Roles of satellite observations for air quality monitoring: New data from the GOSAT-GW mission

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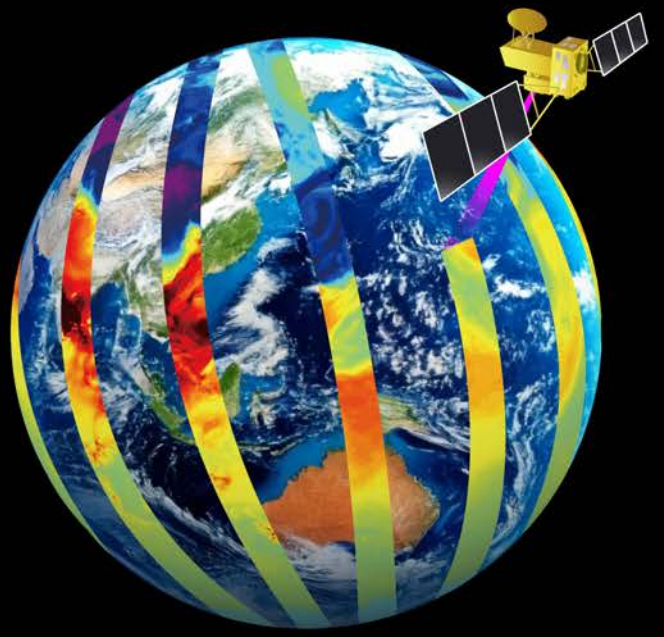
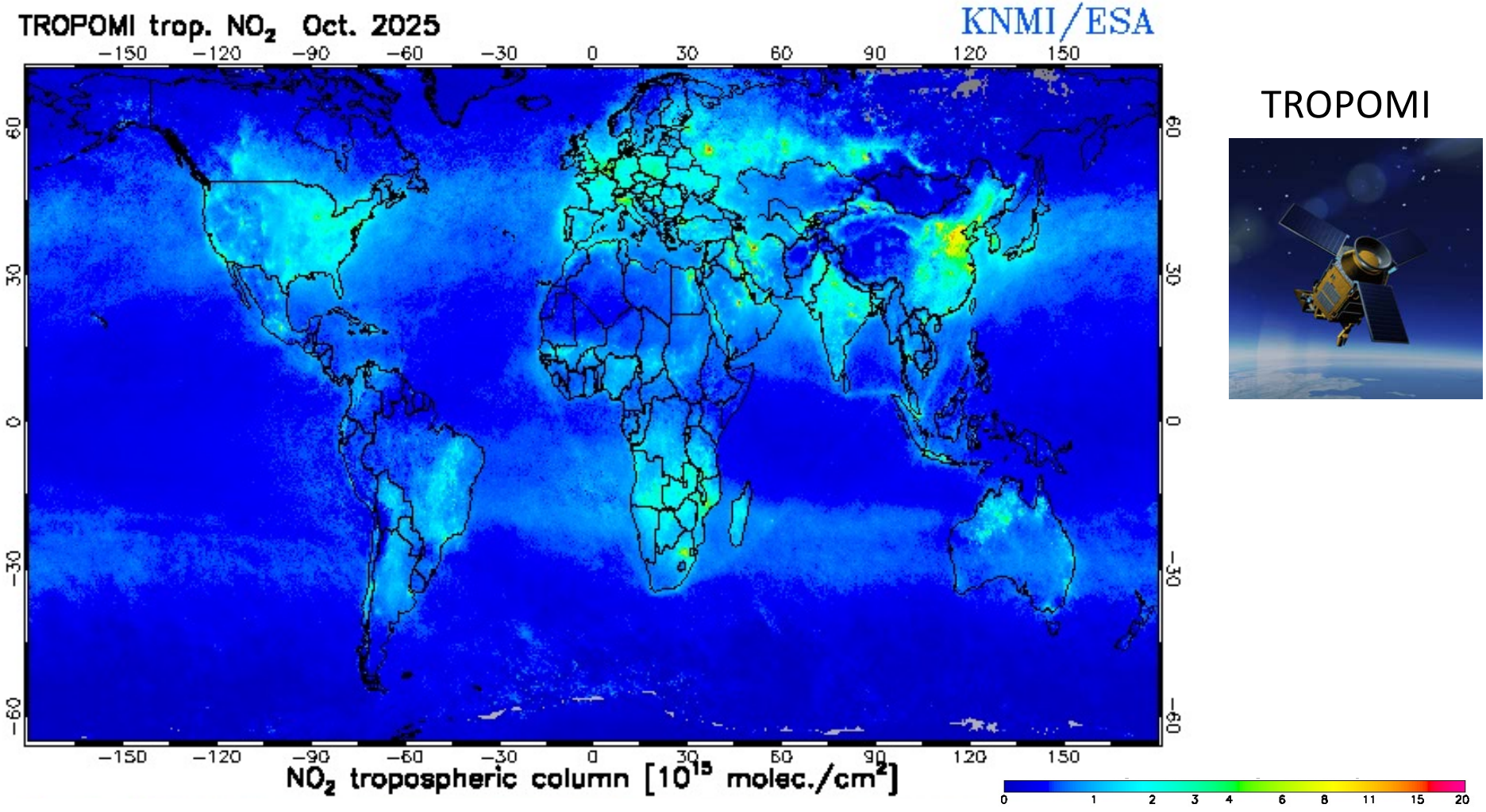
with
Tsuneo Matsunaga, Yu Someya, Tamaki Fujinawa, Hirofumi Ohyama, Isamu Morino, Hisashi Yashiro, Takafumi Sugita, Tazu Saeki, Yukio Yoshida, Astrid Müller, Satoshi Inomata, Hyunkwang Lim, Chi Nguyen Doan Thien, Makoto Saito, Hibiki Noda, Yosuke Yamashita, Sachiko Okamoto, Yosuke Niwa, Kohei Ikeda, Yugo Kanaya, Takashi Sekiya, Prabir Patra, Masayuki Takigawa, Masahiro Yamaguchi, Yasko Kasai, Tomohiro Sato



National Institute for Environmental Studies (NIES)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
National Institute of Information and Communications Technology (NICT)

