TimeSeries2021_GARCH

March 24, 2021

[31]:
```
%matplotlib inline
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

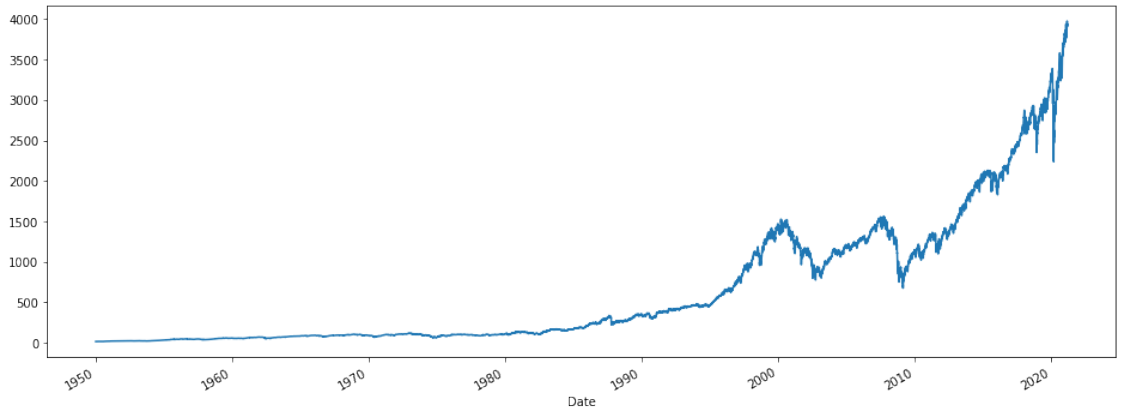
[32]:
```
df = pd.read_csv("GSPC_2021.csv", index_col = 0, parse_dates = True)
```

[33]:
```
ts = df["^GSPC"]
```

[34]:
```
plt.rc("figure", figsize=(16, 6)) # rc = runtime configuration
```

[35]:
```
ts.plot()
```

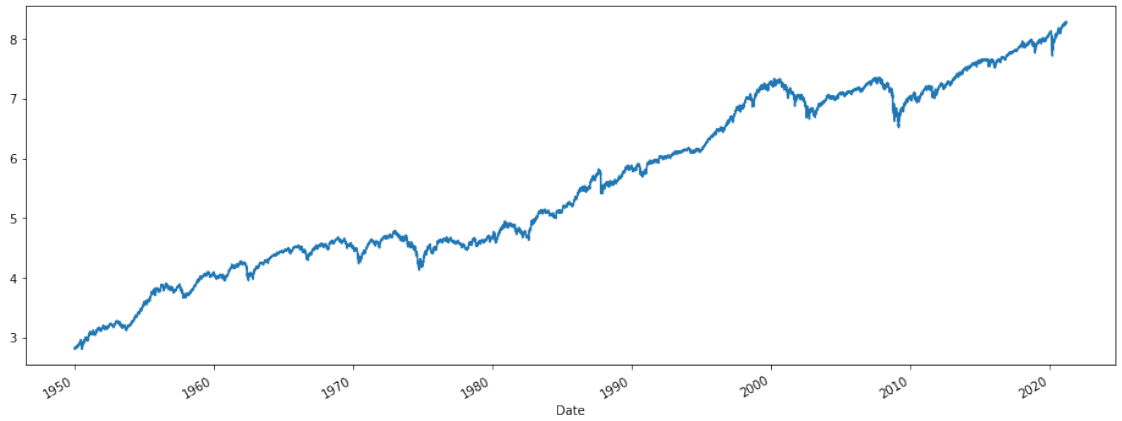
[35]: <matplotlib.axes._subplots.AxesSubplot at 0x131a29190>



[36]:
```
logts = np.log(ts)
```

[37]:
```
logts.plot()
```

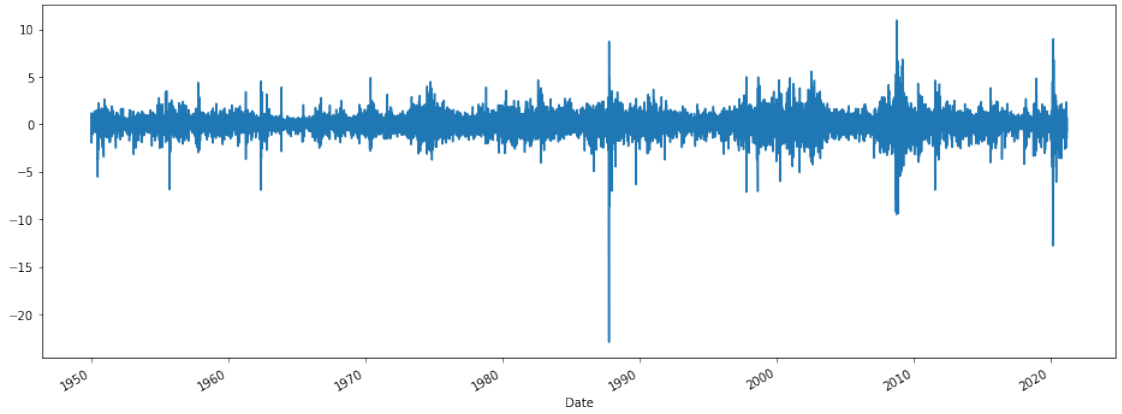
[37]: <matplotlib.axes._subplots.AxesSubplot at 0x131a5ecd0>



[38]:
```
returns = 100*logts.diff().dropna()
```

[39]:
```
returns.plot()
```

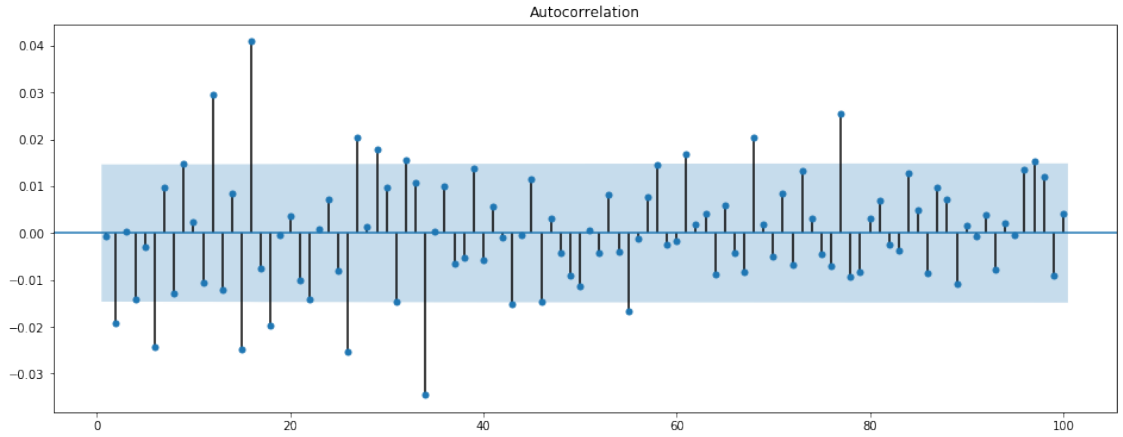
[39]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x133588e90>
```



