Introduction

This application note provides simplified setup instructions for using the eosMX multiplexer and eosAC soil flux chambers with the Gasmet DX4040/4015 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 gas analyzer model with Calcmet Pro software. Please note that this document is not a replacement for the specific product user manuals, which should be read before proceeding.

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

Connecting eosMX / eosACs

With the eosMX plumbed to the Gasmet 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).

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).
Configure Calcmet Software

To properly integrate the Calcmet 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 present in the species name in order for them to be recognized by the Eosense software.

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

Next, you need to ensure that the continuous sample rate of the Gasmet 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).

Figure 5. The Calcmet Measuring Times window with updated value

Finally, ensure that the Calcmet 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 DX4015 (or DX4040 if applicable). See Figure 6 for details on Result Output settings.

Figure 6. The Calcmet Result Output window, showing the proper configuration of the Calcmet 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. For best results, this software can be run on the same laptop as used by the Gasmet analyzer for sampling.

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 Gasmet analyzer results.

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

The chamber accumulation data can be viewed in real-time through the Calcmet software, showing the increase (or decrease) in headspace concentrations as the chamber measurement evolves. 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.

These headspace concentrations are logged to the CalcmetResults 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.

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 Calcmet 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 Plot Testing

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, comprised 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.
While our soil plots exhibited only weak CH\textsubscript{4} activity, they emitted high amounts of CO\textsubscript{2} and N\textsubscript{2}O producers, with fluxes as high as 85 μmols/m\textsuperscript{2}/s and 70 nmols/m\textsuperscript{2}/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 CH\textsubscript{4} in our list of Calcmet species, we may have become interested in methane fluxes after the fact to contextualize the high CO\textsubscript{2} emissions. In this case, it would simply be a matter of adding methane in the Calcmet software and importing the raw data again - even weeks or months later! Users can add IR-absorbing gases to their application libraries to monitor more than just CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O, NH\textsubscript{3}, CO, and H\textsubscript{2}O vapor.

Figure 12. (Top) DX4015 Spectra sample from a closed eosAC during a chamber measurement. (Bottom) Headspace concentrations from two eosAC chambers showing CO\textsubscript{2} (black), N\textsubscript{2}O (red) and CH\textsubscript{4} (blue). The green section highlights the specific sample that produced the spectra shown above. Showing both the Gasmet analyzer spectra and the chamber headspace accumulation, this dual plotting is a critical tool for assessing gas flux measurements and overall system health.

Conclusions

The Eosense eosMX and eosAC products offer Gasmet users an all-in-one solution for measuring multi-species soil gas flux, with the DX4015/4040 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 Gasmet 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.

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