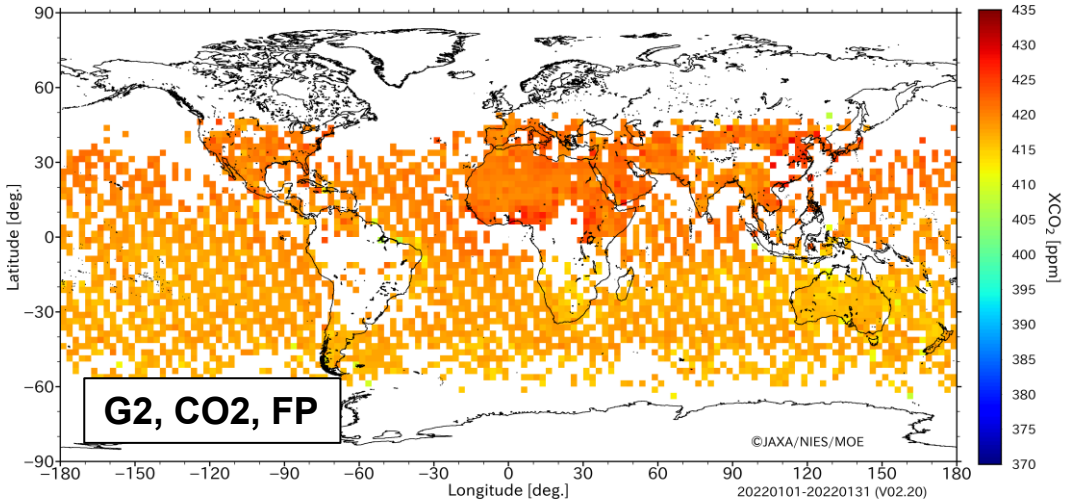
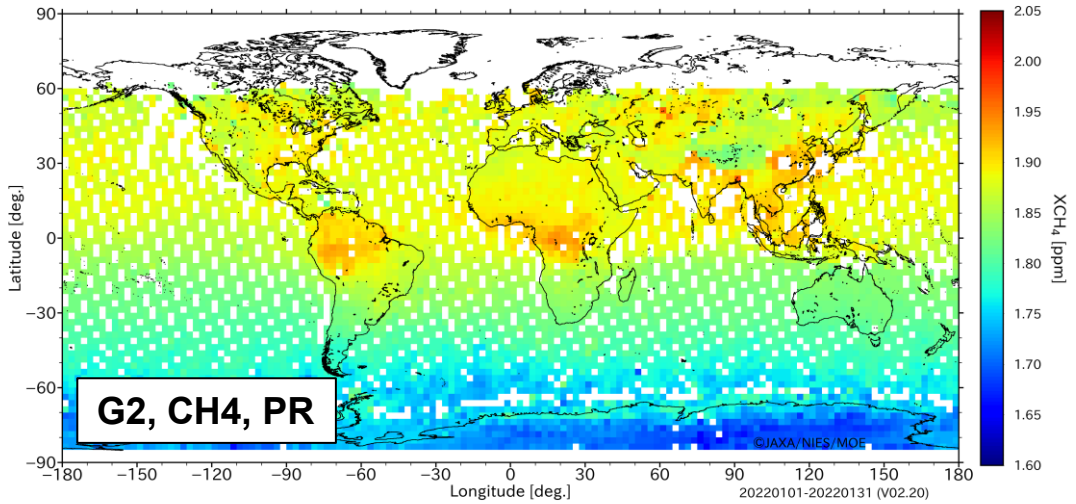
IWGGMS-21 Session 1: Status and results from current missions

Status of NIES GOSAT and GOSAT-2 Projects (Tsuneo Matsunaga, NIES)

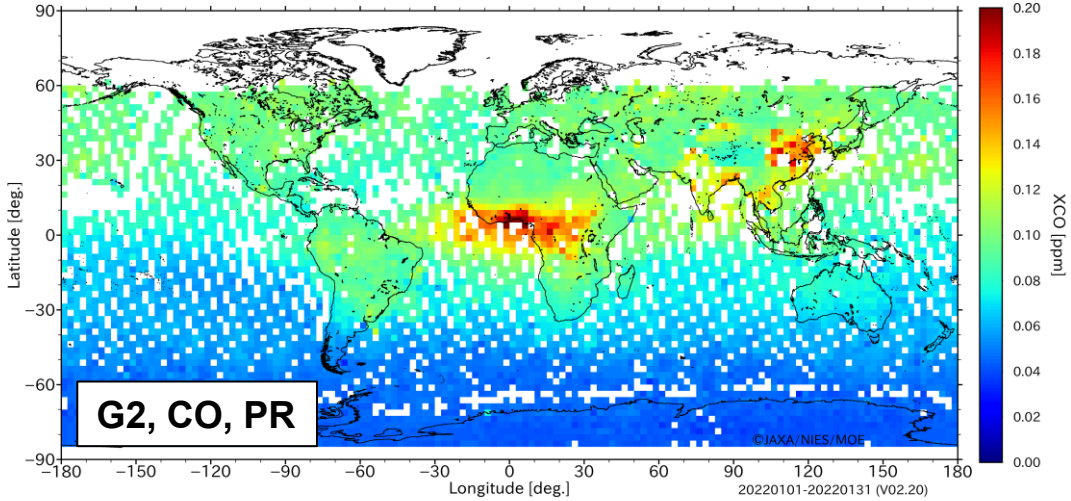
GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product (CO_2)



GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product (CH_4)



GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product (CO)



GOSAT-2 XCO2, XCH4, and XCO maps (V02.20) from January 2022 to December 2023

Status of NIES GOSAT and GOSAT-2 Projects

Tsuneo Matsunaga, Isamu Morino, Yukio Yoshida, Makoto Saito, Hibiki Noda, Hirofumi Ohyama, Yu Someya, Tazu Saeki, Yosuke Niwa, Hiroshi Tanimoto, Akihide Kamei, Fumie Kawazoe, Yukitomo Tsutsumi, Jiye Zeng, Shamil Maksyutov, Rajesh Janardanan, Fenjuan Wang, and Lorna Nayagam

Satellite Observation Center
National Institute for Environmental Studies

IWGGMS-21 Presentations from NIES (1/3)

Oral (10)

Day 1, Session 1: Status and results from current missions / Session 2: Status and plans of future missions

Matsunaga, Status of NIES GOSAT and GOSAT-2 Projects

Tanimoto, The greenhouse gas observation mission with Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW): Updates

Yashiro, Interface with users of GOSAT-GW TANSO-3 observation: observation requests, product downloads, and acquisition of information

Day 2, Session 4: Calibration and validation

Morino, Status and upcoming plans of ground-based FTS measurements for evaluating space-based greenhouse gas measurements and carbon cycle studies at the National institute for Environmental Studies

Day 3, Session 5: Global to regional flux estimates and validation

Niwa, Inverse analysis with in-situ/flask and GOSAT observations to disentangle regional and sectoral emission contributions to the surge of atmospheric CH4 for 2020-2022

Day 3, Session 8: Stakeholder needs and engagement

Tanimoto, Development of the Japan Greenhouse Gas Center and its stakeholder engagement

IWGGMS-21 Presentations from NIES (2/3)

Oral (10)

Day 3, Session 5: Global to regional flux estimates and validation

Maksyutov, Regional carbon sink estimates by NTFVAR inverse model with surface and satellite observations

Maity, Investigating anomalous growth of atmospheric CO2 in 2023-2024 using GOSAT XCO2-constrained inverse modeling

Day 4, Session 5: Global to regional flux estimates and validation

Wang, Methane Budgets of East, Southeast and South Asia (2010-2021): An Inversion Inter-Comparison for Asia (MICA)

Day 4, Session 7: Multi-species observations/modeling and GHG-AQ synergy

Mueller, Towards shipborne emission monitoring and satellite validation of CO2, CH4, CO, and NO2 through simultaneous columnar and in situ observations

IWGGMS-21 Presentations from NIES (3/3)

Poster (12)

Day 1:

Yoshida, Latest topics about the GOSAT-2 SWIR L2 products

Ohyama, Validation plan for GOSAT-GW TANSO-3 Level 2 products

Tsusumi, Validation of the latest GOSAT series L2 products

Janardanan, Localized CO2 enhancements observed by the GOSAT satellite and their relation to country-level anthropogenic emissions

Day 2:

Saito, Global carbon dioxide and methane flux estimates based on GOSAT-2 observations

Nayagam, Quantifying Indian terrestrial biospheric CO2 flux using observations from ground-based network and GOSAT

Tohjima, Global carbon budgets estimated from atmospheric O2 and CO2 observations in the western Pacific over a 20-year period

Day 3:

Bisht, High resolution CO2 simulation over Kanto region in Japan

Yang, Urban CO2 simulations for the Greater Tokyo Area based on high-resolution modeling and comparison with tower observation network

Fujinawa, Retrieval algorithm development for TANSO-3 NO2 product

Yamashita, Development Of A Simple NOx Emission Estimation Method Using Satellite Observations And A Chemistry-Transport Model

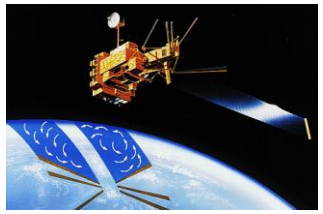
Lim, Development Of A Simple NOx Emission Estimation Method Using Satellite Observations And A Chemistry-Transport Model

Earth Observation Satellite Projects at NIES:
ADEOS/ILAS, ADEOS-II/ILAS-II, GOSAT, GOSAT-2, and GOSAT-GW/TANSO-3

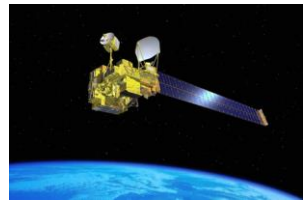
(FY)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004

- Montreal Protocol (1987)
- NIES Satellite Observation Research Team was established in 1991.



- **ADEOS** with Improved Limb Atmospheric Spectrometer (ILAS) was launched in 1996 and operated for 10 months.



- **ADEOS-II** with Improved Limb Atmospheric Spectrometer-II (ILAS-II) was launched in 2002 and operated for 10 months.
- Kyoto Protocol (1997)

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019

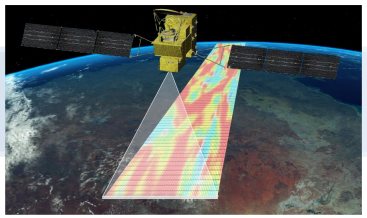
- GOSAT Research Team was established in 2004.

- GOSAT Project Office was established in 2006.
- **GOSAT** was launched in 2009 and has been operated since then.
- GOSAT-2 Project was established. in 2013.

- Paris Agreement (2015)
- NIES Satellite Observation Center was established in 2016.
- **GOSAT-2** was launched in 2018 and has been operated since then.

2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034

- GOSAT-GW Project was established. in 2021.
- **GOSAT-GW** will be launched in FY2025 and operated until FY2032 or beyond.



