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

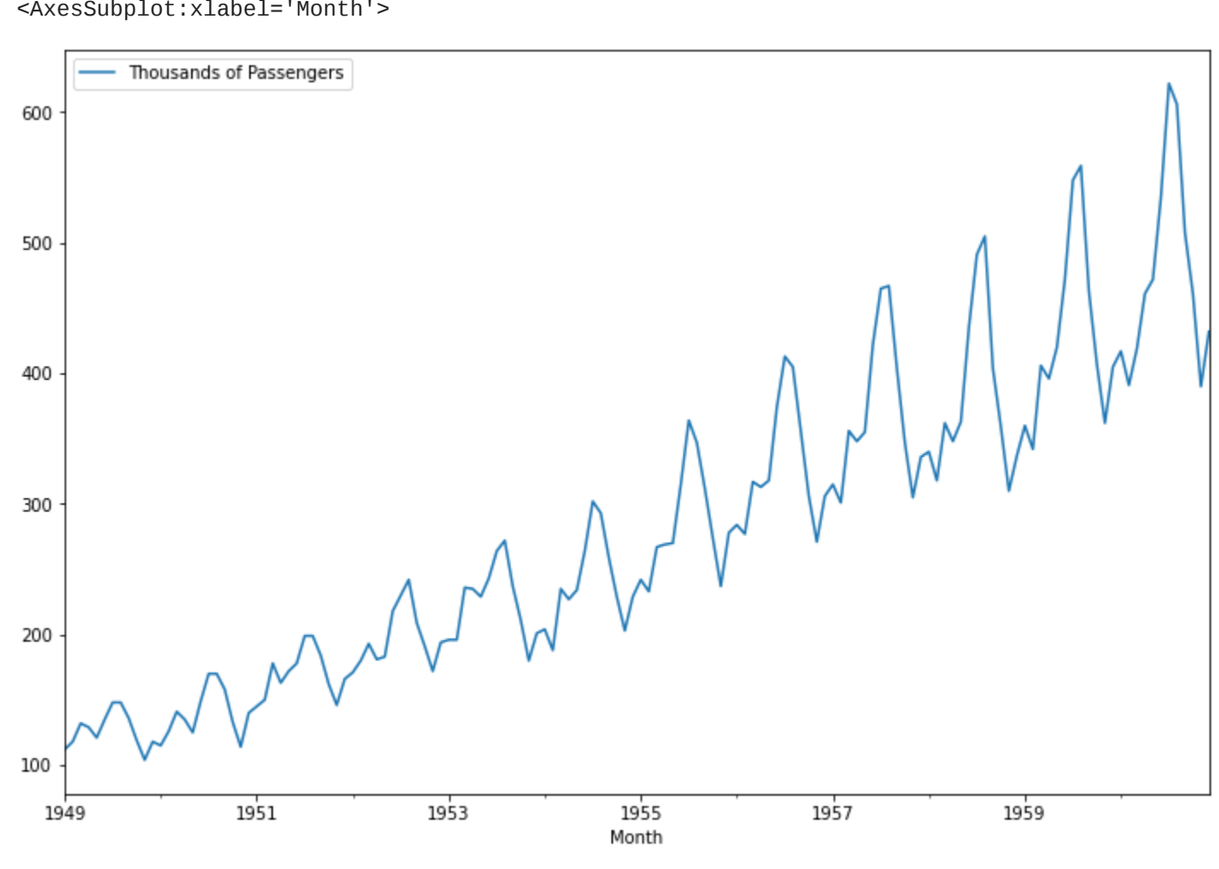
```python
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.statespace.sarimax import SARIMAX
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.tsa.holtwinters import ExponentialSmoothing
from pmdarima import auto_arima
from sklearn.metrics import mean_absolute_percentage_error
```

Airline passengers

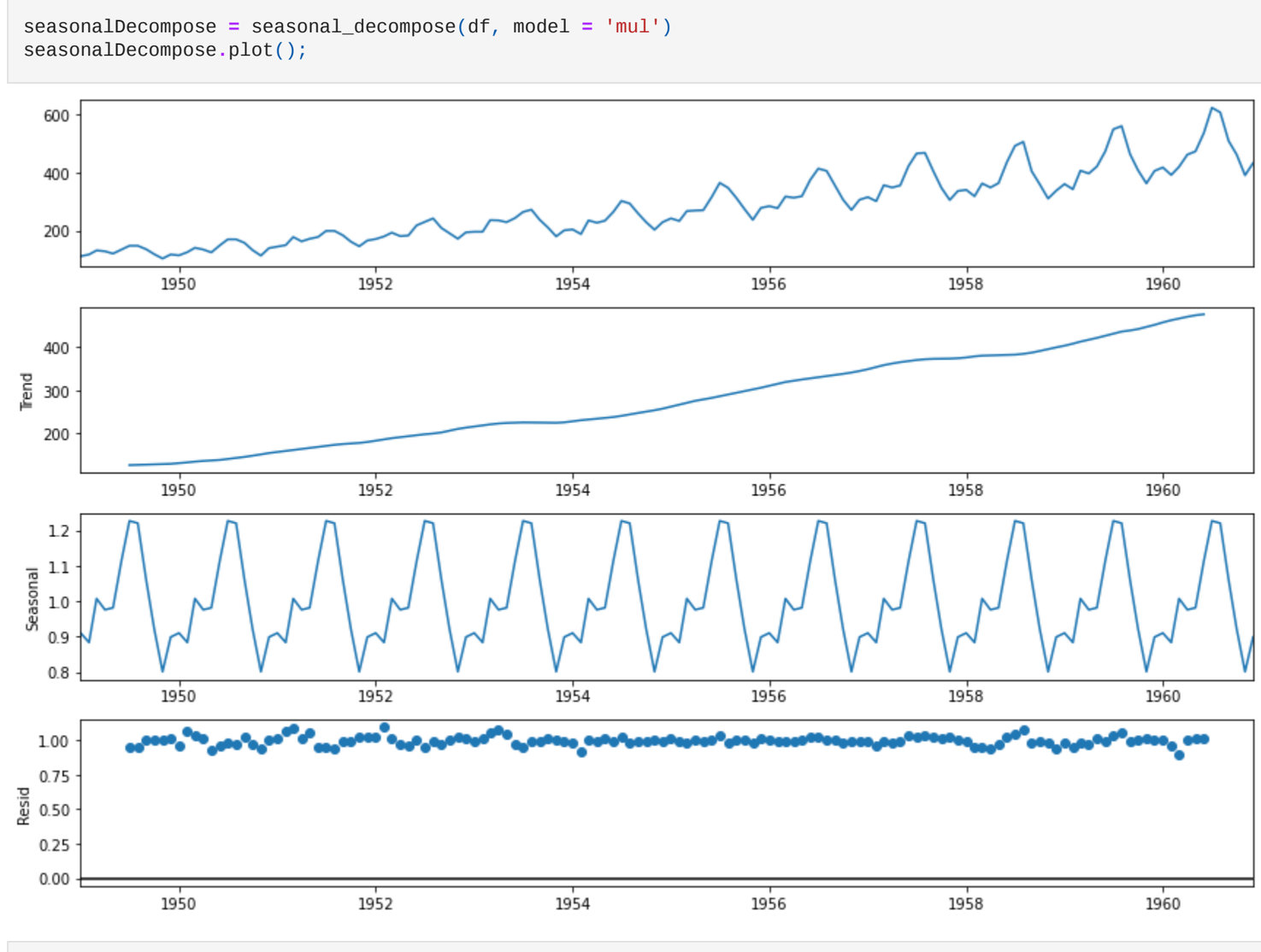
```python
df = pd.read_csv('airline_passengers.csv', index_col = 'Month', parse_dates = True)
df.index.freq = 'MS'
```

```python
plt.rc("figure", figsize=(12,8))
df.plot()
```

Out[ ]: <AxesSubplot:xlabel='Month'>




```python
seasonalDecompose = seasonal_decompose(df, model = 'mul')
seasonalDecompose.plot();
```




```python
auto_arima(df, seasonal = True, m = 12, trace = True).summary()
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(1,1,1)[12]             : AIC=1020.048, Time=0.87 sec
 ARIMA(0,1,0)(0,1,0)[12]             : AIC=1031.508, Time=0.02 sec
 ARIMA(1,1,0)(1,1,0)[12]             : AIC=1020.393, Time=0.08 sec
 ARIMA(0,1,1)(0,1,1)[12]             : AIC=1021.003, Time=0.12 sec
 ARIMA(2,1,2)(0,1,1)[12]             : AIC=1019.935, Time=0.50 sec
 ARIMA(2,1,2)(0,1,0)[12]             : AIC=1019.290, Time=0.17 sec
 ARIMA(2,1,2)(1,1,0)[12]             : AIC=1019.546, Time=0.50 sec
 ARIMA(1,1,2)(0,1,0)[12]             : AIC=1024.160, Time=0.08 sec
 ARIMA(2,1,1)(0,1,0)[12]             : AIC=1017.847, Time=0.20 sec
 ARIMA(2,1,1)(1,1,0)[12]             : AIC=1017.914, Time=0.44 sec
 ARIMA(2,1,1)(0,1,1)[12]             : AIC=1018.359, Time=0.42 sec
 ARIMA(2,1,1)(1,1,1)[12]             : AIC=1018.248, Time=0.88 sec
 ARIMA(1,1,1)(0,1,0)[12]             : AIC=1022.393, Time=0.05 sec
 ARIMA(2,1,0)(0,1,0)[12]             : AIC=1022.393, Time=0.04 sec
 ARIMA(3,1,1)(0,1,0)[12]             : AIC=1019.084, Time=0.19 sec
 ARIMA(1,1,0)(0,1,0)[12]             : AIC=1020.393, Time=0.03 sec
 ARIMA(3,1,0)(0,1,0)[12]             : AIC=1023.666, Time=0.06 sec
 ARIMA(3,1,2)(0,1,0)[12]             : AIC=1021.083, Time=0.31 sec
 ARIMA(2,1,1)(0,1,0)[12] intercept   : AIC=inf, Time=0.36 sec

Best model:  ARIMA(2,1,1)(0,1,0)[12]
Total fit time: 5.342 seconds
```

SARIMAX Results

Dep. Variable:	y	No. Observations:	144
Model:	SARIMAX(2, 1, 1)x(0, 1, [], 12)	Log Likelihood	-504.923
Date:	Tue, 12 Apr 2022	AIC	1017.847
Time:	11:31:16	BIC	1029.348
Sample:	0	HQIC	1022.520
	- 144		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.5960	0.085	6.987	0.000	0.429	0.763
ar.L2	0.2143	0.091	2.343	0.019	0.035	0.394
ma.L1	-0.9819	0.038	-25.601	0.000	-1.057	-0.907
sigma2	129.3132	14.556	8.884	0.000	100.783	157.843

Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	7.68
Prob(Q):	0.98	Prob(JB):	0.02
Heteroskedasticity (H):	2.33	Skew:	-0.01
Prob(H) (two-sided):	0.01	Kurtosis:	4.19

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

```python
train = df.iloc[:-12]
test = df.iloc[-12:]
```

```python
model = SARIMAX(train, order = (2, 1, 1), seasonal_order = (0, 1, 0, 12), enforce_stationarity = False, enforce_invertibility = False)
results = model.fit()
results.summary()
```

SARIMAX Results

Dep. Variable:	Thousands of Passengers	No. Observations:	132
Model:	SARIMAX(2, 1, 1)x(0, 1, [], 12)	Log Likelihood	-439.866
Date:	Tue, 12 Apr 2022	AIC	887.733
Time:	11:37:20	BIC	898.782
Sample:	01-01-1949	HQIC	892.219
	- 12-01-1959		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-1.2150	0.096	-12.620	0.000	-1.404	-1.026
ar.L2	-0.2985	0.083	-3.610	0.000	-0.461	-0.136
ma.L1	1.0000	283.237	0.004	0.997	-554.135	556.135
sigma2	104.5731	2.96e+04	0.004	0.997	-5.79e+04	5.81e+04

