Satellite Utilization for Air Pollution Monitoring

Isamu Morino
Head, Satellite Remote Sensing Section, Earth System Division
National Institute for Environmental Studies, Japan

Satellite Utilization for Air Pollution Monitoring: New data from the GOSAT-GW mission

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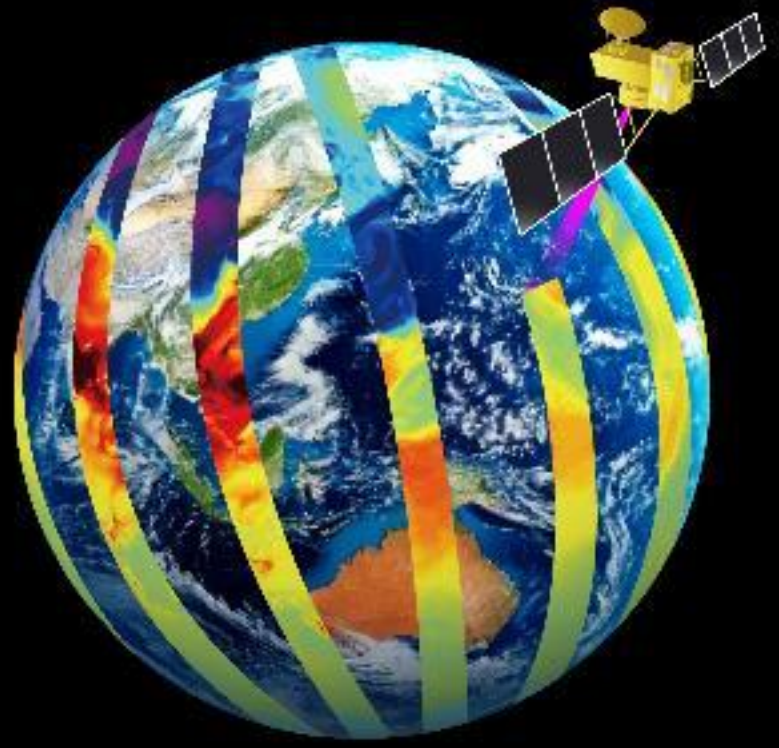
Head, Satellite Remote Sensing Section, Earth System Division
National Institute for Environmental Studies, Japan

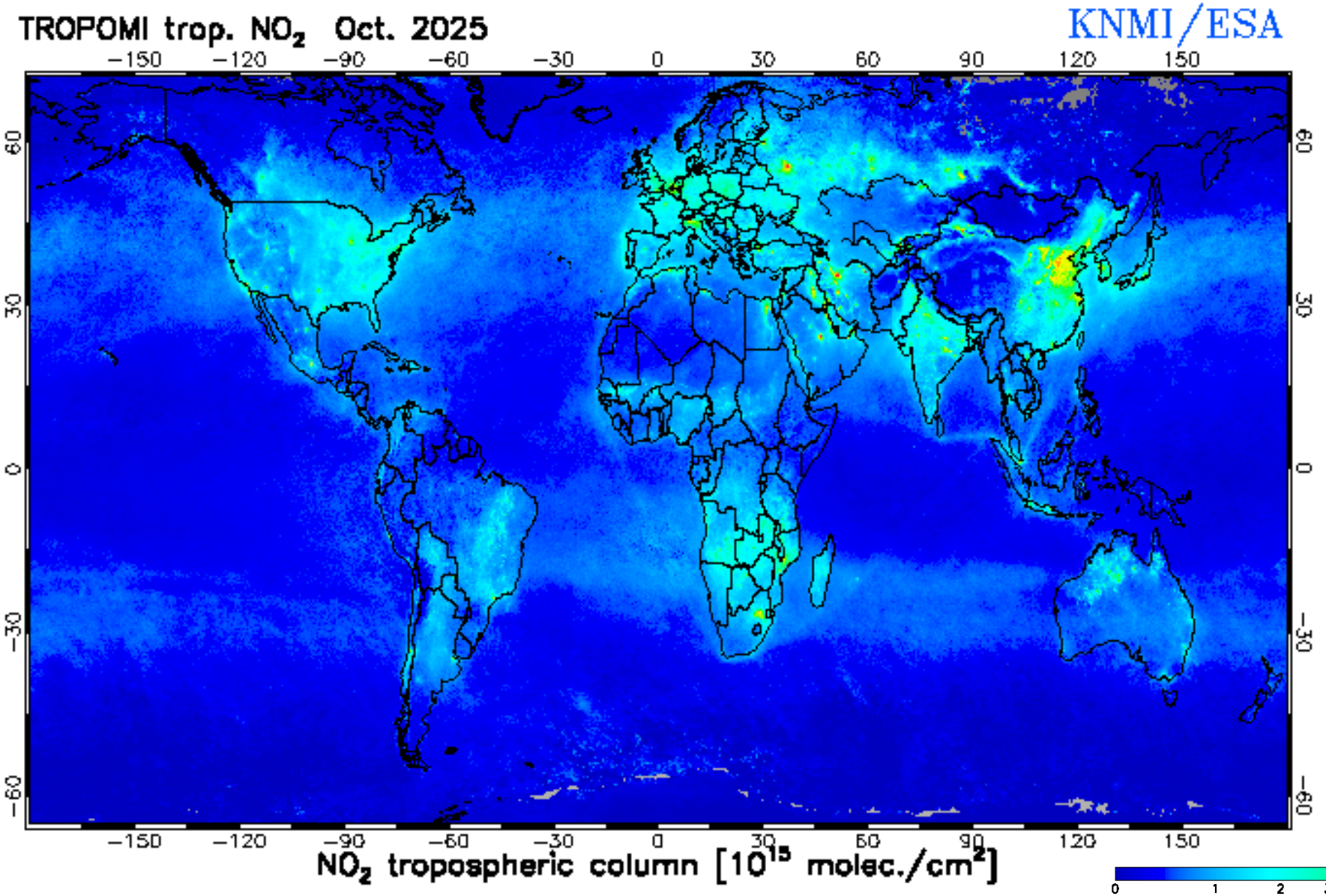
With
Hiroshi Tanimoto, *Science and Application Lead, and Director, Earth System Division*
Tsuneo Matsunaga, *Project Management Lead, and Director, Satellite Observation Center*
Yu Someya, Tamaki Fujinawa, Hirofumi Ohyama, Hisashi Yashiro, Takafumi Sugita, Tazu Saeki, Yukio Yoshida, Astrid Müller, Satoshi 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



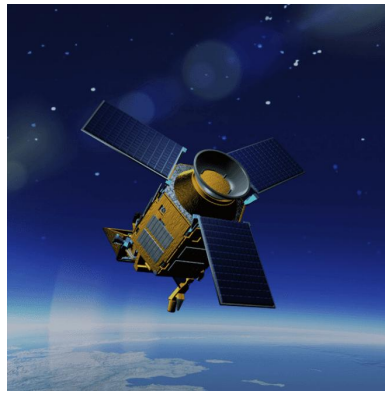
National Institute for Environmental Studies (NIES)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
National Institute of Information and Communications Technology (NICT)

GOSAT-GW
NIES
Project

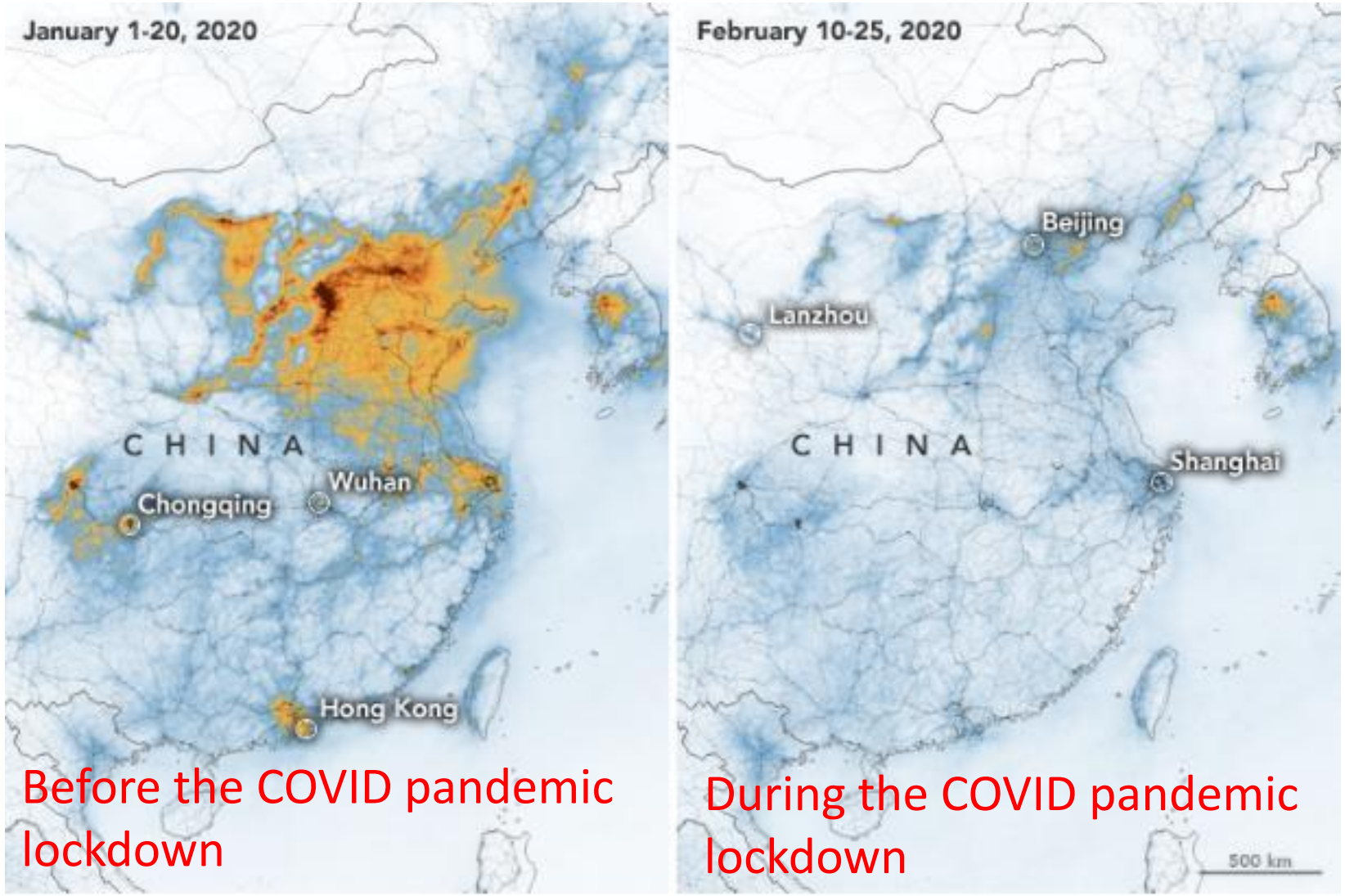
Satellites can observe NO_2 in the troposphere



