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DATA 3320

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Climate Project Report

I. Introduction

The purpose of this report is to identify a trend in climate data using spectral analysis and forecast that trend into the future. The trend that will be explored and forecasted in this report is the annual number of days the Arctic Ocean remains frozen. This data comes from the European Center for Medium-Range Weather Forecasting (ECMWF). The ECMWF collects worldwide climate data including information on the seven ocean basins. This report uses a small subsection from their most recent ERA5 report containing the time, coordinates, sea surface temperature, wave height, and windspeed data for the Arctic Ocean spanning the past eight decades(1940-2024). For more details and to reference worldwide data for all seven oceans their website can be found here: Copernicus Climate Data Store.

II. Data Preparation

Given that the purpose of this report is to examine the annual number of days the Arctic Ocean remains frozen, the first step was to go through a data cleaning and preparation process to make this goal possible. This involved removing outliers, calculating the number of days the ocean is frozen each year, appending the new information to the original dataset for continuity, and creating a new dataset containing the year and number of days the ocean was frozen. This process allows us to have the necessary variables to conduct forecasting and analysis.

III. **Methodology and Analysis**

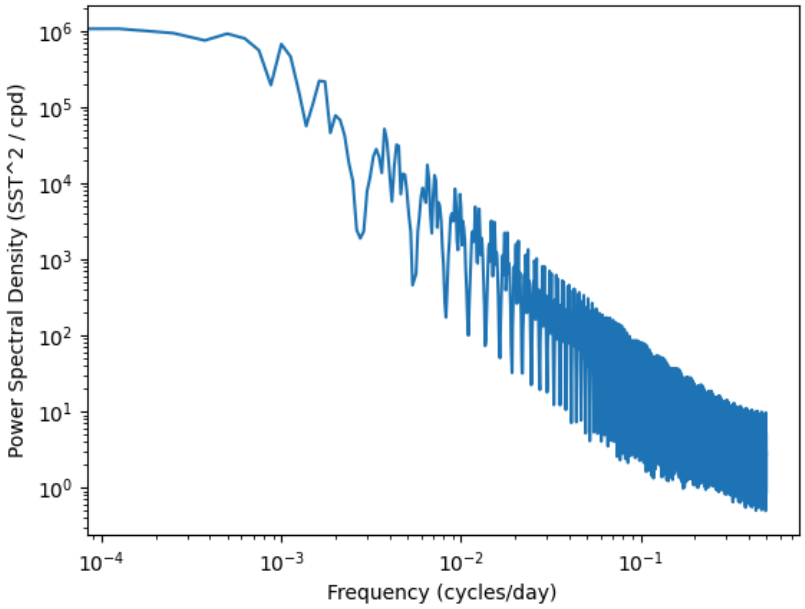

Figure 1: Power Spectral Density Chart

Pictured above is the power spectral density chart for the number of days the ocean remains frozen every year. Since we are looking at the rate of change in the annual number of days frozen and have already created a new grouped sum dataset this graph was not used to find a specific trend in the time series but can still be helpful when looking at the trend of our data.

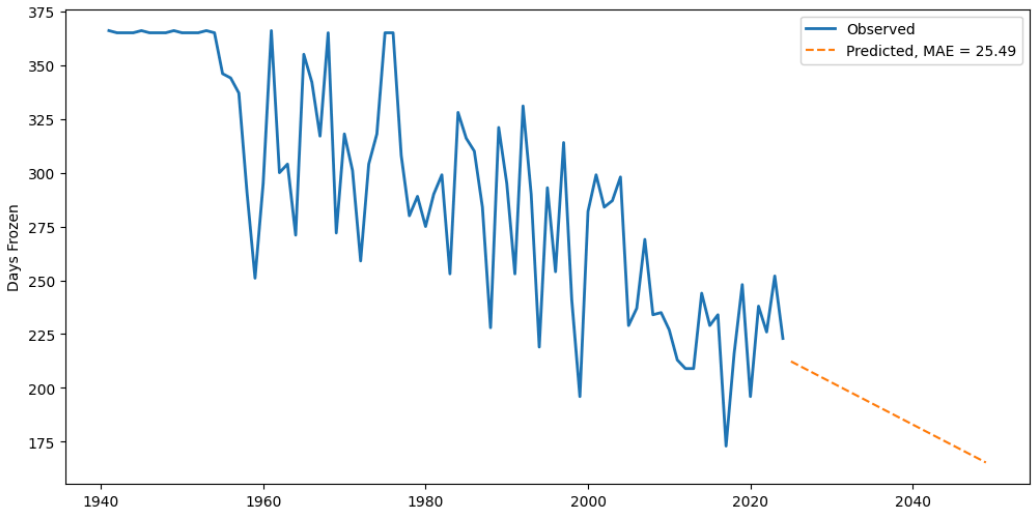

Figure 2: 25 Year Forecast of Days the Arctic Ocean Stays Frozen

This chart uses a trailing window regression to forecast the trend into the future. This chart uses a 30-year window length to forecast the annual number of days the Arctic will be frozen 25 years into the future. As shown by the graph the forecasted trend displays an overall decline in the annual number of days the Arctic will remain frozen. With a predicted mean absolute error (MAE) of 25.49 (in relation to the 365 days in a year) we can see that the model can be a good indicator but is certainly not a perfect prediction for our data. To put the mean absolute error into more context we could say that the model can predict the number of days the ocean will be frozen within three weeks in either direction.

IV. Additional Step

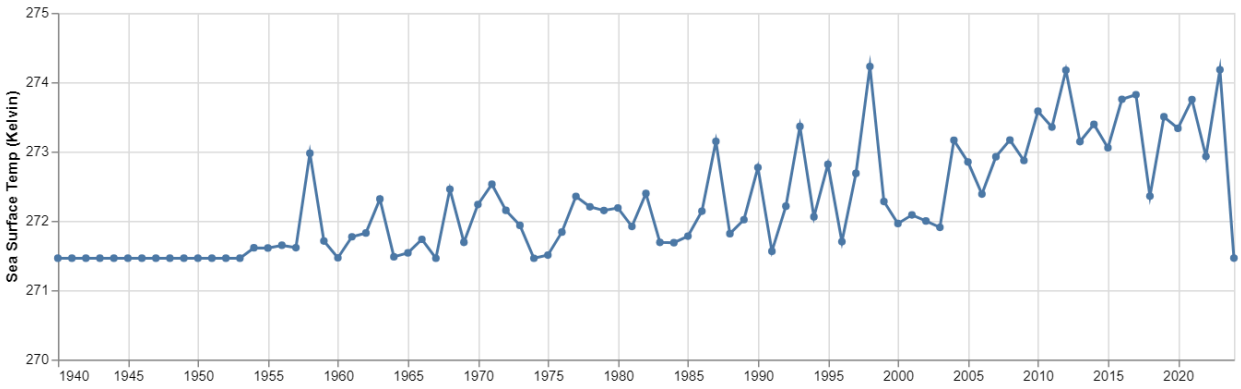

Figure 3: Average Yearly Sea Surface Temperature

The additional step I chose is to look at the (average) sea surface temperature across the dataset. This may help answer the question “does the average sea surface temperature relate to the annual number of days the artic ocean remains frozen?" The chart above represents this and allows us to examine the trend in sea surface temperature (units are in kelvin). From this chart we can see that while there is some variation the overall trend shows increasingly higher yearly temperatures. This would correlate with the overall trend of decreasing frozen days in the Arctic. Addressing the question above there does seem to be a relationship between average temperature

and the number of frozen days however we can't be sure that one is necessarily causing the other (correlation vs causation).