```
In [ ]:    # import all the classes
           from datetime import datetime, date
           from keras.models import Sequential
           from keras.layers import LSTM, Dense, Dropout
           import math
           import matplotlib.pyplot as plt
           import numpy as np
           import pandas as pd
           from sklearn.linear_model import LinearRegression
           from sklearn.metrics import mean_squared_error
           import tensorflow.compat.v1 as tf

           print(tf.__version__)
           from time import *
           # see readme file to know exact libiaries to install and their functions
```

2.7.0

Load data and data preprocessing

```
In [ ]:    class Processing:
               """ read the data
                   and  do some feature engeering
                   after define the class, then call each function in the class
                   to read the data and do some feature engeering
               """
               def __init__(self, filename):
                   self.filename = filename
                   if (self.filename[-4:]) == "xlsx":
                       self.df = pd.read_excel(self.filename,
                                               parse_dates=["Dates"],
                                               index_col="Dates")
                   elif (self.filename[-3:]) == "csv":
                       self.df = pd.read_csv(self.filename,
                                             parse_dates=["Dates"],
                                             index_col="Dates")

               # processing the data(Feature engineering)
               def preprocessing(self, lda_list):  #lda is a parameter
                   """ do the feature engeering, make features baspread, return and RV
                   for each lda values
                   Parameters:
                           lda_list: list
                           Meaning: decaying factors
                   Return:
                           No return values"""

                   self.df = self.df[[
                       'PX_BID', 'PX_ASK', 'PX_LAST', 'PX_OPEN', 'EQY_WEIGHTED_AVG_PX',
                       'PX_VOLUME', 'HIST_CALL_IMP_VOL', 'HIST_PUT_IMP_VOL',
                       '3MTH_IMPVOL_90.0%MNY_DF', '3MTH_IMPVOL_100.0%MNY_DF',
                       '3MTH_IMPVOL_110.0%MNY_DF', '3MO_CALL_IMP_VOL', 'IVOL_MONEYNESS'
                   ]]
                   self.df['baspread'] = self.df['PX_ASK'] - self.df['PX_BID']
                   self.df['Return'] = np.log(self.df['PX_LAST']) - np.log(
                       self.df['PX_LAST'].shift())
```

```
        for lda in lda_list:  #moving average
            vol = [0]
            ret = self.df['Return'].values
            for i in range(1, len(self.df)):
                vol.append(lda * vol[i - 1] + (1 - lda) * ret[i]**2)
            self.df['RV_%s' % (lda)] = np.sqrt(vol) * 16 * 100
        self.df = self.df.iloc[50:, :]
```

In [ ]:
```
data = Processing("GOOGL.csv")
```

In [ ]:
```
lda_list = [0.97, 0.94,
            0.87]  # decaying factors used to calculate realized volatility
df = data.preprocessing(lda_list)
```

In [ ]:
```
data.df
```

Out[ ]:

Dates	PX_BID	PX_ASK	PX_LAST	PX_OPEN	EQY_WEIGHTED_AVG_PX	PX_VOLUME	HIST_CALL_IMP_V(
2014-03-12	603.820	604.246	604.236	598.780	599.7127	1966927	22.9
2014-03-13	595.107	595.112	595.107	604.561	597.9419	2345640	25.1
2014-03-14	586.969	587.029	586.969	591.568	590.2064	2301786	25.3
2014-03-17	596.148	596.628	596.628	590.197	595.6752	2166547	24.5
2014-03-18	606.082	606.353	606.217	597.914	602.9403	1821606	24.4
...	...	...	...	...	...	...	
2021-11-23	2915.870	2916.650	2915.640	2923.060	2910.3419	1361558	23.8
2021-11-24	2921.080	2922.810	2922.400	2909.470	2912.9179	902007	24.1
2021-11-25	2921.080	2922.810	2922.400	2909.470	2912.9179	902007	24.1
2021-11-26	2844.610	2845.560	2843.660	2886.970	2857.0229	1523462	28.5
2021-11-29	2922.880	2924.370	2923.380	2880.000	2899.5976	1141716	28.5

2014 rows × 18 columns
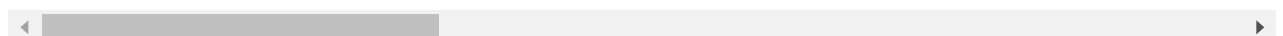
Plotting RV with different lda

```
In [ ]:  class plot_RV:
             """ plotting the RV with different decaying factors
                 as well as impiled volatility
                 after defining the class, call the polt functions
                 with lad values list
             """
             def __init__(self, df):
                 self.df = df

             def plot(self, lda_list):
                 """
                 plotting the realized and implied volatility
                 Parameters:
                     lda_list: list
                     Meaning: decaying factors
                 Return:
                     a plot of 4 cuvres"""
                 for lda in lda_list:
                     plt.plot(self.df['RV_%s' % (lda)], label='lamda=%s' % (lda))
                 plt.plot(self.df['3MO_CALL_IMP_VOL'], label='implied')
                 plt.legend(loc='best')
                 plt.show()
```
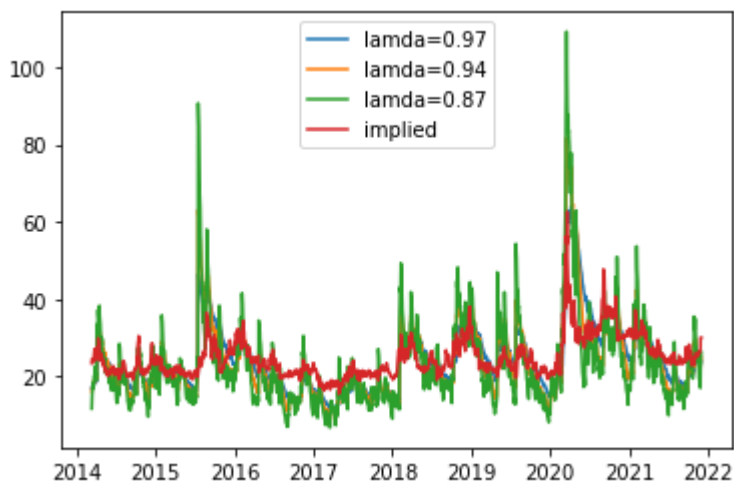
```
In [ ]:  plot = plot_RV(data.df)
```

```
In [ ]:  plot.plot(lda_list)
```



```
In [ ]:  def accuracy_trend(x, y, day=1):
             """
             trend accuracy, defined by the sign of changes, if predcit the same sign as the cha
             then, it predicts correctly
             Parameters:
                 x: numpy.ndarray
                 Meaning: the ture values
                 y: numpy.ndarray
                 Meaning: the predict values
                 day: int
                 Meaning: the difference between t and t-day
```

```
            Return:
                    type: float
                    Meaning: the trend accuracy of the model"""
        return (((pd.Series(x).diff(day) > 0) ==
                 (pd.Series(y).diff(day) > 0)).sum() - day) / (len(x) - day)
```

In [ ]:
```
#using RV with different lda to predict impolied vol
print(
    accuracy_trend(data.df['3MTH_IMPVOL_100.0%MNY_DF'].values,
                   data.df['RV_0.97'].values))
print(
    accuracy_trend(data.df['3MTH_IMPVOL_100.0%MNY_DF'].values,
                   data.df['RV_0.94'].values))
print(
    accuracy_trend(data.df['3MTH_IMPVOL_100.0%MNY_DF'].values,
                   data.df['RV_0.87'].values))
```

```
0.5454545454545454
0.5449577744659712
0.5504222553402881
```

Analyzing data and trying to find the best predictors

In [ ]:
```
class data_analyzing:
    """ analyzing the data, test which feature to include in the model,
        come up with a how we started the process,
        which features to include, and what parts we should focus on more
        call each function step by step, and see the progress we made to analyze
        the data
    """

    def __init__(self, df):
        self.df = df
        self.df['dayofweek'] = df.index.dayofweek + 1

    def accuracy_trend(self, x, y, day=1):
        """
        trend accuracy, defined by the sign of changes, if predcit the same sign as the cha
        then, it predicts correctly
        Parameters:
                x: numpy.ndarray
                Meaning: the ture values
                y: numpy.ndarray
                Meaning: the predict values
                day: int
                Meaning: the difference between t and t-day
        Return:
                type: float
                Meaning: the trend accuracy of the model"""

        return (((pd.Series(x).diff(day) > 0) ==
                 (pd.Series(y).diff(day) > 0)).sum() - day) / (len(x) - day)

    def analyzing_by_days(self):
        """ Sperate the data by days, and for each day calculate the trend accuracy
```

```python
            Parameters: none
            Return:
                    type: float
                    Meaning: the trend accuracy of the model"""
        self.dic = {}
        for i in range(1, 6):
            self.dic[str(i)] = self.df[self.df['dayofweek'] == i]
            self.df1 = self.df[self.df['dayofweek'] == i]
            plt.plot(self.df1['RV_0.97'], label='lamda=0.97')
            plt.plot(self.df1['RV_0.94'], label='lamda=0.94')
            plt.plot(self.df1['RV_0.87'], label='lamda=0.87')
            plt.plot(self.df1['3MO_CALL_IMP_VOL'], label='implied')
            plt.legend(loc='best')
            plt.show()
            print('when i = ', i)
            print(
                self.accuracy_trend(
                    self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                    self.df1['RV_0.97'].values))
            print(
                self.accuracy_trend(
                    self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                    self.df1['RV_0.94'].values))
            print(
                self.accuracy_trend(
                    self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                    self.df1['RV_0.87'].values))

    def regiem_change(self):
        """ plot the realized vol and implied vol, find the relationship between each of
        to see if there is a good sperator to sperate the data.
        Parameters: none
        Return:
                add regime to the column"""
        # Plot of realzied vols
        plt.plot(self.df['RV_0.97'], label='lamda=0.97')
        plt.plot(self.df['RV_0.94'], label='lamda=0.94')
        plt.plot(self.df['RV_0.87'], label='lamda=0.87')
        plt.plot(self.df['3MO_CALL_IMP_VOL'], label='implied')
        plt.legend(loc='best')
        plt.show()
        plt.figure(figsize=(15, 5))
        # edges = np.arange(0, 10, 10)
        plt.hist(self.df['RV_0.87'], edgecolor='black')
        plt.xlabel('Volume')
        plt.ylabel('frequencies')
        plt.title('Frequencies')
        plt.figure(figsize=(15, 5))
        # edges = np.arange(0, 10, 10)
        plt.hist(self.df['3MO_CALL_IMP_VOL'], edgecolor='black')
        plt.xlabel('Volume')
        plt.ylabel('frequencies')
        plt.title('Frequencies')
        self.df['regiem'] = 0
        self.df.loc[self.df['RV_0.87'] > 30, 'regiem'] = 1
        self.df.loc[self.df['RV_0.87'] > 50, 'regiem'] = 2

    def analyzing_by_regiem(self):
        """ Sperate the data by regimes (based on rv_0.87,0< RV_0.87<30, mark 0
          30<RV_0.87<50, mark 1
```

```python
         RV_0.87>50, mark 2
         and for each regime calculate the trend accuracy
     Parameters: none
     Return:
         type: float
         Meaning:the trend accuracy of the model"""
    self.dic = {}
    for i in range(3):
        self.dic[str(i)] = self.df[self.df['regiem'] == i]
        self.df1 = self.df[self.df['regiem'] == i]
        print('when i = ', i)
        print(
            self.accuracy_trend(
                self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                self.df1['RV_0.97'].values))
        print(
            self.accuracy_trend(
                self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                self.df1['RV_0.94'].values))
        print(
            self.accuracy_trend(
                self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                self.df1['RV_0.87'].values))

def analyzing_by_regiem_days(self):
    """ Sperate the data by regimes and days
        and for each regime and day calculate the trend accuracy
    Parameters: none
    Return:
        type: float
        Meaning: the trend accuracy of the model"""
    self.df1 = self.df[(self.df['regiem'] == 1)
                        & (self.df['dayofweek'] == 1)]
    print("regiem = 1 and dayofweek = 1")
    print(
        self.accuracy_trend(self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                            self.df1['RV_0.97'].values))
    print(
        self.accuracy_trend(self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                            self.df1['RV_0.94'].values))
    print(
        self.accuracy_trend(self.df1['3MTH_IMPVOL_100.0%MNY_DF'].values,
                            self.df1['RV_0.87'].values))
```

In [ ]:
```python
new_data = data_analyzing(data.df)
```

In [ ]:
```python
new_data.analyzing_by_days()
```
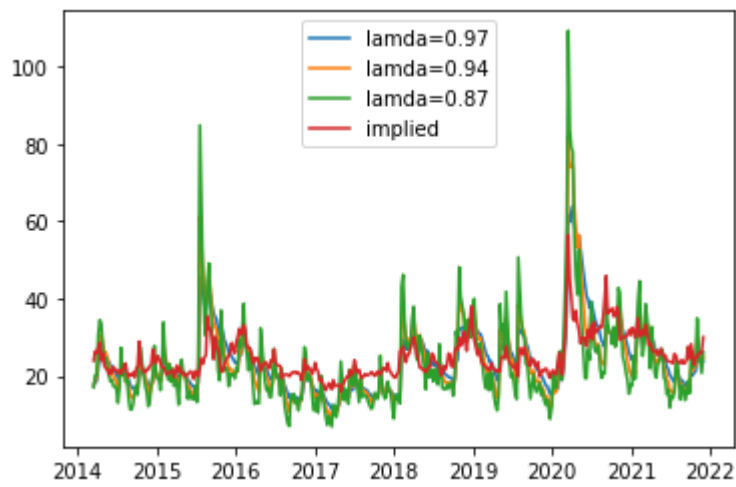
when i = 1
0.554726368159204
0.5746268656716418
0.5796019900497512
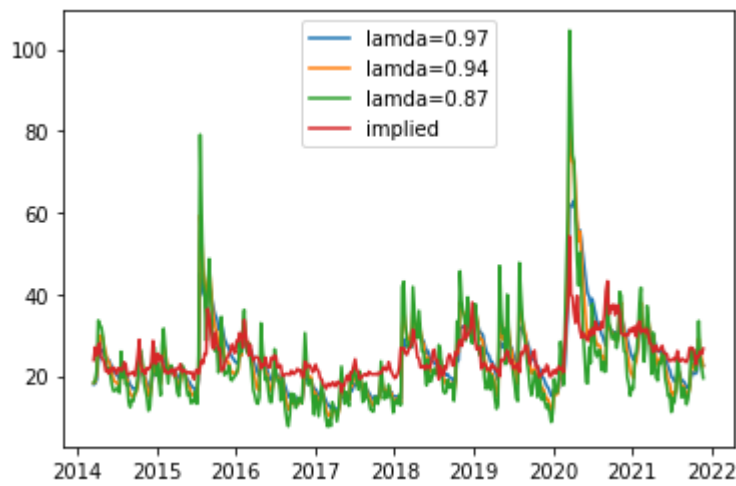
when i = 2
0.5286783042394015
0.5486284289276808
0.5386533665835411
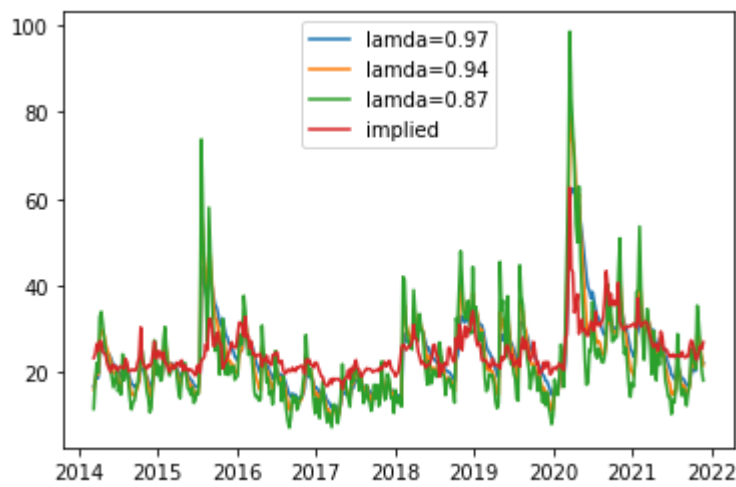
when i = 3
0.5223880597014925
0.5223880597014925
0.5422885572139303
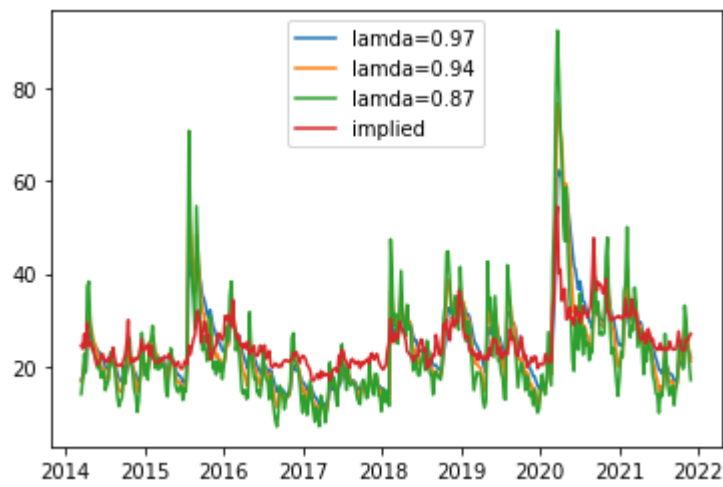
when i = 4
0.5
0.5124378109452736
0.5522388059701493
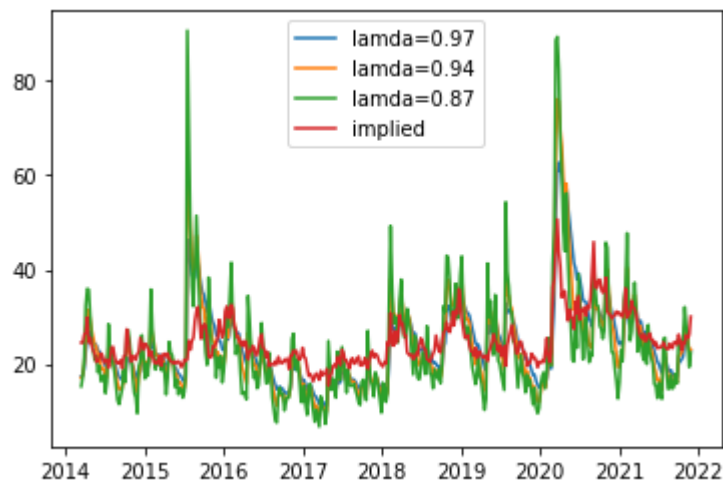
when i = 5
0.5373134328358209
0.5597014925373134
0.5696517412935324

```
In [ ]:    new_data.regiem_change()
```

Frequencies

Frequencies
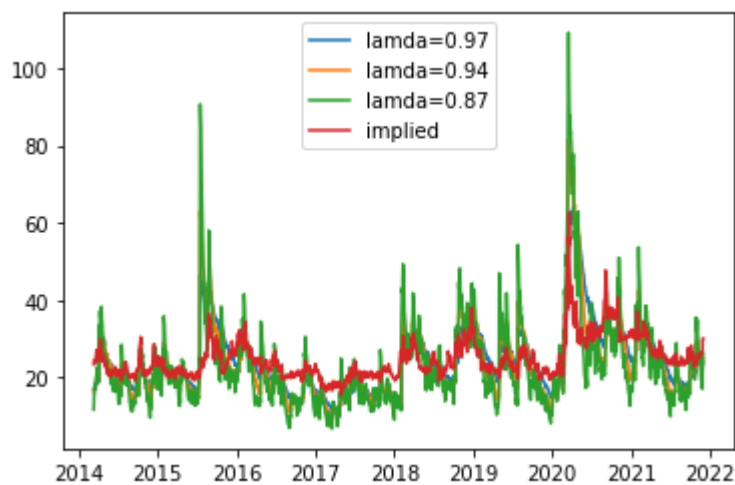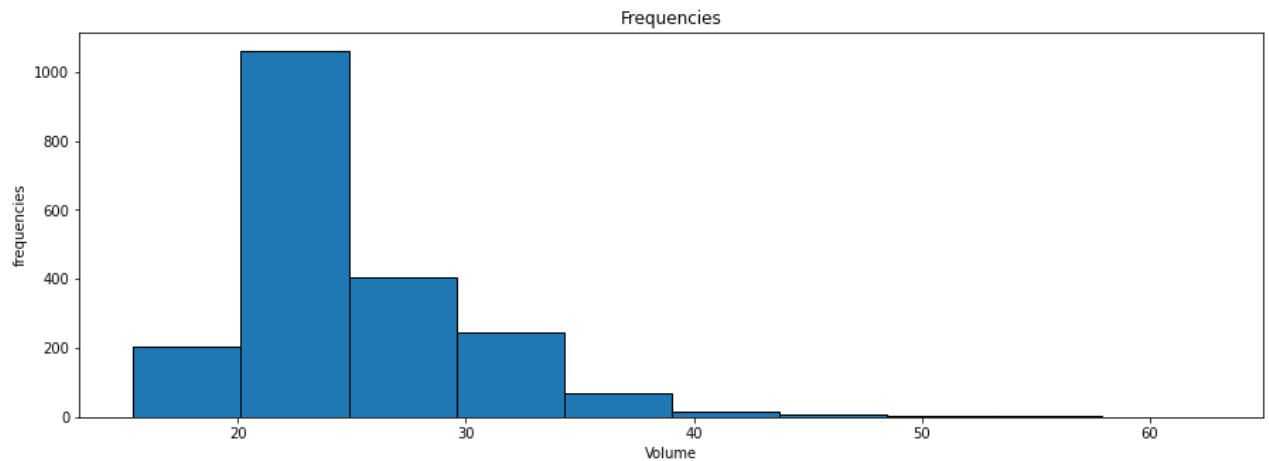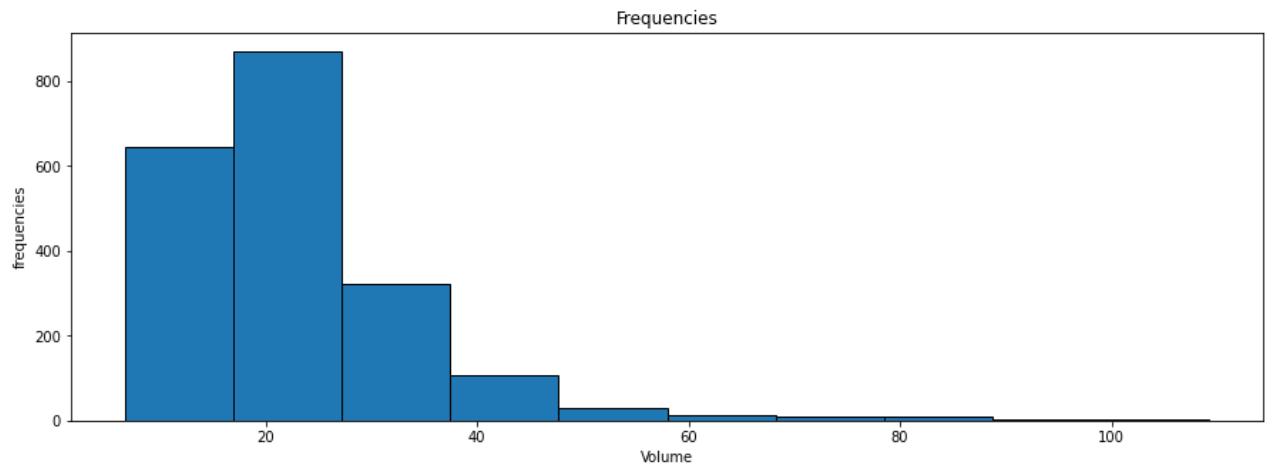
In [ ]:
```python
new_data.analyzing_by_regiem()
```

```
when i =  0
0.5336976320582878
0.5349119611414693
0.5415907710989678
when i =  1
0.592948717948718
0.592948717948718
0.5833333333333334
when i =  2
0.5192307692307693
0.4807692307692308
0.5192307692307693
```

In [ ]:
```python
new_data.analyzing_by_regiem_days()
```

```
regiem = 1 and dayofweek = 1
0.582089552238806
0.582089552238806
0.5671641791044776
```

In [ ]:
```python
# after analyzing the data, we decided to sperate the data into three regiems, according
```

Try different LSTM models to imporve the

prediction

In [ ]:
```python
class LSTM_model:
    """ try LSTM model with differnt layers(1, 2, 3)
        test the model accuracy
        comparsion with the baseline model
        call the functions step by step
    """
    def __init__(self, df):
        df['regiem'] = 0
        df.loc[df['RV_0.87'] > 30, 'regiem'] = 1
        df.loc[df['RV_0.87'] > 50, 'regiem'] = 2
        df1 = df.dropna(how='any')
        dataset = np.array(df1.loc[df['regiem'] == 1, [
            '3MTH_IMPVOL_90.0%MNY_DF', '3MTH_IMPVOL_100.0%MNY_DF',
            '3MTH_IMPVOL_110.0%MNY_DF', 'IVOL_MONEYNESS', 'baspread', 'Return',
            'RV_0.97', 'RV_0.94', 'RV_0.87', 'IVOL_MONEYNESS'
        ]])
        self.dataset = dataset
        self.n_feature = self.dataset.shape[1] - 1
        self.n_time_step = 1

    def split_sequence(self, sequences, n_time_step):
        """
        the way of how we constrct data set which suitable for the model
        Parameters:
            sequences: pd.Dataframe
            Meaning: the data set
            n_time_step: int
            Meaning: the way of constructing the data
        Return:
            type: np.array
            Meaning:the data set we can use as inputs in the LSTM model
        """
        X, y = [], []
        for i in range(len(sequences)):
            end_ix = i + n_time_step

            if end_ix >= len(sequences):
                break
            seq_x, seq_y = sequences[i:end_ix, :-1], sequences[end_ix, -1]
            X.append(seq_x)
            y.append(seq_y)
        return np.array(X), np.array(y)

    def split_train_test(self, n_time_step=1, train_rate=0.8):
        """
        Sperate the data into training data and test data set
        Parameters:
            train_rate: float
            Meaning: what precentage used as training and test set
            n_time_step: int
            Meaning: the way of constructing the data
        Return:
            training data set and testing data set
        """
        self.train_sample_num = int(self.dataset.shape[0] *
                                    train_rate)  #shape[0] = number of rows
```

```python
        #validation_sample_num = self.dataset.shape[0] - train_sample_num
        df_train = self.dataset[:self.train_sample_num, :]
        df_validation = self.dataset[self.train_sample_num:, :]

        self.data_x_train, self.data_y_train = self.split_sequence(
            df_train, n_time_step)
        self.data_x_test, self.data_y_test = self.split_sequence(
            df_validation, n_time_step)

    def fit_model(self, layers):
        """
      Fit the LSTM model using differnt layers
      Parameters:
            layers: int
            Meaning: how many layers in the LSTM model
      Return:
            trained LSTM model
"""
        self.model = Sequential()
        if layers == 1:
            # Train model
            self.model.add(
                LSTM(500,
                    activation='tanh',
                    input_shape=(self.n_time_step, self.n_feature)))
            self.model.add(Dropout(0.3))
            self.model.add(Dense(1, activation='linear'))
            self.model.compile(
                optimizer=tf.keras.optimizers.RMSprop(learning_rate=0.005),
                loss='mse')

        if layers == 2:
            self.model.add(
                LSTM(500,
                    activation='tanh',
                    return_sequences=True,
                    input_shape=(self.n_time_step, self.n_feature)))
            self.model.add(Dropout(0.3))
            self.model.add(LSTM(500, activation='tanh'))
            self.model.add(Dense(1, activation='linear'))
            self.model.compile(
                optimizer=tf.keras.optimizers.RMSprop(learning_rate=0.0005),
                loss='mse')

        if layers == 3:
            # Train model layers = 3
            self.model.add(
                LSTM(500,
                    activation='tanh',
                    return_sequences=True,
                    input_shape=(self.n_time_step, self.n_feature)))
            self.model.add(Dropout(0.3))
            self.model.add(LSTM(500, activation='tanh', return_sequences=True))
            self.model.add(Dropout(0.3))
            self.model.add(LSTM(500, activation='tanh'))
            self.model.add(Dense(1, activation='linear'))
            self.model.compile(
                optimizer=tf.keras.optimizers.RMSprop(learning_rate=0.0005),
                loss='mse')
```

```python
        # Fit model
        self.model.fit(self.data_x_train,
                       self.data_y_train,
                       batch_size=50,
                       epochs=400)

    def predict_result(self):
        """
      Predict the vaule of impolied vol using the model fitted before
      Parameters: none
      Return:
            type:float
            Meaning:the testing MSE of the model
    """
        # Out-of-sample Prediction
        yout = []
        for i in range(len(self.data_x_test)):
            x_input = self.data_x_test[i].reshape(
                (1, self.n_time_step, self.n_feature))
            #print(x_input.shape)
            output = self.model.predict(x_input, verbose=0)
            yout.append(output)
        self.y_pred = np.array(yout)
        self.y_pred = self.y_pred.reshape(-1)
        #print(self.y_pred.shape)
        print('testing MSE: ', mean_squared_error(self.data_y_test,
                                                   self.y_pred))

    def compare_to_baseline(self):
        """
      compare the LSTM model with the baseline model
      Parameters: none
      Return:
            type: float and plot
            the testing MSE of the baseline model
            and plot of the curves of two model prediction
    """
        print(
            "MSE of baseline model: ",
            mean_squared_error(self.dataset[self.train_sample_num + 1:, -1],
                               self.dataset[self.train_sample_num:-1, -1]))
        print("Comparison of model prediction and baseline prediction:")
        plt.plot(self.y_pred, label='Model')
        plt.plot(self.data_y_test, label='Baseline')
        plt.legend(loc='best')
        plt.show()

    def accuracy_trend(self, x, y, day=1):
        """
      trend accuracy, defined by the sign of changes, if predcit the same sign as the cha
      then, it predicts correctly
      Parameters:
            x: numpy.ndarray
            Meaning: the ture values
            y: numpy.ndarray
            Meaning: the predict values
            day: int
            Meaning: the difference between t and t-day
      Return:
            type:float
```

```python
            Meaning:the trend accuracy of the model
        """
        return (((pd.Series(x).diff(day) > 0) ==
                 (pd.Series(y).diff(day) > 0)).sum() - day) / (len(x) - day)

    def test_accuracy(self):
        """
        calculate the trend accuracy of the LSTM model and baseline model by each days
        Parameters: none
        Return:
            type: float
            Meaning: the trend accuracy of each model by differnt days
        """

        print("Day-to-day out-of-sample accuracy: ",
              self.accuracy_trend(self.data_y_test, self.y_pred))
        print("Five-day out-of-sample accuracy: ",
              self.accuracy_trend(self.data_y_test, self.y_pred, 5))
        print(
            "Day-to-day out-of-sample accuracy of baseline: ",
            self.accuracy_trend(self.dataset[self.train_sample_num + 1:, -1],
                                self.dataset[self.train_sample_num:-1, -1]))
        print(
            "Five-day out-of-sample accuracy of baseline: ",
            self.accuracy_trend(self.dataset[self.train_sample_num + 1:, -1],
                                self.dataset[self.train_sample_num:-1, -1], 5))
```

In [ ]:
```python
class model_plot:
    """ plot the True vs Predict values
        the residual plot
        as well as the trend plot
        after define the class,
        call each function with the LSTM model
        and baseline model, to see the comparsion
        of each model
    """
    def __init__(self, true, pred):
        self.true = true
        self.pred = pred

    def true_pred_plot(self):
        """
        the plot of true values vs predict values
        Parameters:
            true: list
            Meaning: the ture values of the model
            predict: list
            Meaning: the predict values of the model
        Return:
            type: plot
            Meaning:the plot of true vs predict values
        """
        plt.scatter(self.pred, self.true)
        plt.plot(self.true, self.true)
        plt.xlabel("predicted value")
        plt.ylabel("true value")
        plt.show()
```

```python
    def residual_plot(self):
        """
        the residual plot (predict values - true values)
        Parameters: none
        Return:
            type: plot
            Meaning:the residual plot
        """
        plt.plot(self.pred - self.true)
        plt.title("Residual plot")
        plt.show()

    def trend_plot(self):
        """
        the trend plot (the changes of true values vs the changes of predict values)
        Parameters: none
        Return:
            type:float
            Meaning:the trend plot
        """

        self.true = pd.Series(self.true).diff()
        self.pred = pd.Series(self.pred).diff()
        plt.scatter(self.true, self.pred)
        plt.hlines(0, np.min(self.true), np.max(self.true), color='red')
        plt.vlines(0, np.min(self.pred), np.max(self.pred), color='red')
        plt.xlabel('change of true')
        plt.ylabel('change of pred')
        x = np.linspace(np.floor(np.min(self.true)),
                        np.ceil(np.max(self.true)))
        y = x
        plt.plot(x, y, label='true = pred', color='orange')
        plt.legend()
        plt.show()
```

LSTM   Model with 1 layer

In [ ]:
```python
LSTM_1 = LSTM_model(data.df)
LSTM_1.split_train_test()
LSTM_1.fit_model(layers=1)
LSTM_1.predict_result()
LSTM_1.compare_to_baseline()
LSTM_1.test_accuracy()
```

```
Epoch 1/400
5/5 [==============================] - 2s 29ms/step - loss: 496.5412
Epoch 2/400
5/5 [==============================] - 0s 29ms/step - loss: 173.0289
Epoch 3/400
5/5 [==============================] - 0s 29ms/step - loss: 144.0431
Epoch 4/400
5/5 [==============================] - 0s 28ms/step - loss: 141.1114
Epoch 5/400
5/5 [==============================] - 0s 28ms/step - loss: 133.0062
Epoch 6/400
5/5 [==============================] - 0s 25ms/step - loss: 130.0450
Epoch 7/400
```

```
5/5 [==============================] - 0s 25ms/step - loss: 128.2097
Epoch 8/400
5/5 [==============================] - 0s 23ms/step - loss: 122.5044
Epoch 9/400
5/5 [==============================] - 0s 26ms/step - loss: 121.5371
Epoch 10/400
5/5 [==============================] - 0s 25ms/step - loss: 118.3647
Epoch 11/400
5/5 [==============================] - 0s 25ms/step - loss: 113.7824
Epoch 12/400
5/5 [==============================] - 0s 24ms/step - loss: 122.8767
Epoch 13/400
5/5 [==============================] - 0s 30ms/step - loss: 101.7920
Epoch 14/400
5/5 [==============================] - 0s 29ms/step - loss: 131.3470
Epoch 15/400
5/5 [==============================] - 0s 28ms/step - loss: 92.7798
Epoch 16/400
5/5 [==============================] - 0s 29ms/step - loss: 116.6733
Epoch 17/400
5/5 [==============================] - 0s 28ms/step - loss: 91.4139
Epoch 18/400
5/5 [==============================] - 0s 28ms/step - loss: 108.4870
Epoch 19/400
5/5 [==============================] - 0s 27ms/step - loss: 107.0305
Epoch 20/400
5/5 [==============================] - 0s 30ms/step - loss: 91.4658
Epoch 21/400
5/5 [==============================] - 0s 27ms/step - loss: 110.7733
Epoch 22/400
5/5 [==============================] - 0s 30ms/step - loss: 93.9305
Epoch 23/400
5/5 [==============================] - 0s 28ms/step - loss: 95.0952
Epoch 24/400
5/5 [==============================] - 0s 30ms/step - loss: 93.5238
Epoch 25/400
5/5 [==============================] - 0s 32ms/step - loss: 105.7582
Epoch 26/400
5/5 [==============================] - 0s 29ms/step - loss: 84.0980
Epoch 27/400
5/5 [==============================] - 0s 27ms/step - loss: 103.3651
Epoch 28/400
5/5 [==============================] - 0s 31ms/step - loss: 87.7375
Epoch 29/400
5/5 [==============================] - 0s 24ms/step - loss: 93.5874
Epoch 30/400
5/5 [==============================] - 0s 24ms/step - loss: 88.7191
Epoch 31/400
5/5 [==============================] - 0s 27ms/step - loss: 83.7071
Epoch 32/400
5/5 [==============================] - 0s 26ms/step - loss: 98.8476
Epoch 33/400
5/5 [==============================] - 0s 25ms/step - loss: 76.1488
Epoch 34/400
5/5 [==============================] - 0s 29ms/step - loss: 92.9794
Epoch 35/400
5/5 [==============================] - 0s 24ms/step - loss: 89.5726
Epoch 36/400
5/5 [==============================] - 0s 23ms/step - loss: 88.4430
Epoch 37/400
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5/5 [==============================] - 0s 25ms/step - loss: 77.3455
Epoch 38/400
5/5 [==============================] - 0s 26ms/step - loss: 97.7898
Epoch 39/400
5/5 [==============================] - 0s 24ms/step - loss: 87.2705
Epoch 40/400
5/5 [==============================] - 0s 28ms/step - loss: 82.4479
Epoch 41/400
5/5 [==============================] - 0s 25ms/step - loss: 81.0464
Epoch 42/400
5/5 [==============================] - 0s 27ms/step - loss: 84.7851
Epoch 43/400
5/5 [==============================] - 0s 24ms/step - loss: 85.9252
Epoch 44/400
5/5 [==============================] - 0s 24ms/step - loss: 77.5290
Epoch 45/400
5/5 [==============================] - 0s 26ms/step - loss: 79.6225
Epoch 46/400
5/5 [==============================] - 0s 25ms/step - loss: 76.2885
Epoch 47/400
5/5 [==============================] - 0s 25ms/step - loss: 83.1282
Epoch 48/400
5/5 [==============================] - 0s 24ms/step - loss: 66.0059
Epoch 49/400
5/5 [==============================] - 0s 25ms/step - loss: 83.4214
Epoch 50/400
5/5 [==============================] - 0s 27ms/step - loss: 80.6378
Epoch 51/400
5/5 [==============================] - 0s 24ms/step - loss: 82.0390
Epoch 52/400
5/5 [==============================] - 0s 25ms/step - loss: 80.8759
Epoch 53/400
5/5 [==============================] - 0s 26ms/step - loss: 78.1178
Epoch 54/400
5/5 [==============================] - 0s 23ms/step - loss: 69.3345
Epoch 55/400
5/5 [==============================] - 0s 25ms/step - loss: 76.0001
Epoch 56/400
5/5 [==============================] - 0s 25ms/step - loss: 73.6183
Epoch 57/400
5/5 [==============================] - 0s 25ms/step - loss: 79.4334
Epoch 58/400
5/5 [==============================] - 0s 25ms/step - loss: 79.0337
Epoch 59/400
5/5 [==============================] - 0s 25ms/step - loss: 71.7249
Epoch 60/400
5/5 [==============================] - 0s 25ms/step - loss: 72.2659
Epoch 61/400
5/5 [==============================] - 0s 24ms/step - loss: 74.7360
Epoch 62/400
5/5 [==============================] - 0s 26ms/step - loss: 83.6906
Epoch 63/400
5/5 [==============================] - 0s 24ms/step - loss: 71.1502
Epoch 64/400
5/5 [==============================] - 0s 24ms/step - loss: 81.6647
Epoch 65/400
5/5 [==============================] - 0s 26ms/step - loss: 65.7985
Epoch 66/400
5/5 [==============================] - 0s 25ms/step - loss: 80.4810
Epoch 67/400
```

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5/5 [==============================] - 0s 27ms/step - loss: 66.5832
Epoch 68/400
5/5 [==============================] - 0s 24ms/step - loss: 69.8630
Epoch 69/400
5/5 [==============================] - 0s 26ms/step - loss: 79.2990
Epoch 70/400
5/5 [==============================] - 0s 24ms/step - loss: 59.5469
Epoch 71/400
5/5 [==============================] - 0s 26ms/step - loss: 78.5490
Epoch 72/400
5/5 [==============================] - 0s 25ms/step - loss: 63.1631
Epoch 73/400
5/5 [==============================] - 0s 36ms/step - loss: 77.4286
Epoch 74/400
5/5 [==============================] - 0s 31ms/step - loss: 77.6932
Epoch 75/400
5/5 [==============================] - 0s 29ms/step - loss: 68.1931
Epoch 76/400
5/5 [==============================] - 0s 31ms/step - loss: 67.1304
Epoch 77/400
5/5 [==============================] - 0s 32ms/step - loss: 74.7166
Epoch 78/400
5/5 [==============================] - 0s 32ms/step - loss: 71.3116
Epoch 79/400
5/5 [==============================] - 0s 28ms/step - loss: 80.2177
Epoch 80/400
5/5 [==============================] - 0s 30ms/step - loss: 71.9251
Epoch 81/400
5/5 [==============================] - 0s 28ms/step - loss: 69.4627
Epoch 82/400
5/5 [==============================] - 0s 29ms/step - loss: 66.6083
Epoch 83/400
5/5 [==============================] - 0s 31ms/step - loss: 69.8084
Epoch 84/400
5/5 [==============================] - 0s 31ms/step - loss: 80.2281
Epoch 85/400
5/5 [==============================] - 0s 33ms/step - loss: 77.7624
Epoch 86/400
5/5 [==============================] - 0s 33ms/step - loss: 74.0333
Epoch 87/400
5/5 [==============================] - 0s 31ms/step - loss: 65.7939
Epoch 88/400
5/5 [==============================] - 0s 33ms/step - loss: 70.8201
Epoch 89/400
5/5 [==============================] - 0s 32ms/step - loss: 78.7867
Epoch 90/400
5/5 [==============================] - 0s 28ms/step - loss: 65.0321
Epoch 91/400
5/5 [==============================] - 0s 31ms/step - loss: 79.0679
Epoch 92/400
5/5 [==============================] - 0s 32ms/step - loss: 63.1522
Epoch 93/400
5/5 [==============================] - 0s 31ms/step - loss: 73.1173
Epoch 94/400
5/5 [==============================] - 0s 32ms/step - loss: 63.4486
Epoch 95/400
5/5 [==============================] - 0s 32ms/step - loss: 73.5320
Epoch 96/400
5/5 [==============================] - 0s 32ms/step - loss: 68.9696
Epoch 97/400
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5/5 [==============================] - 0s 31ms/step - loss: 62.2645
Epoch 98/400
5/5 [==============================] - 0s 28ms/step - loss: 65.4174
Epoch 99/400
5/5 [==============================] - 0s 30ms/step - loss: 71.8330
Epoch 100/400
5/5 [==============================] - 0s 27ms/step - loss: 70.6130
Epoch 101/400
5/5 [==============================] - 0s 27ms/step - loss: 65.0921
Epoch 102/400
5/5 [==============================] - 0s 27ms/step - loss: 62.1352
Epoch 103/400
5/5 [==============================] - 0s 26ms/step - loss: 68.4586
Epoch 104/400
5/5 [==============================] - 0s 25ms/step - loss: 67.3895
Epoch 105/400
5/5 [==============================] - 0s 28ms/step - loss: 58.2563
Epoch 106/400
5/5 [==============================] - 0s 25ms/step - loss: 72.0100
Epoch 107/400
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Epoch 108/400
5/5 [==============================] - 0s 26ms/step - loss: 62.1615
Epoch 109/400
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5/5 [==============================] - 0s 24ms/step - loss: 64.9832
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5/5 [==============================] - 0s 24ms/step - loss: 61.8884
Epoch 112/400
5/5 [==============================] - 0s 25ms/step - loss: 65.2954
Epoch 113/400
5/5 [==============================] - 0s 25ms/step - loss: 75.4756
Epoch 114/400
5/5 [==============================] - 0s 30ms/step - loss: 62.2110
Epoch 115/400
5/5 [==============================] - 0s 26ms/step - loss: 56.0731
Epoch 116/400
5/5 [==============================] - 0s 26ms/step - loss: 75.8243
Epoch 117/400
5/5 [==============================] - 0s 26ms/step - loss: 61.7996
Epoch 118/400
5/5 [==============================] - 0s 25ms/step - loss: 68.0681
Epoch 119/400
5/5 [==============================] - 0s 26ms/step - loss: 71.2951
Epoch 120/400
5/5 [==============================] - 0s 27ms/step - loss: 59.0635
Epoch 121/400
5/5 [==============================] - 0s 25ms/step - loss: 72.2707
Epoch 122/400
5/5 [==============================] - 0s 28ms/step - loss: 61.5791
Epoch 123/400
5/5 [==============================] - 0s 25ms/step - loss: 70.7825
Epoch 124/400
5/5 [==============================] - 0s 25ms/step - loss: 63.0799
Epoch 125/400
5/5 [==============================] - 0s 29ms/step - loss: 70.0908
Epoch 126/400
5/5 [==============================] - 0s 27ms/step - loss: 67.5078
Epoch 127/400
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5/5 [==============================] - 0s 26ms/step - loss: 64.2012
Epoch 128/400
5/5 [==============================] - 0s 27ms/step - loss: 60.8798
Epoch 129/400
5/5 [==============================] - 0s 31ms/step - loss: 57.8524
Epoch 130/400
5/5 [==============================] - 0s 25ms/step - loss: 60.6782
Epoch 131/400
5/5 [==============================] - 0s 25ms/step - loss: 60.2732
Epoch 132/400
5/5 [==============================] - 0s 25ms/step - loss: 58.5466
Epoch 133/400
5/5 [==============================] - 0s 24ms/step - loss: 57.7389
Epoch 134/400
5/5 [==============================] - 0s 28ms/step - loss: 79.3078
Epoch 135/400
5/5 [==============================] - 0s 29ms/step - loss: 55.1607
Epoch 136/400
5/5 [==============================] - 0s 32ms/step - loss: 67.4160
Epoch 137/400
5/5 [==============================] - 0s 31ms/step - loss: 65.8140
Epoch 138/400
5/5 [==============================] - 0s 29ms/step - loss: 57.8887
Epoch 139/400
5/5 [==============================] - 0s 32ms/step - loss: 70.3735
Epoch 140/400
5/5 [==============================] - 0s 32ms/step - loss: 59.9017
Epoch 141/400
5/5 [==============================] - 0s 31ms/step - loss: 65.1059
Epoch 142/400
5/5 [==============================] - 0s 25ms/step - loss: 60.1369
Epoch 143/400
5/5 [==============================] - 0s 27ms/step - loss: 58.1965
Epoch 144/400
5/5 [==============================] - 0s 25ms/step - loss: 60.2029
Epoch 145/400
5/5 [==============================] - 0s 26ms/step - loss: 60.6579
Epoch 146/400
5/5 [==============================] - 0s 25ms/step - loss: 65.2372
Epoch 147/400
5/5 [==============================] - 0s 25ms/step - loss: 58.3490
Epoch 148/400
5/5 [==============================] - 0s 26ms/step - loss: 74.7950
Epoch 149/400
5/5 [==============================] - 0s 26ms/step - loss: 60.9354
Epoch 150/400
5/5 [==============================] - 0s 25ms/step - loss: 58.0868
Epoch 151/400
5/5 [==============================] - 0s 28ms/step - loss: 58.7892
Epoch 152/400
5/5 [==============================] - 0s 26ms/step - loss: 59.4312
Epoch 153/400
5/5 [==============================] - 0s 25ms/step - loss: 56.0093
Epoch 154/400
5/5 [==============================] - 0s 26ms/step - loss: 70.2238
Epoch 155/400
5/5 [==============================] - 0s 26ms/step - loss: 62.7135
Epoch 156/400
5/5 [==============================] - 0s 31ms/step - loss: 69.2772
Epoch 157/400
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5/5 [==============================] - 0s 31ms/step - loss: 56.2212
Epoch 158/400
5/5 [==============================] - 0s 34ms/step - loss: 58.6766
Epoch 159/400
5/5 [==============================] - 0s 29ms/step - loss: 61.2926
Epoch 160/400
5/5 [==============================] - 0s 31ms/step - loss: 54.7475
Epoch 161/400
5/5 [==============================] - 0s 32ms/step - loss: 49.4817
Epoch 162/400
5/5 [==============================] - 0s 30ms/step - loss: 65.4126
Epoch 163/400
5/5 [==============================] - 0s 26ms/step - loss: 58.5689
Epoch 164/400
5/5 [==============================] - 0s 25ms/step - loss: 60.0777
Epoch 165/400
5/5 [==============================] - 0s 24ms/step - loss: 73.3320
Epoch 166/400
5/5 [==============================] - 0s 26ms/step - loss: 53.4304
Epoch 167/400
5/5 [==============================] - 0s 26ms/step - loss: 52.6135
Epoch 168/400
5/5 [==============================] - 0s 27ms/step - loss: 59.6766
Epoch 169/400
5/5 [==============================] - 0s 26ms/step - loss: 59.6153
Epoch 170/400
5/5 [==============================] - 0s 25ms/step - loss: 60.1051
Epoch 171/400
5/5 [==============================] - 0s 33ms/step - loss: 55.4699
Epoch 172/400
5/5 [==============================] - 0s 30ms/step - loss: 61.0821
Epoch 173/400
5/5 [==============================] - 0s 26ms/step - loss: 64.3480
Epoch 174/400
5/5 [==============================] - 0s 25ms/step - loss: 56.9965
Epoch 175/400
5/5 [==============================] - 0s 25ms/step - loss: 61.7441
Epoch 176/400
5/5 [==============================] - 0s 28ms/step - loss: 53.4329
Epoch 177/400
5/5 [==============================] - 0s 25ms/step - loss: 62.9752
Epoch 178/400
5/5 [==============================] - 0s 29ms/step - loss: 55.5059
Epoch 179/400
5/5 [==============================] - 0s 34ms/step - loss: 64.7918
Epoch 180/400
5/5 [==============================] - 0s 33ms/step - loss: 57.1564
Epoch 181/400
5/5 [==============================] - 0s 32ms/step - loss: 55.0860
Epoch 182/400
5/5 [==============================] - 0s 30ms/step - loss: 57.9934
Epoch 183/400
5/5 [==============================] - 0s 30ms/step - loss: 60.6432
Epoch 184/400
5/5 [==============================] - 0s 30ms/step - loss: 63.4195
Epoch 185/400
5/5 [==============================] - 0s 24ms/step - loss: 51.5228
Epoch 186/400
5/5 [==============================] - 0s 27ms/step - loss: 64.9938
Epoch 187/400
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5/5 [==============================] - 0s 26ms/step - loss: 56.4555
Epoch 188/400
5/5 [==============================] - 0s 28ms/step - loss: 76.4476
Epoch 189/400
5/5 [==============================] - 0s 28ms/step - loss: 53.2703
Epoch 190/400
5/5 [==============================] - 0s 27ms/step - loss: 54.7562
Epoch 191/400
5/5 [==============================] - 0s 27ms/step - loss: 53.7667
Epoch 192/400
5/5 [==============================] - 0s 40ms/step - loss: 49.9507
Epoch 193/400
5/5 [==============================] - 0s 39ms/step - loss: 48.3636
Epoch 194/400
5/5 [==============================] - 0s 37ms/step - loss: 60.0901
Epoch 195/400
5/5 [==============================] - 0s 36ms/step - loss: 48.4685
Epoch 196/400
5/5 [==============================] - 0s 38ms/step - loss: 77.5284
Epoch 197/400
5/5 [==============================] - 0s 41ms/step - loss: 49.2167
Epoch 198/400
5/5 [==============================] - 0s 48ms/step - loss: 52.6410
Epoch 199/400
5/5 [==============================] - 0s 36ms/step - loss: 65.1219
Epoch 200/400
5/5 [==============================] - 0s 39ms/step - loss: 46.5704
Epoch 201/400
5/5 [==============================] - 0s 37ms/step - loss: 54.6755
Epoch 202/400
5/5 [==============================] - 0s 42ms/step - loss: 60.2047
Epoch 203/400
5/5 [==============================] - 0s 53ms/step - loss: 53.9523
Epoch 204/400
5/5 [==============================] - 0s 49ms/step - loss: 67.2249
Epoch 205/400
5/5 [==============================] - 0s 49ms/step - loss: 49.6177
Epoch 206/400
5/5 [==============================] - 0s 36ms/step - loss: 52.0840
Epoch 207/400
5/5 [==============================] - 0s 42ms/step - loss: 61.0304
Epoch 208/400
5/5 [==============================] - 0s 38ms/step - loss: 49.0476
Epoch 209/400
5/5 [==============================] - 0s 37ms/step - loss: 60.0344
Epoch 210/400
5/5 [==============================] - 0s 40ms/step - loss: 57.5753
Epoch 211/400
5/5 [==============================] - 0s 28ms/step - loss: 50.3553
Epoch 212/400
5/5 [==============================] - 0s 27ms/step - loss: 52.7610
Epoch 213/400
5/5 [==============================] - 0s 26ms/step - loss: 58.6504
Epoch 214/400
5/5 [==============================] - 0s 25ms/step - loss: 64.3024
Epoch 215/400
5/5 [==============================] - 0s 27ms/step - loss: 50.5771
Epoch 216/400
5/5 [==============================] - 0s 28ms/step - loss: 56.8863
Epoch 217/400
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5/5 [==============================] - 0s 27ms/step - loss: 47.0158
Epoch 218/400
5/5 [==============================] - 0s 25ms/step - loss: 61.7592
Epoch 219/400
5/5 [==============================] - 0s 33ms/step - loss: 51.8921
Epoch 220/400
5/5 [==============================] - 0s 31ms/step - loss: 56.2134
Epoch 221/400
5/5 [==============================] - 0s 32ms/step - loss: 49.3896
Epoch 222/400
5/5 [==============================] - 0s 29ms/step - loss: 49.6918
Epoch 223/400
5/5 [==============================] - 0s 30ms/step - loss: 46.9369
Epoch 224/400
5/5 [==============================] - 0s 30ms/step - loss: 63.7771
Epoch 225/400
5/5 [==============================] - 0s 28ms/step - loss: 54.8351
Epoch 226/400
5/5 [==============================] - 0s 27ms/step - loss: 49.5945
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5/5 [==============================] - 0s 28ms/step - loss: 48.4491
Epoch 229/400
5/5 [==============================] - 0s 25ms/step - loss: 56.6823
Epoch 230/400
5/5 [==============================] - 0s 27ms/step - loss: 55.6126
Epoch 231/400
5/5 [==============================] - 0s 25ms/step - loss: 53.1047
Epoch 232/400
5/5 [==============================] - 0s 32ms/step - loss: 49.7306
Epoch 233/400
5/5 [==============================] - 0s 25ms/step - loss: 56.4272
Epoch 234/400
5/5 [==============================] - 0s 24ms/step - loss: 42.7581
Epoch 235/400
5/5 [==============================] - 0s 28ms/step - loss: 51.1438
Epoch 236/400
5/5 [==============================] - 0s 25ms/step - loss: 47.1320
Epoch 237/400
5/5 [==============================] - 0s 25ms/step - loss: 62.5606
Epoch 238/400
5/5 [==============================] - 0s 26ms/step - loss: 51.4774
Epoch 239/400
5/5 [==============================] - 0s 27ms/step - loss: 45.5814
Epoch 240/400
5/5 [==============================] - 0s 25ms/step - loss: 50.8435
Epoch 241/400
5/5 [==============================] - 0s 27ms/step - loss: 46.6950
Epoch 242/400
5/5 [==============================] - 0s 27ms/step - loss: 46.2594
Epoch 243/400
5/5 [==============================] - 0s 24ms/step - loss: 48.3167
Epoch 244/400
5/5 [==============================] - 0s 25ms/step - loss: 52.9293
Epoch 245/400
5/5 [==============================] - 0s 26ms/step - loss: 50.5026
Epoch 246/400
5/5 [==============================] - 0s 28ms/step - loss: 48.2888
Epoch 247/400
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5/5 [==============================] - 0s 29ms/step - loss: 42.5976
Epoch 248/400
5/5 [==============================] - 0s 29ms/step - loss: 52.8840
Epoch 249/400
5/5 [==============================] - 0s 27ms/step - loss: 52.1379
Epoch 250/400
5/5 [==============================] - 0s 28ms/step - loss: 54.4828
Epoch 251/400
5/5 [==============================] - 0s 26ms/step - loss: 46.7582
Epoch 252/400
5/5 [==============================] - 0s 25ms/step - loss: 54.5047
Epoch 253/400
5/5 [==============================] - 0s 26ms/step - loss: 46.9893
Epoch 254/400
5/5 [==============================] - 0s 26ms/step - loss: 47.7875
Epoch 255/400
5/5 [==============================] - 0s 30ms/step - loss: 63.9313
Epoch 256/400
5/5 [==============================] - 0s 32ms/step - loss: 42.1377
Epoch 257/400
5/5 [==============================] - 0s 30ms/step - loss: 50.3629
Epoch 258/400
5/5 [==============================] - 0s 32ms/step - loss: 48.2097
Epoch 259/400
5/5 [==============================] - 0s 30ms/step - loss: 48.8517
Epoch 260/400
5/5 [==============================] - 0s 33ms/step - loss: 39.6634
Epoch 261/400
5/5 [==============================] - 0s 28ms/step - loss: 46.6349
Epoch 262/400
5/5 [==============================] - 0s 26ms/step - loss: 55.7390
Epoch 263/400
5/5 [==============================] - 0s 30ms/step - loss: 49.1759
Epoch 264/400
5/5 [==============================] - 0s 27ms/step - loss: 44.2600
Epoch 265/400
5/5 [==============================] - 0s 27ms/step - loss: 41.1632
Epoch 266/400
5/5 [==============================] - 0s 29ms/step - loss: 48.9468
Epoch 267/400
5/5 [==============================] - 0s 26ms/step - loss: 43.8343
Epoch 268/400
5/5 [==============================] - 0s 25ms/step - loss: 50.3568
Epoch 269/400
5/5 [==============================] - 0s 25ms/step - loss: 55.8144
Epoch 270/400
5/5 [==============================] - 0s 27ms/step - loss: 45.7798
Epoch 271/400
5/5 [==============================] - 0s 31ms/step - loss: 43.5950
Epoch 272/400
5/5 [==============================] - 0s 25ms/step - loss: 43.0626
Epoch 273/400
5/5 [==============================] - 0s 29ms/step - loss: 48.3336
Epoch 274/400
5/5 [==============================] - 0s 28ms/step - loss: 48.7351
Epoch 275/400
5/5 [==============================] - 0s 25ms/step - loss: 44.9764
Epoch 276/400
5/5 [==============================] - 0s 26ms/step - loss: 45.5332
Epoch 277/400
```

```
5/5 [==============================] - 0s 25ms/step - loss: 50.0223
Epoch 278/400
5/5 [==============================] - 0s 28ms/step - loss: 48.1606
Epoch 279/400
5/5 [==============================] - 0s 27ms/step - loss: 47.3979
Epoch 280/400
5/5 [==============================] - 0s 26ms/step - loss: 45.7635
Epoch 281/400
5/5 [==============================] - 0s 28ms/step - loss: 48.3898
Epoch 282/400
5/5 [==============================] - 0s 27ms/step - loss: 47.6990
Epoch 283/400
5/5 [==============================] - 0s 32ms/step - loss: 38.3798
Epoch 284/400
5/5 [==============================] - 0s 32ms/step - loss: 55.3389
Epoch 285/400
5/5 [==============================] - 0s 35ms/step - loss: 48.4947
Epoch 286/400
5/5 [==============================] - 0s 31ms/step - loss: 42.6018
Epoch 287/400
5/5 [==============================] - 0s 32ms/step - loss: 47.4967
Epoch 288/400
5/5 [==============================] - 0s 30ms/step - loss: 45.2427
Epoch 289/400
5/5 [==============================] - 0s 27ms/step - loss: 45.2988
Epoch 290/400
5/5 [==============================] - 0s 26ms/step - loss: 48.9430
Epoch 291/400
5/5 [==============================] - 0s 26ms/step - loss: 50.2670
Epoch 292/400
5/5 [==============================] - 0s 25ms/step - loss: 53.0980
Epoch 293/400
5/5 [==============================] - 0s 27ms/step - loss: 42.7776
Epoch 294/400
5/5 [==============================] - 0s 25ms/step - loss: 42.4107
Epoch 295/400
5/5 [==============================] - 0s 26ms/step - loss: 37.5827
Epoch 296/400
5/5 [==============================] - 0s 25ms/step - loss: 46.5922
Epoch 297/400
5/5 [==============================] - 0s 27ms/step - loss: 48.0532
Epoch 298/400
5/5 [==============================] - 0s 29ms/step - loss: 52.5761
Epoch 299/400
5/5 [==============================] - 0s 34ms/step - loss: 42.9801
Epoch 300/400
5/5 [==============================] - 0s 27ms/step - loss: 39.5918
Epoch 301/400
5/5 [==============================] - 0s 28ms/step - loss: 48.4841
Epoch 302/400
5/5 [==============================] - 0s 30ms/step - loss: 53.9447
Epoch 303/400
5/5 [==============================] - 0s 25ms/step - loss: 47.5180
Epoch 304/400
5/5 [==============================] - 0s 28ms/step - loss: 49.5602
Epoch 305/400
5/5 [==============================] - 0s 27ms/step - loss: 37.2804
Epoch 306/400
5/5 [==============================] - 0s 29ms/step - loss: 42.3562
Epoch 307/400
```

```
5/5 [==============================] - 0s 25ms/step - loss: 41.4208
Epoch 308/400
5/5 [==============================] - 0s 25ms/step - loss: 40.2157
Epoch 309/400
5/5 [==============================] - 0s 26ms/step - loss: 45.8447
Epoch 310/400
5/5 [==============================] - 0s 31ms/step - loss: 48.0885
Epoch 311/400
5/5 [==============================] - 0s 33ms/step - loss: 36.3799
Epoch 312/400
5/5 [==============================] - 0s 32ms/step - loss: 42.7185
Epoch 313/400
5/5 [==============================] - 0s 35ms/step - loss: 47.9904
Epoch 314/400
5/5 [==============================] - 0s 31ms/step - loss: 47.6214
Epoch 315/400
5/5 [==============================] - 0s 33ms/step - loss: 48.6015
Epoch 316/400
5/5 [==============================] - 0s 30ms/step - loss: 47.1679
Epoch 317/400
5/5 [==============================] - 0s 31ms/step - loss: 41.7444
Epoch 318/400
5/5 [==============================] - 0s 33ms/step - loss: 45.5898
Epoch 319/400
5/5 [==============================] - 0s 32ms/step - loss: 42.2627
Epoch 320/400
5/5 [==============================] - 0s 34ms/step - loss: 42.6612
Epoch 321/400
5/5 [==============================] - 0s 32ms/step - loss: 40.1080
Epoch 322/400
5/5 [==============================] - 0s 31ms/step - loss: 45.6858
Epoch 323/400
5/5 [==============================] - 0s 29ms/step - loss: 38.1407
Epoch 324/400
5/5 [==============================] - 0s 30ms/step - loss: 42.9096
Epoch 325/400
5/5 [==============================] - 0s 30ms/step - loss: 51.7192
Epoch 326/400
5/5 [==============================] - 0s 28ms/step - loss: 47.1228
Epoch 327/400
5/5 [==============================] - 0s 28ms/step - loss: 45.8656
Epoch 328/400
5/5 [==============================] - 0s 26ms/step - loss: 42.7389
Epoch 329/400
5/5 [==============================] - 0s 28ms/step - loss: 39.3097
Epoch 330/400
5/5 [==============================] - 0s 26ms/step - loss: 49.0047
Epoch 331/400
5/5 [==============================] - 0s 29ms/step - loss: 47.8175
Epoch 332/400
5/5 [==============================] - 0s 31ms/step - loss: 46.9317
Epoch 333/400
5/5 [==============================] - 0s 27ms/step - loss: 42.8312
Epoch 334/400
5/5 [==============================] - 0s 26ms/step - loss: 44.5941
Epoch 335/400
5/5 [==============================] - 0s 27ms/step - loss: 48.9596
Epoch 336/400
5/5 [==============================] - 0s 26ms/step - loss: 43.7615
Epoch 337/400
```

```
5/5 [==============================] - 0s 27ms/step - loss: 45.8010
Epoch 338/400
5/5 [==============================] - 0s 29ms/step - loss: 45.5728
Epoch 339/400
5/5 [==============================] - 0s 27ms/step - loss: 43.2033
Epoch 340/400
5/5 [==============================] - 0s 25ms/step - loss: 50.0022
Epoch 341/400
5/5 [==============================] - 0s 26ms/step - loss: 41.6137
Epoch 342/400
5/5 [==============================] - 0s 27ms/step - loss: 45.2232
Epoch 343/400
5/5 [==============================] - 0s 29ms/step - loss: 52.2535
Epoch 344/400
5/5 [==============================] - 0s 28ms/step - loss: 37.8417
Epoch 345/400
5/5 [==============================] - 0s 27ms/step - loss: 53.8168
Epoch 346/400
5/5 [==============================] - 0s 25ms/step - loss: 44.6994
Epoch 347/400
5/5 [==============================] - 0s 30ms/step - loss: 50.2893
Epoch 348/400
5/5 [==============================] - 0s 27ms/step - loss: 45.3311
Epoch 349/400
5/5 [==============================] - 0s 26ms/step - loss: 36.1216
Epoch 350/400
5/5 [==============================] - 0s 27ms/step - loss: 40.9951
Epoch 351/400
5/5 [==============================] - 0s 31ms/step - loss: 44.0382
Epoch 352/400
5/5 [==============================] - 0s 30ms/step - loss: 38.5958
Epoch 353/400
5/5 [==============================] - 0s 31ms/step - loss: 42.4851
Epoch 354/400
5/5 [==============================] - 0s 31ms/step - loss: 37.0714
Epoch 355/400
5/5 [==============================] - 0s 32ms/step - loss: 45.4259
Epoch 356/400
5/5 [==============================] - 0s 30ms/step - loss: 46.1229
Epoch 357/400
5/5 [==============================] - 0s 29ms/step - loss: 39.5805
Epoch 358/400
5/5 [==============================] - 0s 29ms/step - loss: 39.7526
Epoch 359/400
5/5 [==============================] - 0s 27ms/step - loss: 45.9881
Epoch 360/400
5/5 [==============================] - 0s 27ms/step - loss: 49.7888
Epoch 361/400
5/5 [==============================] - 0s 27ms/step - loss: 39.2366
Epoch 362/400
5/5 [==============================] - 0s 26ms/step - loss: 44.7741
Epoch 363/400
5/5 [==============================] - 0s 28ms/step - loss: 53.4429
Epoch 364/400
5/5 [==============================] - 0s 25ms/step - loss: 39.3210
Epoch 365/400
5/5 [==============================] - 0s 25ms/step - loss: 46.1435
Epoch 366/400
5/5 [==============================] - 0s 28ms/step - loss: 39.2583
Epoch 367/400
```

```
5/5 [==============================] - 0s 26ms/step - loss: 34.9357
Epoch 368/400
5/5 [==============================] - 0s 28ms/step - loss: 46.5874
Epoch 369/400
5/5 [==============================] - 0s 26ms/step - loss: 42.7141
Epoch 370/400
5/5 [==============================] - 0s 28ms/step - loss: 37.9228
Epoch 371/400
5/5 [==============================] - 0s 29ms/step - loss: 42.3905
Epoch 372/400
5/5 [==============================] - 0s 32ms/step - loss: 39.0905
Epoch 373/400
5/5 [==============================] - 0s 33ms/step - loss: 40.9009
Epoch 374/400
5/5 [==============================] - 0s 32ms/step - loss: 44.7526
Epoch 375/400
5/5 [==============================] - 0s 32ms/step - loss: 50.4606
Epoch 376/400
5/5 [==============================] - 0s 31ms/step - loss: 40.7840
Epoch 377/400
5/5 [==============================] - 0s 31ms/step - loss: 37.4853
Epoch 378/400
5/5 [==============================] - 0s 30ms/step - loss: 46.9864
Epoch 379/400
5/5 [==============================] - 0s 27ms/step - loss: 37.4459
Epoch 380/400
5/5 [==============================] - 0s 26ms/step - loss: 39.8374
Epoch 381/400
5/5 [==============================] - 0s 30ms/step - loss: 39.3059
Epoch 382/400
5/5 [==============================] - 0s 28ms/step - loss: 40.2229
Epoch 383/400
5/5 [==============================] - 0s 27ms/step - loss: 39.3655
Epoch 384/400
5/5 [==============================] - 0s 32ms/step - loss: 44.9434
Epoch 385/400
5/5 [==============================] - 0s 33ms/step - loss: 40.6242
Epoch 386/400
5/5 [==============================] - 0s 33ms/step - loss: 42.0692
Epoch 387/400
5/5 [==============================] - 0s 35ms/step - loss: 42.6592
Epoch 388/400
5/5 [==============================] - 0s 33ms/step - loss: 41.8765
Epoch 389/400
5/5 [==============================] - 0s 32ms/step - loss: 46.6588
Epoch 390/400
5/5 [==============================] - 0s 30ms/step - loss: 38.3143
Epoch 391/400
5/5 [==============================] - 0s 28ms/step - loss: 34.3034
Epoch 392/400
5/5 [==============================] - 0s 26ms/step - loss: 45.0616
Epoch 393/400
5/5 [==============================] - 0s 25ms/step - loss: 38.9018
Epoch 394/400
5/5 [==============================] - 0s 30ms/step - loss: 44.4901
Epoch 395/400
5/5 [==============================] - 0s 29ms/step - loss: 44.7770
Epoch 396/400
5/5 [==============================] - 0s 30ms/step - loss: 42.7591
Epoch 397/400
```

```
5/5 [==============================] - 0s 33ms/step - loss: 34.8641
Epoch 398/400
5/5 [==============================] - 0s 35ms/step - loss: 47.1436
Epoch 399/400
5/5 [==============================] - 0s 33ms/step - loss: 36.6065
Epoch 400/400
5/5 [==============================] - 0s 35ms/step - loss: 41.9937
testing MSE:  49.86633288021902
MSE of baseline model:  21.05596723741936
Comparison of model prediction and baseline prediction:
```
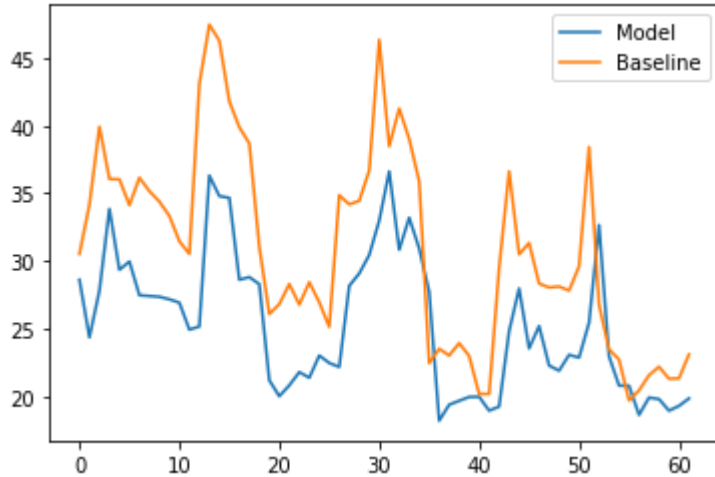


```
Day-to-day out-of-sample accuracy:  0.5573770491803278
Five-day out-of-sample accuracy:  0.8245614035087719
Day-to-day out-of-sample accuracy of baseline:  0.4918032786885246
Five-day out-of-sample accuracy of baseline:  0.7894736842105263
```

In [ ]:
```python
LSTM_1_plot = model_plot(LSTM_1.data_y_test, LSTM_1.y_pred)
baseline_plot = model_plot(LSTM_1.dataset[LSTM_1.train_sample_num + 1:, -1],
                           LSTM_1.dataset[LSTM_1.train_sample_num:-1, -1])
print(" True VS Pred plot of LSTM Model with 1 layer")
LSTM_1_plot.true_pred_plot()
print(" True VS Pred plot of Baseline Model")
baseline_plot.true_pred_plot()
print(" Residual plot of LSTM Model with 1 layer")
LSTM_1_plot.residual_plot()
print(" Residual plot of Baseline Model")
baseline_plot.residual_plot()
print(" Trend plot of LSTM Model with 1 layer")
LSTM_1_plot.trend_plot()
print(" Trend plot of Baseline Model")
baseline_plot.trend_plot()
```

True VS Pred plot of LSTM Model with 1 layer
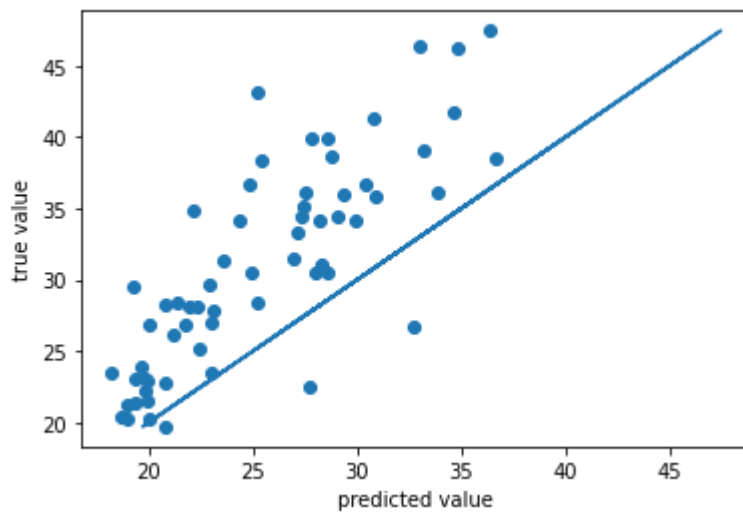
True VS Pred plot of Baseline Model
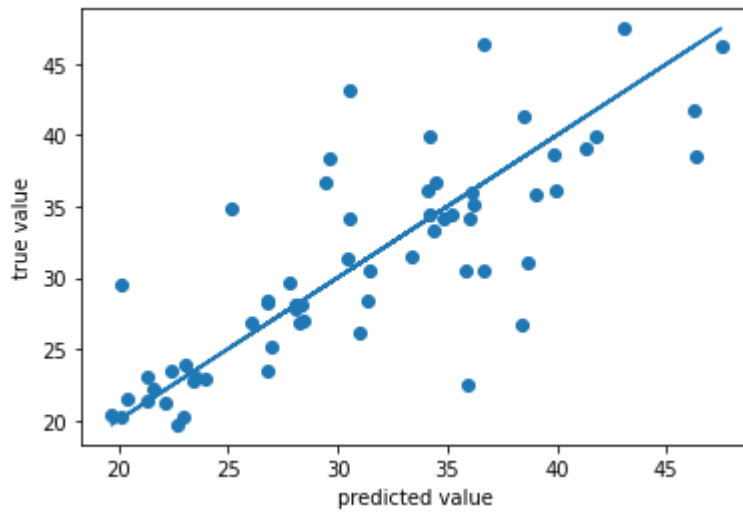
Residual plot of LSTM Model with 1 layer
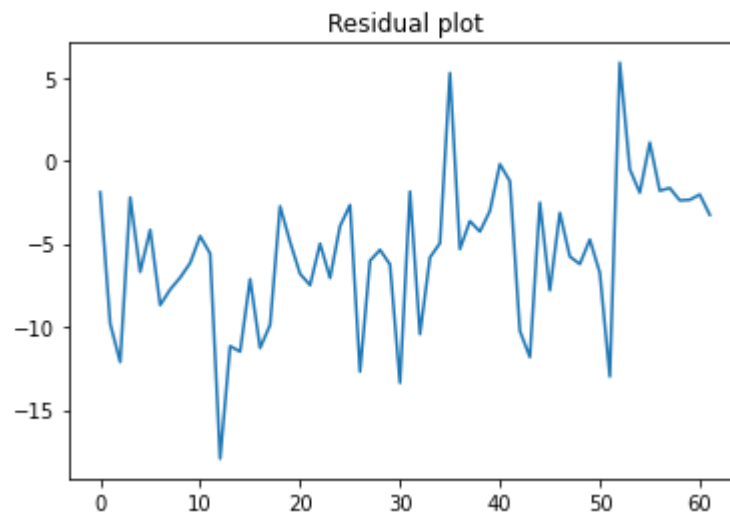
Residual plot of Baseline Model

Residual plot
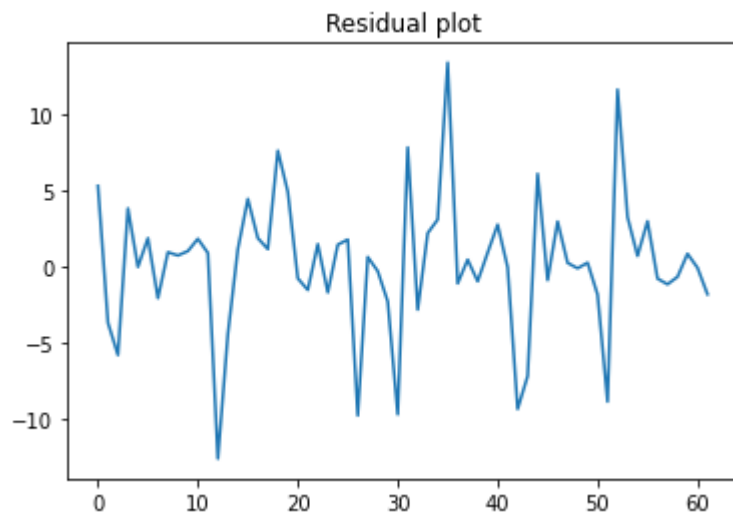
Trend plot of LSTM Model with 1 layer
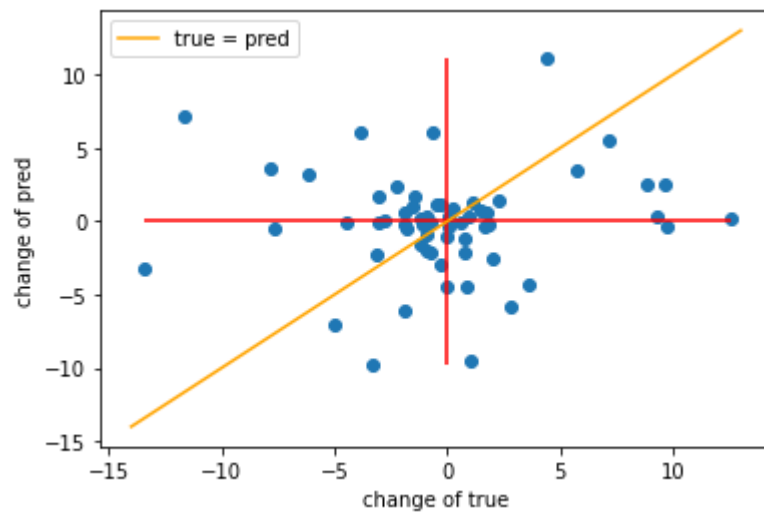
Trend plot of Baseline Model
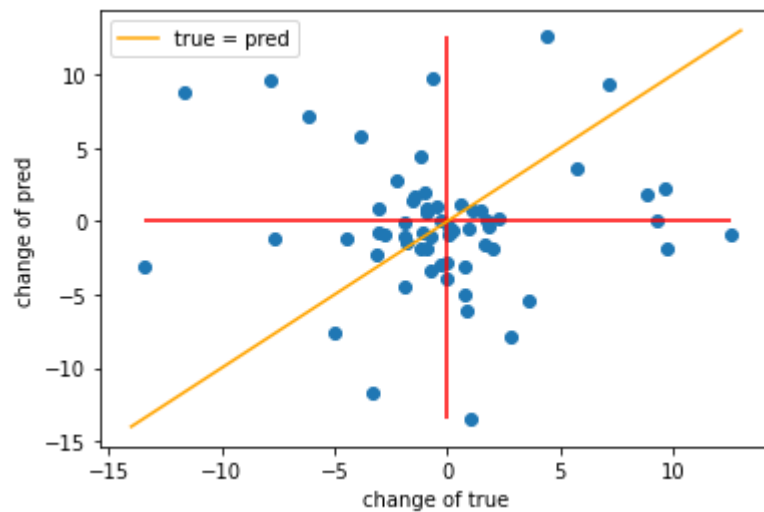
In [ ]:

LSTM   Model with 2 layers

In [ ]:

```python
LSTM_2 = LSTM_model(data.df)
LSTM_2.split_train_test()
LSTM_2.fit_model(layers=2)
LSTM_2.predict_result()
LSTM_2.compare_to_baseline()
LSTM_2.test_accuracy()
```

```
Epoch 1/400
5/5 [==============================] - 4s 57ms/step - loss: 950.1680
Epoch 2/400
5/5 [==============================] - 0s 58ms/step - loss: 494.9225
Epoch 3/400
5/5 [==============================] - 0s 59ms/step - loss: 276.0236
Epoch 4/400
5/5 [==============================] - 0s 57ms/step - loss: 212.1041
Epoch 5/400
5/5 [==============================] - 0s 61ms/step - loss: 185.7451
Epoch 6/400
5/5 [==============================] - 0s 61ms/step - loss: 170.8381
Epoch 7/400
5/5 [==============================] - 0s 59ms/step - loss: 161.2598
Epoch 8/400
5/5 [==============================] - 0s 56ms/step - loss: 155.0193
Epoch 9/400
5/5 [==============================] - 0s 58ms/step - loss: 150.6508
Epoch 10/400
5/5 [==============================] - 0s 63ms/step - loss: 147.5858
Epoch 11/400
5/5 [==============================] - 0s 57ms/step - loss: 144.7436
Epoch 12/400
5/5 [==============================] - 0s 59ms/step - loss: 140.1644
Epoch 13/400
5/5 [==============================] - 0s 59ms/step - loss: 134.3384
Epoch 14/400
5/5 [==============================] - 0s 58ms/step - loss: 127.2346
Epoch 15/400
5/5 [==============================] - 0s 57ms/step - loss: 121.6053
Epoch 16/400
5/5 [==============================] - 0s 58ms/step - loss: 119.8592
Epoch 17/400
5/5 [==============================] - 0s 60ms/step - loss: 116.9109
Epoch 18/400
5/5 [==============================] - 0s 58ms/step - loss: 111.7408
Epoch 19/400
5/5 [==============================] - 0s 59ms/step - loss: 111.2851
Epoch 20/400
5/5 [==============================] - 0s 59ms/step - loss: 113.0877
Epoch 21/400
5/5 [==============================] - 0s 58ms/step - loss: 110.6784
Epoch 22/400
5/5 [==============================] - 0s 57ms/step - loss: 104.0050
Epoch 23/400
5/5 [==============================] - 0s 57ms/step - loss: 106.3624
Epoch 24/400
5/5 [==============================] - 0s 61ms/step - loss: 104.3879
Epoch 25/400
5/5 [==============================] - 0s 58ms/step - loss: 98.2547
Epoch 26/400
5/5 [==============================] - 0s 60ms/step - loss: 106.0296
Epoch 27/400
```

```
5/5 [==============================] - 0s 59ms/step - loss: 96.1806
Epoch 28/400
5/5 [==============================] - 0s 57ms/step - loss: 95.6546
Epoch 29/400
5/5 [==============================] - 0s 62ms/step - loss: 98.3890
Epoch 30/400
5/5 [==============================] - 0s 59ms/step - loss: 102.6623
Epoch 31/400
5/5 [==============================] - 0s 57ms/step - loss: 95.9613
Epoch 32/400
5/5 [==============================] - 0s 59ms/step - loss: 94.1111
Epoch 33/400
5/5 [==============================] - 0s 58ms/step - loss: 90.2113
Epoch 34/400
5/5 [==============================] - 0s 62ms/step - loss: 94.4632
Epoch 35/400
5/5 [==============================] - 0s 59ms/step - loss: 89.3706
Epoch 36/400
5/5 [==============================] - 0s 57ms/step - loss: 90.1246
Epoch 37/400
5/5 [==============================] - 0s 60ms/step - loss: 92.6135
Epoch 38/400
5/5 [==============================] - 0s 58ms/step - loss: 90.0767
Epoch 39/400
5/5 [==============================] - 0s 58ms/step - loss: 86.3740
Epoch 40/400
5/5 [==============================] - 0s 59ms/step - loss: 93.7348
Epoch 41/400
5/5 [==============================] - 0s 63ms/step - loss: 85.5967
Epoch 42/400
5/5 [==============================] - 0s 57ms/step - loss: 89.5105
Epoch 43/400
5/5 [==============================] - 0s 59ms/step - loss: 84.4706
Epoch 44/400
5/5 [==============================] - 0s 62ms/step - loss: 89.7594
Epoch 45/400
5/5 [==============================] - 0s 60ms/step - loss: 87.4884
Epoch 46/400
5/5 [==============================] - 0s 59ms/step - loss: 85.7807
Epoch 47/400
5/5 [==============================] - 0s 59ms/step - loss: 80.3218
Epoch 48/400
5/5 [==============================] - 0s 72ms/step - loss: 89.3819
Epoch 49/400
5/5 [==============================] - 0s 72ms/step - loss: 82.1947
Epoch 50/400
5/5 [==============================] - 0s 77ms/step - loss: 86.8794
Epoch 51/400
5/5 [==============================] - 0s 57ms/step - loss: 81.9643
Epoch 52/400
5/5 [==============================] - 0s 57ms/step - loss: 87.8878
Epoch 53/400
5/5 [==============================] - 0s 59ms/step - loss: 78.2446
Epoch 54/400
5/5 [==============================] - 0s 74ms/step - loss: 80.5955
Epoch 55/400
5/5 [==============================] - 0s 70ms/step - loss: 81.9281
Epoch 56/400
5/5 [==============================] - 0s 69ms/step - loss: 79.5414
Epoch 57/400
```

```
5/5 [==============================] - 0s 65ms/step - loss: 79.0064
Epoch 58/400
5/5 [==============================] - 0s 59ms/step - loss: 83.9179
Epoch 59/400
5/5 [==============================] - 0s 56ms/step - loss: 77.1937
Epoch 60/400
5/5 [==============================] - 0s 60ms/step - loss: 75.5103
Epoch 61/400
5/5 [==============================] - 0s 60ms/step - loss: 76.1530
Epoch 62/400
5/5 [==============================] - 0s 59ms/step - loss: 80.3874
Epoch 63/400
5/5 [==============================] - 0s 58ms/step - loss: 76.5070
Epoch 64/400
5/5 [==============================] - 0s 68ms/step - loss: 77.6710
Epoch 65/400
5/5 [==============================] - 0s 67ms/step - loss: 76.6324
Epoch 66/400
5/5 [==============================] - 0s 69ms/step - loss: 75.1076
Epoch 67/400
5/5 [==============================] - 0s 71ms/step - loss: 71.9045
Epoch 68/400
5/5 [==============================] - 0s 72ms/step - loss: 84.7400
Epoch 69/400
5/5 [==============================] - 0s 73ms/step - loss: 73.2288
Epoch 70/400
5/5 [==============================] - 0s 64ms/step - loss: 78.0701
Epoch 71/400
5/5 [==============================] - 0s 59ms/step - loss: 75.9967
Epoch 72/400
5/5 [==============================] - 0s 66ms/step - loss: 74.6174
Epoch 73/400
5/5 [==============================] - 0s 71ms/step - loss: 73.3998
Epoch 74/400
5/5 [==============================] - 0s 68ms/step - loss: 71.0446
Epoch 75/400
5/5 [==============================] - 0s 67ms/step - loss: 73.0217
Epoch 76/400
5/5 [==============================] - 0s 60ms/step - loss: 76.7701
Epoch 77/400
5/5 [==============================] - 0s 61ms/step - loss: 74.4957
Epoch 78/400
5/5 [==============================] - 0s 60ms/step - loss: 71.0696
Epoch 79/400
5/5 [==============================] - 0s 75ms/step - loss: 70.7333
Epoch 80/400
5/5 [==============================] - 0s 72ms/step - loss: 70.3194
Epoch 81/400
5/5 [==============================] - 0s 71ms/step - loss: 67.4303
Epoch 82/400
5/5 [==============================] - 0s 72ms/step - loss: 72.1477
Epoch 83/400
5/5 [==============================] - 0s 70ms/step - loss: 68.3906
Epoch 84/400
5/5 [==============================] - 0s 72ms/step - loss: 68.0337
Epoch 85/400
5/5 [==============================] - 0s 74ms/step - loss: 69.0263
Epoch 86/400
5/5 [==============================] - 0s 73ms/step - loss: 77.3734
Epoch 87/400
```

```
5/5 [==============================] - 0s 76ms/step - loss: 66.9587
Epoch 88/400
5/5 [==============================] - 0s 71ms/step - loss: 68.8260
Epoch 89/400
5/5 [==============================] - 0s 72ms/step - loss: 69.6788
Epoch 90/400
5/5 [==============================] - 0s 74ms/step - loss: 64.6038
Epoch 91/400
5/5 [==============================] - 0s 69ms/step - loss: 71.8486
Epoch 92/400
5/5 [==============================] - 0s 70ms/step - loss: 67.0187
Epoch 93/400
5/5 [==============================] - 0s 75ms/step - loss: 67.6356
Epoch 94/400
5/5 [==============================] - 0s 70ms/step - loss: 65.3487
Epoch 95/400
5/5 [==============================] - 0s 71ms/step - loss: 69.9810
Epoch 96/400
5/5 [==============================] - 0s 62ms/step - loss: 61.8799
Epoch 97/400
5/5 [==============================] - 0s 59ms/step - loss: 62.5361
Epoch 98/400
5/5 [==============================] - 0s 61ms/step - loss: 67.8619
Epoch 99/400
5/5 [==============================] - 0s 75ms/step - loss: 62.0579
Epoch 100/400
5/5 [==============================] - 0s 70ms/step - loss: 67.0152
Epoch 101/400
5/5 [==============================] - 0s 77ms/step - loss: 60.9451
Epoch 102/400
5/5 [==============================] - 0s 73ms/step - loss: 59.7348
Epoch 103/400
5/5 [==============================] - 0s 72ms/step - loss: 62.1034
Epoch 104/400
5/5 [==============================] - 0s 70ms/step - loss: 60.5333
Epoch 105/400
5/5 [==============================] - 0s 70ms/step - loss: 60.9632
Epoch 106/400
5/5 [==============================] - 0s 68ms/step - loss: 60.4945
Epoch 107/400
5/5 [==============================] - 0s 65ms/step - loss: 53.7794
Epoch 108/400
5/5 [==============================] - 0s 62ms/step - loss: 59.0159
Epoch 109/400
5/5 [==============================] - 0s 62ms/step - loss: 63.1614
Epoch 110/400
5/5 [==============================] - 0s 58ms/step - loss: 54.6700
Epoch 111/400
5/5 [==============================] - 0s 63ms/step - loss: 58.6553
Epoch 112/400
5/5 [==============================] - 0s 58ms/step - loss: 53.9512
Epoch 113/400
5/5 [==============================] - 0s 59ms/step - loss: 54.1744
Epoch 114/400
5/5 [==============================] - 0s 71ms/step - loss: 52.9611
Epoch 115/400
5/5 [==============================] - 0s 75ms/step - loss: 57.7308
Epoch 116/400
5/5 [==============================] - 0s 73ms/step - loss: 51.8273
Epoch 117/400
```

```
5/5 [==============================] - 0s 73ms/step - loss: 58.0222
Epoch 118/400
5/5 [==============================] - 0s 75ms/step - loss: 50.0846
Epoch 119/400
5/5 [==============================] - 0s 72ms/step - loss: 59.5209
Epoch 120/400
5/5 [==============================] - 0s 66ms/step - loss: 50.2042
Epoch 121/400
5/5 [==============================] - 0s 58ms/step - loss: 52.5631
Epoch 122/400
5/5 [==============================] - 0s 61ms/step - loss: 56.7673
Epoch 123/400
5/5 [==============================] - 0s 71ms/step - loss: 52.2176
Epoch 124/400
5/5 [==============================] - 0s 73ms/step - loss: 53.5075
Epoch 125/400
5/5 [==============================] - 0s 70ms/step - loss: 50.0825
Epoch 126/400
5/5 [==============================] - 0s 64ms/step - loss: 52.3918
Epoch 127/400
5/5 [==============================] - 0s 61ms/step - loss: 52.3159
Epoch 128/400
5/5 [==============================] - 0s 61ms/step - loss: 49.8532
Epoch 129/400
5/5 [==============================] - 0s 73ms/step - loss: 53.9831
Epoch 130/400
5/5 [==============================] - 0s 69ms/step - loss: 48.1979
Epoch 131/400
5/5 [==============================] - 0s 70ms/step - loss: 49.7101
Epoch 132/400
5/5 [==============================] - 0s 63ms/step - loss: 48.4564
Epoch 133/400
5/5 [==============================] - 0s 60ms/step - loss: 50.7013
Epoch 134/400
5/5 [==============================] - 0s 61ms/step - loss: 48.3933
Epoch 135/400
5/5 [==============================] - 0s 58ms/step - loss: 50.6695
Epoch 136/400
5/5 [==============================] - 0s 62ms/step - loss: 50.7066
Epoch 137/400
5/5 [==============================] - 0s 59ms/step - loss: 48.1946
Epoch 138/400
5/5 [==============================] - 0s 56ms/step - loss: 46.7098
Epoch 139/400
5/5 [==============================] - 0s 62ms/step - loss: 44.7805
Epoch 140/400
5/5 [==============================] - 0s 60ms/step - loss: 43.6635
Epoch 141/400
5/5 [==============================] - 0s 57ms/step - loss: 52.1525
Epoch 142/400
5/5 [==============================] - 0s 75ms/step - loss: 45.0178
Epoch 143/400
5/5 [==============================] - 0s 72ms/step - loss: 49.2300
Epoch 144/400
5/5 [==============================] - 0s 72ms/step - loss: 46.4728
Epoch 145/400
5/5 [==============================] - 0s 65ms/step - loss: 43.5451
Epoch 146/400
5/5 [==============================] - 0s 62ms/step - loss: 44.6463
Epoch 147/400
```

```
5/5 [==============================] - 0s 60ms/step - loss: 42.0545
Epoch 148/400
5/5 [==============================] - 0s 59ms/step - loss: 43.3545
Epoch 149/400
5/5 [==============================] - 0s 61ms/step - loss: 44.2175
Epoch 150/400
5/5 [==============================] - 0s 58ms/step - loss: 45.3323
Epoch 151/400
5/5 [==============================] - 0s 60ms/step - loss: 44.4502
Epoch 152/400
5/5 [==============================] - 0s 61ms/step - loss: 43.4906
Epoch 153/400
5/5 [==============================] - 0s 58ms/step - loss: 49.5663
Epoch 154/400
5/5 [==============================] - 0s 57ms/step - loss: 41.4128
Epoch 155/400
5/5 [==============================] - 0s 63ms/step - loss: 40.9054
Epoch 156/400
5/5 [==============================] - 0s 61ms/step - loss: 47.2157
Epoch 157/400
5/5 [==============================] - 0s 59ms/step - loss: 41.9600
Epoch 158/400
5/5 [==============================] - 0s 57ms/step - loss: 48.2271
Epoch 159/400
5/5 [==============================] - 0s 61ms/step - loss: 47.2879
Epoch 160/400
5/5 [==============================] - 0s 57ms/step - loss: 39.8057
Epoch 161/400
5/5 [==============================] - 0s 60ms/step - loss: 41.0840
Epoch 162/400
5/5 [==============================] - 0s 60ms/step - loss: 37.3671
Epoch 163/400
5/5 [==============================] - 0s 67ms/step - loss: 46.8912
Epoch 164/400
5/5 [==============================] - 0s 60ms/step - loss: 42.7399
Epoch 165/400
5/5 [==============================] - 0s 62ms/step - loss: 40.1530
Epoch 166/400
5/5 [==============================] - 0s 61ms/step - loss: 43.8245
Epoch 167/400
5/5 [==============================] - 0s 60ms/step - loss: 42.4140
Epoch 168/400
5/5 [==============================] - 0s 62ms/step - loss: 38.3532
Epoch 169/400
5/5 [==============================] - 0s 64ms/step - loss: 38.9619
Epoch 170/400
5/5 [==============================] - 0s 58ms/step - loss: 51.7464
Epoch 171/400
5/5 [==============================] - 0s 73ms/step - loss: 38.0921
Epoch 172/400
5/5 [==============================] - 0s 79ms/step - loss: 39.1784
Epoch 173/400
5/5 [==============================] - 0s 72ms/step - loss: 39.9497
Epoch 174/400
5/5 [==============================] - 0s 60ms/step - loss: 42.5602
Epoch 175/400
5/5 [==============================] - 0s 62ms/step - loss: 39.6584
Epoch 176/400
5/5 [==============================] - 0s 61ms/step - loss: 39.2704
Epoch 177/400
```

```
5/5 [==============================] - 0s 62ms/step - loss: 41.5057
Epoch 178/400
5/5 [==============================] - 0s 64ms/step - loss: 36.9488
Epoch 179/400
5/5 [==============================] - 0s 58ms/step - loss: 39.1407
Epoch 180/400
5/5 [==============================] - 0s 59ms/step - loss: 41.8944
Epoch 181/400
5/5 [==============================] - 0s 62ms/step - loss: 36.1072
Epoch 182/400
5/5 [==============================] - 0s 58ms/step - loss: 38.2106
Epoch 183/400
5/5 [==============================] - 0s 60ms/step - loss: 38.4900
Epoch 184/400
5/5 [==============================] - 0s 61ms/step - loss: 35.6886
Epoch 185/400
5/5 [==============================] - 0s 60ms/step - loss: 47.9008
Epoch 186/400
5/5 [==============================] - 0s 59ms/step - loss: 36.9414
Epoch 187/400
5/5 [==============================] - 0s 75ms/step - loss: 38.5112
Epoch 188/400
5/5 [==============================] - 0s 72ms/step - loss: 38.2456
Epoch 189/400
5/5 [==============================] - 0s 69ms/step - loss: 46.0526
Epoch 190/400
5/5 [==============================] - 0s 66ms/step - loss: 34.9771
Epoch 191/400
5/5 [==============================] - 0s 59ms/step - loss: 34.3891
Epoch 192/400
5/5 [==============================] - 0s 61ms/step - loss: 40.9196
Epoch 193/400
5/5 [==============================] - 0s 58ms/step - loss: 35.5294
Epoch 194/400
5/5 [==============================] - 0s 68ms/step - loss: 35.3956
Epoch 195/400
5/5 [==============================] - 0s 58ms/step - loss: 39.1471
Epoch 196/400
5/5 [==============================] - 0s 58ms/step - loss: 35.2462
Epoch 197/400
5/5 [==============================] - 0s 62ms/step - loss: 35.0213
Epoch 198/400
5/5 [==============================] - 0s 58ms/step - loss: 36.7767
Epoch 199/400
5/5 [==============================] - 0s 61ms/step - loss: 33.9359
Epoch 200/400
5/5 [==============================] - 0s 60ms/step - loss: 37.6252
Epoch 201/400
5/5 [==============================] - 0s 60ms/step - loss: 35.8295
Epoch 202/400
5/5 [==============================] - 0s 67ms/step - loss: 38.8481
Epoch 203/400
5/5 [==============================] - 0s 70ms/step - loss: 34.2585
Epoch 204/400
5/5 [==============================] - 0s 73ms/step - loss: 36.3801
Epoch 205/400
5/5 [==============================] - 0s 64ms/step - loss: 38.6154
Epoch 206/400
5/5 [==============================] - 0s 59ms/step - loss: 38.6252
Epoch 207/400
```

```
5/5 [==============================] - 0s 59ms/step - loss: 34.9555
Epoch 208/400
5/5 [==============================] - 0s 61ms/step - loss: 34.6689
Epoch 209/400
5/5 [==============================] - 0s 61ms/step - loss: 37.1438
Epoch 210/400
5/5 [==============================] - 0s 64ms/step - loss: 34.9822
Epoch 211/400
5/5 [==============================] - 0s 60ms/step - loss: 37.2853
Epoch 212/400
5/5 [==============================] - 0s 70ms/step - loss: 31.6532
Epoch 213/400
5/5 [==============================] - 0s 72ms/step - loss: 40.6423
Epoch 214/400
5/5 [==============================] - 0s 72ms/step - loss: 33.6811
Epoch 215/400
5/5 [==============================] - 0s 61ms/step - loss: 32.2339
Epoch 216/400
5/5 [==============================] - 0s 63ms/step - loss: 33.6820
Epoch 217/400
5/5 [==============================] - 0s 63ms/step - loss: 34.1387
Epoch 218/400
5/5 [==============================] - 0s 63ms/step - loss: 34.0545
Epoch 219/400
5/5 [==============================] - 0s 61ms/step - loss: 35.5301
Epoch 220/400
5/5 [==============================] - 0s 60ms/step - loss: 37.3790
Epoch 221/400
5/5 [==============================] - 0s 60ms/step - loss: 32.7613
Epoch 222/400
5/5 [==============================] - 0s 60ms/step - loss: 35.5318
Epoch 223/400
5/5 [==============================] - 0s 63ms/step - loss: 30.6865
Epoch 224/400
5/5 [==============================] - 0s 59ms/step - loss: 35.8224
Epoch 225/400
5/5 [==============================] - 0s 61ms/step - loss: 32.1554
Epoch 226/400
5/5 [==============================] - 0s 67ms/step - loss: 32.8532
Epoch 227/400
5/5 [==============================] - 0s 62ms/step - loss: 38.5826
Epoch 228/400
5/5 [==============================] - 0s 60ms/step - loss: 33.9153
Epoch 229/400
5/5 [==============================] - 0s 60ms/step - loss: 33.1044
Epoch 230/400
5/5 [==============================] - 0s 59ms/step - loss: 31.9486
Epoch 231/400
5/5 [==============================] - 0s 67ms/step - loss: 34.2157
Epoch 232/400
5/5 [==============================] - 0s 74ms/step - loss: 32.4066
Epoch 233/400
5/5 [==============================] - 0s 75ms/step - loss: 30.9739
Epoch 234/400
5/5 [==============================] - 0s 72ms/step - loss: 31.8224
Epoch 235/400
5/5 [==============================] - 0s 74ms/step - loss: 33.2060
Epoch 236/400
5/5 [==============================] - 0s 71ms/step - loss: 31.3624
Epoch 237/400
```

```
5/5 [==============================] - 0s 62ms/step - loss: 33.1294
Epoch 238/400
5/5 [==============================] - 0s 62ms/step - loss: 33.0394
Epoch 239/400
5/5 [==============================] - 0s 62ms/step - loss: 32.1150
Epoch 240/400
5/5 [==============================] - 0s 59ms/step - loss: 38.9735
Epoch 241/400
5/5 [==============================] - 0s 59ms/step - loss: 30.7085
Epoch 242/400
5/5 [==============================] - 0s 62ms/step - loss: 32.5199
Epoch 243/400
5/5 [==============================] - 0s 64ms/step - loss: 32.8519
Epoch 244/400
5/5 [==============================] - 0s 59ms/step - loss: 35.7125
Epoch 245/400
5/5 [==============================] - 0s 62ms/step - loss: 34.0836
Epoch 246/400
5/5 [==============================] - 0s 64ms/step - loss: 30.3153
Epoch 247/400
5/5 [==============================] - 0s 70ms/step - loss: 31.7181
Epoch 248/400
5/5 [==============================] - 0s 75ms/step - loss: 30.5494
Epoch 249/400
5/5 [==============================] - 0s 68ms/step - loss: 38.6460
Epoch 250/400
5/5 [==============================] - 0s 60ms/step - loss: 32.0932
Epoch 251/400
5/5 [==============================] - 0s 63ms/step - loss: 32.8287
Epoch 252/400
5/5 [==============================] - 0s 61ms/step - loss: 33.2933
Epoch 253/400
5/5 [==============================] - 0s 59ms/step - loss: 36.0091
Epoch 254/400
5/5 [==============================] - 0s 57ms/step - loss: 29.4055
Epoch 255/400
5/5 [==============================] - 0s 62ms/step - loss: 28.0045
Epoch 256/400
5/5 [==============================] - 0s 58ms/step - loss: 29.4281
Epoch 257/400
5/5 [==============================] - 0s 64ms/step - loss: 36.8910
Epoch 258/400
5/5 [==============================] - 0s 62ms/step - loss: 32.1215
Epoch 259/400
5/5 [==============================] - 0s 60ms/step - loss: 30.8772
Epoch 260/400
5/5 [==============================] - 0s 58ms/step - loss: 29.6901
Epoch 261/400
5/5 [==============================] - 0s 59ms/step - loss: 33.6278
Epoch 262/400
5/5 [==============================] - 0s 60ms/step - loss: 29.7157
Epoch 263/400
5/5 [==============================] - 0s 59ms/step - loss: 29.4953
Epoch 264/400
5/5 [==============================] - 0s 58ms/step - loss: 35.7929
Epoch 265/400
5/5 [==============================] - 0s 62ms/step - loss: 34.5664
Epoch 266/400
5/5 [==============================] - 0s 58ms/step - loss: 29.7209
Epoch 267/400
```

```
5/5 [==============================] - 0s 59ms/step - loss: 30.0255
Epoch 268/400
5/5 [==============================] - 0s 67ms/step - loss: 28.6845
Epoch 269/400
5/5 [==============================] - 0s 59ms/step - loss: 32.2374
Epoch 270/400
5/5 [==============================] - 0s 60ms/step - loss: 29.0733
Epoch 271/400
5/5 [==============================] - 0s 64ms/step - loss: 29.5503
Epoch 272/400
5/5 [==============================] - 0s 60ms/step - loss: 28.8326
Epoch 273/400
5/5 [==============================] - 0s 59ms/step - loss: 29.4643
Epoch 274/400
5/5 [==============================] - 0s 60ms/step - loss: 29.9136
Epoch 275/400
5/5 [==============================] - 0s 59ms/step - loss: 36.8917
Epoch 276/400
5/5 [==============================] - 0s 71ms/step - loss: 28.6079
Epoch 277/400
5/5 [==============================] - 0s 73ms/step - loss: 35.7091
Epoch 278/400
5/5 [==============================] - 0s 71ms/step - loss: 31.1243
Epoch 279/400
5/5 [==============================] - 0s 60ms/step - loss: 29.2500
Epoch 280/400
5/5 [==============================] - 0s 61ms/step - loss: 29.1539
Epoch 281/400
5/5 [==============================] - 0s 61ms/step - loss: 28.4022
Epoch 282/400
5/5 [==============================] - 0s 62ms/step - loss: 29.5130
Epoch 283/400
5/5 [==============================] - 0s 62ms/step - loss: 33.7888
Epoch 284/400
5/5 [==============================] - 0s 65ms/step - loss: 29.1210
Epoch 285/400
5/5 [==============================] - 0s 62ms/step - loss: 33.3589
Epoch 286/400
5/5 [==============================] - 0s 61ms/step - loss: 28.0701
Epoch 287/400
5/5 [==============================] - 0s 66ms/step - loss: 33.6398
Epoch 288/400
5/5 [==============================] - 0s 60ms/step - loss: 28.4580
Epoch 289/400
5/5 [==============================] - 0s 65ms/step - loss: 27.6731
Epoch 290/400
5/5 [==============================] - 0s 60ms/step - loss: 31.1315
Epoch 291/400
5/5 [==============================] - 0s 62ms/step - loss: 32.8569
Epoch 292/400
5/5 [==============================] - 0s 61ms/step - loss: 28.5671
Epoch 293/400
5/5 [==============================] - 0s 60ms/step - loss: 28.7116
Epoch 294/400
5/5 [==============================] - 0s 63ms/step - loss: 32.4681
Epoch 295/400
5/5 [==============================] - 0s 62ms/step - loss: 31.6263
Epoch 296/400
5/5 [==============================] - 0s 60ms/step - loss: 28.7408
Epoch 297/400
```

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5/5 [==============================] - 0s 61ms/step - loss: 30.1301
Epoch 298/400
5/5 [==============================] - 0s 60ms/step - loss: 28.2214
Epoch 299/400
5/5 [==============================] - 0s 60ms/step - loss: 29.8835
Epoch 300/400
5/5 [==============================] - 0s 62ms/step - loss: 29.8348
Epoch 301/400
5/5 [==============================] - 0s 64ms/step - loss: 28.3405
Epoch 302/400
5/5 [==============================] - 0s 58ms/step - loss: 27.9603
Epoch 303/400
5/5 [==============================] - 0s 61ms/step - loss: 29.9926
Epoch 304/400
5/5 [==============================] - 0s 64ms/step - loss: 33.8089
Epoch 305/400
5/5 [==============================] - 0s 70ms/step - loss: 30.4915
Epoch 306/400
5/5 [==============================] - 0s 74ms/step - loss: 27.9568
Epoch 307/400
5/5 [==============================] - 0s 61ms/step - loss: 28.3944
Epoch 308/400
5/5 [==============================] - 0s 61ms/step - loss: 30.4135
Epoch 309/400
5/5 [==============================] - 0s 58ms/step - loss: 30.1303
Epoch 310/400
5/5 [==============================] - 0s 62ms/step - loss: 30.6377
Epoch 311/400
5/5 [==============================] - 0s 59ms/step - loss: 30.2180
Epoch 312/400
5/5 [==============================] - 0s 63ms/step - loss: 28.4852
Epoch 313/400
5/5 [==============================] - 0s 67ms/step - loss: 32.2827
Epoch 314/400
5/5 [==============================] - 0s 61ms/step - loss: 30.0569
Epoch 315/400
5/5 [==============================] - 0s 61ms/step - loss: 29.3828
Epoch 316/400
5/5 [==============================] - 0s 64ms/step - loss: 32.1037
Epoch 317/400
5/5 [==============================] - 0s 61ms/step - loss: 29.6087
Epoch 318/400
5/5 [==============================] - 0s 62ms/step - loss: 27.0992
Epoch 319/400
5/5 [==============================] - 0s 62ms/step - loss: 28.6034
Epoch 320/400
5/5 [==============================] - 0s 59ms/step - loss: 26.4381
Epoch 321/400
5/5 [==============================] - 0s 64ms/step - loss: 27.3978
Epoch 322/400
5/5 [==============================] - 0s 61ms/step - loss: 34.2928
Epoch 323/400
5/5 [==============================] - 0s 64ms/step - loss: 27.6287
Epoch 324/400
5/5 [==============================] - 0s 62ms/step - loss: 27.4438
Epoch 325/400
5/5 [==============================] - 0s 60ms/step - loss: 28.9115
Epoch 326/400
5/5 [==============================] - 0s 64ms/step - loss: 31.0378
Epoch 327/400
```

