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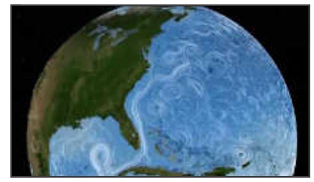
Why is it important to understand ocean salinity?
Why was the SPURS study site chosen?
Why should we worry about an "intensified" water cycle?
Why do we study salinity to better understand ocean circulation?
Why is it important to measure salinity with both in-situ and satellite instruments?

Why is it Important to Understand Ocean Salinity?


Click on the image for a closer view!

Ocean salinity plays key roles in the global hydrological cycle, ocean circulation and in regulating Earth's climate. Today's scientists know that Earth's water cycle is dominated by exchanges between the ocean and atmosphere, with sea surface salinity (SSS) varying because of freshwater input and output, via the processes of evaporation and precipitation.

Having a better understanding of the processes of evaporation and precipitation and how changes to these processes may influence the global hydrological cycle and ocean circulation will improve our abilities to monitor, understand and model the water cycle over the oceans. The ocean is an uncontaminated source for understanding these influences by measuring the changes in salinity and relating them to the changes we see in the water cycle.

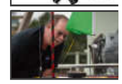
Featured Video: Why SPURS?

Why SPURS?
from **COSEE Ocean Systems** PLUS

05:40

Dr. Raymond Schmitt gives a brief summary of why the SPURS cruise is happening [view transcript]


Earth's Salinity Balance
Dr. Eric Lindstrom
[vimeo, 03:24]


The Importance of Salinity Balance
Dr. Eric Lindstrom
[vimeo, 02:24]


Salinity Balance is Like a Bank Account
Dr. Fred Bingham
[vimeo, 01:19]

view all videos in this album [vimeo]

SPURS Blog

An Oceanographer And The Water Cycle [NASA Earth Observatory]
If one wants to find out what the water cycle is doing, one should be looking at the oceans

Lessons/Tools

Aquarius Classroom Activities [NASA Aquarius]
"Hands on" laboratory activities for Grades K-12

The Water Cycle Activity [NASA Aquarius]
This activity focuses on two aspects of the water cycle: evaporation and condensation

Resources

Sea Surface Salinity and Ocean Circulation [CLIMB]
The effects of sea surface salinity on ocean circulation are illustrated in this interactive concept map from COSEE-Ocean Systems

Salinity Basics [NASA Aquarius]
How much salt is there? Where does it come from? Is salinity uniform throughout the ocean? Answers to these questions and more

Aquarius Student Outcomes [NASA Aquarius]
Twenty three student outcomes addressed by Aquarius EPO materials and aligned with National Science Education Standards

The Power of Sea Salt [YouTube]
A ScienceCast movie from Science at NASA

Ocean Circulation and Climate [NASA Aquarius]
Ocean salinity's influence on the environment can be summarized by looking at Earth's three major latitude zones: high latitudes, mid-latitudes, and the tropics

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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An Oceanographer And The Water Cycle

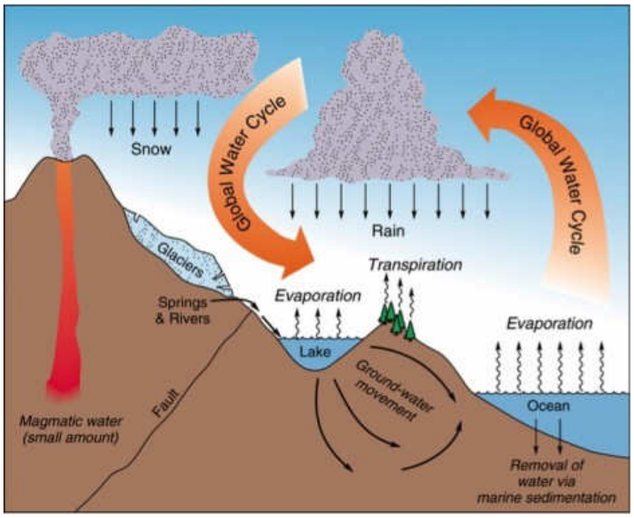
September 19th, 2012 by Maria-Jose Viñas

By Eric Lindstrom

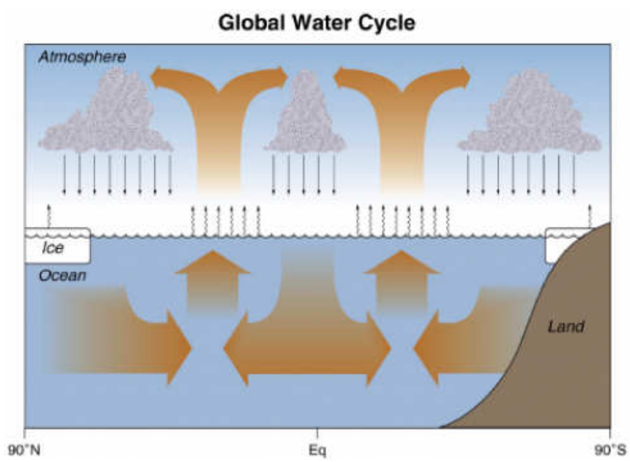
SPURS Chief Scientist Ray Schmitt.

SPURS Chief Scientist Ray Schmitt has been thinking about the salt in the ocean for a long time. He did his PhD thesis on an unusual form of mixing called "salt fingers," which we will discuss in a later post. This small scale mixing process led him to consider the origins of the ocean salinity contrasts that we see around the world.

It's fairly obvious that salty waters arise from high evaporation regions and fresher waters originate from high rainfall areas or river flows into the ocean. But it turns out that accurate estimates of evaporation and rainfall over the ocean were hard to come by. For a long time, it was a relatively neglected research topic. Many meteorologists were only concerned about how much it rained on land and few seemed to care if it rained on the ocean. Pulling together the best data he could, Ray found that, in fact, the ocean completely dominated the global water cycle. The terrestrial part, so important to us on a daily basis, is a much smaller piece. The oceans hold 97 percent of the Earths free water, the atmosphere only 0.001 percent. The oceans provide 86 percent of global evaporation and receive 78 percent of all rainfall. The total of all river flows into the ocean sums to less than 10 percent of global ocean evaporation. Clearly, if one wants to find out what the water cycle is doing, one should be looking at the oceans. The traditional fixation on the terrestrial water cycle is understandable, but risks missing the big picture. It seems that the tail is wagging the dog in terms of research on the global water cycle!



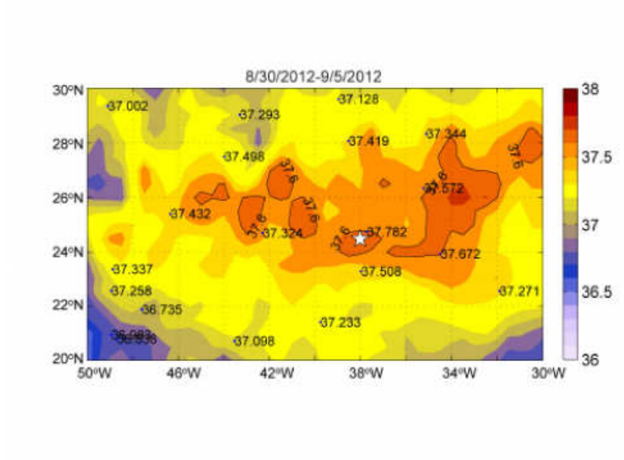
A traditional view of the water cycle.



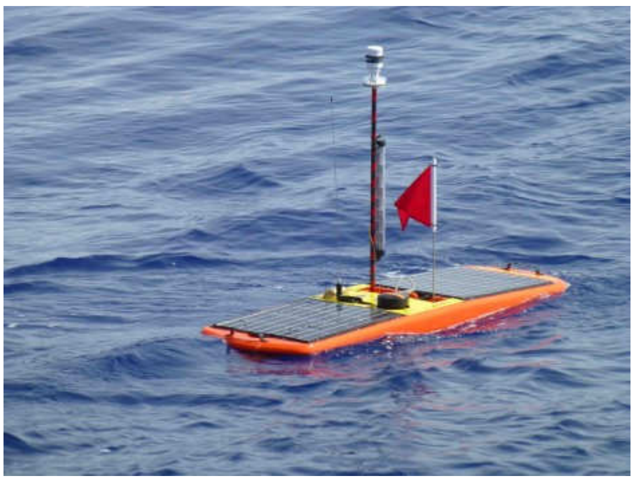
The oceanographers' view of the water cycle.

Of course, one of the most important questions for climate change is what the water cycle will do with continued warming. Basic physics tells us that a warmer atmosphere will hold more water vapor, so an intensified water cycle is expected. Oceanographers should be able to assess any trend in the water cycle if we do a good job in monitoring ocean salinity. On land, man has altered every watershed with dams, groundwater irrigation, deforestation and human consumption. But the ocean's mostly unaltered and its salinity field provides insight into the vast majority of the pristine natural water cycle. The ocean has its own rain gauge in the form of salinity, and our task in SPURS is to learn how to read it.

The combination of the global coverage from Aquarius for surface salinity, detailed process studies in the ocean like SPURS, and sophisticated high-resolution computer models working in concert open up the oceanic water cycle to careful scientific examination.



Aquarius salinity data from the first week of September 2012. (Credit: Oleg Melnichenko at University of Hawaii IPRC.)



A SPURS Waveglider begins its journey to study upper ocean salinity.

We are beginning to deploy the array of instruments on the ship and they are starting their year-long mission to examine the ocean salinity variations. Our challenge is to understand the detailed picture of salinity that will be painted by the various sensors and to make sense of this in the larger picture of the global water cycle.

Tags: Aquarius, Atlantic, NASA, ocean, salinity, SPURS

This entry was posted on Wednesday, September 19th, 2012 at 1:43 pm and is filed under Salinity Processes in the Upper Ocean Regional Study (SPURS). You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

3 Responses to “An Oceanographer And The Water Cycle”

christopher says:
September 19, 2012 at 7:20 pm

I did not know the ocean was salty do to a lack of rain.

Eric Lindstrom says:
September 20, 2012 at 6:25 am

Christopher,
Parts of the ocean may get saltier or fresher because of the dominance of evaporation or precipitation (respectively) in the local water balance. Oceanographers look at maps of the difference between Evaporation and

Precipitation (E-P) over the ocean around the globe. Those maps look very much like the maps of ocean surface salinity. It is saltier where E-P is positive and fresher where E-P is negative. For our purposes the overall the amount of salt in the global ocean stays constant – its the fresh water moving in and out of the ocean that changes surface salinity patterns (along with some other smaller but important factors like ocean currents and mixing). The salinity balance in the upper ocean in this region where E-P is negative is the focus of this SPURS expedition. In some future year we plan to focus studies on a place where E-P is positive (a quite rainy spot).
Eric

Eric Lindstrom says:
September 20, 2012 at 8:04 am

OOPS! Let me correct the last sentence! (I should drink my coffee before answering questions..)

It should say:

The salinity balance in the upper ocean in this region where E-P is POSITIVE is the focus of this SPURS expedition. In some future year we plan to focus studies on a place where E-P is NEGATIVE (a quite rainy spot).

Notes from the Field
« Plastic Ocean NOAA Contributions to SPURS »

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Search NASA Aquarius:

Submit Query

Education: Activities & Documents

Hands-On Activities (29)

Hands-On Activities | Online Activities | Articles & Documents

Answering Questions About the Effect of Salinity on Climate

A short list of salinity-related experiments that could be designed by students in higher grades. MORE

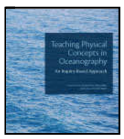
Aquarius/SAC-D Educación Cartel de la Pared (Pre-Lanzamiento)

Cartel de la pared con la información sobre el Aquarius/SAC-D Misión y actividades educativas relacionadas con la salinidad, el ciclo del agua, la circulación y el clima. MORE

Aquarius/SAC-D Pre-Launch Wall Poster (English)

Wall poster with information about the Aquarius/SAC-D Mission and educational activities related to salinity, the water cycle, circulation and climate. MORE

Booklet: Teaching Physical Concepts in Oceanography: An Inquiry Based Approach



This supplement to *Oceanography* magazine focuses on educational approaches to help engage students in learning and offers a collection of hands-on/minds-on activities for teaching physical concepts that are fundamental in oceanography. These key concepts include density, pressure, buoyancy, heat and temperature, and gravity waves. The authors focus on physical concepts for two reasons. First, students whose attraction to marine science stems from an interest in ocean organisms are typically unaware that physics is fundamental to understanding how the ocean, and all the organisms that inhabit it, function. Second, existing marine education and outreach programs tend to emphasize the biological aspects of marine sciences.

The ocean provides an exciting context for science education in general and physics in particular. Using the ocean as a platform to which specific physical concepts can be related helps to provide the environmental relevance that science students are often seeking. MORE

Can Seawater Freeze?

In this activity, students will investigate the idea that salt causes water to freeze at a lower temperature and that the oceans do not freeze (except in extreme polar areas) because of the salinity. MORE

Coastal Versus Inland Temperatures

In this activity, students will use the weather section of the newspaper (or Internet) to help discover why coastal regions have relatively moderate climates. MORE

Convection

Convection and advection are the major modes of heat transfer in the ocean and atmosphere. Convection occurs only in fluids and involves vertical motion of fluid, or flow, rather than interactions at the molecular level. It results from differences in densities - hence buoyancy - of fluids. The purpose of this activity is to review the basic concepts of thermal physics and highlight applications to ocean processes by focusing on the concept of convection. MORE

Convection Under Ice

In oceanography, density is used to characterize and follow water masses as a means to study ocean circulation. Plate tectonics and ocean basin formation, deep-water formation and thermohaline circulation, and carbon transport by particles sinking from surface waters to depth are a few examples of density-driven processes. This activity is designed to highlight links to oceanic processes. MORE

Density: Seawater Mixing & Sinking

Two of the most important characteristics of ocean water are its temperature and salinity. Together they help govern the density of seawater, which is a major factor controlling the ocean's vertical movements and layered circulation. After completing this activity, students should be able to explain the effect of density on ocean circulation. MORE

Effect of Stratification on Mixing

Density is fundamentally important to large-scale ocean circulation. An increase in the density of surface water, through a decrease in temperature (cooling) or an increase in salinity (ice formation and evaporation), results in gravitational instability (i.e., dense water overlying less-dense water) and sinking of surface waters to depth. This experiment looks at the energy required to mix two layers. MORE

Effects of Temperature & Salinity on Density & Stratification (Steps 1-4)

Stratification refers to the arrangement of water masses in layers according to their densities. This activity compares salt and fresh water, demonstrating that fluids arrange into layers according to their densities. MORE

Effects of Temperature & Salinity on Density & Stratification (Steps 5-7)

Stratification refers to the arrangement of water masses in layers according to their densities. This activity compares warm and cold water, demonstrating that fluids arrange into layers according to their densities. MORE

Electrolysis of Salt Water

In this activity, students will conduct an experiment to see that water can be split into its constituent ions through the process of electrolysis; prepare and experiment with a 10% salt solution to better understand the process of ion exchange; discuss and research the "softness" and "hardness" of water; and use the periodic table to identify elements and learn their characteristics. MORE

Evaporation Investigation

Evaporation is the process by which water changes from a liquid to a gas or vapor. Evaporation is the primary pathway that water moves from the liquid state back into the water cycle as atmospheric water vapor. In this activity, students will investigate the idea that water can "disappear" into the air and will be able to explain that evaporation can separate the water from the salt in salt water. MORE

Exploring Polar Oceanography: Ocean Currents and Climate Connections

Parts II and III of this lesson plan from Extra NewsHour focus on exploring global ocean currents, along with examining how regional currents affect coastal climates. MORE

Floating in a Salty Sea

Density is the mass per unit volume (mass/volume) of a substance. Salty waters are denser than fresh water at the same temperature. Both salt and temperature are important influences on density: density increases with increased salinity and decreases with increased temperature. In this activity we will investigate how the density of an object and of the water affects whether the object will float or sink. MORE

Gathering, Analyzing, and Interpreting Environmental Data About the Ocean's Effects on Climate

A short list of salinity-related experiments that could be designed by students in middle grades. MORE

Global Winds and Ocean Currents

Gyres play an important role in redistributing heat from the low to middle and high latitudes, thus influencing air temperature, weather, and climate. After completing this investigation, students should be able to (1) demonstrate the influence of wind on ocean currents, and (2) describe the typical gyre circulation of surface currents in two major ocean basins. MORE

Heat Flow and Latent Heat

A good grasp of the underlying principles of thermal physics is essential for understanding how the ocean functions and how it impacts climate. Thermal physics is one of the science subjects that students are familiar with and experience on a daily basis, but intertwined with the experiential knowledge they bring to class comes a mixed bag of misconceptions that must be identified and addressed. The purpose of this activity is to review the basic concepts of thermal physics and highlight applications to ocean processes by focusing on the concept of latent heat. MORE

Investigating the Earth's Climate System - Energy

Water is a key element of the Earth's energy balance. The Sun's energy drives the water cycle, and in turn, water is a major factor in governing the surface temperature of the Earth. This activity covers multiple objectives related to energy in the climate system (e.g., defining albedo, explaining latent heat, determining the importance of energy absorption at Earth's surface, etc.) MORE

Liquid Rainbow

When solutions of two different densities meet, the less dense solution will move on top of the more dense solution, resulting in a layering or stratification of solutions. Density is an important feature of seawater since many physical and biological processes are affected by it, such as moving heat around the globe (which influences climate and the feeding and reproduction of marine organisms). After completing this activity, students should be able to compare the basic properties of fresh and salt water (e.g., density, ability to dissolve salt, freezing point). MORE

Ocean Currents and Coastal Temperatures

Students will chart the temperatures of two cities at approximately the same latitude but on different sides of North America. They will develop a hypothesis that explains the temperature differences between the two cities and create an air temperature model to test their hypothesis. They will measure the air temperature near a "cold water" current and a "warm water" current. PDF (116 KB)

Ocean Currents and Sea Surface Temperature

In this activity, students will discover the link between ocean temperatures and currents as related to our concern for current climate change. MORE

Potato Float

Seawater contains many dissolved substances and these add mass to the water producing a greater mass per unit volume, or density, than that of pure water. The relationship between the density of a fluid, weight of an object, and buoyancy is critical in understanding the ocean, because density has a direct influence on the way seawater and objects in seawater behave. MORE

Properties of Fresh & Sea Water

In this activity students will investigate water's unique properties, including the differences between fresh water and seawater. MORE

Questions About Oceans or Saltwater

A short list of salinity-related experiments that could be designed by students in lower grades. MORE

The Nature of Salt

Chemically, table salt consists of two elements, sodium (Na) and chloride (Cl). Neither element occurs separately and free in nature, but are found bound together as the compound sodium chloride. Seawater contains an average of 2.6% (by weight) sodium chloride, or 78 million metric tons per cubic kilometer, an inexhaustible supply. After completing this activity, students will be able to explain the general relationship between an element's Periodic Table Group Number and its tendency to gain or lose electron(s); explain the difference between molecular compounds and ionic compounds; use a model to demonstrate sodium chloride's cubic form which results from its microscopic crystal lattice; and describe the nature of the electrostatic attraction of the oppositely charged ions that holds the structure of salt together. MORE

The Water Cycle - Now You See It, Now You Don't

Water can change states among liquid, vapor (gas), and ice (solid) at various stages of the water cycle. Temperature affects the change of water from one state to another. When water vapor gets cold it changes to a liquid. This is called condensation. When heat is applied to water, it changes from a liquid to a gas. This is called evaporation. This activity focuses specifically on two aspects of the water cycle: evaporation and condensation. MORE

The Aquarius/SA(Espaciales (CON. Aquarius mission available here. Cl

Thermal Expansion

In this hands-on activity from Teaching Physical Concepts in Oceanography: An Inquiry Based Approach, students will review the basic concepts of thermal physics and highlight applications to ocean processes by focusing on the concept of thermal expansion. MORE

Online Activities (21)

Hands-On Activities | Online Activities | Articles & Documents

Analyzing Monthly Environmental Data

This online activity challenges students to find the data set (e.g., air temperature, precipitation, evaporation) that most closely corresponds to ocean surface salinity patterns. MORE

Annual Mean Data

Create monthly maps of global salinity, temperature or density at the surface or at specific ocean depths using this interactive data tool by NASA JPL. MORE

Aquarius App

The Aquarius/SAC-D observatory is featured in this free App: "Satellite 3D" for iPhone and Android. ITUNES

Changes in Annual Mean Data

Create global maps of mean salinity, temperature, or density for any year from 1800 to 2005 at designated depths this this data tool from NASA JPL. MORE

Changes in Monthly Mean Data

Create interactive maps of average global salinity, temperature or density at the ocean surface using this interactive tool from NASA JPL. In-water profiles for up to six locations can be plotted for these variables. MORE

Concept Map: Heat Capacity

Learn about heat capacity in water (i.e. heat storage in water molecules) in this concept map, and how this enables life to be sustained on Earth. This map also depicts how heat travels through the ocean (slowly) versus through the atmosphere (quickly). COSEE-OS

Concept Map: Hydrologic Cycle

This concept map shows how the water cycle is connected to Earth processes such as precipitation and evaporation and how these processes can affect global climate. The map also highlights ties between the Aquarius satellite instrument, salinity, and climate. COSEE-OS

Concept Map: Phases of Water

This concept map explains the structure of a water molecule and how changes in the structure of a water molecule create different "states" or phases of water: solid, gas, and liquid. The map also highlights the difference between sea ice and icebergs and what that means in terms of sea level and the "freshness" of ocean water. COSEE-OS

Concept Map: Properties of Water

Learn about the differences between fresh and salty water in this concept map, and how those difference affect water's temperature and density. COSEE-OS

Global Climate Change

This "Vital Signs of the Planet" website features key indicators, evidence, causes, effects, scientific consensus, and NASA's role in monitoring climate change. NASA

Go With the Flow

In this online game, students manage the density of seawater to make a submarine sink or rise in an effort to reach a treasure chest full of gold. NASA

Mapping Our World With Aquarius/SAC-D

What kinds of science questions can we answer with ocean data collected from space? Watch this Spanish-language webinar as we go behind the scenes of this international mission and discover how Aquarius/SAC-D data can be used to map ocean and Earth processes - from the forest landscape of El Impenetrable and the habitat of an endangered dolphin species all the way to Antarctica! MORE

NASA Earth Observations: Sea Surface Salinity

In June 2014, Aquarius salinity imagery on the NASA Earth Observations (NEO) website was updated to use Version 3 processing, including implementation of the smoothed version for the monthly products. On NEO, you can browse and download imagery of satellite data from NASA's constellation of Earth Observing System satellites. NASA NEO

Ocean Motion: Ocean Surface Currents

This data visualizer on NASA's Ocean Motion website gives access to the following global ocean surface current behaviors between 1992 and 2011: current speed, current direction, current convergence, and current vorticity as well as the anomaly values for each. MORE

Ocean Motion: Ocean Surface Winds

This data visualizer on NASA's Ocean Motion website includes wind speeds and directions from 1999 to 2009. MORE

Ocean Thinking: Inside and Outside the Box

Learn about ocean salinity from an entirely different perspective! While Aquarius is measuring ocean salinty from above, a team of NASA researchers have been investigating the ins and outs of salinity - from the ocean's surface to depth - in one of the saltiest places of the ocean. NASA SPURS

Precipitation and the Water Cycle

How much do you know about how water is cycled around our planet and the crucial role it plays in our climate? Take this quiz from NASA's Earth Right Now Initiative and find out! NASA

Quiz: Aquarius Studies Our Salty Seas, Version 1

How much do you know about Aquarius? Find out here! NASA

Quiz: Aquarius Studies Our Salty Seas, Version 2

How much do you know about Aquarius? Take version 2 of our popular quiz and find out! NASA

Sea Salt Quiz

Test your knowledge of ocean salinity and its relation to climate change and ocean circulation in this online quiz from NASA's Global Climate Change website. NASA

Using NASA's Aquarius Sensor to Monitor Salinity Levels in the Amazon Delta

The NASA DEVELOP National Program fosters an interdisciplinary research environment where applied science research projects are conducted under the guidance of NASA and partner science advisors. DEVELOP is unique in that young professionals lead research projects that focus on utilizing NASA Earth observations to address community concerns and public policy issues. For this project, the Langley DEVELOP team created a method for testing how close to the coastline Aquarius observations can be made effective through an analysis of the Amazon River Delta's low salinity plume. NASA DEVELOP

Articles & Documents (7)

Hands-On Activities | Online Activities | Articles & Documents

Aquarius Launch Details

A summary of the launch vehicle and details of the deployment of the Aquarius/SAC-D satellite. PDF (821 KB)

Aquarius/SAC-D: Sea Surface Salinity From Space

The official mission brochure for the Aquarius/SAC-D Mission. PDF (4.6 MB)

Evolution of North Atlantic Water Masses Inferred from Labrador Sea Salinity Series

Researchers Igor Yashayev and Allyn Clarke discuss the evolution and interplay of water masses in the subpolar North Atlantic, an important region in terms of deep-ocean circulation MORE

If Rain Falls on the Ocean - Does It Make a Sound?

In this 1996 overview article, Dr. Raymond Schmitt (Woods Hole Oceanographic Institution) summarizes fresh water's effect on ocean phenomena. MORE

Salinity and the Global Water Cycle

Written three years before the launch of Aquarius in June 2011, this overview by Dr. Raymond Schmitt summarizes the impacts of climate change on the water cycle and ocean salinity. MORE

The Aquarius/SAC-D Mission: Designed to Meet the Salinity Remote-Sensing Challenge

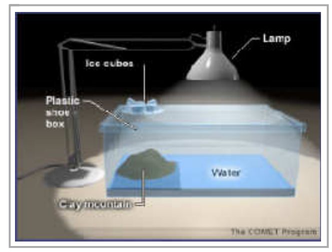
In this article, written many years before the launch of Aquarius, the authors report that a new satellite program will provide data to reveal how the ocean responds to the combined effects of evaporation, precipitation, ice melt, and river runoff on seasonal and interannual time scales. MORE

What's Next for Salinity?

The CLIVAR (Climate Variability and Predictability) Working Group, an international research effort focusing on the variability and predictability of the slowly varying components of the climate system, provides recommendations to improve our understanding, monitoring, modeling and predicting of climate. MORE

Education: Activities & Documents

The Water Cycle - Now You See It, Now You Don't



The water cycle has no starting point. But we'll begin in the oceans, since that is where most of the Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublimate directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures causes it to condese into clouds. Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration.

Evaporation drives the water cycle. Evaporation from the oceans is the primary mechanism supporting the surface-to-atmosphere portion of the water cycle. After all, the large surface area of the oceans (over 70% of the Earth's surface is covered by the oceans) provides the opportunity for such large-scale evporation to occur. On a global scale, the amount of water evaporating is about the same as the amount of water delivered to the Earth as precipitation. This does vary geographically, though. Evaporation is more prevalent over the oceans than precipitation, while over the land, precipitation routinely exceeds evaporation. Most of the water that evaporates from the oceans falls back into the oceans as precipitation. Only about 10% of the water evaporated from the oceans is transported over land and falls as precipitation. Once evaporated, a water molecule spends about 10 days in the air. The process of evaporation is so great that without precipitation, runoff, and discharge from aquifers, oceans would become nearly empty over time.

Condensation is the process by which water vapor in the air is changed into liquid water. Condensation is crucial to the water cycle because it is responsible for the formation of clouds. These clouds may produce precipitation, which is the primary route for water to return to the Earth's surface within the water cycle. Condensation is the opposite of evaporation. You don't have to look at something as far away as a cloud to notice condensation. Condensation is responsible for ground-level fog, for your glasses fogging up when you go from outside on a cold winter day and to inside a warm room, for the water that drips off the outside of your glass of iced tea, and for the water on the inside of the windows in your home on a cold day.

Big Idea. Water can change states among liquid, vapor (gas), and ice (solid) at various stages of the water cycle. Temperature affects the change of water from one state to another. When water vapor gets cold it changes to a liquid. This is called condensation. When heat is applied to water, it changes from a liquid to a gas. This is called evaporation. This activity will focus specifically on two aspects of the water cycle: evaporation and condensation.

Grade Level. Elementary.

Time. 30 minutes; Group Activity - 45 minutes; Wrap Up - 20 minutes.

Content Standard. NSES Physical Science, properties of objects and materials.

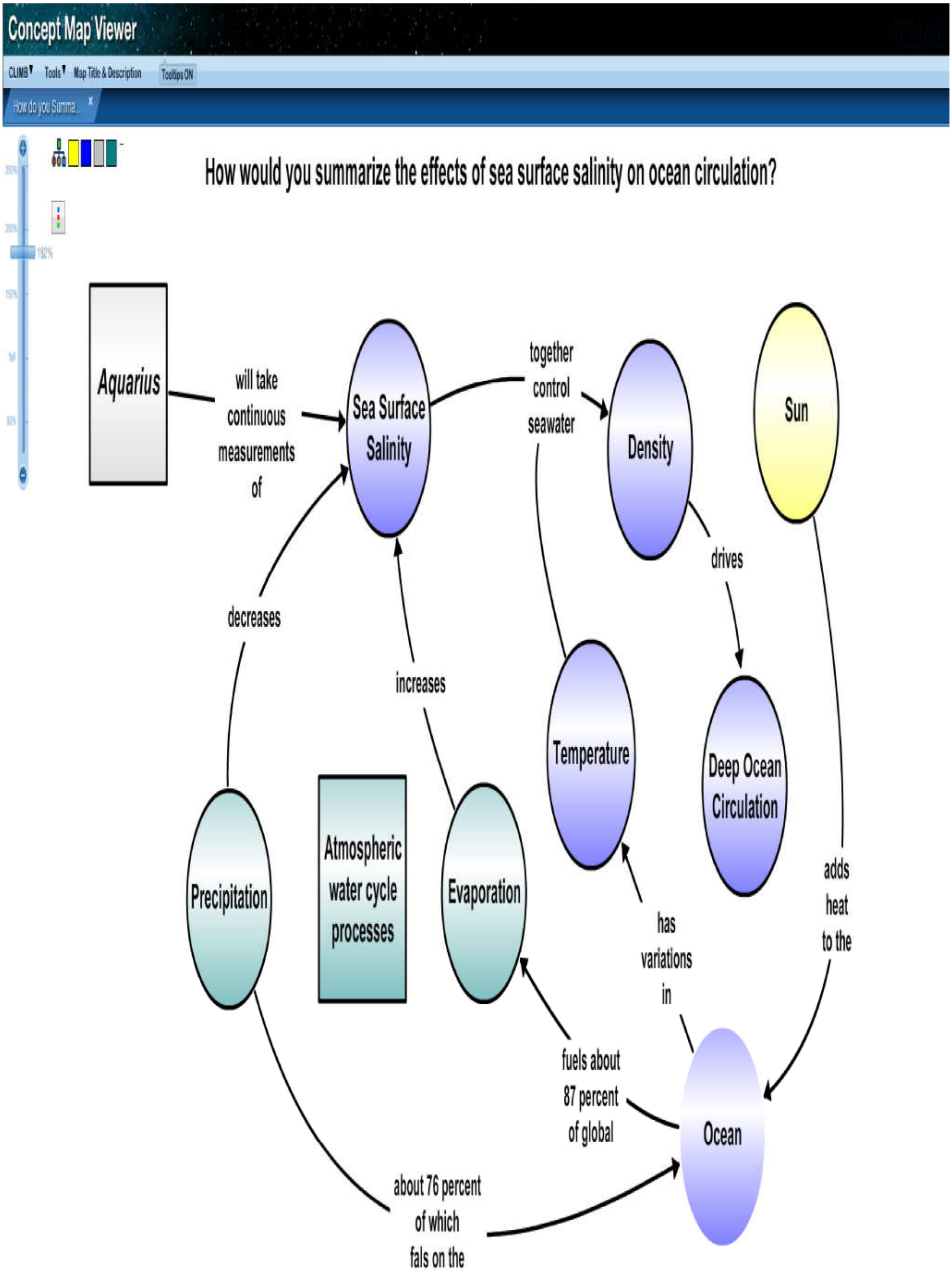
Ocean Literacy Principle. (1e) The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs via evaporation and precipitation.

Materials

Artists clay or plastic mountain model; plastic (transparent) shoebox with cover or a small glass aquarium and plastic wrap for a cover; Petri dish; lamp; water; ice; data sheet.

water_cycle.pdf (1.4 MB)

Back


Concept Map Viewer
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How do you Summa...
How would you summarize the effects of sea surface salinity on ocean circulation?
Aquarius
will take continuous measurements of
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together control seawater
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decreases
increases
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Precipitation
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has variations in
fuels about 87 percent of global
Ocean
about 76 percent of which fals on the

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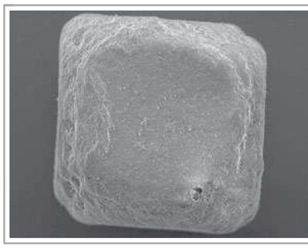
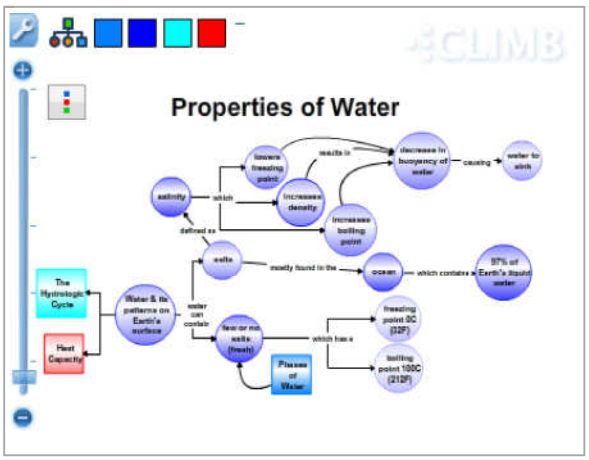
Education: The Role of Salt

What Role Does Salt Play in the Basic Properties of Water?

A defining characteristic of ocean water is its relatively high concentration of dissolved salts or salinity. These concept maps, activities and videos focus on relationships between salt and water, including water properties, phases, heat capacity and the hydrologic cycle. These resources will help to organize information into meaningful patterns that students can use for future problem solving. The interlinked concept maps are provided to illustrate that salinity-related processes do not exist in isolation: each depends on its relationships to others for broader meaning (i.e., square concepts provide direct links to other maps in the series).



Featured Concept Map: Properties of Water

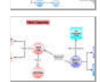


STUDENT OUTCOMES
(Learn More)

Compare the basic properties of fresh and salt water (e.g., density, ability to dissolve salt, freezing point) (NSES,134,160; OLS,10)

Explain that evaporation can separate the water from the salt in salt water (NSES,127; NAAEE,16; OLS,13)

Concept Map: Phases of Water Understand various forms that water can take



Concept Map: Heat Capacity Learn how heat affects water

Concept Map: Hydrologic Cycle Make connections with the water cycle

Hands-On Activities

Can Seawater Freeze?
Electrolysis of Salt Water
Evaporation Investigation
Floating in a Salty Sea
Liquid Rainbow
Potato Float
Properties of Fresh & Sea Water
Questions About Oceans or Saltwater
The Nature of Salt

Movies

Geographic Variation in Salinity
Water, Water Everywhere: Sun Fuels Evaporation

Podcasts

Impact of Climate Change on Ocean Chemistry Has Far Reaching Effects

FAQs

In the global water cycle, is "salty" good?

I understand that (Aquarius) is able to collect data that, for over a hundred years, has been collected by buoys, ships, etc. I'm assuming this instrument will collect data in a more accurate and thorough way and in areas that (we) haven't been able to do before. Are the data going to be useful in comparing what the salinity levels have been in the past? Or is it from just this point on that we'll be able to measure salinity since the older methods might not be as accurate?

Why does freshwater give off more energy than saltwater?

Why do you think that the Atlantic Ocean has a higher salinity content than the Pacific Ocean?

Education: Student Outcomes

The tables posted below show the 23 student outcomes addressed by Aquarius Education and Outreach materials and aligned with National Science Education Standards, North American Association for Environmental Education guidelines, and Ocean Literacy standards. The outcomes are grouped into four major themes that relate to Aquarius science: Water Cycle, Ocean Circulation, Climate, and 21st Century Technology.

Water Cycle

Earth's water cycle is dominated by ocean-atmosphere exchanges: globally, 86% of evaporation and 78% of precipitation occur over the ocean. Ocean surface salinity is a key tracer for understanding the freshwater fluxes into and out of the ocean system. This is because some parts of the water cycle decrease salinity (e.g., precipitation, groundwater flow to the ocean, river runoff) and some parts increase it (e.g., evaporation and freezing of seawater). With Aquarius data, scientists are able to relate ocean surface salinity variations to evaporation and precipitation, providing insight into how the ocean responds to seasonal and annual variability in the water cycle.

Student Outcome	Level	Relevant Sources
Explain that evaporation can separate the water from the salt in salt water	Basic	NSES,127; NAAEE,16; OLS,13
Compare the basic properties of fresh and salt water (e.g., density, ability to dissolve salt, freezing point)	Basic	NSES,134,160; OLS,10
Explain the energy conversions found in the water cycle (e.g., evaporation requires heat energy, condensation releases heat energy)	Intermediate	NSES,161; NAAEE,35; OLS,11
Explain how the processes of the water cycle (e.g., evaporation, precipitation) relate to the oceans	Intermediate	NSES,160; OLS,5
Explain the effect of temperature on density	Intermediate	NSES,180; OLS,12
Explain the relationship between fresh water and ocean dynamics	Advanced	
Determine if global precipitation, evaporation, and the cycling of water are changing	Advanced	

Ocean Circulation

Salinity plays a major role in how ocean waters circulate around the globe. Salinity changes can create ocean circulation changes that, in turn, may impact regional and global climates. The extent to which salinity impacts our global ocean circulation is still relatively unknown, but NASA's new Aquarius mission will help advance that understanding by painting a global picture of our planet's salty waters.

Student Outcome	Level	Relevant Sources
Describe the connections between the salt water found in the ocean and the fresh water in the water cycle	Basic	NSES,160; NAAEE,12,16; OLS,10
Explain the effect of density on ocean circulation	Intermediate	NSES,154; OLS,10
Explain the effect of solar energy heat on ocean circulation	Intermediate	NSES,155,161; NAAEE,35; OLS,11
Explain the influence of the El Niño Southern Oscillation on global weather patterns	Advanced	NAAEE,54; OLS,11
Explain the influence of ocean salinity on the thermohaline circulation (e.g., "global conveyor belt")	Advanced	

Climate

Oceanographers believe that maintaining density-controlled ocean circulation is key to keeping ocean heat transport - and Earth's climate - in balance. Increases in ocean surface salinity in high latitudes can increase seawater density and speed up the deep overturning circulation in the ocean. Conversely, decreases in ocean surface salinity (e.g., by melting ice) may result in widespread decreases in seawater density, reducing its ability to sink. In a very simple model, decreasing ocean surface salinity in the North Atlantic would reduce the efficiency of the ocean "global conveyer belt" which helps to regulate global climate by moving heat from the tropics to higher latitudes.

Student Outcome	Level	Relevant Sources
Compare climates considering factors such as precipitation, temperature, and distance from an ocean	Basic	NAAEE,16; OLS,13

Explain the effect of solar energy on wind and cloud formation and the effect solar energy, wind and clouds have on climate	Intermediate	NSES,160,189; NAAEE,30; OLS,11
Explain that the ocean holds a large amount of heat and the effect this has on climate	Intermediate	NSES,160,189; NAAEE,30; OLS,11
Describe how changes in the ocean's circulation can produce large changes in climate	Advanced	NSES,189; NAAEE,54; OLS,12
Explain how climate variations can induce changes in the global ocean circulation	Advanced	

21st Century Technology

We know climate change can affect us, but does climate change alter something as vast, deep and mysterious as our oceans? For years, scientists have studied the world's oceans by sending out ships and divers, deploying data-gathering buoys, and by taking aerial measurements from planes. But one of the better ways to understand oceans is to gain an even broader perspective - the view from space. NASA's Earth observing satellites do more than just take pictures of our planet. High-tech sensors gather data, including ocean surface temperature, surface winds, sea level, circulation, and even marine life. With the launch of Aquarius, NASA is collecting its first-ever ocean surface salinity data. Information the satellites obtain help us understand the complex interactions driving the world's oceans today - and gain valuable insight into how the impacts of climate change on oceans might affect us on dry land.

Student Outcome	Level	Relevant Sources
Explain that satellites can be used to make measurements at a distance	Basic	NSES,123,138; NAAEE,14
Design a simple experiment to answer a question they have about the ocean or saltwater	Basic	NSES,122; NAAEE,13
Gather, analyze, and interpret environmental data about the ocean's effects on climate	Intermediate	NSES,145; NAAEE,29,32
Explain how new technology can enhance the gathering and manipulation of oceanic data	Advanced	NSES,176; NAAEE,51,52; OLS,14
Conduct a complex experiment to answer a question they have about the effect of ocean salinity on climate	Advanced	NSES,175; NAAEE,49
Explain that ocean science is interdisciplinary and requires new ways of thinking	Advanced	NSES,192; OLS,14

Abbreviations

NSES: National Science Education Standards
NAAEE: North American Association for Environmental Education
OLS: Ocean Literacy Standards

Citations

NAAEE (2000). Excellence in Environmental Education: Guidelines for Learning (K-12). 2nd edition. Rock Spring, GA: North American Association for Environmental Education

National Geographic Society, NOAA, and College of Exploration (2005). Ocean Literacy: The Essential Principles of Ocean Sciences Grades K-12. 2 pp.

National Research Council (1996). National Science Education Standards. Washington, DC: National Academy Press. 272 pp.

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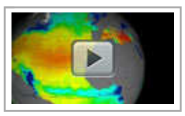
Science

Although everyone knows that seawater is salty, few know that even small variations in ocean surface salinity (i.e., concentration of dissolved salts) can reveal important information about changes in Earth’s water cycle, ocean circulation and climate. Throughout Earth's history, the weathering of rocks has delivered minerals, including salt, into the ocean. Over decades to centuries, the amount of salt in ocean basins is relatively constant. On the other hand, processes that move water into, out of, and around the ocean are in constant motion. As a result, monitoring salinity allows scientists to better understand these processes and how they are changing. The impact of such changes could include altering ocean circulation patterns which move heat around the globe, drive Earth's climate, and affect our daily lives.

The Water Cycle



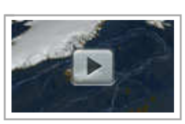
Some water cycle processes, including evaporation of ocean water and formation of sea ice, increase the ocean’s salinity. These salinity-raising factors, however, are offset by processes that decrease salinity: input of fresh water from rivers, precipitation of rain and snow, and melting of ice. On land, water cycle processes are tied to vegetation patterns: deserts occur in regions where evaporation is high and rain forests occur in areas of high precipitation. Similarly, over the ocean, the regional differences between evaporation and precipitation are correlated with patterns of sea surface salinity. This can be seen by comparing historical maps of ocean surface salinity with data showing the imbalance between evaporation and precipitation. In general, ocean regions dominated by evaporation have higher salinities and areas with high precipitation have lower salinities.

Several recent studies have suggested that seawater is becoming fresher in high latitudes and tropical areas dominated by rain, while in sub-tropical high evaporation regions, waters are getting saltier. Every seven days, Aquarius provides a new global map of salinity, delivering steady and reliable information about the vast ocean where about 86% of global evaporation and 78% of global precipitation occur. Aquarius's continuous coverage is allowing scientists to monitor variations in the water cycle and determine if it is indeed accelerating in response to climate change.

Density-Driven Circulation

Surface winds drive currents in the upper ocean. Deep below the surface, however, ocean circulation is primarily driven by changes in seawater density, which is determined by salinity and temperature. In some regions—such as the North Atlantic near Greenland—cooled high-salinity surface waters can become dense enough to sink to great depths. Perturbations to this process, for example from melting of polar ice and associated decrease in seawater salinity, could have significant impacts on Earth's climate. This is because the ocean holds and transports a tremendous amount of thermal energy: the heat stored in the top 3 meters (10 feet) of the ocean is equivalent to the amount held by the entire atmosphere, with an average thickness of about 100 kilometers (62 miles).

Climate Change Implications



The weekly global coverage of Aquarius is crucial because the geographic coverage from in-water observing systems (e.g., ships, buoys) is not extensive enough to fully understand how changes in global salinity affect climate, and vice versa. Excess heat associated with the increase in global temperature during the last century is being absorbed and moved by the ocean. Surface ocean and atmospheric temperature changes may cause evaporation to intensify and, as a result, significantly alter sea surface salinity and ocean circulation patterns. Ocean change may seem

Who Else is Measuring Salinity?

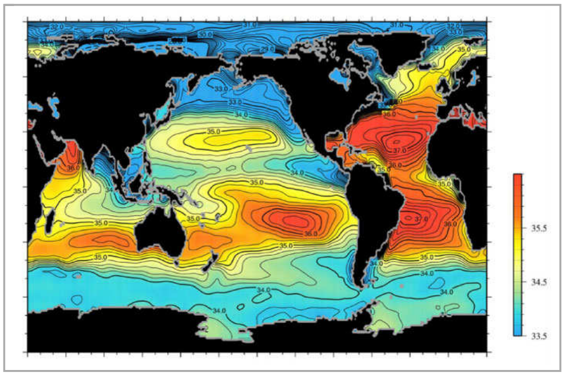
Located at the same latitudes as the great deserts of Africa, the central North Atlantic is home to the saltiest waters in the open ocean. Recent evidence shows that salinity in this area has been increasing in recent decades. The Salinity Processes in the Upper Ocean Regional Study (SPURS) includes a series of expeditions to this "salt maximum" region, funded by NASA and international collaborators. SPURS has employed a variety of tools - floats, gliders, drifters, moorings, ships, satellites, and computer models - to help scientists understand the processes that are controlling upper-ocean salinity. Science objectives include determining what processes maintain the salinity maximum and influence salinity variations over time, finding where the excess salt goes, and examining the effects of salinity change on ocean circulation.

Aquarius + Argo

Like other ocean-observing satellite instruments, Aquarius detects surface seawater properties to depths of about 1 cm (~0.4 in). Given the dynamic nature of Earth's seas, it is important to link Aquarius's "skin" measurements with other observations of the upper ocean. A key advance in this effort is a special series of Argo profiling floats developed at the University of Washington, which are designed to acquire salinity and temperature in the upper 10 cm (~4 in) of the ocean. These enhanced floats help to "close the gap" between Aquarius and conventional Argo floats whose shallowest data are acquired at a depth of 3-5 m (~10-16 ft). Currently, only about 1% of more than 3,000 Argo floats in Earth's ocean have this enhanced capability. However, SPURS has demonstrated the promise of using Aquarius and Argo together to improve our knowledge of how freshwater cycles between the atmosphere and the ocean.

SMOS

A key goal of the oceanographic community is to combine Aquarius measurements with European Space Agency's counterpart, the Soil Moisture like a "faraway" problem but, as the major driver of our planet's climate, it has the potential to impact humans everywhere.



Based on historical observations from in-water instruments collected before the launch of Aquarius, this global map of ocean surface salinity shows areas of high salinity in red (equivalent to 36 parts per thousand or higher) and areas of low salinity in blue (equivalent to 34 parts per thousand or lower). Source: World Ocean Atlas, 2009

and Ocean Salinity (SMOS) satellite to produce an even more accurate picture of ocean salinity. Launched in November 2009, SMOS satellite collects ocean salinity data at the same frequency as Aquarius, but uses a different technology: an interferometric technique in which the signal from many small antennas is used to achieve the resolution of a large antenna. Despite the difference in technology, SMOS data are very complementary to Aquarius data. In fact, early indications are that inter-comparison of results from these two satellites are crucial to better understanding the biases between ascending passes and descending passes seen in both missions, the cause of which may be geophysical in nature. Scientists representing both the Aquarius and SMOS Missions have concluded that providing observational-based measurements that are harmonized between Aquarius, SMOS, and in situ instruments will be the most help to the scientific community.

Why is it important to understand ocean salinity?

Why was the SPURS study site chosen?

Why should we worry about an "intensified" water cycle?

Why do we study salinity to better understand ocean circulation?

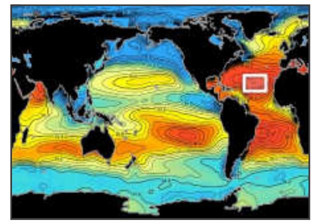
Why is it important to measure salinity with both in-situ and satellite instruments?

Why was the SPURS Study Site Chosen?

Even though water is evaporating from all over the ocean, this is a place where it is particularly strong. It's sort of the "headwaters" of the whole water cycle in the atmosphere. It's the place where the saltiest open ocean salinities are found, indeed they are much higher than previously anticipated.

Focusing on such a place will lead to understanding how the processes happening here apply more generally to these same processes happening around the global ocean.

- Raymond Schmitt, SPURS Chief Scientist



Click on the image for a closer view!

Featured Video: The North Atlantic's Ocean Desert

The North Atlantic's Ocean Desert

from **COSEE Ocean Systems** PLUS

01:35

Dr. Eric Lindstrom explains why the salinity maximum in the North Atlantic is referred to as an "ocean desert" [view transcript]

Optimizing Research Methods
Dr. Eric Lindstrom
[vimeo, 01:21]

Water Cycle Signals
Dr. Lisan Yu
[vimeo, 01:28]

SPURS Come In Pairs: The Next Phase
Dr. Eric Lindstrom
[vimeo, 01:33]

view all videos in this album [vimeo]

SPURS Blog

Ocean Salinity Viewed from Sea and Space [NASA Earth Observatory]

NASA Program Scientist Eric Lindstrom describes why scientists want to spend six weeks at sea measuring ocean saltiness

Lessons/Tools

Aquarius Interactive Tools [NASA Aquarius]

Spatial patterns of long-term mean data, annual cycle of monthly mean data, and change over time of yearly mean data

Salinity Data and Tools [NASA Aquarius]

Find the data set that most closely corresponds to sea surface salinity patterns

Resources

Geographic Variation in Salinity [NASA Aquarius]

Dr. Susan Lozier, Duke University, describes an ocean desert

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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Phone: (207) 563-8176 | Email

Ocean Salinity Viewed from Sea and Space

August 15th, 2012 by Maria-Jose Viñas

By Eric Lindstrom

On September 6, a bunch of NASA-funded scientists, and me among them, will depart on an expedition across the North Atlantic Ocean to study salt concentration levels of seawater. But why do we want to spend six weeks at sea measuring ocean saltiness? Hopefully, over the coming months you will come to understand the motivation and get caught up in the action through this blog.

My name's Eric Lindstrom and I am a program scientist for NASA's Physical Oceanography program. My normal work involves developing and managing NASA's Physical Oceanography research program. I gave up my career as a seagoing oceanographer to become a manager in our offices in Washington, D.C. However, marrying satellite observations with sea-going oceanography has been a long-term goal of NASA and that's why I am about to go back to sea, to participate in a research project that merges both fields.

Eric Lindstrom, NASA's Physical Oceanography program scientist and SPURS blogger.

In September I'll embark on the Research Vessel Knorr, leaving from Woods Hole Oceanographic Institution in Massachusetts toward Punta Delgada, Azores (Portugal), where we plan to arrive on October 9. This cruise is part of a multi-year research project called Salinity Processes in the Upper Ocean Regional Study (SPURS for short) and, in the U.S., it's a collaboration of NASA's Earth Science Division and partners funded by the National Science Foundation Division of Ocean Sciences and the National Oceanic and Atmospheric Administration.

Notes from the Field

Browse by Expedition

Operation IceBridge: Antarctic 2014
Hurricane and Severe Storm Sentinel (HS3) 2014
NASA in Alaska 2014
Ship-Aircraft Bio-Optical Research (SABOR)
LARGE (The Langley Aerosol Research Group Experiment) 2014
South Pacific Bio-optics Cruise 2014
GPM in Japan, the Road to Launch
Operation IceBridge: Antarctic 2013
Greenland Surface Melt Study 2013
Iowa Flood Studies
Greenland Aquifer Expedition
Landsat 8 Launch 2013
Salinity Processes in the Upper Ocean Regional Study (SPURS)
Siberia 2012 – Embenchime River Expedition
Soil Moisture Active Passive (SMAP)
Pine Island Glacier 2011
SEAT: Satellite Era Accumulation Traverse
Eco3D: Exploring the Third Dimension of Forest Carbon
Real-time Observations of Greenland's Under-ice Environment (ROGUE)
Operation IceBridge: Arctic 2011
MABEL: Spring 2011
The Western Siberia Expedition 2010
Urban Aerosols: Who CARES?
Global Hawk Pacific (GLOPAC)
The Uphill Road to Measuring Snow
North Woods, Maine 2009
Journey to Galapagos
Expedition to Siberia 2007
Siberia 2008 Kotuykan River Expedition

Browse by Date

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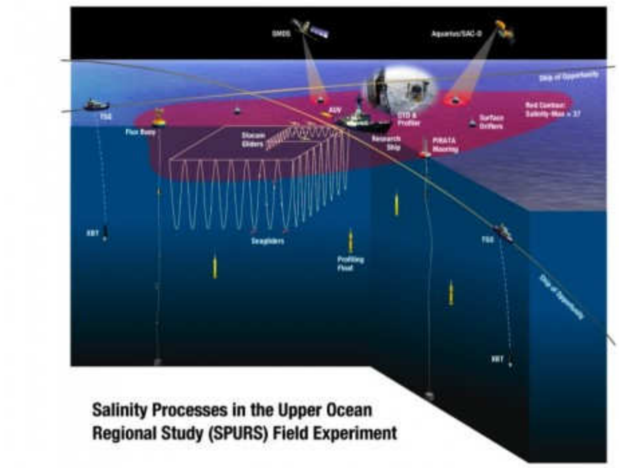
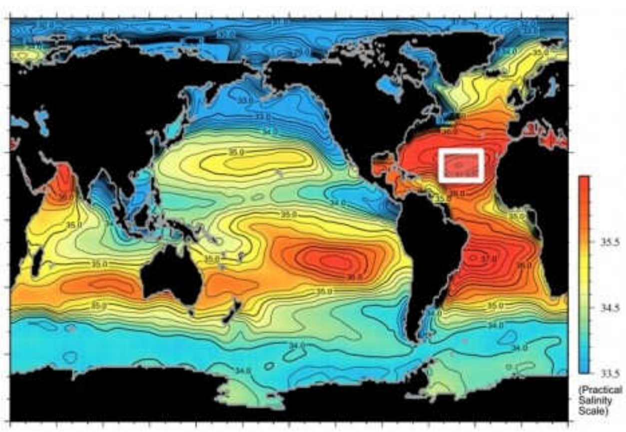


An illustration depicting the instruments SPURS will deploy in the saltiest spot of the Atlantic Ocean.

I plan, over the coming weeks, to introduce the science, the scientists and technicians headed to sea, their individual contributions to the field campaign, and the amazing technology that makes it all possible. But first you need to know some background and what to expect in future posts.

Oceanographers are keenly interested in the smallest variations of the salinity of seawater. How salty the water is from one place to another is one of several key factors in determining the density of seawater – and it's density variations and wind what drives ocean circulation. Density is determined by the water's temperature, salinity, and depth in the ocean. We'll discuss the processes that change temperature and salinity in later posts (as they are at the core of the SPURS field work). In general, the effects of the sun and the atmosphere on the surface of the ocean lead to variations in the temperature and salinity that drive the ocean circulation, which in turn provides energy back to the atmosphere in the form of water vapor, impacting weather (i.e., changes in rainfall frequency and distribution) and climate. I intend to delve into many of the details of this interaction with my posts from R/V Knorr.



A global map of the salinity, or saltiness, of Earth's ocean surface, showing the spot in the North Atlantic Ocean where the SPURS research cruise is headed to.

In June 2011, NASA launched a new Earth-observing instrument to measure the surface salinity of the ocean from space. The instrument, called Aquarius, is flying on the Argentine satellite SAC-D and delivers a global map of ocean surface salinity on a weekly basis. This data give unprecedented insight into the variations of the surface salinity of the ocean. While, sea surface temperature has been regularly measured from space for over 30 years, salinity has been a much more difficult measurement to make from space. The question of how do we measure

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Comments (RSS)

salinity from space is a great subject for later in this blog – I plan on writing about it when we have a quiet day at sea!

A primary objective of SPURS is careful examination of the processes that change salinity in the upper ocean – so we can better interpret the variations in salinity seen globally from space. This year's focus is on a high-salinity region – as is characteristic of the mid-latitude open oceans around the globe. These are relative "ocean deserts," where there is much more evaporation than precipitation leading to saltier surface waters. In the future (circa ~2015), a second SPURS campaign hopes to examine processes in one of the "wet" sectors of the ocean, where rain far exceeds evaporation, freshening surface waters. Other processes affect salinity including advection (water circulation) and vertical mixing. I will discuss these in some detail during the cruise, because they are the subject of specialized measurements and have a big impact on our interpretation of salinity variations.

The study of salinity variations in the ocean from all the accumulated ship-board measurements of surface salinity over the last 50 years has revealed interesting trends. It turns out that the high salinity regions of the subtropics have been tending saltier and the low salinity regions of the rain belts have been tending fresher. This can be interpreted a "fingerprint" of an accelerating water cycle – something we expect in a warmer world where the atmosphere holds more water vapor. Models show that this state, roughly speaking, leads to drier dry places and wetter wet places – just what the salinity of the ocean seems to suggest. Unless there is an alternative explanation: that's where oceanography comes in – the conclusion about the water cycle is only true if purely oceanographic explanations for the trends in surface salinity are ruled out. In other words, is there some other combination of oceanographic processes that could explain why salty places appear to be getting saltier and fresher places fresher? SPURS is ultimately about answering such questions, so we can use global salinity data and ongoing monitoring of salinity as a powerful tool in diagnosing global environmental changes.

And that's all for today. In my next post, I'll explain more about the scientists involved in SPURS and more about the posts you will receive from sea during September and October.

Tags: Aquarius, Atlantic Ocean, salinity, SPURS, water cycle

> This entry was posted on Wednesday, August 15th, 2012 at 11:00 am and is filed under Salinity Processes in the Upper Ocean Regional Study (SPURS). You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

10 Responses to "Ocean Salinity Viewed from Sea and Space"

S.Markanday says:
August 22, 2012 at 7:08 am

Wow !! that is an interesting project – interesting enough for some one practicing applied Oceanography for almost three(3) decades to return to Physical Oceanography.
Is there any plan to extend this study to other Oceans ??
If so What is the scope ??
Please inform where progress on this will be reported .
Thanks .

> **Eric Lindstrom** says:
> September 7, 2012 at 9:22 am
>
> Thanks for your interest! We are now at sea headed toward our primary study location (25N, 38W). Dodging Hurricane Leslie to get there!
>
> SPURS results will be more widely applicable to the high salinity regions which exist in other subtropical oceans (S.Atlantic, N&S Pacific, and Indian Oceans). In the future we would also like to examine in detail a low-salinity, high precipitation

region (the other extreme) to bracket the range of conditions occurring over the ocean. Better accounting of salinity processes in global models will improve understanding the water cycle on the planet (for which the ocean is the central player).

A says:
August 31, 2012 at 11:26 am

Interestin to determine how far below salinity stage is fresh water found to be transfered to the surface to be used on land.

edwin says:
September 5, 2012 at 5:39 am

water vapor
ocean surface salinity
leads to drier dry places and wetter wet places
"ocean deserts,"
they are the subject of specialized measurements and have a big impact on our interpretation of salinity variations.
if you mix all of this
what do you get ???
something is boiling that water in that place where salinity and vapor is taking effect
but since its making a global impact dont you think its coming from under water
i think i believe it might be a volcano (that still hasnt been discovered
i mean thats what it looks like to me
just an opinion

> **Eric Lindstrom** says:
> September 8, 2012 at 9:14 am
>
> Edwin,
> Thanks for your interest in SPURS. The cause of the high salinity area is primarily evaporation (dry air coming off the Sahara picks up moisture in this area of the Atlantic). There is no need to invoke undersea volcanos in this instance and no evidence that they are a factor. We are working over the mid-atlantic ridge and it has volcanism is some localized vents. Signatures of such features have been seen and are largely confined to the deep ocean. If we do discover a volcano out there, I'll be email you right away!
> Regards
> Eric (on R/V Knorr @ http://www.knorr.whoi.edu/n_index.shtml)

edwin says:
September 5, 2012 at 5:48 am

im starting to believe that
that might been the caused of the tsunami in japan

Naomi Harper says:
September 6, 2012 at 2:10 am

The press conference today at Woods Hole Oceanographic Institution and subsequent tour of the Knorr made the purpose of the upcoming expedition clear and understandable. The students at Will Rogers Middle School in Fair Oaks, California will be following your blog with anticipation and excitement. Your blog will bring the ocean right into our classroom.

> **Eric Lindstrom** says:
> September 7, 2012 at 9:30 am
>
> Dear Naomi,
> it was great to meet you in Woods Hole and thanks for seeing us off at the wharf on Thursday morning. I am looking forward to interaction with your class. Its probably easiest to respond to questions via this blog. Also, if you have ideas for content (writing and photos) that would interest you, I can try to work your ideas into daily postings.
> Kindest regards,
> Eric

PJ Friello says:
September 6, 2012 at 8:38 pm

This is a great opportunity to teach numerous facets of Earth-Space Science in my class. Are the salinity profiles to depth at the mooring site available? I am also having difficulty downloading the student and teacher resources, but hoping this will be soon resolved.
thank you

Eric Lindstrom says:
September 7, 2012 at 9:36 am

We are now enroute to the SPURS study area and the mooring will be deployed in about one week. From that point we begin to obtain many salinity profiles with a host of different instruments we plan to deploy over the ensuing weeks. Hope you have solved any issues with downloading educational materials.
Regards
Eric Lindstrom

Notes from the Field
« Siberia 2012: Final Thoughts What will happen aboard the R/V Knorr? »

Education: Analyzing Monthly Environmental Data

Analyzing monthly environmental data from the North Atlantic Ocean will help you to learn more about how the water cycle affects sea surface salinity. Your challenge is to find the data set that most closely corresponds to sea surface salinity patterns. A Data Analysis Sheet will help you keep track of your findings and respond to the Key Question for each data set.

Other Data Sets

- Air Temperature (AT)
- Sea Surface Temperature (ST)
- Evaporation (EV)
- Precipitation (PT)

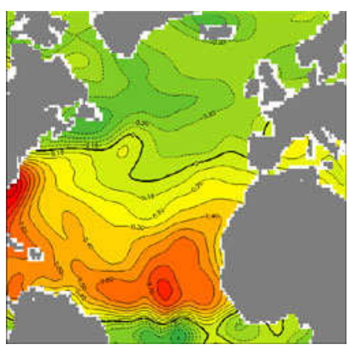
Be sure to view all five pairs of data maps before completing your investigation. GOOD LUCK!

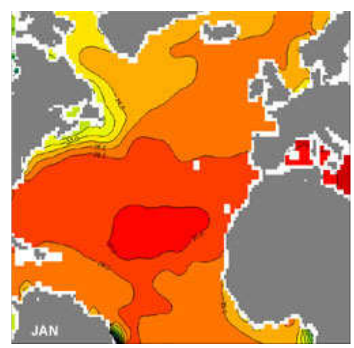
Activity: Evaporation minus Precipitation vs. Sea Surface Salinity

Click the green button for monthly images!

Monthly images in PDF format: Evaporation Minus Precipitation (2.1 MB) | Salinity (1.4 MB)

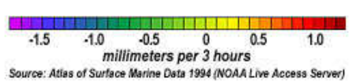
EVAPORATION MINUS PRECIPITATION versus **SALINITY**





EVAPORATION MINUS PRECIPITATION AT SEA SURFACE

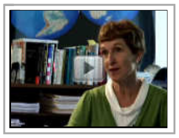
SEA SURFACE SALINITY



KEY QUESTION:
What is the environmental significance of the "0" line on the E-P map (i.e., dark line between the yellow and green areas)?
Bonus: How is E-P determined?

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

Education: Gallery

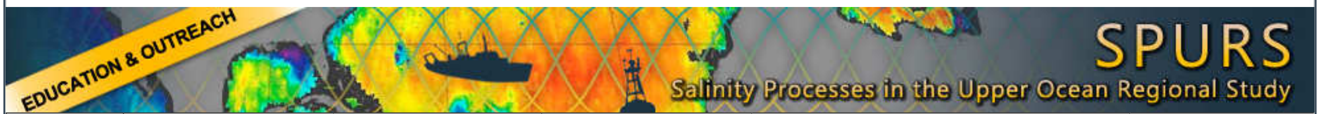


Geographic Variation in Salinity (00:00:59)
[11-Feb-10] Very salty parts of the world's ocean are the Mediterranean Sea and also the Red Sea. In fact, those areas are some of the saltiest places we know in the global ocean. The reason they are so salty is that there is such strong evaporation because they're so warm there and they have high winds. So those places are very salty.

And also in the middle of our subtropical gyres. A gyre is a current system that moves around in a circle. The "subtropics" means that it is located in an area around 30 degrees (north) latitude all around the globe. That area is where we have very strong evaporation. That evaporation means that we lose fresh water from the surface. And we lose more fresh water from the surface than we actually gain through precipitation. That area is what we call "the ocean deserts".

Now on the fresh side, we have very fresh water near the coastlines and that's because we have the river waters flowing in. And we also have fresh water near the high latitudes where we have ice. Credit: Susan Lozier.

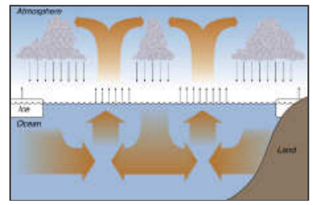
Back



Why Should We Worry About an "Intensified" Water Cycle?

The water cycle is a very large and mainly oceanic process, so terrestrial records cannot tell us much about the global picture. In addition, the oceanic water cycle is untouched by man, and since that is where most of the action is, it makes sense that the ocean is where we need to look for change in the water cycle. Salinity is a great integrator of the water cycle over the ocean and it tells us what changes are afoot.

An intensified water cycle means drier in some places and wetter in others and, in the oceans, the salty regions getting saltier and the fresh regions getting fresher. The rate of intensification appears to be stronger than any of the models have predicted. The main questions are how much and how fast these changes will occur.



Click on the image for a closer view!

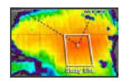
Featured Video: An Intensification of Extremes

An Intensification of Extremes

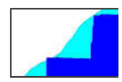
from **COSEE Ocean Systems** PLUS

01:25

Dr. Raymond Schmitt discusses intensification of the water cycle and how this will impact society
[view transcript]



Resolving Salinity Maximum Questions
Dr. Raymond Schmitt
[vimeo, 02:18]



Parallel Trends & Competing Processes
Dr. Lisan Yu
[vimeo, 01:35]

view all videos in this album [vimeo]

SPURS Blog

An Oceanographer And The Water Cycle [NASA Earth Observatory]
If one wants to find out what the water cycle is doing, one should be looking at the oceans

Lessons/Tools

Interactive Data Tools for Changes in Salinity Over Time [NASA Aquarius]
Annual cycle maps and time-series plots for salinity, temperature, and density

Resources

Ocean Salinity Trends Show Human Fingerprint [Scripps Institution of Oceaongraphy]
Like ocean temperature, variations in the last half-century are only explicable in the context of human-caused climate change

Big Changes in Ocean Salinity Intensifying Water Cycle [Mother Jones]
Rapidly changing ocean salinities as a result of a warming atmosphere have intensified the global water cycle by an incredible four percent between 1950 and 2000

Dry Lands Getting Drier, Wet Getting Wetter... Science Daily
A clear change in salinity has been detected in the world's oceans, signalling shifts and an acceleration in the global rainfall and evaporation cycle

Earth's Water Cycle Is Intensifying, Dry Is Getting Drier and Wet Is Getting Wetter [Planetsave]
The Earth's water cycle is intensifying, leading to more evaporation in dry climates and more rain in wet climates

Aquarius Water Cycle [NASA]
Aquarius uses advanced technologies to give NASA its first space-based measurements of sea surface salinity, helping scientists to improve predictions of future climate trends and events

Water, Water Everywhere: Water Cycle & Climate Change [NASA Aquarius]
The water cycle affects and is affected by climate variations

What is Aquarius Data Telling Us? [COSEE-Ocean Systems]
Now that measurements of global salinity are being regularly collected by Aquarius, what type of phenomena have been observed with the data?

What Does Sea Surface Salinity Tell Us About the Global Water Cycle? [COSEE-Ocean Systems]
NASA scientists work collaboratively with educators to examine connections between the water cycle, ocean circulation, climate, and sea surface salinity

The Water Cycle - Water Science for Schools [USGS]
Earth's water is always in movement, and the natural water cycle describes the continuous movement of water on, above, and below the surface of the Earth

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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Big Changes in Ocean Salinity Intensifying Water Cycle

—By ***Julia Whitty*** *(/authors/julia-whitty)* | Thu Apr. 26, 2012 3:56 PM EDT

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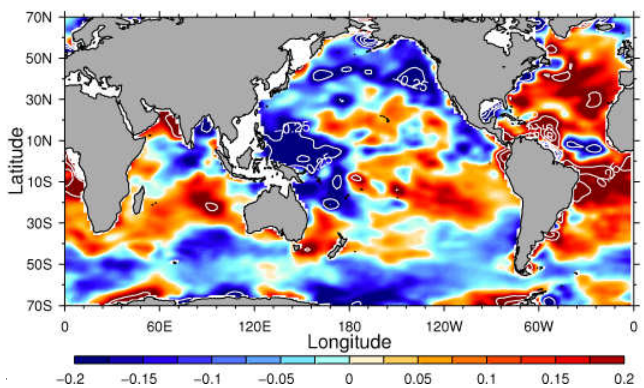
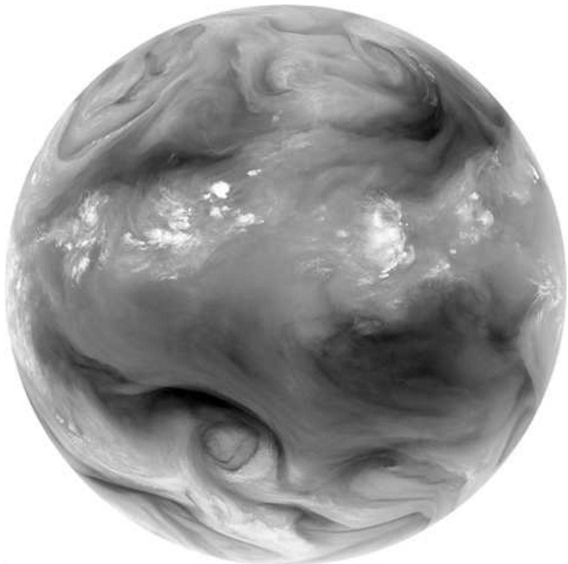


(http://www.sciencemag.org/content/336/6080/455.abstract)

Surface salinity changes from 1950 to 2000. Red shows regions becoming saltier, blue regions becoming fresher: P.J. Durack, et al. Science. 2012. DOI:10.1126/science.1212222

A paper (http://www.sciencemag.org/content/336/6080/455.abstract) in Science today finds rapidly changing ocean salinities as a result of a warming atmosphere have intensified the global water cycle (evaporation and precipitation) by an incredible 4 percent between 1950 and 2000. That's twice the rate predicted by models.

These same models have long forecast that dry areas of Earth will become drier and wet areas wetter in a warming climate—an intensification of the water cycle driven mostly by the capacity of warmer air to hold and redistribute more moisture in the form of water vapor.



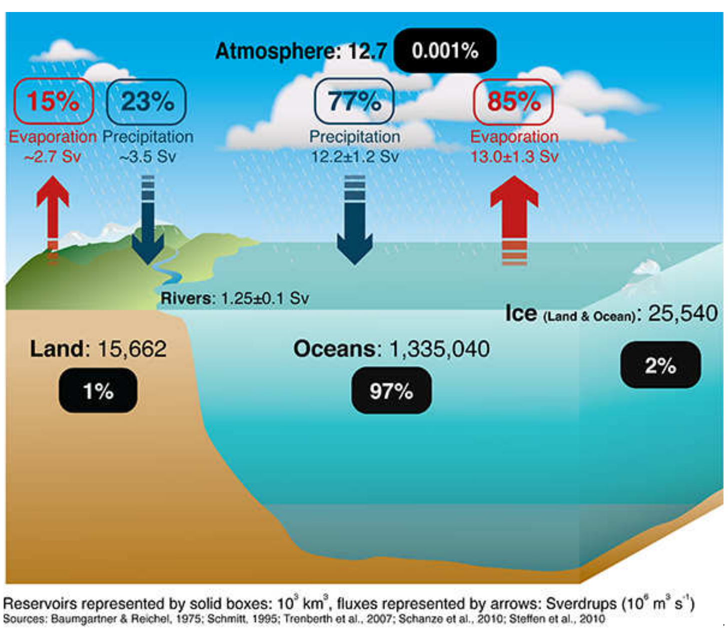
(http://earthobservatory.nasa.gov/Features/Water/)

Satellite image shows the distribution of water vapor over Africa and the Atlantic Ocean on 2 Sept 2010: *NASA*

But the rate of intensification of the global water cycle is happening far faster than imagined: at about 8 percent per degree Celsius of ocean warming since 1950.

At this rate, the authors calculate:

- The global water cycle will intensify by a whopping 16 percent in a 2°C warmer world
- The global water cycle will intensify by a frightening 24 percent in a 3°C warmer world



(http://www-pcmdi.llnl.gov/about/staff/Durack/dump/salinity/)

A schematic representation of the global water cycle, with the key role of the ocean and surface rainfall and evaporation fluxes expressed: Durack et al. Science. 2012. DOI:10.1126/science.1212222

The changes will not be uniform across the globe, but trend toward increased drying of arid areas and increased flooding of wet areas.

And the resulting changes in freshwater availability are likely to be far more destabilizing to human societies and ecosystems than warming alone.

"Changes to the global water cycle and the corresponding redistribution of rainfall will affect food availability, stability, access, and utilization," says lead author Paul Durack (http://csiro.academia.edu/PaulJDurack) at the University of Tasmania and the Lawrence Livermore National Laboratory.

The paper:

- Paul J. Durack, Susan E. Wijffels and Richard J. Matear. Ocean Salinities Reveal Strong Global Water Cycle Intensification During 1950 to 2000. Science 2012. DOI:10.1126/science.1212222 (http://www.sciencemag.org/content/336/6080/455.abstract)

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Feds File First Criminal Charges Related to BP Gulf Spill (/blue-marble/2012/04/feds-file-first-criminal-charges-bp-gulf-spill-deepwater-horizon)

JULIA WHITTY (/authors/julia-whitty) *Environmental Correspondent*

Julia Whitty is the environmental correspondent for *Mother Jones*. Her latest book is *Deep Blue Home* (http://www.julia-whitty.com/books/) *: An Intimate Ecology of Our Wild Ocean*. For more of her stories, click here (http://www.motherjones.com/authors/julia-whitty) .

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Climate Change Bird Atlas (/blue-marble/2012/02/climate-change-bird-atlas)
An interactive online bird atlas gives you a sneak peek at the fate of 150 American bird species under different climate scenarios and emission levels.

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Hint: you're getting warmer.

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A new photo book offers few clues about the woman behind the camera.

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Dry lands getting drier, wet getting wetter: Earth's water cycle intensifying with atmospheric warming

Date: May 21, 2012
Source: CSIRO Australia

Summary: A clear change in salinity has been detected in the world's oceans, signaling shifts and an acceleration in the global rainfall and evaporation cycle. The patterns are not uniform, with regional variations agreeing with the 'rich get richer' mechanism, where wet regions get wetter and dry regions drier.

Deploying an Argo float in the Tasman Sea.

Credit: Image courtesy of CSIRO Australia [Click to enlarge image]

A clear change in salinity has been detected in the world's oceans, signalling shifts and an acceleration in the global rainfall and evaporation cycle.

In a paper just published in the journal *Science*, Australian scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Lawrence Livermore National Laboratory, California, reported changing patterns of salinity in the global ocean during the past 50 years, marking a clear fingerprint of climate change.

Lead author, Dr Paul Durack, said that by looking at observed ocean salinity changes and the relationship between salinity, rainfall and evaporation in climate models, they determined the water cycle has strengthened by four per cent from 1950-2000. This is twice the response projected by current generation global climate models.

"Salinity shifts in the ocean confirm climate and the global water cycle have changed.

"These changes suggest that arid regions have become drier and high rainfall regions have become wetter in response to observed global warming," said Dr Durack, a post-doctoral fellow at the Lawrence Livermore National Laboratory.

With a projected temperature rise of 3ºC by the end of the century, the researchers estimate a 24 per cent acceleration of the water cycle is possible.

Scientists have struggled to determine coherent estimates of water cycle changes from land-based data because surface observations of rainfall and evaporation are sparse. However, according to the team, global oceans provide a much clearer picture.

"The ocean matters to climate -- it stores 97 per cent of the world's water; receives 80 per cent of the all surface rainfall and; it has absorbed 90 per cent of the Earth's energy increase associated with past atmospheric warming," said co-author, Dr Richard Matear of CSIRO's Wealth from Oceans Flagship.

"Warming of the Earth's surface and lower atmosphere is expected to strengthen the water cycle largely driven by the ability of warmer air to hold and redistribute more moisture."

He said the intensification is an enhancement in the patterns of exchange between evaporation and rainfall and with oceans accounting for 71 percent of the global surface area the change is clearly represented in ocean surface salinity patterns.

In the study, the scientists combined 50-year observed global surface salinity changes with changes from global climate models and found "robust evidence of an intensified global water cycle at a rate of about eight per cent per degree of surface warming," Dr Durack said.

Dr Durack said the patterns are not uniform, with regional variations agreeing with the 'rich get richer' mechanism, where wet regions get wetter and dry regions drier.

He said a change in freshwater availability in response to climate change poses a more significant risk to human societies and ecosystems than warming alone.

"Changes to the global water cycle and the corresponding redistribution of rainfall will affect food availability, stability, access and utilization," Dr Durack said.

Dr Susan Wijffels, co-Chair of the global Argo project and a co-author on the study, said maintenance of the present fleet of around 3,500 profilers is critical to observing continuing changes to salinity in the upper oceans.

The work was funded through the Australian Climate Change Science Program, a joint initiative of the Department of Climate Change and Energy Efficiency, the Bureau of Meteorology and CSIRO.

Story Source:

The above story is based on materials provided by **CSIRO Australia**. *Note: Materials may be edited for content and length.*

Journal Reference:

1. P. J. Durack, S. E. Wijffels, R. J. Matear. **Ocean Salinities Reveal Strong Global Water Cycle Intensification During 1950 to 2000**. *Science*, 2012; 336 (6080): 455 DOI: 10.1126/science.1212222

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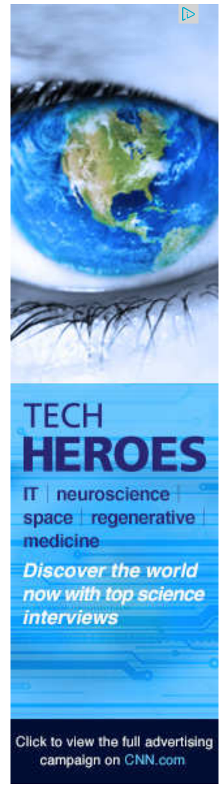

More Earth & Climate News

Thursday, January 29, 2015

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from universities, journals, and other organizations

Iceland Rises as Its Glaciers Melt from Climate Change

Jan. 29, 2015 — Earth's crust under Iceland is rebounding as global warming melts the island's great ice caps. In south-central Iceland some sites are moving upward as much as 1.4 inches (35 mm) per year. A new ... > *full story*

- Global Warming; Climate; Ice Ages; Snow and Avalanches

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Why is it important to understand ocean salinity?

Why was the SPURS study site chosen?

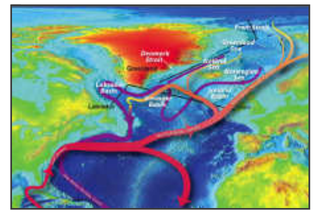
Why should we worry about an "intensified" water cycle?

Why do we study salinity to better understand ocean circulation?

Why is it important to measure salinity with both in-situ and satellite instruments?

Why Do We Study Salinity to Better Understand Ocean Circulation?

Salt ions have a greater mass than water molecules, so anything that increases the concentration of salt in water, such as evaporation, increases the density of that water. As salinity increases, the density of that water increases, causing it to sink below less-dense water. Therefore, deep ocean water mixing is driven by density differences.



Click on the image for a closer view!

This process happens in the North Atlantic where cold, dense water sinks to deep ocean basins and is slowly carried to the tropics, where it is warmed and upwelled. The warmer, less-dense waters are carried back northwards to replace dense, sinking water at the surface. Through the transfer of heat into the atmosphere in the cold polar regions, the process restarts. A simplified version of this is often referred to as the Ocean Conveyor Belt.

Featured Video: Ocean Memory and the Flywheel of Climate

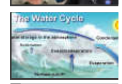
Ocean Memory and the Flywheel of Climate

from **COSEE Ocean Systems** PLUS

01:17

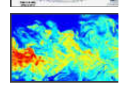
Dr. Eric Lindstrom talks about the ocean's memory and how it plays a role in regulating climate [view transcript]

Tuning Up the Salinity Model
Drs. Eric Lindstrom and Raymond Schmitt
[vimeo, 01:32]



Great Atmospheric Waves
Dr. Raymond Schmitt
[vimeo, 01:42]

A Delicate Balance
Dr. Raymond Schmitt
[vimeo, 01:27]



The Turbulence Cascade
Dr. Andrey Shcherbina
[vimeo, 01:08]

view all videos in this album [vimeo]

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An Oceanographer and the Water Cycle [NASA Earth Observatory]

If one wants to find out what the water cycle is doing, one should be looking at the oceans

Lessons/Tools

Density: Sea Water Mixing & Sinking [NASA Aquarius]

Temperature and salinity help govern the density of seawater, which is a major factor controlling the ocean's vertical movements and layered circulation

Liquid Rainbow [NASA Aquarius]

When solutions of two different densities meet, the lower density solution will move on top of the higher density solution, resulting in a layering or stratification of the solutions

Resources

Ocean Circulation [NASA Aquarius]

A compilation of videos, activities, tools, and articles relating to ocean circulation

Climate Change and the Global Ocean: Monitoring Climate Change Impacts By Satellite [NASA Aquarius]

Soon a new satellite will even help us see tiny particles on the ocean's surface - like salt, which drives huge conveyor belts of water through the world's oceans

Salt of the Earth: Ocean Atmosphere Circulation Helps Moderate Climate [NASA Aquarius]

Things that happen now will still be manifest hundreds of years in the future

Ocean Circulation [Center for Ocean Solutions]

The ocean is a major driver of global climate - it redistributes large amounts of heat around the planet via global ocean currents, through regional scale upwelling and downwelling, and via a process called thermohaline circulation

How Understanding Salinity Helps Us Understand Climate Change [NASA Aquarius]

Part III of this COSEE-OS webinar focuses on the formation and melting of sea ice and how this affects ocean circulation

How Does Salinity Drive Ocean Circulation? [CLIMB]

Concept map created by Dr. Tony Lee at the June 2011 Aquarius Pre-Launch Workshop in Pasadena, CA

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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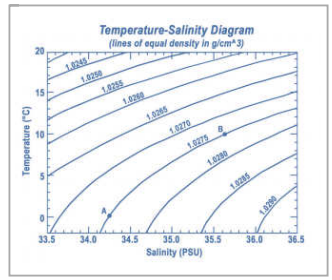
Education: Activities & Documents



Density: Seawater Mixing & Sinking

In the oceans, the salinity varies over time and from place to place. Typical open ocean salinities vary between 33 and 36 PSU (Practical Salinity Units), equivalent to 33-36 parts per thousand. Two of the most important characteristics of ocean water are its temperature and salinity. Together they help govern the density of seawater, which is the major factor controlling the ocean's vertical movements and layered circulation.

This activity investigates the role of temperature and salinity in determining seawater density. It does so by using a Temperature-Salinity (T-S) Diagram to examine the effect of mixing on density. Such mixing can be a significant factor in causing surface seawater to sink as part of vertical circulation. The T-S Diagram is a simple, but powerful tool used in studies of seawater density, mixing, and circulation. In a T-S diagram, temperature is plotted along the vertical axis in degrees Celsius and salinity is measured along the horizontal axis in PSU. Seawater density is illustrated in the diagram by curved lines of constant density.

Surface waters are mixed by winds and deep ocean water mixing is driven by density differences. Circulation in the depths of the ocean is referred to as thermohaline circulation. The deep ocean is layered with the densest water on bottom and the least dense water on top. Water tends to move horizontally throughout the deep ocean, moving along lines of equal density. Vertical circulation is limited because it is easier for water to move along lines of constant density (isopycnals) than across them.

Big Idea. Two of the most important characteristics of ocean water are its temperature and salinity. Together they help govern the density of seawater, which is a major factor controlling the ocean's vertical movements and layered circulation.

Grade Level. Middle or High.

Time. Two 45 minute class periods.

Content Standard. NSES Physical Science, properties and changes of properties in matter.

Ocean Literacy Principle (1e) Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic.

Materials

Pencil, T-S diagram (provided), water sample table (provided), ocean salinity map.

density_SWmix_sink.pdf (1.7 MB)

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Education: Activities & Documents

Liquid Rainbow

Density is a property of matter that can be introduced at the elementary level by thinking of it in terms of the relationship between weight and volume. How can two objects that are the same size have different weights? The answer has to do with their density. An object's density is determined by comparing its mass to its volume. If you compare a rock and a cork that are the same size (they have equal volume), which is heavier? The rock is, because it has more mass. Thus the rock is denser than the cork because it has more mass in the same volume. Liquids have density too. Unlike the densities of solids, which remain relatively constant, the densities of many fluids can be easily changed. Do objects float the same way in fresh water as they do in salt water? If you have the same amount of each, saltwater weighs more than fresh water. Salt water is described as being more dense than fresh water. In the case of ocean water, heating, cooling, and salinity all influence density.

Circulation in the ocean depends in part on differences in density of the water. Water with more salt is denser (heavier) and sinks while fresh water is less dense and "floats" on the surface. These buoyancy differences can result in the separation of water into layers (stratification) within an estuary or ocean. Stratification can be disrupted by tidal mixing, heating and cooling of surface waters,and / or by wind generated water movement, such as waves and currents. This action results in vertical mixing. Density driven currents are an important feature in coastal waters, affecting the physical, chemical, and biological dynamics in the ocean. Many marine organisms use density currents for migration, reproduction, and feeding.

Big Idea. When solutions of two different densities meet, the lower density (less dense) solution will move on top of the higher density (more dense) solution, resulting in a layering or stratification of the solutions. Density is an important feature of seawater since many physical and biological processes are affected by it, such as moving heat around the globe influencing climate and feeding and reproduction by marine organisms.

Grade Level. Elementary.

Time. 45 minutes in class (after preparation).

Content Standard. NSES Physical Science, properties of objects and materials.

Ocean Literacy Principle. (1e) Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic.

Materials

4 large containers (e.g., pitchers or milk jugs), food coloring (4 colors), transparent drinking straws, pickling salt (preferred), 5 vials or test tubes per student group (4 for solutions and 1 for waste).

liquid_rainbow.pdf (1.3 MB)

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The Aquarius/SAC-D mission is a collaboration between NASA and Argentina's space agency, Comisión Nacional de Actividades Espaciales (CONAE). Communication, public engagement and web content for Aquarius is provided by the University of Maine. The Aquarius mission is supported by the NASA Science Mission Directorate and additional information on the Aquarius mission is available here. **Click here for privacy policy and important notices.**

NASA Official: Gene Carl Feldman
Webmaster: Lisa G. Taylor
Last Updated: 2 December 2014

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Education

Launched in June 2011, NASA's Aquarius instrument has been providing unprecedented information on the surface saltiness, or salinity, of our global ocean. Our Mission's Communication & Public Engagement efforts are designed to demonstrate how monitoring changes in salinity patterns can help everyone better understand connections between the water cycle, ocean circulation, and climate.

Visit our Gallery and Activities & Documents pages to access classroom activities, data-driven tools, interactive quizzes, videos, images, podcasts, posters, and more. In addition, these resources have been organized around the following fundamental questions which address educational standards and national ocean literacy efforts:

- What role does salt play in the basic properties of water?
- How do water cycle processes relate to the ocean?
- What are the effects of temperature on seawater density and circulation?
- How does the ocean influence climate?
- How is the water cycle changing, and how are these changes affecting the ocean?
- How does density-driven circulation affect climate – and vice versa?
- How can technology and collaboration enhance understanding of the ocean?

Aquarius also promotes interaction between scientists and educators through in-person and online events. Please visit our Pre-Launch Workshop, JPL Salinity Workshop, and Aquarius Inquiry Education and Science Webinar archives if you are interested in using Aquarius content in the classroom[1].

Mapping Earth's Water Cycle

The Earth's water cycle – the movement of water around the globe – plays a large role in our understanding of global climate. Several Earth-focused NASA missions are shedding new light on the processes within the water cycle; these findings are being used to investigate natural phenomena such as storms, flooding, and drought. On October 16th, two scientists from different NASA missions (Aquarius and GRACE) paired up to present a webinar featuring sea surface salinity measurements from Aquarius and water storage visualizations generated from GRACE gravity field data. View the archived webinar here.

Highlighting Ocean Sciences & Engineering Practices

The Aquarius EPO team works with NASA scientists to broaden the reach of their ocean science research, to both scientific and nonscientific audiences alike using live webinar events. These webinars are excellent ways for researchers to show the public how science is done and the various skills required for this field of study.

Recently, the EPO team deconstructed these webinars into smaller pieces for educators to use in their curriculum and to enhance classroom activities. In the Fall of 2014, this product, Highlighting Ocean Sciences & Engineering Practices, was accepted to the NASA Wavelength resource center. This product has been organized by topic, as well as by science and engineering practices, outlined by the Next Generation Science Standards (NGSS).

NASA Wavelength is a digital repository of Earth and space science resources for educators of all levels. All content on Wavelength has been peer-reviewed to ensure that the content is accurate for use in educational environments.

What's New in Aquarius Education

Aquarius Sea Surface Salinity, 2011-2014 (Flat Map)

[12-Nov-14] This visualization celebrates over three years of successful Aquarius observations, from September 2011 through September 2014. Sea surface salinity is shown on a flat map using simple Cartesian and extended Mollweide projections. Versions are included with and without grid lines, and in both Atlantic- and Pacific-centered projections. This visualization was generated based on version 3.0 of the Aquarius data products. MORE ▸

Aquarius Sea Surface Salinity, 2011-2014 (Rotating Globe)

[12-Nov-14] This visualization celebrates over three years of successful Aquarius observations, from September 2011 through September 2014. Sea surface salinity is shown on a spinning globe (with and without grid lines). This visualization was generated based on version 3.0 of the Aquarius data products. MORE ▸

Using NASA's Aquarius Sensor to Monitor Salinity Levels in the Amazon Delta

[07-Aug-14] The NASA DEVELOP National Program fosters an interdisciplinary research environment where applied science research projects are conducted under the guidance of NASA and partner science advisors. DEVELOP is unique in that young professionals lead research projects that focus on utilizing NASA Earth observations to address community concerns and public policy issues. For this project, the Langley DEVELOP team created a method for testing how close to the coastline Aquarius observations can be made effective through an analysis of the Amazon River Delta's low salinity plume. NASA DEVELOP

Education: Gallery

Monitoring Impacts By Satellite (00:01:10)
[24-Feb-10] Soon a new satellite will even help us see tiny particles on the ocean's surface - like salt, which drives huge conveyor belts of water through the world's oceans, connecting currents and moving heat from pole to pole. Climate change could mean big changes for oceans. And that in turn would make life very different for those of us on dry land.

Paula Bontempi: "If the climate actually changes, and the oceans change or respond to that change, it most definitely will impact life as we know it, and especially humans."

David Adamec: "To understand exactly how we stay here and how we're going to survive both within the climate, and even our life cycle, it requires understanding what the water is doing."

Our climate is changing... in some places, faster than predicted. By using science to understand those changes, we can find ways of protecting our oceans - and ourselves - that make a world of difference. View full movie here. Credit: NASA.

Original Movie: http://climate.nasa.gov/climate_reel/GlobalOceans640360

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Education: Gallery

Salt of the Earth: Ocean Atmosphere Circulation Helps Moderate Climate (00:00:54)
[13-Oct-09] Susan Lozier: "And the atmosphere and the ocean, both being fluids of the earth, really work together. We consider them sort of equal partners in the redistribution of this heat on the planet. So when those warm waters are returning, as they're moving up to the higher and higher latitudes then, they're releasing that heat to the atmosphere. Then the winds blow over the ocean, they pick up that heat and those winds over the Atlantic Ocean are moving from the North American continent to the European continent."

Jeff Halverson: "It takes perhaps a thousand years for the water to cycle through the deep ocean. So we say the oceans have a memory. They're like a tape recorder. Things that happen now will still be manifest hundreds of years in the future as that cold water moves through this giant circulation."

Susan Lozier: "So if there's any change to that overturning circulation, that means that Northern Europe and the British Isles would be robbed of that heat due to those waters that are returning to the high latitudes." View full movie here.
Credit: NASA/Goddard Space Flight Center.

Original Movie: http://svs.gsfc.nasa.gov/vis/a010000/a010500/a010504/

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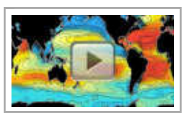
Science Webinars: Key Scientific Connections

In this May 2011 webinar, Principal Investigator Gary Lagerloef and Project Scientist Yi Chao talk about the milestones leading up to the launch of NASA's first space-based measurements of ocean salinity across the globe - an important observation for ocean and climate studies.

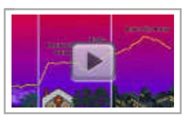
The Aquarius Mission: Key Scientific Connections

From 650 kilometers (400 miles) above Earth's surface, Aquarius is detecting changes in ocean salinity as small as a "pinch" of salt in a gallon of water. Two weeks before the Aquarius/SAC-D satellite launch, these eminent scientists shared their stories about the technological development of the mission and key scientific connections between salinity, the water cycle, ocean circulation and climate.

How was the Technology for Aquarius Developed? Yi Chao illustrates the history and technology behind Aquarius (view concept map)



How Would You Summarize the Effects of Sea Surface Salinity on Ocean Circulation? Gary Lagerloef explains the science goals and broader implications of studying sea surface salinity (view concept map)



How Does Understanding Salinity Help Us Understand Climate Change? Gary and Yi explain the challenges of studying climate at different time scales (view concept map)

About the Presenters

Dr. Gary Lagerloef completed a Ph.D. in Physical Oceanography at the University of Washington in 1984. From 1988-1990, he served as the NASA Physical Oceanography Program Manager in the ocean science remote sensing program. In 1995, he co-founded Earth and Space Research, a non-profit scientific research institute in Seattle where he has developed several research projects devoted to studies of the upper ocean dynamics and climate variability using satellites. Dr. Lagerloef was appointed by NASA to lead the Aquarius/SAC-D satellite mission in December 2003.

Dr. Yi Chao received his Ph.D. from Princeton University (Atmospheric and Oceanic Science Program, NOAA Geophysical Fluid Dynamics Laboratory). His research interests include satellite oceanography with a particular focus on coastal oceans; ocean modeling, data assimilation and forecasting. interdisciplinary science of coupling ocean circulation with ecosystem and air-sea interactions; and climate variability and change.

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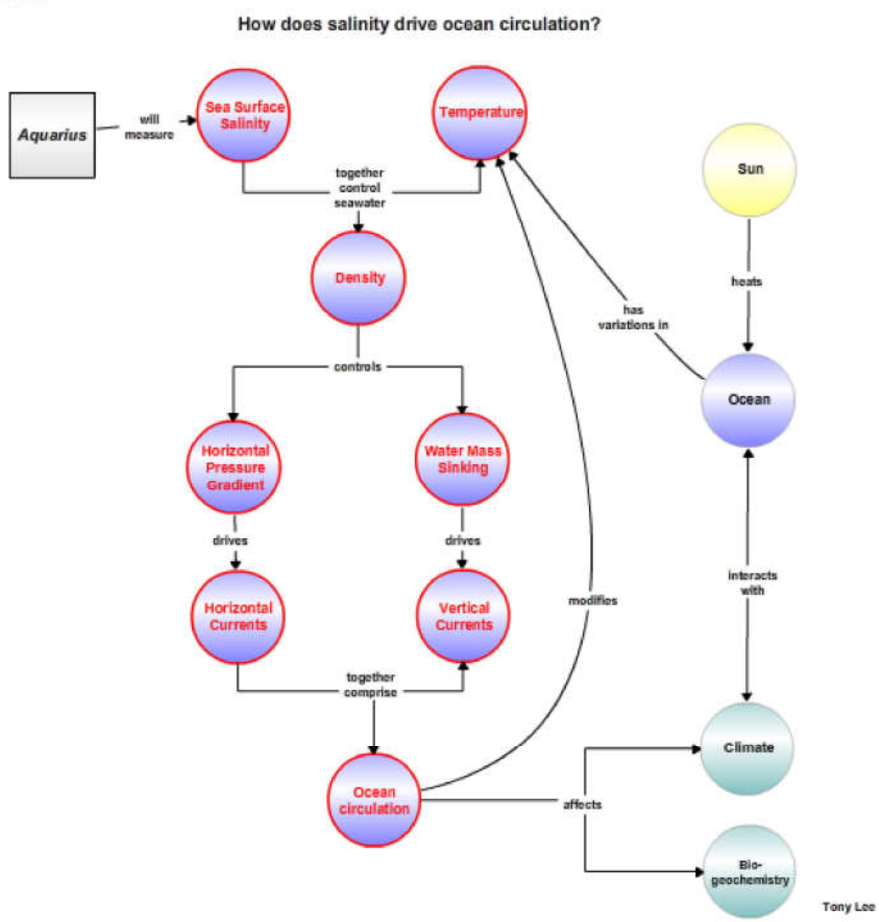
How Does Salinity Drive Ocean Circulation?

Created By: JPL Workshop Scientists
Last Modified: 6/3/2011

Tools: Open Map Log in to Save Copy of Map



MAP DESCRIPTION:

Interactive concept map developed by Dr. Tony Lee (NASA Jet Propulsion Laboratory) for a June 2011 educator workshop held days before the launch of NASA's Aquarius instrument to measure the saltiness, or salinity, of the global ocean.

Why is it Important to Measure Salinity With Both In-Situ and Satellite Instruments?

Satellites can measure SSS alone, but they take these measurements across large areas. In-situ instruments collect data throughout the water column, but have more limited coverage, taking measurements on a much smaller scale.

In-situ instruments are more traditional, while salinity measurements obtained from space still need certain levels of validation and calibration before they can be fully "stand-alone" to the same degree of reliability. In order to understand all of the processes affecting ocean salinity (3-D and 4-D) you need both types of measurements to get a more detailed picture.

Click on the images for a closer view!

Featured Video: Salinity From Space is Awesome

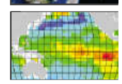
Salinity From Space is Awesome

from **COSEE Ocean Systems** PLUS

04:50

Dr. Eric Lindstrom summarizes the history of salinity measurements [view transcript]


A New View of Ocean Salinity
Dr. Eric Lindstrom
[vimeo, 06:26]


Validating Aquarius
Dr. Fred Bingham
[vimeo, 01:42]


Laying Out a Sensor Web
Dr. Eric Lindstrom
[vimeo, 04:59]


ROVs and Ocean Structure
Dr. David Fratantoni
[vimeo, 01:13]

view all videos in this album [vimeo]

SPURS Blog

Measuring Salinity from Space [NASA Earth Observatory]

Salinity is a challenging but critically important measurement for oceanographers

Ocean Salinity Viewed from Sea and Space [NASA Earth Observatory]

NASA Program Scientist Eric Lindstrom describes why scientists want to spend six weeks at sea measuring ocean saltiness

Resources

Salt of the Earth: Aquarius Will Reveal Salinity Ties to Climate [NASA Aquarius]

People have been measuring salinity for centuries, but ships and buoys alone cannot match the perspective from space

How Do We Cover the Globe with Aquarius Data? [COSEE-Ocean Systems]

The Aquarius/SAC-D satellite has begun collecting global salinity data - but it is not without challenges

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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Measuring Salinity from Space

September 11th, 2012 by Maria-Jose Viñas

By Eric Lindstrom

Recent years have seen significant developments in satellites for oceanographers. The European Space Agency launched the Soil Moisture and Ocean Salinity (SMOS) mission and NASA launched the Aquarius instrument on the Argentine SAC-D mission.

Artist's concept of the Aquarius/SAC-D spacecraft. (Credit: NASA)

Salinity has always been a challenging but critically important measurement for oceanographers. The small changes in salinity that we sea in the ocean are important in determining the density of seawater and density differences are partly responsible for ocean circulation (direct forcing by the wind being another big factor). It's a challenging measurement because we estimate salinity by simultaneously measuring the temperature and conductivity of seawater and using a well-established formula to calculate salt concentration. The salinity of the open ocean ranges from about 33 to 38 parts per thousand and the target accuracy of satellites is to measure differences of 0.2 parts per thousand. That is like measuring the change in salinity from adding a pinch of salt to a gallon of waters. I challenge you to taste the difference!

It's the relationship between conductivity and salinity that allows for its remote sensing of salinity from space. As the conductivity of ocean surface waters change (with salinity) there are minute detectable changes in the "brightness" of the surface in microwave emissions. So, in theory, if we have a sensitive enough microwave radiometer we should be able to detect these variations from low earth orbit and translate them into salinity. In fact, the scientific and technical complexity of this task is enormous (and luckily space agencies feast on such challenges!)

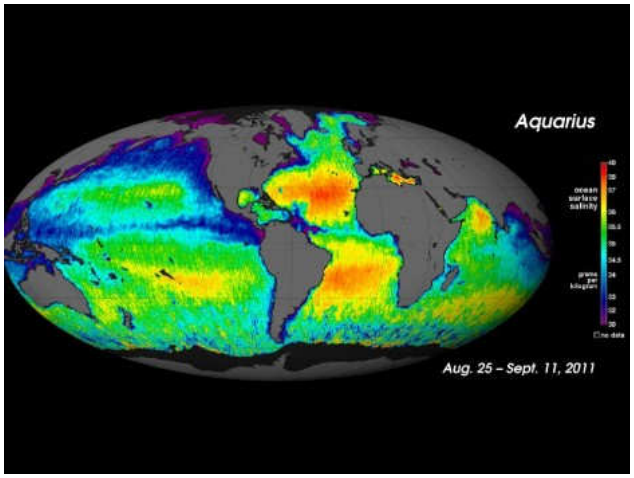
SMOS and Aquarius are two very different solutions to the technical problem of measuring a small microwave signal from Earth orbit. But they both face the daunting task of making adjustments for the sea surface temperature and roughness, the intervening atmosphere and ionosphere, and galactic signals reflected off the sea surface (there are strong sources for the microwaves that astronomers have mapped for decades: in fact we measure salinity at a frequency band 1.4 Ghz that is "protected" for astronomical research.)

Notes from the Field

Browse by Expedition

Browse by Date

Well, you can surf the web sites if you want to go into all the details… but let's get back to the ocean, since I am out here! The advent of SMOS and Aquarius has renewed interest in the details of surface salinity properties of the ocean. Never before had oceanographers had weekly maps of the global salinity field. We have been looking at temperature maps for decades, but salinity is new. It's worth a whole posting on what it means to know both the temperature and salinity maps of the surface of the ocean year-round, and I'll do that another day.



Aquarius's first map of global ocean surface salinity, released in September 2011. (Credit: NASA)

SMOS and Aquarius drive scientists to wonder exactly how the variations of salinity seen from space come to be the way they are. That's where detailed study of a few key ocean sites is so important.

Meanwhile, we are continuing to enjoy beautiful weather despite the hurricanes out and about in the Atlantic. The blue waters of the Sargasso Sea are delightful!

Tags: Aquarius, microwave emissions, radioastronomy, salinity, SMOS

This entry was posted on Tuesday, September 11th, 2012 at 11:17 am and is filed under Salinity Processes in the Upper Ocean Regional Study (SPURS). You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

12 Responses to "Measuring Salinity from Space"

sangeeta deogawanka says:
September 11, 2012 at 11:37 pm

Hi,
I wanted to know whether it is possible to check out salinity of groundwater or open water bodies using either of the two / Grace missions.

In the meantime, I look forward to your post on the implications of mapping ocean salinity and temperature.

> **Eric Lindstrom** says:
> September 12, 2012 at 8:43 am
>
> Sangeeta,
> The GRACE satellites measure gravity variations only and therefore focus on changes in mass on the Earth. The detected changes in mass are related to many things including ground water changes, changing ice sheets, and ocean mass variations. GRACE does not detect changes in ground water salinity. The Aquarius and SMOS missions, using L-Band microwave remote sensing, are sensitive to changes in surface moisture over land and both missions are producing a soil moisture products. We cannot tell the salinity of surface water on land from either mission, just characterize the relative abundance of water.
> Eric

RSS
Entries (RSS)
Comments (RSS)

Sandy says:
September 12, 2012 at 10:06 am

Per the discussion on using gravity sensors to measure salinity, Aquarius measures salinity of sea surface only, correct? If using a gravity sensor to measure salinity (the sensor would have to be incredibly sensitive), it would be measuring gravity of the total water column at a particular location. To calculate salinity at a location, percentage of other dissolved solids and particulate matter would need to be known, as well as the total mass below the water (crust to core) and depth of water column. Unfortunately detailed information on those other variables a priori is just not available to solve the equation…

Eric Lindstrom says:
September 12, 2012 at 11:37 am

Sandy, Thanks for the added clarification. Aquarius is focused on measuring sea surface salinity. I realize that in non-oceanographic circles "salinity" is a big subject related to ground water and surface water on land. We are not examining that issue. Trying to get to salinity of ground water as a "mass" problem through GRACE seems darn near impossible (its such a small signal in the overall mass signal and its variation). Maybe it will be possible one day, but seems like it more directly accessible through in situ measurements.
Eric

ldavidcooke says:
September 12, 2012 at 9:10 am

Hey Dr. Lindstrom,

I am curious as to why they chose to apply microwave as opposed to Lidar, is it due to the optical depth issue at sodium resonate frequency? If so could a harmonic frequency not work? Oh, and while you are on campaign, are you also sampling for dissolved carbonic acid?

Eric Lindstrom says:
September 12, 2012 at 11:22 am

There is a good presentation on this question at the Aquarius mission web site.

Check out: http://aquarius.nasa.gov/pdfs/LeVine_3Jun11b.pdf

David Levine is better trained than this sea-going oceanographer to answer the hypothetical question on other potential choices for remote sensing of ocean salinity.

Eric

David Le Vine says:
September 14, 2012 at 1:34 pm

Reply to the question of why microwave and not Lidar: The microwave response to salinity has a long history of research and validation dating back to the 1970's. There were even reports of changes associated with salinity in the signal from the L-band radiometer on SkyLab. See Section D in Proc IEEE Vol 98 (5) pp 688 for a short history. Salinity changes the conductivity of water and the change in conductivity changes the thermal emission enough at L-band to be measured with modern instruments from space. The change in conductivity is also the basis for measuring salinity in situ. There may be a correlation between ocean color and salinity, but otherwise, I am not aware of passive optical or Lidar remote sensing of salinity. It would be nice, if possible, because the challenge now is to obtain the spatial resolution needed to address issues closer to the coast.

ldavidcooke says:
September 18, 2012 at 8:34 pm

Hey Dr. Le Vine,

Thank you for your response, I was considering a reapplication of the Colorado State, atmospheric sodium lidar. (A reference here: http://lamar.colostate.edu/~lidar) As this device is used as a ground based sensing device for Mesopheric atmospheric activity at 55 – 65 km elevation, it might be difficult.

With the loss of the L band yellow slot below this altitude may suggest it would simply require a slight detuning or retuning for a Na/Cl emission band. I only mention it in passing as it may offer a separate; but, valuable alternative tool for the future of marine research.

Eric Lindstrom says:
September 12, 2012 at 11:29 am

We are not delving into the chemistry and biology of the ocean on this voyage. We have the Knorr labs full with people and various gear to focus on ocean salinity variability.
EJL

ldavid cooke says:
September 12, 2012 at 5:56 pm

Hey Dr. Londstrom,

As you may have surmised, wrt the question about dissolved CO2, is the relationship to ocean surface temperatures. I'm curious if it is possible that the CO2 could "trap" normal insolation near the surface resulting in spikes of salinity, similar to long term synoptic weather conditions of clear skies and "dry" high pressure centers.

It would be very useful to know if there could be a correlation to the atmospheric "thermal blanket" theory. Along the lines of a hypothesis of where the CO2 creates a strong inversion layer both concentrating insolation near the surface and sheilding the water column below, hence, increasing SSTs.

Eric Lindstrom says:
September 13, 2012 at 7:51 am

I am not too sure if I understand this question. Let me just try some stating some facts.

CO2 in water does not have greenhouse blanket properties as in the atmosphere. infrared (thermal) radiation that is "trapped" by CO2 in atmosphere does not penetrate very far in seawater and is more related to the properties of water than small changes in water chemistry (like the amount of trace gases). Low salinity at the surface (as might be caused by rainfall or land runoff) can cause stratification leading to enhanced warming at the surface. Surface water warmed by the sun during the day might not be mixed down due to the buoyancy imparted by the low salinity.

The partial pressure of CO2 in seawater is related to both the temperature and salinity of the seawater, so chemists are interested in precise maps of surface salinity in order to better understand the fluxes of CO2 between the ocean and atmosphere.

ldavidcooke says:
September 18, 2012 at 8:04 pm

Hey Dr. Lindstrom,

My apologies for not being clear, the tought I was trying to share was as the incoming UV, which I have read penetrates to over 40M, is absorbed, with the energy converted to IR by the increase in water molecule vibration which I suspect results in heating of the water or via increased collisions the emission of IR energy.

The question then returns to the basic physics if there is an increase in carbon molecules, ie: carbonic acid or calcium carbonate, near the surface, would these molecules tend to trap incoming solar energy in the upper 10-30 meters of the ocean and shade the deeper water?

Notes from the Field
« Of ship meals and science
Are We There Yet? »

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Salt of the Earth: Aquarius Will Reveal Salinity Ties to Climate (00:00:58)
[13-Oct-09] People have been measuring salinity for centuries, but ships and buoys alone cannot match the perspective from space. In fact, a whole quarter of the oceans have no salinity data at all.

Susan Lozier: "Up until now when we've been trying to understand how density changes impact ocean circulation, we've really just had half the picture."

When the Aquarius/SAC-D satellite is launched, scientists can look at salinity of the surface of the ocean from 400 miles above the earth.

Susan Lozier: "But now with the Aquarius mission, we'll be able to complete that other half. We'll be able to look at the salinity information. And so salinity, combined with temperature, will give us the information about the density field."

The satellite will gather more salinity data than in the last 125 years. This mission will help scientists better understand how salinity and ocean circulation are tied to global climate and how both systems are changing throughout time. View full movie here. Credit: NASA/Goddard Space Flight Center.

Original Movie: http://svs.gsfc.nasa.gov/vis/a010000/a010500/a010504/

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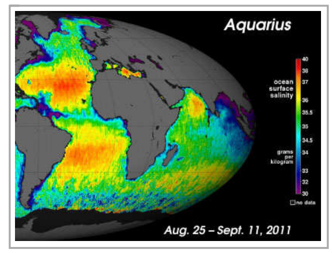
Science Webinars: Our Salty Seas

NASA scientists Yi Chao, Gary Lagerloef and David Le Vine came together for this two part series to discuss the complexities of getting accurate salinity measurements from space. The presentations include the most recent data collected by the instrument.



How Do We Cover the Globe With Aquarius Data? (Part 1)

The Aquarius/SAC-D satellite has begun collecting global salinity data - but it is not without challenges. On January 17, 2012, Dr. Gary Lagerloef, Aquarius Principal Investigator, and Dr. David Le Vine, Aquarius Deputy Principal Investigator, presented a webinar on what it takes to design, develop and test this satellite's capabilities before and after launch, and how this leads to gathering accurate global data.

How Was the Technology for Aquarius Developed and How Does It Work? Aquarius Deputy PI David Le Vine describes how the technology for Aquarius was developed (Session 1) (view concept map)

How Do We Cover the Globe With Aquarius Data? Aquarius PI Gary Lagerloef describes the process by which the Aquarius instrument is able to get a global picture of salinity measurements (Session 2) (view concept map)

Resources

Q&A Transcript Session 1 (PDF, 211KB)

Gary and David answer questions from webinar participants including what is brightness temperature, why are salt levels in the oceans and lakes so different, how long did it take to build Aquarius, and more.

Q&A Transcript Session 2 (PDF, 1.7MB)

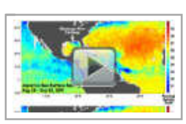
Gary and David expand upon their presentation in this Q&A session covering how fast Aquarius goes, how data are downloaded from the satellite (and how often), correlating satellite data with earth phenomena (volcanoes), accounting for cloud cover, and more.

Webinar Assets

View images, videos, and resources presented during the webinar in the COSEE-OS Ocean Climate Interactive.

What is Aquarius Data Telling Us? (Part 2)

Now that measurements of global salinity are being regularly collected by Aquarius, what type of phenomena are being observed with the data? In this webinar presented on January 24, 2012 - seven months after launch - NASA scientists Dr. Gary Lagerloef and Dr. Yi Chao discuss Aquarius findings, focusing on interesting regions of salinity change and what the data are already teaching us about the global ocean.



What is Aquarius Data Telling Us? Aquarius PI Gary Lagerloef and Project Scientist Yi Chao highlight several months of data received from the Aquarius instrument (view concept map)

Resources

Q&A Transcript (PDF, 3 MB)

Gary and Yi answer webinar participant's questions about Aquarius data, including how tropical storm seasons affect salinity, why the continents appear ringed in black, if Aquarius measurements will be used to determine other ocean parameters such as sea surface height and temperature, do oil spills affect satellite data, and what data have surprised them the most.

Webinar Assets

View images, videos, and resources presented during the webinar in the COSEE-OS Ocean Climate Interactive.

About the Presenters

Dr. Gary Lagerloef completed a Ph.D. in Physical Oceanography at the University of Washington in 1984. From 1988-1990, he served as the NASA Physical Oceanography Program Manager in the ocean science remote sensing program. In 1995, he co-founded Earth and Space Research, a non-profit scientific research institute in Seattle where he has developed several research projects devoted to studies of the upper ocean dynamics and climate variability using satellites. Dr. Lagerloef was appointed by NASA to lead the Aquarius/SAC-D satellite mission in December 2003.

Dr. Yi Chao received his Ph.D. from Princeton University (Atmospheric and Oceanic Science Program, NOAA Geophysical Fluid Dynamics Laboratory). His research interests include satellite oceanography with a particular focus on coastal oceans; ocean modeling, data assimilation and forecasting. interdisciplinary science of coupling ocean circulation with ecosystem and air-sea interactions; and climate variability and change.

Dr. David Le Vine Dr. Le Vine received his Ph.D. degree in electrical engineering from the University of Michigan, Ann Arbor. He was a Research Engineer at the University of Michigan Radiation Laboratory, after which he became an Assistant Professor in the Department of Electrical Engineering, University of Maryland, College Park. In 1973, he joined NASA's Goddard Space Flight Center. His current research has focused on the development of techniques for microwave remote sensing of the environment from space.