Progress in GOSAT-GW

Global Observing SATellite for Greenhouse gases and Water cycle

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with
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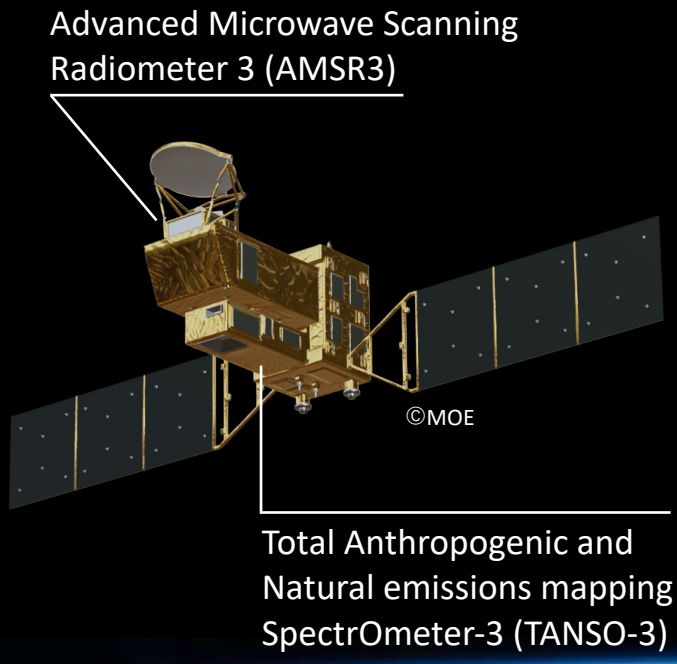
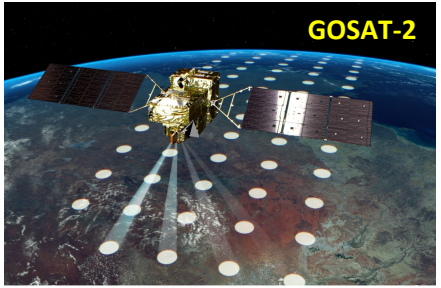
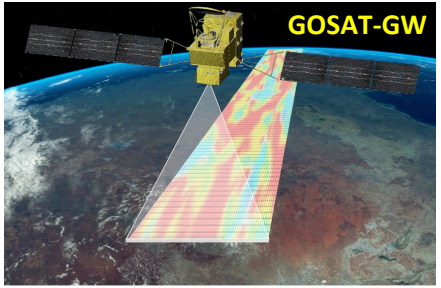
from
National Institute for Environmental Studies (NIES)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
National Institute of Information and Communications Technology (NICT)



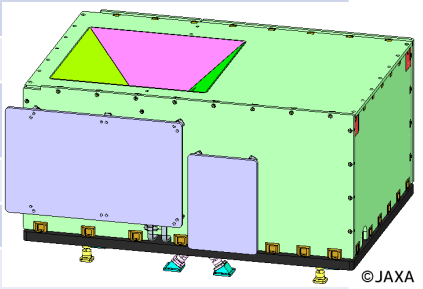
GOSAT, GOSAT-2, and …

Figures: Courtesy of JAXA



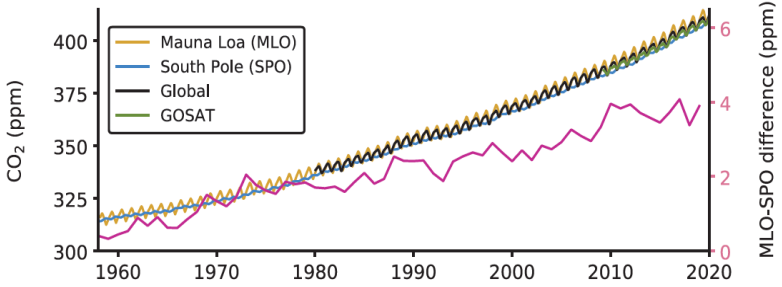


	GOSAT	GOSAT-2	GOSAT-GW
Launch / lifetime	2009 / 5 years	2018 / 5 years	FY2024 / 7 years
Satellite mass / power	1.75 t / 3770 W	1.8 t / 5000 W	2.9 t / 5200 W
Orbit Equator crossing time	666 km, 3 days, 13:00, descending	613 km, 6 days, 13:00, descending	666 km, 3 days, 13:30, ascending
Spectrometer	TANSO-FTS	TANSO-FTS-2	TANSO-3 (Grating)
Major targets	CO_2, CH_4	CO_2, CH_4, CO	CO_2, CH_4, NO_2
Spectral bands	0.76 / 1.6 / 2 μm + TIR	0.76 / 1.6 / 2 μm + TIR	0.45 / 0.76 / 1.6 μm
Spectral Resolution (Sampling interval)	0.2 cm^{-1}, (≈ 0.01 nm @ 0.76 μm, ≈ 0.05 nm @ 1.6 μm)		< 0.5 nm @ 0.45 μm, <0.05 nm @ 0.76 μm, < 0.2 nm @ 1.6 μm
Swath width	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)	± 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)



GOSAT-GW Mission Requirements (by the Ministry of Environ.)

- Monitoring of whole atmosphere global-mean concentrations of GHGs
- Verification of national (or country-specific) anthropogenic emission inventories of GHGs
- Detection of GHGs emissions from large emission sources, such as megacities, power plants (6.5 Mt CO_2/yr), and permafrost



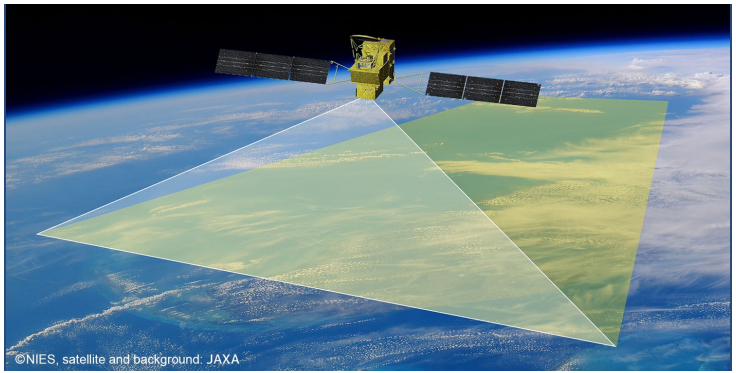
IPCC AR6, 2021

✓ Independent top-down estimates

✓ Contribution to the Global stocktake

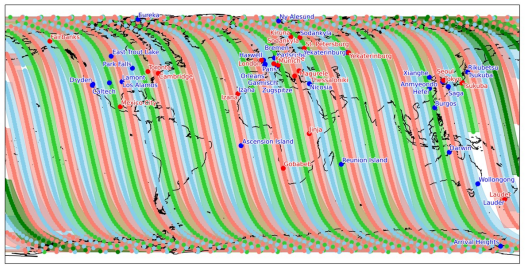
GOSAT-GW TANSO-3 two observation modes

Wide Mode



- Swath: >911 km
- Footprint: 10 km
- No AT/CT Pointing
- Default observations

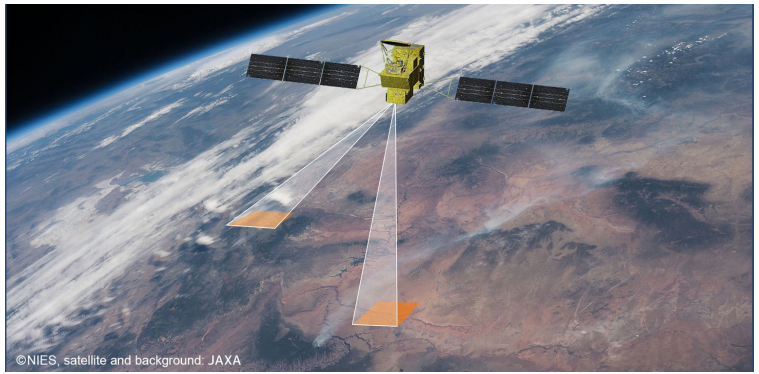
3-day ground track in wide mode



Swath 1 Swath 2 Swath 3

TCCON
COCCON

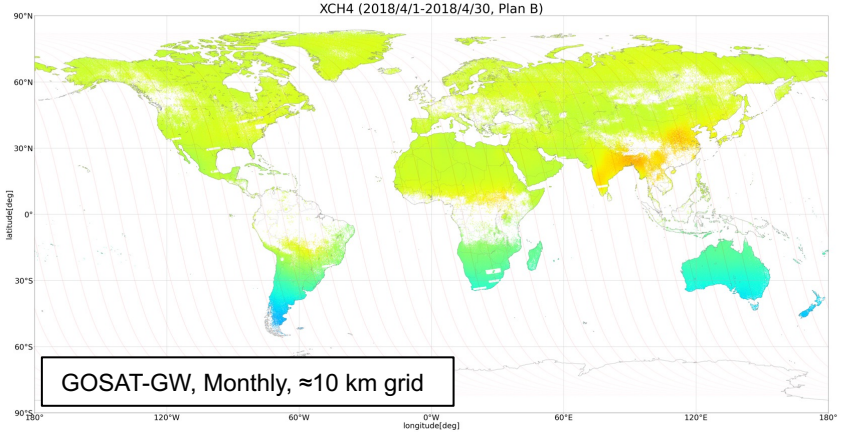
Focus Mode

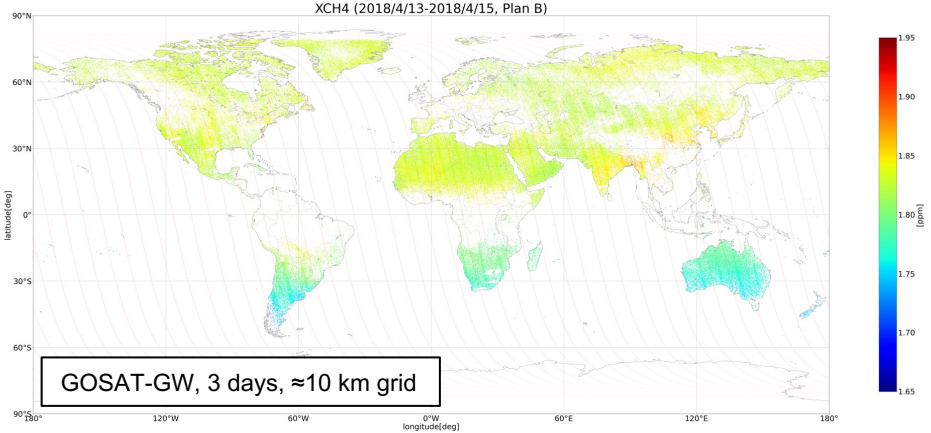


- Swath: >90 km
- Footprint: 1-3 km
- AT/CT Pointing
- Upon requests (~100 during 3-day repeat cycle)

✓ Urban regions (C40 cities)
✓ Large point sources (power plants, oil/gas facilities)
✓ Validation sites (TCCON, COCCON, PGN)
✓ Vicarious calibration sites (RRV)

Simulated over-land GOSAT-GW data in April 2018, based on GOSAT data





But… there are large differences between GOSAT(-2) and GOSAT-GW regarding the number of data point, spectral resolution, observation mode, and so on.

Hence, we need to prepare and develop:

- *ground data-processing system*
- *retrieval algorithm*
- *validation system*
- *chemical transport model*

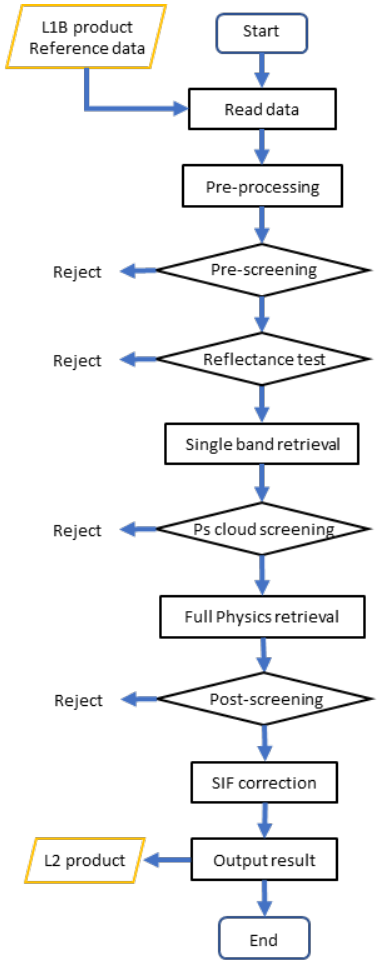
Retrieval algorithm and L2 product - GHGs

GOSAT Retrieval Algorithm (GORAL)

Main targets	XCO_2, XCH_4
Other variables	XH_2O, SIF, AOT, ALH, albedo,…
Retrieval technique	Full Physics (XCO_2, XCH_4, …) Proxy (XCH_4)
A priori	JRA-3Q (Japanese reanalysis) NICAM (for GHGs and aerosols)
Cloud screening	Reflectance test Surface pressure retrieval

TANSO-3 L2 GHG product

Stored items	All the retrieval results from GORAL and ancillary parameters
File format	HDF5
File unit	file/day (Wide mode) file/scene (Focus mode)



Flow of the GORAL processing

Team: Yu Someya, Yukio Yoshida, Hisashi Yashiro, Hirofumi Ohyama, Isamu Morino, Tazu Saeki

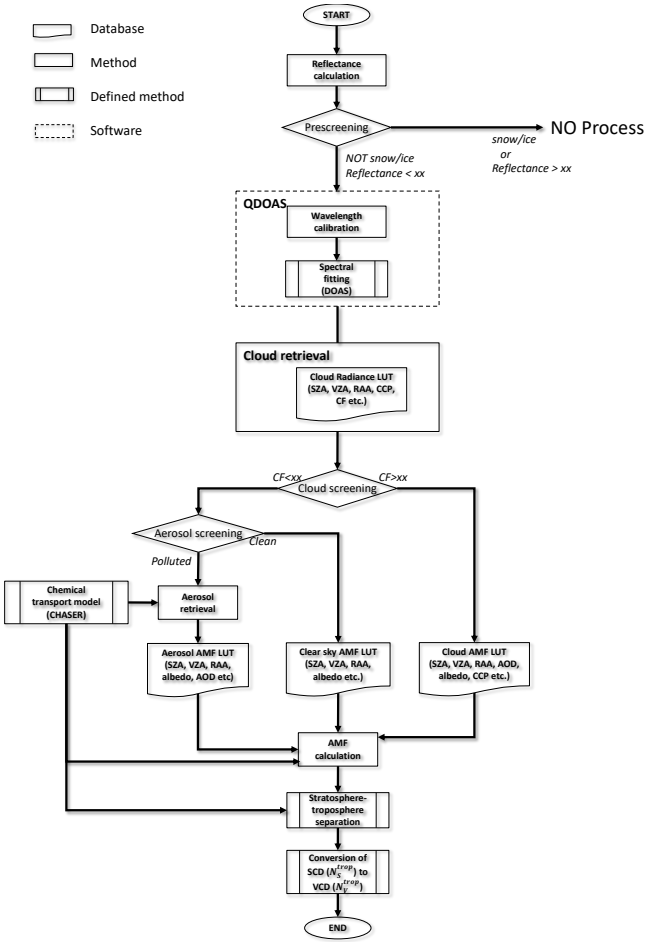
Retrieval algorithm and L2 product - NO_2

GOSAT-GW Retrieval Algorithm

Main targets	NO_2 (total + tropospheric column)
Other variables	Effective cloud fraction, Aerosol optical parameters
Retrieval technique	DOAS (optical density fitting)
A priori	JRA-3Q (Japanese reanalysis) CHASER with bias correction (for gas species, such as NO_2, O_3, … and aerosol optical parameters)
Cloud screening	Cloud fraction derived from O_2–O_2 absorption @ 477 nm

TANSO-3 L2 NO_2 product

Stored items	Total + tropospheric NO_2 vertical column [molecules cm^{-2}] and ancillary parameters
File format	HDF5
File unit	file/day (wide mode) file/scene (Focus mode)

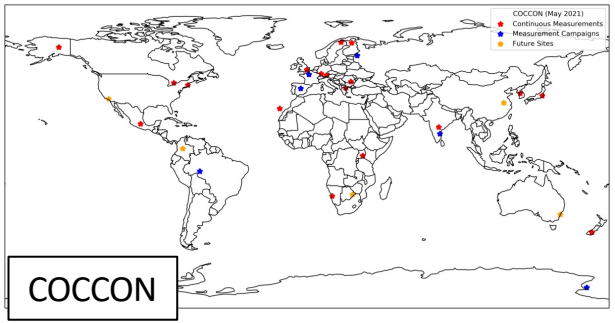


Team: Tamaki Fujinawa, Yosuke Yamashita, Tomohiro Sato, Thi Ngoc Trieu Tran, Takashi Sekiya, Hyunkwang Lim, Takafumi Sugita

Validation plan for GHGs and NO_2

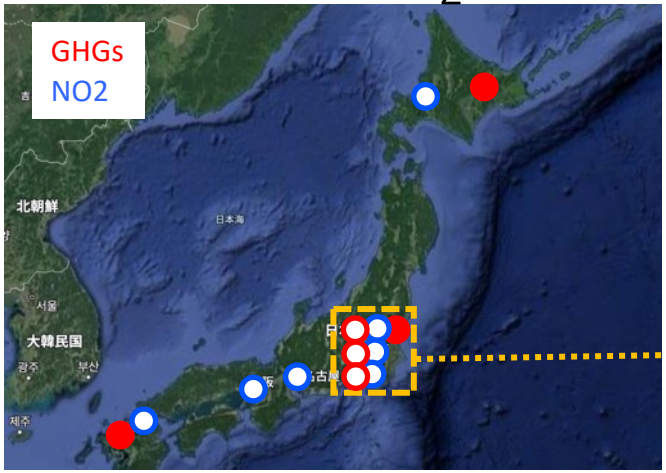
- Primary approach is ground-based column obs., complemented by additional obs. (e.g., airplane, ship, satellite, etc.)
- Besides above, campaign-based measurements will be made as needed
- Separate validation exercises are being planned for the wide- and focus-modes

Platform	CO_2/CH_4	NO_2
Ground-based	TCCON COCOON	PGN MAX-DOAS
Airplane	CONTRAIL IAGOS-CORE	IAGOS-CARIBIC
Satellite	GOSAT, GOSAT-2 OCO-2, OCO-3 TROPOMI	OMI TROPOMI GEMS



Team: Hirofumi Ohyama, Satoshi Inomata, Isamu Morino, Matthias Frey, Astrid Müller, Hao Xu, Yugo Kanaya, Yongjoo Choi

Validation of GHGs and NO_2 in urban areas (focus mode)



EM27/SUN observation sites in Tokyo metropolitan area

	CO_2/CH_4		NO_2
	TCCON	EM27/SUN	Pandora
Hokkaido	ONGOING (Rikubetsu)		ONGOING
Tsukuba	ONGOING	ONGOING	ONGOING
Central Tokyo		IN PREP.	IN PREP.
Suburban Tokyo			ONGOING
Yokohama/Yokosuka		TO BE CONSIDERED	ONGOING
Nagoya			ONGOING
Kobe			ONGOING
Kyushu	ONGOING (Saga)		ONGOING

In performing campaign-based measurements after the launch, several more instruments will be deployed around the Tokyo.

Focus mode observations for validation sites

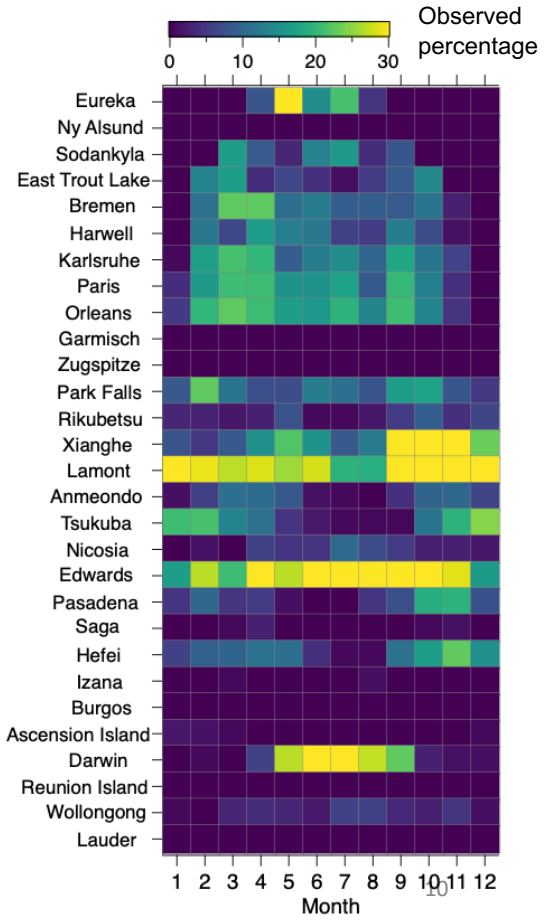
Priority sites and areas

- where both GHGs and NO_2 are observed within a 90 km swath in focus mode
- where multiple validation instruments are operated within a 90 km swath (urban-scale network)
- located in high latitudes, tropics, offshore regions, etc., where the number of ground-based observation sites is relatively small
- where validation data can be provided earlier
- with high observable percentage (high percentage of sunny days)

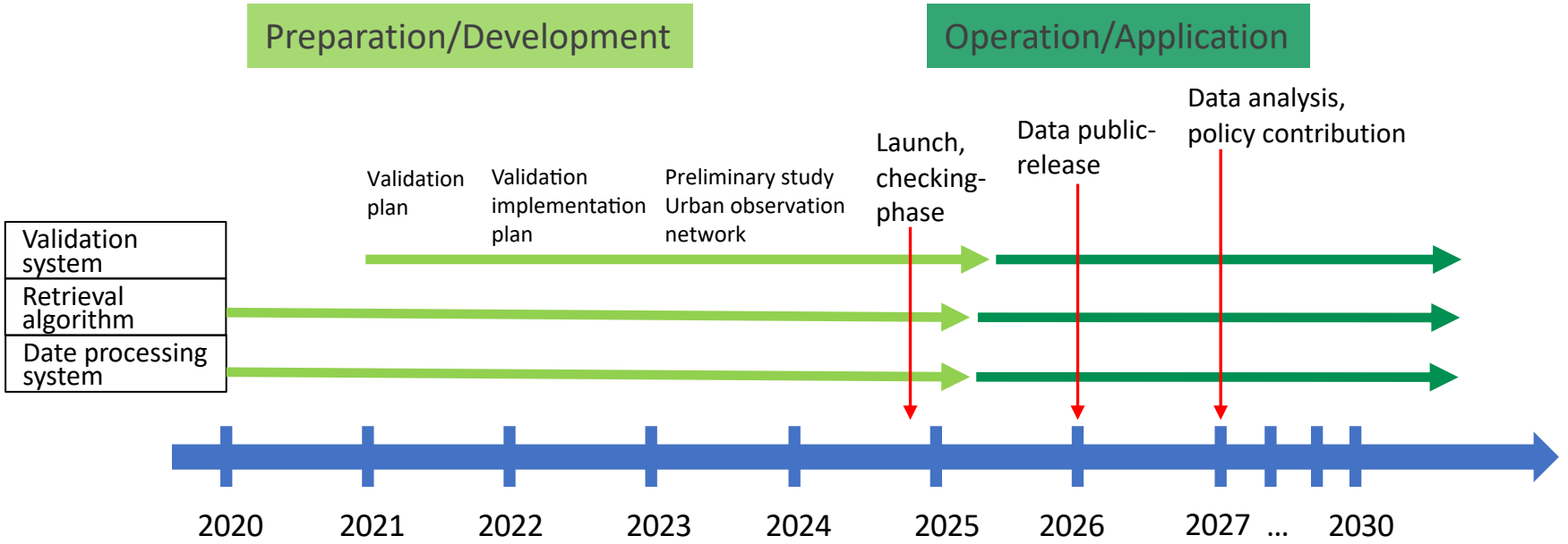
e.g., Evaluation using 5 years of TROPOMI XCH_4 data (global coverage in one day) with qa_value > 0.5

✓Monthly percentage of days with >50 data points (~25%) within 90 km x 90 km around TCCON sites

✓Note: a small percentage for sites surrounded by mountains due to TROPOMI's criteria (terrain roughness > 80 m)



Timeline of Development and Data Release



https://gosat-gw.nies.go.jp/en/

Global Stocktake = “Science” x “Paris Agreement”

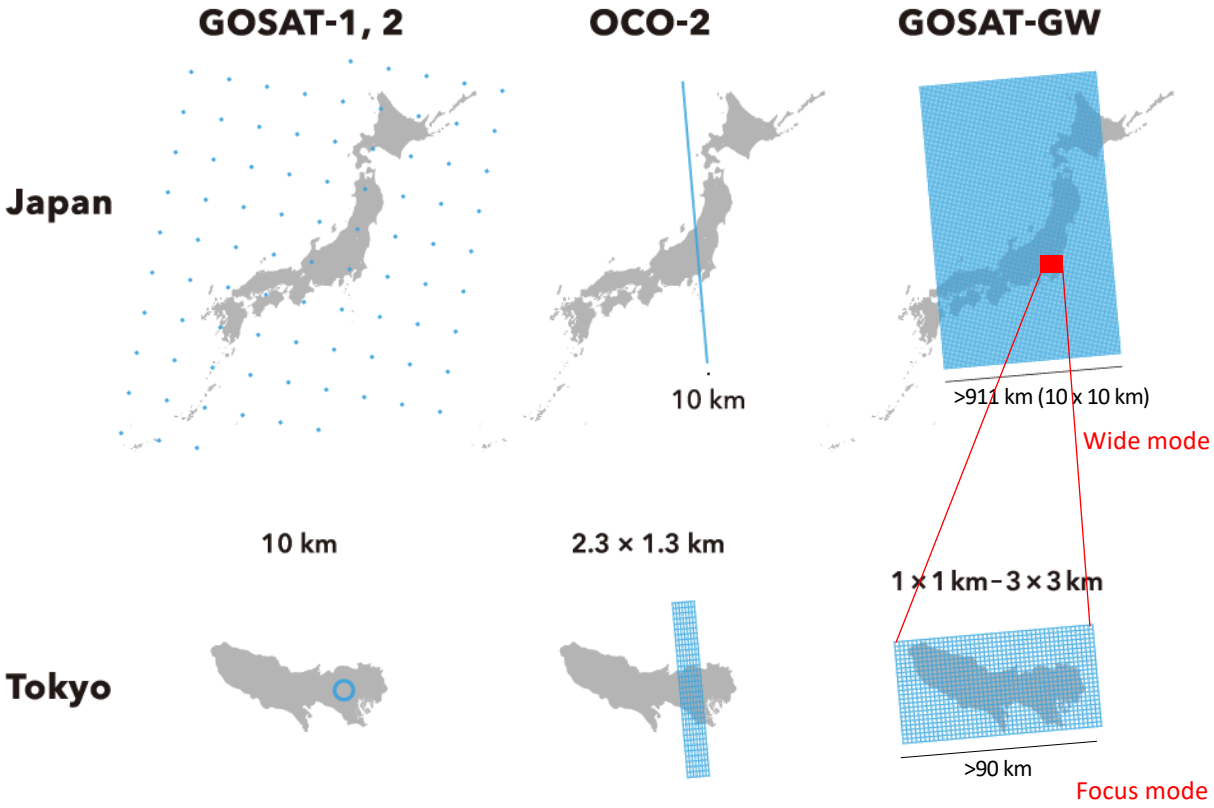
- Global Stocktake (GST) in 2023 and 2028 (and …)
  - New challenge for Earth Science/Environmental Science communities
  - R&D from multiple aspects are needed and can add value
- Visualization of Decarbonizing Process -- Answering to “Do we succeed in GHG emission reduction, to what extent?”

  => Trends and variability of emissions
  - Enhancing **reliability** of NDCs, which are decided by policymaker
  - Improving **accuracy** of bottom-up “national” emission estimates
  - Improving **transparency** by independent top-down estimates
- Country/State/City sectors: validation of current NDC, decision of next NDC
- Private sectors: incentive to reduce GHG emissions

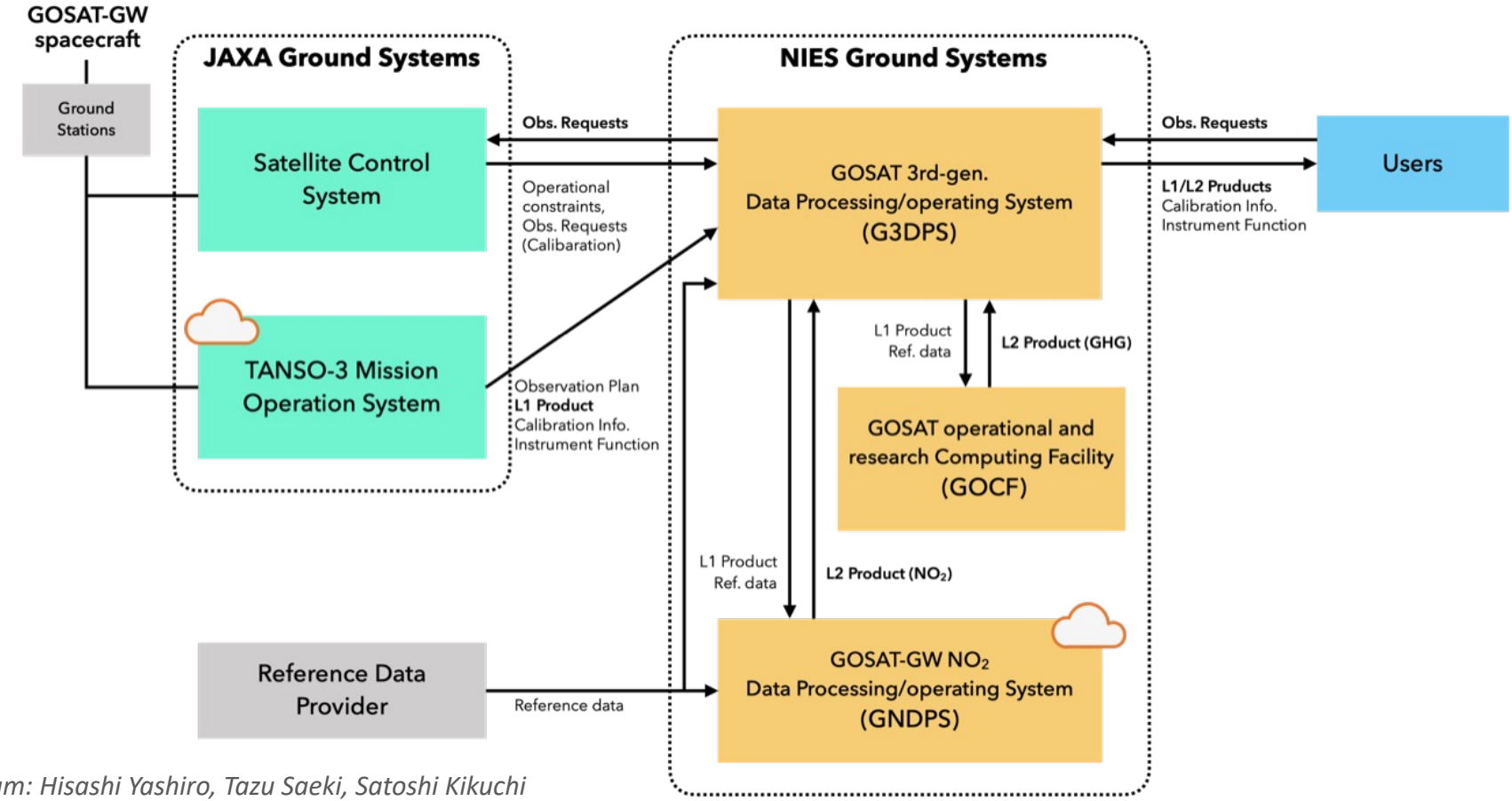
C => A

- Advancing atmospheric chemistry approach to quantify emissions
- Better connecting inventories, observations, and modeling
- Synergetic use of GHGs and air pollutants
- Opportunities to engage society -- public & private sectors

GOSAT-GW TANSO-3 two observation modes

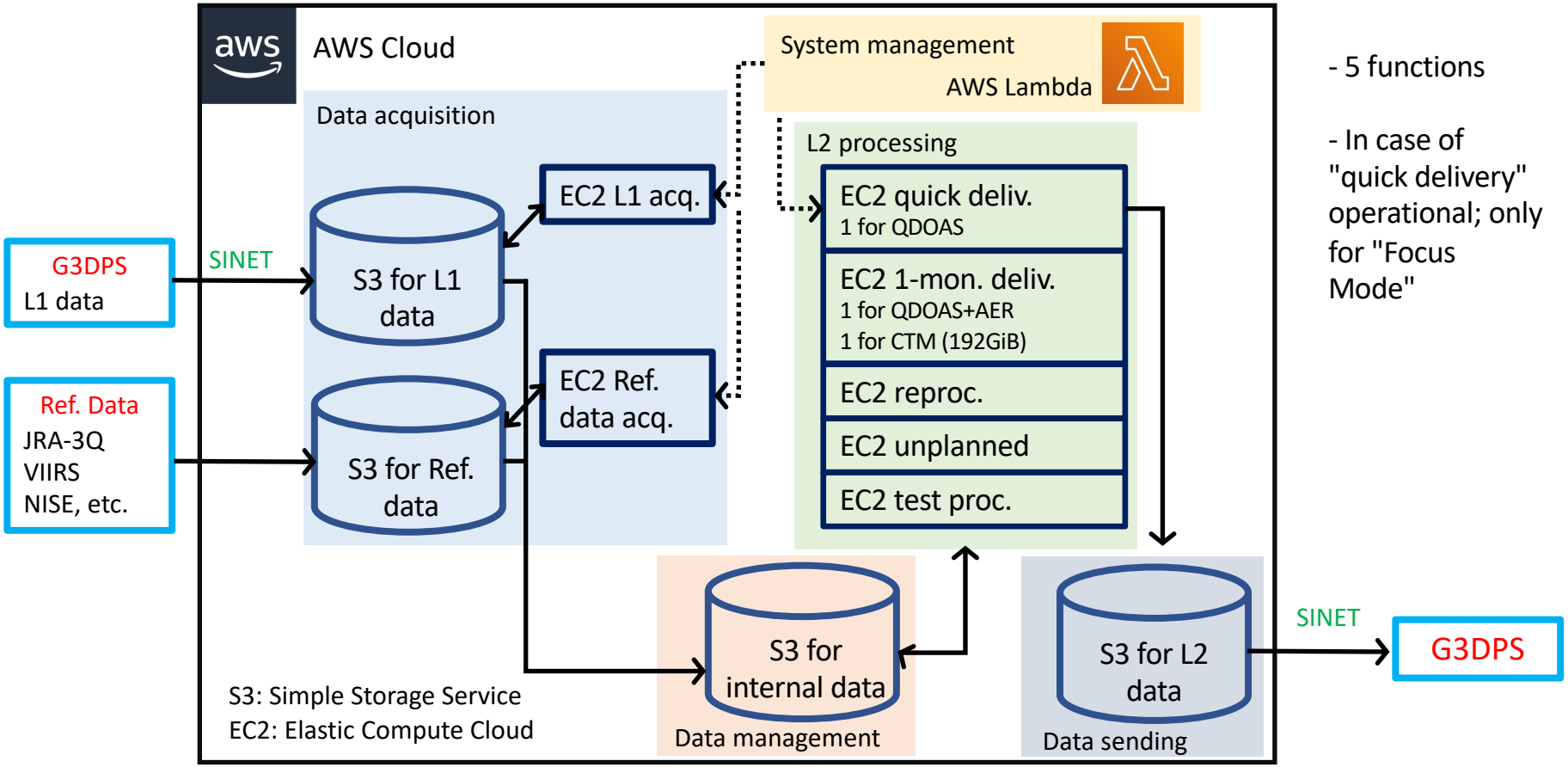


Ground data-processing system (G3DPS, incl. GHGs)



Team: Hisashi Yashiro, Tazu Saeki, Satoshi Kikuchi

NO2 Data Processing System (GNDPS)



- 5 functions

- In case of "quick delivery" operational; only for "Focus Mode"

Team: Takafumi Sugita, Takashi Sekiya, Yousuke Yamashita, Tomohiro Sato, Yasko Kasai, Ayano Nakamura, Thi Ngoc Trieu Tran

NIES ground-based, ship and aircraft GHG monitoring

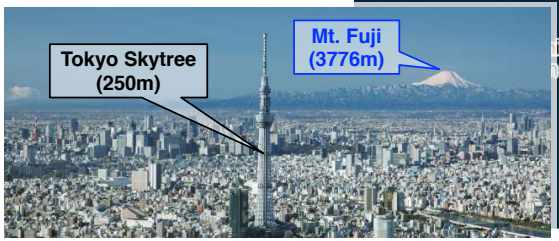
NIES Center for Global Environmental Research (CGER) monitoring platforms


Monitoring station, Cape Ochiishi


Monitoring station, Hateruma


Mt. Fuji automated weather station


Rikubetsu, TCCON site




Trans Future 5

How can we best use these obs. capabilities for the GOSAT-GW validation?