U.S. Greenhouse Gas Inventory

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Overview | Methods | Ongoing Improvement Activities

2025 AiRMAPS Coordination Workshop
September 3rd, 2024

Overview of the U.S. GHG Inventory

Inventory of U.S. Greenhouse Gas Emissions and Sinks (U.S. GHGI)

What?

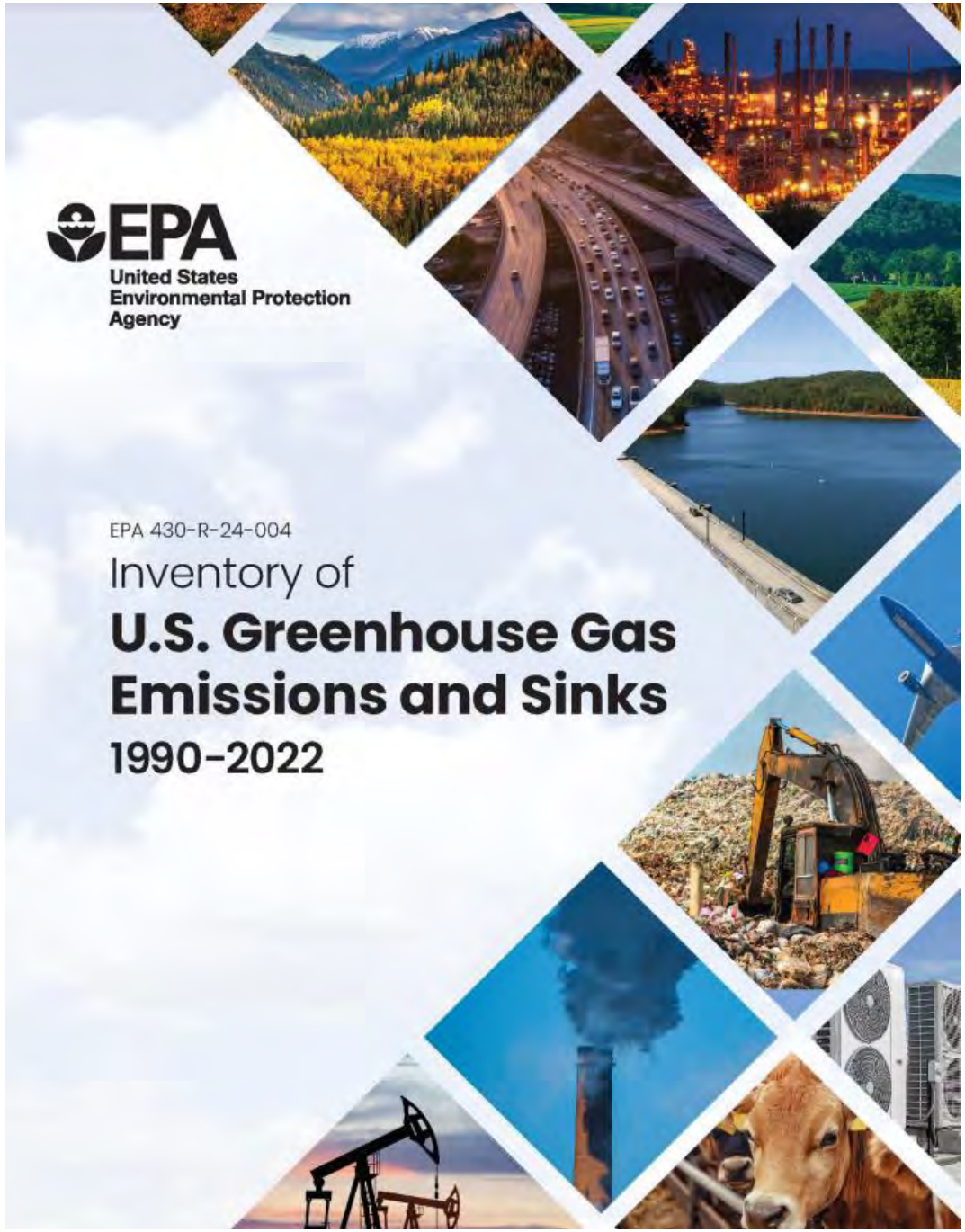
Annual report of national anthropogenic GHG emissions and sinks, by gas and economic sector, overtime from 1990 to current year-2.

