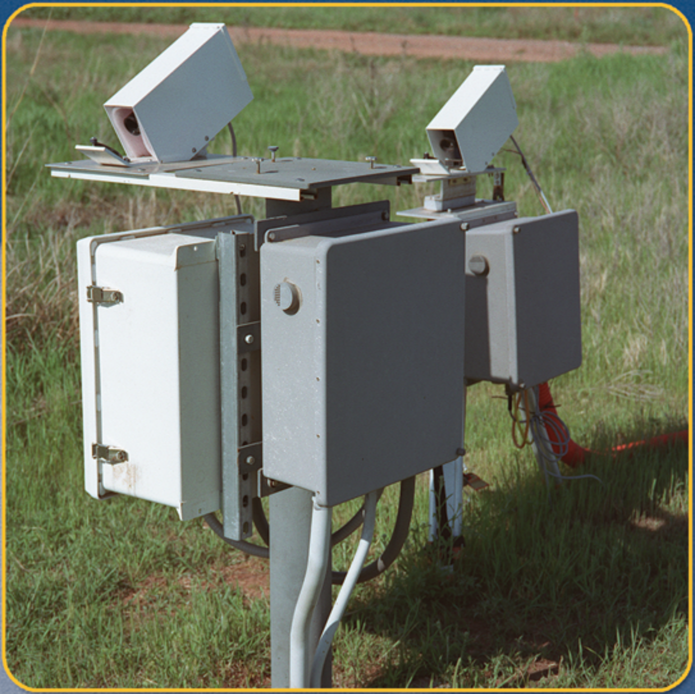
Infrared Thermometer
Handbook



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Infrared Thermometer (IRT) Handbook

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Tables

1. General Overview

The Infrared Thermometer (IRT) is a ground-based radiation pyrometer that provides measurements of the equivalent blackbody brightness temperature of the scene in its field of view. The downwelling version has a narrow field of view for measuring sky temperature and for detecting clouds. The upwelling version has a wide field of view for measuring the narrowband radiating temperature of the ground surface.

2. Contacts

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3. Deployment Locations and History

Table 1. Current Status and Locations

Serial Number	Property Number	Function	Location	Installation Date	Status
517	WD11383	downwelling	Wintronics	--	damaged
863	WD17512	GNDRAD upwelling	TWP/CF2	1998/11/18	operational
864	WD17513	GNDRAD upwelling	TWP/CF3	2002/03/08	operational
865	WD17514	upwelling	TWP/CF3	--	spare
867	WD17516	SKYRAD downwelling	TWP/CF3	2002/02/25	operational
868	WD17517	SKYRAD downwelling	TWP/CF2	1998/11/18	operational
1026	WD18682	10M upwelling	SGP/CF1	1995/10/18	operational
1029	WD18683	25M upwelling	SGP/CF1	1995/10/18	operational
1250	WD20062	GNDRAD upwelling	TWP/CF1	2003/06/29	operational
1251	WD20064	GNDRAD upwelling	NSA/CF1	1999/03/04	operational
1252	WD20063	GNDRAD upwelling	NSA/CF2	1998/04/06	operational
1253	WD20065	SKYRAD downwelling	NSA/CF2	1998/02/14	operational

Table 1. Current Status and Locations (cont'd)

Serial Number	Property Number	Function	Location	Installation Date	Status
1254	WD20066	downwelling	SGP/CF1	2001/01/25	operational
1255	WD20067	SKYRAD downwelling	NSA/CF1	1998/10/15	operational
1553	WD23001	downwelling	PNNL	--	spare
1628	WD23029	upwelling	PNNL	--	spare
1938	WD33301	downwelling	SGP	--	spare
2301	WD45256	GNDRAD	AMF	2004/10/20	operational
2302	WD45257	SKYRAD	AMF	2004/10/20	operational

4. Near-Real-Time Data Plots

Available data plots and other data products.

5. Data Description and Examples

Available data plots and other data products.

