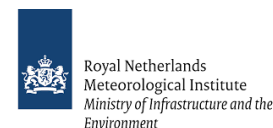# It Takes Two to Tango

The Twin Anthropogenic Greenhouse Gas Observers

Pepijn Veefkind, Jochen Landgraf, Nurcan Alpay Koc, Zeger de Groot and the TANGO Team

TANGO

SRON
Netherlands Institute for Space Research

Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

TNO innovation for life

ISISPACE

TANGO | ESA Scout

Objective: Quantification of CO_2 and CH_4 point source emissions

Two CubeSats (16 units/liter):

- ✓ TANGO-Carbon and TANGO-Nitro
- ✓ Collocated CO_2/CH_4 (1.6 μm and NO_2 measurements (400-500 nm)
- ✓ Time difference < 60 s

$30x30$ km^2 field of view with a spatial resolution of 300 m

**Science mission
open data - open source policy**

CO_2/CH_4

NO_2
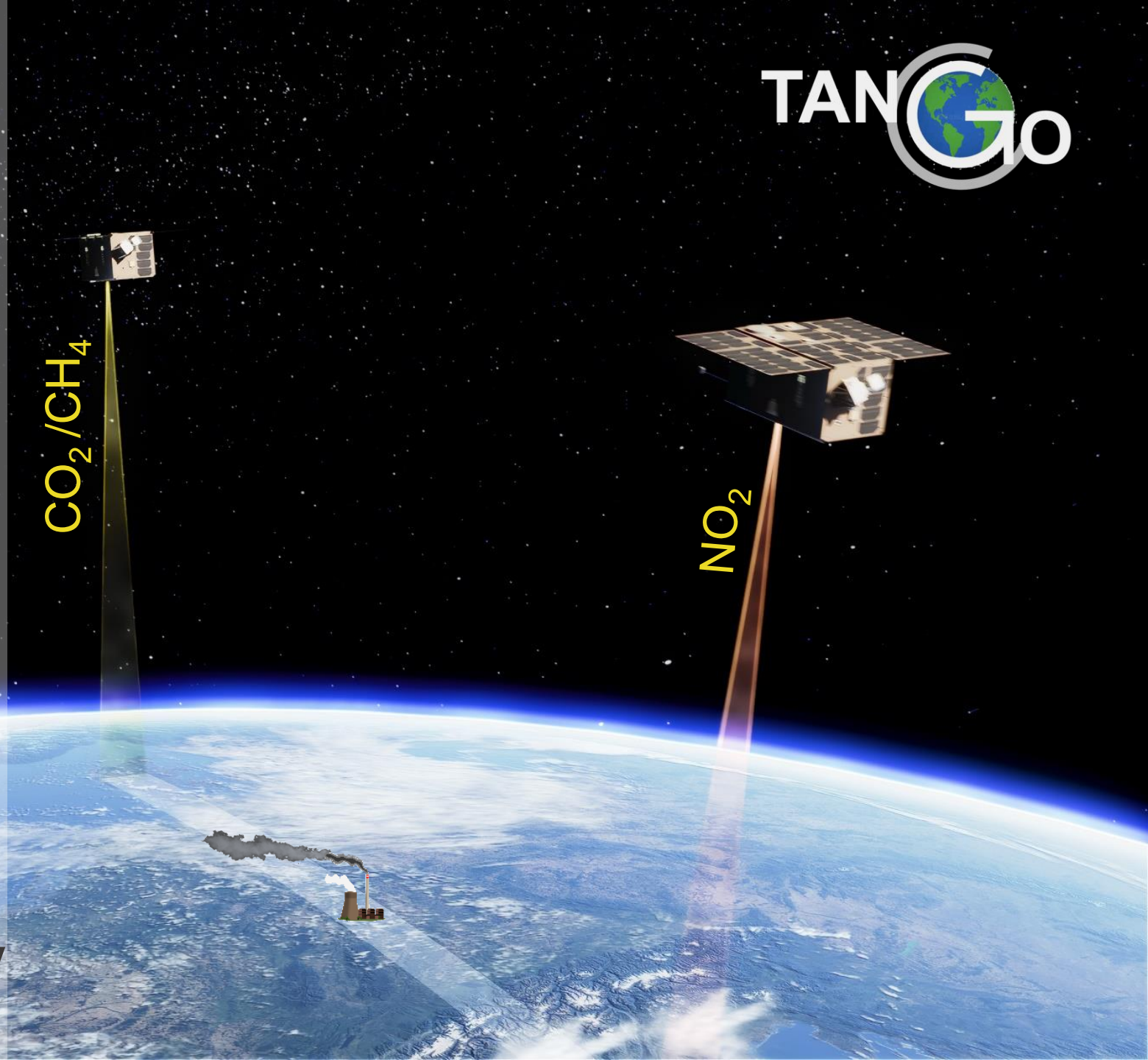
ESA Scout Programme

A Scout mission is defined by three key aspects:

- It delivers innovative science and technology

- It costs less than €35 million

- It is developed within three years, from kick-off to launch

Scout missions are literally scouts:
they pave the way to innovative science in a quick and agile fashion.

TANGO Mission Objective

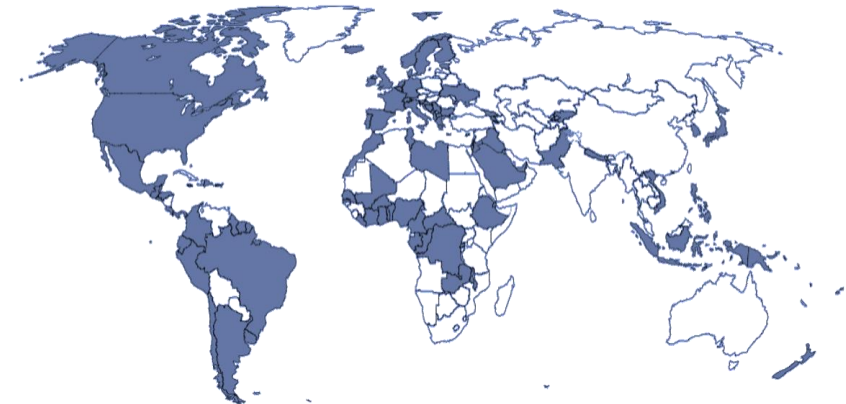## Quantify Point Source Emissions of CO_2 and CH_4 at Facility Scales

- To reduce uncertainties in emissions of point sources.
