In [2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from datetime import date
from scipy import stats

%matplotlib inline
```

In [3]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [3]:
```
!pip install arch
```

```
Requirement already satisfied: arch in /Users/charan/anaconda3/lib/python3.1
1/site-packages (7.0.0)
Requirement already satisfied: numpy>=1.22.3 in /Users/charan/anaconda3/lib/
python3.11/site-packages (from arch) (1.26.4)
Requirement already satisfied: scipy>=1.8 in /Users/charan/anaconda3/lib/pyt
hon3.11/site-packages (from arch) (1.11.4)
Requirement already satisfied: pandas>=1.4 in /Users/charan/anaconda3/lib/py
thon3.11/site-packages (from arch) (2.0.3)
Requirement already satisfied: statsmodels>=0.12 in /Users/charan/anaconda3/
lib/python3.11/site-packages (from arch) (0.14.0)
Requirement already satisfied: python-dateutil>=2.8.2 in /Users/charan/anaco
nda3/lib/python3.11/site-packages (from pandas>=1.4->arch) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /Users/charan/anaconda3/lib/p
ython3.11/site-packages (from pandas>=1.4->arch) (2023.3.post1)
Requirement already satisfied: tzdata>=2022.1 in /Users/charan/anaconda3/li
b/python3.11/site-packages (from pandas>=1.4->arch) (2023.3)
Requirement already satisfied: patsy>=0.5.2 in /Users/charan/anaconda3/lib/p
ython3.11/site-packages (from statsmodels>=0.12->arch) (0.5.3)
Requirement already satisfied: packaging>=21.3 in /Users/charan/anaconda3/li
b/python3.11/site-packages (from statsmodels>=0.12->arch) (23.1)
Requirement already satisfied: six in /Users/charan/anaconda3/lib/python3.1
1/site-packages (from patsy>=0.5.2->statsmodels>=0.12->arch) (1.16.0)
```

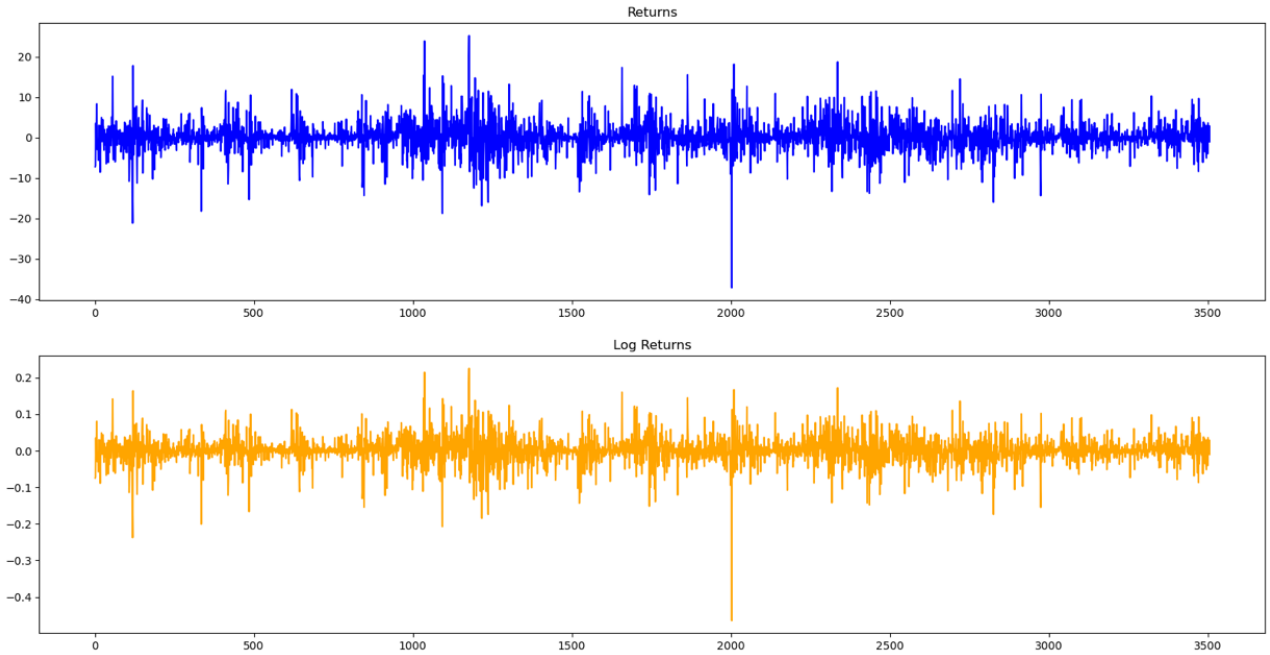
In [4]:
```
from datetime import datetime, timedelta
from sklearn.metrics import mean_squared_error as mse, r2_score
```

In [5]:
```
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime


start = datetime(2019, 1, 1)
end = datetime.today()

tckr = 'BTC-USD'
ticker_historical = pd.read_csv('~/Desktop/untitled folder/abc.csv')


plt.figure(figsize=(15,7))
plt.plot(ticker_historical['Close'])
plt.title('Historical Close Prices')
plt.xlabel('Date')
plt.ylabel('Close Price')
plt.grid(True)
plt.show()
```

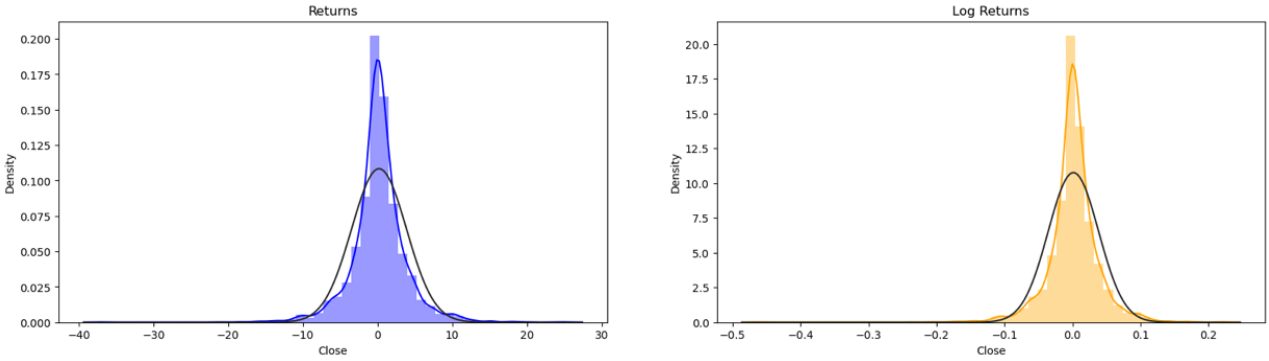
In [6]:
```
returns = 100 * ticker_historical.Close.pct_change().dropna()
```

In [7]:
```
# CALCULATE LOG RETURNS BASED ON ABOVE FORMULA
log_returns = np.log(ticker_historical.Close/ticker_historical.Close.shift(1
```

In [8]:
```
# VISUALIZE RETURNS VS. LOG RETURNS
fig, (ax1, ax2) = plt.subplots(nrows=2, ncols=1, figsize=(20,10))

ax1.plot(returns, color='blue')
ax1.set_title('Returns')

ax2.plot(log_returns, color='orange')
ax2.set_title('Log Returns')

fig.show();
```



In [9]:
```
# PLOT DISTRIBUTION PLOTS OF RETURNS & LOG RETURNS
# AND VISUALLY COMPARE THEM WITH THE STANDARD NORMAL DISTRIBUTION
fig, (ax1, ax2) = plt.subplots(nrows=1, ncols=2, figsize=(20,5))
sns.distplot(returns, norm_hist=True, fit=stats.norm, color='blue',
             bins=50, ax=ax1)
ax1.set_title('Returns')

