# AQUARIUS RFI DETECTION AND MITIGATION

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## ABSTRACT

Aquarius is an L-band instrument designed to map sea surface salinity from space. Monitoring salinity from space is a particularly sensitive measurement and RFI is a concern, even in the protected band at 1.4 GHz where the Aquarius radiometers operate. To protect against RFI, the Aquarius radiometer samples rapidly and a glitch detection algorithm is employed to check each sample for RFI. This strategy has worked well over oceans, but there are large areas over land, especially in Asia and Europe, where contamination by RFI affects most samples.

***Index Terms***— Radio Frequency Interference, L-band, Microwave Radiometry, Microwave Remote Sensing

## 1. INTRODUCTION

Aquarius is an L-band radiometer system designed to map sea surface salinity from space [1,2]. This is a sensitive measurement and protection from RFI (radio frequency interference) is important for success. Aquarius is the primary instrument on the Aquarius/SAC-D observatory, a partnership between the USA space agency, NASA, and the Argentine Space Agency, CONAE which was launched on June 10, 2011 from Vandenberg AFB in California. Aquarius was turned on two months later and has been operating continuously since August 25, 2011. Among the special features of the Aquarius radiometers are the provisions for detecting and mitigating RFI. Although the radiometers are designed to operate in the spectral window at 1.413 GHz which has been set aside for passive use only, the presence of RFI in this band has been well documented. For example, RFI has been reported in airborne instruments operating in this band [3,4] and the recent observations of the MIRAS instrument aboard SMOS [5] confirms that RFI in this band is a serious problem for remote sensing from space. The problem is particularly acute for remote sensing of salinity because of the relatively small dynamic range of the signal. Over the open ocean, salinity changes only a few psu, from about 32 to 37 psu, which corresponds to a change in radiometric brightness temperature of a few Kelvin (the sensitivity is about 0.05 K/psu). Consequently, erroneous measurements due to undetected RFI can have a major impact on the accuracy of the retrieved salinity. In order to mitigate the effects of RFI, Aquarius employs rapid sampling and a "glitch detection" algorithm [6]. The algorithm has its heritage in a procedure designed to detect impulsive RFI such as due to radar which is known to be a source of RFI in this band. The goal is to sample much faster than the Nyquist rate for imaging (i.e. many samples per image pixel) in the hope that samples corrupted with RFI can be identified and removed without having to discard data for the entire pixel. The 'glitch detector" examines each short-time sample to detect outliers which are presumed to be associated with RFI. This approach appears to be working well and Aquarius is producing maps of salinity of high scientific quality over the open ocean. It is also producing maps of the RFI environment at 1.4 GHz

## 2. RFI DISTRIBUTION

The distribution of RFI is consistent with expectations and with the observations of SMOS [7]. Both sensors detect persistent and significant sources of RFI over land in Eastern Asia (China) and Eastern and Central Europe and also associated with radars in the DEW line in North America (red spots parallel to the boundary between the USA and Canada in Fig 1), although Aquarius appears to be detecting more RFI. In addition to high power radar, the RFI detected by Aquarius occurs in the vicinity of the population centers of the world including large cities in South America and Africa. This is illustrated in Figure 1 which shows the percentage of samples flagged by the glitch detector as RFI. The pattern of areas with a high probability of RFI is consistent with similar maps produced by SMOS [7] and the pattern in South America coincides well with population centers.

However, RFI can enter the instrument via the antenna side lobes, and strong sources located far from the current pixel can affect the sensor. An example is the RFI in Figure 1 which appears as a halo around the DEW line, part of which appears over the North Atlantic extending from east of Greenland southward toward the mid-Atlantic states of the USA. Comparing the signal as seen in the different Aquarius beams and the two polarizations suggests that the

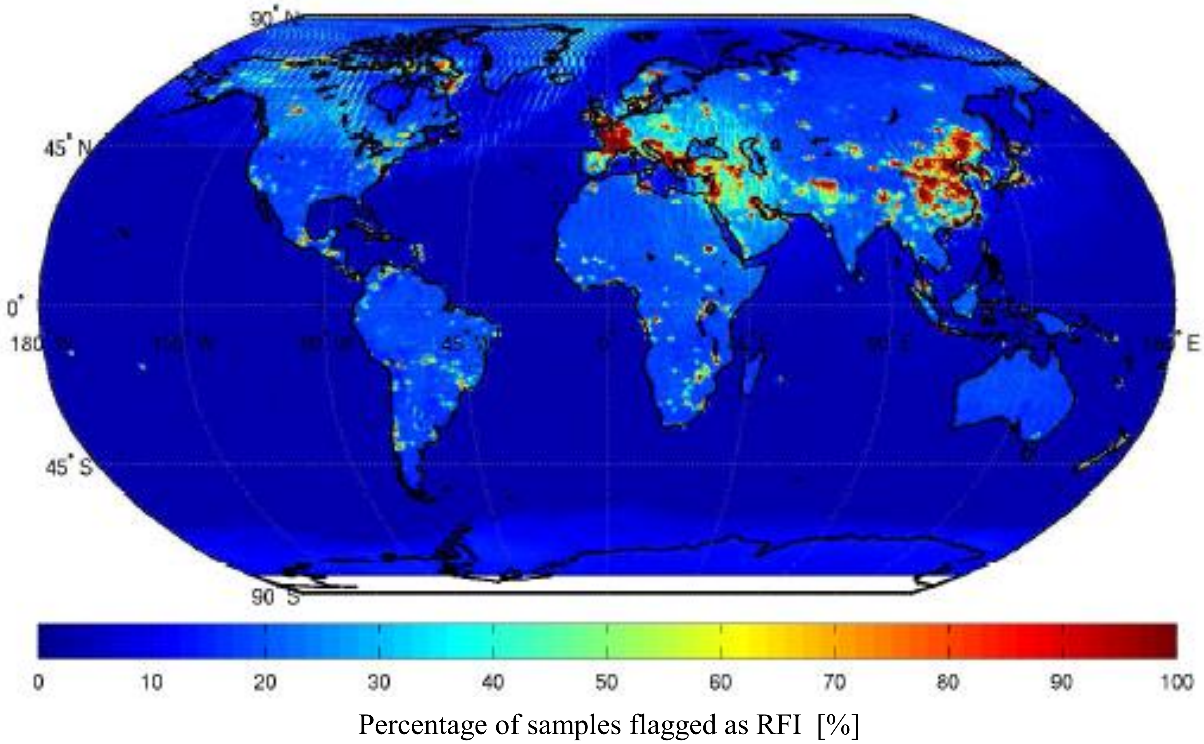


Fig 1. Percentage of Aquarius samples flagged as RFI for one year (August 25, 2011 to August 25, 2012. This is the average of observations at both horizontal and vertical polarization.

source is somewhere else. Radars have been identified as sources of RFI in the past, suggesting that perhaps the source is the DEW line radars. A similar situation occurs in the Western Pacific ocean off the coast of Asia. For the most part, RFI over the oceans is much less than over land and has a smaller impact on the radiometer performance (dark blue in Figure 1).

## 3. RFI MITIGATION

The Aquarius algorithm identifies individual samples suspected of RFI and removes them from the data stream. Individual samples represent an integration of time of about 10 ms. Samples free of RFI are averaged together to produce a single value every 1.44 seconds. This 1.44 sec data "block" is the fundamental unit used in the salinity retrieval algorithm. The effective radiometer NEDT is determined by the number of samples in this data block. The impact of RFI is to reduce the number of samples and thus increase the NEDT. Over the ocean, RFI is generally small enough to have only a minor impact on NEDT, but the situation is much worse over land, where in certain regions (e.g. those areas in red in Figure 1) entire data blocks are removed from the data stream because of RFI.

## 4. SUMMARY

The Aquarius RFI detection and mitigation algorithm is working well over ocean. Research is underway to quantify the false alarm rate and missed detection rate of the algorithm. These metrics depend on the scene (e.g. land or ocean). The brightness temperature of the scene contributes to the total radiometer "system temperature" which determines the NEDT of the radiometer, and the thresholds in the algorithm are based on the NEDT of the radiometer. For example, without tuning the algorithm, data over land will have a higher false alarm rate because of the higher system temperature translates into a higher NEDT. This can be seen in Figure 1 as the lighter blue background over land than over ocean, implying more RFI over land. The goal of the current work is to tune the parameters of the algorithm for optimum observations including viewing over both land and ocean.

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