TROPOMI

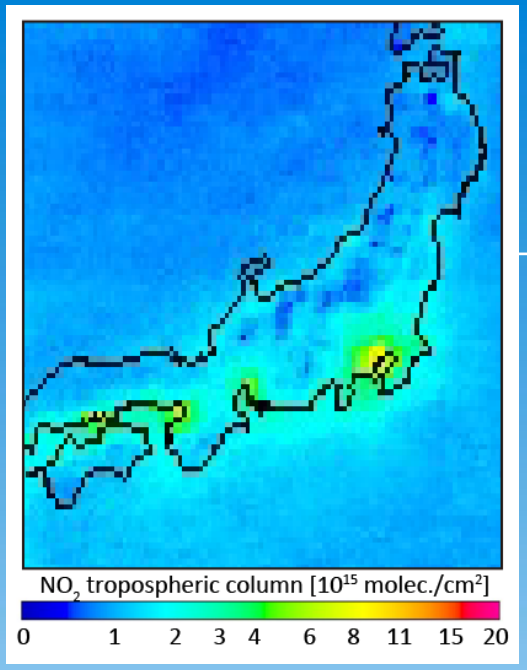


Satellite-derived NO_2 reflects anthropogenic NOx emissions

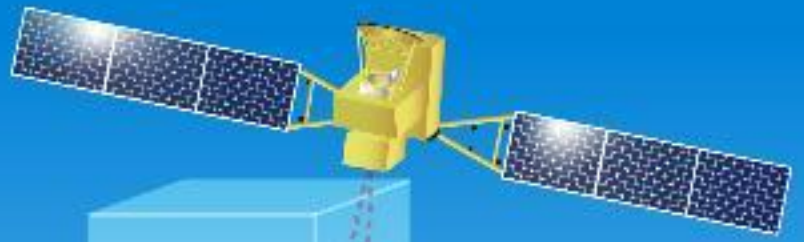


NASA Earth Observatory, 2020

Ground-based monitoring (e.g. AEROS)



Satellite observation (e.g. TROPOMI)



10 km

5 km

0 km

5 km

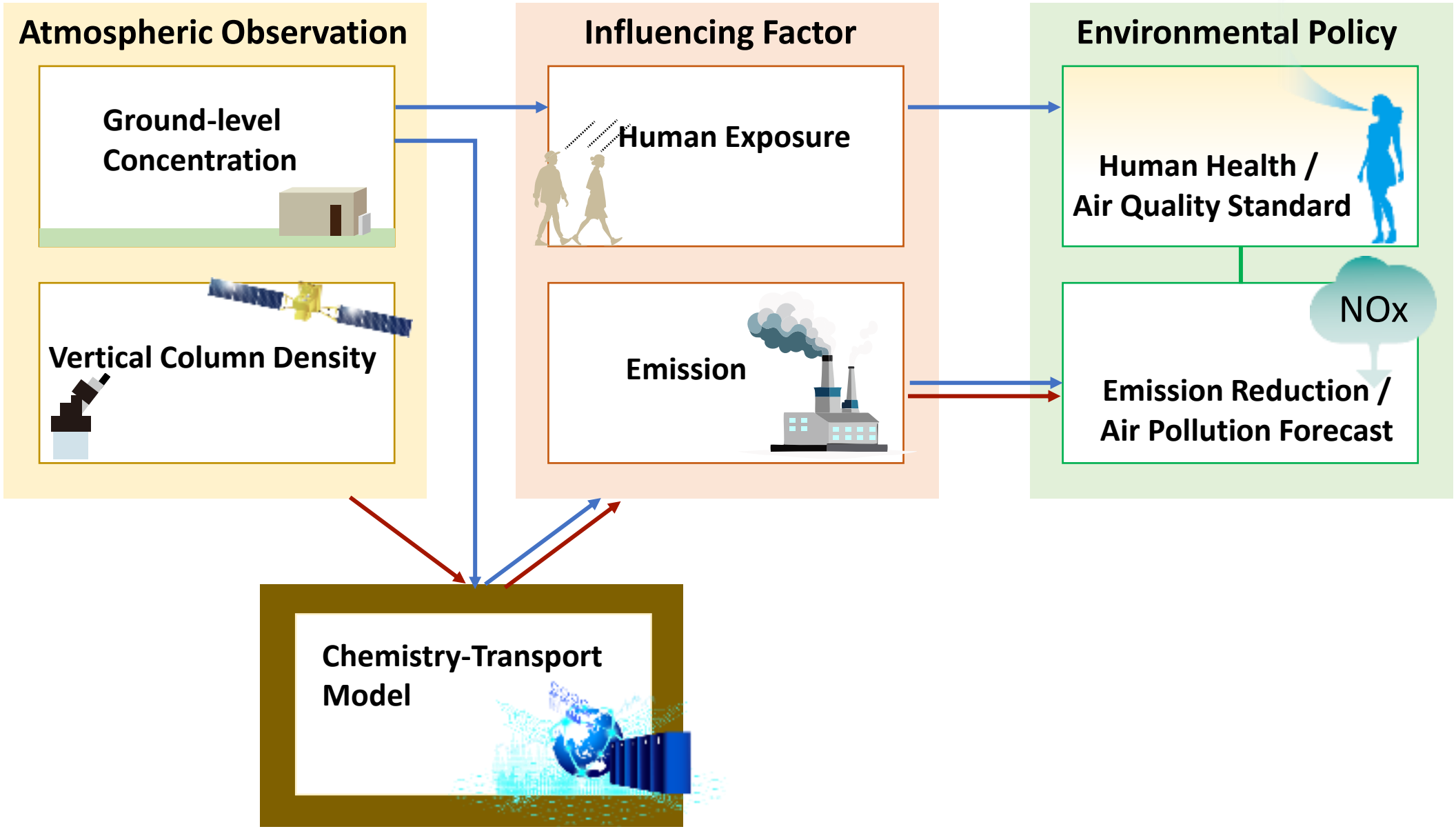
5 km

Satellite observation's spatial footprint:
~several km

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

< 100 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.

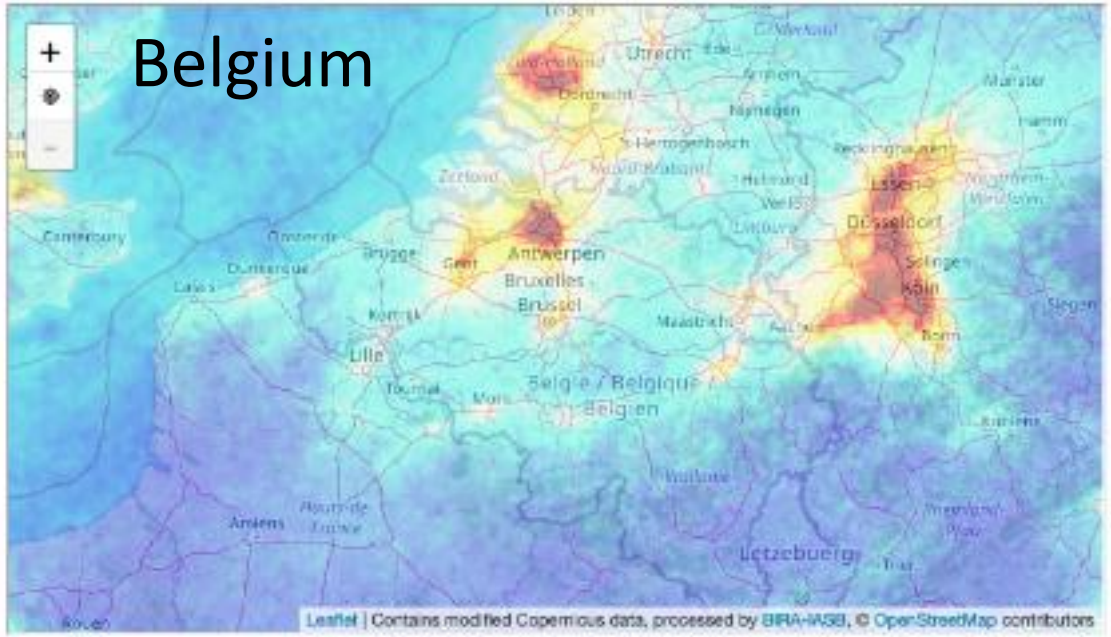
This includes the production of high spatial resolution maps of NO2 based on S5p-TROPOMI data over Belgium, and R&D on the complementarity and synergies within the (future) LEO+GEO constellation.

Example maps

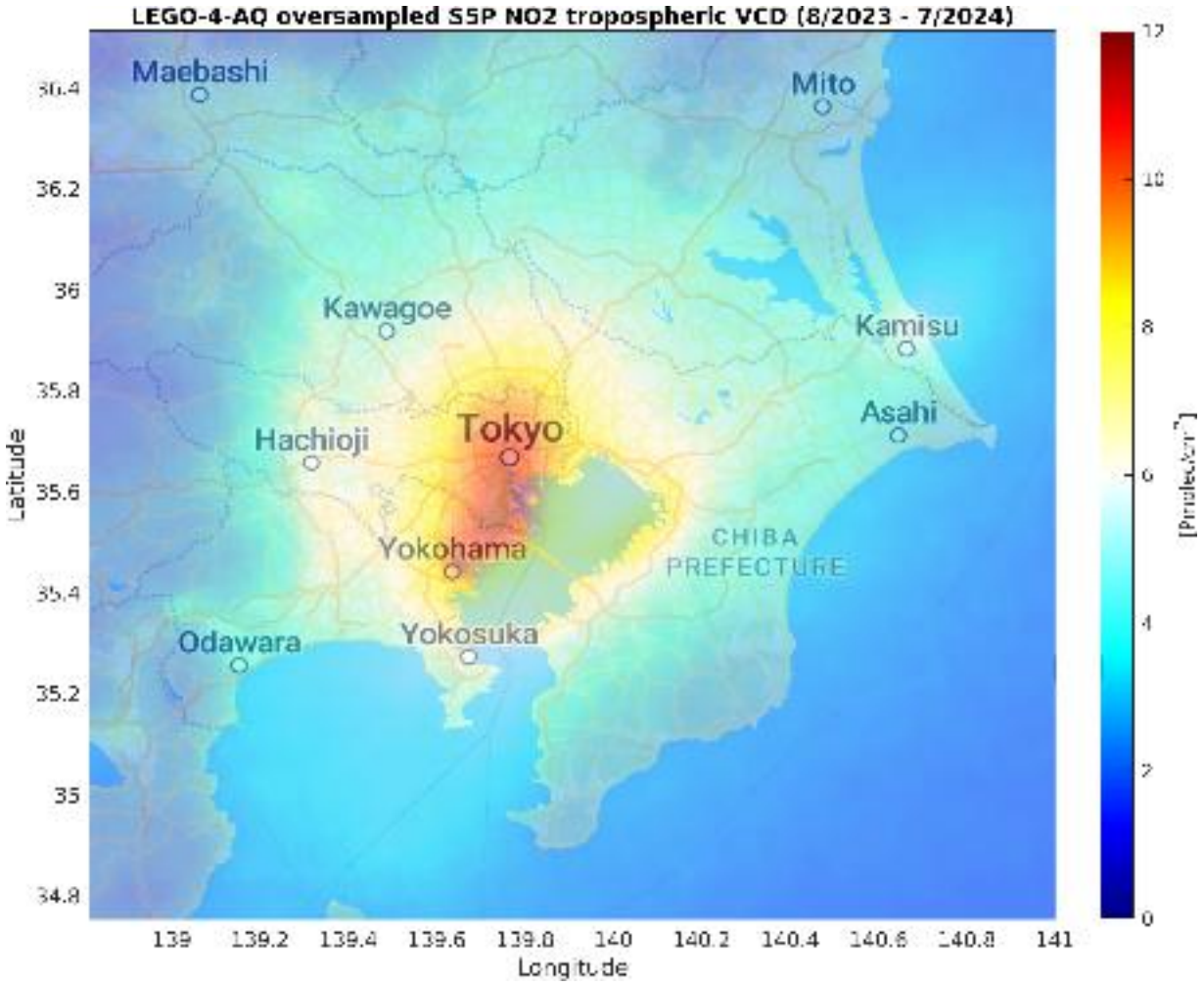
City-specific results can be found here.

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

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

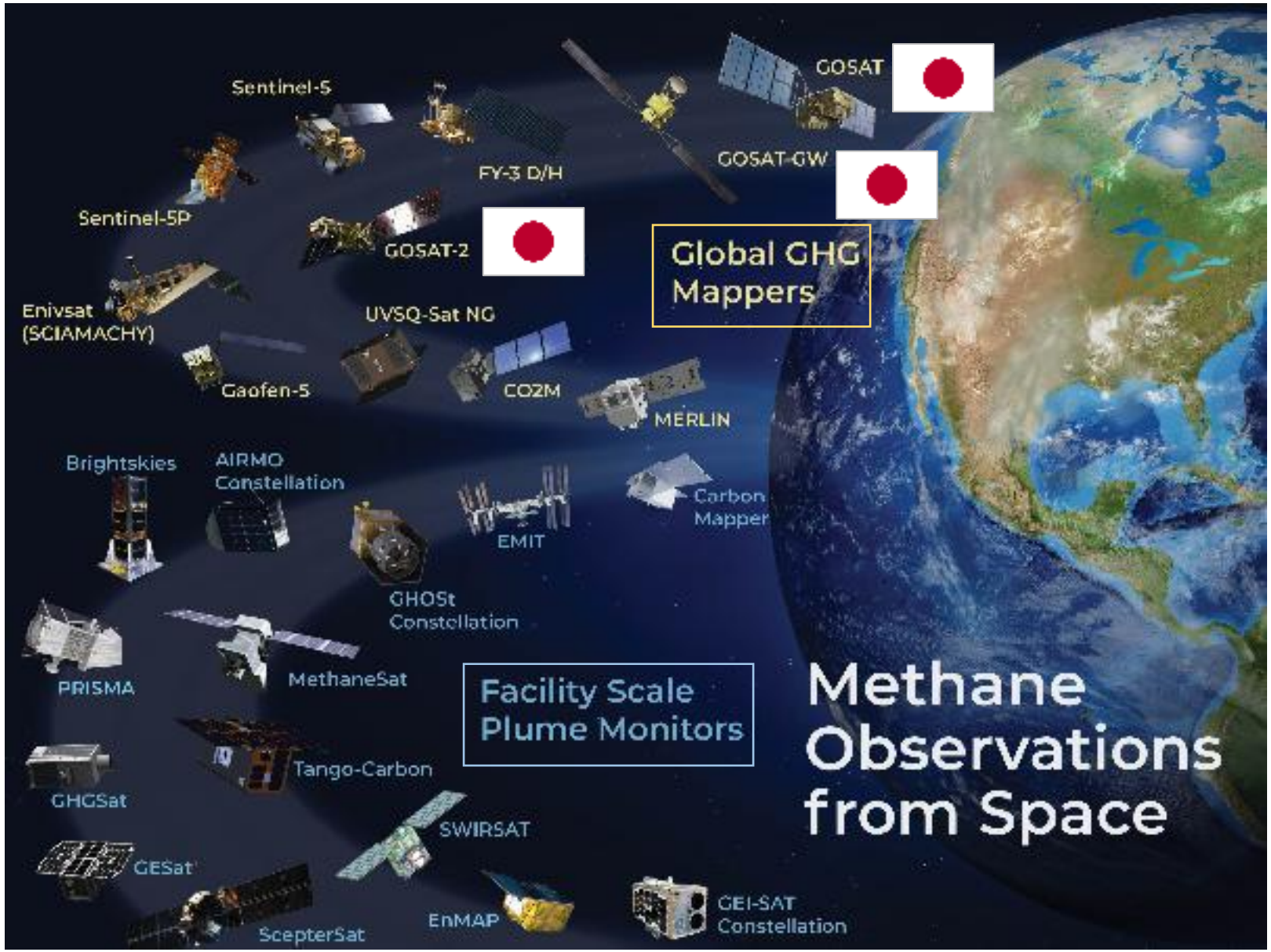


Tokyo



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

Measurements of greenhouse gases from space



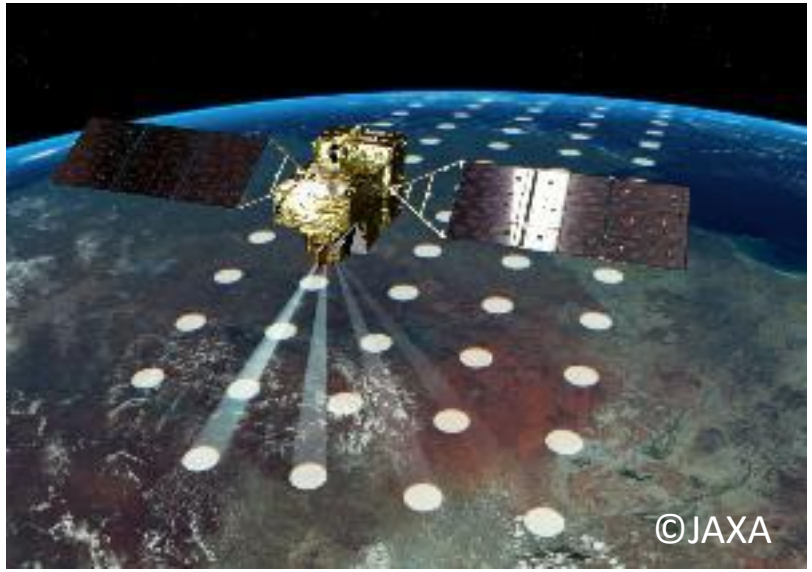
Growing constellation of GHG concentrations observations from the global to the facility scale