sns.distplot(log_returns, norm_hist=True, fit=stats.norm, color='orange',
             bins=50, ax=ax2)
ax2.set_title('Log Returns')

fig.show();
```



In [10]:
```
returns.describe()
```

Out[10]:
```
count    3506.000000
mean        0.210328
std         3.681248
min       -37.169539
25%        -1.241155
50%         0.142533
75%         1.728504
max        25.247169
Name: Close, dtype: float64
```

In [11]:
```
log_returns.describe()
```

Out[11]:
```
count    3506.000000
mean        0.001419
std         0.037092
min        -0.464730
25%        -0.012489
50%         0.001424
75%         0.017137
max         0.225119
Name: Close, dtype: float64
```

In [12]:
```
# CREATE A FUNCTION THAT CALCULATE REALIZED VOLATILITY
def realized_volatility(series_log_return):
    """
    Get realized volatility which is calculated as the square root
    of sum of squares of log returns
    """
    return np.sqrt(np.sum(series_log_return**2))
```

In [13]:
```
log_returns.apply(realized_volatility)
```

Out[13]:
```
1       0.074643
2       0.072402
3       0.035111
4       0.024968
5       0.008317
          ...
3502    0.005195
3503    0.017866
3504    0.001044
3505    0.029009
3506    0.009884
Name: Close, Length: 3506, dtype: float64
```

In [14]:
```
from statsmodels.tsa.stattools import adfuller
```

In [15]:
```
adfuller_results = adfuller(log_returns)

print(f'ADF Statistic: {adfuller_results[0]}')
print(f'p-value: {adfuller_results[1]}')
print('Critical Values:')
for key, value in adfuller_results[4].items():
    print(f'{key}: {value:.4f}')
```

```
ADF Statistic: -17.990347259957403
p-value: 2.755696044243832e-30
Critical Values:
1%: -3.4322
5%: -2.8624
10%: -2.5672
```

In [16]:
```
ticker_historical.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3507 entries, 0 to 3506
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Date          3507 non-null   object
 1   Open          3507 non-null   float64
 2   High          3507 non-null   float64
 3   Low           3507 non-null   float64
 4   Close         3507 non-null   float64
 5   Volume        3507 non-null   int64
 6   Dividends     3507 non-null   float64
 7   Stock Splits  3507 non-null   float64
dtypes: float64(6), int64(1), object(1)
memory usage: 219.3+ KB
```

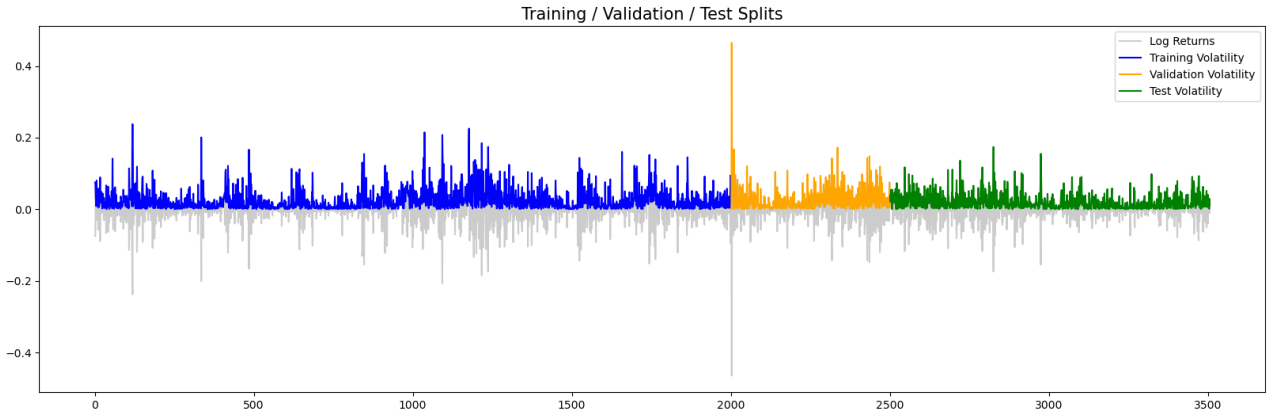
In [17]:
```
split_time_1 = 2000
split_time_2 = 2500

train_idx = log_returns.index[:split_time_1]
val_idx = log_returns.index[split_time_1:split_time_2]
test_idx = log_returns.index[split_time_2:]
```

In [18]:
```
ts_train = log_returns[train_idx]
ts_val = log_returns[val_idx]
ts_test = log_returns[test_idx]
```

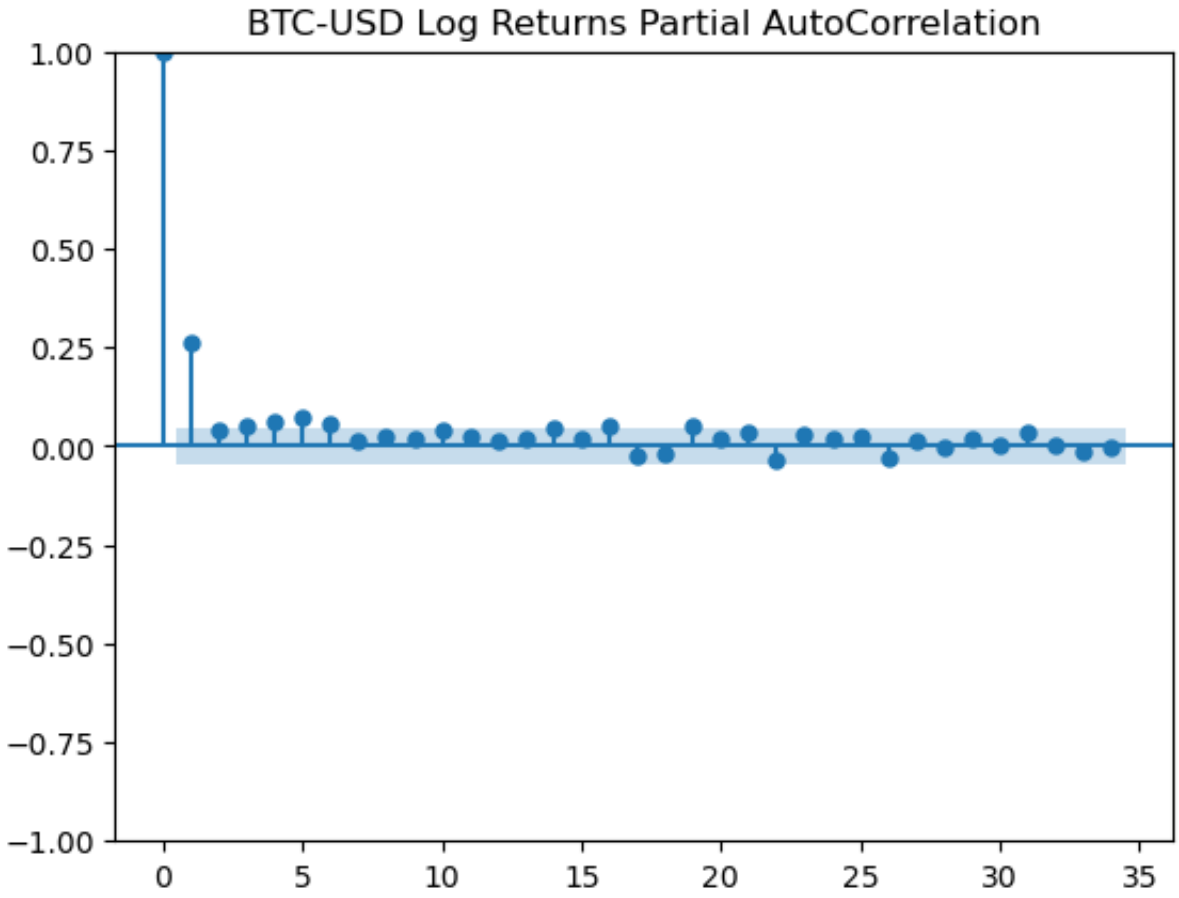
In [19]:
```
# GET VOLATILITY SERIES vols
vols = log_returns.apply(realized_volatility)

# SPLIT vols INTO 3 PARTS
vol_train = vols[train_idx]
vol_val = vols[val_idx]
vol_test = vols[test_idx]
```

In [20]:
```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
```

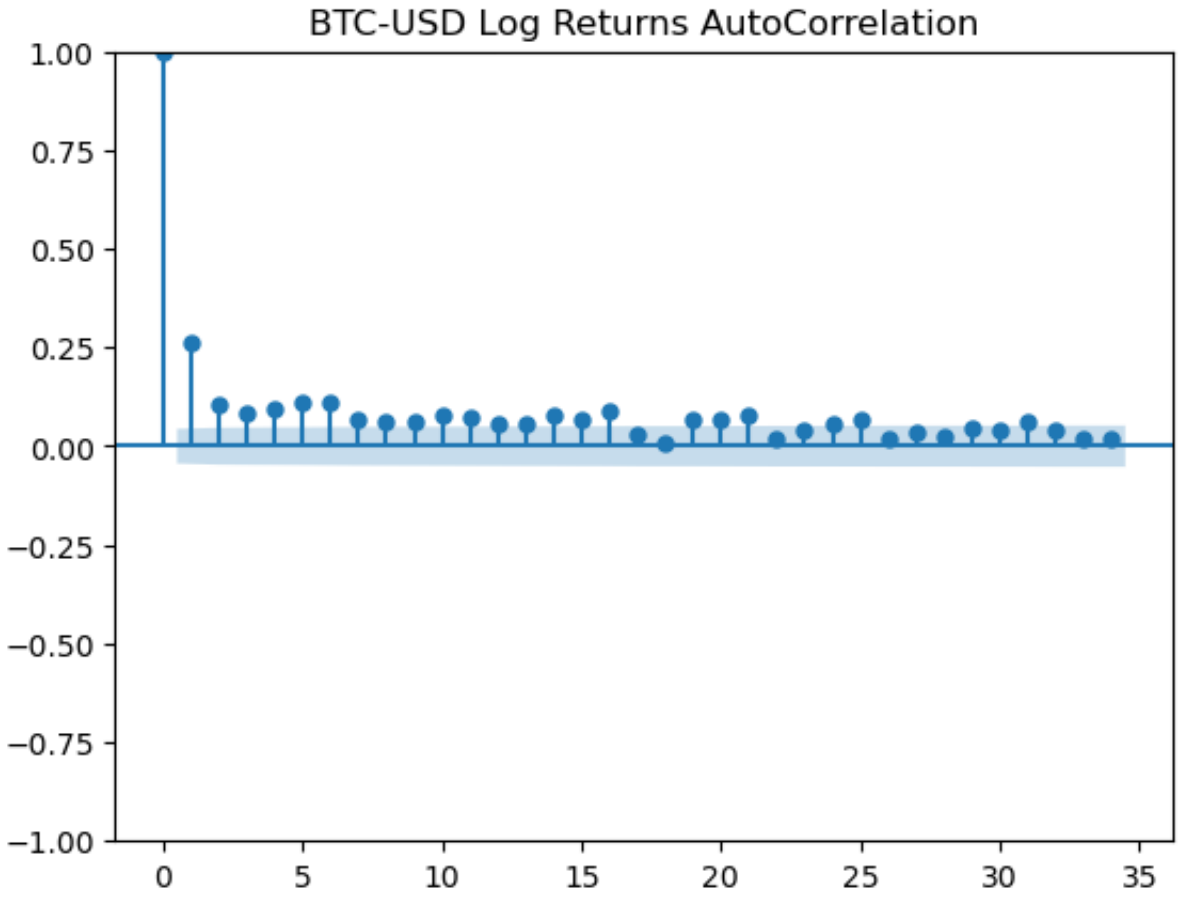
In [21]:
```
plt.figure(figsize=(20,6))

plt.plot(log_returns, color='gray', label='Log Returns', alpha=0.4)

plt.plot(vol_train, color='blue', label='Training Volatility')
plt.plot(vol_val, color='orange', label='Validation Volatility')
plt.plot(vol_test, color='green', label='Test Volatility')

plt.plot()
plt.title('Training / Validation / Test Splits', fontsize=15)
plt.legend()
plt.show();
```



In [22]:
```
plot_pacf(ts_train**2,title=f'{tckr.upper()} Log Returns Partial AutoCorrela
```



In [23]:
```
plot_acf(ts_train**2,
         title=f'{tckr.upper()} Log Returns AutoCorrelation');
```

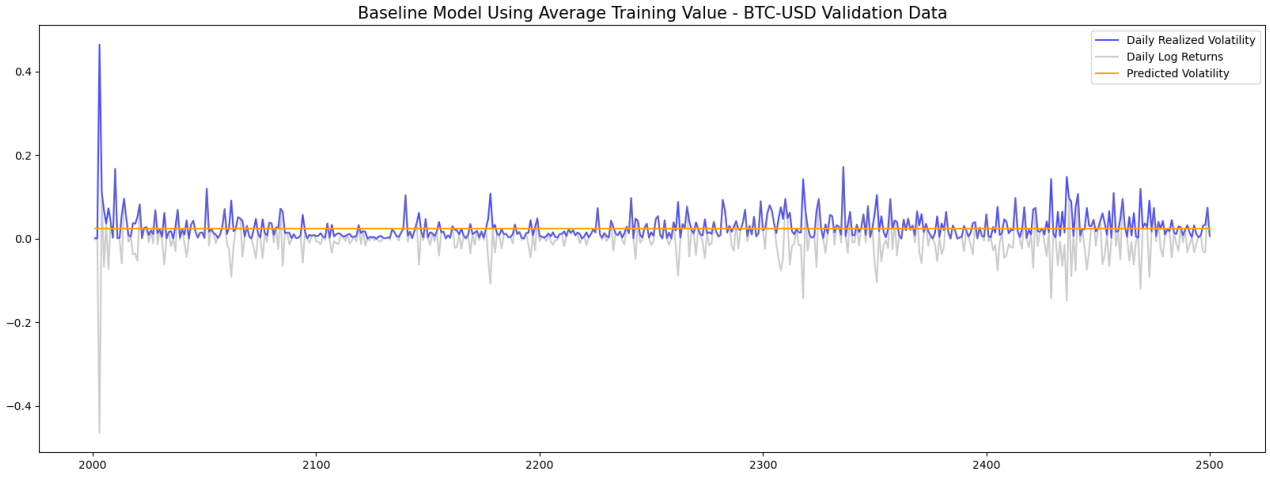


In [24]:
```
# CALCULATE THE MEAN OF TRAINING DATA
mean_train_vol = vol_train.mean()
mean_train_vol
```

Out[24]:
```
0.025001130673677638
```

In [25]:
```
# CREATE SERIES OF PREDICTIONS FOR BASELINE MODEL ON VALIDATION SET
baseline_preds = np.ones(len(ts_val)) * mean_train_vol
baseline_preds = pd.Series(baseline_preds, index=ts_val.index)
```

In [26]:
```
plt.figure(figsize=(20,7))
plt.plot(vol_val, color='blue', label='Daily Realized Volatility', alpha=0.7
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')
plt.plot(baseline_preds, color='orange', label='Predicted Volatility')

