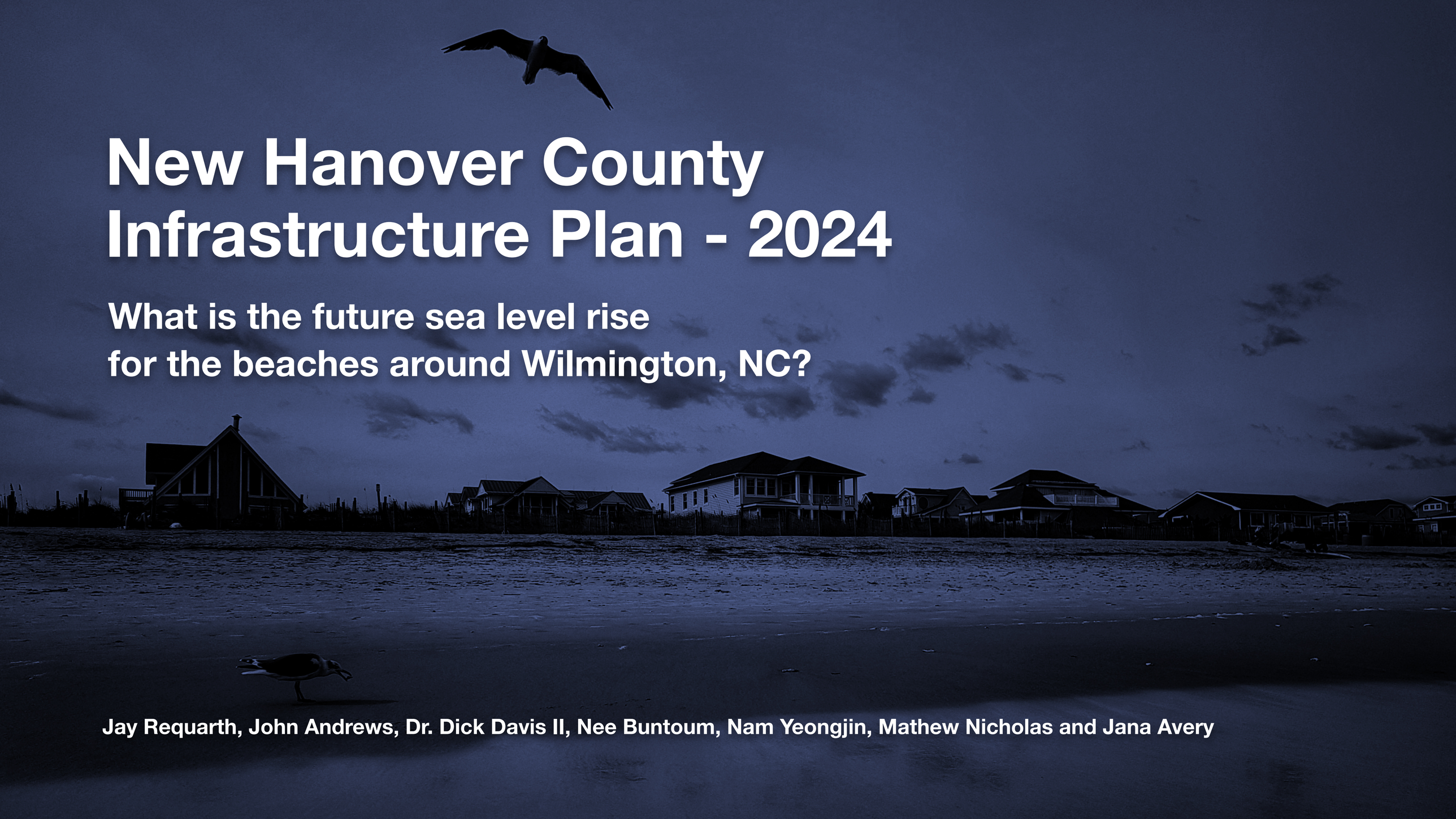


New Hanover County Infrastructure Plan - 2024

What is the future sea level rise for the beaches around Wilmington, NC?

Jay Requarth, John Andrews, Dr. Dick Davis II, Nee Buntoum, Nam Yeongjin, Mathew Nicholas and Jana Avery

What's Happening in Wilmington Today?

https://www.wwaytv3.com/battleship-nc-begins-work-on-living-with-water-project/pic/2408420/

The Wilmington airport may become inaccessible because of flooding.

How should New Hanover County plan for future sea level rise?

Is global warming real?

Is sea level rise real?

How fast are temperature and sea level rising?

What will conditions be like in 10 years?

How should New Hanover county best use its resources?

How quickly do we need to start on building projects – if any?

Is global warming a real thing?

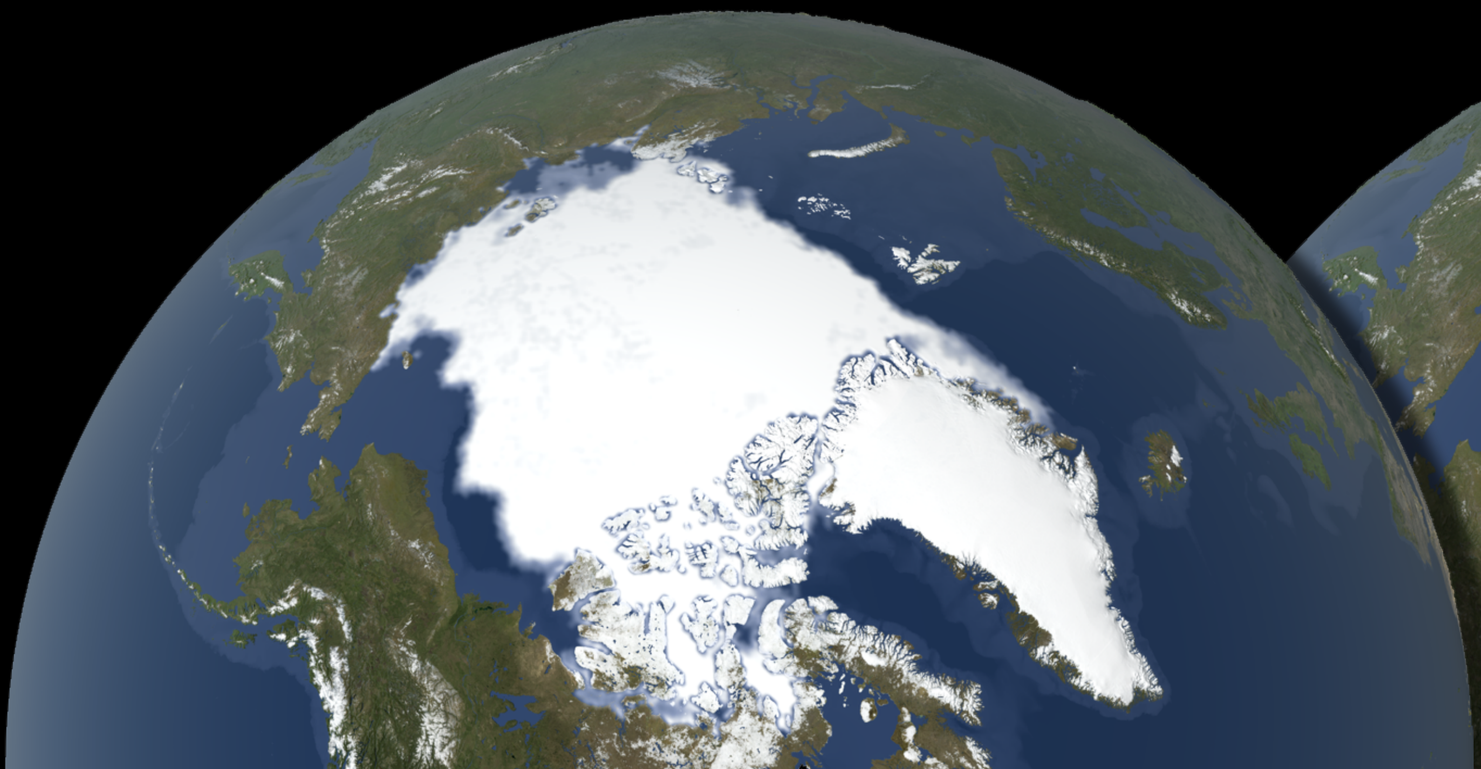
Earth is surrounded by a vacuum.

