

Global Warming - Big Data Analytics Project

JONAS ÖRNFELT

ABSTRACT

Global warming is one of the most crucial challenges in our technology-driven age, as evidenced by past temperature changes. This study aims to investigate the phenomenon of global warming, in particular, to determine if it is a recent phenomenon or has always existed on Earth. It also aims to determine how temperature changes differ across Earth's continents. The study includes an analysis of temperature change data from the National Oceanic and Atmospheric Administration (NOAA) from 1961 to 2019. This data set includes temperature change for 190 countries and 37 other territorial areas around the world. The analysis identifies the areas most, and least affected by global warming and provide insight into the causes of global warming and potential solutions.

Additional Key Words and Phrases: big data, datasets, global warming

1 PROBLEM STATEMENT

One of the most pressing challenges in this technology age is global warming. The past temperature change is the strongest indicator of this circumstance. A related term to global warming is climate change, which is described as the continuing alteration in the Earth's climate and weather patterns (NASA, 2023). It is caused by increased levels of carbon dioxide and other pollutants in the atmosphere, which trap heat and cause the planet to warm. This warming has a range of effects, from rising sea levels to more extreme weather events (Shiryaev, et al., 2022). The climate of the Earth is changing, leading to a shift in the average weather patterns that are experienced in various parts of the planet. This phenomenon affects both local and global climates. Since the beginning of the 20th century, these changes have been largely caused by human undertakings, such as burning fossil fuels, which increases the levels of heat-enclosing greenhouse gases in the atmosphere and raises the average temperature of the Earth's surface. This phenomenon is the essence of global warming (Letcher, 2019).

According to NASA (2023), the greenhouse effect is influenced by water vapor, carbon dioxide (CO₂), methane, nitrous oxide, and chlorofluorocarbons. Human-related activities have raised concentrations drastically of this natural greenhouse over the past century. The environment is currently being affected by the effects of global climate change. The ranges of plants and animals have been altered, glaciers have receded, ice on rivers and lakes is breaking up earlier, and trees are blossoming earlier than usual. Scientists have previously anticipated that the loss of sea ice will hasten the rise in sea level and result in both intense and prolonged heat waves. The reality of the temperature rise caused by industrial activity and the greenhouse effect is examined in this study.

The research questions for this study are:

- (1) Is global warming, as a critical issue, a recent phenomenon?
- (2) How do the temperature changes differ from Earth's continents?

The first research question is in essence a question of whether global warming has always been existing on earth, or if it is a recent phenomenon that has emerged during the last two decades. This is relevant if we want to pinpoint where the global warming stems from, and to find out whether the phenomenon is a natural event that we can't prevent. The second question aims to answer how the temperature alternations differ on a broader scale, based on our planet's continents. The findings can potentially contribute to further research about what circumstances that lead to higher or lower temperature changes.

2 METHODS

The data used in this project is the temperature change data from the National Oceanic and Atmospheric Administration (NOAA). This data set includes the average temperature change for each area from 1961 to 2019. The dataset is divided into two parts: the global average temperature change and the temperature change for each region. The data set is public and can be used for research purposes, as is stated in the FAO Statistical Database Terms of Use license (FAOSTAT, 2022). The analysis of the data set will help in understanding the effects of global warming on different regions of the world. It will also help to identify the areas that are most affected by global warming and the areas that are least affected. The analysis will also provide insight into the causes of global warming and the potential solutions to mitigate its effects. Finally, the results of this analysis will be used to inform policy makers and the public about the reality of global warming and the need for action to address it.

The data set used includes temperature shifts of 190 countries and 37 other territorial entities in the world. It is a comma-separated value (CSV) file with a tabular format and 6.3 megabytes in size. It has 9656 rows and 66 columns, with the first seven columns consisting of information about temperature changes and the remaining columns showing temperature change numbers. The frequency of measurements and releases of the data is based on a yearly basis. Listed below are the columns included in the data set:

- (1) Area: countries or areas.
- (2) Area Code: numerical integer of area column.
- (3) Element Code: numerical integers for mapping elements.
- (4) Element: The terms 'Temperature Change' and 'Standard Deviation' refer to objects.
- (5) Months Code: numerical integers for mapping months.
- (6) Months: Includes Meteorological year, month, season.
- (7) Unit: The Celsius degree (°C).

A few columns were renamed during the analysis to clarify the data included and simplify plotting of statistical results. These changes are listed below:

- (1) The column "Area" was changed to "country names".
- (2) Year data format was changed from YXXXX to only include the relevant information XXXX, for example Y1990 was changed to 1990.
- (3) Format of "Seasons" was changed to explicit names of the four seasons (Spring, Summer, Fall, Winter).

