Global Warming Effects on Ice Thickness

Contents

Summary

We are trying to answer the question, did the median ice thickness in the Canadian Arctic change by a statistically significant amount from the years 1984 to 1996? This question stems from the rising global temperatures and a curiosity of how this warming impacts the depth of the ice. The dataset used in this analysis contains measurements of ice thickness at various established monitoring stations in the Canadian Arctic on a weekly basis. Using exploratory data analysis (EDA) we determined that the data are skewed. We decided to use a hypothesis test for independence of a difference in medians using permutation for our analysis.

Methods

Data

The dataset used in this analysis contains measurements of ice thickness at various established monitoring stations in the Canadian Arctic on a weekly basis. The data is made available from the Government of Canada and the monitoring is done by the Canadian Ice Thickness Program. Information about the program can be accessed through the Government of Canada and the specific dataset we are using is publicly available here.

Analysis

First let's have a look at the median ice thickness from 1981 to 2002.

The above figure shows the median ice thicknesses of the monthly station averages for 1981 to 2002. Excluding the year 2002, there looks to be a downward trend from the earlier years where the median thickness is around 90 centimeters to the later years where it hovers around 60-70 centimeters. Our analysis aims to validate this trend and determine if the downward trend is statistically significant.

Let's take a look at the density distribution to determine whether the difference in median thickness of ice is subject to a certain month or whether this difference is present through all months.

We can see that 1984 distribution has more mass to the right of the 1996, meaning more observations that record thicker ice. The pattern is present for all three months, however, January shows the sharpest example of this whereas the effect is less prominent in March.