How?

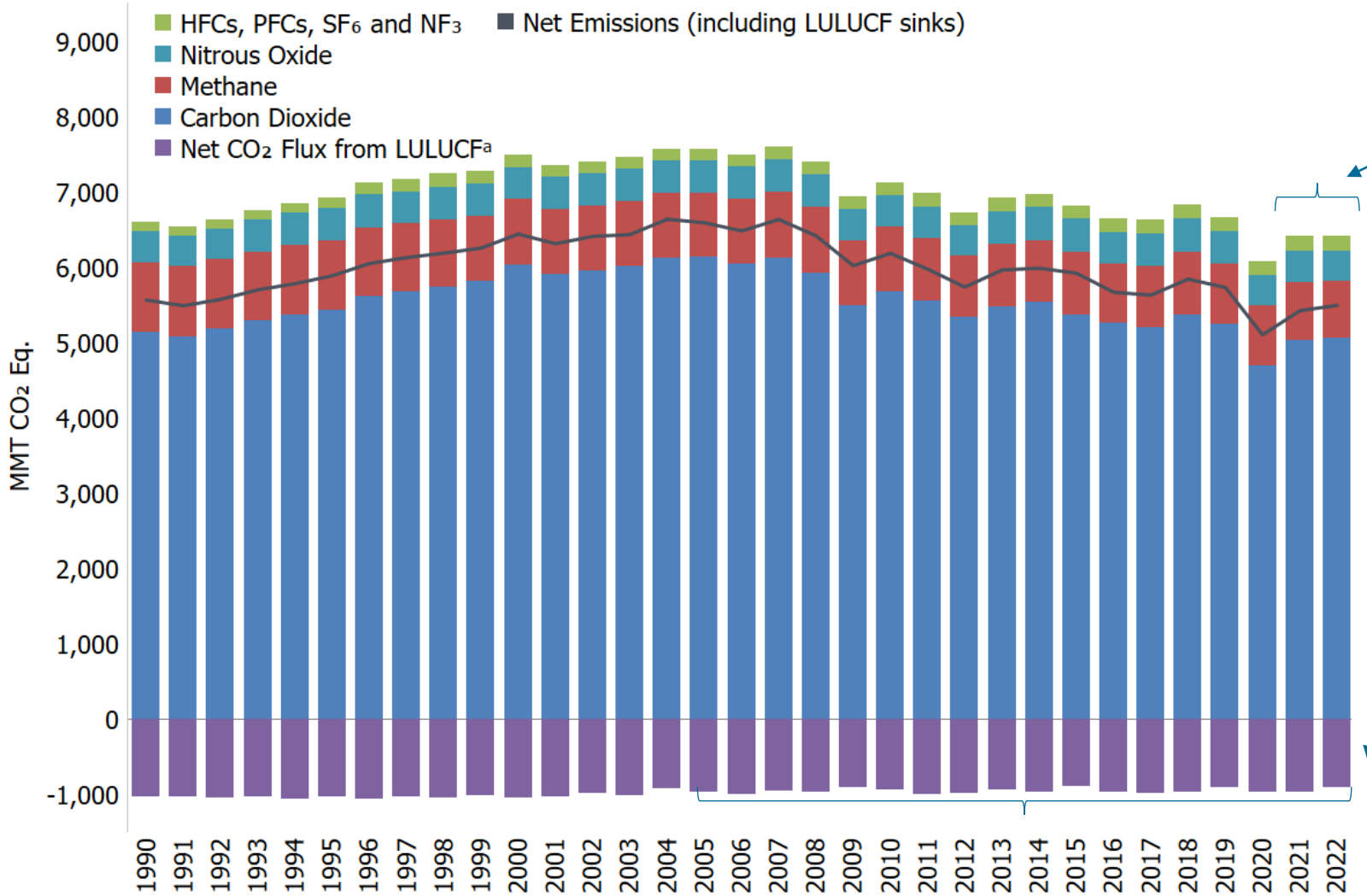
Using tiered methods from the IPCC (e.g., country- or activity-specific Emission Factors, modeling, etc.). Emissions data sources include measurement studies and GHGRP.

Why & When?

Developed and submitted to United Nations as part of the Framework Convention on Climate Change (UNFCCC), annually by April 15th, intended to ensure transparent, accurate, complete, consistent, and comparable inventories across countries to help track progress towards collective climate goals (e.g., Nationally Determined Contribution)



2024 GHGI – Trends by Gas



- **Net emissions (black line), accounting for sequestration, increased 1.3% between 2021 and 2022, but remain 16.7% below 2005 levels**. Energy use increased, in part due to the continued rebound in economic activity after the height of the COVID-19 pandemic. Net emissions total 5,489 MMT CO_2e. GHG shares:
  - CO_2 (79.7%)
  - CH_4 (11.1%)
  - N_2O (6.1%)
  - F-gases (3.1%)

https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

Methods: IPCC Guidelines & US GHG Inventory Methodology

Parties to the Paris Agreement required to report emissions following 2006 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC Guidelines and *Good Practice* Guidance specify Tiers with increasing methodological complexity. As a Party to the UNFCCC the U.S. is obligated to use higher tier methods for all key (i.e., most important) categories

- **Tier 1:** Use of default emission factors at the segment-level, applied to national activity data (feasible for all countries)
- **Tier 2**: Use of country (and segment)-specific emission factors
- **Tier 3**: Use of detailed emission models or measurement data at individual facility or sub-national level

Guidelines Development

- EPA and other experts play a role in the development of IPCC Guidelines
- IPCC Methodology Reports undergo the same review processes as IPCC scientific assessments

U.S. GHG Inventory

- Uses Tier 2/3 methods for all key categories and employs several approaches based on the availability of data and the nature of source/sink
- Recalculates time series when updating methods to ensure consistency

The series consists of 5 volumes:

1. General Guidance and Reporting (*including how to incorporate top-down quantification tools)*
2. Energy (*combustion and fugitive sources)*
3. Industrial Processes and Product Use
4. Agriculture, Forestry, and Other Land Use
5. Waste

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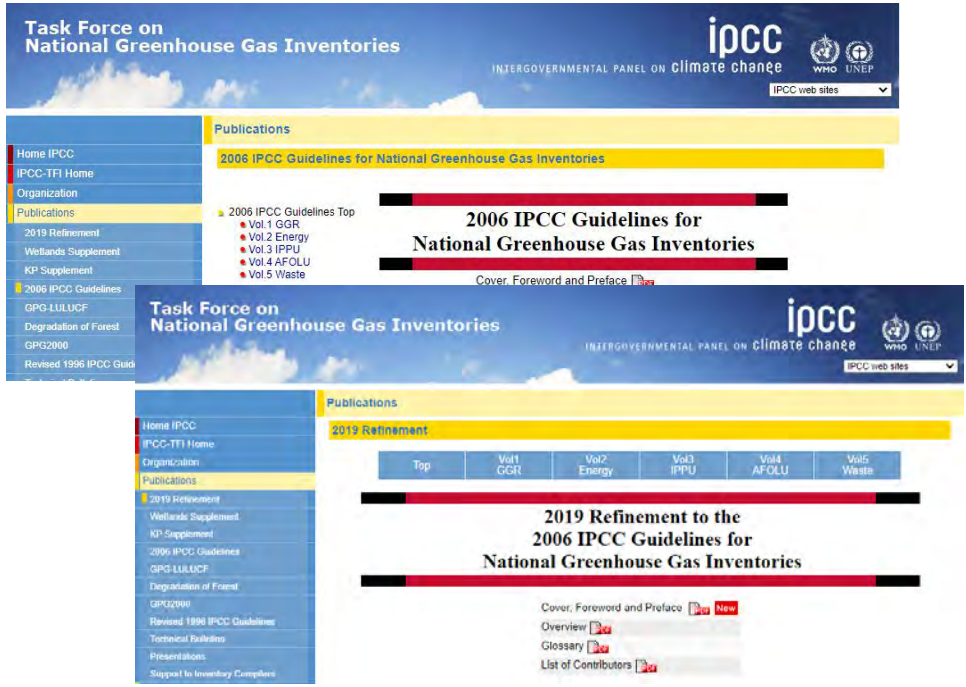

