weather-prediction

May 9, 2024

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit
from sklearn.metrics import mean_squared_error
import warnings
warnings.filterwarnings("ignore")
```

```
C:\Users\dolin\AppData\Local\Temp\ipykernel_33260\4287691399.py:2:
DeprecationWarning:
Pyarrow will become a required dependency of pandas in the next major release of
pandas (pandas 3.0),
(to allow more performant data types, such as the Arrow string type, and better
interoperability with other libraries)
but was not found to be installed on your system.
If this would cause problems for you,
please provide us feedback at https://github.com/pandas-dev/pandas/issues/54466

  import pandas as pd
```

0.1 Data Preprocessing

[2]:
```
data = pd.read_csv("seattle-weather.csv")
```

[3]:
```
data
```

[3]:

	date	precipitation	temp_max	temp_min	wind	weather
0	2012-01-01	0.0	12.8	5.0	4.7	drizzle
1	2012-01-02	10.9	10.6	2.8	4.5	rain
2	2012-01-03	0.8	11.7	7.2	2.3	rain
3	2012-01-04	20.3	12.2	5.6	4.7	rain
4	2012-01-05	1.3	8.9	2.8	6.1	rain
…	…	…	…	…	…	…
1456	2015-12-27	8.6	4.4	1.7	2.9	rain
1457	2015-12-28	1.5	5.0	1.7	1.3	rain
1458	2015-12-29	0.0	7.2	0.6	2.6	fog
1459	2015-12-30	0.0	5.6	-1.0	3.4	sun
1460	2015-12-31	0.0	5.6	-2.1	3.5	sun

```
[1461 rows x 6 columns]
```

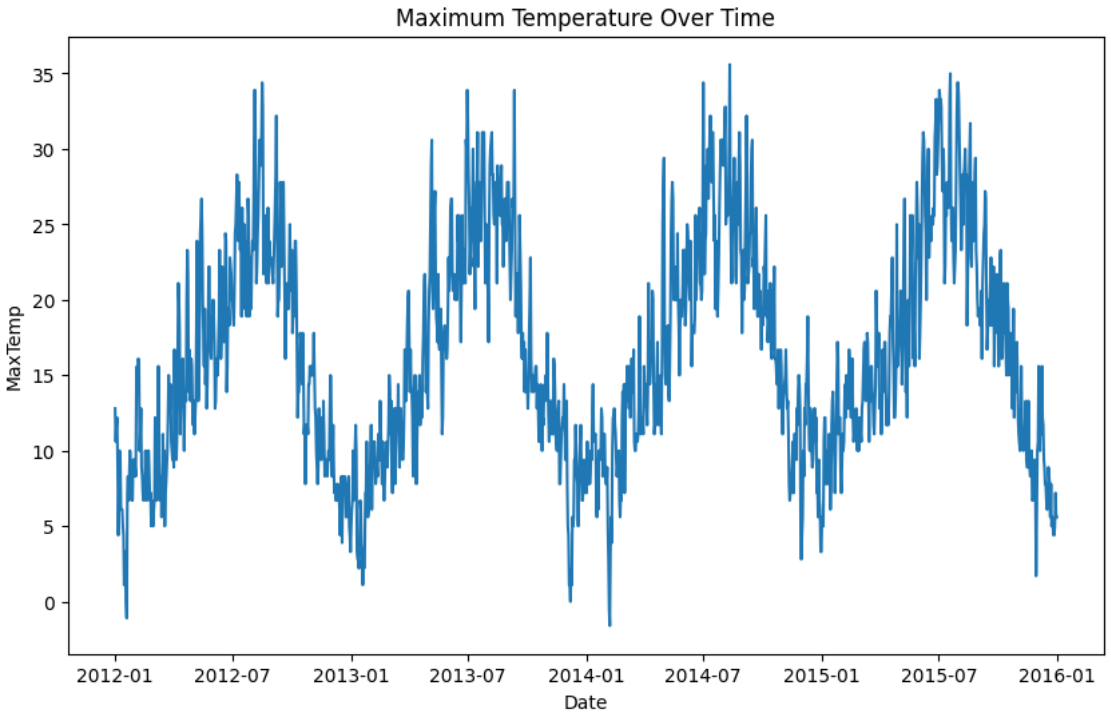
[4]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1461 entries, 0 to 1460
Data columns (total 6 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   date           1461 non-null   object
 1   precipitation  1461 non-null   float64
 2   temp_max       1461 non-null   float64
 3   temp_min       1461 non-null   float64
 4   wind           1461 non-null   float64
 5   weather        1461 non-null   object
dtypes: float64(4), object(2)
memory usage: 68.6+ KB
```

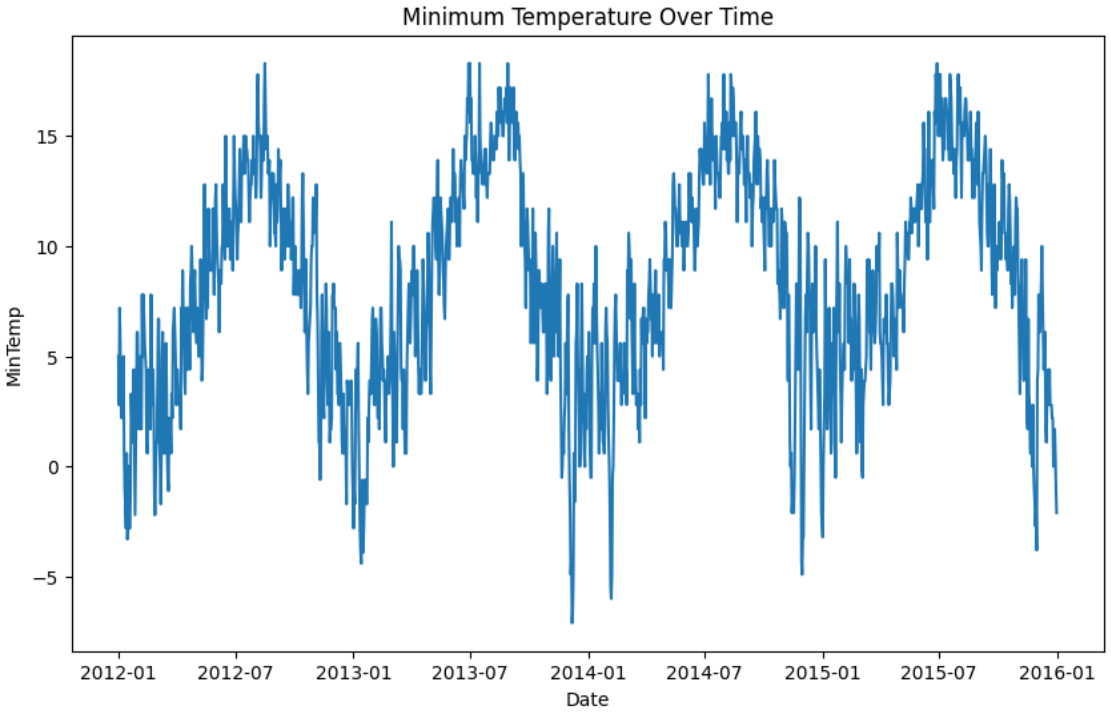
[5]:
```
data.isnull().sum()
```

[5]:
```
date             0
precipitation    0
temp_max         0
temp_min         0
wind             0
weather          0
dtype: int64
```

[6]:
```
data['date'] = pd.to_datetime(data['date'])
plt.figure(figsize=(10,6))
plt.plot(data['date'], data['temp_max'])
plt.title('Maximum Temperature Over Time')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.savefig('maxtemp.png')
plt.show()
```



[7]:
```
plt.figure(figsize=(10,6))
plt.plot(data['date'], data['temp_min'])
plt.title('Minimum Temperature Over Time')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.savefig('mintemp.png')
plt.show()
```



[8]:
```
data['date_code'] = range(1, len(data) + 1)
data
```

[8]:

	date	precipitation	temp_max	temp_min	wind	weather	date_code
0	2012-01-01	0.0	12.8	5.0	4.7	drizzle	1
1	2012-01-02	10.9	10.6	2.8	4.5	rain	2
2	2012-01-03	0.8	11.7	7.2	2.3	rain	3
3	2012-01-04	20.3	12.2	5.6	4.7	rain	4
4	2012-01-05	1.3	8.9	2.8	6.1	rain	5
…	…	…	…	…	…	…	…
1456	2015-12-27	8.6	4.4	1.7	2.9	rain	1457
1457	2015-12-28	1.5	5.0	1.7	1.3	rain	1458
1458	2015-12-29	0.0	7.2	0.6	2.6	fog	1459
1459	2015-12-30	0.0	5.6	-1.0	3.4	sun	1460
1460	2015-12-31	0.0	5.6	-2.1	3.5	sun	1461

[1461 rows x 7 columns]

[9]:
```
date = data['date_code']
mintemp = data['temp_min']
maxtemp = data['temp_max']
```

0.2 Periodic model on entire data

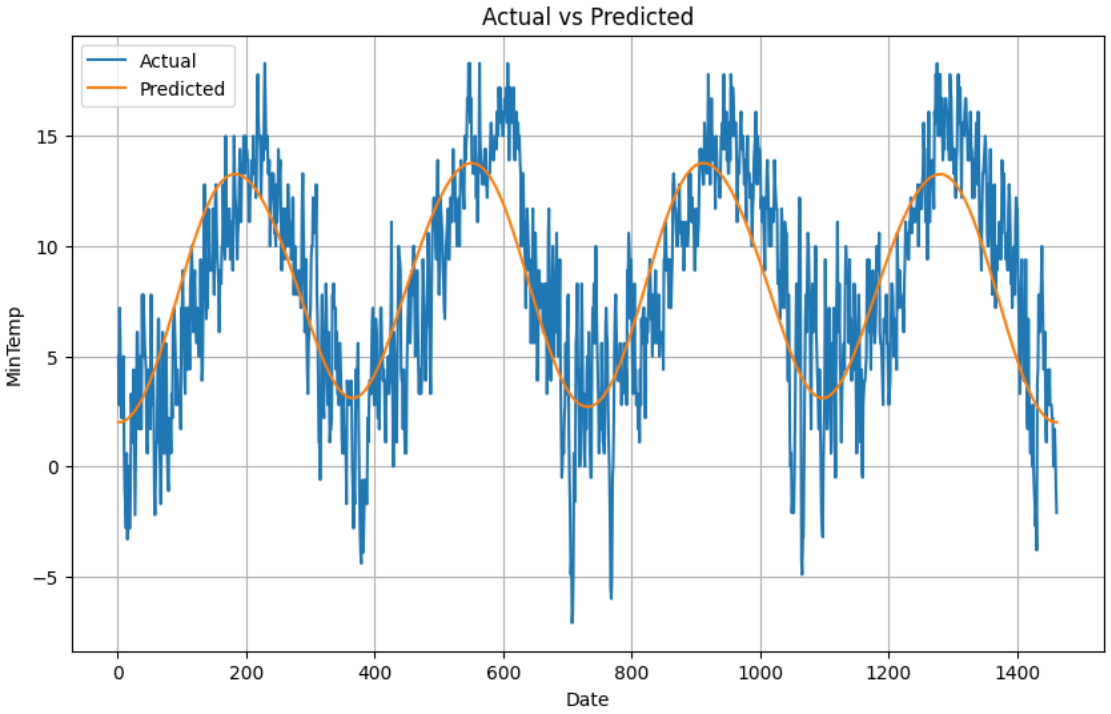
[10]:
```
a = 2*np.pi/len(data)
def periodic_model(t, c1, c2, c3, c4, c5, c6, c7):
    fit = c1 + c2*np.cos(a*t) + c3*np.cos(2*a*t) + c4*np.cos(4*a*t) + c5*np.
 ↪cos(6*a*t) + c6*np.cos(8*a*t) + c7*np.cos(10*a*t)
    return fit
```

[11]:
```
popt, _ = curve_fit(periodic_model, date, mintemp)

popt
```

[11]:
```
array([ 8.2347707 , -0.35348532, -0.42920037, -5.39323589, -0.0508579 ,
       -0.10856173,  0.10548748])
```

[12]:
```
c1, c2, c3, c4, c5, c6, c7 = popt
y_pred = periodic_model(np.linspace(0,len(date),num=len(date)), *popt)
```

[13]:
```
plt.figure(figsize=(10, 6))
plt.plot(date, mintemp, label='Actual')
plt.plot(date, y_pred, label='Predicted')
plt.title('Actual vs Predicted')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.savefig('entire_data.png')
plt.show()
```



[14]:
```
rmse = np.sqrt(mean_squared_error(mintemp, y_pred))
rmse
```

[14]: 3.222613448503364

0.3 Interpolating data per year

[15]:
```
data['date'] = pd.to_datetime(data['date'])
data['day'] = data['date'].dt.day
data['month'] = data['date'].dt.month
data['year'] = data['date'].dt.year
data
```

[15]:

