```
!pip3 install pmdarima
```

```
Requirement already satisfied: pmdarima in /usr/local/lib/python3.7/dist-packages (1
Requirement already satisfied: Cython<0.29.18,>=0.29 in /usr/local/lib/python3.7/dist
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/python3
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages (fro
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: statsmodels!=0.12.0,>=0.11 in /usr/local/lib/python3.7
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.7/dist-package
Requirement already satisfied: patsy>=0.5 in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.7/dis
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from pa
```

```
# Import package
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import warnings
from statsmodels.tsa.api import SimpleExpSmoothing
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
from datetime import datetime
from statsmodels.tsa.arima_model import ARIMA
from statsmodels.graphics.tsaplots import plot_acf,plot_pacf
```

```
warnings.simplefilter('ignore')
```

```
data = pd.read_csv('Dataset1_global_mean_temp.csv',names = ['global_mean_temp'])
```

Applying KPSS and ADF test

1. ADF test

```
#define function for ADF test
from statsmodels.tsa.stattools import adfuller

def adf_test(atr):
    #Perform Dickey-Fuller test:
    timeseries = data[atr].dropna()
    print ('Results of Dickey-Fuller Test for ',atr,'\n')
    dftest = adfuller(timeseries, autolag='AIC')
    dfoutput = pd.Series(dftest[0:4], index=['Test Statistic','p-value','#Lags Used','Numb
    for key,value in dftest[4].items():
       dfoutput['Critical Value (%s)'%key] = value
```

```
        dfoutput['Critical Value (%s)'%key] = value
    print(dfoutput)

#apply adf test on the series
adf_test('global_mean_temp')
```

```
Results of Dickey-Fuller Test for  global_mean_temp

Test Statistic                   0.330692
p-value                          0.978710
#Lags Used                       3.000000
Number of Observations Used    130.000000
Critical Value (1%)             -3.481682
Critical Value (5%)             -2.884042
Critical Value (10%)            -2.578770
dtype: float64
```

2. KPSS test

```
#define function for kpss test
from statsmodels.tsa.stattools import kpss
#define KPSS
def kpss_test(atr):
    timeseries = data[atr].dropna()
    print ('Results of KPSS Test for ',atr)
    kpsstest = kpss(timeseries, regression='c')
    kpss_output = pd.Series(kpsstest[0:3], index=['Test Statistic','p-value','Lags Used'])
    for key,value in kpsstest[3].items():
        kpss_output['Critical Value (%s)'%key] = value
    print (kpss_output)
kpss_test('global_mean_temp')
```

```
Results of KPSS Test for  global_mean_temp
Test Statistic            0.937789
p-value                   0.010000
Lags Used                13.000000
Critical Value (10%)      0.347000
Critical Value (5%)       0.463000
Critical Value (2.5%)     0.574000
Critical Value (1%)       0.739000
dtype: float64
```

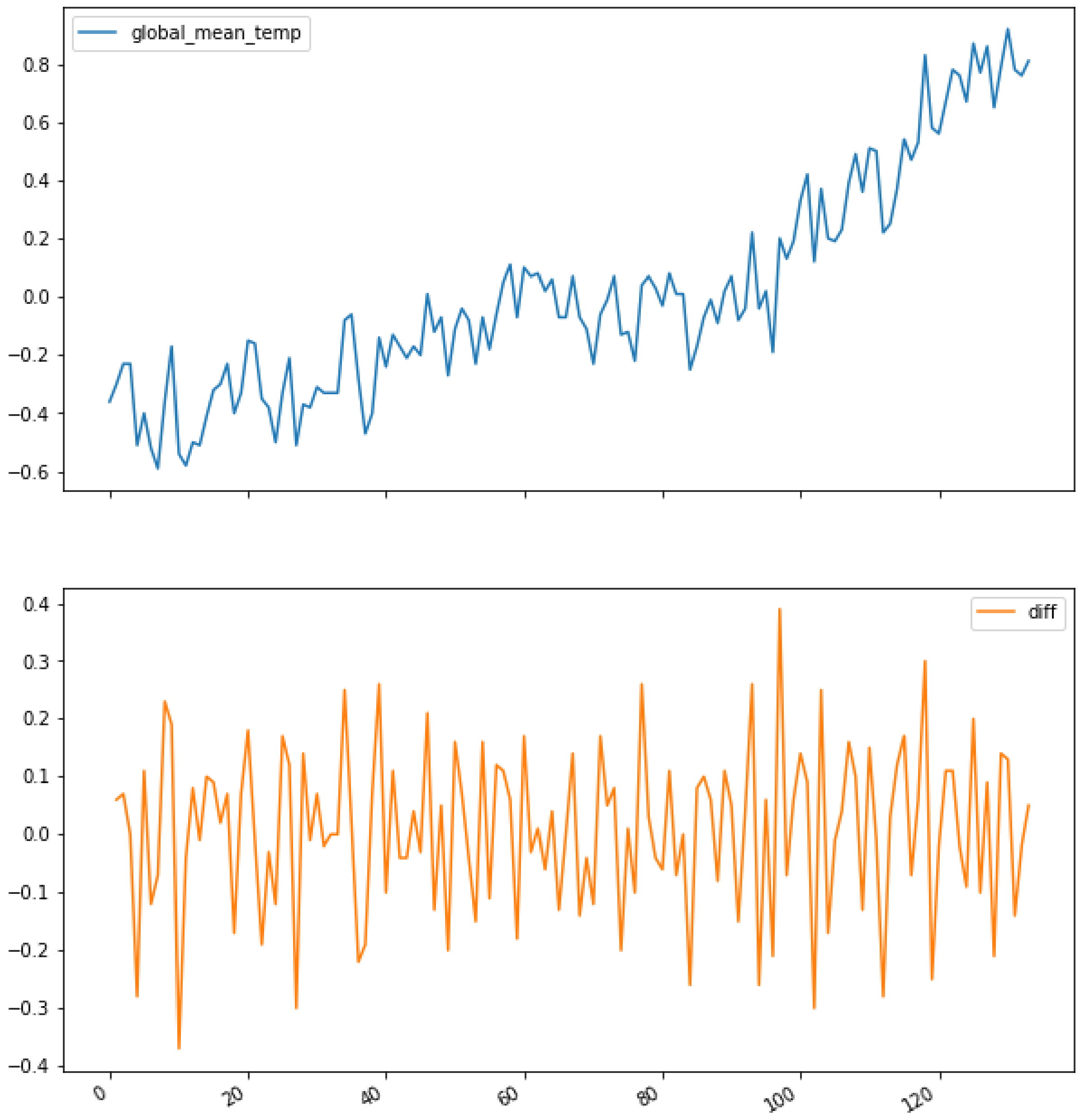
For ADF test, we can see that the p-value is 0.978710, which is more than 0.05. Thus, from ADF test, we can say that the dataset is non-stationary.

For KPSS test, Test Statistic is more than Critical Value, thus we reject the null hypothesis. Thus, from KPSS test, we can say that the dataset is non-stationary.

Since, both tests conclude that the series is stationary, therefore, the dataset is concluded as Non-Stationary.

Making dataset stationary with differencing

```
# Differencing
data['diff'] = data['global_mean_temp'].diff(periods=1)

data.plot(subplots=True, figsize=(10,12))
plt.show()
```



Applying Exponential Smoothening

```
#List of least mse and mae
mseses=[]
msedes=[]
msetes=[]
maeses=[]
```

```
maedes=[]
maetes=[]
```

Single Exponential Smoothing

```
#Defining Single Exponential Smoothing function ses
def ses(arr,alpha):
    arr1 = [arr[0]]
    for i in range(1, len(arr)):
        arr1.append(alpha * arr[i-1] + (1 - alpha) * arr1[i-1])
    return arr1


#Defining Mean of Squared Error Function mse
def mse(arr1,arr2):
  arr3=[0]
  for i, j in zip(arr1, arr2):
    arr3.append(i-j)
  Sum=0
  for i in arr3:
    sqr=i**2
    Sum+=sqr
  mse=Sum/(len(arr2)-1)
  return mse


#Function to make list of demand with interval 'n'
def dem_n(arr,n):
  arr1=[arr[0]]
  for i in range(1,len(arr)):
    if i%n==0:
      arr1.append(arr[i])
  return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
```

```
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
     Mean of Square Errors for alpha = 0.2 is:  0.017627575897166053
     Mean of Square Errors for alpha = 0.5 is:  0.01617131015410465
     Mean of Square Errors for alpha = 0.8 is:  0.017968676960481184
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8 is: ",mae3)
```

```
     Mean Absolute Errors for alpha = 0.2 is:  0.10751676957671709
     Mean Absolute Errors for alpha = 0.5 is:  0.10363842544836274
     Mean Absolute Errors for alpha = 0.8 is:  0.10754580488424474
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
```

alpha: 0.5

Double Exponential Smoothing


```
#Defining Double Exponential Smoothing function des
def des(arr,alpha,beta):
  a=[arr[0]]
  l=len(arr)
  b=[(arr[l-1]-arr[0])/(l-1)]
  arr1 = [arr[0]]
  arr1.append(a[0]+b[0])
  for i in range(1,len(arr)-1):
      a.append(alpha * arr[i] + (1 - alpha) * (a[i-1]+b[i-1]))
      b.append(beta * (a[i]-a[i-1]) + (1 - beta) * (b[i-1]))
      arr1.append(a[i]+b[i])
  return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.017968472190272575
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.023665107048017036
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.03558094712785075
```

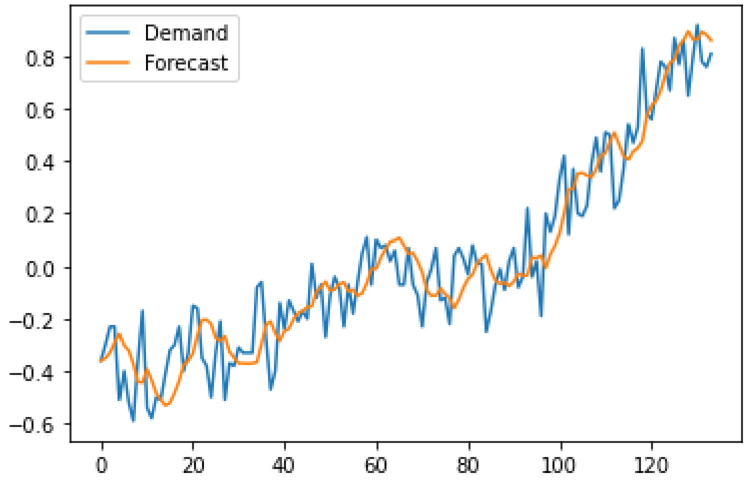
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6 is: ",mae2)
```

```
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3 is:  0.10647490064149882
Mean Absolute Errors for alpha = 0.5,beta= 0.6 is:  0.12040883049870627
Mean Absolute Errors for alpha = 0.8,beta= 0.9 is:  0.14733969382416773
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
```

```
alpha:  0.2
beta:  0.3
```



Triple Exponential Smoothing

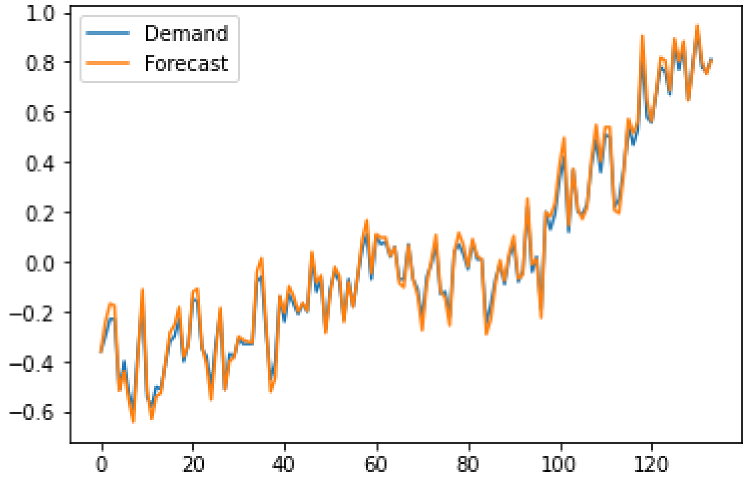
```
#Defining initial trend
def initial_trend(arr, slen):
    Sum = 0
    for i in range(slen):
        Sum += float(arr[i+slen] - arr[i]) / slen
    return Sum / slen
```