THE PERFECT INSULATOR

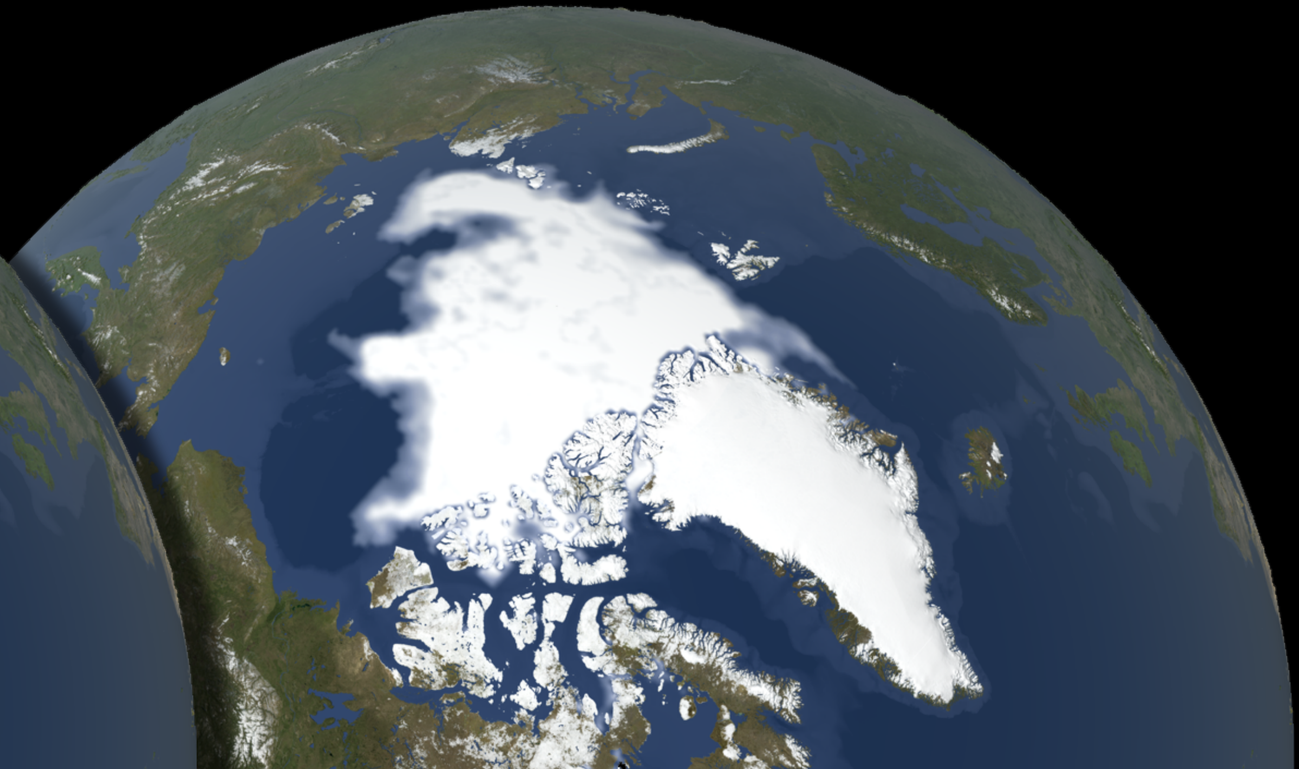
Increased Temperature = Ice Melt

https://www.epa.gov/climate-indicators/climate-change-indicators-arctic-sea-ice

September 1979



September 2023

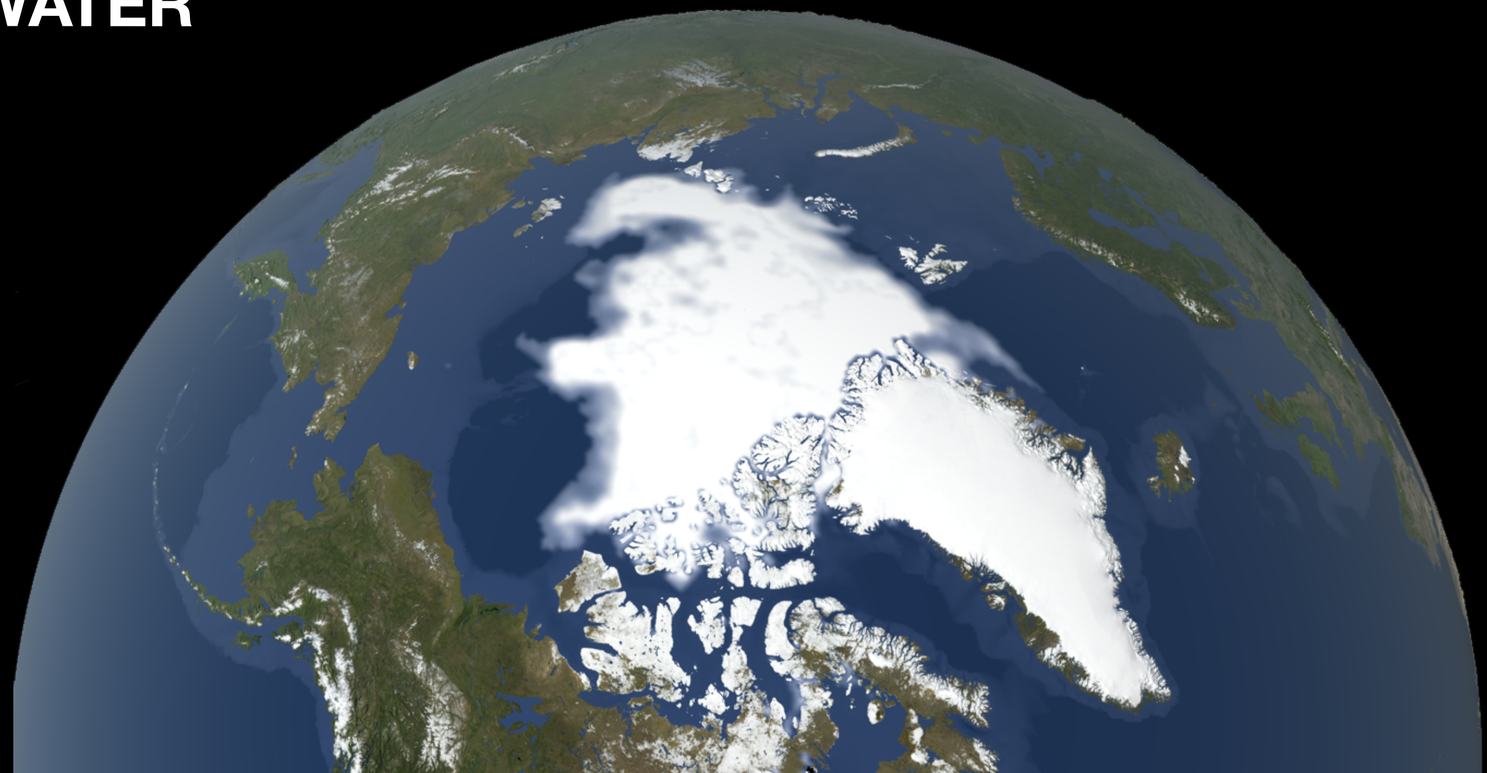


Why Is Sea Level Rising?

ICE MELT

&

THERMAL EXPANSION OF WATER



Sea Level Data Set

PSMSL

Permanent Service
for Mean Sea Level

Permanent Service for Mean Sea Level (PSMSL), 2024, "Tide Gauge Data", Retrieved 15 Jan 2024 from http://www.psmsl.org/data/obtaining/.
Simon J. Holgate, Andrew Matthews, Philip L. Woodworth, Lesley J. Rickards, Mark E. Tamisiea, Elizabeth Bradshaw, Peter R. Foden, Kathleen M. Gordon, Svetlana Jevrejeva, and Jeff Pugh (2013) New Data Systems and Products at the Permanent Service for Mean Sea Level. Journal of Coastal Research: Volume 29, Issue 3: pp. 493 – 504. doi:10.2112/JCOASTRES-D-12-00175.1.

PSMSL.org Data

```
df.iloc[150,0]  # for Miami and Wilmington
```

```
'\xa0 1947.8750'
```

Data is in a Fortran IV datafile

Download via MatLab program in Xcode.

Copy & paste data into Excel spreadsheet.

Save Excel data as a .csv file

Upload data to python program into a Pandas datafile

Parse data on “;”

Remove invisible alpha-numerics from date variable

Using the following formula (M – 0.5)/12 , the month integers were calculated.

A datetime variable was created by concatenating yyyy-mm-01.

Missing sea level height data was recorded as -9999. Those data points were identified and removed.

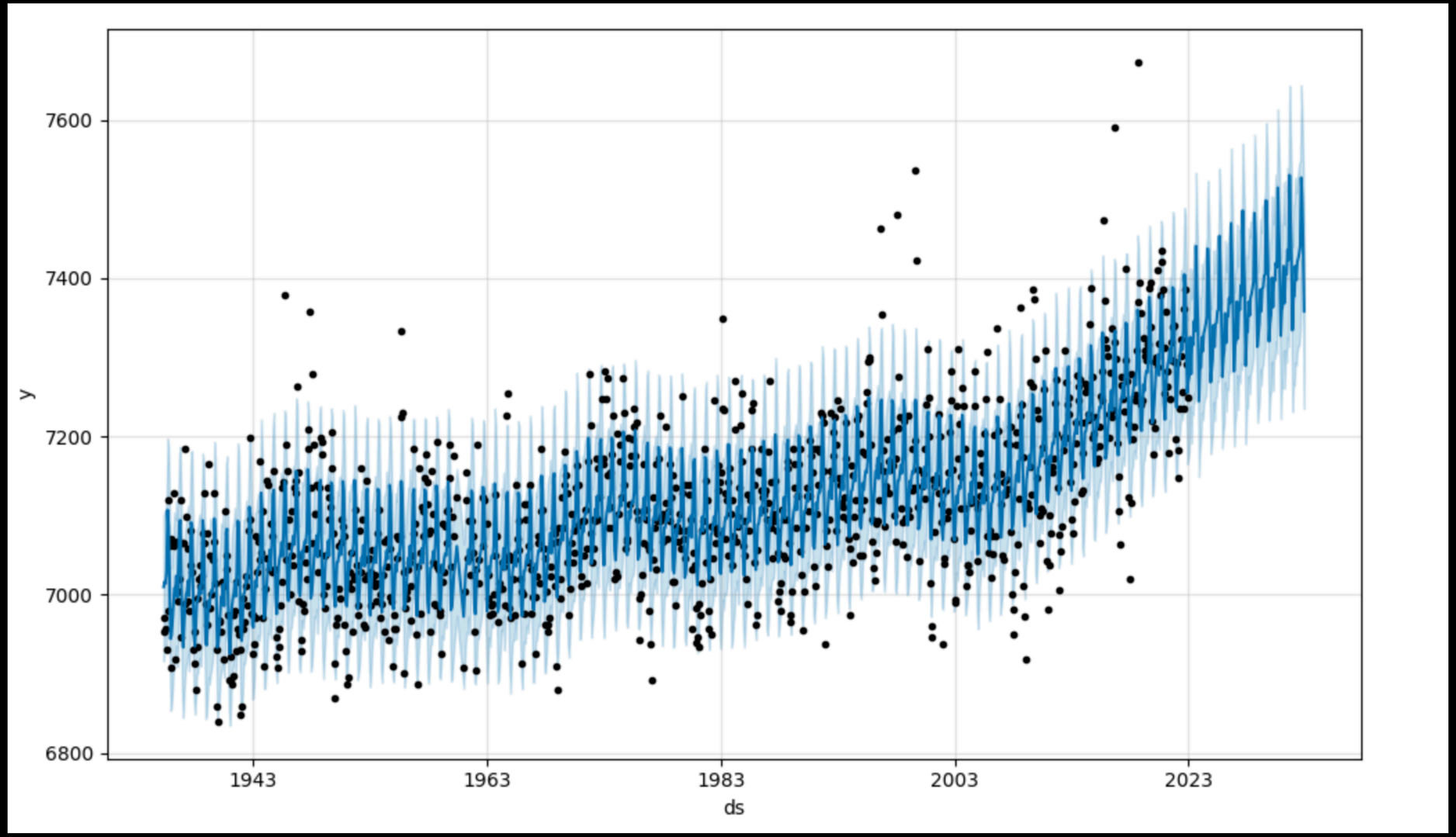
NASA Northern Hemisphere Temperature CVS File

```
Land-Ocean: Northern Hemispheric Means
Year,Jan,Feb,Mar,Apr,May,Jun,Jul,Aug,Sep,Oct,Nov,Dec,J-D,D-N,DJF,MAM,JJA,SON
1880,-.36,-.51,-.24,-.30,-.06,-.16,-.18,-.25,-.22,-.31,-.41,-.40,-.28,***,***,-.20,-.20,-.31
1881,-.31,-.22,-.04,.00,.04,-.34,.08,-.05,-.28,-.45,-.37,-.23,-.18,-.20,-.31,.00,-.10,-.36
1882,.26,.21,.02,-.32,-.24,-.30,-.28,-.14,-.23,-.52,-.32,-.67,-.21,-.17,.08,-.18,-.24,-.36
1883,-.57,-.66,-.15,-.29,-.24,-.13,-.04,-.22,-.32,-.16,-.42,-.15,-.28,-.32,-.63,-.23,-.13,-.30
1884,-.16,-.09,-.63,-.60,-.36,-.43,-.40,-.50,-.45,-.44,-.57,-.46,-.42,-.40,-.13,-.53,-.44,-.49
1885,-1.00,-.46,-.24,-.49,-.58,-.45,-.34,-.41,-.40,-.37,-.38,-.12,-.44,-.47,-.64,-.44,-.40,-.38
1886,-.75,-.84,-.71,-.37,-.33,-.37,-.14,-.43,-.33,-.31,-.40,-.21,-.43,-.43,-.57,-.47,-.31,-.35
1887,-1.08,-.70,-.44,-.39,-.26,-.21,-.25,-.55,-.21,-.49,-.27,-.42,-.44,-.42,-.67,-.36,-.34,-.32
1888,-.48,-.61,-.64,-.22,-.15,-.03,.00,-.21,-.19,-.03,-.01,-.23,-.23,-.25,-.51,-.34,-.08,-.08
1889,-.28,.29,-.02,.16,-.04,-.06,-.08,-.20,-.30,-.41,-.62,-.55,-.17,-.15,-.07,.04,-.12,-.44
1890,-.64,-.58,-.48,-.25,-.36,-.16,-.23,-.39,-.35,-.10,-.63,-.47,-.39,-.39,-.59,-.36,-.26,-.36
```

https://data.giss.nasa.gov/gistemp/tabledata_v4/NH.Ts+dSST.csv

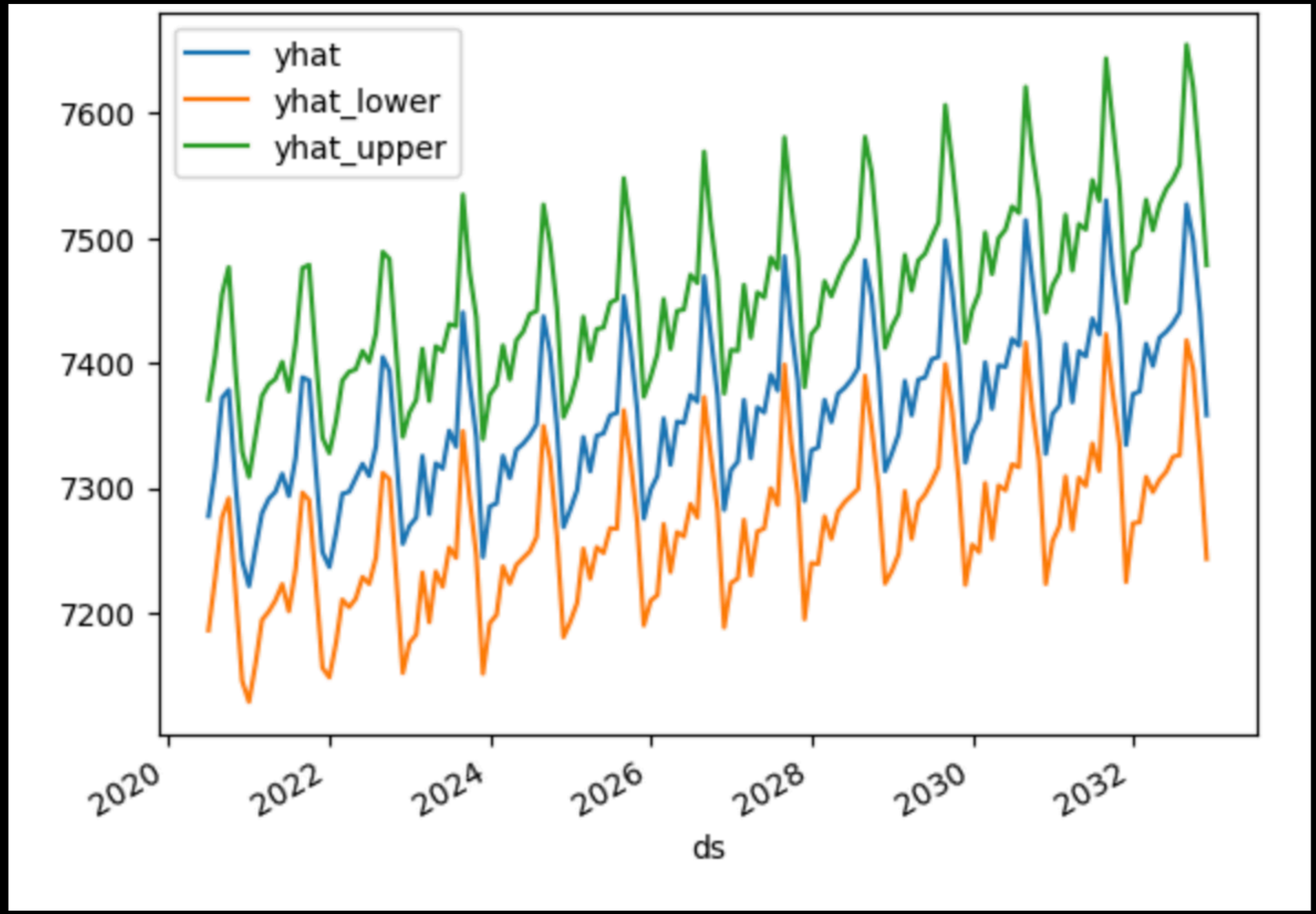
Data retrieved 1-27-2024

Sea Level Rise - Wilmington



Data: 1935 – January 2024; 98% complete. Station ID = 396 (Station Name = Wilmington); PSMSL.org

Wilmington 10 Year Forecast

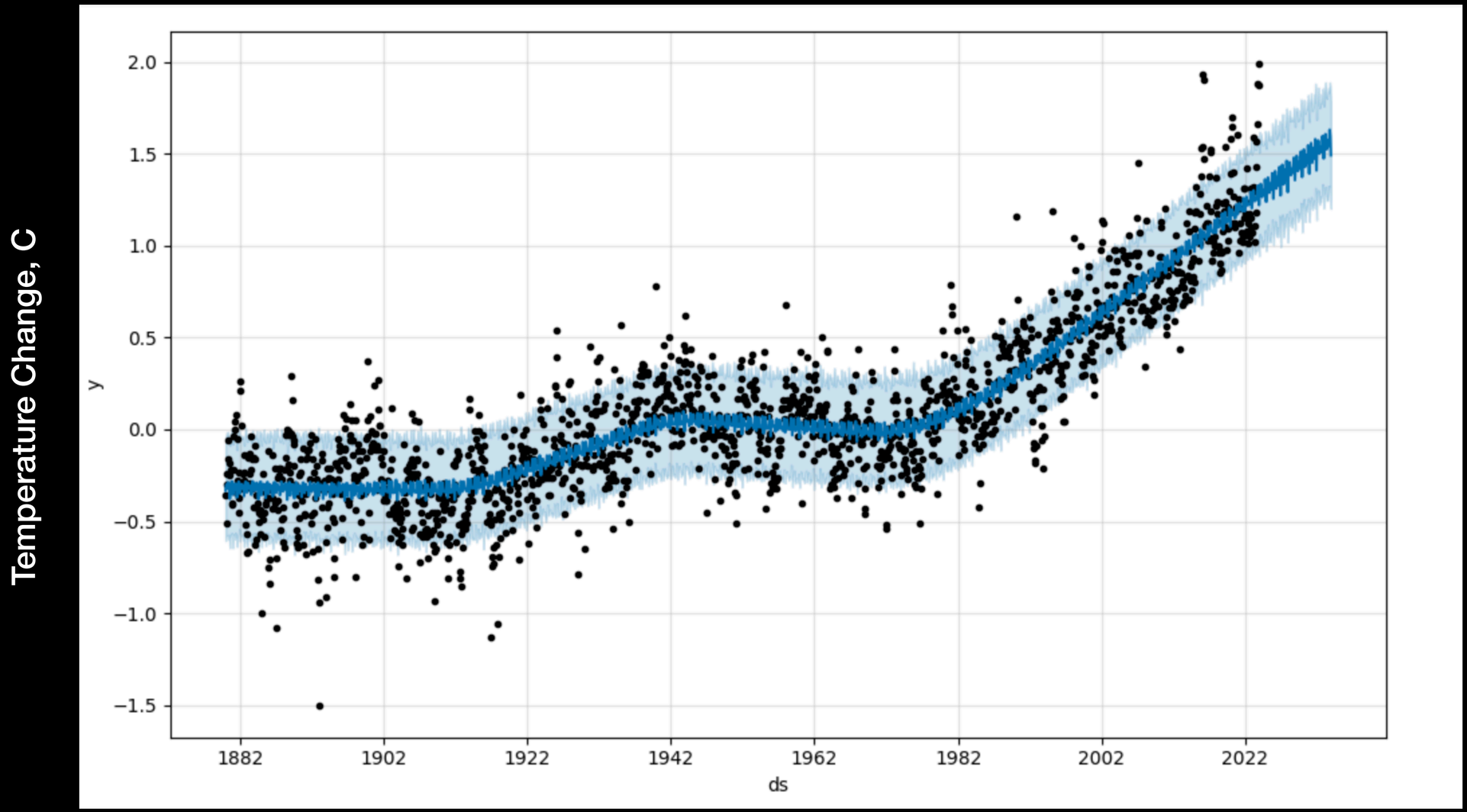


yhat_upper:
upper estimate

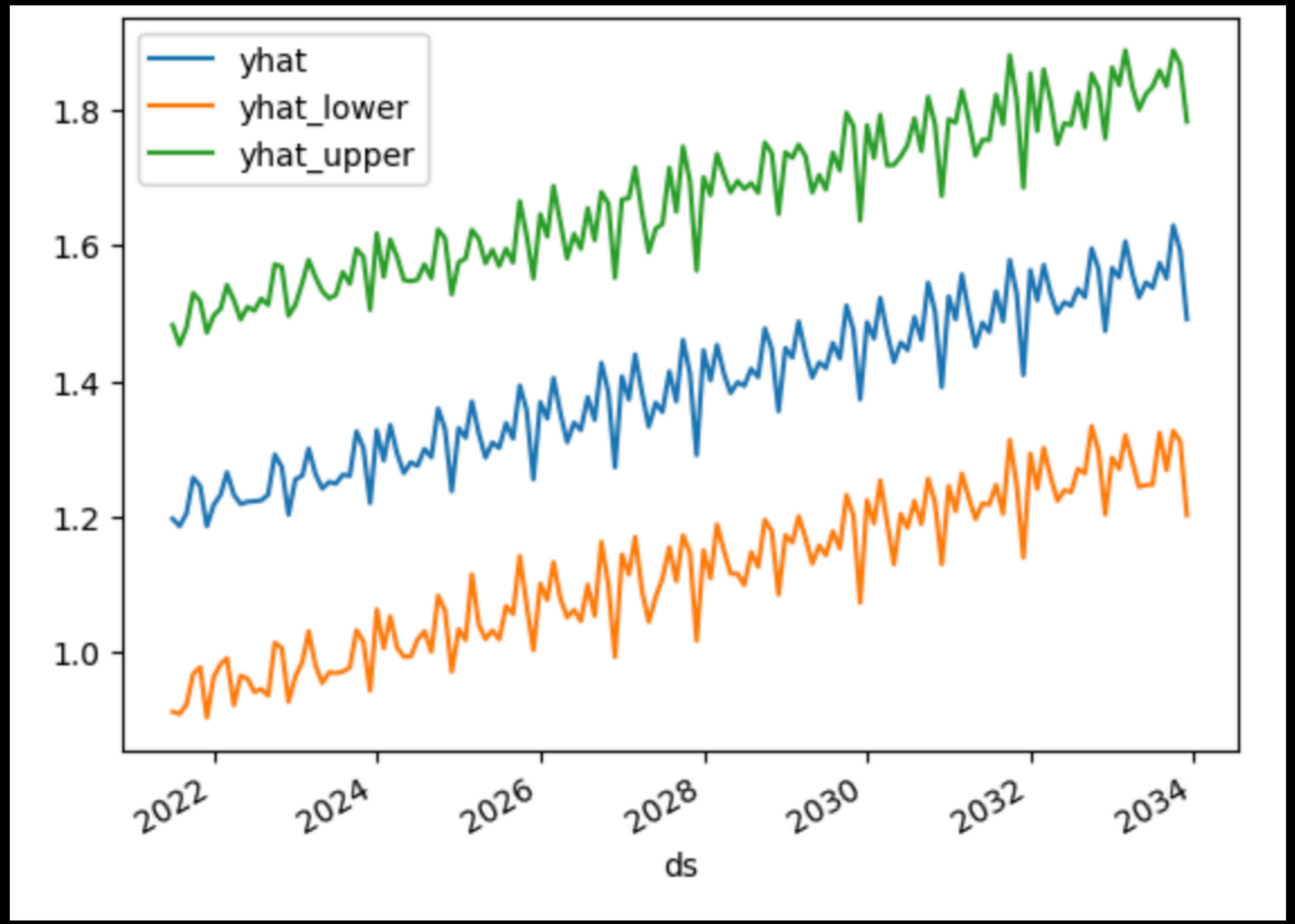
yhat:
best estimate

yhat_lower:
lower estimate

Northern Hemisphere Temperatures (C) vs Time with Future Predictions



Predicted Temperature Rise in Centigrade vs Time

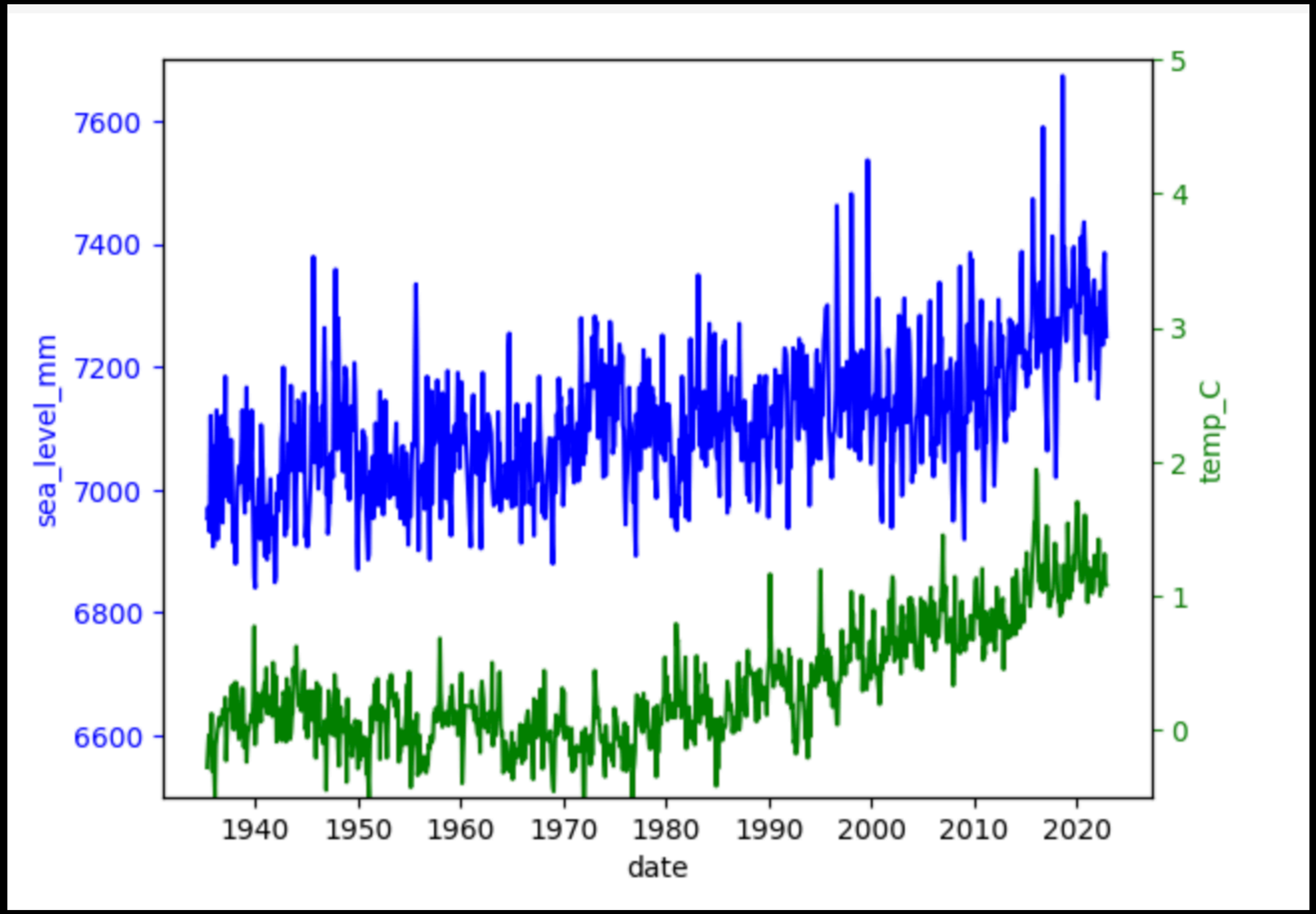


yhat_upper:
upper estimate

yhat:
best estimate

yhat_lower:
lower estimate

Wilmington Sea Level vs NH Temp vs Date

