

# knn\_regression\_v1\_stage\_1

November 25, 2022

## 1 KNN regression

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

import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split, RandomizedSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import Pipeline
from sklearn.neighbors import KNeighborsRegressor
from sklearn.feature_selection import SelectFromModel
from sklearn.metrics import r2_score, mean_absolute_percentage_error, \
    mean_absolute_error, mean_squared_error
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.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
graySigma0           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
dtype: object

```

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

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

```
[ ]: #y_train = df_train[["Stage", "Discharge"]]
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"])
```

```
[ ]: #X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,
↳ random_state=0)
```

## 1.4 Train model

```
[ ]: pipeline = Pipeline([
    ('scaler', StandardScaler()),
    ('clf', KNeighborsRegressor())
])

#param_grid = {'clf__hidden_layer_sizes': [(10), (10, 20), (10, 5, 15), (20,
↳ 30, 10, 15)], 'clf__alpha': np.arange(1e-3, 1, 0.001),
↳ 'clf__learning_rate_init': np.arange(1e-3, 0.1, 0.001), 'clf__activation':
↳ ['tanh', 'relu']}

param_grid = {'clf__n_neighbors': [5, 10, 15, 20, 40, 60], 'clf__leaf_size':
↳ [10, 15, 20, 30, 45, 50, 60]}

clf = RandomizedSearchCV(pipeline, param_distributions=param_grid, n_iter=30,
↳ n_jobs=10, verbose=3, scoring="neg_mean_squared_error")
```

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