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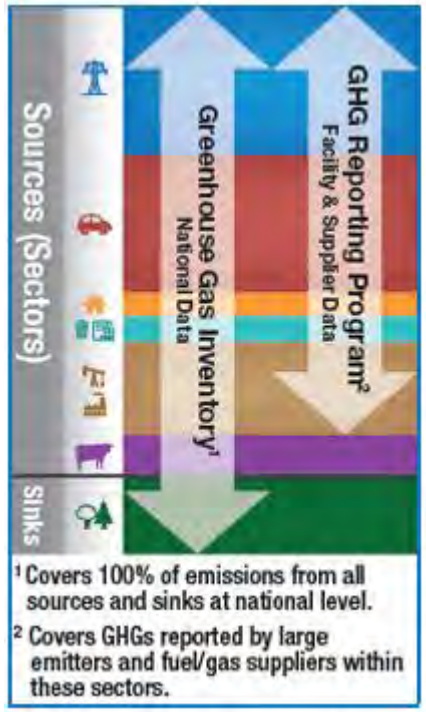
Methods: Example U.S. Data Sources – EPA's GHG Reporting Program

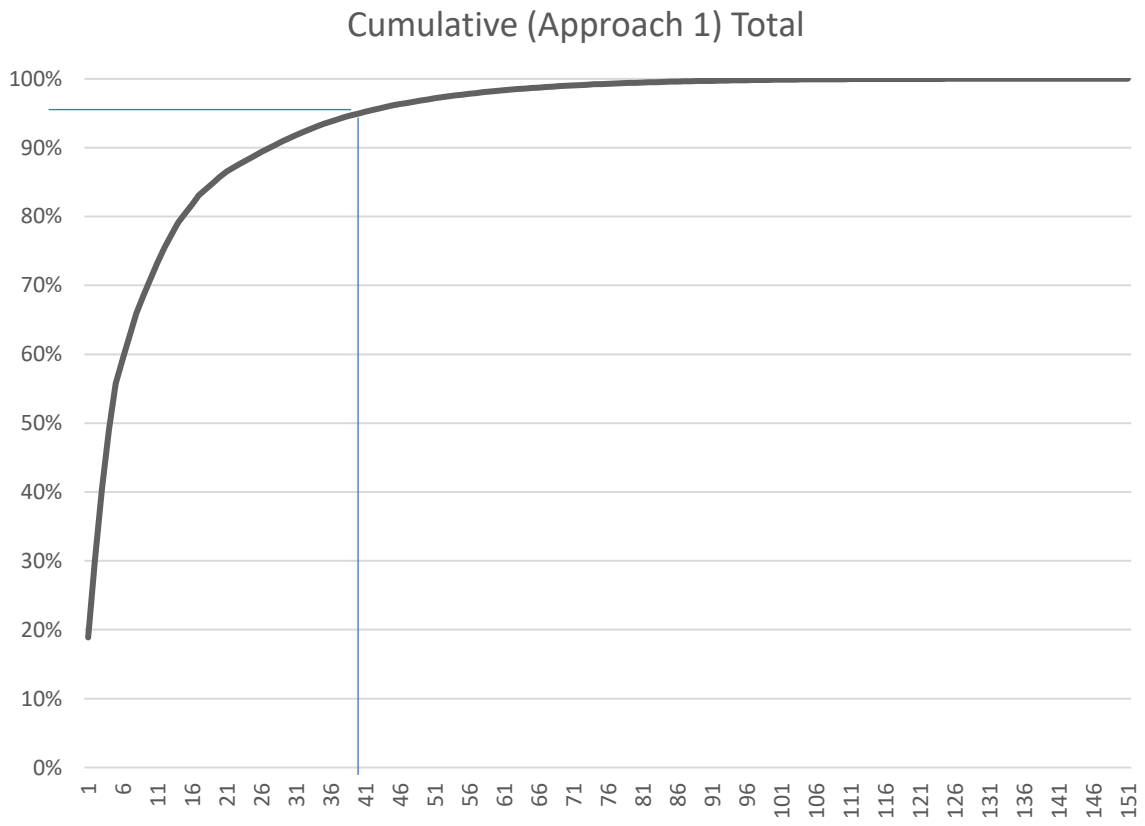
The Inventory uses aggregated national statistics to provide complete national coverage, combined with sub-national data for sources and gases where more detailed estimates are available (e.g., EPAs GHG Reporting Program)