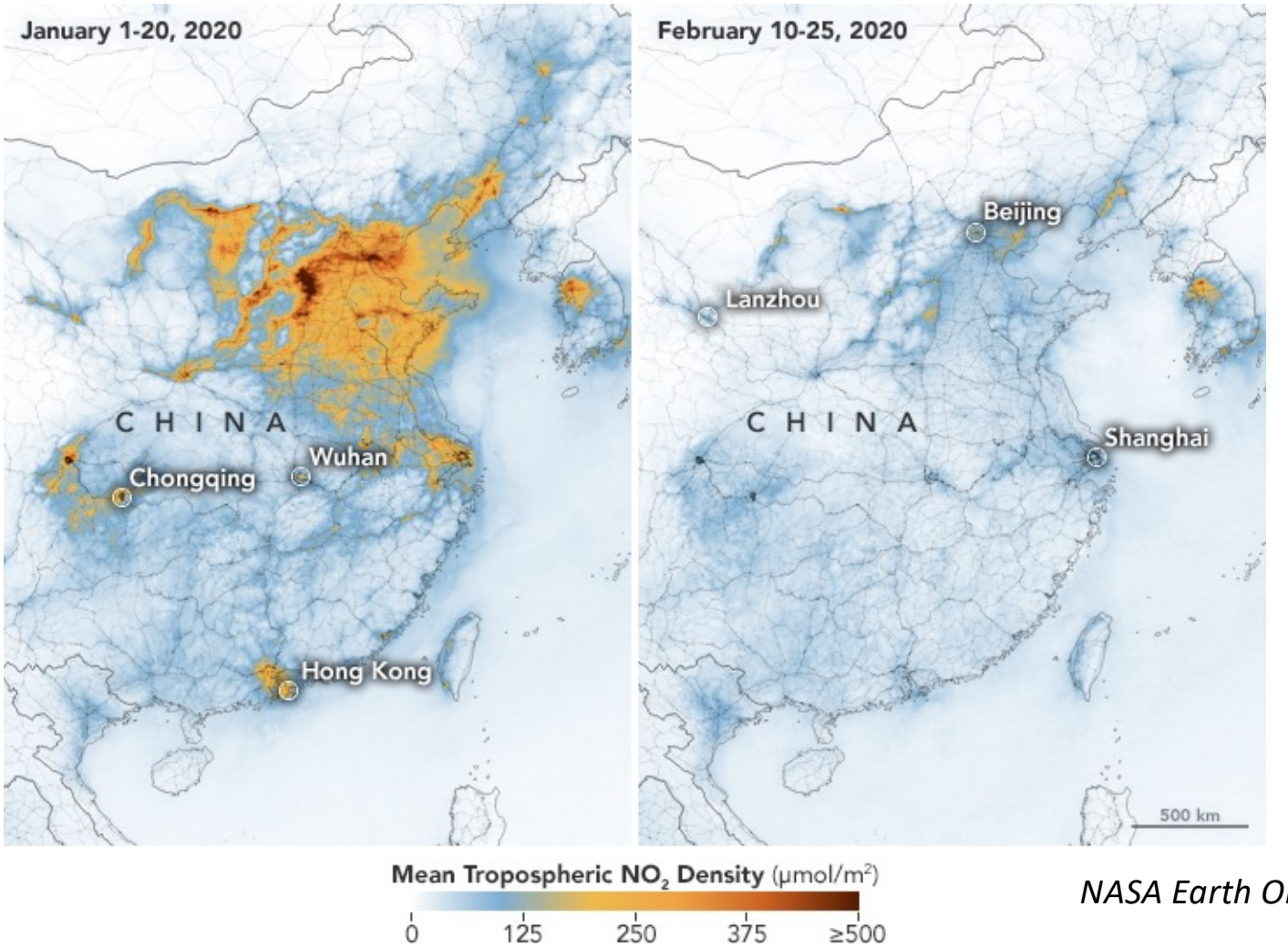
GOSAT-GW
NIES Project

Satellites can observe NO_2 in the troposphere

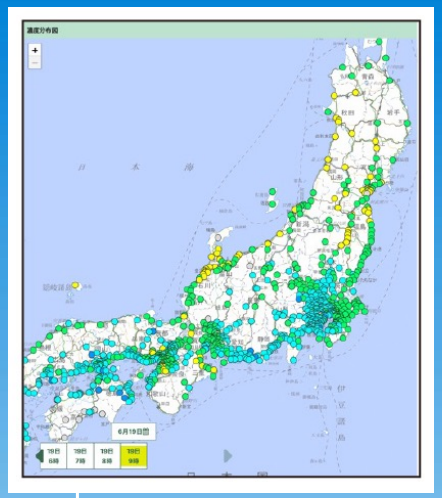


TROPOMI

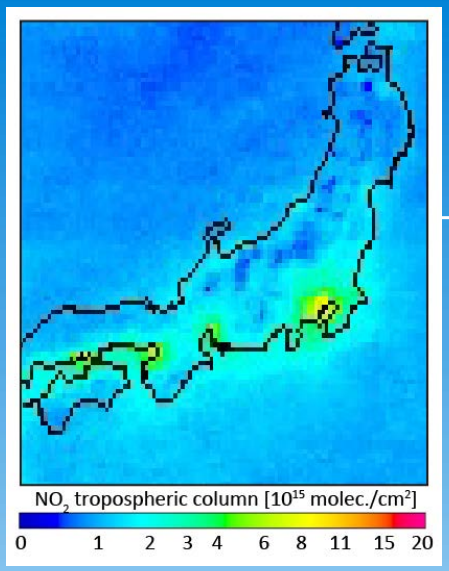
Satellite-derived NO_2 reflects anthropogenic NOx emissions



NASA Earth Observatory, 2020



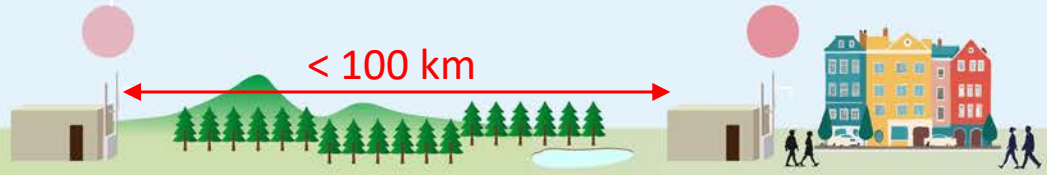
Ground-based monitoring (e.g. AEROS)

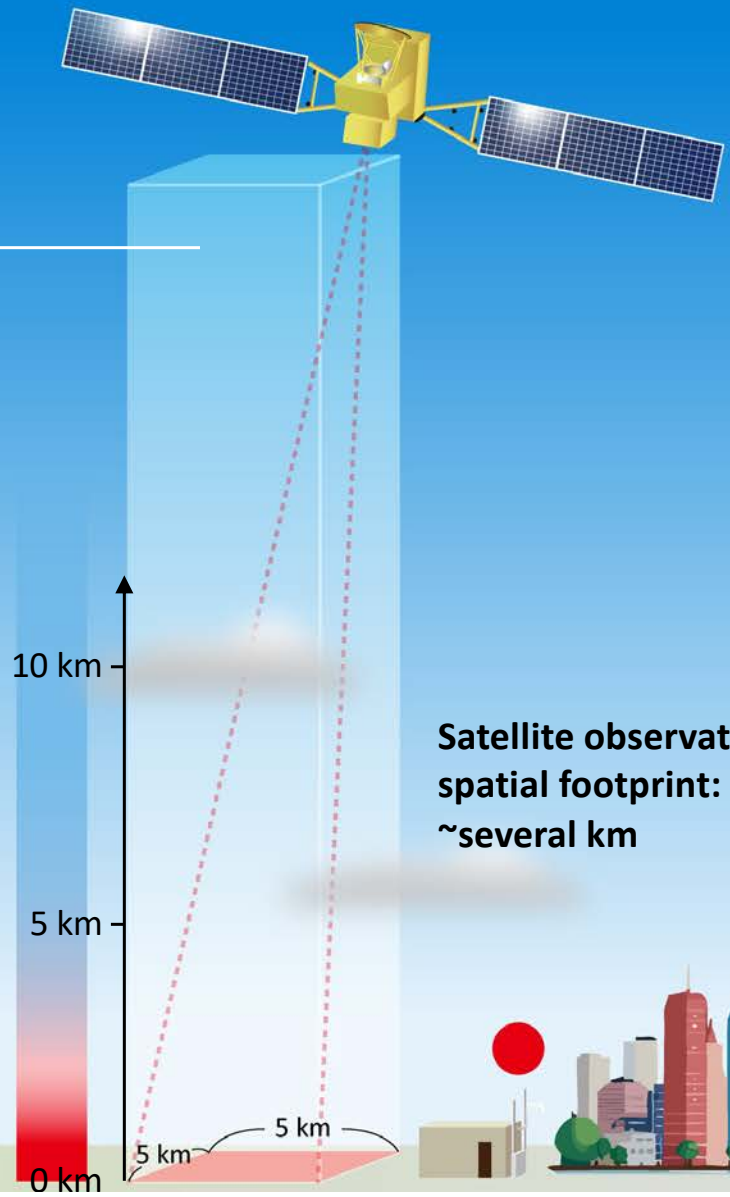


Satellite observation (e.g. TROPOMI)

Ground-based monitoring's spatial footprint:
~several m to several tens of m

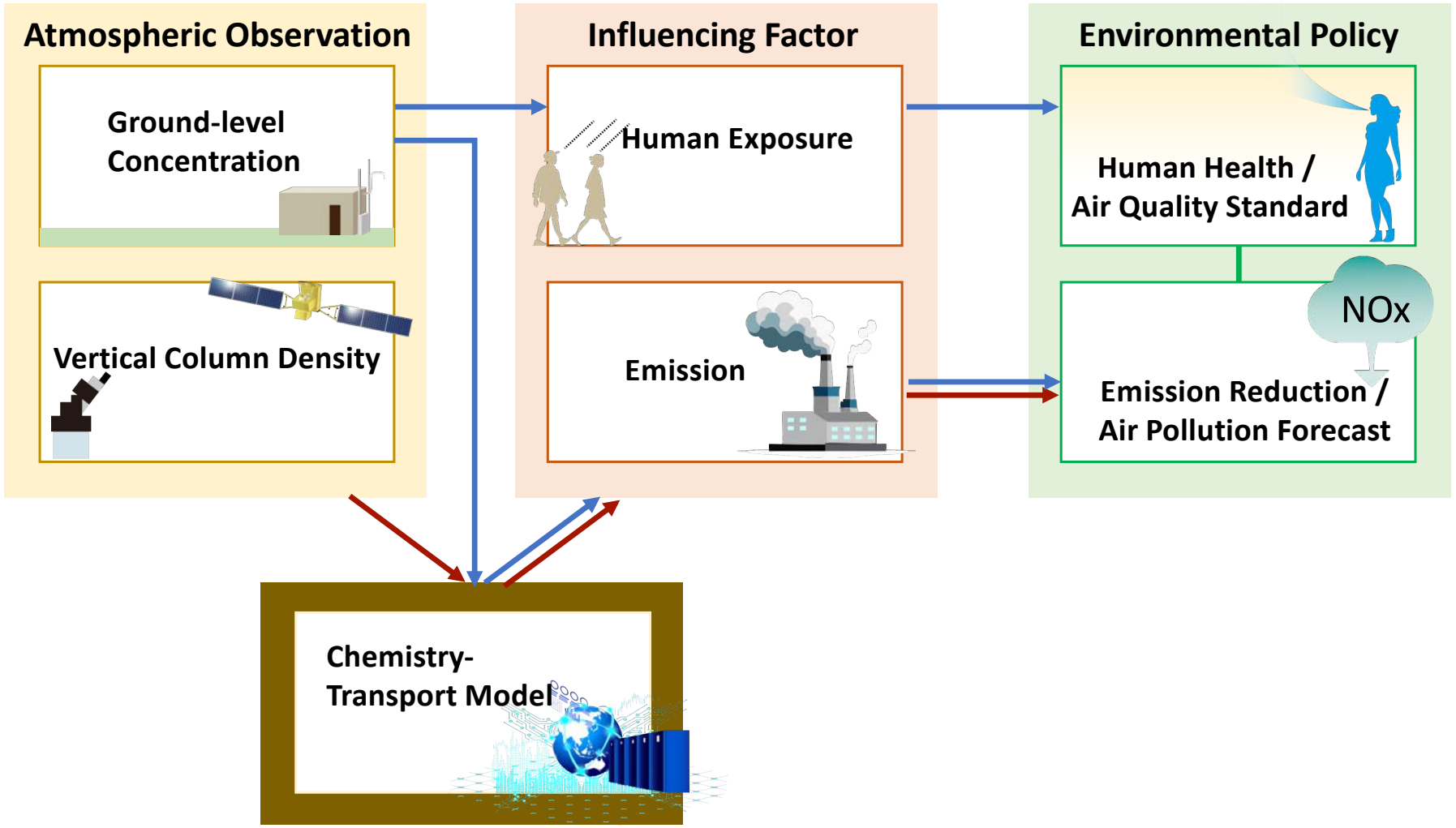
< 100 km





Satellite observation's spatial footprint:
~several km

Models can connect satellite with emissions



Satellite NO_2 can provide municipality-level air quality

Belgian air quality as seen from LEO and GEO

Low-Earth and Geostationary Observations of BELgian Air Quality (LEGO-BEL-AQ) is a project funded by BELSPO under the BRAIN-be 2.0 programme. Its objective is to exploit the full spatio-temporal resolving power of the LEO and GEO Copernicus Atmospheric Sentinel missions to support air quality policies in Belgium.

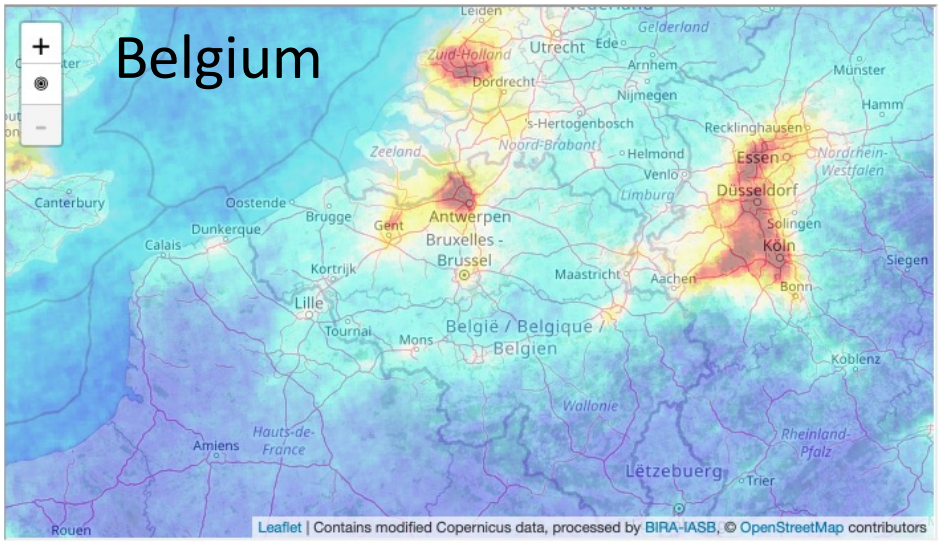
This includes the production of high spatial resolution maps of NO2 based on S5p-TROPOMI data over Belgium, and R&D on the complementarity and synergies within the (future) LEO+GEO constellation.

Example maps

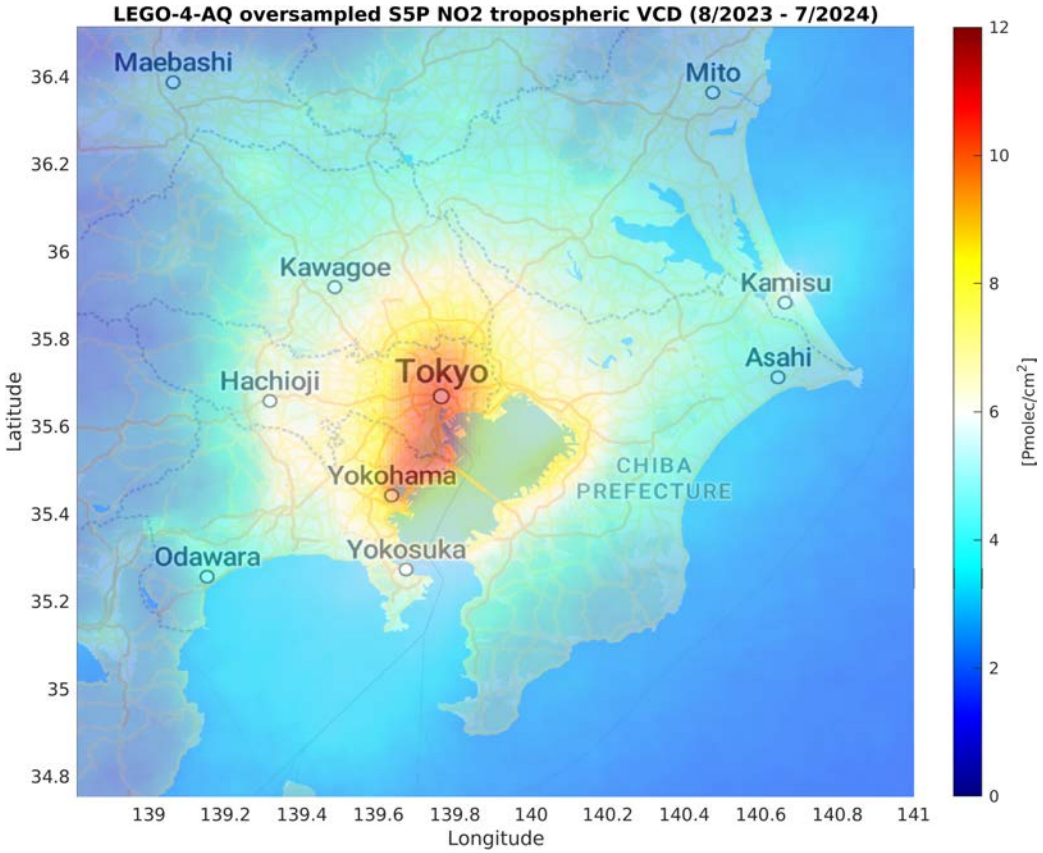
City-specific results can be found here.

S5P-TROPOMI tropospheric NO2 column number density [Pmolec/cm^2]

Grid resolution: 1.0 x 1.0 km2 **Date: June-July-August 2021**



Tokyo

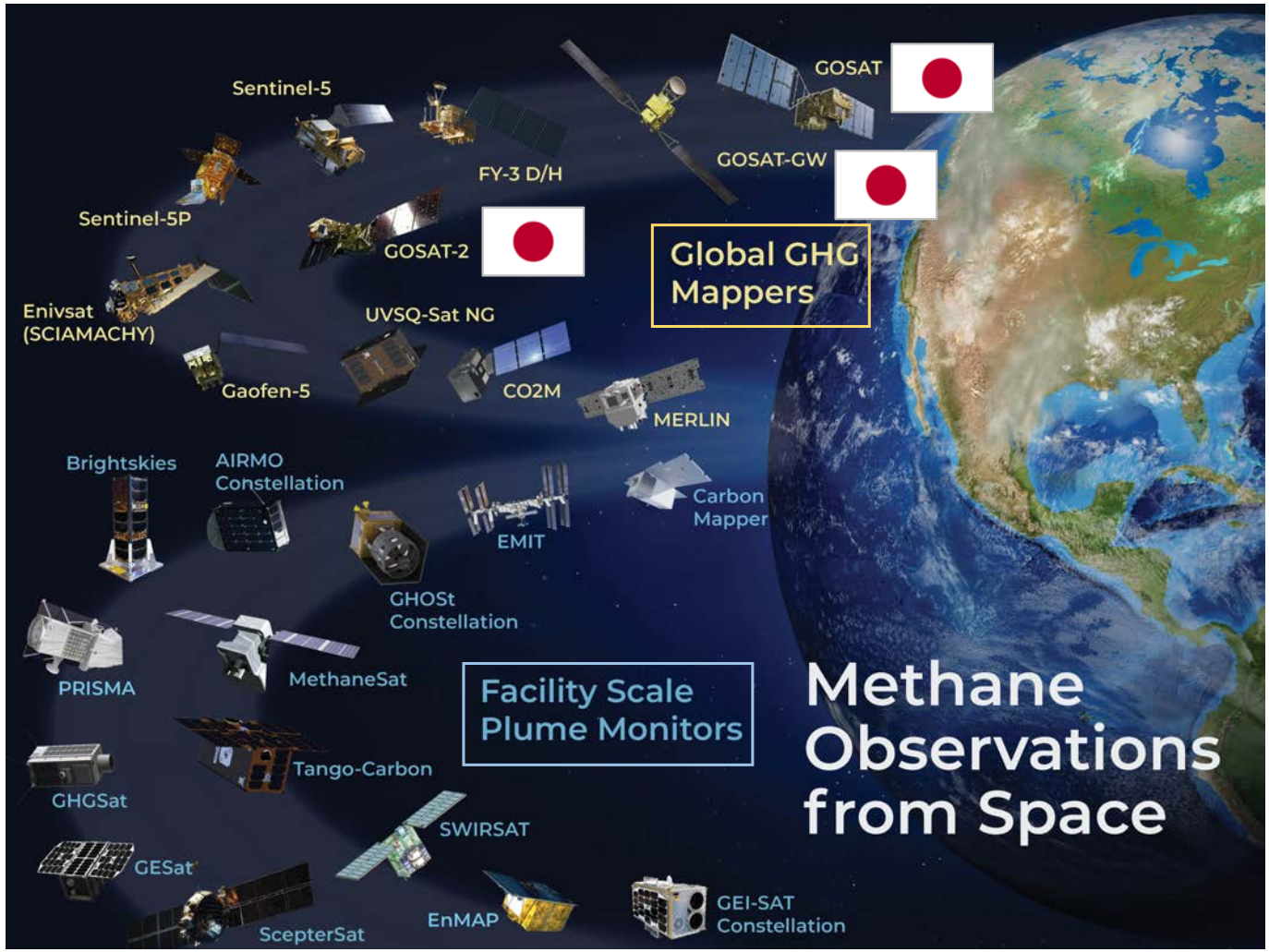


LEGO-BEL-AQ (Low-Earth and Geostationary Observations of BELgian Air Quality)
https://lego-bel-aq.aeronomie.be/index.php

Successful launch of GOSAT-GW in June 2025

The GOSAT-GW satellite was launched at 1:33:03 am Japan time on 29th June at Tanegashima Space Center with the 50th H-IIA rocket, the last vehicle of the H-IIA series

Measurements of greenhouse gases from space



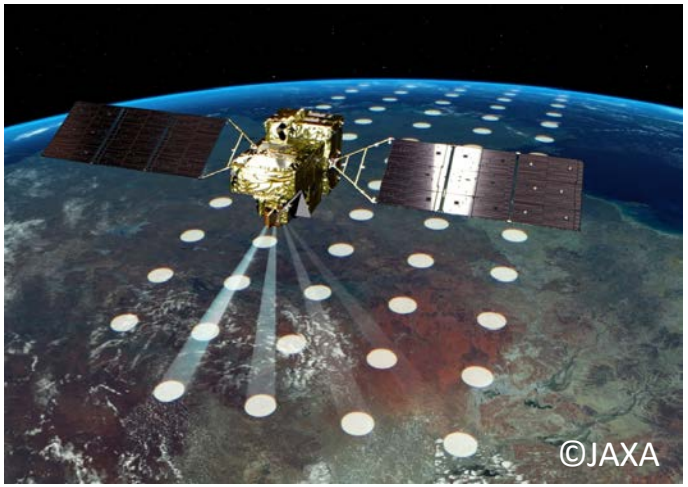
Growing constellation of GHG concentrations observations from the global to the facility scale

https://database.eohandbook.com/ghg/

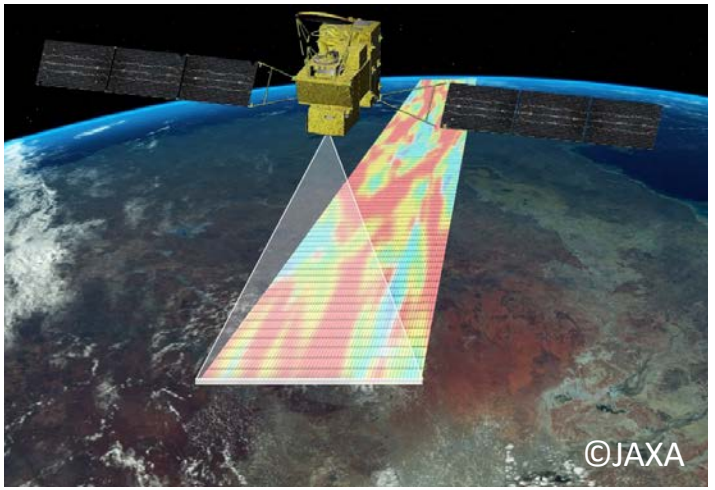
GOSAT, GOSAT-2, and … GOSAT-GW

GOSAT 2009 --

GOSAT-2 2018 --



GOSAT-GW 2025 --



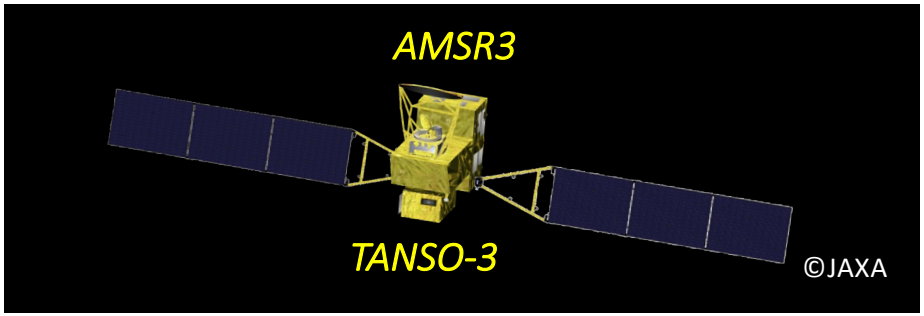
Greenhouse gases GOSAT PROJECT Observing SATellite

GOSAT-2 PROJECT AT THE NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES

GOSAT-GW NIES Project

- TANSO-3 funded by MOEJ, AMSR3 (Advanced Microwave Scanning Radiometer 3) by MEXT
- JAXA is responsible for launch, L0 and L1; NIES for L2 (and higher research products)

TANSO-3 sensor onboard GOSAT-GW



Tanimoto *et al.*
Progress in Earth and Planetary Science (2025) 12:8
https://doi.org/10.1186/s40645-025-00684-9

Progress in Earth and Planetary Science

RESEARCH ARTICLE Open Access

The greenhouse gas observation mission with Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW): objectives, conceptual framework and scientific contributions

Hiroshi Tanimoto[1*], Tsuneo Matsunaga[1], Yu Someya[1], Tamaki Fujinawa[1], Hirofumi Ohyama[1], Isamu Morino[1], Hisashi Yashiro[1], Takafumi Sugita[1], Satoshi Inomata[1], Astrid Müller[1], Tazu Saeki[1], Yukio Yoshida[1], Yosuke Niwa[1], Makoto Saito[1], Hibiki Noda[1], Yousuke Yamashita[1], Kohei Ikeda[1], Nobuko Saigusa[1], Toshinobu Machida[1], Matthias Max Frey[1], Hyunkwang Lim[1], Priyanka Srivastava[1], Yoshitaka Jin[1], Atsushi Shimizu[1], Tomoaki Nishizawa[1], Yugo Kanaya[2], Takashi Sekiya[2], Prabir Patra[2], Masayuki Takigawa[2], Jagat Bisht[2], Yasko Kasai[3] and Tomohiro O. Sato[3]

	GOSAT-GW
Launch / lifetime	FY2025 / 7 years
Satellite mass / power	2.9 t / 5200 W
Launcher	H-IIA rocket
Orbit	666 km, 13:30, ascending
Repeat cycle	3 days (44 cycles/3days)
Spectrometer	TANSO-3 (Grating) by Mitsubishi Electric
Major targets	CO_2 (FP), CH_4 (FP, Proxy), NO_2 (QDOAS)
Spectral bands	0.45 / 0.7 / 1.6 µm
Spectral Resolution (Sampling interval)	< 0.5 nm @ 0.45 µm, <0.05 nm @ 0.7 µm, < 0.2 nm @ 1.6 µm
Swath	911 km (Wide Mode) or 90 km (Focus Mode)
Footprint size, nadir	10 km (Wide Mode) or 1–3 km (Focus Mode)
Pointing	± 40 / ± 34.4 deg (AT/CT) for Focus Mode

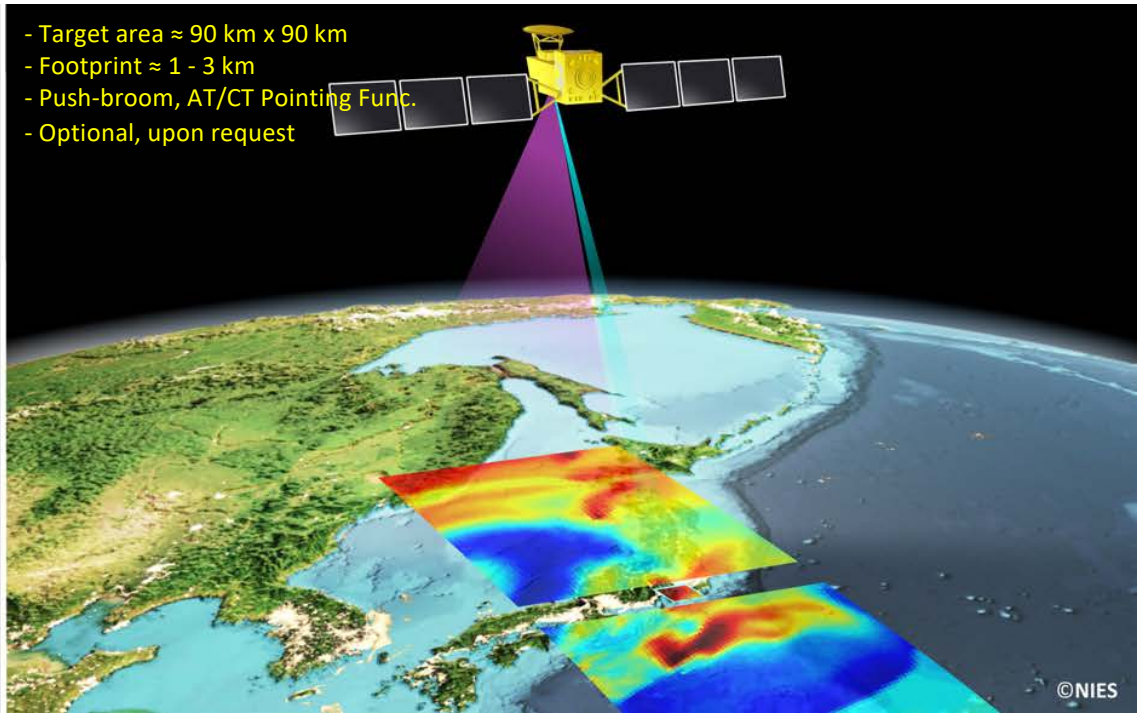
Tanimoto et al., Prog. Earth Planet. Sci., 2025

3-day dense global coverage of CO_2, CH_4 & NO_2 observations

- Monitoring of whole atmosphere global-mean concentrations of GHGs – CO_2 and CH_4
- Verification of country-level anthropogenic emissions inventory of GHGs – CO_2 and CH_4
- Detection of GHGs emissions from large emission sources, such as megacities, power plants, and permafrost

