Visualizing the Impact of Global Climate Change

INFO - I590 Data Visualization
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Abstract

Climate change has emerged as a critical global concern, affecting natural ecosystems, economies, and human well-being. Despite extensive research and awareness campaigns, the complexity of its causes and impacts often hinders widespread understanding. This project addresses this challenge by developing a comprehensive and visually appealing dashboard that presents key insights into the causes, trends, and consequences of climate change. The dashboard integrates global data for cause-and-trend analysis while focusing specifically on the United States for the effects of climate change. By making the information accessible and engaging, our project seeks to foster greater awareness and informed action among the general public.

1. Introduction

1.1 Motivation

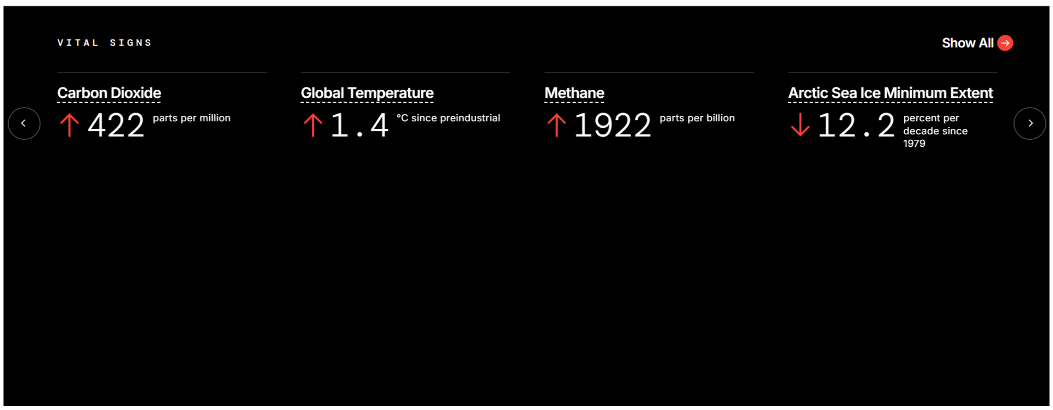
Climate change is a global issue with local implications, affecting every facet of life. However, public understanding of its causes, progression, and consequences often remains superficial due to the complexity of scientific data. The motivation for this project stems from the need to simplify and visualize climate change data in a way that resonates with a broader audience. Our goal is to create an interactive dashboard that conveys the causes and effects of climate change in a clear and impactful manner, empowering individuals with the knowledge needed to drive meaningful discussions and actions.

1.2 Existing Work

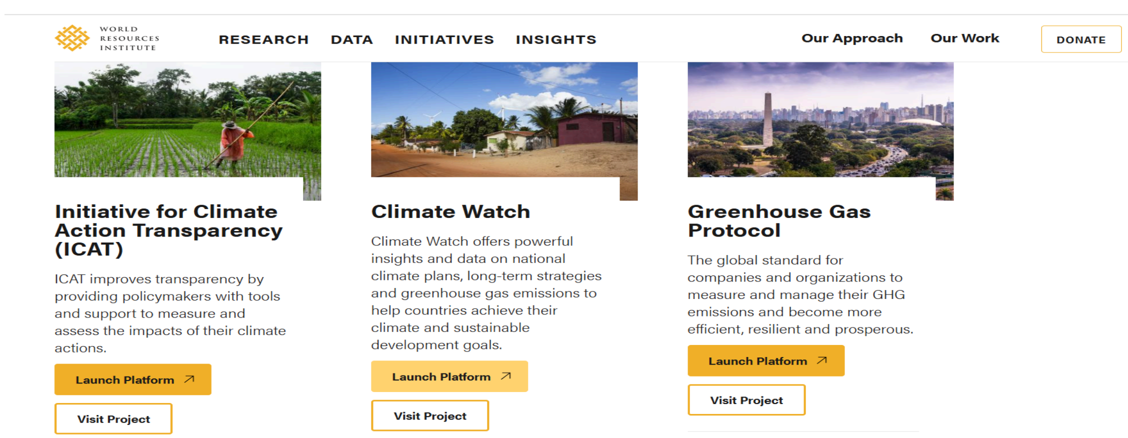
Previous works in climate change visualization primarily focus on either scientific precision or public awareness. Numerous dashboards and reports analyze global emissions, temperature anomalies, and weather patterns, while others emphasize regional impacts or future projections. While these efforts are commendable, they often target specific audiences, such as researchers or policymakers, and may not be easily digestible for the general public. There is a need for a unified tool that combines global analyses of climate change causes and trends with localized insights into its impacts.

Here are some links to climate change dashboards and related works that have inspired and supported our project:

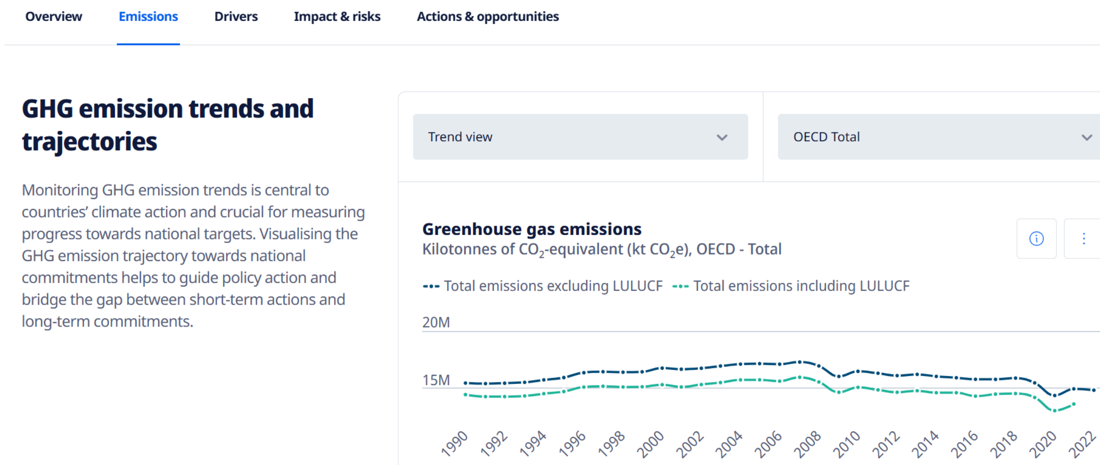
1. **NASA's Climate Change Vital Signs Dashboard**: This platform provides critical climate indicators, such as global temperature, carbon dioxide levels, and Arctic ice measurements. It serves as a comprehensive resource for visualizing real-time and historical climate data.



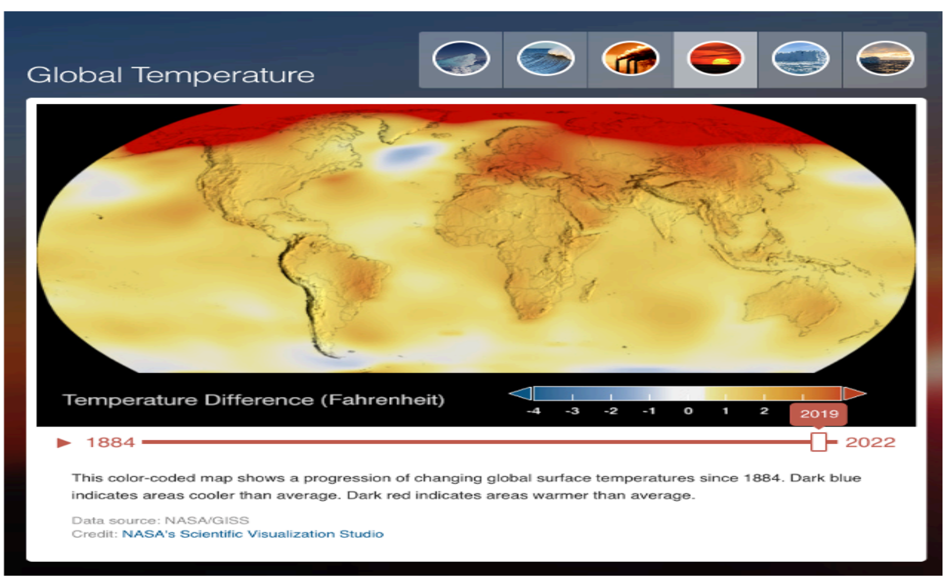
2. **World Resources Institute (WRI) Dashboards**: These dashboards analyze city-level impacts of climate change, including urban flooding, air pollution, and greenspace access. They demonstrate how localized data can be visualized to inform policy decisions.



3. **OECD Climate Action Dashboard**: This tool tracks country-level progress in combating climate change, focusing on emissions, policies, and international commitments. It provides insights into global climate strategies.

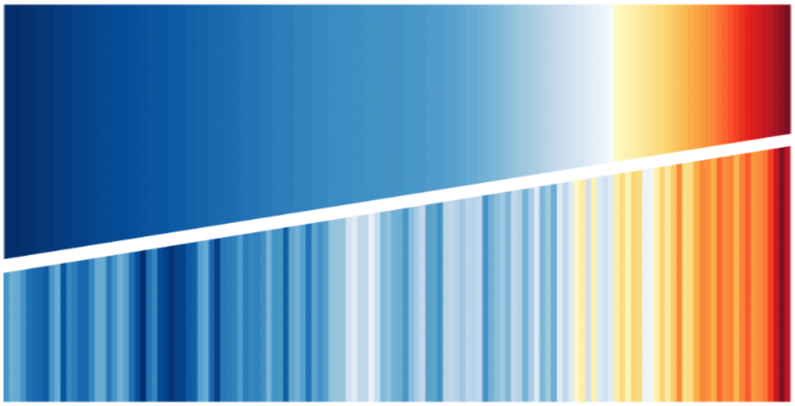


4. **NASA's Climate Time Machine:** This interactive tool allows users to visualize changes in sea ice, sea level, carbon dioxide, and global temperature over time. While comprehensive, it separates different climate factors into distinct visualizations, making it challenging to see interconnections between various aspects of climate change.



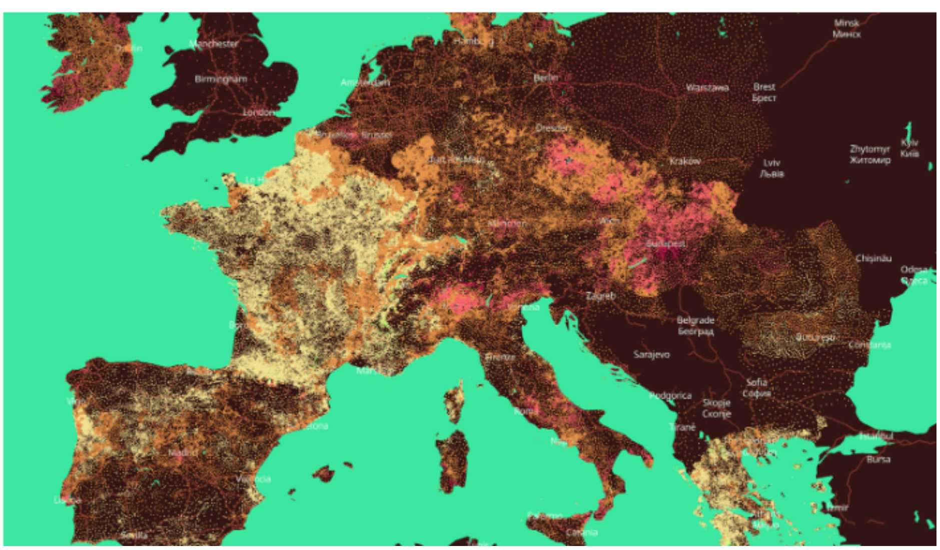
5. **Ed Hawkins' "Warming Stripes" and Variations:** These simple yet powerful visualizations show temperature changes over time using color-coded stripes. While

visually striking and easily understood, they focus solely on temperature and don't provide detailed information or interactivity.



6. **IPCC Visualizations:** The Intergovernmental Panel on Climate Change (IPCC) produces complex visualizations that depict various climate change impacts. However, studies have shown that non-scientists often struggle to interpret these visualizations correctly. The challenge lies in balancing scientific accuracy with accessibility for lay readers.

7. **Interactive Regional Visualizations:** Tools like the European Data Journalism Network's map of rising temperatures in Europe provide detailed, localized information. While valuable for regional insights, such visualizations often lack a global perspective and don't clearly show interconnections between different climate factors.



These examples showcase diverse approaches to visualizing climate data, emphasizing global trends, localized impacts, and policy-driven insights. They could provide valuable context or ideas for our dashboard. What they lack is the appeal to the general public. We aim to use the data and visuals that showcases how this change in climate occurs and how it affects their health and daily lives.

1.3 Our Contribution

Our project aims to bridge the gap between data complexity and public understanding by developing an intuitive dashboard that combines three key aspects:

1. **Causes of Climate Change** – Presenting global datasets on emissions, deforestation, and industrial activities to identify the primary contributors.
2. **Analysis of Climate Trends** – Visualizing global climate patterns and trends over time to provide context to ongoing changes.
3. **Effects of Climate Change (USA Focus)** – Highlighting specific impacts within the United States, including health, environmental, and economic repercussions.

By integrating diverse datasets and designing a user-friendly interface, our dashboard stands out as a versatile tool for education and awareness. It is tailored to help individuals and communities grasp the urgency of climate change and encourages actionable engagement.

2. Data

2.1 Cause and Analysis:

We took data from the IMF **Climate change dashboard** which examines carbon dioxide atmospheric concentrations, as well as trends in global warming, such as rising sea levels, rising temperatures and frequency of natural disasters .

1. **Forest and Carbon:**
    - Offers detailed data of the forest cover and carbon emissions from all countries from the year 1980 to 2020.
    - The data can be used for understanding the correlation between the forest area and the carbon emissions.
    - Columns considered are Country, Year, Indicator, Unit and ISO3.

2. **Annual Surface temperature change:**
    - Offers detailed data of surface temperature change across the globe from the years 1950 to 2020.
    - Can be used for understanding how surface temperature change contributes to total global temperature change.
    - Columns considered are Country, year, temp_change, years, ISO3 (country code).

3. **GCB Emissions:**
    - Offers detailed data on different sources of CO_2 emissions like coal, oil, cement etc.
    - Can be used for understanding which industry or production of which material causes CO_2 emissions.
    - Columns considered are Country, Year, ISO3, coal, oil, cement, gas and per capita.

4. **Climate Change Related Disaster Frequency:**
    - Offers detailed data for the frequency of different types of disasters across the globe.
    - Can be used for analysis of disasters in different countries and studying their underlying causes based on external factors.
    - Columns used are Country, Year, disaster type, ISO3 and Disaster count.

2.2 Effects (USA focused):

We took data from the **National Environmental Public Health Tracking Network** which offers datasets that are directly relevant to understanding the health impacts of climate change. Here's an overview of the selected datasets.

