eosAC, eosMX and eosMX-P

Autochambers, Multiplexers
and related Software

eosense.com

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WARNING: CRUSH HAZARD

This symbol indicates that a crush hazard is present. Keep hands and all other objects clear of the bottom lip of the chamber and the chamber arms during operation. Never attempt to prevent the chamber from opening or closing.
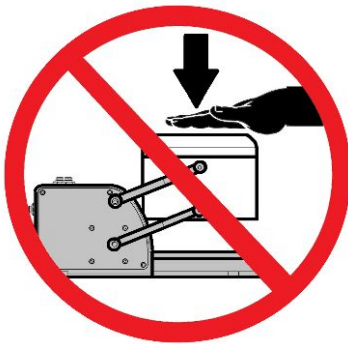
CAUTION: RISK OF DAMAGE TO EQUIPMENT

This symbol indicates that there is a risk of damage to the equipment. Manually forcing an eosAC chamber to close can cause permanent damage to the internal electronics, even when unpowered and disconnected. If absolutely necessary, disconnect the eosAC completely then SLOWLY close the chamber using gentle pressure. Never attempt to manually close a powered chamber.

This product complies with the following directives for CE Marking:

2006/42/EC (Machinery)
2011/65/EU (RoHS2)
2004/108/EC (Electromagnetic compatibility)

For more information, contact support@eosense.com

Contents

!	**This is a warning** It tells you important details about how to keep you and your equipment safe!	?	**This is an infobox** It provides extra information about your eosAC!

1   Summary

1.1 eosAC User Manual

This manual is intended to help end-users of the Eosense eosAC autochamber setup and use their chamber system alongside of a multi-species gas analyzer to measure a variety of soil flux and gas concentration data. The information provided is intended for first time users of the eosAC, and assumes a working knowledge of the gas analyzer in question (the Picarro G2508 is used as an example throughout this document). We highly recommend that you read the document thoroughly before using the eosAC, as each of the hardware and software features are explained in detail.

This manual is intended for users of the eosAC with version 3.5.0 of the eosAnalyze-AC interface. Please check the Eosense website for the most up-to-date manuals and software.

If you have any specific questions or require additional guidance or information, please contact Eosense Technical Support through our website, by phone or by email:

<div align="center">

support@eosense.com
888.352.8313
http://eosense.com/support

</div>

➔   Make sure your system is ready to go: Section 3 (**Quick Start Checklist**) lists everything you need to get your system up and running. Make sure to read the relevant sections of the manual for more information on each step!

➔   Want to jump right into collecting flux measurements? Section 5 (**Chamber Scheduling and Monitoring**) tells you all you need to know to start out. For best results, we do recommend you read the user manuals for both the eosAC and the eosMX multiplexer!

➔   Ready to start viewing and analyzing your flux data? Section 6 (**eosAnalyze-AC**) explains how the eosAnalyze-AC software allows you to import, view and quality check your measurements, before exporting the data.

➔   Running into problems? Section 7 (**Troubleshooting**) covers some of the most common issues and how to address them. And you can always contact us directly at support@eosense.com

2 Introduction to Soil Flux Chambers

2.1 Soil Flux Chamber Measurements

Ecological or anthropogenic processes can produce or consume a variety of gases in the soil subsurface, such as carbon dioxide (CO_2), methane (CH_4) and Nitrous Oxide (N_2O). In the event of production, these gases are transported (typically diffusively) to the surface and emitted into the lower atmosphere, creating a positive flux. In the case of consumption, gases from the lower atmosphere can be absorbed into the soil, creating a negative flux. The most common method for measuring these emissions are soil flux chambers, which fall into a few categories.

The most common commercial flux chamber is the closed dynamic chamber, which when placed on the soil surface, accumulates gas in its headspace. The flux is then calculated based on the rate of increase in the chamber headspace concentration, which is the mostly widely used and studied method of estimating soil fluxes via chamber measurements.

For a detailed explanation and comparison of these different chamber designs, see Pumpenen et al, 2011[1].

2.1 Automated Chambers and External Analyzers

The most common method of capturing the chamber concentration timeseries is through manual sampling, where methods such as syringe extraction are used to collect several samples of headspace gases for laboratory analysis at a later date. In order to automate the process and improve data quality, many researchers had switched to automated chamber systems coupled with dedicated gas analyzers. While the approach is essentially the same - fitting the chamber timeseries to estimate the rate of flux - the vastly improved temporal resolution and automation of the analyzer based system allows for more robust flux estimation.

CO_2 analyzers were among the first instruments to be used in this manner, and led to the development of various automated chamber systems. With the increasing sophistication and affordability of laser-based systems, measurement of other trace gas fluxes has become increasingly common. The eosAC and eosMX automated chamber system was designed for compatibility with leading gas analyzers, such as the Picarro G2508 and the LGR UGGA, allowing the analytical power of these instruments to be easily adapted into soil flux measurements.

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[1] *Pumpanen, J et al. 2003. Comparison of different chamber techniques for measuring soil CO2 efflux. Agric. For. Meteorol. 3-4:159-76*

2.3 Measurement Overview

The following steps illustrate the specific sequences of events that occurs when the eosMX / eosAC system is collecting flux measurements in the field.

1. User connects all eosAC / eosMX / gas analyzer hardware

2. User runs eosLink-MX, which scans and detects any attached eosAC chambers

3. User creates or loads a measurement cycle and starts collecting flux measurements

4. The scheduled flux measurement begins
   a. The eosMX sends a signal to the chamber to close
   b. The eosMX switches valves so that gas from the chamber is flowing to the analyzer
   c. The eosAC sends temperature, pressure and auxiliary data back to eosLink-MX
   d. eosLink-MX stores all received data in an FRMonitor .log file

5. The scheduled flux measurement ends
   a. The eosMX sends a signal to the chamber to open
   b. The eosMX switches valves so that the analyzer is now drawing from the relief valve

6. Steps 4 and 5 repeat until the schedule has ended or the user stops it manually

7. User runs eosAnalyze-AC to begin importing flux measurements

8. eosAnalyze-AC combines analyzer data with the FRMonitor logs to create flux measurements

9. User reviews and adjusts data fitting as needed

10. User exports the flux measurement data for further analysis

3   Quick Start Checklist

❏   **Review Documentation**
    ❏   User Manual for you specific analyzer
    ❏   eosAC / eosMX User Manuals
    ❏   Relevant Application Notes for your study (e.g. AN0010 - Powering the eosAC, eosMX and Gas Analyzer Using a Generator)

❏   **Analyzer Setup (Picarro only)**
    ❏   Send the contents of these folders to Eosense for modification
        ●   C:/Picarro/G2000/AppConfigConfig/DataLogger/
        ●   C:/Picarro/G2000/AppConfig/Config/Archiver/
        ●   C:/Picarro/G2000/AppConfig/Config/PeriphIntrf/   (if present)
    ❏   Overwrite the previous folders with the returned files and restart the analyzer (using the Mode Switcher on the Picarro Desktop)
    ❏   Ensure that the UserData/DataLog_Forerunner directory structure was created
    ❏   Install the USB-Serial driver

❏   **Eosense Software (Picarro)**
    ❏   Download and extract the software folder for eosLink-MX and eosAnalyze-AC onto the analyzer desktop

❏   **Eosense Software (LGR)**
    ❏   Contact support@eosense.com for assistance installing the eosLink-MX software onto your analyzer
    ❏   Download and extract the software folder for eosAnalyze-AC onto the desktop of a windows PC

❏   **eosAC/eosMX Hardware Setup**
    ❏   Review the relevant Application Note (Picarro or LGR) for details on how to connect power, data and gas tubing in your system
    ❏   Connect the eosMX Multiplexer to power using the supplied power cable
    ❏   Connect gas tubing between the eosMX and your analyzer
    ❏   Connect the two USB cables from the eosMX to your analyzer
    ❏   Connect each eosAC to the eosMX using the combined power / data cable
    ❏   Connect gas tubing between each eosAC and the eosMX

4   Hardware and Field Deployment

4.1 Connecting Picarro Gas Analyzers with eosAC/eosMX

The eosMX allows the user to coordinate Picarro gas analyzer samples from up to twelve eosAC autochambers (sequentially). The eosMX is constructed of light weight aluminum, and is designed to stack on top of a Picarro gas analyzer, with the external pump resting on top of the eoxMX. The three instruments should be connected in a continuous loop, as shown in **Figure 1**.

Figure 1 Gas tubing connections between the analyzer, eosMX and external pump.

