How fast does Aquarius go around the Earth?

Gary: It takes 96 minutes to make one orbit.

Carla: Do you have any idea fast that is in miles per hour?

David: I think it's 7 kilometers per second (Gary agrees.)

Gary: It's going 4.2 miles per second; that's very fast. It's about 25,000 miles to circle the earth and we do it in 96 minutes that is about an hour and half so it's something like 15,000 miles per hour.

[Answer: 7 kilometers per second is equal to 15,660 miles per hour.]

Is the data compiled on the satellite and downloaded periodically? How does that data get to earth?

Gary: That's a very good question: yes, the data is downloaded at a station in Cordoba, Argentina (a little north and west of Buenos Aires). The photo (below) shows the ground station. Argentina worked with the U.S. on developing this mission. It's part of a bilateral arrangement between the U.S. and Argentina to co-develop earth remote sensing satellites. Aquarius/SAC-D is the fourth mission that's been developed like this. They have a very sophisticated ground station in Argentina and they have the mission control center for Aquarius/SAC-D, as well. So they're doing all the work to control the satellite and also to download the data. The satellite passes over the Cordova ground station about four times per day. So consequently, Aquarius has to store its data onboard and we have enough storage to hold about 16 hours of data. Every time the satellite crosses over the Cordoba ground station we download all the memory that's onboard and the next time it crosses over, we download it again. So sometimes we get multiple copies of the same data and during our ground processing we remove the duplications.

We also have a backup ground station in Italy so if we miss a pass over Cordoba, we can catch it on the next round when the satellite passes over Italy. This lessens our chances of losing any data. So far since we turned on the Aquarius instrument in August 2011, we have not lost a single bit of data. So we have 100% data recovery up until this point so we're very confident that it's working the way it's supposed to. But to answer your question, we do store the data onboard. We can store up to16 hours of data; sometime during that 16 hours we have to have a download in order to preserve it. If we don't get it downloaded, then we start to lose some of the data because it gets overwritten.

With large eruptions of volcanoes, would those have direct correlations with salinity particularly along streams or water outflows?

Gary: There are two potential ways to look at your question. I don't really know how much of an interference of our microwave frequency signal that we would see from a volcanic eruption. We do know that when there are large volcanic eruptions, it certainly throws off infrared frequency measurements from space because the dust and debris get injected into the stratosphere and creates a horizontal cloud that obscures some of the infrared light. But I think that microwave energy (that Aquarius measures) will pass right through so I don't think it will actually affect our measurement. But its impact on the ocean is going to less direct. It will impact the temperature over the long run because it will shield some sunlight and therefore affect the temperature that, in turn, could affect the interaction of the ocean with the atmosphere to change rainfall patterns that would affect salinity. This is because salinity is directly tied to rainfall and evaporation off the sea surface. There wouldn't be any near-term effect but there could be long-range effects associated with volcanic eruptions. But I don't think a volcano is going to have any *direct* effects on sea surface salinity.

When the mission is complete, will Aquarius be removed or continue to orbit around the earth?

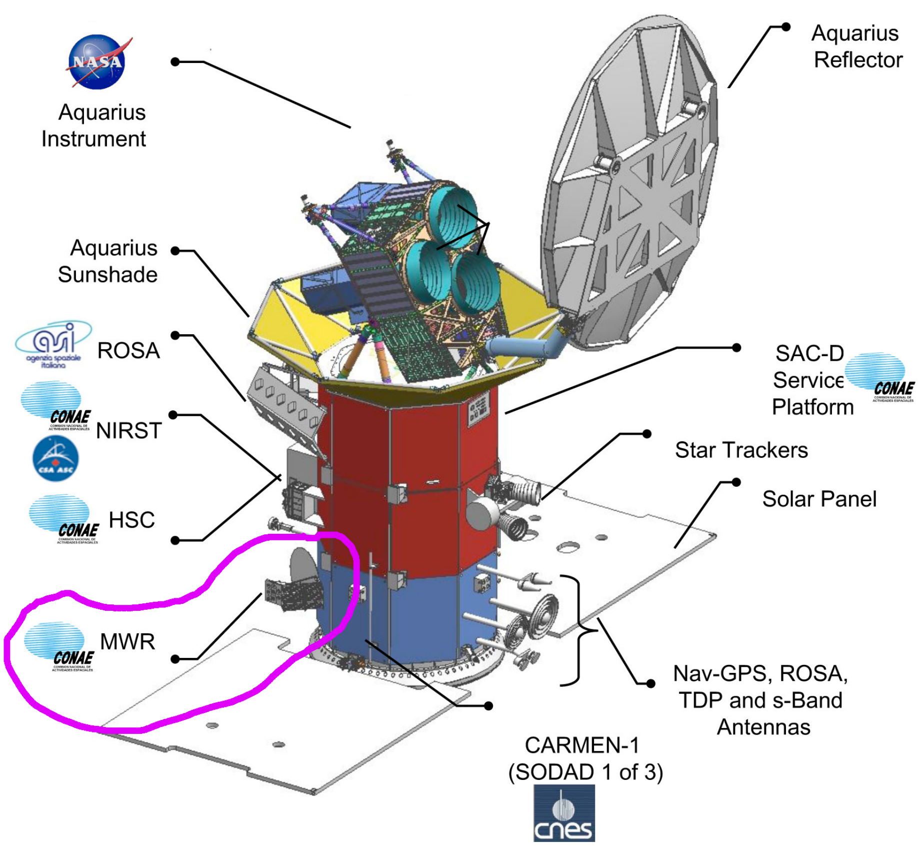
Gary: There are no plans to take it out of orbit. It will stay up there for as long as possible. The way NASA does missions is that they have what is called a "Baseline Mission"; so they give us funding to operate the satellite for three years to meet our baseline science mission goals. We need to demonstrate the feasibility of the technology, which we have done. We also need to make some basic measurements for science: to map the mean salinity field, to look at the seasonal variability, and some interannual (year-to-year) change. After three years, we hope to go to NASA and say, "This is really working well. The scientists love it and are producing a lot of good scientific reports. So we should keep it going." Then NASA could say its okay to keep it going for a few more years, come back again and we'll see how it's going at that point in time. This kind of "leap-frogging" process could keep Aquarius operating for 10-12 years until the satellite finally gives up and stops functioning for some reason or another. Our partners in Argentina intend to keep operating the satellite for as long as possible. We'll continue to collect and process the data and make it available to scientists for as long as we have good data to evaluate. When the mission finally does end and the components stop working, it will just be left in orbit and eventually it will fall out of the sky. But that will probably take 25-30 years before the orbit decays and it comes back toward earth and burns up in the atmosphere as it comes down.

David: I believe that part of the engineering design included a hazards assessment for this final step. There has been a study to make sure that nobody is going to be harmed and it will "end peacefully."

Gary: There's very little probability that any solid debris can hit the ground. There might be a few small metal components -- very tiny things -- but they've done a very careful impact assessment of that and it's considered safe.

Does cloud cover interfere with the measurements?

Gary: Generally no. The microwaves at this frequency band go right through clouds, so clouds are perfectly transparent. The only thing we have to worry about in relation to clouds is that in areas of very heavy rainfall, the rain itself will attenuate (i.e., reduce) some of the signal. We have a way of flagging data where rainfall is heavy by using data from other instruments. We have a microwave radiometer (MWR; see purple circle in lower left of image below) onboard the satellite. The MWR was built by Argentina and its purpose is to look at rainfall and give us that measurement. We can also look at data from other satellites that are orbiting and use that information as well. But we do have to take heavy rainfall into account.



David: I would just like to add that the "L-band" frequency (1.41 GHz) that Aquarius uses is very nice to look at earth's surface because the atmosphere is pretty much transparent so clouds and light rain are not a major factor.

Gary: We ran some simulations before the mission and calculated that we would lose less than 1% of the data due to rainfall. So it's not a significant problem.

Where can we get educational resources associated with this webinar?

These are available on all the concept maps presented by clicking on the "Educational Resources" square at the bottom of each map. The Aquarius website also many educational resources => http://aquarius.nasa.gov

With fourteen orbits per day over three years, especially at the tropical latitudes, will you be able to pick up information on the biological thresholds of organisms related to salinity?

Gary: That's an interesting question. The important thing to understand about marine biology and what affects life in the ocean such as primary productivity is that the saltiness of the water doesn't have much direct effect on sea life. Marine organisms can live pretty much at any ocean salinity. What really governs the concentration of biology in the surface waters is the availability of nutrients and that depends on ocean circulation. The salinity, however, can be a tracer of different water masses, some of which are nutrient-rich and some of which are nutrient-poor. In the coastal areas, there tends to be river water flowing out that can be rich in nutrients. We can also have coastal upwelling that can bring nutrient-rich water from the deeper ocean to the surface; these areas will have surface salinity signatures that we can observe with Aquarius that will help tell us where those nutrient-rich waters are. But it isn't the salinity itself that governs the biological productivity, it's actually the availability of nutrients.

What was the reason the satellite was initially built?

Gary: The mission was conceived with the primary objective to measure the ocean salinity field and the overarching scientific purpose of measuring ocean salinity is to study the interaction between the global water cycle, ocean circulation and climate variability. The global water cycle is rainfall, evaporation off the sea surface, river runoff, freezing of sea ice, melting of ice caps, all of those things that affect where fresh water is in the climate system and how it moves around. In terms of evaporation on earth, 85% comes off of the ocean. So if you look out your window and see clouds, odds are that 85% that the moisture in those clouds was evaporated off the sea surface (as opposed to off a land area). About 78% of the moisture that falls from the sky and back onto earth's surface lands on the ocean.

So more than ¾ of the global water cycle is just the exchange of water between the ocean and the atmosphere. Now that said, we don't really know much about how that affects the ocean. We know it governs the broad-scale patterns of ocean salinity but how small changes in rainfall and evaporation affect the sea surface and how it affects ocean circulation are still largely unknown. That's the essence of what we want to investigate with Aquarius by mapping those variations in sea surface salinity, relating them to rainfall data that we collect from satellites, relating them to ocean temperature data that we collect from satellites, and relating it to ocean circulation data that we collect from satellites. So, in a way, Aquarius is filling in a "missing piece" of information that we really need to completely understand the role of the ocean in regulating climate and interacting with the atmosphere. That's the reason why we built Aquarius.

David: I would just like to add that it's what we call a "Pathfinder Mission" so it has the objectives of demonstrating the technology to measure salinity and then applying the salinity measurements to understanding of ocean dynamics, weather and climate, and the water cycle.

[Next week's webinar (24-Jan-2012) will focus on the scientific results of Aquarius thus far.]

How is the orbital altitude of Aquarius?

Gary: The average altitude of Aquarius/SAC-D is 657 kilometers (408 miles) at the equator.