[40]:
```
returns.describe()
```

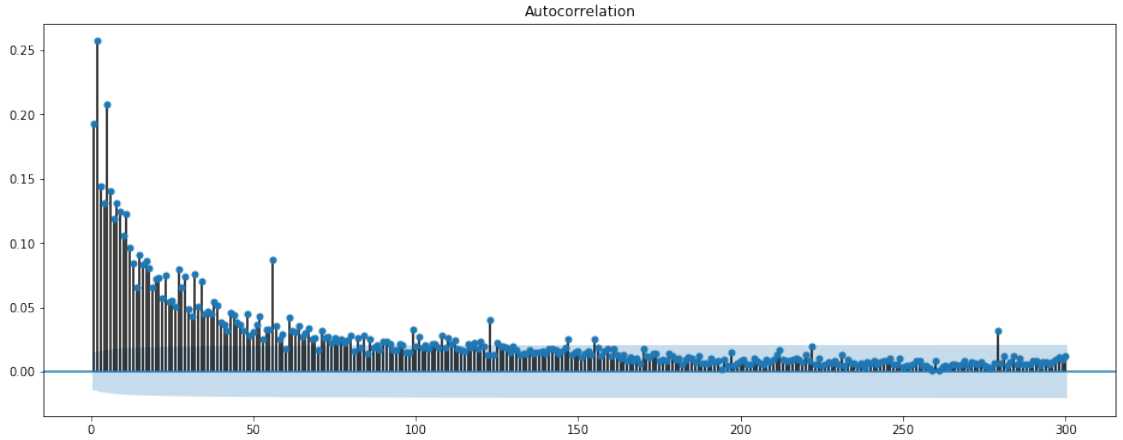
[40]:
```
count    17920.000000
mean         0.030460
std          0.991713
min        -22.899729
25%         -0.403639
50%          0.048844
75%          0.499752
max         10.957197
Name: ^GSPC, dtype: float64
```

