Lower and upper tropospheric CO_2 and CH_4 observed by GOSAT and GOSAT-2 over anthropogenic emission sources since 2009

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Abstract

GOSAT and GOSAT-2 have simultaneously observed both reflected SWIR solar light and TIR emissions with a single FTS mechanism with the Thermal And Near-infrared Sensor for carbon Observation Fourier-Transform Spectrometer (TANSO-FTS) and TANSO-FTS-2 since 2009 and 2018, respectively. Their linear polarization bands provide information on light-path modification and make accurate remote sensing possible, even under aerosol and thin-cloud contaminated conditions. We can retrieve the difference between the partial column-averaged dry-air mole fractions of the two individual layers of lower and upper troposphere (LT and UT) by combining TIR and SWIR spectra data simultaneously, thereby constraining the accurate total column density of XCO2 and XCH4. TANSO-FTS has a two-axis agile pointing system, which allows cross-track and along-track motions It was originally designed for grid scan observations and viewing onboard calibration sources. After the pointing mechanism was switched from primary to secondary on 26 January 2015, We decided to make more frequent target observations, by uploading AT and CT pointing angles and observation timing as commands from the ground every day About 1000 locations are allocated to target observations such as calibration and validation site, megacities, or large emission sources. We define vertical layers of LT and UT not by temperature, but by the retrieved Psurf from individual O2 A band data. The pressure-height ranges of the LT and UT were taken as 0.6–1 Psurf and 0.2–0.6 Psurf, respectively. As the LT includes the entire boundary layer, analysis using XCO2 (LT) and XCH4 (LT) can double the signal of local emissions and remove the effects of CO2 and CH4 variability in the UT, which typically extends over a much wider area. We have targeted intense measurements over mega cities since 2016. We assume the average density of the upper troposphere is a background. We define XCO2 anomalies XCO2(LT)-XCO2(UT average), which show enhancement caused by local anthropogenic emissions. In 2020, we detected lower anomalies than previous years over mega cities such as Tokyo, Beijing, and New York.

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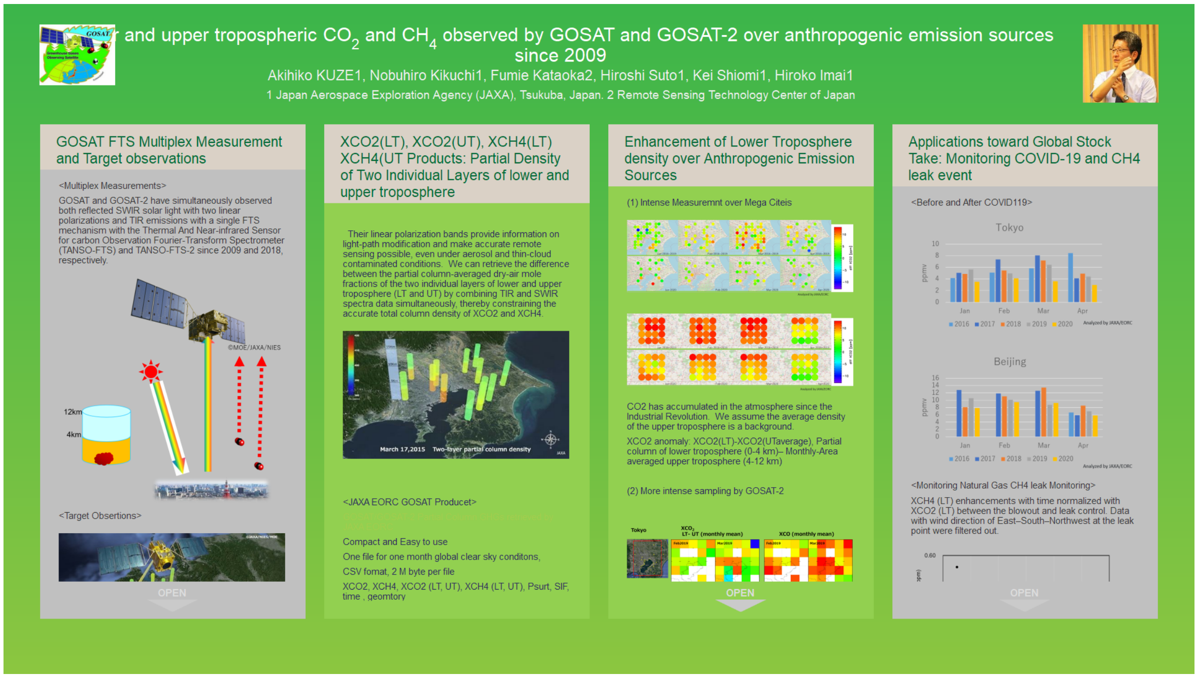

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AGU FALL MEETING
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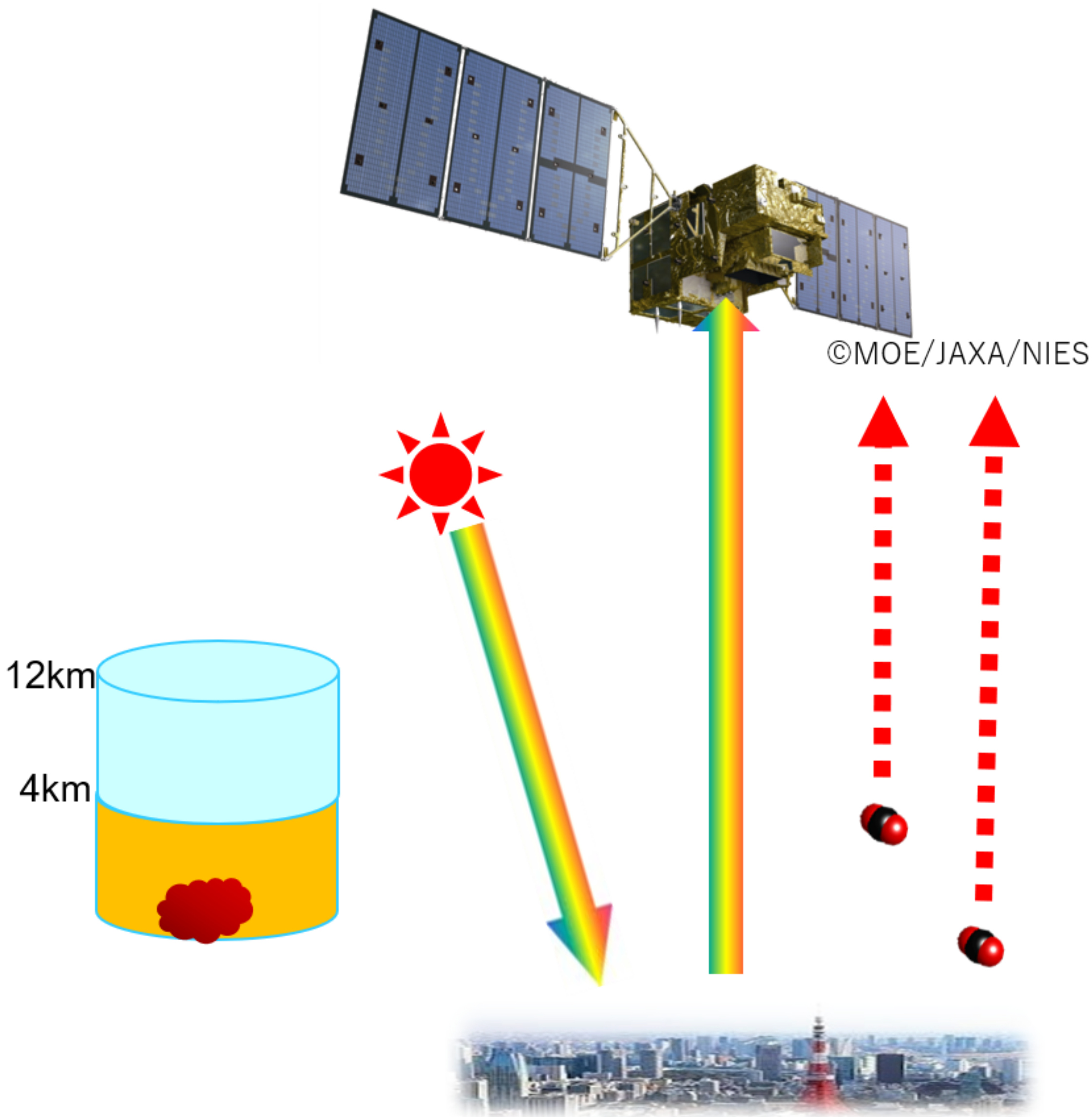
GOSAT FTS MULTIPLEX MEASUREMENT AND TARGET OBSERVATIONS

<Multiplex Measurements>

GOSAT and GOSAT-2 have simultaneously observed both reflected SWIR solar light with two linear polarizations and TIR emissions with a single FTS mechanism with the Thermal And Near-infrared Sensor for carbon Observation Fourier-Transform Spectrometer (TANSO-FTS) and TANSO-FTS-2 since 2009 and 2018, respectively.



<Target Obsertions>

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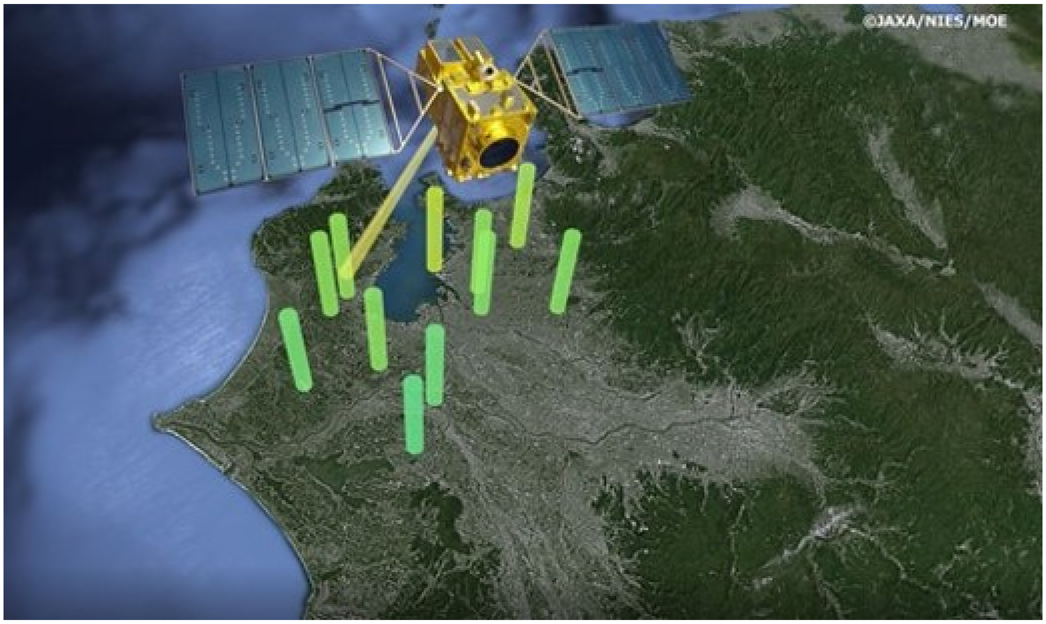
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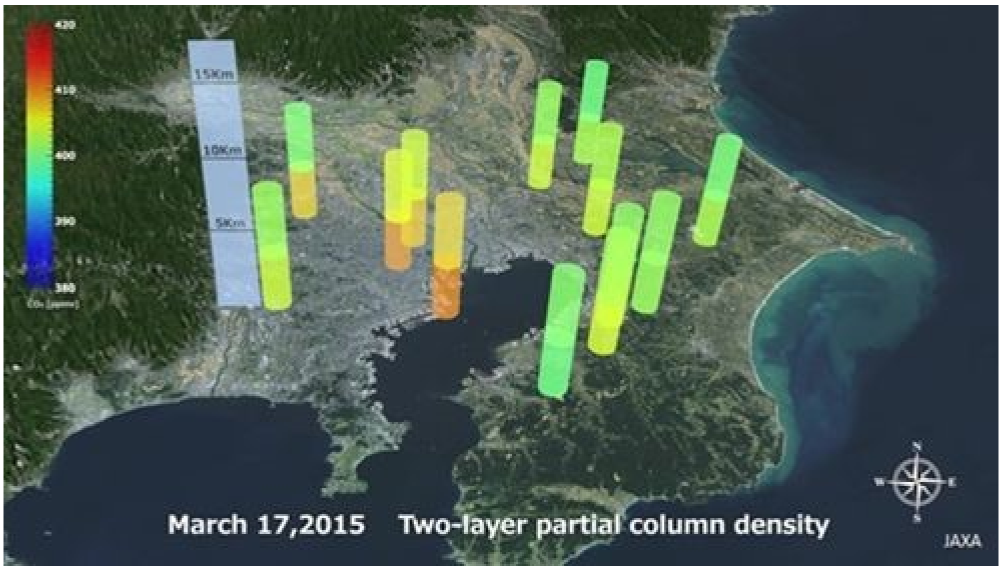
XCO2(LT), XCO2(UT), XCH4(LT) XCH4(UT PRODUCTS: PARTIAL DENSITY OF TWO INDIVIDUAL LAYERS OF LOWER AND UPPER TROPOSPHERE

Their linear polarization bands provide information on light-path modification and make accurate remote sensing possible, even under aerosol and thin-cloud contaminated conditions. We can retrieve the difference between the partial column-averaged dry-air mole fractions of the two individual layers of lower and upper troposphere (LT and UT) by combining TIR and SWIR spectra data simultaneously, thereby constraining the accurate total column density of XCO2 and XCH4.



GOSAT/GOSAT-2 Partial Column GHGs retrieved by JAXA EORC (https://www.eorc.jaxa.jp/GOSAT/GPCG/index_GOSAT.html)

<JAXA EORC GOSAT Producet>

EORC research products are available at https://www.eorc.jaxa.jp/GOSAT/GPCG/index_GOSAT2.html (https://www.eorc.jaxa.jp/GOSAT/GPCG/index_GOSAT2.html)

They are compact and easy to use.

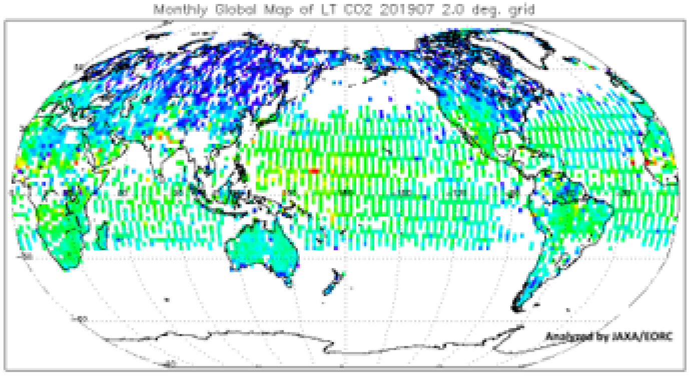
One file for one month global clear sky conditons,

CSV fomat, 2 M byte per file

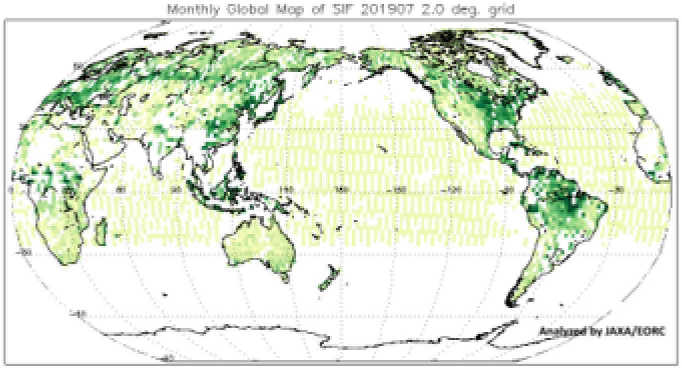
XCO_2, XCH_4, XCO2 (LT, UT), XCH4 (LT, UT), aerosol optical thickness (AOT),Retrieved surface pressure (P_{surf}), solar-induced chlorophyll fluorescence (SIF) time , geomtory

The followins are examaples of July 2019 global map of (XCO2(LT)-XCO2(UT)) and SIF by GOSAT-2.

Monthly Global Map of LT CO2 201907 2.0 deg. grid



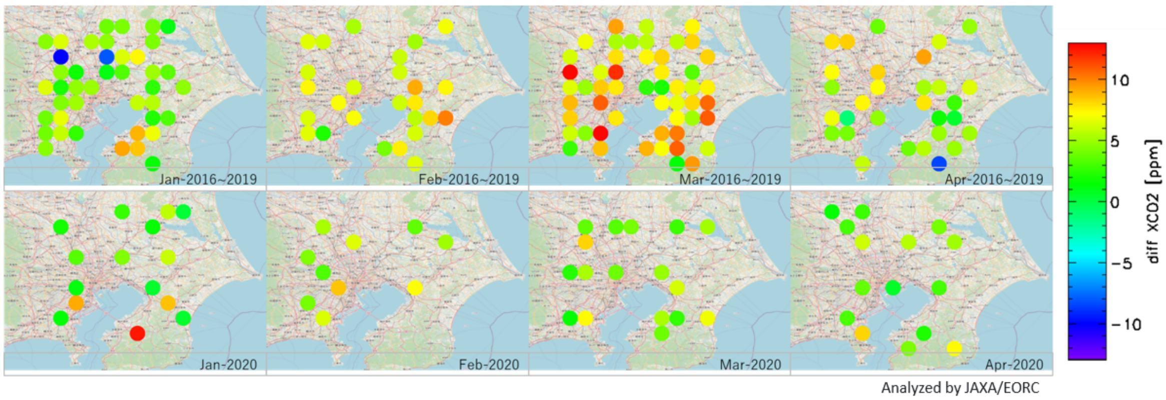
Monthly Global Map of SIF 201907 2.0 deg. grid

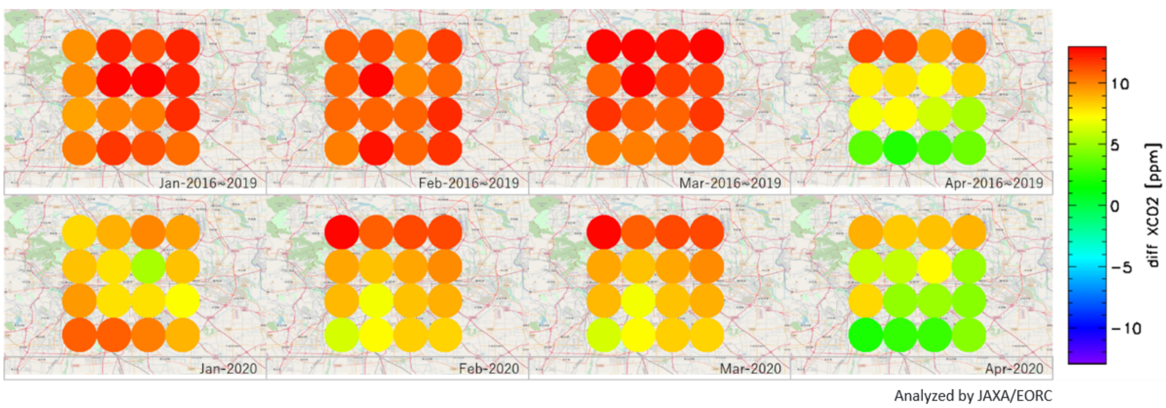


ENHANCEMENT OF LOWER TROPOSPHERE DENSITY OVER ANTHROPOGENIC EMISSION SOURCES

(1) Intense Measuremnt over Mega Citeis

Average monthly abundances of CO_2 in the lower troposphere for the past 4 years (upper) and 2020 (lower) from GOSAT of greater Ttokyo and Beiging.



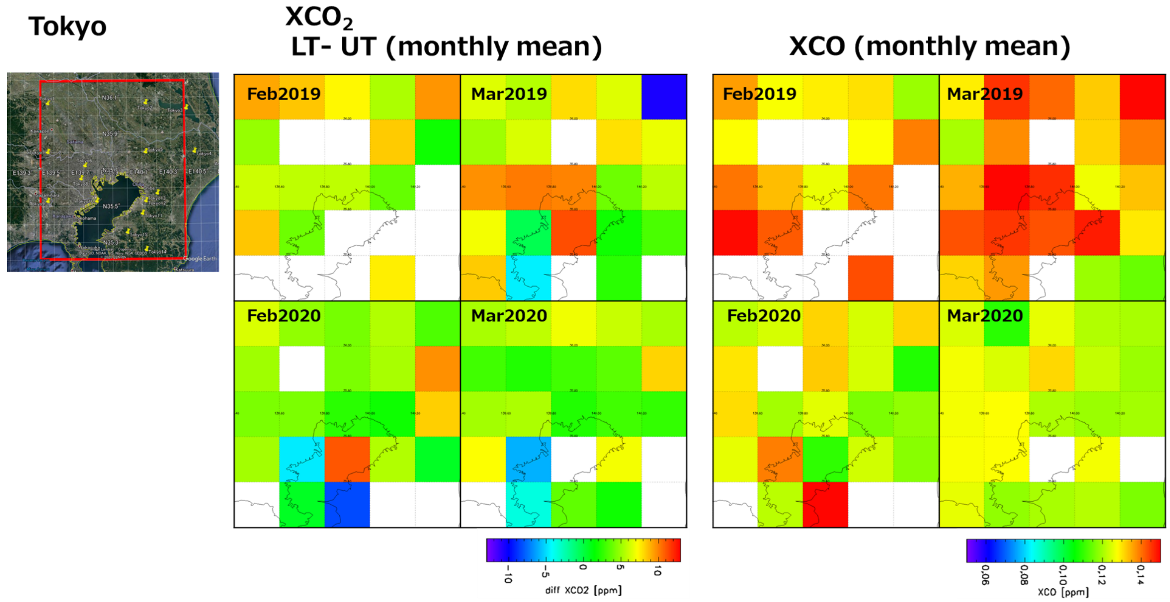


CO_2 has accumulated in the atmosphere since the Industrial Revolution. We assume the average density of the upper troposphere is a background.

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)

