Analyzing Weather Trends in Oakland and the Planet Earth

from 1849 to 2013

Introduction

This project explores weather trends in Oakland United States and generally the Planet Earth. I will try to discover similarities and differences between the world averages and Oakland's averages, as well as overall trends. I will calculate the moving average temperatures to smoothen the plotlines.

Database

This project uses data from the weather trends database which has the following schema:

```
<table>: <fields>
city_data: year, city, country, avg_temp
city_list: city, country
global_data: year, avg_temp
```

There is no data for my residence in Honolulu, Hawaii. The following queries produced zero results.

```sql
select * from city_list
where city like 'Hono%' or city like 'hono%';

select * from city_data
where city like 'Hono%' or city like 'hono%';`
```

The closest cities to Honolulu according to Google are the following:

```
    2550 miles to San Francisco, CA.
    2559 miles to Oakland, CA.
    2567 miles to San Jose, CA.
    2568 miles to Fremont, CA.
```

I chose Oakland, California since I used to live there.

Confirming with following sql query, there is only one city named Oakland in city_list table which produced the solitary result of `Oakland United States` .

```sql
select * from city_list
where city like 'Oak%' or city like 'oak%'
```

Tools Used For the Project

- SQL queries
- Emacs
- Linux commands

- Python
- Python libraries: `csv` , `pandas` , `matplotlib`
- jupyter notebook
- git and GitHub
- Google of course

Data Extraction

I extracted the data from this database using the following queries:

(a)

```
select * from city_data
where city_data.city like 'oak%' or city_data.city like 'Oak%'
```

(b)

```
select city_data.*
from city_data join global_data
on city_data.year = global_data.year
where city_data.city = 'Oakland'
```

(c)

```
select * from global_data
```

(d)

```
select city_data.*, global_data.year as global_year, global_data.avg_temp as
global_avg_temp
from city_data join global_data
on city_data.year = global_data.year
where city_data.city = 'Oakland'
```

SQL queries **(a)** and **(b)** produced the same results saved to `results_oakland.csv` and `results_oakland2.csv` respectively (see directory `other`). I used the following linux command line `diff results_oakland.csv results_oakland2.csv` on the extracted csv files and received no difference between the 2 files. I tried using right, left, and full outer joins on the database and got the same 165 results exactly like **(a) and (b)**. But it seems that outer joins do not work since sql query **(c)** for global data produced 266 results. I will ignore the data previous to Oakland's first year of recorded temperature in 1849.

Hence, I used sql query **(d)** to include both Oakland and global data in one csv file (see `results_oakland_and_global.csv`) which was used for plotting the average temperatures.

Code

```
In [78]: import csv
In [79]: with open('results_oakland_and_global.csv', 'r') as f:
             reader_list = csv.DictReader(f)
             temperatures = list(reader_list)
```

The code below confirms that the years are consecutively ascending, i.e., all years accounted for from 1849 to 2013

```
In [80]: temp_list = [int(temp['year']) for temp in temperatures]
         temp_list == list(range(temp_list[0], temp_list[-1]+1)) # temp_list
         [0]=1849, temp_list[-1]=2013

Out[80]: True
```

```
In [81]: import pandas as pd
```

```
In [82]: data = pd.read_csv('results_oakland_and_global.csv')
```

```
In [83]: data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 165 entries, 0 to 164
Data columns (total 6 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   year             165 non-null    int64  
 1   city             165 non-null    object 
 2   country          165 non-null    object 
 3   avg_temp         165 non-null    float64
 4   global_year      165 non-null    int64  
 5   global_avg_temp  165 non-null    float64
dtypes: float64(2), int64(2), object(2)
memory usage: 7.9+ KB
```

Since there is data in every column and the years are ascending and consecutive, there is need to clean data for now.

Looking at first 5 and last 5 rows, Oakland seems warmer than the rest of the planet. It also seems like the planet is getting warmer globally.

In [84]:

```
# Below are the first 5 and the last 5 rows of data to show how data
 looks.
data.head()
```

Out[84]:

	year	city	country	avg_temp	global_year	global_avg_temp
0	1849	Oakland	United States	14.12	1849	7.98
1	1850	Oakland	United States	13.80	1850	7.90
2	1851	Oakland	United States	14.39	1851	8.18
3	1852	Oakland	United States	13.81	1852	8.10
4	1853	Oakland	United States	14.40	1853	8.04

In [85]:

```
data.tail()
```

Out[85]:

	year	city	country	avg_temp	global_year	global_avg_temp
160	2009	Oakland	United States	15.02	2009	9.51
161	2010	Oakland	United States	14.67	2010	9.70
162	2011	Oakland	United States	14.50	2011	9.52
163	2012	Oakland	United States	15.05	2012	9.51
164	2013	Oakland	United States	16.23	2013	9.61

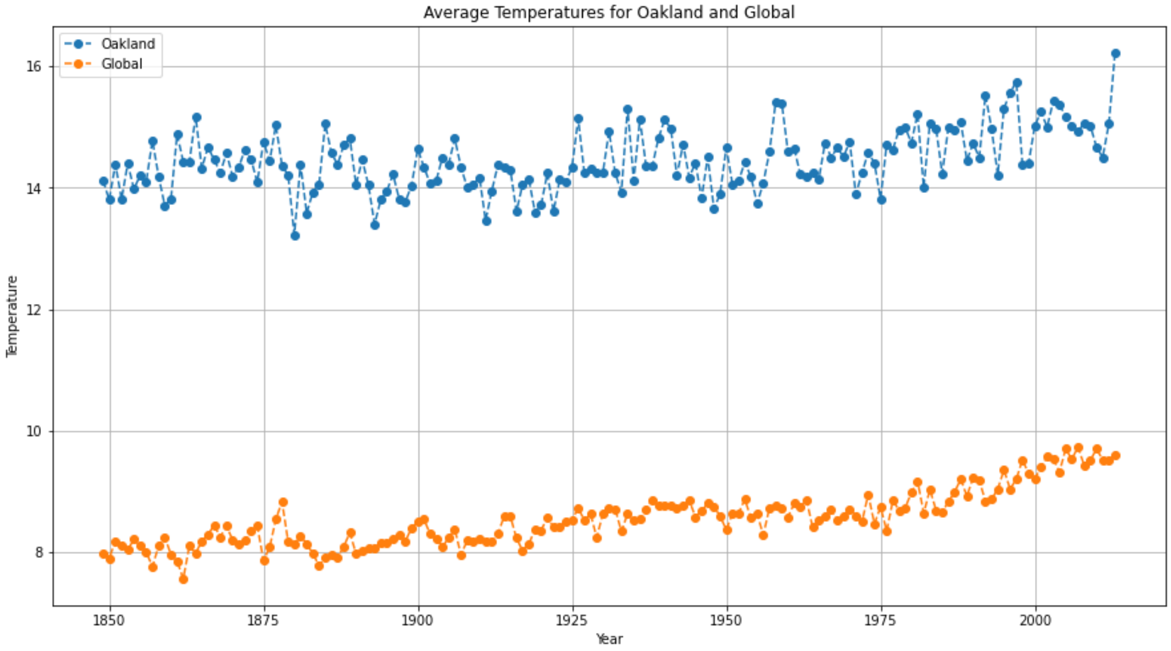
Let's quickly plot the average temperatures

In [86]:

```
import matplotlib.pyplot as plt
%matplotlib inline
```

In [87]:
```
data.index = data['year']
plt.figure(figsize=[15,8])
plt.grid(True)
plt.title('Average Temperatures for Oakland and Global')
plt.xlabel('Year')
plt.ylabel('Temperature')
plt.plot(data['avg_temp'], label = 'Oakland', linestyle='dashed', mar
ker='o')
plt.plot(data['global_avg_temp'], label = 'Global', linestyle='dashe
d', marker='o')
plt.legend(loc=2) # upper left hand corner
```

Out[87]:
```
<matplotlib.legend.Legend at 0x7f5c24acdd30>
```



It's unclear whether there is a trend in Oakland. I will smoothen the plot lines by calculating the moving temperature averages for both Oakland and the planet.

In [88]:

```python
# resource: https://www.datacamp.com/community/tutorials/moving-averages-in-pandas
data['oakland_moving_avg_temp'] = data['avg_temp'].rolling(window=8).mean()
data['global_moving_avg_temp'] = data['global_avg_temp'].rolling(window=7).mean()
data.head(10)
```

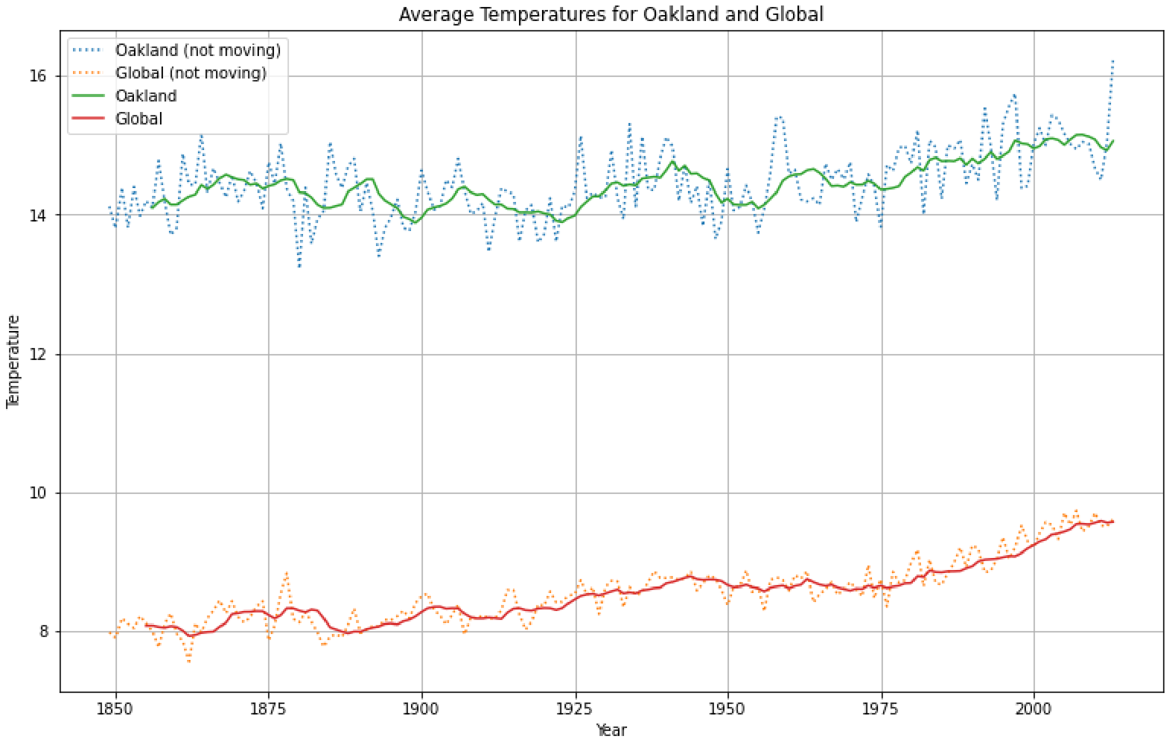
Out[88]:

	year	city	country	avg_temp	global_year	global_avg_temp	oakland_moving_avg_te
year							
1849	1849	Oakland	United States	14.12	1849	7.98	N
1850	1850	Oakland	United States	13.80	1850	7.90	N
1851	1851	Oakland	United States	14.39	1851	8.18	N
1852	1852	Oakland	United States	13.81	1852	8.10	N
1853	1853	Oakland	United States	14.40	1853	8.04	N
1854	1854	Oakland	United States	13.98	1854	8.21	N
1855	1855	Oakland	United States	14.20	1855	8.11	N
1856	1856	Oakland	United States	14.10	1856	8.00	14.10
1857	1857	Oakland	United States	14.78	1857	7.76	14.18
1858	1858	Oakland	United States	14.19	1858	8.10	14.23

I experimented with changing the window period from 1 to 10. Lower numbers give plotlines closer to the unsmoothened plotline of average temperatures. The higher the window period, the smoother are the plotlines. I eventually chose window period of 8 for Oakland to show the trend without deviating too much from the actual temperatures.

In [89]:

```python
plt.figure(figsize=[13,8])
plt.title('Average Temperatures for Oakland and Global')
plt.grid(True)
plt.xlabel('Year')
plt.ylabel('Temperature')
plt.plot(data['avg_temp'], label = 'Oakland (not moving)', linestyle='dotted') # transpose over moving average
plt.plot(data['global_avg_temp'], label = 'Global (not moving)', linestyle='dotted')
plt.plot(data['oakland_moving_avg_temp'], label='Oakland')
plt.plot(data['global_moving_avg_temp'], label='Global')
plt.legend(loc=2)
plt.show()
```



Observations

- Oakland's yearly average temperatures are higher than those of the whole planet.
- The plotline of global average temperatures indicates that there is a general warming of the planet.
- Experimenting with different window periods for the moving average, it was not clear that there was a trend in Oakland. Settling for window period of 8, I noticed that there was a warming trend starting around the year 1975.
- In fact, the global warming trend was much clearer around the year 1975. Although there was already a subtle global warming trend around 1880s.
- Trusting the data, I would like to conclude that it is getting hotter globally and locally. But It was only clear in Oakland starting around 1975.

Resources

- https://matplotlib.org/3.1.1/index.html (https://matplotlib.org/3.1.1/index.html)
- https://www.datacamp.com/community/tutorials/moving-averages-in-pandas (https://www.datacamp.com/community/tutorials/moving-averages-in-pandas)
- Python for Data Analysis by Wes McKinney first edition
- Intro to Data Analysis course

Extra Credit

I included two cities in which I also reside namely Amsterdam and Bangkok.

In [90]:

```
data_ams = pd.read_csv('extra/results_amsterdam.csv')
data_bkk = pd.read_csv('extra/results_bangkok.csv')
data_oak = pd.read_csv('extra/results_oakland.csv')
data_glo = pd.read_csv('extra/results_global.csv')
```

In [91]:

```
merged_data = pd.concat([data_oak, data_ams, data_bkk, data_glo], axi
s=1, sort=False)
```

In [92]:

```
merged_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 165 entries, 0 to 164
Data columns (total 5 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   year                165 non-null    int64  
 1   oakland_avg_temp    165 non-null    float64
 2   amsterdam_avg_temp  165 non-null    float64
 3   bangkok_avg_temp    165 non-null    float64
 4   global_avg_temp     165 non-null    float64
dtypes: float64(4), int64(1)
memory usage: 6.6 KB
```

In [93]:

```
merged_data.index = merged_data['year']
```

In [94]:

```
merged_data['oak_moving'] = merged_data['oakland_avg_temp'].rolling(w
indow=7).mean()
merged_data['glo_moving'] = merged_data['global_avg_temp'].rolling(wi
ndow=7).mean()
merged_data['bkk_moving'] = merged_data['bangkok_avg_temp'].rolling(w
indow=7).mean()
merged_data['ams_moving'] = merged_data['amsterdam_avg_temp'].rolling
(window=7).mean()
```

In [95]:

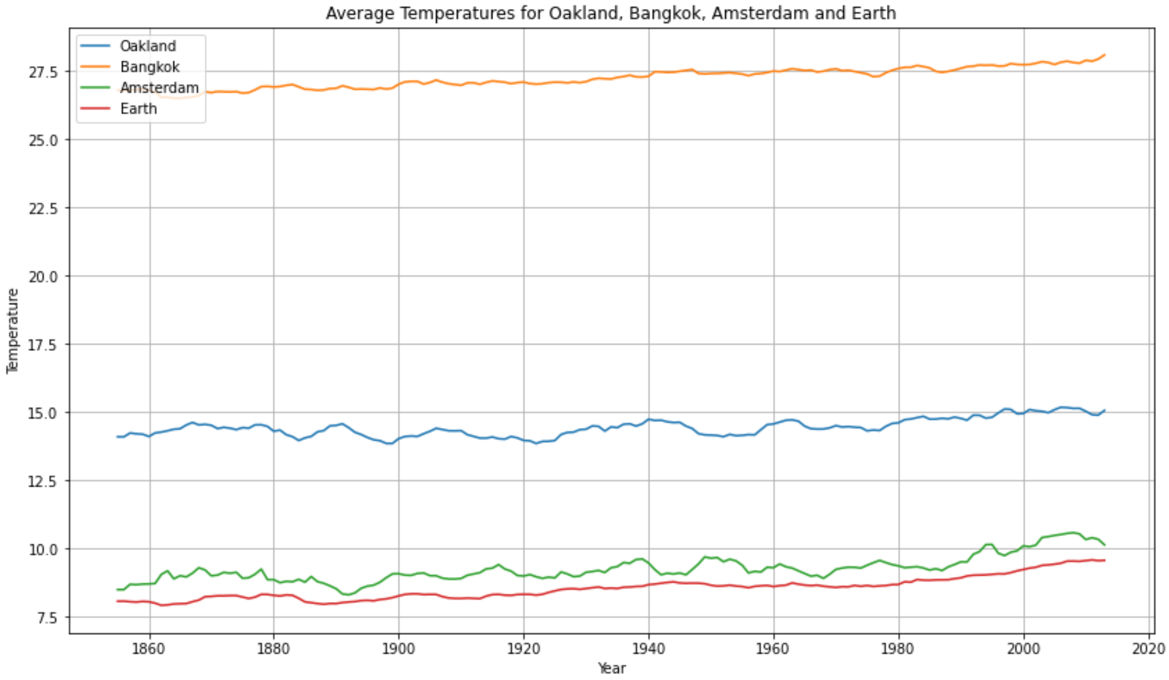
```
merged_data.head(10)
```

Out[95]:

	year	oakland_avg_temp	amsterdam_avg_temp	bangkok_avg_temp	global_avg_temp	oa
year						
1849	1849	14.12	8.80	26.62	7.98	
1850	1850	13.80	8.46	26.72	7.90	
1851	1851	14.39	8.66	26.85	8.18	
1852	1852	13.81	9.66	26.67	8.10	
1853	1853	14.40	7.80	26.94	8.04	
1854	1854	13.98	8.91	26.94	8.21	
1855	1855	14.20	7.22	26.84	8.11	
1856	1856	14.10	8.79	26.56	8.00	
1857	1857	14.78	9.82	26.72	7.76	
1858	1858	14.19	8.57	26.95	8.10	

In [96]:
```
plt.figure(figsize=[14,8])
plt.title('Average Temperatures for Oakland, Bangkok, Amsterdam and E
arth')
plt.grid(True)
plt.xlabel('Year')
plt.ylabel('Temperature')
plt.plot(merged_data['oak_moving'], label='Oakland')
plt.plot(merged_data['bkk_moving'], label='Bangkok')
plt.plot(merged_data['ams_moving'], label='Amsterdam')
plt.plot(merged_data['glo_moving'], label='Earth')
plt.legend(loc=2)
```

Out[96]:
```
<matplotlib.legend.Legend at 0x7f5c24c41be0>
```



I could be convinced that there is a general warming trend in Bangkok, Amsterdam, Oakland and the Earth especially around 1980. Bangkok is just HOT!!