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

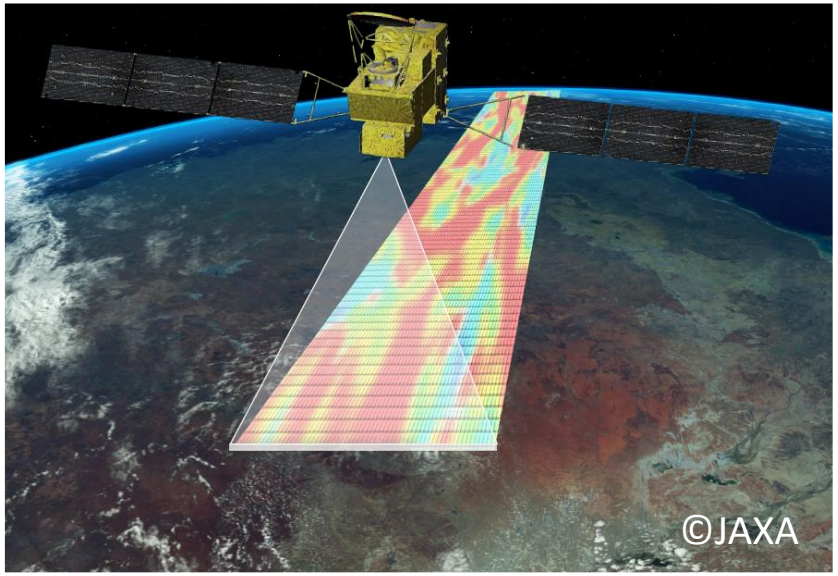
GOSAT, GOSAT-2, and … GOSAT-GW

GOSAT 2009 --

GOSAT-2 2018 --



GOSAT-GW 2025 --



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

Successful launch of GOSAT-GW in June 2025

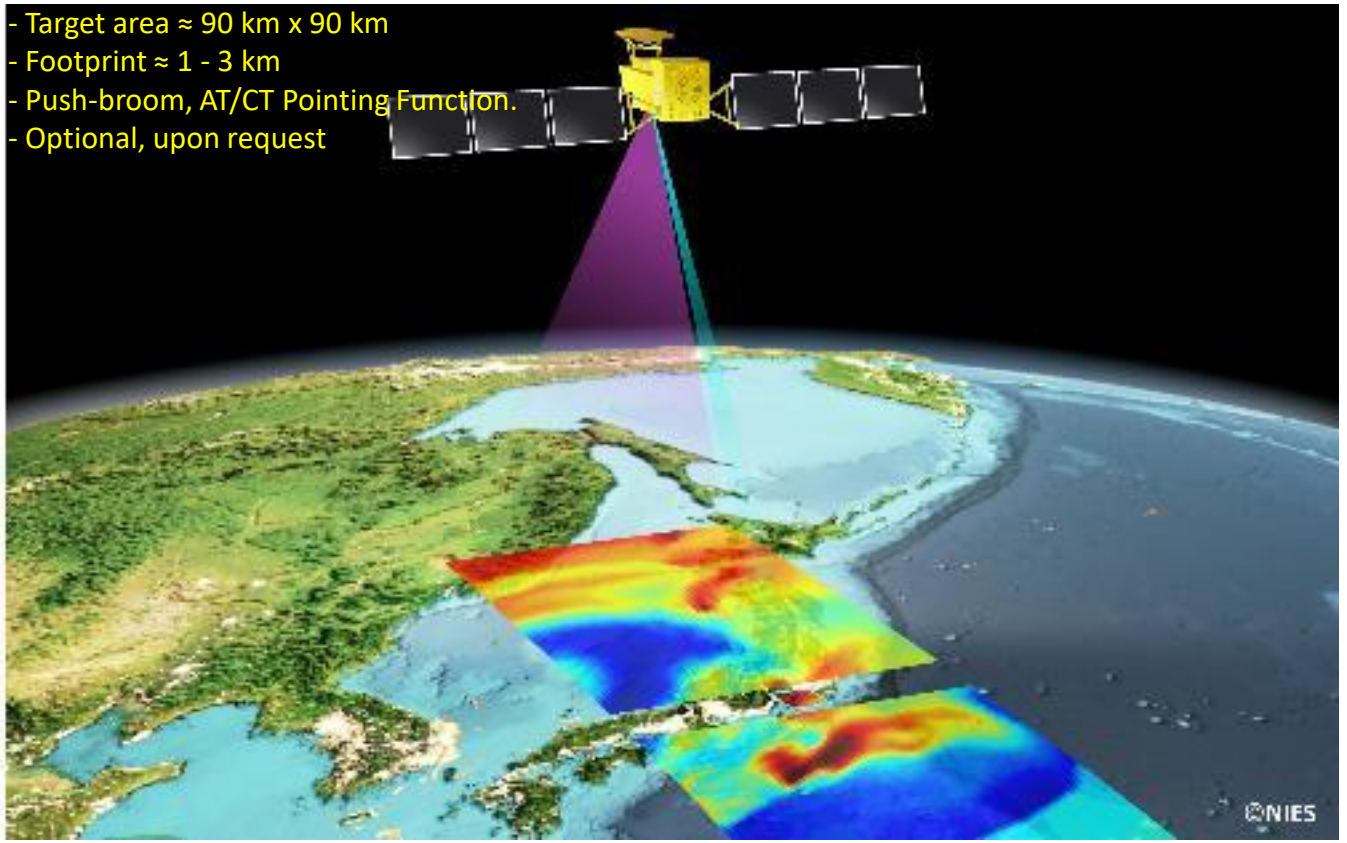
The GOSAT-GW satellite was launched at 1:33:03 am Japan time on 29th June at Tanegashima Space Center with the 50th H-IIA rocket, the last vehicle of the H-IIA series