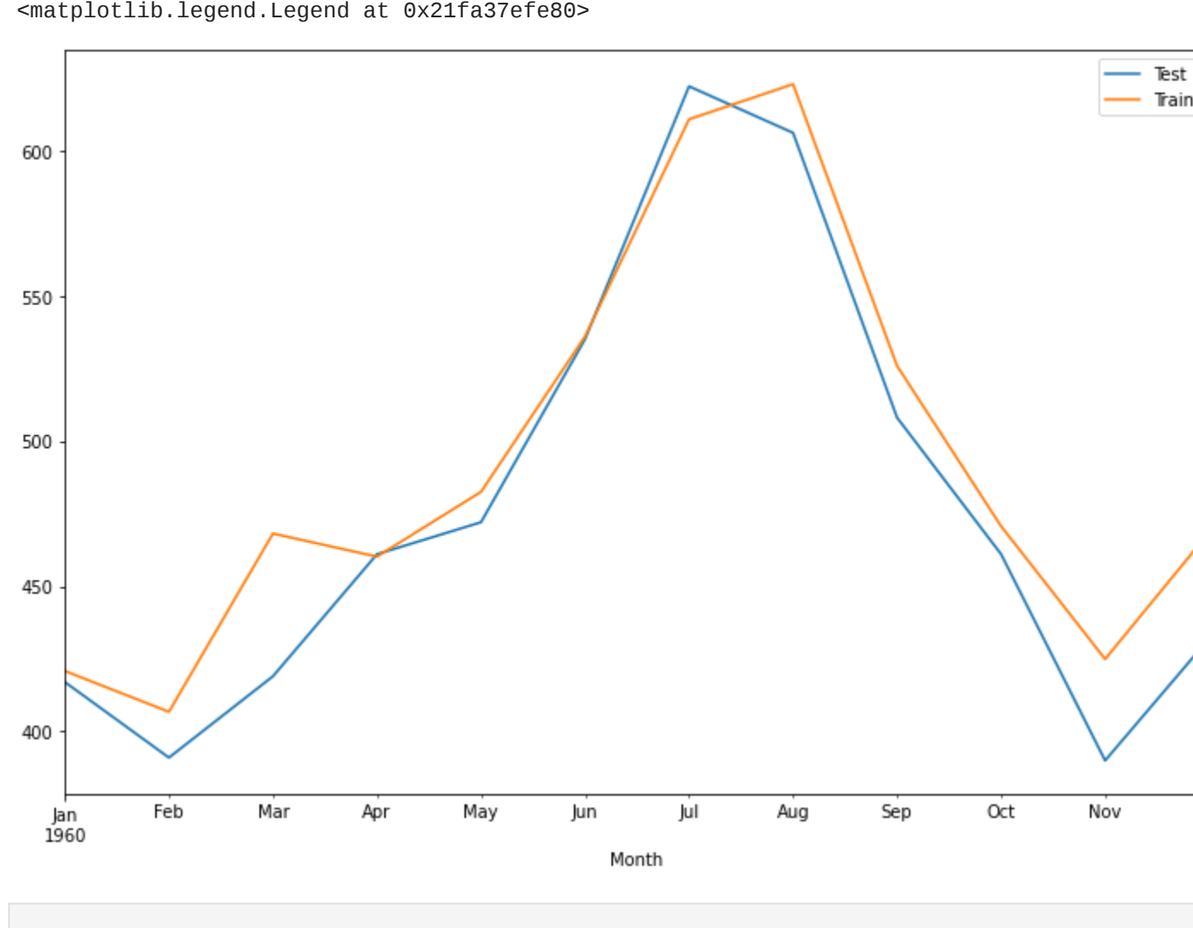
Ljung-Box (L1) (Q):	0.21	Jarque-Bera (JB):	0.30
Prob(Q):	0.64	Prob(JB):	0.86
Heteroskedasticity (H):	1.22	Skew:	-0.05
Prob(H) (two-sided):	0.54	Kurtosis:	3.23

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

```python
start = len(train)
end = start + len(test) - 1
predictions = results.predict(start = start, end = end, dynamic = False).rename('SARIMAX(2, 1, 1)(0, 1, 0, 12)')
```

```python
ax = test.plot()
predictions.plot(ax = ax)
plt.legend(['Test', 'Train', 'SARIMAX(2, 1, 1)(0, 1, 0, 12)'])
```

Out[ ]: <matplotlib.legend.Legend at 0x21fa37efe80>




```python
mean_absolute_percentage_error(test, predictions)
```

Out[ ]: 0.03901651579619179

Ex. 2: Trends in Atmospheric Carbon Dioxide

Import data

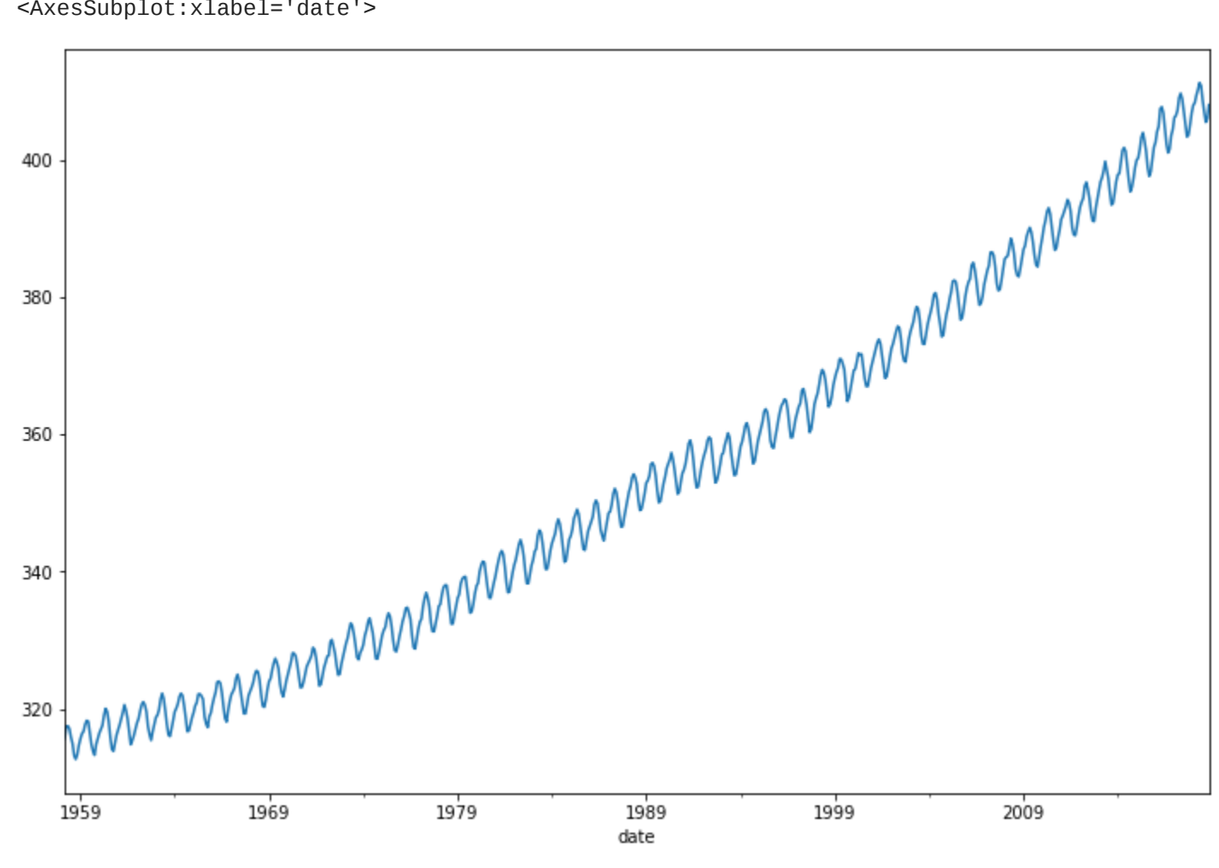
```python
df = pd.read_csv('co2_mm_mlo.csv')
df['date'] = pd.to_datetime(dict(year = df['year'], month = df['month'], day = 1))
```

```python
df = df.set_index(df['date'])
df.index.freq = 'MS'
df.head()
```

date	year	month	decimal_date	average	interpolated	date
1958-03-01	1958	3	1958.208	315.71	315.71	1958-03-01
1958-04-01	1958	4	1958.292	317.45	317.45	1958-04-01
1958-05-01	1958	5	1958.375	317.50	317.50	1958-05-01
1958-06-01	1958	6	1958.458	NaN	317.10	1958-06-01
1958-07-01	1958	7	1958.542	315.86	315.86	1958-07-01

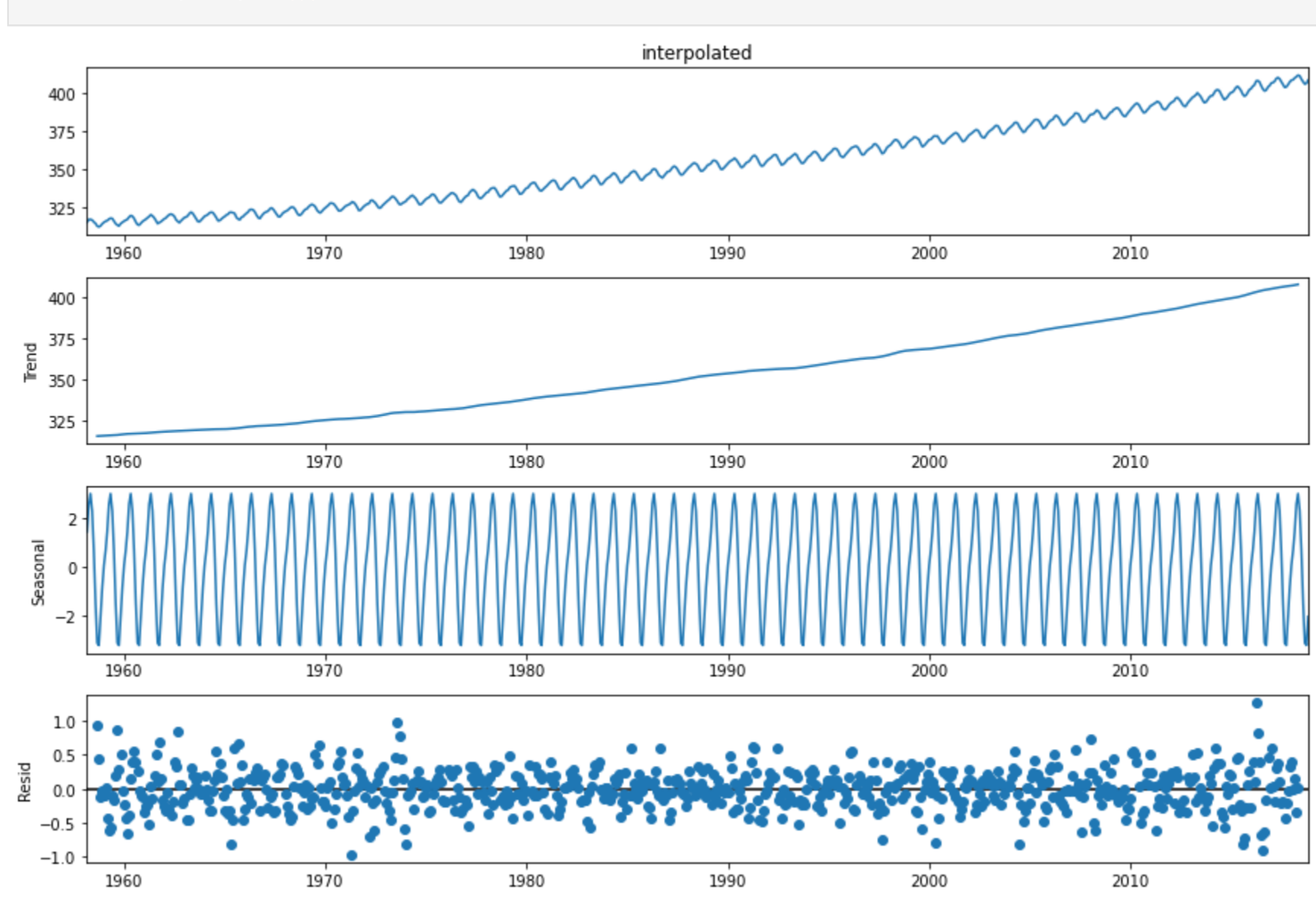
```python
plt.rc("figure", figsize=(12,8))
df['interpolated'].plot()
```

Out[ ]: <AxesSubplot:xlabel='date'>



Check seasonality

```python
seasonalDecompose = seasonal_decompose(df['interpolated'], model = 'add')
seasonalDecompose.plot();
```



