# A bout the Data

1. **Area Code:** The numerical code of area column, type of area code is an integer.
2. **Area:** Countries and Territories (In 2019: 190 countries and 37 other territorial entities.), type of area is an object.
3. **Months Code:** The numerical code of months column, type of months code is an integer.
4. **Months:** Months, Seasons, Meteorological year, type of months is an object.
   - Months: 'January', 'February', 'March', 'April', 'May', 'June', 'July','August', 'September', 'October', 'November', 'December'
   - Seasons: 'Dec\x96Jan\x96Feb', 'Mar\x96Apr\x96May', 'Jun\x96Jul\x96Aug','Sep\x96Oct\x96Nov'
   - Year: 'Meteorological year'
5. **Element Code:** The numerical code of element column, type of element code is an integer.
6. **Element:** 'Temperature change', 'Standard Deviation', type of element is an object.
7. **Unit:** Celsius degrees °C, type of unit is an object.

# Questions

In the first step, I determined what I curious about climate change in light of the above-mentioned information, and I wrote these down:

1. What are the ten most countries that suffer from temperature change mostly in the last ten years?
2. What are the ten countries that suffer from temperature change at the very least in the last ten years?
3. Is there any significant difference between seasons?
4. What is the trend of temperature change in the world?

I will use python libraries within the Jupyter notebook environment for Investigation these questions. The main software libraries I'll be importing are Pandas, NumPy for data wrangling and Matplotlib, Plotly for data visualization.

```
import pandas as pd
import numpy as np
import imageio
import pathlib
import matplotlib.pyplot as plt
import mapclassify as mc
import numpy as np
plt.style.use('ggplot')
#data visualization
import matplotlib as mpl
import plotly.graph_objects as go
import plotly.express as px

import plotly.offline as pyo
```

```
import plotly.graph_objs as go
#visualazation libraries
import plotly.express as px
import plotly.offline as pyo
import plotly.graph_objs as go
pyo.init_notebook_mode()

# read data sets
df =
pd.read_csv("../input/temperature-change/Environment_Temperature_chang
e_E_All_Data_NOFLAG.csv", encoding='latin-1') # csv file is encoding
as latin-1 type
df.head()
```

```
   Area Code         Area  Months Code    Months  Element Code  \
0          2  Afghanistan         7001   January          7271
1          2  Afghanistan         7001   January          6078
2          2  Afghanistan         7002  February          7271
3          2  Afghanistan         7002  February          6078
4          2  Afghanistan         7003     March          7271

               Element Unit  Y1961  Y1962  Y1963  ...  Y2010  Y2011
Y2012  \
0  Temperature change   °C  0.777  0.062  2.744  ...  3.601  1.179 -
0.583
1  Standard Deviation   °C  1.950  1.950  1.950  ...  1.950  1.950
1.950
2  Temperature change   °C -1.743  2.465  3.919  ...  1.212  0.321 -
3.201
3  Standard Deviation   °C  2.597  2.597  2.597  ...  2.597  2.597
2.597
4  Temperature change   °C  0.516  1.336  0.403  ...  3.390  0.748 -
0.527

   Y2013  Y2014  Y2015  Y2016  Y2017  Y2018  Y2019
0  1.233  1.755  1.943  3.416  1.201  1.996  2.951
1  1.950  1.950  1.950  1.950  1.950  1.950  1.950
2  1.494 -3.187  2.699  2.251 -0.323  2.705  0.086
3  2.597  2.597  2.597  2.597  2.597  2.597  2.597
4  2.246 -0.076 -0.497  2.296  0.834  4.418  0.234

[5 rows x 66 columns]
```

```
df.shape
```

```
(9656, 66)
```

```
df.isnull().sum()
```

```
Area Code          0
Area               0
```

```
Months Code         0
Months              0
Element Code        0
                  ...
Y2015            1295
Y2016            1308
Y2017            1290
Y2018            1307
Y2019            1291
Length: 66, dtype: int64
```

```
country_df = pd.read_csv('../input/temperature-change/FAOSTAT_data_11-24-2020.csv') #this csv file includes ISO-3 Country Code, this mentioned in Data Wrangling
country_df.head()
```

```
   Country Code        Country  M49 Code ISO2 Code ISO3 Code  Start Year  \
0             2    Afghanistan       4.0         AF        AFG        NaN
1          5100         Africa       2.0        NaN        X06        NaN
2           284  Åland Islands     248.0        NaN        ALA        NaN
3             3        Albania       8.0         AL        ALB        NaN
4             4        Algeria      12.0         DZ        DZA        NaN

   End Year
0       NaN
1       NaN
2       NaN
3       NaN
4       NaN
```

```
print("Months")
display(df.Months.unique())
```

```
Months
```

```
array(['January', 'February', 'March', 'April', 'May', 'June', 'July',
       'August', 'September', 'October', 'November', 'December',
       'Dec\x96Jan\x96Feb', 'Mar\x96Apr\x96May', 'Jun\x96Jul\x96Aug',
       'Sep\x96Oct\x96Nov', 'Meteorological year'], dtype=object)
```

```
#1. Renaming
df.rename(columns = {'Area':'Country Name'},inplace = True)

df.set_index('Months', inplace=True)
df.rename({'Dec\x96Jan\x96Feb': 'Winter', 'Mar\x96Apr\x96May':
```

```
'Spring', 'Jun\x96Jul\x96Aug':'Summer','Sep\x96Oct\x96Nov':'Fall'},
axis='index',inplace = True)
df.reset_index(inplace = True)

#2. Filtering
df = df[df['Element'] == 'Temperature change']

#2. Drop unwanted columns from df_countrycode
country_df.drop(['Country Code','M49 Code','ISO2 Code','Start
Year','End Year'],axis=1,inplace=True)
country_df.rename(columns = {'Country':'Country Name','ISO3
Code':'Country Code'},inplace=True)

#3. Merging with df to df_country
df = pd.merge(df, country_df, how='outer', on='Country Name')

#2. Drop some columns
df.drop(['Area Code','Months Code','Element
Code','Element','Unit'],axis=1,inplace=True)
```