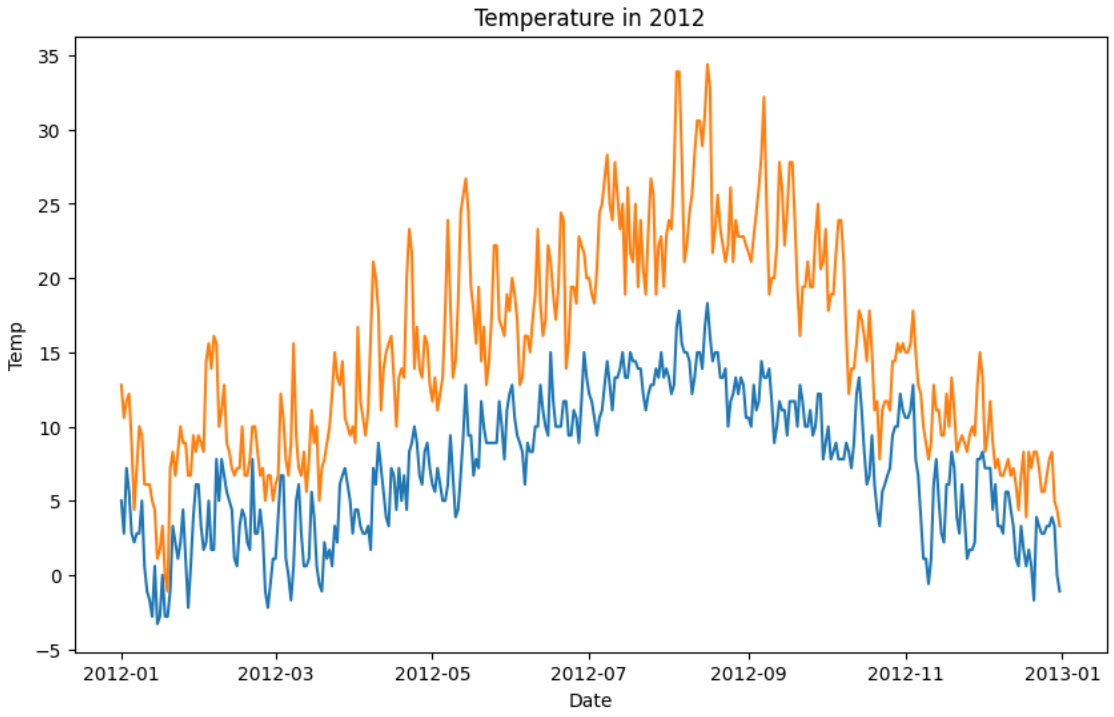
	date	precipitation	temp_max	temp_min	wind	weather	date_code	\
0	2012-01-01	0.0	12.8	5.0	4.7	drizzle	1	
1	2012-01-02	10.9	10.6	2.8	4.5	rain	2	
2	2012-01-03	0.8	11.7	7.2	2.3	rain	3	
3	2012-01-04	20.3	12.2	5.6	4.7	rain	4	
4	2012-01-05	1.3	8.9	2.8	6.1	rain	5	
…	…	…	…	…	…	…	…	
1456	2015-12-27	8.6	4.4	1.7	2.9	rain	1457	
1457	2015-12-28	1.5	5.0	1.7	1.3	rain	1458	
1458	2015-12-29	0.0	7.2	0.6	2.6	fog	1459	
1459	2015-12-30	0.0	5.6	-1.0	3.4	sun	1460	

```
1460 2015-12-31           0.0       5.6      -2.1   3.5      sun       1461

      day  month  year
0       1      1  2012
1       2      1  2012
2       3      1  2012
3       4      1  2012
4       5      1  2012
…     …      …    …
1456   27     12  2015
1457   28     12  2015
1458   29     12  2015
1459   30     12  2015
1460   31     12  2015

[1461 rows x 10 columns]
```

[16]:
```
y1 = data[data["year"] < 2013]
y1
```

[16]:
```
          date  precipitation  temp_max  temp_min  wind  weather  date_code  \
0   2012-01-01            0.0      12.8       5.0   4.7  drizzle          1
1   2012-01-02           10.9      10.6       2.8   4.5     rain          2
2   2012-01-03            0.8      11.7       7.2   2.3     rain          3
3   2012-01-04           20.3      12.2       5.6   4.7     rain          4
4   2012-01-05            1.3       8.9       2.8   6.1     rain          5
..         …             …        …       …    …       …         …
361 2012-12-27            4.1       7.8       3.3   3.2     rain        362
362 2012-12-28            0.0       8.3       3.9   1.7     rain        363
363 2012-12-29            1.5       5.0       3.3   1.7     rain        364
364 2012-12-30            0.0       4.4       0.0   1.8  drizzle        365
365 2012-12-31            0.0       3.3      -1.1   2.0  drizzle        366

     day  month  year
0      1      1  2012
1      2      1  2012
2      3      1  2012
3      4      1  2012
4      5      1  2012
..   …    …    …
361   27     12  2012
362   28     12  2012
363   29     12  2012
364   30     12  2012
365   31     12  2012

[366 rows x 10 columns]
```

[17]:
```
plt.figure(figsize=(10,6))
plt.plot(y1['date'], y1['temp_min'], label='TempMin')
plt.plot(y1['date'], y1['temp_max'], label='TempMax')
plt.title('Temperature in 2012')
plt.xlabel('Date')
plt.ylabel('Temp')
plt.savefig('temp2012.png')
plt.show()
```



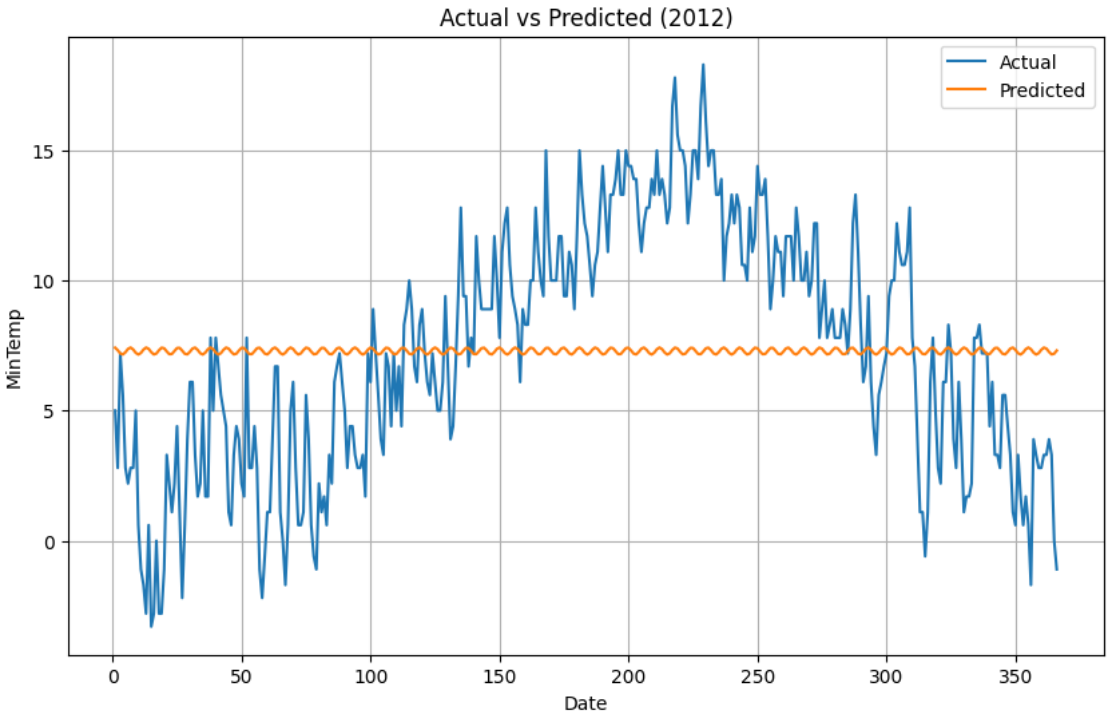
[18]:
```
def cos_model(t, c1, c2, c3, c4):
    fit = c1 + c2*np.cos(c3 + c4*t)
    return fit
popt, _ = curve_fit(cos_model, y1['date_code'], y1['temp_min'])

popt
```

[18]:
```
array([ 7.289848  ,  0.13421592, -0.69729317,  1.01085649])
```

[19]:
```
c1, c2, c3, c4 = popt
y1_pred = cos_model(y1['date_code'], *popt)
```

[20]:
```
plt.figure(figsize=(10, 6))
plt.plot(y1['date_code'], y1['temp_min'], label='Actual')
plt.plot(y1['date_code'], y1_pred, label='Predicted')
```

```
plt.title('Actual vs Predicted (2012)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.savefig('org_model.png')
plt.show()
```



[21]:
```
rmse = np.sqrt(mean_squared_error(y1['temp_min'], y1_pred))
rmse
```

[21]: 4.690062481162516

[22]:
```
y1['date_mod'] = y1['date_code']/366
y1
```

[22]:

	date	precipitation	temp_max	temp_min	wind	weather	date_code	\
0	2012-01-01	0.0	12.8	5.0	4.7	drizzle	1	
1	2012-01-02	10.9	10.6	2.8	4.5	rain	2	
2	2012-01-03	0.8	11.7	7.2	2.3	rain	3	
3	2012-01-04	20.3	12.2	5.6	4.7	rain	4	
4	2012-01-05	1.3	8.9	2.8	6.1	rain	5	
..	…	…	…	…	…	…	…	
361	2012-12-27	4.1	7.8	3.3	3.2	rain	362	

```
362 2012-12-28            0.0       8.3       3.9   1.7     rain        363
363 2012-12-29            1.5       5.0       3.3   1.7     rain        364
364 2012-12-30            0.0       4.4       0.0   1.8  drizzle        365
365 2012-12-31            0.0       3.3      -1.1   2.0  drizzle        366

     day  month  year  date_mod
0      1      1  2012  0.002732
1      2      1  2012  0.005464
2      3      1  2012  0.008197
3      4      1  2012  0.010929
4      5      1  2012  0.013661
..   …    …   …    …        …
361   27     12  2012  0.989071
362   28     12  2012  0.991803
363   29     12  2012  0.994536
364   30     12  2012  0.997268
365   31     12  2012  1.000000

[366 rows x 11 columns]
```

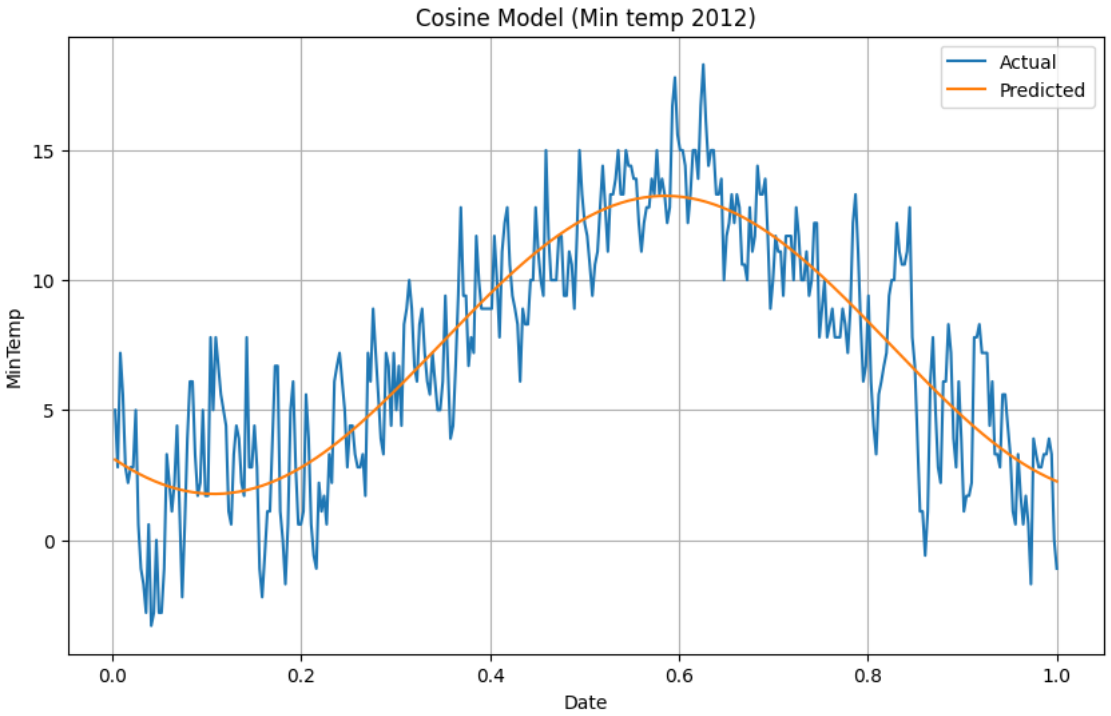
0.3.1 Min temp (2012)

[23]:
```
popt, _ = curve_fit(cos_model, y1['date_mod'], y1['temp_min'])

popt
```

[23]:
```
array([ 7.50822277,  5.73474765,  3.85094057, -6.57887766])
```

[24]:
```
c1, c2, c3, c4 = popt
y1_min = cos_model(y1['date_mod'], *popt)
```

[25]:
```
plt.figure(figsize=(10, 6))
plt.plot(y1['date_mod'], y1['temp_min'], label='Actual')
plt.plot(y1['date_mod'], y1_min, label='Predicted')
plt.title('Cosine Model (Min temp 2012)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.savefig('cos2012.png')
plt.show()
```