plt.title(f'Baseline Model Using Average Training Value - {tckr} Validation
plt.legend();
```



In [27]:
```
def RMSE(y_true, y_pred):
    """
    Compute Root Mean Squared Error between 2 arrays
    """
    output = np.sqrt(mse(y_true, y_pred))
    return output
```

In [28]:
```
def RMSPE(y_true, y_pred):
    """
    Compute Root Mean Squared Percentage Error between 2 arrays
    """
    output = np.sqrt(np.mean(np.square((y_true - y_pred) / y_true)))
    return output
```

In [29]:
```
RMSE(vol_val, baseline_preds)
```

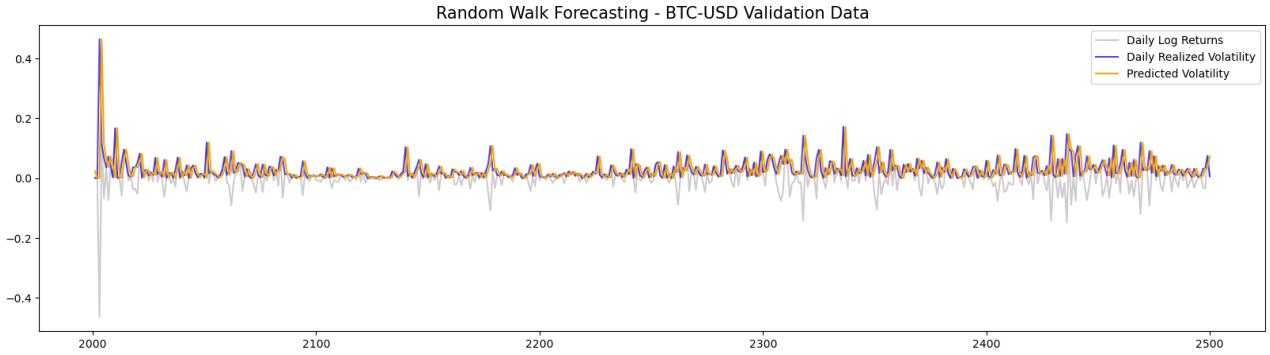
Out[29]:
```
0.0344730298329825
```

In [30]:
```
RMSPE(vol_val, baseline_preds)
```

Out[30]:
```
65.60196881235626
```

In [31]:
```
random_walk_preds = vols.shift(1).dropna()[val_idx]
```

In [32]:
```
plt.figure(figsize=(20,5))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')
plt.plot(vol_val, color='blue', alpha=0.7,
         label='Daily Realized Volatility')
plt.plot(random_walk_preds, color='orange', label='Predicted Volatility')

plt.title(f'Random Walk Forecasting - {tckr} Validation Data', fontsize=15)
plt.legend();
```



In [33]:
```
RMSE(vol_val, random_walk_preds)
```

Out[33]:
```
0.04665309806928882
```

In [34]:
```
RMSPE(vol_val, random_walk_preds)
```

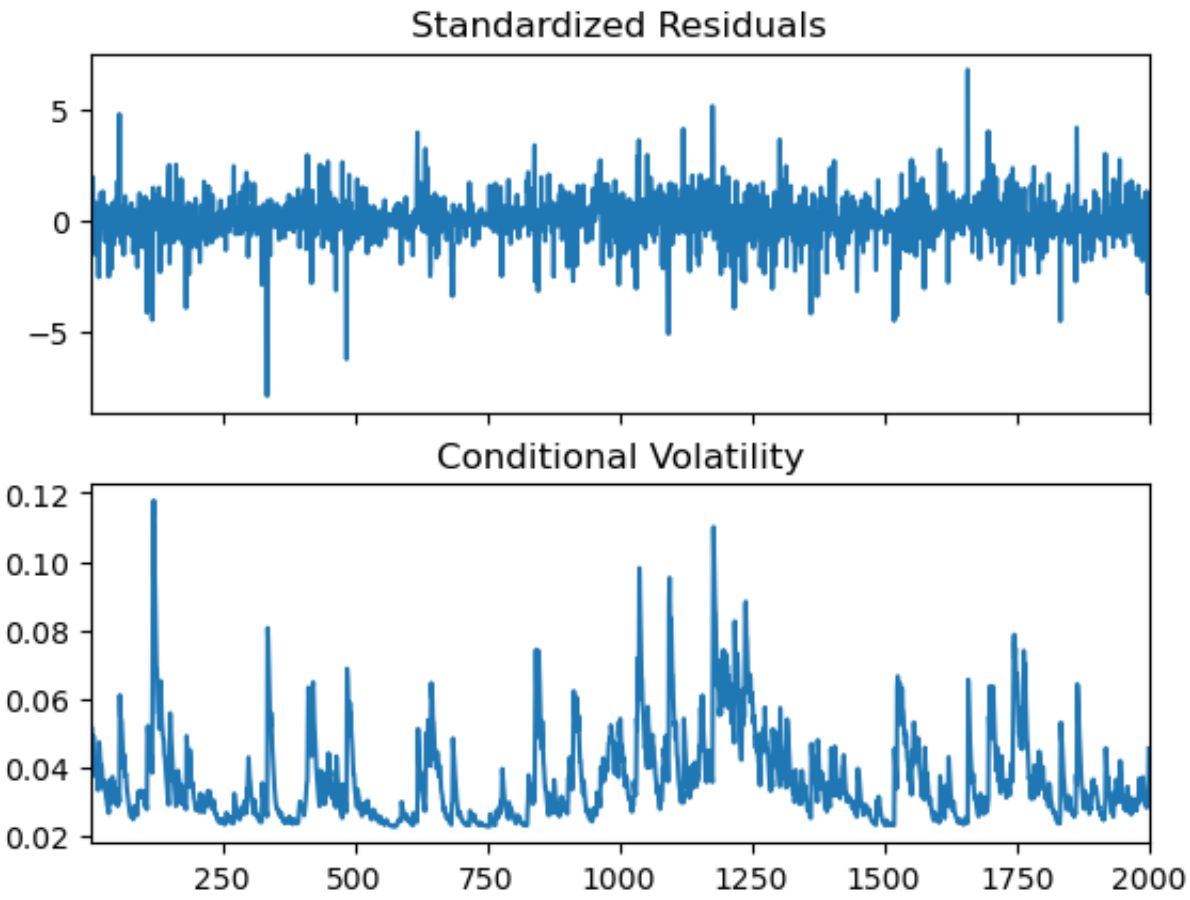
Out[34]:
```
48.95728383668088
```

In [35]:
```
from arch import arch_model
```

In [36]:
```
gm_1 = arch_model(ts_train, vol='GARCH', p=1, q=1,
                  mean='Zero', dist='normal')
result_1 = gm_1.fit(disp='off')
print()
print(result_1.summary())
```

```
                        Zero Mean - GARCH Model Results
==============================================================================
==
Dep. Variable:                  Close   R-squared:                       0.0
00
Mean Model:                 Zero Mean   Adj. R-squared:                  0.0
00
Vol Model:                      GARCH   Log-Likelihood:                3898.
52
Distribution:                  Normal   AIC:                           -7791.
04
Method:            Maximum Likelihood   BIC:                           -7774.
23
                                        No. Observations:                20
00
Date:                Thu, Apr 25 2024   Df Residuals:                    20
00
Time:                        10:00:33   Df Model:
0
                             Volatility Model
==============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
------------------------------------------------------------------------------
omega      1.0831e-04  4.786e-05      2.263  2.363e-02 [1.451e-05,2.021e-04]
alpha[1]       0.1459  2.613e-02      5.582  2.377e-08   [9.466e-02,  0.197]
beta[1]        0.7810  4.880e-02     16.005  1.170e-57     [  0.685,  0.877]
==============================================================================

Covariance estimator: robust
```

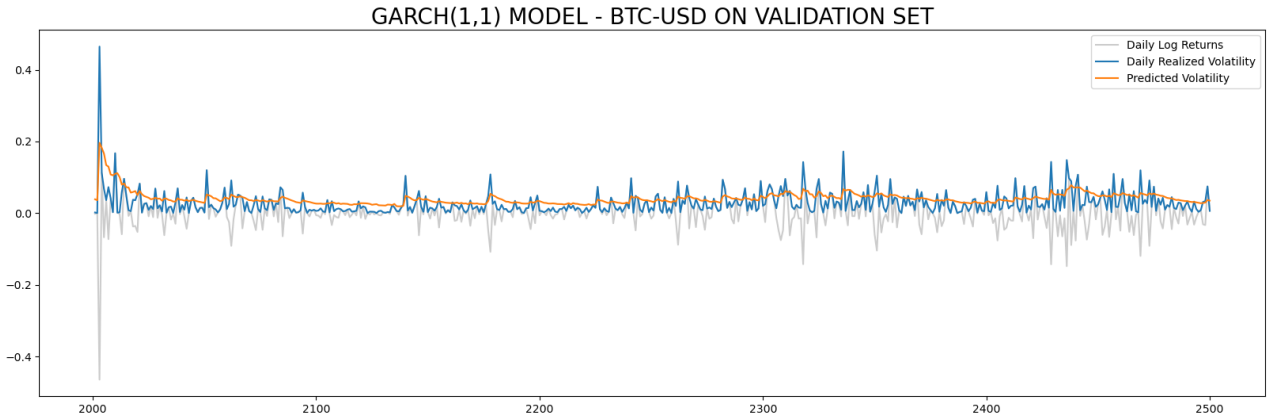
In [37]:
```
result_1.plot()
plt.show();
```



In [38]:
```
# ROLLING FORECAST
# INITIALIZING rolling_forecasts VALUES LIST
rolling_forecasts = []

# ITERATE OVER EACH TIME STEP IN THE VALIDATION SET
for i in range(len(ts_val)):
    # GET THE DATA AT ALL PREVIOUS TIME STEPS
    idx = val_idx[i]
    train = log_returns[:idx]

    # TRAIN MODEL USING ALL PREVIOUS TIME STEPS' DATA
    model = arch_model(train, vol='GARCH', p=1, q=1,
                       mean='Zero', dist='normal')
    model_fit = model.fit(disp='off')

    # MAKE PREDICTION
    pred = (model_fit.forecast(horizon=1, reindex=False).variance.values[0][

    # APPEND TO rolling_forecasts LIST
    rolling_forecasts.append(pred)
```

In [39]:
```
rolling_predictions_1 = pd.Series(rolling_forecasts, index=ts_val.index)
```

In [40]:
```
plt.figure(figsize=(20,6))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')

plt.plot(vol_val, label='Daily Realized Volatility')
plt.plot(rolling_predictions_1, label='Predicted Volatility')

plt.title(f'GARCH(1,1) MODEL - {tckr} ON VALIDATION SET', fontsize=20)
plt.legend();
```



In [41]:
```
RMSE(vol_val, rolling_predictions_1)
```

Out[41]:
```
0.030734388440059997
```

In [42]:
```
RMSPE(vol_val, rolling_predictions_1)
```

Out[42]:
```
80.77265611077499
```

In [43]:
```
gjr_gm = arch_model(ts_train, p=1, q=1, o=1,
                    mean='Zero', vol='GARCH')
```

In [44]:
```
result_2 = gjr_gm.fit(disp='off')
print()
print(result_2.summary())
```

Zero Mean - GJR-GARCH Model Results

Dep. Variable:	Close	R-squared:	0.000
Mean Model:	Zero Mean	Adj. R-squared:	0.000
Vol Model:	GJR-GARCH	Log-Likelihood:	3889.02
Distribution:	Normal	AIC:	-7770.03
Method:	Maximum Likelihood	BIC:	-7747.63
		No. Observations:	2000
Date:	Thu, Apr 25 2024	Df Residuals:	2000
Time:	10:00:58	Df Model:	0

Volatility Model

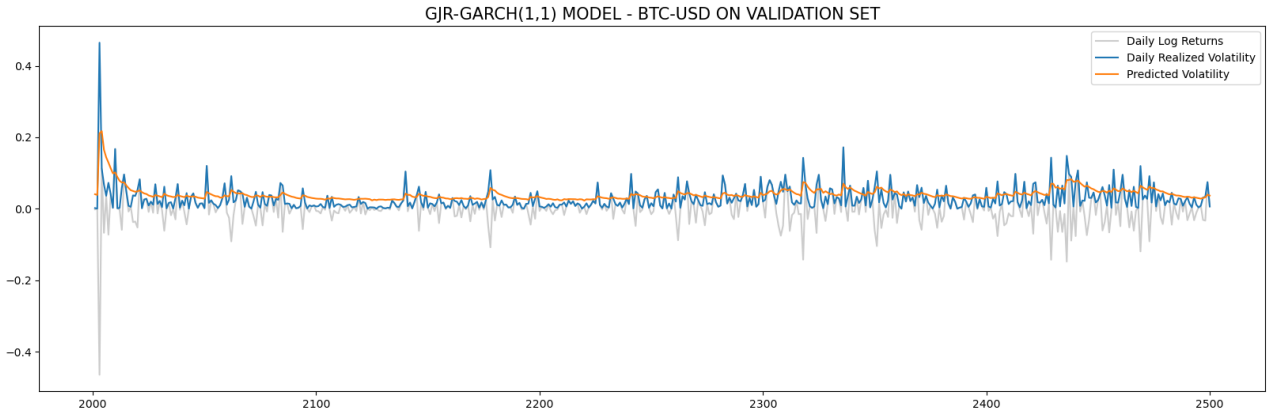
	coef	std err	t	P>|t|	95.0% Conf. Int.
omega	1.4674e-04	1.572e-04	0.933	0.351	[-1.615e-04,4.549e-04]
alpha[1]	0.1000	2.198e-02	4.550	5.365e-06	[5.692e-02, 0.143]
gamma[1]	0.1000	0.131	0.761	0.447	[-0.158, 0.358]
beta[1]	0.7500	0.159	4.728	2.269e-06	[0.439, 1.061]

Covariance estimator: robust

In [45]:
```
# ROLLING FORECAST
# INITIALIZING rolling_forecasts VALUES LIST
rolling_forecasts = []

# ITERATE OVER EACH TIME STEP IN THE VALIDATION SET
for i in range(len(ts_val)):
    # GET THE DATA AT ALL PREVIOUS TIME STEPS
    idx = val_idx[i]
    train = log_returns[:idx]

    # TRAIN MODEL USING ALL PREVIOUS TIME STEPS' DATA
    model = arch_model(train, p=1, q=1, o=1,
                       mean='Zero', vol='GARCH')
    model_fit = model.fit(disp='off')

