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ARM
CLIMATE RESEARCH FACILITY

G-Band Vapor Radiometer Profiler (GVRP) HANDBOOK

June 2010

U.S. DEPARTMENT OF ENERGY | Office of Science

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G-Band Vapor Radiometer Profiler (GVRP) Handbook

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1.0 General Overview

The G-Band Vapor Radiometer Profiler (GVRP) provides time-series measurements of brightness temperatures from 15 channels between 170 and 183.310 GHz. Atmospheric emission in this spectral region is primarily due to water vapor, with some influence from liquid water. Channels between 170.0 and 176.0 GHz are particularly sensitive to the presence of liquid water. The sensitivity to water vapor of the 183.31-GHz line is approximately 30 times higher than at the frequencies of the two-channel microwave radiometer (MWR) for a precipitable water vapor (PWV) amount of less than 2.5 mm. Measurements from the GVRP instrument are therefore especially useful during low-humidity conditions (PWV < 5 mm). In addition to integrated water vapor and liquid water, the GVRP can provide low-resolution vertical profiles of water vapor in very dry conditions.

2.0 Contacts

2.1 Mentor

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2.2 Vendor / Instrument Developer

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2840 Wilderness Place Unit G
Boulder, CO 80301-5414
303.449.9192
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3.0 Deployment Locations and History

Table 1. Status and location of the GVRP.

Serial Number	Property Number	Location	Date Installed	Date Removed	Status
MP3000A 183-2		NSA/C1	2008/03/31		Operational

4.0 Near-Real-Time Data Plots

Plots of near-real-time data can be viewed at the DQHands (Data Quality Health and Status) system accessible through the web site: http://dq.arm.gov/. Click on "QC Metrics and Plots" and select the desired site and data stream. The GVRP is located at the site "NSA", the datastream is "nsagvrpC1.b1" or "nsagvrpC1.a1", and the facility is "C1".

5.0 Data Description and Examples

5.1 Data File Contents

Datastreams available from the ARM Data Archive are:

- **nsagvrpC1.a1**: Raw data
- **nsagvrpC1.b1**: Calibrated, brightness temperatures and surface ambient measurements.

5.1.1 Primary Variables and Expected Uncertainty[1]

The primary variables measured by the GVRP are brightness temperatures at 15 channels between 170 and 183.3 GHz.

Table 2. Primary variables.

Variable Name	Quantity Measured	Unit	Uncertainty
Brightness temperature	Sky brightness temperature (15 channels)	K	2 K
Frequency	170.0, 171.0, 172.0, 173.0, 174.0, 175.0, 176.0, 177.0, 178.0, 179.0, 180.0, 181.0, 182.0, 183.0, and 183.310	GHz	N/A
Elevation	Elevation viewing angles (90=zenith viewing)	Degrees	N/A

5.1.2 Secondary / Underlying Variables

Table 3. Secondary variables.

Variable Name	Quantity Measured	Unit	Uncertainty
time	Time offset from midnight	s	
surfacePressure	Pressure at the surface	kPa	2.0
surfaceTemperature	Temperature at the surface	K	1.0
surfaceRelativeHumidity	Relative humidity at the surface	%	5.0
surfaceRainFlag	Binary rain indicator (1=rain, 0=no-rain)	count	N/A

[1] See section (6.5) for a definition of uncertainty.

5.1.3 Diagnostic Variables

Table 4. Diagnostic variables.

Variable Name	Quantity Measured	Unit	Uncertainty
blackBodyTemperature	Internal blackbody reference temperature	K	0.25 K
noiseDiodePhysicalTemp	Noise diode physical temperature	K	0.25 K

5.1.4 Data Quality Flags

Data quality flags are named qc_'fieldname' (i.e., qc_surfacePressure). Possible values for qc_flags are: 0 (value is within the specified range), 1 (missing value), 2 (value is less than the specified minimum), 4 (value is greater than the specified maximum), and 8 (value failed the valid "delta" check). Specified maximum and minimum values are shown in Table 5.

Table 5. Data quality thresholds.

Field Name	Min	Max
BrightnessTemperature	3	320
surfacePressure	80	110
surfaceTemperature	223.15	323
surfaceRelativeHumidity	1	110
blackBodyTemperature	243	320

5.1.5 Dimension Variables

Table 6. Dimension variables.

Field Name	Quantity	Unit
base_time	Base time in Epoch	seconds since 1970-1-1 0:00:00 0:00
time_offset	Time offset from base_time	s
lat	north latitude	degrees
lon	east longitude	degrees
alt	altitude	meters above Mean Sea Level

5.2 Annotated Examples

This section is not yet available.

5.3 User Notes and Known Problems

The instrument is calibrated with LN2 calibration every 3–4 months. Information on calibration is available in the calibration database and upon request to the instrument mentor.

5.4 Frequently Asked Questions

This section is not yet available.

6.0 Data Quality

6.1 Data Quality Health and Status

Daily quality check on this data stream can be found at the DQHands web page: http://dq.arm.gov/. Click on "QC Metrics and Plots" and select the desired site and datastream. The GVRP is located at the site "NSA", the data stream is "nsagvrpC1.b1" or "nsagvrpC1.a1", and the facility is "C1".

6.2 Data Reviews by Instrument Mentor

The instrument mentor submits a monthly summary report IMMS accessible from the instrument web page. Some of the general checks performed by the instrument mentor are shown below.

1. In general the brightness temperature time series should be smooth and with low noise levels.
2. Brightness temperatures should be greater than 2.75 K and less than approximately 310 K. (We do not expect the ambient temperature in Barrow to be significantly higher than 30°C).
3. Surface meteorological readings (temperature, pressure, and relative humidity) can be compared to tower measurements. The agreement should be +/- 2 K for temperature, about 5 kPa for pressure, and 5% for relative humidity.
4. Measured brightness temperatures are also compared routinely with model computations as a general quality check.

6.3 Data Assessments by Site Scientist / Data Quality Office

The Data Quality office daily data assessment can be viewed at the DQHands web page: http://dq.arm.gov/.

6.4 Value-Added Products and Quality Measurement Experiments

No value-added products are available at this stage.

7.0 Instrument Details

The GVRP is part of a new series of microwave radiometers (Radiometrics MP-3000A series) with advanced frequency agile architecture and user interface.

7.1 Detailed Description

7.1.1 List of Components

- RF section: Mailbox-type container
- Desktop PC host computer with monitor, keyboard, and mouse
- Super-blower
- Calibration target and saddle
- Data and power cables.

7.1.2 System Configuration and Measurement Methods

In this section we give a brief description of the GVRP hardware configuration. The material in this section can be found in [1]. The reference can be obtained from the instrument mentor upon request. The downwelling atmospheric radiation passes through the instrument radome. A parabolic mirror reflects the radiation into the receiver feed-horn. Microwave channels are selected using a frequency synthesizer. Input power is down-converted to an intermediate frequency. The signal is then amplified, filtered, and detected. The receiver has a noise source (noise diode) used to calibrate the gain. The instrument is equipped with elevation-scanning capability. Eleven elevation angles are scanned at each observing cycle.

A super-blower is activated when the rain sensor detects rain. The super blower keeps the radome clear of rain or snow.

7.1.3 Specifications

Table 7. Instrument specifications.

Parameter	Value
Data interface Primary computer port	RS422 57600 kb/s 8N1
Data interface Auxiliary computer port	RS422 1.2—57600 kb/s 8N1
Power requirement (100 to 250 VAC / 50–60 Hz)	~ 200 W (400 W at cold start)
Weight	27 kg
Size	50 X 28 X 76 cm
Radiometric noise	0.25 K (250 ms averaging time)
Long term stability	< 1 K over 1 yr
Measurement rate	~ 1/20 s
Antenna beamwidth	1.0°
Temperature range	-50° to 50°C
Output	ASCII data files

7.2 Theory of Operation

The GVRP measures brightness temperatures at 15 channels between 170.0 and 183.31 GHz. The atmospheric emission in this spectral region is primarily due to water vapor, with some influence from liquid water. Channels in the wing of the absorption line are particularly sensitive to the presence of liquid water.

The sensitivity of the GVRP channels to the presence of water vapor is much stronger than that of the 22-GHz water vapor line; however, the instrument response to the presence of PWV is nonlinear. The GVRP has one channel centered at the peak of the 183.31-GHz line. This channel is sensitive to the presence of stratospheric water vapor when the humidity is very low.

7.3 Calibration

7.3.1 Theory

Each channel of the GVRP is calibrated at the factory by determining several parameters used in the calibration algorithm. Seven parameters are used in the calibration algorithm:

- Linearity correction exponent (α)
- 1/f noise suppression coefficient (dTdG)
- four temperature correction coefficients for the temperature dependence of the noise diode (Ki, i=1, 4)
- the effective noise diode temperature at T=290 K (Tnd290).

The noise diode requires periodic LN2 calibrations that are performed every three months. During LN2 calibrations, the two temperature references used to calibrate the noise diode are the black body and the Liquid Nitrogen.

Once the noise diode is calibrated, it can be used for frequent routine calibration. The black body is viewed every five minutes, and the noise diode is switched on and off while viewing the black body. The GVRP does not perform tip curves because its channels are too opaque.

7.3.2 Procedures

Brightness temperatures T_{sky} are produced for each channel according to:

$$T_{sky} = \left(\frac{V_{sky}}{gain_{sky}} \right)^{1/\alpha} - Trcv_{sky}.$$

where V_{sky} is the signal recorded when the reflector is oriented towards the sky, $gain_{sky}$ is the gain during sky observations, and $Trcv_{sky}$ is the receiver temperature during sky observations. The gain during black body and sky observation is defined as:

$$gain_{bb} = \left(\frac{V_{bb\_nd}^{1/\alpha} - V_{bb}^{1/\alpha}}{Tnd290 + Tc} \right)^{\alpha}$$

$$gain_{sky} = \left(\frac{V_{sky\_nd}^{1/\alpha} - V_{sky}^{1/\alpha}}{Tnd290 + Tc} \right)^{\alpha}.$$

The receiver temperature during black body and sky observations is:

$$Trcv_{bb} = \left(\frac{V_{bb}}{gain_{bb}} \right)^{1/\alpha} - Tk_{bb}$$

$$Trcv_{sky} = Trcv_{bb} + dTdG(gain_{sky} - gain_{bb}).$$

The temperature correction to the effective noise diode temperature is:

$$Tc = K1 + K2 * Tk_{bb} + K3 * Tk_{bb}^{2} + K4 * Tk_{bb}^{3}.$$

Of the seven parameters used in the calibration algorithm, only the effective noise diode temperature is calibrated in the field. The remaining six parameters are determined at the factory.

7.3.3 History

- Deployed during RHUBC I in Barrow, Alaska February 1–March 30, 2007
- Deployed in Barrow, Alaska, April 1, 2008
- Moved to VOCALS campaign in the Southeast Pacific, September–December 2008
- Deployed during RHUBC II in Chile, August–October 2009
- Deployed in Barrow, Alaska, February 2010.

7.4 Operation and Maintenance

7.4.1 User Manual

Available by contacting the instrument mentor.

7.4.2 Routine and Corrective Maintenance Documentation

This information is not available for this instrument system.

7.4.3 Software Documentation

This information is not available for this instrument system.

7.4.4 Additional Documentation

This section is not applicable to this instrument system.

7.5 Glossary

Uncertainty: We define uncertainty as the range of probable maximum deviation of a measured value from the true value within a 95% confidence interval. Given a bias (mean) error *B* and uncorrelated random errors characterized by a variance σ^2, the root-mean-square error (RMSE) is defined as the vector sum of these,

$$RMSE = \left(B^2 + \sigma^2\right)^{1/2}.$$

(*B* may be generalized to be the sum of the various contributors to the bias and σ^2 the sum of the variances of the contributors to the random errors). To determine the 95% confidence interval, we use the Student's *t* distribution: $t_{n;0.025} \approx 2$, assuming the RMSE was computed for a reasonably large ensemble. Then the *uncertainty* is calculated as twice the RMSE.

7.6 Acronyms

See the ARM Acronyms and Abbreviations.

7.7 Citable References

[1] Radiometrics MP-183 User's Manual, REV. A.

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