IMI Description and Capabilities

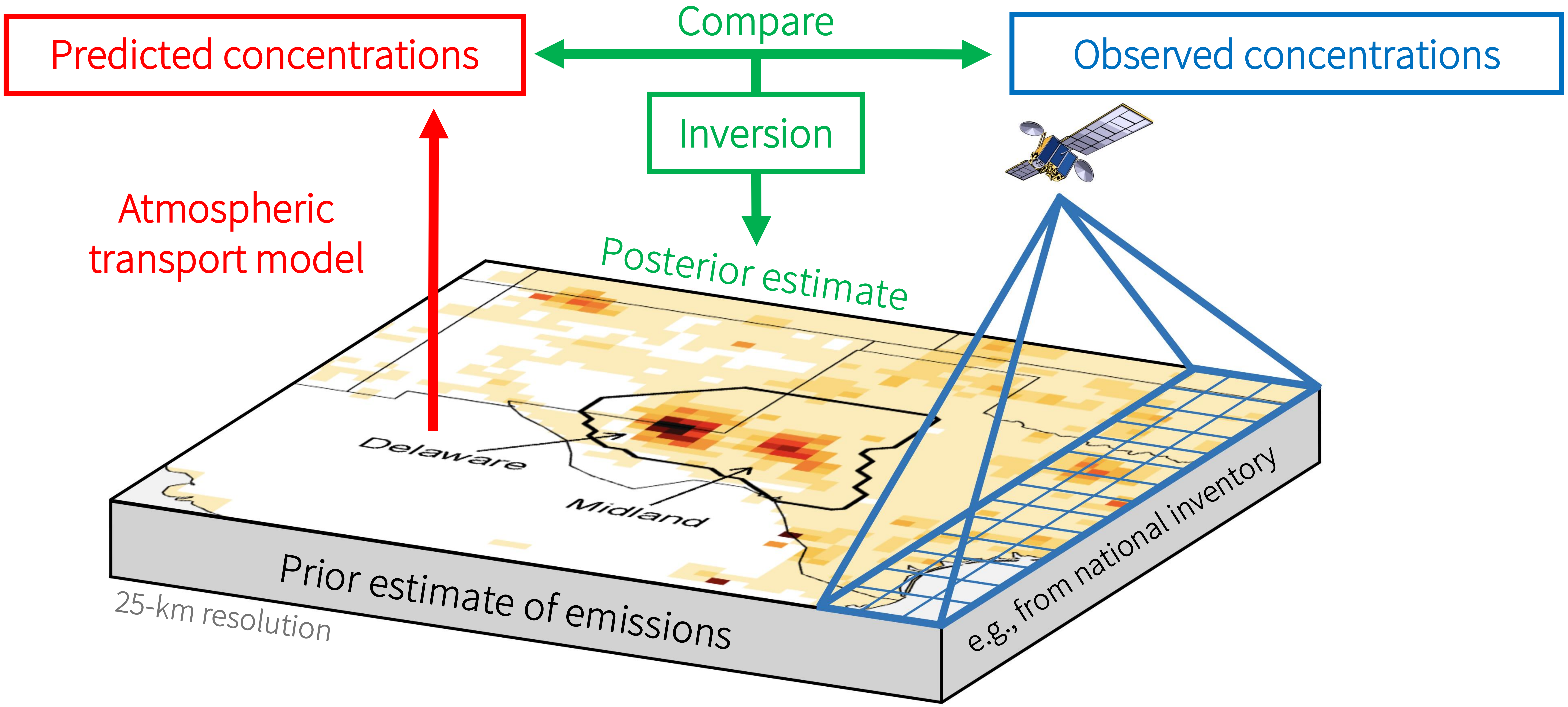
<u>IMI users can:</u>

- Quantify natural and anthropogenic emissions (and uncertainties) for a region of interest:
  - States, countries, continents
  - Wetland regions
  - Oil and gas basins
  - Agricultural areas
  - Cities, landfills
- Compare emission inventories/reports with satellite data
- Monitor emission trends and identify drivers
- Investigate the global methane budget
- …

without needing expertise in inverse modeling or high-performance computing

Methane flux inversions with TROPOMI satellite observations

Improve on prior bottom-up inventory using Bayesian statistics

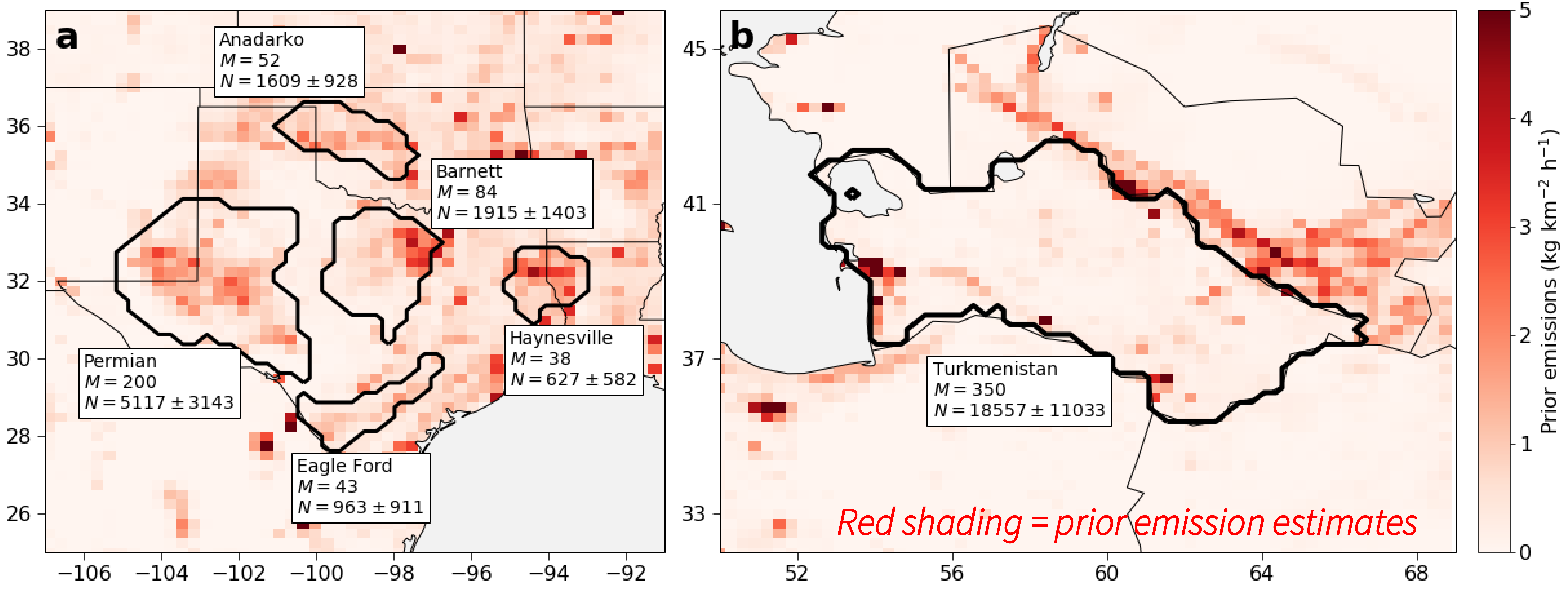


Analytical solution with closed-form error characterization

IMI Preview Capability

Continuous emission monitoring

Applications to US oil and gas basins and Turkmenistan

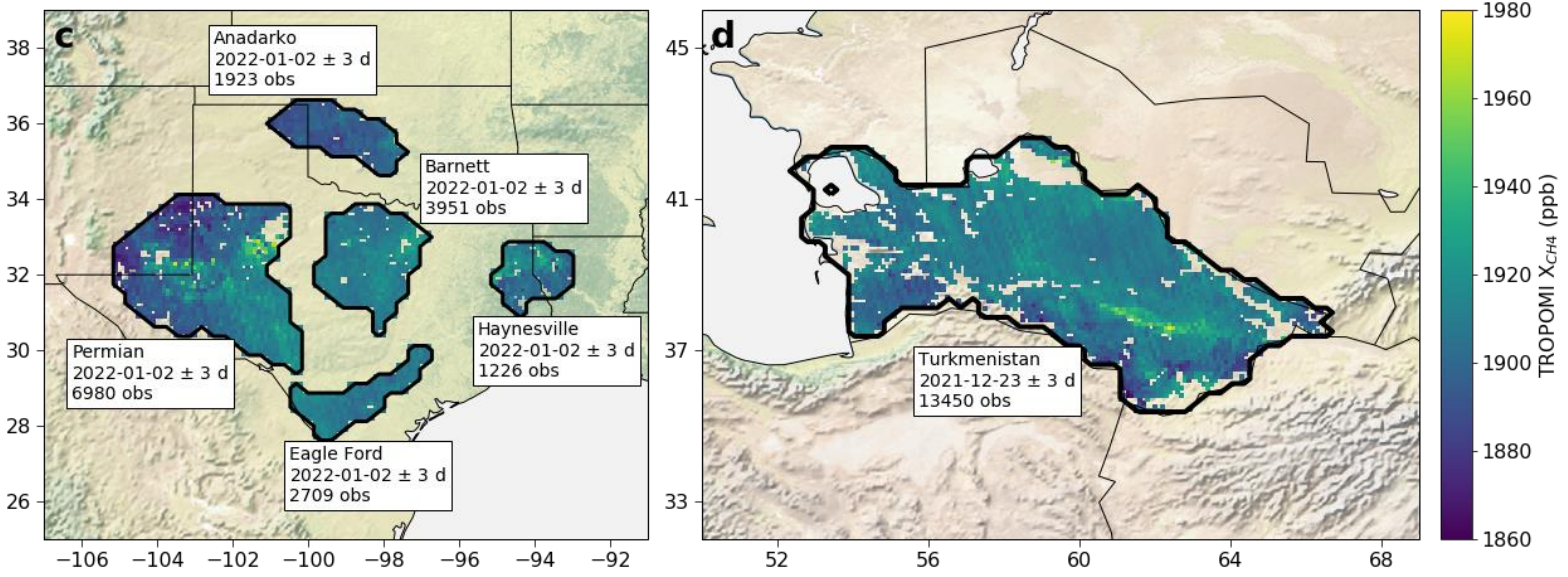


M = number of 2D emission elements to be quantified in the inversion (“state vector”)
N = number of TROPOMI observations available per week (mean ± standard deviation)

Varon et al. in prep

Continuous emission monitoring

Applications to US oil and gas basins and Turkmenistan



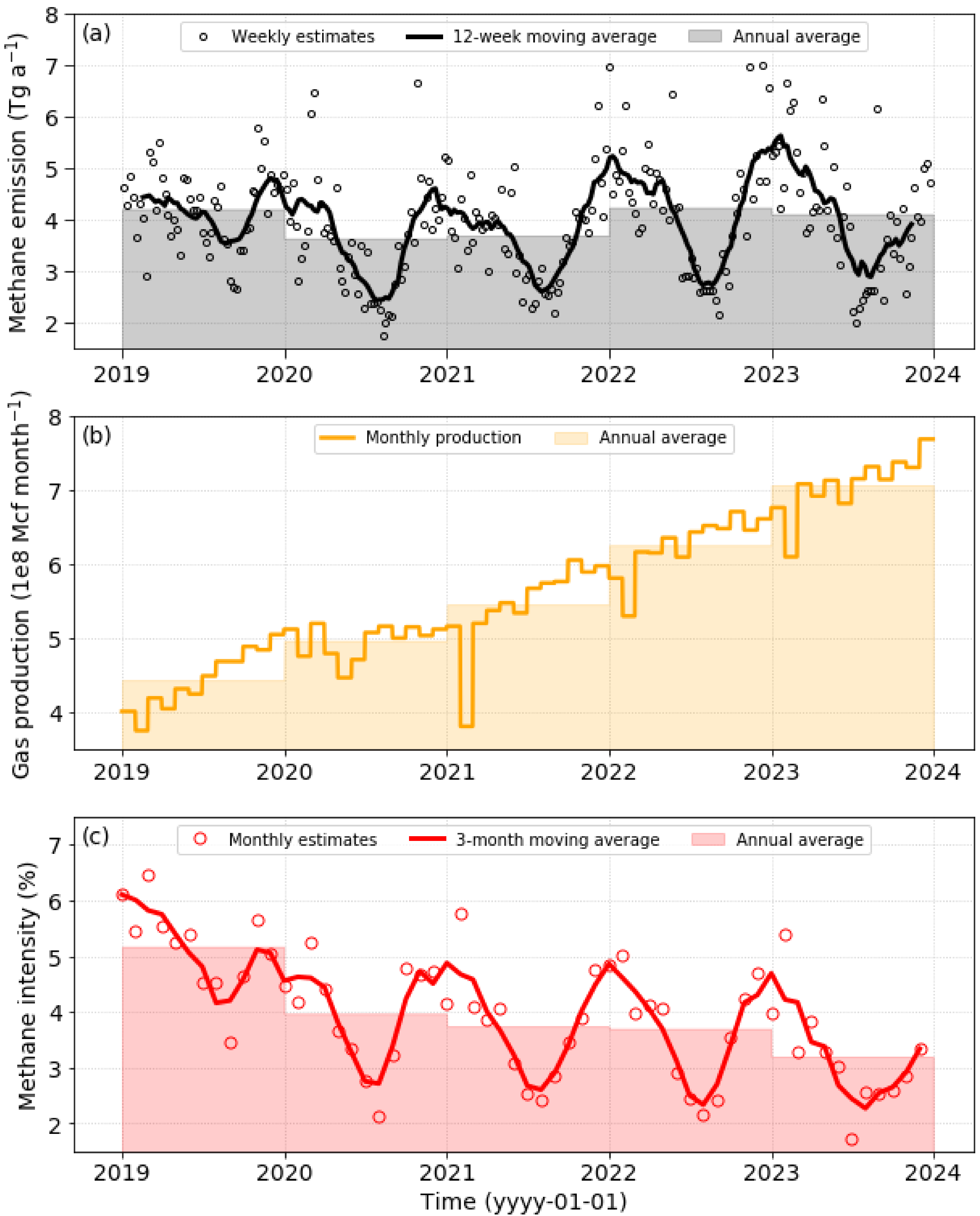
One week of TROPOMI observations for each region

