Introduction to Physical Oceanography Report

Yosef GUEVARA.

Introduction to Physical Oceanography
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Contents

1 Introduction

Physical oceanography is the study of the physical properties and processes of the ocean, including the movements and characteristics of ocean waters. It is one of the main subfields of oceanography, along with biological, chemical, and geological oceanography.

There are two main approaches to physical oceanography: dynamical and descriptive. Descriptive physical oceanography uses observations and numerical models to study and describe the fluid motions of the ocean as accurately as possible. Dynamical physical oceanography focuses on the processes that govern the movement of fluids in the ocean, using theoretical research and numerical models.

The field of physical oceanography has made use of a variety of instruments, methods of observation and analysis, and has seen advances in the way findings are presented. Thanks to sensors and software, scientists can more accurately explain natural phenomena in the ocean using oceanographic theory.

2 Boat trip

2.1 Boat trip General description

Three excursions were conducted over consecutive days to gather data on the movement of ocean currents. The data were collected by analyzing the displacement of drifters and studying the chemical and thermal behavior of the Mediterranean Sea in the Bay of Toulon using CDT. The excursion took place on October 11, 2022 from 9:17 a.m. to 3:01 p.m. During the trips, measurements were taken at various stations, with the boat's coordinates from trip 1 were determined by triangulating the cellular signal. The green dots on the chart represent the stations where drifters were released or measurements with the using CDT were taken, while the orange dots represent the coordinates of the boat.

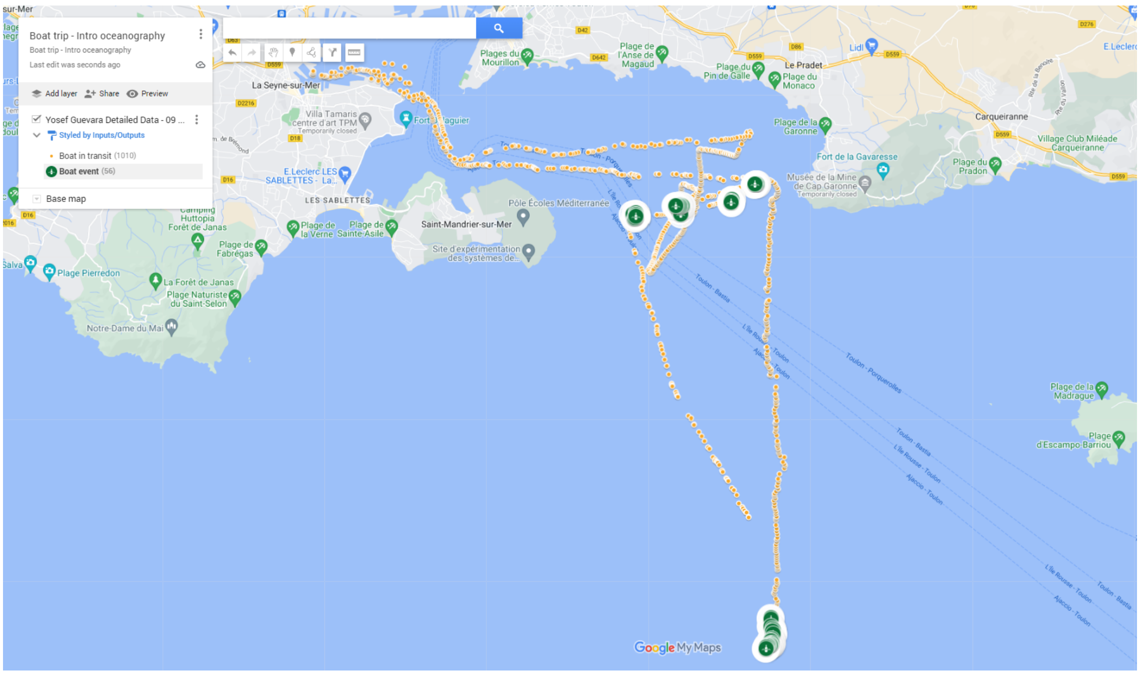


Figure 1: Boat trip trajectory.

To visualize the information on the boat trajectory and the coordinates collected, click here

2.2 Boat trip stations

2.2.1 Drifter stations

Ocean currents and their circulation patterns have gained significant attention in recent years due to their impact on global climate and the resulting effects on habitability. Improved technology in measuring surface currents has allowed for a more comprehensive understanding of ocean circulation. Drifting buoy data is used to validate prediction models, which are important in operational oceanography as they can supplement field measurements and provide updated historical records for evaluating their accuracy.

(a) The Nomad Family drifter from SouthTeck

(b) CARTHE GPS drifter

Figure 2: Drifters used during excursions.

Two types of drifters were used in this study: the Coastal Nomad and the CARTHE drifter. The Coastal Nomad is a durable drifter designed for coastal experiments, while the CARTHE drifter is a low-cost, biodegradable device that tracks surface currents at a depth of 40 cm and is intended for large-scale deployments. Both drifters incorporate advanced positioning and communication technologies, including GPS tracking and GSM coverage.

2.2.2 CTD stations

A CTD (Conductivity, Temperature, and Depth) is a tool used to measure the essential physical properties of seawater, including temperature, salinity, and density. The CTD consists of a set of probes attached to a large metal rosette wheel that is lowered on a cable to the seafloor. Scientists observe the water properties in real-time through a conducting cable that connects the CTD to a computer on the ship. A remotely operated device allows water bottles to be closed selectively as the instrument ascends.

Figure 3: CDT image.

3 Drifter trajectory Analysis

During the three days of the study, the paths and speeds of the deployed drifters were recorded and plotted. There were two types of drifters used: Nomad (which reached a depth of 1 meter) and CARTHE (some of which were equipped with panel drogues to measure current speed at a depth of up to 60 cm). In general, it can be seen that the drifters moved from south to north. As expected, the lowest speeds were recorded immediately after the drifters were deployed, and the drifters reached speeds of 0-0.3 m/s during the study period. The speed of the drifters was not constant. Additionally, surface drifters tended to have higher speeds and greater displacements compared to drifters with drag, with the speed of the latter being relatively similar due to the small variation at the surface of the water.

In other hand, the movement of drifters in the ocean can be affected by the wind. Wind is a significant factor in the movement of surface currents, and it can cause the drifters to be pushed in a certain direction. For example, in areas with strong and consistent wind patterns, such as trade winds, the drifters may be carried along with the wind. However, the movement of the drifters can also be influenced by other factors, such as the Earth's rotation, the shape of the coastline, and the presence of ocean currents.

3.1 Drifter trajectory Day 1.

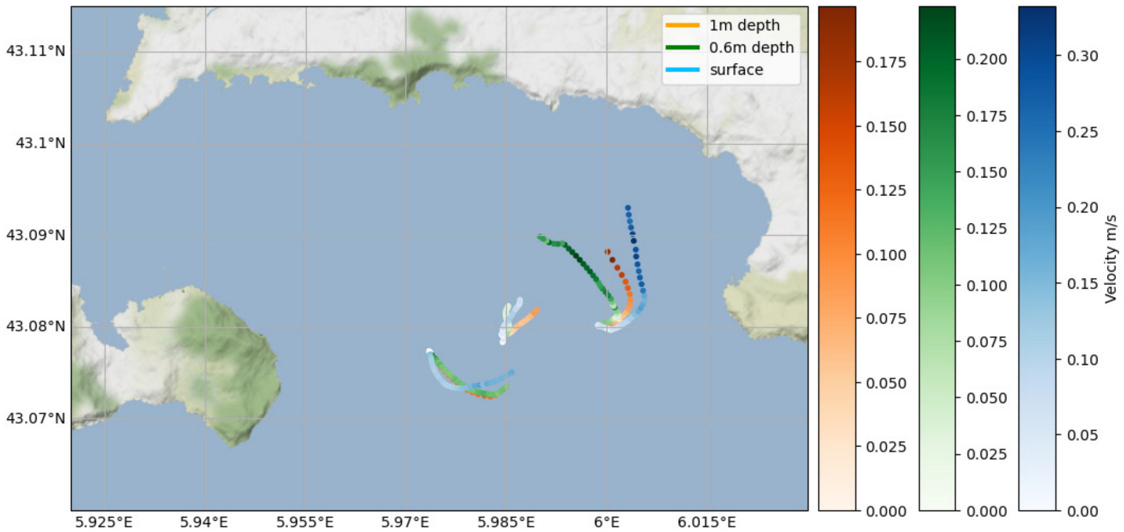
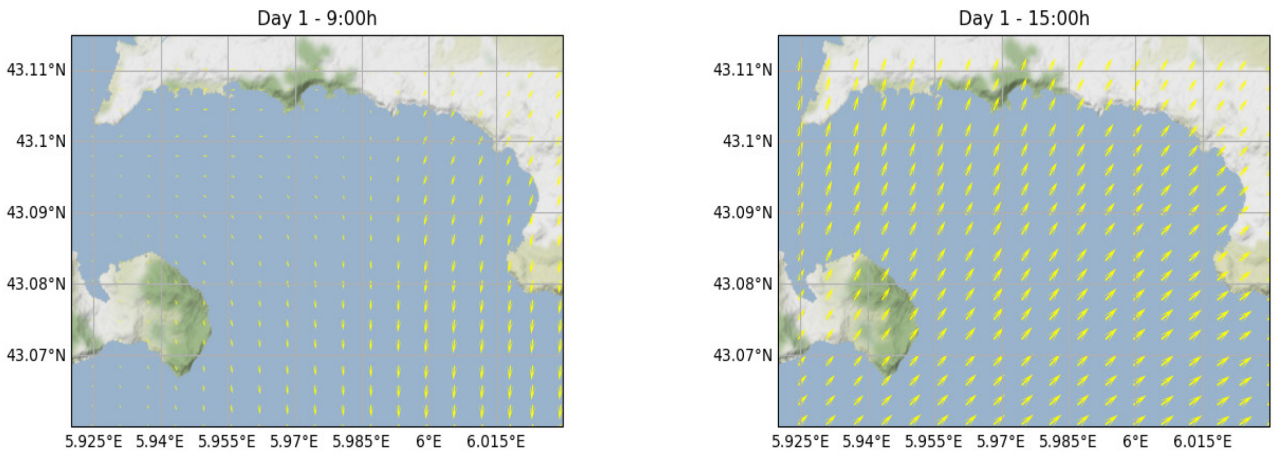


Figure 4: Drifters trajectory, day 1.



(a) Wind trajectory Oct 11 9:00

(b) Wind trajectory Oct 11 15:00

Figure 5: Wind profile Oct 11 9:00 and 15:00.

When examining the contribution of wind to the movement of drifters, we see that on Day 1 the drifters tend to move towards the southwest, before being displaced towards the northeast. We also see that the Nomad class drifters and the CARTHE drifters with drogues tend to follow more closed trajectories, possibly due to the effect of drag. It was observed that in areas where the wind vector was larger, there was a greater displacement of the drifters.

3.2 Drifter trajectory, Day 2.

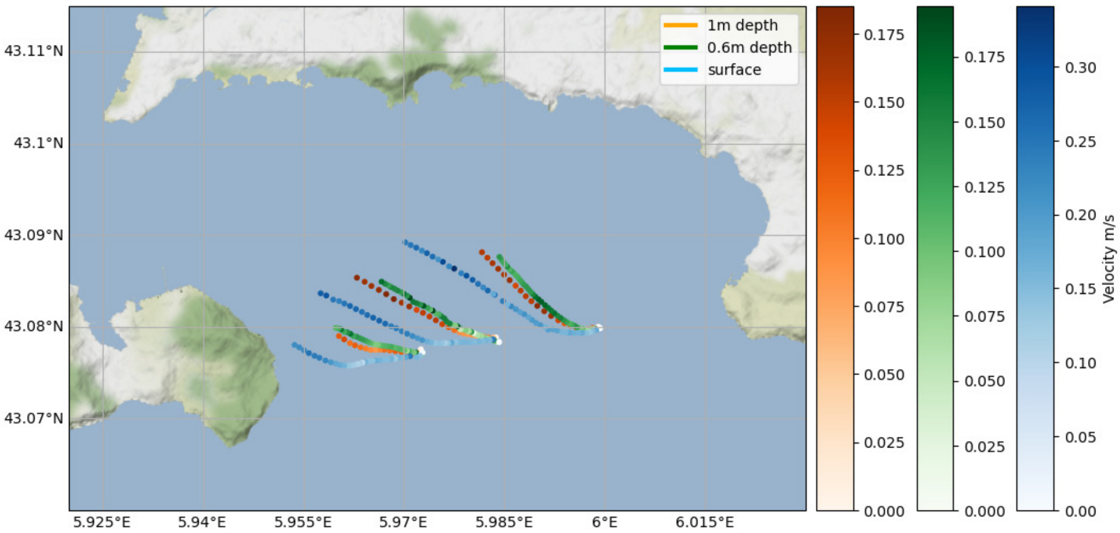


Figure 6: Drifters trajectory, day 2.

On the second day, we can see that the path of the drifters is almost linear, following a path from east to west and south to north. The drifters with drag show the least displacement. It can also be suggested that the direction of the wind vector is oriented in the same direction as the movement of the drifters.

3.3 Drifter trajectory, Day 3.

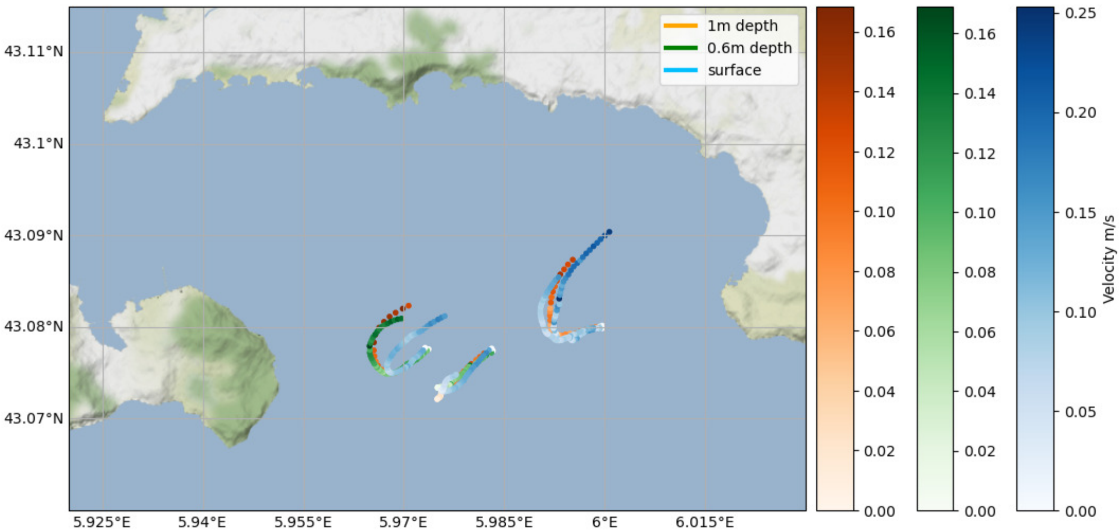


Figure 7: Drifters trajectory, day 3.

On day 3, there is a significant change in the trajectory of the drifters, with their direction changing from southwest to northeast, following a marked curve. However, the drifters located between 43.7 and 43.8 N and 5.97 and 5.98 E show a change in trajectory within their own movement, which could have been caused by aligning with the wind vector.

4 CTD Data analysis

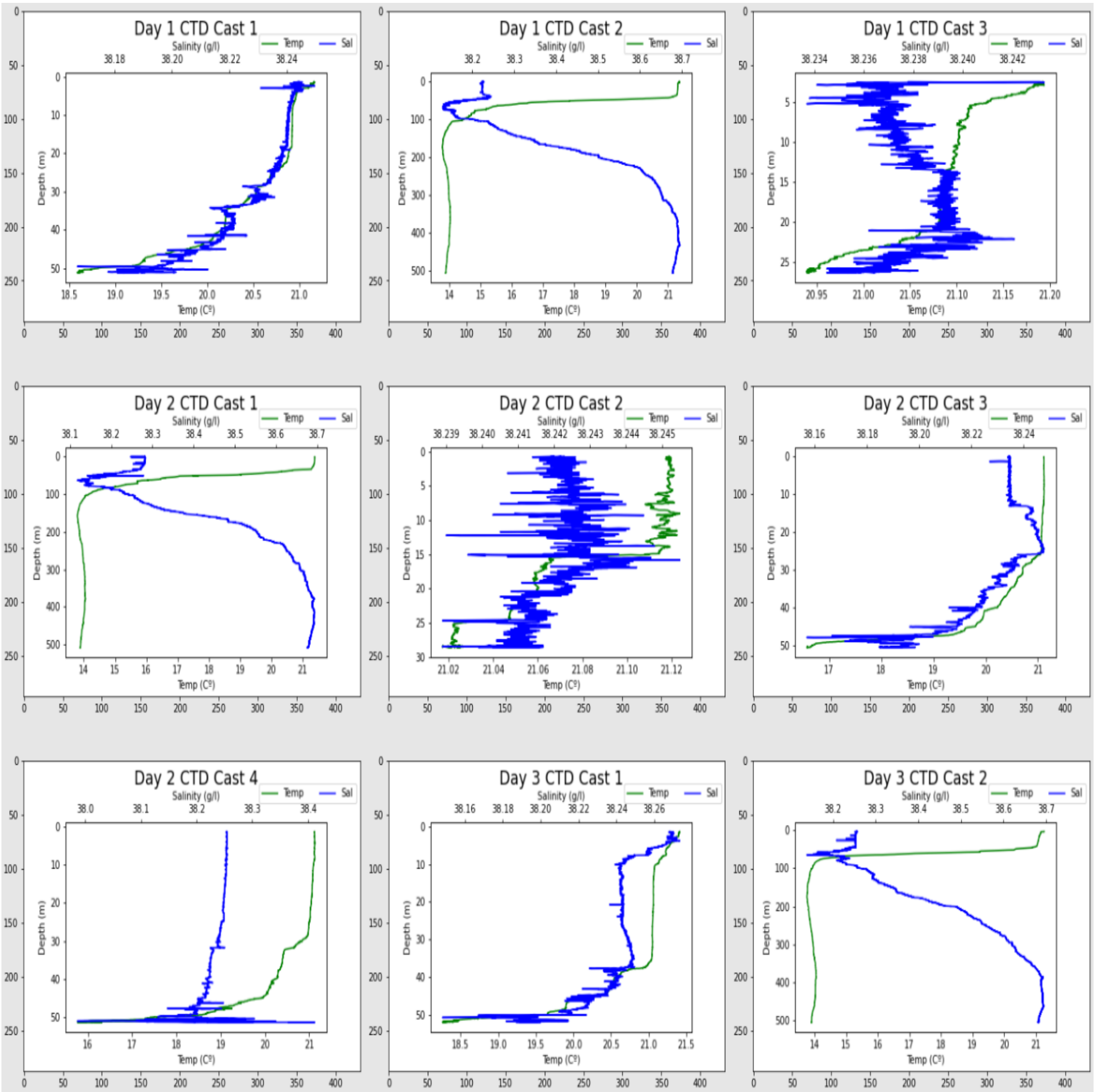
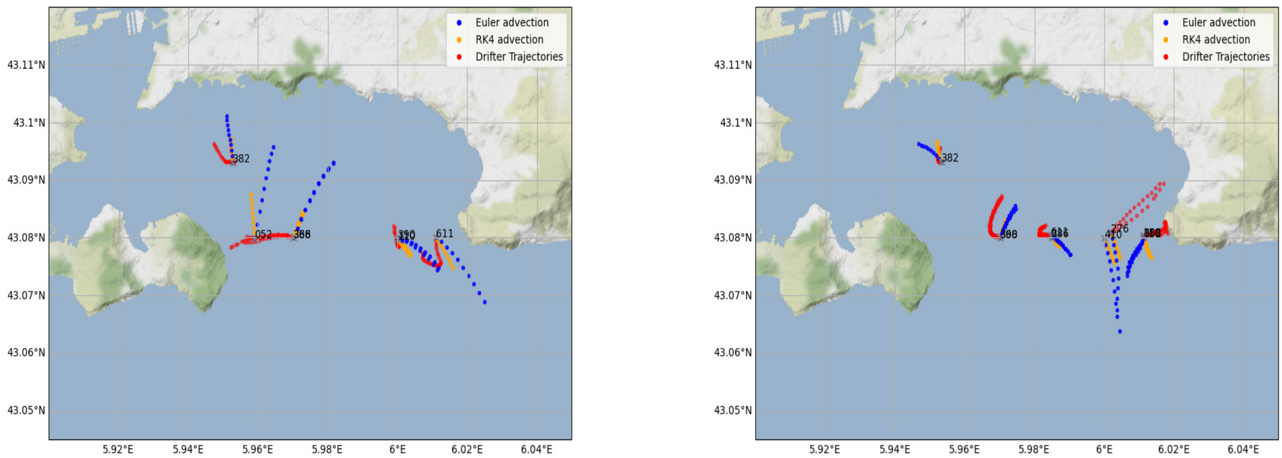


Figure 8: CDT data from (halocline) and temperature (thermocline).

It is known that salinity (halocline) and temperature (thermocline) profiles vary by geographic location. Both types of chemoclines undergo drastic changes in their profiles with increasing depth. When comparing the data plots from the three excursions in Toulon Bay, it is evident that the salinity and temperature profiles behave similarly, with small variations at shallow depths (25-30 meters) due to well-mixed conditions. At these depths, the temperature and salinity (and therefore density) are fairly uniform. However, as depth increases, there is a rapid change in temperature from 21°C at the surface to 14°C at the maximum depth, which may be due to the decrease in temperatures during autumn. Salinity also shows a rapid increase above 100 meters, from 38.3 g/l to 38.7 g/l, with a slight reduction from 38.3 g/l to 38.1 g/l in the mixed layers. It is important to note that the wind stress at the surface is the primary mixing agent, while significant convective mixing driven by heat loss to the atmosphere takes place at night.

5 Model analysis

The Euler advection is an equation that describes the transport of a property (such as mass, momentum, or energy) through a flow field over time. It is used to model the movement of fluids and predict their behavior. The RK4 advection, also known as the Runge-Kutta method, is a numerical method for solving differential equations, particularly advection equations that describe the transport of a property within a fluid or across a surface. It is widely used and accurate, and is often used in fields such as physics, engineering, and computer science.



(a) Drifters trajectory Oct 12 2021

(b) Drifters trajectory Oct 13 2021

Figure 9: Drifters trajectory 12 and 13Oct 2021.

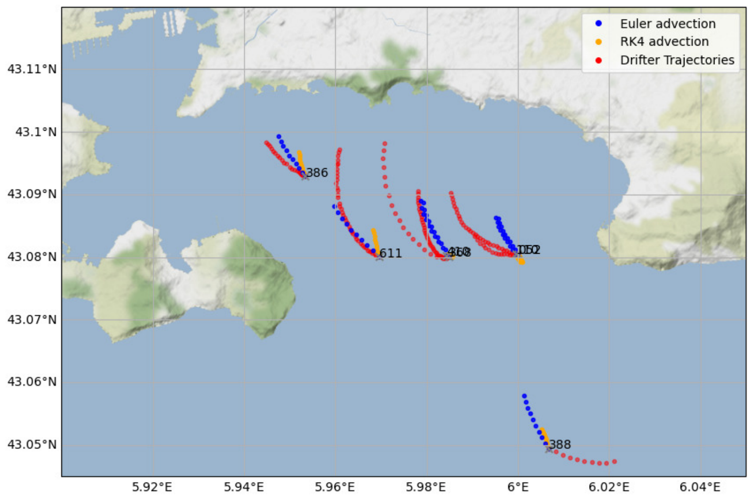


Figure 10: Drifters trajectory Oct 14 2021.

When analyzing the data on the trajectories of the drifters from 2021, it is evident that the estimated trajectories of these models fail to match the actual trajectories of the drifters on October 12 and 13. However, it cannot be ruled out that the drifter trajectory for these days was affected by external factors. In both cases, the drifters follow completely opposite trajectories to those predicted. On the other hand, both types of models fit the data from October 14 better, where the drifters follow a trajectory similar to the predicted one, except for those located between coordinates 43.05 N and 6.02E. There is still an error between the predicted pattern and the actual one, but it is not as significant.

6 Conclusions

In summary, the trajectory of objects in the water can be significantly affected by their geographical location and the amount of drag they generate, depending on how submerged they are. In general, it is evident that objects tend to have less displacement and are less affected by wind and currents when more of their rigid body is underwater. The CDT data shows that conductivity, temperature, and depth are affected by location, depth, and the surrounding ocean conditions, as well as other physical and chemical properties of the water. However, under controlled conditions in the same geographical area, these factors should remain similar. To accurately understand the variations in salinity and temperature, it is necessary to consider these factors and analyze the data in the context of these variables. Multiple factors can influence the movement of drifters in the ocean, including ocean currents, wind, temperature, salinity, and other physical and chemical properties of the water. External forces such as tides and waves can also play a role. To understand the movement of drifters, models must take in count all of these factors and by the size of the study area.