Empty values were examined, and it was discovered that only the temperature change column was affected. Logically, the earlier years had more empty values than the more recent years. The year 1961 had 719 missing values, while 2019 had 385. This decreasing trend was similar for the other columns.

3 RESULTS

To answer the two research questions, related questions were investigated to gather insight into the main questions. Firstly, the most affected areas of temperature change during the last decade were examined. Harvey (2020) argues that the odds of tragic events occurring today due to global warming is underestimated, and that the phenomenon has greatly increased its pace during recent years.

Fig. 1. Highest temperature changes by area

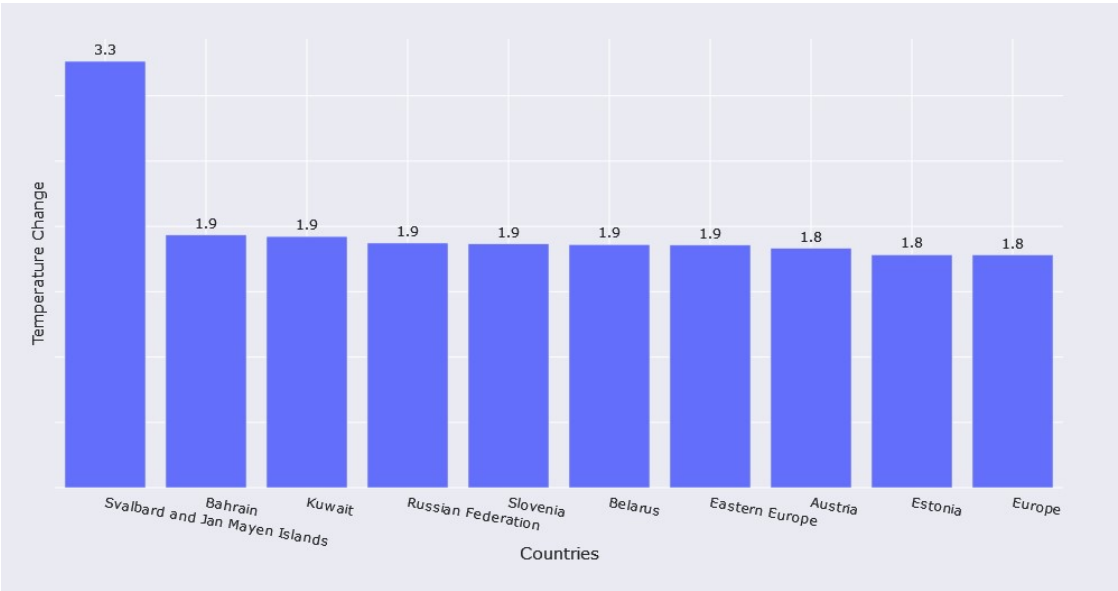
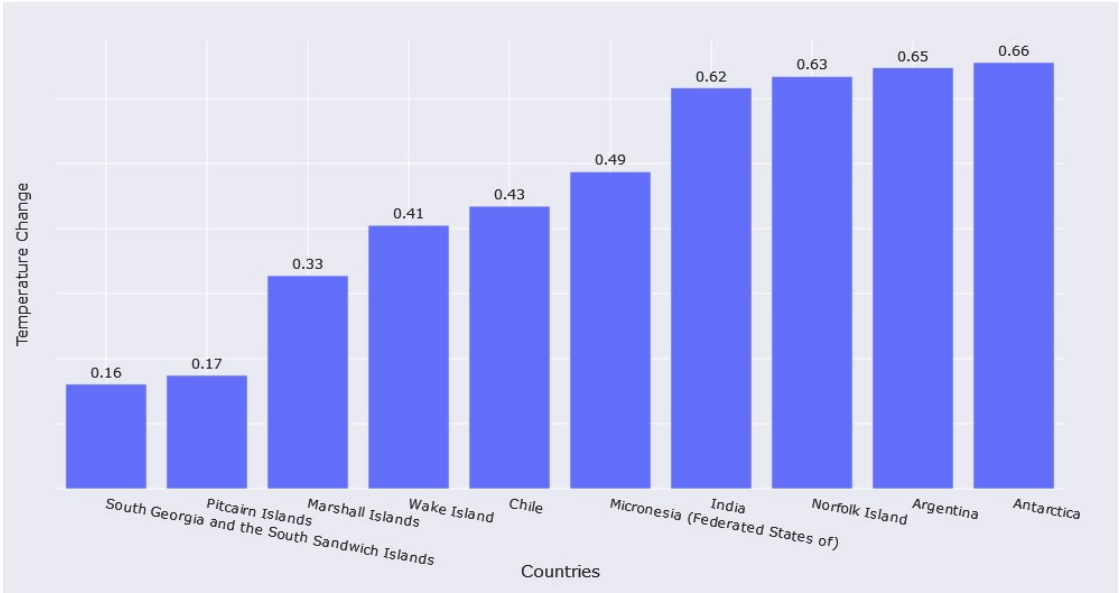


