Sea Ice and Tsunamis - A Geospatial Exploration

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Sea Level Rise: Our Biggest Enemy?

Climate change is depressing. From the inevitable change in society to those who oppose resisting this change or even accepting it as truth, our lives are full of reminders that the grass most certainly will not be greener in the future. A small glimmer of hope is that the more who study and understand its complexties, the more who will be able to influnce decsion-making to lessen or halt its effect.

The most widely publicised effect of climate change is the rise of mean sea level. Ice breaking off land will enter the sea and melt, increasing the oceans' water level which has the potential to displace billions. A less publicised effect of this process of sea ice movement (as a result of climate change) is the formation of tsunami events. Water displacement could lead to massive waves that flood areas already susceptible to sea level rise. This unveils a potentially deadly hazard, made worse and more frequent as our climate continues to shift.

Exploration

This investigation will explore data available on the extent of sea ice and measured wave events. These datasets will be scrutinized and compared to see if these events should be of utmost concern to the public in regards to climate change. Is the amount of sea ice on Earth decreasing through melt? Have there been significant trend changes recently? Are wave events correlated with this? A big data deep dive will help us answer these questions.

First, the datasets. Sea ice data were obtained from the National Snow and Ice Data Center (USA), and an initial sample of data can be seen on Table 1. Tsunami event data (see Table 2 for a similar sample) were obtained from the National Oceanic and Atmosphere Administration (USA). Some points have been dropped where important columns were missing data.

The wave/tsunami (herein referred to as wave) dataset is spatial, containing latitude and longitude for geographic reference. Sea ice data contains no spatial information, other than the hemisphere of sea ice measurement.

Table 1: First 5 data points of sea ice dataset

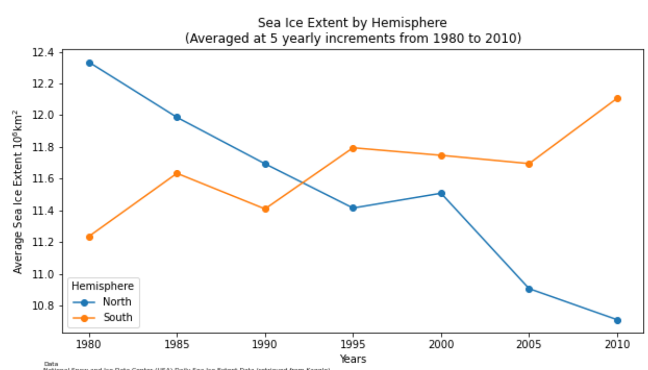
	Year	Month	Extent	hemisphere
0	1978	10	10.231	north
1	1978	10	10.420	north
2	1978	10	10.557	north
3	1978	11	10.670	north
4	1978	11	10.777	north

Table 2: First 5 data points of wave events dataset

	LATITUDE	LONGITUDE	YEAR	MONTH	MAXIMUM_HEIGHT
72	33.9170	136.15	684	11.0	3.0
83	36.5800	140.67	799	9.0	2.0
101	37.9200	139.05	887	8.0	4.0
109	34.8800	132.43	1026	6.0	10.0
110	34.6167	131.60	1026	6.0	10.0

Firstly, we need to take a look at our sea ice data. Assuming climate change is a predominant driving agent in sea ice melt, is it causing a reduction in sea ice extent? Figure 1 plots the average sea ice extent (every half decade) from 1980 to 2010. We are only using this date range as both datasets contain lots of data in this range, and we need to compare them.

Figure 1: Sea ice extent, averaged every 5 years from 1980-2010, by hemisphere



Sea ice extent in the northern hemisphere has been steadily declining, while the opposite is true in the South. Figure 2 plots sea ice extent by month (averaged across all measured years) to see if seasonal variation is a factor in this strange trend. This time we are using the entire dataset, rather than selected years, as we don't need to limit the data to compare to the wave data.

Figure 2: Sea ice extent, averaged every month from across entire dataset, by hemisphere

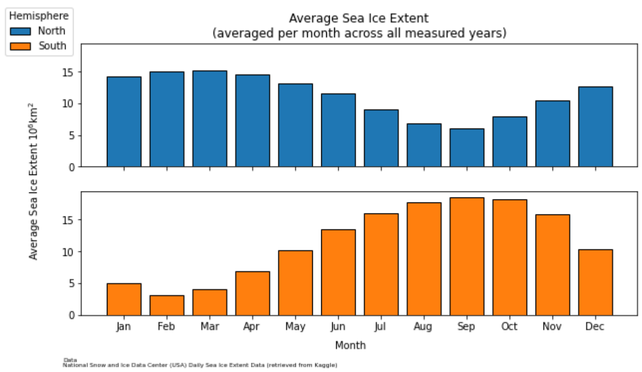


Figure 2 shows that there is a significant seasonal trend, where hotter seasons result in lower sea ice levels in respective hemispheres. For example, here in NZ we have summer from December to Febuary, where this plot shows there is a clear dip in sea ice extent. This seasonal variation is expected, and so there must be another cause for the results seen in Figure 1 - let's take a look at our wave data and see what we can find. We'll start off with wave heights, mapped at the same range as Figure 1 for comparison.

Figure 3: Map of wave events at selected years, plotted with their height

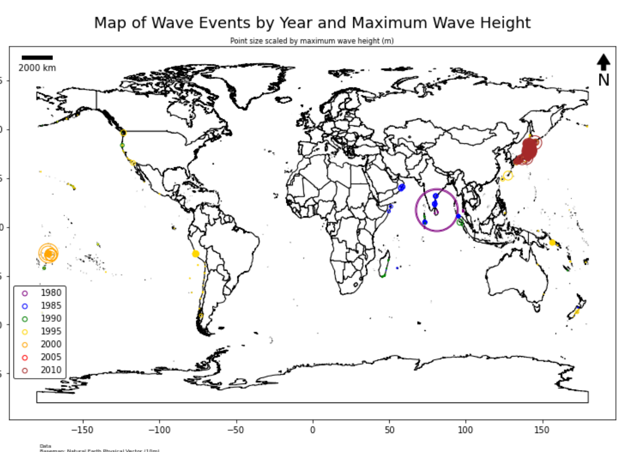
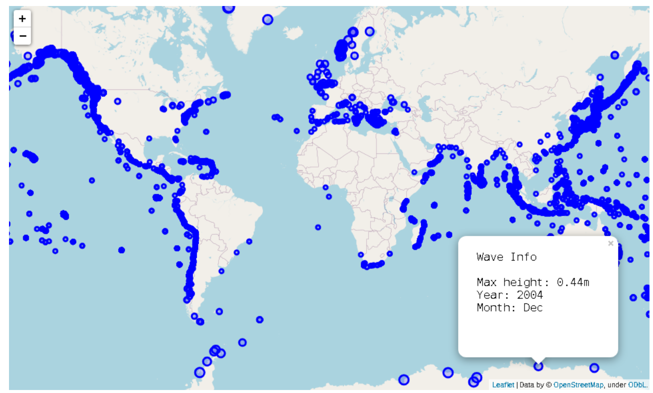


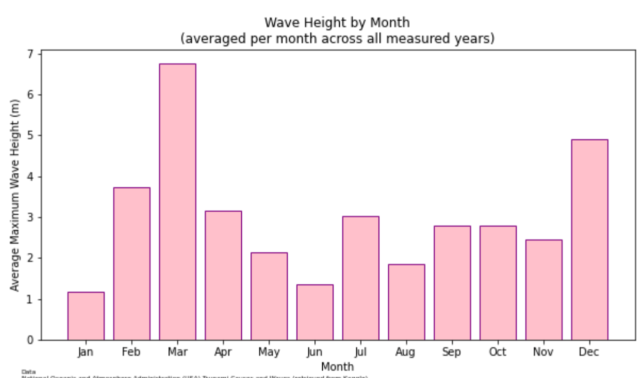
Figure 3 shows how wave events have changed over this date ranges. In 2000 lots of waves were seen in the South Pacific, while in 2010 an unprecedented cluster was seen along the North Asian Coast. Keeping in mind Figure 1, we can see how different wave events do not appear to have a strong correlation with sea ice extent.

Figure 4: Screenshot of interactive map of wave events



Diving further into the wave data on its own, Figure 4 shows an interactive map that shows the location of every wave event that contains valid data (which can be accessed through the accompanying Jupyter Notebook). Panning the data, we can see that most wave events are in the Northern hemisphere. We can also see that the frequency of large wave events is extremely low. Checking for seasonal variation, Figure 5 plots average wave height at each month across all recorded years.

Figure 5: Wave heights, averaged at each month across all recorded years



What Does This Tell Us?

We set out to explore the danger of wave events as a result of climate change. We can see how, while wave events are frequent, large wave heights are rarely seen and do not seem to be strongely correlated to the melt of sea ice. The amount of sea ice does not appear to be decreasing, and there have not been significant trend changes recently. Seasonal variation is presenting as expected.

An interesting phenomenon that was uncovered was the disparity between trends of sea ice extents between hemispheres. While initially appearing as a healthy equlibrium, the trend (see Figure 1) is worrying. Sea ice is increasing in the South as ice breaks off from a landmass, while it is decreasing in the North as sea temperatures rise and melt existing sea ice - both of which a major indication of climate change. The moral of the story is - while you shouldn't be too worried about tsunamis just yet, the melting of the polar ice caps is constantly increasing and not to be avoided when pondering climate-conscious decisions.

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Jupyter Notebook included
Source code, high-res figures available on GitHub