[41]:
```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plot_acf(returns,lags=range(1,101));
```

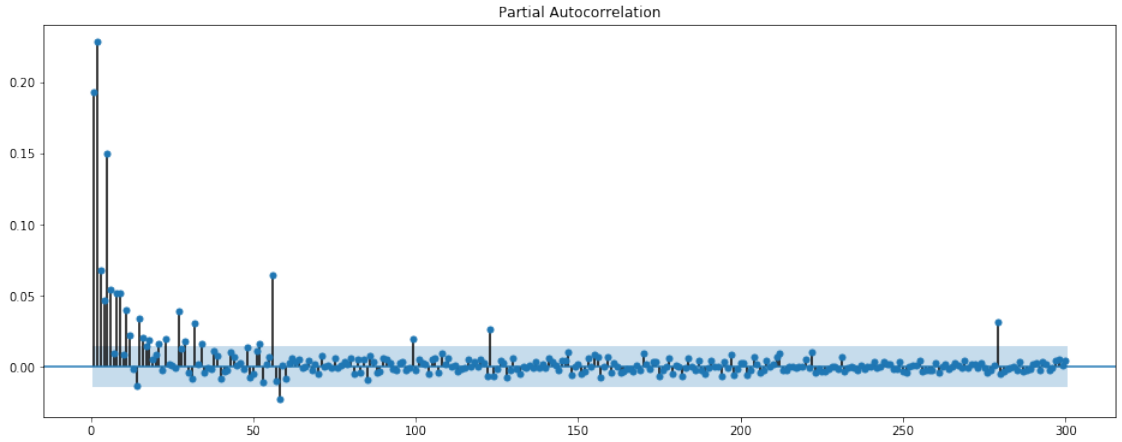


[42]:
```
returnsSquared = returns*returns
```

[43]:
```
plot_acf(returnsSquared,lags=range(1,301));
```



[44]:
```
plot_pacf(returnsSquared,lags=range(1,301));
```



[45]:
```
# ! pip install arch
```

[46]:
```
from arch import arch_model
```

[47]:
```
am = arch_model(returns)
```

[48]:
```
fit = am.fit()
```

```
Iteration:      1,   Func. Count:      6,   Neg. LLF: 21628.90104835164
Iteration:      2,   Func. Count:     17,   Neg. LLF: 21620.717222984866
Iteration:      3,   Func. Count:     26,   Neg. LLF: 21617.48324460558
Iteration:      4,   Func. Count:     33,   Neg. LLF: 21609.05535272595
Iteration:      5,   Func. Count:     42,   Neg. LLF: 21608.8695249287
Iteration:      6,   Func. Count:     49,   Neg. LLF: 21600.902719533915
Iteration:      7,   Func. Count:     56,   Neg. LLF: 21600.381449735345
Iteration:      8,   Func. Count:     63,   Neg. LLF: 21599.15661411486
Iteration:      9,   Func. Count:     69,   Neg. LLF: 21598.987831678816
Iteration:     10,   Func. Count:     75,   Neg. LLF: 21598.982363538627
Iteration:     11,   Func. Count:     81,   Neg. LLF: 21598.98234928877
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 21598.98234928815
            Iterations: 11
            Function evaluations: 81
            Gradient evaluations: 11
```