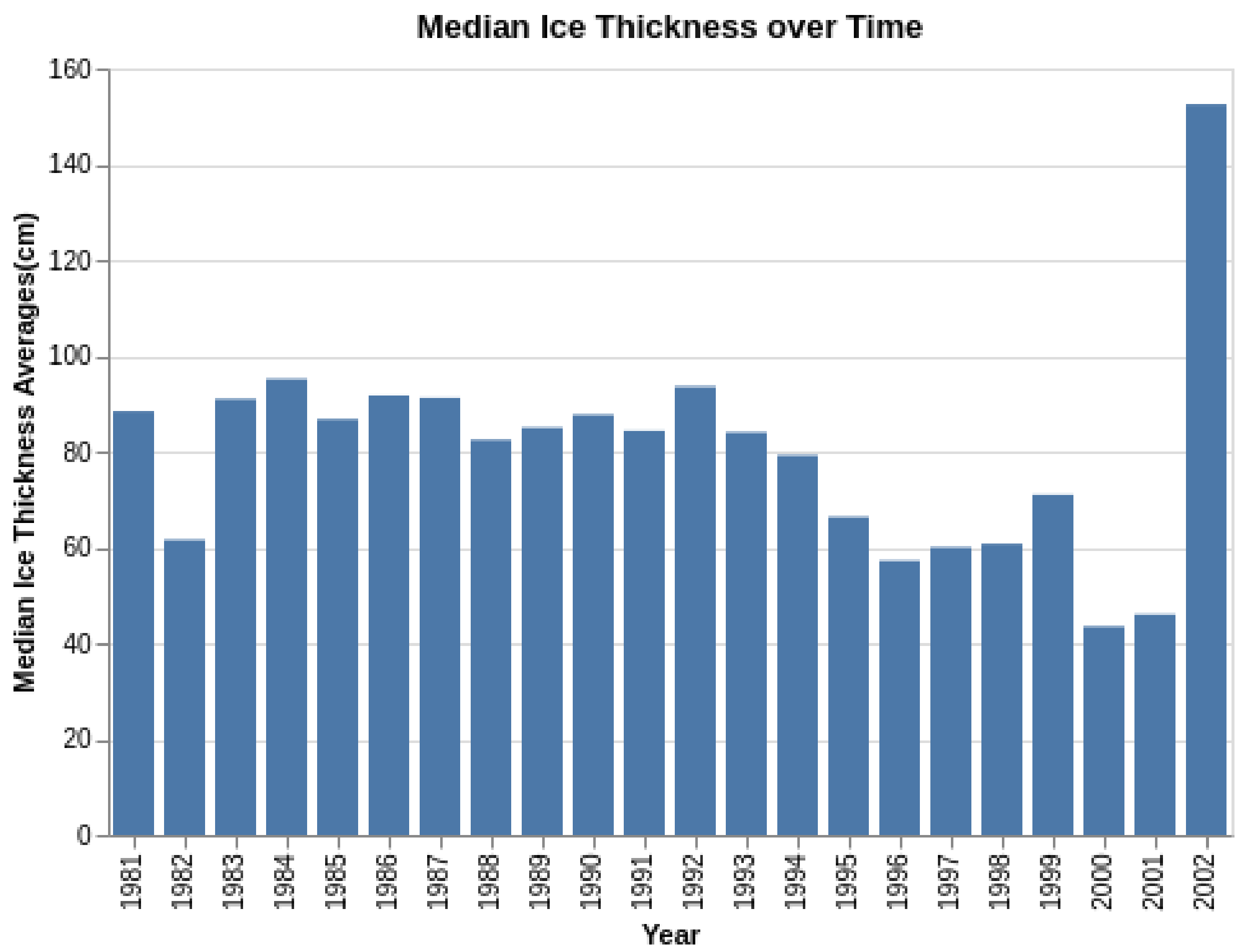


Figure 1: Figure 1. Median Ice Thickness Over Time

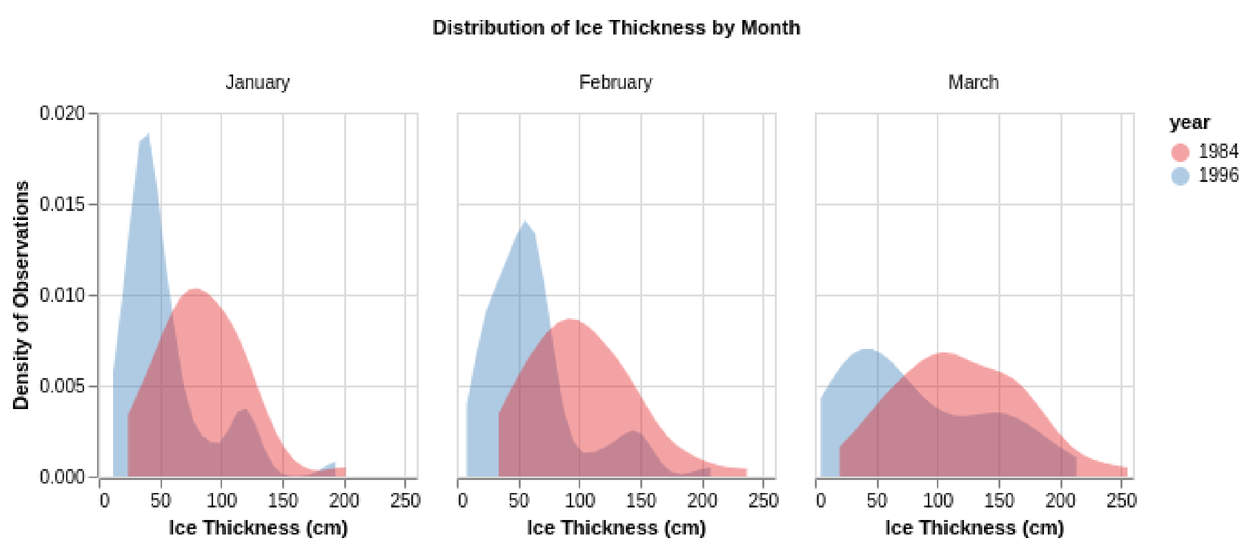


Figure 2: Figure 2. Distribution of Ice Thikness by Month

In this analysis, we will compare the median ice thickness measurements between January-March of 1984 and January-March of 1994 and conduct a hypothesis test to determine if the difference in medians is statistically significant. We decided to use a hypothesis test for independence of a difference in medians using permutation. The permutation test assumes that all observations are independent, so we have adjusted our data in order to meet this condition. The ice thickness measurements are taken weekly, so we decided to take the mean of the ice thickness per station per month in order to compare with other years. With this methodology we satisfy the condition that the observations are from different individuals (stations).

Our null hypothesis is that the median ice thickness in 1984 is the same as the median ice thickness in 1994. Our alternative hypothesis is that the median ice thickness in 1984 is different than median ice thickness in 1994.

$H_0 = \text{median}_{1984} - \text{median}_{1994} = 0$

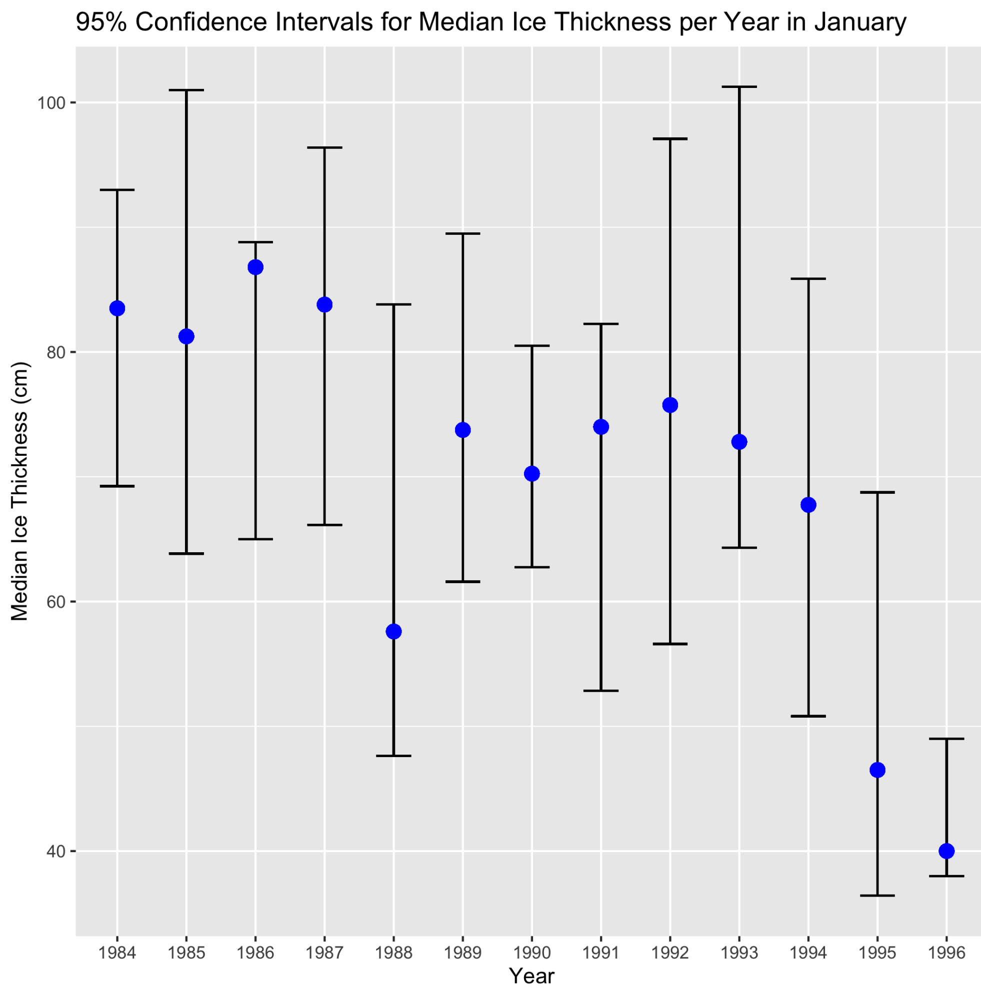
$H_A = \text{median}_{1984} - \text{median}_{1994} \neq 0$

For our hypothesis test we chose an $\alpha = 0.05$, however we would need to do further research to determine if this is the domain standard.

The analysis was completed using the R and Python programming languages (R Core Team 2019); (Van Rossum and Drake 2009). The R packages used to to perform the analysis are tidyverse (Wickham 2017), dplyr (Wickham et al. 2015), datateacher (Boyce and Bourak 2020), infer (Grömping 2010), ggplot (Wickham 2016a), purrr (Wickham 2016b), knitr (Xie 2014), and docopt (de Jonge 2018). The Python packages used for the EDA and data wrangling scripts are pandas (team 2020), docopt (Keleshev 2014) altair (Developers, n.d.), altair_saver (Vanderplas 2019), pytest (Krekel et al. 2004), and chromedriver_binary (Kaiser 2017). The permutation test analysis is based on UBC MDS 552 Lab 2. The code used to perform the analysis and create this report can be found here: here.

Results

We calculated that the difference between the sample medians of average ice thickness measurements by station for January-March of 1984 and January-March of 1994 and the corresponding 95% confidence intervals.



\begin{figure} \caption{Figure 3. 95% Confidence Intervals for Median Ice Thickness in per Year in January} \end{figure}

Using the permutation test we determined the p-value for January is 0.034. Our p-value from our test of independence of a difference in medians using permutation was $< \alpha$, so we fail to reject our null hypothesis, H_0. Based on this evidence, it appears that there is no statistically significant difference between the median ice thickness measurements of January 1984 and January 1994.

In the next Milestone, we hope to explore additional months and years to see if we obtain the same result. As can be seen in the figure below, the years we have chosen have overlapping confidence intervals and the medians are not as dissimilar as other combinations of months and years.

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