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5/5 [==============================] - 0s 59ms/step - loss: 28.9437
Epoch 328/400
5/5 [==============================] - 0s 58ms/step - loss: 32.1562
Epoch 329/400
5/5 [==============================] - 0s 63ms/step - loss: 29.0882
Epoch 330/400
5/5 [==============================] - 0s 61ms/step - loss: 27.6708
Epoch 331/400
5/5 [==============================] - 0s 65ms/step - loss: 29.1667
Epoch 332/400
5/5 [==============================] - 0s 63ms/step - loss: 33.2105
Epoch 333/400
5/5 [==============================] - 0s 61ms/step - loss: 28.1190
Epoch 334/400
5/5 [==============================] - 0s 59ms/step - loss: 31.1441
Epoch 335/400
5/5 [==============================] - 0s 57ms/step - loss: 29.9335
Epoch 336/400
5/5 [==============================] - 0s 61ms/step - loss: 27.1169
Epoch 337/400
5/5 [==============================] - 0s 61ms/step - loss: 31.0336
Epoch 338/400
5/5 [==============================] - 0s 59ms/step - loss: 26.2591
Epoch 339/400
5/5 [==============================] - 0s 63ms/step - loss: 28.8874
Epoch 340/400
5/5 [==============================] - 0s 61ms/step - loss: 30.7456
Epoch 341/400
5/5 [==============================] - 0s 59ms/step - loss: 27.6715
Epoch 342/400
5/5 [==============================] - 0s 62ms/step - loss: 28.6900
Epoch 343/400
5/5 [==============================] - 0s 71ms/step - loss: 30.5130
Epoch 344/400
5/5 [==============================] - 0s 70ms/step - loss: 28.7811
Epoch 345/400
5/5 [==============================] - 0s 72ms/step - loss: 27.1214
Epoch 346/400
5/5 [==============================] - 0s 61ms/step - loss: 25.9281
Epoch 347/400
5/5 [==============================] - 0s 60ms/step - loss: 26.9190
Epoch 348/400
5/5 [==============================] - 0s 65ms/step - loss: 27.4681
Epoch 349/400
5/5 [==============================] - 0s 61ms/step - loss: 29.1485
Epoch 350/400
5/5 [==============================] - 0s 59ms/step - loss: 26.8078
Epoch 351/400
5/5 [==============================] - 0s 63ms/step - loss: 34.3909
Epoch 352/400
5/5 [==============================] - 0s 77ms/step - loss: 26.1159
Epoch 353/400
5/5 [==============================] - 0s 69ms/step - loss: 29.0156
Epoch 354/400
5/5 [==============================] - 0s 73ms/step - loss: 27.6263
Epoch 355/400
5/5 [==============================] - 0s 75ms/step - loss: 25.5469
Epoch 356/400
5/5 [==============================] - 0s 68ms/step - loss: 29.6522
Epoch 357/400
```

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5/5 [==============================] - 0s 72ms/step - loss: 28.8797
Epoch 358/400
5/5 [==============================] - 0s 62ms/step - loss: 27.8334
Epoch 359/400
5/5 [==============================] - 0s 65ms/step - loss: 27.9070
Epoch 360/400
5/5 [==============================] - 0s 61ms/step - loss: 28.9420
Epoch 361/400
5/5 [==============================] - 0s 63ms/step - loss: 29.1267
Epoch 362/400
5/5 [==============================] - 0s 57ms/step - loss: 30.0540
Epoch 363/400
5/5 [==============================] - 0s 58ms/step - loss: 26.3979
Epoch 364/400
5/5 [==============================] - 0s 62ms/step - loss: 27.6617
Epoch 365/400
5/5 [==============================] - 0s 57ms/step - loss: 25.2114
Epoch 366/400
5/5 [==============================] - 0s 60ms/step - loss: 27.7840
Epoch 367/400
5/5 [==============================] - 0s 63ms/step - loss: 30.4416
Epoch 368/400
5/5 [==============================] - 0s 58ms/step - loss: 25.4639
Epoch 369/400
5/5 [==============================] - 0s 60ms/step - loss: 30.7391
Epoch 370/400
5/5 [==============================] - 0s 64ms/step - loss: 26.5557
Epoch 371/400
5/5 [==============================] - 0s 60ms/step - loss: 32.7972
Epoch 372/400
5/5 [==============================] - 0s 58ms/step - loss: 29.0656
Epoch 373/400
5/5 [==============================] - 0s 59ms/step - loss: 27.7276
Epoch 374/400
5/5 [==============================] - 0s 75ms/step - loss: 25.3871
Epoch 375/400
5/5 [==============================] - 0s 71ms/step - loss: 28.1550
Epoch 376/400
5/5 [==============================] - 0s 75ms/step - loss: 28.8479
Epoch 377/400
5/5 [==============================] - 0s 72ms/step - loss: 29.7790
Epoch 378/400
5/5 [==============================] - 0s 69ms/step - loss: 25.5187
Epoch 379/400
5/5 [==============================] - 0s 72ms/step - loss: 25.7319
Epoch 380/400
5/5 [==============================] - 0s 72ms/step - loss: 30.5015
Epoch 381/400
5/5 [==============================] - 0s 74ms/step - loss: 26.8138
Epoch 382/400
5/5 [==============================] - 0s 68ms/step - loss: 27.5698
Epoch 383/400
5/5 [==============================] - 0s 58ms/step - loss: 26.3902
Epoch 384/400
5/5 [==============================] - 0s 77ms/step - loss: 29.1494
Epoch 385/400
5/5 [==============================] - 0s 63ms/step - loss: 26.6116
Epoch 386/400
5/5 [==============================] - 0s 56ms/step - loss: 25.9128
Epoch 387/400
```

```
5/5 [==============================] - 0s 64ms/step - loss: 29.6858
Epoch 388/400
5/5 [==============================] - 0s 62ms/step - loss: 29.2995
Epoch 389/400
5/5 [==============================] - 0s 60ms/step - loss: 26.8901
Epoch 390/400
5/5 [==============================] - 0s 59ms/step - loss: 25.7864
Epoch 391/400
5/5 [==============================] - 0s 59ms/step - loss: 29.9634
Epoch 392/400
5/5 [==============================] - 0s 63ms/step - loss: 27.3040
Epoch 393/400
5/5 [==============================] - 0s 59ms/step - loss: 26.1925
Epoch 394/400
5/5 [==============================] - 0s 61ms/step - loss: 24.4154
Epoch 395/400
5/5 [==============================] - 0s 62ms/step - loss: 26.2931
Epoch 396/400
5/5 [==============================] - 0s 59ms/step - loss: 28.1841
Epoch 397/400
5/5 [==============================] - 0s 60ms/step - loss: 28.4309
Epoch 398/400
5/5 [==============================] - 0s 64ms/step - loss: 27.3387
Epoch 399/400
5/5 [==============================] - 0s 62ms/step - loss: 27.1941
Epoch 400/400
5/5 [==============================] - 0s 61ms/step - loss: 23.1223
testing MSE:  16.691401318024777
MSE of baseline model:  21.05596723741936
Comparison of model prediction and baseline prediction:
```
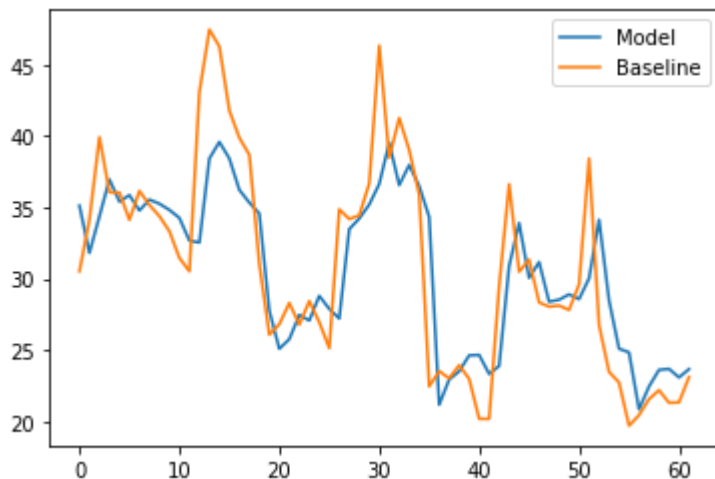


```
Day-to-day out-of-sample accuracy:  0.5245901639344263
Five-day out-of-sample accuracy:  0.8245614035087719
Day-to-day out-of-sample accuracy of baseline:  0.4918032786885246
Five-day out-of-sample accuracy of baseline:  0.7894736842105263
```

In [ ]:
```python
LSTM_2_plot = model_plot(LSTM_2.data_y_test, LSTM_2.y_pred)
baseline_plot = model_plot(LSTM_2.dataset[LSTM_2.train_sample_num + 1:, -1],
                           LSTM_2.dataset[LSTM_2.train_sample_num:-1, -1])
print(" True VS Pred plot of LSTM Model with 2 layers")
LSTM_2_plot.true_pred_plot()
print(" True VS Pred plot of Baseline Model")
baseline_plot.true_pred_plot()
print(" Residual plot of LSTM Model with 2 layers")
LSTM_2_plot.residual_plot()
```

```
print(" Residual plot of Baseline Model")
baseline_plot.residual_plot()
print(" Trend plot of LSTM Model with 2 layers")
LSTM_2_plot.trend_plot()
print(" Trend plot of Baseline Model")
baseline_plot.trend_plot()
```

True VS Pred plot of LSTM Model with 2 layers
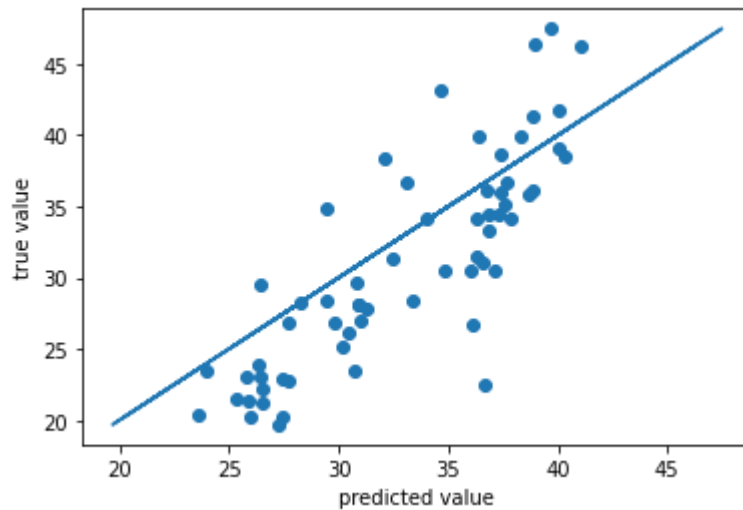
True VS Pred plot of Baseline Model
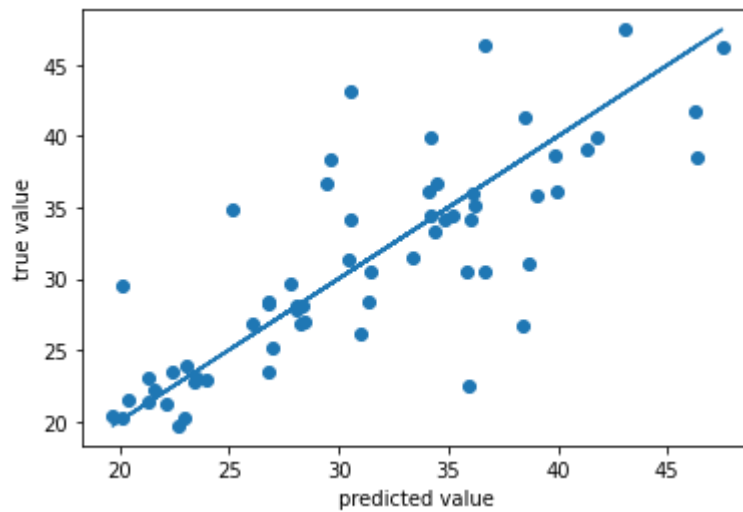
Residual plot of LSTM Model with 2 layers
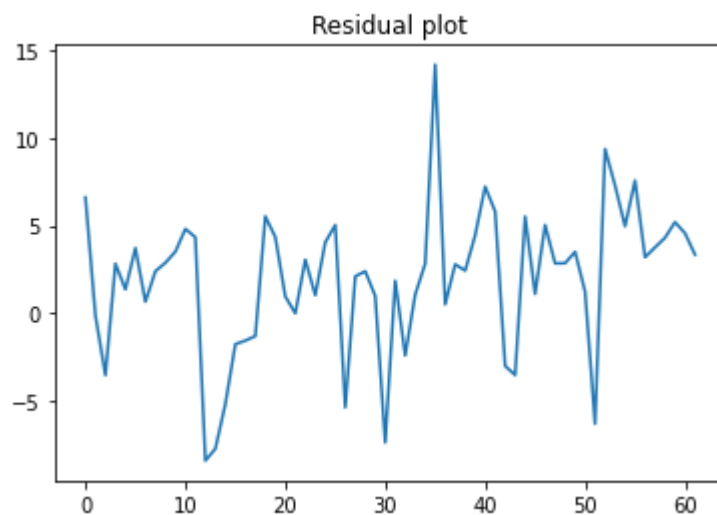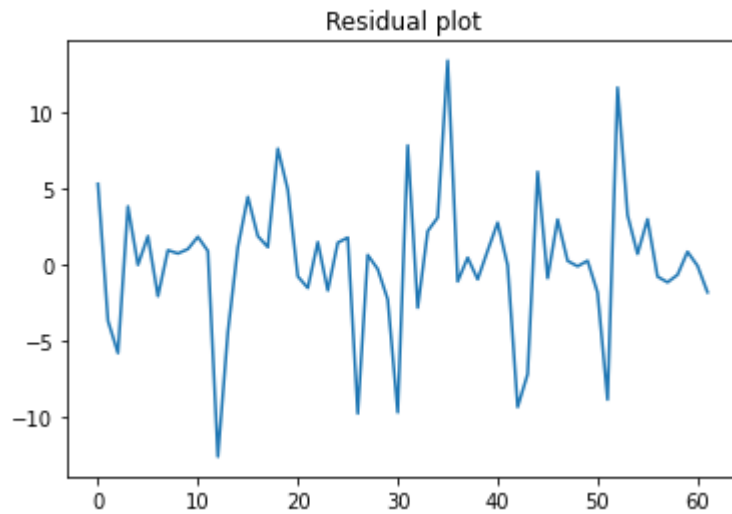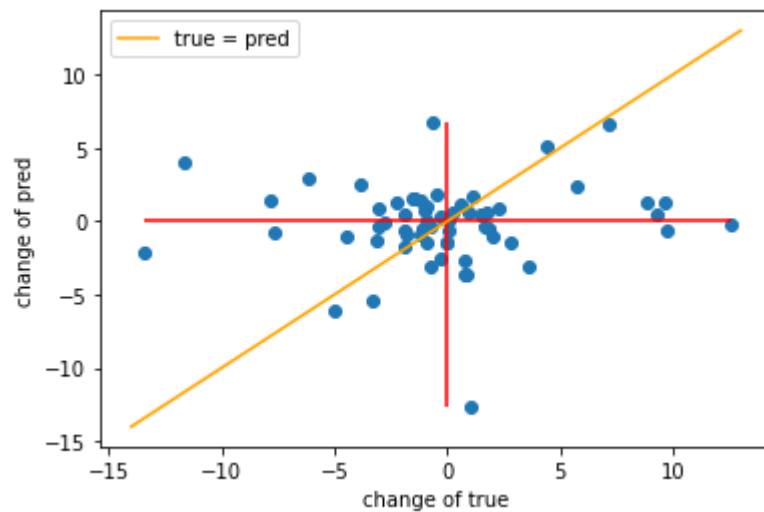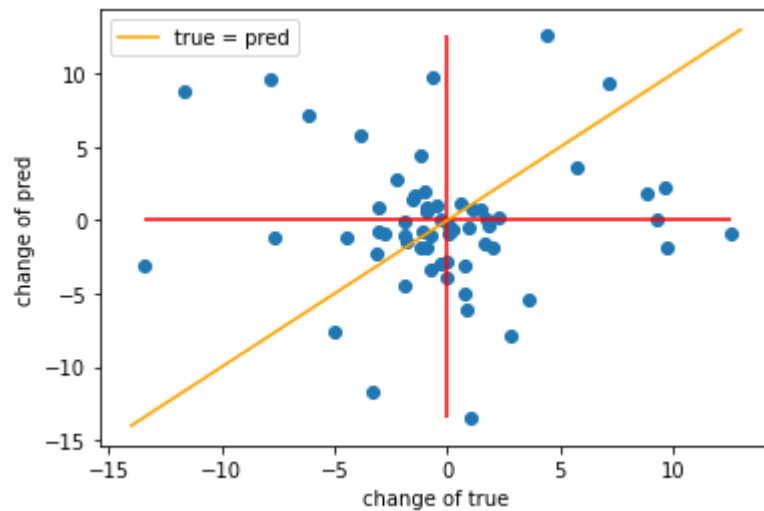
Residual plot of Baseline Model

Residual plot

Trend plot of LSTM Model with 2 layers

Trend plot of Baseline Model

In [ ]:

LSTM   Model with 3 layers

```
In [ ]:  LSTM_3 = LSTM_model(data.df)
         LSTM_3.split_train_test()
         LSTM_3.fit_model(layers=3)
         LSTM_3.predict_result()
         LSTM_3.compare_to_baseline()
         LSTM_3.test_accuracy()
```

```
Epoch 1/400
5/5 [==============================] - 6s 99ms/step - loss: 978.0811
Epoch 2/400
5/5 [==============================] - 0s 89ms/step - loss: 383.1430
Epoch 3/400
5/5 [==============================] - 0s 90ms/step - loss: 219.9250
Epoch 4/400
5/5 [==============================] - 0s 87ms/step - loss: 187.5537
Epoch 5/400
5/5 [==============================] - 0s 88ms/step - loss: 173.1340
Epoch 6/400
5/5 [==============================] - 0s 91ms/step - loss: 163.5319
Epoch 7/400
5/5 [==============================] - 0s 89ms/step - loss: 156.9442
Epoch 8/400
5/5 [==============================] - 0s 93ms/step - loss: 152.5380
Epoch 9/400
5/5 [==============================] - 0s 88ms/step - loss: 149.3941
Epoch 10/400
5/5 [==============================] - 0s 92ms/step - loss: 146.9761
Epoch 11/400
5/5 [==============================] - 0s 86ms/step - loss: 145.6341
Epoch 12/400
5/5 [==============================] - 0s 87ms/step - loss: 144.2821
Epoch 13/400
5/5 [==============================] - 0s 88ms/step - loss: 141.0478
Epoch 14/400
5/5 [==============================] - 0s 85ms/step - loss: 132.1492
Epoch 15/400
5/5 [==============================] - 0s 92ms/step - loss: 127.3366
Epoch 16/400
5/5 [==============================] - 0s 91ms/step - loss: 127.8937
Epoch 17/400
5/5 [==============================] - 0s 91ms/step - loss: 127.0200
Epoch 18/400
5/5 [==============================] - 0s 91ms/step - loss: 118.5612
Epoch 19/400
5/5 [==============================] - 0s 91ms/step - loss: 118.8161
Epoch 20/400
5/5 [==============================] - 0s 89ms/step - loss: 121.1014
Epoch 21/400
5/5 [==============================] - 0s 89ms/step - loss: 113.2979
Epoch 22/400
5/5 [==============================] - 0s 90ms/step - loss: 107.3290
Epoch 23/400
5/5 [==============================] - 0s 93ms/step - loss: 110.1023
Epoch 24/400
5/5 [==============================] - 0s 92ms/step - loss: 112.6739
Epoch 25/400
5/5 [==============================] - 0s 90ms/step - loss: 110.2789
Epoch 26/400
5/5 [==============================] - 0s 93ms/step - loss: 105.8010
Epoch 27/400
```

```
5/5 [==============================] - 0s 93ms/step - loss: 105.2753
Epoch 28/400
5/5 [==============================] - 1s 114ms/step - loss: 106.2163
Epoch 29/400
5/5 [==============================] - 1s 106ms/step - loss: 98.9751
Epoch 30/400
5/5 [==============================] - 0s 94ms/step - loss: 99.7352
Epoch 31/400
5/5 [==============================] - 0s 90ms/step - loss: 107.6665
Epoch 32/400
5/5 [==============================] - 0s 92ms/step - loss: 96.4870
Epoch 33/400
5/5 [==============================] - 0s 87ms/step - loss: 103.7601
Epoch 34/400
5/5 [==============================] - 0s 91ms/step - loss: 100.5146
Epoch 35/400
5/5 [==============================] - 0s 91ms/step - loss: 93.1318
Epoch 36/400
5/5 [==============================] - 0s 89ms/step - loss: 92.3222
Epoch 37/400
5/5 [==============================] - 0s 92ms/step - loss: 96.8435
Epoch 38/400
5/5 [==============================] - 0s 86ms/step - loss: 94.5807
Epoch 39/400
5/5 [==============================] - 0s 90ms/step - loss: 96.2709
Epoch 40/400
5/5 [==============================] - 0s 89ms/step - loss: 90.3738
Epoch 41/400
5/5 [==============================] - 0s 91ms/step - loss: 94.2035
Epoch 42/400
5/5 [==============================] - 0s 89ms/step - loss: 99.8167
Epoch 43/400
5/5 [==============================] - 0s 86ms/step - loss: 88.8163
Epoch 44/400
5/5 [==============================] - 0s 94ms/step - loss: 93.4899
Epoch 45/400
5/5 [==============================] - 0s 92ms/step - loss: 88.5503
Epoch 46/400
5/5 [==============================] - 0s 90ms/step - loss: 84.1843
Epoch 47/400
5/5 [==============================] - 0s 89ms/step - loss: 86.6419
Epoch 48/400
5/5 [==============================] - 0s 90ms/step - loss: 98.2790
Epoch 49/400
5/5 [==============================] - 0s 90ms/step - loss: 86.4419
Epoch 50/400
5/5 [==============================] - 0s 89ms/step - loss: 85.4378
Epoch 51/400
5/5 [==============================] - 0s 94ms/step - loss: 89.7931
Epoch 52/400
5/5 [==============================] - 0s 91ms/step - loss: 89.2340
Epoch 53/400
5/5 [==============================] - 0s 93ms/step - loss: 85.2467
Epoch 54/400
5/5 [==============================] - 0s 88ms/step - loss: 87.7148
Epoch 55/400
5/5 [==============================] - 0s 87ms/step - loss: 83.1731
Epoch 56/400
5/5 [==============================] - 0s 88ms/step - loss: 89.0305
Epoch 57/400
```

```
5/5 [==============================] - 0s 90ms/step - loss: 79.5363
Epoch 58/400
5/5 [==============================] - 0s 89ms/step - loss: 80.4427
Epoch 59/400
5/5 [==============================] - 0s 87ms/step - loss: 87.8735
Epoch 60/400
5/5 [==============================] - 0s 91ms/step - loss: 87.0362
Epoch 61/400
5/5 [==============================] - 0s 88ms/step - loss: 79.4260
Epoch 62/400
5/5 [==============================] - 0s 90ms/step - loss: 77.1851
Epoch 63/400
5/5 [==============================] - 0s 88ms/step - loss: 87.1274
Epoch 64/400
5/5 [==============================] - 0s 90ms/step - loss: 81.8156
Epoch 65/400
5/5 [==============================] - 0s 90ms/step - loss: 79.9450
Epoch 66/400
5/5 [==============================] - 0s 90ms/step - loss: 79.6615
Epoch 67/400
5/5 [==============================] - 0s 91ms/step - loss: 82.5987
Epoch 68/400
5/5 [==============================] - 0s 93ms/step - loss: 81.0956
Epoch 69/400
5/5 [==============================] - 0s 93ms/step - loss: 75.7074
Epoch 70/400
5/5 [==============================] - 0s 86ms/step - loss: 86.0853
Epoch 71/400
5/5 [==============================] - 0s 94ms/step - loss: 72.8136
Epoch 72/400
5/5 [==============================] - 0s 87ms/step - loss: 72.7884
Epoch 73/400
5/5 [==============================] - 0s 94ms/step - loss: 87.3449
Epoch 74/400
5/5 [==============================] - 0s 96ms/step - loss: 76.4699
Epoch 75/400
5/5 [==============================] - 1s 114ms/step - loss: 73.5900
Epoch 76/400
5/5 [==============================] - 1s 110ms/step - loss: 78.6821
Epoch 77/400
5/5 [==============================] - 1s 118ms/step - loss: 73.6501
Epoch 78/400
5/5 [==============================] - 1s 97ms/step - loss: 85.1760
Epoch 79/400
5/5 [==============================] - 0s 93ms/step - loss: 74.8191
Epoch 80/400
5/5 [==============================] - 0s 91ms/step - loss: 69.7880
Epoch 81/400
5/5 [==============================] - 0s 89ms/step - loss: 75.7589
Epoch 82/400
5/5 [==============================] - 0s 90ms/step - loss: 73.0934
Epoch 83/400
5/5 [==============================] - 0s 88ms/step - loss: 67.6930
Epoch 84/400
5/5 [==============================] - 0s 93ms/step - loss: 75.8363
Epoch 85/400
5/5 [==============================] - 0s 92ms/step - loss: 77.8028
Epoch 86/400
5/5 [==============================] - 0s 92ms/step - loss: 71.1202
Epoch 87/400
```

```
5/5 [==============================] - 0s 89ms/step - loss: 68.9555
Epoch 88/400
5/5 [==============================] - 0s 90ms/step - loss: 67.0418
Epoch 89/400
5/5 [==============================] - 1s 106ms/step - loss: 81.4800
Epoch 90/400
5/5 [==============================] - 1s 112ms/step - loss: 69.3117
Epoch 91/400
5/5 [==============================] - 0s 96ms/step - loss: 71.6628
Epoch 92/400
5/5 [==============================] - 0s 98ms/step - loss: 67.3896
Epoch 93/400
5/5 [==============================] - 0s 92ms/step - loss: 68.6802
Epoch 94/400
5/5 [==============================] - 0s 92ms/step - loss: 71.9779
Epoch 95/400
5/5 [==============================] - 0s 99ms/step - loss: 70.8350
Epoch 96/400
5/5 [==============================] - 1s 115ms/step - loss: 66.2755
Epoch 97/400
5/5 [==============================] - 1s 97ms/step - loss: 67.8519
Epoch 98/400
5/5 [==============================] - 0s 90ms/step - loss: 70.8323
Epoch 99/400
5/5 [==============================] - 0s 88ms/step - loss: 68.1503
Epoch 100/400
5/5 [==============================] - 0s 88ms/step - loss: 71.7326
Epoch 101/400
5/5 [==============================] - 0s 90ms/step - loss: 66.1351
Epoch 102/400
5/5 [==============================] - 0s 89ms/step - loss: 67.4847
Epoch 103/400
5/5 [==============================] - 0s 90ms/step - loss: 65.8120
Epoch 104/400
5/5 [==============================] - 0s 88ms/step - loss: 73.0451
Epoch 105/400
5/5 [==============================] - 0s 92ms/step - loss: 64.9268
Epoch 106/400
5/5 [==============================] - 0s 92ms/step - loss: 65.1828
Epoch 107/400
5/5 [==============================] - 0s 88ms/step - loss: 64.4361
Epoch 108/400
5/5 [==============================] - 0s 90ms/step - loss: 58.6234
Epoch 109/400
5/5 [==============================] - 0s 88ms/step - loss: 70.0967
Epoch 110/400
5/5 [==============================] - 0s 100ms/step - loss: 65.0427
Epoch 111/400
5/5 [==============================] - 0s 90ms/step - loss: 59.8955
Epoch 112/400
5/5 [==============================] - 0s 92ms/step - loss: 60.6190
Epoch 113/400
5/5 [==============================] - 0s 89ms/step - loss: 56.2154
Epoch 114/400
5/5 [==============================] - 0s 92ms/step - loss: 53.8188
Epoch 115/400
5/5 [==============================] - 0s 90ms/step - loss: 53.0263
Epoch 116/400
5/5 [==============================] - 0s 88ms/step - loss: 59.4027
Epoch 117/400
```

```
5/5 [==============================] - 0s 90ms/step - loss: 74.5391
Epoch 118/400
5/5 [==============================] - 0s 93ms/step - loss: 56.6422
Epoch 119/400
5/5 [==============================] - 0s 93ms/step - loss: 53.9133
Epoch 120/400
5/5 [==============================] - 0s 90ms/step - loss: 61.0472
Epoch 121/400
5/5 [==============================] - 0s 95ms/step - loss: 58.7442
Epoch 122/400
5/5 [==============================] - 0s 94ms/step - loss: 53.7344
Epoch 123/400
5/5 [==============================] - 0s 92ms/step - loss: 51.6320
Epoch 124/400
5/5 [==============================] - 1s 107ms/step - loss: 59.2592
Epoch 125/400
5/5 [==============================] - 1s 111ms/step - loss: 54.1830
Epoch 126/400
5/5 [==============================] - 0s 93ms/step - loss: 59.5163
Epoch 127/400
5/5 [==============================] - 0s 91ms/step - loss: 49.9798
Epoch 128/400
5/5 [==============================] - 0s 88ms/step - loss: 64.9003
Epoch 129/400
5/5 [==============================] - 0s 89ms/step - loss: 51.0190
Epoch 130/400
5/5 [==============================] - 0s 90ms/step - loss: 52.9615
Epoch 131/400
5/5 [==============================] - 0s 88ms/step - loss: 52.5712
Epoch 132/400
5/5 [==============================] - 0s 98ms/step - loss: 49.3159
Epoch 133/400
5/5 [==============================] - 0s 91ms/step - loss: 48.0866
Epoch 134/400
5/5 [==============================] - 0s 93ms/step - loss: 60.2487
Epoch 135/400
5/5 [==============================] - 0s 92ms/step - loss: 49.4811
Epoch 136/400
5/5 [==============================] - 0s 93ms/step - loss: 48.4465
Epoch 137/400
5/5 [==============================] - 0s 92ms/step - loss: 55.0108
Epoch 138/400
5/5 [==============================] - 0s 90ms/step - loss: 48.6243
Epoch 139/400
5/5 [==============================] - 0s 90ms/step - loss: 47.3160
Epoch 140/400
5/5 [==============================] - 0s 91ms/step - loss: 48.6343
Epoch 141/400
5/5 [==============================] - 0s 91ms/step - loss: 56.3953
Epoch 142/400
5/5 [==============================] - 0s 88ms/step - loss: 56.4852
Epoch 143/400
5/5 [==============================] - 0s 92ms/step - loss: 48.0332
Epoch 144/400
5/5 [==============================] - 0s 88ms/step - loss: 54.5129
Epoch 145/400
5/5 [==============================] - 0s 92ms/step - loss: 46.7282
Epoch 146/400
5/5 [==============================] - 0s 90ms/step - loss: 45.1133
Epoch 147/400
```

```
5/5 [==============================] - 0s 88ms/step - loss: 50.4081
Epoch 148/400
5/5 [==============================] - 0s 88ms/step - loss: 48.4045
Epoch 149/400
5/5 [==============================] - 0s 89ms/step - loss: 47.7842
Epoch 150/400
5/5 [==============================] - 0s 101ms/step - loss: 49.0928
Epoch 151/400
5/5 [==============================] - 1s 110ms/step - loss: 48.6906
Epoch 152/400
5/5 [==============================] - 1s 95ms/step - loss: 45.0497
Epoch 153/400
5/5 [==============================] - 0s 94ms/step - loss: 42.7717
Epoch 154/400
5/5 [==============================] - 0s 93ms/step - loss: 50.2051
Epoch 155/400
5/5 [==============================] - 0s 95ms/step - loss: 47.2632
Epoch 156/400
5/5 [==============================] - 0s 94ms/step - loss: 48.3615
Epoch 157/400
5/5 [==============================] - 0s 89ms/step - loss: 47.9820
Epoch 158/400
5/5 [==============================] - 0s 93ms/step - loss: 44.0097
Epoch 159/400
5/5 [==============================] - 0s 91ms/step - loss: 46.5522
Epoch 160/400
5/5 [==============================] - 0s 92ms/step - loss: 47.6006
Epoch 161/400
5/5 [==============================] - 0s 88ms/step - loss: 43.6456
Epoch 162/400
5/5 [==============================] - 0s 92ms/step - loss: 43.4774
Epoch 163/400
5/5 [==============================] - 0s 93ms/step - loss: 46.0494
Epoch 164/400
5/5 [==============================] - 0s 89ms/step - loss: 46.2709
Epoch 165/400
5/5 [==============================] - 0s 93ms/step - loss: 39.3254
Epoch 166/400
5/5 [==============================] - 0s 90ms/step - loss: 44.8631
Epoch 167/400
5/5 [==============================] - 0s 93ms/step - loss: 45.7512
Epoch 168/400
5/5 [==============================] - 0s 89ms/step - loss: 42.2406
Epoch 169/400
5/5 [==============================] - 0s 94ms/step - loss: 40.4350
Epoch 170/400
5/5 [==============================] - 0s 90ms/step - loss: 47.2918
Epoch 171/400
5/5 [==============================] - 0s 90ms/step - loss: 42.2492
Epoch 172/400
5/5 [==============================] - 0s 91ms/step - loss: 41.9537
Epoch 173/400
5/5 [==============================] - 0s 88ms/step - loss: 40.8483
Epoch 174/400
5/5 [==============================] - 0s 92ms/step - loss: 45.2354
Epoch 175/400
5/5 [==============================] - 0s 89ms/step - loss: 39.9412
Epoch 176/400
5/5 [==============================] - 0s 94ms/step - loss: 40.8601
Epoch 177/400
```

```
5/5 [==============================] - 0s 93ms/step - loss: 48.7720
Epoch 178/400
5/5 [==============================] - 0s 97ms/step - loss: 41.1710
Epoch 179/400
5/5 [==============================] - 0s 92ms/step - loss: 39.3133
Epoch 180/400
5/5 [==============================] - 0s 89ms/step - loss: 47.8353
Epoch 181/400
5/5 [==============================] - 0s 89ms/step - loss: 42.1400
Epoch 182/400
5/5 [==============================] - 0s 89ms/step - loss: 37.2014
Epoch 183/400
5/5 [==============================] - 0s 94ms/step - loss: 42.9761
Epoch 184/400
5/5 [==============================] - 0s 90ms/step - loss: 35.1118
Epoch 185/400
5/5 [==============================] - 0s 93ms/step - loss: 39.2174
Epoch 186/400
5/5 [==============================] - 0s 93ms/step - loss: 40.5152
Epoch 187/400
5/5 [==============================] - 0s 100ms/step - loss: 43.0834
Epoch 188/400
5/5 [==============================] - 1s 111ms/step - loss: 35.4084
Epoch 189/400
5/5 [==============================] - 1s 102ms/step - loss: 40.8354
Epoch 190/400
5/5 [==============================] - 0s 90ms/step - loss: 36.8534
Epoch 191/400
5/5 [==============================] - 0s 94ms/step - loss: 44.4863
Epoch 192/400
5/5 [==============================] - 0s 92ms/step - loss: 37.0568
Epoch 193/400
5/5 [==============================] - 0s 95ms/step - loss: 38.2177
Epoch 194/400
5/5 [==============================] - 0s 91ms/step - loss: 37.6567
Epoch 195/400
5/5 [==============================] - 0s 91ms/step - loss: 39.5290
Epoch 196/400
5/5 [==============================] - 0s 88ms/step - loss: 42.1997
Epoch 197/400
5/5 [==============================] - 0s 92ms/step - loss: 40.8331
Epoch 198/400
5/5 [==============================] - 0s 94ms/step - loss: 39.3507
Epoch 199/400
5/5 [==============================] - 0s 89ms/step - loss: 34.1728
Epoch 200/400
5/5 [==============================] - 0s 95ms/step - loss: 35.7734
Epoch 201/400
5/5 [==============================] - 0s 92ms/step - loss: 41.1038
Epoch 202/400
5/5 [==============================] - 0s 96ms/step - loss: 35.9943
Epoch 203/400
5/5 [==============================] - 0s 93ms/step - loss: 38.4453
Epoch 204/400
5/5 [==============================] - 0s 98ms/step - loss: 33.9475
Epoch 205/400
5/5 [==============================] - 0s 96ms/step - loss: 44.7422
Epoch 206/400
5/5 [==============================] - 0s 93ms/step - loss: 36.5955
Epoch 207/400
```

```
5/5 [==============================] - 0s 93ms/step - loss: 33.2033
Epoch 208/400
5/5 [==============================] - 0s 92ms/step - loss: 41.9445
Epoch 209/400
5/5 [==============================] - 0s 91ms/step - loss: 35.5541
Epoch 210/400
5/5 [==============================] - 0s 89ms/step - loss: 35.3305
Epoch 211/400
5/5 [==============================] - 0s 95ms/step - loss: 38.4185
Epoch 212/400
5/5 [==============================] - 0s 92ms/step - loss: 40.5979
Epoch 213/400
5/5 [==============================] - 0s 92ms/step - loss: 34.8969
Epoch 214/400
5/5 [==============================] - 0s 88ms/step - loss: 36.5092
Epoch 215/400
5/5 [==============================] - 0s 92ms/step - loss: 40.1531
Epoch 216/400
5/5 [==============================] - 0s 90ms/step - loss: 40.7680
Epoch 217/400
5/5 [==============================] - 0s 90ms/step - loss: 38.3766
Epoch 218/400
5/5 [==============================] - 0s 91ms/step - loss: 34.0333
Epoch 219/400
5/5 [==============================] - 0s 91ms/step - loss: 33.5142
Epoch 220/400
5/5 [==============================] - 1s 112ms/step - loss: 34.9580
Epoch 221/400
5/5 [==============================] - 1s 110ms/step - loss: 38.8245
Epoch 222/400
5/5 [==============================] - 0s 89ms/step - loss: 36.7031
Epoch 223/400
5/5 [==============================] - 0s 90ms/step - loss: 35.9094
Epoch 224/400
5/5 [==============================] - 0s 95ms/step - loss: 35.1926
Epoch 225/400
5/5 [==============================] - 0s 92ms/step - loss: 34.7362
Epoch 226/400
5/5 [==============================] - 0s 95ms/step - loss: 31.6823
Epoch 227/400
5/5 [==============================] - 0s 91ms/step - loss: 35.6903
Epoch 228/400
5/5 [==============================] - 0s 94ms/step - loss: 32.7669
Epoch 229/400
5/5 [==============================] - 0s 87ms/step - loss: 32.9158
Epoch 230/400
5/5 [==============================] - 0s 92ms/step - loss: 31.5292
Epoch 231/400
5/5 [==============================] - 0s 88ms/step - loss: 36.8925
Epoch 232/400
5/5 [==============================] - 0s 89ms/step - loss: 32.8036
Epoch 233/400
5/5 [==============================] - 0s 96ms/step - loss: 37.0007
Epoch 234/400
5/5 [==============================] - 0s 90ms/step - loss: 34.7334
Epoch 235/400
5/5 [==============================] - 0s 93ms/step - loss: 32.0963
Epoch 236/400
5/5 [==============================] - 0s 89ms/step - loss: 35.6346
Epoch 237/400
```

```
5/5 [==============================] - 0s 93ms/step - loss: 34.1507
Epoch 238/400
5/5 [==============================] - 0s 90ms/step - loss: 29.5222
Epoch 239/400
5/5 [==============================] - 0s 93ms/step - loss: 29.7480
Epoch 240/400
5/5 [==============================] - 0s 96ms/step - loss: 39.5102
Epoch 241/400
5/5 [==============================] - 0s 93ms/step - loss: 32.4512
Epoch 242/400
5/5 [==============================] - 1s 109ms/step - loss: 32.7735
Epoch 243/400
5/5 [==============================] - 1s 103ms/step - loss: 36.8516
Epoch 244/400
5/5 [==============================] - 0s 91ms/step - loss: 30.0257
Epoch 245/400
5/5 [==============================] - 0s 94ms/step - loss: 31.2934
Epoch 246/400
5/5 [==============================] - 1s 114ms/step - loss: 31.6724
Epoch 247/400
5/5 [==============================] - 1s 103ms/step - loss: 34.5587
Epoch 248/400
5/5 [==============================] - 0s 88ms/step - loss: 32.1415
Epoch 249/400
5/5 [==============================] - 0s 95ms/step - loss: 32.8075
Epoch 250/400
5/5 [==============================] - 0s 92ms/step - loss: 36.3970
Epoch 251/400
5/5 [==============================] - 0s 92ms/step - loss: 30.1505
Epoch 252/400
5/5 [==============================] - 1s 113ms/step - loss: 31.1226
Epoch 253/400
5/5 [==============================] - 1s 105ms/step - loss: 29.3928
Epoch 254/400
5/5 [==============================] - 0s 93ms/step - loss: 37.8975
Epoch 255/400
5/5 [==============================] - 0s 91ms/step - loss: 33.1703
Epoch 256/400
5/5 [==============================] - 0s 92ms/step - loss: 32.8140
Epoch 257/400
5/5 [==============================] - 0s 89ms/step - loss: 33.3009
Epoch 258/400
5/5 [==============================] - 0s 96ms/step - loss: 31.3603
Epoch 259/400
5/5 [==============================] - 0s 90ms/step - loss: 29.9252
Epoch 260/400
5/5 [==============================] - 0s 95ms/step - loss: 30.4647
Epoch 261/400
5/5 [==============================] - 0s 94ms/step - loss: 33.5094
Epoch 262/400
5/5 [==============================] - 0s 93ms/step - loss: 29.0954
Epoch 263/400
5/5 [==============================] - 0s 90ms/step - loss: 29.9179
Epoch 264/400
5/5 [==============================] - 0s 89ms/step - loss: 34.8166
Epoch 265/400
5/5 [==============================] - 0s 94ms/step - loss: 28.9550
Epoch 266/400
5/5 [==============================] - 0s 91ms/step - loss: 34.4305
Epoch 267/400
```

```
5/5 [==============================] - 0s 94ms/step - loss: 29.7936
Epoch 268/400
5/5 [==============================] - 0s 88ms/step - loss: 34.1162
Epoch 269/400
5/5 [==============================] - 0s 93ms/step - loss: 29.9728
Epoch 270/400
5/5 [==============================] - 0s 91ms/step - loss: 29.0897
Epoch 271/400
5/5 [==============================] - 0s 95ms/step - loss: 28.6937
Epoch 272/400
5/5 [==============================] - 0s 94ms/step - loss: 34.7373
Epoch 273/400
5/5 [==============================] - 0s 90ms/step - loss: 38.4067
Epoch 274/400
5/5 [==============================] - 0s 92ms/step - loss: 29.7118
Epoch 275/400
5/5 [==============================] - 0s 88ms/step - loss: 31.2556
Epoch 276/400
5/5 [==============================] - 0s 99ms/step - loss: 29.0910
Epoch 277/400
5/5 [==============================] - 0s 95ms/step - loss: 29.0354
Epoch 278/400
5/5 [==============================] - 1s 110ms/step - loss: 30.3669
Epoch 279/400
5/5 [==============================] - 1s 103ms/step - loss: 31.4214
Epoch 280/400
5/5 [==============================] - 0s 93ms/step - loss: 28.0702
Epoch 281/400
5/5 [==============================] - 0s 90ms/step - loss: 31.5449
Epoch 282/400
5/5 [==============================] - 0s 101ms/step - loss: 29.0499
Epoch 283/400
5/5 [==============================] - 0s 89ms/step - loss: 30.9817
Epoch 284/400
5/5 [==============================] - 0s 91ms/step - loss: 30.6194
Epoch 285/400
5/5 [==============================] - 0s 91ms/step - loss: 30.9830
Epoch 286/400
5/5 [==============================] - 0s 94ms/step - loss: 29.3054
Epoch 287/400
5/5 [==============================] - 0s 90ms/step - loss: 28.2902
Epoch 288/400
5/5 [==============================] - 0s 89ms/step - loss: 33.5070
Epoch 289/400
5/5 [==============================] - 0s 93ms/step - loss: 27.7818
Epoch 290/400
5/5 [==============================] - 0s 90ms/step - loss: 29.3471
Epoch 291/400
5/5 [==============================] - 0s 92ms/step - loss: 31.4478
Epoch 292/400
5/5 [==============================] - 0s 92ms/step - loss: 29.2388
Epoch 293/400
5/5 [==============================] - 0s 96ms/step - loss: 32.1847
Epoch 294/400
5/5 [==============================] - 0s 91ms/step - loss: 27.8618
Epoch 295/400
5/5 [==============================] - 0s 96ms/step - loss: 31.7707
Epoch 296/400
5/5 [==============================] - 0s 89ms/step - loss: 28.4133
Epoch 297/400
```

```
5/5 [==============================] - 0s 93ms/step - loss: 29.2211
Epoch 298/400
5/5 [==============================] - 0s 89ms/step - loss: 40.2477
Epoch 299/400
5/5 [==============================] - 0s 90ms/step - loss: 26.6431
Epoch 300/400
5/5 [==============================] - 0s 89ms/step - loss: 28.9451
Epoch 301/400
5/5 [==============================] - 0s 91ms/step - loss: 28.0244
Epoch 302/400
5/5 [==============================] - 0s 93ms/step - loss: 33.6505
Epoch 303/400
5/5 [==============================] - 0s 90ms/step - loss: 28.5378
Epoch 304/400
5/5 [==============================] - 0s 94ms/step - loss: 27.4646
Epoch 305/400
5/5 [==============================] - 0s 92ms/step - loss: 28.5594
Epoch 306/400
5/5 [==============================] - 0s 95ms/step - loss: 29.9742
Epoch 307/400
5/5 [==============================] - 0s 90ms/step - loss: 28.7383
Epoch 308/400
5/5 [==============================] - 1s 115ms/step - loss: 29.0422
Epoch 309/400
5/5 [==============================] - 1s 109ms/step - loss: 29.4058
Epoch 310/400
5/5 [==============================] - 0s 91ms/step - loss: 30.2996
Epoch 311/400
5/5 [==============================] - 0s 91ms/step - loss: 31.6558
Epoch 312/400
5/5 [==============================] - 0s 96ms/step - loss: 27.8480
Epoch 313/400
5/5 [==============================] - 0s 89ms/step - loss: 30.9411
Epoch 314/400
5/5 [==============================] - 0s 90ms/step - loss: 30.9818
Epoch 315/400
5/5 [==============================] - 0s 90ms/step - loss: 26.1658
Epoch 316/400
5/5 [==============================] - 0s 92ms/step - loss: 33.0852
Epoch 317/400
5/5 [==============================] - 0s 96ms/step - loss: 28.5440
Epoch 318/400
5/5 [==============================] - 0s 90ms/step - loss: 27.9880
Epoch 319/400
5/5 [==============================] - 0s 94ms/step - loss: 28.4291
Epoch 320/400
5/5 [==============================] - 0s 91ms/step - loss: 29.2600
Epoch 321/400
5/5 [==============================] - 0s 96ms/step - loss: 32.0384
Epoch 322/400
5/5 [==============================] - 0s 90ms/step - loss: 29.2012
Epoch 323/400
5/5 [==============================] - 0s 93ms/step - loss: 30.3056
Epoch 324/400
5/5 [==============================] - 0s 89ms/step - loss: 31.1104
Epoch 325/400
5/5 [==============================] - 0s 94ms/step - loss: 30.3363
Epoch 326/400
5/5 [==============================] - 0s 90ms/step - loss: 28.2985
Epoch 327/400
```

```
5/5 [==============================] - 1s 111ms/step - loss: 29.4033
Epoch 328/400
5/5 [==============================] - 1s 107ms/step - loss: 29.0021
Epoch 329/400
5/5 [==============================] - 0s 90ms/step - loss: 29.3166
Epoch 330/400
5/5 [==============================] - 0s 92ms/step - loss: 28.0798
Epoch 331/400
5/5 [==============================] - 1s 112ms/step - loss: 29.6688
Epoch 332/400
5/5 [==============================] - 1s 112ms/step - loss: 30.7563
Epoch 333/400
5/5 [==============================] - 1s 115ms/step - loss: 28.1180
Epoch 334/400
5/5 [==============================] - 1s 107ms/step - loss: 26.4854
Epoch 335/400
5/5 [==============================] - 0s 89ms/step - loss: 29.4150
Epoch 336/400
5/5 [==============================] - 0s 92ms/step - loss: 29.1634
Epoch 337/400
5/5 [==============================] - 1s 110ms/step - loss: 26.7887
Epoch 338/400
5/5 [==============================] - 1s 101ms/step - loss: 27.1755
Epoch 339/400
5/5 [==============================] - 0s 93ms/step - loss: 32.7611
Epoch 340/400
5/5 [==============================] - 0s 93ms/step - loss: 26.9705
Epoch 341/400
5/5 [==============================] - 1s 112ms/step - loss: 26.4673
Epoch 342/400
5/5 [==============================] - 1s 107ms/step - loss: 29.8450
Epoch 343/400
5/5 [==============================] - 1s 116ms/step - loss: 28.9855
Epoch 344/400
5/5 [==============================] - 1s 107ms/step - loss: 30.1973
Epoch 345/400
5/5 [==============================] - 0s 99ms/step - loss: 27.6834
Epoch 346/400
5/5 [==============================] - 1s 102ms/step - loss: 25.9774
Epoch 347/400
5/5 [==============================] - 1s 114ms/step - loss: 26.6153
Epoch 348/400
5/5 [==============================] - 1s 97ms/step - loss: 27.1428
Epoch 349/400
5/5 [==============================] - 0s 94ms/step - loss: 25.6796
Epoch 350/400
5/5 [==============================] - 0s 89ms/step - loss: 26.5383
Epoch 351/400
5/5 [==============================] - 0s 91ms/step - loss: 30.6860
Epoch 352/400
5/5 [==============================] - 0s 88ms/step - loss: 29.3971
Epoch 353/400
5/5 [==============================] - 0s 93ms/step - loss: 26.3372
Epoch 354/400
5/5 [==============================] - 0s 92ms/step - loss: 25.2605
Epoch 355/400
5/5 [==============================] - 0s 92ms/step - loss: 28.2048
Epoch 356/400
5/5 [==============================] - 1s 119ms/step - loss: 25.6138
Epoch 357/400
```

```
5/5 [==============================] - 1s 104ms/step - loss: 29.2636
Epoch 358/400
5/5 [==============================] - 0s 94ms/step - loss: 27.5974
Epoch 359/400
5/5 [==============================] - 0s 92ms/step - loss: 33.1331
Epoch 360/400
5/5 [==============================] - 0s 95ms/step - loss: 25.8812
Epoch 361/400
5/5 [==============================] - 1s 112ms/step - loss: 27.0254
Epoch 362/400
5/5 [==============================] - 1s 113ms/step - loss: 30.4760
Epoch 363/400
5/5 [==============================] - 0s 92ms/step - loss: 26.4585
Epoch 364/400
5/5 [==============================] - 0s 92ms/step - loss: 29.6900
Epoch 365/400
5/5 [==============================] - 0s 89ms/step - loss: 27.3183
Epoch 366/400
5/5 [==============================] - 0s 94ms/step - loss: 28.6072
Epoch 367/400
5/5 [==============================] - 0s 91ms/step - loss: 25.8676
Epoch 368/400
5/5 [==============================] - 0s 95ms/step - loss: 24.7931
Epoch 369/400
5/5 [==============================] - 0s 90ms/step - loss: 29.8044
Epoch 370/400
5/5 [==============================] - 0s 94ms/step - loss: 28.5396
Epoch 371/400
5/5 [==============================] - 1s 101ms/step - loss: 26.8100
Epoch 372/400
5/5 [==============================] - 1s 118ms/step - loss: 26.1516
Epoch 373/400
5/5 [==============================] - 1s 97ms/step - loss: 27.1780
Epoch 374/400
5/5 [==============================] - 0s 91ms/step - loss: 26.2559
Epoch 375/400
5/5 [==============================] - 0s 89ms/step - loss: 28.1593
Epoch 376/400
5/5 [==============================] - 0s 91ms/step - loss: 26.1271
Epoch 377/400
5/5 [==============================] - 0s 95ms/step - loss: 24.3240
Epoch 378/400
5/5 [==============================] - 0s 91ms/step - loss: 29.0050
Epoch 379/400
5/5 [==============================] - 0s 92ms/step - loss: 27.7745
Epoch 380/400
5/5 [==============================] - 0s 89ms/step - loss: 27.0237
Epoch 381/400
5/5 [==============================] - 0s 96ms/step - loss: 30.5515
Epoch 382/400
5/5 [==============================] - 0s 90ms/step - loss: 26.6543
Epoch 383/400
5/5 [==============================] - 0s 93ms/step - loss: 24.7731
Epoch 384/400
5/5 [==============================] - 0s 91ms/step - loss: 27.5044
Epoch 385/400
5/5 [==============================] - 0s 93ms/step - loss: 24.4686
Epoch 386/400
5/5 [==============================] - 0s 97ms/step - loss: 28.2783
Epoch 387/400
```

```
5/5 [==============================] - 0s 94ms/step - loss: 26.7304
Epoch 388/400
5/5 [==============================] - 0s 95ms/step - loss: 25.6852
Epoch 389/400
5/5 [==============================] - 0s 89ms/step - loss: 24.5094
Epoch 390/400
5/5 [==============================] - 0s 94ms/step - loss: 31.3289
Epoch 391/400
5/5 [==============================] - 0s 94ms/step - loss: 26.4735
Epoch 392/400
5/5 [==============================] - 0s 92ms/step - loss: 25.1955
Epoch 393/400
5/5 [==============================] - 0s 91ms/step - loss: 23.2848
Epoch 394/400
5/5 [==============================] - 0s 94ms/step - loss: 28.9048
Epoch 395/400
5/5 [==============================] - 0s 91ms/step - loss: 27.9957
Epoch 396/400
5/5 [==============================] - 0s 89ms/step - loss: 25.0434
Epoch 397/400
5/5 [==============================] - 0s 92ms/step - loss: 23.5724
Epoch 398/400
5/5 [==============================] - 0s 91ms/step - loss: 26.0772
Epoch 399/400
5/5 [==============================] - 0s 94ms/step - loss: 25.0606
Epoch 400/400
5/5 [==============================] - 0s 89ms/step - loss: 28.4389
testing MSE:  17.00090219275806
MSE of baseline model:  21.05596723741936
Comparison of model prediction and baseline prediction:
```
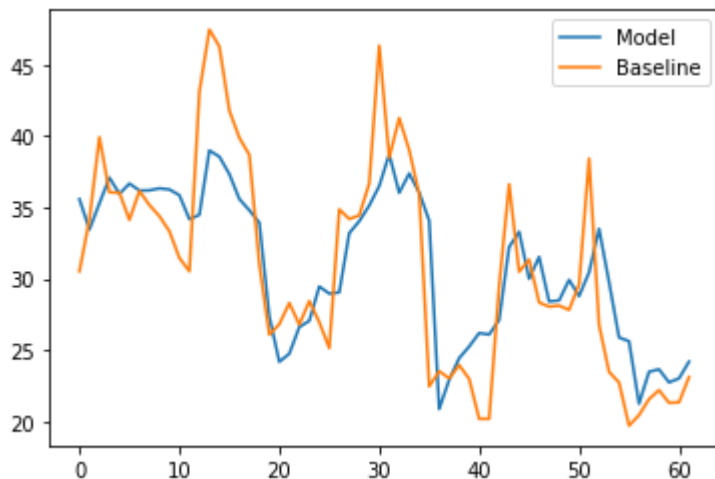


```
Day-to-day out-of-sample accuracy:  0.6065573770491803
Five-day out-of-sample accuracy:  0.7894736842105263
Day-to-day out-of-sample accuracy of baseline:  0.4918032786885246
Five-day out-of-sample accuracy of baseline:  0.7894736842105263
```

In [ ]:
```python
LSTM_3_plot = model_plot(LSTM_3.data_y_test, LSTM_3.y_pred)
baseline_plot = model_plot(LSTM_3.dataset[LSTM_3.train_sample_num + 1:, -1],
                           LSTM_3.dataset[LSTM_3.train_sample_num:-1, -1])
print(" True VS Pred plot of LSTM Model with 3 layers")
LSTM_3_plot.true_pred_plot()
print(" True VS Pred plot of Baseline Model")
baseline_plot.true_pred_plot()
print(" Residual plot of LSTM Model with 3 layers")
LSTM_3_plot.residual_plot()
```
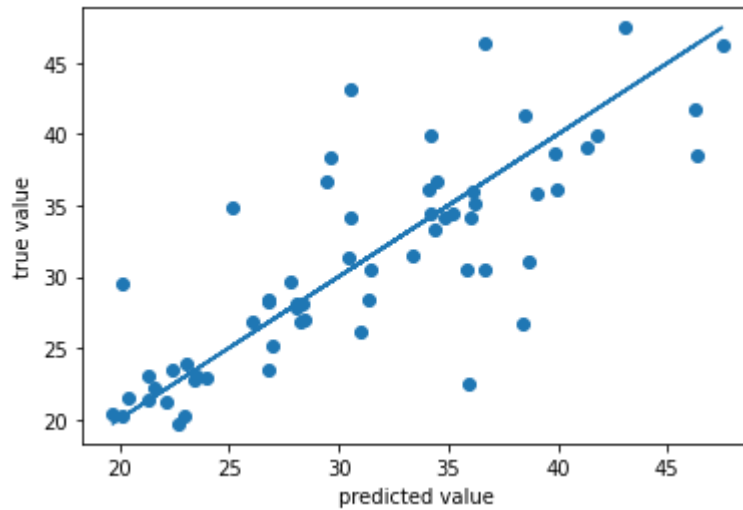
```
print(" Residual plot of Baseline Model")
baseline_plot.residual_plot()
print(" Trend plot of LSTM Model with 3 layers")
LSTM_3_plot.trend_plot()
print(" Trend plot of Baseline Model")
baseline_plot.trend_plot()
```
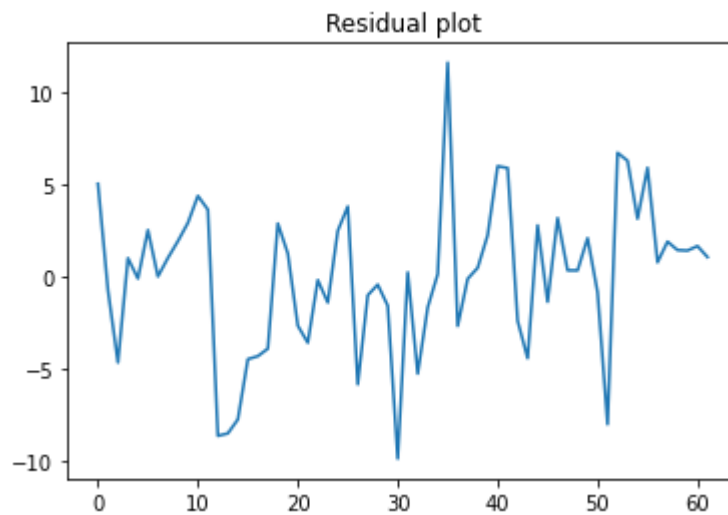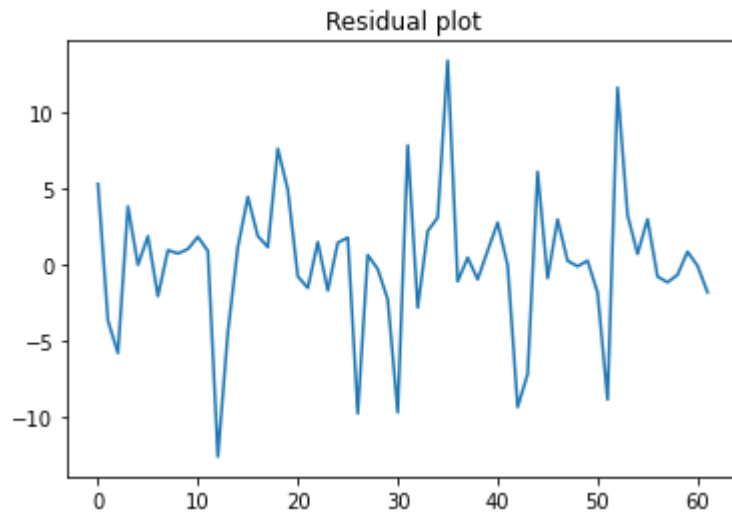
True VS Pred plot of LSTM Model with 3 layers
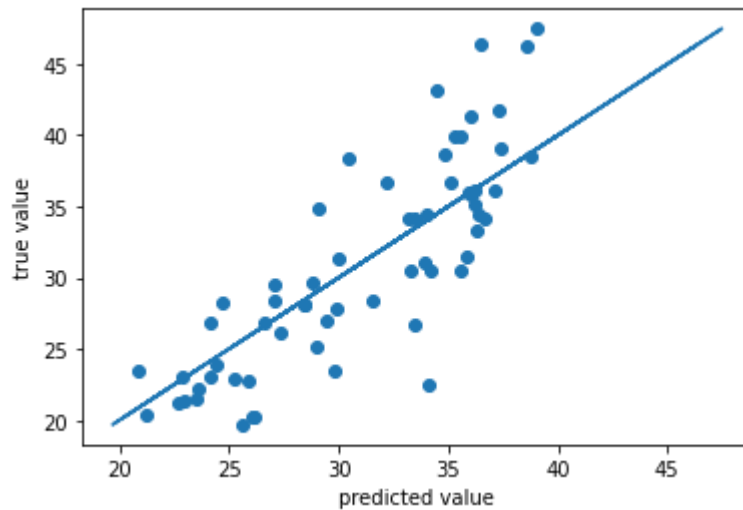
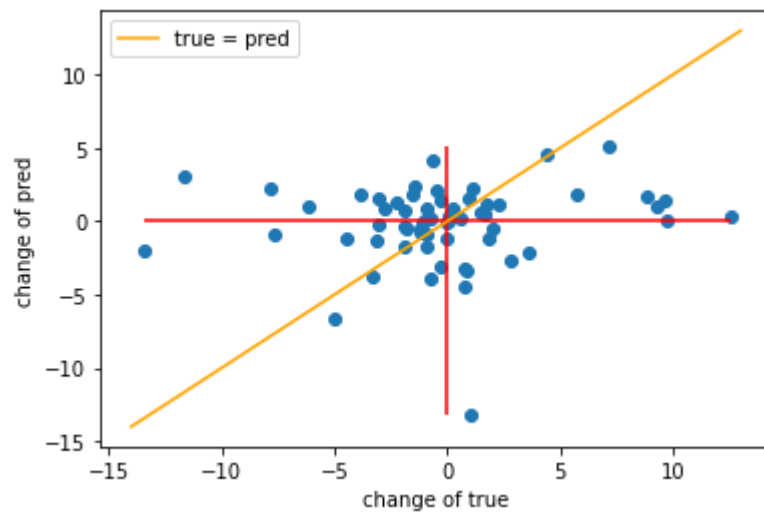True VS Pred plot of Baseline Model
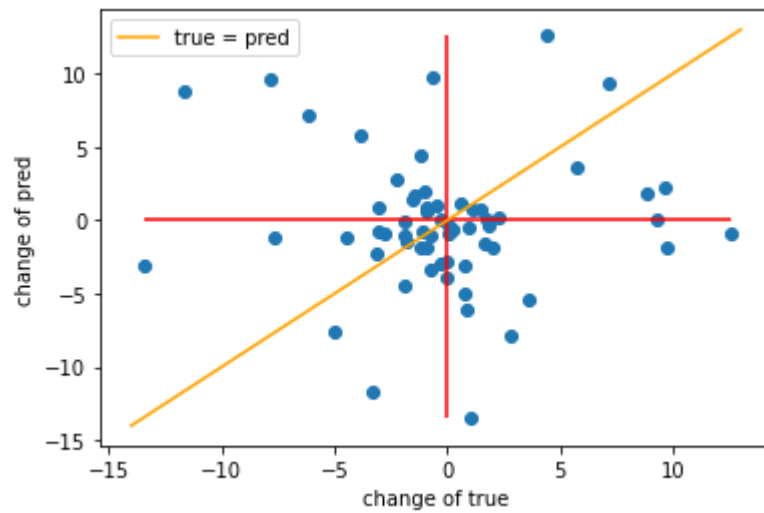

Residual plot of LSTM Model with 3 layers

Residual plot of Baseline Model

Residual plot

Trend plot of LSTM Model with 3 layers

Trend plot of Baseline Model

In [ ]: