# C2_W1_Lab_1_Temperature

August 20, 2023

# 1 Global Temperature Change

In this notebook, you will work with temperature data compiled by the National Oceanic and Atmospheric Administration (NOAA) and data from the National Aeronautics and Space Administration (NASA) covering the years 1880 to 2021.

Here are the steps you will complete in this notebook:

1. Import Python packages.
2. Load and inspect the dataset.
3. Visualize global average temperature rise
4. Visualize local temperature behavior around the globe
5. Visualize global temperature anomalies
6. Visualize the impact of temperature rise

## 1.1 1. Import Python Packages

Run the next cell to import the Python packages you'll be using in this lab exercise. This is a common first step whenever working with Python. If everything goes well you should see a message when the cell has finished running that says "All packages imported successfully!".

Note the `import utils` line. This line imports the functions that were specifically written for this lab. If you want to look at what these functions are, go to `File -> Open...` and open the `utils.py` file to have a look.

[15]:
```
# Import libraries
%matplotlib notebook

import utils
import pandas as pd
import numpy as np
import IPython
from itables import init_notebook_mode
init_notebook_mode(all_interactive = False)
print('All packages imported successfully!')
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
<IPython.core.display.HTML object>
```

```
All packages imported successfully!
```

## 1.2 2. Load and Inspect the Dataset

NOAA offers lots of publicly available weather data you can work with. Here, you will read in a **C**omma **S**eparated **V**alues (CSV) file containing the average yearly temperature for multiple land-based weather stations around the world. Run the next cell to load this data into your notebook.

[2]:
```
temperature_data = pd.read_csv('data/global_temperature.csv') #import the data
temperature_data.columns.values[4:] = temperature_data.columns[4:].map(int)␣
↪#column names to int for easy manipulation
print('the dataset contains', len(temperature_data), 'rows')
temperature_data.tail()
```

```
the dataset contains 794 rows
```

[2]:
```
         STATION                                 NAME  LATITUDE  LONGITUDE  \
789  USW00094014        WILLISTON SLOULIN FIELD, ND US  48.17380 -103.63660
790  USW00094728           NY CITY CENTRAL PARK, NY US  40.77898  -73.96925
791  USW00094849     ALPENA CO REGIONAL AIRPORT, MI US  45.07160  -83.56451
792  USW00094967  PARK RAPIDS MUNICIPAL AIRPORT, MN US  46.89967  -95.06682
793  UZM00038457                         TASHKENT, UZ  41.27000   69.26940

     1880  1881  1882  1883  1884  1885  …  2012  2013  2014  2015  2016  \
789   NaN   NaN   NaN   NaN   NaN   NaN  …   6.7   4.3   4.9   7.0   7.6
790  11.6  11.2  10.9  10.1  11.2  10.3  …  14.1  13.0  12.4  13.7  14.0
791   NaN   NaN   NaN   NaN   NaN   NaN  …   8.4   6.0   4.9   6.9   8.1
792   NaN   NaN   NaN   NaN   NaN   NaN  …   6.3   3.0   2.8   6.3   6.8
793   NaN   NaN   NaN   NaN   NaN   NaN  …   NaN  16.2   NaN   NaN   NaN

     2017  2018  2019  2020  2021
789   6.4   4.8   NaN   NaN   NaN
790  13.5  13.3  13.1  14.1  13.8
791   7.6   6.9   6.0   7.7   8.3
792   5.3   4.0   3.1   4.8   6.1
793  15.9   NaN   NaN   NaN   NaN

[5 rows x 146 columns]
```

## 1.3 3. Visualize Global Average Temperature Rise

Many climate change reports calculate global average temperature rise relative to a baseline that is the global average temperature in the pre-industrial period from 1850-1900. In practice, the global temperature data available prior to 1900 is sparse and therefore the pre-industrial level is often calculated by taking the average from 1981 through 2010 and subtracting 0.69 degrees celsius and that's what you'll do in the next cell. You can learn more about how this offset is calculated here.

When you run the next cell, you'll create a bar plot where a negative value (in blue) indicates that the temperature in that year was below the baseline, while a positive value (in red) indicates a warmer than baseline year. You can left-click on any bar to get the exact value of that year. If you want to delete any of the labels you added, you have to right-click on the top of the label.

[16]:
```
# Selection of the columns with the time series
plot_data = temperature_data[np.array(range(1880,2022,1))]
# Get difference with baseline
diff = plot_data.sub(plot_data.iloc[:, 101:132].dropna().mean(axis=1) - 0.69,␣
 ↪axis=0)

# Create the bar chart
utils.bar_global(diff)
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

## 1.4 4. Visualize Local Temperature Behavior Around the Globe

Temperature changes differently at different locations. For some places, the temperature is rising; for others, the change is not apparent or negligible, while for some points temperature appears to be decreasing over time.

Run the next cell to plot a map with the weather station locations in the dataset. For each one of those points, you can click and explore a bar plot like the one you studied in the previous section. In this case, the baseline you're comparing against is simply the average temperature over the full range of the data at that location. Explore the map and see if you can find places where the temperature trend differs from what is happening globally.

[4]:
```
utils.local_temp_map(temperature_data)
```

[4]:
```
<folium.folium.Map at 0x7fab701403d0>
```

## 1.5 5. Visualize Global Temperature Anomalies

When you run the next cell, you'll generate a visual of the maps that were shown at the end of the last video. These maps were constructed by NASA to show temperature differences around the globe over the years 1884 to 2020. You can learn more about the analysis used to create these maps here.

To change the year of the map in the visualization, move the slider until the year you want to visualize.

[10]:
```
utils.slider_global_temp()
```

```
HBox(children=(IntSlider(value=1884, description='Year', layout=Layout(width='95%'), max=2020,
```

### 1.6 6. Visualize the Impact of Temperature Rise

To wrap up this lab, you will see satellite imagery from NASA demonstrating how glaciers are receding due to global warming. You can interact with each visualization by moving the slider from right to left to look at the images from a previous point in time and from right to left to see them in recent times.

#### 1.6.1 Melting Ice Shelf in Antarctica

Run the following cell, to visualize the state of the Glenzer and Conger ice shelves in Antartica, using satellite imagery from November 1989, and January 2022.

[11]:
```
#https://climate.nasa.gov/images-of-change/?
↪id=796#796-collapsing-ice-shelf-reveals-a-possible-new-island-eastern-antarctica
src = 'https://cdn.knightlab.com/libs/juxtapose/latest/embed/index.html?
↪uid=dab72496-6d1f-11ed-b5bd-6595d9b17862'
IPython.display.IFrame(src, width = 700, height = 720)
```

[11]: <IPython.lib.display.IFrame at 0x7fab63c74190>

#### 1.6.2 Melting Glaciers in Tibet

Here, you can compare satellite imagery from October 1987 and October 2021 in the Tibetan Plateau. Rising temperatures have melted some of the glaciers in that region, enlarging some of the lakes there.

[12]:
```
#https://climate.nasa.gov/images-of-change/?
↪id=778#778-melting-glaciers-enlarge-lakes-on-tibetan-plateau
src = 'https://cdn.knightlab.com/libs/juxtapose/latest/embed/index.html?
↪uid=269f7416-6d21-11ed-b5bd-6595d9b17862'
IPython.display.IFrame(src, width = 750, height = 520)
```

[12]: <IPython.lib.display.IFrame at 0x7fab63c74590>

### 1.6.3 Glacier Retreat in Alaska

Next, you will compare satellite images from September 1984 and September 2019 showing the Grand Plateau glacier in the Glacier Bay National Park in southeast Alaska. In that comparison, you will see how two glaciers' arms have retreated over the years.

[13]:
```python
#https://climate.nasa.gov/images-of-change?
↪id=777#777-grand-plateau-glacier-retreats
src = 'https://cdn.knightlab.com/libs/juxtapose/latest/embed/index.html?
↪uid=0c37b40e-7027-11ed-b5bd-6595d9b17862'
IPython.display.IFrame(src, width = 700, height = 550)
```

[13]: <IPython.lib.display.IFrame at 0x7fab63c74990>

[ ]: