FORERUNNER
RESEARCH INC

AC-001 Autochamber

User Manual

This guide is distributed by FORERUNNER RESEARCH INC ("Forerunner") for users of the AC-001 Autochamber instrument ("AC") in conjunction with the Chamber Data Processor, FRMonitor and FRMonitor-MP software. The AC housing and internal wiring is under warranty by Forerunner to be free from defects in workmanship and materials under normal use and service for thirty-six (**36**) months. The stepper motor and microprocessor control board are covered by warranty against malfunction for twelve (**12**) months. This warranty shall not apply to any Forerunner products which have been subjected to misuse, modification, neglect, accidents of nature, or shipping damage.

Forerunner is not liable for special, indirect, incidental, or consequential damages. Forerunner's obligation under this warranty is limited to repairing or replacing (at Forerunner's discretion) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to Forerunner where applicable. Forerunner will return said products by surface carrier prepaid. This warranty is in lieu of all other warranties, expressed or implied.

DISCLAIMER: Please check the Autochamber product page on the Forerunner website (http://www.forerunnerresearch.ca/autocham.php) for the most up-to-date manual.

REV: February 25, 2015

AC-001 Autochamber User Manual

Contents

1 Introduction

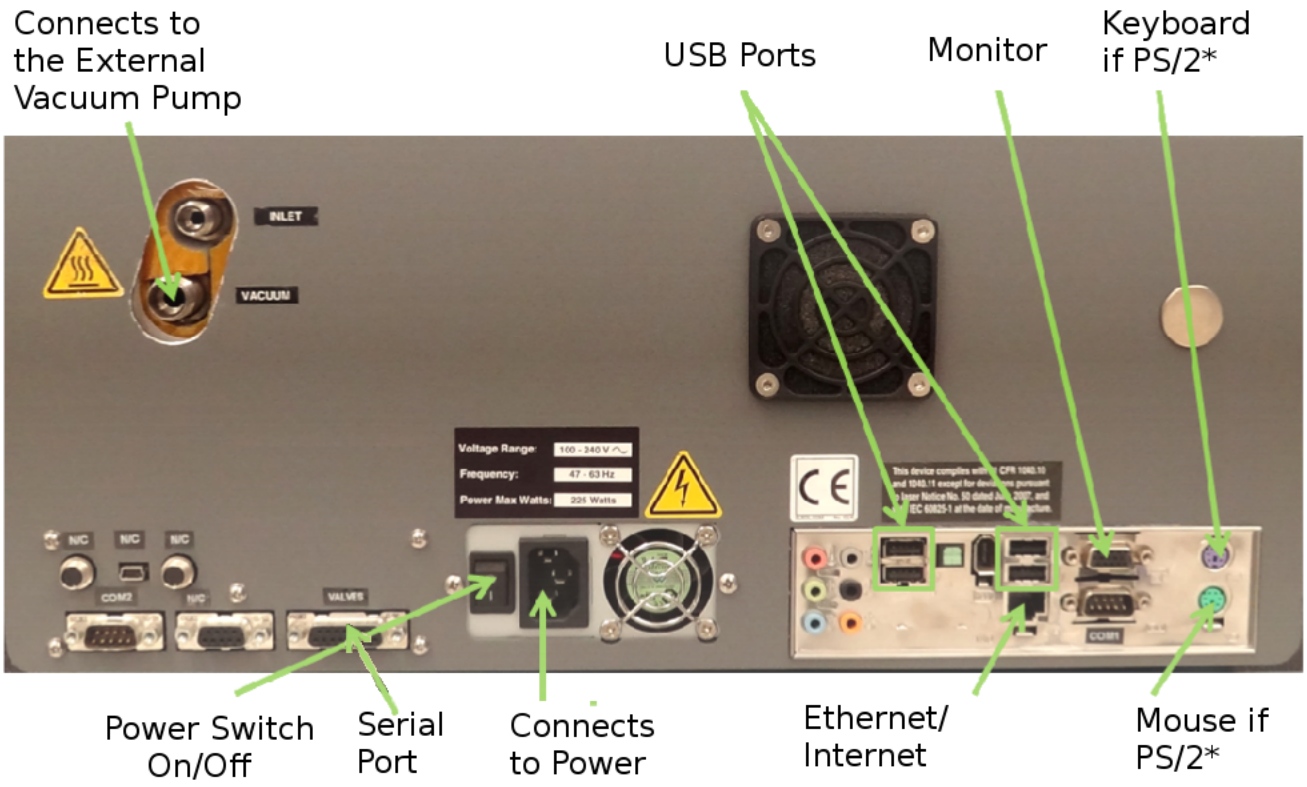
1.1 Overview

This manual outlines how to use the AC-001 Autochamber to measure a variety of soil flux and gas concentration data. The information provided is intended for first time users of a Forerunner Autochamber, and assumes a working knowledge of the gas analyzer in question (the Picarro G2508 is used as an example throughout this document).

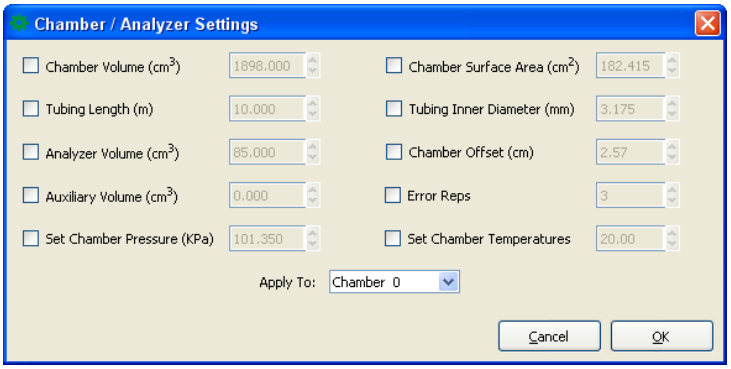
The **Quick Start** section provides a short guide to setting up the software and importing data, however we **strongly recommended** that all users read the complete manual before use. The **Hardware** section explains how to connect the gas analyzer to the Autochamber,and how to install the chamber on the soil surface. The next section, **Single Chamber Scheduling** covers how to use an analyzer's valve sequencer to schedule chamber measurements. **Chamber Data Processor** shows how to use the software to extract and analyze chamber flux measurements from gas analyzer raw data. Finally, the **Troubleshooting** section briefly covers some possible issues that may arise during normal operation of the software. For further information or assistance, please contact support@forerunnerresearch.ca.

2 Quick Start Guide

1. Attach a gas line from the external vacuum pump (**"Vacuum"**) to the analyzer (**"Vacuum"**), tightening the nut by hand, then adding an additional $1/8^{th}$ turn. Connect one of the Autochamber gas ports to the **"Exhaust"** port of the external pump, and another to the **"Input"** port on the back of the analyzer.
2. Connect the AC end of the Power/Data Cable to the back of the Autochamber housing.
3. Connect the USB head of the Power/Data Cable to a USB port on the analyzer, and the Serial head to the analyzer's serial port.

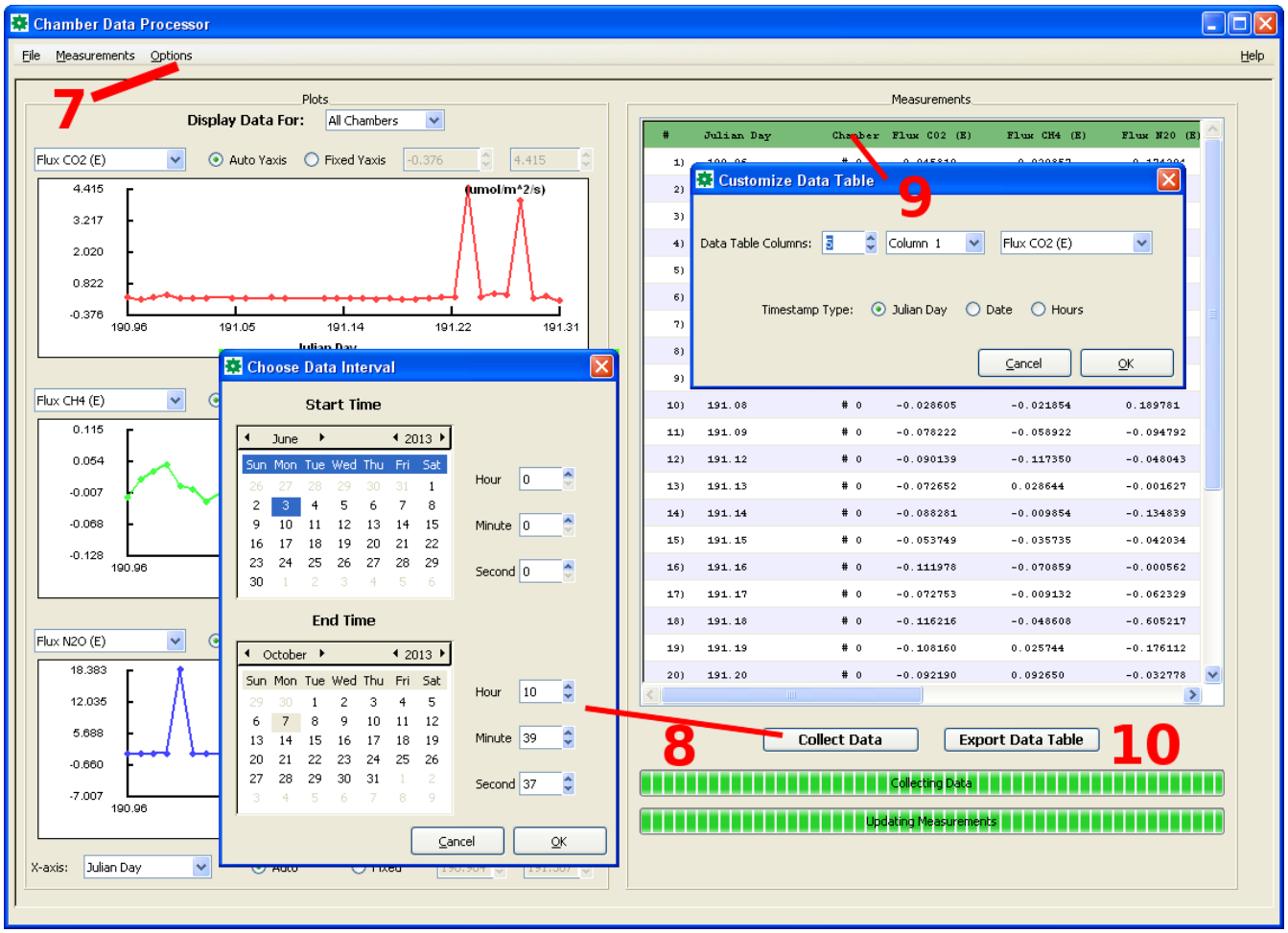


4. Copy the Chamber Data Processor zip file onto your PC and extract the folder. Once extracted, this directory will contain the Chamber Data Processor executable as well as a number of hidden files. Any changes to this folder may prevent the software from functioning as intended. Creating a shortcut to the program on the Desktop is recommended.
5. Launch the FRMonitor (single chamber) or FRMonitor-MP (multiplexed chambers) software and ensure that communication has been established.
6. Launch the software from the executable, or a Desktop shortcut (if created). When prompted, navigate to the gas analyzer data root folder and click OK.
7. Check the chamber/analyzer settings are correct (**Options→Chamber/Analyzer Settings**).

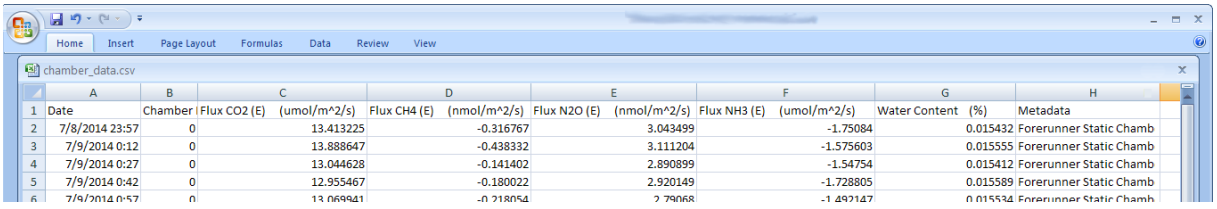


8. Click the **Get Data** button, then in the popup window, choose the time interval over which you wish to import data, then click **Ok**.

9. Wait while the program finds and processes chamber measurements. Once it has finished, you may modify the data table fields by clicking on the header.



10. Once you have finished customizing the data table, click the **Export Data** button to create a .csv file containing the relevant information.



3 Hardware

3.1 Setup

3.1.1 Gas Lines

Carefully set the analyzer 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. Attach a gas line from the external vacuum pump (**Vacuum**) to the analyzer (**Vacuum**), tightening the nut by hand, then adding an additional $1/8^{th}$ turn. If using a single chamber, connect one of the Autochamber gas ports (Figure 2) to the **Exhaust** port of the external pump using the provided tubing and the other Autochamber gas port to the **Input** port on the back of the analyzer. If using multiple Autochambers, please follow the setup instructions in the MP-001 Multiplexer User Manual.

Figure 1: Analyzer and External Pump plumbing

The two analyzer gas lines control sampling of chamber concentrations and recirculation of this gas back to the Autochamber. Depending on the environment in which the analyzer and Autochamber are deployed, steps to protect these lines from rodents and other wildlife may be recommended.

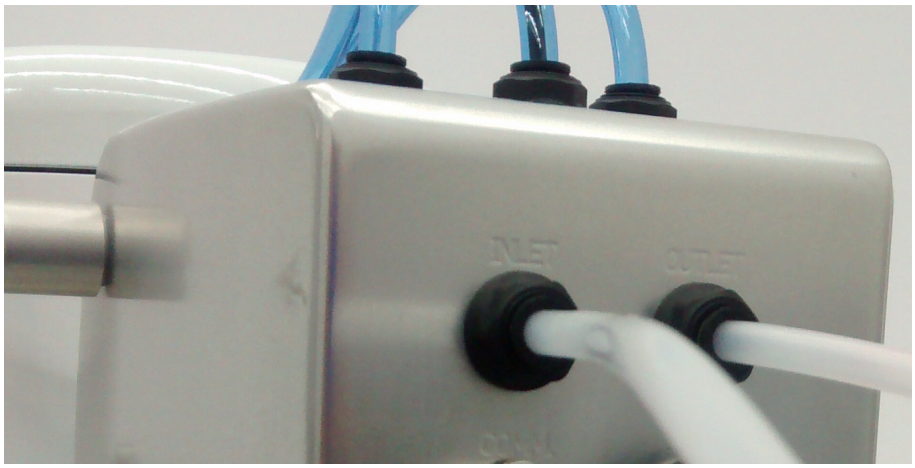


Figure 2: Gas tubing connected to the Autochamber.

3.1.2 Power/Data Cable

Connect the AC end of the Power/Data Cable to the back of the Autochamber housing, as shown in Figure 3.

Figure 3: Power/Data Cable connected to the Autochamber.

If using a Forerunner Multiplexer, connect the other end of the Power/Data cable to one of the Multiplexer chamber ports. If connecting a single Autochamber directly to a gas analyzer, connect the USB head of the other end to a USB port on the analyzer, and the Serial head to the analyzer's serial port (see Figure 4 for details). The USB cable allows the Autochamber to transmit data to and receive instructions from the accompanying FRMonitor software. The Serial cable provides power to the Autochamber, allowing it to open and close when necessary.

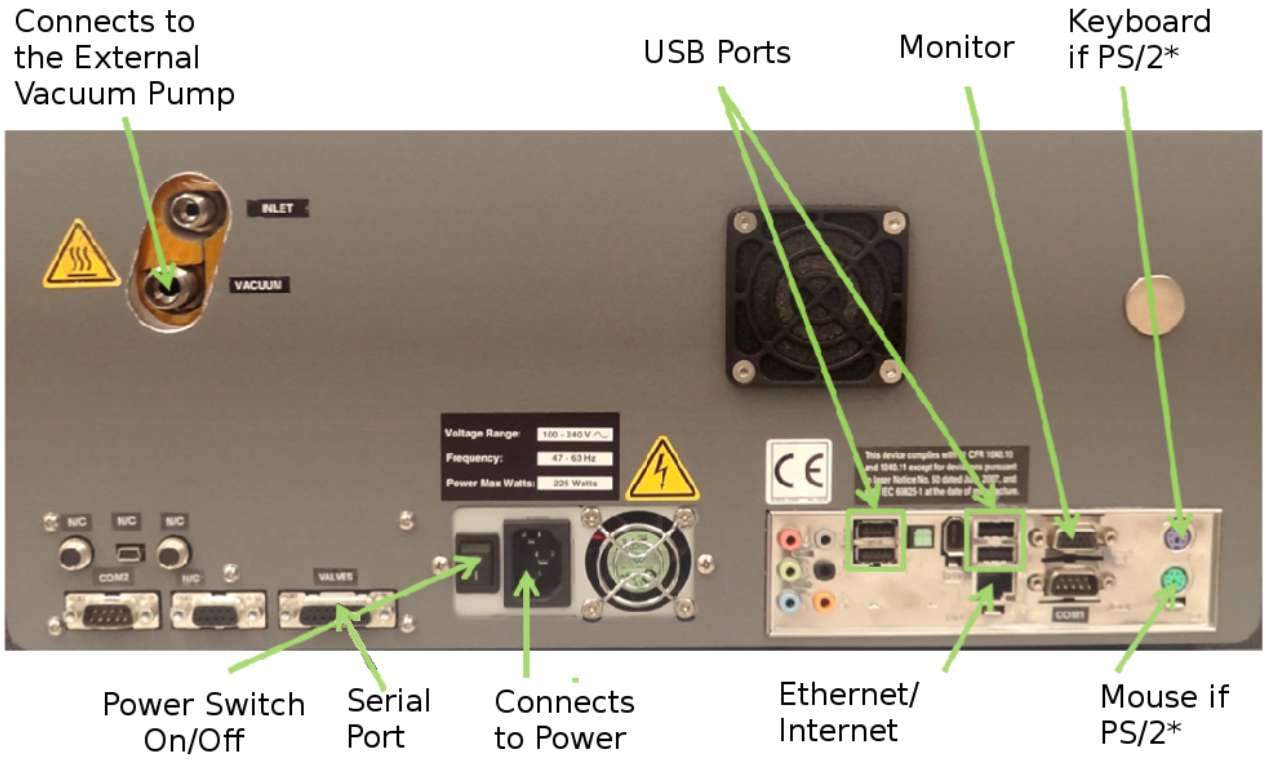


Figure 4: Example Picarro Analyzer port layout, as modified from the G2308/G2508 User Manual, Rev. A, 05-17-13

4 Single Chamber Scheduling

Please Note: The following section applies only to the use of a single Autochamber controlled by a Picarro Gas Analyzer and does not apply to the use of one or more Autochambers in conjunction with a Forerunner MP-001 Multiplexer.

When using a single Autochamber without a MP-001 Multiplexer, the External Valve Sequencer of the Picarro Gas Analyzer is used to control the chamber open and close. To access the valve sequencer, select `Show/Hide Valve Sequencer GUI` from the `Tools` menu of the CRDS Data Viewer.

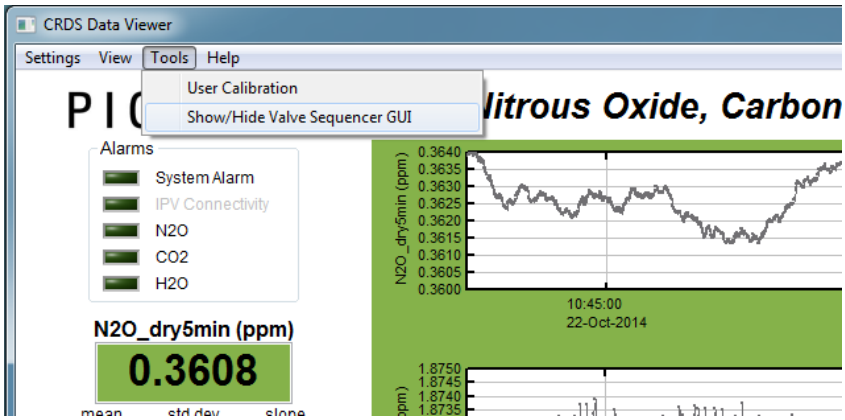


Figure 5: The valve sequencer GUI toggle, currently set to Hide.

This will open the External Valve Sequencer window, which shows the current valving sequence as one or more steps.

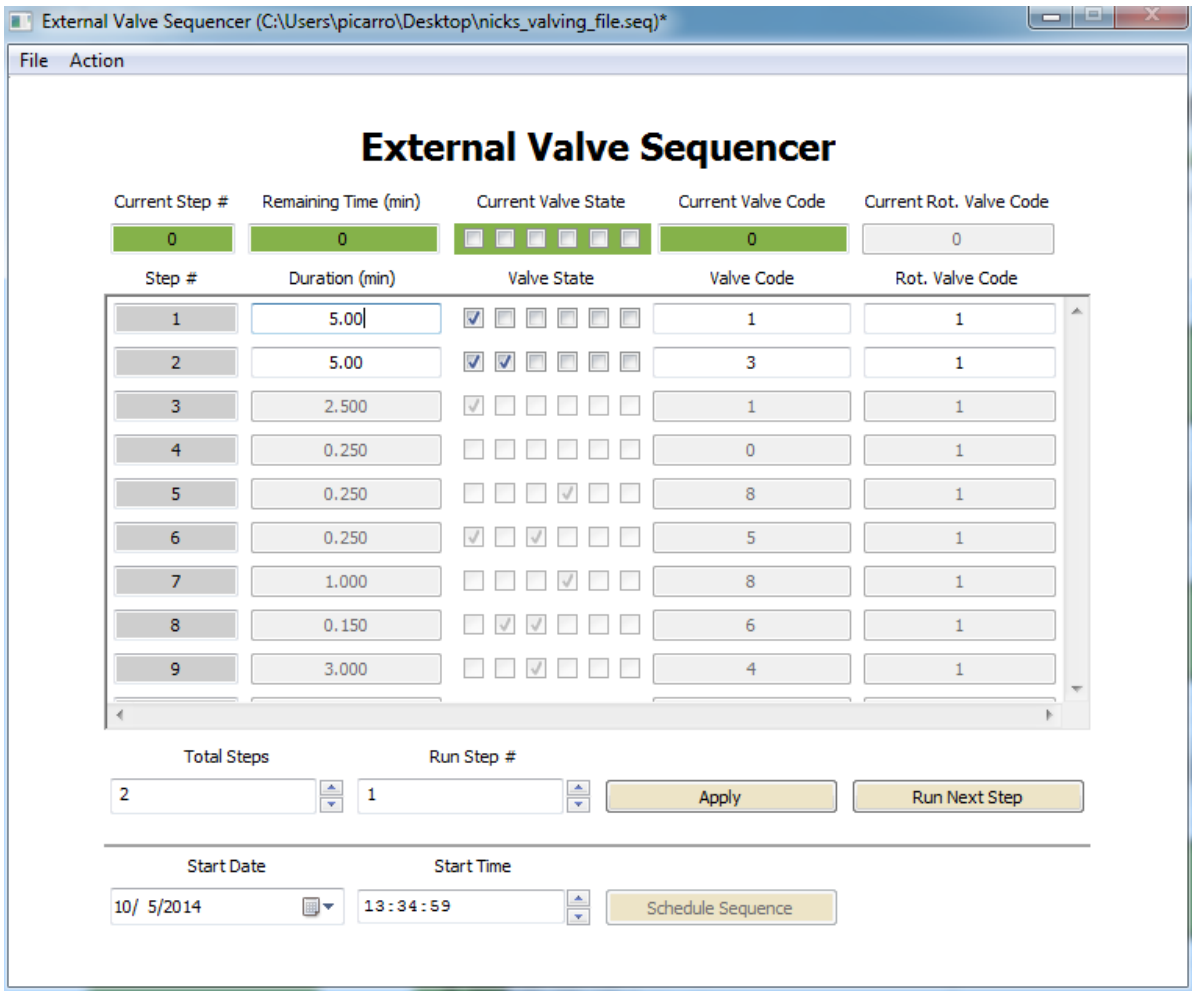


Figure 6: Example valve setup showing a two-step sequence.

To create an Autochamber measurement cycle requires two steps: a wait and a period of chamber closure. During the wait period, only the first valve state (Valve Code 1) should be active. For the chamber measurement, the first and second valves states should be active (Valve Code 3). For example a simple valve sequence is shown in Figure 6 above, consisting of an initial five minute wait, followed by five minutes of chamber closure. Once the two steps are complete, the sequence begins again from Step One. Users can configure these wait and chamber duration as needed; however both should be set to 60 seconds minimum.

Once the valving sequence has been configured, choose `Start Sequencer` from the `Action` menu in the External Valve Sequencer window.

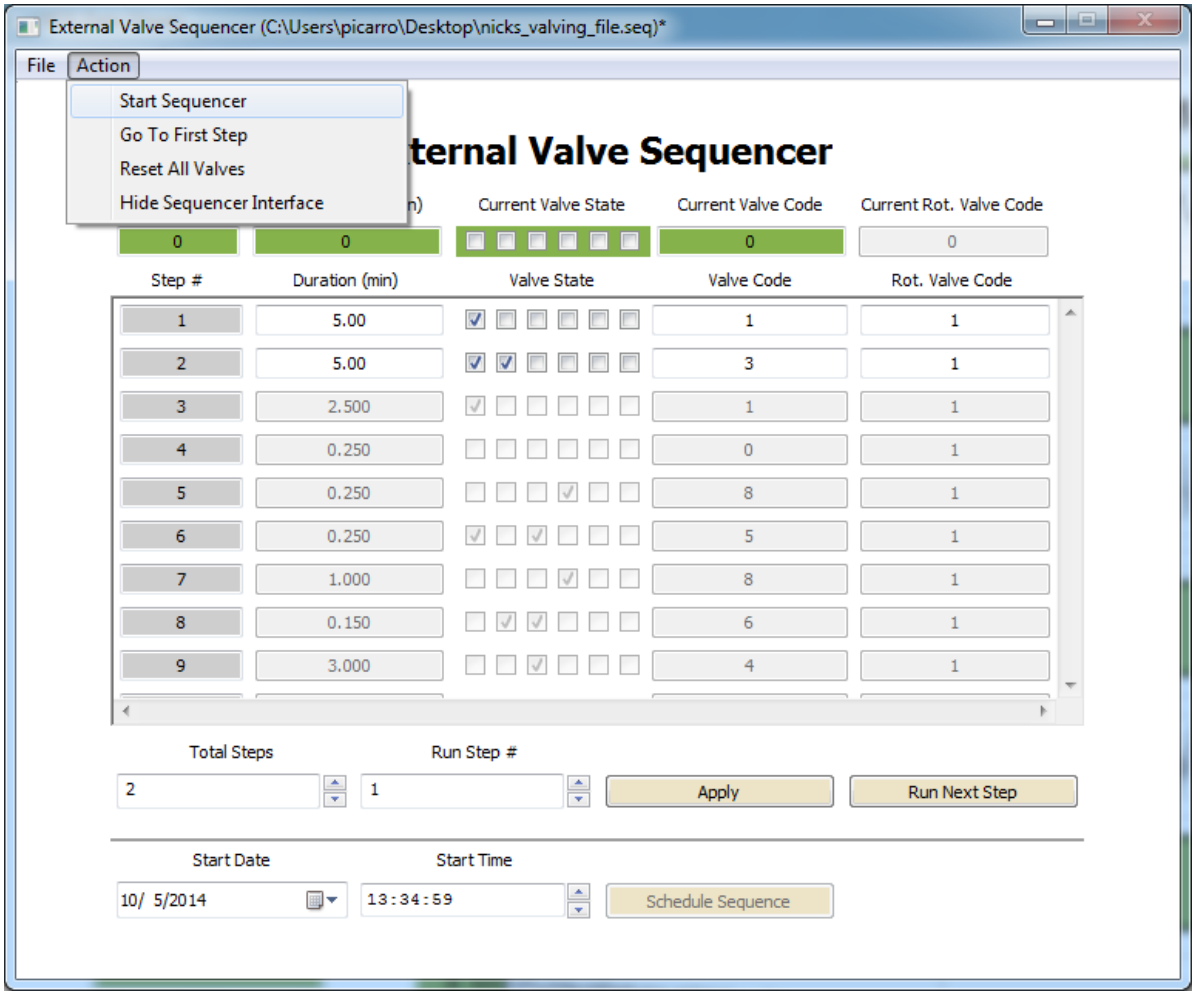


Figure 7: Starting the valve sequence.

Once started, the specified valve sequence will continue to run until the user selects `Stop Sequencer` from the `Action` menu in the External Valve Sequencer window.

5 Chamber Data Processor

5.1 Setup

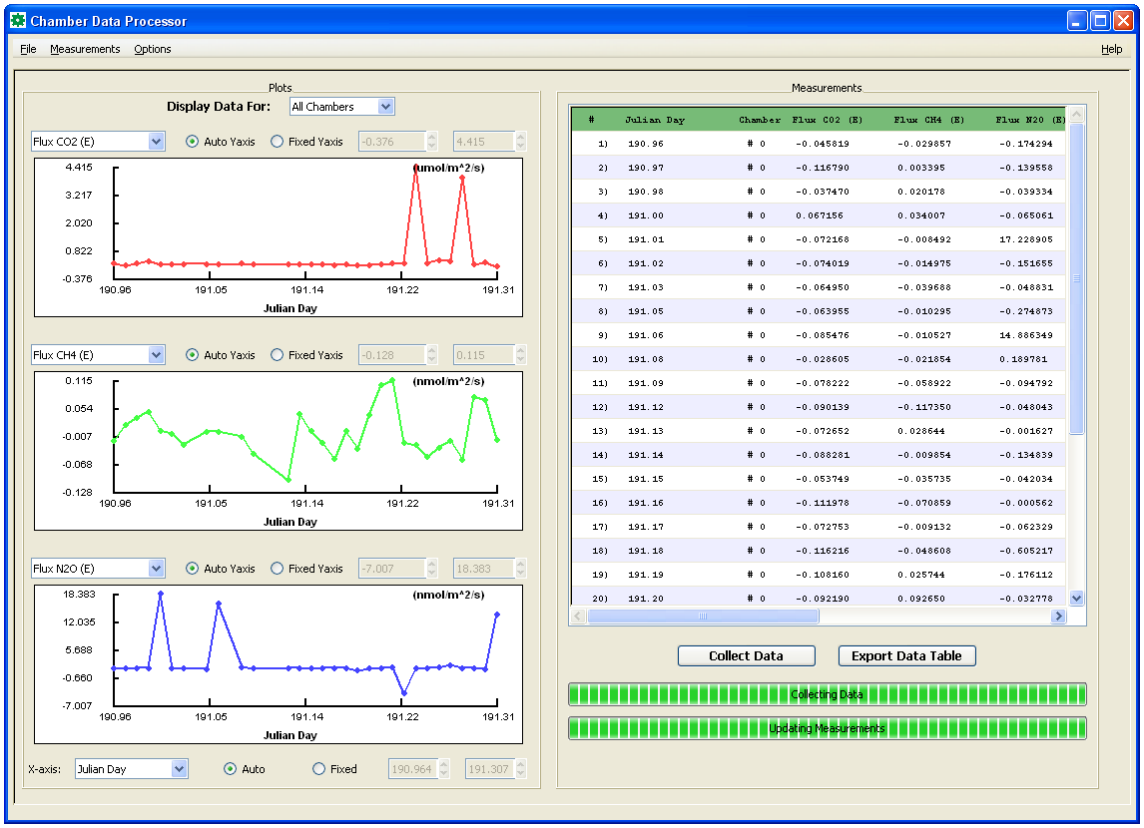
The Chamber Data Processor software requires no installation on the part of the user. Simply copy the "Chamber Data Processor.zip" file to a suitable directory on the PC in question, then unzipthe file (which contains one folder titled "Chamber Data Processor"). None of the files in this folder should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

The program executable is labeled "Chamber Data Processor.exe"[1], 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 companion programs **FRMonitor.exe** (single chamber) or FRMonitor-MP.exe (multiple chambers) are required in order to import accurate temperature measurements, and in the case of a multiplexed system, open and close the chambers. Appendix A provides more information on how to monitor and customize these programs.

5.2 User Interface

Once the program is run, the main viewing window will appear. This window consists of two main areas: the Plotting section and the Measurements section.



The Plotting section on the left of the main window allows the user to view up to three different time-series plots 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

[1] Your computer may be set to hide the .exe extension

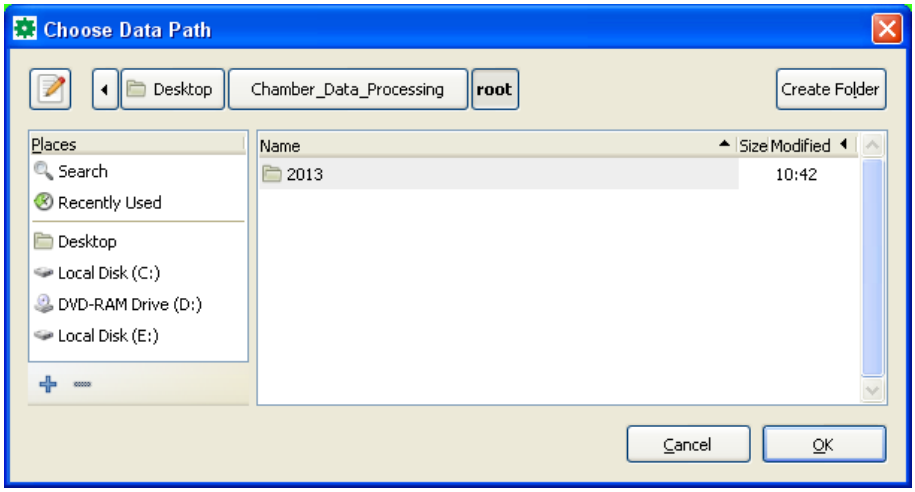
toggled between Automatic and Fixed scaling. The X-axis type and scaling for all three plots can be changed using the buttons at the bottom of the plotting area.

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. The two buttons underneath of the Measurements window allow the user to collect and then export chamber data.

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, Options, Help).

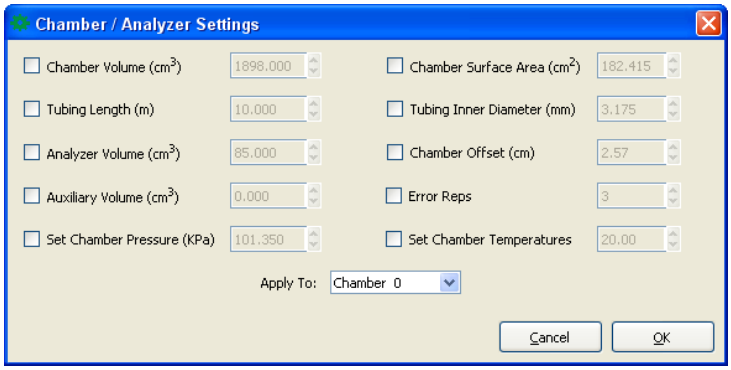
5.3 Chamber/Analyzer Setup

The first parameter that must be set is the analyzer data path. As of version 2.5.6B, this analyzer is assumed to be a Picarro 2508 gas analyzer. The analyzer path can be changed by selecting Change Data Path from the Options menu at the top of the screen. This will prompt the user to specify a data path using a popup Folder Selection widget:



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 2013. 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 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 Autochamber without a Multiplexer, then Chamber 0 is the correct setting. For multiple chambers, the chamber selection corresponds to which Multiplexer port a given Autochamber is connected to (with Chamber 0 representing unidentified Autochamber measurements).



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 after-market 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 the Chamber Offset. This value represents the distance between the bottom of the chamber and the soil surface, a cap typically caused by non-flush soil collars. 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.

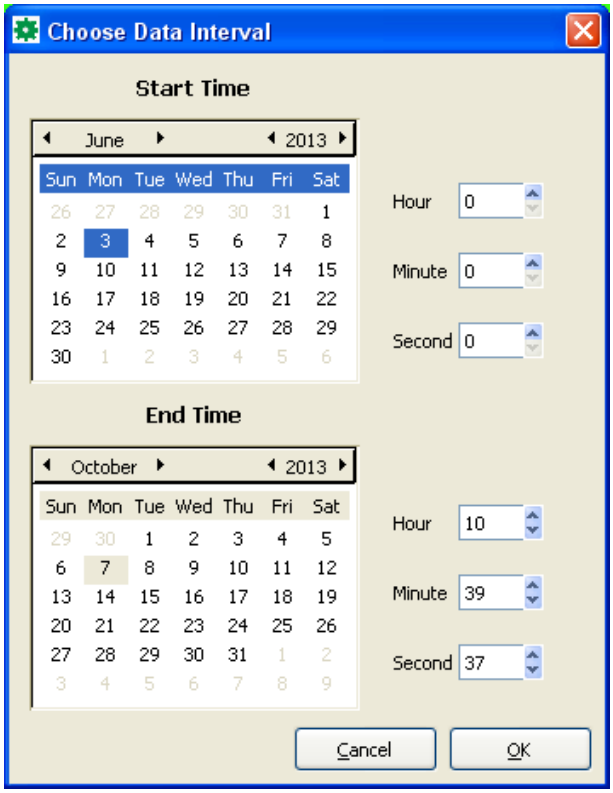
The "Error Reps" setting dictates how many Monte Carlo fitting iterations will be used to estimate the parameter error for the linear and exponential flux/Keeling intercept values. For demonstration purposes, this value defaults to 3. A detailed study of the convergence of this error for typical chamber data is still underway, however a lower bound of 500 is tentatively recommended. 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 "Chamber Pressure" and "Set Chamber Temperature" options.

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.

5.4 Chamber Measurements

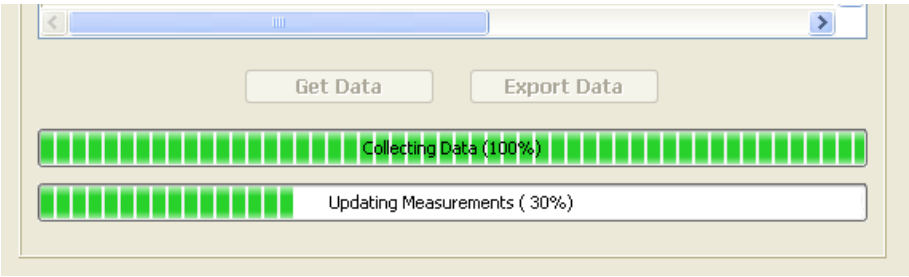
5.4.1 Importing Data

Analyzer data can be imported by clicking the "Get 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 any chamber measurements that do not start after the specified Start Time or finish before the specified End Time will be ignored. Note that a buffer of up to two hours will be used to extend the specified start time in order to account for the logging frequency of the analyzer. These measurements can be excluded afterwards in the event that unwanted portions of data are captured.

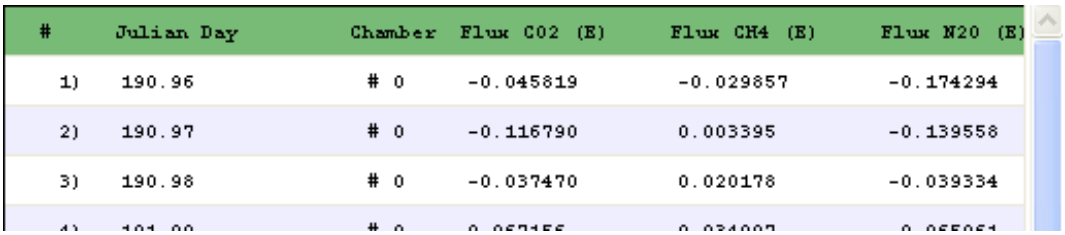
Once the data interval has been set by clicking **Ok**, the program will begin searching through the analyzer data files to find chamber measurements. During this process many GUI elements will be disabled as the Measurement and Plotting sections are updated. Progress bars indicating the status of the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

5.4.2 Data Table Fields

Once analyzer data has been parsed for static chamber measurements, a number of data fields will be displayed in the Data Table. These default parameters are analyzer specific, but generally include flux and water content information.

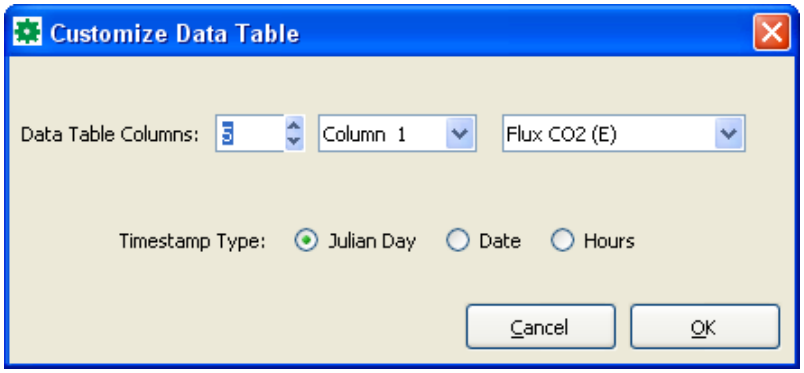


#	Julian Day	Chamber	Flux CO2 (E)	Flux CH4 (E)	Flux N2O (E)
1)	190.96	# 0	-0.045819	-0.029857	-0.174294
2)	190.97	# 0	-0.116790	0.003395	-0.139558
3)	190.98	# 0	-0.037470	0.020178	-0.039334

Depending on the analyzer, a number of other fields can also be displayed, shown in the table below:

Data Field	**G2201-i**	**G2508**
CO_2 (ppm)	X	X
$\delta^{13}CO_2$ (ppm)	X	
CH_4 (ppm)	X	X
$\delta^{13}CH_4$ (ppm)	X	
N_2O (ppm)		X
$\delta^{15}N_2O$ (ppm)		
NH_3 (ppm)		X
CO_2 Flux, Linear Fit (μmols $m^{-2}s^{-1}$)	X	X
CO_2 Flux, Exponential Fit (μmols $m^{-2}s^{-1}$)	X	X
CH_4 Flux, Linear Fit (μmols $m^{-2}s^{-1}$)	X	X
CH_4 Flux, Exponential Fit (μmols $m^{-2}s^{-1}$)	X	X
N_2O Flux, Linear Fit (μmols $m^{-2}s^{-1}$)		X
N_2O Flux, Exponential Fit (μmols $m^{-2}s^{-1}$)		X
NH_3 Flux, Linear Fit (μmols $m^{-2}s^{-1}$)		X
NH_3 Flux, Exponential Fit (μmols $m^{-2}s^{-1}$)		X
CO_2 Flux Error, Linear Fit (μmols $m^{-2}s^{-1}$)	X	X
CO_2 Flux Error, Exponential Fit (μmols $m^{-2}s^{-1}$)	X	X
CH_4 Flux Error, Linear Fit (μmols $m^{-2}s^{-1}$)	X	X
CH_4 Flux Error, Exponential Fit (μmols $m^{-2}s^{-1}$)	X	X
N_2O Flux Error, Linear Fit (μmols $m^{-2}s^{-1}$)		X
N_2O Flux Error, Exponential Fit (μmols $m^{-2}s^{-1}$)		X
NH_3 Flux Error, Linear Fit (μmols $m^{-2}s^{-1}$)		X
NH_3 Flux Error, Exponential Fit (μmols $m^{-2}s^{-1}$)		X
$\delta^{13}CO_2$ Keeling Error (ppm)	X	
$\delta^{13}CH_4$ Keeling Error (ppm)	X	
$\delta^{15}N_2O$ Keeling Error (ppm)		
$\delta^{13}CO_2$ Keeling Error (ppm)	X	
$\delta^{13}CH_4$ Keeling Error (ppm)	X	
$\delta^{15}N_2O$ Keeling Error (ppm)		
$\delta^{13}CO_2$ Isoflux	X	
$\delta^{13}CH_4$ Isoflux	X	
$\delta^{15}N_2O$ Isoflux		
$\delta^{13}CO_2$ Isoflux Error	X	
$\delta^{13}CH_4$ Isoflux Error	X	
$\delta^{15}N_2O$ Isoflux Error		
H_2O Content (%)	X	X
Cavity Pressure	X	X
Cavity Temperature	X	X
Chamber Temperature	X	X

Fields that are not currently displayed can be added by clicking on the Data Table header, and customizing the table using the pop-up window.

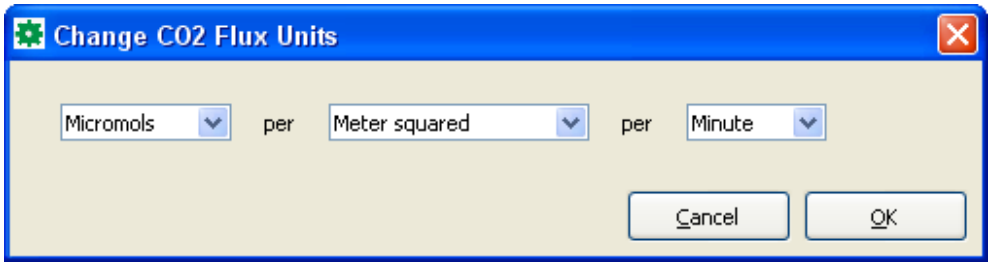


A short description of each of these fields is provided through a tooltip upon mouse-over. From this window the number of columns can be adjusted, as well as what parameter will be displayed in each column. In addition, the timestamp that is used for each line of the Data Table can be changed to one of four options:

- Julian Day - Fractional days elapsed since January 1 of respective year
- Date - Timestamp using MM/DD/YYYY HH:MM: format
- Hours - Hours elapsed since start of first measurement
- Measurements - Simple sequential numbering of chamber measurements

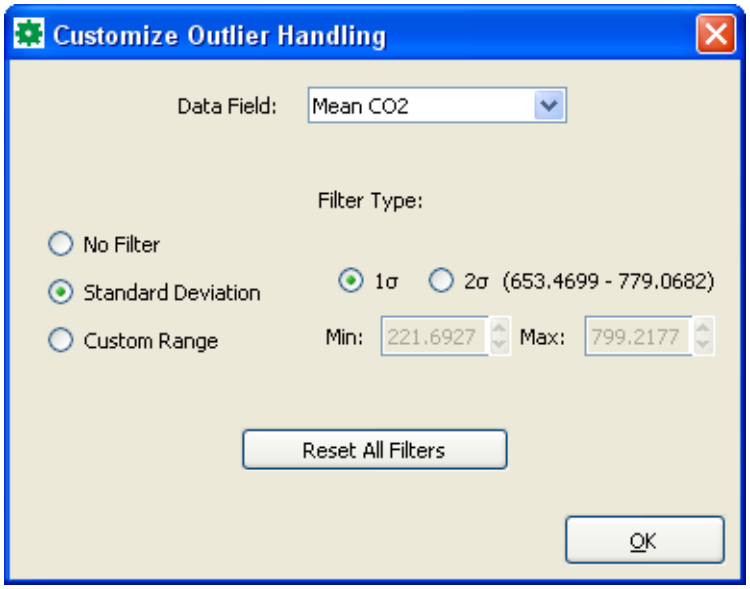
Please note that the number/order of columns and the chosen timestamp will be reflected in any exported data. You may need to scroll the Data Table in order to view all columns.

The flux estimates for each chamber measurement will default to a unit generally appropriate for the gas in question (μmol m^{-2} s^{-1} for CO_2 and NH_3, nmol m^{-2} s^{-1} for CH_4 and N_2O). These can be changed from the Measurements menu under "Flux Units". This window allow the flux units to specified arbitrarily from various mass, area and measurement time settings, such as Kg km^{-2} $year^{-1}$ or nmol ha^{-1} $hour^{-1}$.



5.4.3 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 Outliers in the Measurements menu.



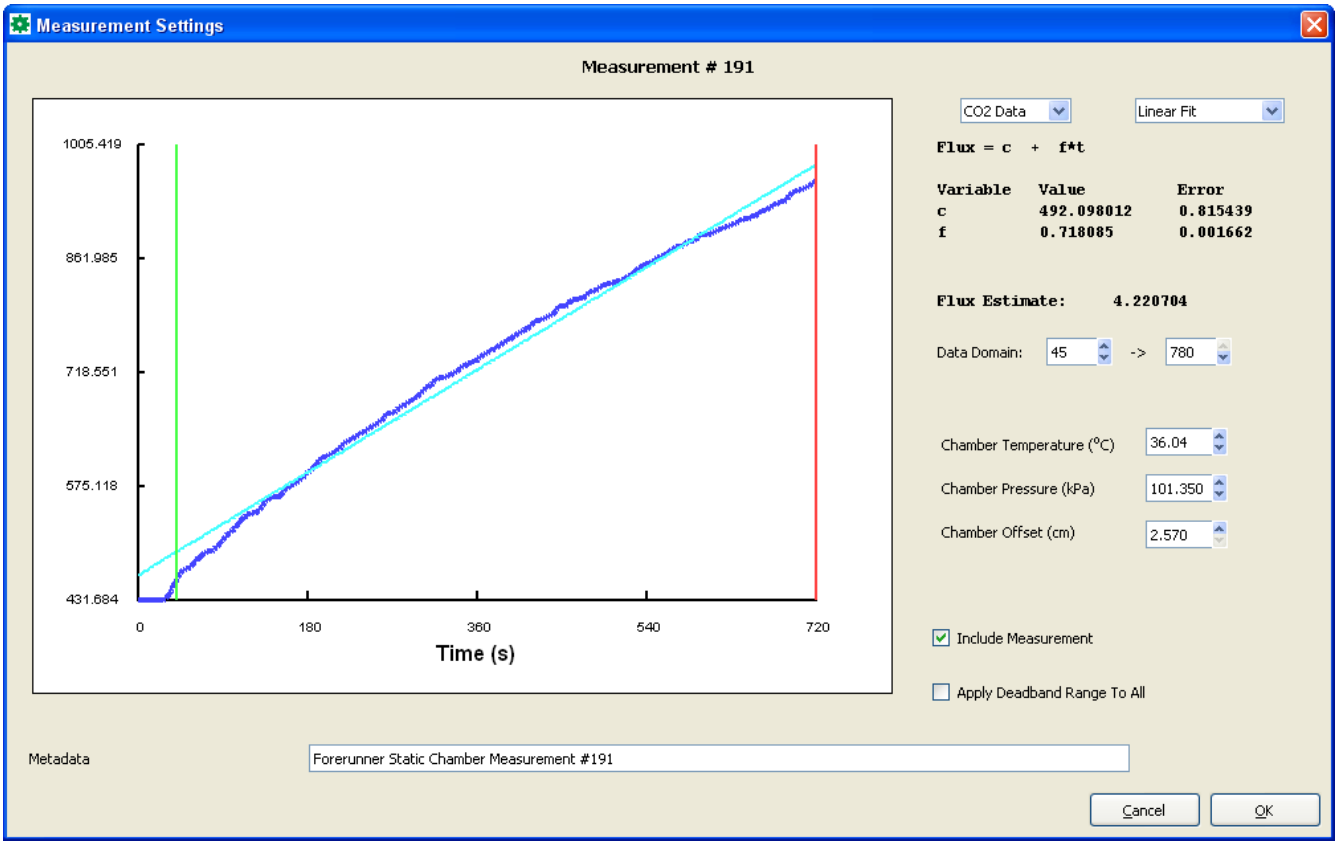
The Data Field drop-down menu selects which measurement value to set the filter for, with all ranges defaulting to No Filter. Selecting a filter will cause measurements outside the allowable range to be disabled (grayed out), meaning that they will not appear in the main window's plots or any exported data files.

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 1σ or 2σ 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% 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).

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.

5.5 Data Processing

Individual measurements can be viewed in greater detail by clicking on them in the Data Table, which brings up the Measurement Settings window:



The flux fits and Keeling plot intercepts 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 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 this measurement from both the (exported) data table and the main window plots. The "Apply 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.

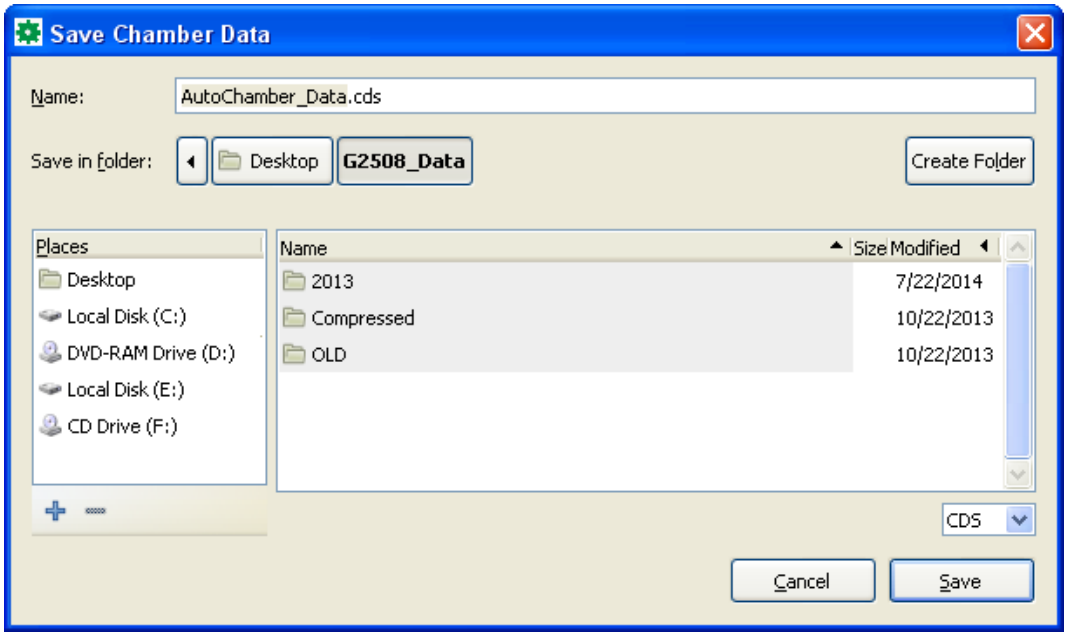
Finally, the user can enter a metadata string directly below the Measurement Settings plot. This string can be up to 200 characters long, and is used to make any notes about the measurement/environment or other important details.

5.6 Saving and Loading Data

Imported data, chamber settings and other parameters can be saved or loaded from the File menu.

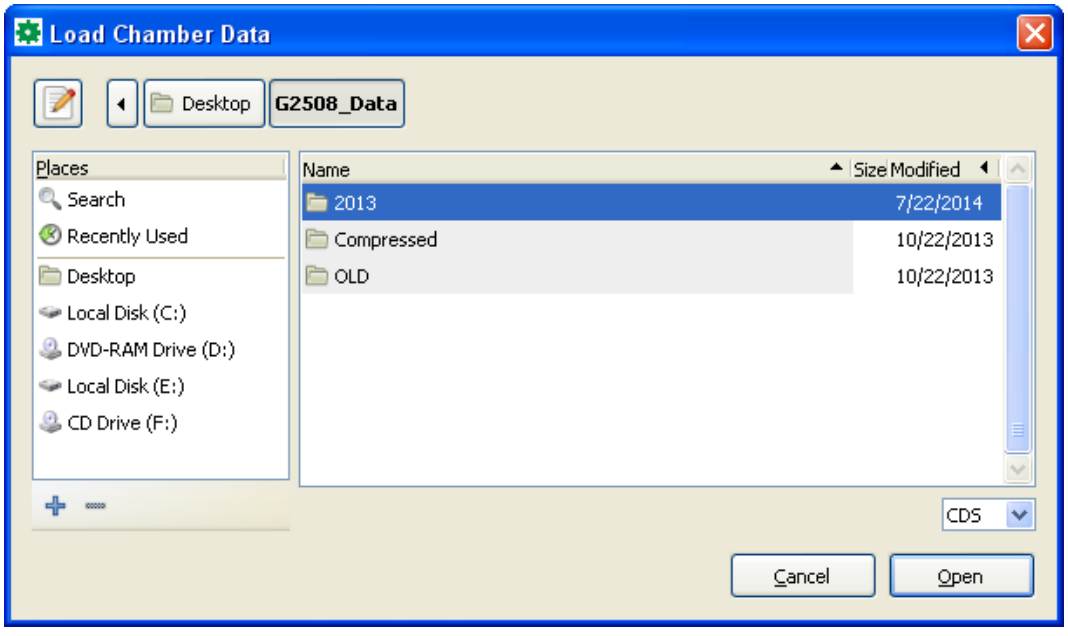
5.6.1 Saving Data

To save a Chamber Data Processor 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 (please contact support@forerunnerresearch.ca if this is required).



5.6.2 Loading Data

To load a Chamber Data Processor 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.

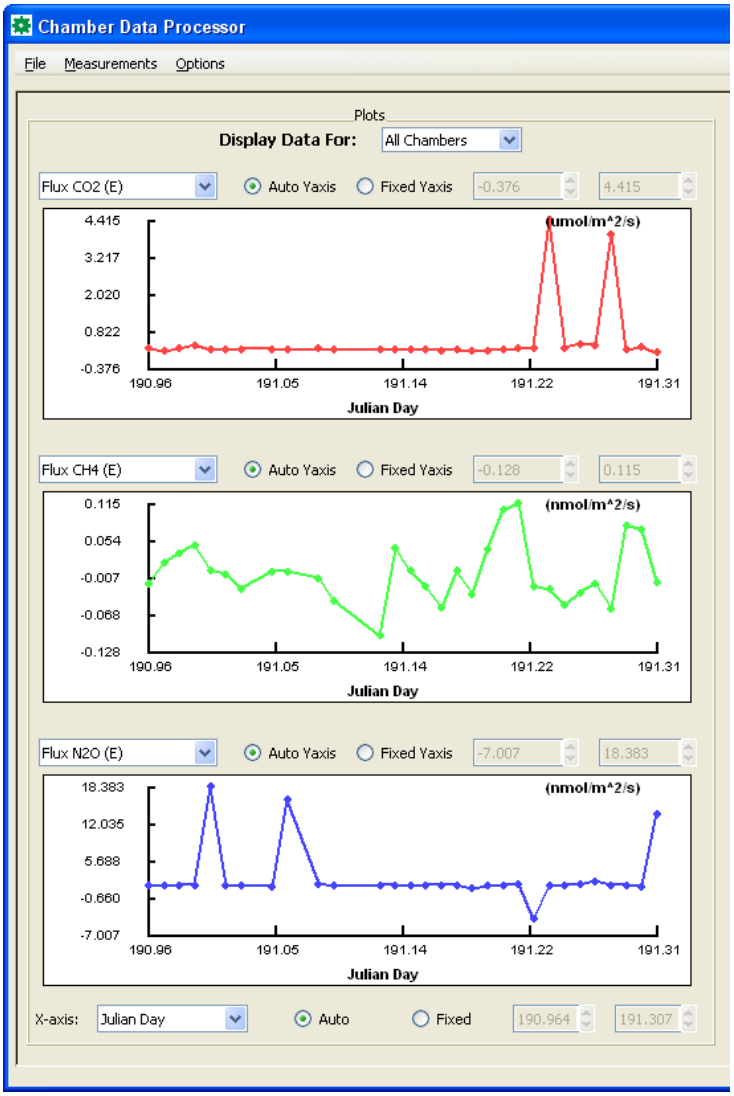


5.7 Viewing Data

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

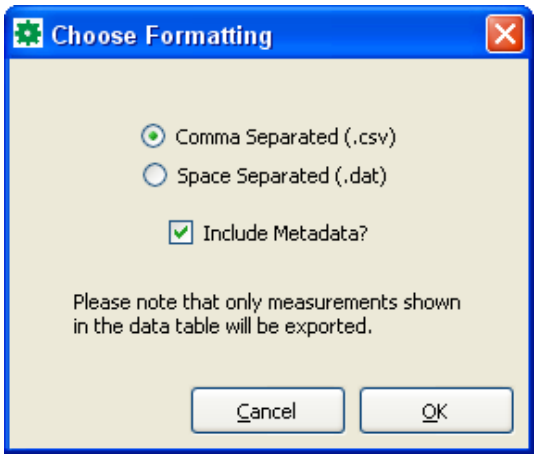
The Y-axis is automatically scaled by default. As long as this option is left unchanged, the (unused) Fixed Y-axis settings will be updated to reflect the current plot zoom. Once "Fixed Y-axis" is selected for the first time, this relationship will be broken, in order to prevent loss of user-specified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

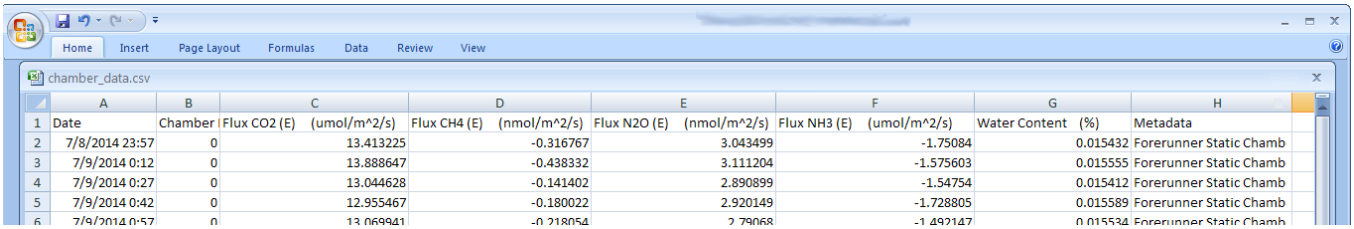


5.8 Exporting Data

Once all the chamber data has been collected
and fine-tuned, the user can export the contents of the Measurements table as either a .csv or .dat file using the "Export Data" button at the bottom left of the screen.



This prompts the user for a formatting type, followed by a File Selection widget 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.



	A	B	C	D	E	F	G	H
1	Date	Chamber	Flux CO2 (E) (umol/m^2/s)	Flux CH4 (E) (nmol/m^2/s)	Flux N2O (E) (nmol/m^2/s)	Flux NH3 (E) (umol/m^2/s)	Water Content (%)	Metadata
2	7/8/2014 23:57	0	13.413225	-0.316767	3.043499	-1.75084	0.015432	Forerunner Static Chamb
3	7/9/2014 0:12	0	13.888647	-0.438332	3.111204	-1.575603	0.015555	Forerunner Static Chamb
4	7/9/2014 0:27	0	13.044628	-0.141402	2.890899	-1.54754	0.015412	Forerunner Static Chamb
5	7/9/2014 0:42	0	12.955467	-0.180022	2.920149	-1.728805	0.015589	Forerunner Static Chamb
6	7/9/2014 0:57	0	13.069941	-0.218054	2.79068	-1.492147	0.015534	Forerunner Static Chamb

6 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 Forerunner Research Inc. at 1-902-870-5220, or by emailing us at support@forerunnerresearch.ca with subject "Chamber Data Processor".

- ***Chamber Data Processor does not find any data when I click "Get Data"***

  Ensure that the Analyzer Path has been set correctly (Options→Change Data Path). Double check the time-frame in which the measurements occurred and/or try expanding the data interval.

- ***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). If the problem remains, restart the Chamber Data Processor Software.

- ***The program takes a long time "Updating 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 resetting this value to 10 to decrease processing time. Finally, if you have turned on symbol plotting from the Visual Options window, disabling this feature can increase plotting speed.

- ***The program claims that no measurements were found when I try to import data.***

  Ensure that the analyzer root path has been set correctly by choosing "Change Data Path" from the Options menu and navigating the the proper directory. One or more folders indicating year (e.g. "2013", "2014") should be visible when clicking OK from the popup window. Double-check the selected date range when importing data to ensure that the measurements fall within the chosen dates. If this does not resolve the issue, try increasing the date range by a full 24 hours. Finally, if the Chamber Data Processor software determines that the imported data has too few measurements to be used (typically <30s of data) then the chamber measurement will be dropped.

A FRMonitor and FRMonitor-MP

FRMonitor and FRMonitor-Mp are programs used to collect and store data transmitted by a Forerunner Autochamber. In addition, FRMonitor-MP is used to control the Forerunner Recirculating Multiplexer. These program must be running and connected prior to deployment, in order to track peripheral data used to correct or augment flux measurements as well as control multiple chambers at once.

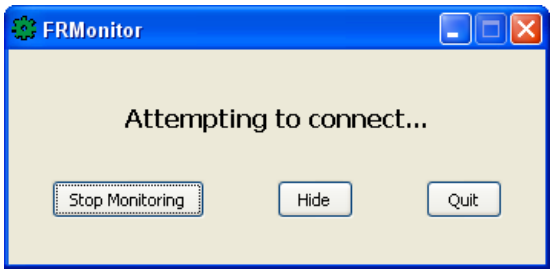
Both executables must be kept in the main Chamber Data Processor folder, and should be launched from here. Doing so adds an icon to the Windows system tray, that can be used to show the program's main window when changes are required. This icon changes color depending on the program's status, where orange indicates that the program is searching for a connection, red indicates that the program has been paused and green indicates that the program is communicating successfully.

Please note that the appropriate monitoring software **must be running** in order for the connected Autochamber(s) to function. For this reason, the software should be added to the list of Windows startup programs using the following steps:

1. Click the Start button, All Programs, right-click the Startup folder and then Open.
2. Open the Chamber Data Processor folder on your PC/Analyzer
3. Right-click FRMonitor-MP.exe/FRMonitor.exe, and then click Create Shortcut.
4. Drag the new shortcut into the Startup folder.

A.1 FRMonitor

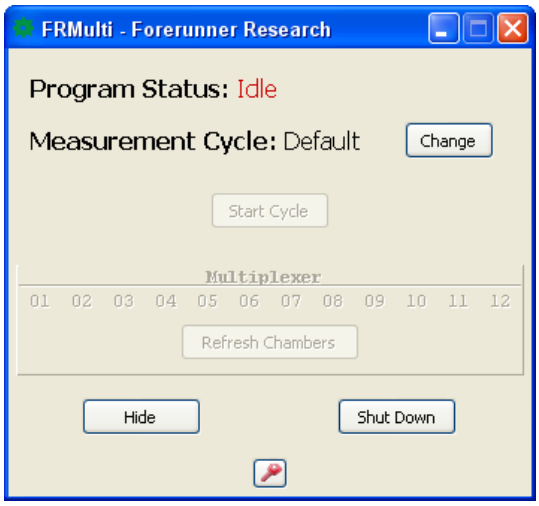
FRMonitor provides software to collect chamber data from a single Forerunner Autochamber, when the chamber is being controlled by the analyzer's valving system. The main window displays the program's current status (Searching, Stopped or Running) and allows the user to pause/resume monitoring, as well as hiding the window again or closing the program outright.



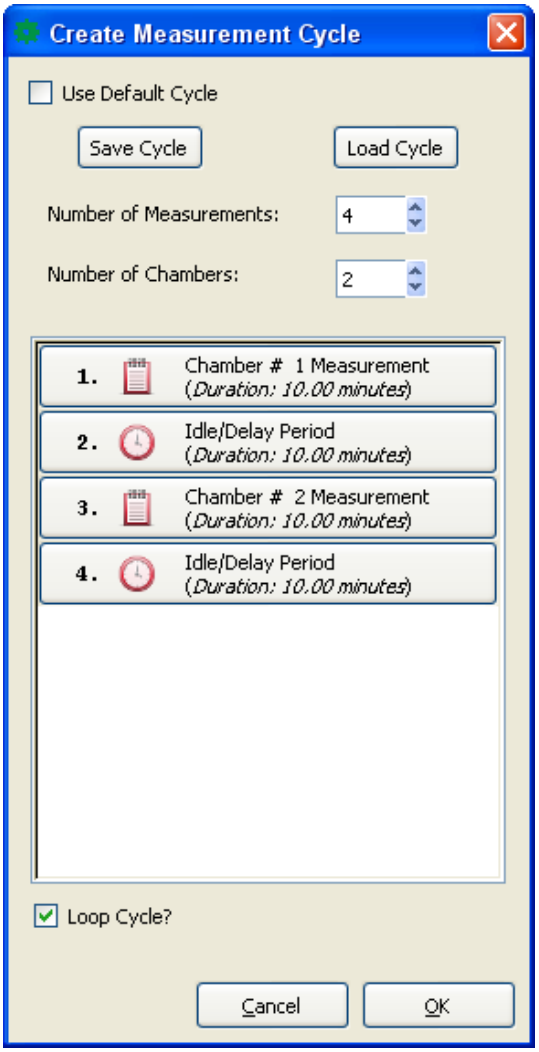
Autochamber temperatures logged by FRMonitor are automatically used to correct flux measurements in the Autochamber Data Processor program. These can be viewed and modified via the Measurement Settings window. If the data processor is unable to retrieve these values, the gas analyzer's Data Acquisition System temperature (DasTemp) will be used in its place. As this temperature does not always match the ambient value, we recommend replacing this with an appropriate fixed vale from the Chamber/Analyzer Settings window (applied to all measurements).

A.2 FRMonitor-MP

Similar to FRMonitor, FRMonitor-MP logs temperature/peripheral data from connected Autochambers, but it also serves as the control panel for the Autochamber Multiplexer. The main window shows the current connection status (Idle, Connecting, Connected), the type of measurement schedule (Default or Custom) and the detected Autochambers.



The measurement cycle can be customized by clicking the Change button on the main window. This brings up a subwindow 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. These steps can be set to either Idle or a Chamber measurement by clicking on them, then setting the measurement type and duration. The number of available chambers can be adjusted from the main window.



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 Autochamber.

Please consult the MP-001 Multiplexer User Manual at (http://www.forerunnerresearch.ca/MP.php) for further information on the FRMonitor-MP software.

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