CHARACTERIZATION AND CORRECTION OF AQUARIUS LONG TERM CALIBRATION DRIFT USING ON-EARTH BRIGHTNESS TEMPERATURE REFERENCES

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1. INTRODUCTION

The Aquarius/SAC-D mission was launched on June 10, 2011 from Vandenberg Air Force Base. Aquarius consists of an L-band radiometer and scatterometer intended to provide global maps of sea surface salinity. One of the main mission objectives is to provide monthly global salinity maps for climate studies of ocean circulation, surface evaporation and precipitation, air/sea interactions and other processes. Therefore, it is critical that any spatial or temporal systematic biases be characterized and corrected. One of the main mission requirements is to measure salinity with an accuracy of 0.2 psu on monthly time scales which requires a brightness temperature stability of about 0.1K, which is a challenging requirement for the radiometer. A secondary use of the Aquarius data is for soil moisture applications, which requires brightness temperature stability at the warmer end of the brightness temperature dynamic range. Soon after launch, time variable drifts were observed in the Aquarius data compared to in-situ data from ARGO and models for the ocean surface salinity. These drifts could arise from a number of sources, including the various components of the retrieval algorithm, such as the correction for direct and reflected galactic emission, or from the instrument brightness temperature calibration. If arising from the brightness temperature calibration, they could have gain and offset components. It is critical that the nature of the drifts be understood before a suitable correction can be implemented. This paper describes the approach that was used to detect and characterize the components of the drift that were in the brightness temperature calibration using on-Earth reference targets that were independent of the ocean model.

2. ON-EARTH REFERENCE TARGETS

To track the calibration of Aquarius, we have extended a technique originally developed to stabilize the climate calibration of the water vapor radiometers on the NASA altimeter missions, Topex/Poseidon, Jason-1 and Jason-2 [1]. The basic technique is to use known references at several brightness temperature levels to track both the gain and offset stability of the radiometer. While the technique is applicable, the particular model references developed for the higher frequency altimeter radiometers are not directly applicable at L-band. This required the development of model references suitable for L-band and a characterization of their uncertainty at various time
scales. Particular to Aquarius, this implies assessing the timescale for which the model uncertainty is less than 0.1K; since the uncertainty is typically Gaussian distributed (e.g. physical temperature knowledge, radiometer NEDT) and reduces with longer period averages (e.g. more samples).

These reference models include very heavily vegetated rainforest, flat dry desert areas and stable regions of Antarctica. We will describe the reference model for each of these areas and the associated uncertainty. We will present the results from the application of these techniques for the characterization and correction of the Aquarius long term calibration during the first two years of the mission.

3. CHARACTERIZATION AND CORRECTION OF DRIFT

It was observed soon after launch that the Aquarius measurements were drifting relative to in-situ data from ARGO and the HYCOM salinity model. An example of the Aquarius drift in brightness temperature compared to that computed from the ocean brightness temperature model available on the Level 2 product that uses HYCOM salinity as input is shown in Figure 1 for the v-pol channel of horn 3. Two features are observed in the bias in Figure 1; one is a longer period exponential drift and the other is shorter term periodic oscillations. The brightness over the ocean is typically near 100 K for the Aquarius incidence angles and the dynamic range is very small. Therefore, the ocean data themselves cannot help to identify the nature of the drifts, whether they are gain drifts, offset drifts, or some combination of both. To do this, comparisons at other brightness temperatures are required. We compared the Aquarius data to the reference model developed for Antarctica and the Amazon to assess the drift at other brightness temperature levels. If the drift was purely a gain drift, then the magnitude would be approximately half around 200K (ice) and nearly zero over the radiometrically warm Amazon (~300K). The results showed that the exponential drift was a gain drift, whereas the shorter period oscillations were biases independent of brightness temperature. This is illustrated in Figures 2 and 3. Figure 2 shows the Aquarius data compared to the Antarctica model. Both types of instability are present, but the long time period exponential drift magnitude is approximately half of that from the ocean comparison. Given this result, an initial correction was made to the Aquarius data to remove the exponential gain drift. The residual oscillations were then compared over the ocean and Antarctica and found to be similar in magnitude. This suggested that these oscillations were independent of brightness temperature level and also not a model error since both models were independent. A third comparison was done over the warm Amazon to verify. Because the emissivity of the Amazon is very close to unity, the surface temperature must be known to the 0.1K level or better to track the observed oscillations. It was found that in situ or model data could not reach this level of precision on time scales less than 30 days and were hence not able to track the wiggles. But it was found that inter-channel differences between the Aquarius V & H-pol channels could be used to track the oscillations at the warm end. Figure 4 shows the inter-channel
It is observed that both show similar calibration oscillations despite the ~200K difference in brightness temperature, indicating these are offset oscillations.

Figure 1. Example of Aquarius Horn 3 V-pol channel TB drift compared to the Level 2 ocean model.

Figure 2. Example of Aquarius Horn 3 V-pol channel TB drift compared to the Antarctic TB model.
Figure 3. Example of Aquarius Horn 3 V-pol channel TB offset oscillations over Antarctica (black line) and from the ocean model (blue line).

Figure 4. Example of Aquarius inter-channel differences over the Amazon and ocean showing similar calibration oscillations despite the ~200K difference in brightness temperature, indicating these are offset oscillations.

4. REFERENCES