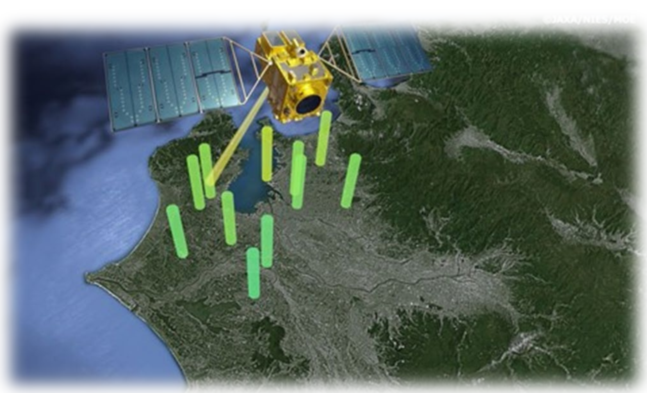
JAXA trace gas products using GOSAT and Airborne spectrometers



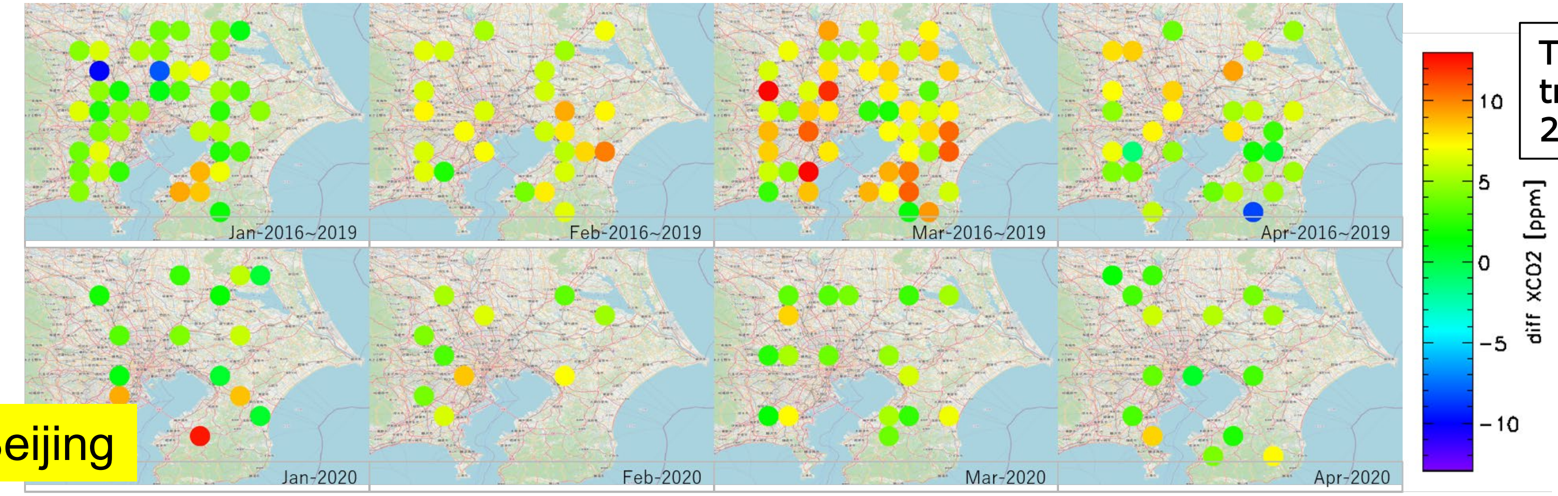
Nov. 22, 2021

Akihiko KUZE

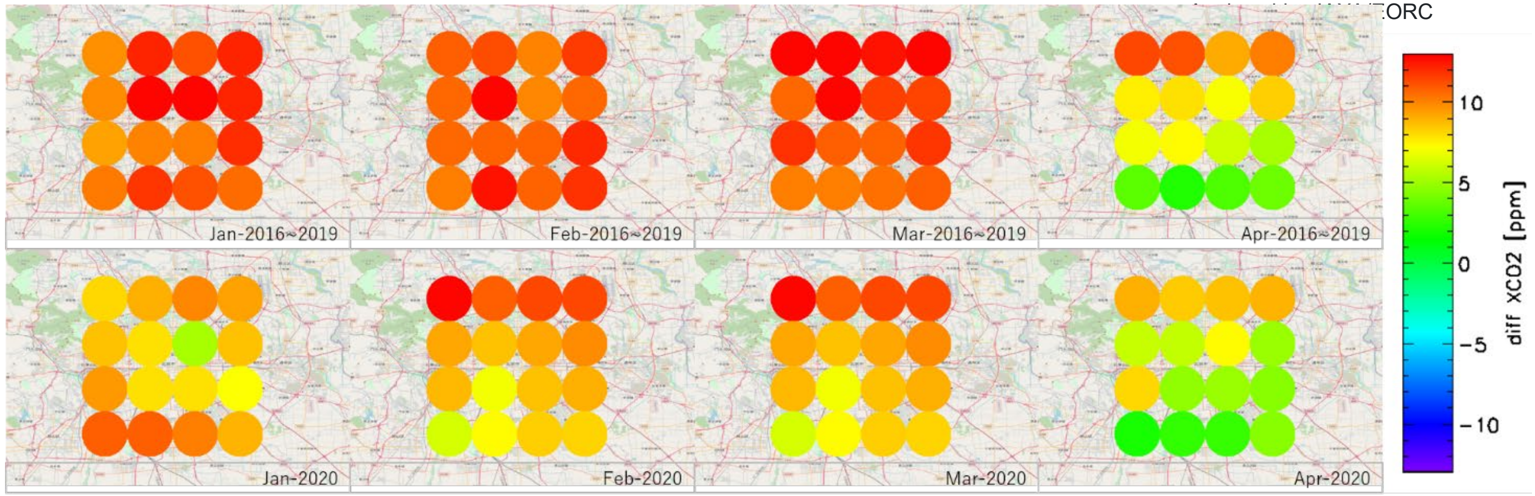
tri-lateral EO-dashboard: COVID-19

Average monthly abundances of CO_2 in the lower troposphere for the past 4 years (upper, reference) and 2020 (lower) from GOSAT

Tokyo

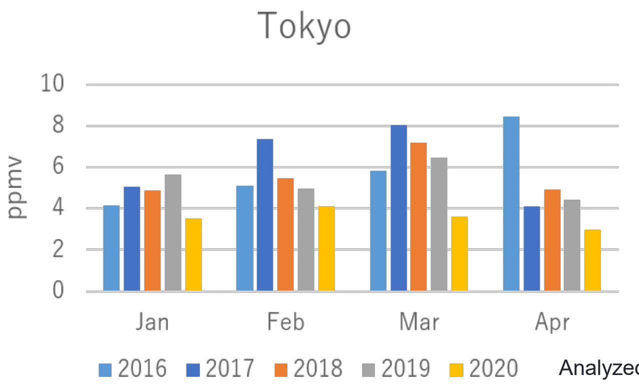


Beijing

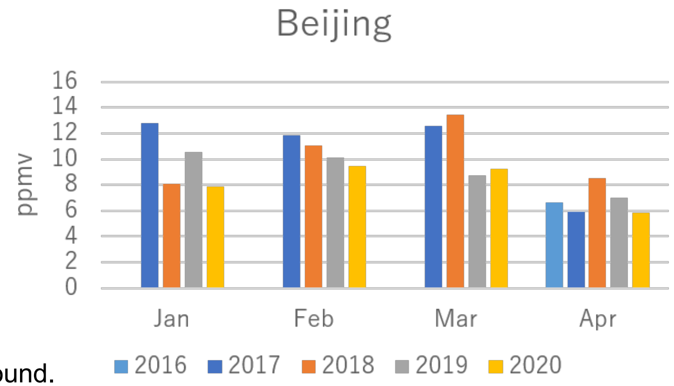


Analyzed by JAXA/EORC

The difference in CO_2 density in the upper and lower troposphere is smaller in 2020 compared to 2016-2019 in Tokyo and Beijing.



Analyzed by JAXA/EORC



Analyzed by JAXA/EORC

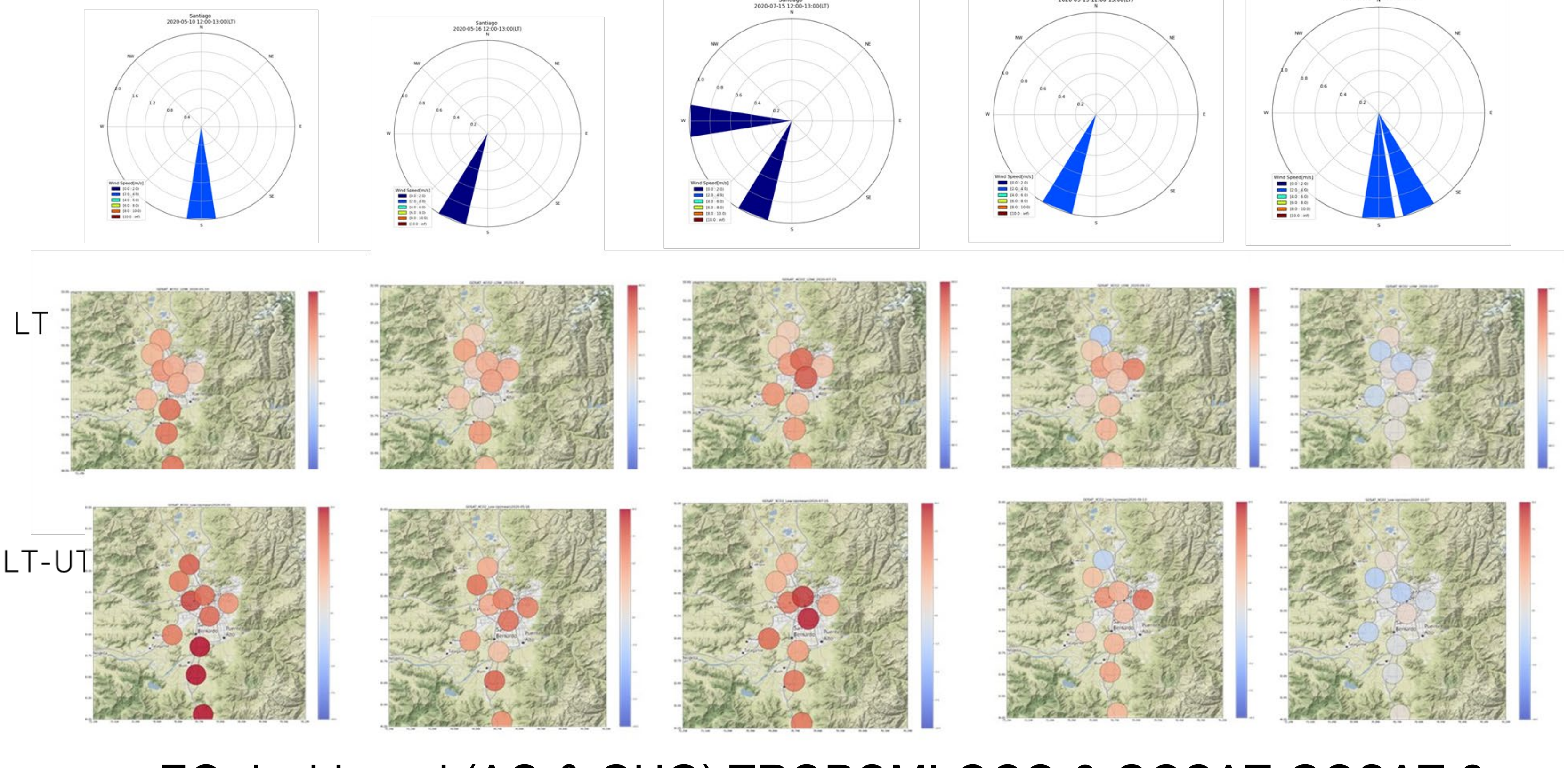
CO_2 has accumulated in the atmosphere since the Industrial Revolution. We assume the average density of the upper troposphere is a background.

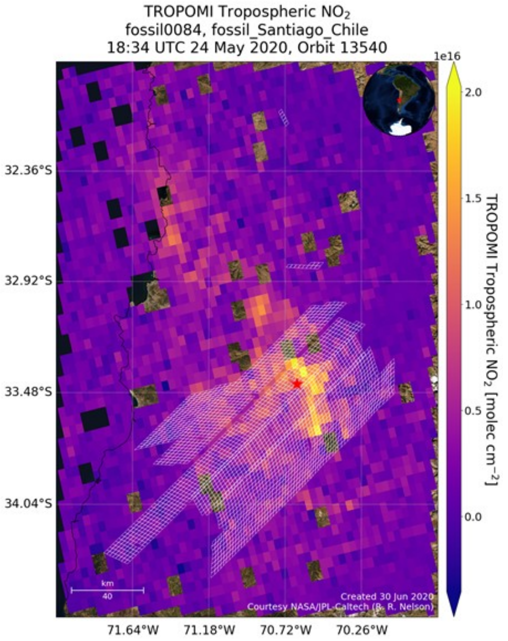
XCO_2 anomaly: $XCO_2(LT)-XCO_2(UT_{average})$, Partial column of lower troposphere (0-4 km)– Monthly-Area averaged upper troposphere (4-12 km)

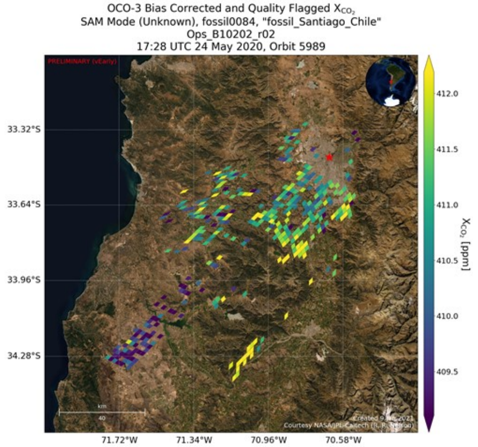
tri-lateral EO-dashboard: post COVID-19

Santiago

2020.5.10	2020.5.16	2020.7.15	2020.9.13	2020.10.7
2.7 m/s	1.3 m/s	1.3 m/s	2.7 m/s	3.6 m/s

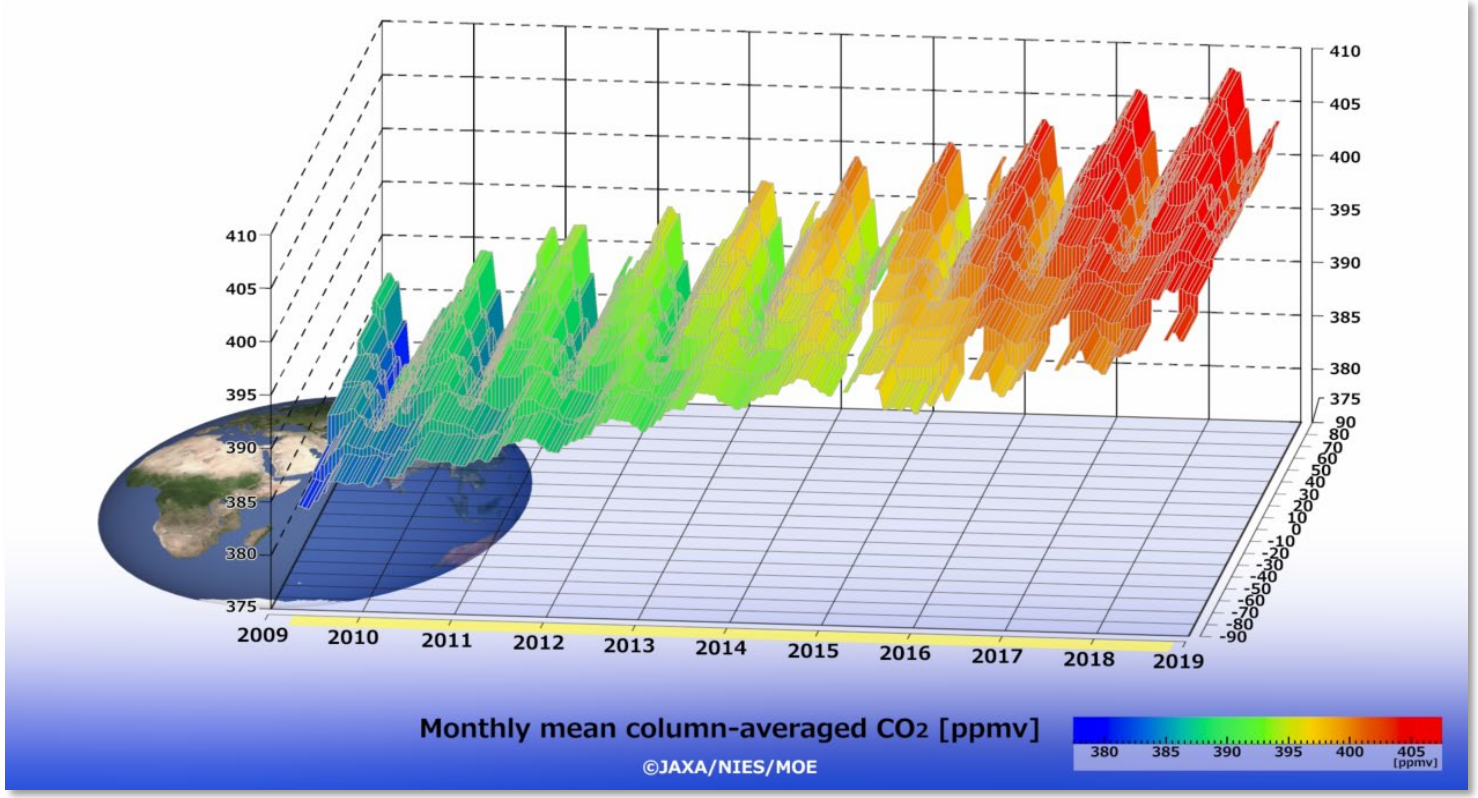






EO dashboard (AQ & GHG) TROPOMI-OCO-3-GOSAT-GOSAT-2

GOSAT 12-year operation in space



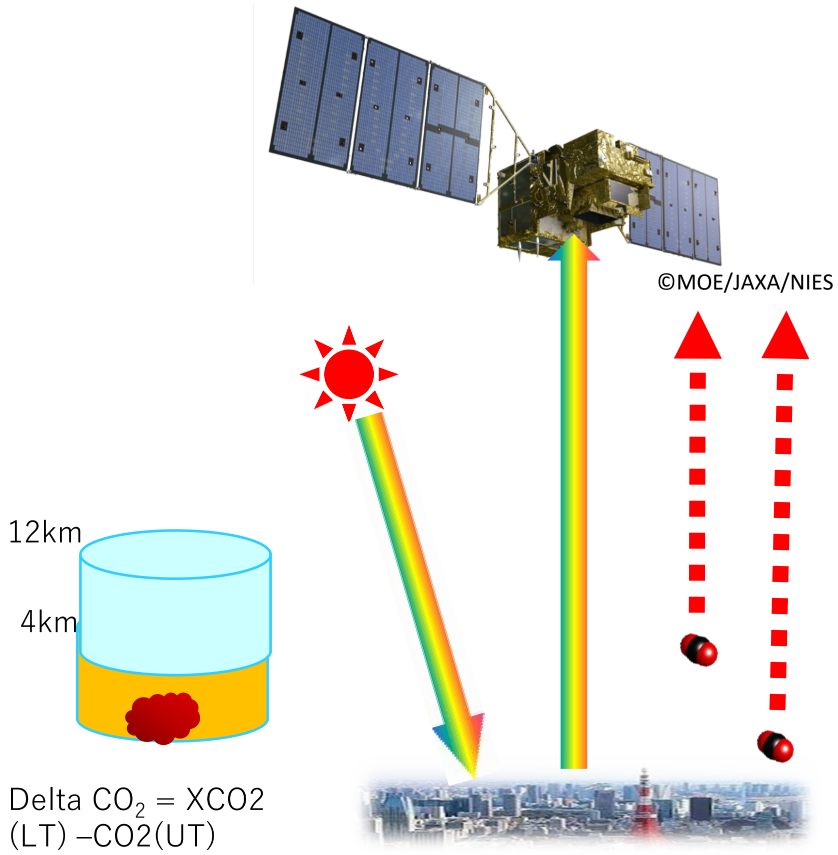
<Demonstrated in early years>

- Accurate and precise CO_2 (1.6 ppm (0.4 %)) CH_4 (13 ppb (0.7 %)) distribution measurements from space.
- Reduce the uncertainties in global and regional flux inverse estimates

Since 2015

Urgent needs for monitoring carbon emissions from intense localized sources, such as cities and power plants to contribute to the global stocktake of the Paris Agreement.

JAXA EORC Partial Column Products



FTS multiplex advantage
(1) SWIR constrains column density
(2) Two independent linear polarization data remove aerosol contamination.
(3) TIR provides difference in partial column density between lower and upper troposphere.

12 year GOSAT and 2 year GOSAT-2 products are available at
https://www.eorc.jaxa.jp/GOSAT/GPCG/index_GOSAT2.html
One file for one month global clear sky conditions,

CSV format, only 2 M byte per month file
XCO_2, XCH_4, XCO_2 (LT, UT), XCH_4 (LT, UT), XCO (GOSAT-2 only), aerosol optical thickness (AOT),Retrieved surface pressure (P), solar-induced chlorophyll fluorescence (SIF) time, geometry

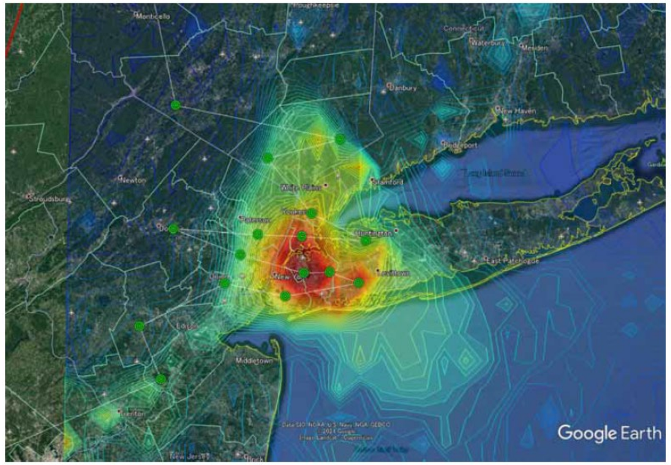
GOSAT-1 Version 1

yyyy/mm/dd	hh:mm:ss	Latitude	Longitude	LSFLG	XCO2_apr	XCO2_tot	XCO2_low	XCO2_upp	XCH4_apr	XCH4_tot	XCH4_low	XCH4_upp	XCO_apr	XCO_tot	Psrf_apr	Psrf_ret	AOT_076	AOT_160	AOT_206	SIF	Cloud	scanID
2019/01/01	01:13:04	-41.3061	173.4926	0	406.5682	397.9352	395.1537	399.3747	1.7439	1.7464	1.8315	1.7634	0.00000	0.00000	967.86	977.05	0.0963	0.0886	0.0820	10.4642	-1.000000	F190101011304
2019/01/01	02:46:15	-23.9153	151.2222	0	407.7506	402.3643	402.1988	403.2452	1.7683	1.8030	1.7950	1.8469	0.00000	0.00000	1007.32	1001.42	0.3487	0.3636	0.3583	1.2205	-1.000000	F190101024615
2019/01/01	02:47:06	-23.9548	148.3777	0	407.6141	404.1903	401.7923	406.6639	1.7696	1.8011	1.8437	1.8281	0.00000	0.00000	990.35	989.26	0.0255	0.0134	0.0110	-0.1822	-1.000000	F190101024706

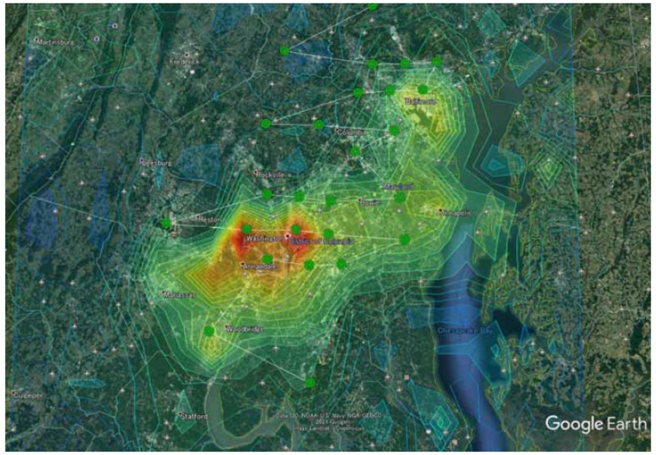
EO dashboard (AQ & GHG)
TROPOMI-OCO-3-GOSAT-GOSAT-2

GOSAT: long term data (2009-) Intense urban data since 2015
Number of target cities are limited due to onboard memories (about 500 targets per day)
High clear sky ratio cities:
Present dashboard cities: Beijing, Shanghai, Tokyo, New Deli, Mumbai, Dhakka, NYC
+ Santiago, Madrid, Lahore, Riyadh

GOSAT-2 Fully-customized target observation
About 50 world mega cities
10 US cities Atlanta, Baltimore-Washington, Boston, Chicago, Denver, LA Basin, Las Vegas, NYC + 2

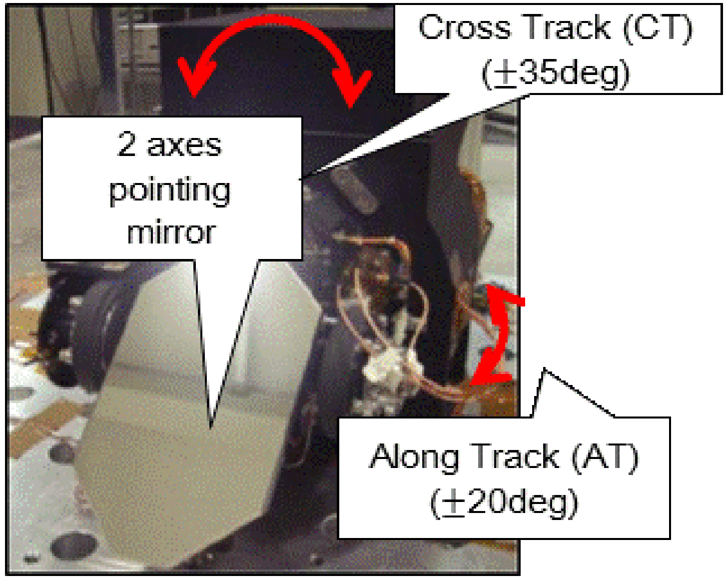


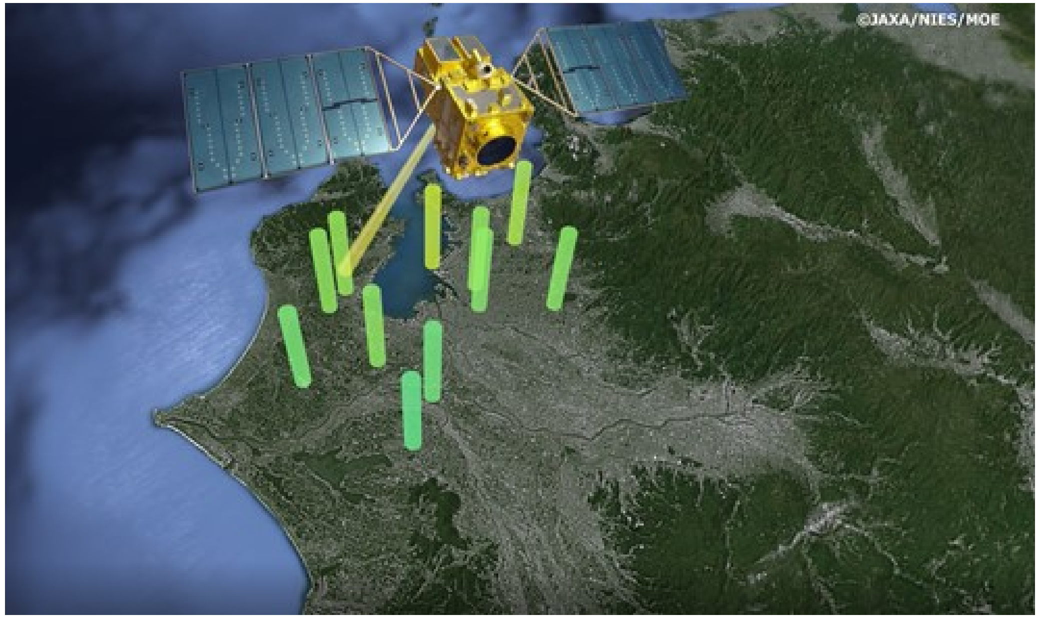
Path63 Baltimore,Washington



Atlanta, Baltimore-Washington, Boston, Chicago, Denver, LA Basin, Las Vegas, NYC

Target Observations with 2-axis Agile Pointing System



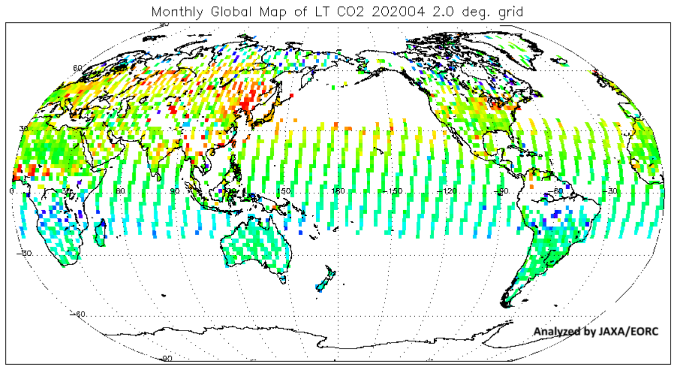


1. After the pointing mechanism was switched from primary to secondary on 26 January 2015, more frequent target observations
2. uploading AT and CT pointing angles and observation timing as commands from the ground every day
3. About 1000 locations are allocated to target observations such as calibration and validation site, megacities, or large emission sources.

Global and Local Flux

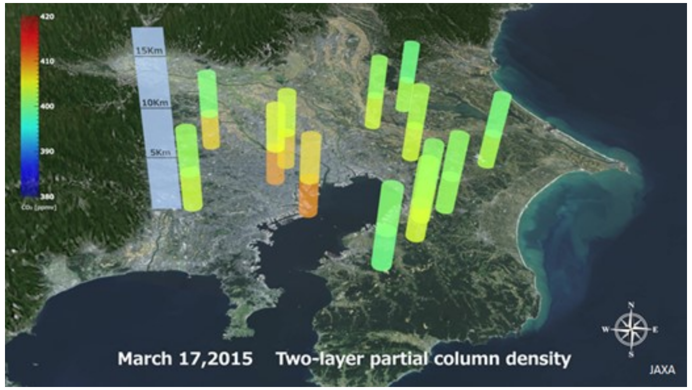
Global Flux

- Only satellites can provide global data
- Large footprint and/or sparse sampling
- Flux estimation needs models.
- Fit models well
- By adding satellite data, uncertainty in global flux has been reduced but still large.



Local flux from large emission sources

- Intense measurement using targeting capability.
- More direct estimation when wind direction and speed data are available



- Emission area information is needed.
- Plume structure helps estimation from individual source sectors.

CO_2: long life, small enhancement, quantitative information for flux estimation
NO_2: short life, higher sensitivity, identifying emission sources and characterizing plumes

Why NO_2 observation by an air-borne spectrometer is needed.

1. Local flux estimations using GOSAT include large uncertainties due to too large footprint, lack of proper upwind reference observation, and lack of wind information.

2. To contribute to the global stocktake of the Paris Agreement, we need an observation system to estimate local flux from individual source sectors.