What are the ten most countries that suffer from temperature change mostly in the last ten years?

```
#3.Channing dataframe organization
df = df.melt(id_vars=["Country Code", "Country Name","Months",],
var_name="year", value_name="tem_change")
df["year"] = [i.split("Y")[-1] for i in df.year]

display(df.sample(5))
```

| | Country Code | Country Name | Months | year | tem_change |
|---|---|---|---|---|---|
| 137103 | CHL | Chile | February | 1989 | 1.152 |
| 85520 | NIU | Niue | November | 1978 | -0.183 |
| 45943 | LBR | Liberia | Spring | 1970 | 0.319 |
| 93700 | ECU | Ecuador | Winter | 1980 | 0.409 |
| 181173 | CIV | Côte d'Ivoire | December | 1998 | 0.831 |

```
df.dropna(inplace=True)

df.isnull().sum()
```

```
Country Code    0
Country Name    0
Months          0
year            0
tem_change      0
dtype: int64
```

```
# Convert the 'year' column to datetime format
df['year'] = pd.to_datetime(df['year'], format='%Y')
```

```
# Filter data for the last ten years
df_filtered = df[df['year'] >= pd.to_datetime('2013-01-01')]

# Calculate the average temperature change for each country
df_average_temp_change = df_filtered.groupby('Country Name')
['tem_change'].mean()

# Sort the DataFrame by average temperature change in descending order
df_average_temp_change =
df_average_temp_change.sort_values(ascending=False)

# Get the top 10 countries with the most temperature change
temp_countries = df_average_temp_change.reset_index()
temp_countries.head()
```

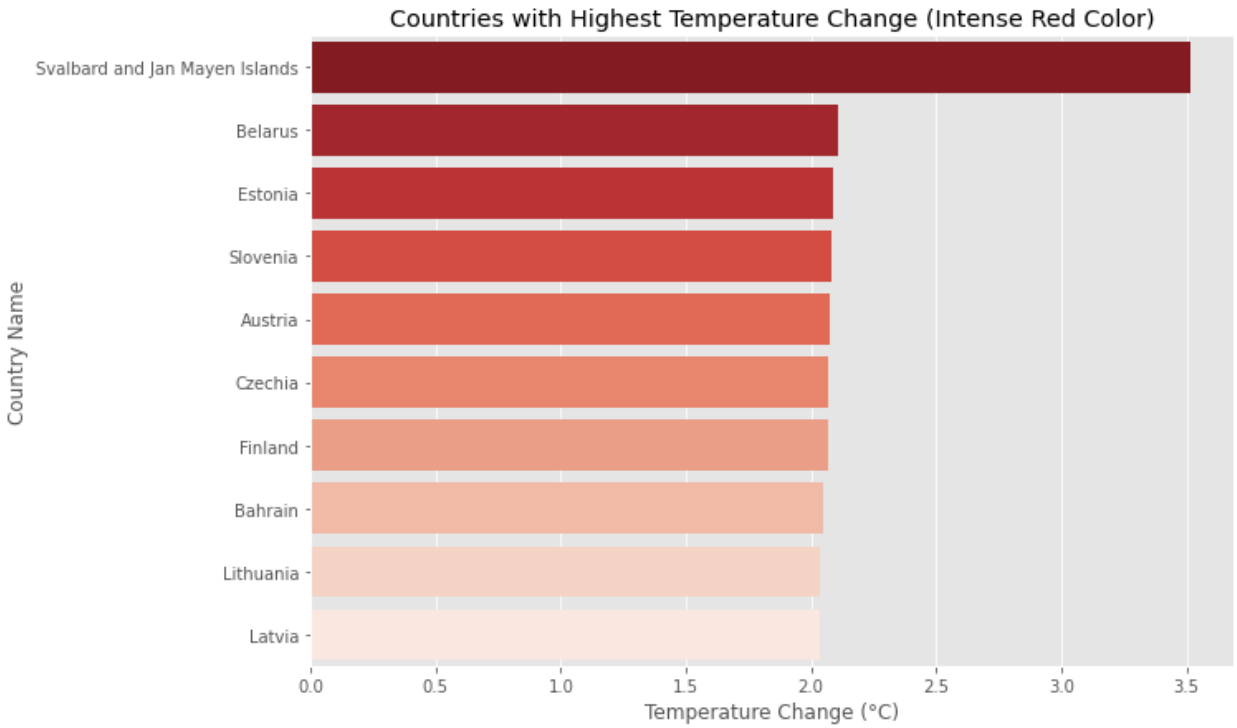
| | Country Name | tem_change |
|---|---|---|
| 0 | Svalbard and Jan Mayen Islands | 3.511697 |
| 1 | Belarus | 2.108445 |
| 2 | Estonia | 2.086681 |
| 3 | Slovenia | 2.080723 |
| 4 | Austria | 2.071319 |

```
# Sort the DataFrame by temperature change in descending order
df_sorted = temp_countries.sort_values(by='tem_change',
ascending=False)
# Separate into highest and lowest countries
highest_countries = df_sorted.head(10)  # Adjust the number as needed
lowest_countries = df_sorted.tail(10)   # Adjust the number as needed
```

