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Exercise 3 Report: Carbon Dioxide and Population Trends from 1990 to 2010

Motivation

The relationship between carbon dioxide (CO2) content in the environment and human population has been extensively studied for more than a century to this date, therefore, it is a popular topic across disciplines and large datasets are available to study. The visualization shown in this report presents CO2 measurements and population number data for all US states ranging from the years of 1990 to 2010, the data is divided by five different sectors including Electric Power, Industrial, Transportation, Residential, and Commercial. All the visual elements and interactions are designed to provide insight in explaining CO2 trends over time and comparing individual contributions across states and sectors.

Tasks

The aim for this visualization is to explore similar questions to the following: How has the population number and CO2 levels trended over time per US state? Which US states contribute the most to CO2 increase? What is the cumulative CO2 contribution for multiple states? How is the contribution distributed per sector?

Expressiveness of design

The visualization is expressed in dark mode with high contrast bright colors to convey the information. There are a total of four main graphs incorporated (*see Figure 1*), the design includes a world map with highlighted US states, a tree map for showing the cumulative distribution of Million Metric Tons CO2 (MMTCO2) per sector, and line charts for time series data (per state) pertaining to population and MMTCO2. All the encoded elements are placed in specific locations for easy data exploration and for making comparisons.

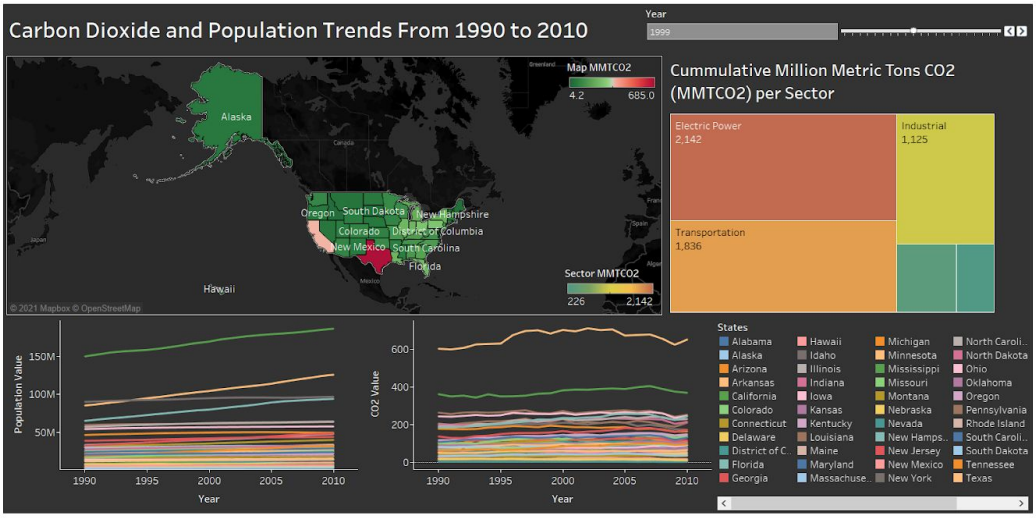

Figure 1. Visualization for CO2 and Population. All states are selected to illustrate a view for high density data.

Effectiveness of the solution

The different channels selected for the visualization work together to facilitate conclusions in the data. First, the colors chosen for expressing the CO2 levels in the US map are based on green for low values and red for high values; this is considering the idea that green is positively associated with environmentalism while red is normally identified as danger. A similar idea was used for the colors in the treemap for the different sectors but with a different color scale to separate both graphs; here low is closer to jungle green while high is closer to red-orange. Colors selected for the time series plots are randomly selected. All of these colors are designed with a dark mode theme to alleviate problems with visibility caused by strain in the eyes, it also provides better focus when exploring states in the map.

Multiple actions are defined to select and filter the data across graphs. When selecting one or multiple states from the US map there are actions to update the other three graphs and display their predefined information regarding the state selection. Both the tree map and time series plots support multi-selection, the first one displays data cumulatively while the later one displays multiple trend lines for each selection. With interactivity, an additional horizontal bar plot is generated when hovering over each state to display a breakdown from the total MMTCO2 value per sector (*see Figure 2*).

Lastly, the design for the visualization is organized in two rows for the graphs. The top row shows a snapshot of detailed information per year, where a single value slider at the top right can be used to toggle the filter. While the two time series plots at the bottom row allow the user to explore moving events. This design is very effective for connecting single year data and time series information and it really empowers the user to analyze state relationships with both CO2 levels and population values across multiple dimensions.

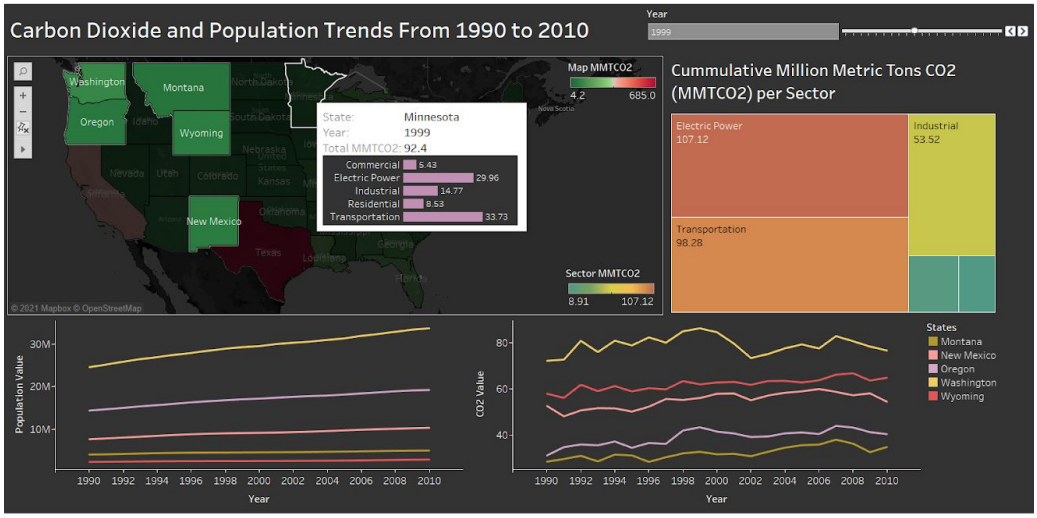

Figure 2. Example for selecting multiple states from the map and getting the breakdown for CO2 values per sector for a particular state.

Interaction

Interactive tools provide an additional layer of data exploration, comparison, and clarification. The visualization takes advantage of a number of associations including data highlights, selection, filtering, hover tool for metadata display, and data relationships between graphs. The US map provides spatial freedom to explore the map and allows the user to highlight and select any state of preference. When hovering over a state there is a window that displays metadata about the state, CO2 levels, and year; adding year to the list facilitates the user to know where the year filter value is applied. In addition, each state also shows an embedded plot to summarize a breakdown of CO2 by sector. Likewise, the treemap displays metadata for the sector name, year, number of states, and CO2 levels (*see Figure 3*). Adding the number of states clarifies how many states are accounted for in the cumulative value. And lastly, both time series plots show metadata for state, year, and either CO2 levels or population.

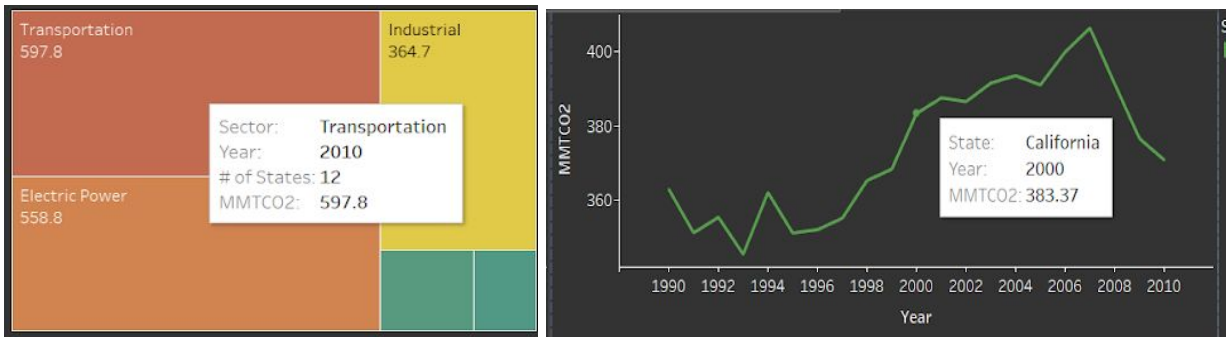

Figure 3. Metadata shown with a hover tool for cumulative CO2 per sector (left) and line chart for both population and CO2 values over time (right).

Conclusion

The visualization presented in this report allows to explore CO2 and population changes over time for the years of 1990 to 2010, the design provides an effective and accurate means for analyzing data for each of the 50 US states and the District of Columbia. For example, at first glance the data reveals that Texas is the state with the most MMTCO2 across all years, followed by California in second. What is interesting about this ranking is that California has always had a higher population, likely suggesting that most CO2 produced in Texas is not directly induced by humans but rather by human activity. In most years, the sectors for both states mentioned above with the highest MMTCO2 are Transportation, Industrial, and Electric Power; where Residential and Commercial tend to be at the lower end. The example above is a single interesting comparison as of how the data can be explored and be used to provide insight to users.