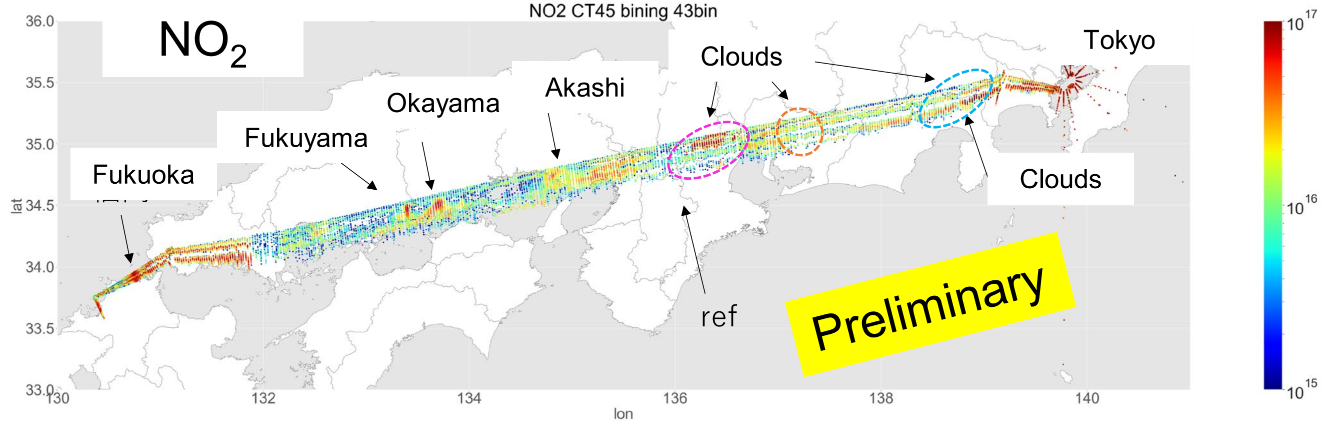
3. We have developed imaging spectrometer suites with optimized spectral resolution and coverage for air borne observations.

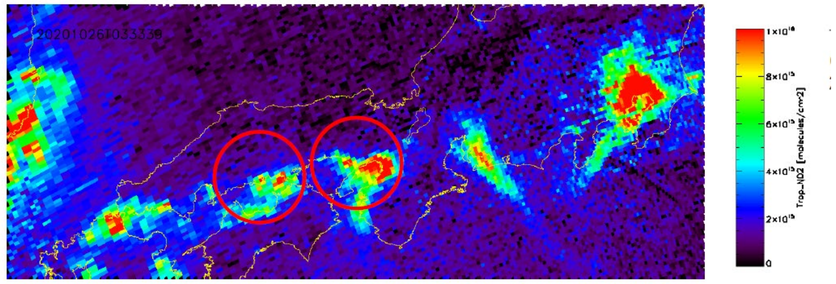
4. We flew over industrial zone and we acquired imaging data oxygen (O_2), CO_2, CH_4 and nitrogen dioxide (NO_2) under different wind conditions.

5. The NO_2 image with plume direction and spreading have detected CO_2 sources and provided wind information.

Identifying emission sources and polluted area

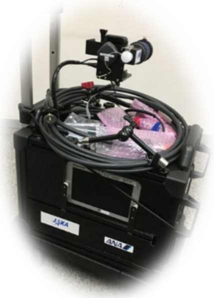
Simultanious measurements of NO_2, CO_2, CH_4, O_2A SIF using passenger aircrafts collaborating with ANA. Boeing 767 flight between Tokyo Haneda and Fukuoka-city

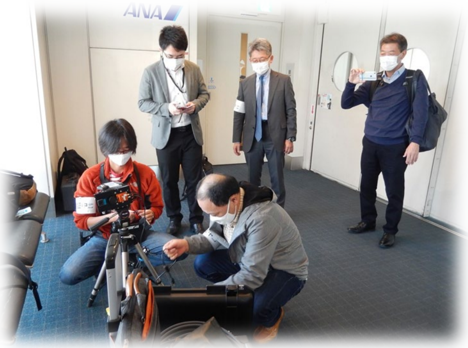


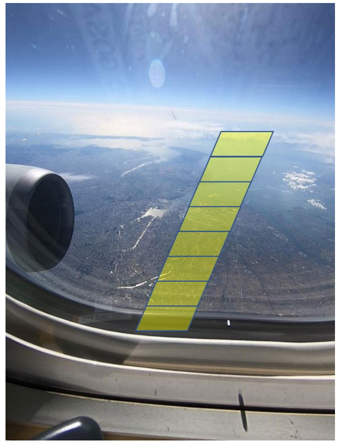


TROPOMI NO2, Oct. 26, 2020

First flight on Oct. 26 from Tokyo Haneda to Fukuoka flew over **Tokyo Bay area, Nagoya , Osaka, Okayama, Hiroshima, Kita-Kyushu, and Fukuoka**
Most of the major mega cities in Japan were included.







