The Costs of Climate Change: An Analysis of Climate and Disaster Cost Trends

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1. Introduction

What areas of the US are experiencing the most climate change and to what extent are changes in temperature and precipitation data correlated with disaster cost data? To address these questions, I gathered precipitation and temperature data and drought and wildfire disaster data from the National Oceanic and Atmospheric Administration. By analyzing summary statistics from county-level climate data, the West and Southwest regions of the US showed the most climate change. The disaster data showed that disasters and disaster costs have increased over time since the records began being tracked in 1980. By using linear regression with the climate and disaster cost data from the West and Southwest, results revealed that there was a general negative correlation between precipitation change and disaster costs and a general positive correlation between temperature change and disaster costs. These results were largely expected and confirm that further more-detailed analysis should be done concerning climate change and disaster costs.

2. Background

Climate change caused by carbon emissions producing the greenhouse effect has been well proven in the scientific community. The effects of climate change have been widespread and include higher temperatures, changing precipitation patterns, more droughts/heat waves, stronger hurricanes, and rising sea levels, according to NASA. All of these changes will inevitably lead to our society making drastic changes in how we live. To make good decisions on how to prioritize resources devoted to climate change in the future, it is critical to know the severity and costs of climate change's effects.

Measurable costs of climate change are certain types of natural disasters. In recent years, evidence has seemed to suggest that there have been more wildfires, droughts, and severe storms than normal. This trend is seen to be a broad occurring phenomenon across the world, but it can also be seen in certain parts of the US that have measured significant climate change. For example, a recent years-long California drought from 2011-2017 has been attributed to climate change numerous times.

This project looks at climate and disaster data in an attempt to answer the following research questions: (A) Which areas of the United States have seen the most extreme changes in precipitation and temperature and (B) to what extent are changes in temperature and precipitation data correlated with disaster cost data. Ultimately, answers to these questions are important because they can further the evidence of a link between climate change and disasters and possibly provide a starting point for predicting disaster costs based on climate data.

Because the western US is known for its increasingly harsh climate, it is expected that the results show that the West has experienced more climate change than other parts of the country. For the climate and disaster data, there is expected to be some sort of correlation between raw

temperature and precipitation data and drought and wildfire cost data since those disasters are heavily influenced by the climate.

3. Methods

- **Data**

The data used in this project is from National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information. More specifically, the temperature and precipitation numbers are from the "Climate at a Glance" (2021) dataset and the disaster cost data is from the "Billion-Dollar Weather and Climate Disasters" (2021) dataset.

The "Climate at a Glance" data used in this project features 2020 county-level data with values for precipitation (in), temperature (F°), and anomalies (temperature and precipitation deviations from a 1901-2000 base mean). The same variables are found in another dataset used which features regional data in the West and Southwest from 1980-2020. The West region is defined as California and Nevada and the Southwest region is defined as Utah, Colorado, New Mexico, and Arizona.

The "Billion-Dollar Weather and Climate Disasters" data used in this project is 1980-2020 Data from the West and Southwest which features many disaster cost variables, namely drought and wildfire cost variables.

Additional data used in this project includes shapefiles from the lecture with the counties/states of the US and a CSV the World Population Review which has the number of counties per state.

- **Procedure**

The first objective of the data was to organize it to find areas of the contiguous US that are currently seeing the worst effects of climate change. In Table 1, by using county-level data from 2020, I calculated the summary statistics for temperature and precipitation anomalies. To find counties with the most climate change, I then subsetted the counties into areas that were in the upper quartile of temperature anomaly and lower quartile of precipitation anomaly (i.e., counties that were drier and hotter than the rest). Table 2 shows the results of this subset by showing the percentage of counties in each state which fit the criteria of being in the upper quartile of temperature anomaly and the lower quartile of precipitation anomaly. Figure 1 further shows the hottest and driest counties in the US in terms of deviations from the base mean by using a map with a color scale.

Table 1

Summary Statistics of County Temperature and Precipitation Data

	Anomaly	Min.	Q1	Median	Mean	Q3	Max.
1	Precipitation	-29.5	-2.44	2.73	4.318	10.61	37.88
2	Temperature	-0.5	1.6	2.2	2.178	2.7	4.6

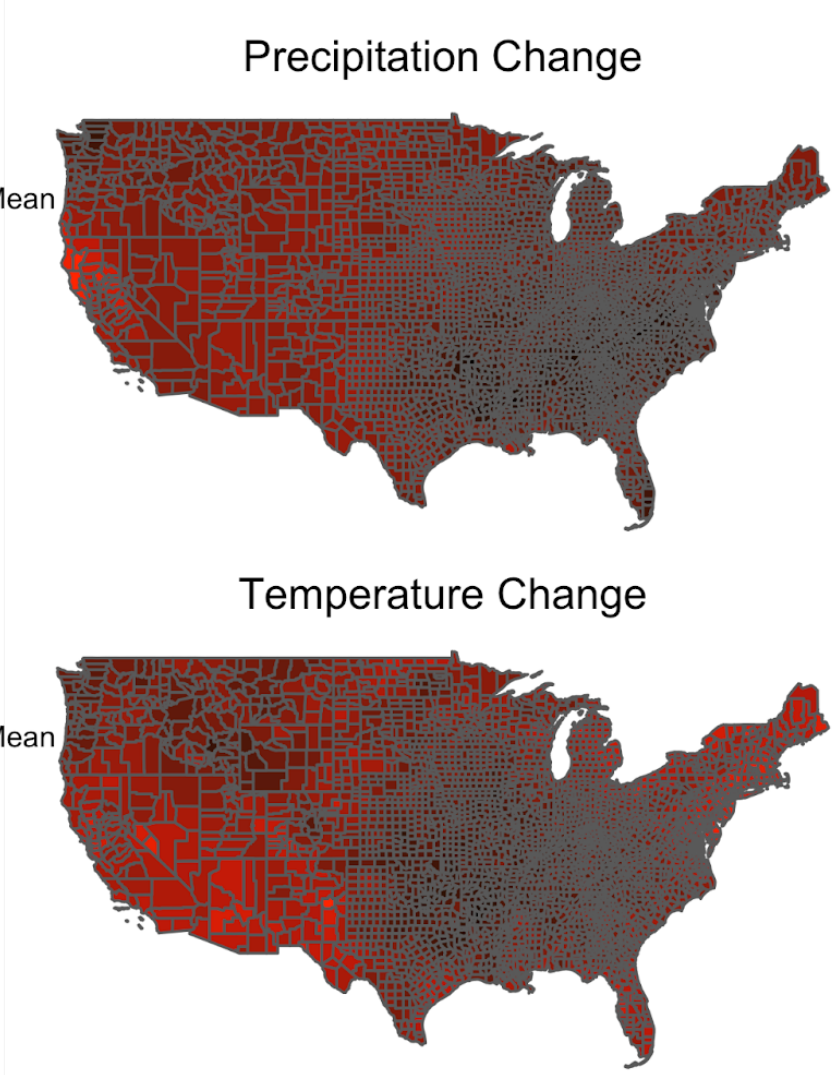
Table 2

Percentage of States' Counties in Top Change Quartiles

	State	Percent
	<chr>	<dbl>
1	NM	90.9
2	CA	86.2
3	NV	81.2
4	AZ	80
5	UT	58.6
6	CT	50
7	MA	50
8	NH	40
9	CO	34.4
10	ND	24.5
11	VT	21.4
12	NY	17.7
13	WY	17.4
14	NJ	14.3
15	TX	14.2
16	ME	12.5
17	FL	9
18	SD	7.6
19	PA	7.5
20	ID	6.8
21	OH	5.7
22	OR	5.6
23	MN	4.6
24	NE	4.3
25	LA	3.1
26	MT	1.8
27	AL	1.5
28	MS	1.2

Figure 1

Climate in 2020 Compared to Base Mean



After finding the regions with the most climate change, I focused on trying to show a relationship between disaster costs and time. To do this, I produced Figure 2 with two axes to show the relationship between disasters/disaster cost over time. I also produced Table 3 which shows conditional means for disaster costs over certain time periods.

Figure 2

Disasters Over Time

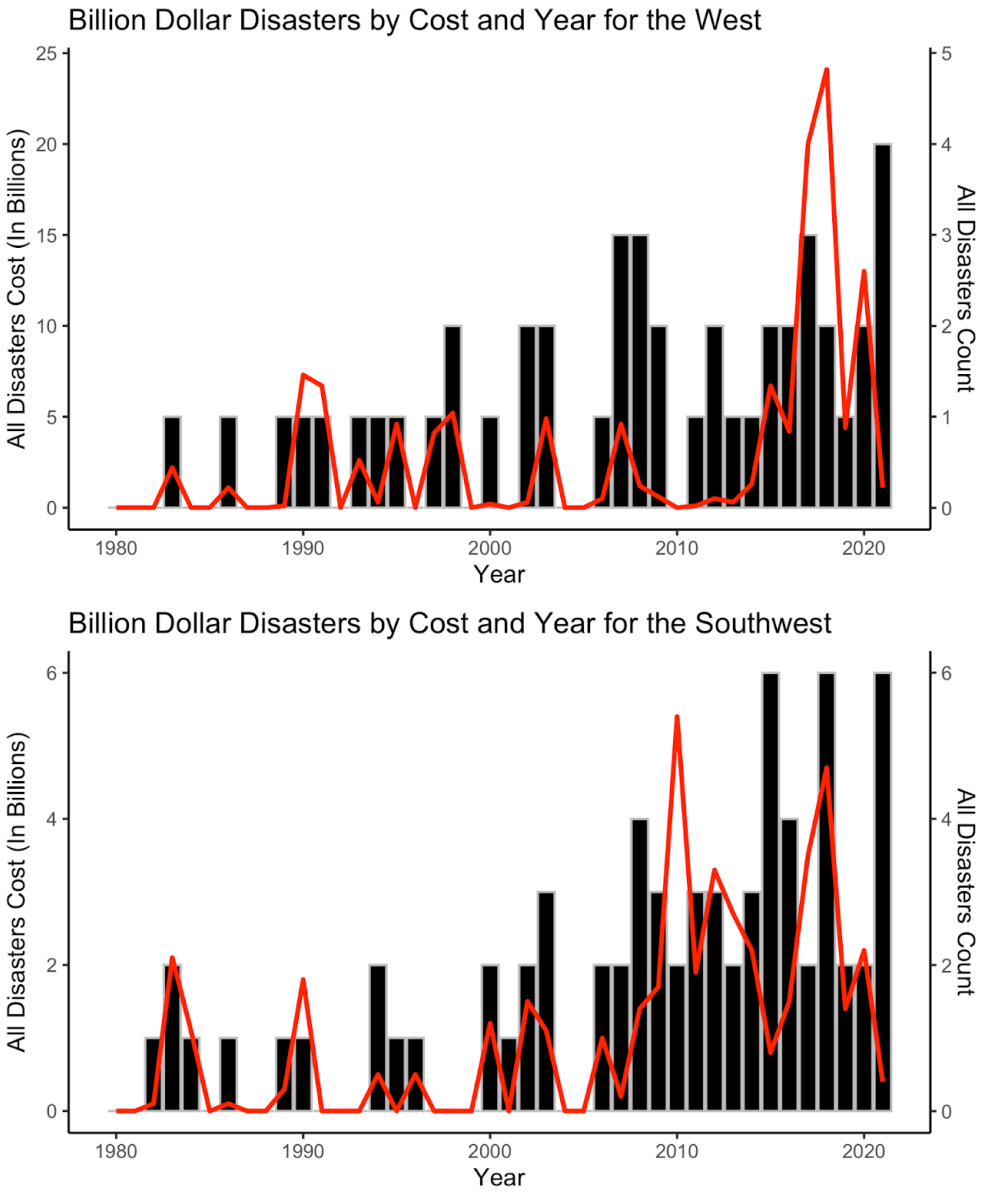


Table 3

Average Disaster Cost by Time Period

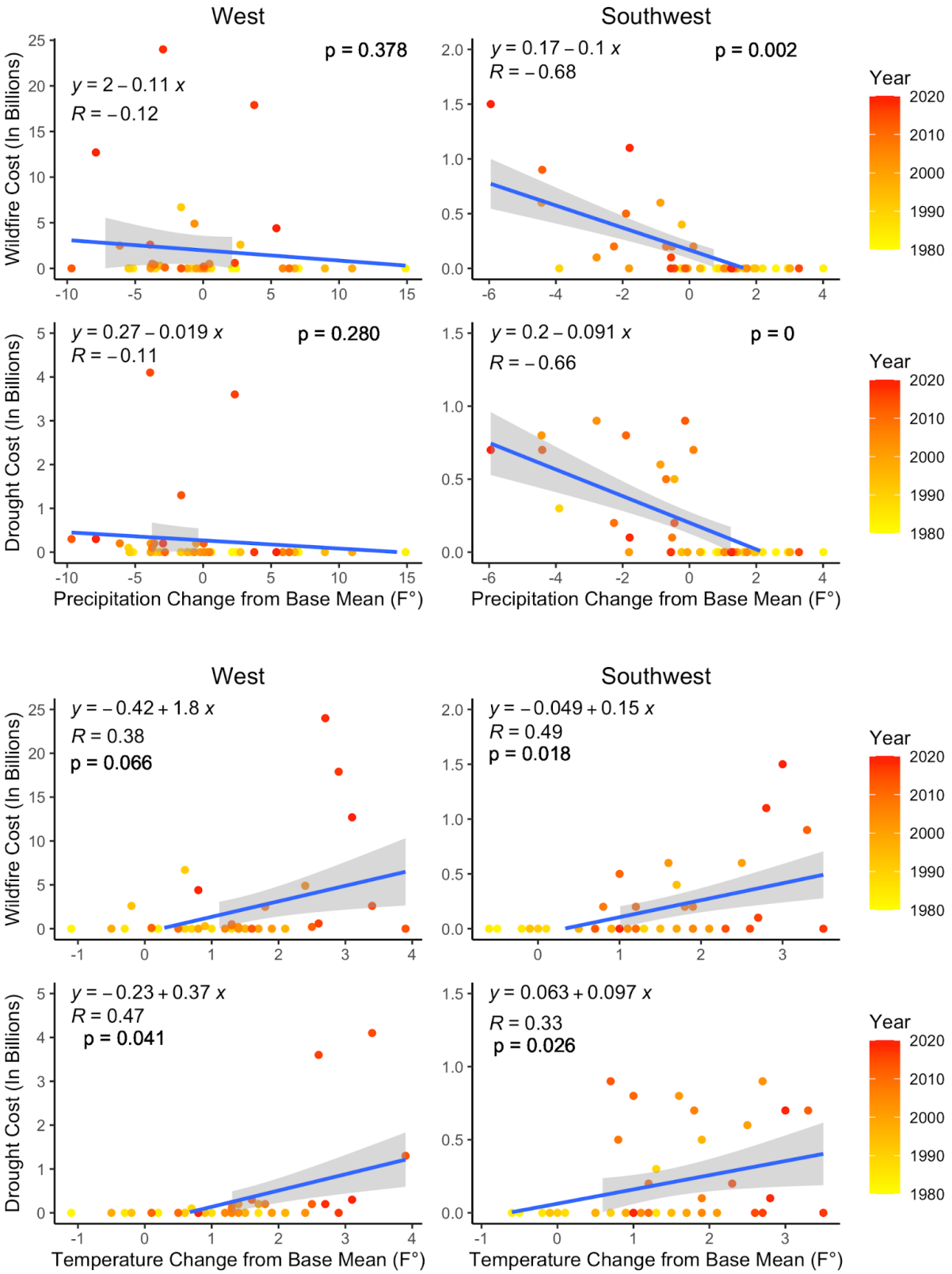
	year_group	`West Average Disaster Cost`
	<fct>	<dbl>
1	1980-1989	0.34
2	1990-1999	3.08
3	2000-2009	1.23
4	2010-2015	1.48
5	2016-2020	13.1

	year_group	`Southwest Average Disaster Cost`
	<fct>	<dbl>
1	1980-1989	0.37
2	1990-1999	0.28
3	2000-2009	0.81
4	2010-2015	2.72
5	2016-2020	2.66

The final and most prominent part of my procedure was attempting to find a correlation between the climate and disaster cost data. I combined the climate and disaster cost datasets for the West and Southwest regions and then tested for correlation between the climate variables of temperature and precipitation and the disaster cost variables of drought and wildfire. The analysis between the climate and cost variables also featured a regression line and displayed the slope of the line to show the scale of a potential relationship.

Figure 3

Correlation Scatterplots Between Climate and Disaster Costs



4. Results

To answer question (A), the county-level analysis revealed an overwhelming pattern that the West and Southwest regions of the US experienced the most climate change. Table 2 showed the percentage of counties within each state that were in the extreme quartiles of perception loss and temperature gain. At the top of Table 2 were five western states with percentages higher than 50. California, Nevada, New Mexico, and Arizona had percentages that were 80 or higher. Additionally, the heat maps of the US in Figure 1 showing precipitation and temperature change also showed that the West and Southwest regions were in red, meaning that they experienced the most climate change. An interesting result of the summary statistics in Table 1 was that precipitation change was positive (2.73 in.), meaning that counties got on average more precipitation than the 1901-200 base mean values. This result could be attributed to the known effect of climate change to produce more severe storms, and therefore, more rainfall in certain areas of the US.

Analysis of disaster costs in the West and Southwest in Figure 2 and Table 3 showed expected trends that disasters and costs both increased over time. Huge spikes in both disasters and cost seemed to happen around 2010 for both the West and Southwest and have largely continued to increase. The maximum West's costs (around 25 billion in a year) were significantly higher than Southwest's (around 5 billion in a year). This discrepancy is most likely due to differences in many factors including climate, land area, and population.

To answer question (B), regional analysis of the West and Southwest shown in Figure 3 revealed that there was a general negative correlation between precipitation change and disaster costs and a general positive correlation between temperature change and disaster costs. This was an expected result. The West's costs were on a larger scale of billions for reasons that I explained above. The highest correlation occurred in the Southwest between precipitation change and drought/wildfire costs with correlation coefficients of -.68 and -.66 respectively. Correlation was weakest between precipitation change and drought/wildfire costs, but results were also statistically insignificant. Correlation coefficients for the West and Southwest between temperature and drought/wildfire cost ranged between .33 and .49. Costs in the West per degree change were also much higher than the Southwest for wildfires and droughts. Overall, correlation seemed to exist between raw climate data and disaster costs. This was especially true for precipitation and disaster cost data for the Southwest. No statistically significant result was obtained for precipitation and disaster cost data for the West, however.

5. Conclusion

- **Limitations**

There are many limitations to this project. One of the most obvious limitations has to do with the correlation analysis. This project is only a simple analysis between two variables and

features no controls or research on what other factors could be affecting cost and climate data. More analysis would have to be done to further the results of this project.

Using regional climate and disaster data is another limitation to this project. Unlike the climate data, I was unable to find a data set for county-level disaster costs. This limited my project to focus on regional data which is imprecise and doesn't narrow down which exact locations are most affected by disaster costs.

Additionally, using climate data from only 2020 and comparing it to base means from 1901-2000 is another limitation of this project. The choice to use data from only a year to show long-term change leaves the possibility of outlier statistics skewing the data. A better analysis would try to avoid potentially skewing the statistics by using a longer timeframe than one year.

Finally, the fact that there are only 40 years of disaster data is a limitation of this project. The lack of data points makes it that much harder to find statistical significance in the data.

- **Implications and Future**

The results of this project gave some evidence that disaster costs were correlated with climate data and furthered the evidence that the West/Southwest is experiencing the most climate change. Evidence that disasters have been continually getting more costly over time was also shown. These results should be particularly important for policymakers in the West/Southwest as it shows that significant climate change along with disaster costs are increasing over time. Future analysis using county-level disaster and climate data could produce results that show specifically which areas in the western US are most susceptible to disaster costs. The disaster risk would be especially useful to know for property buyers and insurance companies in the western US since it will affect prices. The limited analysis in this project already shows that disaster costs are likely to increase as time goes on and climate change worsens. In the future, more detailed analysis that breaks down county-level data and includes more variables will have to be done to get a more complete picture of how disaster costs and climate change are related over time.

References

NOAA National Centers for Environmental Information, Climate at a Glance: Global Mapping, published November 2021, retrieved on December 10, 2021 from https://www.ncdc.noaa.gov/cag/

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73