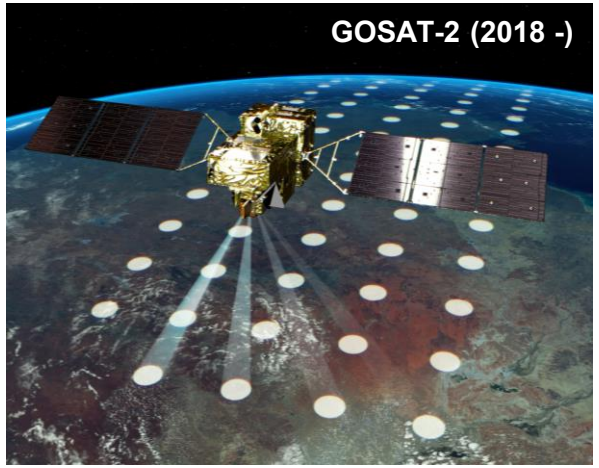
- 1st Global Stocktake (2023)
- 2nd Global Stocktake (2028)
- 3rd Global Stocktake (2033)

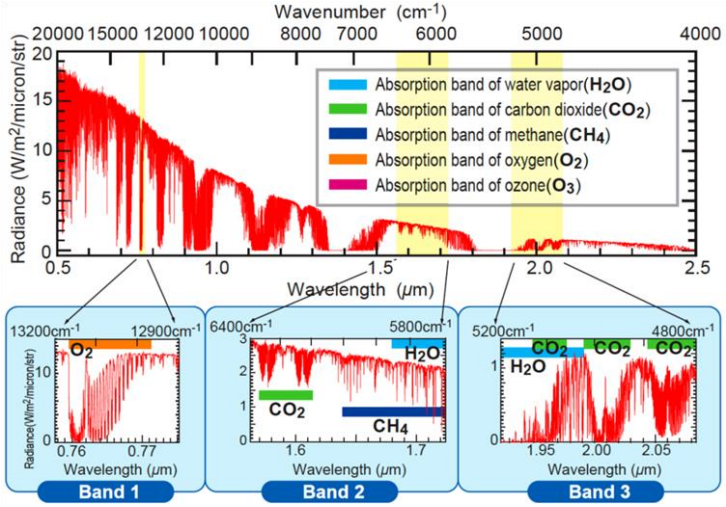
G4?

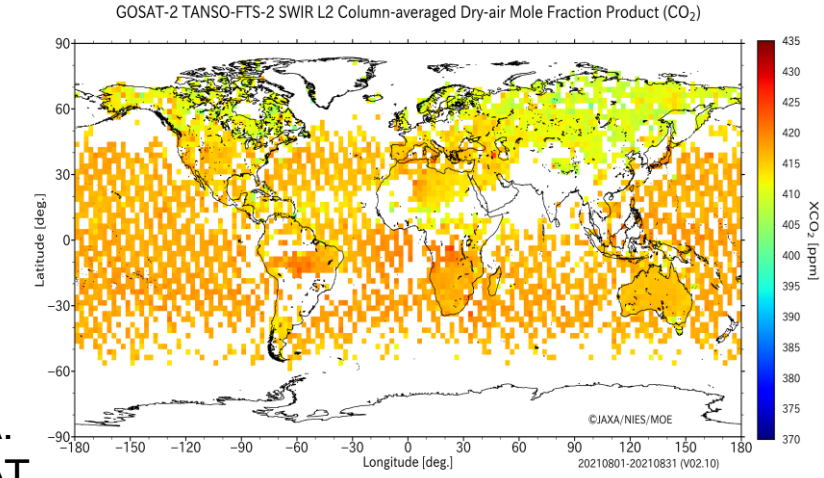
What is GOSAT Series?

- **Japanese earth observation satellite series measuring atmospheric concentrations of greenhouse gases for more than 16 years**
  - **GOSAT** (2009 -)
    Fourier transform spectrometer (FTS) for CO_2 and methane (CH_4)
  - **GOSAT-2** (2018 -)
    FTS-2 for CO_2, CH_4, and carbon monoxide (CO)
  - **GOSAT-GW** (June 2025 -)
    Grating imaging spectrometer (TANSO-3) for CO_2, CH_4, and nitrogen dioxide (NO_2)

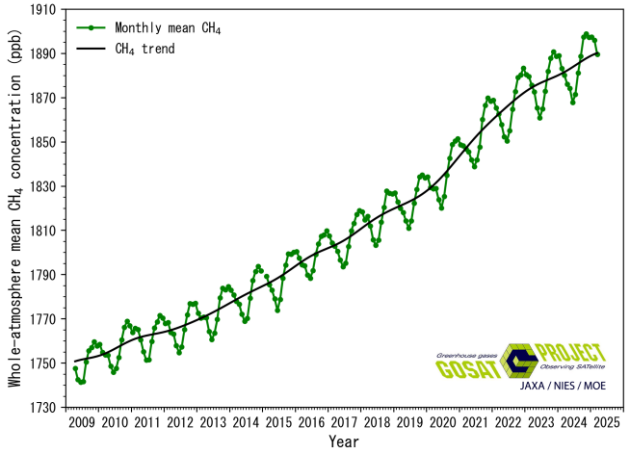
- **Organizations**
  - Joint projects by MOE, NIES, and JAXA
  - NIES is responsible for generation, validation, distribution, and archiving of gas concentration and flux data
  - Science Teams by domestic scientists
  - Collaboration agreements with foreign space agencies such as NASA, CNES, DLR, and ESA.
  - Participation of overseas researchers via GOSAT Series RA







GOSAT-2 FTS-2 SWIR L2 XCO_2 Map of August 2021 (V02.10, Full Physics)



GOSAT Whole-atmosphere Monthly Mean CH_4 Concentration (April 2009 – March 2025)

NIES 衛星観測センター Satellite Observation Center

GOSAT FTS SWIR and GOSAT-2 FTS-2 SWIR L2 Products

See Poster of Yoshida et al.

GOSAT FTS SWIR

Public Release

V3.00 and V03.05 (bias corrected)

In preparation

V03.10 and V03.10 (bias corrected)

GOSAT-2 FTS-2 SWIR

Public release

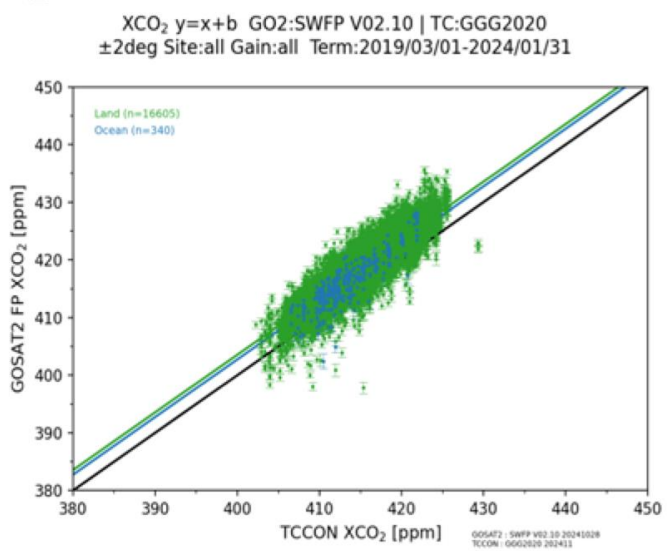
V02.00	With bias correction equations
V02.10	A priori variance-covariance matrix for CO2 profile was modified

RA release

V02.20/V02.21	JRA-55 => JRA-3Q

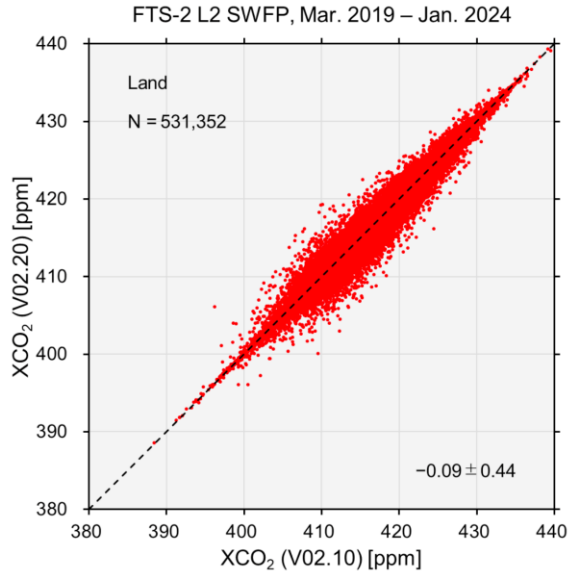
Future release

V02.30?	New L1B and/or other bug fixes



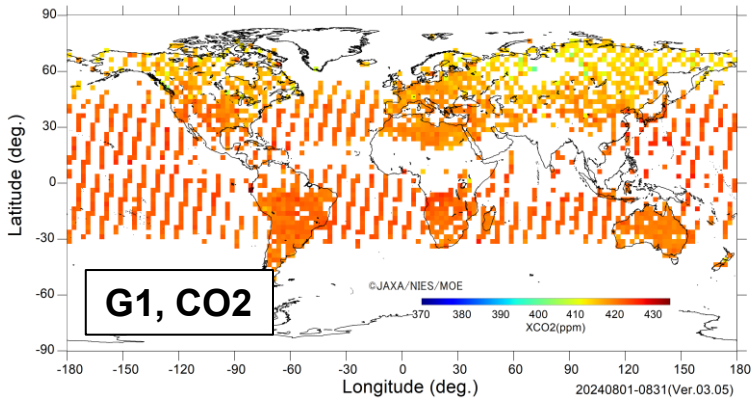
FTS-2 SWFP
Land XCO2
V02.10 – TCCON
= 3.19 ± 2.06 ppm
(2019 – 2024, ±0.1 deg.)

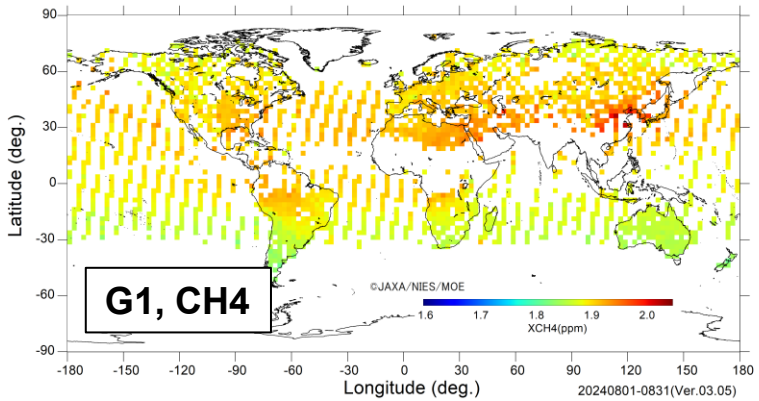
https://prdct.gosat-2.nies.go.jp/documents/pdf/ValidationResult_FTS-2_L2_SWFP_ver0210_en_00.pdf

