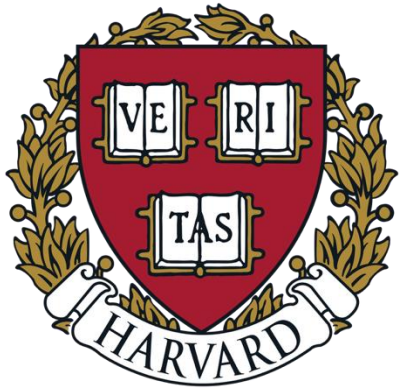
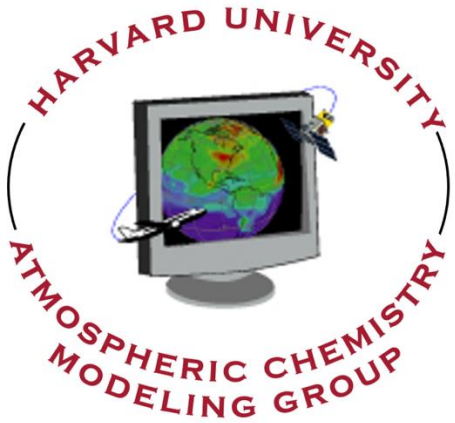
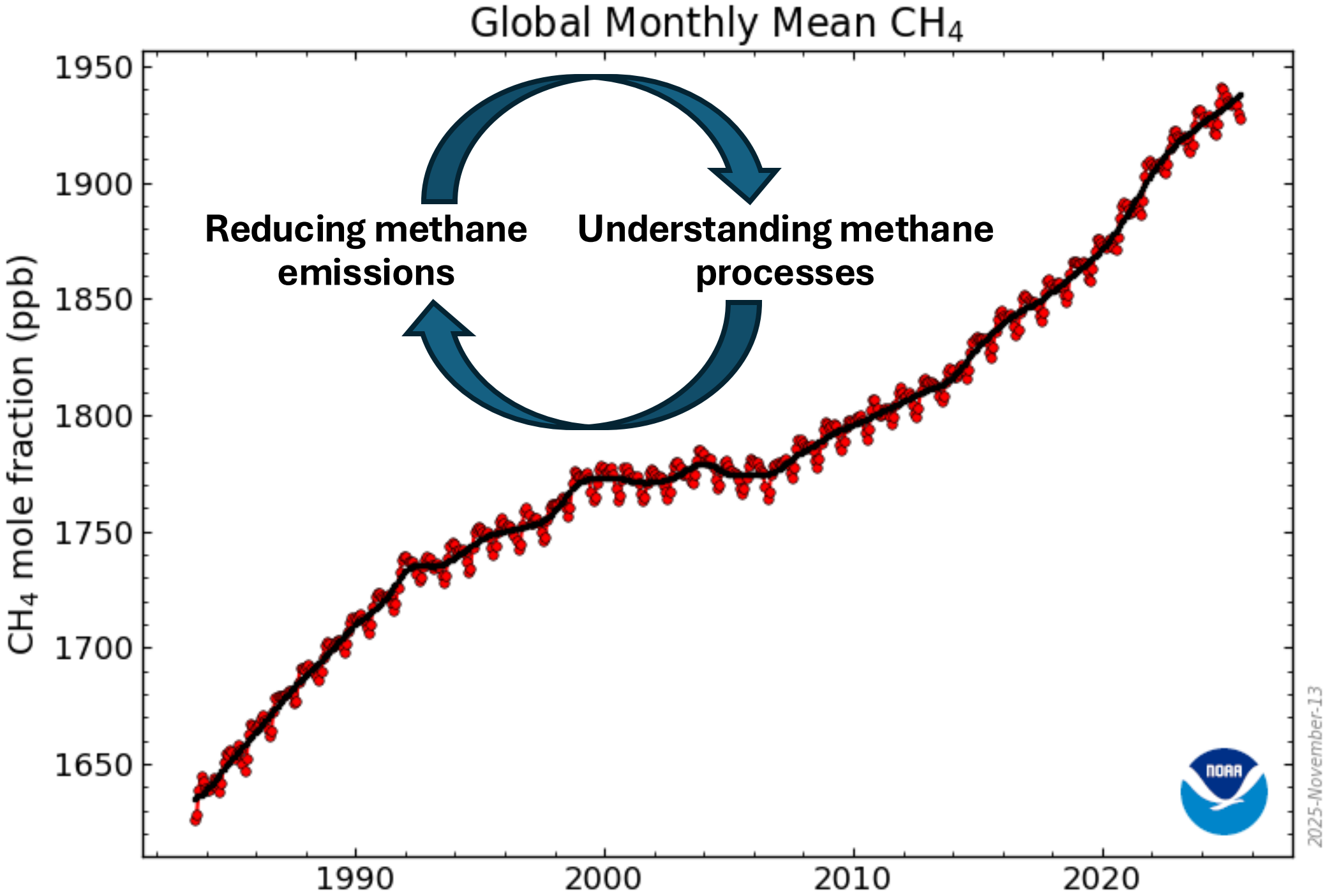
Integrating bottom-up and satellite methods to quantify methane emissions in South America

Sarah Hancock

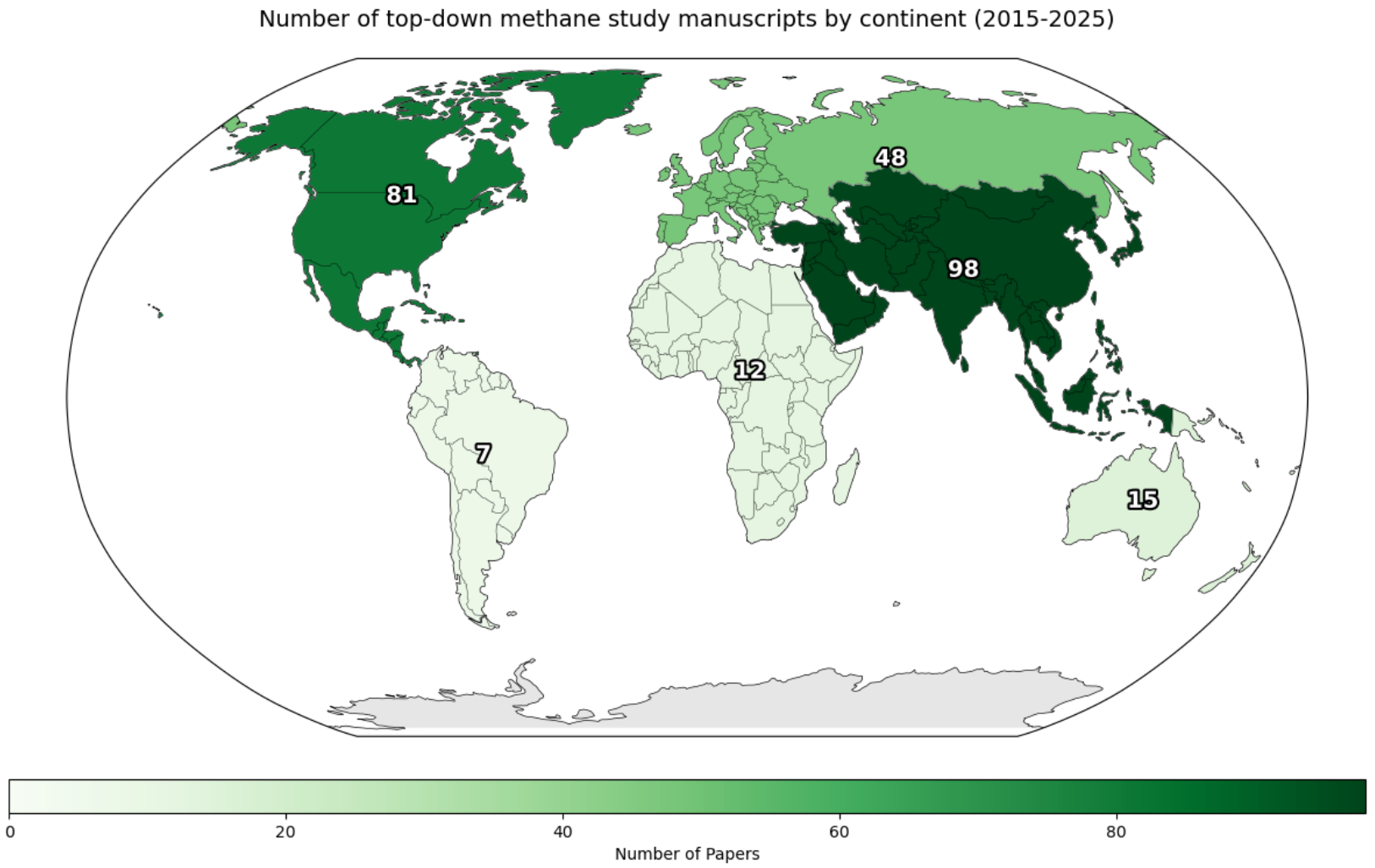





Global Monthly Mean CH_4
Reducing methane emissions
Understanding methane processes
CH_4 mole fraction (ppb)
1950
1900
1850
1800
1750
1700
1650
1990
2000
2010
2020
NOAA
2025-November-13