- In support of the Paris Agreement global stocktakes.
- In support of the Methane Pledge (30% reduction in 2030).
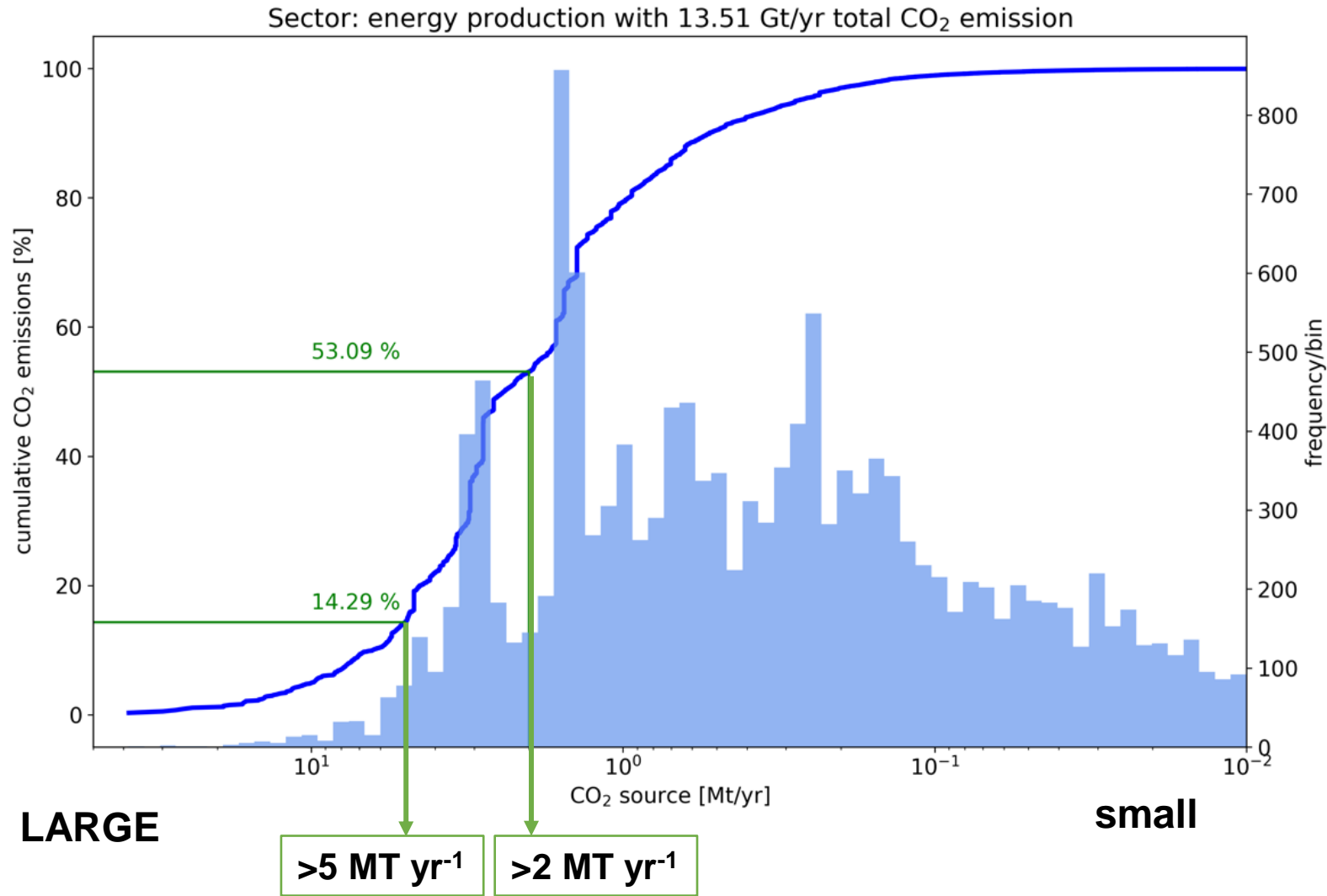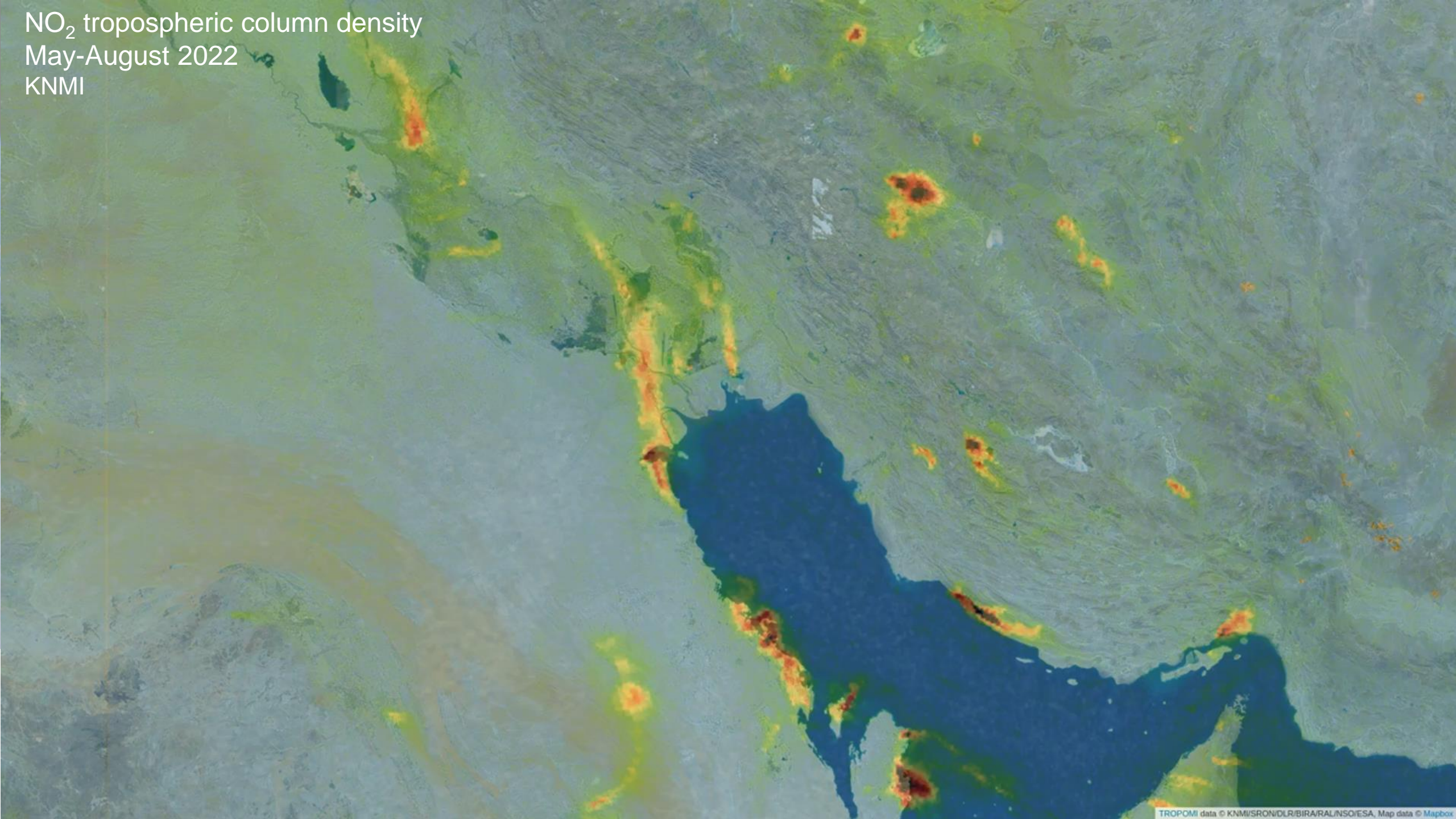
Paris Agreement

Methane Pledge

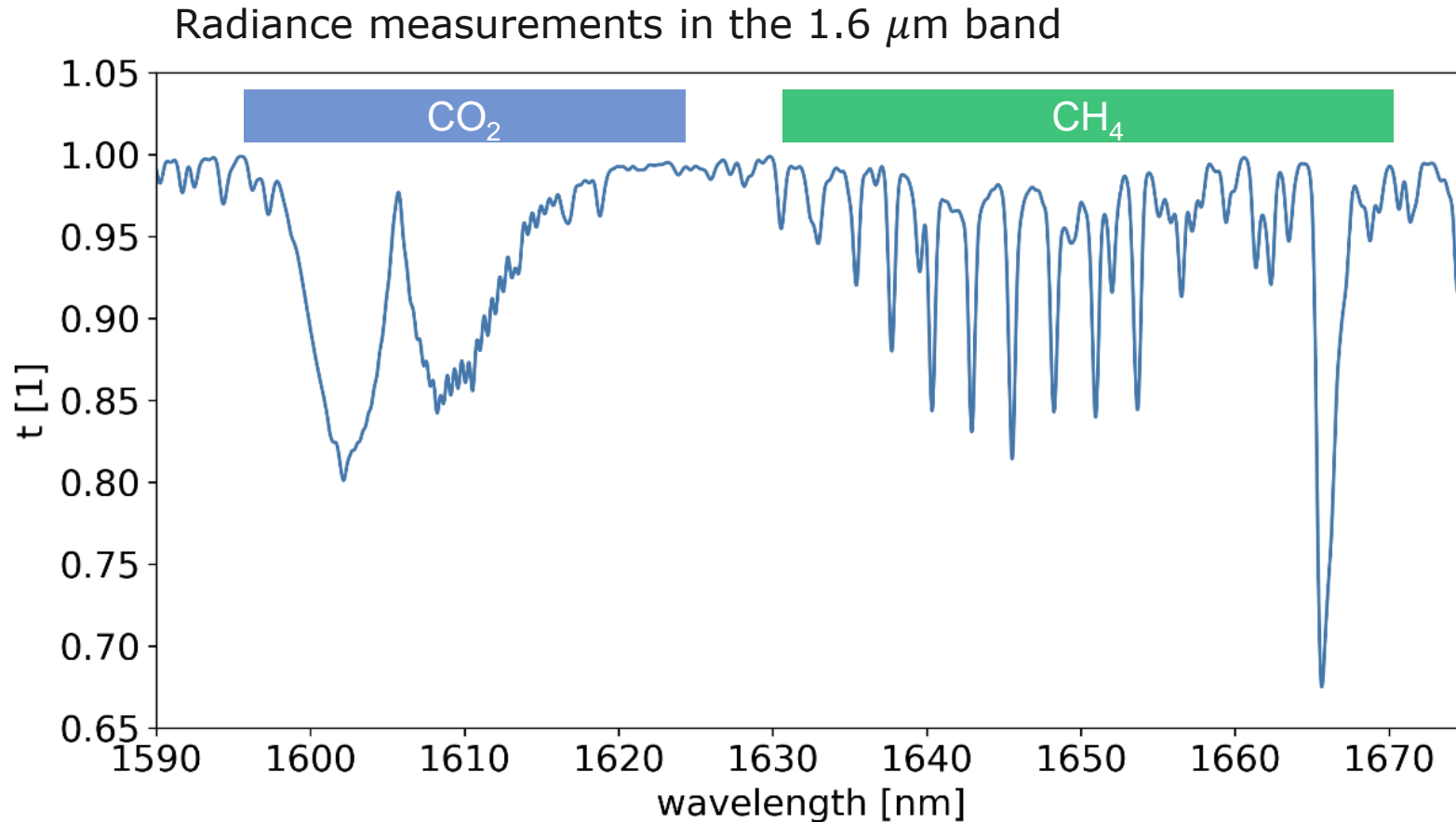# Emissions of the Energy Sector

Sector: energy production with 13.51 Gt/yr total CO_2 emission

NO$_2$ tropospheric column density
May-August 2022
KNMI

TROPOMI data © KNMI/SRON/DLR/BIRA/RAL/NSO/ESA, Map data © Mapbox

The Proxy Retrieval Method

Radiance measurements in the 1.6 μm band

Proxy retrieval approach:

$$\text{XCO}_2^{\text{pro}} = \frac{[\text{CO}_2]}{[\text{CH}_4]} \text{XCH}_4^{\text{mod}}$$

+ Only minor aerosol-induced error
+ Both CH_4 and CO_2 product
- Difficulties in interpreting mixed sources
- Precision is a factor ~1.5 lower than that of $[CH_4]$ and $[CO_2]$

Co-located CO_2-NO_2 Observations

- NO_2 observations will be used as plume indicator.

- CO_2/NO_x ratio can be determined and applied to other NO_2 observations.

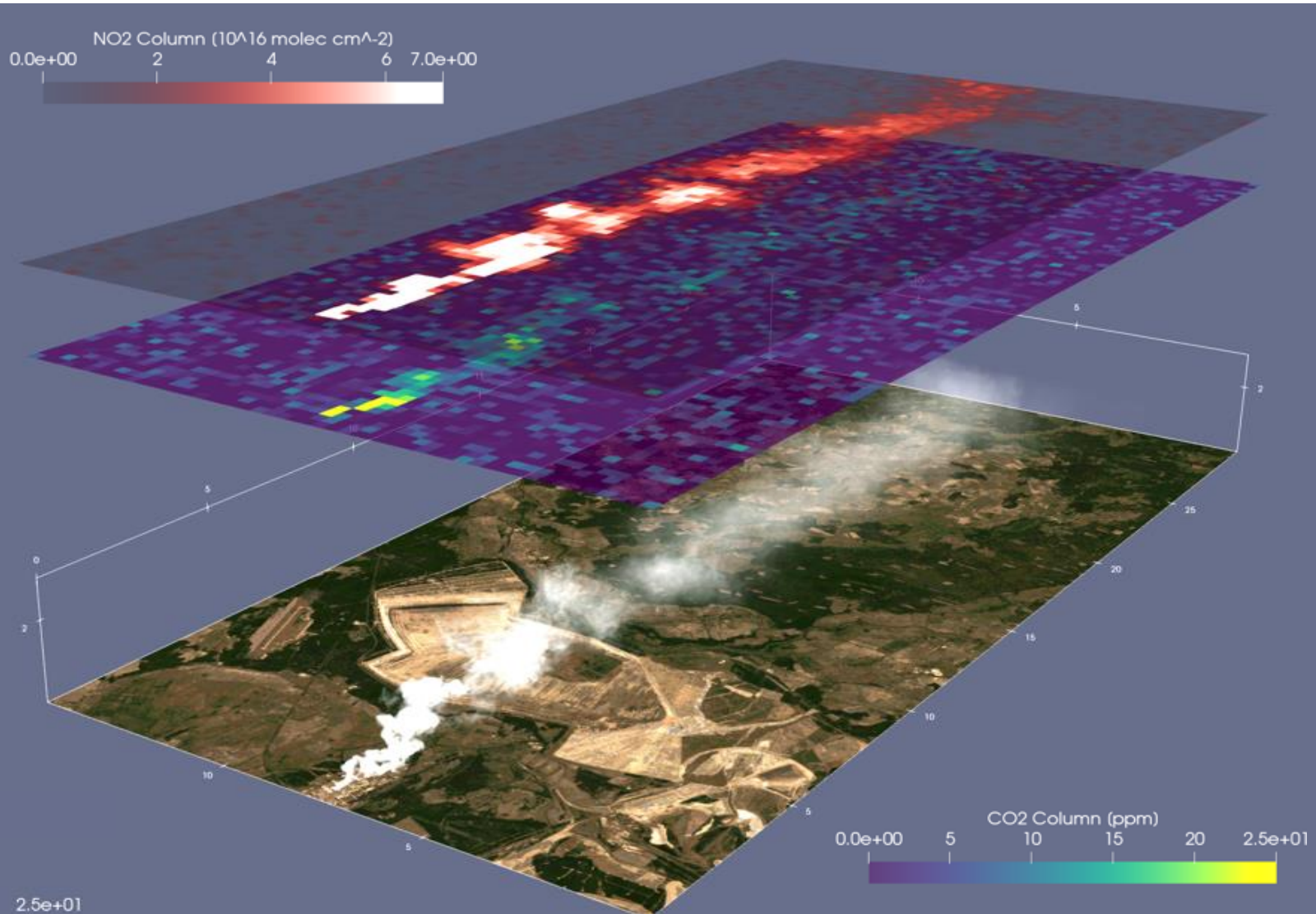- NO_2 can be observed over water for coastal and offshore emissions.
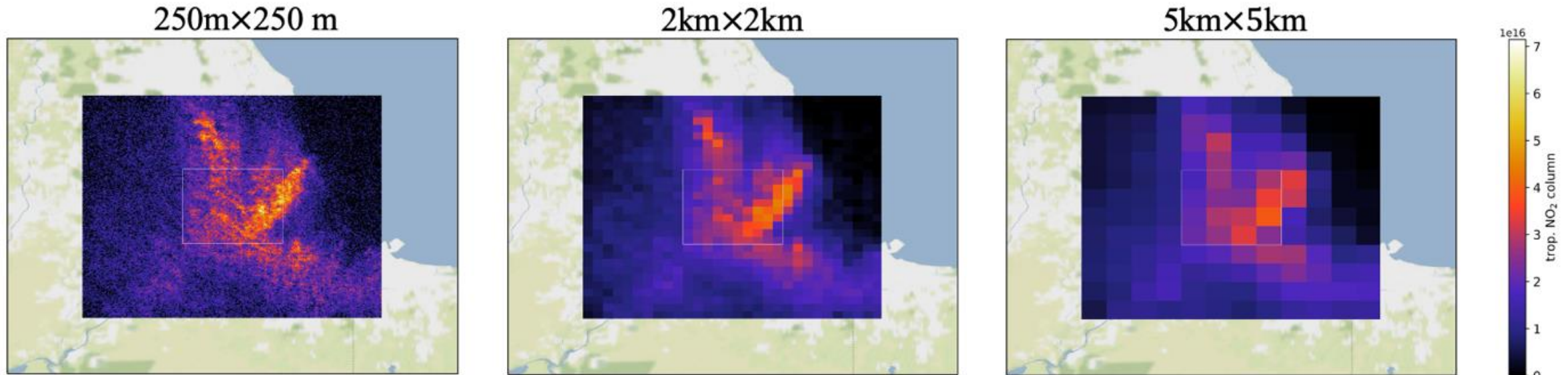
Observations of the GEOTASO airborne instrument