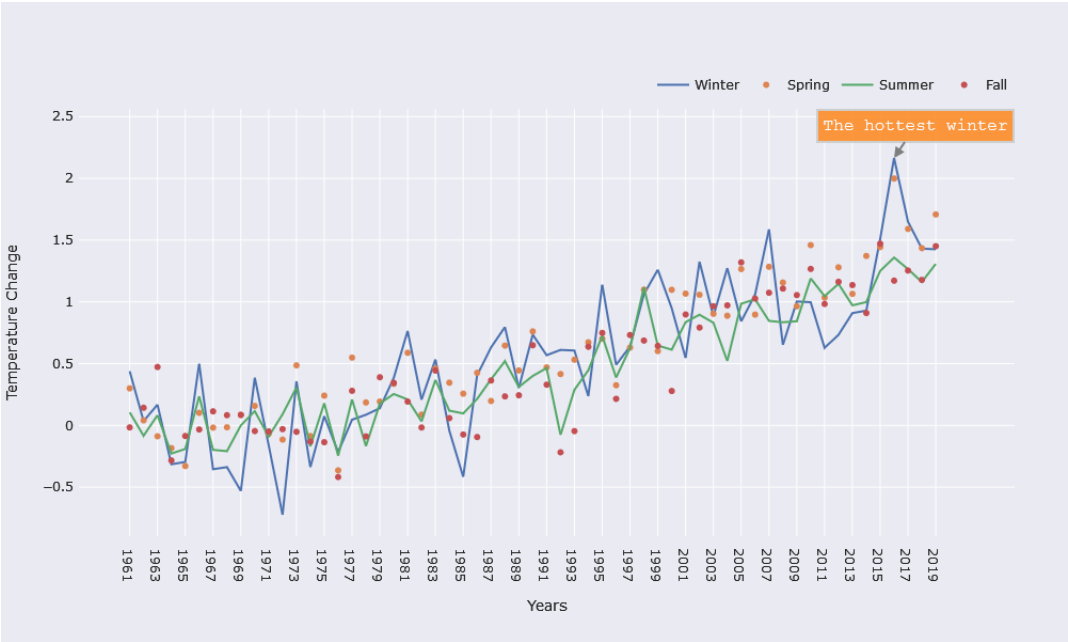
Figure 1 show the most affected areas of temperature changes from the last decade. Almost all areas are highly industrialized, with the exception of the top result "Svalbard and Jan Mayen Islands". This area's natural environment is greatly at threat, especially since it's close to the arctic region.

Fig. 2. Lowest temperature changes by area



The areas with the lowest temperature alterations were also examined, as is shown on Figure 2. Interestingly, India is high up on this chart even if it is very active in terms of industrial pursuits like producing goods and services. In general, smaller islands seem to be rather unaffected by the global warming. The area with the lowest temperature changes overall is “South Georgia and the South Sandwich Islands”. To examine seasonal temperature changes, a table with temperature units was created for each of the four seasons. Then, each temperature alteration was mapped to the related class and then the tables were merged together.

Fig. 3. Seasonal temperature changes



As indicated in Figure 3, the temperature changes are stable during summer. The line follows a linear pattern. The line for temperature changes during winter show significant fluctuation. Notably, the hottest winter on record occurred in 2016. This illustrates that global warming effects are more prominent in the winter season. Spring has a similar fluctuation to winter, while fall has a similar progression line as summer. The data set used in the analysis contain the yearly temperature change for each area. This was utilized to create world maps of how the temperatures have been altered through the years. The following plots show how temperature changes have progressed globally during the years 1968, 1992, 2005, and 2019.

