Sinusoidal Regression - Yuba River - USGS Data

September 22, 2019

[1]:
```
from urllib.request import urlopen

# read web data
url = 'https://waterdata.usgs.gov/nwis/dv?
↪cb_00010=on&format=rdb&site_no=11417500&referred_module=sw&period=&begin_date=1965-02-18&en
webpage = urlopen(url)
charset_encoding = webpage.info().get_content_charset()
webpage = webpage.read().decode(charset_encoding)
```

[2]:
```
import pandas as pd

# wrangle and transform to pd series
splitpage = webpage.split(sep='\n')
header , data = splitpage[28].split(sep='\t'), []

for line in splitpage[30:-1]:
        data.append(line.split(sep='\t'))

data_series = pd.Series(data)
```

[3]:
```
import numpy as np

# transform to pd dataframe
df = pd.DataFrame(data_series.tolist(), columns=splitpage[28].split(sep='\t'),␣
↪index=data_series.index)

# wrangle: fill and drop nan, reset index, rename columns
df['10733_00010_00001'].replace('',np.nan,inplace=True)
df.dropna(subset = ['10733_00010_00001'], inplace=True)
df = df.reset_index(drop=True)
df.columns = ['agency_cd', 'site_no', 'datetime', 'max_temp', 'max_temp_code',␣
↪'min_temp', 'min_temp_code']
```

[4]:
```
# table of record counts and date range
df.groupby(df.datetime.str[0:4]).agg({'max_temp':'count'})
```

[4]:
```
          max_temp
datetime
```

```
1965           317
1966           365
1967           364
1968           355
1969           354
1970           343
1971           365
1972           366
1973           314
1974           253
1975           290
1976           362
1977           348
1978           365
1979           120
2000            60
2001           365
2002           365
2003           365
2004           366
2005            47
```

[5]:
```python
# get beginning date ranges for the 2 obvious segments of data using counts
idx_end_1979 = (-47 - 366 - (365 * 3) - 60) - 1
idx_begin_2000 = idx_end_1979 + 1
df['datetime'].iloc[0],df['datetime'].iloc[idx_end_1979], df['datetime'].
 ↪iloc[idx_begin_2000], df['datetime'].iloc[-1]
```

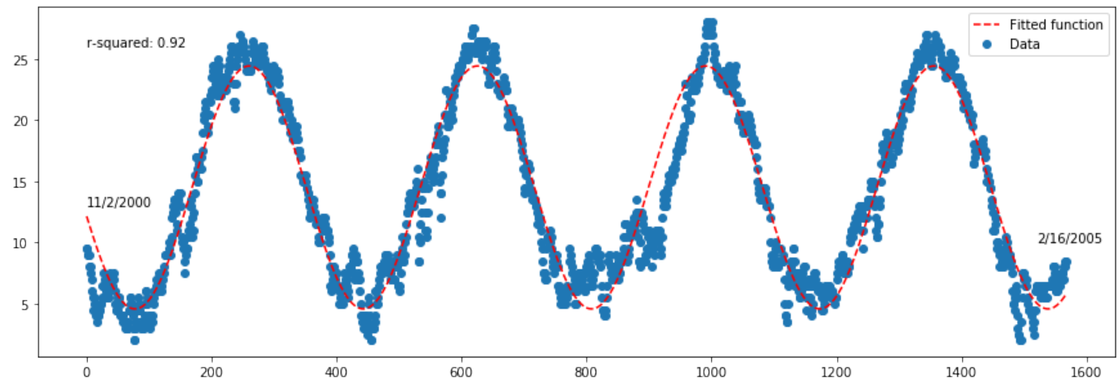
[5]:
```
('1965-02-18', '1979-04-30', '2000-11-02', '2005-02-16')
```

[6]:
```python
# translate segment date ranges into indeces and slice df
idx_lower_df1 = df.loc[df['datetime'] == '1965-02-18'].index.tolist()
idx_upper_df1 = df.loc[df['datetime'] == '1979-04-30'].index.tolist()

idx_lower_df2 = df.loc[df['datetime'] == '2000-11-02'].index.tolist()
idx_upper_df2 = df.loc[df['datetime'] == '2005-02-16'].index.tolist()

df1 = df.iloc[idx_lower_df1[0]:idx_upper_df1[0]]
df2 = df.iloc[idx_lower_df2[0]:idx_upper_df2[0]]
```