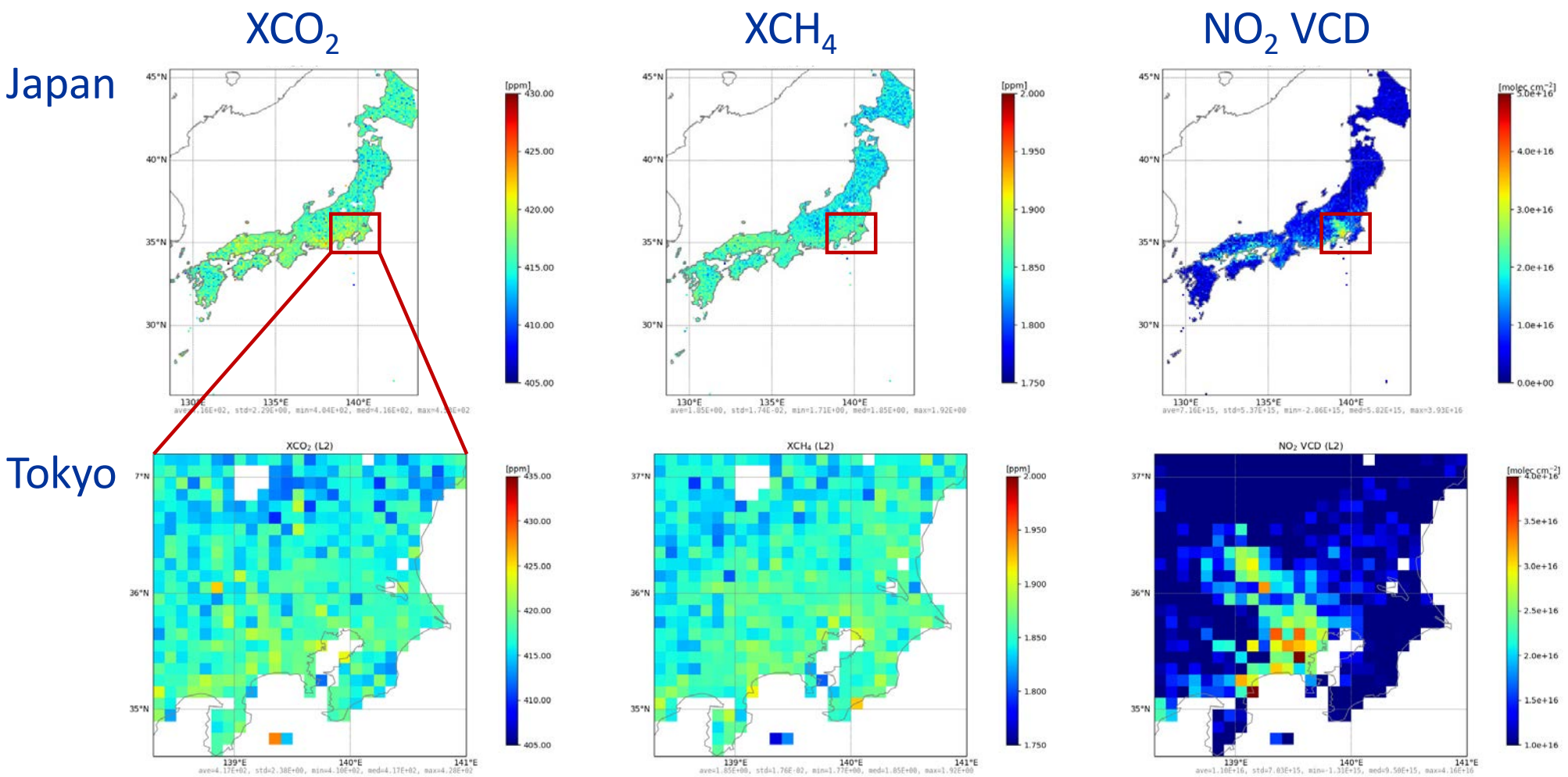
Wide Mode

Focus Mode



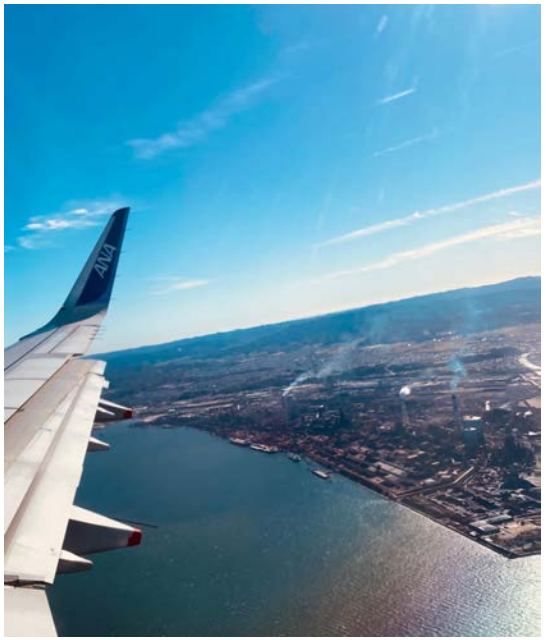
https://esd.nies.go.jp/ja/da/

Simulated GOSAT-GW data – 10 km x 10 km



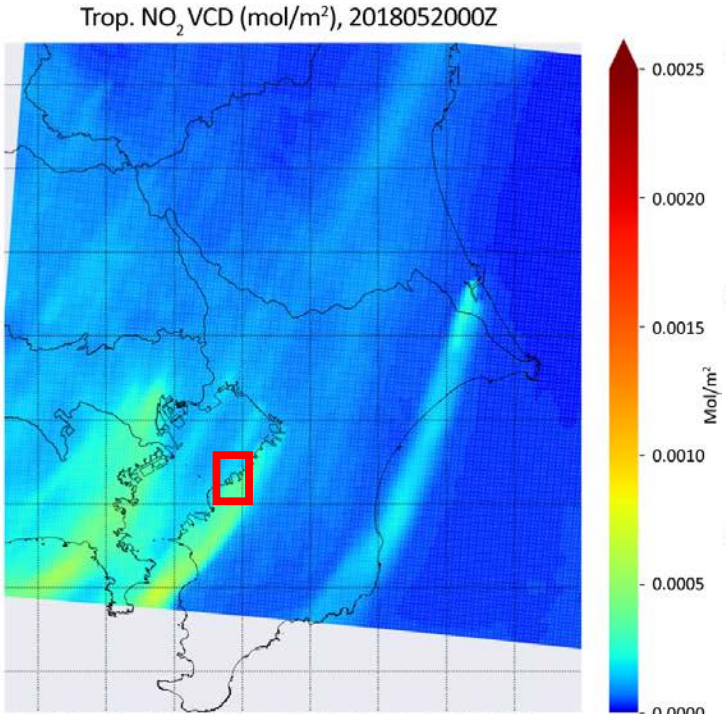
Detection of NOx Emissions from Power Plants

Industries in Tokyo Bay

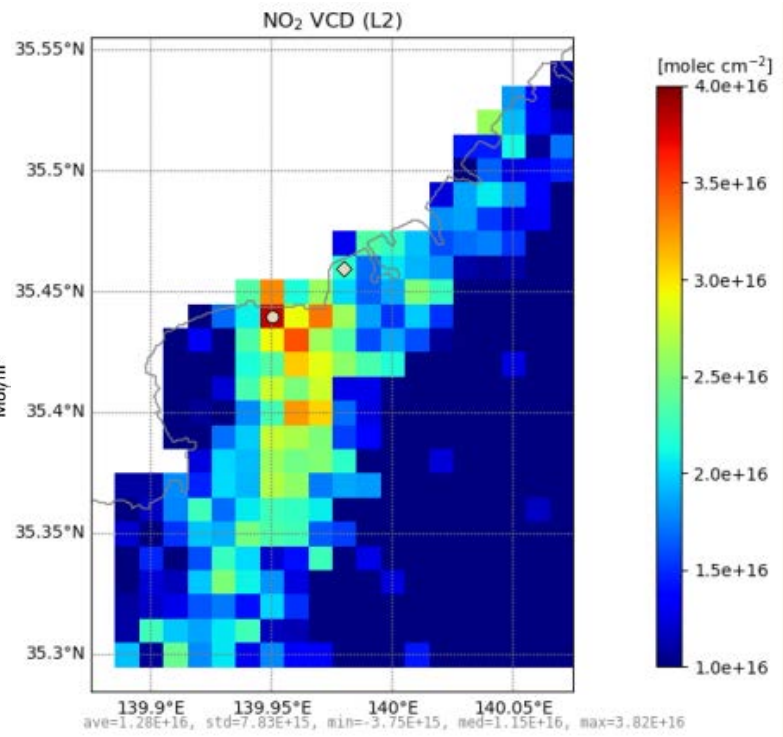


JERA, 3600 MW

1 km x 1 km WRF-Chem model

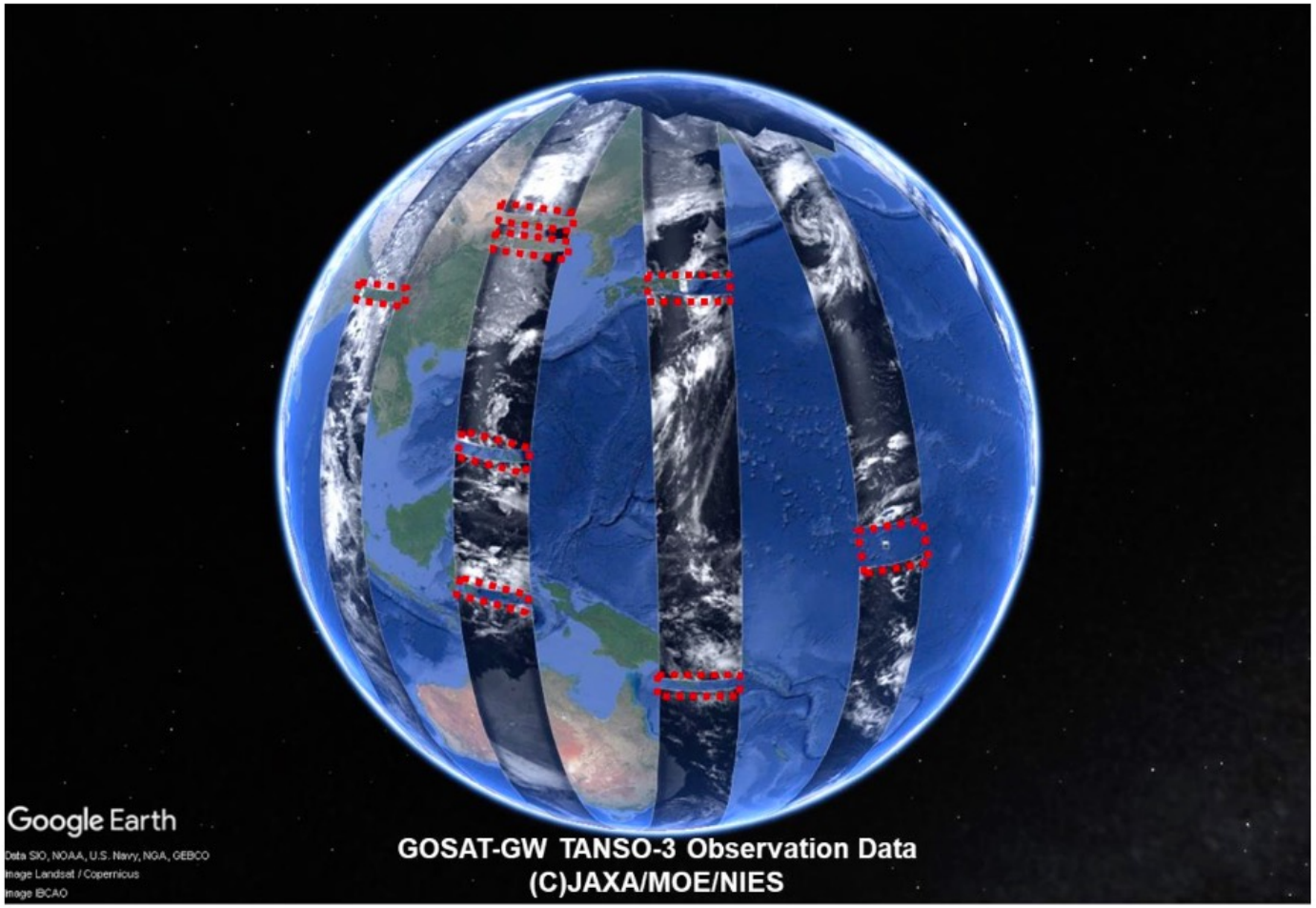


TANSO-3 simulator



WRF model results:
Masahiro Yamaguchi, Masayuki Takigawa, Prabir Patra, Jagat Bisht, Yugo Kanaya

