Metadata for Atmospheric Measurements at the Erie Community Center (ECC) Monitoring station

19 April 2023 Revision

Site location

40.0402 N, 105.0519 W, 1538 m asl (5047 ft asl)

The station facility is a climate-controlled, insulated container building approximately 16 ft long x 8 ft wide x 8 ft tall. Two meters adjacent to the container is a 10 m triangular aluminum meteorological tower which supports the meteorological equipment and air sampling inlet lines.

Wind Speed / Wind Direction

Wind conditions are recorded with a Campbell Scientific MetSENS500, mounted on the meteorological tower at 9.2 m height. The stated resolution for wind speed is 0.01 m/s. The manufacturer stated resolution for wind direction is 1 degree with ±3 degree accuracy.

Temperature, Relative Humidity, Barometric Pressure

Temperature, relative humidity, and barometric pressure are measured with a Campbell Scientific MetSENS500 mounted on the meteorological tower at 9.2 m height above the surface using the factory calibration. An audit was performed by the Colorado Department of Public Health and Environment (CDPHE) of the accuracy of the temperature and relative humidity readings on 19 November 2021. The instrument passed in all audit criteria with temperature reading accuracy having an error of -0.5 degrees C (passing is <2 degrees C), and relative humidity having a -0.2% error (passing is <5%). The manufacturer stated resolution of the temperature measurement is 0.1 degree Celsius with ±3 degree C accuracy. The stated relative humidity resolution is 0.1% with ±2% accuracy. The stated resolution of the pressure measurement is 0.1 hPa with ±0.5 hPa accuracy.

Solar radiation

Incoming solar radiation is monitored with an Apogee SP-110-SS pyranometer on the meteorological tower at 9.6 m height above the surface. The sensor dome is cleaned every 2 months.

Ozone (O_3)

Ozone is recorded with a Thermo Fisher Scientific model 49C UV absorption monitor. Ambient air is sampled from an inlet mounted at 8.7 m height above the surface. The sampling line consists of 10 m length, ¼ inch o.d., 5/32 inch i.d. PFA tubing, equipped with an inlet PFA filter holder that houses a 5 micron Teflon membrane filter. Inlet filters are replaced every two months. The time resolution of the ozone monitoring is one minute. The monitoring and calibration protocol follow the federal regulatory monitoring requirements according to the specifications of '40 Code of Federal Regulations

(CFR) Part 58'. The calibration scale is referenced against an EPA Region 8 primary ozone reference standard. Daily zero and span checks are performed automatically using a Thermo Fisher Scientific 49C calibrator unit. These checks are performed at night by introducing the calibration gases through the calibration valve of the instrument. First, zero air is introduced for 6 minutes, followed by 80 ppb of ozone for 6 more minutes. Two hours later, a mid-range check at 50 ppb is performed for 6 minutes. Quarterly, a full range linearity check is performed using the same calibrator unit. Six different levels of ozone are introduced: 0 ppb, 25 ppb, 50 ppb, 100 ppb, 200 pbb, 400 ppb. Yearly, a calibration check is performed using a level 2 standard (a Thermo Fisher Scientific 49C calibrator unit) following the same protocol as the quarterly checks. The level 2 standard has last been referenced against the EPA Region 8 primary ozone reference standard on May 4th 2022. An audit of the 49C was performed by the Colorado Department of Public Health and Environment (CDPHE) on 19 November 2021. The instrument passed all audit criteria with a calibration agreement slope 0.970 and an offset of 0.411 ppb, meeting EPA measurement quality requirements. The lower detection limit (LDL) for ozone is 1 ppb as reported by the instrument manufacturer. Measurements below this value are replaced with ½ of the LDL, 0.5 ppb.

Carbon Dioxide (CO_2)

Carbon dioxide is monitored with a Picarro G-2301 cavity ring down spectrometer. Ambient air is sampled at 400 scc/min from an inlet at 8.7 m height. The sampling line consists of 10 m length, ¼ inch o.d., 5/32 inch i.d. PFA tubing, equipped with an inlet PFA filter holder that houses a 5 micron Teflon membrane filter. Membrane filters are replaced every two months. The manufacturer's calibration settings are applied. Calibration checks are conducted every 49 hours by introducing a breathing air grade ambient air gas mixture from a compressed tank (543.77 ppm CO_2 (starting 9/29/2021), 613.25 ppm CO_2 (starting 7/19/2022)). The CO_2 mole fraction of this test atmosphere has been cross-referenced against the NOAA Global Atmospheric Monitoring Laboratory (GML) CO_2 scale and is estimated to have an accuracy error of <3 ppm. After ~3 months of use the test atmosphere is again cross-referenced to the NOAA GML scale to account for potential drift. Every 6 months, a calibration check and 5-level linearity check are performed by dynamic dilution of a 4.90% CO_2 primary EPA-grade standard (EPA protocol grade gas, Praxair, production date 06/09/2022) with zero air using a Thermo Fisher Scientific 146i Multi-gas Calibrator. Zero air is supplied from a compressed UHP grade zero-air cylinder (General Air).

Methane (CH_4)

Methane is monitored with a Picarro G-2301 cavity ring down spectrometer. Ambient air is sampled at 400 scc/min from an inlet at 8.7 m height. The sampling line consists of 10 m length, ¼ inch o.d., 5/32 inch i.d. PFA tubing, equipped with an inlet PFA filter holder that houses a 5 micron Teflon membrane filter. Membrane filters are replaced every two months. The manufacturer's calibration settings are applied. Calibration checks are conducted every 49 hours by introducing a breathing air grade compressed gas from a tank (2631.9 ppb CH_4 (starting 9/29/2021), 2337.2 ppb CH_4 (starting 7/19/2022)). The methane mole fraction of this test atmosphere has been cross-referenced to the NOAA GML methane scale before use and is estimated to have an accuracy error of <2 ppb. After ~3 months of use the test atmosphere is again cross-referenced to the NOAA GML scale to account for potential drift. Every 6 months, a calibration check is performed with an 1852.18 ppb CH_4 standard

from NOAA (certification date 04/2015). Additionally, a calibration check and 5-level linearity check are performed by dynamic dilution of a 497 ppm CH_4 primary EPA-grade standard (EPA protocol grade gas, Praxair, production date 06/09/2022) with zero air using a Thermo Fisher Scientific 146i Multi-gas Calibrator. Zero air is supplied from a compressed UHP grade zero-air cylinder (General Air).

Particulate Matter

A GRIMM EDM180 monitor is used for measuring particulate matter (PM). This analyzer measures particles in the 0.25 – 32 µm (micrometer) size range by a laser scattering technique. Air is sampled from an inlet stack protruding approximately 1 m above the instrument shelter roof at ~1.2 L/min. The instrument has EPA certification, and the protocol follows requirements for regulatory PM monitoring. Two size ranges are reported: PM10 (coarse particles) for all particle mass smaller than 10 µm, and PM2.5 (fine particles) for all particle mass smaller than 2.5 µm. Weekly flow rate checks and zero tests using a 0.05 micron particle filter are performed by an operator at the sample inlet. Every 6 months, a field test is performed by an operator to check the instrument performance. For these tests, an aerosol test mixture is generated with a GRIMM Field Test Kit 185 by atomizing a diluted polystyrene latex standard suspension (1 micron and 2.5 micron, Durag Inc), which is then introduced directly into the instrument inlet. During this 6-month maintenance, the sample inlet pipe is also cleaned and internal filters are replaced as needed. The lower detection limit for PM10 and PM2.5 is 0.1 µg/m³ as reported by the manufacturer.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are monitored with a custom-made preconcentration system interfaced to an Agilent 6890 gas chromatograph (GC) using two flame ionization detector (FID) detectors. Sample air is pulled from an inlet at 8.7 m above the surface on a meteorological tower at a purge rate of ~1.5 L/min. The sampling line consists of 12 m length, ¼ inch o.d., 5/32 inch i.d. PFA tubing, equipped with an inlet PFA filter holder that houses a 5 micron Teflon membrane filter which is replaced every two months. The sampling line is inside a conduit heated to 40°C. Hourly, VOCs are extracted over a 10-minute time window at 40 cc/min. Results represent the 10 min mean concentration over the ten-minute sample collection period, with the recorded time stamp at the middle of that sampling period. To preconcentrate VOCs, sample air is directed through a Peltier-cooled water freezeout trap that is held at -45°C. The dried air then flows through an ozone scrubber that contains sodium thiosulfate-impregnated glass wool. VOCs are then extracted from the downstream air flow on a micro-adsorbent trap (Carboxen 1000 and Carboxen 1016) held at -40°C. VOCs are transferred by rapid heating of the micro-adsorbent trap to 290°C to a 30 m DB-624 column, after which a column switch facilitates directing the lighter VOCs (ethane through isoprene) to a 30 m alumina PLOT column, while the heavier VOCs are directed to a second 30 m DB-624 column. After temperature-programmed GC separation, each GC column is directed to separate FIDs. Compound identification and quantification are accomplished using PeakSimple software (SRI Instruments, version 4.89). Within PeakSimple, specifically programmed peak integration is done automatically following each run. The tabulated peak area results are processed by automated scripts using calibration carbon response factors (monthly updated) to calculate mixing ratios, which are reported in real time on the program website.

Approximately twenty VOCs are traced and quantified routinely. A subset of selected VOC tracers (ethane, propane, butane, pentane, hexane, heptane, octane, benzene, toluene, acetylene, ethene, propene, isoprene, cyclopentane, ethyl-benzene, *m&p-*, *o*-xylene) are plotted on the web portal. The calibration scale is tied to the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW) VOCs scale, using a certified multicomponent 4-ppb primary standard acquired from the U.K. National Physics Laboratory (calibration date 2/5/2020), the central calibration laboratory recommended by the WMO-GAW program (Table 1). The calibration standard is run weekly by an operator. In addition, a 200-ppb NPL standard is run annually to check for the linearity of the instrument response. A zero air (blank) sample is run every 65 runs (~every three days). Zero air is generated from a Parker zero-air generator followed by Sofnofil and Charcoal scrubbers.

Table 1

National Physics Laboratory VOCs primary calibration standard composition.

Database component name	mole fraction (ppbv)	Uncertainty (ppbv)	Name on certificate
ethane	4.00	0.09	
ethene	3.92	0.08	
propane	3.95	0.08	
propene	3.93	0.08	
i-butane	4.02	0.11	2-methylpropane
acetylene	4.14	0.21	ethyne
n-butane	3.99	0.08	
trans-2-butene	4.00	0.09	trans-but-2-ene
1-butene	3.98	0.08	but-1-ene
cis-2-butene	3.99	0.08	cis-but-2-ene
i-pentane	3.94	0.08	2-methylbutane
n-pentane	3.95	0.08	
1_3-butadiene	4.03	0.09	1,3-butadiene
trans-pent-2-ene	3.97	0.08	
pent-1-ene	4.04	0.09	
2-methylpentane	4.15	0.09	
n-hexane	4.15	0.09	
isoprene	4.13	0.09	
n-heptane	4.16	0.09	
benzene	3.93	0.08	
2_2_4_trimethylpentane	3.90	0.08	2,2,4-trimethylpentane
n-octane	3.91	0.08	
toluene	3.82	0.10	
ethyl-benzene	4.13	0.11	
m&p-xylene	8.03	0.21	m-xylene+p-xylene
o-xylene	3.95	0.10	
1_3_5_trimethylbenzene	3.87	0.10	1,3,5-trimethylbenzene
1_2_4_trimethylbenzene	3.93	0.10	1,2,4-trimethylbenzene
1_2_3_trimethylbenzene	4.06	0.11	1,2,3-trimethylbenzene

Blanks are assessed from the periodic collection of the VOC-scrubbed zero air. Most VOCs show blank values below the limit of detection, or well below the response seen in ambient levels, and are therefore deemed negligible**.** Blank peak area value subtraction for benzene and toluene occurs as follows: from 10/1/2021 0:00 UTC until 11/1/2021 0:00 UTC, peak area values of 0.62 and 0.78, respectively, were subtracted. From 11/1/21 0:00 UTC until 1/1/2022 0:00 UTC, peak area values of 0.43 and 0.74, respectively, were subtracted. After 1/1/2022 0:00 UTC there were no longer benzene nor toluene blank values observed. Blank peak area subtractions are determined using the mean peak area of blank runs during that time window. The blank peak areas correspond to approximate mixing ratio corrections of 0.033 ppb and 0.023 ppb benzene, respectively, and 0.0385 ppb and 0.0365 ppb toluene, respectively.

Two xylene isomers, meta-xylene and para-xylene, elute very closely together in the chromatogram and often cannot be separated as individual peaks. The results for these isomers are therefore reported at the sum of both.

VOC data are reported in nanomoles per mole by volume (nmol mol^{-1}, i.e. 10^{-9}). The more commonly used unit ppb (parts-per-billion by volume) is used as a surrogate.

VOCs detection limits were estimated from the smallest, reliably identifiable GC peak areas and the compound carbon response factors. Lower detection limits (LDL) are provided in Table 2. VOC species with no detected or quantifiable peak in the GC chromatograms are recorded as ½ of the lower detection limit (LDL). Ethane, propane, i-butane, n-butane, i-pentane, and n-pentane are always present above the detection limit in ambient air therefore never will be recorded in this way.

Table 2

VOCs lower detection limits.

VOC	**LDL Value (ppb)**
ethane	0.025
ethene	0.023
propane	0.017
propene	0.017
i-butane	0.013
n-butane	0.013
acetylene	0.038
i-pentane	0.010
n-pentane	0.010
1,3-butadiene	0.013
n-hexane	0.008
isoprene	0.010
n-heptane	0.007
benzene	0.010

2,2,4-trimethylpentane	0.005
n-octane	0.007
toluene	0.010
ethyl-benzene	0.010
m&p-xylene	0.008
o-xylene	0.008
1,3,5-trimethylbenzene	0.009