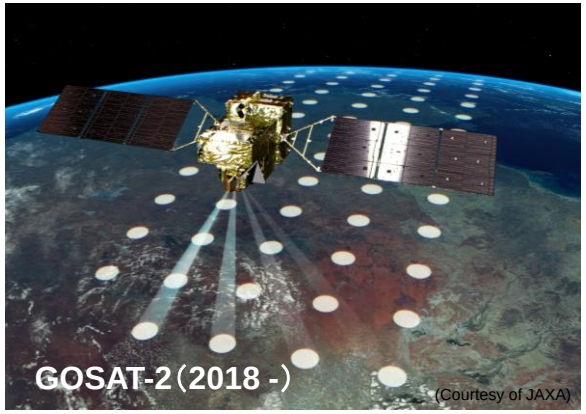
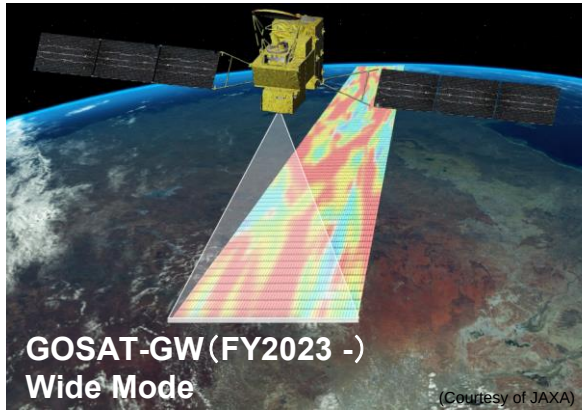
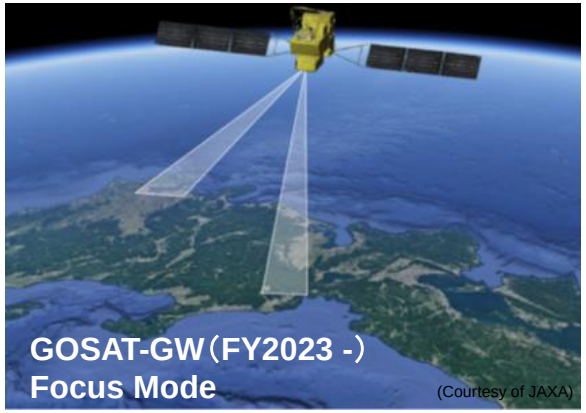
GOSAT-2 Observation in Southeastern Asia Over the Past Three Years: CO_2, CH_4, CO, and Aerosol





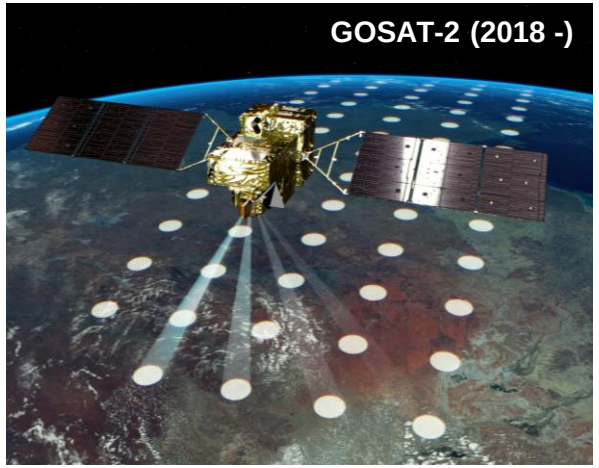


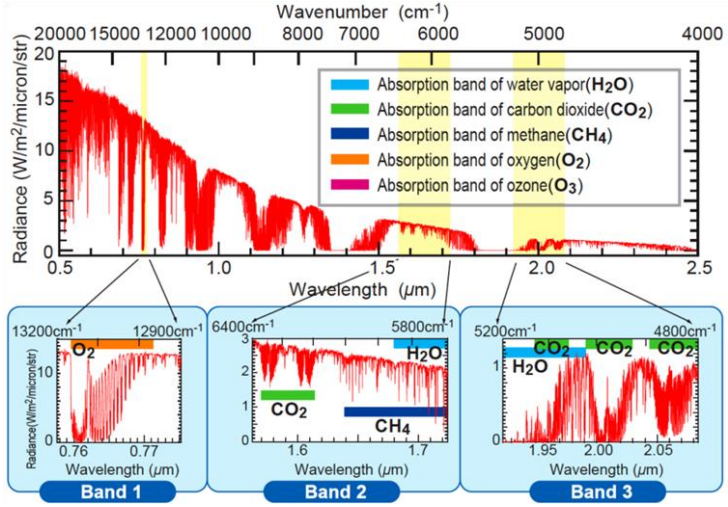
Tsuneo Matsunaga [*1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki Noda[1], Hirofumi Ohyama[1], Hisashi Yashiro[1], Yu Someya[1], Tazu Saeki[1], Yosuke Niwa[1], Akihide Kamei[1], Fumie Kawazoe[1], Jiye Zeng[1], Tomohiro Shiraishi[1], Ryuichi Hirata[1], Ryoichi Imasu[2], Teruyuki Nakajima[2], Takashi Nakajima[3], Naoko Saitoh[4], and Makiko Hashimoto[5]

[1] NIES, [2] Univ. Tokyo, [3] Tokai Univ., [4] Chiba Univ., [5] JAXA

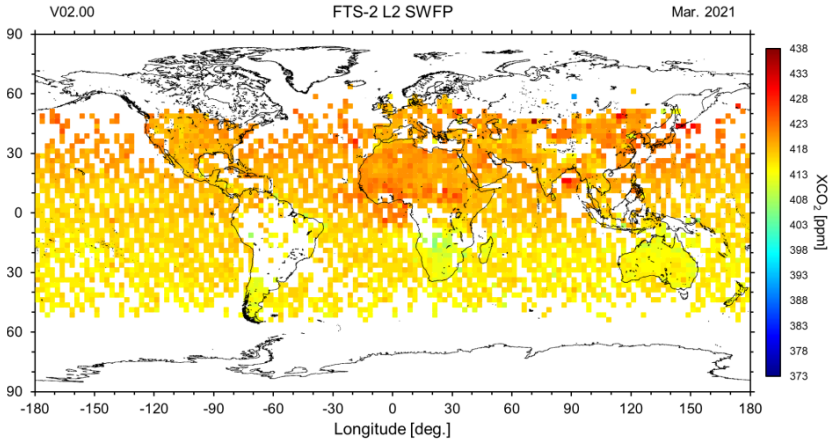
What is GOSAT Series?

- **Japanese earth observation satellite series for measurements of atmospheric concentrations of greenhouse gases**
  - **GOSAT** (2009 -)
    FTS for CO_2 and CH_4
  - **GOSAT-2** (2018 -)
    FTS for CO_2, CH_4, and CO
  - **GOSAT-GW** (FY2023 -)
    Imaging spectrometer for CO_2, CH_4, and NO_2

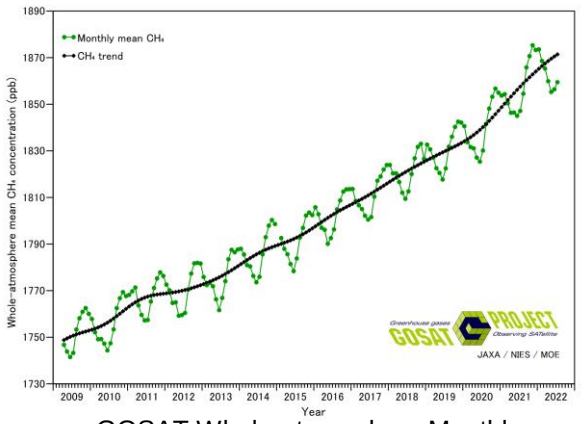




- **Organizations**
  - Joint projects by MOE, NIES, and JAXA
  - NIES is responsible for generation, validation, distribution, and archiving of gas concentration and flux data
  - Science Teams by domestic scientists
  - Collaboration agreements with foreign space agencies
  - Participation of overseas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

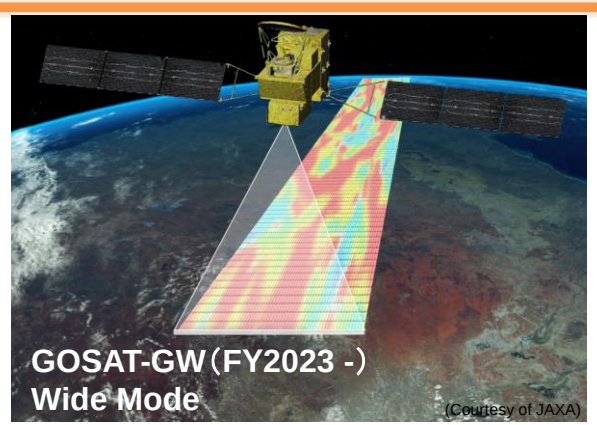


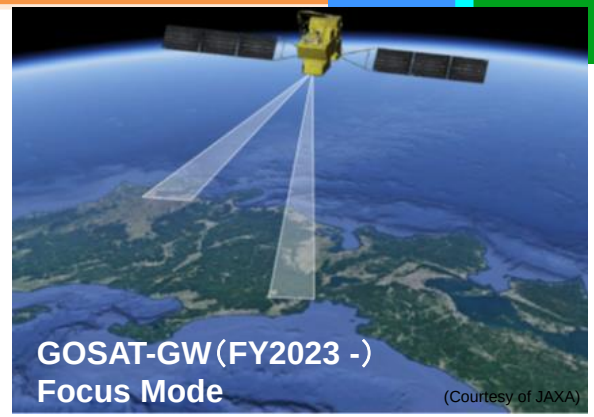
GOSAT-2 FTS-2 SWIR L2 XCO_2 Map of March 2021
(V02.00, Full Physics)



GOSAT Whole-atmosphere Monthly Mean CH_4 Concentration
(April 2009 – July 2022)