Fig. 4. Map of temperature changes 1968

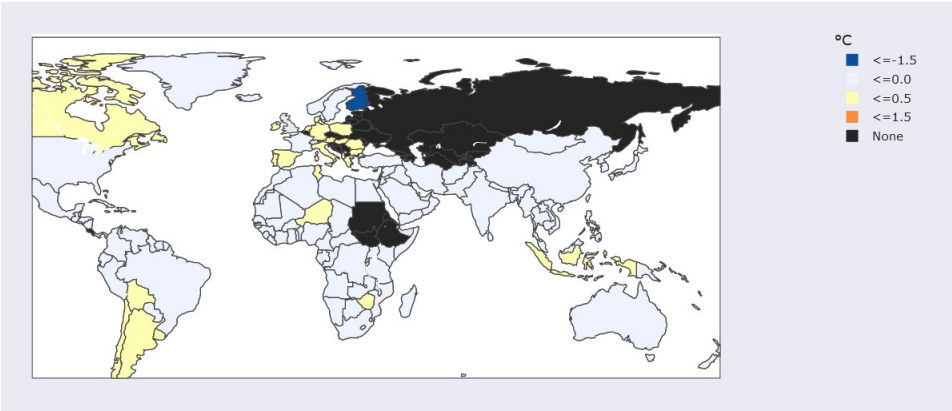


Fig. 5. Map of temperature changes 1992

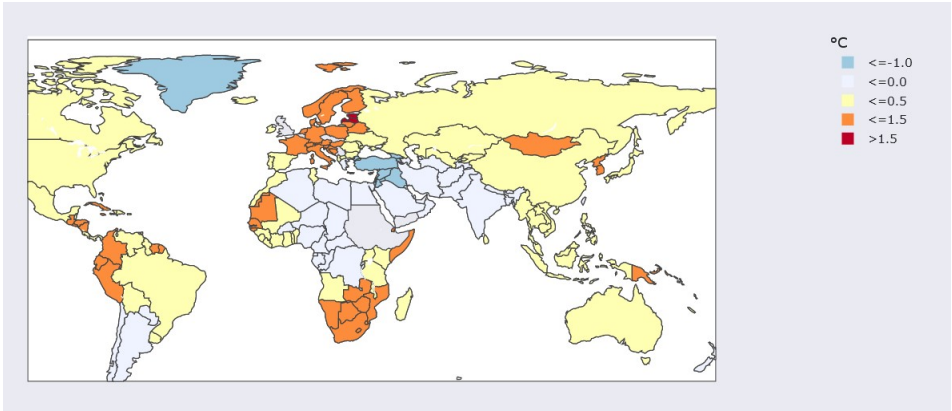


Fig. 6. Map of temperature changes 2005

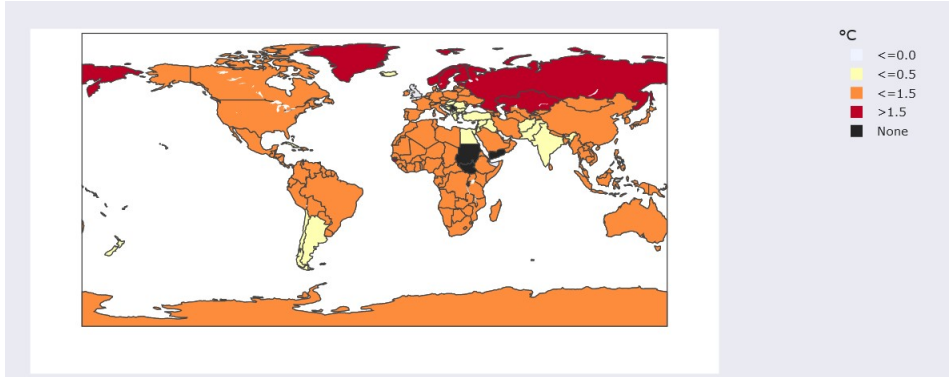


Fig. 7. Map of temperature changes 2019

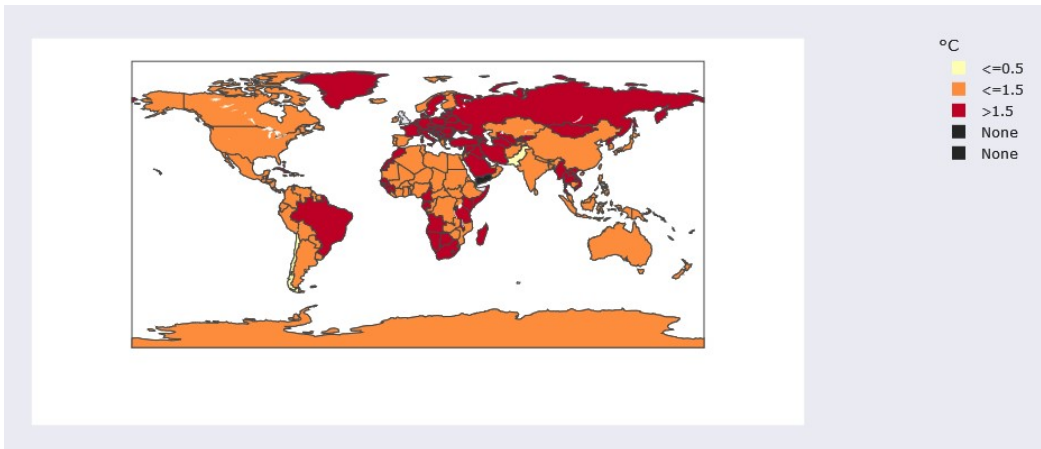


Figure 4 – 7 demonstrates the increased temperature changes around the world. Europe has been affected the most where there's several areas with an increase higher than 1.5 °C. The differences between year 1968 and year 1992 indicate that global warming occurred during this time span, but to a lesser extent than the last two decades. Areas with temperature changes less than 0.5 °C are minimal which further illustrates how drastically the temperatures have changed compared to the beginning of the 21st century.

4 SIGNIFICANCE

This study analysis examined global surface temperature change between 1961 and 2019. The top ten environments with the highest temperature change in the last decade were mostly industrialized areas. Additionally, every ten decades saw a significant rise in temperature, with the last decade being the warmest. The results of the continental analysis (see Figure 4 – 7) showed a clear trend of increasing temperatures worldwide, indicating global warming. There is a global increase in the range of 1.5°C and 2°C. This number might not seem that high, but the alterations are not equally distributed which endangers the natural life in some areas more than others. Europe is the continent with highest temperature changes, followed by North America. The other continents show a less significant temperature increase – however, all continents suffer from abnormal temperature alterations. The results indicate that from year 2000, the temperature has increased significantly, the temperature shifts have extreme values since approximately 2002 – 2005. Conclusively, global warming, as an urgent phenomenon, is from the recent two decades.

Global warming could potentially be disastrous for the Netherlands, as a rise in sea levels due to the temperature increase could cause the country, which has a low elevation, to be submerged and disappear (Koningsveld, et al., 2008). As temperatures rise, icy areas such as Russia, Scandinavia, and Alaska may become viable locations for agriculture in the future. With a more temperate climate, these regions could be utilized for agricultural purposes, and this has the potential to cause major disturbances in the world we live in (Shiryaev, et al., 2022). It is necessary to cut back on the CO₂ that is being released into the air, and, if possible, investigate ways to reduce CO₂ already present in the air. The current CO₂ levels in the atmosphere surpass the regular balance

of CO₂ that is dissolved in oceans and the CO₂ that is taken in by land-based living things. It is furthermore important that renewable sources of energy and nuclear power replace fossil fuels as soon as possible (Letcher, 2019).