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

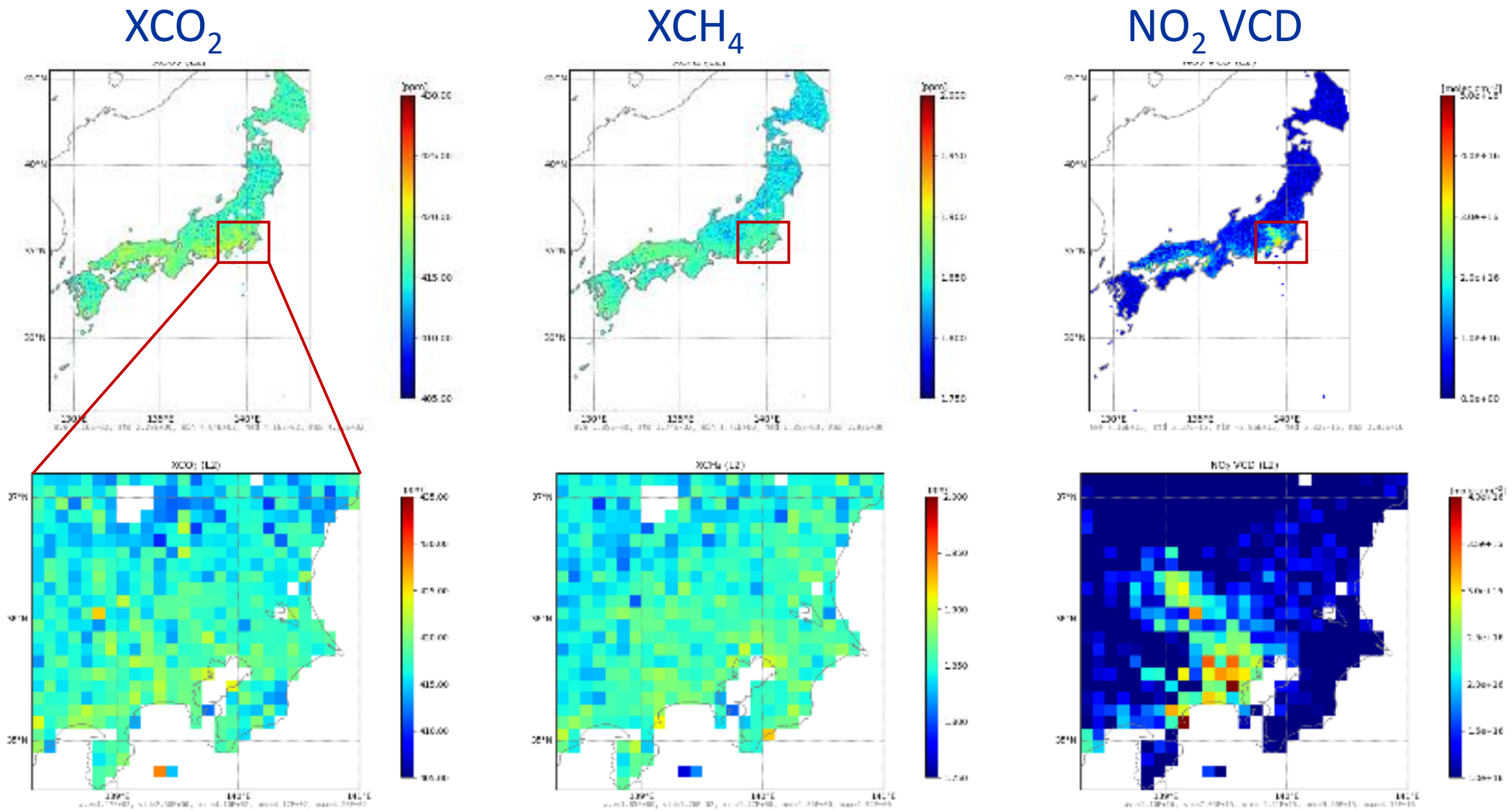
Wide Mode

Focus Mode



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

Simulated GOSAT-GW data – 10 km x 10 km

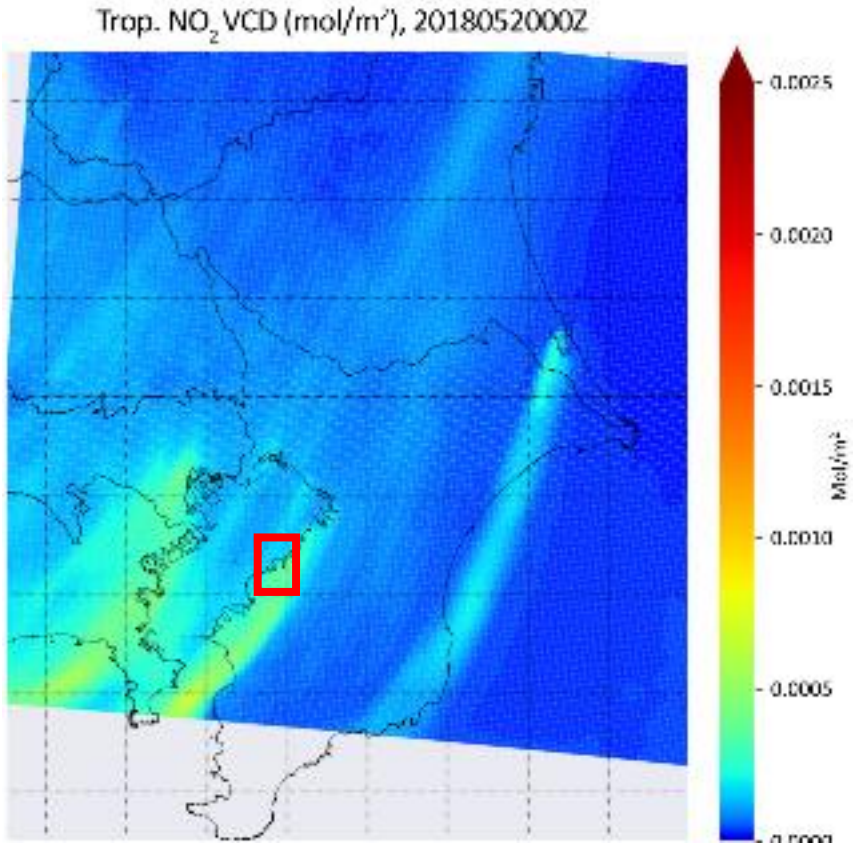


Detection of NOx Emissions from Power Plants

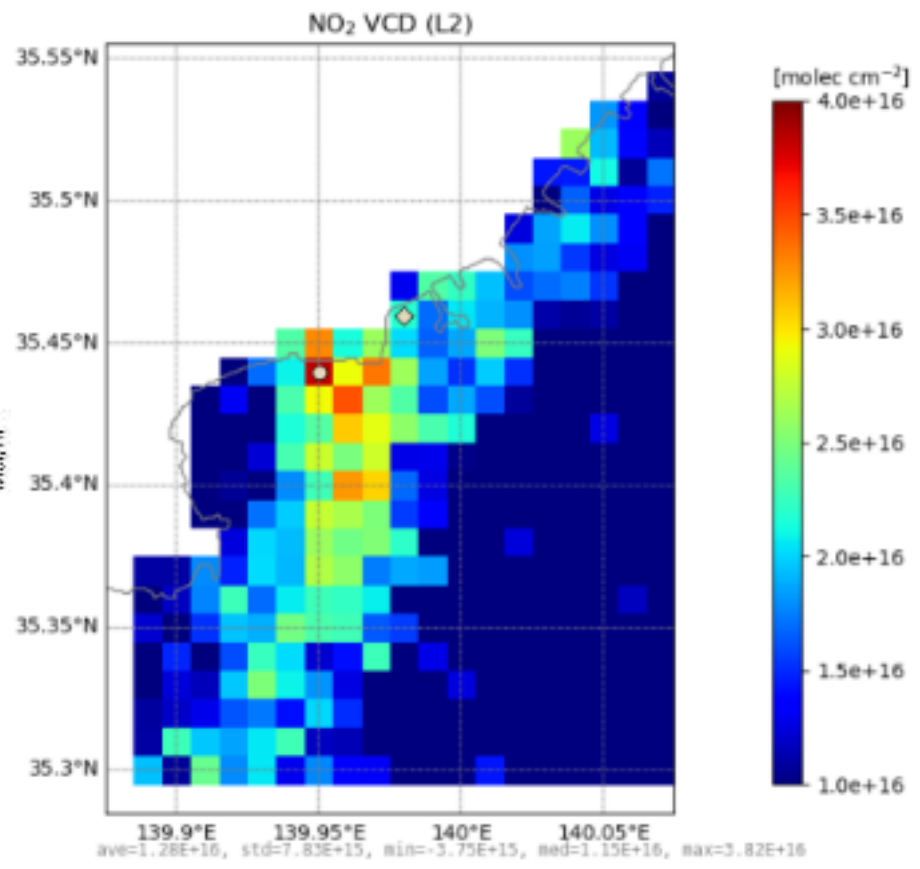
Industries in Tokyo Bay

JERA, 3600 MW

1 km x 1 km WRF-Chem model

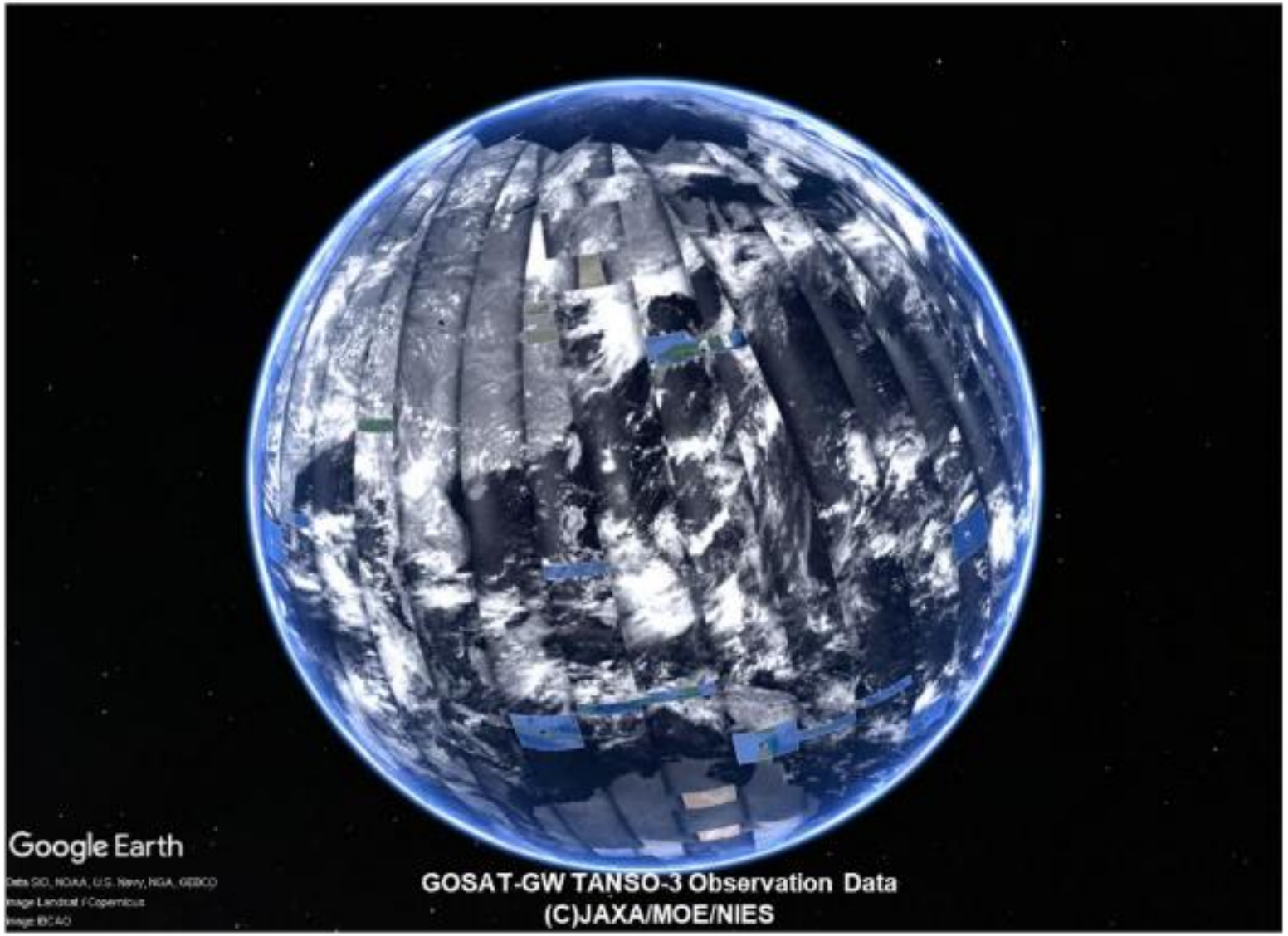


TANSO-3 simulator



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

First light: Wide Mode, July 14-16 2025