Varon et al. in prep

Continuous emission monitoring: **Permian Basin (2019-2023)**

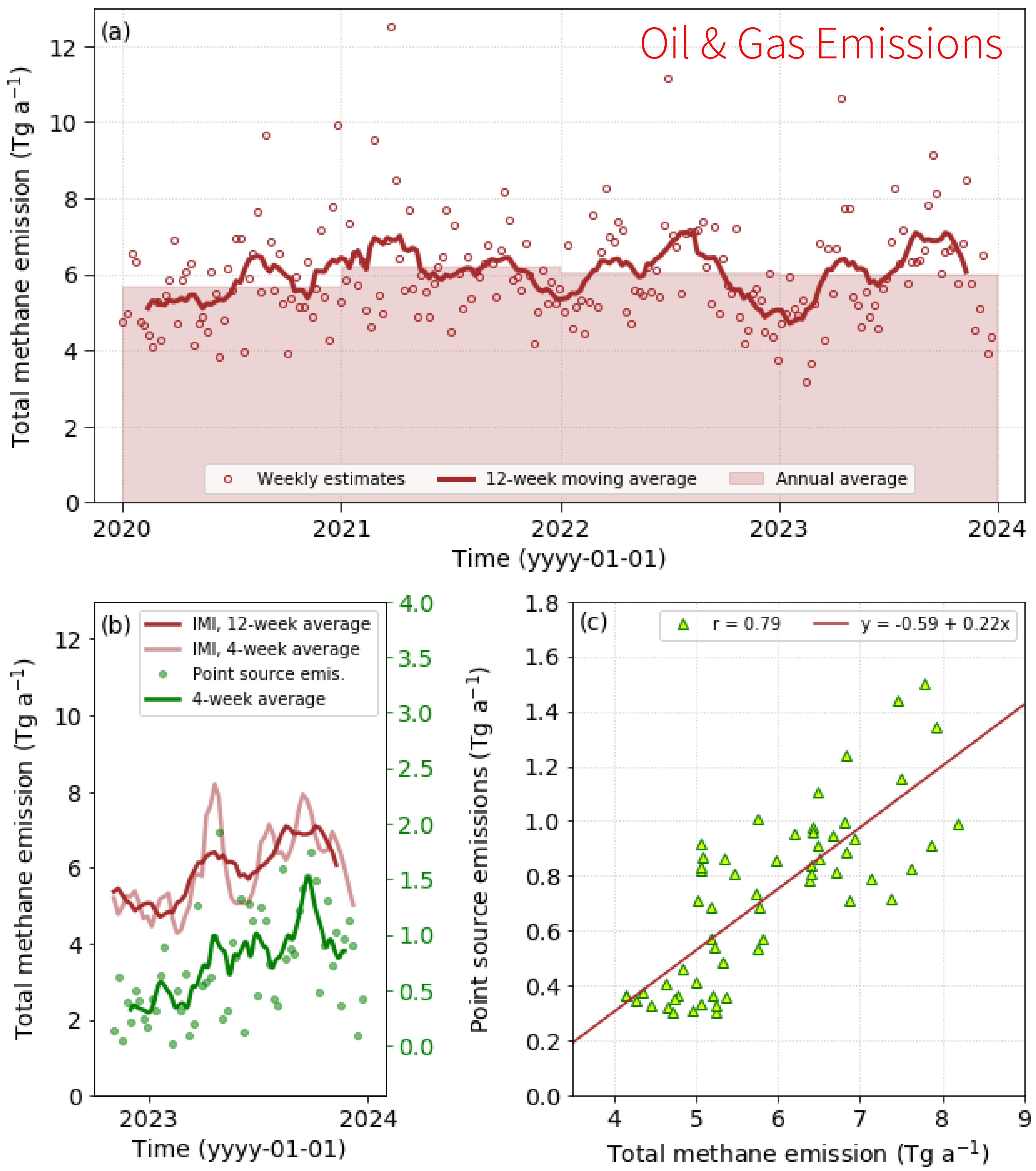
<u>Quantify oil & gas emissions/intensity trends</u>

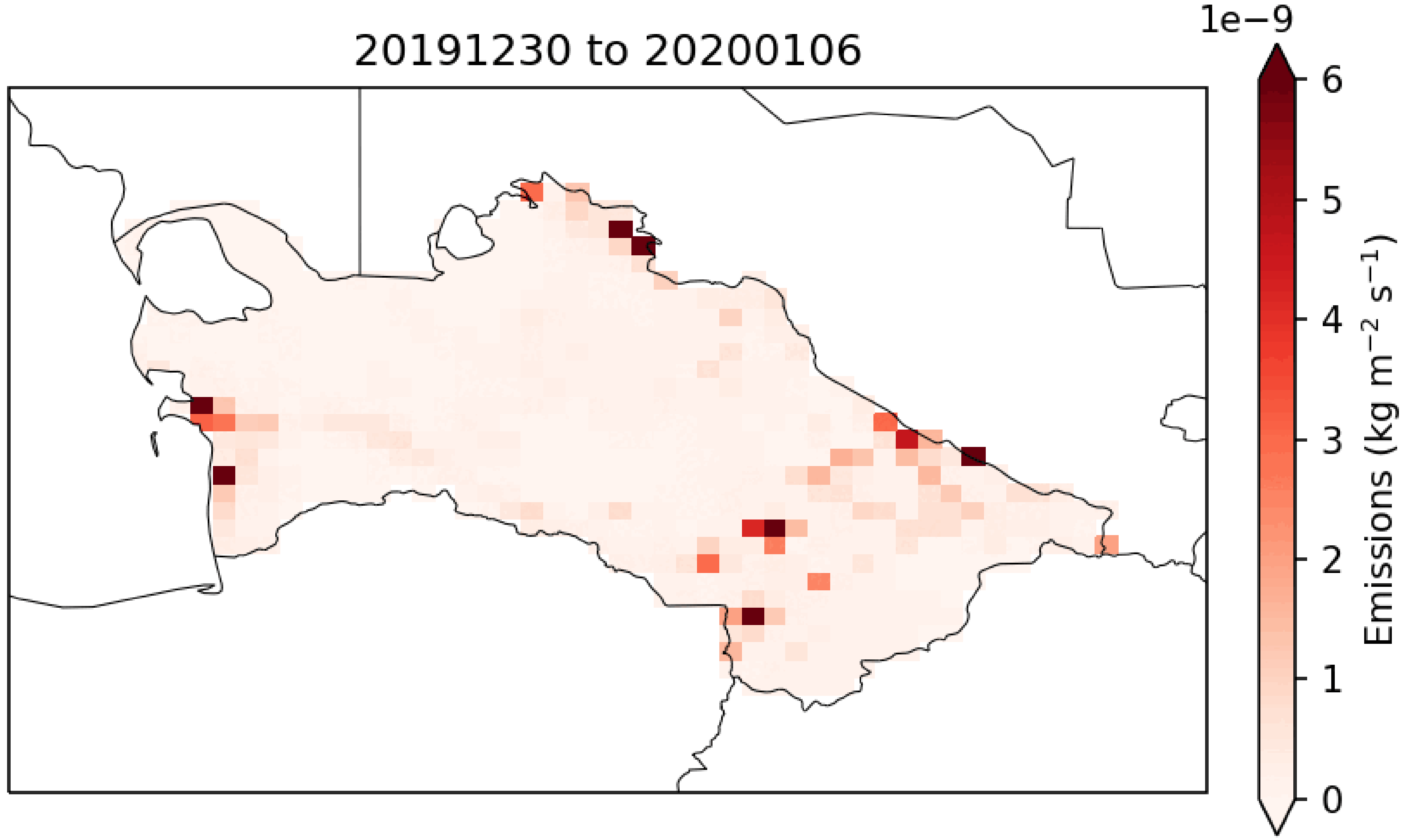
- IMI 2.0 continuous monitoring (Kalman filter feature):
  - Five years of weekly Permian emissions (2019-2023)
- Combine with Enverus production data
- Insight: Permian methane intensity (avg. 4%) is decreasing, but the decrease is driven by production
- Error characterization by inversion ensemble



Varon et al. in prep

National emission monitoring: **Turkmenistan**





IMI 2.0 continuous monitoring supports diplomatic activities of the UNEP International Methane Emissions Observatory (IMEO)

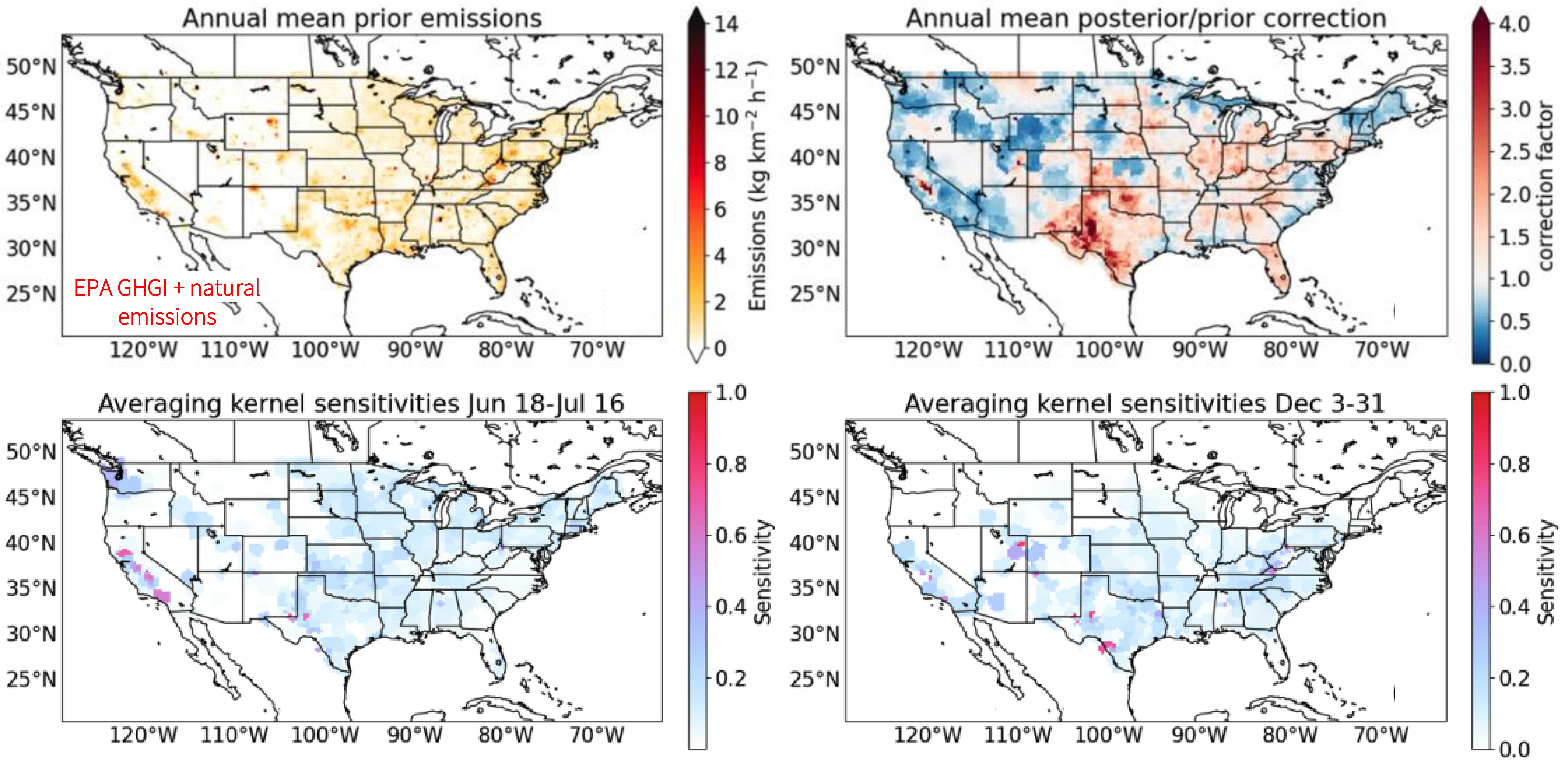
- 4 years of weekly IMI runs (2020-2023)

<u>Compare with independent point source data</u>

- Total methane emissions strongly correlated with sums of point source detections (panel c, left)

Varon et al. in prep

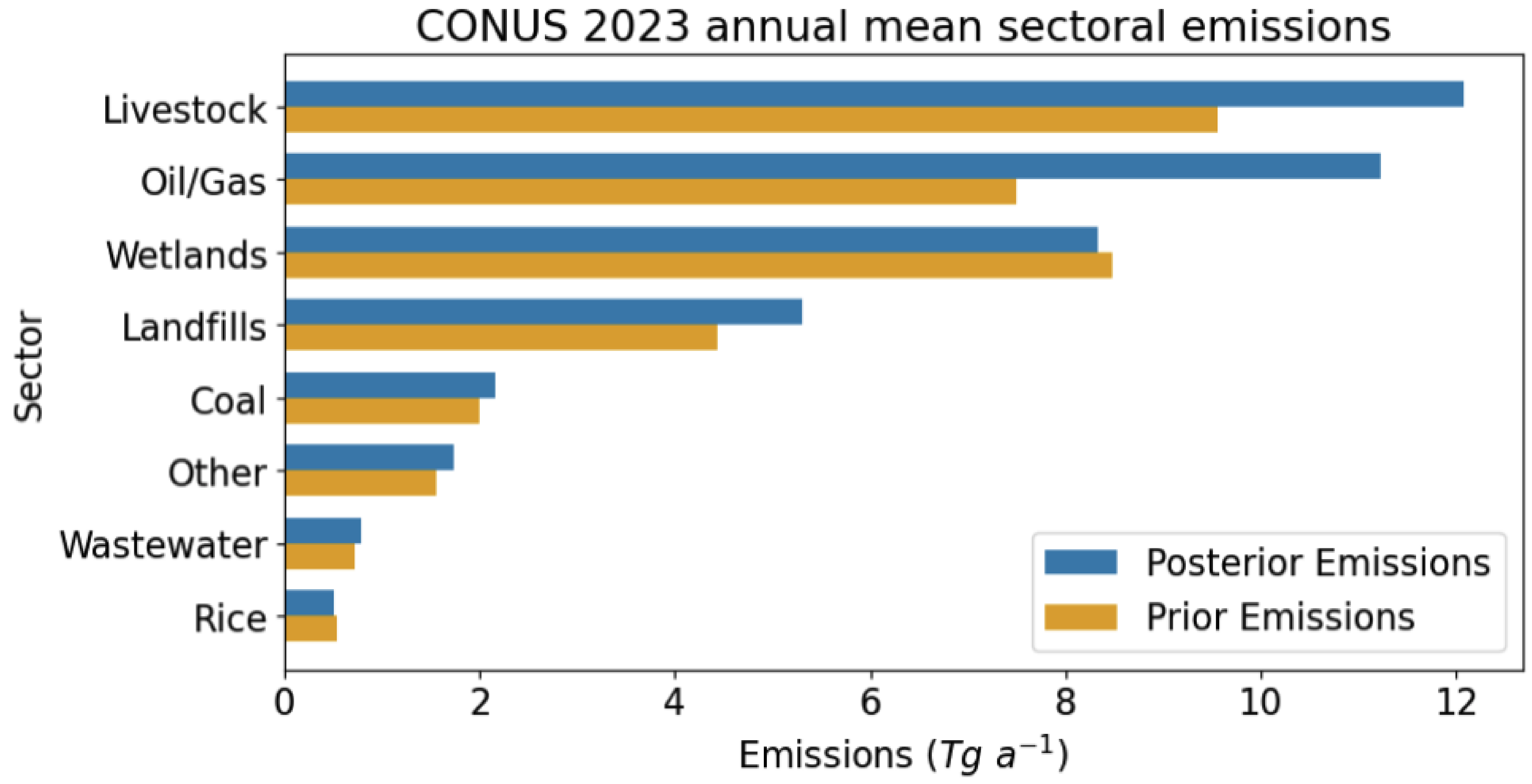
Quantifying national emissions: **CONUS**



<u>IMI can help improve greenhouse gas inventories</u>

Estrada et al. (2024)

