**SLIDE 1 [00:00]:**

*Moderator:*

Liukang and Georges talk is titled Open-path vs. Closed-path Gas Exchange Measurement. Liukang.

*Speaker:*

Thanks Ashlee. Good afternoon from LI-COR Biosciences here in Lincoln, Nebraska. It’s nice to see so many joined the webinar today. Today we are going to discuss Open-path and the Closed-path gas Analyzer for Eddy-covariance Flux measurement. And we’re going to focus on the advantage and benefit of using either one of the Analyzers in the Eddy Flux measurement. And, I will talk first on the Open-path, then George will discuss the Closed-path Analyzer. Do to the half hour time limitation our discussion will be on some highlights only, regarding the two types of instruments, without going into all the details. You’re welcome to contact us, after the webinar for further discussion.

The Earth is getting warmer and warmer, no single day goes by without hearing from the news media

**SLIDE 2 [01:01]:**

on the topic such as global warming, climate change, sea level rising, carbon dioxide emission, carbon dioxide sequestration, carbon cycle research. As we all know that global warming or climate change, mainly is due to the continuously rising of the atmosphere CO2 concentration, since the Industrial Revolution at the end of the 18th century. Here, we show a Simplified Global Carbon Cycle from 2007 IPCC report. A human being, every year dump about 6 gigaton carbon into the atmosphere, from burning fossil fuel, cement production and land use change, such as deforestation. The ocean takes about 2 gigaton carbon each year, and the terrestrial ecosystem takes about 1 gigaton carbon. So, every years net increase in atmosphere carbon will be around 3 to 4 gigaton.

**SLIDE 3 [02:02]:**

Scientist want to know more detail on how much carbon is uptake by the terrestrial ecosystem. As we show in this slides, for ecosystem carbon uptake is through the Photosynthesis process, CO2 release
through the plant respiration, soil respiration and maybe erosion. Some carbon will be stored in the soil as organic material. To understand how environmental and biological variable including radiation, temperature, precipitation, soil moisture and plant canopy size, mainly the leaf area index, control or regulate the carbon cycle process at ecosystem level. Research monitors long-term or all year round net carbon flux, using the popular Eddy Covariance method. This kind of information is necessary for large scale modeling study.

SLIDE 4 [02:58]:

The Eddy Covariance method measures the high frequency of vertical wind speed and CO₂ density, then using the equation here to compute the flux. Basically, this method measures how much CO₂ in the updraft air parcel we call Eddy, and how much CO₂ in the downdraft air parcel, then average it over half-hour. You will get net CO₂ flux exchange between the ecosystem and the atmosphere.

In the turbulent air near the surface, Eddy size varies quite a bit, but for flux measurement it is sufficient, if you have a wind speed sensor like sonic anemometer, or CO₂ Analyzer with a 10 Hz response. Since higher frequency Eddy, faster than 10 Hz, won’t contribute to the net CO₂ transport. So normally the login frequency for Eddy Flux measurement is 10 Hz. Using the same method, with a H₂O analyzer and faster temperature measurement, you can estimate a sensible heat flux and a latent heat flux, as I showed in the equation above.

SLIDE 5 [04:11]:

Vertical wind speed, W, can be measured with a sonic anemometer, quite a few companies manufacture excellent sonic anemometers, like Campbell Scientific, Gill, Metek, and R. M. Young. From a 3-D sonic anemometer we can get UVW and sonic temperature. In theory, we only need vertical wind speed to compute the flux, but 3-D wind speed, and UVW are needed for the coordination rotation, so the mean vertical wind speed would be zero during the half hour averaging time to satisfy the requirement of air mass conservation.

Sonic temperature can be used for sensible heat flux computation after converting the virtual temperature from the sonic to real temperature. CO₂ and H₂O can be measured with each open-path and closed-path analyzer. Here I showed an open-path CO₂ and H₂O analyzer the LI-COR 7500. I also showed an example of 10 Hz vertical wind speed W and CO₂ data from 10:40 a.m. on April 14, 2002
from active grassland in California, when I worked in Professor Dennis Baldocchi’s group as a postgrad at UC Berkeley. Since grass was very active, up-taking CO₂ by photosynthesis, when you have a positive W, means the Eddy is moving upward, the Eddy’s from the grass canopy, the CO₂ concentration was decrease, when you have an negative W, means you have a downward moving Eddy, the analyzer sees the fresh air from above, so the CO₂ is increase.

SLIDE 6 [6:05]:

The main advantage of the open-path analyzer is the lower power consumption. The open-path 7500 is designed for remote field sites. The main advantage of open-path analyzer is lower power consumption. A LI-COR 7500 on a steady-state condition only needs about 10 Watts. The whole flux sites, which I showed here as example, including; anemometer, data logging, and other various sensor, can operate with a solar panel. This will give you a huge flexibility to select location of your research sites, when you don’t have AC power.

SLIDE 7 [6:52]:

Other advantage for open-path analyzer; high speed, you can log into the data up to 40 Hz, high position, root mean square noise of only 0.1 ppm CO₂ at a, 360 ppm ambient level, and .0047 ppt H₂O at 10 Hz sampling frequency. Also, since there is no tubing needed and it eliminates the delay, and also no tubing attenuation for CO₂ and H₂O signal. This instrument also has excellent stability; it’s very good for a harsh environment.

According to Fluxnet office at Oakridge National Lab, as of March 31, 2009 globally we have 576 towers to monitor CO₂ and H₂O flux over various ecosystems. The majority of the tower are using open-path CO₂ and H₂O analyzer, the 7500.

SLIDE 8 [8:04]:

One additional calculation of the Eddy Flux measurement, when you using open-path gas analyzer, is the density correction, we call Webb & Pearman, Leuning correction, often referred to as WPL correction. Open-path analyzer measures number density CO₂ which has a unit of µmol CO₂ per cubic meter of air, not the mole fraction.
SLIDE 9 [8:34]:

So the number density will change if the number of CO₂ molecules changes in the sample air due to uptake by leaves or released from respiration, this is what we want to measure, and this is what we want to know. But the number density will also change, if the volume of the air expands or contracts due to the changing in air temperature, or due to change in air moisture content.

If you’re using Eddy Covariance method to measure carbon flux over a parking lot in a hot dry summer, you will see huge carbon uptake by the concrete if you don’t apply the WPL correction. This has been explained in theory and confirmed by experiments done by Ray Leuning and Jay Ham.

SLIDE 10 [9:24]:

We’re not going to show all details in the derivation the WPL equation, but here is the final version. You might see some other version of this final equation in the literature. The w’ ρₚ is a raw flux. And w’ ρᵥ is a latent heat flux. That is a dilution from the water vapor. w’T’ is a sensible heat flux term. That is air expansion due to the sensible heat flux. And the ρₚ is a CO₂ number density. ρₚ is a dry air density. ρᵥ is water vapor number density. T is air temperature. mₚ is a dry air molecular weight. mᵥ is a water vapor molecular weight. And Fₑ is the final flux.

SLIDE 11 [10:21]:

I show an example on this slide, to see how big the magnitude of the WPL term as compare with the final flux. This data set is from grassland in a dry summer when the grass and the soil was almost oven dry. The soil volume moisture content was down to 3 to 4%, so all available radiation energy partitioning into the sensible heat flux and only small portion of the latent heat flux, LE.

SLIDE 12 [10:57]:

When you calculate W’ row C’, you see a huge downward flux during the daytime, up to -20 micromole CO₂ per square meter, per second. But after you apply the WPL term, very good respiration, upward flux was observed, averaged around .5 micromoles per square meter second. This lower respiration rate was consistent with chamber based soil CO₂ flux measurement.
SLIDE 13 [11:29]:

The WPL correction term has a sound physical explanation and it is well accepted in the carbon flux community. It is not due to instrument errors or any kind of artifacts in the measurement. One should not look at the relative magnitude of the WPL term and the final flux term ($F_c$). WPL correction term must be measured in order to have an accurate CO$_2$ flux measurement. In fact, many scientists are starting to refer to WPL correction term as the “WPL term” simply because it is not an error term.

SLIDE 14 [12:11]:

Since the optical path of the open-path is open to the air, the analyzer will not properly operational, so during rain, snow, foggy weather conditions, the data will be invalid. Therefore, if a study site has high precipitation or frequent foggy weather, a close-path analyzer is preferred. My friend, George, will discuss close-path analyzer configuration.

Moderator:

Thank you Liukang.

SLIDE 15 [12:40]:

Before we move on there are a couple of good questions I’d like you to answer. Um, the first question is; how often do you have to calibrate the LI-7500?

Speaker:

That’s good question, and we got a phone call from a customer and quite often, normally you need to calibrate 7500 every month. And since it is used for the flux measurement, use the Eddy Covariance technique, zero drift won’t have any impact on the flux measurement. For example, 1% of span drift will translate only 1% error in your flux value. And, the instrument is very stable; it is often installed in the field without calibration for months and months.
Moderator:

Thank-you Liukang. The second question is, how often do you need to replace the internal chemical bottles?

Speaker:

We have a, two small chemical bottles inside the analyzer housing that keep the detector free of CO₂ and water vapor, and one is a, contains Ascarite to removes CO₂, another one is Magnesium Perchlorate, removes water vapor. Those two chemical bottles need replaced on an annual basis. You can buy these two chemical bottles from LI-COR. For a research site it’s very humid, like a tropical area, these bottles need replaced more often.

Moderator:

Great, thank you Liukang. I encourage you to keep submitting your questions throughout this presentation. Liukang will be online to answer anything that might come up. And I’m going to turn the floor over now to George.

Speaker 2:

Thanks Ashlee. Liukang just told you about open-path gas analyzers and their key principles and operation standards and field maintenance. Now let’s switch gears and talk about closed-path gas analyzers. We’ll review the key features and important moments of field operations for those sensors. Closed path gas analyzers are well-established,

SLIDE 16 [14:56]:

and widely used to measure concentrations and fluxes of CO₂, H₂O and other gases. When main principles of operation are recognized, and proper care is taken during setup and data processing, close-path analyzers provide highest quality of data; this has been proven over and over again by over 30 years of research by thousands of scientific groups.
In this presentation we will touch upon key features of closed-path analyzers and on most important operational moments related to demanding fast applications, such as Eddy Covariance flux measurements.

**SLIDE 17 [15:37]:**

We’ll touch upon the most important points in the interest of time, and we go in the following sequence; first we’ll discuss principles of operation, then we’ll discuss key differences from open-path analyzers, then we’ll talk about how sample error is modified when it’s pulled into the analyzer and how to correct for such modification. Then, we also talk about key moments in set-up and operation and data processing and analysis. Then we summarize all the key points, and I’ll talk to you about some news related to closed-path, open-path instruments at LI-COR.

**SLIDE 18 [16:20]:**

Close-path gas analyzers can employ various technology of sensing gas. For example, non-dispersive infrared technology is main standard analyzers use. It can also use single line or narrow band laser absorption, approach as used by newer laser based analyzers. They also can utilize gas chromatography, flame ionization spectrometry and many other methods. They can be applied to slow or fast techniques of measuring fluxes.

Slow techniques usually refers to techniques requiring <5 Hz of data collection. Examples would be; Bowen Ration method, gradient method, inverse flux calculations and so on. The fast term, usually refers to the techniques requiring high-precision concentration measurements with frequencies >5-10 Hz, such as Eddy Covariance technique. And the later one would be the main focus for this presentation.

**SLIDE 19 [17:28]:**

Examples of sensors used for slow techniques are CO₂ gas analyzer LI-820 and CO₂/H₂O gas analyzer LI-840, 6251, 6262 and the latest LI-7000. Out of those the fast techniques only can be used with 6251, 6262 and 7000, because of requirements for high-speed and high precision measurements. Closed-path gas analyzers have number of advantages and fast techniques. They have minimal data loss due to precipitation and icing, minimal uncertainty associated with fast temperature fluctuation and with Webb & Pearman, Leuning sensible heat flux term, possibility of outputting mixing ratio and avoiding using
Webb & Pearman, Leuning term, no surface heating issues, possibility of automated calibration and possibility of climate control. And, we’ll go through these features in more detail in the next few slides. Let’s go to applications now.

SLIDE 20 [18:37]:

Applications for closed-path analyzer are very wide, here are just three examples. The terrestrial application refers to flux networks, which—employ 7000’s and 6262’s all over the world. The advantage to closed-path analyzers for this application is ---the data collection is limited by sonic data precipitation, not by the gas analyzer itself.

Airborne applications refer to the instrument usually housed inside the aircraft, and air is pulled into the sample cell. Such measurements, taken over short periods of time, like hours and used in modeling and sometimes in direct Eddy covariance measurements of flux from an airplane or helicopter. Oceanographic applications usually refer to CO₂ and water flux measurements from the ocean and sea surfaces. And, the advantage of closed-path analyzer there is that they’re not susceptible to spray, and rain, and fog, and salt deposits when you measure directly from the ship or the boat. However, these measurements are challenging because of ship pitch and other movements which effect gyroscopic effects on the analyzer chopper wheels and other parts.

SLIDE 21 [20:17]:

The main principles of operation for closed-path analyzers are pretty simple. The air sample goes through the tube and enters into the cell, and when it happens, the air sample is of course affected by the tube and the cell walls. So we need to understand and compensate for this effect. At the bottom of this slide and the bottom of a few other slides you will see the link which gives you more explanation and provides references for some of the points we discuss here. So, you can just write it down and go to our web page and see it.

SLIDE 22 [21:01]:

How exactly, are samples measured by the flow? Let’s look into the details. The picture here you must trace the usual set-up of closed-path analyzer. The air is sampled through the rain cap and some kind of filter. It goes through the tube, maybe to the bottom of the tower, or to the middle of the tower. It
usually has a water trap, and then it has a fine particle filter to prevent the cell from getting dirty. And then, it goes through the closed-path cell and out to the pump. As you see on the screen there are several things here. The first thing would be the turn of the tube, which happens on the border of the rain cap and the inlet tube. Second thing, would be the flow restriction by inlet filter. The third one would be flow disturbance by water trap. And the forth one would be another flow restriction, by fine particle filter before entering the sample cell.

All these things, and tube itself and cell itself of course affect the analyzer. And, there are some good affects, and some bad affects in there. The first air temperature fluctuations attenuated stronger by the tube, this is a good affect. We don’t want first temperature changes to be present in the cell, because it would imply the need for Webb & Pearman, Leuning sensible heat flux term. The non-reactive, non-sticky gases such as CO₂ or Methane are attenuated very little even in the long tube, this is another good point about this.

Water molecule is polarized and it behaves a little sticky. So, attenuation of water flux would depend on the tube length, your diameter, cleanliness and dustiness in the tube, flow rate and humidly. If you pay special attention to properly correcting water flux, this can be good. And in any case, water flux is needed for various corrections and models, so most people have to pay special attention to how water flux is sampled and corrected.

The reactive for sticky gases, such as NH₄, volatile organic compounds and so on, are difficult to measure with closed-path, because of interruptions with filters and tube and cell walls. Because of this modification to air samples done by the tube and cell walls, the following four moments has become quite important during setup and data processing.

**SLIDE 23 [23:45]:**

Frequency response correction for tube attenuation are required, they should be individual for CO₂ and water fluxes. Such corrections are unique to closed-path fast techniques, and we will go into further details with those.

The second one, is the sensible heat flux portion of Webb & Pearman, Leuning term, is not needed if the tube is long enough to attenuate the sample temperature, this is also unique to closed-path fast techniques. And, it’s important to remember that Webb & Pearman, Leuning term includes three main
components: the sensible heat flux component, the latent heat flux component and the pressure component. Pressure component, usually neglected and for closed-paths with long tube, the temperature component should be neglected. And again, we’ll go through this in detail.

The latent heat flux portion of the Webb & Pearman, Leuning density corrections for water dilution, is still needed and should be based on actual slightly attenuated water vapor fluctuations in the cell. Also, it would really be great to have sample temperature pressure measured inside the cell. Now, let’s look at all this key correction

SLIDE 24 [25:07]:

to the closed-path data in more detail. First let’s look at frequency response correction. The frequency response corrects refer to a family of corrections compensating for the flux losses at different frequencies for a number of reasons. All of these reasons related to instrument and system performance and applied to Eddy covariance technique.

The key frequency response corrections are; time response corrections, sensor separation, scalar path averaging, tube attenuation, high pass filtering, low pass filtering, sensor response mismatch, digital sampling. And tube attenuation here of course is unique to closed-path instruments, because open-path instruments do not have intake tube. Again, look at the bottom of the page and note the link which will give you very detailed description of how these corrections are computed and applied.

SLIDE 25 [26:12]:

Frequency response corrections calculated from something is data using co-spectra. Co-spectra is simply the distribution of flux transported by frequency. The transfer functions describe how each sampling problem, such as sensor separation or tube attenuation would affect ideal co-spectra at each frequency. For closed-path analyzer specifically there is a transfer function for tube attenuation. This function helps compensate for the loss of flux due to the fact that sampling air through the inlet tube, attenuates, dampens, small fluctuations. It is very strong dampening for temperature, very little dampening for CO₂ or Methane, and variable, sometimes strong, sometimes weak dampening for water.

Frequency response corrections I applied while transfer functions using Kaimal-Moore’s co-spectral models, or actual sensible heat flux co-spectra. When co-spectra is dimensionalized,
you can look at sensible heat flux co-spectra, and compare it to latent heat flux co-spectra, or to CO₂ flux co-spectra. That’s why you can actually use sensible heat flux co-spectra as a correction base for other fluxes. However, co-spectra models of Kaimal-Moore are perhaps more advisable, because they are tested for a very long time, and you don’t have to run a sensible heat flux co-spectra for every half-hour. Kaimal-Moore co-spectra models present set of equations, describing the shape of co-spectra for unstable, stable, and neutral conditions. And they’re usually un-dimensionalized. So, you have to know your height—measurement height, [inaudible] and wind speed and so on. Such co-spectral models suggest using transfer functions at each frequency and correction factor is computed for the entire co-spectra. Then you apply all these corrections, including tube attenuation correction for closed-path, and when you do it, it can increase fluxes up to 30% or more. And frequency response corrects usually larger at night because you have less turbulence at night.

The second big correction used in the closed-path, and the open-path as well is Webb & Pearman, Leuning density term, this term is strictly speaking, not a correction, because it describes the actual events occurring in the analyzer, or outside—in the air. However, you have to have this term to get the flux corrected. This term compensates for the effects of fluctuations of temperature (for thermal expansion), and water vapor (for dilution) on measured gas fluctuations.

One easy way to imagine this process, is by considering a surface with actual zero flux, and with warming air of constant gas concentration, as you see on the illustration below. As a result, instrument measures flux because of thermal expansion of air parcel, not because actual flux occurs. Again see please see pages 97 and 98 on the link below for more detail.

As I mentioned before the Webb & Pearman, Leuning term, includes three major terms inside of it. Dilution term, computed from water vapor density measured in the cell simultaneously with CO₂. Thermal Expansion Term, this term in the close-path instrument with long and thick tube, is below 1% of ambient and usually neglected. And Pressure Expansion Term, or contraction, is usually neglected,
especially if buffer is used between pump and the sampling cell, so you do not have periodic fluctuation of pressure, due to imperfections of the pump.

So, the bottom equation is Traditional close-path Webb & Pearman, Leuning term equation, where you have your initial flux, and the--term correcting for the water delusion. We talked about the sensible heat or temperature fluctuations being almost fully eliminated in the long tube,

SLIDE 29 [30:59]:

and it’s important to understand what is long, long enough to eliminate them. The usual rule of thumb is ratio of 1:500, or 1:1000, relating tube diameter to the length of the tube. This has been traditionally used by most groups and confirmed by experimental studies. Tubes longer than this ratio are not recommended, because not much is gained by temperature attenuation anymore, but you might start losing CO₂, and water methane fluxes, due to attenuation of fast gas fluctuation in excessively long tubes. It’s also difficult to maintain very long tubes, clean and free of algae and water and dust. Keeping tube, relatively short is especially important when water fluxes are the focus of the study, because water is a --somewhat sticky molecular, and water fluxes are affected by the tube more than CO₂ or methane, or any other gas.

All these effects are well known and correctable, but each of them has associated uncertainties; so it would probably be best to optimize the system design from the beginning to make uncertainties minimal. So, how could we optimize the system when we design the Eddy covariance experiment?

SLIDE 30 [32:37]:

First of all, we need to make sure that there are no leaks, that’s a big one for closed-path analyzers, because leaks may lead to alien air entering sample flow, thus corrupting the data. We should also avoid sharp corners in the intake tube, especially with high flow rates, the sharp turns may lead to difficult to predict flow disturbances, such as standing waves or vortices. We also want to minimize flow restrictions, without sacrificing filtering. We can use low restriction filters, use contamination resistant cell designs when possible, so even if some dust gets in, it doesn’t affect the reading, and such technology is available and being used.
It’s also important to have a buffer, the large volume container, between pump and the cell: it will help to keep Webb & Pearman, Leuning pressure term negligible, and it wouldn’t have associated uncertainties if your pressure changes periodically due to the pump. It’s important to replace intake tube regularly, especially if it’s long, because contamination on the tube walls increases flux attenuation. It’s also important to avoid extremely high flow rates when possible, because small imperfections of the tube may lead to waves and flow disturbances when flow rate is very high.

SLIDE 31 [34:17]:

Another important point is to keep analyzer in climate control box, unless it’s specifically designed for outdoors. Independently of the design principle of operation and manufacturer, electronic, optical and other components may and will drift with temperature, that’s why climate control box is always a good idea. It’s also important to calibrate regularly, because again, independent of method of detection or principle of operation or design of the instrument, the electronic, optical and other components may and will drift with time.

It would be nice to avoid vacuum when possible because, when sample comes into the cell and expands 5-10 or 20 times, the fast effects are difficult to predict and leaks may become a problem with time, when experiment is long term. If water is of main interest it’s important to avoid excessive tube lengths, even though 1:500, 1:1000 is general rule of thumb, the 3-4 meters is usually a sufficient tube length for ¼” or 3/8” internal diameter tube. Longer tubes may attenuate water without much gain in attenuating temperature.

SLIDE 32 [35:50]:

Let’s have a few moments dedicated to data processing. The recommendations for closed-path analyzers would be to correct for tube attenuation, sensor separation and path averaging, these are frequency response correction, parts of the entire data processing. Then we need to adjust for time delay in the tube. It’s probably better to do it by circular correlation, but if you have very stable pump, good buffer and clean power you can also do it via flow rate and tube length calculation. So you know exactly how much time it took for a sample to travel though the tube.

It’s good to use actual co-spectra during midday to check if theoretical corrections worked properly. If the Kaimal-Moore co-spectra and your actual co-spectra look generally the same. Your actual co-
spectra will be slightly below Kaimal-Moore co-spectra because of frequency losses, and the difference in percent should come out roughly to frequency response correction. You also need to correct for water dilution, the latent heat flux portion of Webb & Pearman, Leuning term, using in cell latent heat flux, the one that has been partially attenuated. You do not want to use the outside flux, because this is not what you instrument sees in the cell, and this is not how the gas fluctuation is diluted in the cell.

It’s important to incidentally not correct for thermal expansion because your tube is long enough and your temperature is attenuated. It’s good to check data every few days because bugs and algae can live, and have lived in tubes with 15 to 20 liter per minute flow.

SLIDE 33 [38:01]:

So, in summary, the main strengths of closed-path analyzers are; excellent data quality, minimal data loss due to precipitation and icing, minimal uncertainty associated with fast temperature fluctuations and Webb & Pearman, Leuning sensible heat flux term, possibility of outputting mixing ratio and avoiding Webb & Pearman, Leuning term, no surface heating issues, automated calibration and possibility of climate control of the instrument and the sample flow.

And the most important items specific to closed-path analyzers are; to eliminate temperature fluctuations without dampening gas fluctuations, minimize flow distortions and eliminate leaks, sample air at proper flow rate, which is fast enough for 10 or 20 Hz sampling but not too fast, calibrate and check data periodically. And key processing steps for closed-path analyzers are; correcting for tube attenuation and time delay, correcting for water dilution using in-cell water data and not correcting for thermal expansion when long intake tubes are used.

SLIDE 34 [39:11]:

Now, let’s talk about something new in this open-path, closed-path business which is coming from LI-COR this year. Knowing both open-path principles described by Liukang and closed-path principles described here, we have developed the new instrument. We have united strengths and minimized weaknesses of closed-path and open-path analyzer design in a new design. This is not exactly the open-path analyzer and doesn’t have to be exactly traditional closed-path analyzer. It’s a compact enclosed gas analyzer enabled for operation with short intake tubes. It has strengths similar to closed-path analyzers, such as minimal data-loss due to precipitation and icing, no surface heating issues, improved
water specifications due to absence of solar filter. It also has strengths similar to open-path analyzers, such as; small easily correctable flux attenuation loss in short intake, infrequent calibration requirements, minimum maintenance requirements, low power configuration when used with short intake tube, small size, lightweight and weatherproof design. It basically gives you all the advantages of LI-7500 and LI-7000 or LI-6262 in one instrument.

SLIDE 35 [40:49]:

For details on this design, please see our web-page, at the link here and you could also register for LI-7200 webinar, at another link here. And, here the picture of this instrument deployed in Canada in the Vancouver Island. Thank you very much.

Moderator:

Now we are going to transition into our live question and answer session. Most of you have been submitting questions along the way during the presentation, so thank-you. If your question isn’t addressed during this live Q & A, a panelist has either already gotten back to you or will get back to you as soon as possible. For those of you, who haven’t submitted your question yet, you can send them to us by expanding the questions panel in the control panel window, and typing into the dialog box in the panel, then clicking the send button. Alright, I think we’re ready to go with questions here. It looks like our first question is for George, and it is; how often do you have to calibrate closed-path instruments?

SLIDE 36 [41:47]:

Speaker 2:

The closed-path instruments are different from each other, and depends on conditions at the site, and how well they are climate controlled. And what is the underlying principle of operation. For most of the closed-path analyzers used for Eddy covariance operations, people calibrate them daily or weekly, somewhere else, somewhere in-between. People who are interested in high precision mean concentration to compute flux is using conversion models, or just for general modeling, sometimes calibrate hourly. And, people who are positioned at the remote site, or do not have infrastructure to bring calibration cylinders to the site, calibrate monthly or bi-monthly.
Moderator:

Great, thank you George. It looks like our next question is for you as well. And this participant asks; George said the LI-7200 is enabled for short intake tubes, how short?

Speaker 2:

We run 7200’s in our field tests with 4 meter tube, 1 ½ meter tube, 1 meter long tube, 90 centimeters, 50 centimeters, 40 centimeters, and no tube, and in all cases it provides the correct flux. So, it gives you a lot of flexibility. I wouldn’t suggest using it for Eddy covariance without a tube, because you have to bring the sensor head very close to the sonic when you monitor. Optimum tube length, we figured out theoretically and in experiments is between 50 centimeters and 1 meter. This way you attenuate most of the temperature and you almost do not attenuate—CO₂ and water. And, whatever you didn’t attenuate in temperature, you measure directly in the cell, but that would be for the next seminar on 7200.

Moderator:

Great, thank you. It looks like our next question is for Liukang. Liukang, any news regarding the LI-COR open-path CO₂/H₂O analyzer?

Speaker:

We introduced that open-path 7500 analyzer in 1999; it quickly became a standard analyzer on the flux tower around the world. With all the experience and expertise we get from the past 10 years, LI-COR is introducing a new generation of the open-path CO₂/H₂O analyzer we call the 7500A. It has lots of new features, one of them is, you can change the chopper motor housing temperature to be used at 30°C or 5°C, depend on ambient temperature. This way you can reduce the power consumption in the cold weather. It also has data logging capabilities; you can synchronize and record sonic wind speed data and CO₂ data with this new analyzer. It has many options of data output, including Ethernet, SDM, serial and analogue. See our website and we have more information.

Moderator:
Thank you. It looks like our next question is for George. How much power does it take to provide proper flow rate to the LI-7200?

Speaker 2:

The LI-7200 is different from most of the traditional closed-path analyzers. It doesn’t have to have fine particle filter because it uses same principles and optics of 7500, which is fairly insensitive to dirt. It normalizes the dirt out of there, so you’re still measuring correct concentration of flux even when your windows, or cell walls, in case of the closed-path are dusty. Because of that, and because your tube is short, you can provide, let’s say 15 liters per minute flow, which is plenty, with the 15 watt flow module. And, this flow module is available for LI-COR for people who do not have their own pumps, and this flow module is designed for the solar power operation. It gives you 15 liters per minute, with 15 watts, it uses precision mass flow controller, and it’s fully controlled remotely using Ethernet. You can also use the fan instead of this--flow module. With the fan [inaudible] you can get to maybe 7 watts. And this is described in Agriculture and Forest Meteorology paper by Clement, Burba, and Grelle from 2008 I believe. We used several designs, and some of us use fans and some of us use pumps in different configurations.

Moderator:

Great, thank you. It looks like that’s going to have to be our last live question. I want to take a moment to thank the participants for their questions, and remind them, that if their question didn’t get answered to stick around for just a little bit, our panelist will get back to you as soon as they can.