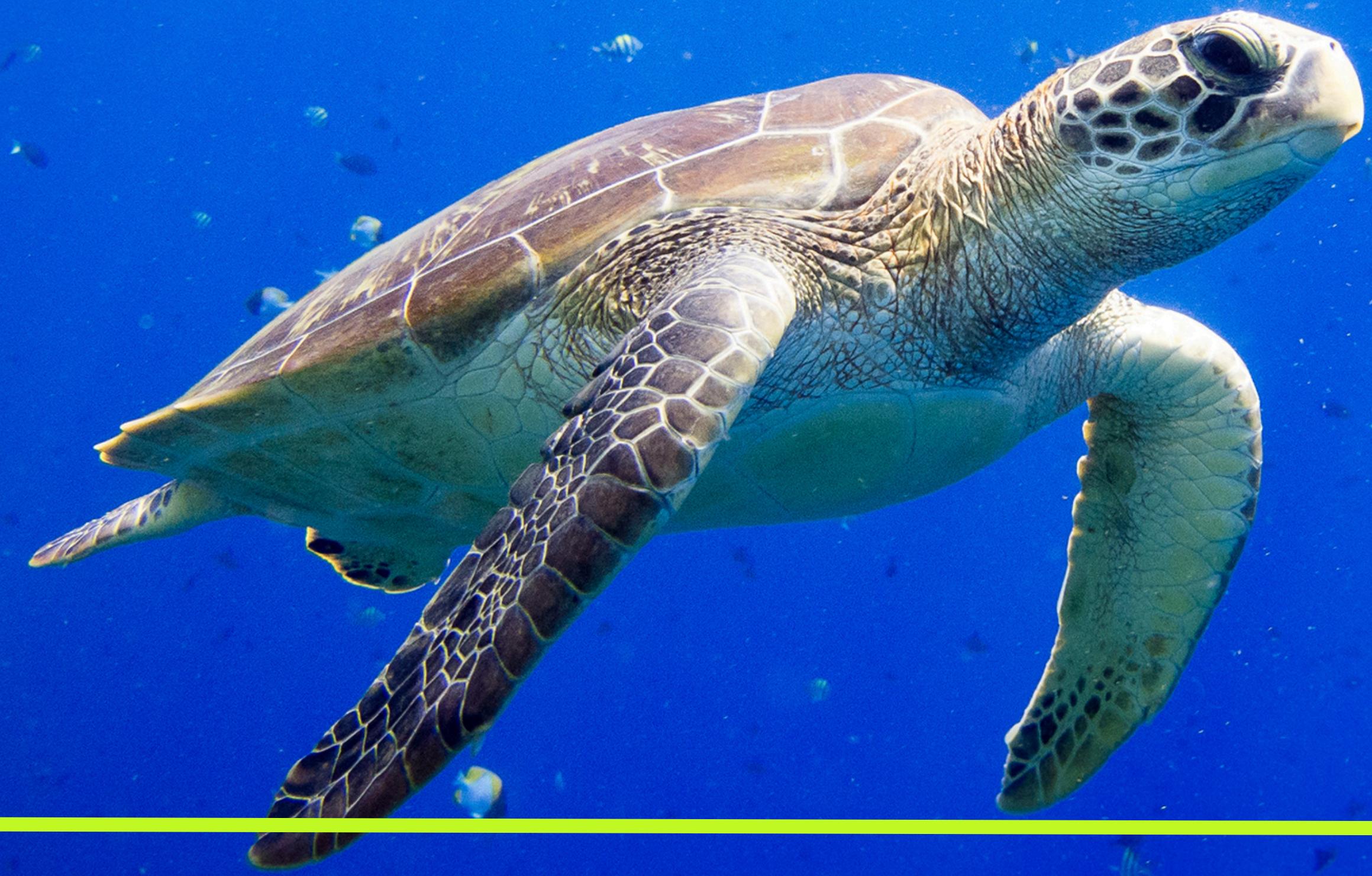


Time Series Modeling



Global Temperature Anomaly

LUCAS DWYER, SEPTEMBER 2020

Agenda

- Problem Statement
- Background
- Data
- Modeling
- Conclusions & Future Work

Problem Statement

- The potential impacts of climate change affect many facets of our everyday lives.
- One important metric one can use to keep track of exactly how severely the climate has changed is the *Global Temperature Anomaly* (GTA), which is the rise in the global average temperature over the past few decades.
- Forecasting the GTA years in advance is necessary in order to give prompt insight to policy makers regarding timetables for green climate policy changes.

2° Celsius

A temperature anomaly of just +2° C will likely result in:

- Mass Droughts / Flooding depending on locale**
- Severe heat waves at least once every 5 years for 37% of the global populations**
- Loss of biodiversity (18% of insects, 16% of plants, and 8% of vertebrates)**
- Deforestation in rainforests and Boreal forests**
- ~2/3' sea level rise across 70% of the world's coasts.**
- A loss of sea ice resulting in likely at least 1 ice free Arctic summer per decade**
- Coral reefs more or less wiped out**
- Decreased crop production.**
- Economic impact: about 2.3% loss on GDP per degree Celsius increase.**

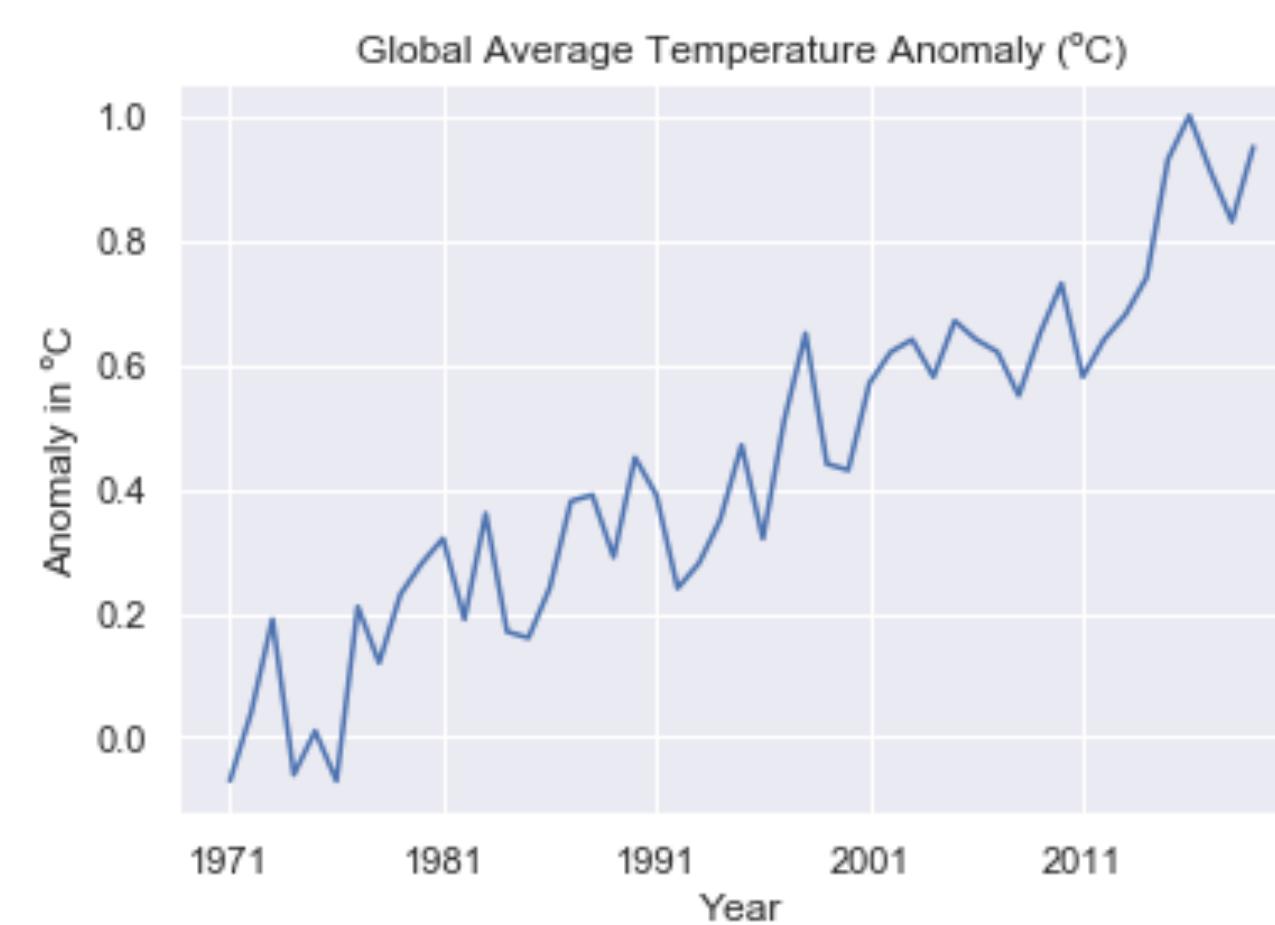
Background

- One of the major, human-influenced factors of climate change are emissions of gasses known as green-house gases.
- While there are many kinds of green house gases which are damaging in different concentrations, by volume, the two largest threats are carbon dioxide (CO₂) and methane (CH₄).

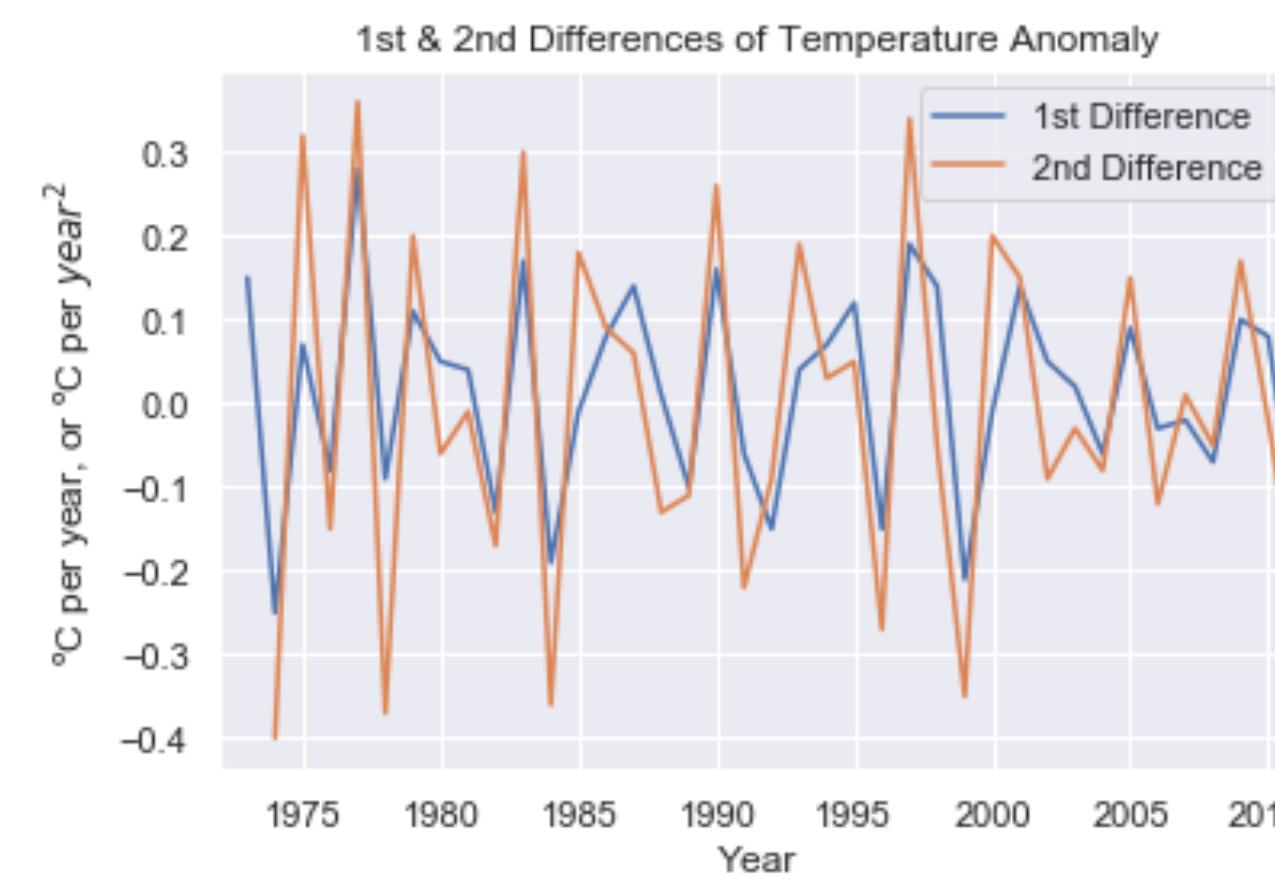
Data

- Global Average Temperature Anomaly dataset from National Centers for Environmental Information at the National Oceanic and Atmospheric Administration (NCEI-NOAA).
- Global Methane Emissions Dataset from the European Commission, Joint Research centre (JRC) & Netherlands Environmental Assessment Agency (PBL): hosted by World BankEmission Database for Global Atmospheric Research (EDGAR)
- Historical Carbon levels dataset: Years 0000-2014. Institute for Atmospheric and Climate Science (IAC) at Eidgenössische Technische Hochschule in Zürich, Switzerland

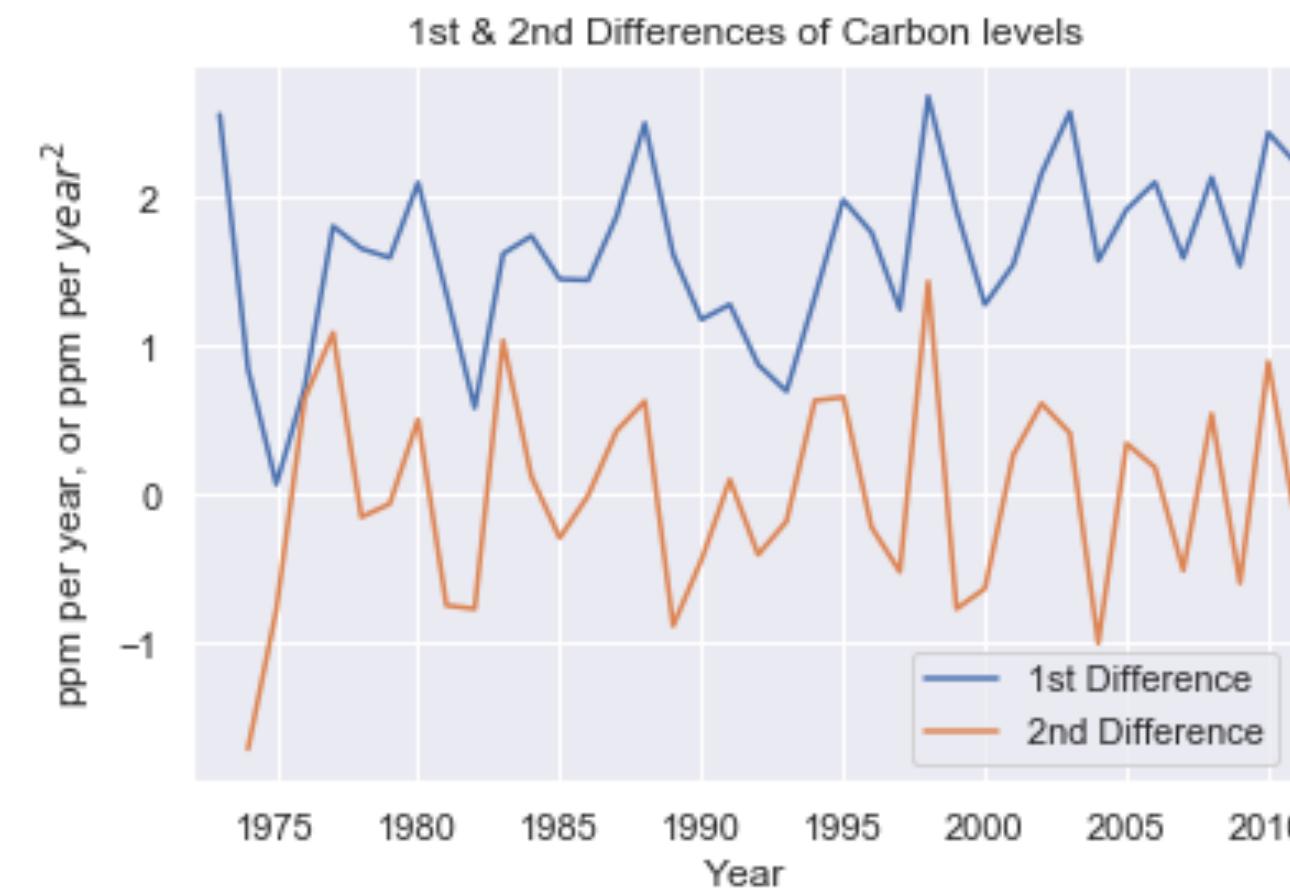
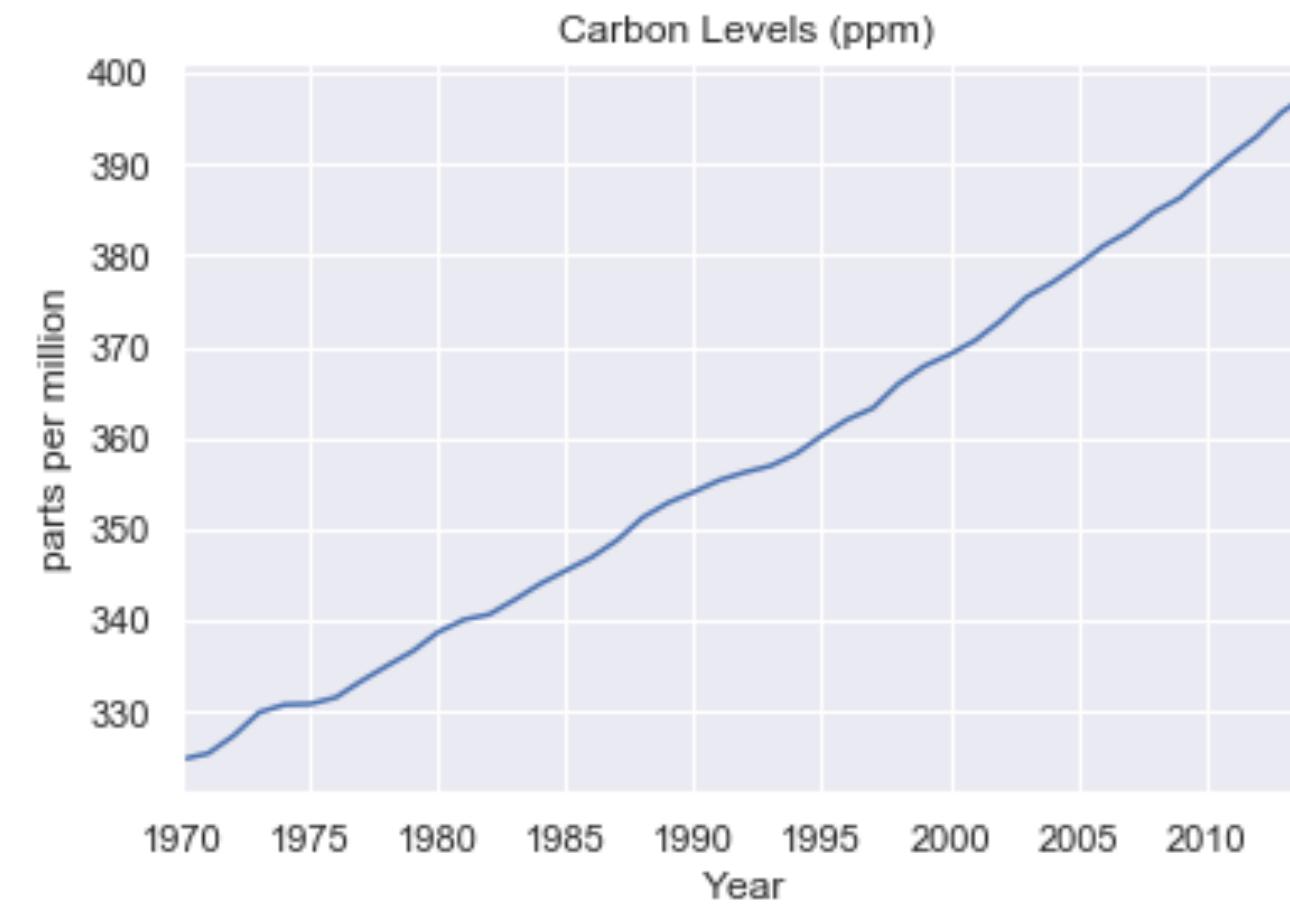
Global Temperature Anomaly



- Both 1st and 2nd difference have stationarity, while undifferenced temperature anomaly has a clear positively- linear trend.

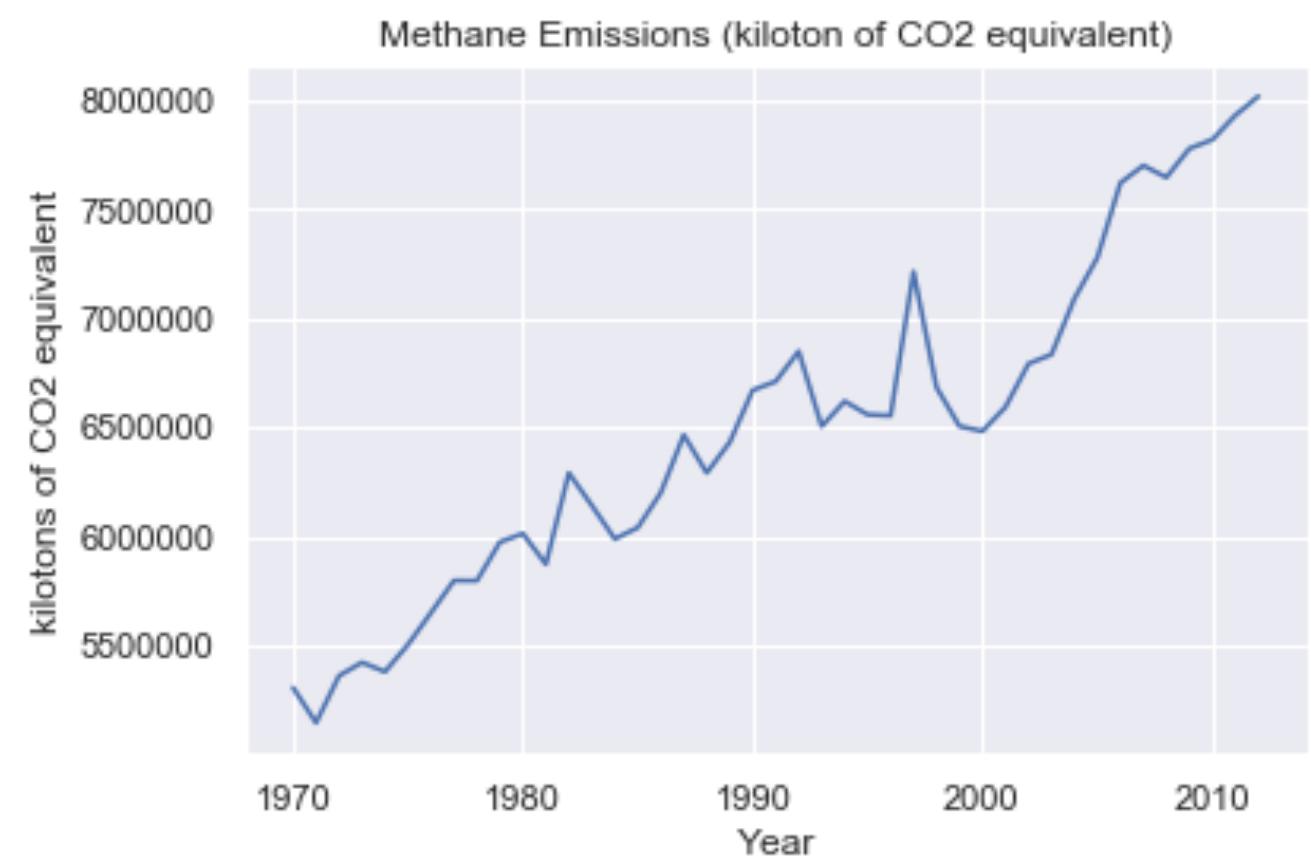


Carbon Levels

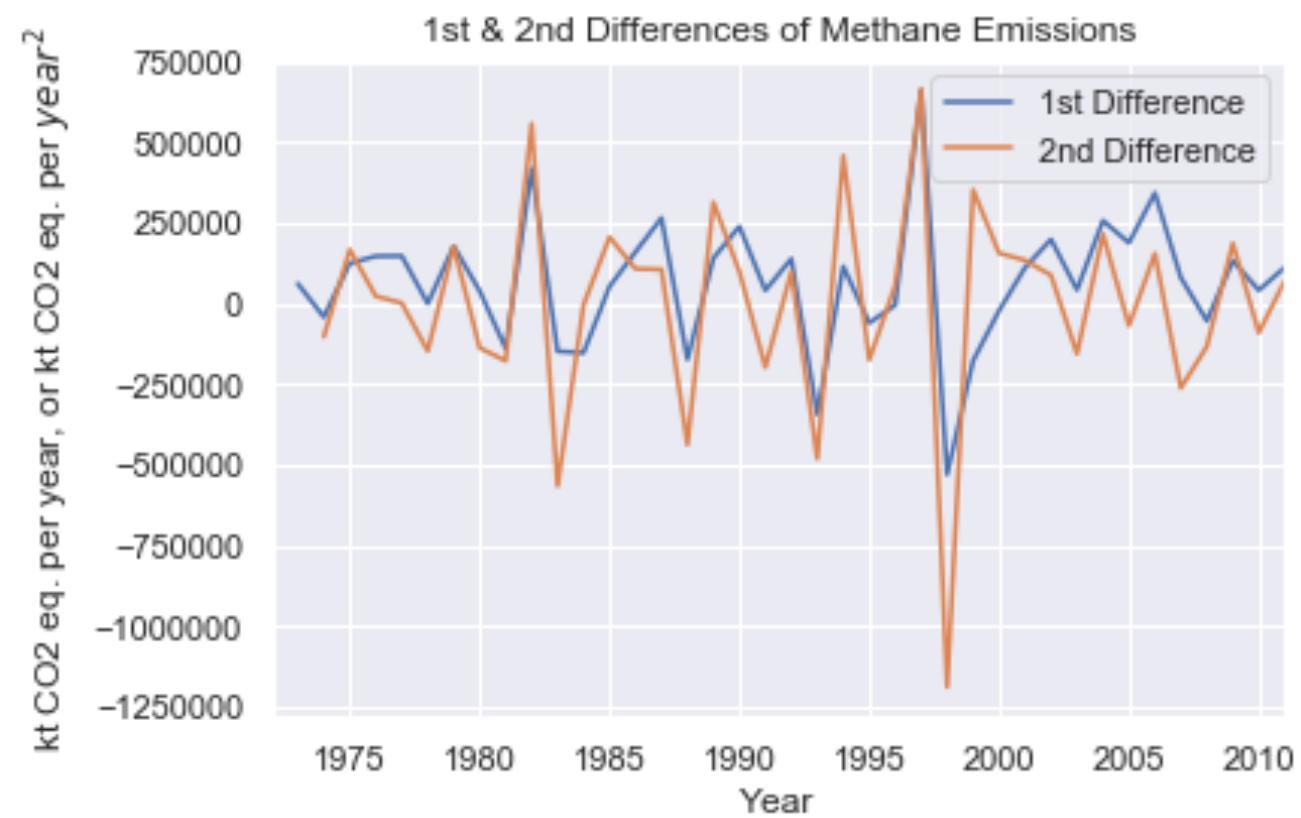


- Only the 2nd difference had stationarity, the 1st had a slight positive trend and failed to reject the null hypothesis under an Augmented Dickey-Fuller test.

Methane Emissions



- Both 1st and 2nd difference have stationarity, while the undifferenced methane emission levels have a clear positively- linear trend.

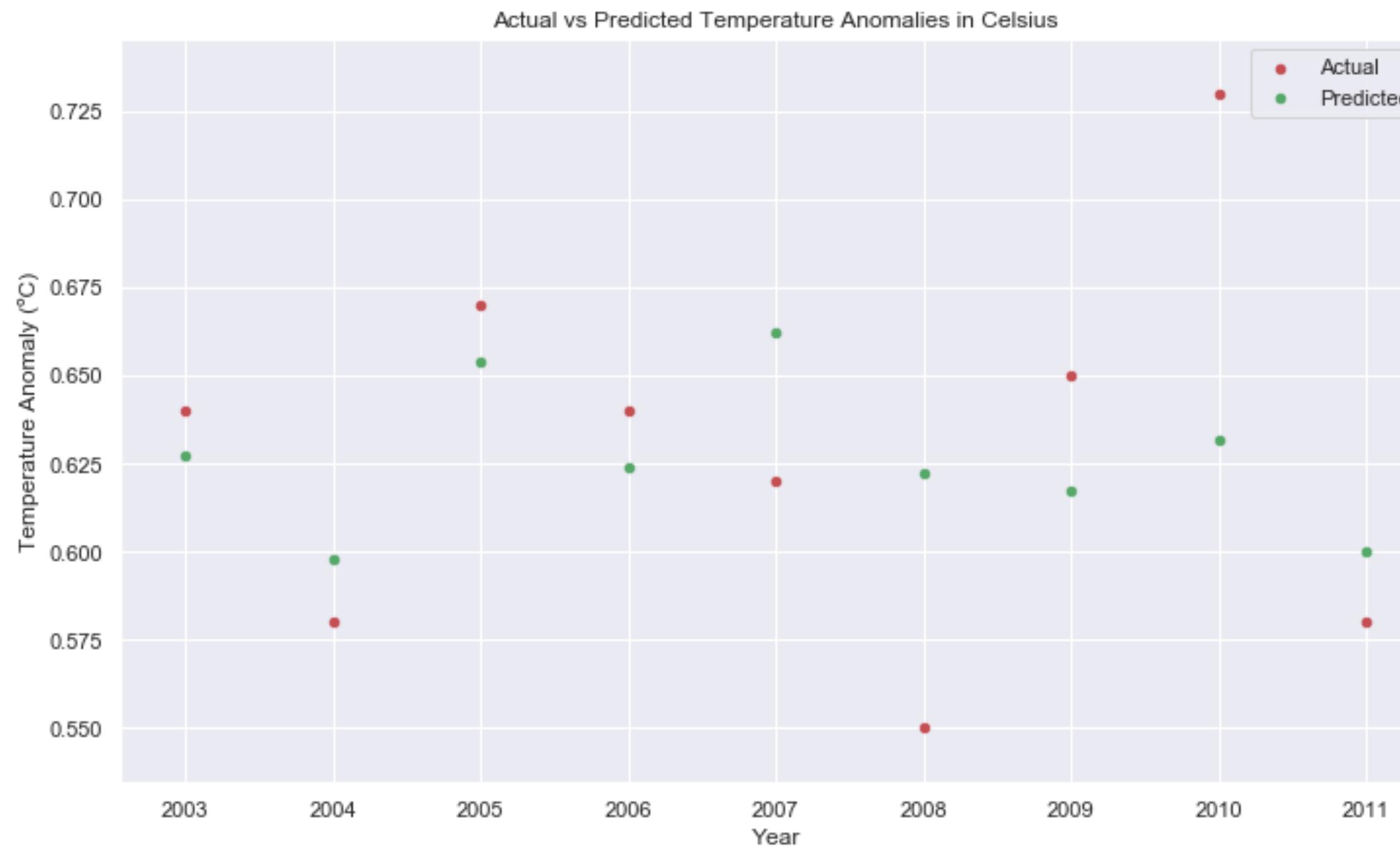


Modeling

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Ridge Regression	X					X	
LASSO Regression		X					X
Linear Regression (OLS)			X				
ARIMA				X			
VAR					X		
PCA						X	X
MSE (1st diff)	0.0037	0.0036	0.0047	0.0040	0.0070	0.0035	0.0035
MSE	0.0019	0.0021	0.0140	0.0029	0.0061	0.0023	0.0024

2nd Place Model

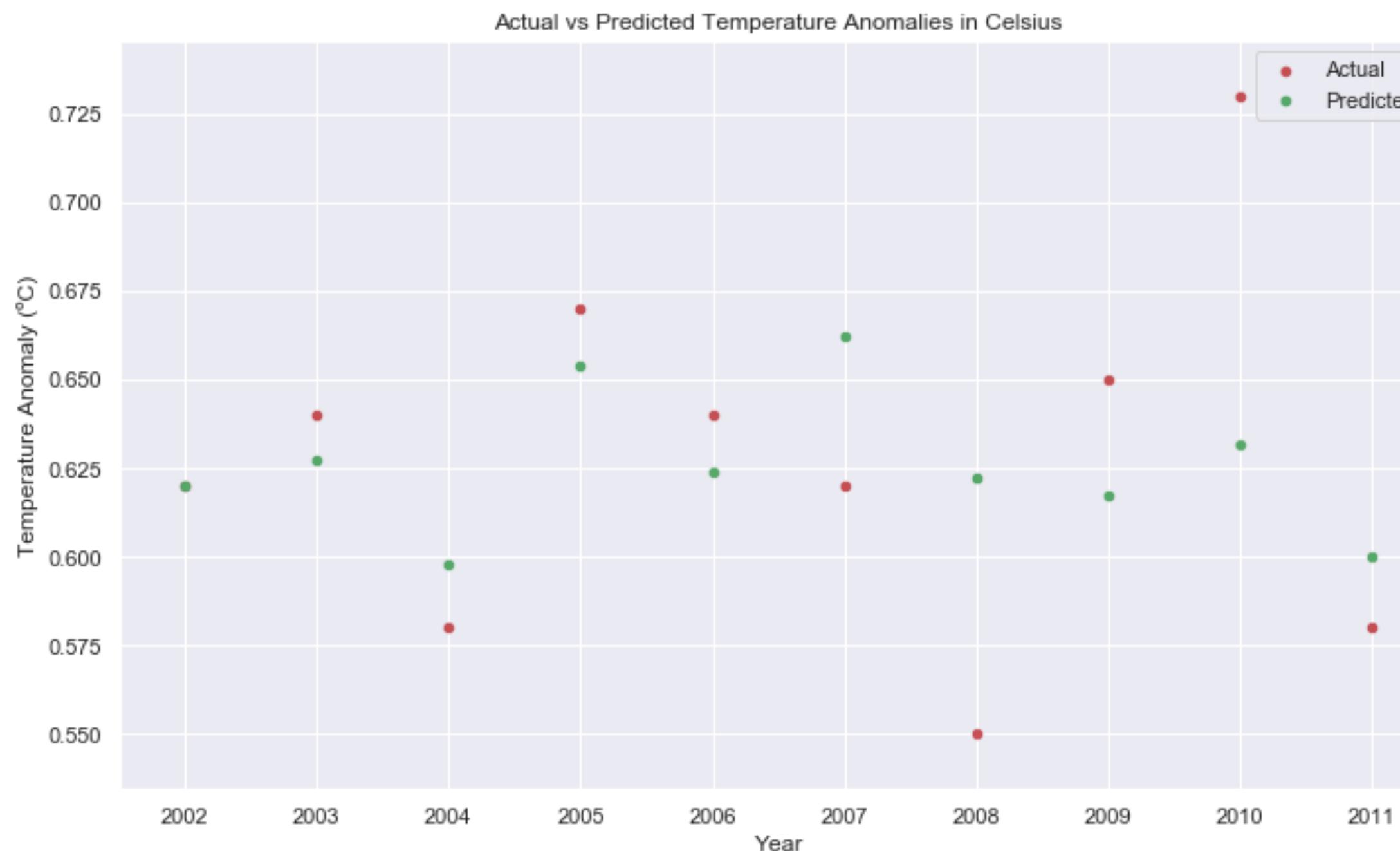
LASSO Regression



- Mean Squared Error (MSE) 1st temperature anomaly predictions:
 - .0036
- MSE temperature anomaly predictions:
 - .0021

Best Model

Ridge Regression



- Mean Squared Error (MSE) 1st temperature anomaly predictions:
 - .0037
- MSE temperature anomaly predictions:
 - .0019
 - Roughly a $.04^{\circ}\text{C}$ error in Temperature Anomaly

Conclusions & Future Work

- A model with relatively low error was found which could be useful in forecasting global temperature anomaly.
- While performing well in general, this model is clearly overfit and fails to account for some of the variance in the target.
- In the future, using VAR modeling to model the 2nd differences of methane and carbon emissions could be used to extend forecasting capabilities of the model.

References

- Global Temperature Anomaly:
 - NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series <https://www.ncdc.noaa.gov/cag/>
 - Buis, Ala. "A Degree of Concern: Why Global Temperatures Matter — Climate Change: Vital Signs of the Planet." NASA, 25 June 2019 climate.nasa.gov/news/2865/a-degree-of-concern-why-global-temperatures-matter/
- Methane Emissions:
 - World Bank: European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR)
- Carbon levels:
 - Institute for Atmospheric and Climate Science (IAC) : ETH Zurich

questions?