

Final Project Report: Data Visualizations of Carbon Dioxide Emissions by Economic Region
using JavaSwing and JFreeChart

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Abstract

For our final project, we analyzed trends in CO2 emissions from 1902-2018 in various regions of the world. The dataset we used was a large dataset with around 23,000 entries. In our data selection process, we decided to select our data by economic regions, namely: South America, 28 countries of the European Union (EU-28), European countries outside the EU-28, United States, China, Africa, Asia (excl. China & India), North America (excl. USA), Oceania, and India. Analyzing by economic region rather than singular countries allows us to make comparisons between over-developed and under-developed regions of the globe. Each entry in our dataset showed the billion tons of CO2 that the certain region emitted in a specific year. The dataset can be found here: ourworldindata.org/co2-emissions. In our final project, we created a time series data visualization dashboard displaying this CO2 emissions data in order to better visualize climate change in various regions of the world over time.

Program Structure

The program follows a Model-View-Controller (MVC) design pattern that divides it into three major interconnected parts in order to separate the internal representations of information from those shown to the user through the Graphic User Interface (GUI). While the various graphical representations of data are coded in the View with various forms of visualizations (a line chart, a bar chart, or a pie chart), the actual data and the structure that represents CO2 emissions using our imported .csv file is stored in an object in the Model where it is managed. The Controller manages the interaction between the data stored in the Model and the visual representation of the CO2 emission data through the View. We also created an abstract class View that outlines the visual representation components of each type of data plot. As such, our

program effectively exemplifies Java inheritance by allowing the child classes—`LineViewA`, `BarView`, `PieView`, and `LineViewB`—to be built upon the existing parent class, `View`, allowing the reuse of Java GUI without repetition. Our program contains the following classes:

- **Model** — Manages the program data which is contained in a hash map.
- **Controller** — Performs operations on the data model objects and mediates the interaction between the Model and the View.
- **View (Abstract)** — Represents the generic program view. It contains GUI components that are shared among the other View child classes.
- **LineViewA** — A line graph view of the data using a collection of time series to show the CO2 emissions per year in various regions over an adjustable period of time.
- **BarView** — A bar chart view of the data representing the growth rate of CO2 emissions compared between various regions over a time interval.
- **PieView** — A pie chart view of the data showing the numerical proportions of CO2 emissions compared between various regions during a single year.
- **LineViewB** — A line chart view of the data using a collection of time series to show the year-by-year change in CO2 emissions from one year to the next.

Functionality

The program implements various interactive components that allows the user to explore, change, and revisualize the CO2 emissions data both by regions and by years. Such elements include:

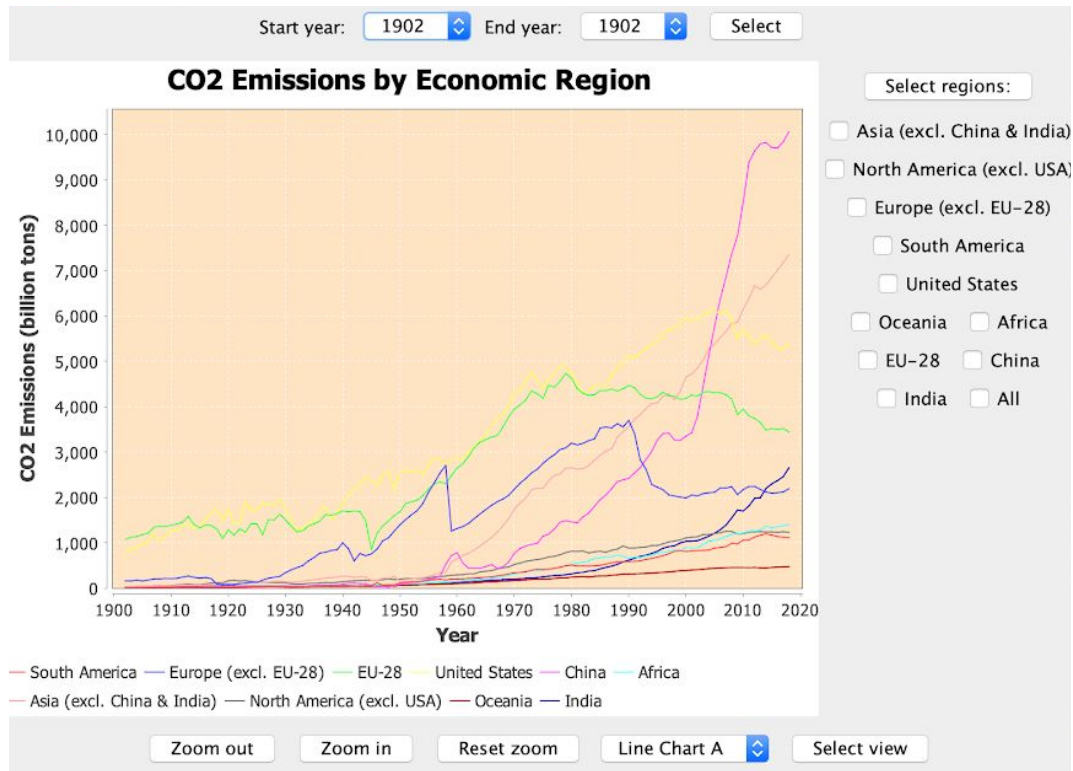
- **Plot/visualization type dropdown menu** — We have implemented a dropdown menu on all charts that allows the user to choose which chart to view by selecting it in the menu.

Whenever the user changes the chart, the previous chart is hidden, so the user is only ever viewing one chart at a time. The four options are: Line Chart A, Line Chart B, Bar Chart, and Pie Chart. We implemented this using a JComboBox on a panel attached to the frame.

- Region selection checkboxes — We have implemented another JComboBox that allows the user to select which regions they want to view on the currently displayed chart. We used JCheckboxes to allow the user to select multiple or singular regions at a time in whatever combination they may desire.
- Zoom in/zoom out buttons — We also implemented another JComboBox with three buttons, zoom in, zoom out, and reset zoom. These allow the user to zoom on the currently displayed chart.
- Date selection buttons — We can also change the granularity of the time axis on each chart through the implementation of our date selection buttons. For the line charts and bar chart, we implemented two date selection dropdown menus by year that allow the user to choose in which time period they would like to visualize the data. For the pie chart, we implemented one date selection dropdown menu that allows the user to choose which year they would like to visualize the amount of CO2 emitted per region as a percent of all of the regions for which data is visualized. JComboBoxes were used to create these menus and attach them to a JPanel attached to a JFrame.

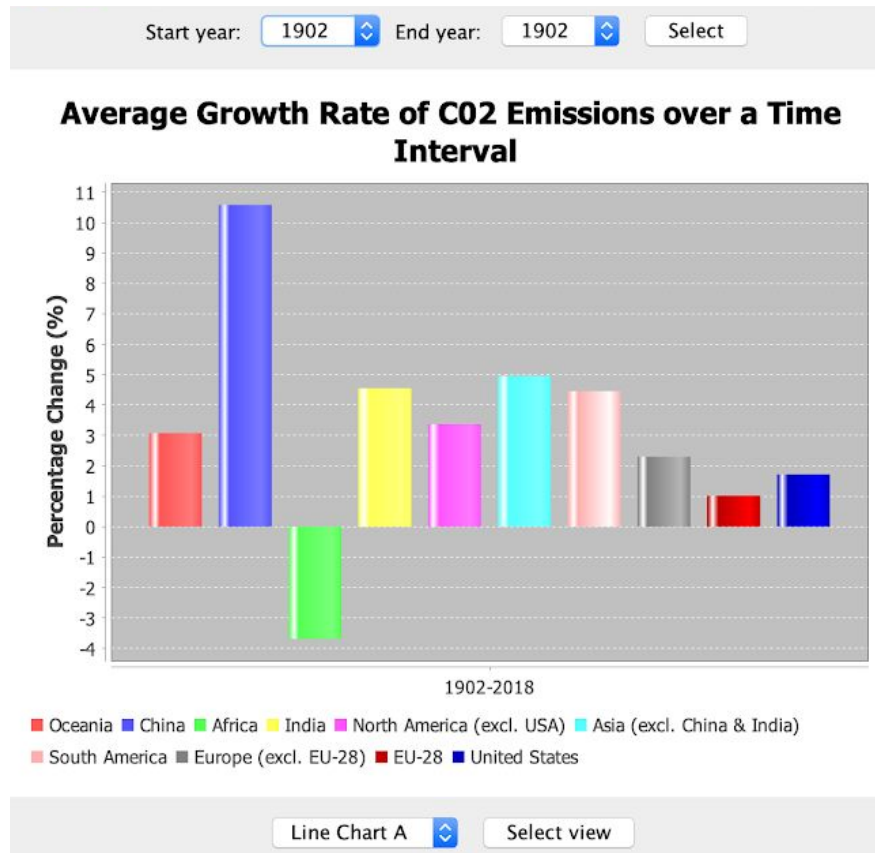
Charts

Total CO2 Emissions by Economic Region over a Select Time Period



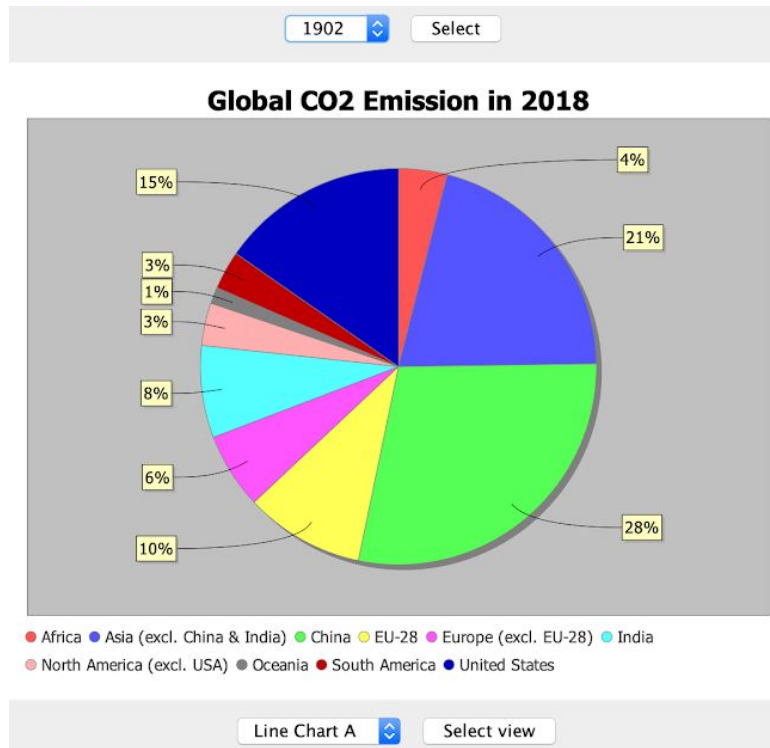
The above line chart displays the total CO2 emissions per year between the time period of 1910 and 1950 of all regions in our dataset. (This is an example of the functionality of the date selection buttons; any range of years where data exists in our dataset can be viewed when chosen.)

Average Growth Rate of CO2 Emissions over a Time Interval



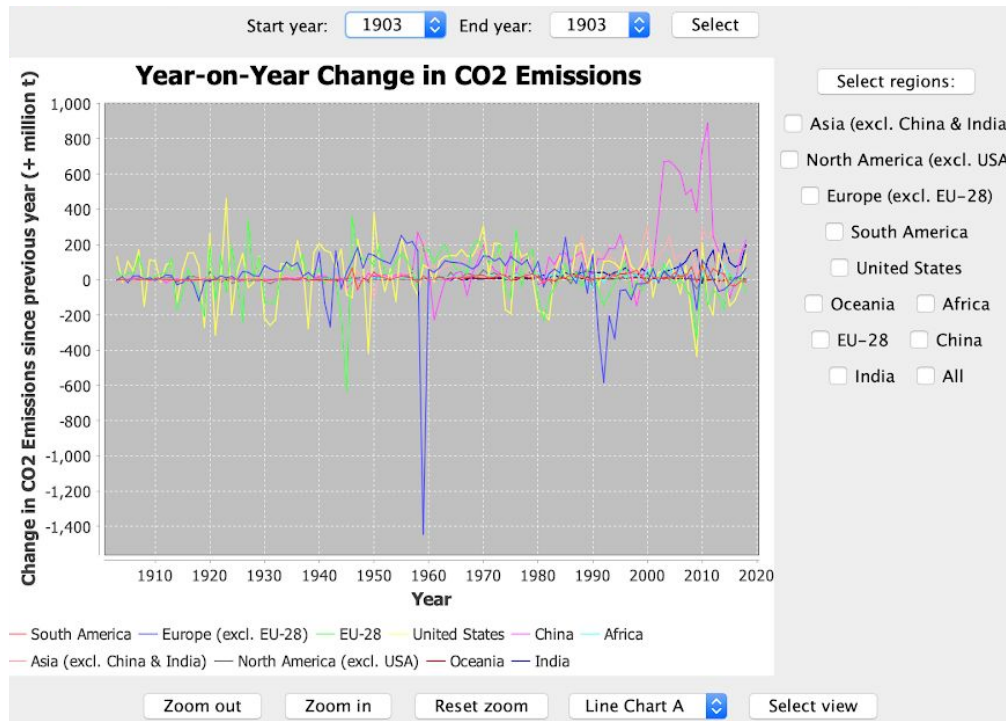
The above bar chart displays the average growth rate of CO2 emissions per region over the time period of 2000-2018 for all regions in our dataset. (This is another example of the functionality of the date selection buttons; any range of years where data exists in our dataset can be viewed when chosen.)

Regional Percentage Proportions of Total CO2 Emissions for One Year



The above pie chart displays the numerical percentage proportions of the total amount of CO2 emissions in 2000 between various regions of the world. (This is an example of the functionality of the year button; any year between 1903 and 2018 can be chosen to be displayed.)

Year-on-Year Change in CO2 Emissions



The above line chart displays the changes in CO2 from one year to the next between 1903 and 2018 of China and the US (This is an example of the functionality of the regional selection checkboxes; all regions or specific ones can be viewed when chosen.)

Conclusion

In this project, we analyzed trends in CO2 emissions from 1902-2018 in various economic regions of the world. We decided to analyze by economic regions rather than by individual countries because this allows us to make relatively unbiased comparisons between over-developed and under-developed regions of the globe. By analyzing and visualizing CO2 emission trends, we are able to understand how the responsibility of reducing emissions is shared by the various regions. We are also able to see how major world events impacted the CO2 emissions. For example, during the World War II period, we observe that China's CO2 emissions significantly increased.

Dataset visualizations like ours of global CO2 emissions over time are socially beneficial as carbon dioxide emissions drive climate change. By being able to understand the amount of emissions globally, in which regions of the world they are increasing or decreasing, or during what time periods they change by analyzing patterns or outliers, we can come to better conclusions about what sorts of events may increase CO2 emissions and thus contribute to climate change. Positively, we can also look toward regions that contribute less to climate change and begin to model such changes that these regions have made—to public policies, laws, and people's daily lives—in regions where CO2 emissions have contributed excessively to climate change.