NO2

November 30, 2017

```
In [1]: import numpy as np
        import pandas as pd
        import os
        import matplotlib.pyplot as plt

In [2]: os.listdir('data')

Out[2]: ['AllNO2_QH.csv',
         'AllPM_QH.csv',
         'Env_QH.csv',
         'GradientTemp_15minDataSet.csv',
         'micro_sud3.pkl',
         'micro_sud3_normalized.pkl',
         'Patm_15minDataSet.csv',
         'pickles']

In [3]: df = pd.read_pickle('data/micro_sud3_normalized.pkl')
        df = df.reset_index()
        df.head(100)

Out[3]:     index                 date  PM_ref   PM_6182   PM_6179   PM_617B  \
        0      15  2017-09-28 14:00:00    16.2 -1.178505 -1.137844 -1.134624
        1      16  2017-09-28 14:15:00     9.6 -1.108262 -1.085060 -1.121956
        2      17  2017-09-28 14:30:00    10.3 -1.178505 -1.169515 -1.257077
        3      18  2017-09-28 14:45:00     9.4 -1.137530 -1.000606 -1.206407
        4      19  2017-09-28 15:00:00    10.7 -1.166798 -1.164236 -1.138846
        5      20  2017-09-28 15:15:00    10.7 -1.166798 -1.201185 -1.037506
        6      21  2017-09-28 15:30:00     9.6 -1.078994 -1.169515 -1.007948
        7      22  2017-09-28 15:45:00    10.2 -1.032164 -1.132566 -0.995280
        8      23  2017-09-28 16:00:00     9.8 -1.043872 -1.095617 -0.910830
        9      24  2017-09-28 16:15:00     8.9 -1.043872 -1.042833 -1.181072
        10     25  2017-09-28 16:30:00     9.8 -0.915092 -0.889760 -1.185294
        11     26  2017-09-28 16:45:00    10.1 -0.920945 -0.784192 -1.029061
        12     27  2017-09-28 17:00:00    10.7 -0.862409 -0.842254 -0.969945
        13     28  2017-09-28 17:15:00    12.0 -0.932653 -0.778913 -0.915052
        14     29  2017-09-28 17:30:00    12.3 -0.903385 -0.905595 -0.817934
        15     30  2017-09-28 17:45:00    13.7 -0.967775 -0.805305 -0.843269
        16     31  2017-09-28 18:00:00    14.3 -0.698507 -0.615283 -0.910830
```

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17     32  2017-09-28 18:15:00    14.7 -0.885824 -0.662789 -0.847492
18     38  2017-09-28 19:45:00     9.4 -0.751190 -0.625840 -0.796821
19     39  2017-09-28 20:00:00    20.1 -0.827287 -0.757800 -0.813711
20     40  2017-09-28 20:15:00    20.0 -0.721922 -0.794749 -0.906607
21     41  2017-09-28 20:30:00    19.2 -0.598996 -0.757800 -0.915052
22     42  2017-09-28 20:45:00    17.9 -0.803873 -0.889760 -0.898162
23     43  2017-09-28 21:00:00    16.0 -0.757044 -0.842254 -0.733483
24     44  2017-09-28 21:15:00    16.0 -0.798019 -0.858089 -0.695481
25     45  2017-09-28 21:30:00    17.0 -0.973628 -0.873925 -0.670145
26     46  2017-09-28 21:45:00    18.5 -0.838995 -0.810584 -0.657478
27     47  2017-09-28 22:00:00    18.6 -0.838995 -0.831697 -0.678591
28     48  2017-09-28 22:15:00    18.8 -0.622410 -0.678624 -0.535024
29     49  2017-09-28 22:30:00    18.5 -0.657532 -0.652232 -0.678591
..    ...                  ...     ...       ...       ...       ...
70     94  2017-09-29 09:45:00    26.6 -0.236071 -0.018825 -0.146552
71     95  2017-09-29 10:00:00    29.4 -0.236071 -0.134949 -0.311230
72     96  2017-09-29 10:15:00    29.9 -0.165827  0.033959 -0.370346
73     97  2017-09-29 10:30:00    30.1 -0.066315  0.023403 -0.218335
74     98  2017-09-29 10:45:00    29.7 -0.253631 -0.024103  0.056130
75     99  2017-09-29 11:00:00    27.5 -0.095583  0.134249 -0.176109
76    100  2017-09-29 11:15:00    26.4 -0.095583  0.213425 -0.150774
77    101  2017-09-29 11:30:00    26.3 -0.037047  0.313714 -0.015653
78    102  2017-09-29 11:45:00    28.0 -0.312168  0.055073 -0.129661
79    103  2017-09-29 12:00:00    28.8 -0.277046 -0.177176 -0.345011
80    106  2017-09-29 12:45:00    24.9 -0.312168 -0.076887 -0.450574
81    107  2017-09-29 13:00:00    23.0 -0.470216 -0.156063 -0.302785
82    108  2017-09-29 13:15:00    22.5 -0.645825 -0.467488 -0.391458
83    109  2017-09-29 13:30:00    20.9 -0.874116 -0.810584 -0.712371
84    110  2017-09-29 13:45:00    18.9 -0.897531 -0.794749 -0.953055
85    111  2017-09-29 14:00:00    17.4 -0.604849 -0.768357 -0.893940
86    112  2017-09-29 14:15:00    16.4 -0.680947 -0.678624 -0.991058
87    113  2017-09-29 14:30:00    18.4 -0.879970 -0.546664 -0.995280
88    114  2017-09-29 14:45:00    19.3 -0.774605 -0.573056 -0.868604
89    115  2017-09-29 15:00:00    19.9 -0.704361 -0.536107 -0.716593
90    116  2017-09-29 15:15:00    19.9 -0.581435 -0.778913 -0.771486
91    117  2017-09-29 15:30:00    18.9 -0.405826 -0.710294 -0.868604
92    118  2017-09-29 15:45:00    20.1 -0.575581 -0.414704 -0.817934
93    119  2017-09-29 16:00:00    22.6 -0.692654 -0.483323 -0.649033
94    120  2017-09-29 16:15:00    23.9 -0.446801 -0.610005 -0.767264
95    121  2017-09-29 16:30:00    25.7 -0.429240 -0.076887 -0.450574
96    122  2017-09-29 16:45:00    26.4  0.173684  0.355941  0.187028
97    123  2017-09-29 17:00:00    29.3  0.144416  0.398169  0.524831
98    124  2017-09-29 17:15:00    31.2 -0.259485  0.334828  0.305259
99    125  2017-09-29 17:30:00    30.7 -0.054608  0.387612  0.305259

    PM25_6182  PM25_6179  PM25_617B  NO2_ref  NO2_61FD  NO2_61F0  NO2_61EF  \
0   -1.183081  -1.128074  -1.148204     10.1 -0.392423 -0.621107 -0.419097
1   -1.101652  -1.071229  -1.128278      9.9 -0.392423 -0.621107 -0.419097
```

```
2    -1.176817  -1.167865  -1.252817     16.1 -0.392423 -0.621107 -0.419097
3    -1.139235  -1.008700  -1.222928     10.9 -0.392423 -0.621107 -0.419097
4    -1.164290  -1.167865  -1.148204     16.0 -0.392423 -0.621107 -0.419097
5    -1.158026  -1.196288  -1.038610      9.7 -0.392423 -0.621107 -0.419097
6    -1.070333  -1.162181  -0.998757     10.0 -0.392423 -0.621107 -0.419097
7    -1.032750  -1.122389  -0.988794     19.1 -0.392423 -0.621107 -0.419097
8    -1.039014  -1.093967  -0.919052     15.0 -0.392423 -0.621107 -0.419097
9    -1.039014  -1.037122  -1.173112     19.4 -0.392423 -0.621107 -0.419097
10   -0.913739  -0.889325  -1.178094     20.6 -0.392423 -0.621107 -0.419097
11   -0.926266  -0.787005  -1.013702     17.3 -0.392423 -0.576624 -0.419097
12   -0.869892  -0.843850  -0.963886     16.3 -0.392423 -0.621107 -0.419097
13   -0.932530  -0.775636  -0.914070     16.4 -0.392423 -0.621107 -0.419097
14   -0.901211  -0.900694  -0.814439     22.0 -0.392423 -0.621107 -0.419097
15   -0.963849  -0.804058  -0.844329     28.2 -0.392423 -0.525787 -0.419097
16   -0.688243  -0.616470  -0.904107     27.1 -0.392423 -0.589334 -0.419097
17   -0.876156  -0.667631  -0.839347     21.9 -0.392423 -0.589334 -0.419097
18   -0.744617  -0.616470  -0.794513     32.4 -0.392423 -0.363744 -0.419097
19   -0.826046  -0.741529  -0.819421     37.0 -0.392423 -0.427290 -0.419097
20   -0.725825  -0.787005  -0.889163     27.5 -0.392423 -0.576624 -0.419097
21   -0.600550  -0.752898  -0.914070     25.6 -0.392423 -0.589334 -0.419097
22   -0.807254  -0.895010  -0.899126     27.3 -0.392423 -0.621107 -0.419097
23   -0.750880  -0.838165  -0.729752     26.3 -0.392423 -0.589334 -0.419097
24   -0.788463  -0.860903  -0.684918     27.0 -0.392423 -0.621107 -0.419097
25   -0.963849  -0.872272  -0.655029     25.7 -0.392423 -0.621107 -0.419097
26   -0.832310  -0.809743  -0.660010     23.2 -0.392423 -0.621107 -0.419097
27   -0.838573  -0.821112  -0.674955     21.2 -0.392423 -0.621107 -0.419097
28   -0.619341  -0.684684  -0.540453     20.8 -0.392423 -0.621107 -0.419097
29   -0.663188  -0.656262  -0.674955     22.3 -0.392423 -0.621107 -0.419097
..         ...        ...        ...      ...       ...       ...       ...
70   -0.243514  -0.025284  -0.156872     40.8 -0.392423 -0.106382 -0.419097
71   -0.243514  -0.150342  -0.311301     29.2 -0.392423 -0.459064 -0.419097
72   -0.168349   0.014508  -0.381043     32.3 -0.392423 -0.331971 -0.266085
73   -0.086920   0.020192  -0.206688     27.2 -0.392423 -0.363744 -0.419097
74   -0.262306  -0.002546   0.062317     20.5 -0.392423 -0.427290 -0.419097
75   -0.099448   0.133882  -0.161853     12.3 -0.392423 -0.621107 -0.419097
76   -0.086920   0.207780  -0.161853     16.2 -0.392423 -0.621107 -0.419097
77   -0.024282   0.298732  -0.017388     32.0 -0.392423 -0.192169 -0.419097
78   -0.299888   0.054299  -0.131964     17.8 -0.392423 -0.621107 -0.419097
79   -0.268570  -0.167396  -0.341190     30.7 -0.392423 -0.459064 -0.419097
80   -0.299888  -0.087813  -0.440821     21.3 -0.392423 -0.589334 -0.419097
81   -0.462747  -0.161711  -0.301337     14.3 -0.392423 -0.589334 -0.419097
82   -0.644396  -0.468674  -0.381043     16.1 -0.392423 -0.621107 -0.419097
83   -0.863628  -0.792689  -0.689900      8.9 -0.392423 -0.621107 -0.419097
84   -0.888684  -0.792689  -0.948941     11.6 -0.392423 -0.621107 -0.419097
85   -0.606814  -0.764267  -0.889163     13.5 -0.392423 -0.621107 -0.419097
86   -0.688243  -0.696053  -0.963886     17.2 -0.392423 -0.557560 -0.419097
87   -0.876156  -0.553941  -0.983812     12.2 -0.392423 -0.621107 -0.419097
88   -0.763408  -0.582363  -0.864255     21.3 -0.392423 -0.621107 -0.419097
```

