GLACIERS IN GREENLAND

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INTRODUCTION AND MOTIVATION

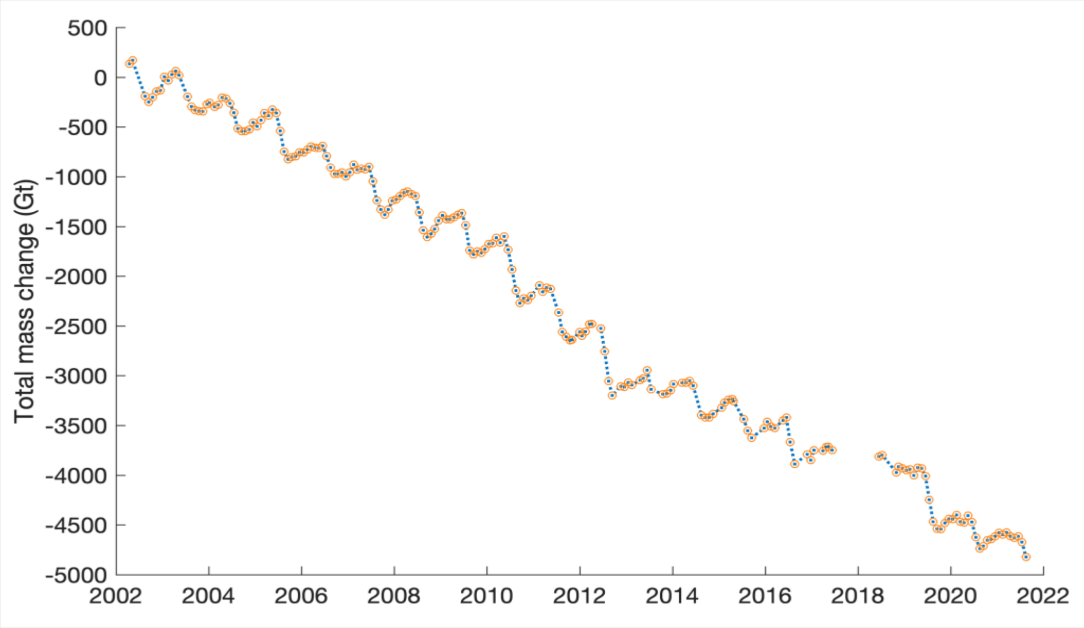
- We want to analyze and model glaciers in Greenland.
- Visualized aspects of glacier ice thickness across 26 years of data
- We chose this topic because climate change is important to understand as future geophysicists and engineers

- We look at:
- The corresponding areas of Greenland and the years we have data on
- Average ice thickness over time
- The relationship between ice thickness and elevation
- Change of ice thickness in the same location
- Latitude vs Ice Thickness

RESEARCH QUESTION:

How has the distribution and thickness of glaciers in Greenland changed over the past couple of decades?

- We aim to answer this question through data visualizations and interpretation.
- This is important because glacier research is a relatively new idea. That is proving to be more impactful and important as scientists have begun to understand glaciers more deeply.



National Oceanic and Atmospheric Administration 2021 [1]

