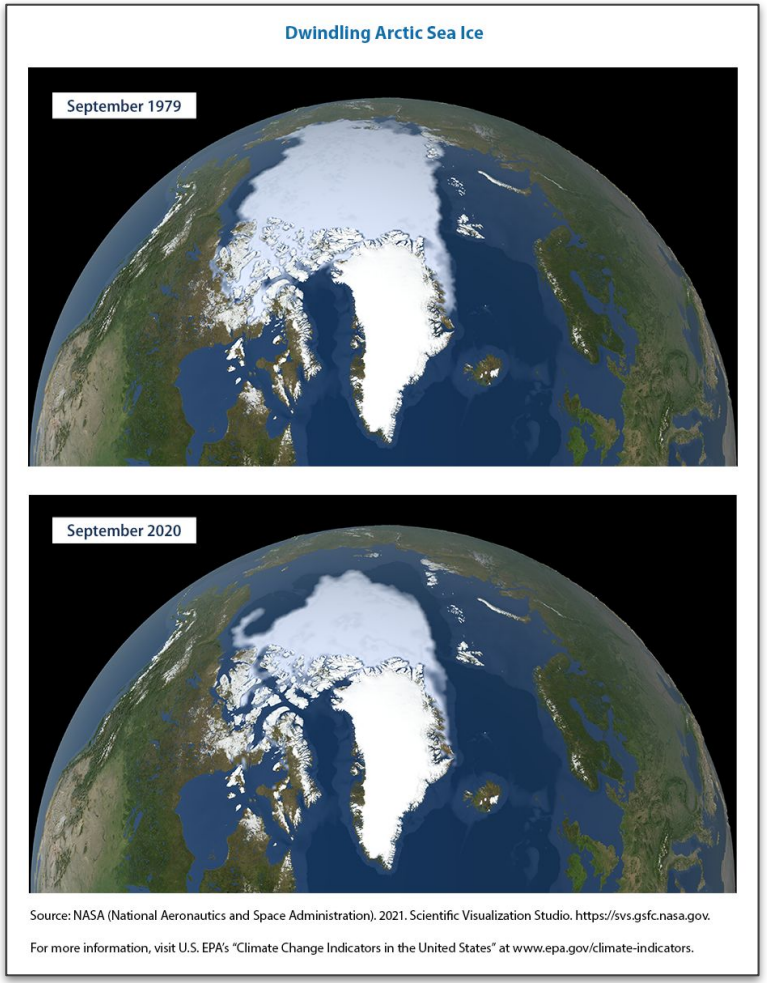
Multivariate Linear Regression - Arctic Ice Area and Co2

Jonathan Perlin

PROJECT - Main Idea

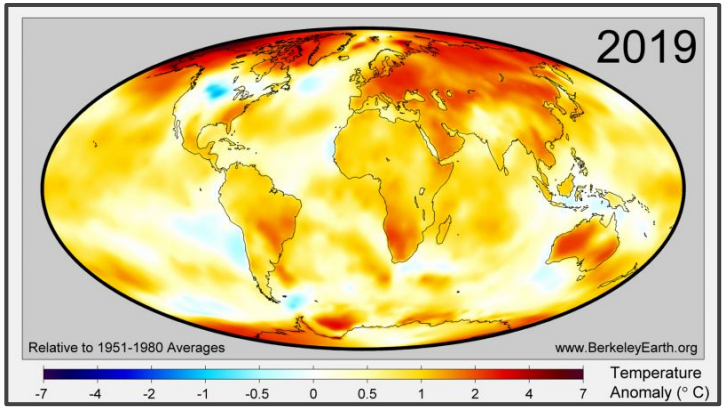
- Climate change is an environmental as well as a sociological issue that needs to be addressed
- As technology and industry continue to develop, so does our impact on the global environment
- ANTHROPOCENE
- Many areas to focus on:
  - For this issue, chose to investigate arctic ice area by year
- DEPENDENT VARIABLE - arctic ice area
- INDEPENDENT VARIABLES - Carbon Dioxide emissions by sector

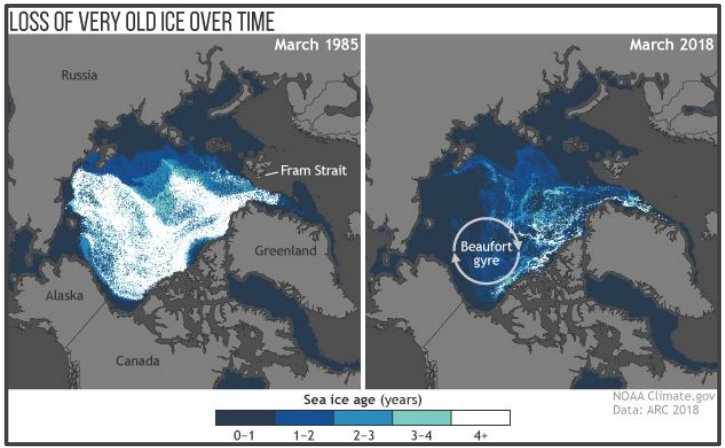


Research Question

Hypothesis: with an expected increase in greenhouse gasses, the overall area of arctic ice will decrease over time.

I expect a strong relationship between volume of greenhouse gas emission and the decrease in the area of arctic ice.





Dataset

- **Time:** 1990 - 2018
- **Arctic Ice Area**
  - Billions of Km Squared
- **Emissions of CO2**
  - Billions of Tons Squared

Project_Data

Year	Ice	Buildings	Industry	Land-use&Forestry	Other-fuel-combustion	Transport	Manufacturing&construction	Fugitive	Electricity&heat
1990	4.55E+09	2.6E+09	5.01E+08	1.67E+09	7.59E+08	4.61E+09	3.96E+09	1.64E+08	8.6E+09
1991	4.51E+09	2.62E+09	5.14E+08	1.67E+09	7.59E+08	4.65E+09	3.88E+09	2.33E+08	8.74E+09
1992	5.43E+09	2.51E+09	5.36E+08	1.67E+09	6.75E+08	4.75E+09	3.74E+09	2.03E+08	8.89E+09
1993	4.58E+09	2.57E+09	5.56E+08	1.67E+09	6.89E+08	4.79E+09	3.69E+09	2.01E+08	8.95E+09
1994	5.13E+09	2.49E+09	5.92E+08	1.67E+09	6.6E+08	4.89E+09	3.71E+09	2.01E+08	9.04E+09
1995	4.43E+09	2.57E+09	6.26E+08	1.67E+09	6.12E+08	5.02E+09	3.94E+09	2.17E+08	9.23E+09
1996	5.62E+09	2.64E+09	6.4E+08	1.52E+09	5.41E+08	5.23E+09	3.83E+09	2.3E+08	9.59E+09
1997	4.89E+09	2.62E+09	6.59E+08	2.21E+09	5.88E+08	5.31E+09	3.85E+09	2.05E+08	9.85E+09
1998	4.3E+09	2.46E+09	6.56E+08	1.65E+09	5.65E+08	5.43E+09	3.85E+09	1.9E+08	1.01E+10
1999	4.29E+09	2.53E+09	6.85E+08	1.56E+09	5.76E+08	5.59E+09	3.69E+09	1.82E+08	1.01E+10
2000	4.35E+09	2.53E+09	7.16E+08	1.51E+09	5.17E+08	5.77E+09	3.87E+09	1.74E+08	1.06E+10
2001	4.59E+09	2.55E+09	7.48E+08	1.23E+09	5.29E+08	5.8E+09	3.9E+09	1.58E+08	1.08E+10
2002	4.03E+09	2.55E+09	7.91E+08	1.6E+09	5.3E+08	5.95E+09	3.9E+09	1.67E+08	1.1E+10
2003	4.05E+09	2.63E+09	8.51E+08	1.33E+09	5.48E+08	6.08E+09	4.08E+09	1.67E+08	1.16E+10
2004	4.39E+09	2.68E+09	9.07E+08	1.6E+09	5.82E+08	6.36E+09	4.52E+09	1.81E+08	1.2E+10
2005	4.07E+09	2.68E+09	9.59E+08	1.4E+09	6.02E+08	6.5E+09	4.93E+09	2.27E+08	1.24E+10
2006	4.01E+09	2.64E+09	1.05E+09	1.7E+09	6.12E+08	6.65E+09	5.18E+09	2.22E+08	1.29E+10
2007	2.82E+09	2.64E+09	1.12E+09	1.27E+09	6.16E+08	6.86E+09	5.45E+09	2.28E+08	1.34E+10
2008	3.26E+09	2.7E+09	1.14E+09	1.26E+09	6.21E+08	6.86E+09	5.56E+09	2.49E+08	1.35E+10
2009	3.76E+09	2.65E+09	1.17E+09	1.56E+09	6.09E+08	6.72E+09	5.55E+09	2.41E+08	1.33E+10
2010	3.34E+09	2.71E+09	1.25E+09	1.28E+09	6.24E+08	7.01E+09	6.09E+09	2.21E+08	1.42E+10
2011	3.21E+09	2.65E+09	1.34E+09	2.01E+08	6.09E+08	7.13E+09	6.31E+09	2.26E+08	1.48E+10
2012	2.41E+09	2.6E+09	1.37E+09	2.11E+08	6.33E+08	7.18E+09	6.33E+09	2.32E+08	1.51E+10
2013	3.78E+09	2.71E+09	1.42E+09	1.94E+08	6.4E+08	7.37E+09	6.32E+09	2.3E+08	1.53E+10
2014	3.74E+09	2.66E+09	1.47E+09	4.6E+08	6.37E+08	7.5E+09	6.36E+09	2.39E+08	1.52E+10
2015	3.42E+09	2.69E+09	1.43E+09	4.83E+08	6.33E+08	7.72E+09	6.32E+09	2.43E+08	1.5E+10
2016	2.91E+09	2.74E+09	1.46E+09	1.08E+09	6.21E+08	7.88E+09	6.19E+09	2.45E+08	1.49E+10
2017	3.35E+09	2.8E+09	1.47E+09	1.05E+09	6.21E+08	8.08E+09	6.17E+09	2.33E+08	1.52E+10
2018	3.35E+09	2.88E+09	1.5E+09	1.19E+09	6.24E+08	8.26E+09	6.16E+09	2.33E+08	1.56E+10

Descriptive Statistics of Variables

Table 1: Descriptive Statistics – Billions Sq Metric Tons

Variables	Mean	Std. Dev.	Skew.
Ice (mil km²)	22.10	0.20	-0.42
Buildings	21.69	0.03	0.34
Industry	20.63	0.38	-0.05
Forestry	20.83	0.68	-1.67
Transport	22.54	0.18	-0.13
Other	20.23	0.09	0.34
Construction	22.28	0.22	0.17
Fugitive	19.16	0.14	-0.67
Electricity	23.19	0.21	-0.11
Year	2004	8.51	0.00

Most Skewness:

- **Forestry**

Least Skewness:

- **Fugitive**

Pearson Correlation Matrix

OBSERVATIONS

- Looking for a strong negative correlation
  - As emissions increase, ice decreases
- Strong negative correlations:
  - Electricity & Heat
  - Manufacturing & Construction
  - Industry
- Weaker negative correlations:
  - Buildings
  - Fugitive
- Positive - Land Use & Forestry

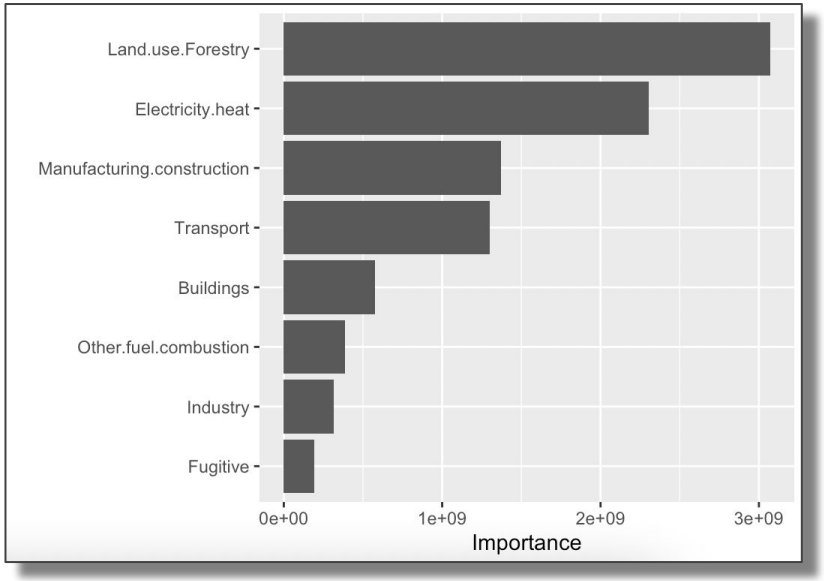
Table 2: Correlation Matrix

	1	2	3	4	5	6	7	8	9
1	1	-0.548	-0.828	0.650	-0.013	-0.818	-0.832	-0.485	-0.844
2	-0.548	1	0.758	-0.383	0.117	0.781	0.740	0.594	0.742
3	-0.828	0.758	1	-0.769	-0.049	0.981	0.975	0.642	0.993
4	0.650	-0.383	-0.769	1	-0.037	-0.691	-0.787	-0.435	-0.771
5	-0.013	0.117	-0.049	-0.037	1	-0.164	0.113	0.307	-0.102
6	-0.818	0.781	0.981	-0.691	-0.164	1	0.926	0.569	0.983
7	-0.832	0.740	0.975	-0.787	0.113	0.926	1	0.715	0.966
8	-0.485	0.594	0.642	-0.435	0.307	0.569	0.715	1	0.601
9	-0.844	0.742	0.993	-0.771	-0.102	0.983	0.966	0.601	1

Variable Importance Plot

```
model7 <- lm(Total ~ Buildings + Industry + Land.use.Forestry + Other.fuel.combustion +
Transport + Manufacturing.construction + Fugitive + Electricity.heat, Complete_Data)
```

- Model7 renders all of the variables significant
- Running a VIP on the model demonstrates that Land Use & Forestry is the most significant variable in the data set
- This makes sense as trees naturally remove Carbon Dioxide from our atmosphere
  - Removing trees for land usage not only contributes emissions from the construction work, but also removes natural Co2 vacuums from our environment



Moving Forward

- In order to make the data set more significant in terms of seeing a decrease in the extent of arctic ice:
  - Instead of focusing SOLELY on Co2 emissions, bring in other greenhouse gasses (Methane, Nitrous Oxide, etc.) to compare and see which emission has the largest effect on arctic ice
- Once the main contributing factor has been isolated, then we can come up with proposals on how we can decrease the amount of greenhouse gas emissions and then hopefully see a mitigation of the Arctic Ice decrease we have noticed in the last few decades
- A time series model involving all greenhouse gas emissions compared with Arctic Ice extent could be helpful here
- Also helpful could be utilizing global sea ice extent, which would include Antarctic and other glacial melting in addition to Arctic Ice

Why do we care?

- With an understanding of which sector is contributing the most to decrease in arctic ice area, we can propose changes in each sector to mitigate the amount of emissions

- As society rapidly develops, our world is developing and changing with it

- While the planet will heal itself invariably, our presence will be recognizable on it for hundreds of millions of years

QUESTIONS?