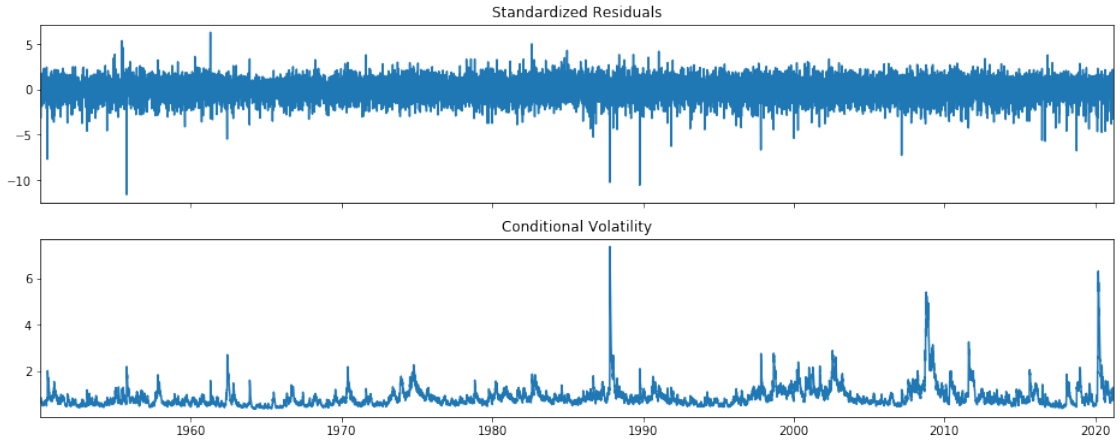
[49]:
```
fit
```

[49]:
```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                    ^GSPC   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                      GARCH   Log-Likelihood:               -21599.0
```

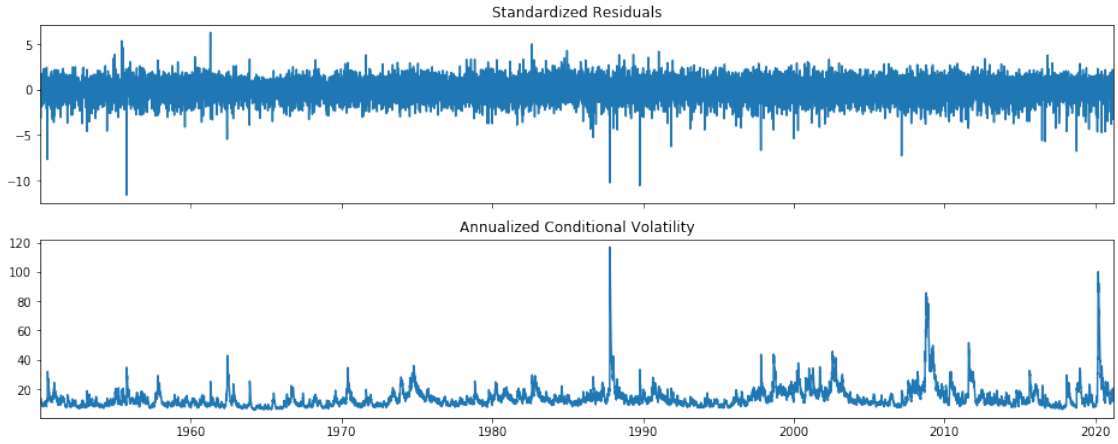
```
Distribution:                  Normal   AIC:                           43206.0
Method:            Maximum Likelihood   BIC:                           43237.1
                                        No. Observations:                17920
Date:                Wed, Mar 24 2021   Df Residuals:                    17919
Time:                        11:08:09   Df Model:                            1
                           Mean Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.0510  6.284e-03      8.116  4.824e-16 [3.868e-02,6.332e-02]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
omega          0.0115  2.236e-03      5.135  2.828e-07 [7.097e-03,1.586e-02]
alpha[1]       0.0945  1.195e-02      7.910  2.574e-15   [7.112e-02,  0.118]
beta[1]        0.8954  1.215e-02     73.692      0.000     [  0.872,  0.919]
============================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x13278e890
```

