

REMOTE SENSING OF SALINITY AND OVERVIEW OF RESULTS FROM AQUARIUS

D.M. Le Vine¹, E.P. Dinnat¹, T. Meissner², F. Wentz², S.H. Yueh³, G.S.E. Lagerloef⁴

Goddard Space Flight Center, Greenbelt, MD 20771
Remote Sensing Systems, Santa Rosa, CA 95401
Jet Propulsion Laboratory, Pasadena, CA 91109
Earth and Space Research, Seattle, WA 98121

1. INTRODUCTION

Aquarius is a combined active/passive microwave (L-band) instrument designed to map the salinity of global oceans from space. The specific goal of Aquarius is to monitor the seasonal and interannual variation of the large scale features of the sea surface salinity (SSS) field of the open ocean (i.e. away from land). The instrumentation has been designed to provide monthly maps with a spatial resolution of 150 km and an accuracy of 0.2 psu.

2. REMOTE SENSING SALINITY

These are requirements derived from the need to better understand the buoyancy driven circulation of the ocean and its relationship to climate and the global water cycle. The thermohaline circulation moves large masses of water and heat around the globe and understanding this flow is important for understanding climate and climate change. For example, changes in fresh water input due to melting polar ice, can change alter the path of warm salty water from the Gulf Stream into the North Atlantic where it helps moderate the climate of Europe. Salinity is also an indicator of the balance between evaporation and precipitation over the oceans and therefore is an indicator for understanding the global water cycle.

Salt modifies the conductivity of water and the conductivity of water determines the thermal emission of the water. The sensitivity of changes in thermal emission to changes in salinity is strong enough at the low frequency (long wavelength) end of the microwave spectrum to measure with modern day radiometers. A practical frequency to make this measurement from space is in the window at 1.413 GHz set aside for passive use only. But in the real world there are other considerations. The most important are the effect of surface roughness (waves) on the emissivity, Faraday rotation, and other sources of radiation in this band (e.g. from galaxy, the Sun and atmosphere, and also manmade interference, RFI).

3. AQUARIUS

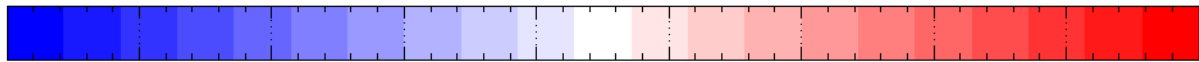
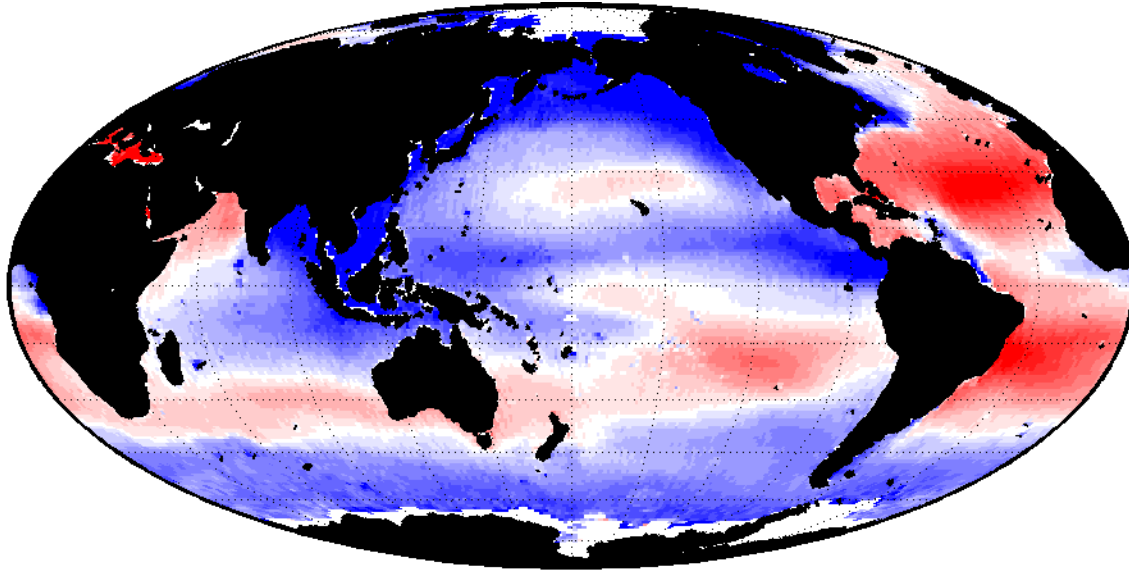
Aquarius is a radiometer/scatterometer combination instrument specifically designed to address these issues. The radiometer (1.413 GHz) measures thermal radiation from the surface and is the primary instrument for detecting salinity. It includes a measure of the third Stokes parameter to provide an in situ measure of Faraday rotation. The scatterometer has been added to provide a measure of roughness and help correct for the effect of waves. Other features such as the orientation and antenna design have been selected to avoid contamination from the Sun, and careful thermal design and internal reference sources provide the stability needed to detect the small signal changes associated with the dynamic range of sea surface salinity in the open ocean. Special provision, rapid sampling, have also been made to help mitigate the impact of RFI.

Aquarius is doing well. The instrument was launched in June, 2011 and produced its first map of sea surface salinity in September. It has been operating successfully since and with accuracy close to the goal of 0.2 psu (RMS error of monthly global map). Figure 1 shows the retrieved salinity field for the most recent year of Aquarius data (August, 2013 – September, 2014). The major features expected from climatology are present, including the saltier Atlantic Ocean and the freshwater signature of the Inter-Tropical Convergence Zone (ITCZ). Other features such as the salty Arabian Sea and much fresher Bay of Bengal in the Indian Ocean can also be seen. Dynamic features of salinity field, such as the response of salinity in the Bay of Bengal to the ebb and flow of the Indian monsoon and changes in the freshwater plume from the Amazon River can be seen in the monthly salinity maps.

4. STATUS

Data from a new version of the retrieval algorithm, V3.0, was released in June. This involves substantial improvements such as reduction in a bias between salinity retrieved during ascending and descending passes over the same region (due to incomplete correction of galactic background radiation) and improved calibration at the warm (land) and cold (celestial sky) extremes. Triple location estimates of the accuracy of the new retrieval compared to ARGO float and HYCOM ocean model data (Table I) indicate that Aquarius is close to achieving its goal of 0.2 psu.

The observatory itself, Aquarius/SAC-D, is doing well. Most instruments are now producing science results and initial issues with the star tracker have been resolved. However, the Microwave Radiometer (MWR) is currently off-line due to as yet unresolved issues. The CONAE technical demonstration package (TDP) is no longer working but met its technology goals.



33 33.5 34 34.5 35 35.5 36 36.5 37 37.5
Aquarius SSS year #3 (Sept 2013 - Aug 2014)

Figure 1: Average global salinity field for the year September, 2013 through August, 2014. The data were produced by V3.0 of the retrieval algorithm and represent Level 2 data mapped to a 1 degree grid.

Table I: Aquarius Error Estimates

Differences: Aquarius – HYCOM - ARGO		
Aquarius --- HYCOM	Aquarius --- ARGO	HYCOM --- ARGO
0.24	0.27	0.25
Triple Location		
Aquarius	HYCOM	ARGO
0.22	0.16	0.19