

eosMX Valve Delay and Setting Data Deadbands

Introduction

Eosense's eosAC and eosMX/MX-P allow the user to design a customized measurement cycle that best meets the needs of their specific field location and experimental design. As the length of gas tubing, the magnitude of the fluxes and the analyzer will vary from case to case, several tools are provided in the eosLink-MX and eosAnalyze-AC software to ensure optimal flux measurement and analysis.

In this application note, we will review two such settings: the Valve Delay parameters in the eosLink-MX software, and the Data Deadbands in the eosAnalyze-AC software. Both of these options should be carefully considered when creating and examining scheduled measurements, as improper use can lead to biased measurements and/or poor flux estimates.

IMPORTANT

This application note is not a replacement for the eosAC or eosMX user manuals. We strongly recommend reading them before proceeding.

Gas Transport and eosMX Valve Delay

While an eosAC is closed, the user's analyzer draws air from the chamber, analyzes the gas concentrations and then recirculates the sample back to the chamber. This transport of gas is not instantaneous, and varies depending on the flow rate of the analyzer and the total length of tubing. Table 1 below shows normal transport times for several common gas analyzers and tubing lengths.



eosMX multiplexer



eosAC automated flux chamber

Table 1: Transport time along tubing of various length, for the most common Picarro and LGR analyzers. Note that this assumes that the default flow rate of 240 sccm (G2508) and 1000 sccm (UGGA) is used.

Analyzer	Tubing Length (m)		
	5	10	30
Picarro G2508	11 s	22 s	33 s
LGR UGGA	3 s	5 s	8 s

Please note that these values represent the estimated amount of time for a sample in the chamber to reach the analyzer - not the total time required before the analyzer can provide a true measurement of the current chamber concentration. In general, these should be considered the absolute minimum amount of time before a gas sample leaving an eosAC chamber reaches the paired analyzer.

The eosLink-MX software uses the Valve Delay (pre) setting to allow sufficient time for gas transport and mixing at the start of a flux measurement, to ensure that the initial concentration observed matches the eosAC's ambient concentration. This value can be set between 30-600 seconds, using the values shown in Table 1 as guidelines for the minimum recommended values.

The gas transport time also impacts the end of a measurement. When a measurement ends and the eosAC chamber opens, there are still important gas samples in the tubing between the chamber and the analyzer. If the eosMX multiplexer were to immediately switch to another chamber, these gas samples would not be analyzed, and the final portion of the accumulation timeseries would be lost. Depending on the flow rate of the analyzer, the type of fitting and the length of the chamber measurement, truncating the chamber concentration timeseries in this manner can significantly impact the resulting flux estimation.

To prevent this effect, the eosLink-MX software has a second setting, Valve Delay (post), which determines how long gas should continue to be drawn from the chamber after it has opened. Eosense recommends using a similar amount of time for both Valve Delay parameters. For both the pre and post options, setting a longer delay can help ensure clearly defined accumulation curves, though measurement frequency will be affected.

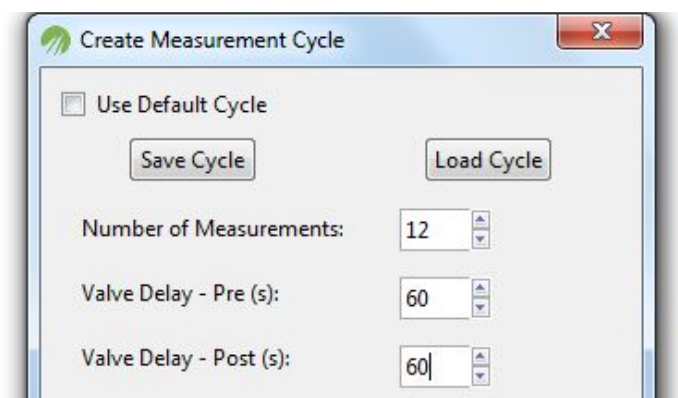


Figure 1: eosLink-MX window showing the pre and post Valve Delay settings

eosAC Accumulation Curves

When the eosAC chamber closes to begin collecting flux measurement data, gas concentrations start to increase (or decrease) in the chamber headspace. This timeseries of chamber concentration is then fit to either a linear or exponential function in order to estimate the rate of gas flux into the chamber, as shown in Figure 2. Depending on the production rates, chamber closure time and physical characteristics of your site, the shape of the accumulation curve can vary substantially.

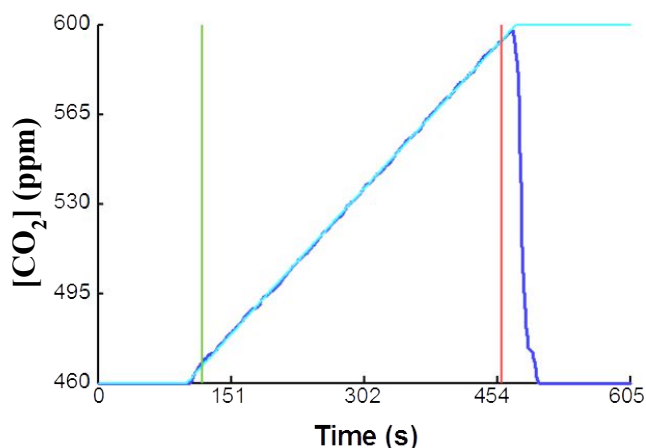


Figure 2. A steady flux of CO_2 , suitable for linear fitting. The observed flux ($3.99 \mu\text{mol}/\text{m}^2/\text{s}$) is proportional to the slope of the fitted line.

In Figure 2, the rapid drop in concentration near the end of the timeseries shows when gas drawn from the now open eosAC chamber reached the analyzer. By setting a generous post Valve Delay (120 s in this example), the end of the accumulation curve - and thus the range of data over which to fit - is clearly defined.

Figure 3 shows another example accumulation curve, where the pre Valve Delay was set to only 30 s. As a result, gas from the previous measurement was still present in the tubing / analyzer cavity, and the start of the new accumulation curve is poorly defined. As a result, it is difficult to determine what area of data to fit over, which can have significant implications for the estimate flux rate.

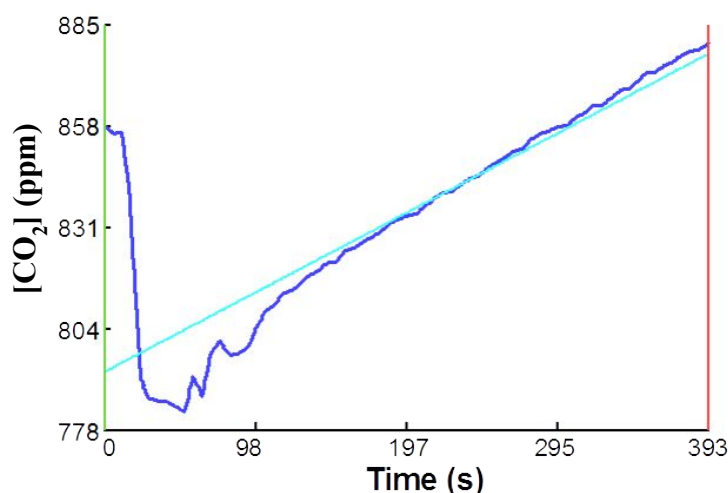


Figure 3: Example of a steady flux of CO_2 , where the initial portion of the accumulation curve has been contaminated by gas from the previous measurement.

Setting Data Deadbands

When processing eosAC flux measurements, it is critical that the range of chamber data used for fitting is set correctly. As shown in the previous Figures, the values for both of the Valve Delays can significantly change the data available for fitting, as can other parameters such as measurement time and site productivity. Figure 4 shows the full concentration data captured for an eosAC flux measurement using pre and post Valve Delays of 120 seconds each. Note the clearly defined, exponential accumulation curve. In order to produce an accurate estimation of the flux rate, the ambient portions of this data (corresponding to before and after the chamber measurement) must be excluded, so that the exponential fit matches the accumulation closely.

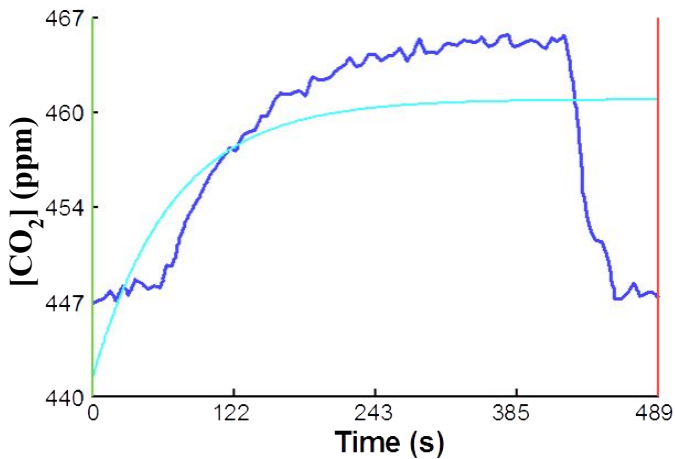


Figure 4: Example of an exponential accumulation curve. Note the light blue line, representing a poor attempt at fitting the entire range of available data.

The eosAnalyze-AC software uses two Deadband settings to select what region of data is suitable for fitting. When viewing an eosAC measurement in the Measurement Settings window (shown when clicking on a measurement in the Data Table), these settings are shown visually as vertical green (Start) and red (End) lines bracketing the selected fitting range. These bands can be adjusted using the Data Domain parameters, which will update the position of the Deadband markers. Figure 5 shows the same chamber measurement as shown in Figure 4, now using more appropriate Deadbands. Note the improvement in the fitted line (light blue). As a result, the calculated flux rate changes from the previous value of 3.20 to 2.44 $\mu\text{mols}/\text{m}^2/\text{s}$, showing that the previous fit overestimated by more than 30%.

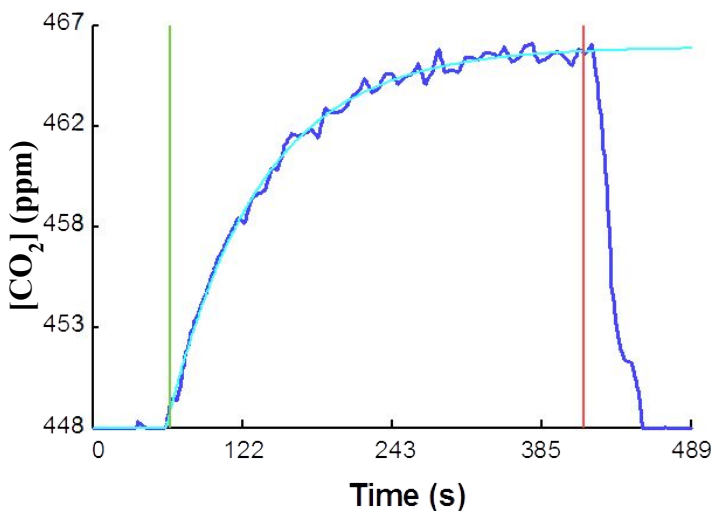


Figure 5: The same accumulation curve as shown in Figure 4, now with appropriate Deadband settings. Note the improved fit (light blue)

For most deployments, the same set of Deadband values can be used for all measurements and chambers, assuming that the same tubing length has been used for each. In this case, the same set of Deadbands can be applied to all measurements, either through the Measurement Settings window for a given data point (via the “Apply Deadband Range To All” option), or by specifying the range through the Chamber and Analyzer Settings window.

Figure 6: The right portion of the Measurement Settings window, showing both the Data Domain (Deadband) settings and the Apply Deadband Range To All checkbox.

Conclusion

Allowing sufficient time for gas transport and mixing is crucial to getting the best performance and data out of your eosAC system, as is ensuring that your measurement fitting range is appropriate for your observed fluxes. Varying field conditions (e.g. those causing predominantly linear or exponential accumulation) can significantly impact the effects that these parameters may have on your flux estimations, and so Eosense recommends that you always examine the accumulation curves underlying your flux measurements to ensure optimal accuracy and data confidence.