```
#Defining initial seasonal
def initial_seasonal(arr, slen):
    arr1 = {}
    s_avg = []
    m = int(len(arr)/slen)
    for j in range(m):
        s_avg.append(sum(arr[slen*j:slen*j+slen])/float(slen))
    for i in range(slen):
        Sum = 0
        for j in range(m):
            Sum += arr[slen*j+i]-s_avg[j]
        arr1[i] = Sum/m
    return arr1


#Defining Triple Exponential Smoothing function tes with interval 'n'
def tes(arr, slen, alpha, beta, gamma, n):
    arr1 = []
    seasonals = initial_seasonal(arr, slen)
    for i in range(len(arr)+n):
        if i == 0:
            smooth = arr[0]
            trend = initial_trend(arr, slen)
            arr1.append(arr[0])
            continue
        if i >= len(arr):
            m = i - len(arr) + 1
            arr1.append((smooth + m*trend) + seasonals[i%slen])
        else:
            val = arr[i]
            lsmooth, smooth = smooth, alpha*(val-seasonals[i%slen]) + (1-alpha)*(smooth+tr
            trend = beta * (smooth-lsmooth) + (1-beta)*trend
            seasonals[i%slen] = gamma*(val-smooth) + (1-gamma)*seasonals[i%slen]
            arr1.append(smooth+trend+seasonals[i%slen])
    return arr1


#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here
```

```
forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)

     Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.004115481353097386
     Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.0010619297688366797
     Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.0087458931387771


#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)

     Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.05096165897173092
     Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.026609223640182905
     Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.07517010749800324


#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
```

```
df3.plot(style=['-','-'])
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```



For 1 Unit

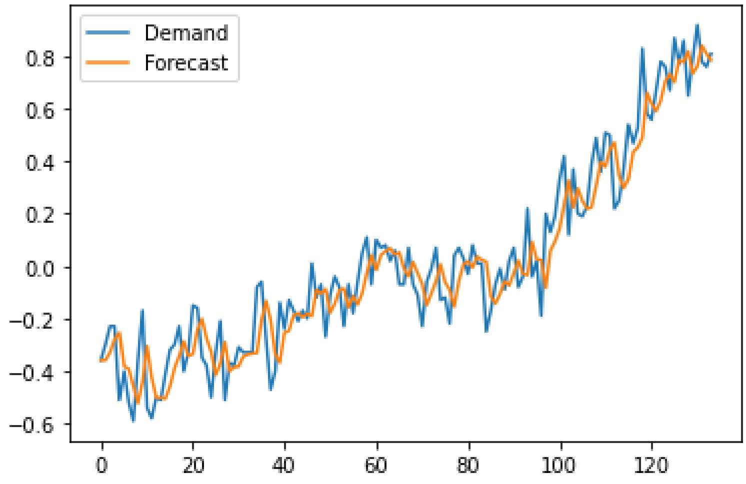
Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  0.017627575897166053
Mean of Square Errors for alpha = 0.5 is:  0.01617131015410465
Mean of Square Errors for alpha = 0.8 is:  0.017968676960481184
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.5
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)
```

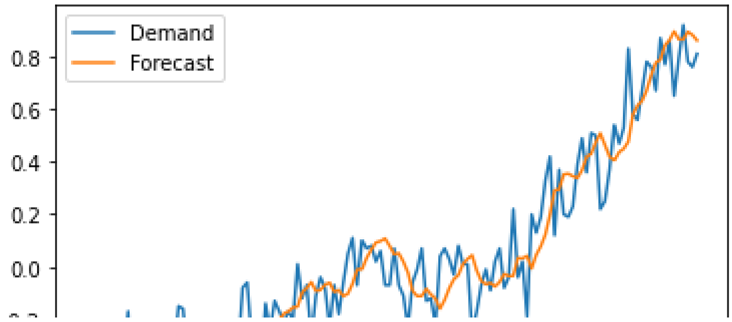
```
#Forecasting
alpha1=0.2
```

```
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.017968472190272575
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.023665107048017036
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.03558094712785075
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.2
beta:  0.3
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,1)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.004115481353097386
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.0010619297688366797
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.0087458931387771
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.05096165897173092
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.026609223640182905
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.07517010749800324
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```


```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 2 Unit

Single Exponential Smoothing

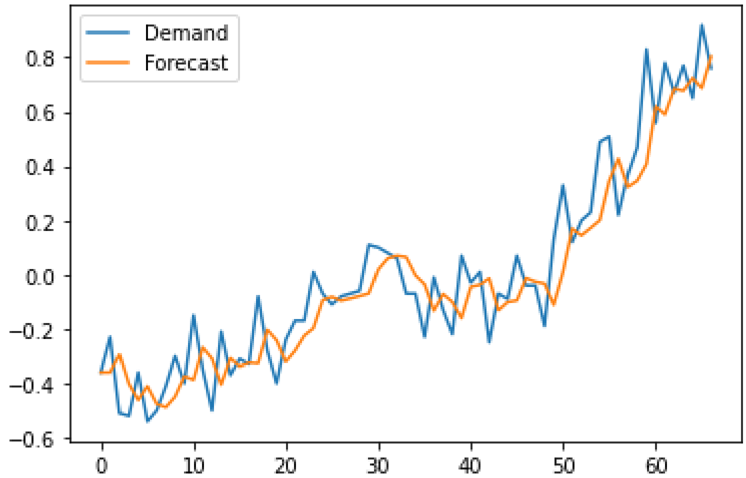
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  0.028057403955295324
Mean of Square Errors for alpha = 0.5 is:  0.02035445919597396
Mean of Square Errors for alpha = 0.8 is:  0.022901086822187305
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}
```

```
df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.5
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
```

```
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.01999545954388405
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.026251623176574396
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.04539202303859103
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.2
beta:  0.3
```


```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,2)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.008236314412753888
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.0016388047846092593
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.010997893163717798
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.06932163770874376
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.03133931987936451
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.08426318449948132
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
    alpha:  0.5
    beta:  0.6
    gamma:  0.7
```

```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 4 Unit

Single Exponential Smoothing

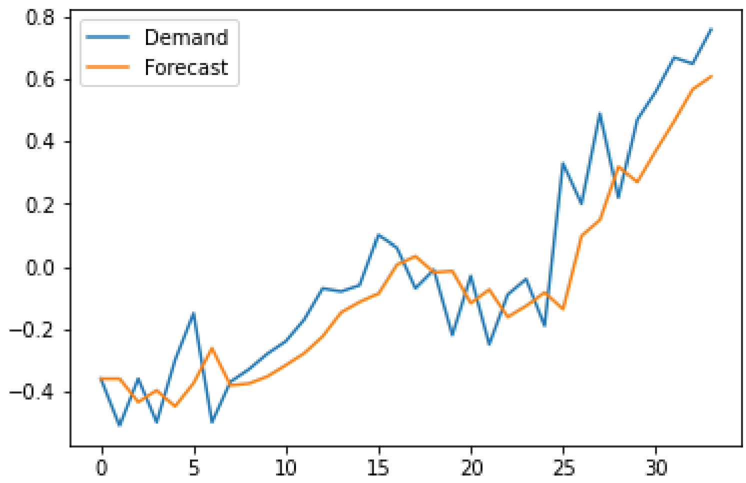
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
    Mean of Square Errors for alpha = 0.2 is:  0.04595174517032602
    Mean of Square Errors for alpha = 0.5 is:  0.025889497431882152
    Mean of Square Errors for alpha = 0.8 is:  0.026282815521385526
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
```

```
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.5
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

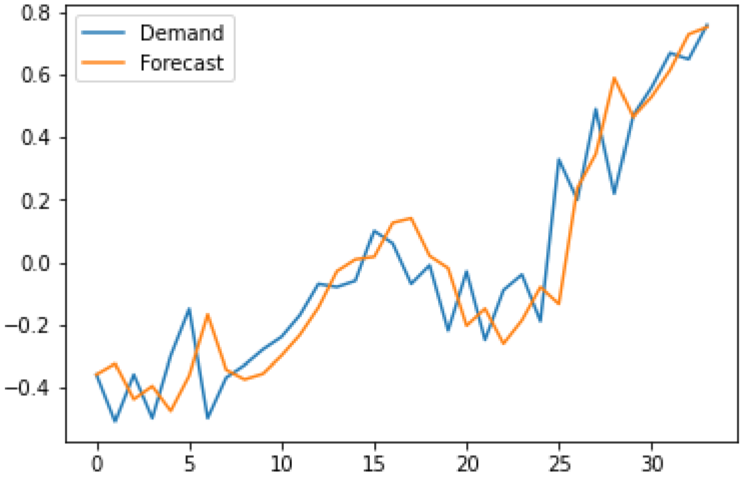
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)
```

```
#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.031130343809725954
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.025086948873225354
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.046265818205273715
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
```



```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,4)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.01514477148242445
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.003449731691962658
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.012850622128417841
```

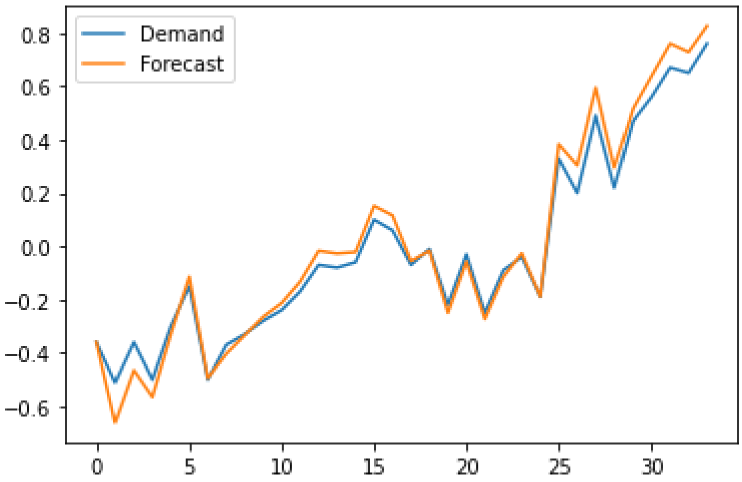
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
```

```
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.09356505028570597
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.047139660620951956
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.08996675396865808
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
```

```
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 8 Unit

Single Exponential Smoothing

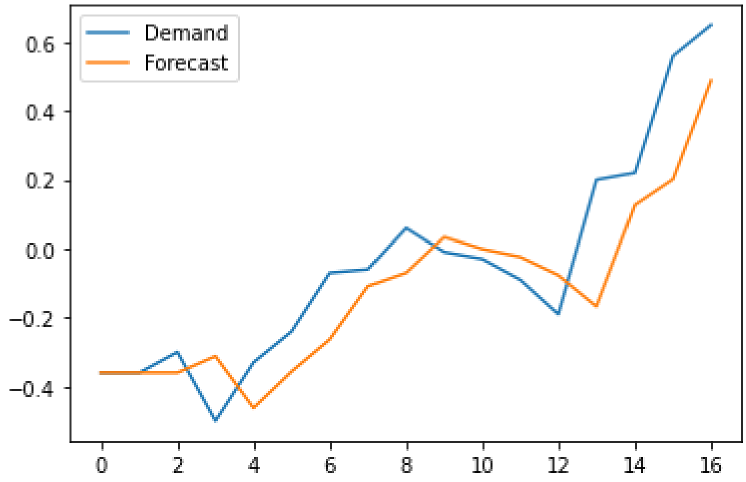
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  0.0661955638561374
Mean of Square Errors for alpha = 0.5 is:  0.03545046620342662
Mean of Square Errors for alpha = 0.8 is:  0.02617769649822023
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
```

```
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

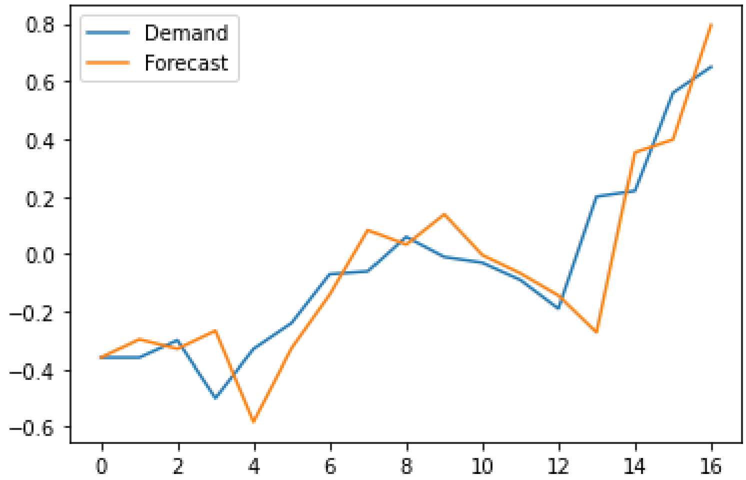
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)
```

```
print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.03366151460950395
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.03154046355796777
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.027693931545014937
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.8
beta:  0.9
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
```

```
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,8)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

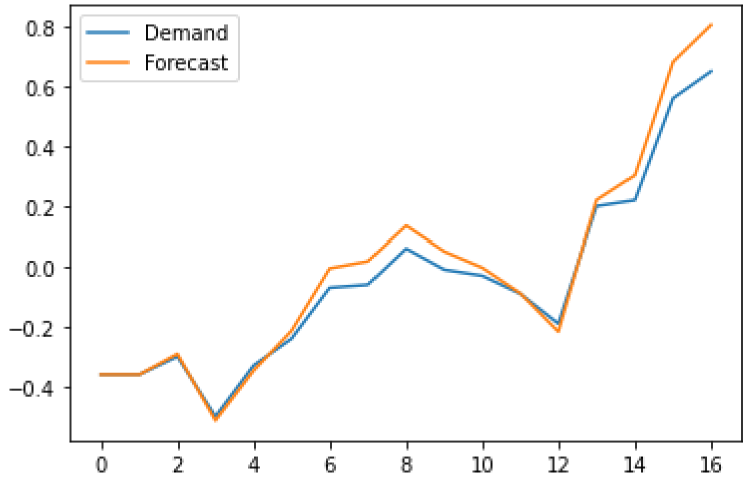
```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.004245136804195677
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.004016988867984858
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.014150748017754799
```

```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.05458128905756587
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.04576964175516354
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.09224994318817883
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 12 Unit

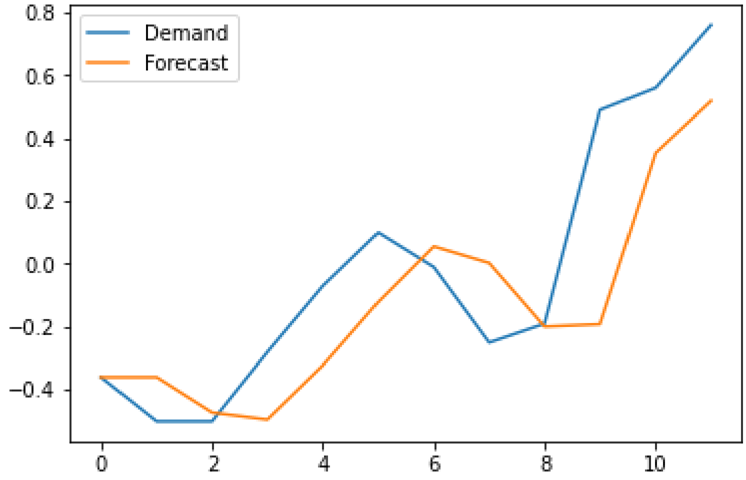
Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  0.14439120293179095
Mean of Square Errors for alpha = 0.5 is:  0.08774129603703816
Mean of Square Errors for alpha = 0.8 is:  0.06776960314809816
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.8
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

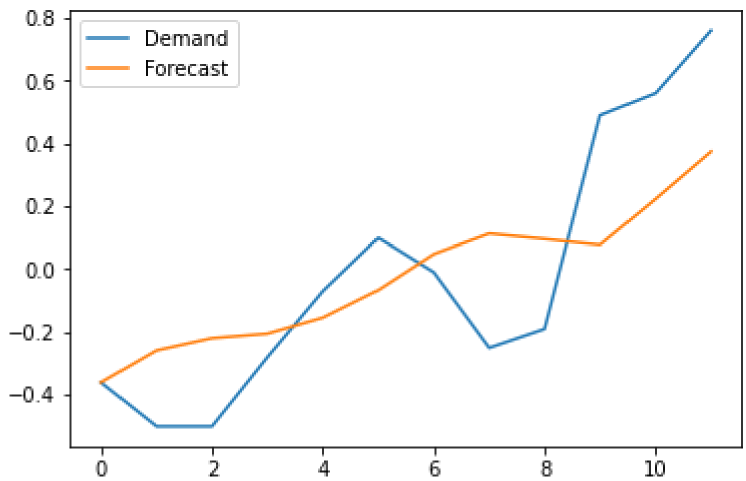
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.06896961923406343
```

```
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.08297600551033225
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.0924795098069323
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.2
beta:  0.3
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maedes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maedes.append(mae2)
else:
  maedes.append(mae3)
```

Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,12)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.04382522920312487
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.011070620993134666
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.03782372844198626
```

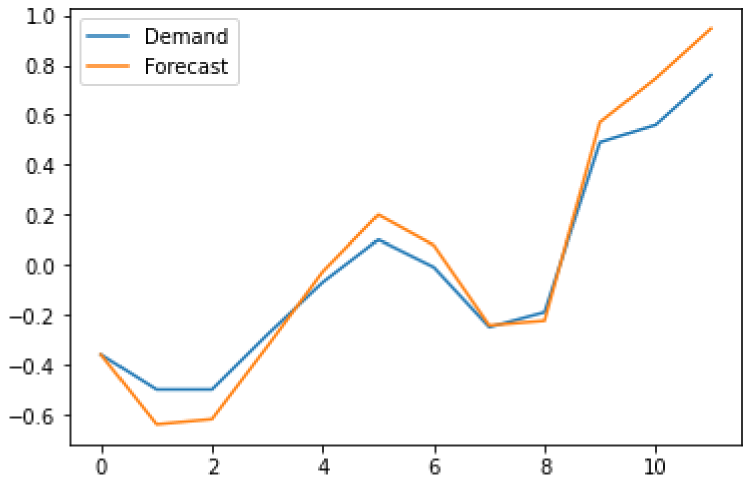
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.17492533053808723
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.08594612043585888
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.14923404244967667
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}
```

```
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

For 24 Interval

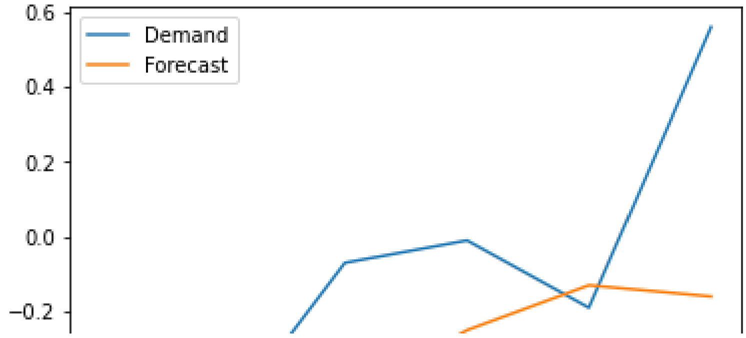
Single Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

forecast1=ses(demand,alpha1)
forecast2=ses(demand,alpha2)
forecast3=ses(demand,alpha3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2 is:  0.1460473568426667
Mean of Square Errors for alpha = 0.5 is:  0.12146666666666668
Mean of Square Errors for alpha = 0.8 is:  0.12364050564266665
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  df1.plot(style=['-','-'])
  mseses.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  df2.plot(style=['-','-'])
  mseses.append(mse2)
else:
  print('alpha: ',alpha3)
  df3.plot(style=['-','-'])
  mseses.append(mse3)
```

```
alpha:  0.5
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maeses.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maeses.append(mae2)
else:
  maeses.append(mae3)
```

Double Exponential Smoothing

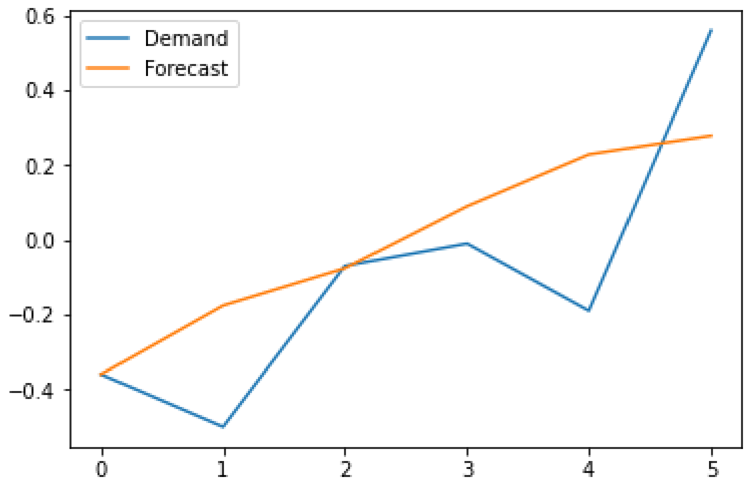
```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9

forecast1=des(demand,alpha1,beta1)
forecast2=des(demand,alpha2,beta2)
forecast3=des(demand,alpha3,beta3)


#Calculating Mean of Square Errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 is:  0.061580160134174604
Mean of Square Errors for alpha = 0.5,beta= 0.6 is:  0.08896061492949336
Mean of Square Errors for alpha = 0.8,beta= 0.9 is:  0.17058349780417123
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
```

```
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  df1.plot(style=['-','-'])
  msedes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
  df2.plot(style=['-','-'])
  msedes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  df3.plot(style=['-','-'])
  msedes.append(mse3)
```

```
alpha:  0.2
beta:  0.3
```



Triple Exponential Smoothing

```
#Creating demand list in 'n' intervals
demand=dem_n(data.global_mean_temp,24)


#Forecasting
alpha1=0.2
alpha2=0.5
alpha3=0.8

beta1=0.3
beta2=0.6
beta3=0.9
```

```
gamma1=0.4
gamma2=0.7
gamma3=0.95

#Considering season of 1 hours here

forecast1=tes(demand,1,alpha1,beta1,gamma1,0)
forecast2=tes(demand,1,alpha2,beta2,gamma2,0)
forecast3=tes(demand,1,alpha3,beta3,gamma3,0)


#Calculating mean of sqaured errors
mse1=mean_squared_error(demand,forecast1)
mse2=mean_squared_error(demand,forecast2)
mse3=mean_squared_error(demand,forecast3)

print("Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is: ",mse1)
print("Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is: ",mse2)
print("Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is: ",mse3)
```

```
Mean of Square Errors for alpha = 0.2,beta= 0.3 gamma=0.4 is:  0.07630571317837302
Mean of Square Errors for alpha = 0.5,beta= 0.6 gamma=0.7 is:  0.0061379864648235674
Mean of Square Errors for alpha = 0.8,beta= 0.9 gamma=0.95 is:  0.0610634506977876
```

