Name: Jegadit Sakthi Saravanan

Client name: Prof. Akintomide Afolayan Akinsanola, PhD (Assistant Professor, Department of Earth and Environmental Sciences, University of Illinois Chicago)

Project title: Interactive Visualization of Global Heatwaves and Drought Patterns

Brief project description:
Extreme climate events, such as heatwaves and droughts, have significant impacts on ecosystems, agriculture, and human health. Prof. Akinsanola has provided historical heatwave data, as well as global drought data spanning 1900s to the 21st century, from the CRU TS v4.09 dataset. This project aims to create an interactive visualization platform that enables exploration of data for both scenarios. Users will view a heatwave map over a particular region or globally, where clicking on a country dynamically generates a spiral visualization showing temperature trends in that region across decades. Additionally, a global drought map will display anomaly intensity and standard deviation, allowing users to explore patterns of drought severity worldwide. The interface will combine country-level choropleth maps with linked temporal visualizations to enable intuitive, multi-dimensional exploration of climate extremes. This platform will help researchers, educators, and policy analysts better understand spatial and temporal climate patterns, uncover anomalies, and generate hypotheses for climate-related research.

Project significance:
Understanding climate extremes is critical for climate science, disaster preparedness, and policy planning. Current tools for exploring historical heatwave and drought data are limited, often requiring extensive preprocessing, statistical expertise, and non-interactive plotting. By leveraging advanced interactive visualizations, this project provides domain experts with intuitive, exploratory tools to investigate complex spatiotemporal patterns. Linked visualizations such as country-level heatwave maps and spiral temperature plots allow users to detect trends, anomalies, and region-specific behaviors that are difficult to observe using standard plotting tools. The global drought visualization highlights intensity and variation, providing context for regional heatwave events. This project demonstrates a practical application of visual data science techniques to large, multidimensional climate datasets, bridging the gap between raw data and actionable insights while offering a reusable framework for future climate studies.

From a Visual Data Science perspective, the project aligns with three major contribution areas:

Applications: This project primarily contributes to the Applications area by addressing a real-world domain problem, analyzing and visualizing global heatwave and drought patterns. It tailors visualization techniques to support climate scientists and policy analysts in exploring environmental data, highlighting trends, anomalies, and correlations that inform research and decision-making.

Representations & Interaction: The project also contributes to Representations & Interaction through the design of interactive visual components. These linked visualizations enable intuitive exploration of spatiotemporal data, allowing users to switch between spatial and temporal perspectives seamlessly.

Data Transformations: A contribution lies in the Data Transformations area. Large, multidimensional datasets from the CRU TS v4.09 archive are aggregated, cleaned, and transformed into country-level and temporal formats suitable for visualization. This data wrangling process ensures efficient mapping and responsive interactivity during exploration.

Requirements Analysis

I. Humans

The primary user is Prof. Akintomide Afolayan Akinsanola, a climate scientist specializing in heatwaves and droughts. Other users are expected to include members of his lab and environmental researchers, policy analysts, and other graduate students exploring climate patterns. Users will interact with the system to explore global climate trends. The system must support domain experts with minimal training, enabling intuitive exploration of large spatiotemporal datasets.

II. Tasks

1. Visualize heatwave severity at a country-level granularity.
2. Allow users to click on a country to display a chart of temperature trends over decades.
3. Show global drought intensity and standard deviation using color-coded maps.
4. Enable filtering by year or decade to focus on specific time periods.
5. Identify regions or countries with the most extreme heatwave events.
6. Detect trends in temperature anomalies over time within selected countries.
7. Highlight correlations between drought intensity and regional heatwave severity.
8. Enable comparison of temperature trends across multiple countries simultaneously.
9. Display tooltip metadata for selected countries (e.g., average temp, max deviation).
10. Support exporting visualizations for reports or presentations.

III. Data

Heatwaves and Global drought data:

- Processed data provided by Prof. Akinsanola, spanning 1950-present, stored as CRU TS v4.09 Data Variables (e.g., temperature, precipitation).

- CRU TS v4.09 datasets include multiple variables (e.g., cld, dtr, frs, pet, pre, tmn, tmp, tmx, vap, wet). These will be visualized in terms of anomaly intensity and standard deviation.
- Both datasets will be processed into country-level aggregates for map visualizations; temporal data will be structured for spiral visualizations.

IV. Flow

1. Load global data into the visualization interface.
2. Display heatwave map; color-coded by severity.
3. Click a country to generate a linked spiral temperature chart for that country.
4. Display global drought map with intensity and standard deviation metrics.
5. Users filter or select time ranges; visualizations update interactively.

V. Nonfunctional requirements

- Interactive rendering for hundreds of countries/data points with no perceptible lag.
- Intuitive interface usable by climate scientists with minimal training.
- Responsive web design supporting D3.js visualizations.
- Tooltips and interactivity to highlight specific regions or anomalies.

VI. Probes

- **What are existing tools' disadvantages?**
  Most current tools are static or require heavy data preprocessing. They rarely integrate both spatial and temporal perspectives, making it hard to connect long-term temperature trends with regional drought anomalies or extreme events.

- **How does this go beyond off-the-shelf BI tools like Tableau or Power BI?**
  This project builds domain-specific, linked visualizations, combining heatwave maps with temperature plots and global drought metrics. It is tailored for environmental research, enabling anomaly detection, cross-country comparisons, and correlation analysis beyond what generic BI dashboards can support.

Work Plan

Week 1: Completed Requirements Analysis
- Consolidate datasets and confirm preprocessing requirements.
- Define interactive elements (map click, spiral chart, filtering).

Week 2: Build aggregation scripts and data pre-processing.

Week 3: Prototype

- Basic heatwave map with interactive country selection.
- Spiral chart visualization for a selected country.

Week 4: Alpha version

- Link map and spiral chart interactivity.
- Implement global drought map with intensity and standard deviation metrics.
- Enable year/decade filtering.

Week 5: Beta version

- Enhanced tooltips and interactivity.
- Side-by-side country comparisons.
- Minor UI/UX polishing and bug fixes.

Week 6: Final Deliverable

- Full system integration.
- Documentation and presentation preparation.
- Final testing and deployment-ready visualization.

Bios/CVs

Jegadit Sakthi Saravanan

- CS Graduate Student at UIC
- Skills: D3.js, JavaScript, Python, data visualization, climate data processing

Prof. Akintomide Afolayan Akinsanola (Client / Domain Expert)

- PhD, Earth & Environmental Sciences, UIC
- Expertise: Climate extremes, heatwaves, droughts, environmental data analysis