Computer Based Analysis of Sea Water Conductivity Using Real Time Data

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Abstract

In this paper we used real time data to find conductivity of sea water from surface of sea to 5500 m depth of sea, while in past the scientists cannot used real time data they used data as a supposition to find conductivity of sea water. In this paper we used Ellison et al model 1998 as a reference model this model used Fixed frequency of 3GHz and fixed salinity, which is not possible in real because at each depth of sea salinity varies due inorganic compounds concentrations, and we brought some changes to this model by using real time data from National Oceanic and Atmospheric Administration in form of salinity and Temperature from surface of sea to 5500m depth of sea. The salinity is not fixed and it varies., In this paper we used Mat lab as a simulation tool to find salinity, temperature and conductivity of sea water from surface of sea to depth of 5500 m.

Key words: salinity, Temperature, standard deviation (σ), Variance (σ²), Conductivity.

1. Introduction

The sea water behavior change’s with respect to weather’s and with depth’s, the water in its natural state behave like pure insulator, which means a substance
in which the current does not passed like plastic, glass and ceramic, it is in between conductor and semiconductor, in insulator the forbidden band is more as compared to conductor and semiconductor, so electron’s cannot jumps from valence band to conduction band to release energy, so that’s why cannot pass electricity. The sea water consists of different salts and also different matter’s which makes them to behave like partial conductor, if the conductivity is higher the Electromagnetic wave attenuates more as compared to low conductivity. Conductivity varies with temperature and salinity at different sea water depth. At the surface of sea water the salt’s content’s are more, so the conductivity varies from 2s/m in winter and 8s/m in warm weather. The average conductivity mostly are 4 s/m. In this paper we bring the conductivity to minimum level to decrease the attenuation of Electromagnetic waves at higher depth 5500m.

2. Factors Affecting Sea Water Conductivity

2.1. Salinity

Salinity is a measure of salt contents dissolved in sea water or the concentration of salt’s dissolved in sea water. Sea water contains different salt’s concentration but they contains mostly sodium chlorides (NaCl), which is also called table salt. In sea water 86% sodium chlorides ions are dissolved, the other salt’s which is also found in maximum quantity are calcium chloride (CaCl), magnesium chloride (MgCl), magnesium sulfate (MgSO4), potassium nitrate (KNO3) and sodium bicarbonate (NaHCO3). The dissolved chlorine ions concentration called chlorinity. The
The history of salinity is that it comes from Volcanoes when the earth formed, during this process the Volcanoes released different types of chemicals and different types of salts. The other reason is that Rains also washes different salts from mountains and Land to the oceans. The average salinity of sea water is 35% parts per thousand (ppt). Sea water salinity varies geographically and mostly with time, salinity also affected by evaporation, which is vaporization of liquid surface of sea water, it decreases the amount of fresh water. The salinity also depends on locations in high subtropical Latitudes, the evaporation is high near seawater surfaces so the salinity is high. While at sub polar Latitudes the precipitation is high so the salinity is low and it creates layers of high and low salinity at sea water depth. The salinity also affects sea water density which depends on pressure and temperature. The amount of salt is constant for millions of years, while only concentration of water changes due to rainfall, ice melting, which increases the contents of fresh water, so it decreases the salinity. Ice formation also affects the salinity by the process of brine rejection, which means that when the water temperature reaches -1.9 (°C), the water freeze and salts contents are released from ice crystal and the sea water becomes denser and saltier due to this process which increases the salinity. The reference salinity is the best parameter of the absolute salinity of sea water to calculate the practical salinity. The reference salinity is related to absolute salinity by the following equation:

\[ S_R = S_p \left(\frac{35.16504}{35}\right) \text{ g kg}^{-1} \]  

(1)
While Absolute salinity is related to the reference salinity by the following equation

\[ S_A = S_R + \delta S_A \]  

(2)

Where " \( \delta S_A \)" is due to silicon dioxide \( \text{SiO}_2 \), calcium carbonate \( \text{CaCO}_3 \), phosphate \( \text{PO}_4 \), and carbon dioxide \( \text{CO}_2 \). It is due to oxidation of plant material in sea water depth, the value of " \( \delta S_A \)" at constant pressure temperature and at reference salinity is \( \delta S_A = \Delta P/0.75179 \text{ g kg}^{-1} \).

The salinity affects the plants that grow under water depth. 1, 2

2.2. Simulation Results of Salinity

a) Salinity vs Temperature

In the fig 1 at 35( ppt) the concentration of salinity is high because the concentration of inorganic compounds are too high and the temperature is also too high, but when we moving from surface of sea to depth of sea, the salinity concentration decreases because the inorganic compound decreases and the temperature also decreases at depth of sea like at 5( ppt).

2.3. Salinity vs Conductivity

In fig 2 salinity is a function of conductivity, when the concentration of salinity is high like at 40 ppt the conductivity is 6.5 s/m, it means at this point the inorganic compound are in abundant quantity, so the conductivity increases. When the concentration of salinity is low means inorganic compounds are in less...
quantity because we moving from surface of sea to depth of sea as shown in fig 2 at 5 ppt the conductivity is less. In fig 3, the mean values of mean salinity and mean temperature are shown, mean values means the average of numbers, in fig 3 at each point mean value of salinity and mean value of temperature is shown which shows that salinity is a function of temperature. In fig 4, the mean values of salinity and mean conductivity are shown, in fig 4 at each point mean value of salinity and mean value of conductivity is shown, which indicate that conductivity is also a function of salinity.

2.4. Standard Deviation($\sigma$) and Variance ($\sigma^2$) of Sea Water Salinity

It shows the relationship between original data with respect to expected data. It is represented by a Greek word ($\sigma$). If the standard deviation ($\sigma$) have minimum value it means that it is near to the expected value. While
higher value of standard deviation means that the data is deviate from its expected value as shown in fig 5. Mathematically, 

\[ SD \ (\sigma) = \sqrt{\frac{\sum (x-x')^2}{n-1}} \]  

(3)

where in equation (3) “x’” is the mean value “Σ” is the summation and “n” is the number in sample. While variance shows a relationship between expected value with respect to spread data from mean as shown in fig 6. Mathematically

\[ Variance \ (\sigma^2) = \frac{\sum (x-x')^2}{N} \]  

(4)

Where in equation (4) “Σ” is the summation “x’” is the mean value “x” is data point and “N” sample no. 3

![Fig 5 standard deviation vs sea water depth](image1)

![Fig 6 variance of salinity vs sea water depth](image2)

2.5. Salinity vs Depth of Sea

In fig 7 at 1000 m the salinity concentration is high because at this depth the inorganic compounds are low, while at 5500m the salinity concentration is not high because at this depth the inorganic compounds are in low quantity, as moving from surface of sea to depth of sea concentration of salinity decreases while at 5500m the salinity concentration is low.
Fig 7 means salinity vs sea water depth

2.6. Temperature

It is a parameter shows an object hotness or coldness. It is measured by Celsius (°C). It is in the range of -2 to 28(°C). The temperature of sea water is directly proportional to the salinity concentration and conductivity of sea water. At the surface of sea water the temperature is high, the salinity concentration is high due to inorganic compounds in abundant form, which increases the conductivity at surface of sea water, while at depth of sea water the salinity and conductivity decreases. As shown in fig 9), The conductivity is maximum at 30 °C, while minimum at 5 °C in fig 10 a), b), c). standard deviation, variance and mean conductivity versus temperature is shown.
Fig 10 b) Variance vs Temperature

Fig 10 c) Mean conductivity vs Mean Temperature

2.7. Temperature vs Depth of Sea and Permittivity of Sea Water

The salinity and conductivity decreases at depth due to low concentration of inorganic compounds so the fresh water behave like an insulator, which also causes to decrease the temperature at depth. As shown in fig 11.

Fig 11 Mean temperature vs sea water depth

3. Conductivity of Sea Water at Depth of Sea 5500m

In electrical engineering conductivity is the ability of substance or material to pass electric current, it is also opposite to the resistivity, while water conductivity means the ability of water to pass electric current. It is measured in Siemens per meter (s/m). The conductivity of sea water is also a function of salinity concentration and temperature of sea water, they are directly proportional to each other. As shown in fig 12 at the surface of sea the conductivity is maximum because the inorganic compounds
concentration is high at surface of sea water, but when we moving from 1000 m to 5500 m of sea depth there is a significant change in the conductivity of sea water, the reason is that the inorganic compounds like sodium chloride, magnesium chlorides and phosphates are not in abundant form at the depth of sea water and this concentration levels is changed at depth of sea, the higher the depth, lower is the concentration of inorganic compounds. The organic compounds like bacteria, and carbon materials have no effect on the conductivity of sea water. Mathematically conductivity

\[ \sigma(s,t) = d(t) + g(t) s \quad (5) \]

\[ d(t) = 0.086374 + 0.030606t - 0.0004121t^2 \]

\[ g(t) = 0.077454 + 0.001687t + 0.00001937 t^2 \]

Where in equation (5) “d(t)” is coefficient of time, and “ g(t) " is coefficient of salinity. 5,6,7,8,9,10.

Fig 12  Seawater depth vs Conductivity

In fig 12 the conductivity is high in between 0 to 1000m of sea water and it is almost 4 to 2.7s/m. In this range the conductivity is high and the Electromagnetic waves loses more energy. While in 1000 to 3000m depth of sea water the conductivity reduces from 2.7 to 2.2 s/m and from 3000m to 5500m the conductivity is 2.2 to 0.25 s/m at this stage the Electromagnetic waves loses minimum energy and the water behave like insulator.
<table>
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<tr>
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<td>0.25</td>
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Table 1: Conductivity vs depth

![Graph 1: Conductivity vs depth](image)

6. Conclusion Remarks
As we concluded that the conductivity of sea water linearly increases and decreases with temperature and salinity at depth and at the surface of sea water. We also noticed that at depth of sea water the water behave like an insulator because the inorganic compounds are found in less quantity. While on the other hand at the surface of sea water the conductivity is too high, because it's a function of salinity and temperature. The inorganic compounds concentration at the surface of sea increases. The organic compounds of sea water like carbon and bacteria have no effect on conductivity at depth and surface of sea water.

7. Future Work
For future the conductivity can also be find if we have real time data for more depth of sea water. It can also be used to find Refraction Loss and attenuation of Electromagnetic waves.

8. Acknowledgment
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