```
89  -0.694506  -0.553941  -0.729752     18.6 -0.392423 -0.621107 -0.419097
90  -0.575495  -0.781320  -0.774587     25.7 -0.392423 -0.589334 -0.419097
91  -0.400109  -0.701737  -0.864255     45.4 -0.331906  0.344797 -0.209981
92  -0.575495  -0.411829  -0.814439     49.9 -0.350061 -0.071431 -0.419097
93  -0.688243  -0.497096  -0.635103     58.8 -0.271390  0.668883 -0.317089
94  -0.462747  -0.627839  -0.749679     50.4  0.097758 -0.007885  0.203151
95  -0.431428  -0.087813  -0.440821     77.2  0.466906  0.668883  0.565278
96   0.176159   0.327154   0.186856     86.4  1.017602  1.269396  1.600657
97   0.144840   0.389684   0.505677     88.7  1.084170  0.506840  2.013788
98  -0.262306   0.349892   0.296451     87.3  1.326234  1.765057  1.804672
99  -0.049337   0.401053   0.281506    124.1  3.044891  2.861231  3.344989

        temp        rh     tgrad  pressure    pluvio
0   1.986031 -1.114144 -0.922393  0.315942 -0.150524
1   2.057032 -1.123212 -0.977185  0.335134 -0.150524
2   2.080699 -1.232038 -1.086769  0.315942 -0.150524
3   2.009698 -1.259245 -0.812809  0.315942 -0.150524
4   1.867697 -1.141350 -0.922393  0.315942 -0.150524
5   1.749363 -1.050662 -0.867601  0.315942 -0.150524
6   1.654695 -0.959974 -0.812809  0.315942 -0.150524
7   1.583695 -0.887423 -0.758017  0.315942 -0.150524
8   1.536361 -0.851148 -0.758017  0.315942 -0.150524
9   1.489027 -0.851148 -0.703225  0.335134 -0.150524
10  1.441693 -0.805804 -0.648433  0.315942 -0.150524
11  1.370693 -0.715116 -0.648433  0.315942 -0.150524
12  1.299692 -0.642565 -0.648433  0.335134 -0.150524
13  1.228692 -0.506533 -0.593641  0.335134 -0.150524
14  1.134024 -0.397707 -0.538849  0.354326 -0.150524
15  1.063024 -0.288882 -0.429265  0.354326 -0.150524
16  0.992023 -0.189125 -0.319681  0.373518 -0.150524
17  0.921022 -0.044024 -0.264889  0.392710 -0.150524
18  0.613353  0.382210  0.009071  0.431095 -0.150524
19  0.566019  0.427554 -0.155305  0.431095 -0.150524
20  0.518686  0.509174  0.009071  0.431095 -0.150524
21  0.495019  0.554518  0.063863  0.431095 -0.150524
22  0.495019  0.581724  0.173447  0.431095 -0.150524
23  0.471352  0.581724  0.118655  0.431095 -0.150524
24  0.471352  0.636137  0.009071  0.411902 -0.150524
25  0.447685  0.672412  0.173447  0.392710 -0.150524
26  0.447685  0.672412  0.118655  0.392710 -0.150524
27  0.471352  0.672412  0.228239  0.392710 -0.150524
28  0.471352  0.672412  0.611783  0.373518 -0.150524
29  0.447685  0.717756  0.830951  0.373518 -0.150524
..       ...       ...       ...       ...       ...
70  1.252359 -0.370501 -1.031977 -0.183054 -0.150524
71  1.276025 -0.352363 -1.251145 -0.202246 -0.150524
72  1.323359 -0.352363 -1.031977 -0.221438 -0.150524
73  1.394360 -0.307019 -1.141561 -0.240630 -0.150524
```

```
74  1.465360 -0.343295 -1.086769 -0.240630 -0.150524
75  1.536361 -0.433983 -0.977185 -0.221438 -0.150524
76  1.489027 -0.397707 -1.086769 -0.221438 -0.150524
77  1.465360 -0.370501 -0.977185 -0.202246 -0.150524
78  1.465360 -0.352363 -1.031977 -0.221438 -0.150524
79  1.441693 -0.370501 -1.031977 -0.202246 -0.150524
80  1.441693 -0.361432 -1.031977 -0.279014 -0.150524
81  1.441693 -0.397707 -0.922393 -0.298206 -0.150524
82  1.560028 -0.433983 -1.141561 -0.298206 -0.150524
83  1.867697 -0.706047 -1.086769 -0.317398 -0.150524
84  1.915031 -0.987180 -0.977185 -0.298206  0.647429
85  1.796696 -0.932767 -0.922393 -0.317398 -0.150524
86  1.725696 -0.896492 -0.922393 -0.298206 -0.150524
87  1.702029 -0.950905 -0.867601 -0.317398 -0.150524
88  1.654695 -0.932767 -0.703225 -0.317398 -0.150524
89  1.607362 -0.914630 -0.703225 -0.298206 -0.150524
90  1.536361 -0.896492 -0.648433 -0.298206 -0.150524
91  1.489027 -0.914630 -0.648433 -0.298206 -0.150524
92  1.394360 -0.842079 -0.648433 -0.279014 -0.150524
93  1.299692 -0.751391 -0.648433 -0.279014  0.647429
94  1.252359 -0.742322 -0.703225 -0.240630  0.647429
95  1.157691 -0.461189 -0.812809 -0.240630 -0.150524
96  1.063024 -0.325157 -0.812809 -0.183054 -0.150524
97  0.944689 -0.216331 -0.758017 -0.144669  0.647429
98  0.850022 -0.053093 -0.593641 -0.106285  3.041287
99  0.708021  0.110146 -0.538849 -0.106285  7.031051

[100 rows x 18 columns]
```

```
In [4]: df = df[['date', 'NO2_ref', 'NO2_61FD', 'NO2_61F0', \
                'NO2_61EF', 'temp', 'rh', 'tgrad', 'pressure', 'pluvio']]
```

1 Premier modèle: simple DNN

```
In [5]: from keras.models import Sequential
        from keras.layers import Dense
        from keras.callbacks import EarlyStopping

        def baseline_model(dense_size, input_dim, loss='mean_squared_error', optimizer='adam')
            # create model
            model = Sequential()
            model.add(Dense(dense_size, input_dim=input_dim, kernel_initializer='normal', acti
            model.add(Dense(1, kernel_initializer='normal'))
            # Compile model
            model.compile(loss=loss, optimizer=optimizer)
            model.summary()
            return model
```

```
Using TensorFlow backend.
```

```
In [6]: df = df.reindex(np.random.permutation(df.index))

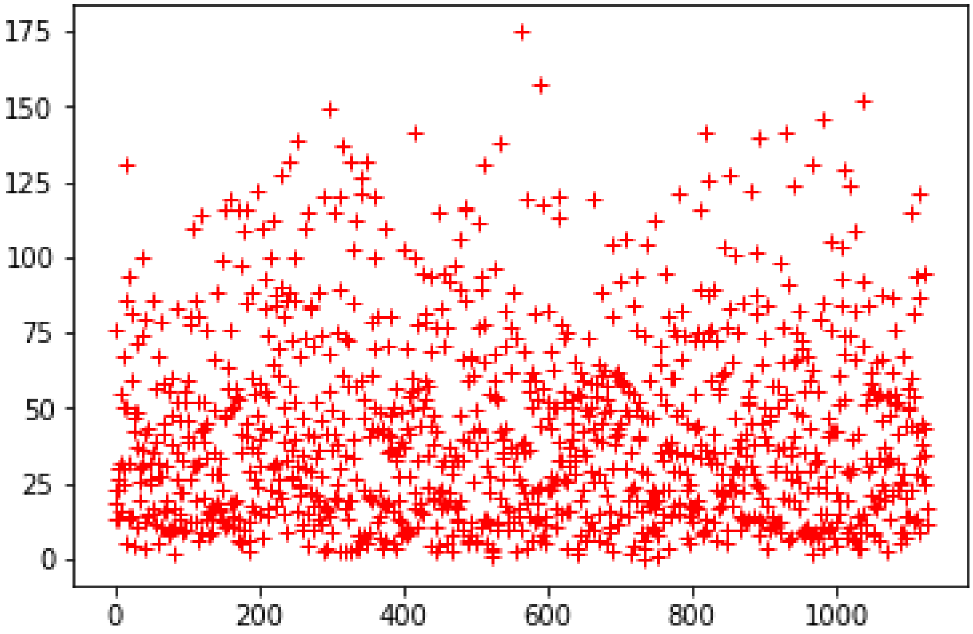
        def split_dataframe(dataframe, percent):
            nb_rows = int(np.floor(percent * len(dataframe)))
            return dataframe[:nb_rows], dataframe[nb_rows:]

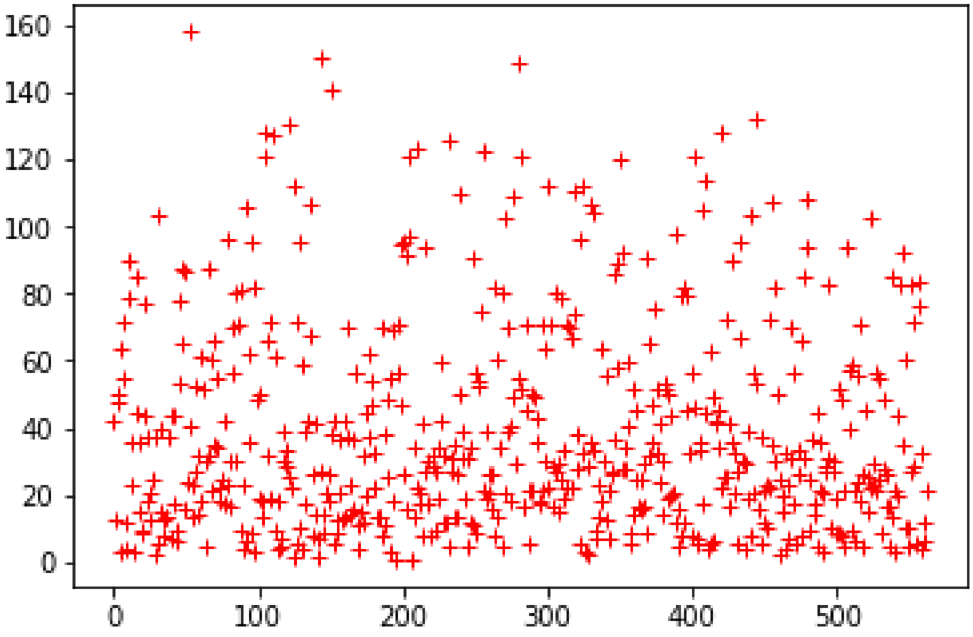
        def dataframe_to_xy(df):
            return (np.array(df[['NO2_61FD', 'NO2_61F0', 'NO2_61EF', 'temp', 'rh',\
                                 'tgrad', 'pressure', 'pluvio']]),\
                    np.array(df['NO2_ref']))

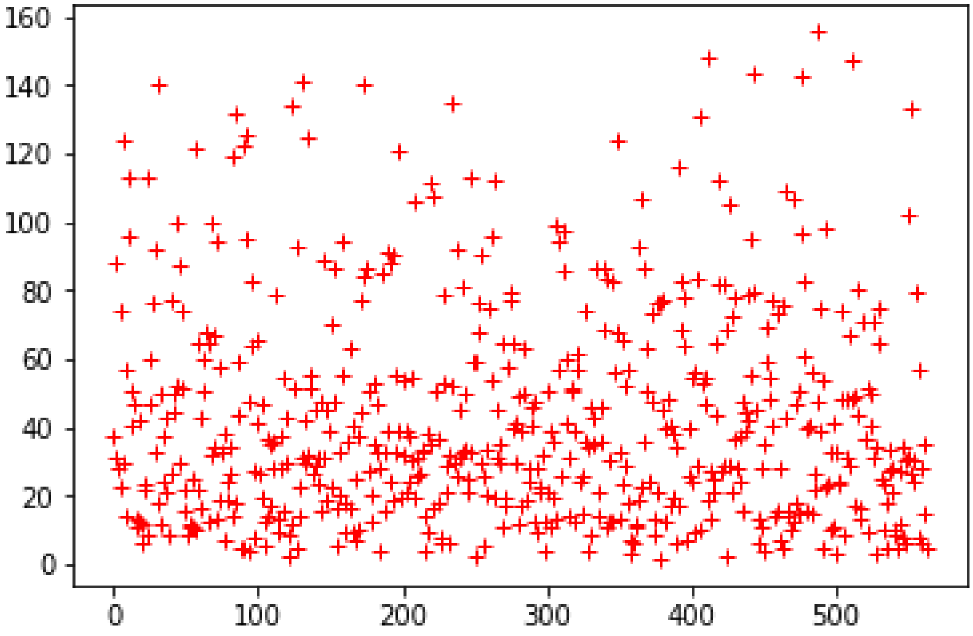
        df_train, df_test = split_dataframe(df, 0.5)
        df_valid, df_test = split_dataframe(df_test, 0.5)

        X_train, y_train = dataframe_to_xy(df_train)
        X_valid, y_valid = dataframe_to_xy(df_valid)
        X_test, y_test = dataframe_to_xy(df_test)
```

```
In [7]: plt.plot(y_train, '+r')
        plt.show()
        plt.plot(y_valid, '+r')
        plt.show()
        plt.plot(y_test, '+r')
        plt.show()
```







```
In [8]: model = baseline_model(32, X_train.shape[1], 'mean_squared_error', 'adam')
        early_stopping = EarlyStopping(monitor='val_loss', verbose=1, mode='auto', patience=10
        history = model.fit(X_train, y_train, batch_size=32, epochs=5000, validation_data=(X_va
```

```
-----------------------------------------------------------------
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 32)                288
-----------------------------------------------------------------
dense_2 (Dense)              (None, 1)                 33
=================================================================
Total params: 321
Trainable params: 321
Non-trainable params: 0
-----------------------------------------------------------------
Train on 1126 samples, validate on 563 samples
Epoch 1/5000
1126/1126 [==============================] - 0s 443us/step - loss: 2781.5261 - val_loss: 2508.
Epoch 2/5000
1126/1126 [==============================] - 0s 47us/step - loss: 2752.6032 - val_loss: 2470.5
Epoch 3/5000
1126/1126 [==============================] - 0s 48us/step - loss: 2694.3008 - val_loss: 2400.4
Epoch 4/5000
1126/1126 [==============================] - 0s 46us/step - loss: 2597.3296 - val_loss: 2293.2
Epoch 5/5000
1126/1126 [==============================] - 0s 50us/step - loss: 2460.6427 - val_loss: 2149.2
Epoch 6/5000
1126/1126 [==============================] - 0s 47us/step - loss: 2288.1625 - val_loss: 1983.3
Epoch 7/5000
1126/1126 [==============================] - 0s 47us/step - loss: 2093.1475 - val_loss: 1796.5
Epoch 8/5000
1126/1126 [==============================] - 0s 48us/step - loss: 1881.4570 - val_loss: 1599.0
Epoch 9/5000
1126/1126 [==============================] - 0s 50us/step - loss: 1657.6843 - val_loss: 1394.9
Epoch 10/5000
1126/1126 [==============================] - 0s 49us/step - loss: 1434.3633 - val_loss: 1200.7
Epoch 11/5000
1126/1126 [==============================] - 0s 48us/step - loss: 1234.4759 - val_loss: 1025.1
Epoch 12/5000
1126/1126 [==============================] - 0s 47us/step - loss: 1049.1299 - val_loss: 869.92
Epoch 13/5000
1126/1126 [==============================] - 0s 48us/step - loss: 893.1093 - val_loss: 737.270
Epoch 14/5000
1126/1126 [==============================] - 0s 51us/step - loss: 761.9224 - val_loss: 629.706
Epoch 15/5000
1126/1126 [==============================] - 0s 51us/step - loss: 655.9455 - val_loss: 541.541
Epoch 16/5000
1126/1126 [==============================] - 0s 53us/step - loss: 573.2662 - val_loss: 477.472
Epoch 17/5000
1126/1126 [==============================] - 0s 50us/step - loss: 512.6189 - val_loss: 426.915
Epoch 18/5000
1126/1126 [==============================] - 0s 49us/step - loss: 467.6023 - val_loss: 391.697
```

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Epoch 19/5000
1126/1126 [==============================] - 0s 62us/step - loss: 434.4035 - val_loss: 364.5187
Epoch 20/5000
1126/1126 [==============================] - 0s 49us/step - loss: 410.1337 - val_loss: 344.5599
Epoch 21/5000
1126/1126 [==============================] - 0s 47us/step - loss: 390.5729 - val_loss: 328.3883
Epoch 22/5000
1126/1126 [==============================] - 0s 48us/step - loss: 374.7627 - val_loss: 315.4675
Epoch 23/5000
1126/1126 [==============================] - 0s 49us/step - loss: 360.3925 - val_loss: 303.3226
Epoch 24/5000
1126/1126 [==============================] - 0s 45us/step - loss: 347.1892 - val_loss: 292.4300
Epoch 25/5000
1126/1126 [==============================] - 0s 48us/step - loss: 334.9128 - val_loss: 281.6309
Epoch 26/5000
1126/1126 [==============================] - 0s 51us/step - loss: 322.5714 - val_loss: 271.1792
Epoch 27/5000
1126/1126 [==============================] - 0s 50us/step - loss: 310.3080 - val_loss: 261.1138
Epoch 28/5000
1126/1126 [==============================] - 0s 47us/step - loss: 298.0337 - val_loss: 251.6564
Epoch 29/5000
1126/1126 [==============================] - 0s 52us/step - loss: 286.2926 - val_loss: 241.7081
Epoch 30/5000
1126/1126 [==============================] - 0s 49us/step - loss: 274.0643 - val_loss: 231.1999
Epoch 31/5000
1126/1126 [==============================] - 0s 50us/step - loss: 261.2273 - val_loss: 221.8276
Epoch 32/5000
1126/1126 [==============================] - 0s 48us/step - loss: 249.3111 - val_loss: 212.2287
Epoch 33/5000
1126/1126 [==============================] - 0s 50us/step - loss: 237.6641 - val_loss: 203.3601
Epoch 34/5000
1126/1126 [==============================] - 0s 49us/step - loss: 226.3875 - val_loss: 194.8508
Epoch 35/5000
1126/1126 [==============================] - 0s 50us/step - loss: 216.4259 - val_loss: 187.3805
Epoch 36/5000
1126/1126 [==============================] - 0s 52us/step - loss: 206.8391 - val_loss: 180.5998
Epoch 37/5000
1126/1126 [==============================] - 0s 51us/step - loss: 198.3697 - val_loss: 174.1484
Epoch 38/5000
1126/1126 [==============================] - 0s 50us/step - loss: 190.2108 - val_loss: 168.1262
Epoch 39/5000
1126/1126 [==============================] - 0s 47us/step - loss: 182.6863 - val_loss: 162.8862
Epoch 40/5000
1126/1126 [==============================] - 0s 47us/step - loss: 176.1663 - val_loss: 158.0892
Epoch 41/5000
1126/1126 [==============================] - 0s 49us/step - loss: 169.7631 - val_loss: 153.4353
Epoch 42/5000
1126/1126 [==============================] - 0s 46us/step - loss: 164.0514 - val_loss: 149.5631
```