# Highest Countries

**What are the ten most countries that suffer from temperature change mostly in the last ten years?**

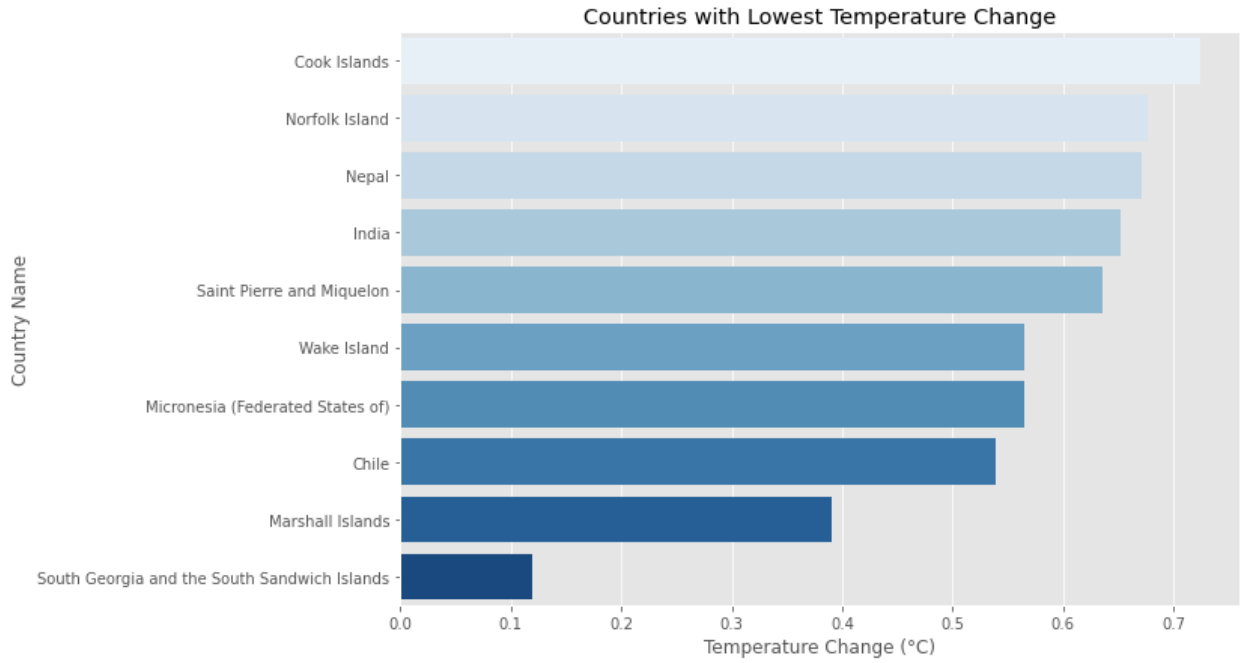
```
# Bar plot for highest countries with more intense red color
import seaborn as sns
plt.figure(figsize=(10, 7))
sns.barplot(x=highest_countries['tem_change'],
y=highest_countries['Country Name'], palette='Reds_r')
plt.title('Countries with Highest Temperature Change (Intense Red
Color)')
plt.xlabel('Temperature Change (°C)')
plt.ylabel('Country Name')
plt.show()
```




# Lowest Countries

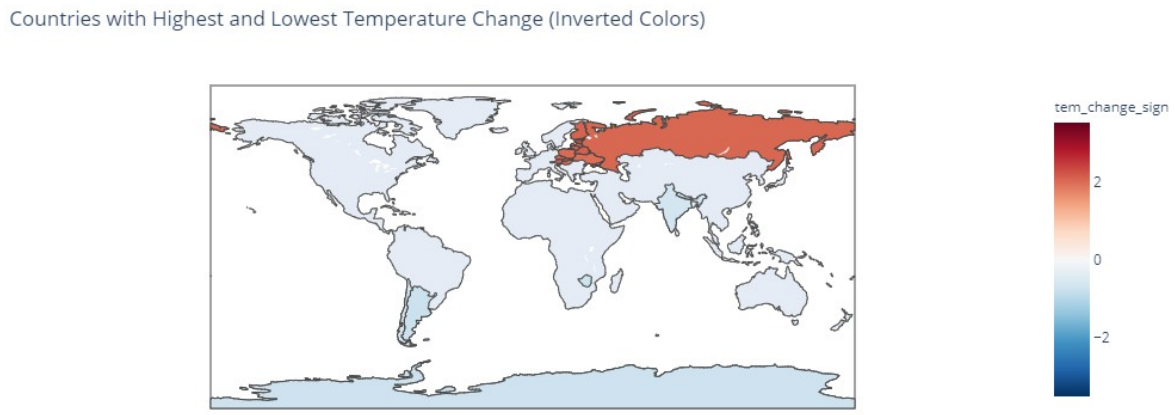
**What are the ten countries that suffer from temperature change at the very least in the last ten years?**

```
# Bar plot for lowest countries
plt.figure(figsize=(10, 7))
sns.barplot(x=lowest_countries['tem_change'],
y=lowest_countries['Country Name'], palette='Blues')
plt.title('Countries with Lowest Temperature Change')
plt.xlabel('Temperature Change (°C)')
plt.ylabel('Country Name')
plt.show()
```