	U.S. GHG Inventory (UN Requirement)	**GHG Reporting Program** (Facility Reporting by Clean Air Act Regulation)
Scale	• National	• Facility
Coverage	• All U.S. anthropogenic emissions and sinks • Energy; Industrial Processes; Agriculture; Forestry and Land Use; Waste	• ~85-90% of total U.S. GHG Emissions • Over 8,000 facilities (> 25,000 metric tons CO_2 equivalent per year) • Excludes agriculture, forestry and land use
GHGs	• CO_2, CH_4, N_2O, Fluorinated GHGs	• CO_2, CH_4, N_2O, Fluorinated GHGs
Methods	• IPCC Tier 2 and 3 • Measurement-based emission factors, models, and GHGRP data	• Continuous, periodic measurements, and sampling • Engineering calculations & emission factors
Time series	• Annual, 1990 – present (-2)	• Annual, since 2010
Key dates	• Annual public review every February • Final report published by April 15	• Annual reporting deadline March • Data published every Fall
Updates	• Continuous improvements	• Updates to methods or EFs require additional rulemaking (multi-year process) • E.g., May 2024 Final Rule on Subpart W Amendments (to incorporate additional direct measurements, add new sources, etc.)



GHG Inventory Improvement Prioritization

How do GHG inventory compilers make decisions about where to expend resources on improving results?



Key Category Analysis

- When ranking from largest to smallest GHG categories, ~40 GHGI categories make up over 95 percent of overall U.S. emissions
- Improvements in accuracy to these 40 categories will have the biggest impact on improving the overall topline results

GHG Inventory Improvement Prioritization

How do GHG inventory compilers make decisions about where to expend resources on improving results?

Gas/Category	2022 Emissions (MMT CO_2e)	Contribution to 2022 (% gross emissions)
CO_2		
1.A.3.b. Transportation - On-Road Mobile Combustion	1438.1	19
1.A.1. Stationary Combustion - Electricity Generation - Coal	851.5	11
4.A.1. Net CO_2 Emissions from Forest Land Remaining Forest Land	(787)	(10)
1.A.1. Stationary Combustion - Electricity Generation – Natural Gas	659.3	9
1.A.2. Stationary Combustion – Industrial – Natural Gas	510.4	7
CH_4		
3.A.1 Enteric Fermentation (Cattle)	185.9	2
1.B.2. Natural Gas Systems	173.1	2
5.A. Landfills (MSW)	100.9	1
4.D.1. Flooded Lands Remaining Flooded Lands	44.2	1
N_2O		
3.D.1. Direct Emissions from Agricultural Soil Management	262.5	3
3.D.2. Indirect Emissions from Applied Nitrogen	28.3	0.4
5.D. Wastewater Treatment	21..4	0.3
Fluorinated GHGs (F-GHGs)		
2.F.1. Substitutes for Ozone Depleting Substances: Refrigeration and Air conditioning	144.6	2
2.F.4. Substitutes for Ozone Depleting Substances: Aerosols	17	0.2