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



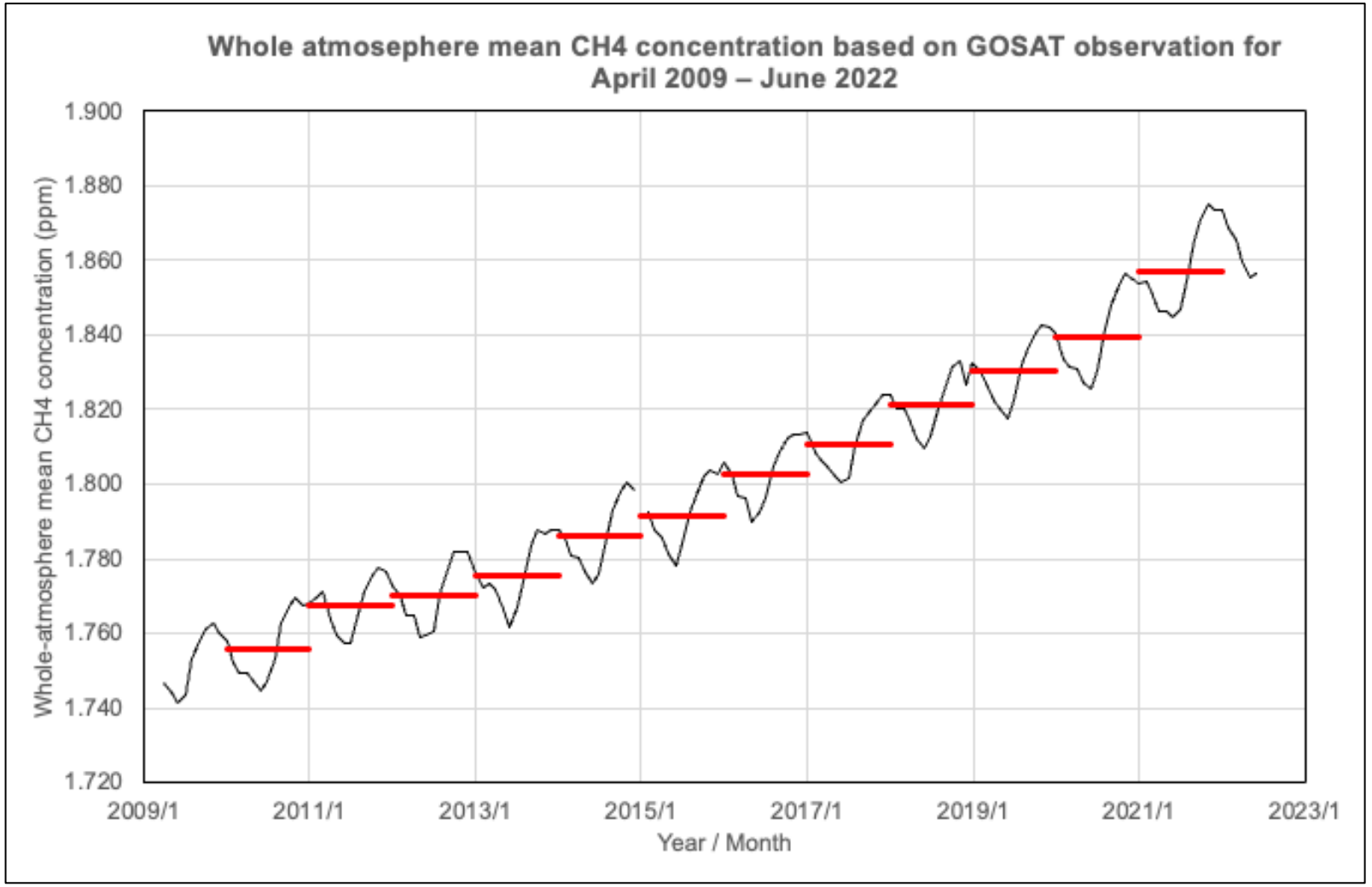


	GOSAT	GOSAT-2	GOSAT-GW
Launch / lifetime	2009 / 5 years	2018 / 5 years	FY2023 / 7 years
Satellite mass / power	1.75 t / 3770 W	1.8 t / 5000 W	2.9 t / 5200 W
Orbit	666 km, 3 days, 13:00, descending	613 km, 6 days, 13:00, descending	666 km, 3 days, 13:30, ascending
Spectrometer	FTS	FTS-2	**TANSO-3** (Grating)
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 (AT/CT)	±40 /±35 deg (AT/CT) **Intelligent Point**	± 40 /± 34.4 deg (AT/CT) for Focus Mode
Other instruments	CAI (Cloud and Aerosol Imager)	CAI-2 (Cloud and Aerosol Imager 2)	AMSR3 (Advanced Microwave Scanning Radiometer 3)

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

Recent Increase of GOSAT Whole-atmosphere CH4 Concentration

https://www.gosat.nies.go.jp/en/recent-global-ch4.html



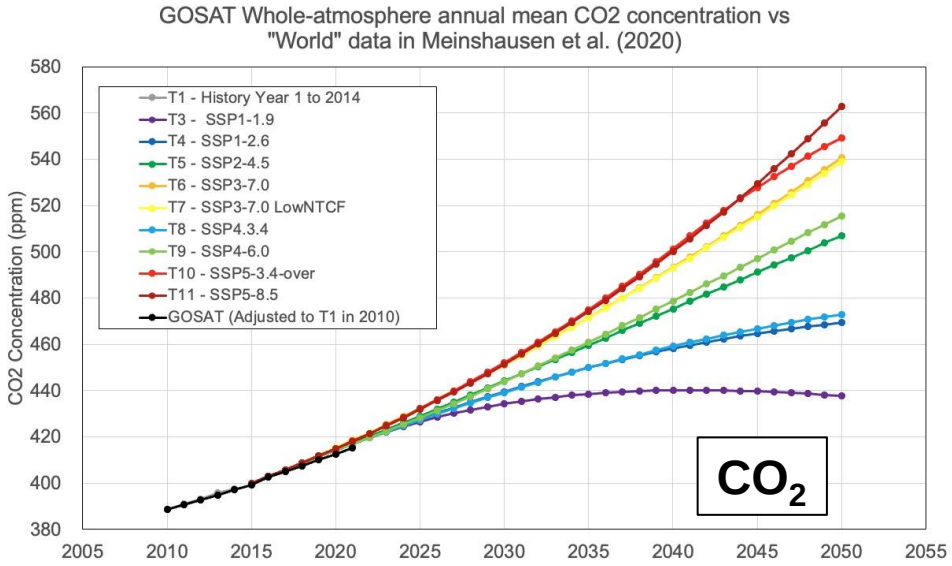
Year	Annual Mean (ppb)	Annual Increase (ppb)
2010	1756	-
2011	1768	12
2012	1770	2
2013	1776	6
2014	1786	10
2015	1792	6
2016	1803	11
2017	1811	8
2018	1821	10
2019	1831	10
2020	1840	9
2021	**1857**	**17**
2022		

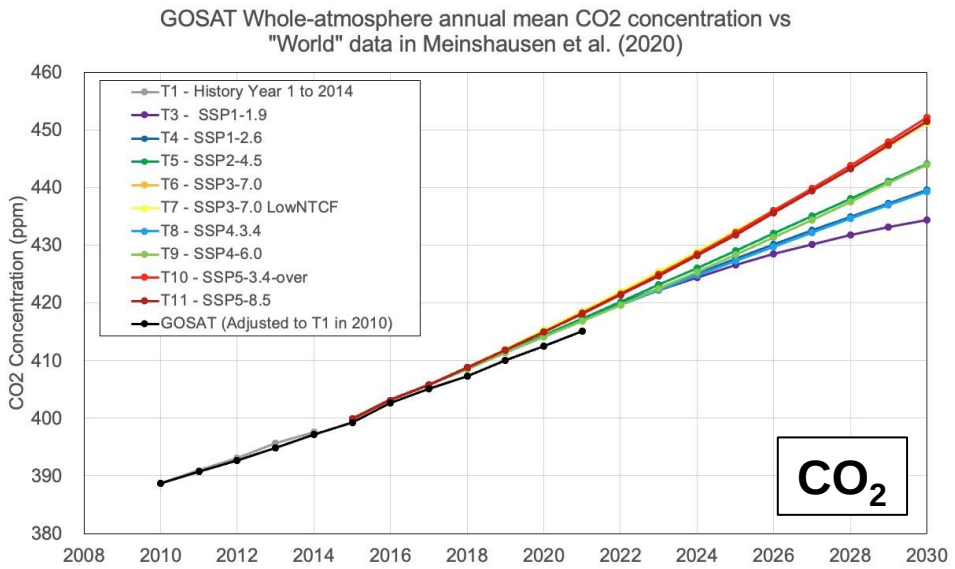
Year	Jan - June Mean (ppb)	Jan - June Increase (ppb)
2019	1825	-
2020	1832	7
2021	1849	17
2022	1863	14

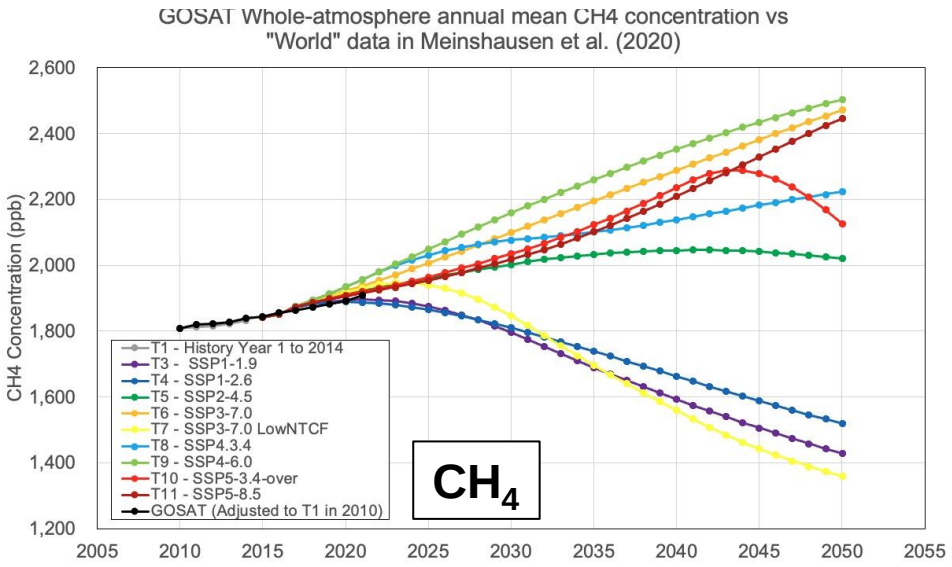
Press release: https://www.nies.go.jp/whatsnew/20220323/20220323-e.html, https://www.eurekalert.org/multimedia/822274

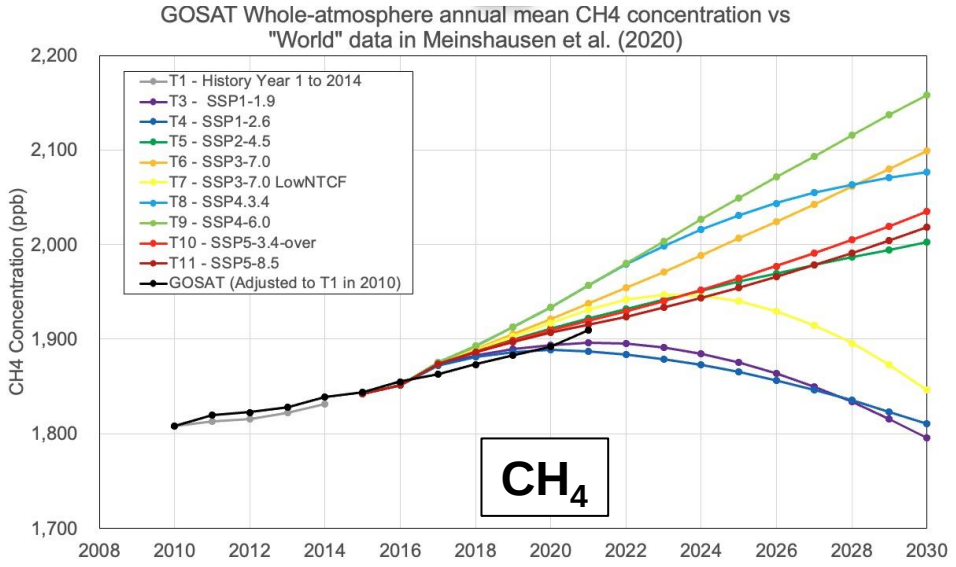
Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

Global CO2 and CH4 Concentrations by GOSAT and from Various Shared Socioeconomic Pathways (submitted to UNFCCC's 1st Global Stocktake)







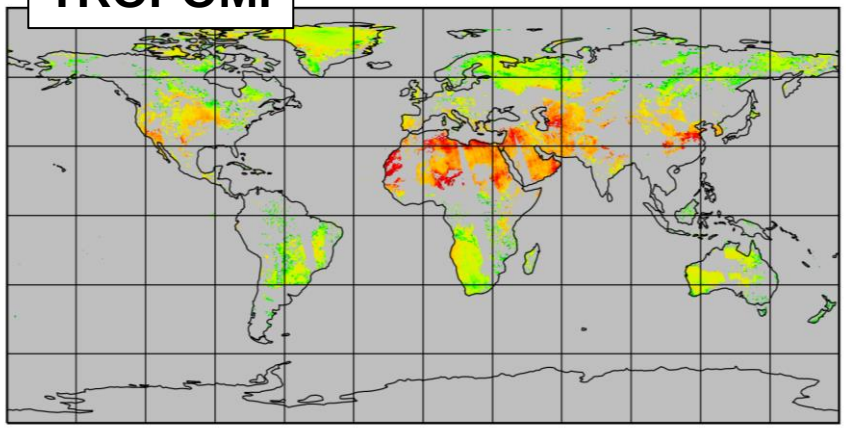


GOSAT whole-atmosphere mean CO_2 and CH_4 concentrations can be indicators to show the degree of achievements of efforts to reduce greenhouse gas emissions in order to realize the Paris Agreement's goals.

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

Methane Leakage in Tatarstan, Russia (June 4, 2021)

TROPOMI 2021-06-04



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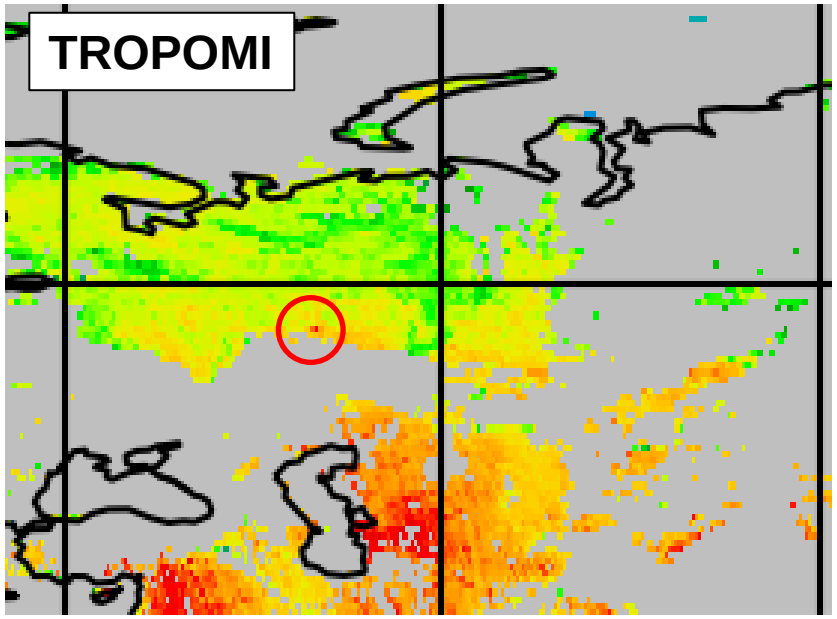
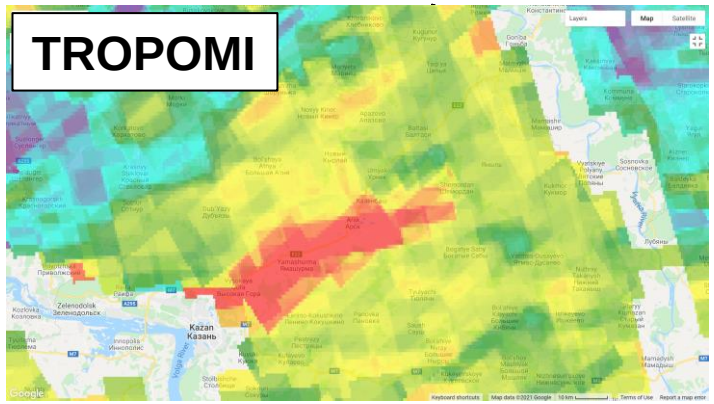
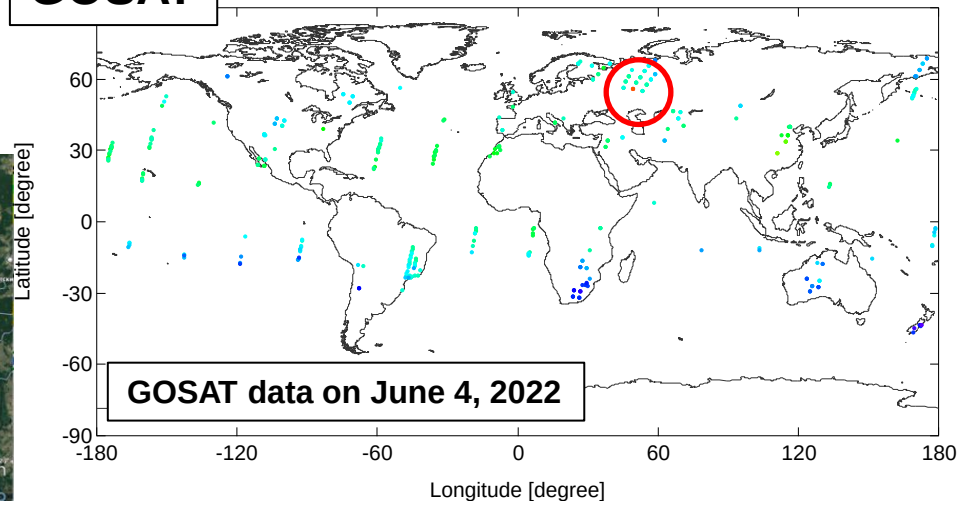


