Broadband Outdoor Radiometer Calibration
Longwave

BORCAL-LW
2024-01

Generated by

Radiometer Calibration and Characterization

Calibration Facility

Southern Great Plains

Latitude: 36.605°N
Longitude: 97.488°W
Elevation: 317.0 meters AMSL
Time Zone: -6.0

Calibration date
02/09/2024 to 04/01/2024

Report Date
April 1, 2024

NOTICE

Broadband Outdoor Radiometer Calibration Report

Table of contents

Introduction

This report compiles the calibration results from a Broadband Outdoor Radiometer Calibration (BORCAL). The work was accomplished at the Radiometer Calibration Facility shown on the front of this report. The calibration results reported here are traceable to the World Infrared Standard Group (WISG).

This report includes these sections:

- Control Instruments - a group of instruments included in each BORCAL event that provides a measure of process consistency.
- Results Summary - a table of all instruments included in this report summarizing their calibration results and uncertainty.
- Instrument Details - the calibration certificates for each instrument.
- Environmental and Sky Conditions - meteorological conditions and reference irradiance during the calibration event.

Control Instrument History

Figure 1. Eppley PIR Control Instrument (Residual means of current data using historical coefficients)

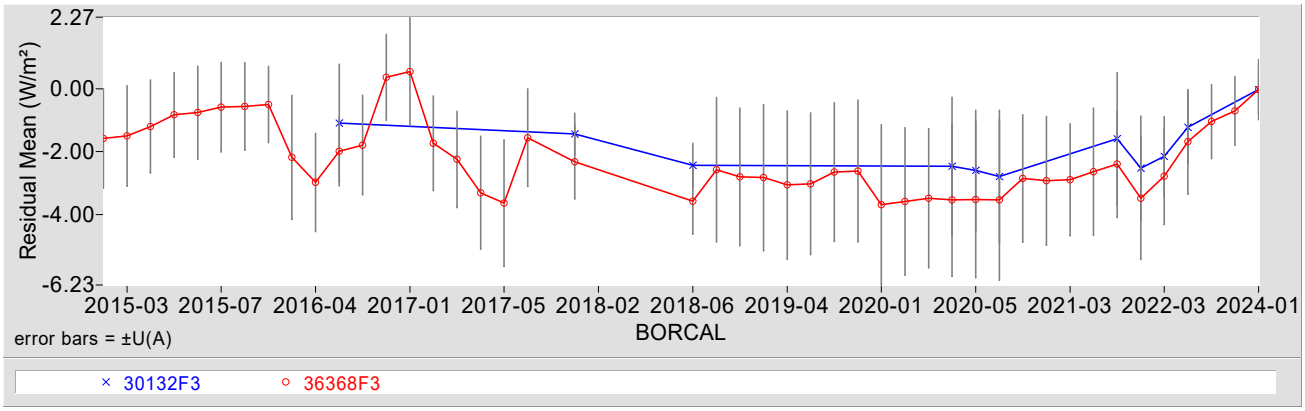


Figure 2. Eppley PIR Control Instrument History (K1 Coefficient)

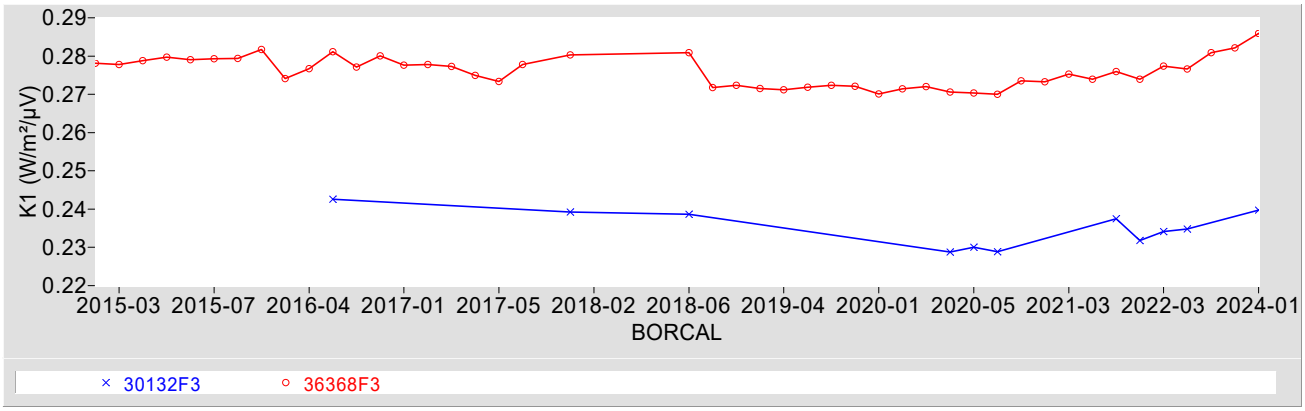


Figure 3. Eppley PIR Control Instrument History (K2 Coefficient)

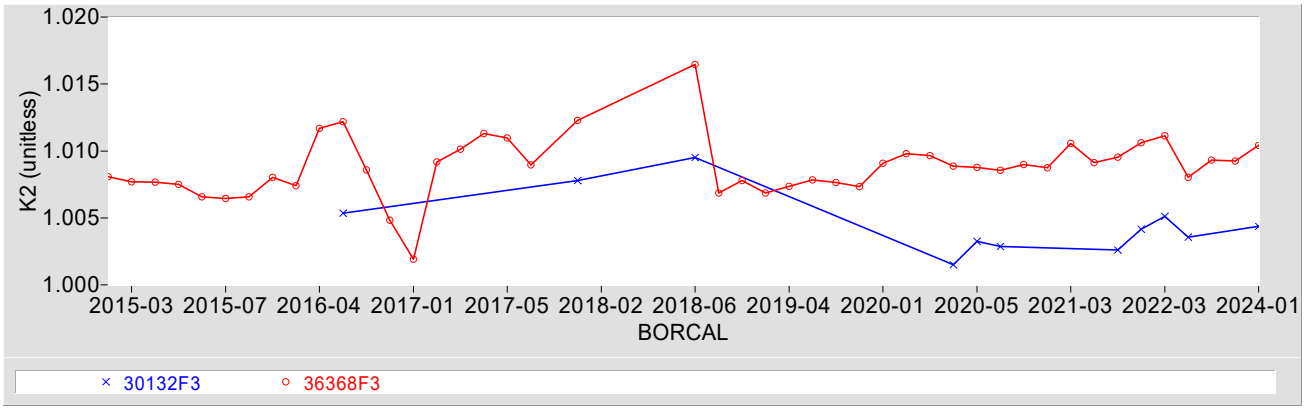
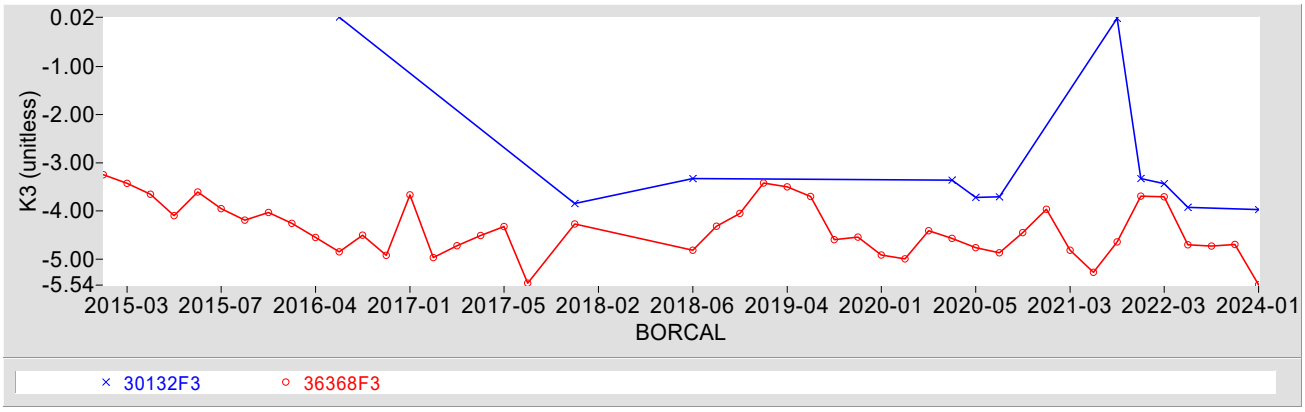


Figure 4. Eppley PIR Control Instrument History (K3 Coefficient)



Results Summary

Table 1. Results Summary

Instrument	Customer	K1 (W/m²/µV)	K2	K3	Kr * (K/µV)	U95 (W/m²)	Page
30084F3	TWP	0.26823	1.0003	-3.60	7.044e-4	±3.2	A1-2
30085F3	SGP	0.23940	1.0015	-5.40	7.044e-4	±3.2	A1-5
30132F3	SGP	0.23978	1.0044	-3.97	7.044e-4	±3.0	A1-8
30168F3	NSA	0.37568	0.9997	-4.05	7.044e-4	±3.1	A1-11
30357F3	SGP	0.24465	1.0014	-4.29	7.044e-4	±3.1	A1-14
30681F3	SGP	0.25723	0.9982	-4.13	7.044e-4	±3.0	A1-17
30687F3	SGP	0.24544	1.0015	-3.35	7.044e-4	±3.1	A1-20
30688F3	SGP	0.24174	1.0003	-2.99	7.044e-4	±3.1	A1-23
30689F3	SGP	0.26455	0.9981	-2.98	7.044e-4	±3.1	A1-26
30691F3	SGP	0.24272	0.9942	-3.08	7.044e-4	±3.2	A1-29
30695F3	SGP	0.25639	0.9984	-3.15	7.044e-4	±3.1	A1-32
30780F3	SGP	0.25328	1.0026	-3.35	7.044e-4	±3.1	A1-35
30781F3	SGP	0.28193	0.9980	-3.65	7.044e-4	±3.0	A1-38
30835F3	SGP	0.23440	1.0009	-3.53	7.044e-4	±3.1	A1-41
30837F3	SGP	0.25176	1.0015	-4.22	7.044e-4	±3.2	A1-44
31299F3	NSA	0.23301	0.9888	-4.14	7.044e-4	±3.1	A1-47
31300F3	TWP	0.28183	1.0012	-5.10	7.044e-4	±3.4	A1-50
31309F3	TWP	0.24648	1.0031	-2.94	7.044e-4	±3.1	A1-53
31390F3	TWP	0.23518	0.9992	-3.96	7.044e-4	±3.2	A1-56
31391F3	TWP	0.25329	0.9989	-3.29	7.044e-4	±3.1	A1-59
32040F3	NSA	0.24920	1.0009	-3.88	7.044e-4	±3.0	A1-62
32042F3	NSA	0.23748	1.0063	-3.53	7.044e-4	±3.1	A1-65
32044F3	SGP	0.22207	1.0039	-3.17	7.044e-4	±3.1	A1-68
32047F3	NSA	0.23055	1.0034	-3.46	7.044e-4	±3.0	A1-71
32049F3	SGP	0.24272	1.0050	-3.50	7.044e-4	±3.0	A1-74
32054F3	NSA	0.22602	1.0099	-3.21	7.044e-4	±3.0	A1-77
32832F3	TWP	0.24094	1.0041	-3.21	7.044e-4	±3.2	A1-80
32998F3	TWP	0.24203	1.0014	-2.60	7.044e-4	±3.3	A1-83
33058F3	TWP	0.24776	0.9980	-2.78	7.044e-4	±3.2	A1-86
34303F3	AMF	0.22297	1.0089	-3.61	7.044e-4	±3.1	A1-89
35840F3	AMF	0.29273	1.0023	-5.89	7.044e-4	±3.2	A1-92
36368F3	SGP	0.28586	1.0104	-5.53	7.044e-4	±3.1	A1-95
37325F3	AMF	0.27287	0.9993	-7.17	7.044e-4	±3.3	A1-98
38865F3	SGP	0.31788	1.0054	-5.08	7.044e-4	±3.1	A1-101
38869F3	SGP	0.31238	1.0005	-4.99	7.044e-4	±3.0	A1-104
38870F3	SGP	0.27976	0.9943	-5.23	7.044e-4	±3.0	A1-107

Note: Environmental Conditions for BORCAL starts on page A1-110.

* Kr used to derive coefficients

Appendix 1
Instrument Details

Calibration Certificates: 3 pages for each radiometer (4 including Environmental Conditions)
Environmental Conditions for BORCAL: Last Page of a Calibration Certificate. Note: This appears only once, at the end of Appendix 1.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30084F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30084F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

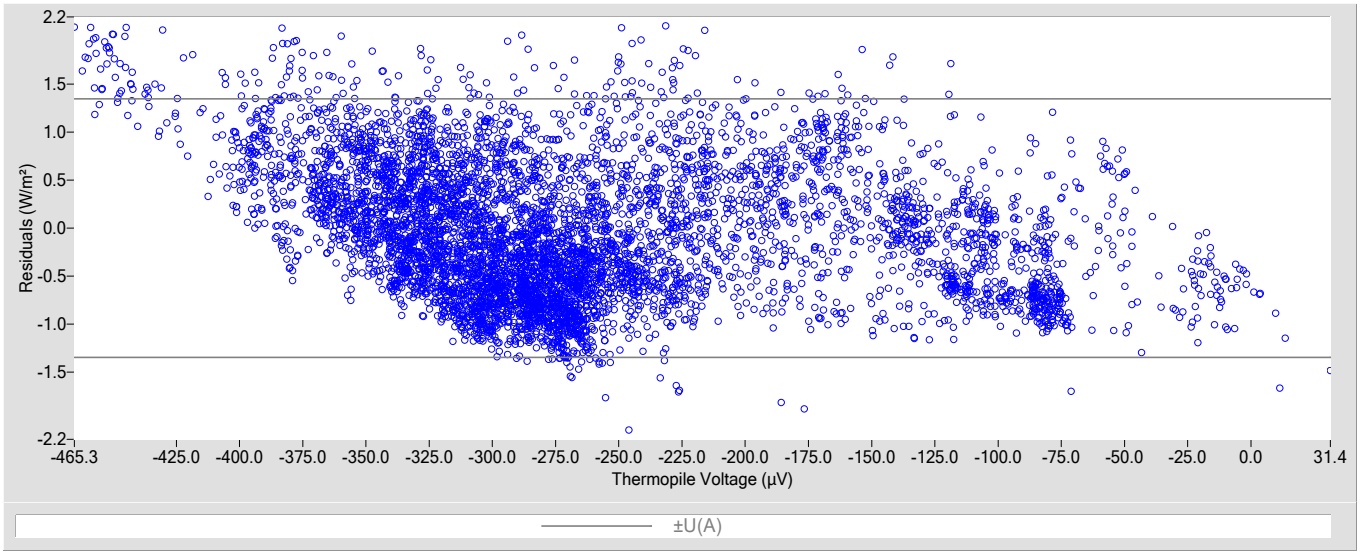


Table 1. Calibration Coefficients

K1	0.26823
K2	1.0003
K3	-3.60
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.69
Combined Standard Uncertainty, u(c) (W/m²)	±1.7
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

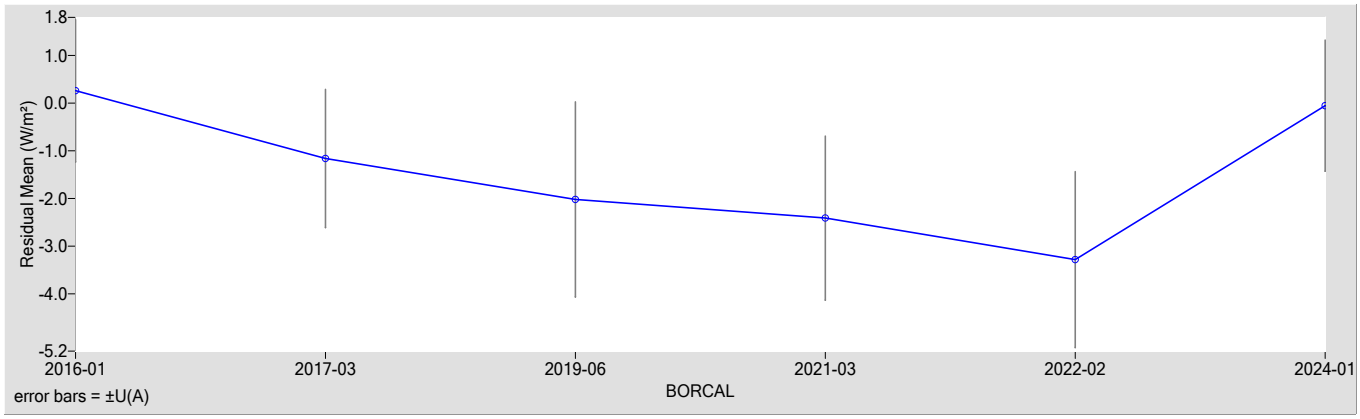


Figure 3. History of instrument (K1 Coefficient)

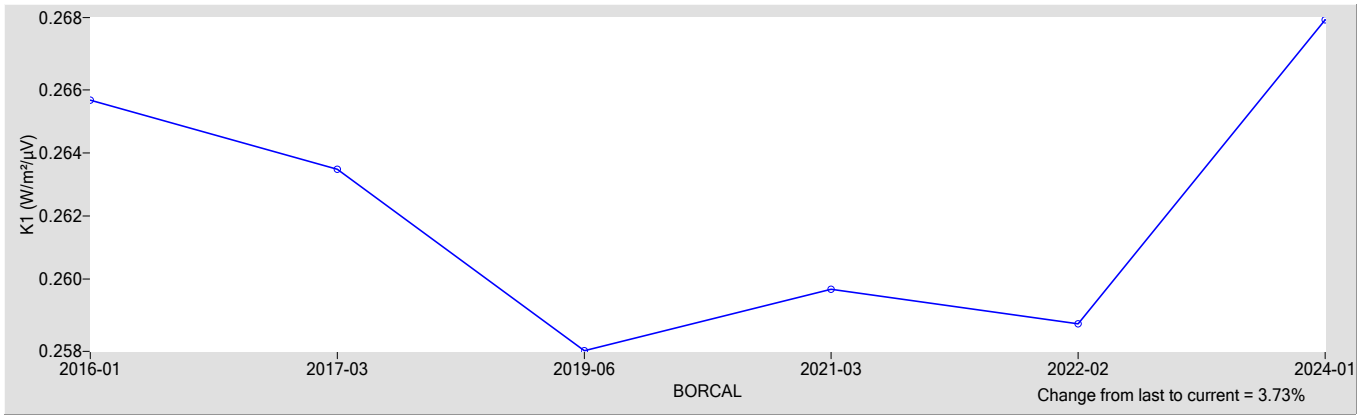


Figure 4. History of instrument (K2 Coefficient)

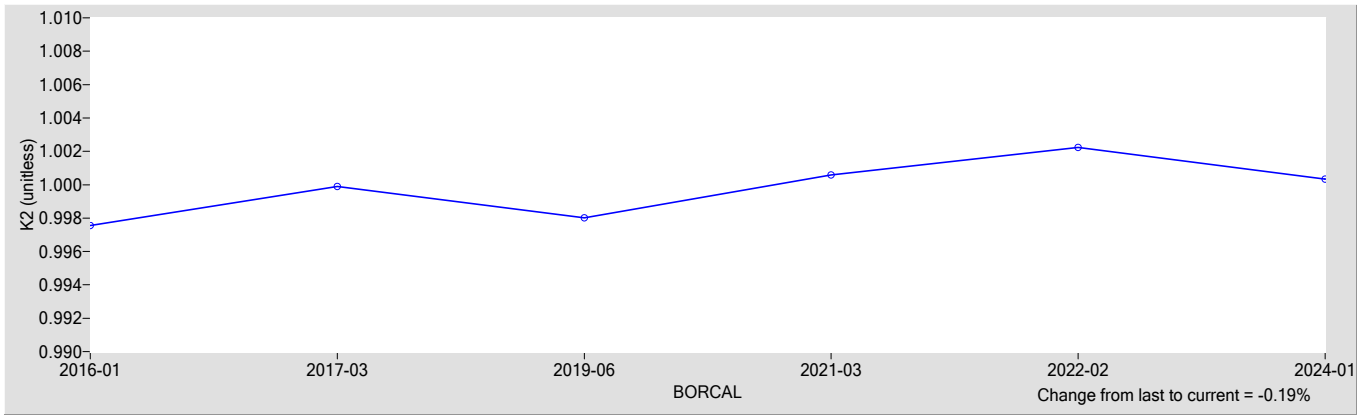
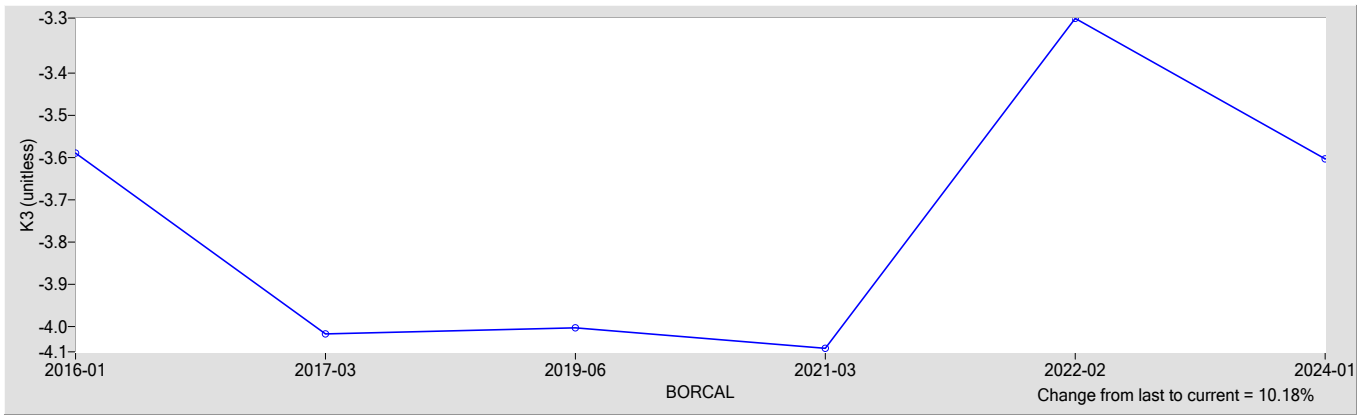


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30085F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

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Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30085F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

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Figure 1. Residuals for calculated using coefficients vs reference irradiance

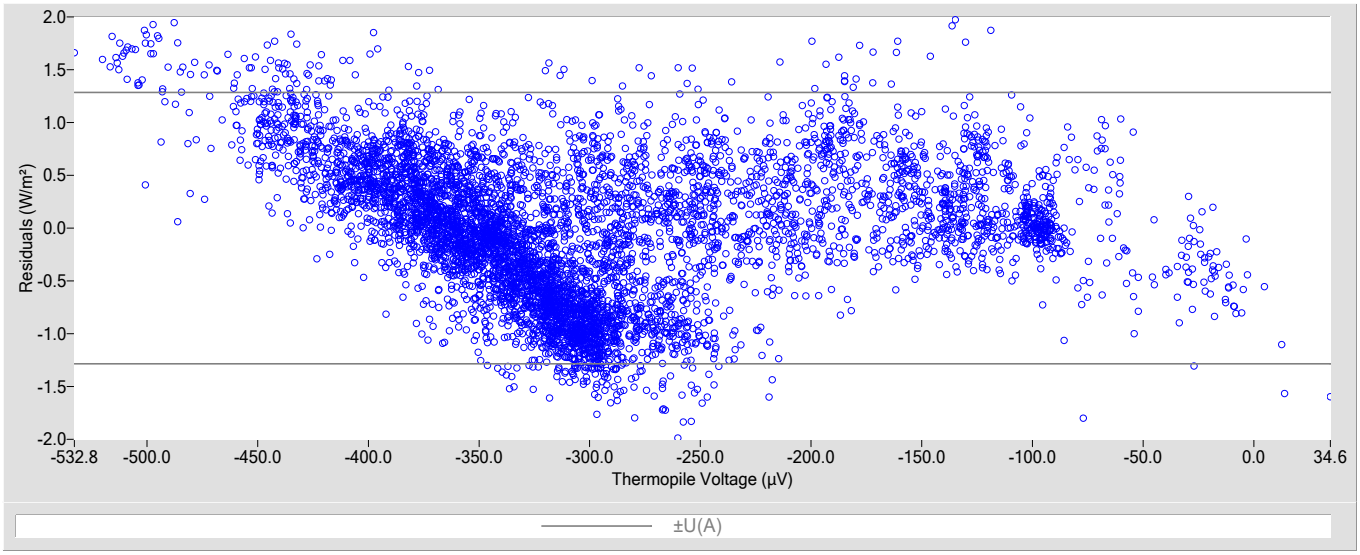


Table 1. Calibration Coefficients

K1	0.23940
K2	1.0015
K3	-5.40
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.66
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

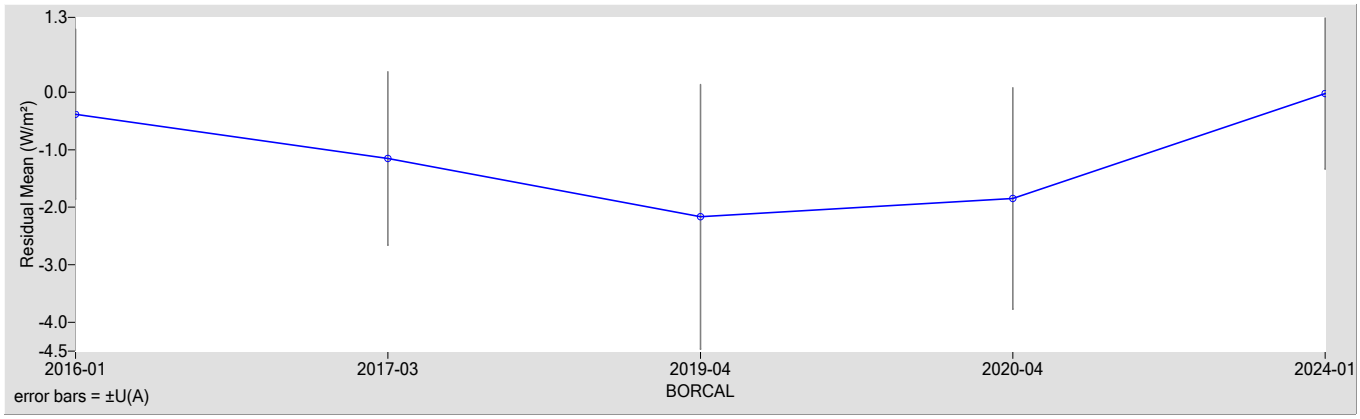


Figure 3. History of instrument (K1 Coefficient)

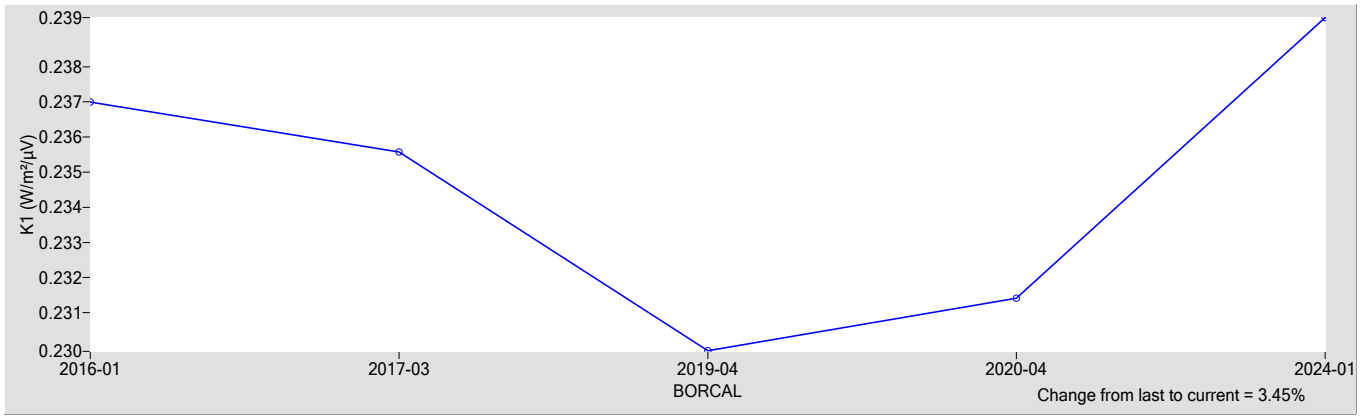


Figure 4. History of instrument (K2 Coefficient)

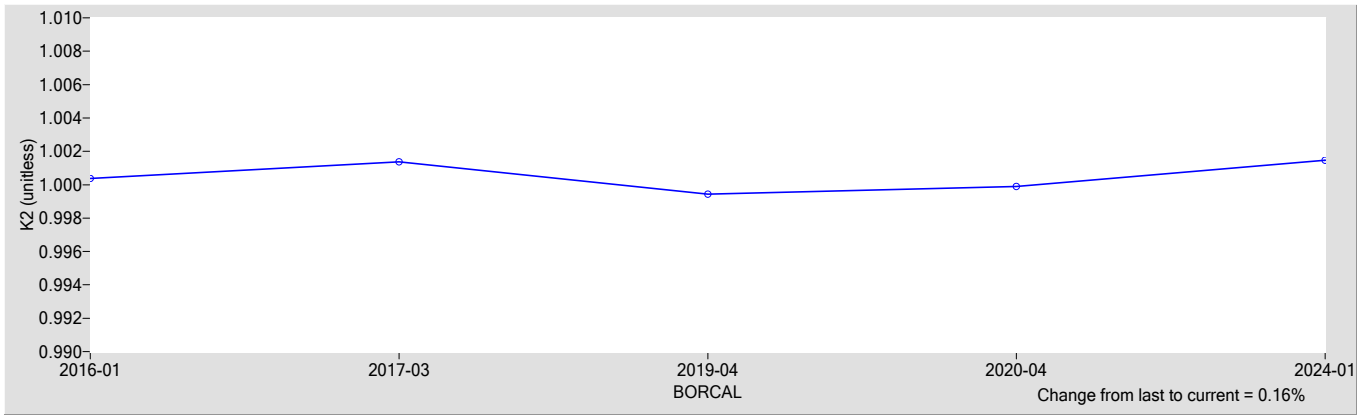
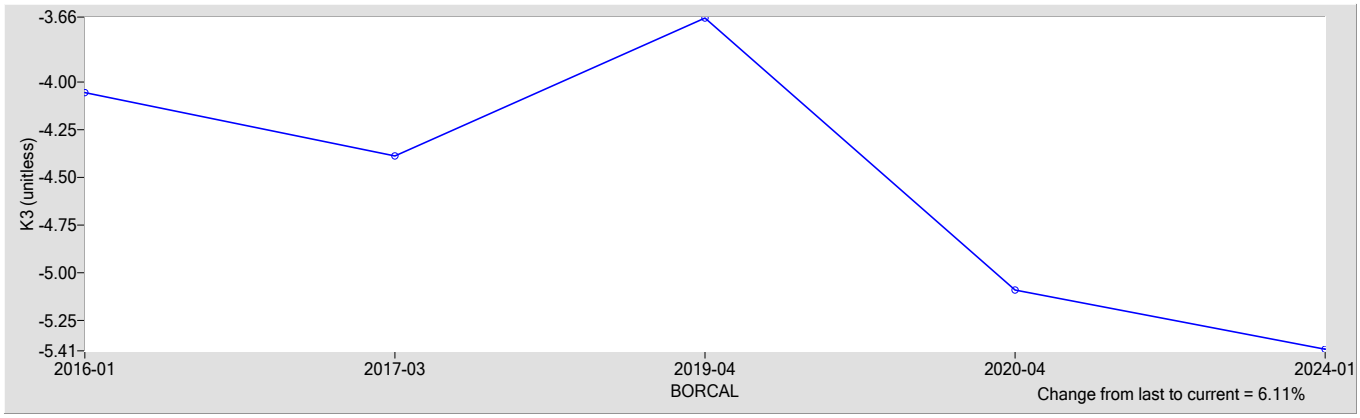


Figure 5. History of instrument (K3 Coefficient)



References:

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Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30132F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

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Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
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Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30132F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (µV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/µV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

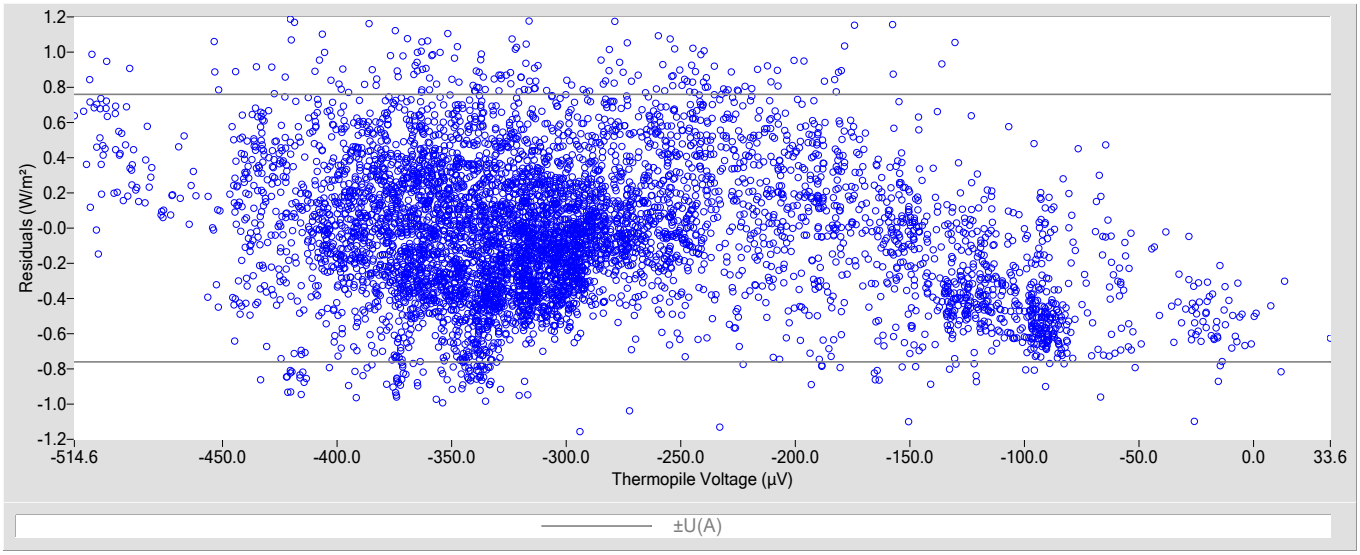


Table 1. Calibration Coefficients

K1	0.23978
K2	1.0044
K3	-3.97
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.39
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

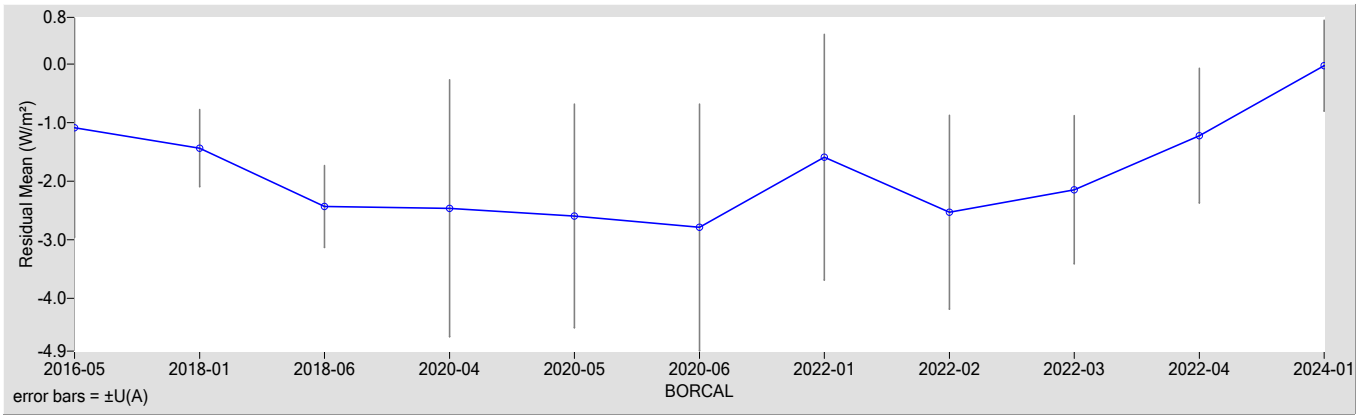


Figure 3. History of instrument (K1 Coefficient)

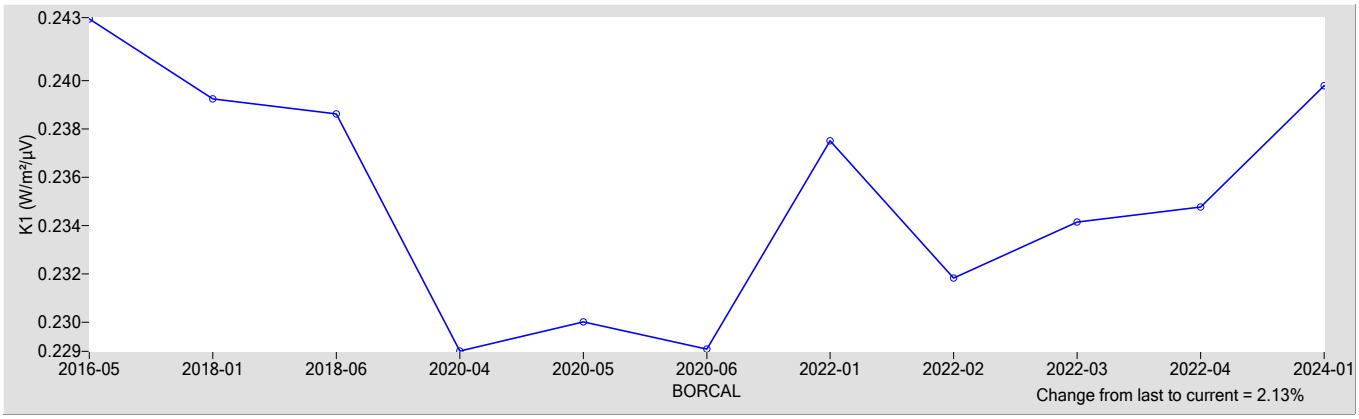


Figure 4. History of instrument (K2 Coefficient)

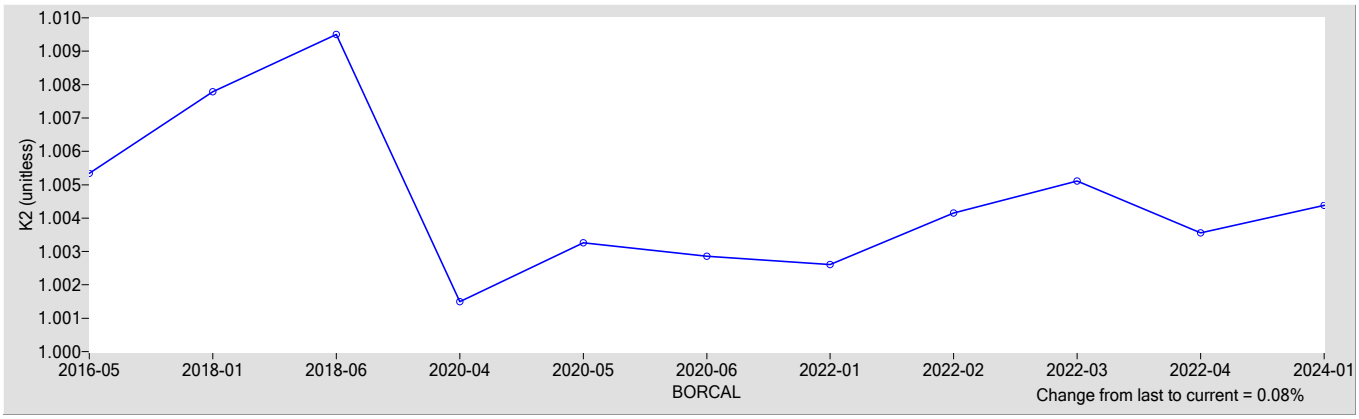
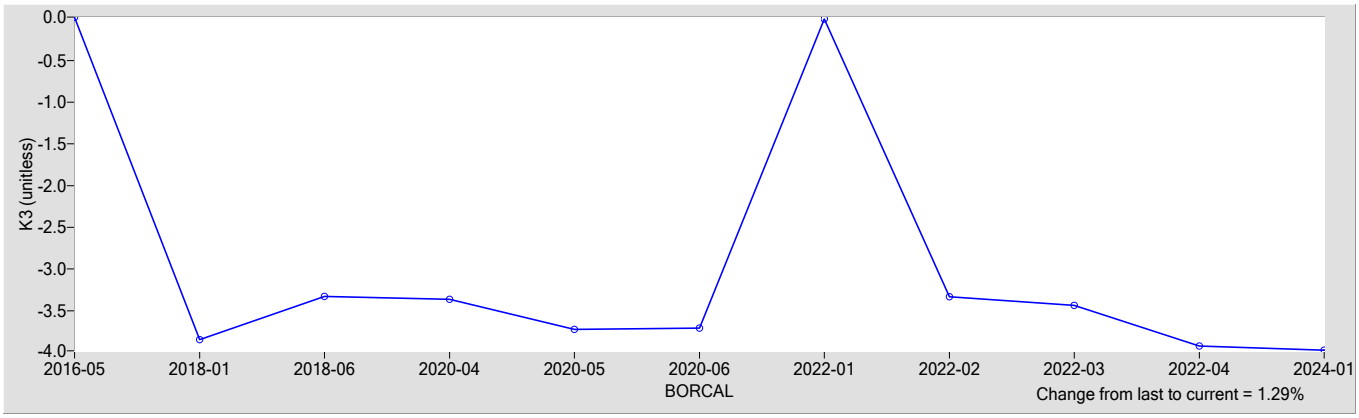


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30168F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30168F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

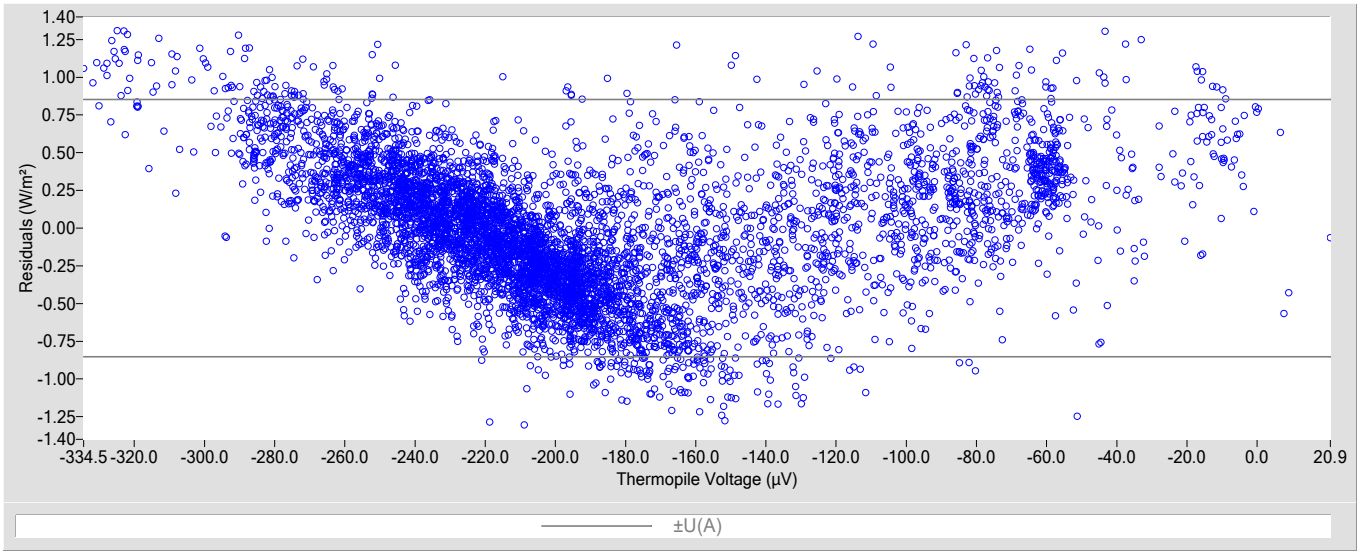


Table 1. Calibration Coefficients

K1	0.37568
K2	0.9997
K3	-4.05
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.44
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

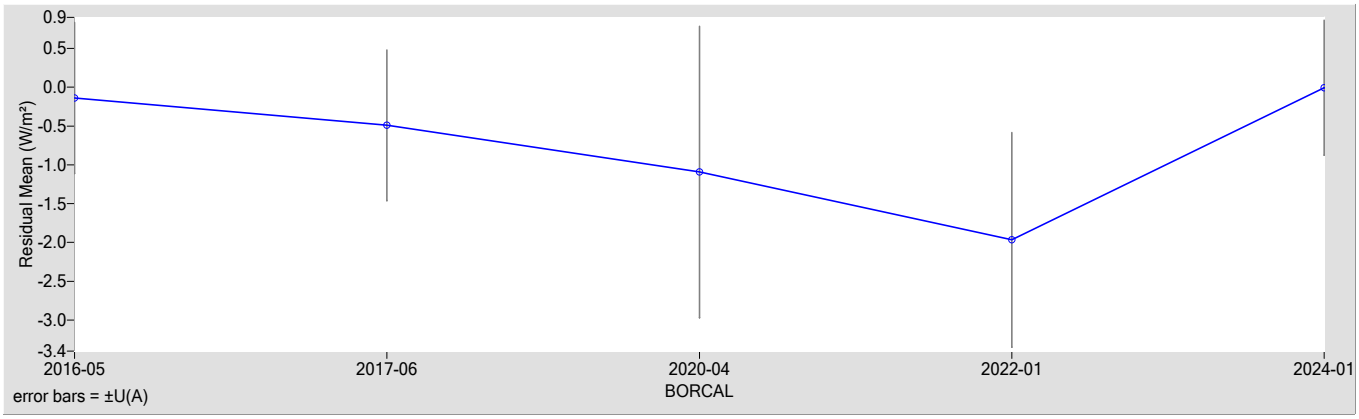


Figure 3. History of instrument (K1 Coefficient)

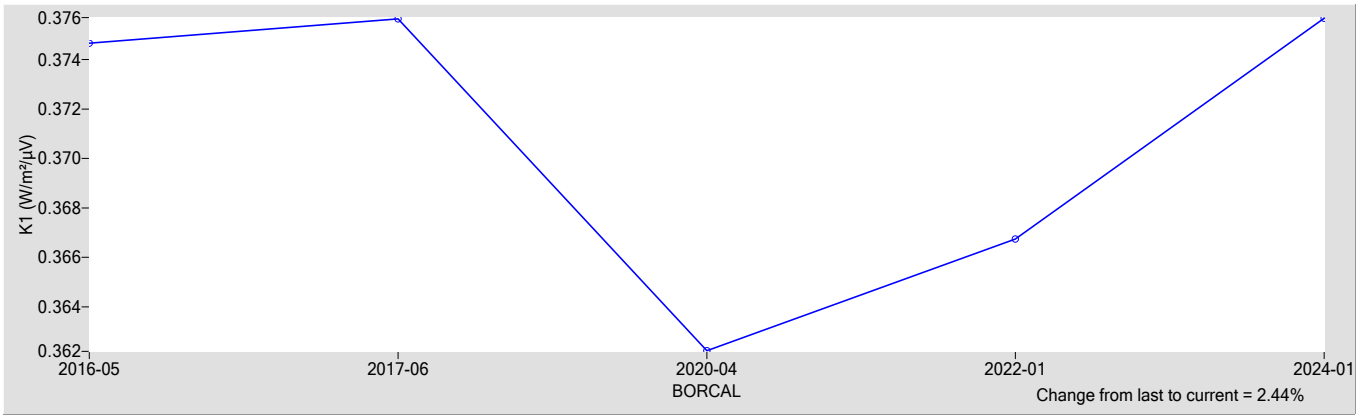


Figure 4. History of instrument (K2 Coefficient)

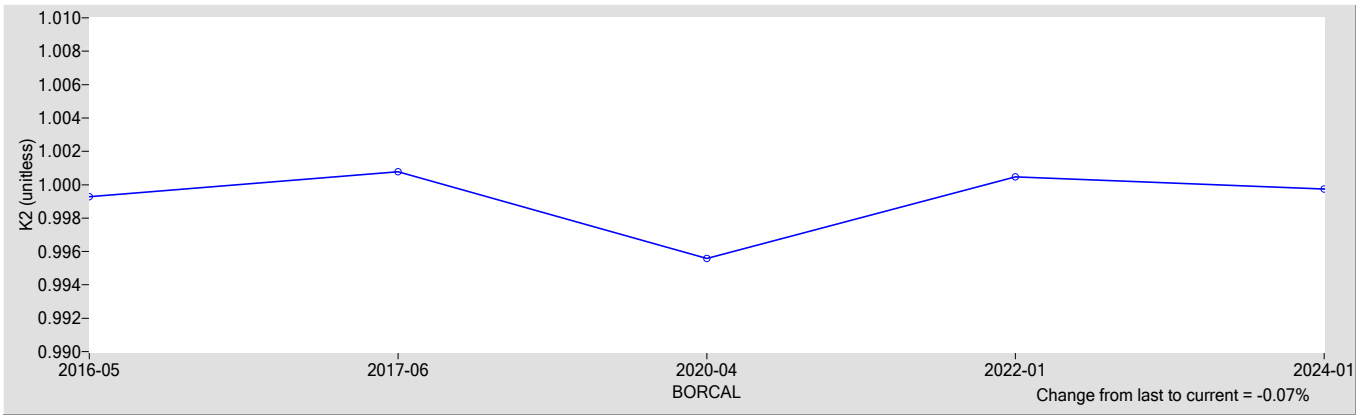
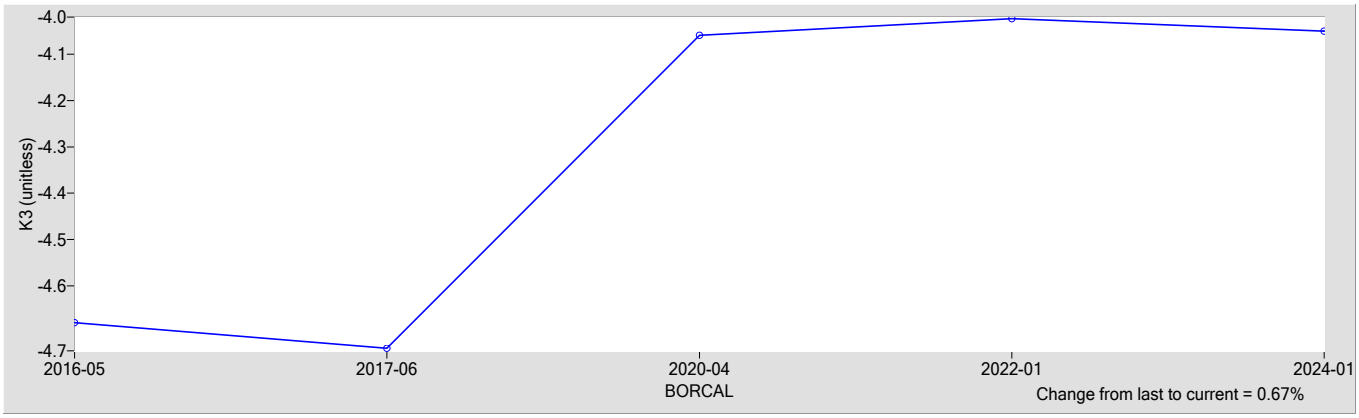


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30357F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30357F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

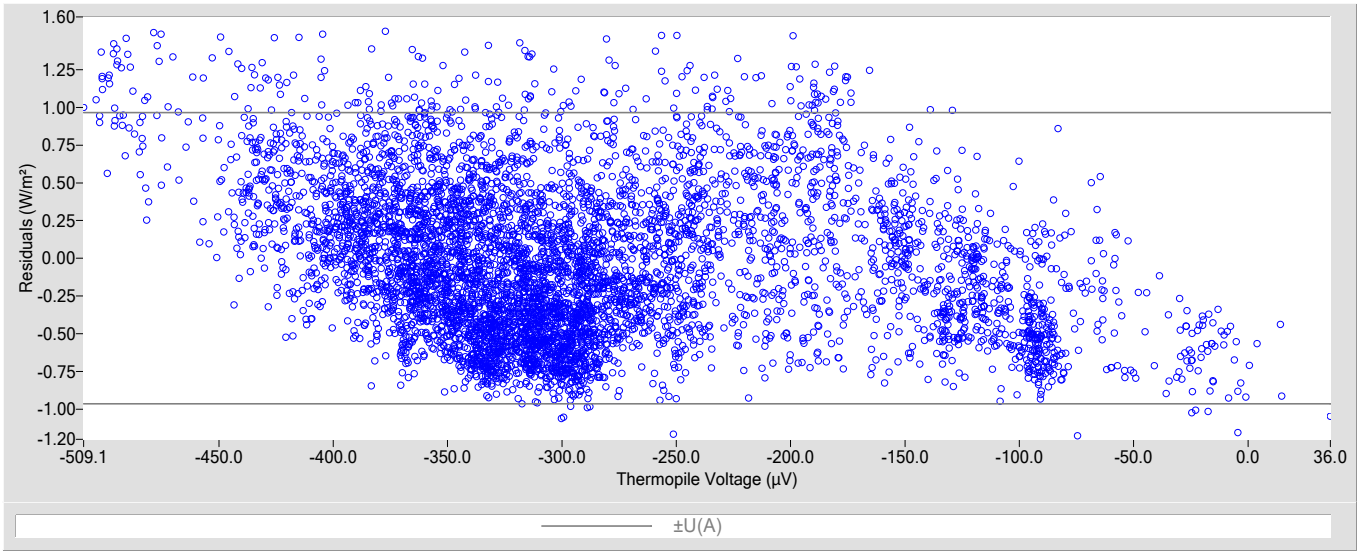


Table 1. Calibration Coefficients

K1	0.24465
K2	1.0014
K3	-4.29
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.49
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

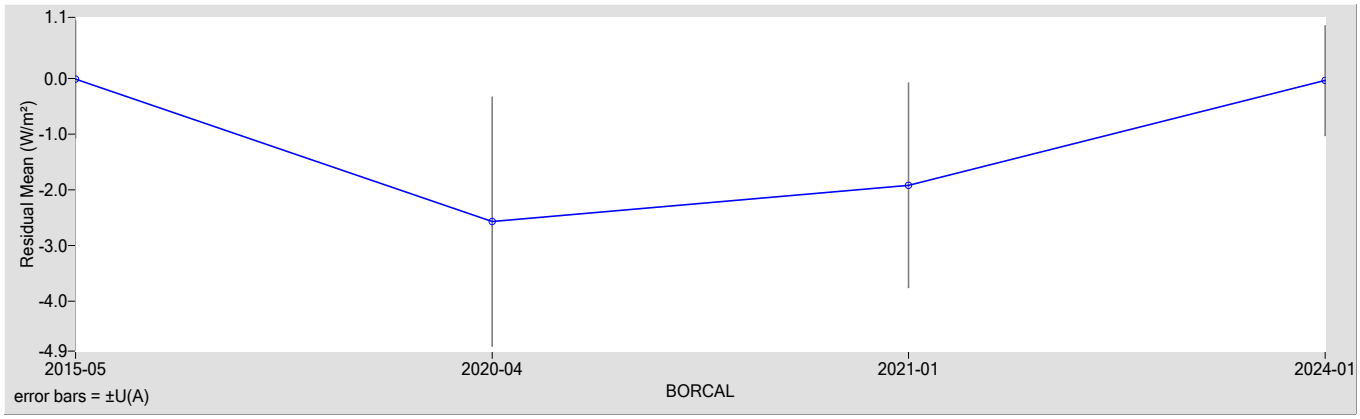


Figure 3. History of instrument (K1 Coefficient)

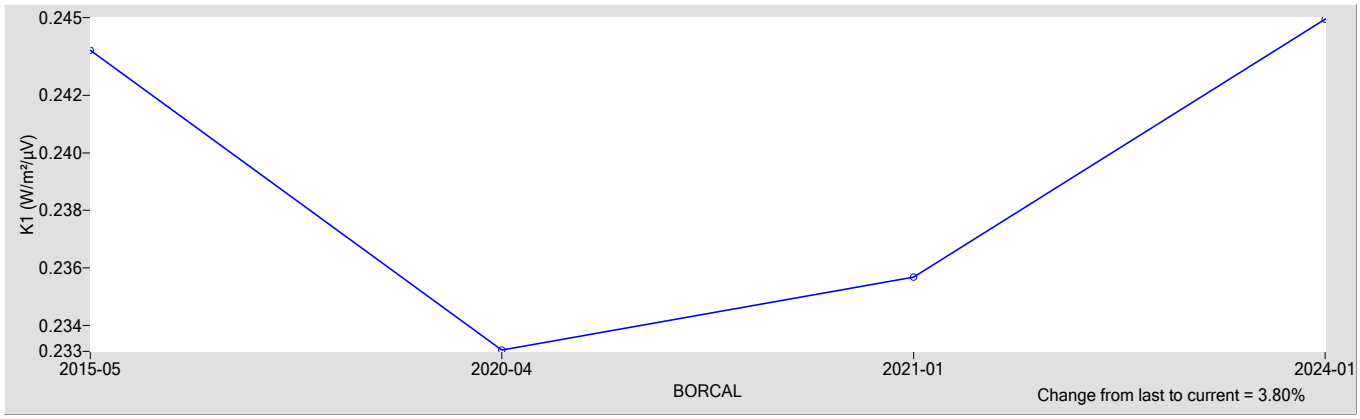


Figure 4. History of instrument (K2 Coefficient)

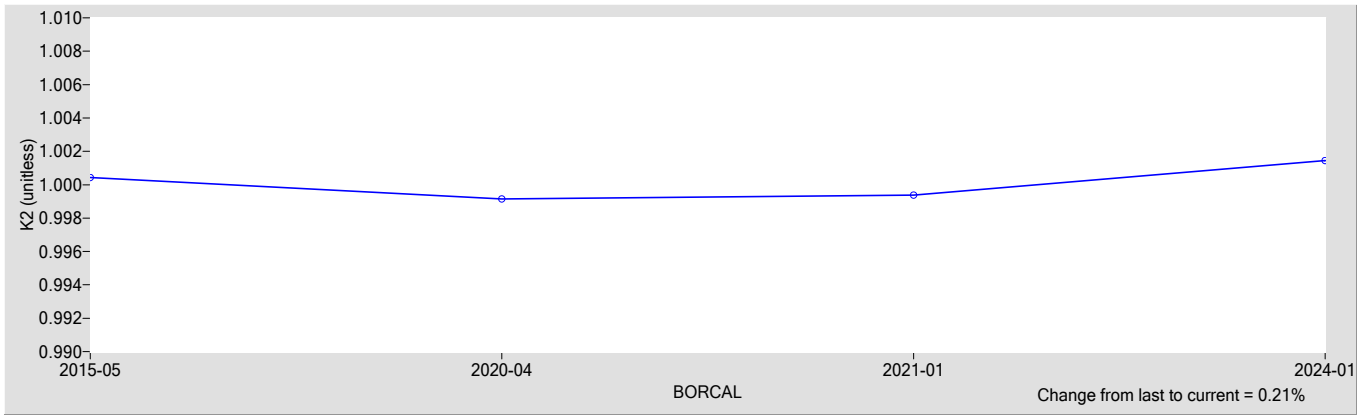
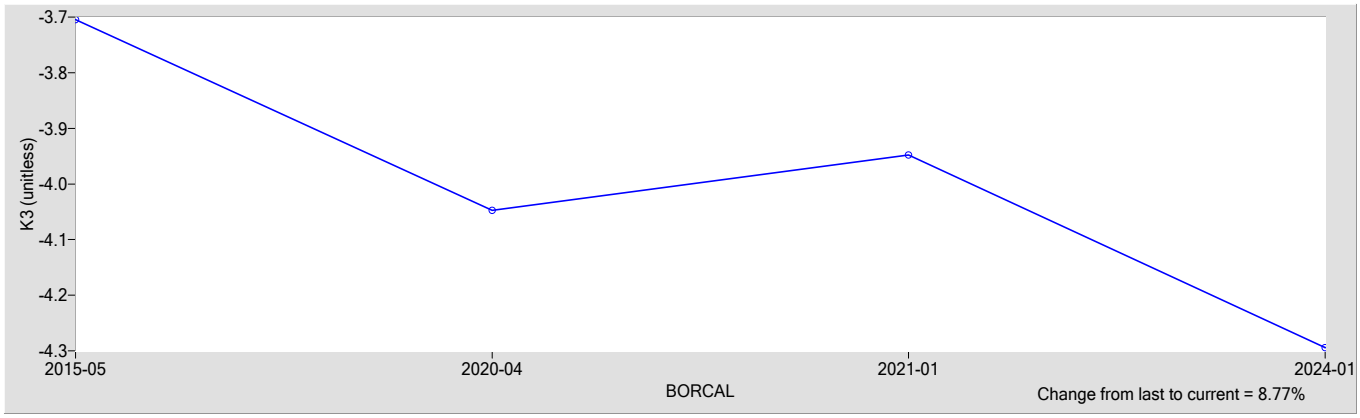


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30681F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30681F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

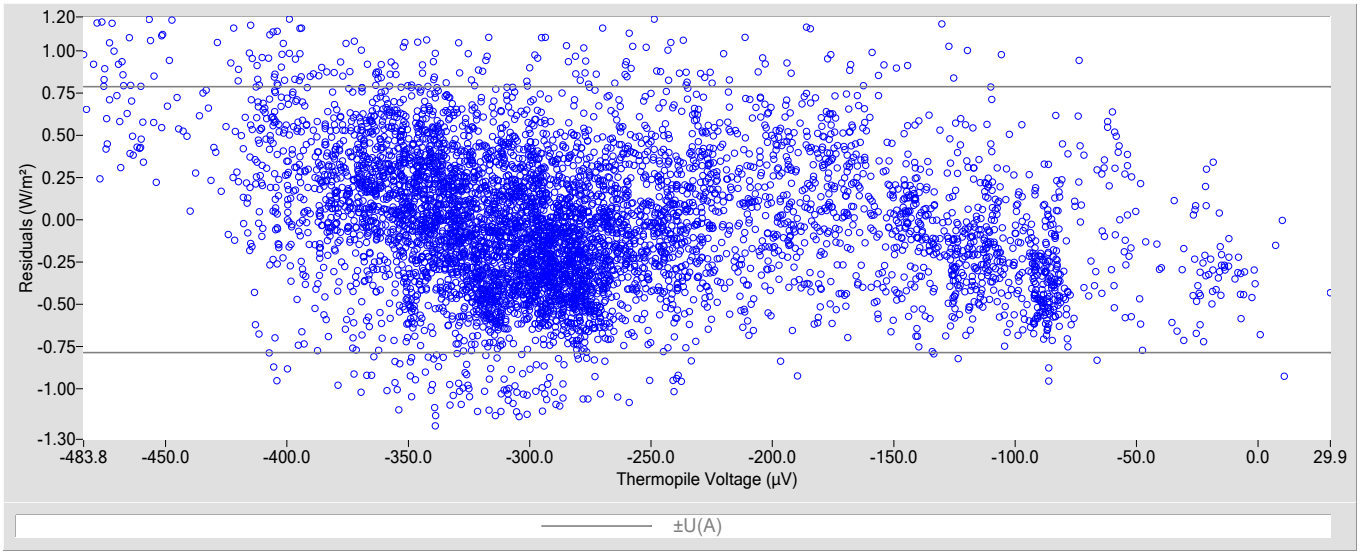


Table 1. Calibration Coefficients

K1	0.25723
K2	0.9982
K3	-4.13
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.40
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

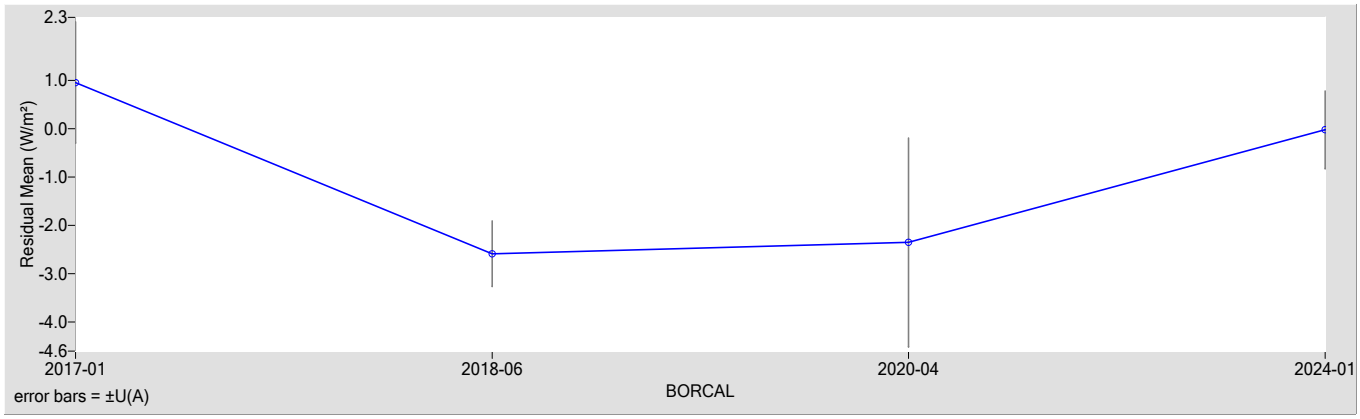


Figure 3. History of instrument (K1 Coefficient)

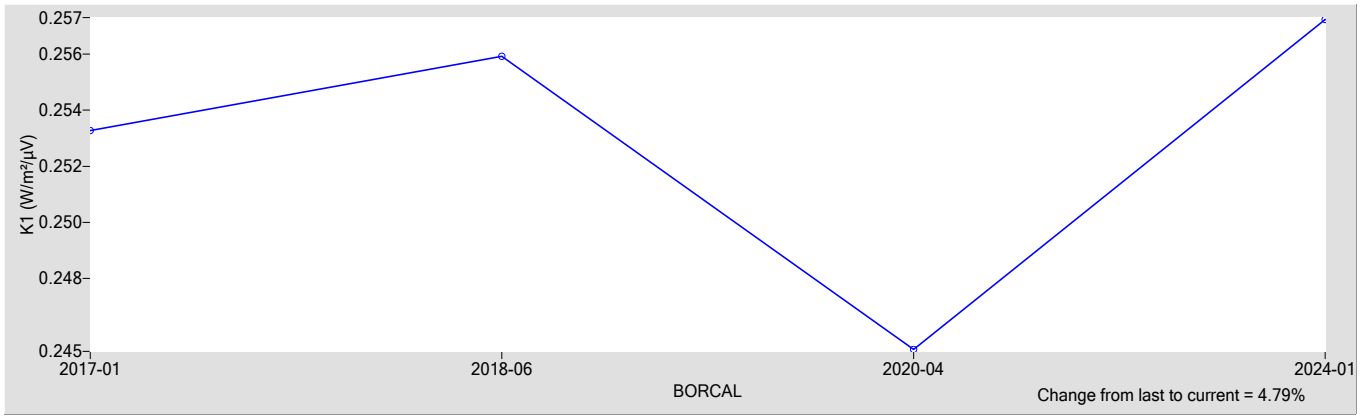


Figure 4. History of instrument (K2 Coefficient)

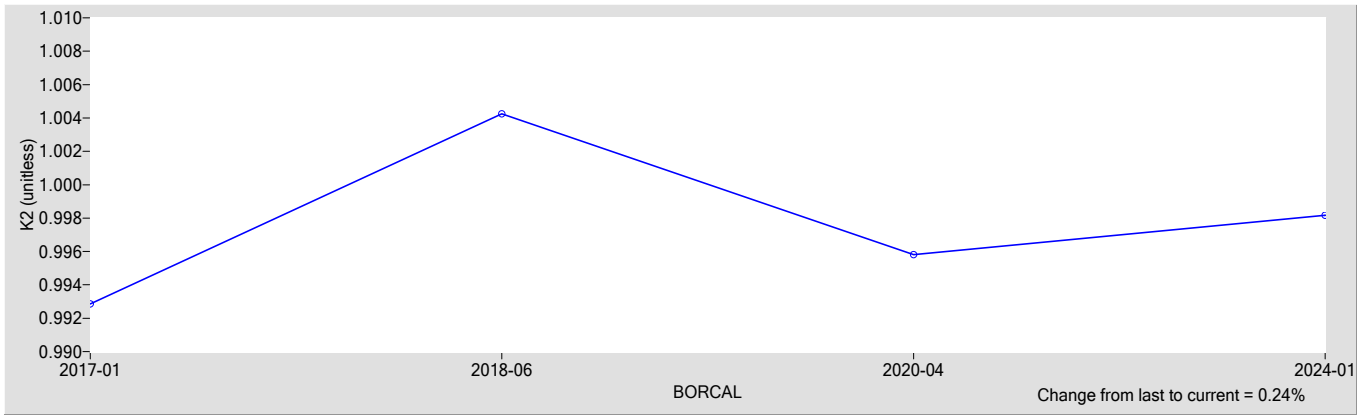
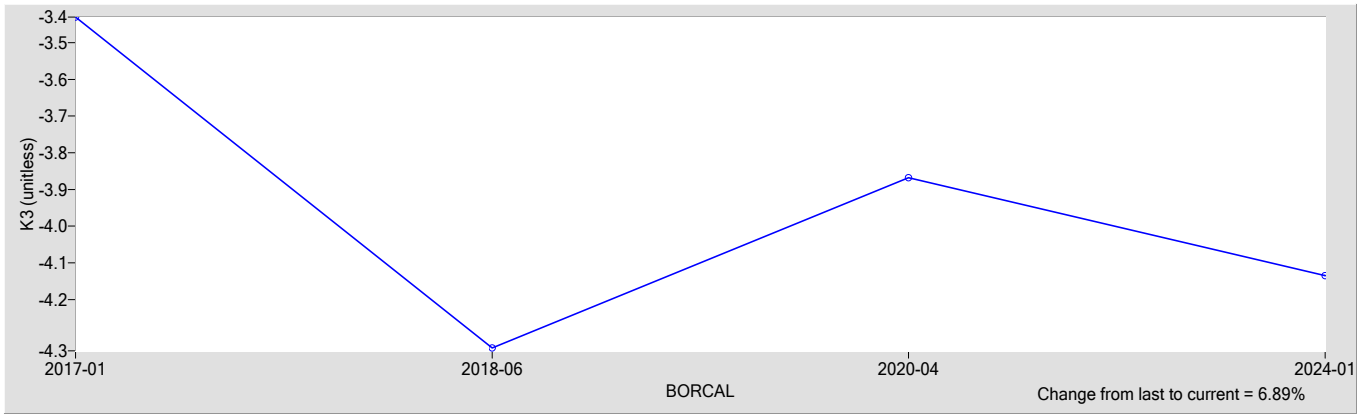


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30687F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30687F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

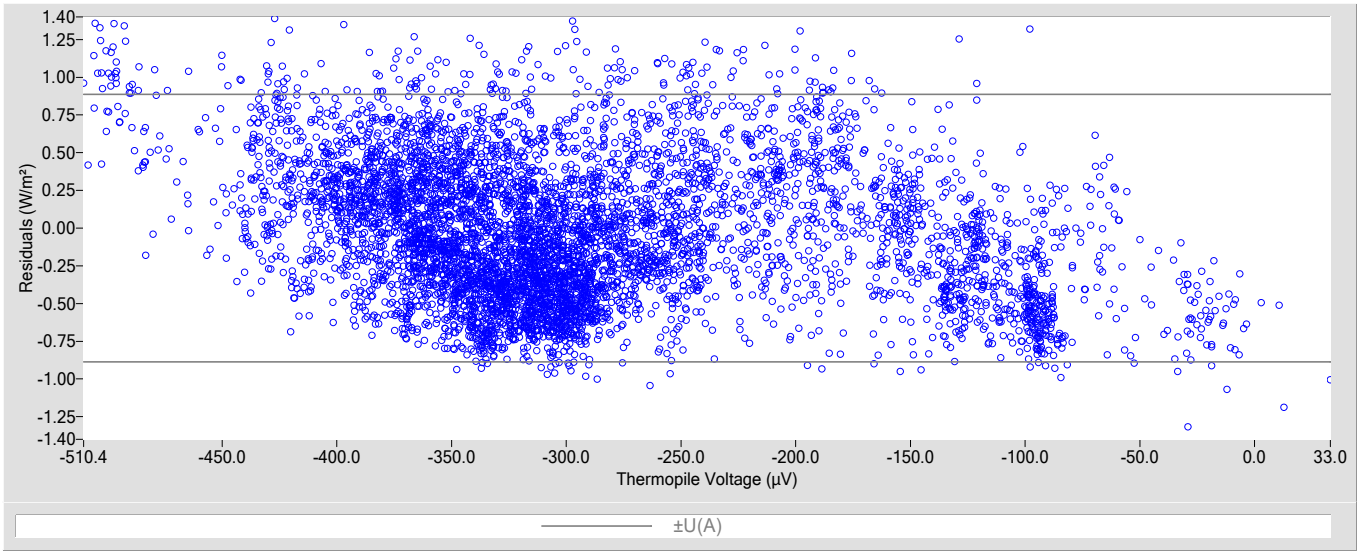


Table 1. Calibration Coefficients

K1	0.24544
K2	1.0015
K3	-3.35
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.45
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

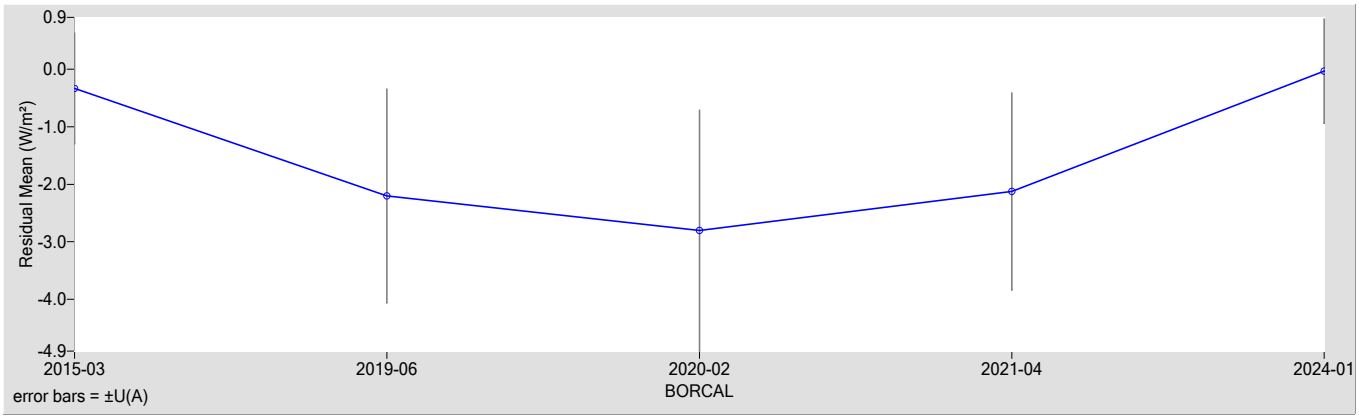


Figure 3. History of instrument (K1 Coefficient)

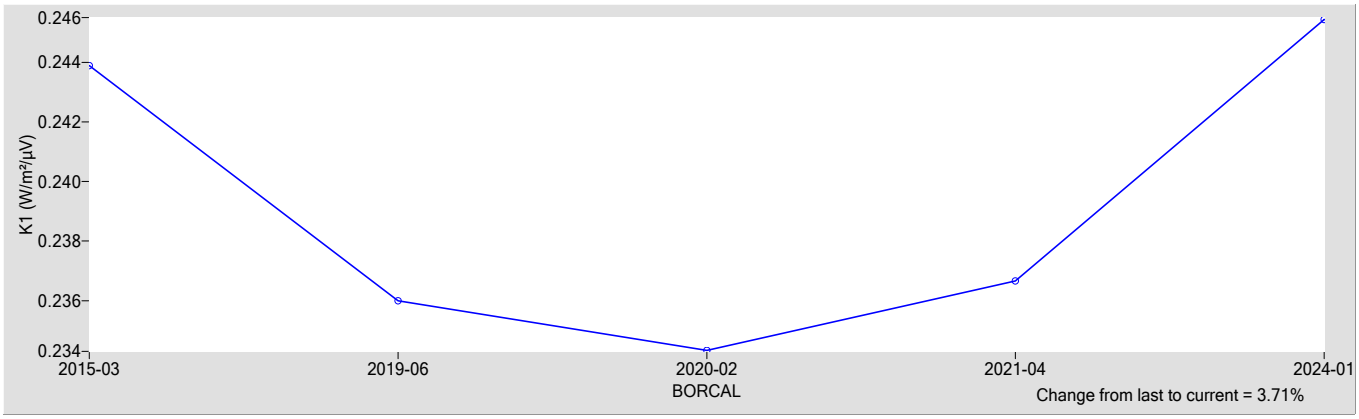


Figure 4. History of instrument (K2 Coefficient)

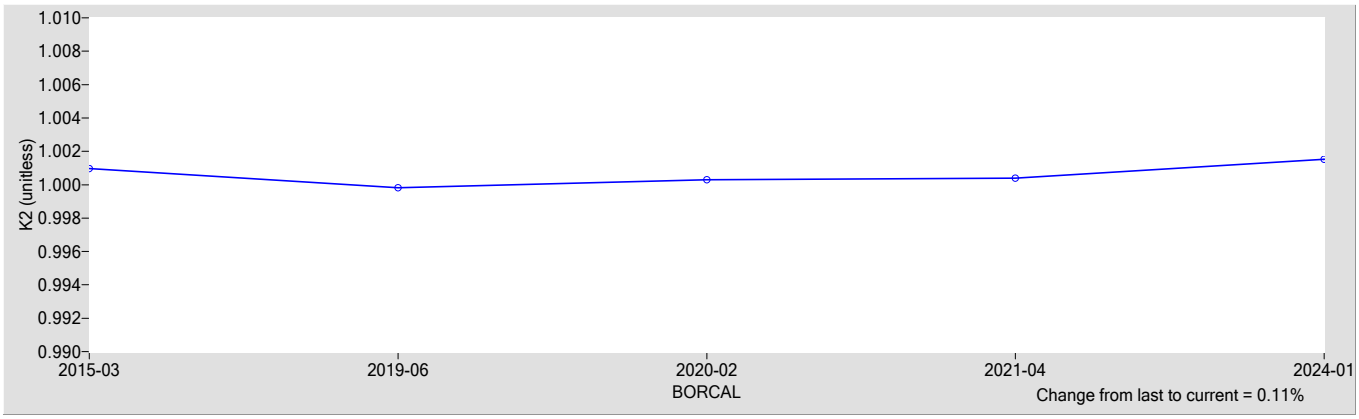
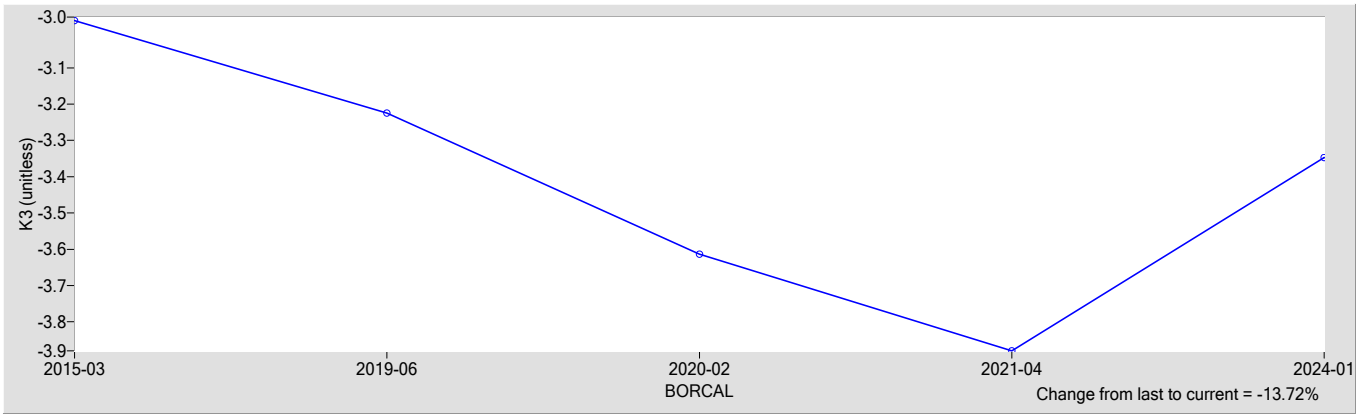


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30688F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30688F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

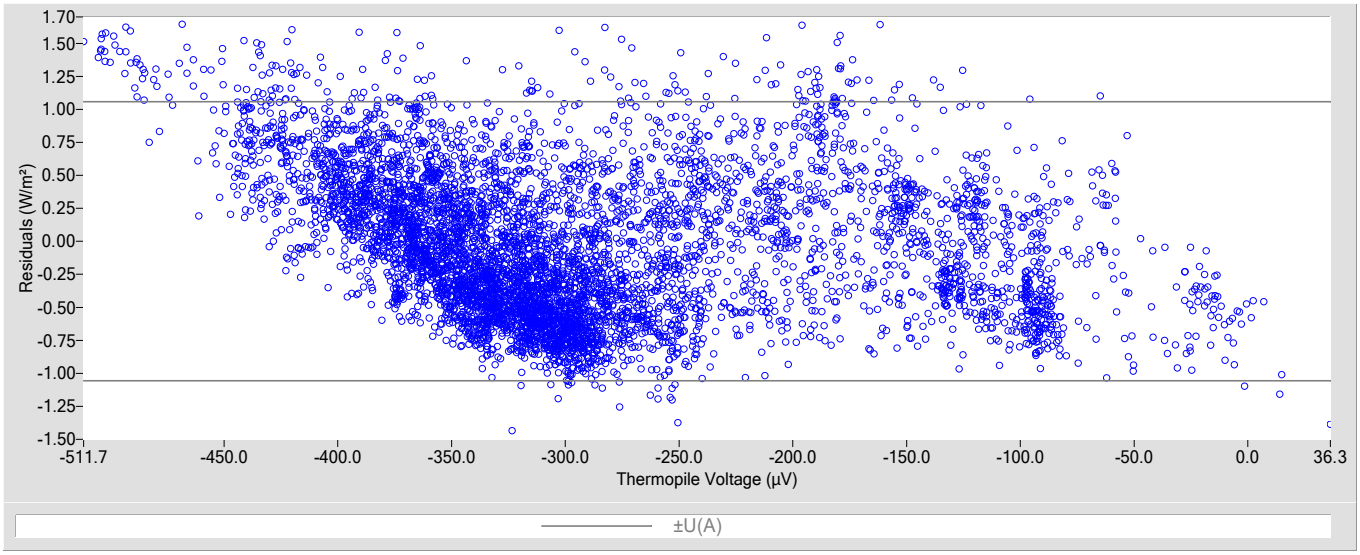


Table 1. Calibration Coefficients

K1	0.24174
K2	1.0003
K3	-2.99
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.54
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

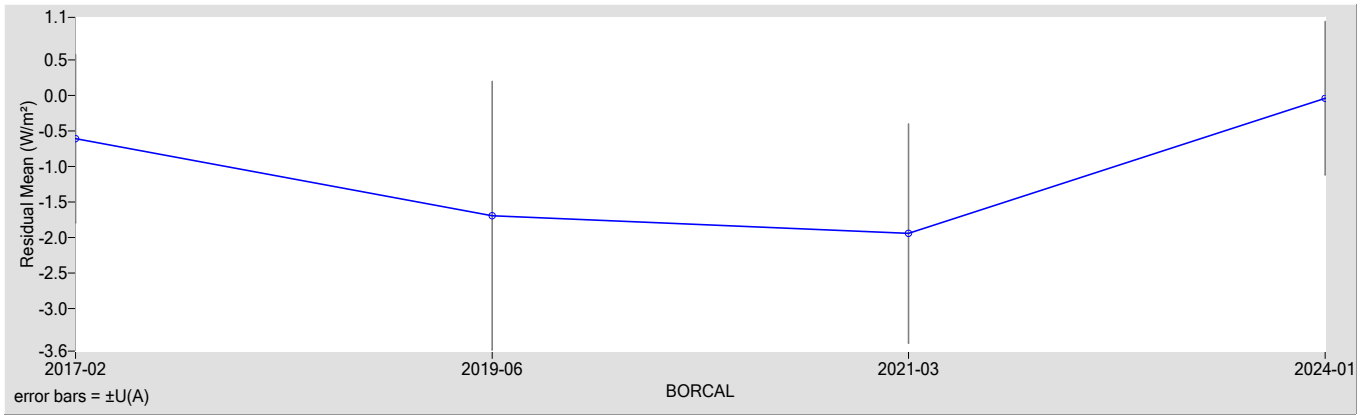


Figure 3. History of instrument (K1 Coefficient)

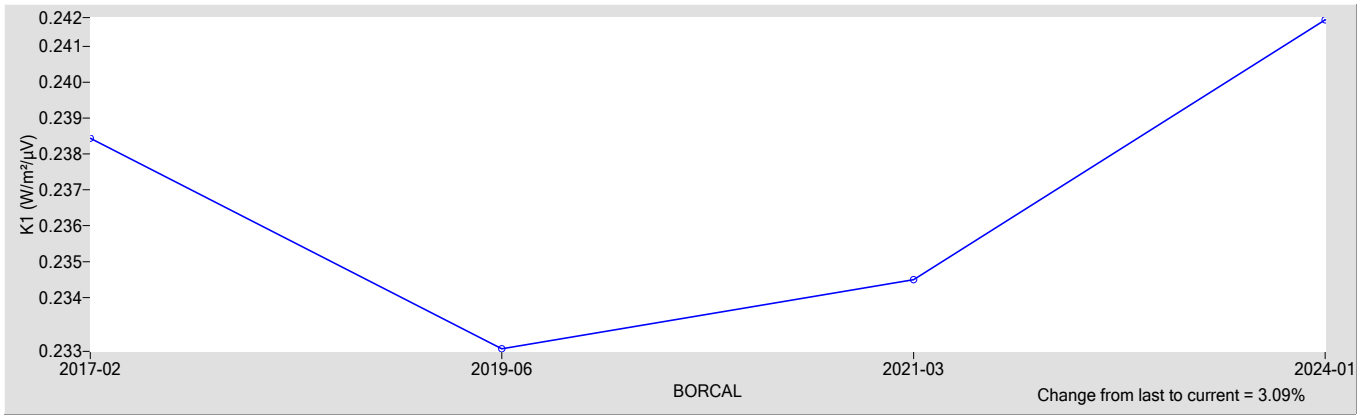


Figure 4. History of instrument (K2 Coefficient)

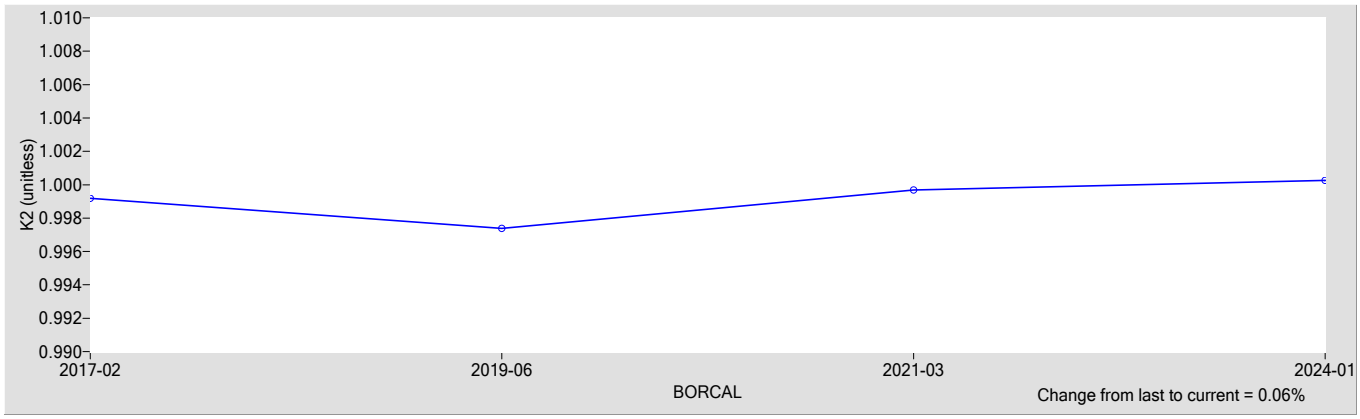
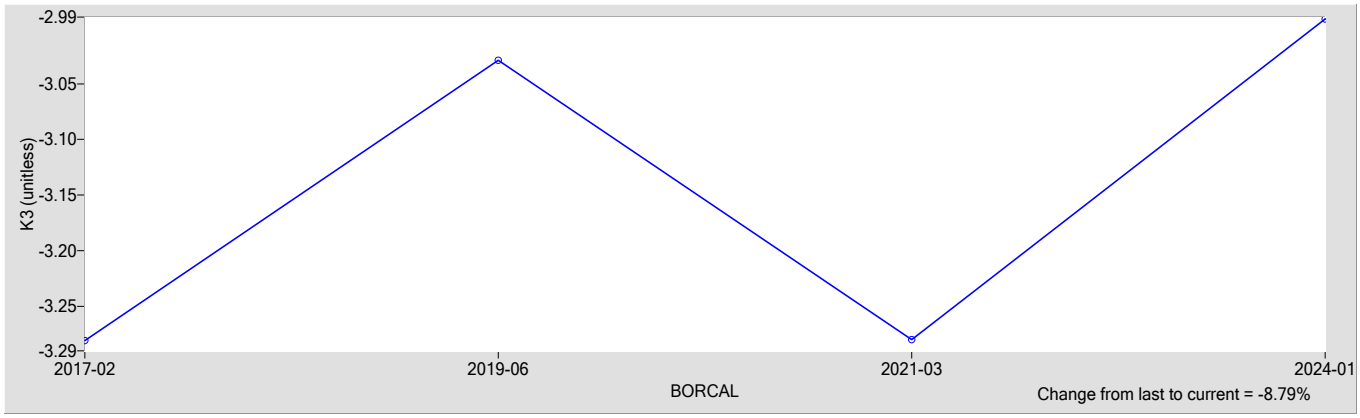


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30689F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30689F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

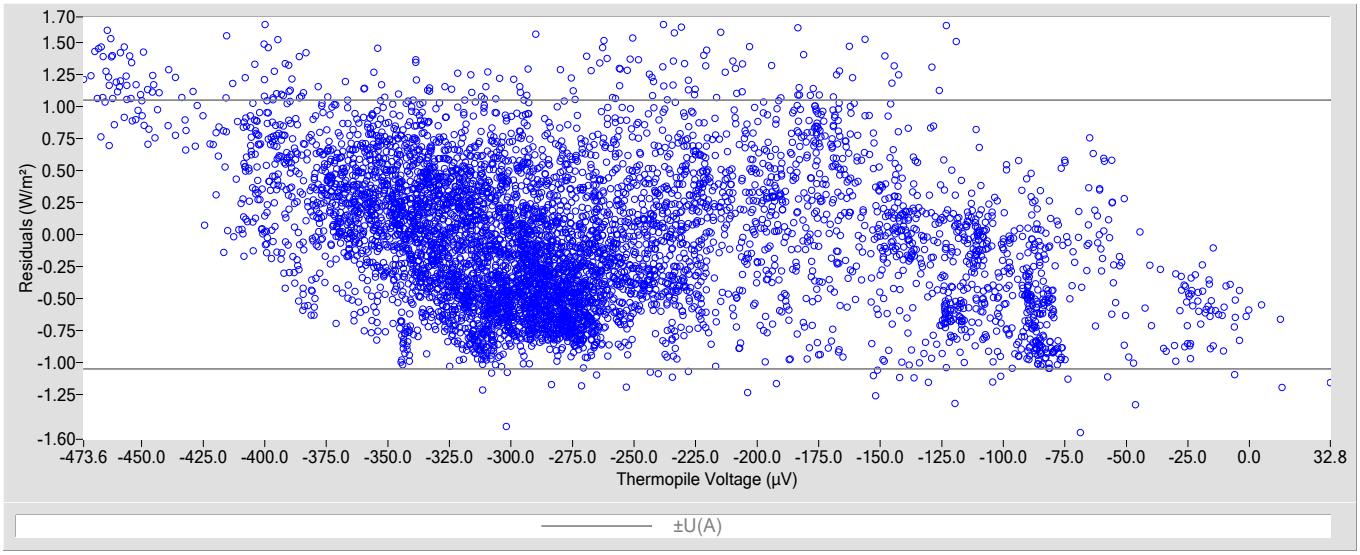


Table 1. Calibration Coefficients

K1	0.26455
K2	0.9981
K3	-2.98
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.54
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

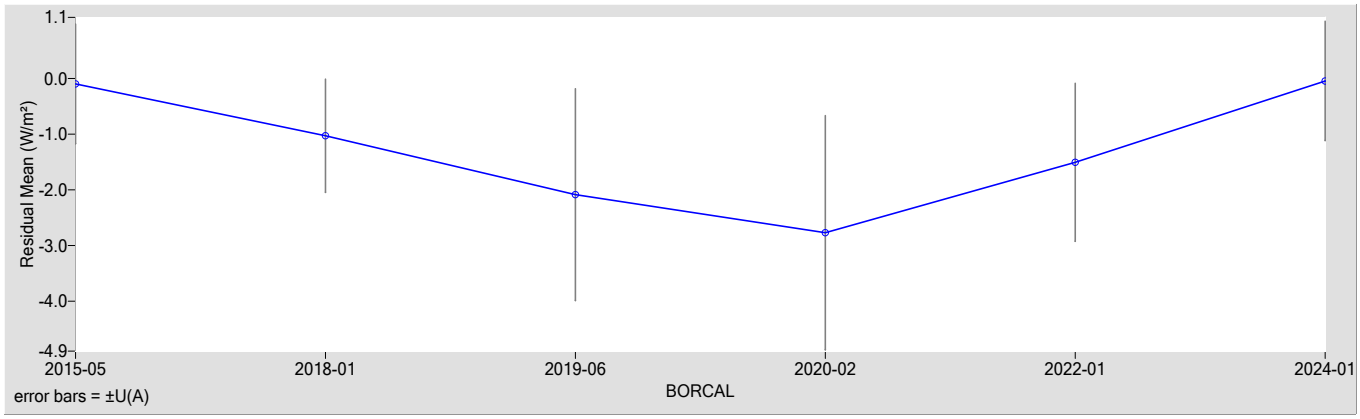


Figure 3. History of instrument (K1 Coefficient)

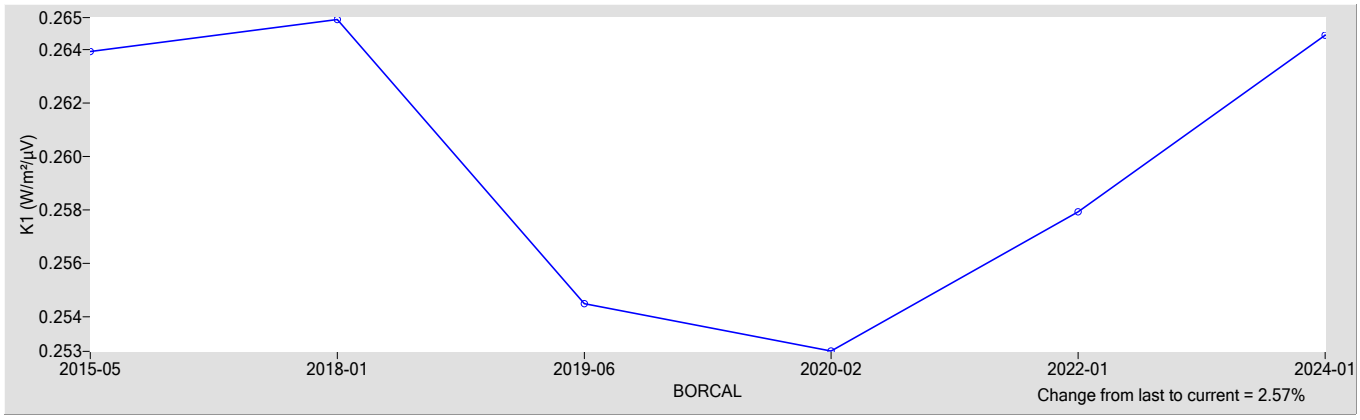


Figure 4. History of instrument (K2 Coefficient)

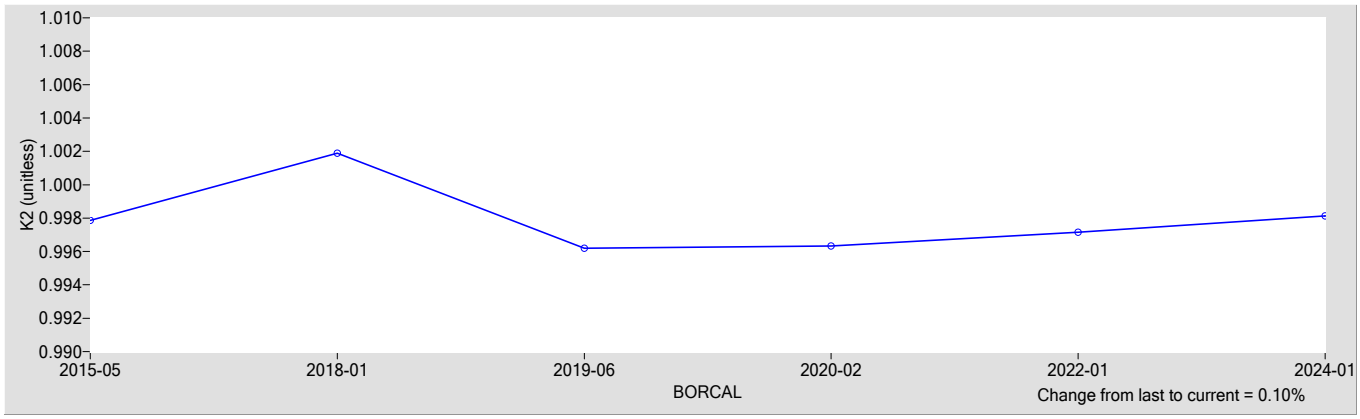
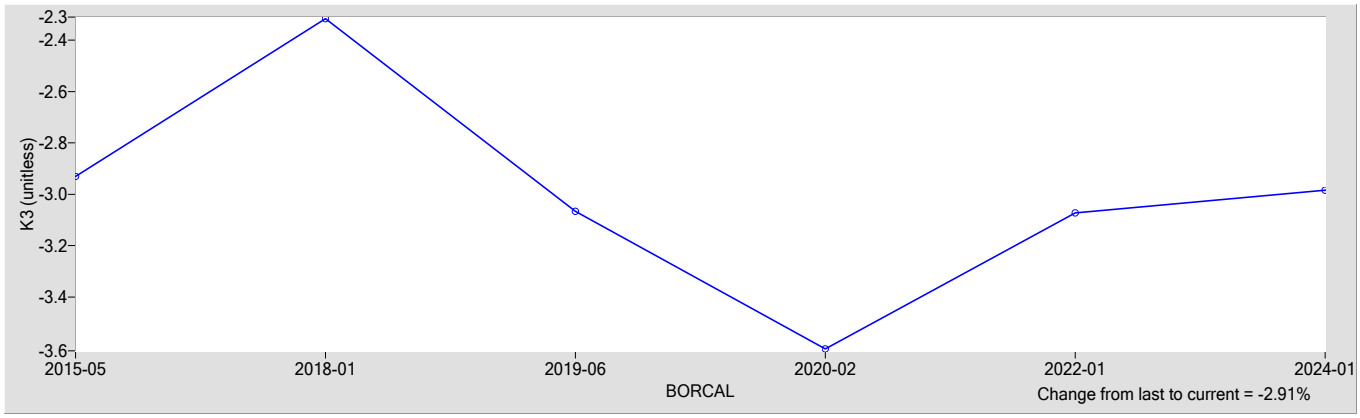


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30691F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30691F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

*Win = K1*V + K2*Wr + K3*(Wd - Wr)* [1]

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (µV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/µV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

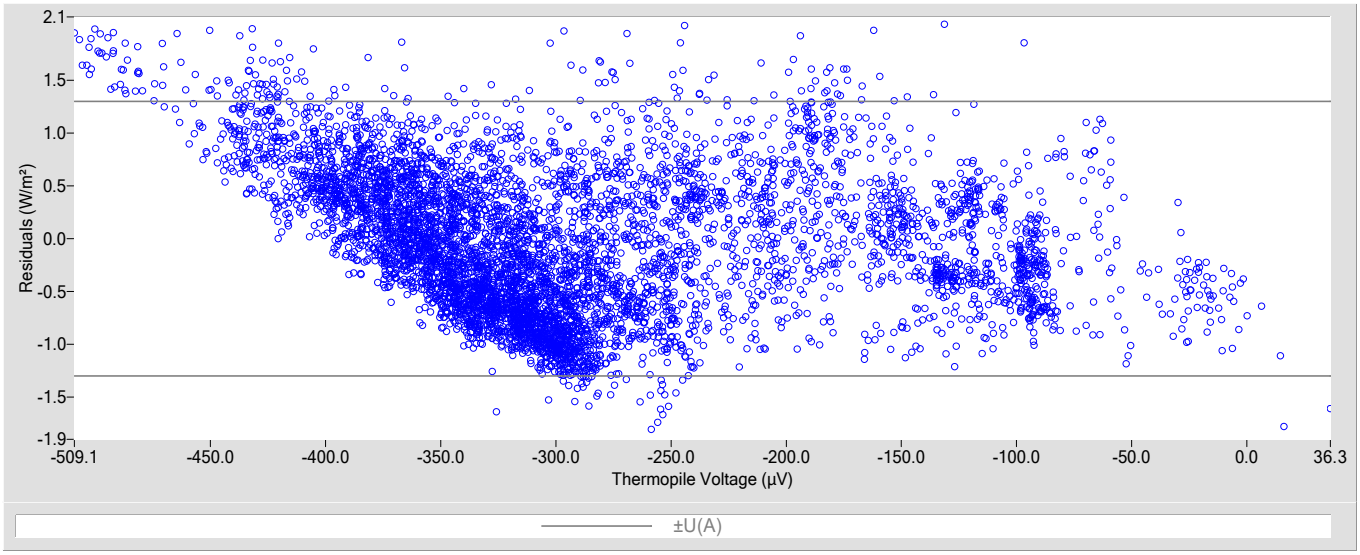


Table 1. Calibration Coefficients

K1	0.24272
K2	0.9942
K3	-3.08
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.66
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

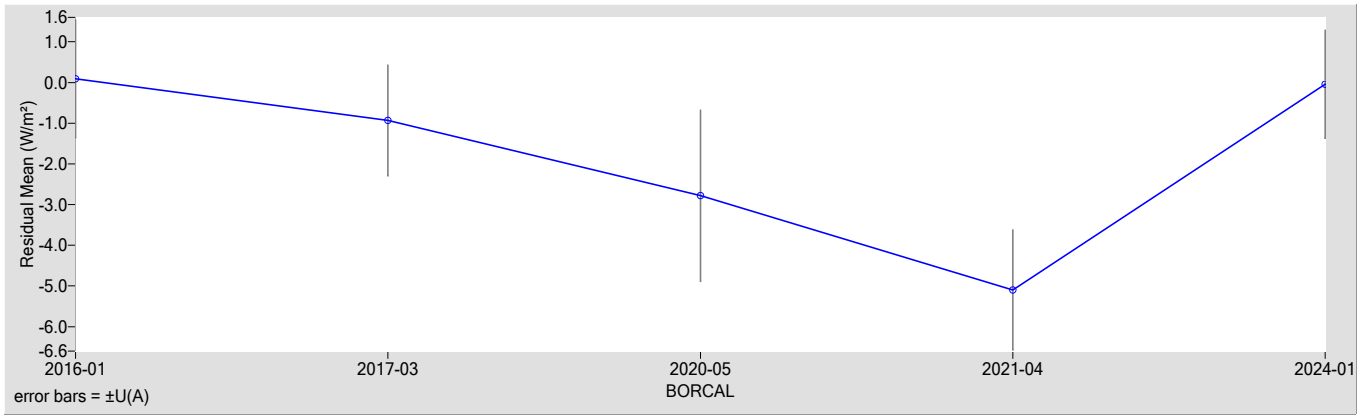


Figure 3. History of instrument (K1 Coefficient)

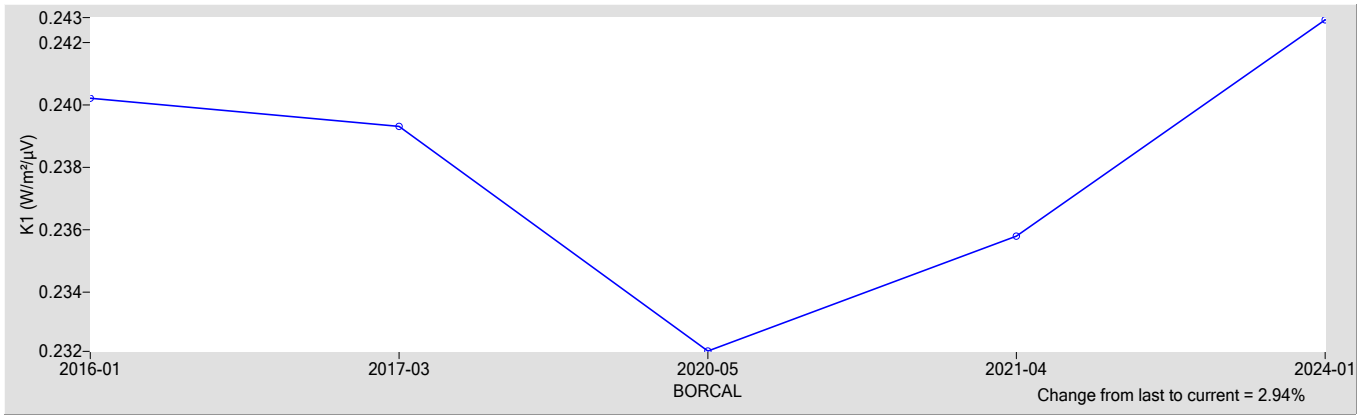


Figure 4. History of instrument (K2 Coefficient)

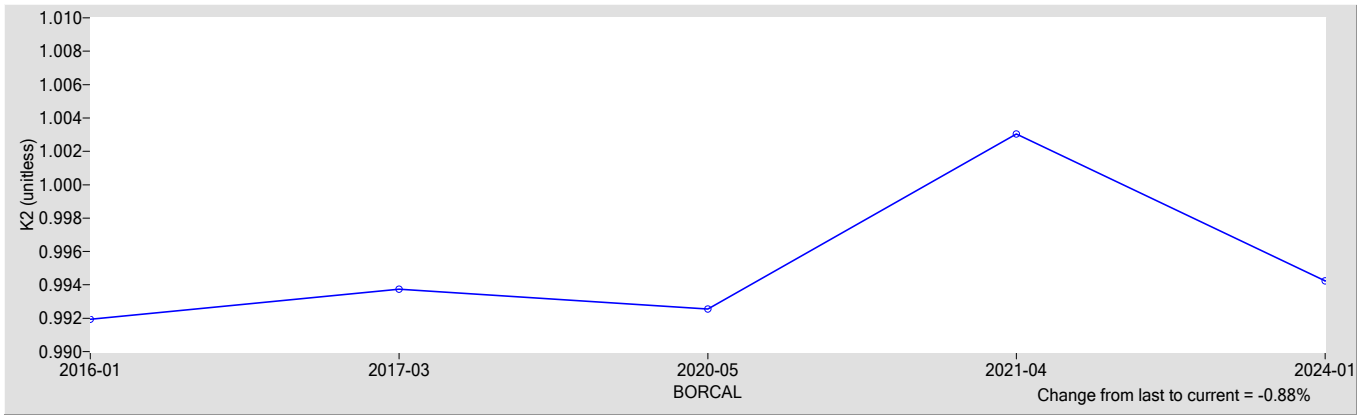
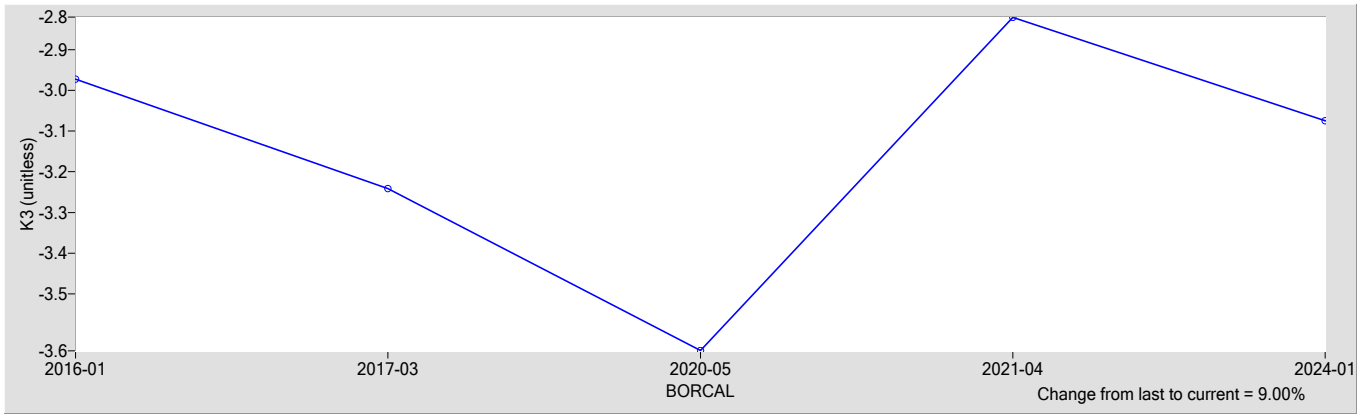


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30695F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30695F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

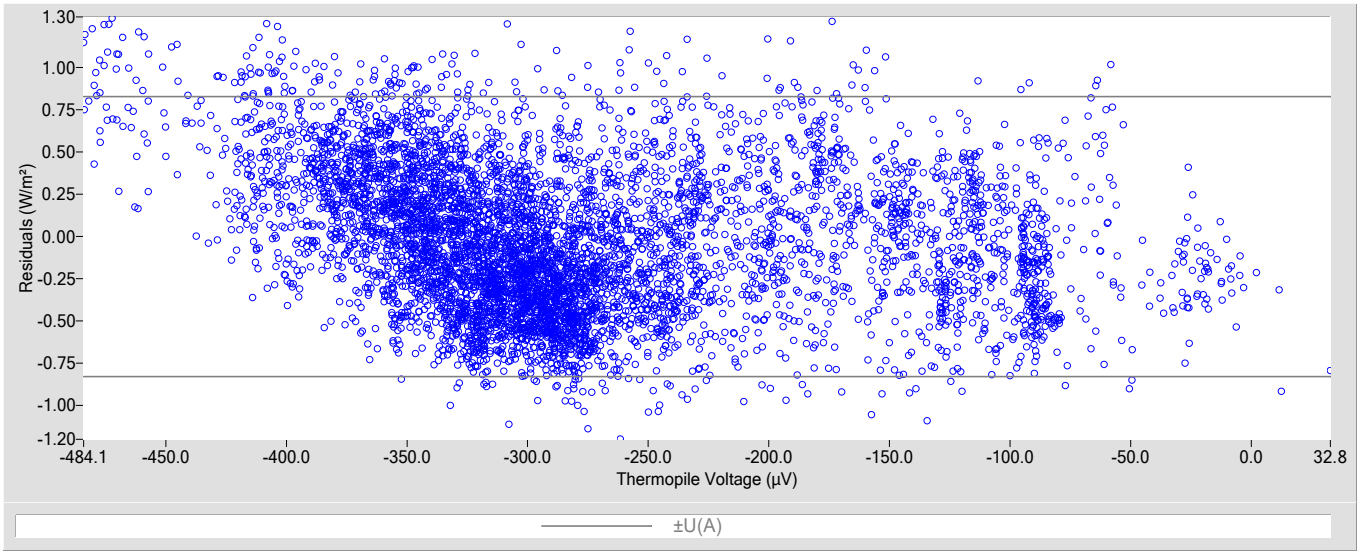


Table 1. Calibration Coefficients

K1	0.25639
K2	0.9984
K3	-3.15
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.42
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

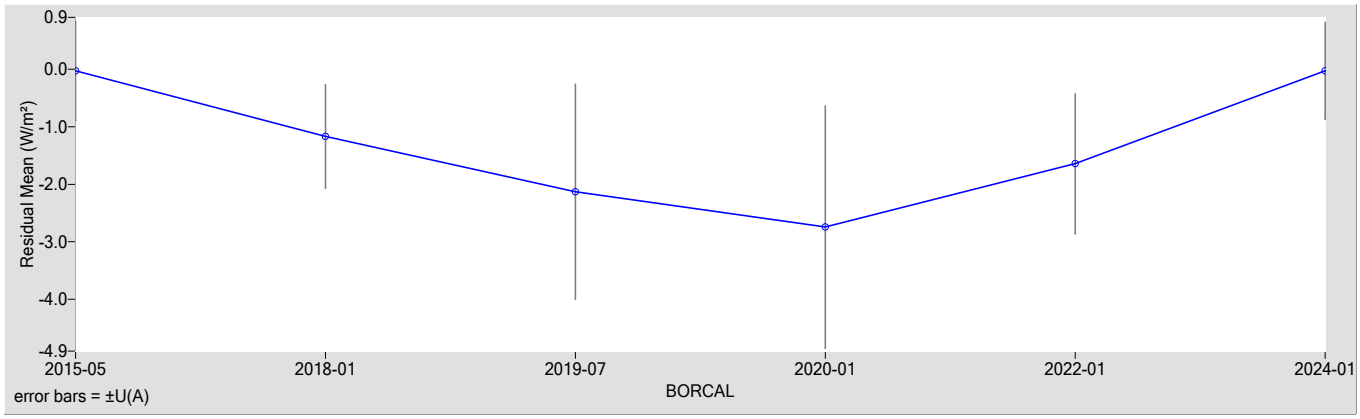


Figure 3. History of instrument (K1 Coefficient)

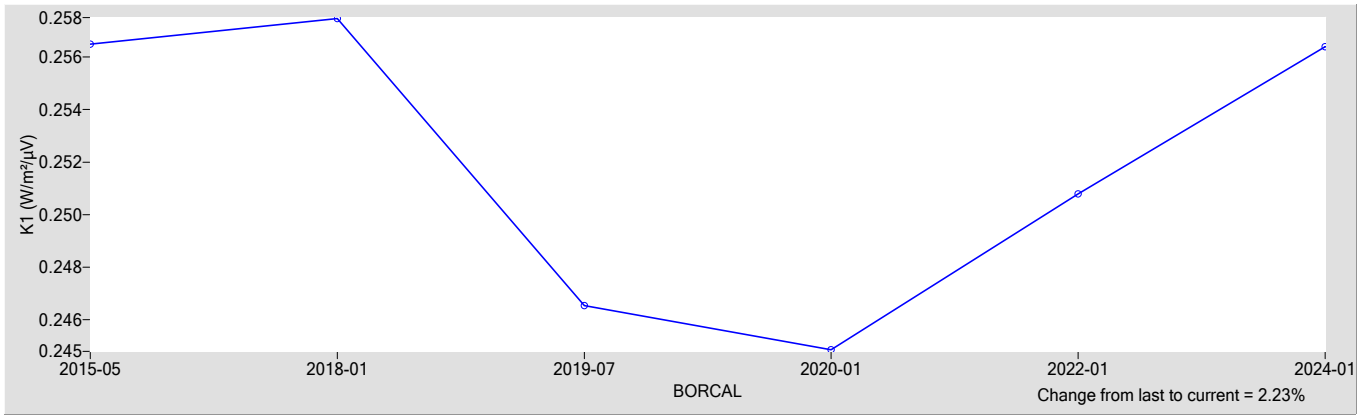


Figure 4. History of instrument (K2 Coefficient)

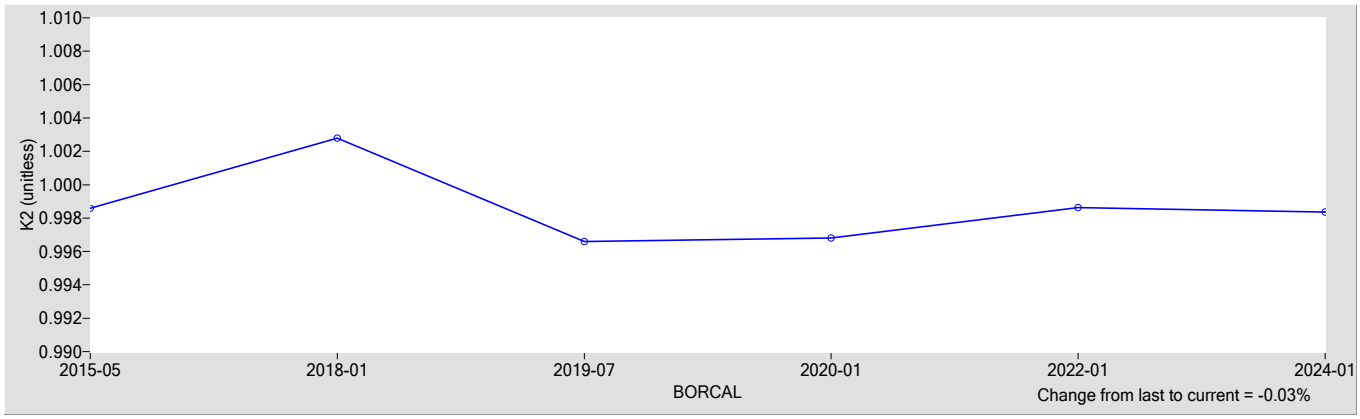
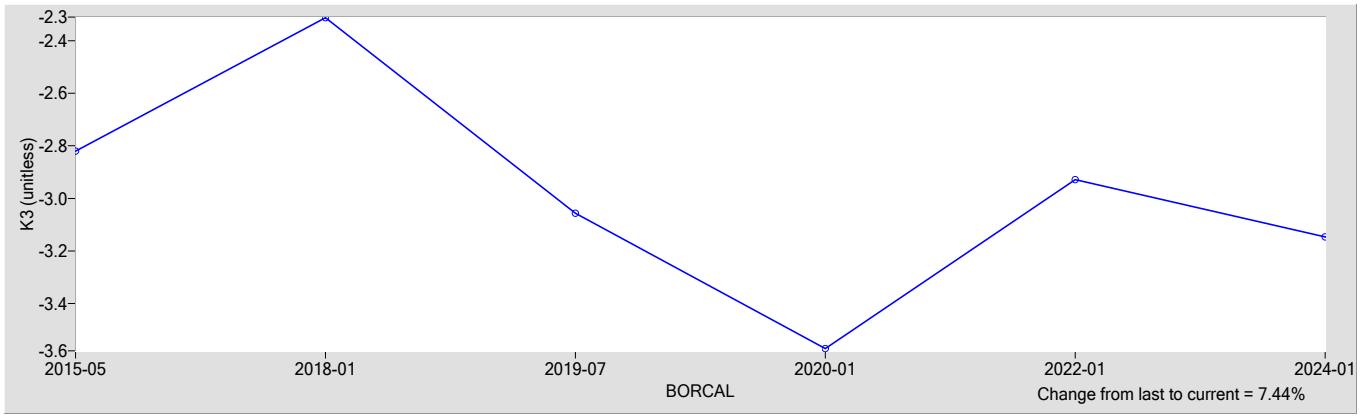


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30780F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30780F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

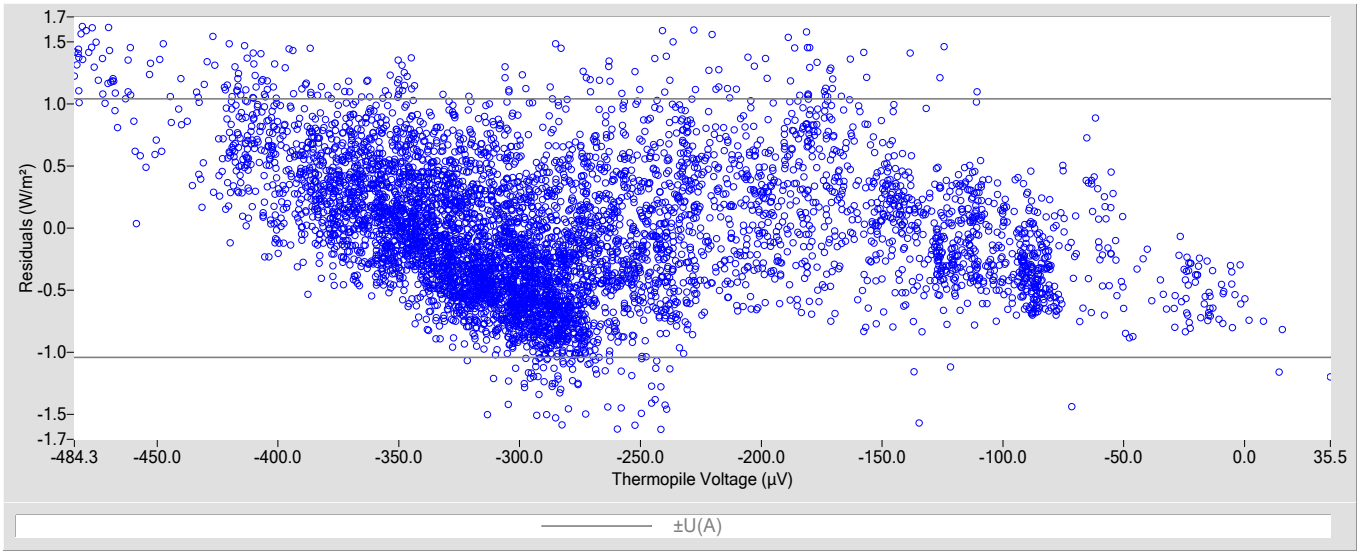


Table 1. Calibration Coefficients

K1	0.25328
K2	1.0026
K3	-3.35
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.53
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

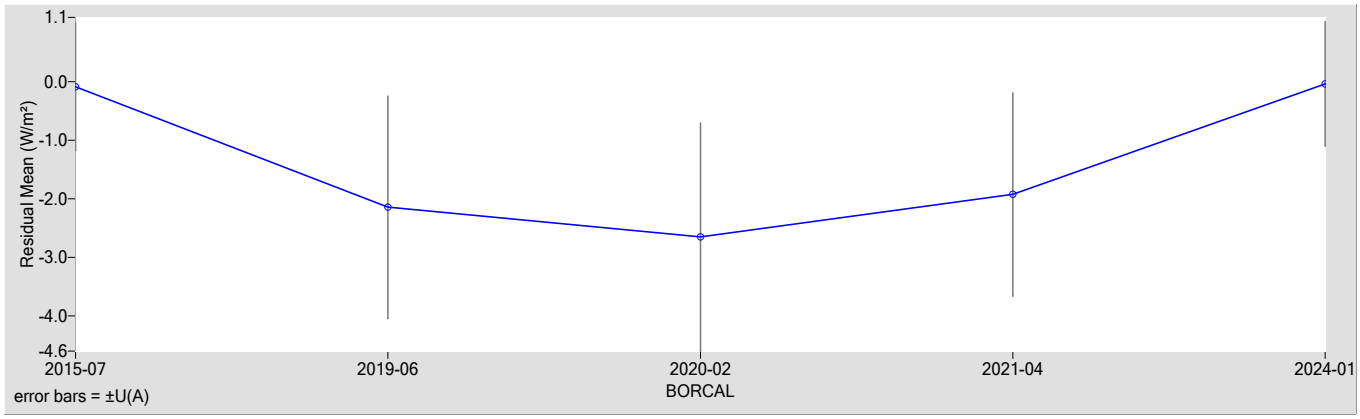


Figure 3. History of instrument (K1 Coefficient)

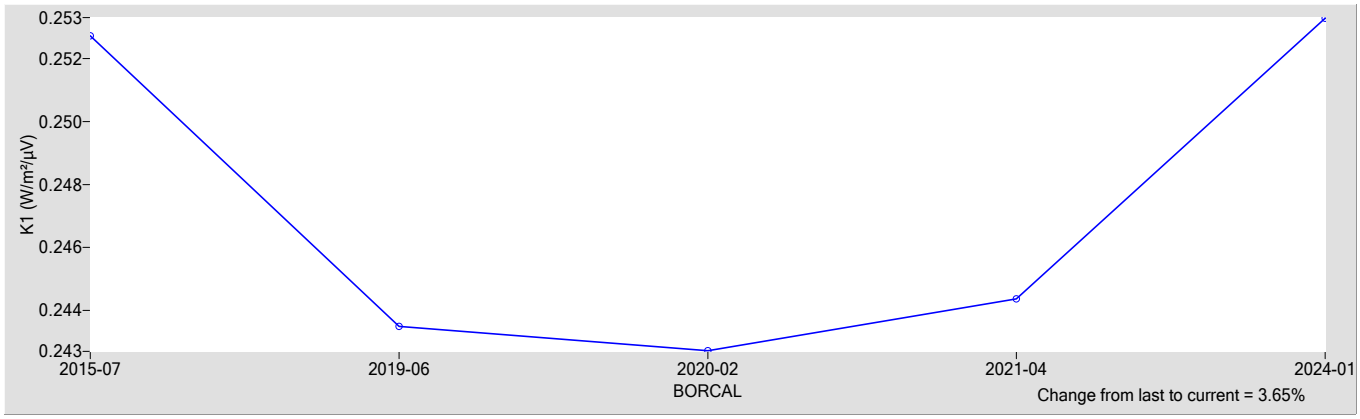


Figure 4. History of instrument (K2 Coefficient)

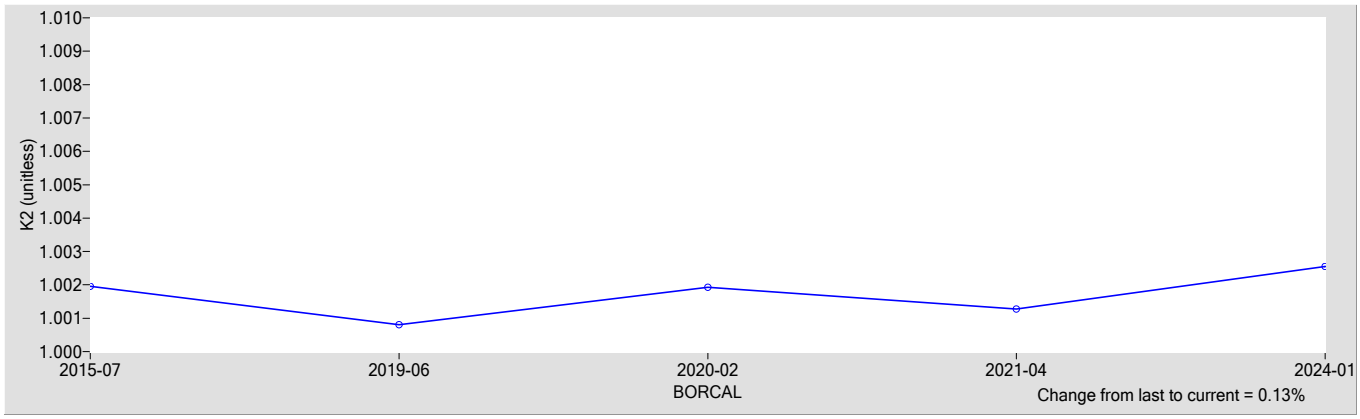
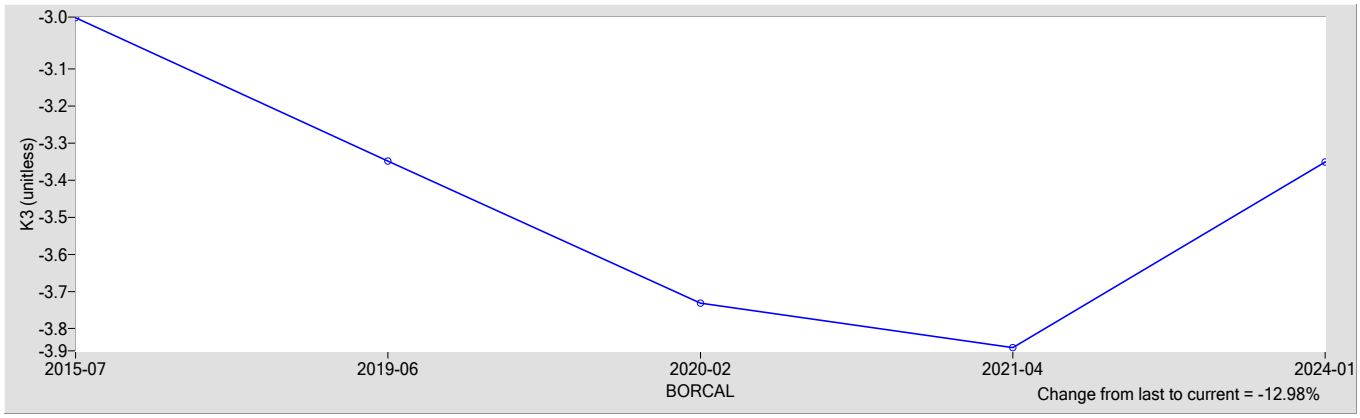


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30781F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30781F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

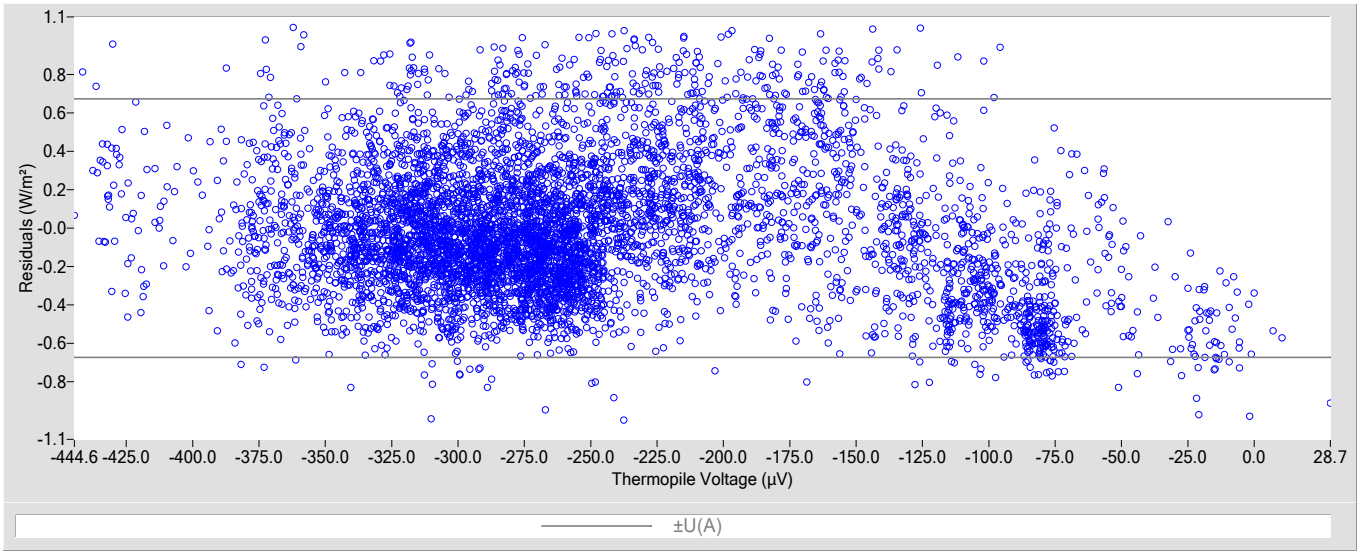


Table 1. Calibration Coefficients

K1	0.28193
K2	0.9980
K3	-3.65
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.34
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

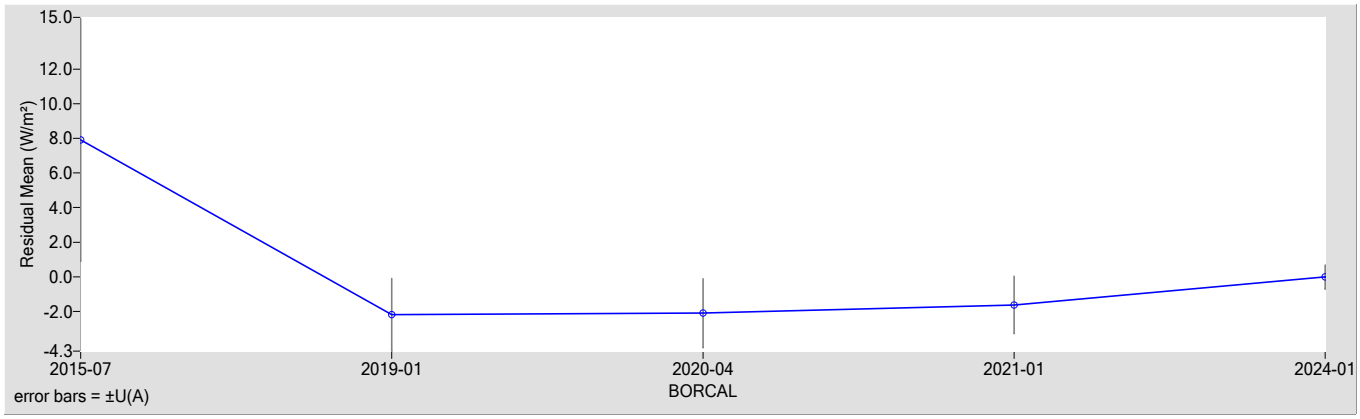


Figure 3. History of instrument (K1 Coefficient)

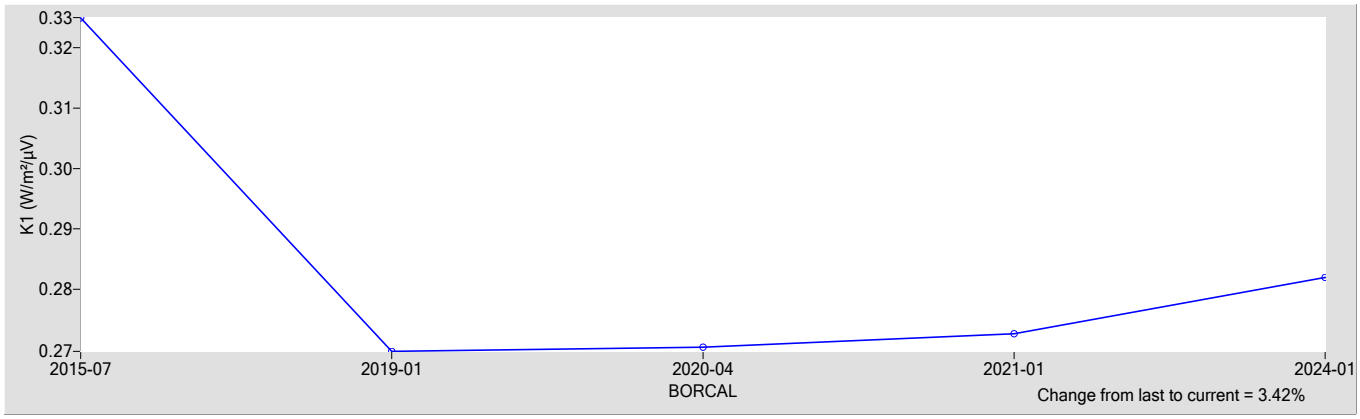


Figure 4. History of instrument (K2 Coefficient)

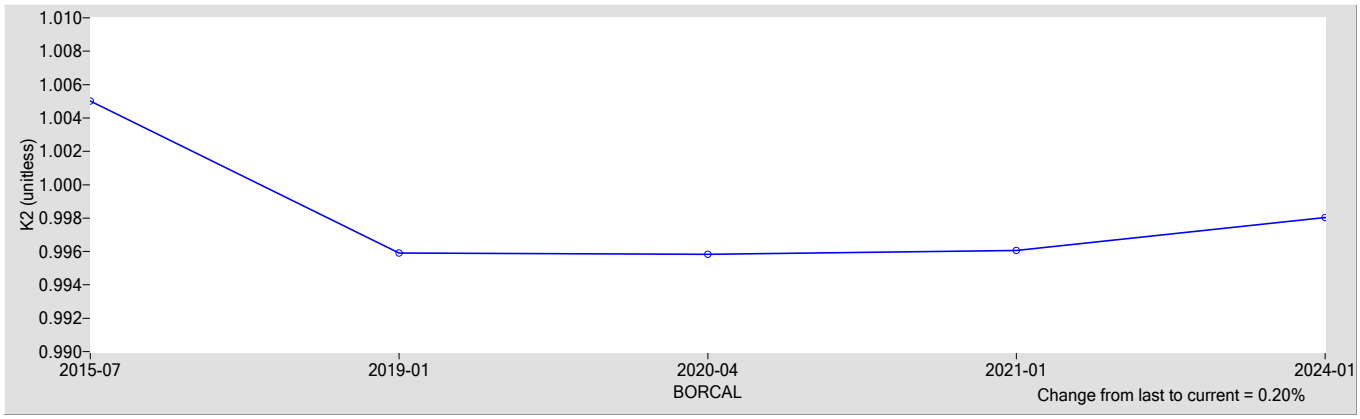
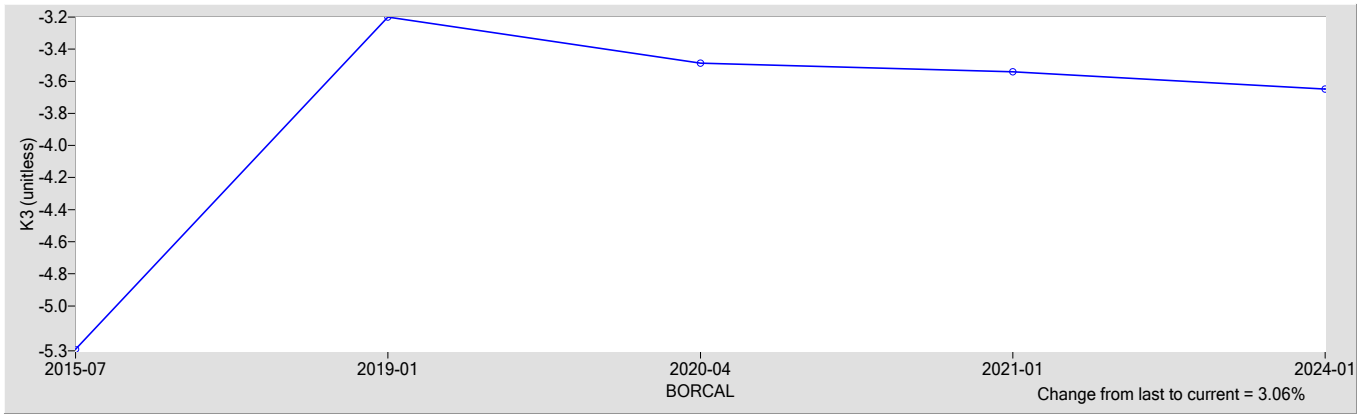


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30835F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30835F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

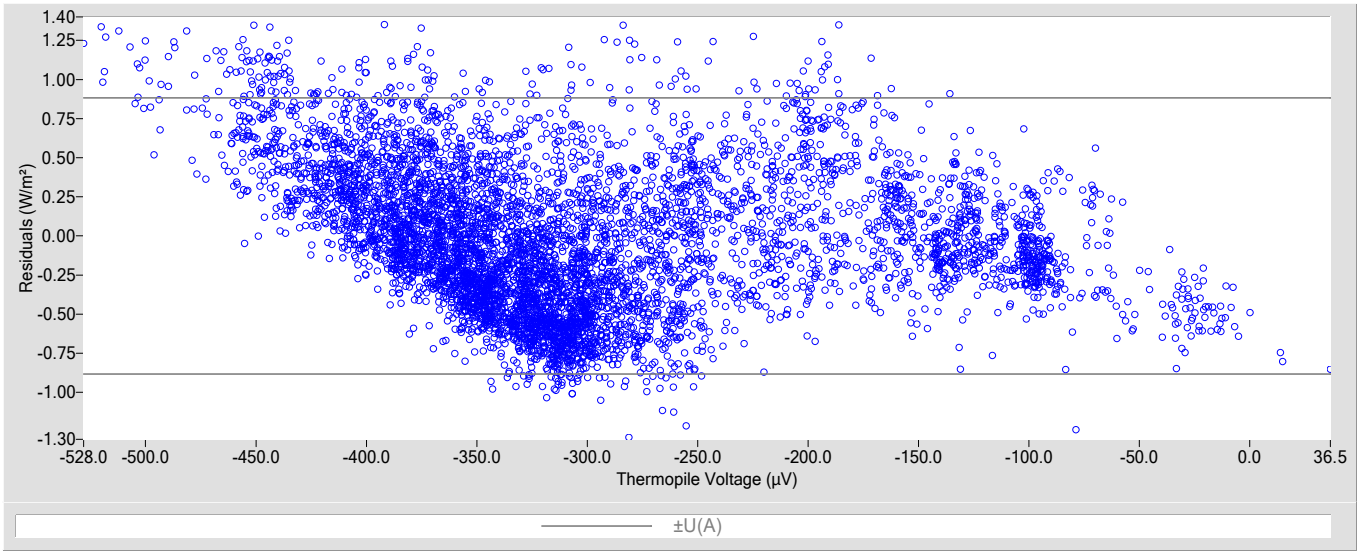


Table 1. Calibration Coefficients

K1	0.23440
K2	1.0009
K3	-3.53
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.45
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

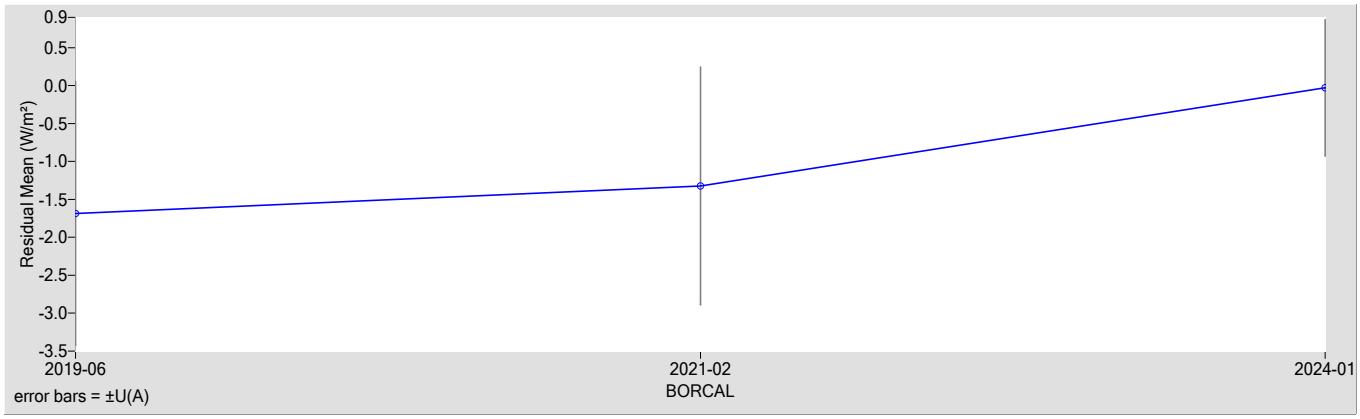


Figure 3. History of instrument (K1 Coefficient)

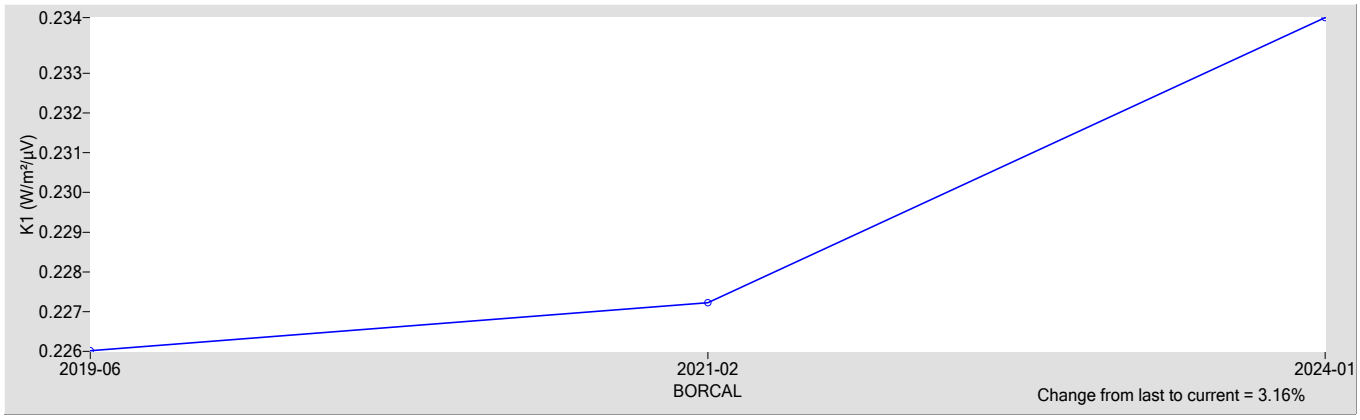


Figure 4. History of instrument (K2 Coefficient)

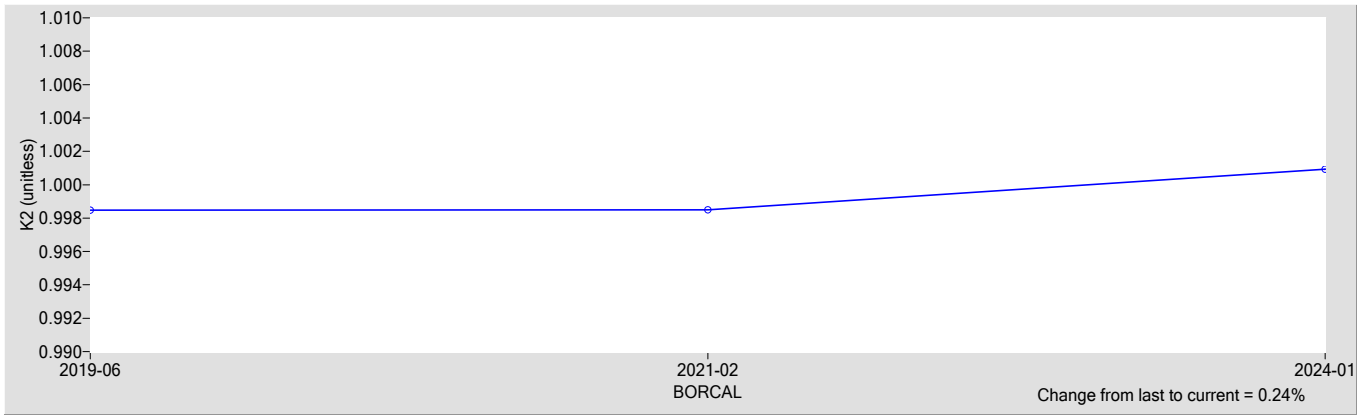
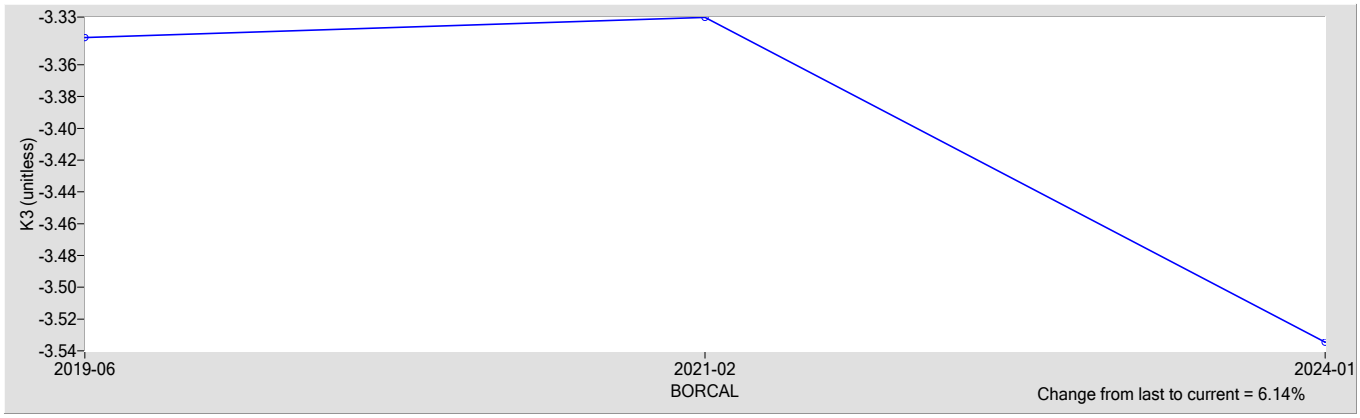


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	30837F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

30837F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

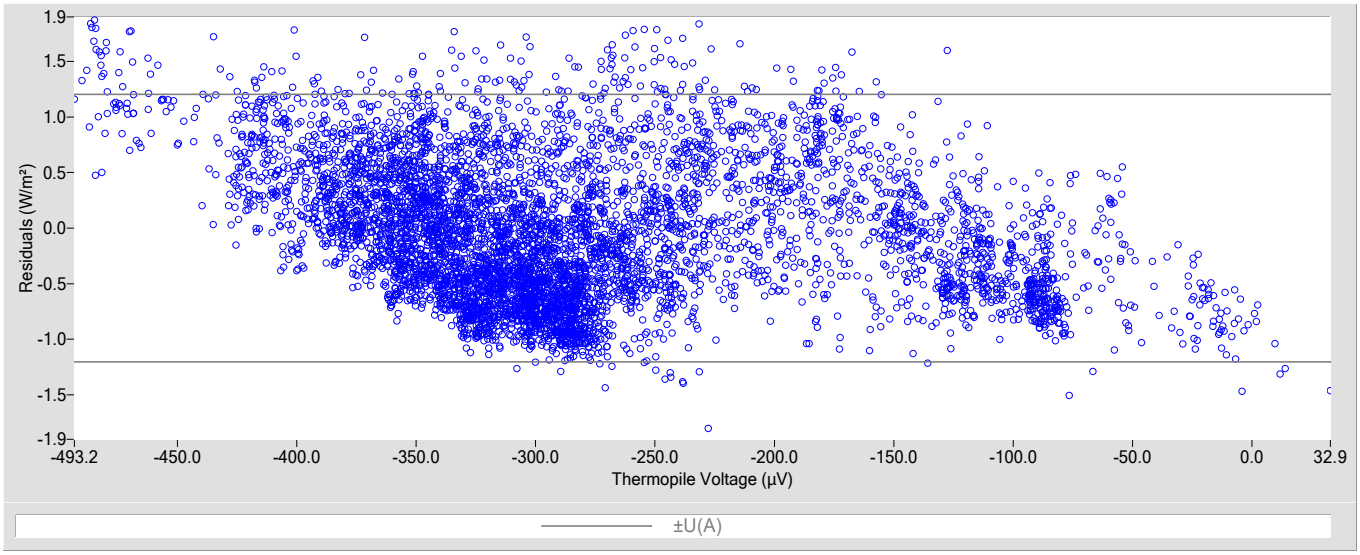


Table 1. Calibration Coefficients

K1	0.25176
K2	1.0015
K3	-4.22
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.61
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

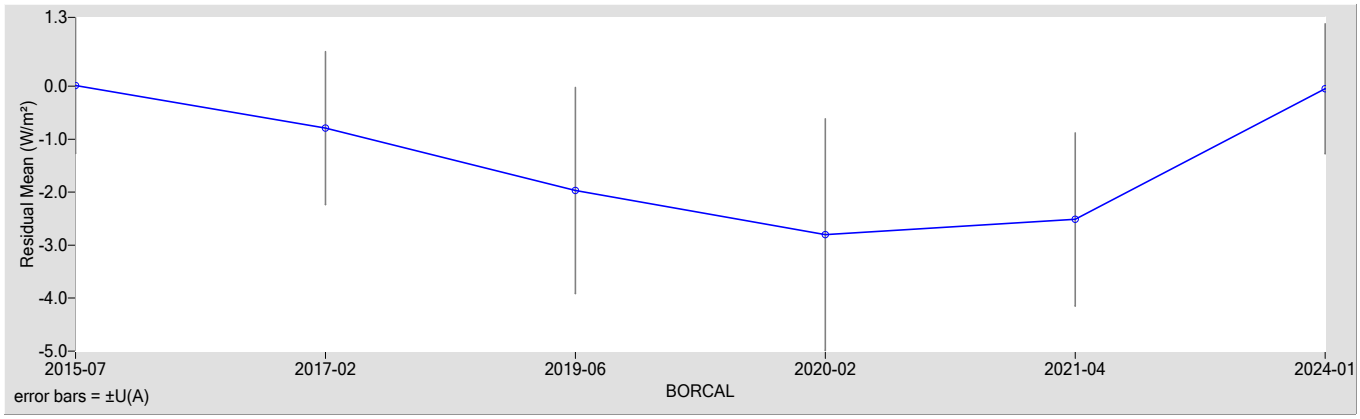


Figure 3. History of instrument (K1 Coefficient)

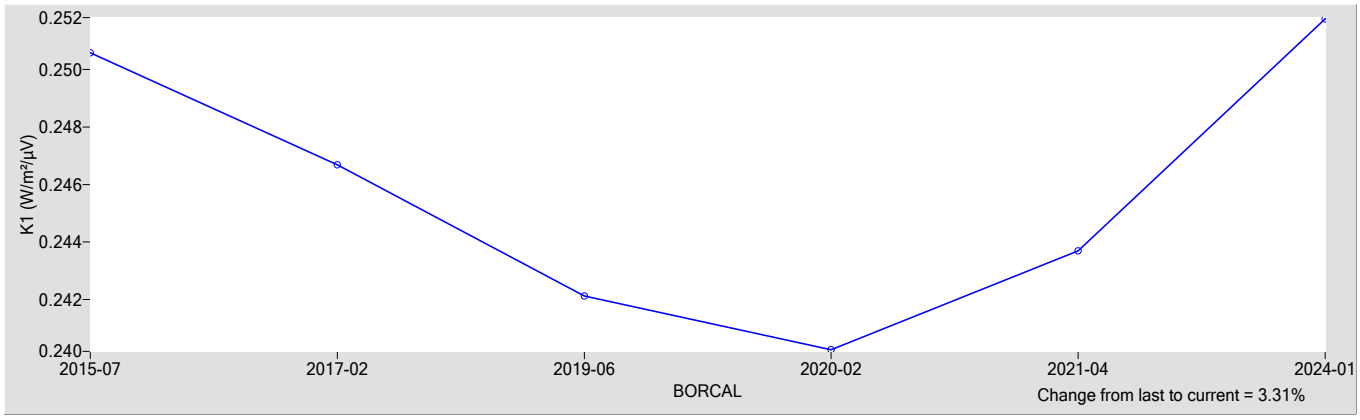


Figure 4. History of instrument (K2 Coefficient)

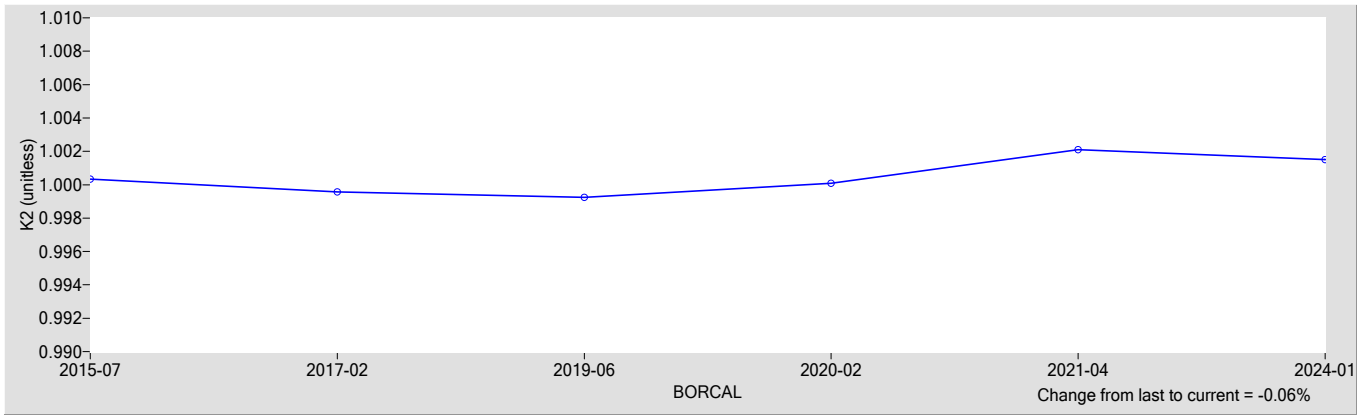
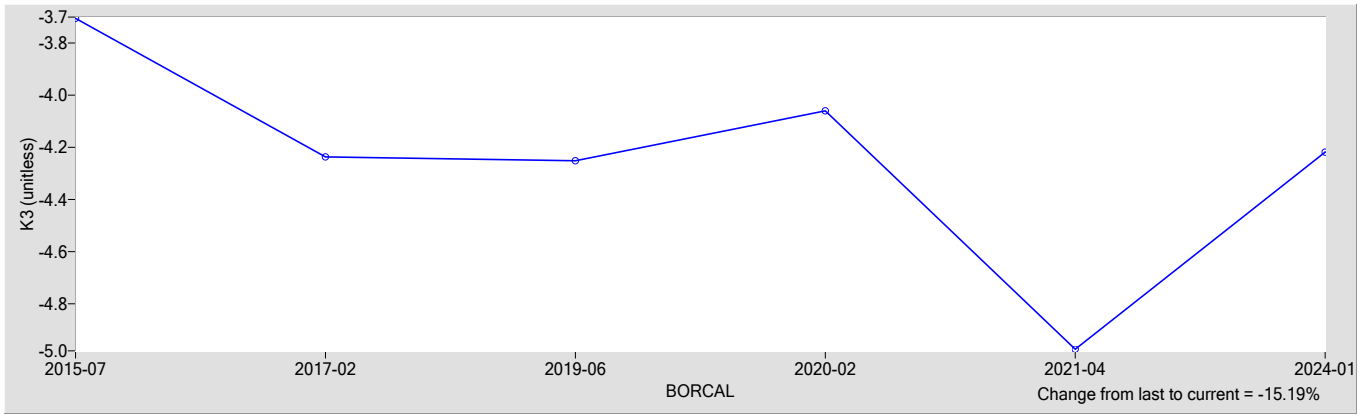


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	31299F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

31299F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

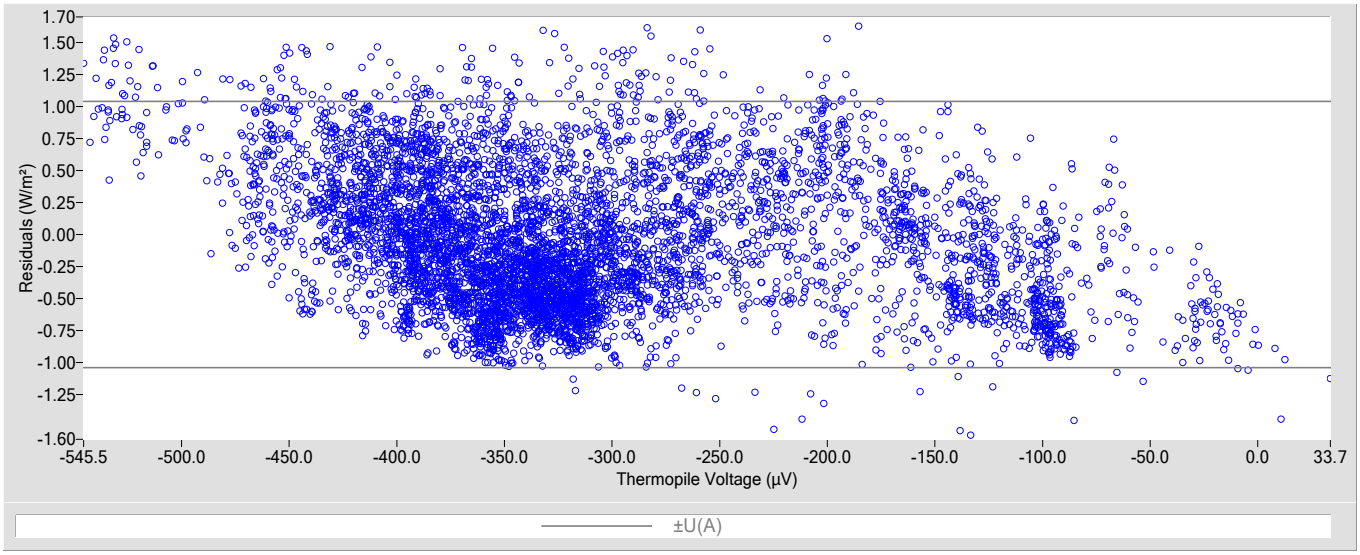


Table 1. Calibration Coefficients

K1	0.23301
K2	0.9888
K3	-4.14
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.53
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

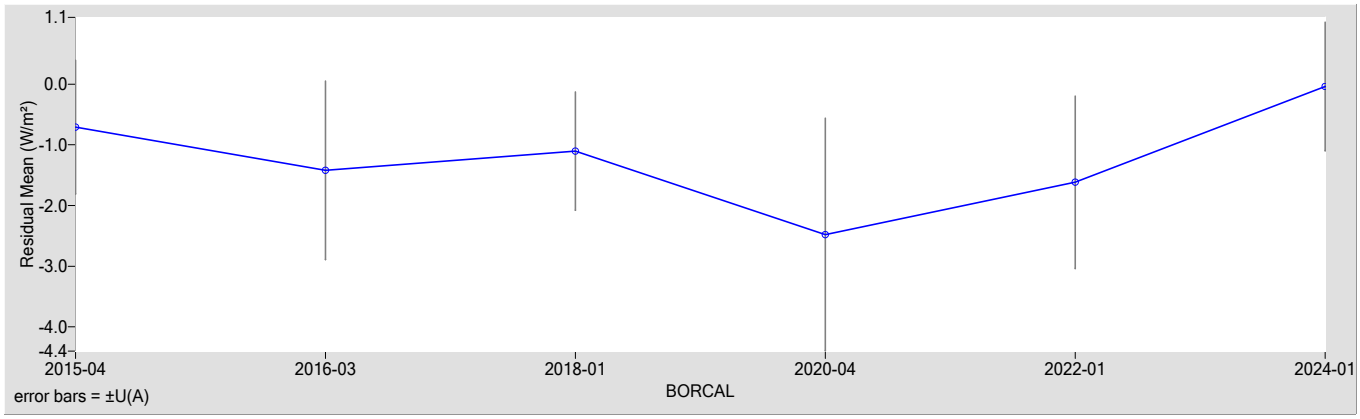


Figure 3. History of instrument (K1 Coefficient)

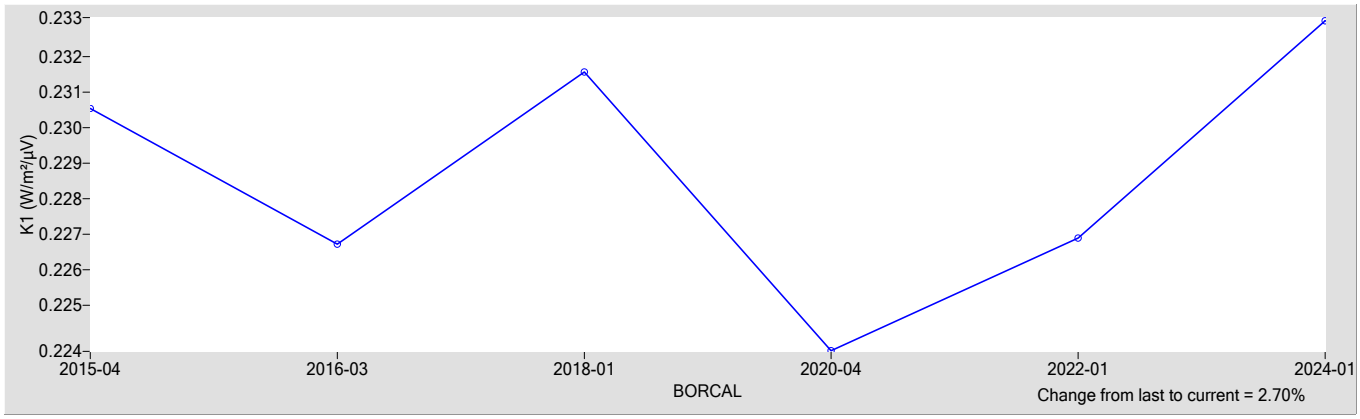


Figure 4. History of instrument (K2 Coefficient)

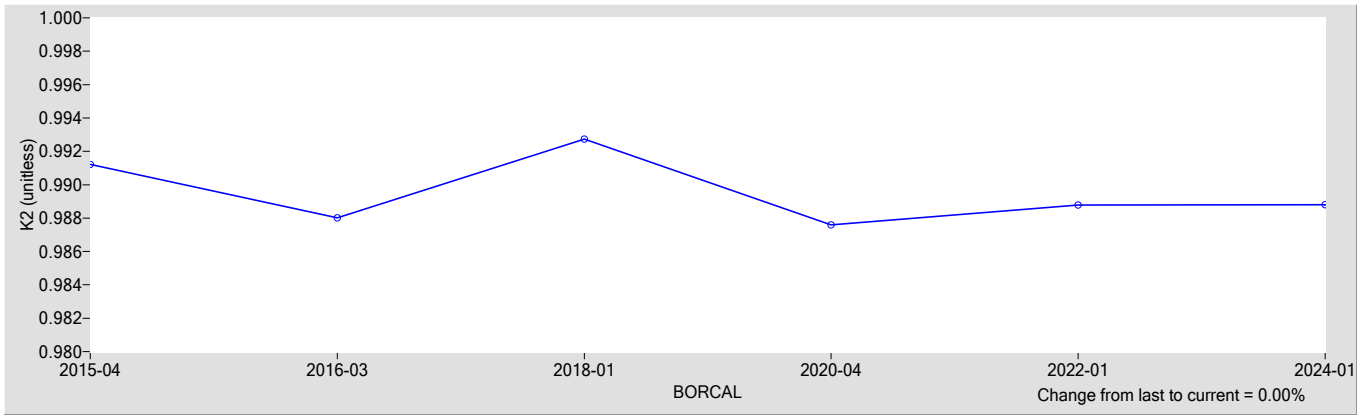
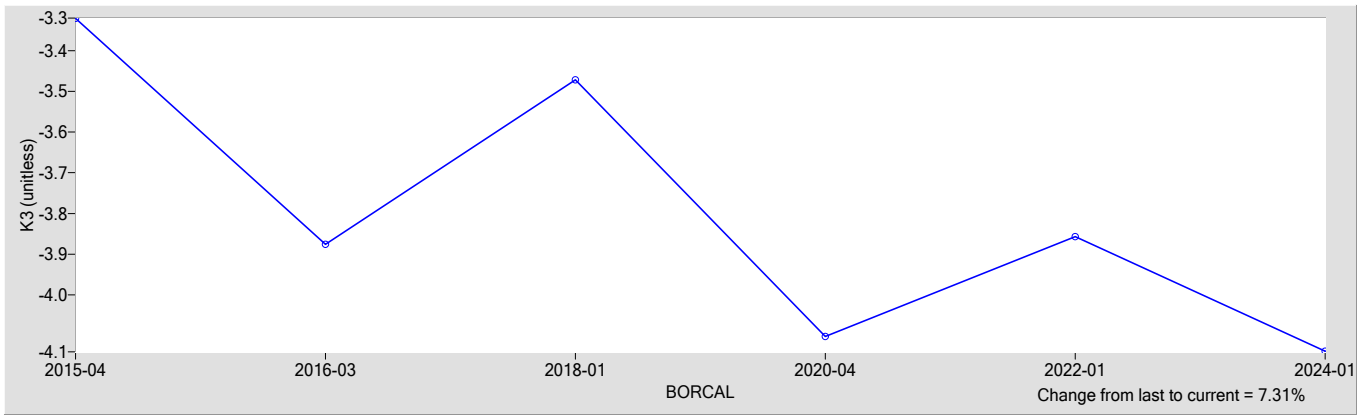


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	31300F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

31300F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

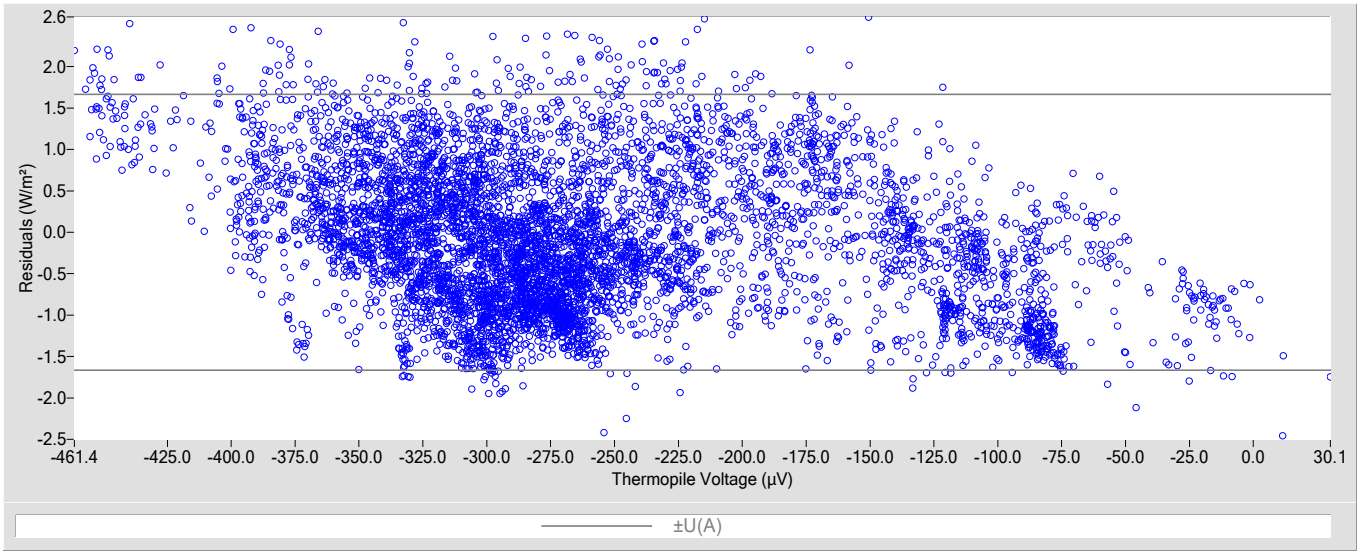


Table 1. Calibration Coefficients

K1	0.28183
K2	1.0012
K3	-5.10
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.85
Combined Standard Uncertainty, u(c) (W/m²)	±1.7
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.4

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

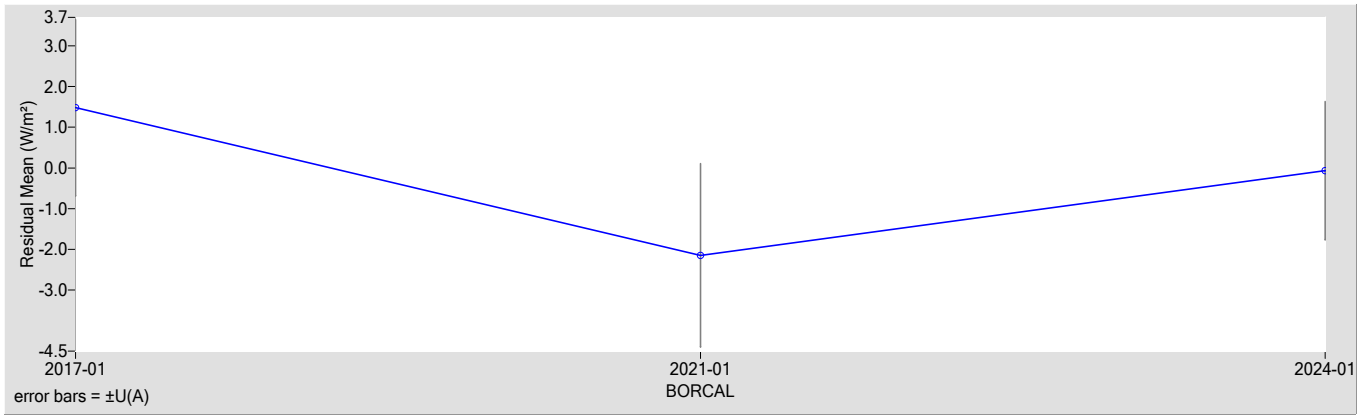


Figure 3. History of instrument (K1 Coefficient)

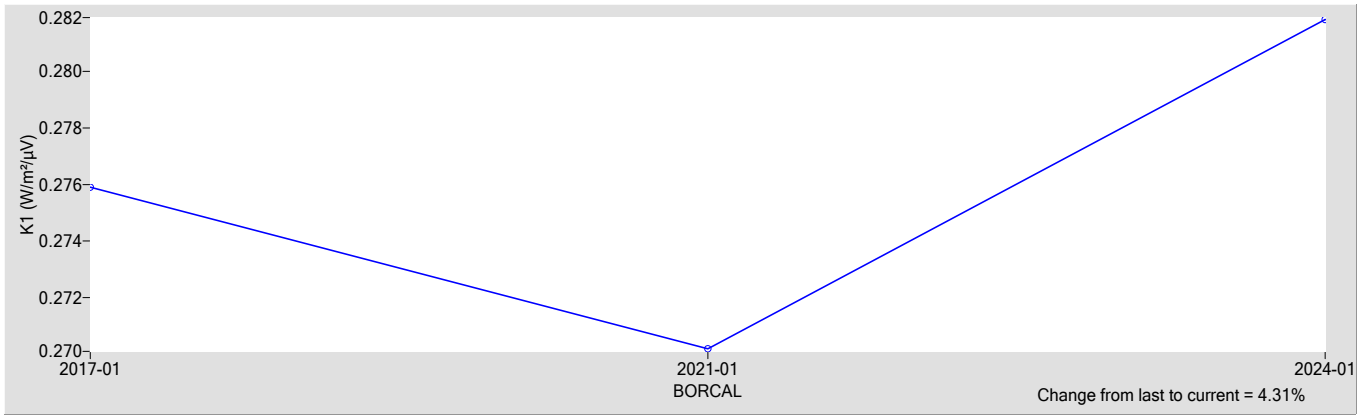


Figure 4. History of instrument (K2 Coefficient)

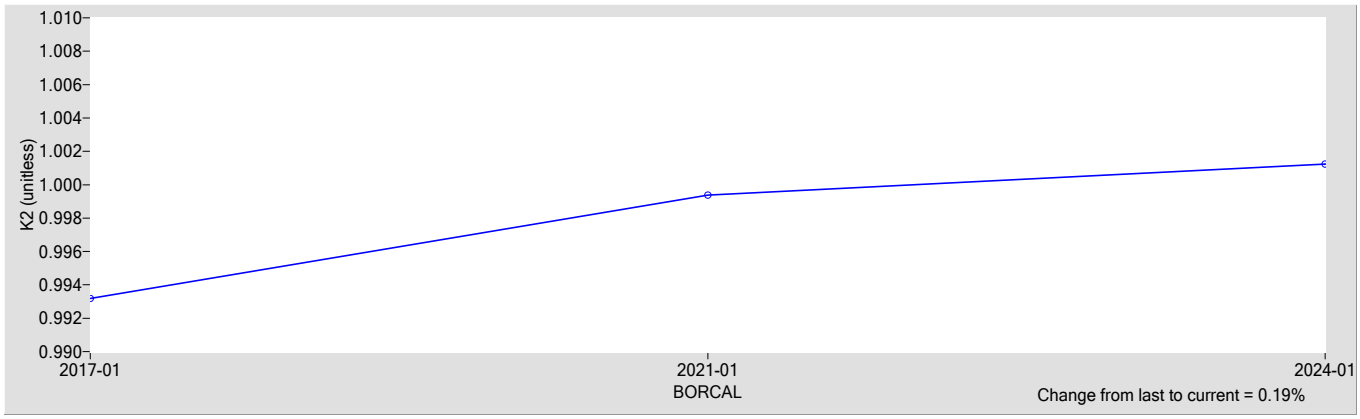
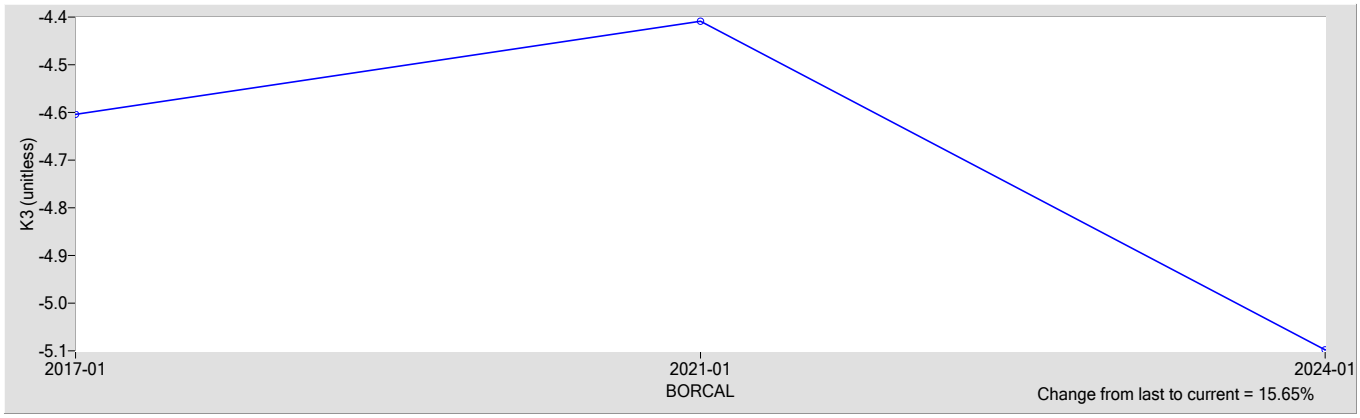


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	31309F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

31309F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

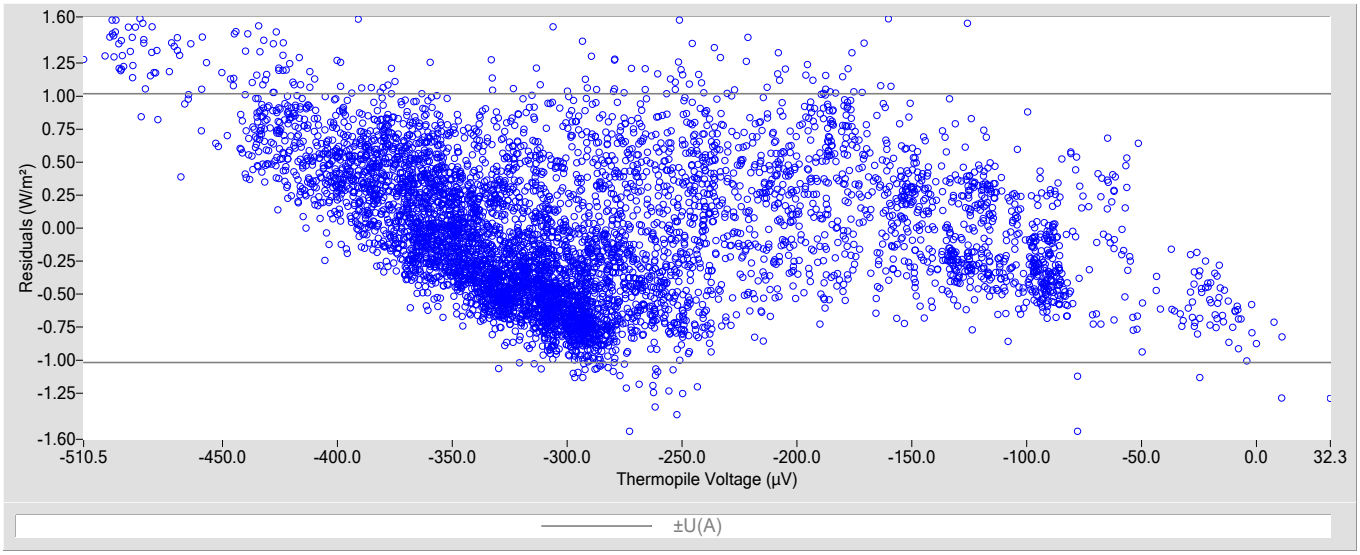


Table 1. Calibration Coefficients

K1	0.24648
K2	1.0031
K3	-2.94
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.52
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

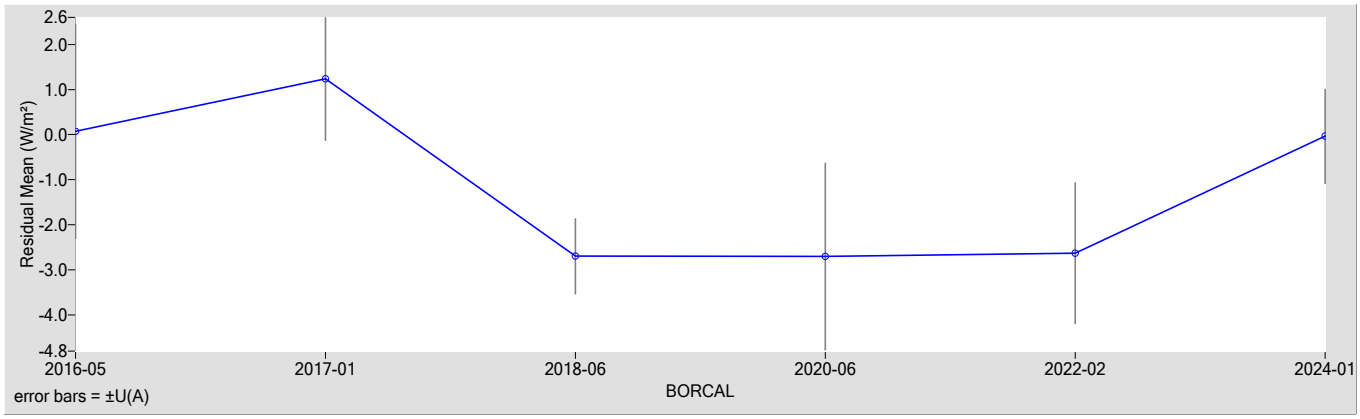


Figure 3. History of instrument (K1 Coefficient)

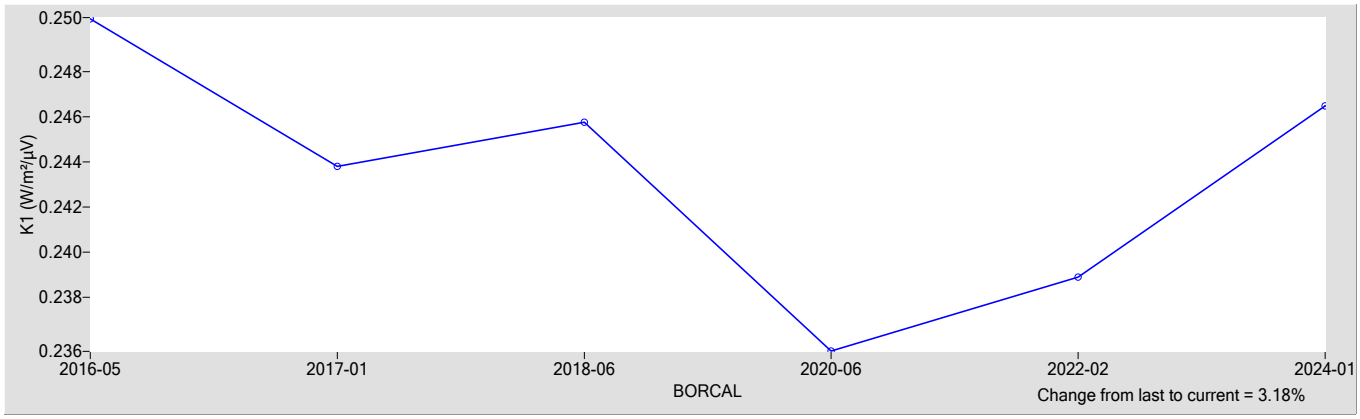


Figure 4. History of instrument (K2 Coefficient)

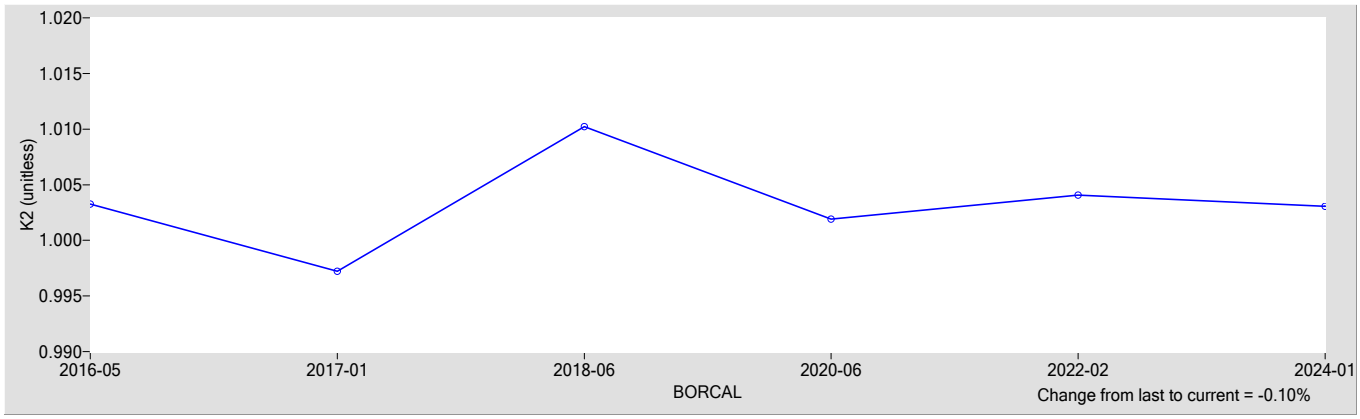
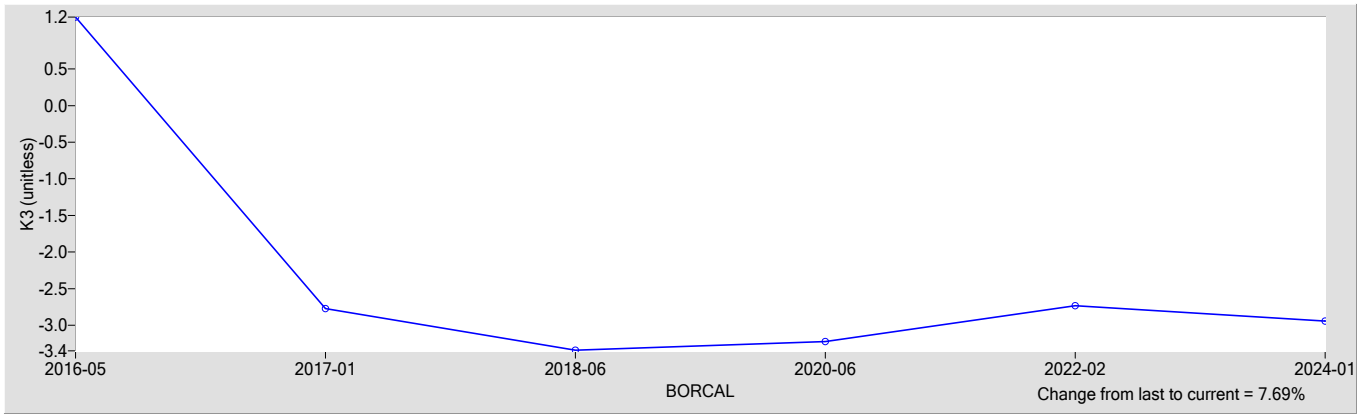


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	31390F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

31390F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (µV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/µV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

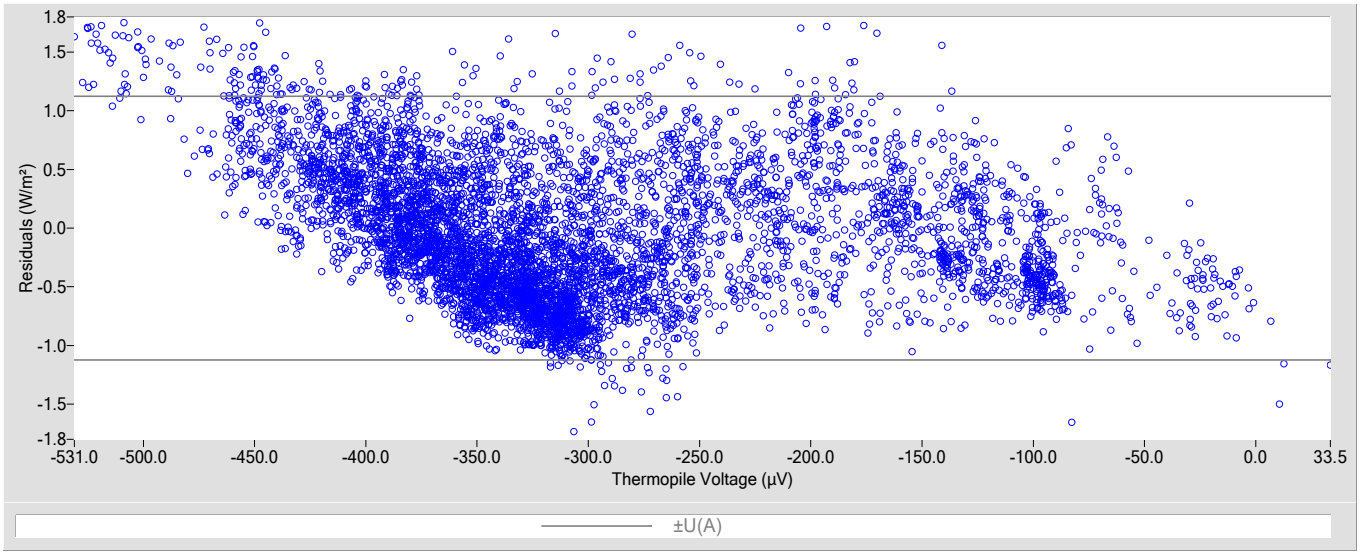


Table 1. Calibration Coefficients

K1	0.23518
K2	0.9992
K3	-3.96
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.57
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

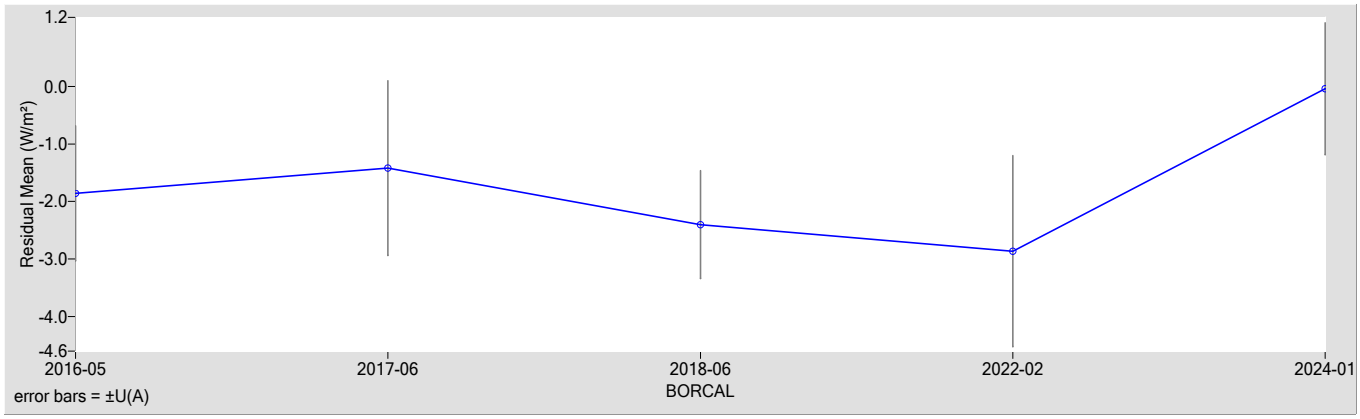


Figure 3. History of instrument (K1 Coefficient)

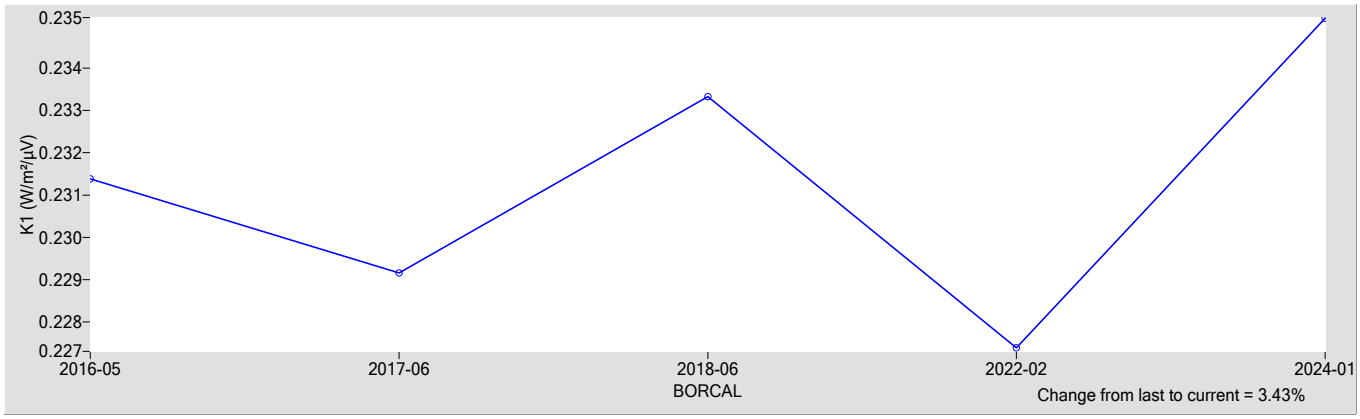


Figure 4. History of instrument (K2 Coefficient)

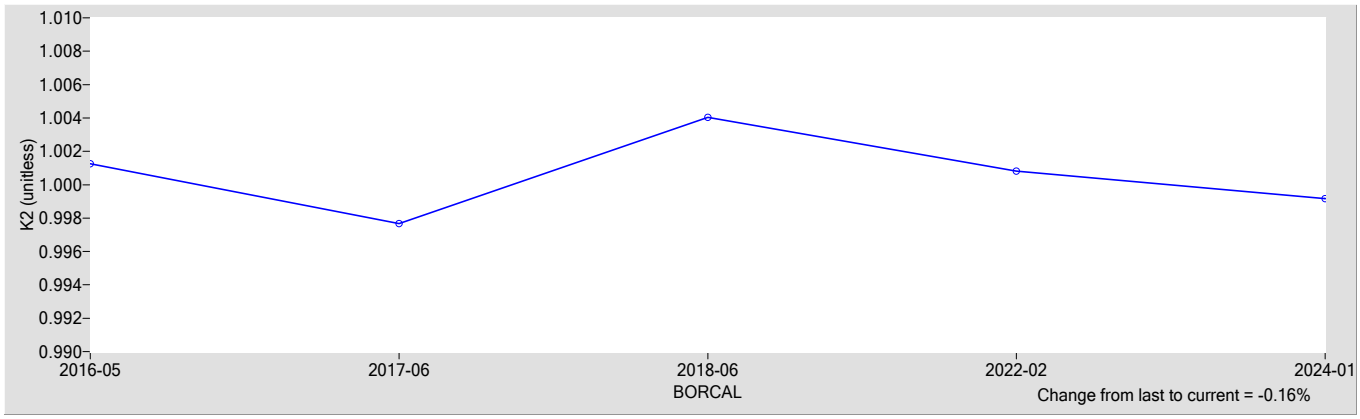
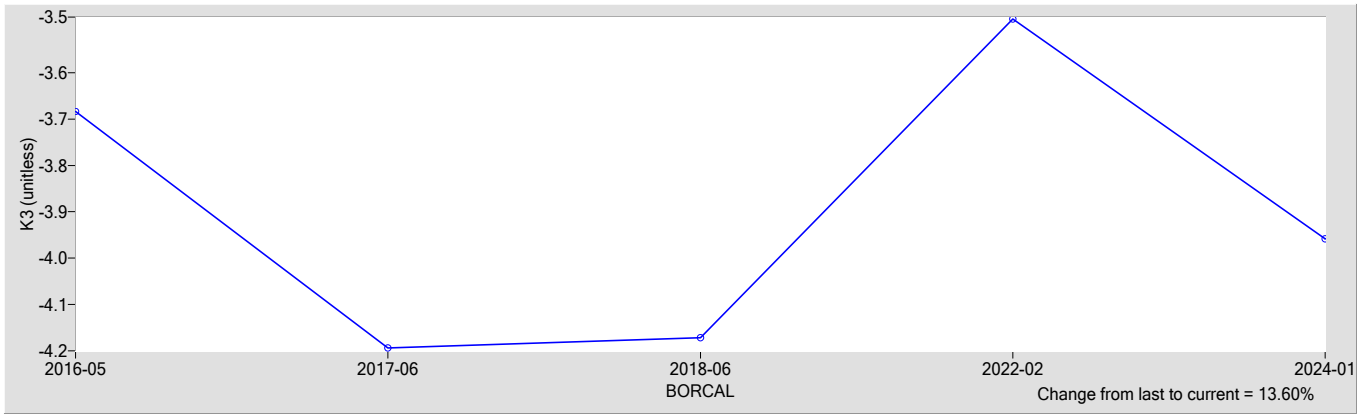


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	31391F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

31391F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

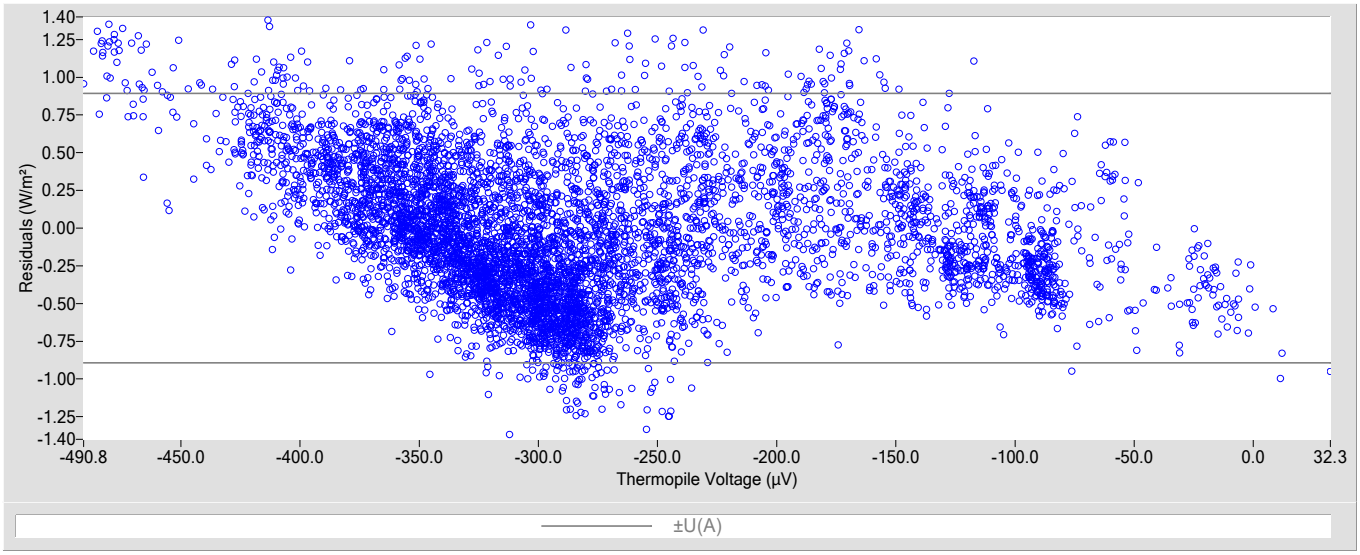


Table 1. Calibration Coefficients

K1	0.25329
K2	0.9989
K3	-3.29
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.46
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

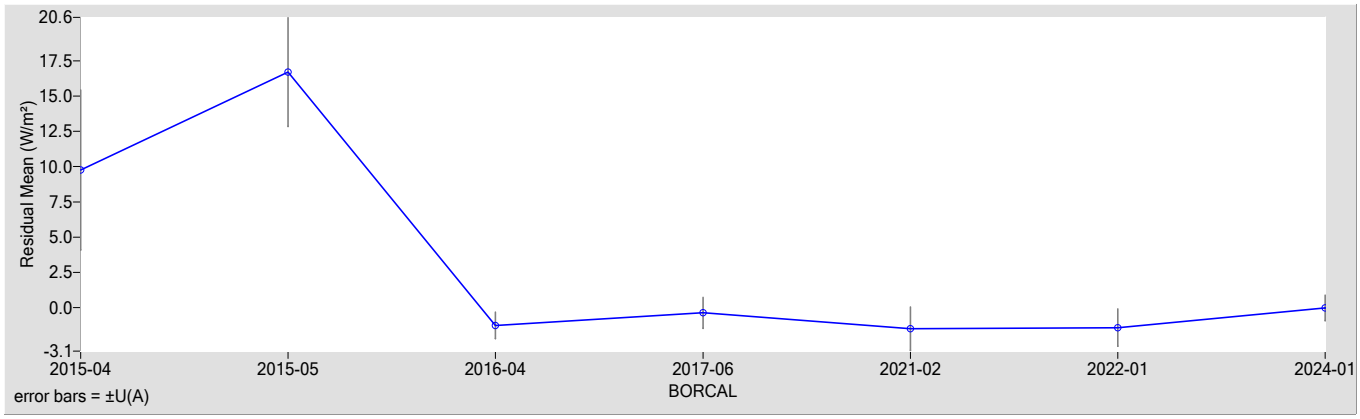


Figure 3. History of instrument (K1 Coefficient)

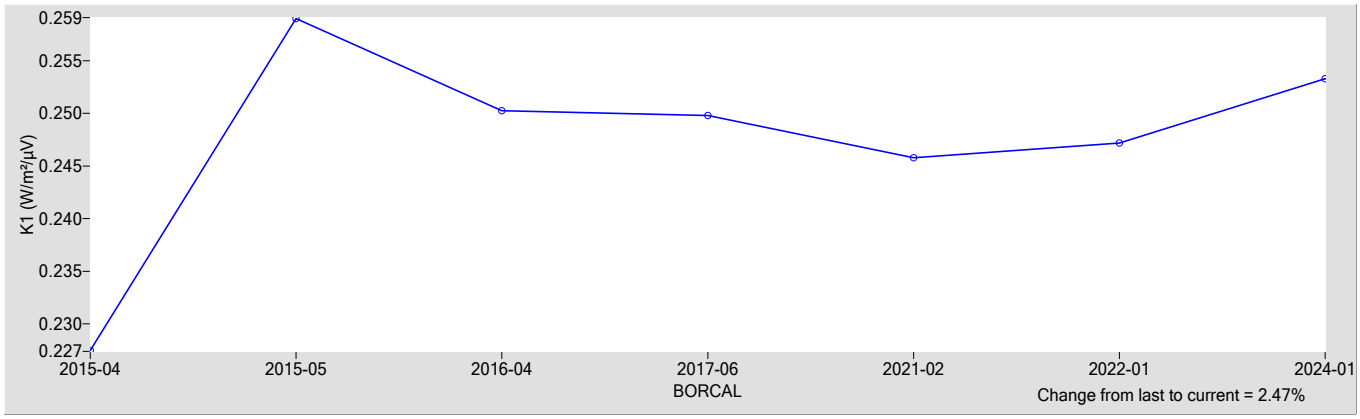


Figure 4. History of instrument (K2 Coefficient)

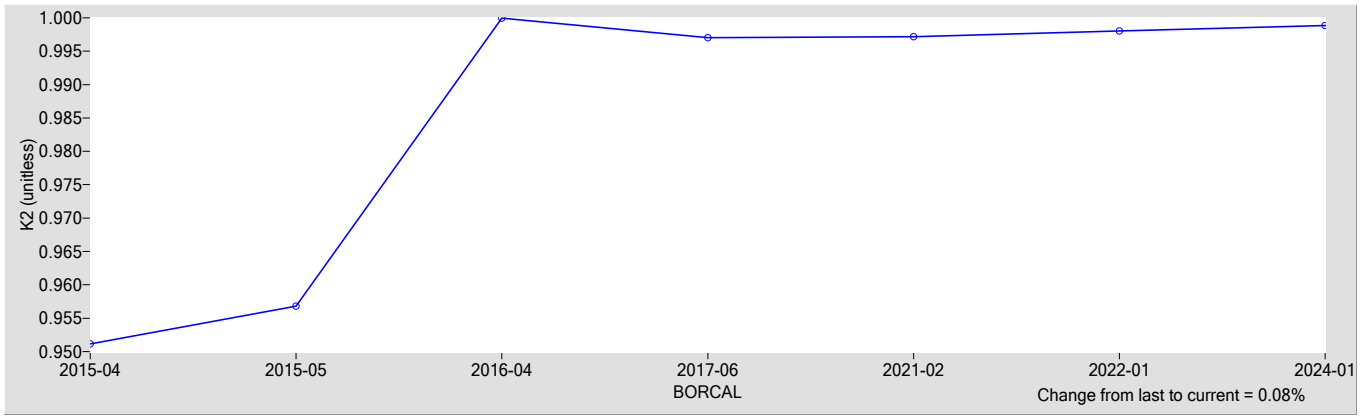
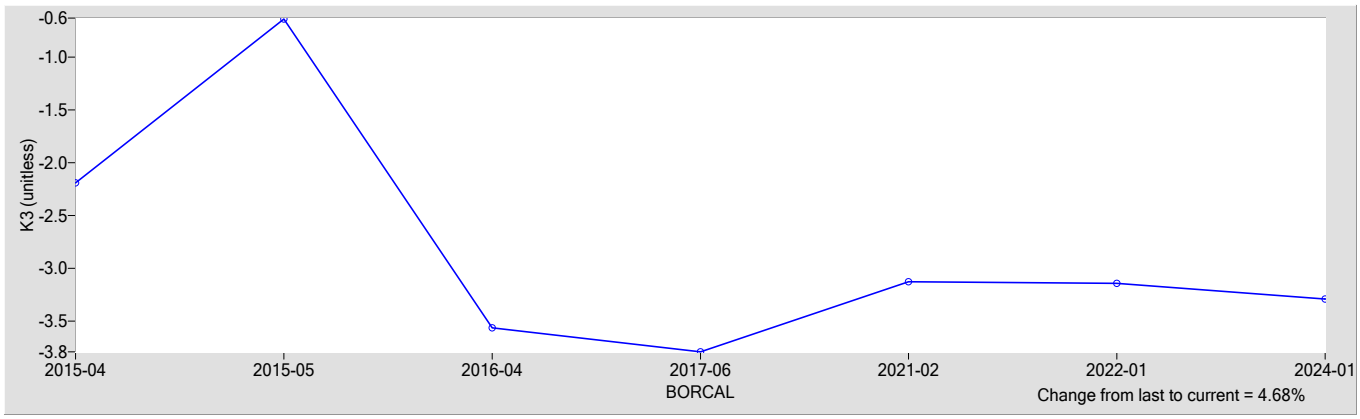


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32040F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32040F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

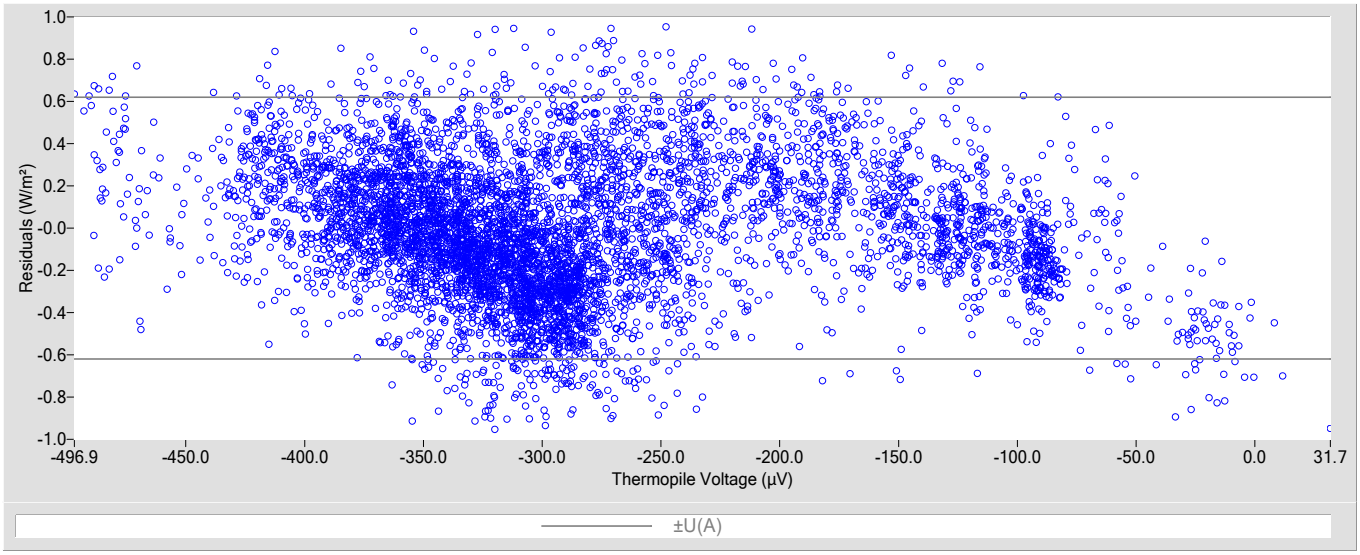


Table 1. Calibration Coefficients

K1	0.24920
K2	1.0009
K3	-3.88
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.32
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

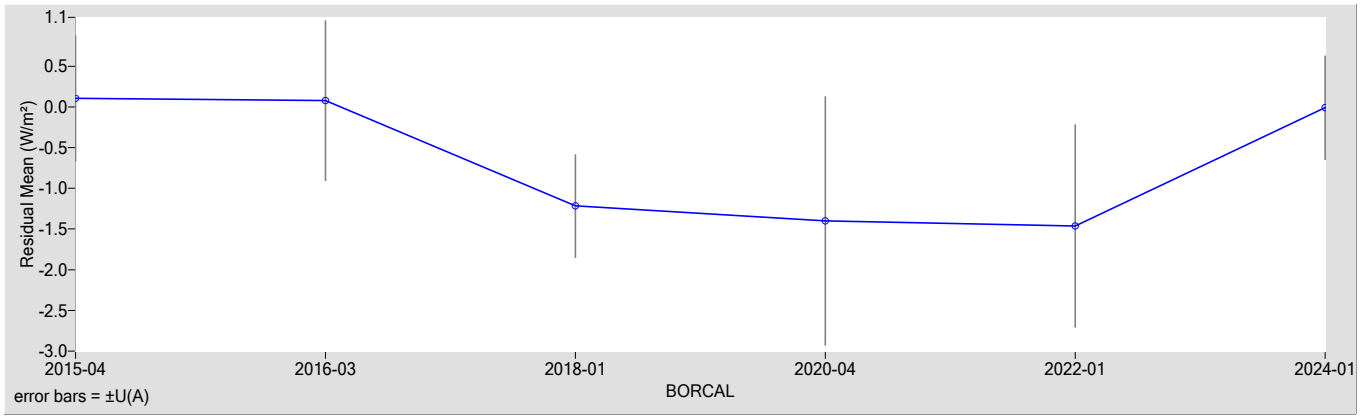


Figure 3. History of instrument (K1 Coefficient)

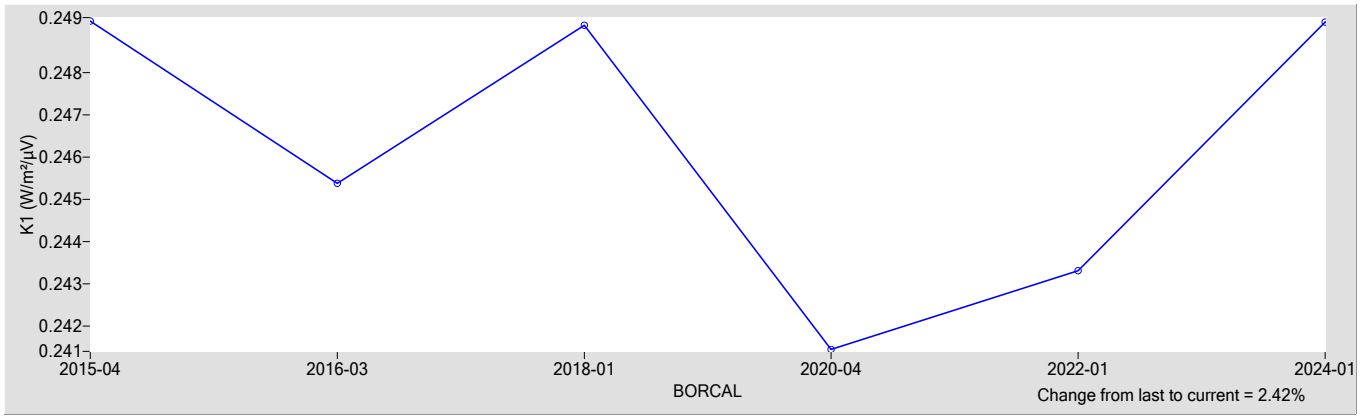


Figure 4. History of instrument (K2 Coefficient)

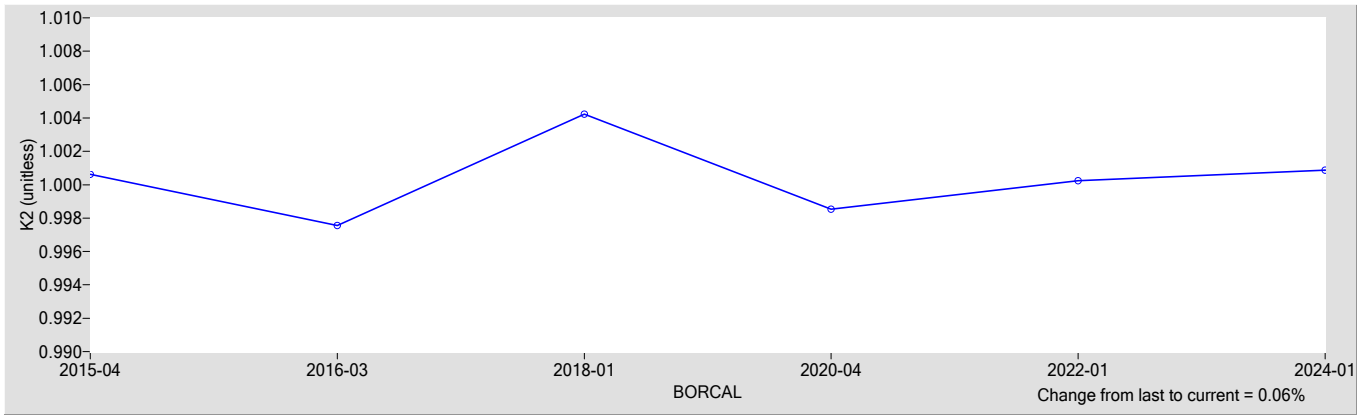
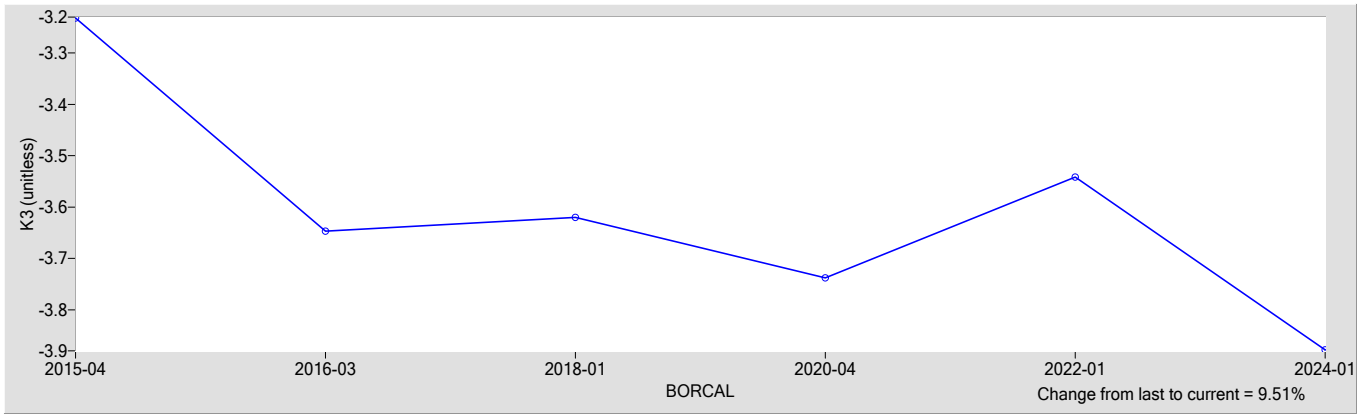


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32042F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32042F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

*Win = K1*V + K2*Wr + K3*(Wd - Wr)* [1]

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

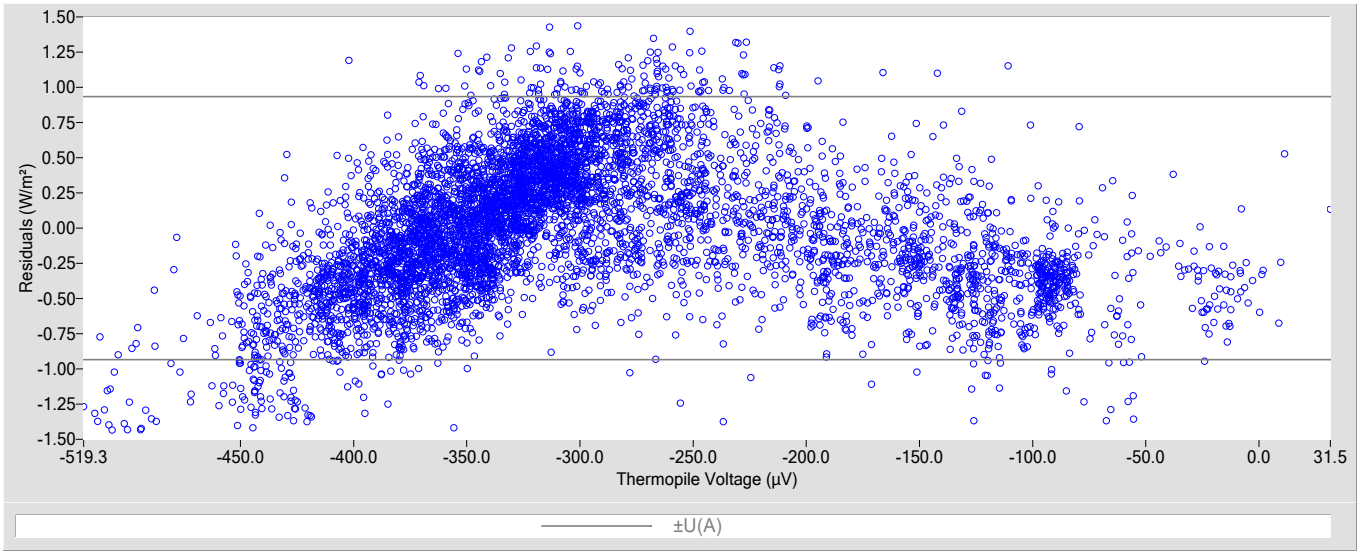


Table 1. Calibration Coefficients

K1	0.23748
K2	1.0063
K3	-3.53
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.48
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

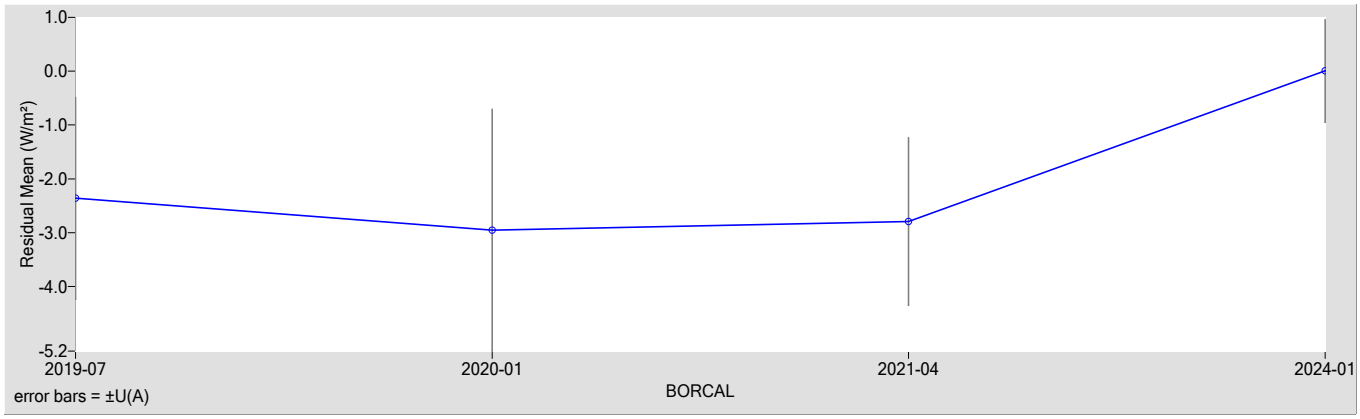


Figure 3. History of instrument (K1 Coefficient)

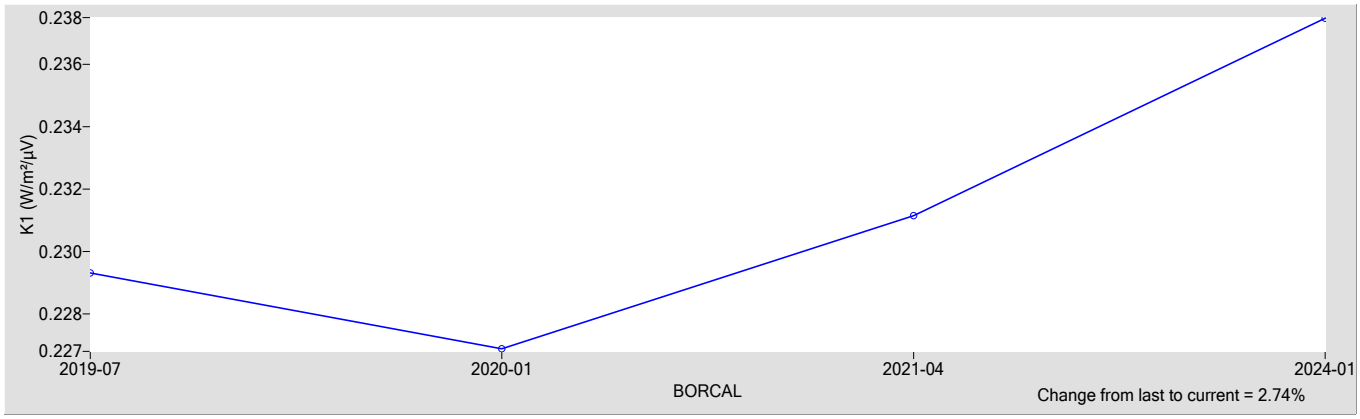


Figure 4. History of instrument (K2 Coefficient)

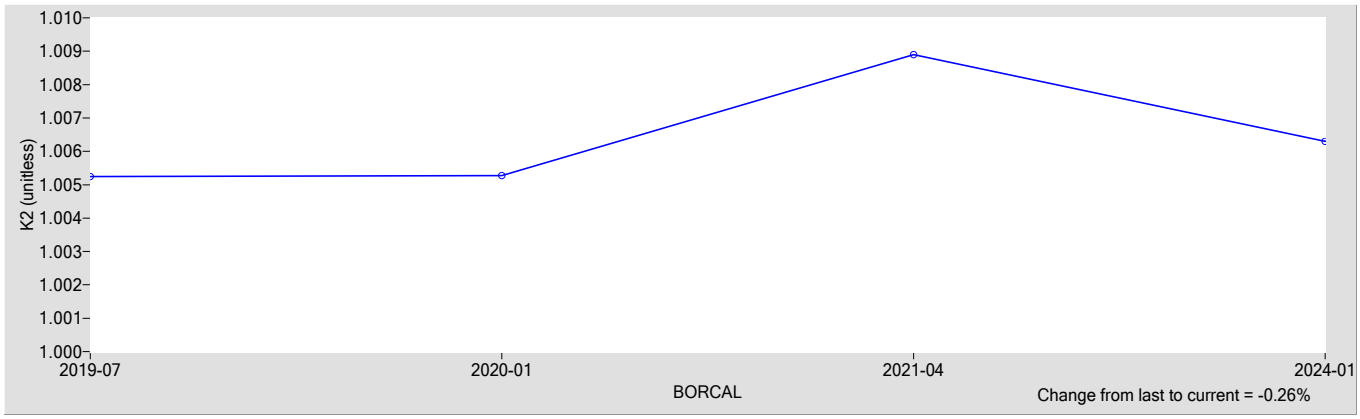
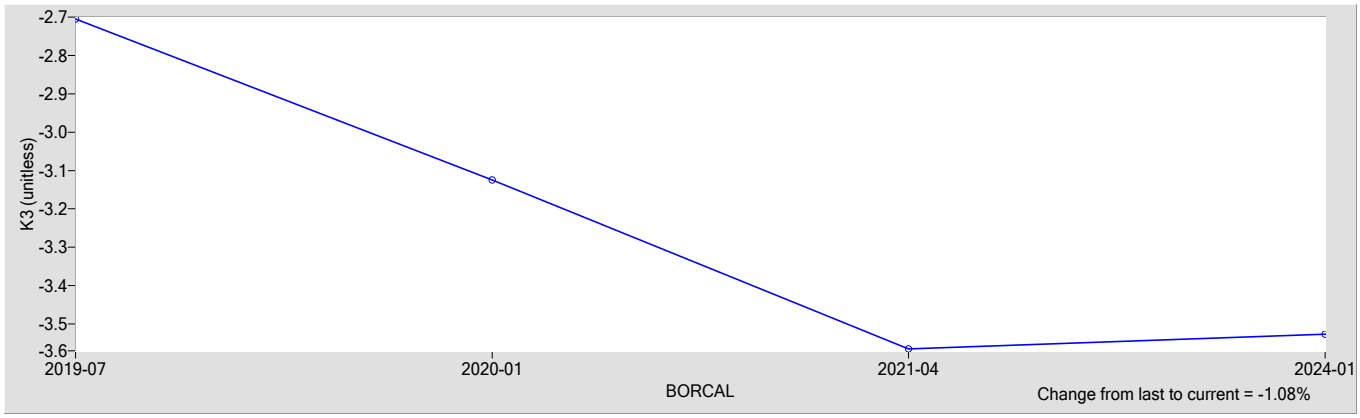


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32044F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32044F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

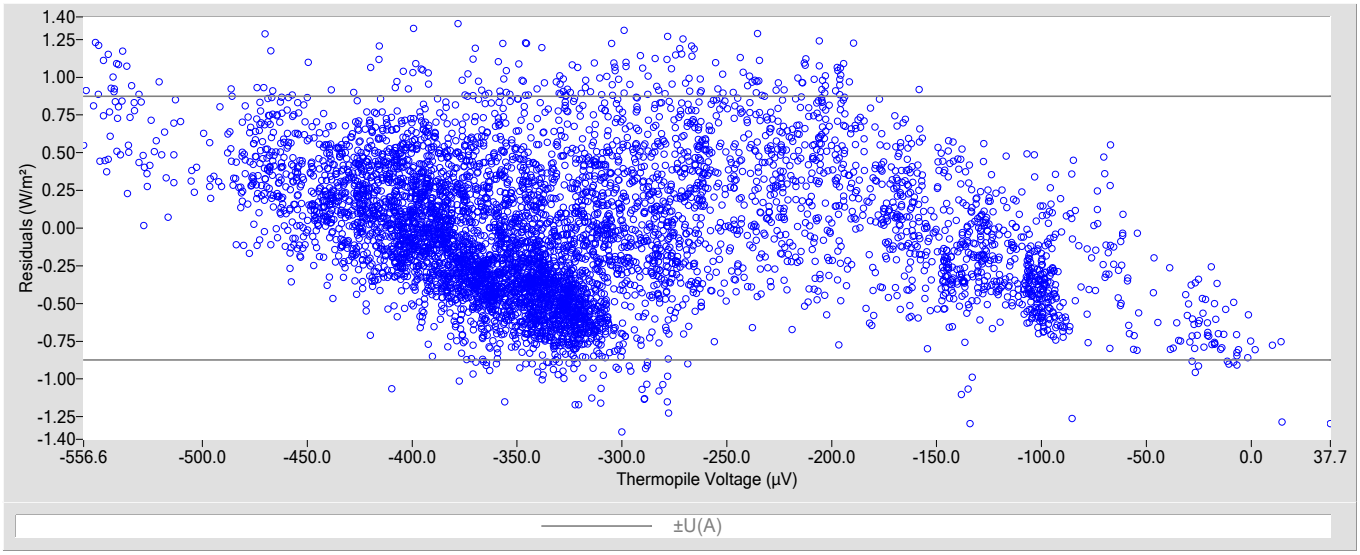


Table 1. Calibration Coefficients

K1	0.22207
K2	1.0039
K3	-3.17
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.45
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

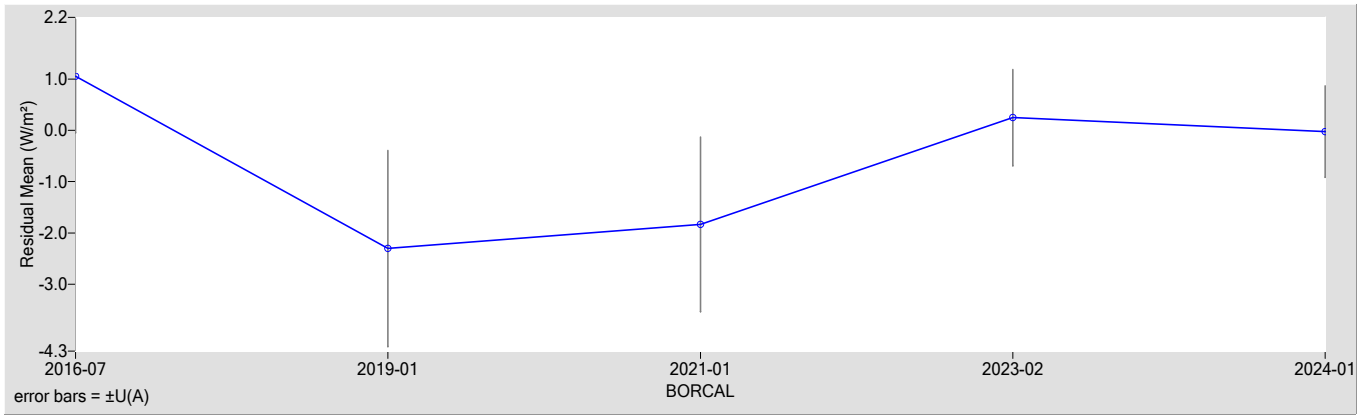


Figure 3. History of instrument (K1 Coefficient)

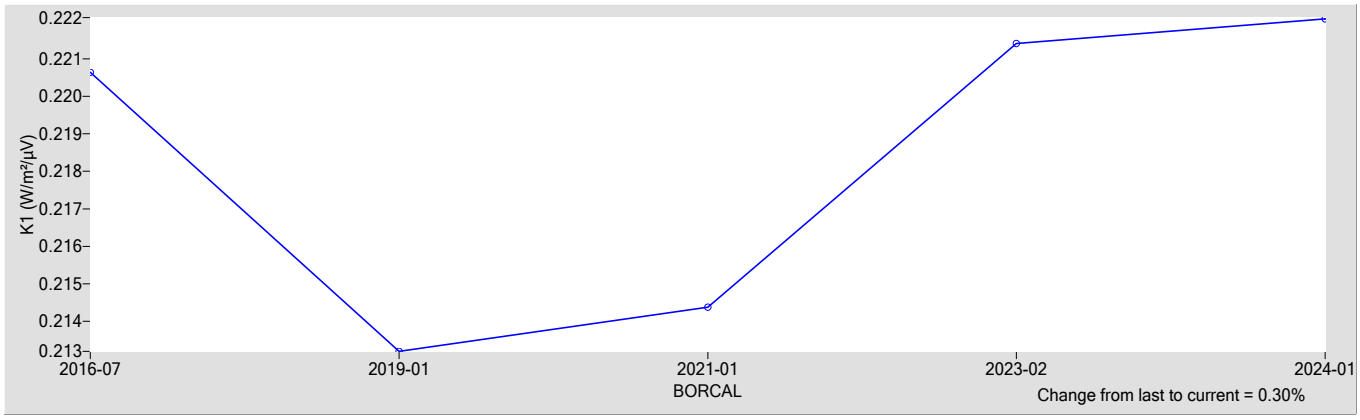


Figure 4. History of instrument (K2 Coefficient)

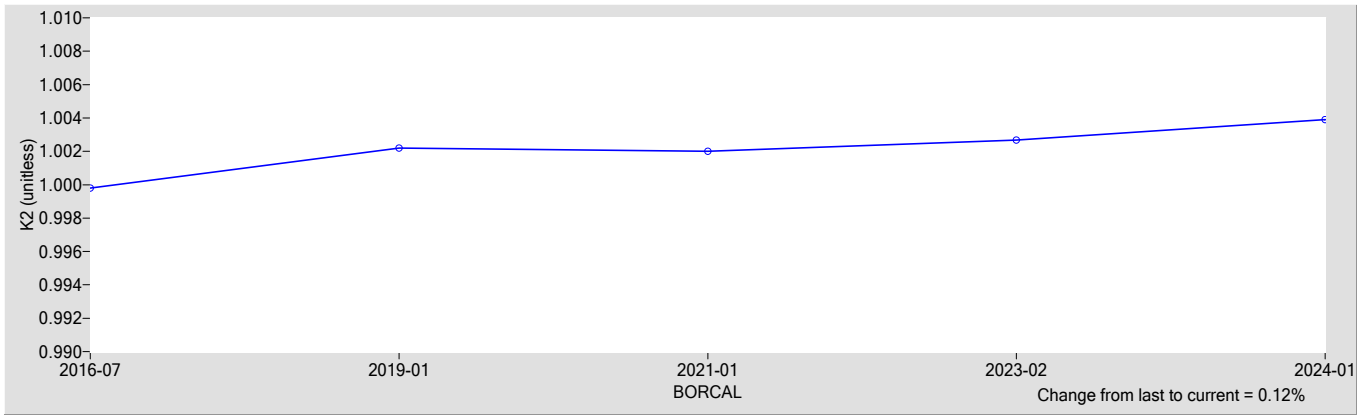
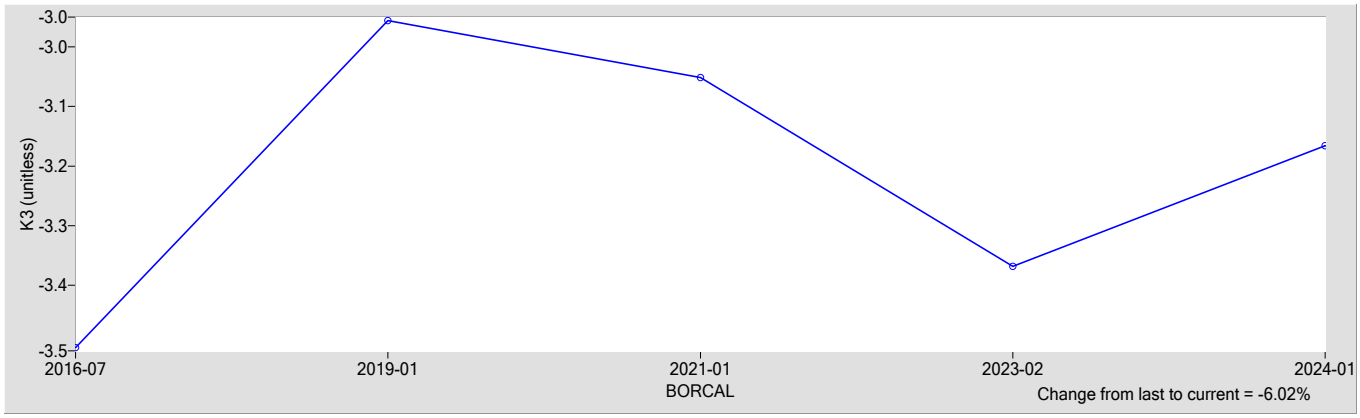


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32047F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32047F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

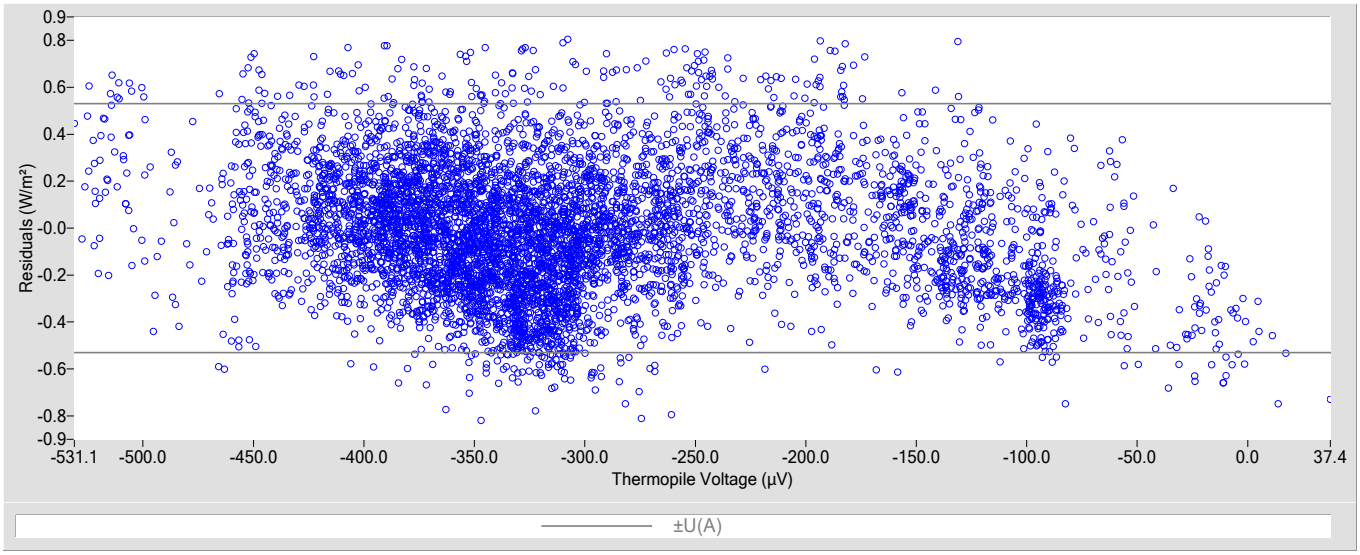


Table 1. Calibration Coefficients

K1	0.23055
K2	1.0034
K3	-3.46
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.27
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

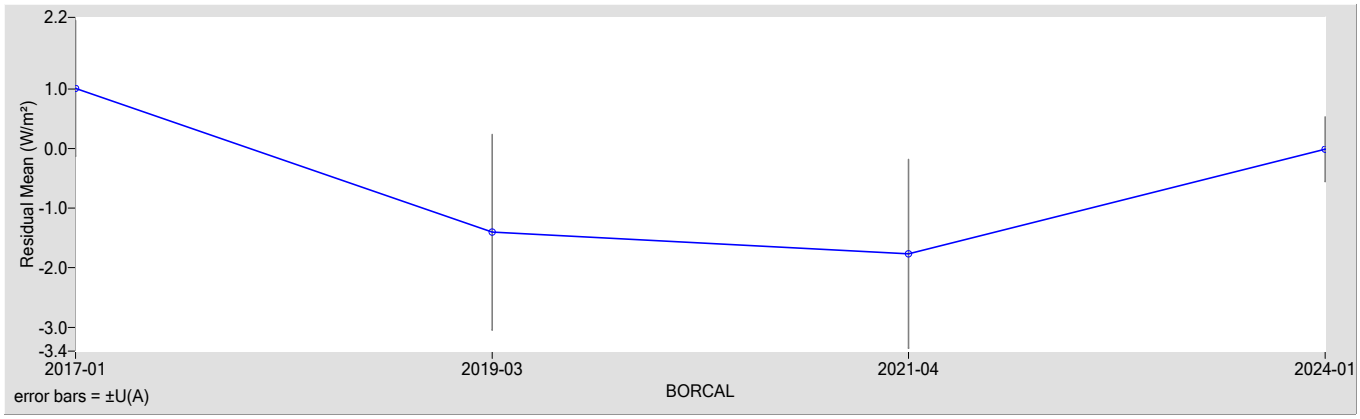


Figure 3. History of instrument (K1 Coefficient)

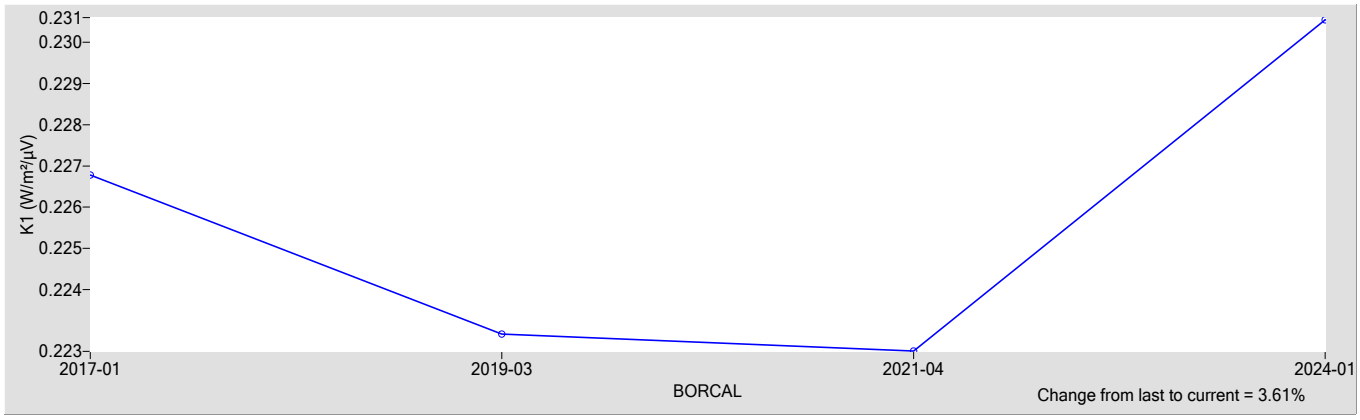


Figure 4. History of instrument (K2 Coefficient)

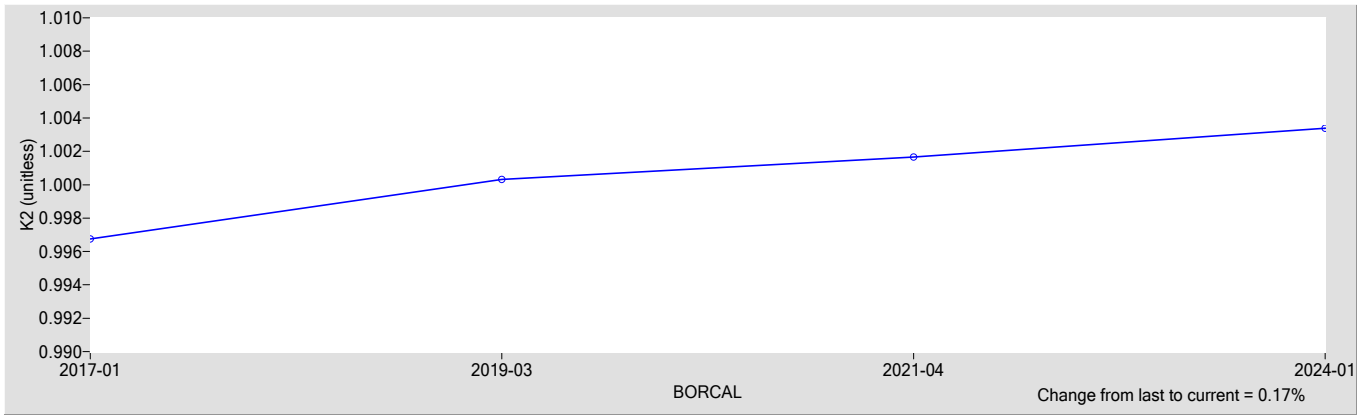
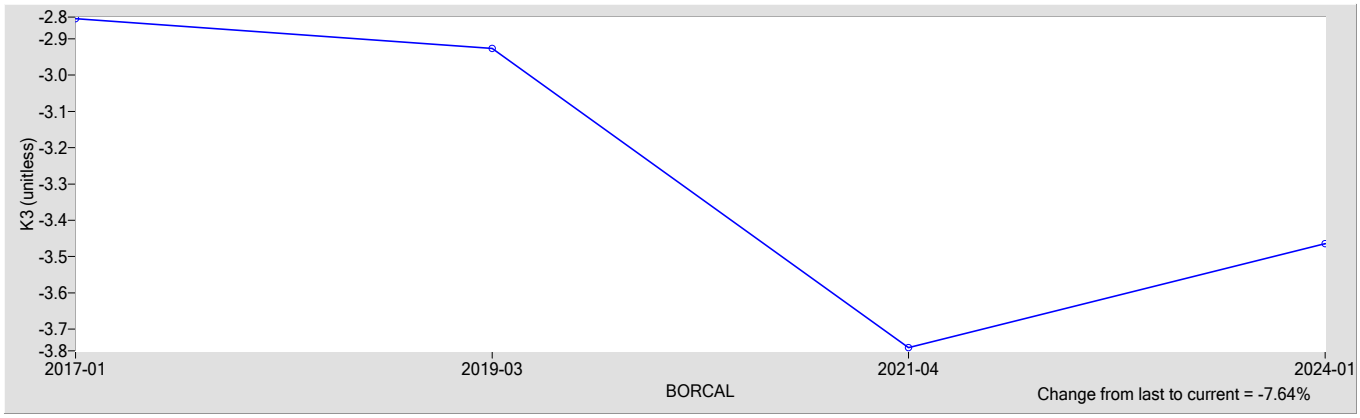


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32049F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32049F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

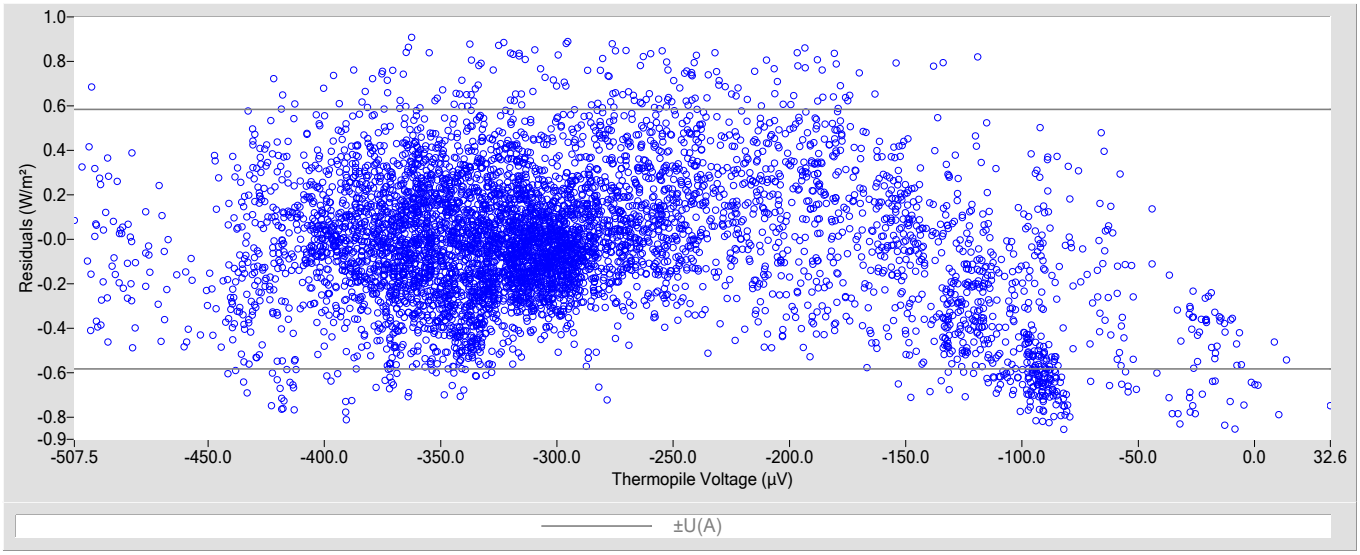


Table 1. Calibration Coefficients

K1	0.24272
K2	1.0050
K3	-3.50
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.30
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

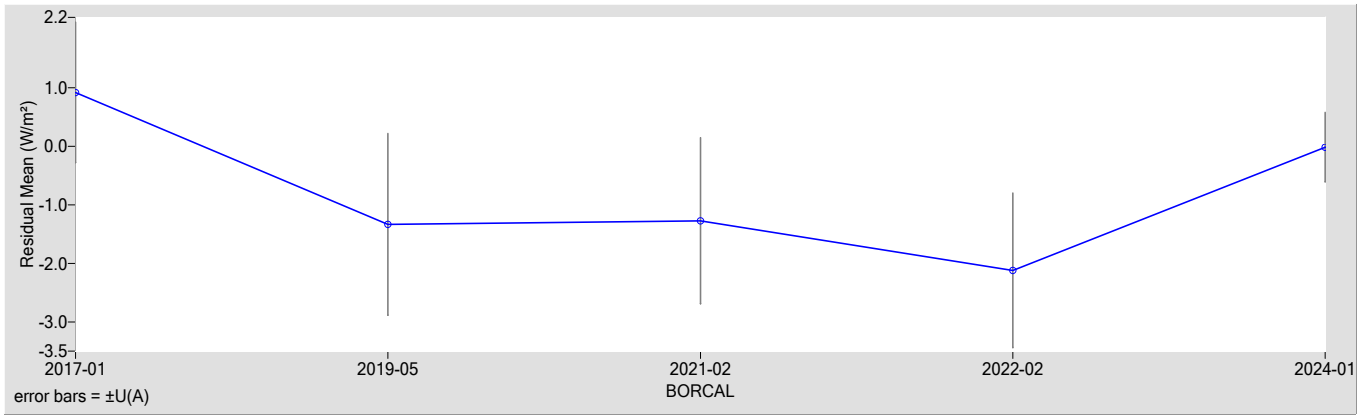


Figure 3. History of instrument (K1 Coefficient)

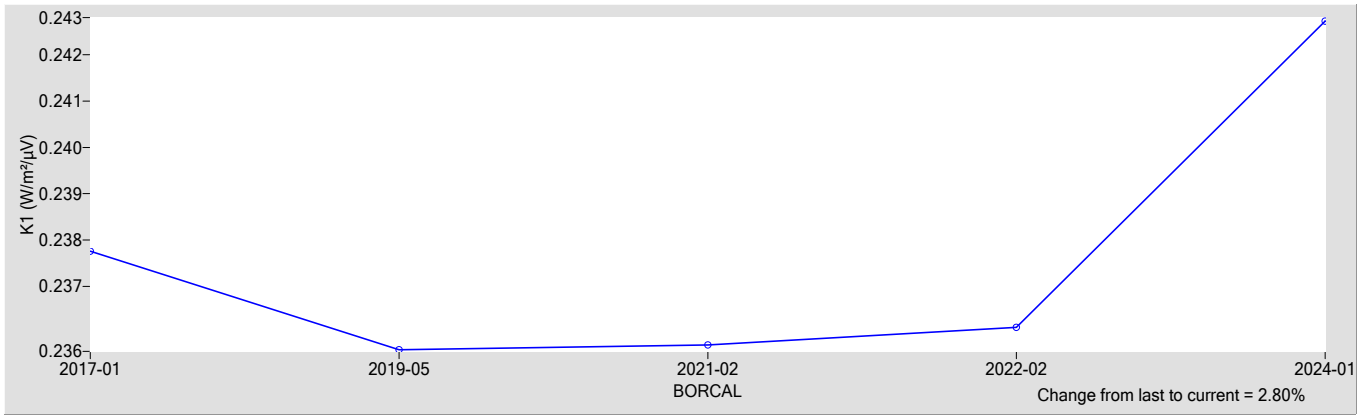


Figure 4. History of instrument (K2 Coefficient)

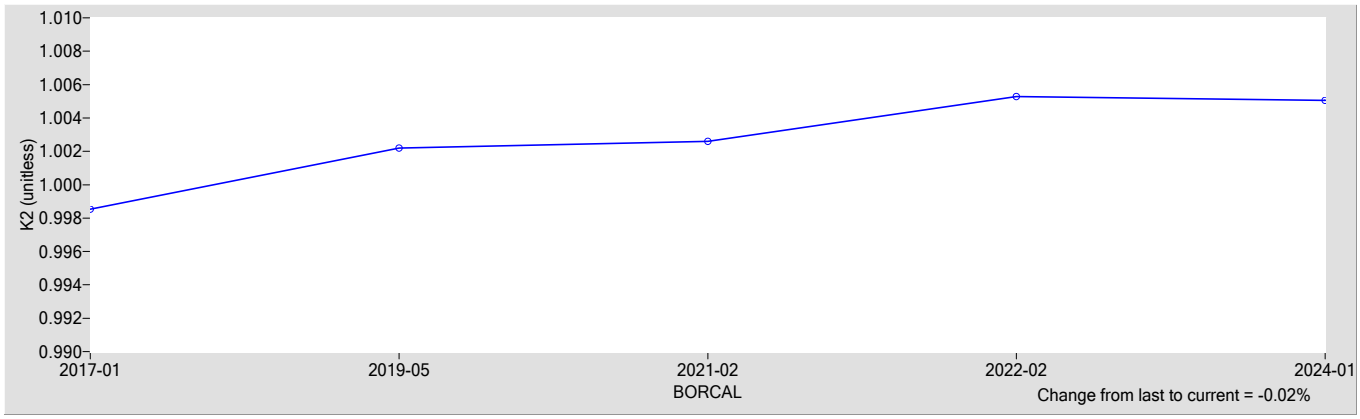
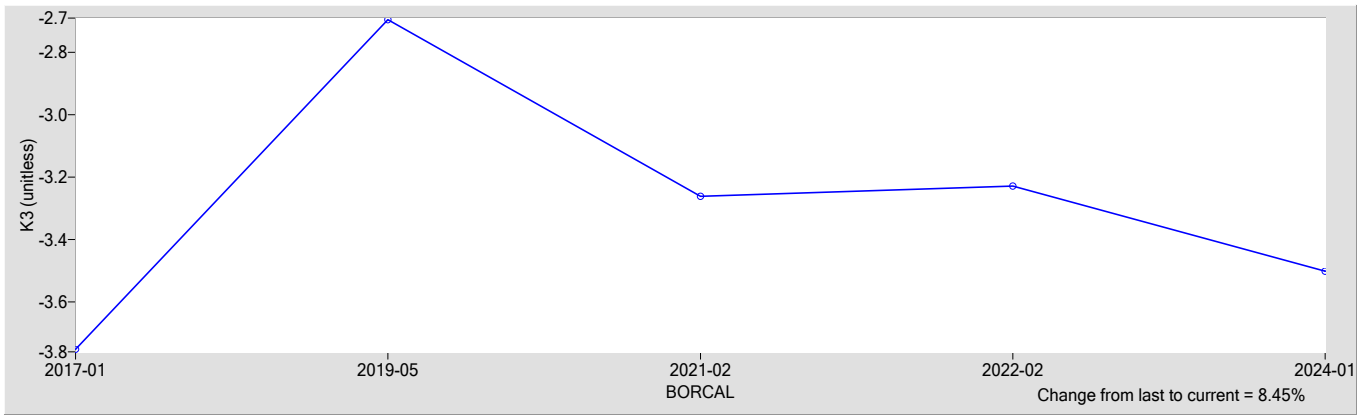


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32054F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	NSA	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32054F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

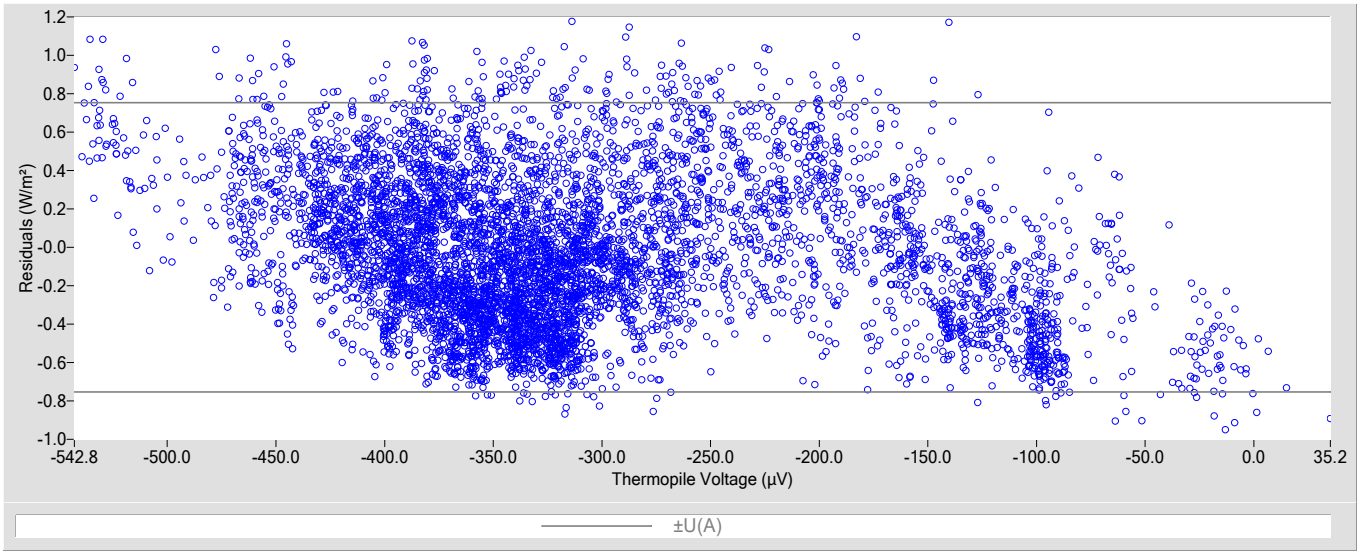


Table 1. Calibration Coefficients

K1	0.22602
K2	1.0099
K3	-3.21
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.38
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

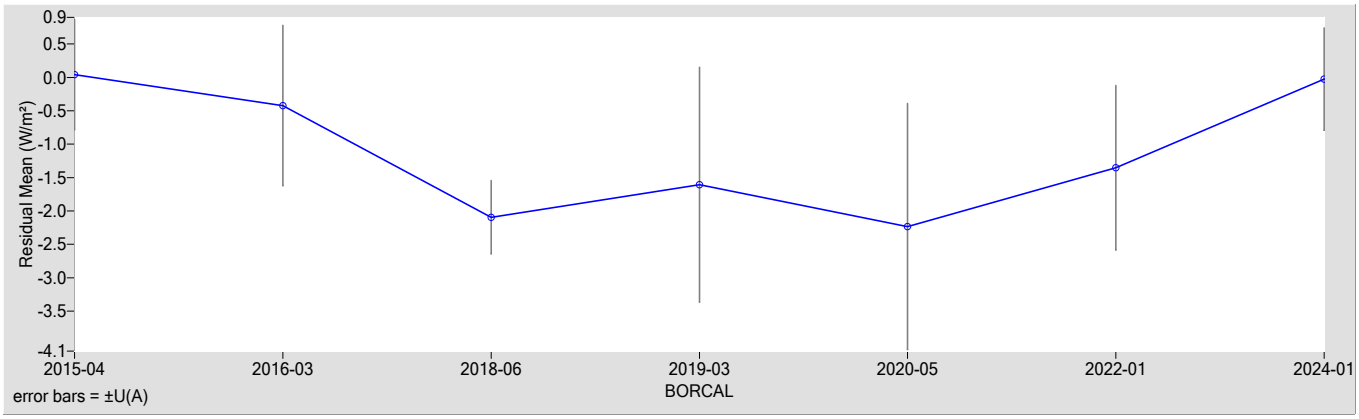


Figure 3. History of instrument (K1 Coefficient)

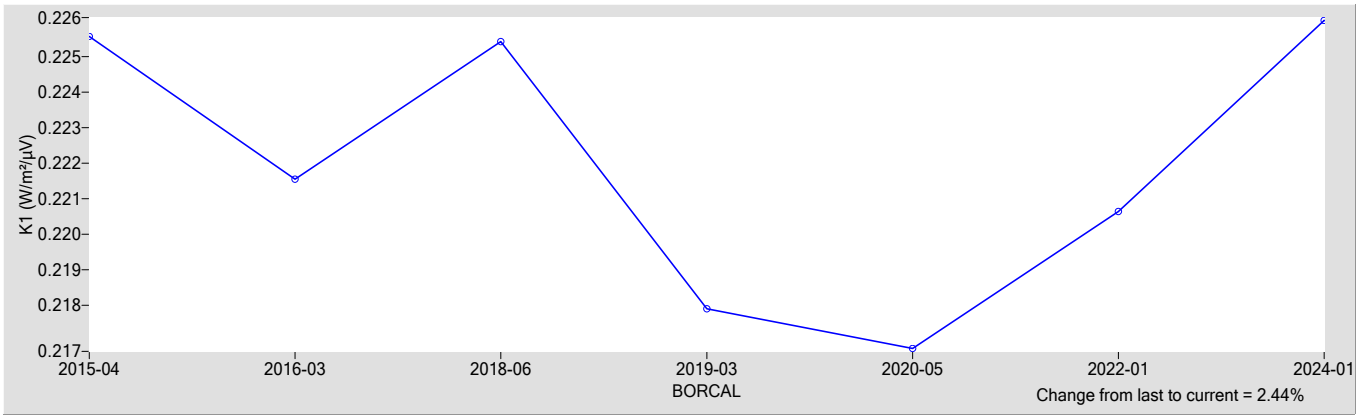


Figure 4. History of instrument (K2 Coefficient)

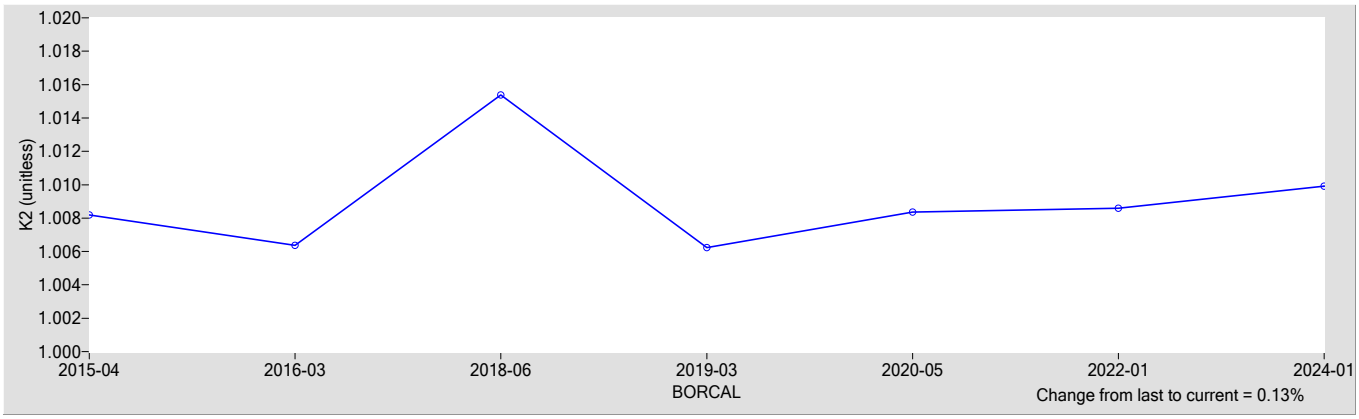
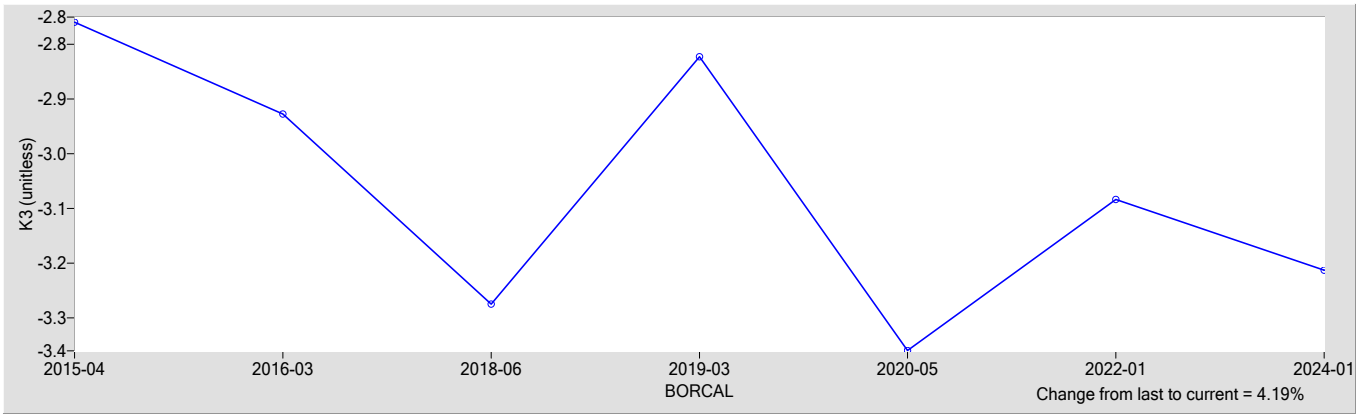


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32832F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32832F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

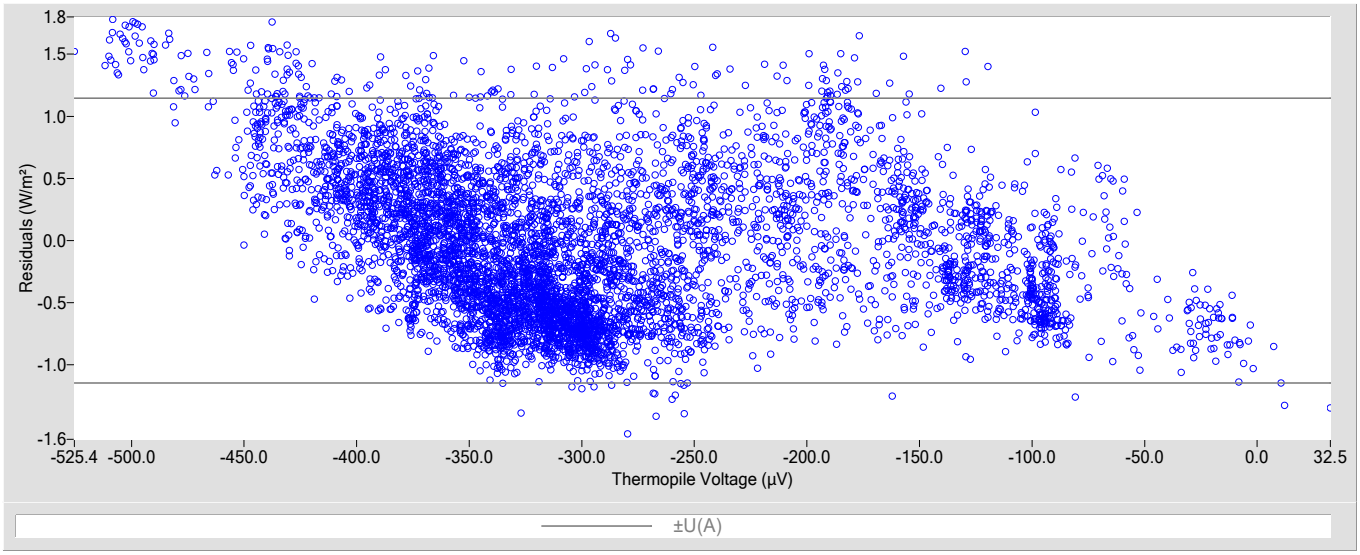


Table 1. Calibration Coefficients

K1	0.24094
K2	1.0041
K3	-3.21
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.58
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

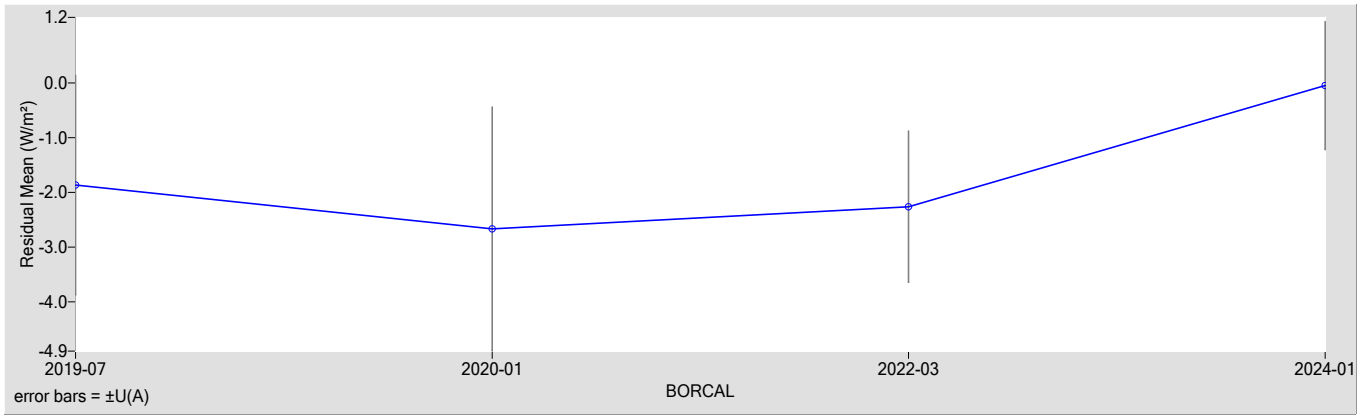


Figure 3. History of instrument (K1 Coefficient)

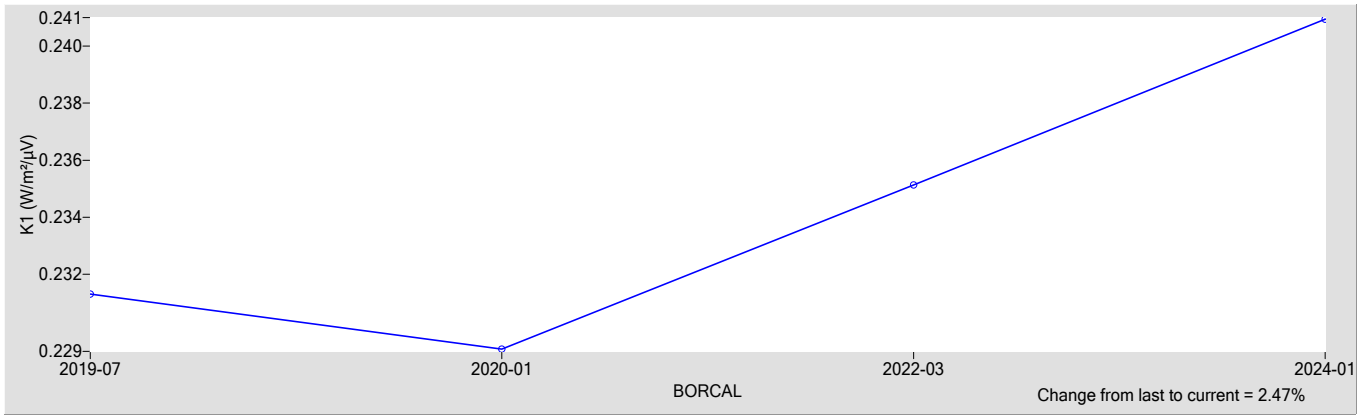


Figure 4. History of instrument (K2 Coefficient)

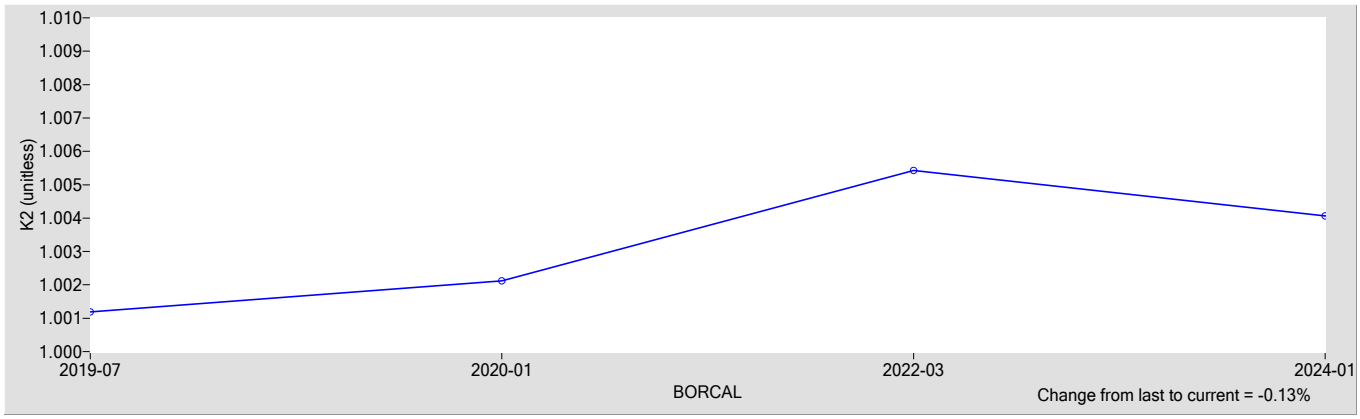
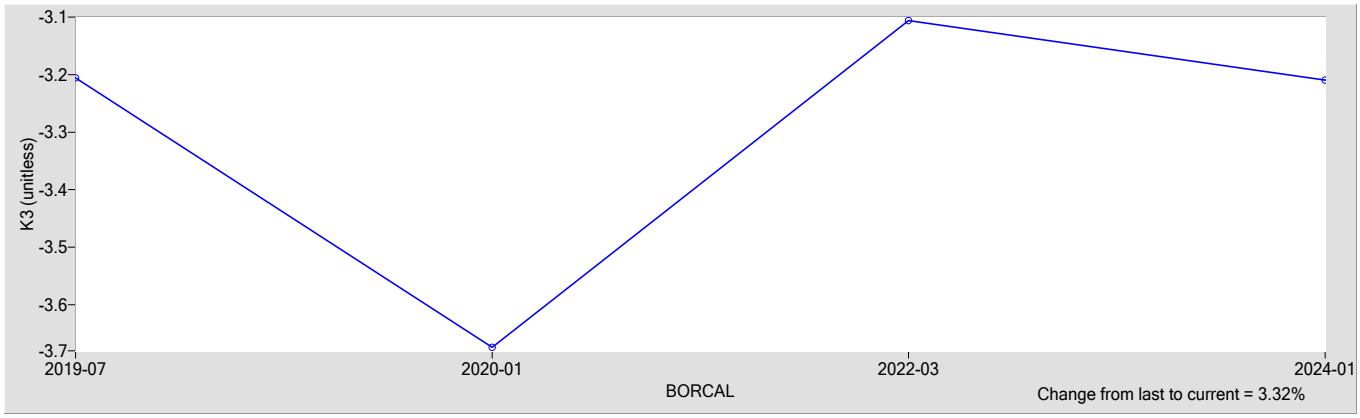


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	32998F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

32998F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (µV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/µV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

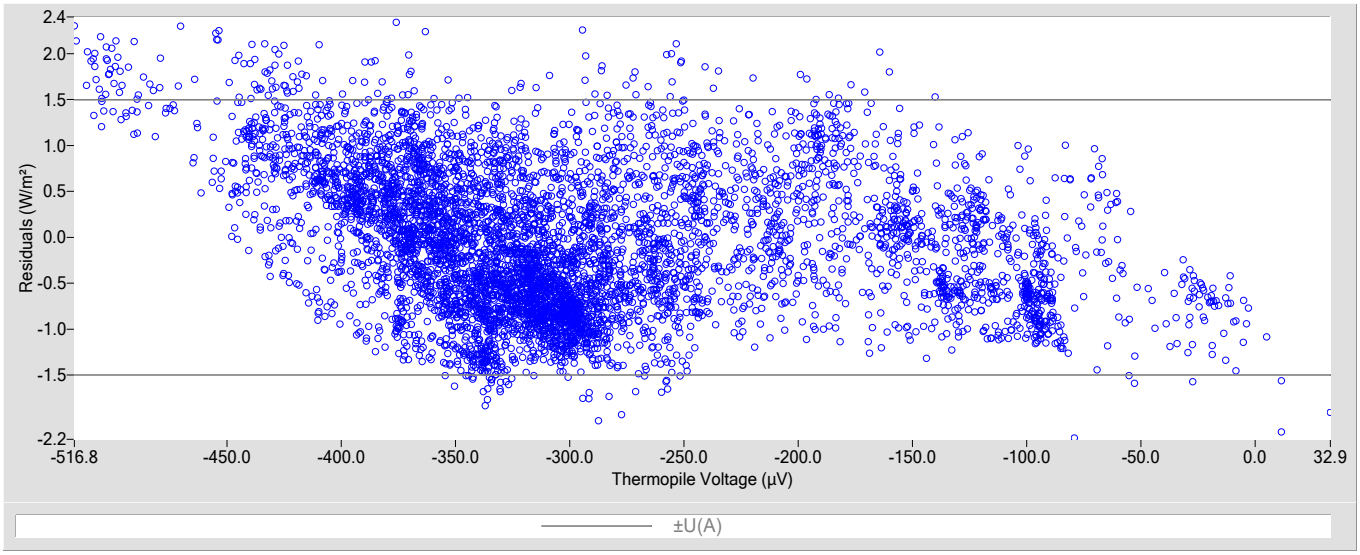


Table 1. Calibration Coefficients

K1	0.24203
K2	1.0014
K3	-2.60
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.76
Combined Standard Uncertainty, u(c) (W/m²)	±1.7
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.3

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

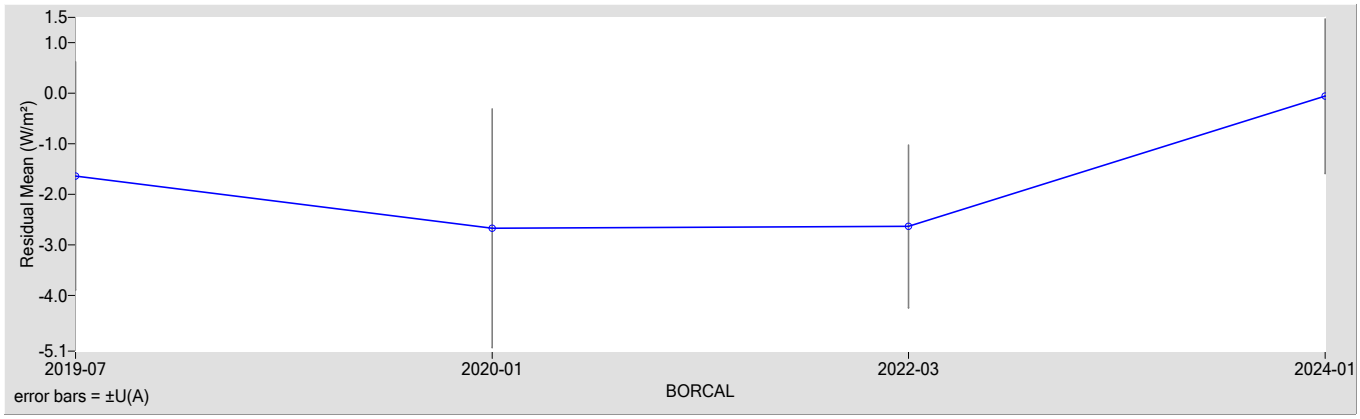


Figure 3. History of instrument (K1 Coefficient)

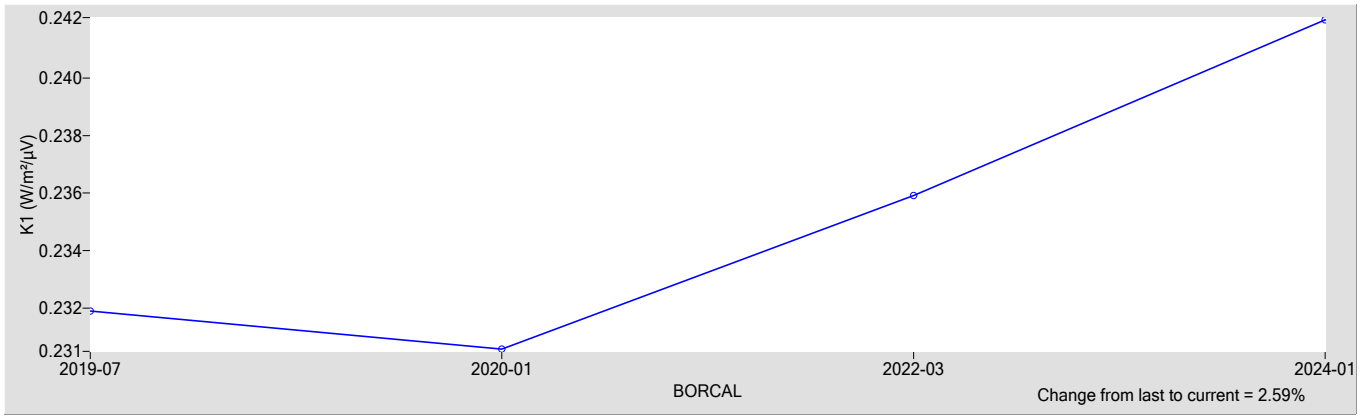


Figure 4. History of instrument (K2 Coefficient)

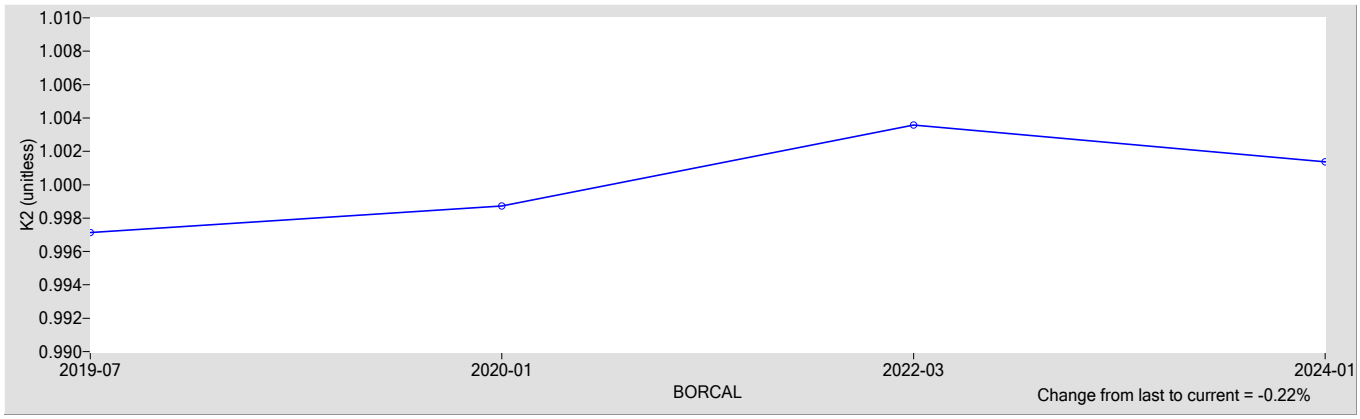
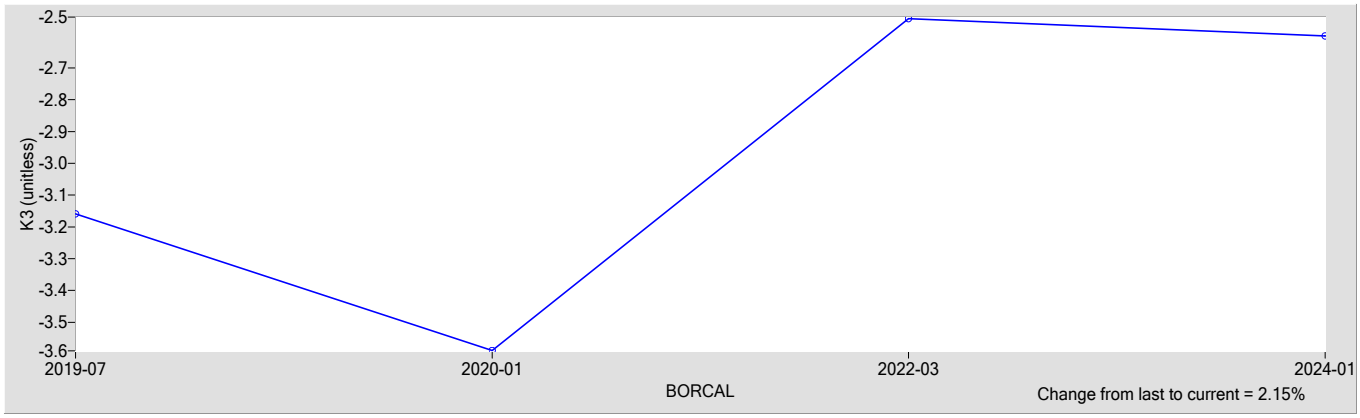


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	33058F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	TWP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

33058F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

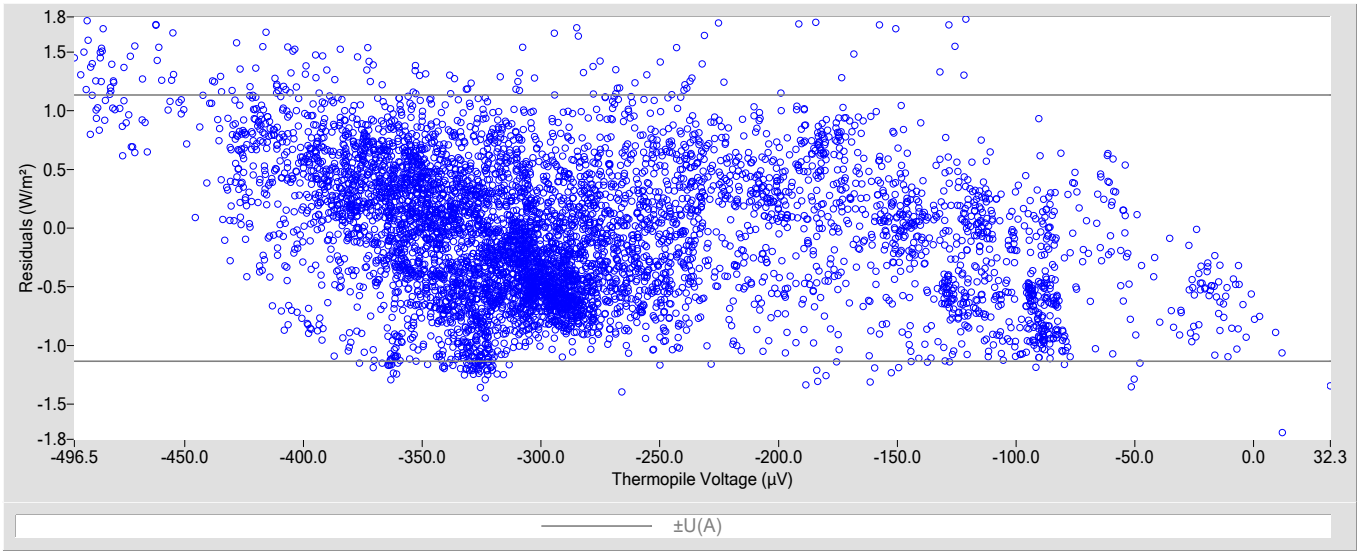


Table 1. Calibration Coefficients

K1	0.24776
K2	0.9980
K3	-2.78
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.58
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

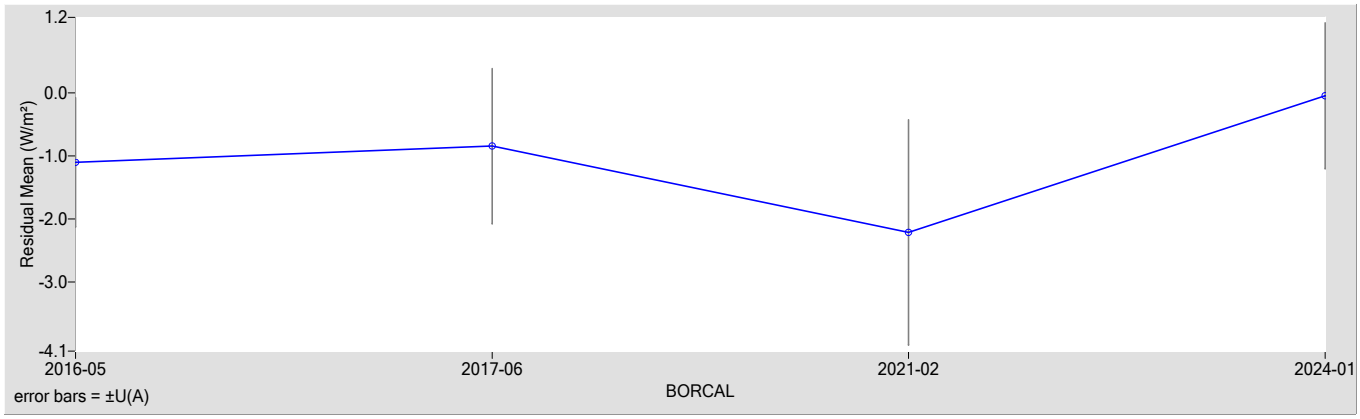


Figure 3. History of instrument (K1 Coefficient)

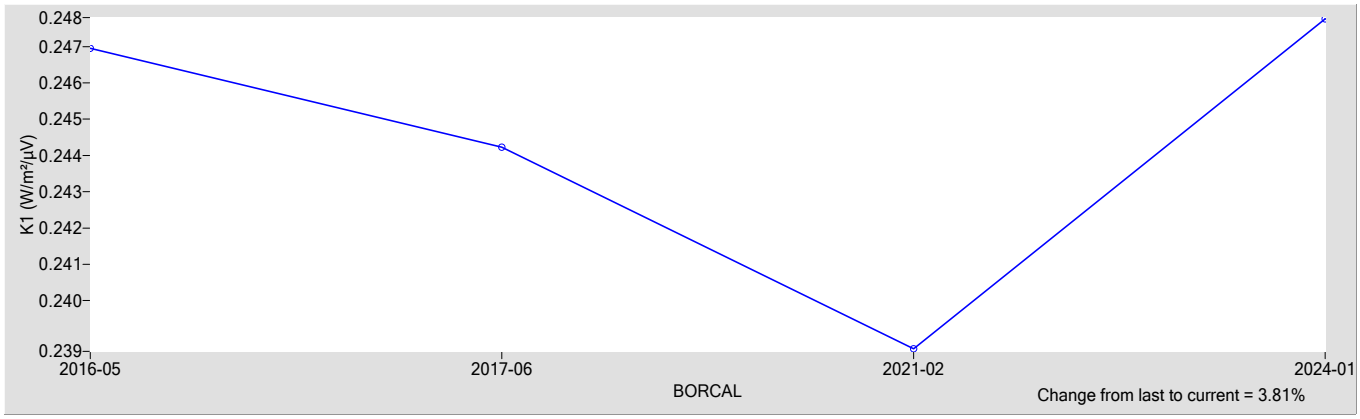


Figure 4. History of instrument (K2 Coefficient)

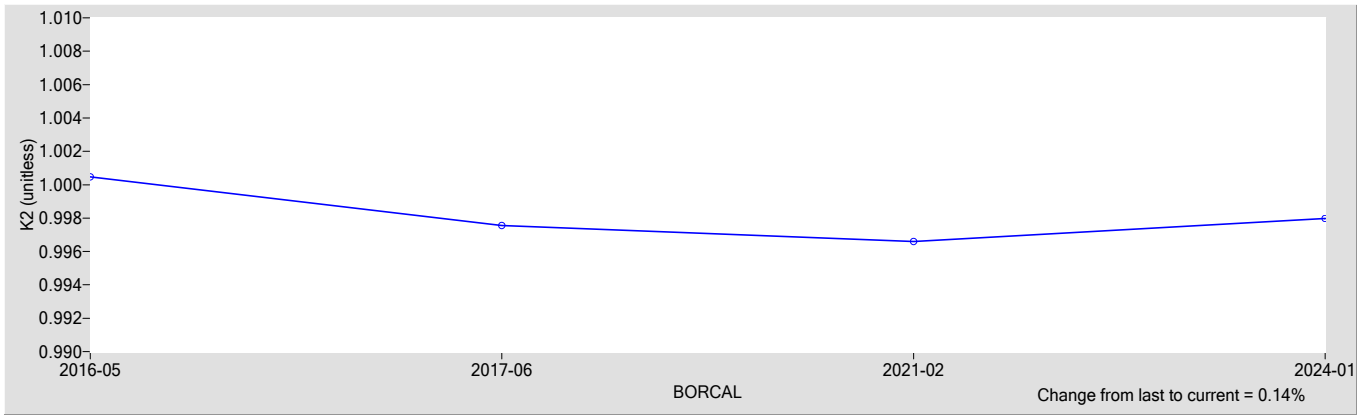
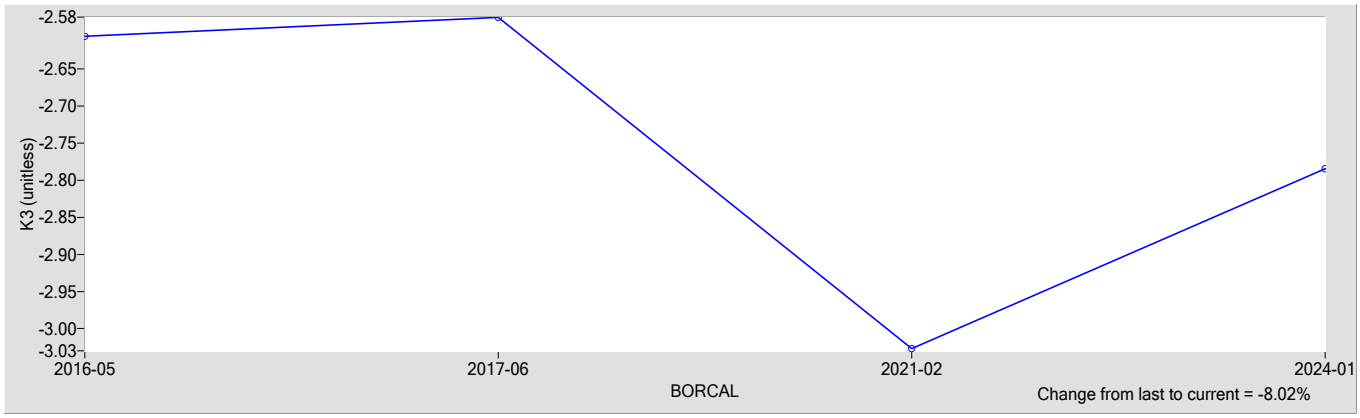


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	34303F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	AMF	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

34303F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

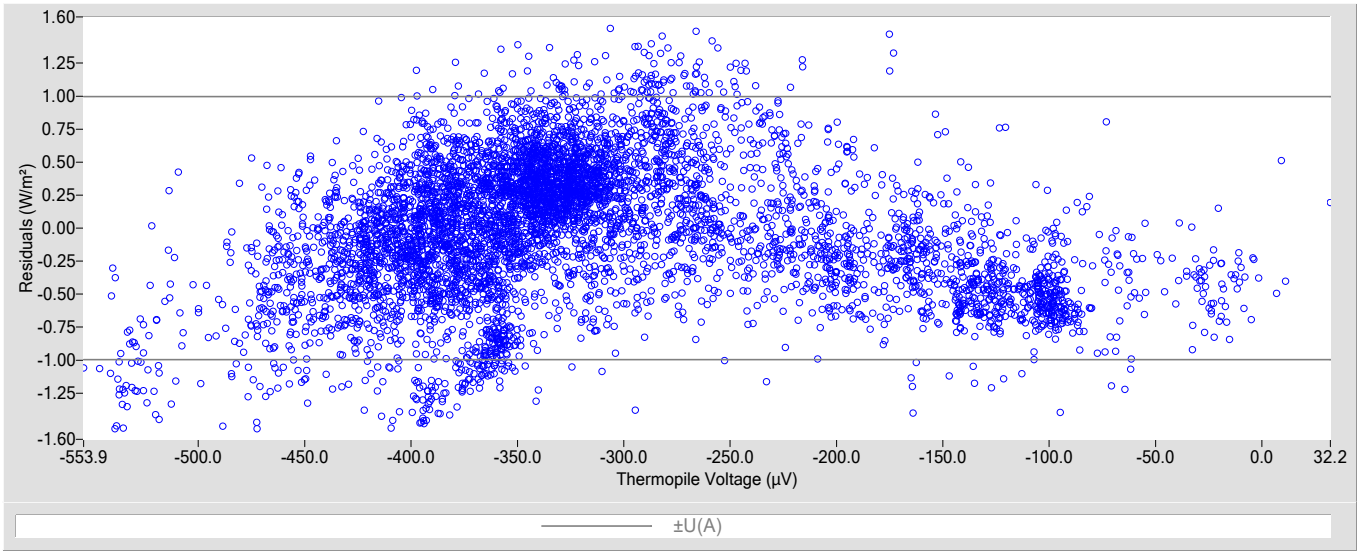


Table 1. Calibration Coefficients

K1	0.22297
K2	1.0089
K3	-3.61
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.51
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

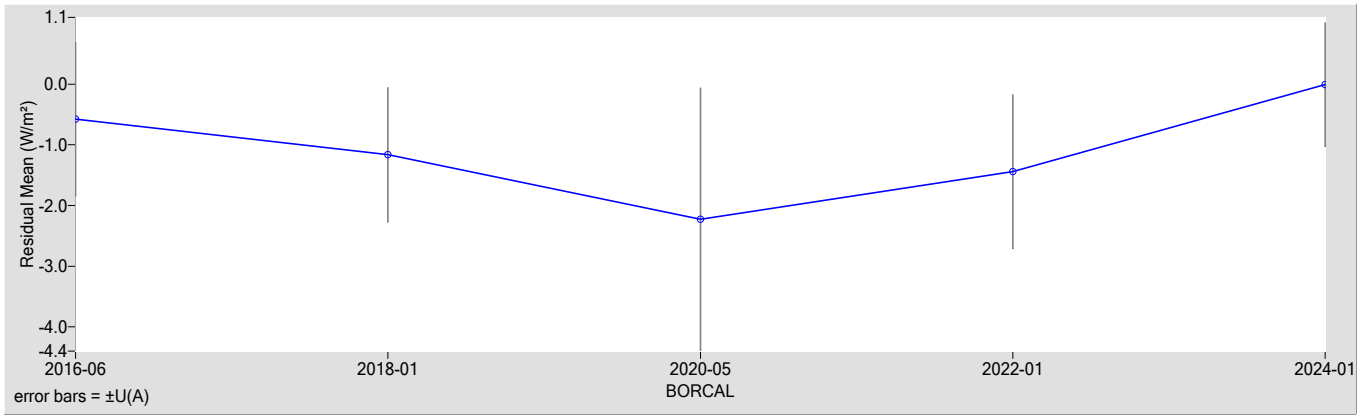


Figure 3. History of instrument (K1 Coefficient)

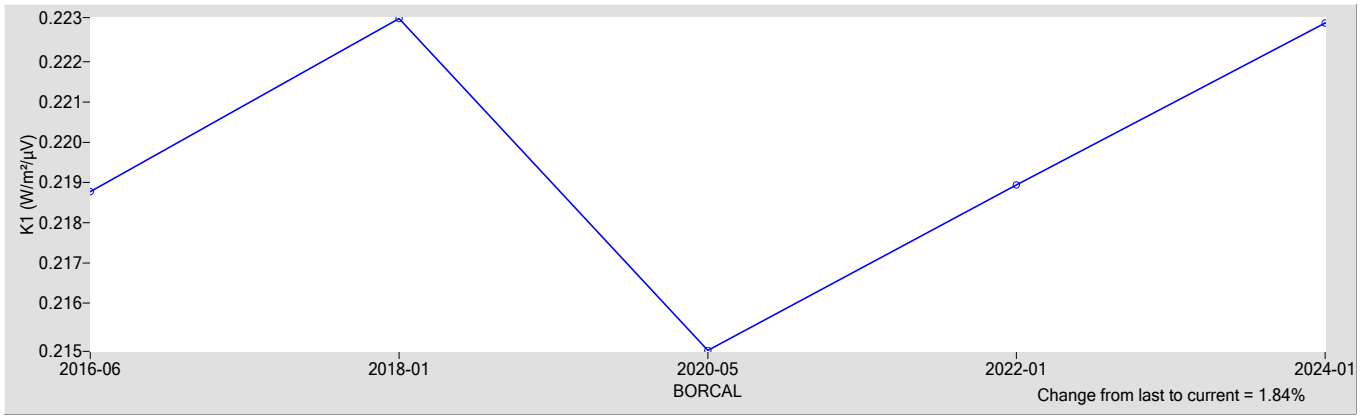


Figure 4. History of instrument (K2 Coefficient)

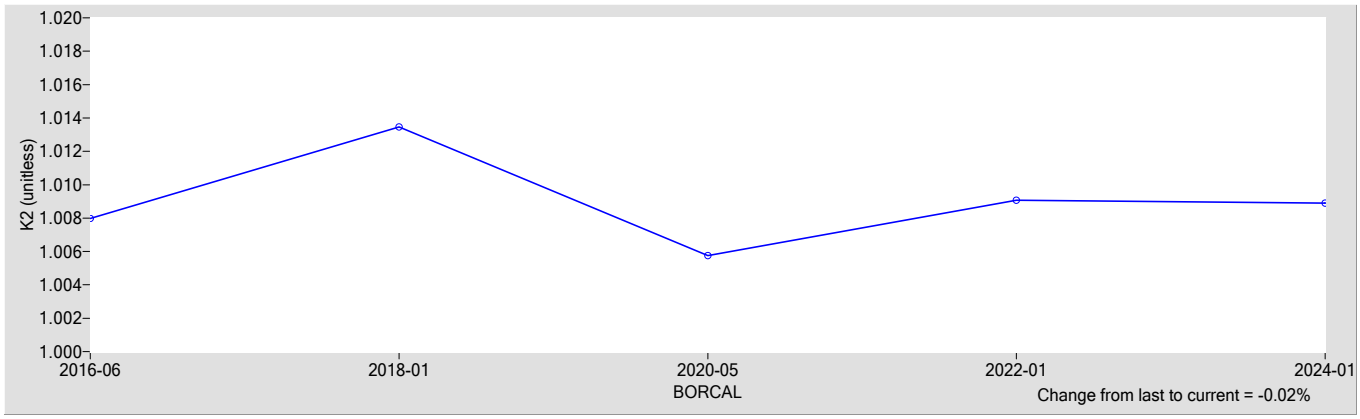
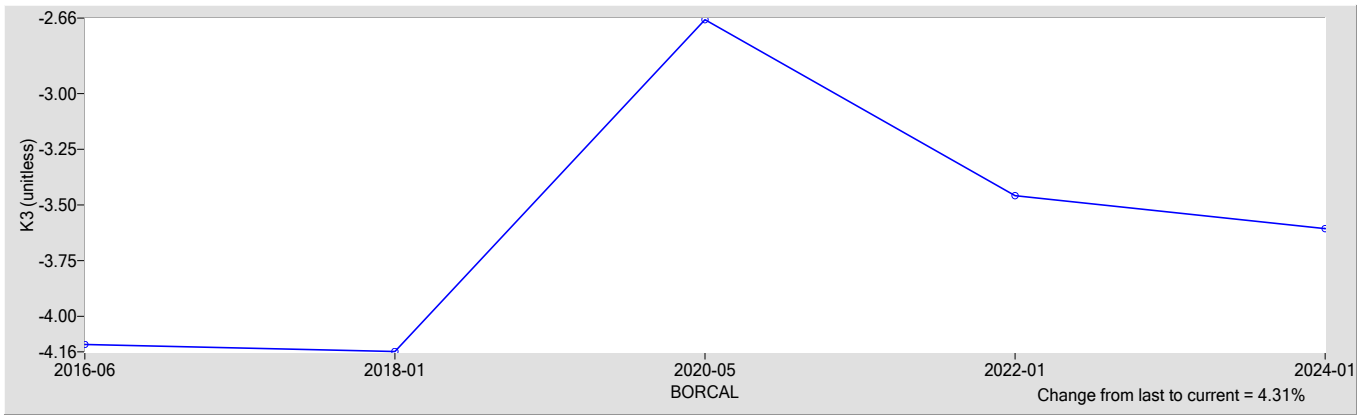


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	35840F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	AMF	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

35840F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

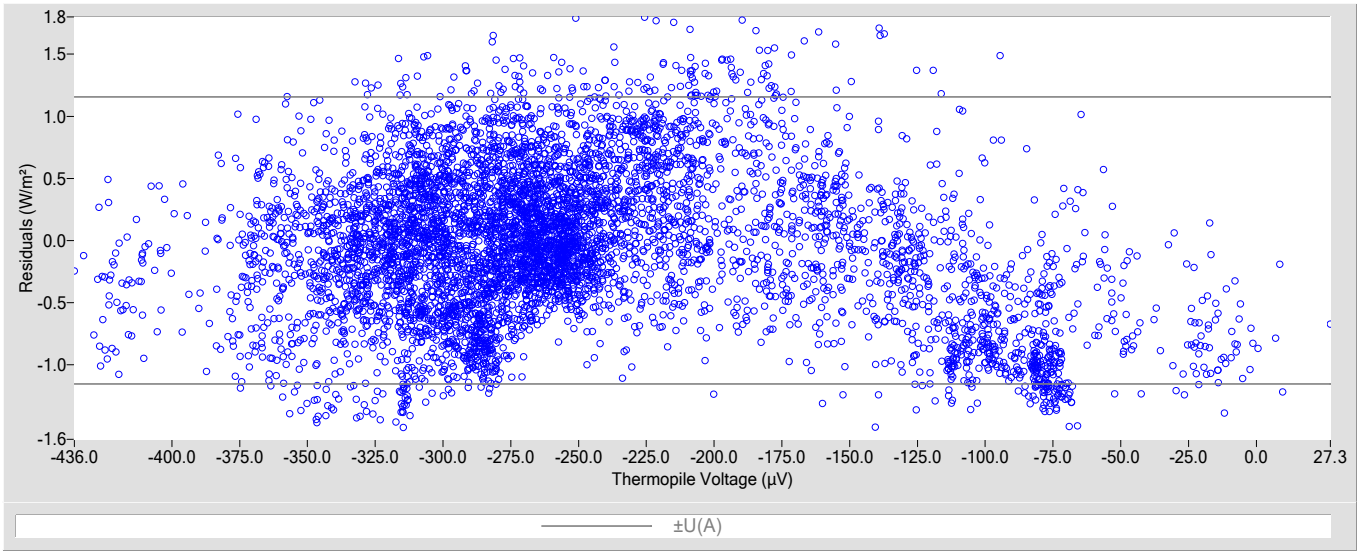


Table 1. Calibration Coefficients

K1	0.29273
K2	1.0023
K3	-5.89
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.59
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.2

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

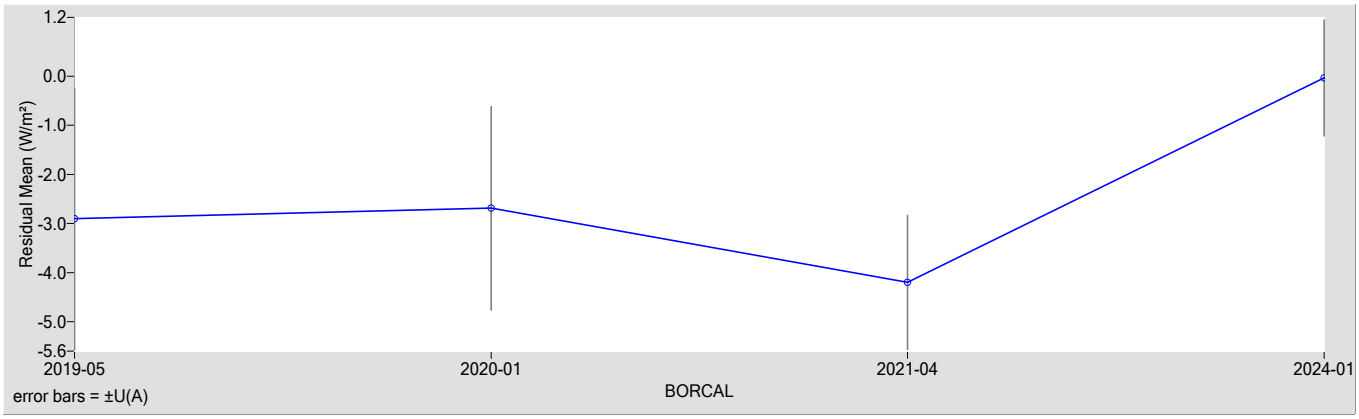


Figure 3. History of instrument (K1 Coefficient)

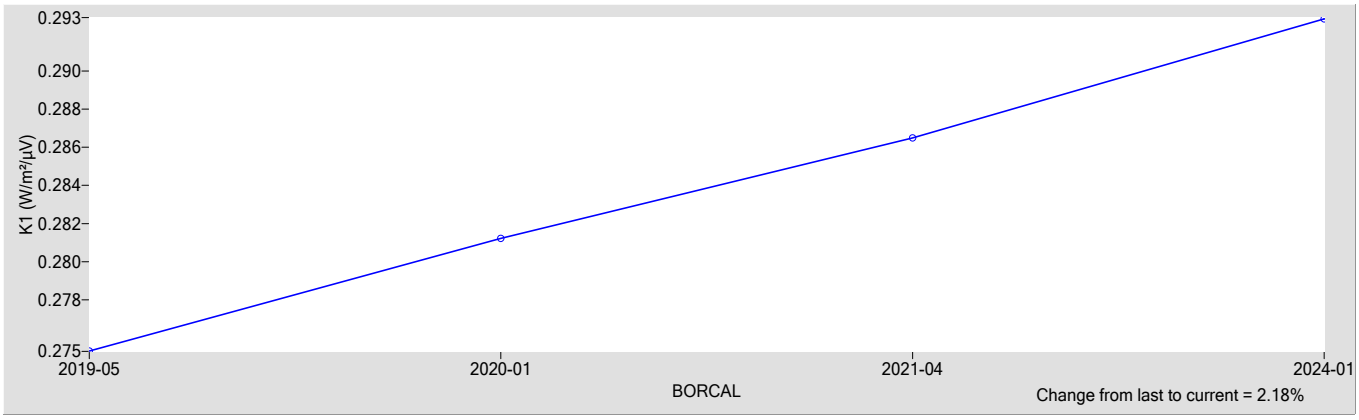


Figure 4. History of instrument (K2 Coefficient)

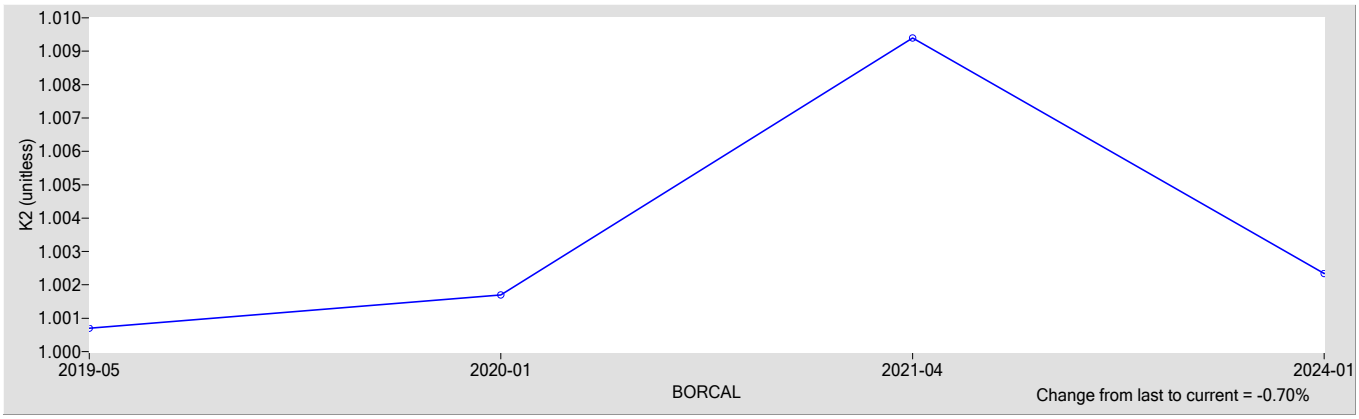
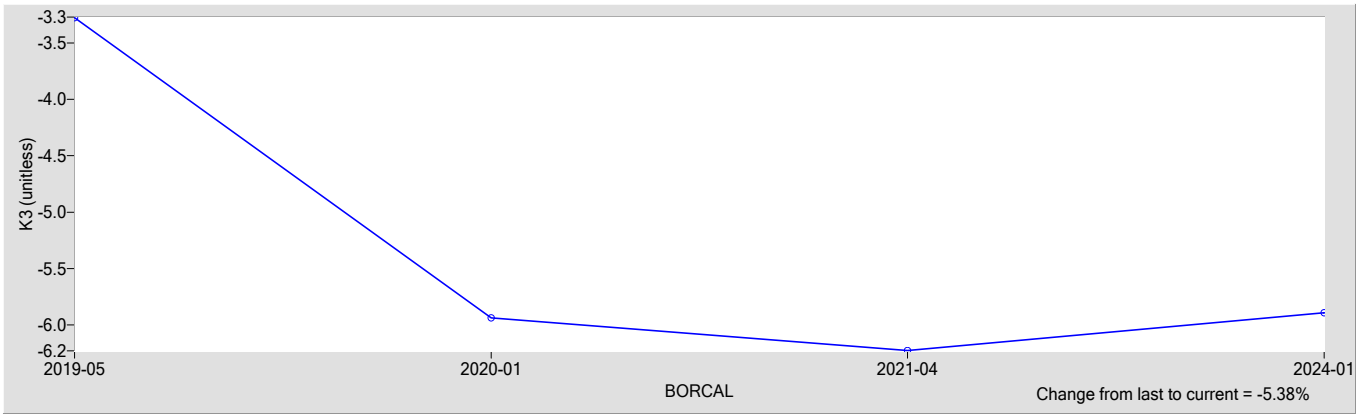


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	36368F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

36368F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

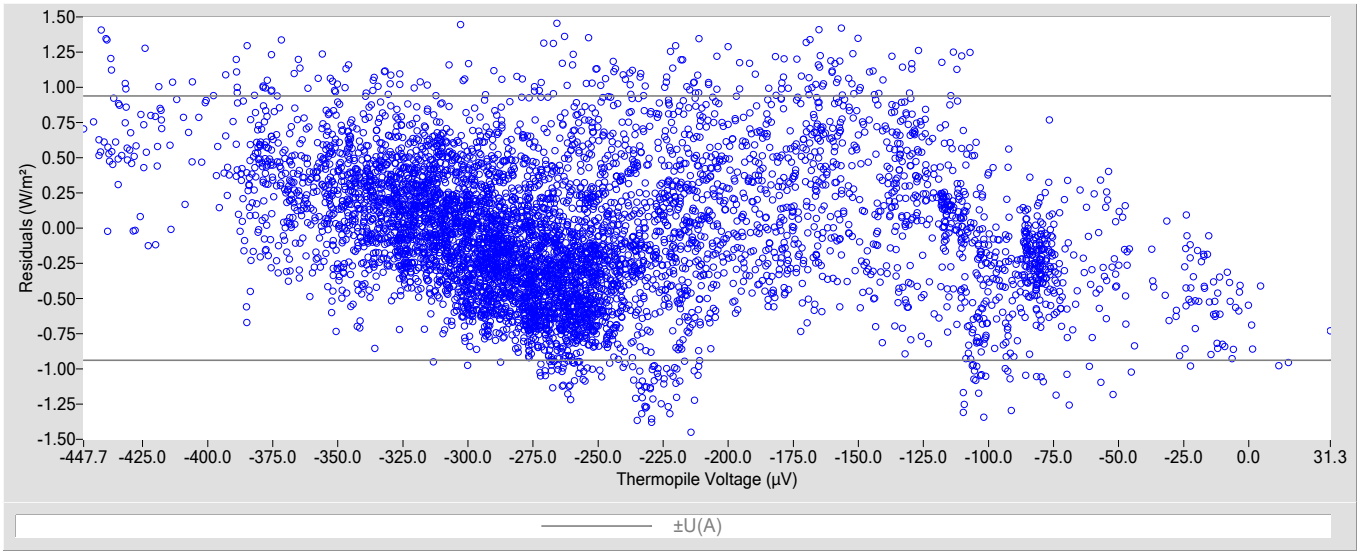


Table 1. Calibration Coefficients

K1	0.28586
K2	1.0104
K3	-5.53
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.48
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

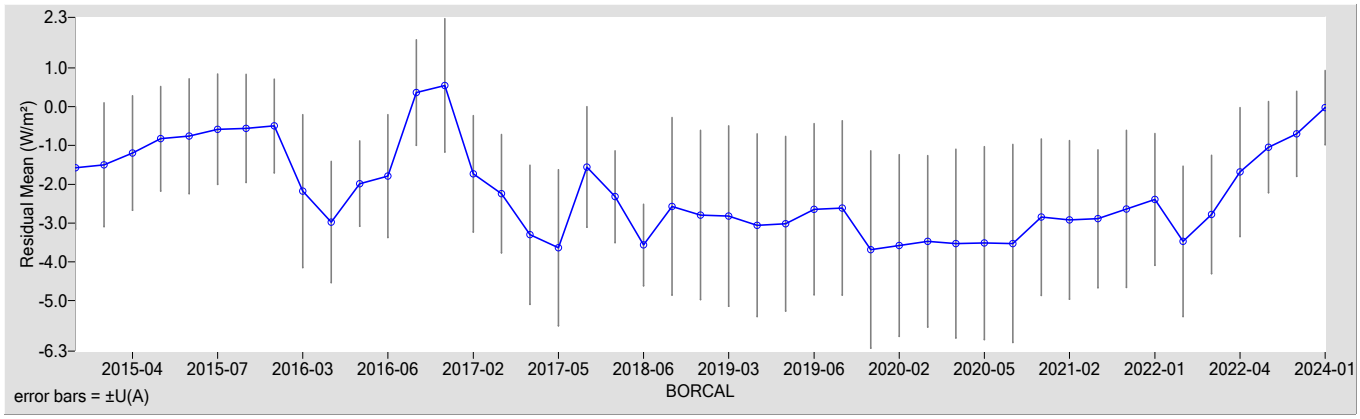


Figure 3. History of instrument (K1 Coefficient)

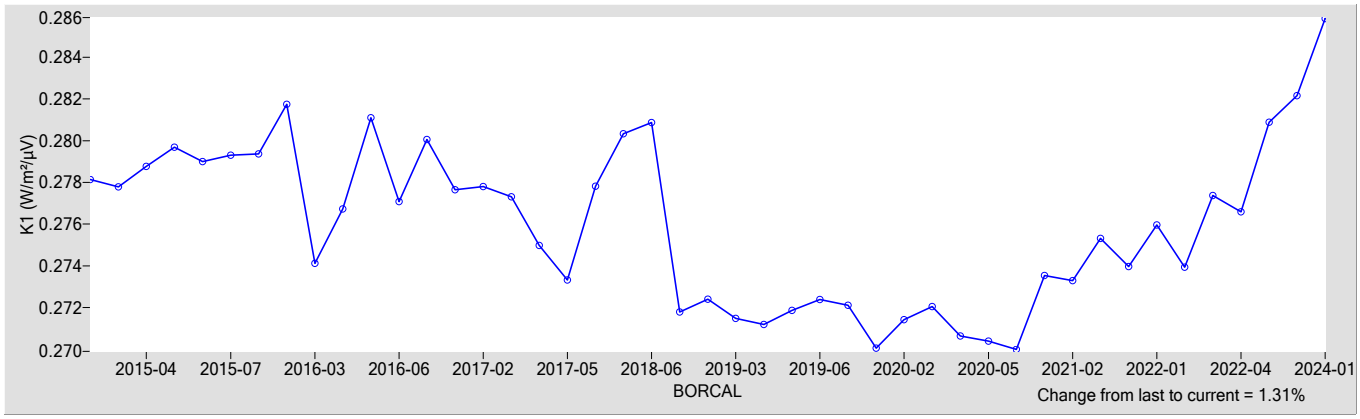


Figure 4. History of instrument (K2 Coefficient)

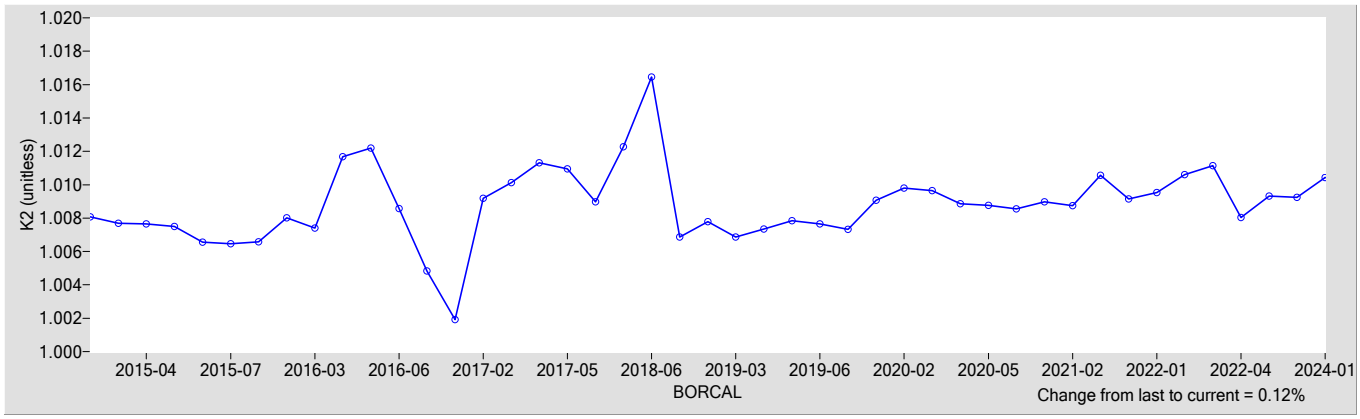
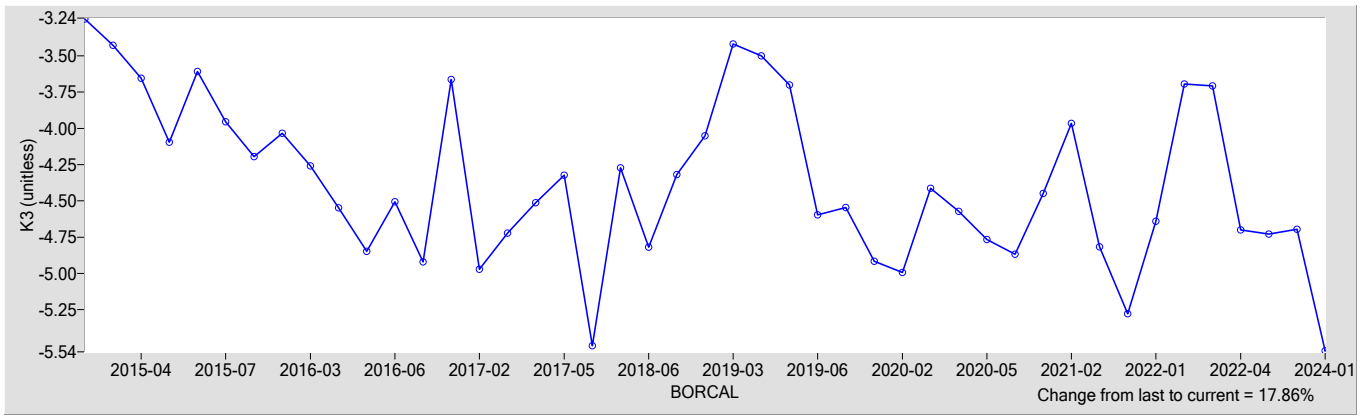


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	37325F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	AMF	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

This certificate applies only to the item identified above and shall not be reproduced other that in full, without specific written approval from the calibration facility. Certificate without signature is not valid.

Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

37325F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

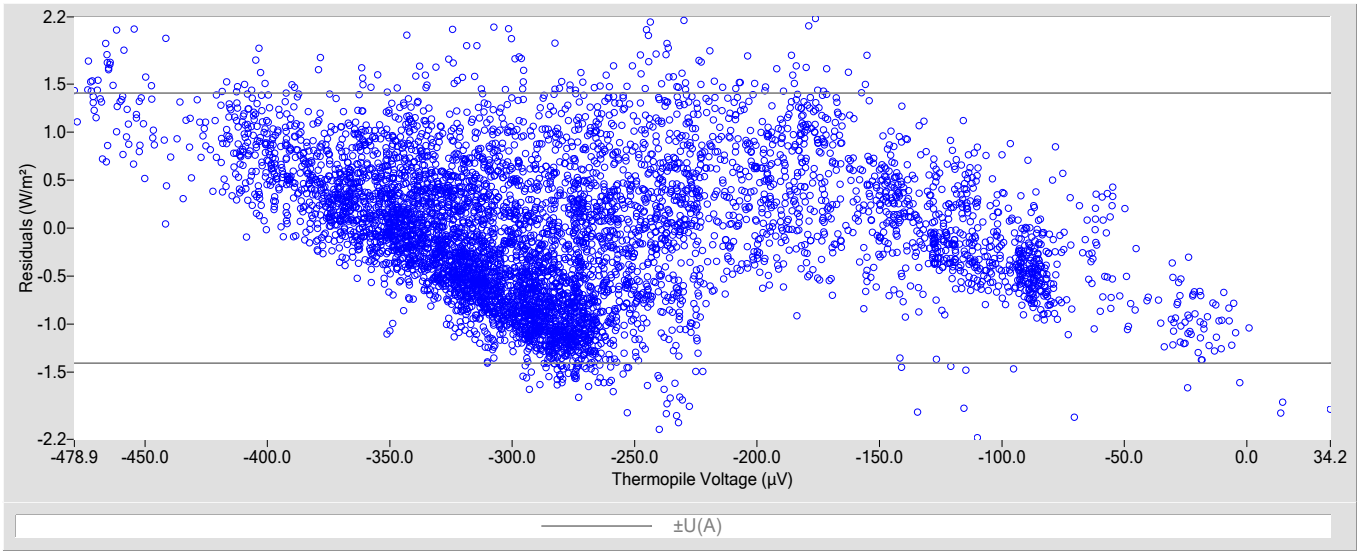


Table 1. Calibration Coefficients

K1	0.27287
K2	0.9993
K3	-7.17
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.72
Combined Standard Uncertainty, u(c) (W/m²)	±1.7
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.3

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

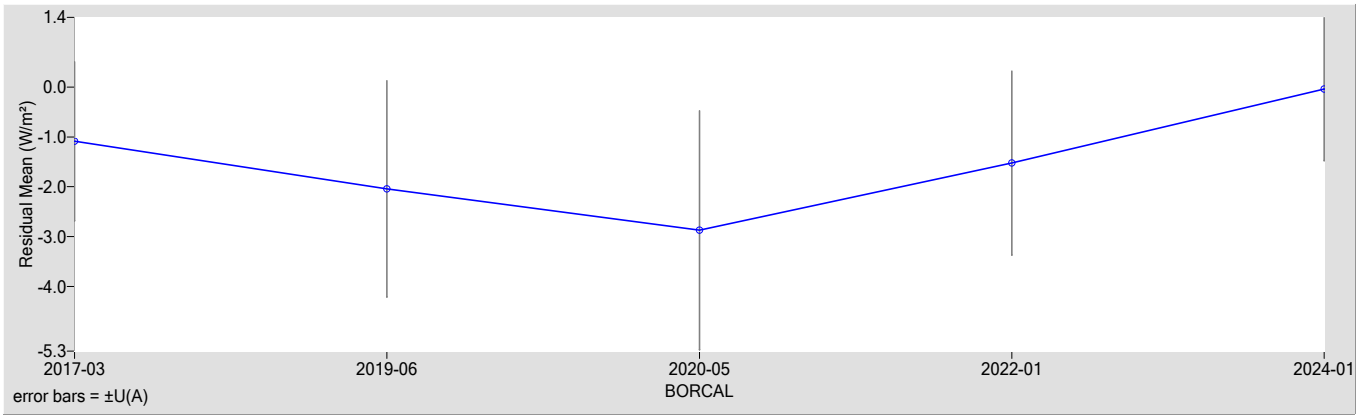


Figure 3. History of instrument (K1 Coefficient)

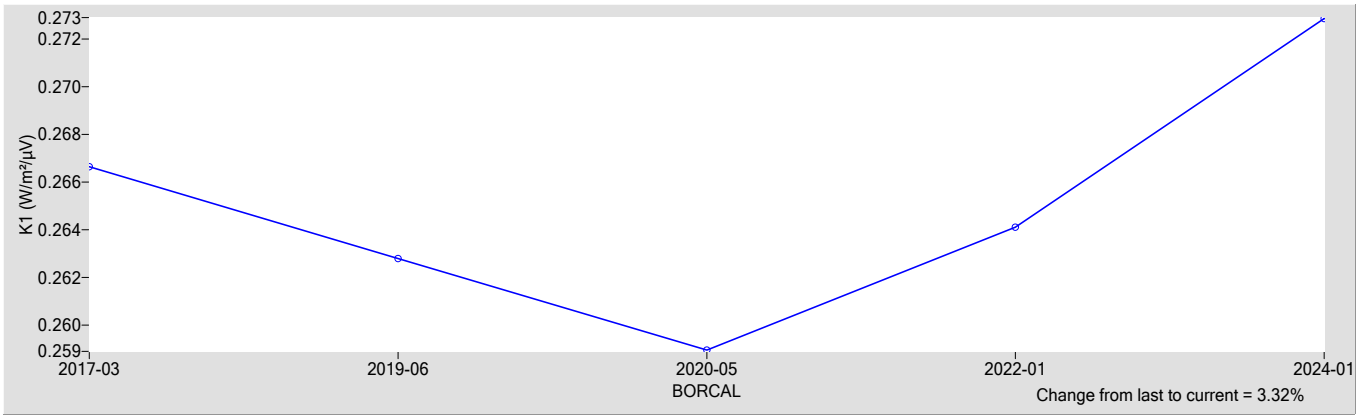


Figure 4. History of instrument (K2 Coefficient)

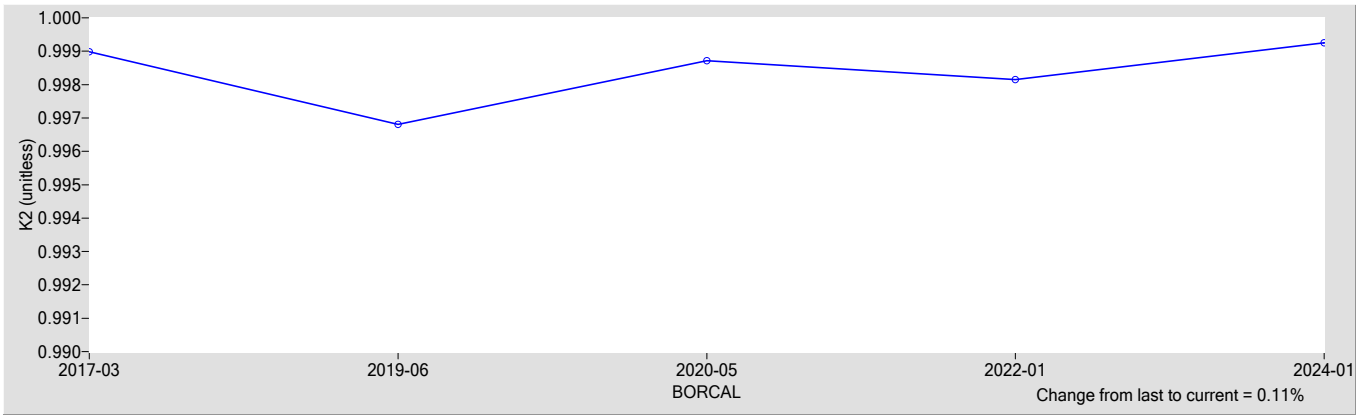
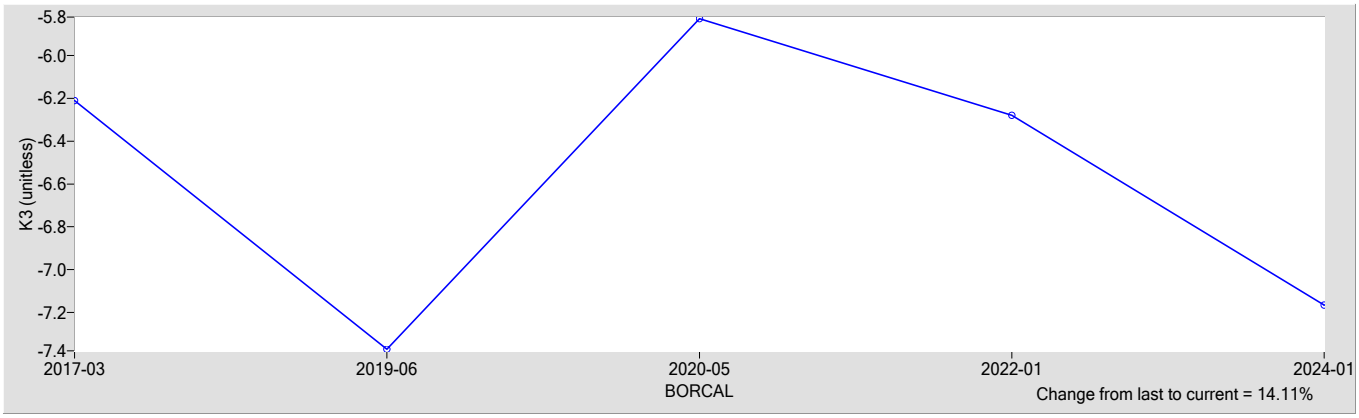


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	38865F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

38865F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

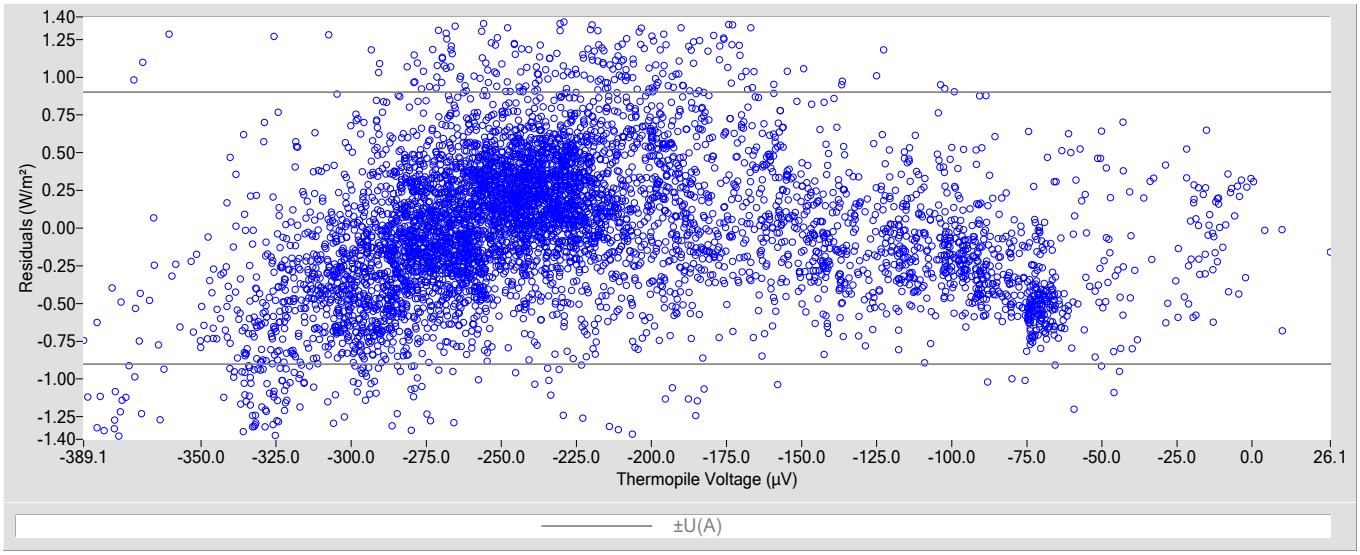


Table 1. Calibration Coefficients

K1	0.31788
K2	1.0054
K3	-5.08
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.46
Combined Standard Uncertainty, u(c) (W/m²)	±1.6
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.1

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

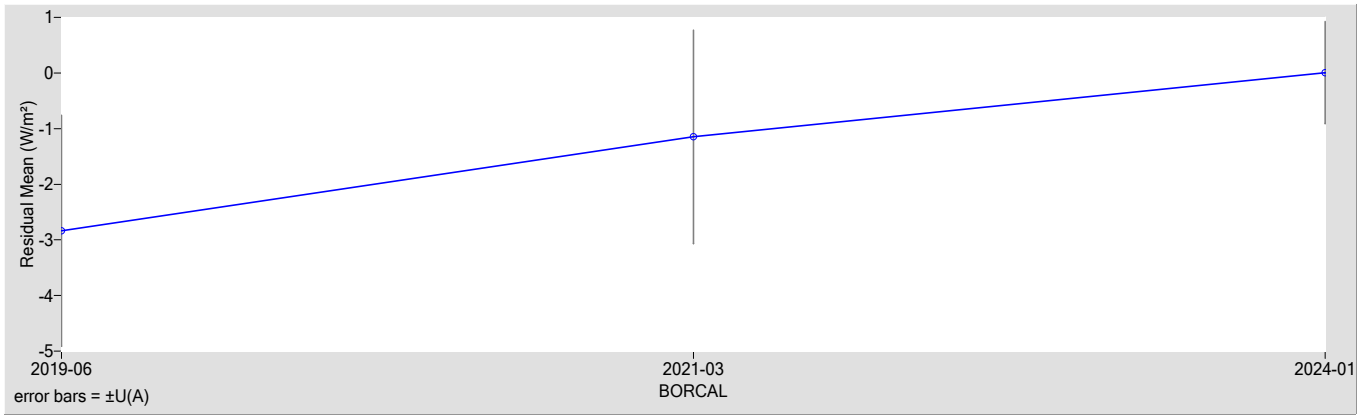


Figure 3. History of instrument (K1 Coefficient)

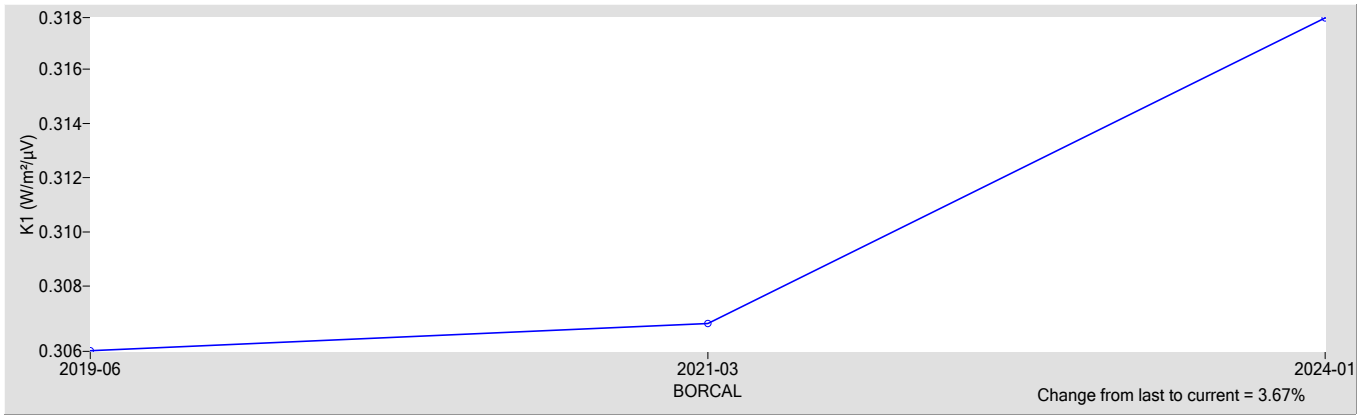


Figure 4. History of instrument (K2 Coefficient)

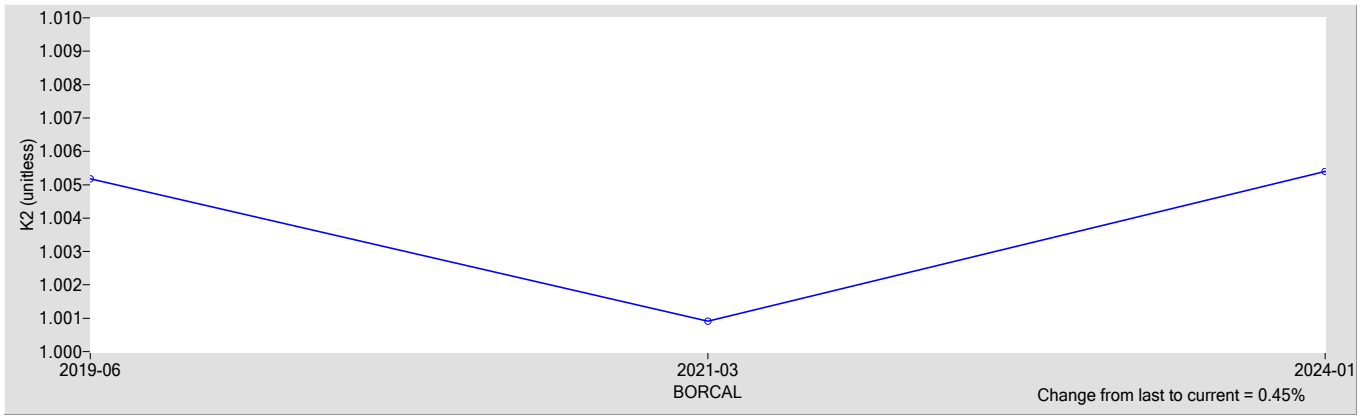
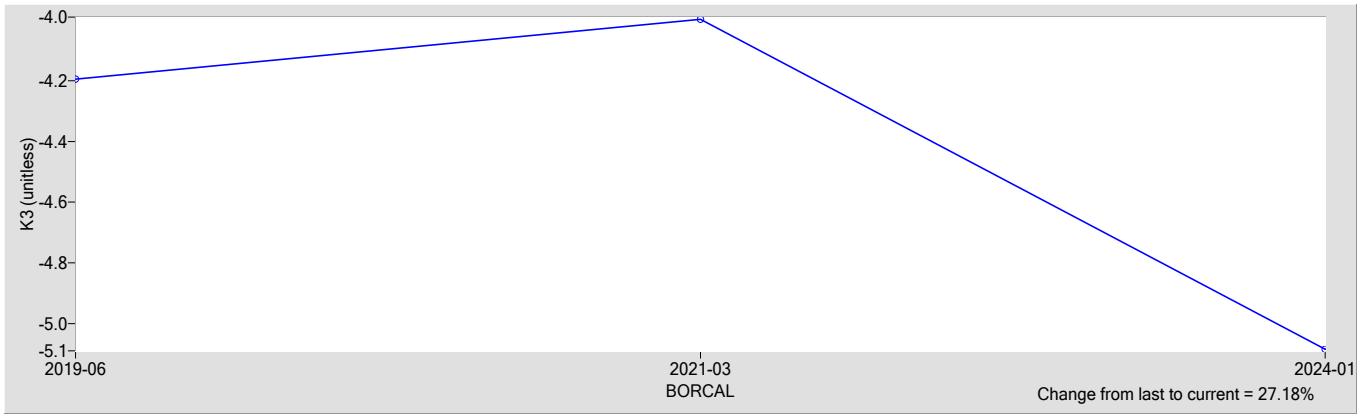


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	38869F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

38869F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
$Wd = \sigma * Td^4$ = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

$Wr = \sigma * Tr^4$ = receiver irradiance (W/m²),
where, σ = 5.6704e-8 W·m-2·K-4,
$Tr = Tc + Kr * V$ = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

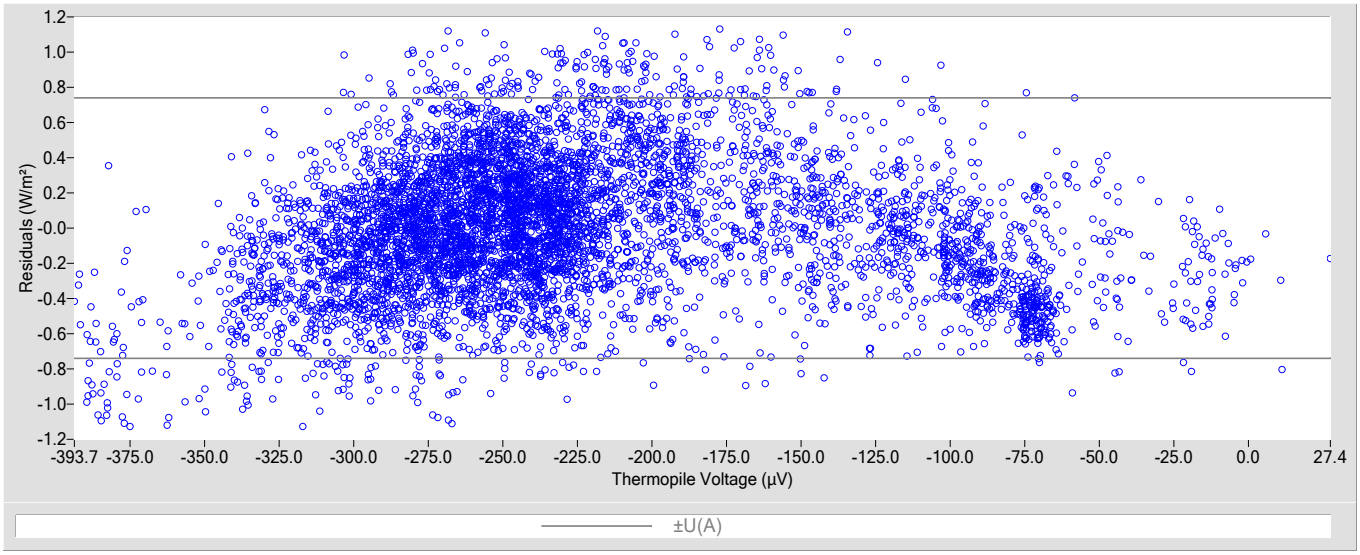


Table 1. Calibration Coefficients

K1	0.31238
K2	1.0005
K3	-4.99
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.38
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

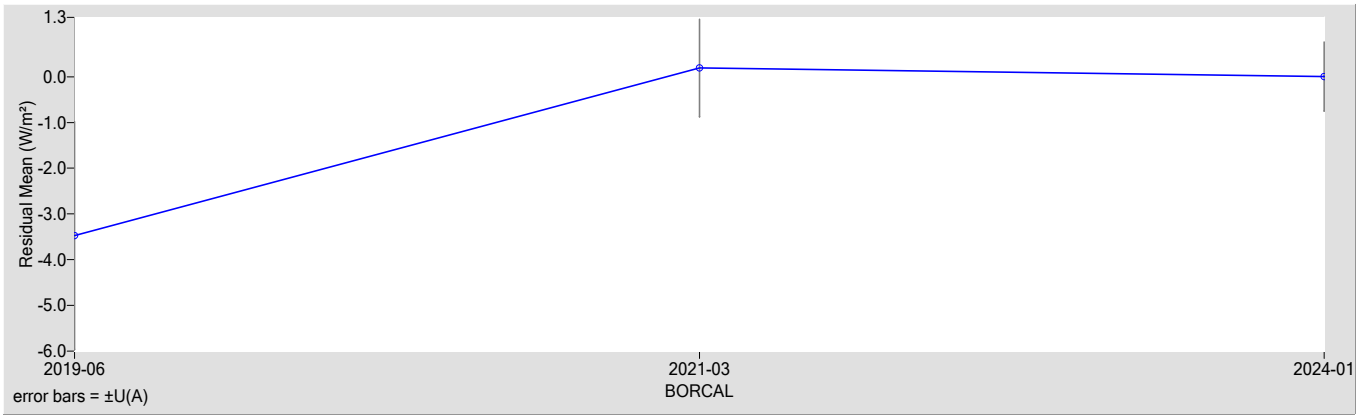


Figure 3. History of instrument (K1 Coefficient)

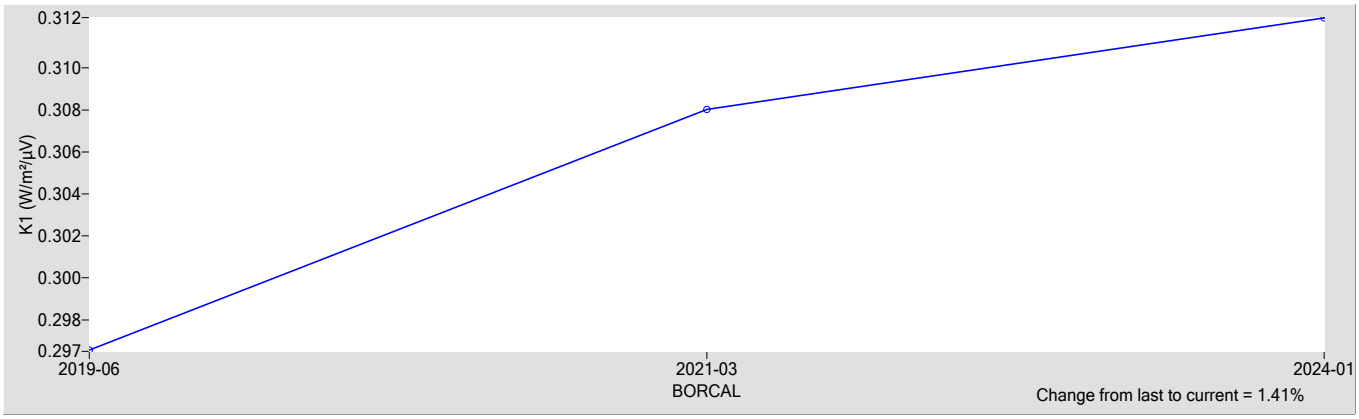


Figure 4. History of instrument (K2 Coefficient)

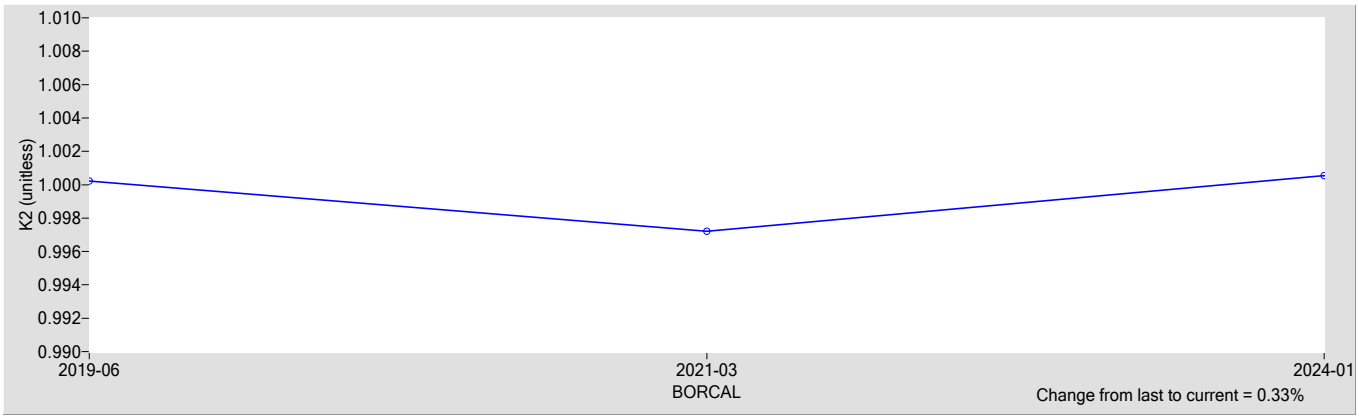
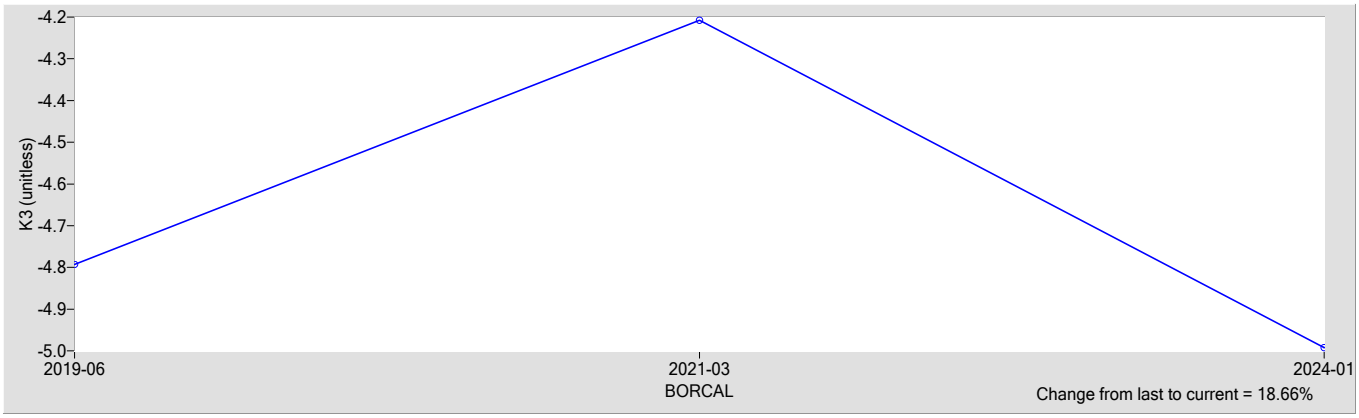


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

Southern Great Plains Radiometer Calibration Facility

National Renewable Energy Laboratory

Metrology Laboratory

Calibration Certificate

Test Instrument:	Downwelling Pyrgeometer (Ventilated)	**Manufacturer:**	Eppley
Model:	PIR	**Serial Number:**	38870F3
Calibration Date:	4/1/2024	**Due Date:**	4/1/2026
Customer:	SGP	**Environmental Conditions:**	see page 4
Test Dates:	2/9-29, 3/1-6, 3/9-31, 4/1		

This certifies that the above product was calibrated in compliance with procedure listed below. Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) using Reda et al., 2008. All nominal values are traceable to the World Infrared Standard Group (WISG).

No statement of compliance with specifications is made or implied on this certificate. However, the estimated uncertainties are the uncertainties of the calibration process; users must add other uncertainties that are relevant to their measuring system, environmental and sky conditions, outdoor set-up, and site location.

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Table 1. Traceability

Measurement Type	Instrument	Calibration Date	Calibration Due Date
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1206	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1207	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2009-1208	04/19/2023	04/19/2024
Data Acquisition	NREL Data Acquisition System Model RAP-DAQ, S/N 2014-1302	04/19/2023	04/19/2024
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29590F3	04/10/2023	04/10/2025
Infrared Irradiance ‡	Eppley Downwelling Pyrgeometer (Ventilated) Model PIR-V, S/N 29927F3	04/10/2023	04/10/2025

‡ Through the World Infrared Standard Group (WISG)

Number of pages of certificate: 4

Calibration Procedure: SGP BORCAL-LW Calibration Procedure

Setup: Radiometers are calibrated outdoors, using the atmosphere as the source. Pyranometers and pyrgeometers are installed for horizontal measurements, with their signal connectors oriented north, if their design permits.

Calibrated by: James Martin

_____ _____

Afshin M. Andreas, Technical Manager Date

For questions or comments, please contact the technical manager at:
Afshin.Andreas@nrel.gov; 15013 Denver West Parkway, Golden, CO 80401, USA

Calibration Results

38870F3 Eppley PIR

The incoming irradiance (Win, W/m²) of the test instrument during calibration is calculated using this Measurement Equation:

$$Win = K1*V + K2*Wr + K3*(Wd - Wr) \quad [1]$$

where,

K1,K2,K3 = calibration coefficeints,
V = thermopile output voltage (μV),
*Wd = σ * Td^4* = dome irradiance (W/m²),
where, *Td* = dome temperature (K),

*Wr = σ * Tr^4* = receiver irradiance (W/m²),
where, *σ* = 5.6704e-8 W·m-2·K-4,
*Tr = Tc + Kr * V* = receiver temperature (K),
Tc = case temperature (K),
Kr = efficiency coefficient (K/μV).

Figure 1. Residuals for calculated using coefficients vs reference irradiance

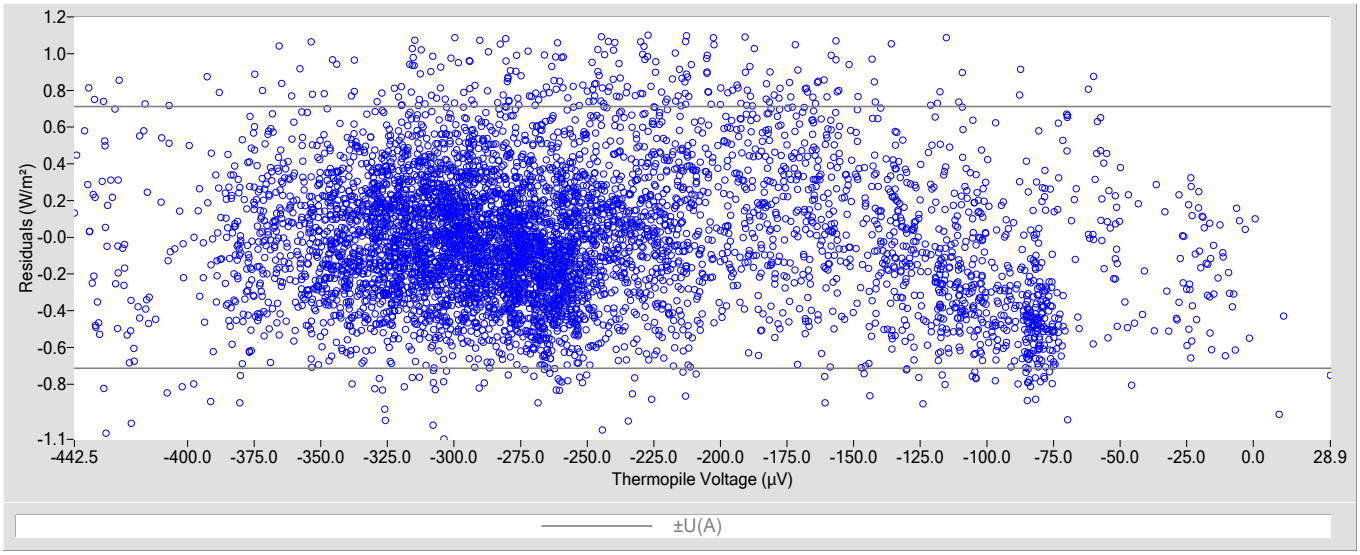


Table 1. Calibration Coefficients

K1	0.27976
K2	0.9943
K3	-5.23
Kr used to derive coefficients	7.044e-4

Table 2. Uncertainty using coefficients

Type-B Standard Uncertainty, u(B) (W/m²)	±1.5
Type-A Standard Uncertainty, u(A) (W/m²)	±0.36
Combined Standard Uncertainty, u(c) (W/m²)	±1.5
Effective degrees of freedom, DF(c)	+Inf
Coverage factor, k	1.96
Expanded Uncertainty, U95 (W/m²)	±3.0

Figure 2. History of instrument (Residual means of current data using historical BORCAL coefficients)

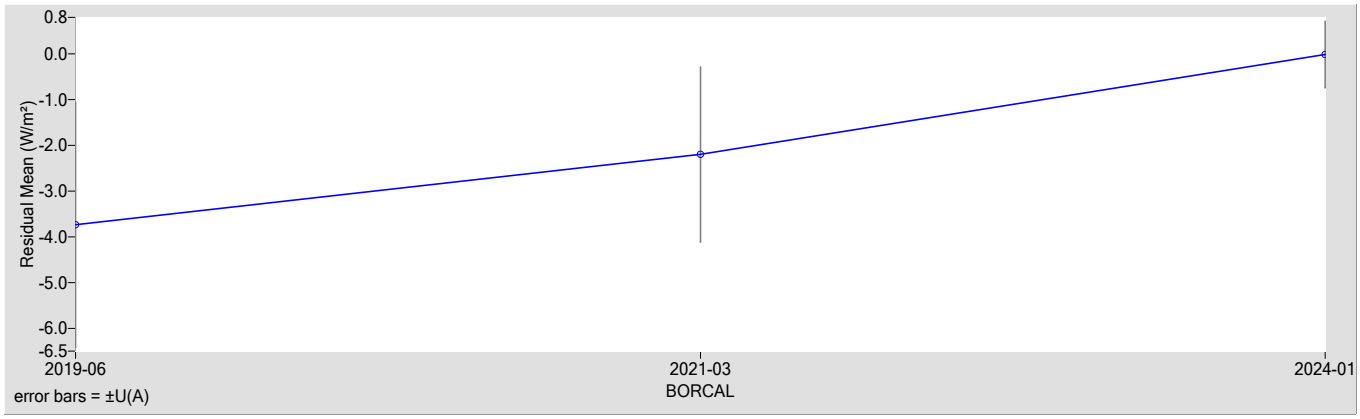


Figure 3. History of instrument (K1 Coefficient)

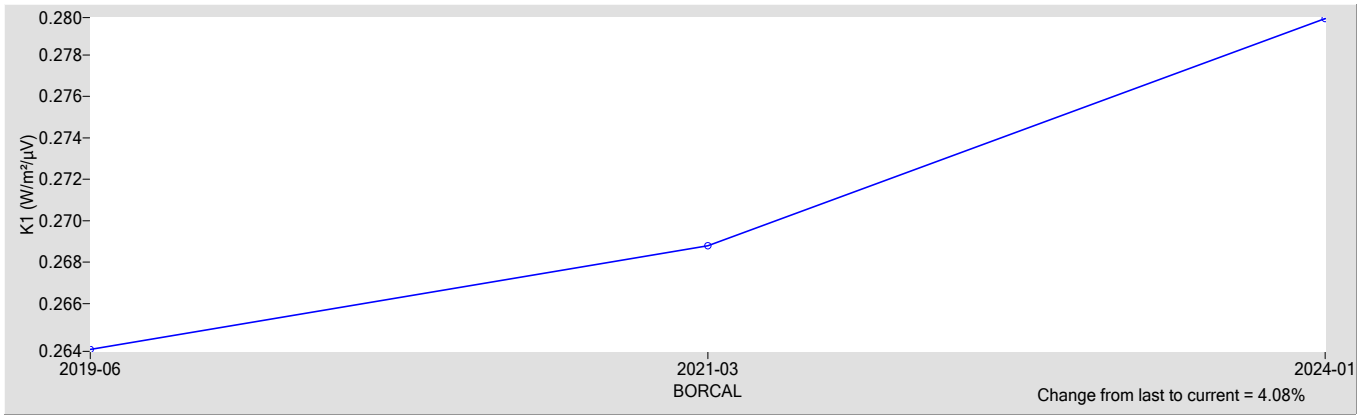


Figure 4. History of instrument (K2 Coefficient)

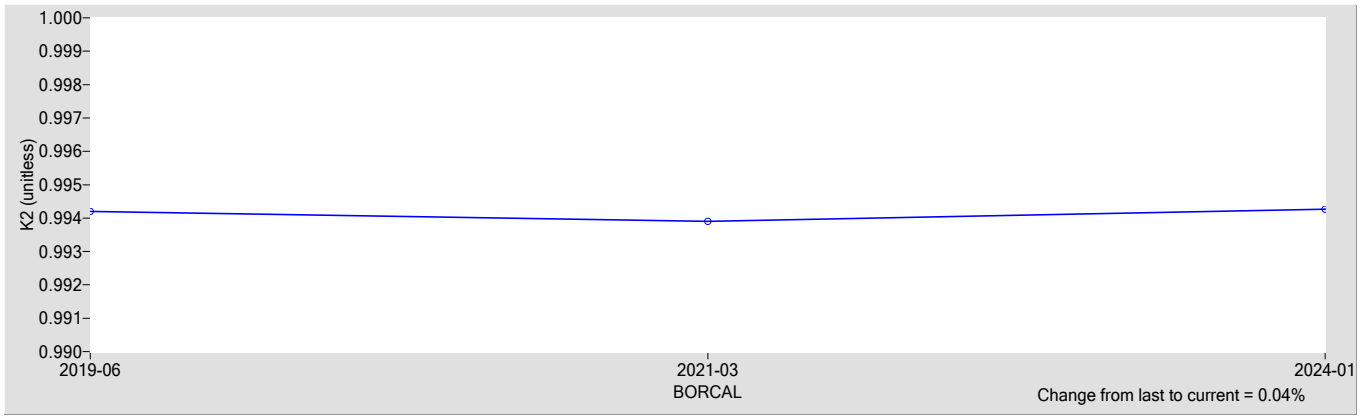
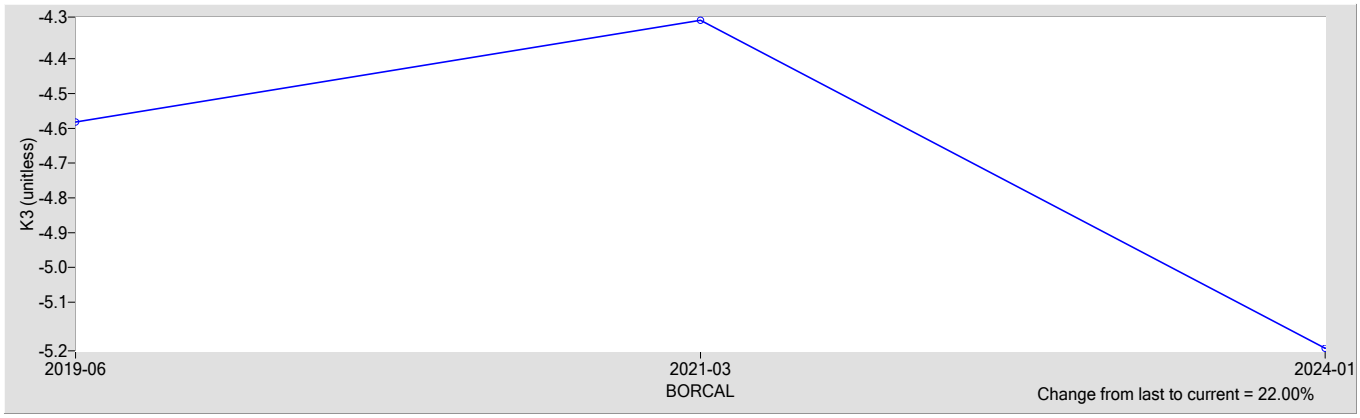


Figure 5. History of instrument (K3 Coefficient)



References:

[1] Reda, I.; Stoffel, T. (2010). Pyrgeometer Calibration for DOE-Atmospheric System Research Program using NREL Method (Presentation). 9 pp.; NREL Report No. PR-3B0-47756; http://www.nrel.gov/docs/fy10osti/47756.pdf.

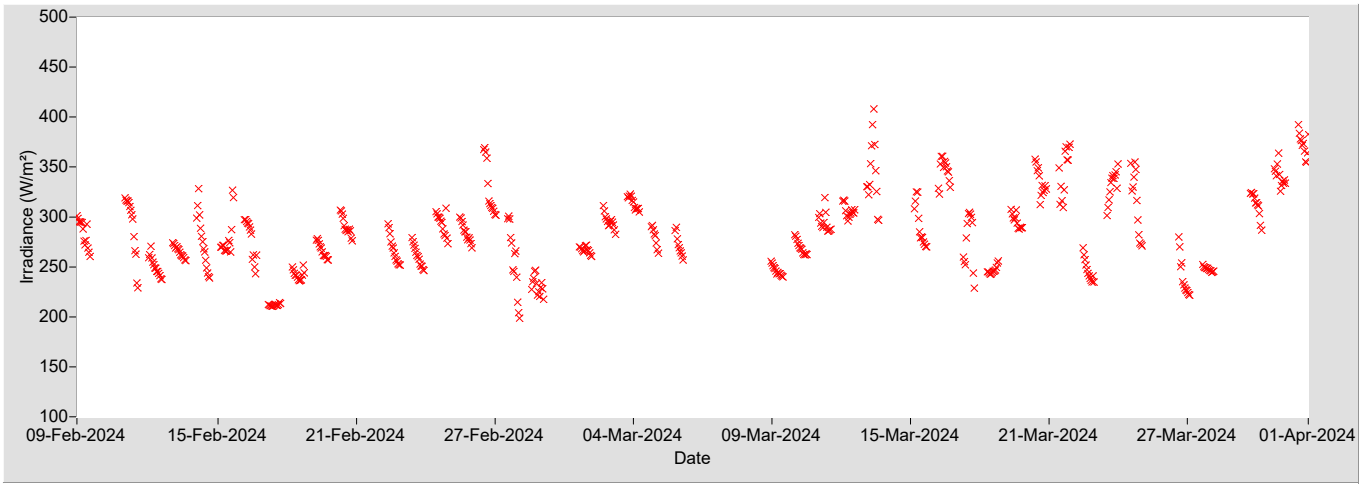
Environmental and Sky Conditions for BORCAL-LW 2024-01

Calibration Facility: Southern Great Plains

Latitude: 36.605°N Longitude: 97.488°W Elevation: 317.0 meters AMSL Time Zone: -6.0

Reference Irradiance (hourly averages):

Figure 6. Reference Irradiance



Meteorological Observations (hourly averages):

Figure 7. Temperature

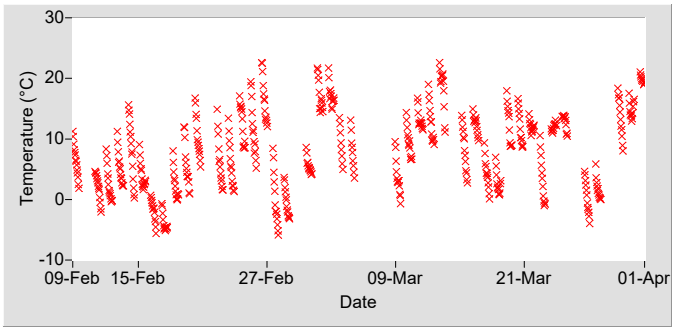


Figure 8. Humidity

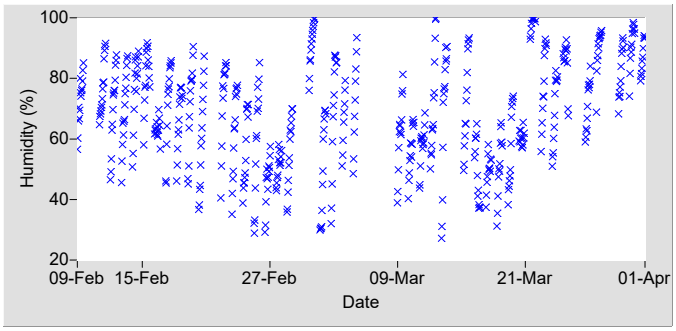


Figure 9. Pressure

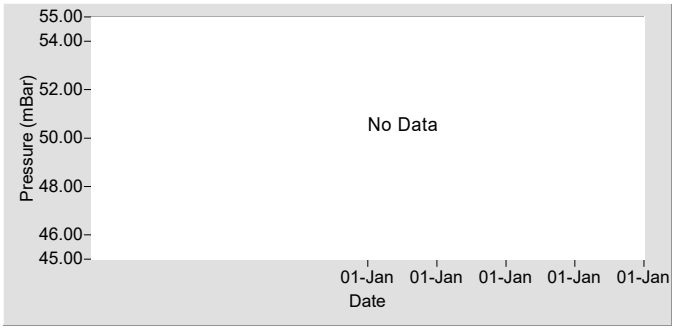


Figure 10. Estimated Precipitable Water Vapor (PWV)

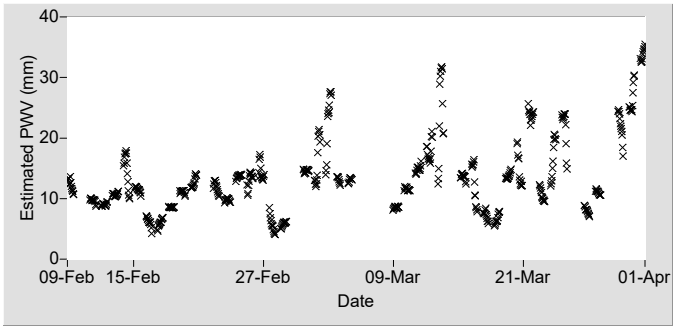


Table 6. Meteorological Observations

Observations	Mean	Min	Max
Temperature (°C)	7.92	-6.27	23.68
Humidity (%)	68.59	23.62	100.02
Pressure (mBar)	N/A	N/A	N/A
Est. Precipitable Water Vapor (mm)	13.5	3.6	35.8

For other information about the calibration facility visit: https://www.arm.gov/capabilities/observatories/sgp

Appendix 2
BORCAL Notes

Instrument, Configuration, and Session Notes for the BORCAL

BORCAL Notes

Facility: Southern Great Plains
Comments:
Avg. Station Pressure and Temperature is for Tulsa, OK, which is used for the Solar Position Algorithm (SPA).

Appendix 3
Session Configuration Audit Report

Latest Session Configuration Audit Report for the BORCAL

BORCAL/LW 2024-01 Session Configuration Audit Report

LOCATION

Facility	Facility Abbrev.	Contact	Latitude	Longitude	Elevation (m)	Avg press (mbr)	Avg temp (C)	Time zone	ISO
Southern Great Plains	SGP	James Martin	36.605	-97.488	317.0	992.0	15.0	-6.0	

SYSTEM

% Error Thresholds

TP(x) / TP(x-1)	25.0

Delta Thresholds

Ref Pyg Stability	4.0
Temp(x) - Temp(x-1)	5.0
Hum(x) - Hum(x-1)	20.0
Bar(x) - Bar(x-1)	5.0
Thrm(x) - Temp(x)	10.0

Analysis Rejection

Threshold 1 (Blue)	3.000
Threshold 2 (Green)	4.000
Threshold 3 (Brown)	5.000
No. of Std. Dev.	3

Clock

Reset Interval (m)	30
Warning Threshold (s)	0
Delta UT1	-0.100

Misc

Scan Rate (s)	300
Uncert. Significant Figures	2

Auto Mode Zenith Angle

Afternoon Startup	94
Morning Shutdown	94

Solar Position Algorithm

Delta T (s)	69.284
Atmos. Refraction (deg)	0.5667

METEOROLOGICAL INSTRUMENTS

Channel	Junction Box	Cable	Location
Temperature: E0710025T Vaisala HMP155 T			
239			Temp
		Scale 100	Offset -40
Humidity: E0710025H Vaisala HMP155 H			
255			Hum
		Scale 100	Offset 0
Pressure: None			
		Scale 0	Offset 0

GPS TIME RECIEVER

SGP Symmetricom NTP

Type	Port	Baud	Parity	Stop bits	Data bits
RS232	0	115200	0	1	8

DATALOGGER

Logger/Relay		DMM
Unit 1	2009-1207 NREL RAP-DAQ	MY42002864 Agilent 34420A
Unit 2	2009-1208 NREL RAP-DAQ	MY42002866 Agilent 34420A
Unit 3	2014-1302 NREL RAP-DAQ	SG42000596 Agilent 34420A
Unit 0	2009-1206 NREL RAP-DAQ	MY61001148 Keysight 34420A

		Unit 1	Unit 2	Unit 3	Unit 0
	Cal Date	04/19/2023	04/19/2023	04/19/2023	04/19/2023
	Cal Due Date	04/19/2024	04/19/2024	04/19/2024	04/19/2024
System Offsets:	Volts DC (µV)	0.38	0.38	0.38	0.38
	2-Wire Res. (mOhms)	2690.00	2690.00	2690.00	2690.00
	4-Wire Res. (mOhms)	0.00	0.00	0.00	0.00

Communications

	Unit	Type	Addr.	Board	Parity	Stop	Data
DMM	1	GPIB	22	0	0	0	0
Relay	1	GPIB	25	1	0	0	0
DMM	2	GPIB	23	0	0	0	0
Relay	2	GPIB	26	1	0	0	0
DMM	3	GPIB	1	0	0	0	0
Relay	3	GPIB	4	1	0	0	0
DMM	0	GPIB	21	0	0	0	0
Relay	0	GPIB	24	1	0	0	0

BORCAL/LW 2024-01 Session Configuration Audit Report

PYRGEOMETER REFERENCE INSTRUMENTS

		Calibration Coefficients					Uncert.	Max Out					
Cal Date	Cal Due Date	K0	K1	K2	K3	Kr	(W/m^2)	(mV)	Channel	Junction Box	Cable	Location	Active
Pyrgeometer 1: 29590F3 Eppley PIR-V (Ventilated)													
04/10/2023	04/10/2025	0.00000	0.26233	0.99970	-3.81000	7.04400E-4	2.70	9	23		2	T5-2	☑
Pyrgeometer 1: Case 10K Temperature									19		2		
Pyrgeometer 1: Dome 10K Temperature									27		2		
Pyrgeometer 2: 29927F3 Eppley PIR-V (Ventilated)													
04/10/2023	04/10/2025	0.00000	0.27564	1.00460	-3.51000	7.04400E-4	2.50	9	71		2	T6-2	☑
Pyrgeometer 2: Case 10K Temperature									67		2		
Pyrgeometer 2: Dome 10K Temperature									75		2		

BORCAL/LW 2024-01 Session Configuration Audit Report

INSTRUMENTS

Serial Number / Model	Customer	Mfg RS	Ch	Box	Cable	Act	ISO	AIM	Stickr	Vent	Use	Kr	Location	Due
30084F3	TWP	3.5900	135		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T7-3	24
PIR	(Case 10K Temperature)		131		3									
	(Dome 10K Temperature)		139		3									
30085F3	SGP	4.0800	80		19	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	19/9	24
PIR	(Case 10K Temperature)		88		19									
	(Dome 10K Temperature)		10		9									
30132F3 ‡	SGP	3.9000	215		2	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T9-2	24
PIR	(Case 10K Temperature)		211		2									
	(Dome 10K Temperature)		219		2									
30168F3	NSA	2.6100	7		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T5-1	24
PIR	(Case 10K Temperature)		3		1									
	(Dome 10K Temperature)		11		1									
30357F3	SGP	3.8800	146		74	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	74/54	24
PIR	(Case 10K Temperature)		154		74									
	(Dome 10K Temperature)		34		54									
30681F3	SGP	3.8100	82		29	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	29/18	24
PIR	(Case 10K Temperature)		90		29									
	(Dome 10K Temperature)		18		18									
30687F3	SGP	3.7600	113		55	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	55/61	24
PIR	(Case 10K Temperature)		121		55									
	(Dome 10K Temperature)		40		61									
30688F3	SGP	3.9000	145		73	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	73/53	24
PIR	(Case 10K Temperature)		153		73									
	(Dome 10K Temperature)		33		53									
30689F3	SGP	3.4200	46		90	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	83	24
PIR	(Case 10K Temperature)		240		83									
	(Dome 10K Temperature)		248		83									
30691F3	SGP	3.7800	128		57	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	57/58	24
PIR	(Case 10K Temperature)		136		57									
	(Dome 10K Temperature)		137		58									
30695F3	SGP	3.5100	161		84	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	84/85	24
PIR	(Case 10K Temperature)		169		84									
	(Dome 10K Temperature)		170		85									
30780F3	SGP	3.7500	114		56	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	56/62	24
PIR	(Case 10K Temperature)		122		56									
	(Dome 10K Temperature)		41		62									
30781F3	SGP	3.7300	81		28	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	28/17	24
PIR	(Case 10K Temperature)		89		28									
	(Dome 10K Temperature)		17		17									
30835F3	SGP	4.0700	98		37	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	37/43	24
PIR	(Case 10K Temperature)		106		37									
	(Dome 10K Temperature)		24		43									
30837F3	SGP	3.8700	199		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T9-1	24
PIR	(Case 10K Temperature)		195		1									
	(Dome 10K Temperature)		203		1									
31299F3	NSA	4.2000	39		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T5-3	24
PIR	(Case 10K Temperature)		35		3									
	(Dome 10K Temperature)		43		3									

‡ Control Instrument

BORCAL/LW 2024-01 Session Configuration Audit Report

INSTRUMENTS

Serial Number / Model	Customer	Mfg RS	Ch	Box	Cable	Act	ISO	AIM	Stickr	Vent	Use	Kr	Location	Due
31300F3	TWP	3.4100	183		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T8-3	24
PIR	(Case 10K Temperature)		179		3									
	(Dome 10K Temperature)		187		3									
31309F3	TWP	3.8700	48		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	1/8	24
PIR	(Case 10K Temperature)		56		1									
	(Dome 10K Temperature)		9		8									
31390F3	TWP	4.1800	87		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T6-3	24
PIR	(Case 10K Temperature)		83		3									
	(Dome 10K Temperature)		91		3									
31391F3	TWP	3.7800	49		10	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	10/16	24
PIR	(Case 10K Temperature)		57		10									
	(Dome 10K Temperature)		16		16									
32040F3	NSA	3.8000	55		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T6-1	24
PIR	(Case 10K Temperature)		51		1									
	(Dome 10K Temperature)		59		1									
32042F3	NSA	3.8200	103		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T7-1	24
PIR	(Case 10K Temperature)		99		1									
	(Dome 10K Temperature)		107		1									
32044F3	SGP	4.2500	65		13	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	13/14	24
PIR	(Case 10K Temperature)		73		13									
	(Dome 10K Temperature)		74		14									
32047F3	NSA	3.9800	119		2	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T7-2	24
PIR	(Case 10K Temperature)		115		2									
	(Dome 10K Temperature)		123		2									
32049F3	SGP	3.8400	231		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T9-3	24
PIR	(Case 10K Temperature)		227		3									
	(Dome 10K Temperature)		235		3									
32054F3	NSA	4.1600	151		1	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T8-1	24
PIR	(Case 10K Temperature)		147		1									
	(Dome 10K Temperature)		155		1									
32832F3	TWP	3.9800	61		3	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	3/5/7	24
PIR	(Case 10K Temperature)		1		5									
	(Dome 10K Temperature)		8		7									
32998F3	TWP	4.0200	50		11	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	11/12	24
PIR	(Case 10K Temperature)		58		11									
	(Dome 10K Temperature)		72		12									
33058F3	TWP	3.8300	60		2	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	2/4/6	24
PIR	(Case 10K Temperature)		0		4									
	(Dome 10K Temperature)		2		6									
34303F3	AMF	4.0400	96		31	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	31/32	24
PIR	(Case 10K Temperature)		104		31									
	(Dome 10K Temperature)		105		32									
35840F3	AMF	3.1500	208		30	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	30	24
PIR	(Case 10K Temperature)		216		30									
	(Dome 10K Temperature)		224		30									
36368F3 ‡	SGP	3.0200	167		2	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	T8-2	24
PIR	(Case 10K Temperature)		163		2									
	(Dome 10K Temperature)		171		2									

‡ Control Instrument

BORCAL/LW 2024-01 Session Configuration Audit Report

INSTRUMENTS

Serial Number / Model	Customer	Mfg RS	Ch	Box	Cable	Act	ISO	AIM	Stickr	Vent	Use	Kr	Location	Due
37325F3	AMF	3.7800	144		65	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	65/45	24
PIR	(Case 10K Temperature)		152		65									
	(Dome 10K Temperature)		26		45									
38865F3	SGP	2.8600	112		46	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	46/52	24
PIR	(Case 10K Temperature)		120		46									
	(Dome 10K Temperature)		32		52									
38869F3	SGP	2.9100	160		82	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	82/63	24
PIR	(Case 10K Temperature)		168		82									
	(Dome 10K Temperature)		42		63									
38870F3	SGP	3.3200	130		64	Yes	No	Yes	K0=0	Yes	PYG	7.044e-4	64/44	24
PIR	(Case 10K Temperature)		138		64									
	(Dome 10K Temperature)		25		44									