5.1 Data File Contents

Datastreams produced by the IRT that are available from the ARM Archive are as follows:

- **irt -** 1-min averaged sky temperature
- **irt2s** - 2-sec instantaneous sky temperature
- **irt10m -** 1-min averaged surface temperature from 10 m
- **irt25m -** 1-min averaged upwelling irradiance and surface temperature from 25 m
- **skyrad60s -** 1-min averaged downwelling irradiance and sky temperature from SKYRAD
- **gndrad60s -** 1-min averaged upwelling irradiance and surface temperature from GNDRAD.

5.1.1 Primary Variables and Expected Uncertainty

The downwelling IRT measures the infrared radiation emitted by the sky or cloud-base and transforms it into a standardized output signal that is proportional to temperature in Kelvins. The upwelling IRT measures the ground-surface temperature in Kelvins.

Table 2. Primary Variables

Variable Name	Quantity Measured	Unit
sky_ir_temp	Sky Infrared Temperature	K
sfc_ir_temp	Surface Infrared Temperature	K

5.1.1.1 Definition of Uncertainty

For a 0-1 volt output range and 100 K span, the temperature uncertainty is 0.0244 K.

5.1.2 Secondary/Underlying Variables

Table 3. Secondary Variables

Variable Name	Quantity Measured	Unit
time	Time offset from midnight	seconds
sky_ir_temp_std	Sky Infrared Temperature, Standard Deviation	K
sky_ir_temp_max	Sky Infrared Temperature Maxima	K
sky_ir_temp_min	Sky Infrared Temperature Minima	K
sfc_ir_temp_std	Surface Infrared Temperature, Standard Deviation	K
sfc_ir_temp_max	Surface Infrared Temperature Maxima	K
sfc_ir_temp_min	Surface Infrared Temperature Minima	K

5.1.3 Diagnostic Variables

Table 4. Diagnostic Variables

Variable Name	Quantity Measured	Unit
time_offset	Time offset from base_time	seconds
logger_temp	Logger Temperature	C
internal_voltage	Battery Voltage	V

5.1.4 Data Quality Flags

Most fields contain a corresponding, sample by sample, automated quality check field in the b1 level datastreams. These flags are named **qc_<fieldname>**. For example, the **sky_ir_temp** field also has a companion **qc_sky_ir_temp** field. Possible values for each sample of the **qc_<fieldname>** are shown in the table below.

Table 5. Data Quality Flags

Value	Definition
0	All QC checks passed
1	Sample contained 'missing data' value
2	Sample was less than prescribed minimum value
3	Sample failed both 'missing data' and minimum value checks
4	Sample greater than prescribed maximum value
5	Sample failed both minimum and maximum value checks (highly unlikely)
7	Sample failed minimum, maximum and missing value checks (highly unlikely)

Table 5. Data Quality Flags (cont'd)

Value	Definition
8	Sample failed delta check (change between this sample and and previous sample exceeds a prescribed value
9	Sample failed delta and missing data checks
10	Sample failed minimum and delta checks
11	Sample failed minimum, delta and missing value checks
12	Sample failed maximum and delta checks
14	Sample failed minimum, maximum and delta checks
15	Sample failed minimum, maximum, delta and missing value checks.

The minimum and maximum thresholds are currently defined as follows for datastreams **irt**, **irt2s**, and **skyrad60s**:

Table 6. Thresholds for SKYRAD

Field Name	Units	Min	Max	Delta
sky_ir_temp	K	213	313	50
sky_ir_temp_max	K	213	313	50
sky_ir_temp_min	K	213	313	50
sky_ir_temp_std	K	0	20	--

The minimum and maximum thresholds are currently defined as follows for datastreams **irt10m**, **irt25m**, and **gndrad60s**:

Table 7. Thresholds for GNDRAD

Field Name	Units	Min	Max	Delta
sfc_ir_temp	K	223	323	50
sfc_ir_temp_max	K	223	323	50
sfc_ir_temp_min	K	223	323	50
sfc_ir_temp_std	K	0	20	--

In addition to the above data quality checks, the **qc_time** field is also supplied. The purpose of the qc_time field is to help detect duplicate samples, missing samples or other sample time problems. The qc_time field contains a value for each sample time. Refer to the table below for details.

Table 8. Time Quality Flags

Value	Description
0	Dt is within specified range
1	Dt is 0, duplicate sample
2	Dt is less than specified lower limit
4	Dt is greater than specified upper limit

Finally, the table below specifies the **qc_time limits** used for each of the irt datastreams.

Table 9. Limits for Time

Datastream	Lower Limit	Upper Limit
irt	60	60
irt2s	2	2
irt10m	60	60
irt25m	60	60
skyrad60s	60	60
gndrad60s	60	60

Additional information may be found at GNDRAD and SKYRAD Data Object Design Changes for ARM netCDF file header descriptions.

5.1.5 Dimension Variables

Table 10. Dimension Variables

Variable Name	Quantity Measured	Unit
base_time	Base time in Epoch	seconds
lat	north latitude	degrees
lon	east longitude	degrees
alt	Altitude	meters above Mean Sea Level

5.2 Annotated Examples

This section is not applicable to this instrument.

5.3 User Notes and Known Problems

Positive “spikes” are produced in the sky temperature measurements during daily preventative maintenance due to water and/or alcohol used to clean the gold mirror.

An apparent warm bias of the surface temperature is exhibited by the IRT, compared to the PIR, at sites where the instrument is mounted on a tower 10 m above the ground, especially in summer. The PIR responds strongly to air temperature while the IRT responds strongly to ground temperature. The bias goes away or becomes very small at night because the ground temperature approaches equilibrium with the air. The bias is also small when it is raining or very overcast (as indicated by low solar values). The bias becomes large during the day when the sun is out. For example, on sunny days at TWP/CF3, the ground temperature as seen by the IRT is about 51C while the PIR sees a temperature about 10C cooler. The actual air temperature at Darwin in the afternoon is about 32C. So it appears that the PIR is reporting a temperature approximately mid-way between the ground temperature and the air temperature. This effect is also experienced at Manus and Nauru but it is more pronounced at Darwin because the radiometers are further from the ground.

The SGP downwelling IRT was removed from the microwave radiometer (MWR) and associated datastreams on 11/5/2002 (ECO-267, BCR-581).

The SGP upwelling 10m and 25m IRTs were removed from the MFR dataloggers and associated datastreams on 9/26/2001 and 9/27/2001, respectively (ECO-149, BCR-306).
The Tropical Western Pacific (TWP) SKYRAD IRT rain detector/shutter/enclosure assemblies were replaced with a gold mirror/solar cover assembly at ARCS1 on 10/19/2001 and at ARCS2 on 10/29/2001 (P000610.1, ECO-170).

5.4 Frequently Asked Questions

How is the IRT compared with AERI?

See Calibration Theory, Section 7.3.1.

What is the difference between the skin temperature, the effective ground radiating temperature measured with the upwelling IRTs, and the radiative temperature determined with the upwelling PIRs?
The skin temperature is the actual temperature of the ground surface, as measured with a thermometry device. The effective ground radiating temperature measured with IRTs is the temperature equivalent, using the Stefan-Boltzmann law, of the infrared radiant energy from the ground, assuming it acts as a blackbody with an emissivity of 1. The radiative temperature measured with the PIRs is longwave irradiance emitted and reflected by the ground surface.

What is the spectral response function of the IRT?
See table below or download this space-delimited file for use.

Table 11. Spectral Response Function

Wave Length µm	Spectral Response %
9.40	0.000000
9.46	4.580252
9.58	12.273370
9.70	29.645053
9.82	48.180234
9.94	56.015325
10.06	59.592843
10.18	59.582579
10.30	61.141282
10.42	63.120466
10.54	64.794606
10.66	66.224009
10.78	67.286336
10.90	66.575086
11.02	65.575695

Table 11. Spectral Response Function (cont'd)

Wave Length µm	Spectral Response %
11.14	65.601176
11.26	66.965032
11.38	67.696559
11.50	42.629668
11.62	14.432280
11.74	4.815956
11.80	0.000000

Which datastreams contain the surface temperature measurements for the SGP central facility?

The "sfc_ir_temp" data are found in datastreams sgpmfr10mC1.a1 and sgpmfr25mC1.a1 from 5/19/1997 to 3/31/2001, sgpmfrirt10mC1.a1 and sgpmfrirt25mC1.a1 from 4/1/2001 to 9/26/2001, sgpirt10mC1.a1 and sgpirt25mC1.a1 from 9/26/2001 to 12/18/2003, and sgpirt10mC1.b1 and sgpirt25mC1.b1 from 12/18/2003 to present.

6. Data Quality

6.1 Data Quality Health and Status

The following links go to current data quality health and status results.

- DQ HandS (Data Quality Health and Status)
- NCVweb for interactive data plotting using.

The tables and graphs shown contain the techniques used by ARM's data quality analysts, instrument mentors, and site scientists to monitor and diagnose data quality.

6.2 Data Reviews by Instrument Mentor

On a weekly basis, the instrument mentor produces and inspects plots of the data from the downwelling and upwelling IRTs at the SGP central facility and the TWP, North Slope of Alaska (NSA), and AMF SKYRAD and GNDRAD IRTs. Time series and scatter plots are produced and inspected to compare sky temperature measured by the IRT and atmospheric emitted radiance interferometer (AERI) and the surface temperature measured by the IRT and precision infrared radiometer (PIR). Data Quality Reports (DQRs) are submitted when needed, and a summary report of data quality is sent monthly to the DQ Office.

6.3 Data Assessments by Site Scientist/Data Quality Office

All DQ Office and most Site Scientist techniques for checking have been incorporated within DQ HandS and can be viewed there.

6.4 Value-Added Procedures and Quality Measurement Experiments

Many of the scientific needs of the ARM Program are met through the analysis and processing of existing data products into “value-added” products (VAPs). Despite extensive instrumentation deployed at the ARM CART sites, there will always be quantities of interest that are either impractical or impossible to measure directly or routinely. Physical models using ARM instrument data as inputs are implemented as VAPs and can help fill some of the unmet measurement needs of the program. Conversely, ARM produces some VAPs not in order to fill unmet measurement needs, but instead to improve the quality of existing measurements. In addition, when more than one measurement is available, ARM also produces “best estimate” VAPs. A special class of VAP called a Quality Measurement Experiment (QME) does not output geophysical parameters of scientific interest. Rather, a QME adds value to the input datastreams by providing for continuous assessment of the quality of the input data based on internal consistency checks, comparisons between independent similar measurements, or comparisons between measurement with modeled results, and so forth. For more information, see the VAPs and QMEs web page and specifically, the AERI LBL CLOUDS VAP.

7. Instrument Details

7.1 Detailed Description

7.1.1 List of Components

Heitronics KT19.85 Infrared Radiation Pyrometer

Wintronics PSJB300.24 Power Supply and Junction Box

Radiometrics MP3965 IRT Case (downwelling only)

Radiometrics MP3964 IRT Saddle (downwelling only)

Edmund NT32-089 gold mirror (downwelling only)

DC power/analog signal cable

7.1.2 System Configuration and Measurement Methods

The downwelling IRT is mounted at a height of 1-2 m above the ground, oriented so the zenith view of the sky is reflected into the lens by a gold mirror. The upwelling IRT is mounted at a height of 2-10 m above the ground, oriented so the mounting platform is not in the field of view and to ensure that the ground and vegetation cover are representative of the local area.
The following internal configuration is presently in use:

Table 12. Configuration

Parameter	Downwelling	Upwelling
Target emissivity	1.0	1.0
Temperature unit	Kelvins	Kelvins
Temperature span (TWP&NSA)	213-463 K	223-473 K
Temperature span (SGP)	213-313 K	223-323 K

Table 12. Configuration (cont'd)

Parameter	Downwelling	Upwelling
Response time (90%)	1 second	3 seconds
Analog output (TWP&NSA)	0-10 volts	0-10 volts
Analog output (SGP)	0-1 volt	0-1 volt
Digital output	9.6Kb/8NP/1S/LF	9.6Kb/8NP/1S/LF

The radiation pyrometer is a measuring transducer, which receives the infrared radiation emitted by the measuring object and transforms it into a standardized output signal. If the emissivity is known, the temperature of the object can be determined. The ARM IRTs use a constant emissivity of 1.0 for sky, clouds, and ground. The radiation pyrometer KT19.85 operates within the spectral range of 9.6 to 11.5 µm where the transmission of the atmosphere is very high. There is very little weakening of the infrared radiation due to CO_2 or to water vapor contained in the air.

The working principle of infrared radiation pyrometers uses optical modulation of thermal radiation intercepted by an infrared detector. In general, this is accomplished by an optical chopper (mechanical blades driven by an electric motor), which periodically interrupts the incident radiation from the measured target to the detector. During each interruption the detector is exposed to an internal blackbody reference source having a defined temperature. Infrared detectors of the pyroelectric type must be operated with the "chopped radiation" method because they respond to radiation differences and not to absolute radiation intensities. The detector intercepts infrared radiation emitted by the measured target and, at the same time, radiation emitted by the detector enclosure. During the short chopping cycles, in the millisecond range, the temperature of the pyrometer's housing does not change. The bias is thus eliminated and substituted by the reference signal, which can be easily measured or controlled within the specified reference accuracy over the operational ambient temperature range. Thus, the "chopped radiation" method eliminates thermal drift and automatically provides a modulated signal with a precisely defined frequency.

Each IRT has its own characteristics because of small deviation in filters, detector sensitivity, and lenses. These individual characteristics are compensated by comparing the temperature reading of the instrument with the blackbody radiation at several temperatures and adapting the linearization. The radiance can be calculated from the measured temperature by integrating Plank's law over the spectral range.

The downwelling IRT reports the effective blackbody temperature of the sky in the portion of the infrared spectrum sensed by the instrument. When there is no cloud within the field of view of the instrument, this temperature depends almost entirely on the amount of water vapor in the atmosphere above the instrument. When there is a lot of water vapor present (e.g., during summer), the sky temperatures may exceed 250 K. When there is very little water vapor present (e.g., during winter at the Southern Great Plains [SGP] site), the sky temperatures may fall below 180 K. Note that the lower limit of the IRT range is 213 K (although its calibration is only good down to 223 K). When the sky temperature falls below 213 K, the IRT will signal an error condition. When a cloud enters the field of view of the IRT, an increase in the reported temperature should be observed. How much the temperature will increase depends on how high the cloud is, how thick the cloud is, and how much water vapor is in the atmosphere between the instrument and the cloud. Low, heavy clouds will generally produce the largest increase in temperature, especially in winter when the clear-sky temperature is low; high, wispy clouds will produce a lesser increase. During the summer when the clear sky temperature is relatively large, high clouds may produce only a slight increase.

The narrowband radiating temperature reported by the upwelling IRT will be very close to the physical temperature of the ground/vegetation in its field of view. To the extent that the physical temperature varies in the course of a diurnal cycle so too will the IR temperature reported by the instrument.

7.1.3 Specifications

Spectral Sensitivity: 9.6 to 11.5 µm.

Temperature Measuring Range: 213 to 673 K.

Temperature Resolution in ±K (emissivity = 1, response time = 1 s): 1.10 K at 223 K; 0.45 K at 293 K; 0.25 K at 373 K.

Accuracy: ±0.5 K.

Operational Ambient Temperature: 0° to 60°C.

Storage Temperature: -20° to +70°C.

Weight: 1.5 kg.

Analog Output Resolution: 12 bit.

Optical Field of View (at 3 m): downwelling (S921 lens, f = 120 mm) - 2.64°; upwelling (M6 lens, f = 20 mm) - 30.51°.

Operating Voltages: 24 V AC (±10%) at 48 to 400 Hz or 26 V DC (±15%).

Current Consumption: 80 mA.

7.2 Theory of Operation

It is well known that radiation emitted by objects can be felt by the thermal sensors of our skin. “Temperature radiation” is emitted by all material objects at temperatures above the absolute zero point. Temperature radiation is primarily emitted at wavelengths in the invisible infrared region, but at high temperatures also in the visible spectrum. Instruments capable of measuring this radiation and providing an output signal calibrated in temperature units are called radiation thermometers, radiation pyrometers, or simply pyrometers. The scientific study of the determination of temperatures by the noncontact measurement of self-emitted surface radiation is called radiation pyrometry.

A radiation thermometer measures the radiance power from the target area. The self-emitted radiant power is smaller than the radiant power from a blackbody surface at the same temperature. The reflected and transmitted radiant powers are emitted by the foreground and the background, respectively. The sum of emissivity, reflectance, and transmittance is always 1. In accordance with Planck's law, the radiances are clearly related to the temperatures, provided the relative spectral response (determined by the optical system and the radiation detector) is known. The output signal of a linear detector is proportional to the measured radiance. It is thus permissible to read the measured radiance in terms of a “measured temperature” and to calibrate the indicating meter for the output signal in temperature units (i.e., in Kelvins).

7.3 Calibration

7.3.1 Theory

The calibration and testing of Heimann Radiation Pyrometers are done according to the *Standard Test Methods for Radiation Thermometers (Single Waveband Type) E1256-88* of the American Society for Testing and Materials (ASTM).

7.3.2 Procedures

Factory Calibration Procedures

By means of a blackbody calibration source, the display of the radiation pyrometer can be checked and recalibrated, if required. It is advisable to carry out the test under high temperature (80°-100°C). For this purpose, the radiation pyrometer is placed in front of a blackbody calibration source so that the IRT is focused on the radiator. The temperature of the blackbody radiator must be measured by means of a calibrated probe. On the indicator at the back of the device, select operating mode “CAL” via the “MODE” key after entering the code. After pressing key “ENTER,” the calibration factor and measure temperature can be read from the display. Using the “UP/DOWN” keys, the factor can be changed so the temperature matches the blackbody temperature. By actuating key “ENTER” again, the new calibration factor is stored and the device will automatically be adjusted to this temperature.

Mentor Calibration Procedures

The ASTM method utilizes a blackbody radiator heated to 350°C (623 K). This is 350-400 degrees above the range of sky temperatures to be measured. For this reason, the mentor recommends calibrating the upward-looking instruments against a cyrogenically-cooled spectrometer such as the AERI spectrometer built by the University of Wisconsin. This is accomplished as follows:

Collocate the IRT with the AERI to observe the same sky conditions. AERI provides a spectrally resolved measurement over the range of the IR thermometer's detector response. For each AERI spectrum, compute the narrowband radiance observed by the IRT:

$$L_{IRT} = \int L(l,T)S(l)dl$$

where l is the wavelength or wavenumber, L(l,T) is the AERI spectral radiance, and S(l) is the IRT spectral response function. Then iteratively solve the following expression for the blackbody radiating temperature T_{bb} until it agrees with the narrowband radiance computed from the AERI spectrum:

$$L_{IRT} = \int B(T_{bb},l)S(l)dl$$

where $B(T_{bb},l)$ is the Planck function.

Plotting the temperature reported by the IRT, T_{obs}, against the blackbody temperature computed from the AERI spectra, T_{bb}, for a wide range of sky temperatures (i.e., clear and cloudy skies, low to high precipitable water vapor) will permit the construction of a regression: $T_{bb} = a + b\ T_{obs}$. The IRT calibration can then be adjusted (see above) to match the AERI-derived values.

Although this is not an absolute calibration, it will reference the IRT to AERI and will permit the calibration to be tuned to the range of sky temperatures actually encountered. Additionally, one could use the AERI data to determine corrections for water vapor contribution (since what we hope to measure with the IRT is cloud base temperature). This will be significant during the summer at SGP and year round at TWP.

7.3.3 History

Table 13. Calibration History

Serial Number	Calibration Date	Calibration Factor	Comments
517	91/90/12	2263	Initial calibration by Heimann
	96/10/28	2263	Lens replaced and compared with AERI (PIF 960809.2)
	96/12/10	2263	Compared with SN 1254 by NREL (PIF 961203.2)
	97/09/10	2263	Compared with AERI (PIF 970428.1)
863	93/09/19	2440	Initial calibration by Pyrometrics
864	93/09/19	2300	Initial calibration by Pyrometrics
	99/04/07	2300	Compared with SN 517 and AERI
865	93/09/19	2640	Initial calibration by Pyrometrics
	03/11/04	2628	Repaired and calibrated by Wintronics
866	93/09/19	1649	Initial calibration by Pyrometrics
867	93/09/19	1847	Initial calibration by Pyrometrics
	98/01/10	2358	Repaired and calibrated by Wintronics
	99/04/07	2358	Compared with SN 517 and AERI
868	93/09/19	2221	Initial calibration by Pyrometrics
	97/09/19	2239	Repaired and calibrated by Wintronics
1026	95/08/16	2276	Initial calibration by Pyrometrics
1029	96/08/16	2114	Initial calibration by Pyrometrics
1250	96/10/01	2214	Initial calibration by Wintronics
	97/09/10	2214	Compared with SN 517 and AERI (PIF 970428.1)
	99/04/07	2214	Compared with SN 517 and AERI
1251	96/10/01	2106	Initial calibration by Wintronics
1252	96/10/01	2116	Initial calibration by Wintronics
	99/04/07	2116	Compared with SN 517 and AERI
	01/03/22	2138	Repaired and calibrated by Wintronics
1253	96/10/01	1300	Initial calibration by Wintronics
	98/01/10	4600	Repaired and calibrated by Wintronics (PIF 980918.3)
	99/04/07	4600	Compared with SN 517 and AERI
1254	96/10/01	1307	Initial calibration by Wintronics
	97/09/10	1307	Compared with SN 517 and AERI (PIF 970428.1)
	97/12/19	1281	Calibrated by Wintronics
	99/04/07	1281	Compared with SN 517 and AERI
1255	96/10/01	1255	Initial calibration by Wintronics
	98/07/13	1207	Repaired and calibrated by Wintronics

Table 13. Calibration History (cont'd)

Serial Number	Calibration Date	Calibration Factor	Comments
	02/10/17	1145	Repaired and calibrated by Wintronics
1553	98/01/10	1260	Initial calibration by Wintronics
	99/04/07	1260	Compared with SN 517 and AERI
1628	98/03/04	4226	Initial calibration by Wintronics
	99/04/07	4226	Compared with SN 517 and AERI
1938	01/09/01	5086	Initial calibration by Wintronics

7.4 Operation and Maintenance

7.4.1 User Manual

This section is not applicable to this instrument.

7.4.2 Routine and Corrective Maintenance Documentation

See the following links:

- SGP IRT Preventative Maintenance Procedure
- TWP Operating Procedure
- NSA Preventative Maintenance Procedure Manual.

7.4.3 Software Documentation

ARM netCDF file header descriptions may be found at GNDRAD and SKYRAD Data Object Design Changes.

7.4.4 Additional Documentation

See Routine and Corrective Maintenance Documentation, Section 7.4.2.

7.5 Glossary

See the ARM Glossary.

7.6 Acronyms

See the ARM Acronyms.

7.7 Citable References

None