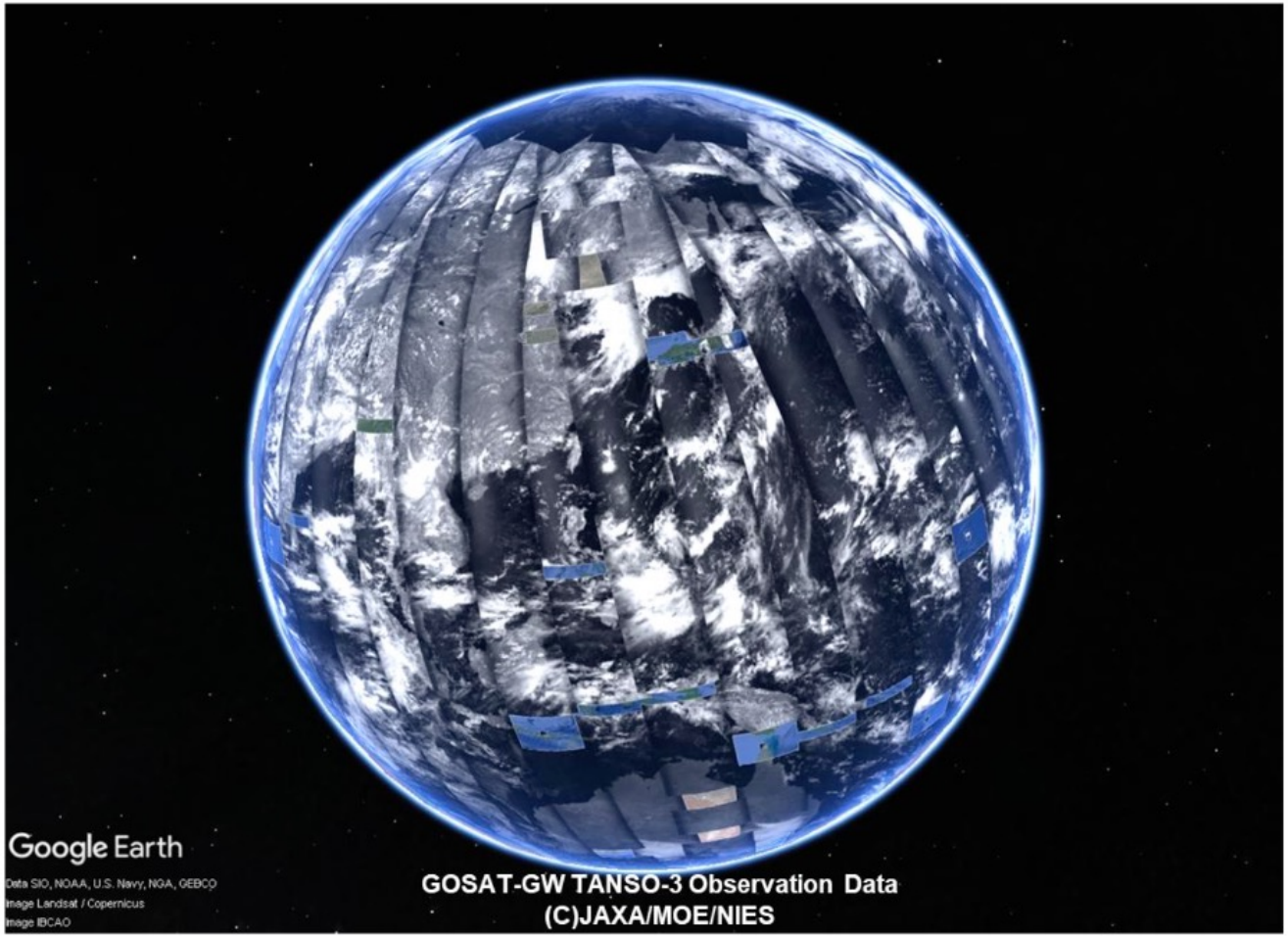
First light: Wide Mode, July 14



Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus Image IBCAO

https://www.nies.go.jp/whatsnew/2025/20250808/20250808.html

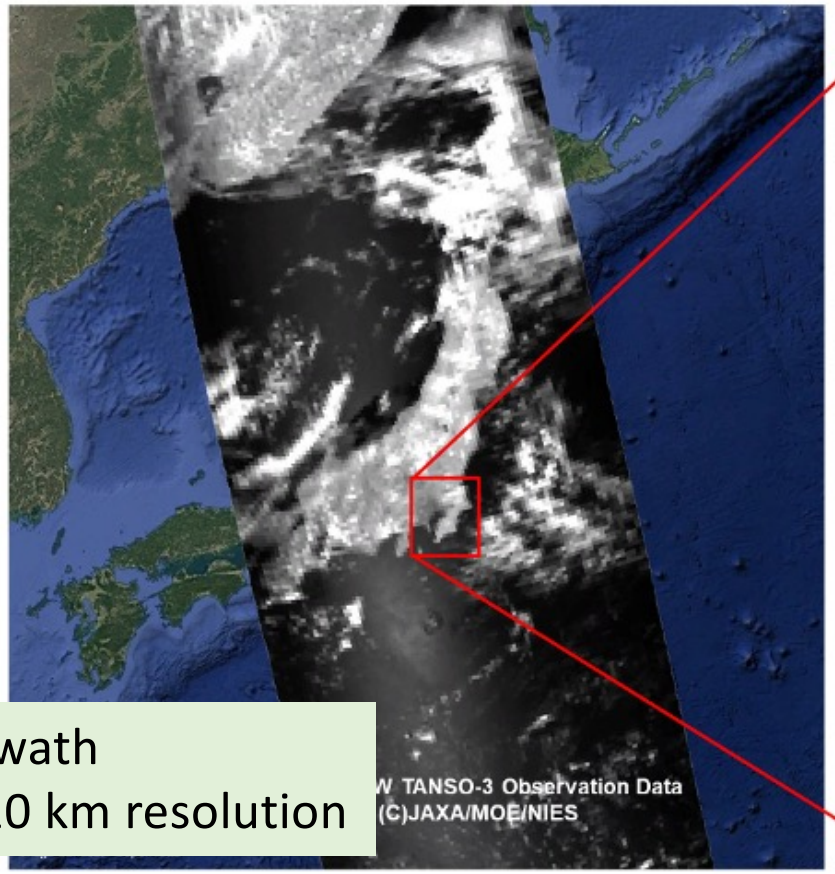
First light: Wide Mode, July 14-16



Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus Image IBCAO

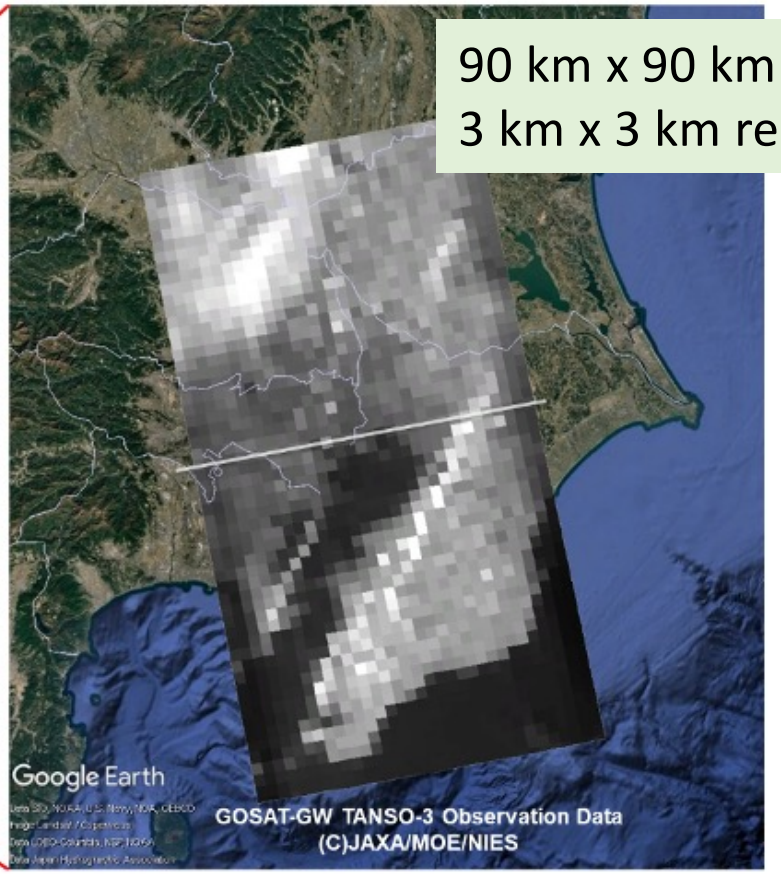
https://www.nies.go.jp/whatsnew/2025/20250808/20250808.html

First light: Wide Mode, July 20th and Focus Mode, July 17th



911 km swath
10 km x 10 km resolution

Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus



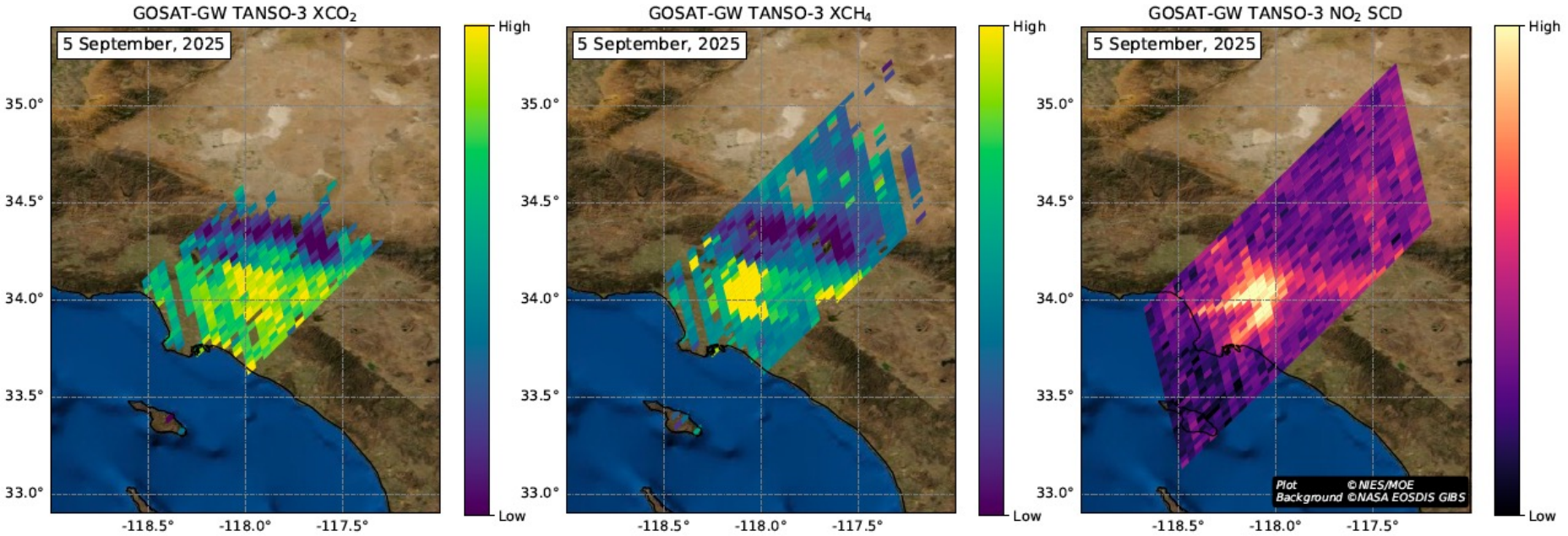
90 km x 90 km area
3 km x 3 km resolution

Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus Data
LDEO-Columbia, NSF, NOAA Data Japan Hydrographic Association

First results of co-located CO_2, CH_4, and NO_2 from GOSAT-GW

Focus Mode

CO_2 CH_4 NO_2



Yu Someya, Tamaki Fujinawa, Hyunkwang Lim, NIES

!! CAUTION !! Initial analysis based on preliminary data

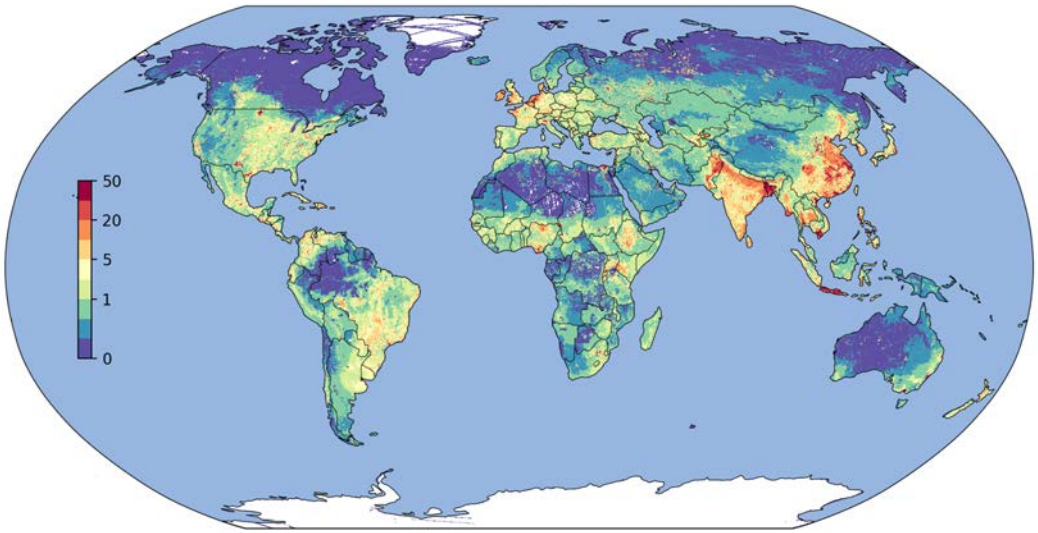
NIES

Ministry of the Environment
Government of Japan

“Flux” information for climate change mitigation policy

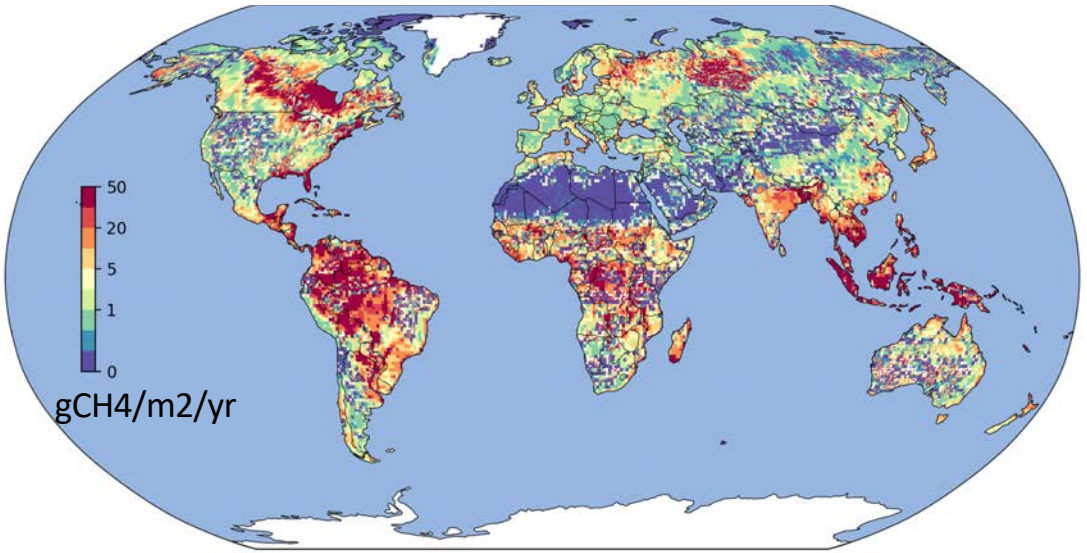
CH_4 emissions derived from GOSAT data, 2009-2022

Anthropogenic emissions, total



Total = oil and gas, fossil, agriculture, landfill, biomass burning

Natural wetland emissions

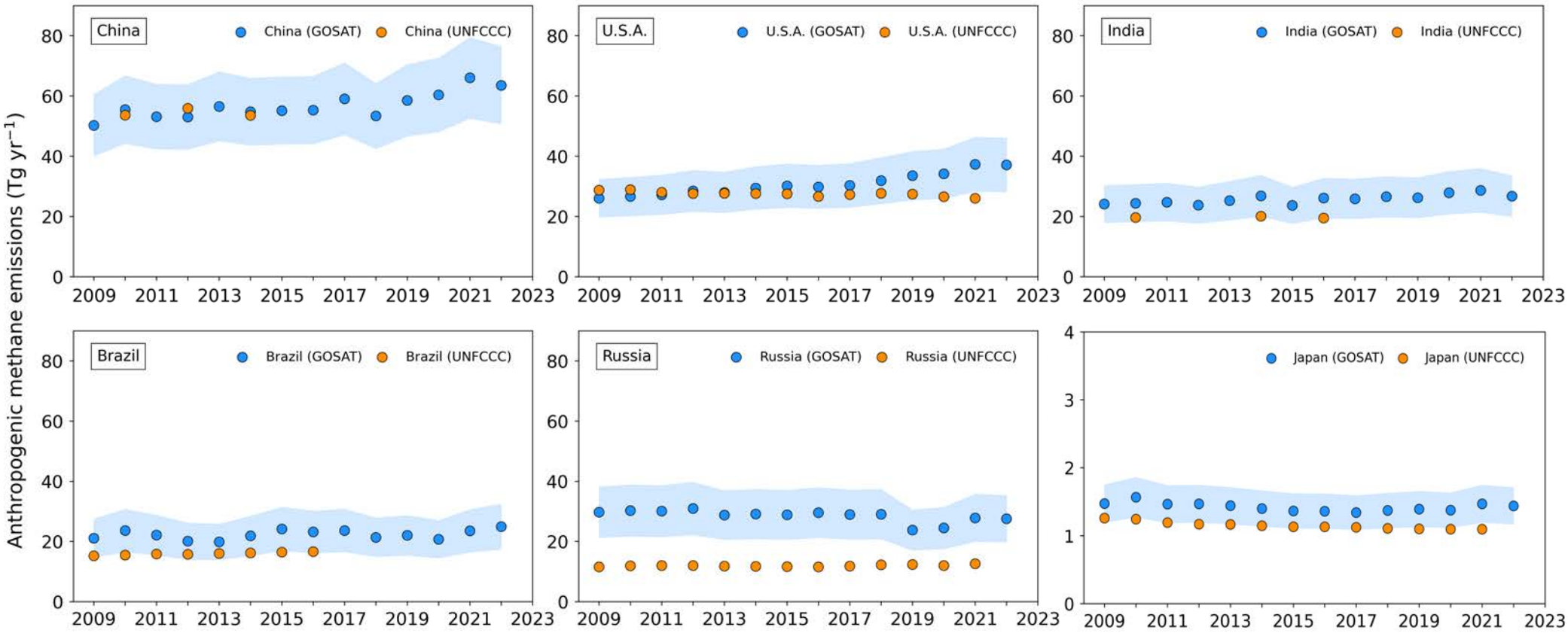


Janardanan et al., 2024, 2025

Anthropogenic emissions in Asia are substantial contributors to the global total emissions

