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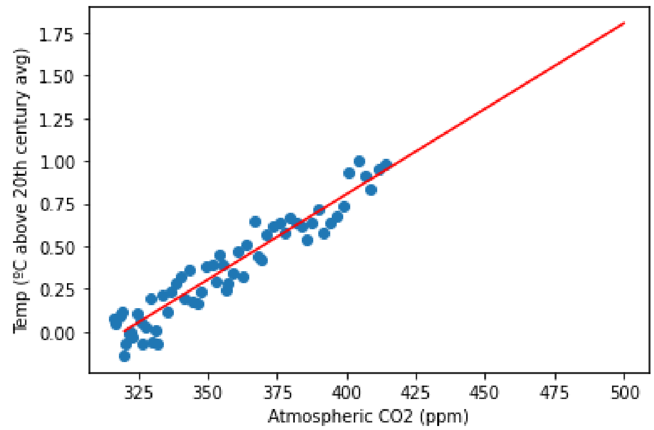
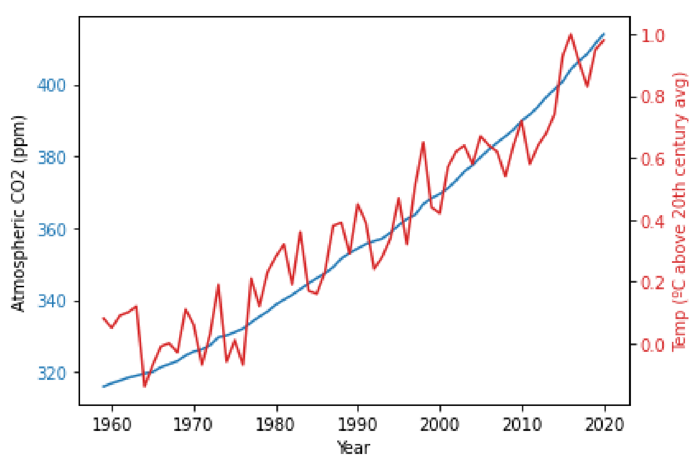
Creating a Simple Climate Model from Scratch

One of the greatest applications of science, broadly speaking, is to give insight into how some aspect of life may change in the future. When faced with a problem, science can often lead the way to find a solution. In the case of climate change, the idea is the same, but the scale, pressure, and repercussions are serious. Climate modeling is one way scientists attempt to shed light on the Earth's future using a system of equations to model some part of its climate. Laws governing thermodynamics, the sun's radiation, air and water properties, and other parts of the planet's function combine to make a somewhat comprehensive depiction of Earth's climate (McSweeney 2018). These models can be used for anything from weather forecasting to predicting social impacts of certain changes, but perhaps their greatest purpose is that of predicting the future effects of climate change. In an attempt to have the experience myself, I set out to make my own model that would predict a range of temperatures Earth could experience by the year 2100.

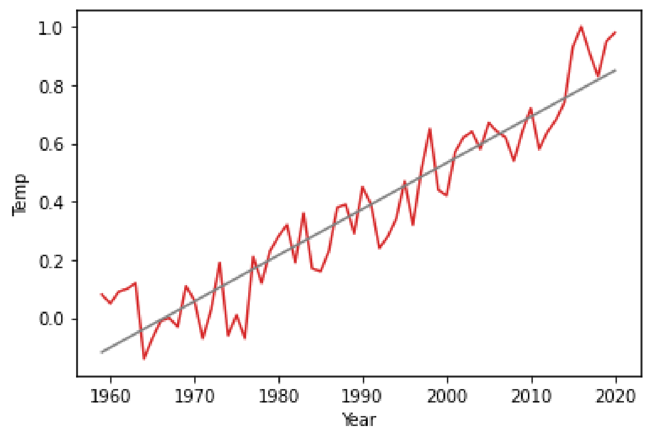
My version is quite simplistic, as I do not have years to conduct research or access to a supercomputer. But while it might not be the most precise fortune teller, it can be used to give a qualitative overview glimpse into the future. First, I merged two datasets from the National Oceanographic and Atmospheric Administration (NOAA) into a single spreadsheet. The first of these, my independent variable, represents atmospheric carbon dioxide emissions at the Mauna Loa Observatory in Hawai'i. Far from local carbon emission sites, the remote location of Mauna Loa was ideal for these readings, which began in 1959. The second dataset is global land and ocean temperature averages, specifically the anomaly when compared to the 20th-century average. After importing the spreadsheet to a Python notebook (a common method of programming in the Python language) and executing necessary formatting, viewing the data as a scatter plot shows a strong linear correlation:



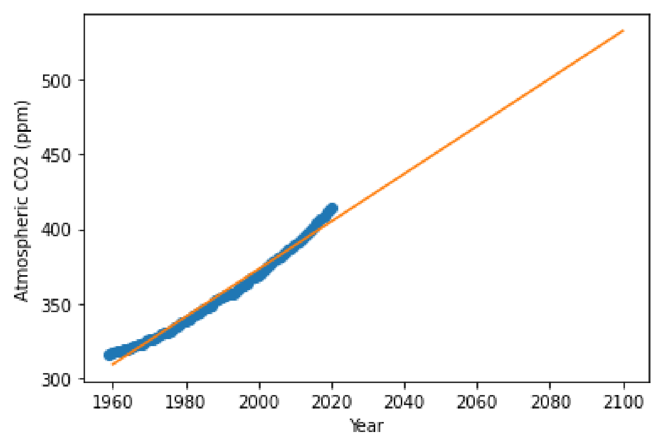
Specifically, the line follows Temp = 0.01001608 * CO2 - 3.20224, an equation which will be useful later. After further consideration on using these axes, however, I decided that adding the dimension of time was crucial to better understand possible temperature scenarios in the future. After these changes, the plot looked quite different:



Although an exact prediction for future temperatures is never possible, predicting within a range of feasibility is. To compute this range of feasibility, I found the standard deviation of the temperature data from its line of best fit:

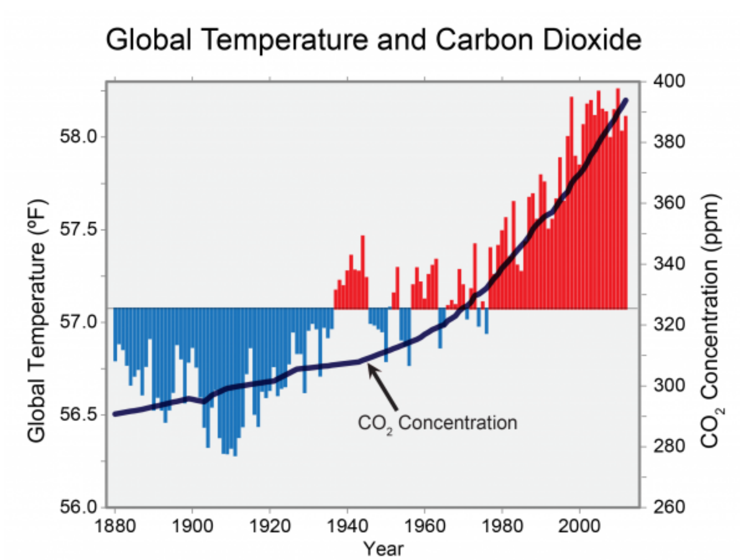


After a simple linear regression, I found the standard deviation (average difference between line of best fit and real values) to be about 0.10425ºC. The next step was to predict atmospheric carbon levels for the year 2100. A second linear regression predicts this value to be around 532.547ppm by that year.



Using the relationship between CO2 and temperature from the first model and the margin of error found using standard deviation, we can estimate that Earth's temperature in 2100 will be around 0.01001608 * 532.547ppm - 3.20224 ≈ 2.13ºC ± 0.10425ºC higher than the 20th century average of 13.9ºC (NOAA). According to my model, which can be found here, Earth's temperature would be between about 15.93ºC and 16.14ºC by 2100. It should be noted that there are several assumptions that are made in my model. First of all, while CO2 and temperature levels do follow a somewhat linear trajectory from 1959 - 2020, there is no guarantee these data will continue linearly (in fact, the well-being of our planet depends on decreasing the slope of these curves). Second, the predicted temperature range for 2100 assumes that the standard deviation of temperature will remain constant into the future. Finally, atmospheric carbon dioxide levels are not the only factor influencing global temperature, as this model assumes.

Although my model is simple compared to some complex global prediction models, it can be compared to other simple graphs to check its accuracy. One model from the United States Global Change Research Program also shows the correlation between Atmospheric carbon dioxide and Earth's temperature, a similar trend to what I produced:



Taking a step back, this research and work produces only numbers, varying degrees of arbitrary projections. Implementing stricter environmental policy is one of the most important steps to mitigating climate change. While these predictions are not direct solutions, they can help envision a future much different from ours today. Based on the data, Earth's future looks feeble, so immediate, widespread climate action has never been more crucial.

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