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Mapping Methane: A Review of Bottom-up Gridded Inventories

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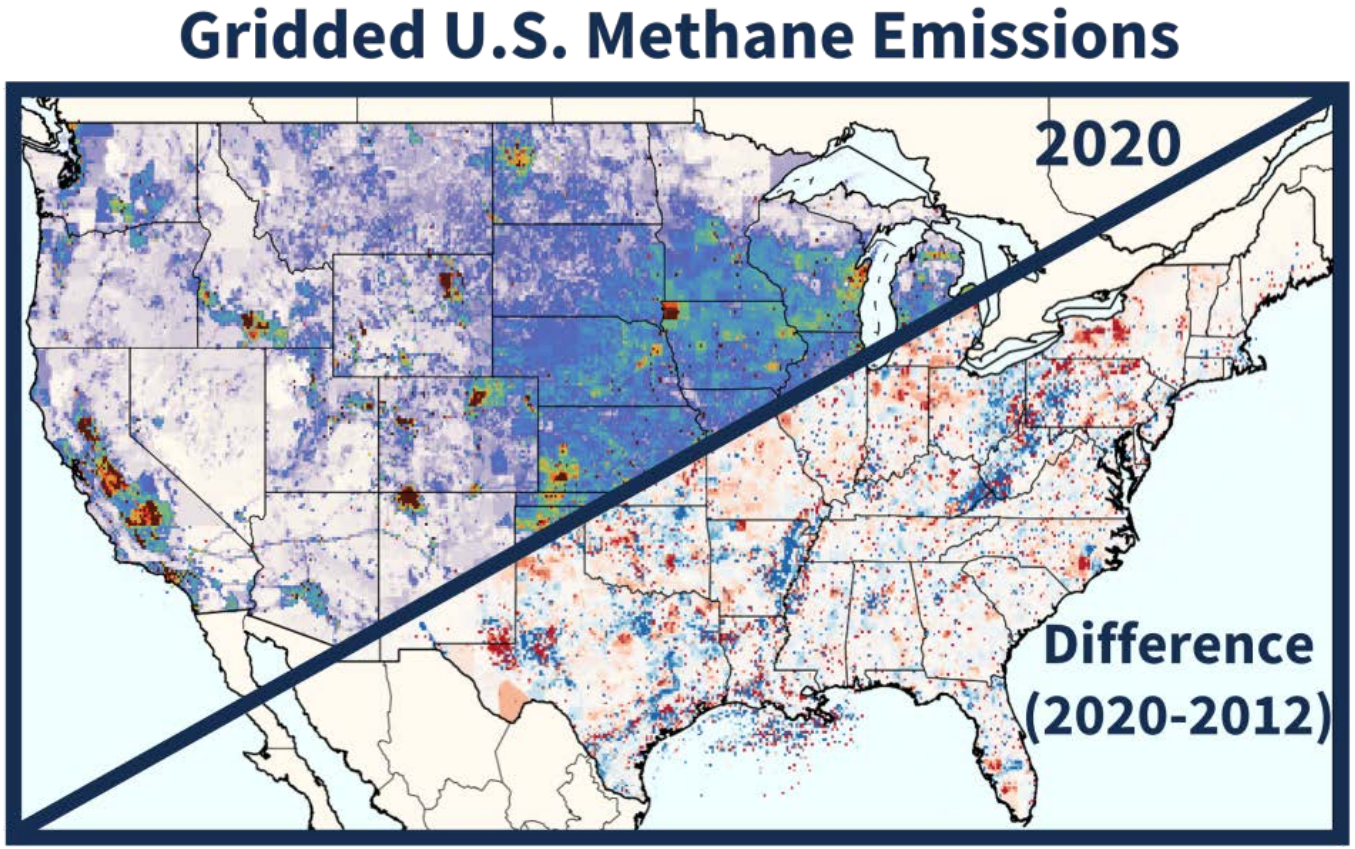
An Example of Methane Gridded Inventory

- E.g., The **gridded EPA U.S. Methane Greenhouse Gas Inventory (GHGI)** offers annual methane emission maps for the contiguous United States at a **0.1° x 0.1° (~10 x 10 km) resolution** with **monthly temporal details.**



❖ Maasakkers et al. 2023

https://www.epa.gov/ghgemissions/us-gridded-methane-emissions

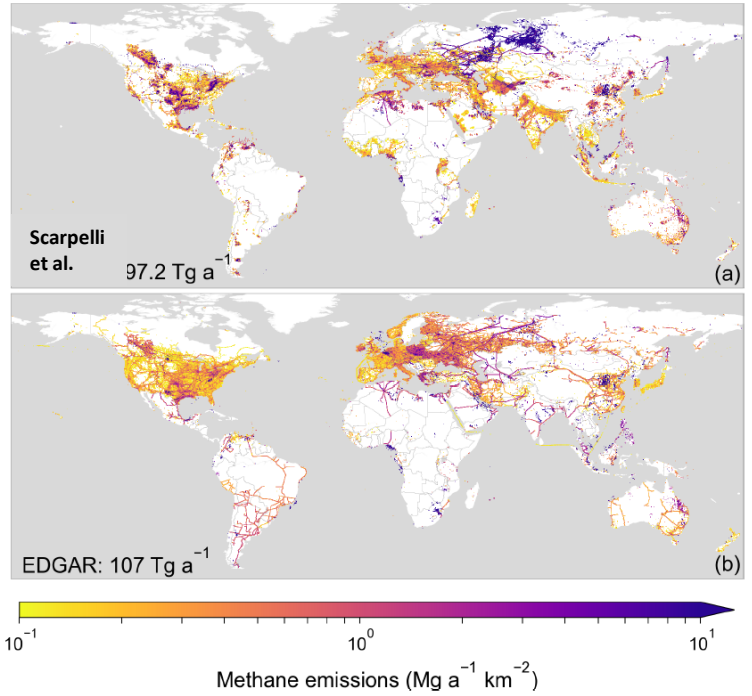
The Role of Methane Gridded Inventories

- **Supports Inverse Atmospheric Analyses**: Provide a prior estimate for inverse atmospheric analyses.
- **Simulates Large Emission Events**: Provide baseline emission data to simulate large, short-term emission events.
- **Enhances Local Emission Estimates**: Assists in estimating and comparing emissions for localized studies.
- **Provides Seamless Coverage**: Offers consistent data across boundaries (county, basin, provincial).
- **Engages Non-Technical Audiences**: Presents emissions data in an intuitive, accessible format.

❖ Chen et al. 2022
❖ Huang et al. 2024

Existing Global Gridded Inventories

- **Emissions Database for Global Atmospheric Research (EDGAR)**
  - Resolution: 0.1° × 0.1°
  - Spatial proxies used to downscale national emission totals globally.
  - Based on IPCC Tier 1 methods with limited source type breakdown.
  - Independent, multipurpose database of global anthropogenic emissions.
- **Scarpelli's Global Gridded Inventory**
  - Resolution: 0.1° × 0.1°
  - Global methane emissions inventory focused on oil, gas, and coal sectors.
  - Allocates national emissions reported to the UNFCCC in 2016.
  - Shows significant differences from EDGAR v4.3.2 inventory.

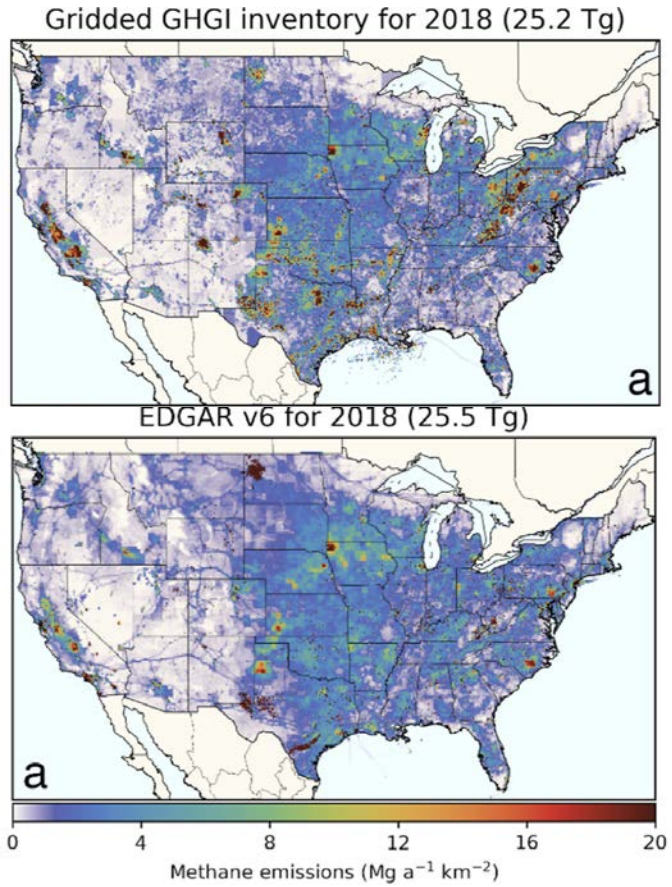


- Scarpelli et al. 2020
- Crippa et al. 2024
- EDGAR 2023

Existing National Gridded Inventories

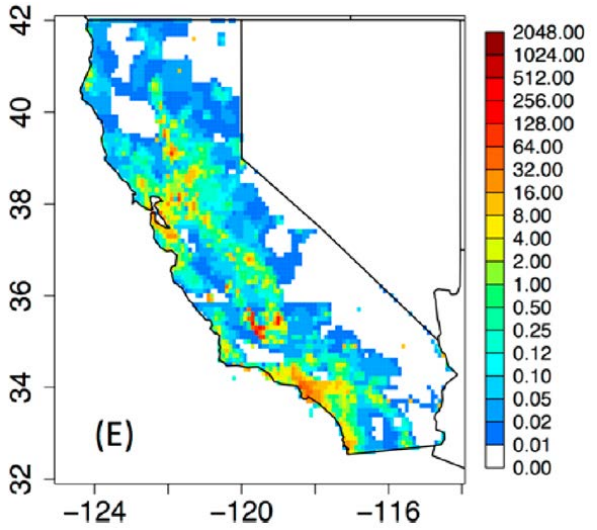
- **Maasakkers's U.S. Gridded Inventory** ❖ Maasakkers et al. 2023
  - Resolution: 0.1° × 0.1°
  - Anthropogenic methane inventory for the contiguous U.S. from 2012-2018.
  - Aligned with the EPA Greenhouse Gas Inventory (GHGI) and includes error estimates by scale.
  - Uses proxy data to match GHGI activity and reported emissions data.
  - Shows notable spatial differences from EDGAR v6, especially in oil and gas sectors.
- **National Gridded Inventories in Other Countries**
  - Available for Canada, Mexico, Australia, Switzerland, and others.

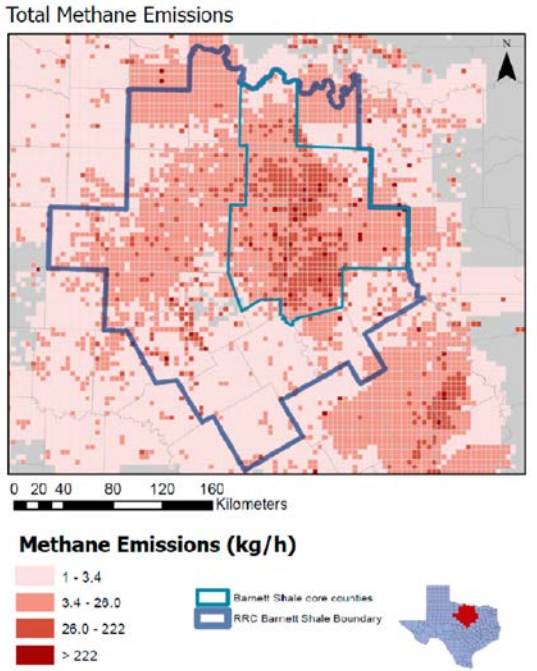
❖ Wang and Bentley 2002, Hiller et al. 2014, Scarpelli et al. 2020, Scarpelli et al. 2021



Existing Regional Gridded Inventories

- **California**
  - ❖ Jeong et al. 2014
  - Resolution: 0.1° × 0.1°
  - Based on US-EPA emission factors and 2010 publicly available activity data for petroleum and natural gas sectors.
  - Scaled using sector-specific results from a Southern California aircraft measurement campaign applied statewide.
- **Barnett Shale Region, Texas**
  - ❖ Lyon et al. 2015
  - Resolution: 4 km × 4 km
  - Covers methane emissions from oil & gas industry, thermogenic, and biogenic sources.
  - Uses spatially referenced activity data from federal and state databases.
  - Emission factors are calculated with Monte Carlo simulations to capture high-emission sites ("fat-tail" distribution).





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Limitations of Current Gridded Inventories

- **Graticule-Based Limitations:**
  - Inconsistent resolution across grids.
  - Limited support for rigorous inter-cell comparison.
  - Inaccurate location intensity due to varying grid area.
  - Lack of coverage in polar regions.

❖ Maasakkers et al. 2016
❖ Shen et al. 2021
❖ Johnson et al. 2023

- **Spatial Misallocation:**
  - Misplaced emissions (e.g., EDGAR locates oil/gas emissions in urban areas).
  - Inaccurate source attribution (e.g., oil/gas emissions confused with livestock).
- **Magnitude Underestimation:**
  - Any limitations or biases present in the underlying coarse-resolution data are propagated to finer scales.
  - Need for upward corrections (e.g., EDGAR underestimations in South-Central US).

Need for an Improved Gridded Inventory

- **For Graticule-Based Limitations:**
  - Discrete Global Grid Systems for consistent resolution and accurate spatial representation.

- **For Spatial Misallocation:**
  - Integrate source emission data at its native resolution.
  - Avoid disaggregation methods that misplace emissions.
- **For Magnitude Underestimation:**
  - Representativeness of emission factors.
  - Comprehensiveness of the activity data.

Take Home Messages

- **Importance of High-Quality Methane Gridded Inventories:** Essential for inverse atmospheric analyses and simulating large emission events.
- **Current Inventories and Limitations:** Global, national, and regional inventories exist but face issues like graticule-based limitations, spatial misallocations, and magnitude errors.
- **Need for Improvement:** A high-quality, improved gridded inventory is needed for more accurate methane representations.

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