Московский государственный технический университет им. Н.Э. Баумана

Факультет «Радиотехнический»
Кафедра ИУ5 «Системы обработки информации и управления»

Курс «Технологии машинного обучения»

Отчёт по лабораторной работе №6
«Анализ и прогнозирование временного ряда.»

Выполнил:
студент группы РТ5-61Б
Агеев Алексей
Подпись и дата:

Проверил:
преподаватель каф. ИУ5
Гапанюк Ю.Е.
Подпись и дата:

Москва, 2023 г

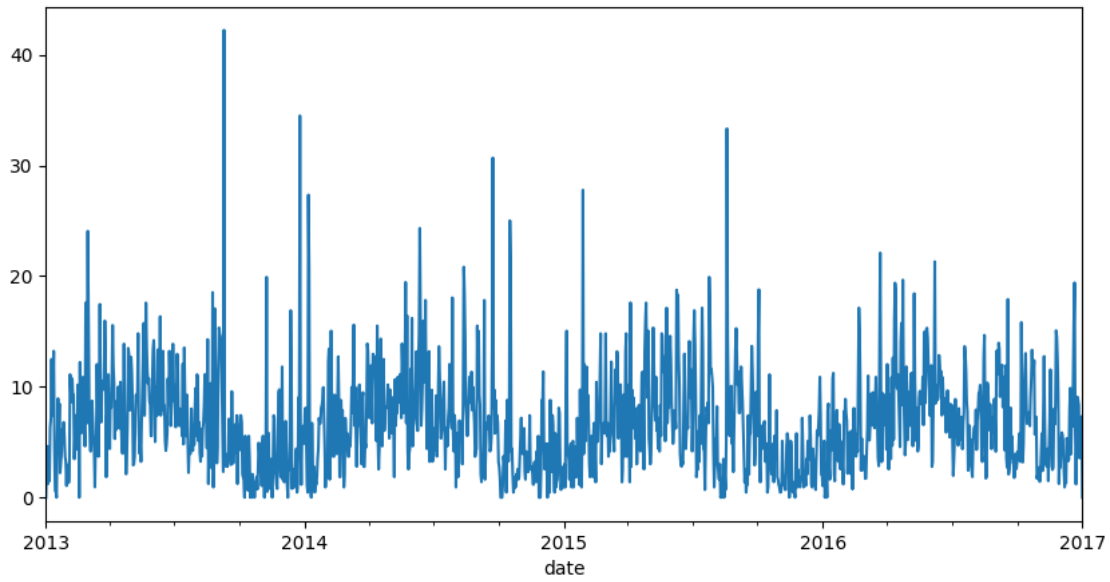
Описание задания

1. Выберите набор данных (датасет) для решения задачи прогнозирования временного ряда.
2. Визуализируйте временной ряд и его основные характеристики.
3. Разделите временной ряд на обучающую и тестовую выборку.
4. Произведите прогнозирование временного ряда с использованием как минимум двух методов.
5. Визуализируйте тестовую выборку и каждый из прогнозов.
6. Оцените качество прогноза в каждом случае с помощью метрик.

