MIDDLETON SOLAR

CE 2022

NSK4 NET RADIOMETER

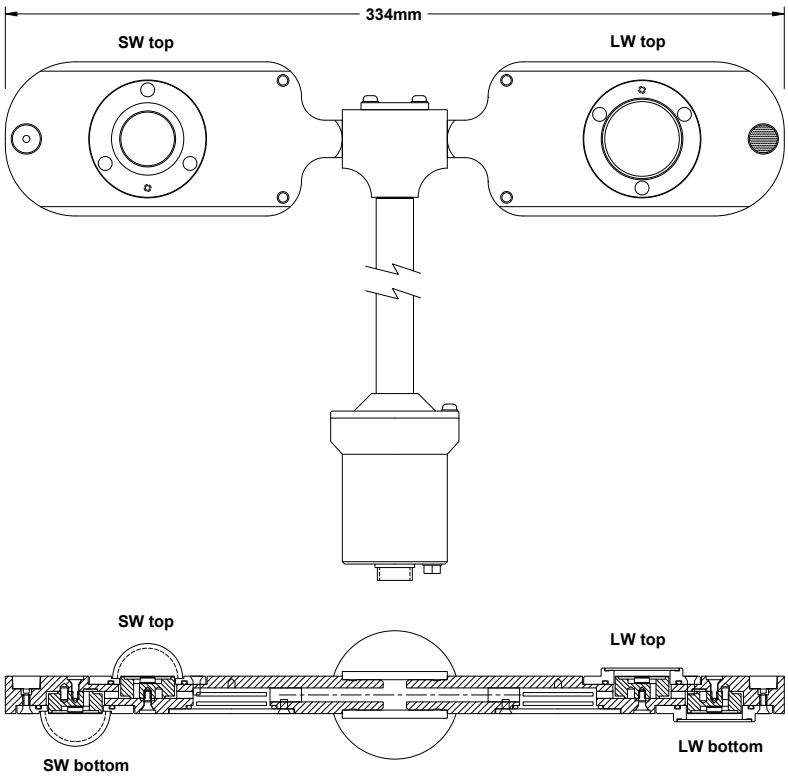
APPLICATION NOTE – QUAD OUTPUT

The Middleton Solar **NSK4 is a 4-component Net Radiometer** for measuring the Net (total) Radiation at the earth's surface. It has four separate thermoelectric sensors: two solar sensors (global & reflected) are shielded by glass domes that are transparent to shortwave (SW) solar radiation but block longwave (LW); two longwave sensors (downward & upward) are shielded by silicon windows that are transparent to longwave radiation but block solar wavelengths. Each output signal is a passive analogue voltage proportional to the incident radiation.

Installation. Select a site that has an unobstructed view of the sky and the ground. Secure the handle tube and adjust position so the instrument is horizontal, approximately 1.5 to 2m above the ground, with the bubble level facing upwards. The available *3-Axis Clamp* can facilitate mounting to a flat plate.

Measurement. Connect the output cable to a data acquisition system. Use differential inputs for each sensor signal. Use a 3-wire connection for the body temperature sensor (if measured). LW top signal is normally negative because the sky is usually cooler than the instrument. Water on the silicon windows (rain or dew) is a strong absorber of IR radiation and can cause temporary errors to the LW radiation response.

output cable	wire color	sensor signal range (typical)
LW top sensor, signal +ve	red	-0.6 mV to +0.2 mV
LW top sensor, signal –ve	blue	
LW bottom sensor, signal +ve	yellow	-0.3 mV to +0.1 mV
LW bottom sensor, signal –ve	green	
SW top sensor, signal +ve	white	0.0 mV to +15 mV
SW top sensor, signal –ve	black	
SW bottom sensor, signal +ve	grey	0.0 mV to +5 mV
SW bottom sensor, signal –ve	brown	
body temperature; Pt100, 3-wire		
+ve	pink	
-ve	violet, orange	



Maintenance. Keep the domes and windows clean and free from debris; use water and mild detergent only. Calibration is recommended every two years. Desiccant is inside the cylinder at the end of the handle; it should be replenished at calibration.

Net (total) radiation. E_{net} = (SW top) + (LW top) - (SW bot) - (LW bot), written as:

$E_{net} = E_s$ down + E_l down - E_s up - E_l up, where:

$E_s = U_s / C_s$, in W.m^{-2}

U_s is the top or bottom SW output in µV; C_s is the SW sensitivity in µV/W.m^{-2}

$E_l = U_l / C_l$, in W.m^{-2}

U_l is the top or bottom LW output in µV, and is <u>normally negative</u>

C_l, is the LW sensitivity in µV/W.m^{-2}

example: if U_{s_top} = 10,120 µV, and C_{s_top} = 10.4 µV/W.m-2

U_{l_top} = -420 µV, and C_{l_top} = 4.6 µV/W.m-2

U_{s_bot} = 530 µV, and C_{s_bot} = 10.6 µV/W.m-2

U_{l_bot} = -60 µV, and C_{l_bot} = 4.4 µV/W.m-2

E_{net} = (SW top) + (LW top) - (SW bot) - (LW bot)

= (10,120/10.4) + (-420/4.6) - (530/10.6) - (-60/4.4)

= 973.1 - 91.3 - 50.0 + 13.6

= 845.4 W.m-2

The sensitivities *C* are provided on the Factory Calibration Certificate.
The body temperature signal is not required for Net measurement.
The SW components (E_s down & E_s up) dominate the Net measurement.

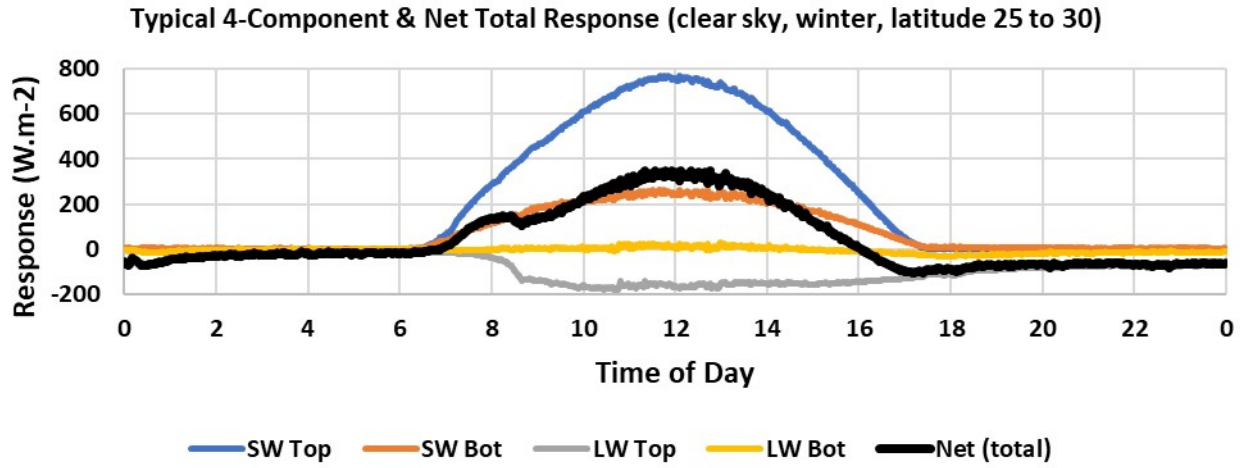
Longwave radiation. $E_l = U_l / C_l + \sigma T_B^4$, in W.m^{-2}

where, T_B is the instrument body temperature in Kelvin

σ = 5.6704 · 10^{-8} is the Stephan-Boltzmann constant

Separate top or bottom LW radiation measurement requires the inclusion of T_B.

Typical response



Conditions	Net (total) Radiation
clear sunny day	300 to 1,000 W.m^{-2}
partly cloudy day	200 to 400 W.m^{-2}
fully cloudy day	25 to 200 W.m^{-2}
clear night	-200 to -50 W.m^{-2}
cloudy night	-50 to 0 W.m^{-2}

Technical specification

sensitivity	4-11 µV/W.m^{-2} x 4 outputs
calibration traceability	LW: WISG (World Infrared Standard Group) SW: WRR (World Radiometric Reference)
spectral range	LW: 4.5 to 42µm SW: 0.3 to 3µm
field of view	LW: 2 x 170° SW: 2 x 180°
response time (95%)	7s (typical)
irradiance	LW: ±1,000 W.m^{-2} SW: ±2,000 W.m^{-2}
impedance	20 Ω x 4 outputs
operating temperature	-40 to +60°C
non-stability (1 year interval)	< ±1%
non-linearity	< ±1%
temperature dependence of sensitivity	< ±2% (-10 to +40°C)
window heating offset (LW signals)	< 10 W.m^{-2}, shaded
directional response (w.r.t 1,000 W.m^{-2})	LW: not relevant to isotropic IR SW: < 20 W.m^{-2} (0-80°)
level accuracy	0.4°
desiccant (in endcap)	orange silica gel (non-toxic)
sensors	thermopile x 4
window/dome	LW: solar-blind silicon SW: glass dome
temperature sensor (body)	Pt100 platinum resistor; DIN IEC 751, Class A
output lead	6m, with connector at instrument end
construction	anodized aluminum; stainless steel
IP rating	sealed to IP66 (when output lead fitted)
dimensions & weight	head 66x45x334mm; handle Ø16x640; 1.5kg
shipping size & weight	90 x 40 x 9cm; 5kg

Available Option 3-Axis Clamp (for mounting to a flat plate), P/N 123.910