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- Improvements in accuracy to these 40 categories will have the biggest impact on improving the overall topline results
- Potential priorities for new measurements and observations (large non-CO2 sources, land sector CO2)

The Role of Atmospheric Observations in Inventory Improvements

To facilitate improvements in bottom-up methods (GHGMMIS Objective #1) and convergence in bottom-up and top-down approaches (GHGMMIS Objective #3), atmospheric information can be used to help evaluate and refine bottom-up emission estimates, particularly for sources with limited information

General Types of Relevant Atmospheric Studies		Possible Feedbacks Into the GHG Inventory
1. Measurements of specific activities, processes, equipment, emission factors	→	Direct use; verification/QA of EPA measurements
2. Facility-scale measurements	→	If extrapolated to quantify annual emissions, can potentially provide information assess GHGRP methods and emissions totals
3. Estimates of regional/continental scale emissions through analysis of atmospheric observations (e.g., inverse modeling, isotopic/gas ratios)	→	Broad evaluations of specific regions or sectors; can be used to inform inventory improvement planning; CANNOT be used to 'scale' inventory estimates as inventories MUST RETAIN the source, segment, and equipment level detail required for rulemaking and policy development

Additional Resources:

2019 IPCC GHG Guideline Refinements

2018 National Academies Report: *Improving Characterization of Anthropogenic Methane Emissions in the U.S.*

2010 National Academies Report: *Verifying GHG Emissions and Methods to Support International Climate Agreements*

The Role of Atmospheric Observations in Inventory Improvements: Examples of Recent and Ongoing Activities

Areas for Assessment/Improvement		Ongoing Activities
1. Activity data and EF improvements (direct GHGI improvements)	→	working with other agency, academic, and consulting partners to identify and develop new data sources

The Role of Atmospheric Observations in Inventory Improvements: Examples of Recent and Ongoing Activities

Areas for Assessment/Improvement

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Ongoing Activities

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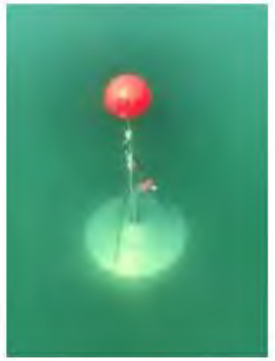
Example: Tier 2 Emission Factor Development – Flooded Lands



Inverted funnel device for measuring ebullition in a water body.

Aluminum floating chamber for measuring diffusive emissions from a reservoir.

Data Collection Sources

Emissions data is being gathered from reservoirs distributed across 41 states and the nine major ecoregions of the contiguous United States. Ownership of the 108 reservoirs in the SuRGE Project encompass public and private lands, and tribes. Access to the reservoirs is being arranged with each local landowner.

Map of reservoirs being sampled for the Survey of Reservoir Greenhouse gas Emissions (SuRGE).

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2. Facility-scale measurements (GHGRP assessment; indirect GHGI improvement)	→	Subpart W amendments to incorporate additional observations; GHGRP RFI on Advanced Technologies; quantification of anomalous events

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Ongoing Activities

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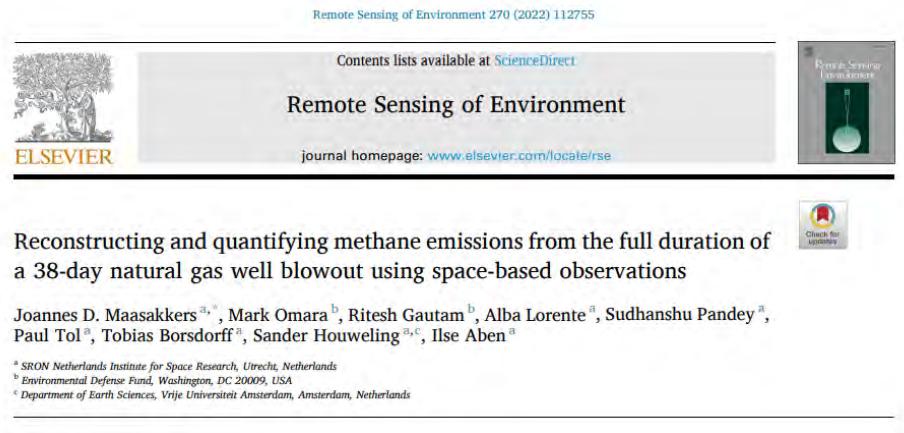
Example #1: Well blowout events added directly to GHGI


Remote Sensing of Environment 270 (2022) 112755

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Reconstructing and quantifying methane emissions from the full duration of a 38-day natural gas well blowout using space-based observations

Joannes D. Maasakkers[a,c], Mark Omara[b], Ritesh Gautam[b], Alba Lorente[a], Sudhanshu Pandey[a], Paul Tol[a], Tobias Borsdorff[a], Sander Houweling[a,c], Ilse Aben[a]

[a] SRON Netherlands Institute for Space Research, Utrecht, Netherlands
[b] Environmental Defense Fund, Washington, DC 20009, USA
[c] Department of Earth Sciences, Vrije Universiteit Amsterdam, Amsterdam, Netherlands

Example #2: EPA RFI on the use of Advanced Technologies in the GHGRP


NOTICE

Use of Advanced and Emerging Technologies for Quantification of Annual Facility Methane Emissions under the Greenhouse Gas Reporting Program

Agency Environmental Protection Agency | Posted Aug 29, 2024 | ID EPA-HQ-OAR-2024-0350-0001

Comment

Comments Due Oct 28, 2024

Please consider providing comments on Regulations.gov!
Deadline: Oct 28th, 2024

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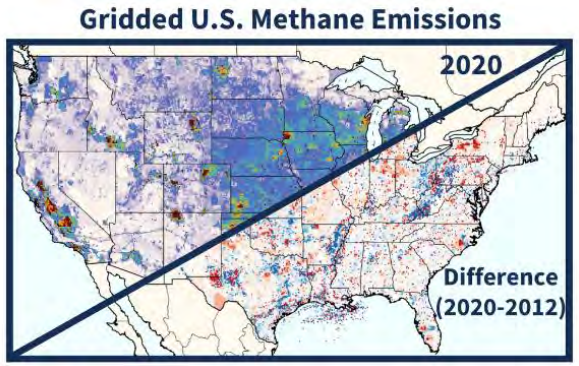
Areas for Assessment/Improvement

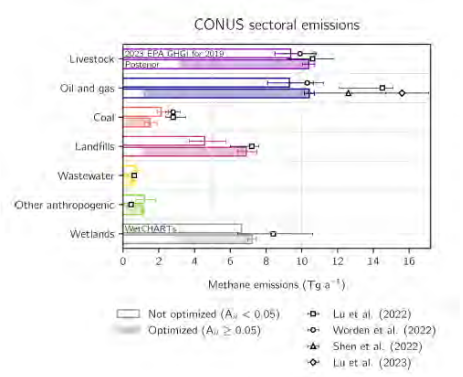
Ongoing Activities

1. Activity data and EF improvements (direct GHGI improvements) → working with other agency, academic, and consulting partners to identify and develop new data sources

2. Facility-scale measurements (GHGRP assessment; indirect GHGI improvement) → Subpart W amendments to incorporate additional observations; GHGRP RFI on Advanced Technologies; quantification of anomalous events

3. Regional/continental scale emission estimates (GHGI assessment, potentially identify priority areas for improvement) → Regular development of gridded version of methane emissions from the GHGI; EPA scoping out operational methane inversion system; source-specific continental scale assessments





Examples:
Maasakkers, McDuffie et al., 2023
Nesser et al., 2024

Thank You!

For more information:

- GHG Inventory Information and Report – https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
- State GHG Inventory – https://www.epa.gov/ghgemissions/state-and-tribal-greenhouse-gas-data-and-resources
- Gridded methane GHGI – https://www.epa.gov/ghgemissions/us-gridded-methane-emissions
- EPA GHGRP – https://www.epa.gov/ghgreporting

Contact: McDuffie.Erin.E@epa.gov