South America is underrepresented in top-down methane research

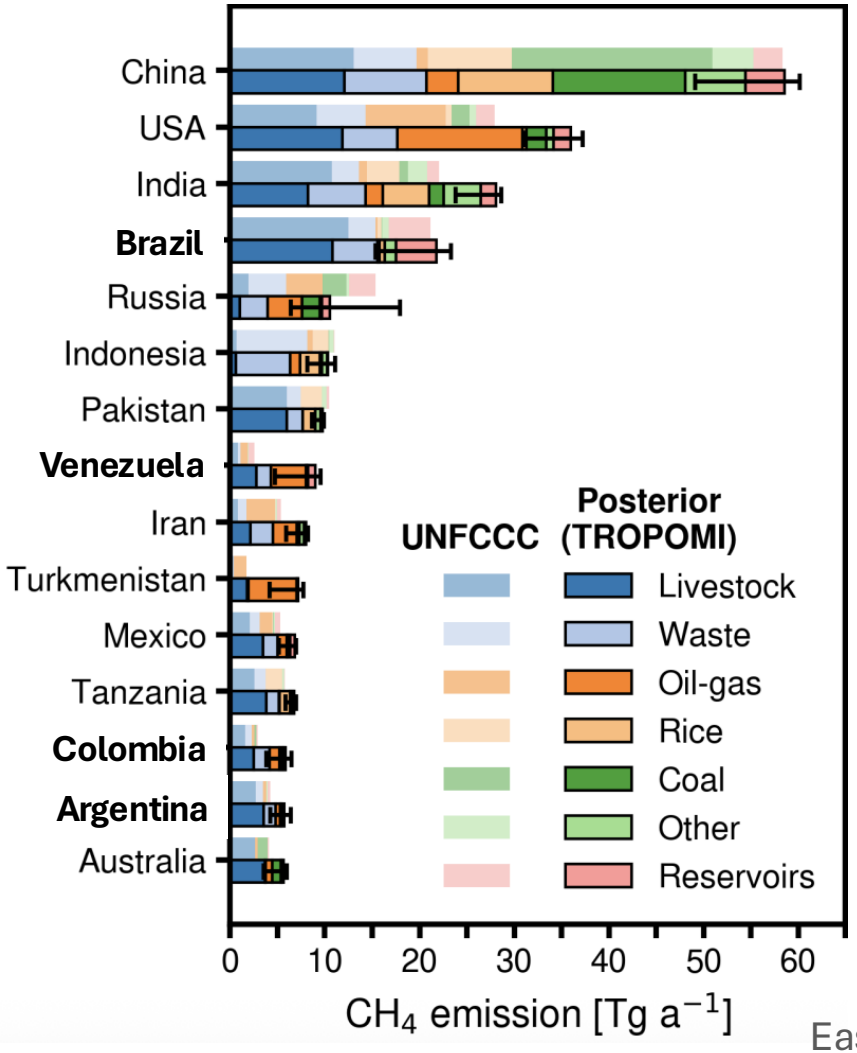
Number of top-down methane manuscripts from 2015-2025 by continent



*Simple search using OpenAlex: any papers with "methane" and “inversion”/"inverse modeling" /"top-down" in the title

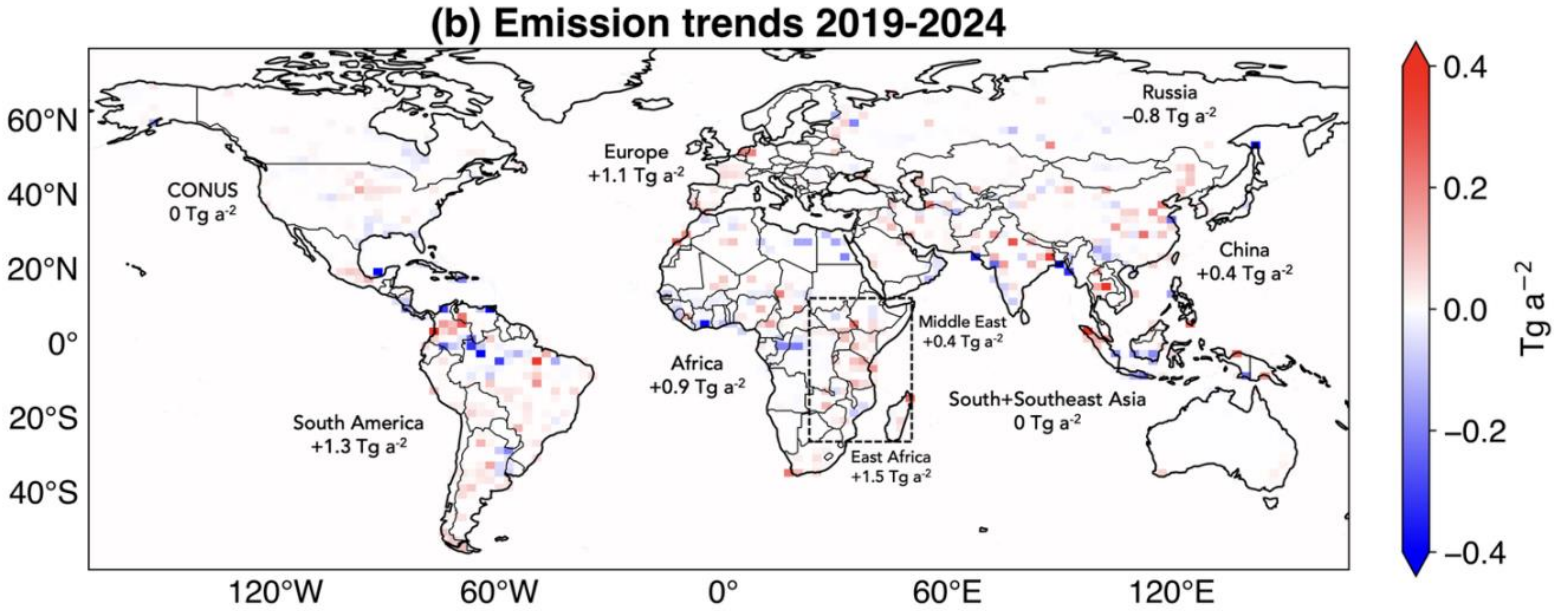
South America is a key player in the global methane budget

South American countries among highest emitters



East et al., 2025

Large contributor to recent global methane surge

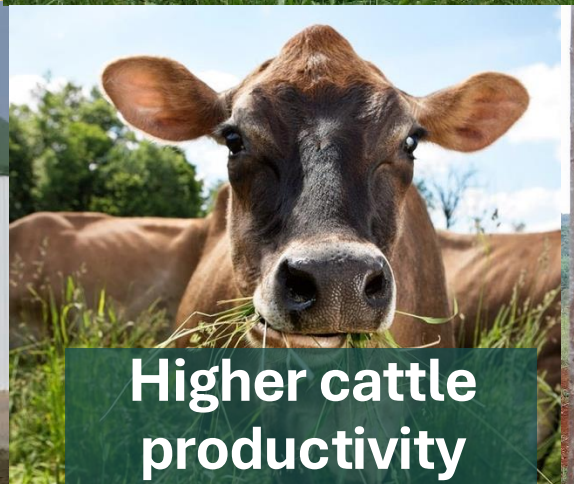


He et al., 2025

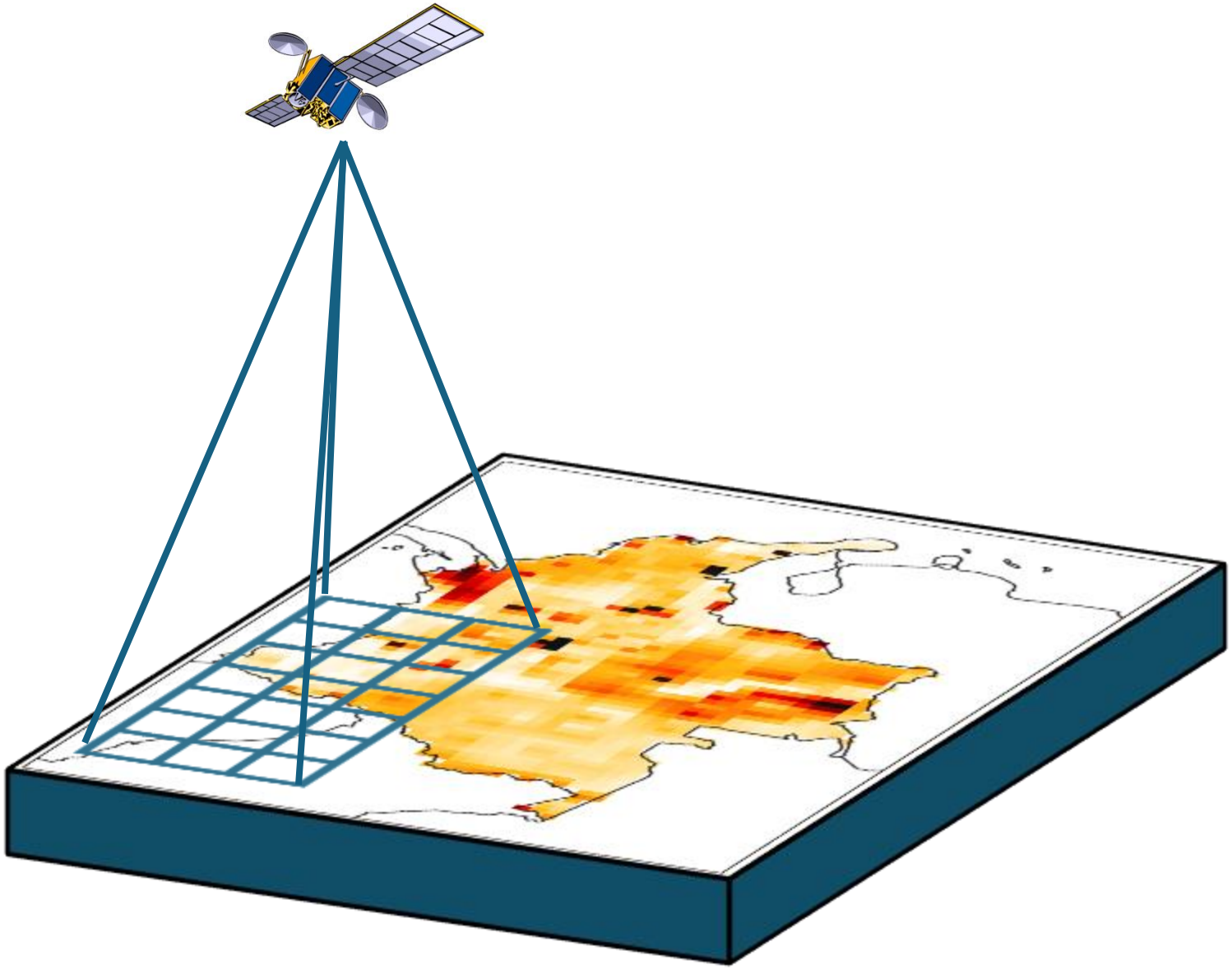
Methane mitigation requires region-specific strategies

United States

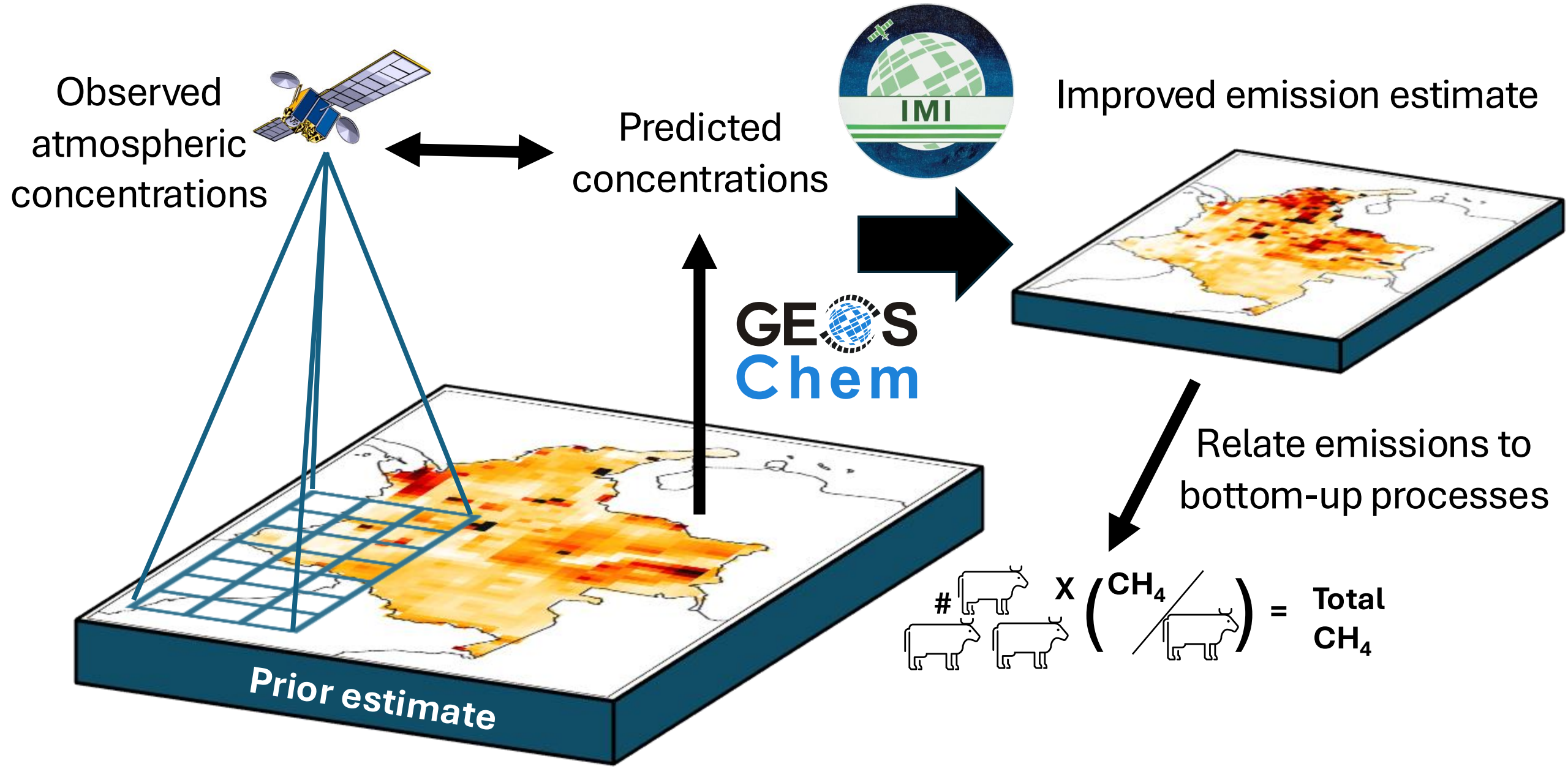
South America



Satellite observations of methane concentrations can improve emission estimates



Analytical inversion provides top-down emission estimate based on satellite observations



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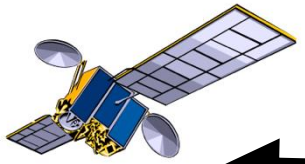


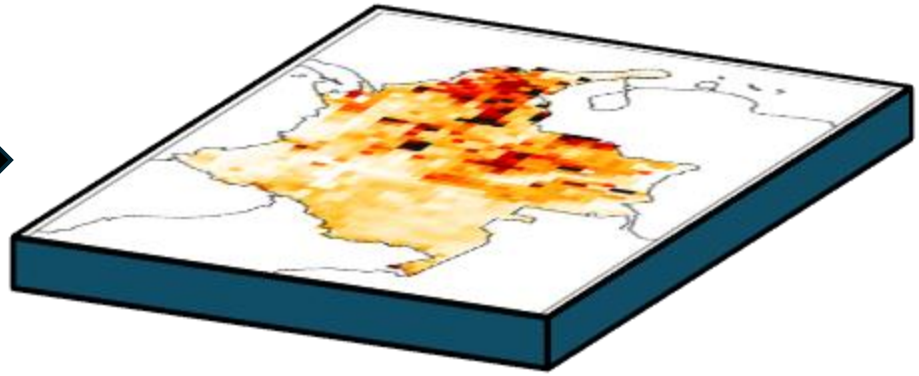
Observed atmospheric concentrations

Predicted concentrations

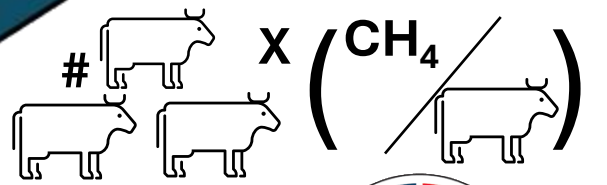
IMI

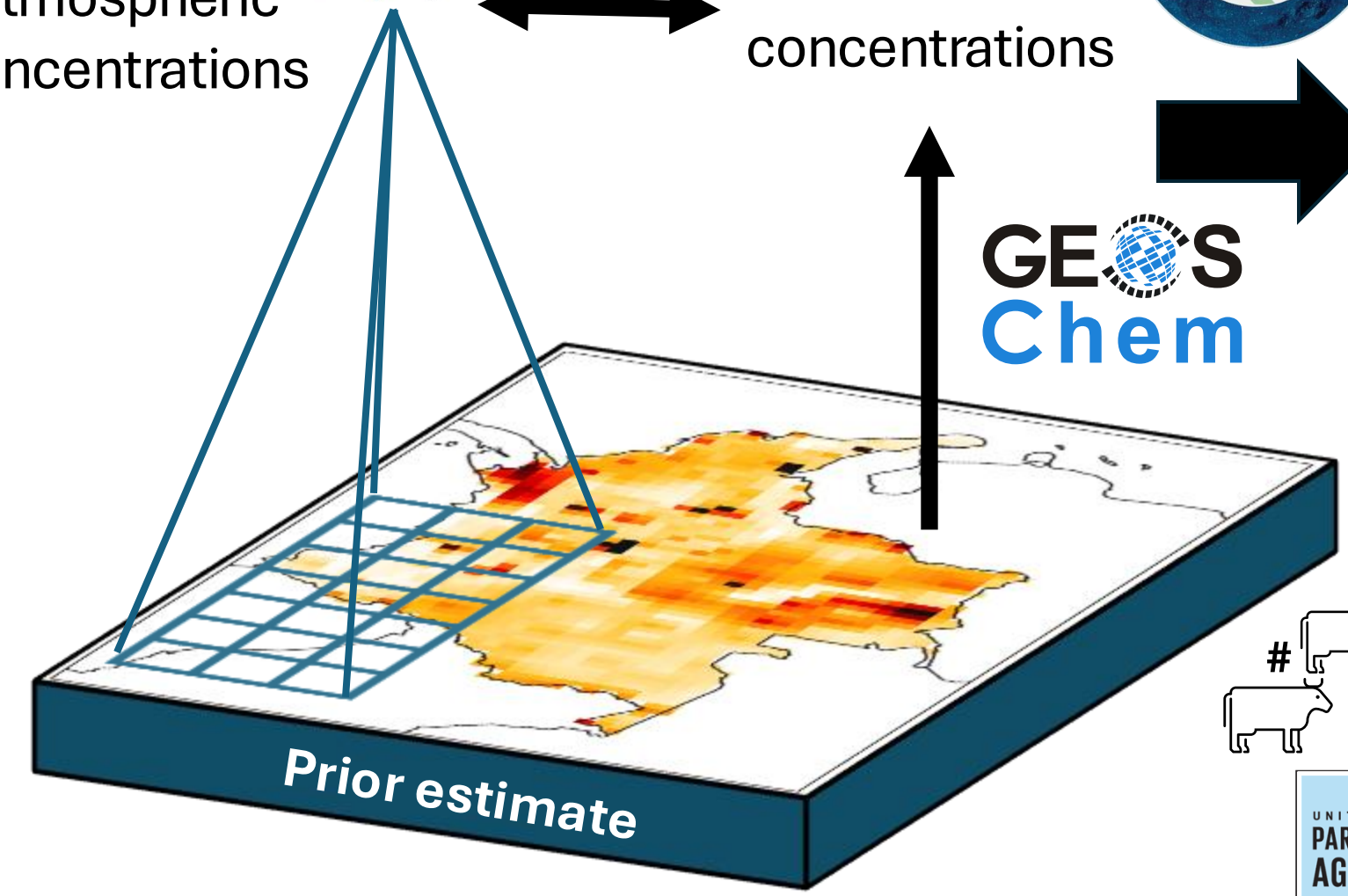
GEOS Chem

Improved emission estimate



Relate emissions to bottom-up processes





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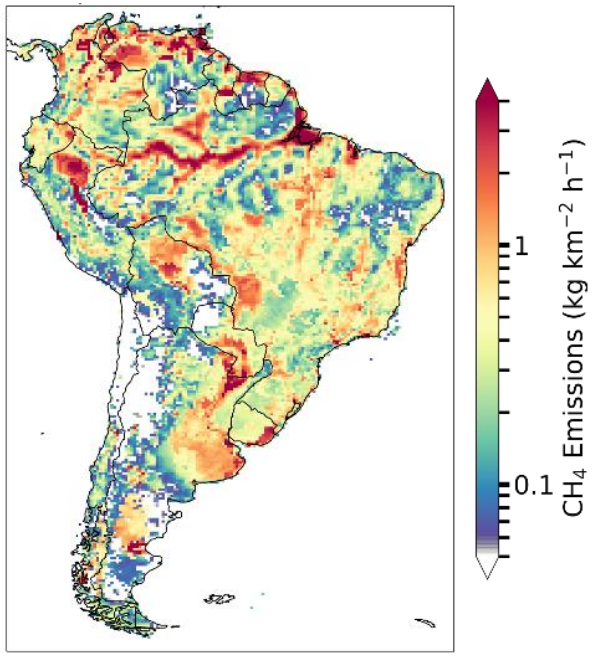
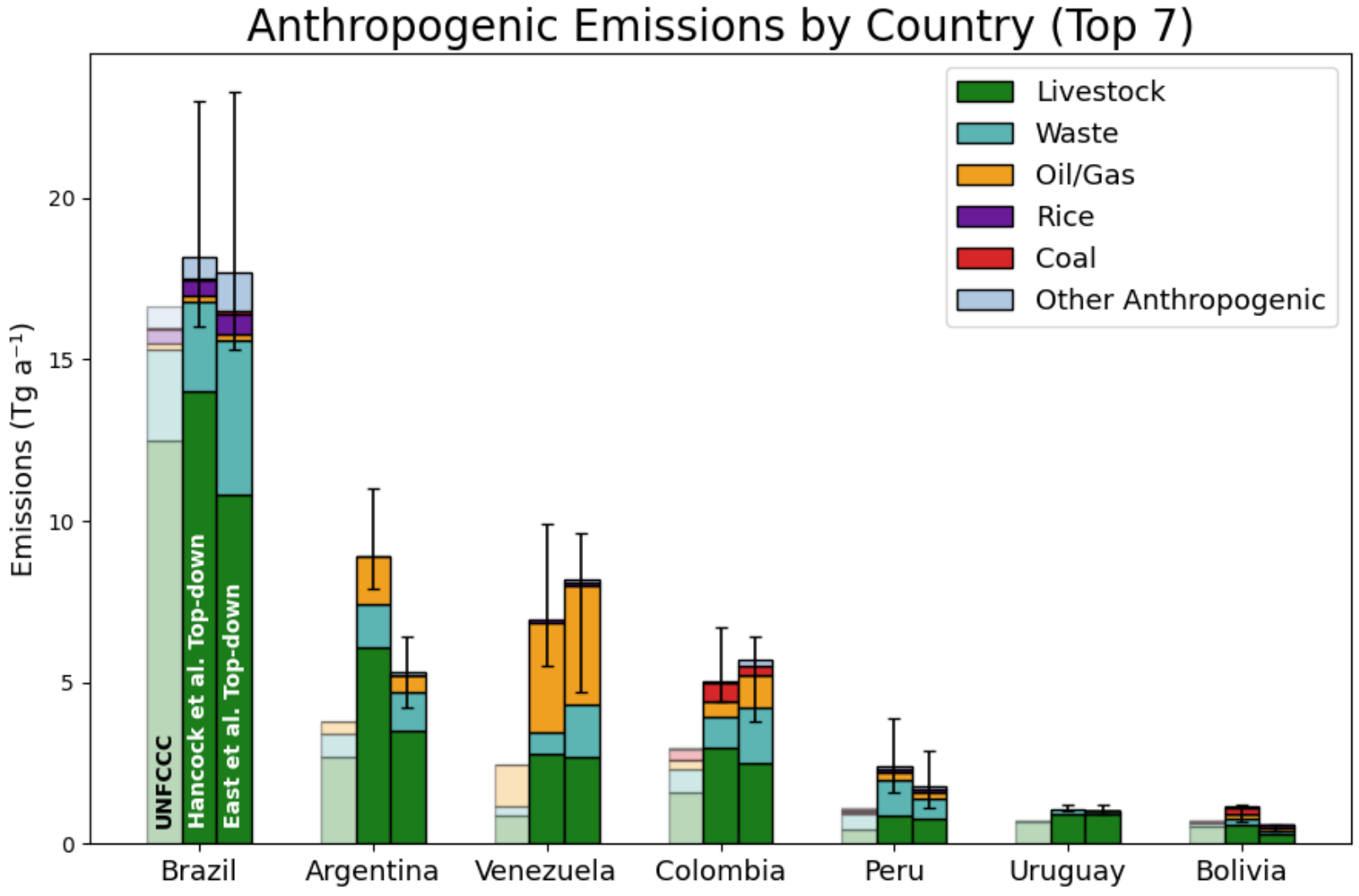
Two different high-resolution inversions over South America find similar results

Hancock et al. (2025)

East et al. (2025)



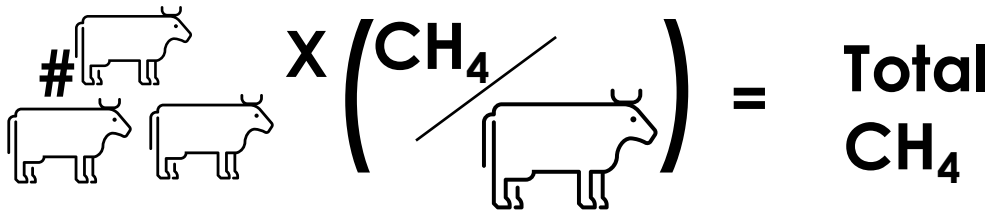
Emissions are underestimated in almost all sectors, but especially livestock



How much methane do countries emit, and from what sectors?

Country	Total anthropogenic	Livestock	Waste	Rice	Oil/Gas	Coal
Argentina						
UNFCCC	4.3	3.0	0.82	0.02	0.36	<0.01
Posterior	9.2 (7.9-11)	6.1 (5.1-7.1)	1.3 (1.1-1.6)	0.02 (0.02-0.03)	1.5 (1.4-1.6)	<0.01
Bolivia						
UNFCCC	0.75	0.58	0.09	0.02	0.05	<0.01
Posterior	0.96 (0.66-1.2)	0.61 (0.47-0.77)	0.18 (0.11-0.20)	0.02 (0.01-0.02)	0.13 (0.07-0.19)	0.18 (0.11-0.19)
Brazil						
UNFCCC	16	12	2.8	0.44	0.18	0.04
Posterior	19 (16-23)	14 (12-18)	2.8 (2.4-3.3)	0.49 (0.42-0.61)	0.16 (0.13-0.17)	0.04 (0.03-0.05)
Chile						
UNFCCC	0.67	0.24	0.34	<0.01	0.04	<0.01
Posterior	0.88 (0.69-0.96)	0.36 (0.26-0.41)	0.41 (0.34-0.44)	0.01 (<0.01-0.01)	0.05 (0.04-0.15)	<0.01
Colombia						
UNFCCC	3.0	1.6	0.69	0.03	0.28	0.35
Posterior	5.0 (4.4-6.7)	3.0 (2.5-4.2)	0.91 (0.78-1.1)	0.04 (0.03-0.05)	0.48 (0.38-0.8)	0.53 (0.35-1.4)

What's missing in our bottom-up estimates of emissions?

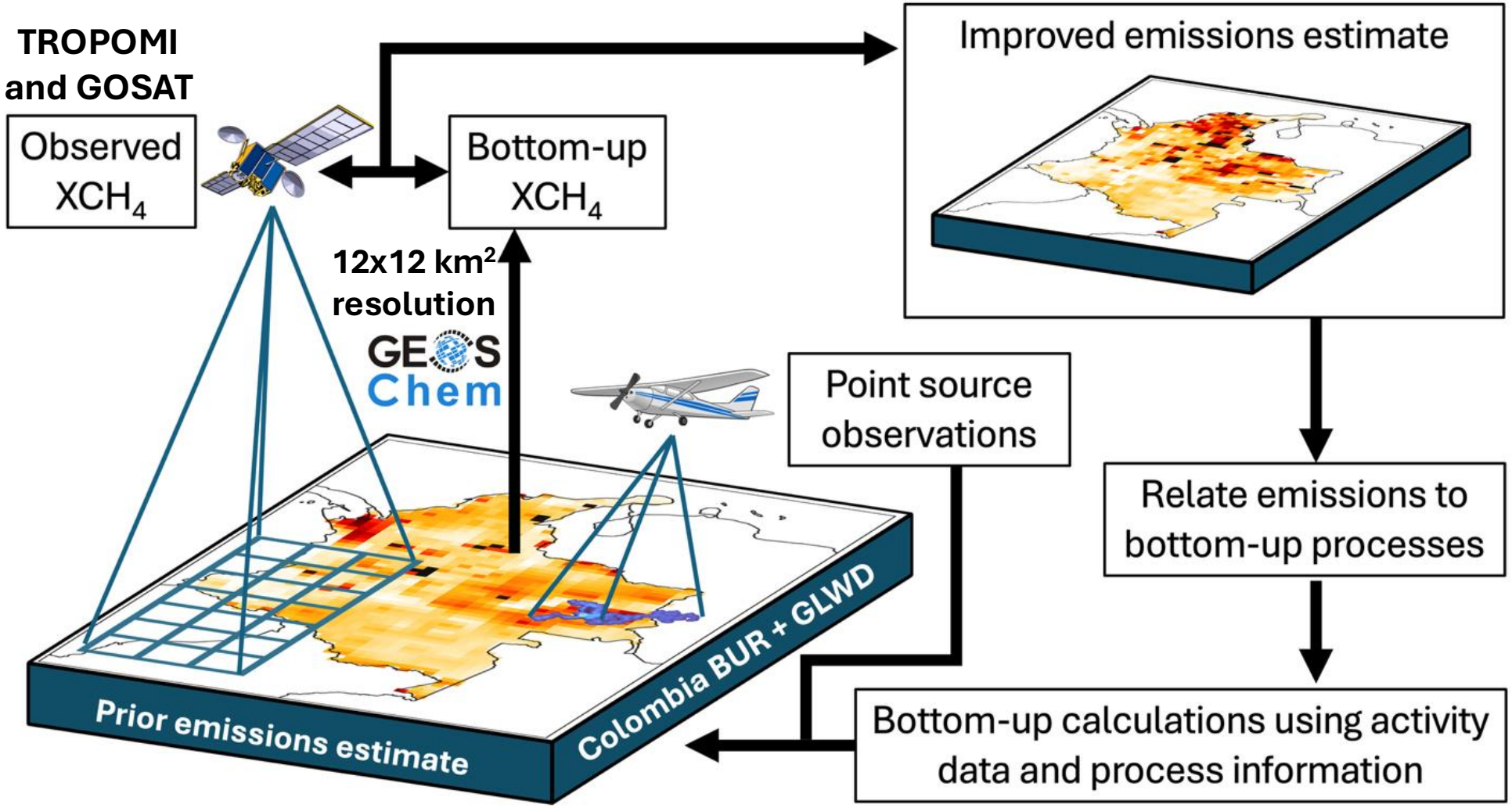


South America is complex and heterogeneous

Inversion resolution is limited at continental-scale

Local expertise is needed to link results to infrastructure

IMEO baseline science studies integrate top-down and bottom-up methods to improve national emission inventories



