Continuous Measurements of Atmospheric Carbon Monoxide at the ACRF Southern Great Plains Site

April 2006

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Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

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1. General Overview

The Southern Great Plains (SGP) Carbon Monoxide (CO) system provides high-precision atmospheric concentration measurements of CO mixing ratio (ppbv dry air) every 10 minutes in air collected at 60 meters above ground level. Concentrations measurements are based on the principle that carbon monoxide absorbs infrared radiation at a wavelength of 4.6 µm.

2. Contacts

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2.2 Instrument Developer

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

Thermo Electron Corporation is the vendor CO gas analyzer model 48°C (see http://www.thermo.com/com/cda/product/detail/1,1055,14684,00.html for product description).

For instrument repair and maintenance contact:
Thermo electron Corporation
Service: Air Quality Instruments
27 Forge Parkway
Franklin, MA 02038
Phone: 1-866-282-0430
Fax: 1-508-520-1460

3. Deployment Locations and History

The CO system is located at the base of the 60-meter tower (36.607 ºN, 97.489 ºW, and 314 meters above sea level) at the Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) SGP Central Facility.

The system was deployed on May 25, 2005, and operates continuously, except for occasional power outages and scheduled maintenance.

4. Near-Real-Time Data Plots

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

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

5. Data Description and Examples

5.1 Data File Contents

The data are presented in two levels of processing: a1 and b1. Each level of processing has a directory, which is named accordingly. For more detailed information on processing, please see Section 6.1.
In summary:

- Directory ‘a1’: sgpcoC1.a1.YYYYMMDD.HHMMSS.asc. First level of processing where raw data are time stamped every 5 seconds. “YYYYMMDD” denotes year, month, day of the file. “HHMMSS” denotes hour, minute, and second of the file. All data are in ASCII format.

- Directory ‘b1’: sgpcoC1.b1.YYYYMMDD.HHMMSS.cdf. Second level of processing where data are quality checked and corrections for offset and span are applied.

5.1.1 Primary Variables and Expected Uncertainty

The CO system provides carbon monoxide mixing ratio in dry air in ppbv units. Uncertainty of the instrument is estimated to be on the order of 5 ppb.

5.1.1.1 Definition of Uncertainty

Uncertainties in the measurements obtained under well-mixed conditions are typically dominated by random noise from atmospheric turbulence and the instrument. The data processing software is designed to provide diagnostic variables to identify the sources of uncertainty that affect the measurements.

Samples are bracketed by two secondary calibration standards. These standards have been calibration against two primary National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) certified standards. Concentrations of these primary standards are shown in Table 1.

Table 1. Primary standards specifications

Manufacturer	Type	Serial #	Mixture	Concentrations	Performed by	Date
SCOTT MARRIN	150A	CA05962	CO in air	95±1 ppb	NOAA - D. Kitzis	1-Dec-03
SCOTT MARRIN	150A	CA05909	CO in air	292.5±2.9 ppb	NOAA - D. Kitzis	1-Dec-03

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

Output files include quality control (qc) flags. Almost every variable 'x' has a qc flag named 'qc_x'. The values of qc flags values and definitions are shown in Tables 2 and 3.

Table 2. Quality Control flags value

QC Value	Relevant Condition
0	value not suspect.
1	value in a range that might point toward a problem.
2	value below minimum or 2 above maximum threshold.

Table 3. "Warning" and "bad" quality control flag scheme

qc Flag Associated to Variable	Units	"Warning" Condition	"Bad" Condition
CO	ppb	50 < CO < 60 600 < CO < 800	CO < 50 CO > 800
int_temp	Deg. Celsius	25 < int_temp < 30 40 < int_temp < 45	int_temp < 25 int_temp > 45
chamber_tem p	Deg. Celsius	35.0 < chamber_temp < 42.4 47.5 < chamber_temp < 55.0	chamber_temp < 35.0 chamber_temp > 55.0
agc	Hz	1.90e5 < agc < 1.95e5 2.05e5 < agc < 2.1e5	agc < 1.9e5 agc > 2.1e5
pres_TE48C	Torr	790 < pres_TE48C < 800 820 < pres_TE48C < 830	pres_TE48C < 790 pres_TE48C > 830
flow_TE48C	LPM	0.40 < flow_TE48C < 0.45 0.55 < flow_TE48C < 0.60	flow_TE48C < 0.40 flow_TE48C > 0.60
pres_control	Torr	785 < pres_control < 795 805 < pres_control < 815	pres_control < 785 pres_control > 815
flow_control	LPM	0.40 < flow_control < 0.45 0.55 < flow_control < 1.00	flow_control < 0.40 flow_control > 1.00
dpt	Deg. Celsius	-15 < dpt < -10	dpt > -10.0

5.1.5 Dimension Variables

Each variable has dimensions included in the data files.

5.2 Annotated Examples

The variable for CO mixing ratio is co. Typical daytime values are 60 ppb <co< 600 ppb. The corresponding qc variable is qc_co (dimensionless), which when normal has a value of zero.

5.3 User Notes and Known Problems

The instrument has provided high quality data for a large fraction (>90%) of its operating lifetime. Occasional loss of data has occurred due to loss of power communications or instrument malfunction. All data users are strongly urged to review the quality reports, which describe the intermittent problems and changes to sensor and the data processing, then refer further questions to the instrument mentor.

5.4 Frequently Asked Questions

Where do I get more information?

Contact the instrument mentors at scbiraud@lbl.gov or mlfischer@lbnl.gov.

6. Data Quality

6.1 Data Quality Health and Status

Data quality is evaluated by inspecting qc flags and variables in processed data.

Data Processing Algorithms

The first stage of the data processing program reads in raw data files (a0) to produce intermediate a1 files. These a1 *daily* files contain time stamped 5 Hz data but are not yet corrected for sensor offset and drifts. It is also worth to note that from time to time the CO system has hiccups (mostly windows operating system related) and a0 data contains truncated lines. These lines are purged during the a0 to a1 processing.

The second stage of data processing reads a1 files to produce estimates of CO mixing ratios with qc flags.

- Calculate average concentrations for each channel (sampled, zero, and span air).
- Correct for offset of the instrument.
- Find calibration data and correct for drifts.
- Write out results.

6.2 Data Reviews by Instrument Mentor

ARM staff perform preventive maintenance checks weekly and post-preventive maintenance reports on the internet. ARM carbon staff at LBNL checks these reports on a weekly basis. Instrument mentor Sébastien Biraud routinely views graphical displays produced at LBNL. The displays include graphs of CO concentrations, flow rate, pressure, automatic gain control, and dew point temperature.

6.3 Data Assessments by Site Scientist/Data Quality Office

Not available at this time.

6.4 Value-Added Procedures and Quality Measurement Experiments

Not available at this time.

7. Instrument Details

7.1 Detailed Description

7.1.1 List of Components

Thermo Electron Gas Analyzer Model 48°C

- Zero Noise : 5.0 ppb RMS (120 second averaging time)
- Zero Drift (24 hour): less than 100 ppb
- Response Time: 60 seconds (30 second averaging time)
- Precision: 10.0 ppb
- Sample Flow Rate: 0.5 liter/min
- Operating Temperature: 20°〵30°C (may be safely operated over the range 5°-45°C)
- Power Requirements: 90-100 VAC; 210-240 VAC, 50 Hz, 100 Watts

Tylan mass flow controller (FC-2900)

- Flow: 0.5 LPM
- Step Response Time: 1 sec (dependent on step request and conditions)
- Accuracy: ± 1.0% full scale
- Linearity: ± 0.5% full scale
- Repeatability: ± 0.2% full scale
- Valve Normally-open or normally-closed solenoid
- Supply Voltage: ± 12 VDC to ± 18 VDC
- Supply Current: 110 mA nominal (125 mA max @ ± 18 VDC)
- Power Consumption: 3.3 watts @ ± 15 volts
- Input/Output Signal: 0-5 VDC

MKS Pressure controller (model 640)

- Pressure: 100 PSI
- Supply Voltage: 15 VDC ± 5%
- Supply Current: 200 mA max
- Input/Output Signal: 0-5 VDC

Vaisala Dewpoint Transmitter DMT142

- Operating Dewpoint Temperature: -50°C 〵+60°C (-76°F 〵+140°F)
- Accuracy: ±3°C (± 5.4°F)
- Withstands condensation

7.1.2 System Configuration and Measurement Methods

We measure one sample for 5 minutes at a time; the reported value is the average of the last 2 minutes. Every 6 hours, we run two calibration standards (NOAA/ESRL) certified standards at approximately 100 and 300 ppb. Sample CO concentration is calculated with the standards run before and after it.

Data from the CO analyzer are transmitted to a personal computer (PC) located in an instrument shed at the base of the 60-meter tower. The PC collects and stores ASCII data stream from the gas analyzer using LABVIEW software. The raw data are transferred to LBNL, processed into the ARM Archive format, and inspected for problems on a daily basis. Processed files are sent to the ARM Archive using the Site Transfer Suite on a weekly basis.

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

See Section 7.1, Detailed Description.

7.3.2 Procedures

See Section 7.1, Detailed Description.

7.3.3 History

Currently, the instrument performance is checked against weekly NOAA/ESRL flask samples collected from the 60-meter tower 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

This section is not applicable to this instrument.

7.4.3 Software Documentation

General description of the data product formats can be found in Section 5.

7.4.4 Additional Documentation

This section is not applicable to this instrument.

7.5 Glossary

See the ARM Glossary.

7.6 Acronyms

ARM	Atmospheric Radiation Measurement (Program)
CO	carbon monoxide
ESRL	National Earth System Research Laboratory
LBNL	Lawrence Berkeley National Laboratory
NOAA	National Oceanic and Atmospheric Administration
PC	personal computer
qc	quality control

See the ARM Acronyms and Abbreviations.

7.7 Citable References

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