From an ethical standpoint, the temperature data set seems objective and of high quality. However, it's difficult to fully assess the quality of the data set. Data might have been altered by areas that wish to gain advantages from suppressing global warming as a phenomenon or wishes to conceal the level of their emissions. Processes like altering the weather artificially could also have an affect on temperature data. Weather modification is a controversial activity which involves intentionally changing or manipulating the weather. The most common approach is a process called cloud seeding, which is used to artificially increase the amount of rain or snowfall in a region, typically for increased water supplies. This technique has been widely argued on ethical grounds, as it could be seen as compromising the naturalness of the weather and potentially having a lasting impact on temperature data (Bruitjes, 1999).

The primary ethical dilemma related to global warming involves how much and what type of action should be taken to reduce the issue. On one hand, there is the argument that drastic and immediate action is necessary in order to avoid irreversible damage to our planet. On the other hand, some believe that a slower, more moderate approach is necessary in order to protect people and economies from the negative impacts of extreme action (Letcher, 2021). Additionally, there is the dilemma of who will bear the economic costs of reducing emissions, and who will be responsible for repairing the damage that has already been done. To ensure that ethical and quality standards are met, a consistent approach must be taken with regards to ethical issues within Big Data. Mechanisms should be expanded to ensure accountability and guarantee the quality of the data. Tools and processes in climate service must be made transparent, thereby providing the necessary trust and assurance (Letcher, 2021).

Future work in this area could utilize these results and compare other data sets of temperature change to verify the results. Continents and areas could be further examined to see if there are patterns in temperature alterations and factors that could affect the temperature – for example the ratio of electrical vehicles in comparison to fossil fueled vehicles, or the amount of weather modifications practiced in a specific area. Future analyzes of temperature data are vital to see if there is an increase or decrease in how much the alterations fluctuate. Keeping track of the temperatures can also aid in exploring whether future paradigm shifts reduce the global warming or not. Improving on current measurement tools and techniques is also a topic worth exploring to increase the quality and reliability of the temperature data sets.

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