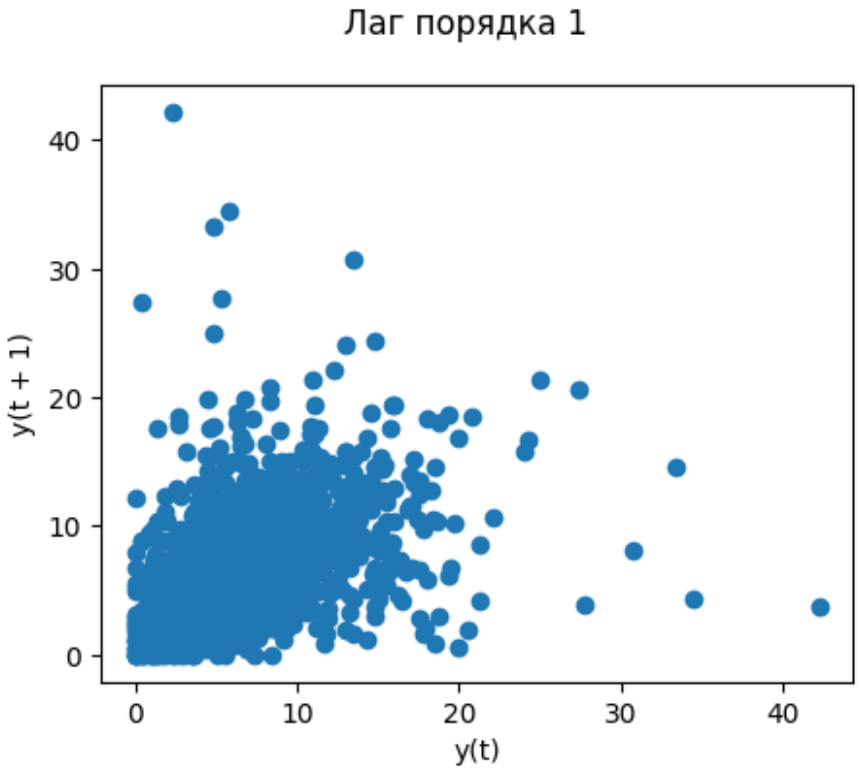
Ход работы

```
import numpy as np
import pandas as pd
from matplotlib import pyplot
import matplotlib.pyplot as plt

def clear(data):
    data['humidity'] = None
    data['meantemp'] = None
    data['meanpressure'] = None

data_start = pd.read_csv('DailyDelhiClimateTrain.csv', header=0, index_col=0,
parse_dates=True)

clear(data_start)

data_test = pd.read_csv('DailyDelhiClimateTest.csv', header=0, index_col=0, p
arse_dates=True)
clear(data_test)

data_train = data_start['wind_speed']

data_train.head()

date
2013-01-01    0.000000
2013-01-02    2.980000
2013-01-03    4.633333
2013-01-04    1.233333
2013-01-05    3.700000
Name: wind_speed, dtype: float64

fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Временной ряд в виде графика')
data_train.plot(ax=ax, legend=False)
pyplot.show()
```