```
Fitting 5 folds for each of 30 candidates, totalling 150 fits
[CV 2/5] END clf__leaf_size=50, clf__n_neighbors=10;; score=-0.104 total time=
1.2s
[CV 3/5] END clf__leaf_size=50, clf__n_neighbors=5;; score=-0.086 total time=
1.2s
[CV 1/5] END clf__leaf_size=50, clf__n_neighbors=5;; score=-0.088 total time=
1.2s
[CV 2/5] END clf__leaf_size=50, clf__n_neighbors=5;; score=-0.091 total time=
1.3s
[CV 5/5] END clf__leaf_size=50, clf__n_neighbors=5;; score=-0.083 total time=
1.3s
[CV 1/5] END clf__leaf_size=50, clf__n_neighbors=10;; score=-0.099 total time=
1.3s
[CV 4/5] END clf__leaf_size=50, clf__n_neighbors=5;; score=-0.102 total time=
1.4s
[CV 3/5] END clf__leaf_size=50, clf__n_neighbors=10;; score=-0.094 total time=
1.4s
[CV 4/5] END clf__leaf_size=50, clf__n_neighbors=10;; score=-0.105 total time=
1.4s
[CV 5/5] END clf__leaf_size=50, clf__n_neighbors=10;; score=-0.092 total time=
1.4s
[CV 1/5] END clf__leaf_size=45, clf__n_neighbors=60;; score=-0.145 total time=
1.0s
[CV 2/5] END clf__leaf_size=45, clf__n_neighbors=60;; score=-0.151 total time=
```

1.0s  
 [CV 1/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=5;; score=-0.088 total time=0.9s  
 [CV 4/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=60;; score=-0.148 total time=1.0s  
 [CV 5/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=60;; score=-0.141 total time=1.0s  
 [CV 2/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=5;; score=-0.091 total time=0.9s  
 [CV 5/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=5;; score=-0.083 total time=0.9s  
 [CV 3/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=5;; score=-0.086 total time=1.0s  
 [CV 3/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=60;; score=-0.150 total time=1.1s  
 [CV 4/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=5;; score=-0.102 total time=1.0s  
 [CV 1/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=10;; score=-0.099 total time=0.9s  
 [CV 2/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=10;; score=-0.104 total time=1.0s  
 [CV 4/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=10;; score=-0.105 total time=0.9s  
 [CV 3/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=10;; score=-0.094 total time=1.1s  
 [CV 4/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=40;; score=-0.134 total time=0.9s  
 [CV 2/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=40;; score=-0.138 total time=1.0s  
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 [CV 5/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=40;; score=-0.127 total time=1.1s  
 [CV 3/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=5;; score=-0.086 total time=0.7s  
 [CV 1/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=5;; score=-0.088 total time=0.9s  
 [CV 5/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=5;; score=-0.083 total time=0.7s  
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 [CV 4/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=5;; score=-0.102 total time=0.9s  
 [CV 1/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=15;; score=-0.108 total time=

0.9s  
[CV 2/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=15;;, score=-0.113 total time=0.9s  
[CV 4/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=15;;, score=-0.111 total time=0.9s  
[CV 3/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=15;;, score=-0.104 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=15;;, score=-0.101 total time=0.9s  
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[CV 4/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=5;;, score=-0.102 total time=1.0s  
[CV 1/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=10;;, score=-0.099 total time=0.9s  
[CV 2/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=10;;, score=-0.104 total time=0.8s  
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[CV 2/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=20;;, score=-0.121 total time=0.8s  
[CV 4/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=20;;, score=-0.118 total time=0.8s  
[CV 1/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=20;;, score=-0.114 total time=0.9s  
[CV 3/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=20;;, score=-0.113 total time=1.0s  
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[CV 1/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=10;;, score=-0.099 total time=0.9s  
[CV 3/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=10;;, score=-0.094 total time=0.7s  
[CV 2/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=10;;, score=-0.104 total time=1.0s  
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[CV 5/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=15;;, score=-0.101 total time=0.9s  
[CV 4/5] END clf\_\_leaf\_size=10, clf\_\_n\_neighbors=15;;, score=-0.111 total time=1.0s  
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1.0s  
[CV 5/5] END clf\_\_leaf\_size=50, clf\_\_n\_neighbors=15;;, score=-0.101 total time=0.9s  
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[CV 3/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=10;;, score=-0.094 total time=0.9s  
[CV 1/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=60;;, score=-0.145 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=45, clf\_\_n\_neighbors=10;;, score=-0.092 total time=1.0s  
[CV 1/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=15;;, score=-0.108 total time=0.8s  
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[CV 2/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=60;;, score=-0.151 total time=1.0s  
[CV 5/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=60;;, score=-0.141 total time=1.0s  
[CV 3/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=60;;, score=-0.150 total time=1.0s  
[CV 4/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=60;;, score=-0.148 total time=1.1s  
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0.7s  
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[CV 4/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=40;;, score=-0.134 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=40;;, score=-0.127 total time=1.0s  
[CV 4/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=10;;, score=-0.105 total time=0.8s  
[CV 2/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=10;;, score=-0.104 total time=1.0s  
[CV 3/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=10;;, score=-0.094 total time=1.0s  
[CV 5/5] END clf\_\_leaf\_size=30, clf\_\_n\_neighbors=10;;, score=-0.092 total time=0.9s  
[CV 4/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=15;;, score=-0.111 total time=0.7s  
[CV 2/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=15;;, score=-0.113 total time=0.9s  
[CV 1/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=15;;, score=-0.108 total time=0.9s  
[CV 3/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=15;;, score=-0.104 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=15;;, score=-0.101 total time=0.8s  
[CV 1/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=40;;, score=-0.133 total time=1.0s  
[CV 2/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=40;;, score=-0.138 total time=1.0s  
[CV 3/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=40;;, score=-0.134 total time=1.0s  
[CV 4/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=40;;, score=-0.134 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=20, clf\_\_n\_neighbors=40;;, score=-0.127 total time=0.9s  
[CV 5/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=60;;, score=-0.141 total time=0.8s  
[CV 1/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=60;;, score=-0.145 total time=1.0s  
[CV 2/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=60;;, score=-0.151 total time=1.0s  
[CV 3/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=60;;, score=-0.150 total time=1.0s  
[CV 4/5] END clf\_\_leaf\_size=15, clf\_\_n\_neighbors=60;;, score=-0.148 total time=1.0s  
[CV 3/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=20;;, score=-0.113 total time=0.7s  
[CV 1/5] END clf\_\_leaf\_size=60, clf\_\_n\_neighbors=20;;, score=-0.114 total time=

```

0.9s
[CV 2/5] END clf__leaf_size=60, clf__n_neighbors=20;;, score=-0.121 total time=
0.9s
[CV 4/5] END clf__leaf_size=60, clf__n_neighbors=20;;, score=-0.118 total time=
0.9s
[CV 5/5] END clf__leaf_size=60, clf__n_neighbors=20;;, score=-0.108 total time=
0.9s
[CV 1/5] END clf__leaf_size=30, clf__n_neighbors=20;;, score=-0.114 total time=
0.8s
[CV 2/5] END clf__leaf_size=30, clf__n_neighbors=20;;, score=-0.121 total time=
0.8s
[CV 4/5] END clf__leaf_size=30, clf__n_neighbors=20;;, score=-0.118 total time=
0.9s
[CV 1/5] END clf__leaf_size=60, clf__n_neighbors=5;;, score=-0.088 total time=
0.9s
[CV 5/5] END clf__leaf_size=30, clf__n_neighbors=20;;, score=-0.108 total time=
0.9s
[CV 3/5] END clf__leaf_size=30, clf__n_neighbors=20;;, score=-0.113 total time=
1.0s
[CV 3/5] END clf__leaf_size=60, clf__n_neighbors=5;;, score=-0.086 total time=
0.8s
[CV 2/5] END clf__leaf_size=60, clf__n_neighbors=5;;, score=-0.091 total time=
0.9s
[CV 4/5] END clf__leaf_size=60, clf__n_neighbors=5;;, score=-0.102 total time=
0.8s
[CV 5/5] END clf__leaf_size=60, clf__n_neighbors=5;;, score=-0.083 total time=
0.6s
[CV 3/5] END clf__leaf_size=15, clf__n_neighbors=5;;, score=-0.086 total time=
0.6s
[CV 4/5] END clf__leaf_size=15, clf__n_neighbors=5;;, score=-0.102 total time=
0.6s
[CV 2/5] END clf__leaf_size=15, clf__n_neighbors=5;;, score=-0.091 total time=
0.8s
[CV 1/5] END clf__leaf_size=15, clf__n_neighbors=5;;, score=-0.088 total time=
0.9s
[CV 5/5] END clf__leaf_size=15, clf__n_neighbors=5;;, score=-0.083 total time=
0.6s

```

