Evaluation of Radiometer RFI Flagging Algorithm Performance Using TVAC Data

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Status

- Fixed: negative values for T_F (except -9999)
- In progress: tuning algorithm parameters (U/Mich and RSS; GSFC) in order to
  - reduce high false RFI detection rate over ocean
  - improve performance over land where strong RFI is present
- Recently discovered issue: short accumulations

TVAC Data

- Measurements performed at GSFC TVAC in December 2007
- Only radiometer electronics present (no antennas and no diplexers)
- ColdFET Targets
- Thermal stability « 0.1 K

Statistics of TVAC Short Accumulations

Radiometer 1

SA	V-pol μ	V-pol σ	CP-pol μ	CP-pol σ	CM-pol μ	CM-pol σ	H-pol μ	H-pol σ
1	1341.44	2.094	1035.17	1.272	1129.77	1.446	1172.04	1.498
2	1344.31	1.519	1036.68	1.095	1131.49	1.158	1173.54	1.302
3	672.30	1.062	518.42	0.769	565.83	0.814	586.83	0.920
4	672.33	1.055	518.44	0.772	565.85	0.816	586.85	0.922
5	672.34	1.058	518.44	0.768	565.85	0.814	586.85	0.919

Radiometer 2

SA	V-pol μ	V-pol σ	CP-pol μ	CP-pol σ	CM-pol μ	CM-pol σ	H-pol μ	H-pol σ
1	1217.12	1.692	941.39	1.204	990.25	1.277	1280.87	1.625
2	1219.10	1.385	942.81	0.980	991.75	1.061	1282.86	1.264
3	609.65	0.974	471.47	0.682	495.95	0.741	641.52	0.888
4	609.68	0.975	471.48	0.684	495.96	0.744	641.53	0.892
5	609.69	0.979	471.49	0.681	495.97	0.750	641.55	0.893

Correction of Short Accumulation 1

- use coefficients α and β:

$$s'_1 = \alpha\, s_1 + \beta$$

such that

- mean

$$\mu'_1 = \bar{\mu} = \frac{\mu_2 + 2\,\mu_3 + 2\,\mu_4 + 2\,\mu_5}{4}$$

- standard deviation

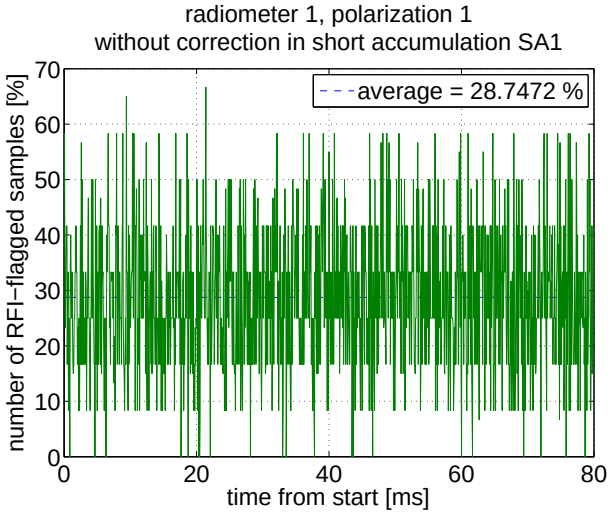
$$\sigma'_1 = \bar{\sigma} = \frac{\sigma_2 + \sqrt{2}\,\sigma_3 + \sqrt{2}\,\sigma_4 + \sqrt{2}\,\sigma_5}{4}$$

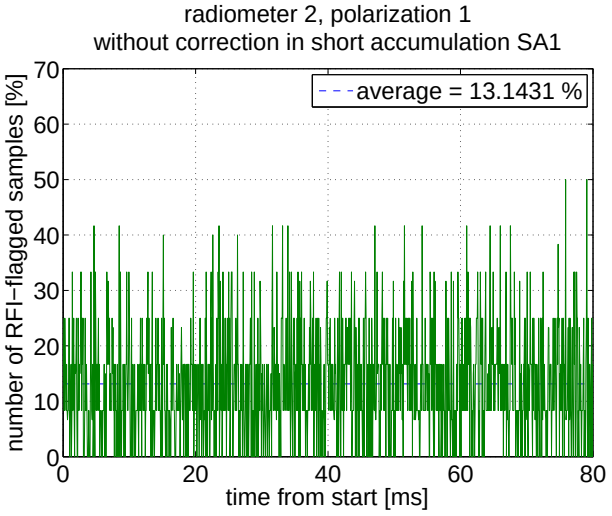
$$\Longrightarrow \begin{cases} \alpha = \dfrac{\bar{\sigma}}{\sigma_1} \\ \beta = \bar{\mu} - \dfrac{\bar{\sigma}}{\sigma_1}\,\mu_1 \end{cases}$$

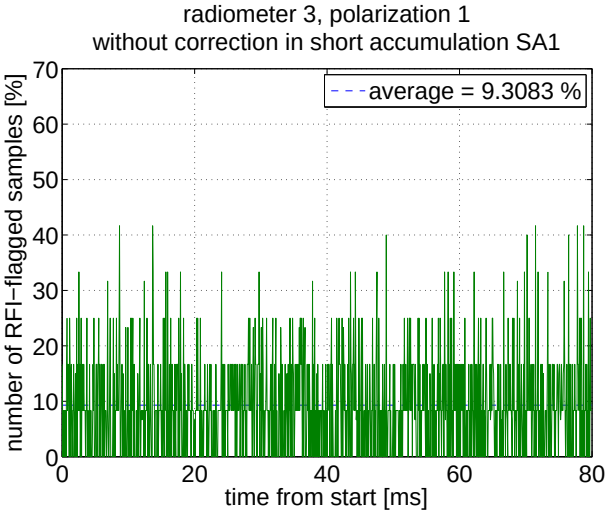
Statistics of TVAC Short Accumulations after Correction

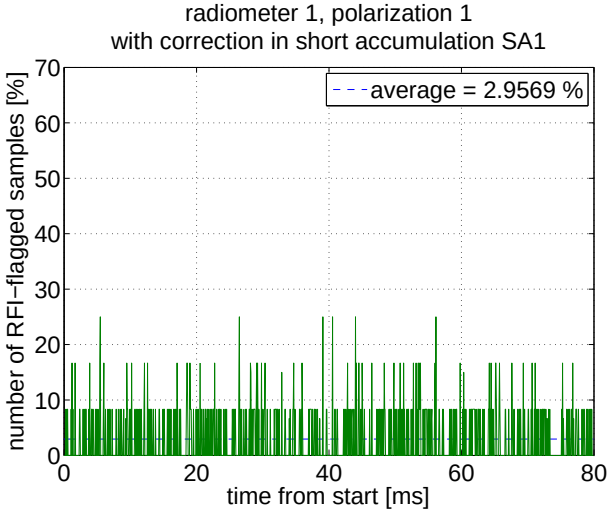
SA	V-polarization		CP-polarization		CM-polarization		H-polarization	
	Radiometer 1		Radiometer 1		Radiometer 1		Radiometer 1	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1344.56	1.503	1036.82	1.090	1129.77	1.446	1173.65	1.301
2	1344.31	1.519	1036.68	1.095	1131.49	1.158	1173.54	1.302
3	672.30	1.062	518.42	0.769	565.83	0.814	586.83	0.920
4	672.33	1.055	518.44	0.772	565.85	0.816	586.85	0.922
5	672.34	1.058	518.44	0.768	565.85	0.814	586.85	0.919
	Radiometer 2		Radiometer 2		Radiometer 2		Radiometer 2	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1219.29	1.381	942.93	0.969	991.88	1.055	1283.02	1.261
2	1219.10	1.385	942.81	0.980	991.75	1.061	1282.86	1.264
3	609.65	0.974	471.47	0.682	495.95	0.741	641.52	0.888
4	609.68	0.975	471.48	0.684	495.96	0.744	641.53	0.892
5	609.69	0.979	471.49	0.681	495.97	0.750	641.55	0.893

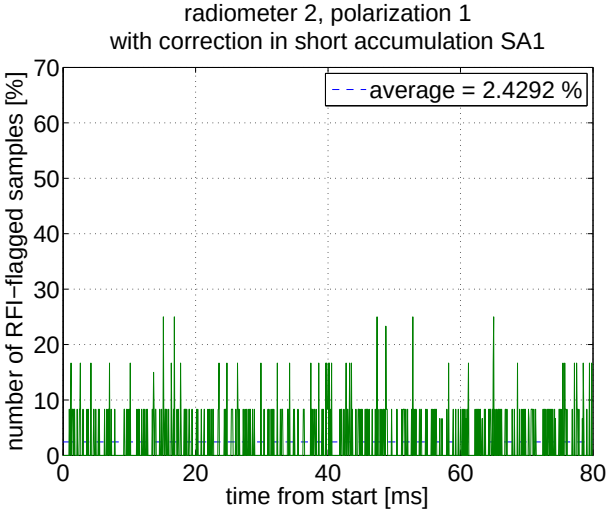
Probability of False RFI Detection

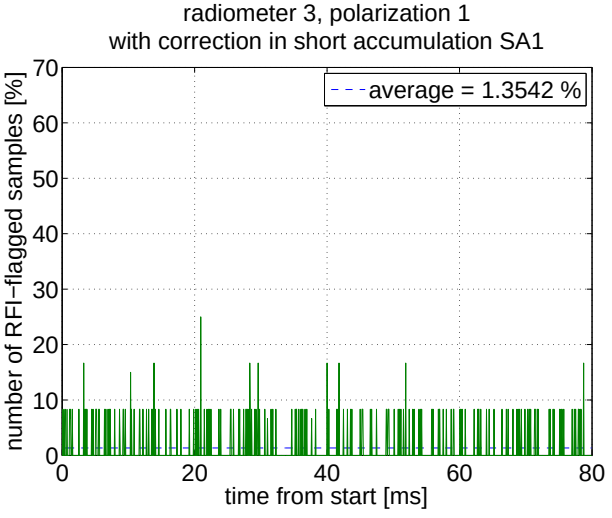












Probability of False RFI Detection - TVAC Data

without SA1 correction

	Radiometer		
	1	2	3
V	28.75 %	13.14%	9.31%
CP	27.50 %	27.57%	19.94%
CM	24.12 %	29.76%	22.43%
H	16.41 %	30.25%	32.69%

with SA1 correction

	Radiometer		
	1	2	3
V	2.96 %	2.43%	1.35%
CP	10.68 %	11.84%	9.28%
CM	7.21 %	6.03%	10.72%
H	5.51 %	8.89%	13.53%

- correction of SA1 accumulation reduces the probability of false RFI detection to more reasonable levels

Effect on T_A and T_F mean values

without SA1 correction

	Radiometer		
	1	2	3
$T_{A,V}$	71.62 K	70.08 K	68.34 K
$T_{A,H}$	64.77 K	70.35 K	74.46 K
$T_{A,3}$	-0.04 K	-0.11 K	0.23 K
$T_{F,V}$	71.64 K	70.08 K	68.34 K
$T_{F,H}$	64.76 K	70.36 K	74.46 K
$T_{F,3}$	-0.08 K	-0.18 K	0.26 K

with SA1 correction

	Radiometer		
	1	2	3
$T_{A,V}$	71.88 K	70.29 K	68.52 K
$T_{A,H}$	64.91 K	70.57 K	74.65 K
$T_{A,3}$	-0.04 K	-0.10 K	0.23 K
$T_{F,V}$	71.88 K	70.28 K	68.52 K
$T_{F,H}$	64.91 K	70.55 K	74.63 K
$T_{F,3}$	-0.05 K	-0.11 K	0.23 K

- implications on calibration, etc.?

Statistics of Aquarius Short Accumulations - Open Ocean

SA	V-polarization		CP-polarization		CM-polarization		H-polarization	
	Radiometer 1		Radiometer 1		Radiometer 1		Radiometer 1	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1501.22	2.175	1094.92	1.249	1142.48	1.498	1340.96	1.682
2	1504.14	1.597	1096.34	0.998	1144.15	1.228	1342.54	1.465
3	752.23	1.108	548.21	0.703	572.17	0.820	671.35	1.019
4	752.23	1.119	548.21	0.685	572.12	0.854	671.27	1.028
5	752.21	1.147	548.24	0.692	572.23	0.819	671.41	0.991
	Radiometer 2		Radiometer 2		Radiometer 2		Radiometer 2	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1287.33	1.749	1048.03	1.266	1037.51	1.414	1373.65	1.709
2	1289.27	1.439	1049.52	1.081	1039.13	1.098	1375.86	1.381
3	644.78	0.992	524.84	0.746	519.65	0.765	688.01	0.994
4	644.78	1.026	524.86	0.755	519.63	0.786	688.03	0.973
5	644.73	1.003	524.86	0.753	519.62	0.776	688.06	0.975

Corrected Aquarius Short Accumulations - Open Ocean

SA	V-polarization		CP-polarization		CM-polarization		H-polarization	
	Radiometer 1		Radiometer 1		Radiometer 1		Radiometer 1	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1504.42	1.592	1096.42	0.985	1144.25	1.188	1342.64	1.440
2	1504.14	1.597	1096.34	0.998	1144.15	1.228	1342.54	1.465
3	752.23	1.108	548.21	0.703	572.17	0.820	671.35	1.019
4	752.23	1.119	548.21	0.685	572.12	0.854	671.27	1.028
5	752.21	1.147	548.24	0.692	572.23	0.819	671.41	0.991
	Radiometer 2		Radiometer 2		Radiometer 2		Radiometer 2	
	μ	σ	μ	σ	μ	σ	μ	σ
1	1289.41	1.428	1049.66	1.067	1039.21	1.097	1376.08	1.385
2	1289.27	1.439	1049.52	1.081	1039.13	1.098	1375.86	1.381
3	644.78	0.992	524.84	0.746	519.65	0.765	688.01	0.994
4	644.78	1.026	524.86	0.755	519.63	0.786	688.03	0.973
5	644.73	1.003	524.86	0.753	519.62	0.776	688.06	0.975

Probability of False RFI Detection - Open Ocean

without SA1 correction

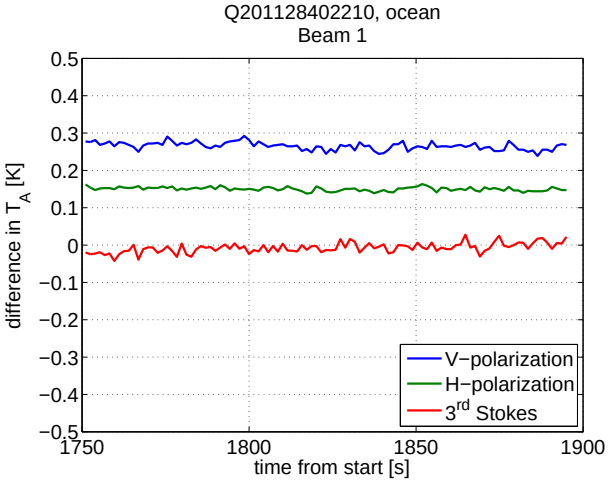
	Radiometer		
	1	2	3
V	32.53 %	21.46%	18.47%
CP	31.88 %	36.24%	37.58%
CM	29.25 %	34.64%	33.32%
H	30.45 %	42.09%	38.29%

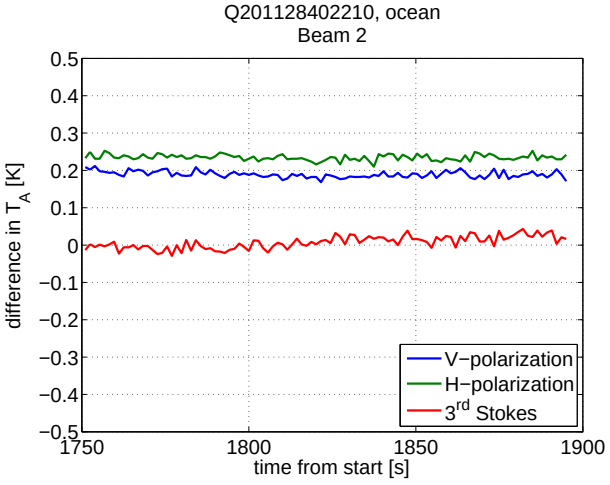
with SA1 correction

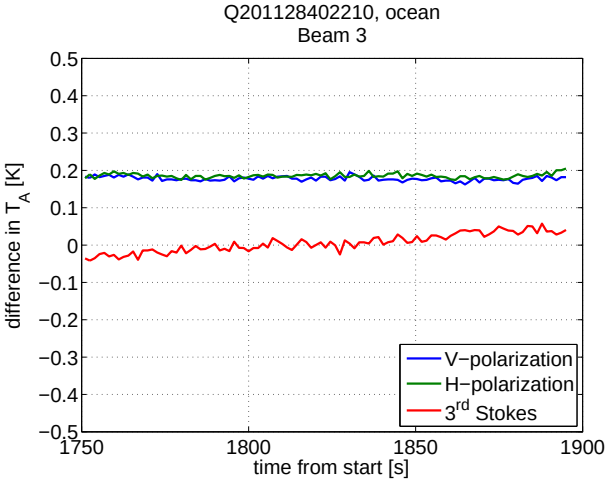
	Radiometer		
	1	2	3
V	6.10 %	6.08%	6.75%
CP	8.07 %	9.96%	13.45%
CM	6.91 %	9.49%	11.55%
H	9.07 %	10.71%	12.07%

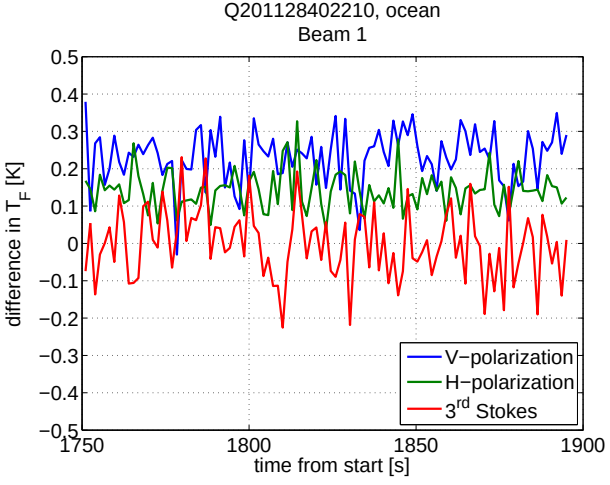
- dramatic reduction of RFI false detection rate

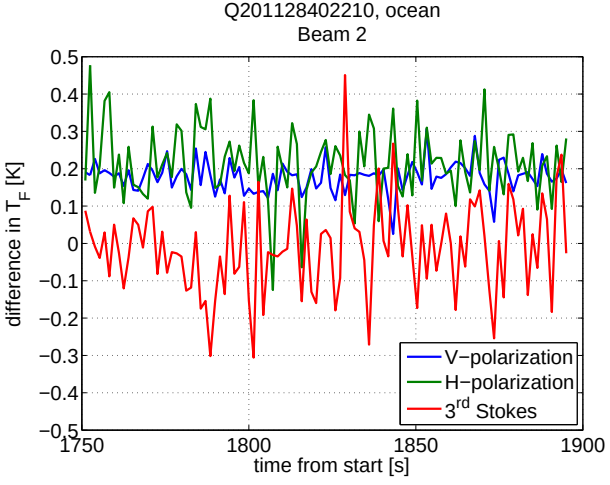
Effect on T_A and T_F for ocean data

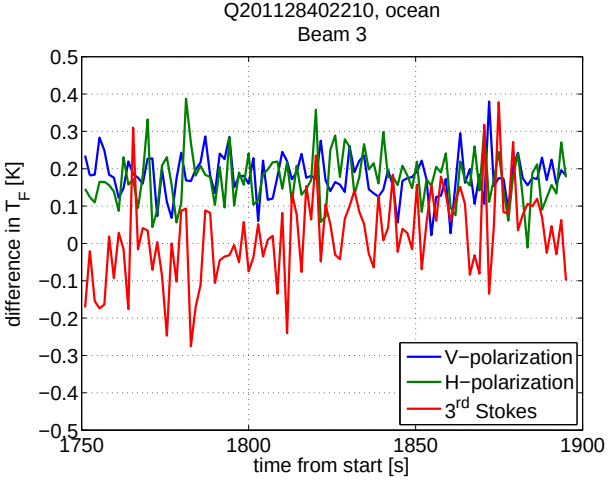








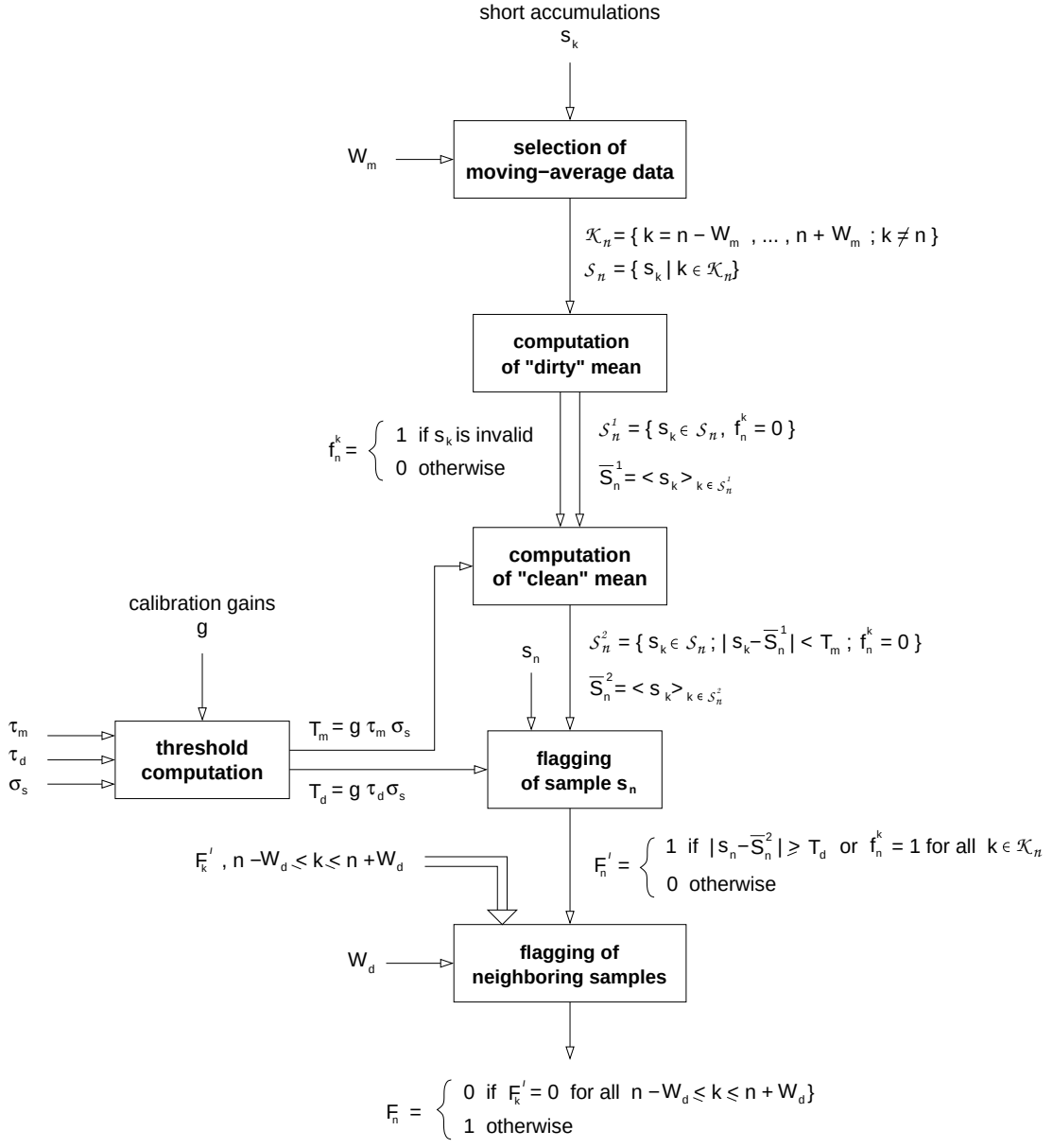




Correction of Short Accumulation

- Level of short accumulations needs to be adjusted in order to improve false RFI detection rate
- Adjustment using α and β not constant in Aquarius data
- Alternative options:
  - remove short accumulations 1
  - approach based on understanding of underlaying cause

RFI flagging algorithm



W_m	10
W_d	5
σ	~ 0.5
g	0.8-1.6
τ_m	1.5
τ_d	4.0

Tuning of Thresholds T_m and T_d

- $T_m = g(\text{beam}, \text{pol})\, \sigma\, \tau_m(\text{lat}, \text{lon})$, $T_d = g(\text{beam}, \text{pol})\, \sigma\, \tau_d(\text{lat}, \text{lon})$

  where

$$\sigma = \frac{T_A^0 + T_N}{\sqrt{B\,\tau}}$$

$T_N =$ receiver noise

$B\,\tau =$ bandwidth $\times$ integration time product

$T_A^0 =$ nominal antenna temperature after front-end losses

- in the RFI code:

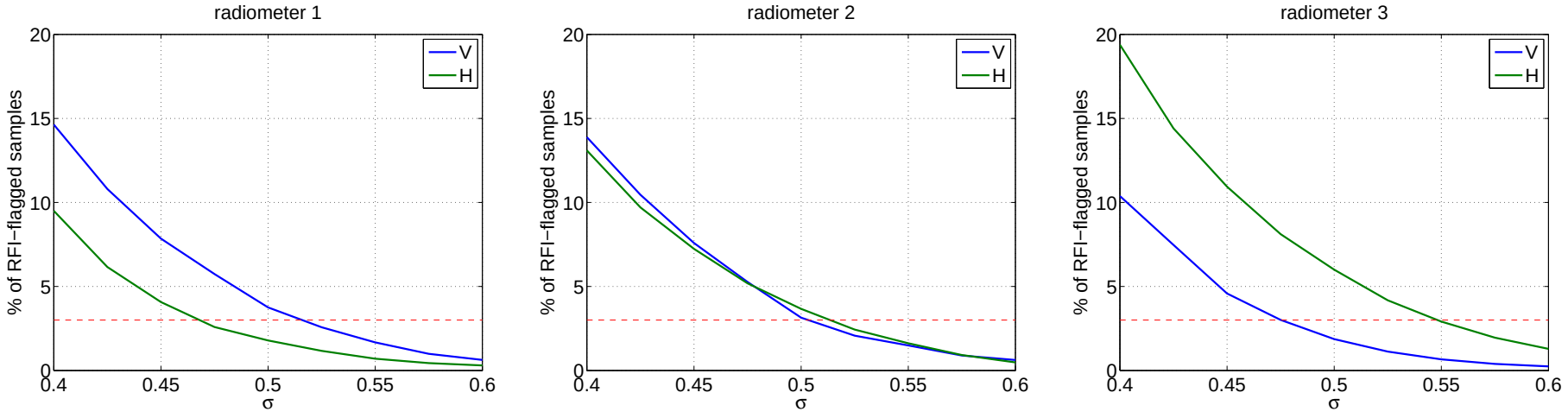
$$T_N = 74.6\,\text{K}$$

$$B\,\tau = 25\,\text{MHz} \times 9\,\text{ms}$$

$$T_A^0 = \begin{cases} 170\,\text{K, V-pol} \\ 150\,\text{K, CP-pol} \\ 150\,\text{K, CM-pol} \\ 130\,\text{K, H-pol} \end{cases} \quad \Longrightarrow \quad \sigma = \begin{cases} 0.5157\text{, V-pol} \\ 0.4735\text{, CP-pol} \\ 0.4735\text{, CM-pol} \\ 0.4313\text{, H-pol} \end{cases}$$

Tuning of T_m and $T_d \Rightarrow$ tuning of σ

- tuning of σ instead of T_m, T_d
- constrained to a certain value of RFI false detection rate in TVAC analysis



Tuning of σ

values of σ

	Radiometer		
	1	2	3
V	0.52	0.52	0.48
CP	0.55	0.56	0.56
CM	0.54	0.52	0.55
H	0.47	0.52	0.56

false RFI detection rate

	Radiometer		
	1	2	3
V	2.81 %	2.26 %	2.77 %
CP	2.40 %	2.18 %	3.04 %
CM	2.73 %	2.85 %	2.90 %
H	2.90 %	2.63 %	2.50 %

- τ_m and τ_d used for geographical location variability (ocean, land, etc.)

Conclusions

- Values of short accumulations 1 are not consistent with values of short accumulations 2-5
- False RFI detection rate greatly decreases when short accumulations 1 are corrected
- False RFI detection rate varies with radiometer number and polarization
- Tuning of T_m,T_d could be split into tuning of σ and tuning of τ_m,τ_d.