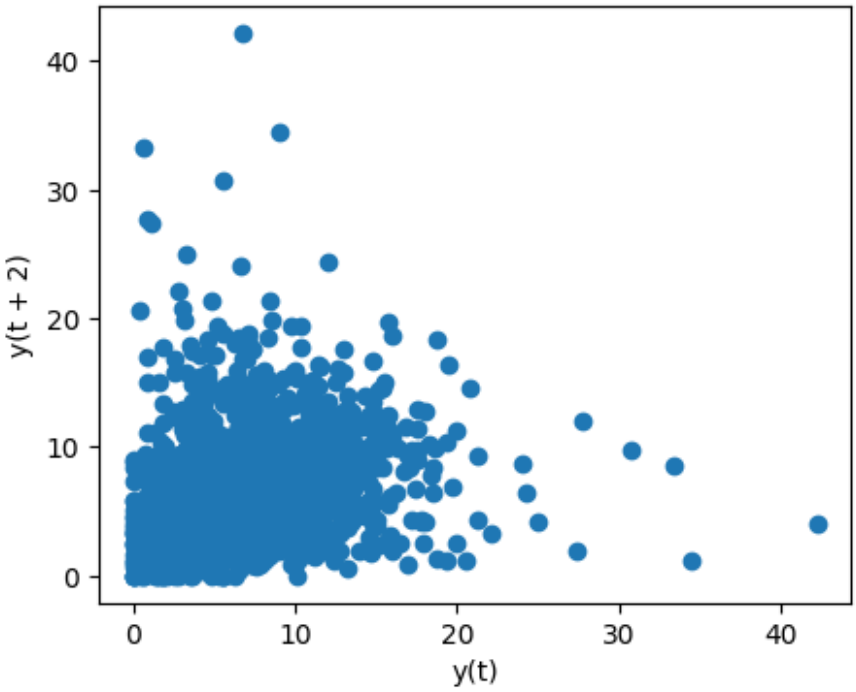
Временной ряд в виде графика



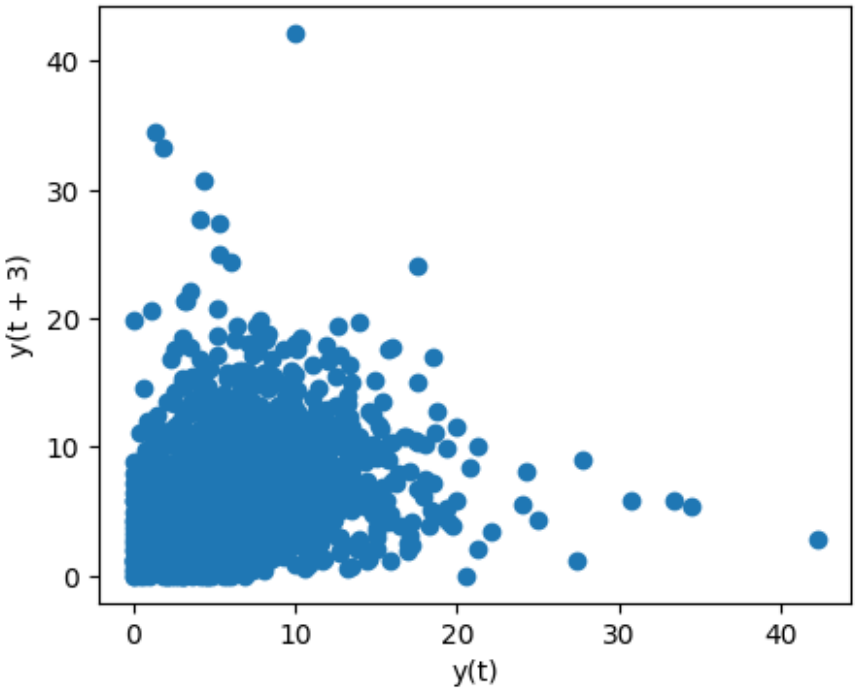

```
for i in range(1, 5):
    fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(5,4)
)
    fig.suptitle(f'Лаг порядка {i}')
    pd.plotting.lag_plot(data_train, lag=i, ax=ax)
    pyplot.show()
```