[26]:
```
rmse = np.sqrt(mean_squared_error(y1['temp_min'], y1_min))
rmse
```

[26]: 2.2984085025440923

[27]:
```
data['date_mod'] = data['date_code']/365
data
```

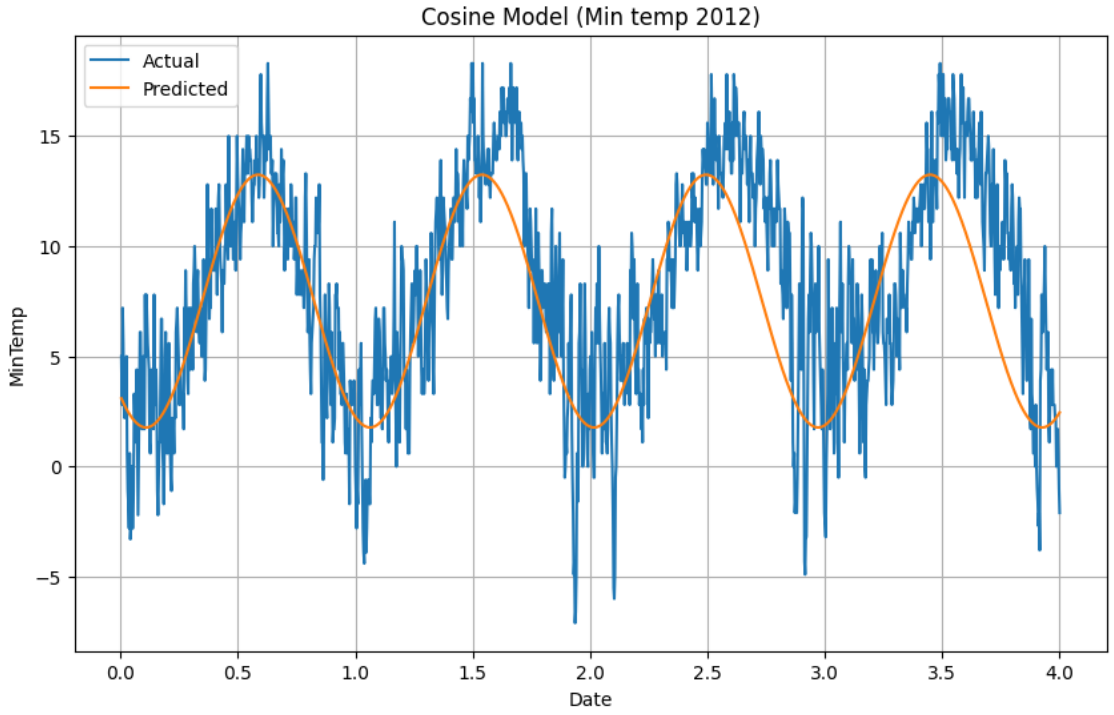
[27]:

	date	precipitation	temp_max	temp_min	wind	weather	date_code	\
0	2012-01-01	0.0	12.8	5.0	4.7	drizzle	1	
1	2012-01-02	10.9	10.6	2.8	4.5	rain	2	
2	2012-01-03	0.8	11.7	7.2	2.3	rain	3	
3	2012-01-04	20.3	12.2	5.6	4.7	rain	4	
4	2012-01-05	1.3	8.9	2.8	6.1	rain	5	
…	…	…	…	…	…	…	…	
1456	2015-12-27	8.6	4.4	1.7	2.9	rain	1457	
1457	2015-12-28	1.5	5.0	1.7	1.3	rain	1458	
1458	2015-12-29	0.0	7.2	0.6	2.6	fog	1459	
1459	2015-12-30	0.0	5.6	-1.0	3.4	sun	1460	
1460	2015-12-31	0.0	5.6	-2.1	3.5	sun	1461	

	day	month	year	date_mod
0	1	1	2012	0.002740
1	2	1	2012	0.005479

```
2        3       1  2012  0.008219
3        4       1  2012  0.010959
4        5       1  2012  0.013699
…      …       …    …        …
1456    27      12  2015  3.991781
1457    28      12  2015  3.994521
1458    29      12  2015  3.997260
1459    30      12  2015  4.000000
1460    31      12  2015  4.002740

[1461 rows x 11 columns]
```

[28]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_min'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Min temp 2012)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[29]:
```
rmse = np.sqrt(mean_squared_error(data['temp_min'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

[29]:
```
3.3900658543877413
```

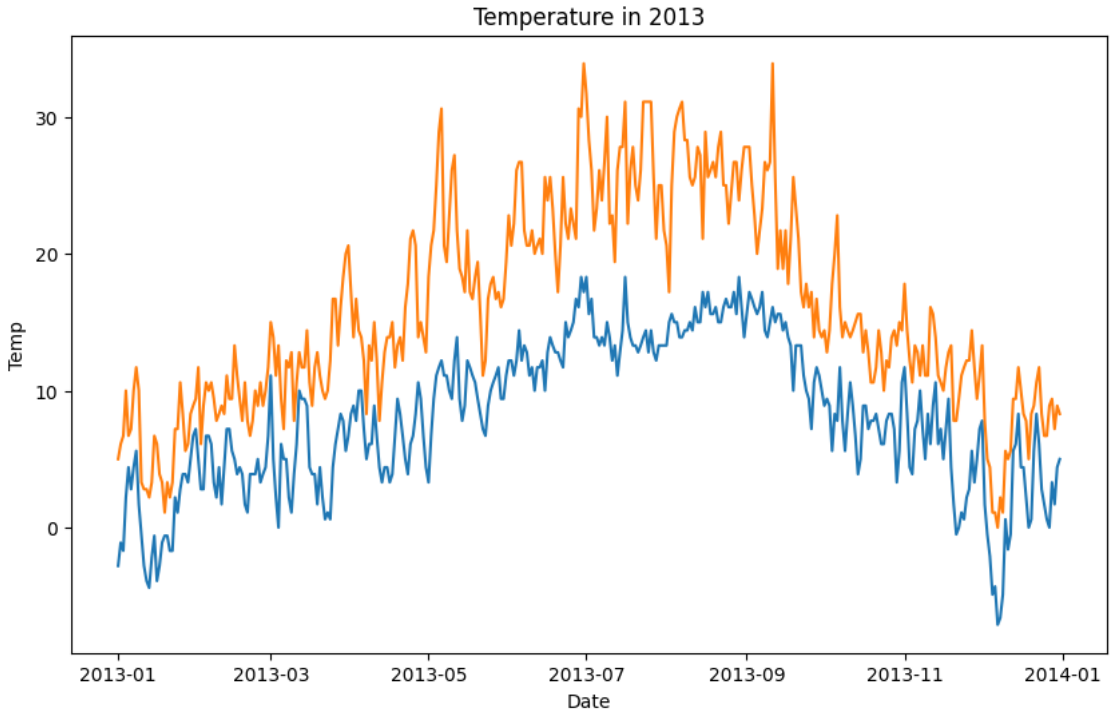
0.3.2 Min temp (2013)

[30]:
```
y2 = data[data["year"] == 2013]
y2['date_code'] = range(1, len(y2) + 1)
y2['date_mod'] = y2['date_code']/365
y2
```

[30]:
```
          date  precipitation  temp_max  temp_min  wind weather  date_code  \
366 2013-01-01            0.0       5.0      -2.8   2.7     sun          1
367 2013-01-02            0.0       6.1      -1.1   3.2     sun          2
368 2013-01-03            4.1       6.7      -1.7   3.0    rain          3
369 2013-01-04            2.5      10.0       2.2   2.8    rain          4
370 2013-01-05            3.0       6.7       4.4   3.1    rain          5
..         …              …         …         …     …       …          …
726 2013-12-27            0.3       8.9       0.0   2.1    rain        361
727 2013-12-28            0.0       9.4       3.3   1.3     sun        362
728 2013-12-29            0.0       7.2       1.7   1.1     sun        363
729 2013-12-30            0.3       8.9       4.4   2.6    rain        364
730 2013-12-31            0.5       8.3       5.0   1.7    rain        365

     day  month  year  date_mod
366    1      1  2013  0.002740
367    2      1  2013  0.005479
368    3      1  2013  0.008219
369    4      1  2013  0.010959
370    5      1  2013  0.013699
..   …    …   …   …         …
726   27     12  2013  0.989041
727   28     12  2013  0.991781
728   29     12  2013  0.994521
729   30     12  2013  0.997260
730   31     12  2013  1.000000

[365 rows x 11 columns]
```

[31]:
```
plt.figure(figsize=(10,6))
plt.plot(y2['date'], y2['temp_min'], label='TempMin')
plt.plot(y2['date'], y2['temp_max'], label='TempMax')
plt.title('Temperature in 2013')
plt.xlabel('Date')
plt.ylabel('Temp')
```

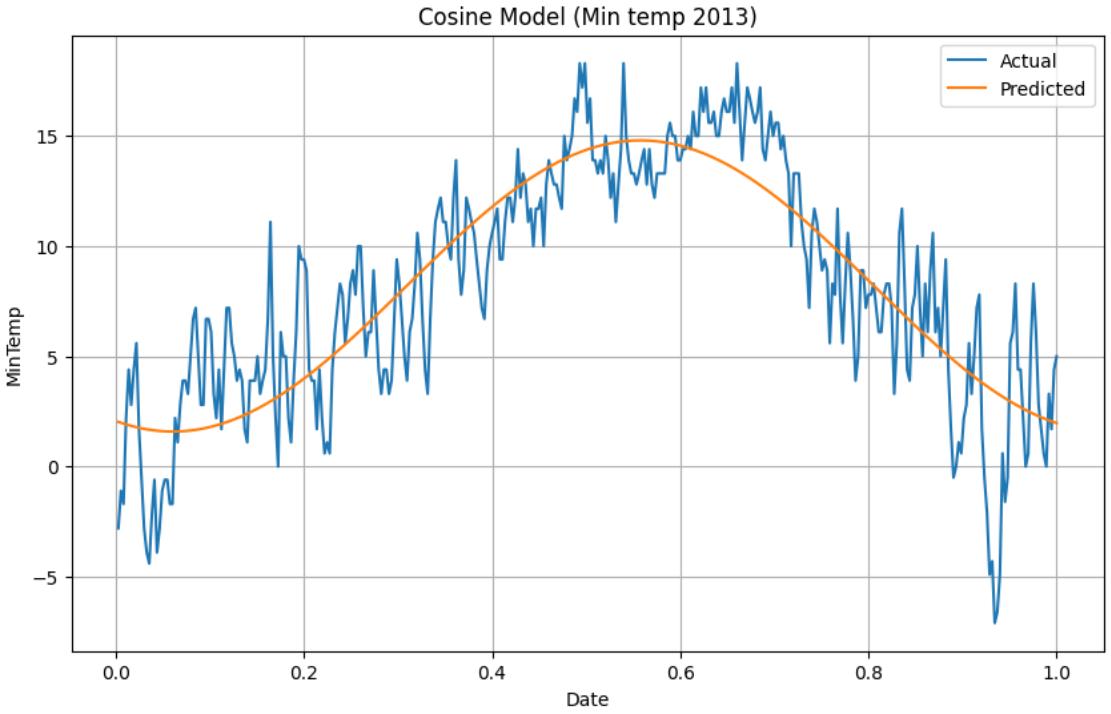
```
plt.show()
```



[32]:
```
popt, _ = curve_fit(cos_model, y2['date_mod'], y2['temp_min'])
c1, c2, c3, c4 = popt
popt
```

[32]:
```
array([ 8.19400656,  6.60691809,  3.52539001, -6.32405134])
```

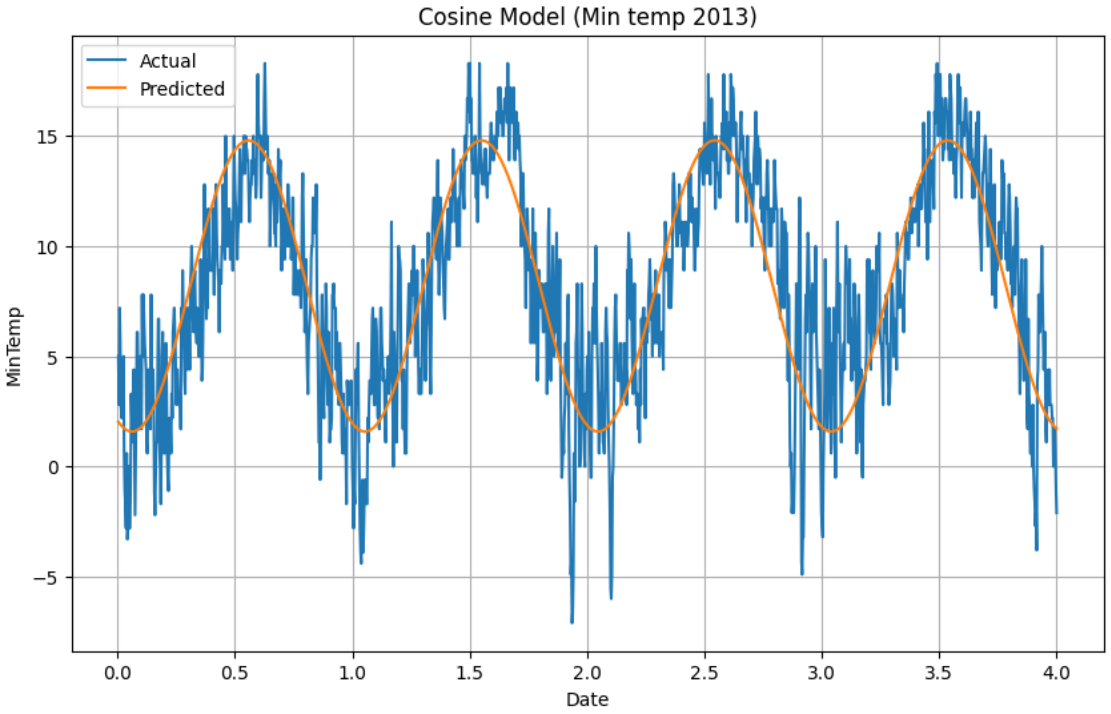
[33]:
```
y2_min = cos_model(y2['date_mod'], *popt)
plt.figure(figsize=(10, 6))
plt.plot(y2['date_mod'], y2['temp_min'], label='Actual')
plt.plot(y2['date_mod'], y2_min, label='Predicted')
plt.title('Cosine Model (Min temp 2013)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[34]:
```
rmse = np.sqrt(mean_squared_error(y2['temp_min'], y2_min))
rmse
```

