A Study on Sea Ice Anomalies using Sea Ice–Index data

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1. Motivation

Sea ice is one of the most important entities of the Earth's climate system, which influenced by the various other components of the Earth such as atmospheric gases, ocean currents, etc. Sea ice also affects multiple facets of Earth climate by the exchange of heat, moisture, and momentum between the atmosphere and ocean. Moreover, sea ice can reflect the incoming solar incoming heat radiation in the form of surface albedo and helps to keep the atmosphere cooler. Hence, the variations in sea ice can modulate climate (specifically long–term temperature variations) by altering the surface albedo, which considered being one of the dominant factors for global warming. The land/sea area coved by ice near the North and South poles is a direct measure of the extent of sea ice, commonly known as sea ice-index. Decades of previous studies have shown that there is a variability of sea ice impacts winter snowfall; Arctic and Antarctic sea flora and fauna formation that affects food web etc. Most of the variability in sea ice comes from seasonal trends. However, sea ice anomalies, a deviation from the expected seasonal variability, are phenomena that influence all these previously described facets of the climate system. Hence, predicting these sea ice anomalies in the North and South poles is one of the challenges for modern civilization. The overarching goal of this project is to analyze the sea ice data to find trends in sea ice anomalies.

Note that, entire Northern hemisphere is divided into 16 Arctic regions and fine resolution sea ice data has been collected for these individual regions since 2006. However, this data is only available for Northern hemisphere. The proposed project uses this high–resolution data to find the regions having intense sea ice anomalies.

2. Questions and Objectives

The effects of seasonal variability of sea ice have been extensively studied and are reasonably well understood. However, sea ice anomalies are not yet fully understood. Besides, an effective way to detect and now-cast sea ice anomaly has not yet been developed. Our proposal addresses the following needs.

Specifically we propose to answer the following scientific questions in this proposal:

a. Is the intensity of sea ice anomalies increasing during the last few decades?
b. Which of these 16 Arctic regions shows maximum sea ice anomalies?

Engineering / operational aspect:

a. Can we develop a model to predict sea ice anomalies?

3. Dataset and Methodology

In this proposed project, sea ice–index and Multisensory Analyzed Sea Ice Extent data are used to find the trends in sea ice anomaly. The data link is – https://nsidc.org. Note that, Multisensory Analyzed Sea Ice Extent dataset is only available for Northern hemisphere, and commonly known as MASIE–NH, however, the sea ice–index data is available for both hemispheres. The entire Northern hemisphere is divided into 16 Arctic regions, and MASIE data (in million square kilometers) is available for individual regions. Spaceborne satellite microwave data is processed to estimate the sea ice–index dataset. The FTP server listed under the URL given above has the data from 01 January 1979 to the present (usually yesterday) at a daily resolution in CSV format (≈30 years of data). Both the dataset are time series by nature. The following task is proposed, corresponding to each of the science objectives mentioned in Section – 2.

One of the engineering goals of this project is to provide (transform) a dataset from the existing parameters to build a model for sea ice anomaly forecasting. The primary datasets used to investigate the statistical characterization of sea ice anomaly and its trends over last 30 years is NSIDC sea ice–index and MSAIE. A sea ice anomaly is defined as a deviation in sea ice–index measurement from its five–day mean. The distribution of estimated anomalies using the proposed formulation produced a skewed non–Gaussian distribution. Instead of using this, I defined a yearly curve by taking the median value of each day for 30 years and then subtract the daily values form that to obtain the anomaly. Following this method leads to produce significantly better (more near to Gaussian distribution) distribution. *This new transformed dataset can be used in a regression model to forecast sea ice anomaly.*

4. Analysis

This Section answers a couple of questions raised in Section – 2. First, we are going to focus on the general trend of the intensity of anomalies for both hemisphere, and then we are going to analyze the trend in sea ice anomaly is for past 14 years for 16 different Arctic regions.

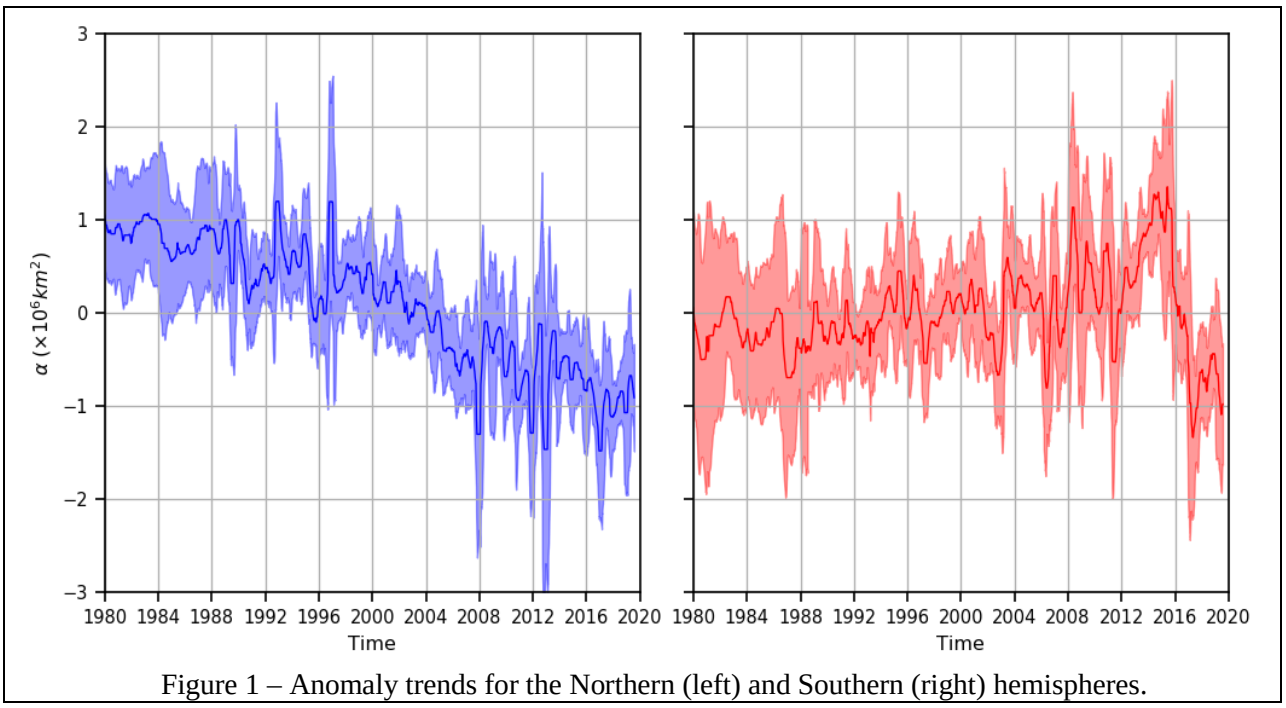

Figure 1 – Anomaly trends for the Northern (left) and Southern (right) hemispheres.

Figure 1 presents anomaly trends of the Northern and Southern hemisphere, where x–axis is time and y–axis presents anomaly (α in $10^6 km^2$). In other words, figure represents an increase or decrease in sea ice in million square kilometers for last three decades. From the figure, it is evident that since the last 30 years anomalies in the sea ice–index for Northern hemisphere shows a constant negative trend (the rate of which has sea ice depleted during last decades). Southern hemisphere shows a rapid negative rate during the last half a decade. *The data shows concerning evidence for a long–term climate change that will affect sea–level rise, term temperature variations (albedo, greenhouse effects), food web at polar cap regions and other entities of the climate system.*

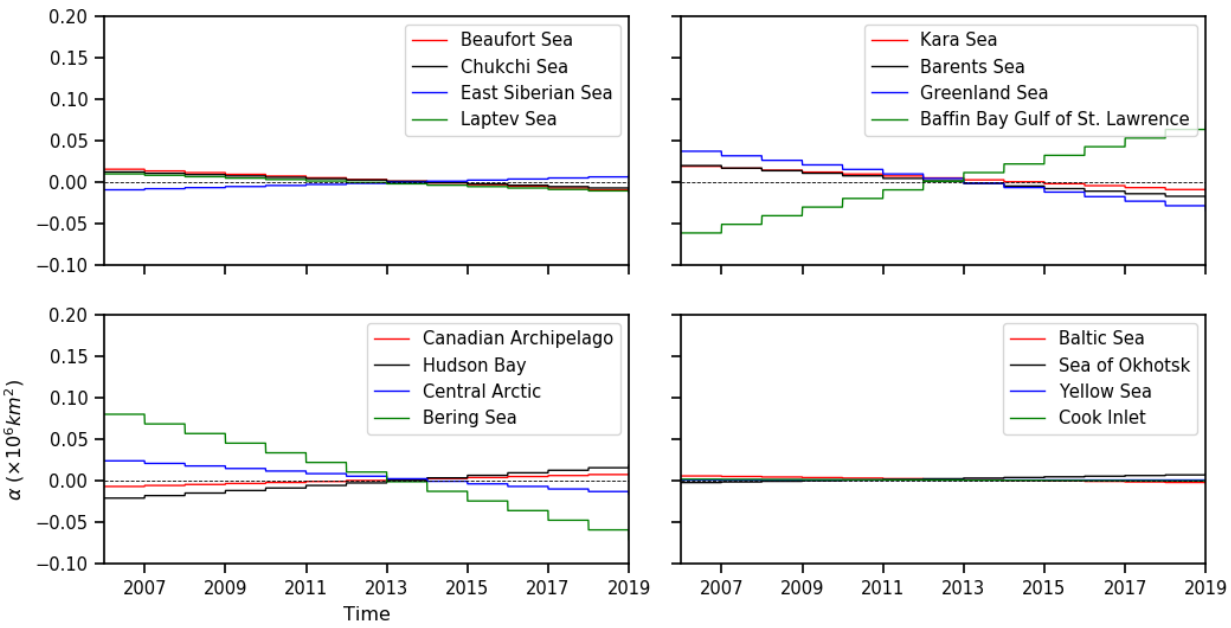

Figure 2 – Anomaly trends for the 16 Arctic region in Northern hemispheres.

Figure 2 presents trends of sea ice anomalies for 16 different Arctic regions of Northern hemisphere in four panels (each panels having four different Arctic regions). In each panel of Figure 2 x–axis presents time and y–axis presents anomaly (α in $10^6 km^2$). In other words, the figure represents increase or decrease in sea ice in million square kilometers for the last 14 years. Black dashed line passing through each panel show zero lines, which represents no change in sea ice. *Regions listed in top–left and bottom–right panels (Beaufort Sea, Chukchi Sea, East Siberian Sea, Laptev Sea, Baltic Sea, Sea of Okhotsk, Yellow Sea, Cook Inlet) show negligible change during the last 14 years. However, Baffin Bay Gulf of St. Lawrence and the Bering Sea are showing the maximum change in the sea ice–index.*

5. Intellectual Merit

The intellectual merit of this project lies in the prospect of significantly advancing our current understanding effects and impacts of seasonal variability of the sea ice anomaly. Specifically, the proposed work is focused on characterizing general trends of the sea ice anomaly and find out any anomalies around the North and South poles' climate system. Understanding the underlying principle of the sea ice anomalies is thus an essential step in comprehending the widespread impacts of its variability on the weather, atmosphere, ocean currents, and food web.

6. Broader Impacts

This project seeks to characterize the anomalies in the sea ice that influences various facets of our climate, also to understand the fundamental processes that drive them. This project is directly relevant to the Earth's climatological studies. These studies not only improves the ability of anomaly detection in sea ice and provide an early warning about any forthcoming weather anomalies associated to the event but also can give now-cast indications of the severity of weather anomalies near the North and South poles. In summary, this project is (1) provide a better understanding of sea ice variability, and (2) advance our predictability of sea ice anomalies.

Resource URL

a. Project (Heroku) – https://sea-ice-anomaly.herokuapp.com/
b. Figure 1 – https://github.com/shibaji7/sea-ice-anomaly/blob/master/out/anomaly_intensity_trends.png
c. Figure 2 – https://github.com/shibaji7/sea-ice-anomaly/blob/master/out/16_anomaly_intensity_trends.png

d. This document – https://github.com/shibaji7/sea-ice-anomaly/blob/master/Chakraborty%2CShibaji.Data-Incubator.Proposal.pdf
e. Dataset – https://nsidc.org;
https://nsidc.org/data/G02135/versions/3;
https://nsidc.org/data/G02186/versions/1;
f. Github (Code & Data) – https://github.com/shibaji7/sea-ice-anomaly

References

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