```

[ ]: RandomizedSearchCV(estimator=Pipeline(steps=[('scaler', StandardScaler()),
                                                    ('clf', KNeighborsRegressor())]),
                        n_iter=30, n_jobs=10,
                        param_distributions={'clf__leaf_size': [10, 15, 20, 30, 45,
                                                                50, 60],
                                             'clf__n_neighbors': [5, 10, 15, 20, 40,
                                                                60]},
                        scoring='neg_mean_squared_error', verbose=3)

```

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

```
[ ]: -0.08998663923283912
```

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

```
[ ]: {'clf__n_neighbors': 5, 'clf__leaf_size': 50}
```

## 1.5 Test model

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

```
[ ]: -0.1774365638406537
```

```
[ ]: 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=len(X_train.columns) + 1))
```

```
R^2: 0.5456623200193147
```

```
mse: 0.1774365638406537
```

```
rmse: 0.42123219706078224
```

```
mae: 0.28218637542233044
```

```
mape: 0.10649063061565943
```

```
Error estandar: 0.3760388151618439
```

```
[ ]: 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")
```

```

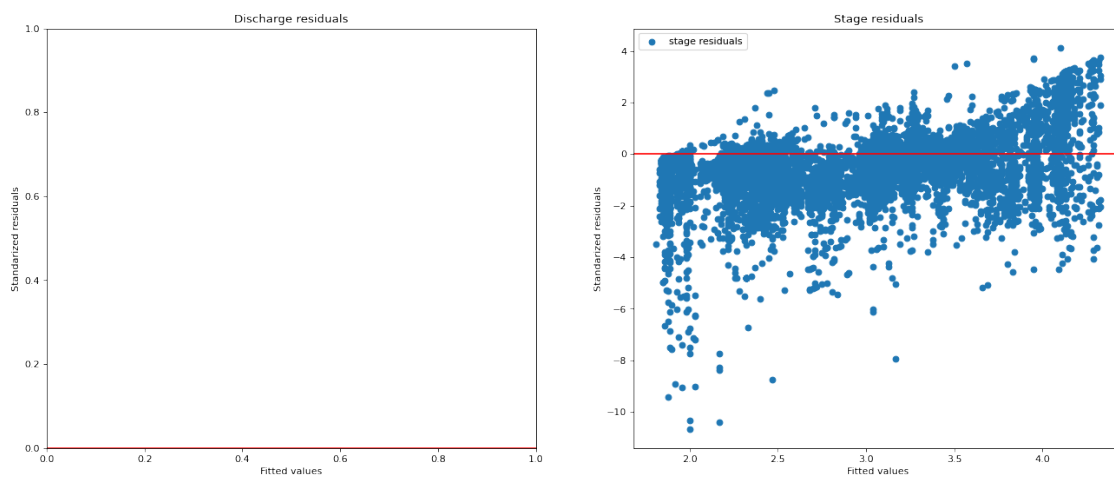
ax[1].axhline(y=0.0, color='r', linestyle='-')
ax[0].axhline(y=0.0, color='r', linestyle='-')

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()

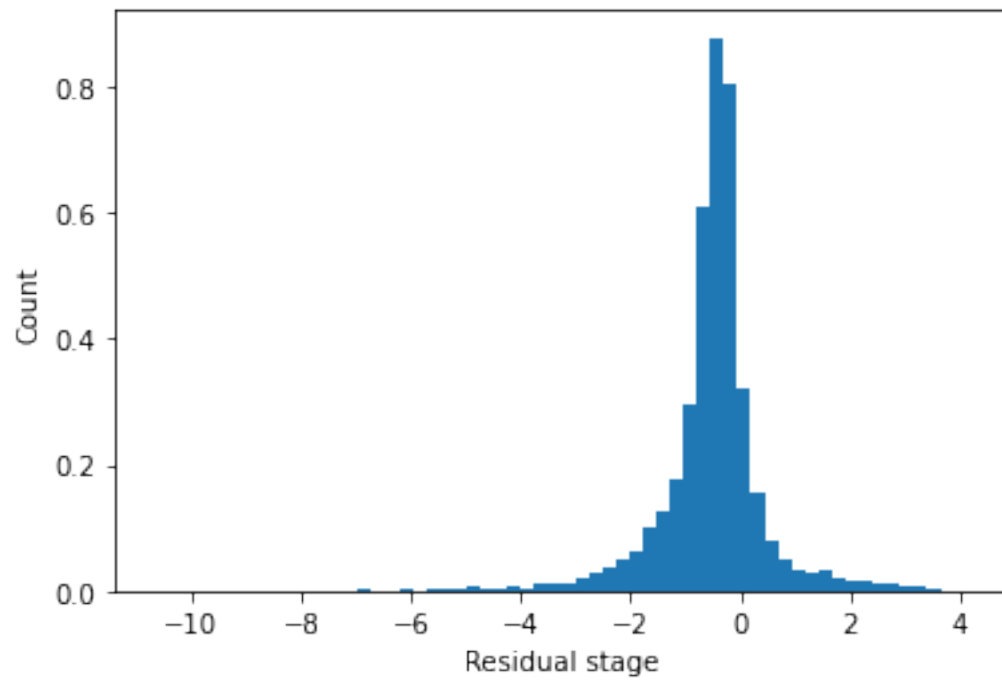
```



```

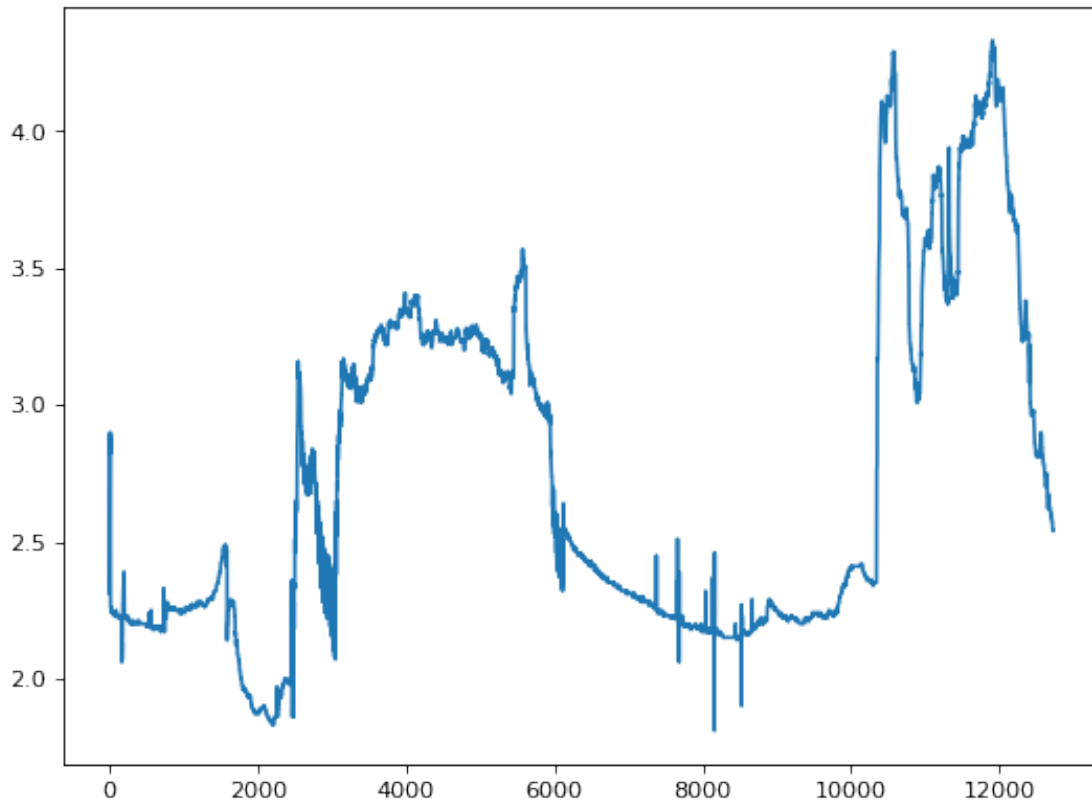
[ ]: plt.hist(residual_stage / residual_stage.std(), density=True, bins = 60)
plt.ylabel('Count')
plt.xlabel('Residual stage');
plt.show()

```



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

```
[ ]: [ <matplotlib.lines.Line2D at 0x7f81cf7dcd60>]
```



```
[ ]: 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")

ax[0].legend()
ax[1].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.

