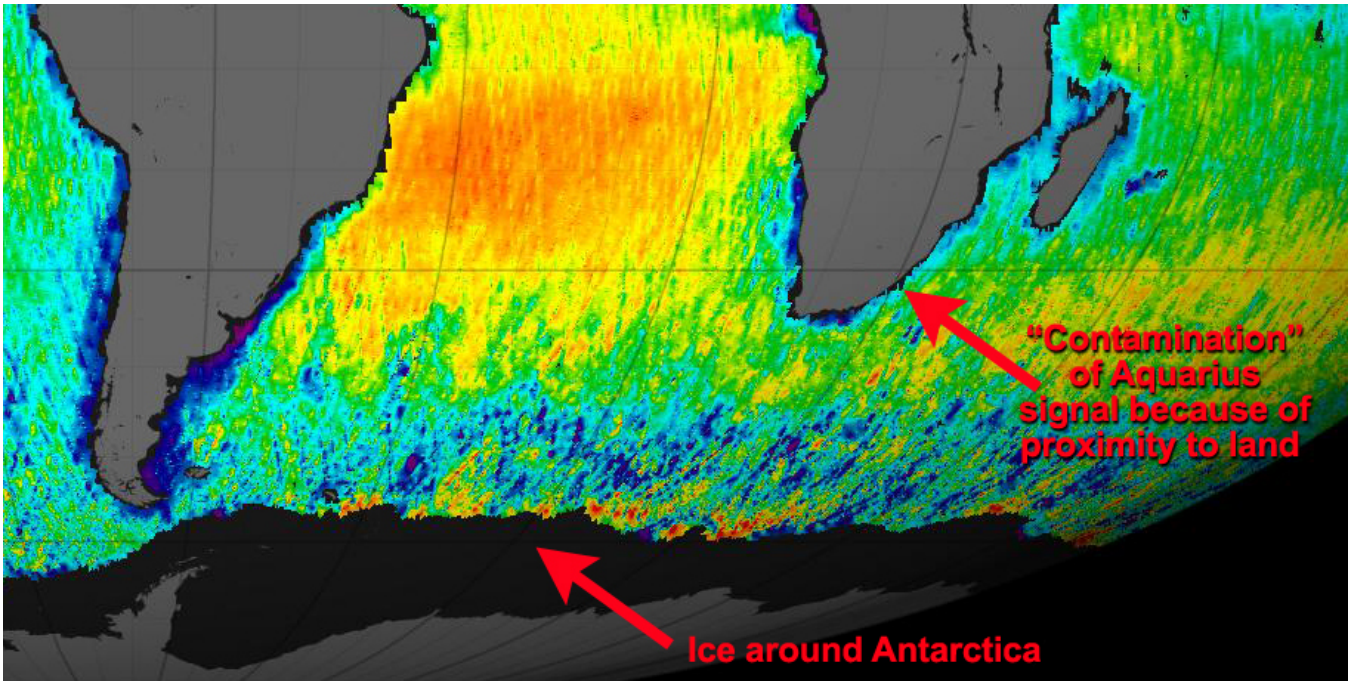
What are the black areas around the edge of the continents in the Aquarius maps?

Gary: If you at the bottom of the "First Light" image around Antarctica, you'll see an area that covered in all black. The reason it's colored in black is because there is sea ice that is surrounding Antarctica; we're not able to retrieve any salinity data in ice-covered waters. We can't through the ice to the water below it. So that area is all blacked out.

If you look around the perimeter of the land areas, you'll see a zone that colored purple. In most of the coastal waters, the salinity is generally lower than it is in the open ocean. But in those areas we are not able to retrieve salinity very accurately. The reason is that Aquarius measures a parameter called "brightness temperature" which has to do with the emissivity* of the surface. The emissivity of the ocean and the emissivity of the land are very different. As the instrument's field of view gets close to the coastline, the energy coming off the land "contaminates" or biases the measurement that we're making, so we can't make very accurate measurements close to shore. It's probably a zone of 300-400 kilometers away from the edge of the coastline is the best that we can do to get accurate retrievals. Some areas of the ocean, like the South Atlantic, it looks like we can get much closer to the coastline so it's going to vary from one part of the ocean to the other; it depends on the contrast of the salinity. So the reason why you see that (black) "halo" around the continents is because there's some bias due to land effects.

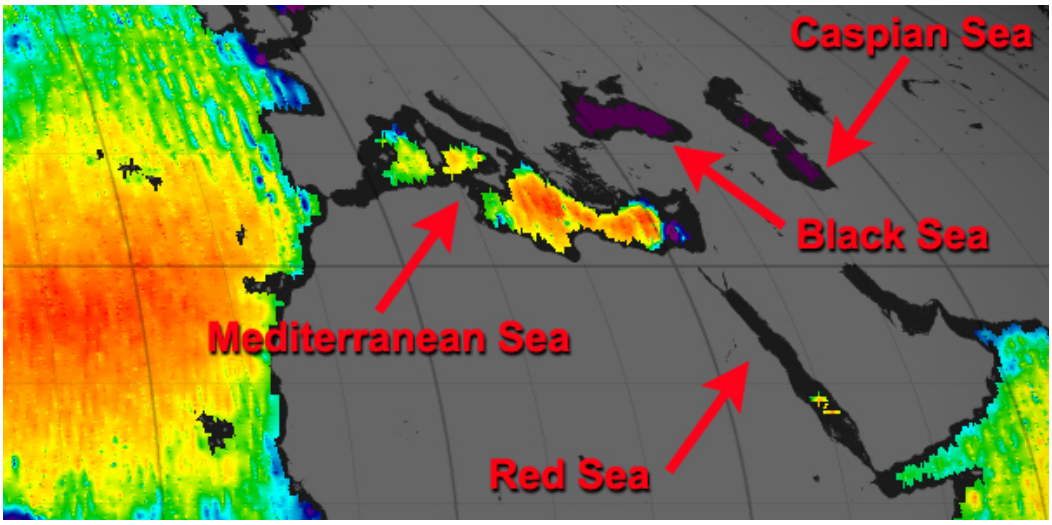
** Definition of "emissivity": the relative power of a surface to emit heat by radiation*



Is the data accurate for the seas and gulfs? Or are they also biased by land?

Gary: You can see (in the figure below) that we have some salinity measurements in the Mediterranean Sea. Those are going to be difficult to calibrate accurately for the same reason. We do have a land correction algorithm in the data processing system that tries to compensate for this. In some areas, it works pretty well, for example in the Gulf of Mexico.

Yi: Land will contaminate the measurements over waters. The data have larger errors as land is approached. Depending upon their size, there might be some good quality salinity data in the "open" seas.



How do you anticipate that Aquarius data will be used by others?

Gary: The main scientific focus of Aquarius is to understand the coupling between changes in the water cycle, ocean circulation and climate. Clearly there are a number of oceanographers that are interested in looking at the data. This is because we really want to understand how ocean salinity varies, in ways we have never been able to measure before. Climate modelers are also very interested in this data because computer models of climate do a very good job of reproducing global temperatures but they don't do as good of job reproducing global ocean salinity or the global water cycle (i.e., rainfall or global evaporation patterns). So ocean salinity it going to be very useful to improving climate models that will also help to improve forecasts of future climate change.

There are probably other practical uses for the data, as well. I would imagine that fishermen who track where major commercial fish go -- like tuna, marlin and others – will find that there are some associations with ocean salinity patterns as well as temperature patterns. We will learn more about how these data can be used as time goes on. So there could be some practical applications down the road but, for the most part, this is going to continue to be a scientific research experiment that will go on for the next 3 to 10 years.

Yi: One thing I want to add is that because this is the first satellite designed to measure ocean salinity, we are still in the process of validating and understanding the data. Things will evolve as the technology gets more mature. This happened for sea surface temperature: satellite-based sea surface temperature data (has been measured for decades) and is being used for a variety of people. This includes researchers and application users who, on a routine basis, look at temperature for fisheries, oil spills, and other applications as well.

What data has surprised you the most thus far?

Gary: I think it's a toss up between what we see off the Amazon River and the fact that were able to see the low-salinity signature associated with Tropical Storm Lee. Those were real surprises.

Since salinity is so directly related to density, will the Aquarius measurements be used with sea surface topography to determine sea surface height and infer temperature?

Gary: Well that's a very insightful question! This is correct: ocean salinity is part of the density equation. Both salinity and temperature govern the density of seawater. As you might guess, as the salinity goes up, the density also goes up. It does the opposite for temperature: as the temperature goes up, the density goes down. So, often times in the ocean, temperature and salinity "offset" each other. That said, satellite altimeters measure sea level that is an integration of the density distribution from the ocean surface all the way to the bottom. As water masses change (i.e., as salinity and/or temperature increase or decrease), you are going to see a change in sea level. So there is going to be connection that we're going to see between Aquarius data and sea level measurements.

However, you have to remember that over most of the ocean, that temperature slightly dominates over salinity in terms of what governs the density of seawater and what governs the sea level. I don't think we're going to use salinity data with altimetry data to derive temperature because we already have very good measurements of sea surface temperature. I think the important thing is to combine the temperature data with salinity data to better understand the ocean's density distribution and how that affects ocean circulation.

How does the tropical storm season affect salinity (e.g., during the peak of the tropical storms in the Atlantic area from August through October)? Is more rainfall going to affect the data Aquarius gathers?

Gary: In heavy rain there is some masking of the data that we collect with Aquarius. We flag that data but it's quite rare: about a couple of percent of the data. So by and large, we're able to accurately retrieve salinity measurements over tropical regions. What's important, though, is that this question is correct: August – October is the rainiest season in the tropics and is also the hurricane season in the Atlantic. So that extra rainfall on the ocean is going to have an impact on ocean salinity and we're able to measure it, we've demonstrated that.

Yi: Tropical storms are usually associated with heavy rainfall, so should have strong salinity expressions: there should be fresh-water signals associated with strong storms that have a lot of rain. Once we validate the Aquarius data, scientists will use the data to study the oceanic response to tropical storms.

Is the data from Aquarius available for use in educational uses such as projection on spherical displays (e.g., SOS or MP or iGlobe)?

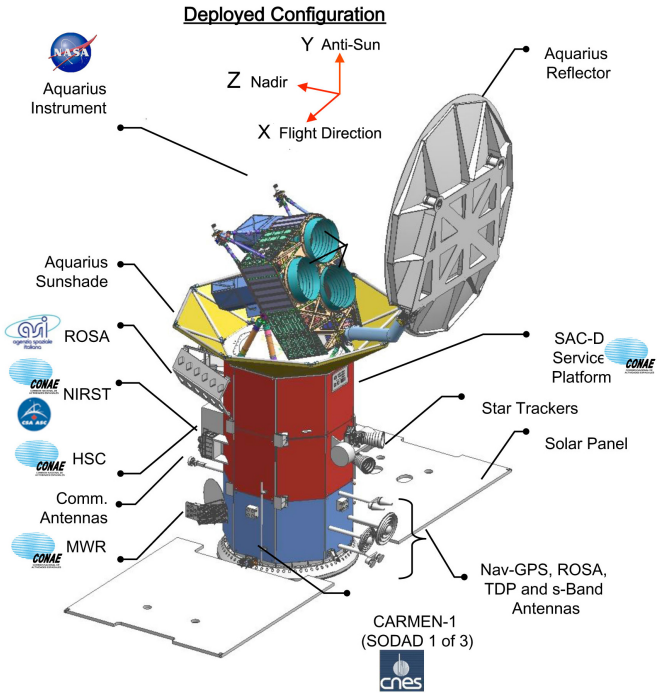
Annette: We are putting the data maps that you've seen on the Aquarius public website for easy access (http://aquarius.nasa.gov/gallery-science.html). In terms of the spherical projections, we're getting to the point of being confident that the data are very good. At that point, we will get together and see if we're ready to distribute data maps in more "fancy" ways such as "Science on a Sphere" or other global projections.

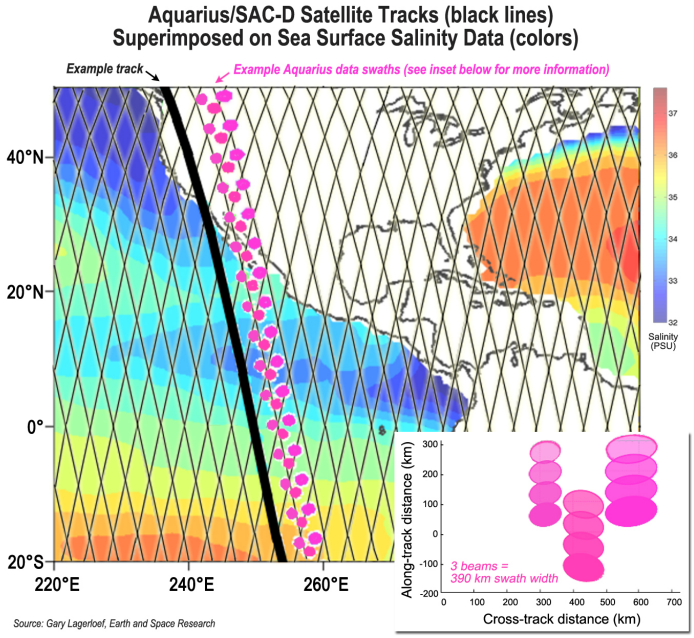
In terms of general education resources, there's a box labeled "Education Resources" on the concept map you're viewing tonight. On the interactive version of the map, you can access links to background videos on Aquarius and its connections to the water cycle, ocean circulation and climate. Also, for folks who like to hear scientists' explanations of basic concepts behind Aquarius, we've got some videos with Dr. Susan Lozier (Duke University). We also have some non-video

resources, including links to the Aquarius website, some "hands on" activities, and data-related activities as well.

Yi: We can certainly share GoogleEarth KML files with Aquarius data; if you are interested please email annette.decharon@maine.edu.

Annette: We also have data tools (http://aquarius.jpl.nasa.gov) that we've been developing with some of the historical salinity data (i.e., World Ocean Atlas). Over time, we are going add Aquarius data to these tools, as well. We briefly presented these types of education resources in last week's webinar (17-Jan-12).





What's the size of samples and what kind of precision do you expect to get?

Gary: That's a good question. We discussed this a little bit during last week's webinar (17-Jan-12) that focused on the instrument but, basically, Aquarius is designed with three separate radiometer instruments. Each one is aligned onboard the satellite such that it reflects off the big parabolic antenna (see "Aquarius Reflector" in image). This creates three "footprints" on the ground and each of the three radiometer beams is slightly different in size: the smallest one has a maximum dimension of 90 kilometers (56 miles) and the largest one has a maximum dimension of 150 kilometers (93 miles). So that gives you an idea of the spatial footprint of the instrument.

Here's a schematic image that shows how Aquarius "paints" its swaths along earth's surface. The black lines are the orbit traces on the ground (i.e., path directly below the satellite). For the thick black line, the pink dots show the three beams' positions relative to that orbit as it moves along. So that's the spatial resolution that we have: roughly 100 – 150 kilometers.

In terms of precision, we are working towards achieving a global accuracy of 0.2 parts per thousand (also called 0.2 practical salinity units). That's 2 parts in 10,000. If you were to take a gallon of freshwater and put a pinch of salt in it (1/8th teaspoon), that's approximately the precision we'll be able to measure with the Aquarius instrument after we get it completely calibrated.

Is there a correlation between salinity and pH?

Yi: Not directly but scientists are still in the process of developing better sensors for in-water samples and it's still a challenge to measure pH from space. It's a research topic.

Is there any way to use Aquarius data as a proxy for ocean pH?

Gary: Salinity can be useful as a proxy for one of the terms that's used to calculate the partial pressure of carbon dioxide gas ("pCO2") in ocean surface waters. There's a parameter called total alkalinity* and salinity factors into the equation for total alkalinity. So some researchers who study the carbon budget in the ocean are interested in using salinity data to help improve their calculations of pCO2. And pCO2 is directly related to pH.

** "Total alkalinity" is usually defined as the quantity of hydrogen ions in millimoles required to neutralize the weak bases in 1 kilogram of seawater (Source: University of Hawaii at Manoa)*

Do oil spills affect any of the satellite data?

Gary: There are some satellites that can pick up oil spill signatures: synthetic aperture radars can and some of the optical instruments showed that they could see the Gulf of Mexico oil spill last year. We don't have any Aquarius data that we can look at to test whether we would see such a signature because the satellite wasn't flying when the Gulf of Mexico oil spill occurred. I think this is something we're going to have to look for opportunities down the road. Of course, we don't want to see any "opportunities" like that but, if there are, we'll certainly take a look at the data.

Do you think you're going to be able to see hurricanes in Aquarius data?

Gary: We think that we did see the signature of one of the Atlantic hurricanes when the satellite passed right over it. It looks like a slow salinity spot in the image but I think that it's as much as an effect of the wind and rain (i.e., changing the roughness of the ocean surface) as it is a change in the ocean salinity. We really don't quite know how to interpret that signature yet… but currently we do see some kind of signature from hurricanes.

Yi: From the theoretical point of view, hurricanes can be strong enough to have very strong rainfall and we should be able to detect the changes in salinity (i.e., decrease because of added freshwater).

Q&A from the "Chat Box"

Does anyone know of instructions for students to make a model of a Lagrangian buoy?

Yi: Here is a student project to build and deploy surface drifting buoys, see http://coseenow.net/mate/

And here is a web tool where students can release surface drifting buoys virtually in a computer model, see http://cencoos.org/sections/products/drop_a_drifter.shtml

Where would someone obtain an electric-powered profiling buoy?

Yi: The profiling buoys powered by battery (i.e., electric) can be purchased from a commercial company, see http://www.webbresearch.com/apex.aspx, costing about $20,000 a piece.

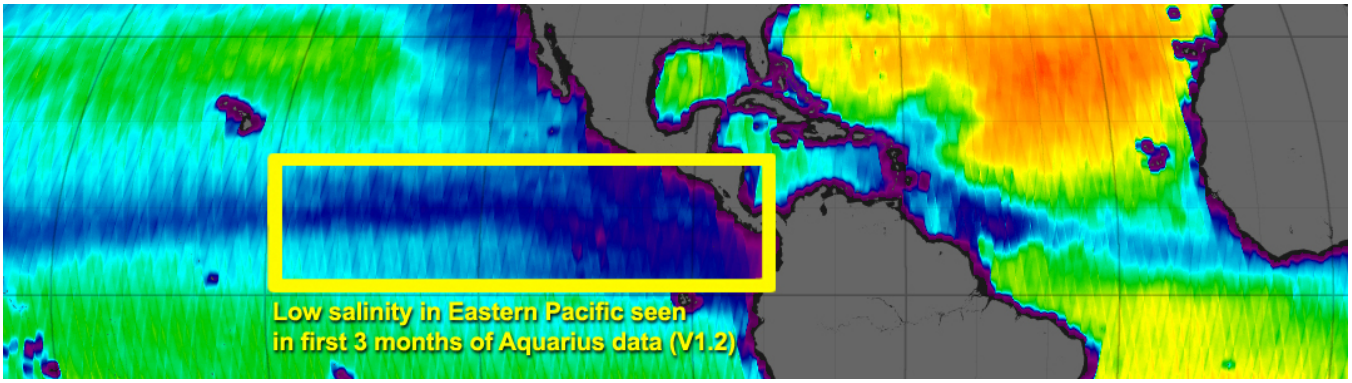
Are buoys still being used?

Yi: Yes, both surface drifting and profiling buoys are used on the routine basis. See http://www.argo.ucsd.edu/ and http://www.pmel.noaa.gov/tao/for more information.

I recently read about the fresh water bulge underneath the Arctic sea ice, does Aquarius have any way to view that or is it based on density, sea-surface height, etc.?

Yi: If there is a fresh-water discharge from the Arctic Ocean and it has a strong enough surface expression, Aquarius should be able to detect it.

Could the low Eastern Pacific low salinity area seen in the first three months of Aquarius be part of the reason for the Costa Rica Dome?



Yi: The Costa Rica Dome* is driven by wind, and has strong signatures in sea surface temperature. It would be great to detect the sea surface salinity expression from Aquarius.

**From National Geographic's "Inside NGC" Blog: The (Costa Rica) Dome is an area of the Pacific Ocean about 500 to 800 miles west of Costa Rica, really closer to Acapulco, Mexico. The spot is hard to find because its actual location changes every year, and that may have saved the whales from whalers, who could not relocate this wintering area from year to year. We had an advantage with satellite tools that gave us vital information on water temperature, so we could identify this upwelling area. http://ngccommunity.nationalgeographic.com/ngcblogs/inside-ngc/2009/03/kingdom-of-the-blue-whale-interview-with-scientist-bruce-mate.html*

How does Aquarius actually measure salinity?

Yi: The measurement that is actually being taken is 'brightness temperature' which is the emissivity (microwave) from the ocean that correlates with salinity/temperature. They use a formula to translate this brightness temp to salinity.

This topic was covered in detail during the 17-Jan-2012 webinar archived at http://cosee.umaine.edu/programs/webinars/aquarius/aqwebinarsjan2012/aqwebinars011712