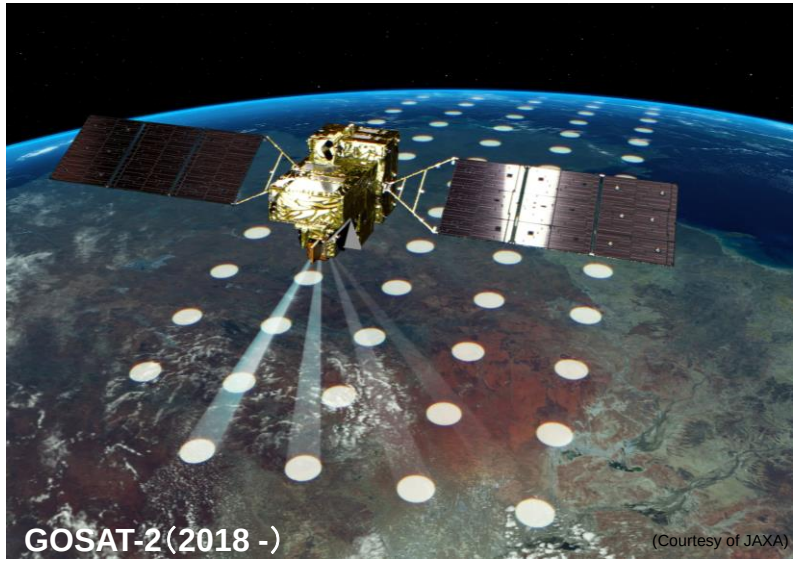
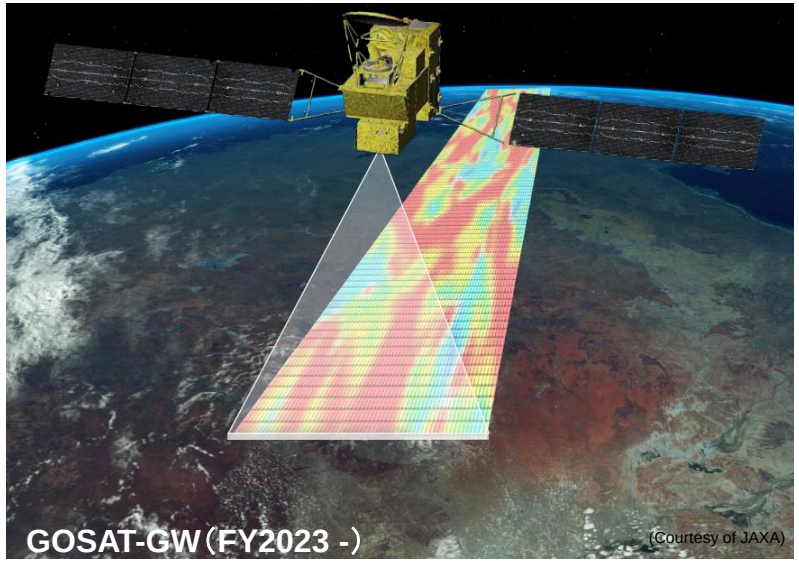
Japan's Contribution to Space-based Greenhouse Gas Observing Systems: GOSAT Series


GOSAT (2009 -) (Courtesy of JAXA)

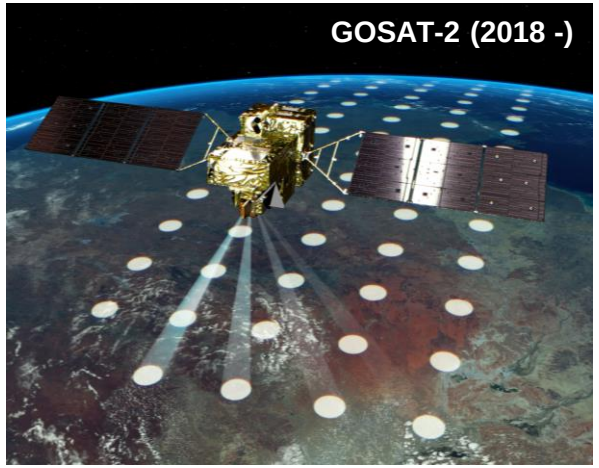

GOSAT-2（2018 -） (Courtesy of JAXA)

