# Detecting methane emissions from palm oil mills with airborne and spaceborne imaging spectrometers

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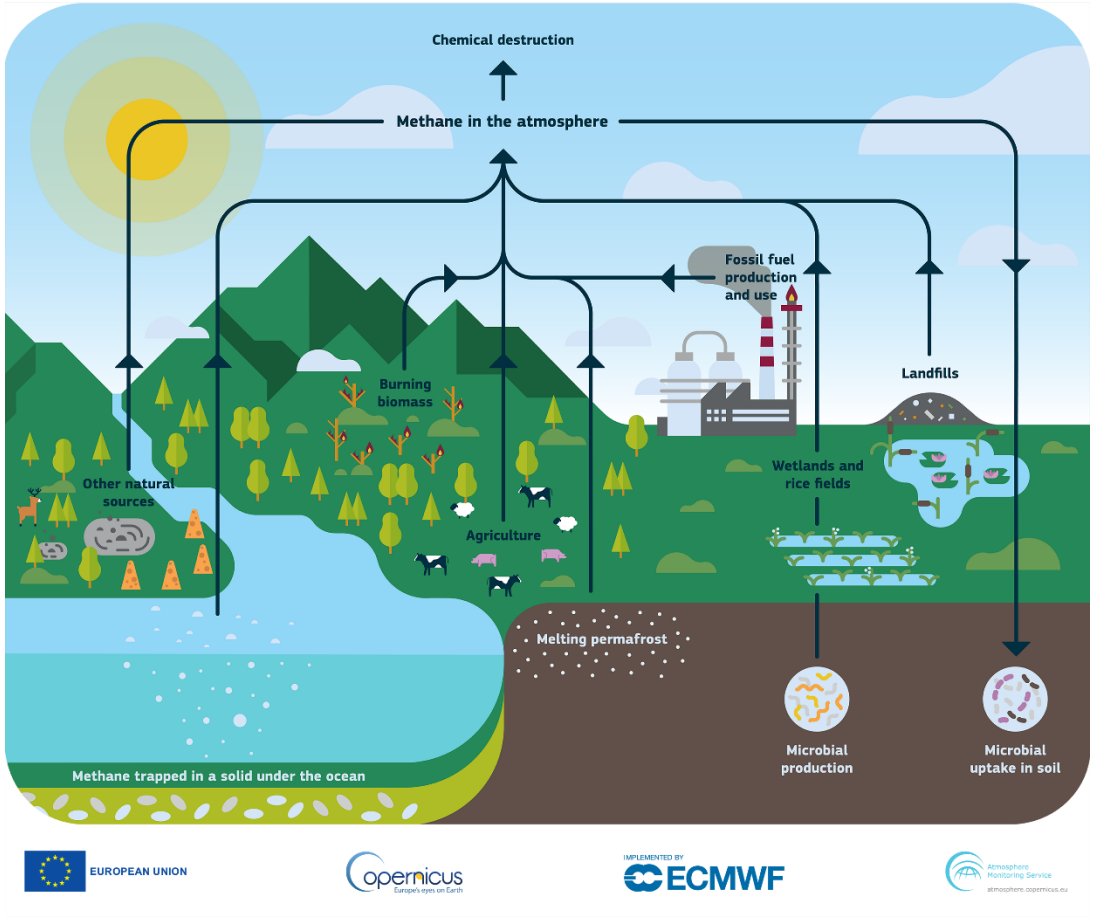
**Methane** ($CH_4$) is the second strongest anthropogenic greenhouse gas after $CO_2$



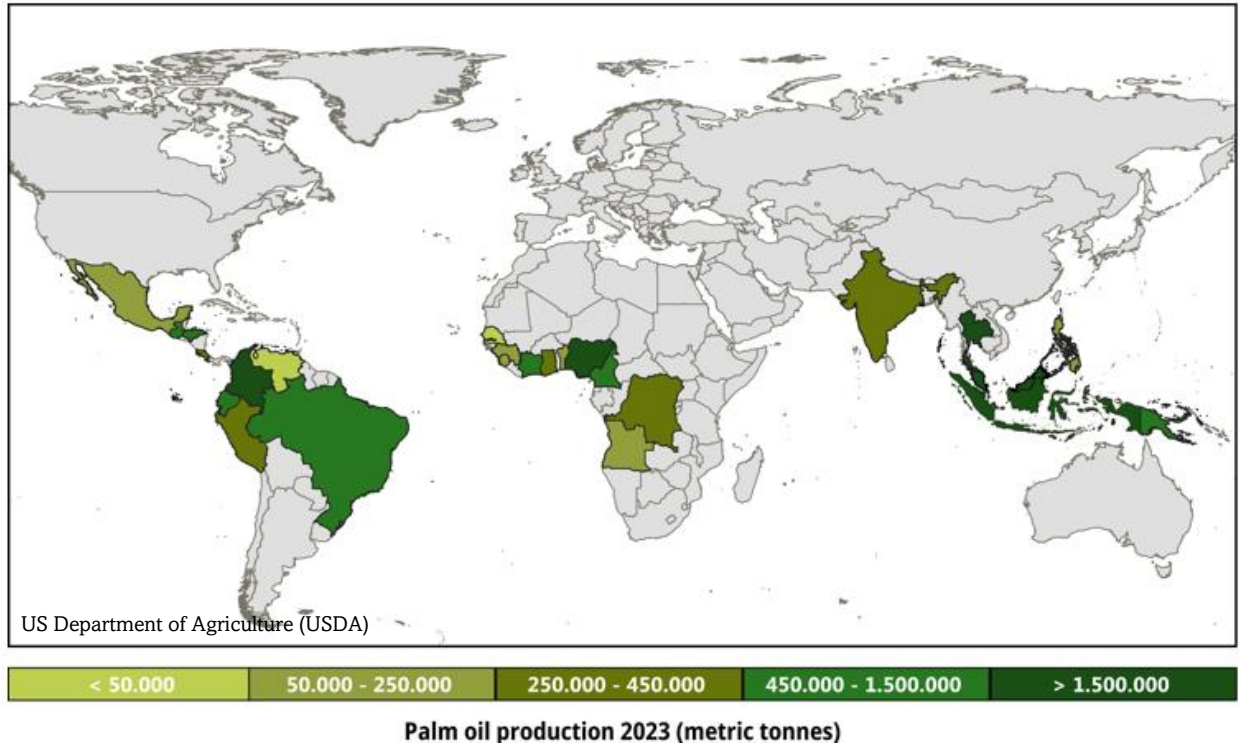

Waste sector

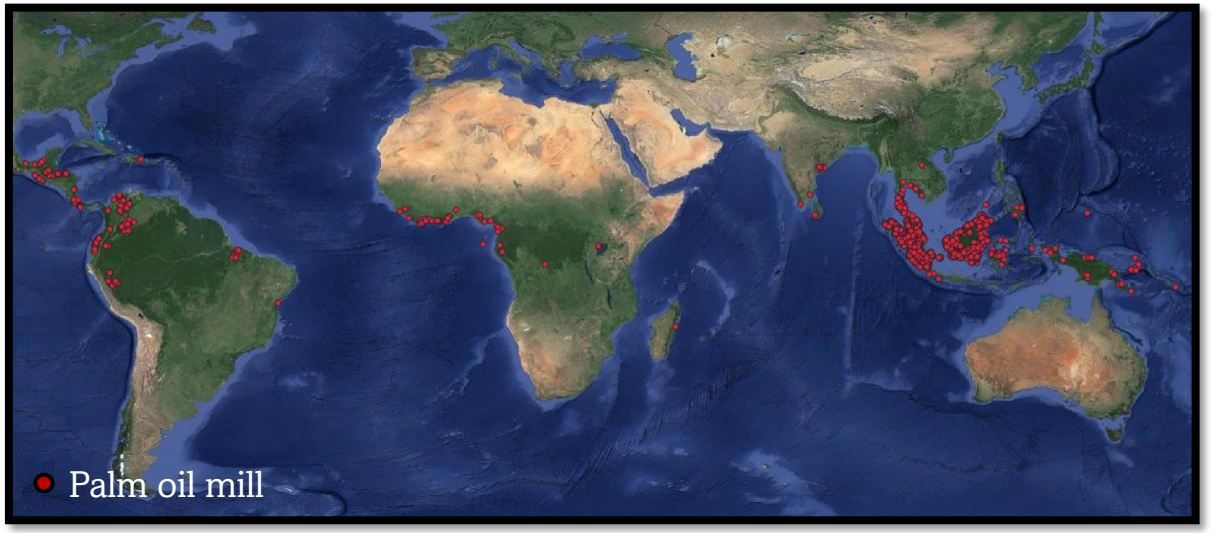
↓

~15% of these emissions

# Introduction

**Palm Oil Global Production** (2023) → **79.76 million metric tons**




Universal Mill List (UML)

- **Study Area**: Indonesia, Malaysia and Colombia.

To identify palm oil mills, we use the database of Universal Mill List (UML) of Global Forest Watch.

