Proposed APC Changes from V2.0 to V3.0

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This memo summarizes the results for the adjustments to the V2.0 APC matrix and TND values:

1. APC Matrix

horn 1

1	1.0448	-0.0383	+0.0500
2	- 0.0030	1.0786	+0.0300
3	-0.0009	-0.0258	1.0755

horn 2

1	1.0497	-0.0343	0.0000
2	-0.0006	1.0593	0.0000
3	-0.0067	+0.0111	1.0555

horn 3

1	1.0580	-0.0344	+0.0250
2	-0.0004	1.0485	+0.0300
3	-0.0045	-0.0148	1.0489

Table 1: V2.0 A matrix

horn 1

1	**1.0300**	**-0.0350**	+0.0500
2	**0.0001**	**1.0641**	+0.0300
3	**0.0000**	-0.0258	1.0755

horn 2

1	**1.0337**	**-0.0304**	0.0000
2	**0.0027**	**1.0435**	**-0.0144**
3	**-0.0006**	**+0.0211**	1.0555

horn 3

1	**1.0420**	**-0.0326**	+0.0250
2	**0.0011**	**1.0328**	**+0.0215**
3	**0.0000**	-0.0148	1.0489

Table 2: Proposed V3.0 A matrix

The changes are in **red**.

The notation is:

$$\mathbf{TB}_{\mathbf{TOI}} = \mathbf{A} \cdot \mathbf{TA}_{\mathbf{Earth}}$$

$$\mathbf{TA}_{\mathbf{Earth}} = \mathbf{A}^{-1} \cdot \mathbf{TB}_{\mathbf{TOI}}$$

$$\text{x-polarization: } \chi_p \equiv \frac{\left[A^{-1}\right]_{pq}}{\left[A^{-1}\right]_{pp}}$$

$$\text{spillover: } \eta_p \equiv 1 - \left[A^{-1}\right]_{pp} \cdot \left(1 + \chi_p\right)$$

$$p = V, H \text{ co-pol} \quad q = H, V \text{ cross-pol}$$

2. Noise Diode

TND is adjusted to fix the ocean TB to its RTM (expected) value.

	TND [K]		
	Pre-Launch	V2.0	Proposed V3.0
1V	652.40	642.25	638.09
1H	670.93	672.86	667.77
2V	673.53	661.80	656.54
2H	690.75	692.24	687.25
3V	724.15	713.35	705.80
3H	681.61	683.92	679.92

Table 3: The table shows the values for TND at the beginning of the mission:
1 week average rev # 1121 (08/25/2011) – 1227 (09/01/2011).

3. Determination of V/H (I/Q) Matrix Elements

1. We take spillover η from pre-launch (scale model) patterns.
2. We take x-pol χ from GRASP July 2012 patterns that was found by running the orbit simulator (ADPS V2.0).
3. We adjust T_{ND} so that the ocean keeps at its value that is determined by the RSS Testbed RTM.
4. In addition,we have tweaked te spillover values by slightly increasing the V/H asymmetry in horn 2 and slightly decreasing the V/H asymmetry in horn 3. The reason for doing that is to get a reasonable behaviour of the Q = V – H (2^{nd} Stokes) over the Amazon and Congo rain forest sites. We expect the Q values to be roughly between 2 – 3 K from Frank's and my WindSat/AMSR results. The Q value of horn 2 should lie some where in between the values of horn 1 and horn 3 an the Q values should decrease with decreasing EIA being 0 at nadir.

Those are the values for η and χ:

	GRASP July 2012		Scale Model		Proposed V3.0	
	η	χ	η	χ	η	χ
1V	0.04018	-0.00041	0.02923	0.01318	0.02923	-0.00041
1H	0.04545	0.03356	0.02902	0.03141	0.02902	0.03356
2V	0.04669	-0.01106	0.03329	0.00582	0.03516	-0.01106
2H	0.04788	0.02095	0.03204	0.02148	0.03016	0.02095
3V	0.05447	-0.02034	0.04220	-0.00626	0.04134	-0.02034
3H	0.05508	0.01197	0.03848	0.01444	0.03934	0.01197

Table 4: Values for spillover η and cross polarization χ.

Note: **The APC were found from the orbit simulator by minimizing the least square differences between true and expected TB**. This effectively absorbs change of local incidence angle within antenna pattern into the coefficients. The effects are different for v and h-pol. That is the reason for the rather strange looking values for the cross pol χ.

The values for χ are hard to verify from actual observations: For the rain forest and cold space look the effect is very small. For the ocean they are basically just a bias, as the dynamical range of Q = V – H over the ocean is small.

Amazon Rainforest:

Those are the results for the TB TOI at the Amazon Rain Forest. We use the same lat/lon box as in our WindSat/AMSR analysis, which is [52W-59W] and [1S-3N]. Only the descending (morning) swath (6 AM) is used.

TB TOI [K]	horn 1	horn 2	horn 3
I/2 = (V+H)/2	**283.6** **279.7**	**283.8** **279.6**	**281.5** **277.3**
Q = V-H	**0.3** **2.0**	**0.7** **2.5**	**2.6** **3.4**

Table 5: TB TOI for the Amazon Rain Forest Site: **V2.0** and **proposed V3.0**.

The values compare reasonable with our WindSat/AMSR values extrapolated to L-band. The value for I/2 of horn 3 seems to come in somewhat low.

Cold Space Maneuver:

Those are the biases TB measured – expected the cold space looks (from Emmanuel Dinnat).

TB TOI meas – exp [K]	horn 1	horn 2	horn 3
V	**-2.4**	**-2.4**	**-2.0**
H	**-2.8**	**-3.1**	**-2.8**
I/2 = (V+H)/2	**-2.6**	**-2.7**	**-2.4**

Table 6: Biases for cold space look in V2.0.

Changes in TB TOI from V2.0:

The changes at the warm end (Amazon) and cold end (CS) are related by the pivoting around the ocean (Table 7), assuming that everything is linear. Note that the ocean TB pivot points are different for different channels (polarization and EIA).

Demanding a change on the warm end by 6 – 8 K as some of the SMOS people do, would necessarily mean that the CS will get worse.

	Change in TB TOI [K]		
	Ocean	Amazon RF	CS
1V	None	- 3.1	+1.9
1H		- 4.8	+2.1
2V		- 3.3	+2.3
2H		- 5.1	+2.1
3V		- 3. 8	+3.0
3H		- 4.6	+1.6

Table 7: Absolute changes in TB TOI from the APC of V2.0 to the proposed V3.0 for the 6 channels.

4. Determination of the 3rd Stokes Couplings

Biases over the Ocean:

Table 8 shows TB TOI measured – expected as well as the average TA over the ocean. The expected value was calculated from the TEC of the ionospheric model assuming a 0.75 scaling to the Aquarius S/C altitude.

	BIAS TB TOI meas - exp	SDEV TB TOI meas - exp	average I antenna	average Q antenna	average U antenna
Horn 1	-0.237	0.498	191.773	18.636	0.809
Horn 2	-1.659	0.811	194.113	32.973	0.744
Horn 3	-0.958	1.219	197.799	49.922	1.343

Table 8: TB TOI measured – expected (Bias and standard deviation) and average antenna Stokes over the ocean in V2.0.

Biases over the Rain Forest:

We expect the TB TOI 3rd Stokes to be over to 0 over the rain forest. The TA values do not necessarily have to be 0 if there is a finite coupling a_{UI} from the 1st Stokes. Because the 1st Stokes over the rain forest is very large even a small a_{UI} coupling can lead to a finite TA 3rd Stokes. It seems to me that the values which Shannon presented at the GSFC meeting were actually for the TA 3rd Stokes.

Table 9 shows TB TOI as well as the average TA over the rain forest.

	TB TOI	SDEV TB TOI	average I antenna	average Q antenna	average U antenna
Horn 1	-0.42	0.40	545.68	1.95	0.05
Horn 2	-3.23	0.38	543.98	0.94	0.39
Horn 3	-2.41	0.40	535.16	2.50	-0.07

Table 9: TB TOI measured – expected (Bias and standard deviation) and average antenna Stokes over the Amazon in V2.0.

Couplings UI and UQ:

The values in Table 8 and Table 9 clearly indicate that our V2.0 coupling UI in the APC matrix is off. In first order the results for amazon and Ocean agree. We can make the biases for both scenes close to 0 when setting the UI coupling to 0 for horn 1 and horn 3. For horn 2 we keep a very small UI matrix element and we also change the UQ coupling from the V2.0 values to minimize the biases for both scenes.

We have at this point not changed the count to TA calibration for the 3rd Stokes. One could certainly do that as well, e.g. changing the CND, but the results show that it does not the major problem. We also confirmed this by checking the TA 3rd Stokes at the cold space maneuver. We did find small biases, in the order of 0.2 – 0.3 K for all 3 horns.

The results from Table 8 (Ocean) and Table 9 (Amazon) for the TB TOI biases clearly indicate that the a_{UI} couplings were our major problem for the 3rd Stokes. In V2.0 its absolute value was too large and negative. The biases suggest going to very small to 0 couplings for all 3 horns.

TB TOI [K]	horn 1	horn 2	horn 3
U	**-0.42** **+0.01**	**-3.23** **+0.09**	**-2.41** **-0.10**

Table 10: TB TOI of the 3rd Stokes over the Amazon rain forest: V2.0 and **proposed V3.0.** It is assumed that the TB TOI expected is very close to 0.

TB TOI [K]	horn 1	horn 2	horn 3
U	**-0.24** **-0.05**	**-1.66** **-0.15**	**-0.96** **-0.07**

Table 11: TB TOI measured – expected of the 3rd Stokes over the open ocean: V2.0 and **proposed V3.0. The expected value was calculated from the TEC of the ionospheric model assuming a 0.75 scaling to the Aquarius S/C altitude.**

The improvement of the biases is shown in Table 10 (rain forest) and in Table 11 (open ocean).

Diagonal Elements UU:

Those can be verified from the pitch maneuver, where the 3rd Stokes gets very large due to the polarization rotation. we checked and found that our old analysis that was done for V2.0 still holds, so we left a_{UU} at their V2.0 values (Figure 1).

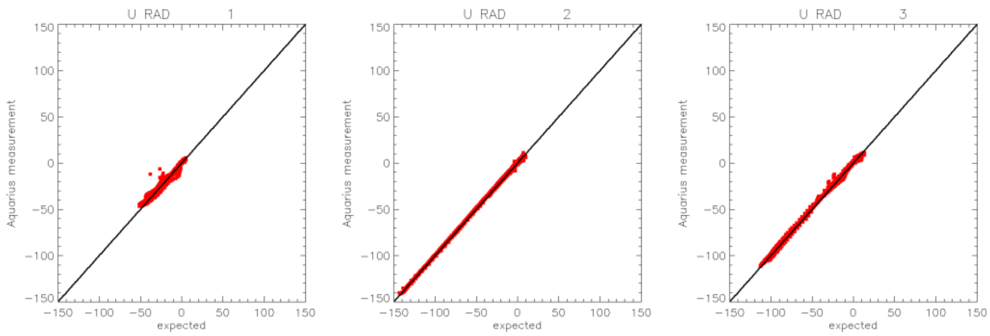

Figure 1: TOI measured – expected 3rd Stokes during the pitch maneuvers. The outliers in horn 1 are due to land contamination.

<u>Couplings IU and QU:</u>

We had adjusted in V2.0 to minimize the spurious images of U in I and Q that we have seen near the magnetic equator in V1.3.

After performing all the changes mentioned abovewel have rechecked TB TOI measured – expected as function U_{ant}.

The values of I are unchanged and therefore I did not change the IU couplings.

The values for Q are unchanged for horn 1. For horn 2 and horn 3 we see a small positive slope, and therefore we have adjusted the QU couplings for these horns slightly (Figure 2).

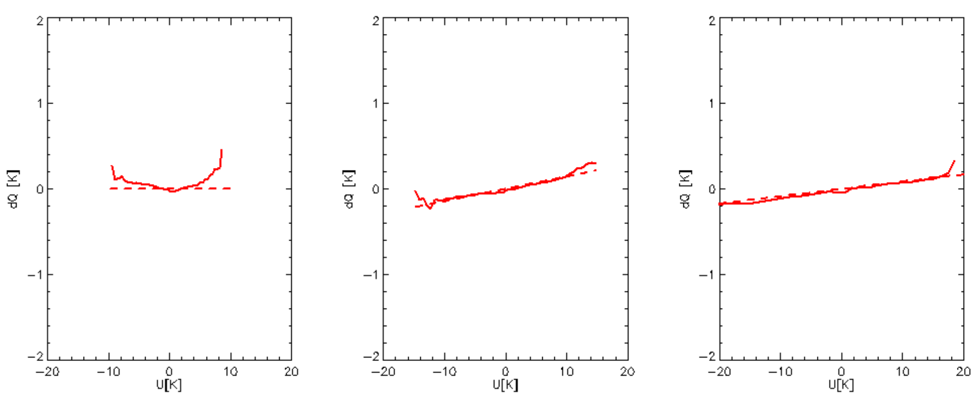

Figure 2: TOI Q measured – expected as function of U_{ant} for the 3 Aquarius horn. In order to get the curves flat the values for a_{QU} were slightly adjusted. The dashed lines indicate linear fits.

5. Ocean: Model Function and SSS Retrievals

The changes in APC and T_{ND} necessitate rederiving the geophysical model function (GMF) for surface emissivity and the surface roughness correction.

We have decided to introduce a temperature dependent model function for the wind induced excess emissivity ΔE_W. The Aquarius observations and our emissivity model for higher frequency [Meissner and Wentz, IEEE TGRS, vol. 50(8), pp 3004-3026, 2012] suggest that the temperature dependence of ΔE_W (W, T_S) can be approximately modeled by assuming that ΔE_W is proportional to the specular emissivity $E_0(T_S)$. The final form of our surface roughness model is:

$$\Delta E_{W,rough} = A(W_{HHH},\varphi_{rel}) \cdot \frac{E_0(T_S)}{E_0(T_{S,ref})} + r_1(W_{HHH},\sigma'_{0VV}) + r_2(W_{HHH},SWH)$$

$$A(W_{HHH},\varphi_{rel}) = \left[A_0(W_{HHH}) + A_1(W_{HHH})\cdot\cos(\varphi_{rel}) + A_2(W_{HHH})\cdot\cos(2\cdot\varphi_{rel})\right]$$

$$\sigma_0(W_{HHH},\varphi_{rel}) = \left[B_0(W_{HHH}) + B_1(W_{HHH})\cdot\cos(\varphi_{rel}) + B_2(W_{HHH})\cdot\cos(2\cdot\varphi_{rel})\right]$$

$$\sigma'_0 = \sigma_{0,meas} - \left[B_1(W_{HHH})\cdot\cos(\varphi_{rel}) + B_2(W_{HHH})\cdot\cos(2\cdot\varphi_{rel})\right]$$

I have rederived expressions and tables for all the model parameters: $A_i, B_i, i = 0,1,2$, r_1 and r_2 .

The SSS statistics (Aquarius – HYCOM) are shown in Table 12 and Figure 3 (versus wind speed) and Figure 4 (versus SST).

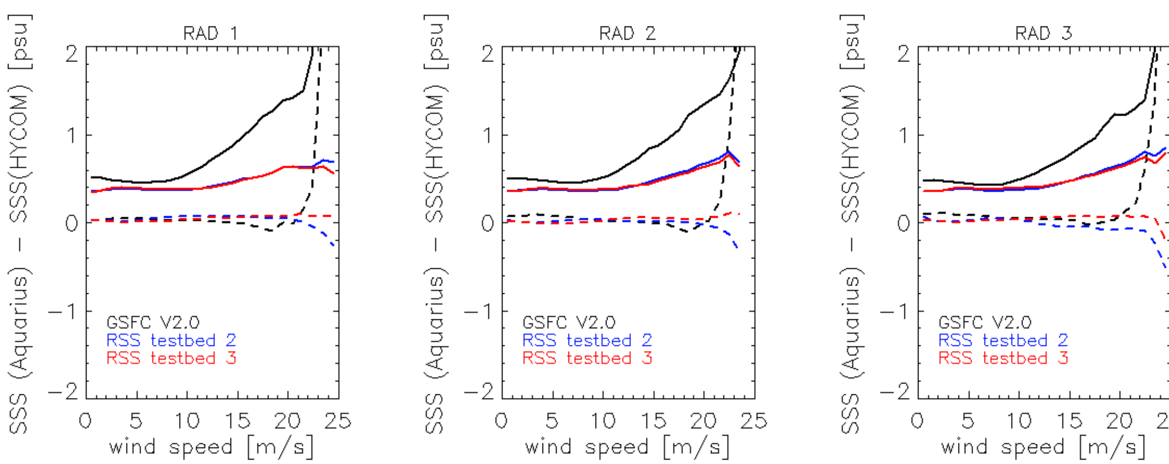

Figure 3: SSS Aquarius – HYCOM stratified versus wind speed. Dashed lines = Biases. Full lines = Standard deviations. Black = ADPS V2.0, blue = RSS Testbed 2, red = RSS Testbed 3.

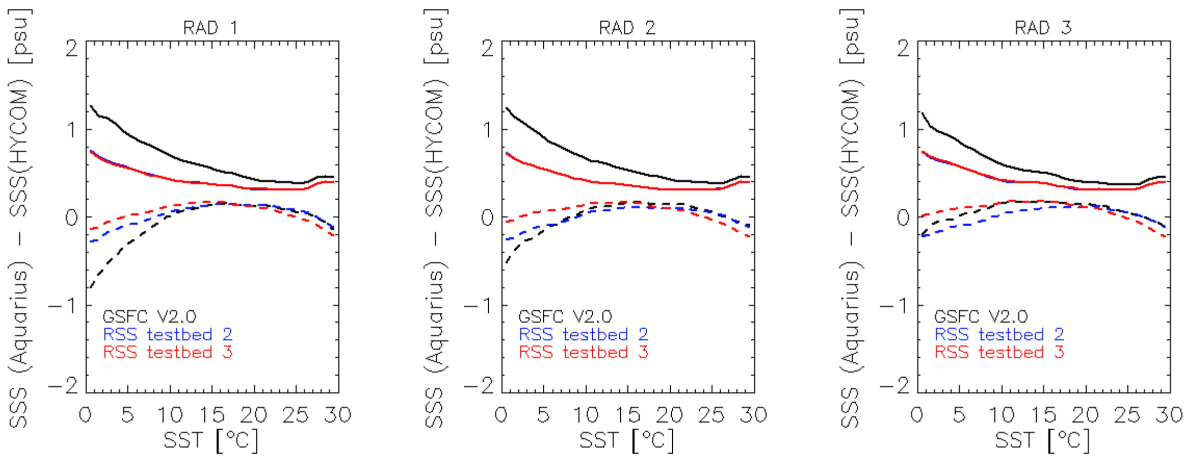

Figure 4: SSS Aquarius – HYCOM stratified versus SST. Dashed lines = Biases. Full lines = Standard deviations. Black = ADPS V2.0, blue = RSS Testbed 2, red = RSS Testbed 3.

Horn	Bias	Standard Deviation
1	0.023	0.393
2	0.010	0.389
3	0.028	0.397

Table 12: Statistics: SSS Aquarius – HYCOM. All values are in psu.