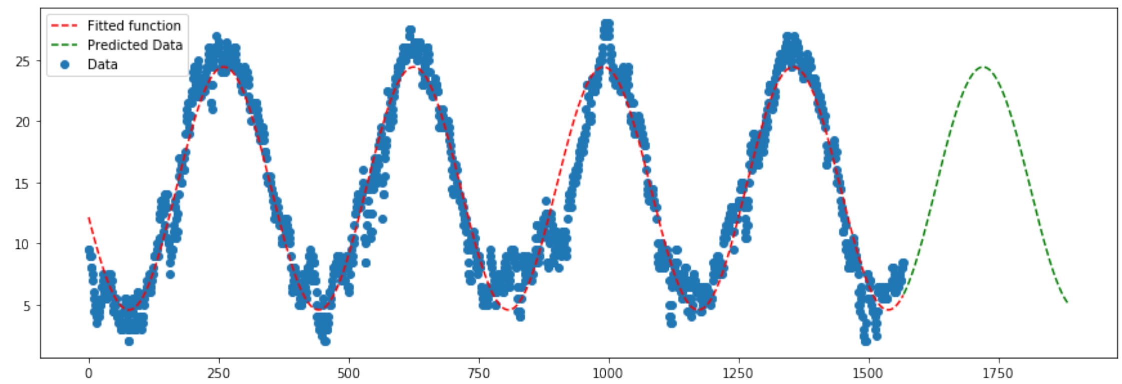
[7]:
```python
# transform into np arrays for sinusoidal regression modeling
y_data_df1 = np.array(df1['max_temp'].tolist(),dtype = np.float32)
y_data_df2 = np.array(df2['max_temp'].tolist(),dtype = np.float32)

# represent dates as continuous variable of same length
x_data_df1 = np.array(list(range(1,len(y_data_df1) + 1)))
x_data_df2 = np.array(list(range(1,len(y_data_df2) + 1)))
```

[8]:
```
# define sinusoidal fxn with scale var so final value maps to roughly 2pi
scale = 2 * np.pi / 365

def test_func(x, a, b, c, d):
    return a * np.sin(b * x * scale + c) + d

# define r-squared function
def r_func(y, y_predict):
    residuals = y - y_predict
    ss_residuals = np.sum(residuals**2)
    ss_total = np.sum((y-np.mean(y))**2)
    r_sq = 1 - (ss_residuals / ss_total)
    return r_sq
```

[10]:
```
from scipy import optimize
import matplotlib.pyplot as plt

# perform regression and plot, start with df2 because data is more complete
params, params_covariance = optimize.curve_fit(test_func, x_data_df2,␣
↪y_data_df2, p0=None)

# calculate coef of determination
r_sq = r_func(y_data_df2, test_func(x_data_df2, params[0], params[1],␣
↪params[2], params[3]))

# plot
plt.figure(figsize = (15, 5))
plt.scatter(x_data_df2, y_data_df2, label = 'Data')
plt.plot(x_data_df2, test_func(x_data_df2, params[0], params[1], params[2],␣
↪params[3]), 'r--',label = 'Fitted function')
plt.legend(loc = 'best')
plt.annotate('r-squared: '+str(round(r_sq,2)),xy=(0,26))
plt.annotate('11/2/2000',xy=(0,13))
plt.annotate('2/16/2005',xy=(1520,10))
plt.show()
```



[11]:
```
# use model to predict the rest of 2005 and plot
date1 = x_data_df2[-1] + 1 # represents 2/17/2005
date2 = date1 + 317 # represents 12/31/2005

predict_x_data = np.arange(date1,date2,1)
predict_y_data = np.array(test_func(predict_x_data, params[0], params[1],␣
 ↪params[2], params[3]))

plt.figure(figsize=(15, 5))
plt.scatter(x_data_df2, y_data_df2, label='Data')
plt.plot(x_data_df2, test_func(x_data_df2, params[0], params[1], params[2],␣
 ↪params[3]), 'r--',label='Fitted function')
plt.plot(predict_x_data,predict_y_data, 'g--',label='Predicted Data')
plt.legend(loc='best')
plt.show()
```



[12]:
```
import datetime

predict_x_data_date_objs = np.arange((np.datetime64('2005-02-17')), np.
 ↪datetime64('2005-12-31')).tolist()

predict_x_data_dates = []
for date in predict_x_data_date_objs:
    predict_x_data_dates.append(date.strftime("%#m/%#d/%Y"))

predict_df = pd.DataFrame({'x_date': predict_x_data_dates,'y': predict_y_data.
 ↪round(1)})

min, max = predict_df.loc[predict_df['y'].idxmin(), ['x_date','y']].tolist(),␣
 ↪predict_df.loc[predict_df['y'].idxmax(), ['x_date','y']].tolist()
```

```
min, max
```

[12]: (['12/29/2005', 5.1], ['7/12/2005', 24.4])

[13]:
```
# for df1 - which is larger span but incomplete data - perform regression for␣
↪purpose of fit stats
scale = 2 * np.pi / 351 # reduce scaling due to data integrity
params, params_covariance = optimize.curve_fit(test_func, x_data_df1,␣
↪y_data_df1, p0=None)

# calculate coef of determination
r_sq = r_func(y_data_df1,test_func(x_data_df1, params[0], params[1], params[2],␣
↪params[3]))

# plot
plt.figure(figsize=(15, 5))
plt.scatter(x_data_df1, y_data_df1, label='Data')
plt.plot(x_data_df1, test_func(x_data_df1, params[0], params[1], params[2],␣
↪params[3]), 'r--',label='Fitted function')
plt.legend(loc='best')
plt.annotate('r-squared: '+str(round(r_sq,2)),xy=(600,28))
plt.annotate('2/18/1965',xy=(0,4))
plt.annotate('4/30/1979',xy=(4750,17))
plt.show()
```