The North Atlantic Subtropical Surface Salinity Maximum as Observed by Aquarius

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Abstract

The subtropical surface salinity maximum (SSS-max) in the North Atlantic was studied as part of the SPURS (Salinity Processes in the Upper Ocean Regional Study) experiment in 2012-2013. This poster documents the structure and variability of the SSS-max using Aquarius data during the two-year period August 2011 – September 2013. The Aquarius data show the seasonal migration and freshening of the SSS-max in good agreement with previous observations. The extent of the SSS-max has a surprisingly large amount of interannual variability. It has decreased in area by about 20% over the time period that Aquarius has been making measurements. There has also been a general freshening of the area where the SSS-max is located, larger than any expected seasonal changes. The seasonal variability of sea surface salinity is documented. The SSS-max itself shows almost no seasonal variability of salinity, whereas to the north and south of it there is a well-defined seasonal cycle. This highlights the important role played by Ekman transport in the formation of the SSS-max.

Introduction

The SPURS (Salinity Processes in the Upper ocean Regional Study) experiment seeks to understand the dynamics of the sea surface salinity maximum (SSS-max) in the North Atlantic ocean.

The SSS-max has been sparely observed in the past, relying on observations that are coarse in space and time, so we have little knowledge of its structure or variability.

Figure 1. The North Atlantic SSS-max and the SPURS study region. Color is SSS from Aquarius (spurs.jpl.nasa.gov).

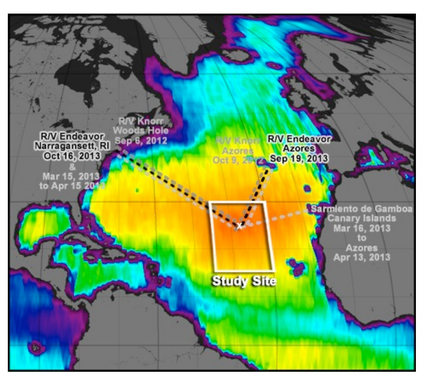
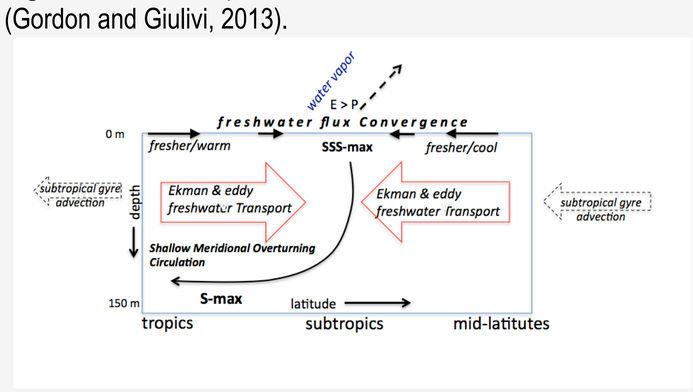


Figure 2. Schematic picture of formation of the SSS-max (Gordon and Giulivi, 2013).

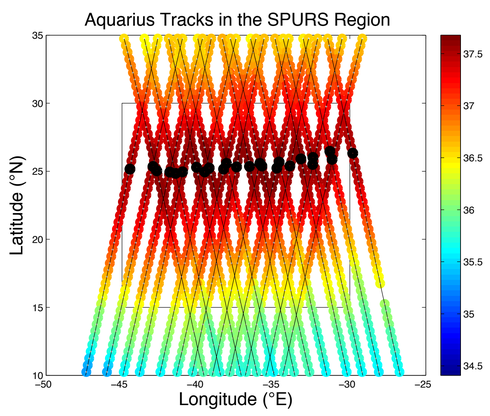


Data and Methods

Aquarius data: Level 2 non-CAP, 10ºN-35ºN. Along-track passes were averaged into 0.5º latitude bins and put into repeat orbits to form time series at "nodes" (Fig. 3).

Time series at nodes were used to do a fit to an annual harmonic to get amplitude and phase

Figure 3. Ground paths of the Aquarius satellite tracks used in this study (slanted black lines). There are 4 ascending (southeast-northwest) and 4 descending (northeast-southwest) tracks, each with 3 beams for a total of 24 lines. The SPURS region (15-30°N, 30-45°W; Fig. 1) is outlined as a black rectangle. Colored symbols indicate mean salinity over the length of the Aquarius mission for each particular node. Black symbols are the mean location of the maximum salinity for a particular track and beam. Note, the colored symbols are about 1/2 the size of the typical Aquarius footprint.



Results

Figure 4. Salinity as a function of latitude averaged for all Aquarius tracks for different months displayed. Curves are color-coded by month, with the code shown in text at the bottom of the figure. a) Aquarius data. b) Volunteer observing ship data.

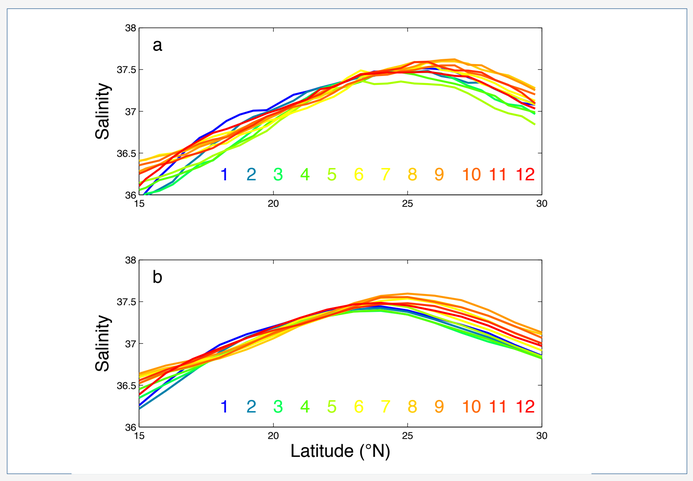


Figure 5. Amplitude (left column) and phase (right column) of the seasonal harmonic of SSS in the SPURS region. Top panels present amplitude and phase as a function of latitude and longitude with color scale at right. Bottom panels present a scatter plot of amplitude and phase as a function of latitude with one dot for each node. Phase value indicates month of maximum in SSS.

The SSS-max is at a location of minimum in seasonal amplitude. Larger amplitudes are seen in the ITCZ (8-10ºN) and 28-30ºN.

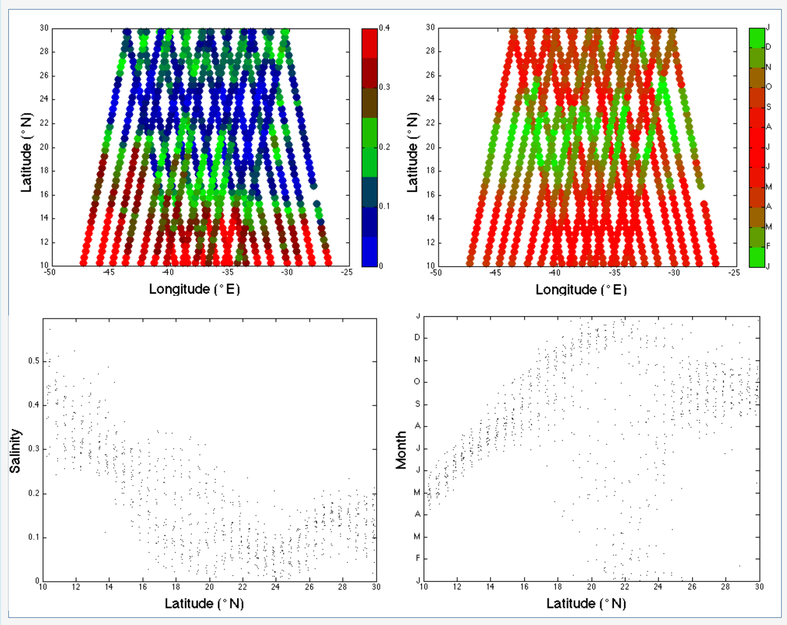


Figure 6. Latitude of SSS maximum as a function of time. Each dot is the location of the maximum for a particular satellite track. Solid line is a monthly average. Light lines are monthly average plus or minus the standard deviation. The figure shows the seasonal migration of the SSS-max, with southward excursions in early spring and northward in late summer.

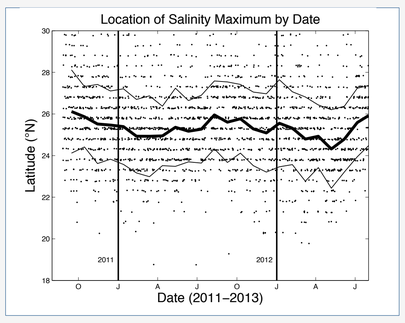


Figure 7. As in Fig. 6, but for the along-track maximum salinity.

The figure shows a large scale freshening that occurred in fall 2011 – spring 2012. It indicates that there are previously unobserved large scale changes in the SSS-max.

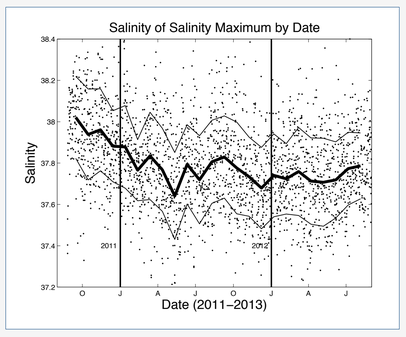
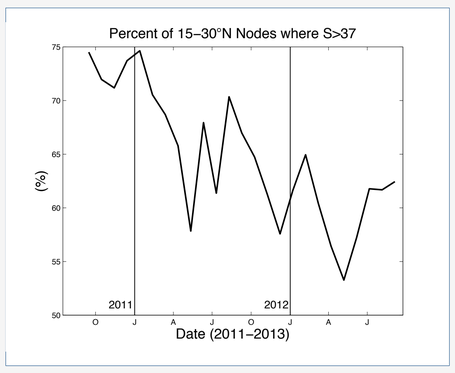


Figure 8. Percent of nodes in the SPURS region where SSS>37 as a function of time.

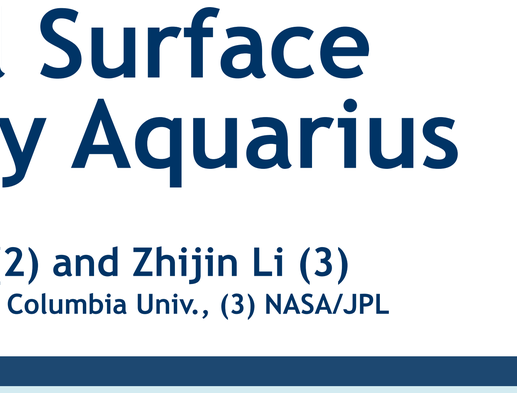
This shows a major decrease in the size of the SSS-max feature, or a decrease in its salinity.



Results

Figure 9. Linear trend of SSS from Aquarius data in the SPURS region. Color code at right indicates the slope of the salinity-time curve in pss/year.

This figure shows that SSS has been decreasing over most of the SPURS region since Aquarius went into orbit.



Global Results

Harmonic analysis was also done on a global Aquarius dataset and separately with Argo data to compare the way that the seasonal cycle is depicted by the two different data sources.

Results show that the seasonal cycle is very consistent between the two datasets. Median amplitude difference between Argo and Aquarius is 0.1. Median phase difference is 0.09 months (2.7 days).

Agreement in phase is better with larger amplitudes.

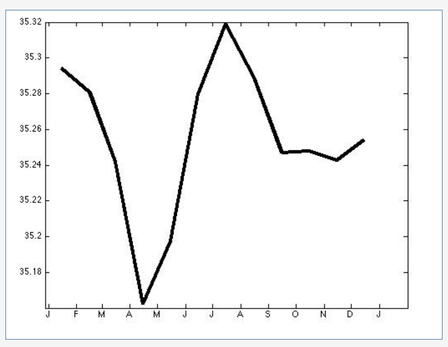
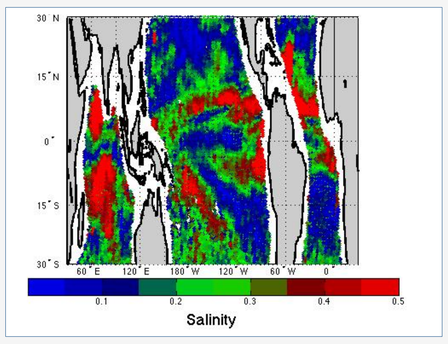


Figure 10. Monthly average SSS 30ºS-30ºN. Average SSS has a semi-annual component to its variability, with maxima in January and July and minima in April and November.

Figure 11. Amplitude (pss) of the seasonal cycle of SSS from Aquarius data. A figure made using Argo data looks very similar (not shown).



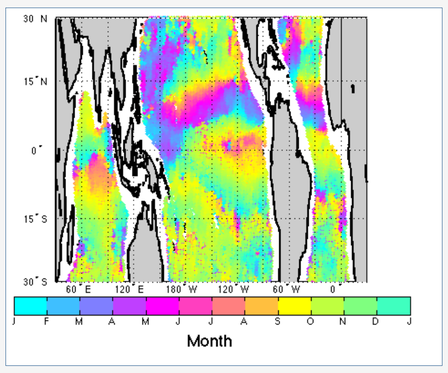
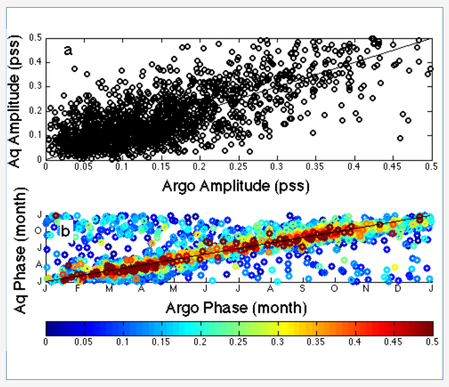


Figure 12. Phase (month of maximum SSS) from Aquarius data. A figure made using Argo data looks very similar (not shown).

Figure 13. Scatterplot of amplitude (a) and phase (b) of Argo (x-axis) vs. Aquarius (y-axis). Each symbol represents one 2.5ºX2.5º square in the range 30ºS-30ºN. In b), the symbols are color-coded by the Aquarius amplitude, with scale in pss at bottom.



Acknowledgments

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