Carry-on size

Set up before boarding

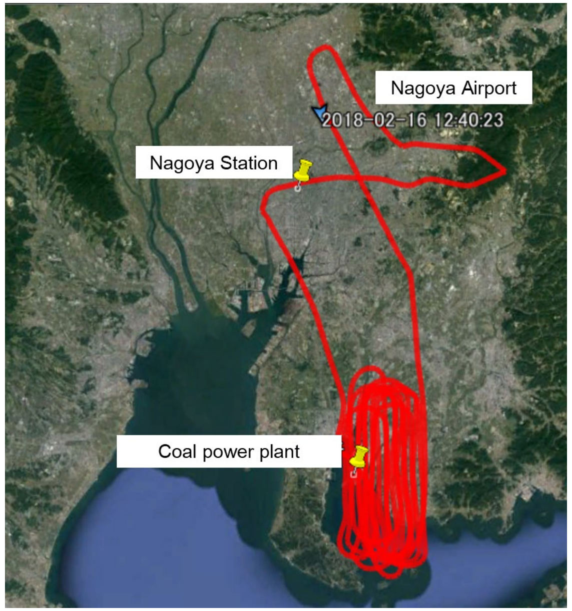
3 imaging spectrometers on cabin seats

Characterizing Plumes with fine scale CO_2 and NO_2 map

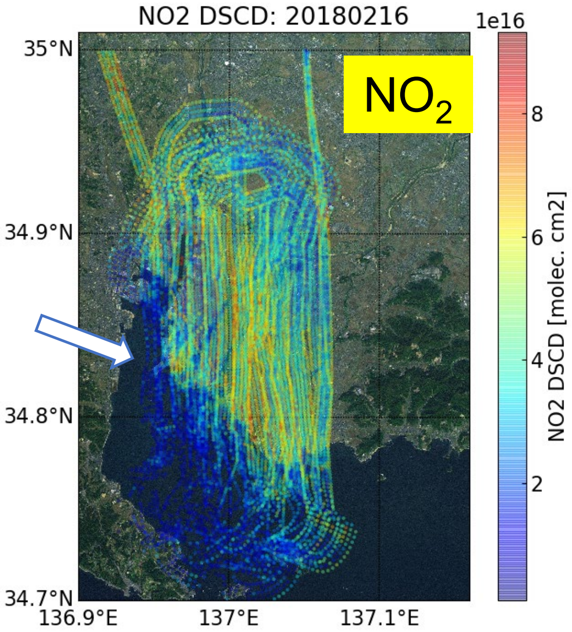
We confirmed coincident plume shape of CO_2 and NO_2
Can NO_2 map constrain plume and wind (speed and direction)?

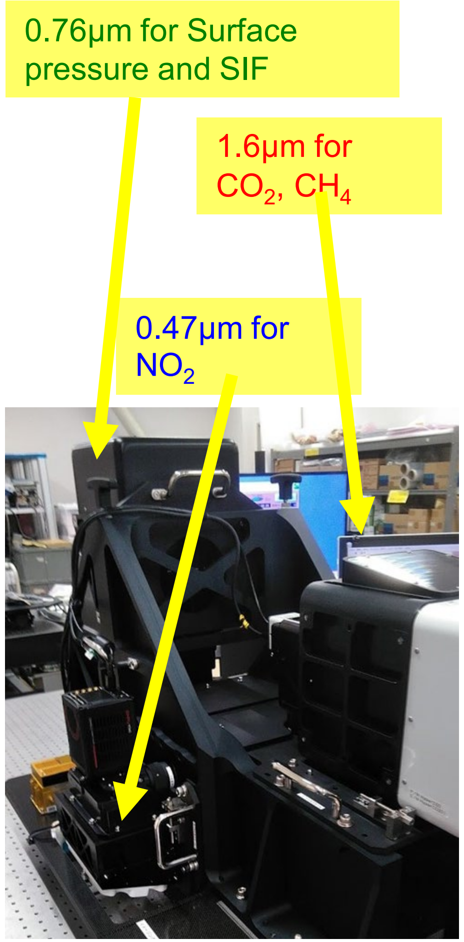
Feb 2018 flight over greater Nagoya

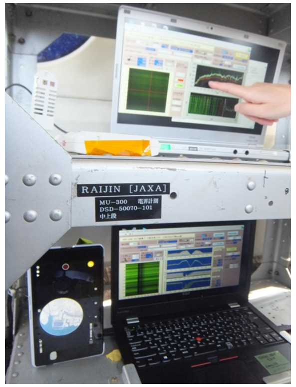
cruising altitude of 2893 m

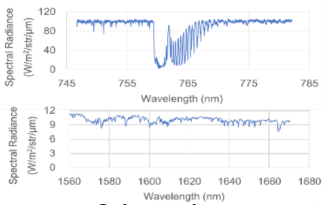


The wind direction and speed at the Nagoya Chubu Airport at noon were northwest and 3 m/s









3 imaging spectrometers (1.6, 0.76 μm, wide U-V) CO_2 CH_4 O_2 NO_2

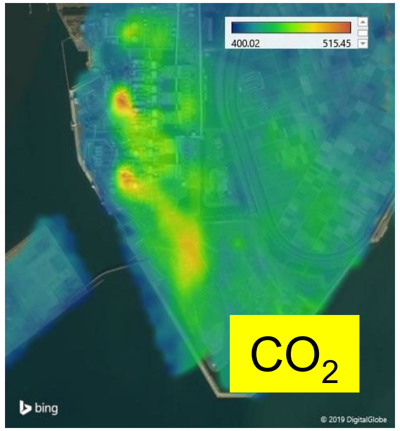
Different GHG source sector

location of greater Nagoya

CO_2: Poser plant, traffic, industry

CH_4: Waste water, liver stock,

Gas production



NO_2 Fujinawa et al. 2019
XCO_2 Kawashima et al. 2019

Upgraded spectrometers waiting for a next flight