Assignment: Salinity and Temperature Report

Madhushree Sannigrahi

Instructor: Prof. Anne Molcard
Fundamentals of Oceanography

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1 Introduction:

The oceans of the world are vital components of the Earth's climate system and are home to a diverse range of marine ecosystems. This study presents a comprehensive analysis of oceanographic data, with a particular focus on exploring the temperature and salinity variables across different latitudes, longitudes, depths, and seasons. Using Python as an analytical tool, the primary aim is to unveil crucial insights into the intricate patterns of temperature and salinity across the world's oceans.

Ocean salinity and temperature significantly impact our lives, influencing weather patterns, food security, global climate, and coastal communities. Ocean temperature shapes weather patterns by influencing air pressure systems and storm formation. Understanding these parameters is crucial for addressing global challenges and ensuring a sustainable future.

2 Data Overview:

We utilized ocean data in two formats: '.cdf' and ".nc", which provided detailed insights into essential factors. The '.cdf' format, or Common Data Format, and '.nc', or NetCDF (Network Common Data Form), are commonly used in scientific data storage and exchange, particularly in atmospheric and oceanographic research fields. CDF files are structured to contain various data types, including numerical, textual, and multi-dimensional arrays.

▸ Dimensions: (**time**: 1, **depth**: 50, **latitude**: 2041, **longitude**: 4320)

▾ Coordinates:

depth	(depth)	float32	0.494 1.541 ... 5.2...
longitude	(longitude)	float32	-180.0 -179.9 ... 1...
latitude	(latitude)	float32	-80.0 -79.92 -79....
time	(time)	datetime64[ns]	2020-07-16T12:0...

▾ Data variables:

thetao	(time, depth, latitude, longitude)	float32	...
so	(time, depth, latitude, longitude)	float32	...

▸ Indexes: (4)

▸ Attributes: (14)

Figure 1: Copernicus Marine Data for July

As part of our assignment, we examined Temperature and Salinity data for ocean depths around the world with the provided "Ocean Data". The dataset contains the temperature and salinity of all the oceans of the world across every longitude and latitude with various depths.

Additionally, we analyzed the salinity and Temperature differences in ocean water during a colder month like January and a warmer month like July, using the "Copernicus Oceanographic Dataset" from July 2020 and January 2020. This dataset also contained the temperature and salinity of all the oceans of the world across every longitude and latitude with various depths for 2 different months,i.e., January and July.

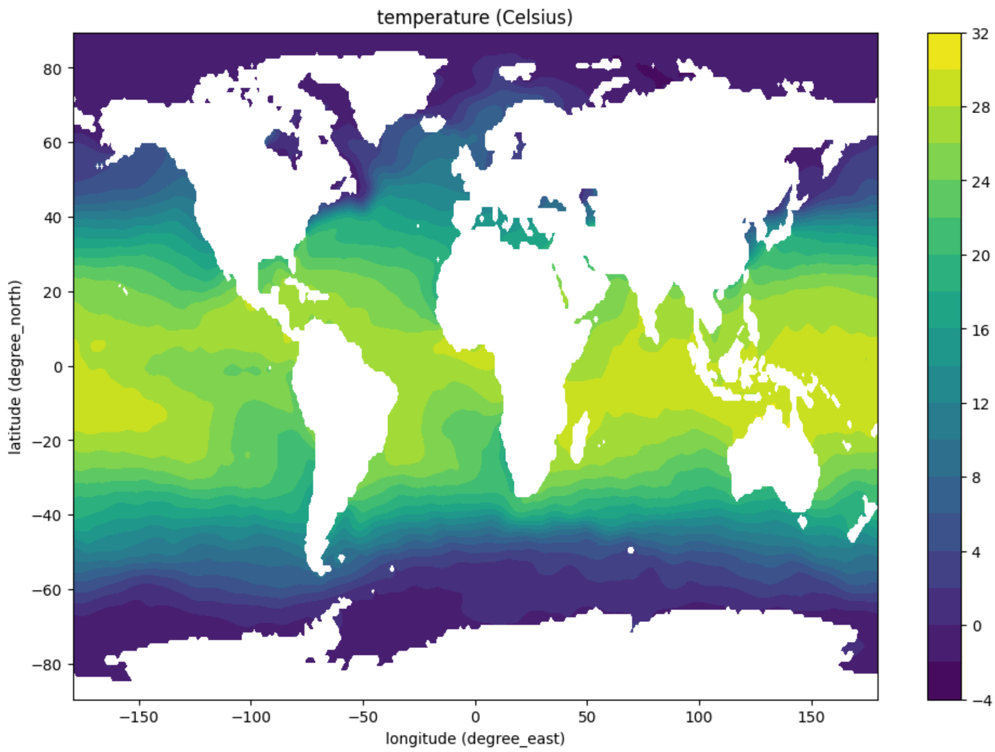

Figure 2: Sea Surface Temperature during January

3 Results and Analysis

3.1 Oceanographic Data

3.1.1 Temperature

The Sea Surface Temperature is an important variable in ocean physics because it affects the circulation of the ocean, the weather, and the climate. In general, the SST is warmer in the tropics and colder at the poles as given in Figure 2. This is because the equator receives more sunlight and sun radiations than the poles. However, other factors can affect SST, such as ocean current circulation, which keeps transporting heat around the globe by circulating the warm water from the tropics to the colder waters in the poles. Upwelling and downwelling can also be reasons for temperature variations in oceans. Upwelling is the process of bringing cold water from the deep ocean to the surface, while downwelling is the sinking of surface water to the deep ocean. Upwelling occurs in certain coastal regions and can significantly lower surface water temperatures.

The temperature of the sea surface might also differ due to seasons. The maps in the figure 3 show the sea surface temperature (SST) in the Atlantic Ocean in January, April, July, and October. In January, the SST in the Atlantic Ocean is coldest in the north and warmest in the south. This may be because the North Atlantic is influenced by the cold currents from the North, which receives very low sunlight as compared to the South.

In April, the SST in the Atlantic Ocean is starting to warm up in the north and cool

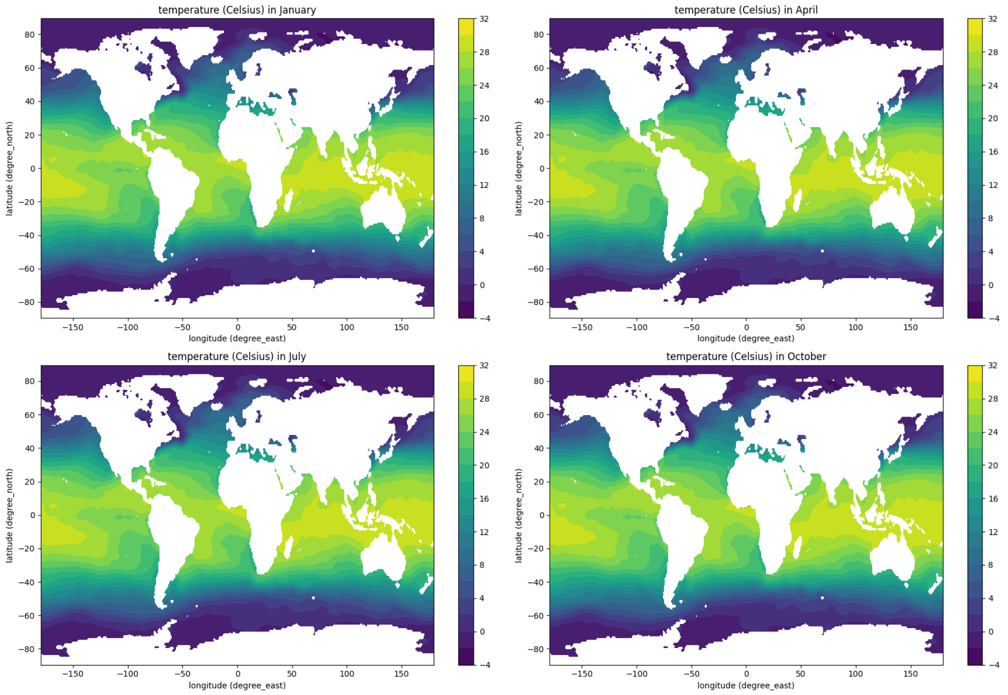

Figure 3: Sea Surface Temperature during January, April, July and October

down in the south. This may be because the North Atlantic is starting to receive more sunlight and the South Atlantic is starting to receive less sunlight. Also, the Southern pole is getting cooler and cooler, leading to cool currents over the ocean.

In July, the SST in the Atlantic Ocean is warmest in the north and coldest in the south. This may be because the North Atlantic is receiving the most sunlight and the South Atlantic is receiving the least sunlight.

In October, the SST in the Atlantic Ocean is starting to cool down in the north and warm up in the south. This may be because the North Atlantic is starting to receive less sunlight and the South Atlantic is starting to receive more sunlight.

Ocean temperature varies significantly along its depth, creating a distinct vertical profile as provided in figure 4. Here the latitude is actually numbered from 0 to 180, starting from the South pole to the North pole. The surface layer, typically extending to a depth of 100-200 meters, is the warmest due to the direct absorption of sunlight. This warm surface water is less dense than the deeper, colder water, and it tends to float on top, creating a stable stratification.

Below the surface layer, temperature decreases rapidly with increasing depth. This transition zone is called the thermocline. The thermocline is found between 100 and 800 meters deep, and it marks a sharp decrease in temperature from the warm surface water to the cold deep ocean. The strength of the thermocline can vary depending on location and season, but it generally acts as a barrier to vertical mixing of water masses. The coldest latitudes mixes this layer with deep seas as both are equally cold.

The deep ocean, below the thermocline, is characterized by relatively constant temper-

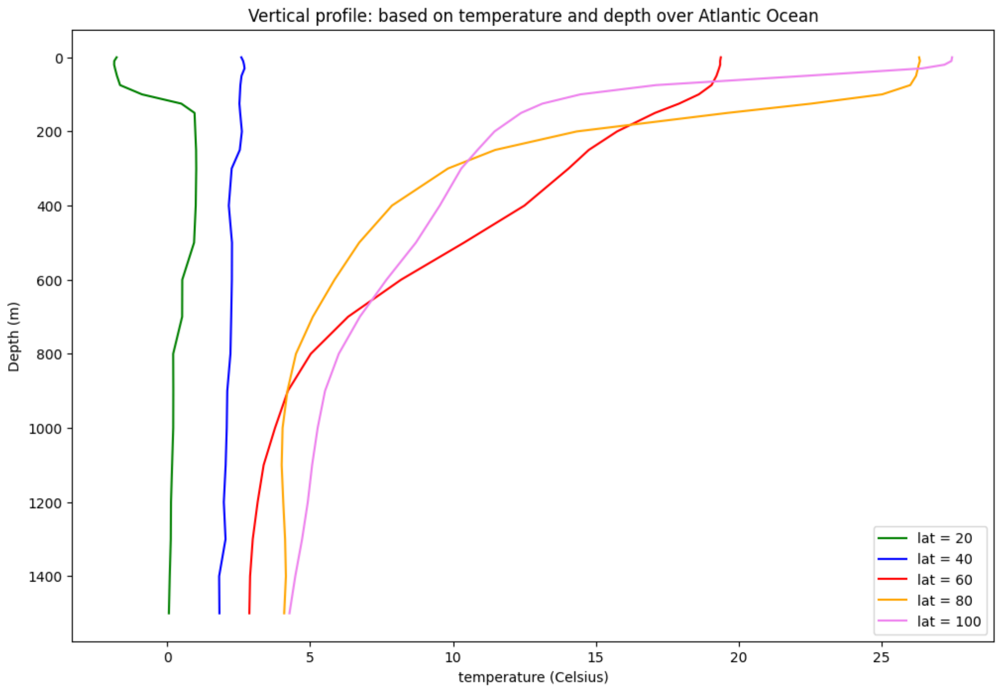

Figure 4: Vertical Profile of temperature along various depths during July

atures that range from 2 to 5 degrees Celsius. The limited sunlight penetration at these depths prevents significant warming, and the deep ocean is also insulated by the overlying thermocline.

3.1.2 Salinity

Salinity, the measure of dissolved salts in seawater, also varies along the depth of the ocean. While the overall salinity of seawater is about 35 parts per thousand (ppt), there can be significant variations depending on location since rivers, runoffs and melting glaciers bring freshwater into the oceans, diluting seawater and reducing salinity. Additionally, latitude influences evaporation rates and precipitation patterns, which in turn affect salinity distribution. Evaporation removes water from seawater, leaving behind dissolved salts, which increases salinity. Precipitation, on the other hand, adds freshwater to the ocean, reducing salinity. That explains the low salinity near the tropics in the Figure 5.

The salinity (PSU or parts per thousand) maps of the global ocean surface in January, April, July, and October show a clear seasonal pattern (Figure 6). In general, salinity is higher in the tropics and lower in the polar regions. This is because the tropics receive more sunlight, which increases evaporation rates. Evaporation leaves behind the salts that were dissolved in the water, increasing the salinity of the seawater.

In January, the highest salinity values are found in the subtropics, with values reaching up to 37 PSU. These high salinity values are due to the high evaporation rates in these regions.

In April, the salinity distribution remains similar to January, with the highest salinity

