Analysis of Average Annual Temperature per Countries

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ABSTRACT

Climate change is the long-term alteration of average temperatures and weather patterns that have come to define Earth's local, regional, and global climates. These changes appear in the form of extreme weather events, ecosystem shifts, and changing temperature patterns. Analyzing historical temperature trends is a crucial aspect to understanding and visualizing climate change. In this research paper, we examine the historical average yearly temperatures of each country in the world and analyze their changes from 1901-2019. To help visualize the data, we created a map animation created with D3 and Angular. The animation displays the yearly average temperatures of each country and represents them through a designated color-coding scheme. Each country is colored with a specific hue, and an accompanying color legend ranging from blue to red is provided to indicate where on the range of cooler to warmer temperatures the country falls in. Our visualization shows that the global average temperature has risen steadily over the past century, with most countries experiencing an increase in temperature. From the visualization, we are also able to identify several regions of the world that are particularly vulnerable to the effects of climate change, including coastal regions, areas with fragile ecosystems, and regions with high levels of poverty. Among the vulnerable countries, Chad stands out due to its high poverty rates, frequent conflicts from military confrontation, and the risk of droughts and floods. Our findings emphasize the urgent need for effective policies to mitigate the effects of climate change and protect vulnerable communities and ecosystems. Overall, this research paper highlights the critical importance of understanding historical temperature trends to address the dire issue of climate change.

Keywords: Climate Change, Global Warming, D3, Angular.

1 INTRODUCTION

The Earth's climate is changing at an unprecedented rate, with global temperatures rising rapidly across all regions of the world. A comprehensive understanding of how temperatures have changed over the past century is necessary to comprehend the current state of the climate and its potential future trajectory. By analyzing historical temperature data, we can identify the underlying causes of these changes, as well as the regions and populations that are most vulnerable to the effects of climate change. This knowledge can help policymakers prioritize resources and develop targeted interventions to protect these vulnerable communities. Historical temperature data can also inform the development of other policies that address climate change, such as ones that aim to reduce greenhouse gas emissions, promote the use of renewable energy sources, and support sustainable land use practices. This is a vital part of the foundation in creating a more sustainable future for the world.

An interesting aspect of analyzing historical temperatures and climate change is that we can use the data to gain additional context for a cultural and historical perspective. From the data, we can find evidence of how climate has shaped human history and how human activity has influenced the climate. For example, scientists researched the Little Ice Age, which was a period of regional cooling from 1300-1850. Scientists are able to confirm this event occurred through a variety of techniques for assessing historical temperatures. These techniques include "studying ice cores and tree rings" [1]. Furthermore, analyzing the data can provide insight into how societies coped with extreme weather events and changing agricultural conditions.

Similarly, studying the effects of human activity on climate change in the context of the timeline of historical temperature trends can help us understand the implications of our actions on the environment and what significant events may have caused consequential impact on the climate. A prime example is the industrial revolution, which began in the late eighteenth and early nineteenth centuries when "manual labor began to be replaced by machinery fueled" by new sources of energy [2]. The revolution promoted activities such as burning fossil fuels, including coal and oil, which contributed to an increase of greenhouse gas concentrations in the atmosphere. Carbon emissions also increased when carbon-absorbing forests were cut down to make way for human developments. Learning about historical yearly temperatures and climate change offers a glimpse into Earth's past, present, and future. By understanding the trends and patterns of climate change through historical temperature data, we have a foundational knowledge of where to start in addressing climate change.

2 Related Works Section

Climate change is one of the most heavily researched and studied topics of our time. It is an incredibly complicated and politicized subject but the scientific consensus is clear: human-caused climate change has already been affecting the global average weather and extreme weather events across the entire world [4]. The goal for this section is to cover some important research that has already been done on climate change and that influenced and provided context for our project as well as research that has been done on creating visualizations. This research has helped us to create a better visualization and paper of our own.

One of the most important organizations working on climate change is the Intergovernmental Panel on Climate Change. It is the United Nations body for assessing the science related to climate change and they regularly release assessment reports detailing the most current and up to date climate science information. Part of the IPCC's mission is to release this information worldwide to governments, policy makers, and the general public in a format that is more accessible than traditional academic papers. They accomplish this in their most recent AR6 Synthesis Report with a series of Headline Statements and a thirty-six page Summary for Policymakers that is published alongside an eighty-five page academic report. The report and summary both go into far greater detail than we will about the current state of climate change, what humans have done to cause this, what the projected effects of climate change will be, and offer solutions and plans to help limit the impact of climate change on future generations [4]. We recommend the IPCC AR6 synthesis report for anyone looking for a scientific well-rounded paper on the current state of climate change. But to summarize, human-caused climate change is happening at an alarming rate and unless drastic actions are taken to slow and stop the rise of average global temperatures the results will be catastrophic.

