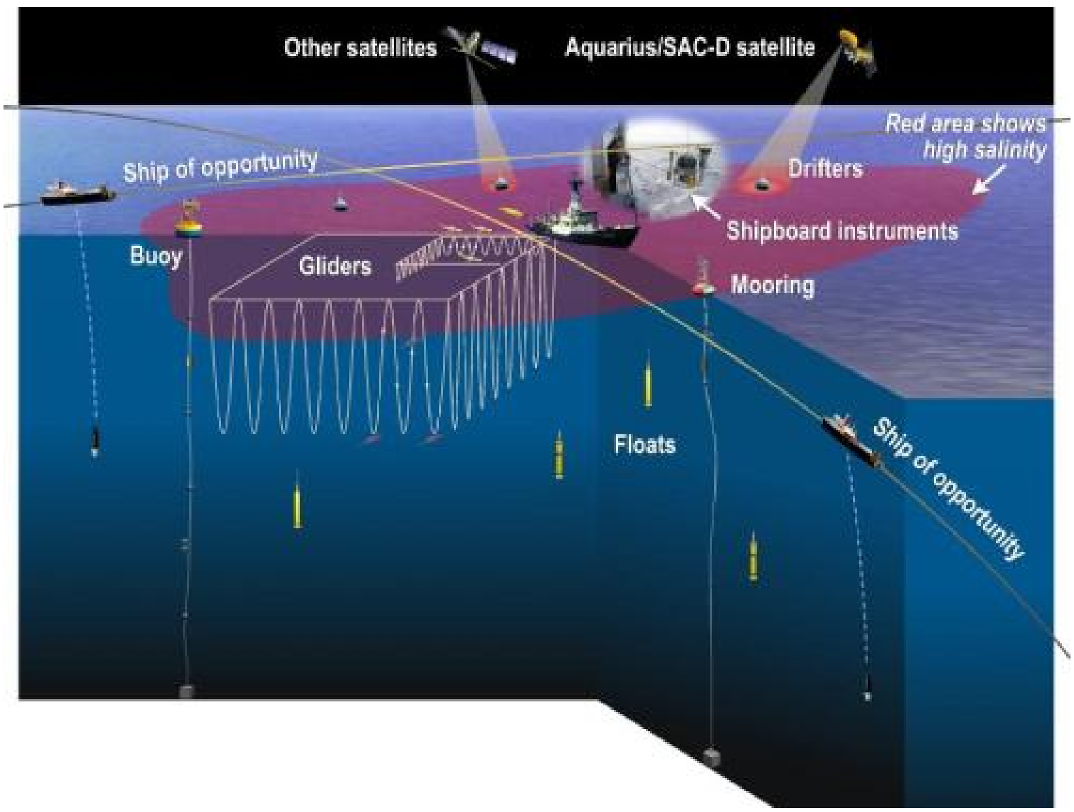
NASA goes below the surface to understand salinity

June 8 2011, By Alan Buis and Patrick Lynch



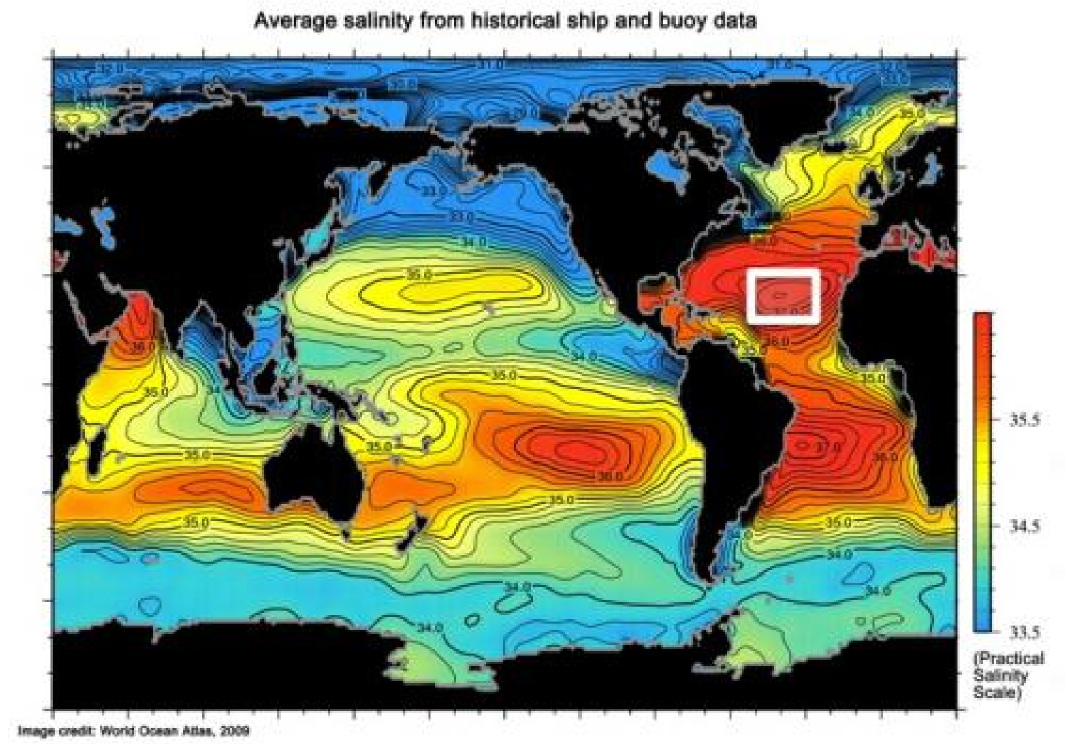
Scientists will set their sights on taking an unprecedented variety of measurements around one of the saltiest spots in the Atlantic Ocean as part of the Salinity Processes in the Upper Ocean Regional Study (SPURS) experiment, in concert with NASA's Aquarius mission. Credit: NASA/SPURS

(PhysOrg.com) -- When NASA's Aquarius mission launches this week, its radiometer instruments will take a "skin" reading of the oceans' salt content at the surface. From these data of salinity in the top 0.4 inch (1 centimeter) of the ocean surface, Aquarius will create weekly and monthly maps of ocean surface salinity all over the globe for at least three years. To better understand what's driving changes and fluctuations in salinity -- and how those changes relate to an acceleration of the global water cycle and climate change -- scientists will go deeper.

That's why scientists working on, Aquarius, the newest NASA Earth System Science Pathfinder mission aboard the Argentine-built Satelite de Aplicaciones Cientificas (SAC)-D observatory, have devised a plan. They will deploy instruments on floats, research ships, commercial cargo ships, free-drifting platforms, buoys, underwater gliders, and an autonomous underwater vehicle to build a 3-D view of what's happening beneath the ocean surface that affects salinity distribution.

Along with temperature, ocean salinity is a key driver of ocean currents, a critical factor in climate processes, and an indicator of Earth's changing water cycle. Measuring salinity from space has been one of the great technological challenges of satellite ocean studies. But once Aquarius starts delivering its salinity data, with accuracy equal to a pinch of salt in a gallon of water, a new challenge begins.

"The next question is: How do you understand what the satellite sees?" said Yi Chao of NASA's Jet Propulsion Laboratory in Pasadena, Calif. Cho is the Aquarius project scientist. "Without deploying instruments under the ocean's surface, we do not know how to fully interpret the satellite observations of surface salinity."



SPURS will include five month-long research cruises to a region known as the Atlantic Ocean's salinity maximum, centered around 25 degrees north and 38 degrees west. The cruises will begin in the spring of 2012 and continue through the summer of 2013. Credit: NOAA

To help address that question, NASA has a new field experiment: SPURS – Salinity Processes in the Upper Ocean Regional Study. The experiment, which will sample salinity and other key factors, such as ocean temperature and velocity, will take place from spring 2012 to summer 2013 and will include five month-long research ship cruises to the center of the saltiest region in the Atlantic Ocean. In oceanography lingo, it's known as the "Atlantic surface salinity maximum," and it's located about halfway between the southeast U.S. coast and the western coast of North Africa, at about 25 degrees north and 38 degrees west. Many of the methods used for years to take in-ocean measurements of salinity will be put to use, but in a far more concentrated and intensive manner, and, for the first time, they'll be used in combination with Aquarius' satellite salinity readings.

SPURS scientists hope to replicate the study in a contrasting, relatively low-salinity region elsewhere in the ocean in the future.

The scope of the measurements taken during SPURS will give scientists deeper insights into the salinity observations from Aquarius and the physical processes -- temperature changes, currents, turbulence, evaporation, precipitation -- that affect salinity. These are all aspects of the global water cycle, the continuous movement of water through the Earth system by evaporation, condensation, precipitation and runoff. Water cycles from the ocean to the atmosphere and then back to the ocean, either directly or via melting ice caps, rivers or underground aquifers. Scientists see evidence of an accelerating water cycle, driven by climate change. Salinity measurements can indicate how the patterns of freshwater mixing with saltwater are changing due to changes in precipitation, evaporation, and freshwater runoff from rivers and melting ice.

"One of the big questions is how much will the water cycle accelerate because of warming?" said Raymond Schmitt, project scientist for SPURS and an oceanographer at Woods Hole Oceanographic Institution in Woods Hole, Mass. In short, as Earth's lowermost atmospheric layer, the troposphere, warms, its ability to hold water in the form of water vapor increases. This, in turn, increases evaporation over land and the ocean, and quickens the cycle as a whole. As precipitation and evaporation patterns change -- thus changing how freshwater mixes with salty water -- so do salinities.

"We're seeing big changes in ocean salinities that can only be explained by an increase in the water cycle," Schmitt said. "We see this changing salinity, and we want to relate it to the changing water cycle -- but we have to understand what the ocean is doing."

Designing a Multi-platform Experiment at Sea

The ocean makes up 71 percent of Earth's surface area and represents 97 percent of the world's volume of water. Measuring what's happening with salinity everywhere in the ocean at every depth is an impossible task. So the SPURS scientists decided to focus on one representative region and measure that as a proxy. A network of different instruments creates a "bounded" volume of water to study in the SPURS experiment.

SPURS precisely identifies a specific 3-D portion of the Atlantic Ocean, and sets out to measure key ocean processes there as thoroughly as possible. Starting at the surface, commercial cargo ships carrying basic salinity gauges and deploying disposable thermometers will criss-cross the target region on their regular trade routes. Ocean scientists have partnered with commercial ships to do this for years. SPURS will also take advantage of the existing Argo network of profiling floats that measure temperature and salinity at the surface and below. The floats dive as deep as 1.2 miles (2 kilometers), while returning to the surface every 10 days to transmit their measurements via satellite. The international scientific collaboration began in the late 1990s and now maintains more than 3,000 floats worldwide.

It is the multiple additions beyond these existing measurements that will make SPURS more complex than a typical study of ocean processes. Multiple buoys will take basic meteorological measurements at the surface. But cables running to anchors on the ocean bottom will stretch down as deep as 2.5 miles (4 kilometers) below the surface, while instruments deployed on the cables at different depths will take salinity, temperature and velocity readings. SPURS will also draw on data from NOAA's existing PIRATA (Prediction and Research Array Moored in the Atlantic) network, which uses similar buoys moored to the ocean floor.

In addition, about 75 free-floating surface drifters, outfitted with GPS, temperature and salinity instruments, will be deployed in a radius of several hundred kilometers. Beneath the surface, NASA will deploy teams of two kinds of "gliders" -- torpedo-like autonomous devices that use slight changes in buoyancy and wings to dive up and down and propel themselves forward, collecting data with instruments onboard.

One class of smaller gliders, called "Slocum gliders," which operate in shallower water, will be deployed for 20 to 30 days during each research cruise. Multiple "Seagliders" will also be deployed for six to nine months at a time. These gliders travel in a wider circumference and dive to greater depths.

Finally, from on board during each of the five one-month ship cruises to the site, scientists will operate a CTD profiler (CTD stands for Conductivity, Temperature and Depth) and a battery-powered, propeller-driven autonomous underwater vehicle that they'll be able to control remotely.

"Salinity has never been measured to the level of detail that SPURS is planning," Chao said.

The questions Chao, Schmitt and others hope to begin to answer with SPURS range from the smallest to the largest scale. For one, what are the physical processes that determine the location and magnitude of the high-salinity region in the Atlantic being studied? What is the salinity balance on monthly and seasonal time scales, plus regional and larger spatial scales?

Larger questions include how the ocean will respond to temperature and freshwater changes likely to come with a warming climate. How will the meridional overturning circulation -- the "global ocean conveyor belt," which has such a dominant effect on the planet's climate -- change?

"We can see in the patterns of salinity change that something big is going on with the water cycle," Schmitt said. "Eighty percent of the water cycle happens over the ocean. We need to document and understand how the ocean is responding."

More information: For more information on this topic, see: www.nasa.gov/aquarius and spurs.jpl.nasa.gov/ .

Provided by JPL/NASA