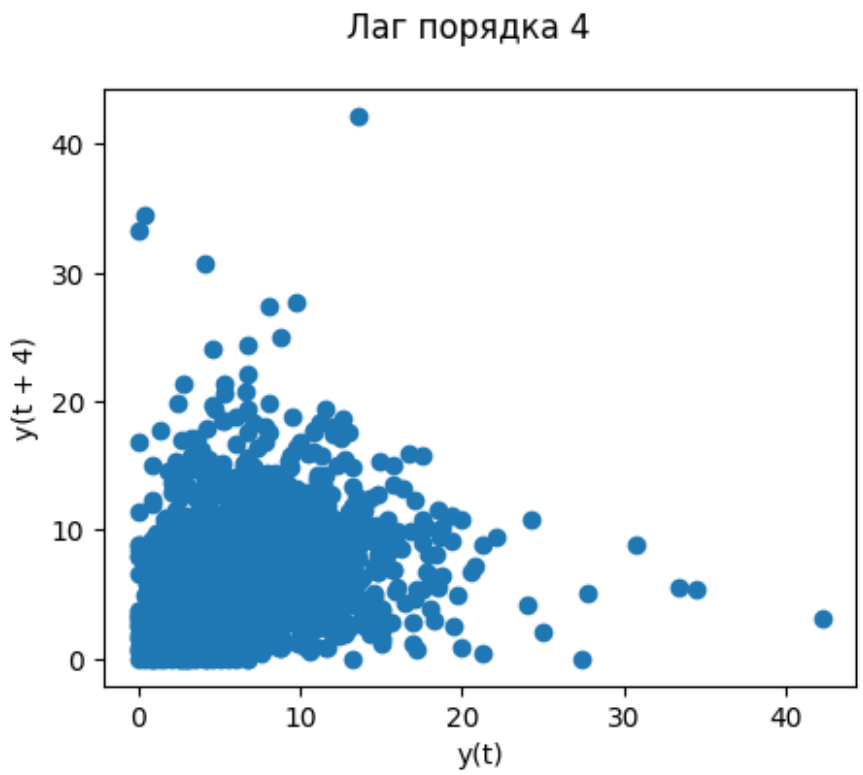


Лаг порядка 2

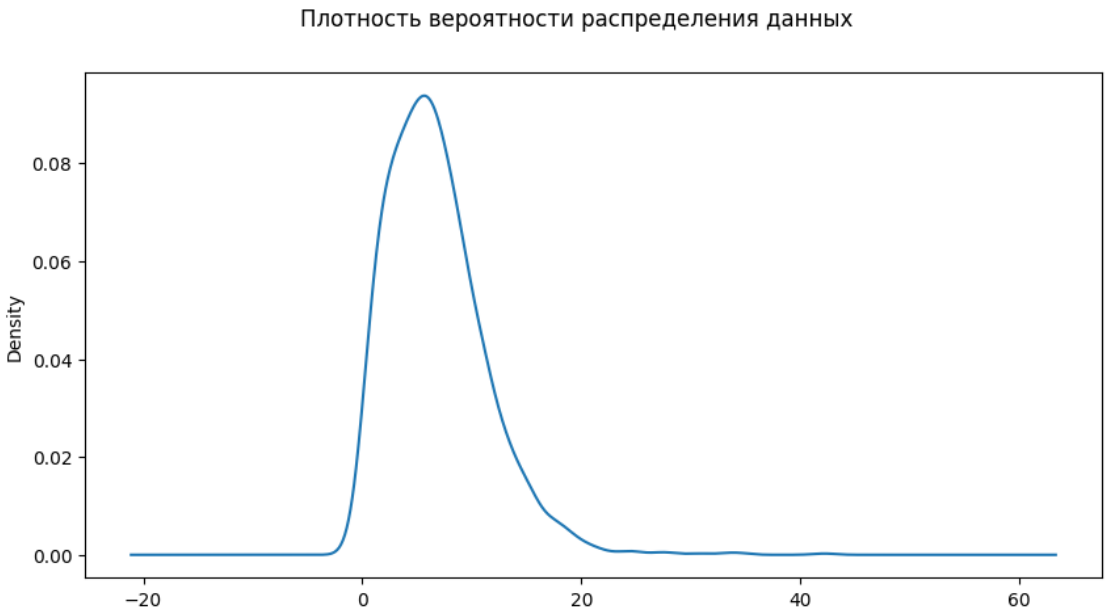


Лаг порядка 3

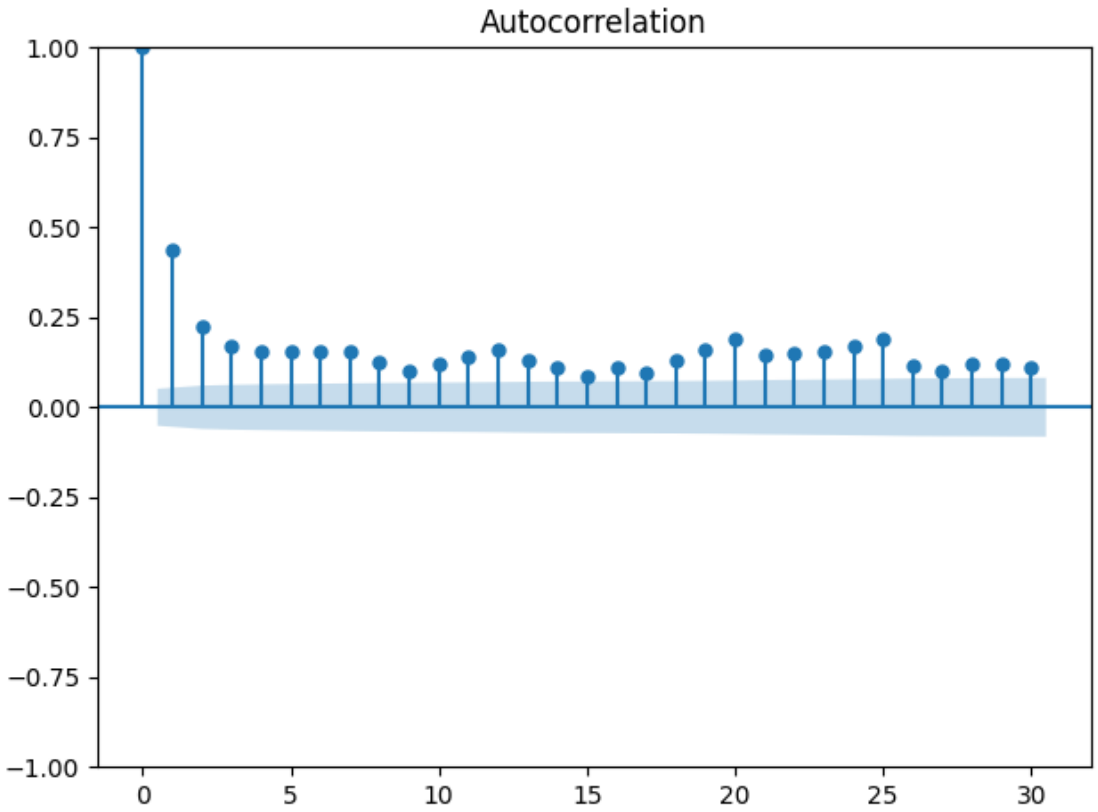




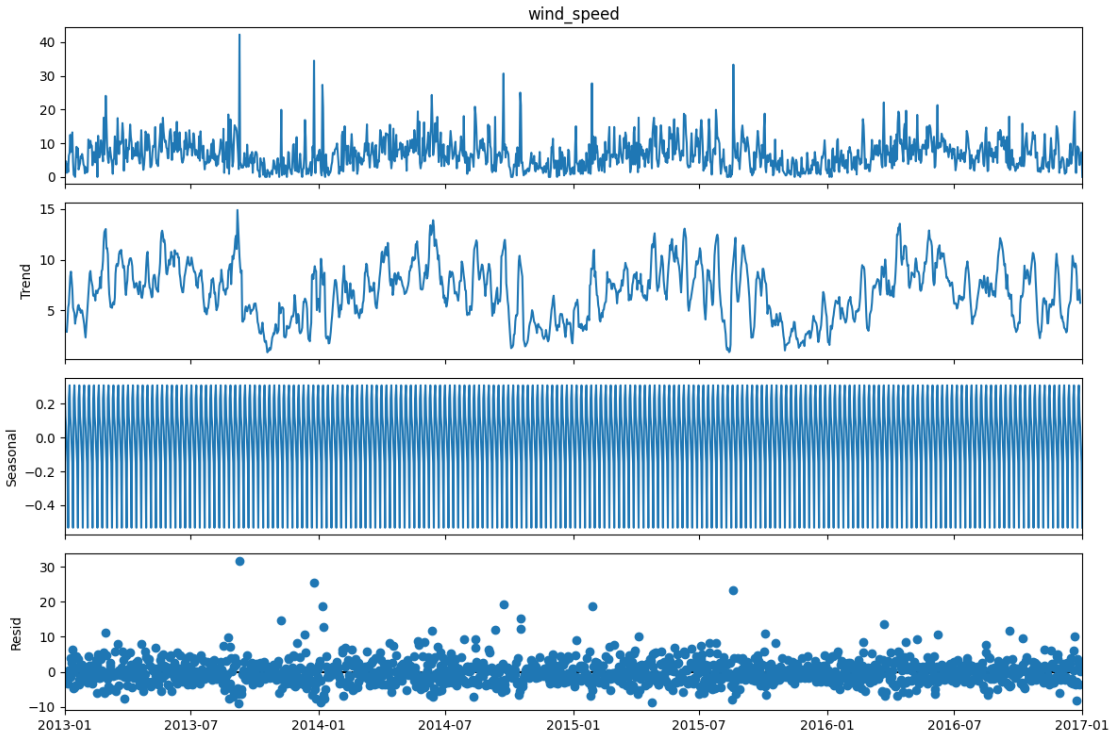

```
fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Плотность вероятности распределения данных')
data_train.plot(ax=ax, kind='kde', legend=False)
pyplot.show()
```




```
from statsmodels.graphics.tsaplots import plot_acf
plot_acf(data_train, lags=30)
plt.tight_layout()
```



