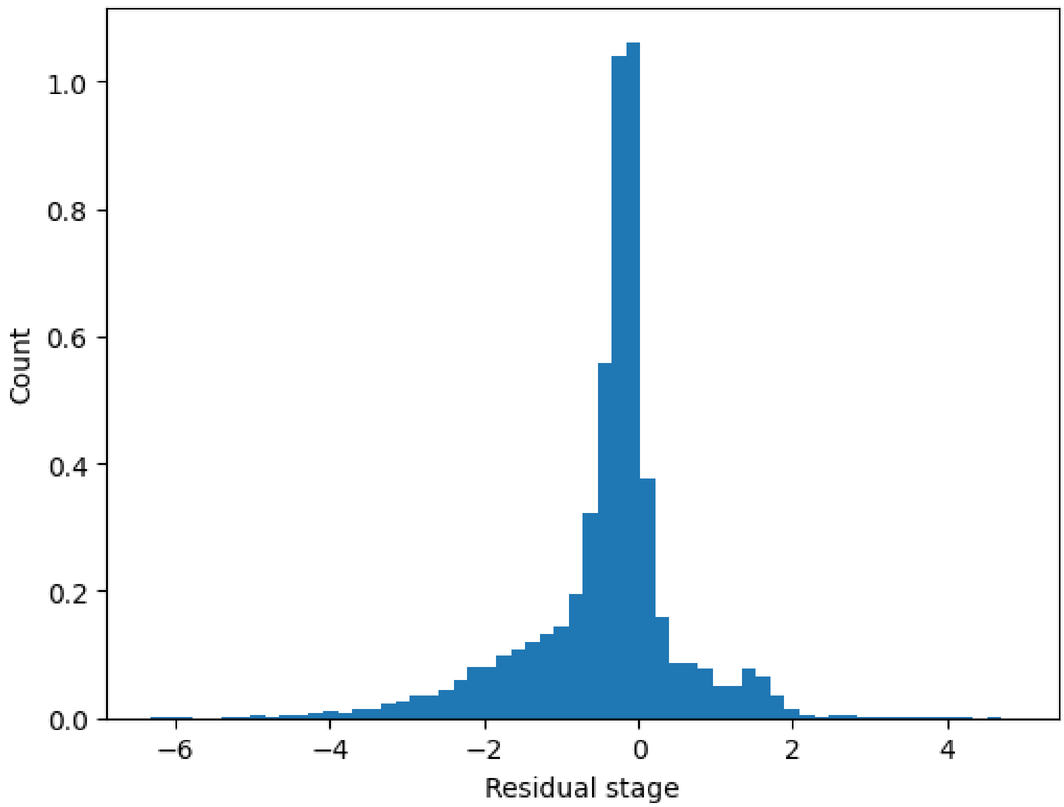



```
[ ]: import statsmodels.api as sm
     from statsmodels.stats.diagnostic import normal_ad

     #figure = sm.qqplot(residual_stage / residual_stage.std(), line ='45',␣
      ↪label='stage')
     plt.show()
```

```
[ ]: figure = sm.qqplot(residual_stage / residual_stage.std(), line='45',␣
      ↪label='discharge')
     plt.show()
```



[ ]:
```
plt.hist(residual_stage / residual_stage.std(), density=True, bins = 60)
plt.ylabel('Count')
plt.xlabel('Residual stage');
plt.show()
```



[ ]:
```
"""plt.hist(residual_discharge / residual_discharge.std(), density=True, bins =␣
↪60)
plt.ylabel('Count')
plt.xlabel('Residual discharge');
plt.show()"""
```

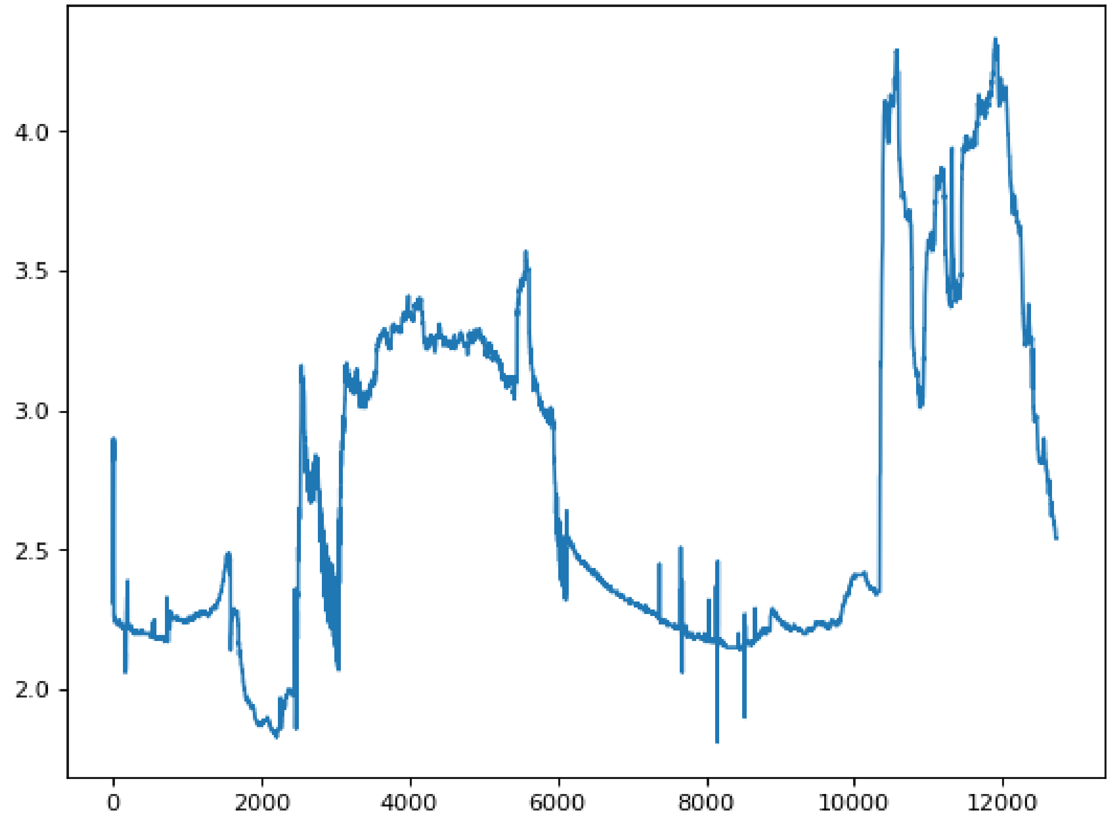
[ ]:
```
"plt.hist(residual_discharge / residual_discharge.std(), density=True, bins =
60)\nplt.ylabel('Count')\nplt.xlabel('Residual discharge');\nplt.show()"
```

[ ]:
```
stat, pval = normal_ad(residual_stage / residual_stage.std())
print("p-value:", pval)

if pval < 0.05:
    print("Hay evidencia de que los residuos no provienen de una distribución␣
↪normal.")
else:
    print("No hay evidencia para rechazar la hipótesis de que los residuos␣
↪vienen de una distribución normal.")
```

```
p-value: 0.0
Hay evidencia de que los residuos no provienen de una distribución normal.
```

[ ]:
```
plt.figure(figsize=(8, 6), dpi=80)
plt.plot(np.arange(len(y_test)), y_test, label="Stage real")
```

[ ]:
```
[<matplotlib.lines.Line2D at 0x7f7bc2d64c40>]
```



[ ]:
```
figure, ax = plt.subplots(ncols=2, figsize=(20, 8), dpi=80)

ax[0].plot(np.arange(len(y_test)), y_test, label="Stage real")
ax[0].plot(np.arange(len(y_test)), y_pred, label="Stage pred")

ax[0].set_title("Stage predictions")
ax[1].set_title("Discharge predictions")

ax[1].set_ylabel("Values")
ax[0].set_ylabel("Values")
ax[1].set_xlabel("Time")
ax[0].set_xlabel("Time")

plt.legend()
plt.show()
```

```
No artists with labels found to put in legend.  Note that artists whose label
start with an underscore are ignored when legend() is called with no argument.
```