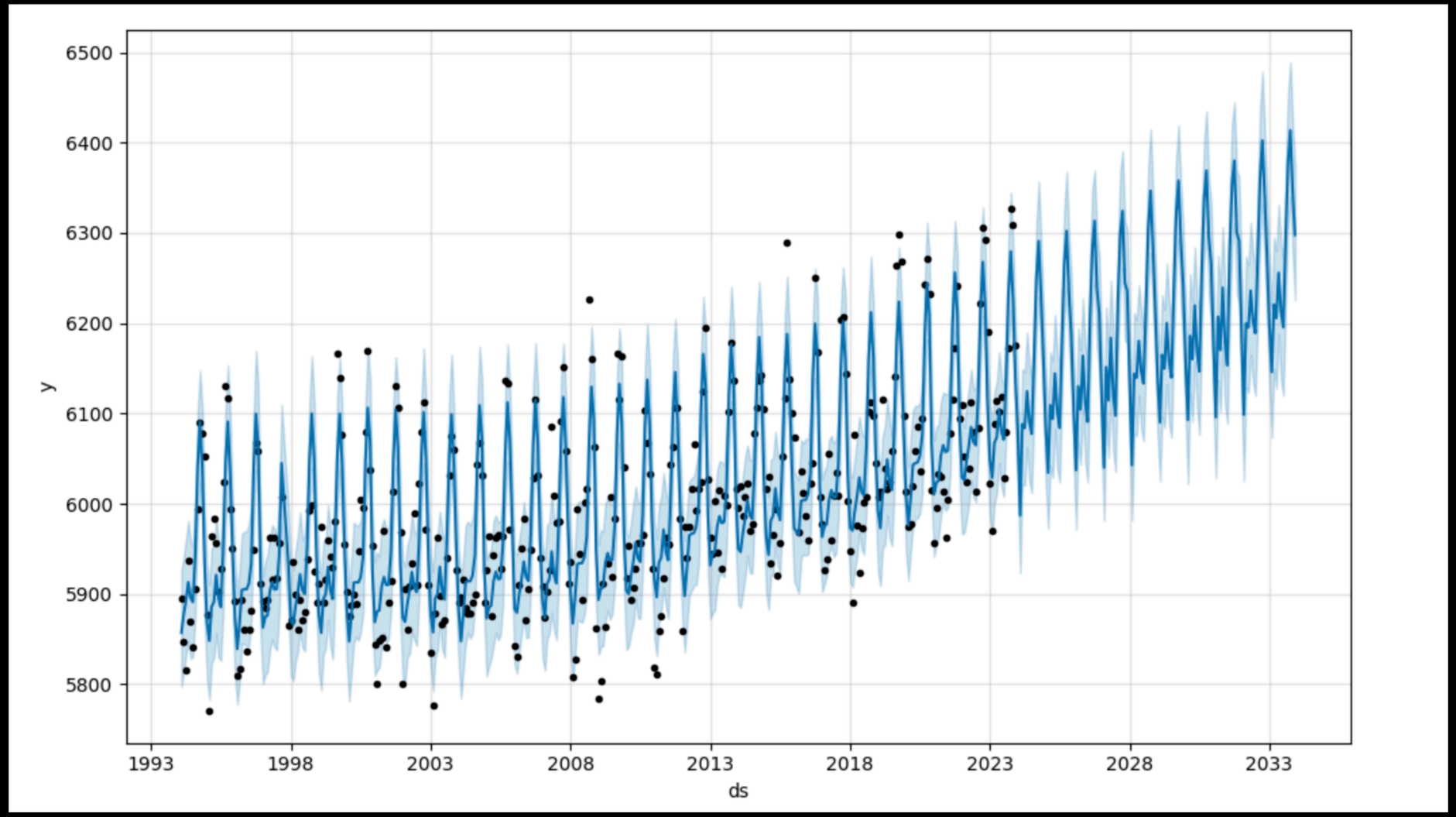


Correlation Coefficient (r) between Northern Temperature Rise and Wilmington Sea Level Rise

$$r = 0.5$$

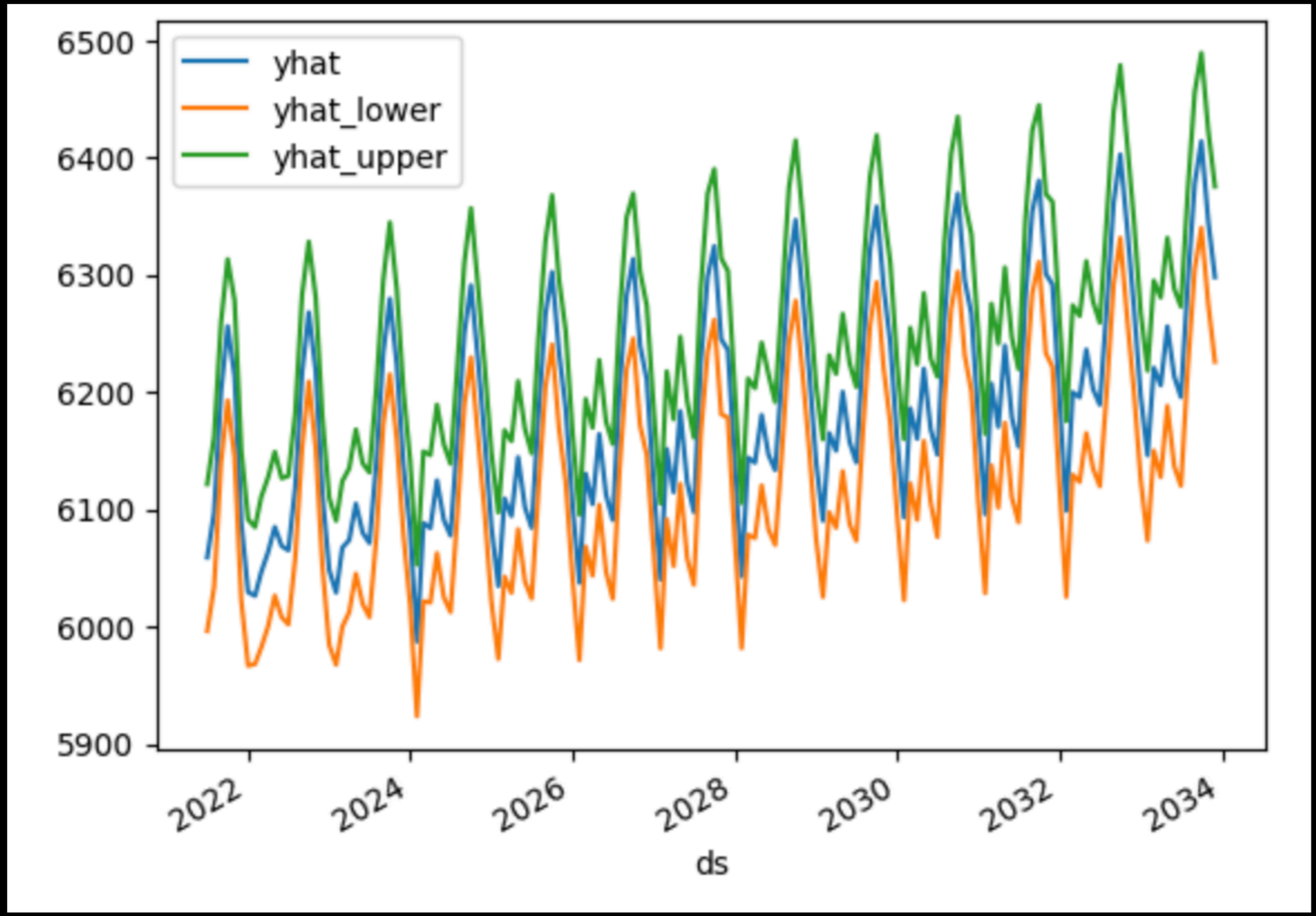
Moderate positive correlation between temperature rise and sea level rise. Data is noisy because of tidal fluctuations.

Sea Level Rise - Miami



Data: 1994 — January 2024. 99%complete. Station ID: 1858 (Station Name: Virginia Key) PSMSL.org

