

# **AQUARIUS RADIOMETER PERFORMANCE: EARLY ON-ORBIT CALIBRATION AND RESULTS**

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## **1. INTRODUCTION**

The Aquarius/SAC-D observatory was launched into a 657-km altitude, 6-PM ascending node, sun-synchronous polar orbit from Vandenberg, California, USA on June 10, 2011. The Aquarius instrument was commissioned two months after launch and began operating in mission mode August 25. The Aquarius radiometer meets all engineering requirements, exhibited initial calibration biases within expected error bars, and continues to operate well. A review of the instrument design, discussion of early on-orbit performance and calibration assessment, and investigation of an on-going calibration drift are summarized in this abstract.

## **2. RADIOMETER HARDWARE AND PRE-LAUNCH CALIBRATION**

The Aquarius radiometer is a three-beam pushbroom radiometer measuring the first three Stokes parameters at 1413 MHz with 25-MHz bandwidth [1]. It operates within the 1400-1427 MHz primary exclusive allocation for passive sensing to avoid severe radio-frequency interference (RFI) and still maintain sensitivity to sea surface salinity. The radiometer is internally calibrated with a reference load and multiple noise diodes to maintain 0.13Krms/7-day stability [2] and externally calibrated using global averaged expected antenna temperatures or the oceanic vicarious cold-point brightness temperature [3] for longer term time periods. Pre-launch calibration measurements were carried out to measure values and temperature coefficients of front-end losses and noise diode excess noise temperatures after the methods in [4]. The predicted calibration bias prior to launch was +/- 4.4-K (3-sigma).

### 3. INITIAL PERFORMANCE AND CALIBRATION BIAS ASSESSMENT

Upon power-up the radiometer achieved thermal and radiometric stability within the first few hours. This allowed an initial performance estimate to be completed on the first day of operation. NEDT estimates were made over the open ocean using two-sample Allan deviation calculations. The measured NEDT's are 0.12 K (on 1.44 second integration footprints) for vertical and horizontal polarizations and 0.15 K for third Stokes parameter channels. The instrument starting on the first day continues to produce high-quality antenna temperatures of the Earth's surface. Two key design features enabling the observed performance are the strict thermal controller and oversampling for mitigation of RFI. The stable thermal environment created by the automatic thermal controller allowed the radiometer to produce quality data almost immediately after turn-on. Likewise, the RFI mitigation system, which is a combination of hardware-based oversampling [5] and ground-software based detection and removal [6], allows the radiometer to operate through the challenging RF environment found at L-band. Evidence of stable, RFI-free data over the ocean can be seen in the antenna temperature mosaic (horizontal-polarization) shown in Fig. 1. (The diagonal striations are an artifact of the three distinct incidence angles and by using both ascending and descending passes.)

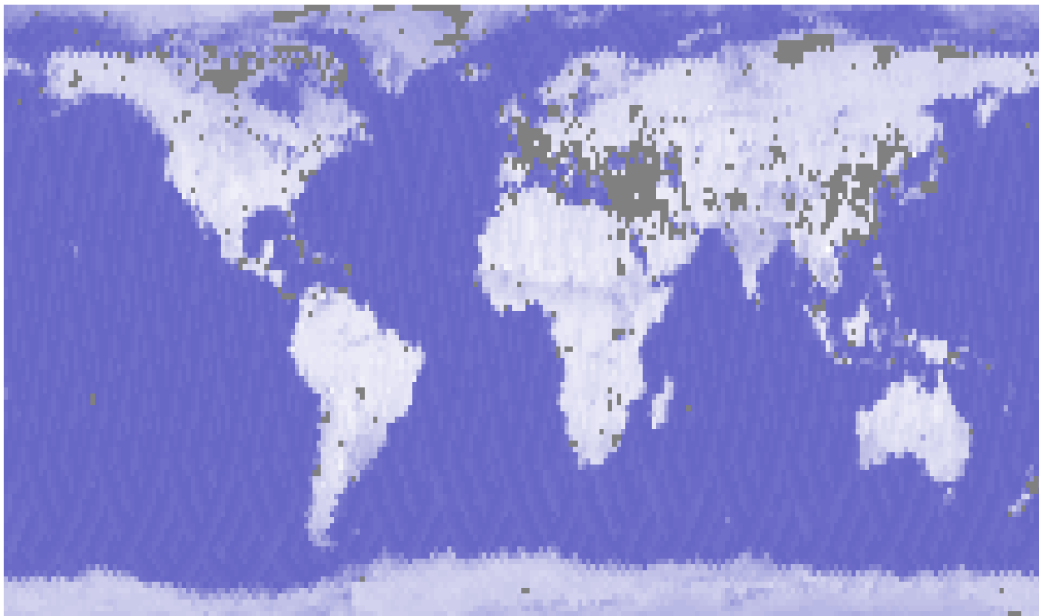


Figure 1. Mosaic of horizontal-polarized antenna temperature during first week of operation starting August 26, 2011. Data are gridded on 1.5-deg grid preserving the last acquired value. Gray areas represent locations where at least one of three radiometers suffered persistent RFI.

Finally, an initial calibration bias (reference to ocean TA's) was performed using both vicarious cold point and global average expected antenna temperatures. Biases on all channels were smaller than the maximum expected and negative, indicating a systematic error in the pre-launch calibration. Values of the initial biases are shown in Table 1.

Table 1. Day-1 (25-Aug-2011) Estimates of Antenna Temperature Calibration Bias.

Method (Polarization)	Beam 1	Beam 2	Beam 3
Vicarious Cold (H-pol)	-1.2	-0.8	-0.3
Vicarious Cold (V-pol)	-3.7	-3.7	-2.7
Global Average (H-pol)	-1.7	-1.1	-0.3
Global Average (V-pol)	-3.6	-3.6	-2.6

#### 4. CALIBRATION DRIFT CORRECTION

Subsequent daily analysis reveals a slowly varying drift in the calibration bias. Such a drift was not unexpected and similar settling was witnessed during engineering model testing [7]. The majority of the drift is a monotonic change in gain calibration, likely due to changes in the noise diode coupling circuits. However, a second non-monotonic component is also present and may be due to RF impedance changes in the front-end. The exact physical mechanism is still under investigation, but presently the drift signature can be explained by two different ratios of radiometer calibration counts (i.e., detector outputs):

$$D_1 = \Delta C_{ND1} / \Delta C_{ND2} \quad D_2 = \Delta C_{ND1/DL} / \Delta C_{ND1/ANT}$$

where the first ratio is one of internal noise diode counts to external noise diode counts and the second is formed by the ratio internal noise counts while switched to the Dicke load vs. the antenna. The former yields the relative drift of the two different noise sources and is found to vary monotonically with time. The latter is sensitive to front-end impedance changes and carries the non-monotonic signature. The signatures of  $D_1$  and  $D_2$  can be fit to the observed calibration drift and used to reproduce it with an error of  $\sim 60$  mKrms, providing strong evidence the drift is indeed due to hardware changes. A correction algorithm based on these results is being developed.

## 5. ACKNOWLEDGMENTS

Data were furnished through the NASA/CONAE Aquarius/SAC-D Project.

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