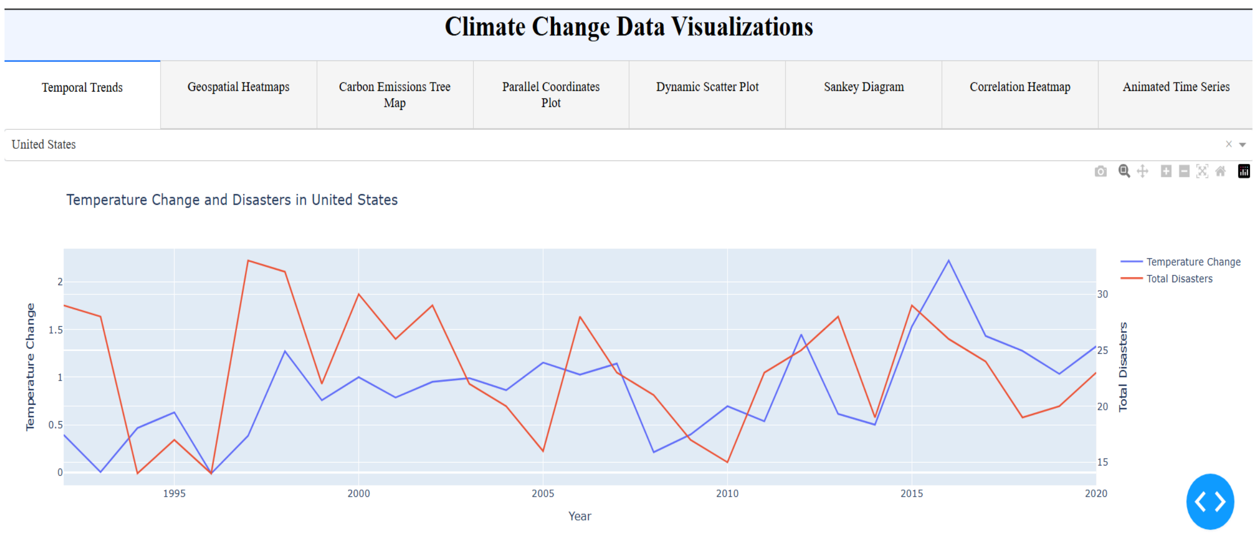
1. **Heat-Related Illness**
    - Data on heat-related emergency department visits and hospitalizations.
    - Useful for analyzing patterns and trends in health issues linked to rising temperatures, and for identifying vulnerable populations.
    - Columns considered (State Name , State id , Value)
2. **Extreme Precipitation**
    - Tracks instances of extreme rainfall events, which are increasing due to climate change.
    - Can be used to correlate precipitation events with flood-related health impacts or property damage.
    - Columns Considered(county FIPS, year , Value)
3. **Exposure to UV Radiation**
    - Data on UV Index levels across regions, which influence skin cancer risks and other health effects.
    - Useful for assessing how changes in UV exposure relate to climate and environmental factors.
    - Columns considered (State Name , State id , Value)

4. **Cases of Melanoma of the Skin**
    - Provides statistics on incidences and rates of melanoma diagnoses.
    - Allows for exploration of correlations between UV exposure and skin cancer trends.
    - Columns considered (State Name , State Id , year ,Value)

2.3 Visualization Methods

2.3.1 Cause and Analysis:

A. Temporal Trends:

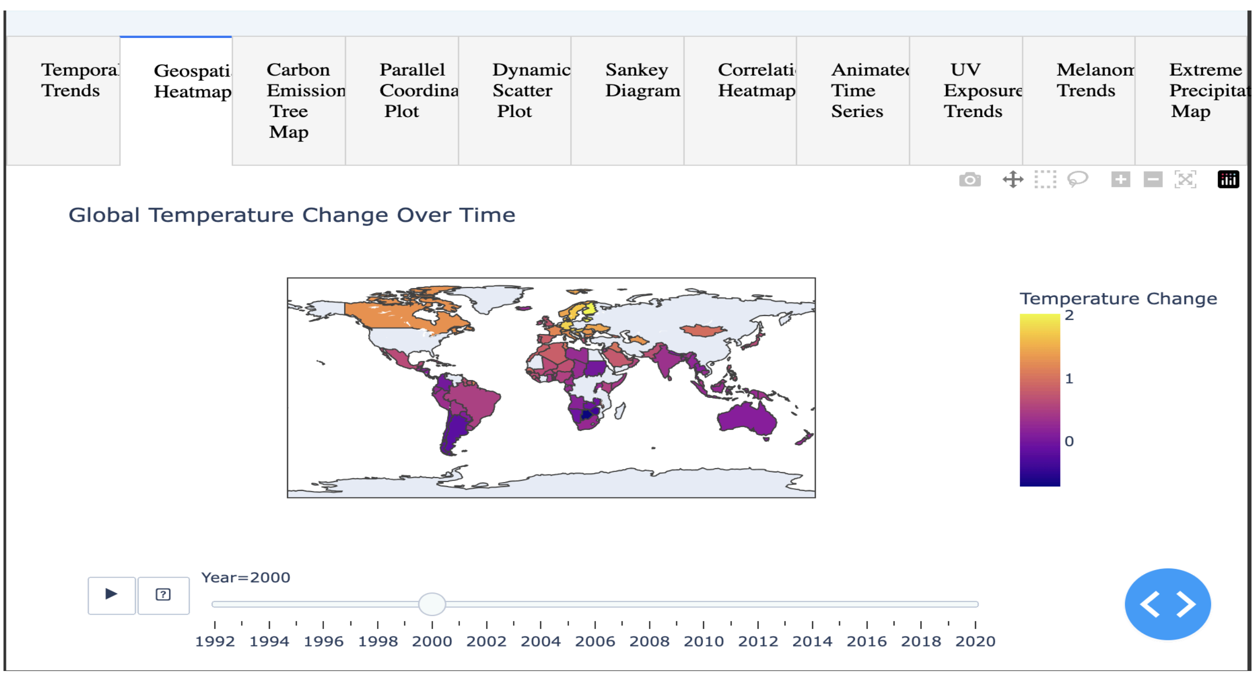


1. **Selected Method: Line Chart**
    - **Why Suitable:**
        - Perfect for analyzing temporal trends (1990–2020).
        - Dual-axis design allows comparison of temperature changes and disaster frequency effectively.
    - **Pros:**
        - Highlights peaks, trends, and correlations.
        - Easy to interpret for time-series data.
    - **Cons:**
        - Overlapping lines can obscure details.
        - Dual-axis requires clear labeling for accurate interpretation.

2. **Alternative Methods Considered:**
    ○ Bar Chart: Effective for discrete data like yearly disasters but fails to show trends over time.
    ○ Scatter Plot: Good for correlation analysis but lacks time progression.
    ○ Area Chart: Visualizes magnitude but causes clutter when multiple variables overlap.

3. **Ideas, Sketches and Prototypes:**
    a. **Core Idea:**
    ○ To illustrate the correlation between climate change (temperature) and disaster frequency in Albania over three decades.
    b. **Sketches and Prototypes:**
    ○ Initial designs considered bar charts for disaster counts and scatter plots for temperature-disaster correlation.
    ○ Line charts proved most effective for representing both temporal and relational data.

B. Geographical Heatmap:



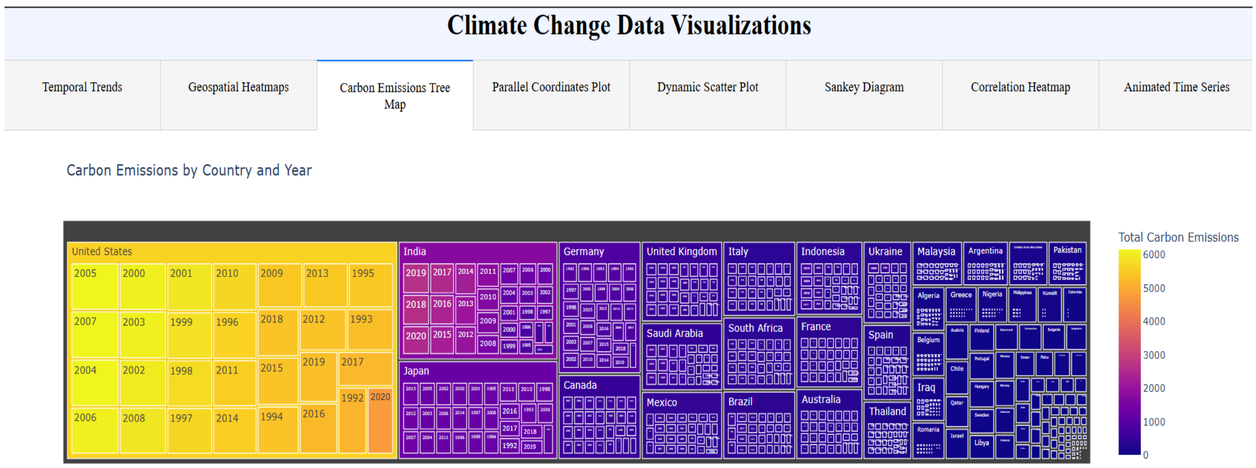
1. **Selected Method: Geospatial Heatmap**
   - **Why Suitable:**
     - Visualizes global temperature changes over time across regions.
     - Enables spatial comparison of temperature variation using color gradients.
   - **Pros:**
     - Captures both spatial and temporal patterns effectively.
     - Intuitive color coding for temperature changes (e.g., warmer colors for increases, cooler colors for decreases).
   - **Cons:**
     - Complex data visualization may require clear legends and instructions.
     - Requires high-resolution data for detailed insights.

2. **Alternative Methods Considered:**
   - Bar Chart: Effective for comparing individual countries but lacks spatial representation.
   - Line Chart: Good for temporal trends but cannot represent spatial variation.
   - Scatter Plot: Ineffective for large datasets and does not support spatial visualization.

3. **Ideas, Sketches, and Prototypes**
   a. **Core Idea:**
   - To represent global temperature changes spatially and temporally, highlighting trends across different regions and years.

   b. **Sketches and Prototypes:**
   - Initial designs considered individual bar charts for country-wise temperature changes.
   - The interactive heatmap proved more effective in showing spatial trends and year-by-year variation.

C. Carbon Emissions Tree Map:



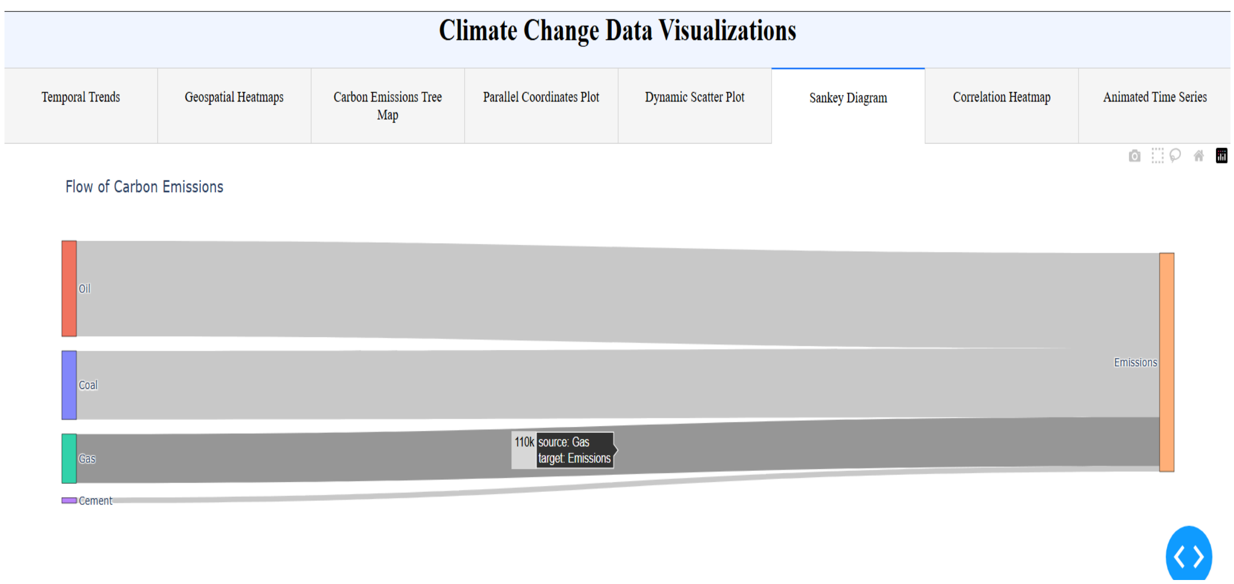
1. **Selected Method: Tree Map**
   - **Why Suitable:**
     - Provides an intuitive representation of carbon emissions by country and year.
     - Highlights relative contributions visually through block sizes and colors.
   - **Pros:**
     - Easy comparison across countries and time periods.
     - Uses hierarchical layout for both countries and years, making patterns easy to spot.
     - Color gradient enhances understanding of emission intensity (e.g., yellow for high emissions, purple for low).
   - **Cons:**
     - Smaller countries or years may be visually minimized, obscuring detail.
     - Requires a legend for accurate interpretation.

2. **Alternative Methods Considered:**
   - Bar Chart: Suitable for individual country/year analysis but cannot show hierarchical relationships effectively.
   - Heatmap: Captures intensity but lacks clear spatial organization for country-wise emissions.
   - Bubble Chart: Good for proportional comparisons but less structured than a tree map.

3. **Ideas, Sketches, and Prototypes:**
    a. **Core Idea:**
    - Represent global carbon emissions in a hierarchical, spatially structured way, emphasizing both country-wise and year-wise variations.

    b. **Sketches and Prototypes:**
    - Initial designs included grouped bar charts for each country, but these failed to represent the relative scale effectively.
    - The tree map was chosen for its ability to show both hierarchy and proportionality clearly.

D. Total Carbon Emissions by Different Sources (Sankey Diagram):



1. **Selected Method: Sankey Diagram**
    - **Why Suitable:**
        - Effectively represents the flow of carbon emissions from sources (e.g., Oil, Coal) to targets (e.g., Total Emissions).
        - Highlights proportional contributions of each source.
    - **Pros:**
        - Clearly visualizes relationships and flows between categories.
        - Thickness of flows conveys magnitude, making it intuitive to compare contributions.
    - **Cons:**
        - Becomes cluttered with too many categories or connections.

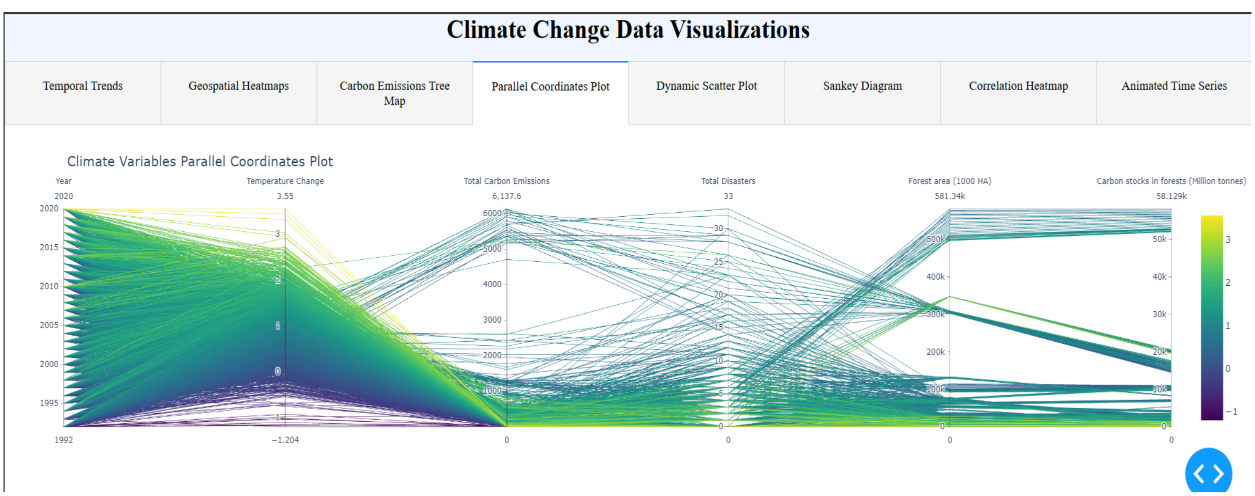
■ Requires interactive features or labels for detailed analysis.

2. **Alternative Methods Considered:**
   - Pie Chart: Good for proportional comparisons but fails to show the relationship between sources and targets.
   - Bar Chart: Effective for categorical comparisons but lacks the flow visualization of sources to targets.
   - Tree Map: Suitable for hierarchical data but not for showcasing flows or relationships.

3. **Ideas, Sketches, and Prototypes:**
   a. **Core Idea:**
   - Illustrate the flow and proportional contribution of various carbon emission sources (e.g., Oil, Coal, Gas) to overall emissions.

   b. **Prototypes:**
   - Early designs included pie charts and bar charts, but these did not capture the relational aspect effectively.
   - The Sankey diagram was selected for its ability to represent flow and proportionality simultaneously.

E. Parallel Coordinate Plot:



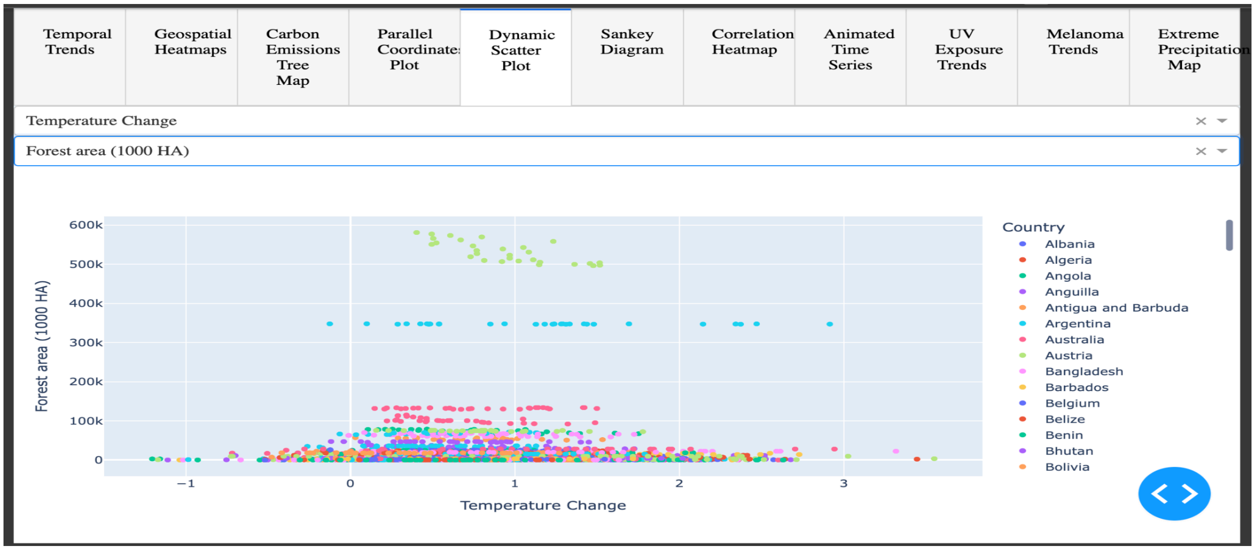
1. **Selected Method: Parallel Coordinates Plot**
   - **Why Suitable:**
     - Visualizes multivariate data effectively, allowing the comparison of multiple climate-related variables (e.g., Temperature Change, Carbon Emissions, Total Disasters, Forest Area, Carbon Stocks).
     - Shows relationships and patterns across years for diverse variables in a single chart.
   - **Pros:**
     - Captures complex relationships between multiple variables simultaneously.
     - Interactive features enhance exploration and filtering of specific trends.
     - Color gradient represents additional information (e.g., magnitude of temperature change).
   - **Cons:**
     - Overlapping lines can make interpretation challenging for dense datasets.
     - Requires familiarity with the visualization type for effective interpretation.

2. **Alternative Methods Considered:**
   - Scatter Plot Matrix: Good for pairwise relationships but inefficient for high-dimensional data.
   - Heatmap: Effective for correlations but cannot show individual data points or trends over time.
   - Line Chart: Suitable for temporal trends but limited to fewer variables.

3. **Ideas, Sketches, and Prototypes:**
   a. **Core Idea:**
   - Represent multivariate climate data over time to identify interdependencies and trends across key variables.

   b. **Prototypes:**
   - Early designs included heatmaps and scatter plot matrices but lacked the ability to represent all variables effectively.
   - The parallel coordinates plot was chosen for its capacity to display high-dimensional relationships in a compact format.

F. Dynamic Scatter Plot:



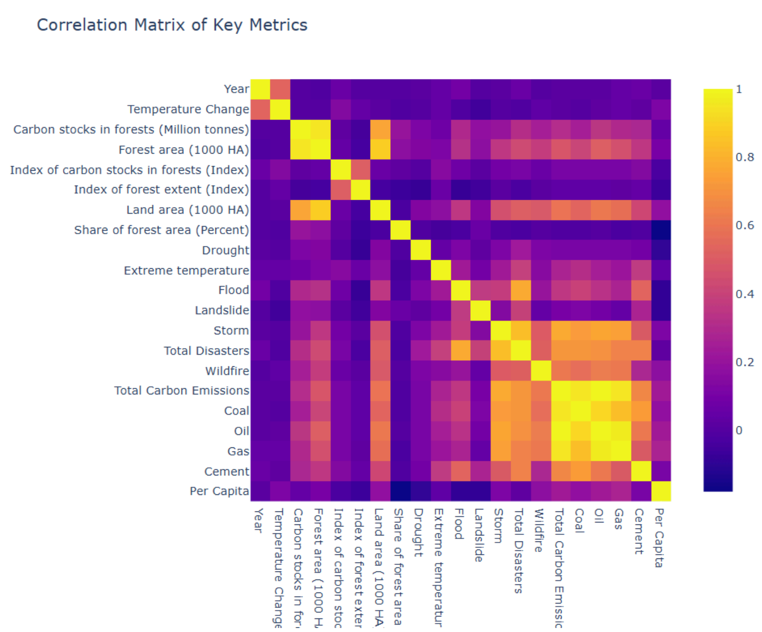
1. **Selected Method: Scatter Plot**
    - **Why Suitable:**
        - Visualizes the relationship between Temperature Change and Forest Area across different countries.
        - Dynamic features allow filtering by country or region for detailed analysis.
    - **Pros:**
        - Effectively highlights the distribution and clustering of data points.
        - Facilitates comparison of temperature change impacts on forest area globally.
        - Color coding helps distinguish between countries.
    - **Cons:**
        - Overlapping points can obscure trends for smaller values.
        - Dense datasets require zooming or filtering for clarity.

2. **Alternative Methods Considered:**
    - Line Chart: Ineffective for non-temporal data with multiple categories.
    - Bar Chart: Limited to categorical comparisons and unsuitable for continuous relationships.
    - Bubble Chart: Could add a size dimension for additional insights but risks clutter with dense datasets.

3. **Ideas, Sketches, and Prototypes**
   a. **Core Idea:**
   - Analyze the relationship between forest area and temperature change to identify patterns and outliers among countries.
   - Focus on global data to understand broader environmental impacts**.**

   b. **Prototypes:**
   - Early designs included static scatter plots but lacked interactivity for large datasets.
   - Dynamic scatter plots were chosen to allow detailed exploration of specific regions or countries.

G. **Correlation Heatmap:**



1. **Selected Method: Correlation Heatmap**
   - **Why Suitable:**
     - Represents the correlation matrix of multiple climate metrics, allowing users to observe relationships between variables.
     - Color gradient intuitively displays the strength of correlation (e.g., yellow for strong, purple for weak).
   - **Pros:**
     - Compact representation of pairwise relationships for numerous variables.
     - The Color-coded system provides quick visual insights into positive and negative correlations.

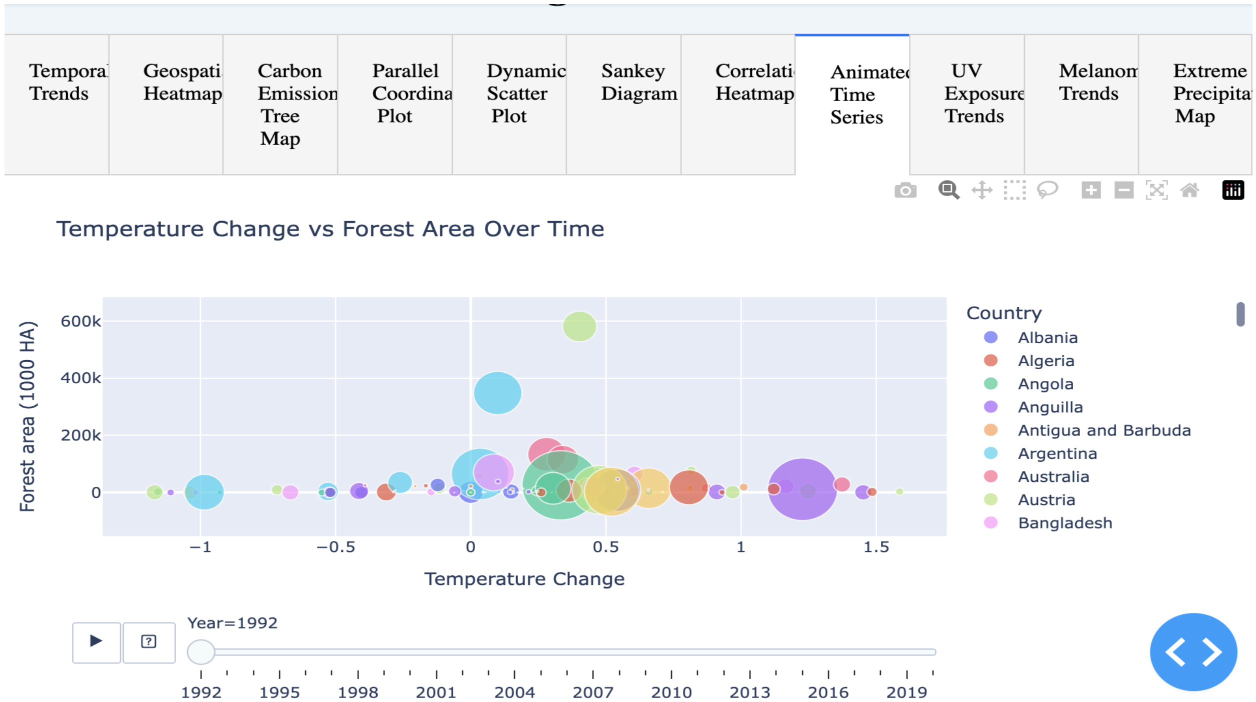
- **Cons:**
  - Can become overwhelming with too many variables.
  - Requires proper labeling and legends for interpretation.

2. **Alternative Methods Considered:**
   - Scatter Plot Matrix: Effective for pairwise relationships but less compact and visually clear for larger datasets.
   - Bar Chart: Limited to representing one-dimensional relationships, unsuitable for pairwise comparisons.
   - Parallel Coordinates Plot: Visualizes relationships but does not clearly quantify correlation strength.

3. **Ideas, Sketches, and Prototypes:**
   a. **Core Idea:**
   - To identify significant correlations among climate variables (e.g., temperature change, carbon emissions, disasters, forest area) and understand interdependencies.

   b. **Prototypes:**
   - Initial designs included scatter plot matrices, but these were cumbersome for large datasets.
   - The correlation heatmap was chosen for its clarity and ability to summarize all relationships in a single view.

H. Temperature Change and Forest Area over time:



1. **Selected Method: Animated Scatter Plot**
   - **Why Suitable:**
     - Displays the relationship between Temperature Change and Forest Area over time.
     - Animation highlights changes dynamically, emphasizing temporal trends and country-level variations.
   - **Pros:**
     - Engages the audience with interactive and temporal visual storytelling.
     - Bubble size represents additional data (e.g., forest area), adding a layer of analysis.
     - Easily distinguishes between countries using color coding.
   - **Cons:**
     - Requires interaction or time to fully grasp temporal patterns.
     - Overlapping bubbles may obscure smaller data points.

2. **Alternative Methods Considered:**
   - Line Chart: Effective for temporal trends but limited for multi-variable comparisons.
   - Bar Chart: Inefficient for representing relationships between temperature change and forest area.

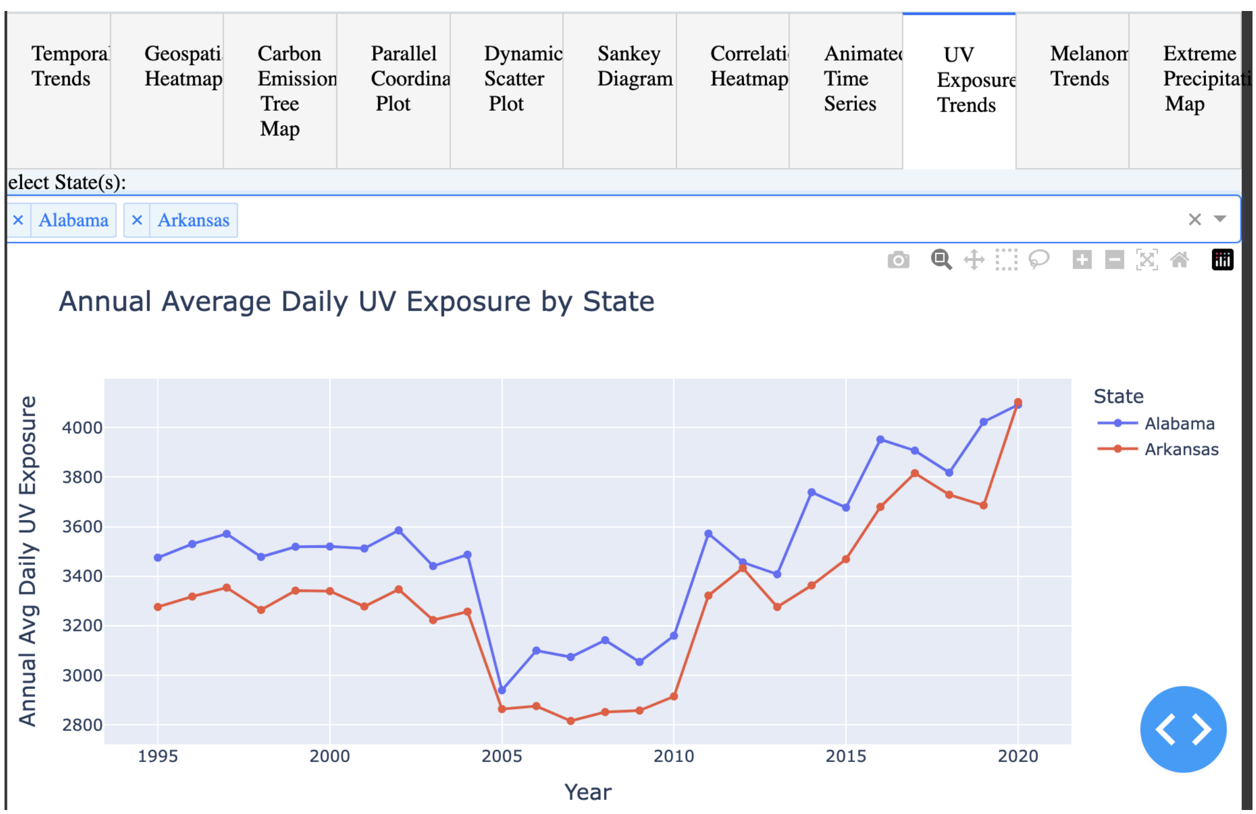
- Static Scatter Plot: Cannot capture the progression of trends over time.

3. **Ideas, Sketches, and Prototypes**
   a. **Core Idea:**
   - To showcase how forest area and temperature changes evolve globally over the years, providing insights into their correlation.

   b. **Prototypes:**
   - Early designs included static scatter plots for specific years but failed to illustrate temporal progression effectively.
   - The animated scatter plot was chosen for its ability to visualize dynamic changes over time.

2.3.2 Effects:

1. **Trend Chart - UV Exposure Analysis**
   We analyzed 20 years of UV exposure data across different states in the USA. The trend reveals a significant increase in UV exposure from 2000 to 2020.



1. **Selected Method: Line Chart**
    - **Why Suitable**:
        - Ideal for analyzing temporal trends in **UV exposure** over 20 years.
        - Enables comparison across states (e.g., Alabama and Arkansas) using distinct lines.
    - **Pros**:
        - Clearly shows year-over-year trends and variations.
        - Multiple lines effectively compare data between regions.
    - **Cons**:
        - Overlap of lines can make interpretation challenging with more states.
        - Limited to two variables for effective readability.

2. **Alternative Methods Considered**:
    - **Bar Chart**: Inefficient for showing continuous trends over time.
    - **Scatter Plot**: Lacks the flow and continuity of trends across years.
    - **Area Chart**: Overlaps can obscure individual trends.

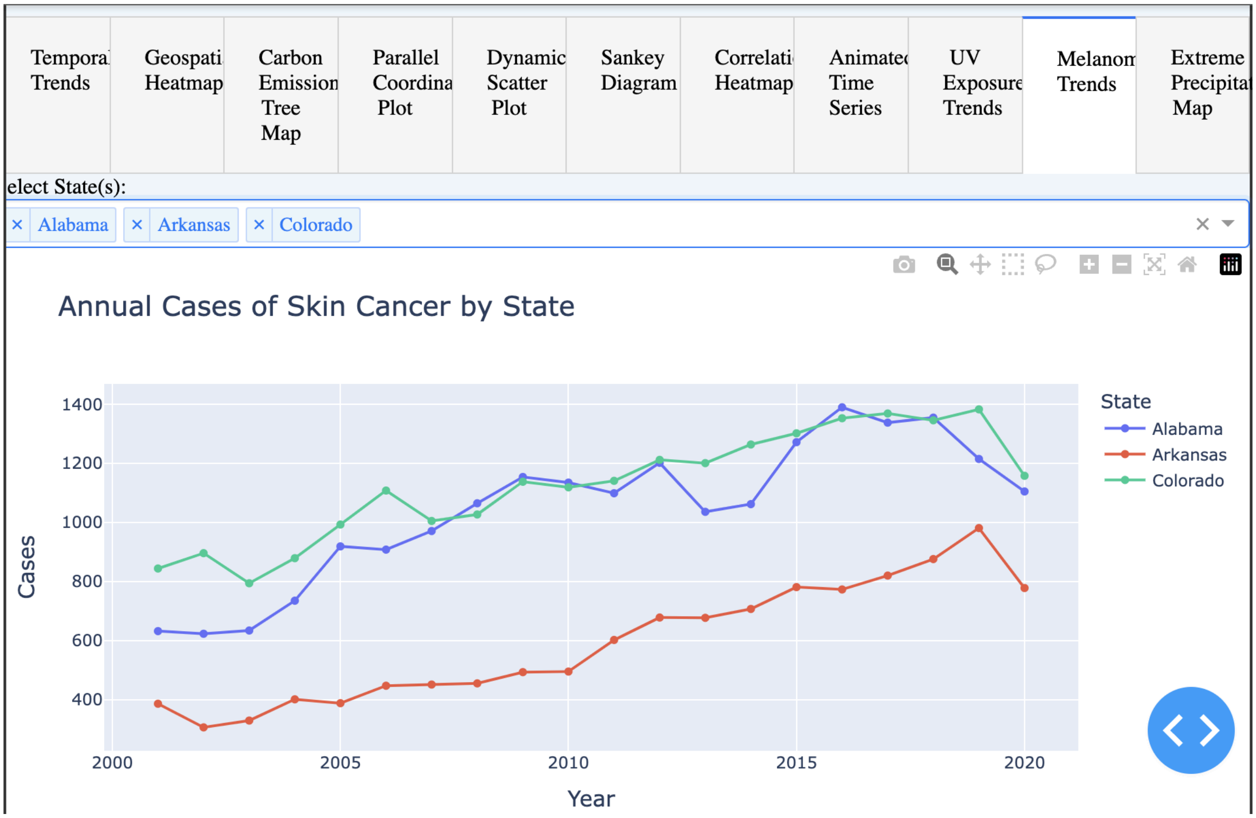
3. **Ideas, Sketches, and Prototypes**

    a. **Core Idea**:
    - To analyze and compare **UV exposure trends** across states over 20 years, highlighting significant increases.

    b. **Prototypes**:
    - Early sketches included bar charts, but these failed to capture the flow of UV exposure over time.
    - The line chart was chosen for its ability to clearly display temporal changes and inter-state comparisons.

2. **Line Chart - Skin Cancer Analysis:**

   Melanoma, a type of skin cancer, is caused by UV exposure. With the increase in UV exposure, primarily due to climate change, the number of skin cancer cases has also risen across various states.



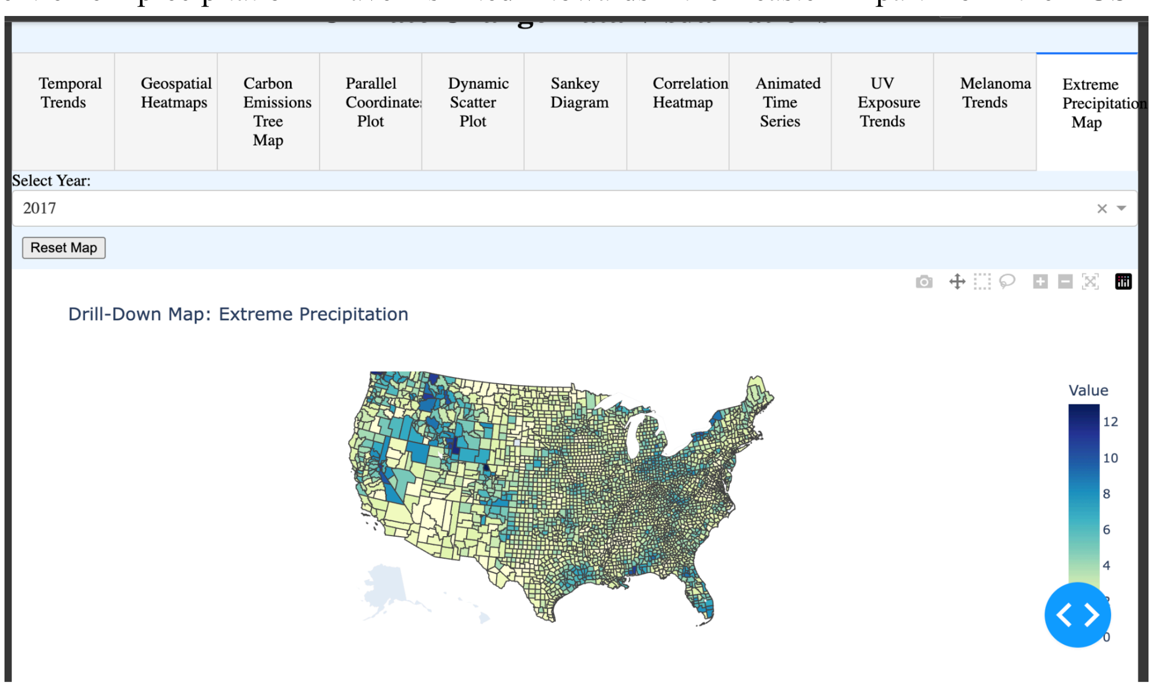
1. **Selected Method: Line Chart**
   - **Why Suitable**:
     - Ideal for showing the temporal trend of annual **skin cancer cases** across states (Alabama, Arkansas, Colorado).
     - Enables easy comparison between states using distinct lines.
   - **Pros**:
     - Clearly highlights year-over-year trends and regional differences.
     - Effective for identifying patterns and shifts in skin cancer cases.
   - **Cons**:
     - Overlapping lines may make detailed comparisons challenging with additional states.
     - Limited insight into external contributing factors without additional context.

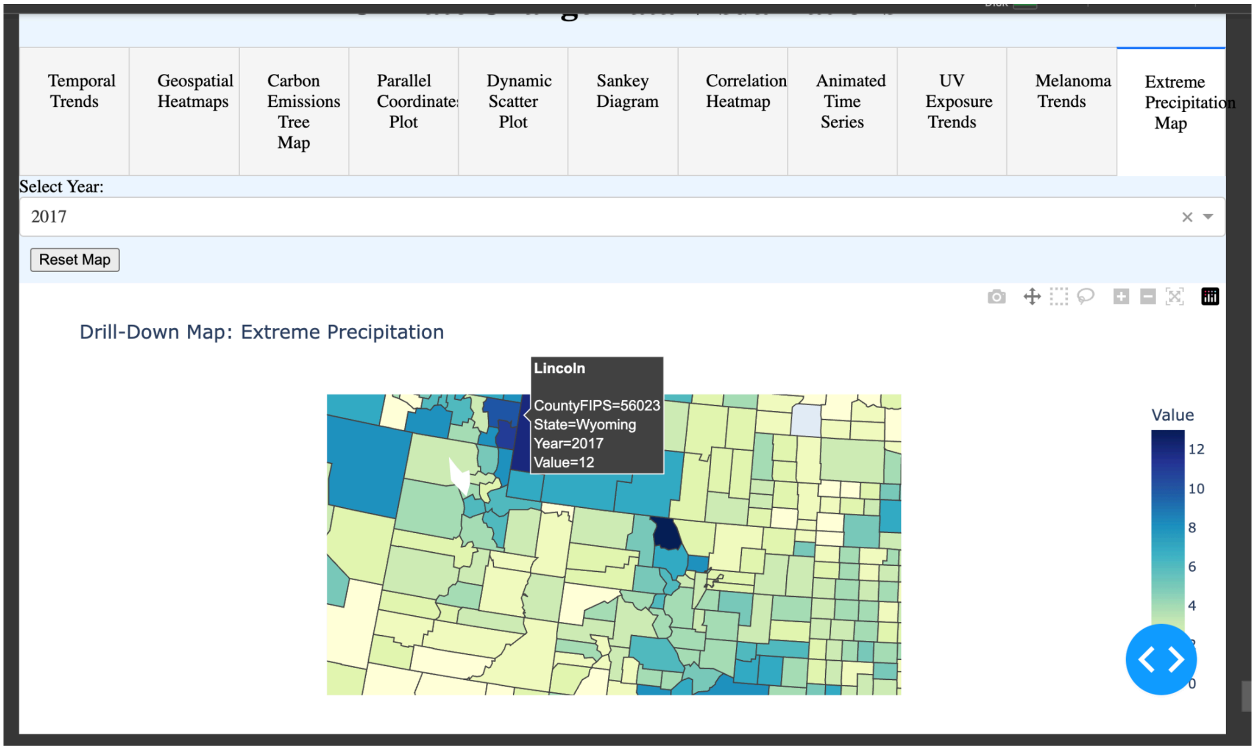
2. **Alternative Methods Considered**:
   - **Bar Chart**: Ineffective for continuous temporal data and comparisons between states.
   - **Scatter Plot**: Lacks continuity for trend analysis over time.
   - **Area Chart**: Overlaps can obscure trends when comparing multiple states.
3. **Ideas, Sketches, and Prototypes**
   a. **Core Idea**:
   - Visualize the rising trend in skin cancer cases over two decades due to increasing **UV exposure**.
   - Compare trends across different states to understand regional variations.

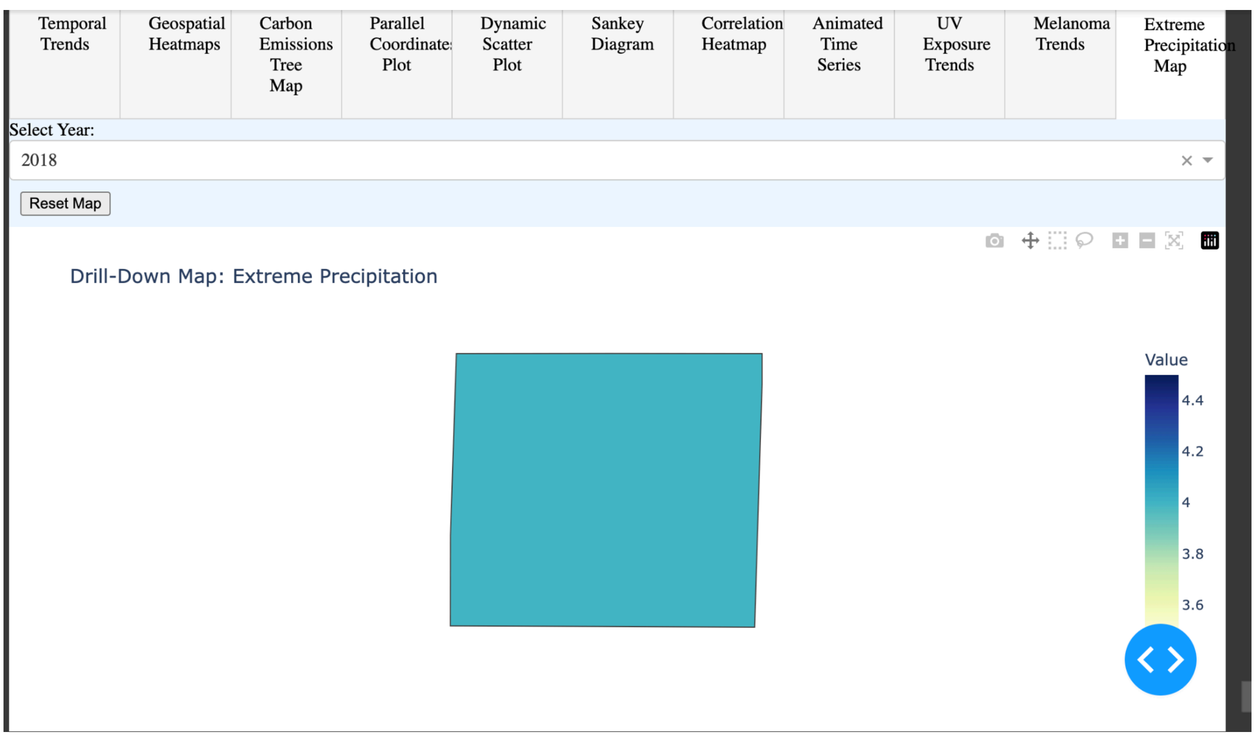
   b. **Prototypes**:
   - Initial designs considered scatter plots, but these lacked the temporal flow needed for trend analysis.
   - The line chart was selected for its clarity and ability to display comparative trends over time.

3. Extreme Precipitation - Choropleth Map

The choropleth map illustrates that counties experiencing extreme precipitation were primarily located on the west coast initially. Over time, however, the areas receiving extreme precipitation have shifted towards the eastern part of the USA







1. **Selected Method: Choropleth Map**
   - **Why Suitable:**
     - Effectively displays geographic distribution of extreme precipitation across counties in the USA.

        - Highlights regional shifts over time using color gradients to represent intensity.
    - **Pros:**
        - Provides spatial context, making it easy to identify regions experiencing significant precipitation changes.
        - Interactive drill-down feature enables exploration of specific years or regions.
    - **Cons:**
        - Dependent on high-quality geographic data for accuracy.
        - Dense data may require zooming in for detailed analysis.

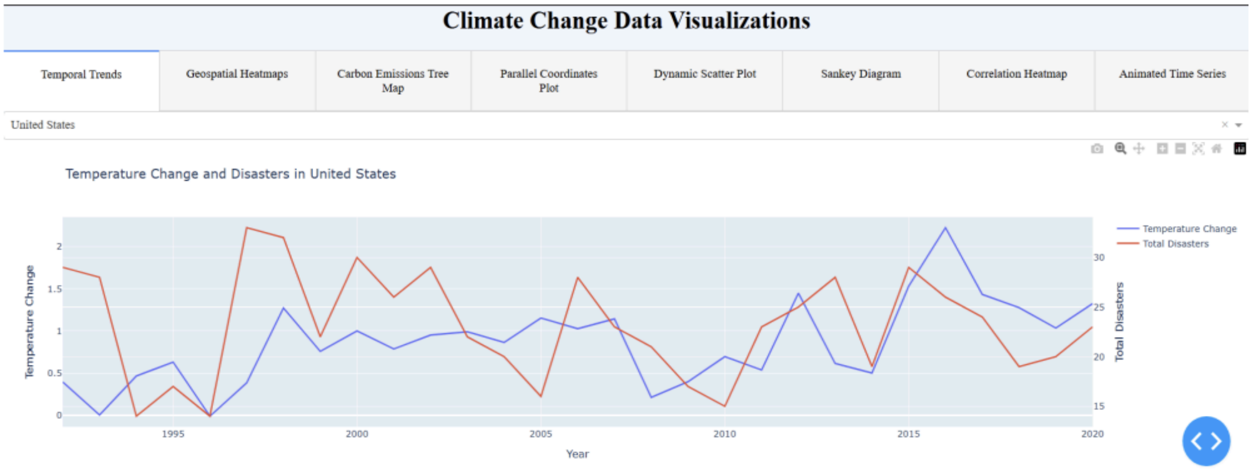
2. **Alternative Methods Considered:**
    - Heatmap: Effective for intensity representation but lacks geographic specificity.
    - Bar Chart: Suitable for comparing precipitation by region but cannot show spatial shifts or trends.
    - Scatter Plot: Ineffective for spatially distributed data.

3. **Ideas, Sketches, and Prototypes**
    a. **Core Idea:**
    - Highlight the spatial distribution and temporal shifts of extreme precipitation events in the USA, emphasizing the west-to-east shift over time.

    b. **Prototypes:**
    - Initial designs included static heatmaps for selected years, but these failed to illustrate spatial movement.
    - The choropleth map was chosen for its ability to represent regional variation and allow time-based exploration.

3. RESULTS:

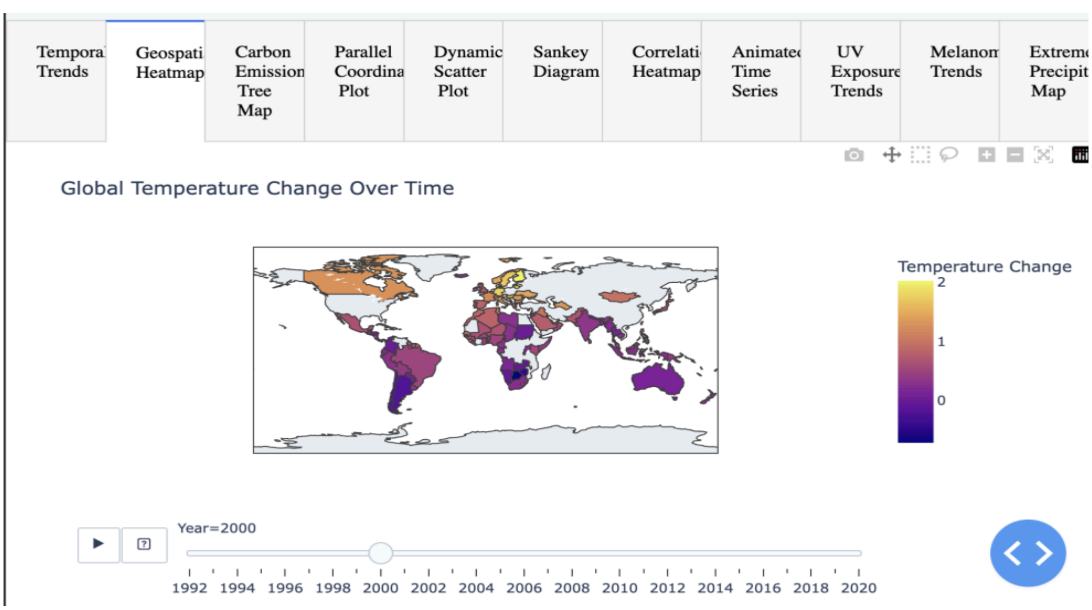
1. Temporal Trends



Key Insights from Visualization

1. **Trends Observed:**
   - Peaks in disaster frequency (2015) correlate with significant temperature changes.
   - Periods of stability in disasters often align with smaller temperature fluctuations.
2. **Analysis:**
   - Indicates a potential link between temperature variability and disasters in Albania.
   - Suggests Albania's vulnerability to even moderate climate fluctuations.

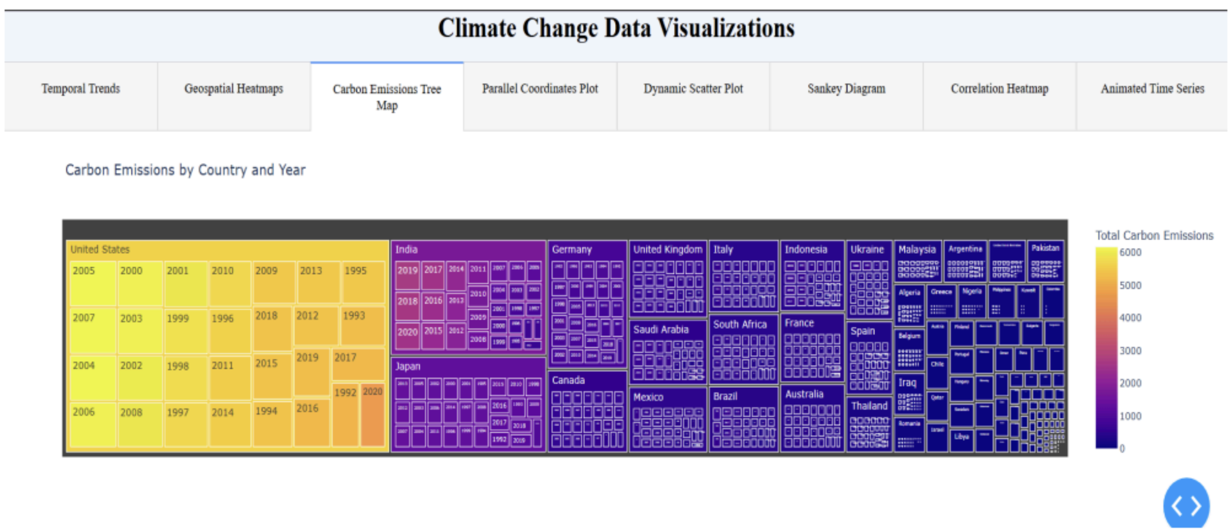
2. Geographical Heatmaps



Key Insights from Visualization

1. **Global Trends:**
    - Significant warming trends in regions like South America and parts of Europe over time.
    - Variability across regions highlights uneven temperature changes globally.
2. **Interactive Features:**
    - Allows exploration of specific years (e.g., 1996) and regions (e.g., Brazil).
    - Color gradients provide a clear representation of positive and negative temperature changes**.**

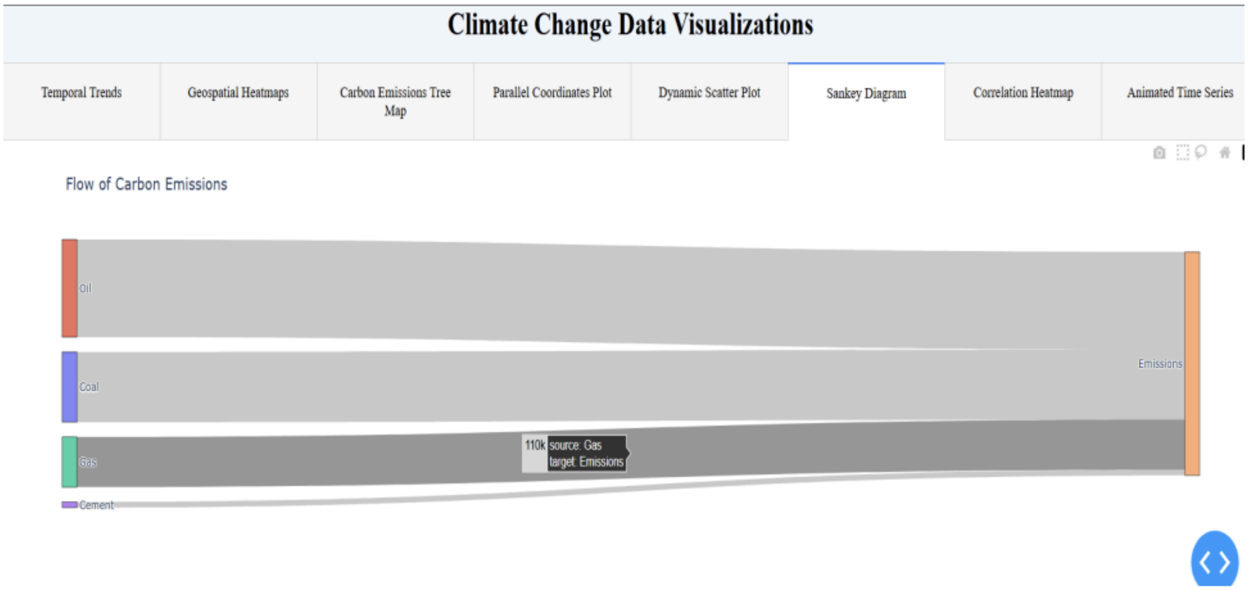
3. Carbon Emissions Tree Map



Key Insights from Visualization:

1. **Trends Observed:**
    - High-emission countries like India, China, and the US dominate the chart with larger, brightly colored blocks.
    - Emission growth is notable in recent years for some countries.
2. **Comparative Analysis:**
    - Countries like Germany and Japan show steady but relatively lower emissions.
    - Smaller countries with minimal emissions are visible but less prominent, emphasizing the disparities.
3. **Interactive Features:**
    - Users can explore emission trends year-by-year and country-by-country, facilitating deeper analysis of global carbon contributions.

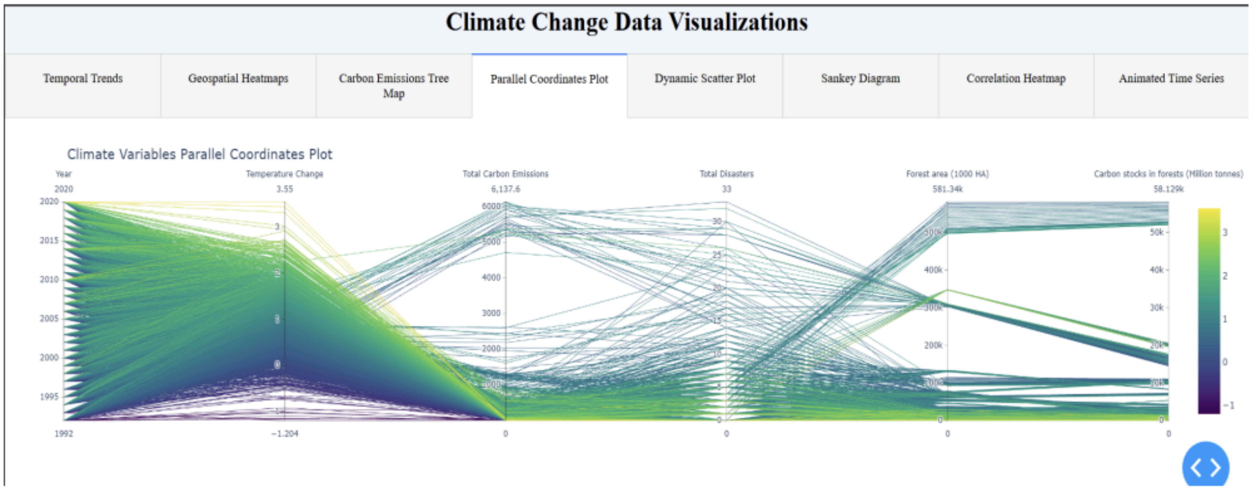
4. Total Carbon Emissions by Different Sources (Sankey Diagram)



Key Insights from Visualization:

1. **Emission Sources:**
    - Oil is a dominant source of emissions, as shown by the thickest flow line.
    - Coal and Gas also contribute significantly, while Cement has a smaller impact.
2. **Comparative Analysis:**
    - The thickness of flows enables quick comparison of source contributions.
    - Interactive features provide detailed insights into exact values (e.g., Oil: 146k emissions).
3. **Actionable Insights:**
    - Focus on reducing emissions from dominant sources like Oil and Coal.
    - Highlight the need for cleaner energy alternatives to mitigate major contributors.

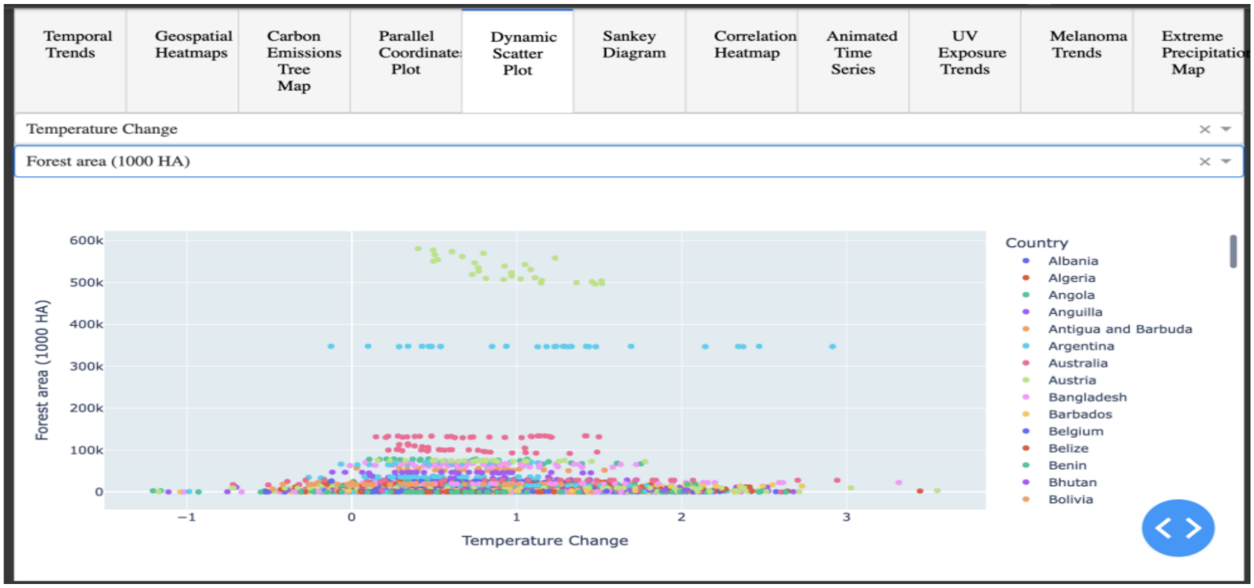
5. Parallel Coordinate Plot:



Key Insights from Visualization

1. **Variable Interconnections:**
   - High carbon emissions correlate with increased temperature changes and total disasters.
   - Forest area and carbon stocks show inverse relationships with emissions and temperature changes over time.
2. **Temporal Trends:**
   - Steady increases in carbon emissions and temperature change are observed from 1992 to 2020.
   - Declines in forest area and carbon stocks highlight deforestation and resource depletion over the years.
3. **Actionable Insights:**
   - Addressing deforestation (declining forest area and carbon stocks) could mitigate emissions and reduce climate impacts.
   - Further exploration of years with extreme values (e.g., high temperature changes or disasters) is essential to identify causal factors.

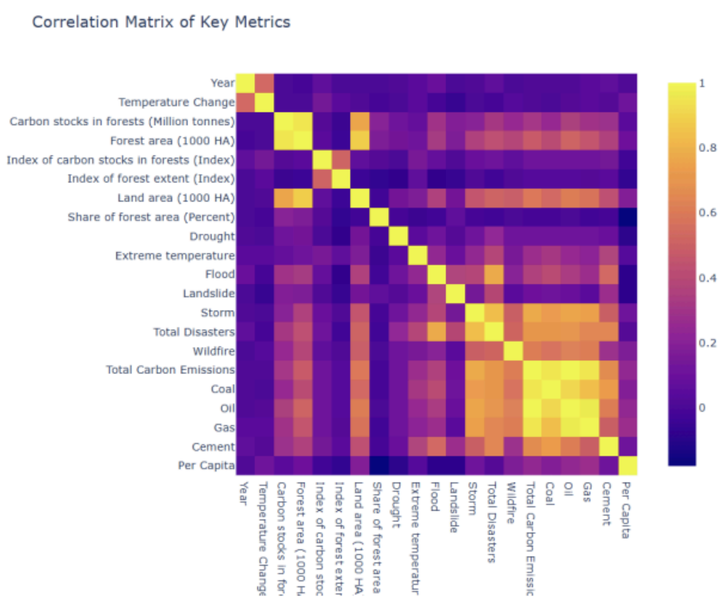
6. Dynamic Scatter plot



Key Insights from Visualization

1. **Relationships:**
   a. High carbon emissions correlate with increased temperature changes and total disasters.
2. **Global Trends:**
   a. Countries with minimal forest cover show higher temperature variability, indicating vulnerability.
   b. Brazil shows a steady decline in forest cover with increase in temperature and so does the rest of the countries.
3. **Actionable Insights:**
   a. Focus on reforestation and emissions control in regions with significant deviations to mitigate climate impacts.

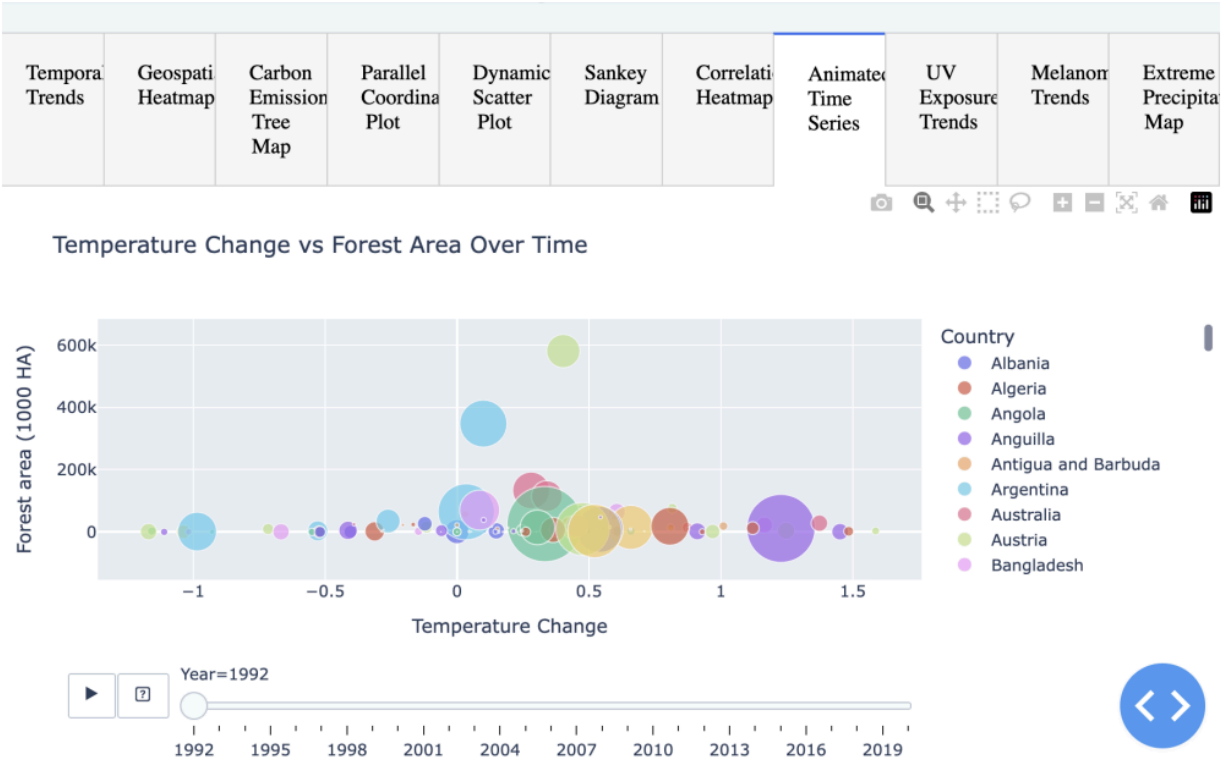
7. Correlation Heatmap



Key Insights from Visualization

1. **Strong Correlations:**
   - Total Carbon Emissions are strongly correlated with Temperature Change and Total Disasters.
   - Forest area and Carbon stocks in forests show a negative correlation with emissions, highlighting deforestation impacts.
2. **Weak/Neutral Correlations:**
   - Variables like Gas and Index of forest extent show weak correlations, as observed in specific cells with low color intensity.
3. **Actionable Insights:**
   - Focus efforts on reducing emissions to mitigate disasters and temperature changes.
   - Preserve forest area and carbon stocks as these are inversely related to harmful climate trends.

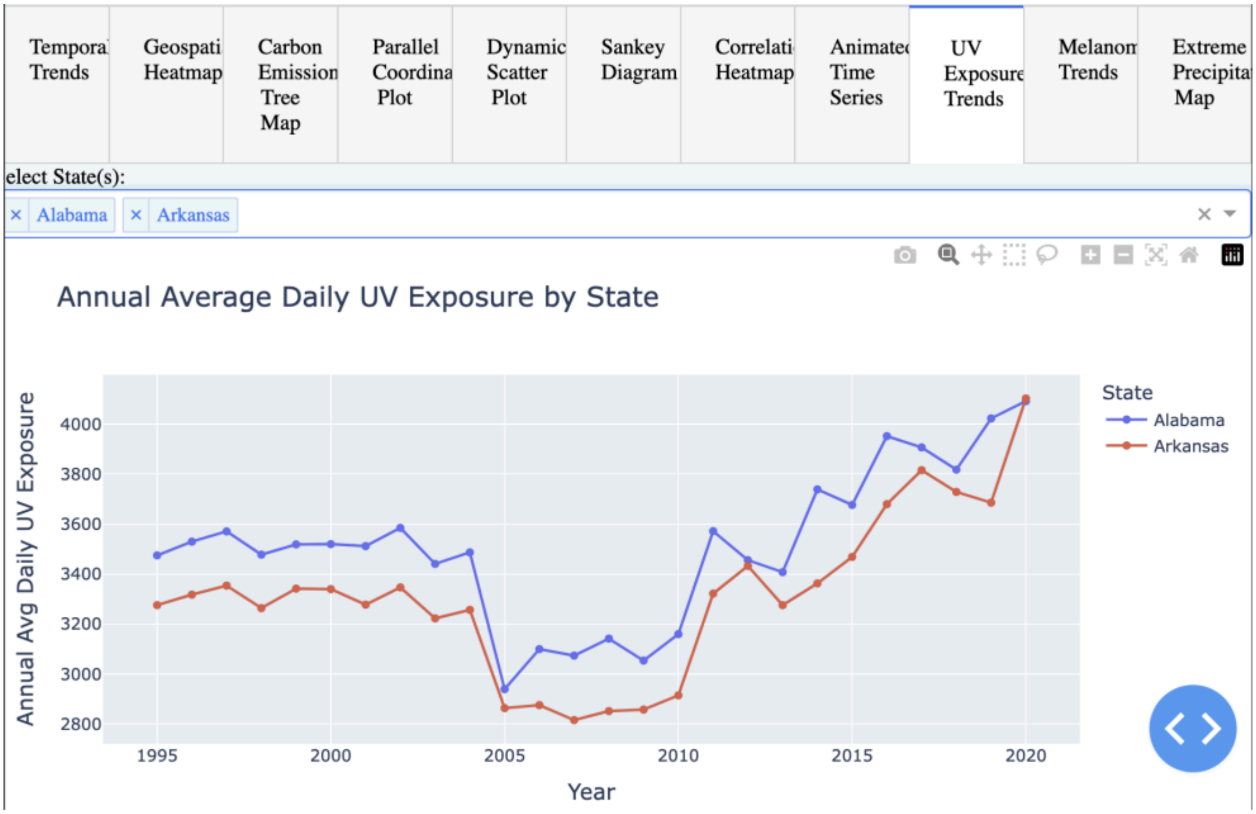
8. Temperature Change and Forest Area over time



Key Insights from Visualization

1. **Variable Interdependencies:**
   - Countries with significant forest areas (e.g., Brazil) show varying levels of temperature change over time.
   - A general trend of decreasing forest area aligns with increasing temperature changes globally.
2. **Temporal Dynamics:**
   - The animation highlights critical years with significant shifts, such as noticeable increases in temperature change after 2000.
3. **Actionable Insights:**
   - Focus on preserving forest areas as a buffer against climate change impacts.
   - Explore regions with extreme temperature changes or sharp declines in forest areas for targeted interventions.

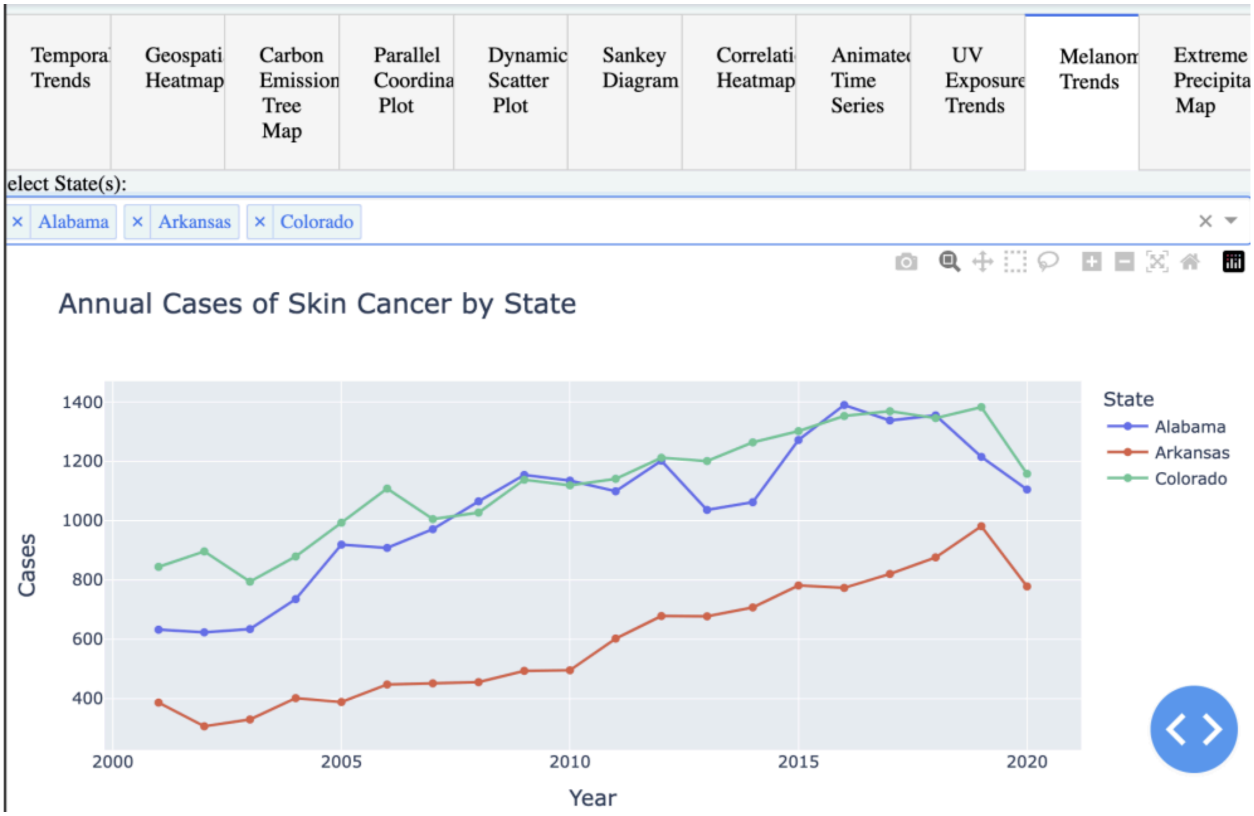
9. UV Exposure Analysis



Key Insights from Visualization

1. **Temporal Trends:**
   - Both **Alabama** and **Arkansas** show a steady increase in annual average daily UV exposure from 2000 to 2020.
   - A sharp dip around 2005 is followed by a rapid rise in UV exposure.
2. **Comparative Insights:**
   - Alabama consistently has higher UV exposure levels compared to Arkansas throughout the observed period.
3. **Actionable Insights:**
   - Rising UV exposure calls for increased awareness and policies on sun protection and skin health.
   - Further analysis is needed to identify causal factors for the sharp dip and subsequent increase post-2005.

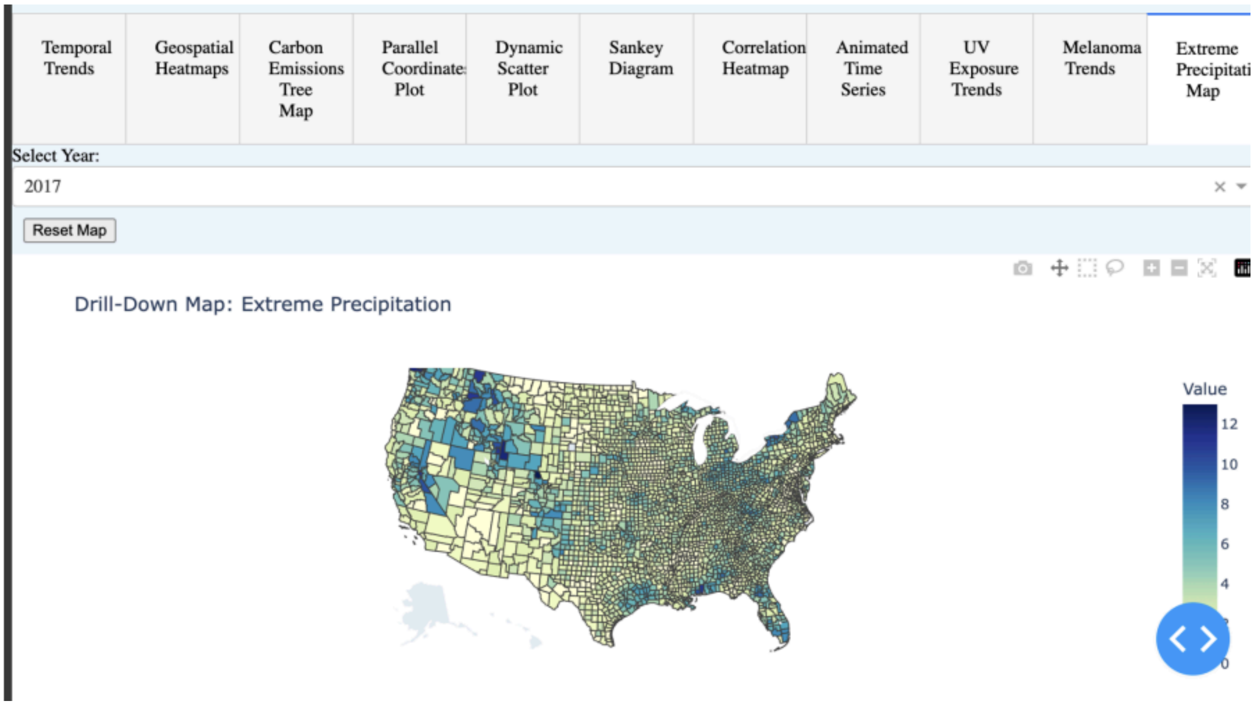
10. Skin Cancer Analysis:



Key Insights from Visualization

1. **Temporal Trends**:
    - **Alabama** and **Colorado** show consistently higher skin cancer cases compared to **Arkansas**.
    - A steady rise in cases across all states from 2000 to 2020, with slight stabilization or decline in recent years.
2. **Comparative Insights**:
    - Colorado has the highest peak in skin cancer cases, indicating a strong correlation with higher UV exposure levels.
    - Arkansas shows a slower but steady increase in cases over the years.
3. **Actionable Insights**:
    - Rising skin cancer cases highlight the need for public health interventions and awareness campaigns.
    - Future studies could explore the direct relationship between UV exposure levels and skin cancer incidents in specific regions.

11. Extreme Precipitation - Choropleth Map:



Key Insights from Visualization

1. **Regional Shifts:**
   - 1990s: Extreme precipitation events concentrated primarily on the west coast.
   - 2010s: Significant shift towards the eastern USA, indicating evolving climate patterns.
2. **Temporal Trends:**
   - Increase in the intensity and distribution of extreme precipitation events over time.
   - Certain regions consistently experience higher precipitation (e.g., Pacific Northwest, parts of the Southeast).
3. **Actionable Insights:**
   - Inform regional planning and infrastructure development to mitigate the impacts of extreme precipitation in high-risk areas.
   - Explore causes for the geographical shift to adapt climate policies accordingly.

3.1 Novelty and Insights

Key Findings:

- Visualizations highlighted the relationship between rising global temperatures, carbon emissions, and increasing natural disasters.
- Geospatial heat maps revealed significant warming trends in regions like South America and Europe, showcasing uneven temperature changes globally.
- Temporal trends identified correlations between temperature anomalies and disaster frequency, providing new perspectives on climate patterns.
- A notable shift in extreme precipitation events from the west coast to the eastern USA was observed over the decades.