# Highest Countries && Lowest Countries

```
# Add a sign to the temperature change for positive/negative
differentiation
highest_countries['tem_change_sign'] = highest_countries['tem_change']
lowest_countries['tem_change_sign'] = lowest_countries['tem_change'] *
-1
# Concatenate the DataFrames
combined_df = pd.concat([highest_countries, lowest_countries])

# Create choropleth map for both highest and lowest countries with
inverted colors
fig_combined = px.choropleth(
    combined_df,
    locations=combined_df['Country Name'],
    locationmode='country names',
    color=combined_df['tem_change_sign'],
    color_continuous_scale='RdBu_r',  # Use 'RdBu_r' for inverted
colors
    color_continuous_midpoint=0,      # Set midpoint to 0 to have
white color for zero temperature change
    title='Countries with Highest and Lowest Temperature Change
(Inverted Colors)'
)

# Show the combined map
fig_combined.show()
```



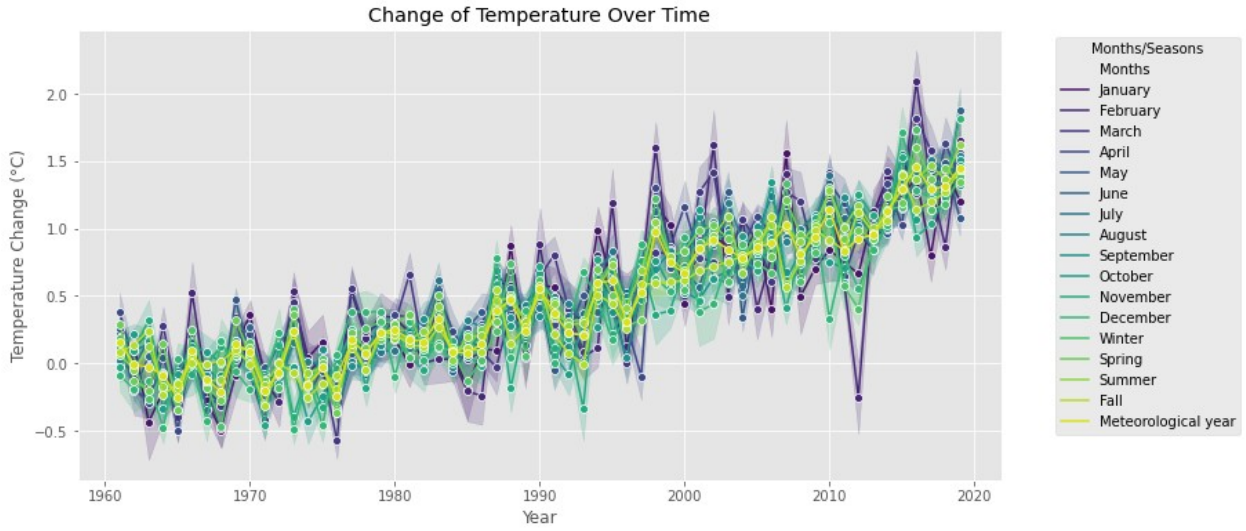

# Is there any significant difference between seasons?

```
from scipy.stats import f_oneway