Quantifying national emissions: **CONUS**



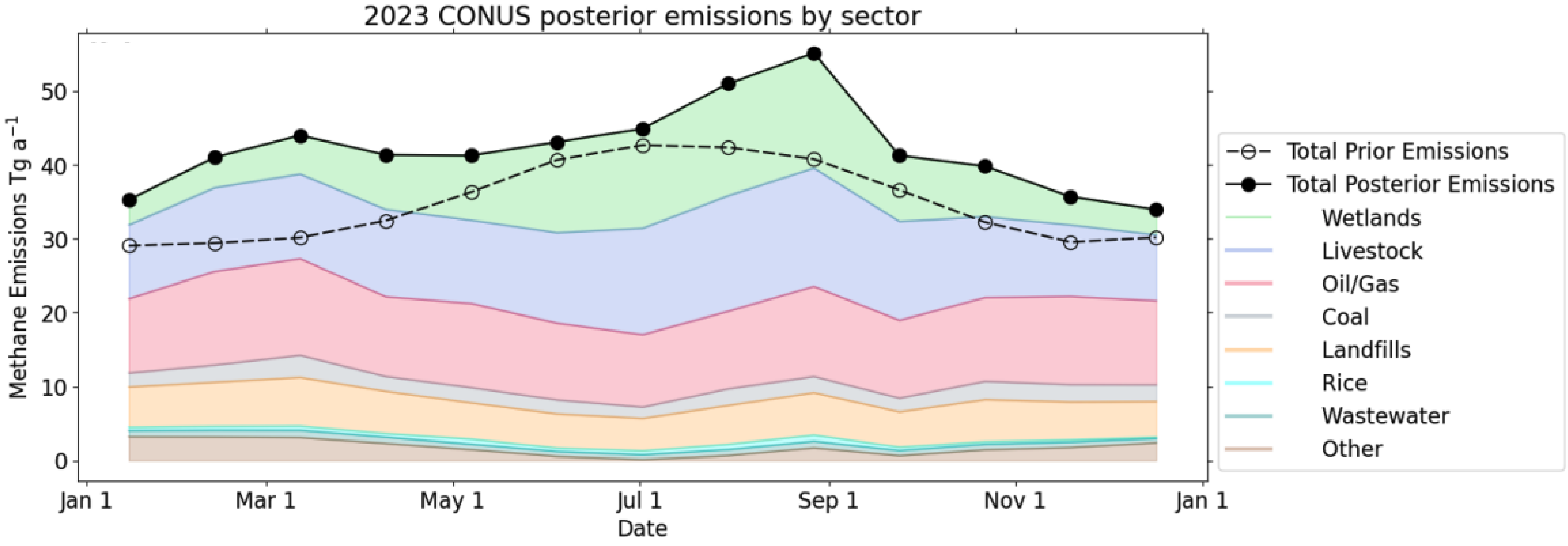
Sectoral disaggregation

- IMI enables sectoral disaggregation of emissions.
- CONUS inversion suggests emissions from US livestock, oil and gas, and landfills are underestimated

Quantification of natural emissions

CONUS seasonal wetland offset:

- Prior (July peak) **vs.** posterior (September peak)
- Test wetland process model

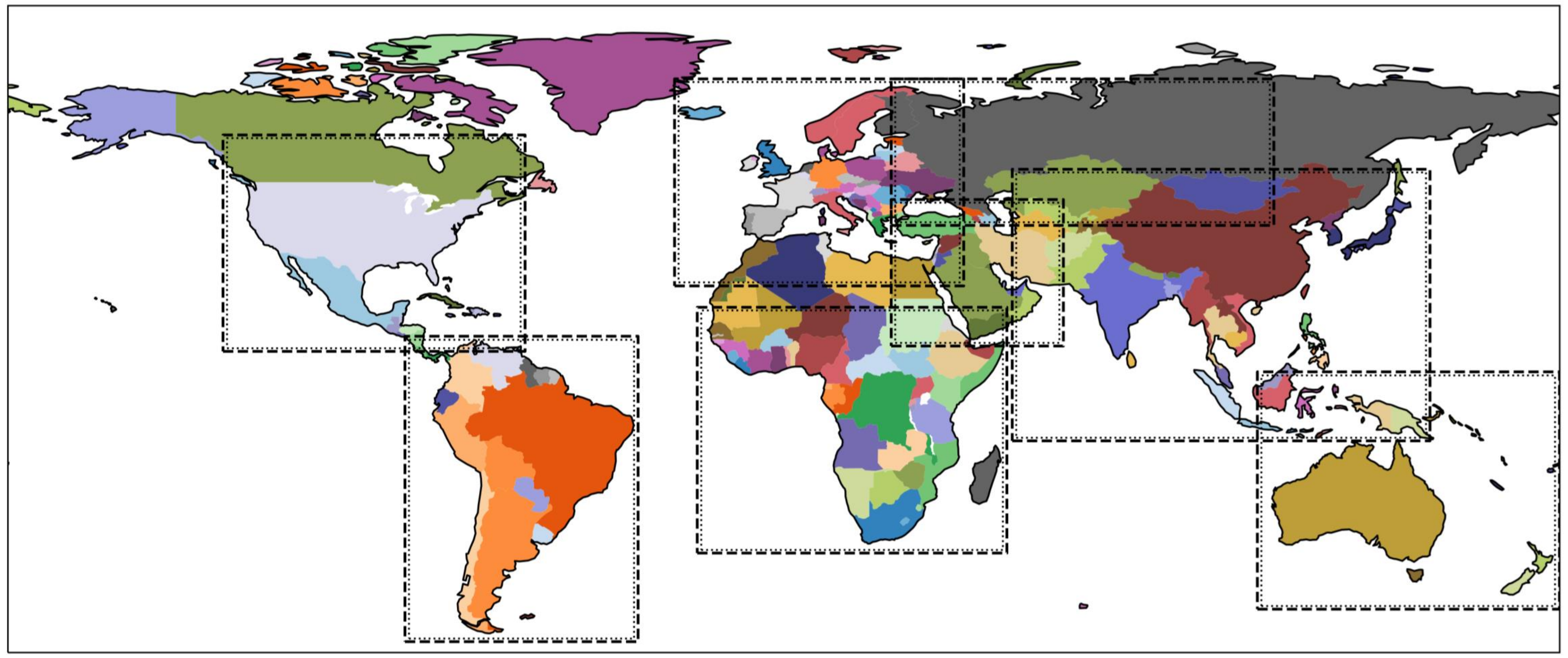


IMI can separate natural and anthropogenic emissions

Estrada et al. (2024)