Miami

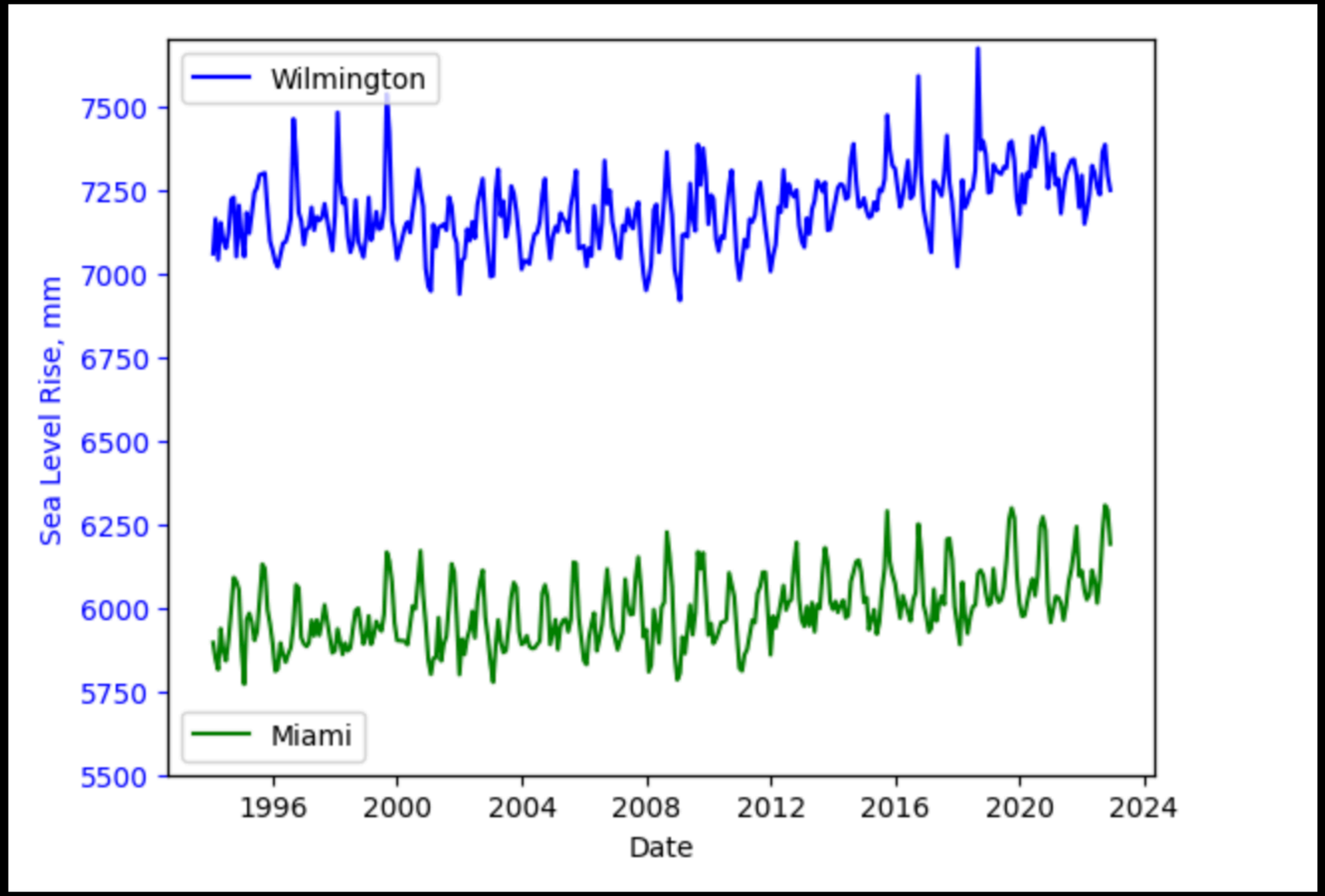


yhat_upper:
upper estimate

yhat:
best estimate

yhat_lower:
lower estimate

Wilmington vs Miami Sea Level

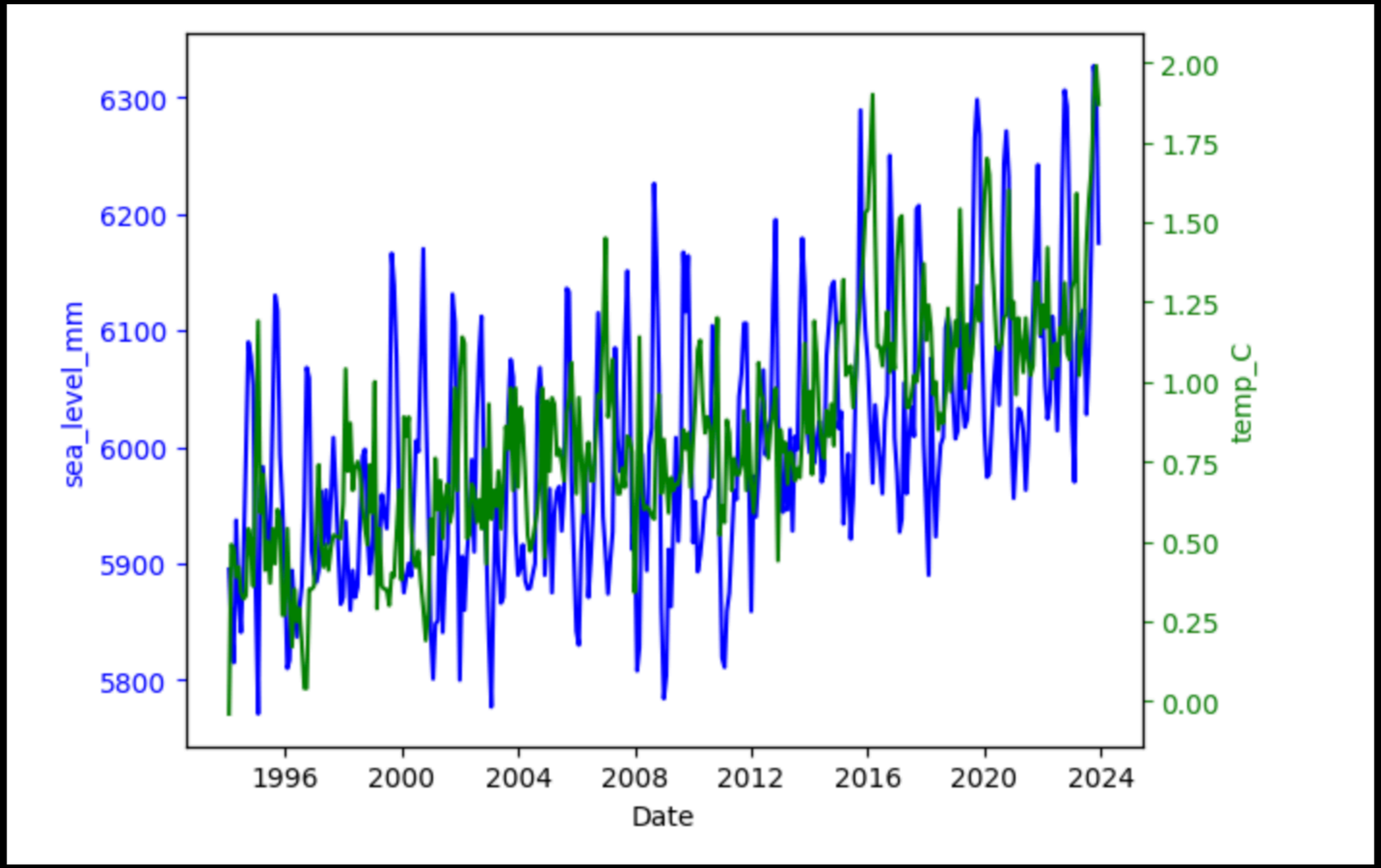


Correlation between Sea Level Rise in Wilmington vs Miami

```
# Determine the coooelation coefficient
from scipy import stats as st
sea_level_rise_wilmington = cities_df['Wilmington']
sea_level_rise_miami = cities_df['Miami']
correlation = st.pearsonr(sea_level_rise_wilmington, sea_level_rise_miami)
r = round(correlation[0],2)
print(f'Correlation r = {r}')
```

```
Correlation r = 0.74
```

Miami Sea Level vs Northern Hemisphere Temperatures (C)



Correlation of Miami Sea Level vs Temperature

```
# Determine the coooelation coefficient
from scipy import stats as st
var_sea_level = combined_df['sea_level_mm']
var_temp = combined_df['temp_C']
correlation = st.pearsonr(var_sea_level, var_temp)
r = round(correlation[0],2)
print(f'Correlation r = {r}')
```

```
Correlation r = 0.42
```

Data Analysis

- The data is very good.
- Only 17 months of tide data is missing over nearly 90 years.
- Sea level data was confounded by king tides and storms.
- The Northern Hemisphere temperature data is good, but the is an average over the entire hemisphere.
- Specific Wilmington temperature data was not found.

Best Guess for Wilmington - 10 years hence

Excluding storm surges and tidal variations, the mean sea level in Wilmington, NC, will increase ~4 inches (10 cm).

High estimate is ~8 inches (20 cm)

However, the average temperature in the Northern Hemisphere will increase 0.5 F (0.3 C) making summers hotter.

High estimate is ~1.0 F (0.6 C)

Recommendations

- Begin constructing a sea wall that will protect vital areas of the city.
- Stop all coastal development in low lying areas.
- Rather than spending money to replenish sand-depleted beaches, construct a jetty to protect the beaches from depletion.
- Begin placing anti-reflux valves in storm drains.
- Begin constructing cooling centers for summer residents without AC.

THE END

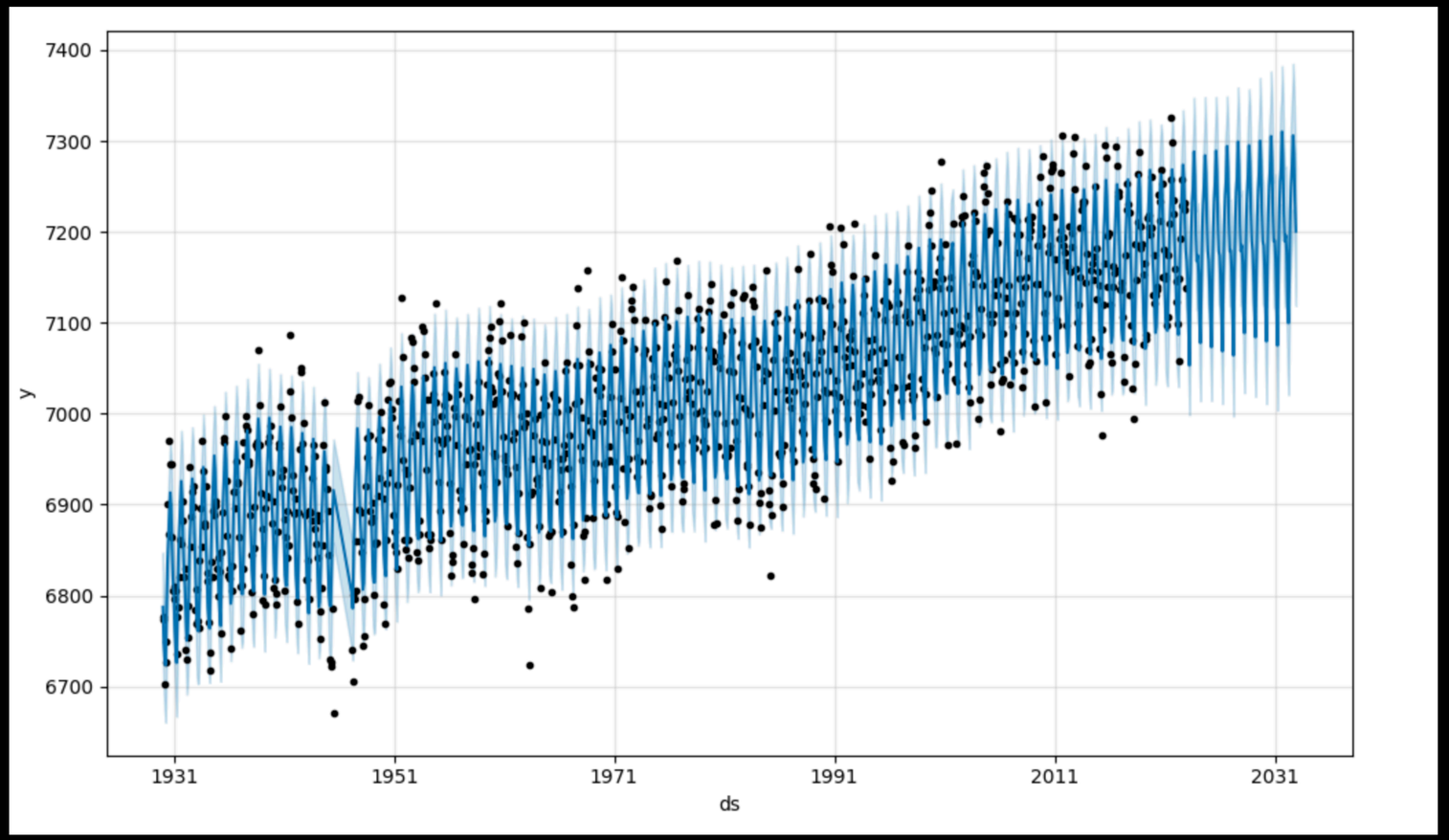
THANK YOU FOR YOUR ATTENTION

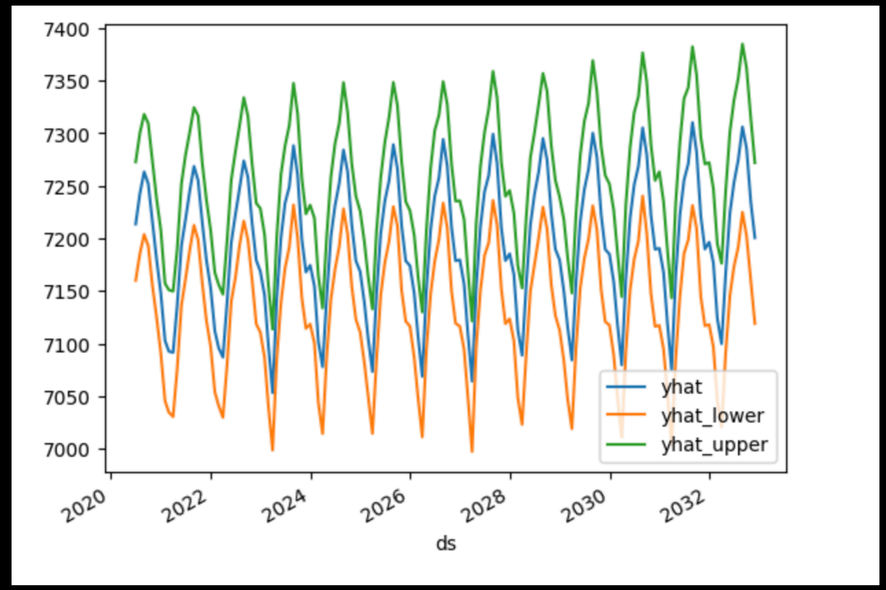
Appendix follows

1. Program is generic

2. Nerd (thermodynamics) information

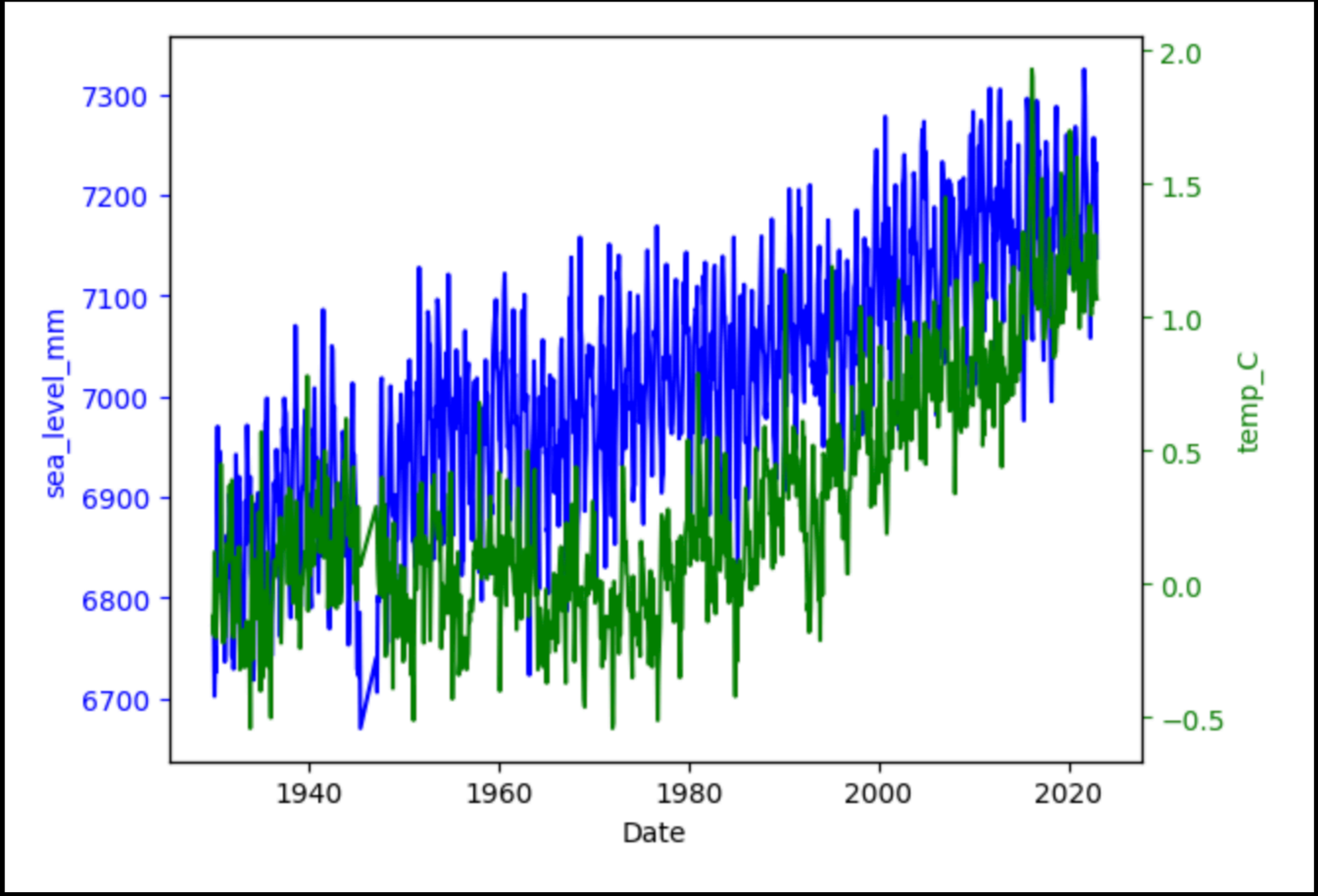
Our program can compare any two cities in the world.





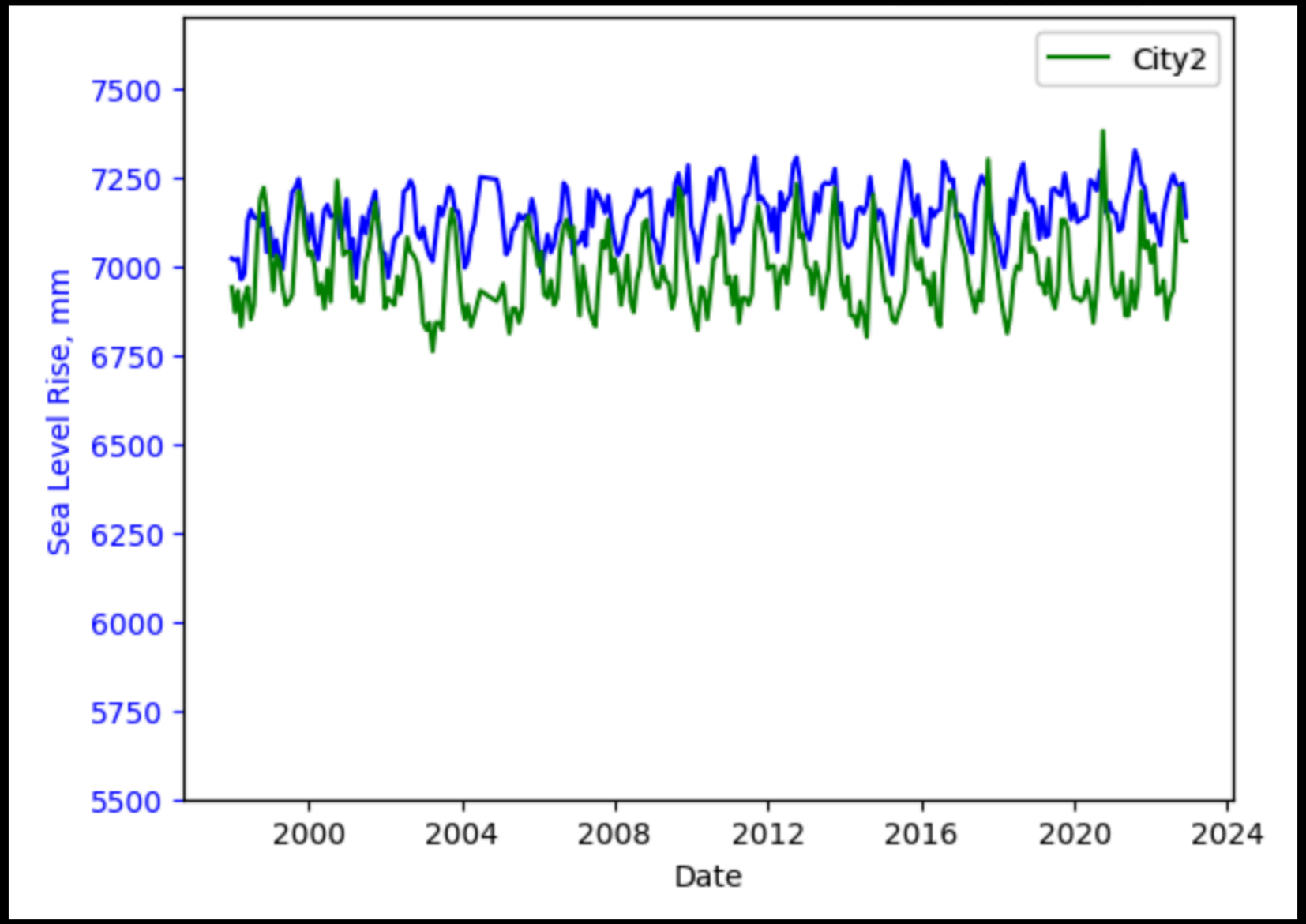
Sea Level Rise Tokyo
(Station Number: 130)

Sea Level Rise in Tokyo vs NH Temp



(r=0.59)

Sea Level Tokyo vs Singapore



(r=0.39)

The only way heat escapes Earth is by radiant energy into space.

This transfer of energy is expressed with the Stefan-Boltzmann Law.

$$E_{Radiant} = \sigma T^4$$

$$\sigma_{Stefan's\ constant} = 5.6703x10^{-8}\ (\frac{W}{m^2T^4})$$

Energy require to melt ice vs heat water?

334 J/g

Enthalpy of fusion of water at 32C, 1 atm
(Energy required to melt ice without temperature change)

4.2 J/g

Heat capacity of water at 32C, 1 atm
(Energy required to heat water 1C)