# Perform ANOVA
anova_result = f_oneway(
    df['tem_change'][df['Months'] == 'Winter'],
    df['tem_change'][df['Months'] == 'Spring'],
    df['tem_change'][df['Months'] == 'Summer'],
    df['tem_change'][df['Months'] == 'Fall'],
    df['tem_change'][df['Months'] == 'Meteorological year']
)

# Print ANOVA result
print("ANOVA p-value:", anova_result.pvalue)

# Check if p-value is significant (e.g., p < 0.05)
if anova_result.pvalue < 0.05:
    print("There is a significant difference between seasons.")
else:
    print("No significant difference between seasons.")
```

```
ANOVA p-value: 4.5255782200100006e-27
There is a significant difference between seasons.
```

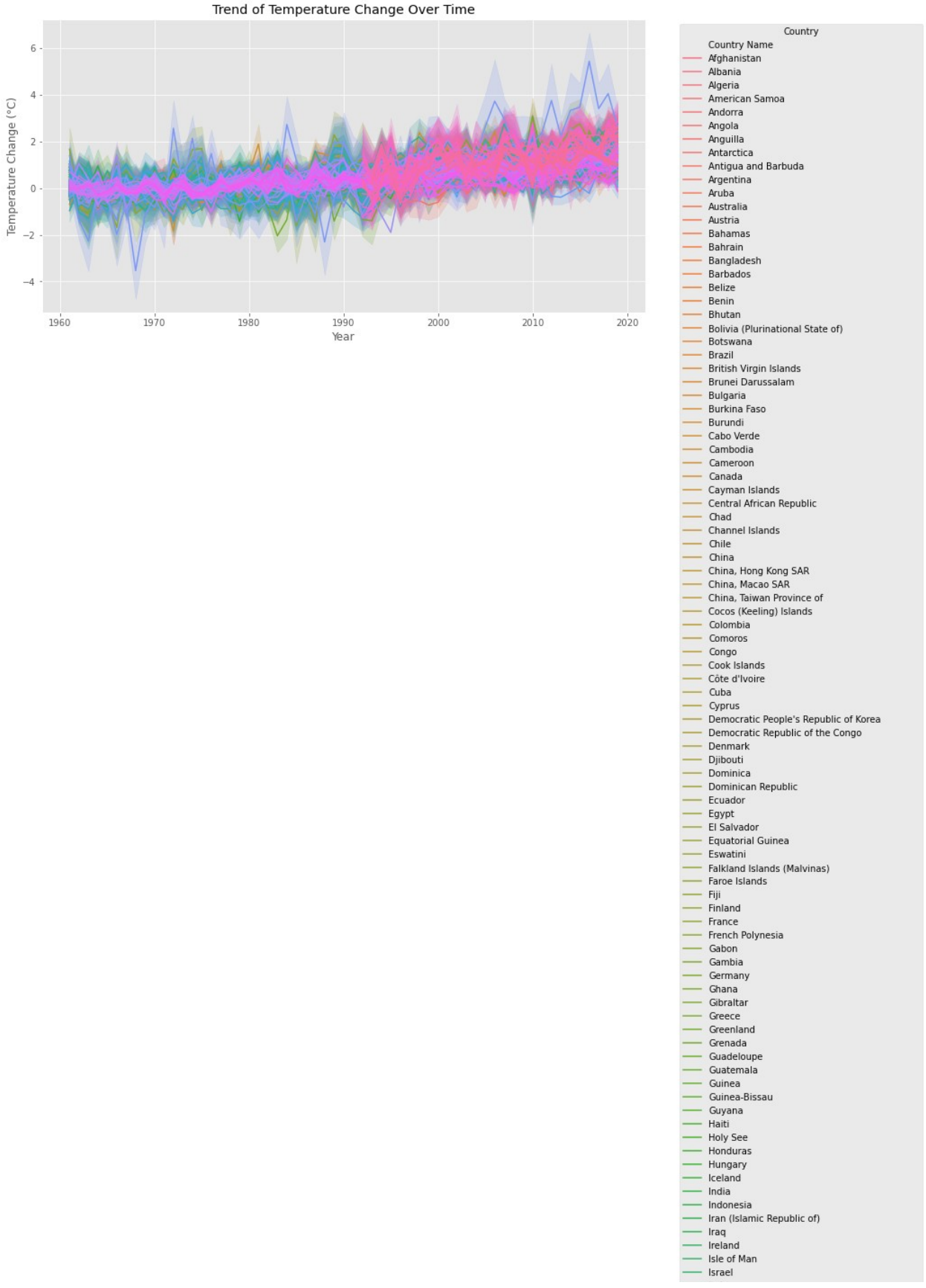
```
plt.figure(figsize=(12, 6))
sns.lineplot(x='year', y='tem_change', hue='Months', data=df,
marker='o', palette='viridis')
plt.title('Change of Temperature Over Time')
plt.xlabel('Year')
```

```
plt.ylabel('Temperature Change (°C)')
plt.legend(title='Months/Seasons', bbox_to_anchor=(1.05, 1),
loc='upper left')
plt.show()
```