## Methane emissions during the palm oil mil process

*Palm Oil Fruit Bunches*

*Palm Oil Mill Efluent* (POME)

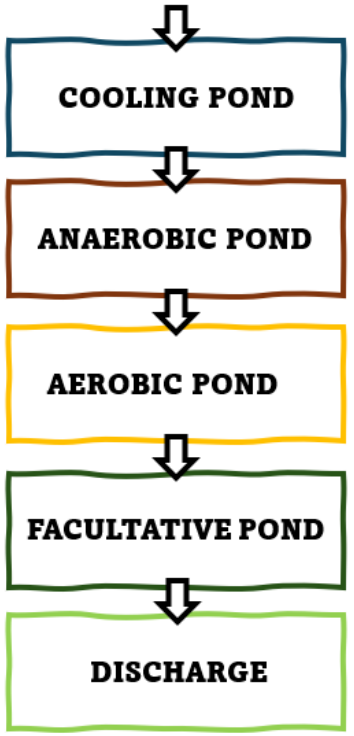
**Crude Palm Oil** (CPO)
**Palm Kernel Oil** (PKO)

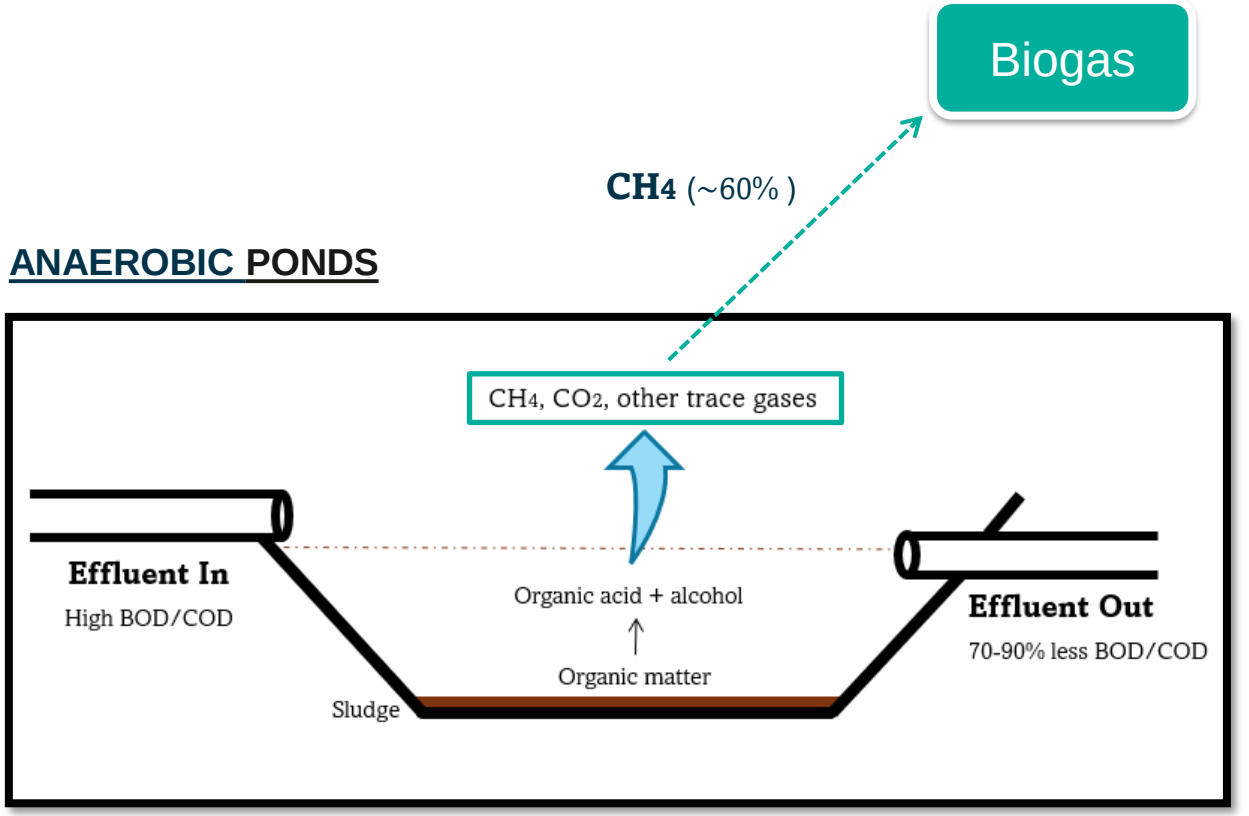
| | |
|---|---|
| **Temperature (°C)** | 80-90 |
| **pH** | 4-5 |
| **COD*** **(mg $L^{-1}$)** | 25,000 |
| **BOD**** **(mg $L^{-1}$)** | 51,000 |

* Chemical Oxygen Demand
** Biochemical Oxygen Demand

## Methane emissions during the palm oil mil process

**Palm Oil Mill Effluent (POME) → Ponding system**




**Previous studies → $CH_4$ emissions 100 - 450 kg/h**

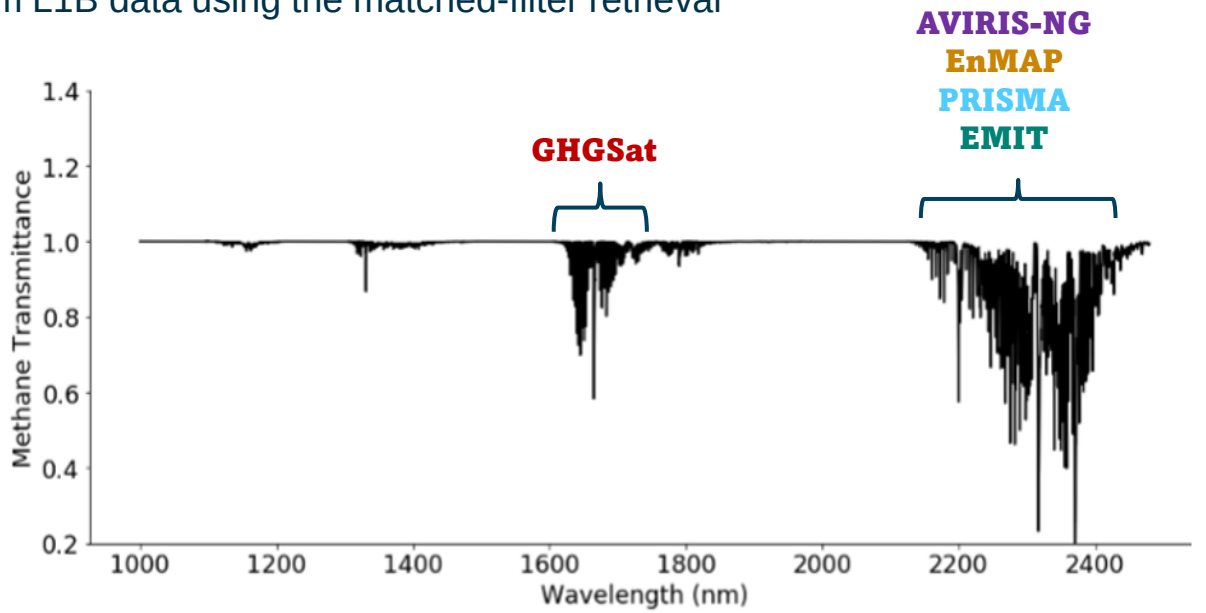
# Methods

- **Methane data from air/spaceborne imaging spectrometers:**
  - **GHGSat:** official ΔXCH4 * user product
  - **AVIRIS-NG:** ΔXCH4 * maps downloaded from the Carbon Mapper data portal
  - **EnMAP, PRISMA** and **EMIT:** ΔXCH4 * maps derived from L1B data using the matched-filter retrieval

- **Detection limit of these instruments:**
  - ~ 500 kg/h for PRISMA, EnMAP and EMIT
  - ~ 100 kg/h for GHGSat
  - ~ 10 kg/h for AVIRIS-NG

… Can they detect these emissions?

