ARM TR-049

Precision Gas System Handbook

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Atmospheric Radiation Measurement
Climate Research Facility
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Contents

1. General Overview

This precision gas system (PGS) makes high-accuracy, high-precision measurements of CO_2 mixing ratio (ppmv dry air) in air sampled at 2, 4, 25, and 60 m above the ground.

2. Contacts

2.1 Mentor

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2.2 Instrument Developer

Lawrence Berkeley National Laboratory (LBNL) staff built the system.

Li-Cor is the vendor for the infrared gas analyzer (IRGA), model LI-6252 CO_2 Analyzer (see http://www.licor.com/env/Products/GasAnalyzers/li6262/6262.jsp for product description).

3. Deployment Locations and History

The precision gas system is located at the base of the 60 m tower at the Central Facility at the Atmospheric Radiation Measurement (ARM) Program's Climate Research Facility Southern Great Plains (SGP) locale. The system operates continuously, except for occasional power outages.

4. Near-Real-Time Data Plots

Data stream 1: Quick views of the precision gas system data for yesterday are available at http://co2anal.lbl.gov/worldview/pgs-yest.html.

Data stream 2: Quick views of the precision gas system data for the past week are available at http://co2anal.lbl.gov/worldview/pgs-week.html.

5. Data Description and Examples

5.1 Data File Contents

Data are reported as ppm (V) CO_2 in dry air.

5.1.1 Primary Variables and Expected Uncertainty

CO_2 mixing ratio in dry air.

5.1.1.1 Definition of Uncertainty

Samples are bracketed by certified standards.

5.1.2 Secondary/Underlying Variables

This section is not applicable to this instrument.

5.1.3 Diagnostic Variables

The diagnostic variables are listed in the table for Data Quality Flags, Section 5.1.4.

5.1.4 Data Quality Flags

QC flag name	Function (abbreviations defined below)
qc_co2mv_ch5	qc flag on co2mv_ch5 (reference channel)
qc_co2mv_slope	qc flag on co2mv_slope
qc_co2mv_slope_se	qc flag on co2mv_slope_se
qc_co2ppm	qc flag on co2ppm
qc_co2ppm_25m	qc flag on co2ppm_2m
qc_co2ppm_2m	qc flag on co2ppm_2m
qc_co2ppm_4m	qc flag on co2ppm_2m
qc_co2ppm_60m	qc flag on co2ppm_2m
qc_co2stor_25m	qc flag on co2stor_25m
qc_co2stor_4m	qc flag on co2stor_4m
qc_co2stor_60m	qc flag on co2stor_60m
qc_coeff1_se	qc flag on coeff1_se
qc_coeff2_se	qc flag on coeff2_se
qc_coeff3_se	qc flag on coeff3_se
qc_del_co2stor_25m	qc flag on del_co2stor_25m
qc_del_co2stor_4m	qc flag on del_co2stor_4m
qc_del_co2stor_60m	qc flag on del_co2stor_60m
qc_flow_rate	qc flag on flow rate
qc_pres	qc flag on pres
qc_pres_ctrlr	qc flag on pres_controller
qc_pres1	qc flag on pres1
qc_pres2	qc flag on pres2
qc_pres3	qc flag on pres3

qc_pres4	qc flag on pres4
qc_q_25m	qc flag for q_25m
qc_q_60m	qc flag for q_60m
qc_t_irga	qc flag on t_irga
qc_t_refrig	qc flag on t_refrig
qc_temp_10m	qc flag on temp_10m
qc_temp_25m	qc flag for temp_25m
qc_temp_60m	qc flag for temp_60m

Where:
heights are 2, 4, 10, 25, and 60 meters above ground level.
irga = IRGA, infra red gas analyzer
pres = pressure
q = humidity
refrig = cooling system for condensing water out of sample stream
stor = calculated C2 storage term
t = temperature
temp = temperature.

5.1.5 Dimension Variables

This section is not applicable to this instrument.

5.2 Annotated Examples

QC flag name	Function (abbreviations defined below)
qc_co2mv_ch5	qc flag on co2mv_ch5 (reference channel)
qc_co2mv_slope	qc flag on co2mv_slope
qc_co2mv_slope_se	qc flag on co2mv_slope_se
qc_co2ppm	qc flag on co2ppm
qc_co2ppm_25m	qc flag on co2ppm_2m
qc_co2ppm_2m	qc flag on co2ppm_2m
qc_co2ppm_4m	qc flag on co2ppm_2m
qc_co2ppm_60m	qc flag on co2ppm_2m
qc_co2stor_25m	qc flag on co2stor_25m
qc_co2stor_4m	qc flag on co2stor_4m
qc_co2stor_60m	qc flag on co2stor_60m
qc_coeff1_se	qc flag on coeff1_se
qc_coeff2_se	qc flag on coeff2_se
qc_coeff3_se	qc flag on coeff3_se
qc_del_co2stor_25m	qc flag on del_co2stor_25m
qc_del_co2stor_4m	qc flag on del_co2stor_4m

qc_del_co2stor_60m	qc flag on del_co2stor_60m
qc_flow_rate	qc flag on flow rate
qc_pres	qc flag on pres
qc_pres_ctrlr	qc flag on pres_controller
qc_pres1	qc flag on pres1
qc_pres2	qc flag on pres2
qc_pres3	qc flag on pres3
qc_pres4	qc flag on pres4
qc_q_25m	qc flag for q_25m
qc_q_60m	qc flag for q_60m
qc_t_irga	qc flag on t_irga
qc_t_refrig	qc flag on t_refrig
qc_temp_10m	qc flag on temp_10m
qc_temp_25m	qc flag for temp_25m
qc_temp_60m	qc flag for temp_60m

Where:
heights are 2, 4, 10, 25, and 60 meters above ground level.
irga = IRGA, infra red gas analyzer
pres = pressure
q = humidty
refrig = cooling system for condensing water out of sample stream
stor = calculated C2 storage term
t = temperature
temp = temperature.

5.3 User Notes and Known Problems

Datastreams are available through the ARM Data Archive.

5.4 Frequently Asked Questions

Where do I get more information?

Contact the instrument mentor (see Section 2.1).

6. Data Quality

6.1 Data Quality Health and Status

The instrument has operated continuously since July, 2001. Occasional loss of data has occurred due to loss of site power or other causes (ice storm, pump failure). Please check data quality reports for specifics.

6.2 Data Reviews by Instrument Mentor

ARM staff perform preventive maintenance checks weekly and post-preventive maintenance reports on the internet. ARM carbon scientists at LBNL check these reports each week. We evaluate the zero drift (change in reference gas value) and specifications of all instrument components every week.

Examples of variables that are diagnostic of instrument performance include:

- Temperature of IRGA
- Pressure of gas in IRGA
- Pressure of each air sample supplied to valve manifold
- Temperature of the cooling (drying) unit
- Flow rate of sample gas through the IRGA.

6.3 Data Assessments by Site Scientist/Data Quality Office

Not available at this time.

6.4 Value-Added Procedures and Quality Measurement Experiments

None at present.

7. Instrument Details

7.1 Detailed Description

7.1.1 List of Components

QC flag name	Function (abbreviations defined below)
qc_co2mv_ch5	qc flag on co2mv_ch5 (reference channel)
qc_co2mv_slope	qc flag on co2mv_slope
qc_co2mv_slope_se	qc flag on co2mv_slope_se
qc_co2ppm	qc flag on co2ppm
qc_co2ppm_25m	qc flag on co2ppm_2m
qc_co2ppm_2m	qc flag on co2ppm_2m
qc_co2ppm_4m	qc flag on co2ppm_2m
qc_co2ppm_60m	qc flag on co2ppm_2m
qc_co2stor_25m	qc flag on co2stor_25m
qc_co2stor_4m	qc flag on co2stor_4m
qc_co2stor_60m	qc flag on co2stor_60m
qc_coeff1_se	qc flag on coeff1_se
qc_coeff2_se	qc flag on coeff2_se
qc_coeff3_se	qc flag on coeff3_se

qc_del_co2stor_25m	qc flag on del_co2stor_25m
qc_del_co2stor_4m	qc flag on del_co2stor_4m
qc_del_co2stor_60m	qc flag on del_co2stor_60m
qc_flow_rate	qc flag on flow rate
qc_pres	qc flag on pres
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qc_pres1	qc flag on pres1
qc_pres2	qc flag on pres2
qc_pres3	qc flag on pres3
qc_pres4	qc flag on pres4
qc_q_25m	qc flag for q_25m
qc_q_60m	qc flag for q_60m
qc_t_irga	qc flag on t_irga
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qc_temp_25m	qc flag for temp_25m
qc_temp_60m	qc flag for temp_60m

Where:
heights are 2, 4, 10, 25, and 60 meters above ground level.
irga = IRGA, infra red gas analyzer
pres = pressure
q = humidty
refrig = cooling system for condensing water out of sample stream
stor = calculated C2 storage term
t = temperature
temp = temperature.

Infra-Red Gas Analyzer (IRGA), LI-6252 (see http://env.licor.com/):

- Sample is dried with a cooling unit and a Nafion membrane drier.
- Flow is regulated with mass flow controller, pumps, and valves.
- A 1-liter buffer volume is used to dampen very-short-term variation in CO_2 concentration.
- System is directed by a datalogger (Campbell 23x) that downloads to a computer every day.

Data collection system uses a 2.8 GHz Intel PC clone; operating system Windows 2000.

7.1.2 System Configuration and Measurement Methods

We measure one sample for 3 minutes at a time; the reported value is the average of the last 30 seconds.

The IRGA is run in differential mode, with a reference gas (ca 360 ppm) through the reference cell at all times. Every 15 minutes, we analyze the reference gas through the sample cell as well, to correct for gain (zero drift) in the system. Every 4 hours, we run four calibration standards (National Oceanic and Atmospheric Administration Climate Monitoring Diagnostics Laboratory (NOAA CMDL) certified

standards at approximately 330, 360, 390, and 420 ppm). Sample CO_2 concentration is calculated with the standards run before and after it.

We have followed protocols developed by the NOAA CMDL (e.g., Bakwin et al.) for their high precision, continuous CO_2 monitoring instruments.

7.1.3 Specifications

This section is not applicable to this instrument.

7.2 Theory of Operation

See Section 7.1, Detailed Description.

7.3 Calibration

7.3.1 Theory and Procedures

See above.

7.3.2 History

Before deployment at ARM SGP, we did a blind comparison of a tank of CO_2 in air with the NOAA-CMDL standards lab. Our measurement agreed with theirs to 0.05 ppm.

Currently the instrument performance is checked against weekly NOAA CMDL flask samples collected from the 60-m air-sampling inlet.

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

ARM staff perform preventive maintenance checks weekly and post-preventive maintenance reports on the internet. ARM carbon scientists at LBNL check these reports each week. We evaluate the zero drift (change in reference gas value) and specifications of all instrument components every week. For examples of instrument operations that we manage through the Routine and Corrective Maintenance documents, See Data Reviews by Instrument Mentor.

7.4.3 Software Documentation

There is none at this time.

7.4.4 Additional Documentation

There is none at this time.

7.5 Glossary

See the ARM Glossary.

7.6 Acronyms

ARM: Atmospheric Radiation Measurement (Program)
CMDL: Climate Monitoring Diagnostics Laboratory
IRGA: infrared gas analyzer
LBNL: Lawrence Berkeley National Laboratory
NOAA: National Oceanic and Atmospheric Administration
PGS: precision gas system
SGP: Southern Great Plains

Also see the ARM Acronyms and Abbreviations.

7.7 Citable References

Bakwin P.S., P.P. Tans, C.L. Zhao, W. Ussler, and E. Quesnell. 1995. Measurements of carbon dioxide on a very tall tower. *Tellus Series B-Chemical and Physical Meteorology*, V47(N5):535-549.

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Tans P.P., P.S. Bakwin, and D.W. Guenther. 1996. A Feasible global carbon cycle observing system - a plan to decipher todays carbon cycle based on observations. *Global Change Biology*, V2(N3):309-318.