NSSL's Dual-polarization Censoring Algorithm

This technique is recommended for the first release of the dual-polarimetric WSR-88D. In general, it applies to any radar that transmits and receives simultaneously horizontally and vertically (SHV) polarized waves at a uniform PRT of duration T_s.

Let H_i denote a complex signal (in-phase and quadrature phase) of horizontally polarized echoes at a fixed range location (same range gate) where the first echo received is H_0. The spacing between H_i samples is T_s and the total number of H samples is M (that is the index i goes from 0 to M-1). Let V_i denote a complex signal of vertically polarized echoes, the spacing between V_i s is also T_s and the total number of V_i samples is also M. So the sequence of sample pairs is (H_0, V_0), (H_1, V_1), (H_2, V_2), (H_3, V_3)…etc.

The two quantities used for the censoring are the signal-to-noise (SNR) estimate in the H channel (SNR_h) and the "uniform sum" (US). The SNR_h is computed as

$$SNR_h = \frac{\frac{1}{M}\sum_{i=0}^{M-1}\left|H_i\right|^2}{N_h} - 1, \qquad (1)$$

where N_h is the measured noise in the H channel. The uniform sum is computed as

$$US = \frac{1}{M}\sum_{i=0}^{M-1}\left|H_i\right|^2 + \frac{1}{M}\sum_{i=0}^{M-1}\left|V_i\right|^2 + \frac{1}{M-1}\left|\sum_{i=0}^{M-2}H_i^*H_{i+1} + \sum_{i=0}^{M-2}V_i^*V_{i+1}\right| + \frac{1}{M}\left|\sum_{i=0}^{M-1}H_i^*V_i\right|, \qquad (2)$$

where * stands for the complex conjugate.

Let THR_{dB} be the SNR threshold specified in dB used in the legacy detector for the given variable (i.e., Z, v, or σ_v; for Z_{DR}, ρ_{hv}, and ϕ_{dp} the threshold is the same as for Z). The SNR threshold is computed as

$$THR_{SNR} = 10^{\frac{THR_{dB}}{10}}. \qquad (3)$$

The threshold for the "uniform sum" is computed as

$$THR_{US} = \max\left(N_h, N_v\right)\cdot\left(\frac{\min\left(N_h, N_v\right)}{\max\left(N_h, N_v\right)}\right)^B \cdot\exp\left(A + C\cdot\frac{\min\left(N_h, N_v\right)}{\max\left(N_h, N_v\right)}\right), \qquad (4)$$

where N_v is the measured noise power in the vertical (V) channel, and the coefficients A, B, and C are obtained from Table 1. Note that each M value has the corresponding set of coefficients associated to it. It is recommended that Table 1 be implemented so that the coefficients can be easily updated (e.g., as part of adaptation data or in a separate configuration file). Note that only a partial table is given in this paper, and a full table is provided in a separate file.

The step by step procedure of the proposed signal censoring algorithm that applies to each range gate is as follows.

if $M > 89$

if $SNR_h \geq THR_{SNR}/2$

accept as “significant return”

else

reject as “non-significant return”

end

else

if $(SNR_h \geq THR_{SNR})$ or $(SNR_h \geq THR_{SNR}/2$ and $US \geq THR_{US})$

accept as “significant return”

else

reject as “non-significant return”

end

end

M	6	7	8	9	10	11	12
A	1.4463	1.4367	1.4296	1.4044	1.3975	1.3615	1.3298
B	-0.1011	-8.9699e-2	-0.0863	-9.3613e-2	-9.3940e-2	-8.0318e-2	-6.7912e-2
C	0.6126	0. 59579	0.5898	0.59864	0.59725	0.58165	0.56929
M	13	14	15	16	17	18	19
A	1.3024	1.2576	1.239	1.1946	1.2039	1.1552	1.1511
B	-5.5740e-2	-6.1595e-2	-4.8790e-2	-3.9140e-2	-2.9329e-2	-4.5421e-2	-2.9440e-2
C	0.55685	0.56567	0.55126	0.54377	0.52846	0.55309	0.53341
M	20	21	22	23	24	25	26
A	1.1223	1.1026	1.0953	1.0798	1.0691	1.0622	1.0454
B	-3.2664e-2	-3.1927e-2	-2.1782e-2	-1.8855e-2	-1.3561e-2	-6.1736e-3	-6.1895e-3
C	0.54113	0. 53956	0.52826	0.52593	0.51962	0.50996	0.51269
M	27	28	29	30	31	32	33
A	1.0313	1.028	1.0098	0.99348	0.99406	0.98481	0.98154
B	-5.1542e-3	2.1922e-3	-2.6402e-4	-2.9082e-3	6.8651e-3	9.0159e-3	1.5671e-2
C	0.51222	0.50091	0.50718	0.51114	0.49914	0.49704	0.4895
M	34	35	36	37	38	39	40
A	0.96288	0.95693	0.94897	0.93505	0.93681	0.92138	0.9188
B	9.7531e-3	1.3140e-2	1.5368e-2	1.2681e-2	2.0367e-2	1.5745e-2	2.0107e-2
C	0.49788	0.49382	0.49269	0.49756	0.48692	0.49384	0.48811
M	41	42	43	44	45	46	47
A	0.93523	0.90515	0.91548	0.89475	0.89016	0.89692	0.8842
B	3.9809e-2	2.2990e-2	3.5888e-2	2.6591e-2	2.8431e-2	3.9408e-2	3.5303e-2
C	0.46344	0.48666	0.46772	0.48242	0.47995	0.46646	0.4728
M	48	49	50	51	52	53	54
A	0.87752	0.87178	0.86942	0.85894	0.85721	0.85255	0.83821
B	3.5153e-2	3.4939e-2	3.8871e-2	3.5241e-2	3.9386e-2	3.9818e-2	3.3166e-2
C	0.47314	0.47245	0.46917	0.47388	0.47038	0.46945	0.47848

Table 1. Excerpt of the table with coefficients for the "uniform sum" threshold (THR_{US}) calculation as a function of the number of samples *M*. The complete table is provided in an electronic form as a separate file.