



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-F504

Greenhouse Gas Measurements – Picarro G2508 with Eosense Soil Flux Chambers

Standard Operating Procedure

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1. Purpose

This procedure describes how to install Eosense eosAC soil gas flux chambers, connect them to the eosMX-P multiplexer, and operate the Picarro G2508 cavity ring-down spectroscopy (CRDS) analyzer for measuring greenhouse gas fluxes (N₂O, CH₄, CO₂, NH₃, and H₂O) from soil. The SOP also covers data acquisition using the eosAnalyze-AC software and data export for analysis (Eosense Inc., 2019; Picarro, Inc., 2021).

This SOP was originally developed for greenhouse gas emission measurements from strawberry fields in Northern California and has been modified as new projects have come on line.

2. Scope

- **Applies to:** Field deployment of the Picarro G2508 CRDS analyzer coupled with Eosense eosAC dynamic soil flux chambers and the eosMX-P multiplexer for automated soil greenhouse gas flux measurements
- **Does not apply to:** Laboratory (bench-top) Picarro configuration (see [SOP-L504](#)), atmospheric concentration monitoring without flux chambers, or eddy covariance measurements
- **Location:** All EA Program field sites within 30 m cable reach of a power source

3. Responsibilities

Role	Responsibility
Lab PI	Approve deployment plan, review data
Trained Personnel	Set up instruments, run cycles, retrieve data
New Students	Complete training before independent use

3.1. Acknowledgements

We thank Isaac Medina, Neha Vaingankar, and Bailey Lai, who worked with the instrument early on and developed early versions of this SOP. Improvements were made by Allison Joseph and Virginia Paschal.

4. Definitions

- **Cavity ring-down spectroscopy (CRDS):** The laser-based optical detection technique used by the Picarro G2508; a laser pulse is injected into a high-finesse optical cavity and the rate of light decay is measured; the decay rate is proportional to the concentration of absorbing gas molecules, enabling parts-per-billion sensitivity.
- **Chamber closure period:** The time interval during which the eosAC chamber lid is sealed over the soil surface; CO₂, N₂O, CH₄, and NH₃ accumulate in the chamber headspace during this period; flux is calculated from the rate of concentration change.
- **Dead volume:** The total volume of gas in the measurement system (chamber headspace, tubing, and instrument internal volume) that dilutes gas emitted from the soil; must be accurately characterized to calculate flux.
- **Drierite:** Anhydrous calcium sulfate desiccant used to remove water vapor from the gas stream before it enters the Picarro analyzer; must be regenerated or replaced when exhausted (color change from blue to pink for indicating Drierite).
- **eosMX-P multiplexer:** The Eosense controller that cycles sequentially through up to 16 chamber ports, directing flow from each chamber to the Picarro analyzer in turn; automates multi-chamber deployments without manual valve switching.
- **eosAC chamber:** An automated, transparent polycarbonate flux chamber manufactured by Eosense; opens and closes on a programmable schedule; connected to the eosMX-P multiplexer and Picarro analyzer via Teflon tubing.
- **Flux calculation:** Derivation of the gas flux ($\mu\text{mol m}^{-2} \text{s}^{-1}$ or $\text{nmol m}^{-2} \text{s}^{-1}$) from the linear or non-linear rate of concentration increase in the chamber headspace, chamber volume, soil surface area enclosed, and air temperature and pressure.
- **N₂O (nitrous oxide):** A potent greenhouse gas (298x CO₂ warming potential over 100 years) produced in soil by nitrification and denitrification; the primary target of many EA Program field campaigns; measured simultaneously with CH₄, CO₂, NH₃, and H₂O by the Picarro G2508.

5. Safety and Hazards

Hazards

- **Physical:** Compressed gas cylinders (calibration standards) pose crush and high-pressure hazards. The generator (if used) presents fuel spill, carbon monoxide, and noise hazards.
- **Chemical:** Drierite desiccant is a mild irritant. Calibration gas cylinders may contain pressurized gases.
- **Electrical:** Power strip, generator, and instrument connections in outdoor conditions; keep connections dry and off the ground.
- **Environmental:** High ambient temperatures (above 35 C) can cause instrument overheating.

5.1. Required PPE

- ☐ Closed-toed shoes or field boots
- ☐ Safety glasses (when handling gas cylinders)
- ☐ Work gloves (when handling cylinders and generator)
- ☐ Sun protection (hat, sunscreen)
- ☐ Hearing protection (if generator is running nearby)

5.2. Required Training

- [SOP-F001 Field Safety](#)
- [SOP-F101 Electrical Power in the Field](#)

5.3. Emergency Procedures

In case of gas leak from calibration cylinders, move upwind and ventilate the area. For generator fuel spills, contain with absorbent materials. Refer to [SOP-F001 Field Safety](#) for general field emergency response.

6. Equipment and Materials

6.1. Instruments

Item	Serial / Model	Notes
Picarro G2508 CRDS Analyzer	S/N 2143-JFAADS2048	Measures N ₂ O, CH ₄ , CO ₂ , NH ₃ , H ₂ O
Eosense eosMX-P Multiplexer	S/N listed inside device	Connects up to 12 eosAC chambers

Item	Serial / Model	Notes
Recirculation Pump (PN: A0702)	–	Provides vacuum for gas sequencing
Monitor, mouse, and keyboard	–	Connected to Picarro via USB

6.2. Chambers

Chamber S/N (old)	Firmware	Software ID	Field ID	Notes
AC20150501 (1001501)	2.2.4	50501	#1	Unable to identify
NA (1001502)	2.2.4	NA	#2	
AC20150503 (1001503)	2.2.4	50503	#3	
AC20150504 (1001504)	2.2.4	50504	#4	Repaired
AC20150505 (1001505)	2.2.4	50505	#5	
AC20190333 (1001506)	2.2.4	31333	#6	
AC20150507 (1001507)	2.2.4	50507	#7	Unable to identify
AC20150508 (1001508)	2.2.4	50508	#8	
AC20150509 (1001509)	2.2.4	NA	#9	
AC20150510 (1001510)	2.2.4	50510	#10	Fails to close properly / not fully open
AC20150511 (1001511)	2.2.4	50511	#11	
AC20150512 (1001512)	2.2.4	50512	#12	Unsure of status
AC20XX33714 (44714)	??	??	#14	
AC20190315	2.1.1	31315	#15	
AC20190316	2.2.4	31316	#16	
AC20190317	2.2.4	31317	#17	

6.3. Additional Supplies

Item	Notes
Teflon tubing and cables (30 m each)	Lettered; check for damage before use
Corrugated metal hose	Connects pump to analyzer VACUUM port
Swagelok washers	Use new washers each connection
Drierite desiccant	For moisture management
Generator (if no grid power)	Place 100+ feet downwind
Zip ties / Velcro straps	For cable management

6.4. Customer Support Contacts

Organization	Contact
Picarro	Melissa, 408-962-3978; Scott, 408-962-3987; Karrin Alstad (applications/calibration), 408-962-3991

Organization	Contact
Eosense	888-352-8313 (toll-free); support@eosense.com (Eastern Time Zone)

7. Procedure

7.1. Sampling Design

1. Locate the Picarro analyzer, multiplexer, and pump at the base station. Choose a level, shaded location if possible.
2. Use a random number generator to determine the chamber placement locations within the study area
3. All chambers must be within 30 m of the multiplexer (the length of the cables and tubing)
4. If a generator is used, place it at least 100 feet downwind of the chambers to avoid contaminating flux measurements with exhaust

7.2. Hardware Setup

1. Connect the recirculation pump to the analyzer VACUUM port using the corrugated metal hose. Use new Swagelok washers each time. Hand-tighten, then seal with a wrench.
2. Connect the multiplexer to the Picarro through USB ports on the Picarro (any port)
3. Connect the monitor, mouse, and keyboard to the Picarro via the remaining USB ports (two additional ports are available on the front of the Picarro)
4. Connect the blue monitor cable to the Picarro and the monitor power cable to the outlet
5. Ensure all machines are in the off position (circle symbol = off) before connecting power
6. Connect power cables for the CRDS analyzer, multiplexer, and pump
7. Connect the pump to the multiplexer:
 - a. Connect the control and data ports on the back of the pump to the Picarro, ensuring the white triangles face upward
 - b. Insert the other ends into any USB port on the Picarro
8. Connect clear tubing from the pump inlet (left side, clear tube) to the multiplexer inlet (right side, labeled)
9. Connect the outlet tubing: multiplexer outlet to the Picarro inlet (clear tube); pump outlet (right side, silver tube) to the Picarro outlet
10. Attach one end of the power/data cable to the COMM port on the pump and the other end to the matching COMM port on the multiplexer

! Important

Never turn off the pump while the Picarro is running. Never disconnect the vacuum while the analyzer is operating. Doing so can damage the instrument.

7.3. Installing Chamber Rings

Chamber ring installation varies based on experimental design. Install rings in advance of the measurement day to minimize soil disturbance during data collection. *TBD – add project-specific ring installation protocols as needed.*

7.4. Picarro Startup

1. Ensure all instruments are off and turn on the power strip
2. Turn on the recirculation pump first (no wait time required)
3. Switch on the Picarro. The boot-up sequence initializes the CRDS software and analyzer.
4. Switch on the multiplexer. The system requires approximately 30 minutes to warm up; warning alarms are normal until the cavity and other components reach operating temperature.
5. Keep ambient temperature below 35 C. If the DAS temperature approaches 45 C, shut down or use a fan to cool the air around the Picarro.

7.5. Placing Chambers

1. While the Picarro is warming up, connect all tubing and cables. Route tubing along the bed surface; do not let tubes fall into furrows.
2. Place chambers onto the ring bases, pressing down to achieve a good seal. Try to avoid disturbing the chamber after installation.
3. After all chambers have opened, perform a second check for foliage or debris that might obstruct the chamber seal.

7.6. Data Collection

Once the Picarro alarm indicator is green, the system is ready.

1. Verify typical atmospheric concentrations on the Picarro display:

Gas	Expected Ambient Concentration
N ₂ O	Approximately 0.3 ppm
CH ₄	Approximately 2.4 ppm
CO ₂	300–600 ppm
NH ₃	Variable
H ₂ O	1–5%

2. Open the FP-Monitor multiplexer software
3. Uncheck “Default Cycle”
4. Load the appropriate cycle from the user folder. Available cycles include:

- TBD – list current cycle names (e.g., “Straw 5 Chamber,” “Full 12,” “Full 12 minus #4”)
5. When the Picarro G2508 is warm, press “Start Cycle”
 6. Check all chambers to ensure good seals
 7. If a generator is in use, check fuel every two hours and top off. Release pressure before inserting the nozzle into the filler throat. Open the valve and press the green button for 3–5 second intervals, checking between fills to see if fuel is at or near the red line.
 8. Aim for at least 3 complete measurement cycles. For irrigation studies, target 2 cycles before irrigation, 2 during, and 2 after.

7.7. Shutdown

1. After at least two post-irrigation cycles (or at the end of the measurement period), begin retrieving chambers after each one completes its measurement, starting with chamber #1
2. Cap all tube ends with a glove secured by tape
3. Carefully coil each set of tubes and cables to limit twisting and scratching of the Teflon. Zip-tie or Velcro together and stack in order on the ground.
4. Remove chambers from the sampling locations. Separate bases from chambers and repackage into boxes.
5. When the final chamber measurement is complete, end the sampling cycle in the software
6. Connect a spare chamber to a channel and select the “Desiccate” method. Run dry air through the Picarro for 10 minutes to prevent condensation damage (Picarro, Inc., 2021).
7. Initiate the Picarro shutdown sequence; select the option for moving the instrument
8. After the Picarro has fully shut down, manually switch off in this order:
 - a. Multiplexer
 - b. Picarro
 - c. Vacuum pump
 - d. Power strip

8. Calibration

The Picarro G2508 analyzer calibration is intended to be performed infrequently (Picarro, Inc., 2021). The procedure requires three calibration standards per gas species (two points define the calibration line and a third intermediate point is used for verification).

8.1. Calibration Procedure

1. Select calibration standards that span the representative range of concentrations the analyzer will typically measure. A concentration of zero is acceptable for the low-end standard.
2. Introduce the first calibration standard into the analyzer for long enough to yield a stable reading
3. Record the stated concentration of the standard and the analyzer’s displayed value

4. Repeat for the remaining two standards
5. Plot the data with the analyzer's reported concentration on the horizontal axis and the standards' stated concentrations on the vertical axis
6. Calculate a linear best-fit equation. The slope and intercept are used to apply a correction to the analyzer's factory calibration.

i Note

TBD – develop a dedicated calibration SOP including parts to order (permeation tubes, calibration gas cylinders) and a step-by-step calibration workflow. Contact Karrin Alstad at Picarro (408-962-3991) for calibration supplies.

9. Data Export and Analysis

9.1. Using eosAnalyze-AC

1. On the Picarro desktop, open the “eosAnalyze-AC” program. If it is not on the desktop, navigate to Start Menu and search “eosAnalyze-AC.” Open the “eosAnalyze-AC-v3.4.2” folder and run the .exe application.
2. You do not need to wait for the Picarro system to warm up if you are only downloading data.
3. Click “Collect Data.” Enter the start and end times for the period you want to download. Repeat for each cycle separately; combining multiple non-contiguous periods into one export will produce a single table with large time gaps.
4. Ensure the time zone is set correctly. Pacific Time Zone is UTC-8:00.
5. Verify the data under “Measurements.” Check that the correct dates, times, and data graphs look reasonable.
6. Click “Export Data Table” and save the CSV to the desktop or an accessible location.
7. To export additional data tables, close and reopen the program before creating each new export.
8. Transfer the .csv files to a USB drive or external hard drive for analysis on another computer. The files are compatible with Excel or R (R Core Team, 2024).

9.2. Troubleshooting Data Export

If data does not load or you see a “No measurements detected” message:

1. Go to **Data > Analyzer Data Path** in eosAnalyze-AC. The data path should be \UserData\DataLog_Forerunner\. You should see subfolders organized by year.
2. Click OK, then retry collecting data.
3. If the problem persists, use Windows Explorer to search for .DAT files in \UserData\DataLog_Forerunner\YE. The file naming convention is: JFAADS2048-YYYYMMDD-HHMMSS-DataLog_Forerunner.dat where JFAADS2048 is the instrument serial number, followed by the date and time the file was created in 24-hour format.

9.3. Flux Calculation

Soil gas fluxes are calculated from the rate of change of gas concentration within the chamber headspace over the closure period. The eosAnalyze-AC software fits both linear and exponential models to the concentration time series for each closure event (Hutchinson & Mosier, 1981; Livingston & Hutchinson, 1995).

$$F = \frac{V}{A} \cdot \frac{dC}{dt} \cdot \frac{P}{RT}$$

where:

- F = flux (mass per area per time)
- V = chamber headspace volume (L)
- A = chamber area (m²)
- dC/dt = rate of concentration change (ppm/s)
- P = atmospheric pressure (atm)
- R = ideal gas constant
- T = temperature (K)

TBD – clarify in eosAnalyze-AC output what (L) and (E) designations mean for flux values (likely Linear and Exponential fits). Confirm whether “dead band range” and “chamber offset” in the data processor options need to be set for each deployment.

10. Quality Control

- Verify atmospheric background concentrations before starting each measurement cycle (see table in Section 6.6)
- Inspect all tubing connections for leaks before each deployment
- Check chamber seals visually and by monitoring initial concentration traces
- Log any chambers that fail to open or close properly and remove them from the dataset
- Do not disconnect chambers from the multiplexer during an active measurement cycle, as this can cause the data processor to miss measurements
- Ensure the FRMonitor software recognizes all connected chambers at startup; use the “System Info” button to verify. Chambers not recognized will not record data even if they open and close.
- Use FRMonitor software version 1.6.2 or later to schedule measurements

10.1. Biases and Interferences

- Ambient temperature extremes can prevent the analyzer from stabilizing properly
- High-moisture gas samples can cause condensation damage. Always run dry air through the instrument for several minutes before shutdown (Picarro, Inc., 2021).
- *TBD – develop QC criteria for acceptable flux curve fits (r^2 thresholds, maximum allowable dead band)*

11. Waste Disposal

Waste Type	Disposal Method
Spent Drierite desiccant	Regenerate by heating at 210 C or dispose as non-hazardous solid waste
Generator fuel spills	Absorb with spill kit materials; dispose per EH&S
Damaged Teflon tubing	Standard trash (non-hazardous)

12. References

- Eosense Inc. (2019). *eosAC automated soil CO₂ flux chamber and eosMX-P multiplexer: User manual*. <https://eosense.com/products/eosac/>
- Hutchinson, G. L., & Mosier, A. R. (1981). Improved soil cover method for field measurement of nitrous oxide fluxes. *Soil Science Society of America Journal*, 45(2), 311–316. <https://doi.org/10.2136/sssaj1981.03615995004500020017x>
- Livingston, G. P., & Hutchinson, G. L. (1995). Enclosure-based measurement of trace gas exchange: Applications and sources of error. *Biogenic Trace Gases: Measuring Emissions from Soil and Water*, 14–51.
- Picarro, Inc. (2021). *G2508 gas concentration analyzer for N₂O, CH₄, CO₂, NH₃, and H₂O: User's guide*. https://www.picarro.com/environmental/products/g2508_gas_concentration_analyzer
- R Core Team. (2024). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>

13. Training Record

Before deploying this instrument independently, personnel must:

1. Read this SOP, [SOP-F001 Field Safety](#), and [SOP-F101 Electrical Power in the Field](#)
2. Observe a trained operator perform a full deployment (setup through shutdown)
3. Demonstrate competence with hardware connections (pump, multiplexer, tubing, chambers)
4. Perform a supervised deployment including startup, data collection, and shutdown
5. Demonstrate ability to export data using eosAnalyze-AC
6. Be signed off by the PI or field lead

14. Appendix A: Troubleshooting

14.1. Days with Unexpected Data

If data appears on unexpected Julian days, check whether the system clock or local time on the analyzer has been changed. Compare the processed measurements against field notes to identify obvious gaps that may correspond to mislabeled days.

14.2. Days That Should Have More Data

Errors in FRMonitor log files can cause the data processor to overlook measurements. If measurements appear to be missing, check the FRMonitor logs for errors. Do not disconnect chambers from the multiplexer while it is actively running a measurement cycle, as this can cause the data processor to miss measurements, especially if the chamber was closed when removed.

14.3. Days Where Some Chambers Are Missing

If certain chambers (e.g., #1 or #2) are not sending data, this indicates either a communication issue between the multiplexer and analyzer or that the chambers were not connected. Verify that the FRMonitor software recognizes all connected chambers at startup using the “System Info” button. Disconnecting and reconnecting chambers during a measurement cycle can also cause communication errors.

14.4. N₂O Noise

N₂O measurements from the Picarro G2508 can be noisy at ambient concentrations. *TBD – document strategies for reducing N₂O noise (e.g., longer closure times, post-processing smoothing, data filtering thresholds). Contact Picarro technical support for recommendations.*

15. Appendix B: Open Questions

The following questions from previous deployments remain unresolved. Update this appendix as answers are obtained.

1. What is the difference between “dry,” “regular,” and “timed” data columns in the Data Logger setup tool?
2. What is “etalon temp” (listed under sensors in the data source)?
3. Recommendations for car-mounting the instrument? Is it acceptable to stack the multiplexer on top of the Picarro during transport?
4. Is there a way to turn on the computer without powering on the gas analyzer and vacuum?
5. What files need to be sent to the PI for reprocessing?
6. Should chamber offset (distance between the bottom of the chamber and the soil surface due to the collar) be measured for each chamber at each deployment?