

Workshop on EC CEOS Priority on GHG Monitoring
Japan's Greenhouse Gases
Observation from Space

18 June, 2018@Ispra, Italy

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Japan Aerospace Exploration Agency

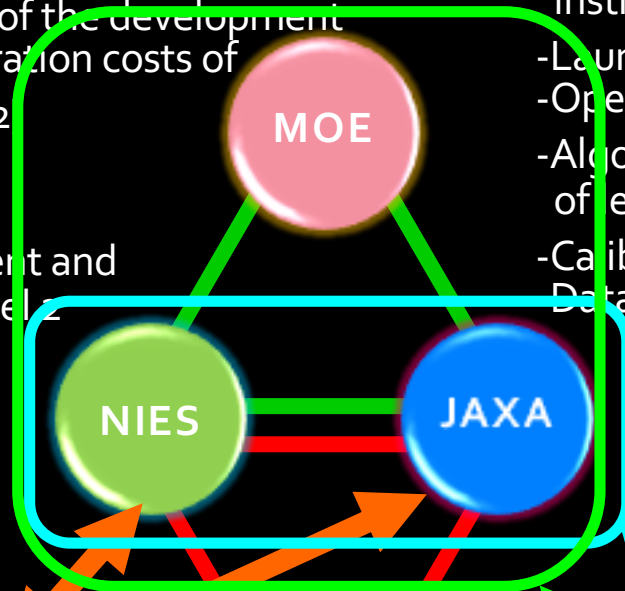
Development and Operation Structure of GOSAT, GOSAT-2



Data Utilization for global warming policies
(Pay half of the development and operation costs of GOSAT-2)

- Development of satellite including mission instruments , satellite operation system
- Launch
- Operation and data acquisition
- Algorithm Development and data processing of level 1)
- Calibration
- Data distribution to organization

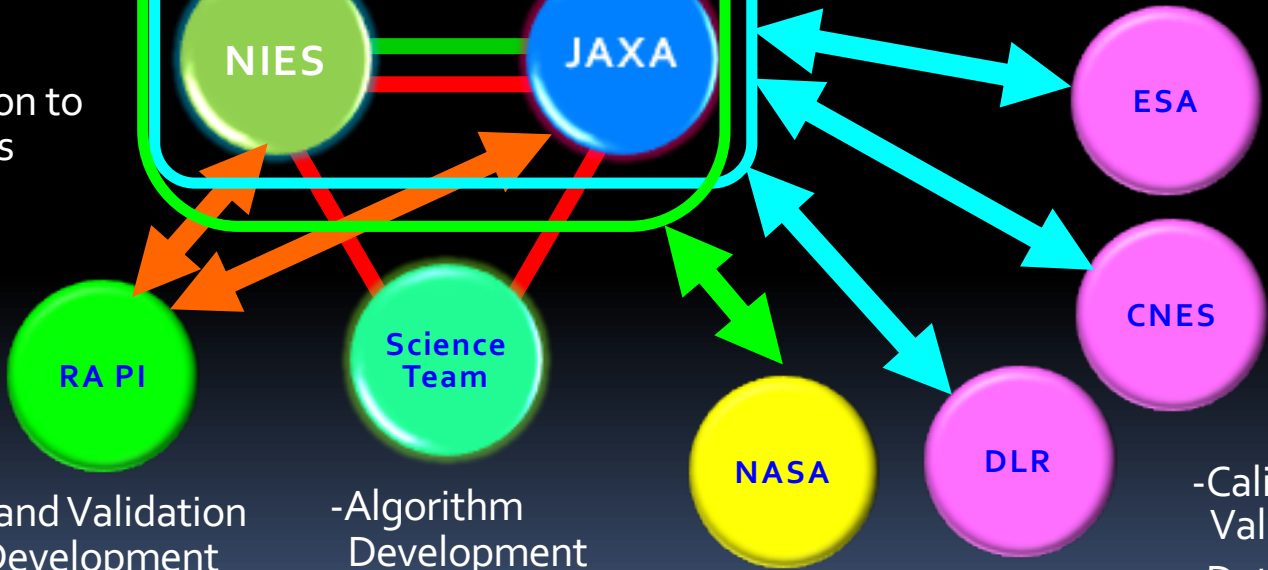
- Algorithm Development and data processing of level 2 and higher
- Validation
- Data distribution to individual users



- Calibration and Validation
- Algorithm Development
- Data Application
- Others

- Algorithm Development

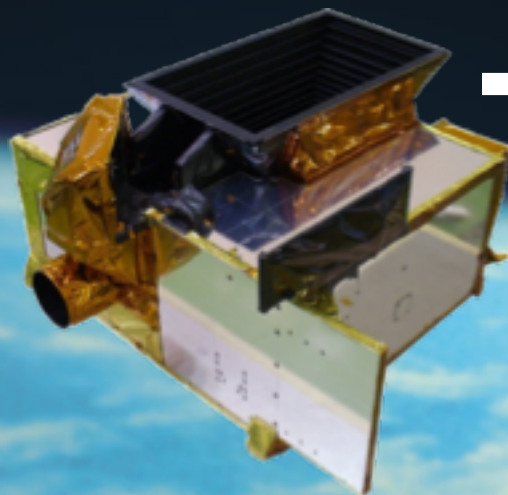
- Calibration and Validation
- Data Distribution
- Others



GOSAT and TANSO onboard GOSAT

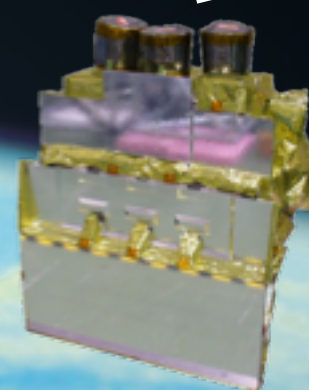
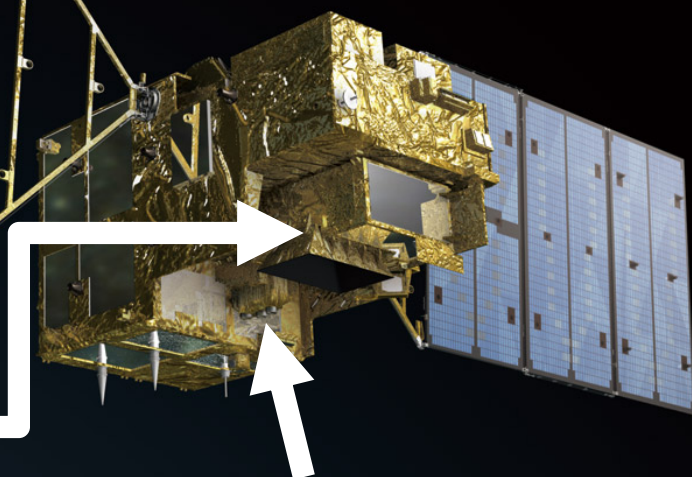
TANSO = Thermal And Near infrared Sensor for carbon Observation

Size	Main body	3.7 m x 1.8 m x 2.0 m (Wing Span 13.7m)
Mass	Total	1750kg
Power	Total	3.8 kW (EOL)
Life Time		5 years
Orbit	sun synchronous orbit	
	Local time	13:00+/-0:15
	Altitude	666km
	Inclination	98deg
	Repeat	3 days (44 revol.)
Launch	Vehicle	H-IIA
	Schedule	Jan. 23, 2009



TANSO-FTS
(Fourier Transform Spectrometer)

-SWIR reflected on the earth's surface
-TIR radiated from the ground and the atmosphere



TANSO-CAI
(Cloud and Aerosol Imager)

UV : 0.38 μm
V : 0.67 μm
NIR : 0.87 μm
SWIR : 1.6 μm

Brief History of GOSAT



January 2009 : Launch of GOSAT

**April 2009 : Completed the on orbit initial check out phase
and started the observation**

April 2009 : Start of the L1B Products distribution to the PIs

August 2009 : Start of the L2 products distribution to the PIs

October 2009 : Start of the L1B Products distribution to the Public

February 2010 : Start of the L2 products distribution to the Public

(Calibration/Validation have been continued.)

**January 2014 : End of the nominal operation phase
(Phase E) and Start of the Phase F**

**April 2014 : Start of the development of
GOSAT-2**

January 2018 : Start of the tenth year

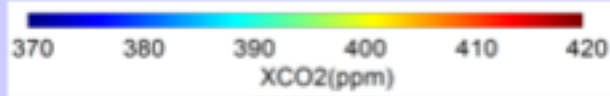
**2018 : Launch of GOSAT-2
(design life time is 5 years.)**

2022 : Launch of GOSAT-3

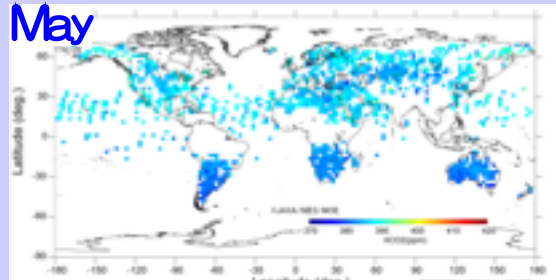
**(according to "The Basic
Plan for Space Policy")**

GOSAT-captured CO₂ Global Map (Monthly mean map in every 2.5 degrees mesh)

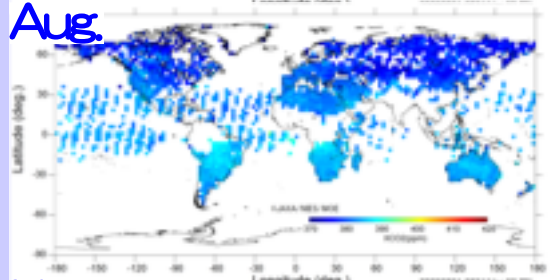
2009



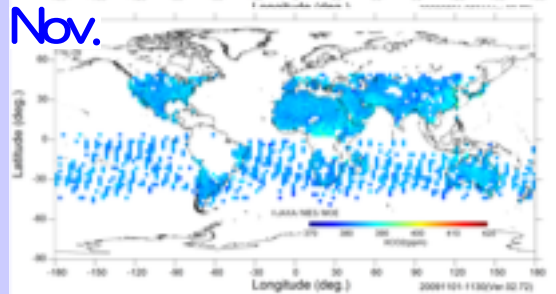
May



Aug.