In addition to the vast amount of research that has been done on climate change, there are also a wide variety of visualizations that are available that help to give meaning and understanding to all of the climate data that has been collected. For example, this visualization from the International Monetary Fund's Climate Change Data presents the mean surface temperature change during the period 1961-2021, using temperatures between 1951 and 1980 as a baseline. It shows a clear and obvious rise in global average temperature since the 1980s [7].

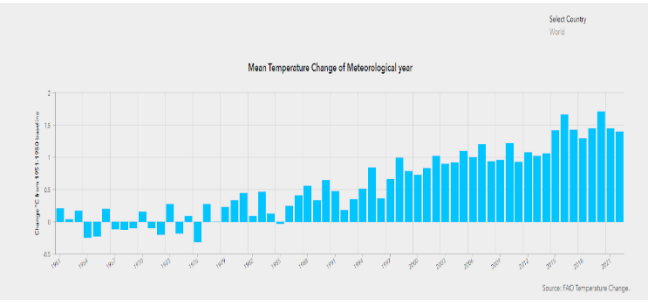

Figure 1: Mean temperature change over time, per year.

2.1 Visualizations

The IMF presents these types of visualizations along with the data that supports them on their climate change dashboard. Its visualizations and papers shown often have economic backgrounds and themes, but that shouldn't be surprising considering the massive amount of money that climate change will cost as well as generate in industries that focus on green technologies. The world economy has been projected by the global insurance company Swiss Re Institute to lose up to nearly 20% of its GDP by 2050 due to climate change unless dramatic action is taken to limit it. In no uncertain terms they state "Climate change poses the biggest long-term threat to the global economy" [5]. Additionally, they highlight that developing countries with the least available resources to adapt to the changing climate are also the most likely to feel the greatest impact, countries like the Philippines, Thailand, and Singapore. These types of visualizations and reports are what prompted us to create our project. We wanted to develop a way to clearly show how the entire world has been affected by climate change but also how specific countries have been and are continuing to be more affected than others.

Papers like D3: Data-Driven Documents show the potential for creating interactive visualizations using D3 "promotes expressiveness and better integrates with developer tools", additionally they show d3 to have both better performance and be more iterative than prior approaches [6]. D3 is a proven, widely used, and effective tool commonly used to transform significant amounts of data into compelling visualizations. These features were important to us because interaction with visualizations "is now seen as a mean to amplify cognition in active, human-driven data exploration in which the user is in control of the information space" [3]. Interaction with visualizations helps promote a deeper, more connected understanding of the material and data. The next section goes into further detail about why we made certain design decisions and justifications.

3 Detailed Descriptions and Justifications

Our project consists of a choropleth map that shows the increase or decrease of temperature, in Celsius, of most countries around the world. A choropleth map uses shading and coloring to define average values of a property within specific areas. Since we want to show the change in temperature over a 118-year span, we believe that it would be best to present it as a choropleth map since color coding temperatures would make it a lot easier to see the change compared to overloading the user with temperatures for each country being shown. When loading onto our website, the map instantly starts to show the temperatures starting from 1901 and goes through all of the years up until 2019.

To develop this project, we decided on using D3, a JavaScript library used for manipulating data, and

Angular, a framework used for hosting. Using D3, we designed and implemented the choropleth map as well as pulled in the temperatures to color code each country. Deciding on which color to use for a specific range of temperature was a fairly simple task. We decided on using “colder” colors, e.g. purple, blue, light blue, to indicate the colder temperatures while the “hotter” colors, e.g. yellow, orange, red, would indicate warmer temperatures. The figure [12] below shows a few more examples of the different colors in both categories.

Figure 2: Warm vs. Cool Colors

Angular was used to format the design of our website. We formatted the design to be very simple because we wanted the map to be very easy to use as well as being pleasing to the eye. Making the design very minimal, e.g. simple title and year in a different color, helped contribute to this plan.

4 What we Found

After completing our visualization and analyzing the data we have identified several key insights that shed light on our topic of climate change. If we just look at the data we can see that the average annual temperature worldwide has been increasing steadily over time and for some areas more drastically. Almost all parts of the world are seeing an increase in annual temperature every year compared to when the data starts in 1901. There is almost not any part of the world that is not experiencing climate change. For examples of this, we can look toward the continent of Africa.