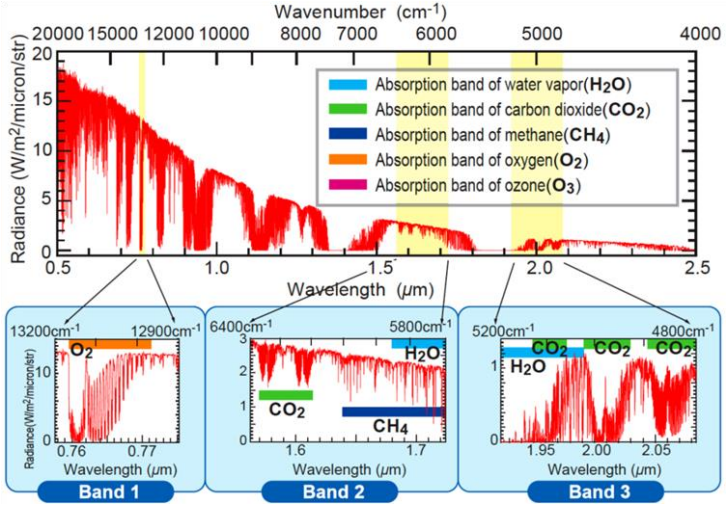

GOSAT-GW（FY2023 -） (Courtesy of JAXA)

Tsuneo Matsunaga and Hiroshi Tanimoto
National Institute for Environmental Studies (NIES), Japan

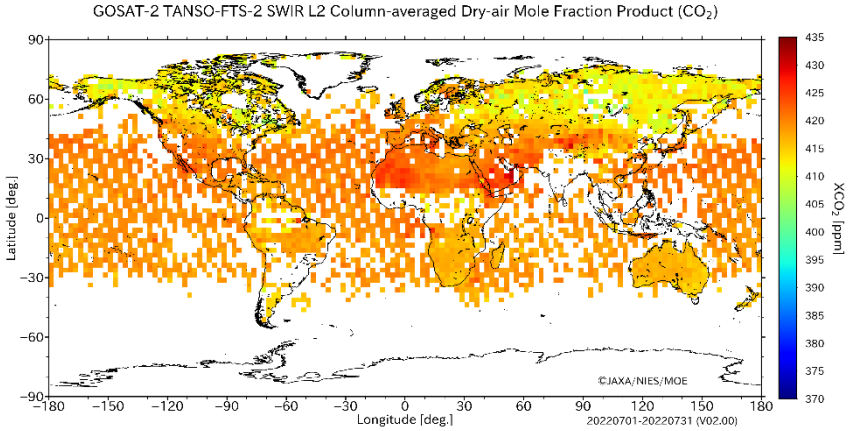
What is GOSAT Series?

- **Japanese earth observation satellite series for measurements of atmospheric concentrations of greenhouse gases**
  - **GOSAT** (2009 -)
    FTS for CO_2 and 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

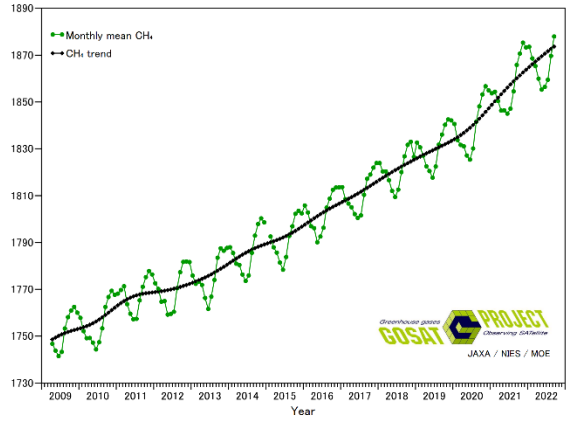




- **Organizations**
  - Joint projects by MOE, NIES, and JAXA
  - NIES is responsible for generation, validation, distribution, and archiving of gas concentration and flux data
  - Science Teams by domestic scientists
  - Collaboration agreements with foreign space agencies
  - Participation of overseas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