[34]: 2.762412420655088

[35]:
```
popt, _ = curve_fit(cos_model, y2['date_mod'], y2['temp_min'])
c1, c2, c3, c4 = popt
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_min'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Min temp 2013)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[36]:
```
rmse = np.sqrt(mean_squared_error(data['temp_min'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

[36]: 2.835601138202228

0.3.3 Min temp (2014)

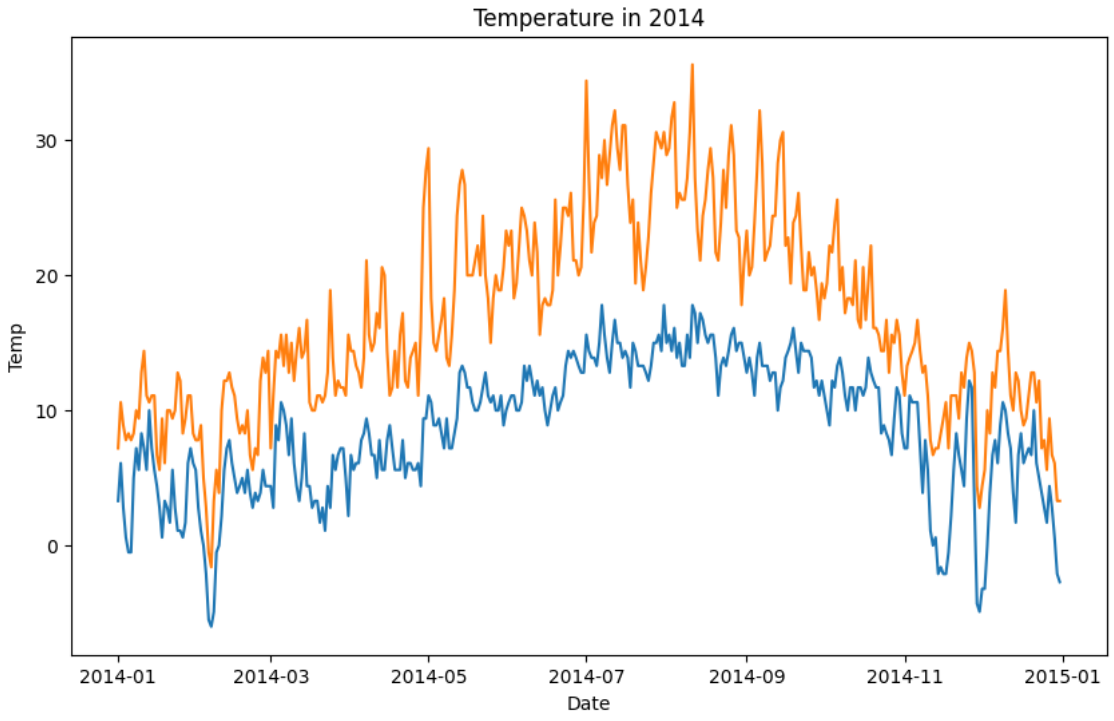
[37]:
```
y3 = data[data["year"] == 2014]
y3['date_code'] = range(1, len(y3) + 1)
y3['date_mod'] = y3['date_code']/365
y3
```

[37]:

	date	precipitation	temp_max	temp_min	wind	weather	date_code	\
731	2014-01-01	0.0	7.2	3.3	1.2	sun	1	
732	2014-01-02	4.1	10.6	6.1	3.2	rain	2	
733	2014-01-03	1.5	8.9	2.8	2.6	rain	3	
734	2014-01-04	0.0	7.8	0.6	2.7	fog	4	
735	2014-01-05	0.0	8.3	-0.5	3.7	sun	5	
…	…	…	…	…	…	…	…	
1091	2014-12-27	3.3	9.4	4.4	4.9	rain	361	
1092	2014-12-28	4.1	6.7	2.8	1.8	rain	362	
1093	2014-12-29	0.0	6.1	0.6	4.3	fog	363	
1094	2014-12-30	0.0	3.3	-2.1	3.6	sun	364	

```
1095 2014-12-31            0.0       3.3      -2.7    3.0      sun         365

      day  month  year  date_mod
731     1      1  2014  0.002740
732     2      1  2014  0.005479
733     3      1  2014  0.008219
734     4      1  2014  0.010959
735     5      1  2014  0.013699
…     …    …    …     …
1091   27     12  2014  0.989041
1092   28     12  2014  0.991781
1093   29     12  2014  0.994521
1094   30     12  2014  0.997260
1095   31     12  2014  1.000000

[365 rows x 11 columns]
```

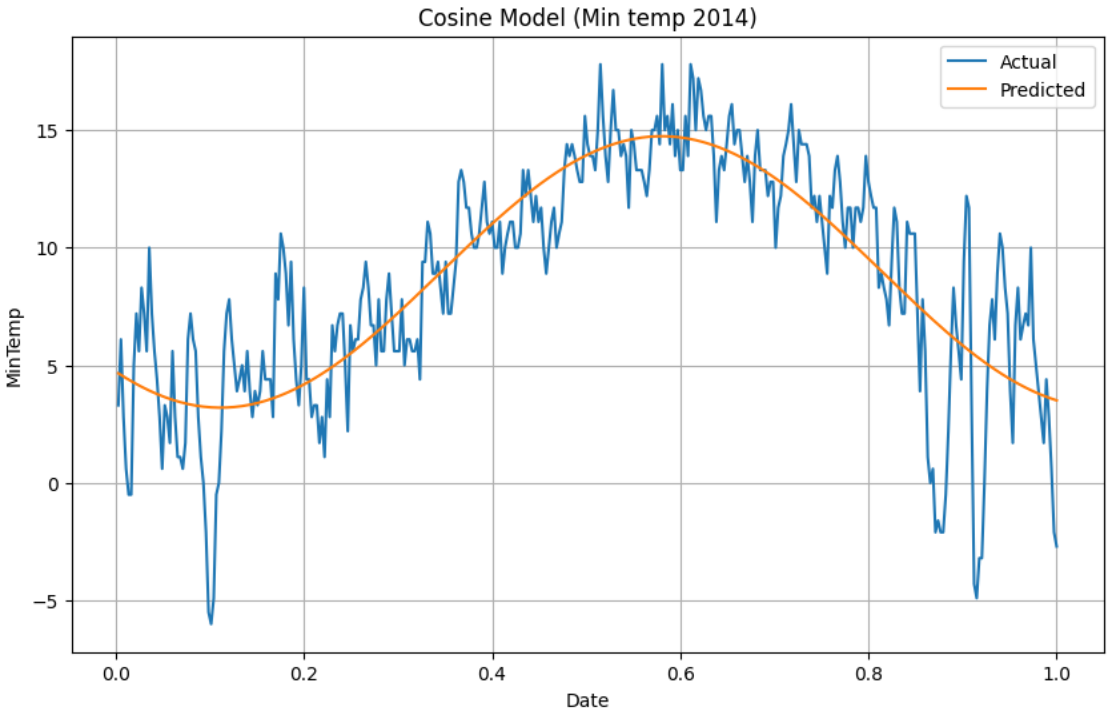
[38]:
```
plt.figure(figsize=(10,6))
plt.plot(y3['date'], y3['temp_min'], label='TempMin')
plt.plot(y3['date'], y3['temp_max'], label='TempMax')
plt.title('Temperature in 2014')
plt.xlabel('Date')
plt.ylabel('Temp')
plt.show()
```



[39]:
```
popt, _ = curve_fit(cos_model, y3['date_mod'], y3['temp_min'])
c1, c2, c3, c4 = popt
popt
```

[39]:
```
array([ 8.9699997 ,  5.77149132,  3.88750265, -6.69957774])
```

[40]:
```
y3_min = cos_model(y3['date_mod'], *popt)
plt.figure(figsize=(10, 6))
plt.plot(y3['date_mod'], y3['temp_min'], label='Actual')
plt.plot(y3['date_mod'], y3_min, label='Predicted')
plt.title('Cosine Model (Min temp 2014)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```

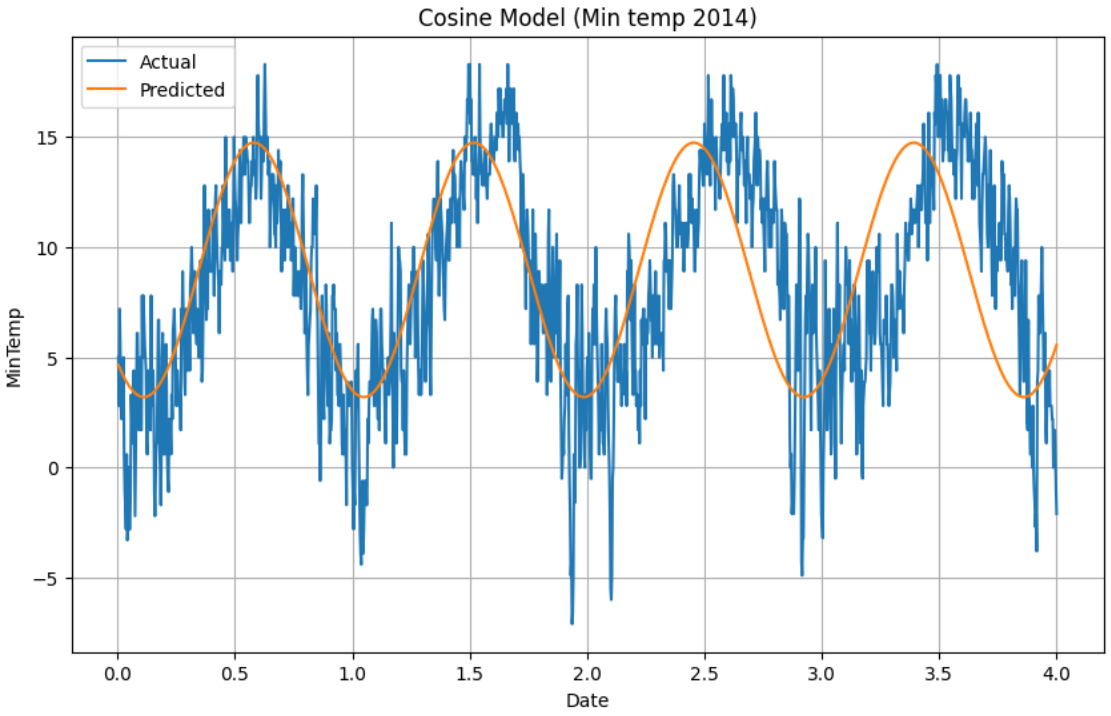


[41]:
```
rmse = np.sqrt(mean_squared_error(y3['temp_min'], y3_min))
rmse
```

[41]:
```
2.761276364400289
```

[42]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_min'], label='Actual')
```

```
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
  ↪label='Predicted')
plt.title('Cosine Model (Min temp 2014)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[43]:
```
rmse = np.sqrt(mean_squared_error(data['temp_min'], cos_model(data['date_mod'],␣
  ↪*popt)))
rmse
```

[43]: 3.841787024160479

0.3.4 Min temp (2015)

[44]:
```
y4 = data[data["year"] == 2015]
y4['date_code'] = range(1, len(y4) + 1)
y4['date_mod'] = y4['date_code']/365
y4
```

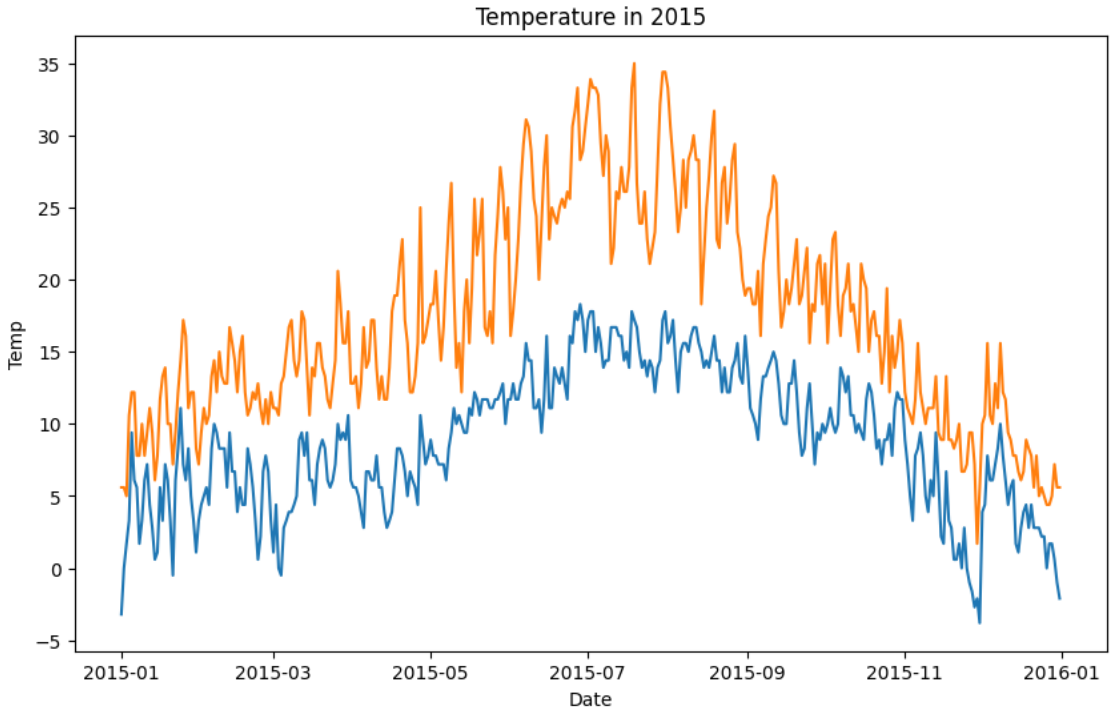
[44]:

	date	precipitation	temp_max	temp_min	wind	weather	date_code	\
1096	2015-01-01	0.0	5.6	-3.2	1.2	sun	1	
1097	2015-01-02	1.5	5.6	0.0	2.3	rain	2	
1098	2015-01-03	0.0	5.0	1.7	1.7	fog	3	
1099	2015-01-04	10.2	10.6	3.3	4.5	rain	4	
1100	2015-01-05	8.1	12.2	9.4	6.4	rain	5	
…	…	…	…	…	…	…	…	
1456	2015-12-27	8.6	4.4	1.7	2.9	rain	361	
1457	2015-12-28	1.5	5.0	1.7	1.3	rain	362	
1458	2015-12-29	0.0	7.2	0.6	2.6	fog	363	
1459	2015-12-30	0.0	5.6	-1.0	3.4	sun	364	
1460	2015-12-31	0.0	5.6	-2.1	3.5	sun	365	

	day	month	year	date_mod
1096	1	1	2015	0.002740
1097	2	1	2015	0.005479
1098	3	1	2015	0.008219
1099	4	1	2015	0.010959
1100	5	1	2015	0.013699
…	…	…	…	…
1456	27	12	2015	0.989041
1457	28	12	2015	0.991781
1458	29	12	2015	0.994521
1459	30	12	2015	0.997260
1460	31	12	2015	1.000000

[365 rows x 11 columns]

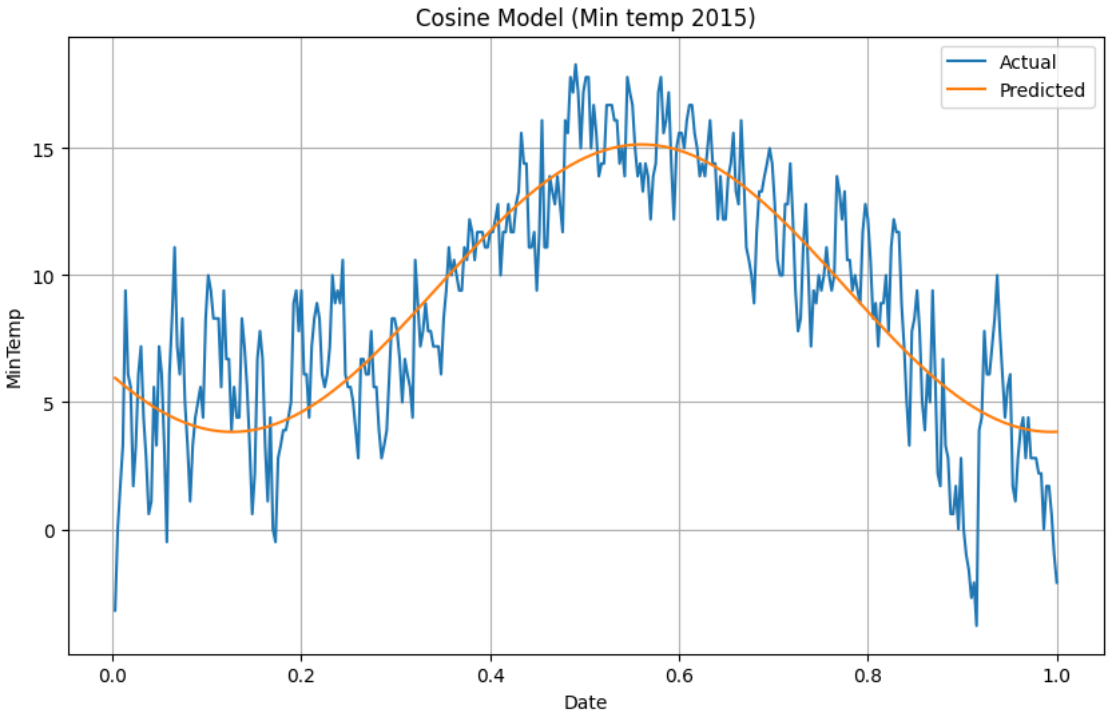
[45]:
```
plt.figure(figsize=(10,6))
plt.plot(y4['date'], y4['temp_min'], label='TempMin')
plt.plot(y4['date'], y4['temp_max'], label='TempMax')
plt.title('Temperature in 2015')
plt.xlabel('Date')
plt.ylabel('Temp')
plt.show()
```



[46]:
```
popt, _ = curve_fit(cos_model, y4['date_mod'], y4['temp_min'])
c1, c2, c3, c4 = popt
popt
```

[46]:
```
array([ 9.49089796,  5.65957919,  4.05740185, -7.24042615])
```

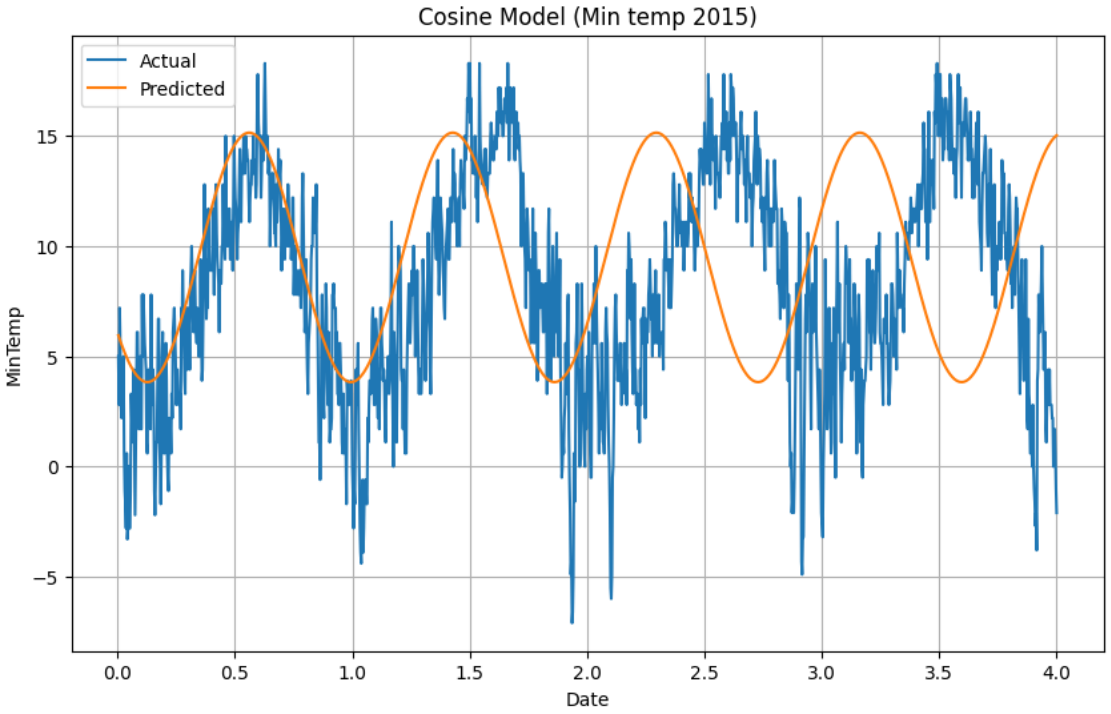
[47]:
```
y4_min = cos_model(y4['date_mod'], *popt)
plt.figure(figsize=(10, 6))
plt.plot(y4['date_mod'], y4['temp_min'], label='Actual')
plt.plot(y4['date_mod'], y4_min, label='Predicted')
plt.title('Cosine Model (Min temp 2015)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[48]:
```
rmse = np.sqrt(mean_squared_error(y4['temp_min'], y4_min))
rmse
```

[48]: 2.528895875599613

[49]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_min'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Min temp 2015)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```

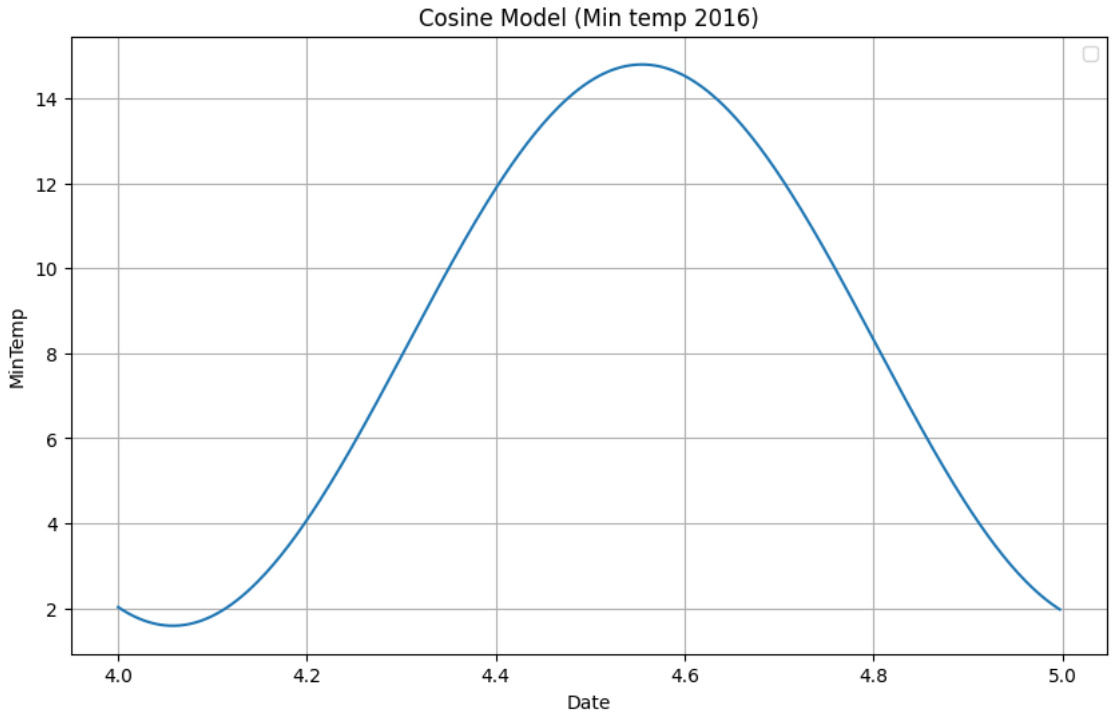


[50]:
```
rmse = np.sqrt(mean_squared_error(data['temp_min'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

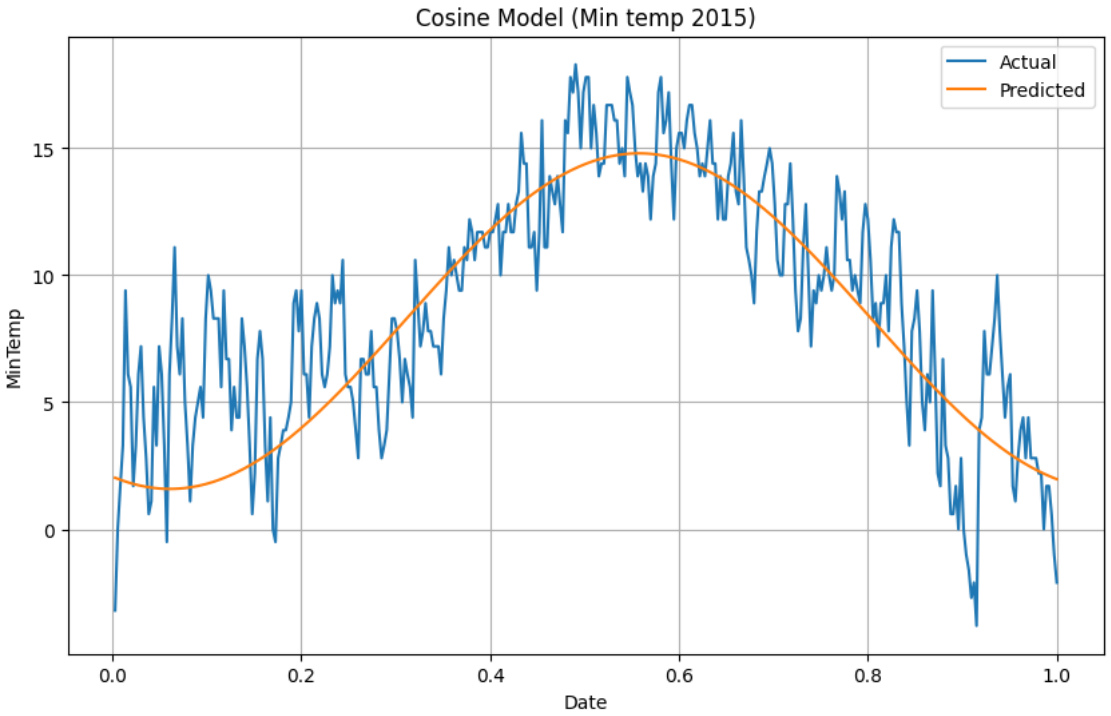
[50]: 6.248447353150017

[51]:
```
plt.figure(figsize=(10, 6))
plt.plot(np.arange(4, 5, 0.00274), y2_min)
plt.title('Cosine Model (Min temp 2016)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```

```
No artists with labels found to put in legend.  Note that artists whose label
start with an underscore are ignored when legend() is called with no argument.
```



