Space-based detection and quantification of methane super-emitters: a global overview and a case study investigating large emissions from surface coal mines

Shubham Sharma[1], Joannes D. Maasakkers[1], Tobias A. de Jong[1], Berend J. Schuit[1,2], Matthieu Dogniaux[1], Ana Isabel Lopez Norena[1], Tobias Borsdorff[1], Mari Martinez Velarte[1], Daniel J. Varon[3], Jason McKeever[2], Dylan Jervis[2], Marianne Girard[2], Itziar Irakulis-Loitxate[4,5], Marc Watine-Guiu[5], Cynthia Randles[5] and Ilse Aben[1,6]

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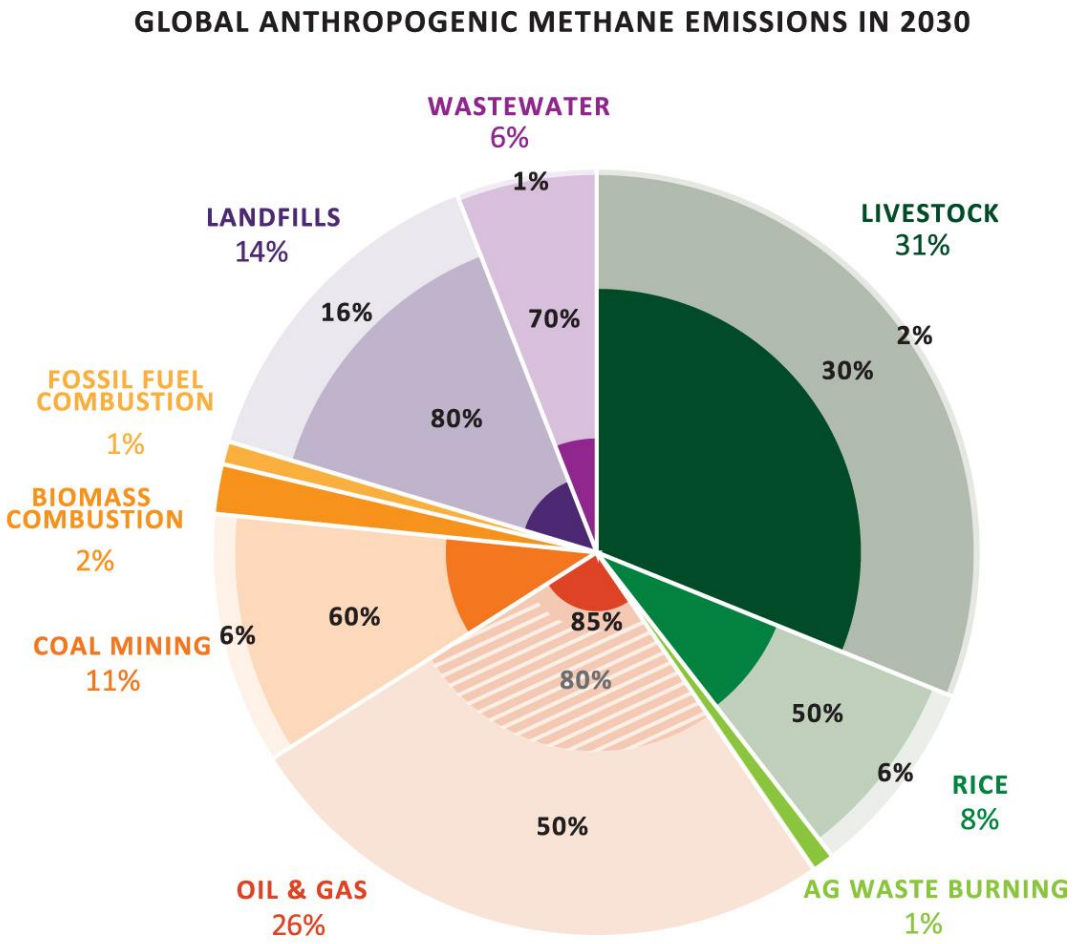
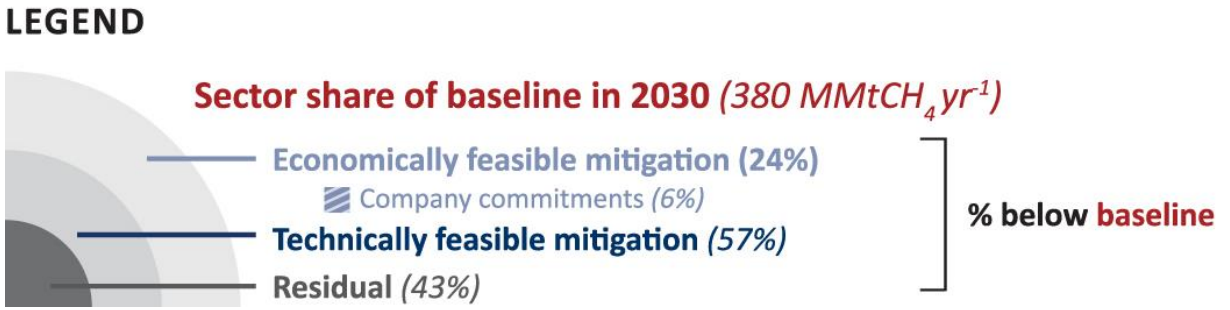
2: GHGSat Inc, Montréal, Canada
3: Harvard University, Cambridge, MA, US
4: Research Institute of Water and Environmental Engineering (IIAMA), Universitat Politècnica de València (UPV), Valencia, Spain
5: International Methane Emission Observatory, United Nations Environment Program, Paris, France
6: Department of Earth Sciences, Vrije Universiteit, Amsterdam, The Netherlands

This research has been funded in the framework of UNEP's International Methane Emissions Observatory (IMEO).

Why is methane important?



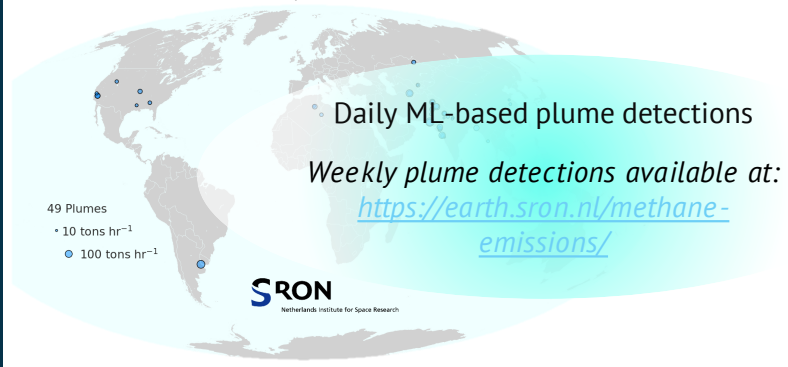


"while the existing potential to reduce methane emissions varies considerably by sector and by mitigation level, if deployed in parallel, they can cut anticipated methane emissions in 2030 in half, with a quarter of total emissions reduced at no net cost."

Ocko et al. 2021

Methane hotspot detection using TROPOMI

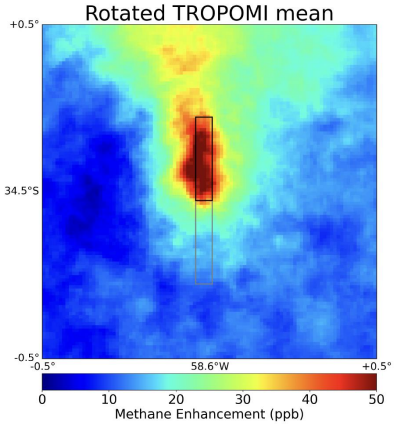
TROPOMI-detected methane plumes for 16/03/2024-22/03/2024



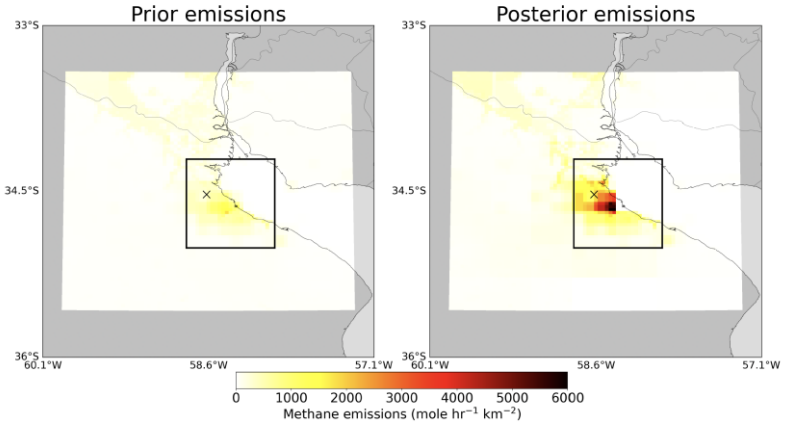
Daily ML-based plume detections

Weekly plume detections available at: https://earth.sron.nl/methane-emissions/

Source location estimate using wind-rotated TROPOMI data



Max downwind enhancement



Parallel efforts using inversions

Super emitter characterization (Activity and Quantity)

Tip and Cue

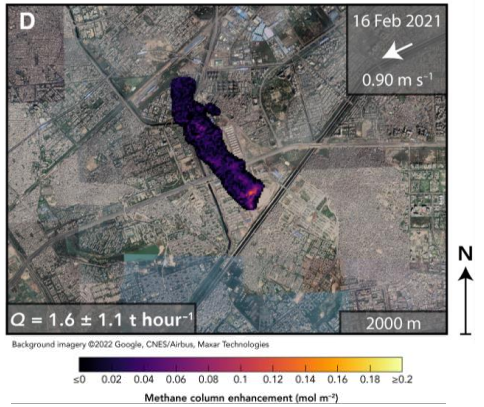
UNEP-IMEO Methane Alert Response System

(Targeted measurements using PRISMA, EnMAP, Sentinel-2, Landsat)

Image source: UNEP-IMEO (Accessed via : www.unep.org)

GHGSat

(Targeted measurements using the GHGSat constellation)



Methane hotspot detection using TROPOMI

TROPOMI-detected methane plumes for 16/03/2024-22/03/2024

- Daily ML-based detections using TROPOMI methane data (Schuit et. al 2023)
- Estimated source location & quantification
- Manual verification every week
- *Weekly plume maps are available at:* *https://earth.sron.nl/methane-emissions/*

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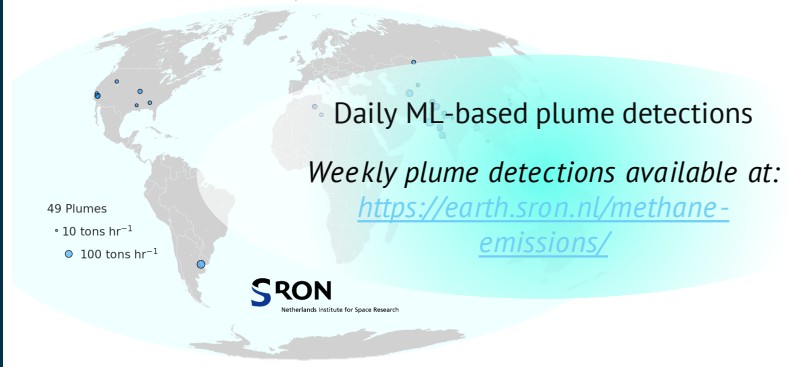

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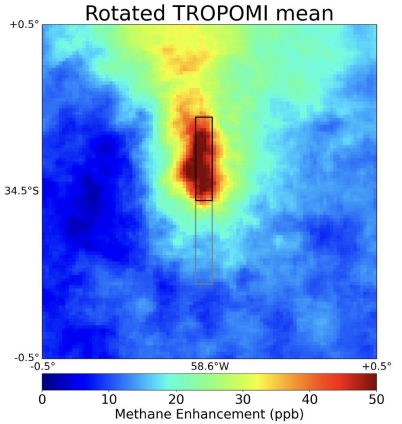

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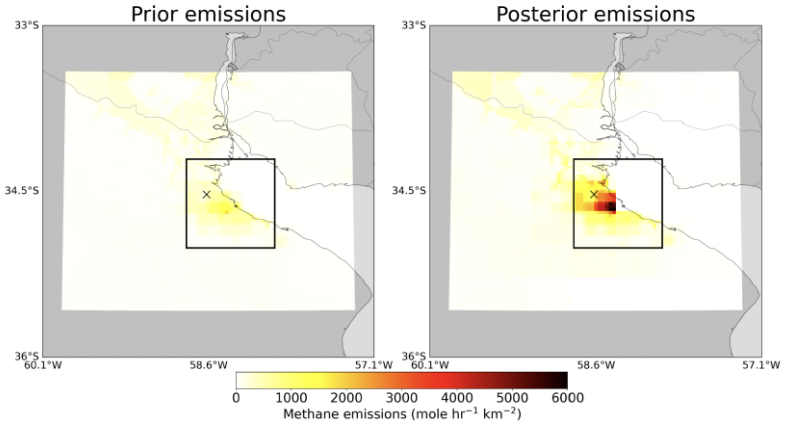

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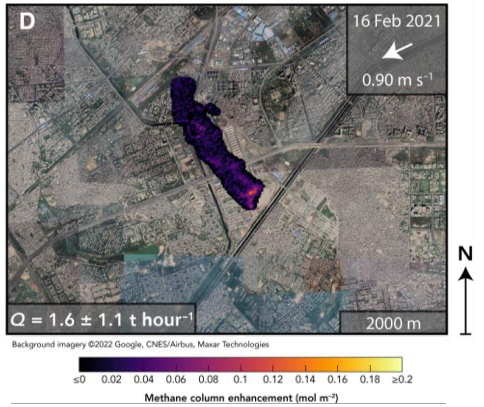

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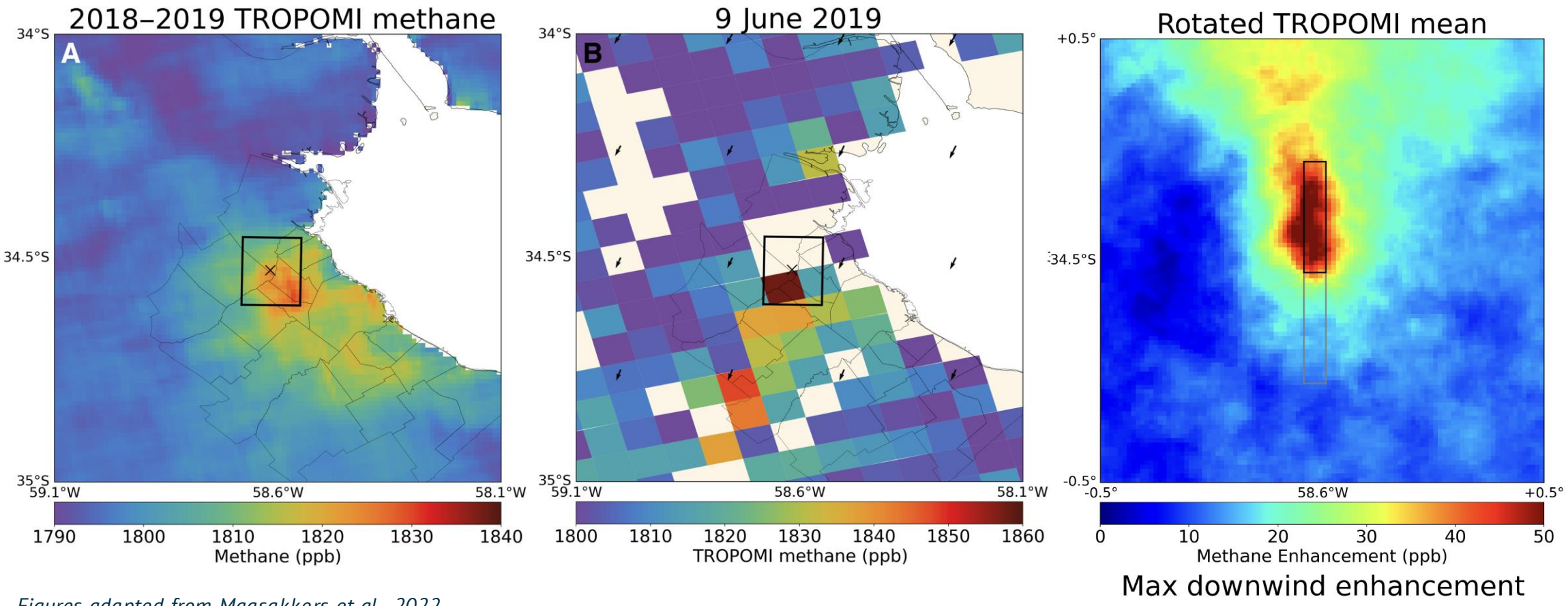

Figures adapted from Maasakkers et al., 2022

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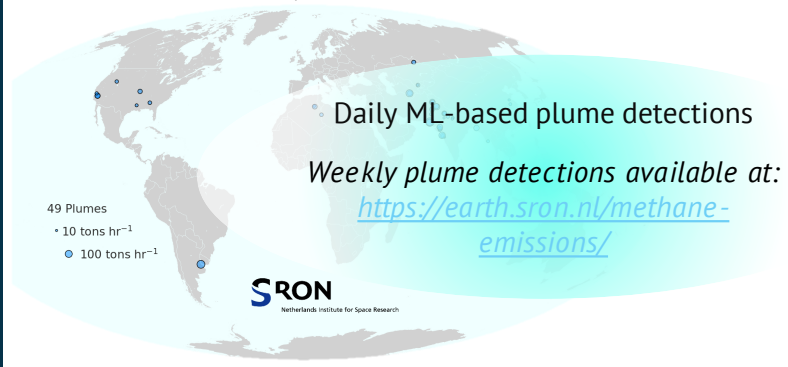

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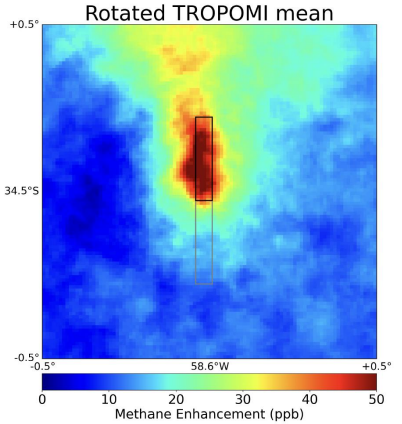

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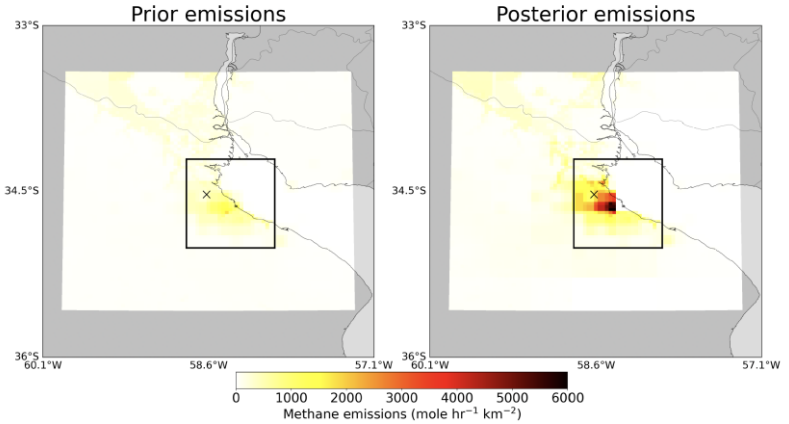

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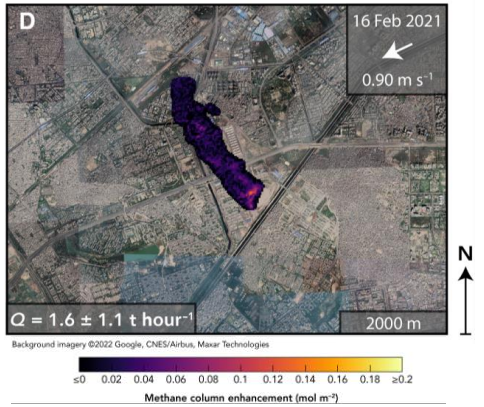

Methane hotspot detection using TROPOMI

> New hotspots communicated to IMEO and GHGSat every three weeks

> Use targeted high-resolution instruments to pin-point source locations

> IMEO additionally engages with stakeholders

> Mitigation of methane emissions at detected hotspots

Super emitter characterization
(Activity and Quantity)

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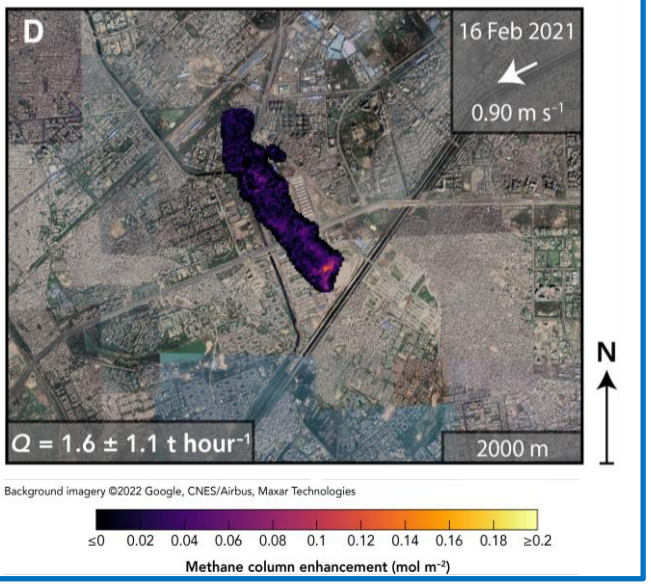
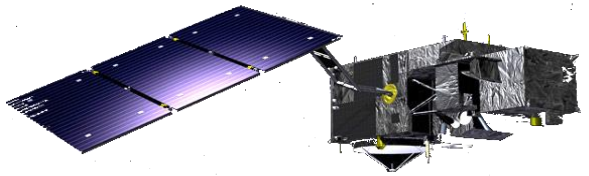


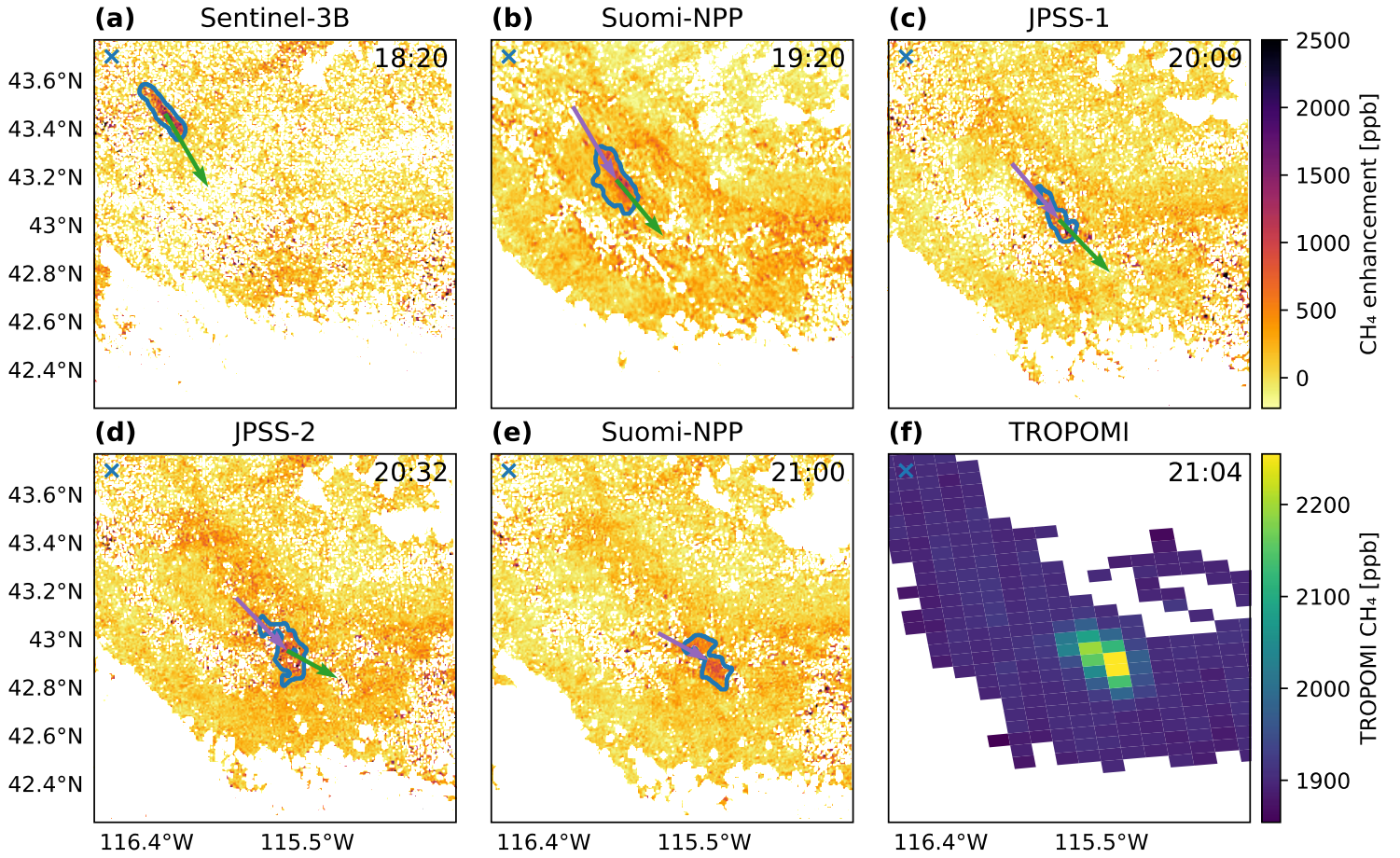
Added capabilities of using high resolution instruments

Sentinel-2

Sentinel-3

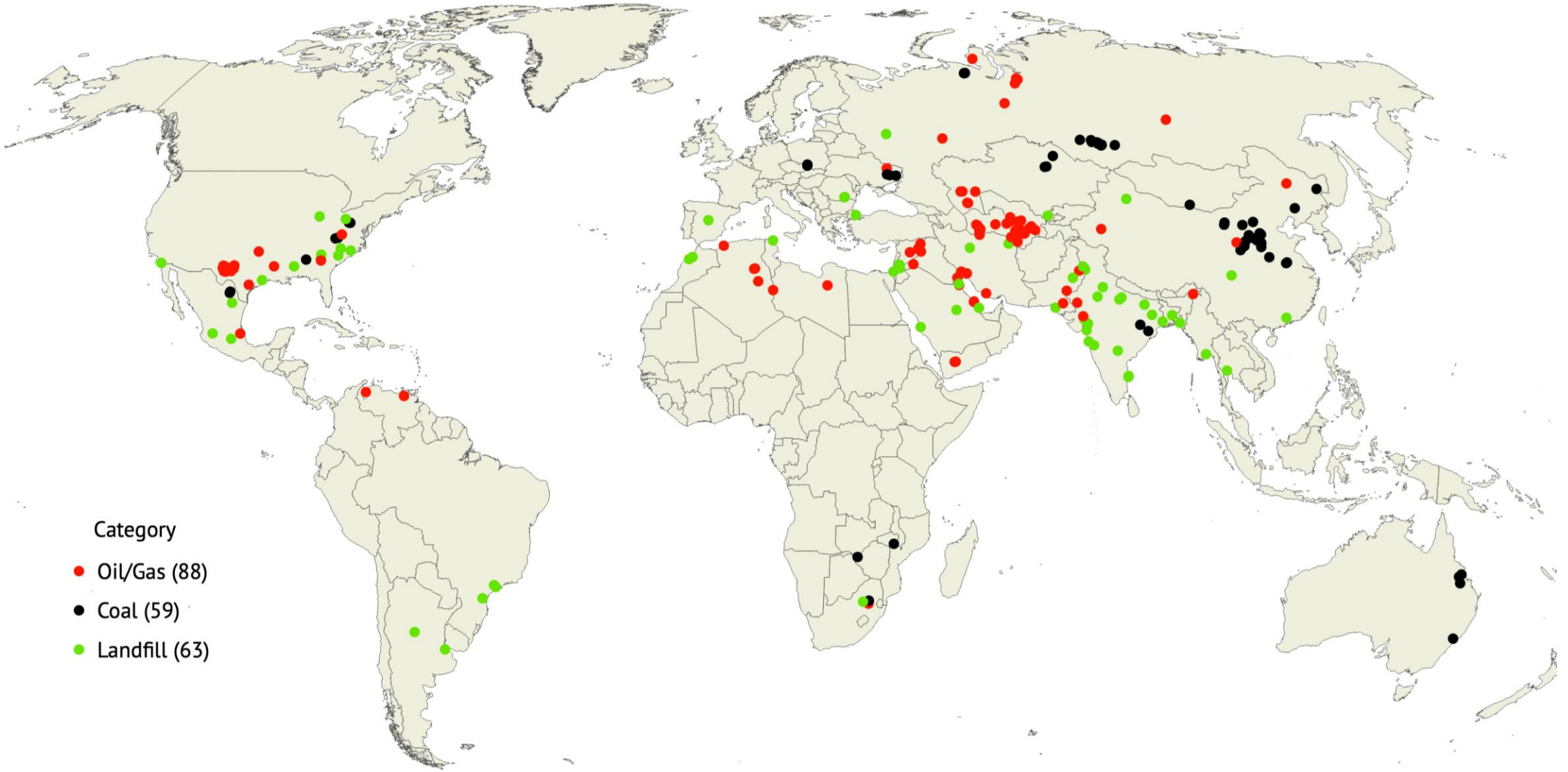


JPSS (VIIRS)



Jong et al. 2024

Persistent methane hotspots detected using TROPOMI data categorized into potential source-categories



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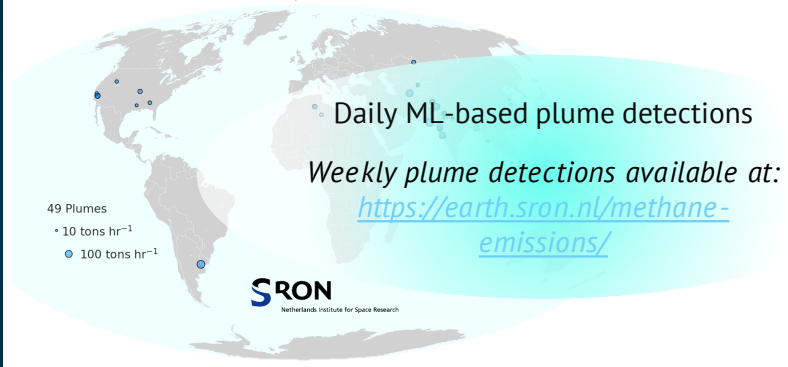

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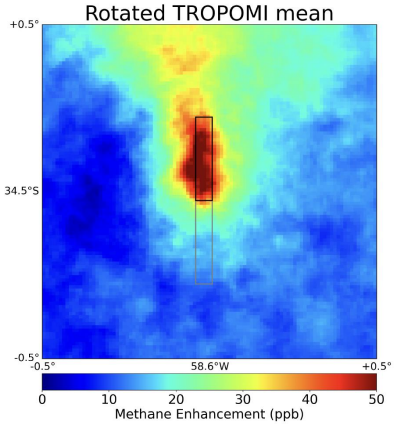

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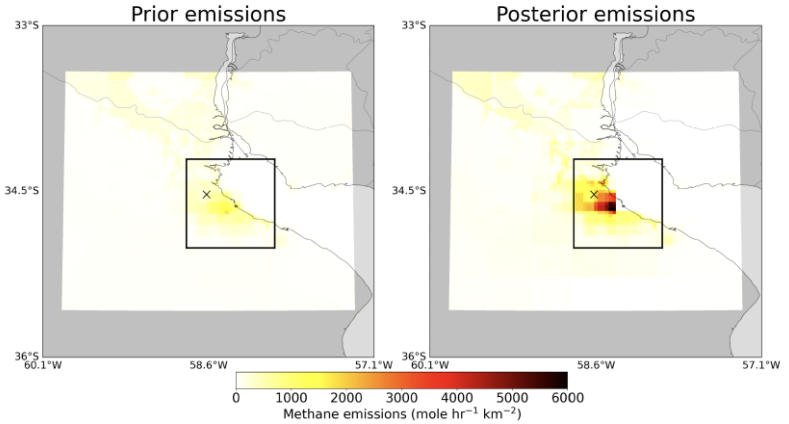

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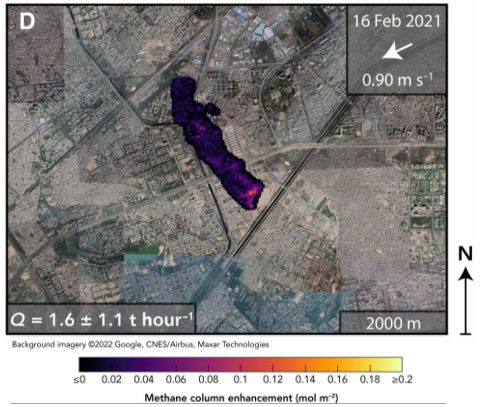
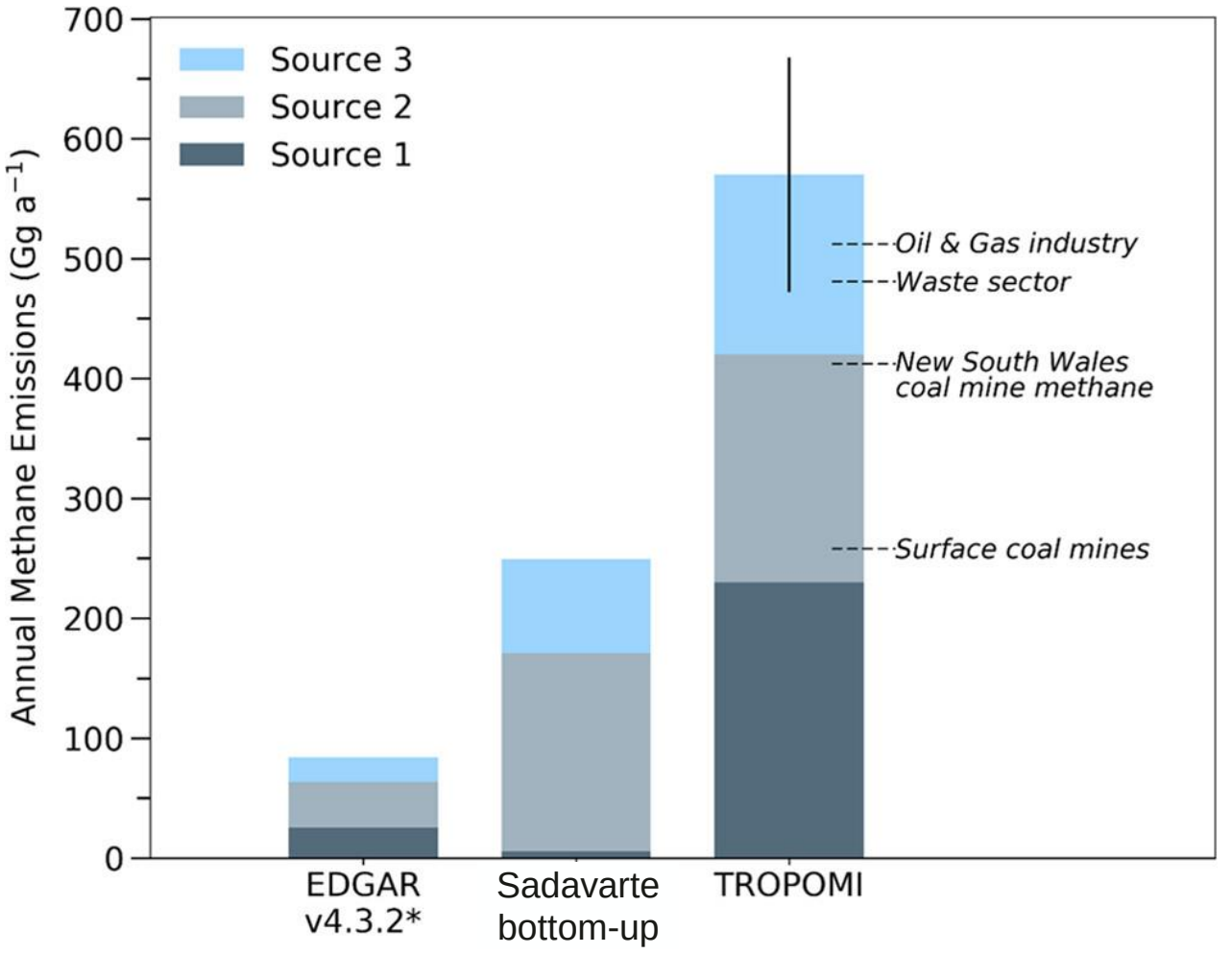


Parallel efforts using inversions

Sadavarte et al. 2021

> The study, using TROPOMI observations (2018), quantified unexpectedly high emissions at the Australian Hail Creek surface coal mine

> The study highlighted a significant discrepancy with bottom-up emission estimates, especially for the surface coal mine



Case study of the Kazakhstan Coal Mine

Bogatyr, Severny & Vostochny Coal Mines

> Operating since 1979

> Combined, the three coal mines account for more than ~45% (~60Mt) of Kazakhstan's coal production

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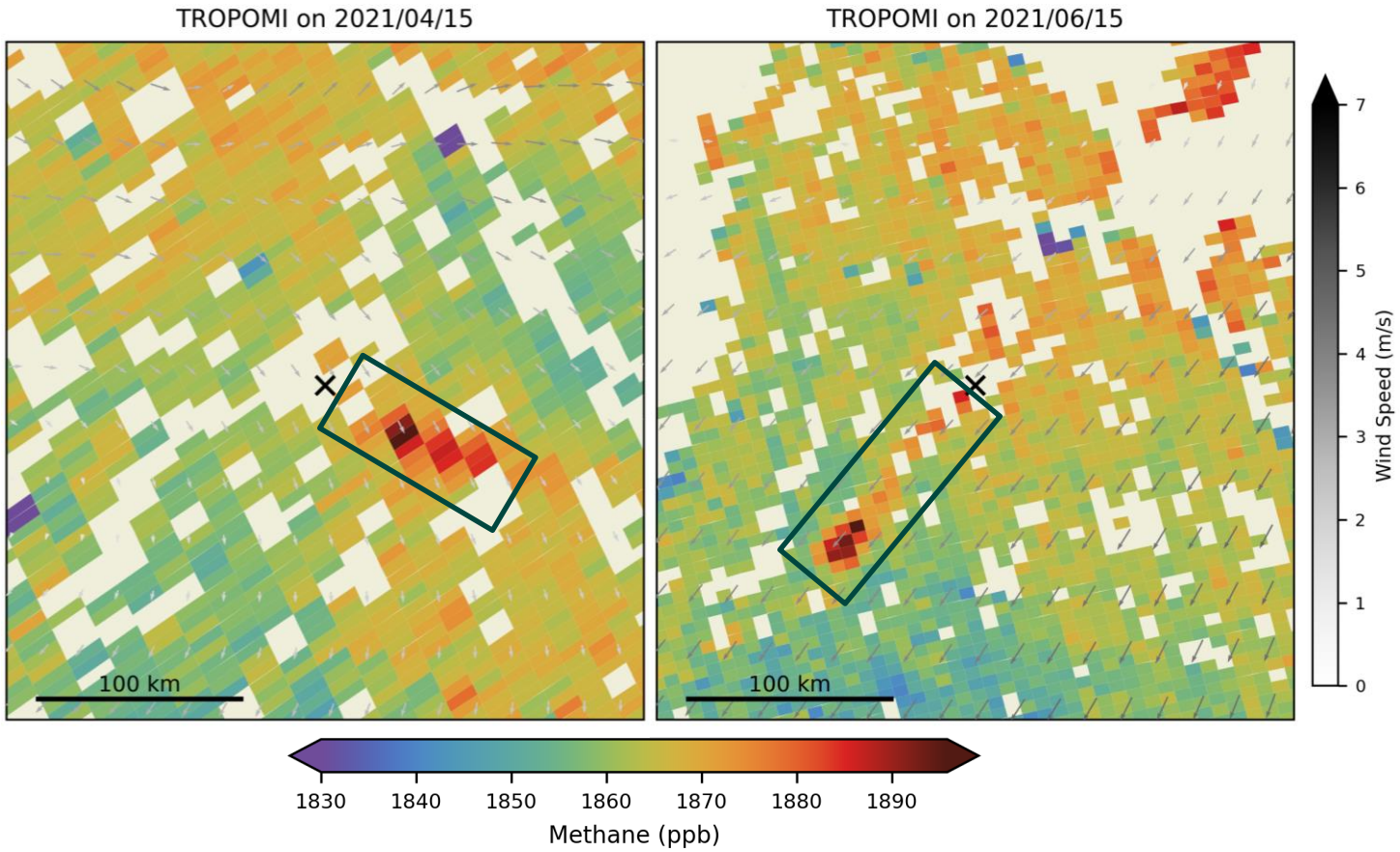

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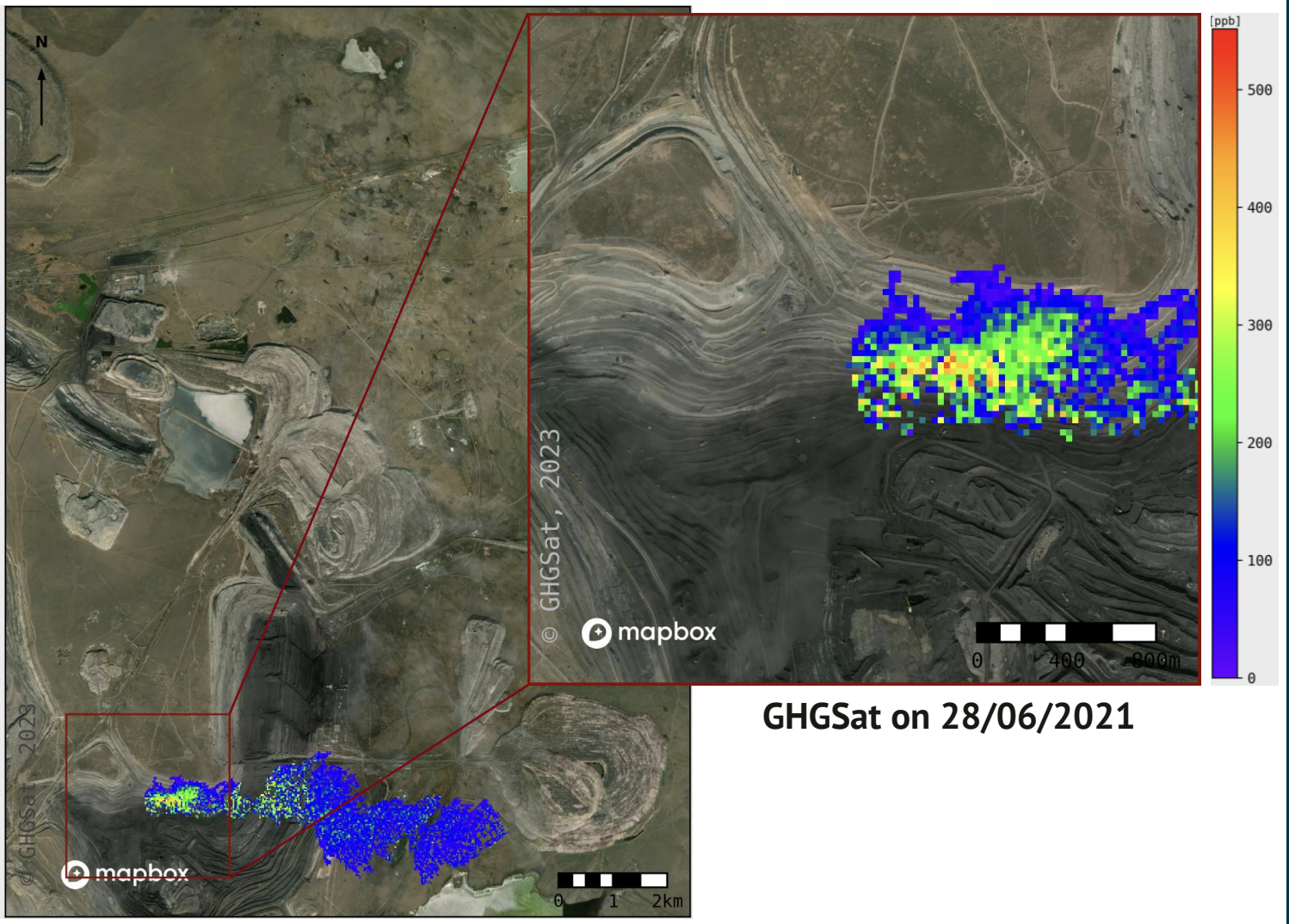
Bogatyr, Severny & Vostochny Coal Mines

- Operating since 1979
- Combined, the three coal mines account for more than ~45% (~60Mt) of Kazakhstan's coal production
- A persistent source with frequent emission detections in TROPOMI data
- Emissions are also frequently detected in GHGSat observations



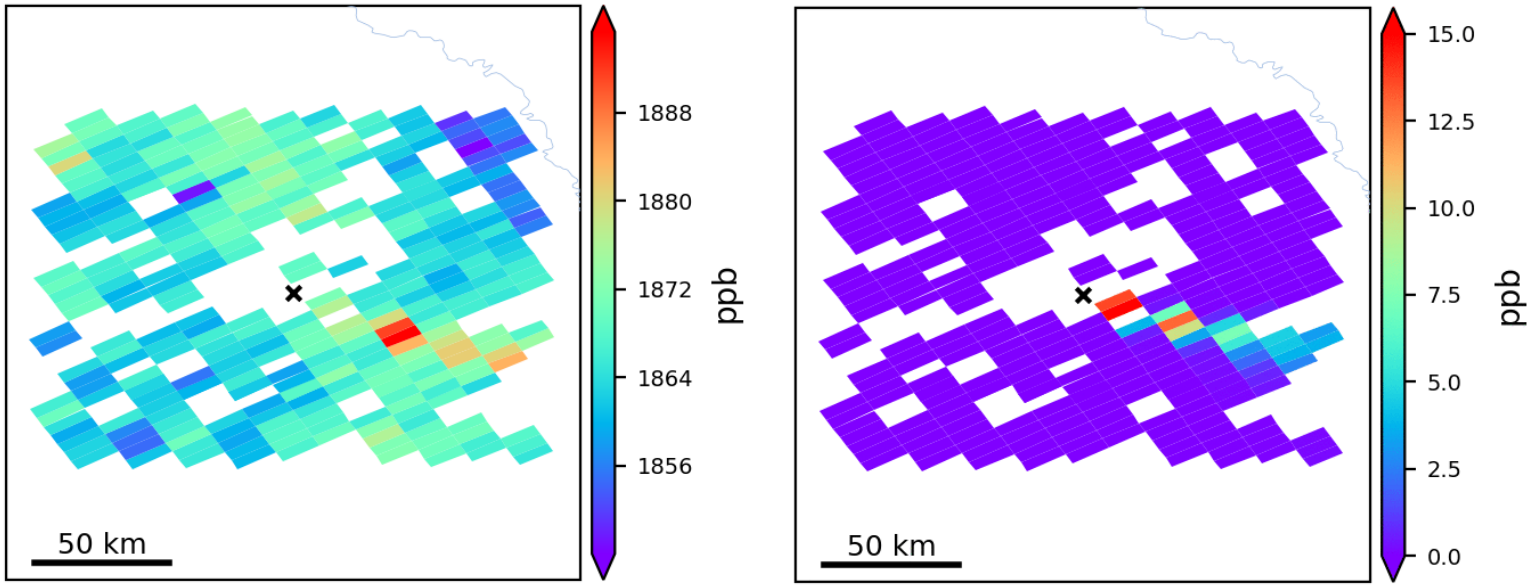
GHGSat on 28/06/2021

Case study of the Kazakhstan Coal Mine

Quantifications of TROPOMI detected emissions using Inversions

TROPOMI observation

Simulated plumes



Bayesian Inversion framework

Optimized Emission Rate

Case study of the Kazakhstan Coal Mine

	UNFCCC (using country av. EF)	GFEI v2 (Scarpelli et al. 2022)	EDGAR v7	TROPOMI based inversion
Emission Rate (t/hr) (2021)	**9.9**	**7.2**	**8.6**	**10.9 ± 5.7***

> Emissions rates estimated from TROPOMI observations-based inversions align with reported and bottom-up estimates.

> GHGSat observations-based emission rates for 2021 are also consistent with the quantified emission rates

> Expand this analysis to include other large surface mines from which we observe emissions in TROPOMI

**Results are preliminary*

Conclusions and Outlook

- The **synergy between TROPOMI and high-resolution satellites has proven effective** for the detection and location of methane super-emitters and hotspots.
- Utilizing observations from more high-resolution instruments to support hotspot detections and improve emission quantification.

Upcoming projects

- MEDUSA: Methane Emission Detection Using Satellites Assessment

  Intercomparison and validation of methane detection and emission quantifications across research groups.

  (Poster (P2.18) by Ilse Aben & Matthieu Dogniaux)

Climate > News

Oil giant fined just $780,000 after 'one of world's biggest ever' methane leaks

Leak comparable to that of driving more than 717,000 petrol cars for a year

Stuti Mishra • Wednesday 21 February 2024 13:55 • Comments

Home > News > New EU Methane Regulation to reduce harmful emissions from fossil fuels in Europe and abroad

NEWS ANNOUNCEMENT | 27 May 2024 | Directorate-General for Energy | 1 min read

New EU Methane Regulation to reduce harmful emissions from fossil fuels in Europe and abroad

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The **first-ever EU rules to curb methane emissions from the energy sector** in Europe and across the globe have become legislation today. This adoption marks another step in the implementation of the European Green Deal and REPowerEU. It shows Europe's determination to tackle harmful emissions at home and internationally.