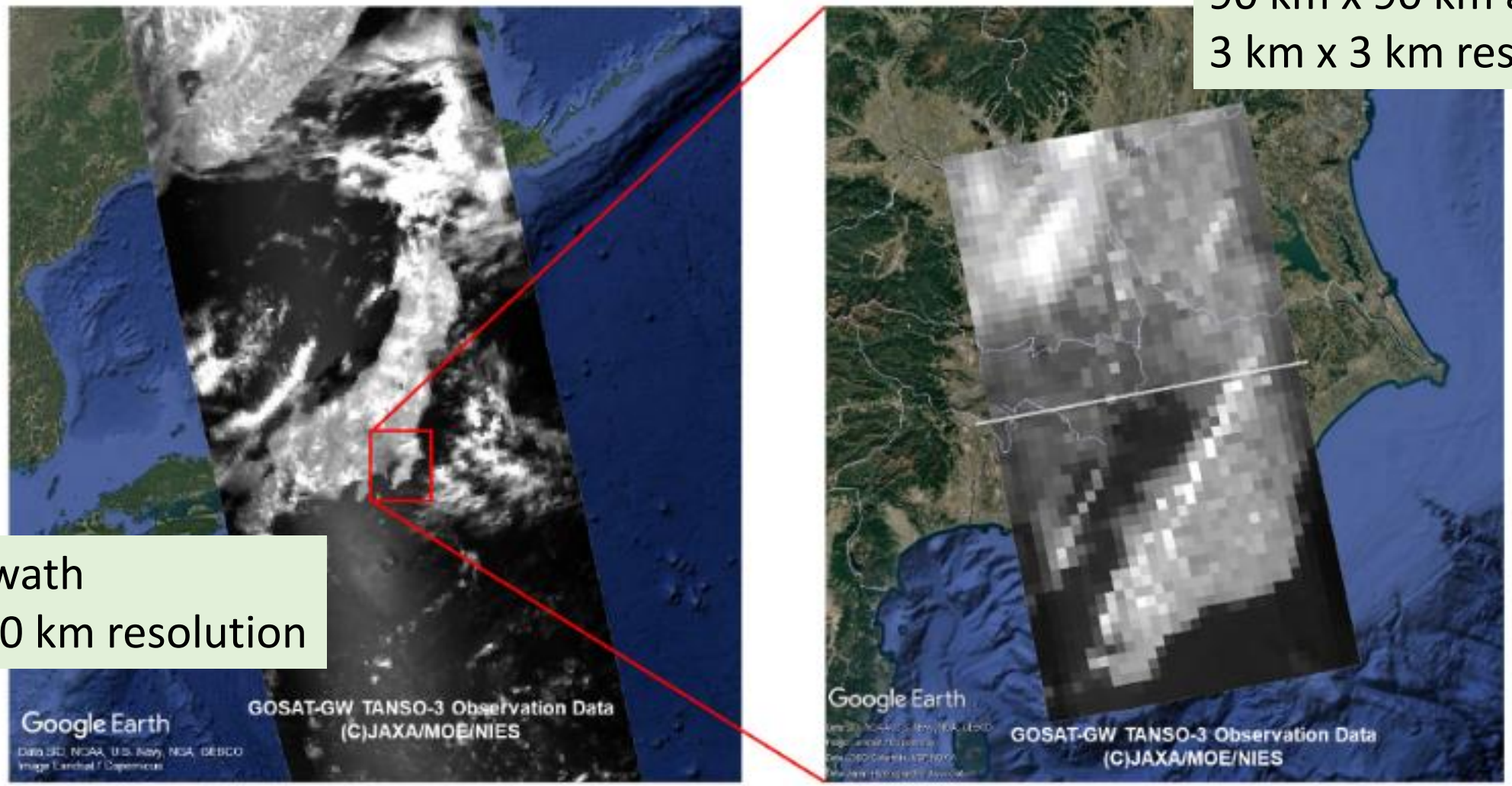
Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus Image IBCAO

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

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

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

911 km swath
10 km x 10 km resolution



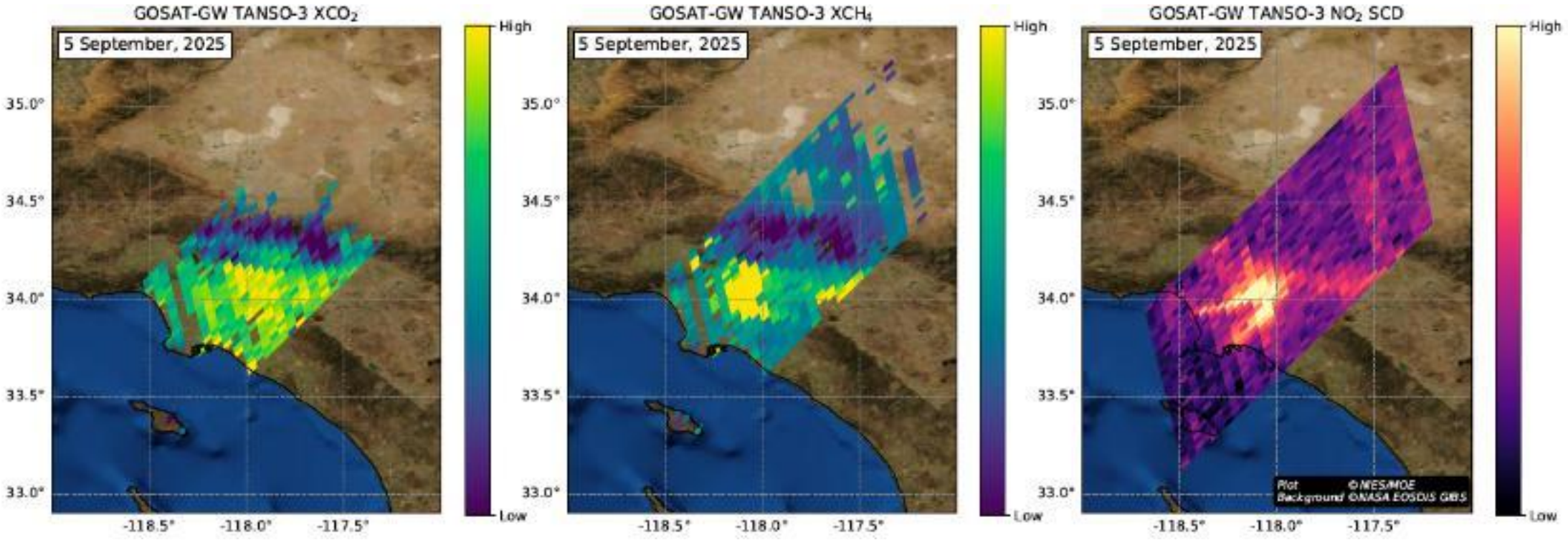
Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image Landsat / Copernicus

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



NIES (Yu Someya, Tamaki Fujinawa, Hyunkwang Lim)

