RE: Small Lysimeter Calibration

Simmons,Lane <Lane.Simmons@ColoState.EDU>

Mon 11/7/2022 3:03 PM

To:Brown,AJ <Ansley.Brown@colostate.edu>;Andales,Allan <Allan.Andales@colostate.edu>;Dale Straw <destraw@msn.com>; Ma,Jianbing <Jianbing.Ma@colostate.edu>;Chavez,Jose <Jose.Chavez@colostate.edu>;Kelley Thompson <kelley.thompson@state.co.us>;Tom Ley - NRCE <TLey@NRCE.COM>;Bauder,Troy <Troy.Bauder@ColoState.EDU>
Cc:Bartolo,Michael <Michael.Bartolo@ColoState.EDU>

I apologize – but you can ignore the text box containing the formula for determining the calibration. It contains errors.

Lane

From: Simmons,Lane
Sent: Monday, November 7, 2022 2:54 PM
To: AJ Brown <Ansley.Brown@colostate.edu>; Allan Andales; Dale Straw <destraw@msn.com>; Jianbing (JB) Ma <Jianbing.Ma@colostate.edu>; Jose Chavez <jose.chavez@colostate.edu>; Kelley Thompson <kelley.thompson@state.co.us>; Tom Ley - NRCE <TLey@NRCE.COM>; Troy Bauder <troy.bauder@colostate.edu>
Cc: Bartolo,Michael <Michael.Bartolo@ColoState.EDU>
Subject: RE: Small Lysimeter Calibration

Good afternoon,

Dale was able to review the results of the 10/6/2022 SL scale calibration, so I feel confident in the new coefficient.

New calibration: 1 mV/V change in the load cell = 157.43 mm (6.198 in) of water added or removed.

Pictures: https://www.dropbox.com/sh/5ltr12yjm3rlcll/AAB06bNN9dyE9AwIvgWayX04a?dl=0

This calibration was very similar to the 11/15/2021 Large Lysimeter calibration. The weight sequencing for this scale calibration was simpler than earlier calibrations. The first lysimeter scale calibrations served as a 'proof of concept' for the entire lysimeter system, while this calibration had the narrower objective of just establishing a calibration slope for the new load cell(s).

Prior to the calibration, multiple layers of 6mm plastic sheeting were placed over the monolith soil surface to prevent evaporation weight loss during the calibration. Four wood pallets were placed on top of the plastic sheeting to hold the plastic down and serve as a platform for the test weights. Sheets of plywood and additional pallets were placed on three sides of the surface to help protect the grass and soil, and serve as a staging area for the certified weights. Temporary weights were carefully placed on the below-ground, scale counterweight assembly, bringing the load cell output down to about 0.14 mV/V prior to the start of the calibration. This was done so that the full range of load cell output was available during the calibration. After these preparations were made, the datalogger recorded the load cell readings with no disturbance for about 30 minutes. The actual calibration started at 6:53 AM MST and concluded at 10:35 AM MST for total time of 3.5 hours. Two technicians with the company, Scales Sales and Service (SSS) were onsite to provide State certified weights for the calibration. Apart from the shift test, all weights were placed in the center of the lysimeter surface, while trying to avoid the NMM access tube.

- The previous calibration with the old load cell was 151.09 mm.
- We now have two load cells daisy chained together. The new calibration is for the upper (top) cell that we consider primary. The other unit is considered a backup.
- 38 data points.
- Increasing load from 0 lbs to 2400 lbs in 150 lb increments.
- Decreasing load from 2400 lbs to 0 lbs in 200 lb increments.
- Shift test at 600 lbs – all four corners and center of monolith.

- Increasing load and decreasing load using 1.5 lb jumps between 1800 lbs and 1806 lbs.
- The calibration was computed based on Allan's 12/26/2012 adjusted surface area calculations. This was based on the Bushland, TX group's recommendations.
- Load cell capacity: 25 lbs
- State of CO weight calibration certificates were provided by SSS.

Two separate, daisy chained, Interface SM-25 load cells are installed in the SL. The Campbell Scientific CR7 datalogger was programed by Dale Straw to record the load cell weight output, load cell standard deviation, air temperature, relative humidity, 2m wind speed, and 2m wind direction. The datalogger was programed to make load cell measurements at a 0.5 second scan rate, and then average these measurements into a 1-minute data table. The program uses a four-wire full bridge instruction, with 3333mV excitation applied to the load cell; this matches the programing used on the LL CR1000X datalogger and the original calibrations with CR7 loggers.

Handwritten field notes were taken during the calibration, recording:

1. Weight change (the weight amount added or removed).
2. Total weight on the surface after the weight change.
3. The time at which the weight was added or removed.
4. The time at which the load cell value of record was recorded.
5. The load cell reading (mV/V) of record.

The handwritten notes served as a ground-truth for weight amounts and timing, as well as data backup. The data recorded by hand were taken from the 1-minute data table using the Numeric Display functionality in LoggerNet.

After a given weight load was added or removed from the surface, the scale system was given time to 'settle' to an acceptable standard deviation, at which point the mV/V load cell reading and time stamp were recorded in the field notes. This settling typically required 2-4 minutes.

The field notes were used to select calibration data points from the datalogger-recorded 1-minute data set.

A slope, intercept, correlation, and r^2 were determined from the data. Using a slope of 812.488, assumed water density of 1000 kg/m3, and a surface area of 2.341 m2 a calibration coefficient of 157.43 mm/mV/V was determined.

$$\left(\frac{368.538\ kg}{mV/V}\right)\left(\frac{1\ m^3}{1000\ kg}\right)\left(\frac{1}{2.341\ m^2}\right)\left(\frac{1000\ mm}{1.0\ m}\right) =$$

Dale Straw is reviewing the data, so it is important to note that the 76.20 coefficient is still subject to alteration.

As a reality check, this coefficient is close to the theoretical calibration slope that can be calculated using the load cell capacity, scale mechanical advantage, full load cell output, and lysimeter surface area. The theoretical and actual coefficients are not expected to be the same for a variety of reasons.

Two articles were used as reference material during the planning phase for the LL and SL calibrations.

S.R. Evett, et al. (2009). A Weighing Lysimeter for Crop Water Use Determination in the Jordan Valley, Jordan

T.A. Howell, et al. (1995). Calibration and Scale Performance of Bushland Weighing Lysimeters

Thanks,

Lane Simmons

From: Simmons,Lane
Sent: Friday, October 7, 2022 3:19 PM
To: Brown,AJ <Ansley.Brown@colostate.edu>; Andales,Allan <Allan.Andales@colostate.edu>; Dale Straw <destraw@msn.com>; Ma,Jianbing <Jianbing.Ma@colostate.edu>; Chavez,Jose <Jose.Chavez@colostate.edu>; Kelley Thompson <kelley.thompson@state.co.us>; Tom Ley - NRCE <tley@nrce.com>; Bauder,Troy <Troy.Bauder@ColoState.EDU>
Cc: Bartolo,Michael <Michael.Bartolo@ColoState.EDU>
Subject: Small Lysimeter Calibration

Good afternoon,

Two pictures attached.

Yesterday, on 10/6/22, I was able to calibrate the Small Lysimeter scale system; I feel like we were able to get really solid data for establishing a calibration coefficient. The weather was excellent, a sunny day and wind speed averaging only 1.138 m/s (2.55 mph) during the project. Frankly, I don't think we could have had a better weather day. The low wind speed allowed us to grab mV/V data points with load cell standard deviations very low – an 0.00033 average standard deviation.

We had all but finished the calibration when the SSS truck-mounted crane broke down. At that point we still had three, 500 lb weights on the ground on the staging platform. In order to get those guys on the road, I had to use our backhoe to finish loading their weights on the truck. Anyway, everything turned out ok.

I'm going to start analyzing the data to determine a calibration coefficient. Dale has offered to check my work, so I'll be sending him a complete data package. Also – much thanks to Dale for writing the new CR7 calibration program last January. We had to write new CR7 programs since we moved from a one load cell setup to a two load cell setup on the SL. This calibration was modeled after the LL calibration we did last November. Thanks to Dale for his coaching, the process I used for these recent scale calibrations were modeled after the work he originally did.

Once the data analysis is complete, I'll share the results with you as well as the full slate of pictures.

Thanks,

Lane Simmons