

Global satellite survey of landfill methane emissions

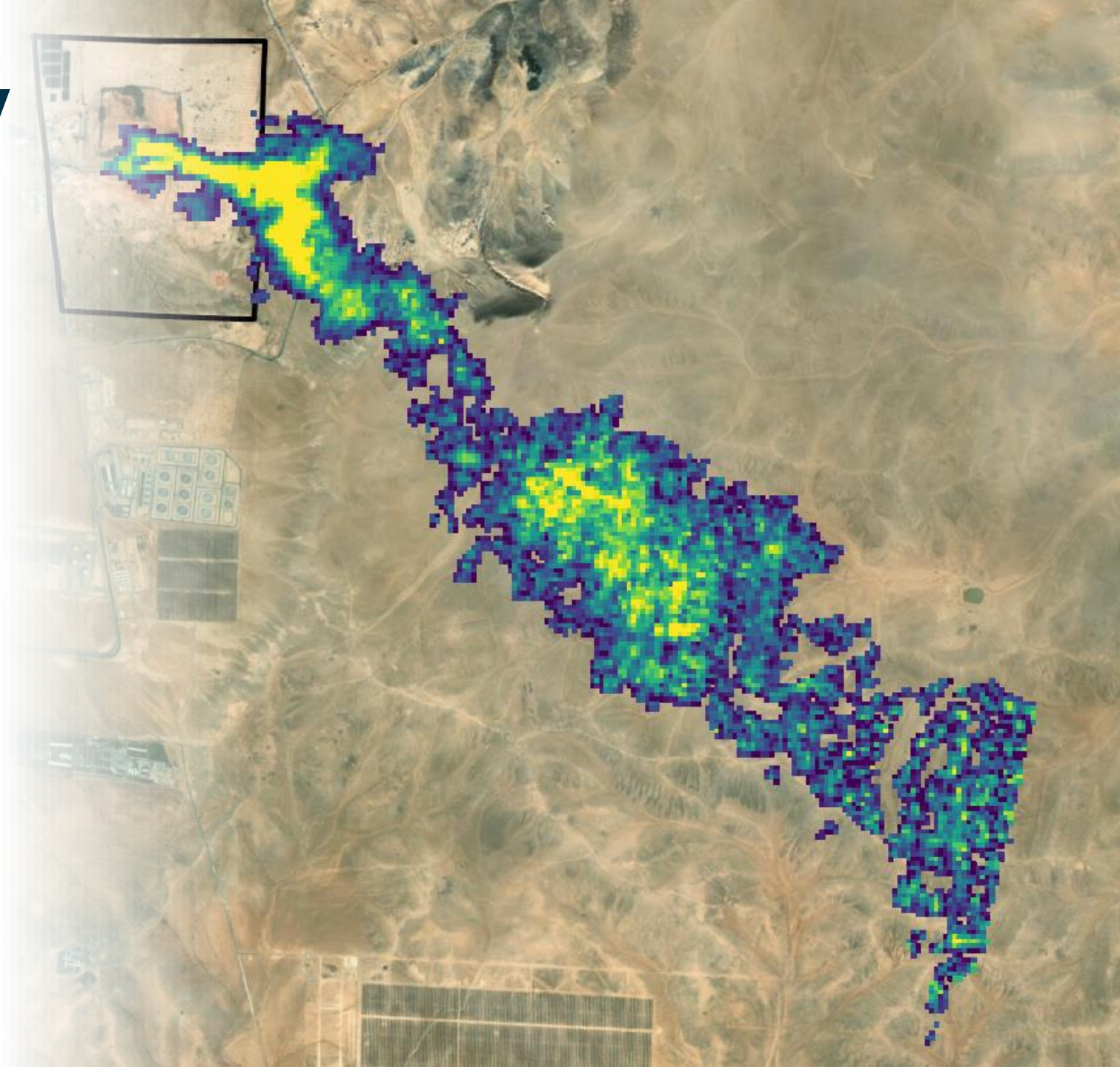
ATMOS 2024 – Bologna – July 2nd, 2024

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¹SRON Netherlands Institute for Space Research

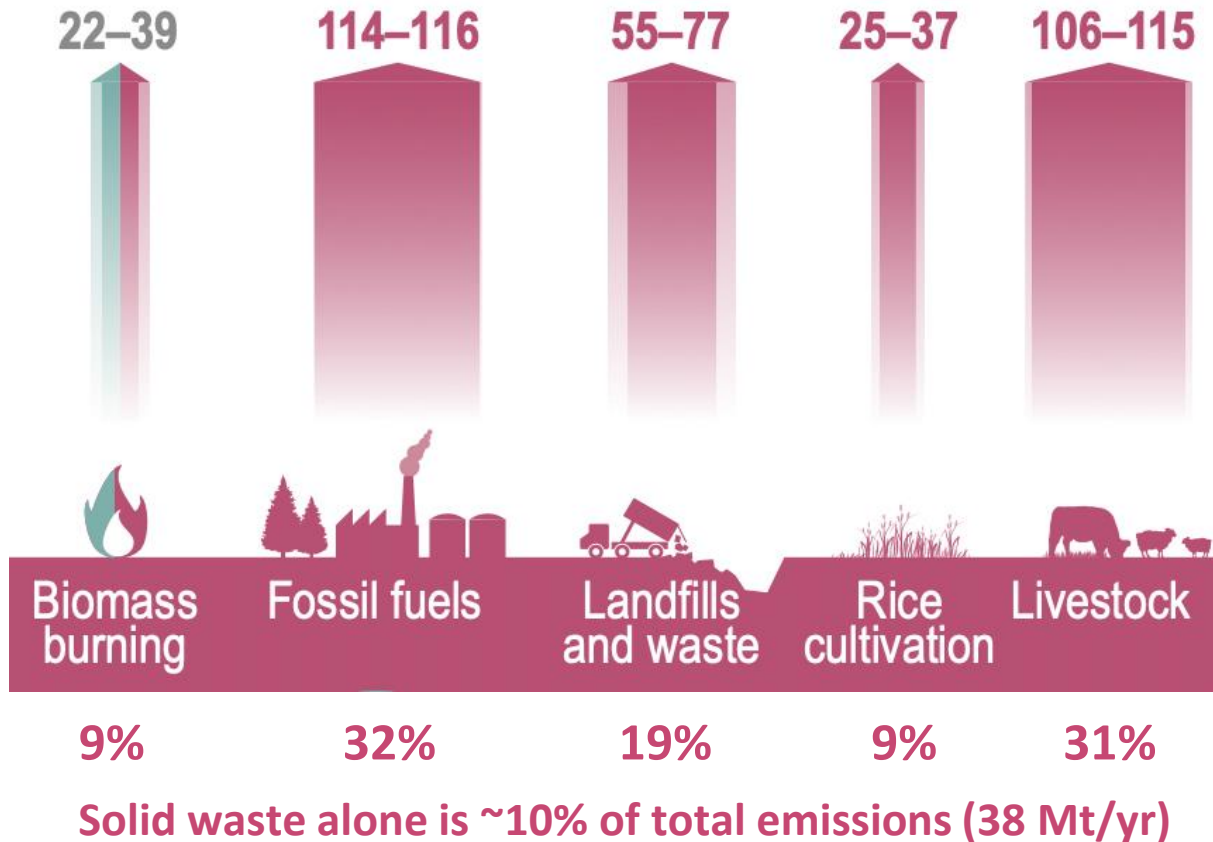
²GHGSat, Inc.