Interactive Features:

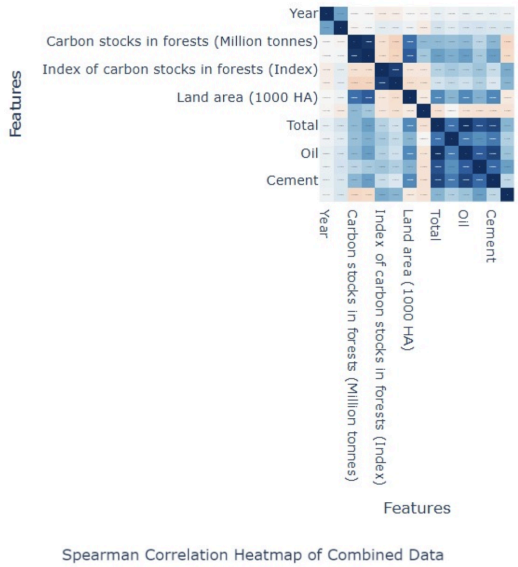
- The Sankey diagram illustrated emissions sources and their proportional contributions, allowing users to explore dominant contributors like oil and coal.
- Animated scatter plots dynamically showcased the relationship between temperature change and forest area, emphasizing temporal and regional variations.

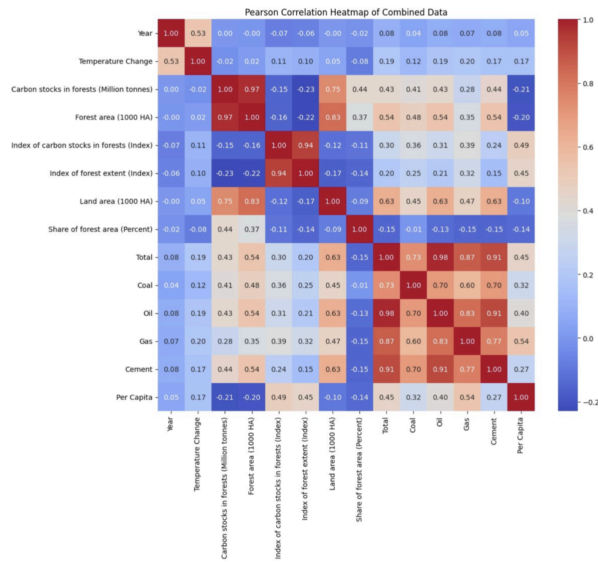
Actionable Insights:

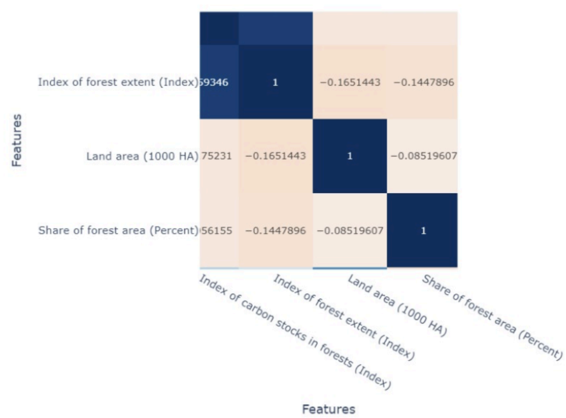
- The visualizations emphasize the urgency of reducing carbon emissions and addressing deforestation as key mitigation strategies.
- Patterns from UV exposure and melanoma trends call for increased public awareness and health policy interventions.

3.2 Craftsmanship and Details

A.







Initial Design:
Static Pearson correlation heatmap with numerical values and basic color gradients.

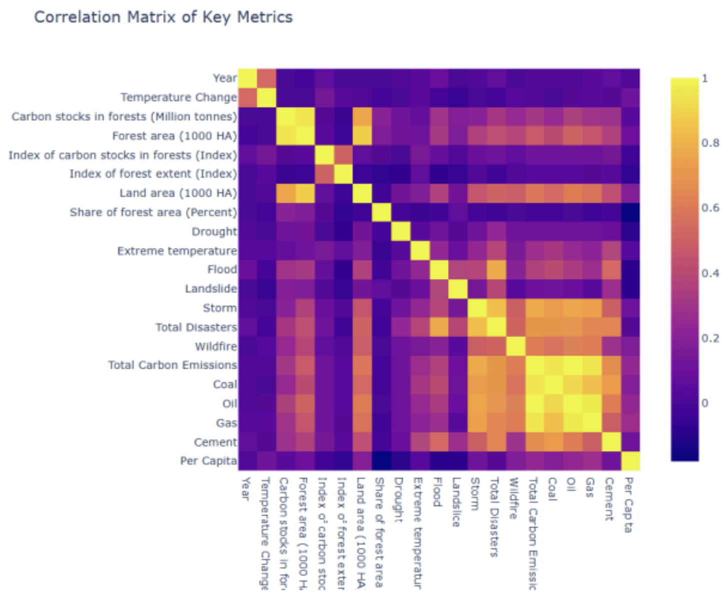
Refinements:

1. Made the heatmap interactive, showing values on hover.
2. Switched to Spearman correlation for better monotonic relationship analysis.
3. Enhanced visuals with improved color schemes and dynamic labels for clarity.
4. Removed cluttered numerical values from tiles, making the design cleaner.

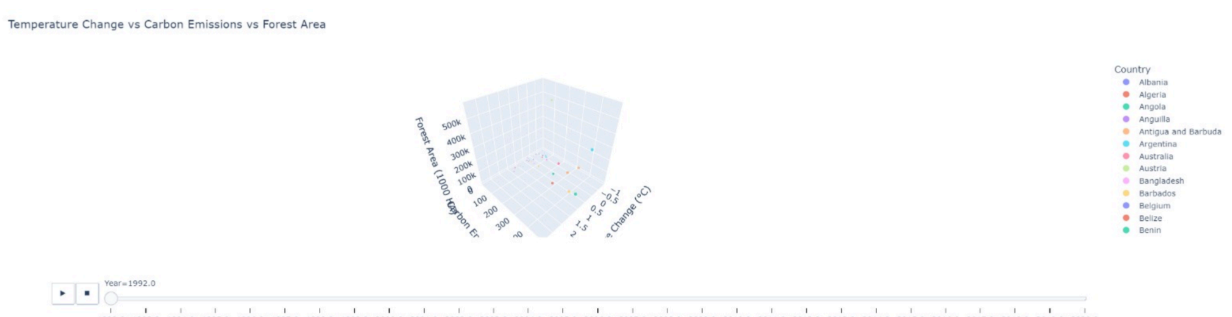
Key Insights:

- Strong links between temperature change, carbon emissions, and disasters.
- Inverse correlation between forest area and emissions highlighted.
- Interactivity improved usability and data exploration.

Final Design:



B.



Initial Design:

A basic static 3D scatter plot representing the relationship between temperature change, carbon emissions, and forest area. The design included minimal interactivity and lacked clarity in representing temporal dynamics.

Refinements:

1. Incorporated an animated timeline to visualize changes over years dynamically.

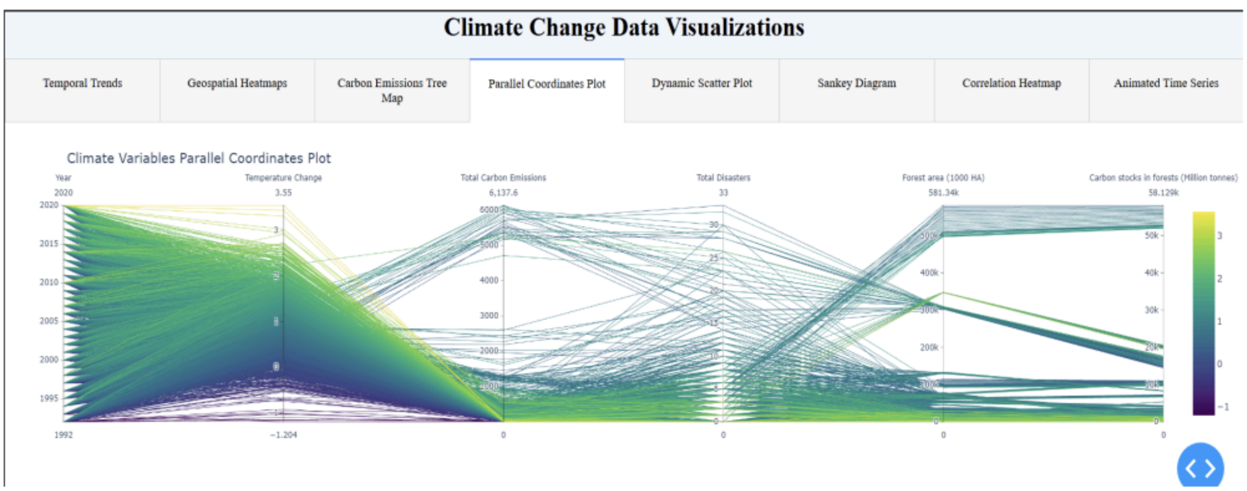
2. Improved interactivity, enabling filtering by country or region for detailed exploration.
3. Enhanced axis labeling and added a legend for better interpretation of variables.
4. Optimized the visualization with clear color coding to distinguish between countries.

Key Insights:

- Countries with larger forest areas experience varying impacts of temperature change over time.
- A general trend shows that declining forest areas correlate with increasing temperature changes and carbon emissions.
- Temporal analysis highlights critical years where shifts in climate variables are evident.

Final Design:

An interactive and dynamic 3D scatter plot with an animated timeline, offering a comprehensive visualization of the interplay between temperature change, carbon emissions, and forest area over time.



C.

Initial Design:

A static treemap representing carbon emissions by country and year. While visually hierarchical, the initial design had limited interactivity, making it challenging to explore specific data points effectively.

Refinements:

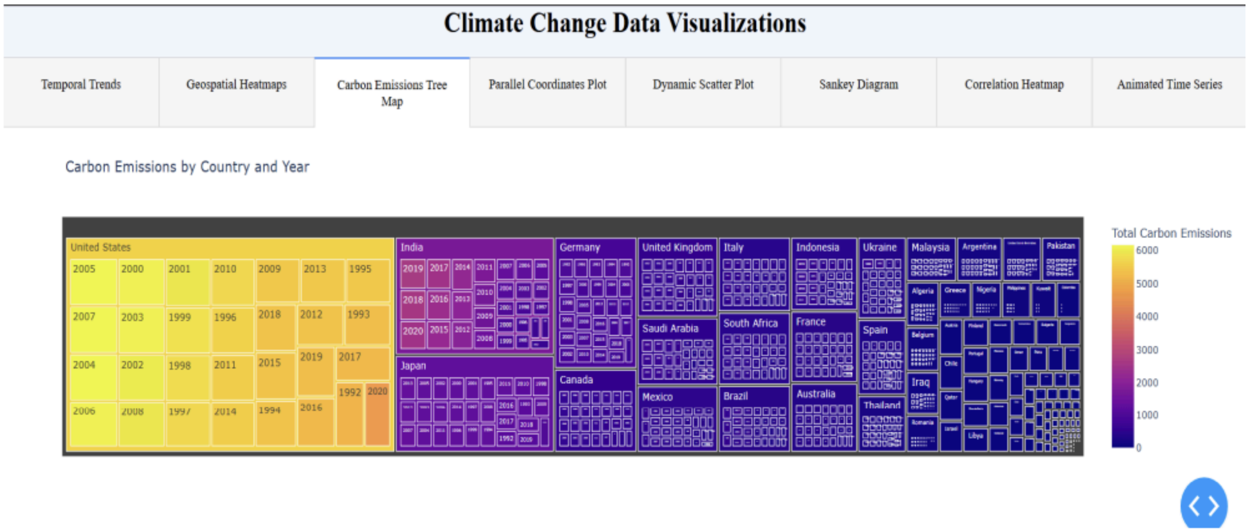
1. Enhanced interactivity to allow users to drill down into specific years or countries.
2. Improved color gradient to better represent the intensity of emissions, with a clear and intuitive scale.
3. Added hover-over tooltips displaying detailed emission data for precise insights.
4. Optimized layout to ensure smaller countries and years are more visible and not overshadowed by dominant emitters.

Key Insights:

- Countries like India, China, and the USA exhibit consistently high emissions, as indicated by larger and more prominently colored blocks.
- The treemap highlights significant year-on-year emission growth in specific countries, emphasizing disparities.
- Smaller countries with minimal emissions are visible but less prominent, illustrating the global emission hierarchy.

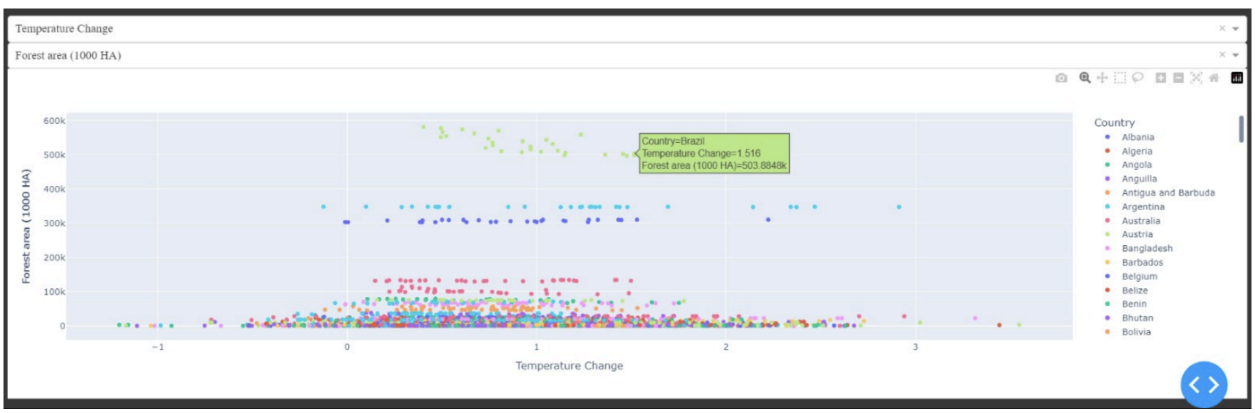
Final Design:

An interactive treemap with refined visuals, intuitive color coding, and dynamic features for detailed exploration of carbon emissions by country and year, offering a comprehensive understanding of global emission patterns.



D.

Initial Design:



A basic static 3D scatter plot representing the relationship between temperature change, carbon emissions, and forest area. The design included minimal interactivity and lacked clarity in representing temporal dynamics.

Refinements:

1. Incorporated an animated timeline to dynamically visualize changes over years.
2. Improved interactivity by enabling filtering by country or region for detailed exploration.
3. Enhanced axis labeling and added a legend for better interpretation of variables.
4. Optimized the visualization with clear color coding to distinguish between countries.

Key Insights:

- Countries with larger forest areas experience varying impacts of temperature change over time.
- A general trend shows that declining forest areas correlate with increasing temperature changes and carbon emissions.
- Temporal analysis highlights critical years where shifts in climate variables are evident.

Final Design:

An interactive and dynamic 3D scatter plot with an animated timeline, offering a comprehensive visualization of the interplay between temperature change, carbon emissions, and forest area over time.

E.

Initial Design:

A triangular plot showcasing the composition of energy sources (Oil, Coal, Gas) contributing to carbon emissions. While visually unique, it struggled to effectively communicate information:

- The dots were too small, making it hard to interpret values.
- Converting data to a scale of 0-1 made it less relatable and understandable for a layman audience.

Challenges:

- Limited clarity in representing the actual contribution of each energy source.
- Aesthetic appeal overshadowed the functional aspect of delivering insights.

