Demonstration for Time series forecasting

Forecasting for the count infected by COVID-19 (USA)

Author: Jim Xie

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In [1]:
```python
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import pandas as pd
import seaborn as sns
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.stattools import adfuller
from statsmodels.stats.diagnostic import acorr_ljungbox
from statsmodels.tsa.arima_model import ARMA
from statsmodels.tsa.arima_model import ARIMA
import json
plt.style.use({'figure.figsize':(12, 5)})
sns.set_style('dark')
sns.set_context("poster")
#np.set_printoptions(suppress=True,   precision=10,  threshold=2000,  linewidth=150)
pd.set_option('display.float_format',lambda x : '%.2f' % x)
plt.rcParams['axes.unicode_minus'] = False
from warnings import filterwarnings
filterwarnings('ignore')
```

Prepare train data

In [2]:
```python
df = pd.read_csv('./US/us_states_covid19_daily.csv')
df = pd.read_csv('./US-812/us_states_covid19_daily.csv')
df = pd.read_csv('./US-830/us_states_covid19_daily.csv')
del df['hash']
del df['commercialScore']
del df['negativeRegularScore']
del df['negativeScore']
del df['positiveScore']
del df['score']
del df['grade']
del df['hospitalizedIncrease']
del df['deathIncrease']
del df['hospitalizedCumulative']
del df['hospitalizedCurrently']
del df['inIcuCurrently']
del df['inIcuCumulative']
del df['onVentilatorCurrently']
del df['onVentilatorCumulative']
del df['recovered']
del df['lastUpdateEt']
del df['dateModified']
del df['checkTimeEt']
del df['dateChecked']
df['date'] = df['date'].astype(str)
df.fillna(value=0,inplace=True)
df.head(5)
```

Out[2]:

	date	state	positive	negative	pending	dataQualityGrade	death	hospitalized	totalTestsViral	positiveTestsViral	...	totalTestsAntigen	positiveTes
0	20200829	AK	6035.00	339660.00	0.00	A	37.00	0.00	345695.00	5558.00	...	0.00	
1	20200829	AL	123889.00	851929.00	0.00	B	2152.00	14267.00	967213.00	0.00	...	0.00	
2	20200829	AR	60378.00	646592.00	0.00	A	772.00	4142.00	706970.00	0.00	...	3610.00	
3	20200829	AS	0.00	1514.00	0.00	C	0.00	0.00	0.00	0.00	...	0.00	
4	20200829	AZ	201287.00	991089.00	0.00	A+	5007.00	21433.00	1190668.00	0.00	...	0.00	

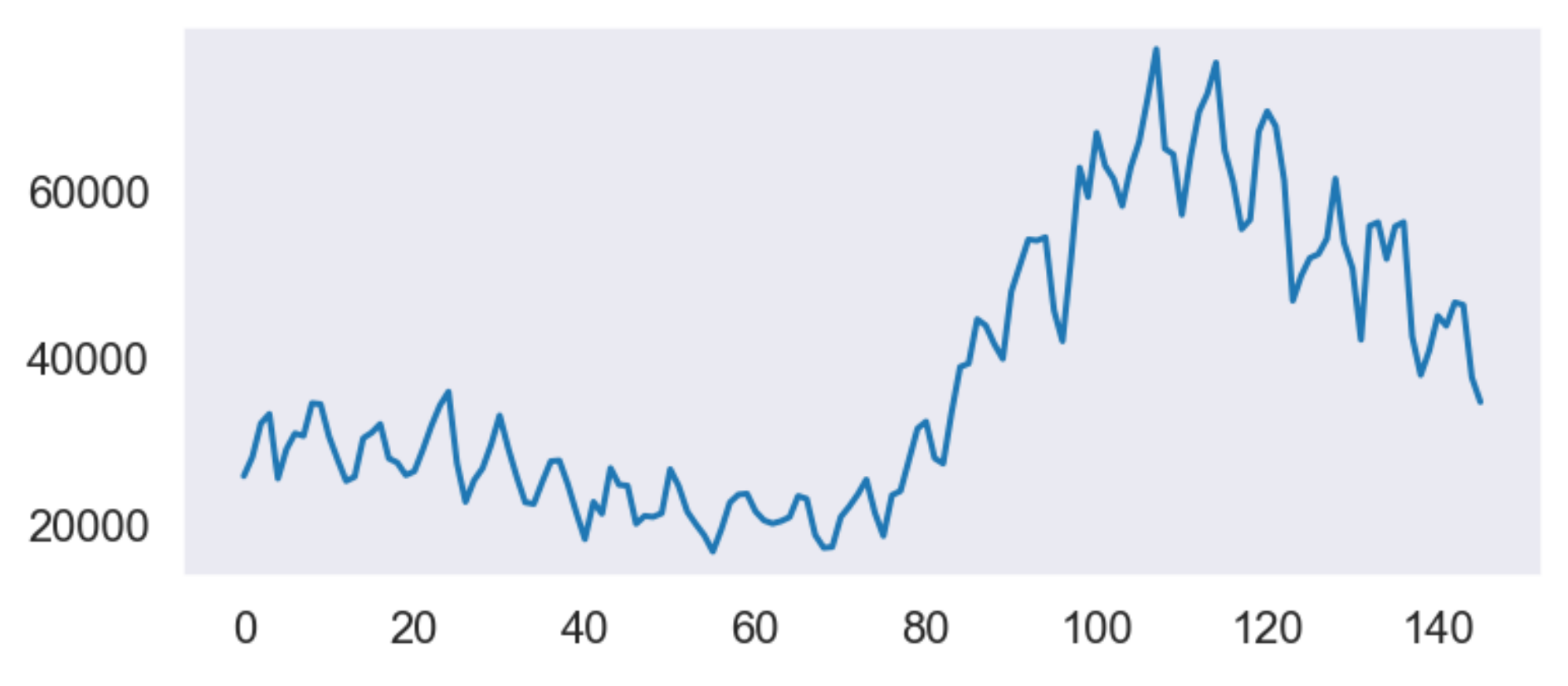
5 rows × 34 columns

In [3]:
```python
def GetRawSamples():
    df2 = pd.DataFrame()
    df2['date'] = df['date']
    df2['state'] = df['state']
    df2['positive']=df['positive']
    df2['positiveIncrease']=df['positiveIncrease']
    df2['test'] = df['total']
    df2['testIncrease'] = df['totalTestResultsIncrease']
    df2.sort_values('date',ascending=True,inplace=True)
    df2 = df2[df2['date']>='20200401']
    df2 = df2.reset_index()
    del df2['index']
    return df2

def GetSamples(state = None):
    dr = GetRawSamples()
    if state:
        dr = dr[dr['state']==state]
    else:
        dr = dr.groupby(['date'])['positive','positiveIncrease','test','testIncrease'].agg('sum')
        #dr = dr.to_frame().reset_index()
        dr['state'] = 'ALL'
    dr.sort_values('date',ascending=True,inplace=True)
    dr = dr.reset_index()
    return dr
```

In [4]:
```python
#ADF Test result同时小于1%、5%、10%
#P-value（不变显著性）接近0。
def check_stationarity(timeSeries):
    dftest = adfuller(timeSeries)
    dfoutput = pd.Series(dftest[0:4], index=['Test Statistic','p-value','#Lags Used','Number of Observations Used'])
    for key,value in dftest[4].items():
        dfoutput['Critical Value (%s)'%key] = value
    del dfoutput['#Lags Used']
    del dfoutput['Number of Observations Used']
    return dfoutput
```

In [5]:
```python
df0 = GetSamples()
verify_count = 5
df_verify = df0.tail(verify_count)
df0.drop(df0.tail(verify_count).index,inplace=True)
data = pd.DataFrame()
raw_data = df0['positiveIncrease']
raw_date = df0['date']
log_data = np.log(raw_data)
raw_data.plot()
```

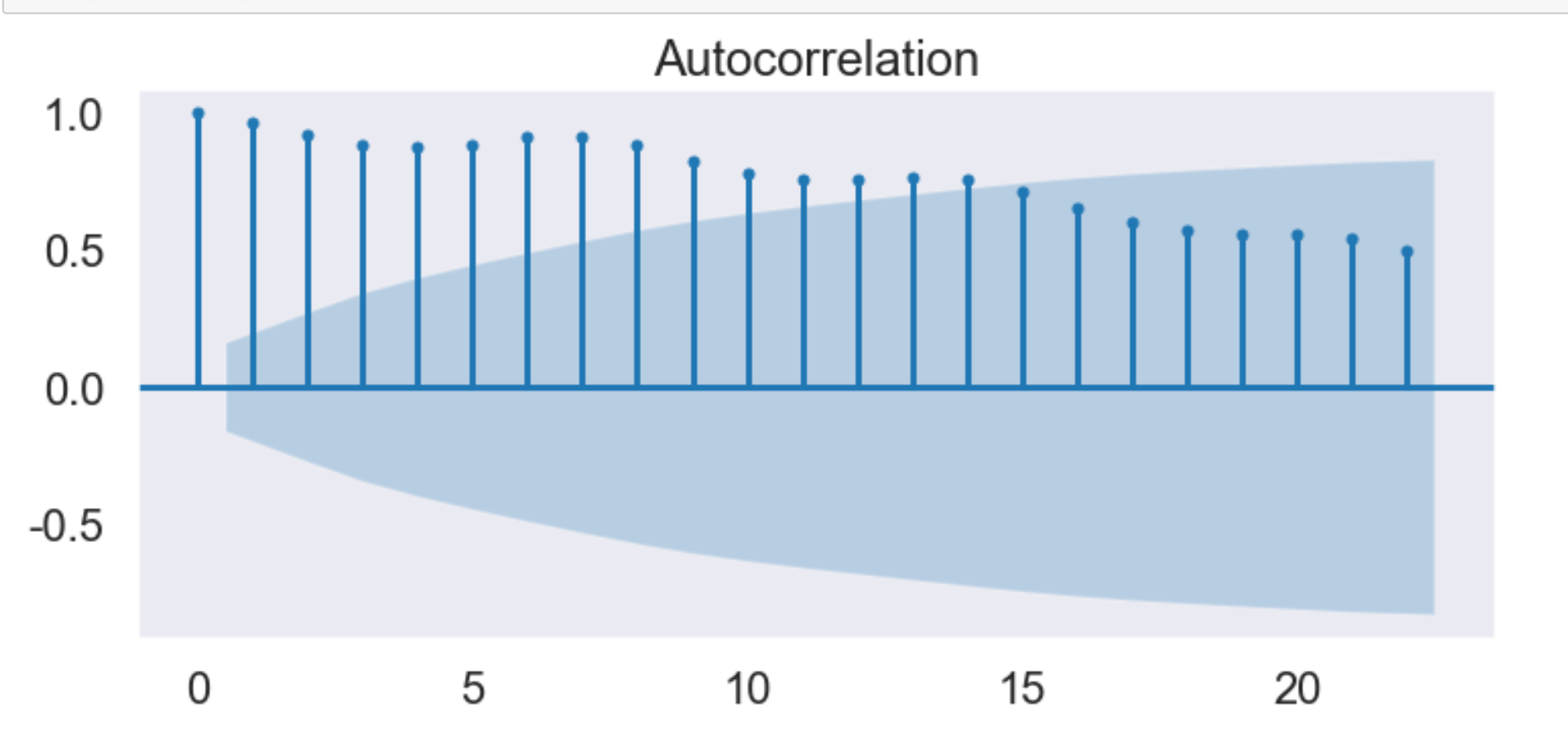
Out[5]:
```
<AxesSubplot:>
```

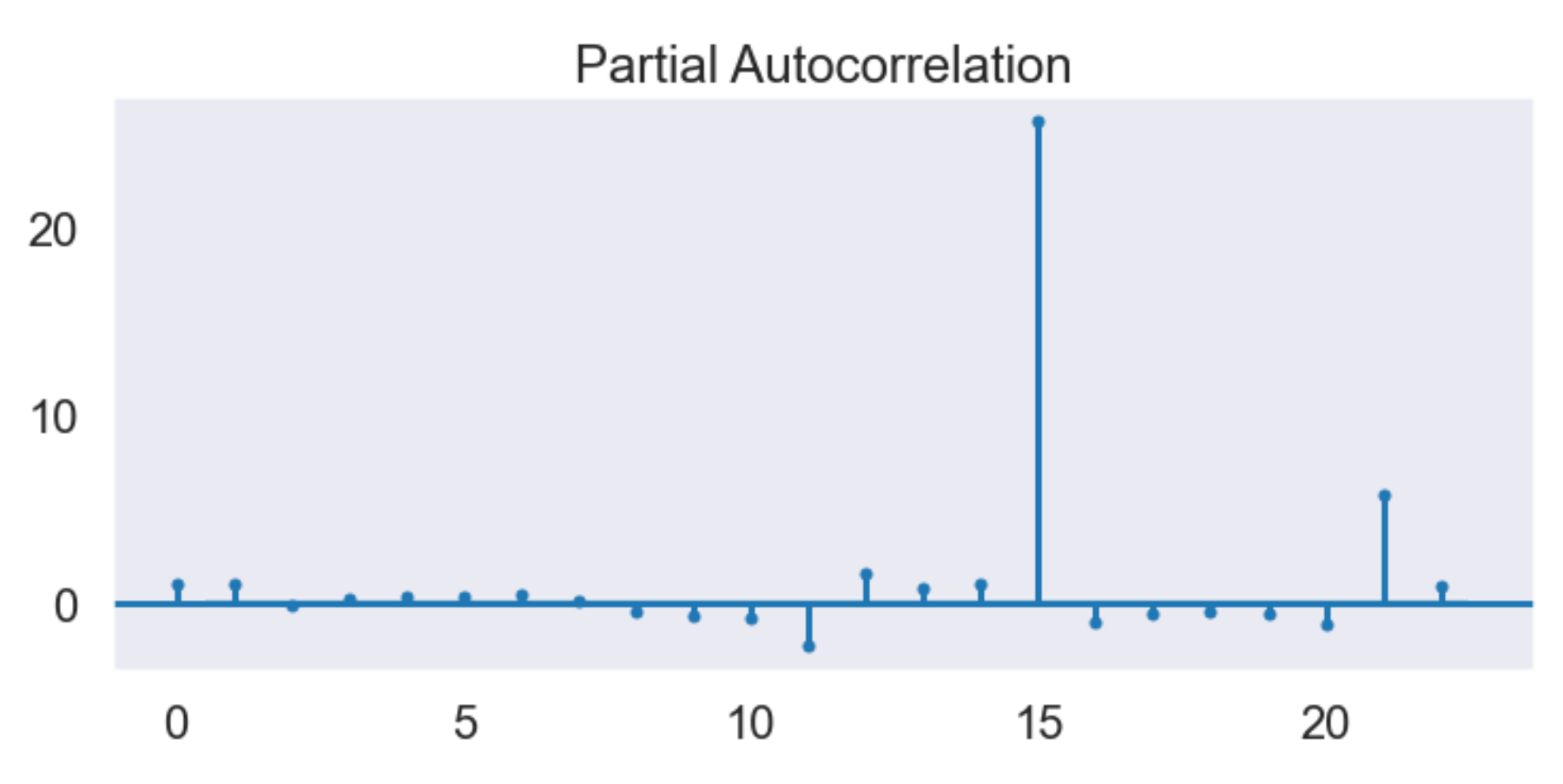


In [6]:
```python
check_stationarity(raw_data)
```

Out[6]:
```
Test Statistic         -1.74
p-value                 0.41
Critical Value (1%)    -3.48
Critical Value (5%)    -2.88
Critical Value (10%)   -2.58
dtype: float64
```

In [7]:
```python
plot_acf(raw_data).show()
plot_pacf(raw_data).show()
```



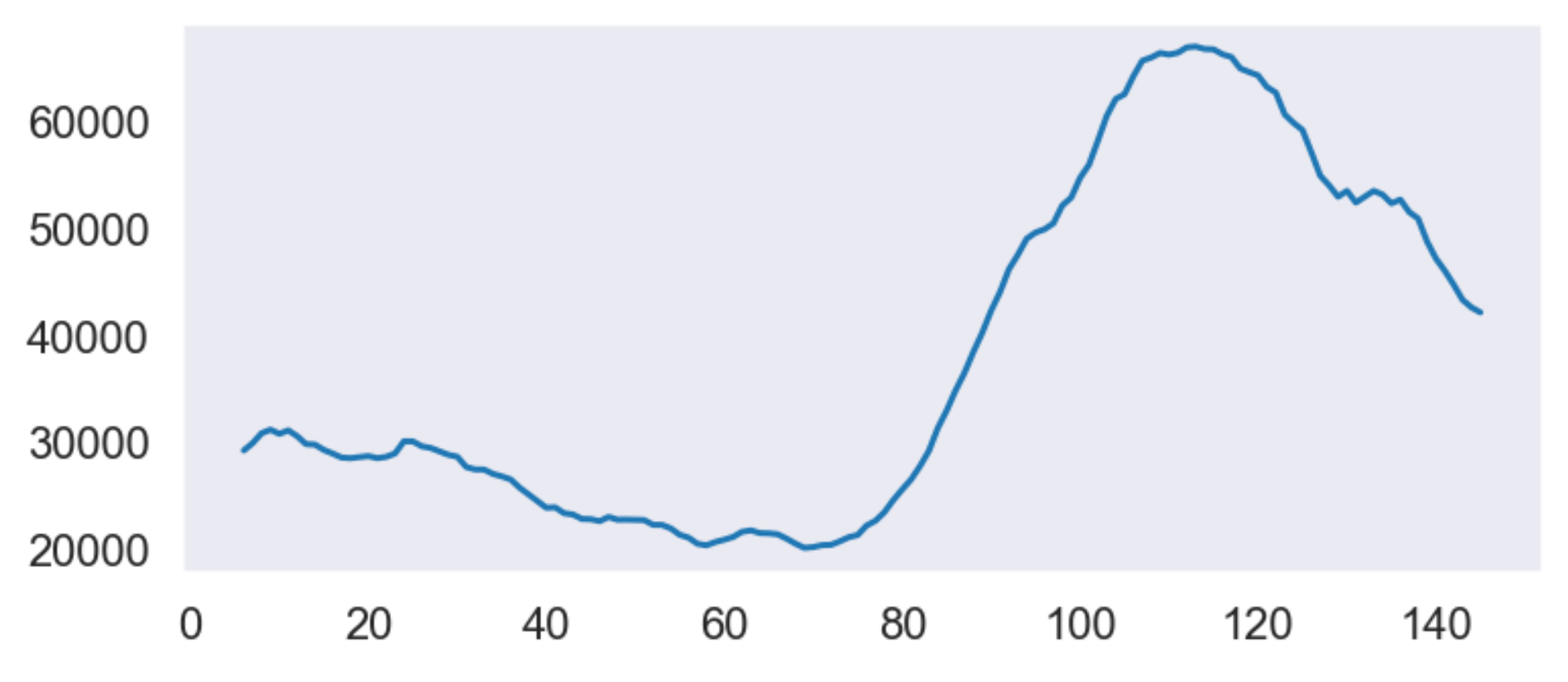


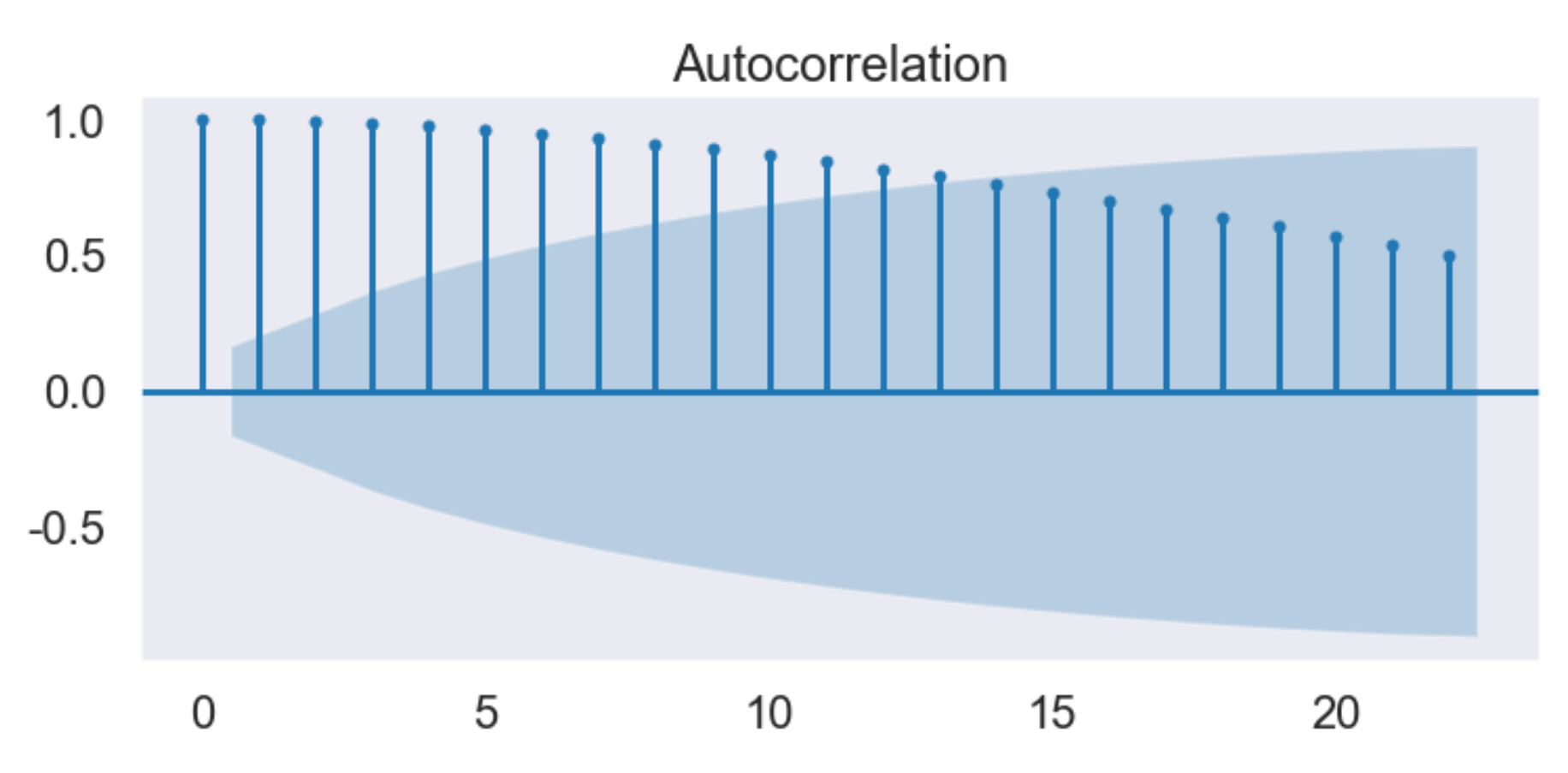
In [8]:
```python
data_mean = raw_data.rolling(window=7).mean()
data_mean.dropna(inplace=True)
```

In [9]:
```python
check_stationarity(data_mean)
```

Out[9]:
```
Test Statistic         -2.09
p-value                 0.25
Critical Value (1%)    -3.48
Critical Value (5%)    -2.88
Critical Value (10%)   -2.58
dtype: float64
```

In [10]:
```python
data_mean.plot()
plot_acf(data_mean).show()
```



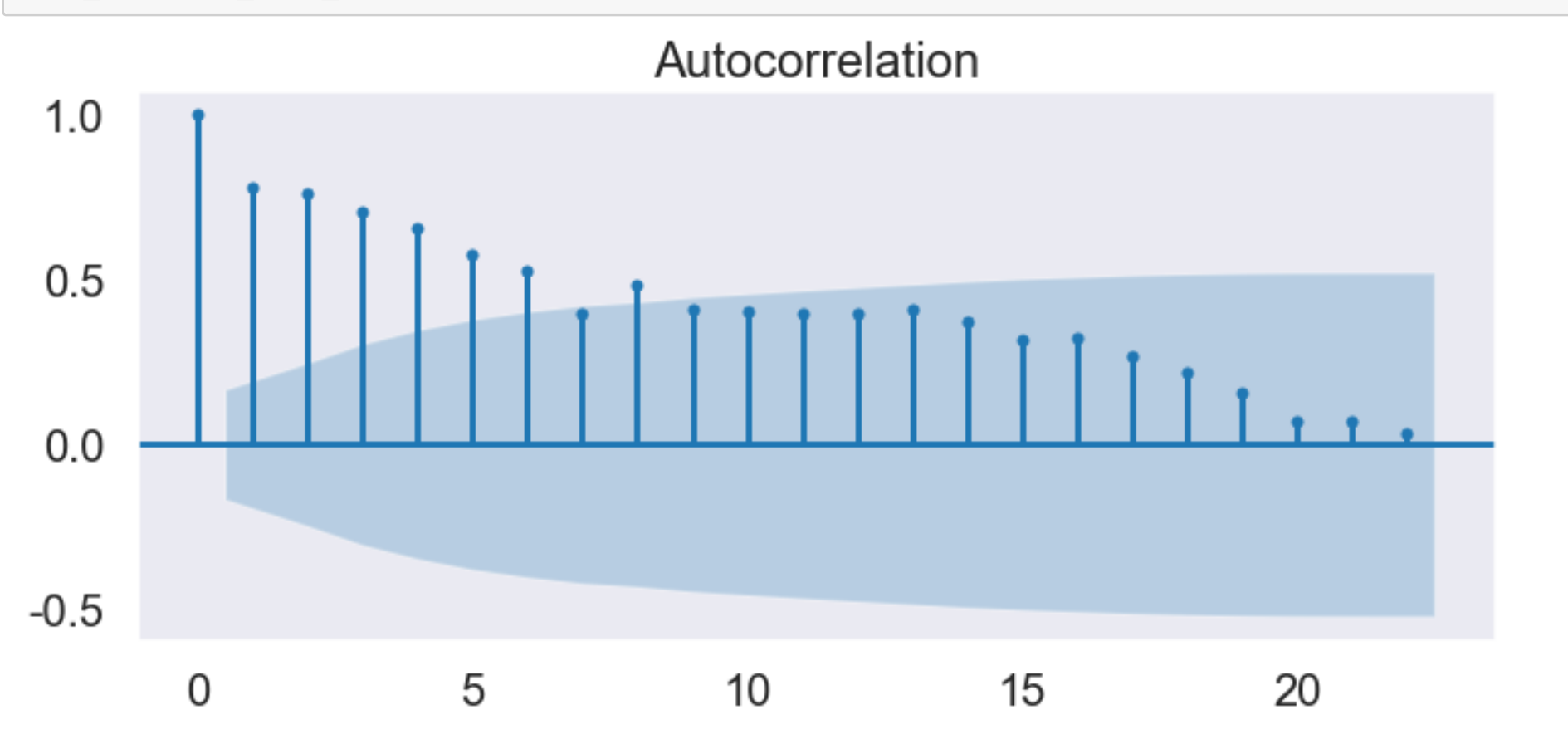


In [11]:
```python
data_diff_1 = data_mean.diff(1)
data_diff_1.dropna(inplace=True)
data_diff_2 = data_diff_1.diff(1)
data_diff_2.dropna(inplace=True)
#data_diff_3 = data_diff_2.diff(1)
#data_diff_3.dropna(inplace=True)
#check_stationarity(data_diff_3)
```

In [12]:
```python
check_stationarity(data_diff_1)
```

Out[12]:
```
Test Statistic         -1.57
p-value                 0.50
Critical Value (1%)    -3.48
Critical Value (5%)    -2.88
Critical Value (10%)   -2.58
dtype: float64
```

In [13]:
```python
plot_acf(data_diff_1).show()
```

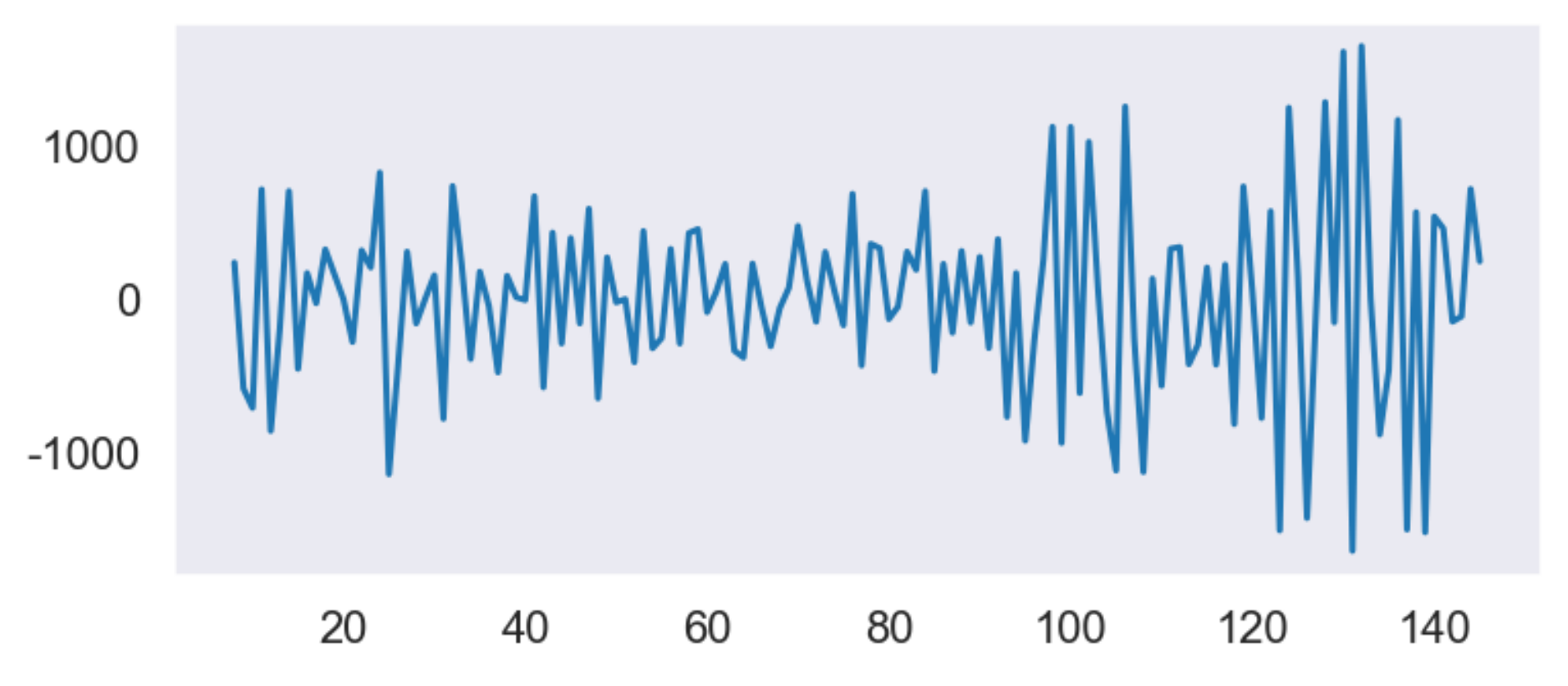


In [14]:
```python
check_stationarity(data_diff_2)
```

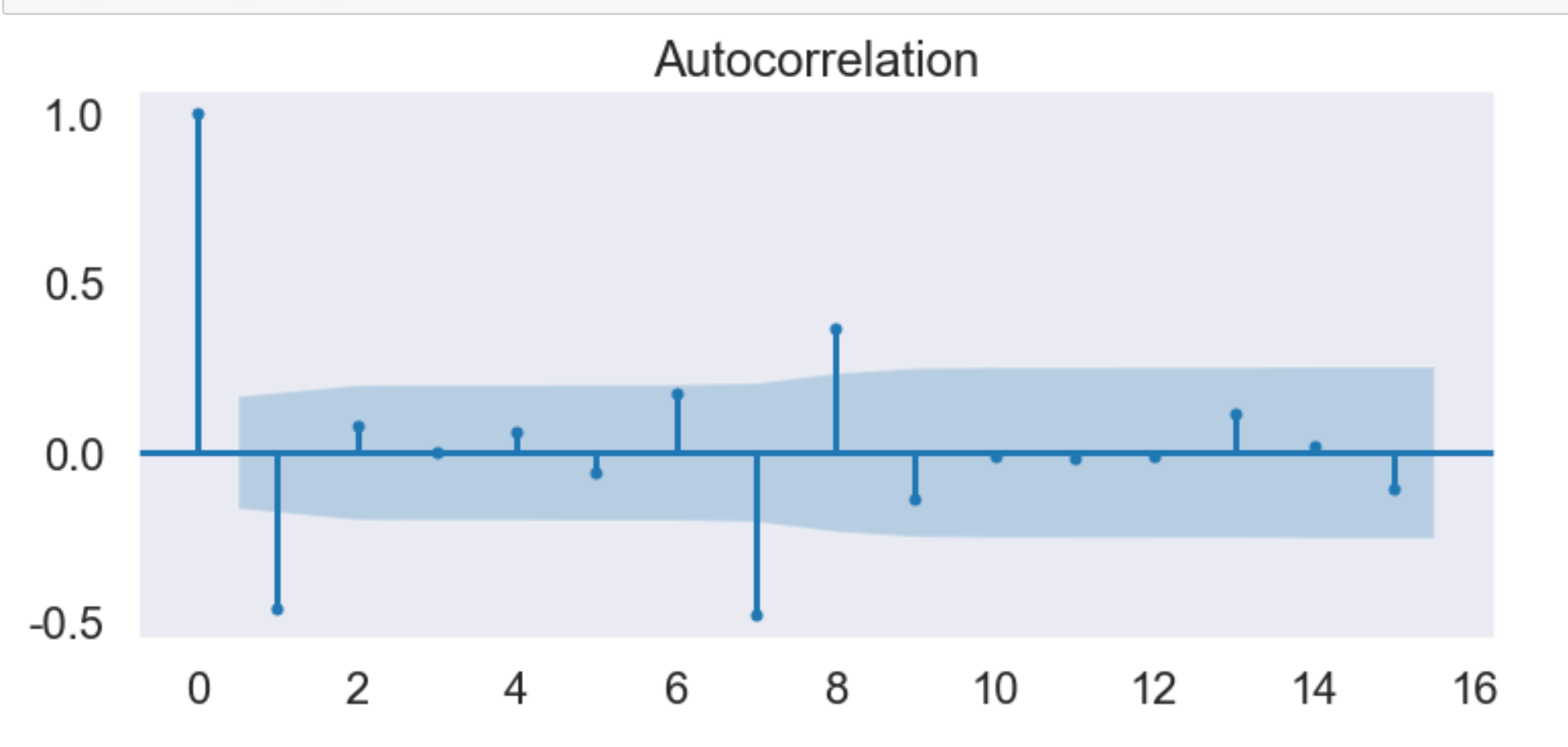
Out[14]:
```
Test Statistic         -3.15
p-value                 0.02
Critical Value (1%)    -3.48
Critical Value (5%)    -2.88
Critical Value (10%)   -2.58
dtype: float64
```

In [15]:
```python
data_diff_2.plot()
```

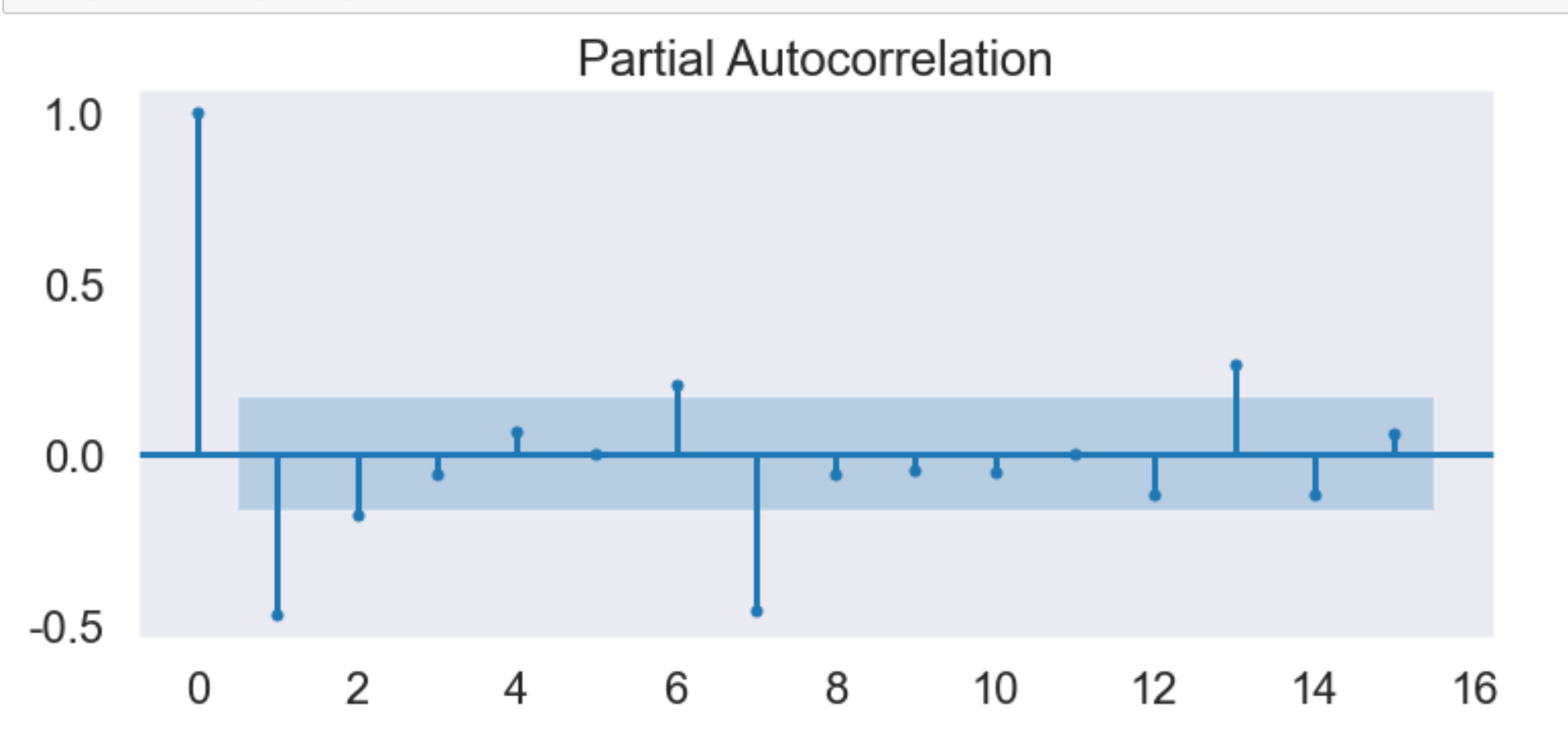
Out[15]:
```
<AxesSubplot:>
```



In [16]:
```python
plot_acf(data_diff_2,lags=15).show()
```



In [17]:
```python
plot_pacf(data_diff_2,lags=15).show()
```

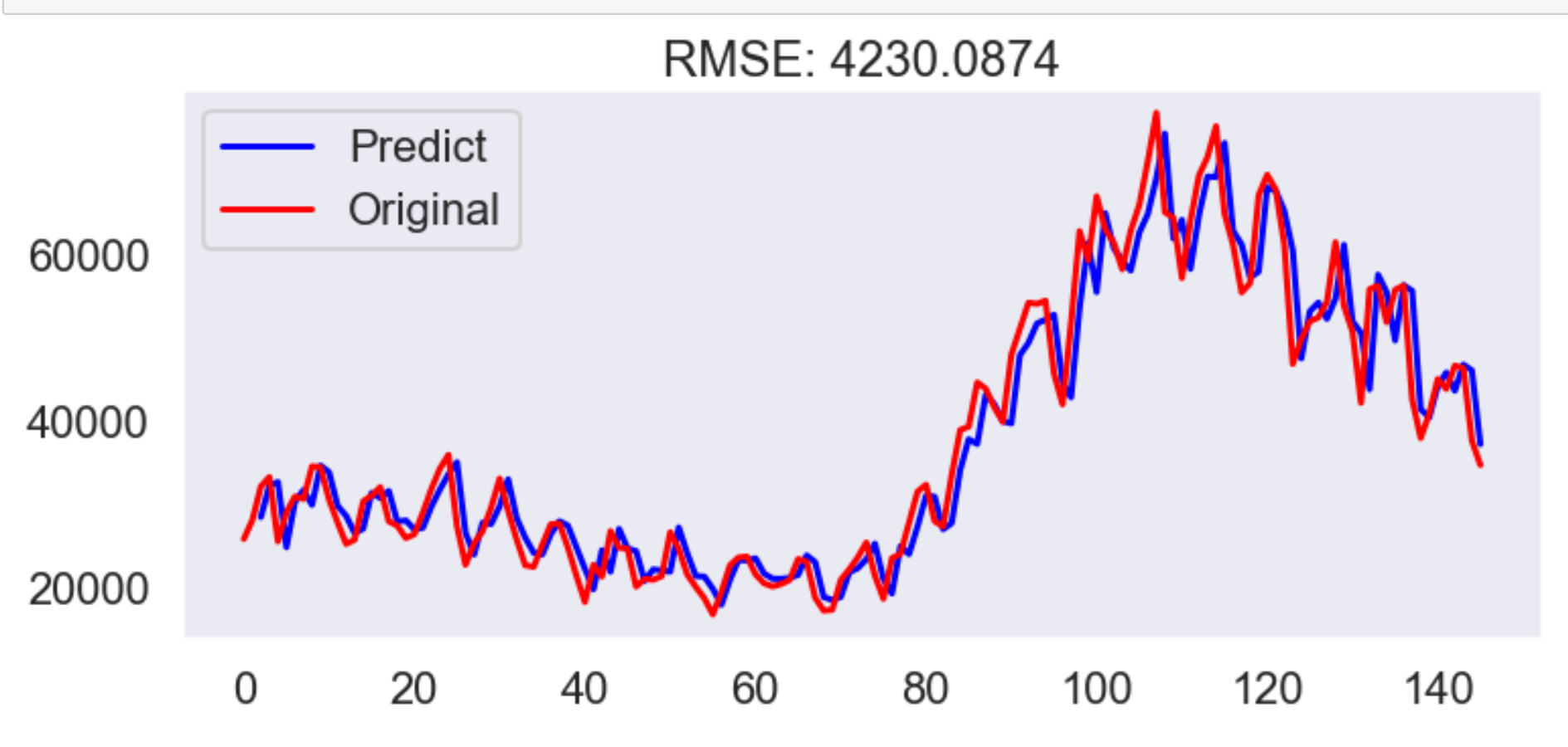


模型选择

In [18]:
```python
train_data = raw_data.copy()

rol_mean = log_data.rolling(window=7).mean()
rol_mean.dropna(inplace=True)
ts_diff_1 = rol_mean.diff(1)
ts_diff_1.dropna(inplace=True)

ts_diff_2 = ts_diff_1.diff(1)
ts_diff_2.dropna(inplace=True)

def show_result(ts,log_recover,error):
    plt.figure(facecolor='white')
    log_recover.plot(color='blue', label='Predict')
    ts.plot(color='red', label='Original')
    plt.legend(loc='best')
    plt.title('RMSE: %.4f'% error)
    plt.show()
```

Test with ARIMA recommand params

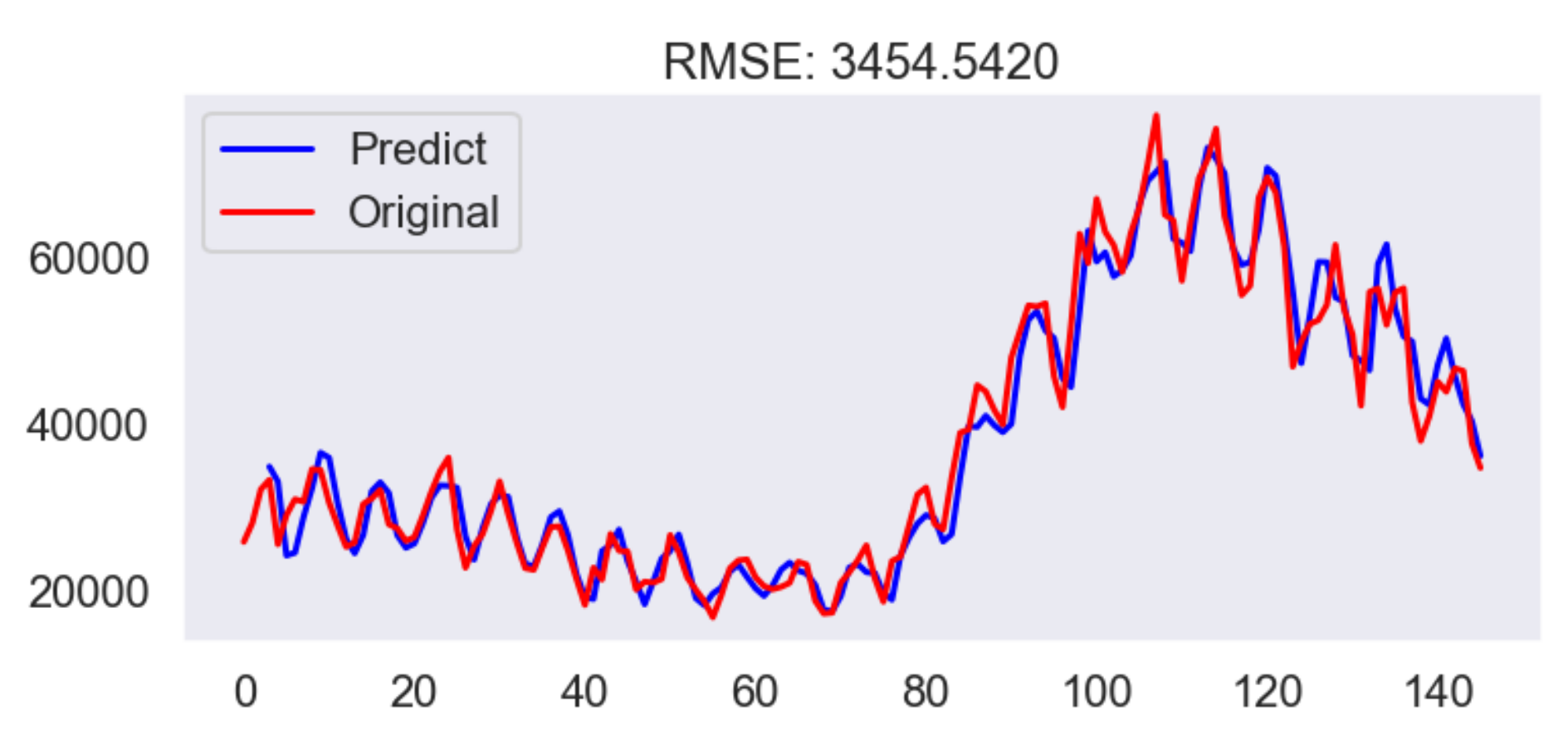
In [19]:
```python
train_data = raw_data.copy()
train_data = train_data.astype("float64")

result_arima = ARIMA(train_data, order=(2, 0, 3)).fit( disp=-1, method='css')
predicted = result_arima.predict()
error = (np.sqrt(sum((predicted-train_data).dropna()**2/train_data.size)))
show_result(train_data,predicted,error)
```



Train all params

In [20]:
```python
train_data = raw_data.copy()
train_data = train_data.astype("float64")

result_arima = None
min_error = 65536
min_predicted = None
min_p = None
min_q = None
min_d = None
for p in range(4):
    for q in range(4):
        for d in range(2):

            try:
                model = ARIMA(train_data, order=(p, d, q))
                res_arima = model.fit( disp=-1, method='css')
                predicted = res_arima.predict()
                error = (np.sqrt(sum((predicted-train_data).dropna()**2/train_data.size)))
                if error < min_error:
                    result_arima = res_arima
                    min_predicted = predicted
                    min_error = error
                    min_p = p
                    min_d = d
                    min_q = q
            except:
                pass
print(min_p,min_d,min_q)
show_result(train_data,min_predicted,min_error)
```

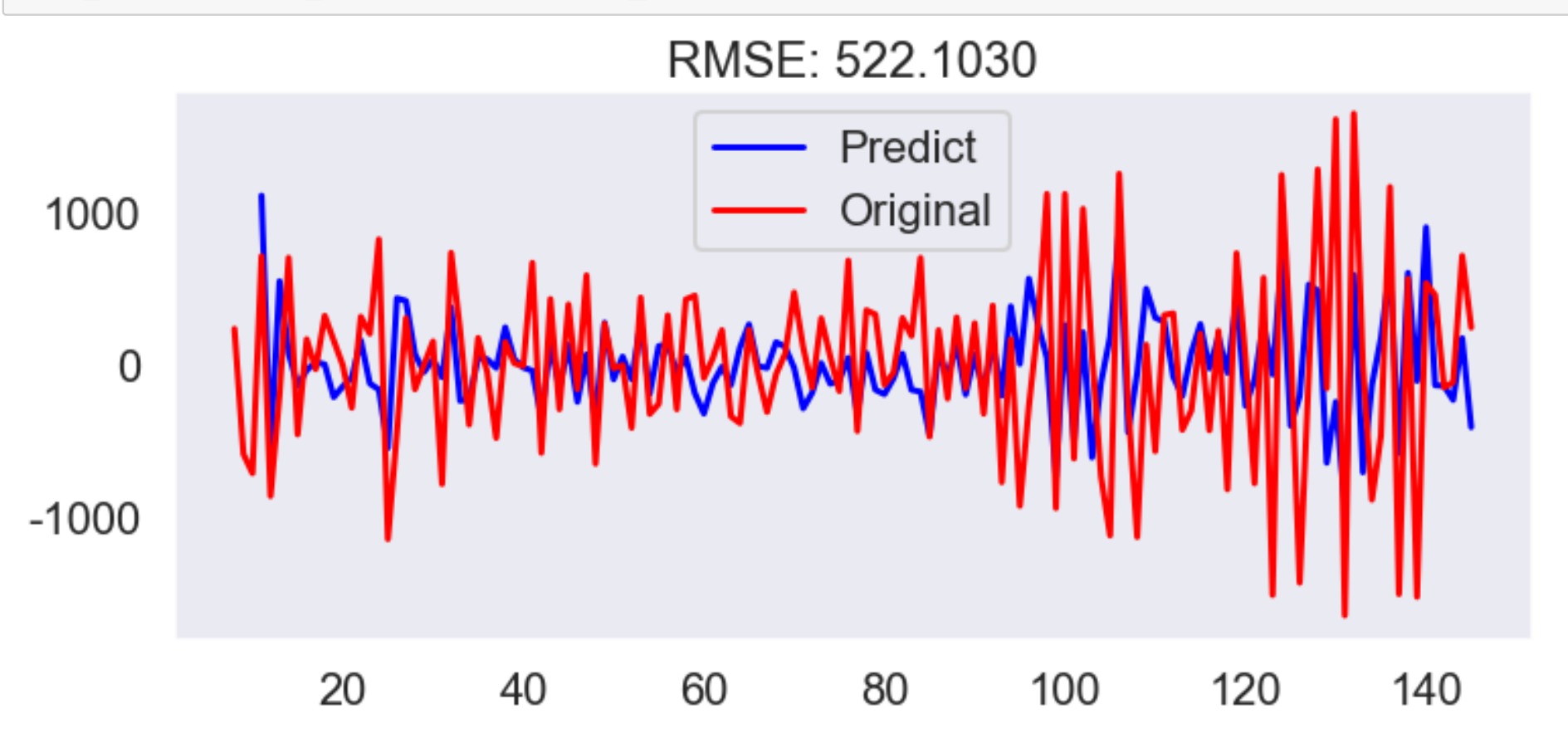
```
3 0 3
```



In [21]:
```python
predict_ts=result_arima.forecast(verify_count)
for i in range(verify_count):
    real = df_verify.iloc[i]['positiveIncrease']
    real_date = df_verify.iloc[i]['date']
    predicted = int(predict_ts[0][i])

    diff = abs(predicted-real)
    rate = "%.4f"%(diff*100/real)
    print(real_date,"real:",real, " pred :",predicted, " error :",diff," rate :",rate)
```

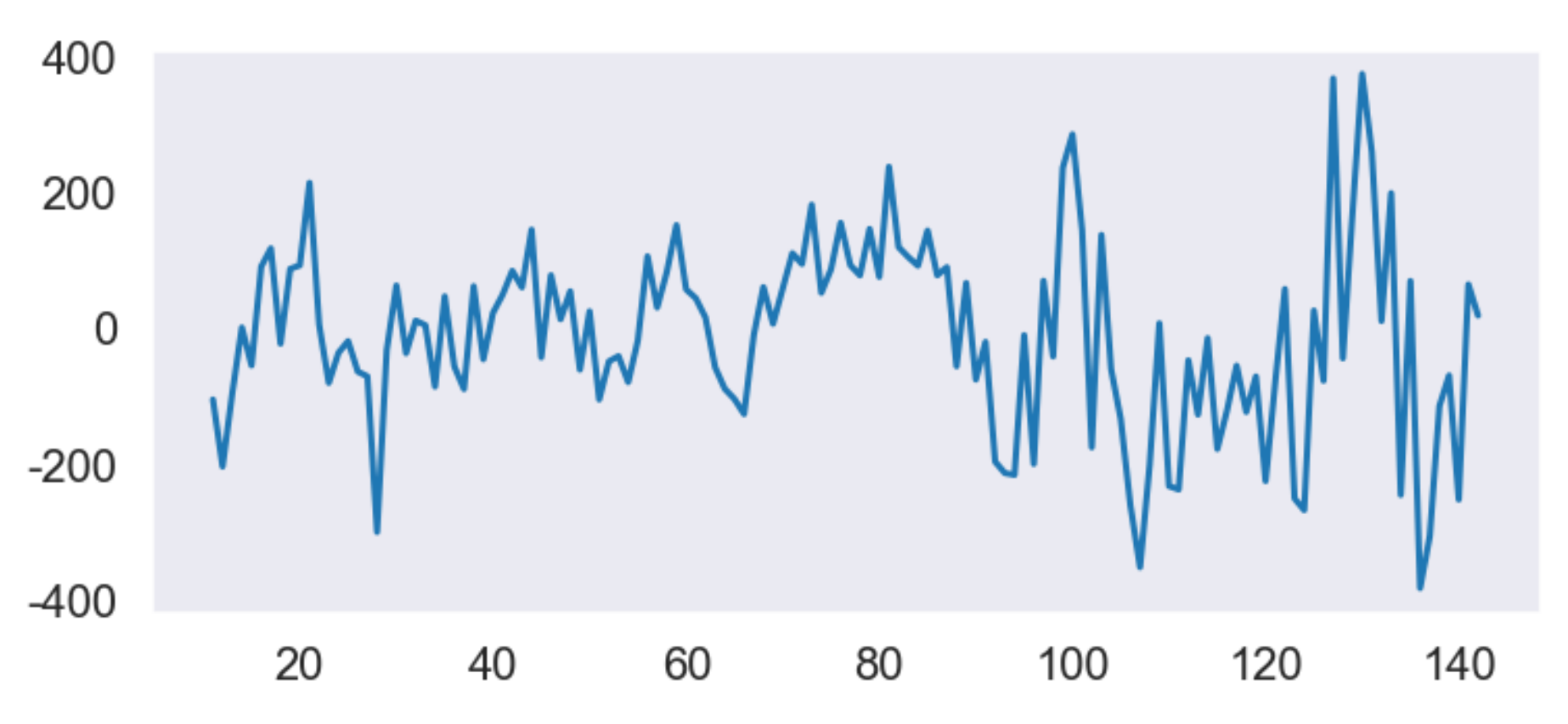
```
20200825 real: 36374  pred : 37078  error : 704  rate : 1.9354
20200826 real: 43356  pred : 42058  error : 1298  rate : 2.9938
20200827 real: 43984  pred : 46269  error : 2285  rate : 5.1951
20200828 real: 46546  pred : 46514  error : 32  rate : 0.0687
20200829 real: 44328  pred : 42609  error : 1719  rate : 3.8779
```

In [22]:
```python
train_data = data_diff_2.astype("float64")

model = ARIMA(train_data, order=(3, 0, 2))
result_arima = model.fit( disp=-1, method='css')
predicted = result_arima.predict()

min_error = (np.sqrt(sum((predicted-train_data).dropna()**2/train_data.size)))
show_result(train_data,predicted,min_error)
```



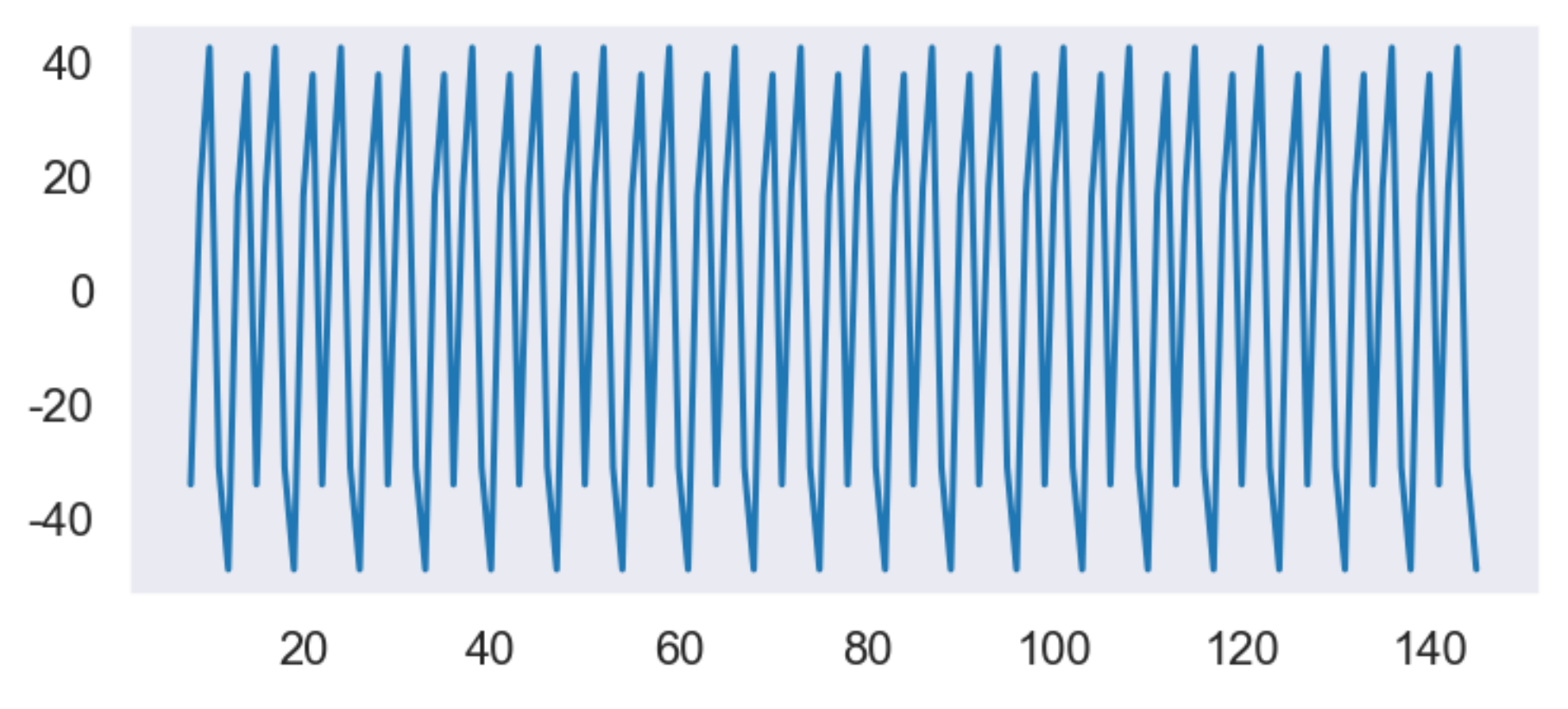
In [23]:
```python
from statsmodels.tsa.seasonal import seasonal_decompose
decomposition = seasonal_decompose(data_diff_2, period=7,model="additive")

trend = decomposition.trend
seasonal = decomposition.seasonal
residual = decomposition.resid
trend.dropna(inplace=True)
seasonal.dropna(inplace=True)
residual.dropna(inplace=True)
trend.plot()
```

Out[23]:
```
<AxesSubplot:>
```



In [24]:
```python
seasonal.plot()
```

Out[24]:
```
<AxesSubplot:>
```



In [25]:
```python
residual.plot()
```

Out[25]:
```
<AxesSubplot:>
```