Surface Radiation Measurement QC tests, including user configurable climatological tests, V1.0

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Define:

SZA = solar zenith angle

μ_0 = Cos(SZA)

NOTE: In the formulas below, if SZA > 90^O, μ_0 is set to 0.0 in the formula

S_0 = solar constant at mean Earth-Sun distance

AU = Earth – Sun distance in Astronomical Units **[**1 AU = mean E-S distance**]**

$S_a = S_0/AU^2$ = solar constant adjusted for Earth – Sun distance

Sum SW = **[**Diffuse SW + (Direct Normal SW) x μ_0**]**

σ = Stephan-Boltzman constant = 5.67×10^{-8} Wm^{-2} K^{-4}

T_a = air temperature in Kelvin [must be in range 170K < T_a < 350K]

T_d = pyrgeometer dome temperature

T_c = pyrgeometer case temperature

T_{snw} = temperature limit for albedo limit test, temp at which "snow" limit is allowed

Global SWdn: SW measured by unshaded pyranometer

Diffuse SW: SW measured by shaded pyranometer

Direct Normal SW: direct normal component of SW

Direct SW: direct normal component of SW times the cosine of SZA

[(Direct Normal SW) x μ_0**]**

LW_{dn}: downwelling LW measured by a pyrgeometer

LW_{up}: upwelling LW measured by a pyrgeometer

Prs: surface station pressure in millibars (NOT adjusted to sea level)

NOTE:
If the input data includes pyrgeometer case and dome temperatures, and/or air temperature, then these temperatures are tested by:

$T_{min} < T_x < T_{max}$

Where T_{min} and T_{max} are user defined using climatological data.

Then if each T_c-T_d pair is within +/- 10 K of each other, the average of all T_c and T_d is calculated.

T_a must fall within +/- 20 K of this average and each individual T_c and T_d must fall within +/- 15 K of this average, else set to -999.

It is recommended that these tests be performed in the order listed to achieve maximum benefit and minimum impact for “missing” or “bad” cases of some values.

Physically Possible Limits [Global] per BSRN (QC Flags set to 5 or 6)

Global SWdn

Min: -4 Wm^{-2}

Max: $S_a \times 1.5 \times \mu_0^{1.2} + 100\ Wm^{-2}$

Diffuse SW

Min: -4 Wm^{-2}

Max: $S_a \times 0.95 \times \mu_0^{1.2} + 50\ Wm^{-2}$

Direct Normal SW

Min: -4 Wm^{-2}

Max: S_a

[for Direct SW, Max: $S_a \times \mu_0$]

SWup

Min: -4 Wm^{-2}

Max: $S_a \times 1.2 \times \mu_0^{1.2} + 50\ Wm^{-2}$

LWdn

Min: 40 Wm^{-2}

Max: 700 Wm^{-2}

LWup

Min: 40 Wm^{-2}

Max: 900 Wm^{-2}

Extremely Rare Minimum Limits [Global] per BSRN (QC Flags set to 3)

Global SWdn

Min: -2 Wm^{-2}

Diffuse SW

Min: -2 Wm^{-2}

Direct Normal SW

Min: -2 Wm^{-2}

SWup

Min: -2 Wm^{-2}

Comparisons [Global] per BSRN

Ratio of Global over Sum SW:

(Global)/(Sum SW) should be within +/- 8% of 1.0 for SZA < 75^O, Sum > 50 Wm^{-2}

(Global)/(Sum SW) should be within +/- 15% of 1.0 for 93^O > SZA > 75^O, Sum > 50 Wm^{-2}

For Sum SW < 50 Wm^{-2}, test not possible

Diffuse Ratio:
(Dif SW)/(Global SW) < 1.05 for SZA < 75^{O}, GSW > 50 Wm^{-2}
(Dif SW)/(Global SW) < 1.10 for 93^{O} > SZA > 75^{O}, GSW > 50 Wm^{-2}
For Global SW < 50 Wm^{-2}, test not possible

SWup comparison
SWup < (Sum SW) [or Global SW if Sum SW missing or "bad"]
For Sum SW [or Global SW] > 50 Wm^{-2}
For Sum SW [or Global SW] < 50 Wm^{-2}, test not possible
If SWup > (Sum SW) AND SWup > (Global SW), Swup = "bad"

Climatological (Configurable) Limits

Global SWdn
Max: $S_a \times D_1 \times \mu_0^{1.2} + 55\ Wm^{-2}$ (2^{nd} level)
Max: $S_a \times C_1 \times \mu_0^{1.2} + 50\ Wm^{-2}$ (1^{st} level)

Diffuse SW
Max: $S_a \times D_2 \times \mu_0^{1.2} + 35\ Wm^{-2}$ (2^{nd} level)
Max: $S_a \times C_2 \times \mu_0^{1.2} + 30\ Wm^{-2}$ (1^{st} level)

Direct Normal SW
Max: $S_a \times D_3 \times \mu_0^{0.2} + 15\ Wm^{-2}$ (2^{nd} level)
[for Dir, Max: $S_a \times D_3 \times \mu_0^{1.2} + 15\ Wm^{-2}$] ($2^{nd}$ level)
Max: $S_a \times C_3 \times \mu_0^{0.2} + 10\ Wm^{-2}$ (1^{st} level)
[for Dir, Max: $S_a \times C_3 \times \mu_0^{1.2} + 10\ Wm^{-2}$] ($1^{st}$ level)

SWup
Max: $S_a \times D_4 \times \mu_0^{1.2} + 55\ Wm^{-2}$ (2^{nd} level)
Max: $S_a \times C_4 \times \mu_0^{1.2} + 50\ Wm^{-2}$ (1^{st} level)

LWdn
Min: $D_5\ Wm^{-2}$ (2^{nd} level)
Max: $D_6\ Wm^{-2}$ (2^{nd} level)
Min: $C_5\ Wm^{-2}$ (1^{st} level)
Max: $C_6\ Wm^{-2}$ (1^{st} level)

LWup
Min: $D_7\ Wm^{-2}$ (2^{nd} level)
Max: $D_8\ Wm^{-2}$ (2^{nd} level)
Min: $C_7\ Wm^{-2}$ (1^{st} level)
Max: $C_8\ Wm^{-2}$ (1^{st} level)

Climatological (Configurable) Comparisons

"Tracker off" test

Using ClrSW = [**a**/AU^2] x $\mu_0^{\mathbf{b}}$, where "a" and "b" are configured by user
Then for dif > 50 Wm^{-2},
if (Sum SW)/ClrSW > 0.85 [or Global SW if Sum SW missing or "bad"]
AND if Dif/(Sum SW) > 0.85 [or Global SW if Sum SW missing or "bad"]
Then the tracker is not properly following the sun

Rayleigh Limit Diffuse Comparison

Rayleigh (R_L) diffuse SW is estimated using:

$$R_L = a\mu_0 + b\mu_0^2 + c\mu_0^3 + d\mu_0^4 + e\mu_0^5 + f\mu_0 Prs$$

Where:
a = 209.3
b = -708.3
c = 1128.7
d = -911.2
e = 287.85
f = 0.046725
μ_0 = cosine of the solar zenith angle
Prs = station surface pressure in millibars

If Global SW is greater than 50 Wm^{-2}, and (Diffuse SW)/(Global SW) is less than 0.8, and diffuse SW is less than (R_L-1.0), then diffuse is set to "bad", QC2 is set to "8"

SWup comparison

SWup < C_x x (Sum SW) + 25 Wm^{-2} [or Global SW if Sum SW missing or "bad"]
For Sum SW [or Global SW] > 50 Wm^{-2}
For Sum SW [or Global SW] < 50 Wm^{-2}, test not possible
D_9 and C_9 if $T_a > T_{snw}$ limit ("normal" ground cover)
D_{10} and C_{10} if $T_a < T_{snw}$ limit (ground may be "snow covered")
NOTE: if limit greater than Sum SW+25, set equal to Sum SW +25
[or Global SW if Sum SW missing or "bad"]
T_{snw} = Temperature limit for test, degrees C, > 0^O C

LWdn to Air Temperature comparison

$D_{11} \times \sigma T_a^4 < LWdn < \sigma T_a^4 + D_{12}$ (2^{nd} level)
$C_{11} \times \sigma T_a^4 < LWdn < \sigma T_a^4 + C_{12}$ (1^{st} level)

LWup to Air Temperature comparison

$\sigma(T_a - D_{13}\ K)^4 < LWup < \sigma(T_a + D_{14}\ K)^4$ (2^{nd} level)
$\sigma(T_a - C_{13}\ K)^4 < LWup < \sigma(T_a + C_{14}\ K)^4$ (1^{st} level)

LWdn to LWup comparison

$LWup - D_{15}\ Wm^{-2} < LWdn < LWup + D_{16}\ Wm^{-2}$ (2^{nd} level)

$LWup - C_{15}\ Wm^{-2} < LWdn < LWup + C_{16}\ Wm^{-2}$ (1^{st} level)

Test/Compare T_a, T_c, T_d

$T_a - C_{17} < T_x < T_a + C_{17}$ (1^{st} level)

(for both LW_{dn} and LW_{up} instruments. If have all 3, can determine "bad" one)

If T_a not available, test not possible.

$C_{18} <= (T_c - T_d) < C_{19}$

If either T_c and T_d "bad", test not possible.