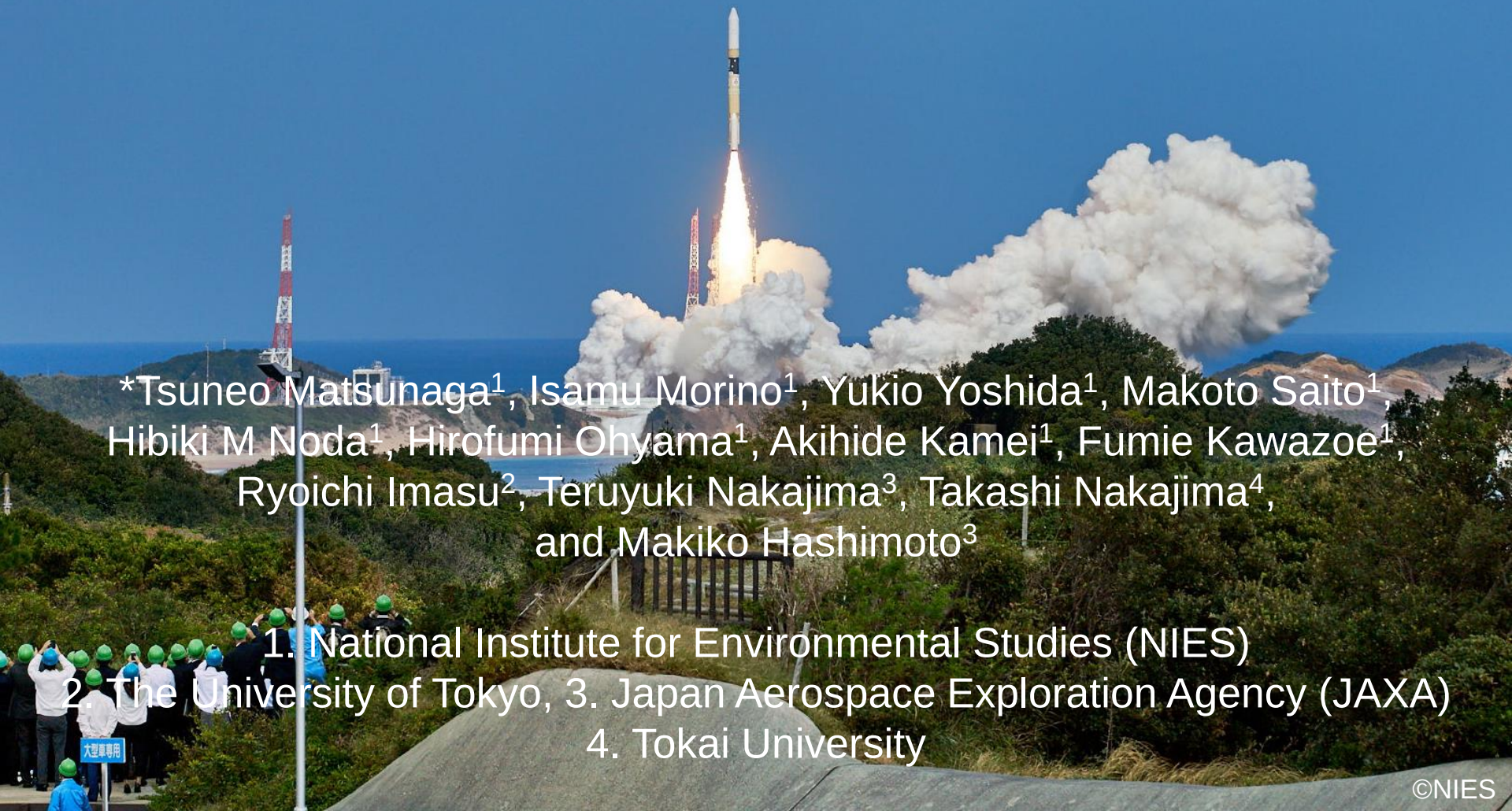
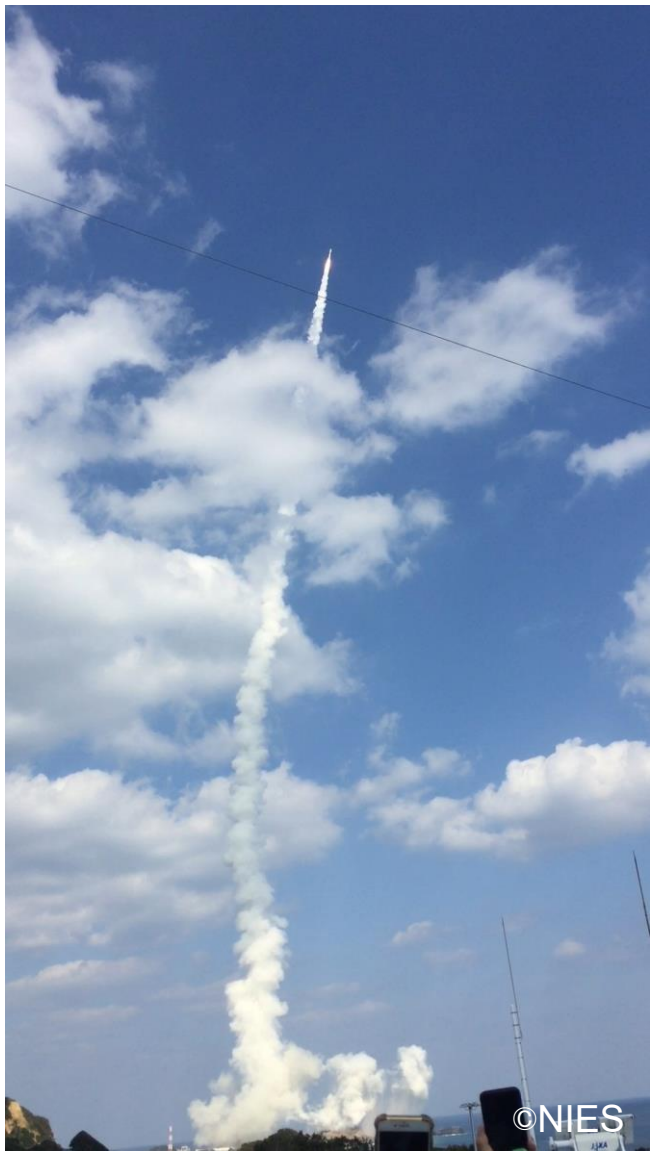
The Launch Of GOSAT-2 and GHG/Air Quality Monitoring By GOSAT Satellite Series

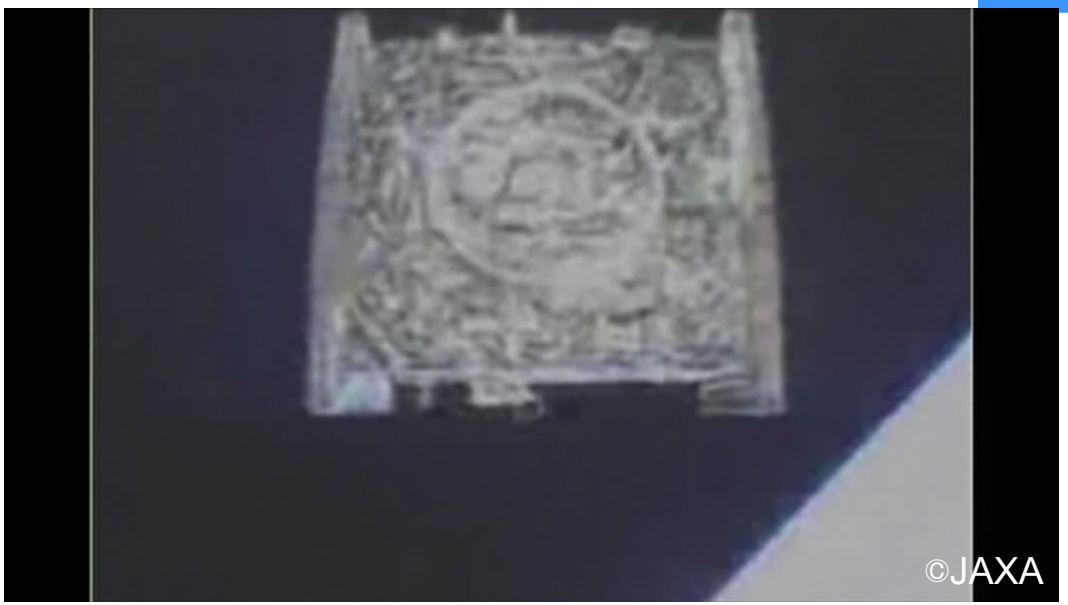


*Tsuneo Matsunaga[1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki M Noda[1], Hirofumi Ohyama[1], Akihide Kamei[1], Fumie Kawazoe[1], Ryoichi Imasu[2], Teruyuki Nakajima[3], Takashi Nakajima[4], and Makiko Hashimoto[3]

1. National Institute for Environmental Studies (NIES)
2. The University of Tokyo, 3. Japan Aerospace Exploration Agency (JAXA)
4. Tokai University

Successful Launch of GOSAT-2 on October 29, 2018 by H-IIA Rocket from JAXA Tanegashima Space Center

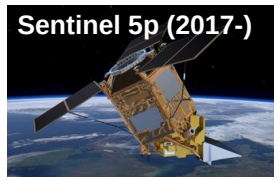


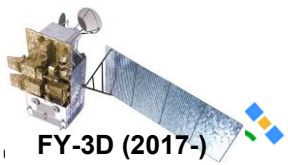


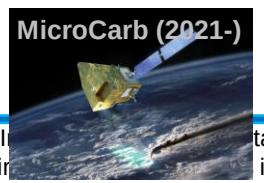
- (Left) H-IIA F-40 Launch from JAXA Tanegashima Space Center (13:08, October 29, 2018). DIWATA-2 was also onboard.
- (Top) Separated GOSAT-2 spacecraft taken from the launch vehicle (16 minutes after launch)
- CAI-2 first light images (Nov. 5 and 6, 2018)
- FTS-2 first data (Dec. 13, 2018)

Satellites for Greenhouse Gases Observation (Column observation only)

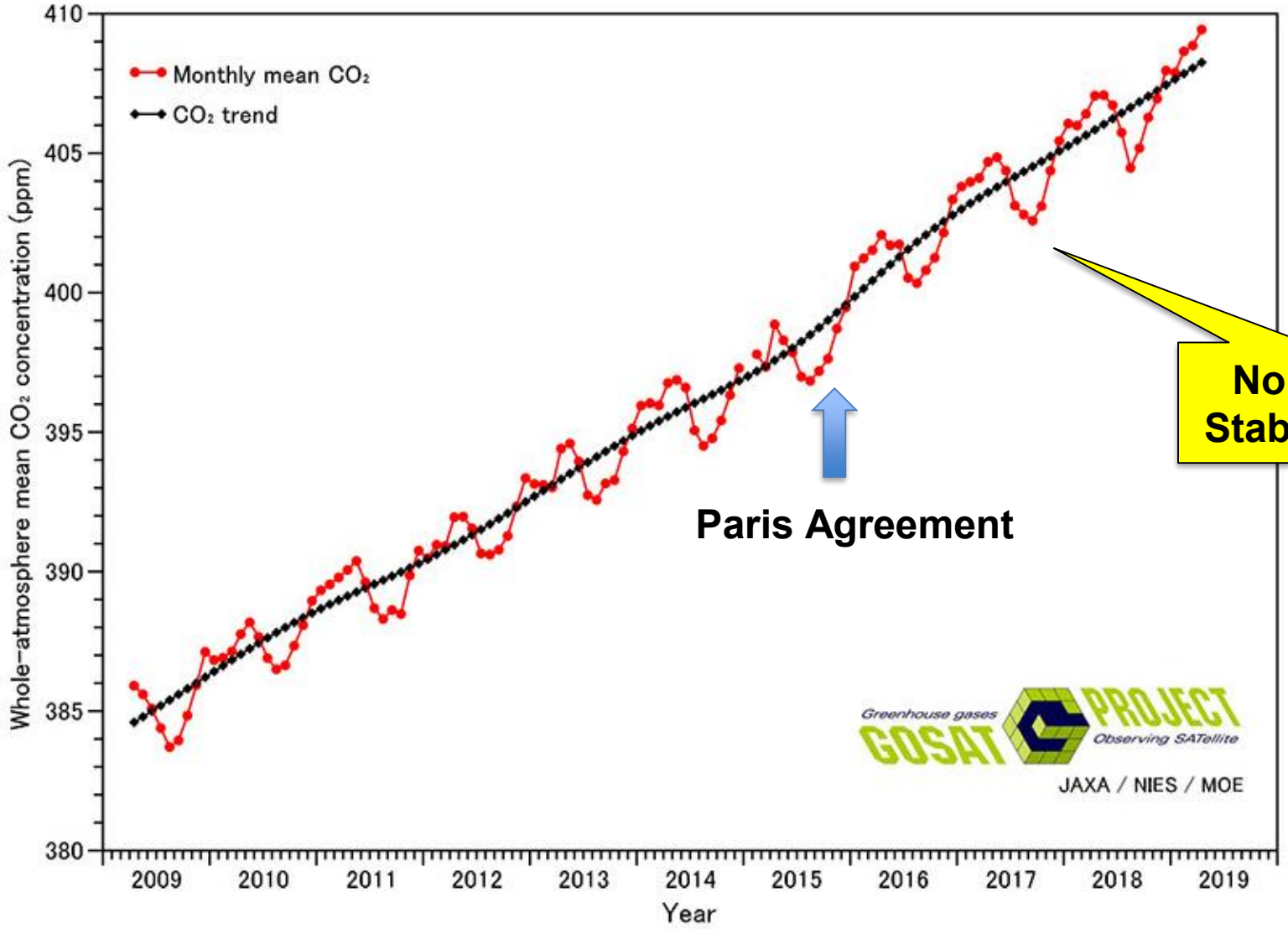
Mission	Country / Organization	Period	GHGs	Comments
ENVISAT / SCIAMACHY	ESA	2002 -2012	CO2, CH4	Grating, CO
GOSAT	Japan	2009 -	CO2, CH4	FTS
OCO-2	US	2014 -	CO2	Grating
GHGSat-D/CLAIRE	GHGSat (Canada)	2016 -	CO2, CH4	Fabry–Pérot
TanSat	China	2016 -	CO2	Grating
Sentinel-5p / TROPOMI	EC	2017 -	CH4	Grating
FY-3D / GAS	China	2017 -	CO2, CH4	FTS
GF-5 / GMI	China	2018 -	CO2, CH4	Spatial Heterodyne
GOSAT-2	Japan	2018 -	CO2, CH4	FTS, CO
ISS / OCO-3	US	2019 -	CO2	Grating
MicroCarb	France	2021 -	CO2	
MethaneSAT	EDF (NPO in US)	2021-	CH4	
Sentinel 5A, 5B, 5C	EC	2022 -	CH4	CO
GOSAT-3	Japan	2022 -	CO2, CH4	TBD
GeoCARB	US	2023-	CO2, CH4	Geostationary, Grating, CO
MERLIN	France/ Germany	2024 -	CH4	Laser
Copernicus CO2	EC	2025 -	CO2, CH4	3 satellites







GOSAT Global CO2 Trend in Past Ten years



Decision IPCC-XLIX-9. Adoption and Acceptance of the Methodology Report "2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories"

Adopted in May 2019 !

Volume 1	General Guidance and Reporting
Chapter 6	**Quality Assurance / Quality Control and Verification**
6.10.2	**Comparisons with Atmospheric Measurements**
6.10.2.5	Use of Complimentary Observations and Global Modelling Product • Comparing National Inventory to the Global Inverse Model Products • **Satellite Observations**
6.10.2.6	Procedures for Inventory Comparison to Estimates based on Atmospheric Measurements
6.10.2.7	Check List for Applying Inverse Model Estimates for Comparison with National Inventories
6.10.2.8	Necessary Steps for Comparing National Inventory to the Global / Regional Inverse Modelling Products

Satellite Observations

"Satellite observations by **GOSAT** were used for national scale methane emission estimates with regional inverse models by (Ganesan et al. 2017) for India and (Turner et al. 2015) for the US. "

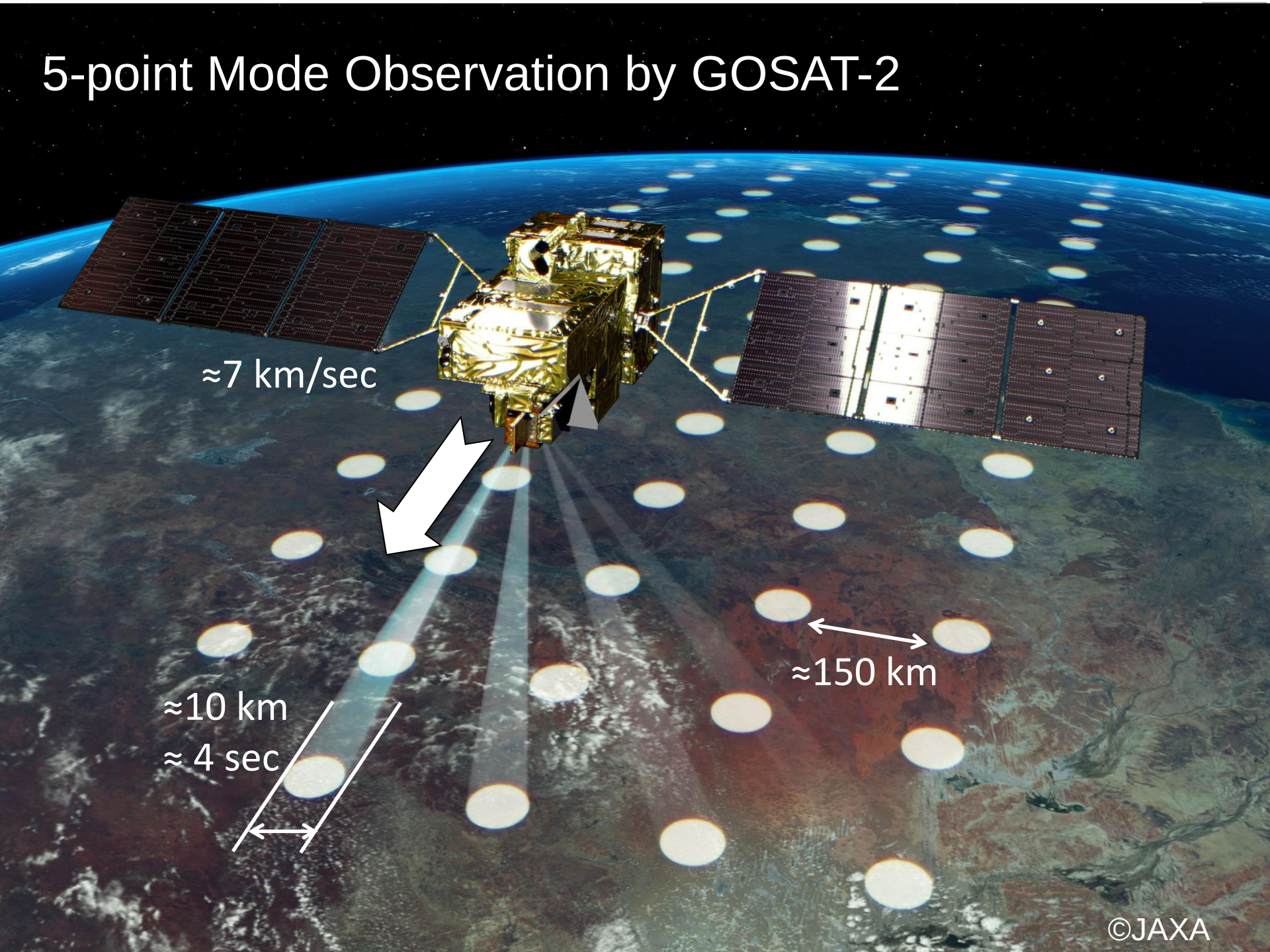
"Local GHG concentration enhancements observed by the **GOSAT** satellite correlate well with transport model simulations (Janardanan et al. 2016; Janardanan et al. 2017),"

https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

GOSAT and GOSAT-2 Specifications / Requirements

	GOSAT	GOSAT-2
Launch year and life time	Jan. 2009, 5 years	Oct. 2018, 5 years
Satellite (Dimension, mass, power)	3.7 x 1.8 x 2.0 m, 1750 kg, 3.8 KW (EOL)	5.3 x 2.0 x 2.8 m, 1784 kg, 5.0 KW
Orbit (Type, altitude, repeat cycle, equator crossing time)	Sun synchronous, 666 km, 3 days, 13:00	Sun synchronous, 613 km, 6 days, 13:00±15 min
Target gases	CO_2, CH_4, O_2, O_3, H_2O	CO_2, CH_4, O_2, O_3, H_2O, CO
Fourier Transform Spectrometer (FTS* and FTS-2) *https://www.eorc.jaxa.jp/GOSAT/instrument_1.html	Band 1 : 0.758 – 0.775 μm Band 2 : 1.563 – 1.724 μm Band 3 : 1.923 – 2.083 μm Band 4 : 5.56 – 14.3 μm Spectral resolution = 0.24 - 0.37 cm^{-1} IFOV = 10.5 kmϕ Pointing = ±20° (AT), ±35° (CT) Polarimetry = Band 1, 2, 3	Band 1 : 0.754 – 0.772 μm Band 2 : 1.563 – 1.695 μm Band 3 : 1.923 – 2.381 μm Band 4 : 5.56 – 8.42 μm Band 5 : 8.42 – 14.29 μm Spectral resolution = 0.2 cm^{-1} IFOV = 9.7 kmϕ Pointing = ±40° (AT), ±35° (CT) Polarimetry = Band 1, 2, 3
Cloud and Aerosol Imager (CAI and CAI-2)	Nadir B1 = 380 nm B2 = 674 nm B3 = 870 nm B4 = 1600 nm B1-B3 = 500 m / 1000 km, B4 = 1500 m / 750 km	B1-5: Forward (+20°), B6-10: Backward(-20°) B1 = 343 nm B6 = 380 nm B2 = 443 nm B7 = 550 nm B3 = 674 nm B8 = 674 nm B4 = 869 nm B9 = 869 nm B5 = 1630 nm B10= 1630 nm B1-B4, B6-B9= 460 m / 920 km B5, B10 = 920 m / 920 km
Other new features of GOSAT-2 FTS-2	Intelligent pointing using FTS-2 FOV camera, fully programmable (target mode) observation, and improved SNR.	

5-point Mode Observation by GOSAT-2



NIES GOSAT FTS and GOSAT-2 FTS-2 SWIR Level 2 Products

GOSAT (April 2009 -)

Yoshida et al., EGU, 2019

CO_2 column amount product

CH_4 column amount product

H_2O column amount product

~ XCO_2, XCH_4, and XH_2O over the cloud-free region are simultaneously retrieved by the **full-physics based algorithm**.

GOSAT-2 (March 2019 -)

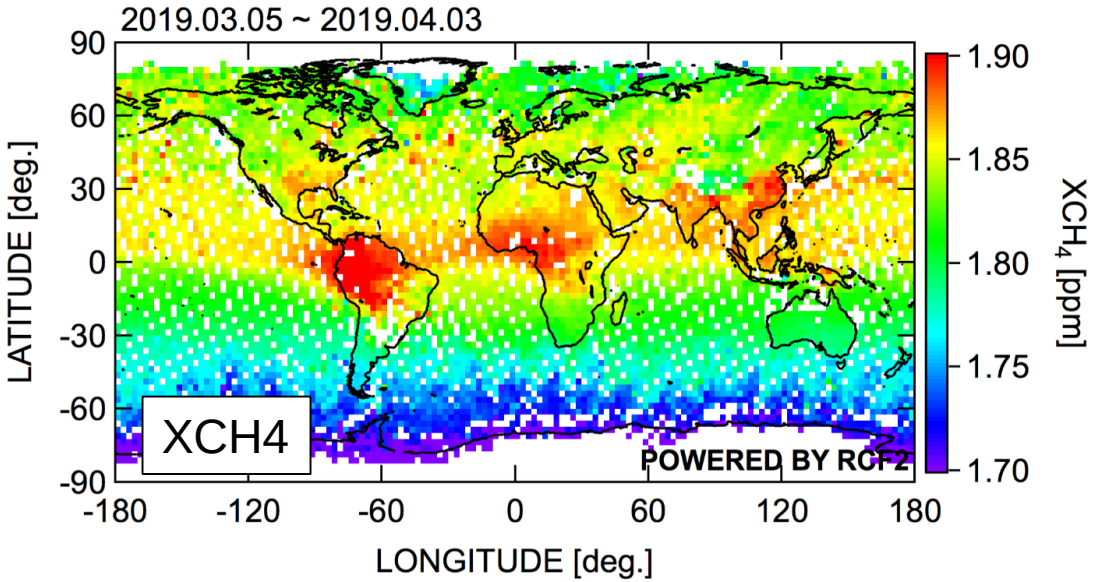
Chlorophyll fluorescence and proxy-method product

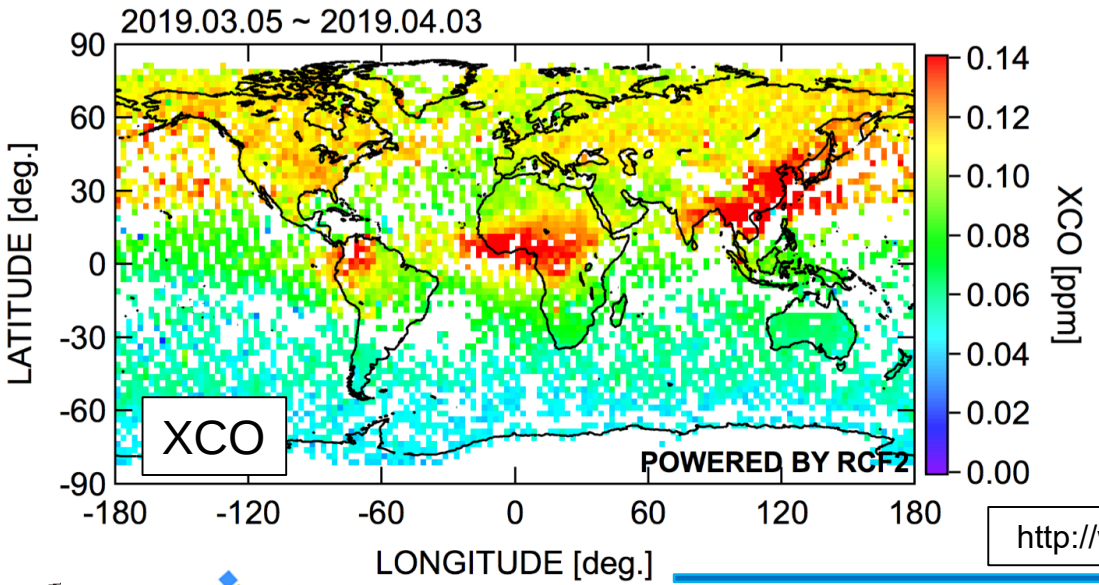
~ SIF, **proxy-based** XCH_4 & XCO, and aerosol/cloud related information are retrieved under the cloud-free assumption.

Column-averaged dry-air mole fraction product

~ XCO_2, XCH_4, XCO, and XH_2O over the cloud-free region are simultaneously retrieved by the **full-physics based algorithm**.

GOSAT-2 SWIR L2: Proxy-based XCH4 & XCO March, 2019 (2.5 deg average)





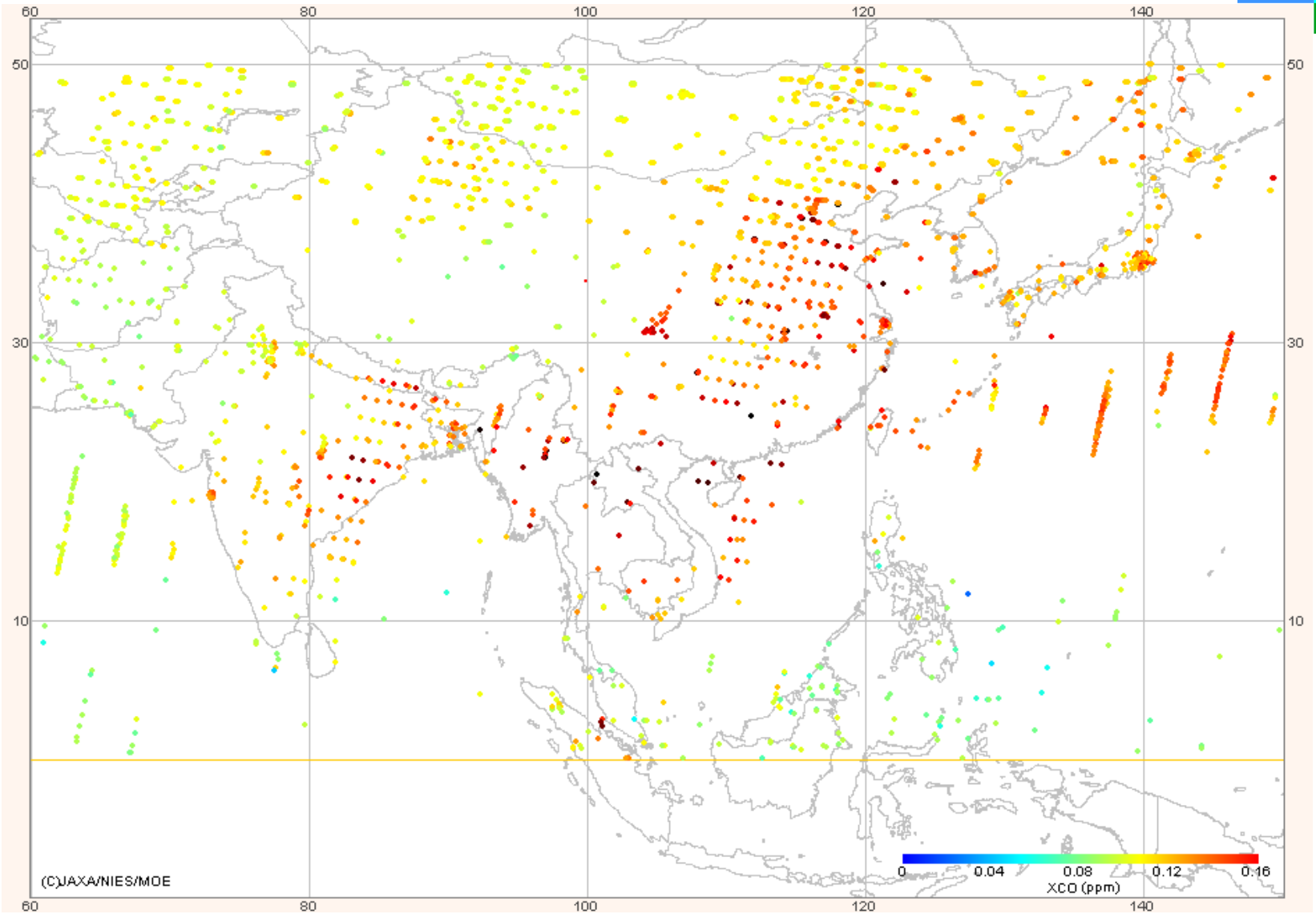
Based on L1B V002.004

Cloud-screening is insufficient because CAI-2 L2 cloud mask is not used. Only FTS-2 2 μm-band cloud-screening is applied.

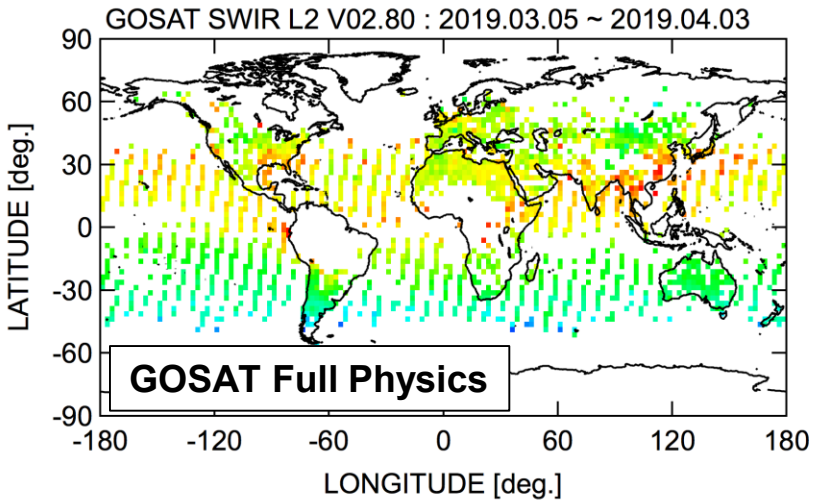
The proxy method uses a ratio of the column concentrations of two gases whose absorption bands are adjacent to each other. It can obtain relatively accurate column concentrations even if clouds and aerosols somewhat affect the optical path length. But its target gases of retrieval are limited, and CO_2 is not applicable.

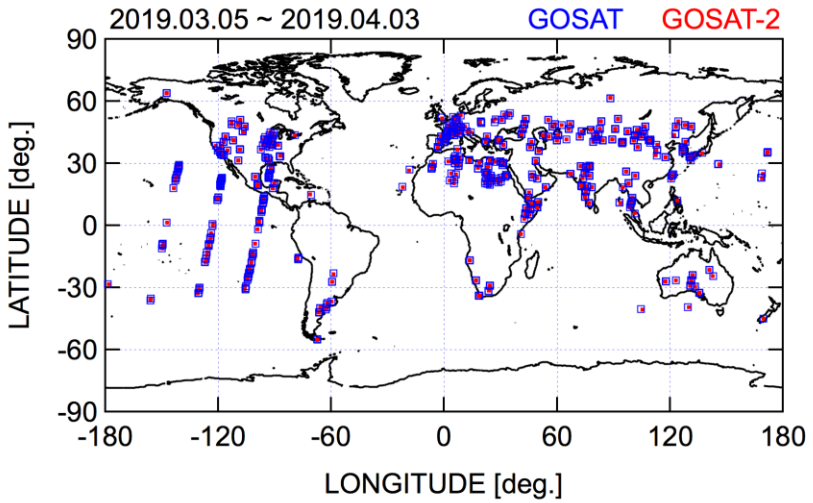
http://www.nies.go.jp/whatsnew/20190705/20190705.html

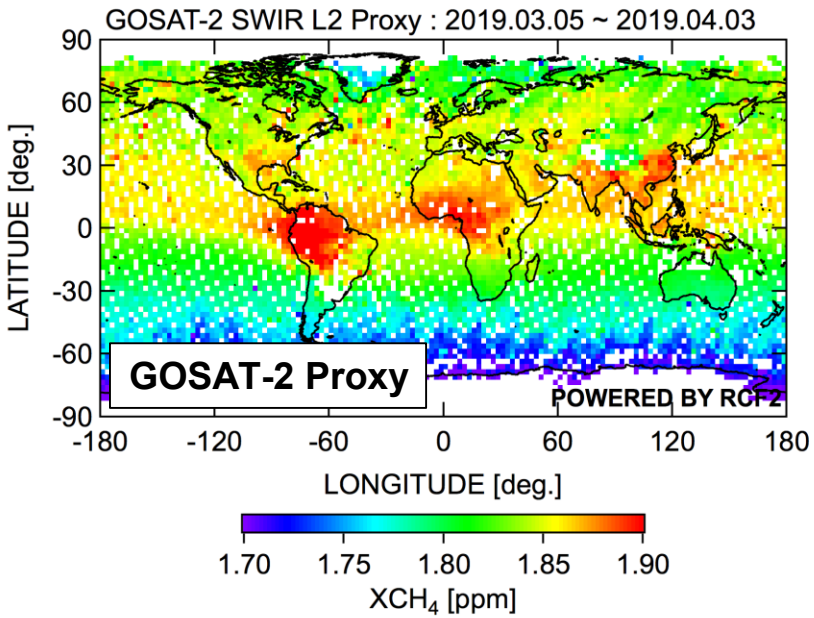
GOSAT-2 FTS-2 SWIR Level 2 Proxy in March 2019
Column Concentration of Carbon Monoxide

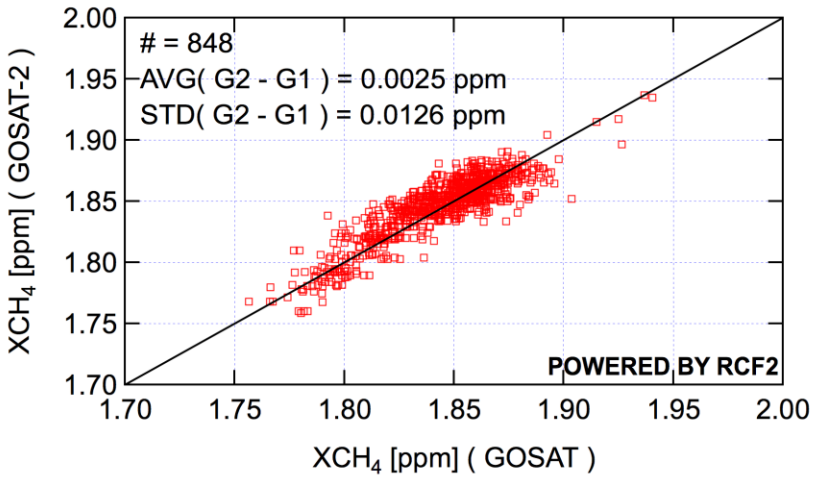


Comparison between GOSAT Full Physics XCH4 and GOSAT-2 Proxy XCH4





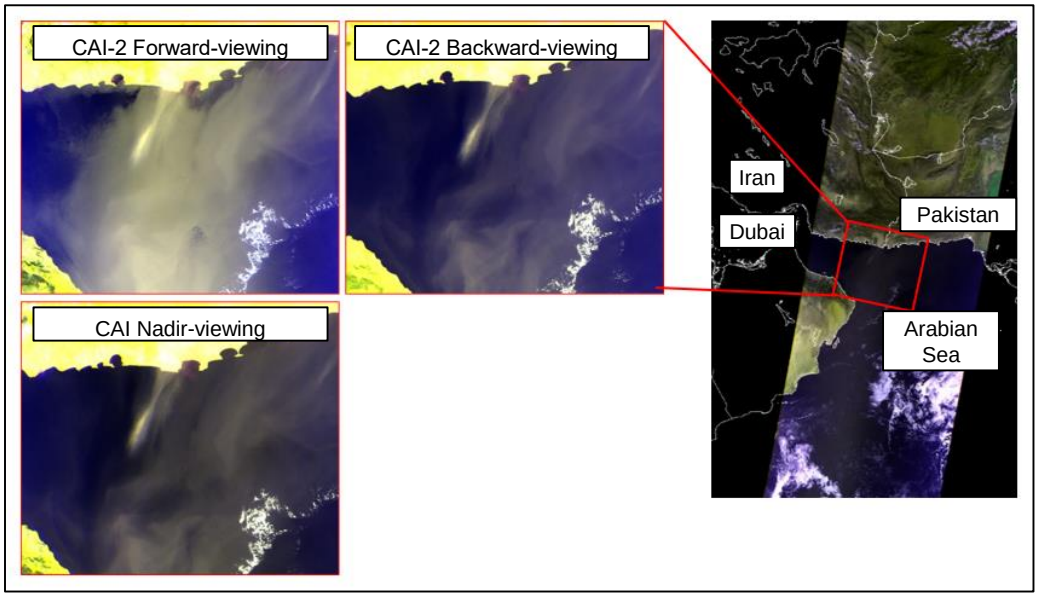


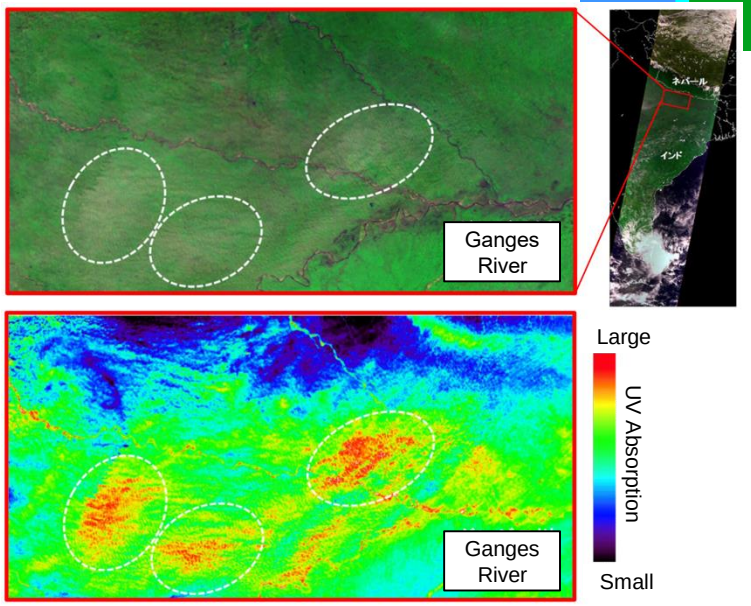


Provided by Yukio Yoshida, NIES

Validation of GOSAT Series Column Concentration Using Total Carbon Column Observing Network (TCCON)

CAI-2 First Light Images (Nov. 5 and 6, 2018)



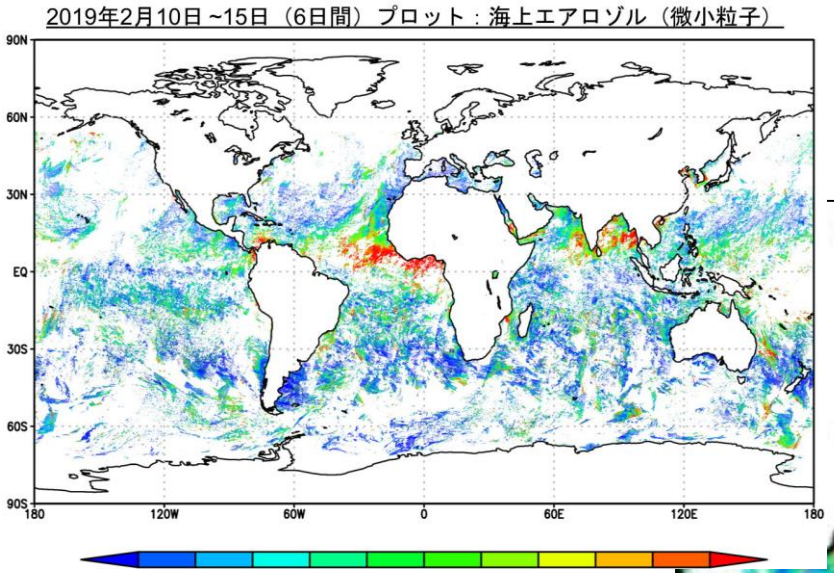


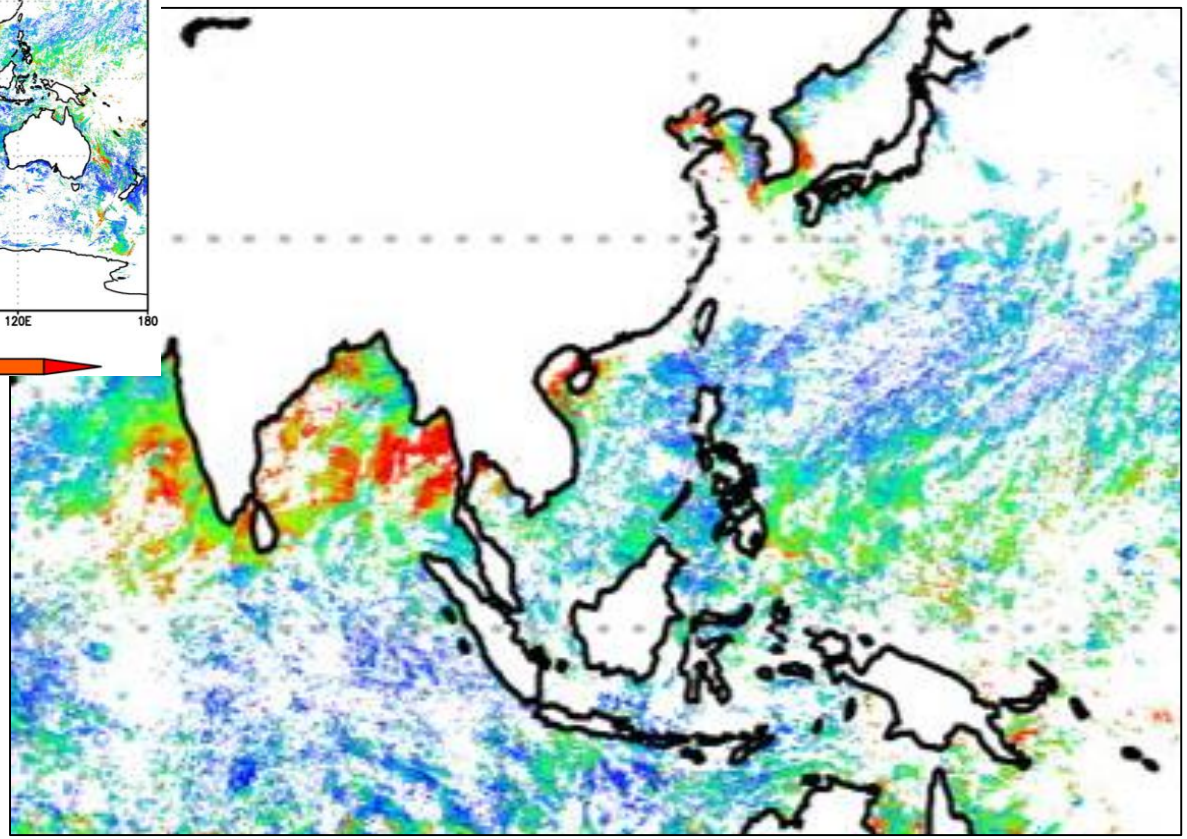
- Images of Arabian Sea taken by GOSAT CAI and GOSAT-2 CAI-2 on Nov. 5, 2018.
- Combination of forward and backward viewing data provides more information on aerosols than nadir-only data.

- Images of Ganges River in India taken by GOSAT-2 CAI-2 on Nov. 6, 2018.
- Strong UV absorption (441 nm / 339 nm) indicates the presence of black carbon by fires.

http://www.jaxa.jp/press/2018/11/20181109_CAI-2_j.html

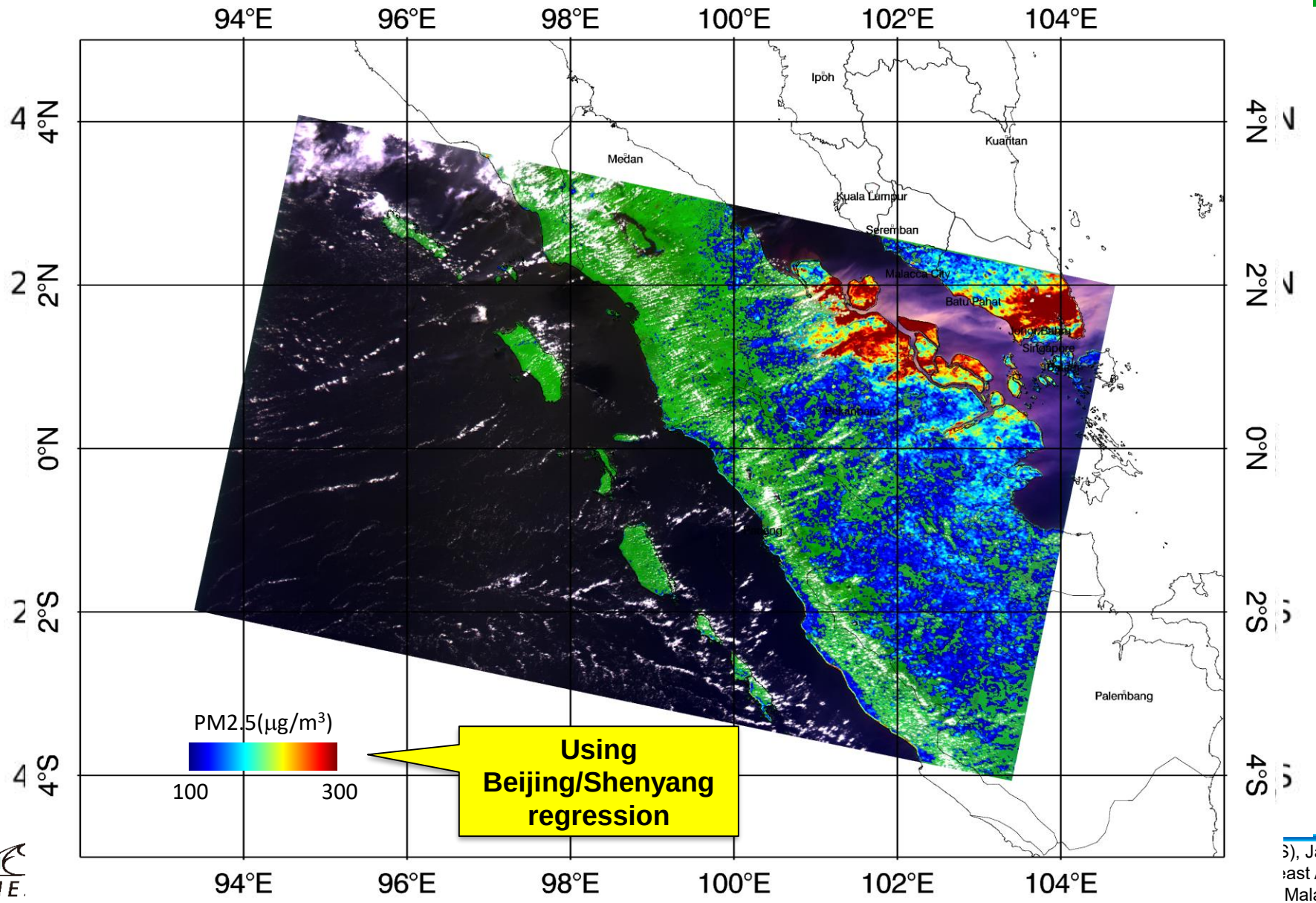
GOSAT-2 CAI-2 Level 2 Aerosol Product (Sample)
Ocean / Fine mode, Feb. 10 - 15, 2019





See Hashimoto-san's presentation tomorrow

GOSAT Air Pollution Watch
Sample 1: Indonesia June 20, 2013(P9F31)



2nd GOSAT Series Research Annoucement

- 36 proposals were adopted in 1st RA.
- **2nd RA Application deadline: November, 2019**

Merits of becoming GOSAT RA PI and Co-I

1. Submitting observation requests for FTS and FTS-2
2. Requesting a delivery of standard products before the release to the public.
3. Requesting a delivery of research products and internal products
4. Requesting a “forced” processing of FTS and FTS-2 L2 products
5. PIs can obtain additional information and the technical materials.
6. Requesting a delivery of the FTS or FTS-2 L2 data products generated with less strict screening criteria than the products for general users.
7. PIs are entitled to participate in the “PI Meeting”.

Future Plan

- Test of GOSAT-2 Level 2 processing and validation of Level 2 products using TCCON and other data
  - FTS-2 SWIR Level 2 proxy (XCH4, XCO)
  - FTS-2 SWIR Level 2 full physics (**XCO2**, XCH4, XCO)
  - FTS-2 TIR Level 2
  - CAI-2 Level 2 Cloud Discrimination and Aerosol

- Evaluation of Level 1 products through Level 2 processing

- Public release of GOSAT-2 standard products from NIES website.
  - Level 1 products (July/August 2019 -)
  - Level 2 products (October/November 2019 -)
  - Level 4 Flux Products (FY2020 -)
  - Level 1 products are already available from NIES for GOSAT RA PIs.

- GOSAT Series Research Announcement (GOSAT RA)
  - 1st GOSAT Series RA = 36 joint research contracts
  - **2nd GOSAT Series RA will be issued around September, 2019.**

Thank you for your attention.

Contact
matsunag@nies.go.jp, soc-info@nies.go.jp

Website
http://www.nies.go.jp/soc/en/
http://www.gosat.nies.go.jp/en/
http://www.gosat-2.nies.go.jp

GOSAT standard products are freely available from
GOSAT Data Archive Service
https://data2.gosat.nies.go.jp