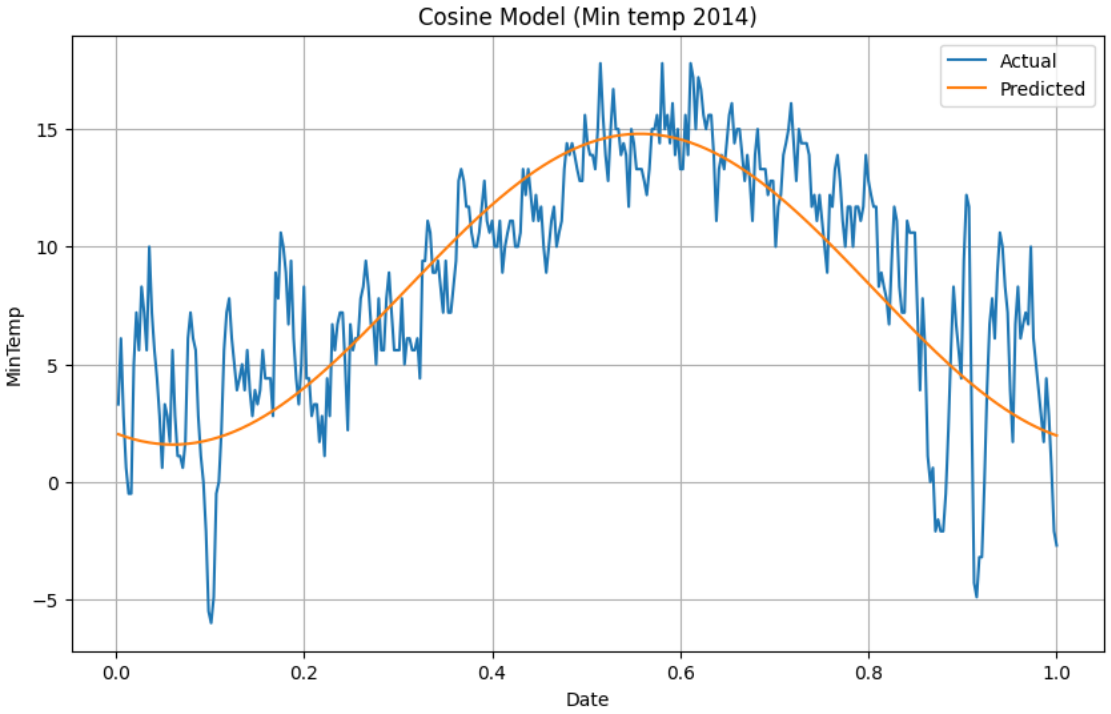
[52]:
```
popt, _ = curve_fit(cos_model, y2['date_mod'], y2['temp_min'])
c1, c2, c3, c4 = popt
y2_min = cos_model(y2['date_mod'], *popt)
plt.figure(figsize=(10, 6))
plt.plot(y4['date_mod'], y4['temp_min'], label='Actual')
plt.plot(y4['date_mod'], y2_min, label='Predicted')
plt.title('Cosine Model (Min temp 2015)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[53]:
```
rmse = np.sqrt(mean_squared_error(y4['temp_min'], y2_min))
rmse
```

[53]: 2.7723458276782558

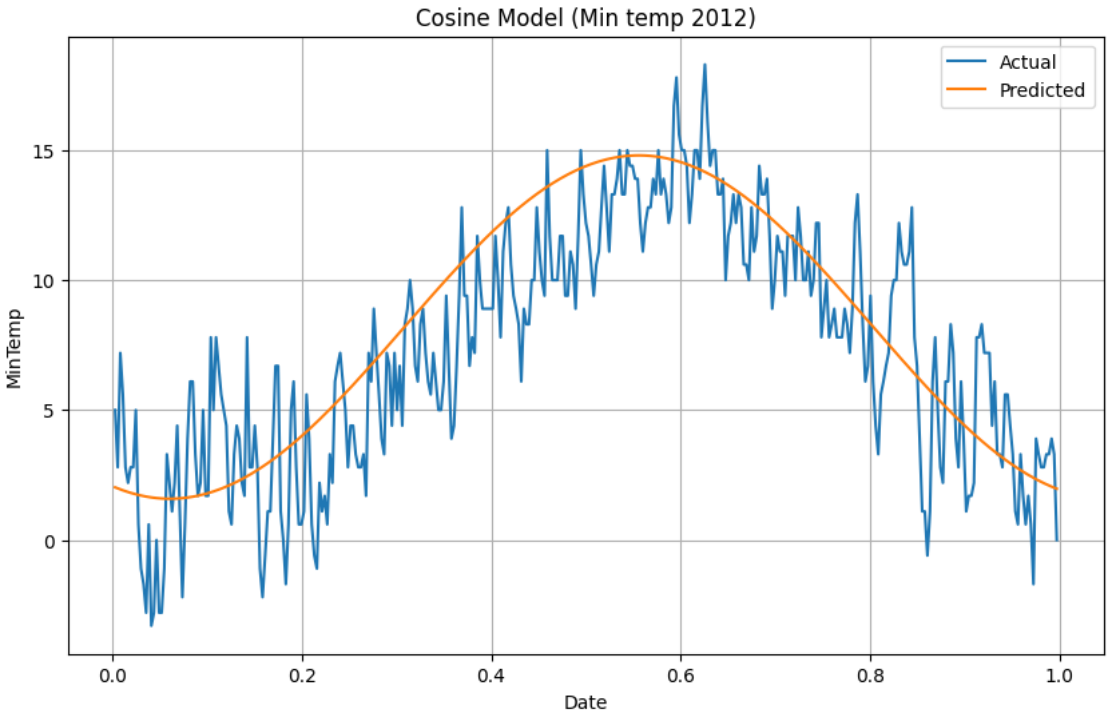
[54]:
```
plt.figure(figsize=(10, 6))
plt.plot(y3['date_mod'], y3['temp_min'], label='Actual')
plt.plot(y3['date_mod'], y2_min, label='Predicted')
plt.title('Cosine Model (Min temp 2014)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[55]:
```
rmse = np.sqrt(mean_squared_error(y3['temp_min'], y2_min))
rmse
```

[55]: 2.9458845416999426

[56]:
```
y1 = y1.drop(365)
plt.figure(figsize=(10, 6))
plt.plot(y1['date_mod'], y1['temp_min'], label='Actual')
plt.plot(y1['date_mod'], y2_min, label='Predicted')
plt.title('Cosine Model (Min temp 2012)')
plt.xlabel('Date')
plt.ylabel('MinTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[57]:
```
rmse = np.sqrt(mean_squared_error(y1['temp_min'], y2_min))
rmse
```

[57]: 2.6580975036027725

0.3.5 Max temp (2012)

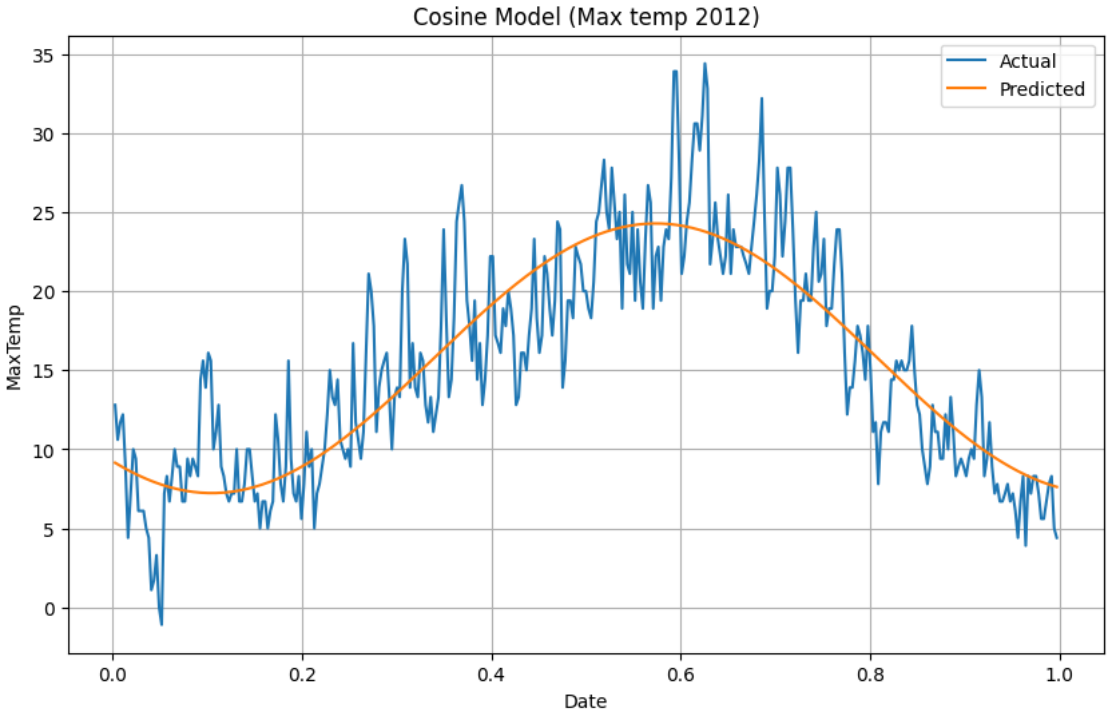
[58]:
```
popt, _ = curve_fit(cos_model, y1['date_mod'], y1['temp_max'])

popt
```

[58]: array([15.75379516, 8.52648155, -8.72286835, -6.69939324])

[59]:
```
c1, c2, c3, c4 = popt
y1_max = cos_model(y1['date_mod'], *popt)
```

[60]:
```
plt.figure(figsize=(10, 6))
plt.plot(y1['date_mod'], y1['temp_max'], label='Actual')
plt.plot(y1['date_mod'], y1_max, label='Predicted')
plt.title('Cosine Model (Max temp 2012)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
```

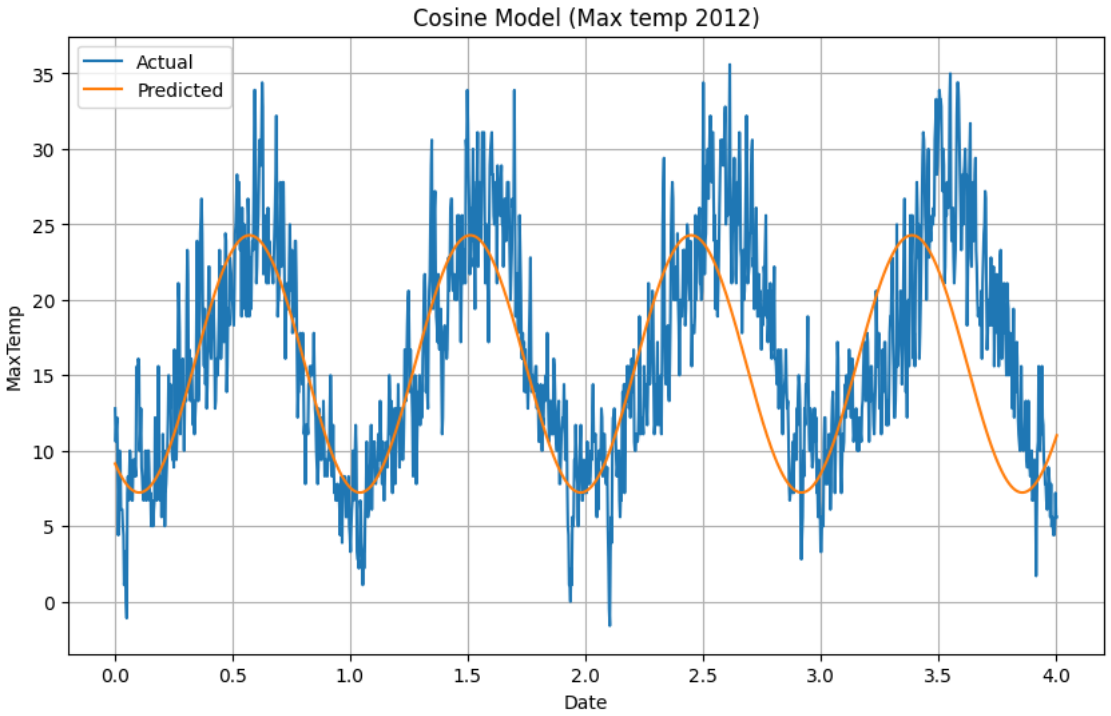
```
plt.show()
```



[61]:
```
rmse = np.sqrt(mean_squared_error(y1['temp_max'], y1_max))
rmse
```

[61]: 3.5238936345525955

[62]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_max'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Max temp 2012)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[63]:
```
rmse = np.sqrt(mean_squared_error(data['temp_min'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

[63]: 8.505269282127149

0.3.6 Max temp (2013)

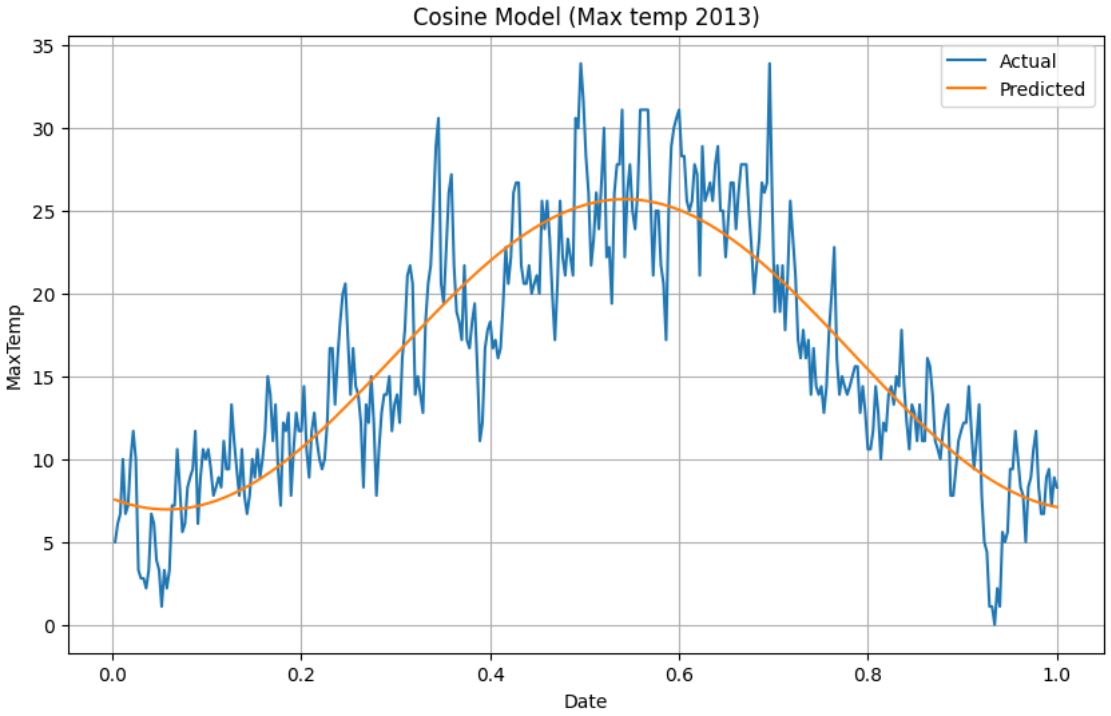
[64]:
```
popt, _ = curve_fit(cos_model, y2['date_mod'], y2['temp_max'])

popt
```

[64]: array([16.33337112, 9.36906958, -2.76767591, -6.48028796])

[65]:
```
c1, c2, c3, c4 = popt
y2_max = cos_model(y2['date_mod'], *popt)
```

[66]:
```
plt.figure(figsize=(10, 6))
plt.plot(y2['date_mod'], y2['temp_max'], label='Actual')
plt.plot(y2['date_mod'], y2_max, label='Predicted')
plt.title('Cosine Model (Max temp 2013)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
```

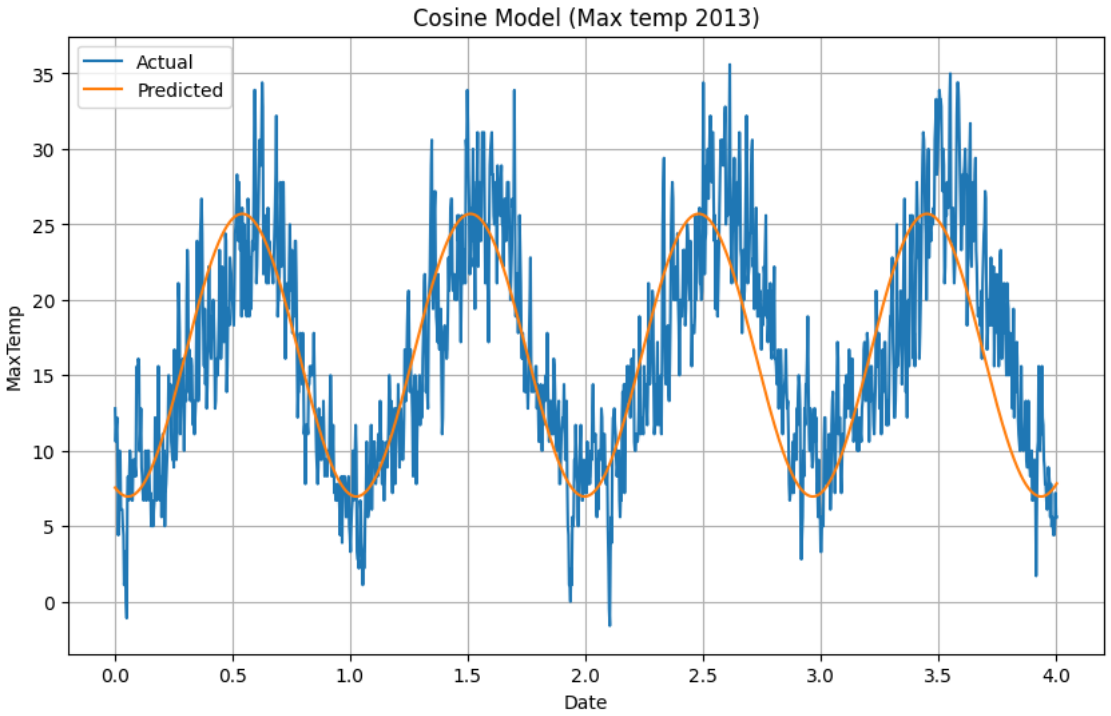
```
plt.grid(True)
plt.show()
```



[67]:
```
rmse = np.sqrt(mean_squared_error(y2['temp_max'], y2_max))
rmse
```

[67]: 3.4726436770101046

[68]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_max'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Max temp 2013)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[69]:
```
rmse = np.sqrt(mean_squared_error(data['temp_max'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

[69]: 4.465022770061978

0.3.7 Max temp (2014)

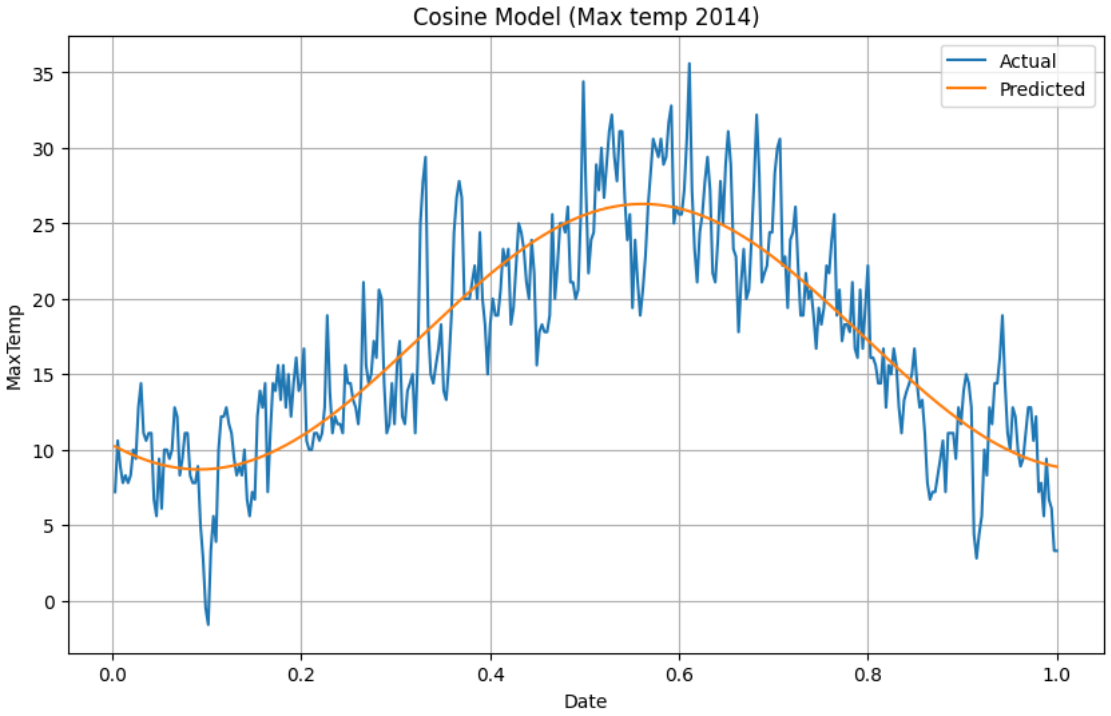
[70]:
```
popt, _ = curve_fit(cos_model, y3['date_mod'], y3['temp_max'])

popt
```

[70]: array([17.49124643, 8.79727693, -2.52642758, -6.69538688])

[71]:
```
c1, c2, c3, c4 = popt
y3_max = cos_model(y3['date_mod'], *popt)
```

[72]:
```
plt.figure(figsize=(10, 6))
plt.plot(y3['date_mod'], y3['temp_max'], label='Actual')
plt.plot(y3['date_mod'], y3_max, label='Predicted')
plt.title('Cosine Model (Max temp 2014)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
```

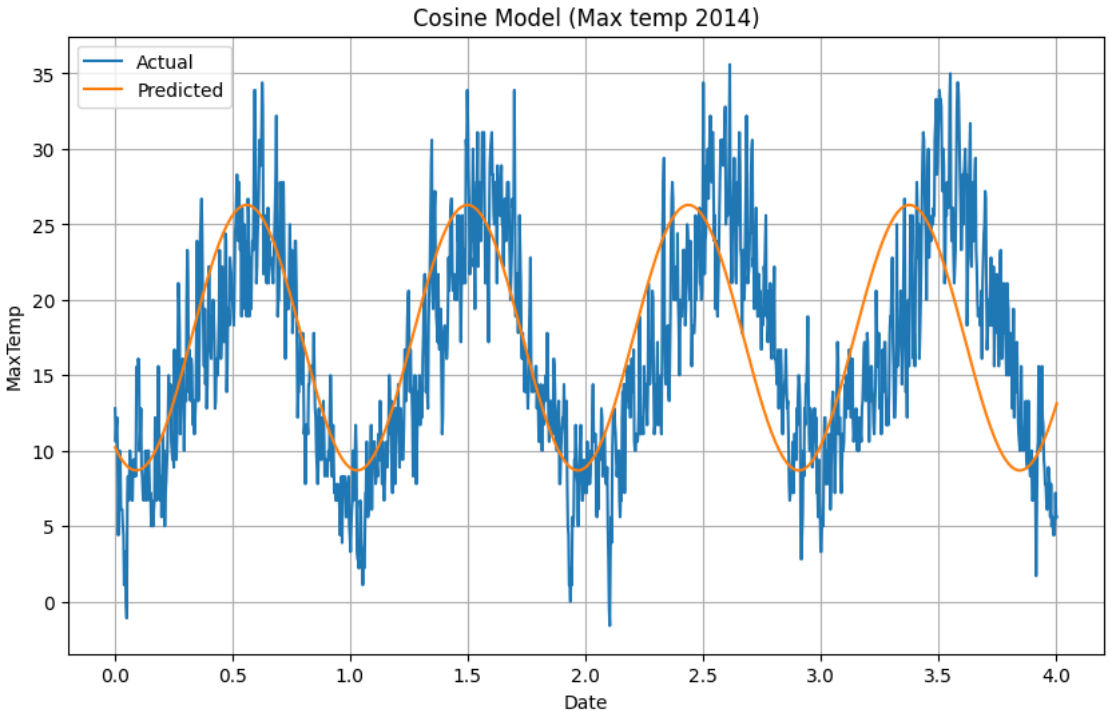
```
plt.grid(True)
plt.show()
```



[73]:
```
rmse = np.sqrt(mean_squared_error(y3['temp_max'], y3_max))
rmse
```

[73]: 3.55321173786433

[74]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_max'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Max temp 2014)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[75]:
```
rmse = np.sqrt(mean_squared_error(data['temp_max'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

[75]: 5.481272911571637

0.3.8 Max temp (2015)

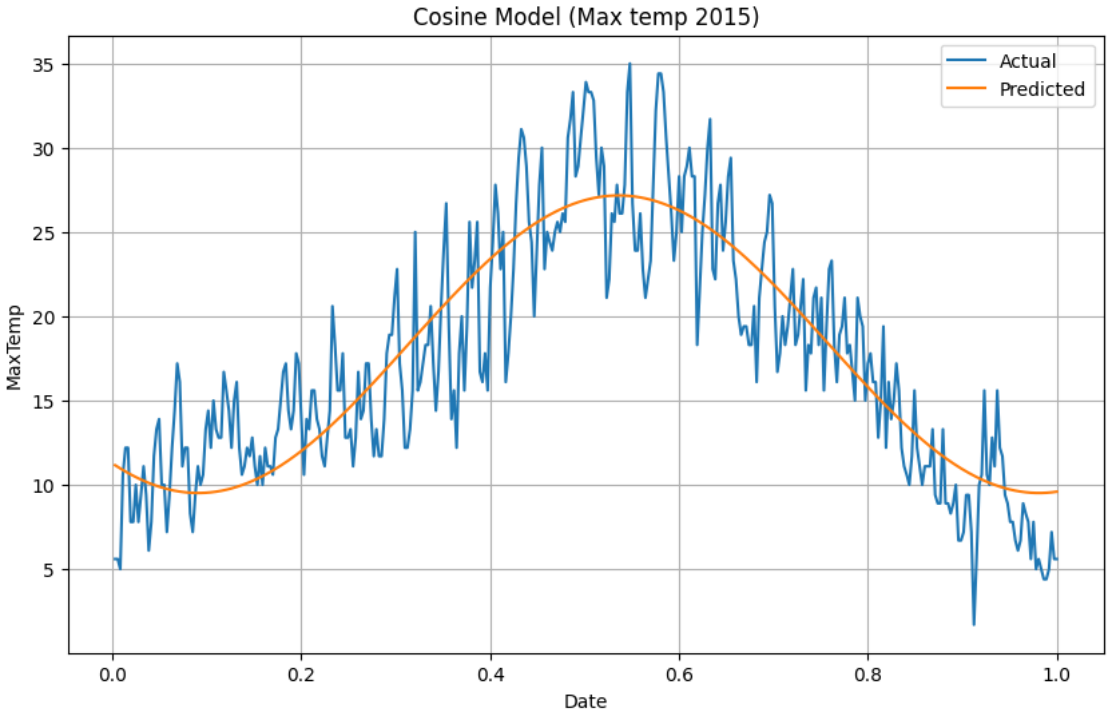
[76]:
```
popt, _ = curve_fit(cos_model, y4['date_mod'], y4['temp_max'])

popt
```

[76]: array([18.34243691, 8.8263542 , -2.50128207, -7.05565959])

[77]:
```
c1, c2, c3, c4 = popt
y4_max = cos_model(y4['date_mod'], *popt)
```

[78]:
```
plt.figure(figsize=(10, 6))
plt.plot(y4['date_mod'], y4['temp_max'], label='Actual')
plt.plot(y4['date_mod'], y4_max, label='Predicted')
plt.title('Cosine Model (Max temp 2015)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
```

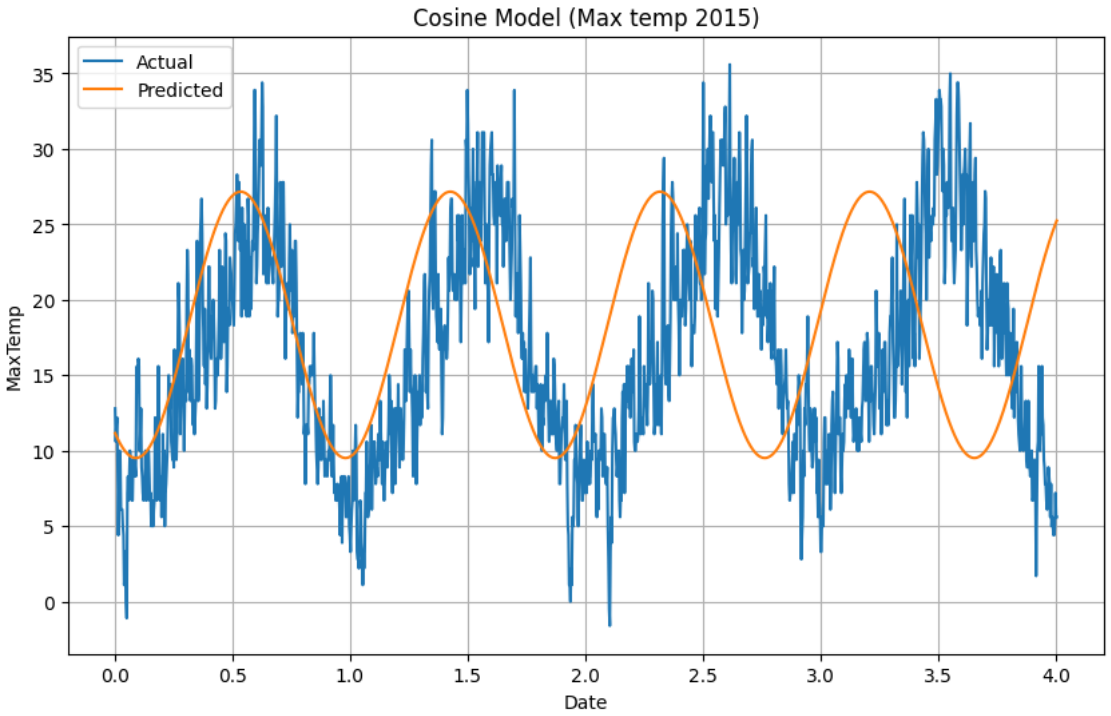
```
plt.grid(True)
plt.show()
```



[79]:
```
rmse = np.sqrt(mean_squared_error(y4['temp_max'], y4_max))
rmse
```

[79]: 3.45529404117358

[80]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_max'], label='Actual')
plt.plot(data['date_mod'], cos_model(data['date_mod'], *popt),␣
 ↪label='Predicted')
plt.title('Cosine Model (Max temp 2015)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[81]:
```
rmse = np.sqrt(mean_squared_error(data['temp_max'], cos_model(data['date_mod'],␣
↪*popt)))
rmse
```

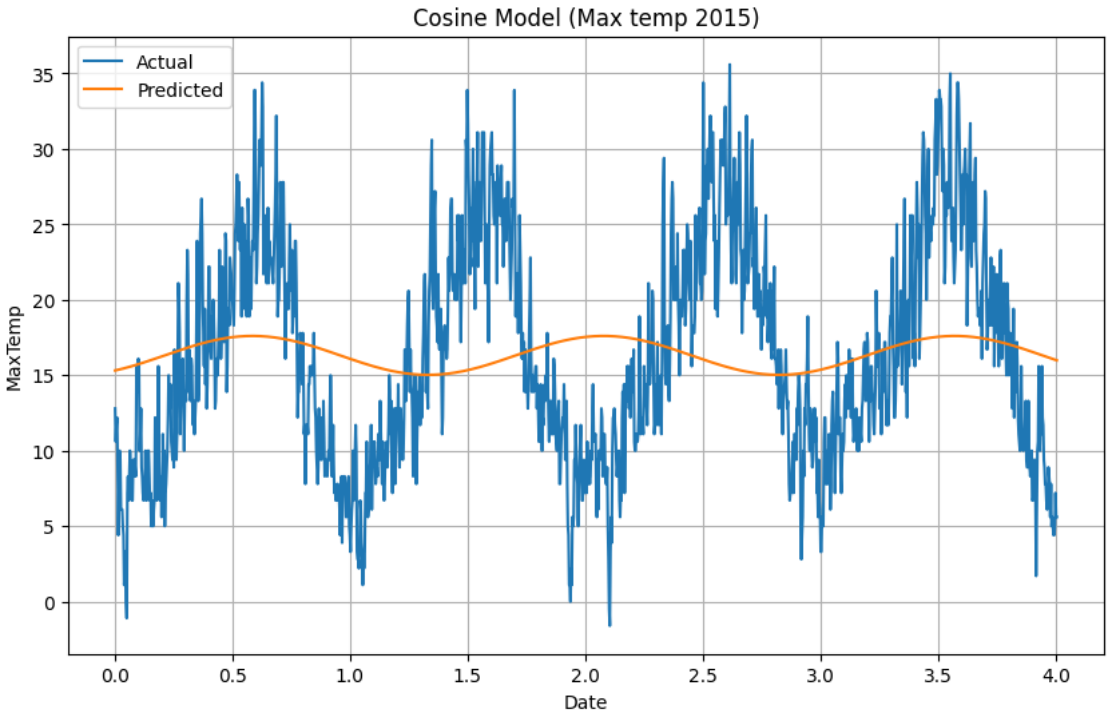
[81]: 8.714719696231851

[82]:
```
popt, _ = curve_fit(cos_model, data['date_mod'], data['temp_max'])

popt
```

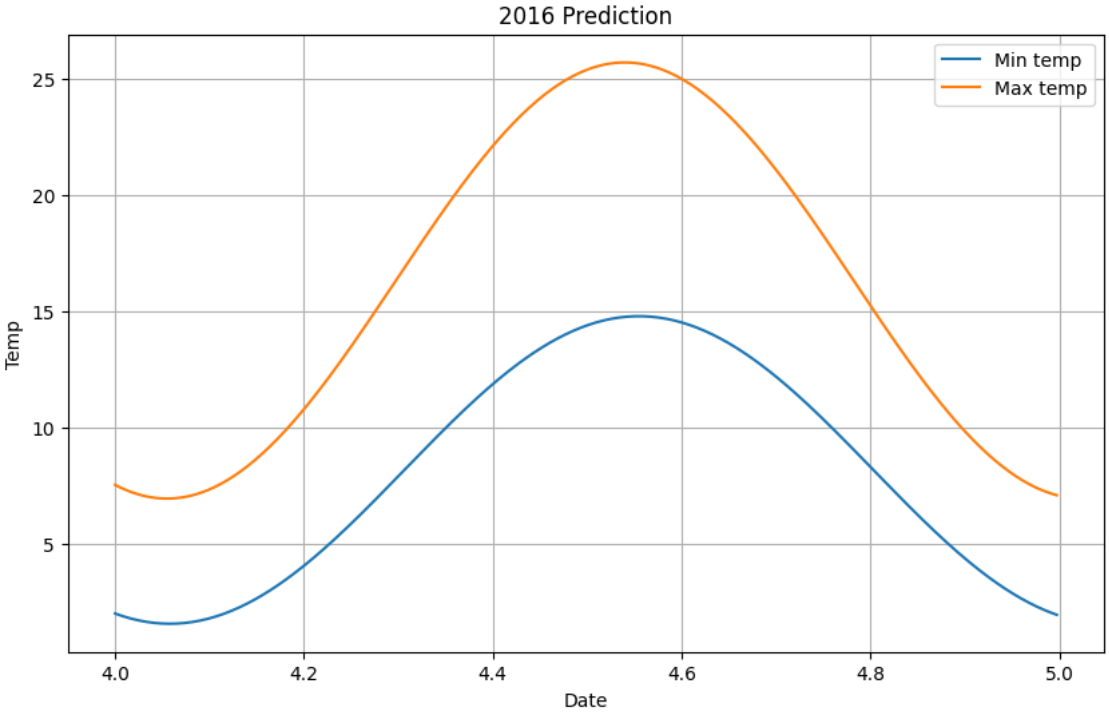
[82]: array([16.31712832, -1.29012176, 0.67307713, 4.21250352])

[83]:
```
c1, c2, c3, c4 = popt
data_max = cos_model(data['date_mod'], *popt)
```

[84]:
```
plt.figure(figsize=(10, 6))
plt.plot(data['date_mod'], data['temp_max'], label='Actual')
plt.plot(data['date_mod'], data_max, label='Predicted')
plt.title('Cosine Model (Max temp 2015)')
plt.xlabel('Date')
plt.ylabel('MaxTemp')
plt.legend()
plt.grid(True)
plt.show()
```



[85]:
```
plt.figure(figsize=(10, 6))
plt.plot(np.arange(4, 5, 0.00274), y2_min, label='Min temp')
plt.plot(np.arange(4, 5, 0.00274), y2_max, label='Max temp')
plt.title('2016 Prediction')
plt.xlabel('Date')
plt.ylabel('Temp')
plt.legend()
plt.grid(True)
plt.show()
```


2016 Prediction
Min temp
Max temp
Temp
25
20
15
10
5
4.0
4.2
4.4
4.6
4.8
5.0
Date