[50]:
```
fit.plot();
```



[51]:
```
fit.plot(annualize="D");
```



[52]:
```
arch_model(returns, vol='ARCH', p=1).fit(disp='off')
```

[52]:
```
                     Constant Mean - ARCH Model Results
==============================================================================
Dep. Variable:                    ^GSPC   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                       ARCH   Log-Likelihood:               -23878.4
Distribution:                  Normal   AIC:                           47762.9
Method:            Maximum Likelihood   BIC:                           47786.2
                                        No. Observations:                17920
Date:                Wed, Mar 24 2021   Df Residuals:                    17919
Time:                        11:08:11   Df Model:                            1
                            Mean Model
==============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
------------------------------------------------------------------------------
mu             0.0480  7.855e-03      6.113  9.747e-10 [3.263e-02,6.342e-02]
                          Volatility Model
============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
----------------------------------------------------------------------------
omega          0.6408  2.064e-02     31.044 1.378e-211 [  0.600,  0.681]
alpha[1]       0.3487  3.253e-02     10.718  8.373e-27 [  0.285,  0.412]
============================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x133fe3750
```

[53]:
```
arch_model(returns, vol='ARCH', p=10).fit(disp='off')
```

[53]:
```
                     Constant Mean - ARCH Model Results
==============================================================================
Dep. Variable:                    ^GSPC   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                       ARCH   Log-Likelihood:               -21710.1
Distribution:                  Normal   AIC:                           43444.2
Method:            Maximum Likelihood   BIC:                           43537.7
                                        No. Observations:                17920
Date:                Wed, Mar 24 2021   Df Residuals:                    17919
Time:                        11:08:12   Df Model:                            1
                            Mean Model
==============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
------------------------------------------------------------------------------
mu             0.0556  6.015e-03      9.246  2.330e-20 [4.382e-02,6.740e-02]
                          Volatility Model
==============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
------------------------------------------------------------------------------
omega          0.1674  1.173e-02     14.270  3.350e-46     [  0.144,  0.190]
alpha[1]       0.1281  1.980e-02      6.471  9.734e-11   [8.931e-02,  0.167]
alpha[2]       0.1042  1.317e-02      7.908  2.605e-15   [7.835e-02,  0.130]
alpha[3]       0.0869  1.273e-02      6.823  8.918e-12   [6.192e-02,  0.112]
alpha[4]       0.0963  1.450e-02      6.643  3.080e-11   [6.789e-02,  0.125]
alpha[5]       0.0774  1.106e-02      7.005  2.468e-12 [5.577e-02,9.911e-02]
alpha[6]       0.0634  1.145e-02      5.539  3.041e-08 [4.098e-02,8.586e-02]
alpha[7]       0.0652  1.167e-02      5.589  2.282e-08 [4.237e-02,8.813e-02]
alpha[8]       0.0872  1.606e-02      5.430  5.626e-08   [5.572e-02,  0.119]
alpha[9]       0.0884  1.973e-02      4.479  7.501e-06   [4.970e-02,  0.127]
alpha[10]      0.0544  1.001e-02      5.440  5.333e-08 [3.483e-02,7.406e-02]
==============================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x133909290
```

[54]:
```
arch_model(returns, vol='GARCH', p=1, q=2).fit(disp='off')
```

[54]:
```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                    ^GSPC   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                       GARCH   Log-Likelihood:               -21592.9
Distribution:                  Normal   AIC:                           43195.7
Method:            Maximum Likelihood   BIC:                           43234.7
                                        No. Observations:                17920
Date:                Wed, Mar 24 2021   Df Residuals:                    17919
Time:                        11:08:14   Df Model:                            1
```

```
                             Mean Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.0512  6.290e-03      8.138  4.005e-16 [3.886e-02,6.352e-02]
                           Volatility Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
omega          0.0131  2.623e-03      4.989  6.069e-07 [7.946e-03,1.823e-02]
alpha[1]       0.1126  1.680e-02      6.702  2.054e-11   [7.966e-02,  0.146]
beta[1]        0.6372      0.106      5.993  2.061e-09     [  0.429,  0.846]
beta[2]        0.2389  9.517e-02      2.511  1.205e-02   [5.240e-02,  0.425]
============================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x132792b50
```

[ ]: