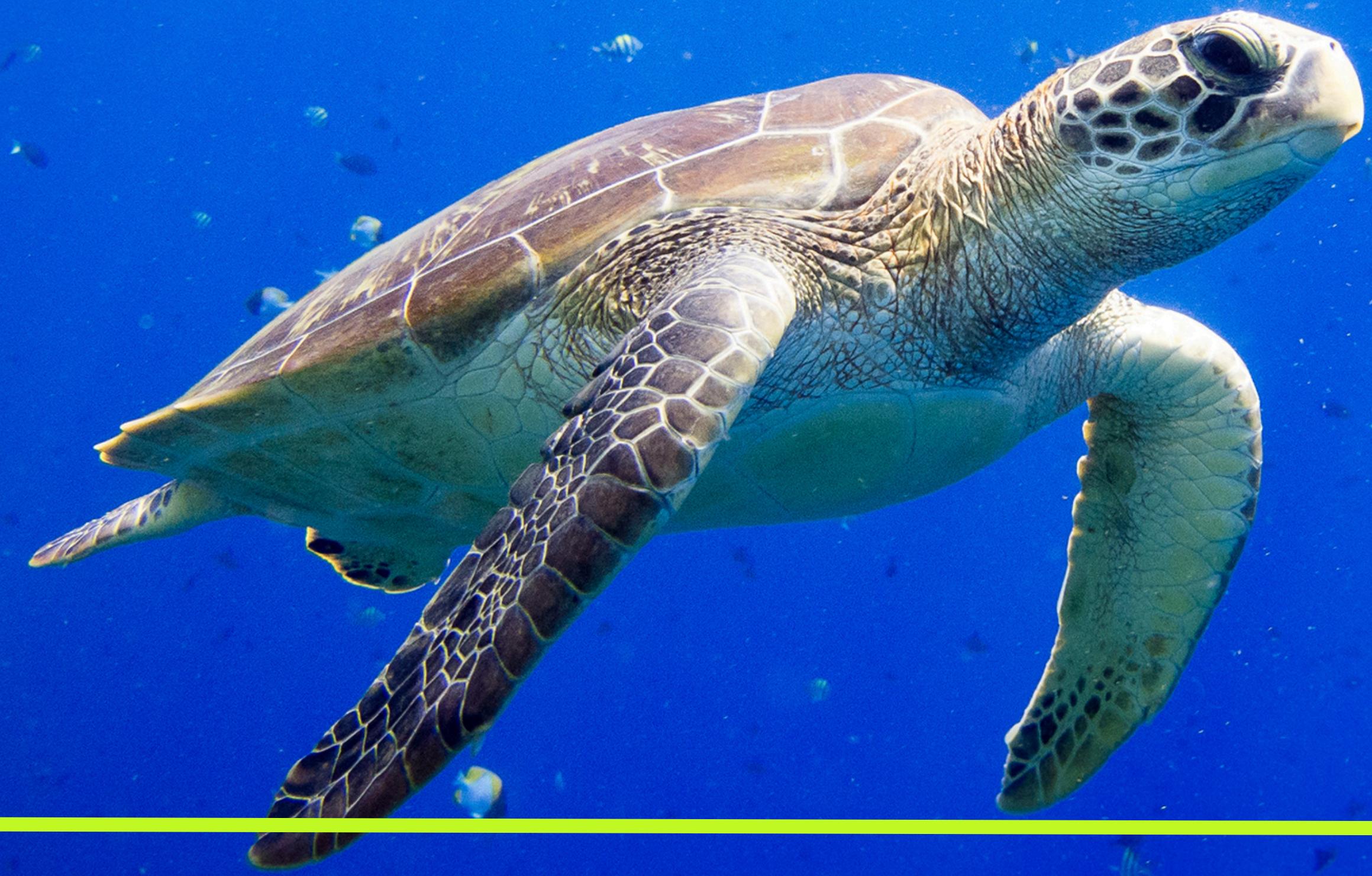


# Time Series Modeling



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# Global Temperature Anomaly

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LUCAS DWYER, SEPTEMBER 2020

# Agenda

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- 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.**

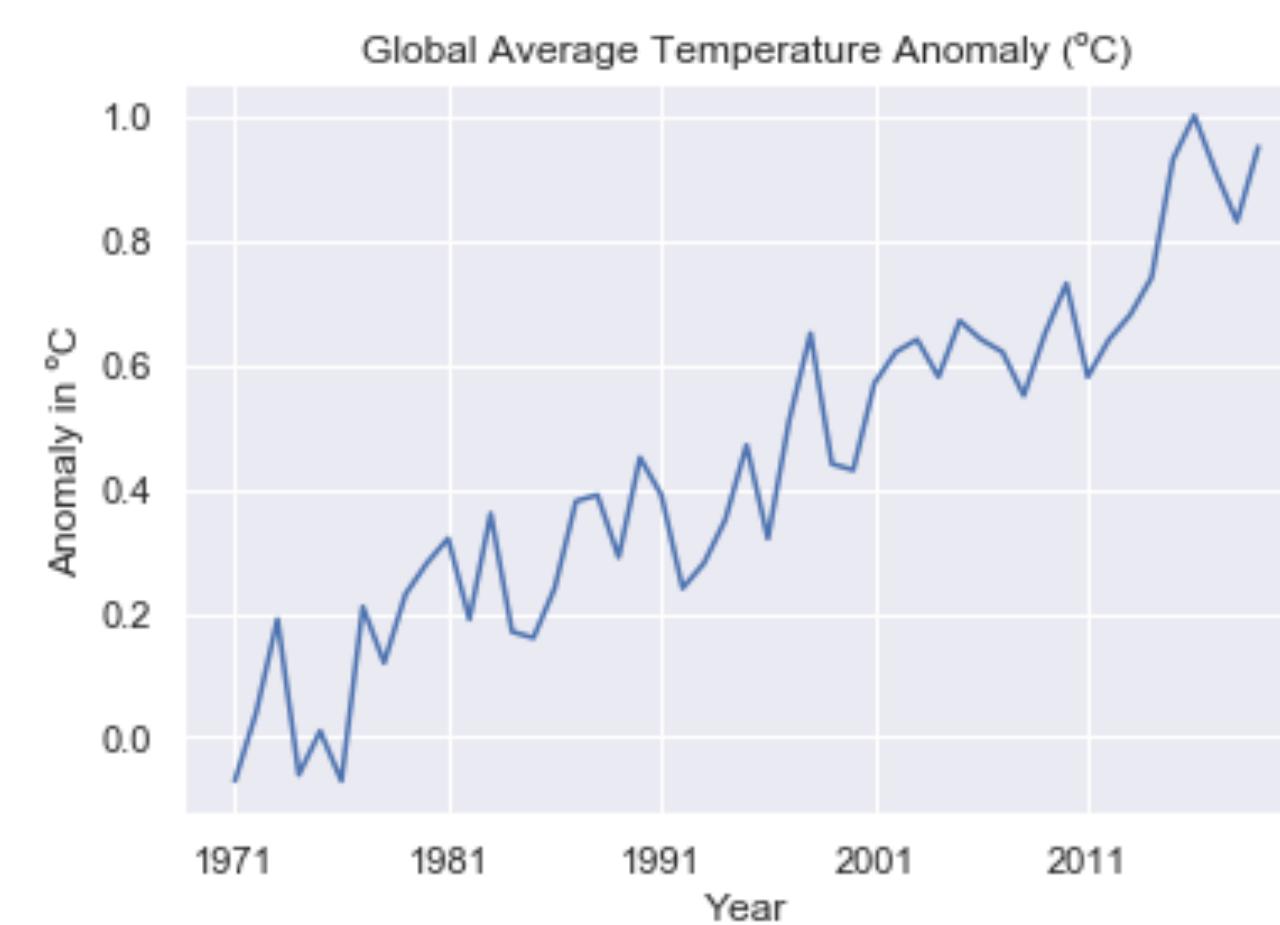
# Background

- 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 (CO<sub>2</sub>) and methane (CH<sub>4</sub>).

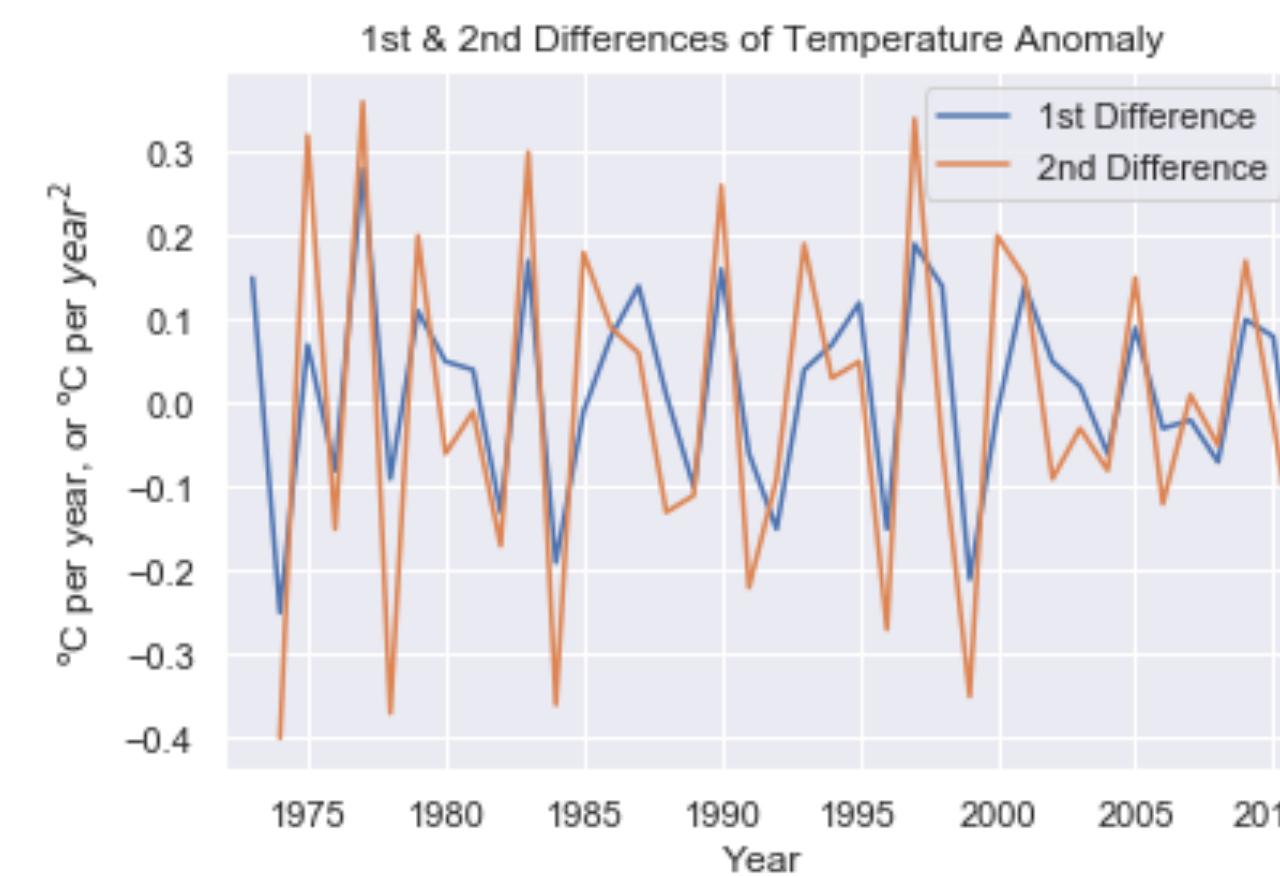
# Data

- 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 Bank Emission 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

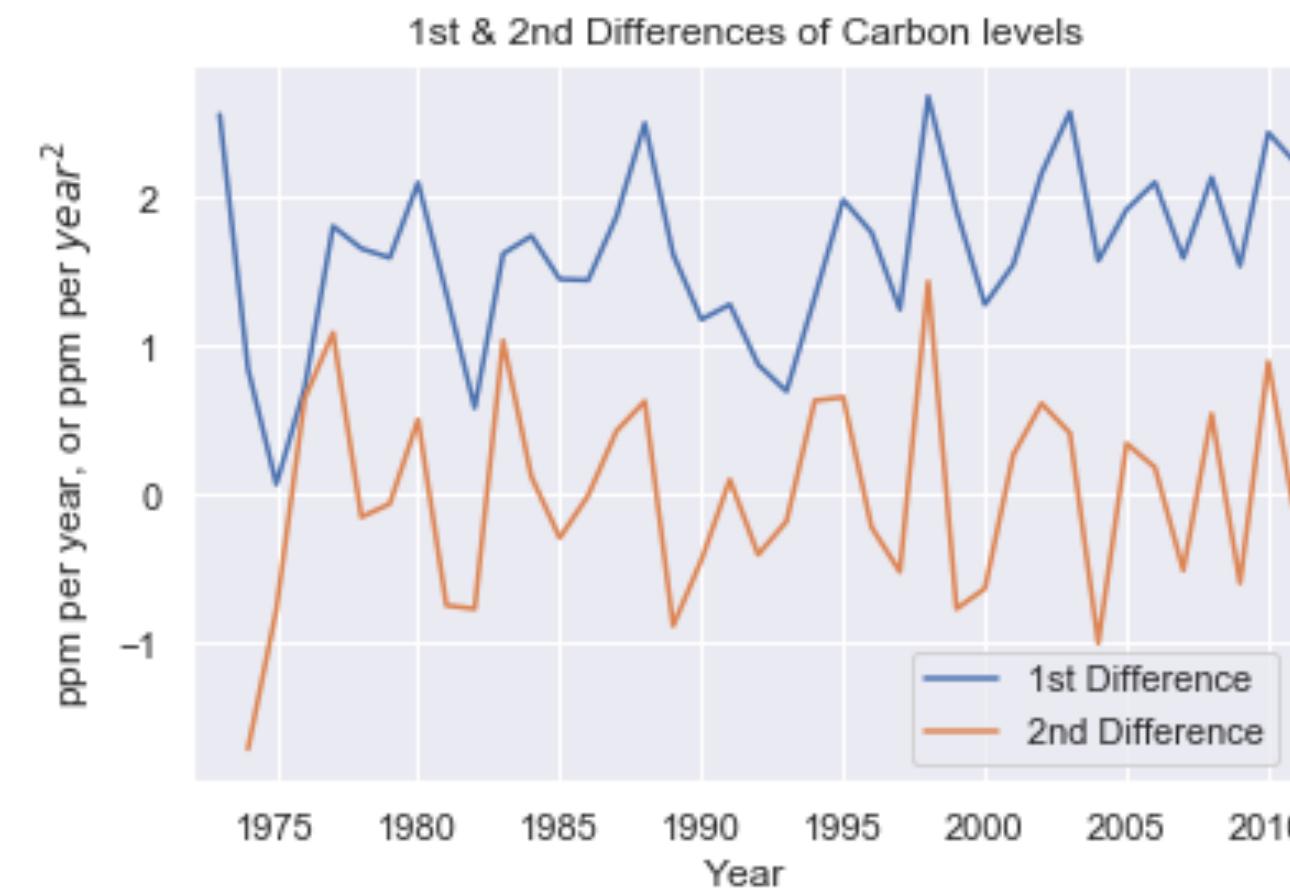
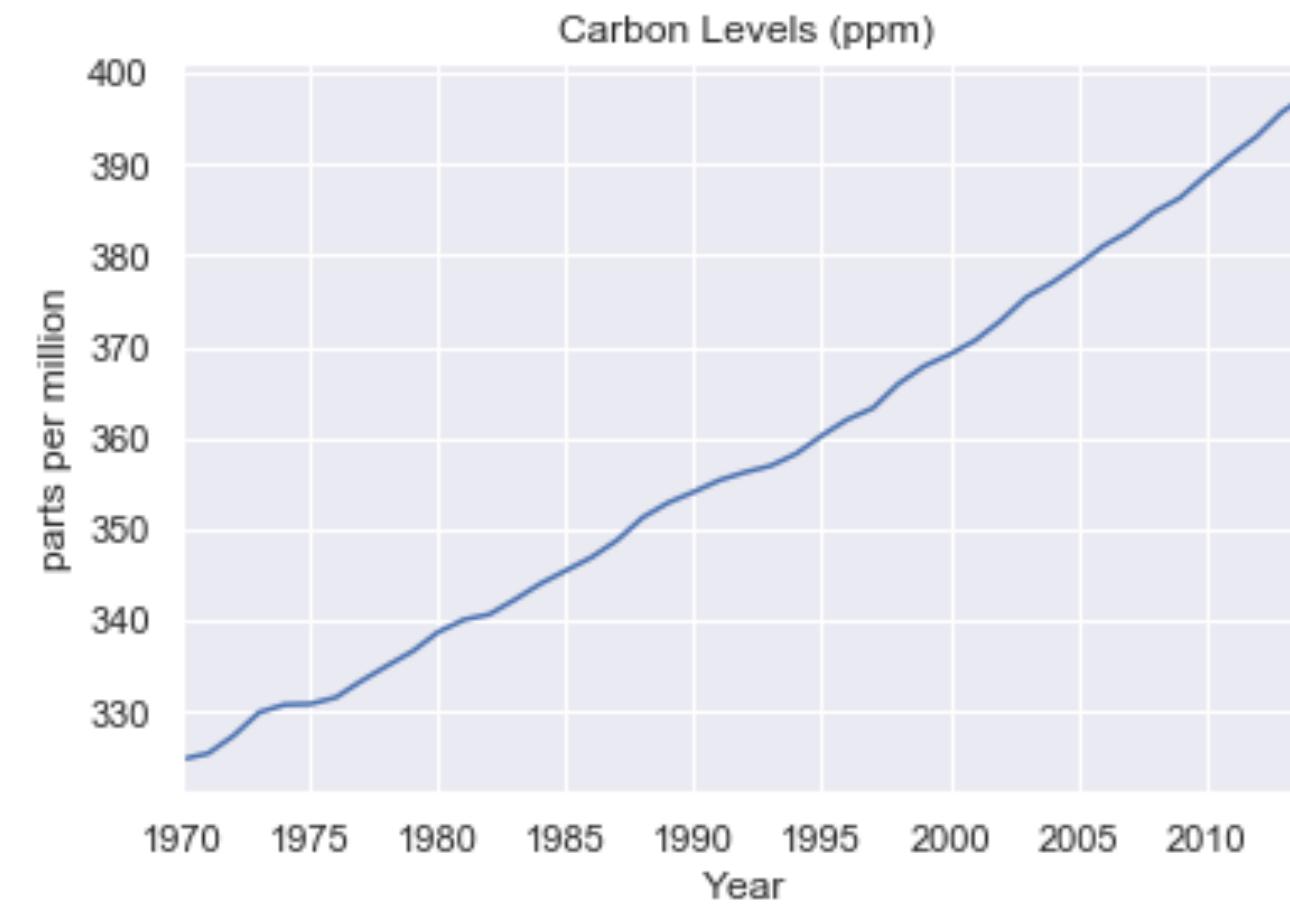
# Global Temperature Anomaly



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

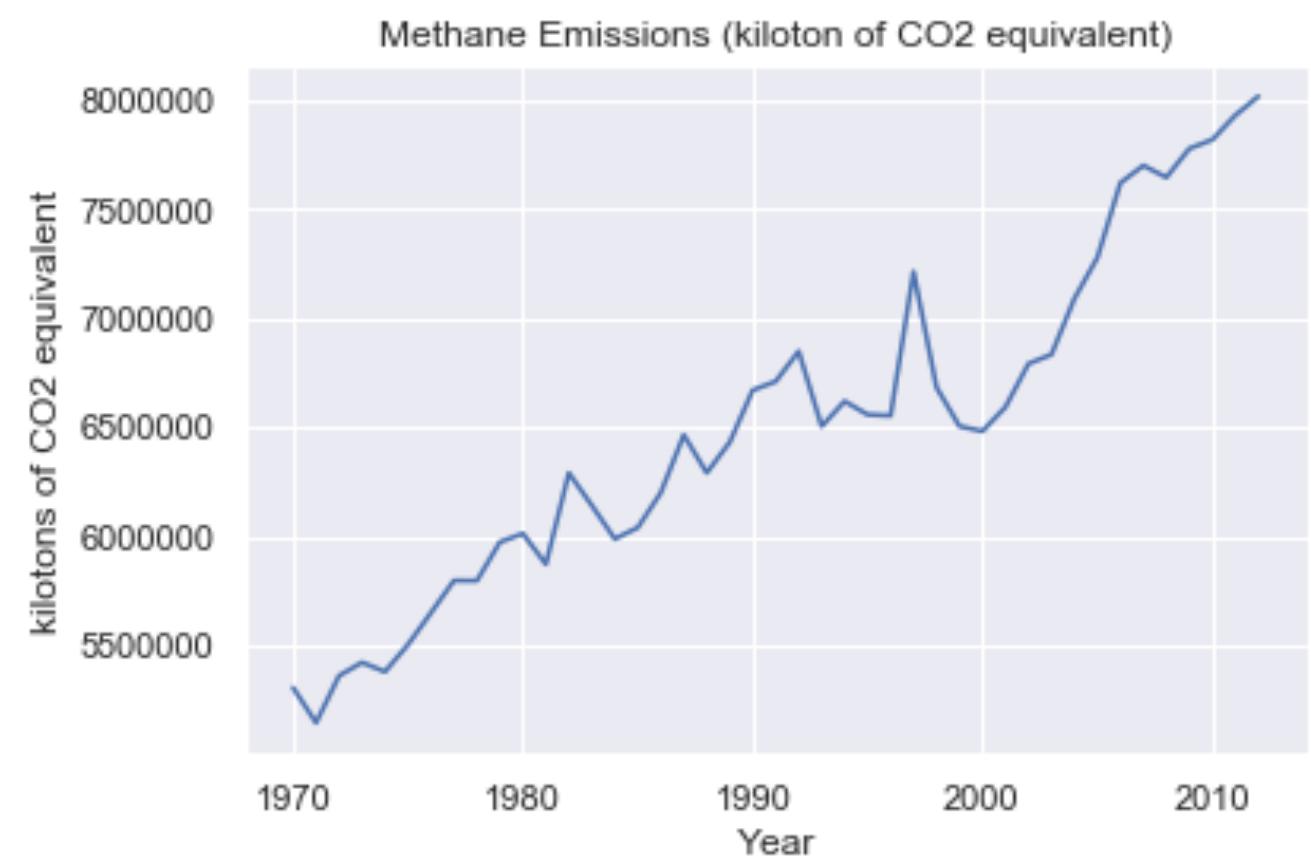


# Carbon Levels

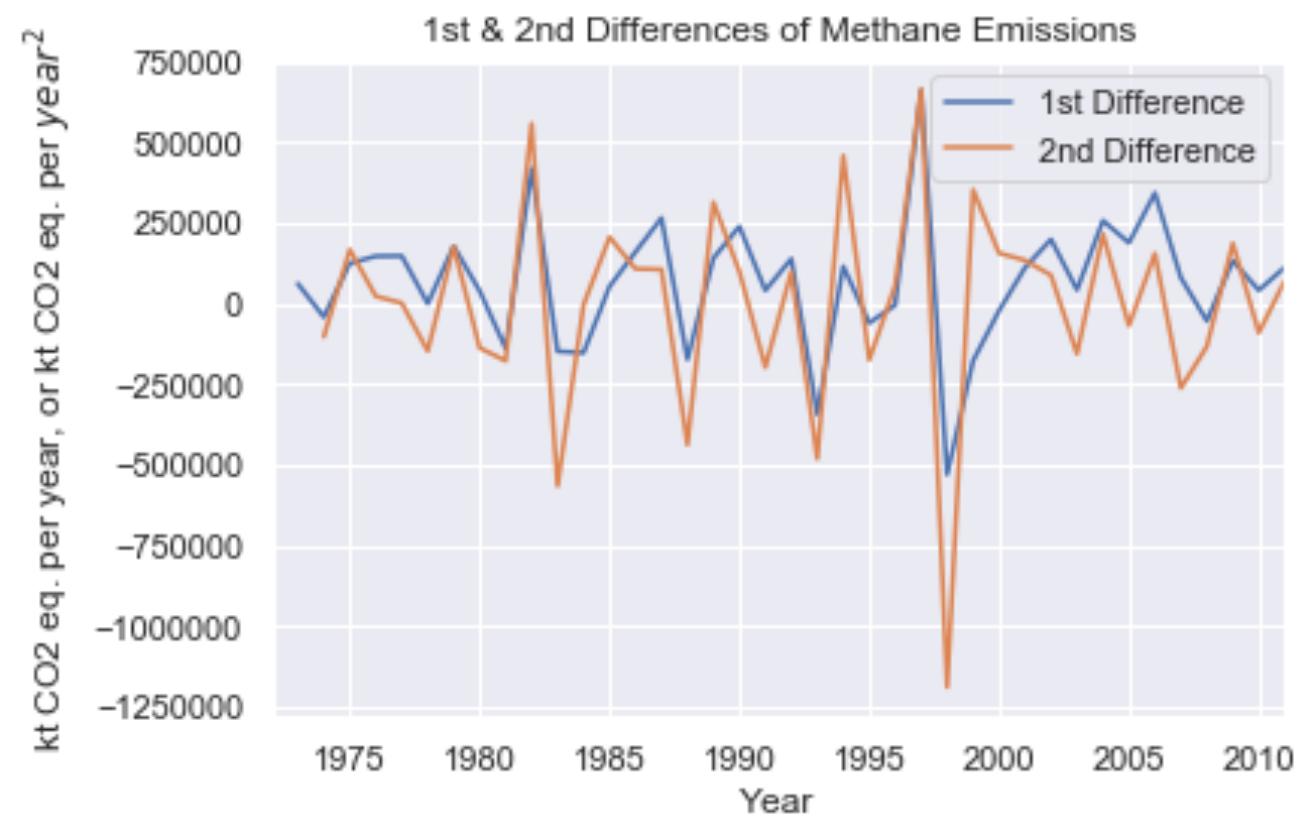


- Only the 2nd difference had stationarity, the 1st had a slight positive trend and failed to reject the null hypothesis under an Augmented Dickey-Fuller test.

# Methane Emissions



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

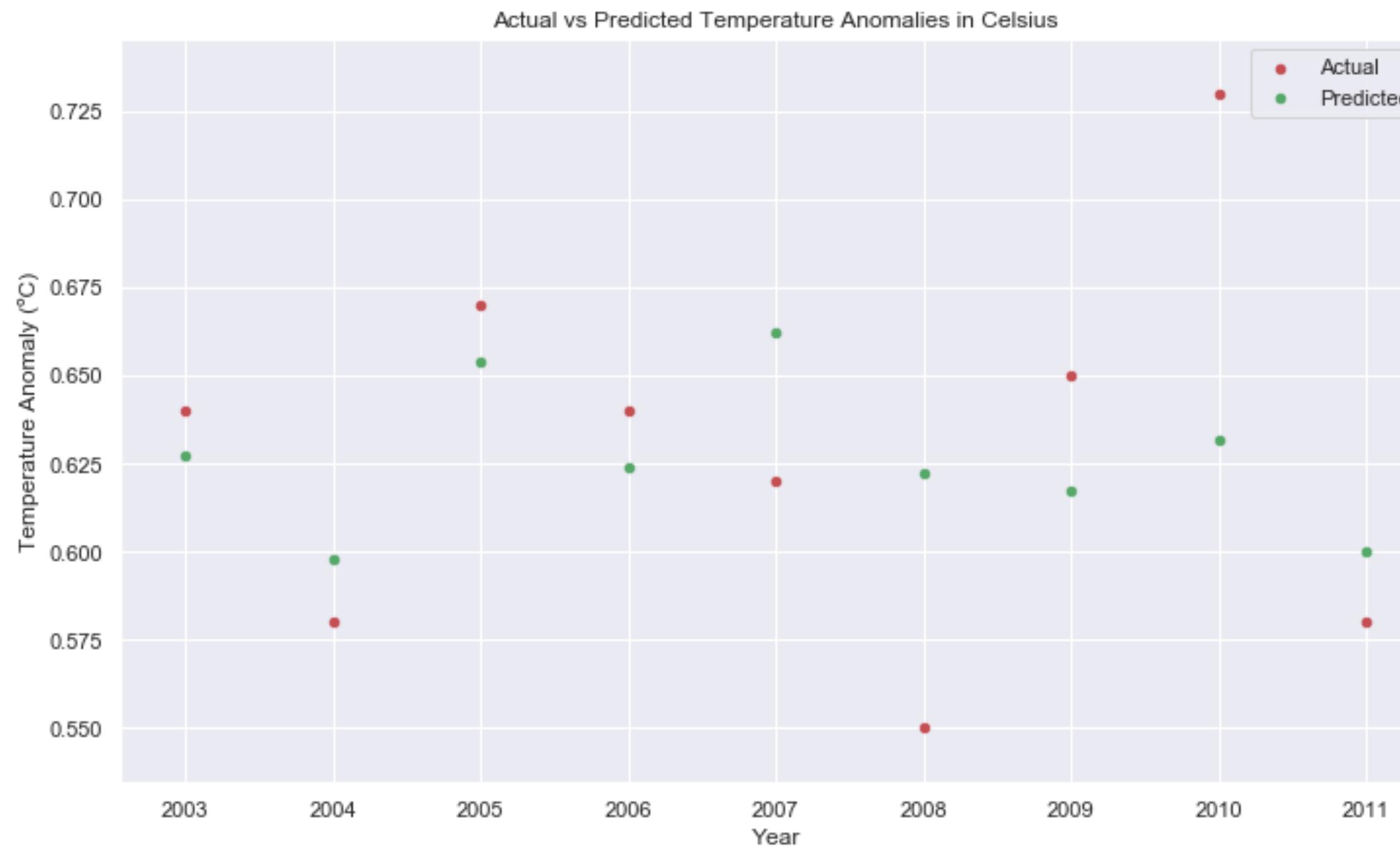


# Modeling

|                         | 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)          | <b>0.0037</b> | 0.0036  | 0.0047  | 0.0040  | 0.0070  | 0.0035  | 0.0035  |
| MSE                     | <b>0.0019</b> | 0.0021  | 0.0140  | 0.0029  | 0.0061  | 0.0023  | 0.0024  |

# 2nd Place Model

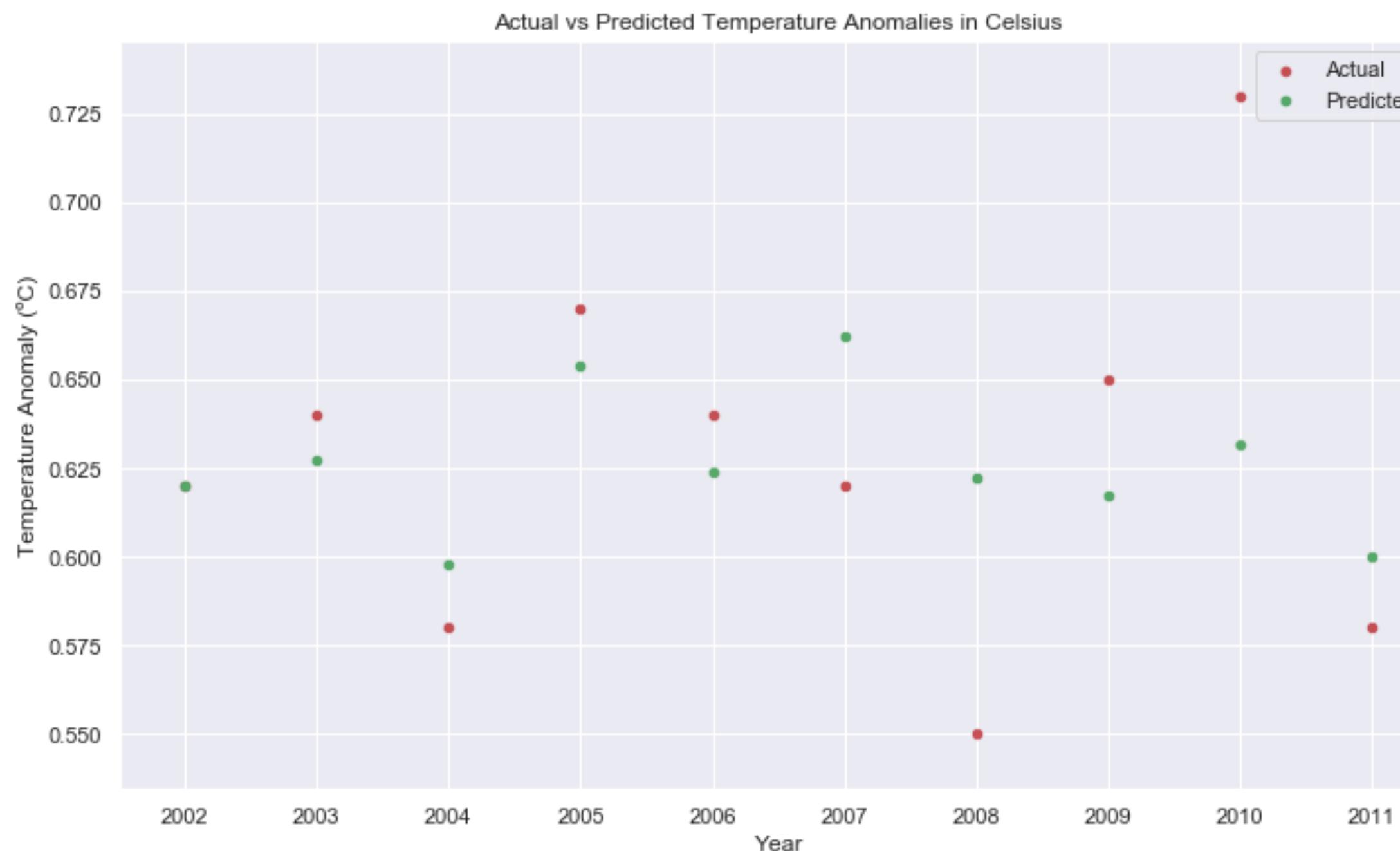
## LASSO Regression



- 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

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- 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.
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# References

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- 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/](https://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?