# What is the trend of temperature change in the world?

```
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd


# Convert 'year' to datetime
df['year'] = pd.to_datetime(df['year'])

# Create a time series plot
plt.figure(figsize=(12, 6))
sns.lineplot(x='year', y='tem_change', hue='Country Name', data=df,
             markers={'January': 'o', 'February': 's', 'March': '^',
'April': 'D', 'May': 'v',
                      'June': 'o', 'July': 's', 'August': '^',
'September': 'D', 'October': 'v',
                      'November': 'o', 'December': 's', 'Winter': '^',
'Spring': 'D', 'Summer': 'v',
                      'Fall': 'o', 'Meteorological year': 's'})
plt.title('Trend of Temperature Change Over Time')
plt.xlabel('Year')
plt.ylabel('Temperature Change (°C)')
```


Trend of Temperature Change Over Time
Temperature Change (°C)
6
4
2
0
−2
−4
1960
1970
1980
1990
2000
2010
2020
Year
Country
Country Name
Afghanistan
Albania
Algeria
American Samoa
Andorra
Angola
Anguilla
Antarctica
Antigua and Barbuda
Argentina
Aruba
Australia
Austria
Bahamas
Bahrain
Bangladesh
Barbados
Belize
Benin
Bhutan
Bolivia (Plurinational State of)
Botswana
Brazil
British Virgin Islands
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Cayman Islands
Central African Republic
Chad
Channel Islands
Chile
China
China, Hong Kong SAR
China, Macao SAR
China, Taiwan Province of
Cocos (Keeling) Islands
Colombia
Comoros
Congo
Cook Islands
Côte d'Ivoire
Cuba
Cyprus
Democratic People's Republic of Korea
Democratic Republic of the Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eswatini
Falkland Islands (Malvinas)
Faroe Islands
Fiji
Finland
France
French Polynesia
Gabon
Gambia
Germany
Ghana
Gibraltar
Greece
Greenland
Grenada
Guadeloupe
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Holy See
Honduras
Hungary
Iceland
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland
Isle of Man
Israel

# References

https://www.ipcc.ch/sr15/chapter/chapter-1/ http://www.fao.org/faostat/en/#data/ET

http://www.fao.org/faostat/en/#definitions https://ocw.mit.edu
https://climate.nasa.gov/resources/global-warming-vs-climate-change/
[https://climate.nasa.gov/effects/ https://www.scientificamerican.com/article/in-just-10-years-warming-has-increased-the-odds-of-disasters/ https://www.deepdyve.com/lp/wiley/climate-change-impacts-on-wildlife-in-a-high-arctic-archipelago-zKjAbf0Y5t
https://unfccc.int/parties-observers#:~:text=Annex%20I%20Parties%20include%20the,Central%20and%20Eastern%20European%20States https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally