Multi-scale Measurement and Reconciliation of Methane Emissions in the Appalachian Shale Basin

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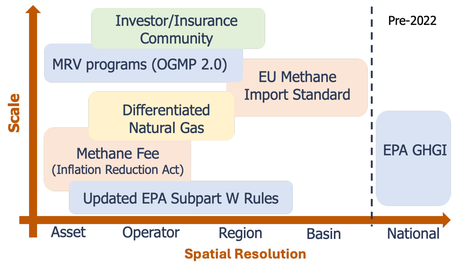
Introduction

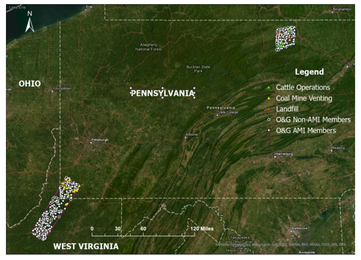
- Methane is a potent greenhouse gas, with global warming potential 34x that of carbon dioxide
- Recent regulations such as the methane fees in the Inflation Reduction Act and voluntary initiatives such as Oil and Gas Methane Partnership (OGMP 2.0) require high spatial resolution, measurement-informed emissions estimates



- The **Marcellus Methane Monitoring (M3) Project** undertakes multi-scale measurements and reconciliation of site-level methane emissions in the Appalachian Basin
- The M3 project will develop new models and tools for developing measurement informed inventories (MII) and high-resolution gridded inventories

Pilot Measurement Campaign

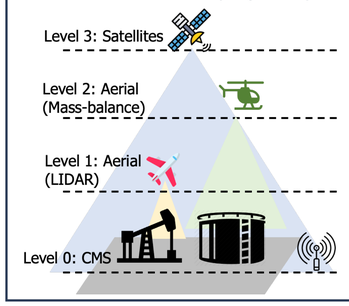
- Two pilot regions in the southwest and northeast Marcellus chosen to correspond to the wet gas and dry gas regions of the Appalachian Basin



Included site-types:

- O&G upstream
- O&G midstream
- O&G pipelines
- Coal mines
- Landfills
- CAFOs
- Wastewater

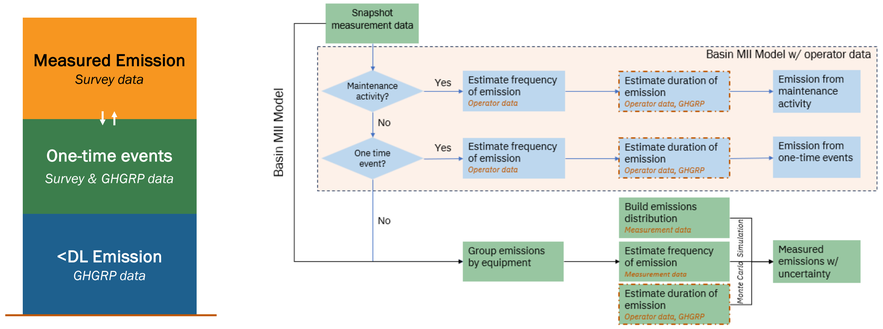
- Technologies deployed included continuous monitoring system, aerial LIDAR surveys (Bridger Photonics), aerial mass-balance surveys (ChampionX), and satellites (*future*)



- Different technologies provide complementary spatio-temporal data on methane emissions
- Emissions reconciliation between technologies needed to enable independent verification

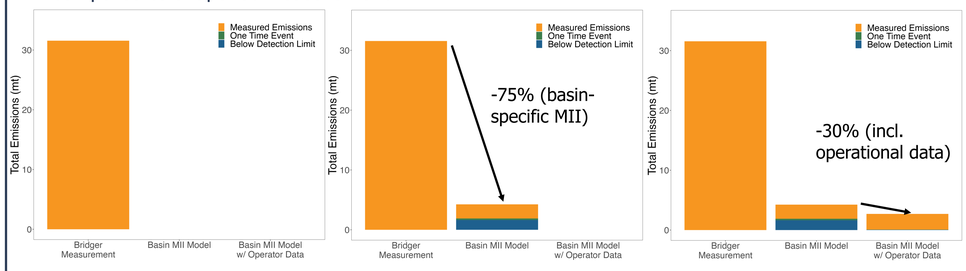
Measurement-Informed Inventory Model

- Measurement informed inventory (MII) model is a tool to develop annualized, facility-level methane emissions inventory based on measurement data
- Basin MII model uses measurement data and basin specific parameters to estimate facility–level emissions inventory
- Incorporating operational data (e.g., maintenance activity records, below detection threshold emissions, one-time emissions events, etc.) helps further refine basin-specific MII



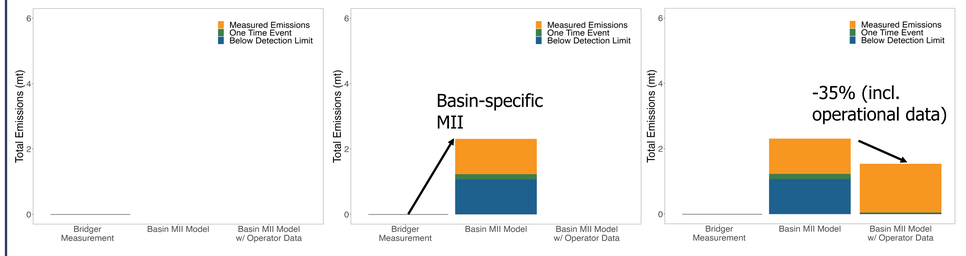
Case study A: When Bridger Photonics measured an emission of 760 scfh on a tank at a production site

- Basin-wide statistical analysis provides tank emitter frequency – 5% in the Appalachian basin
  - Combine frequency and duration of emissions to estimate annualized average
- Add basin-wide average estimates for one-time events (e.g., liquids unloadings) and below detection threshold emissions (GHGRP data) → results in 75% reduction in basin-specific MII compared to snapshot measurement



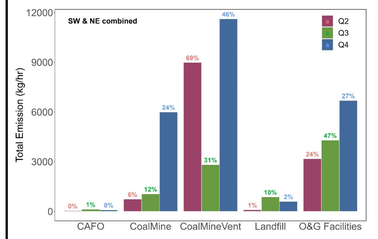
Case study B: When Bridger Photonics measured zero emissions at a production site

- Zero emissions during snapshot measurement does not imply zero emissions inventory
  - Use basin-specific emitter frequency and duration, and equipment-specific emissions distribution to develop MII
- Operational data includes information on maintenance activities and liquids unloading events during the 3-month period between surveys and OGI-based LDAR records for below detection threshold emissions



Pilot Measurement Results

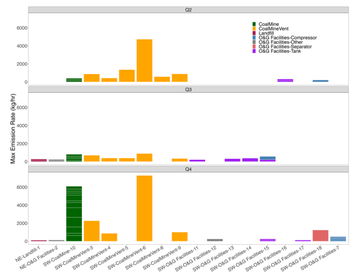
Source Attribution



- In the pilot region, non-oil and gas sources is the largest contributor to total methane emissions in the region, contributing between 53% and 76% across all surveys
- Coal mines and coal mine vents are the largest source methane in the southwest pilot region while landfills are the largest contributor in the northeast pilot region

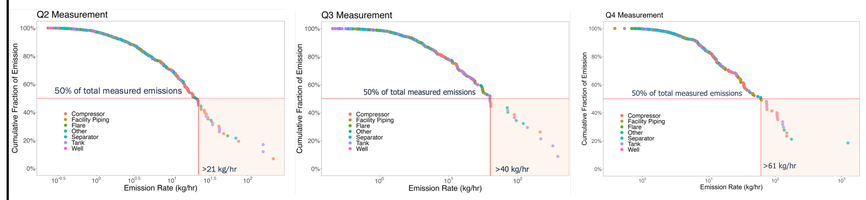
Large Release Events

- Large release events are defined as any event with an instantaneous emission rate > 100 kg/h
- Coal mines and coal mine vents are two most common sources of large emissions, with individual emission rates > 6000 kg/h
- Emission rates vary significantly over time – e.g., coal mine vent #6 exhibited emissions < 1000 kg/h in Q2 but >6000 kg/h in Q3



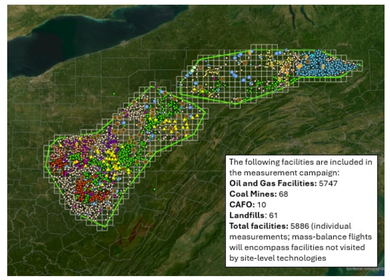
Emissions Distributions: Oil and Gas Sources

- All three surveys exhibited skewed emissions distribution with a small number of sources contributing to a large fraction of emissions
- 50% of emissions can be attributed to sources emitting over 21 kg/h, 40 kg/h, and 61 kg/h in Q2, Q3, and Q4 2023 surveys
- Most large emitters were found on tanks or compressors



Future Work

- Expand pilot region to cover a significant portion of the Appalachian shale basin, covering 90% of gas production in the region



- Included site-types: O&G upstream, O&G midstream, O&G pipelines, Coal mines, Landfills, CAFOs, Wastewater
- Multi-scale measurement to estimate emissions at facility, regional, and basin-scale
- Develop high-resolution gridded inventories of all methane emissions

2024 NETL Resource Sustainability Project Review Meeting, Pittsburgh PA

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