In order to create this loop, a number of components are required:

Picarro Analyzer (e.g. G2508)
Recirculation Pump (A0702)
Eosense eosMX Multiplexer
(A) Convoluted Metal Hose (VCR)
(B) VCR Coupling (SS-4-VCR-CG)
(C) VCR →Swagelok Fitting (SS-4-VCR-6-400)
(D) 1/4 Ferrule x2 (SS-403-1, SS-404-1)
(E) 1/4 Swage Nut x2 (SS-402-1)
(F) Vacuum VCR Connection
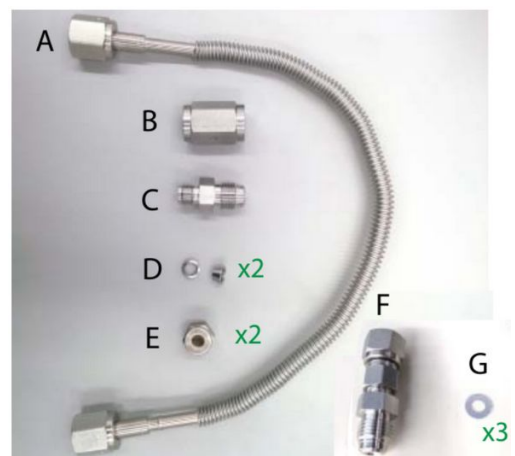(G) VCR Metal Gasket x3 (SS-4-VCR-2)

Figure 2 Gas tubing connections between the analyzer, eosMX and external pump.

Carefully set the analyzer, eosMX and external pump on a flat surface and remove the caps from the analyzer (Vacuum and Input) and pump (Vacuum and Exhaust), if still present. There are two ports on the back of the recirculating pump: one provides vacuum to the Picarro analyzer, which is necessary for its operation, while the other port acts as the gas exhaust for the system. To connect the external recirculating pump into the gas sampling loop, begin by attaching the VCR coupling (B) to the outlet port of the pump. Next, insert the VCR Metal Gasket (G) into the coupling and attach the VCR to Swagelok fitting (C). Once the VCR to Swagelok fitting (C) is finger tight, turn the fitting an additional 1/8th turn to compress the gasket. Next, attach the Vacuum VCR Connection (F) to the Vacuum port of the gas analyzer. Connect the pump and analyzer vacuum ports using the convoluted metal hose (A). Ensure that each connection receives a VCR Metal Gasket (G) and is tightened 1/8th of a turn past finger tight.

Before attaching the tubing between the analyzer and the eosMX unit, ensure that the unit's main power is turned on so that the pressure relief valves are active. Depending on application, the tubing lengths for the eosMX setup may vary. If the eosMX will rest on top of the analyzer, then two lengths of tubing approximately 60 cm long are sufficient to connect the eosMX and analyzer. Pre-Swagelock fitted tubing lengths are included with your eosMX equipment. Using one of these pieces, attach one end to the gas analyzer inlet and the other end to the eosMX Inlet, hand tightening and then turning an extra 1/4 turn with a wrench. Using the other piece, repeat this process between the external pump Swagelock fitting (C) and the eosMX Outlet

Note: The Inlet port is required in order for the the gas analyzer to draw chamber samples, however the Outlet port need only be connected if you are interested in recirculating the sampled gas back to the chamber. Recirculation is recommended, as this minimizes the impact on the soil system and thus allows for unbiased flux measurements.
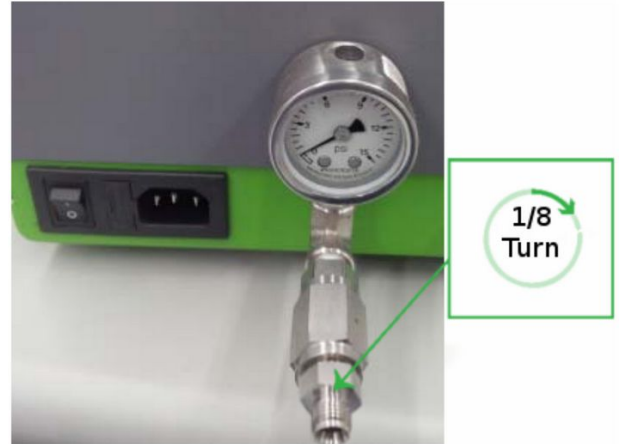

Figure 3 External recirculating pump with VCR coupling and Swagelok fitting attached.

Figure 4 External recirculating pump with CVR coupling and Swagelok fitting attached.

4.2 Connecting LGR Gas Analyzers with eosAC/eosMX

Up to twelve eosAC autochambers can be linked to the UGGA through the eosMX. Connecting the UGGA to the eosMX is accomplished through two pieces of tubing (Swagelock fitting on one end) and the two USB cables from the eosMX. With the UGGA off and using one piece of the provided tubing, connect the Swagelock end to the Inlet port on the back of the eosMX, and plug the bare end into the Inlet push-connect port of the UGGA, making sure it is firmly seated. Using the other piece of tubing, connect the Swagelock end to the Outlet port on the back of the eosMX, and plug the bare end into the Waste push-connect port of the UGGA, making sure it is firmly seated.

Figure 5 Top: Inlet and Waste push-connect ports on the UGGA. Bottom: Inlet and Outlet ports on the eosMX.

Note: The Inlet port is required in order for the the gas analyzer to draw chamber samples, however the Waste port need only be connected if you are interested in recirculating the sampled gas back to the chamber. Recirculation is recommended, as this minimizes the impact on the soil system and thus allows for unbiased flux measurements.

4.3 Connecting eosAC autochambers to the eosMX

The eosMX front face has connections for up to twelve Eosense eosAC autochambers, which include a combined power / communication port and two Swagelok gas fittings for transporting gases to and from the analyzer. Each connected eosAC will require a power/data cable and two lengths of tubing (Swage fitting on one end only), with a maximum length of 15 m (LGR Analyzers) or 30 m (Picarro Analyzers). Connect each chamber by attaching the bare end of one length of tubing to the Inlet port on the rear of the eosAC by pushing the tubing into the quick connect port until held securely. Repeat this process with the other length of tubing and the eosAC's Outlet port. Connect the Inlet tubing to an Inlet port on the front of the eosMX and the Outlet tubing to the paired Outlet port using the Swage fittings. Depending on the environment in which the analyzer and eosAC are deployed, steps to protect these lines from rodents and other wildlife may be recommended. Attach one end of the eosAC power/data cable to the back of the eosAC, ensuring that it is connected to the top left electrical port, labelled COMM. Connect the other end of the cable to one of the power/data ports on the front of the eosMX. Each eosAC should be connected to a power/communication port and the matching Inlet/Outlet fittings. For example, the first eosAC would connect to COMM 1, Inlet 1 and Outlet 1, while the next would connect to COMM 2, Inlet 2 and Outlet 2 and so on. Each eosAC must be connected to matched gas and data ports. Connecting the power/data cable or tubing to the wrong ports will result in failed measurements and/or pressure issues with the connected gas analyzer.
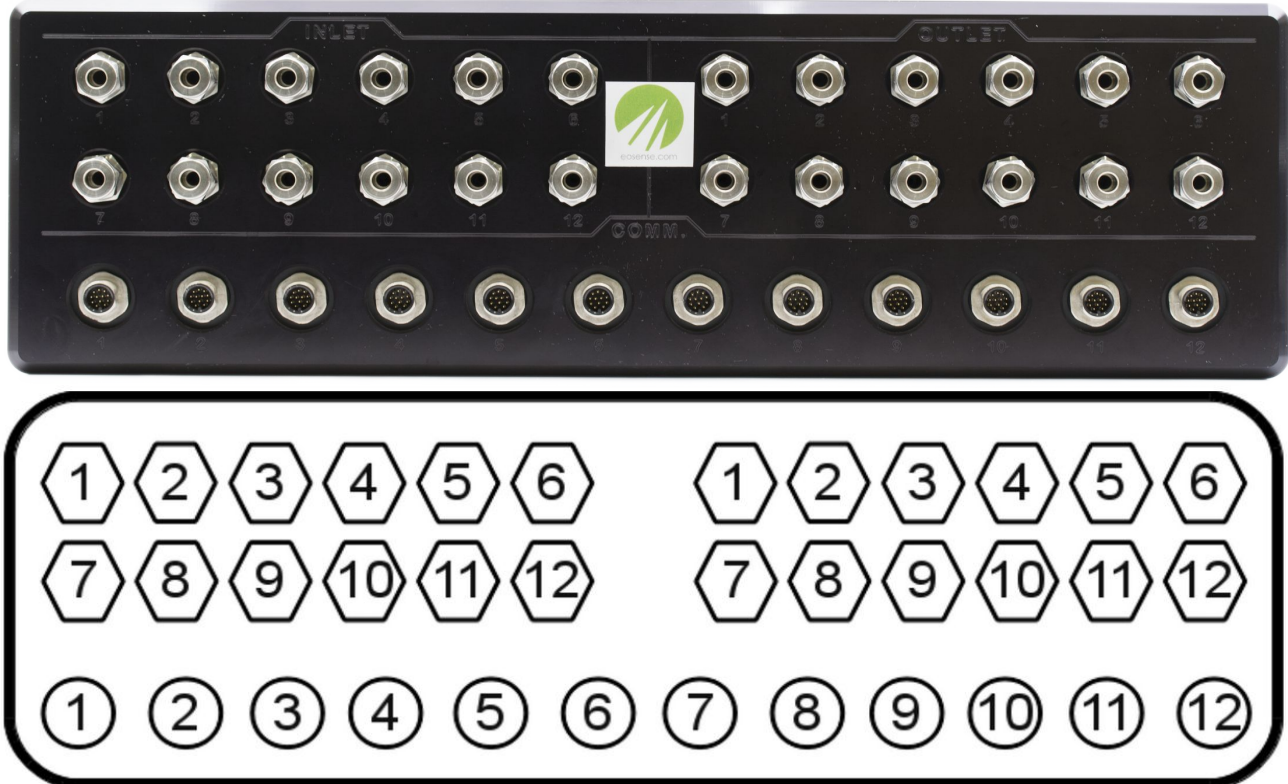

Figure 6 Top: eosMX front face. Bottom: Diagram of the eosMX front face showing the correct pairing between power/data, inlet and outlet ports.

Figure 7 Power/Data Cable connected to the eosAC

4.4 eosMX Power and Communication

The eosMX power cable should be connected to stable 100-240 VAC power (43-67 Hz), and draws a absolute maximum of 430 W (under normal operation, peak draw is 108 W and the average is 20 W). The On/Off switch is located directly under the cable, with 1 indicating that the eosMX is powered, and 0 indicating no power. The two USB cables should be connected to the computer that will be operating the chamber scheduling software and storing measurement logs (typically the gas analyzer itself).

Figure 8 The rear face of the eosMX, showing gas analyzer Inlet and Outlet fittings; the eosMX power cable and On/Off switch; and the two USB communication cables.

4.5 Deploying eosACs in the field

Before deploying an eosAC, first clear any vegetation from the soil surface. The eosAC can be installed onto a previously installed soil collar (use a collar of at least 5 cm), or directly on the soil surface. Push the eosAC into the collar so that it is flush with the surface. Depending on the density of the soil, you may need to precut a circle for insertion. While the eosAC is water resistant, avoid situating the probe in areas of standing water or hollows where flooding is a possibility. For best results choose a flat, clear soil surface to deploy the chamber.

Figure 9 An eosAC deployed in the field using a simple PVC collar.

When collecting eosACs from your field site, first close the chamber using the **eosAC Control** option in the eosLink-MX software. Once the chamber has fully closed, disconnect the power/data cable and tubing, then gently remove the chamber from its collar, disturbing the soil as little as possible.

WARNING: Manually forcing an eosAC chamber to close can cause permanent damage to the internal electronics, even when unpowered and disconnected. Always use the eosLink-MX software to close the chamber whenever possible.

If absolutely necessary to close by hand, disconnect the eosAC completely, then SLOWLY close the chamber using gentle pressure.

Never attempt to manually close a powered chamber.

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5 Chamber Scheduling and Monitoring

5.1 Single eosAC

Please see Application Note AN0006 (available through support@eosense.com) for information on how to connect a single eosAC directly to a Picarro gas analyzer.

5.2 Multiplexed eosACs

The eosLink-MX software is used to collect and store peripheral data from and control the measurement cycle of up to twelve eosACs. eosLink-MX logs temperature, pressure and peripheral data from connected eosACs while also serving as the control panel for the eosMX Multiplexer.

The main window shows the current connection status (Idle, Searching, or Measuring), the type of Measurement Cycle (Default or Custom), the current and next steps in the current cycle, and the detected eosAC. Once a Measurement Cycle has been selected, clicking the Start button will begin the cycle, with a new option to Stop measuring at any point.

As each step in the cycle completes, the main window will be updated to show the new current step (with time remaining) and the next step in the cycle (with duration). The numbers underneath the "Multiplexer" heading will also update, with unused multiplexer ports grayed out, and currently closed chambers in bold. If the cycle is set to loop (see **Figure 13**), it will continue until manually stopped, otherwise the program will return to an idle status when the cycle is complete.

A number of chamber specific notifications can be viewed by clicking on the **System Info** button. This window contains a tab for each of the twelve possible eosACs, showing the most recently collected temperature and pressure data, as well as the current status of the chamber and any related warnings or

Figure 10 The eosLink-MX main window, showing an active cycle with two detected eosACs

messages. If eosACs are experiencing issues, this is the first place to look for diagnostic and troubleshooting purposes. The **Refresh Data** button will update the displayed chamber data, while the **Chamber Timing** button opens the Adjust Chamber Timing window. This screen shows the current chamber's ID number and on-board compression time, which controls the seal of the chamber against the lower gasket. In the event that a chamber is not seating properly when closed (either not closing tightly enough or "popping"), the compression time can be adjusted from this window to resolve the issue, with the Open and Close Chamber buttons allowing you to quickly test different compression settings.
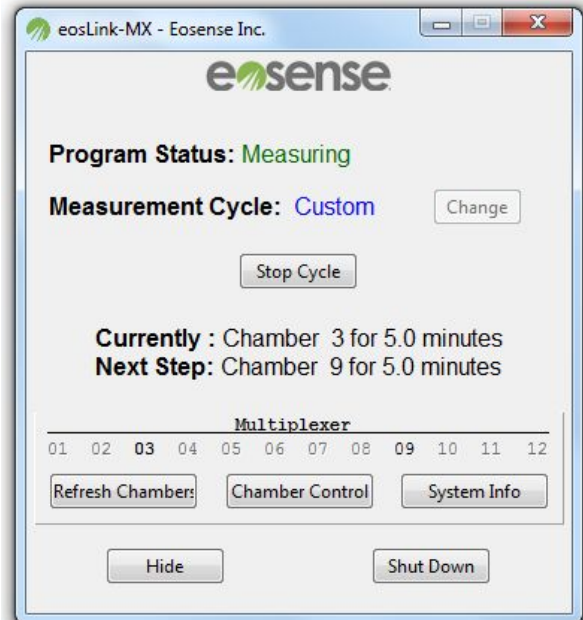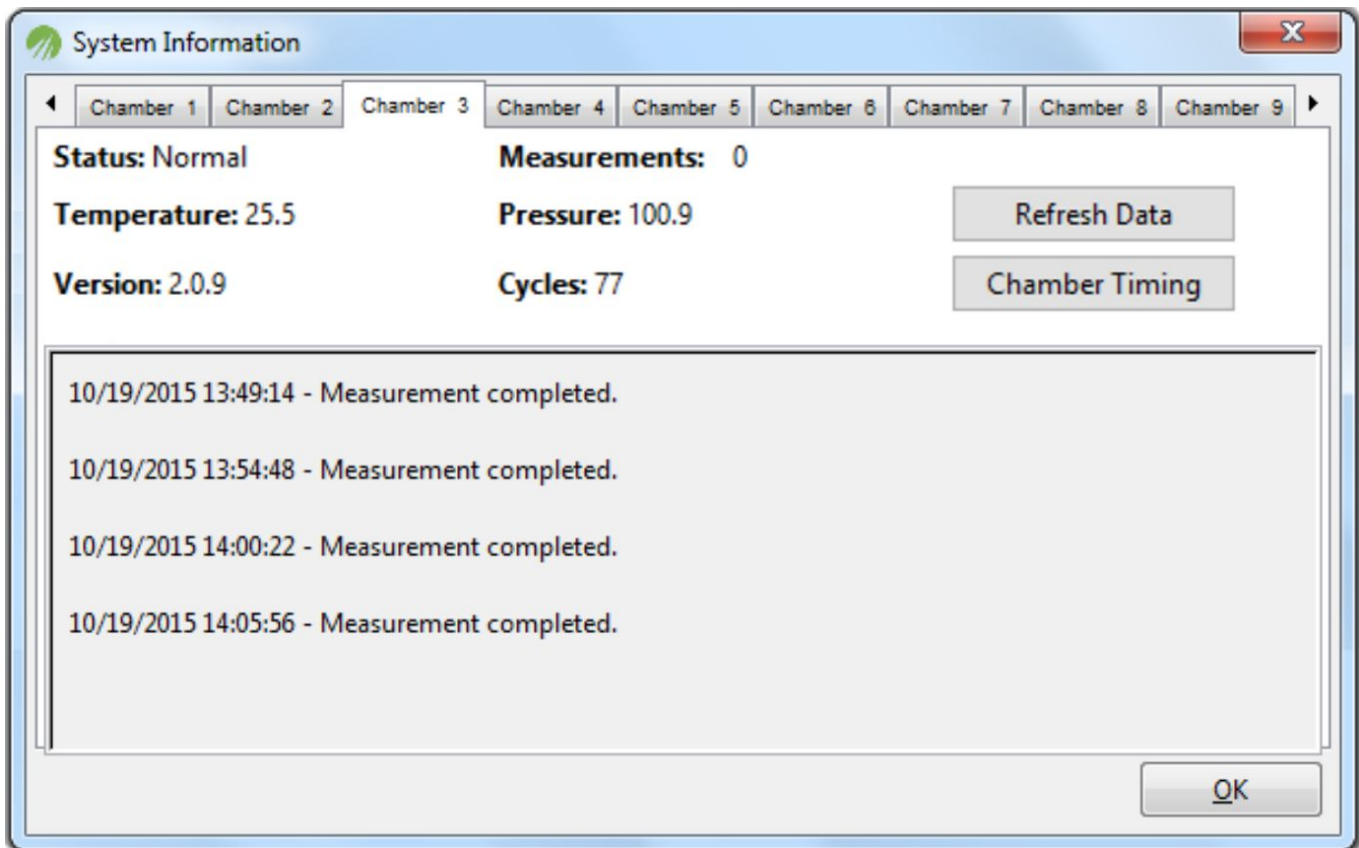
Figure 11 The System Information window, showing chamber notifications and recent data collected.
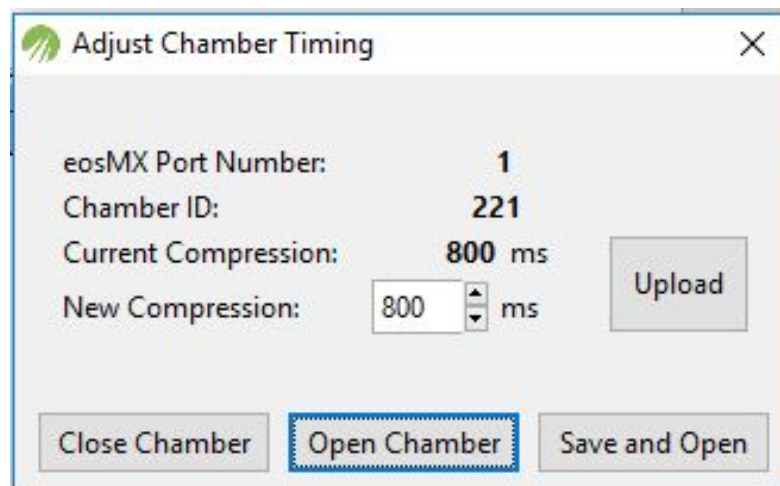

Figure 12 The Adjust Chamber Timing window, showing an eosAC
using a compression time of 800 ms.

From the main eosLink-MX window, the measurement cycle can be configured by clicking the **Change** button. This brings up a window that allows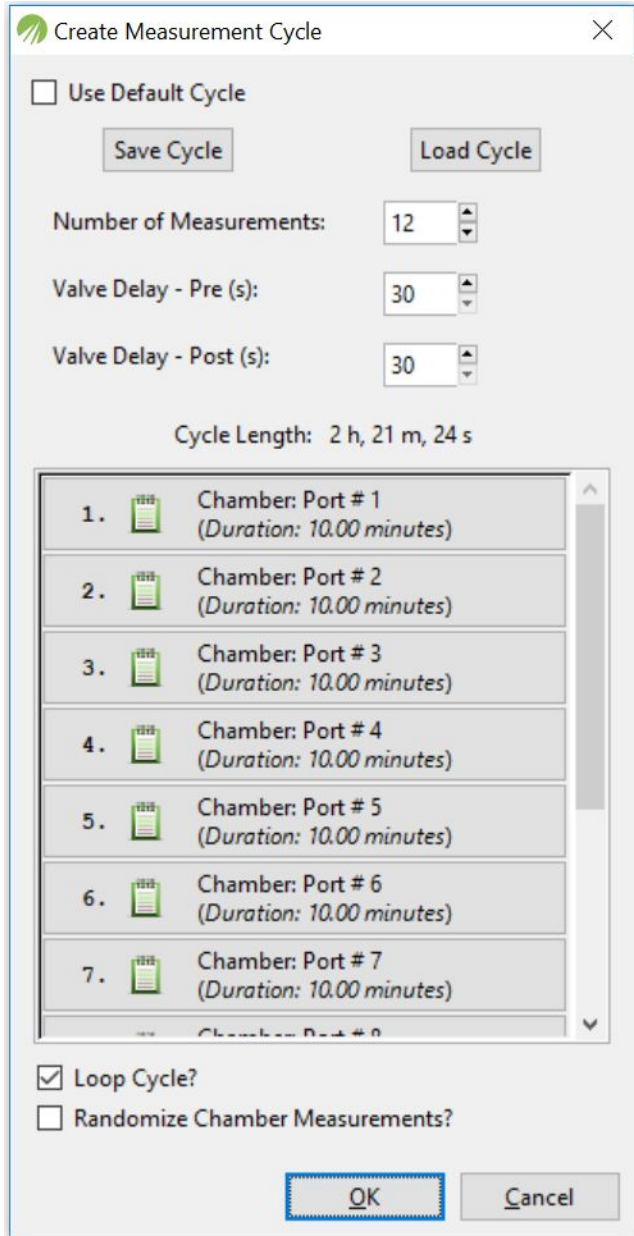 the user to choose the number and type of measurement steps, as well as save or load custom cycles. As the number of measurements is increased, steps will be added to the scrolling window, to a maximum of 50. These steps can be set to either Idle or a Chamber measurement by clicking on them, then setting the measurement type and duration.

Checking **Loop Cycle** will cause the specified measurement cycle to begin from the first step each time the cycle completes. Checking the **Use Default** box will reset the measurement cycle to a simple loop through each detected eosAC.

The **Valve Delay** options specifies the amount of time to wait between starting to draw gas from the chamber and the chamber closing ("**Pre**") and the length of time to wait between the chamber opening and the end of gas being drawn from this chamber ("**Post**"). The optimal setting for these delays varies depending on a number of factors - increasing with tubing length and other factors that increase the total system volume, and decreasing with increased flow rate. Generally, we recommend setting these Pre and Post values to **at least 45 and 90 seconds respectively**, but **strongly recommend you review these settings after collecting representative field measurements**, in order to prevent data issues.

Figure 13 The Create Measurement Cycle Window, showing a custom chamber cycle

Valve Delays and Good Data

? Setting sufficiently long Valve Delays is crucial to collecting accurate flux data. Application Note 011 ("eosMX Valve Delay and Setting Data Deadbands") provides additional details concerning how these parameters affect flux estimation.

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6   eosAnalyze-AC

6.1 Setup

The eosAnalyze-AC software requires no installation on the part of the user. Simply copy the "eosAnalyze- AC.zip" file to a suitable directory on the PC in question, then unzip the file (which contains one folder titled "eosAnalyze-AC"). None of the files in this folder should be removed or changed in any way. If this occurs, simply delete the entire folder from your PC and re-extract from the zip file to recreate the folder.

The program executable is labeled "eosAnalyze-AC.exe", and creating a shortcut to this file program on the Desktop is recommended. Double clicking this icon or a Desktop Shortcut will launch the software. Please note that the data collected by the companion programs **eosMonitor-AC** (no eosMX) or **eosLink-MX** (multiplexed chambers) is required in order to import accurate temperature measurements, and in the case of a multiplexed system, open and close the chambers. Section 4 provides more information on how to monitor and customize these programs.

The first time eosAnalyze-AC is run, both the Analyzer and Chamber types need to be selected, and the user will be prompted to chose both sequentially. The Chamber Type indicates whether a single eosAC is connected directly to the gas analyzer, or if multiple chambers are connected via a eosMX unit. The Analyzer Type indicates which gas analyzer the user will be collecting data from.
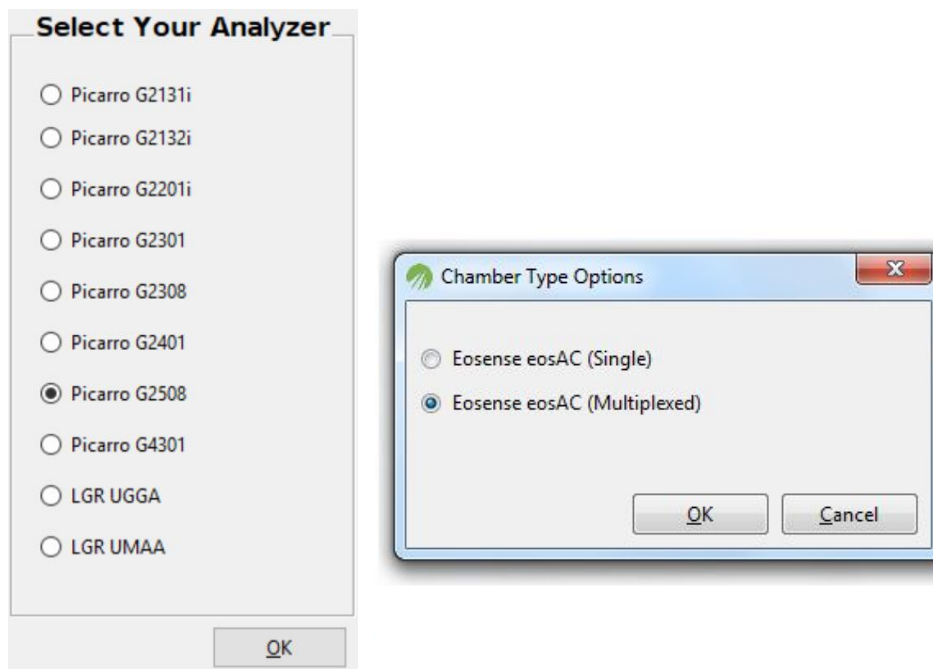

Figure 14 The windows for selecting the Analyzer and Chamber types.

These choices will be saved and loaded on each subsequent use of the eosAnalyze-AC. If required, they can be changed from the **Options⇒Equipment** menu. Please note that incorrect measurement data or processing issues may occur if these options are set incorrectly. The currently selected Analyzer and Chamber will be displayed in the software's title bar (see **Figure 15**).

6.2 User Interface

Once the program is running, the main viewing window will appear. This window consists of two main areas: the Plotting section and the Measurements section. Both sections will be empty until data has been imported.
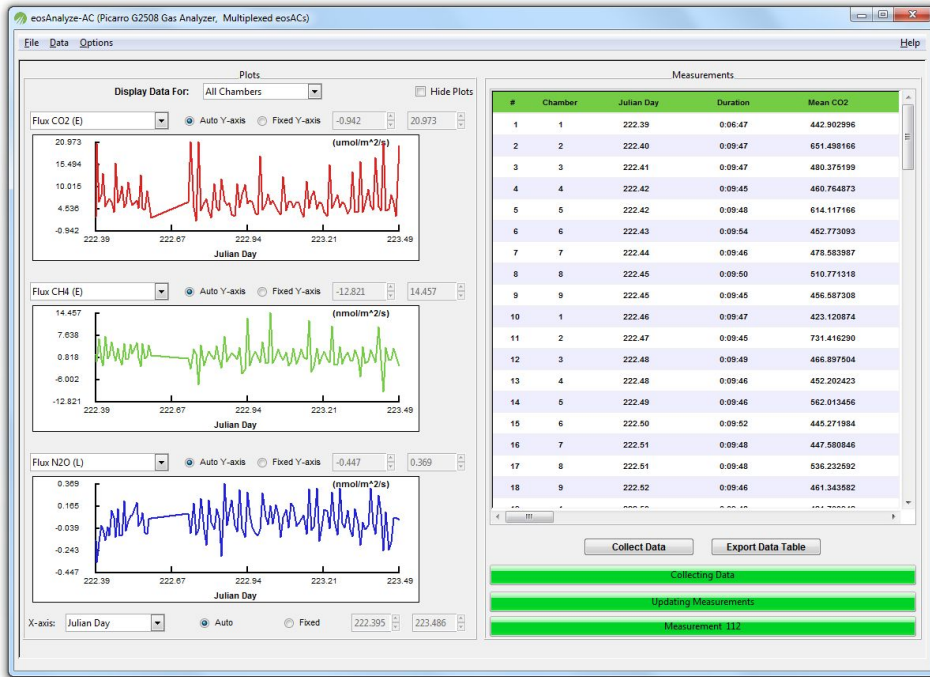

Figure 15 The main eosAnalyze-AC window, showing imported chamber measurements.

The Plotting section on the left of the main window allows the user to quickly inspect up to three different time-series plots at a time from the chamber measurements collected. The **Display Data For** drop-down menu allows measurements from one or all detected chambers to be displayed. Each of the three plots can be changed using the drop-down menus in the upper left of their areas, and the Y-axis behavior can be toggled between Automatic and Fixed scaling. The X-axis type and scaling for all three plots can be changed using the buttons at the bottom of the plotting area.

The two buttons underneath of the Measurements window allow the user to collect and then export chamber data. Chamber measurements detected by the program will populate a list in the Measurements area to the right of the main window. This scrolled window allows the user to view a customized table of data from the analyzer and chamber, as well as modify individual measurement parameters such as the deadband range or chamber offset.

In addition to these two main sections, a number of options are available from the menu toolbar at the very top of the screen (**File**, **Data**, **Options**, **Help**).

6.3 Chamber/Analyzer Setup

The first parameter that must be set is the analyzer data path, which corresponds to the location of stored analyzer data files on the computer. The analyzer path can be changed by selecting **Analyzer Data Path** from the **Data** menu at the top of the screen. This will prompt the user to specify a data path using a popup window:
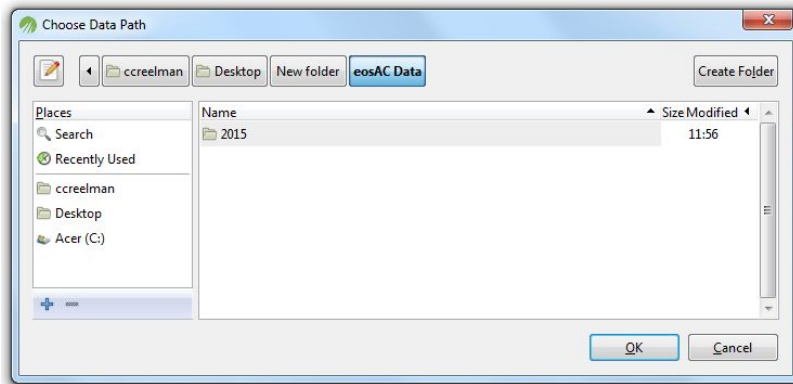

Figure 16 The data path selection window, showing the expected annual data folders.

Please note that the correct folder is selected by navigating to the root level of the data folder. In the case of Picarro analyzers, this is the folder containing annual folders such as "2015". Once you have navigated to the correct location, click **OK** to set the path.

The **Chamber and Analyzer Settings** window can be found under the **Options⇒Equipment** menu at the top of the screen, and allows the user to modify a number of chamber and analyzer specific settings. The majority of these settings are related to the total volume occupied by the chamber, the analyzer cavity and the tubing connecting the two. These values are chamber specific: if using a single eosAC without a Multiplexer, then Chamber 1 is the correct setting. For multiple chambers, the chamber selection corresponds to which Multiplexer port a given eosAC is connected to). These settings can be changed after data has been imported, however this will require reprocessing of all of the flux data, so configuring these values before collecting data is recommended.

The tubing volume is expressed via the length (m) and inner diameter (mm) for convenience. The chamber and analyzer volumes would remain unchanged under normal operation, as the **Auxiliary Volume** and **Chamber Surface Area** options allows the user to include any aftermarket modifications they may have made to the system (with the latter corresponding to the total surface area exposed to the soil). The final volume related setting is **Chamber Offset**. This value represents the distance between the top of the soil collar and the soil surface, with the minimum value being 2.57 cm. This offset is then transformed into an additional volume by assuming that the soil surface area within the collar is equal to the chamber's surface area.

The **Error Reps** setting dictates how many fitting iterations will be used to estimate the parameter error for the linear and exponential flux/Keeling intercept values. For demonstration purposes, this value defaults to 3.
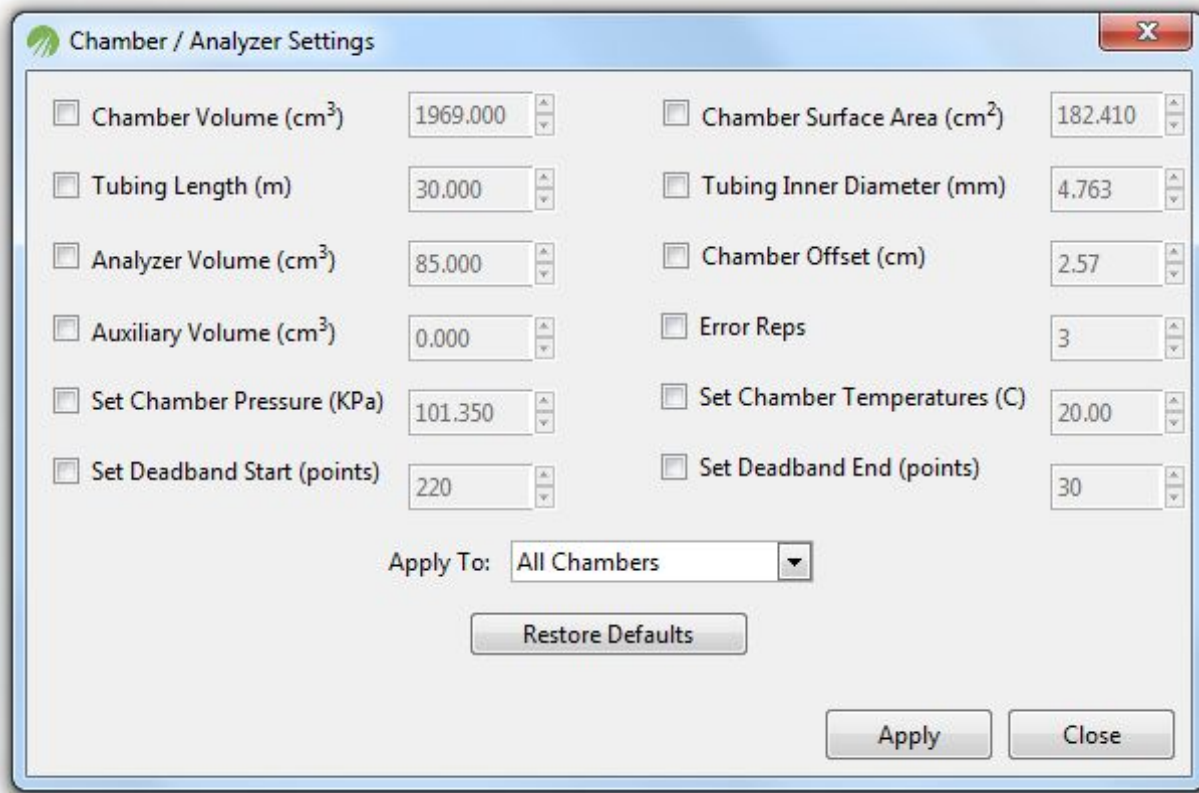
Figure 17 The Chamber/Analyzer settings window, where a number of equipment settings can be modified.

Note that changing this value can dramatically increase processing time, depending on the amount of data collected. A more in-depth explanation of this error estimation is available upon request. Finally, a global temperature and pressure can be applied to all chamber measurements using the **Set Chamber Pressure** and **Set Chamber Temperature** options. These temperature and pressure values will override those reported by the eosAC chambers, and should only be applied in the event of chamber data loss or malfunction.

The **Apply To** drop-down menu at the bottom of the window specifies which set of chamber measurements to modify. Please note however that any changes to the number of error reps or the analyzer volume will affect all chamber measurements.

6.4 Chamber Measurements

6.4.1 Importing Data

Analyzer data can be imported by clicking the **Collect Data** button below the Measurements window. This will prompt the user to select a time and date range in which to search for chamber measurements.

This data interval does not need to be exact, however only chamber measurements falling within this range will be processed. The Analyzer Local Time option at the bottom is used to correct for any GMT offsets that may exist: this value should be set to correspond with the analyzer's local clock **at the time the chamber data was measured.**

Once the data interval has been set by clicking **OK**, the program will begin searching through the analyzer data files to find chamber measurements. During this process many GUI elements will be disabled as the Measurement and Plotting sections are updated. Progress bars indicating the status of the data search and measurement processing can be found in the area directly below the **Collect Data** and **Export Data Table** buttons:

As new measurements are found, they will be used to populate the Measurement and Plotting sections of the main window. Once the entire data interval has been searched and all fitting is complete, normal GUI interaction will be restored. Additional measurements can be added to the same data table by clicking the **Collect Data** button again, and by specifying a new data interval. Any measurements that have already been added to the Data Table will be ignored on subsequent searches.
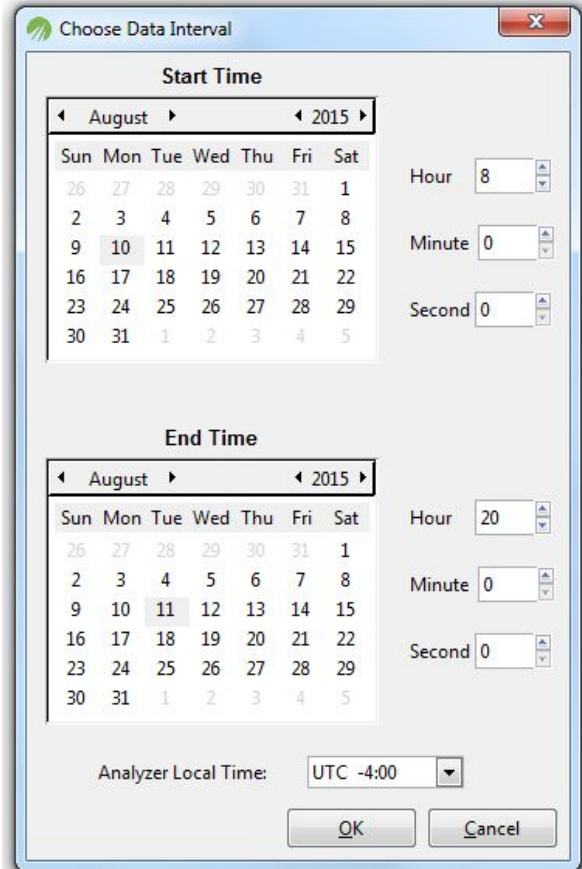

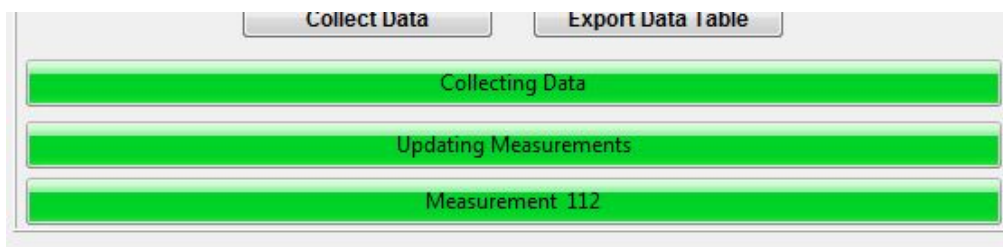**Figure 18** The data interval selection window

Figure 19 The eosAnalyze-AC main window progress bars, indicating that the imported measurements are currently being processed.

6.4.2 Data Table Fields

Once analyzer data has been parsed for the eosAC measurements, a number of data fields will be displayed in the Data Table. These default parameters are analyzer specific, but generally include gas flux, gas concentration and analyzer diagnostics information. Mousing over any of the table values will indicate what field it corresponds to as well as the units.

#	Julian Day	Mean CO2	Mean CH4	Mean CH4 (HP)
1	68.53	767.236971	1.951528	0.000000
2	68.54	753.900097	1.952030	0.000000
3	68.54	807.628578	1.953125	0.000000
4	68.55	814.415881	1.954743	0.000000
5	68.56	858.279185	1.955862	0.000000
6	68.56	851.556620	1.956296	0.000000
7	68.57	880.441358	1.956488	0.000000

Figure 20 The eosAnalyze-AC main window data table, with several chamber measurements shown.

> **?** **Chamber Errors**
>
> Chamber errors logged by the eosLink-MX software will be read by the eosAnalyze-AC software and indicated both by marking the Data Table entry in red for the associated measurements, and by flagging the exported data. This includes incidents where a chamber may be unable to open or close fully.

Fields that are not currently displayed can be added by clicking on the Data Table header (or from **Data⇒Customize Data Table**), and customizing the table using the pop-up window. From this window the number of columns can be adjusted, as well as what parameter will be displayed in each column. In addition, the timestamp that is used for each line of the Data Table can be changed to one of three options:

- **Julian Day** - Fractional days elapsed since January 1 of respective year
- **Date/Time** - Timestamp using MM/DD/YYYY HH:MM: format
- **Hours Elapsed** - Hours elapsed since start of first measurement

Please note that the number/order of columns and the chosen timestamp will be reflected in any exported data. You may need to scroll the Data Table in order to view all columns.

The flux estimates for each chamber measurement will default to a unit generally appropriate for the gas in question (μmol/m^2/s for CO_2 and NH_3, nmol/m/^{2}/s for CH_4 and N_2O). These can be changed from the Data menu under Flux Units, either prior to or after data collection. This window allows the flux units to specified arbitrarily from various mass, area and measurement time settings, such as kg/km^2/year or nmol/ha/hour.

Note that some combinations of units may be rejected if they would typically produce extremely large (e.g. nmol/km^2/yr for CO_2 flux) or extremely small values (e.g. kg/m^2/s for CH_4 flux).
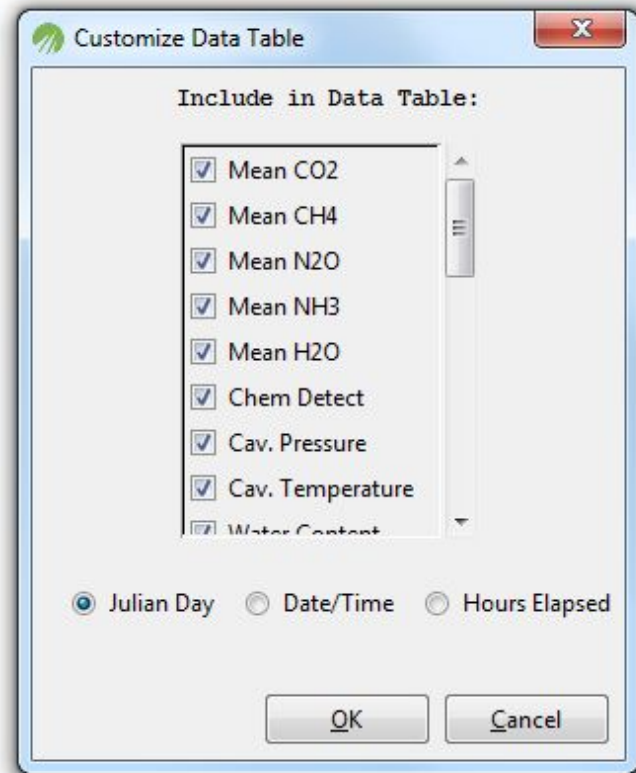
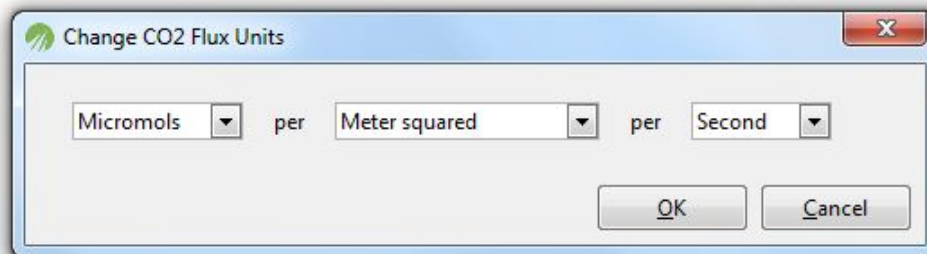**Figure 21** The Customized Data Table Window

Figure 22 The window used to change the flux units displayed

6.4.3 Filtering Data

Chamber data can be filtered in order to automatically disable any measurements which qualify as outliers. The outlier range is a field-specific setting, accessed from **Outlier Filters** in the **Data menu**.

The **Data Field** drop-down menu selects which measurement value to set the filter for, with all ranges defaulting to **No Filter**. Selecting a filter will cause measurements outside the allowable range to be disabled (grayed out), meaning that they will not appear in the main window's plots or any exported data files. Please note that this feature is not intended as a replacement for robust statistical post-processing, but as a means to quickly remove outliers.

Choosing **Standard Deviation** allows the user to choose the distance from the mean value a measurement can be before it is considered an outlier. The user can choose between 1 or 2 for the allowable range, with the corresponding minimum and maximum values shown in parentheses. For normally distributed data, this represents inclusion ranges of 68 and 95% of the total range, respectively. By choosing **Custom Range**, the inclusion range can be set arbitrarily, within the limits of the value's global minimum and maximum. This can be used to select only certain portions of the dataset, or to avoid problematic measurements (e.g.: high Water Content or ChemDetect).
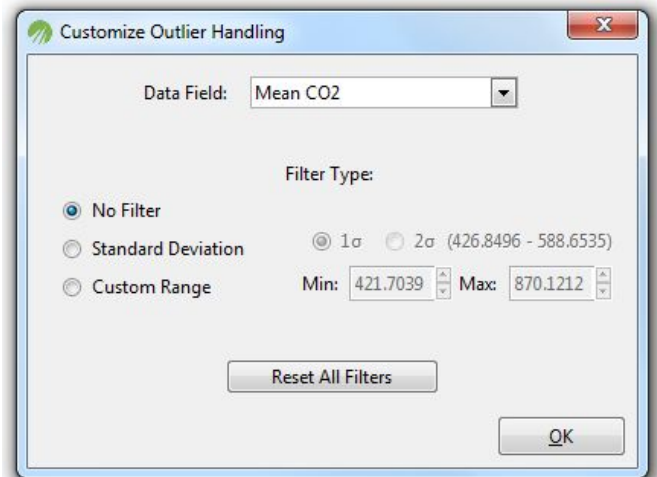
Figure 23 The Customized Data Table Window

Finally, clicking **Reset All Filters** will select **No Filter** for each data field. Please note that this will enable **all** chamber measurements, including those manually disabled by the user through the Measurement Settings window.

6.4.4 Hiding Data Files

In the event that any of the default data fields are unlikely to be useful for your application, they can be hidden ("ignored") from all eosAnalyze-AC options. To ignore a data field, select **Ignored Data Fields** from the **Data** menu, choose a field from the drop- down menu and then click **Add**. To remove an ignored field, simply click the corresponding name in the scrolling list to the right.

Ignored data fields will not show up as options in the plot selection or data table customization menus until they are removed from this list.
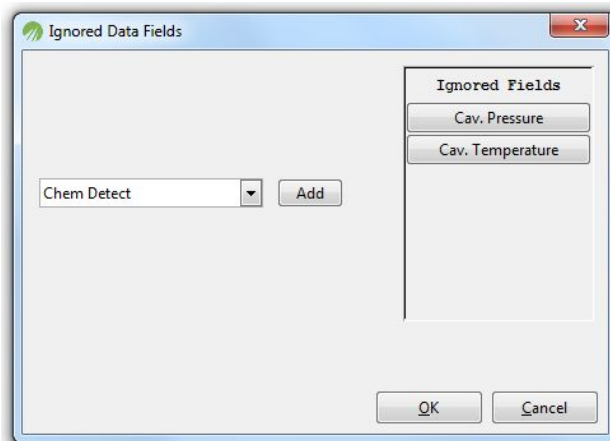
Figure 24 The window used to change which data fields are ignored by the data processing software

6.5 Data Processing

Individual measurements can be viewed in greater detail by clicking on them in either the Data Table or one of the main plots, which brings up the Measurement Settings window:
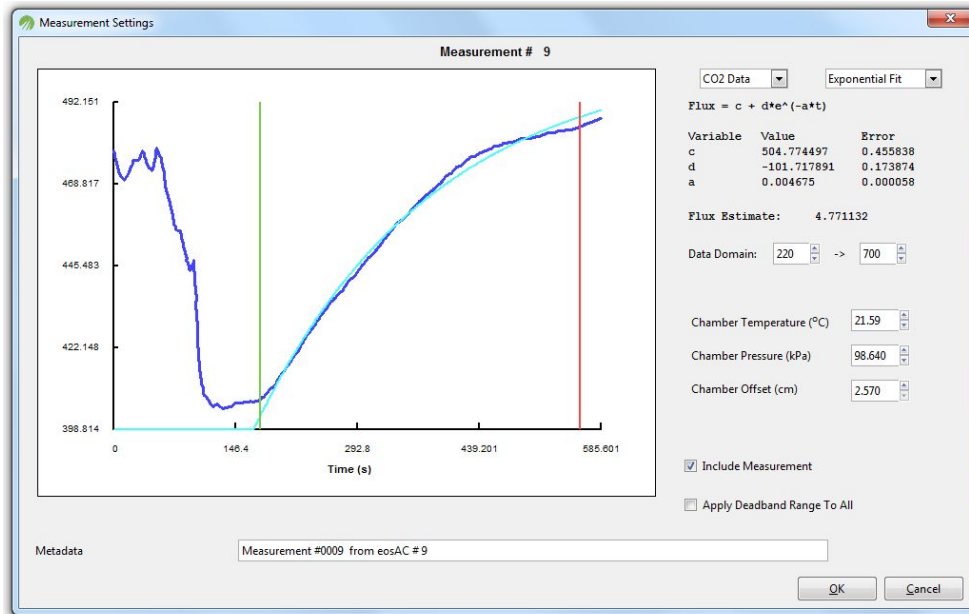

Figure 25 The Measurement Settings window, used to view and alter the fits to chamber timeseries.

The flux fits and Keeling plot intercepts (isotopic analyzers only) for any relevant gases can be viewed using the drop down menus in the top right of the window. Directly below these buttons are the specific parameter estimates for the shown fit, followed by the current deadband settings. Data from the beginning or end of the timeseries can be omitted by changing these settings using the **Data Domain** spin buttons. Note that changing these options will result in a brief updating period while the fits are recalculated, once the Measurement Settings window is closed.

The chamber temperature, chamber pressure and chamber offset (distance between bottom of chamber and soil due to collar) can be modified from their default values as well. Note that chamber temperatures and pressures will be read in from a separate log file if available (see Appendix A). The **Use Measurement** check box can be unchecked to exclude the displayed measurement from both the (exported) data table and the main window plots. The **Apply Deadband Range** To All check box can be checked to apply the deadband setting to all current data table measurements. Please note that no other measurement settings will be affected by this option.

The user can enter a metadata string directly below the Measurement Settings plot. This string can be up to 200 characters long, and is used to make any notes about the measurement/environment or other important details. Holding shift while clicking the plot provides an option to export the current data as a PNG or JPEG image.

6.6 Saving and Loading Data

6.6.1 Saving Data

To save a eosAnalyze-AC session, select Save from the File menu, then choose a filename and path. This creates a .cds settings file and archives all analyzer data for the collected chamber measurements. In the event that this file is transferred to a different PC, the settings file can be used to reload the Data Table and chamber/analyzer/measurement settings, however the data can not be re-processed without also transferring the archived folder of analyzer data.
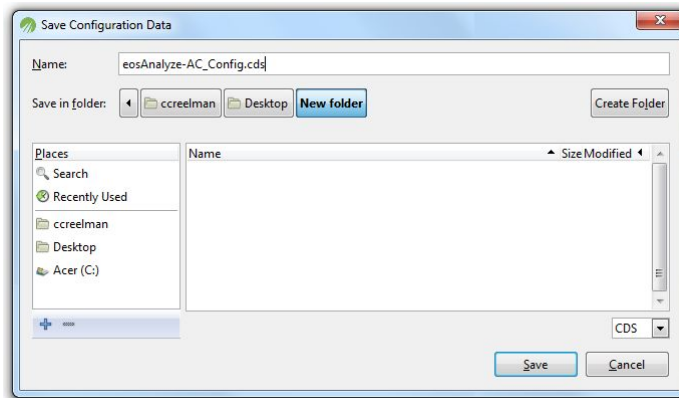

Figure 26 The eosAnalyze-AC Save window, used to select a filename and location.

6.6.2 Loading Data

To load a eosAnalyze-AC session, select **Load** from the **File** menu, then browse to a .cds save file. Clicking **Open** will repopulate the Data Table as well as load all previously selected plotting, measurement, chamber and analyzer settings. As long as the settings file is loaded on the same PC that created it, measurements can be reprocessed and modified exactly as if they had been newly imported.
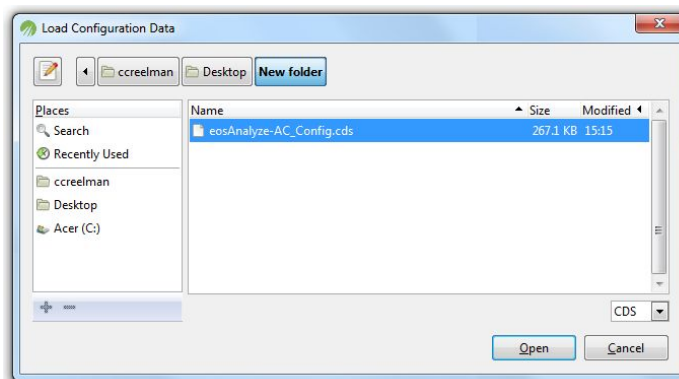

Figure 27 The eosAnalyze-AC Load window, used to select a CDS file to open.

6.7 Viewing Data

Along with the Data Table, chamber data can be viewed via three plots on the left of the main window. Each plot can be customized using the drop down data selector, the Y-axis settings and the X-axis settings, and all three can be hidden using the **Hide Plots** checkbox. In addition, the style of all three plots can be modified from the **Plotting Options** window, found under the **Options** menu. Note that if both Lines and Symbols are turned off, nothing will be shown in the plots.

The Y-axis is automatically scaled by default. As long as this option is left unchanged, the (unused) Fixed Y-axis settings will be updated to reflect the current plot zoom. Once Fixed Y-axis is selected for the first time, this relationship will be broken, in order to prevent loss of user-specified axis settings.

The X-axis type can be selected at the bottom of the Plotting section, and can be set to Julian Day (since January 1 of that year), Hours Elapsed (since start time) and Measurements (sequential numbering). Unlike the Y-axis settings, switching back to Automatic X-axis scaling will always result in the Fixed X-axis settings being changed along with the plot, to allow for the inclusion of new data.

Mousing over a plot will display the X/Y coordinates at that location and holding shift while clicking will save the current plot as an image
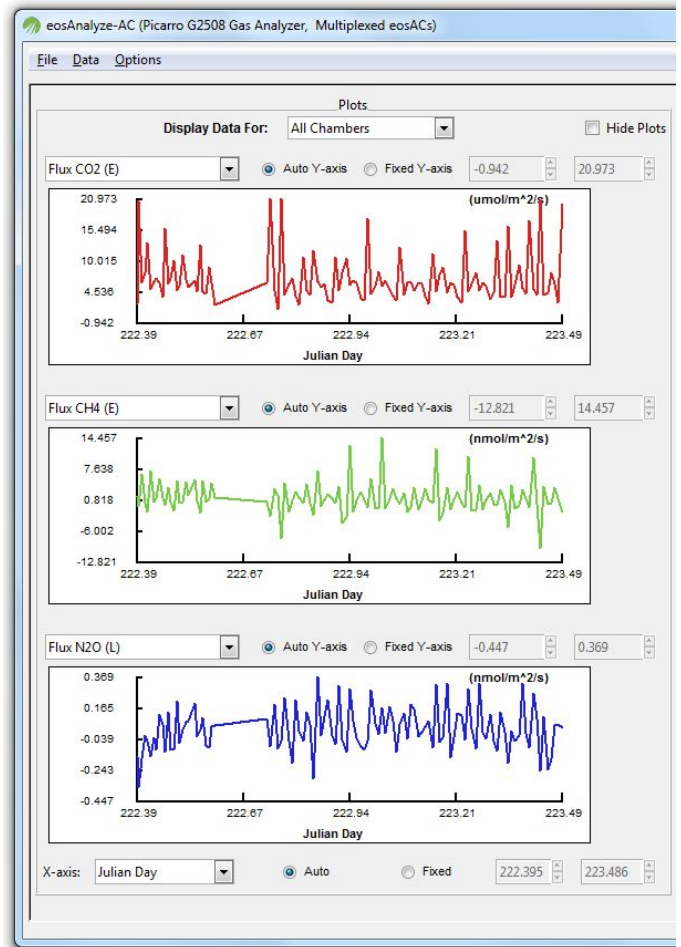

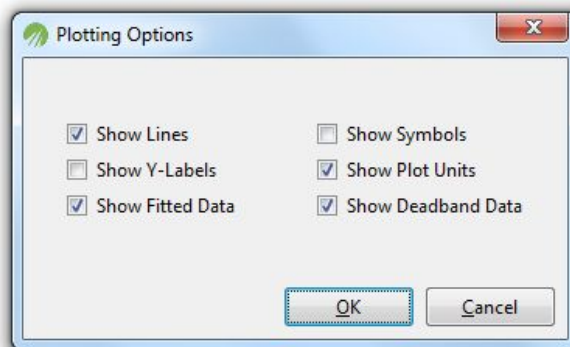**Figure 28** The eosAnalyze-AC main window showing three plots.

Figure 29 The Plotting Options window

6.8 Exporting Data

Once all the chamber data has been collected and fine- tuned, the user can export the Data table as either a .csv or .dat file using the **Export Data Table** button at the bottom left of the screen. This prompts the user for a for- matting type, followed by a pop-up window to choose the save location. Note that data fields present in the table will be present in this exported file, and that measurements that have been deselected (appearing grayed out) will be excluded. This data can then either be used directly, or easily imported into a spreadsheet for further analysis.
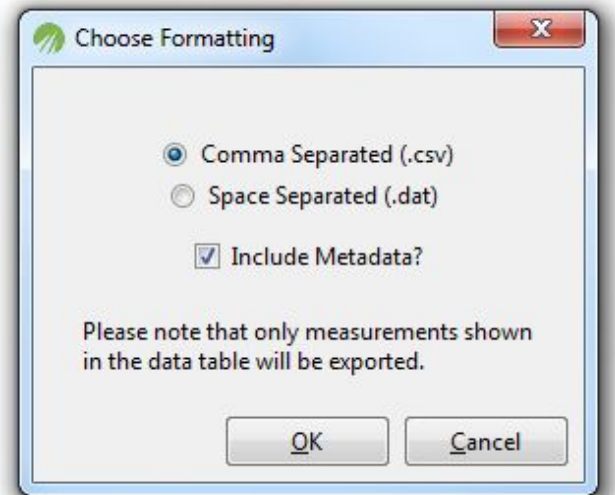

Figure 30 The window showing selection of the output file type.

Figure 31 A sample of exported chamber data, viewed as a spreadsheet.

7 Troubleshooting

This section provides a few example problems that may occur during use, and the appropriate action that should be taken to resolve the issue. For these issues as well as any others that arise, please contact Eosense through email at support@eosense.com with subject "eosAC Support", or through the support section of our website (http://www.eosense.com/support/).

- ***eosAnalyze-AC does not find any data***
  Ensure that the analyzer root path has been set correctly by choosing **Analyzer Data Path** from the **Data** menu and navigating the the proper directory. One or more folders indicating year (e.g. "2014", "2015") should be visible when clicking **OK** from the pop-up window. Ensure that all relevant FRMonitor ####.log files are present. Double check the time-frame in which the measurements occurred and/or try expanding the data interval. Ensure that the Analyzer Local Time option has been set to correspond with the analyzer clock setting at the time the data was recorded. Finally, note that very short chamber measurements (typically <45 s) will be dropped.

- ***The window failed to render properly/plots are not displaying, how can I fix this?***
  Clicking on an empty part of the screen will refresh the display. If this does not resolve the problem, try changing the X-axis plotting type (Measurements, Timestamp, etc). You should also check that at least one of **Show Lines** or **Show Symbols** is checked in the Plotting Options window. If the problem remains, restart the eosAnalyze-AC software.

- ***The program takes a long time processing chamber measurements, is there any way to speed this up?***
  The majority of processing time occurs when the data is being fit to linear and exponential forms. If the chamber concentration data is particularly unusual, this can increase the fitting time significantly. Once the measurements have been imported, inspect measurements visually (via the Measurement Settings window) to ensure that the data is correct. In addition, the estimation of flux fitting errors/sensitivities can be very time consuming. If you have increased the error reps value beyond the default 3 (Chamber/Analyzer Settings window), try reducing this value to decrease processing time. If you have turned on symbol plotting from the Visual Options window, disabling this feature can increase plotting speed, and plots can be temporarily hidden entirely from the Hide Plots checkbox.

- ***Running the software gives an error:"libgdk-win32-2.0-0.dll is missing from the computer"***
  This error indicates that the executable is missing the (hidden) system files. This happens when the .exe is moved from its original position in the software folder. To resolve this problem, keep the executable in the same folder as it was downloaded in (or re-extract the .zip file and use that as the new software folder).

Eosense Inc
1 Research Drive
Dartmouth, Nova Scotia
Canada, B2Y 4M9
Email: support@eosense.com
http://eosense.com/support