

Automated Multi-species Flux Measurements with eosAC and Gasmeter DX4015/4040 and GT5000 Terra Portable Gas Analyzers

INTRODUCTION

This application note provides simplified setup instructions for using the [eosMX](#) multiplexer and [eosAC](#) soil flux chambers with the [Gasmeter DX4040/4015](#) and [GT5000 Terra](#) Portable FTIR Gas Analyzers. This combined system allows the user to collect multi-species soil gas flux measurements from up to 12 locations at once. For this document, we will be assuming the use of a DX4015, however all details also apply to the DX4040 and GT5000 Terra gas analyzer models with Calcmeter Pro software.

1. Connect eosAC<=>eosMX<=>DX4015
2. eosLink-MX collects eosAC data
3. Calcmeter exports chamber concentrations
4. eosAnalyze-AC calculates flux estimates

IMPORTANT

This application note is not a replacement for the user manuals for each product. We recommend reading both of them before proceeding.

CONNECT eosMX TO GASMETER DX4015

The eosMX and DX4015 are connected by two lengths of tubing, which recirculate sampled gas between the analyzer and the eosAC chamber. Connect one piece from the Outlet port of the eosMX to the Out port of the DX4015 (Sample Out port in the DX4040). Connect the other piece from the Inlet port of the eosMX to the Sample port of the DX4015 (Sample In port in the DX4040). When using the DX4015, hand tighten the swage nuts and then turn a further 1/4" turn to secure using a wrench. If connecting to a DX4040, use its quick connect fittings and snap into the corresponding front panel port. Hand tighten the swage nuts and then turn a further 1/4 turn to secure using a wrench.



Figure 1. Out, Zero and Sample ports on the DX4015 gas analyzer.

CONNECTING eosMX / eosACs

With the eosMX plumbed to the Gasmeter analyzer, we now have to provide power for the multiplexer, as well as establish the data connections required for eosAC measurement scheduling and reporting. This is established by first connecting the eosMX to the monitoring PC via the provided USB cords and the CONTROL and DATA ports on the rear of the multiplexer.

Next, each eosAC is connected to the eosMX multiplexer through two lengths of tubing and one power/data cable. Using the provided eosAC tubing, insert the bare ends of the tubing into the INLET and OUTLET ports on the rear of the eosAC. Attach the swaged end of the tubing connected to the eosAC INLET port to Inlet 1 on the front of the eosMX. Next, attach the swaged end of the tubing connected to the eosAC OUTLET port to Outlet 1 on the front of the eosMX-P (Figure 2).



Figure 2. Attach swaged ends of eosAC tubing to the eosMX on Inlet and Outlet ports 1 and attach the AC power/data cable to COMM 1.

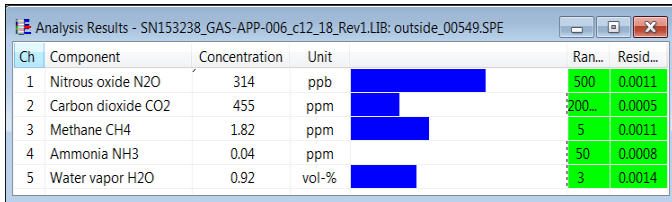
Attach the power/data cable to the COMM 1 port of the eosMX and then to the COMM port on the back of the eosAC (Figure 5). Repeat this process of connecting the tubing and the communication cable for each eosAC that will be connected to the eosMX-P, ensuring that each new eosAC is connected to matching port numbers (Input 2, Outlet 2, COMM 2, etc).

CONFIGURING CALCMET SOFTWARE

To properly integrate the Calcmeter software with eosAC chamber measurements, there are three main steps. First, the specific gas species you are interested in collecting flux measurements for must be configured for the eosAnalyze-AC software - this can be done before or after you collect chamber measurements, but must occur before processing the data in eosAnalyze-AC. Ensure that the chemical formula (e.g. CO₂ for carbon dioxide) is

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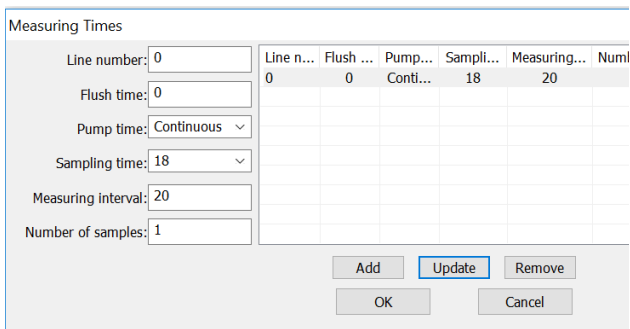
present in the species name in order for them to be recognized by the Eosense software.



Ch	Component	Concentration	Unit	Ran...	Resid...
1	Nitrous oxide N2O	314	ppb	500	0.0011
2	Carbon dioxide CO2	455	ppm	200...	0.0005
3	Methane CH4	1.82	ppm	5	0.0011
4	Ammonia NH3	0.04	ppm	50	0.0008
5	Water vapor H2O	0.92	vol-%	3	0.0014

Figure 4. Example gas species imported for analysis by the Calcmeter software. Note the chemical formula included in each field name.

Next, you need to ensure that the continuous sample rate of the Gasmeter analyzer is appropriate for flux chamber measurements. For the best balance of data density and analytical accuracy, we recommend a total measurement time of 20 seconds. Using a shorter sampling time can compromise the accuracy of concentration measurements, while using a longer one results in too few points for flux fitting. Adjust this value through Options => Measuring Times, setting the Measuring interval to 20 s and the Sampling time to 18 s, before clicking Update (see **Figure 5**).



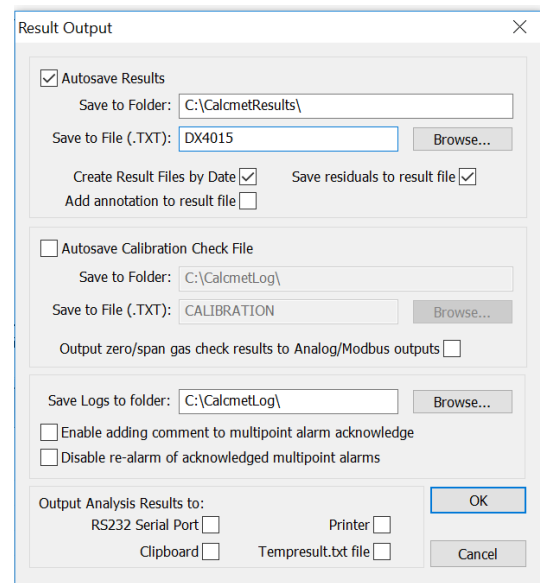
Line n...	Flush ...	Pump...	Sampli...	Measuring...	Numl
0	0	Conti...	18	20	

Line number: 0
 Flush time: 0
 Pump time: Continuous
 Sampling time: 18
 Measuring interval: 20
 Number of samples: 1

Add Update Remove
 OK Cancel

Figure 5. The Calcmeter Measuring Times window with updated value.

Finally, ensure that the Calcmeter software is logging data in a format expected by the eosAnalyze-AC software. Choose Result Output from the Options menu. Ensure that Autosave Results is checked, as well as Create Result Files by Date and Save residuals to results file. Change the default Save To File (.TXT) filename to DATA. See **Figure 6** for details on Result Output settings.



☒ Autosave Results
 Save to Folder: C:\CalcmeterResults\
 Save to File (.TXT): DX4015
☒ Create Result Files by Date
☒ Save residuals to result file
☐ Add annotation to result file

☐ Autosave Calibration Check File
 Save to Folder: C:\CalcmeterLog\
 Save to File (.TXT): CALIBRATION
☐ Output zero/span gas check results to Analog/Modbus outputs

Save Logs to folder: C:\CalcmeterLog\
☐ Enable adding comment to multipoint alarm acknowledge
☐ Disable re-alarm of acknowledged multipoint alarms

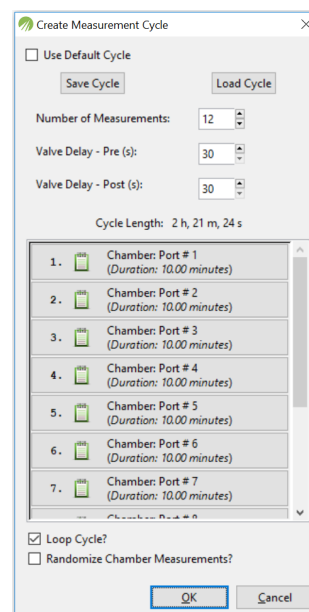
Output Analysis Results to:
 RS232 Serial Port ☐ Printer ☐
 Clipboard ☐ Tempresult.txt file ☐

OK Cancel

Figure 6. The Calcmeter Result Output window, showing the proper configuration of the Calcmeter software logging for compatibility with the eosAnalyze-AC analysis software.

SCHEDULING CHAMBER MEASUREMENTS

The eosLink-MX software runs on any Windows-based PC, serving as the control panel for up to 12 eosAC's and logging chamber peripheral data. Users can customize measurement schedules, incorporating both chambers and calibration standards, which can be run as a single sequence or looped continuously (**Figure 7**). For best results, this software can be run on the same laptop as used by the Gasmeter analyzer for sampling.



☐ Use Default Cycle
 Save Cycle Load Cycle

Number of Measurements: 12
 Valve Delay - Pre (s): 30
 Valve Delay - Post (s): 30

Cycle Length: 2 h, 21 m, 24 s

1.	Chamber: Port # 1 (Duration: 10.00 minutes)
2.	Chamber: Port # 2 (Duration: 10.00 minutes)
3.	Chamber: Port # 3 (Duration: 10.00 minutes)
4.	Chamber: Port # 4 (Duration: 10.00 minutes)
5.	Chamber: Port # 5 (Duration: 10.00 minutes)
6.	Chamber: Port # 6 (Duration: 10.00 minutes)
7.	Chamber: Port # 7 (Duration: 10.00 minutes)

☒ Loop Cycle?
☐ Randomize Chamber Measurements?

OK Cancel

Figure 7. The Create Measurement Cycle window from the eosLink-MX software. Here, users can customize the schedule of chamber measurements to best suit their field site.

The eosLink-MX software acts as the coordinator for the eosMX multiplexer and connected chambers, ensuring that all eosAC measurements are logged for data integration with the Gasmeter analyzer results.

See Section 6 of the eosAC/eosMX User Manual for more details.

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CALCULATING FLUX MEASUREMENTS

The chamber accumulation data can be viewed in real-time through the Calcmeter software, showing the increase (or decrease) in headspace concentrations as the chamber measurement evolves (**Figure 8**). We strongly recommend paying close attention to these plots during the first few chamber measurements, as any issues with your measurement system will be most obvious in the shape of these curves.

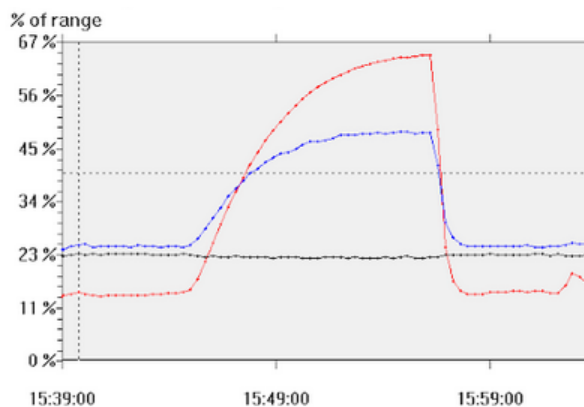


Figure 8. The Calcmeter software Trend View showing two timeseries data for an eosAC chamber measurement. CO₂, CH₄ and N₂O headspace concentrations are shown, demonstrating characteristic exponential increases.

These headspace concentrations are logged to the CalcmeterResults folder mentioned earlier. The eosAnalyze-AC software automatically combines these raw concentration measurements with the recorded chamber events and peripheral data, in order to produce multi-species flux estimates without the need for extensive manual calculation. Once your system is configured, you simply select the date range to import data from, review the flux fits and headspace concentrations, then export the data table for post processing (**Figure 9**).

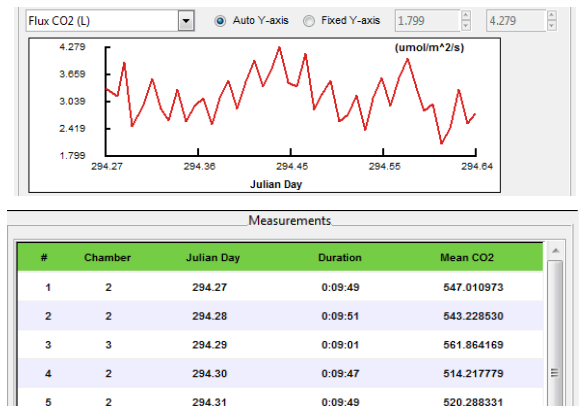


Figure 9. eosAnalyze-AC software showing a sample of measurement data for each chamber closure as a flux timeseries (top) and as tabulated data (bottom).

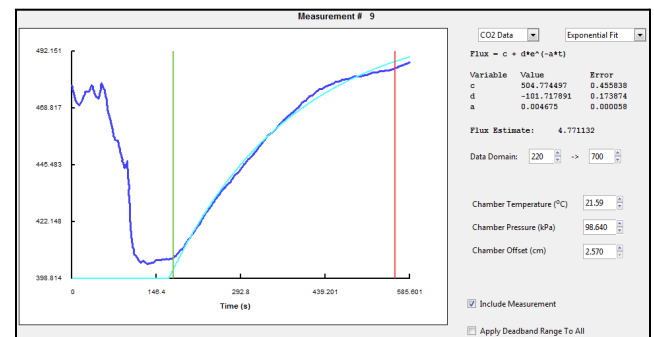


Figure 10. The eosAnalyze-AC showing CO₂ accumulation in an eosAC chamber measurement. This tool allows you to compare the validity of linear vs exponential fits, exclude bad portions of your data and optimize your estimation accuracy.

In summation, to measure multi-species gas fluxes with the combined Gasmet and Eosense systems you simply:

1. Use eosLink-MX to schedule and collect eosAC data from up to 12 chambers
2. Use Calcmeter to export the chamber headspace concentrations and choose your gas species
3. Use eosAnalyze-AC to combine chamber events and concentrations into exportable flux estimates

SOIL PILOT EXPERIMENT

When first integrating the eosAC/eosMX chamber system with the Gasmet DX4015 Portable FTIR gas analyzer, we set up a simple series of soil plots, consisting of a varying mixture of potting soil and plant fertilizer. To produce some more interesting gas emissions, biomaterial from a local marsh was added to several of the plots, along with a sugar catalyst.

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Figure 11. An eosAC sitting on the prepared soil plot, plumbed to the eosMX and Gasmeter DX4015 analyzer.

While our soil plots exhibited only weak CH₄ activity, they emitted high amounts of CO₂ and N₂O producers, with fluxes as high as 85 $\mu\text{mol}/\text{m}^2/\text{s}$ and 70 $\text{nmol}/\text{m}^2/\text{s}$ respectively, due to the added fertilizer and various catalytic additives.

One of the benefits of the FTIR approach to measuring gas concentration is that the raw spectra data can be easily reanalyzed later to look for new gas species. For example, if we had not originally included CH₄ in our list of Calcmeter species, we may have become interested in methane fluxes after the fact to contextualize the high CO₂ emissions. In this case, it would simply be a matter of adding methane in the Calcmeter software and importing the raw data again - even weeks or months later! Users can add IR-absorbing gasses to their application libraries to monitor more than just CO₂, CH₄, N₂O, NH₃, CO, and H₂O vapor.

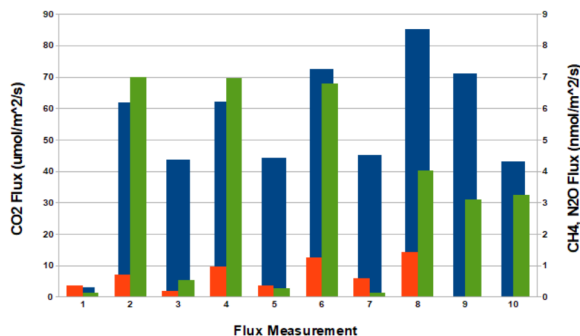


Figure 12. Flux measurements from the eosACs. Note the extreme magnitudes of CO₂ and N₂O, caused by the intentional soil priming.

CONCLUSIONS

The Eosense eosMX and eosAC products offer Gasmeter users an all-in-one solution for measuring multi-species soil gas flux, with the DX4015/4040 or GT5000 Terra providing an unparalleled range of analysis options for soil researchers. This combined system can measure from up to 12 eosAC chambers in a radius of 30 m from the central Gasmeter analyzer.

Our laboratory soil plot test demonstrated the ability of the DX4015 to resolve chamber accumulation timeseries and produce eosAC flux estimates for a variety of gas species.

ACKNOWLEDGEMENTS

Thanks to Allan Bradey of Gasmeter Technologies Inc. for his help in preparing and testing the combined Eosense and Gasmeter systems.

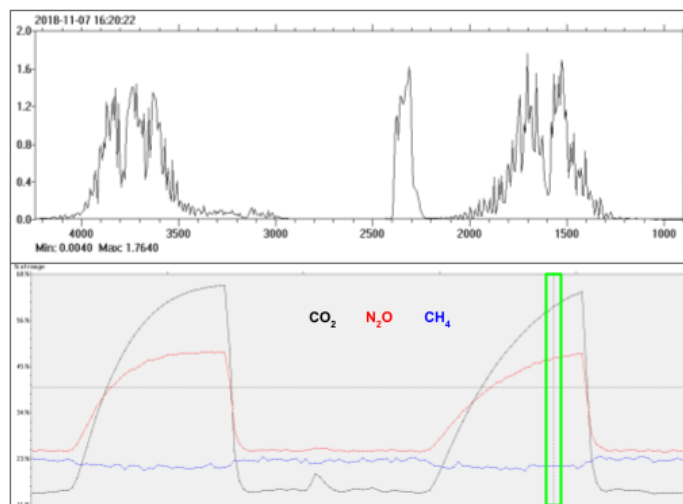


Figure 13. (Top) DX4015 Spectra sample from a closed eosAC during a chamber measurement.

(Bottom) Headspace concentrations from two eosAC chambers showing CO₂ (black), N₂O (red) and CH₄ (blue). The green section highlights the specific sample that produced the spectra shown above.

Showing both the Gasmeter analyzer spectra and the chamber headspace accumulation, this dual plotting is a critical tool for assessing gas flux measurements and overall system health.