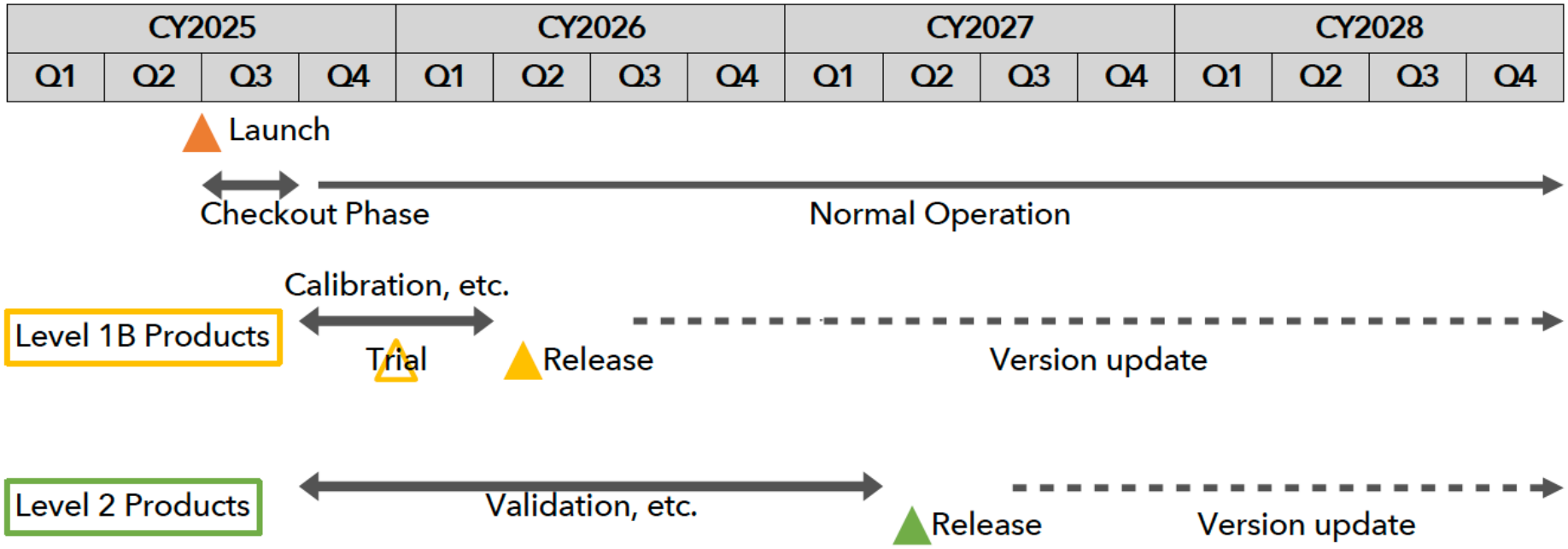
“Flux” information for climate change mitigation policy

Anthropogenic CH_4 fluxes from inversion analyses of GOSAT data (Janardanan et al. 2024, 2025) and UNFCCC inventories



Satellite-based estimates are helpful as a supplement to the UNFCCC emission inventories

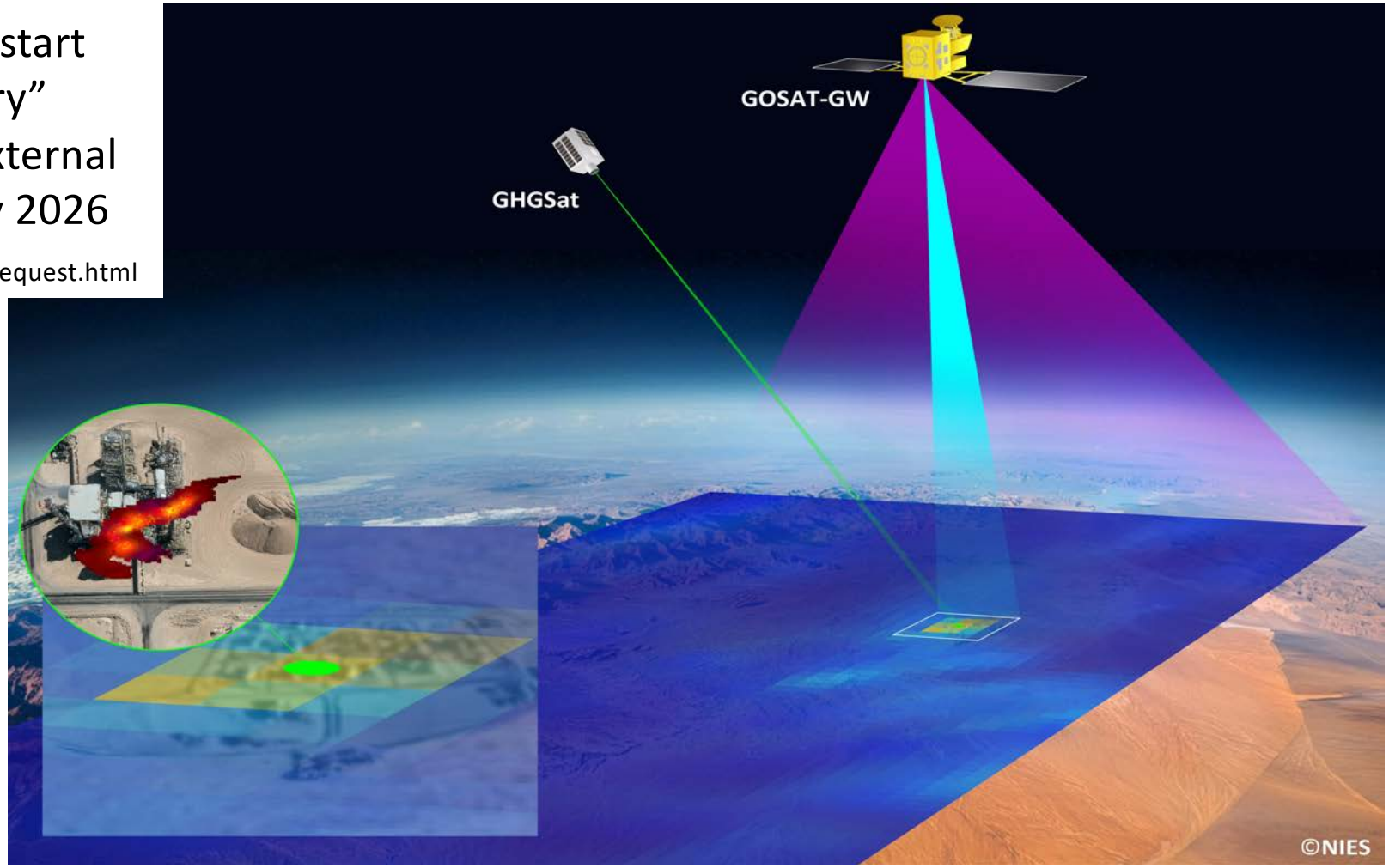
Schedule of Data Release/Sharing



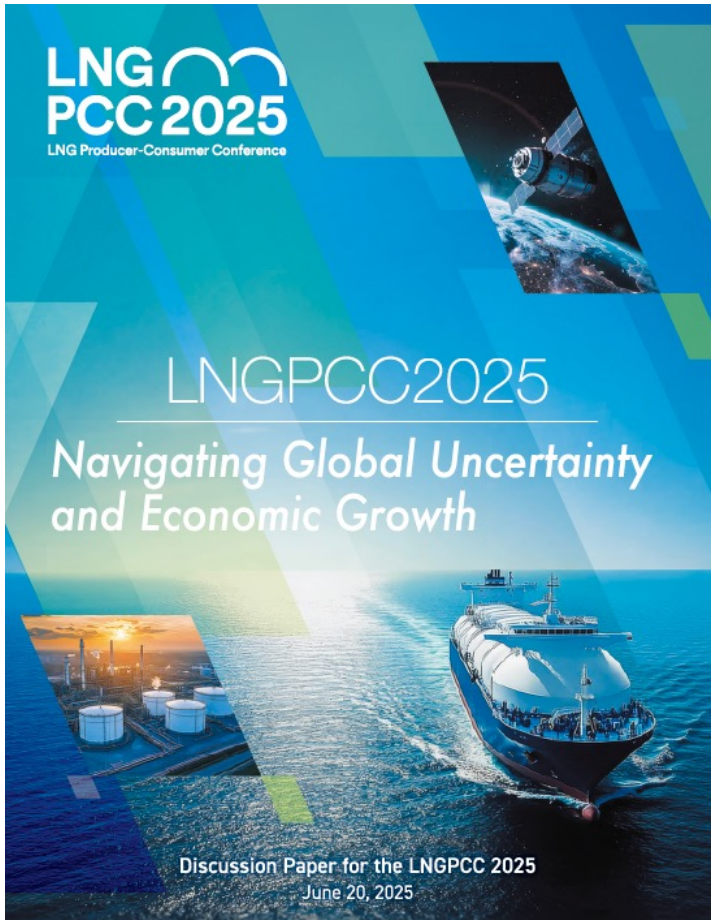
International collaborations to better identify/quantify CH_4 emissions

NIES and MOE will start sharing “preliminary” TANSO-3 data to external partners in January 2026

https://gosat-gw.nies.go.jp/en/request.html



Japan’s inter-agency collaboration with IMEO on methane



Joint Statement on Technical Collaboration and Data Transparency on Methane Abatement from LNG Value Chain

by

Ministry of Economy, Trade and Industry of Japan (METI)
Ministry of Environment of Japan (MOE)
Japan Organization for Metals and Energy Security (JOGMEC)
National Institute for Environmental Studies (NIES)

“MOE, NIES and UNEP’s IMEO will collaborate on the usage of data from GOSAT-GW when it becomes available, and IMEO will integrate the data from GOSAT-GW into IMEO’s Methane Alert and Response System (MARS), which notifies government and industry stakeholders of large emissions to enable swift mitigation.”

METI
Ministry of Economy, Trade and Industry

Ministry of the Environment
Government of Japan

JOGMEC

NIES

Ministry of the Environment
Government of Japan

https://gosat-gw.nies.go.jp/en/