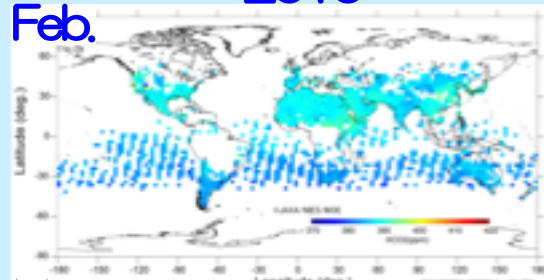


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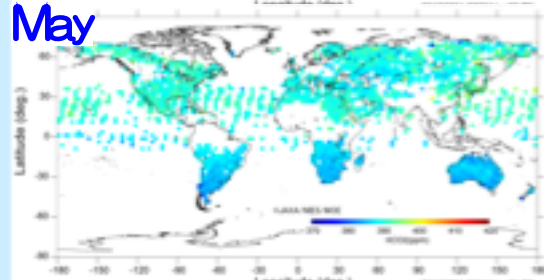


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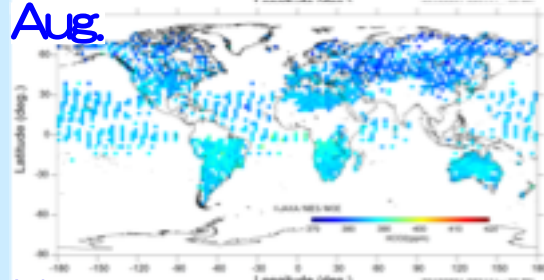
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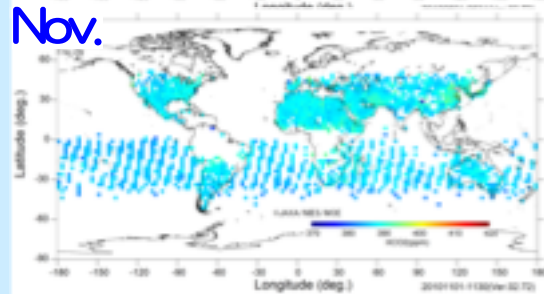
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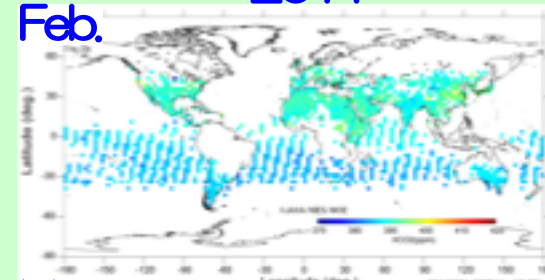


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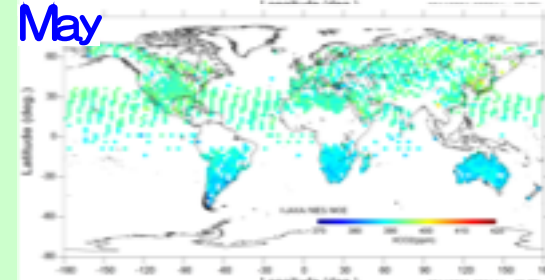


2011

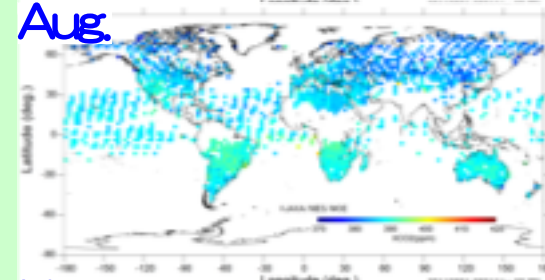
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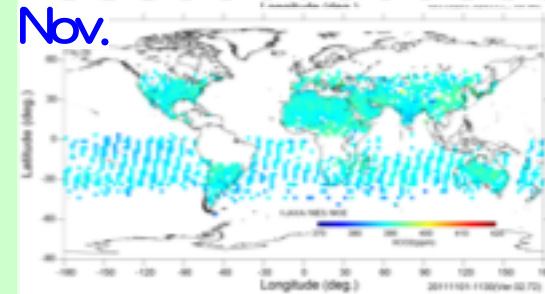
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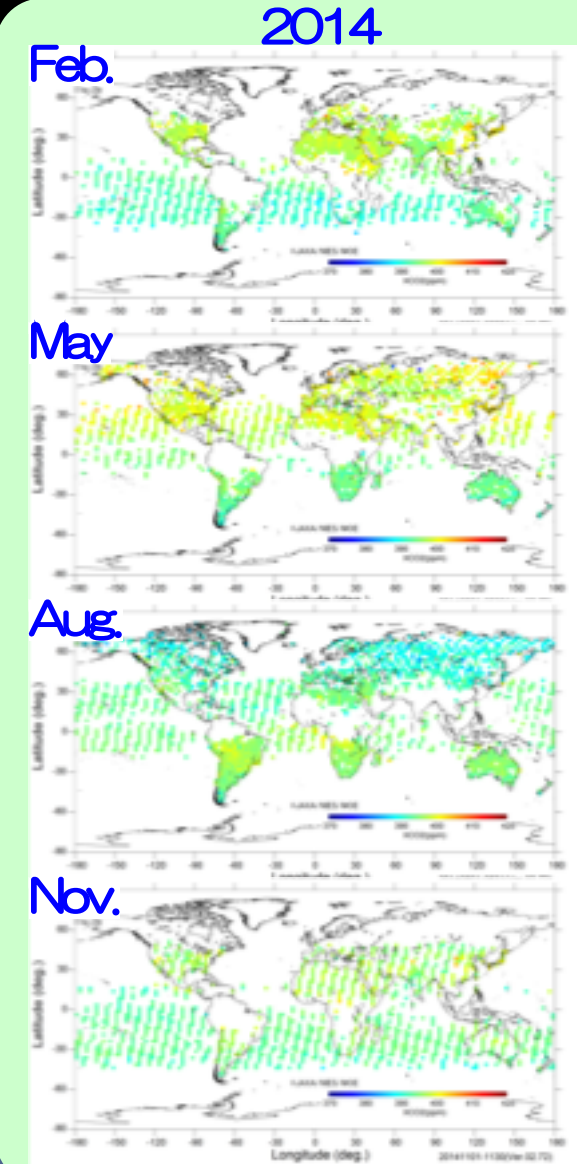
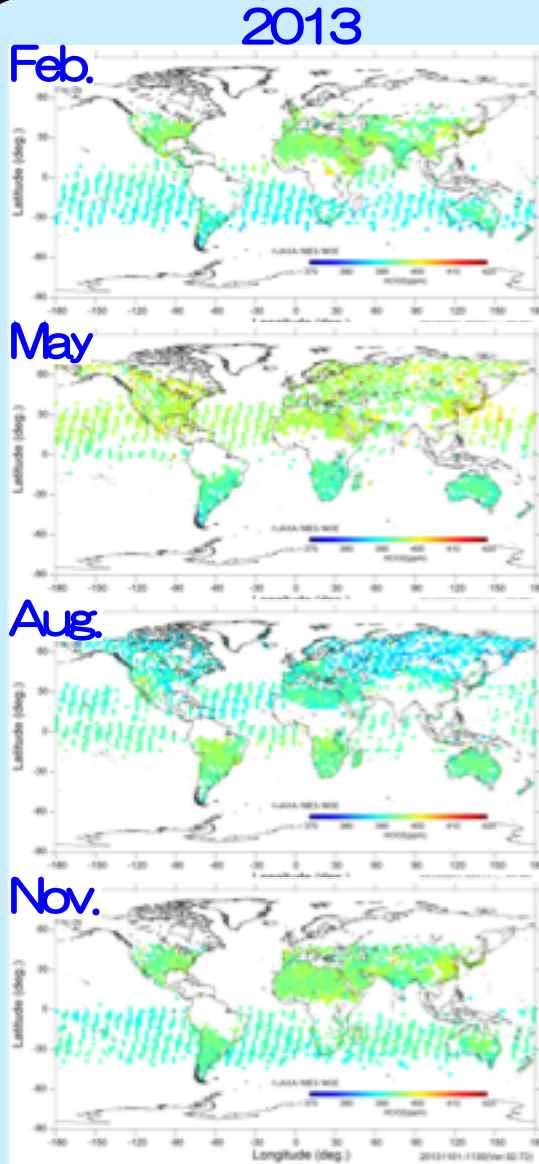
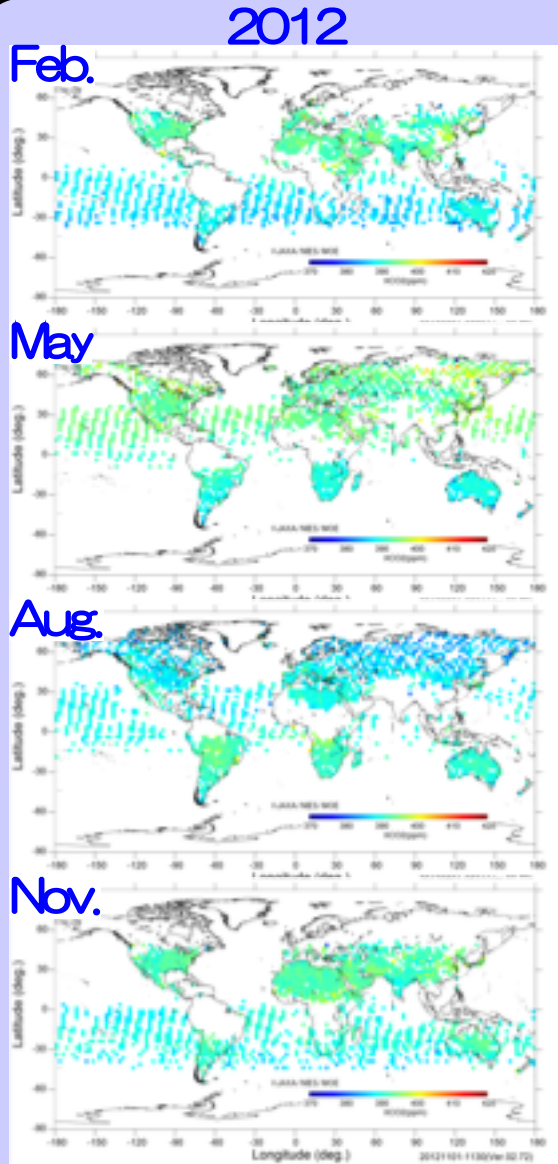
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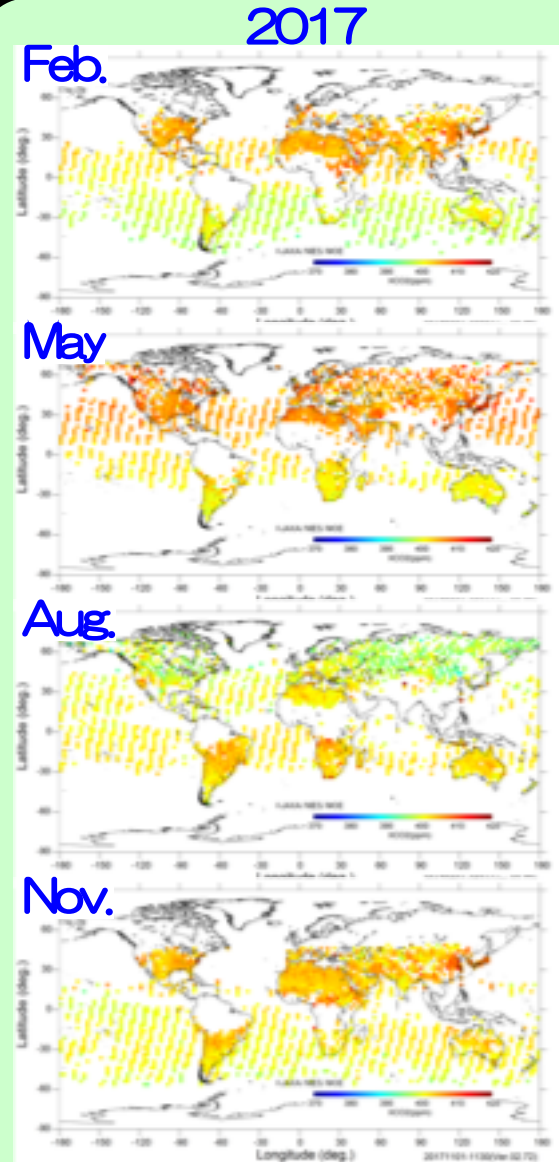
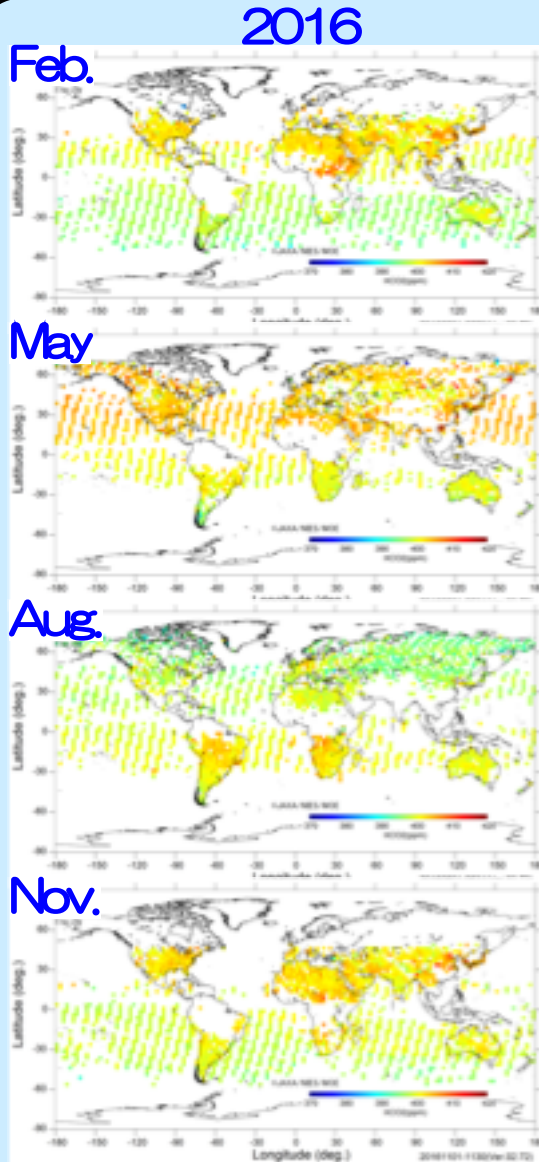
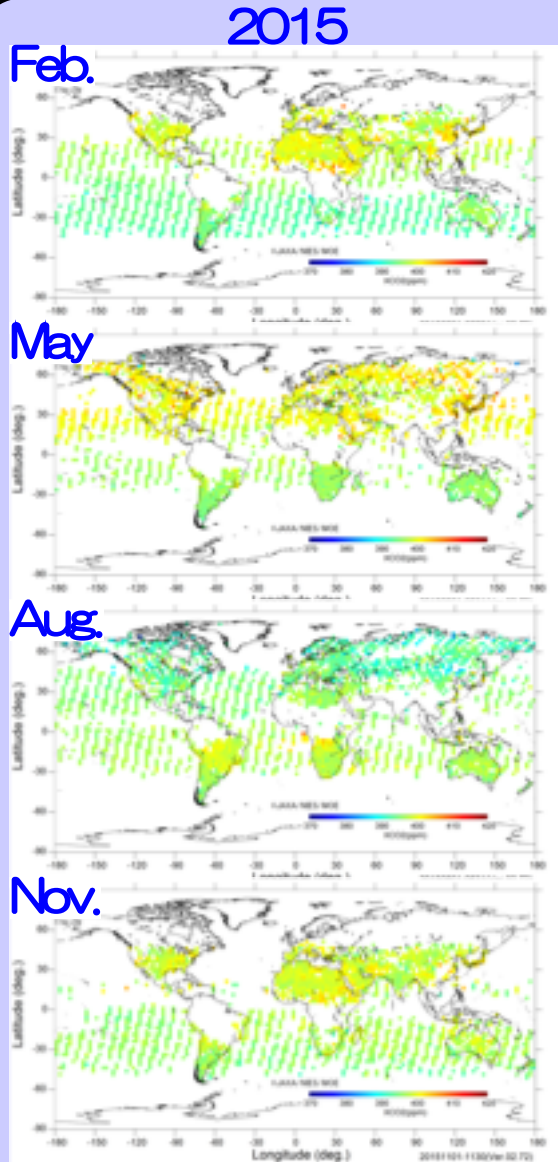
Nov.



GOSAT-captured CO₂ Global Map (Monthly mean map in every 2.5 degrees mesh)

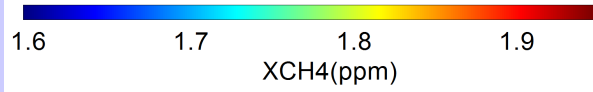


GOSAT-captured CO₂ Global Map (Monthly mean map in every 2.5 degrees mesh)

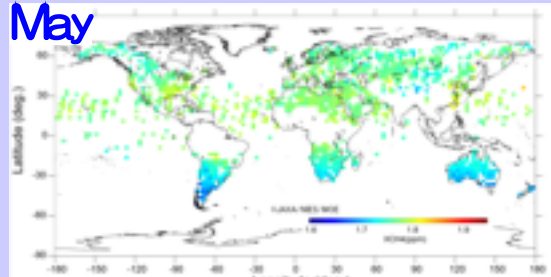


GOSAT-captured CH₄ Global Map (Monthly mean map in every 2.5 degrees mesh)

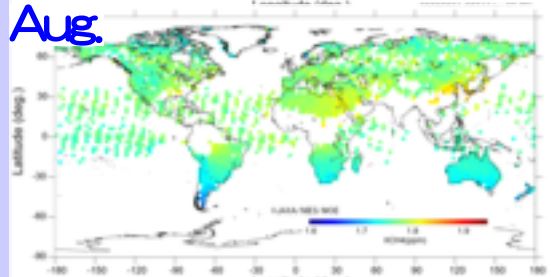
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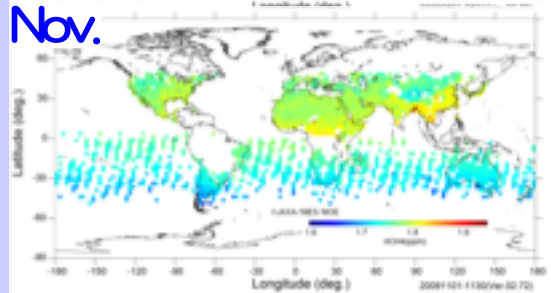
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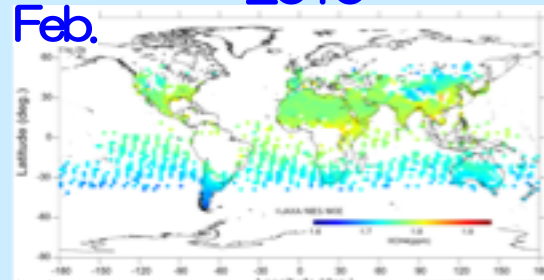


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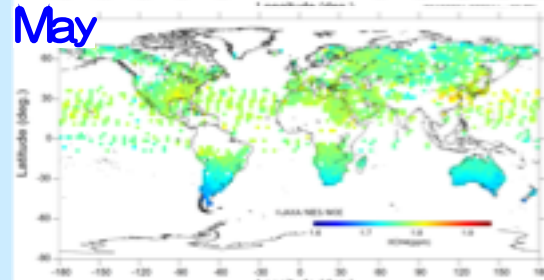


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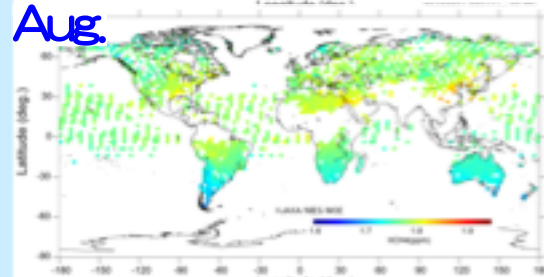
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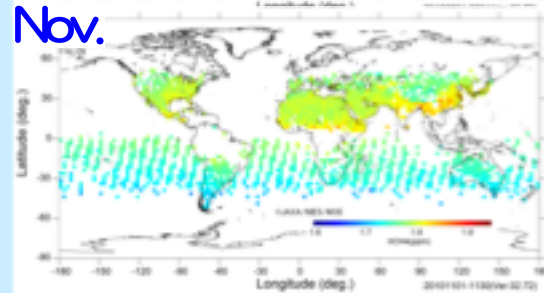
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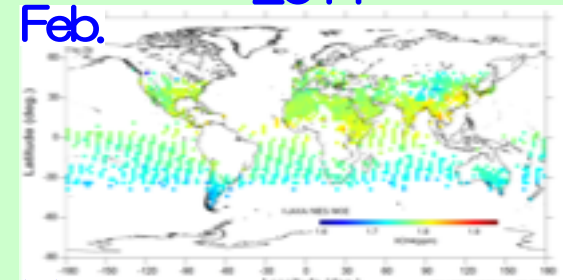


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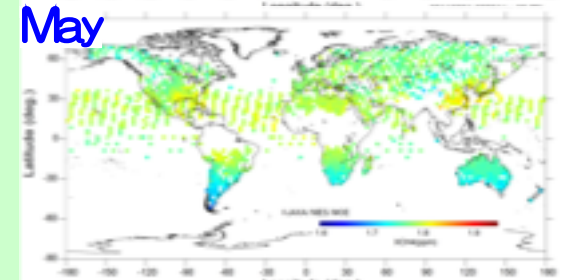


2011

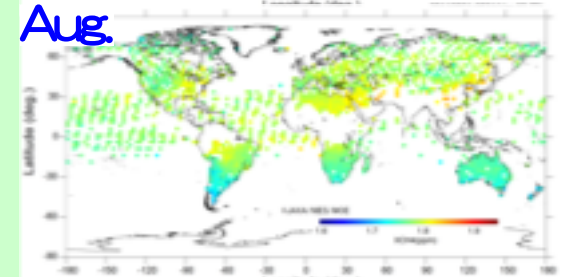
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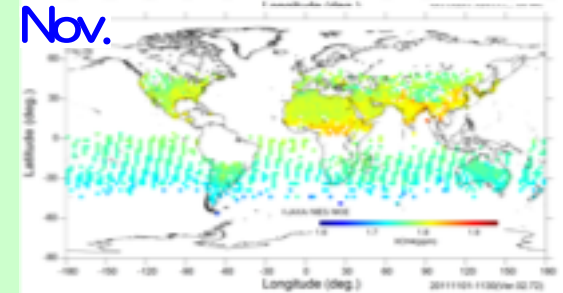
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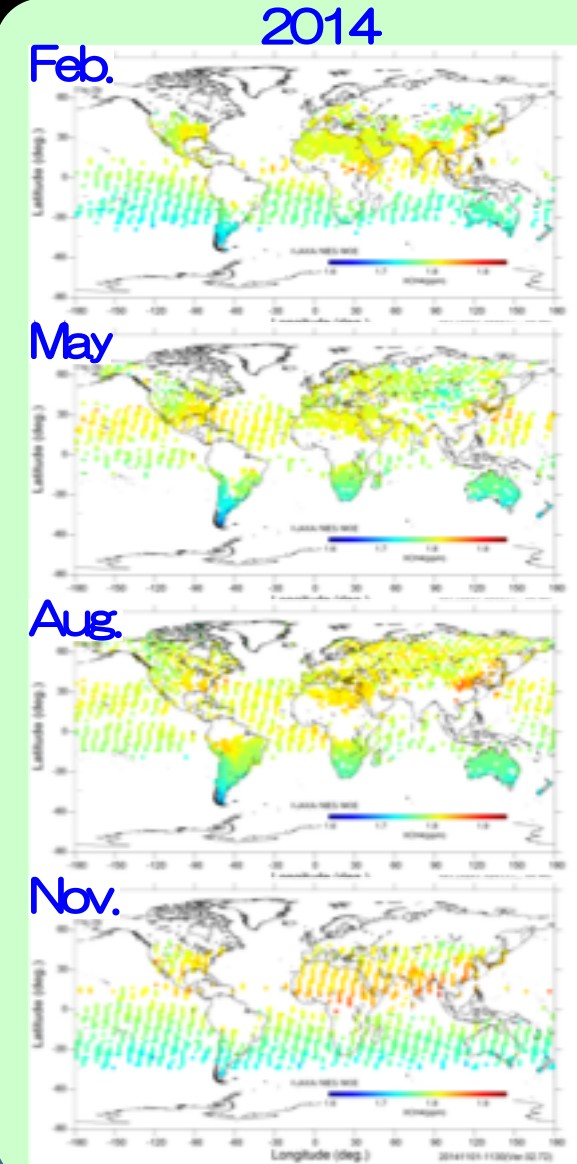
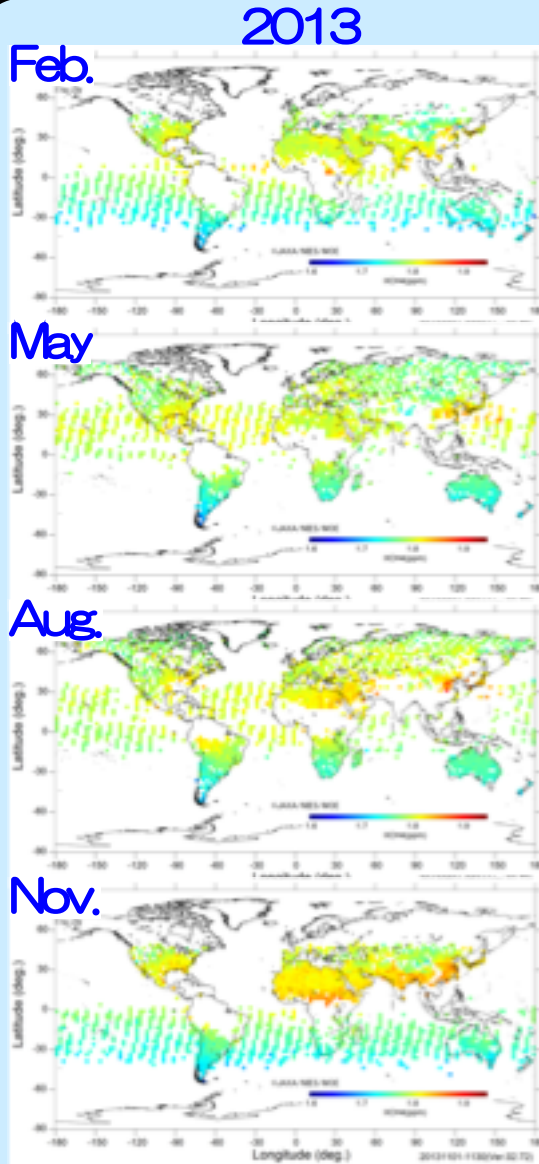
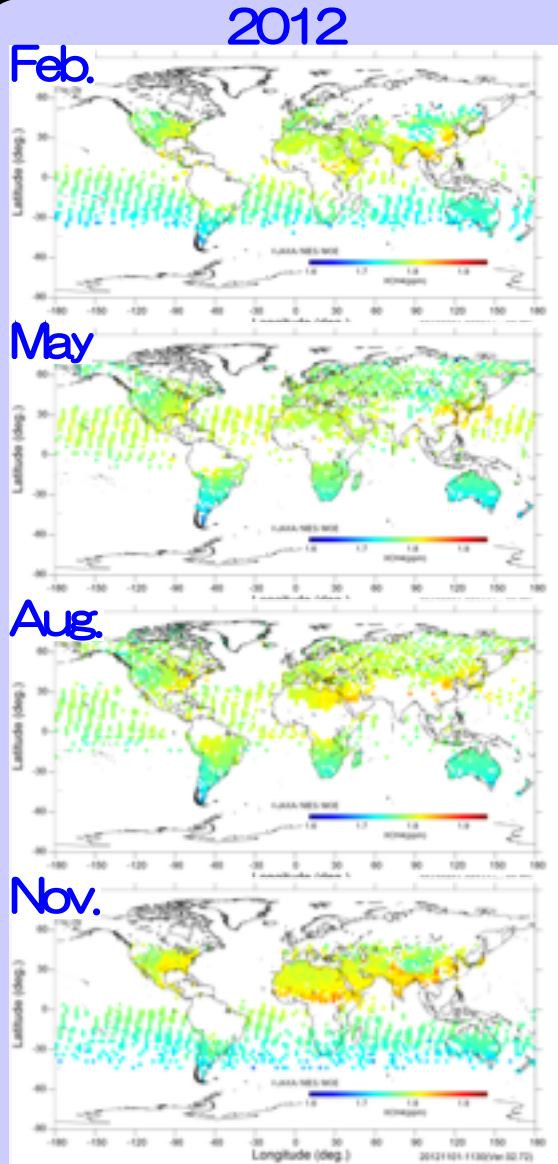
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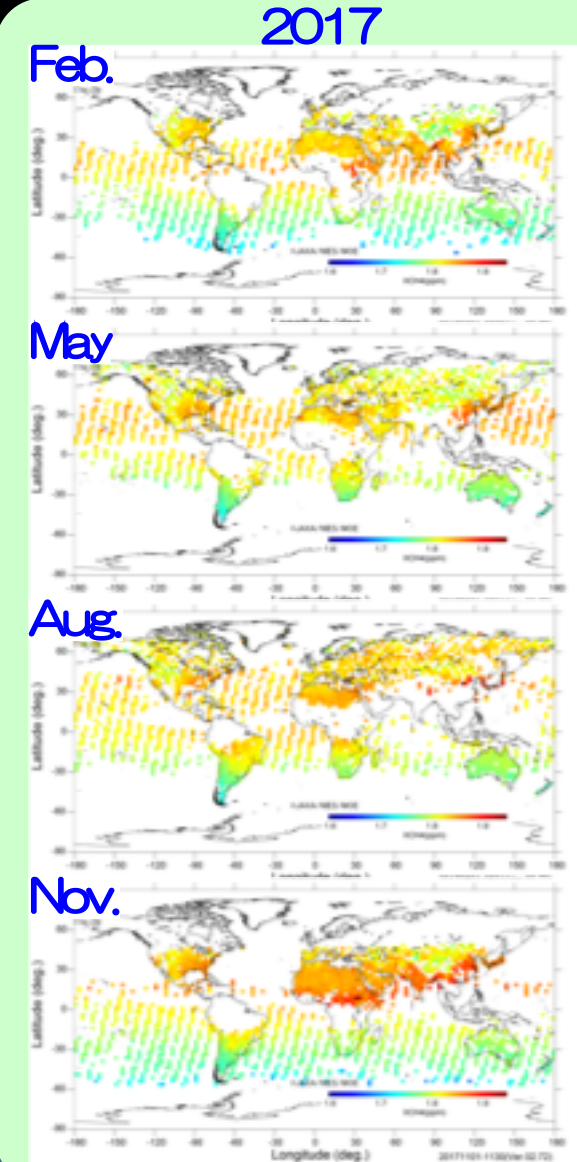
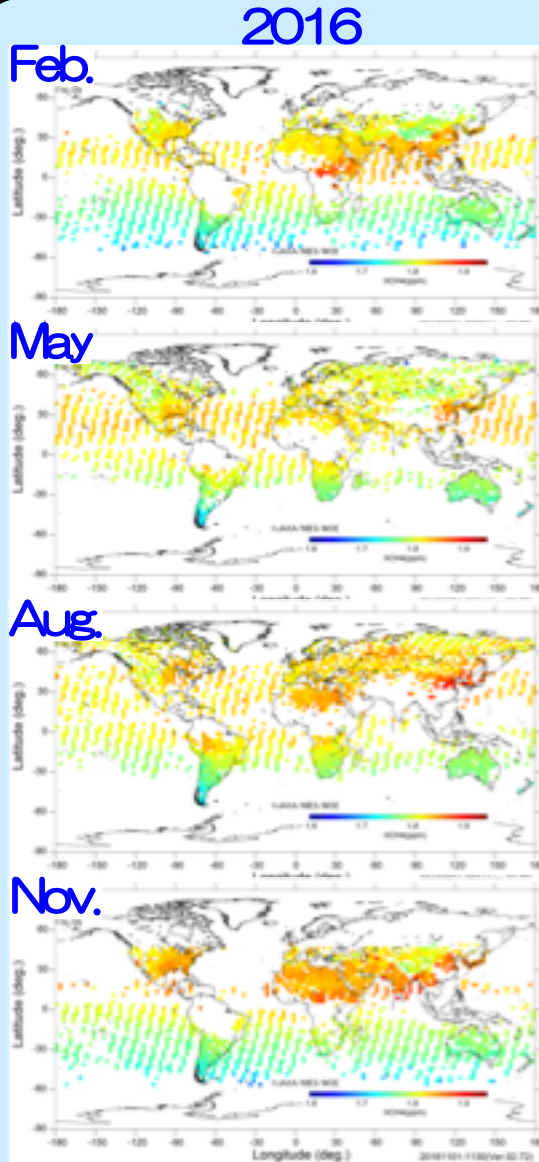
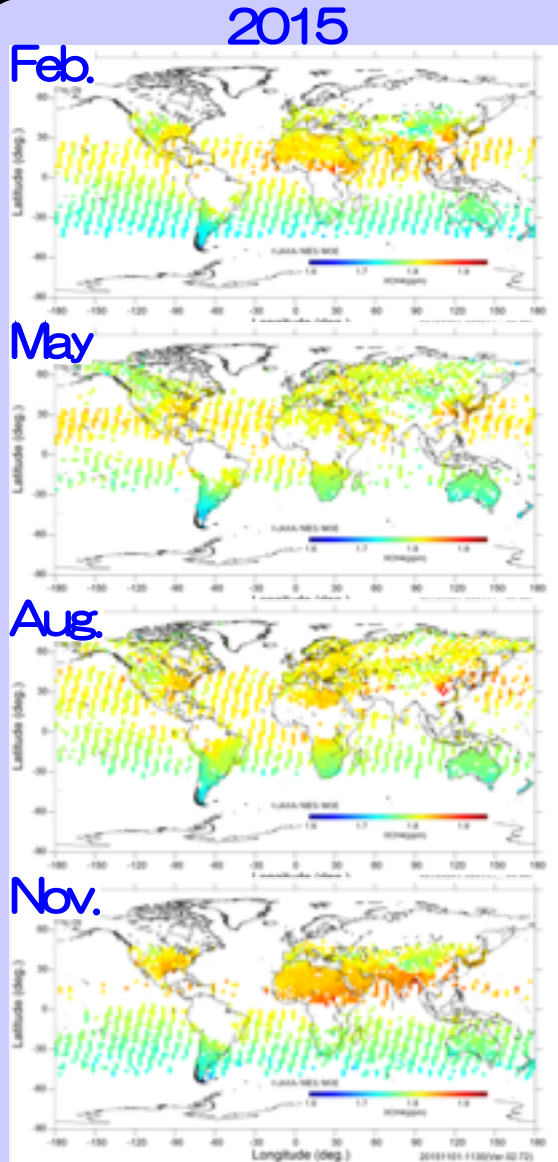
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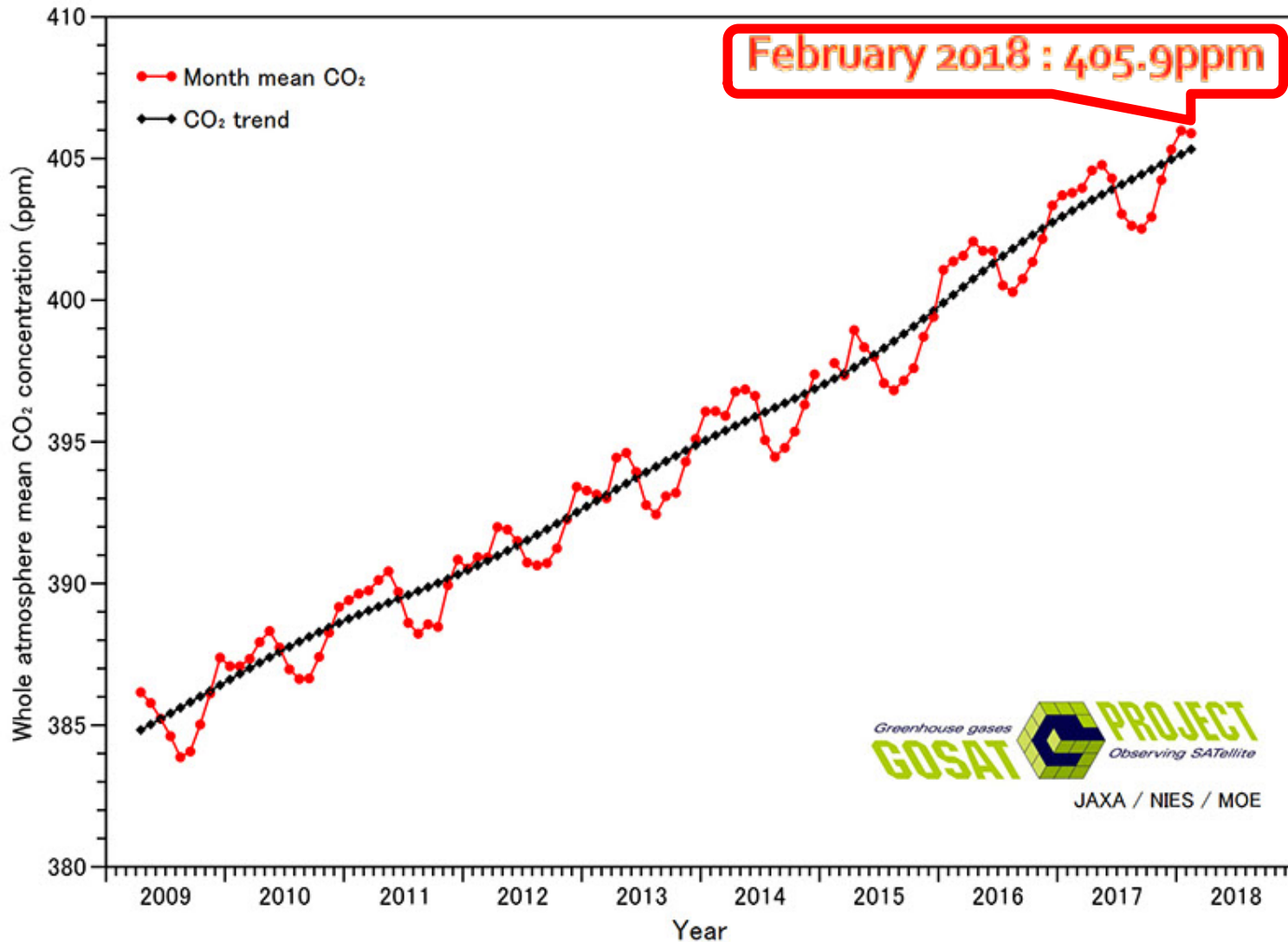
GOSAT-captured CH₄ Global Map (Monthly mean map in every 2.5 degrees mesh)



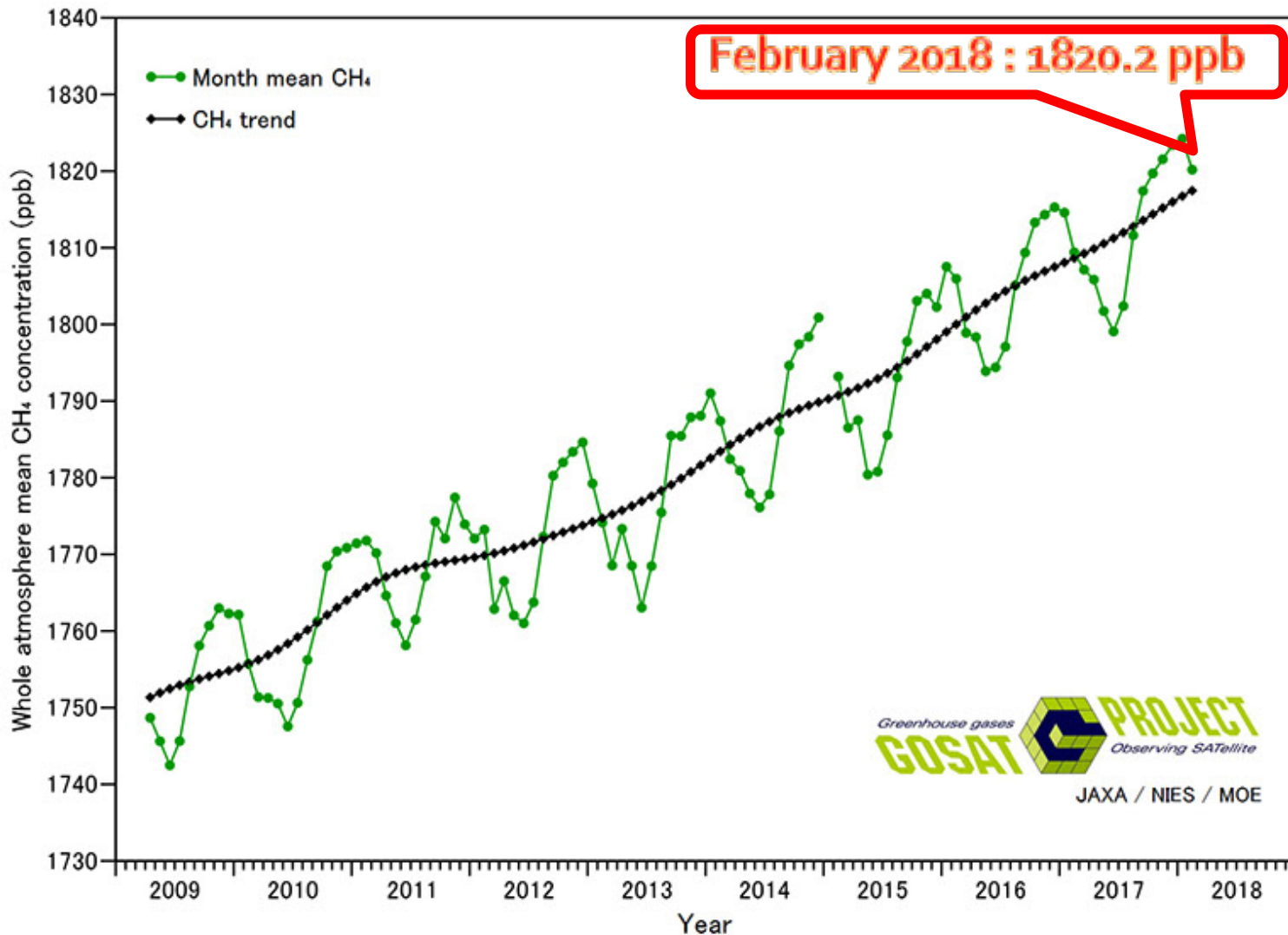
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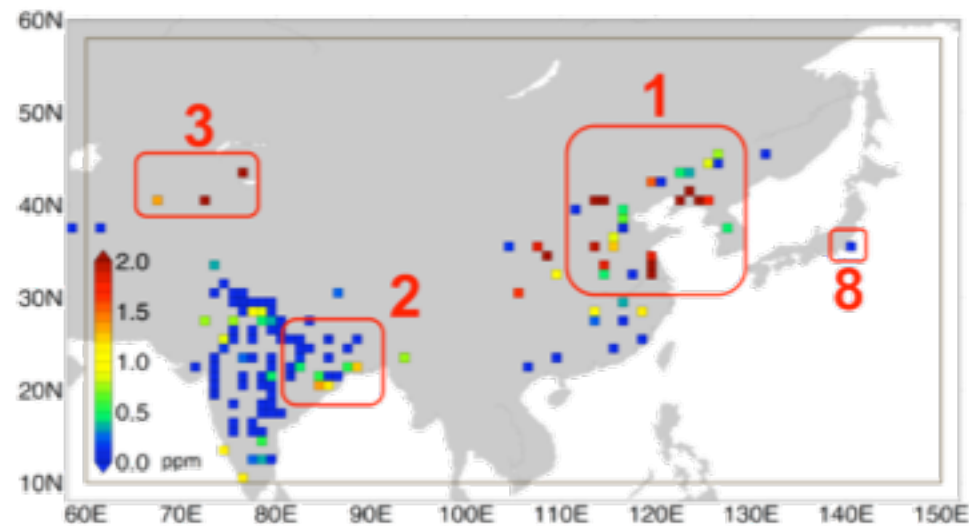
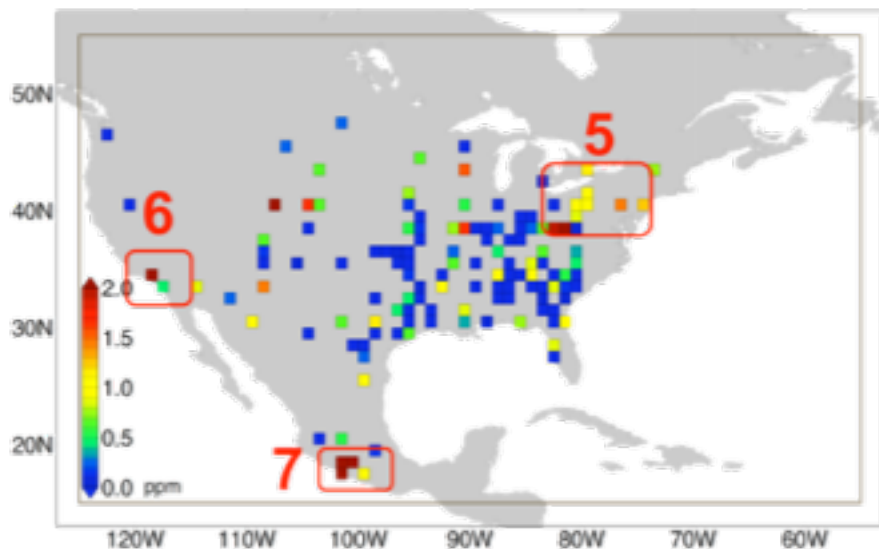
Whole-atmosphere monthly mean CO₂ concentration based on GOSAT data



Whole-atmosphere monthly mean CH₄ concentration based on GOSAT data

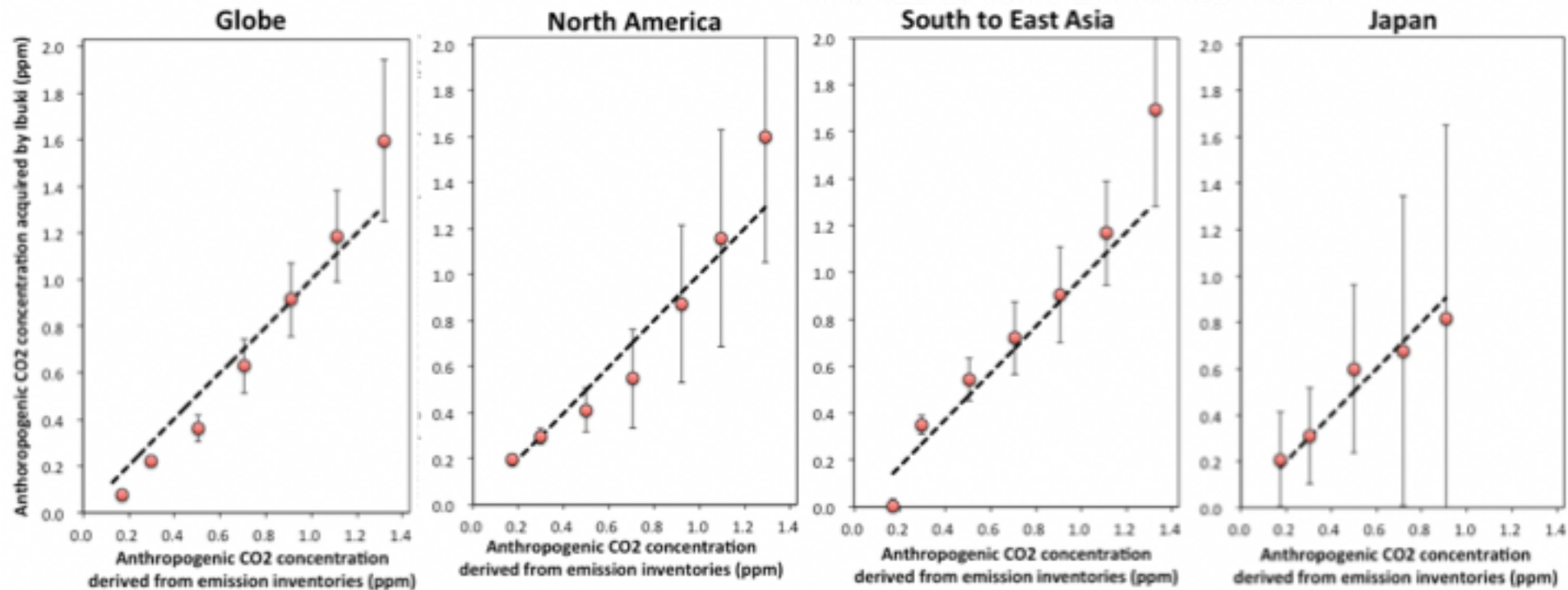


Detecting Anthropogenic CO₂ Concentrations in Mega-City Regions from Space by GOSAT



1	China	6.2 ppm	6	USA (LA)	3.5 ppm
2	India(Calcutta)	2.1 ppm	7	Mexico (Acapulco)	2.7 ppm
3	Uzbekistan, Kazakhstan etc.	2.8ppm	8	Japan (Tokyo)	0.5 ppm
5	USA (Pittsburgh)	2.1ppm			

Relationship between anthropogenic CO₂ concentrations derived from emission inventories and those acquired by GOSAT



Estimation of the anthropogenic CO₂ concentrations in Japan

- GOSAT data
 - data on fossil fuel emissions (inventory)
- Generally agreed

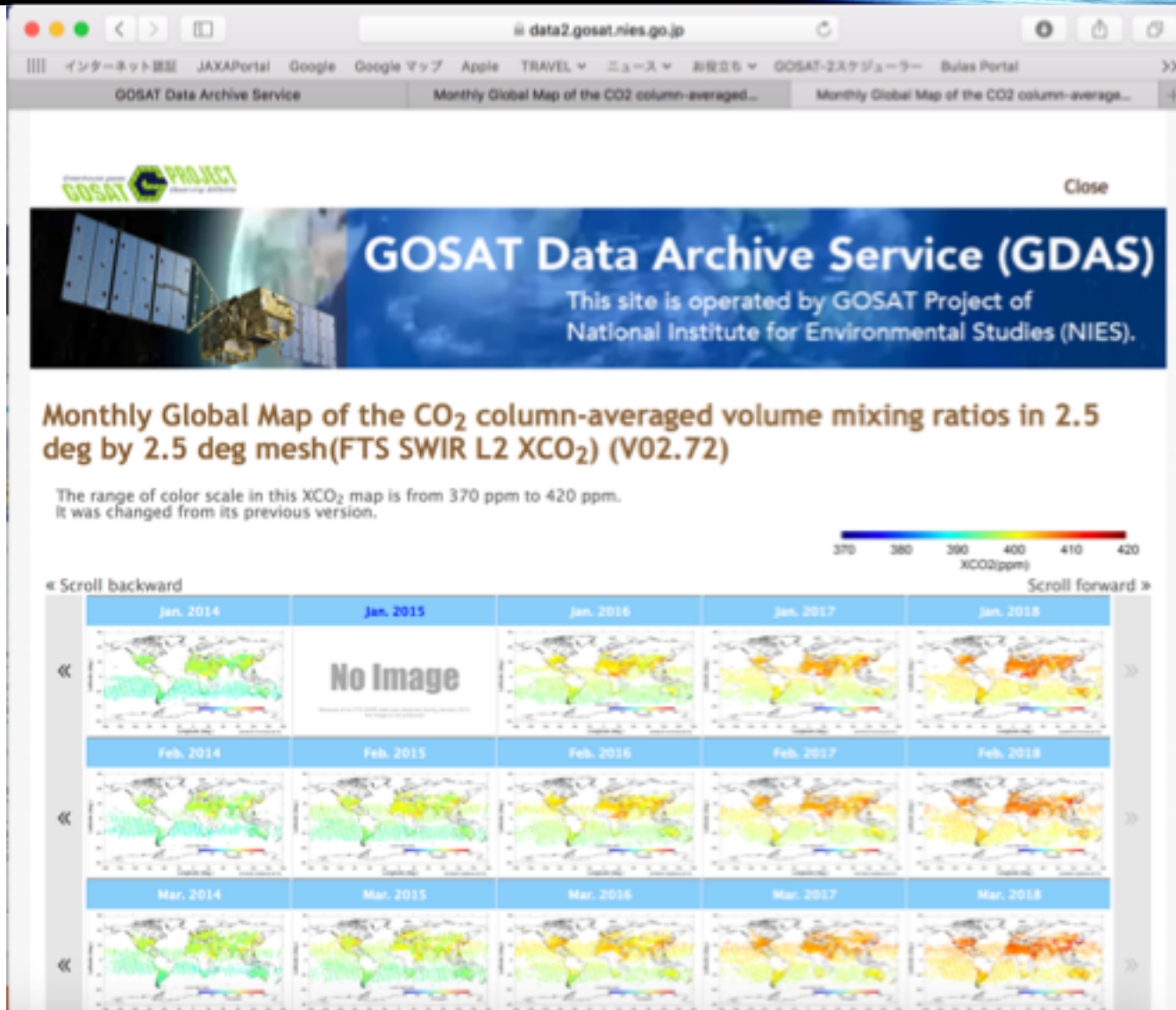
→ Satellite observations from space can become useful to monitor and verify CO₂ emission rates that were aggregated and published by all nations of the world based on the framework of "The Paris Agreement".



The screenshot shows a web browser window displaying the GOSAT Data Archive Service (GDAS) website. The browser's address bar shows the URL https://data2.gosat.nies.go.jp/index_en.html. The website header includes navigation links for Home, Documents & Information, Gallery, User Registration, and Login. A prominent banner features the text "GOSAT Data Archive Service (GDAS)" and states that the site is operated by the GOSAT Project of the National Institute for Environmental Studies (NIES). Below the banner, a "News & Topics" section lists three recent updates: a service maintenance announcement from 2018/06/13, a new score map for RA users from 2018/06/06, and a note from 2018/05/30. A "Gallery" section on the right displays three satellite data maps. A "Submenu" link for "How to use this website" is visible at the bottom right.

https://data2.gosat.nies.go.jp/index_en.html

Archive of GOSAT Data



https://data2.gosat.nies.go.jp/gallery/fts_l2_swir_co2_gallery_en.html

Mission of GOSAT-2



GOSAT-2

**0.5 ppm (CO₂)
5 ppb (CH₄)
per 1 month
at 500 km mesh (land)
at 2,000 km mesh (ocean)**

**estimate the monthly net fluxes with
the accuracy of $\pm 100\%$
at 1,000 km mesh (land)
at 4,000 km mesh (ocean)
($> \pm 0.2 \text{ GtC/area/year}$)**

**examine the feasibility of the
estimation of the anthropogenic
emission with the observation of
CO which is the correlated matter**

**calculate the optical thickness of
the aerosols at 550nm and 1.6 μm
with 0.1 accuracy
(for estimation of the moving state
of the PM_{2.5})**

GOSAT

**4 ppm (CO₂)
34 ppb (CH₄)
per 3 months
at 1,000km mesh (land)**

**reduce the annual
estimation error to half
compared with the
existing estimation error
-sub-continental scale**

improvement of
concentration
measurement
precision

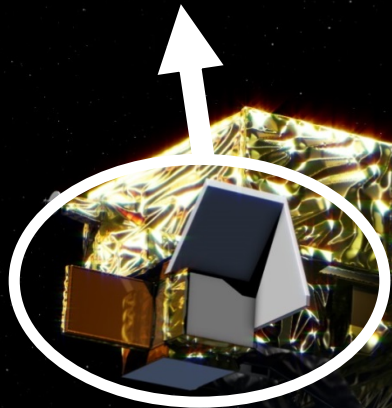
improvement of
estimation
accuracy of flux

estimation of the
anthropogenic
emission

monitoring of
the aerosols in
the atmosphere

GOSAT-2 artist's illustration

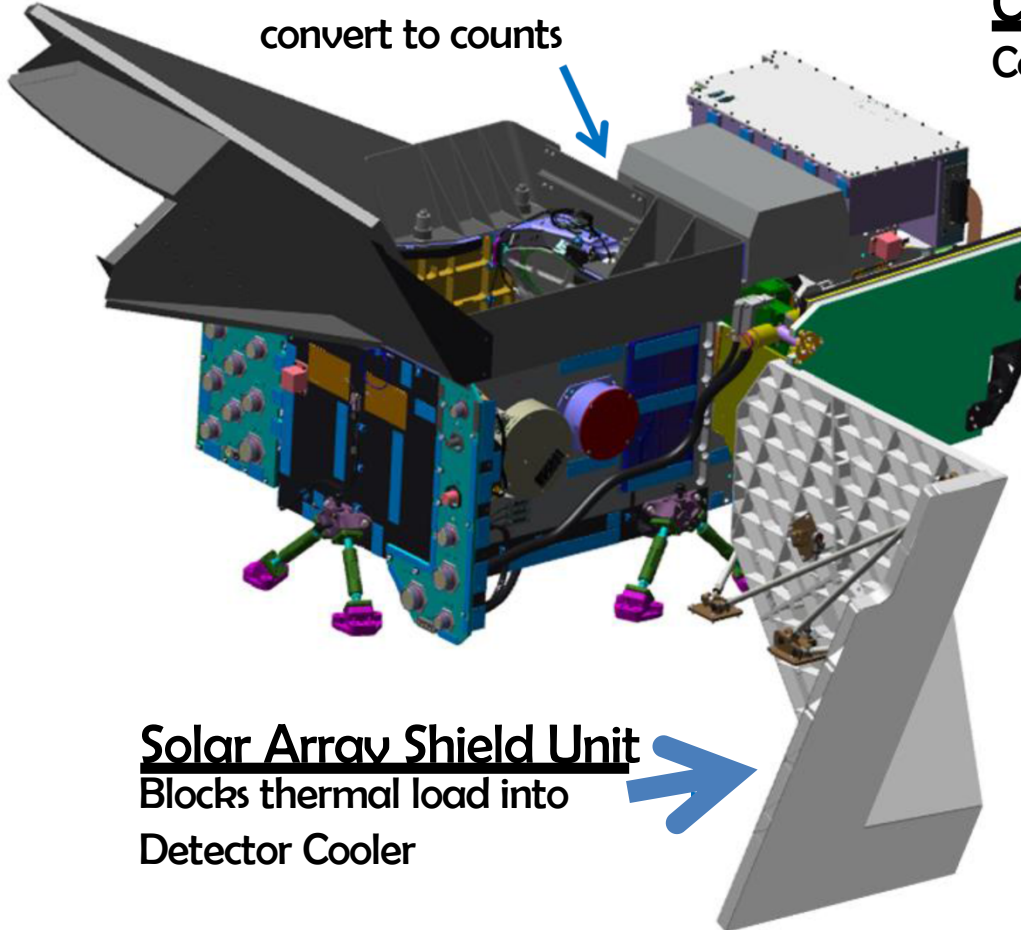
TANSO-FTS-2



TANSO-CAI-2

Sensor Unit

Collect scene radiance & convert to counts

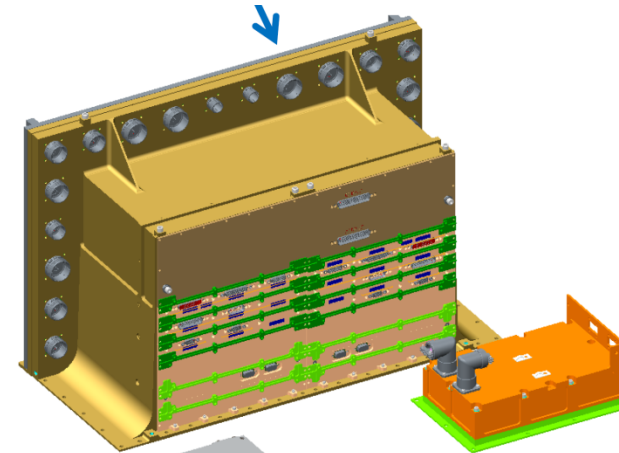


Solar Array Shield Unit

Blocks thermal load into Detector Cooler

Command and Control Electronics Unit

Command & control and data handling

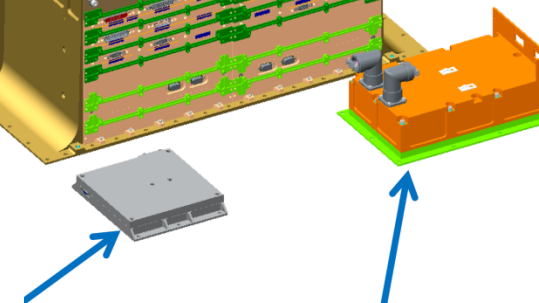


DVR Unit

For camera image storage & pixel aggregation

External Filter Unit

Conditions power

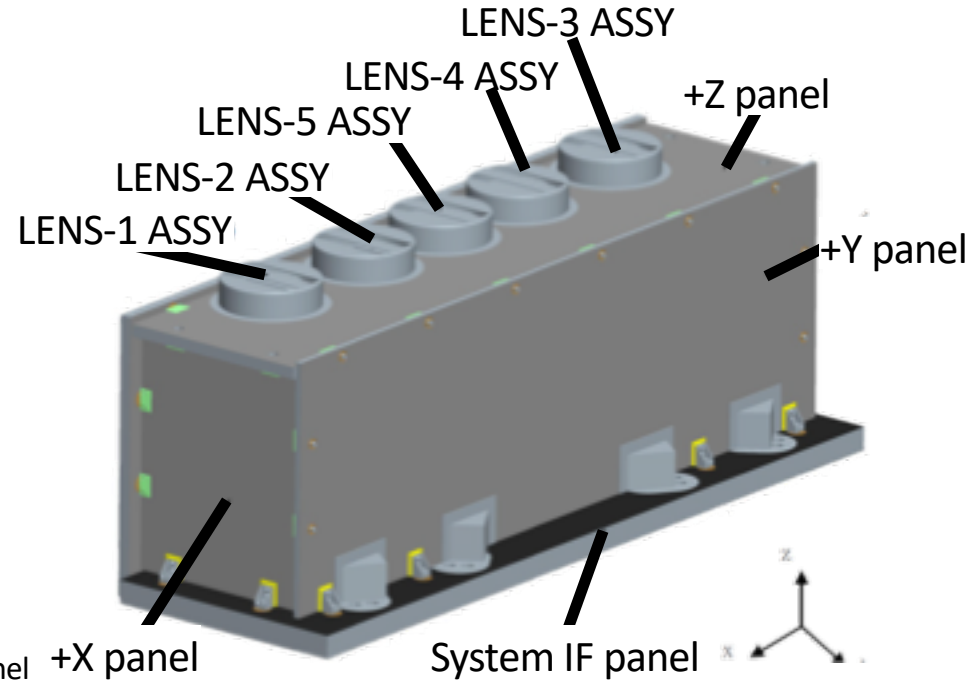
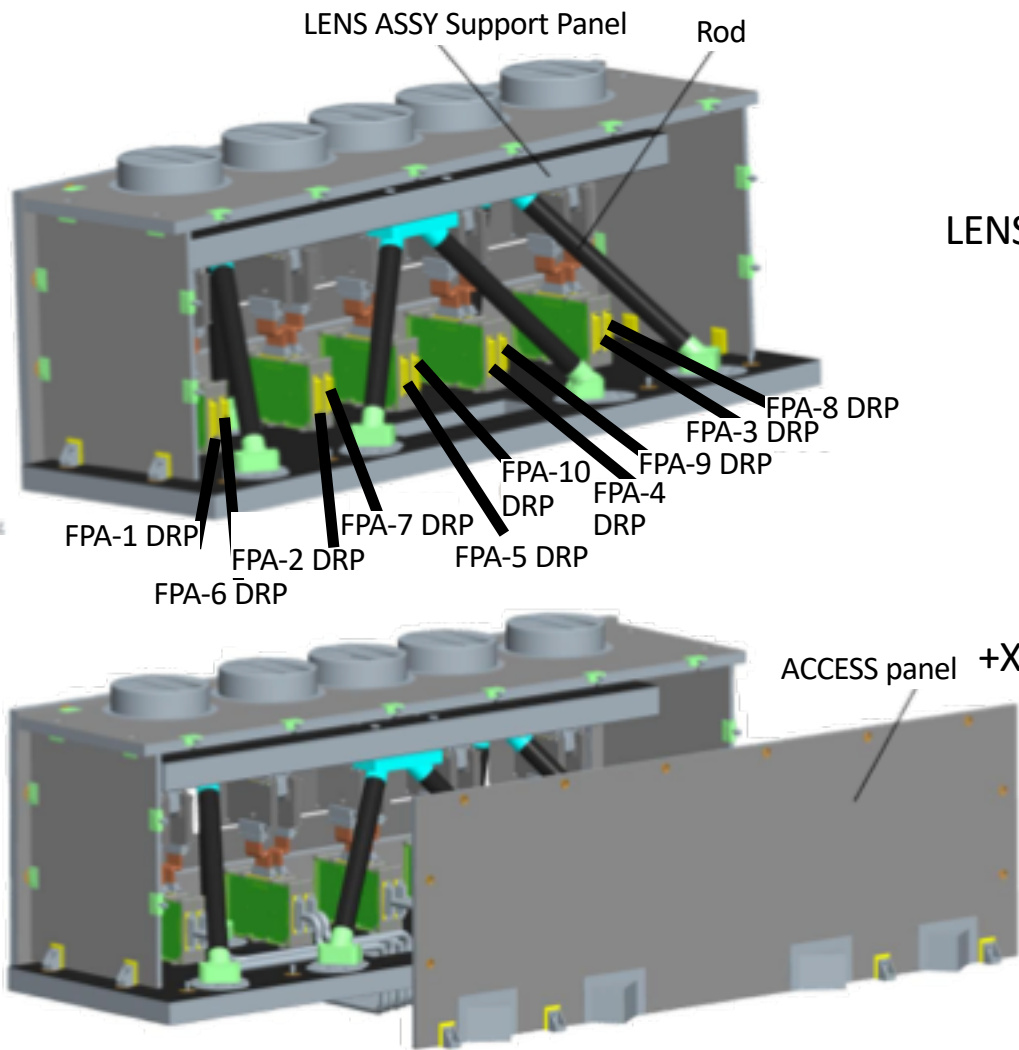


TANSO-FTS-2 Specifications



Items	GOSAT-2	GOSAT
Measurement Gases	CO ₂ , CH ₄ , O ₃ , H ₂ O, CO	CO ₂ , CH ₄ , O ₃ , H ₂ O
Footprint size (FOV)	9.7 kmϕ (15.8mrad)	10.5 km ϕ (15.8mrad)
Spectral Ranges (μ m)(cm ⁻¹)	band 1 : 0.75-0.77 (12,950-13,250) band 2: 1.56- 1.69 (5,900 -6,400) band 3: 1.92- 2.33 (4,200 -5,200) band 4: 5.5- 8.4 (1,188-1,800) band 5: 8.4 -14.3 (700-1,188)	band 1: 0.75-0.77 (12,900-13,200) band 2: 1.56-1.72 (5,800-6,400) band 3: 1.92-2.08 (4,800-5,200) band 4: 5.5-14.3 (700-1,800)
SNR	band 1: >400 (S@ 13,050cm ⁻¹) band 2: >300 (S@6,200cm ⁻¹) band 3: >300 (S@5,000cm ⁻¹) >250 (S@4,250cm ⁻¹) band 4: >300 (@1,300cm ⁻¹) band 5: >300 (@700cm ⁻¹)	band 1: >300 (345) band 2: >300 (322) band 3: >300 (412) band 4: >300 (304)
Observation Mesh	160km (5 points in the CT direction)	160km (5 points in the CT direction)
Scan duration	4 seconds / interferogram	4, 2, 1.1 seconds / interferogram
Sampling resolution	0.2cm ⁻¹	0.2cm ⁻¹
Effective Aperture size	Φ73mm	Φ 64mm
Gain steps	16	2
Avoidance of the cloud	Intelligent pointing	-----

External appearance and inside of the TANSO-CAI-2 Optical Unit

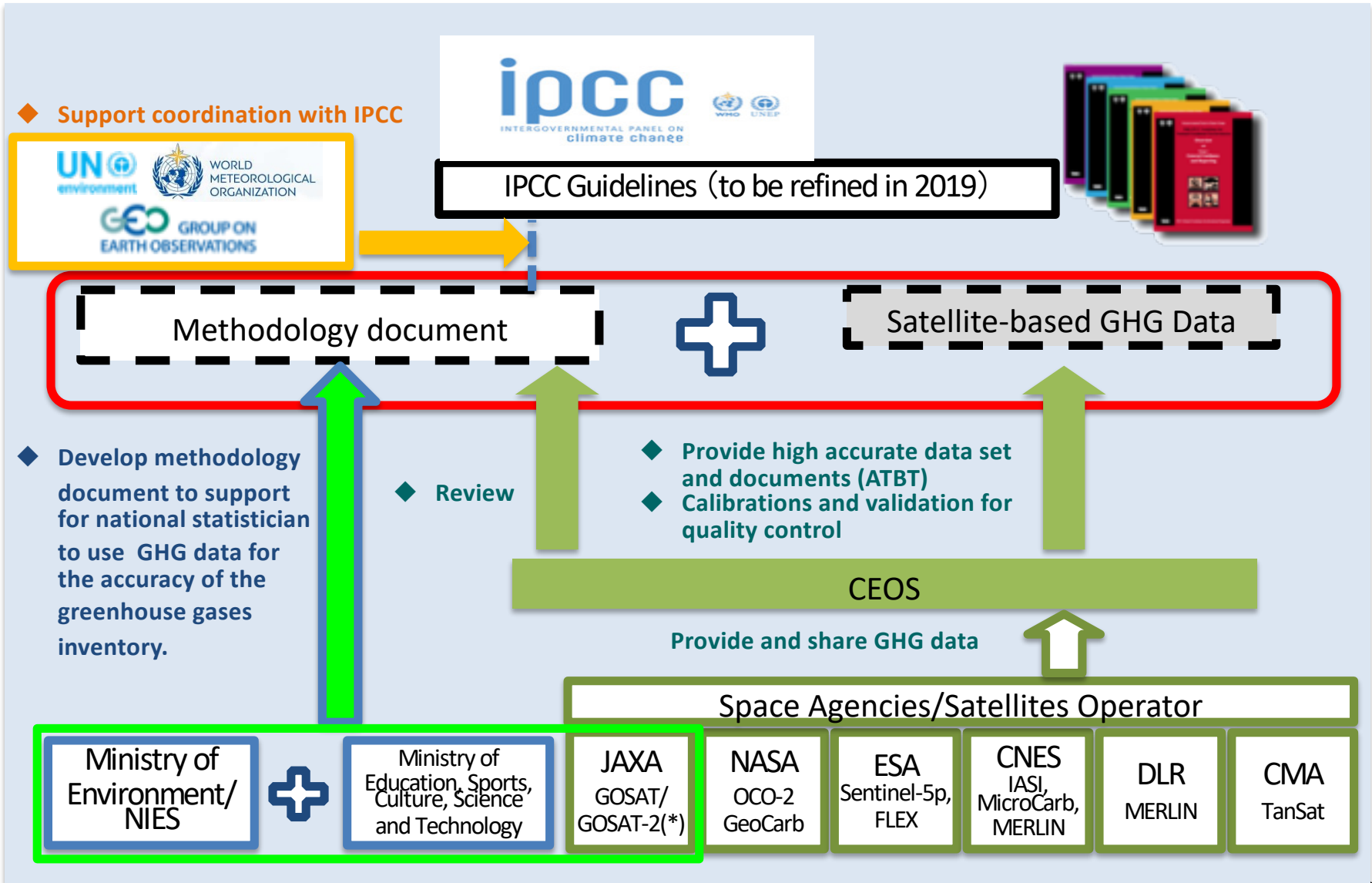


TANSO-CAI-2 Specifications



Items		GOSAT-2		GOSAT	
Spectral Ranges (nm)	Ranges	Forward Viewing (+20 deg)	Backward Viewing (-20deg)	Nadir Viewing	
		b 1: 333-353 b 2: 433-453 b 3: 664-684 b 4: 859-879 b 5: 1585-1675	b 6: 370-390 b 7: 540-560 b 8: 664-684 b 9: 859-879 b 10: 1555-1645	band 1: 370-390	band 2: 664-684
Spatial Resolution		except band 5, 10	band 5, 10	Band 1-3	Band 4
	nadir	460m (700μrad)	920m(1,400μrad)	500m(750μrad)	1,500m(2,250μrad)
swath/FOV		every points on the earth to be observed at least twice a recurrent cycle		Band 1-3	Band 4
				1,002 km / 72 deg	786km / 60 deg
SNR (@spectral-radiance/albedo) (W/m ² /sr/μm)		b 1 : >200 (45/0.158)	b 6 : >200 (48/0.152)	b 1 : >200 (47/0.149)	
		b 2 : >200 (79/0.144)	b 7 : >200 (65/0.125)	b 2 : >200 (45/0.104)	
		b 3 : >200 (46/0.106)	b 8 : >200 (46/0.106)	b 3 : >200 (29/0.108)	
		b 4 : >200 (30/0.112)	b 9 : >200 (30/0.112)	b 4 : >200 (7/0.101)	
		b 5 : >200 (7/0.101)	b 10 : >200 (7/0.101)		

Road to IPCC



Summary



- GOSAT Has been operated over 9 years.
- Estimation of the anthropogenic CO₂ concentration in Japan using GOSAT data generally agreed with the one derived from the inventory.
- The observation from space will become one of the useful means for the inventory.
- GOSAT follow on mission, GOSAT-2, will be launched in JFY 2018 which has 5 years design life time.
- Japan is now under consideration for GOSAT-3 to continue the GHGs observation.