Quantifying national methane emissions globally

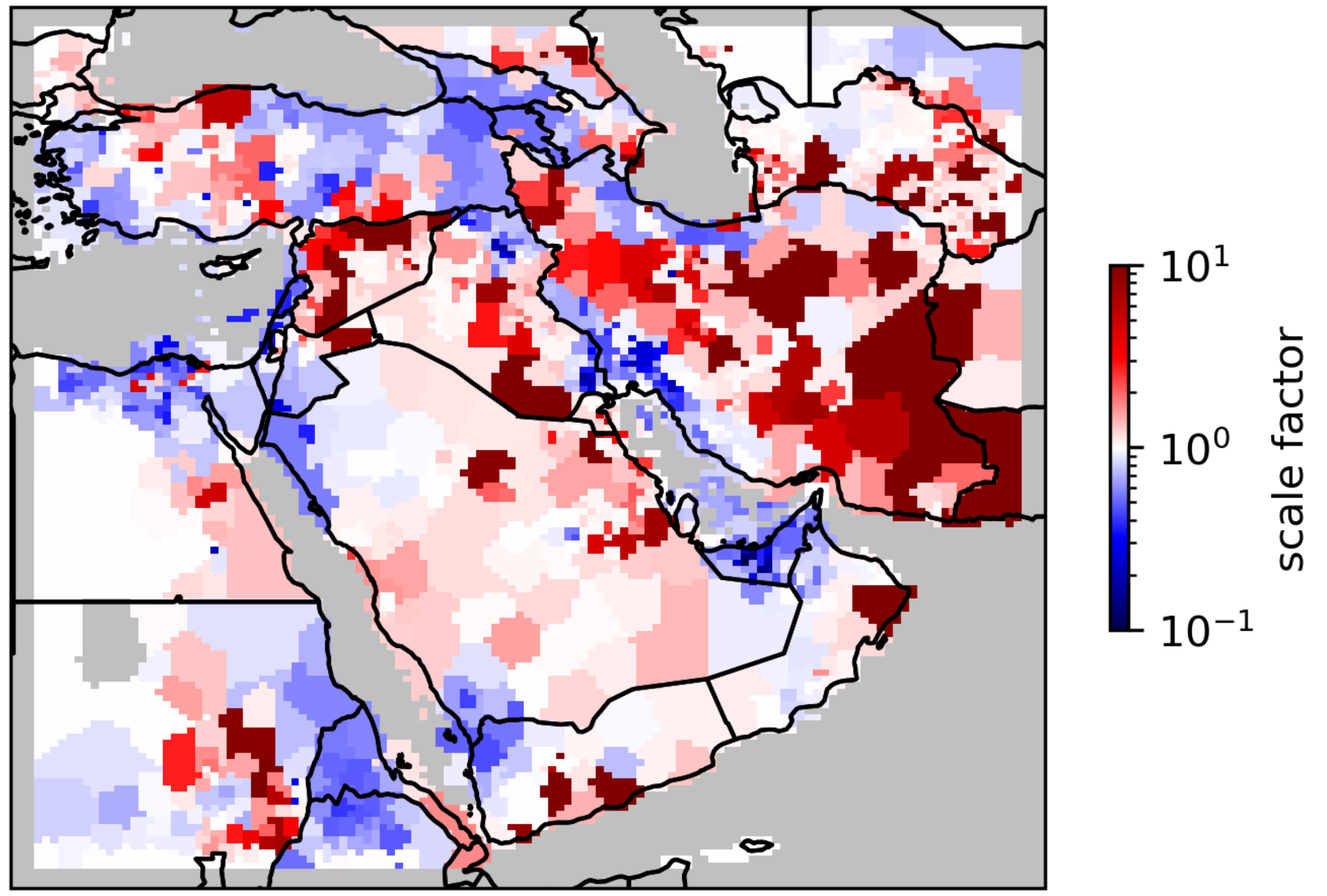
Regional inversions tiling the world



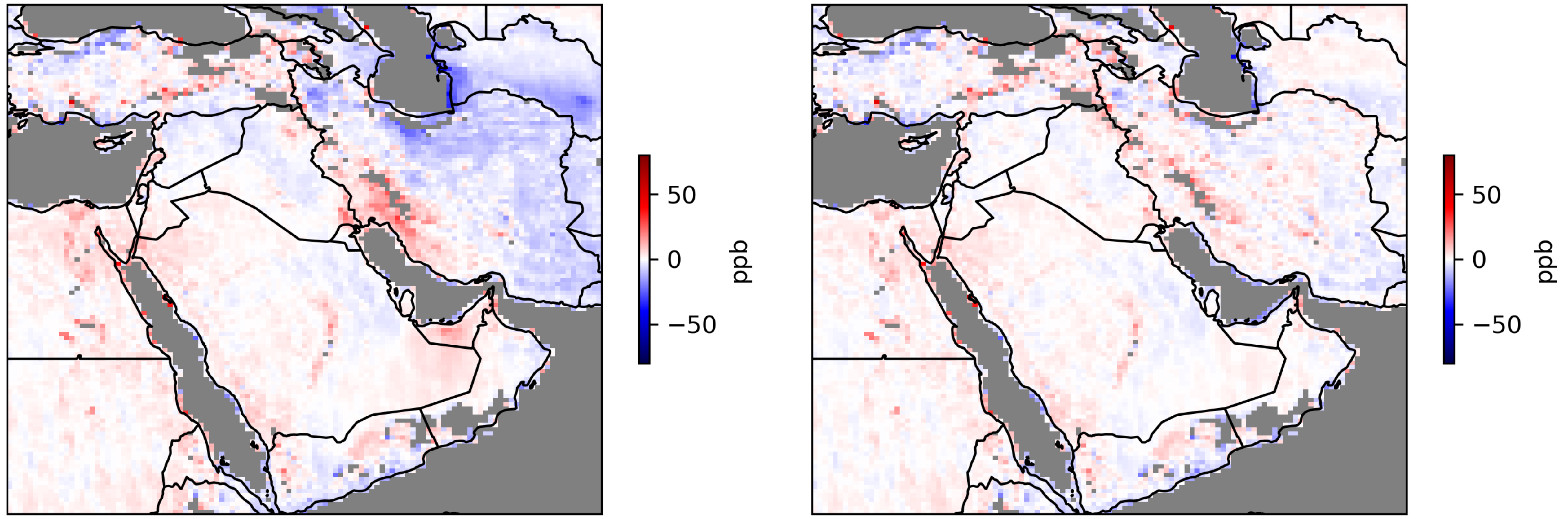
Prior emissions updated with point source imagers

EMIT · CARBON MAPPER · UN environment programme · SRON Netherlands Institute for Space Research