over Chicago for 1 June 2017 at a spatial sampling of 250x250 m^2 (left panel), 2x2 km^2 (middle panel), and 5x5 km^2 (right panel). Artificial noise was added corresponding to the TANGO requirement
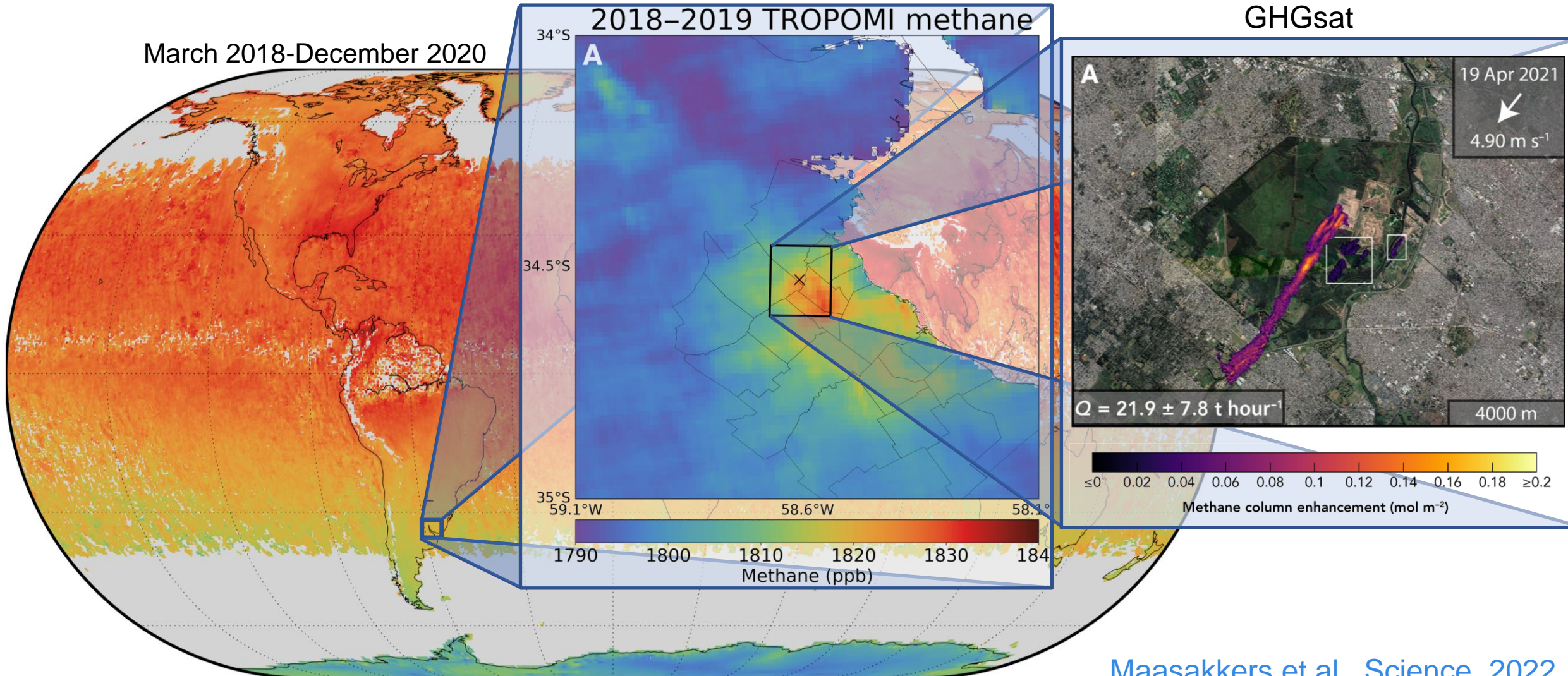
TANGO Plume Observations

Jänschwalde, East Germany

Spatial resolution	<300 x 300 m^2
Spatial scenes	>30 x 30 km^2
Number of cloud-free scenes	>10,000 per year
XCO$_2$ precision	<4 ppm
XCH$_4$ precision	<18 ppm
NO$_2$ tropospheric column	< 5 10^{15} molec.cm^{-2}
XCO$_2$ relative bias in a scene	<3 ppm
XCH$_4$ relative bias in a scene	<14 ppm
NO$_2$ relative bias in a scene	< 2 10^{15} molec.cm^{-2}
Level 2 Products	CO$_2$, CH$_4$, NO$_2$, Clouds

Zoom-in for Mapping Missions

Using satellites to uncover large methane emissions from landfills

March 2018-December 2020

2018–2019 TROPOMI methane

GHGsat

19 Apr 2021

4.90 m s⁻¹

Q = 21.9 ± 7.8 t hour⁻¹

4000 m

Methane (ppb)

Methane column enhancement (mol m⁻²)

Maasakkers et al., Science, 2022

The Dance Moves of TANGO

swath width not up to scale
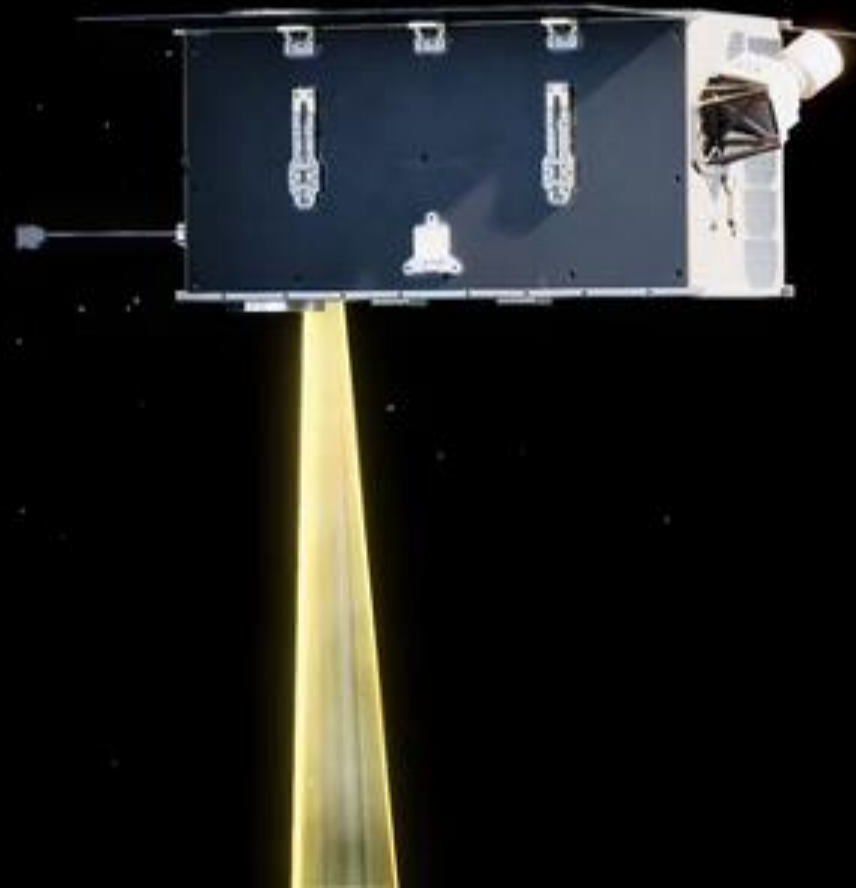
Flexible target selection

TANGo

Objective: ~ 11 000 successful point source targets/year

Target selection one day before sensing using cloudiness forecast to push data yields and user input.
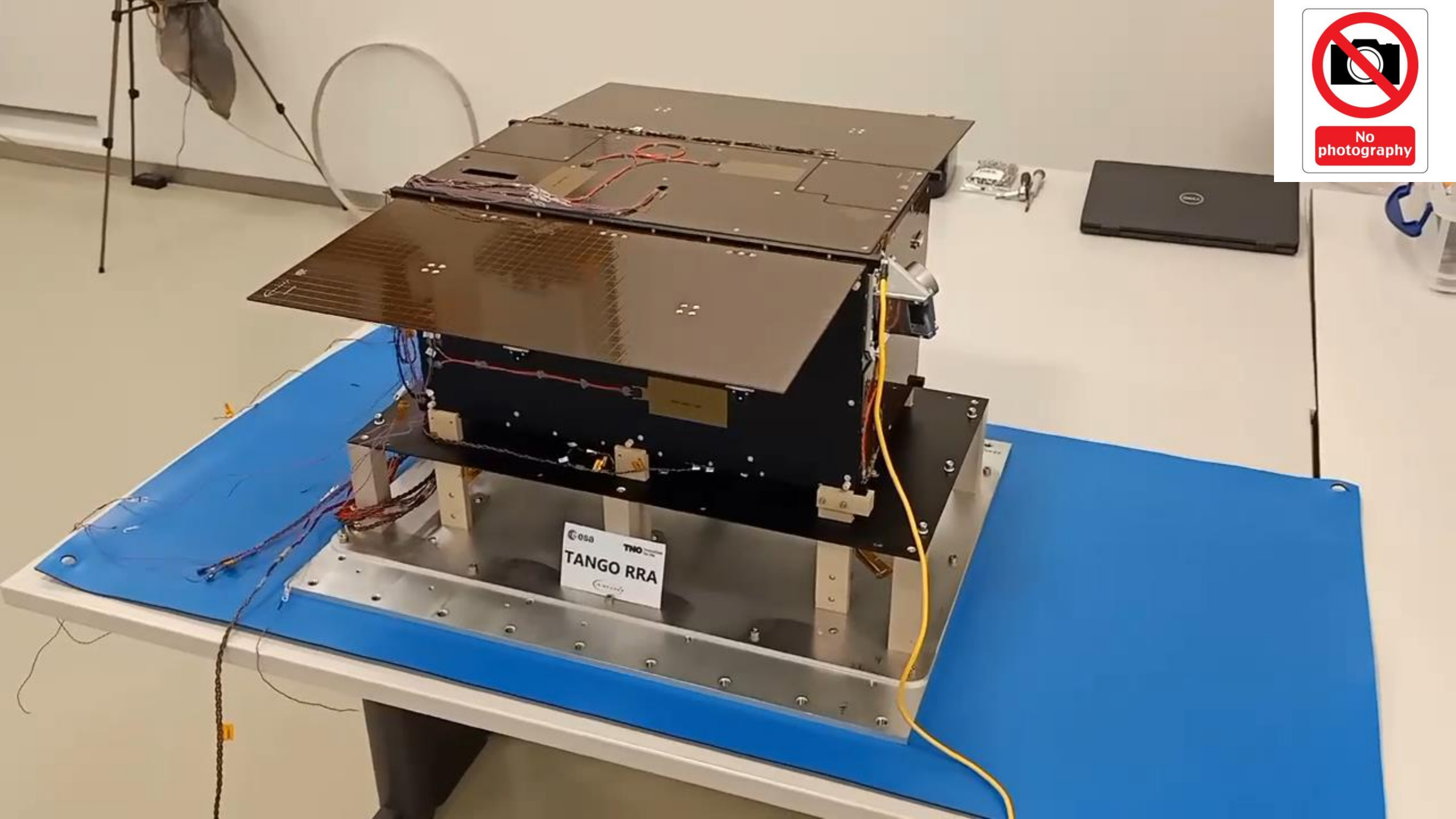
Inventory support (70 %)

Open observation time (25 %)

Cal/Val targets (5 %)

Summary

- TANGO is a cubesat mission providing observations of CO_2, CH_4 and NO_2, with a planned launch around 2027.

- TANGO aims to observe >10,000 scenes per year, at facility scale spatial resolution (<300 x 300 m^2)

- TANGO consist of two agile platforms that fly in formation.

- The TANGO spectrometers have Tropomi heritage and measure the 1.6 µm and 400-500 nm bands.

- All TANGO L1B and L2 data and algorithms will be open

- The TANGO welcomes inputs from the science community!

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