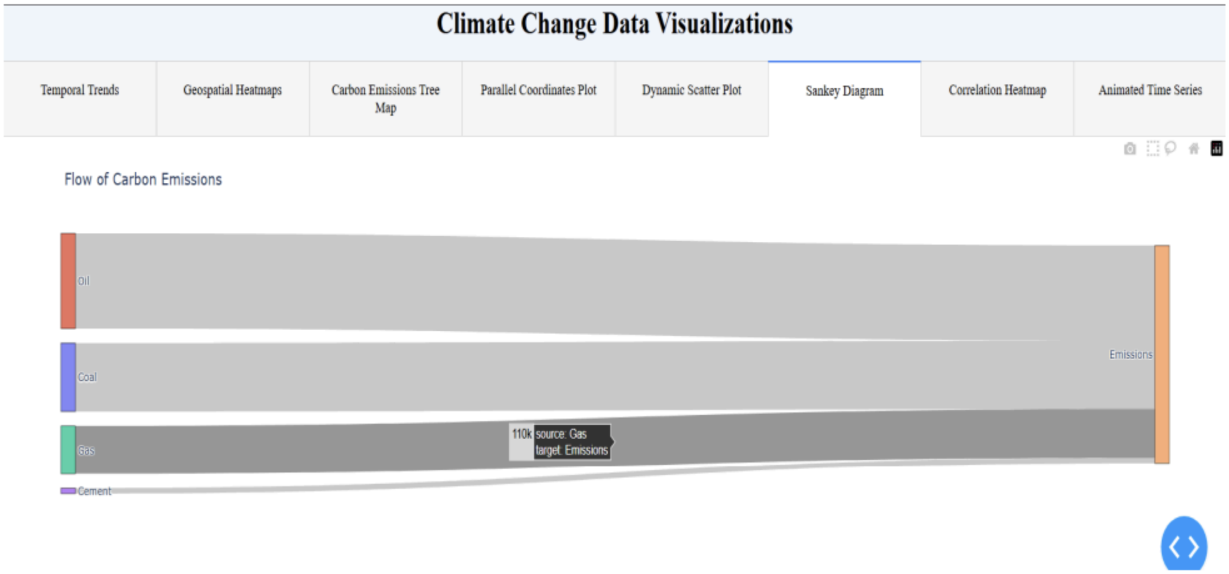
Refinements and Final Design:

The concept was refined by transitioning to a **Sankey Diagram**:

1. **Clear Flow Representation**: The Sankey diagram effectively shows the flow and relative contributions of energy sources to total carbon emissions.
2. **Improved Interpretability**: By using proportional flows and clear labeling, the Sankey diagram provides an intuitive understanding of how different sources contribute to emissions.
3. **Actionable Insights**: The diagram highlights dominant contributors like oil and coal, helping audiences focus on areas for emission reduction.

Key Insights from Final Design:

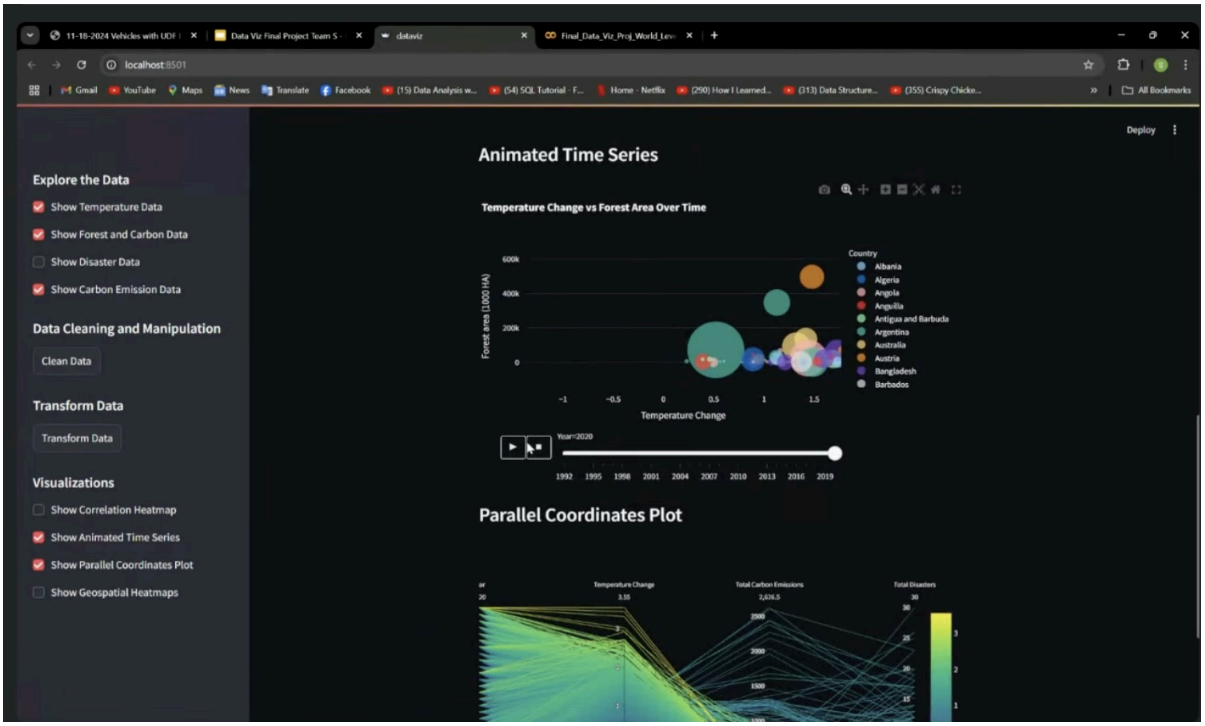
- Oil is the dominant contributor to carbon emissions, followed by coal and gas.
- The visual hierarchy emphasizes the scale of impact for each source, enabling targeted discussions on mitigating emissions.

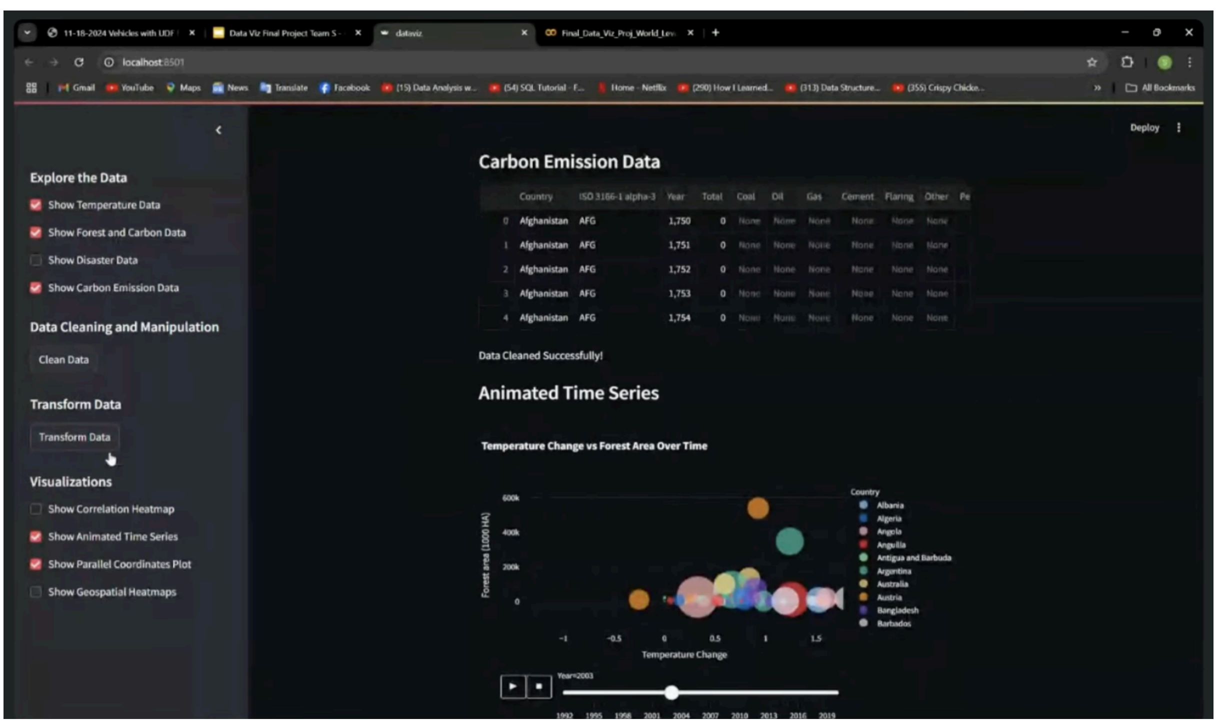


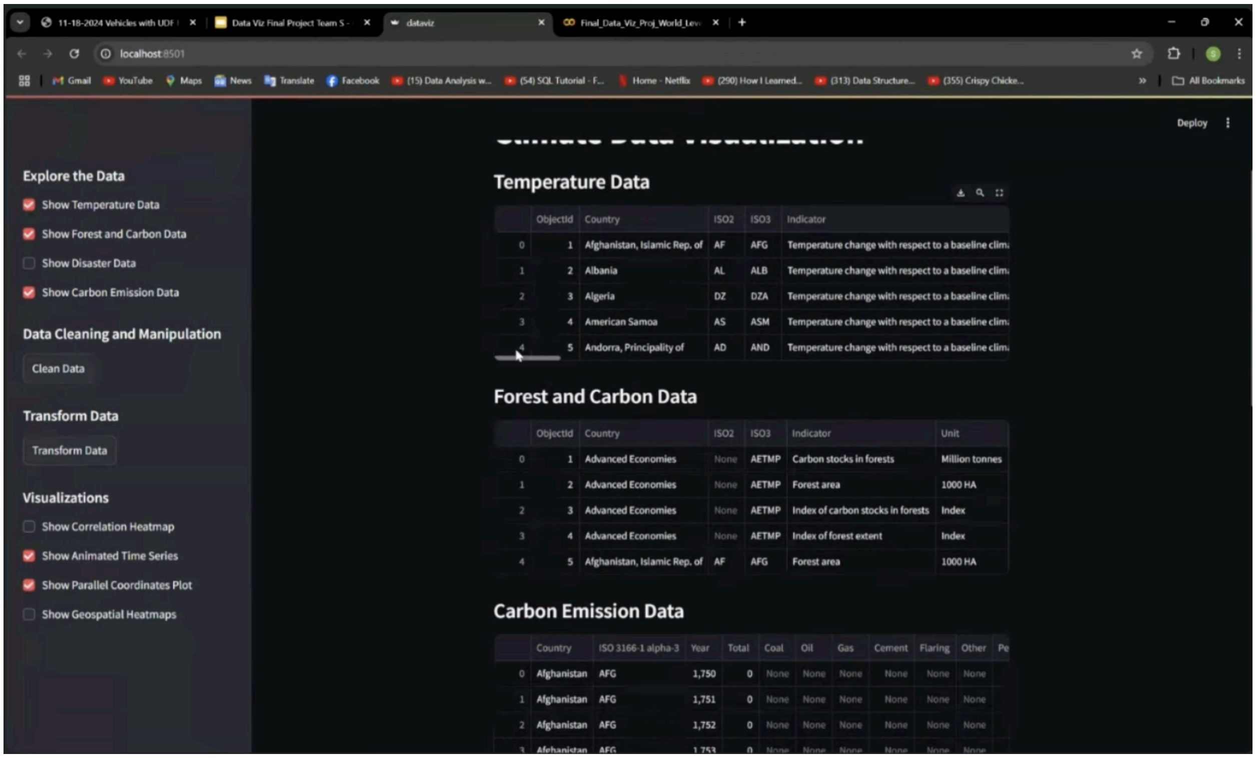
- **Visual Quality:**
  - Exceptional care was taken in crafting clear, polished, and engaging visualizations tailored for user interaction and exploration.
  - Effective use of color gradients, legends, and interactive elements ensure ease of interpretation and audience engagement.
- **Design Improvements:**
  - Overlapping issues in scatter plots were minimized using interactivity and zooming tools.
  - Detailed labeling and tooltips improved the clarity of dual-axis charts and dense datasets.
- **Refinement and Testing:**
  - Prototypes such as static scatter plots and heatmaps were tested and replaced with more effective dynamic alternatives, ensuring a cohesive design approach.

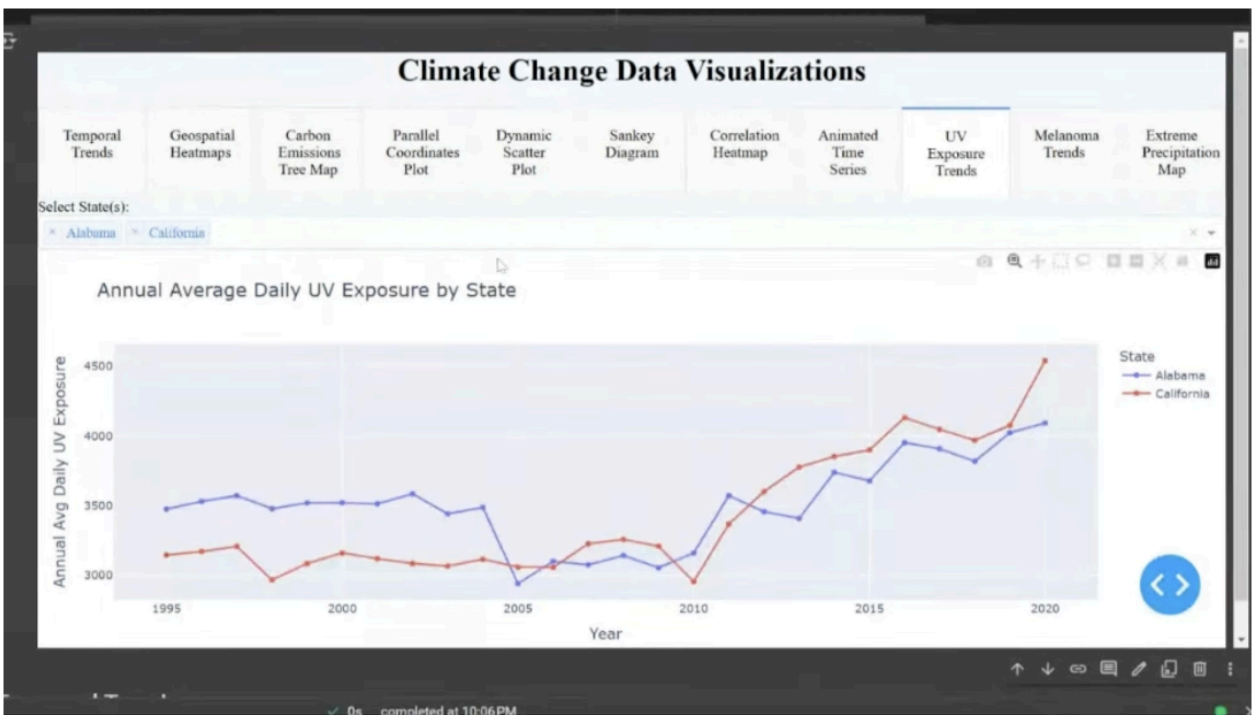
3.3 Discussion and Conclusion

Insights and Effectiveness:









- The dashboard effectively communicates the causes, trends, and effects of climate change, bridging scientific data with public understanding.
- Multivariate visualizations like parallel coordinate plots successfully illustrated complex relationships, such as the inverse correlation between forest area and carbon emissions.

Limitations:

- The complexity of some visualizations, such as correlation heatmaps, required additional context for general audiences.
- Smaller countries and data points in tree maps were less prominent, potentially obscuring critical details.

Future Work:

- Incorporate more granular datasets for regions with limited data representation.
- Enhance interactivity with predictive modeling tools to simulate future climate scenarios.

Conclusion:

This project successfully developed an engaging and informative dashboard that balances scientific rigor with accessibility. By integrating diverse datasets and implementing advanced visualizations, the dashboard empowers users to understand the urgent impacts of climate change while promoting actionable engagement. The visualizations are designed to convey complex relationships between variables like temperature change, carbon emissions, and forest area in a manner that resonates with a wide audience.

Furthermore, to enhance user accessibility, we have hosted the same visualizations on Streamlit. This allows for interactive exploration, ensuring that the information is not only insightful but also readily available for users to engage with on various devices. By making the dashboard both dynamic and accessible, the project aims to bridge the gap between data complexity and public understanding, fostering awareness and inspiring informed decision-making.