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Epoch 43/5000
1126/1126 [==============================] - 0s 47us/step - loss: 158.8799 - val_loss: 145.8587
Epoch 44/5000
1126/1126 [==============================] - 0s 51us/step - loss: 154.1968 - val_loss: 142.2463
Epoch 45/5000
1126/1126 [==============================] - 0s 51us/step - loss: 149.7311 - val_loss: 139.3933
Epoch 46/5000
1126/1126 [==============================] - 0s 49us/step - loss: 145.8988 - val_loss: 136.4244
Epoch 47/5000
1126/1126 [==============================] - 0s 52us/step - loss: 142.1967 - val_loss: 133.9994
Epoch 48/5000
1126/1126 [==============================] - 0s 50us/step - loss: 139.0513 - val_loss: 131.7839
Epoch 49/5000
1126/1126 [==============================] - 0s 48us/step - loss: 136.0343 - val_loss: 129.7454
Epoch 50/5000
1126/1126 [==============================] - 0s 48us/step - loss: 133.2760 - val_loss: 127.3062
Epoch 51/5000
1126/1126 [==============================] - 0s 49us/step - loss: 130.8140 - val_loss: 125.5816
Epoch 52/5000
1126/1126 [==============================] - 0s 46us/step - loss: 128.7272 - val_loss: 123.8401
Epoch 53/5000
1126/1126 [==============================] - 0s 48us/step - loss: 126.5977 - val_loss: 122.1814
Epoch 54/5000
1126/1126 [==============================] - 0s 49us/step - loss: 124.9579 - val_loss: 120.8459
Epoch 55/5000
1126/1126 [==============================] - 0s 48us/step - loss: 123.2888 - val_loss: 119.6220
Epoch 56/5000
1126/1126 [==============================] - 0s 48us/step - loss: 121.7510 - val_loss: 118.3136
Epoch 57/5000
1126/1126 [==============================] - 0s 45us/step - loss: 120.4017 - val_loss: 117.2464
Epoch 58/5000
1126/1126 [==============================] - 0s 49us/step - loss: 119.2474 - val_loss: 116.5372
Epoch 59/5000
1126/1126 [==============================] - 0s 50us/step - loss: 118.1796 - val_loss: 115.5154
Epoch 60/5000
1126/1126 [==============================] - 0s 48us/step - loss: 117.1929 - val_loss: 114.7570
Epoch 61/5000
1126/1126 [==============================] - 0s 47us/step - loss: 116.2677 - val_loss: 113.9306
Epoch 62/5000
1126/1126 [==============================] - 0s 51us/step - loss: 115.5200 - val_loss: 113.4239
Epoch 63/5000
1126/1126 [==============================] - 0s 47us/step - loss: 114.6976 - val_loss: 112.7728
Epoch 64/5000
1126/1126 [==============================] - 0s 45us/step - loss: 113.9036 - val_loss: 112.2018
Epoch 65/5000
1126/1126 [==============================] - 0s 49us/step - loss: 113.3173 - val_loss: 111.3092
Epoch 66/5000
1126/1126 [==============================] - 0s 49us/step - loss: 112.6448 - val_loss: 111.6751
```

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Epoch 67/5000
1126/1126 [==============================] - 0s 45us/step - loss: 112.1339 - val_loss: 110.8356
Epoch 68/5000
1126/1126 [==============================] - 0s 51us/step - loss: 111.5857 - val_loss: 110.4274
Epoch 69/5000
1126/1126 [==============================] - 0s 48us/step - loss: 111.2429 - val_loss: 109.7327
Epoch 70/5000
1126/1126 [==============================] - 0s 42us/step - loss: 110.6758 - val_loss: 109.4487
Epoch 71/5000
1126/1126 [==============================] - 0s 46us/step - loss: 110.3384 - val_loss: 109.1534
Epoch 72/5000
1126/1126 [==============================] - 0s 44us/step - loss: 110.0463 - val_loss: 108.6923
Epoch 73/5000
1126/1126 [==============================] - 0s 48us/step - loss: 109.6243 - val_loss: 108.5233
Epoch 74/5000
1126/1126 [==============================] - 0s 48us/step - loss: 109.2389 - val_loss: 108.0040
Epoch 75/5000
1126/1126 [==============================] - 0s 40us/step - loss: 108.9889 - val_loss: 107.6430
Epoch 76/5000
1126/1126 [==============================] - 0s 32us/step - loss: 108.7005 - val_loss: 107.5015
Epoch 77/5000
1126/1126 [==============================] - 0s 44us/step - loss: 108.5178 - val_loss: 107.3735
Epoch 78/5000
1126/1126 [==============================] - 0s 45us/step - loss: 108.2708 - val_loss: 106.9653
Epoch 79/5000
1126/1126 [==============================] - 0s 53us/step - loss: 108.3069 - val_loss: 106.9553
Epoch 80/5000
1126/1126 [==============================] - 0s 43us/step - loss: 108.0226 - val_loss: 106.8576
Epoch 81/5000
1126/1126 [==============================] - 0s 48us/step - loss: 107.7967 - val_loss: 106.7560
Epoch 82/5000
1126/1126 [==============================] - 0s 49us/step - loss: 107.5421 - val_loss: 106.3844
Epoch 83/5000
1126/1126 [==============================] - 0s 58us/step - loss: 107.5045 - val_loss: 106.0737
Epoch 84/5000
1126/1126 [==============================] - 0s 45us/step - loss: 107.2228 - val_loss: 105.9090
Epoch 85/5000
1126/1126 [==============================] - 0s 59us/step - loss: 107.1244 - val_loss: 105.9597
Epoch 86/5000
1126/1126 [==============================] - 0s 47us/step - loss: 106.8920 - val_loss: 105.4604
Epoch 87/5000
1126/1126 [==============================] - 0s 43us/step - loss: 106.8475 - val_loss: 105.4398
Epoch 88/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.6759 - val_loss: 105.5577
Epoch 89/5000
1126/1126 [==============================] - 0s 51us/step - loss: 106.7223 - val_loss: 105.2194
Epoch 90/5000
1126/1126 [==============================] - 0s 41us/step - loss: 106.5891 - val_loss: 105.2085
```

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Epoch 91/5000
1126/1126 [==============================] - 0s 46us/step - loss: 106.4391 - val_loss: 105.5312
Epoch 92/5000
1126/1126 [==============================] - 0s 48us/step - loss: 106.5306 - val_loss: 105.5093
Epoch 93/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.4167 - val_loss: 104.9729
Epoch 94/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.1631 - val_loss: 105.1561
Epoch 95/5000
1126/1126 [==============================] - 0s 42us/step - loss: 106.1623 - val_loss: 104.9044
Epoch 96/5000
1126/1126 [==============================] - 0s 43us/step - loss: 106.0970 - val_loss: 104.5948
Epoch 97/5000
1126/1126 [==============================] - 0s 44us/step - loss: 106.0137 - val_loss: 104.7175
Epoch 98/5000
1126/1126 [==============================] - 0s 44us/step - loss: 105.9741 - val_loss: 104.2927
Epoch 99/5000
1126/1126 [==============================] - 0s 43us/step - loss: 105.8697 - val_loss: 104.4232
Epoch 100/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.7984 - val_loss: 104.4650
Epoch 101/5000
1126/1126 [==============================] - 0s 44us/step - loss: 105.7271 - val_loss: 104.1156
Epoch 102/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.7057 - val_loss: 104.4178
Epoch 103/5000
1126/1126 [==============================] - 0s 43us/step - loss: 105.5159 - val_loss: 104.0974
Epoch 104/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.4939 - val_loss: 104.0684
Epoch 105/5000
1126/1126 [==============================] - 0s 47us/step - loss: 105.4642 - val_loss: 103.9659
Epoch 106/5000
1126/1126 [==============================] - 0s 52us/step - loss: 105.3383 - val_loss: 104.2280
Epoch 107/5000
1126/1126 [==============================] - 0s 46us/step - loss: 105.3649 - val_loss: 104.2618
Epoch 108/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.3737 - val_loss: 103.9537
Epoch 109/5000
1126/1126 [==============================] - 0s 48us/step - loss: 105.1499 - val_loss: 104.1718
Epoch 110/5000
1126/1126 [==============================] - 0s 41us/step - loss: 105.0914 - val_loss: 103.7883
Epoch 111/5000
1126/1126 [==============================] - 0s 50us/step - loss: 105.1475 - val_loss: 103.9555
Epoch 112/5000
1126/1126 [==============================] - 0s 47us/step - loss: 105.0160 - val_loss: 104.2080
Epoch 113/5000
1126/1126 [==============================] - 0s 45us/step - loss: 104.9024 - val_loss: 103.7413
Epoch 114/5000
1126/1126 [==============================] - 0s 44us/step - loss: 105.0413 - val_loss: 103.5132
```

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Epoch 115/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.9284 - val_loss: 103.5086
Epoch 116/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.9341 - val_loss: 103.5212
Epoch 117/5000
1126/1126 [==============================] - 0s 48us/step - loss: 104.8336 - val_loss: 103.7334
Epoch 118/5000
1126/1126 [==============================] - 0s 43us/step - loss: 104.7442 - val_loss: 103.7586
Epoch 119/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.7402 - val_loss: 103.5081
Epoch 120/5000
1126/1126 [==============================] - 0s 43us/step - loss: 104.8178 - val_loss: 103.7871
Epoch 121/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.5422 - val_loss: 103.5859
Epoch 122/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.5457 - val_loss: 103.4343
Epoch 123/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.4940 - val_loss: 103.4790
Epoch 124/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.7323 - val_loss: 103.5854
Epoch 125/5000
1126/1126 [==============================] - 0s 50us/step - loss: 104.4015 - val_loss: 103.8414
Epoch 126/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.4829 - val_loss: 103.7331
Epoch 127/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.5080 - val_loss: 104.2345
Epoch 128/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.4201 - val_loss: 103.5330
Epoch 129/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.2571 - val_loss: 103.5585
Epoch 130/5000
1126/1126 [==============================] - 0s 47us/step - loss: 104.2824 - val_loss: 103.7111
Epoch 131/5000
1126/1126 [==============================] - 0s 48us/step - loss: 104.1935 - val_loss: 103.5216
Epoch 132/5000
1126/1126 [==============================] - 0s 44us/step - loss: 104.2215 - val_loss: 103.3508
Epoch 133/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.1531 - val_loss: 103.1256
Epoch 134/5000
1126/1126 [==============================] - 0s 45us/step - loss: 104.1196 - val_loss: 103.1125
Epoch 135/5000
1126/1126 [==============================] - 0s 43us/step - loss: 104.0082 - val_loss: 103.2897
Epoch 136/5000
1126/1126 [==============================] - 0s 50us/step - loss: 104.2055 - val_loss: 103.3277
Epoch 137/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.1266 - val_loss: 102.9908
Epoch 138/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.9604 - val_loss: 103.0124
```

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Epoch 139/5000
1126/1126 [==============================] - 0s 41us/step - loss: 103.9431 - val_loss: 103.0238
Epoch 140/5000
1126/1126 [==============================] - 0s 42us/step - loss: 103.9985 - val_loss: 102.9390
Epoch 141/5000
1126/1126 [==============================] - 0s 43us/step - loss: 103.9065 - val_loss: 102.7266
Epoch 142/5000
1126/1126 [==============================] - 0s 45us/step - loss: 103.9113 - val_loss: 103.0755
Epoch 143/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.9607 - val_loss: 103.4912
Epoch 144/5000
1126/1126 [==============================] - 0s 46us/step - loss: 104.0255 - val_loss: 103.2501
Epoch 145/5000
1126/1126 [==============================] - 0s 49us/step - loss: 103.9490 - val_loss: 103.0072
Epoch 146/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.7445 - val_loss: 102.6647
Epoch 147/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.7987 - val_loss: 102.7499
Epoch 148/5000
1126/1126 [==============================] - 0s 43us/step - loss: 103.8921 - val_loss: 102.8476
Epoch 149/5000
1126/1126 [==============================] - 0s 50us/step - loss: 103.7312 - val_loss: 103.5674
Epoch 150/5000
1126/1126 [==============================] - 0s 50us/step - loss: 103.7189 - val_loss: 102.6921
Epoch 151/5000
1126/1126 [==============================] - 0s 56us/step - loss: 103.6566 - val_loss: 102.9843
Epoch 152/5000
1126/1126 [==============================] - 0s 51us/step - loss: 103.7022 - val_loss: 103.2261
Epoch 153/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.8566 - val_loss: 102.9857
Epoch 154/5000
1126/1126 [==============================] - 0s 45us/step - loss: 103.6974 - val_loss: 102.5375
Epoch 155/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.7194 - val_loss: 102.5054
Epoch 156/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.6955 - val_loss: 102.8486
Epoch 157/5000
1126/1126 [==============================] - 0s 43us/step - loss: 103.5493 - val_loss: 102.5147
Epoch 158/5000
1126/1126 [==============================] - 0s 41us/step - loss: 103.6051 - val_loss: 102.8619
Epoch 159/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.5269 - val_loss: 103.1038
Epoch 160/5000
1126/1126 [==============================] - 0s 45us/step - loss: 103.4965 - val_loss: 102.5534
Epoch 161/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.6308 - val_loss: 102.7077
Epoch 162/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.3214 - val_loss: 102.4509
```

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Epoch 163/5000
1126/1126 [==============================] - 0s 45us/step - loss: 103.4184 - val_loss: 102.5696
Epoch 164/5000
1126/1126 [==============================] - 0s 49us/step - loss: 103.3258 - val_loss: 102.7685
Epoch 165/5000
1126/1126 [==============================] - 0s 49us/step - loss: 103.3216 - val_loss: 102.6613
Epoch 166/5000
1126/1126 [==============================] - 0s 58us/step - loss: 103.3810 - val_loss: 102.4637
Epoch 167/5000
1126/1126 [==============================] - 0s 57us/step - loss: 103.3555 - val_loss: 102.5015
Epoch 168/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.2615 - val_loss: 102.4487
Epoch 169/5000
1126/1126 [==============================] - 0s 57us/step - loss: 103.2440 - val_loss: 102.1517
Epoch 170/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.2429 - val_loss: 102.5475
Epoch 171/5000
1126/1126 [==============================] - 0s 49us/step - loss: 103.3466 - val_loss: 102.1878
Epoch 172/5000
1126/1126 [==============================] - 0s 51us/step - loss: 103.1347 - val_loss: 102.7182
Epoch 173/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.1692 - val_loss: 102.3327
Epoch 174/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.2833 - val_loss: 102.4809
Epoch 175/5000
1126/1126 [==============================] - 0s 48us/step - loss: 103.1833 - val_loss: 102.0801
Epoch 176/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.1519 - val_loss: 102.2730
Epoch 177/5000
1126/1126 [==============================] - 0s 48us/step - loss: 103.1574 - val_loss: 102.1321
Epoch 178/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.1315 - val_loss: 101.7802
Epoch 179/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.0311 - val_loss: 102.1119
Epoch 180/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.0747 - val_loss: 102.0562
Epoch 181/5000
1126/1126 [==============================] - 0s 47us/step - loss: 103.1823 - val_loss: 102.0222
Epoch 182/5000
1126/1126 [==============================] - 0s 46us/step - loss: 102.9104 - val_loss: 102.0098
Epoch 183/5000
1126/1126 [==============================] - 0s 44us/step - loss: 103.0198 - val_loss: 102.0002
Epoch 184/5000
1126/1126 [==============================] - 0s 46us/step - loss: 102.9852 - val_loss: 101.6536
Epoch 185/5000
1126/1126 [==============================] - 0s 49us/step - loss: 103.0887 - val_loss: 101.6079
Epoch 186/5000
1126/1126 [==============================] - 0s 47us/step - loss: 102.8521 - val_loss: 102.1309
```

```
Epoch 187/5000
1126/1126 [==============================] - 0s 45us/step - loss: 102.9042 - val_loss: 101.624
Epoch 188/5000
1126/1126 [==============================] - 0s 44us/step - loss: 102.9748 - val_loss: 101.9674
Epoch 189/5000
1126/1126 [==============================] - 0s 44us/step - loss: 102.8152 - val_loss: 101.6077
Epoch 190/5000
1126/1126 [==============================] - 0s 46us/step - loss: 103.0000 - val_loss: 101.2177
Epoch 191/5000
1126/1126 [==============================] - 0s 48us/step - loss: 102.8651 - val_loss: 102.1440
Epoch 192/5000
1126/1126 [==============================] - 0s 49us/step - loss: 102.8744 - val_loss: 101.4384
Epoch 193/5000
1126/1126 [==============================] - 0s 60us/step - loss: 102.8045 - val_loss: 101.6837
Epoch 194/5000
1126/1126 [==============================] - 0s 60us/step - loss: 102.9813 - val_loss: 101.7480
Epoch 195/5000
1126/1126 [==============================] - 0s 49us/step - loss: 102.9435 - val_loss: 101.8260
Epoch 196/5000
1126/1126 [==============================] - 0s 60us/step - loss: 102.7584 - val_loss: 101.8805
Epoch 197/5000
1126/1126 [==============================] - 0s 48us/step - loss: 102.8398 - val_loss: 101.5988
Epoch 198/5000
1126/1126 [==============================] - 0s 50us/step - loss: 102.6423 - val_loss: 101.3976
Epoch 199/5000
1126/1126 [==============================] - 0s 52us/step - loss: 102.7073 - val_loss: 101.6318
Epoch 200/5000
1126/1126 [==============================] - 0s 54us/step - loss: 102.7097 - val_loss: 101.7363
Epoch 00200: early stopping
```

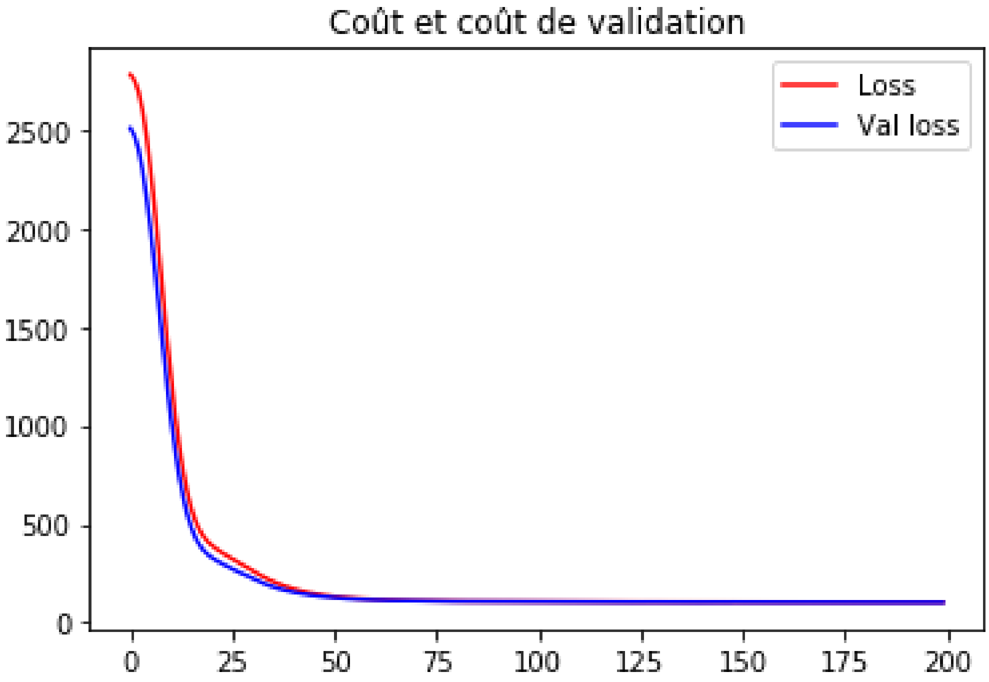
In [9]:

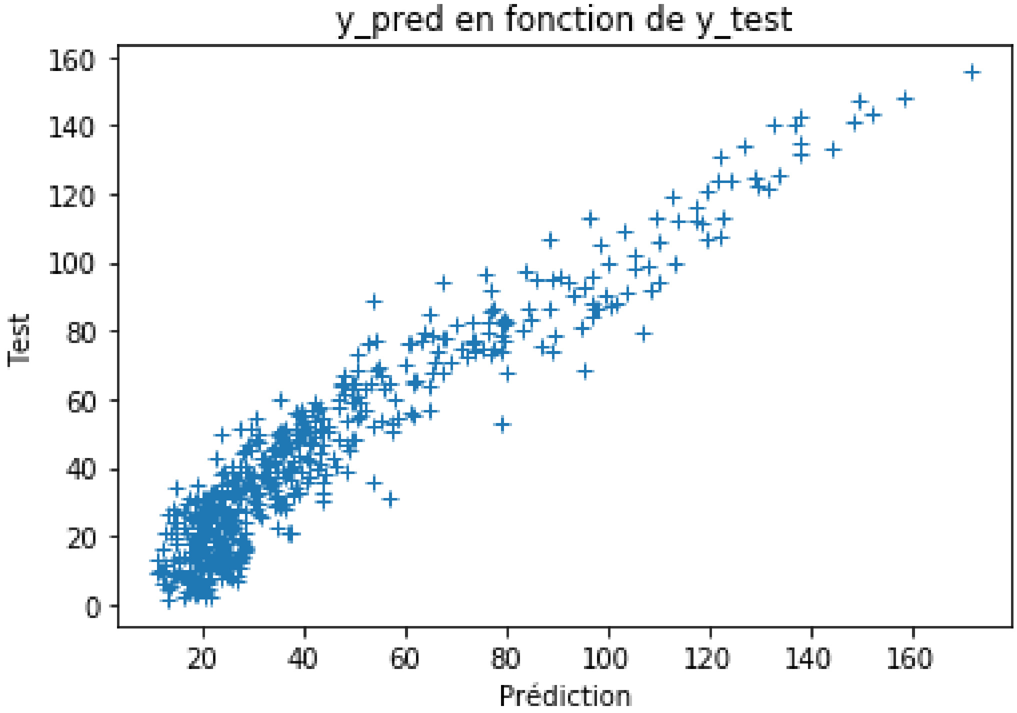
```
y_pred = model.predict(X_test)
plt.title('Coût et coût de validation')
line1,=plt.plot(history.history['loss'], label="Loss", linestyle='-', color='r')
line2,=plt.plot(history.history['val_loss'], label="Val loss", linestyle='-', color='b
first_legend = plt.legend(handles=[line1, line2], loc=1)

plt.show()

plt.title('y_pred en fonction de y_test')

plt.plot(y_pred[:], y_test[:], '+')
plt.ylabel('Test')
plt.xlabel('Prédiction')
plt.show()
```


Coût et coût de validation
Loss
Val loss
2500
2000
1500
1000
500
0
0
25
50
75
100
125
150
175
200


y_pred en fonction de y_test
Test
160
140
120
100
80
60
40
20
0
20
40
60
80
100
120
140
160
Prédiction

1.1 DNN 2 Couches

```
In [10]: from keras.layers import SimpleRNN

         df = pd.read_pickle('data/micro_sud3_normalized.pkl')
         df = df[['date', 'NO2_ref', 'NO2_61FD', 'NO2_61F0', \
                 'NO2_61EF', 'temp', 'rh', 'tgrad', 'pressure', 'pluvio']]
         df = df.reset_index()
         df_train, df_test = split_dataframe(df, 0.5)
         df_valid, df_test = split_dataframe(df_test, 0.5)

         X_train, y_train = dataframe_to_xy(df_train)
         X_valid, y_valid = dataframe_to_xy(df_valid)
         X_test, y_test = dataframe_to_xy(df_test)

         def simple_rnn_model(nb_units, dense_size, loss='mean_squared_error', optimizer='adam
             model = Sequential()
             model.add(Dense(dense_size, input_dim=dense_size, kernel_initializer='normal', ac
             model.add(Dense(dense_size//2, kernel_initializer='normal', activation='relu'))
             model.add(Dense(1, kernel_initializer='normal'))
             model.compile(loss=loss, optimizer=optimizer)
             model.summary()
             return model


         model = simple_rnn_model(32, X_train.shape[1])
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_3 (Dense)              (None, 8)                 72
_________________________________________________________________
dense_4 (Dense)              (None, 4)                 36
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 5
=================================================================
Total params: 113
Trainable params: 113
Non-trainable params: 0
_________________________________________________________________
```

```
In [11]: early_stopping = EarlyStopping(monitor='val_loss', verbose=1, mode='auto', patience=1
         history = model.fit(X_train, y_train, batch_size=32, epochs=5000, validation_data=(X_
```

```
Train on 1126 samples, validate on 563 samples
Epoch 1/5000
1126/1126 [==============================] - 0s 399us/step - loss: 3350.9350 - val_loss: 3012.
Epoch 2/5000
```

```
1126/1126 [==============================] - 0s 62us/step - loss: 3346.1066 - val_loss: 3006.4
Epoch 3/5000
1126/1126 [==============================] - 0s 50us/step - loss: 3335.8177 - val_loss: 2991.5
Epoch 4/5000
1126/1126 [==============================] - 0s 48us/step - loss: 3309.5349 - val_loss: 2958.5
Epoch 5/5000
1126/1126 [==============================] - 0s 51us/step - loss: 3253.8119 - val_loss: 2899.7
Epoch 6/5000
1126/1126 [==============================] - 0s 50us/step - loss: 3159.1789 - val_loss: 2805.0
Epoch 7/5000
1126/1126 [==============================] - 0s 50us/step - loss: 3018.4637 - val_loss: 2676.6
Epoch 8/5000
1126/1126 [==============================] - 0s 47us/step - loss: 2826.6789 - val_loss: 2503.0
Epoch 9/5000
1126/1126 [==============================] - 0s 49us/step - loss: 2596.0587 - val_loss: 2294.8
Epoch 10/5000
1126/1126 [==============================] - 0s 48us/step - loss: 2325.9794 - val_loss: 2067.1
Epoch 11/5000
1126/1126 [==============================] - 0s 50us/step - loss: 2033.7568 - val_loss: 1818.8
Epoch 12/5000
1126/1126 [==============================] - 0s 54us/step - loss: 1726.1532 - val_loss: 1571.1
Epoch 13/5000
1126/1126 [==============================] - 0s 49us/step - loss: 1428.6559 - val_loss: 1330.6
Epoch 14/5000
1126/1126 [==============================] - 0s 49us/step - loss: 1165.4457 - val_loss: 1128.9
Epoch 15/5000
1126/1126 [==============================] - 0s 48us/step - loss: 956.9867 - val_loss: 969.704
Epoch 16/5000
1126/1126 [==============================] - 0s 52us/step - loss: 800.1353 - val_loss: 841.514
Epoch 17/5000
1126/1126 [==============================] - 0s 49us/step - loss: 689.0915 - val_loss: 744.711
Epoch 18/5000
1126/1126 [==============================] - 0s 66us/step - loss: 609.4700 - val_loss: 667.648
Epoch 19/5000
1126/1126 [==============================] - 0s 51us/step - loss: 549.5801 - val_loss: 606.985
Epoch 20/5000
1126/1126 [==============================] - 0s 49us/step - loss: 504.2915 - val_loss: 555.285
Epoch 21/5000
1126/1126 [==============================] - 0s 50us/step - loss: 466.4507 - val_loss: 514.051
Epoch 22/5000
1126/1126 [==============================] - 0s 52us/step - loss: 434.0599 - val_loss: 481.533
Epoch 23/5000
1126/1126 [==============================] - 0s 50us/step - loss: 405.9722 - val_loss: 450.545
Epoch 24/5000
1126/1126 [==============================] - 0s 54us/step - loss: 381.4657 - val_loss: 428.872
Epoch 25/5000
1126/1126 [==============================] - 0s 48us/step - loss: 360.0252 - val_loss: 408.768
Epoch 26/5000
```

```
1126/1126 [==============================] - 0s 51us/step - loss: 341.1278 - val_loss: 392.8151
Epoch 27/5000
1126/1126 [==============================] - 0s 48us/step - loss: 324.2364 - val_loss: 377.1160
Epoch 28/5000
1126/1126 [==============================] - 0s 55us/step - loss: 309.3226 - val_loss: 364.7721
Epoch 29/5000
1126/1126 [==============================] - 0s 51us/step - loss: 295.9603 - val_loss: 356.3484
Epoch 30/5000
1126/1126 [==============================] - 0s 49us/step - loss: 283.8096 - val_loss: 348.1651
Epoch 31/5000
1126/1126 [==============================] - 0s 50us/step - loss: 272.9213 - val_loss: 342.2406
Epoch 32/5000
1126/1126 [==============================] - 0s 50us/step - loss: 262.7270 - val_loss: 338.1132
Epoch 33/5000
1126/1126 [==============================] - 0s 53us/step - loss: 252.9792 - val_loss: 329.2858
Epoch 34/5000
1126/1126 [==============================] - 0s 52us/step - loss: 244.3955 - val_loss: 323.8381
Epoch 35/5000
1126/1126 [==============================] - 0s 52us/step - loss: 236.3760 - val_loss: 317.4807
Epoch 36/5000
1126/1126 [==============================] - 0s 49us/step - loss: 228.9311 - val_loss: 313.3112
Epoch 37/5000
1126/1126 [==============================] - 0s 51us/step - loss: 221.7505 - val_loss: 307.4399
Epoch 38/5000
1126/1126 [==============================] - 0s 50us/step - loss: 215.1786 - val_loss: 303.6010
Epoch 39/5000
1126/1126 [==============================] - 0s 53us/step - loss: 208.6228 - val_loss: 298.4892
Epoch 40/5000
1126/1126 [==============================] - 0s 55us/step - loss: 202.7060 - val_loss: 293.9418
Epoch 41/5000
1126/1126 [==============================] - 0s 58us/step - loss: 196.9509 - val_loss: 289.5439
Epoch 42/5000
1126/1126 [==============================] - 0s 55us/step - loss: 191.7542 - val_loss: 284.4888
Epoch 43/5000
1126/1126 [==============================] - 0s 53us/step - loss: 186.5732 - val_loss: 278.4020
Epoch 44/5000
1126/1126 [==============================] - 0s 51us/step - loss: 181.9072 - val_loss: 273.0048
Epoch 45/5000
1126/1126 [==============================] - 0s 52us/step - loss: 177.6010 - val_loss: 267.8757
Epoch 46/5000
1126/1126 [==============================] - 0s 51us/step - loss: 173.4793 - val_loss: 262.1376
Epoch 47/5000
1126/1126 [==============================] - 0s 55us/step - loss: 169.6841 - val_loss: 258.5268
Epoch 48/5000
1126/1126 [==============================] - 0s 55us/step - loss: 166.0459 - val_loss: 253.3523
Epoch 49/5000
1126/1126 [==============================] - 0s 54us/step - loss: 162.7010 - val_loss: 248.2592
Epoch 50/5000
```

```
1126/1126 [==============================] - 0s 59us/step - loss: 159.6383 - val_loss: 243.1217
Epoch 51/5000
1126/1126 [==============================] - 0s 51us/step - loss: 156.6947 - val_loss: 239.2991
Epoch 52/5000
1126/1126 [==============================] - 0s 52us/step - loss: 154.1675 - val_loss: 234.2092
Epoch 53/5000
1126/1126 [==============================] - 0s 50us/step - loss: 151.6095 - val_loss: 229.3478
Epoch 54/5000
1126/1126 [==============================] - 0s 49us/step - loss: 149.4681 - val_loss: 225.7464
Epoch 55/5000
1126/1126 [==============================] - 0s 42us/step - loss: 147.1088 - val_loss: 219.6407
Epoch 56/5000
1126/1126 [==============================] - 0s 36us/step - loss: 145.0495 - val_loss: 214.9789
Epoch 57/5000
1126/1126 [==============================] - 0s 44us/step - loss: 143.0731 - val_loss: 211.0128
Epoch 58/5000
1126/1126 [==============================] - 0s 37us/step - loss: 141.1736 - val_loss: 208.3823
Epoch 59/5000
1126/1126 [==============================] - 0s 35us/step - loss: 139.5013 - val_loss: 203.6348
Epoch 60/5000
1126/1126 [==============================] - 0s 33us/step - loss: 137.7997 - val_loss: 199.6619
Epoch 61/5000
1126/1126 [==============================] - 0s 34us/step - loss: 136.2115 - val_loss: 194.9780
Epoch 62/5000
1126/1126 [==============================] - 0s 35us/step - loss: 134.7474 - val_loss: 191.0059
Epoch 63/5000
1126/1126 [==============================] - 0s 36us/step - loss: 133.4273 - val_loss: 188.1423
Epoch 64/5000
1126/1126 [==============================] - 0s 49us/step - loss: 132.0208 - val_loss: 183.5623
Epoch 65/5000
1126/1126 [==============================] - 0s 51us/step - loss: 130.7860 - val_loss: 181.0031
Epoch 66/5000
1126/1126 [==============================] - 0s 51us/step - loss: 129.5259 - val_loss: 177.3776
Epoch 67/5000
1126/1126 [==============================] - 0s 60us/step - loss: 128.4160 - val_loss: 174.0751
Epoch 68/5000
1126/1126 [==============================] - 0s 63us/step - loss: 127.2607 - val_loss: 172.3289
Epoch 69/5000
1126/1126 [==============================] - 0s 39us/step - loss: 126.1351 - val_loss: 169.1405
Epoch 70/5000
1126/1126 [==============================] - 0s 52us/step - loss: 125.1537 - val_loss: 167.6180
Epoch 71/5000
1126/1126 [==============================] - 0s 52us/step - loss: 124.1970 - val_loss: 165.1012
Epoch 72/5000
1126/1126 [==============================] - 0s 48us/step - loss: 123.2802 - val_loss: 162.6812
Epoch 73/5000
1126/1126 [==============================] - 0s 37us/step - loss: 122.4344 - val_loss: 159.8061
Epoch 74/5000
```

```
1126/1126 [==============================] - 0s 50us/step - loss: 121.5435 - val_loss: 157.9258
Epoch 75/5000
1126/1126 [==============================] - 0s 37us/step - loss: 120.8001 - val_loss: 155.6464
Epoch 76/5000
1126/1126 [==============================] - 0s 50us/step - loss: 120.0158 - val_loss: 153.9022
Epoch 77/5000
1126/1126 [==============================] - 0s 42us/step - loss: 119.3499 - val_loss: 152.2483
Epoch 78/5000
1126/1126 [==============================] - 0s 50us/step - loss: 118.6884 - val_loss: 151.2738
Epoch 79/5000
1126/1126 [==============================] - 0s 39us/step - loss: 118.0460 - val_loss: 148.6904
Epoch 80/5000
1126/1126 [==============================] - 0s 45us/step - loss: 117.4445 - val_loss: 146.6501
Epoch 81/5000
1126/1126 [==============================] - 0s 51us/step - loss: 116.9225 - val_loss: 145.1672
Epoch 82/5000
1126/1126 [==============================] - 0s 51us/step - loss: 116.3547 - val_loss: 144.0818
Epoch 83/5000
1126/1126 [==============================] - 0s 34us/step - loss: 115.8632 - val_loss: 142.6816
Epoch 84/5000
1126/1126 [==============================] - 0s 40us/step - loss: 115.4416 - val_loss: 141.7810
Epoch 85/5000
1126/1126 [==============================] - 0s 49us/step - loss: 114.9923 - val_loss: 139.8973
Epoch 86/5000
1126/1126 [==============================] - 0s 50us/step - loss: 114.5405 - val_loss: 139.5659
Epoch 87/5000
1126/1126 [==============================] - 0s 38us/step - loss: 114.1254 - val_loss: 139.2916
Epoch 88/5000
1126/1126 [==============================] - 0s 46us/step - loss: 113.8992 - val_loss: 137.6800
Epoch 89/5000
1126/1126 [==============================] - 0s 42us/step - loss: 113.3936 - val_loss: 135.7041
Epoch 90/5000
1126/1126 [==============================] - 0s 42us/step - loss: 113.1289 - val_loss: 134.6776
Epoch 91/5000
1126/1126 [==============================] - 0s 58us/step - loss: 112.7011 - val_loss: 133.8376
Epoch 92/5000
1126/1126 [==============================] - 0s 63us/step - loss: 112.4044 - val_loss: 133.5377
Epoch 93/5000
1126/1126 [==============================] - 0s 40us/step - loss: 112.1617 - val_loss: 132.4943
Epoch 94/5000
1126/1126 [==============================] - 0s 58us/step - loss: 111.8308 - val_loss: 132.5489
Epoch 95/5000
1126/1126 [==============================] - 0s 54us/step - loss: 111.5385 - val_loss: 131.2195
Epoch 96/5000
1126/1126 [==============================] - 0s 54us/step - loss: 111.3059 - val_loss: 130.8774
Epoch 97/5000
1126/1126 [==============================] - 0s 51us/step - loss: 111.1081 - val_loss: 130.0690
Epoch 98/5000
```

```
1126/1126 [==============================] - 0s 53us/step - loss: 110.8343 - val_loss: 129.0204
Epoch 99/5000
1126/1126 [==============================] - 0s 52us/step - loss: 110.6443 - val_loss: 129.2805
Epoch 100/5000
1126/1126 [==============================] - 0s 55us/step - loss: 110.4344 - val_loss: 128.3337
Epoch 101/5000
1126/1126 [==============================] - 0s 61us/step - loss: 110.2320 - val_loss: 128.8492
Epoch 102/5000
1126/1126 [==============================] - 0s 68us/step - loss: 110.0990 - val_loss: 127.7274
Epoch 103/5000
1126/1126 [==============================] - 0s 72us/step - loss: 109.9402 - val_loss: 127.6131
Epoch 104/5000
1126/1126 [==============================] - 0s 66us/step - loss: 109.7868 - val_loss: 126.8862
Epoch 105/5000
1126/1126 [==============================] - 0s 70us/step - loss: 109.6355 - val_loss: 126.5161
Epoch 106/5000
1126/1126 [==============================] - 0s 53us/step - loss: 109.5200 - val_loss: 125.9380
Epoch 107/5000
1126/1126 [==============================] - 0s 54us/step - loss: 109.3870 - val_loss: 124.9902
Epoch 108/5000
1126/1126 [==============================] - 0s 42us/step - loss: 109.2682 - val_loss: 124.9282
Epoch 109/5000
1126/1126 [==============================] - 0s 37us/step - loss: 109.2809 - val_loss: 124.9555
Epoch 110/5000
1126/1126 [==============================] - 0s 49us/step - loss: 109.1187 - val_loss: 125.5331
Epoch 111/5000
1126/1126 [==============================] - 0s 64us/step - loss: 109.2668 - val_loss: 124.0171
Epoch 112/5000
1126/1126 [==============================] - 0s 71us/step - loss: 108.9907 - val_loss: 123.8798
Epoch 113/5000
1126/1126 [==============================] - 0s 65us/step - loss: 109.0491 - val_loss: 124.0130
Epoch 114/5000
1126/1126 [==============================] - 0s 64us/step - loss: 108.8372 - val_loss: 123.2062
Epoch 115/5000
1126/1126 [==============================] - 0s 74us/step - loss: 108.8034 - val_loss: 122.8727
Epoch 116/5000
1126/1126 [==============================] - 0s 51us/step - loss: 108.6418 - val_loss: 123.1993
Epoch 117/5000
1126/1126 [==============================] - 0s 39us/step - loss: 108.6371 - val_loss: 123.7972
Epoch 118/5000
1126/1126 [==============================] - 0s 36us/step - loss: 108.5399 - val_loss: 122.4178
Epoch 119/5000
1126/1126 [==============================] - 0s 38us/step - loss: 108.6176 - val_loss: 123.0374
Epoch 120/5000
1126/1126 [==============================] - 0s 34us/step - loss: 108.4456 - val_loss: 123.2561
Epoch 121/5000
1126/1126 [==============================] - 0s 35us/step - loss: 108.4088 - val_loss: 122.0945
Epoch 122/5000
```

```
1126/1126 [==============================] - 0s 36us/step - loss: 108.2660 - val_loss: 122.5107
Epoch 123/5000
1126/1126 [==============================] - 0s 37us/step - loss: 108.4963 - val_loss: 122.9494
Epoch 124/5000
1126/1126 [==============================] - 0s 34us/step - loss: 108.2633 - val_loss: 121.6800
Epoch 125/5000
1126/1126 [==============================] - 0s 41us/step - loss: 108.3071 - val_loss: 121.4797
Epoch 126/5000
1126/1126 [==============================] - 0s 48us/step - loss: 108.2629 - val_loss: 120.8889
Epoch 127/5000
1126/1126 [==============================] - 0s 33us/step - loss: 108.0957 - val_loss: 120.9726
Epoch 128/5000
1126/1126 [==============================] - 0s 34us/step - loss: 108.0269 - val_loss: 122.2995
Epoch 129/5000
1126/1126 [==============================] - 0s 36us/step - loss: 108.0726 - val_loss: 121.2629
Epoch 130/5000
1126/1126 [==============================] - 0s 35us/step - loss: 107.9440 - val_loss: 121.3468
Epoch 131/5000
1126/1126 [==============================] - 0s 41us/step - loss: 107.8717 - val_loss: 121.6366
Epoch 132/5000
1126/1126 [==============================] - 0s 55us/step - loss: 107.9872 - val_loss: 121.4182
Epoch 133/5000
1126/1126 [==============================] - 0s 51us/step - loss: 107.8363 - val_loss: 120.3753
Epoch 134/5000
1126/1126 [==============================] - 0s 43us/step - loss: 107.8651 - val_loss: 120.6486
Epoch 135/5000
1126/1126 [==============================] - 0s 33us/step - loss: 107.9096 - val_loss: 122.1322
Epoch 136/5000
1126/1126 [==============================] - 0s 40us/step - loss: 107.6646 - val_loss: 121.1994
Epoch 137/5000
1126/1126 [==============================] - 0s 44us/step - loss: 107.8343 - val_loss: 120.0749
Epoch 138/5000
1126/1126 [==============================] - 0s 49us/step - loss: 107.7350 - val_loss: 121.5816
Epoch 139/5000
1126/1126 [==============================] - 0s 63us/step - loss: 107.6868 - val_loss: 121.5465
Epoch 140/5000
1126/1126 [==============================] - 0s 57us/step - loss: 107.5592 - val_loss: 120.3520
Epoch 141/5000
1126/1126 [==============================] - 0s 64us/step - loss: 107.4438 - val_loss: 120.3729
Epoch 142/5000
1126/1126 [==============================] - 0s 57us/step - loss: 107.5192 - val_loss: 120.0216
Epoch 143/5000
1126/1126 [==============================] - 0s 58us/step - loss: 107.5481 - val_loss: 118.4088
Epoch 144/5000
1126/1126 [==============================] - 0s 52us/step - loss: 107.4135 - val_loss: 119.8297
Epoch 145/5000
1126/1126 [==============================] - 0s 55us/step - loss: 107.2650 - val_loss: 120.2021
Epoch 146/5000
```

```
1126/1126 [==============================] - 0s 60us/step - loss: 107.2745 - val_loss: 120.4267
Epoch 147/5000
1126/1126 [==============================] - 0s 45us/step - loss: 107.1814 - val_loss: 119.0705
Epoch 148/5000
1126/1126 [==============================] - 0s 47us/step - loss: 107.1437 - val_loss: 118.9210
Epoch 149/5000
1126/1126 [==============================] - 0s 65us/step - loss: 107.2549 - val_loss: 119.7686
Epoch 150/5000
1126/1126 [==============================] - 0s 68us/step - loss: 107.1368 - val_loss: 119.5166
Epoch 151/5000
1126/1126 [==============================] - 0s 49us/step - loss: 107.1534 - val_loss: 119.0081
Epoch 152/5000
1126/1126 [==============================] - 0s 48us/step - loss: 107.0312 - val_loss: 118.5460
Epoch 153/5000
1126/1126 [==============================] - 0s 32us/step - loss: 107.1727 - val_loss: 118.2075
Epoch 154/5000
1126/1126 [==============================] - 0s 39us/step - loss: 106.9842 - val_loss: 117.9845
Epoch 155/5000
1126/1126 [==============================] - 0s 47us/step - loss: 106.9753 - val_loss: 118.8669
Epoch 156/5000
1126/1126 [==============================] - 0s 48us/step - loss: 106.8440 - val_loss: 118.7181
Epoch 157/5000
1126/1126 [==============================] - 0s 47us/step - loss: 106.8786 - val_loss: 119.4560
Epoch 158/5000
1126/1126 [==============================] - 0s 50us/step - loss: 106.9676 - val_loss: 118.8622
Epoch 159/5000
1126/1126 [==============================] - 0s 47us/step - loss: 106.8945 - val_loss: 119.1453
Epoch 160/5000
1126/1126 [==============================] - 0s 42us/step - loss: 106.9077 - val_loss: 118.4429
Epoch 161/5000
1126/1126 [==============================] - 0s 41us/step - loss: 106.7239 - val_loss: 118.4394
Epoch 162/5000
1126/1126 [==============================] - 0s 33us/step - loss: 106.8782 - val_loss: 118.3071
Epoch 163/5000
1126/1126 [==============================] - 0s 42us/step - loss: 106.7131 - val_loss: 117.6495
Epoch 164/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.7834 - val_loss: 118.5915
Epoch 165/5000
1126/1126 [==============================] - 0s 41us/step - loss: 106.7057 - val_loss: 119.1096
Epoch 166/5000
1126/1126 [==============================] - 0s 34us/step - loss: 106.6250 - val_loss: 118.1796
Epoch 167/5000
1126/1126 [==============================] - 0s 33us/step - loss: 106.5983 - val_loss: 118.2189
Epoch 168/5000
1126/1126 [==============================] - 0s 41us/step - loss: 106.5638 - val_loss: 118.8728
Epoch 169/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.5120 - val_loss: 117.7220
Epoch 170/5000
```

```
1126/1126 [==============================] - 0s 50us/step - loss: 106.4253 - val_loss: 118.1670
Epoch 171/5000
1126/1126 [==============================] - 0s 55us/step - loss: 106.4537 - val_loss: 117.5650
Epoch 172/5000
1126/1126 [==============================] - 0s 54us/step - loss: 106.3741 - val_loss: 118.0439
Epoch 173/5000
1126/1126 [==============================] - 0s 63us/step - loss: 106.4510 - val_loss: 117.6671
Epoch 174/5000
1126/1126 [==============================] - 0s 53us/step - loss: 106.3560 - val_loss: 117.4173
Epoch 175/5000
1126/1126 [==============================] - 0s 50us/step - loss: 106.2523 - val_loss: 117.5468
Epoch 176/5000
1126/1126 [==============================] - 0s 50us/step - loss: 106.2617 - val_loss: 116.9284
Epoch 177/5000
1126/1126 [==============================] - 0s 45us/step - loss: 106.3900 - val_loss: 117.3073
Epoch 178/5000
1126/1126 [==============================] - 0s 46us/step - loss: 106.0485 - val_loss: 117.5028
Epoch 179/5000
1126/1126 [==============================] - 0s 38us/step - loss: 106.2887 - val_loss: 117.6575
Epoch 180/5000
1126/1126 [==============================] - 0s 32us/step - loss: 106.0960 - val_loss: 117.6455
Epoch 181/5000
1126/1126 [==============================] - 0s 35us/step - loss: 106.3603 - val_loss: 117.8707
Epoch 182/5000
1126/1126 [==============================] - 0s 35us/step - loss: 106.0162 - val_loss: 117.2491
Epoch 183/5000
1126/1126 [==============================] - 0s 34us/step - loss: 106.0383 - val_loss: 117.3894
Epoch 184/5000
1126/1126 [==============================] - 0s 34us/step - loss: 106.0633 - val_loss: 116.3727
Epoch 185/5000
1126/1126 [==============================] - 0s 51us/step - loss: 105.9616 - val_loss: 116.1228
Epoch 186/5000
1126/1126 [==============================] - 0s 49us/step - loss: 105.9612 - val_loss: 116.8049
Epoch 187/5000
1126/1126 [==============================] - 0s 53us/step - loss: 105.7975 - val_loss: 115.9202
Epoch 188/5000
1126/1126 [==============================] - 0s 49us/step - loss: 105.7850 - val_loss: 116.2099
Epoch 189/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.7562 - val_loss: 116.3444
Epoch 190/5000
1126/1126 [==============================] - 0s 40us/step - loss: 105.8995 - val_loss: 115.6151
Epoch 191/5000
1126/1126 [==============================] - 0s 33us/step - loss: 105.6819 - val_loss: 115.8957
Epoch 192/5000
1126/1126 [==============================] - 0s 34us/step - loss: 105.7969 - val_loss: 116.5914
Epoch 193/5000
1126/1126 [==============================] - 0s 35us/step - loss: 105.7376 - val_loss: 117.0570
Epoch 194/5000
```