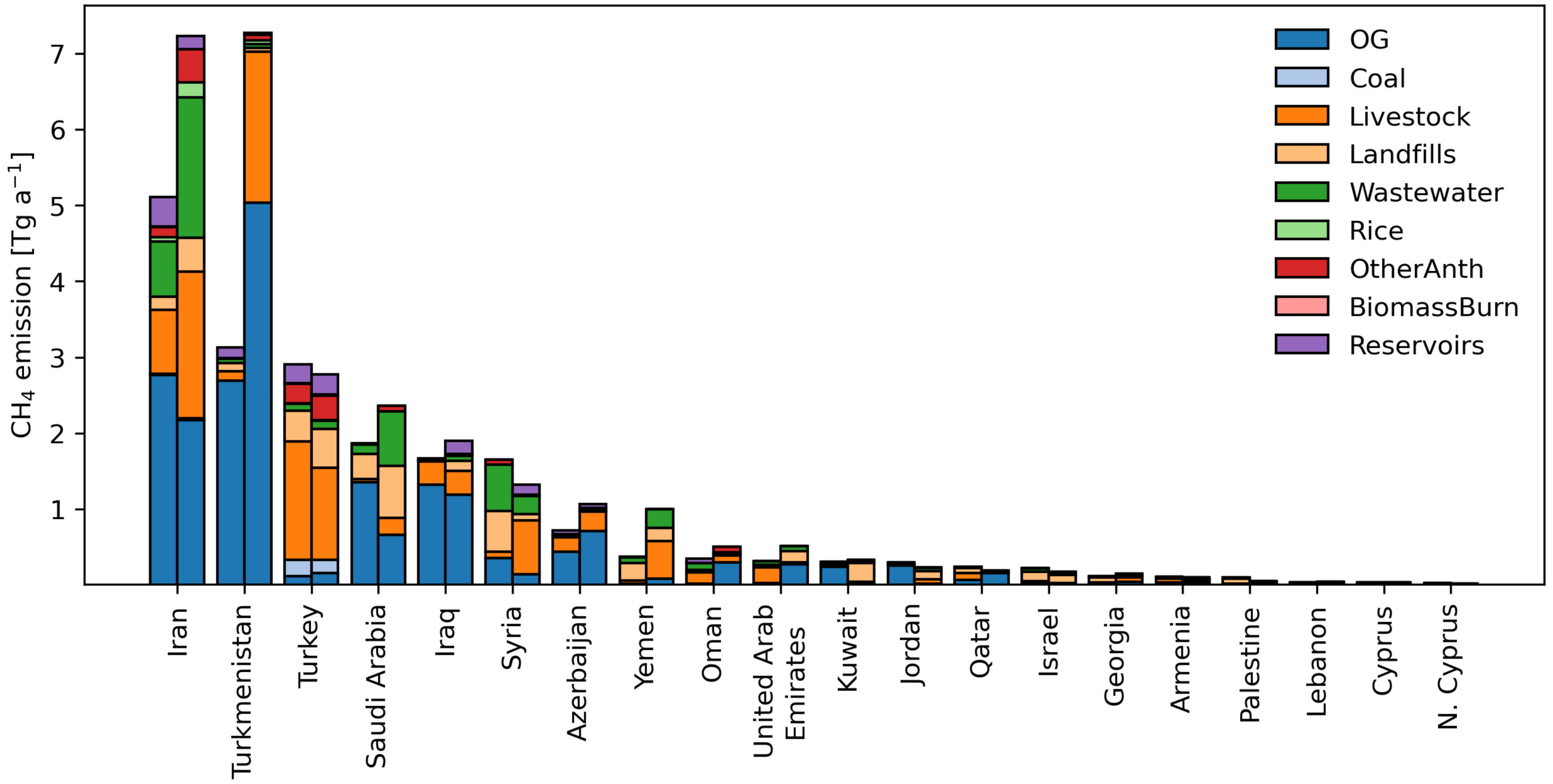
Up to 25 km resolution



Inversions improve fit to TROPOMI observations

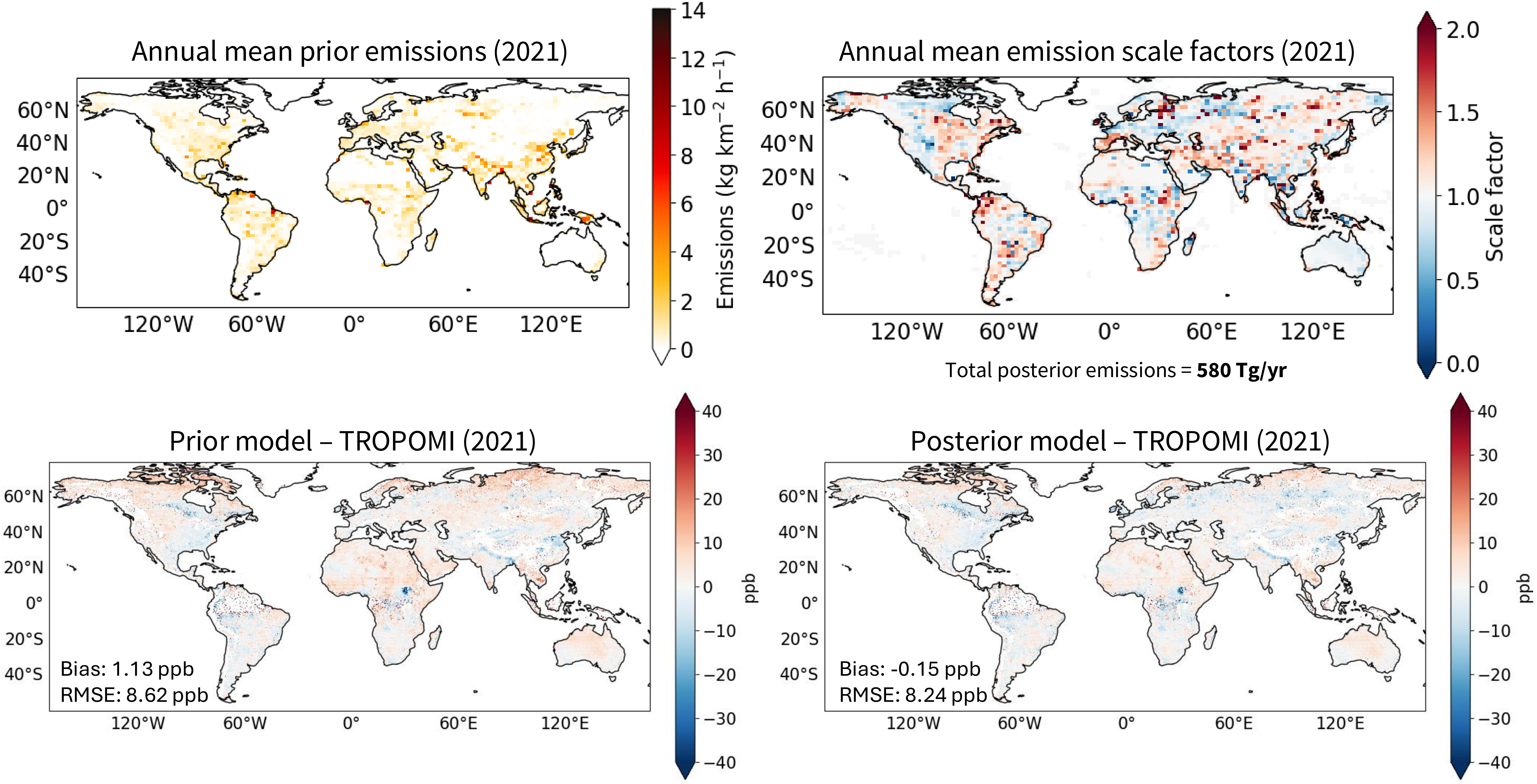


Country-level sectoral prior and posterior emissions



East et al. in prep.

Understanding the global methane budget and trends

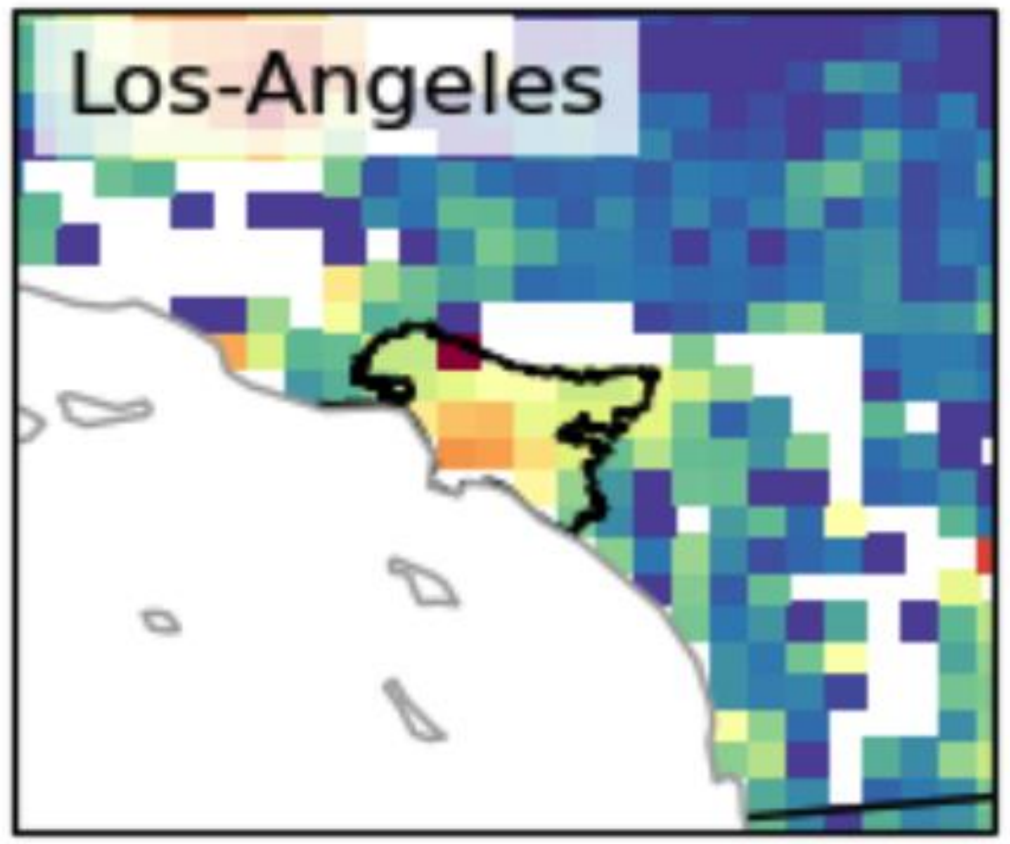


Annual global inversions optimizing emissions and OH (methane sink) with IMI 2.0

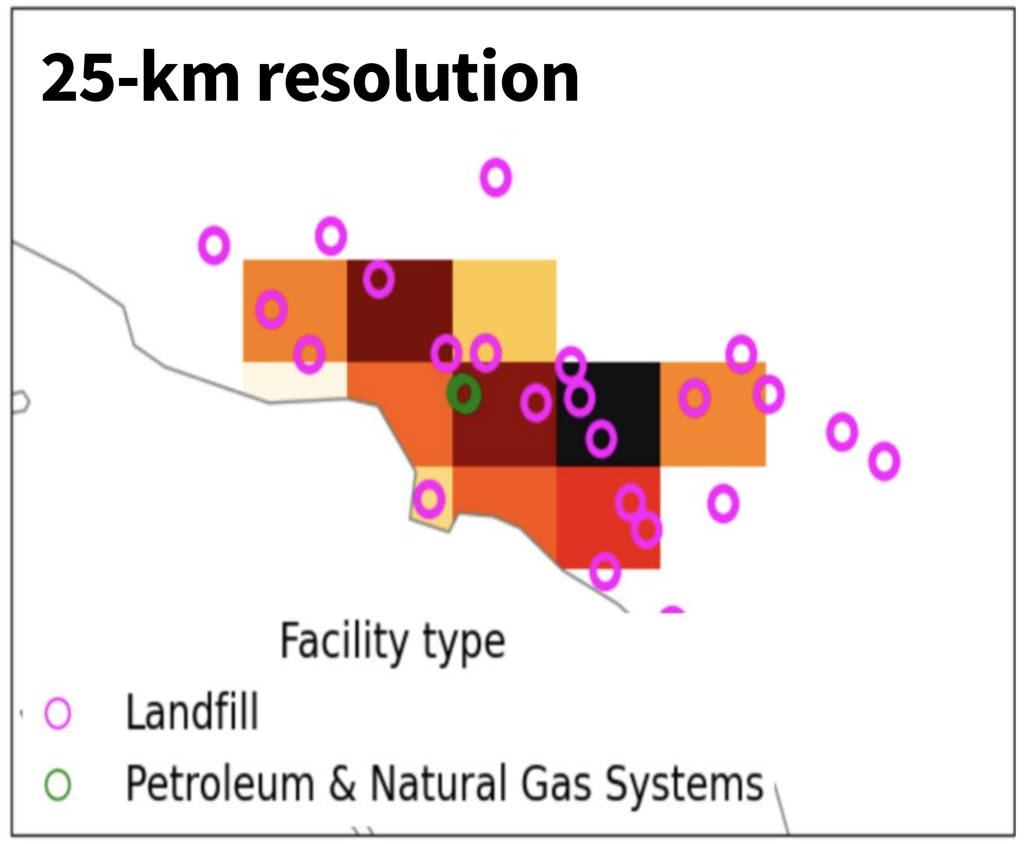
He et al. in prep.

Quantifying city-level methane emissions (12-km resolution)

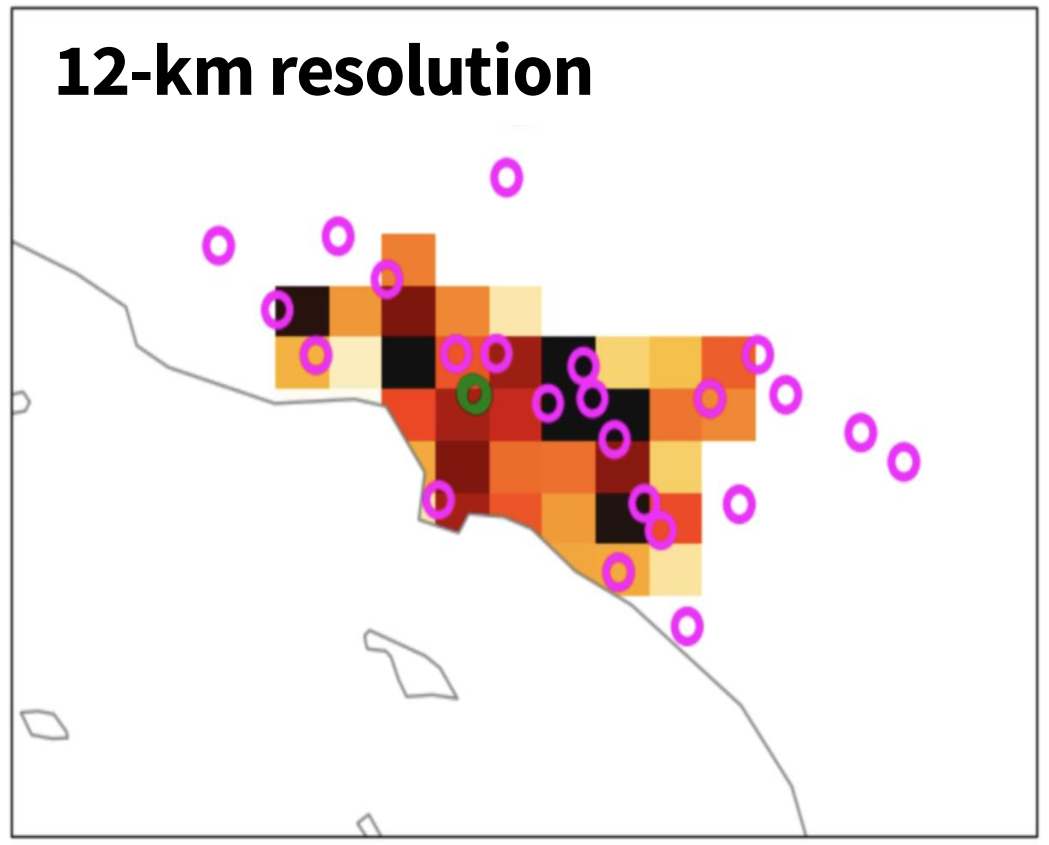
TROPOMI



Posterior methane emission



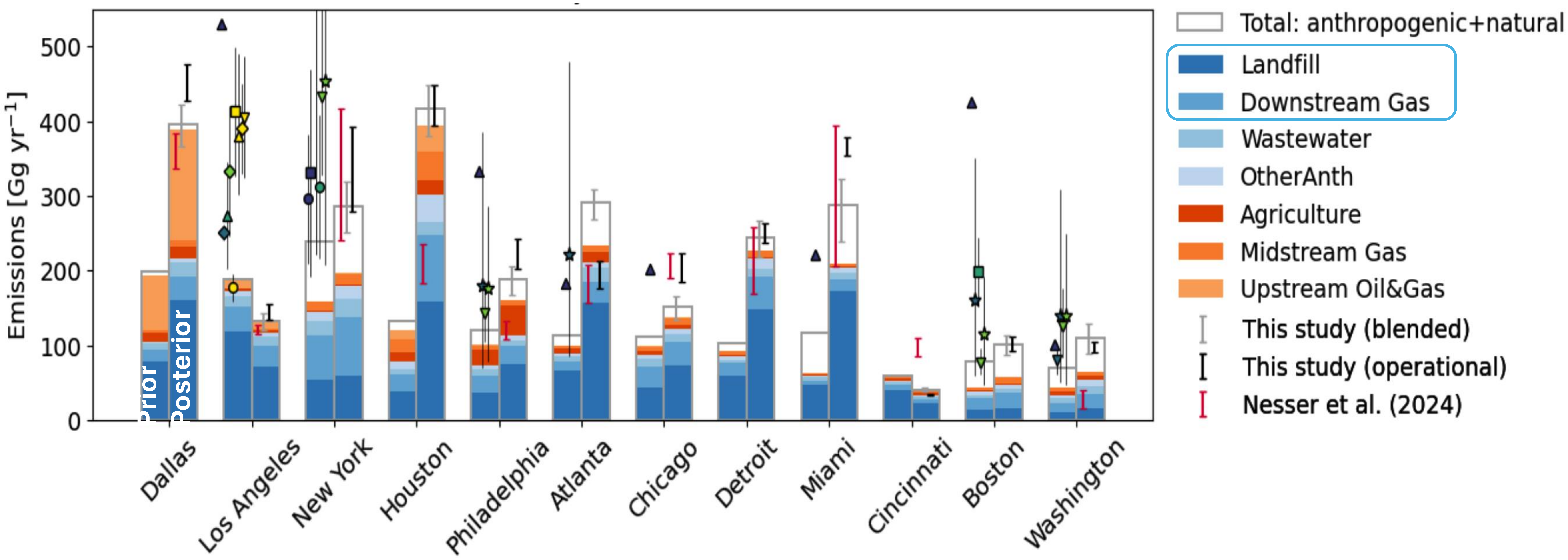
Posterior methane emission



Quantify urban emissions

- Coming in IMI 3.0: 12-km resolution
- Used here to quantify urban emissions at high resolution

City emissions (Gg yr^{-1})



- Hotspots in satellite-based emission estimates correspond with landfills, downstream gas

Wang et al. in prep.