DATASET

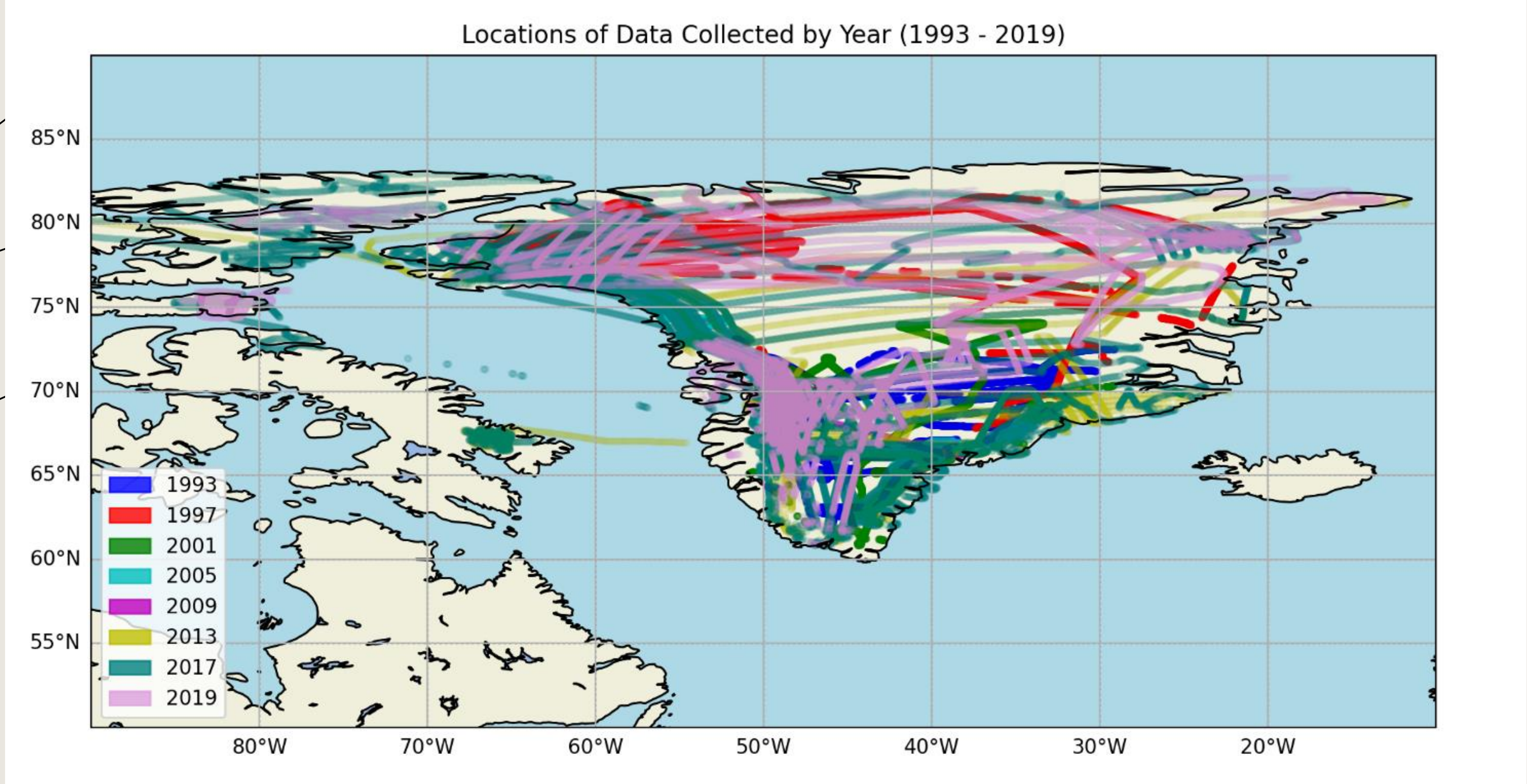
- National Snow and Ice Data Center (NSIDC)
- The data contains CSV files of the ice thickness of Greenland’s glaciers from 1993-2019
- Collected with DC-8 and P-3B aircraft equipped with GPS, LIDAR altimeters, MCoRDS, and radar echo sounders to measure ice thickness and location
- Contains latitude, longitude, time, thickness, elevation, frame, surface, bottom and quality
- Challenges with determining the data subset

DATASET

- For each year’s CSV file, we applied the following:
  - Transformed each CSV file into a Pandas DataFrame
  - Renamed the features to more descriptive and useable names
  - Converted the thickness values into float format
  - Replaced all negative thicknesses with NaN

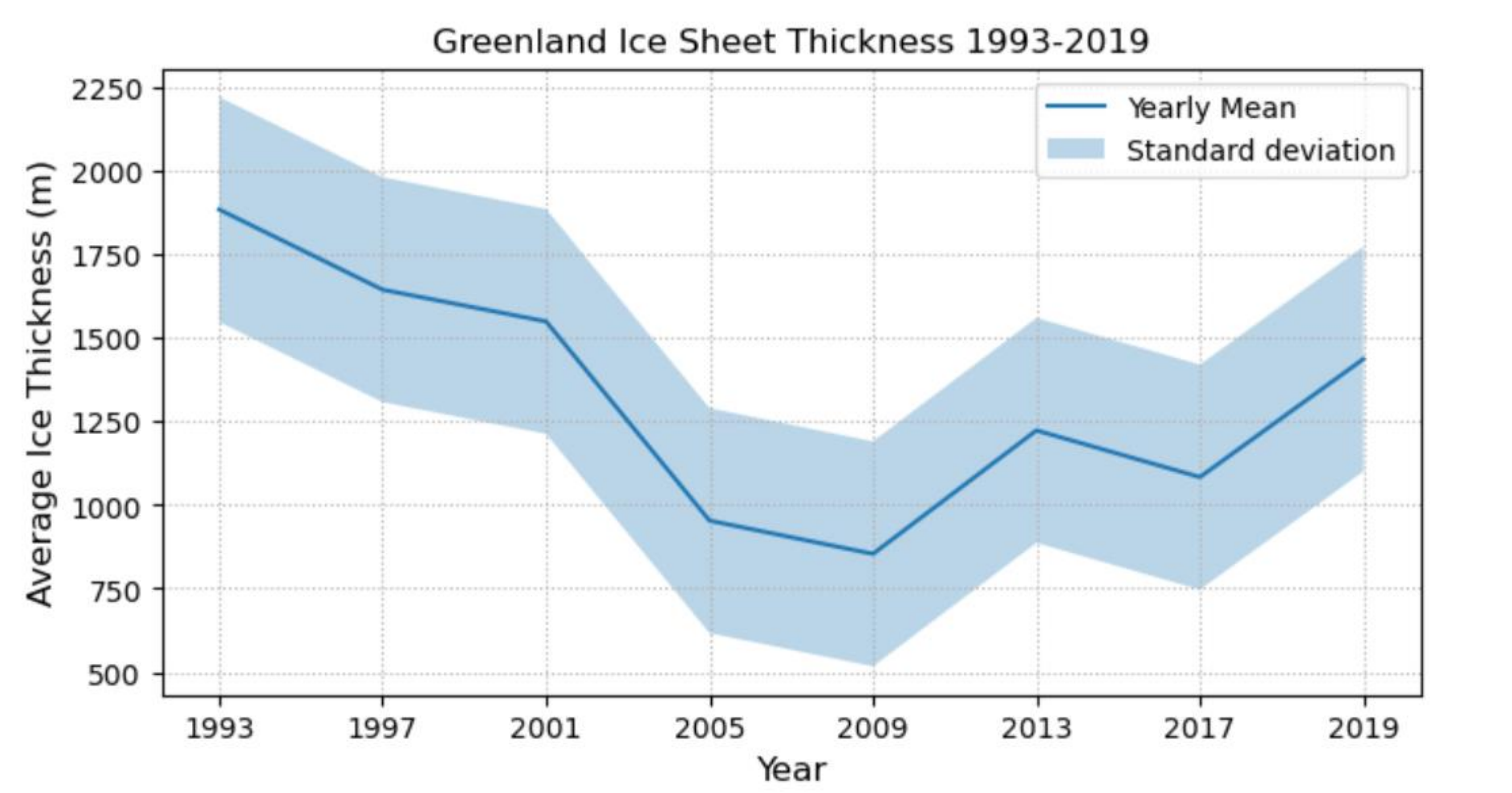
```
# Defines the path to the data from 1997
path_97 = "../data/1997_Greenland_P3.csv"
# Read the csv file
df_97 = pd.read_csv(path_97)
# Renames each column of the dataframe to make it uniform and easier to type
df_97.rename(columns = {'LAT':'latitude', 'LON':'longitude','TIME':'time','THICK':'thickness',
                        'ELEVATION':'elevation', 'FRAME':'frame', 'SURFACE':'surface', 'BOTTOM':'bottom', 'QUALITY':'quality'}, inplace = True)
# make the thickness column float vlaues so we can replace the negative thicknesses with nan values since its impossible to have a negative thickness
df_97['thickness'] = df_97['thickness'].astype(float)
df_97.loc[df_97['thickness'] < 0, 'thickness'] = float('nan')
```

FIGURE 1 – LOCATIONS OF DATA COLLECTED



- Pandas DataFrames
- Used Cartopy with Matplotlib to create visualization
- Can see the flight path/sites of data collected each year
- Helps with interpretations of next figures

FIGURE 2 - GREENLAND ICE SHEET THICKNESS



- Found mean and standard deviation using NumPy functions
- Plotted the average ice thickness and the standard deviation for each year using Matplotlib
- Icesheet thickness declined from 1993 – 2009 from 1900(m) to 900(m), then increased slightly from 2009-2019 reaching about 1400(m).
  - Difference in sample locations
  - General warming trends
- Standard deviation shows the variability was relatively high early on but became more consistent after the mid-2000s

FIGURE 3 – ICE THICKNESS MAP

- Measurement locations from 1993 and 2017 were plotted onto a projection, and then a gradient was applied to the scatterplot to show ice thickness
- 2017 was chosen over 2019 because the 2017 data had higher resolution in South Greenland
- Mass loss can be observed on the southeast coast, but the inland ice thickness appears to be mostly unchanged
- Mass loss is also seen in the surveyed area east of the 40° W longitude line

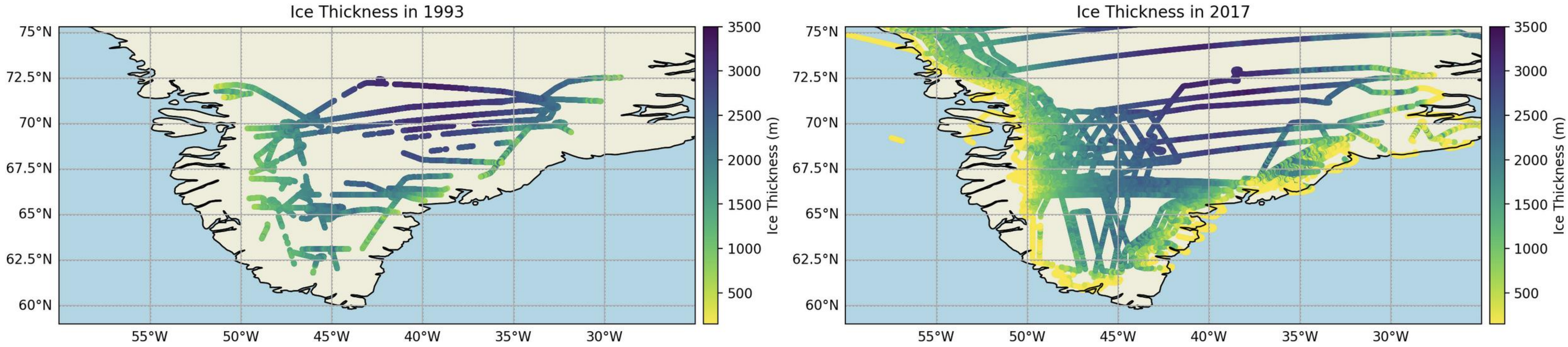


FIGURE 4 – BOTTOM ELEVATION VS THICKNESS

- Thickness tends to decrease at higher base elevations
- Generally, there appears to be a maximum thickness to base elevation ratio at approximately 1 meter less of thickness per meter of elevation
- Glaciers seem to have a maximum glacier base elevation at approximately 3000 meters, which likely corresponds with the maximum elevation in the surveyed area, but individual observation of these points can determine any significance of this

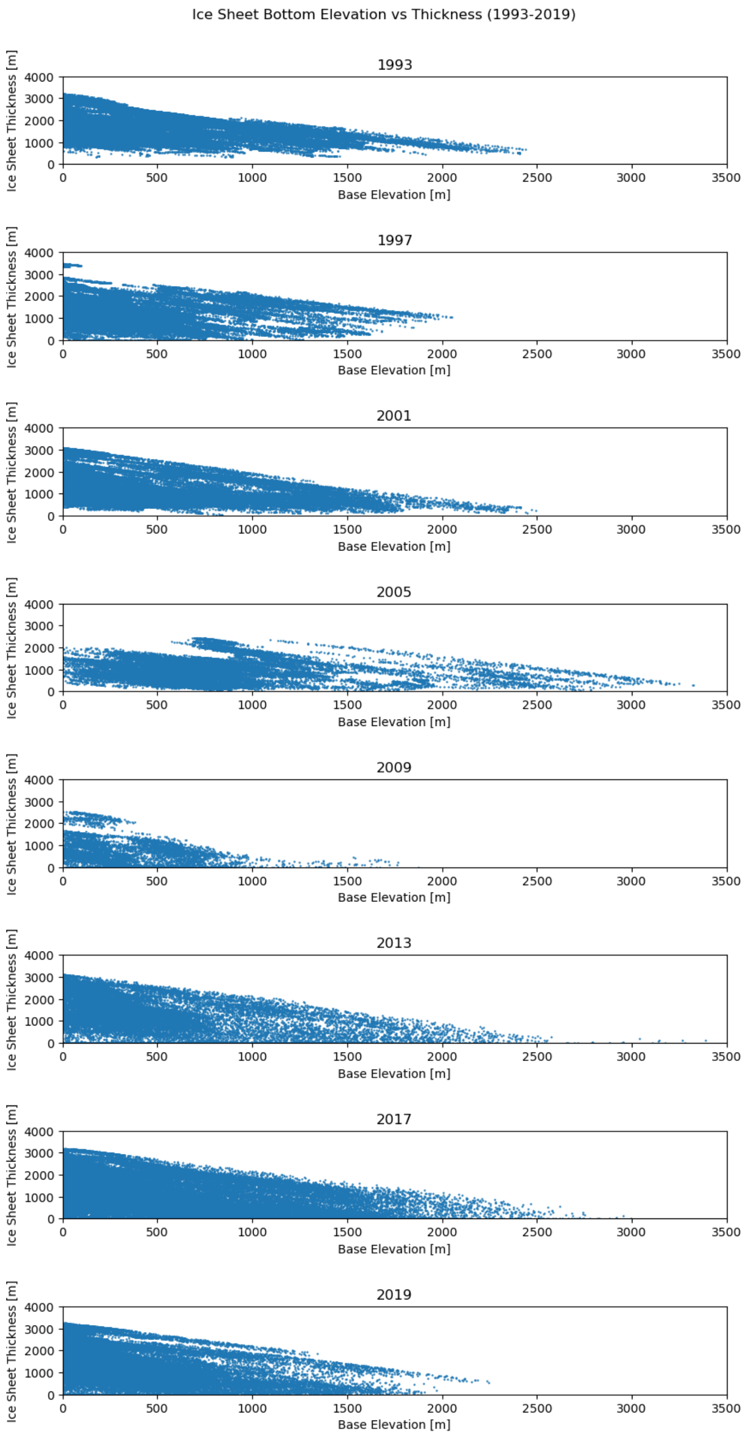
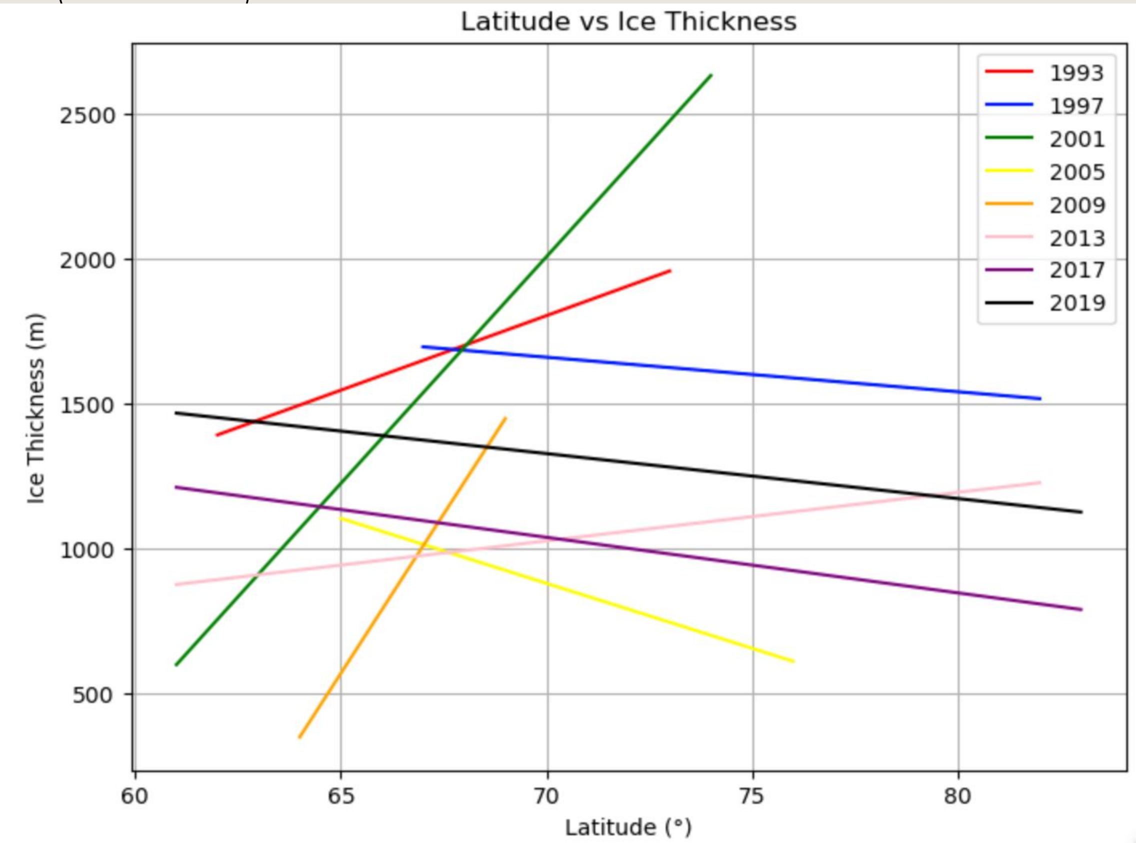


FIGURE 5 – LATITUDE VS ICE THICKNESS



- Rounded latitude values so thickness values could be grouped and averaged
- Used Pandas, Numpy and Matplotlib
- Showing little to no coorleation between ice thickness and latitude
- The positively associated years have higher rates of change and cover less latitude than the negatively associated years.
- Highest ice thickness values on average are between 70 and 75 degrees

MAIN FINDINGS/SIGNIFICANCE

- We found that mass loss occurred along the coasts of Greenland
- This is significant as this mass loss contributes to sea level rise as well as potential ice sheet instability

IMPLICATIONS OF FINDINGS

- There is a reduction in coastal ice thickness over our study period, but variances in data sampling by year limit the certainty of this observation
- This variation emphasizes the need for more consistent observation areas to maximize value of data

LIMITATIONS AND WEAKNESS

- The main limitation of this data is the lack of consistency in survey area
- This makes direct comparisons between different years much more difficult
- The relatively low spatial resolution of this data means that small sections of Greenland which underwent major changes would be overlooked due to not being surveyed

FUTURE RESEARCH

- Future observations of Greenland glacier data are crucial to both monitoring change and improving models
- The observed maximum relationship between thickness and base elevation is an area of investigation which could benefit greatly from improved understanding of glacial dynamics

THANK YOU BIA AND THE NSIDC

WORKS CITED

[1] Kiest, Kristina. “Greenland Ice Sheet.” *NOAA Arctic*, 31 Oct. 2023, arctic.noaa.gov/report-card/report-card-2021/greenland-ice-sheet-2/.