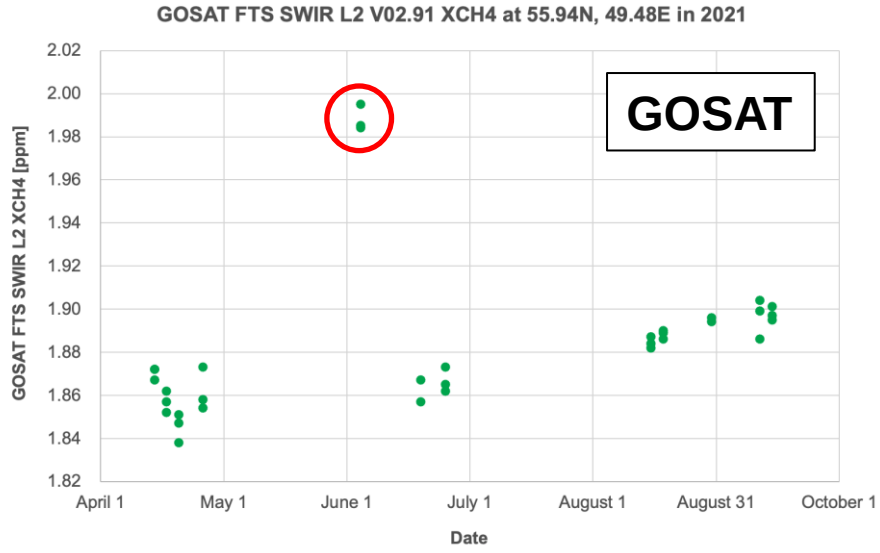
GOSAT

TROPOMI



GOSAT



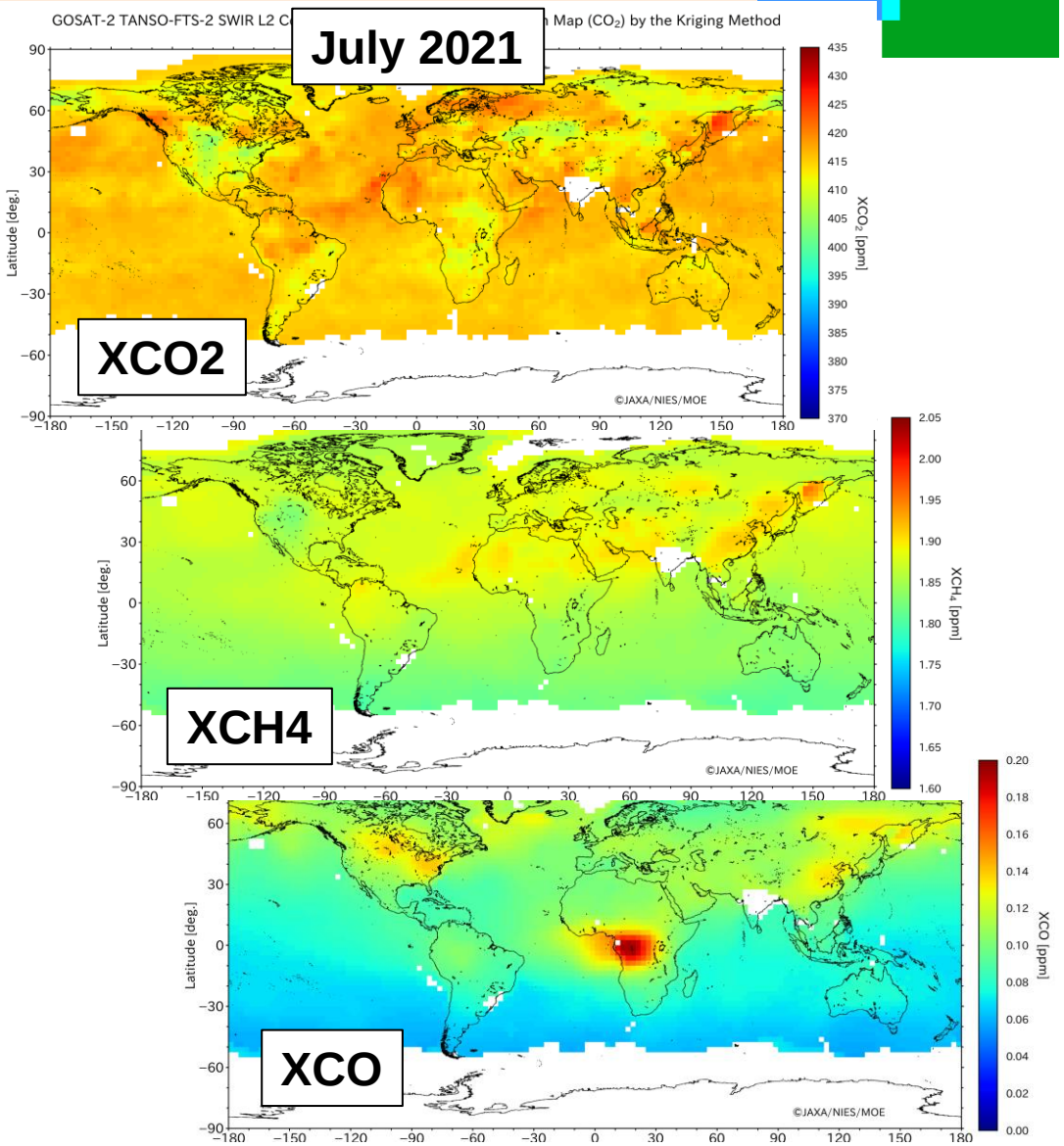


Provided by H. Ohyama and S. Maksyutov

NIES SOC 衛星観測センター Satellite Observation Center

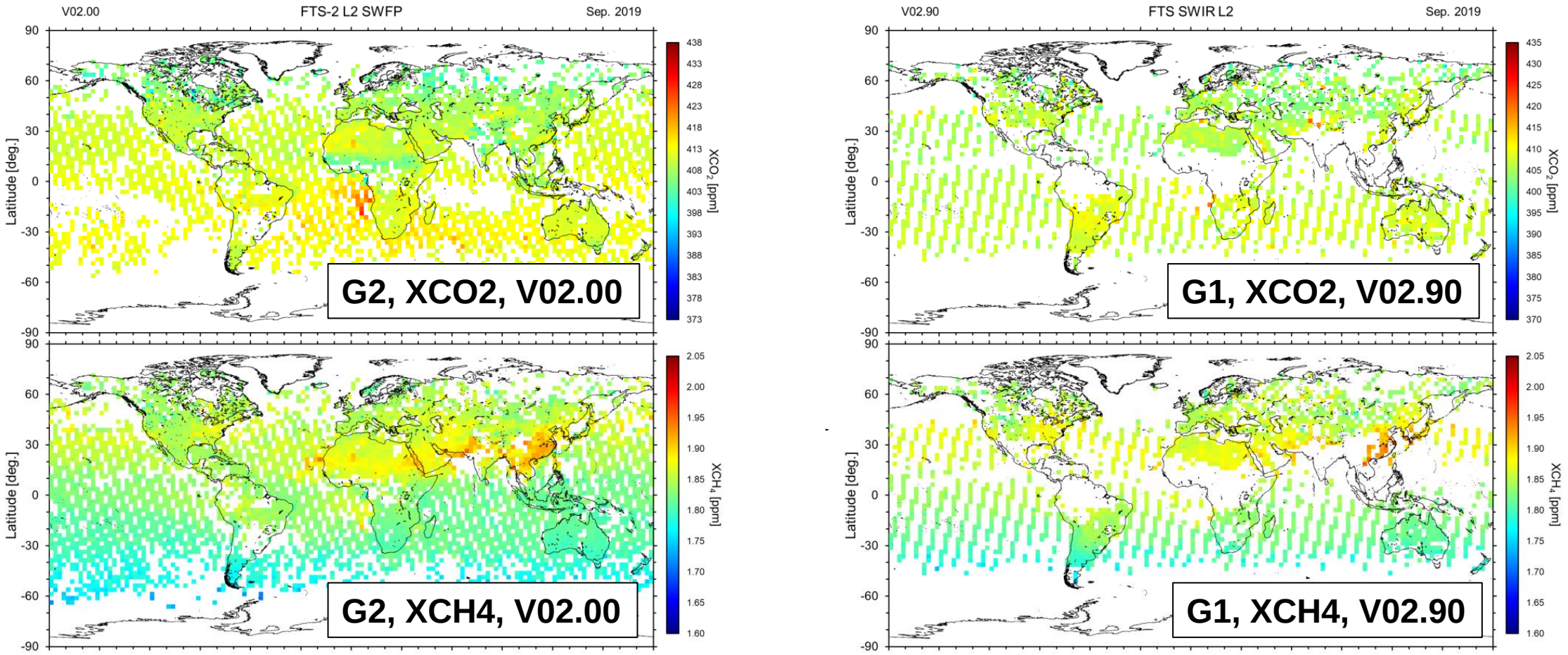
Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-2 XCO2, XCH4, and XCO Global Maps (Full Physics, V01.07) with Kriging Interpolation from March 2019 to December 2021



Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

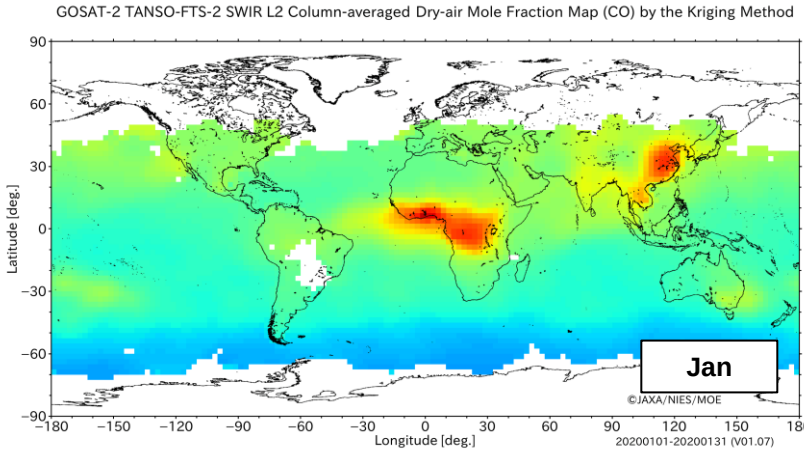
GOSAT-2 FTS-2 SWIR Full Physics (V02.00) and GOSAT FTS SWIR (V02.90) XCO2 and XCH4 Maps in September 2019

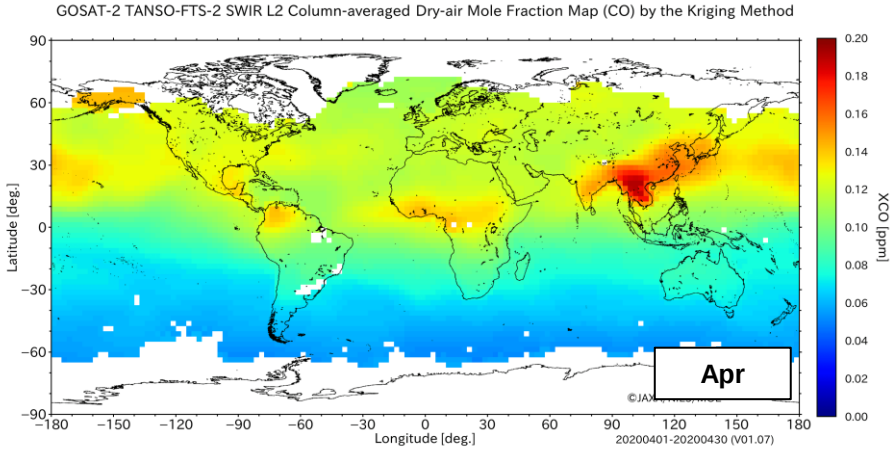


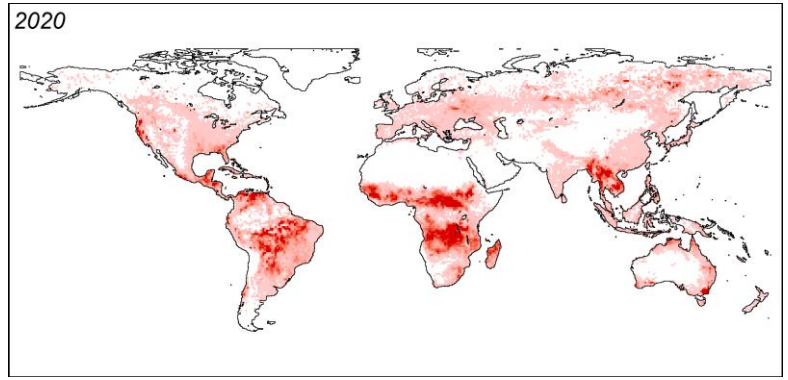
More sunglint ocean data due to larger AT pointing angle range.
More land data due to intelligent pointing to avoid cloud contamination in FTS-2‘s IFOV
Precision : XCO2 ≈ 2 ppm, XCH4 ≈ 12 – 20 ppb from TCCON comparison

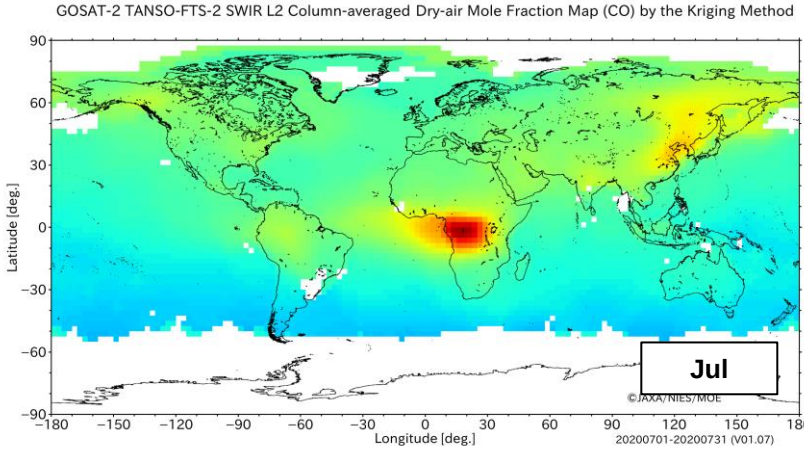
Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

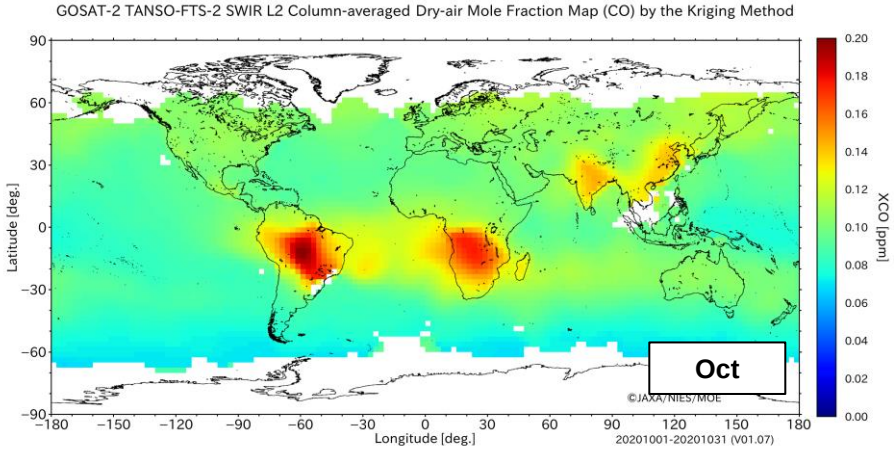
GOSAT-2 XCO Monthly Maps with Kriging Interpolation and Annual Global CO2 Biomass Burning Emission Map in 2020











CO_2 emission =

$$\sum_{i=1}^{n}(BAi \cdot BDi \cdot BEi \cdot \mathrm{EF}i)$$

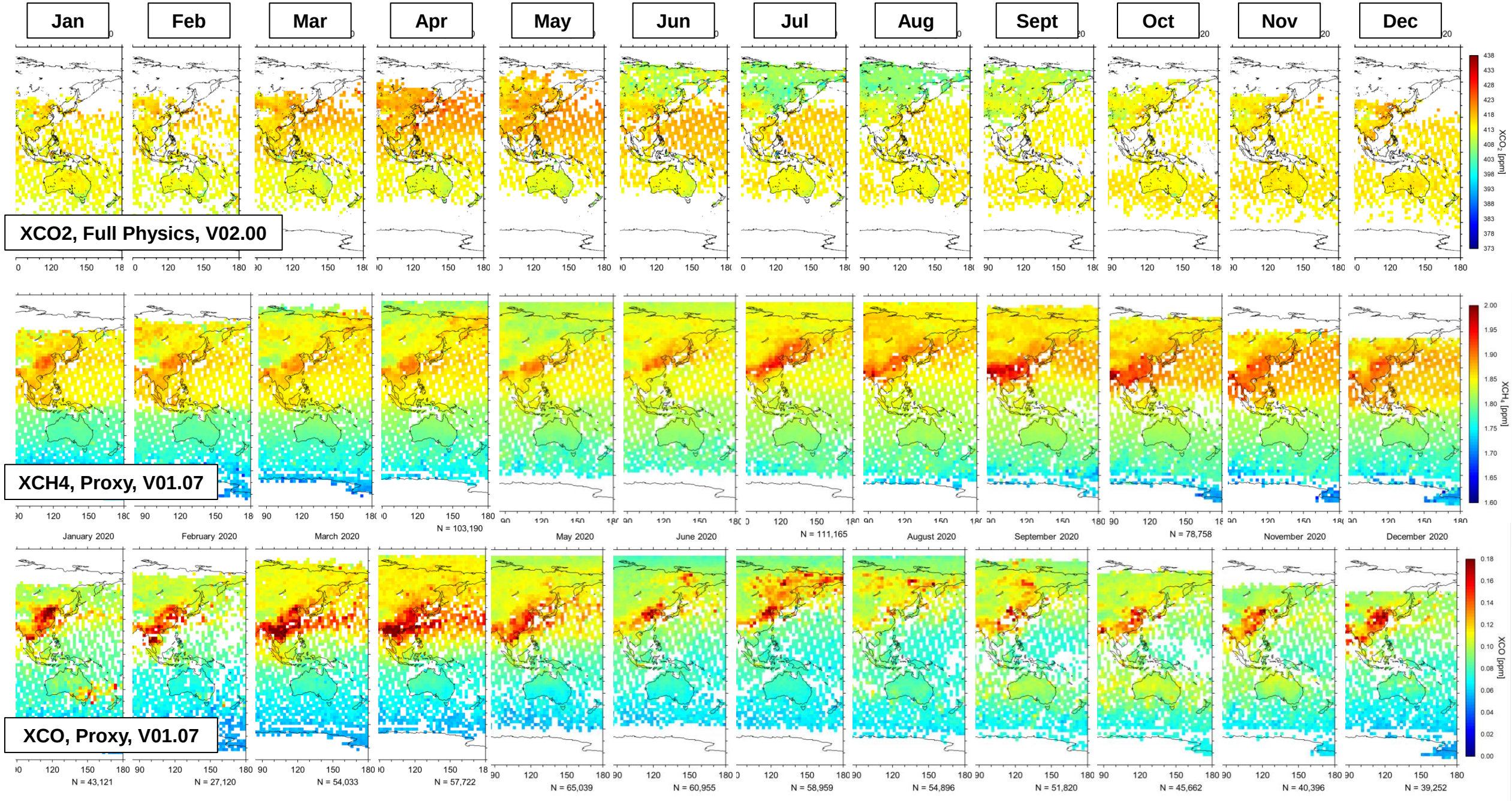
$$\mathrm{BD}= \sum_{j=1}^{m}\left\{BD \cdot (1-BE)^{j-1}\right\}$$

BA:burnt area, BD:biomass density, BE:burnt efficiency, EF:emission factor, n:land cover

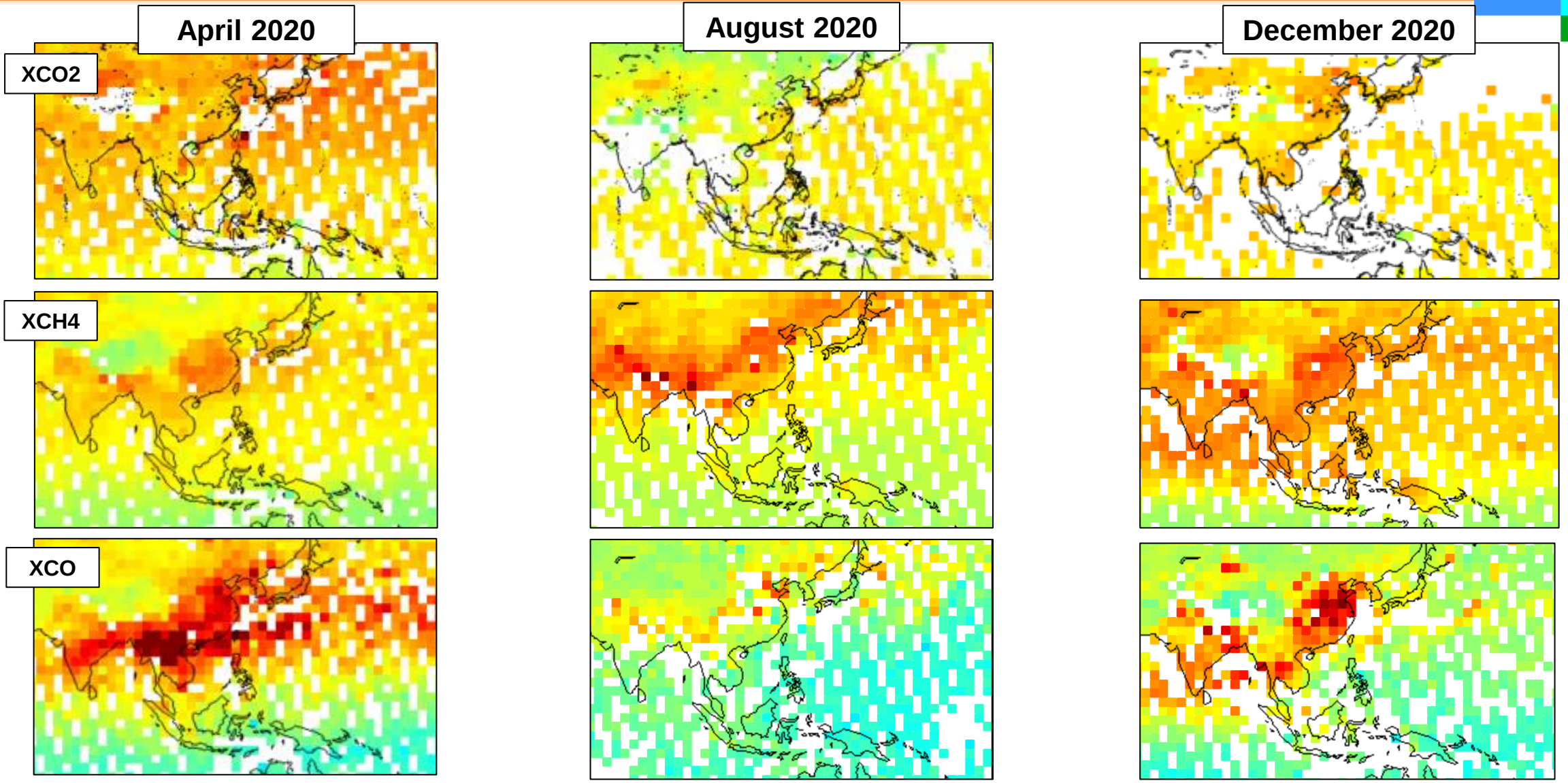
Shiraishi et al., Remote Sensing, 2021

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-2 XCO2/XCH4/XCO Monthly Maps: East/Southeastern Asia and Oceania in 2020

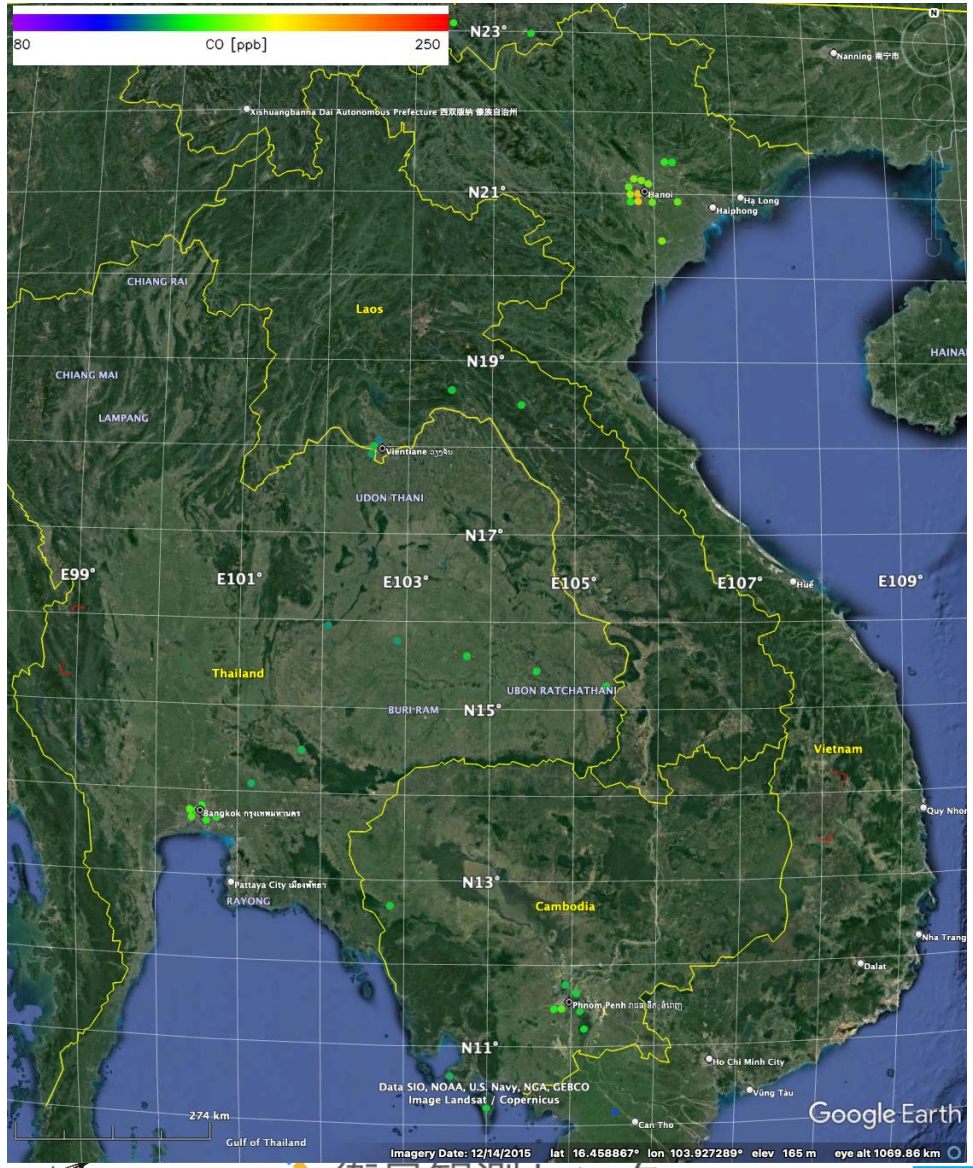


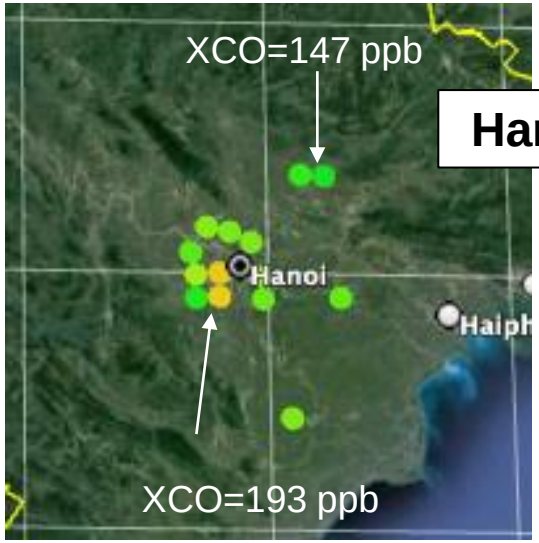
GOSAT-2 XCO2/XCH4/XCO Monthly Maps: East/Southeastern/South Asia in April, August, and December 2020



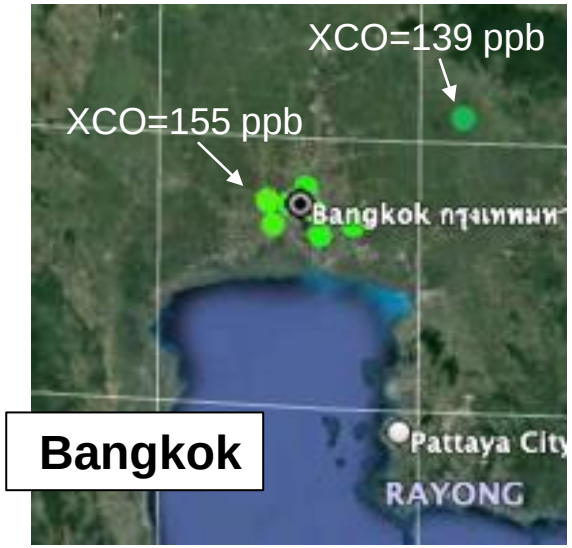
Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

XCO Observations by GOSAT-2 in January 2 and 14, 2021
Target Observations in Hanoi, Bangkok, and Phnom Penh

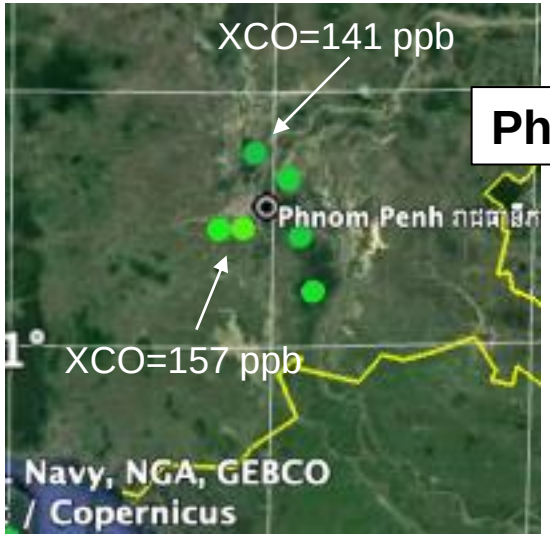




Hanoi



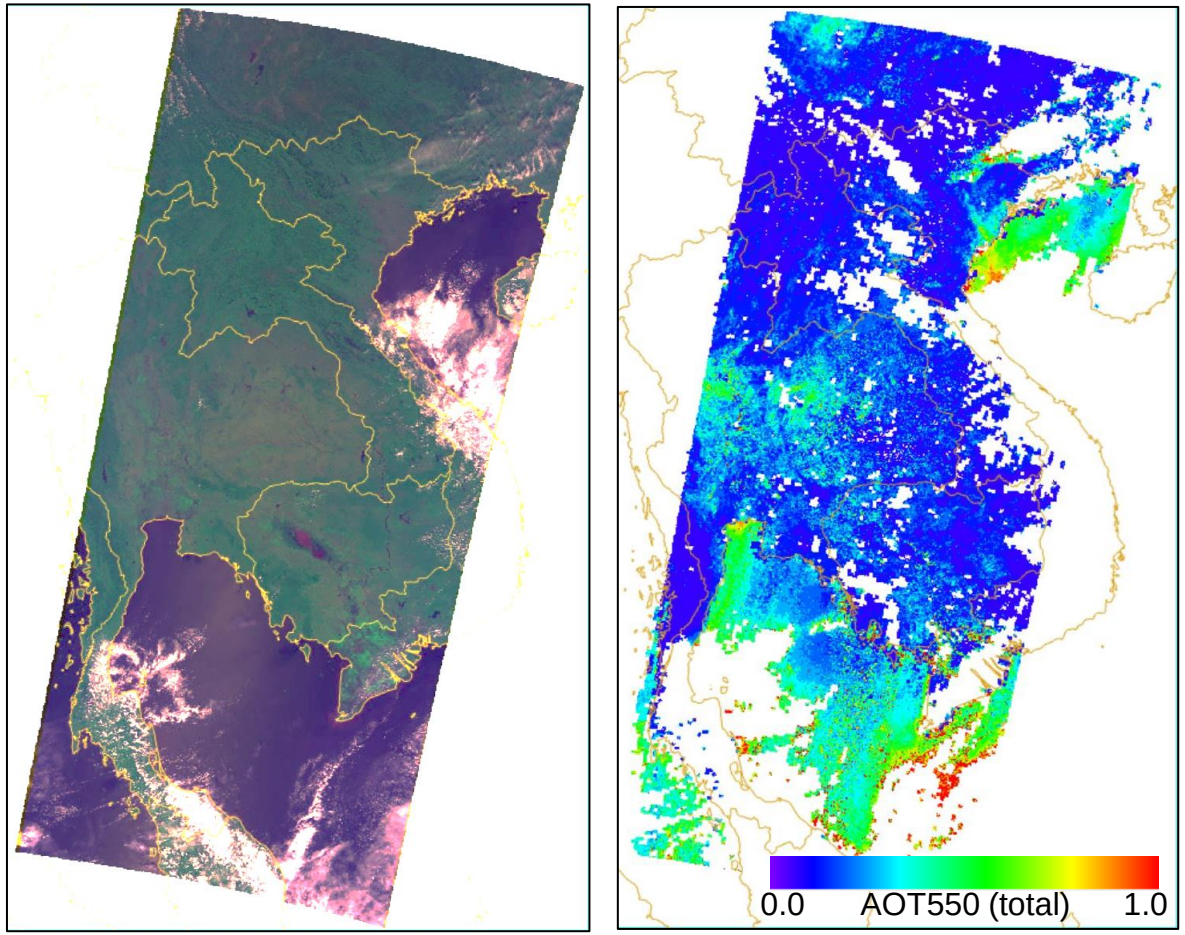
Bangkok



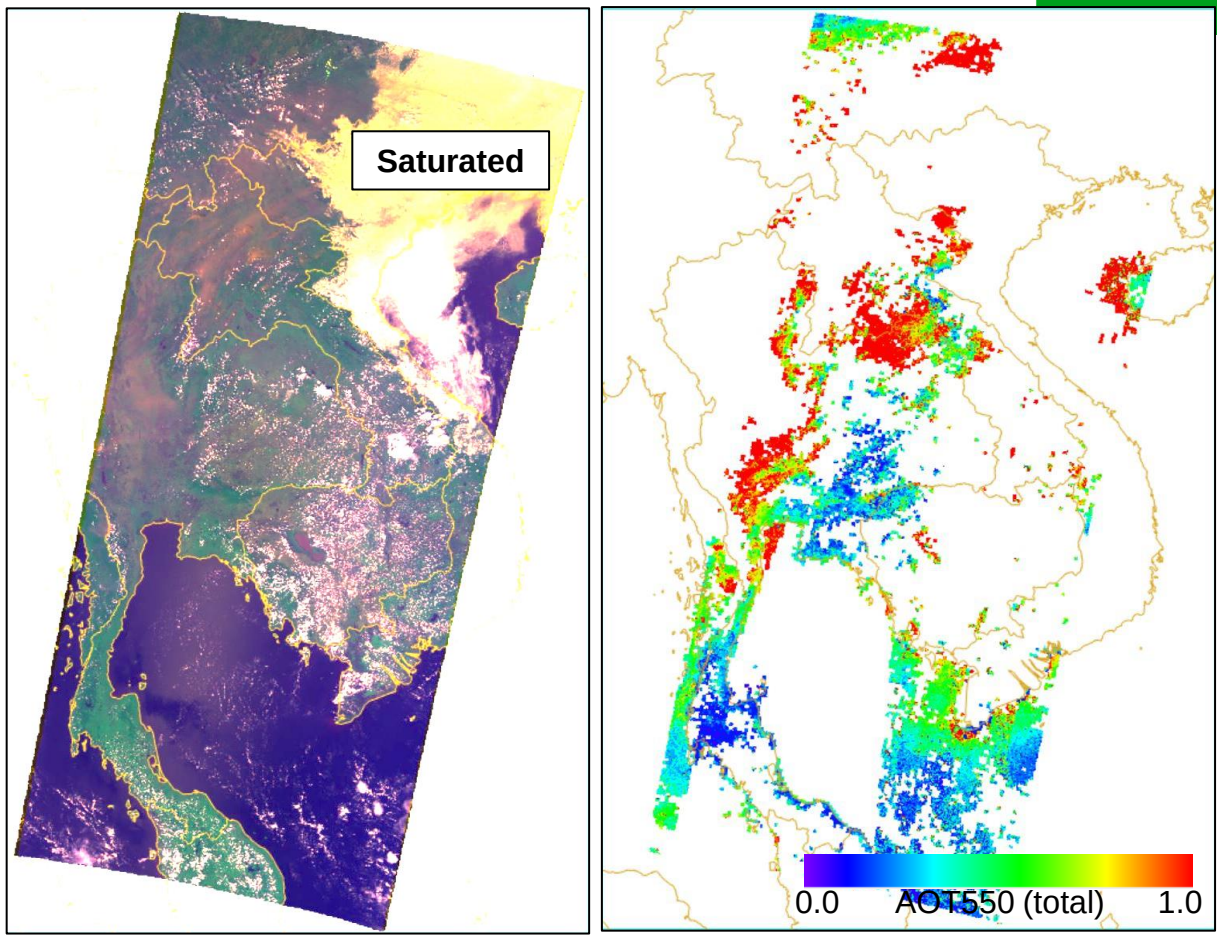
Phnom Penh

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-2 Aerosol Observations in Southeastern Asia
GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product (V01.04)



GOSAT-2 CAI-2 L1B and L2 Aerosol (AOT550)
December 9, 2019 Path 17 Frame 17-18 Forward



GOSAT-2 CAI-2 L1B and L2 Aerosol (AOT550)
April 1, 2020 Path 17 Frame 17-18 Forward

See Uchiyama-san's presentation for validation using ground-based data

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-2 Level 4 Global Surface Net Flux Estimates (in preparation)

GOSAT-2 Level 4 System (CO2)

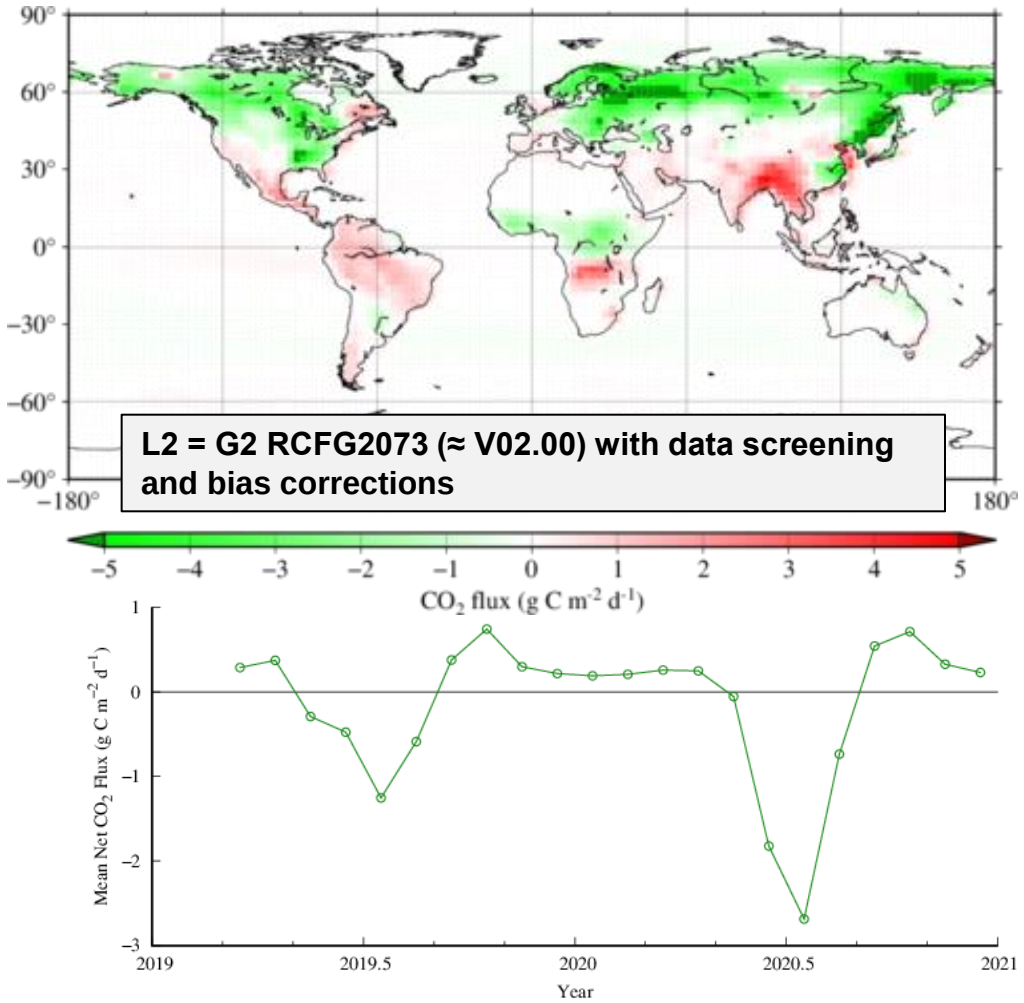
- **Atmospheric Transport / Inverse Model**
  NICAM-TM 4D-Var（NISMON）
  Nonhydrostatic ICosahedral Atmospheric Model
  Horizontal resolution = 2.5 degree (glevel5)
  Vertical layers = 40

- **A Priori Fluxes**
  Fossil fuel : ODIAC2020（monthly）
  Terrestrial biosphere : VISIT
  GPP, RE: hourly
  BVOC, LUC: monthly
  Forest fires : Shiraishi et al., *Remote Sensing*, 2021
  Ocean: JMA Ocean CO_2 Map

- **Meteorological data**
  JRA-55

Provided by M. Saito

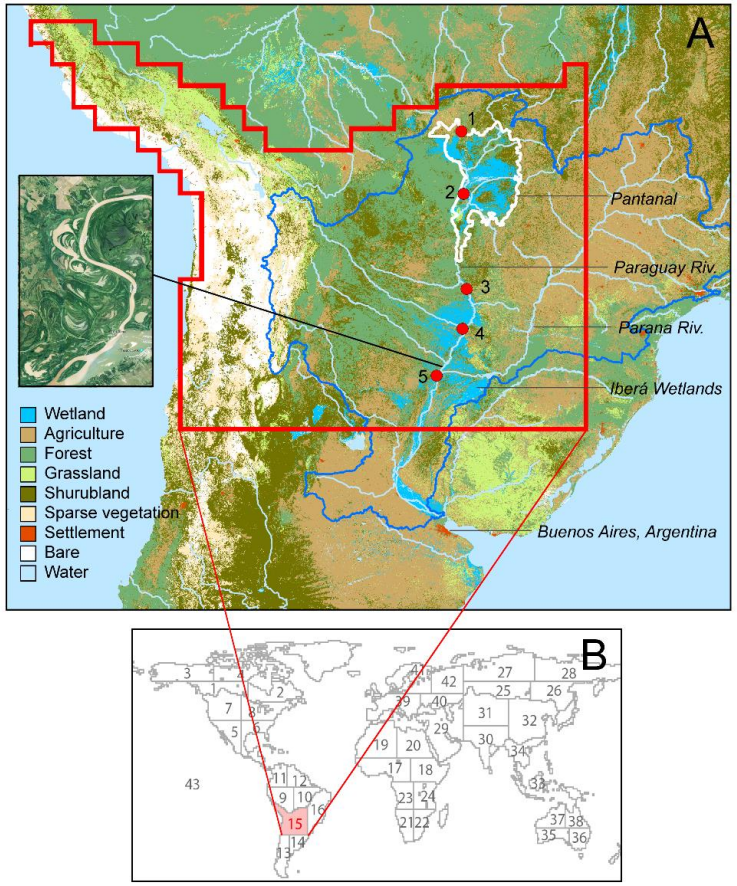
Posterior CO_2 Flux (July 2019)

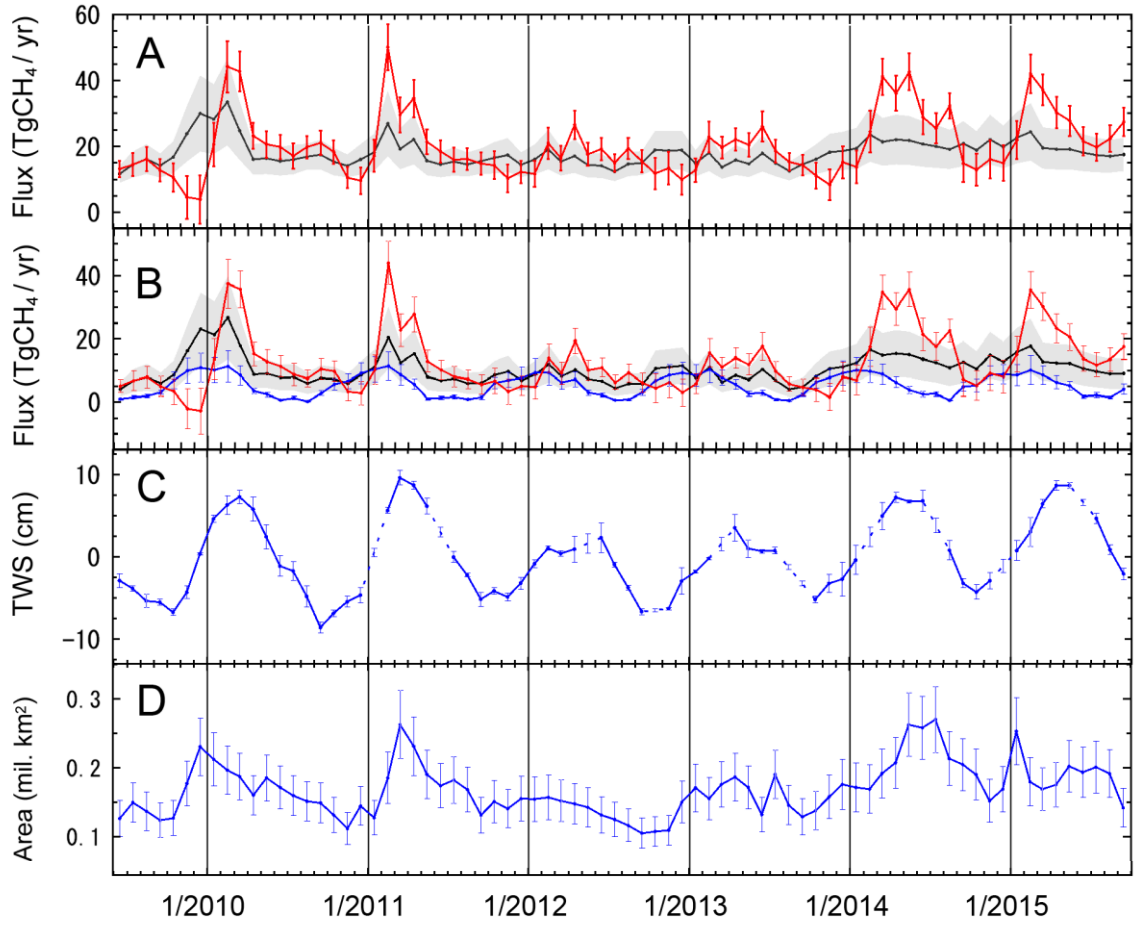


GOSAT-2 CO_2 flux time series from March 2019 to December 2020 for 10 x 10 degree area in Central Asia (45N-55N, 115E-125E) showing strong CO_2 uptake in summer

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

Meteorological control of subtropical South American methane emissions estimated from GOSAT observations (Takagi et al., SOLA, 2021)





GOSAT L4A CH_4 flux and its prior

GOSAT L4A wetland flux and WetCHARTs

GRACE terrestrial water storage

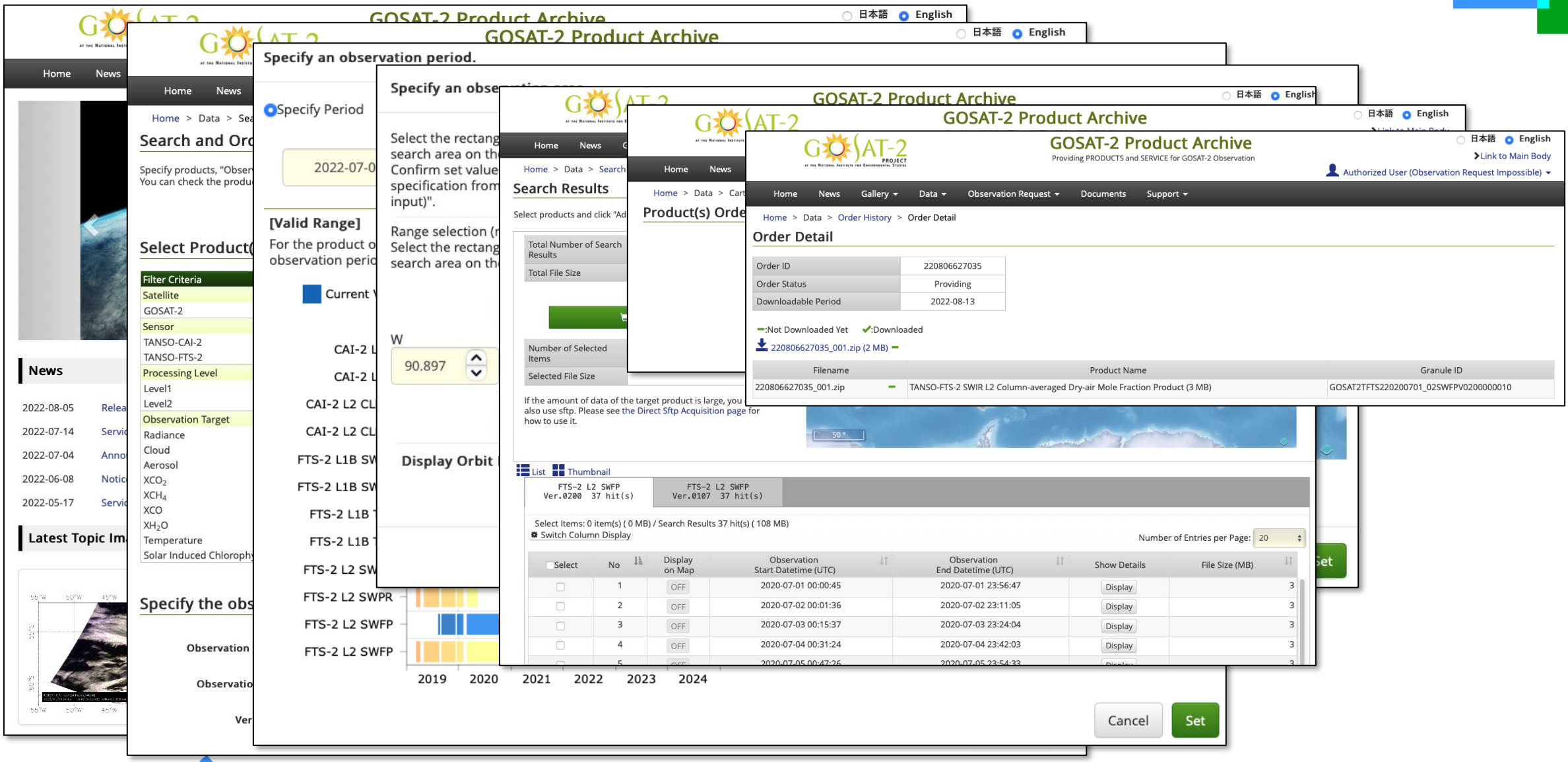
SSA **inundated area** extent based on SWAMPS

Fig. 1. (Left) (A) ESA-CCI land cover 2015 with Paraná Basin boundary (blue), Pantanal boundary (white), and subtropical South America CH_4 flux source region (red). Red circles indicate river water level measurement sites selected in this study. Left inset: areal view over the confluence of Paraguay and Paraná Rivers (photo from Google Maps 2020). (B) Boundaries of GOSAT Level 4 CH_4 flux source regions. (Right) (A) Monthly net posterior (red) and prior (black) CH_4 fluxes and their uncertainties for the SSA region (GOSAT Level 4A CH_4 product ver. 01.04). (B) SSA posterior wetland emission (red), SSA prior wetland emission (black), and WetCHARTs model ensemble mean (blue). (C) GRACE terrestrial water storage (TWS). (D) SSA inundated area extent based on SWAMPS inundation fraction greater than 0.1.

Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-2 Product Archive

https://prdct.gosat-2.nies.go.jp/



Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

Thank you for your attention.

Contact
matsunag@nies.go.jp

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

In 2023 or later, GOSAT-GW TANSO-3 standard products will be freely available from
GOSAT-GW TANSO-3 Product Archive (G3PA: L1B, L2)
(URL: TBD)