**Previous studies → $CH_4$ emissions 100 - 450 kg/h**

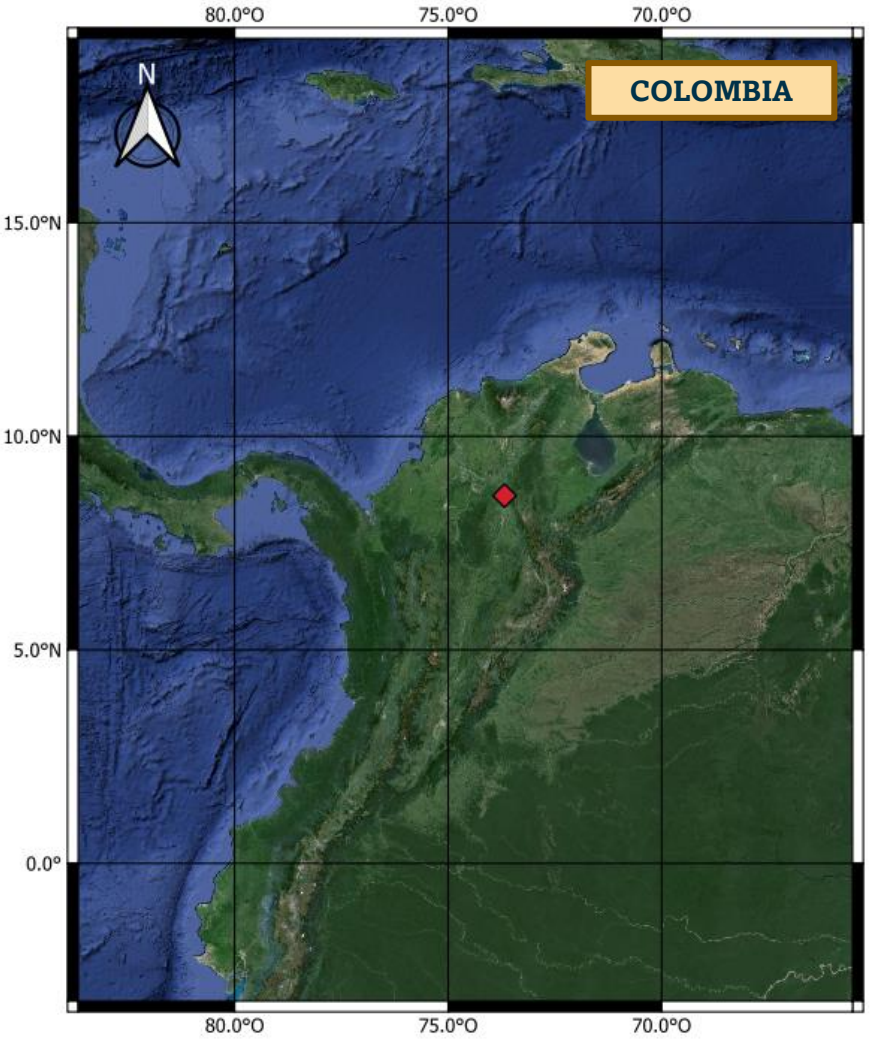


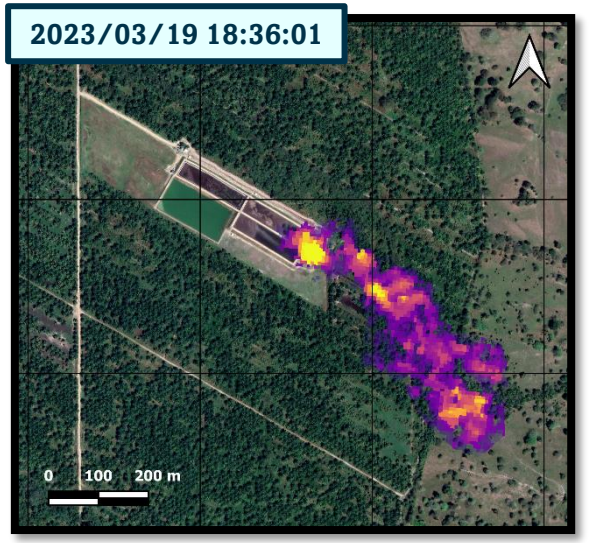

* $\Delta XCH_4$ : methane concentration enhancement

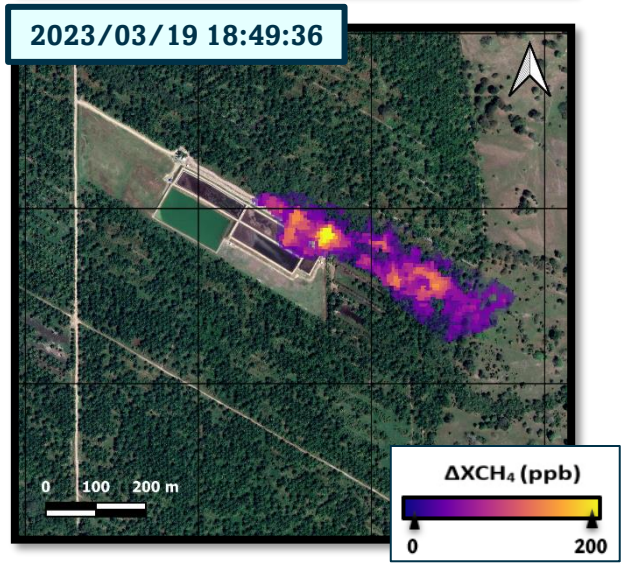
# Results

❖ **Plume detections in Colombia with AVIRIS-NG**

- Two methane plumes over the ponds of a palm oil mill in Colombia, within a 13-minute interval
- In operation since 2008, with a processing capacity of 45 t/h in 2023
- Estimated emissions are:
  - 2023/03/19-18:36:01 = **130 ± 80 kg $CH_4$**
  - 2023/03/19-18:49:36 = **142 ± 51 kg $CH_4$**



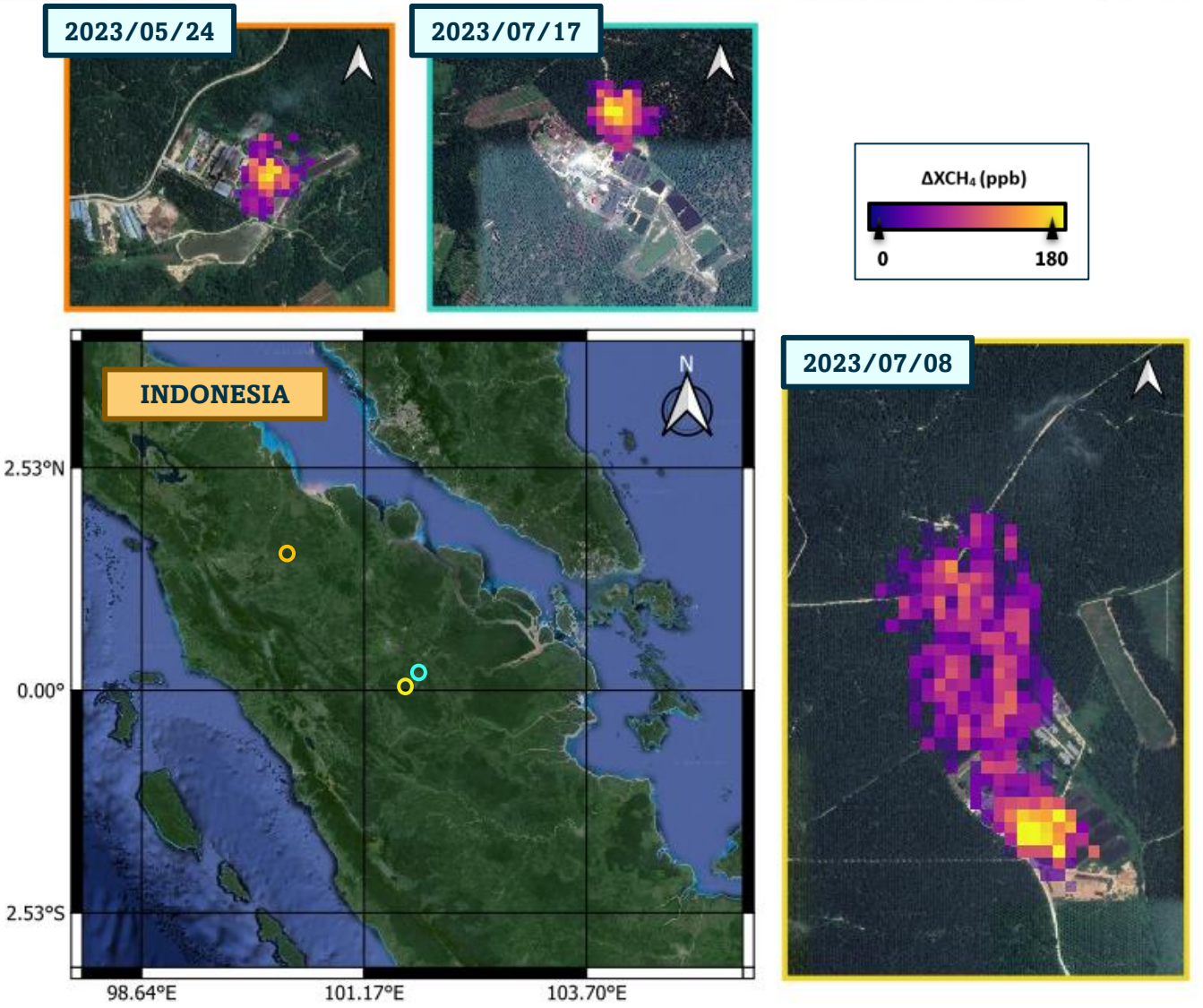



# Results

❖ **Plume detections in Indonesia with GHGSat**

- Three methane enhancements over different palm oil mills in Indonesia
- These mills have a processing capacity between 20-40 t/h and none of these have a biogas system
- Estimated emission:

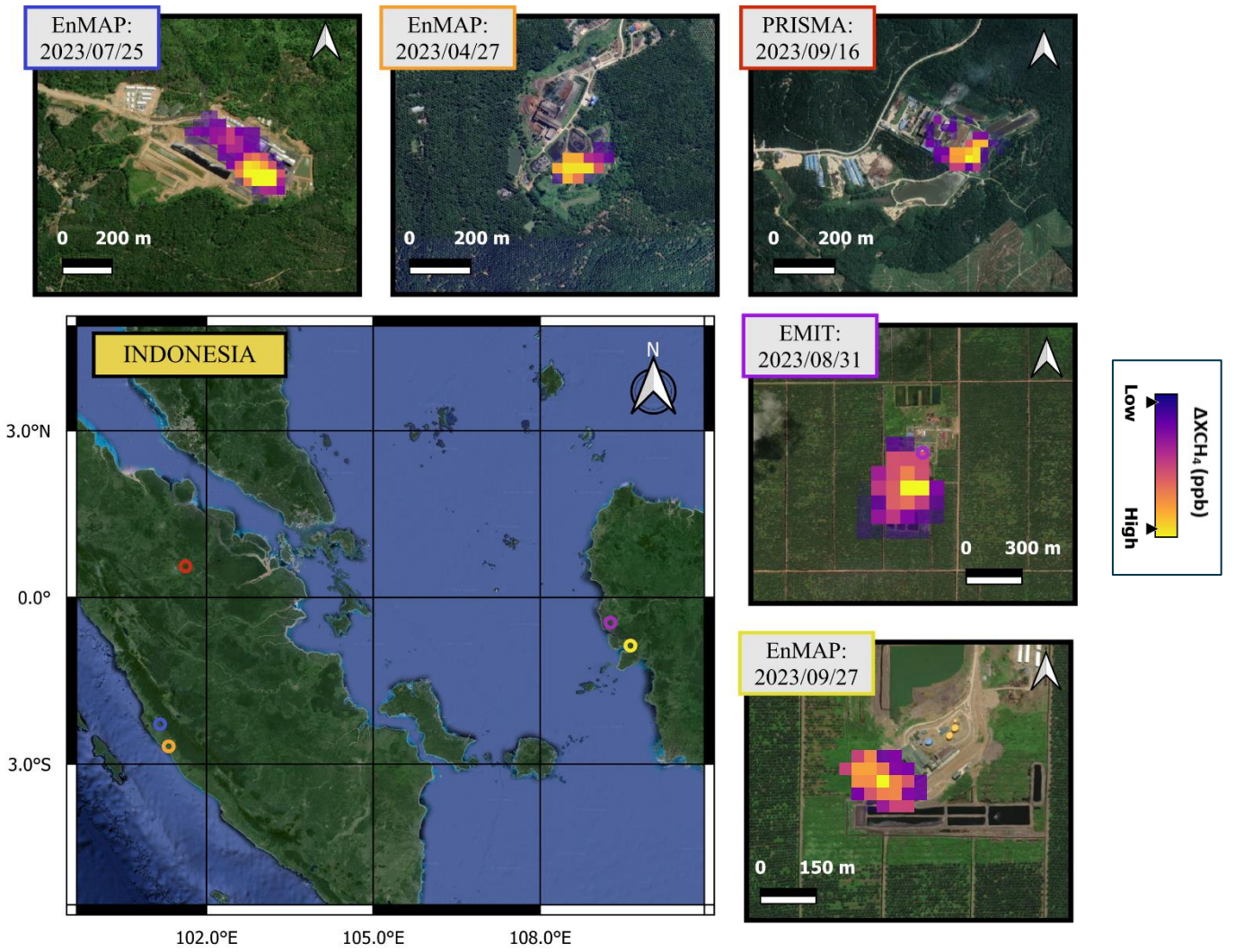
  - 2023/07/08 = **515 ± 303 kg $CH_4$**



# Results

- **Test of plume detections with PRISMA, EnMAP and EMIT**

  - We have detected more than 20 methane enhancements in different palm oil mills in Indonesia, Malaysia and Colombia

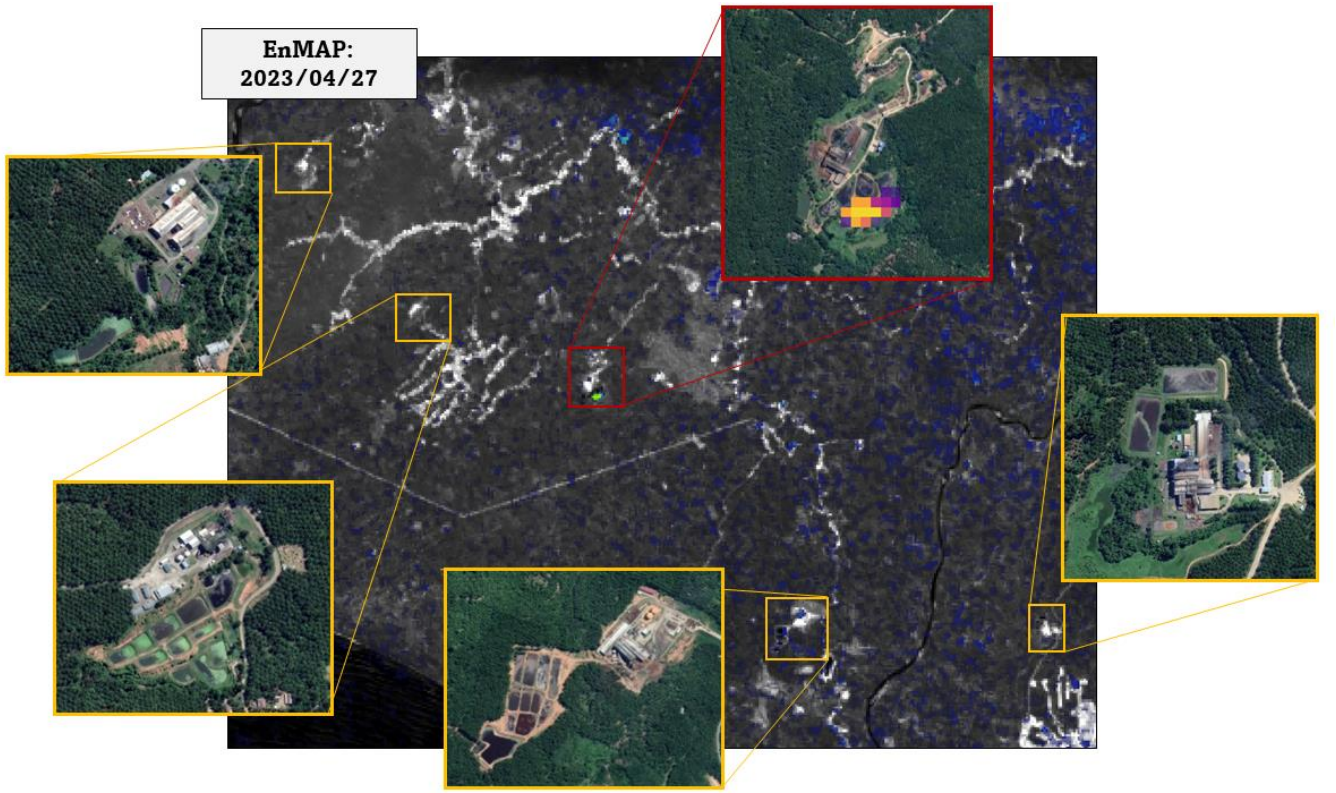


# Results

❖ **Test of plume detections with PRISMA, EnMAP and EMIT**

- We have detected more than 20 methane enhancements in different palm oil mills in Indonesia, Malaysia and Colombia

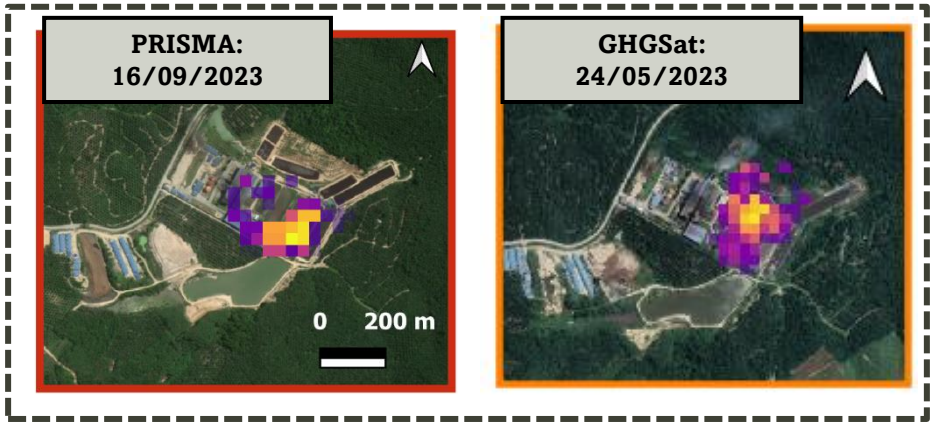
- Some of them correspond to ponds with apparently similar spectral characteristics as those of other ponds from which no enhancement was found

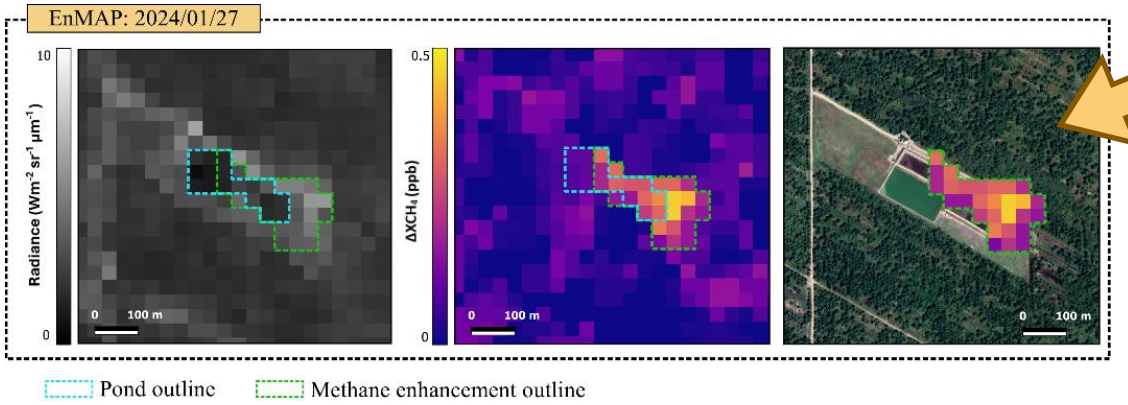


# Results

## ❖ Test of plume detections with PRISMA, EnMAP and EMIT

- We detected with PRISMA a methane enhancement in the same pond in Indonesia as GHGSat
- We detected with EnMAP a methane enhancement in the same pond in Colombia as AVIRIS-NG
- We do not observe a direct correlation between the retrieval pixels of the possible methane enhancement map and the radiance pixels



# Conclusions

- Improved methodologies are increasing the capabilities to detect **new sources** of methane emissions. One of these is methane emissions from palm oil mills, a challenge for sensors due to **low emissions** combined with **low surface reflectance** and **high scene heterogeneity**

- Currently, we have detected several methane emissions using the airborne **AVIRIS-NG** and **GHGSat** satellite constellation, in Colombia and Indonesia, respectively. Their flux rate estimates are consistent with emission estimates for palm oil mill in the literature

- The analysis of the potential of **EnMAP, PRISMA and EMIT** for this application needs further research. We have tried to reconcile the apparent methane enhancements derived from those instruments with their relatively high detection limits. Are palm oil emissions **stronger** than previous studies reported, or we are only looking at **retrieval artifacts**?

# Thank you for your attention!

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