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



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

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

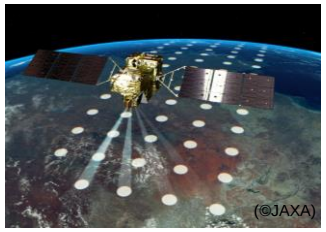
• Paris Agreement

• 1st Global Stocktake

• 2nd GST

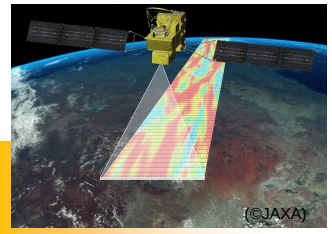
• 3rd GST

GOSAT



GOSAT-2

GOSAT-GW



SCIAMACHY

OCO-2

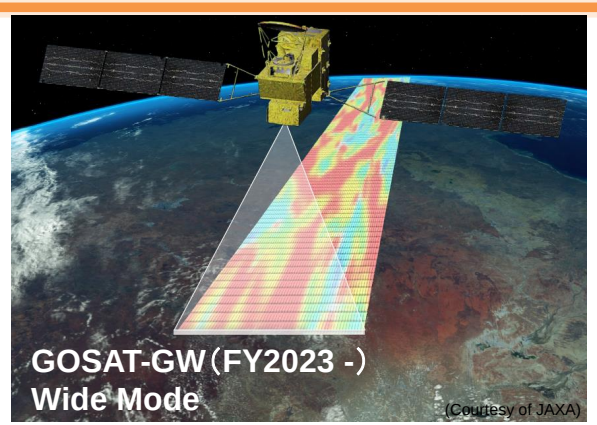
TROPOMI

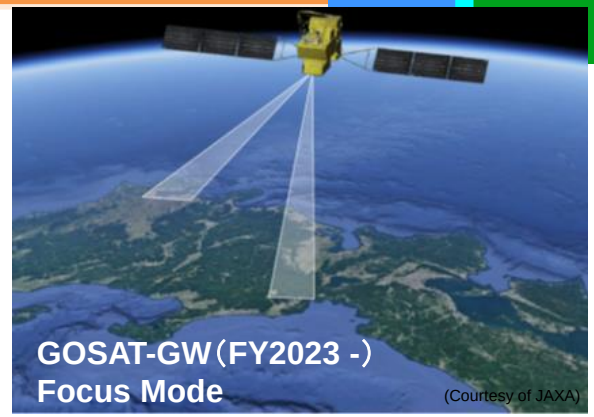
CO2M

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

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



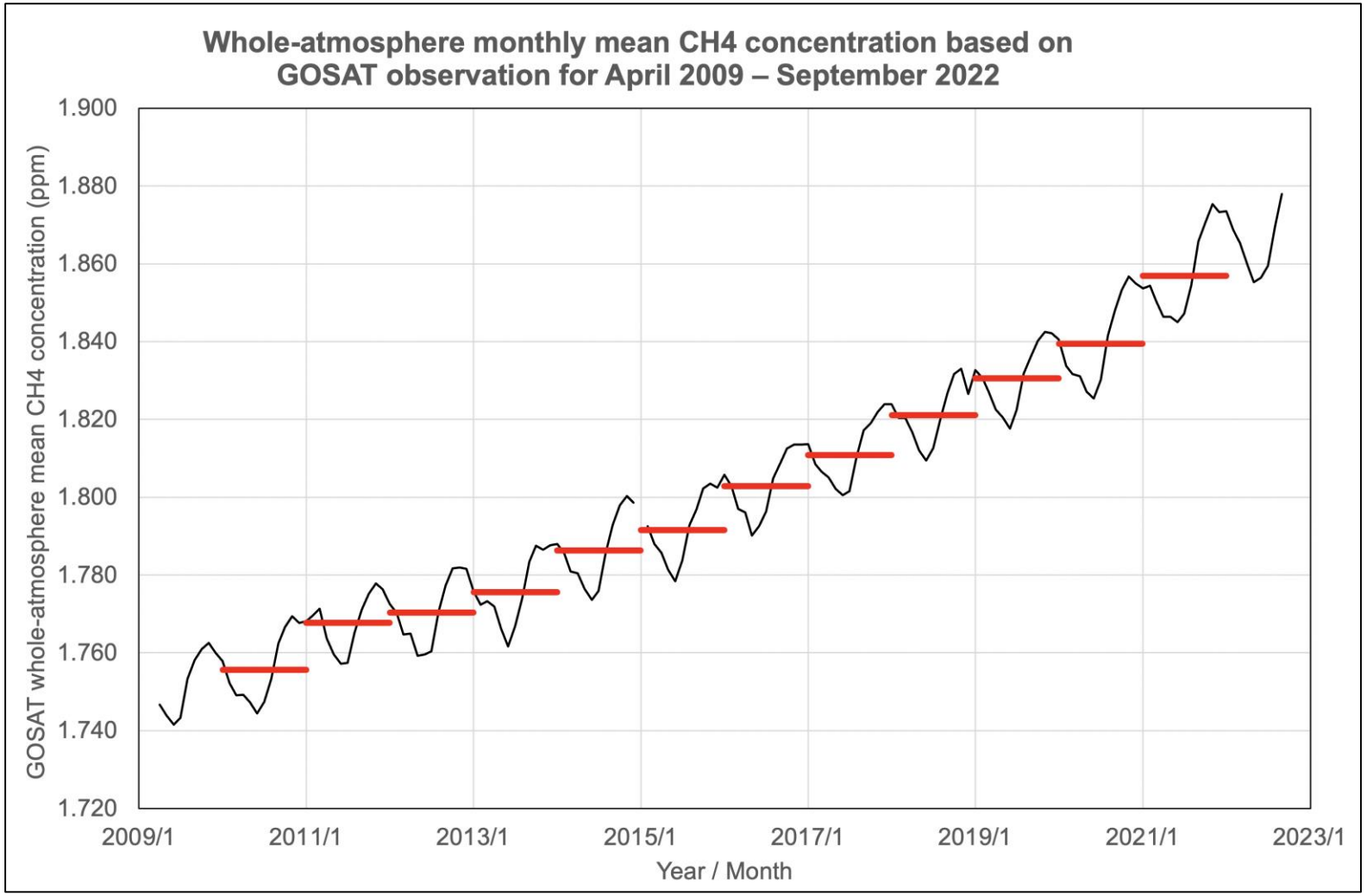


	GOSAT	GOSAT-2	GOSAT-GW
Launch / lifetime	2009 / 5 years	2018 / 5 years	FY2023 / 7 years
Satellite mass / power	1.75 t / 3770 W	1.8 t / 5000 W	2.9 t / 5200 W
Orbit	666 km, 3 days, 13:00, descending	613 km, 6 days, 13:00, descending	666 km, 3 days, 13:30, ascending
Spectrometer	FTS	FTS-2	TANSO-3 (Grating)
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)

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

Recent Increase of GOSAT Whole-atmosphere CH_4 Concentration

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



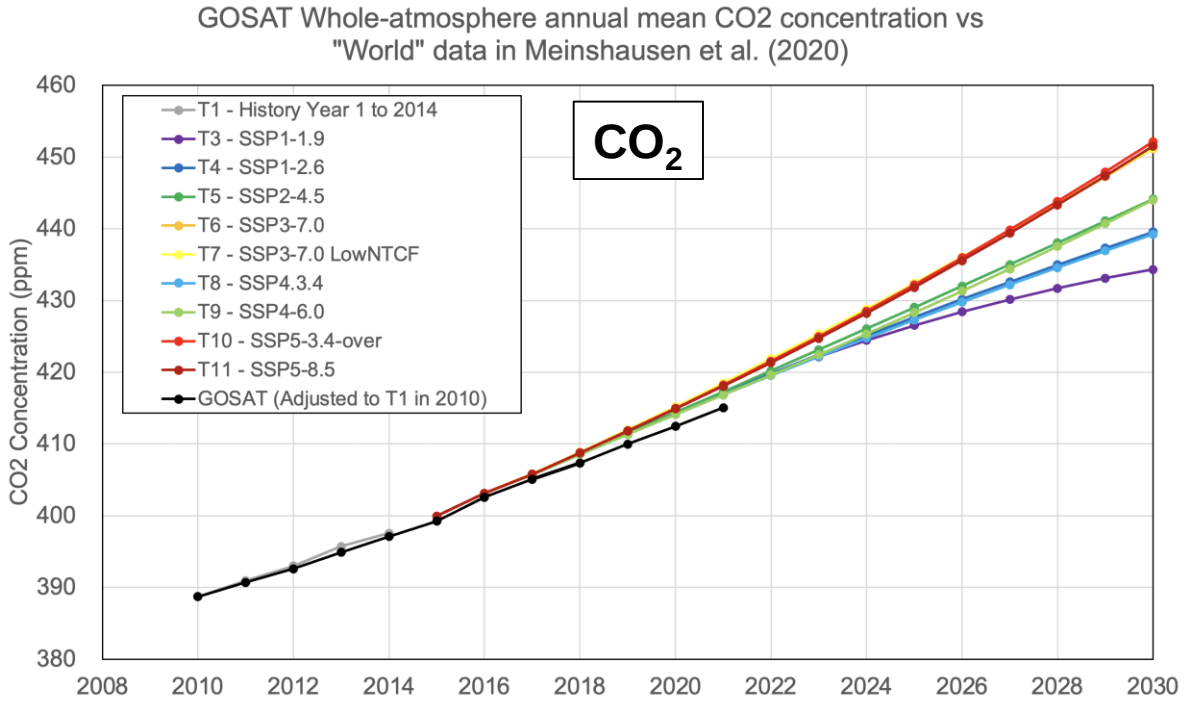
Year	Annual Mean (ppb)	Annual Increase (ppb)
2010	1756	-
2011	1768	12
2012	1770	2
2013	1776	6
2014	1786	10
2015	1792	6
2016	1803	11
2017	1811	8
2018	1821	10
2019	1831	10
2020	1840	9
2021	**1857**	**17**
2022		

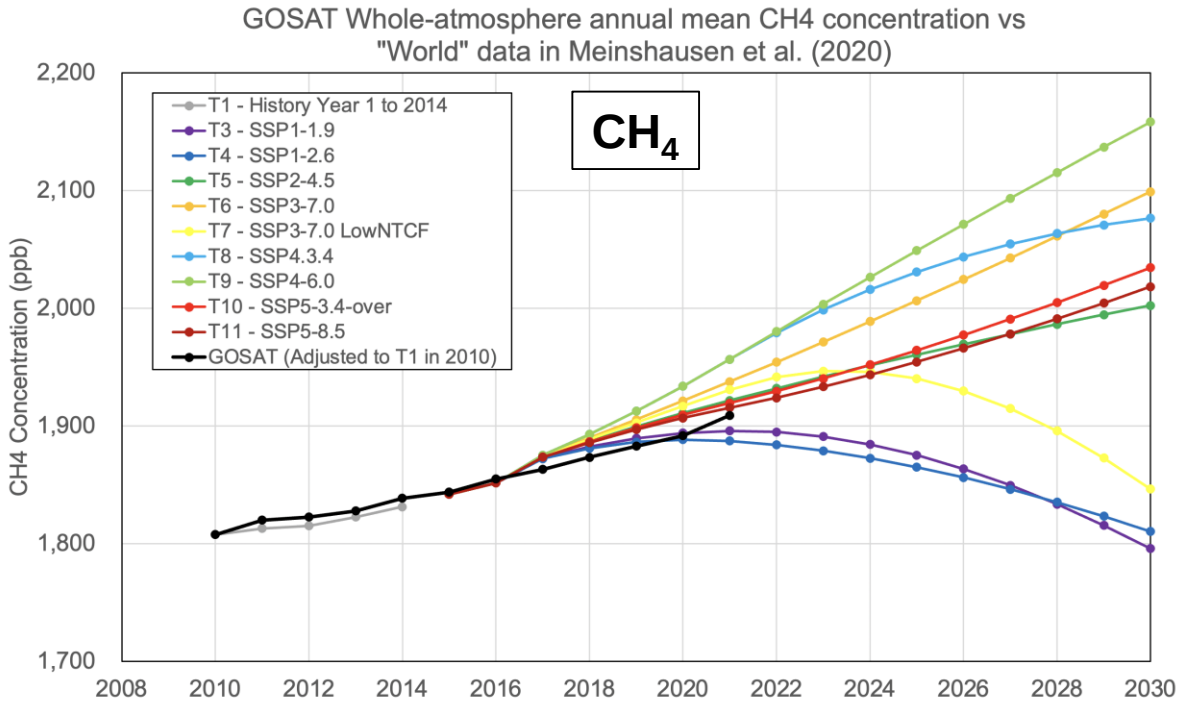
Year	Jan - Sept Mean (ppb)	Jan - Sept Increase (ppb)
2019	1827	-
2020	1834	7
2021	1852	18
2022	1865	13

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 CO_2 and CH_4 Concentrations by GOSAT and from Shared Socioeconomic Pathways (submitted to UNFCCC's 1st Global Stocktake)





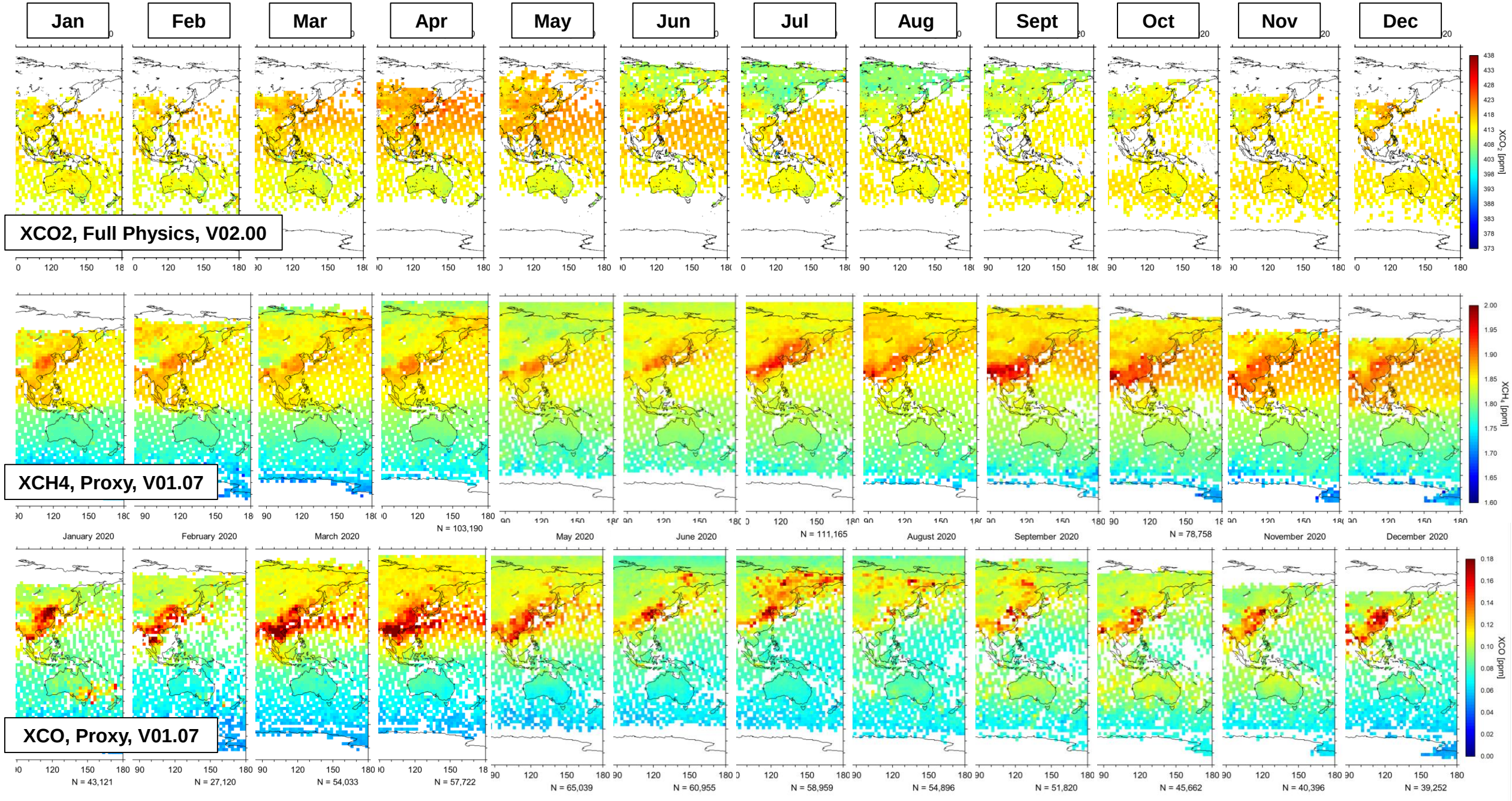
Scenario	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
	Best estimate	Very likely range	Best estimate	Very likely range	Best estimate	Very likely range
SSP1-1.9	1.5 degC	1.2 to 1.7 degC	1.6 degC	1.2 to 2.0 degC	1.4 degC	1.0 to 1.8 degC
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 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

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.

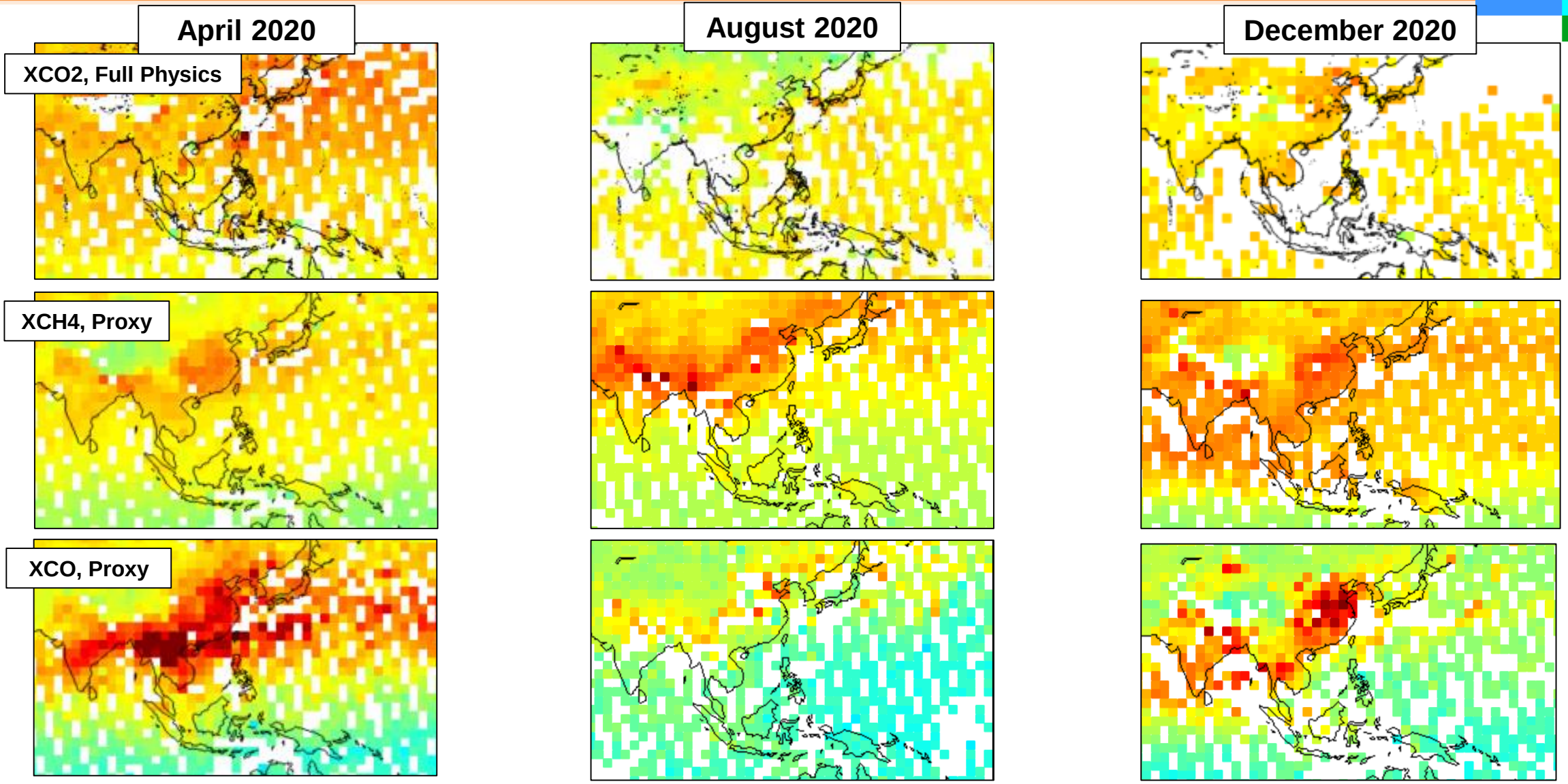
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

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

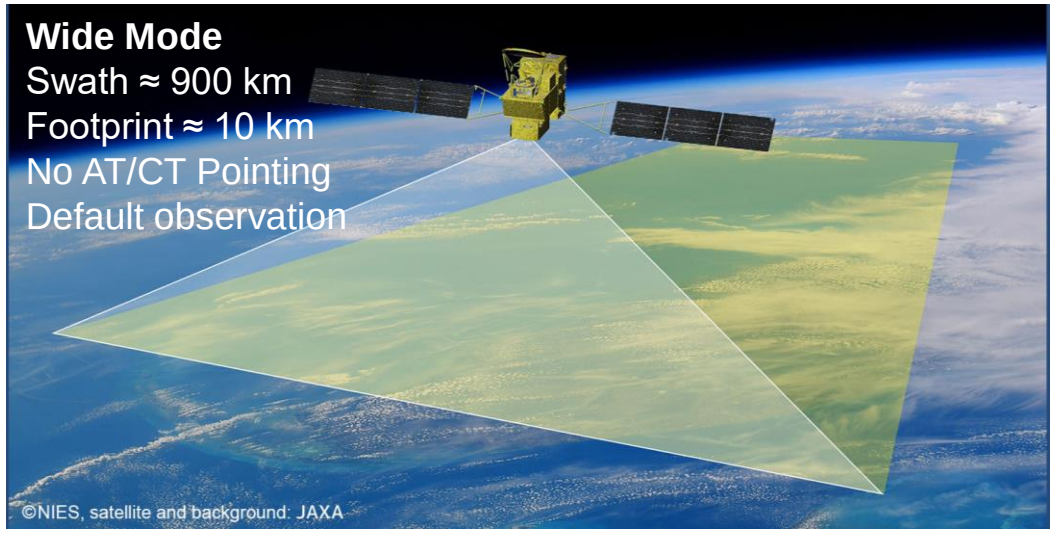


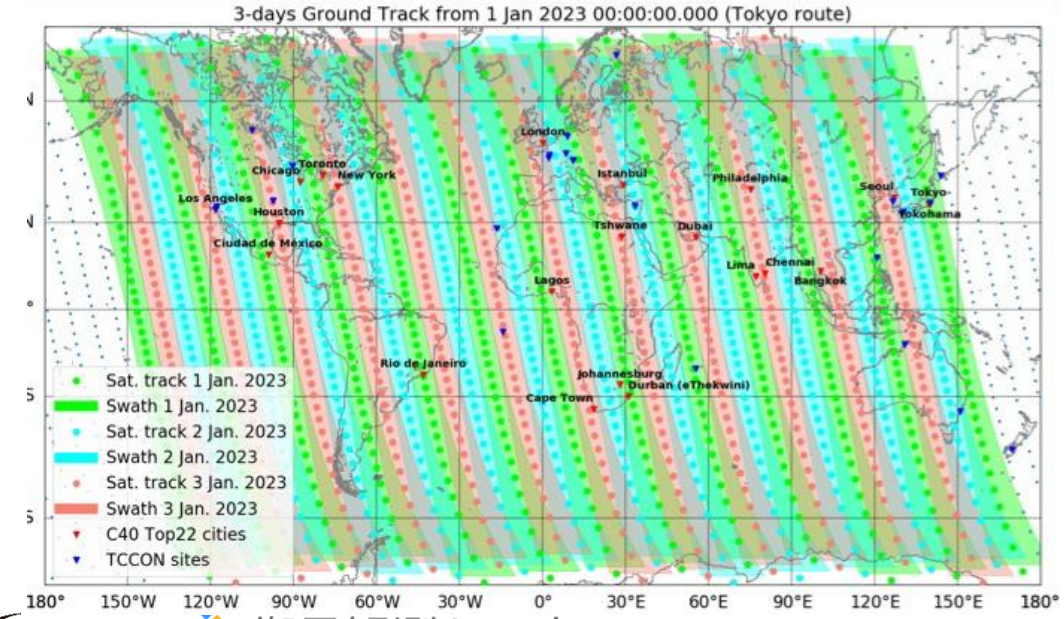
GOSAT-2 XCO2/XCH4/XCO Monthly Maps: East/Southeastern/South Asia in April, August, and December 2020

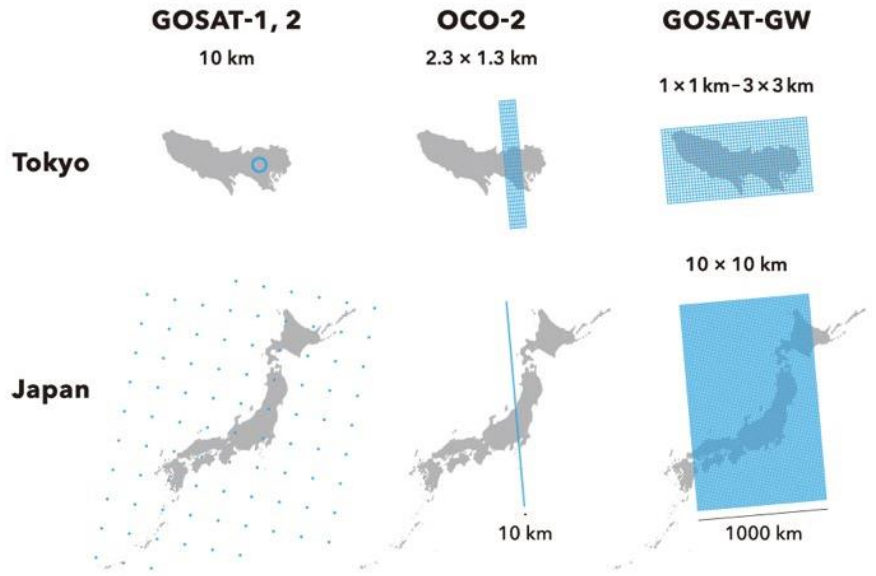


The Second GCOS Climate Observation Conference (17 -19 October 2022, Darmstadt, Germany)
Tsuneo Matsunaga (matsunag@nies.go.jp), National Institute for Environmental Studies (NIES), Japan

GOSAT-GW TANSO-3 Observation: Wide Mode and Focus Mode







Focus Mode for Megacity scale observation

Wide Mode for Country or sub-continental scale observation

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

Summary

- Japan will continue to provide validated spaceborne GHG concentration data from 2009 to 2030 (and beyond).

- Japan is and will be collaborating with other satellite, ground-based, ship, and aircraft observation operators to keep the quality and the continuity of the data.

✓ **What are the bottlenecks in today's observation system you encountered in terms of developing climate observation networks (Topic 1, Cluster 1 & 2)**
=> Available (quality-controlled) ground-based column-GHG validation sites are limited and their geographical distribution is not at all homogeneous. Few sites exist near emission sources.
=> Quality controls of global dataset are insufficient.
=> Methodologies / protocols to estimate emissions from satellite data are still immature.

✓ **Which are the most urgent yet feasible actions for improving the situation?**
=> Establish a strategy to maintain and increase ground-based GHG validation sites.
=> MIP involving various stakeholders (data providers and modelers)

✓ **Your vision for the future: By 2050, I imagine GCOS to**
…Witness the decreasing or stabilized trends of atmospheric GHG concentrations…

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)