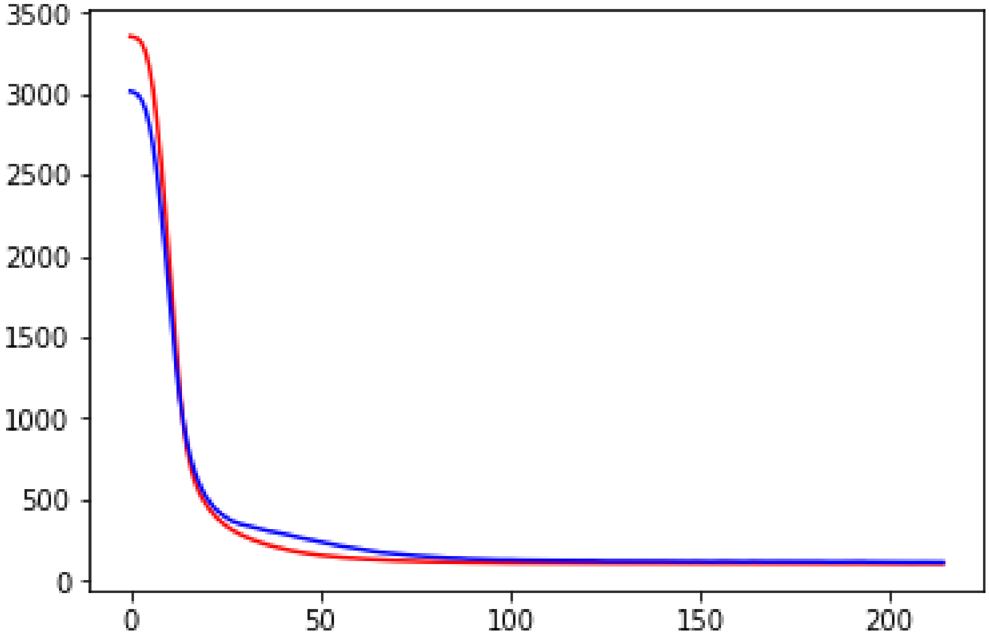
```
1126/1126 [==============================] - 0s 42us/step - loss: 105.6602 - val_loss: 117.2297
Epoch 195/5000
1126/1126 [==============================] - 0s 51us/step - loss: 105.7949 - val_loss: 115.7781
Epoch 196/5000
1126/1126 [==============================] - 0s 49us/step - loss: 105.5089 - val_loss: 116.4587
Epoch 197/5000
1126/1126 [==============================] - 0s 56us/step - loss: 105.5086 - val_loss: 115.4254
Epoch 198/5000
1126/1126 [==============================] - 0s 42us/step - loss: 105.5438 - val_loss: 115.1320
Epoch 199/5000
1126/1126 [==============================] - 0s 34us/step - loss: 105.4836 - val_loss: 115.2506
Epoch 200/5000
1126/1126 [==============================] - 0s 34us/step - loss: 105.3843 - val_loss: 114.9215
Epoch 201/5000
1126/1126 [==============================] - 0s 36us/step - loss: 105.4154 - val_loss: 113.2857
Epoch 202/5000
1126/1126 [==============================] - 0s 34us/step - loss: 105.3151 - val_loss: 114.0834
Epoch 203/5000
1126/1126 [==============================] - 0s 33us/step - loss: 105.4029 - val_loss: 113.8900
Epoch 204/5000
1126/1126 [==============================] - 0s 38us/step - loss: 105.3463 - val_loss: 113.8296
Epoch 205/5000
1126/1126 [==============================] - 0s 44us/step - loss: 105.2474 - val_loss: 113.2288
Epoch 206/5000
1126/1126 [==============================] - 0s 48us/step - loss: 105.1995 - val_loss: 113.8120
Epoch 207/5000
1126/1126 [==============================] - 0s 50us/step - loss: 105.0951 - val_loss: 113.8405
Epoch 208/5000
1126/1126 [==============================] - 0s 48us/step - loss: 105.4364 - val_loss: 114.3460
Epoch 209/5000
1126/1126 [==============================] - 0s 39us/step - loss: 105.1974 - val_loss: 113.8604
Epoch 210/5000
1126/1126 [==============================] - 0s 45us/step - loss: 105.1933 - val_loss: 114.3338
Epoch 211/5000
1126/1126 [==============================] - 0s 41us/step - loss: 105.0273 - val_loss: 113.9939
Epoch 212/5000
1126/1126 [==============================] - 0s 41us/step - loss: 105.0495 - val_loss: 114.2093
Epoch 213/5000
1126/1126 [==============================] - 0s 40us/step - loss: 105.0614 - val_loss: 113.9618
Epoch 214/5000
1126/1126 [==============================] - 0s 39us/step - loss: 104.9053 - val_loss: 113.6082
Epoch 215/5000
1126/1126 [==============================] - 0s 36us/step - loss: 104.9757 - val_loss: 113.5212
Epoch 00215: early stopping
```

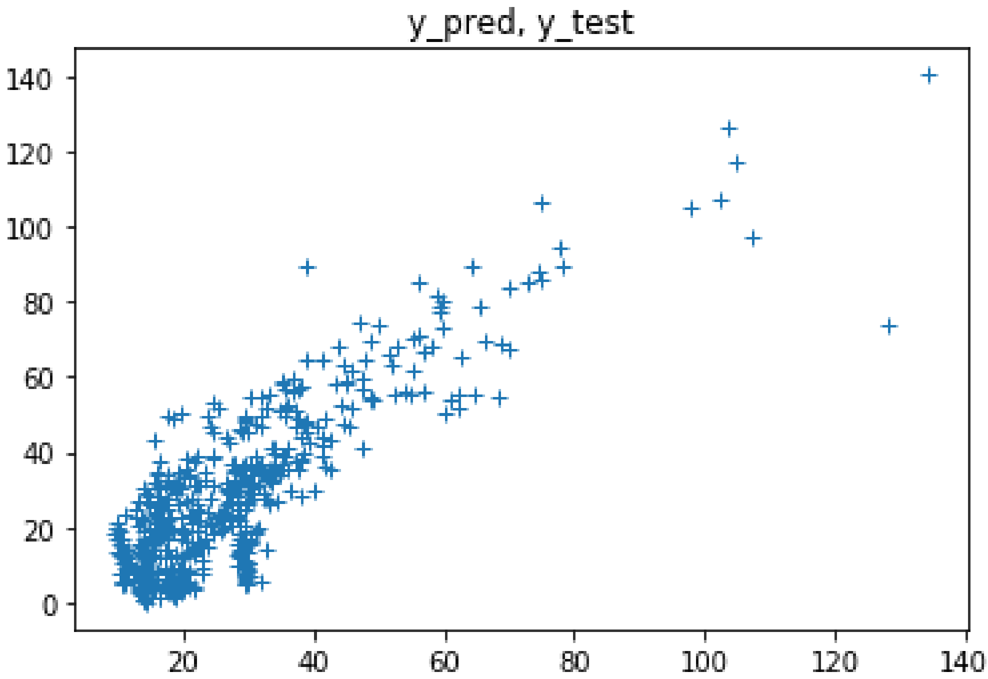
```
In [12]: y_pred = model.predict(X_test)
         plt.plot(history.history['loss'], 'r-')
```

```
plt.plot(history.history['val_loss'], 'b-')
plt.show()

plt.title('y_pred, y_test')

plt.plot(y_pred[:], y_test[:], '+')
plt.show()
percent_high_detected = np.sum(y_pred.reshape((len(y_pred), )) > 20) / np.sum(y_test.
print(percent_high_detected)
```





```
1.11627906977
```

```
In [ ]:
```