Performance Degradation and Q/C Flagging of Aquarius L2 Salinity Retrievals

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1 Objective

This memo summarizes the results of an analysis of the degradation in the Aquarius Level 2 salinity retrievals under a variety of environmental and geophysical conditions. The performance metric is SSS Aquarius – HYCOM or, equivalently, TF measured – expected. Based on the observed performance degradation we have derived threshold values for the L2 Q/C (quality control) flag. Most of the flags have a moderate (most data excluded) and a severe (less data excluded) setting. Some flags have only one setting. The conditions for the moderate/sever setting are written in a mutually exclusive way. One important guideline for the setting is to maximize the quality of the unflagged data while at the same time minimizing unnecessary data loss.

The analysis is based on RSS testbed V4.2, which is equivalent to ADPS V2.5.1.

2 Results for Performance Degradation

2.1 Land Contamination

gland interval		number of events	BIAS	STANDARD DEVIATION
0.00000	0.00010	22783096	0.007	0.420
0.00010	0.00020	3853818	-0.029	0.481
0.00020	0.00050	5115499	-0.061	0.484
0.00050	0.00100	3651109	0.002	0.558
0.00100	0.00200	3172253	0.034	0.658
0.00200	0.00400	2452960	-0.004	0.906
0.00400	0.00800	1180918	-0.168	1.267
0.00800	0.01200	418335	-0.395	2.123
0.01200	0.02000	455848	-0.434	2.289

Table 1: SSS Aquarius – HYCOM [psu] as function of g_{land}. The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,8,13,14,15,18,19 were set.

Recommended threshold:

1. moderate: $0.001 \leq g_{land} < 0.01$
2. severe: $g_{land} \geq 0.010$

2.2   Sea Ice Contamination

We use the same threshold setting as for land contamination (section 2.1). The degradation for sea ice contamination is slightly less than for land contamination without using land correction table. However, currently we do not perform any sea ice correction in the L2 algorithm.
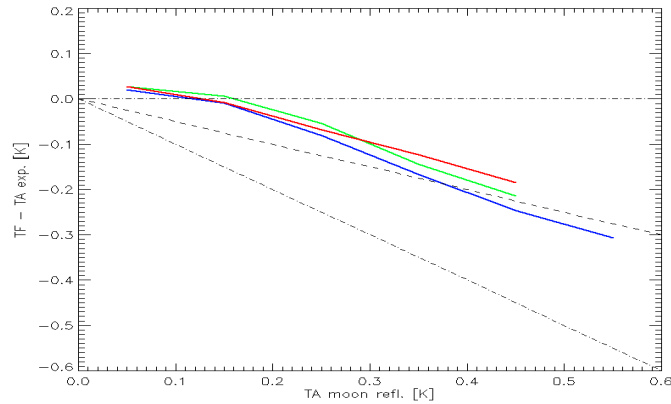
2.3   Lunar contamination

Figure 1: Bias TF measured – expected [K] as function of reflected moon TA. Blue = horn 1. Green = horn 2. Red=horn 3. The figure shows I/2 = (V+H)/2.

Recommended threshold:

1. moderate: 0.25 K < TA moon refl (I=V+H) < 0.50 K.
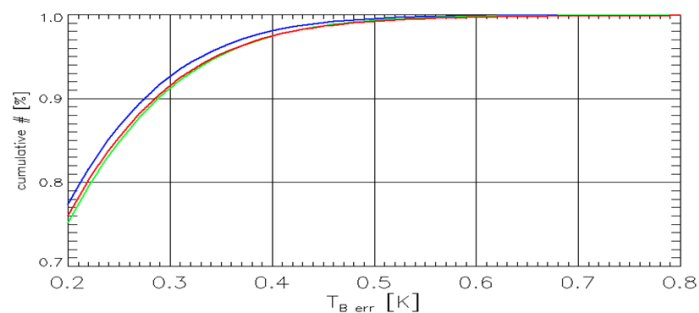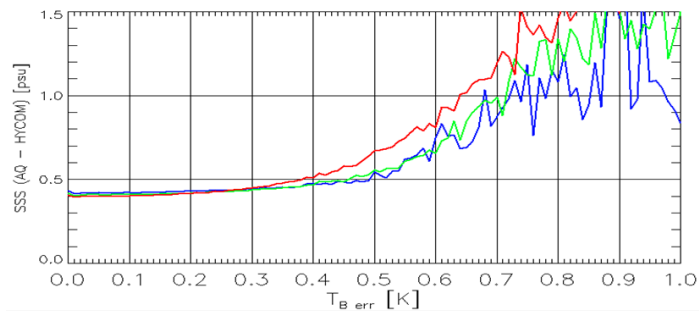2. severe: TA moon refl (I=V+H) ≥ 0.50 K.

2.4   Tb$_{err}$ (Consistency)

Figure 2: Upper panel: RMS of SSS Aquarius – HYCOM versus Tb_{err}. Lower panel: Cumulative histogram. Blue = horn 1. Green = horn 2. Red=horn 3.

Recommended threshold:

$Tb_{err} \geq 0.4$ K. This eliminates about 2% open ocean data. We use only one setting.
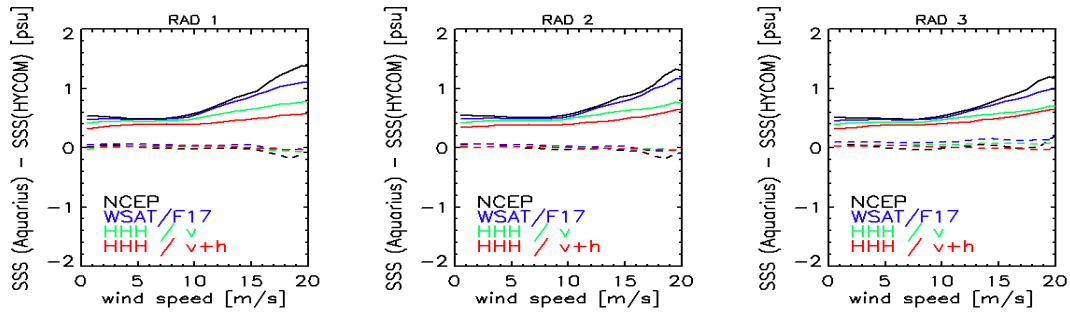
2.5 Wind Speed

Figure 3: Aquarius – HYCOM SSS [psu] as function of wind speed that is used in the roughness correction. The red curve corresponds to RSS testbed V3 and ADPS V2.3.1. Dashed lines are biases. Full lines are standard deviations.

Recommended threshold:

1. moderate: 15 m/s < W_{HH} < 20 m/s
2. severe: $W_{HH} \geq 20$ m/s.

We note that the difference between W_{HH} and W_{HHH} is small below 20 m/s. We decide to use W_{HH} for setting the flag as W_{HHH} is not available in the calibration loop.
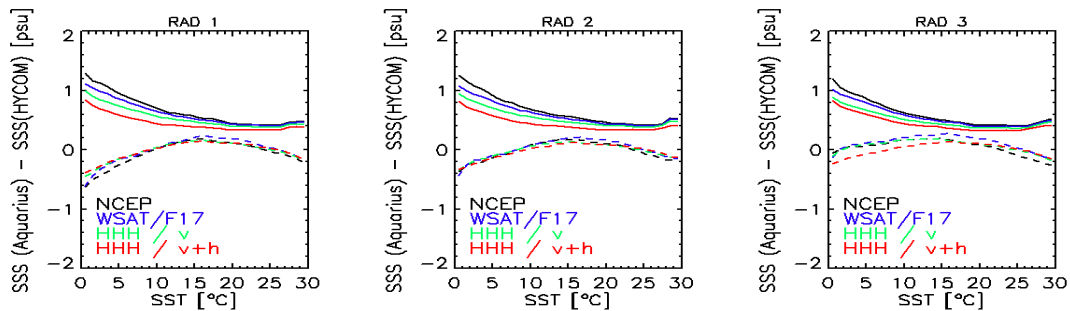
2.6 Sea Surface Temperature

Figure 4: Aquarius – HYCOM SSS [psu] as function of SST. The red curve corresponds to RSS testbed V3 and ADPS V2.3.1. Dashed lines are biases. Full lines are standard deviations.

Recommended threshold

1. moderate: $0^{o}C \leq T_S < 5^{o}C$
2. severe: $T_S \geq 0^{o}C$

2.7   Radiometer RFI: TF – TA

TF – TA [K]	number of events	BIAS	STANDARD DEVIATION
-2.00	5664	-0.258	0.729
-1.80	7136	-0.244	0.758
-1.60	8679	-0.265	0.809
-1.40	10791	-0.246	0.763
-1.20	13398	-0.239	0.773
-1.00	18297	-0.229	0.766
-0.80	25591	-0.218	0.745
-0.60	39360	-0.204	0.733
-0.40	69955	-0.188	0.711
-0.20	689586	0.032	0.531
0.00	35365081	-0.007	0.445
0.20	380681	-0.13	0.506
0.40	479	-2.847	3.843
0.60	53	-8.065	4.029
0.80	30	-8.79	4.776
1.00	21	-10.598	5.08
1.20	12	-10.379	3.691
1.40	6	-13.354	6.611
1.60	5	-11.239	5.778
1.80	7	-12.68	4.907
2.00	1	-9.768	95.409

Table 2: SSS Aquarius – HYCOM [psu] as function of TF – TA (v-pol). The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,9,10,11,12,1318,19 were set.

TF − TA [K]	number of events	BIAS	STANDARD DEVIATION
-2.00	8216	-0.211	0.698
-1.80	9851	-0.199	0.684
-1.60	12034	-0.201	0.715
-1.40	14591	-0.189	0.675
-1.20	18888	-0.175	0.651
-1.00	25253	-0.179	0.683
-0.80	35574	-0.169	0.692
-0.60	55051	-0.154	0.652
-0.40	109283	-0.11	0.655
-0.20	2023028	0.045	0.487
0.00	32897189	-0.007	0.445
0.20	1391688	-0.093	0.47
0.40	7421	-0.325	0.958
0.60	128	-2.431	3.214
0.80	11	-5.384	7.387
1.00	13	-6.528	2.311
1.20	3	-5.756	0.116
1.40	3	-8.119	2.933
1.60	2	-5.599	3.052
1.80	1	-4.115	16.934
2.00	1	-12.43	154.495

Table 3: SSS Aquarius − HYCOM [psu] as function of TF − TA (h-pol). The values are summed over all 3 horns. The RSS testbed Q/C flag bins: 1,2,3,4,5,6,7,9,10,11,12,1318,19 were set.

For regular RFI and RFI filtering TF − TA is always negative, as the filter throws out the high values within the cycle. The cases in the tables where TF − TA is positive indicates a pathological event, where the RFI is so strong and constant in time, that the RFI filter takes it as normal and discards the smaller values within the cycle. As the tables indicate, that happens extremely rarely. The RSS testbed flag 20 will likely filter out those cases. We want, however, to flag them already right at the TA/TF level. It is very possible that those very bad events are still in the current V2.3.1 L2 files and could cause a degradation of the performance statistics.

Recommended threshold:

1. moderate: -1.0 K < TF − TA < -0.3 K or TF − TA > 0.3 K
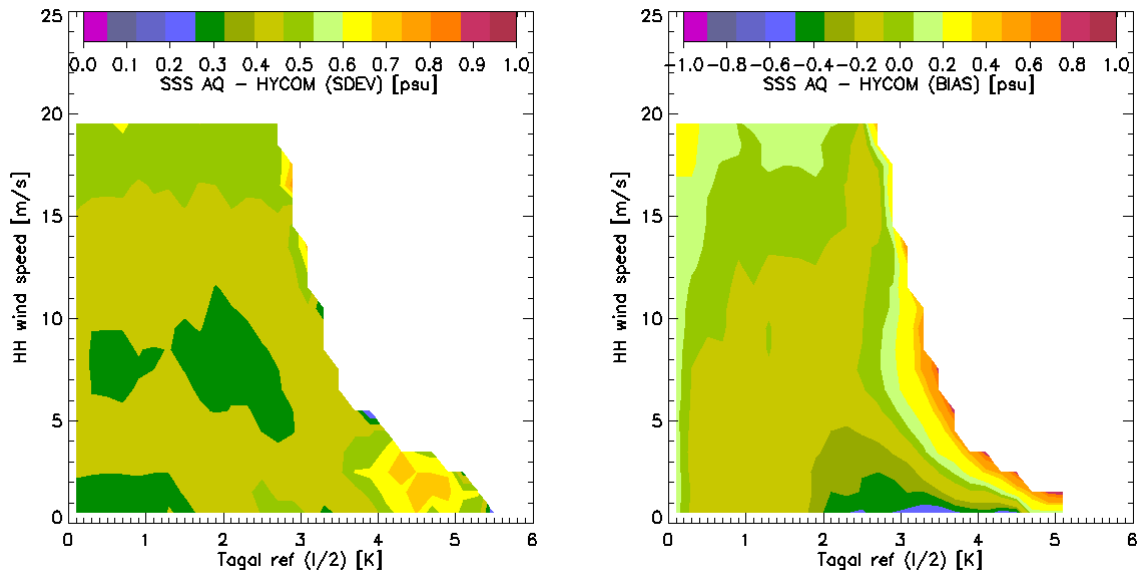2. severe: TF − TA ≤ -1.0 K or TF − TA > 0.3 K

2.8 Galactic Contamination

Figure 5: SSS Aquarius V2.6.1 (September 2011 – August 2013) versus HYCOM stratified by the strength of the reflected galactic radiation (V+H)/2 (x-axis) and HH wind speed (y-axis). Left: Standard Deviation. Right: Bias.

Recommended threshold:

Discard data if **either one** of the following conditions exists:

1. $I = V + H$ (1st Stokes) of the reflected galactic radiation exceeds 5.6 K (independent on the wind speed).
2. The wind speed is less than 3 m/s and $I = V + H$ (1st Stokes) of the reflected galactic radiation exceeds 3.6 K.

There is only 1 flag setting.
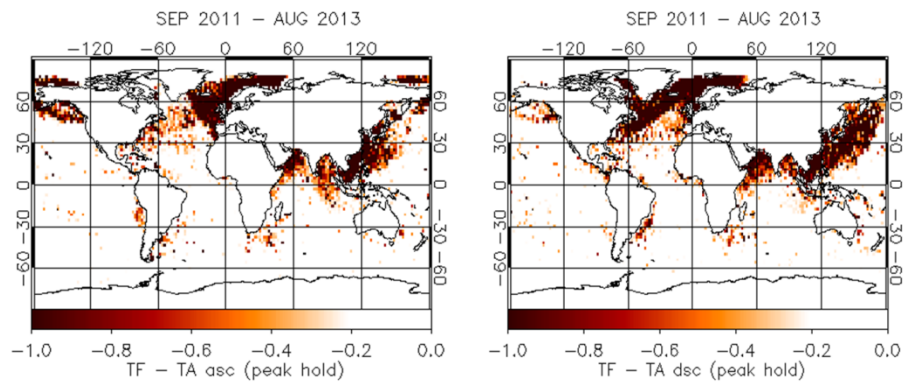
2.9 Suspected RFI Areas

Figure 6: TF – TA peak hold maps: ascending (left), descending (right). Each map shows the minimum of the 24 monthly average values (September 2011 – August 2013) of RFI filtered (TF) minus unfiltered (TA) antenna temperatures. The resolution is 2° by 2°.
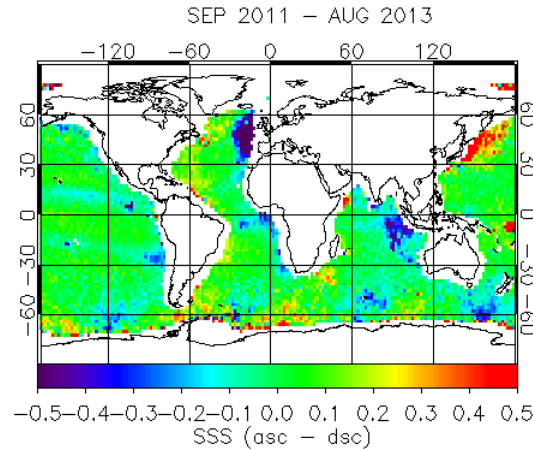
Figure 7: Observed average of ascending – descending Aquarius salinity between September 2011 – August 2013. The resolution is 2º by 2º.

The TF – TA peakhold maps (Figure 6) are a measure for the highest level of detected RFI that occur within the 24 months period September 2011 – August 2013.

The residual observed ascending – descending biases (Figure 7) indicate undetected low-level RFI in or close to many of the areas where RFI was detected.

The derivation of the L2 RFI mask is done as follows.

1. Mask 1 = Location of the TF – TA peakhold map (Figure 6) where TF – TA < -0.3 K.
2. Mask 2 = Extend Mask 1 by +/4 deg. This is done as the RFI can enter through the side-lobes. Do not include pixels whose latitude is lower than 45S, as we assume that the southern oceans do not have RFI.
3. Mask 3 = Map of pixels for which SSS ascending minus descending exceeds 0.15 psu in absolute values.
4. Mask 4 = Mask 2 ∩ Mask 3.
5. Optical smoothing: Fill holes and discard isolated single pixels in Mask 4. This is the final RFI mask (Figure 8).
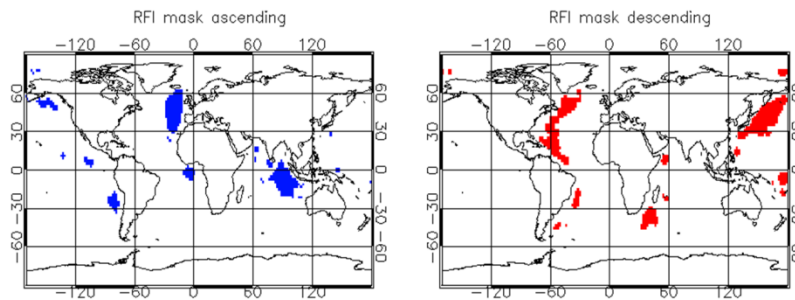6. Separate masks are derived separately for the ascending swath (blue) and descending swath (red).

Figure 8: RFI masks: ascending (left, blue), descending (right, red). The resolution is 2º by 2º.

3   Recommended Use for Aquarius L2 Q/C Flags

Data should be excluded if the moderate flag setting or single flag setting applies for:

1. During the calibration loop. The exception is the Tberr/Consistency flag, which is not yet available in the calibration loop, as the SSS retrieval cannot be done.
2. Validation.
3. L3 processing of the smoothed ocean product.

4   Q/C Flags in the RSS Testbed

RSS Testbed V6 Q/C bit	Definition in RSS Testbed V6.
0	Sparse.
1	No or invalid radiometer data.
2	No or invalid time or geolocation.
3	No or invalid scatterometer data.
4	S/C maneuver. R/P > 1°, Y>5°. No boresight Earth intersection.
5	ACS mode not equal 5. Indicates degraded geolocation.
6	Bad orbit: Listed on ADPS for maneuver or anomaly.
7	Scatterometer RFI.
8	Radiometer RFI: |TA-TF|>0.30 Kelvin or bit overflow in radiometer counts.
9	AQ wind speed retrievals (HH and/or HHH wind speeds) did not converge.
10	Full roughness correction could not be performed: underpopulated bin in table and/or no SWH.
11	Severe land contamination: g_{land}>0.01.
12	Moderate land contamination: g_{land}>0.001.
13	Sea ice contamination: g_{ice}>0.001.
14	High galactic radiation: [tagal ref (V+H)/2.0 > 2.8 K] OR [tagal ref (V+H)/2.0 > 1.8 K AND W_{HH} < 3 m/s].
15	High lunar radiation: tamon ref (V+H)/2.0 > 0.125 K.
16	No MWR observation exists.
17	MWR observation exists and indicates rain (rain rate > 0.25 mm/h).
18	Cold SST: sst=surtep-273.15 < 5.0^{o}C.
19	High wind speed: winspd_HH >15.0 m/s.
20	High error or poor or no convergence in SSS retrieval Tb_{err} > 0.40 K.
21	Observation falls within RFI mask.

Table 4: Definition of RSS Testbed V6 Q/C flag bits.