Global Temperature Changes

Final Project Proposal
DS 4630/CS 5630
Dr. Paul Rosen

Github Repository

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Background and Motivation:

Climate change is one of the largest challenges facing the human race in the 21st century[1]. Rising global temperatures, food scarcity, and impacts on infrastructure are changing the world we live in. Though the issue affects all of us, there is still much debate around the subject, preventing actionable steps from being taken to address it. For the last half century[2], the conversation around climate change and global surface temperatures has been growing, but with that growth, public skepticism has grown as well. The public's skepticism can be tied to a misunderstanding of how the data is collected and analyzed, misinformation being pushed for political gain, and/or a general ignorance of the details surrounding the climate change issue[3].

By creating data-based, easy-to-understand visualizations of surface temperatures from across the country and the globe, we hope to make the data clearer and more accessible. The U.S. is both a leading emitter of greenhouse gases and highly vulnerable to climate-related risks, including heatwaves, hurricanes, and droughts. Looking at U.S. climate trends gives a closer view of how global warming shows up at a national scale. By analyzing the raw temperature data, we can see whether long-term changes match what mainstream claims about climate change suggest, while also highlighting the impacts that communities in the U.S. are already facing[4].

Project Objectives:

Our first objective is to track how average temperatures in the United States have changed from the 19th century through today. Looking this far back lets us contextualize recent warming in the broader scope of history, rather than just the last few decades. By extending the timeline to the early 1800s, we capture key historical periods: the Industrial Revolution, the Second Industrial Revolution, and even the tail end of the Little Ice Age, when cooler conditions still shaped much of the Northern Hemisphere[5]. This longer view makes it possible to see whether the shifts of the past century stand apart from natural variations or fit into a broader global trend. Using the Berkeley Earth dataset, which brings together millions of historical temperature records, we can trace those changes with enough resolution to show how today's climate compares with that of the earlier baseline.

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[1] Intergovernmental Panel on Climate Change, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report (Cambridge: Cambridge University Press, 2021), https://www.ipcc.ch/report/ar6/wg1/

[2] Kieran Mulvaney, "4 Key Moments That Forced Americans to Confront Climate Change," HISTORY, A&E Television Networks, April 19, 2022, updated May 28, 2025, https://www.history.com/articles/climate-change-global-warming-events

[3] John Cook et al., "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming," Environmental Research Letters 11, no. 4 (2016): 048002, IOP Publishing, https://repository.library.noaa.gov/view/noaa/62111

[4] U.S. Global Change Research Program, Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II (Washington, DC: U.S. Government Publishing Office, 2018), https://repository.library.noaa.gov/view/noaa/19487

[5] Emmanuel Le Roy Ladurie, Times of Feast, Times of Famine: A History of Climate Since the Year 1000, trans. Barbara Bray (Garden City, NY: Doubleday, 1971).

The second objective is to take what we find and make it understandable to people outside of climate science. A lot of climate graphs are either overly technical or stripped down to the point of being unclear. We want to avoid both of those extremes. Our plan is to build straightforward visuals such as line charts, heat maps, and trend plots that show the main story without overwhelming the viewer. The idea is that someone looking at our charts should walk away with a clearer picture of how U.S. temperatures have shifted without needing to dig through a scientific paper to get there.

Data:

The main data source will be a data set pulled from Kaggle. This data set was put together by Berkeley Earth and it combines 1.6 billion recorded temperatures across 16 different archives. This project will utilize the files which provide global average land temperatures by city and state.

https://www.kaggle.com/datasets/berkeleyearth/climate-change-earth-surface-temperature-data

Exploratory Data Analysis:

After a preliminary analysis in a Google Colab and Python libraries pandas and numpy, we found that there would not need to be substantial data clean up on the Berkeley Earth data set. We will extract data for the United States from the early 19th century to the 21st century and utilize the columns for date, longitude, latitude, and average temperature. After filtering the city and state datasets for only US cities and states and limiting the date range for everything after January 1, 1800, we found the only NaN data points were in the columns for average temperature and average temperature uncertainty. It was also found that not all states or cities had the same number of entries, meaning we are also missing dates for some of the locations. The entries for each month and the missing values for average temperature became more consistent after the late 1800s, so we may have to adjust the date range that we want to explore or find additional data sets to fill in some of the missing values.

In addition to handling the missing temperature values, we will have to transform the recorded temperature to Fahrenheit to make it easier for a US audience to understand the temperature changes. The date ranges account for the average temperature for the first day of the month, so we may have to extract yearly averages from the dates already in the data set to add in any missing months for the date range we chose. The set also has the expected number of states represented, including the District of Columbia. There are 248 unique cities, which will be enough to use as points of interest in the visualizations, but not enough for a density heat map.

Visual Design:

The visualization design will contain three different components:

- A nationwide map view
- A state map view
- Static visualizations for overall trends and comparisons.

State Map View: The state map view was explored in three stages: a design idea stage, three proposed designs, and a final design. During the idea stage, different visualizations were suggested as well as the pros and cons of each idea. Weaker ideas and ones not compatible with the data set were then filtered out and the remaining ideas were combined. The three initial designs were for a single state overview with a heat map, a state by state comparison design that also used heat maps for comparison, and a single state overview that combined a heat map with points of interest for cities throughout the state. The final design combined elements from the second and third proposed designs.

Must-Have Features

- **Interactive U.S. Map (Choropleth)**
  A dynamic U.S. map where each state is shaded based on its average temperature for a given year. This map will be the central element of the project.

- **Year Slider**
  A timeline slider that allows users to move through years and see how the color encoding on the map changes to reflect climate change over time.

- **State-Level Drill-Down**
  Clicking on a state zooms into that state view, showing more granular trends across time. This ensures both macro (U.S.) and micro (state) perspectives.

- **Bottom Graphs Panel**
  A set of linked graphs (line charts of temperature change) at the bottom of the visualization that update when a state is selected. Users can click these graphs to expand them for a detailed view.

- **Cleaned, Integrated Dataset**
  The Kaggle climate dataset processed into a usable format (e.g., state-year averages). Without clean and accurate data powering the visualization, the project would not achieve its goal.

Optional Features

- **Tooltips and Popups**
  Hovering over a state reveals a small popup with summary stats: average temperature in a given year, long-term increase, and key anomalies.

- **Playback Animation**
  A “play” button that automatically moves the slider across years to animate climate change progression.

- **Comparison Mode**
  Users can select two states to view their graphs side by side, enabling direct comparison.

- **Multiple Climate Variables**
  If available in the dataset, add precipitation, anomaly indexes, or seasonal variations to expand insights beyond just surface temperature.

- **Accessibility Options**
  Colorblind-friendly palettes or the ability to switch color themes to ensure inclusivity.

- **Mobile-Friendly Layout**
  Responsive design so the map and graphs adapt to smaller screens.

- **Narrative Highlights**
  Preloaded “story points” (e.g., 1930s Dust Bowl, 1998 El Niño, 2016 hottest year) that users can jump to for context.

Project Schedule (9 Weeks)

Week 1: Team Formation & Planning

- Finalize team roles, communication channels, and GitHub repository.
- Define scope, clarify must-have vs. optional features.

Week 2: Data Acquisition & Exploration

- Download Kaggle dataset.
- Perform initial cleanup (missing values, normalize units).
- Explore structure (state-level aggregation, yearly averages).

Week 3: Data Processing Pipeline

- Implement scripts for preprocessing and deriving state/year averages.
- Produce first visual summaries (basic charts) to validate dataset.

Week 4: Prototype Visualizations

- Create static prototype of U.S. choropleth map.
- Experiment with color scales (sequential/diverging).
- Sketch three alternative design concepts.

Week 5: Year Slider & Interactivity

- Implement year slider controlling the map.
- Link slider movement to map color updates.
- Start implementing drill-down into individual states.

Week 6: Graphs Panel & State-Level Views

- Build bottom panel of graphs showing state-level climate trends.
- Connect graphs dynamically to state selection.
- Add zoom and expand functionality for graphs.

Week 7: Feature Expansion & Polish

- Add optional features (tooltips, playback animation).
- Refine visuals: legends, labels, titles, color schemes.
- Begin integrating accessibility adjustments.

Week 8: Testing & Evaluation

- Conduct peer user testing to assess usability and clarity.
- Refine based on feedback (e.g., interaction flow, readability).
- Start drafting process book sections (design evolution, evaluation).

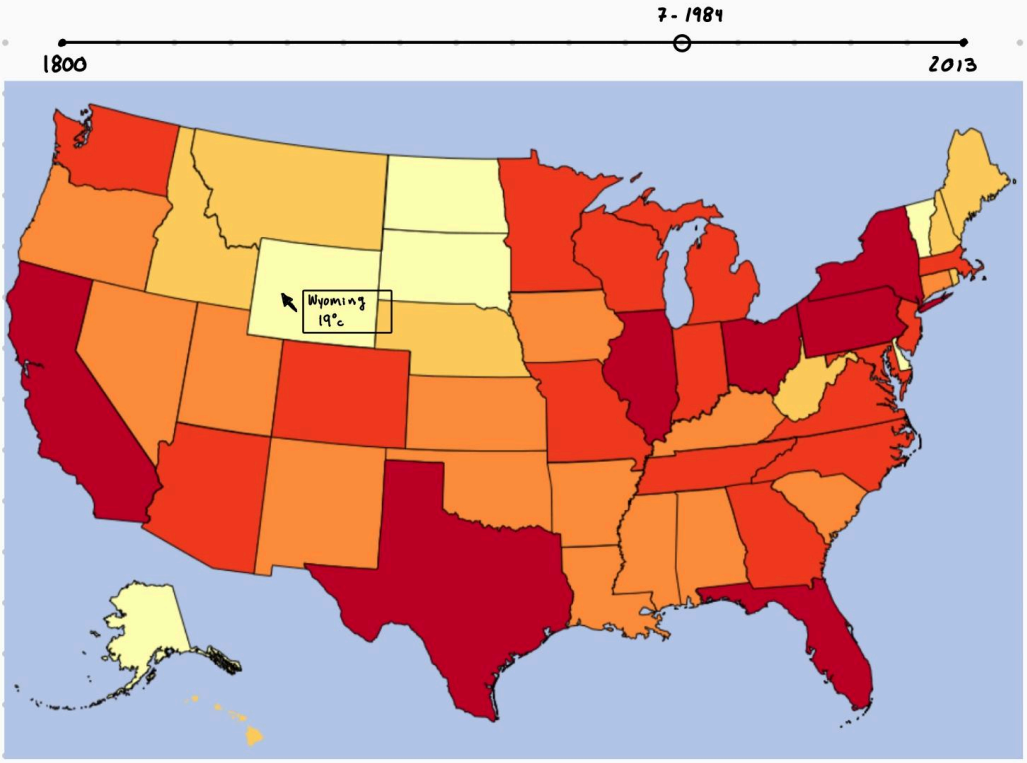
Week 9: Final Deliverables

- Finalize process book (with figures, sketches, evolution).

- Prepare project website with embedded visualization and data links.
- Record and edit 2-minute screencast with narration.
- Submit final project materials and peer evaluations.

Project Title

Project Details ▾ Data Sources ▾ FAQ ▾



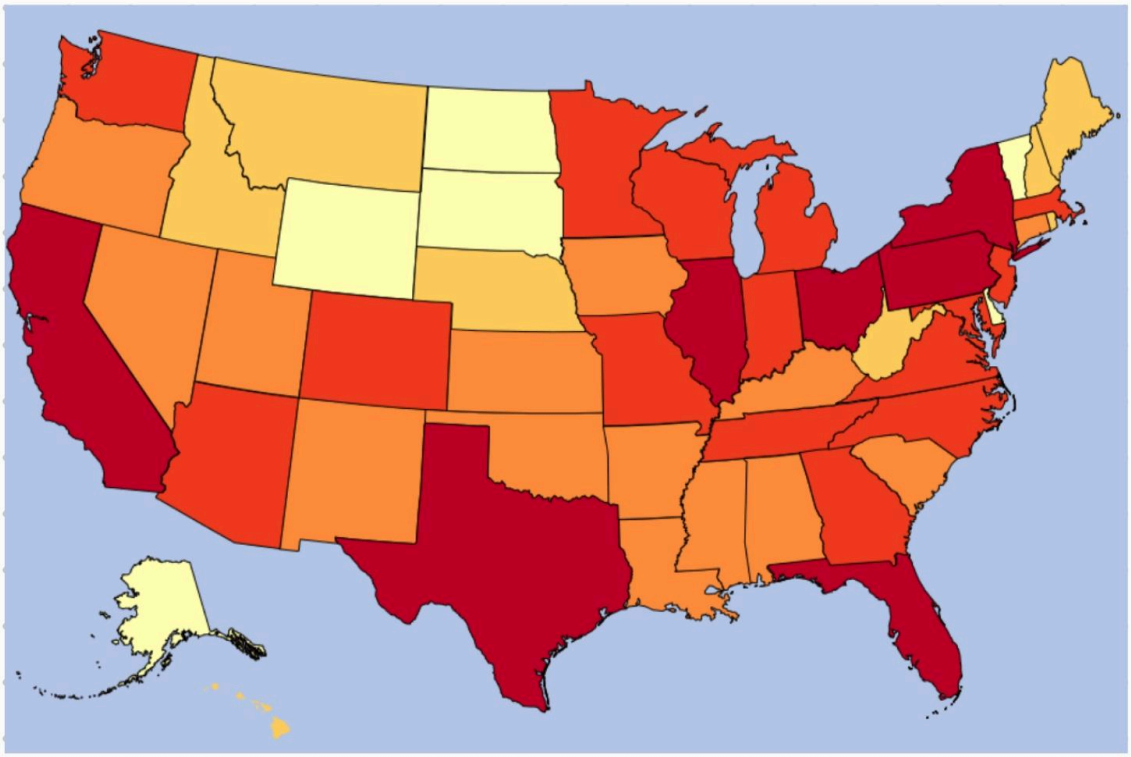
Key features:

- Heat map showing Avg. Temp for that month
- Interactive State Tiles, linking to indv. State pages
- Menu for other Related info like Group members, Sources, and any other info, leaving a clean UI
- State info On Hover

[6] Someka Ltd., United States Heat Map Excel Template (USA Geographic Heat Map Generator), Excel template, accessed 09/13/2025, https://www.someka.net/products/united-states-heat-map-excel-template/

Project Title

Date:
07/04/1984



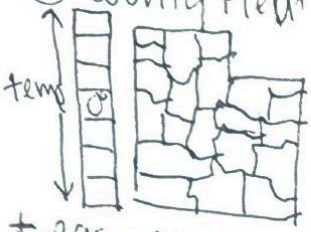
Team members:
- KA: email
- JC: email
- MT: email
- Class info

Data Source:
Kaggle Link.com

Key Features/Changes
- Date Block as opposed to a date slider
- Remove Menubar and list details Below visulization
- This option has better potential for a P.o.P. National map (where state displays change in average temp.

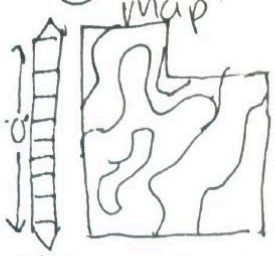
State Level Design Ideas

① County Heat Map



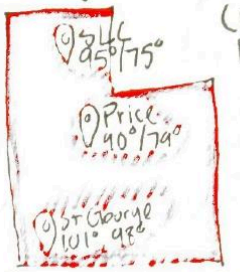
+ easy to sort long/lat data into county average
- might not have access to data for all counties as far back as the 1800's

② Density Heat Map



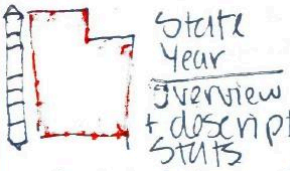
+ More accurate depiction of surface temps.
+ More visually appealing
- Requires a lot of long/lat data points

③ City Map



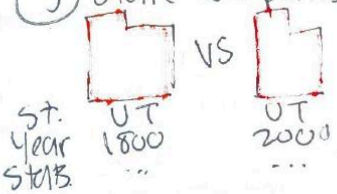
+ Shows areas of interest
+ Easy to compare temp. spread
- Excludes rural & unpopulated areas

④ Single State Overview



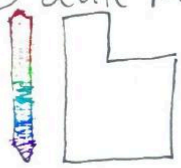
+ Quick view of state history
- Hard to see trends compared to other years or the same year

⑤ State Comparison



+ Easy to compare multiple states or years
- might be more complicated for users, takes more user input

⑥ Continuous Color Scale Map



+ Most accurate scale
- Harder for the human eye to spot differences

⑦ Seasonal Comparison

+ Overview of yearly seasonal changes
- User's can't specify month by month comparisons
- Seasonal fluctuations vary wildly by state

Filter

② Density Heat Map - Requires more data points than we can get for historical data

① County Map → Becomes less accurate for larger counties with large ∅

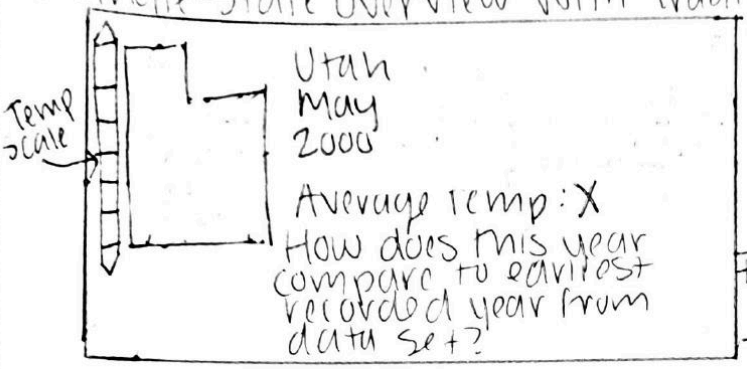
⑥ Continuous Color Scale → Harder for the human eye to distinguish this color scheme

⑦ Season Comparison → Comparing only seasonal trends in one year doesn't show the larger yearly/decade long changes associated with global warming.

Combine ④⑤③ : can mix/map different map types to either Single State Overview or State×State Comparison

State Level Design: 3 Prototypes

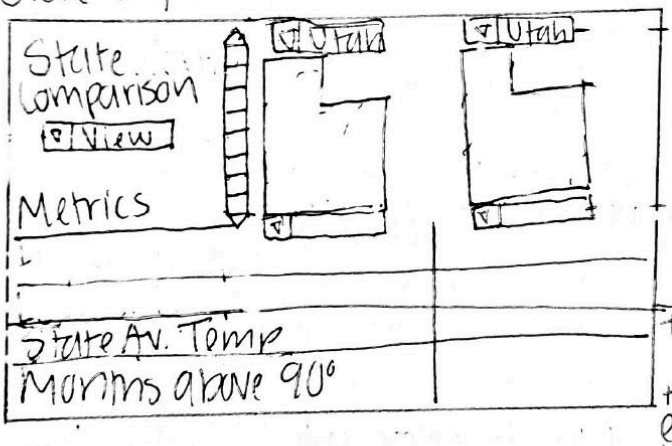
1. Single State Overview W/ m Traditional Heat Map



Operations
→ User selects state & year. can see the summary for the whole year or a specific month
→ Set comparisons with oldest recorded temps in the data set

+ Clean snapshot that is easy to use
- doesn't allow options for comparisons

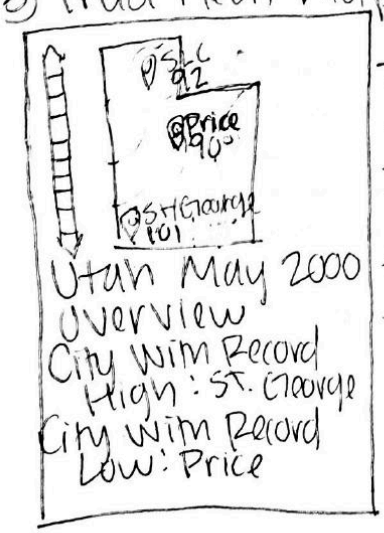
2. Side By Side State Comparison (Trad Heat Map)



Operations
→ Drop down menus to select view (yearly or monthly overview), states (can be same state or two diff ones), and year & / month.
→ Metrics for each selection shown side by side.

+ Gives users more freedom & control
+ Makes comparisons easy
- Heat map doesn't include specific points of interest