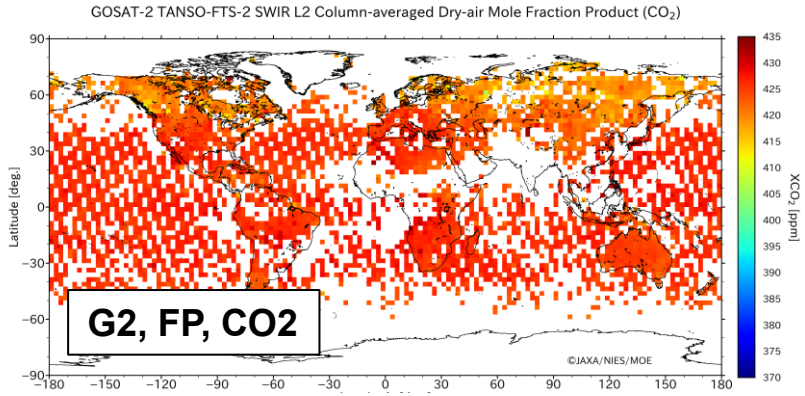


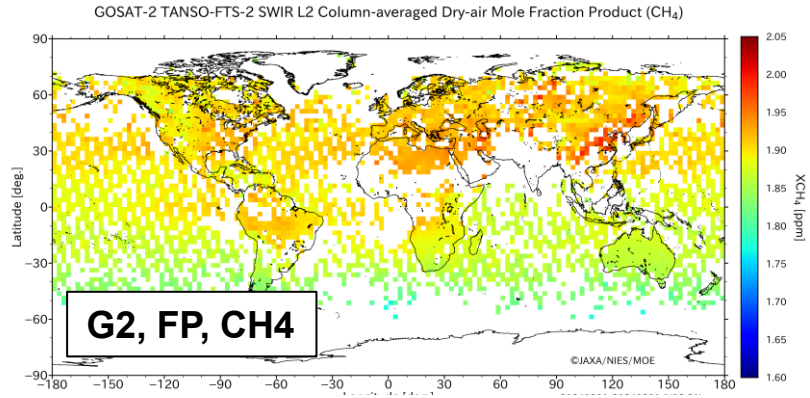
FTS-2 SWFP
Land XCO2
V02.20 – V02.10
= -0.09 ± 0.44 ppm

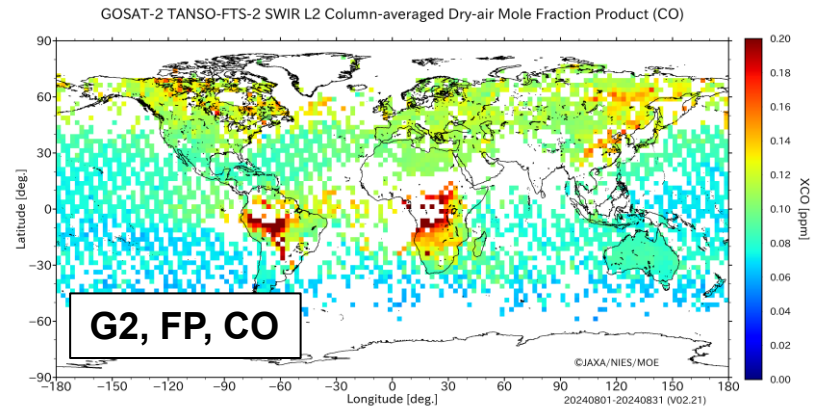
GOSAT FTS SWIR (V3.05) and GOSAT-2 FTS-2 SWIR L2 (V2.21) Maps (August 2024)

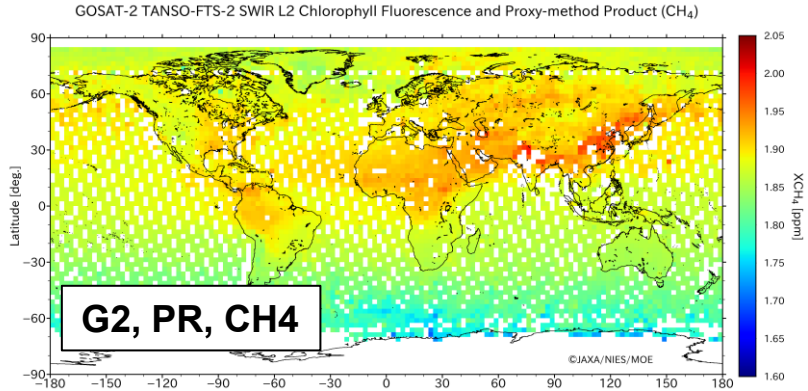


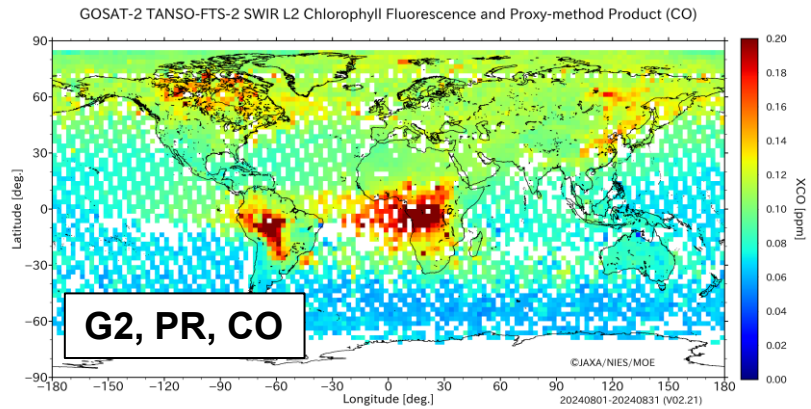








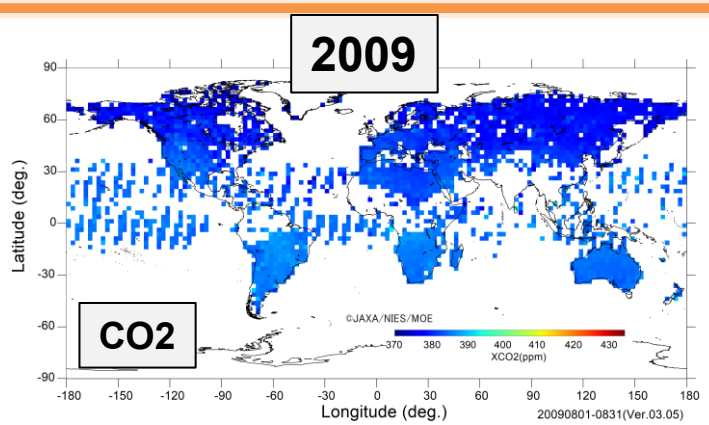


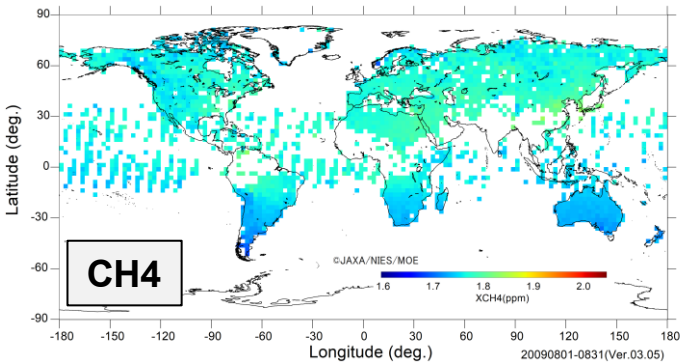


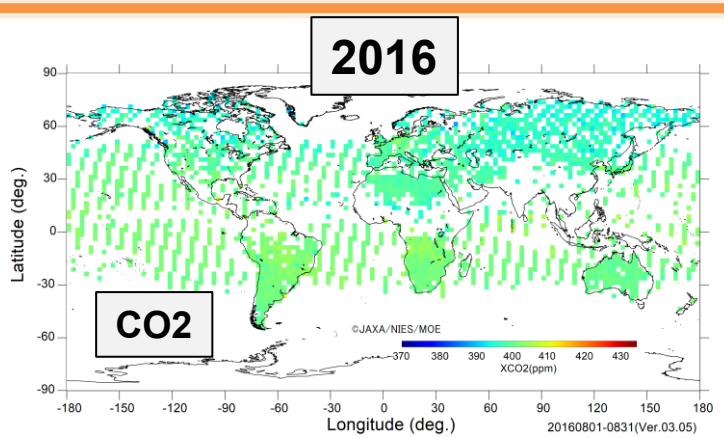
NIES 衛星観測センター Satellite Observation Center

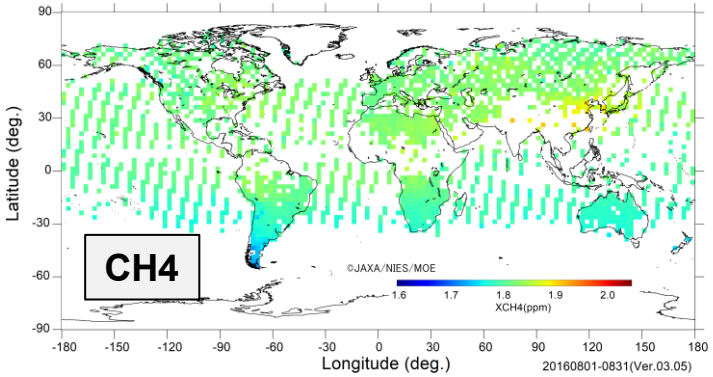
Tsuneo Matsunaga, Satellite Observation Center, National Institute for Environmental Studies, Japan

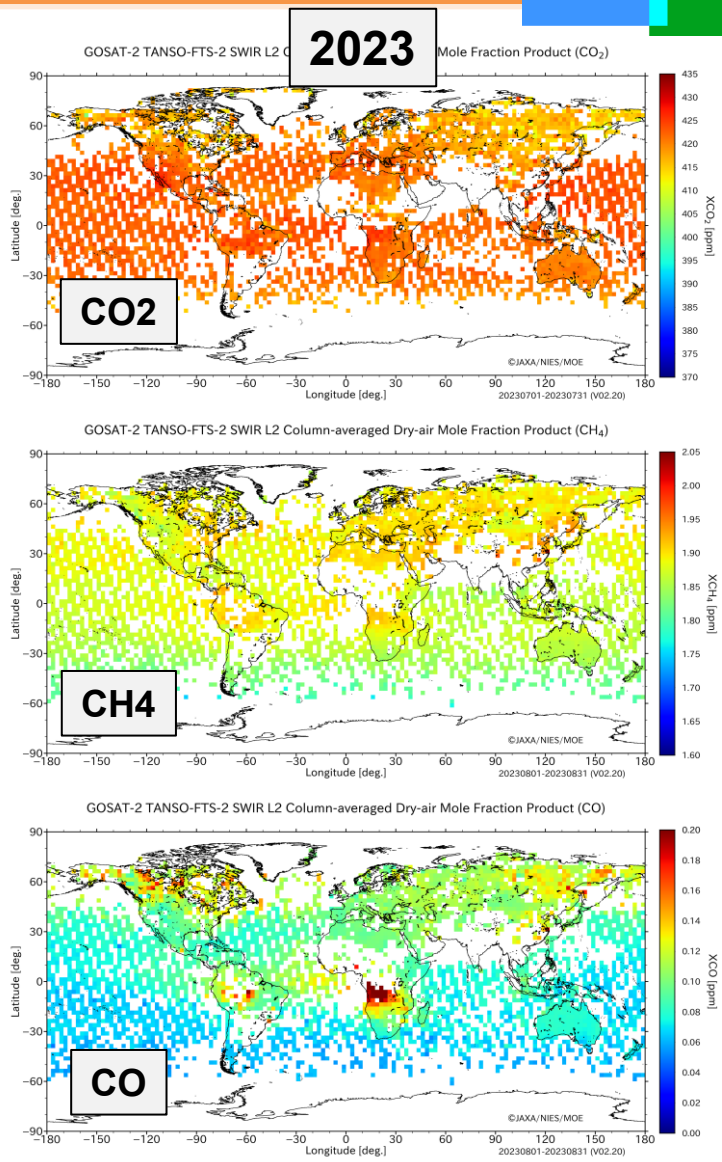
GOSAT(2009 and 2016) and GOSAT-2 (2023) August Maps of XCO_2, XCH_4, and XCO





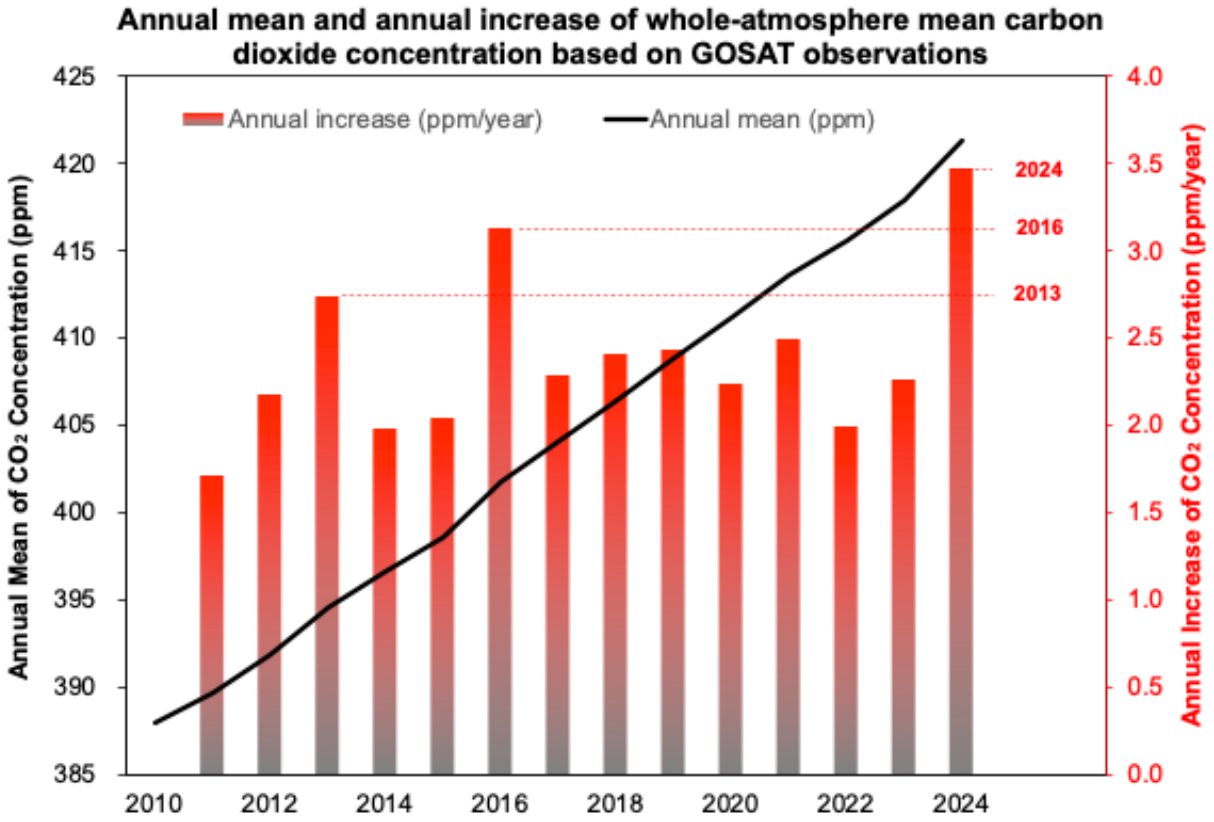






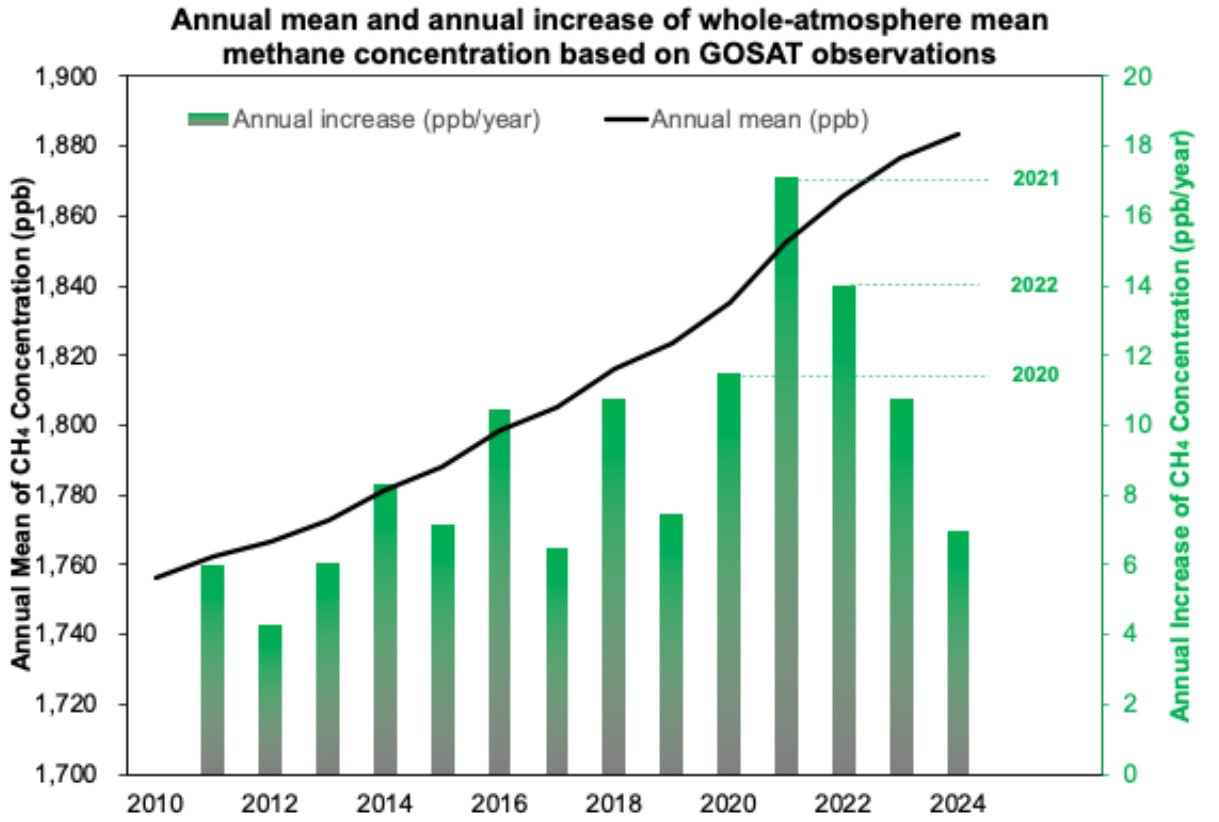
GOSAT Whole-atmosphere Mean Concentrations of CO2 and CH4: Annual Mean and Annual Increase

See Niwa et al. and Maity et al. on Day 3



GOSAT annual mean CO2 concentration and its annual increase from 2023 to 2024 were highest in the past 15 years.

https://www.nies.go.jp/whatsnew/20250214/20250214-e.html



GOSAT annual mean CH4 concentration in 2024 and its annual increase from 2020 to 2021 were highest in the past 15 years.

https://www.nies.go.jp/whatsnew/20220323/20220323-e.html

2016 – 2022 CH4 Inversion Using Surface, Airborne, and GOSAT Data (Niwa et al., accepted)

See Niwa et al. on Day 3

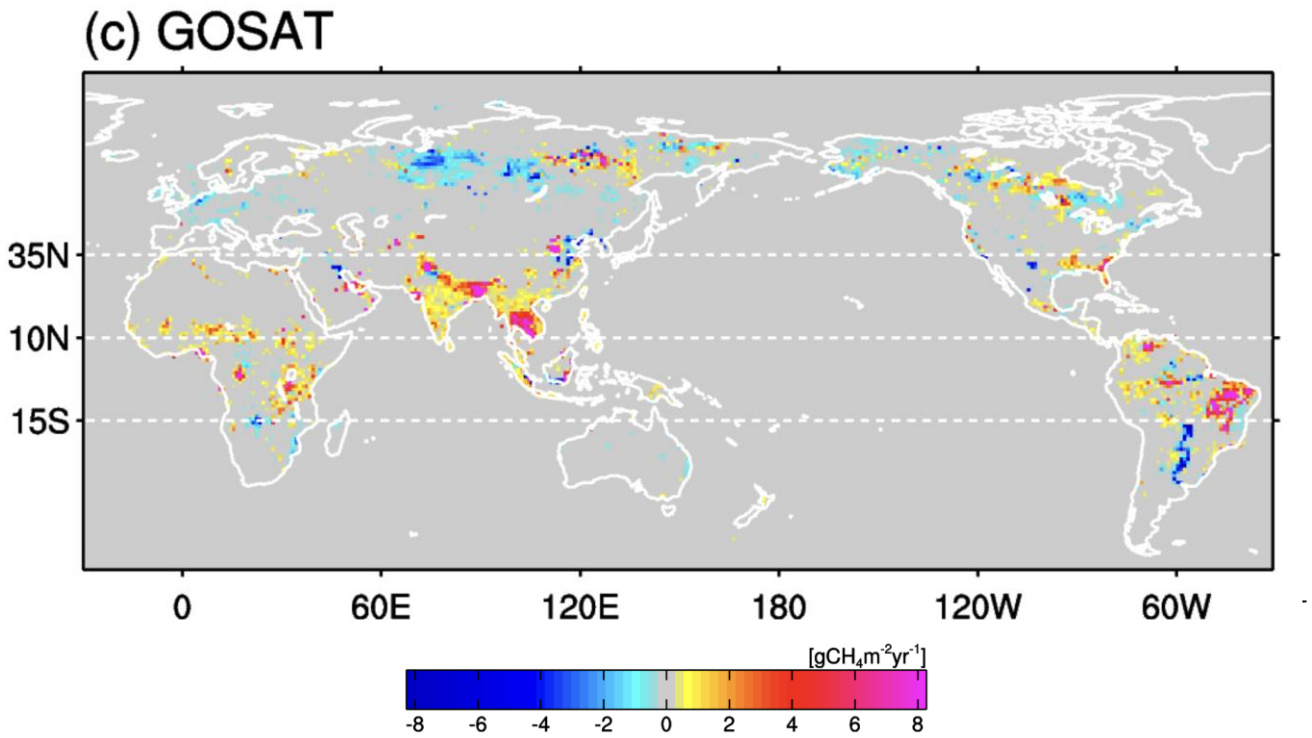


Figure 4c Spatial patterns of the total net CH_4 emissions increase (ΔfCH_4) from 2016–2019 to 2020–2022 in the GOSAT inversion.

Increase of emissions from Wetland in Tropics and Agri + Waste in North Low were significant.

https://egusphere.copernicus.org/preprints/2024/egusphere-2024-2457/

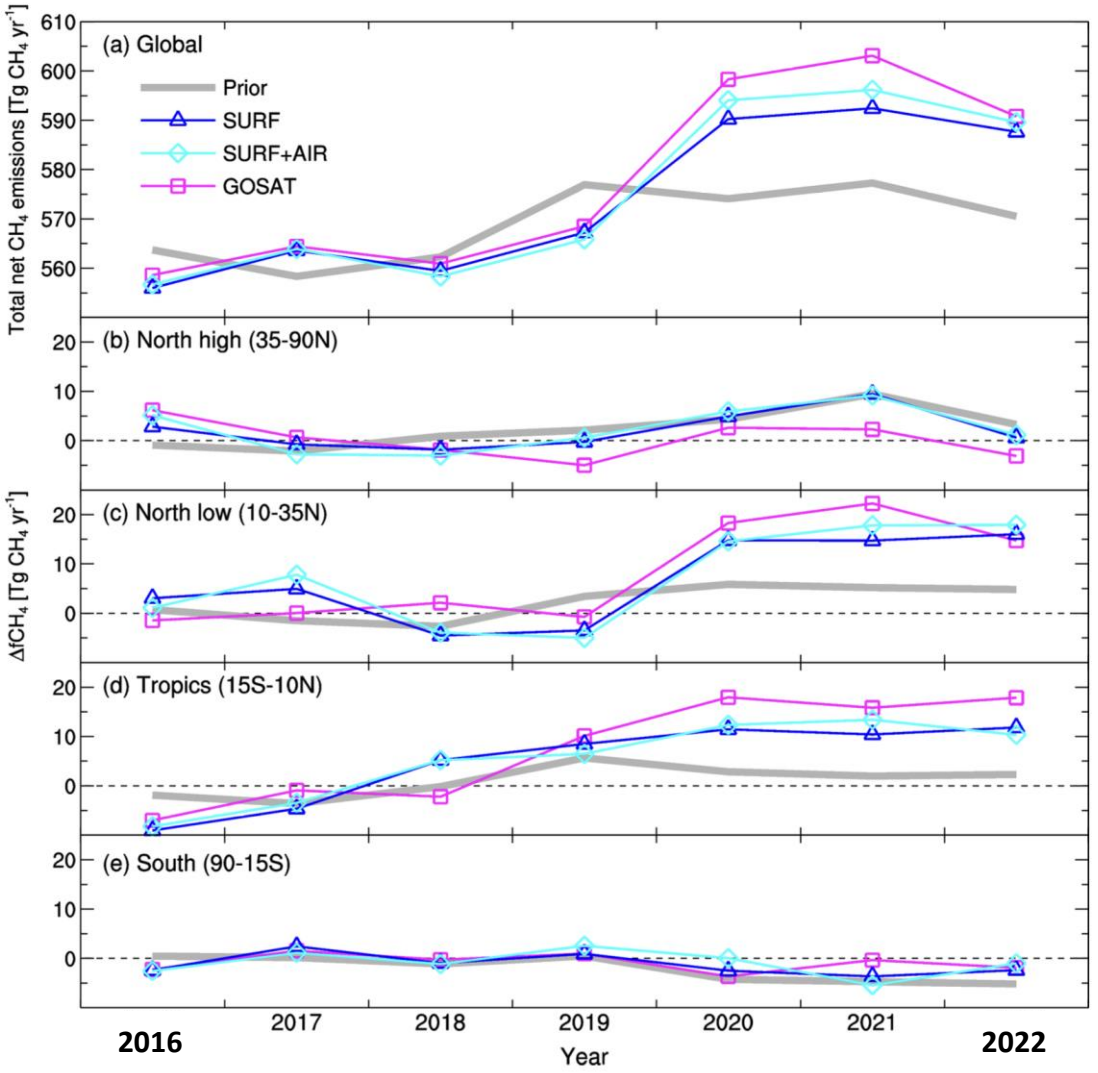
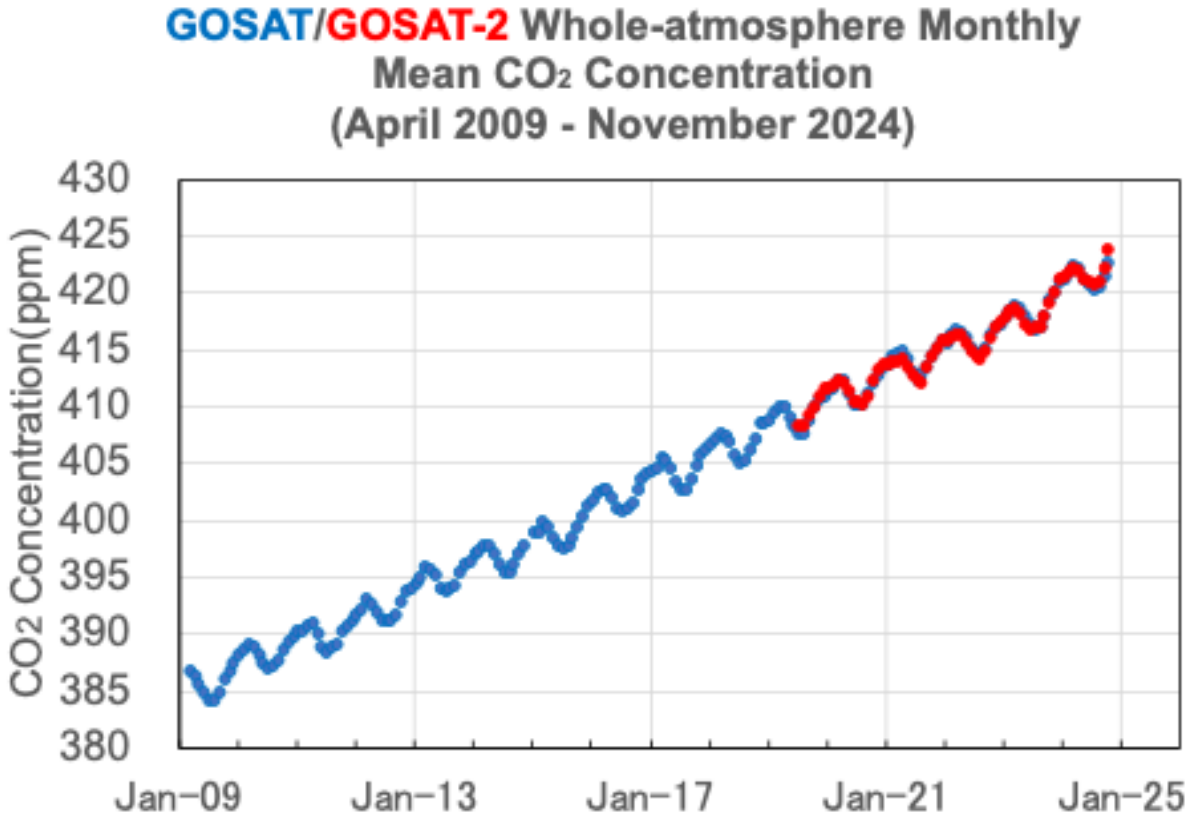
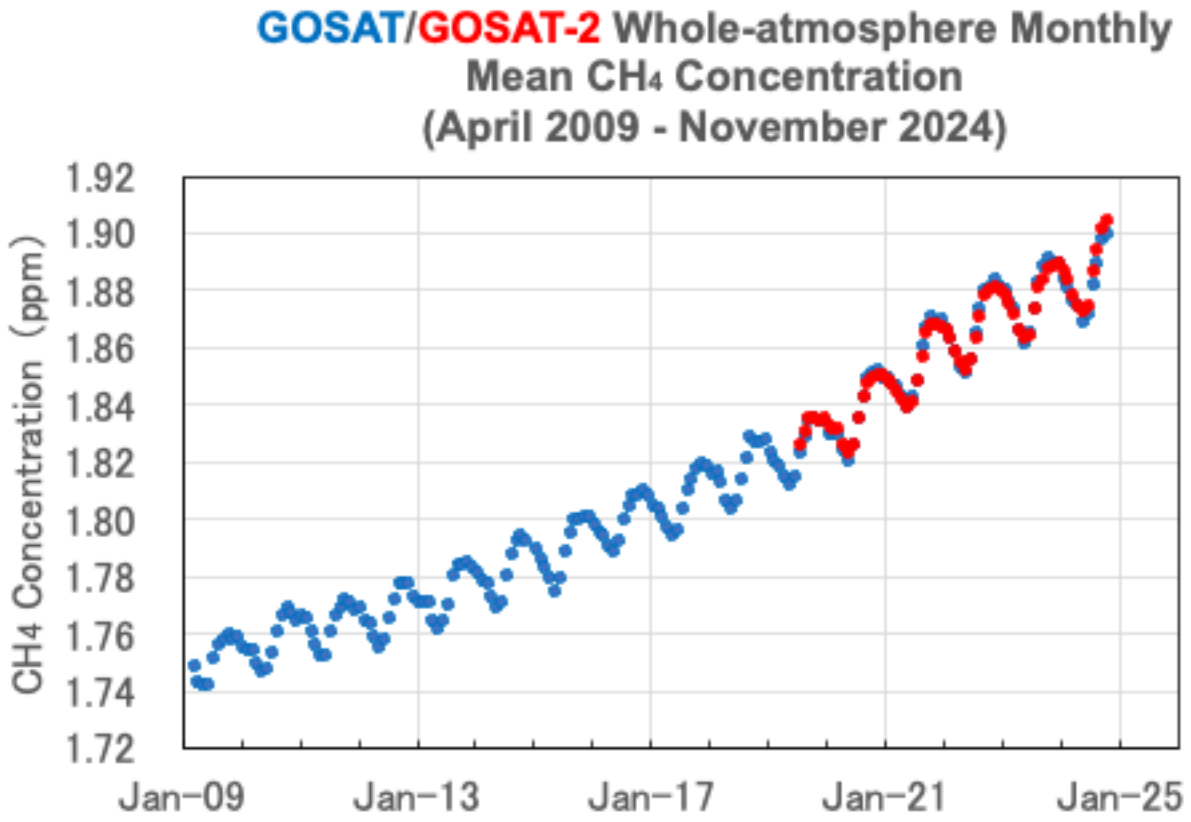


Figure 5 Year-to-year variations of total net CH_4 emissions

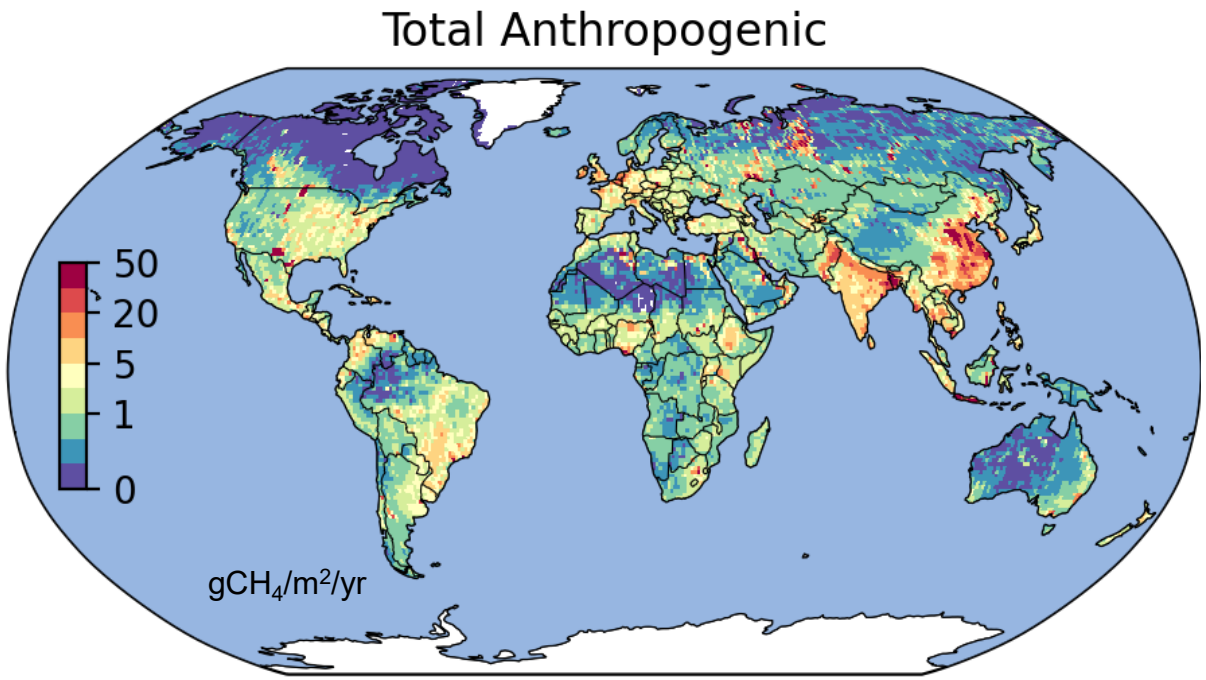
GOSAT (2009 – 2024) and GOSAT-2 (2019- 2024) Whole-atmosphere Monthly Mean CO2 and CH4 Concentrations

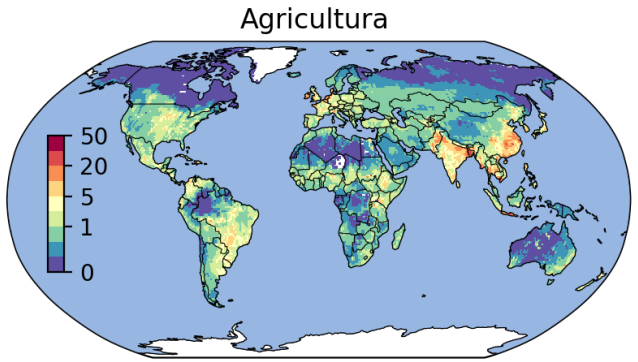


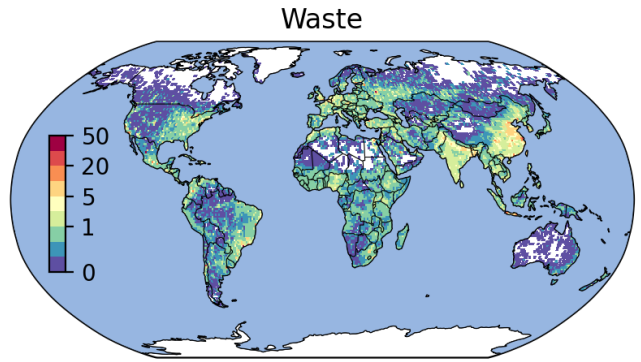


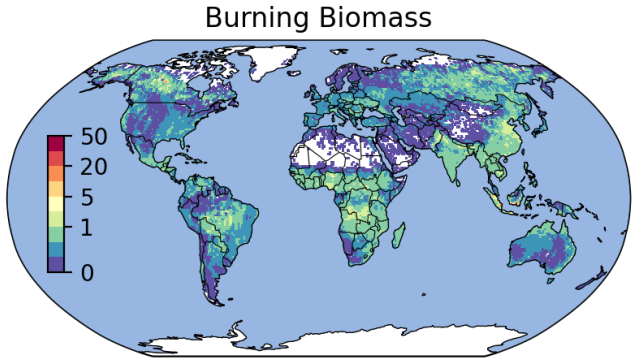
GOSAT-2 data (V02.20/V02.21) are adjusted to GOSAT data (V03.05) using linear equations derived from regression analyses of 2019 – 2024 data.

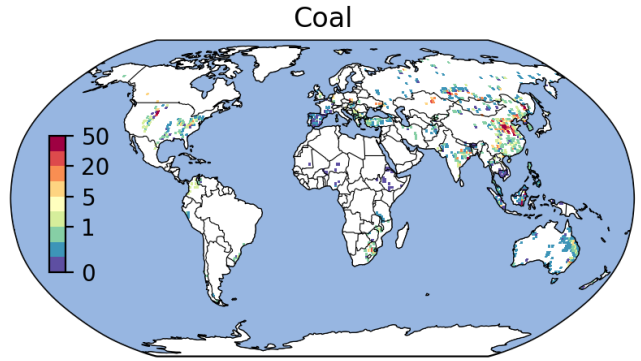
2009-2020 Global Methane Flux Maps Derived from GOSAT Inversion

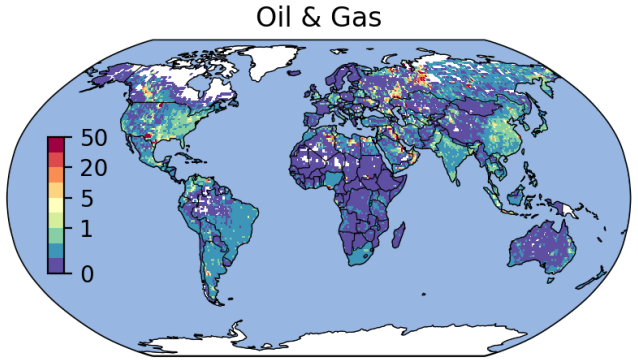


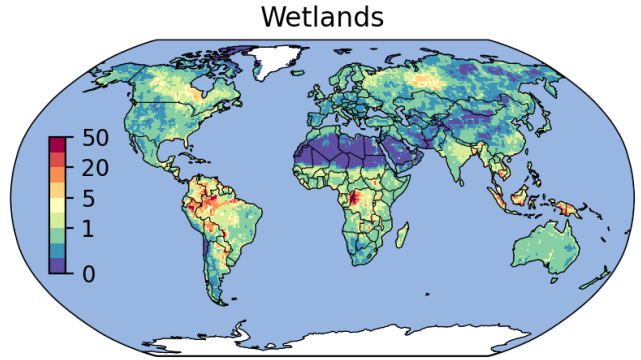






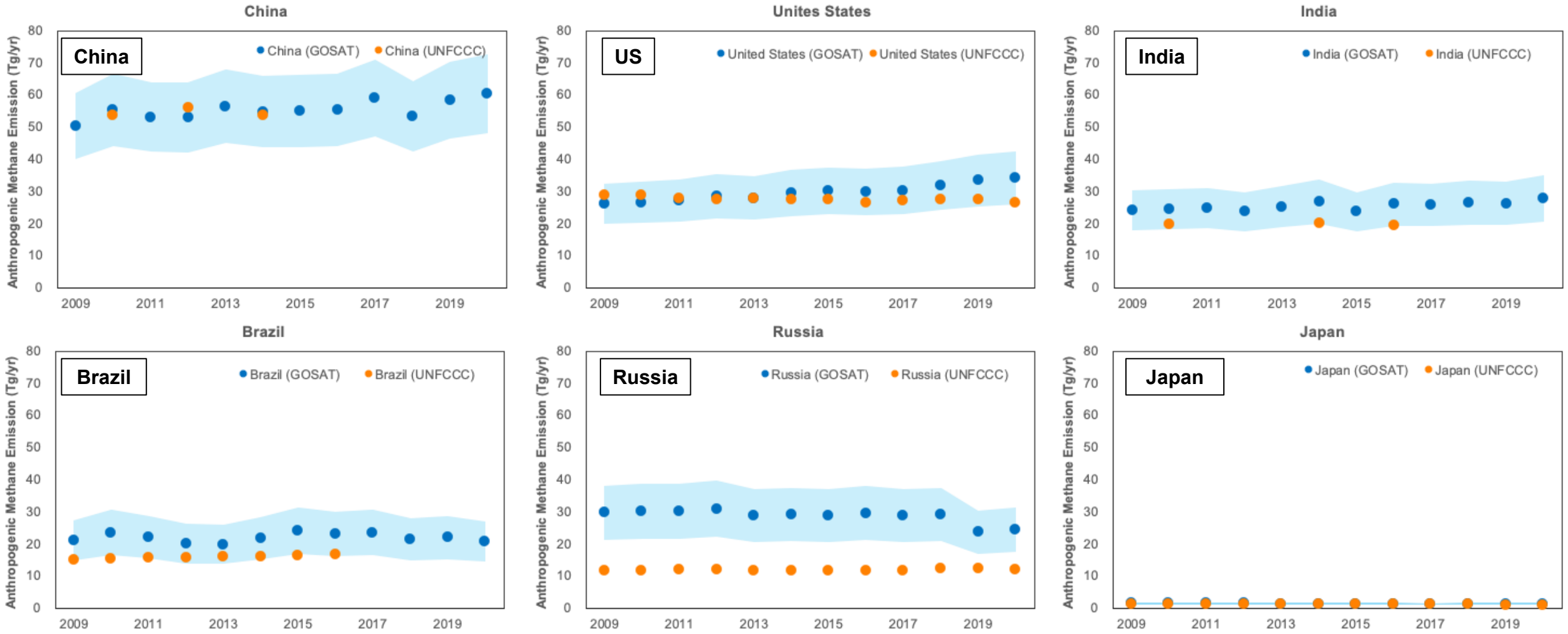






- Janardanan et al., ERL (2024)
  High-resolution NTFVAR inversion (0.2 x 0.2 deg.)
  using GOSAT and ground-based observation data
- “Natural” = “Wetland”
- “Total Anthropogenic”
  = “Agriculture” + “Waste” + “Biomass Burning”
  + “Coal” + “Oil & Gas”
- Prior = EDGAR6 + GFED 4.1 + Saunois et al. (2020) for wetlands

2009 – 2020 National Anthropogenic Methane Emissions Derived from GOSAT Data (UNFCCC COP29, November 2024)

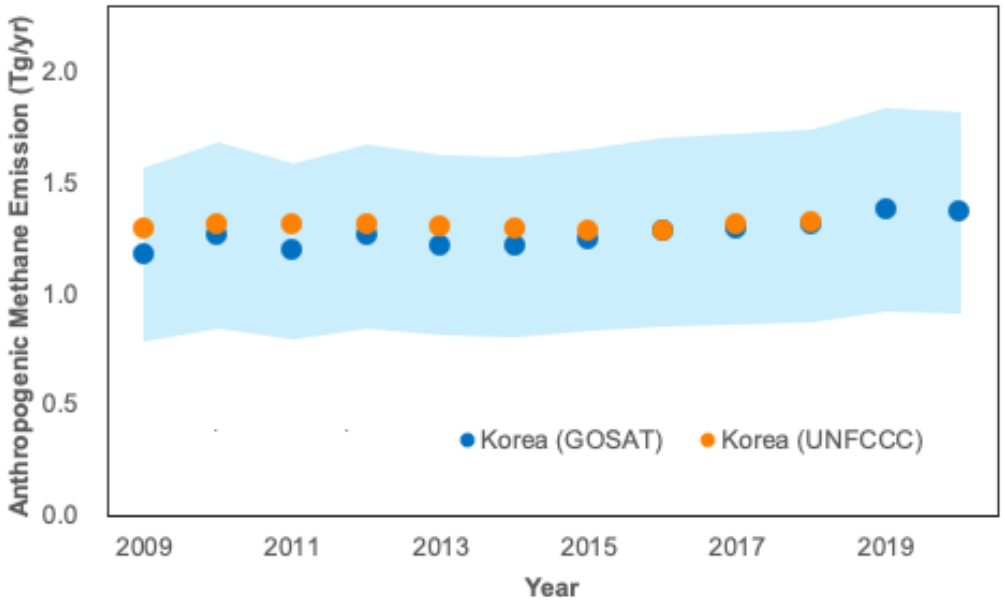


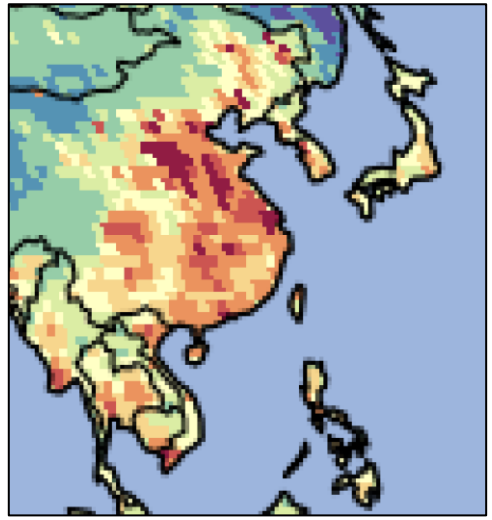
Anthropogenic methane fluxes from inversion analyses of GOSAT data（Janardanan et al. 2024）and UNFCCC Data

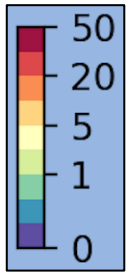
https://esd.nies.go.jp/ghg-information/

2009 – 2020 Anthropogenic Methane Emissions (Korea and Japan) Derived from GOSAT Data

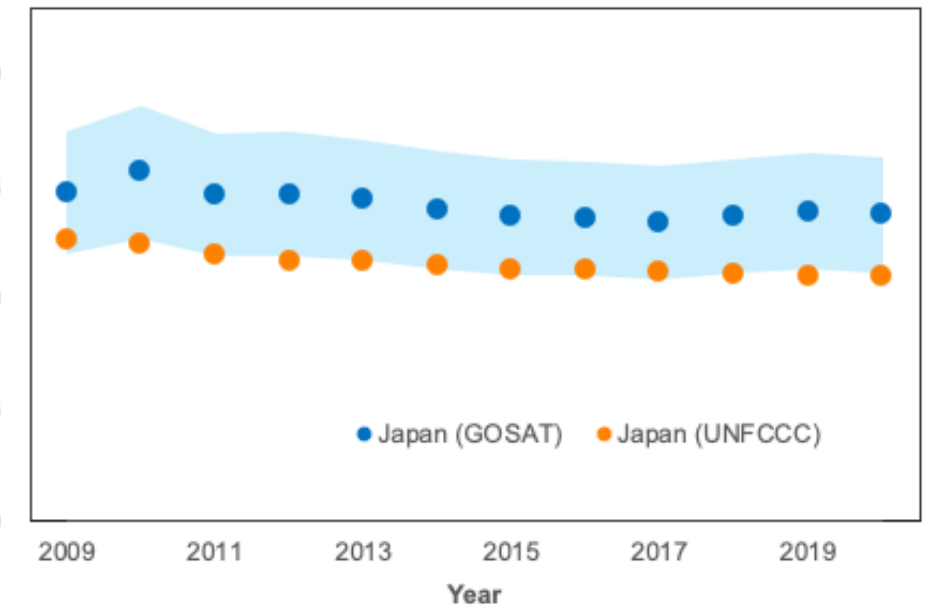
Total Anthropogenic Methane Flux Map (2009-2020)







$gCH_4/m^2/yr$



Anthropogenic methane fluxes from inversion analyses of GOSAT data（Janardanan et al. 2024）
UNFCCC Data (https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc)

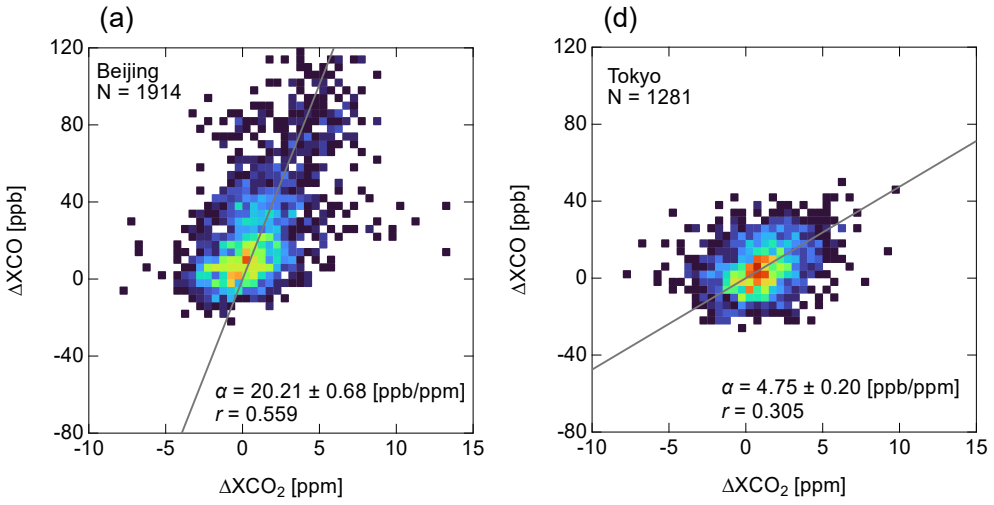
Estimation of CH4 and CO emissions in megacities by using simultaneous GHGs and air pollutant observations by GOSAT-2 (Ohyama et al., ERL, 2024)

ENVIRONMENTAL RESEARCH
LETTERS

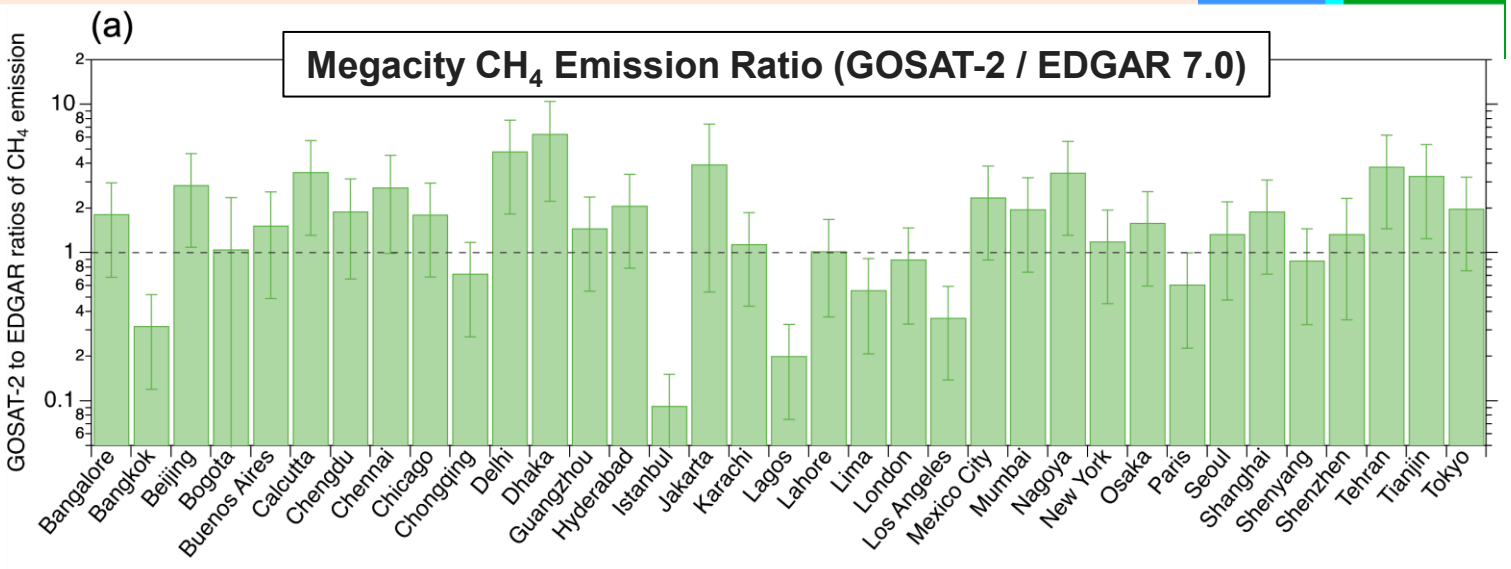
LETTER

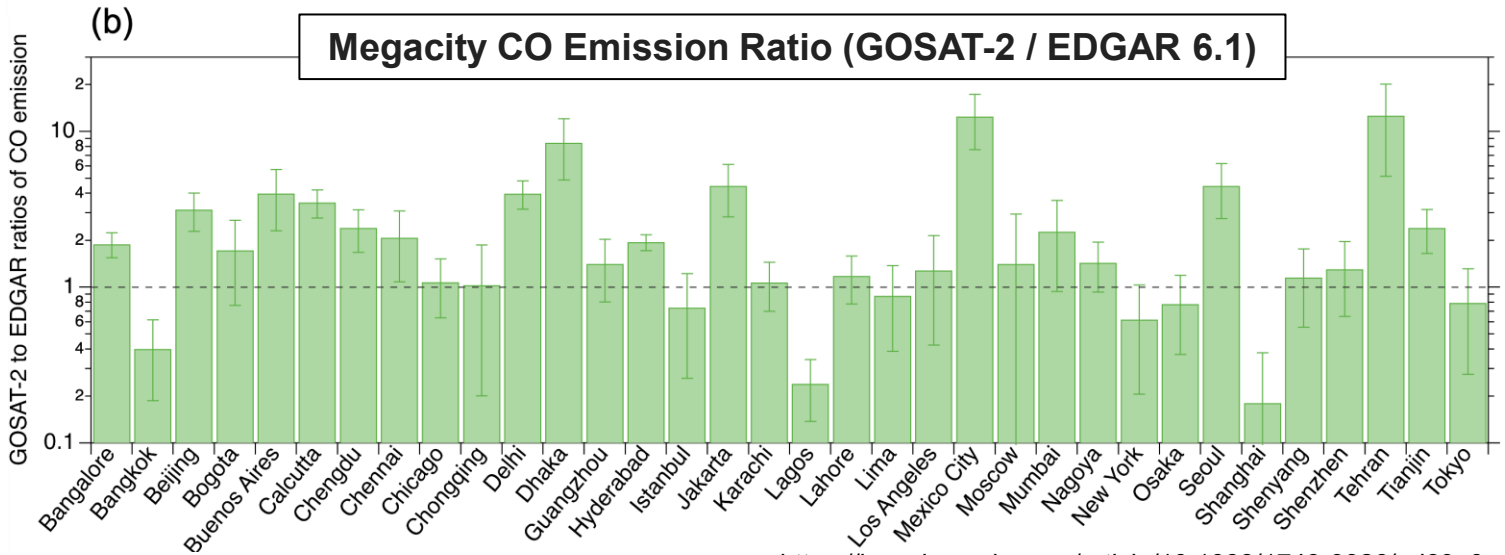
CH_4 and CO emission estimates for megacities: deriving enhancement ratios of CO_2, CH_4, and CO from GOSAT-2 observations

Hirofumi Ohyama*, Yukio Yoshida and Tsuneo Matsunaga



ΔXCO vs ΔXCO2 plots for Beijing and Tokyo.



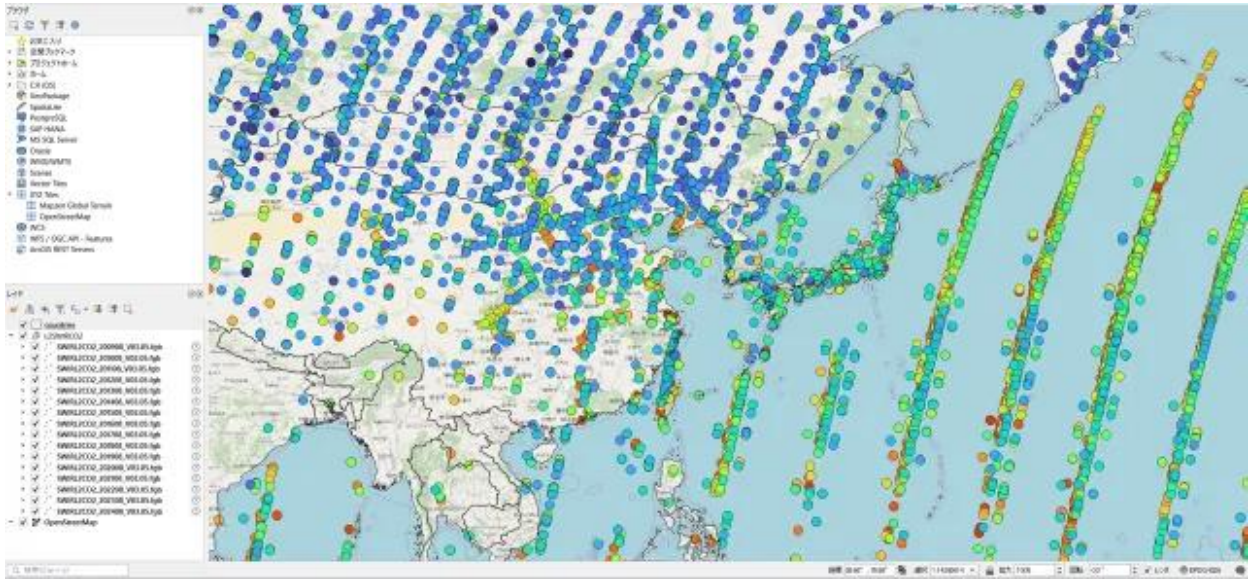


https://iopscience.iop.org/article/10.1088/1748-9326/ad89e0

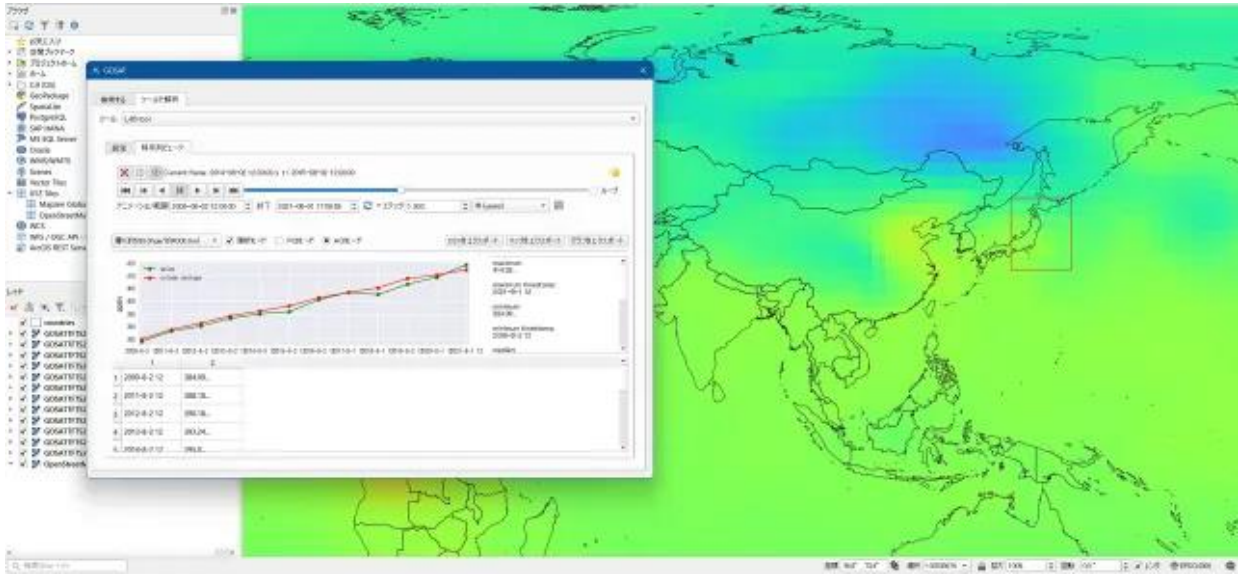
NIES 衛星観測センター Satellite Observation Center

GOSAT and GOSAT-2 data are now available via Tellus QGIS plugin and API
https://www.tellusxdp.com/en-us/

- ✓ Tellus is a cloud-based satellite data platform originally funded by Japanese Ministry of Economy, Trade, and Industry. Tellus extension to GOSAT is supported by MOE and NIES.
- ✓ From March 2025, the most of L2, L3, and L4 GOSAT / GOSAT-2 data can be obtained and analyzed using QGIS plugin and API provided by Tellus.
- ✓ Tellus system is now automatically downloading latest GOSAT and GOSAT-2 data.
- ✓ A simple online visualization environment, Tellus Traveler, is also provided.



Global Point Cloud 2D Observation Data Visualization Tool（L2 SWIR）



Global Mesh 3D Analysis Data Visualization Tool (L4B)

Thank you for your attention

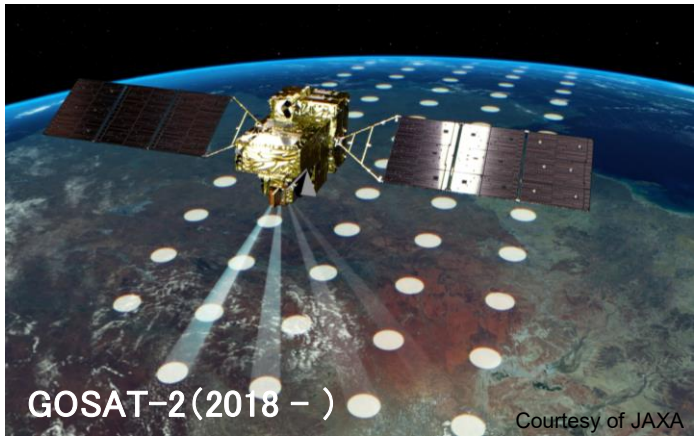
Contact
matsunag@nies.go.jp

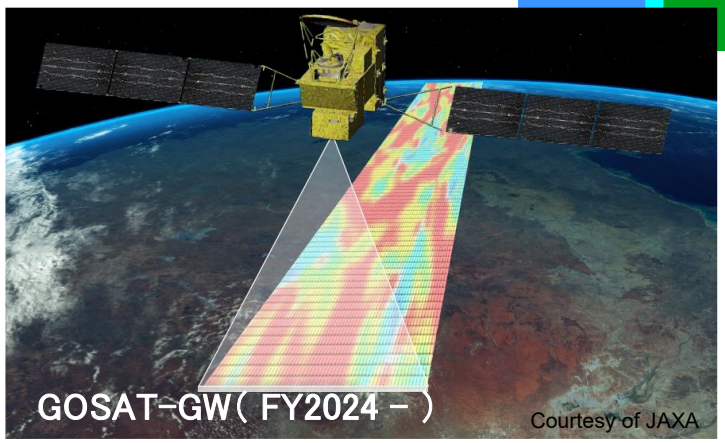
Website
https://www.nies.go.jp/soc (Satellite Observation Center)
https://www.gosat.nies.go.jp (NIES GOSAT Project)
https://www.gosat-2.nies.go.jp (NIES GOSAT-2 Project)
https://gosat-gw.nies.go.jp (NIES GOSAT-GW Project)

GOSAT and GOSAT-2 standard products are freely available from
GOSAT Data Archive Service (GDAS: L1B, L2, L3, L4)
https://data2.gosat.nies.go.jp
GOSAT-2 Product Archive (L1B, L2, L4)
https://prdct.gosat-2.nies.go.jp

From 2025 or later, GOSAT-GW TANSO-3 standard products will be freely available from
GOSAT-GW TANSO-3 Product Archive (G3PA: L1B, L2)
(URL: TBD)

Specifications of GOSAT, GOSAT-2, and GOSAT-GW





	GOSAT	GOSAT-2	GOSAT-GW
Launch / lifetime	2009 / 5 years	2018 / 5 years	FY2025 / 7 years
Satellite mass / power	1.75 t / 3770 W	1.8 t / 5000 W	2.9 t / 5200 W
Orbit	666 km, 3 days, 13:00, descending	613 km, 6 days, 13:00, descending	666 km, 3 days, 13:30, ascending
Spectrometer	**FTS**	FTS-2	TANSO-3 (**Grating**)
Major targets	**CO_2, CH_4**	CO_2, CH_4, **CO**	CO_2, CH_4, **NO_2**
Spectral bands	**0.7 / 1.6 / 2 μm + TIR**	0.7 / 1.6 / 2 μm + TIR	**0.45** / 0.7 / 1.6 μm
Spectral Resolution (Sampling interval)	**0.2 cm^{-1}, (≈ 0.01 nm @ 0.7 μm, ≈ 0.05 nm @ 1.6 μm)**		< 0.5 nm @ 0.45 μm, <0.05 nm @ 0.7 μm, < 0.2 nm @ 1.6 μm
Swath	**Discrete, 1 – 9 points**	Discrete, 5 points	**Selectable, 911 km (Wide Mode) or 90 km (Focus Mode)**
Footprint size, nadir	**10.5 km**	9.7 km	**Selectable, 10 km (Wide Mode) or 1 – 3 km (Focus Mode)**
Pointing	**±20 /±35 deg (Along Track/Cross Track)**	±40 /±35 deg (AT/CT) **Intelligent Pointing**	± 40 /± 34.4 deg (AT/CT)
Other instruments	CAI (Cloud and Aerosol Imager)	CAI-2 (Cloud and Aerosol Imager 2)	AMSR3 (Advanced Microwave Scanning Radiometer 3)