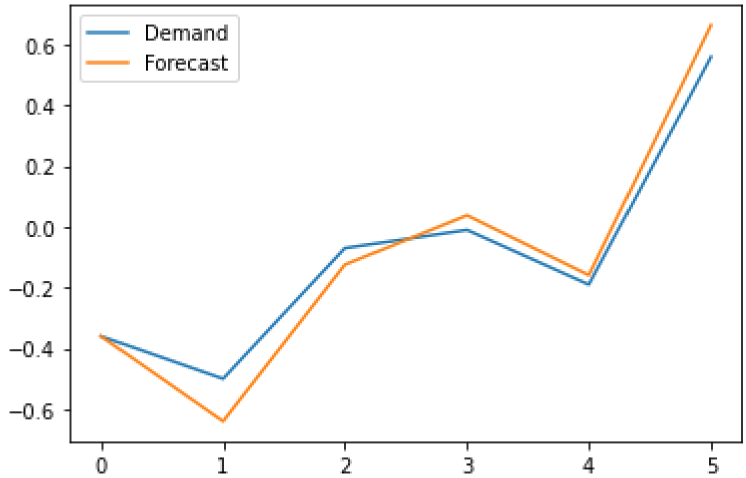
```
#Calculating Mean Absolute Errors
mae1=mean_absolute_error(demand,forecast1)
mae2=mean_absolute_error(demand,forecast2)
mae3=mean_absolute_error(demand,forecast3)

print("Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is: ",mae1)
print("Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is: ",mae2)
print("Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is: ",mae3)
```

```
Mean Absolute Errors for alpha = 0.2,beta= 0.3, gamma=0.4 is:  0.22936229786666665
Mean Absolute Errors for alpha = 0.5,beta= 0.6, gamma=0.7 is:  0.06308794791666666
Mean Absolute Errors for alpha = 0.8,beta= 0.9, gamma=0.95 is:  0.18760887805000004
```

```
#Comparing mse and plotting for least mse
d1={'Demand':demand,'Forecast':forecast1}
d2={'Demand':demand,'Forecast':forecast2}
d3={'Demand':demand,'Forecast':forecast3}

df1=pd.DataFrame(d1)
df2=pd.DataFrame(d2)
df3=pd.DataFrame(d3)

if mse1<=mse2 and mse1<=mse3:
  print('alpha: ',alpha1)
  print('beta: ',beta1)
  print('gamma: ',gamma1)
  df1.plot(style=['-','-'])
  msetes.append(mse1)
elif mse2<=mse1 and mse2<=mse3:
  print('alpha: ',alpha2)
  print('beta: ',beta2)
```

```
  print('beta: ',beta2)
  print('gamma: ',gamma2)
  df2.plot(style=['-','-'])
  msetes.append(mse2)
else:
  print('alpha: ',alpha3)
  print('beta: ',beta3)
  print('gamma: ',gamma3)
  df3.plot(style=['-','-'])
  msetes.append(mse3)
```

```
alpha:  0.5
beta:  0.6
gamma:  0.7
```




```
#Storing least mae values
if mae1<=mae2 and mae1<=mae3:
  maetes.append(mae1)
elif mae2<=mae1 and mae2<=mae3:
  maetes.append(mae2)
else:
  maetes.append(mae3)
```

Least MSE and MAE values are

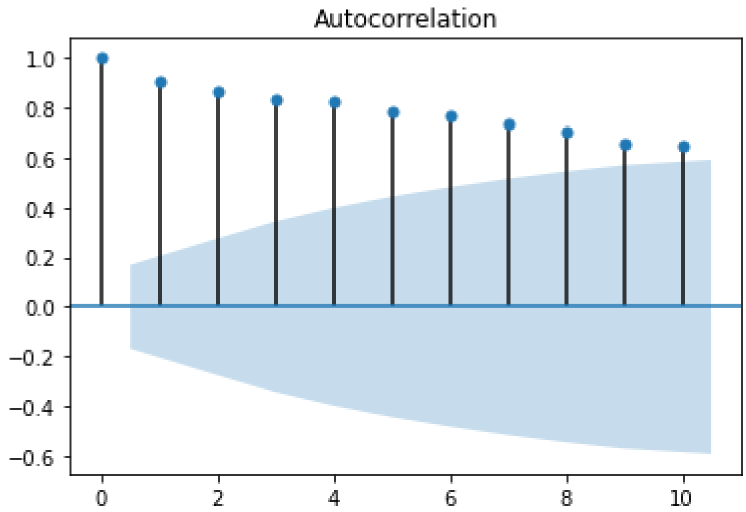
```
print("Least MSE ses")
print(mseses)
print("Least MSE des")
print(msedes)
print("Least MSE tes")
print(msetes)


print("Least MAE ses")
print(maeses)
print("Least MAE des")
print(maedes)
print("Least MAE tes")
print(maetes)
```

```
Least MSE ses
[0.01617131015410465, 0.02035445919597396, 0.025889497431882152, 0.02617769649822023,
Least MSE des
[0.017968472190272575, 0.01999545954388405, 0.025086948873225354, 0.0276939315450149
Least MSE tes
[0.0010619297688366797, 0.0016388047846092593, 0.003449731691962658, 0.00401698886798
Least MAE ses
[0.026609223640182905, 0.026609223640182905, 0.03133931987936451, 0.0471396606209519
Least MAE des
[0.026609223640182905, 0.026609223640182905, 0.03133931987936451, 0.0471396606209519
Least MAE tes
[0.026609223640182905, 0.03133931987936451, 0.047139660620951956, 0.0457696417551635
```

Applying ACF and PACF

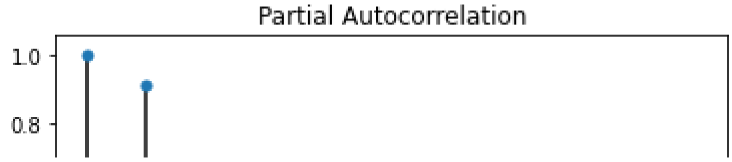
```
#Plotting ACF
plot_acf(data.global_mean_temp,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```




```
#plotting PACF
plot_pacf(data.global_mean_temp,lags=10)
plt.show
```

```
<function matplotlib.pyplot.show>
```



Applying AR, MA, ARIMA Models

```
#AR

#fit model
model=ARIMA(data['global_mean_temp'], order=(1,0,0))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastAR'] = model_fit.predict()
data[['global_mean_temp','forecastAR']].plot()
```

```
                         ARMA Model Results
==============================================================================
Dep. Variable:       global_mean_temp   No. Observations:                  134
```

```
mse=mean_squared_error(data.global_mean_temp,data.forecastAR.dropna())
print("MSE for AR is:",mse)
```

```
MSE for AR is: 0.02075665468619131
```

```
mae=mean_absolute_error(data.global_mean_temp,data.forecastAR.dropna())
print("MAE for AR is:",mae)
```

```
MAE for AR is: 0.11471516004965322
```

```
#MA

#fit model
model=ARIMA(data['global_mean_temp'].dropna(), order=(0,0,2))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastMA'] = model_fit.predict()
data[['global_mean_temp','forecastMA']].plot()
```