3) Trad Heat Map + City Map

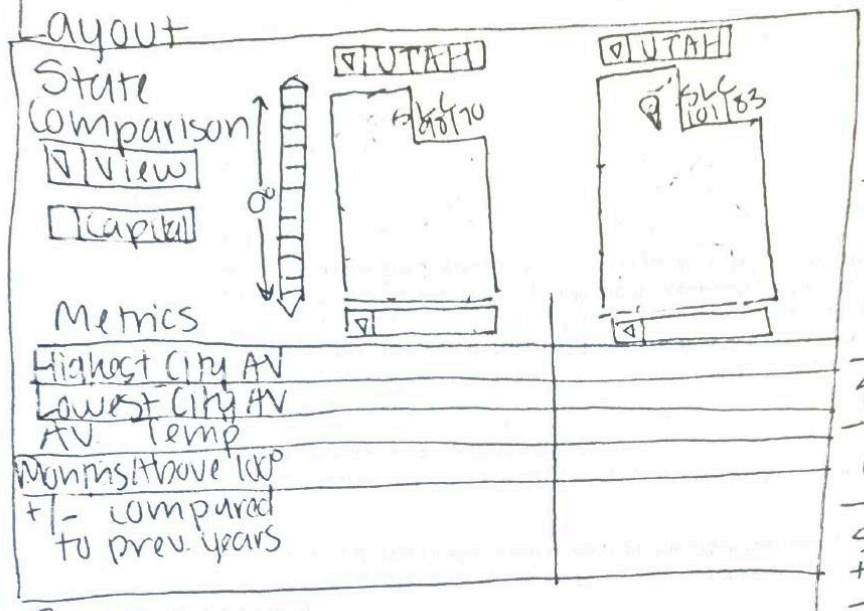


Operations
→ User can select state, year, and month
→ Metrics include city specific details

+ combines traditional heat map with points of interest
+ can see how certain cities change
- Adding a metric for high/low based on location gets complicated if the high/low was not in a city, but in an unpopulated area

Final State Level Design

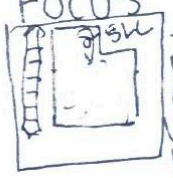
Layout



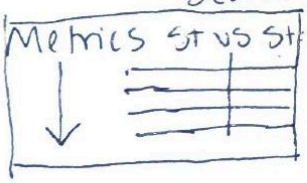
Operations

→ Drop down to select yearly vs. monthly view
→ Check box to select addition of state capitals temp month/year high & low
→ Drop down to select state
→ Drop down to add year &/month
→ Heat map scale 0° = white, +0° = red scale, -0° = blue scale
→ Side by side metric comparisons
→ State Heat Map -
→ Capital City temps

Focus



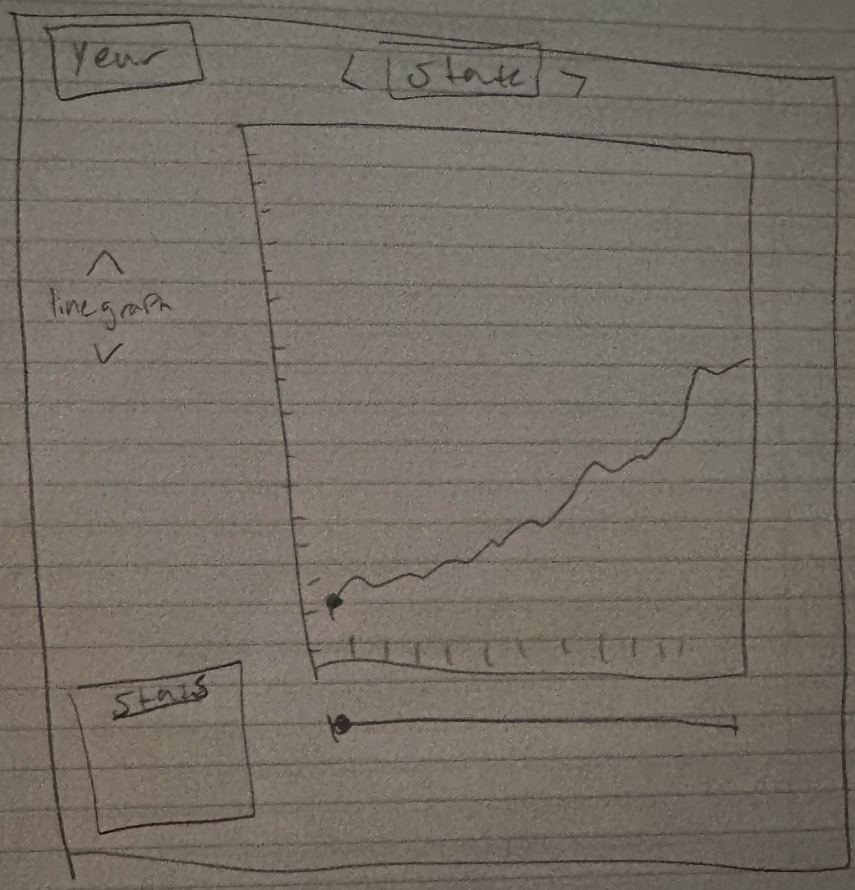
→ Heat Map + Capital City Paints a clear picture of how temp. fluctuates across state geography. Users can easily spot highs and lows using the hot/cold color scale.



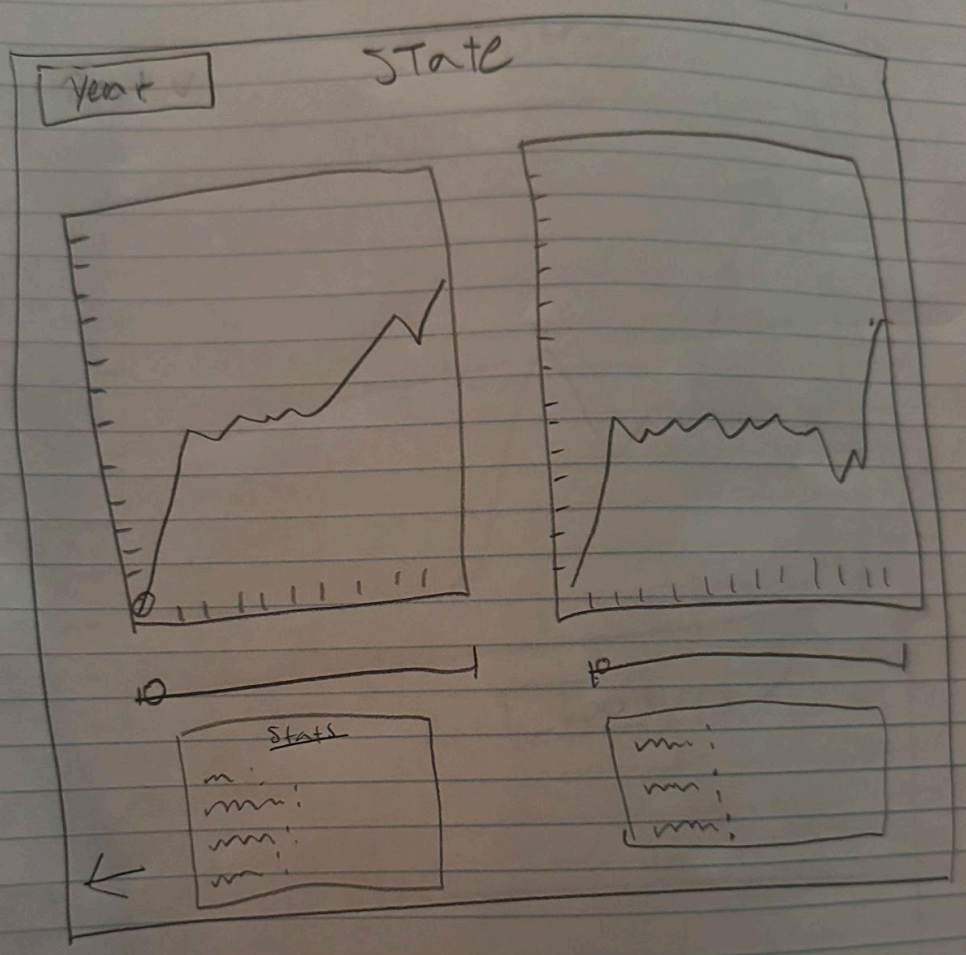
→ Metrics Side by side comparison of points of interest, descriptive statistics, and trends relating to global warming makes it easy for users to make side by side comparisons. Uses structure similar to product comparison tools

Detail

- In order to map latitude & longitude coordinates to a map, we may have to wait for the relevant course section after fall break.
- Will need to find lat/long. for 50 state capitols and extract those from state data
- Requires finding the average & the min/max temp for each state for either the whole year or specific months.
- This data extraction and analysis can be done in python with libraries (pandas, numpy, matplot)
- Data extraction & refinement might take a day. More time will be spent on the visualization.



- Slider view of time
- stats view
- state by state selection
- graph type changes



Features

- side by side view
- slider with traveling circle
- Stats box

- large view of graph
- year by year view of graph
- stats view in the corner