³School of Engineering and Applied Sciences, Harvard University



Methane, the second most important greenhouse gas

Anthropogenic emissions of methane (2008-2017) Mt CH₄/yr

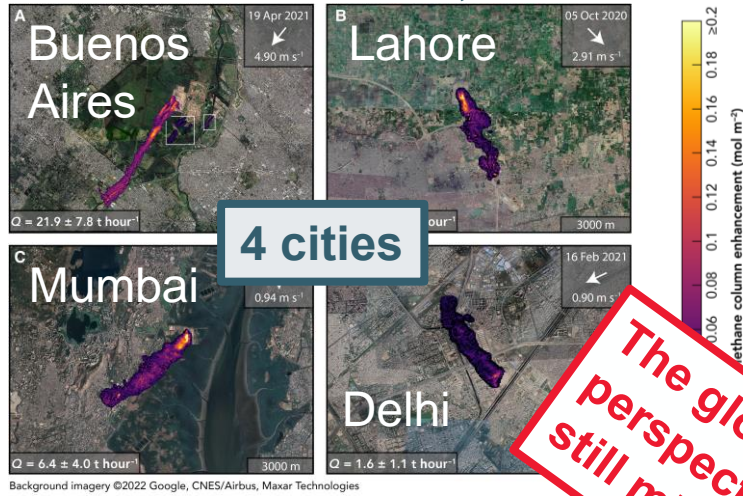


Adapted from IPCC AR6 WGI Chap. 5 Fig. 5.14



Top-down satellite and airborne observations of landfill emissions

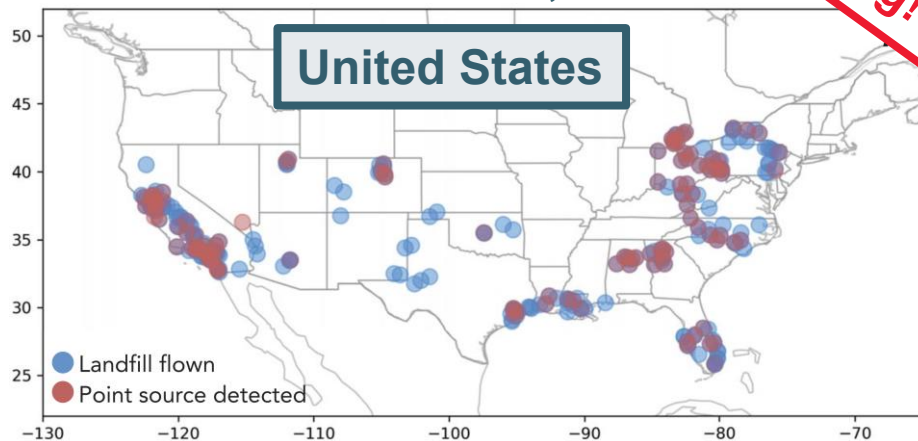
Maasackers et al., 2022



4 cities

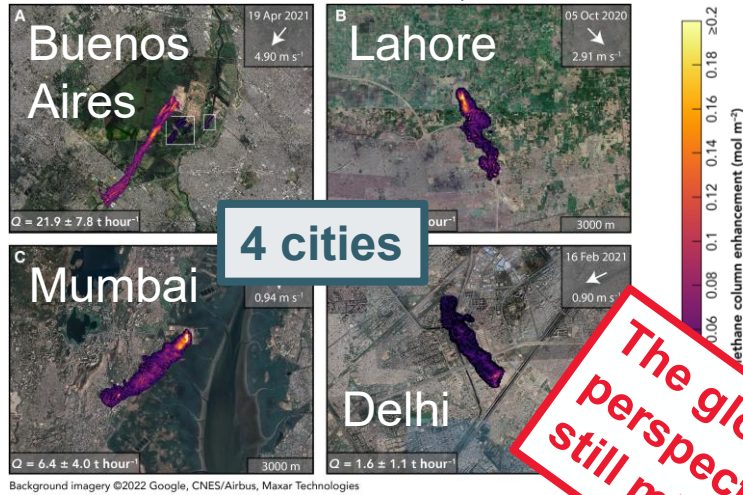
The global perspective is still missing!

Cusworth et al., 2024



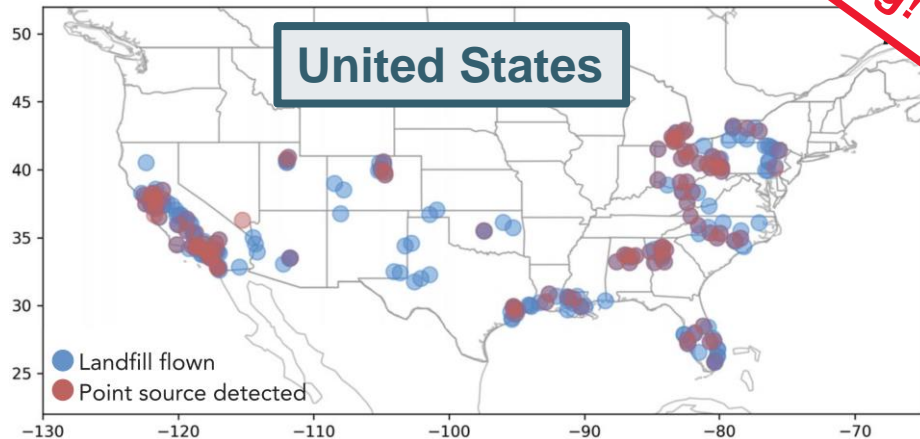
Top-down satellite and airborne observations of landfill emissions

Maasackers et al., 2022

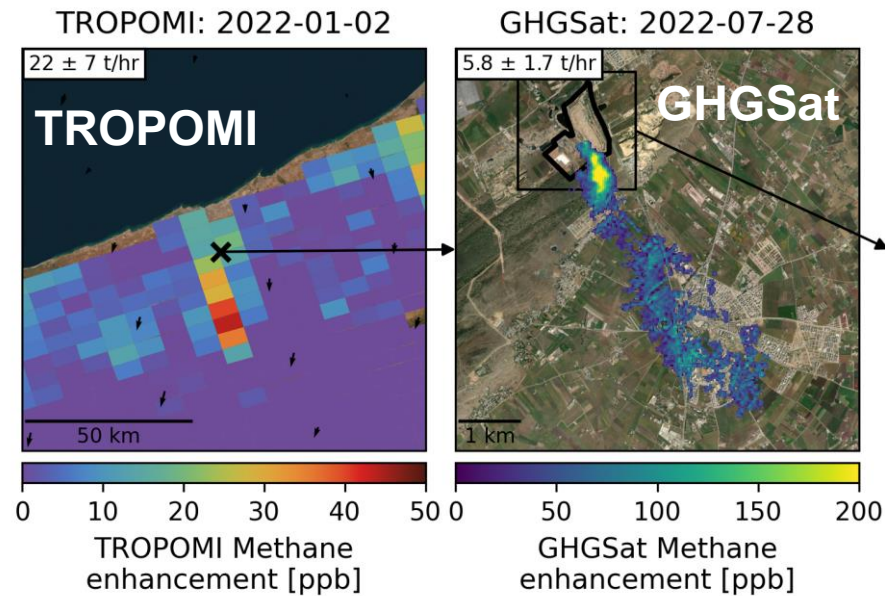


The global perspective is still missing!

Cusworth et al., 2024

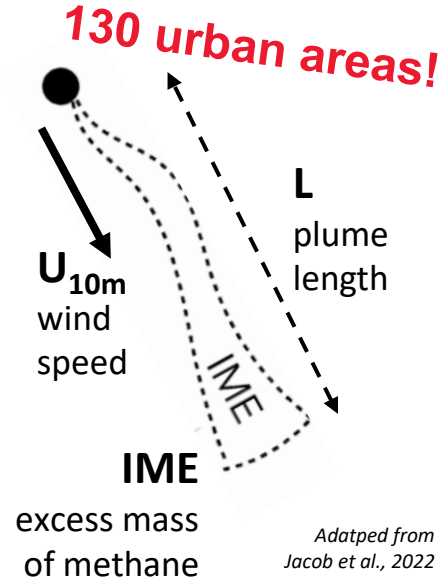


This study presents a global survey of urban and landfill methane emissions using TROPOMI and GHGSat observations



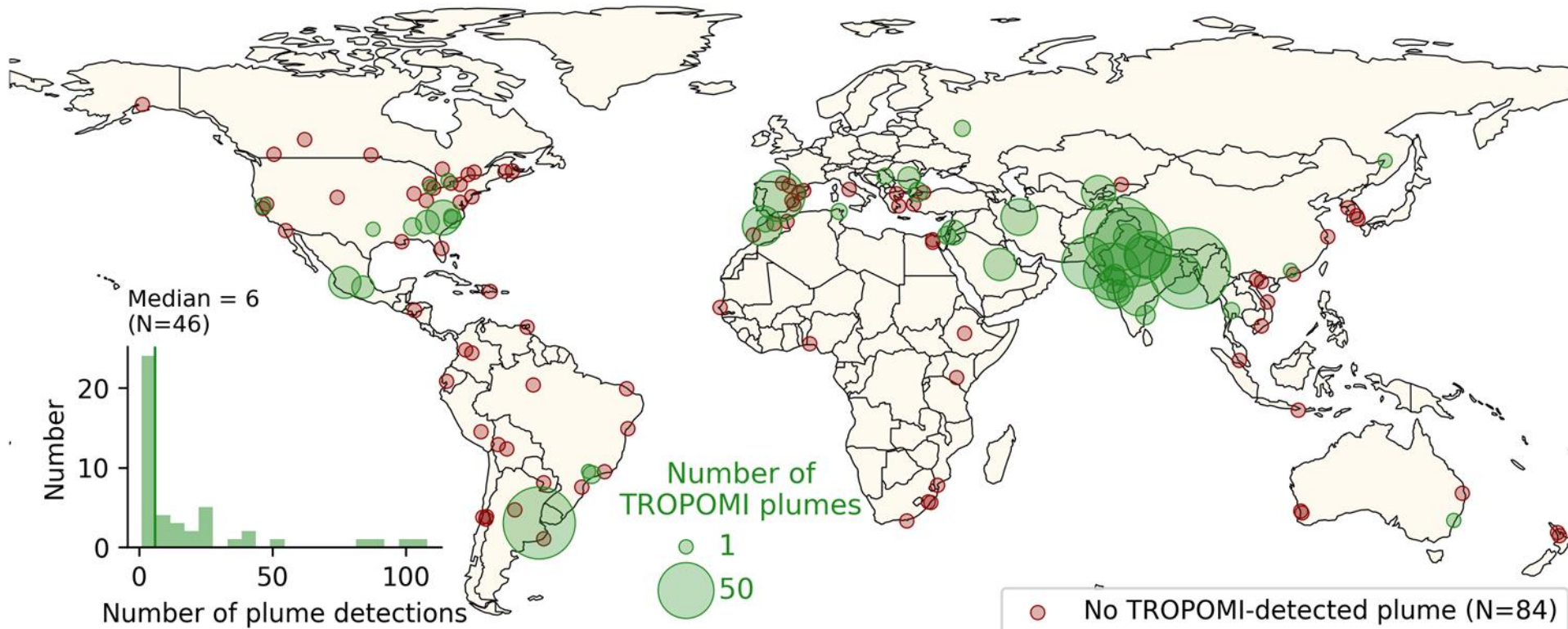
5.5 x 7 km²
Urban scale emissions

25 x 25 m²
Facility scale emissions



$$Q = \frac{f(U_{10m})}{L} \text{IME}$$

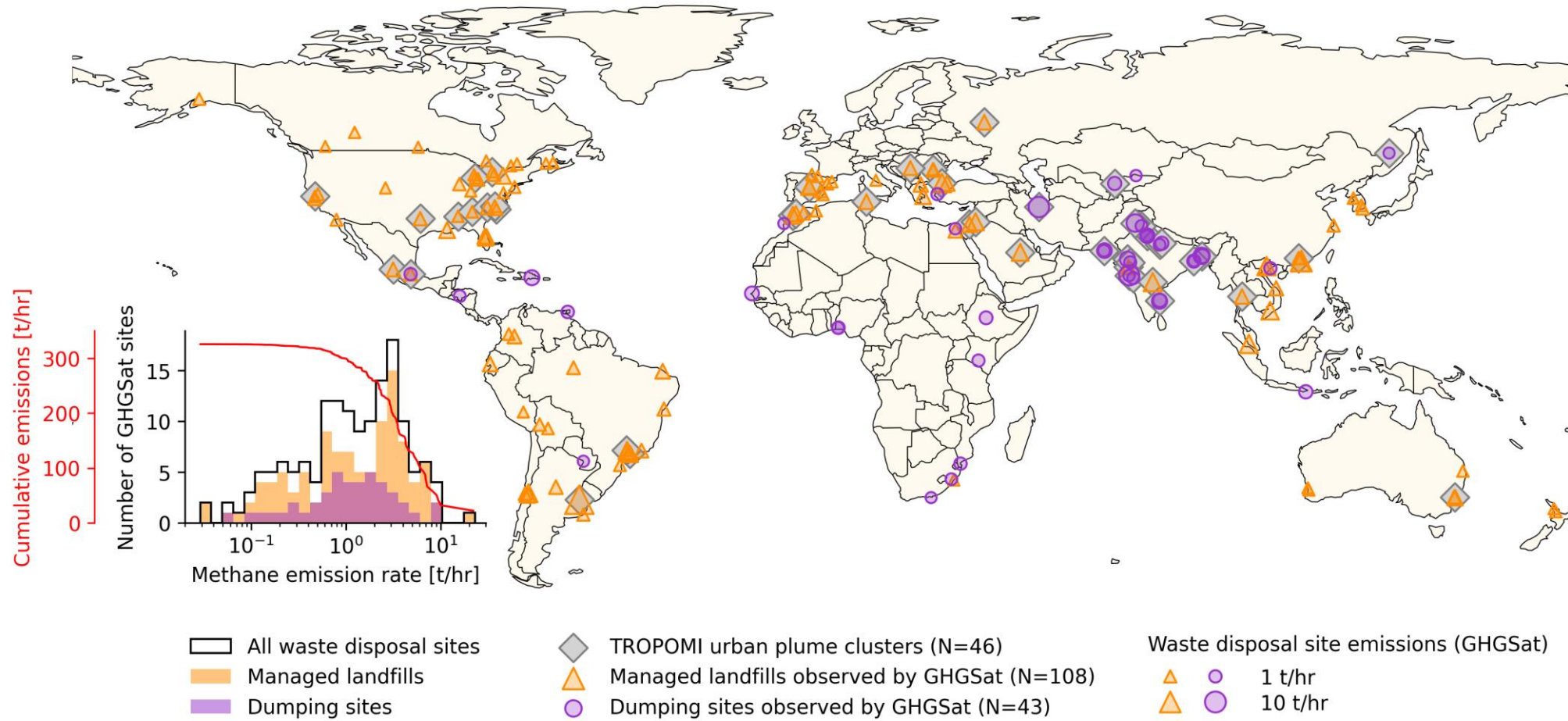
TROPOMI urban hotspot plume detections over 130 urban areas



14/46
urban areas
encompass
80% of
detected
plumes in
TROPOMI
data over the
130 targeted
urban areas

84 targeted urban areas show no plume in TROPOMI data, due to data coverage, albedo correlation artefacts and/or expected emissions below the ~8 t/hr plume detection threshold in TROPOMI data

A global survey with unprecedented coverage



close to
1500
GHGSat obs.

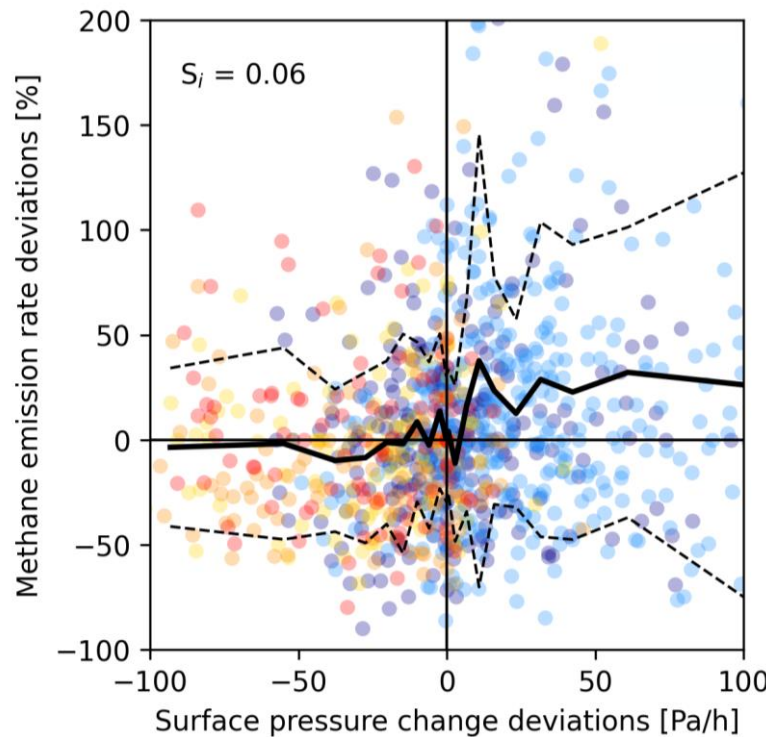
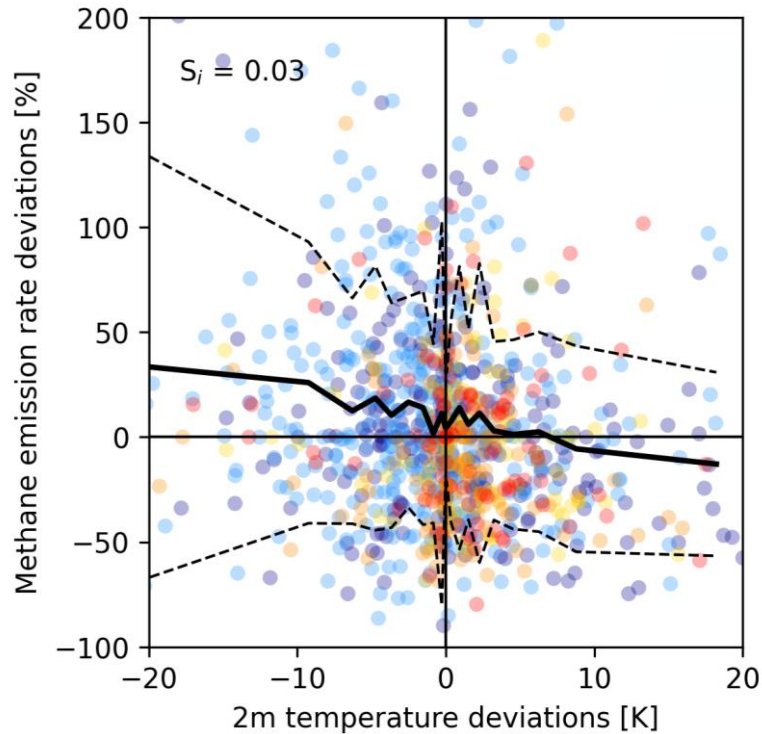
151
waste disposal
sites

130
urban areas

47
countries

6
continents

Meteorological driving of landfill emissions ?

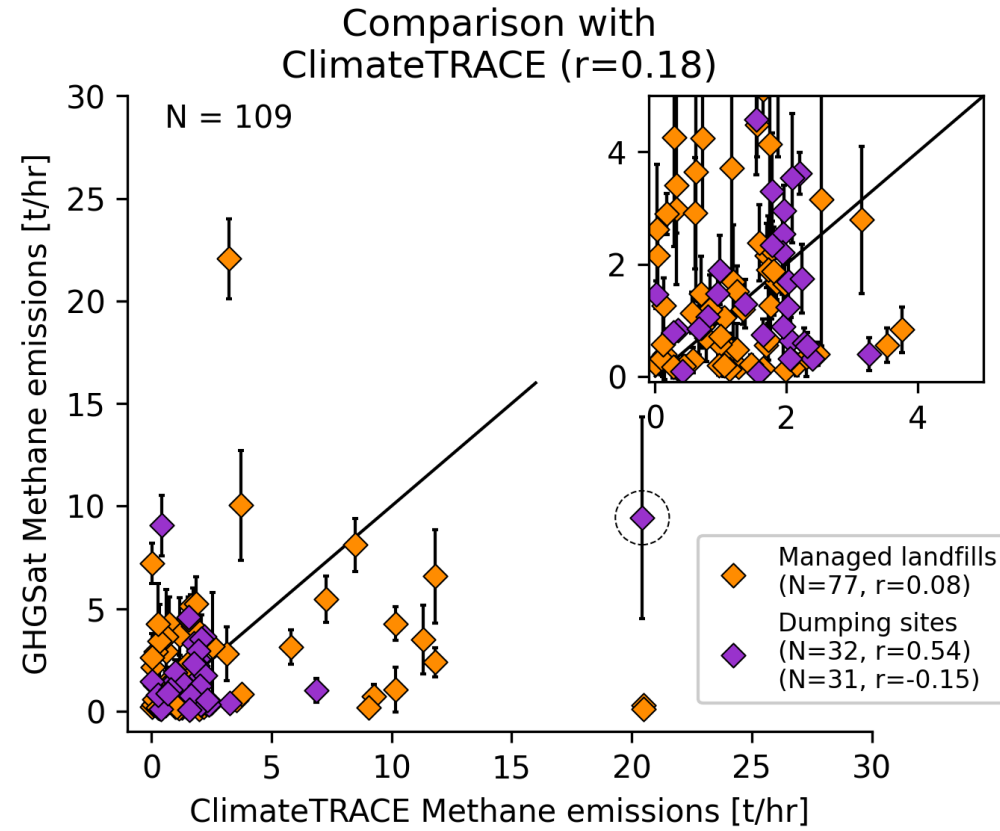
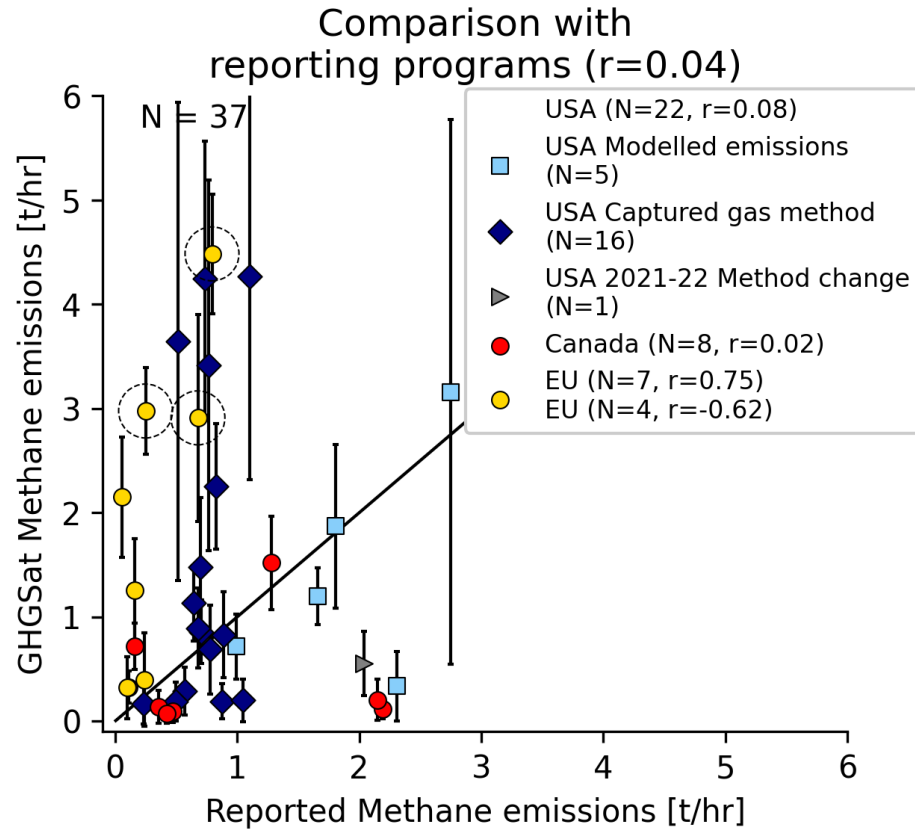


- Satellite C1 (morning)
- Satellite C2 (morning)
- Satellite C3 (afternoon)
- Satellite C4 (afternoon)
- Satellite C5 (afternoon)
- Mean
- - - Mean \pm Standard deviation

We find no evidence of meteorological driving of landfill methane emissions, consistently with Cusworth et al., 2024

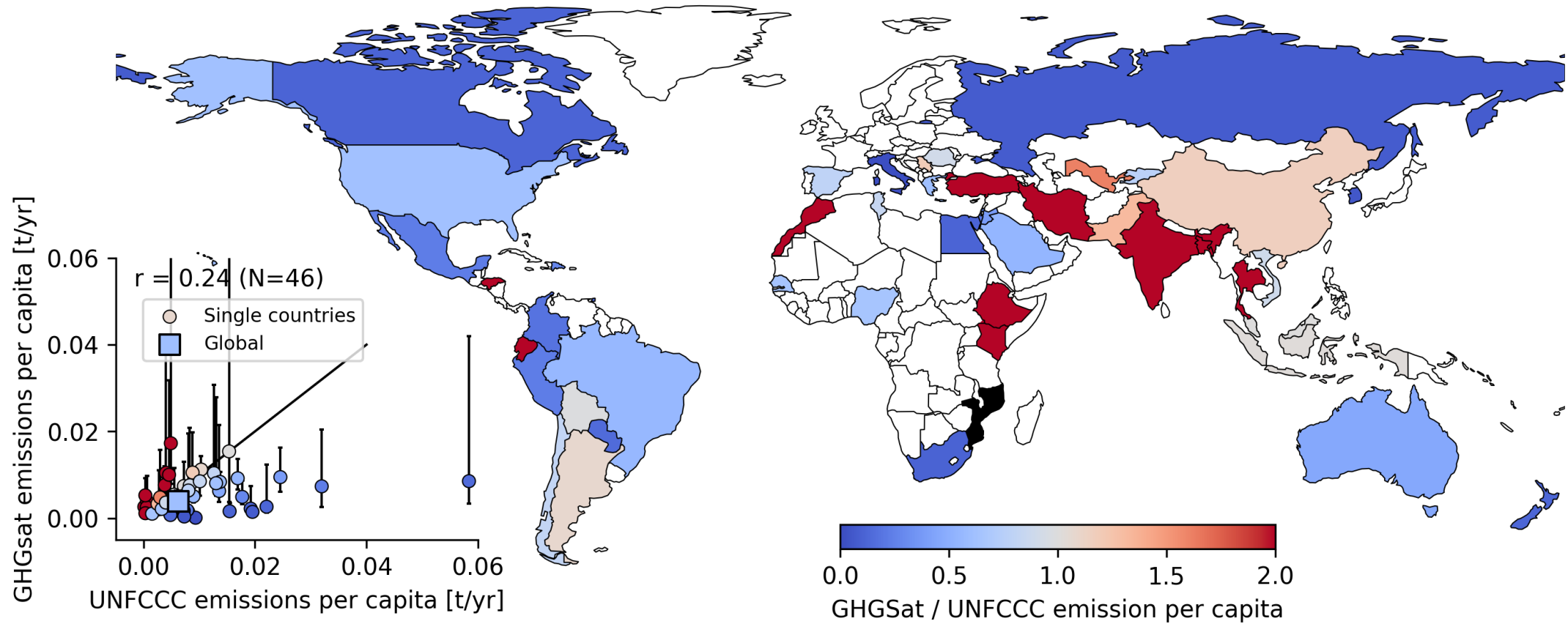
*same for wind speed, surface pressure, precipitation and seasons

Comparison between bottom-up and top-down approaches (1/2)



Bottom-up and top-down emissions estimates cannot currently be reconciled at site level

Comparison between bottom-up and top-down approaches (2/2)

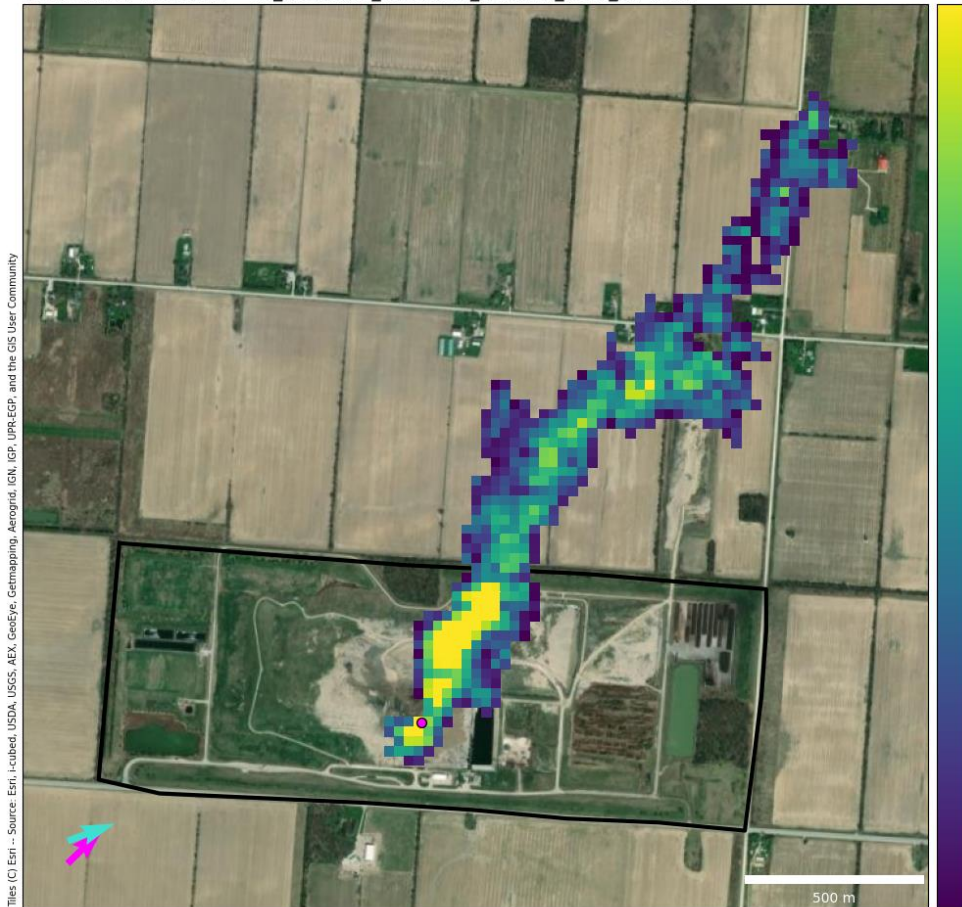


**boundaries follow the de facto policy of Natural Earth*

9 countries show GHGSat emissions per capita more than twice as large as those reported to UNFCCC

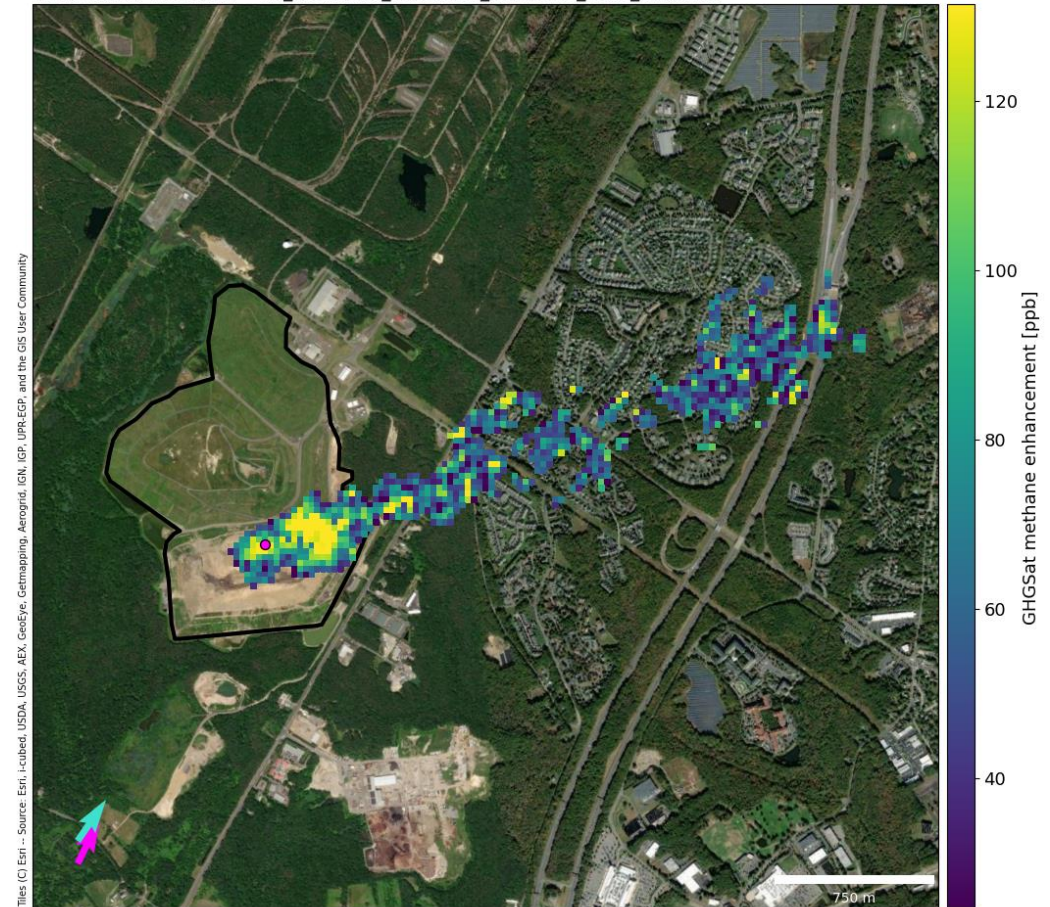
Origin of methane emission plumes

Site_ID = 31
 Town of Essex, Ontario (Canada)
 Latitude, Longitude = 42.089, -82.866
 Date = 2022-06-21T15:16:09, Satellite = C2
 Methane emission rate = 2.12 ± 0.66 t/hr
 Plume raster file name = C2_20220621_20220624_AZv2r59_4246_CH4PL.tif



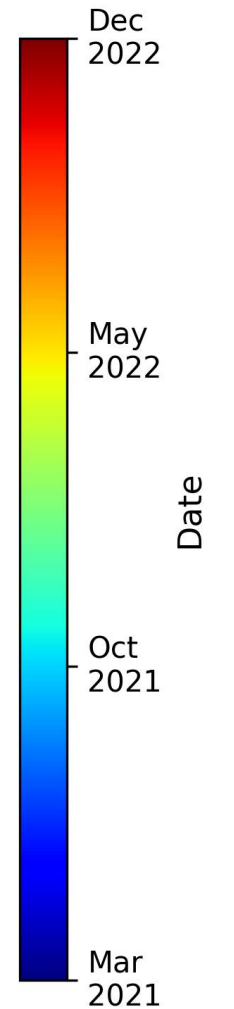
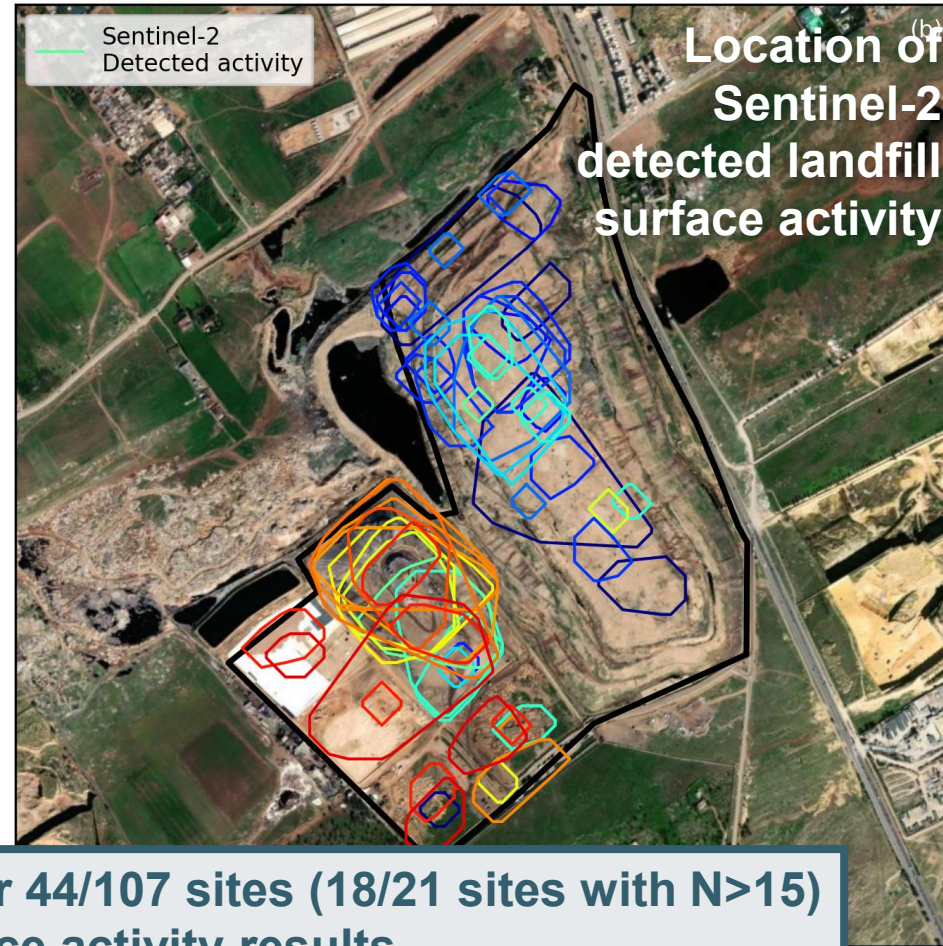
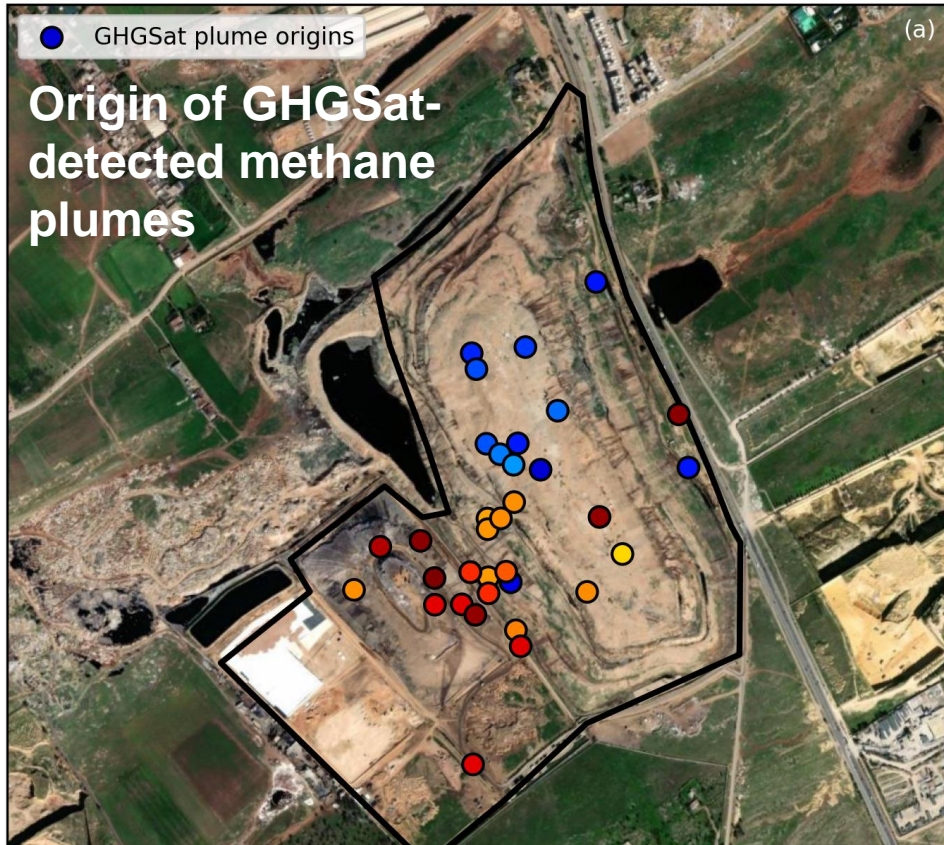
— Landfill mask Wind (ERA5) Wind (GEOS-CF) ● Plume origin(s)

Site_ID = 139
 Tinton Falls, New Jersey (United States)
 Latitude, Longitude = 40.239, -74.114
 Date = 2021-10-21T14:55:30, Satellite = C2
 Methane emission rate = 1.54 ± 0.80 t/hr
 Plume raster file name = C2_20211021_20220423_AW8292O_2403_CH4PL.tif



— Landfill mask Wind (ERA5) Wind (GEOS-CF) ● Plume origin(s)

Origin of methane emission plumes and landfill surface activity !



Statistically-significant proximity for 44/107 sites (18/21 sites with N>15) with good Sentinel-2 detected surface activity results

World Imagery

- **Observation-based estimates** for 151 waste disposal sites scattered on all six continents
- **Bottom-up and top-down approaches cannot be reconciled** at facility and country scales
- **Active surface of waste disposal sites** are important sources of emission

Further studies are necessary to close the gap between bottom-up and top-down approaches in quantifying methane emissions from solid waste.

Ideally **involving all expertises:**

- Site operators
- Bottom-up modellers
- Ground, aerial and satellite based estimates

Pre-print “Satellite survey sheds new light on global solid waste methane emissions” available soon!!