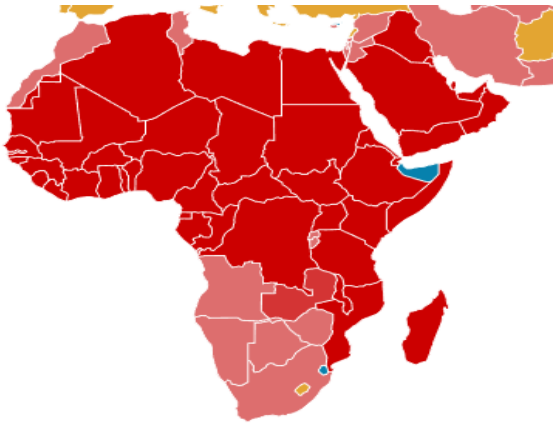

Figure 3.1: Shows the continent of Africa in 1901 when the visualization starts

Figure 3.2 shows the same area in 2021 and as we can see for the most part, the entire continent of Africa has turned into a darker shade of red which according to our color schema scale means that the average annual temperature is increasing. If we look toward the more Northwestern part of the continent we can see that a couple of countries have even turned into an almost dark brown color showing that the increase in temperature is more drastic in some areas.

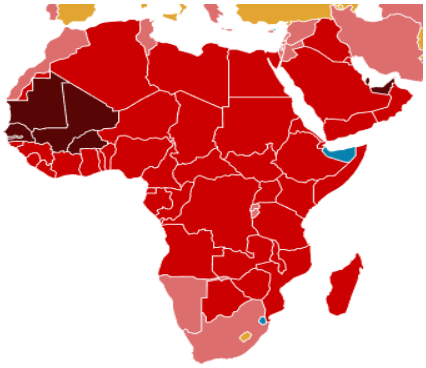

Figure 3.2: Shows Africa in 2021

One more example of this is on the other side of the world in North America where if we look at the figures below of Mexico.

Figure 3.3

Figure 3.4

Figure 3.3 shows Mexico in 1901 and Figure 3.4 shows Mexico in 2021. The temperature rise has caused the color scheme to display a darker red for the entire country of Mexico and from the data this is on trend for many other countries around the world. But why is this and what problems arise from this temperature rise?

From our research and from our data it seems that the continent of Africa is quite susceptible to climate change. There are many reasons for this but one of the main reasons is some of the country's economic reliance on climate-altering activities and products and its inability to adapt to these rising temperatures. These rising temperatures threaten the health of African peoples by threatening food security, increases in extreme events, coastal erosion, rising sea levels, and rises in disease.

Food security is directly affected by the rest of the problems that arise from rising temperatures. Agriculture is one of the main driving economic forces for many people around the continent. With rising temperatures, agriculture is sure to be heavily impacted. The rise in droughts, flooding events, and pests that damage crops have all negatively impacted the agricultural systems and according to the Food

and Agriculture Organization of the United Nations (FAO): since 2012, the number of undernourished individuals in sub-Saharan African countries that are prone to droughts has risen by 45.6%.

Coastal erosion and rising sea levels are also evident with the sea-level increase at African shorelines to be at 5mm per year and some exceeding this number which is higher than the global average sea-level rise of 3-4mm per year. Many coasts are also facing lots of erosion due to these rising sea levels and both of these factors combined will increase many extreme events around the continent.

Another big health risk for Africa and potentially the rest of the world is a rise in diseases. With a rise in temperatures and changes in rainfall insects that survive and carry diseases in warmer temperatures are able to thrive and spread more diseases causing adverse health effects on the population. These health effects include the transmission of diseases like malaria, yellow fever, and dengue fever.

On the bright side, many countries in Africa recognize these climate changes as a major concern and are taking big steps to combat these problems. Many countries have filled out their Nationally Determined Contributions to the Paris Agreement and many countries have ratified the Paris Agreement and are working toward switching to cleaner energy sources, new agricultural techniques, and socio-economic reform all in an effort to combat the rising temperatures.

5 CONCLUSION

While it may seem like these problems aren't an immediate danger if you don't live in Africa, it is important to note that Africa may just be the first one to experience the negative impacts of climate change but with the consistent rise in temperature, these drastic dangers to Africa could easily affect many other parts of the world soon. That is why it is important that we all work together to combat climate change.

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