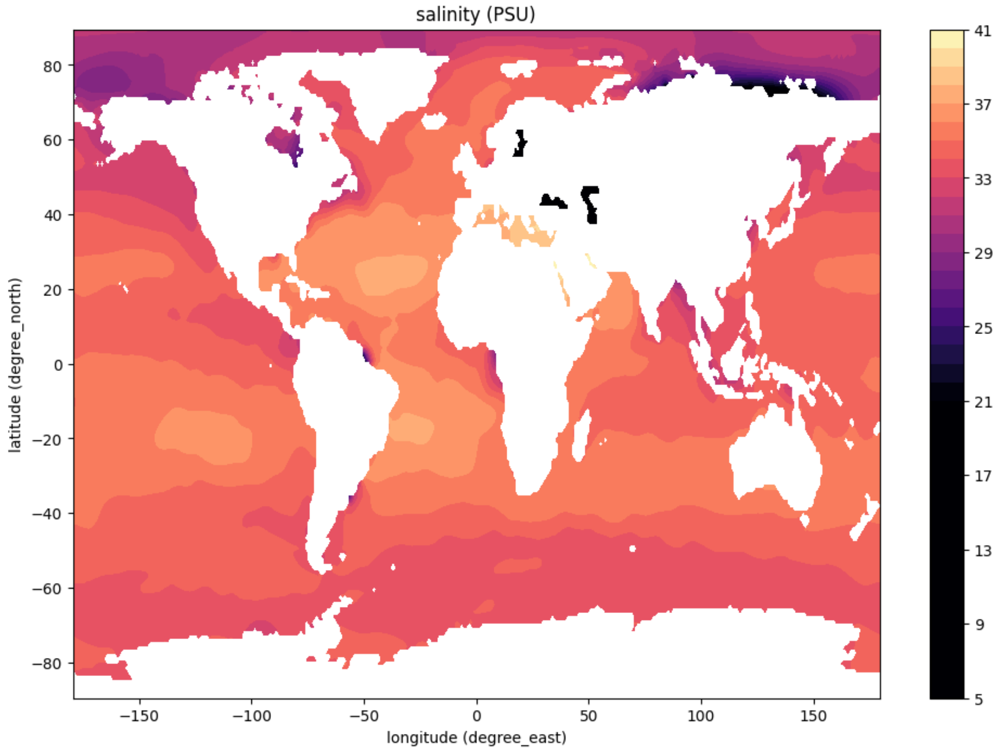

Figure 5: Sea Surface Salinity during January

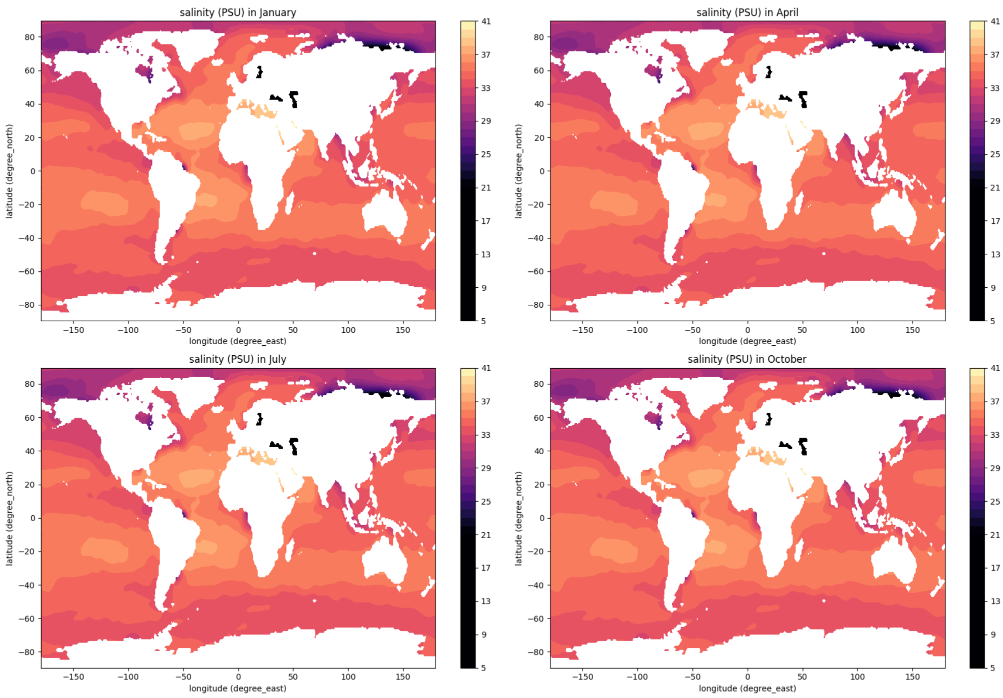

Figure 6: Sea Surface Salinity during January, April, July and October

values found in the subtropics and the lowest salinity values found in the Arctic and Antarctic. However, there are some notable changes. For example, salinity values in the North Atlantic and North Pacific are slightly higher in April than in January. This is due to the increased evaporation rates in these regions during the spring months.

In July, the highest salinity values are found in the tropics, but in a slightly larger area. This is due to the high evaporation rates and low precipitation rates in these regions during the summer months.

In October, the salinity distribution begins to resemble the January distribution.

The lowest salinity values are found in the Arctic and Antarctic, where sea ice melting and freshwater runoff from rivers and glaciers reduce salinity.

Salinity also varies with ocean depth as shown in Figure 7. Here the latitude is actually numbered from 0 to 180, starting from the South pole to the North pole. Surface salinity in the polar region is generally lower than deep ocean salinity because of freshwater from precipitation, melting glaciers and runoffs. The warmer areas(>=60) near the equator have higher salinity at the surface due to the high evaporation rates at the surface.

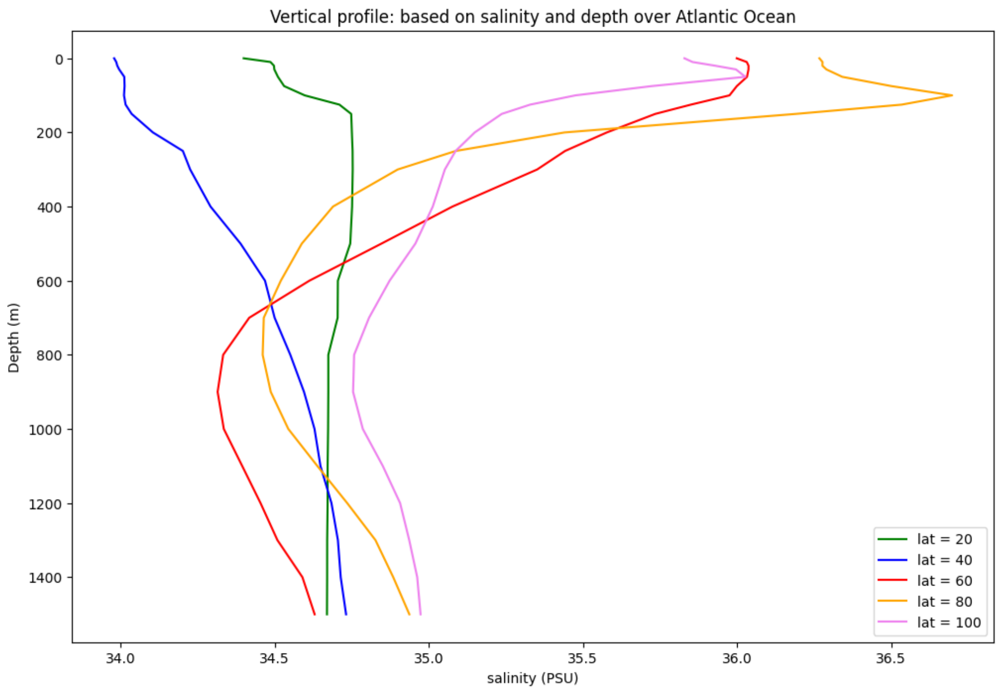

Figure 7: Vertical Profile of salinity along various depths during July

Below the surface layer, there is a transition zone called the halocline, where salinity increases rapidly with depth. The halocline is found between 200 and 500 meters deep, and it marks a sharp increase in salinity from the lower surface water to the saltier deep ocean. The halocline is caused by the sinking of saltier water from higher evaporation zones and the mixing of freshwater with seawater.

Deep ocean salinity is relatively constant, ranging from 34.5 to 35.5 ppt. The limited mixing of water masses and the absence of freshwater input contribute to the stable salinity of the deep ocean.

3.2 Copernicus Data

3.2.1 Temperature

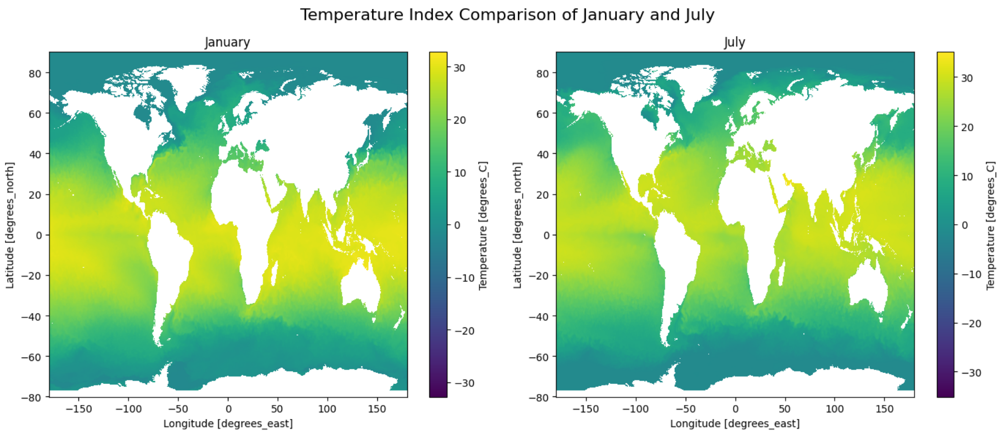

Figure 8: Temperature comparison of Ocean Water during January and July

The temperature index maps for January and July show that the average temperature in July is higher than the average temperature in January in most parts of the world. This is because the Earth is tilted on its axis, and in July, the Northern Hemisphere is tilted towards the Sun, receiving more sunlight and therefore more heat. The Southern Hemisphere has tilted away from the Sun in July, receiving less sunlight and therefore less heat.

The temperature index maps also show that the temperature difference between January and July is greater in the Northern Hemisphere than in the Southern Hemisphere. This is because the Northern Hemisphere has more land mass than the Southern Hemisphere, and land masses heat up and cool down more quickly than oceans. The Vertical Profile of

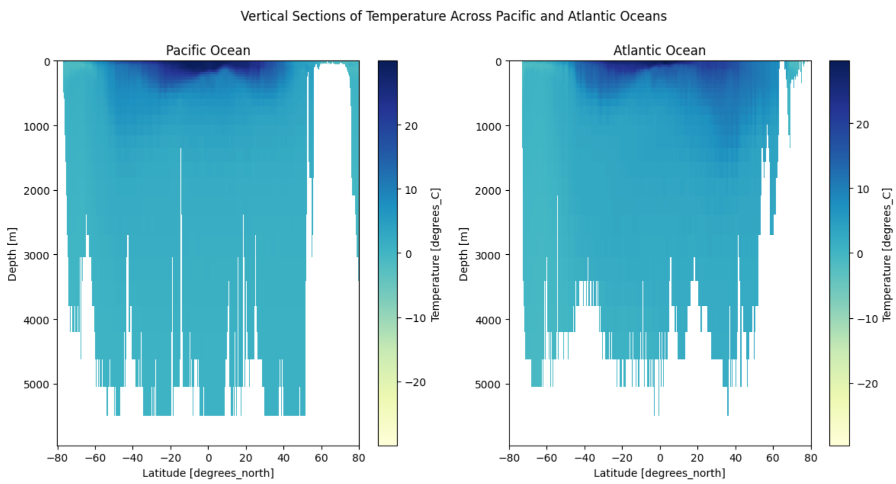

Figure 9: Vertical Profile of temperature during January

the temperature of the Pacific and Atlantic Oceans during January (Figure 9) reveals a similar pattern. The surface has the maximum temperature which is greater than 20 degree

Celsius. The uneven thermocline layer lies just below it, stretching to about 1000m depth. The temperature here lies between 20 -0 degree Celsius where it merges with the deep ocean water.

3.2.2 Salinity

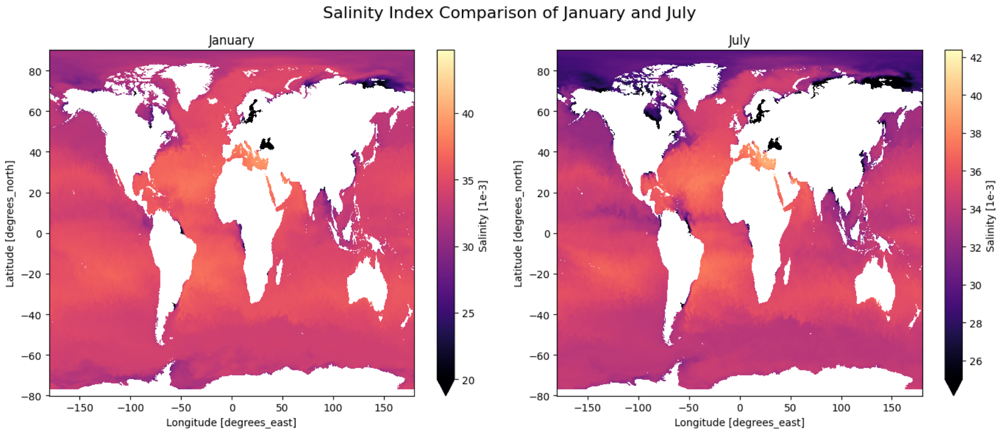

Figure 10: salinity comparison of Ocean Water during January and July

The salinity index maps for January and July show that the salinity of the ocean surface is generally higher in the subtropics and lower in the polar regions. This is because the subtropics receive more sunlight, which increases evaporation and leaves behind the salt. The polar regions receive less sunlight and have more sea ice, which reduces salinity.

There are a few exceptions to the general trend of higher salinity in the subtropics. For example, the salinity in the Baltic Sea is lower than the salinity in the surrounding ocean. This is because the Baltic Sea receives a lot of freshwater input from rivers and streams.

The salinity index maps also show that the salinity of the ocean surface is generally higher in July than in January. This is because evaporation rates are higher in the summer months. The vertical profile of salinity in the Arctic and Pacific Oceans (figure 11) shows that salinity increases with depth in both oceans. However, the salinity gradient is steeper in the Arctic Ocean than in the Pacific Ocean. This is because the Arctic Ocean is more stratified than the Pacific Ocean.

The vertical profile of salinity in the Arctic and Pacific Oceans has a number of implications for marine life. For example, many marine organisms in the Arctic Ocean have evolved to live in the cold, stratified water. These organisms are not able to live in the warmer, saltier water found at the surface. The vertical profile of salinity also affects the distribution of nutrients in the ocean. Nutrients are typically concentrated in the deep water, and the salinity gradient prevents them from mixing with the surface water. This lack of nutrients can limit the growth of phytoplankton, which are the base of the marine food chain.

Overall, the vertical profile of salinity in the Arctic and Pacific Oceans is a reflection of the different physical and biological processes that are occurring in these two oceans.

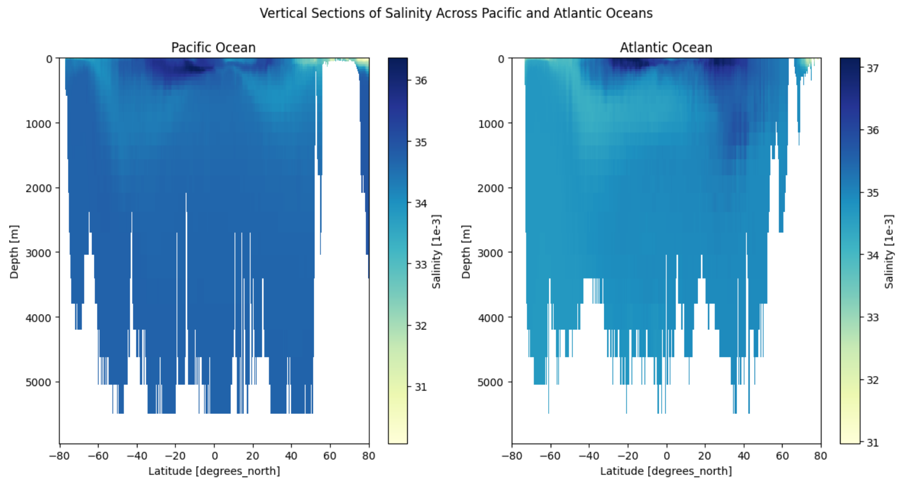

Figure 11: Vertical Profile of salinity during January

4 Code:

- Oceanography Lab 1: https://www.kaggle.com/code/madhushreesannigrahi/oceanog-raphylab1
- Oceanography Lab 2: https://www.kaggle.com/code/madhushreesannigrahi/oceanog-raphylab2