Exploring Climate Change

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***Project Breakdown*- Climate change topics were divided among the team members as the following: Kiran covered droughts and CO_2 emissions. Santosh explored global temperatures. Praveena investigated changes in glaciers and sea levels.**

I. Introduction

Climate change is the long-term change in the Earth's weather patterns that defines changes in Earth's regional, local and global climates. Climate change can be quantified using many different variables including rise in temperature, rise in sea levels, melting glaciers, and extreme weather events like, droughts etc. One of the factors that has been attributed to climate change and global warming are high levels of Carbon Dioxide emissions.

In this paper, we will analyse the following measures (in the given order): droughts, global temperatures, CO_2 emissions, glacier size, sea level. We will conduct time series analysis and create geospatial data to examine how the changes in the environment have taken place over time and how it is different according to location. We will also explore how all of these factors are interrelated like how rise in temperatures can cause an impact in melting of glaciers, increase in sea levels etc.

II. Droughts

Droughts are prolonged shortages in the water supply, primarily caused by low rainfall. Droughts can have profound social, environmental or economic effects, including increased food prices, agricultural losses, scarcity of drinking water, and increases in wildfire. Climate change can contribute and exacerbate drought conditions in a variety of ways, including increased temperatures, increased transpiration, and enhanced evaporation from soil. In this section, I will explore the intensity, breadth, and changes in drought conditions in the United States.

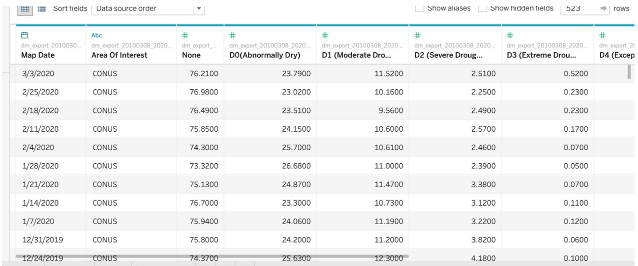
A. Methods:

To develop a better understanding of the patterns and intensity of the drought in the US in the past decade, I used datasets from The U.S. Drought Monitor [1], which contains weekly assessment of drought conditions in the US since 1999. The US Drought Monitor is produced through a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Specifically, the Drought Monitor map identifies areas of drought and labels them by intensity, where D1 is the least intense level and D4 the most intense. Main indicators used to determine a drought include: Palmer Drought Severity Index, the Standardized Precipitation Index, CPS Soil moisture model, and USGS Weekly streamflow [2]. A chart is included below (see Fig. 1), detailing indicators and ranges used to determine the drought level.

			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Fig. 1. Category Description: Description of categories in the drought dataset and respective ranges of various drought indicators.

For my first visualization (Fig.3) I used the following dataset made available from US Drought Monitor:



Map Date	Area Of Interest	None	D0(Abnormally Dry)	D1 (Moderate Dro...	D2 (Severe Droug...	D3 (Extreme Drou...	D4 (Excep
3/3/2020	CONUS	76.2100	23.7900	11.5200	2.5100	0.5200	
2/25/2020	CONUS	76.9800	23.0200	10.1600	2.2500	0.2300	
2/18/2020	CONUS	76.4900	23.5100	9.5600	2.4900	0.2300	
2/11/2020	CONUS	75.8500	24.1500	10.6000	2.5700	0.1700	
2/4/2020	CONUS	74.3000	25.7000	10.6100	2.4600	0.0700	
1/28/2020	CONUS	73.3200	26.6800	11.0000	2.3900	0.0500	
1/21/2020	CONUS	75.1300	24.8700	11.4700	3.3800	0.0700	
1/14/2020	CONUS	76.7000	23.3000	10.7300	3.1200	0.1100	
1/7/2020	CONUS	75.9400	24.0600	11.1900	3.2200	0.1200	
12/31/2019	CONUS	75.8000	24.2000	11.2000	3.8200	0.0600	
12/24/2019	CONUS	74.3700	25.6300	12.3000	4.1800	0.1000	

Specifically, this dataset contained data for each week. There were 5 columns for each of the drought levels and the columns contained the percentage area in the US classified in the respective drought levels. The classes cumulative (i.e if a region is in D2, it is also in D1 and D0). Areas classified as D0 are not considered to be in a drought, however abnormally dry conditions can turn into drought. D1-D4 areas are considered to be in a drought.

Since the classes were cumulative and contained area information, overlapping area maps was the best way to visualize the information. The independent variable was date (x-axis) and dependent variable was Percent Area Affected by Drought (y-axis).

For my second visualization, I used another GIS (geographic information system) data made available on the US monitor website. There are multiple datasets available, however, you can only view one week at a time. So, I ended up downloading multiple datasets and performing unions. The datafiles included a shapefile (*.shp) which is a common vector data format and contains one polygon object for each DM class aka drought level (0, 1, 2, etc.). I dragged the column that contained into the middle, which resulted in a blue map as shown below. To create the layers, I converted DM into a Dimension and then dragged it onto the map to create the layers.

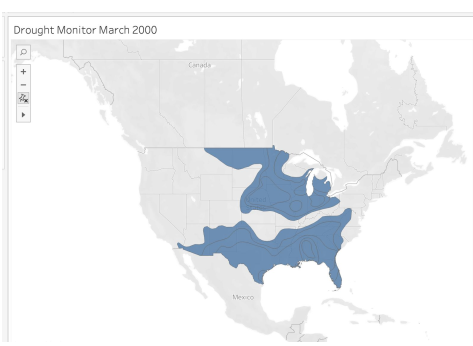


Fig. 2. Gomap without dimension

B. *Results:*

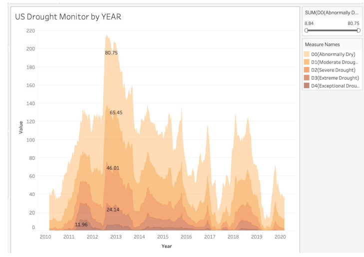


Fig. 3. Time Series Visualization- US Drought Percentage Area Affected (2010-2020)

My first visualization (Fig. 3) displays overlapping area graphs which illustrate the high levels of drought (in terms of percentage area) in the past decade. The US experienced the most intense drought in 2012 with 63% of the area in the US considered in Moderate Drought. The scope and severity of the drought in the US started to steadily decrease after 2013. In 2017, only about 5% of the area in the US was classified under Moderate Drought. However, the US experienced another sudden increase in drought in 2018, when around 30% of the area was classified as Severe Drought.

To further identify patterns in US drought conditions, I was created and explored a series of geomaps. The purpose was to compare and contrast the geo maps showing the drought condition of the US at different times. For example, after creating different graphs, I noticed how over time there were larger areas that were classified as Extreme Drought. I also noticed certain areas, such as Texas, tended to be impacted by droughts more so than others. The two images (Fig 4 and 5) below are included here to show an example of a comparison. However, only the most current map reflecting the latest conditions is included in the dashboard.

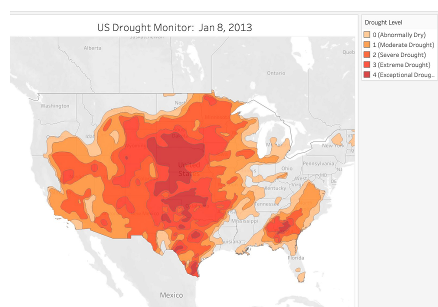


Fig. 4. Geomap reflecting US drought conditions in Jan 2013

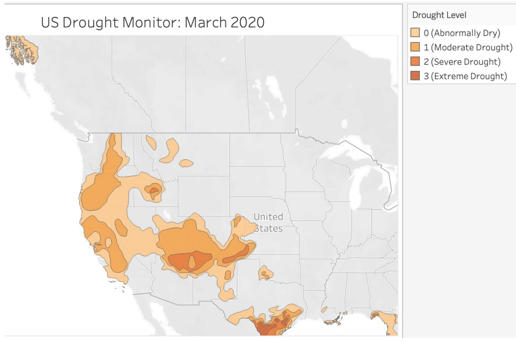


Fig. 5. Geomap reflecting US Drought conditions in March 2020.

C. Discussion:

The visualization proves the importance of picking the right chart type to view the data. We were able to very quickly and efficiently see overall trends of multiple levels in one graph. Seeing the overlap and different gradients helps see how prevalent droughts were in different time periods. For example, overlapping the different levels of intensity demonstrated how much area was at Level 0 - Abnormally Dry. This would not have been possible through viewing the data in a tabular format.

The second set of visualizations (geomaps) prove the importance of analyzing spatial data. By viewing the data as such, one can find unique,interesting patterns which would be very hard otherwise. For example, we were able to find how certain areas were impacted more frequently than others, indicating certain regions are more drought-prone than others.

D. Results

First, I learned how to overlay area charts in Tableau with multiple measures, instead of having them stacked individually. Overlaying the 5 levels (which were cumulative in their measurements) helped me identify the overall changes in intensity of drought conditions. But, I also learned how easy (and useful) it is to view specific elements of a graph in Tableau. For example, if I just wanted to focus on Moderate Drought percent areas, I just had to click the specific area and the graph illustrating Moderate Drought became more prominent.

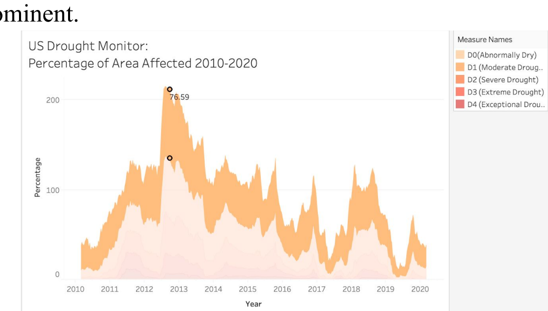


Fig. 6. Tableau allows one to select a specific area graph to bring focus.

Secondly, I learned that in order to visualize the different levels, the DM column had to be converted into a Dimension from a Measure because the DM represented different categories.

III. Atmospheric Carbon Dioxide Concentrations

Global warming has been attributed to greenhouse emissions and other air pollutants, in particular to Carbon Dioxide. Carbon Dioxide, a greenhouse gas, is very long-lasting and traps the heat radiated from Earth's land and oceans. Because of the billion tons of CO2 emissions a year, the greenhouse effect has been profound, accelerating the increase of global average temperatures.This global warming, caused in return contributes to extreme weather events, including frequent droughts, melting glaciers, rising sea levels, heavy rainfall, and extreme heat waves.

In this section, we will explore how Carbon Dioxide concentrations in the atmosphere have changed over time.

A. Methods

To explore trends in atmospheric Carbon Dioxide, I created a time series graph using the dataset available by Earth System Research Laboratory: Global Monitoring Division [3]. This data is collected at Mauna Loa Observatory (Hawaii), a facility of the National Oceanic and Atmospheric Administration. NOAA has been measuring CO2 since March of 1958, making it the longest record of direct rigorous measurements of CO2 concentration in the atmosphere. Moreover, the Observatory, located near the Mauna Loa summit, is at 3400 m altitude,consequently making it ideal for air mass measurements that are representative of large areas. The time range of the data analyzed in this project is 8/20/1969 to 12/27/2018.

The CO2 levels are measured as the mole fraction in dry air, which is "number of carbon dioxide molecules in a given number of molecules of air, after removal of water vapor". So, 300 ppm (parts per million) of CO2 levels means that there are 300 CO2 molecules for every 1 million dry air molecules.

1. The following were the steps to create a time series chart. I first downloaded and imported the data(.txt file). The data was imported as one column and was split into different columns through the Text File Properties option and using Space to separate the fields.

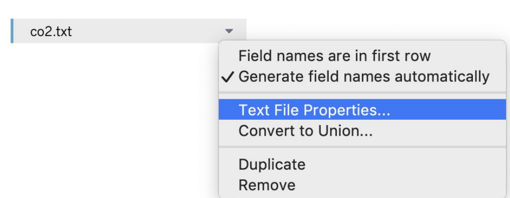


Fig. 7. First step to splitting a column in a table..

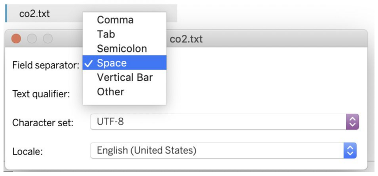


Fig. 8. Indicating Tableau to split columns based on space.

2. There were now 3 separate columns - Day, Month, Year. The columns were aggregated into 1 date column by using a formula and creating a new calculated field. The datatype of the newly created column was then converted into Date. To create the actual graph, I dragged the Date column into the Column section as it was the independent variable, and CO2 level column into the rows section.

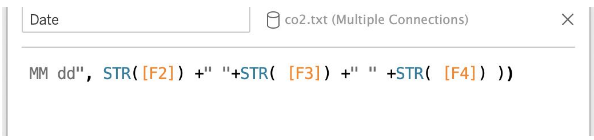


Fig. 9. Creating a Calculating Field

3. Another issue I ran into was dealing with missing values, which were represented by the -999, resulting in an inaccurate graph. To address this issue, rows containing the value -999 in the CO2 level column by adding a filter.

4. To create the time series chart, I dragged the Date dimension into the Columns sections and CO2 Levels columns in the Rows sections (dependent variable).

B. Results

The system produces the following time series graph [below]. The fluctuations indicate seasonality of CO2 levels in the atmosphere. But more importantly, the graph points to an overall steady upward trend in CO2in the past decades. As shown, the CO2 levels increased from around 330 ppm in the 1970s to 410 ppm in 2018 - more than 20% increase in CO2 concentrations within forty years.

This rise in atmospheric Carbon Dioxide can be attributed to human activities, such as the burning of fossil-fuels like oil and coal, which are fossilized remains of plants. When fossil fuels are burned, the carbon dioxide, which plants had pulled from the atmosphere over a span of a million years, is released back into the atmosphere.

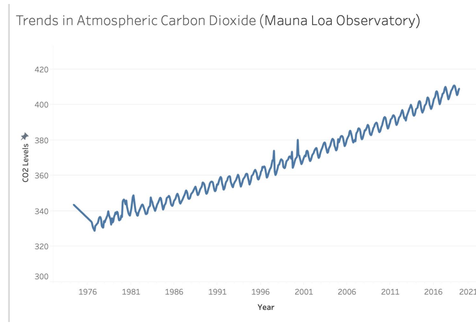


Fig. 1. Trends in Atmospheric Carbon Dioxide

C. Discussions

The visualization for this section, the time series plot "Trends in Atmospheric Carbon Dioxide", helps the audience to quickly identify the rise in Carbon Dioxide concentrations in the atmosphere. Time series graphs are excellent in helping the reader identify unique patterns or trends in a numerical variable over a span of time (a continuous variable). Since the data has seasonal fluctuations(discussed in the next section), it would have been very difficult to identify the patterns in data without a timeplot.

In particular, this visualization offers one perspective of understanding global warming and, specifically, the role of increase of CO2 emissions on climate change. For example,this visualization of CO2 concentration, along with the graphs demonstrating rise of temperature, can indicate a possible relationship between CO2 levels and global warming.

D. What I Learned

By creating and exploring the time series plot, I learned the importance of detecting and interpreting seasonality in time series data. Seasonality can be understood as periodic fluctuations that occur in time series data at regular intervals can be understood as seasonality. Seasonality in a model may occur because of season variation and one should dig deeper to understand the underlying causes of such fluctuations.

Upon more research, for example, I learned how the season variation in the CO2 concentration levels (i.e peak in May and drop in November) is caused by changes in plant photosynthesis:

> *Levels of carbon dioxide in the atmosphere rise and fall each year as plants, through photosynthesis and respiration, take up the gas in spring and summer, and release it in fall and winter. Now the range of that cycle is expanding as more carbon dioxide is emitted from burning fossil fuels and other human activities. [5]*

Overall, I learned that time series graphs are not only useful for overall trends, but to identify unique and interesting patterns occurring in your data.

IV. Global Temperatures

Global temperature is the average of all the temperatures recorded from each of the weather stations. Climate change can be recognized by understanding the rise in temperatures over a period of time and later drill down to understand the exact reasons. The planet's average temperature has risen of about 0.9 degrees centigrade since the 19th century and this change has been recorded essentially because of the rise in emissions like Carbon-dioxide and CFCs by humans. Most of the activities like increase in emissions from industries and thermal power plants, deforestation all of these direct impact on temperatures.

Consequences of Increase in Temperature

With the constant rise in Global Warming or increase in temperature it leads to several adverse consequences which even leads to extinction of animals and plants. Some of its consequences are: increase in sea levels, impact on human's health with heat waves resulting in heart diseases, changes in Weather patterns (Seasons tend to stay for a longer time than their usual), and droughts.

Datasets:

The dataset that we used is the global temperature dataset which recorded temperatures from 1850 to 2015 on a monthly level basis. The dataset consisted of different features like Average Land Temperature, Average Land Temperature Uncertainty, Land Max Temperature, Land Min Temperature, Land and Ocean Temperature. Also used Temperature Anomaly dataset and global temperatures by country and state to understand the temperature anomalies over a period of time and also understand which states in the United States had highest uncertainties in temperature.

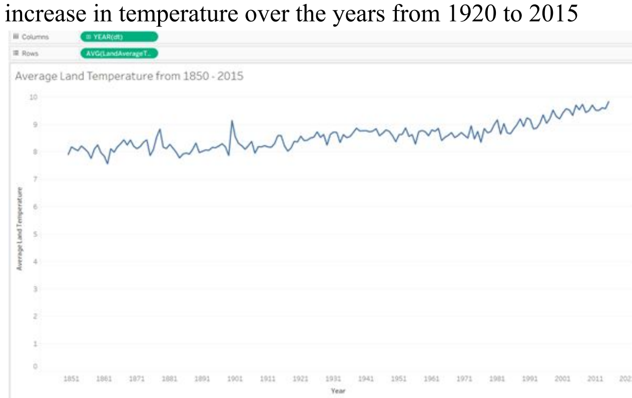
A. Methods

Data Cleaning

The data obtained from the data sources had null values for the data collected from the year 1750 to 1849 in most of its columns. Since our analysis mostly focused on the data from the 20th century, I deleted the rows from the dataset. After deleting the dataset, I extracted the year from the dataset and made it as a separate column so that it would be easy for me to join temperature anomaly data on the basis of year. But while doing this task, I got into a problem with excel which is excel formula Year(date) gives out the year of the specific date and it worked fairly well but for only the date values starting from 1900. To retrieve the year numbers of the specific dates I used another formula from excel which is =LEFT(A2,4) where A2 is the date cell and 4 represents the number of characters. Left() function returns a string as an output so converted all those years into numbers and extracted all the years for their corresponding dates.

For my first visualization I started on working with a line chart to understand the pattern of temperatures over years and started to put the date dimension on the columns tab and avg(Land Temperature) on the rows tab.

From the line chart, we can clearly observe a relative increase in temperature over the years from 1920 to 2015



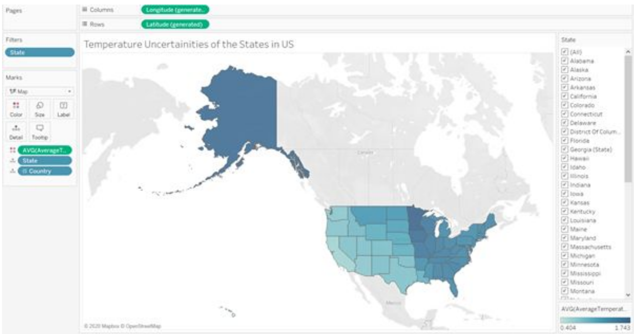
After understanding the relative pattern in temperatures, I wanted to drill down further and wanted to analyze more on decade wise split. For this I tried several different drags and drop of dimensions and measures to get average temperatures on a monthly basis on a decade wise split but I wasn't successful with this approach on Tableau. Later on, I realized that the data needs to be changed or needs to pivoted to get a decade wise split. For this I did a pivot breakdown on months for specific months and aggregated average of 10 years for specific month and the data looks like the following

Decades	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1900	2.0306	2.7468	4.8283	7.9543	10.9439	13.126	14.0794	13.5834	11.7717	9.0714	5.7199	3.234
1910	2.302	2.8051	4.6799	8.1183	10.9535	13.1389	14.1549	13.5721	11.7476	9.0475	5.739	3.1114
1920	2.599	2.8669	5.1365	8.1724	11.0668	13.2201	14.2071	13.6819	11.9423	9.3643	6.1748	3.4799
1930	2.613	3.2038	5.1188	8.2534	11.2448	13.3959	14.4204	13.8863	12.0866	9.5243	6.1763	3.7765
1940	2.8759	3.2417	5.2831	8.5866	11.3615	13.4402	14.405	13.9112	12.1343	9.6491	6.1823	3.6341
1950	2.7117	3.1225	5.1982	8.3764	11.2603	13.4353	14.3084	13.8376	12.0651	9.381	5.9639	3.7896
1960	2.6805	3.3151	5.2737	8.3039	11.205	13.4252	14.272	13.8061	12.0104	9.446	6.1176	3.742
1970	2.6803	3.1885	5.3576	8.5577	11.3616	13.4545	14.3103	13.7838	12.0372	9.2699	6.1009	3.7985
1980	3.1313	3.5739	5.6023	8.7258	11.6052	13.5938	14.5428	14.1388	12.2637	9.4998	6.1911	4.0694
1990	3.2805	4.0127	5.8955	8.9413	11.6889	13.9922	14.7864	14.2709	12.393	9.8282	6.492	4.2806
2000	3.6022	4.1433	6.3918	9.3587	12.0813	14.1734	15.0525	14.5592	12.8763	10.1717	7.0282	4.4881
2010	3.579	4.026	6.3735	9.462667	12.34517	14.4485	15.11633	14.812	13.00983	10.43483	7.171167	4.690167

After breaking down the data imported into Tableau and converted Decades into a categorical variable or simply a dimension in Tableau and visualized it.

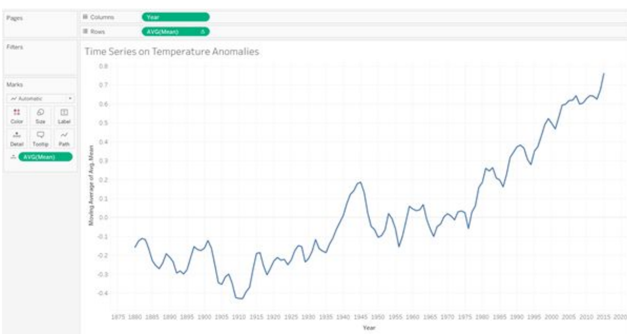
Similarly, I wanted to understand the temperature anomalies so joined it with the existing global temperatures dataset on the year column and did a time series analysis of temperature anomalies from 1850-2015 timeframe. Also, did a geographical map for the states in the United States to determine which states had highest anomalies.

Temperature Anomaly is determined by the uncertainty in temperature with the average baseline temperature or in simple terms it is defined as the deviation from the average baseline temperature. Temperature Anomaly variable helps us to understand the warming up of climate over a period of time. Positive value indicates a rise and negative value indicates the fall in temperature from the average baseline temperature. For the G-Maps I used the latitude and longitude of the states and plotted them to determine the states with greater anomalies.



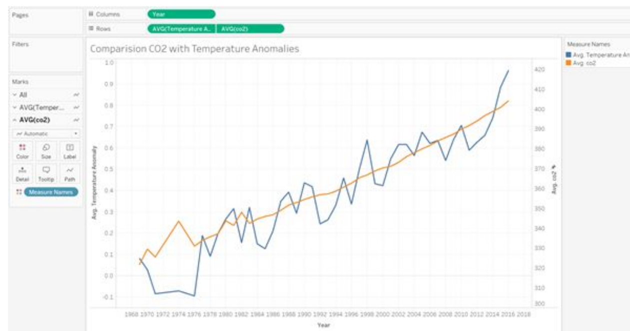
The states with dark blue color have greater temperature uncertainties than with the states in light blue colors. There's a clear indication or pattern that there's a rise in temperature in eastern states of the United States and also Alaska.

B. Results



My first visualization displays the time-series analysis of temperature anomalies from the year 1875 to 2015. It gives a moving average of temperature uncertainties, from the chart it's evident that from the year 1910 there's a continuous rise in temperature from the average baseline temperature and there's a peak or a sudden rise in 1940 and from there it has constantly kept rising.

From the second visualization, it is evident that there's a drastic rise in temperature in each month for 1900 and 2010 and also for 1990. This graph clearly gives an idea about how adverse climate change is and how temperatures are increasing recently. When you compare 1990 and 2010 there's roughly a 1-degree centigrade increase in the temperature across all the months.



This visualization helps to understand the correlation between carbon dioxide emissions and atmospheric temperature. It is evident from the graph that there's a linear trend between temperatures and carbon emissions. As and as the emissions kept increasing there was a clear surge in temperatures. In this visualization we used temperature anomalies to better understand the increase in temperatures over the years. This rise in temperature affects the climate drastically and the main reasons for this was due to emissions of carbon-di-oxide, CFC's by the industries and thermal power plants. Temperature rise has adverse effects like melting glaciers which causes rise in sea level which in turn causes natural calamities like Floods, Tsunamis, Hurricanes etc.

C. Discussions

The visualizations help the audience understand the importance of climate change and specifically how the temperatures are rising constantly because of human needs and greed. The time series graph and the line charts are specifically made for the audience to understand the trend in temperatures over the years and how badly it kept increasing. With the geographical map visualizations audience can easily understand that eastern states have higher temperature anomalies and there's a surge in temperature in these particular states including Alaska.

These graphs are particularly made for the audience to understand the importance of climate change and how global warming and deforestation are mainly responsible for the change in weather patterns. I personally knew that climate change is the real problem that we are all facing but I didn't know that the temperatures varied this drastically over the past few years and particularly recently Antarctica reached 18-degree centigrade, these graphs were specifically designed to create a perspective among the audience and make them think about the real problem we are facing. The way the world is responding over the pandemic of COVID19 is reasonable and if the world responded equally or at least 20% to what it is responding then we could get things under control

D. What I Learned

In the first instance, I thought Tableau was just a drag and drop tool to visualize which is easy to use but I was totally wrong. Tableau wasn't that easy, I realized that it is important to understand the data clearly and oversee which variables turn into dimensions and which turn into measures. Firstly, I learned that understanding the data is the key to get good visualizations and also not all visualizations can be achieved with the same data. Sometimes, converting the data is important to achieve specific graphs like in this case, decade wise split of global temperatures wherein I aggregated the data into decade wise and made use of it. I also learnt how and when to use different graphs and which graphs are effective for a particular visualization. I initially struggled combining two different line charts into one but learned that we either use Dual axes or drag the y axis on the bottom or the second graph onto the first one to merge both of them. I also learned to plot Geographical maps which I was most interested in and it was fun learning Tableau.

V. Glaciers

A glacier is a body of snow and ice of sufficient size and mass to move under its own weight. Glacier forms when winter snowfall exceeds summer melting. Glaciers are dynamic, changing in response to temperature and precipitation. The commonly accepted guidelines to define glaciers is that the body of ice has an area of at least 25acres or 0.1km2(100,000m2).

Why are glaciers important?

Glaciers play an integral role in the ecology of the region where they exist. They are essentially frozen reservoirs of water which release cold water in late summer when streams might otherwise have low flows or no flows. They play an important role in the survival of aquatic life. Glaciers provide drinking water to some communities, agriculture and recreation.

Consequences of melting glaciers: Melting glaciers are important indicators of Global Warming and Climate Change. Some of the consequences of melting glaciers are:

- Rising sea levels
- Large additions of fresh water changes oceans ecosystem
- Causes more frequent coastal storms and affects wildlife habitats
- Reduction in freshwater input for the survival of plants and animals
- Impacts vegetation and results in dryer landscapes.

A. Methods

In order to understand how glaciers looked like a long time ago and how they changed over years, I used datasets that have information about Glacier National Park that spans around 4000 square kilometers between Canada and the US state of Montana. Currently this park has around 37 glaciers and is evolving over time. The park is home to 1000 different species of plants and animals.The U.S.Geological Survey have mapped the outlines of the glaciers in Glacier National Park over time based on aerial photography and satellite imagery.

This dataset consists of shape files that can be overlayed to compare how the glaciers looked like 50 years ago versus now.

I was particularly interested in analyzing the changes by looking at the glacier outlines from the 1966 dataset and compared them with the glacier outlines from the 2015 dataset.

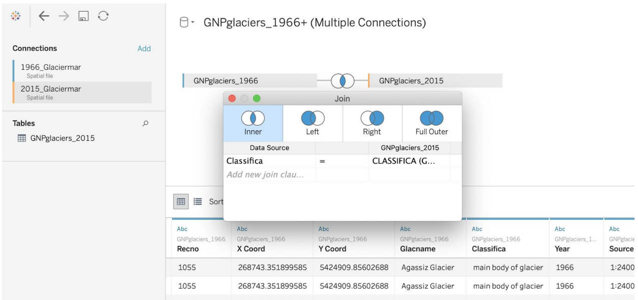
Abc GNPglaciers_1966 Recno	Abc GNPglaciers_1966 X Coord	Abc GNPglaciers_1966 Y Coord	Abc GNPglaciers_1966 Glacname	Abc GNPglaciers_1966 Classifica	Abc GNPglaciers_1... Year	Abc GNPglaciers_1966 Source Sca	Abc GNPglaciers_1966 Source	Abc GNPglaciers_1966 Comment	# GN Sh
1041	273967.708607631	5427330.78714926	Boulder Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1132	276453.100195484	5419732.76738801	Carter Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	1966 margin edited u...	
1185	292401.981825031	5414857.32230536	Chaney Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1094	279133.259744622	5423939.24915264	Dixon Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1283	299428.059935107	5402885.93646811	Gem Glacier	main body of glacier	1966	1:24000	USGS Orthorectified ...	no comment	
1593	296042.327952401	5356015.8412555	Grant Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1277	299561.317272131	5403522.05663152	Grinnell Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1044	263607.079053399	5426928.2393769	Harris Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1601	298787.822549643	5385327.89371717	Harrison Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1013	276809.067840272	5430336.81735584	Herbst Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1029	277158.159051008	5428021.99999975	Hudson Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	

Visualizing Glaciers:

I have taken the Glacier datasets for years 1966, 2015 and imported the data into Tableau data sources

1. Click on Connections -> Add to select 2015 data.
2. I then did an inner join for all the two databases combining them by Glacier names. Then I calculated the area difference for each glacier from 1966 to

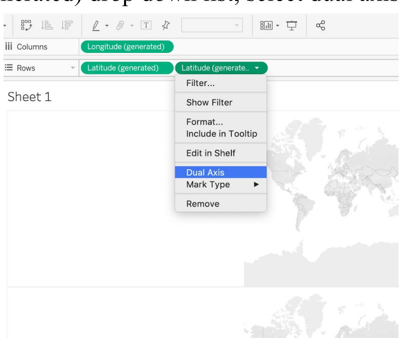
2015 and added a measure for it so that I can show it in the details.



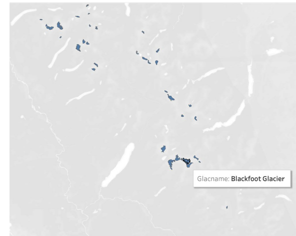
Create a calculated field ‘Area Difference’ by right clicking on one of the datasource table column names and give the formula for calculating the area difference between the area of the glacier in 1966 and area of the glacier in 2015

Steps for visualizing the Glacier National Park(Canada) :

On a new sheet
i) Drag Longitude(generated) to the columns
ii) Drag Latitude(generated) to the rows and again drag Latitude(generated) to the rows. In the second Latitude(generated) drop down list, select dual axis

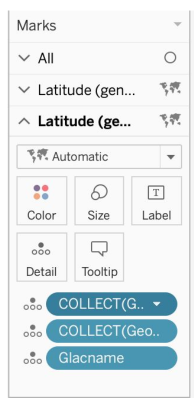


iii) Drag Geometry under GNPglaciers_1966 on to the map
iv) Drag Glacname under Dimensions-> GNPglaciers_1966 on to detail
Now we can see all the glaciers in the Glacier National Park. You can hover on each visualized glacier to notice the name of each glacier that you are pointing to.



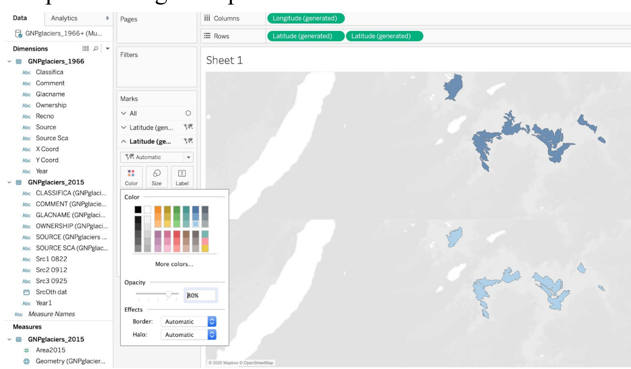
Steps for overlapping the visualizations of glaciers from 1966 to 2015 to show the difference:

In a new sheet
i) Drag Longitude(generated) to the columns
ii) Drag Latitude(generated) to the rows
iii) Under Measures -> GNPglaciers_1966, drag Geometry onto the map. Now you can start seeing the glaciers in the Glacier National Park as small figures on the map colored in dark blue by default.
iv) Drag Glacname under Dimensions-> GNPglaciers_1966 on to detail. Now you can see all the glacier names when you hover over them
v) Hold the command key on your keyboard and click and drag the Latitude(generated) to the right to create a dual geo map. Now you can see two similar looking maps one top of the other.
vi) Under Mark's-> select the second Latitude(generated) arrow to list all the details of the second map

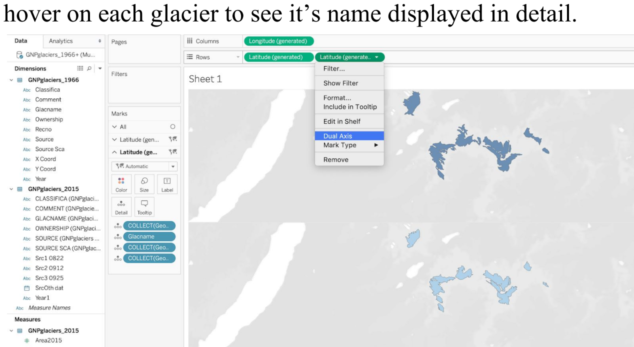


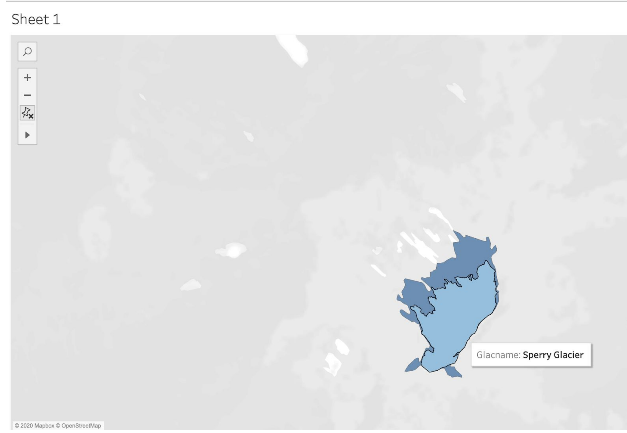
vii) Remove Geometry of the 1966 Glacier and drag and drop the Geometry under GNPglacier_2015 onto the bottom map. Now you can see the visualization of how the same glaciers looked in 2015

viii) Change the color of the visualization to light blue to show the difference of how the glacier looked in 1966(dark blue) to how it looked in 2015(light blue). At this point, you should see a dark blue colored glacier(1966) on the top half part of the geo map and light blue colored(2015) glacier on the bottom half part of the geo map.

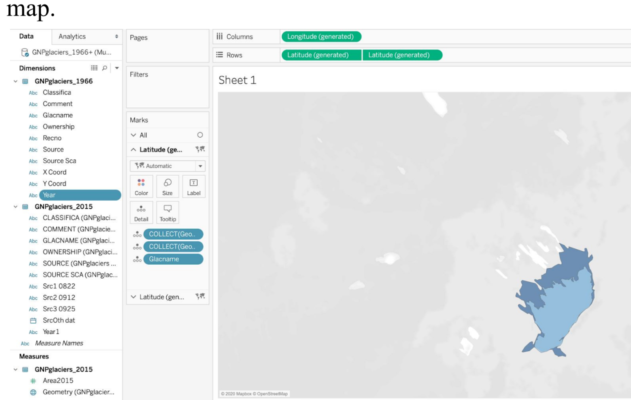


ix) In the second Latitude(generated) drop down list, select the sixth option 'Dual Axis' to create a dual geo map. Now you can see a combined map with two figures overlapped which shows how the glaciers changed from 1966 to 2015. You can hover on each glacier to see it's name displayed in detail.





x) To display year information on the map, Click on the first Latitude(generated) tab to get a list of details. You can see COLLECT([Geometry]) and Glacname already listed under it. In the DataPane, drag Dimension ->GNPglaciers_1966-> Year to the first Latitude(generated) listed at the top. Now you can see Glacname: Boulder ,Year:1966 on the dark blue part of the map.



xi) Click on the second Latitude(generated) tab to get a list of details. You can see COLLECT([Geometry]) and Glacname already listed under it. Drage Year1 listed under GNPglaciers2015 under dimensions area to the second Latitude(generated) listed at the bottom.

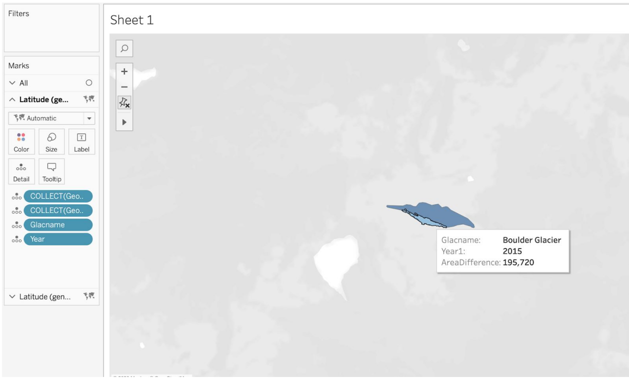
Now you can see Glacname: Boulder ,Year:2015 on the light blue part of the map.

xii) To show how much the area of the glacier has shrunk overtime, drag the custom created measure 'Area Difference' listed under Measures into the bottom Latitude(generated) list. Now when you hover over the glacier, you can see all the details of that particular glacier

Eg: Glacname: Boulder Glacier

Year1: 2015

Area Difference: 195,720



AreaDifferenceCalculations

Glacname	Area1966	Area2015	AreaDiffer..
Agassiz Glacier	1,600,560	736,670	863,890
Ahern Glacier	589,186	511,590	77,596
Baby Glacier	117,171	75,563	41,609
Blackfoot Glacier	1,832,451	1,498,506	333,945
Boulder Glacier	231,018	35,298	195,720
Carter Glacier	355,743	224,774	130,970
Chaney Glacier	563,819	334,485	229,334
Dixon Glacier	291,142	125,831	165,311
Gem Glacier	29,140	22,157	6,983
Grant Glacier	347,753	279,158	68,595
Grinnell Glacier	1,020,200	563,720	456,480
Harris Glacier	148,502	34,261	114,241
Harrison Glacier	2,059,377	1,661,457	397,920
Herbst Glacier	170,234	31,886	138,348
Hudson Glacier	90,213	52,168	38,046
Ipasha Glacier	328,609	194,739	133,870
Jackson Glacier	1,280,508	756,864	523,644
Kintla Glacier	1,309,016	877,726	431,290
Logan Glacier	503,361	219,017	284,344
Lupfer Glacier	126,376	73,275	53,101
Old Sun Glacier	421,347	341,078	80,269
Piegan Glacier	280,152	244,307	35,845
Pumpelly Glacier	1,006,470	902,787	103,682
Rainbow Glacier	1,430,411	1,053,376	377,035
Red Eagle Glacier	134,710	63,685	71,025
Salamander Glacier	229,028	176,109	52,919
Sexton Glacier	400,494	298,682	101,812
Shepard Glacier	250,679	70,739	179,939
Siyeh Glacier	306,296	205,386	100,909

Steps to generate area difference calculations:
In a seperate sheet

i) Drag 'Glacname' under Dimensions to the Rows on the right side in the Column and Rows Shelves

ii) Drag 'Measure Names' under Dimensions to the columns

Now you can see a tabular format of Glacier names as a long list on the canvas part .

iii) Drag 'Mesures Names' into the Filter area

iv) Under Measures in the DataPane, drag 'Measure Values' into Marks-> Text(T) space

v) Under GNPglaciers_1966, drag Area1966 into the canvas pane

vi) Under GNPglaciers_2015, drag Area2015 into the canvas pane

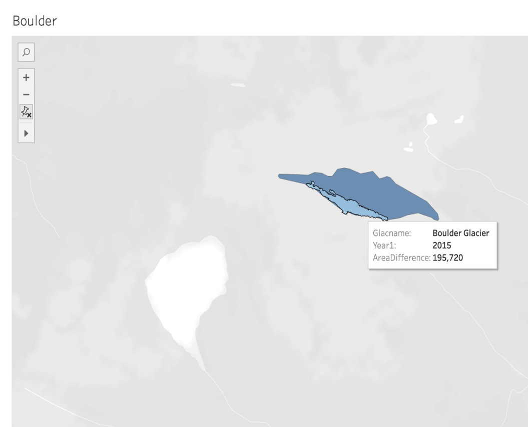
vii) Create a new column in the canvas area and name it as AreaDifference which is calculated by subtracting the area of the glacier in 2015 from the area of the glacier in 1966 to get the area difference.

viii) Now we can see a new measure named 'AreaDifference' under Measures in the data pane.

B. Results

By looking at some of the glaciers (eg: Boulder, Harris, Kintla and Herbst) , we can see a significant decrease in their sizes from 1966 to 2015.

- The Boulder glacier was spread across 231,018 square meters in 1966. The same glacier was measured to 35,298 square meters in 2015 showing the area difference of 195,720.
- The difference in area that existed in our data is getting reflected in our visualizations.



Similarly our visualizations of all the glaciers are reflecting the area differences from 1966 to 2015.

C. Discussions

The visualizations in this section takes the audience through step by step procedure to view all 37 glaciers from Glacier National Park on the map and also enables them to zoom in and zoom out a selected glacier to clearly differentiate the glacier margins from the year 1966 to 2015. As you can see, climate change has a profound effect on melting down the glaciers all around the world which could impact our ecology.

D. What I Learned

I learnt about how to do Geo maps on a dual axis and showing two different information and project a combined visualization on a geomap. How to add filters and change color settings and other filterings in Tableau.

VI. Sea Levels

Sea-level rise due to climate change is a serious global threat.

- Melting ice sheets in Greenland and the Antarctic as well as ice melt from glaciers all over the world are causing sea levels to rise. Glaciers alone lost more than 9,000 billion tons of ice since 1961, raising water levels by 27 millimeters, an international research team has now found. The glacial melt represents about 30 percent of the sea-level rise in that time period of 2003 - 2009.
- Sea levels also go up as the oceans warm, because warm water takes up more space.

A. Methods

Global Average Absolute Sea Level change:

Global Average Absolute Sea Level Change, 1880-2014 from the US Environmental Protection Agency using data from CSIRO, 2015; NOAA, 2015. This project uses two of their datasets: csiro_alt_gmsl_yr_2015_csv and epa-sea-level_csv.

CSIRO (Commonwealth Scientific and Industrial Research Organization)

EPA (United States Environmental Protection Agency)

epa-sea-level_c... Year	epa-sea-level_csv.csv CSIRO Adjusted S...	epa-sea-level_csv.csv Lower Error Bound	epa-sea-level_csv.csv Upper Error Bound	epa-sea-level_csv.csv NOAA Adjusted Se...
3/15/1880	0.00000	-0.9528	0.95276	null
3/15/1881	0.22047	-0.7323	1.17323	null
3/15/1882	-0.44094	-1.3465	0.46457	null
3/15/1883	-0.23228	-1.1299	0.66535	null
3/15/1884	0.59055	-0.2835	1.46457	null
3/15/1885	0.53150	-0.3307	1.39370	null
3/15/1886	0.43701	-0.3819	1.25591	null
3/15/1887	0.21654	-0.6024	1.03543	null
3/15/1888	0.29921	-0.5197	1.11811	null
3/15/1889	0.36220	-0.4567	1.18110	null
3/15/1890	0.44094	-0.3740	1.25591	null

csiro_alt_gmsl_... Time	csiro_alt_gm... Gmsl
3/15/1993	1.4000
3/15/1994	2.7000
3/15/1995	5.7000
3/15/1996	11.4000
3/15/1997	16.1000
3/15/1998	21.9000
3/15/1999	22.1000
3/15/2000	25.0000
3/15/2001	29.6000
3/15/2002	33.3000
3/15/2003	35.4000

This data contains cumulative changes in sea level for the world's oceans since 1880, based on a combination of long-term tide gauge measurements and recent satellite measurements. It shows average absolute sea level change, which refers to the height of the ocean surface, regardless of whether nearby land is rising or falling. Satellite data are based solely on measured sea level, while the long-term tide gauge data include a small correction factor because the size and shape of the oceans are changing slowly over time. (On average, the ocean floor has been gradually sinking since the last Ice Age peak, 20,000 years ago.)

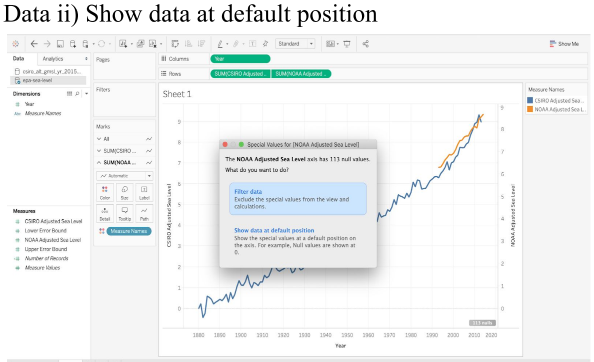
Cumulative changes (in inches) in sea level for the world's oceans based on the combination of long-term tide gauge measurements and recent satellite measurements.

Steps for visualizing Global Average Absolute Sea Level Change:

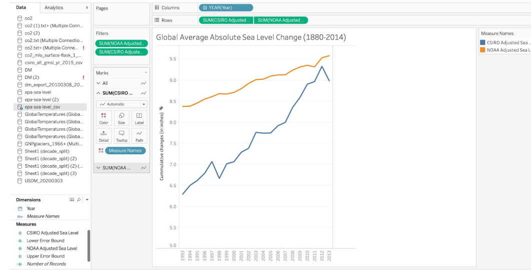
1) I got two datasets csiro_alt_gmsl_yr_2015_csv and epa-sea-level_csv for Sea level change data for years 1993-2013 and imported the data into Tableau data sources.
2) On a new sheet, I selected the epa-sea-level database to create visualizations for that data.
3) Drag year dimension to the columns.
4) Drag CSIRO Adjusted Sea Level and NOAA Adjusted Sea Level to the rows

5) The visualization indicated 113 nulls in the bottom right corner of the visualization.

6) To remove null values, click on the 113nulls and tableau shows two options to remove nulls i) Filter Data ii) Show data at default position



7) Click on Filter Data to exclude the null values from the view using a filter. The null values will now be excluded from any calculations used in the view.



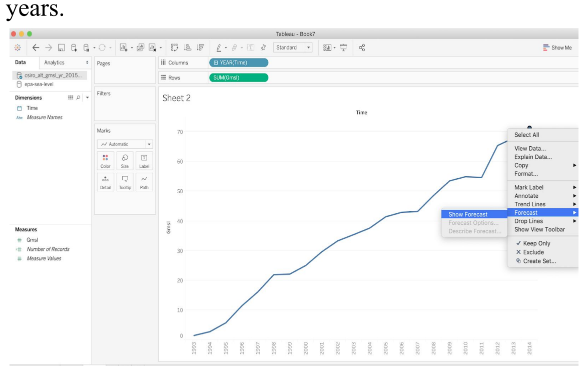
8) You can now see a trend line of changes in sea level over time.

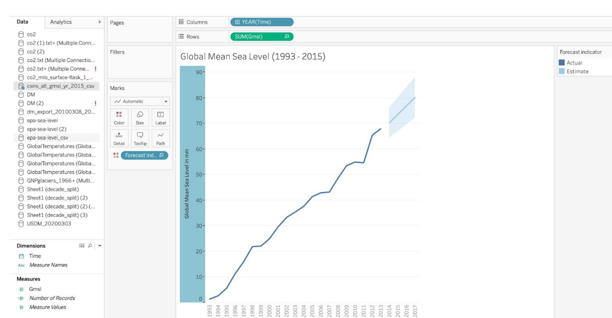
B. Results

The visualizations clearly indicate a linear trend in Global Average Absolute Sea Level change over years

Steps for visualizing Global Mean Sea Level:

1) On a new sheet, select csiro_alt_gmsl_yr_2015_csv database.
2) Drag the time dimension on to columns
3) Drag gmsl measure on to rows
4) You can now see a trend line from the year 1993 - 2015
5) Right click on the trend line, select Forecast -> show forecast to show forecasting trend for the future years.





C. Discussions

The visualizations in this section take the audience through step by step procedure to create a multi line trend chart, how to clean the data with nulls and project the right information on the charts and how to forecast from the history of data available.

D. What I Learned

I learnt how to create dual line trends from a dataset and look at the hidden patterns in data and was able to identify linear trends and at the same time visualize it. During this process, I found many null values in data. I got to experience how to remove null values from data using tableau. I also learned how to make a forecast from the history of data that we have and predict sea level changes in future. This could be very helpful in taking necessary precautions to avoid the problem.

Future Work

For further analysis, one could explore other factors, deforestation and oil and gas drilling, which has known to cause global warming. Additional areas would include impact air circulation and weather patterns.

The human contribution to global warming is heavily contested in the scientific community. In this paper, we established the increase in carbon dioxide emission and discussed the impact of carbon dioxide on global warming and climate change. Further work could include exploring the greenhouse gasses and natural causes (i.e volcanoes and solar activity) to find the relationship between both human and natural causes to climate.

References

[1] https://droughtmonitor.unl.edu/Data/DataDownload.aspx
[2] https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx
[3] https://www.esrl.noaa.gov/gmd/ccgg/trends/
[4] https://www.sciencedaily.com/releases/2013/08/130812170338.htm
[5] https://medium.com/nightingale/how-data-visualization-helps-us-see-the-effects-of-climate-change-8b937ab7a71f
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[7] https://www.usgs.gov/centers/norock/science/retreat-glaciers-glacier-national-park?qt-science_center_objects=0#qt-science_center_objects
[8] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
[9] https://www.nationalgeographic.org/encyclopedia/glacier/
[10] http://documents.worldbank.org/curated/en/156401468136816684/pdf/wps4136.pdf
[11] https://datahub.io/core/sea-level-rise#readme
[12] https://www.sciencedaily.com/releases/2019/04/190408114013.htm
[13] Map of temperatures and analysis of global warming
[14] https://datahub.io/core/global-temp
[15] https://community.tableau.com/thread/142018
[16] https://public.tableau.com/profile/panuwat.monongdern#!/vizhome/AverageTemperatureMapandGraph/Dashboard4
[17] https://www.pryor.com/blog/how-to-work-with-excel-pivottable-dates/
[18] https://climate.nasa.gov/evidence/

Appendix A: Drought Datasets

Drought Dataset 1 for Time Series Area Graphs (Fig. 3)

Sort fields Data source order   Show aliases Show hidden fields 523 rows

Map Date	Area Of Interest	None	D0(Abnormally Dry)	D1 (Moderate Dro...	D2 (Severe Droug...	D3 (Extreme Drou...	D4 (Excep
3/3/2020	CONUS	76.2100	23.7900	11.5200	2.5100	0.5200	
2/25/2020	CONUS	76.9800	23.0200	10.1600	2.2500	0.2300	
2/18/2020	CONUS	76.4900	23.5100	9.5600	2.4900	0.2300	
2/11/2020	CONUS	75.8500	24.1500	10.6000	2.5700	0.1700	
2/4/2020	CONUS	74.3000	25.7000	10.6100	2.4600	0.0700	
1/28/2020	CONUS	73.3200	26.6800	11.0000	2.3900	0.0500	
1/21/2020	CONUS	75.1300	24.8700	11.4700	3.3800	0.0700	
1/14/2020	CONUS	76.7000	23.3000	10.7300	3.1200	0.1100	
1/7/2020	CONUS	75.9400	24.0600	11.1900	3.2200	0.1200	
12/31/2019	CONUS	75.8000	24.2000	11.2000	3.8200	0.0600	
12/24/2019	CONUS	74.3700	25.6300	12.3000	4.1800	0.1000	

Drought Dataset 2 for US Geomaps Graphs (Fig. 4, Fig.5 respectively)

Sort fields Modified   Show alias

Objectid	DM	Drought Level	Shape Leng	Shape Area	Geometry
1	0	0 (Abnormally Dry)	57,268,058.51	1,050,641,317,080.00	MultiPolygon
2	1	1 (Moderate Drought)	18,425,590.65	702,275,939,129.00	MultiPolygon
3	2	2 (Severe Drought)	6,756,777.60	155,415,703,796.00	MultiPolygon
4	3	3 (Extreme Drought)	1,648,339.57	40,324,626,443.80	MultiPolygon

Sort fields Modified Show al

USDM_202003... Objectid	USDM_20... DM	Calculation Drought Level	USDM_20200303.shp Shape Leng	USDM_20200303.shp Shape Area	USDM_20200303.shp Geometry
1	0	0 (Abnormally Dry)	57,268,058.51	1,050,641,317,080.00	MultiPolygon
2	1	1 (Moderate Drought)	18,425,590.65	702,275,939,129.00	MultiPolygon
3	2	2 (Severe Drought)	6,756,777.60	155,415,703,796.00	MultiPolygon
4	3	3 (Extreme Drought)	1,648,339.57	40,324,626,443.80	MultiPolygon

Appendix B: Carbon Dioxide Dataset

As a text file:

```
# data_fields: sample_month sample_day sample_hour sample_minute sample_seconds sample_id sample_method parameter_formula analysis_group_abbr analysis_value
analysis_uncertainty analysis_flag analysis_instrument analysis_year analysis_month analysis_day analysis_hour analysis_minute analysis_seconds sample_latitude
sample_longitude sample_altitude sample_elevation sample_intake_height event_number
MLO 1969 08 20 17 55 00    33-69 N      co2     CCGG   323.170     0.530 ..L  L1 1969 09 09 09 02 00  19.5300 -155.5800  3399.00  3397.00     2.00    78808
MLO 1969 08 20 17 55 00    34-69 N      co2     CCGG   324.720     0.530 +..  L1 1969 09 09 09 12 00  19.5300 -155.5800  3399.00  3397.00     2.00    78809
MLO 1969 08 20 18 30 00    31-69 N      co2     CCGG  -999.990  -999.990 *..  L1 1969 09 09 08 58 00  19.5300 -155.5800  3399.00  3397.00     2.00    78810
MLO 1969 08 20 18 30 00    32-69 N      co2     CCGG  -999.990  -999.990 *..  L1 1969 09 09 09 00 00  19.5300 -155.5800  3399.00  3397.00     2.00    78811
MLO 1969 08 27 19 15 00    35-69 N      co2     CCGG  -999.990  -999.990 *..  L1 1969 09 09 08 42 00  19.5300 -155.5800  3399.00  3397.00     2.00    78812
MLO 1969 08 27 19 15 00    36-69 N      co2     CCGG   326.280     0.530 -..  L1 1969 09 09 08 44 00  19.5300 -155.5800  3399.00  3397.00     2.00    78813
MLO 1969 08 27 19 50 00    37-69 N      co2     CCGG   322.870     0.530 ..L  L1 1969 09 09 08 46 00  19.5300 -155.5800  3399.00  3397.00     2.00    78814
MLO 1969 08 27 19 50 00    38-69 N      co2     CCGG  -999.990  -999.990 *..  L1 1969 09 09 08 56 00  19.5300 -155.5800  3399.00  3397.00     2.00    78815
MLO 1969 09 02 19 20 00    21-69 N      co2     CCGG   320.320     0.530 .X.  L1 1969 09 09 08 28 00  19.5300 -155.5800  3399.00  3397.00     2.00    78816
MLO 1969 09 02 19 20 00    22-69 N      co2     CCGG   320.310     0.530 .X.  L1 1969 09 09 08 26 00  19.5300 -155.5800  3399.00  3397.00     2.00    78817
MLO 1969 09 02 20 00 00    39-69 N      co2     CCGG   322.900     0.530 ..L  L1 1969 09 09 08 30 00  19.5300 -155.5800  3399.00  3397.00     2.00    78818
MLO 1969 09 02 20 00 00    40-69 N      co2     CCGG  -999.990  -999.990 *..  L1 1969 09 09 08 40 00  19.5300 -155.5800  3399.00  3397.00     2.00    78819
MLO 1969 09 12 17 50 00     3-69 N      co2     CCGG   320.790     0.530 ..H  L1 1969 09 19 08 28 00  19.5300 -155.5800  3399.00  3397.00     2.00    78820
MLO 1969 09 12 17 50 00     4-69 N      co2     CCGG   320.440     0.530 ..L  L1 1969 09 19 08 30 00  19.5300 -155.5800  3399.00  3397.00     2.00    78821
MLO 1969 09 12 18 30 00     5-69 N      co2     CCGG   321.150     0.530 ..L  L1 1969 09 19 08 26 00  19.5300 -155.5800  3399.00  3397.00     2.00    78822
MLO 1969 09 12 18 30 00     6-69 N      co2     CCGG   321.400     0.530 ..H  L1 1969 09 19 08 24 00  19.5300 -155.5800  3399.00  3397.00     2.00    78823
MLO 1969 09 24 17 55 00    21-69 N      co2     CCGG   320.280     0.530 ...  L1 1969 10 10 08 08 00  19.5300 -155.5800  3399.00  3397.00     2.00    78824
MLO 1969 09 24 17 55 00    22-69 N      co2     CCGG   320.250     0.530 ...  L1 1969 10 10 08 10 00  19.5300 -155.5800  3399.00  3397.00     2.00    78825
MLO 1969 09 24 18 40 00    29-69 N      co2     CCGG   321.760     0.530 ...  L1 1969 10 10 08 12 00  19.5300 -155.5800  3399.00  3397.00     2.00    78826
MLO 1969 09 24 18 40 00    30-69 N      co2     CCGG   321.270     0.530 ...  L1 1969 10 10 08 14 00  19.5300 -155.5800  3399.00  3397.00     2.00    78827
MLO 1969 10 03 17 50 00    16-69 N      co2     CCGG   320.660     0.530 ...  L1 1969 10 10 08 24 00  19.5300 -155.5800  3399.00  3397.00     2.00    78828
MLO 1969 10 03 17 50 00    17-69 N      co2     CCGG   320.410     0.530 ...  L1 1969 10 10 08 26 00  19.5300 -155.5800  3399.00  3397.00     2.00    78829
MLO 1969 10 17 17 55 00    46-69 N      co2     CCGG   321.400     0.530 ...  L1 1969 10 22 09 48 00  19.5300 -155.5800  3399.00  3397.00     2.00    78830
MLO 1969 10 17 17 55 00    47-69 N      co2     CCGG   321.300     0.530 ...  L1 1969 10 22 09 50 00  19.5300 -155.5800  3399.00  3397.00     2.00    78831
MLO 1969 10 17 19 00 00    48-69 N      co2     CCGG   320.740     0.530 ...  L1 1969 10 22 09 46 00  19.5300 -155.5800  3399.00  3397.00     2.00    78832
```

In Tableau:

co2.txt F1	co2.txt Year	co2.txt Month	co2.txt Day	co2.txt F5	co2.txt F6	co2.txt F7	co2.txt F8	co2.txt F9	co2.txt F10	co2.txt F11	co2.txt CO2 Levels	co2.txt F13	co2.txt F14
MLO	1,969	8	20	17	55	0	33-69	N	co2	CCGG	323.1700	0.530000	..L
MLO	1,969	8	20	17	55	0	34-69	N	co2	CCGG	324.7200	0.530000	+..
MLO	1,969	8	27	19	15	0	36-69	N	co2	CCGG	326.2800	0.530000	-..
MLO	1,969	8	27	19	50	0	37-69	N	co2	CCGG	322.8700	0.530000	..L
MLO	1,969	9	2	19	20	0	21-69	N	co2	CCGG	320.3200	0.530000	.X.
MLO	1,969	9	2	19	20	0	22-69	N	co2	CCGG	320.3100	0.530000	.X.
MLO	1,969	9	2	20	0	0	39-69	N	co2	CCGG	322.9000	0.530000	..L

Appendix C :
Glacier Dataset:

Recno	X Coord	Y Coord	Glacname	Classifica	Year	Source Sca	Source	Comment	Sh
1041	273967.708607631	5427330.78714926	Boulder Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1132	276453.100195484	5419732.76738801	Carter Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	1966 margin edited u...	
1185	292401.981825031	5414857.32230536	Chaney Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1094	279133.259744622	5423939.24915264	Dixon Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1283	299428.059935107	5402885.93646811	Gem Glacier	main body of glacier	1966	1:24000	USGS Orthorectified ...	no comment	
1593	296042.327952401	5356015.8412555	Grant Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1277	299561.317272131	5403522.05663152	Grinnell Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1044	263607.079053399	5426928.2393769	Harris Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1601	298787.822549643	5385327.89371717	Harrison Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1013	276809.067840272	5430336.81735584	Herbst Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	
1029	277158.159051008	5428021.99999975	Hudson Glacier	main body of glacier	1966	1:24000	USGS 7.5 minute qua...	no comment	

Appendix D:
Global Average Absolute Sea Level Change:

Year	CSIRO Adjusted S...	Lower Error Bound	Upper Error Bound	NOAA Adjusted Se...
3/15/1880	0.00000	-0.9528	0.95276	null
3/15/1881	0.22047	-0.7323	1.17323	null
3/15/1882	-0.44094	-1.3465	0.46457	null
3/15/1883	-0.23228	-1.1299	0.66535	null
3/15/1884	0.59055	-0.2835	1.46457	null
3/15/1885	0.53150	-0.3307	1.39370	null
3/15/1886	0.43701	-0.3819	1.25591	null
3/15/1887	0.21654	-0.6024	1.03543	null
3/15/1888	0.29921	-0.5197	1.11811	null
3/15/1889	0.36220	-0.4567	1.18110	null
3/15/1890	0.44094	-0.3740	1.25591	null

Appendix E:
Global Mean Sea Level change:

csiro_alt_gmsl_... Time	csiro_alt_gm... Gmsl
3/15/1993	1.4000
3/15/1994	2.7000
3/15/1995	5.7000
3/15/1996	11.4000
3/15/1997	16.1000
3/15/1998	21.9000
3/15/1999	22.1000
3/15/2000	25.0000
3/15/2001	29.6000
3/15/2002	33.3000
3/15/2003	35.4000

Appendix F: Temperature Anomaly and Carbon emissions

annual.txt Source	annual.txt Year	annual.txt Temperature ...	co2.txt F1	co2.txt F2	co2.txt F3	co2.txt F4	co2.txt F5	co2.txt F6	co2.txt F7	co2.txt F8	co2.txt F9	co2.txt F10	co2.txt F11	co2.txt co2	co2.txt F13	co2.txt F14	co2.txt F15
GISTEMP	1969	0.070000	MLO	1,969	8	20	17	55	0	33-69	N	co2	CCGG	323.170	0.53	..L	L1
GCAG	1969	0.092900	MLO	1,969	8	20	17	55	0	33-69	N	co2	CCGG	323.170	0.53	..L	L1
GISTEMP	1969	0.070000	MLO	1,969	8	20	17	55	0	34-69	N	co2	CCGG	324.720	0.53	+..	L1
GCAG	1969	0.092900	MLO	1,969	8	20	17	55	0	34-69	N	co2	CCGG	324.720	0.53	+..	L1
GISTEMP	1969	0.070000	MLO	1,969	8	27	19	15	0	36-69	N	co2	CCGG	326.280	0.53	-..	L1
GCAG	1969	0.092900	MLO	1,969	8	27	19	15	0	36-69	N	co2	CCGG	326.280	0.53	-..	L1
GISTEMP	1969	0.070000	MLO	1,969	8	27	19	50	0	37-69	N	co2	CCGG	322.870	0.53	..L	L1
GCAG	1969	0.092900	MLO	1,969	8	27	19	50	0	37-69	N	co2	CCGG	322.870	0.53	..L	L1
GISTEMP	1969	0.070000	MLO	1,969	9	2	19	20	0	21-69	N	co2	CCGG	320.320	0.53	.X.	L1
GCAG	1969	0.092900	MLO	1,969	9	2	19	20	0	21-69	N	co2	CCGG	320.320	0.53	.X.	L1

Appendix G: Decade Split

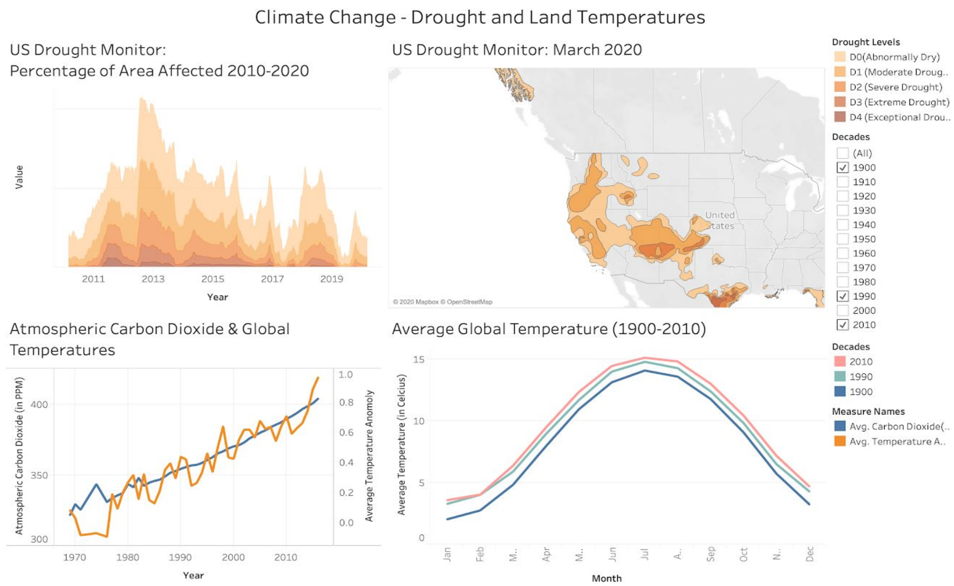
Sheet1 Decades	Sheet1 Jan	Sheet1 Feb	Sheet1 Mar	Sheet1 Apr	Sheet1 May	Sheet1 Jun	Sheet1 Jul	Sheet1 Aug	Sheet1 Sep	Sheet1 Oct	Sheet1 Nov	Sheet1 Dec
1900	2.03060	2.74680	4.82830	7.95430	10.94390	13.12600	14.07940	13.58340	11.77170	9.07140	5.71990	3.23400
1910	2.30200	2.80510	4.67990	8.11830	10.95350	13.13890	14.15490	13.57210	11.74760	9.04750	5.73900	3.11140
1920	2.59900	2.86690	5.13650	8.17240	11.06680	13.22010	14.20710	13.68190	11.94230	9.36430	6.17480	3.47990
1930	2.61300	3.20380	5.11880	8.25340	11.24480	13.39590	14.42040	13.88630	12.08660	9.52430	6.17630	3.77650
1940	2.87590	3.24170	5.28310	8.58660	11.36150	13.44020	14.40500	13.91120	12.13430	9.64910	6.18230	3.63410
1950	2.71170	3.12250	5.19820	8.37640	11.26030	13.43530	14.30840	13.83760	12.06510	9.38100	5.96390	3.78960
1960	2.68050	3.31510	5.27370	8.30390	11.20500	13.42520	14.27200	13.80610	12.01040	9.44600	6.11760	3.74200
1970	2.68030	3.18850	5.35760	8.55770	11.36160	13.45450	14.31030	13.78380	12.03720	9.26990	6.10090	3.79850
1980	3.13130	3.57390	5.60230	8.72580	11.60520	13.59380	14.54280	14.13880	12.26370	9.49980	6.19110	4.06940

Appendix H: Global Temperatures

Sheet1 dt	Sheet1 AverageTemperature	Sheet1 AverageTemperatureUncertainty	Sheet1 Country
01-02-1824 00:0...	5.5600	2.15300	Bhutan
01-03-1824 00:0...	9.3730	1.66300	Bhutan
01-04-1824 00:0...	12.3350	2.03200	Bhutan
01-05-1824 00:0...	15.0440	1.72300	Bhutan
01-06-1824 00:0...	17.4710	2.41100	Bhutan
01-07-1824 00:0...	18.9100	2.73900	Bhutan
01-08-1824 00:0...	17.4990	1.82400	Bhutan
01-09-1824 00:0...	15.9120	1.78200	Bhutan
01-10-1824 00:0...	11.8620	1.60100	Bhutan
01-11-1824 00:0...	8.6350	1.78200	Bhutan

Appendix: Dashboard

Dashboard 1:



Dashboard 2: