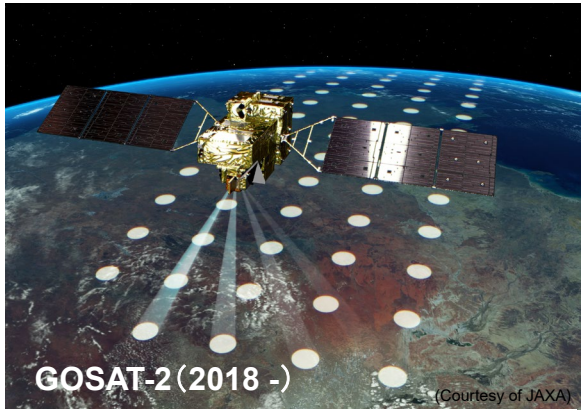
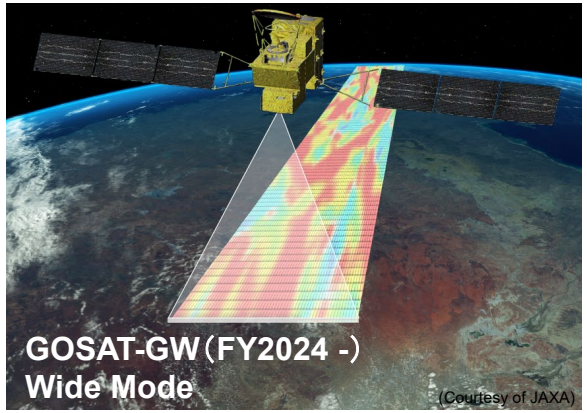
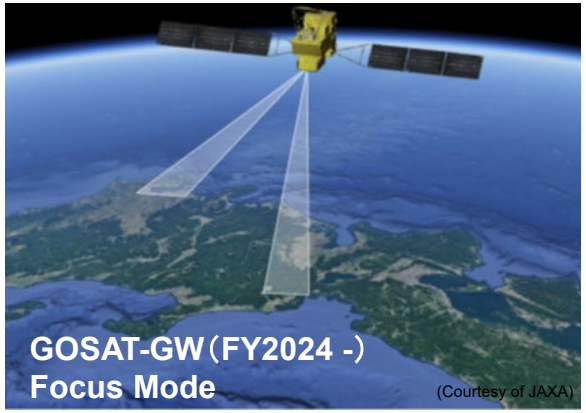
Overview of GOSAT Series
- GOSAT, GOSAT-2, and GOSAT-GW -







Greenhouse gases GOSAT PROJECT Observing SATellite

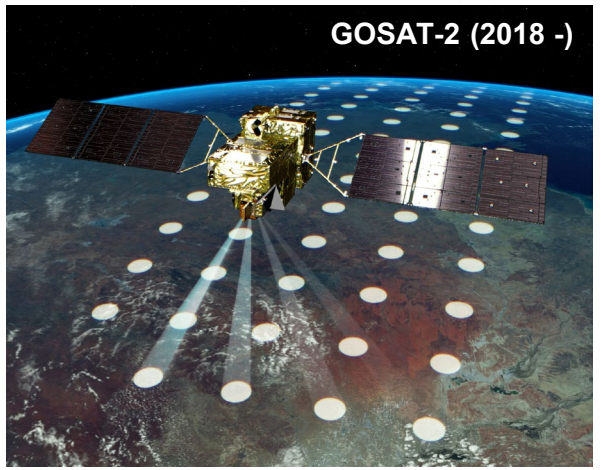
GOSAT-2 PROJECT AT THE NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES

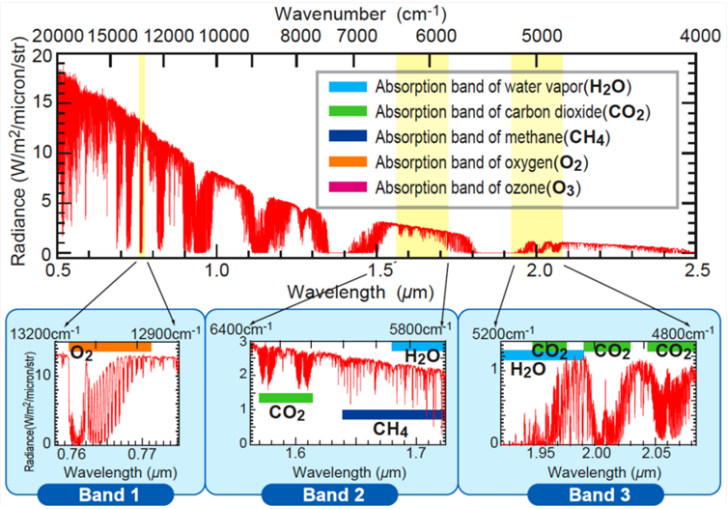
GOSAT-GW NIES Project

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

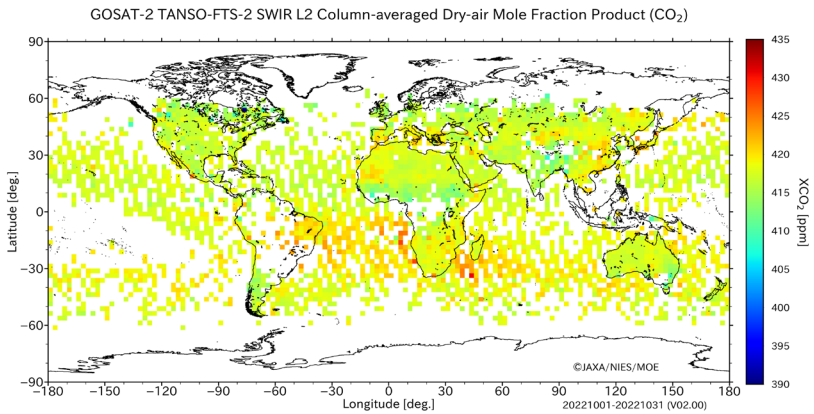
What is GOSAT Series?

- **Japanese earth observation satellite series for measurements of atmospheric concentrations of greenhouse gases**
  - **GOSAT** (2009 -)
    FTS for CO_2 and methane (CH_4)
  - **GOSAT-2** (2018 -)
    FTS for CO_2, CH_4, and carbon monoxide (CO)
  - **GOSAT-GW** (FY2024 -)
    Imaging spectrometer for CO_2, CH_4, and nitrogen dioxide (NO_2)

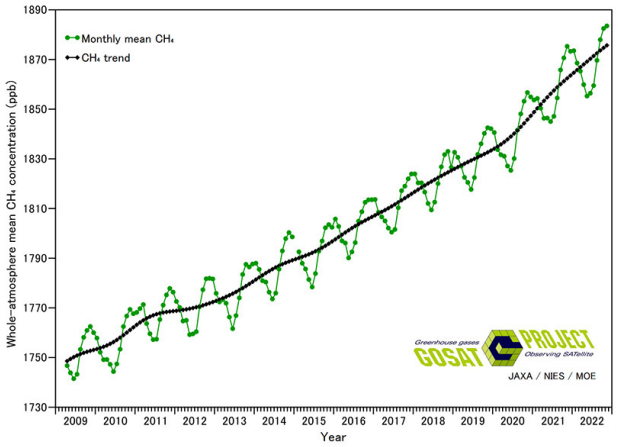




- **Organizations**
  - Joint projects by MOE, NIES, and JAXA
  - NIES is responsible for generation, validation, distribution, and archiving of gas concentration and flux data
  - Science Teams by domestic scientists
  - Collaboration agreements with foreign space agencies
  - Participation of overseas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



GOSAT-2 FTS-2 SWIR L2 XCO_2 Map of October 2022
(V02.00, Full Physics)



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

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

Timeline of UNFCCC/IPCC Activities and Japanese GOSAT Series

09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

ipcc INTERGOVERNMENTAL PANEL ON climate change

• IPCC AR5

• IPCC AR6

"It is unequivocal that human influence has warmed the atmosphere, ocean and land. "

• 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

United Nations Framework Convention on Climate Change

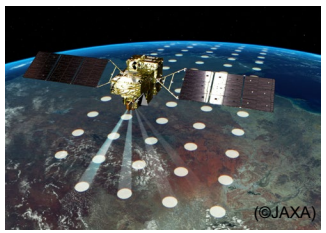
• Paris Agreement

• 1st Global Stocktake

• 2nd GST

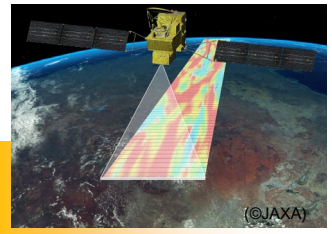
• 3rd GST

GOSAT



GOSAT-2

GOSAT-GW



SCIAMACHY

OCO-2

TROPOMI

CO2M

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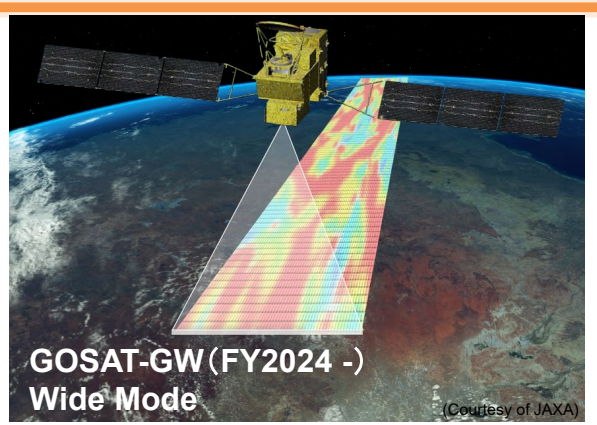
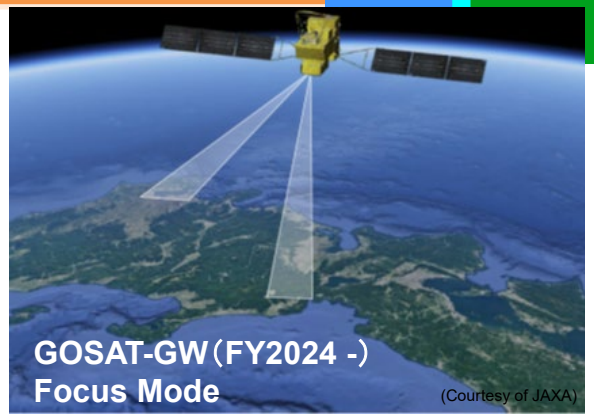
Specifications of GOSAT, GOSAT-2, and GOSAT-GW





	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 Pointing	± 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)

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Global Observation by GOSAT and GOSAT-GW

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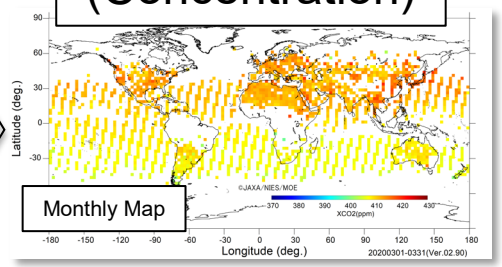
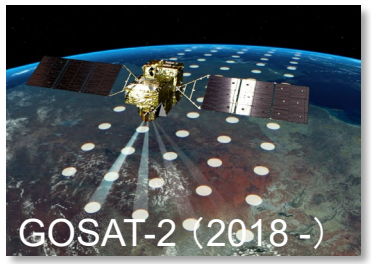
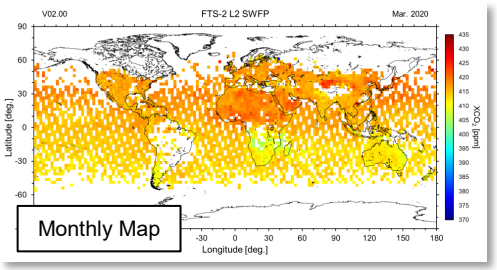
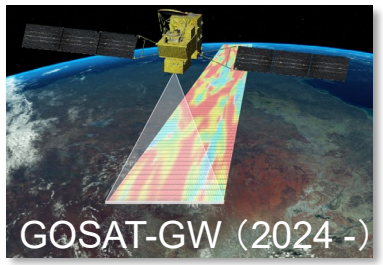
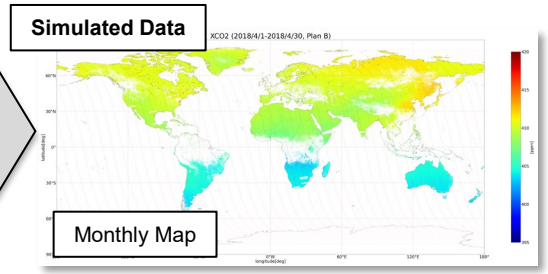
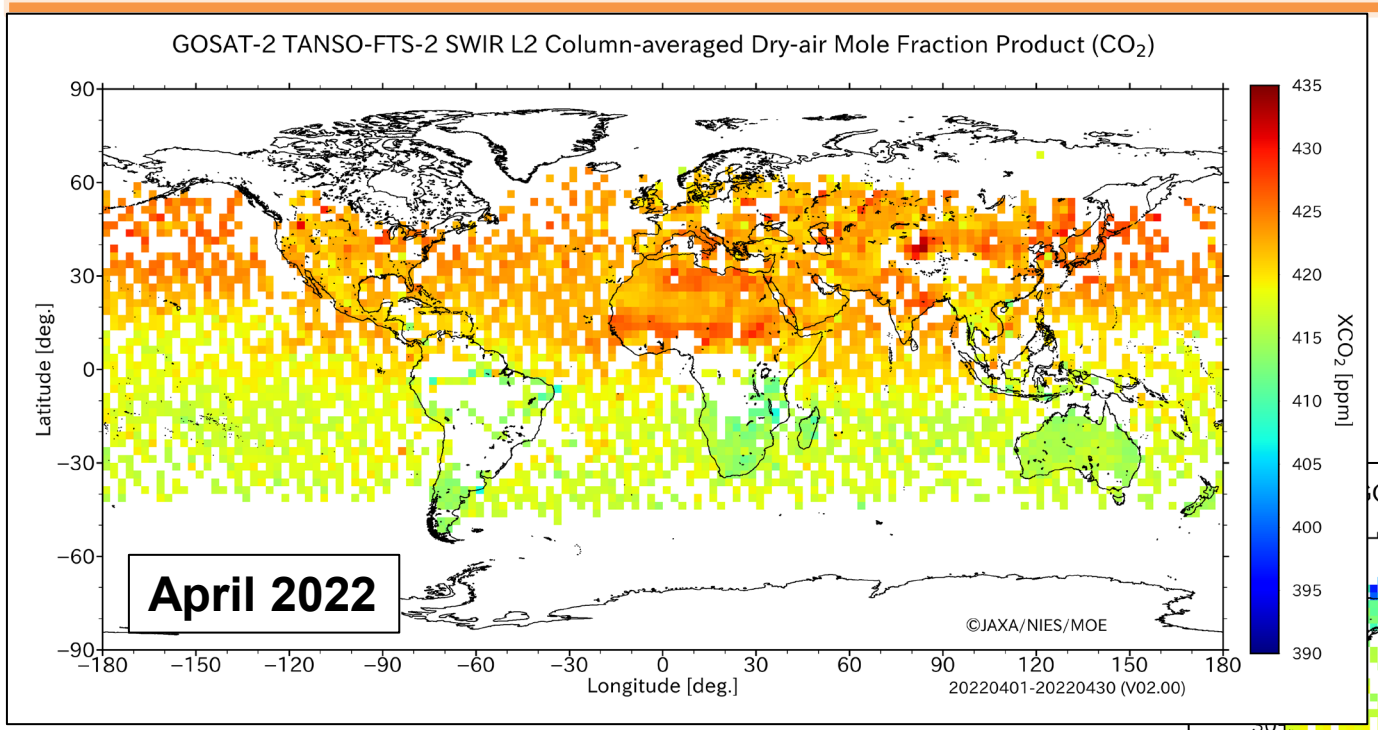
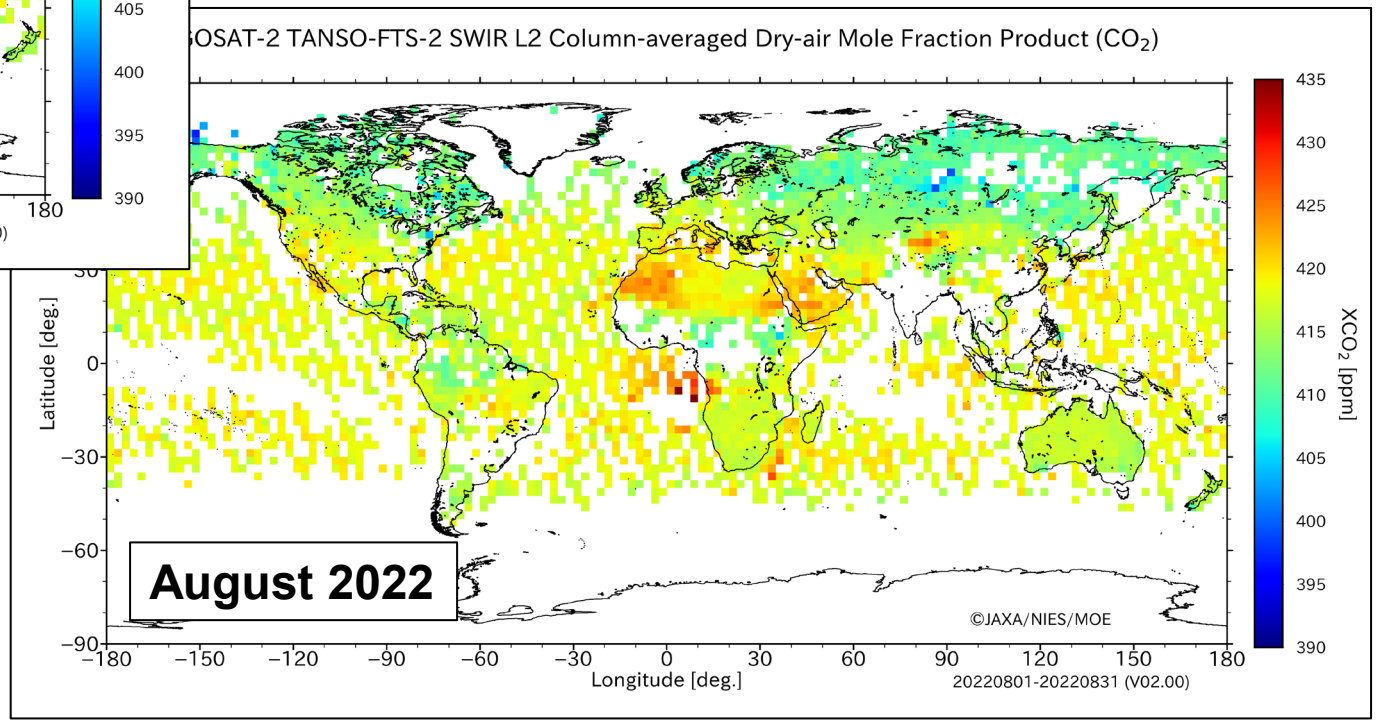
GOSAT Series Data Flow from Satellite to NIES

Satellite	JAXA		NIES		Level 2 Product (Concentration)	
		25GB/day		**GOSAT DHF**		≈ 400 point/day
		131GB/day		**G2DPS**		≈ 800 point/day
	aws	60～160 GB/day		**G3DPS** （under development）		≈ 100,000～ 300,000 point/day

Global CO_2 Distribution Observed by GOSAT-2 April and August 2022



GOSAT and GOSAT-2 data are being processed in NIES on a monthly basis.



The GOSAT GHG concentration data are validated by ground-based observation data.
The relative accuracy is about **0.5%.**

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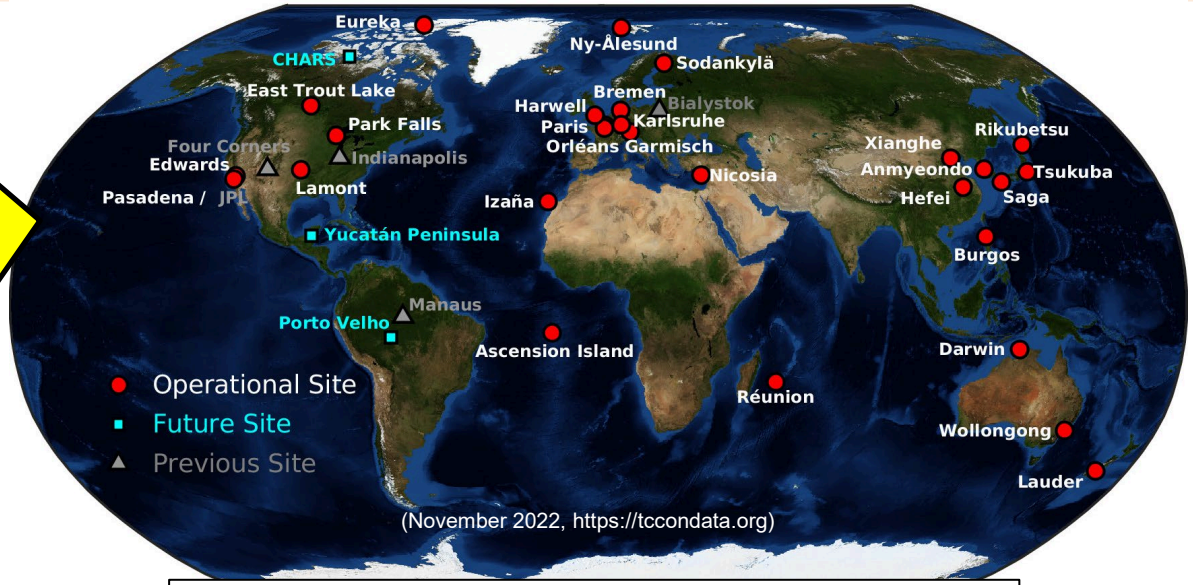
Fourier Transform Spectrometer with Solar Tracker for GOSAT Data Validation

Satellite GHG concentration data are validated by world-wide simultaneous ground-based observation using more precise instruments.

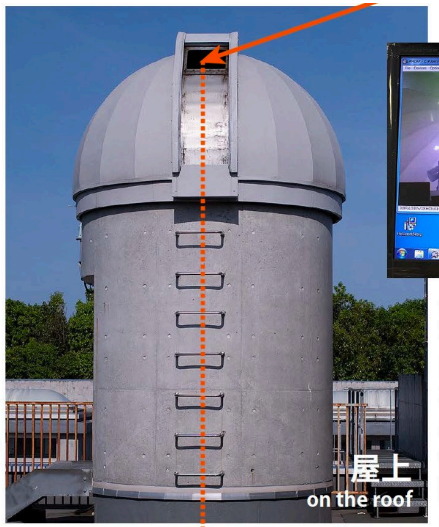


Total Carbon Column Observing Network (TCCON)

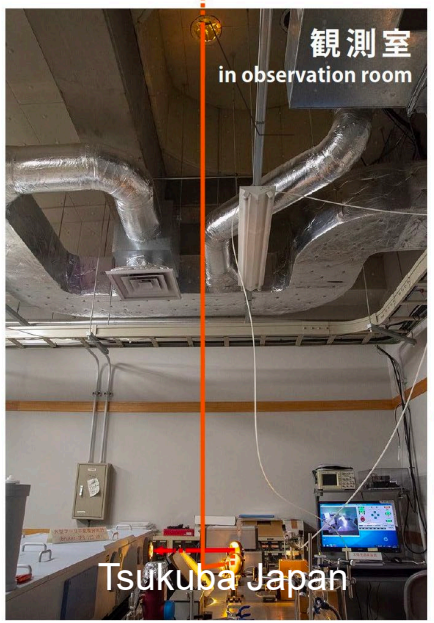
Pasadena, US

Burgos, Philippines

Rikubetsu, Japan



太陽光追尾装置
Solar tracker
太陽光を階下の観測室に導くために2枚の鏡を動かして太陽を追尾します。
設置場所の緯度、経度、高度、時刻から計算で鏡の位置を調整します。
更に太陽光の中心を捉えるように微調整します。



FTS
光学干渉計により干渉させた光を測定し、フーリエ変換（計算処理）して波長に対する光の強度のデータ（スペクトル）を得ます。

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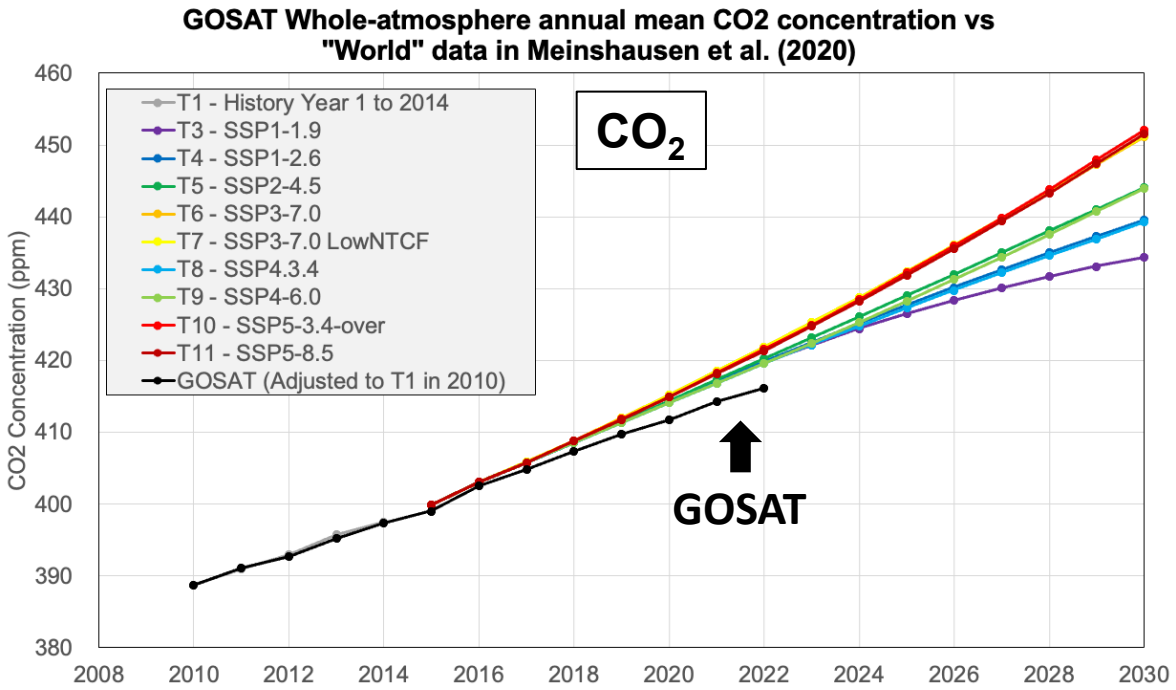
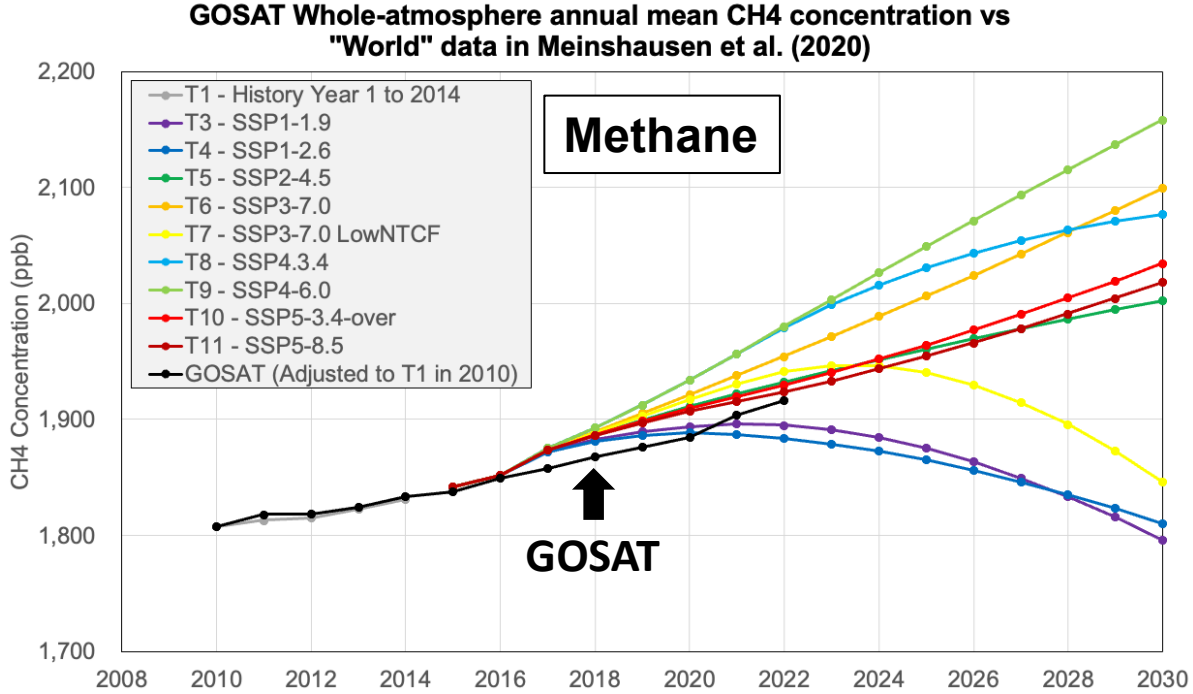
Global CO_2 and CH_4 Concentrations by GOSAT (2010 – 2022) and from Shared Socioeconomic Pathways (SSPs)





Scenario	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
	Best estimate	Very likely range	Best estimate	Very likely range	Best estimate	Very likely range
SSP1-1.9	1.5 degC	1.2 to 1.7 degC	1.6 degC	1.2 to 2.0 degC	1.4 degC	1.0 to 1.8 degC
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

} Scenarios toward 2 deg. temperature target

GOSAT whole-atmosphere mean CO_2 and CH_4 concentrations can be indicators of which emission scenario the real-world greenhouse has emissions are close to.

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

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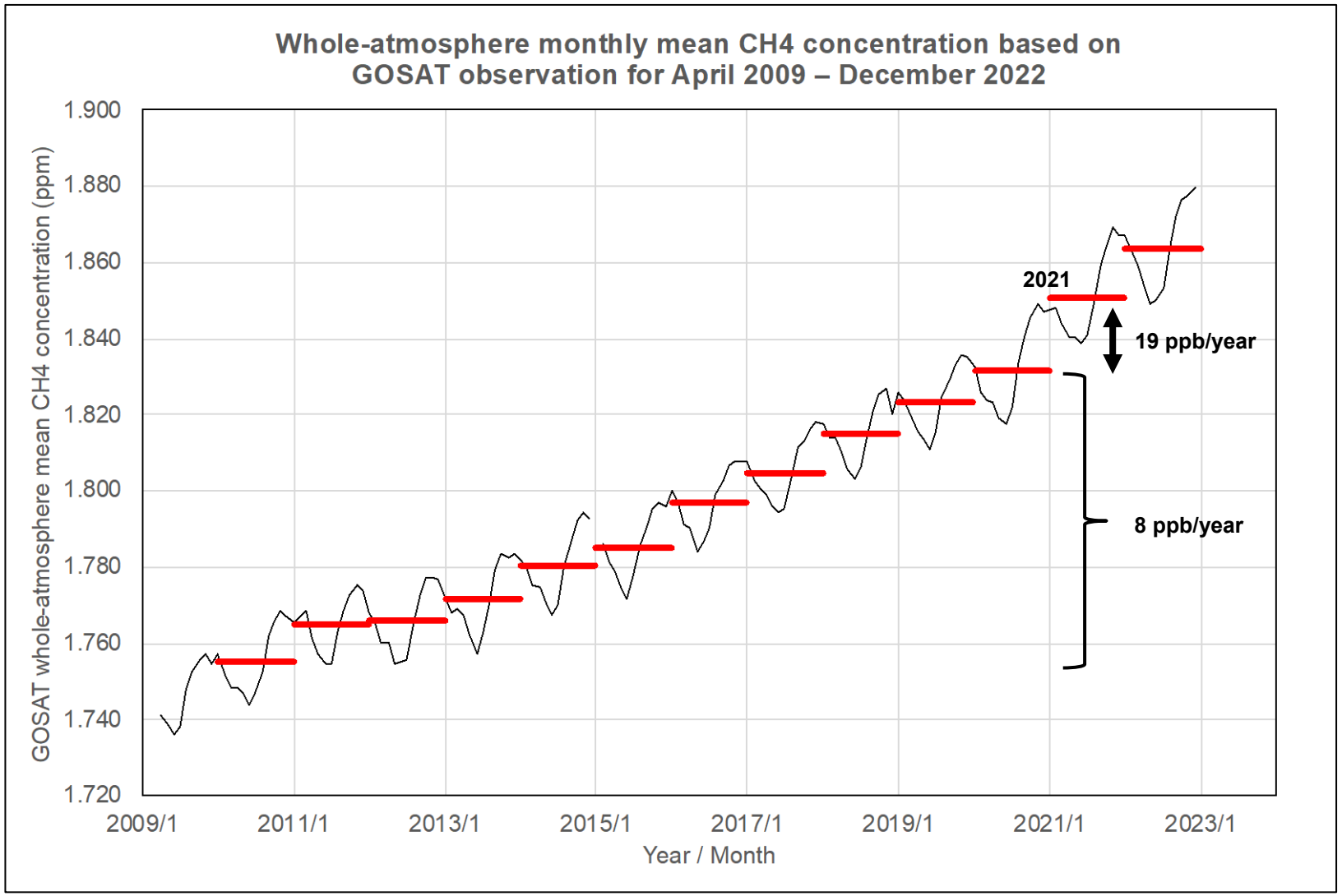
Recent Increase of GOSAT Whole-atmosphere CH4 Concentration

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



Year	Annual Mean (ppb)	Annual Increase (ppb)
2010	1755	-
2011	1765	10
2012	1766	1
2013	1771	5
2014	1780	9
2015	1785	5
2016	1797	12
2017	1805	8
2018	1815	10
2019	1823	8
2020	1832	9
2021	1851	**19**
2022	1864	13

As of January 2022

2011-2020 average of the annual increase ≈ 8 ppb/year

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

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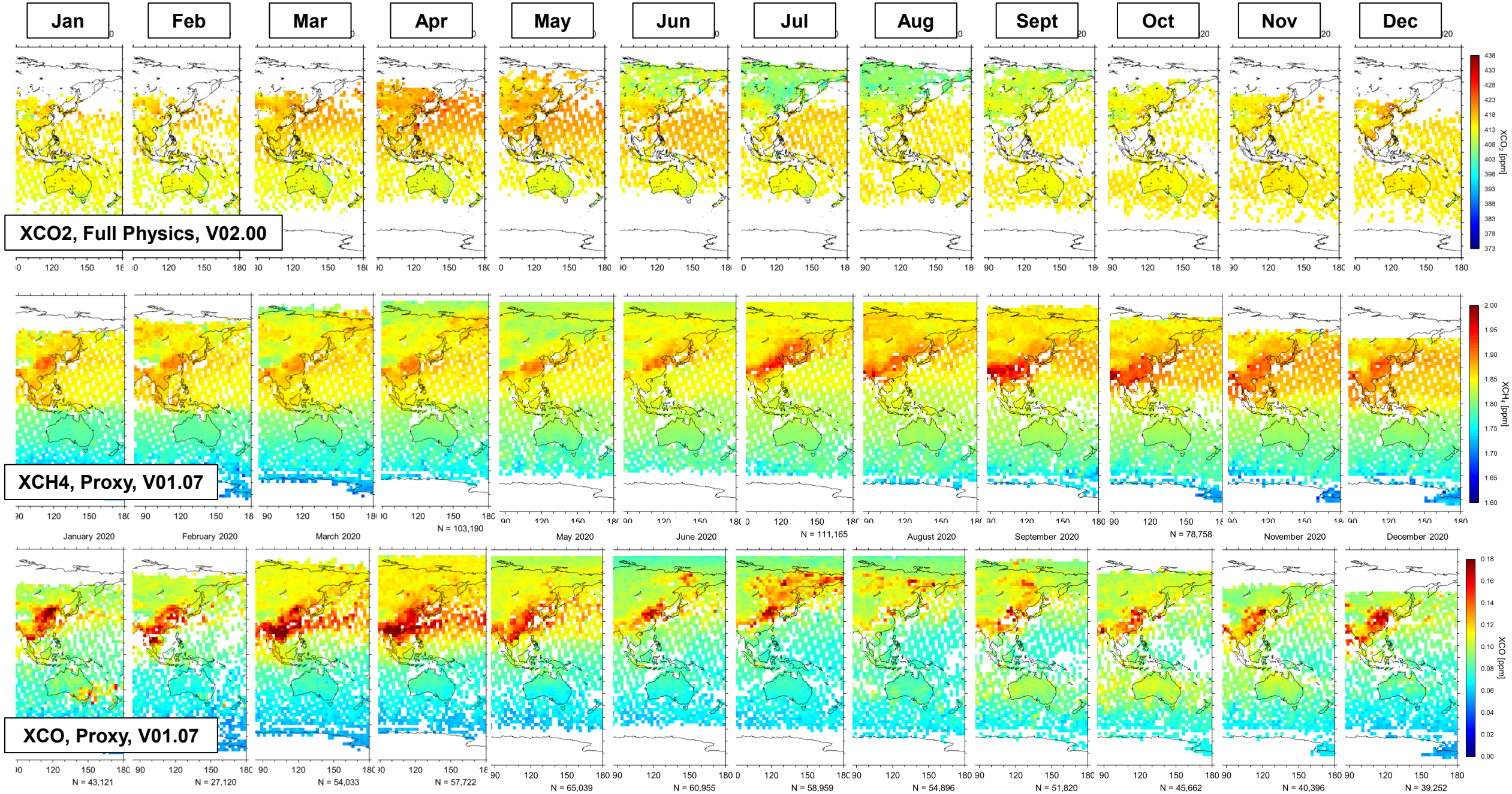
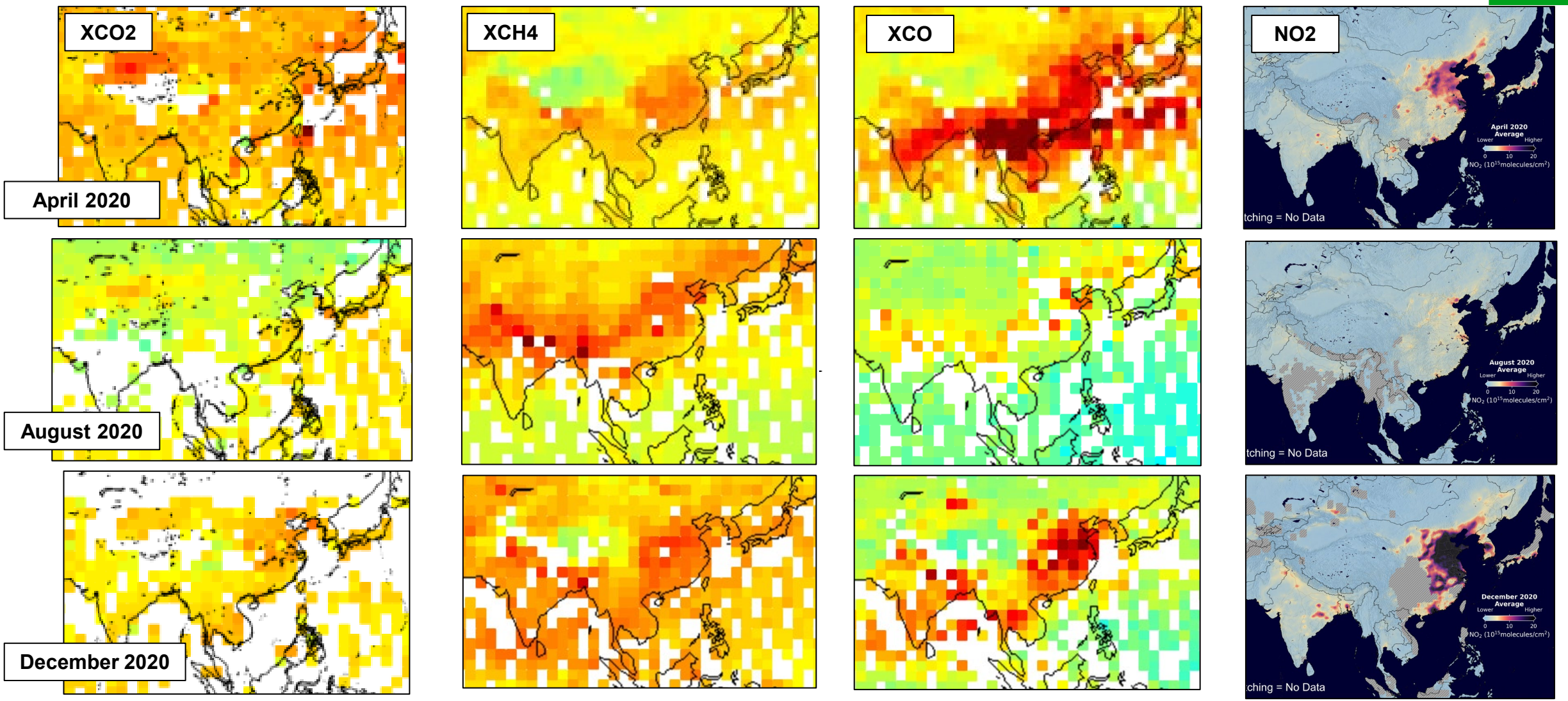
GOSAT-2 XCO2/XCH4/XCO Monthly Maps: East/Southeastern Asia and Oceania in 2020



GOSAT-2 XCO2/XCH4/XCO and AURA/OMI NO2 Monthly Maps: East/Southeastern/South Asia in April, August, and December 2020



https://so2.gsfc.nasa.gov/no2/regionals.html

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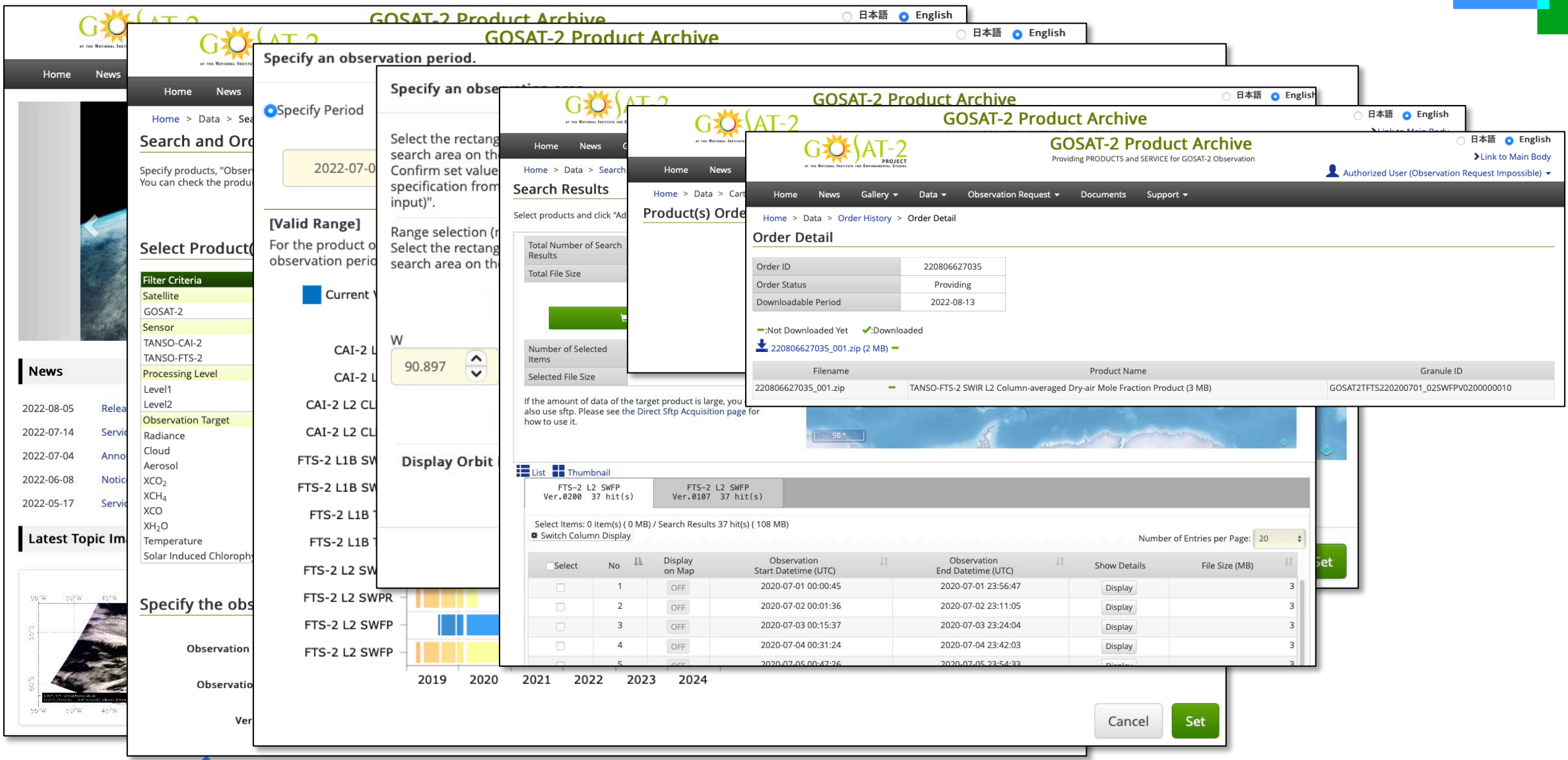
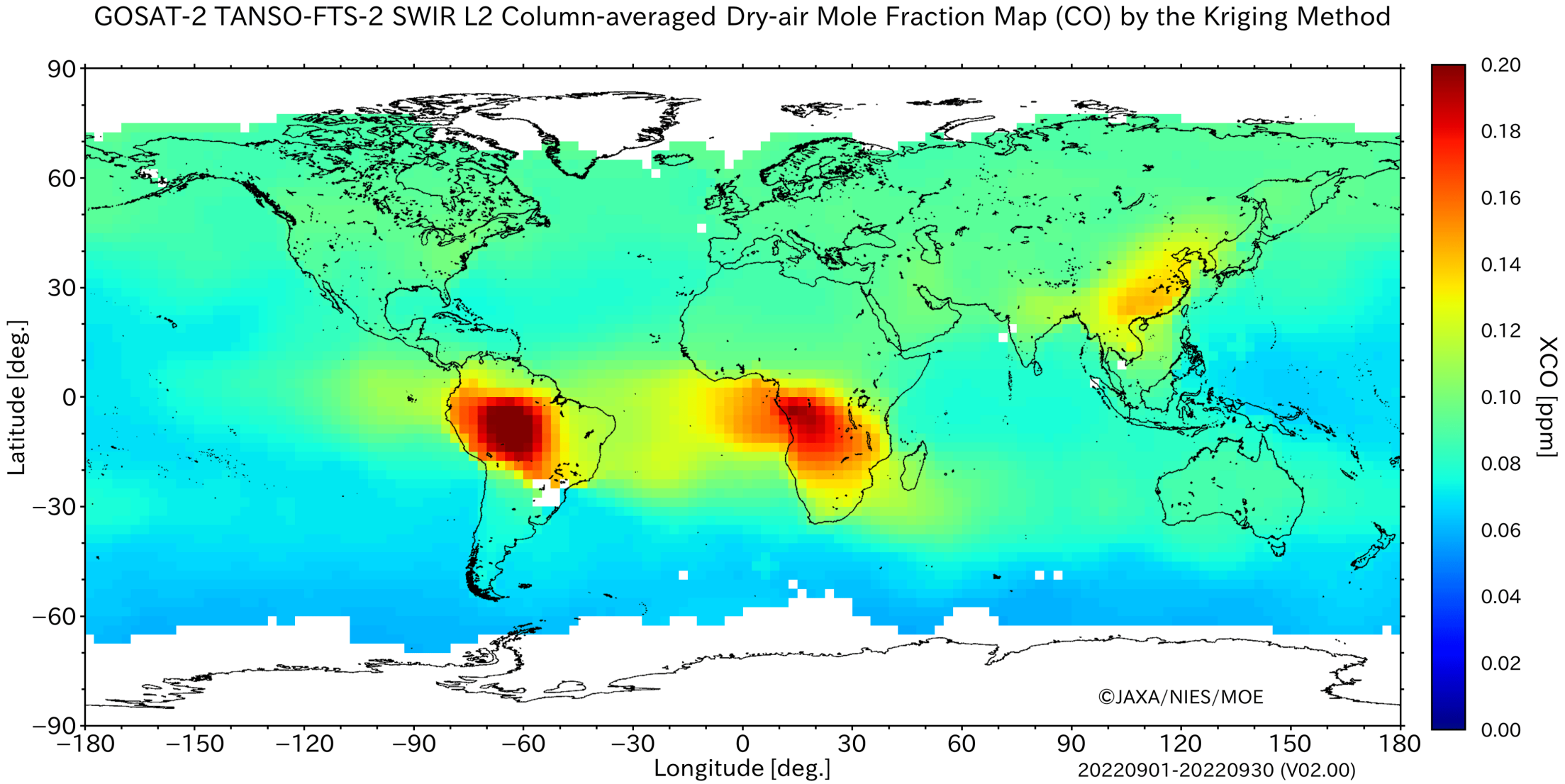
GOSAT-2 Product Archive

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



Global Monthly XCO2, XCH4, and XCO (Kriging) Maps from GOSAT-2 Data

https://www.gosat-2.nies.go.jp/gallery/photos/products/co2 (or ch4 or co)



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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 2024 or later, GOSAT-GW TANSO-3 standard products will be freely available from
GOSAT-GW TANSO-3 Product Archive (G3PA: L1B, L2)
(URL: TBD)