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Ocean Salinity

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ABSTRACT

The ocean (also the sea or the world ocean) is the body of salt water that covers approximately 70.8% of the surface of Earth and contains 97% of Earth's water.There are many chemicals in ocean that make it salty. Most of them get there from rivers carrying chemicals dissolved out of rock and soil. The main one is sodium chloride, often just called salt. Most ocean water has about 35 g (7 teaspoons) of salt in every 1,000 g (about a litre) of water. This doesn't sound very much, but it would take close to two 6 m shipping containers full of salt to make an Olympic-size swimming pool as salty as the ocean. The commonest way to record salinity is to measure the amount of salt in 1,000 g of water, so it is referred to as 'parts per thousand' or ppt. Most of the ocean has a salinity of between 34 ppt and 36 ppt.

Some properties of water are changed by having salt in it:

- *Salt makes ocean water more dense than freshwater.*
- *Salty water needs to be colder than freshwater before it freezes.*

The salinity of the ocean varies from place to place, especially at the surface. Much of the ocean has salinity between 34 ppt and 36 ppt, but there are places that tend to be higher or lower. There are parts of the ocean where hardly any rain falls but warm dry winds cause lots of evaporation. This evaporation removes water – when water vapour rises into the atmosphere, it leaves the salt behind, so the salinity of the ocean water increases. This causes the ocean water to become denser. You can see on the map that the north and south Atlantic have high salinity – these are areas where there are strong winds and not much rain. Much of the open ocean has a salinity between 34ppt and 36ppt. Salinity is controlled by a balance between water removed by evaporation and freshwater added by rivers and rain.The Mediterranean Ocean in Europe has very high salinity – 38 ppt or more. It is almost closed from the main ocean, and there is more evaporation than there is rain or extra freshwater added from rivers.Some parts of the ocean have lots of rain. The freshwater added at the surface dilutes the ocean water, reduces the salinity and so makes the oceanwater less dense. Ocean water can also be less saline near land, where rivers add freshwater.The ocean around Antarctica has a low salinity of just below 34ppt, and around the Arctic it is down to 30ppt in places. Thawing icebergs add freshwater – icebergs that have broken off ice sheets formed over land do not contain salt, and the freezing of ocean water into ice floes removes more salt. Water density changes with temperature and salinity. When water freezes at 0°C, a rigid open lattice (like a web) of hydrogen-bonded molecules is formed. It is this open structure that makes ice less dense than liquid water. This is why icebergs float.

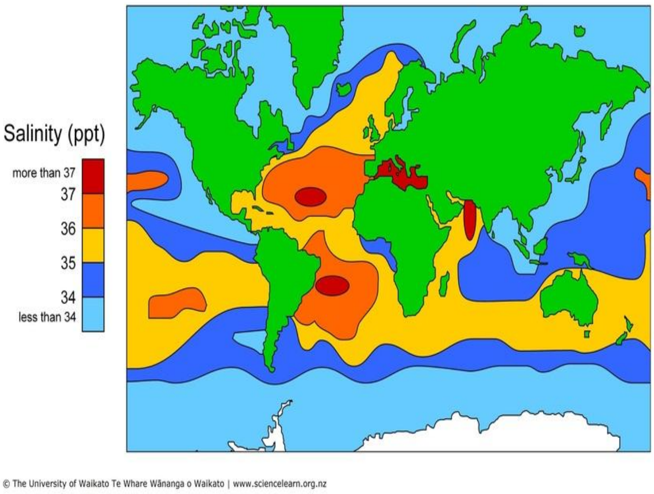
The Baltic Ocean, almost enclosed by northern Europe and Scandinavia, has a very low salinity of about 10 ppt. This is mainly due to the huge amount of freshwater added from hundreds of rivers.The difference between 34 ppt and 36 ppt salinity doesn't sound very much, but it is enough to cause a difference in density. Even slightly denser oceanwater sinks below less dense water.However, the effect is greater if the salty water gets cold, as temperature has a greater effect on density than salinity does. A combination of high salinity and low temperature makes oceanwater so dense that it sinks to the bottom of the ocean and flows across ocean basins as deep, slow currents.

KEYWORDS: ocean, salinity, salt, currents, temperature, dense, freezing, ice, chemicals

1. INTRODUCTION

Role of ocean salinity

- Salinity determines compressibility, thermal expansion, temperature, density, absorption of insolation, evaporation and humidity.
- It also influences the composition and movement of the sea: water and the distribution of fish and other marine resources.[1,2]



Share of different salts is as shown below—

- sodium chloride — 77.7%
- magnesium chloride—10.9%
- magnesium sulphate —.4.7%
- calcium sulphate — 3.6%
- potassium sulphate — 2.5%

Factors affecting ocean salinity:

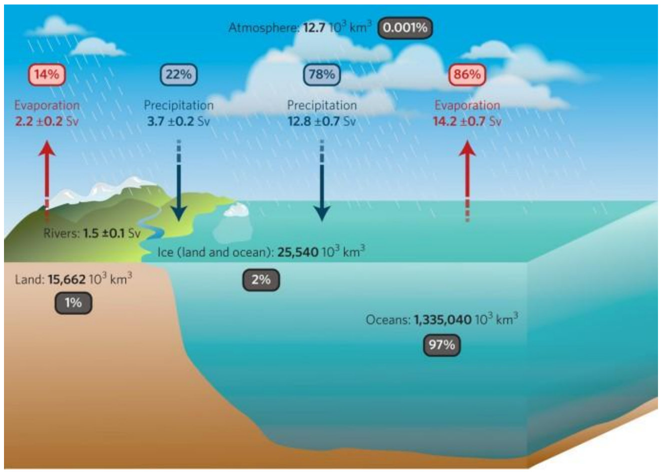
- The salinity of water in the surface layer of oceans depend mainly on evaporation and precipitation.
- Surface salinity is greatly influenced in coastal regions by the fresh water flow from rivers, and in polar regions by the processes of freezing and thawing of ice.
- Wind, also influences salinity of an area by transferring water to other areas.
- The ocean currents contribute to the salinity variations.
- Salinity, temperature and density of water are interrelated. Hence, any change in the temperature or density influences the salinity of an area.[3,4]

Horizontal distribution of salinity:

- The salinity for normal open ocean ranges between 33 and 37.

High salinity regions:

- In the land locked Red Sea (don't confuse this to Dead Sea which has much greater salinity), it is as high as 41.



Global ocean salinity observation

- In hot and dry regions, where evaporation is high, the salinity sometimes reaches to 70.

Comparatively low salinity regions:

- In the estuaries (enclosed mouth of a river where fresh and saline water get mixed) and the Arctic, the salinity fluctuates from 0 – 35, seasonally (fresh water coming from ice caps).

Pacific-The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent.

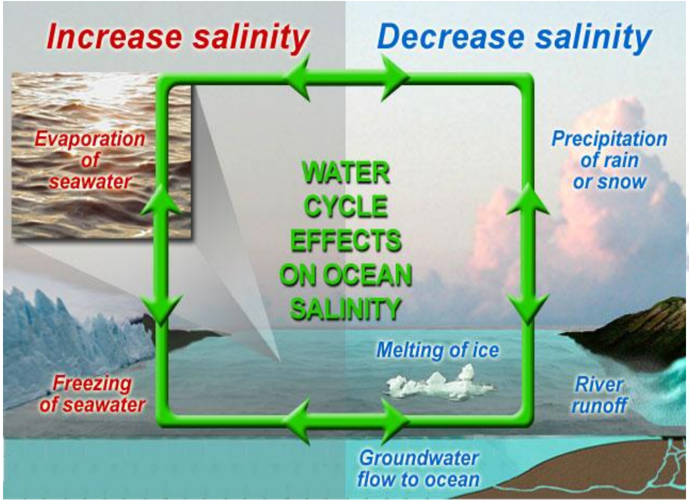
Atlantic:

- The average salinity of the Atlantic Ocean is around 36-37.
- The equatorial region of the Atlantic Ocean has a salinity of about 35.
- Near the equator, there is heavy rainfall, high relative humidity, cloudiness and calm air of the doldrums.
- The polar areas experience very little evaporation and receive large amounts of fresh water from the melting of ice. This leads to low levels of salinity, ranging between 20 and 32.
- Maximum salinity (37) is observed between 20° N and 30° N and 20° W – 60° W. It gradually decreases towards the north.

Indian ocean:

- The average salinity of the Indian Ocean is 35.[5,6]
- The low salinity trend is observed in the Bay of Bengal due to influx of river water by the river Ganga.

- On the contrary, the Arabian Sea shows higher salinity due to high evaporation and low influx of fresh water.



Marginal seas:
- The North Sea, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift.
- Baltic Sea records low salinity due to influx of river waters in large quantity.
- The Mediterranean Sea records higher salinity due to high evaporation.
- Salinity is, however, very low in Black Sea due to enormous fresh water influx by rivers.

Inland seas and lakes:
- The salinity of the inland Seas and lakes is very high because of the regular supply of salt by ' the rivers falling into them.
- Their water becomes progressively more saline due to evaporation.
- For instance, the salinity of the Great Salt Lake , (Utah, USA), the Dead Sea and the Lake Van in Turkey is 220, 240 and 330 respectively.
- The oceans and salt lakes are becoming more salty as time goes on because the rivers dump more salt into them, while fresh water is lost due to evaporation.[7,8]

Observations

Cold and warm mixing zones:
- Salinity decreases from 35 – 31 on the western parts of the northern hemisphere because of the influx of melted water from the Arctic region.

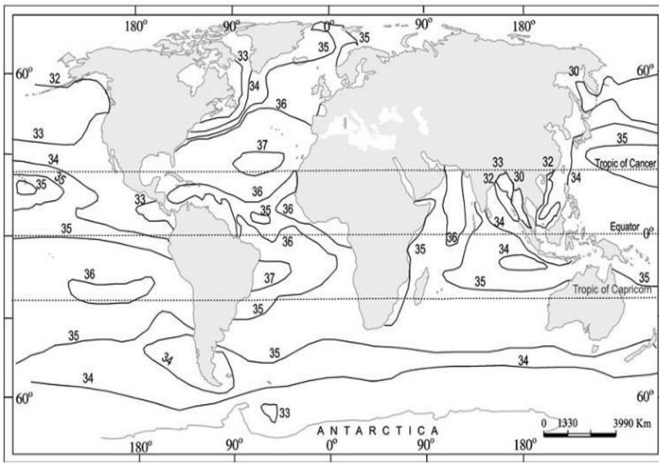


Figure13.5 : Surface salinity of the World's Oceans

- With depth, the salinity also varies, but this variation again is subject to latitudinal difference. The decrease is also influenced by cold and warm currents.
- In high latitudes, salinity increases with depth. In the middle latitudes, it increases up to 35 metres and then it decreases. At the equator, surface salinity is lower.

Vertical distribution of salinity:
- Salinity changes with depth, but the way it changes depends upon the location of the sea.
- Salinity at the surface increases by the loss of water to ice or evaporation, or decreased by the input of fresh waters, such as from the rivers.
- Salinity at depth is very much fixed, because there is no way that water is 'lost', or the salt is 'added.' There is a marked difference in the salinity between the surface zones and the deep zones of the oceans.
- The lower salinity water rests above the higher salinity dense water.
- Salinity, generally, increases with depth and there is a distinct zone called the halocline (compare this with thermocline), where salinity increases sharply.
- Other factors being constant, increasing salinity of seawater causes its density to increase. High salinity seawater, generally, sinks below the lower salinity water. This leads to stratification by salinity.[9,10]

2. SIGNIFICANCE OF OCEAN SALINITY

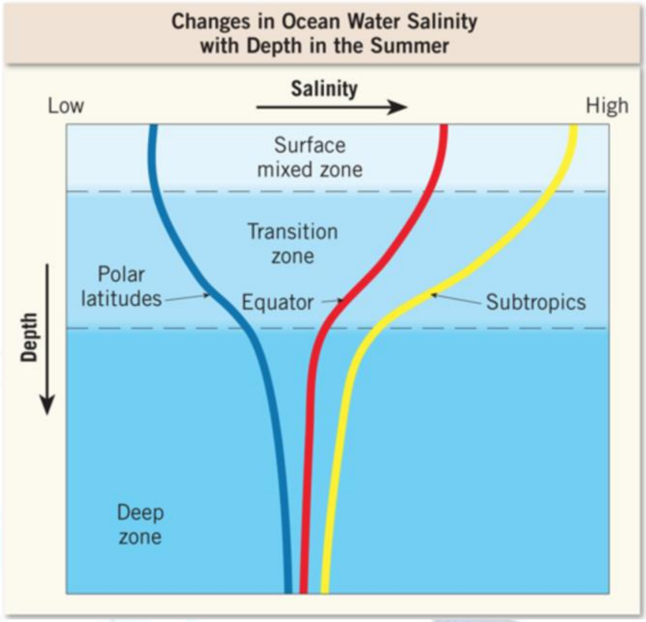
The habitability of the growing number of confirmed exoplanets is a question of wide interest and importance. A key factor determining habitability is planetary climate, which is influenced heavily by the presence of liquid water oceans, and in particular, the heat transported around the planet by these oceans. Here the impact of average ocean salinity, a key property in determining the density of water, on ocean state is investigated. It is shown that oceans that have sufficiently different average salinities to Earth consist of circulations of opposite direction: sinking in the tropics, filling the deep ocean with warm water, and ultimately warming the polar regions. Variations in ocean properties can therefore extend the range of exoplanet habitability.

3. DISCUSSION

Ocean salinity and global water cycle:

Alterations to the global water cycle are of concern as Earth's climate changes. Although policymakers are mainly interested in changes to terrestrial rainfall—where, when, and how much it's going to rain—the largest component of the global water cycle operates over the ocean where nearly all of Earth's free water resides. Approximately 80% of Earth's surface freshwater fluxes occur over the ocean; its surface salinity responds to changing evaporation and precipitation patterns by displaying salty or fresh anomalies. The salinity field integrates sporadic surface fluxes over time, and after accounting for ocean circulation and mixing, salinity changes resulting from long-term alterations to surface evaporation and precipitation are evident. Thus, ocean salinity measurements can provide insights into water-cycle operation and its long-term change. Although poor observational coverage and an incomplete view of the interaction of all water-cycle components limits our understanding, climate models are beginning to provide insights that are complementing observations. This new information suggests that the global water cycle is rapidly intensifying.[11,12]

Satellite salinity observing systems



Advances in L-band microwave satellite radiometry in the past decade, pioneered by ESA's SMOS and NASA's Aquarius and SMAP missions, have demonstrated an unprecedented capability to observe global sea surface salinity (SSS) from space. Measurements from these missions are the only means to probe the very-near surface salinity (top cm), providing a unique monitoring capability for the interfacial exchanges of water between the atmosphere and the upper-ocean, and delivering a wealth of information on various salinity processes in the ocean, linkages with the climate and water cycle, including land-sea connections, and providing constraints for ocean prediction models. The satellite SSS data are complimentary to the existing in situ systems such as Argo that provide accurate depiction of large-scale salinity variability in the open ocean but under-sample mesoscale variability, coastal oceans and marginal seas, and energetic regions such as boundary currents and fronts. In particular, salinity remote sensing has proven valuable to systematically monitor the open oceans as well as coastal regions up to approximately 40 km from the coasts. This is critical to addressing societally relevant topics, such as land-sea linkages, coastal-open ocean exchanges, research in the carbon cycle, near-surface mixing, and air-sea exchange of gas and mass. [13,14]

4. RESULTS

ESAs soil moisture and ocean salinity mission:

Mapping soil moisture and ocean salinity

The Soil Moisture and Ocean Salinity (SMOS) mission, launched in November 2009, is the European Space Agency's (ESA) second Earth Explorer Opportunity mission. The scientific objectives of the SMOS mission directly respond to the need for global observations of soil moisture and ocean salinity, two key variables used in predictive hydrological, oceanographic and atmospheric models. SMOS observations also provide information on vegetation, in particular plant available water and water content in a canopy, drought index and flood risks, surface ocean winds in storms, freeze/thaw state and sea ice and its effect on ocean–atmosphere heat fluxes and dynamics affecting large-scale processes of the Earth's climate system.

Significant progress has been made over the course of the now 6-year life time of the SMOS mission in improving the ESA provided level 1 brightness temperature and level 2 soil moisture and sea surface salinity data products. The main emphasis of this paper is to review the status of the mission and provide an overview and performance assessment of SMOS data products, in particular with a view towards operational applications, and using SMOS products in data assimilation.

SMOS is in excellent technical condition with no limiting factors for operations beyond 2017. The instrument performance fulfils the requirements. The radio-frequency interference (RFI) contamination originates from man-made emitters on ground, operating in the protected L-band and adding signal to the natural radiation emitted by the Earth. RFI has been detected worldwide and has been significantly reduced in Europe and the Americas but remains a constraint in Asia and the Middle East. The mission's scientific objectives have been reached over land and are approaching the mission objectives over ocean.[15,16]

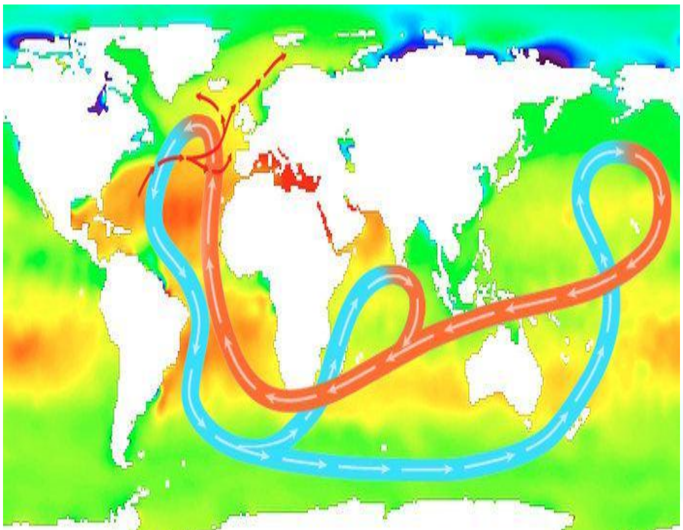
NASA Mission Measures How Ocean Salinity Affects Climate and Water Cycle - Circle of Blue

5. CONCLUSION

Atmospheric warming altering ocean salinity:

The warming climate is altering the saltiness of the world's oceans, and the computer models scientists have been using to measure the effects are underestimating changes to the global water cycle, a group of Australian scientists have found. The water cycle is the worldwide phenomenon of rainwater falling to the surface, evaporating back into the air and falling again as rain.The wetter parts of the world are getting wetter and the drier parts drier. The researchers know this because the saltier parts of the ocean are getting saltier and the fresher parts, fresher.Records showed that the saltier parts of the ocean increased salinity -- or their salt content -- by 4 percent in the 50 years between 1950 and 2000. If the climate warms by an additional 2 or 3 degrees, the researchers project that the water cycle will turn over more quickly, intensifying by almost 25 percent.Reporting in Science magazine, the researchers said the results of the change in climate would affect agriculture and the ability of drier areas to capture and use fresh water from rain, creating serious problems, including droughts and floods. But they had to look offshore to find their data.[17,18]

"The oceans are really where the action is happening," said Paul Durack, the lead author.The study uses 50 years of data -- from 1950-2000 -- gathered by instruments, some adrift on the ocean currents, some tethered in place. Some of the instruments are tiers of bottles that open at various depths as they are lowered into the sea, and they take measurements as far down as 9,000 feet.Durack, who received his Ph.D. from the University of Tasmania, and is now in a post-doctoral fellowship at Lawrence Livermore Laboratory in California, said that "salinity shifts in the ocean confirm climate and the global water cycle have changed.[19,20]



Measuring ocean salinity from space

"The oceans cover 71 percent of the Earth's surface. They contain 97 percent of the world's water; receive 80 percent of the rainfall, and have absorbed 90 percent of the energy produced by global warming.The relationship between salinity in the sea and the water cycle is well documented, the scientists wrote. Changes in salinity could also affect water currents because saltwater is denser than fresh water and sinks.Warmer air can absorb more water than cooler air, so as the climate warms, more water can evaporate into the air. The amount evaporated increases 7 percent for every degree Celsius the temperature increases, the scientists reported.That intensifies the water cycle on both ends of the spectrum. In places where rainfall exceeds evaporation, the rain is increasing; in the places where evaporation rates are higher than rainfall, it gets drier.[21,22]

Some of the change is directly caused by warmer temperatures. For instance, the ocean waters around Antarctica are getting less salty because the waters are being refreshed by the melting ice cap.Arid areas that require rainfall to provide water for irrigation, for drinking and industry, will see less rainfall, he said. That is a more significant threat than just an increase in temperature[23]."Changes in the global water cycle and the corresponding redistribution of rainfall will affect food availability, stability, access, and utilization," Durack said. "I come from Perth, in dry western Australia, and you can see the change."Most computer models depend on land-based observation, which accounts for the difference, but Durack and his collaborators, Susan E. Wijffels and Richard J. Matea, think measuring the oceans gives a more accurate picture, what they called an "identifiable fingerprint." Their work covers 71 percent of the world's water cycle."The most important part of the research is the basic observation that the 50-year trend in salinization is indeed that the fresh water is getting fresher and the saltwater saltier," said Dean Roemmich, a professor of oceanography at the Scripps Institution of Oceanography. "It is a fundamental change."[24,25]

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