EEMDL
Energy Emissions Modeling and Data Lab

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Facility-level Methane Emissions Reconciliation of Bottom-up Inventory with Top-down Measurements: A Case Study in the Marcellus Basin

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[2]*Energy Emission Data and Modeling Lab (EEMDL)*
[3]*Colorado School of Mines*
[4]*Colorado State University*
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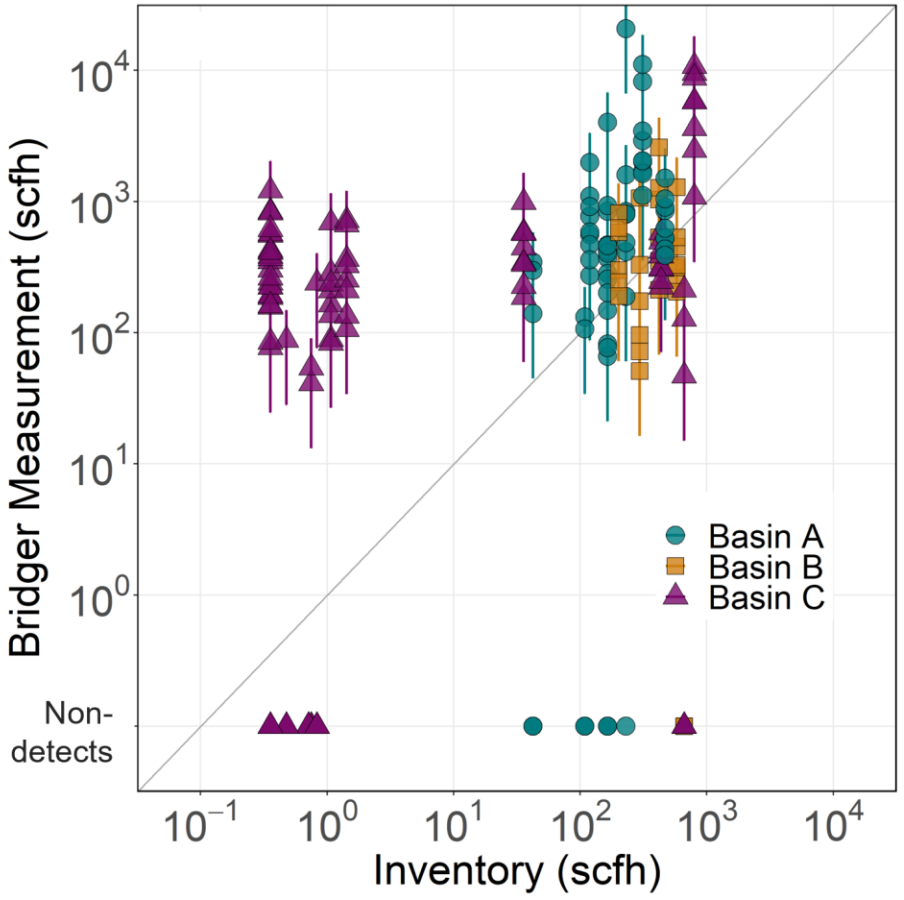
September 28th, 2023

Methane emissions from oil and gas facilities exhibit significant spatial and temporal variations.



- Existing study observed significant spatial and temporal variation at equipment- and facility-level within hours and days
  - Emissions from facilities operated by the same operator vary significantly
- Measured emissions can be higher or lower than inventory estimates from operators for a facility
- Current greenhouse gas reporting program (GHGRP) inventory calculation does not capture the spatial and temporal variation of methane emissions below the annual time scale

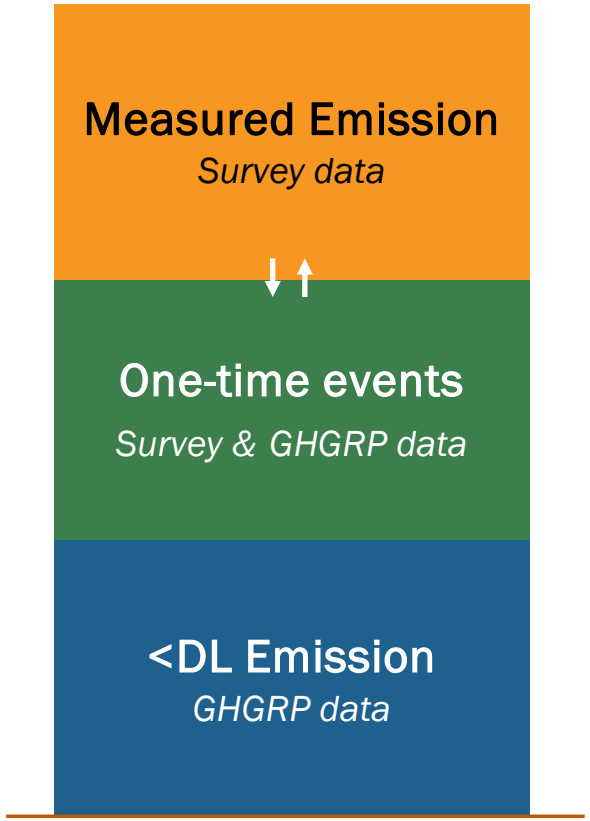
Wang et al. (2022), Environmental Science & Technology

Accurate facility-level inventory is critical for emissions mitigation

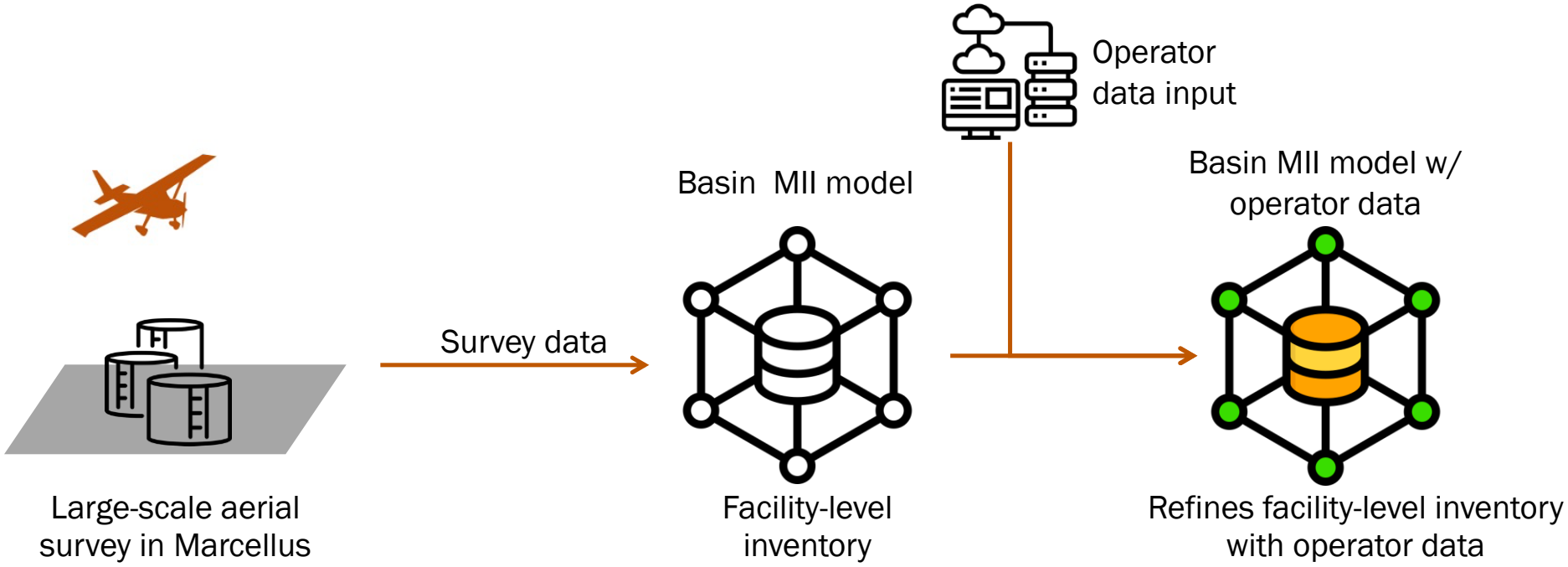
- The Inflation Reduction Act (IRA) introduces a charge on methane emissions, which require accurate accounting of facility-level emissions
  - Develop facility specific, differentiated inventory estimates
- Novel detection technologies can measure emissions at equipment-, facility-, and basin-level
  - Capture emissions variations and develop empirical emissions distribution
  - Gap between measured emissions and inventory estimates
- However, how to incorporate snapshot measurements into inventory calculation remains challenging
  - Low frequency, snapshot measurements do not fully characterize emissions variation
  - Develop models to account for emission intermittency and incorporate snapshot measurements into inventory calculation

The measurement informed inventory (MII) model

- The **measurement informed inventory (MII) model** is a tool to develop annualized, facility-level methane emissions inventory based on measurement data
- The basin measurement informed inventory (MII) model uses measurement data and basin specific parameters to estimate facility–level emissions
- Incorporate operator data into the basin measurement informed inventory model (MII) to refine facility-level emissions



Present two case studies from a Marcellus survey



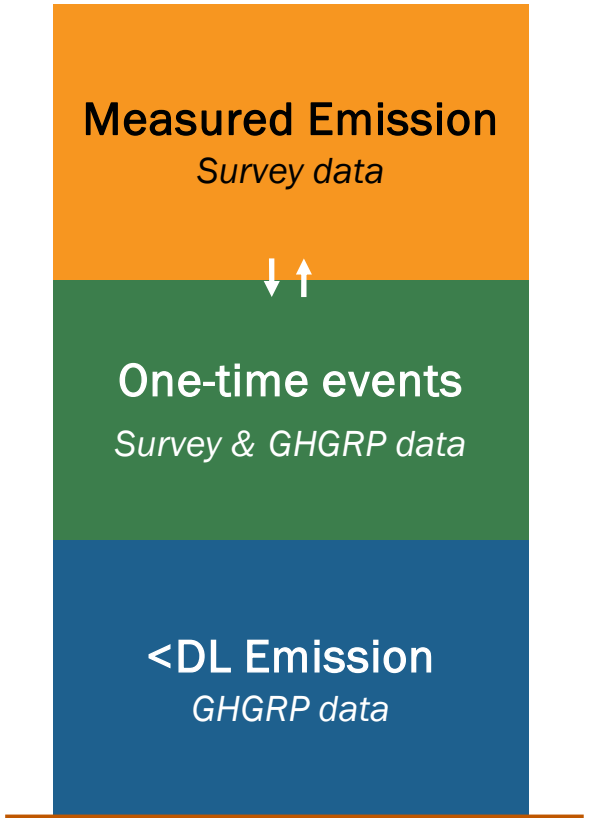
- Bridger Photonics measured methane emissions from ~ 500 oil and gas production facilities in Marcellus in summer 2023
- Case studies on using measurement data to develop 90-day facility-level inventory estimates with measurement informed inventory (MII) model
- Showcase importance of operator data in refining facility-level inventory estimates

Measurement informed inventory (MII) model

Accounting for intermittency

Emission Rate

- Build equipment-level emissions distribution using survey data
- Monte-Carlo simulations on regional (basin MII) or operator (basin MII with operator data) measured emission distribution by equipment



Measurement informed inventory (MII) model

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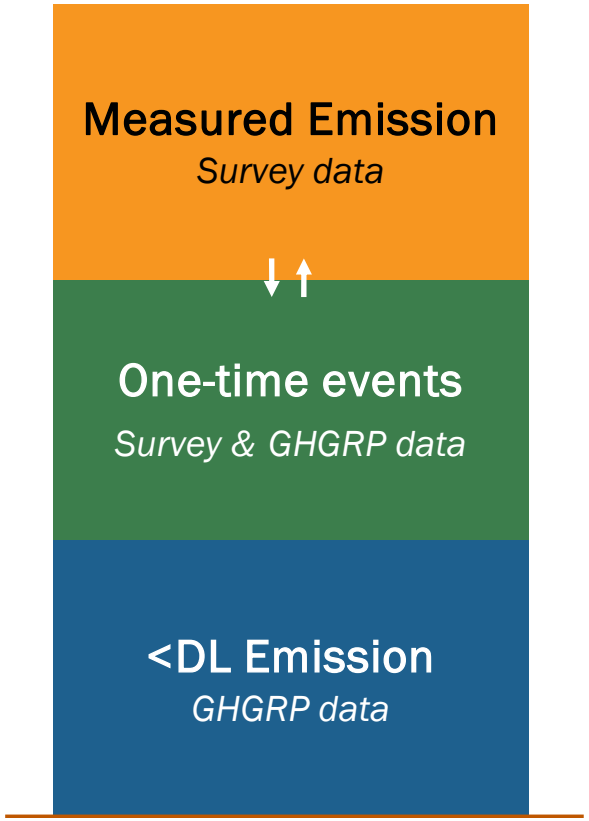
Duration

$$Fugitive = 24\ hrs * n\ days$$

$$Normal\ operation\ (Tank\ only) = \frac{flash\ duration\ (2\ min) * flash\ count}{60\ min/hr}$$

$$flash\ count = \frac{observed\ tank\ frequency}{flash\ duration\ (2\ min)} * 24\ hrs * \frac{60\ min}{hr} * n\ days$$



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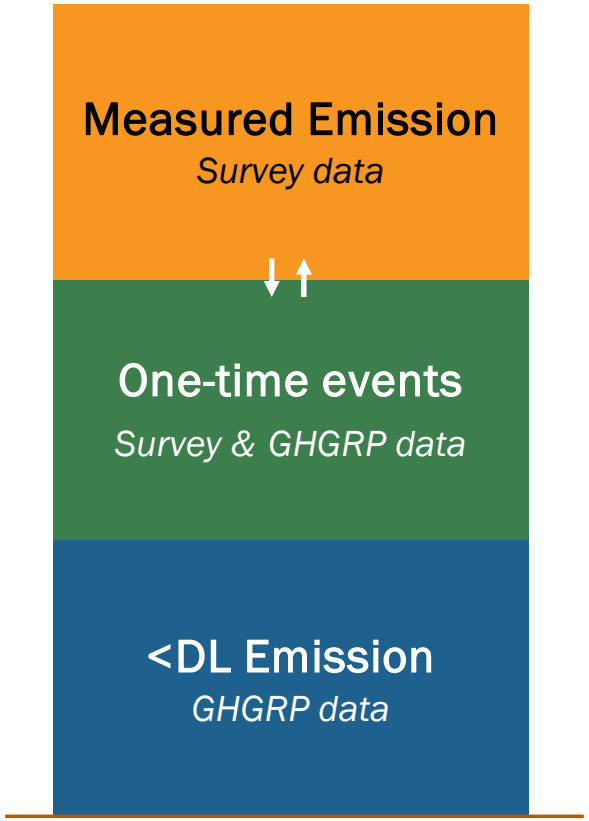
Frequency

$Frequency = \frac{emitting\ count}{total\ count}$, basin / operator specific



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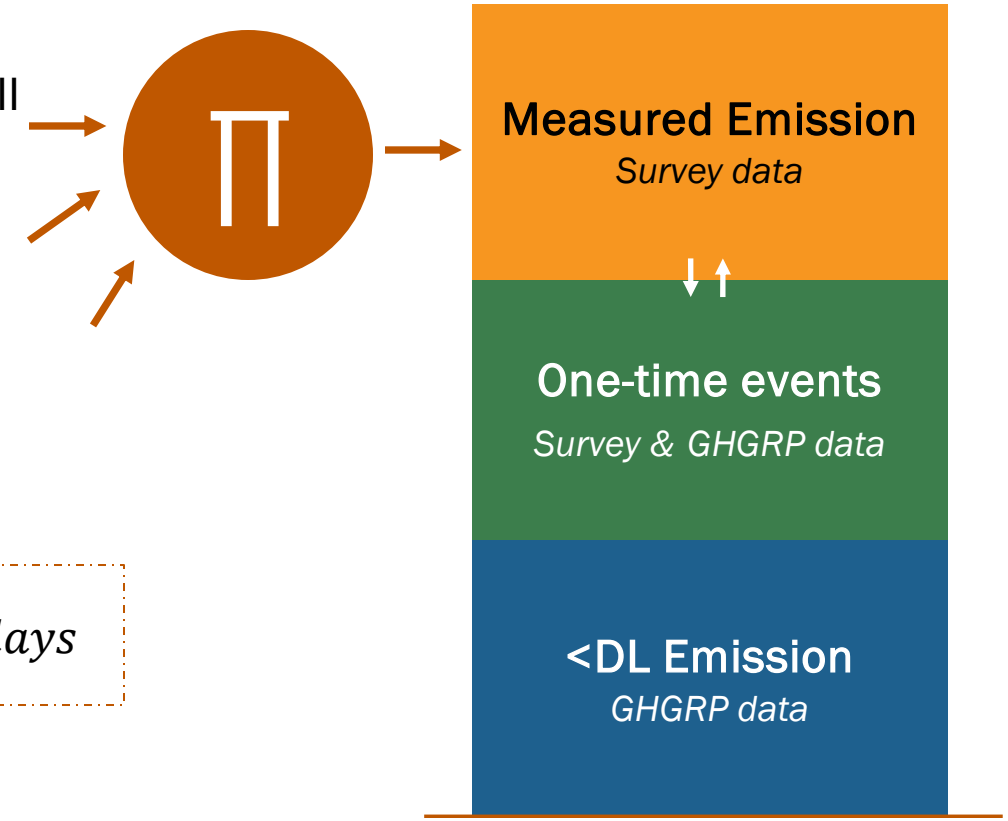

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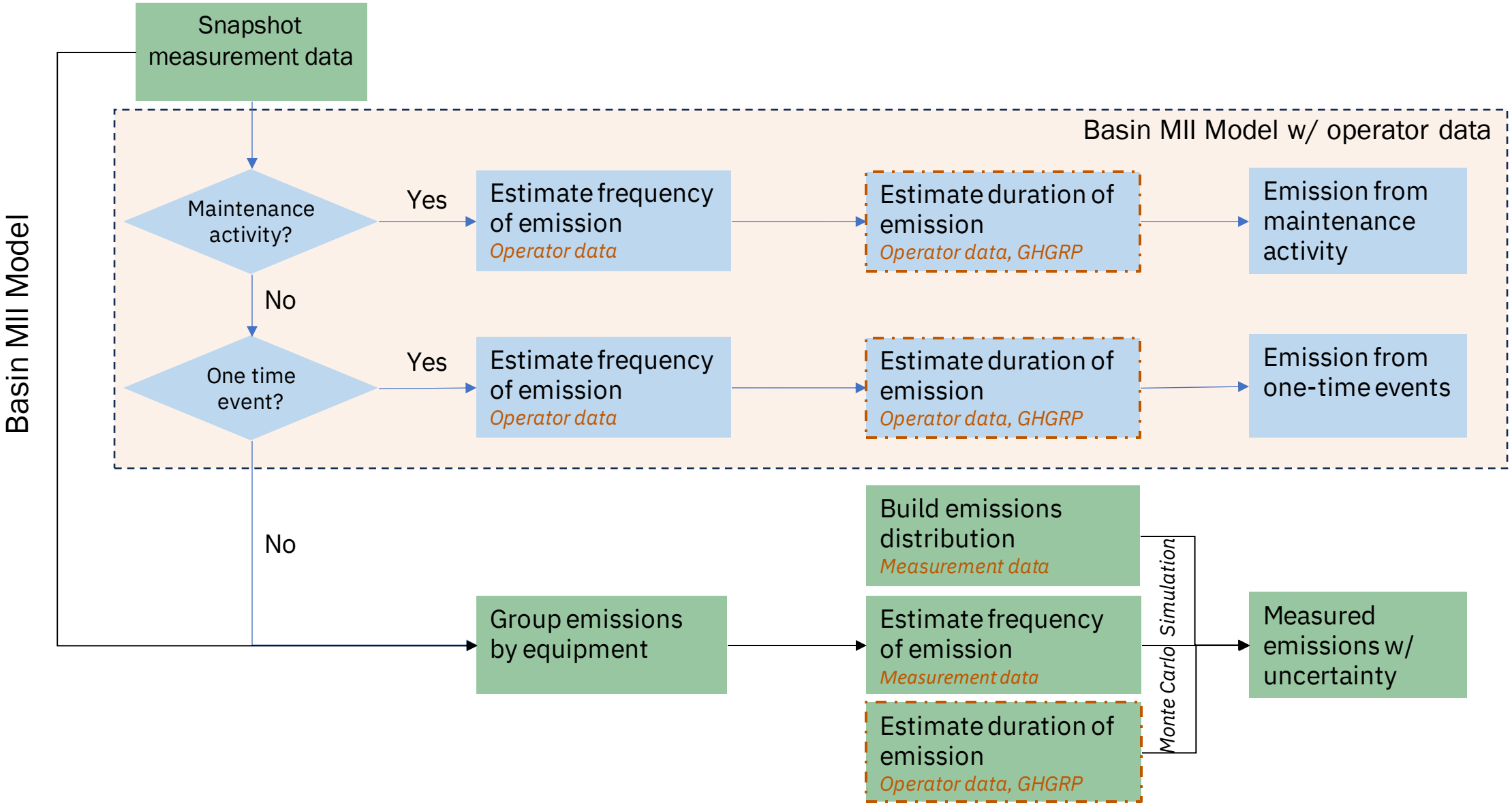
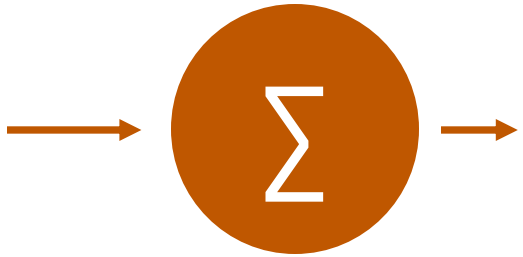
Model workflow – accounting for intermittency

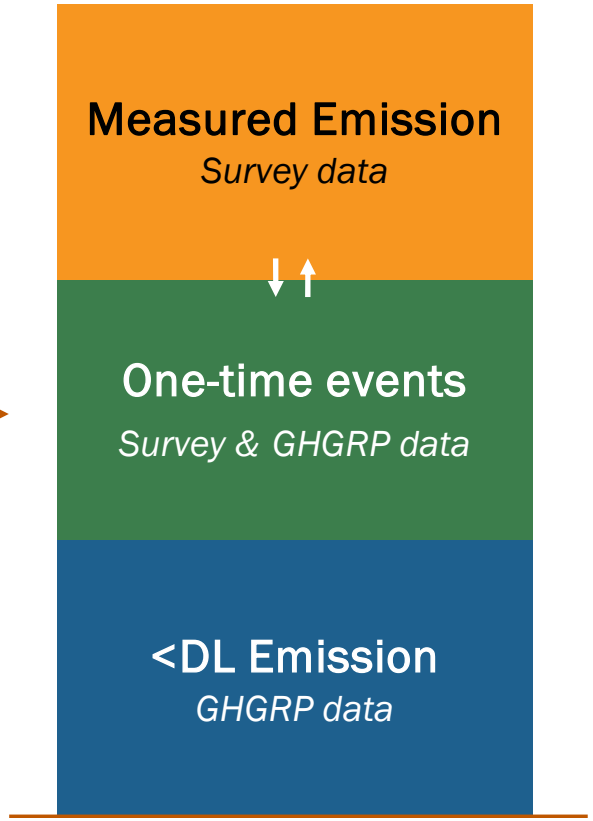


Measurement informed inventory (MII) model

One-time events

Basin MII model: Liquid unloading w/o plunger lift





Measurement informed inventory (MII) model

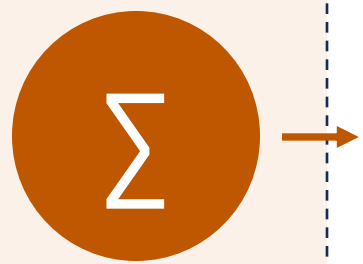
One-time events

Basin MII model w/ operator data:

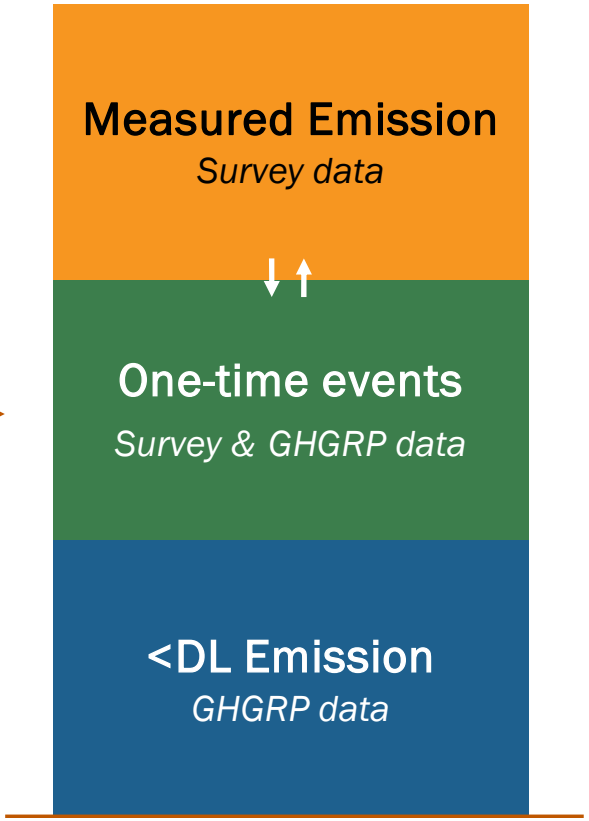
Liquid unloading

Bridger measured one-time event

Operator identified one-time event



Use operator data to inform one-time event and liquid unloading method

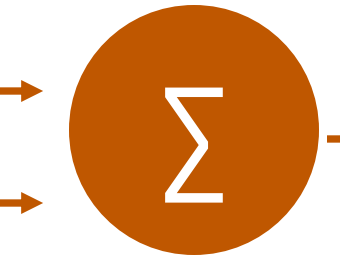


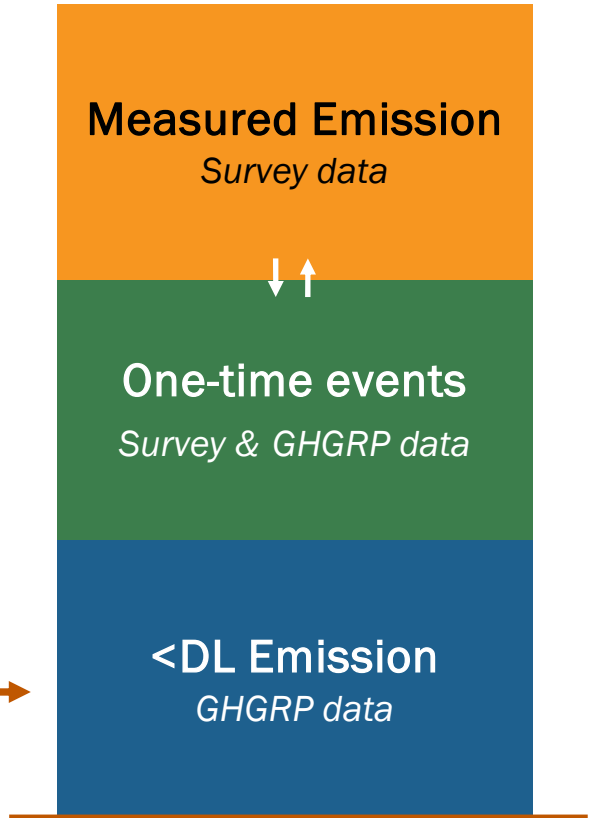
Measurement informed inventory (MII) model
<DL emissions

Basin MII model:

Pneumatic controllers and pumps w/ GHGRP factors →

Equipment leaks w/ GHGRP factors and 0.5% leaking frequency →



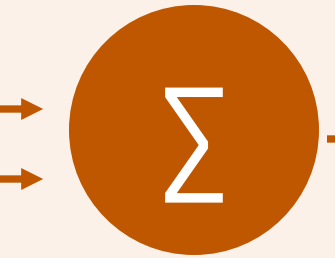


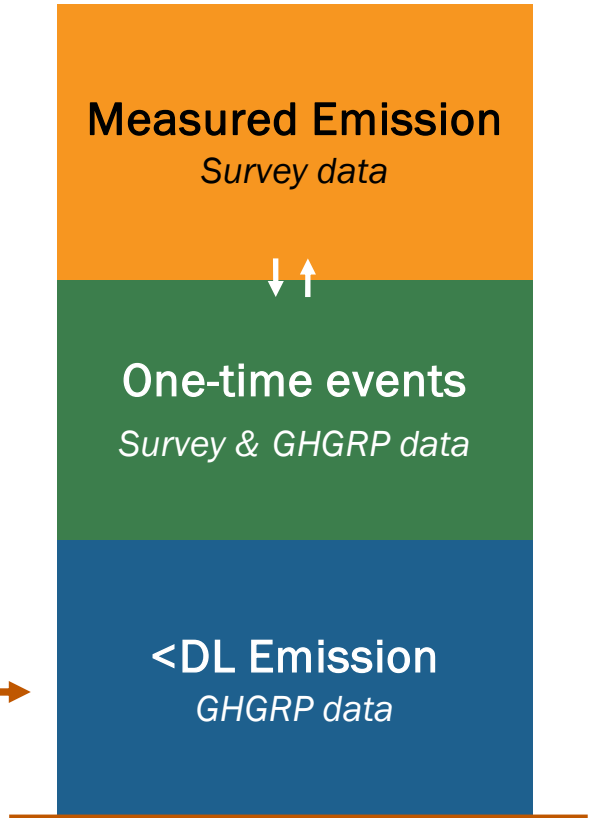
Measurement informed inventory (MII) model

<DL emissions

Basin MII model w/ operator data:

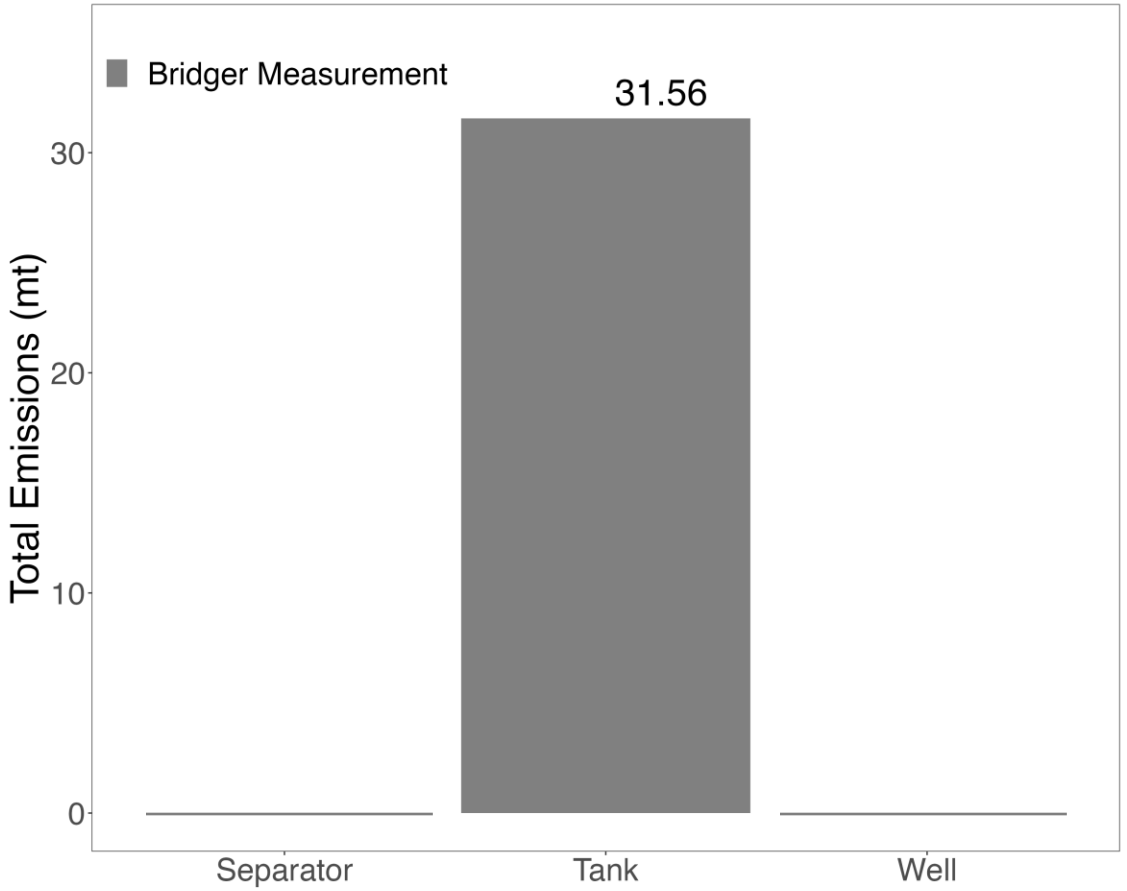
Pneumatic controllers and pumps →
Equipment leaks →





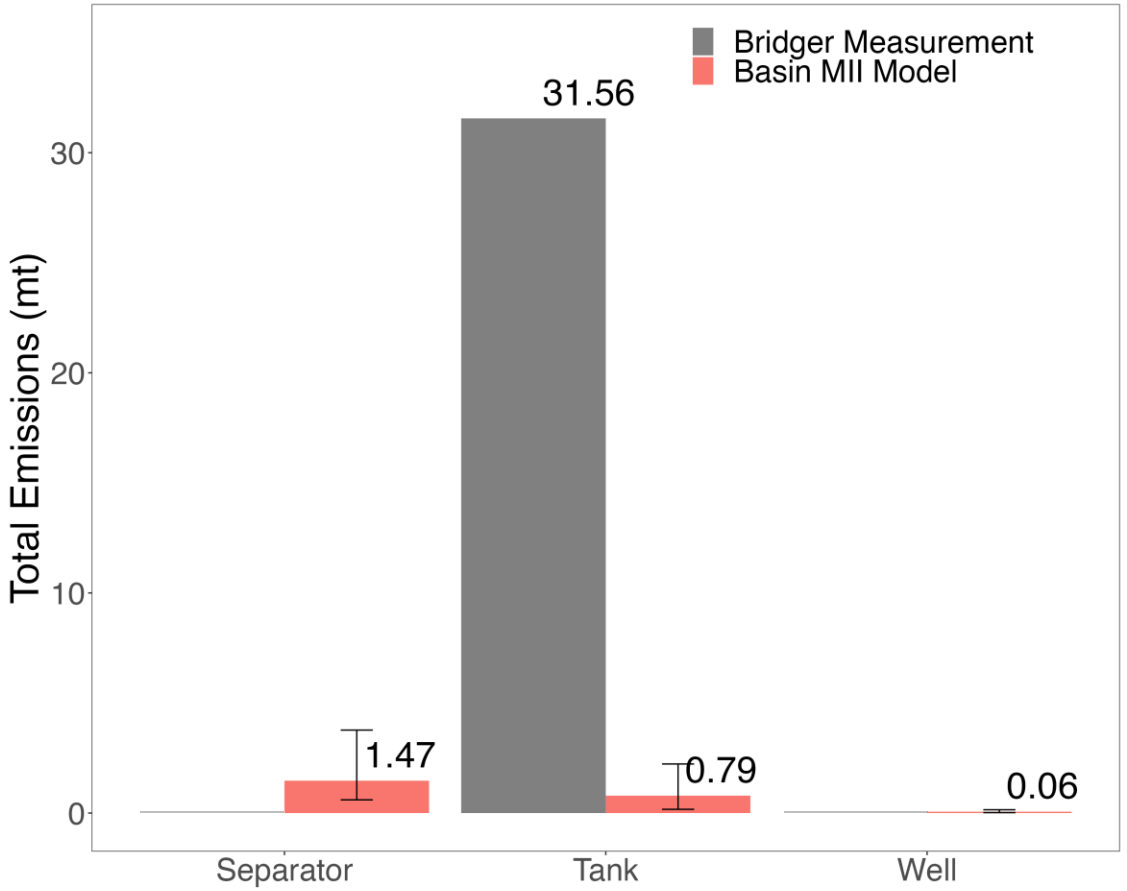
Use operator data to inform count of pneumatics and leaking frequency

Case A: high Bridger snapshot measurement



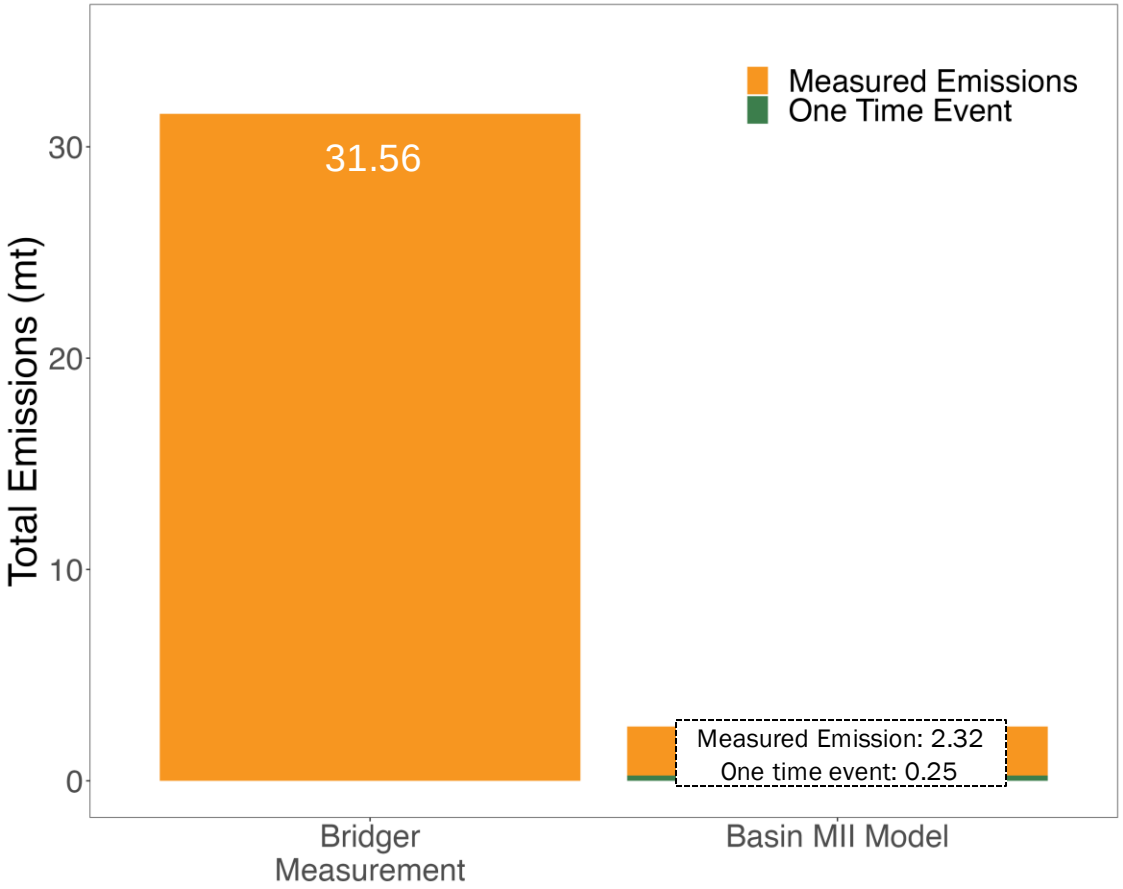
- Facility A has 3 wells, 6 separators, and 3 tanks
- One tank emission detected by Bridger at 761 SCFH
- Bridger measurement is extrapolated to 90 days

Case A: accounting for emission intermittency



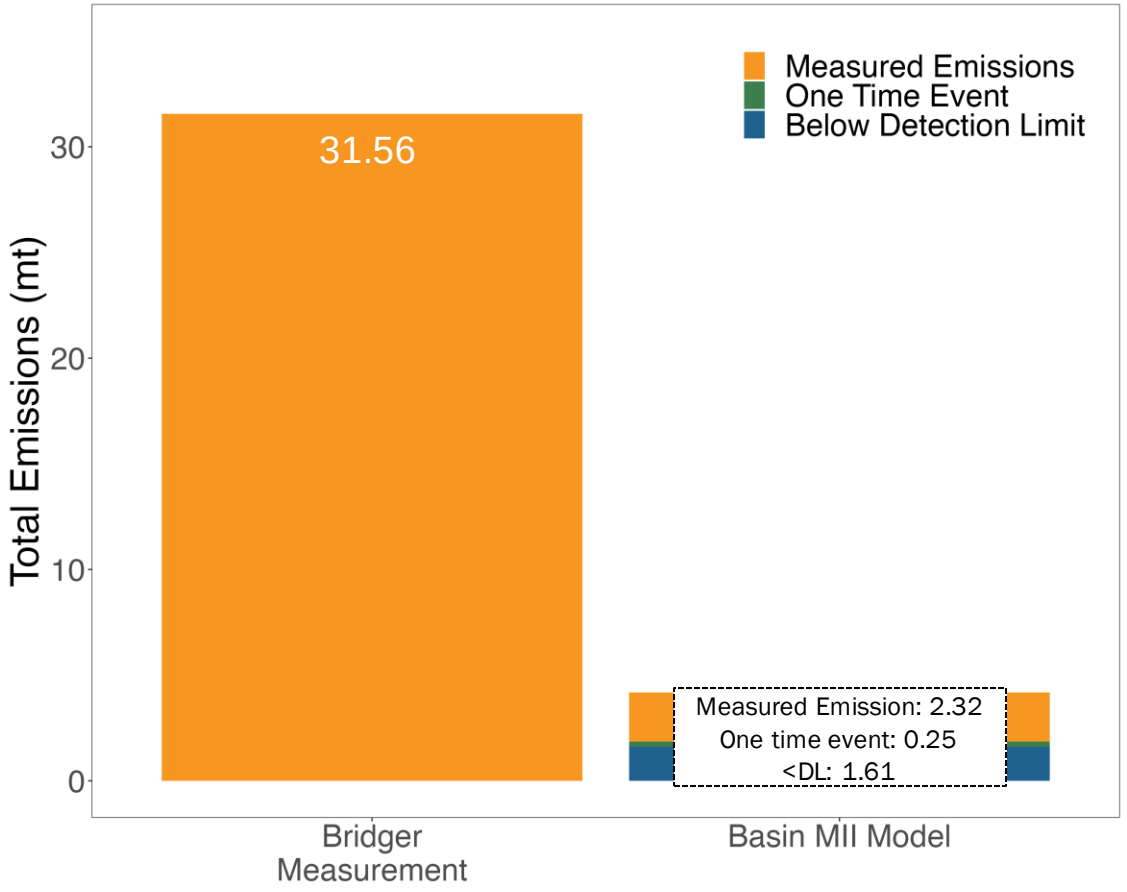
- Emission rates are simulated from regional measurements for each equipment and multiplied with duration and frequency
- Simulate for 90 days
- Simulated tank emission is 97% lower than extrapolated Bridger measurement
- Even though no emission was detected on separator and well, Basin MII model produces inventory estimates for them based on regional separator and well emissions distribution from the survey

Case A: accounting for emission from one-time event



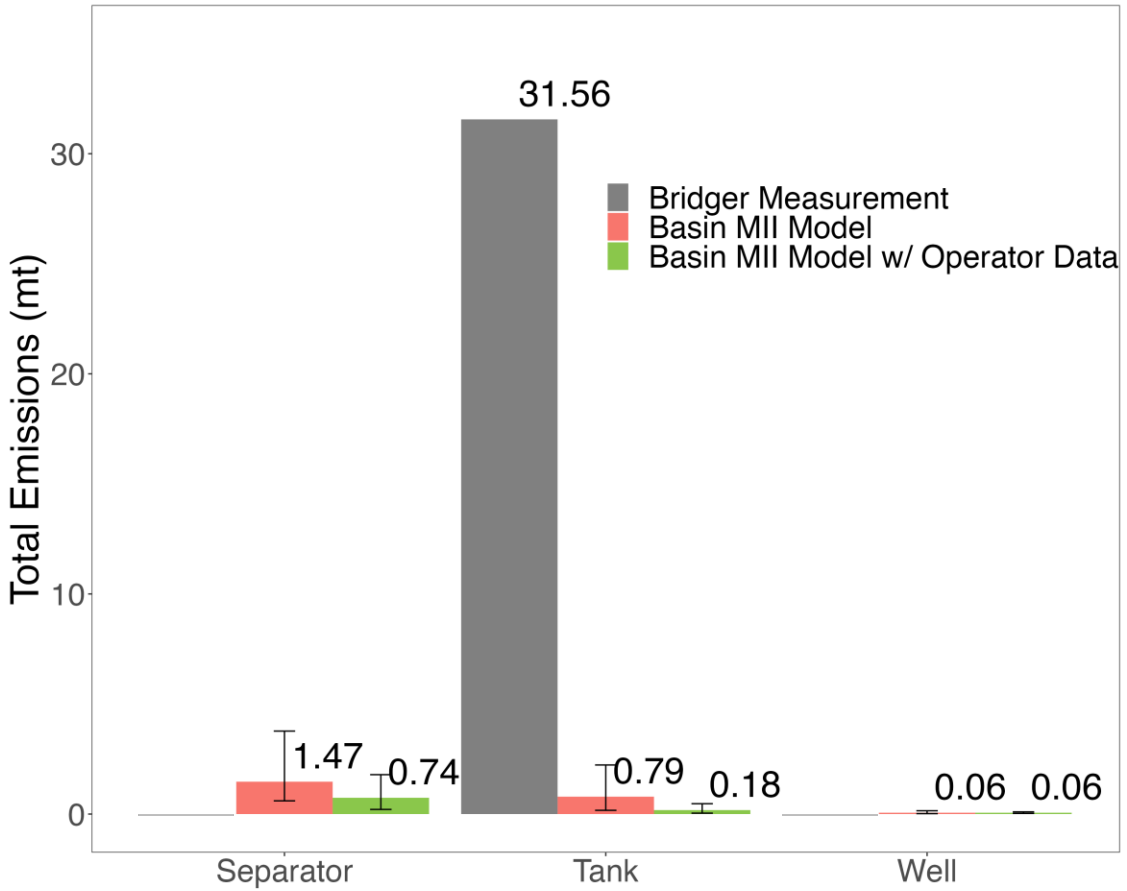
- One-time event includes emission from liquid unloading assuming no plunger lift
- No additional one-time event is identified
- Emissions from one-time event is 0.25 mt

Case A: accounting for <detection limit emission



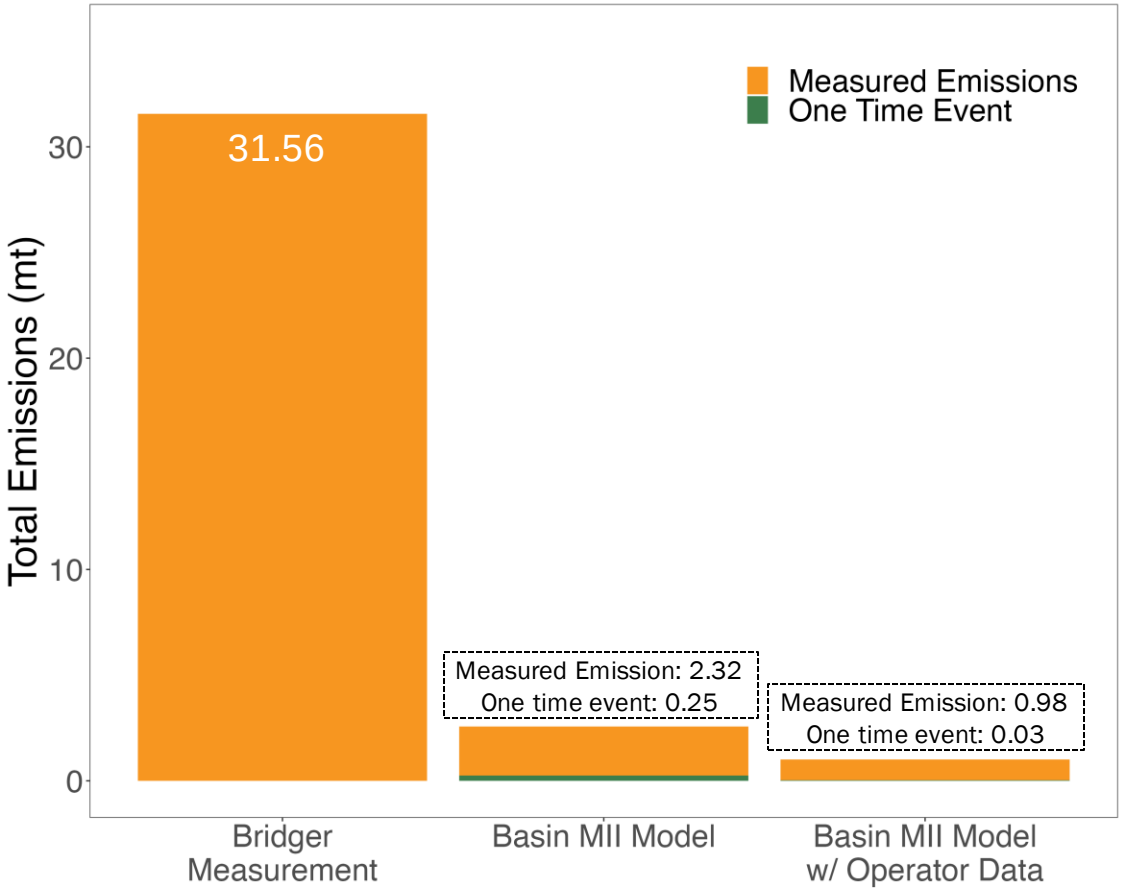
- Emissions from pneumatic controllers and pumps are simulated using GHGRP data
- Equipment leaks are simulated with GHGRP data
- Facility-level inventory from Basin MII model is 4.18 mt

Case A: incorporating operator data on equipment characteristics



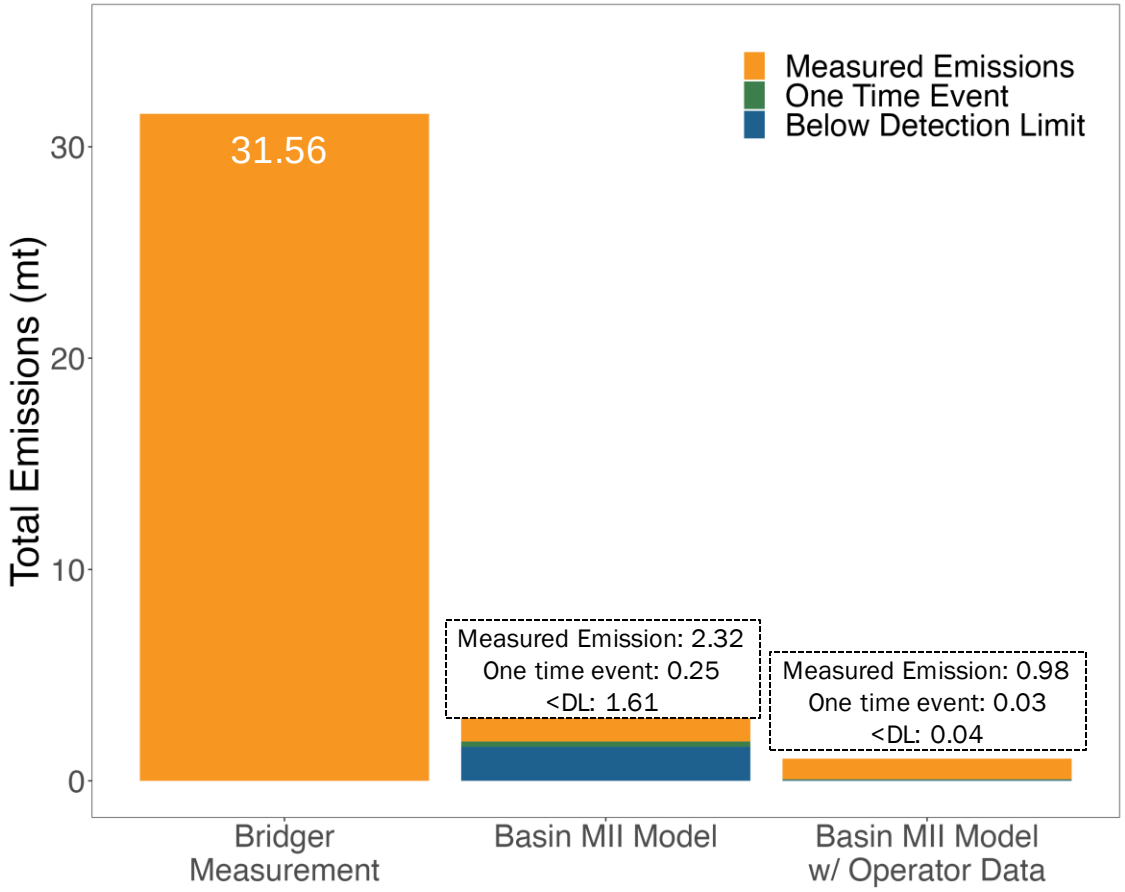
- Separators and wells are simulated from equipment emissions distributions of the operator
- All tanks on the facility are uncontrolled
- Tank emissions are simulated from emissions distribution of uncontrolled tanks
- With operator data, total equipment-level emissions refined from 2.32 mt to 0.98 mt

Case A: refining one time event with operator data



- Facility conduct liquid unloading with plunger lift
- Emission from liquid unloading refined from 0.25 mt to 0.03 mt

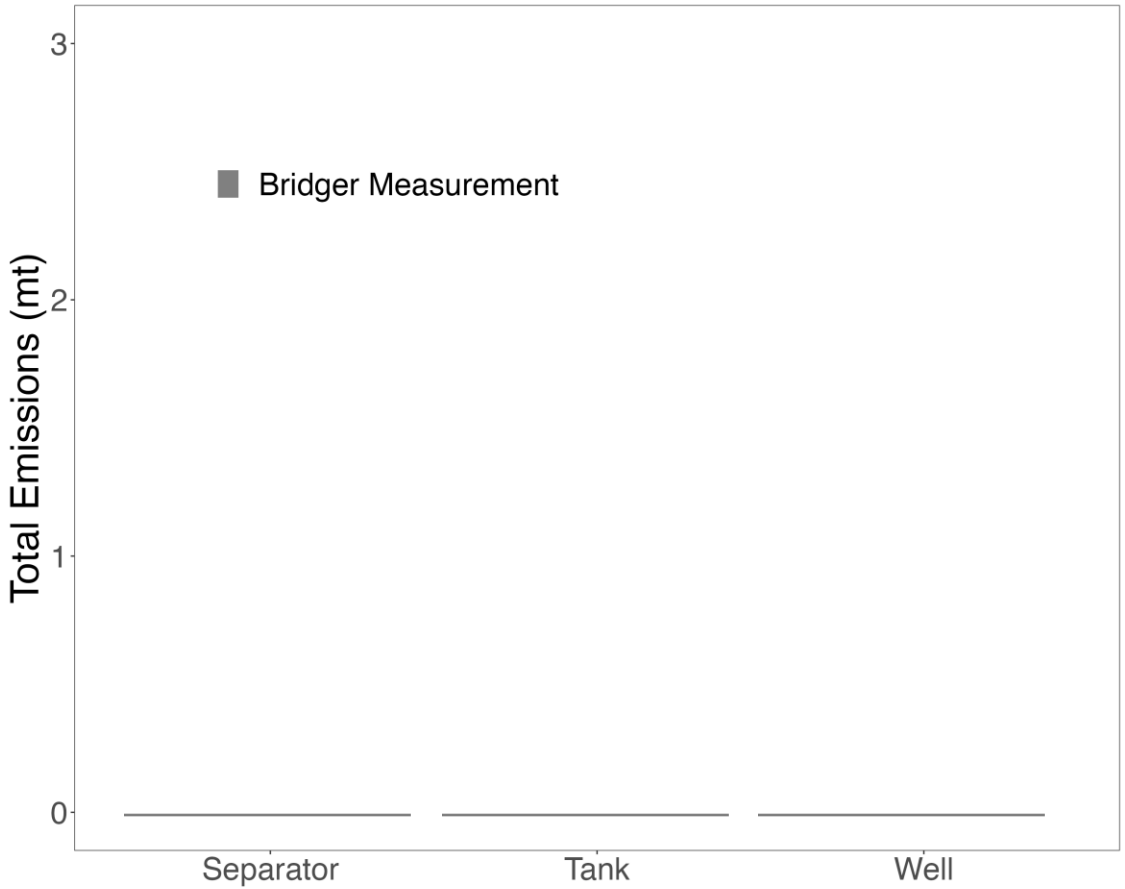
Case A: refining <DL emission with operator data



- Facility does not have any natural-gas driven pneumatic controllers
- Operator component leaking frequency derived from LDAR surveys are use for equipment leak simulation
- Below detection limit emission refined from 1.61 mt to 0.04 mt
- Bridger measurement: 31.56 mt
- Basin MII model: 4.18 mt
- Basin MII model w/ operator data: 1.05 mt

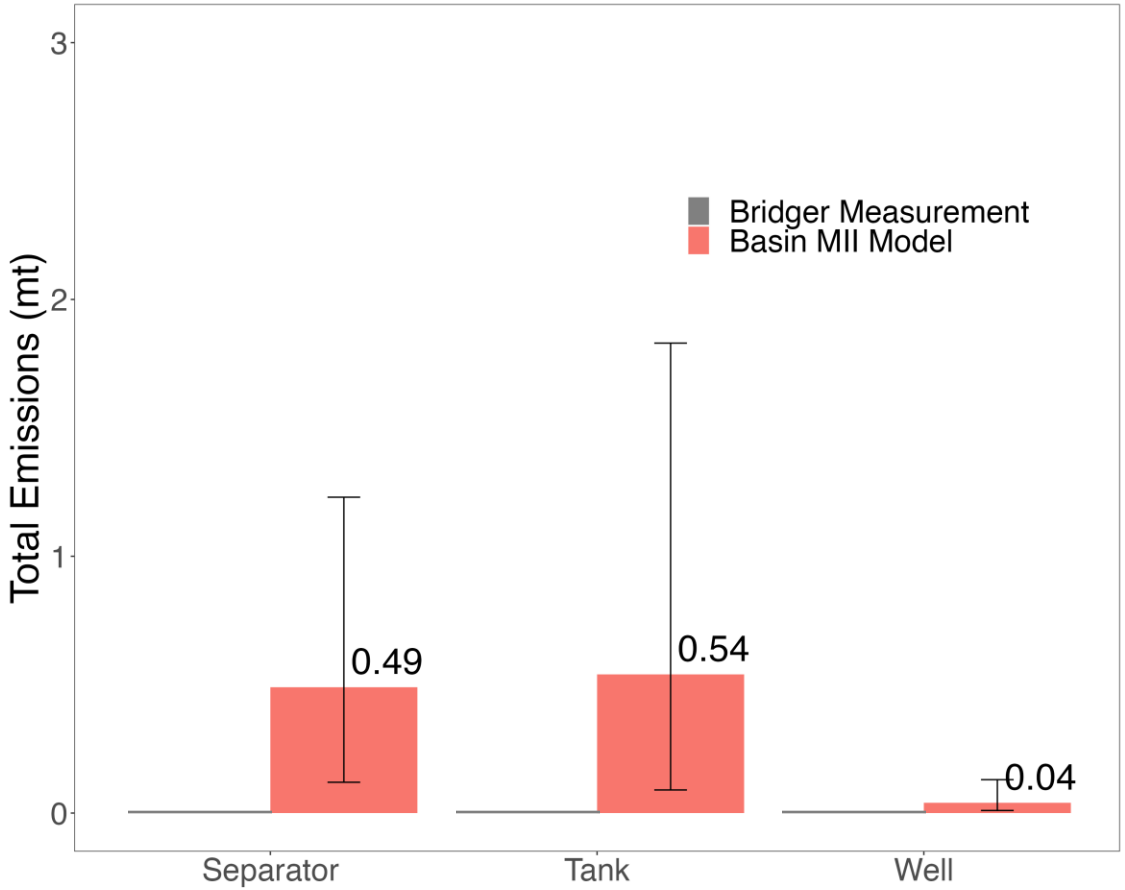
Case B: no detected emission from Bridger

- Facility B has 2 wells, 2 separators, and 2 tanks
- No emission detected from aerial survey
- Emissions could be below the detection limit of aerial technology



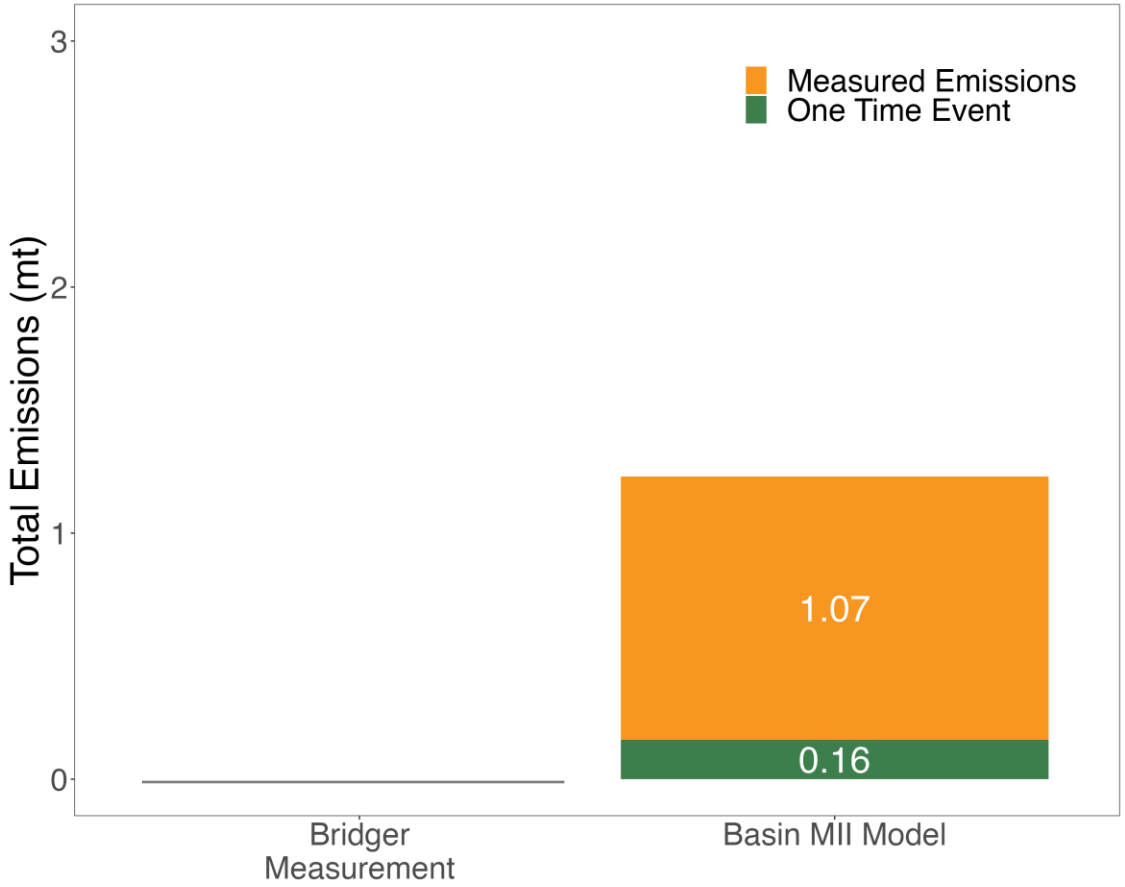
Case B: accounting for emission intermittency

- Emission rates are simulated from regional measurements for each equipment and multiplied with duration and frequency
- Simulate for 90 days
- Even though no emission was detected on the facility, MII model produces inventory estimates for all equipment based on regional equipment-level emissions distribution from the survey
- Total equipment-level emissions from the Basin MII model is 1.07 mt



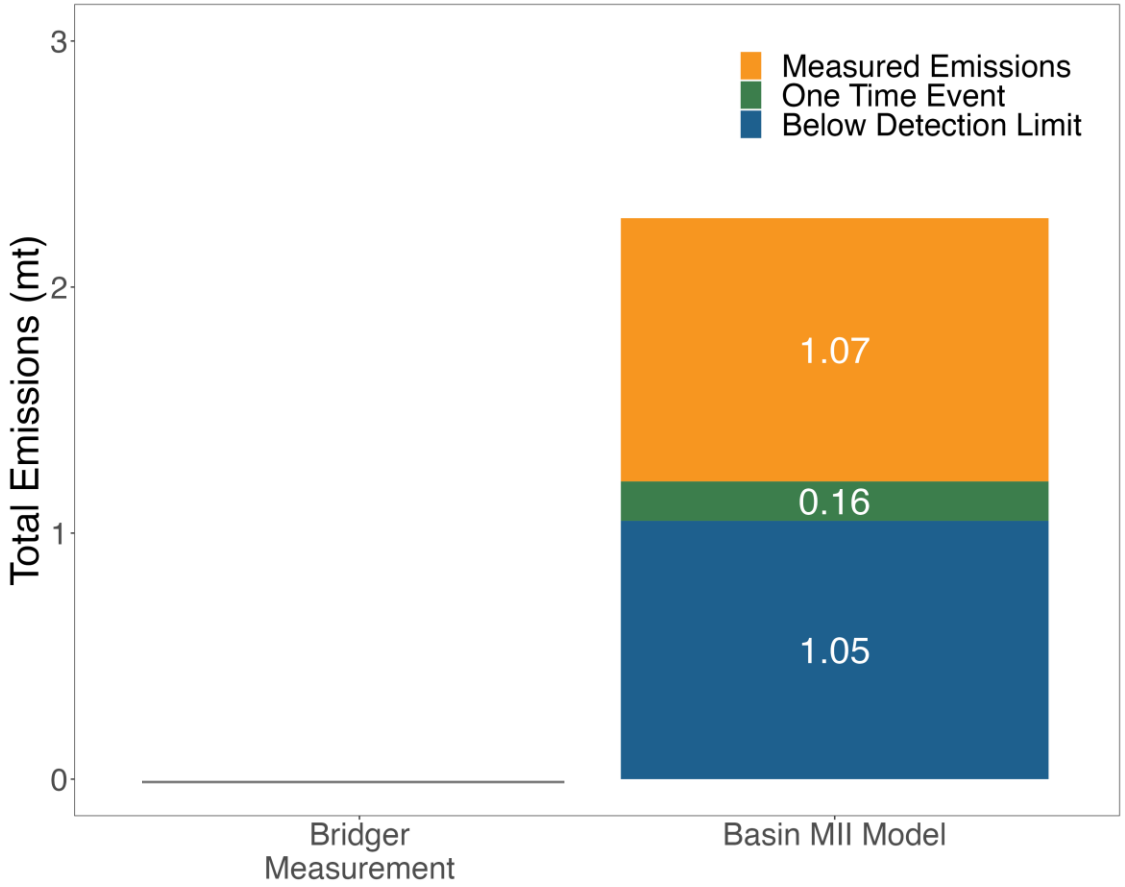
Case B: accounting for emission from one-time event

- One-time event includes emission from liquid unloading assuming no plunger lift
- No additional one-time event is identified
- Emissions from one-time event is 0.16 mt



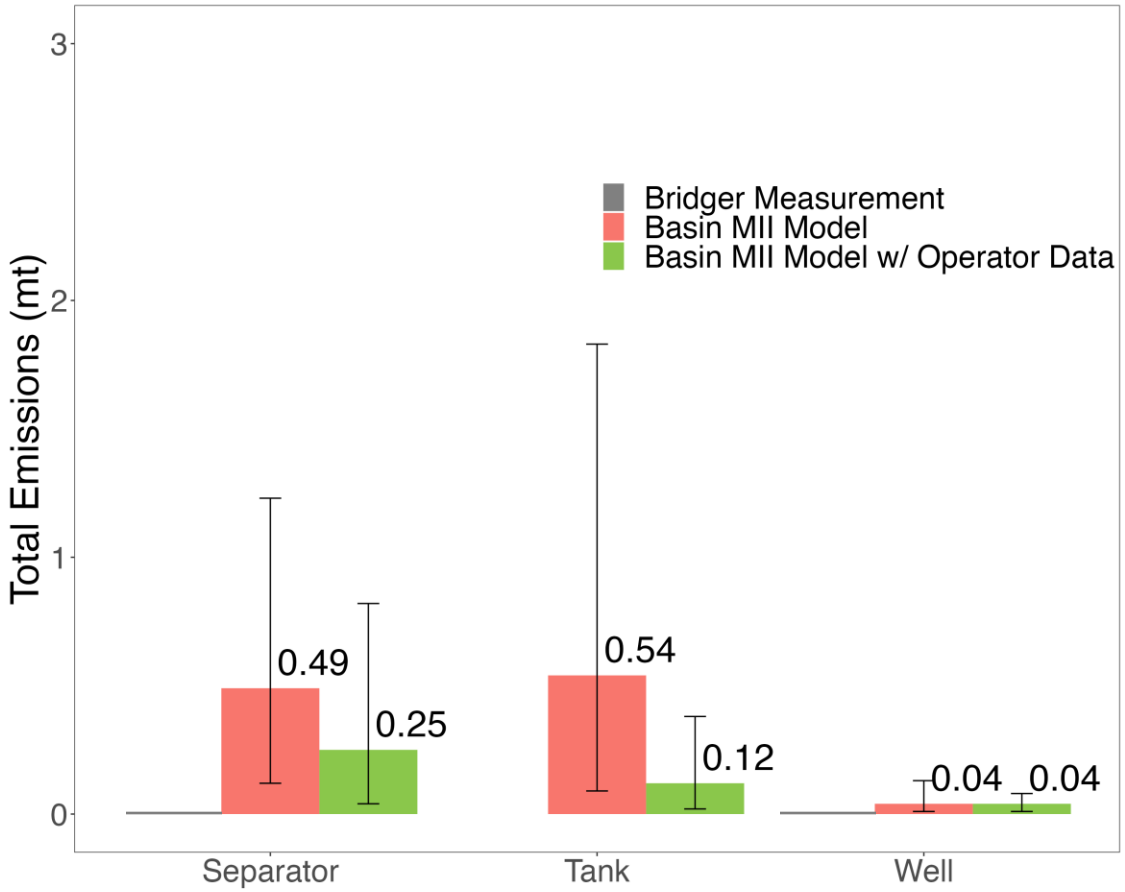
Case B: accounting for <detection limit emission

- Emissions from pneumatic controllers and pumps are simulated using GHGRP data
- Equipment leaks are simulated with GHGRP data
- Facility-level inventory from Basin MII model is 2.28 mt



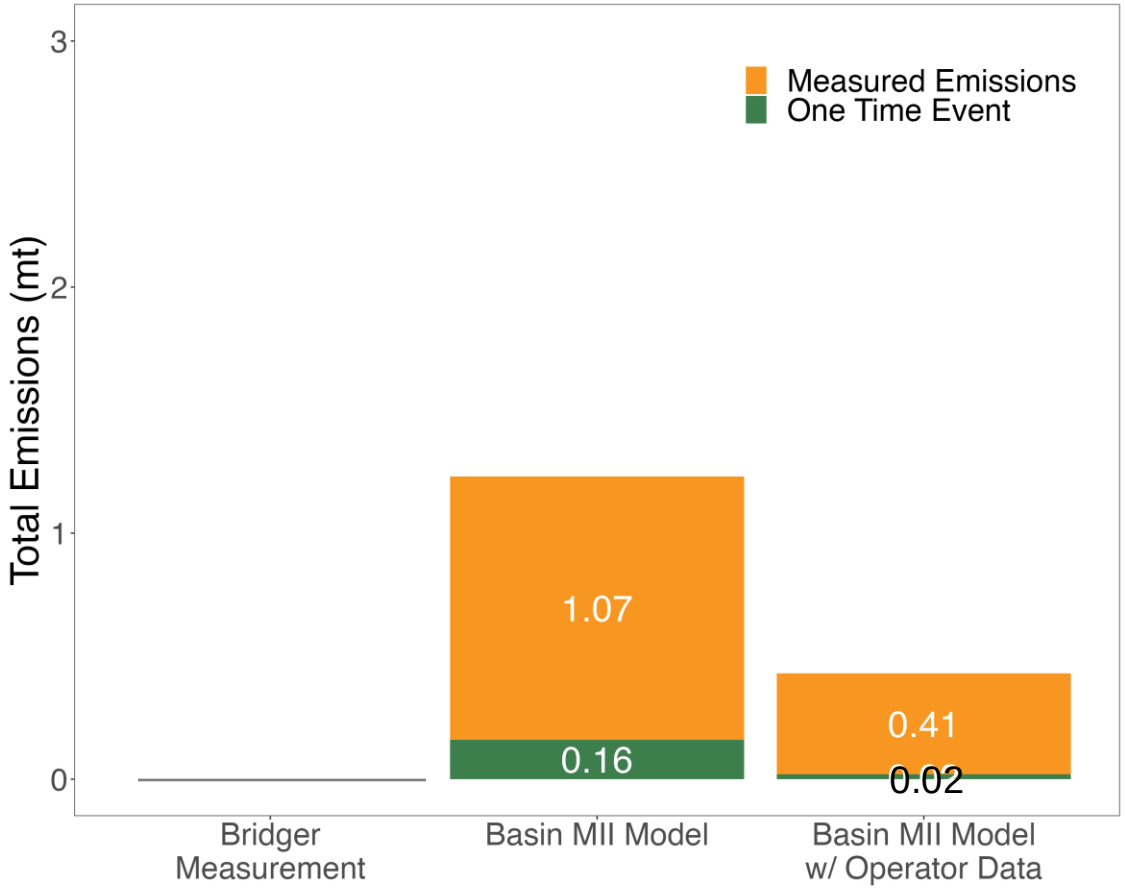
Case B: incorporating operator data on equipment characteristics

- Separators and wells are simulated from equipment emissions distributions of the operator
- All tanks on the facility are uncontrolled
- Tank emissions are simulated from emissions distribution of uncontrolled tanks
- With operator data, total equipment-level emissions refined from 1.07 mt to 0.41 mt



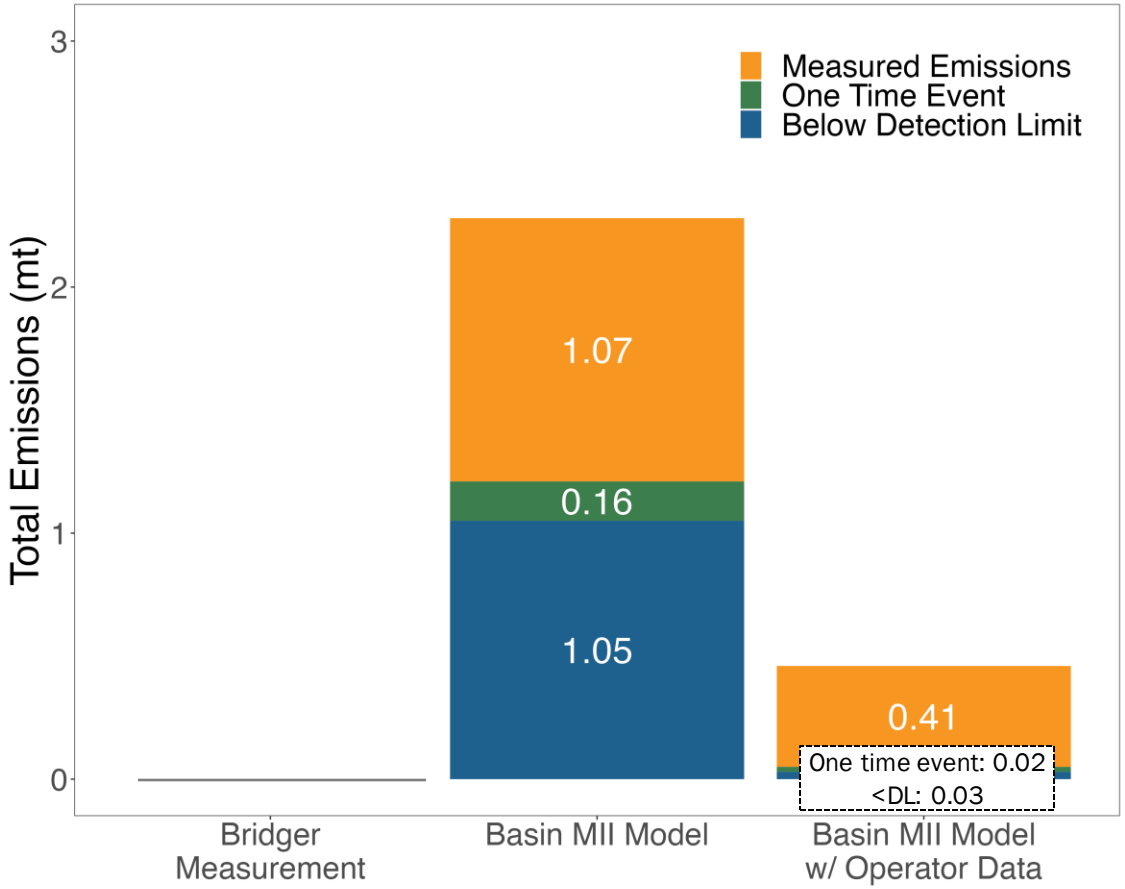
Case B: refining one time event with operator data

- Facility conduct liquid unloading with plunger lift
- Emission from liquid unloading refined from 0.16 mt to 0.02 mt



Case B: refining <DL emission with operator data

- Facility does not have any natural-gas driven pneumatic controllers
- Operator component leaking frequency derived from LDAR surveys are use for equipment leak simulation
- Below detection limit emission refined from 1.05 mt to 0.03 mt
- Bridger measurement: < detection limit
- Basin MII model: 2.28 mt
- Basin MII model w/ operator data: 0.46 mt



MII model paired with operator data for accurate facility-level emission inventory

- Measurement informed inventory (MII) model provides solution to incorporate snapshot measurements into inventory estimation and estimate inventories at facility-level
- Case A and B demonstrate how MII model accounts for emission intermittency, one time event, and below detection limit emissions to generate facility-level inventory
  - Moreover, how MII model can estimate facility-level inventory when no emission was detected during aerial survey
- Operator data is helpful in refining and reflecting operational characteristics on facility-level emissions inventory
- Future MII model will incorporate other technologies including continuous monitoring systems and satellites

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THANK YOU!

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