NIES

!! CAUTION !! Initial analysis based on preliminary data

Ministry of the Environment
Government of Japan

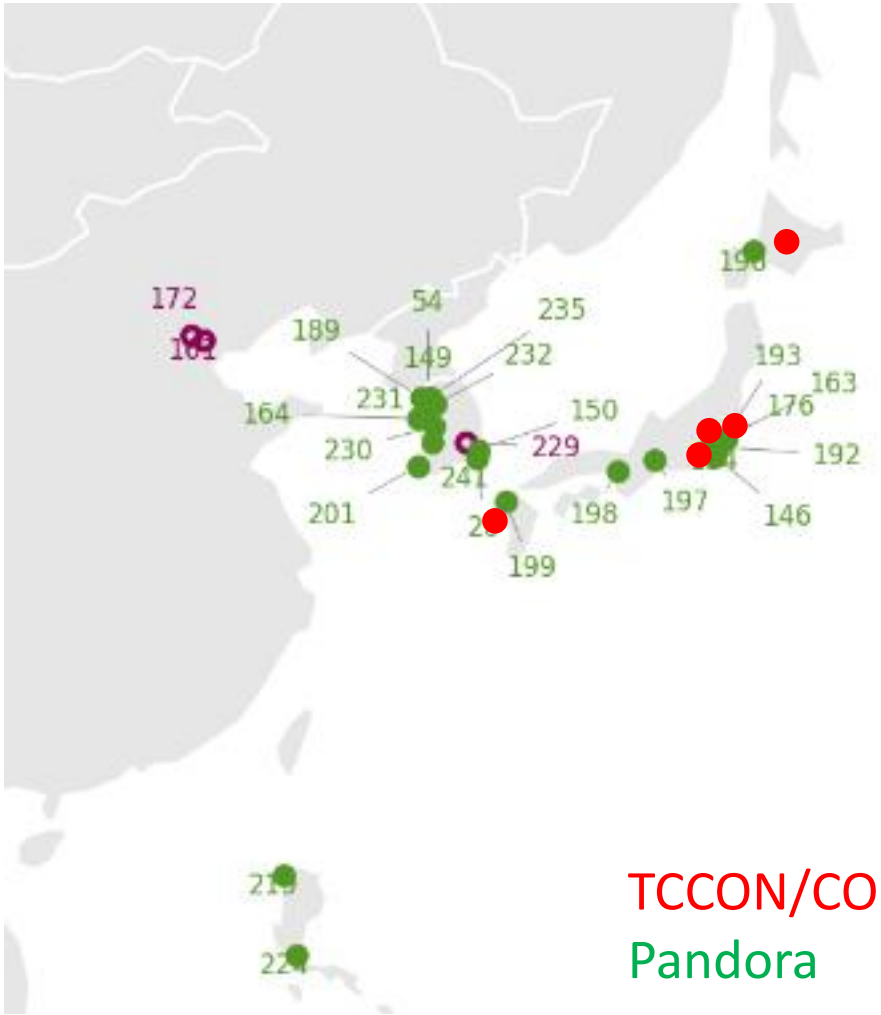
Since wind direction is southeast, NO_2 is flowing southeast from the coastline. The coastline has two thermal power plants.

EM27/SUN and Pandora validation of GOSAT-GW CO_2, CH_4, and NO_2

EM27/SUN – CO_2, CH_4, CO

Pandora – NO_2, O_3, HCHO

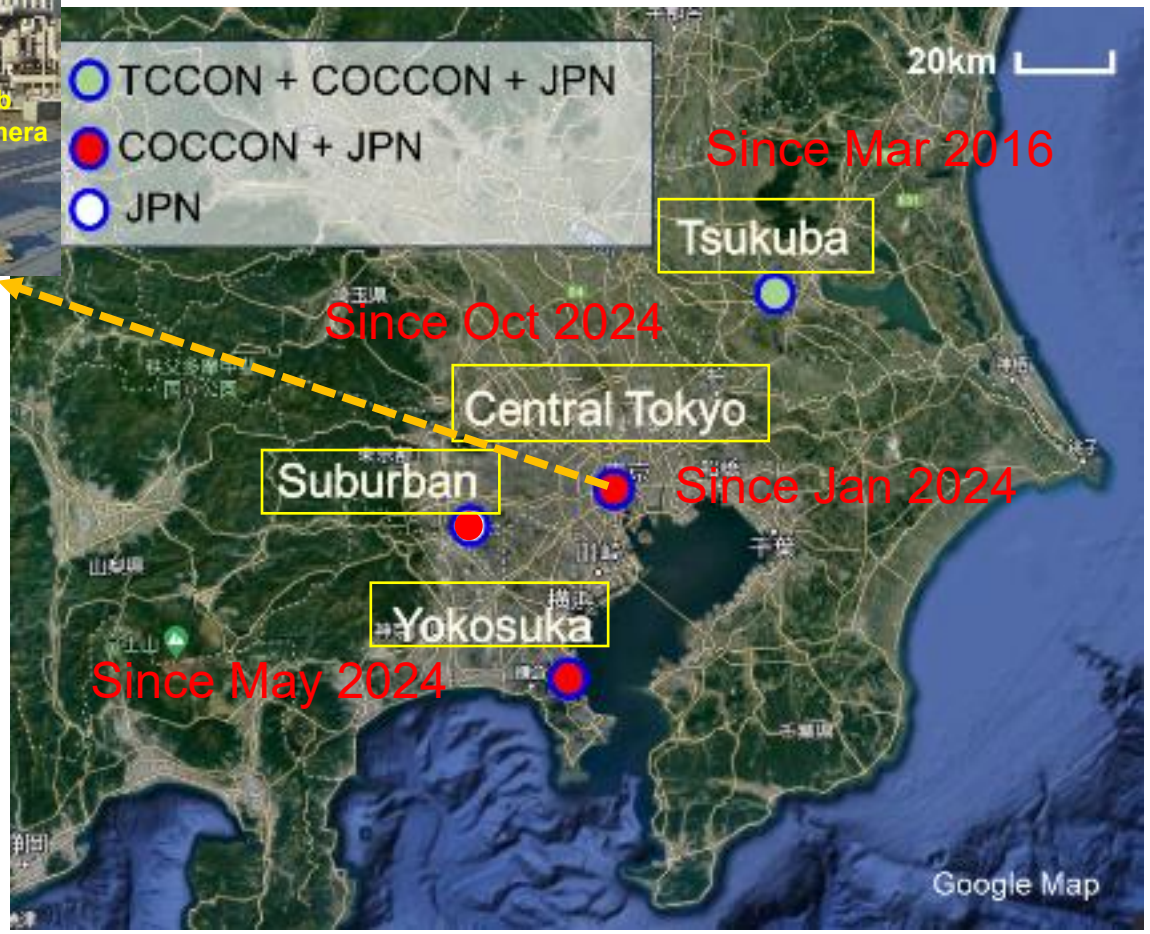
	CO_2/CH_4		NO_2
	TCCON	EM27/SUN	Pandora
Hokkaido	ONGOING		ONGOING
Tsukuba	ONGOING	ONGOING	ONGOING
Central Tokyo		ONGOING	ONGOING
Suburban Tokyo			ONGOING
Yokosuka		ONGOING	ONGOING
Nagoya			ONGOING
Kobe			ONGOING
Kyushu	ONGOING		ONGOING



NIES (Morino, Ohyama, Müller, Inomata, Sugita, Fujinawa), JAMSTEC (Kanaya, Patra, Miyakawa)

Measurements by COCCON FTSs (EM27/SUN) in the Kanto area, Japan

JPN: Japan Pandora Network
(NO_2, O_3, HCHO)



NIES, Tsukuba

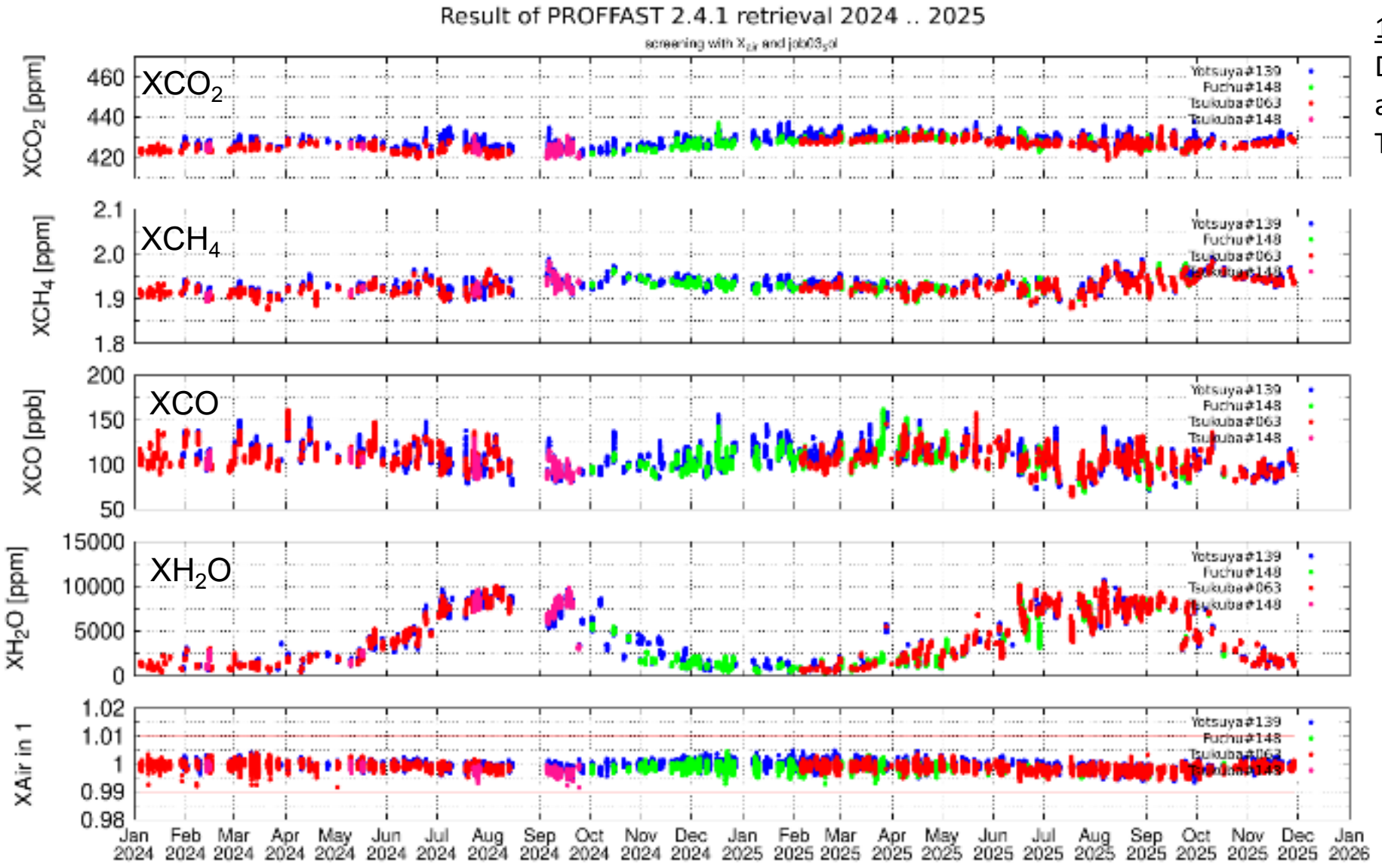
Tokyo University of Agriculture and Technology, Fuchu

JAMSTEC, Yokosuka

Contributors: NIES *(Isamu Morino, Astrid Müller, Hirofumi Ohyama, Hiroshi Tanimoto, Akihiro Hori, Kenji Yamaguchi, Toshifumi Fujimoto, Atsuya Kinoshita), KIT(Matthias Max Frey),* ***Sophia University, Yotsuya campus*** *(Nobuhiko Kuze),* ***JAMSTEC*** *(Takuma Miyakawa, Masahiro Yamaguchi, Yugo Kanaya),****Tokyo University of Agriculture and Technology, Fuchu campus*** *(Yoshihiro Nakashima, Soshi Shuto)*

Tsukuba, Yotsuya, Fuchu COCCON data time series from Jan 2024

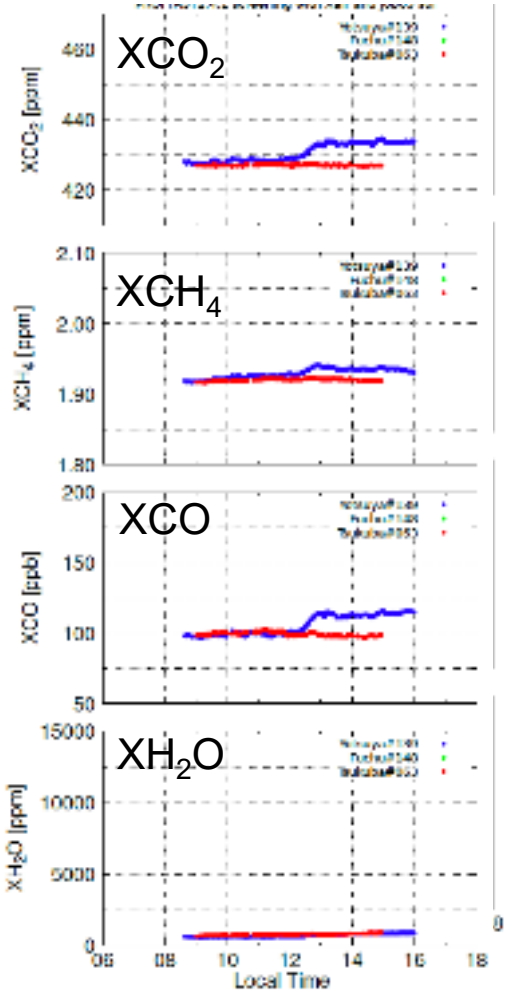
Yotsuya (SN 139): blue, Fuchu (SN 148): green, Tsukuba (SN 063): red, Tsukuba (SN148): magenta



No records at Tsukuba between Jul 2024 and Jan 2025 due to solar tracker repair.

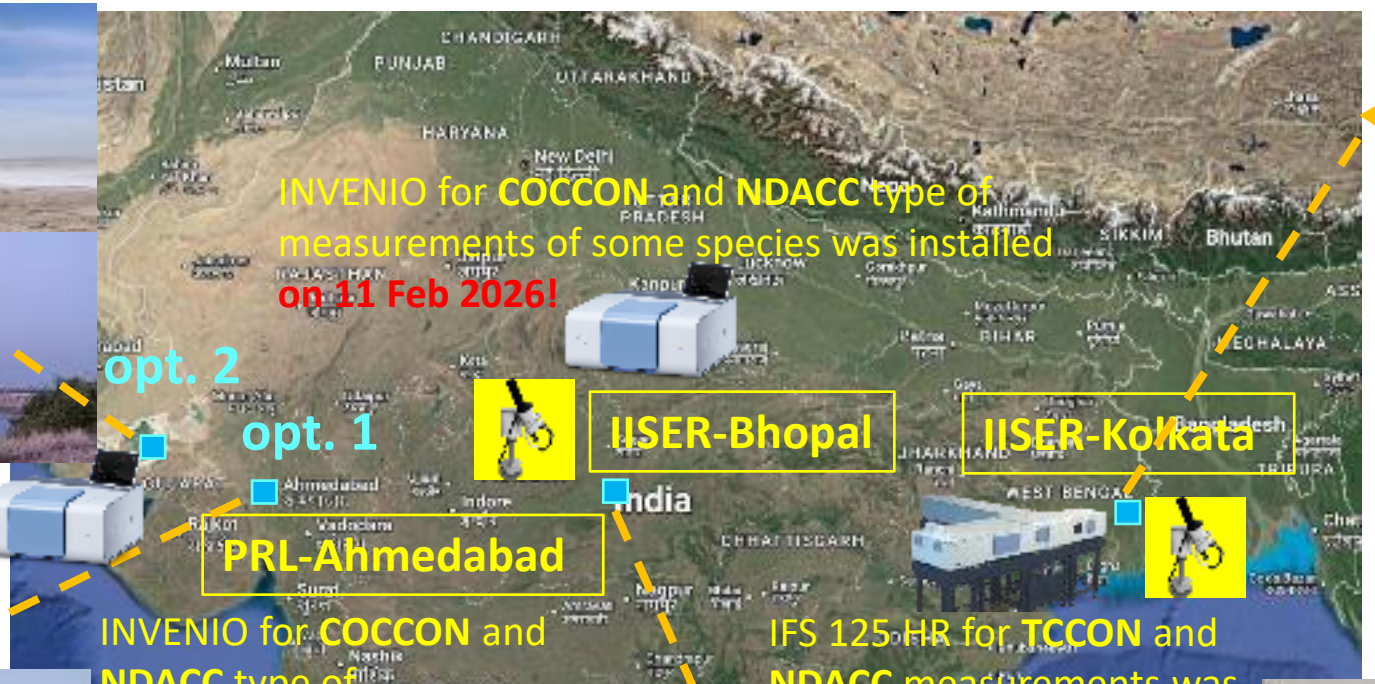
<u>10 Feb 2025</u>

Day when high values of XCO_2, XCH_4, and XCO were observed in central Tokyo



New TCCON, COCCON, and NDACC FTS sites: just established in India

Rann of Kachchh



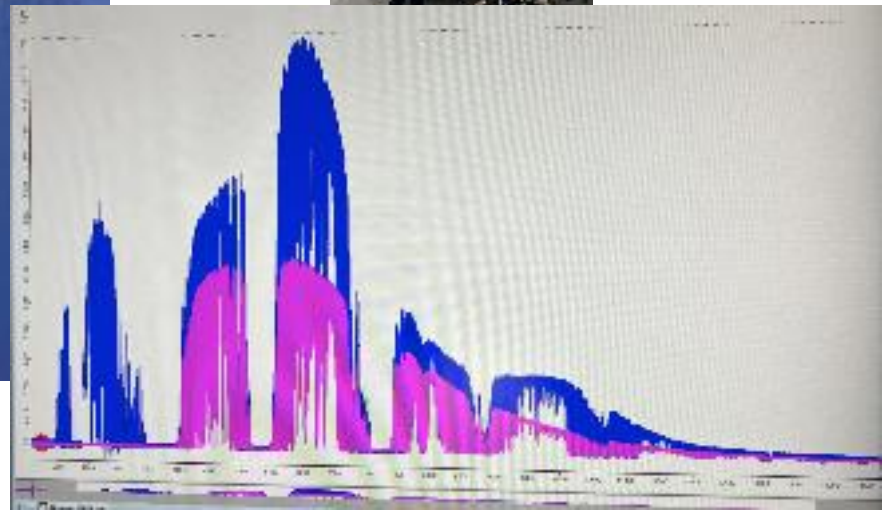
IISER-Kolkata

PRL-Ahmedabad

Roof of the building at PRL

IISER-Bhopal

Roof of the building and the observatory at IISER-Bhopal



We have started the new ground-based FTS measurement project focusing on India with the aim to have the first ones starting in 2026 as one of the **GOSAT-GW validation activities**.

NIES (Morino), BIRA-IASB (Sha, De Mazière, Desmet, Kumps, Langerock, Boonants, Vigouroux), IISER-Kolkata (Ray, Banerjee), IISER-Bhopal (Pillai, Kumar), PRL (Gadhavi)

GOSAT-GW

NIES Project

Ministry of the Environment
Government of Japan

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

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Thank you very much