Find the best SARIMA model

```python
auto_arima(df['interpolated'], seasonal = True, m = 12, trace = True).summary()
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(1,0,1)[12] intercept   : AIC=468.335, Time=2.13 sec
 ARIMA(0,1,0)(0,0,0)[12] intercept   : AIC=2369.532, Time=0.02 sec
 ARIMA(1,1,0)(1,0,0)[12] intercept   : AIC=inf, Time=0.56 sec
 ARIMA(0,1,1)(0,0,1)[12] intercept   : AIC=1614.808, Time=0.41 sec
 ARIMA(0,1,0)(0,0,0)[12]             : AIC=2375.248, Time=0.02 sec
 ARIMA(2,1,2)(0,0,1)[12] intercept   : AIC=1101.960, Time=1.91 sec
 ARIMA(2,1,2)(1,0,0)[12] intercept   : AIC=770.631, Time=2.01 sec
 ARIMA(2,1,2)(2,0,1)[12] intercept   : AIC=497.272, Time=6.29 sec
 ARIMA(2,1,2)(1,0,2)[12] intercept   : AIC=538.245, Time=5.87 sec
 ARIMA(2,1,2)(0,0,0)[12] intercept   : AIC=1440.918, Time=0.42 sec
 ARIMA(2,1,2)(0,0,2)[12] intercept   : AIC=inf, Time=5.91 sec
 ARIMA(2,1,2)(2,0,0)[12] intercept   : AIC=611.699, Time=5.79 sec
 ARIMA(2,1,2)(2,0,2)[12] intercept   : AIC=inf, Time=8.81 sec
 ARIMA(1,1,2)(1,0,1)[12] intercept   : AIC=463.577, Time=1.54 sec
 ARIMA(1,1,2)(0,0,1)[12] intercept   : AIC=1491.576, Time=0.60 sec
 ARIMA(1,1,2)(1,0,0)[12] intercept   : AIC=775.953, Time=1.58 sec
 ARIMA(1,1,2)(2,0,1)[12] intercept   : AIC=466.421, Time=4.63 sec
 ARIMA(1,1,2)(1,0,2)[12] intercept   : AIC=476.781, Time=6.03 sec
 ARIMA(1,1,2)(0,0,0)[12] intercept   : AIC=1715.503, Time=0.16 sec
 ARIMA(1,1,2)(0,0,2)[12] intercept   : AIC=1348.445, Time=1.61 sec
 ARIMA(1,1,2)(2,0,0)[12] intercept   : AIC=617.614, Time=4.10 sec
 ARIMA(1,1,2)(2,0,2)[12] intercept   : AIC=inf, Time=6.60 sec
 ARIMA(0,1,2)(1,0,1)[12] intercept   : AIC=464.176, Time=1.78 sec
 ARIMA(1,1,1)(1,0,1)[12] intercept   : AIC=460.496, Time=1.90 sec
 ARIMA(1,1,1)(0,0,1)[12] intercept   : AIC=1546.940, Time=0.36 sec
 ARIMA(1,1,1)(1,0,0)[12] intercept   : AIC=789.550, Time=0.82 sec
 ARIMA(1,1,1)(2,0,1)[12] intercept   : AIC=464.588, Time=4.37 sec
 ARIMA(1,1,1)(1,0,2)[12] intercept   : AIC=471.510, Time=5.49 sec
 ARIMA(1,1,1)(0,0,0)[12] intercept   : AIC=1785.006, Time=0.10 sec
 ARIMA(1,1,1)(0,0,2)[12] intercept   : AIC=1393.618, Time=1.23 sec
 ARIMA(1,1,1)(2,0,0)[12] intercept   : AIC=616.707, Time=3.95 sec
 ARIMA(1,1,1)(2,0,2)[12] intercept   : AIC=inf, Time=5.04 sec
 ARIMA(0,1,1)(1,0,1)[12] intercept   : AIC=428.691, Time=1.60 sec
 ARIMA(0,1,1)(1,0,0)[12] intercept   : AIC=791.747, Time=0.47 sec
 ARIMA(0,1,1)(2,0,1)[12] intercept   : AIC=459.525, Time=4.17 sec
 ARIMA(0,1,1)(1,0,2)[12] intercept   : AIC=461.538, Time=4.14 sec
 ARIMA(0,1,1)(0,0,0)[12] intercept   : AIC=1935.623, Time=0.08 sec
 ARIMA(0,1,1)(0,0,2)[12] intercept   : AIC=1425.289, Time=1.28 sec
 ARIMA(0,1,1)(2,0,0)[12] intercept   : AIC=617.368, Time=2.14 sec
 ARIMA(0,1,1)(2,0,2)[12] intercept   : AIC=inf, Time=7.40 sec
 ARIMA(0,1,0)(1,0,1)[12] intercept   : AIC=inf, Time=1.20 sec
 ARIMA(1,1,0)(1,0,1)[12] intercept   : AIC=455.055, Time=1.21 sec
 ARIMA(0,1,1)(1,0,1)[12]             : AIC=426.890, Time=1.15 sec
 ARIMA(0,1,1)(0,0,1)[12]             : AIC=1617.225, Time=0.22 sec
 ARIMA(0,1,1)(1,0,0)[12]             : AIC=790.167, Time=0.22 sec
 ARIMA(0,1,1)(2,0,1)[12]             : AIC=428.901, Time=2.66 sec
 ARIMA(0,1,1)(1,0,2)[12]             : AIC=428.894, Time=3.13 sec
 ARIMA(0,1,1)(0,0,0)[12]             : AIC=1938.917, Time=0.04 sec
 ARIMA(0,1,1)(0,0,2)[12]             : AIC=1427.141, Time=0.61 sec
 ARIMA(0,1,1)(2,0,0)[12]             : AIC=615.666, Time=0.57 sec
 ARIMA(0,1,1)(2,0,2)[12]             : AIC=inf, Time=3.57 sec
 ARIMA(0,1,0)(1,0,1)[12]             : AIC=inf, Time=0.73 sec
 ARIMA(1,1,1)(1,0,1)[12]             : AIC=424.791, Time=1.46 sec
 ARIMA(1,1,1)(0,0,1)[12]             : AIC=1547.266, Time=0.19 sec
 ARIMA(1,1,1)(1,0,0)[12]             : AIC=788.123, Time=0.27 sec
 ARIMA(1,1,1)(2,0,1)[12]             : AIC=426.795, Time=3.15 sec
 ARIMA(1,1,1)(1,0,2)[12]             : AIC=426.790, Time=3.92 sec
 ARIMA(1,1,1)(0,0,0)[12]             : AIC=1785.060, Time=0.05 sec
 ARIMA(1,1,1)(0,0,2)[12]             : AIC=1394.106, Time=0.66 sec
 ARIMA(1,1,1)(2,0,0)[12]             : AIC=615.077, Time=0.79 sec
 ARIMA(1,1,1)(2,0,2)[12]             : AIC=inf, Time=4.44 sec
 ARIMA(1,1,0)(1,0,1)[12]             : AIC=440.281, Time=0.98 sec
 ARIMA(2,1,1)(1,0,1)[12]             : AIC=424.506, Time=1.65 sec
 ARIMA(2,1,1)(0,0,1)[12]             : AIC=1359.815, Time=0.29 sec
 ARIMA(2,1,1)(1,0,0)[12]             : AIC=768.982, Time=0.48 sec
 ARIMA(2,1,1)(2,0,1)[12]             : AIC=426.546, Time=4.18 sec
 ARIMA(2,1,1)(1,0,2)[12]             : AIC=426.504, Time=5.49 sec
 ARIMA(2,1,1)(0,0,0)[12]             : AIC=1532.865, Time=0.08 sec
 ARIMA(2,1,1)(0,0,2)[12]             : AIC=1268.501, Time=0.81 sec
 ARIMA(2,1,1)(2,0,0)[12]             : AIC=607.889, Time=1.75 sec
 ARIMA(2,1,1)(2,0,2)[12]             : AIC=inf, Time=7.50 sec
 ARIMA(2,1,0)(1,0,1)[12]             : AIC=435.234, Time=1.61 sec
 ARIMA(3,1,1)(1,0,1)[12]             : AIC=448.825, Time=2.24 sec
 ARIMA(2,1,2)(1,0,1)[12]             : AIC=427.219, Time=1.91 sec
 ARIMA(1,1,2)(1,0,1)[12]             : AIC=441.903, Time=1.55 sec
 ARIMA(3,1,0)(1,0,1)[12]             : AIC=430.476, Time=1.28 sec
 ARIMA(3,1,2)(1,0,1)[12]             : AIC=427.893, Time=1.96 sec
 ARIMA(2,1,1)(1,0,1)[12] intercept   : AIC=462.283, Time=2.44 sec

Best model:  ARIMA(2,1,1)(1,0,1)[12]
Total fit time: 179.819 seconds
```

SARIMAX Results

Dep. Variable:	y	No. Observations:	729
Model:	SARIMAX(2, 1, 1)x(1, 0, 1, 12)	Log Likelihood	-206.253
Date:	Tue, 12 Apr 2022	AIC	424.506
Time:	12:17:37	BIC	452.047
Sample:	0	HQIC	435.133
	- 729		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.3482	0.058	6.042	0.000	0.235	0.461
ar.L2	0.0877	0.021	4.091	0.000	0.046	0.130
ma.L1	-0.7045	0.046	-15.157	0.000	-0.796	-0.613
ar.S.L12	0.9996	0.000	3009.602	0.000	0.999	1.000
ma.S.L12	-0.8661	0.021	-40.621	0.000	-0.908	-0.824
sigma2	0.0957	0.005	21.160	0.000	0.087	0.105

Ljung-Box (L1) (Q):	0.06	Jarque-Bera (JB):	4.47
Prob(Q):	0.81	Prob(JB):	0.11
Heteroskedasticity (H):	1.13	Skew:	-0.00
Prob(H) (two-sided):	0.34	Kurtosis:	3.38

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

Train the model

```python
train = df.iloc[:-12]
test = df.iloc[-12:]
```

```python
model = SARIMAX(train['interpolated'], order = (2, 1, 1), seasonal_order = (1, 0, 1, 12), enforce_stationarity = False, enforce_invertibility = False)
results = model.fit()
results.summary()
```

```
C:\Users\Rudy\AppData\Local\Programs\Python\Python39\lib\site-packages\statsmodels\base\model.py:604: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
```

SARIMAX Results

Dep. Variable:	interpolated	No. Observations:	717
Model:	SARIMAX(2, 1, 1)x(1, 0, 1, 12)	Log Likelihood	-172.734
Date:	Tue, 12 Apr 2022	AIC	357.468
Time:	12:21:17	BIC	384.792
Sample:	03-01-1958	HQIC	368.029
	- 11-01-2017		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.2547	0.128	1.992	0.046	0.004	0.505
ar.L2	0.0517	0.068	0.756	0.450	-0.082	0.186
ma.L1	-0.6287	0.126	-4.993	0.000	-0.875	-0.382
ar.S.L12	1.0036	0.001	1114.837	0.000	1.002	1.005
ma.S.L12	-1.1222	0.027	-41.728	0.000	-1.175	-1.069
sigma2	0.0739	0.005	14.837	0.000	0.064	0.084

Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	6.11
Prob(Q):	0.98	Prob(JB):	0.05
Heteroskedasticity (H):	1.17	Skew:	-0.04
Prob(H) (two-sided):	0.22	Kurtosis:	3.45

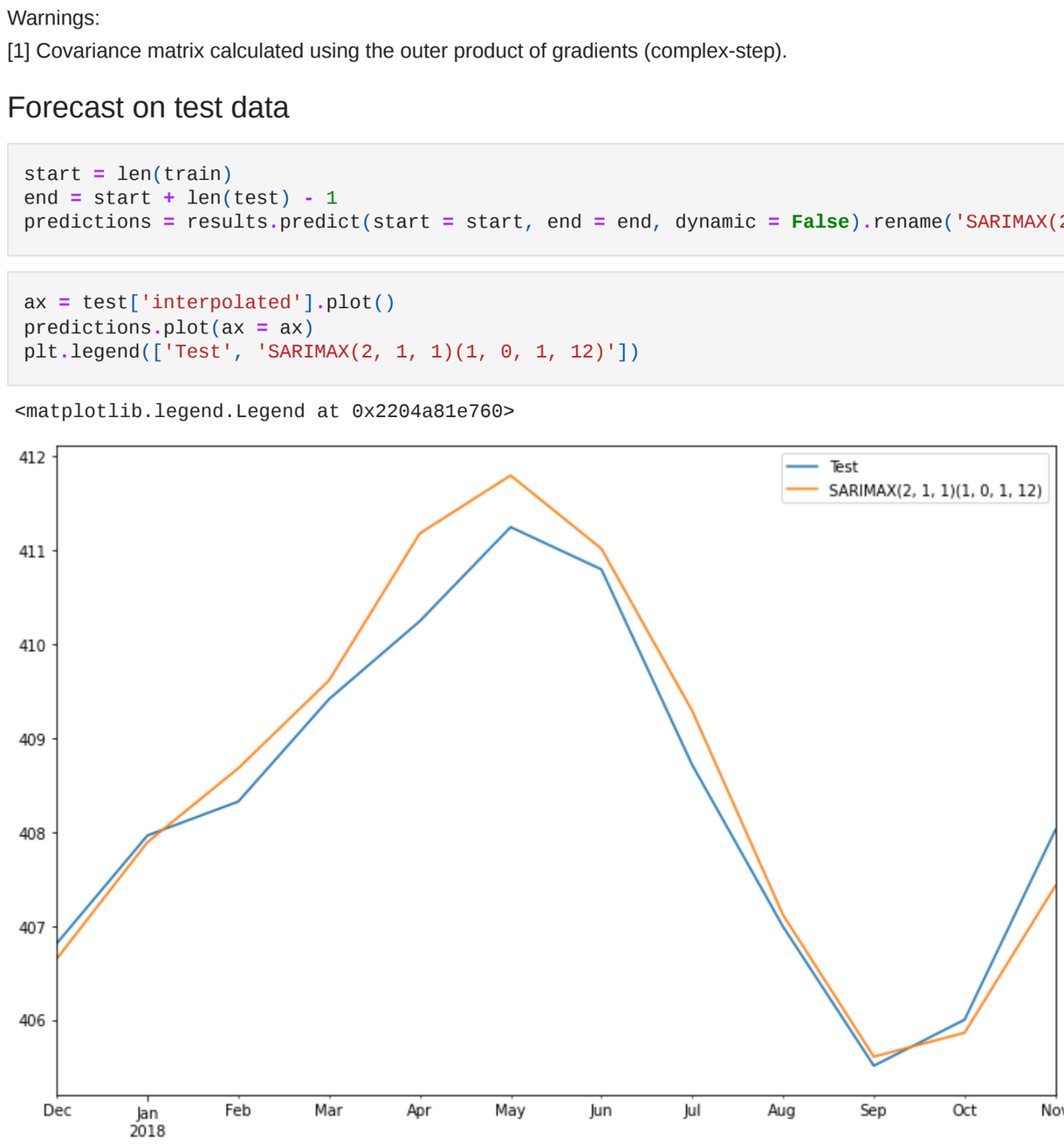
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Forecast on test data

```python
start = len(train)
end = start + len(test) - 1
predictions = results.predict(start = start, end = end, dynamic = False).rename('SARIMAX(2, 1, 1)(1, 0, 1, 12)')
```

```python
ax = test['interpolated'].plot()
predictions.plot(ax = ax)
plt.legend(['Test', 'SARIMAX(2, 1, 1)(1, 0, 1, 12)'])
```

Out[ ]: <matplotlib.legend.Legend at 0x2204a81e760>




```python
mean_absolute_percentage_error(test['interpolated'], predictions)
```

Out[ ]: 0.0008194089691475436

Holt-Winter's method

```python
fitHoltWinter = ExponentialSmoothing(train['interpolated'], trend = 'mul', seasonal = 'add', seasonal_periods = 12).fit()
fcastHoltWinter = fitHoltWinter.forecast(len(test)).rename("Holt-Winter's predict")
```

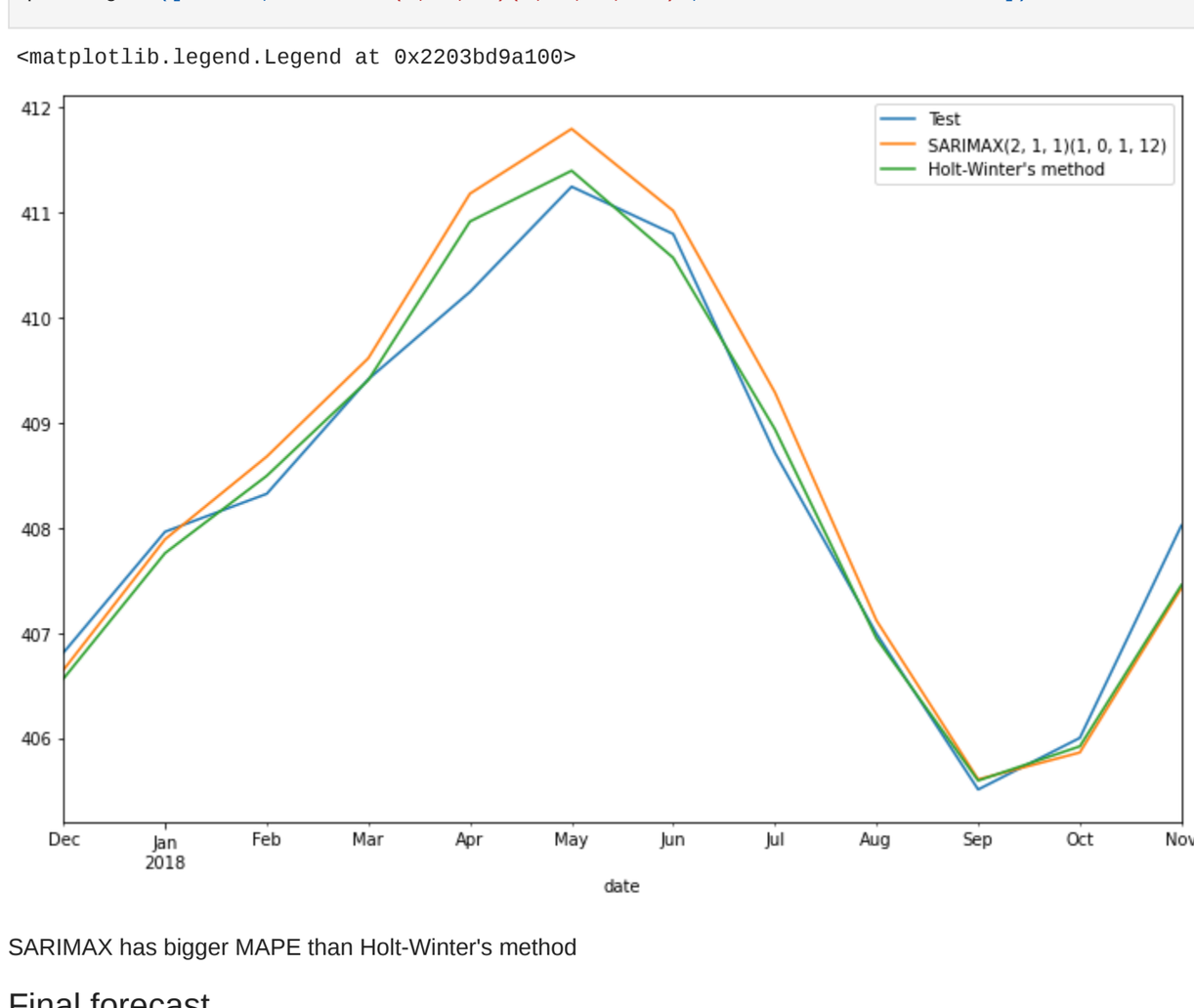
```
C:\Users\Rudy\AppData\Local\Programs\Python\Python39\lib\site-packages\statsmodels\tsa\holtwinters\model.py:83: RuntimeWarning: overflow encountered in matmul
  return err.T @ err
```

```python
mean_absolute_percentage_error(test['interpolated'], fcastHoltWinter)
```

Out[ ]: 0.0005456164306626218

```python
ax = test['interpolated'].plot()
predictions.plot(ax = ax)
fcastHoltWinter.plot(ax = ax)
plt.legend(['Test', 'SARIMAX(2, 1, 1)(1, 0, 1, 12)', "Holt-Winter's method"])
```

Out[ ]: <matplotlib.legend.Legend at 0x2203bd9a100>



SARIMAX has bigger MAPE than Holt-Winter's method

Final forecast

```python
model = SARIMAX(df['interpolated'], order = (2, 1, 1), seasonal_order = (1, 0, 1, 12), enforce_stationarity = False, enforce_invertibility = False)
results = model.fit()
results.summary()
```

SARIMAX Results

Dep. Variable:	interpolated	No. Observations:	729
Model:	SARIMAX(2, 1, 1)x(1, 0, 1, 12)	Log Likelihood	-177.823
Date:	Tue, 12 Apr 2022	AIC	367.646
Time:	12:32:11	BIC	395.071
Sample:	03-01-1958	HQIC	378.238
	- 11-01-2018		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.2595	0.130	1.999	0.046	0.005	0.514
ar.L2	0.0577	0.069	0.841	0.400	-0.077	0.192
ma.L1	-0.6326	0.128	-4.949	0.000	-0.883	-0.382
ar.S.L12	1.0034	0.001	1113.951	0.000	1.002	1.005
ma.S.L12	-1.1232	0.026	-43.202	0.000	-1.174	-1.072
sigma2	0.0743	0.005	15.266	0.000	0.065	0.084

Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	5.94
Prob(Q):	0.98	Prob(JB):	0.05
Heteroskedasticity (H):	1.17	Skew:	-0.06
Prob(H) (two-sided):	0.22	Kurtosis:	3.43

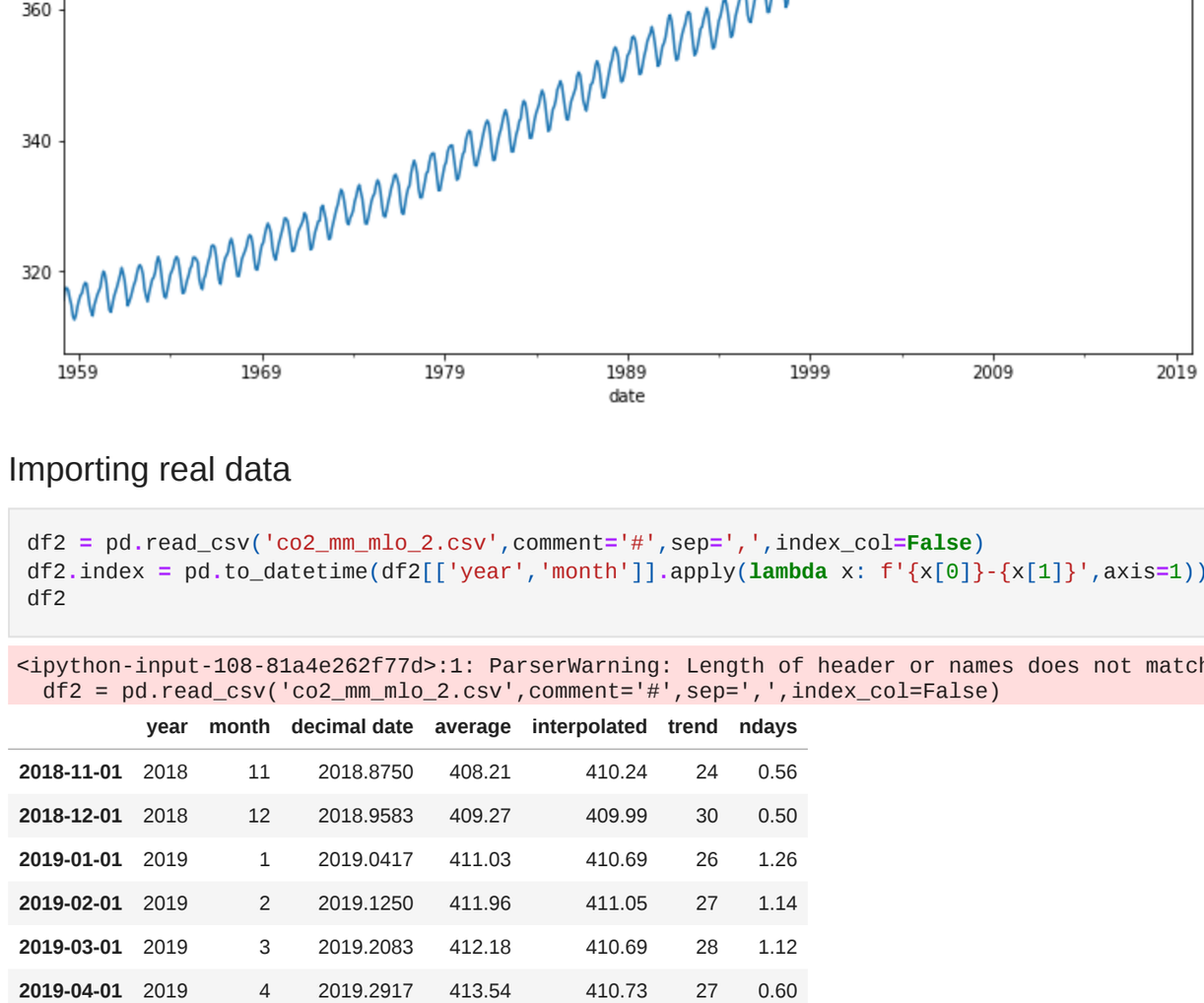
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

```python
start = len(df) - 1
end = start + 12
predictions = results.predict(start = start, end = end, dynamic = False).rename('SARIMAX(2, 1, 1)(1, 0, 1, 12)')
predictions
```

```
2018-11-01    407.432756
2018-12-01    409.285287
2019-01-01    410.476142
2019-02-01    411.187804
2019-03-01    412.132612
2019-04-01    413.613458
2019-05-01    414.272541
2019-06-01    413.527971
2019-07-01    411.758880
2019-08-01    409.636435
2019-09-01    408.128743
2019-10-01    408.411478
2019-11-01    410.029608
Freq: MS, Name: SARIMAX(2, 1, 1)(1, 0, 1, 12), dtype: float64
```

```python
ax = df['interpolated'].plot()
predictions.plot(ax = ax)
plt.legend(['Data', 'SARIMAX(2, 1, 1)(1, 0, 1, 12)'])
```

Out[ ]: <matplotlib.legend.Legend at 0x220444c3eb0>



Importing real data

```python
df2 = pd.read_csv('co2_mm_mlo_2.csv',comment='#',sep=',',index_col=False)
df2.index = pd.to_datetime(df2[['year','month']].apply(lambda x: f'{x[0]}-{x[1]}',axis=1))
df2
```

```
<ipython-input-108-81a4e262f77d>:1: ParserWarning: Length of header or names does not match length of data. This leads to a loss of data with index_col=False.
  df2 = pd.read_csv('co2_mm_mlo_2.csv',comment='#',sep=',',index_col=False)
```

	year	month	decimal date	average	interpolated	trend	ndays
2018-11-01	2018	11	2018.8750	408.21	410.24	24	0.56
2018-12-01	2018	12	2018.9583	409.27	409.99	30	0.50
2019-01-01	2019	1	2019.0417	411.03	410.69	26	1.26
2019-02-01	2019	2	2019.1250	411.96	411.05	27	1.14
2019-03-01	2019	3	2019.2083	412.18	410.69	28	1.12
2019-04-01	2019	4	2019.2917	413.54	410.73	27	0.60
2019-05-01	2019	5	2019.3750	414.86	411.38	28	0.50
2019-06-01	2019	6	2019.4583	414.16	411.76	27	0.36
2019-07-01	2019	7	2019.5417	411.97	411.63	25	0.82
2019-08-01	2019	8	2019.6250	410.18	412.12	29	0.33
2019-09-01	2019	9	2019.7083	408.76	412.37	30	0.38
2019-10-01	2019	10	2019.7917	408.75	412.12	29	0.31
2019-11-01	2019	11	2019.8750	410.48	412.52	26	0.40

```python
ax = df2['average'].plot()
predictions.plot(ax = ax)
plt.legend(['Data', 'SARIMAX(2, 1, 1)(1, 0, 1, 12)'])
```

Out[ ]: <matplotlib.legend.Legend at 0x21fb0ed5610>


```python
mean_absolute_percentage_error(df2['average'], predictions)
```

Out[ ]: 0.0010542615361251405