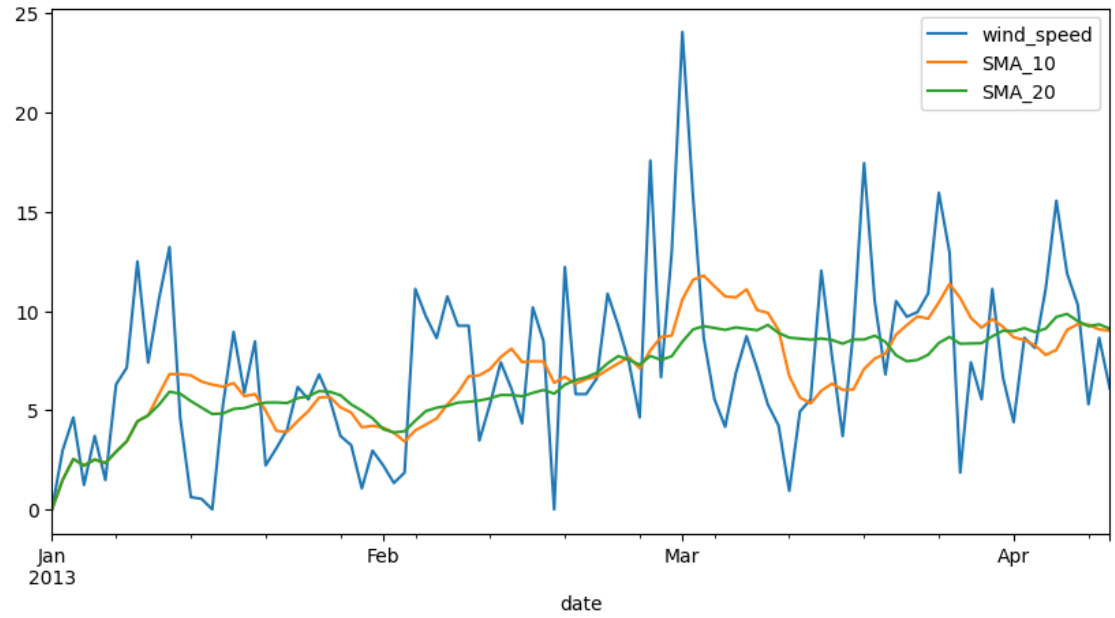

```
# https://www.statsmodels.org/dev/generated/statsmodels.tsa.seasonal.seasonal
_decompose.html
from statsmodels.tsa.seasonal import seasonal_decompose
# Аддитивная модель
def plot_decompose(data=data_train, model='add'):
    result_add = seasonal_decompose(data, model = 'add')
    fig = result_add.plot()
    fig.set_size_inches((12, 8))
    # Перерисовка
    fig.tight_layout()
    plt.show()

plot_decompose()
```




```
data_train2 = data_start.copy()

# Простое скользящее среднее (SMA)
data_train2['SMA_10'] = data_train2['wind_speed'].rolling(10, min_periods=1).
mean()
data_train2['SMA_20'] = data_train2['wind_speed'].rolling(20, min_periods=1).
mean()

print(data_train2)

fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Временной ряд со скользящими средними')
data_train2[:100].plot(ax=ax, legend=True)
pyplot.show()
```

```
            meantemp humidity  wind_speed meanpressure    SMA_10    SMA_20
date
2013-01-01      None     None    0.000000         None  0.000000  0.000000
2013-01-02      None     None    2.980000         None  1.490000  1.490000
2013-01-03      None     None    4.633333         None  2.537778  2.537778
2013-01-04      None     None    1.233333         None  2.211667  2.211667
2013-01-05      None     None    3.700000         None  2.509333  2.509333
...              ...      ...         ...          ...       ...       ...
2016-12-28      None     None    3.547826         None  8.812007  7.059632
2016-12-29      None     None    6.000000         None  8.370578  7.294007
2016-12-30      None     None    6.266667         None  7.404578  7.339562
2016-12-31      None     None    7.325000         None  6.196602  7.469979
2017-01-01      None     None    0.000000         None  5.578507  7.305888

[1462 rows x 6 columns]
```

Временной ряд со скользящими средними




```
from gplearn.genetic import SymbolicRegressor
xnum = list(range(data_train.shape[0]))
print(data_train)

function_set = ['add', 'sub', 'mul', 'div', 'sin']
est_gp = SymbolicRegressor(population_size=2000, metric='mse',
                           generations=40, stopping_criteria=0.01,
                           init_depth=(5, 10), verbose=1, function_set=fu
nction_set,
                           const_range=(-100, 100), random_state=0)

date
2013-01-01    0.000000
2013-01-02    2.980000
2013-01-03    4.633333
2013-01-04    1.233333
2013-01-05    3.700000
                ...
2016-12-28    3.547826
2016-12-29    6.000000
2016-12-30    6.266667
2016-12-31    7.325000
2017-01-01    0.000000
Name: wind_speed, Length: 1462, dtype: float64

est_gp.fit(np.array(xnum).reshape(-1, 1), data_train.values.reshape(-1, 1))

C:\Users\prite\AppData\Local\Packages\PythonSoftwareFoundation.Python.3.9_qbz
5n2kfra8p0\LocalCache\local-packages\Python39\site-packages\sklearn\utils\val
idation.py:1143: DataConversionWarning: A column-vector y was passed when a 1
d array was expected. Please change the shape of y to (n_samples, ), for exam
ple using ravel().
  y = column_or_1d(y, warn=True)

    |   Population Average    |             Best Individual              |
---- ------------------------- ------------------------------------------ ---
```

```
-------
 Gen    Length          Fitness   Length          Fitness      OOB Fitness  Ti
me Left
   0   297.43      9.43328e+84       39           28.775              N/A
12.86m
   1   143.69      6.80794e+24        1            21.19              N/A
4.81m
   2   166.51      1.14107e+28       31          21.1583              N/A
4.89m
   3    61.78      1.19262e+30       54          20.7418              N/A
2.44m
   4    66.11       3.8987e+27       49          20.7036              N/A
2.45m
   5    48.95      1.40798e+18       89          20.3482              N/A
2.31m
   6    45.22      7.09192e+18       94          20.3169              N/A
2.12m
   7    53.20      5.62913e+09       94          20.1546              N/A
2.48m
   8    74.17      5.39694e+12       94          20.0701              N/A
2.45m
   9    96.85      1.53548e+09       94          20.0701              N/A
3.23m
  10   100.87      2.33378e+09       95          19.6012              N/A
2.71m
  11   105.54      1.22694e+09       95          19.6012              N/A
3.00m
  12   107.11      6.42066e+07       92          19.5817              N/A
2.64m
  13   109.15      1.54232e+10      101          19.5498              N/A
2.89m
  14   108.67      3.11581e+08      197           19.353              N/A
2.64m
  15   102.74      5.36926e+20      197           19.348              N/A
2.60m
  16   111.07      2.47606e+11      166           19.095              N/A
2.78m
  17   159.09       1.5796e+08      176          19.0736              N/A
3.32m
  18   180.97      6.10213e+08      334          18.9785              N/A
3.45m
  19   162.14      8.20035e+06      347           18.901              N/A
3.00m
  20   170.77      6.43466e+08      174           18.571              N/A
2.88m
  21   174.03      3.83843e+10      173           18.555              N/A
2.75m
  22   177.52      1.52191e+14      160          18.4278              N/A
2.81m
  23   189.01      2.33866e+08      253          18.1846              N/A
2.81m
  24   180.82       5.1718e+06      339          18.1173              N/A
2.42m
  25   182.46      3.32823e+08      228          18.0277              N/A
2.18m
  26   203.65      1.25802e+11      258           17.845              N/A
```

```
2.23m
  27   231.16      3.07297e+08      285           17.772              N/A
2.37m
  28   218.41      2.70998e+06      296          17.7681              N/A
2.10m
  29   218.16      3.05825e+08      414          17.6717              N/A
1.98m
  30   246.08      1.26852e+09      282          17.6014              N/A
1.95m
  31   246.72       1.1634e+06      412          17.5028              N/A
1.80m
  32   238.89      1.24001e+06      412          17.5028              N/A
1.41m
  33   236.99      2.59995e+06      506          17.4542              N/A
1.18m
  34   233.55           690935      287          17.4636              N/A
1.04m
  35   219.81      7.32465e+06      259          17.4514              N/A
43.18s
  36   209.18      1.04928e+14      267          17.4386              N/A
34.33s
  37   209.59      5.16712e+06      284          17.4153              N/A
22.15s
  38   220.14      1.84657e+06      275          17.3796              N/A
12.33s
  39   224.67      6.65885e+08      304          17.3242              N/A
0.00s

SymbolicRegressor(const_range=(-100, 100),
                  function_set=['add', 'sub', 'mul', 'div', 'sin'],
                  generations=40, init_depth=(5, 10), metric='mse',
                  population_size=3000, random_state=0, stopping_criteria=0.0
1,
                  verbose=1)
```

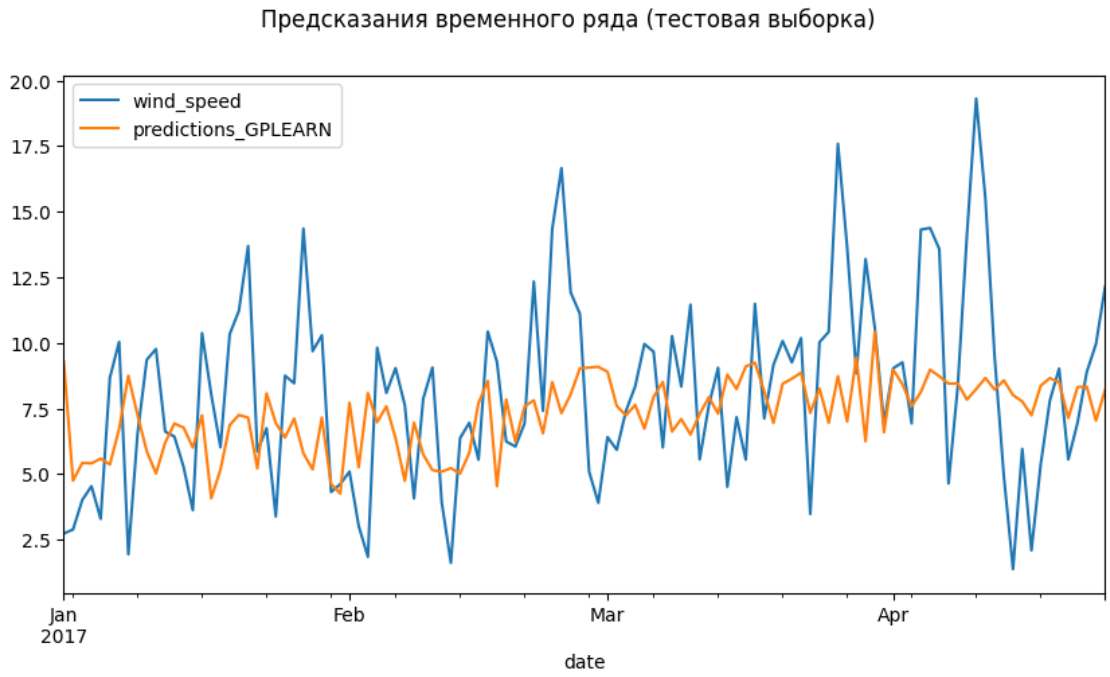
```
import graphviz
dot_data = est_gp._program.export_graphviz()
graph = graphviz.Source(dot_data)
graph
```

```
xnum_test = list(range(data_test.shape[0]))
# Предсказания
y_gp = est_gp.predict(np.array(xnum_test).reshape(-1, 1))
y_gp[:10]
```

```
mean_squared_error(test, y_gp, squared=False)
```

```
3.6427624900222955
```

```
# Записываем предсказания в DataFrame
data_test['predictions_GPLEARN'] = list(y_gp)

fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Предсказания временного ряда (тестовая выборка)')
data_test.plot(ax=ax, legend=True)
pyplot.show()
```




```
# Целочисленная метка шкалы времени
xnum = list(range(data_start.shape[0] + data_test.shape[0]))
# Разделение выборки на обучающую и тестовую
train_size = len(data_start)
train, test = data_start['wind_speed'].values, data_test['wind_speed'].values
history_arima = [x for x in train]
history_es = [x for x in train]

print(train)
print(test)
```

```
[0.         2.98       4.63333333 ... 6.26666667 7.325      0.        ]
[ 2.74347826  2.89444444  4.01666667  4.545       3.3         8.68181818
 10.04166667  1.95        6.54285714  9.36111111  9.77222222  6.62631579
  6.43529412  5.276       3.63043478 10.38        8.03888889  6.02916667
 10.33809524 11.22631579 13.69565217  5.868       6.75294118  3.39130435
  8.756       8.46785714 14.35833333  9.69090909 10.29444444  4.32222222
  4.625       5.1         3.02727273  1.85454545  9.82        8.1
  9.04444444  7.6375      4.08        7.875       9.06666667  3.95
  1.625       6.37777778  6.9625      5.55714286 10.4375      9.28
  6.25        6.05454545  6.9375     12.34166667  7.4125     14.35
 16.6625     11.92857143 11.1125      5.1         3.91111111  6.41538462
  5.93        7.4125      8.35        9.9625      9.66666667  6.025
```

```
 10.26363636  8.34285714 11.4625      5.56666667  7.6375      9.05555556
  4.52222222  7.175       5.56        11.49        7.12307692  9.16111111
 10.07777778  9.2625     10.1875      3.4875      10.03333333 10.425
 17.59        13.65       8.84444444 13.2         10.58571429  6.95
  9.0375      9.2625      6.9375      14.32        14.38461538 13.57777778
  4.65        8.3375     14.125       19.31428571 15.5125      9.4875
  4.94444444  1.3875      5.96666667  2.1          5.36666667  7.81111111
  9.025       5.5625      6.9625      8.89         9.9625     12.15714286]
```

```
from sklearn.metrics import mean_squared_error
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.holtwinters import ExponentialSmoothing

# Параметры модели (p,d,q)
arima_order = (6,1,0)
# Формирование предсказаний
predictions_arima = list()
for t in range(len(test)):
    model_arima = ARIMA(history_arima, order=arima_order)
    model_arima_fit = model_arima.fit()
    yhat_arima = model_arima_fit.forecast()[0]
    predictions_arima.append(yhat_arima)
    history_arima.append(test[t])
# Вычисление метрики RMSE

mean_squared_error(test, predictions_arima, squared=False)
```

```
3.3452863559955994
```

```
data_test['predictions_ARIMA'] = list(predictions_arima)

fig, ax = pyplot.subplots(1, 1, sharex='col', sharey='row', figsize=(10,5))
fig.suptitle('Предсказания временного ряда (тестовая выборка)')
data_test.plot(ax=ax, legend=True)
pyplot.show()
```