Climate Trend Analysis

For CSCI 4502: Data Mining

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Introduction

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- Climate change is still a very controversial topic, mostly among the non-scientific community
- We want to easily and precisely describe a correlation between global temperatures and CO_2 emissions

Related Work

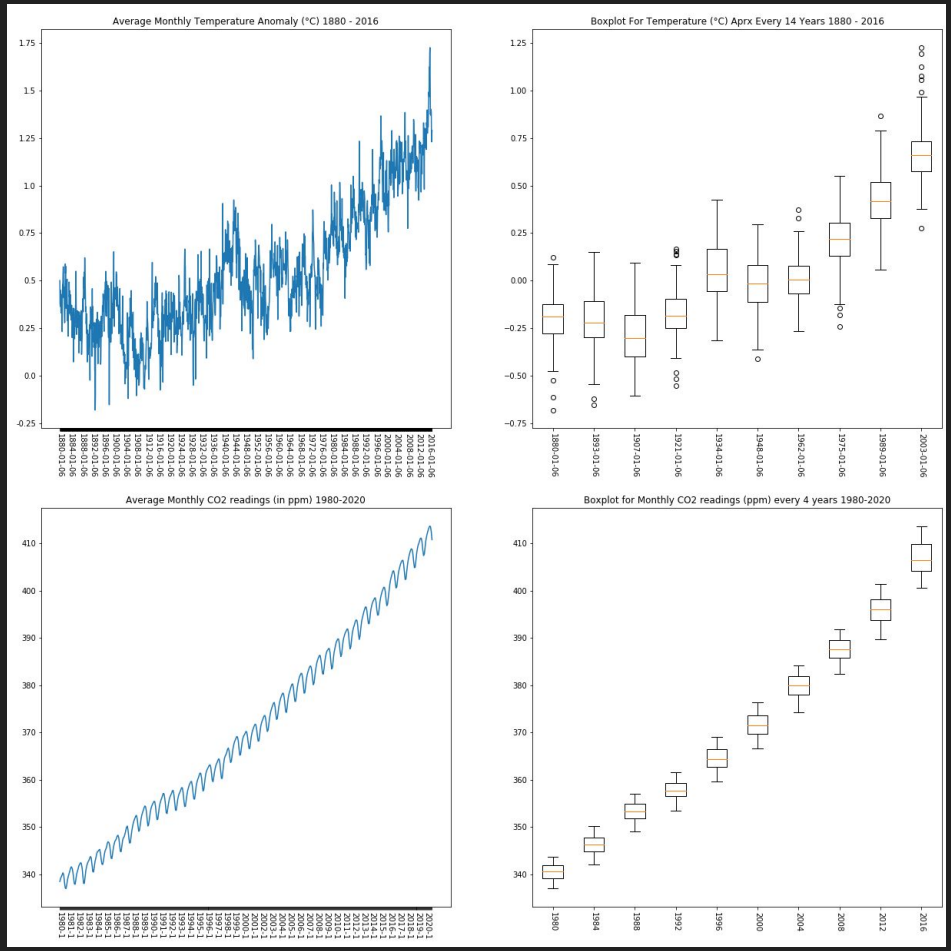
- The US government agency, NOAA, has a carbon tracker that tracks the release of CO_2 at certain points on the globe. They also have data on the minimum size of the arctic sea ice over the years.
- NASA also has a climate website with scientific consensus of the correlation of CO_2 emissions and the rise in global temperature from multiple research groups. It also lists multiple correlations such as sea ice minimums, sea level, and ice sheet size variation.
- This information has been used by scientists and citizens to look at the relationship of CO_2 emissions with temperature. We hoped to corroborate their conclusions and analyze the trends of emissions with temperature as well as Arctic sea ice annual minimums (the lowest level of each year) and other factors.

Background: Carbon Cycle

- Carbon is stored below ground as minerals and oil, as well as living things
- This is why burning fossil fuels (underground stores of carbon) and deforestation (a living storage of carbon) are likely sources of man-made carbon dioxide emissions
  - Fossil fuels are used for many applications such as transportation/shipping, manufacturing, and producing energy
- An article from the NOAA also describes “Blue Carbon” (References #3)
  - Coastal soils and vegetation that can store carbon for much longer than forests

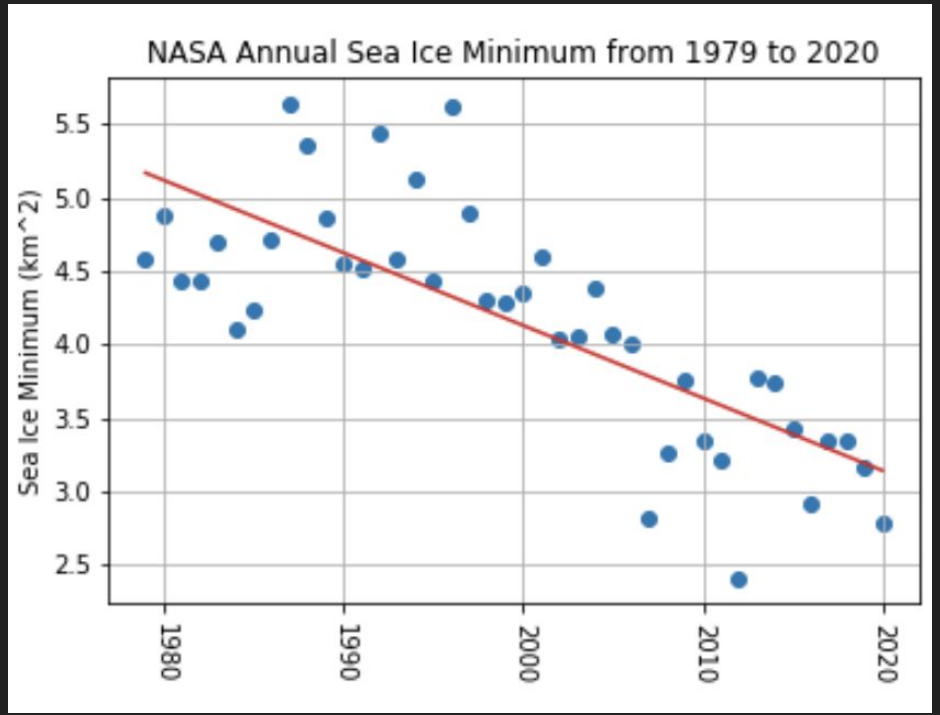
Visualization

- Visualizing the temperature datasets has shown us that there has been a steady increase in the temperature anomaly (difference from the temperature mean of 1880 average temperature) over time
- CO_2 levels have increased at a constant rate; summers contain the peak levels for each year
- The box plot shows that there have been many outlier years where the temperature anomaly has deviated significantly above and below the average.
    - Recently, there have been more outliers above the average temperature



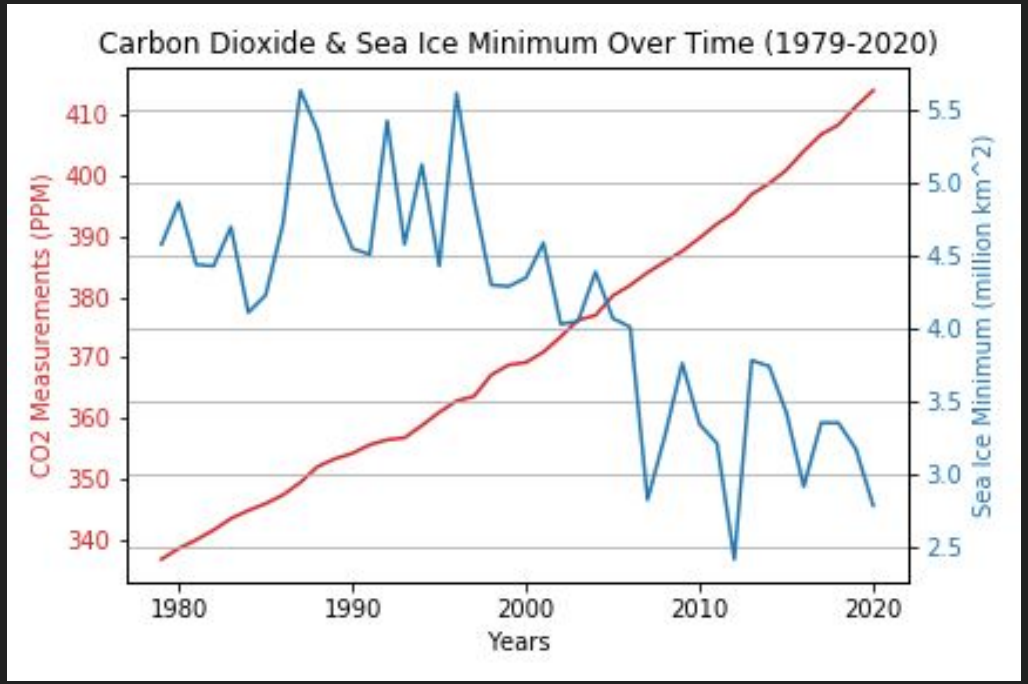
Visualization

- General downward trend in annual sea ice levels
- Mean: 4.154 million km^2
- Median: 4.295 million km^2



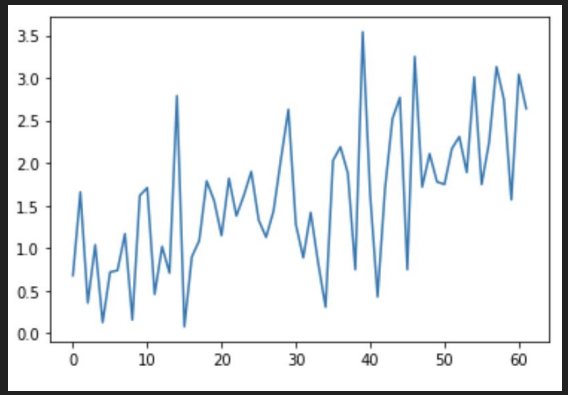
Analysis

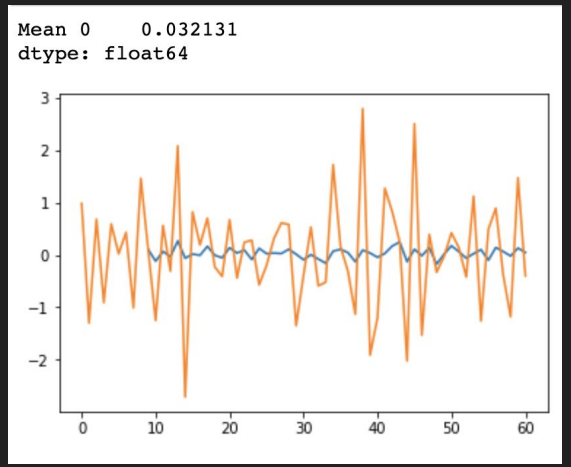
- There also appears to be a correlation between the increase in CO_2 levels and the decrease in annual sea ice minimum measurements.
- A loss of over 1 million km^2 of sea ice over 40 years is significant
  - 20% decrease in average levels (4.5 million km^2 to 3.5 million km^2)



Analysis

- We calculated the first derivative to see how the rate of change of CO_2 levels was changing
  - Positive trend
- Found second derivative of the CO_2 measurements dataset to observe if it was increasing in the atmosphere at an increasing rate
- A mean of the second derivative values for the range of the data was positive: 0.0321
  - Moving average graphed in blue





Correlation of Temp. Anomaly

- Used two linear regression(LR) models (using scikit-learn) and fit them on two different ranges
  - 1880-1930: The R^2 value for the LR trained on the first 50 years is incredibly low, although the accuracy of data collection is likely lower for this period.
    - Little correlation
  - 1930-2016: The R^2 value for LR trained on last 86 years of dataset is much greater
    - Possible correlation

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R^2 for 1880-1930:  3.599101122120363e-05
R^2 for 1930-2016:  0.6394000467793297
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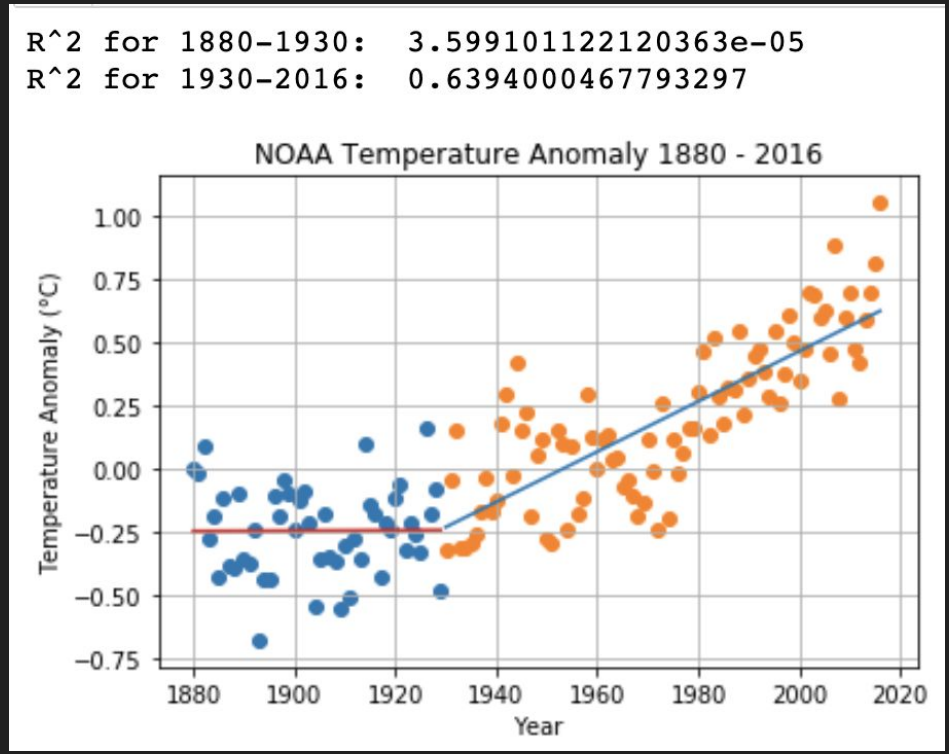
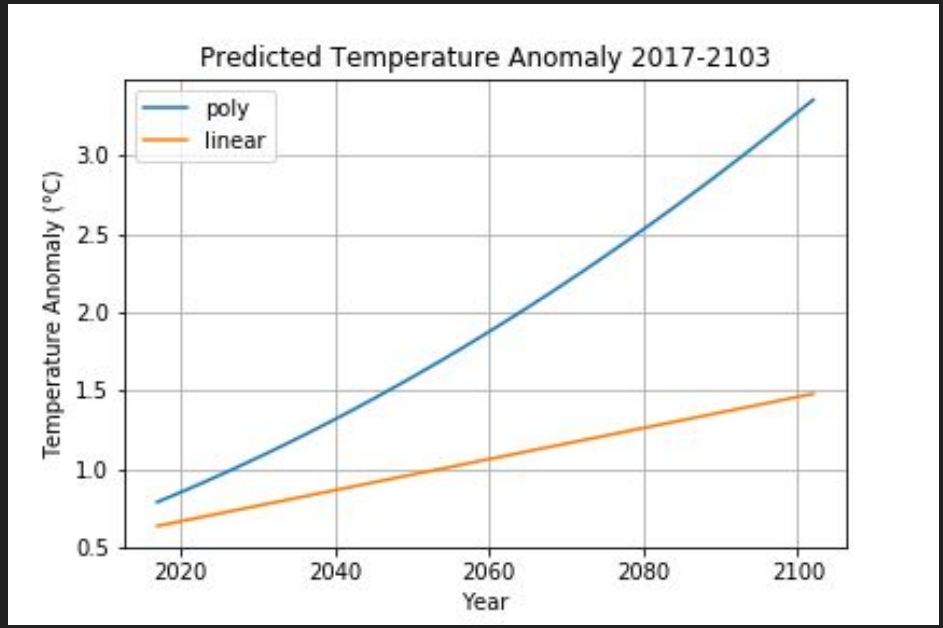


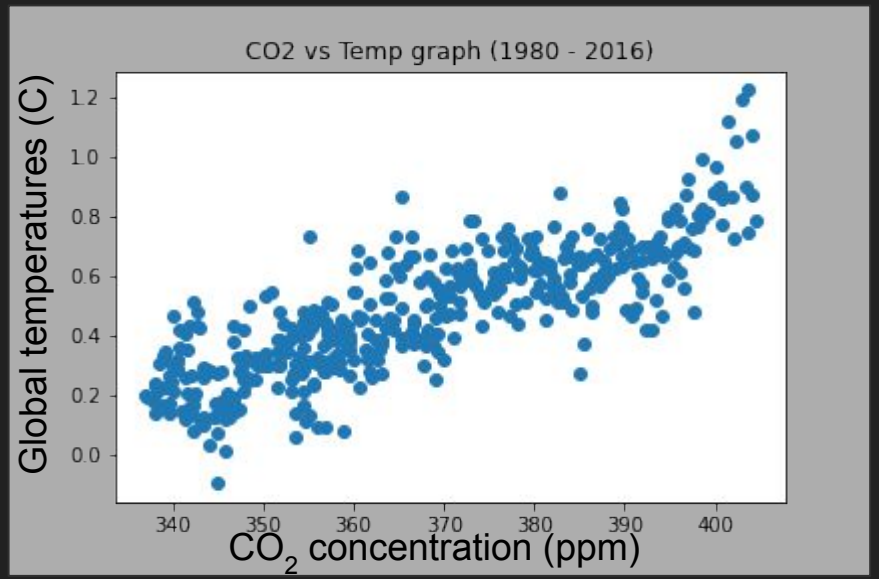
Projecting Data

- Used a regular linear regression and a linear regression with polynomial features to fit to temperature anomaly data
  - The polynomial fit showed a more aggressive increase in temp. anomaly (Which is measured at 1.0569 degrees in 2016)
  - Polynomial increase to 2103: 3.356 degrees Celsius
  - Linear increase to 2103: 1.479 degrees Celsius



Conclusions

- There is a definite relationship between atmospheric CO2 levels and global temperature increase
  - Correlation: 0.82
- The rapid rise of these atmospheric levels, as well as our projections of temperature increase up to 2103, call for dramatic action by humans to reduce the level of carbon in the atmosphere



Conclusions

- The only way to reduce atmospheric CO2 levels is to store the carbon in a solid state
- A study from 13 institutions, which focused on forests in Malaysian Borneo, found that forest restoration methods could speed up the storage of carbon from the atmosphere
    - This is done by increasing the speed of forests' natural growth rates (methods such as nurseries for native tree species)
    - They report that it would take 40 years to restore an average forest if these methods were used aggressively

Conclusions

- The NOAA also reports that the level of CO2 in the atmosphere is greater than any other time in the last 800,000 years (Reference #4)
- Governments need to incentivize forest restoration practices in order to begin the storage of atmospheric carbons
    - Carbon offset programs, like carbon credits for manufacturing corporations, could help fund these types of forest restoration projects
- Some initiatives require governments to set aside land for reforestation, but these agreements are flawed because plantations satisfy the requirement (Reference #5)
    - These plantations will not reduce the atmospheric carbon levels because they are eventually deforested in order to harvest the wood
    - Natural forests are the only real solution

Questions for further research

- How might melting ice caps affect further temperature change?
  - “When warming temperatures gradually melt sea ice over time, fewer bright surfaces are available to reflect sunlight back into the atmosphere. More solar energy is absorbed at the surface and ocean temperatures rise. This begins a cycle of warming and melting.” - NOAA
- How can other factors such as location/region affect the data we looked into?
  - Could percentage of land as natural forests could be a factor in regional CO2 levels?
- Do longer wildfire and heat waves seasons correlate with increased temperature anomaly and CO2 atmospheric levels?

References

1. https://oceanservice.noaa.gov/facts/sea-ice-climate.html
2. https://phys.org/news/2020-08-degraded-tropical-forests-big-carbon.html
3. https://oceanservice.noaa.gov/facts/carbon-cycle.html
4. https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide
5. https://phys.org/news/2019-04-natural-forests-global-climate-goals.html