Process book
COM-480: Data visualization

Team: DFL
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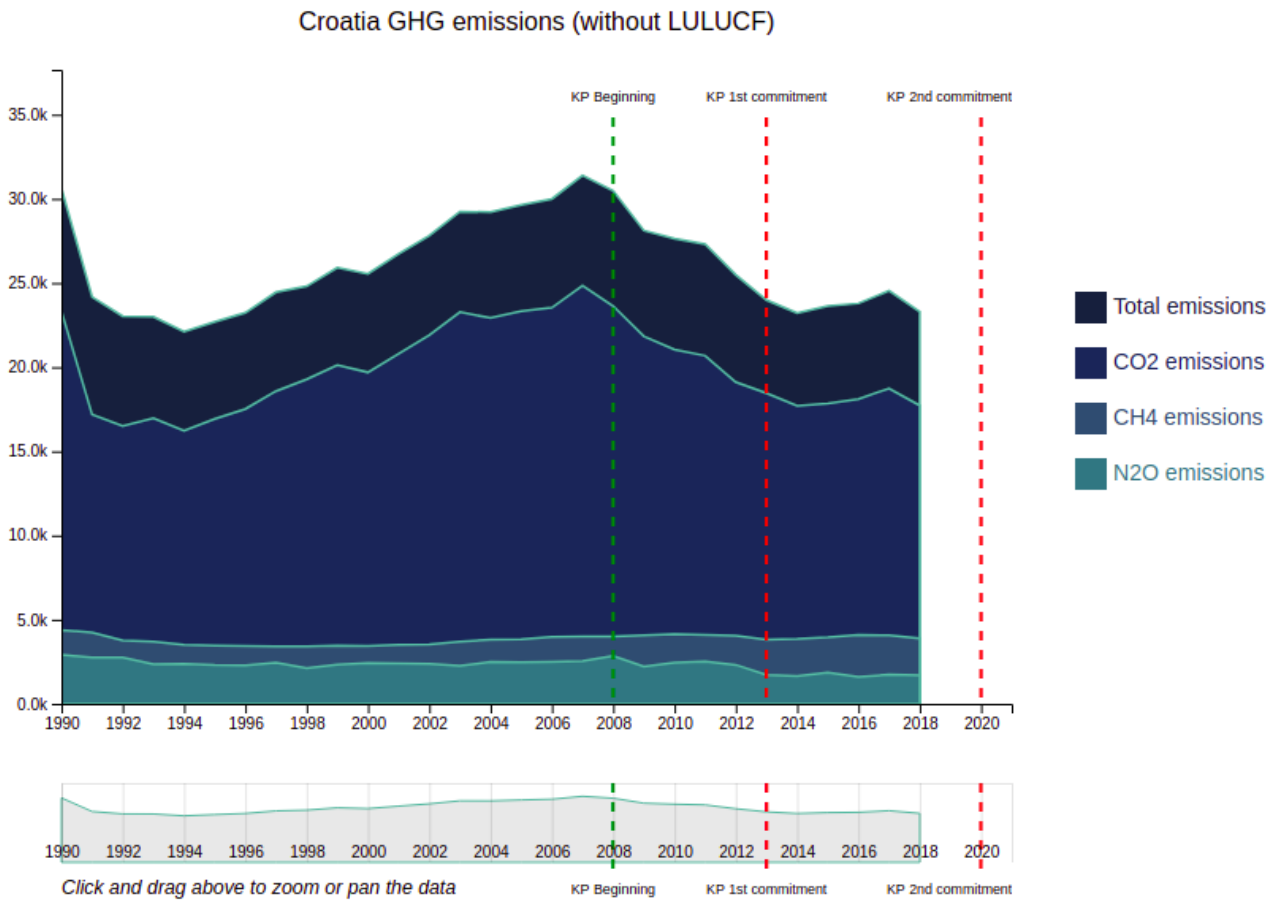


1 Introduction

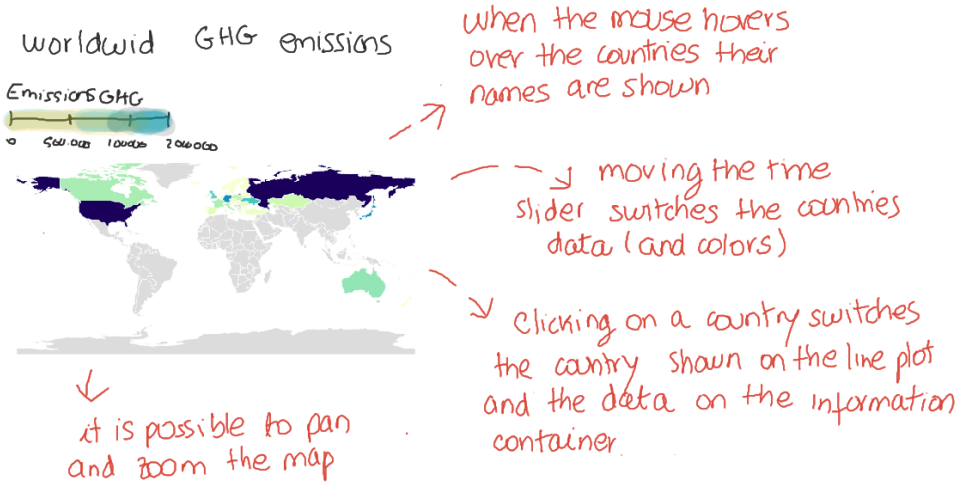
Our project aims at showing the effect of the Kyoto Agreement in reducing GHG emissions. To do so, we explored the United Nations Framework Convention on Climate Change (UNFCCC) dataset in which GHG total emissions as well as CO_2, N_2O and CH_4 gas emissions per country and per year are saved. In addition to this, we also used a dataset regrouping the percentage changes in emissions (compared to the year 1990) aimed by each country as part of the Kyoto protocol. The Kyoto protocol is separated into two phases: The first one sets a goal to be achieved by December 31rst 2012 (first commitment period) and a second one sets a goal to be achieved by December 31rst 2020 (second commitment period). Note that all countries do not have the same goals (some aim at reducing their emission by 8%, while others aim at keeping their emission constant). It is interesting to note that some countries withdrew of the second commitment period (such as Canada) or did not ratify (such as the United States). Finally, some countries did not specify their targets (N/A).

The main issue about this data is how overwhelming it can be to explore and to fully understand. However, thanks to visualization techniques, our goal is to display the data in an intuitive manner to provide the user with all the information needed to understand the impact of climate change policies and agreements in a few clicks. To do so, the website has to be self explanatory, straightforward, with as little text as possible, so that a child or a busy adult could get the main ideas in a matter of seconds.

To do so, our website is organized around 3 interlinked data visualizations: a World Map, an Area Chart, and a Ranking Bar Chart. Each of these visualizations brings a different view and allows the user to quickly grasp the different aspects of the situation at hand (either geographically, or through time, or allowing comparison/ranking between countries).

2 Core Visualizations

2.1 The World Map

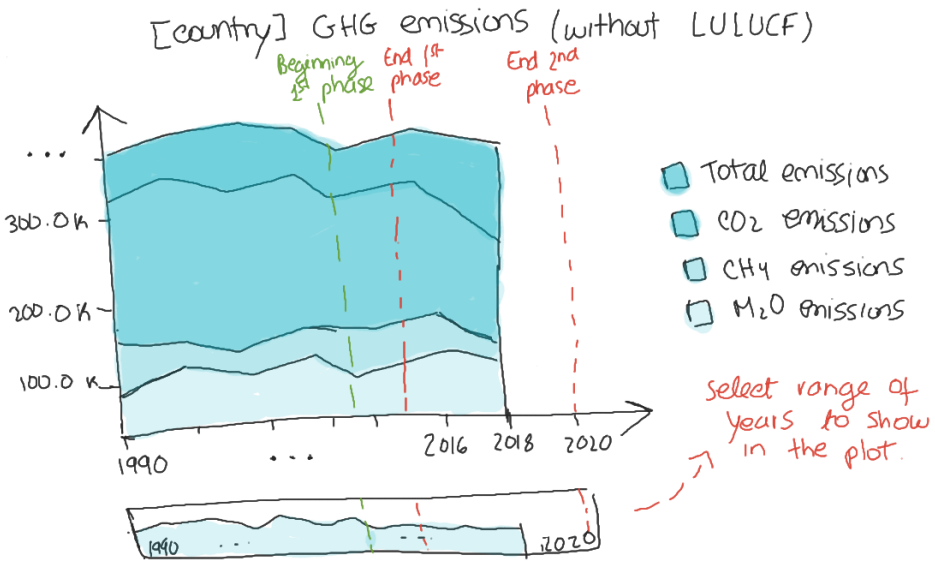


The World Map is the first data visualization on the website (upper left), as it is the one giving the broadest overview of the GHG total emissions of each country both geographically (thanks to the color map), and through time (thanks to the slider). Note that only countries belonging to the Annex I Parties are colored, as the others are not part of the Kyoto Protocol (countries colored in grey). We can zoom and pan on the map to better visualize each country. Also, when the countries are hovered, their name shows up for easier identification. We used the geoEquirectangular projection for the map, as it is commonly known and familiar to the majority of people. Furthermore, the user can click on a country of interest. On click, some more precise information about the selected country is displayed on the following plot: The

Area Chart. Information is also displayed in the Information Container represented in the overall layout of the website in section 3.5 of this report.

2.2 The Area Chart

The Area Chart is the second data visualization on the website (upper right), as it pairs well with the map, giving a better overview of what the selected country emissions in all CO_2, N_2O and CH_4 look like. The brushing helps navigating through the years, isolating part of interest, offering a more flexible experience. Reference dates such as the Kyoto Protocol beginning (in 2008) and the two different commitment dates (2013 and 2020 respectively) are displayed to help the user to better analyze the curve and see the influence (or the none influence) of the KP on GHG emissions. Moreover, the interactive legend highlights (on hover) the different type of emissions for a better readability. Note that the variable LULUCF (Land Use, Land-Use Change and Forestry) can be taken (or not) into account using the dropdown menu below, and the country on the Area Chart can be either selected on the World Map, or thanks to the dropdown menu at the top. On selection, it will highlight (in blue) the bar corresponding to this country in the final plot: The Bar Chart Ranking.



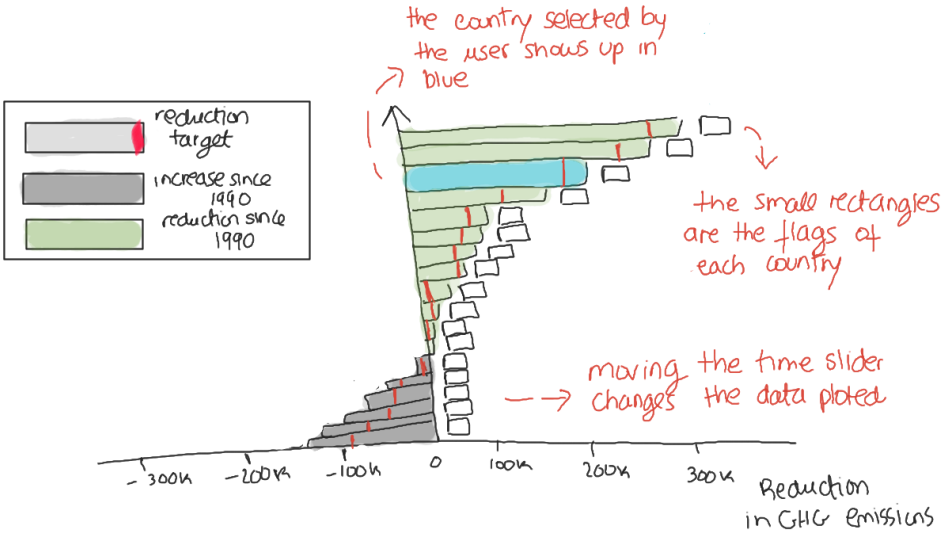
2.3 The Bar Chart Ranking

The Bar Chart Ranking is the third and final visualization on the website (bottom), as it allows to see which countries did or did not respect the Kyoto Protocol and, as a result, its overall success rate. It is also used to *praise* (and respectively *shame*) countries reducing their emissions by a large amount (and respectively, those increasing their emissions instead of reducing them). This strategy of *Praise or Shame* is implemented through the ranking system displaying not only the best k countries, but also the worst k countries (with k being a parameter that the user can set thanks to the dropdown menu). That way, not only really well performing countries are brought forward for praise (k of them), but also really bad performing countries are pointed fingers at (k of them as well) and displayed on the screen.

On the X axis is displayed the reduction in GHG emission (in kt CO_2 equivalent). As a result, positive values (in green) corresponds to a decrease in GHG emission since 1990. On the contrary, negative values (in black) corresponds to a increase in GHG emission since 1990. The Kyoto Target of the respective countries are represented by a red mark. The gray bar is the bar *to be filled* in order for the country to

reach its Kyoto target. Note that this Kyoto target is updated for years that are after the first commitment (so to refer to the second commitment).

The Ranking Bar Chart can be displayed for GHG emission with or without LULUCF (Land Use, Land-Use Change and Forestry) thanks to the dropdown menu. The years for which the ranking is displayed can be modified using the same slider as the one attached to the World Map. Selecting another year will trigger transition effects that change the size of bars, the scale, as well as the country flags to represent the ranking of that particular year. As a result sliding continuously from left to right allows the user to see the evolution of the ranking through time: from the year 1990 to 2018. Note that if the user wants to highlight (in blue) one particular country to better follow its emissions (and ranking) through time, he can select it using the Dropdown menu of the Area Chart.



On this plot, we can see that all countries at the top have managed to reduce their emissions by more than their Kyoto target (red mark), which is really good. However, we see than the bottom countries have actually increased their emissions by more than their Kyoto target (red mark), which is really bad. Note that this drawing is a simplified example, as in reality some countries might be half way through their target, or going in the opposite direction.

3 Project Journey, Challenges and Decisions

Our original idea was to show the progress of the several countries on emission reduction for both the Kyoto protocol and the Paris Agreement. However, we had difficulties finding the target emissions for the Paris agreement and we realized it would also make our visualizations more complex. So, we decided to simplify the project and only keep the Kyoto protocol.

3.1 Acquiring the Dataset

The first challenge we encountered was at the beginning of the project, when looking for a dataset about air pollution. It was surprisingly hard to find a clean and complete dataset about air pollution for many years, for many different types of gas and for a large enough number of countries. We first went for the OpenAQ dataset but we encountered a bunch of challenges along the way. The API was a bit overwhelming and restricted the number of requests. We contacted their team, who gave us access to all the data directly from their AWS S3 bucket, allowing the use of Athena to query the bucket. However, this resulted in a steep learning curve, and we were getting issues while querying the data. Ultimately, we found what we

were looking for with the UNFCCC dataset which was much simpler to use and decided to go on with this one.

3.2 Aim and Means

Once we had the dataset, we had to think about what to do with it. After searching what has already been done, we found out that not many visualizations aimed at investigating (and/or criticizing) the effect of the Kyoto Protocol in reducing GHG emissions. We therefore took this challenge and started exploring the data (Exploratory Analysis in Milestone 1) to get a sense of what the data had to offer. We've spent some time searching for the best visualizations to display the data. The hardest part was to combine all the information into a small number of visualizations. Indeed, we wanted the user to have a sense of the geolocation of emissions, as well as having an analysis through time of multiple type of emissions of different countries, while giving a sense of how good or how poorly one country is performing compared to the others. Finally, all this information should converge back to the question of the Kyoto Protocol and its effectiveness in reducing GHG emissions. This lead to the idea of having a World Map, an Area Chart, and a Ranking Bar Chart as we talked about in the last section.

3.3 On to the coding adventure

After producing some sketches of what we thought would best represent our ideas, we built a skeleton of the website. All visualizations were not present yet (for instance, the Ranking Bar Chart), as we were still debating on what metric to use for the ranking. Indeed, we faced the challenge of choosing a metric to represent the countries in the ranking plot. We came up with two different rankings but had a hard time deciding which one would best suit our needs. The first idea we had was to do the ranking using the reduction in emissions of countries. Meaning that a country who reduced its emissions by 300 kt would be ranked higher than one who reduced its emissions by 200 kt. It is a really nice and intuitive metric, but is unfair to small countries that have already low emissions compared to the big polluting countries. The second metric we thought about was to rank the countries considering how close they were from their target. It is a more fair metric for small countries than the previous one, but has one major issue: all targets are not the same for every country, and as a result, countries with easy reachable targets would be advantaged too much. This is why we decided to use the first option in the end. Nevertheless, this skeleton allowed us to get started and to apply what we have learnt this semester in the lectures and the exercise sessions from scratch.

After Milestone 2, each of us focused their efforts on the realization of a different plot, before re-converging together to share ideas, implement interlinks between visualizations, and working on the overall layout and presentation of the website. A big challenge we have met was to combine all scripts together. The main issue was to listen to events and pass values from one visualization to another. We spent quite a large amount of time trying to find ways to import and export variables from one script to the other, without much success. Initially, we coded our visualizations on different scripts so that variables wouldn't mix and as a good practice of separating the different parts/modules of the project in different files. However, because we wanted our modules to be linked to one another, this separation became cumbersome and therefore we decided to merge everything back to one script. This took quite an amount of debugging but allowed the use of many interesting and visually pleasing interactions between the plots.

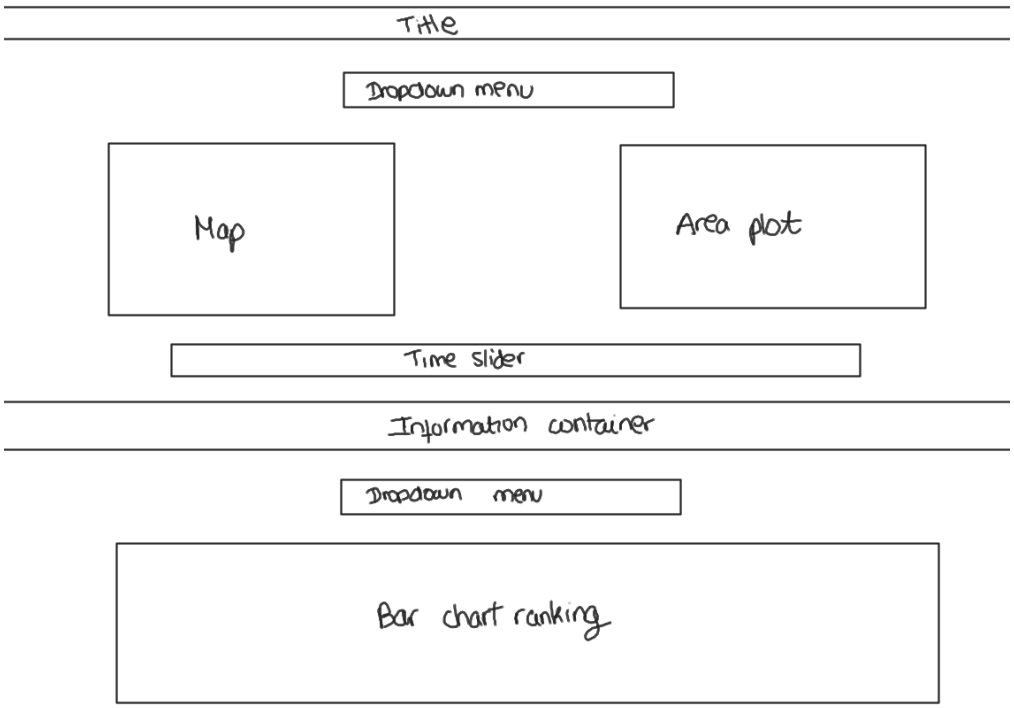
3.4 Time is valuable

As in any projects, time is not infinite and thus valuable, and we had to be careful not to lose too much time on implementing optional features before being finished with the core product. It was a really hard

thing to do, as it is difficult to let go of an idea that we thought could have been a good addition to the overall website. As an example, we did not have time to include a tutorial (inspired by Sand dance) with pop-up messages to teach the user how to best use the different visualizations, nor did we include GHG by sector analysis visualizations. We also wanted to make the website responsive for any device size by changing the overall structure of the website if the view is too small (on smartphones for instance).

3.5 Overall layout of the website and Story telling

When all the core features were implemented, we then improved the overall layout of the website using *Bootstrap*. The goal was to have a simple yet visually pleasing interface where the visualizations could be displayed. In the end, we came with this final design:



One of the final addition to our project was the use of dynamic text (inspired by the lecture about Story telling and the website https://population.io/). This dynamic text allows the reader to get a summary of the selected country key indicators regarding its Kyoto target, its reduction (or increase) in GHG emissions, and its ranking. The use of dynamically updated and colored text was important in our project, as we did not want to overcrowd the website so to keep it as simple and as informative as possible. Too often we encountered websites online with an overwhelming amount of text that discourages most of the readers and thus, convey no information at all. Here, we reduced the amount of text by making it adaptive to the country the user is interested in.

3.6 Report and Screencast

Came the day when unfortunately we had to wrap up the project. One of the challenge here was to know when and where to stop the improvements we were still making on the website on a daily basis, and which one to prioritize. We thus decided to make the website as complete as possible (visualizations, layout, story telling,...), even though some improvements could have been made on specific (yet optional) details. At the time of writing this report, we are proud of what we have achieved and of the work we have put in during the whole semester. We have learned a lot, and managed to come up with a well functioning website, even though some of us didn't even know HTML before starting this class!

Overall, most of the design follows our initial plan except for a few details that we decided to drop. However, we also made some additions that were not planned at the beginning. Here are some examples:

- We decided to include a box of text that changes when the user picks a country, displaying more information.
- When we hover over the map, now the names of the countries show up, as it makes it easier to identify and select them.
- We also decided to add the LULUCF variable, as emissions of countries can change drastically depending on if we consider LULUCF or not (take for instance Australia seen in the Screencast example).
- We also added the principle of *Praise and Shame* by forcing in the ranking the display of not only the k best ones, but also the k worst one.
- We also added interactions between every plot (may it be through country selection, or common year slider).

As a result, we have recorded our Screencast proud of our journey, yet sad of not being able to implement the extra ideas we had left. In this Screencast, you will find a presentation of how to use the website, and how to retrieve as much information as possible from all the visualizations and their interactions.

4 Implementation details

In this section, we will dig deeper on the implementation details, such as the tools and lectures used for the different visualizations:

4.1 Overall website

The overall website is developed using HTML, CSS and JavaScript. The grid that contains the elements is created using Bootstrap. In the following subsections we describe in more detail the implementation of each of the main plots.

4.2 World Map

Both the legend, map and time slider where created using D3. We also used D3 for all the transitions like zoom, clicking a country and selection of a year on the slider. The legend and slider where created based on implementations found online, which we include in the references. To create the map itself we used the knowledge learned in the classes and practical assignments.

4.3 Area Chart

All the elements of the Area Chart module were created using D3. This includes not only the stacked area chart itself but also the possible interactions like transitions, brushing and dynamic highlighting of the individual stacked charts for each gas. An AreaChart class allows the creation of the chart, and includes an update method for transitions.

4.4 Bar Chart Ranking

Everything has been created using D3, may it be for the axis (using scales), or for the different rectangles and flags that are bound to the data. The code basically loads the data using d3.queue, and then once ready, create the bar chart as well as event listeners, that when triggered, update the graph using d3 transitions for smooth changes. Note that some events can come from other visualizations (such as the slider and the selected country).

5 Peer assessment

- Loïc Busson:
  - Wrote a full first version for all Milestones 1, 2 and 3
  - Took care of acquiring the Kyoto target dataset
  - Worked on the Area Chart of the skeleton
  - Took care of the Ranking Bar Chart
  - Wrote the script of the Screencast
- Dora Lourenço:
  - Drew all sketches for Milestones 2 and 3
  - Participated in writing all milestones
  - Took care of the World Map
  - Took care of the README.md
- Francis Murray:
  - Search and found the first dataset, contacted OpenAQ, and found the UNFCCC dataset after.
  - Participated in writing all milestones
  - Implemented the Area Chart module
  - Took care of the website layout and style
  - Wrote the script of the Screencast
  - Took care of the Screencast shooting, editing and upload

Note that, even though for the sake of the *Peer assessment* assignment we have assigned different parts completed to different people, we have in reality participated to weekly meetings to discuss ideas, and spent a lot of time helping each other out, even though it was not on our own *assigned* task. We were all invested equally in this project to share inputs and lend a hand to ultimately have a better overall website.

6 Conclusion

Our final product achieves all our initial goals. Not only we created visualizations of the affects of the Kyoto Protocol on total greenhouse gas emissions, but our website is also simple to navigate and to use. Moreover, the interaction between plots allows for a much richer interaction with the data.

References

- https://bl.ocks.org/lkopacz/dfd9cc04a4d5a5f0fe87c89a79524479,
- https://bl.ocks.org/vasturiano/f821fc73f08508a3beeb7014b2e4d50f
- https://www.d3-graph-gallery.com/graph/stackedarea_template.html