RandomForestRegressor_v1_stage_1

November 23, 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             False                   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	…	

	WeirPt2X	WeirPt2Y	WwRawLineMin	WwRawLineMax	WwRawLineMean	\
0	-1	-1	0.0	0.0	0.000000	
1	-1	-1	0.0	0.0	0.000000	
2	-1	-1	0.0	0.0	0.000000	
3	-1	-1	0.0	0.0	0.000000	
4	-1	-1	0.0	0.0	0.000000	
…	…	…	…	…	…	
42054	2446	1900	9284.0	77521.0	38385.370066	
42055	2440	1900	10092.0	74614.0	40162.989292	
42056	2447	1900	7067.0	83260.0	42095.946590	
42057	2443	1900	6283.0	83045.0	45345.490954	
42058	2436	1900	7375.0	89813.0	47877.870782	

	WwRawLineSigma	WwCurveLineMin	WwCurveLineMax	WwCurveLineMean	\
0	0.000000	0.0	0.0	0.000000	
1	0.000000	0.0	0.0	0.000000	

```
2            0.000000             0.0             0.0         0.000000
3            0.000000             0.0             0.0         0.000000
4            0.000000             0.0             0.0         0.000000
…                 …               …               …               …
42054    15952.029728             0.0         70085.0     37550.894823
42055    15467.708856             0.0         70061.0     39397.339095
42056    16770.357949             0.0         76335.0     41350.006568
42057    17498.432849             0.0         78882.0     44553.920296
42058    19963.166359             0.0         82630.0     47280.270559

       WwCurveLineSigma
0              0.000000
1              0.000000
2              0.000000
3              0.000000
4              0.000000
…                   …
42054      16444.401209
42055      16009.008049
42056      17489.374617
42057      18268.294896
42058      20559.358767

[42059 rows x 48 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
areaFeatCount                int64
grayMean0                  float64
```

```
grayMean0                float64
grayMean0                float64
entropyMean0             float64
entropySigma0            float64
hMean0                   float64
hSigma0                  float64
sMean0                   float64
sSigma0                  float64
vMean0                   float64
vSigma0                  float64
grayMean1                float64
graySigma1               float64
entropyMean1             float64
entropySigma1            float64
hMean1                   float64
hSigma1                  float64
sMean1                   float64
sSigma1                  float64
vMean1                   float64
vSigma1                  float64
WeirAngle                float64
WeirPt1X                   int64
WeirPt1Y                   int64
WeirPt2X                   int64
WeirPt2Y                   int64
WwRawLineMin             float64
WwRawLineMax             float64
WwRawLineMean            float64
WwRawLineSigma           float64
WwCurveLineMin           float64
WwCurveLineMax           float64
WwCurveLineMean          float64
WwCurveLineSigma         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
areaFeatCount       0
grayMean0           0
graySigma0          0
entropyMean0        0
entropySigma0       0
hMean0              0
hSigma0             0
sMean0              0
sSigma0             0
vMean0              0
vSigma0             0
grayMean1           0
graySigma1          0
entropyMean1        0
entropySigma1       0
hMean1              0
hSigma1             0
sMean1              0
sSigma1             0
vMean1              0
vSigma1             0
WeirAngle           0
WeirPt1X            0
WeirPt1Y            0
WeirPt2X            0
WeirPt2Y            0
WwRawLineMin        0
WwRawLineMax        0
WwRawLineMean       0
WwRawLineSigma      0
WwCurveLineMin      0
WwCurveLineMax      0
WwCurveLineMean     0
WwCurveLineSigma    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, 45)
(27421,)
```

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

print(input_shape, output_shape)
```

```
(27421, 45) (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=40,␣
↪n_jobs=8, verbose=3, scoring="neg_mean_squared_error")
```

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

```
Fitting 5 folds for each of 40 candidates, totalling 200 fits
```

```
[CV 5/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.075 total
time=  27.3s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.074 total
time=  27.5s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.079 total
time=  27.5s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.076 total
time=  28.2s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=193;, score=-0.073 total
time=  28.3s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.076 total
time=  28.7s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.073 total
time=  29.9s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.074 total
time=  30.1s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.074 total
time=  11.1s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.079 total
time=  10.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.077 total
time=  11.8s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.074 total
time=  11.8s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=118;, score=-0.075 total
time=  11.1s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.075 total
time=  19.4s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=206;, score=-0.078 total
time=  19.8s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.075 total
time=   8.6s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.077 total
time=   8.5s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.075 total
time=   8.5s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.080 total
time=   8.4s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=91;, score=-0.075 total
time=   8.6s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.071 total
time=  20.3s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.074 total
time=  20.9s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.071 total
time=  19.0s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.076 total
time=  20.7s
```

```
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=187;, score=-0.074 total
time=  21.1s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.066 total
time= 1.8min
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.064 total
time= 2.0min
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.067 total
time= 1.9min
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.066 total
time= 2.0min
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=162;, score=-0.064 total
time= 2.0min
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.064 total
time= 1.7min
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.067 total
time= 1.8min
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.067 total
time= 1.8min
[CV 1/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.073 total
time=  15.9s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.064 total
time= 1.4min
[CV 2/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.077 total
time=  15.9s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.067 total
time= 1.4min
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.068 total
time= 1.5min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.066 total
time= 1.7min
[CV 3/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.074 total
time=  15.4s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.079 total
time=  15.9s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=166;, score=-0.075 total
time=  14.4s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=150;, score=-0.064 total
time= 1.9min
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.071 total
time=  23.4s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.066 total
time= 1.5min
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.074 total
time=  22.7s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.070 total
time=  20.9s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.073 total
time=  13.9s
```

```
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.074 total
time=  21.2s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=209;, score=-0.076 total
time=  23.6s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.079 total
time=  12.1s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.077 total
time=  13.8s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.074 total
time=  14.0s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=118;, score=-0.065 total
time= 1.4min
[CV 5/5] END clf__max_features=log2, clf__n_estimators=145;, score=-0.075 total
time=  13.9s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.073 total
time=   7.3s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.076 total
time=   7.3s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.073 total
time=   7.8s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.078 total
time=   7.8s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=68;, score=-0.076 total
time=   7.6s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.074 total
time=   6.0s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.074 total
time=  25.5s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.073 total
time=  27.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.076 total
time=  26.9s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.078 total
time=   5.6s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.073 total
time=   5.4s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.079 total
time=   5.9s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.078 total
time=  24.9s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=52;, score=-0.076 total
time=   5.8s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=290;, score=-0.075 total
time=  27.6s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.073 total
time=  10.7s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.072 total
time=  10.3s
```

```
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.075 total
time=  11.0s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.077 total
time=  10.2s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=97;, score=-0.075 total
time=   9.9s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.075 total
time=   8.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.078 total
time=   8.4s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.075 total
time=   7.3s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.080 total
time=   8.4s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=88;, score=-0.075 total
time=   8.4s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.072 total
time=  16.1s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.075 total
time=  15.9s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.070 total
time=  16.3s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.076 total
time=  16.5s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=146;, score=-0.074 total
time=  15.8s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.067 total
time= 2.0min
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.067 total
time= 2.1min
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.064 total
time= 2.1min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.066 total
time= 2.1min
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=177;, score=-0.064 total
time= 2.1min
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.073 total
time=   7.0s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.076 total
time=   7.1s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.073 total
time=   6.6s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.079 total
time=   6.3s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=62;, score=-0.076 total
time=   6.5s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.064 total
time= 2.0min
```

```
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.067 total
time= 2.0min
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.066 total
time= 2.0min
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=272;, score=-0.071 total
time=  30.1s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=119;, score=-0.064 total
time= 1.3min
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=119;, score=-0.068 total
time= 1.4min
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=119;, score=-0.067 total
time= 1.4min
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=272;, score=-0.073 total
time=  29.7s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.064 total
time= 2.0min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=119;, score=-0.066 total
time= 1.5min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=163;, score=-0.066 total
time= 2.0min
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=272;, score=-0.070 total
time=  30.3s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=122;, score=-0.072 total
time=  12.4s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=119;, score=-0.065 total
time= 1.4min
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=272;, score=-0.076 total
time=  29.6s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=272;, score=-0.074 total
time=  29.1s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=122;, score=-0.076 total
time=  13.4s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=122;, score=-0.071 total
time=  13.2s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=122;, score=-0.077 total
time=  13.7s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=122;, score=-0.075 total
time=  13.7s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=93;, score=-0.073 total
time=  10.4s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=93;, score=-0.075 total
time=  10.6s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=93;, score=-0.072 total
time=  10.6s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=239;, score=-0.071 total
time=  27.2s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=239;, score=-0.070 total
time=  25.4s
```

```
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=93;, score=-0.077 total
time=  10.7s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=239;, score=-0.074 total
time=  27.2s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=93;, score=-0.075 total
time=  10.3s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=84;, score=-0.073 total
time=   9.6s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=239;, score=-0.074 total
time=  24.7s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=239;, score=-0.076 total
time=  27.0s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=84;, score=-0.075 total
time=   9.2s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=84;, score=-0.072 total
time=   9.0s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=84;, score=-0.076 total
time=   9.3s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=84;, score=-0.078 total
time=  10.0s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=149;, score=-0.073 total
time=  14.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=149;, score=-0.077 total
time=  14.0s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=149;, score=-0.074 total
time=  14.3s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=149;, score=-0.079 total
time=  13.8s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=149;, score=-0.075 total
time=  13.5s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=155;, score=-0.072 total
time=  17.6s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=234;, score=-0.070 total
time=  25.1s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=234;, score=-0.071 total
time=  26.7s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=155;, score=-0.075 total
time=  17.1s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=155;, score=-0.070 total
time=  16.4s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=234;, score=-0.074 total
time=  26.8s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=234;, score=-0.074 total
time=  24.9s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=234;, score=-0.076 total
time=  26.8s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=155;, score=-0.076 total
time=  16.4s
```

```
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=155;, score=-0.074 total
time=  16.3s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=268;, score=-0.076 total
time=  24.7s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=268;, score=-0.079 total
time=  24.6s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=268;, score=-0.073 total
time=  26.1s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=268;, score=-0.073 total
time=  26.1s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=268;, score=-0.075 total
time=  23.1s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=237;, score=-0.073 total
time=  22.4s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=237;, score=-0.076 total
time=  21.2s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=237;, score=-0.074 total
time=  21.3s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=174;, score=-0.076 total
time=  15.9s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=174;, score=-0.073 total
time=  16.8s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=174;, score=-0.074 total
time=  16.3s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=174;, score=-0.079 total
time=  16.0s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=237;, score=-0.079 total
time=  22.9s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=237;, score=-0.075 total
time=  21.7s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=174;, score=-0.075 total
time=  15.5s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=190;, score=-0.071 total
time=  20.9s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=190;, score=-0.074 total
time=  20.8s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=190;, score=-0.071 total
time=  21.5s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=190;, score=-0.076 total
time=  20.0s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=190;, score=-0.074 total
time=  20.1s
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=280;, score=-0.070 total
time=  30.7s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=280;, score=-0.073 total
time=  31.0s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=280;, score=-0.070 total
time=  31.0s
```

```
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=69;, score=-0.068 total
time=  50.0s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=69;, score=-0.065 total
time=  50.6s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=69;, score=-0.068 total
time=  48.8s
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=69;, score=-0.066 total
time=  48.3s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=69;, score=-0.066 total
time=  50.3s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=216;, score=-0.073 total
time=  20.9s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=216;, score=-0.074 total
time=  19.3s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=216;, score=-0.076 total
time=  20.5s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=216;, score=-0.078 total
time=  20.7s
[CV 1/5] END clf__max_features=log2, clf__n_estimators=111;, score=-0.075 total
time=  10.7s
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=280;, score=-0.074 total
time=  29.6s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=216;, score=-0.075 total
time=  18.9s
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=280;, score=-0.076 total
time=  31.6s
[CV 4/5] END clf__max_features=log2, clf__n_estimators=111;, score=-0.080 total
time=   9.6s
[CV 2/5] END clf__max_features=log2, clf__n_estimators=111;, score=-0.077 total
time=  11.0s
[CV 3/5] END clf__max_features=log2, clf__n_estimators=111;, score=-0.074 total
time=  10.8s
[CV 5/5] END clf__max_features=log2, clf__n_estimators=111;, score=-0.075 total
time=   9.6s
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=89;, score=-0.068 total
time=  59.6s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=89;, score=-0.067 total
time= 1.0min
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=89;, score=-0.064 total
time= 1.1min
[CV 1/5] END clf__max_features=sqrt, clf__n_estimators=63;, score=-0.073 total
time=   6.8s
[CV 2/5] END clf__max_features=sqrt, clf__n_estimators=63;, score=-0.076 total
time=   6.1s
[CV 3/5] END clf__max_features=sqrt, clf__n_estimators=63;, score=-0.073 total
time=   6.7s
[CV 1/5] END clf__max_features=1.0, clf__n_estimators=143;, score=-0.064 total
time= 1.6min
```

```
[CV 4/5] END clf__max_features=sqrt, clf__n_estimators=63;, score=-0.079 total
time=   6.8s
[CV 3/5] END clf__max_features=1.0, clf__n_estimators=143;, score=-0.067 total
time= 1.7min
[CV 5/5] END clf__max_features=sqrt, clf__n_estimators=63;, score=-0.076 total
time=   6.0s
[CV 2/5] END clf__max_features=1.0, clf__n_estimators=143;, score=-0.067 total
time= 1.7min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=143;, score=-0.066 total
time= 1.7min
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=143;, score=-0.064 total
time= 1.7min
[CV 4/5] END clf__max_features=1.0, clf__n_estimators=89;, score=-0.067 total
time=  57.4s
[CV 5/5] END clf__max_features=1.0, clf__n_estimators=89;, score=-0.065 total
time= 1.0min
```

[ ]:
```
RandomizedSearchCV(estimator=Pipeline(steps=[('scaler', StandardScaler()),
                                             ('clf',
RandomForestRegressor(random_state=0))]),
                   n_iter=40, 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_
```

[ ]:
```
-0.0655240231675966
```

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

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

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

[ ]:
```
-0.19841446452847838
```

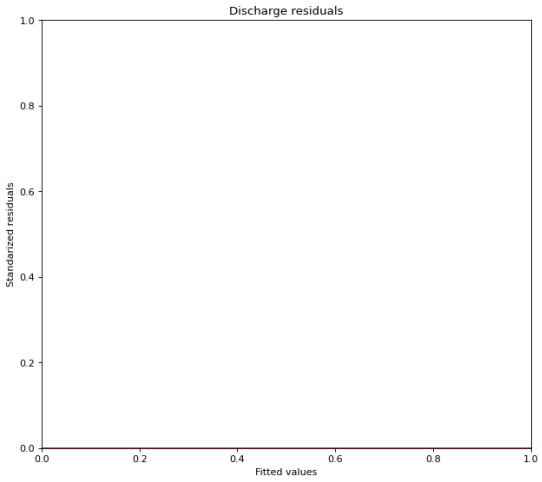
[ ]:
```
y_pred = clf.predict(X_test)
```

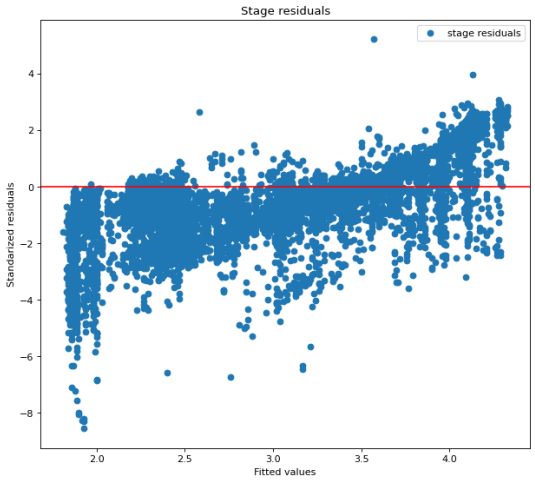
[ ]:
```
print("R^2: ", r2_score(y_test, y_pred))
print("mse: ", mean_squared_error(y_test, y_pred))
print("rmse: ", mean_squared_error(y_test, y_pred, squared=False))
print("mae: ", mean_absolute_error(y_test, y_pred))
print("mape: ", mean_absolute_percentage_error(y_test, y_pred))
print("Error estandar: ", stde(y_test.squeeze(),
      y_pred.squeeze(), ddof=2))
```

```
R^2:  0.4919470624474266
mse:  0.19841446452847838
rmse:  0.4454373856430086
mae:  0.31277947279661256
mape:  0.1214667584681884
Error estandar:  0.3798932957248546
```

[ ]:
```
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")
```

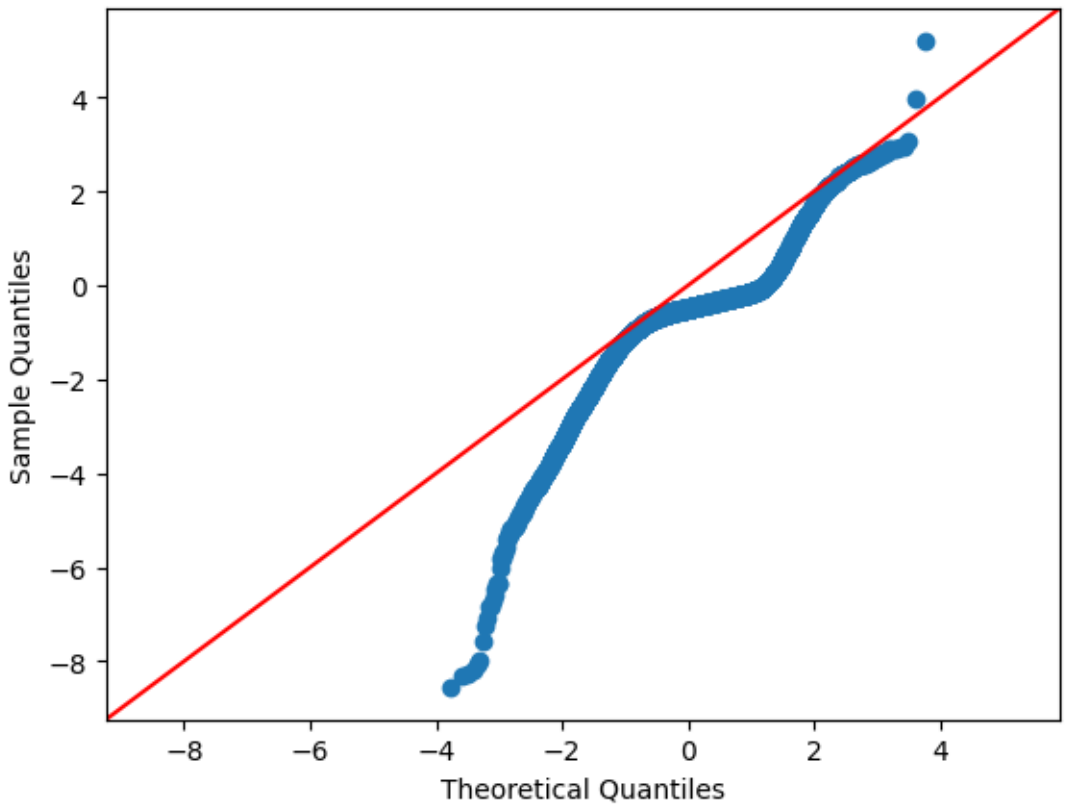
```
plt.legend()
plt.show()
```



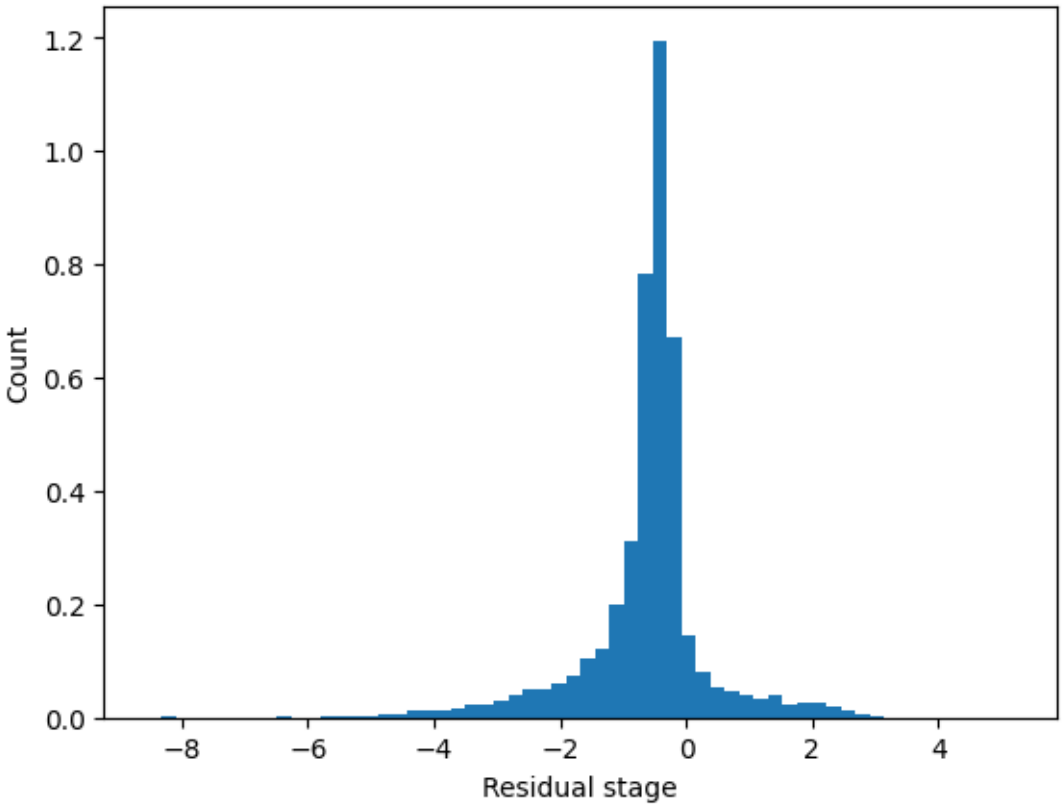


[ ]:
```
import statsmodels.api as sm
from statsmodels.stats.diagnostic import normal_ad

#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()"""
```

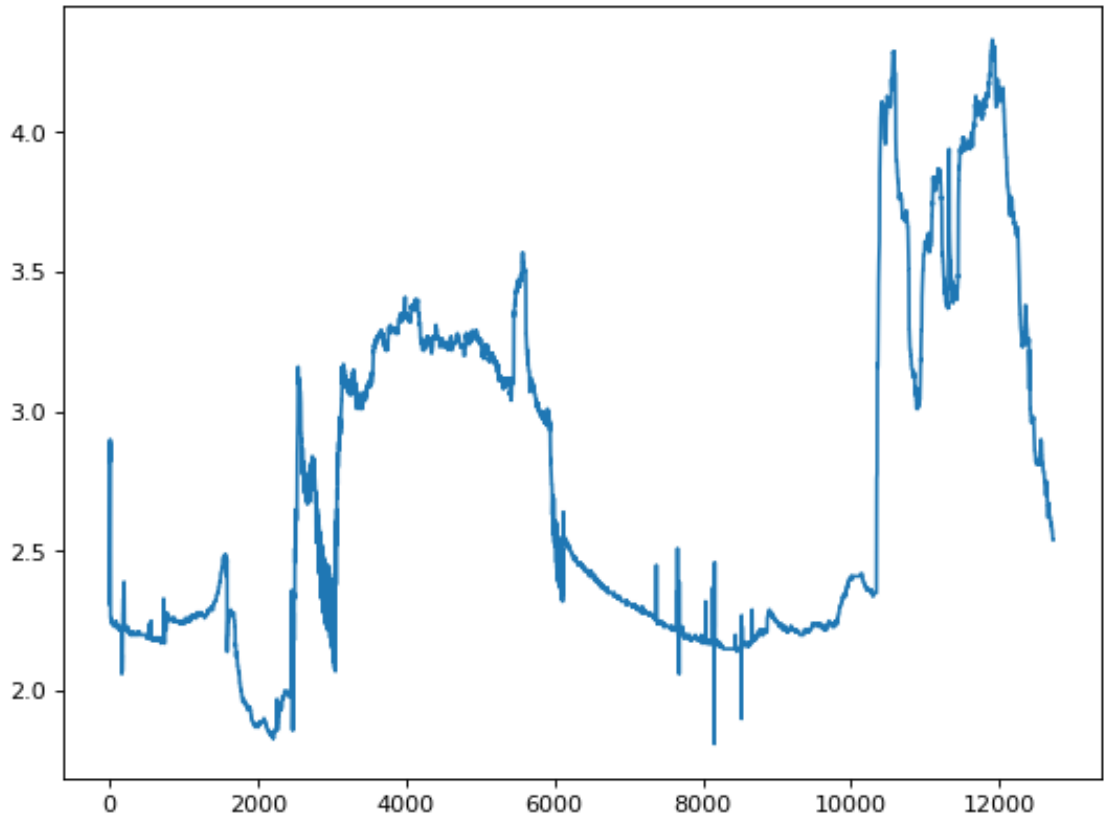
[ ]:
```
"plt.hist(residual_discharge / residual_discharge.std(), density=True, bins =
60)\nplt.ylabel('Count')\nplt.xlabel('Residual discharge');\nplt.show()"
```

[ ]:
```
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 0x7f3c75744910>]
```



[ ]:
```
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.
```