Supplementary Information for:

Evaluating mass flow meter measurements from chambers for greenhouse gas emission from orphan wells and other point sources

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MFM Chamber Construction Details

A MFM chamber testing system was constructed using a 10 gallon (37.85 liter) rectangular HDPE Tank (US Plastics PN P-296/Tamco 14546) that was converted into a 30 cm × 30 cm × 45 cm chamber by inverting it. A 2" NPT bulkhead union was installed in the top for the MFM. A 4 mm bulkhead gas fitting was installed in the side for a calibrated air input port (Parker Prestolok 3-32-PLP-BH-5/32), followed by a 2" to ¾" reducer bushing (US Plastics PN 30978) and associated ¾" fittings (US Plastics 64696) to allow connection of the MFM (Alicat Scientific MWB-100SLPM-TFT) to the chamber vent. The MFM was selected for its wide dynamic range of 0-100 standard liters per minute (slpm) and its low pressure drop (2.72184 atm/(m^3/h)). The MFM was configured with response factors for air, with zero deadband and 0.1 second integration to enable resolution of transient gas flow events on the order 0.006 slpm. To allow gases to vent above the head level of the operator and to reduce the amount of material blown into the MFM, a 3-foot stack pipe vent was constructed from 2" PVC pipe with a 90-degree union. For some tests, an HDPE plastic ground skirt was attached to assess the feasibility of a passive seal at the ground

surface that did not require digging for placement (Parkin et al., 2005; Thalasso et al., 2023). Notably, for applications of low volumetric flow rates and/or low concentrations, the permeability of the materials used could result in diffusive losses through the chamber walls.

The reference gas was ambient air delivered via an oil-free air compressor to the mass flow controller (MFC), which permits large flow rates to be tested for extended periods of time in safety from combustion or asphyxiation and without the associated costs of compressed pure gases. Reference gas flows were created using a 0-5 standard liters per minute (slpm) MFC (Alicat MC-5SLPM-D_SV/50). The MFC dynamic range allows mass flow rates of air equivalent to be added to the chamber that are equivalent to 0.02 to 214.5 g/h of methane and 0.06 to 589.2 g/h of CO_2. The control and data recording of the MFM and MFC were managed by a python script running on a laptop at data rates of 1-10 hz, collecting flow, pressure, and temperature data from the MFM measurement and MFC control. For evaluation on environmental factors, additional sensors were mounted on the chamber. Humidity, temperature, and pressure in the chamber vent stack were measured using a Bosch BME 280 (Adafruit inc, PN 2652), ambient temperature and humidity was collected from under a shaded structure using a SHT-40 (Adafruit inc, PN 5064), solar gain was measured on the body of the chamber using a quantum flux sensor (Apogee Inc sq 215), using a hourly average windspeed obtained from the nearest NOAA weather station (KAID) (API Web Service (weather.gov)). For these tests, chamber was sitting on the ground without sealing to accurately represent the scenario where the chamber is over gas source with a large volume, such as cave, mine vents, and open well bores, which we believe are the typical use case for the method. Reference flows were supplied to the chamber during environmental tests to evaluate if a seal would form as the chamber settled, but they did not yield useful information and were removed

from the data before interpretation. Due to this, there are small gaps in the measurement regularity during periods of fast changes in the plots in the manuscript.

Disclaimer:

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References:

Parkin, T. B., Kaspar, T. C., Senwo, Z., Prueger, J. H., and Hatfield, J. L.: Relationship of Soil Respiration to Crop and Landscape in the Walnut Creek Watershed, Journal of Hydrometeorology, 6, 812-824, doi: 10.1175/JHM459.1, 2005.

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