Global Average Temperature

Compared with mid-20th century

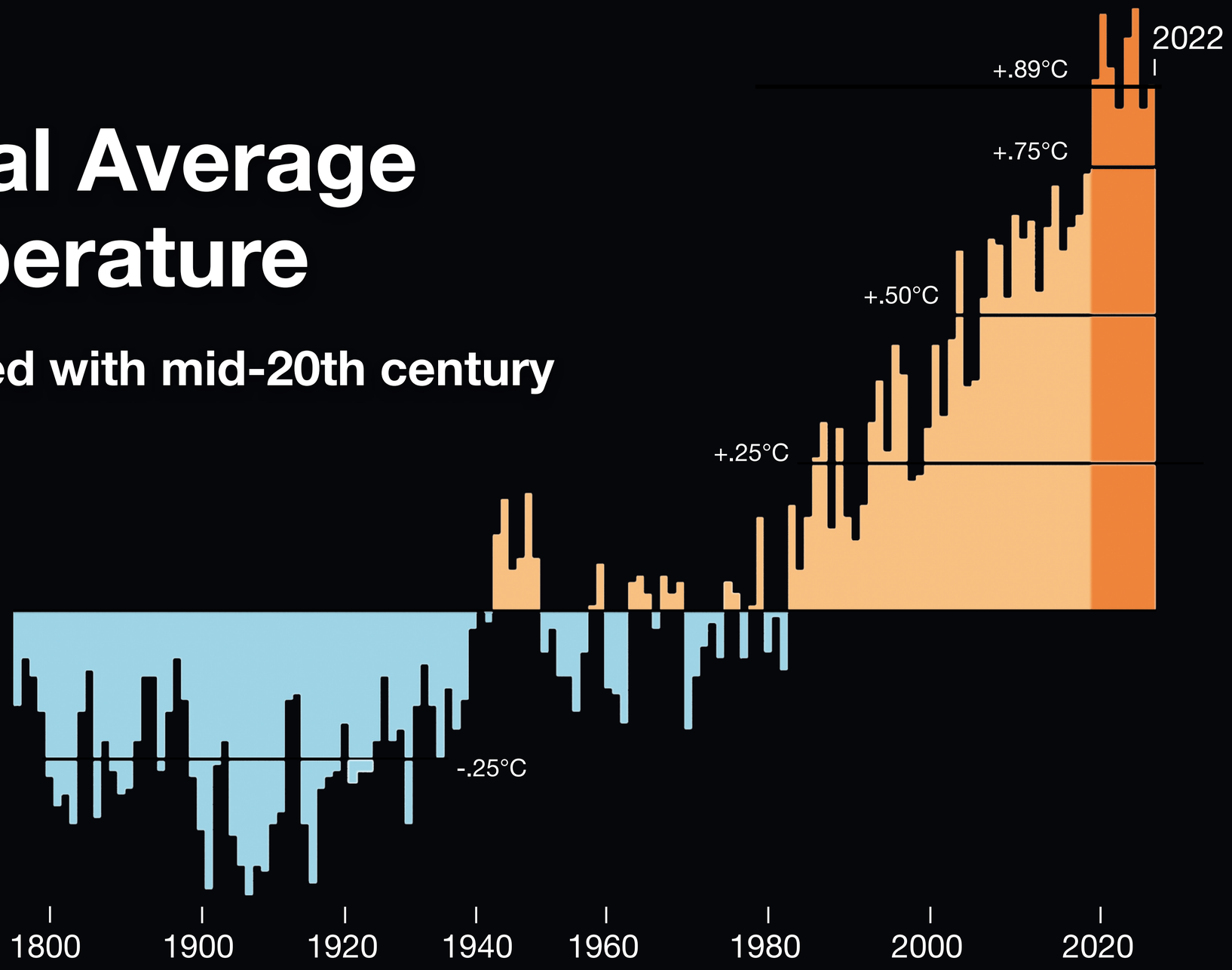


Figure 1. March and September Montly Average Sea Ice Extent, 1979-2023

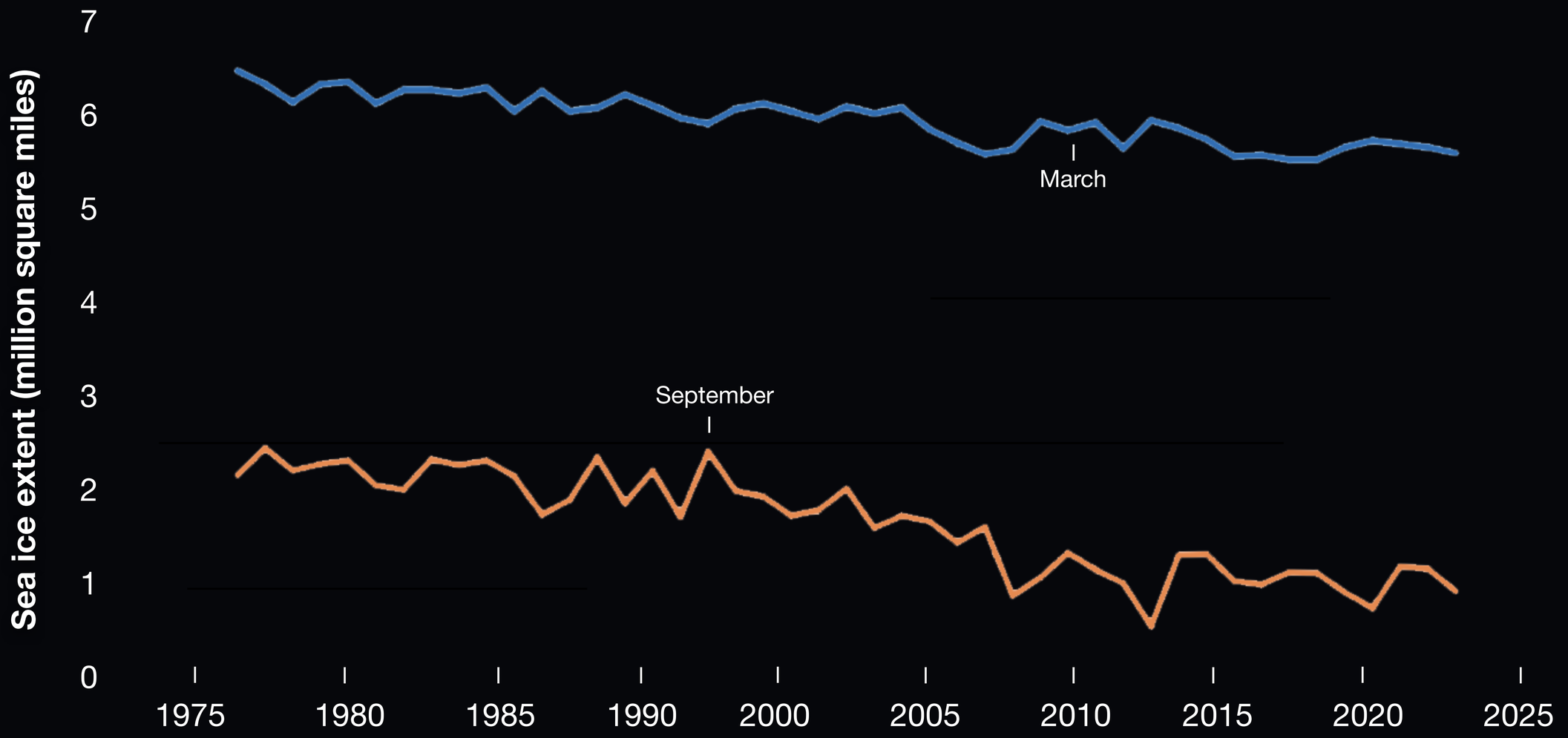


Figure 2. Age of Arctic Sea Ice at Minimum September Week, 1984-2023

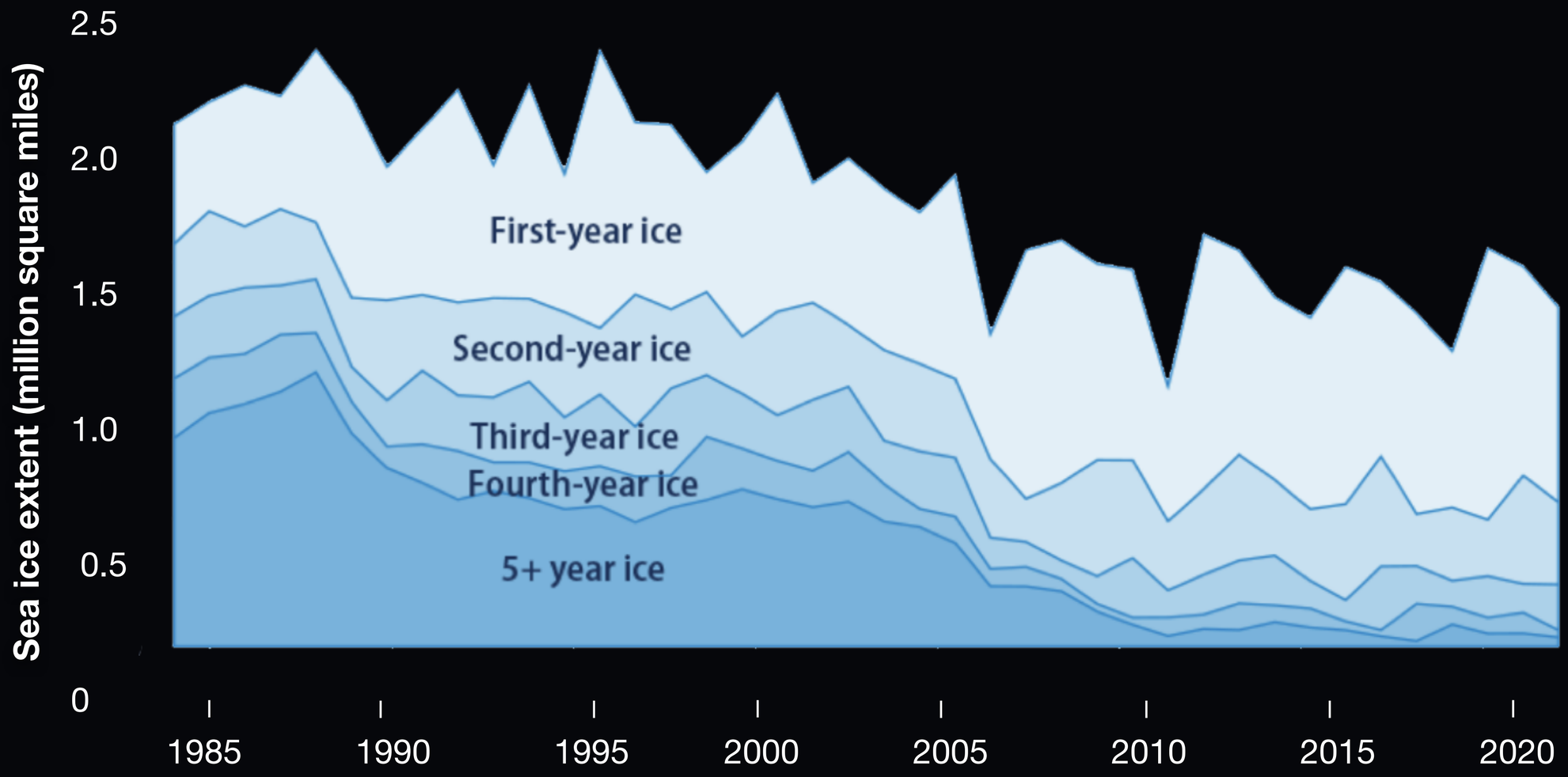


Figure 3. Arctic Sea Ice Melt Season, 1979-2022