```
                              ARMA Model Results
==============================================================================
Dep. Variable:       global_mean_temp   No. Observations:                  134
Model:                     ARMA(0, 2)   Log Likelihood                  26.824
Method:                       css-mle   S.D. of innovations              0.197
Date:                Mon, 01 Mar 2021   AIC                            -45.647
Time:                        04:45:00   BIC                            -34.056
Sample:                             0   HQIC                           -40.937
```

```
mse=mean_squared_error(data.global_mean_temp,data.forecastMA.dropna())
print("MSE for MA is:",mse)
```

```
MSE for MA is: 0.039539084324022956

ma.L2.global_mean_temp     0.5786      0.058      9.901      0.000       0.464
```

```
mae=mean_absolute_error(data.global_mean_temp,data.forecastMA.dropna())
print("MAE for MA is:",mae)
```

```
MAE for MA is: 0.15743063176569777

MA.2           -0.8531           +1.0002j            1.3146            0.3624
```

```
#ARIMA

#fit model
model=ARIMA(data['diff'].dropna(), order=(0,1,2))
model_fit=model.fit()

#model summary
print(model_fit.summary())

#make prediction
data['forecastARIMA'] = model_fit.predict()
data[['diff','forecastARIMA']].plot()
```

```
                              ARIMA Model Results
==============================================================================
Dep. Variable:                 D.diff   No. Observations:                  132
Model:                 ARIMA(0, 1, 2)   Log Likelihood                  85.246
Method:                       css-mle   S.D. of innovations              0.123
Date:                Mon, 01 Mar 2021   AIC                           -162.493
Time:                        05:08:19   BIC                           -150.961
Sample:                             1   HQIC                          -157.807

================================================================================
                   coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------
const            0.0002   7.94e-05      2.031      0.042    5.65e-06       0.000
ma.L1.D.diff    -1.7309      0.079    -21.779      0.000      -1.887      -1.575
```

```
mse=mean_squared_error(data.global_mean_temp[0:-2],data.forecastARIMA.dropna())
print("MSE for MA is:",mse)
```

```
MSE for MA is: 0.14726118059230633
```

```
MA.1            1.0004           +0.0000j            1.0004            0.0000
```

```
mae=mean_absolute_error(data.global_mean_temp[0:-2],data.forecastARIMA.dropna())
print("MAE for MA is:",mae)
```

```
MAE for MA is: 0.30145636480679083
```

Applying Auto ARIMA


```
import pmdarima as pm
model = pm.auto_arima(data.iloc[:,0], start_p=1, start_q=1,test='adf',max_p=3, max_q=3,m=1
print(model.summary())
```

```
Performing stepwise search to minimize aic
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=-172.662, Time=0.25 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=-138.203, Time=0.04 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=-150.647, Time=0.16 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=-170.641, Time=0.12 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=-139.692, Time=0.03 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=-171.777, Time=0.44 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=-171.188, Time=0.31 sec
 ARIMA(0,1,2)(0,0,0)[0] intercept   : AIC=-173.183, Time=0.16 sec
 ARIMA(0,1,3)(0,0,0)[0] intercept   : AIC=-171.195, Time=0.41 sec
 ARIMA(1,1,3)(0,0,0)[0] intercept   : AIC=-172.644, Time=0.50 sec
 ARIMA(0,1,2)(0,0,0)[0]             : AIC=-168.699, Time=0.09 sec

Best model:  ARIMA(0,1,2)(0,0,0)[0] intercept
Total fit time: 2.533 seconds
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  134
Model:               SARIMAX(0, 1, 2)   Log Likelihood                  90.592
Date:                Mon, 01 Mar 2021   AIC                           -173.183
Time:                        04:45:27   BIC                           -161.622
Sample:                             0   HQIC                          -168.485
                                - 134
```

```
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0090      0.003      3.000      0.003       0.003       0.015
ma.L1         -0.5536      0.091     -6.055      0.000      -0.733      -0.374
ma.L2         -0.1737      0.092     -1.880      0.060      -0.355       0.007
sigma2         0.0149      0.002      7.529      0.000       0.011       0.019
===================================================================================
Ljung-Box (L1) (Q):                   0.00   Jarque-Bera (JB):                 0.68
Prob(Q):                              0.99   Prob(JB):                         0.71
Heteroskedasticity (H):               1.14   Skew:                            -0.11
Prob(H) (two-sided):                  0.66   Kurtosis:                         2.72
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step)
```

Best model: ARIMA(0,1,2)(0,0,0)[0]

Final Result

Dataset 1													
Is Dataset Stationery	No												
	For ADF test, we can see that the p-value is more than 0.05. the dataset is non-stationary. For KPSS test, Test Statistic is more than Critical Value, thus we reject the null hypothesis. Thus, from KPSS test, we can say that the dataset is non-stationary.												
If yes, why, and if not, why not	Non-Stationary												
If differencing was done, how many times it was done?	One Time												
		Prediction FOR ->											
		MSE						MAE					
		1 UNIT	2 UNIT	4 UNIT	8 UNIT	12 UNIT	24 UNIT	1 UNIT	2 UNIT	4 UNIT	8 UNIT	12 UNIT	24 UNIT
Single Exponential Smoothing	alpha(?)	0.01617131	0.020354	0.025889	0.026178	0.06777	0.121467	0.026609	0.026609	0.031339	0.04714	0.04577	0.085946
Double and triple Exponential Smoothing	alpha(?), beta(?)	0.017968472	0.019995	0.025087	0.027694	0.06897	0.06158	0.026609	0.026609	0.031339	0.04714	0.04577	0.085946
Triple Exponential Smoothing	alpha(?), beta(?), gamma(?)	0.00106193	0.001639	0.00345	0.004017	0.011071	0.006138	0.026609	0.031339	0.04714	0.04577	0.085946	0.063088
Only AR	AR(?)	0.020756655						0.114715					
Only MA	MA(?)	0.039539084						0.157431					
ARIMA	ARIMA(?)	0.147261181						0.301456					
SARIMA (if the data has seasonality)	season(?)												

+ Code + Text