    # MAKE PREDICTION
    pred = (model_fit.forecast(horizon=1, reindex=False).variance.values[0][
    # APPEND TO rolling_forecasts LIST
    rolling_forecasts.append(pred)
```

In [46]:
```
rolling_predictions_2 = pd.Series(rolling_forecasts, index=ts_val.index)
```

In [47]:
```
plt.figure(figsize=(20,6))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')

plt.plot(vol_val, label='Daily Realized Volatility')
plt.plot(rolling_predictions_2, label='Predicted Volatility')

plt.title(f'GJR-GARCH(1,1) MODEL - {tckr} ON VALIDATION SET', fontsize=15)
plt.legend();
```



In [48]:
```
RMSPE(vol_val, rolling_predictions_2)
```

Out[48]:
```
80.12139811392387
```

In [49]:
```
RMSE(vol_val, rolling_predictions_2)
```

Out[49]: 0.03001151720799619

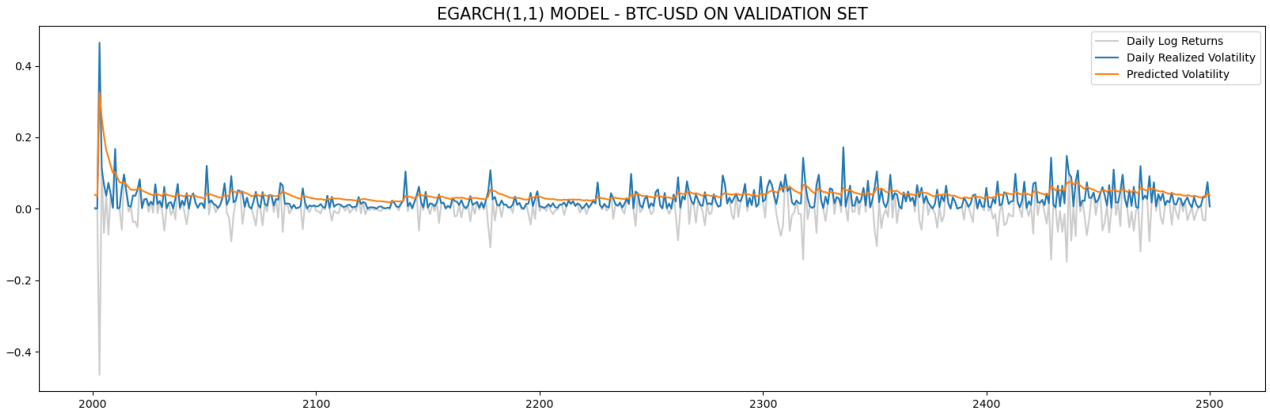
In [50]:
```
e_gm = arch_model(ts_train, p=1, q=1, o=1,
                  mean='Zero', vol='EGARCH')
result_3 = e_gm.fit(disp='off')
print()
print(result_3.summary())
```

```
                      Zero Mean - EGARCH Model Results
==============================================================================
==
Dep. Variable:                  Close   R-squared:                       0.0
00
Mean Model:                 Zero Mean   Adj. R-squared:                  0.0
00
Vol Model:                     EGARCH   Log-Likelihood:                3913.
05
Distribution:                  Normal   AIC:                           -7818.
10
Method:            Maximum Likelihood   BIC:                           -7795.
69
                                        No. Observations:                 20
00
Date:                Thu, Apr 25 2024   Df Residuals:                     20
00
Time:                        10:01:16   Df Model:
0
                            Volatility Model
==============================================================================
=
                 coef    std err          t      P>|t|       95.0% Conf. In
t.
------------------------------------------------------------------------------
-
omega         -0.4853      0.144     -3.361  7.775e-04      [ -0.768, -0.20
2]
alpha[1]       0.2789  4.416e-02      6.316  2.679e-10      [  0.192,  0.36
5]
gamma[1]      -0.0221  2.624e-02     -0.842      0.400 [-7.353e-02,2.935e-0
2]
beta[1]        0.9227  2.237e-02     41.251      0.000      [  0.879,  0.96
7]
==============================================================================
=

Covariance estimator: robust
```

In [51]:
```
# EXPANDING WINDOW FORECAST
# INITIALIZING rolling_forecasts VALUES LIST
rolling_forecasts = []

# ITERATE OVER EACH TIME STEP IN THE VALIDATION SET
for i in range(len(ts_val)):
    # GET THE DATA AT ALL PREVIOUS TIME STEPS
    idx = val_idx[i]
    train = log_returns[:idx]

    # TRAIN MODEL USING ALL PREVIOUS TIME STEPS' DATA
    model = arch_model(train, p=1, q=1, o=1,
                       mean='Zero', vol='EGARCH')
    model_fit = model.fit(disp='off')

    # MAKE PREDICTION
    pred = (model_fit.forecast(horizon=1, reindex=False).variance.values[0][
    # APPEND TO rolling_forecasts LIST
    rolling_forecasts.append(pred)
```

In [52]:
```
rolling_predictions_3 = pd.Series(rolling_forecasts, index=ts_val.index)
```

In [53]:
```
plt.figure(figsize=(20,6))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')

plt.plot(vol_val, label='Daily Realized Volatility')
plt.plot(rolling_predictions_3, label='Predicted Volatility')

plt.title(f'EGARCH(1,1) MODEL - {tckr} ON VALIDATION SET', fontsize=15)
plt.legend();
```



In [54]:
```
RMSPE(vol_val, rolling_predictions_3)
```

Out[54]:
```
81.77383780712229
```

In [55]:
```
RMSE(vol_val, rolling_predictions_3)
```

Out[55]: 0.029717514642188726

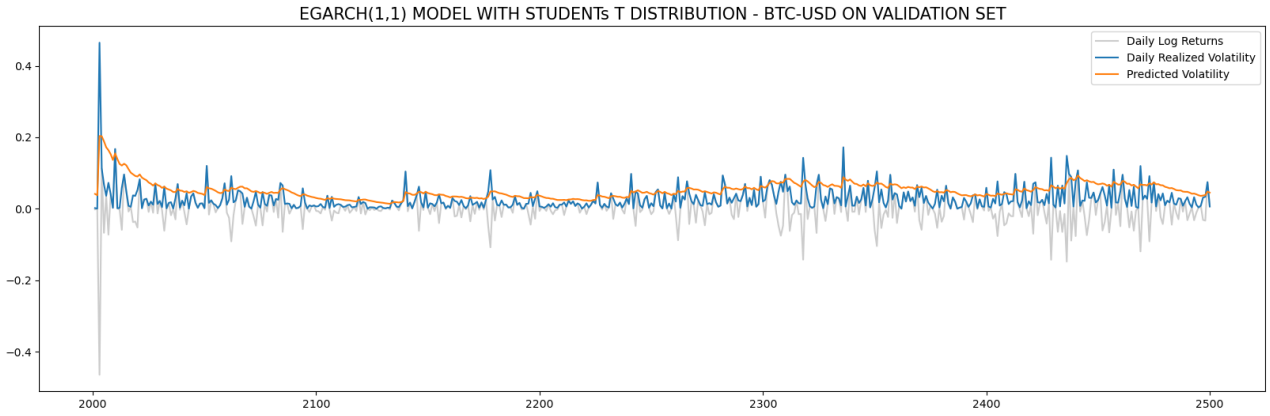
In [56]:
```
e_gm_t = arch_model(ts_train, p=1, q=1, o=1,
                    mean='Zero', vol='EGARCH', dist='StudentsT')
result_4 = e_gm_t.fit(disp='off')
print()
print(result_4.summary())
```

```
                           Zero Mean - EGARCH Model Results
==============================================================================
========
Dep. Variable:                          Close   R-squared:
0.000
Mean Model:                         Zero Mean   Adj. R-squared:
0.000
Vol Model:                            EGARCH   Log-Likelihood:
4193.61
Distribution:      Standardized Student's t   AIC:
-8377.23
Method:                  Maximum Likelihood   BIC:
-8349.22
                                              No. Observations:
2000
Date:                      Thu, Apr 25 2024   Df Residuals:
2000
Time:                             10:01:43   Df Model:
0
                              Volatility Model
==============================================================================
==
                 coef    std err          t      P>|t|       95.0% Conf. In
t.
------------------------------------------------------------------------------
--
omega      -4.5194e-03  4.417e-02     -0.102      0.919 [-9.110e-02,8.206e-0
2]
alpha[1]        0.3140  4.872e-02      6.444  1.161e-10      [  0.219,  0.40
9]
gamma[1]        0.0301  1.846e-02      1.629      0.103 [-6.100e-03,6.625e-0
2]
beta[1]         0.9885  7.037e-03    140.465      0.000      [  0.975,  1.00
2]
                              Distribution
==============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
------------------------------------------------------------------------------
nu             2.6486      0.171     15.454  7.101e-54 [  2.313,  2.985]
==============================================================================

Covariance estimator: robust
```

In [57]:
```
# ROLLING FORECAST
# INITIALIZING rolling_forecasts VALUES LIST
rolling_forecasts = []

# ITERATE OVER EACH TIME STEP IN THE VALIDATION SET
for i in range(len(ts_val)):
    # GET THE DATA AT ALL PREVIOUS TIME STEPS
    idx = val_idx[i]
    train = log_returns[:idx]

    # TRAIN MODEL USING ALL PREVIOUS TIME STEPS' DATA
    model = arch_model(train, p=1, q=1, o=1,
                       mean='Zero', vol='EGARCH', dist='StudentsT')
    model_fit = model.fit(disp='off')

    # MAKE PREDICTION
    pred = (model_fit.forecast(horizon=1, reindex=False).variance.values[0][

    # APPEND TO rolling_forecasts LIST
    rolling_forecasts.append(pred)
```

In [58]:
```
rolling_predictions_4 = pd.Series(rolling_forecasts, index=ts_val.index)
```

In [59]:
```
plt.figure(figsize=(20,6))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')

plt.plot(vol_val, label='Daily Realized Volatility')
plt.plot(rolling_predictions_4, label='Predicted Volatility')

plt.title(f'EGARCH(1,1) MODEL WITH STUDENTs T DISTRIBUTION - {tckr} ON VALID
plt.legend();
```



In [60]:
```
RMSPE(vol_val, rolling_predictions_4)
```

Out[60]:
```
104.18692628877179
```

In [61]:
```
import tensorflow as tf
```

In [62]:
```
def windowed_dataset(series, window_size, batch_size, shuffle_buffer):
    dataset = tf.data.Dataset.from_tensor_slices(series)
    dataset = dataset.window(window_size+1, shift=1, drop_remainder=True)
    dataset = dataset.flat_map(lambda window: window.batch(window_size+1))
    dataset = dataset.shuffle(shuffle_buffer).map(lambda window: (window[:-1
    dataset = dataset.batch(batch_size).prefetch(1)

    return dataset
```

In [63]:
```
window_size = 14
batch_size = 32
shuffle_buffer_size = 1000

dataset = windowed_dataset(vol_train, window_size, batch_size, shuffle_buffe
```

In [64]:
```
lstm_1 = tf.keras.models.Sequential([
    tf.keras.layers.Lambda(lambda x: tf.expand_dims(x, axis=-1), input_shape
    tf.keras.layers.LSTM(28, activation='relu'),
    tf.keras.layers.Dense(1)
])

lstm_1.compile(optimizer='adam', loss='mse')
lstm_1.fit(dataset, epochs=100, batch_size=1, verbose=2)
```

```
Epoch 1/100
63/63 - 1s - 10ms/step - loss: 7.8948e-04
Epoch 2/100
63/63 - 0s - 2ms/step - loss: 7.6316e-04
Epoch 3/100
2024-04-25 10:02:26.551428: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:26.687944: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.5582e-04
Epoch 4/100
63/63 - 0s - 2ms/step - loss: 7.4443e-04
Epoch 5/100
2024-04-25 10:02:26.822322: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:26.955180: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4331e-04
Epoch 6/100
63/63 - 0s - 3ms/step - loss: 7.4640e-04
Epoch 7/100
```

```
2024-04-25 10:02:27.085133: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:27.264055: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3785e-04
Epoch 8/100
63/63 - 0s - 2ms/step - loss: 7.3652e-04
Epoch 9/100
2024-04-25 10:02:27.400482: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:27.533699: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4313e-04
Epoch 10/100
63/63 - 0s - 2ms/step - loss: 7.3682e-04
Epoch 11/100
2024-04-25 10:02:27.665439: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:27.797105: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4140e-04
Epoch 12/100
63/63 - 0s - 2ms/step - loss: 7.3518e-04
Epoch 13/100
2024-04-25 10:02:27.927732: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:28.058010: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3576e-04
Epoch 14/100
63/63 - 0s - 2ms/step - loss: 7.3972e-04
Epoch 15/100
2024-04-25 10:02:28.187896: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:28.324709: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4349e-04
Epoch 16/100
63/63 - 0s - 2ms/step - loss: 7.4094e-04
Epoch 17/100
```

```
2024-04-25 10:02:28.453746: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:28.582424: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.5347e-04
Epoch 18/100
63/63 - 0s - 2ms/step - loss: 7.3611e-04
Epoch 19/100
2024-04-25 10:02:28.712331: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:28.841997: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3831e-04
Epoch 20/100
63/63 - 0s - 2ms/step - loss: 7.4275e-04
Epoch 21/100
2024-04-25 10:02:28.971395: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:29.101022: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3712e-04
Epoch 22/100
63/63 - 0s - 2ms/step - loss: 7.3386e-04
Epoch 23/100
2024-04-25 10:02:29.231790: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:29.364244: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3666e-04
Epoch 24/100
63/63 - 0s - 2ms/step - loss: 7.3977e-04
Epoch 25/100
2024-04-25 10:02:29.498505: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:29.631347: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4001e-04
Epoch 26/100
63/63 - 0s - 2ms/step - loss: 7.3897e-04
Epoch 27/100
```

```
2024-04-25 10:02:29.763779: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:29.896117: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3608e-04
Epoch 28/100
63/63 - 0s - 2ms/step - loss: 7.3278e-04
Epoch 29/100
2024-04-25 10:02:30.028434: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:30.162005: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3853e-04
Epoch 30/100
63/63 - 0s - 2ms/step - loss: 7.4334e-04
Epoch 31/100
2024-04-25 10:02:30.292458: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:30.424905: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3790e-04
Epoch 32/100
63/63 - 0s - 2ms/step - loss: 7.3513e-04
Epoch 33/100
2024-04-25 10:02:30.556197: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:30.689735: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3813e-04
Epoch 34/100
63/63 - 0s - 2ms/step - loss: 7.3765e-04
Epoch 35/100
2024-04-25 10:02:30.821510: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:30.954189: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3936e-04
Epoch 36/100
63/63 - 0s - 2ms/step - loss: 7.4399e-04
Epoch 37/100
```

```
2024-04-25 10:02:31.085883: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:31.219082: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3696e-04
Epoch 38/100
63/63 - 0s - 2ms/step - loss: 7.3447e-04
Epoch 39/100
2024-04-25 10:02:31.350357: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:31.481835: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3874e-04
Epoch 40/100
63/63 - 0s - 2ms/step - loss: 7.4395e-04
Epoch 41/100
2024-04-25 10:02:31.613099: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:31.743490: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4785e-04
Epoch 42/100
63/63 - 0s - 2ms/step - loss: 7.4740e-04
Epoch 43/100
2024-04-25 10:02:31.872808: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:32.002469: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3918e-04
Epoch 44/100
63/63 - 0s - 2ms/step - loss: 7.4010e-04
Epoch 45/100
2024-04-25 10:02:32.132597: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:32.263517: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3880e-04
Epoch 46/100
63/63 - 0s - 2ms/step - loss: 7.3240e-04
Epoch 47/100
```

```
2024-04-25 10:02:32.396178: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:32.527775: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3820e-04
Epoch 48/100
63/63 - 0s - 2ms/step - loss: 7.3277e-04
Epoch 49/100
2024-04-25 10:02:32.678176: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:32.829246: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4098e-04
Epoch 50/100
63/63 - 0s - 2ms/step - loss: 7.3559e-04
Epoch 51/100
2024-04-25 10:02:32.959994: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:33.091750: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3976e-04
Epoch 52/100
63/63 - 0s - 2ms/step - loss: 7.3721e-04
Epoch 53/100
2024-04-25 10:02:33.223485: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:33.353742: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3164e-04
Epoch 54/100
63/63 - 0s - 2ms/step - loss: 7.3968e-04
Epoch 55/100
2024-04-25 10:02:33.486789: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:33.620606: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3947e-04
Epoch 56/100
63/63 - 0s - 2ms/step - loss: 7.3861e-04
Epoch 57/100
```

```
2024-04-25 10:02:33.754152: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:33.887466: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.4111e-04
Epoch 58/100
63/63 - 0s - 2ms/step - loss: 7.3176e-04
Epoch 59/100
2024-04-25 10:02:34.024702: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:34.157841: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2896e-04
Epoch 60/100
63/63 - 0s - 2ms/step - loss: 7.3598e-04
Epoch 61/100
2024-04-25 10:02:34.290340: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:34.420853: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3216e-04
Epoch 62/100
63/63 - 0s - 2ms/step - loss: 7.5934e-04
Epoch 63/100
2024-04-25 10:02:34.550636: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:34.679338: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3615e-04
Epoch 64/100
63/63 - 0s - 2ms/step - loss: 7.3405e-04
Epoch 65/100
2024-04-25 10:02:34.808583: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:34.938123: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3305e-04
Epoch 66/100
63/63 - 0s - 2ms/step - loss: 7.4018e-04
Epoch 67/100
```

```
2024-04-25 10:02:35.069005: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:35.198440: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3899e-04
Epoch 68/100
63/63 - 0s - 2ms/step - loss: 7.3386e-04
Epoch 69/100
2024-04-25 10:02:35.328408: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:35.458042: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2599e-04
Epoch 70/100
63/63 - 0s - 2ms/step - loss: 7.3118e-04
Epoch 71/100
2024-04-25 10:02:35.587956: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:35.718503: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2994e-04
Epoch 72/100
63/63 - 0s - 2ms/step - loss: 7.3066e-04
Epoch 73/100
2024-04-25 10:02:35.848239: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:35.978399: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3030e-04
Epoch 74/100
63/63 - 0s - 2ms/step - loss: 7.3175e-04
Epoch 75/100
2024-04-25 10:02:36.107486: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:36.236707: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3517e-04
Epoch 76/100
63/63 - 0s - 2ms/step - loss: 7.3460e-04
Epoch 77/100
```

```
2024-04-25 10:02:36.365554: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:36.494367: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3206e-04
Epoch 78/100
63/63 - 0s - 2ms/step - loss: 7.4174e-04
Epoch 79/100
2024-04-25 10:02:36.623902: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:36.753332: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3001e-04
Epoch 80/100
63/63 - 0s - 2ms/step - loss: 7.2867e-04
Epoch 81/100
2024-04-25 10:02:36.882880: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:37.012149: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2687e-04
Epoch 82/100
63/63 - 0s - 2ms/step - loss: 7.3042e-04
Epoch 83/100
2024-04-25 10:02:37.141469: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:37.270656: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2747e-04
Epoch 84/100
63/63 - 0s - 2ms/step - loss: 7.4528e-04
Epoch 85/100
2024-04-25 10:02:37.400300: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:37.531097: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3149e-04
Epoch 86/100
63/63 - 0s - 3ms/step - loss: 7.3014e-04
Epoch 87/100
```

```
2024-04-25 10:02:37.660011: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:37.826525: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2632e-04
Epoch 88/100
63/63 - 0s - 2ms/step - loss: 7.2842e-04
Epoch 89/100
2024-04-25 10:02:37.964021: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:38.093238: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2670e-04
Epoch 90/100
63/63 - 0s - 2ms/step - loss: 7.2479e-04
Epoch 91/100
2024-04-25 10:02:38.221785: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:38.350688: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2749e-04
Epoch 92/100
63/63 - 0s - 2ms/step - loss: 7.3737e-04
Epoch 93/100
2024-04-25 10:02:38.480322: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:38.608222: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3311e-04
Epoch 94/100
63/63 - 0s - 2ms/step - loss: 7.3506e-04
Epoch 95/100
2024-04-25 10:02:38.738132: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:38.867030: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2820e-04
Epoch 96/100
63/63 - 0s - 2ms/step - loss: 7.3223e-04
Epoch 97/100
```

```
2024-04-25 10:02:38.996743: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:39.125578: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.2812e-04
Epoch 98/100
63/63 - 0s - 2ms/step - loss: 7.3804e-04
Epoch 99/100
2024-04-25 10:02:39.255665: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:39.383960: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
63/63 - 0s - 2ms/step - loss: 7.3820e-04
Epoch 100/100
63/63 - 0s - 2ms/step - loss: 7.2380e-04
2024-04-25 10:02:39.514071: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
2024-04-25 10:02:39.642892: W tensorflow/core/framework/local_rendezvous.cc:
404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
         [[{{node IteratorGetNext}}]]
```

Out[64]:

```
<keras.src.callbacks.history.History at 0x313278550>
```

In [65]:

```python
forecast = []
idx = vols.index

# ITERATE OVER EACH TIME STEP IN THE VALIDATION SET
for i in range(len(vol_val)):
    # GET THE DATA AT THE PREVIOUS window_size TIME STEPS
    from_idx = idx[split_time_1 + i - window_size]
    to_idx = idx[split_time_1 + i - 1]
    pred = lstm_1.predict(vols[from_idx:to_idx].values[np.newaxis])
    forecast.append(pred)

forecast = np.array(forecast[-len(vol_val):])[:, 0, 0]
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
```

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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step
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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
```
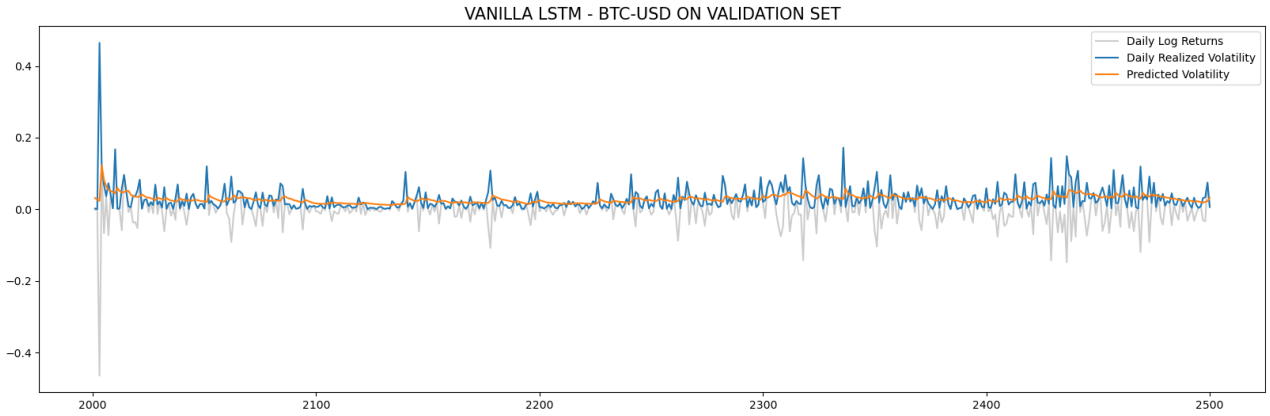

In [66]:
```
rolling_predictions_5 = pd.Series(forecast, index=ts_val.index)
```

In [68]:
```
plt.figure(figsize=(20,6))
plt.plot(ts_val, color='gray', alpha=0.4, label='Daily Log Returns')

plt.plot(vol_val, label='Daily Realized Volatility')
plt.plot(rolling_predictions_5, label='Predicted Volatility')

plt.title(f'VANILLA LSTM - {tckr} ON VALIDATION SET', fontsize=15)
plt.legend();
```



In [69]:
```
RMSPE(vol_val, rolling_predictions_5)
```

Out[69]:
```
59.57101805373266
```

In [70]:
```
RMSE(vol_val, rolling_predictions_5)
```

Out[70]:
```
0.03383412834066305
```

In [ ]: