Constructing a measurement-based spatially explicit inventory of US oil and gas methane emissions for interpretation of remote sensing observations

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Accurate and comprehensive quantification of oil and gas methane emissions is pivotal in informing effective methane mitigation policies, while also supporting the assessment and tracking of progress towards emissions reduction targets set by governments and industry. While national bottom-up source-level inventories are useful for understanding the sources of methane emissions, they are often unrepresentative across spatial scales, and their reliance on generic emission factors produces underestimations when compared with measurement-based inventories. Here, we compile and analyze previously reported ground-based facility-level methane emissions measurements in the major US oil and gas producing basins and develop representative methane emission profiles for key facility categories in the US oil and gas supply chain, including well sites, natural gas compressor stations, processing plants, crude oil refineries, and pipelines. We then integrate these emissions data with comprehensive spatial data on national oil and gas activity to estimate each facility's mean total methane emissions and uncertainties, from which we develop a mean estimate of national methane emissions, resolved at 0.1º × 0.1º spatial scales (~10 km × 10 km). From this measurement-based methane emissions inventory (EI-ME), we estimate total US national oil/gas methane emissions of 15.7 Tg (95% confidence interval of 14-18 Tg) in 2021 which is 1.9× and 1.8× greater total methane emissions than is estimated by the EPA Greenhouse Gas Inventory and EDGAR v8 inventories. Our estimate represents a mean gas production-normalized methane loss rate of 2.6%, consistent with recent satellite-based estimates. We find significant variability in both the magnitude and spatial distribution of basin-level methane emissions, ranging from <1% methane loss rates in the gas-dominant Appalachian and Haynesville regions to >3-6% in oil-dominant basins, including the Permian, Bakken, and the Uinta. Our assessment offers key insights into plausible underlying drivers of basin-to-basin variabilities in oil and gas methane emissions, emphasizing the importance of integrating measurement-based data in developing high-resolution, spatially explicit methane inventories. Our work supports accurate methane assessments, including use as prior information in Bayesian inversions of satellite observations, while providing key insights for methane source attribution and mitigation of regional methane emissions. The high-resolution spatially explicit EI-ME inventory is publicly available at https://doi.org/10.5281/zenodo.10734300 (Omara et al. 2024)

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