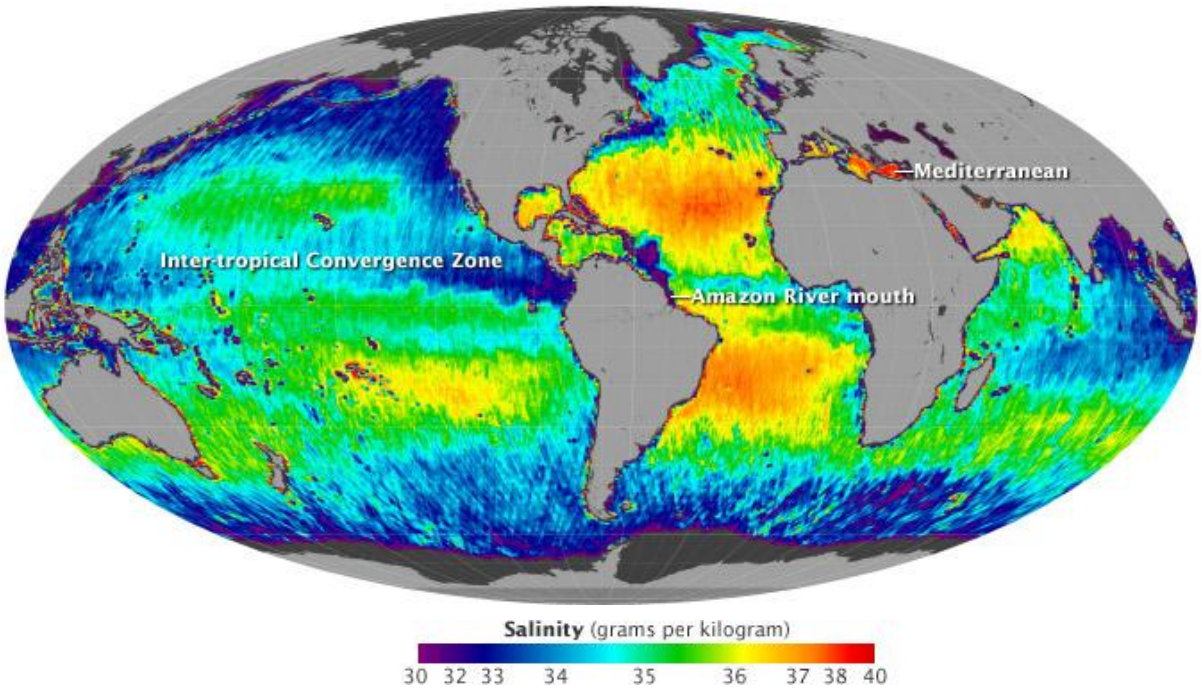
http://earthobservatory.nasa.gov/IOTD/view.php?id=78250&src=eoa-iotd

A Measure of Salt



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Salinity—the amount of dissolved salt in the water—is critical to so many aspects of the ocean, from circulation to climate to the global water cycle. For much of the past year, NASA and Argentina's Comisión Nacional de Actividades Espaciales (CONAE) have been making comprehensive observations of sea surface salinity from space. Launched on June 10, 2011, the Aquarius mission is slowly compiling a more complete picture of the salty sea and how it varies.

The map above shows salinity near the ocean surface as measured by the Aquarius instrument on the Satélite de Aplicaciones Científicas (SAC)-D satellite. The data depicted shows average salinity from May 27 to June 2, 2012, in a range from 30 to 40 grams per kilogram, with 35 grams being the average. Lower values are represented in purples and blues; higher values are shown in shades of orange and red. Black areas occur where no data was available, either due to the orbit of the satellite or because the ocean was covered by ice, which Aquarius cannot see through.

Click on the animation below the main image to see salinity patterns changing week by week over the past year. A few features stand out. As oceanographers have known for many years—but now can "see"—the Atlantic Ocean is saltier than the Pacific and Indian Oceans. Rivers such as the Amazon carry tremendous amounts of fresh runoff from land and spread plumes far into the sea. And in the tropics—particularly near the Pacific's Inter-Tropical Convergence Zone—extra rainfall makes equatorial waters somewhat fresher.

Near most coastlines and inland seas in the map, waters appear much fresher or saltier than in open-ocean locations. Look, for instance, at the Red Sea and the Mediterranean for saltier waters; significantly fresher waters appear in the Black Sea, in the icy high latitudes, and around the many islands and peninsulas of Southeast Asia. Indeed, runoff from rivers and melting ice does make water fresher, and strong evaporation and other processes do make the Red and Mediterranean Seas saltier. But mostly those extreme salinity measurements around the coastlines are a distortion of the satellite signal.

Technically, Aquarius measures the emissivity or "brightness temperature" of the surface waters, notes Gary Lagerloef, Aquarius principal investigator, based at Earth and Space Research in Seattle. Land masses have a higher emissivity than the ocean, so any measurement close to land tends to be skewed by its brightness. Over time, the Aquarius research team should be able to calibrate the measurements and develop mathematical tools to better distinguish the salt signal. But for now, the measurements are so new that the team is still working on the big picture of ocean salinity.

Aquarius is the first NASA instrument specifically designed to study surface ocean salinity from space, and it does so at a rate of 300,000 measurements per month. It uses three passive microwave sensors, called radiometers, to record the thermal signal from the oceans' top 10 millimeters (about 0.4 inches).

"An overarching question in climate research is to understand how changes in the Earth's water cycle—meaning rainfall and evaporation, river discharges and so forth—ocean circulation, and climate link together," said Lagerloef. Most global precipitation and evaporation events take place over the ocean and are very difficult to measure. But rainfall freshens the ocean's surface waters, and Aquarius can detect these changes in saltiness. "Salinity is the variable we can use to measure that coupling. It's a critical factor, and it will eventually be used to improve climate forecasts."

Related Resources

- Comisión Nacional de Actividades Espaciales (CONAE) (n.d.) Aquarius / SAC-D. Accessed June 11, 2012.
- NASA (n.d.) Aquarius / SAC-D. Accessed June 11, 2012.
- NASA (n.d.) Salinity Basics. Accessed June 11, 2012.

NASA images by Norman Kuring, Goddard Space Flight Center. Animation by Robert Simmon. Caption by Mike Carlowicz, Earth Observatory, with reporting from Maria-Jose Vinas, NASA Earth Science News Team.

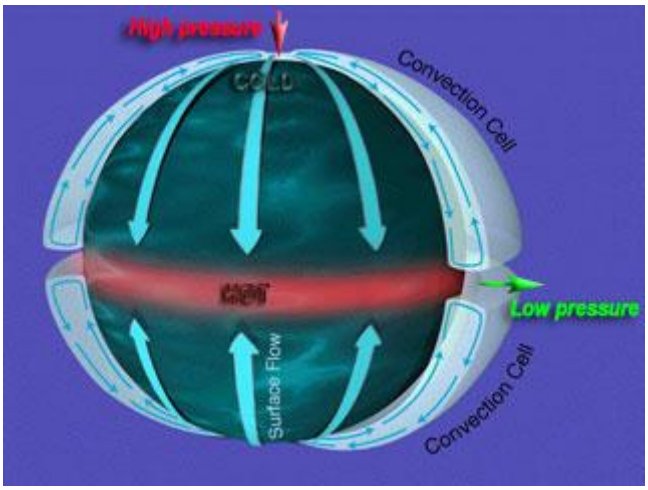
EDUCATION: SALINITY BASICS

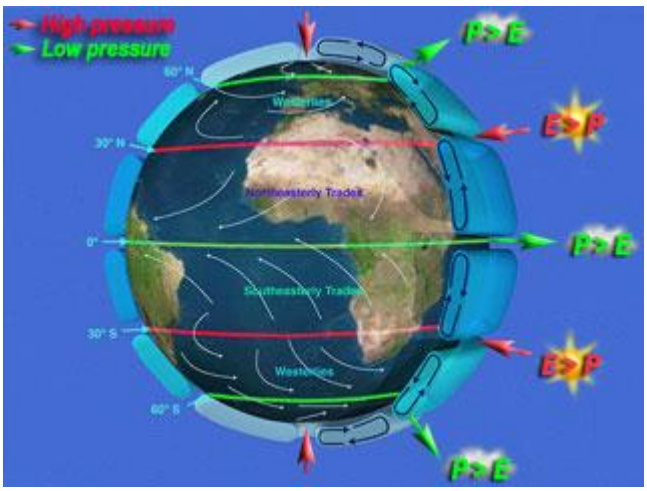
How much salt is there? Probably more than you think. Some scientists estimate that the oceans contain as much as 50 quadrillion tons (50 million billion tons) of dissolved solids. If the salt in the sea could be removed and spread evenly over Earth's land surface it would form a layer more than 500 feet thick (152.4 meters), about the height of a 40-story building. Seawater is 220 times saltier than fresh lake water. Unrefined sea salt contains 98.0% sodium chloride and up to 2.0% other minerals (salts). Together there are over 100 minerals, composed of 80 chemical elements, in sea salt. The composition of a single crystal of ocean salt is so complicated that no laboratory in the world can produce it from its basic 80 chemical elements. *(From "Why is the Ocean Salty" by Herbert Swenson, US Geological Survey)*

Where does the salt come from? The answer may surprise you.

How much salt is there relative to water? Yes, there is a lot of salt in the ocean, but there is ***a lot more*** water. In ocean waters of average salt content (35 *psu*), the weight of water is over 28.5 times greater than the weight of salt it contains. Oceanographers use the measure of *salinity* to describe the relative amount of salt to water.

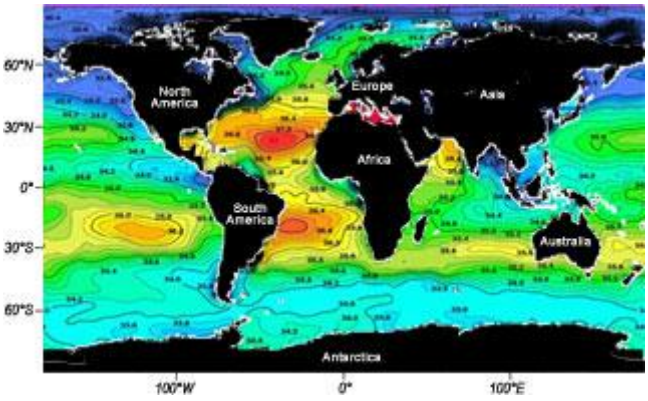
Is salinity uniform throughout the ocean? No. Although the amount of salt in the ocean is relatively constant on time scales of years to decades, sea surface salinity (SSS) varies because freshwater input & ouput – part of the global hydrologic or water cycle – varies from place-to-place. The large scale pattern of *evaporation* and *precipitation* is established by earth's atmospheric *convection* cells. In the simplest case – for example, if earth were covered by oceans and not spinning (shown at right) – the atmosphere would move heat between the hot tropics and cold poles in a very simple way. Hot air would rise along the equator, creating a band of low *atmospheric pressure*. Cold air would sink at the poles, creating regions of high atmospheric pressure.





The presence of continents and earth's rotation complicates the idealized "two cell" system. A fairly realistic model of earth's atmospheric circulation consists of six cells: three on each side of the equator (shown at left). This pattern has atmospheric pressure highs at the poles, 30°N and 30°S. It also has atmospheric lows along the equator, 60°N and 60°S. Away from the poles, cloudiness and precipitation (P) dominate bands of low pressure: these latitudes host the world's rainforests. Dryness and evaporation (E) dominate bands of high pressure: these latitudes are home to deserts.

In terms of SSS, lower salinity generally occurs where precipitation is greater than evaporation (P>E). Higher SSS generally occurs where evaporation is greater than precipitation (E>P). Compare this "six cell" model with the map of global average SSS (below). How well do SSS patterns mirror bands of high and low atmospheric pressure? In places where they do not match, what other types of freshwater inputs & outputs might be occurring?



To learn more about monthly SSS variations in our "saltiest" ocean, the North Atlantic, visit the "Salinity Data and Tools" section.

To learn more about how salinity influences ocean circulation – and earth's climate zones – visit the "Ocean Circulation & Climate" section.

Aquarius is NASA's first mission to measure ocean *salinity*. Our first installment of educational materials – "Salinity Patterns & the Water Cycle" – meet physical science content standards of the National Science Education Standards. Find out more about the importance of ocean salinity, we offer several classroom activities and supplemental ocean-atmosphere data investigation tools. And, learn more from Aquarius Project Scientist Dr. Yi Chao who explained the mission to students during an "Online Learning Community LiveRoom Chat".

Questions or comments? Contact Annette deCharon, Senior Science Educator and Aquarius EPO Manager.

Glossary

atmospheric pressure: Force per unit area (pressure) exerted on a surface area, created by the weight of air above it.

climate: The prevailing or normal pattern of weather at a place, or in a region, averaged over a long period of time; in contrast to weather, which is the state of the atmosphere at a particular time.

conductivity: A measure of the ability of a material to conduct or transmit an electric charge.

convection: Vertical air circulation in which warm air rises and cool air sinks, resulting in vertical transport and mixing of atmospheric properties; the flow of heat by this circulation.

evaporation: The physical process of converting a liquid to a gas. Commonly considered to occur at a temperature below the boiling point of the liquid.

practical salinity unit (psu): Used to describe the concentration of dissolved salts in water, the

UNESCO Practical Salinity Scale of 1978 (PSS78) defines salinity in terms of a conductivity ratio, so it is dimensionless. Salinity was formerly expressed in terms of parts per thousand (ppt) or by weight (parts per thousand or 0/00). That is, a salinity of 35 ppt meant 35 pounds of salt per 1,000 pounds of seawater. Open ocean salinity is generally in the range from 32 to 37.

precipitation: Water released from the atmosphere in the form of rain, snow, hail, or sleet onto Earth's surface.

salinity: A measure of the quantity of dissolved solids in ocean water. In general, salinity reflects the total amount of dissolved solids in ocean water in parts per thousand by weight after all carbonate has been converted to oxide, the bromide and iodide to chloride, and all the organic matter oxidized. Salinity is now measured as practical salinity units (psu).