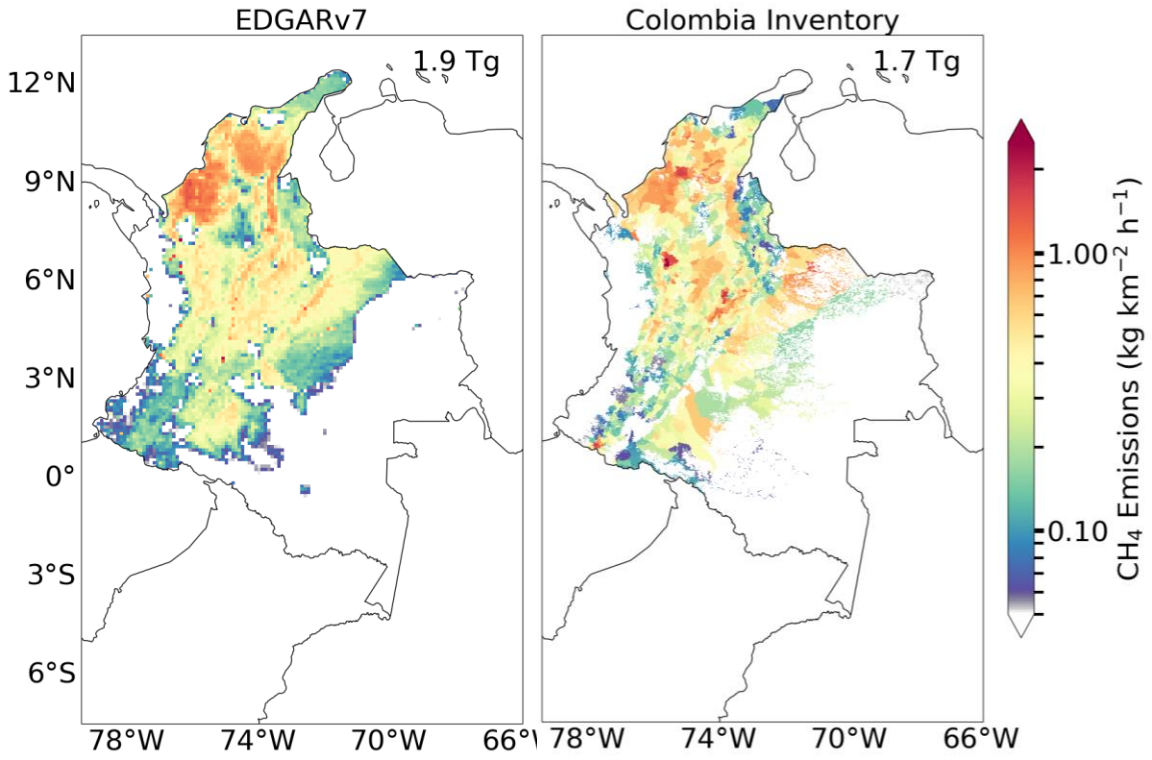
Led by Colombian researchers

Rodrigo Jimenez
Universidad Nacional de Colombia

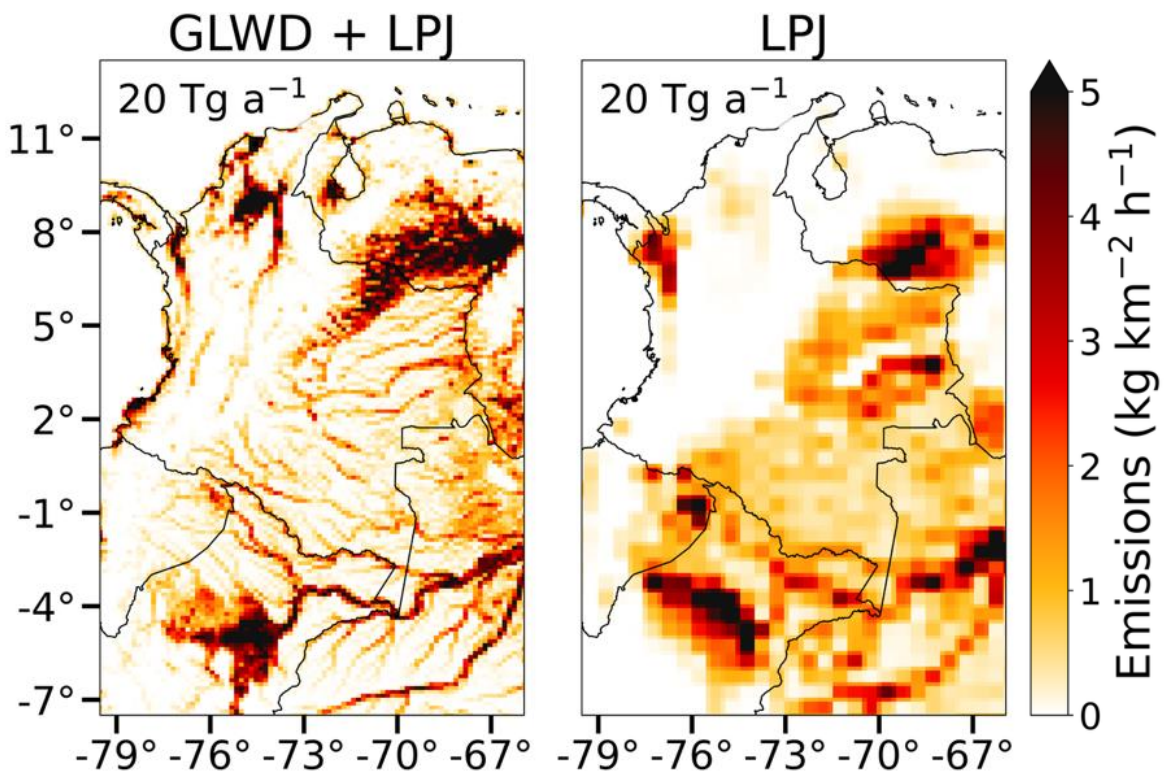
Hancock et al. (2025), submitted to ACP

Collaborating with local scientists to improve emission inventories so we can better relate results to bottom-up processes: case study over Colombia

Cattle vaccination records used to improve livestock inventory



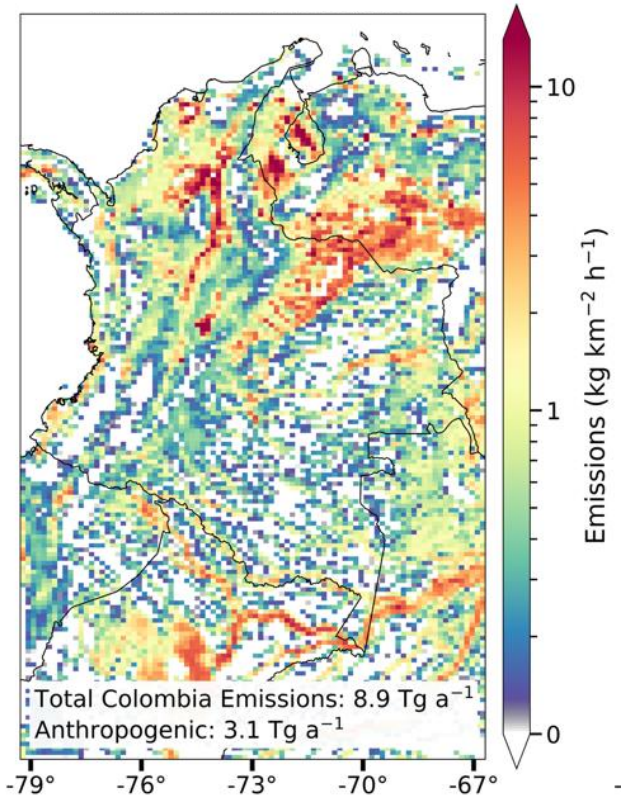
High-resolution surface water extent map (GLWDv2) used to improve wetland inventory

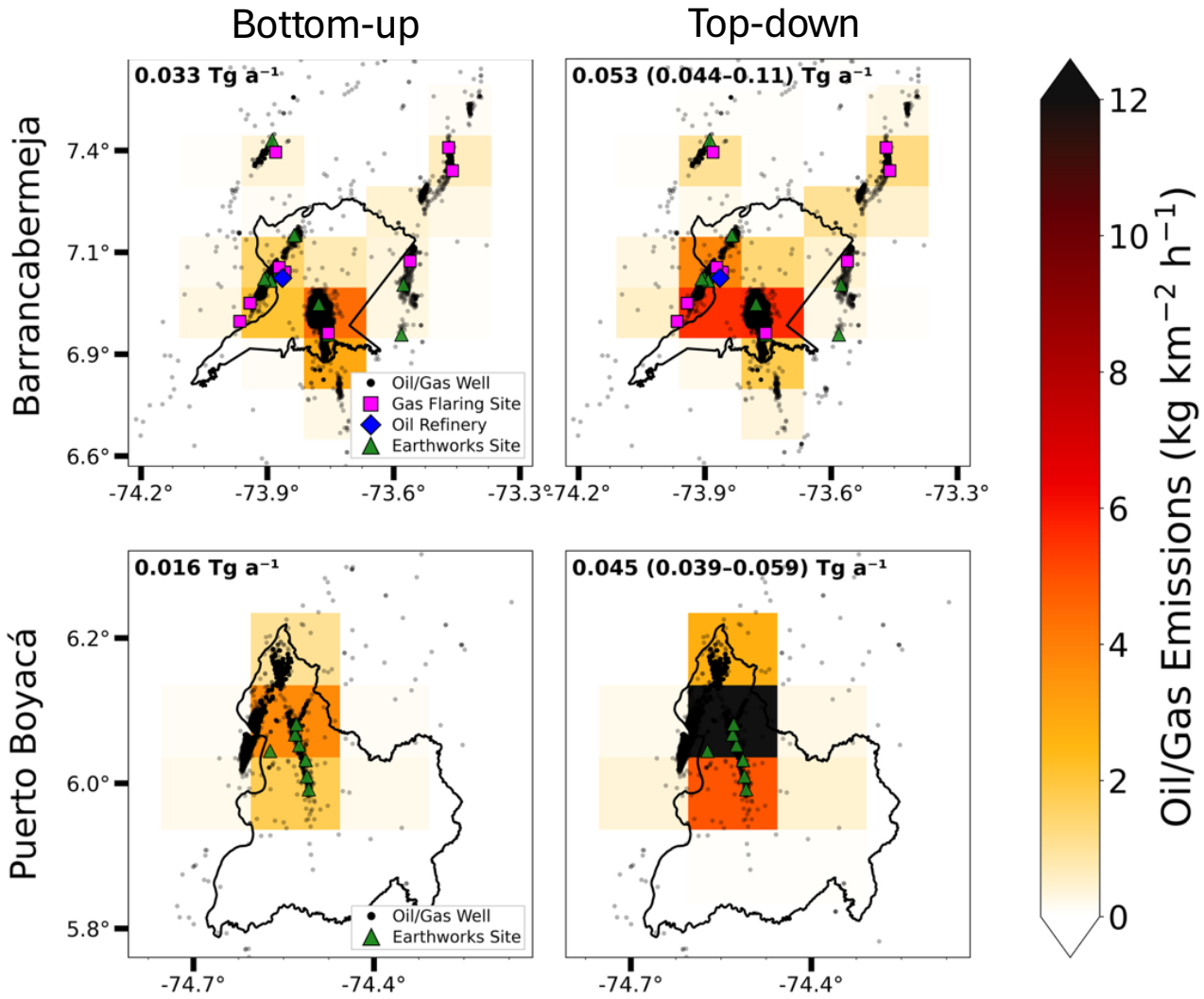


Hancock et al. (2025), submitted to ACP

Higher resolution results and local infrastructure data allow us to provide stronger recommendations for improving the national inventories

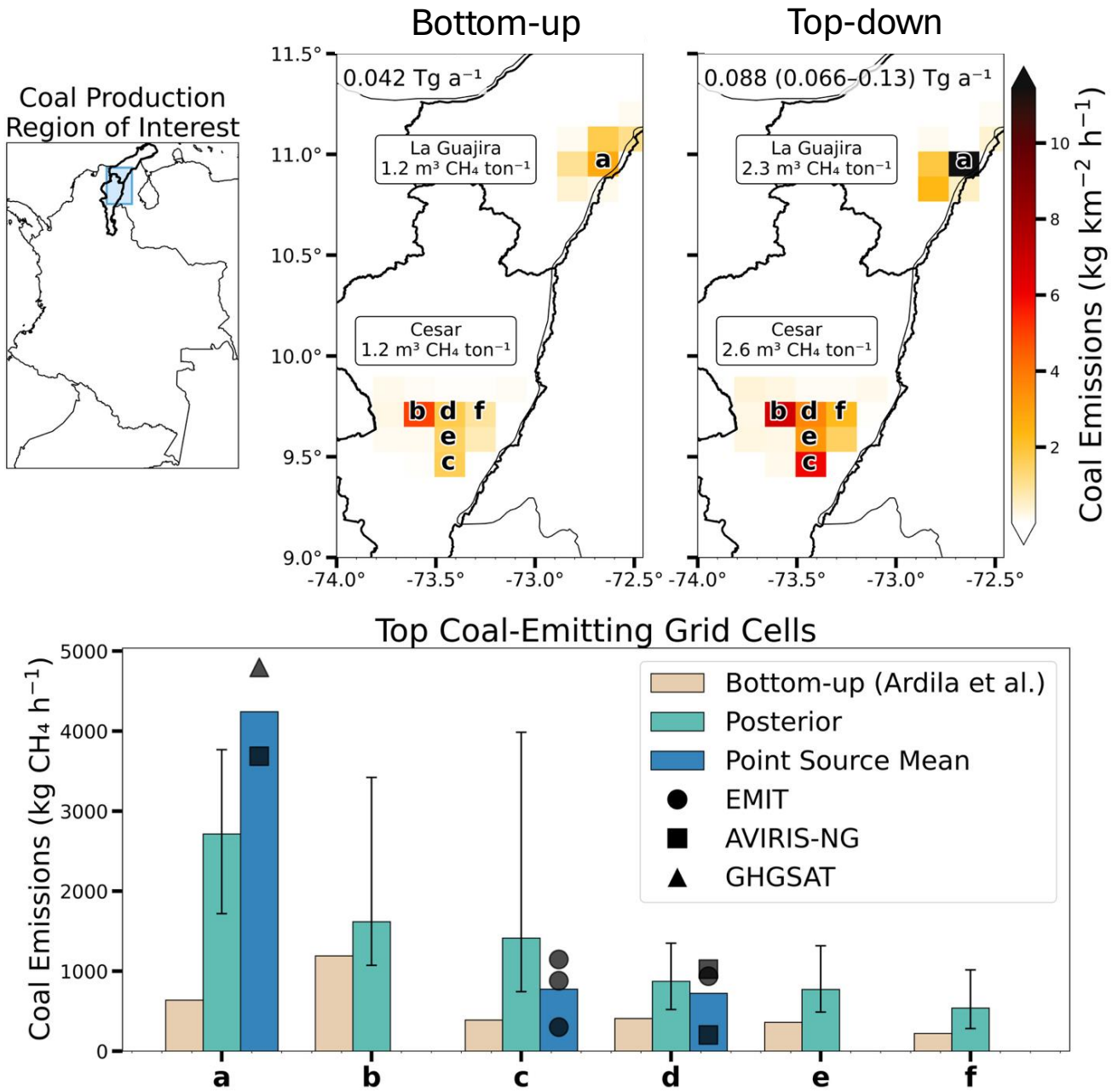
Top-down emissions





Hancock et al. (2025), submitted to ACP

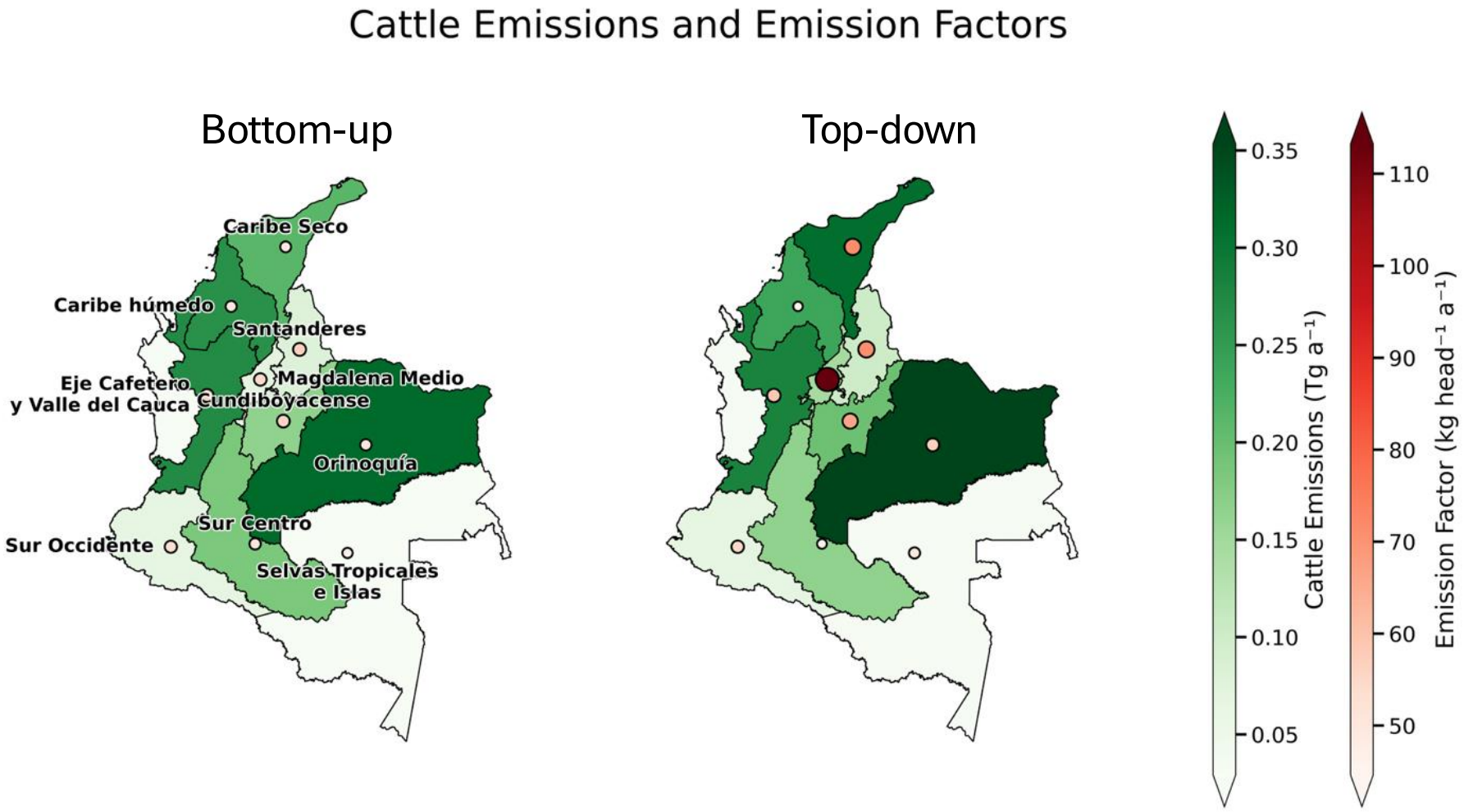
Recommending larger emission factors for Colombian open-pit coal mines



- Colombian open-pit coal mines are deeper than average
- Top-down derived emission factors for coal align with in-situ measurements in each basin at larger depths
- Updating evolving mine depths into estimates could improve national reporting

Hancock et al. (2025), submitted to ACP

Assessing livestock emissions and intensity by province

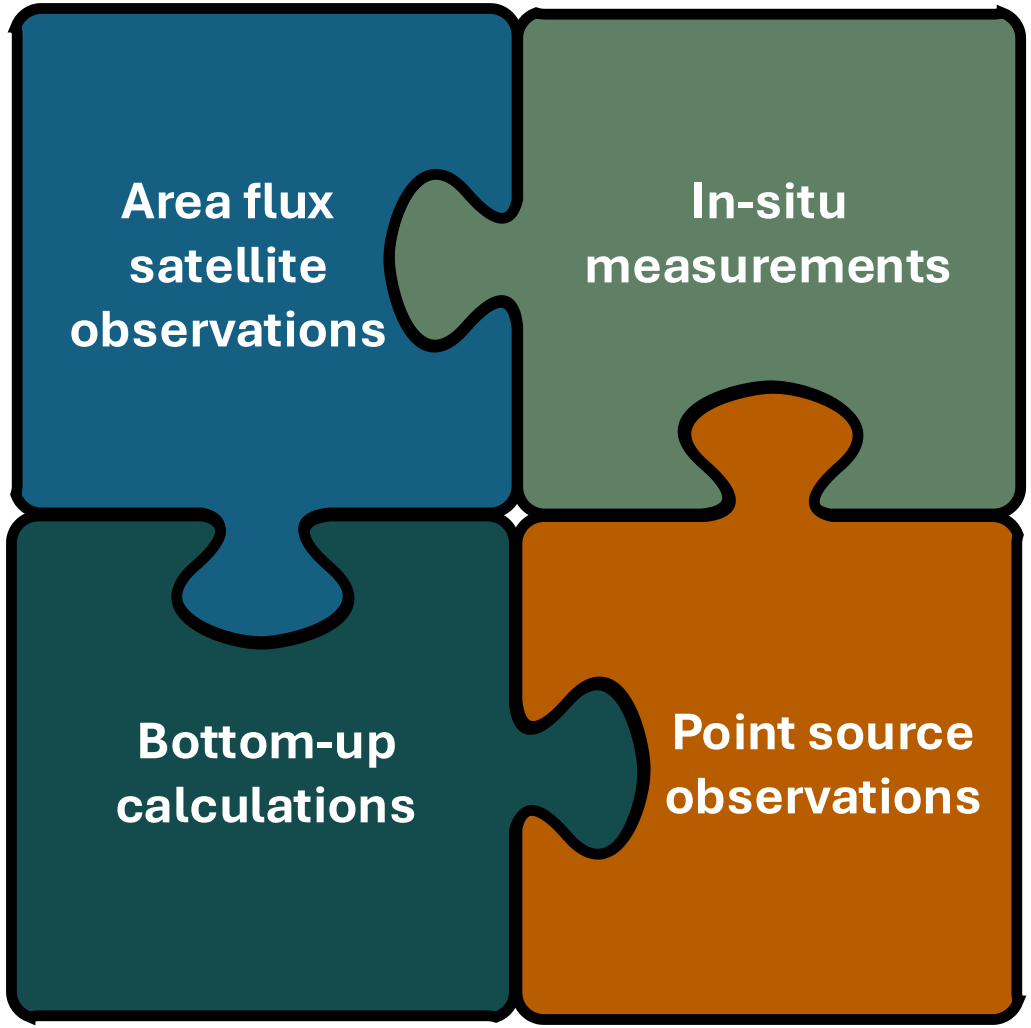


Hancock et al. (2025), submitted to ACP

Livestock measurement team led by Ciniro Costa Jr

CIAT
International Center for Tropical Agriculture

Satellite observations are useful, but local measurements and bottom-up calculations are essential for understanding methane and driving policy change



Measurements sites from NOAA CarbonTracker-CH_4

NOAA Global Greenhouse Gas Reference Network

Conclusions

- South America is an important location for mitigating methane emissions
- Inversions of satellite observations of methane give us improved emission estimates
- Connecting inversion results to bottom-up processes is challenging, but local expertise can help
- Our Colombia inversions serve as an example of how we can integrate satellite observations into national emission inventories