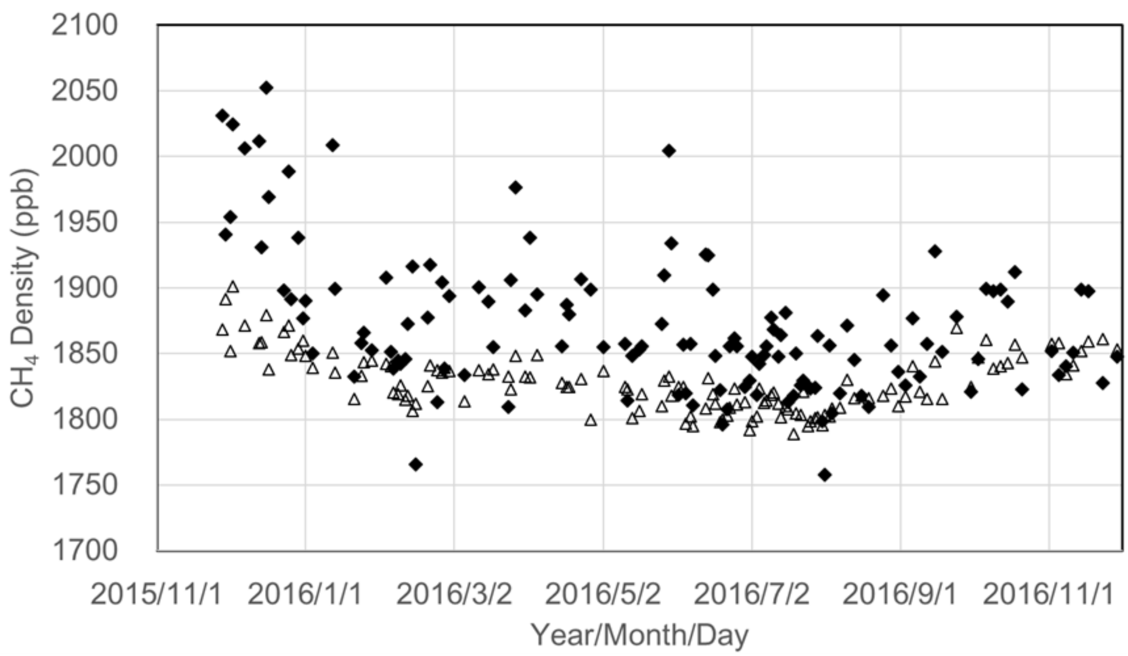
(2) More intense sampling by GOSAT-2

With wider pointing range, GOSAT-2 can provide more intense data over megacities. It also provide CO in addition to CO_2



(3) XCH_4(LT) and XCH_4(UT) at Aliso Canyon CA

CH4 total partial column-averaged dry-air mole fractions (XCH_4) (triangles) and the lower troposphere (XCH_4 (LT)) (diamonds) at Aliso Canyon.

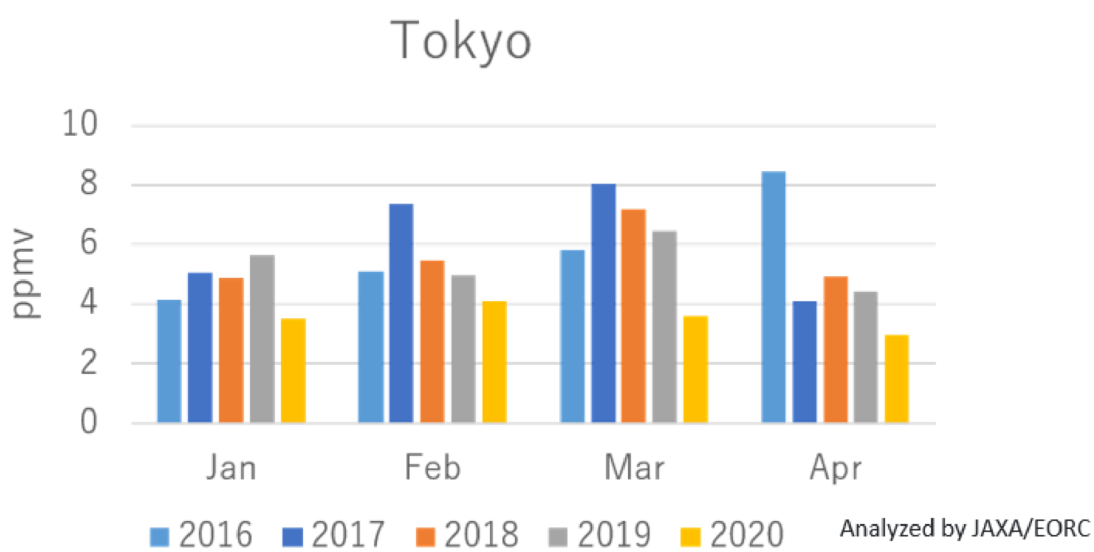


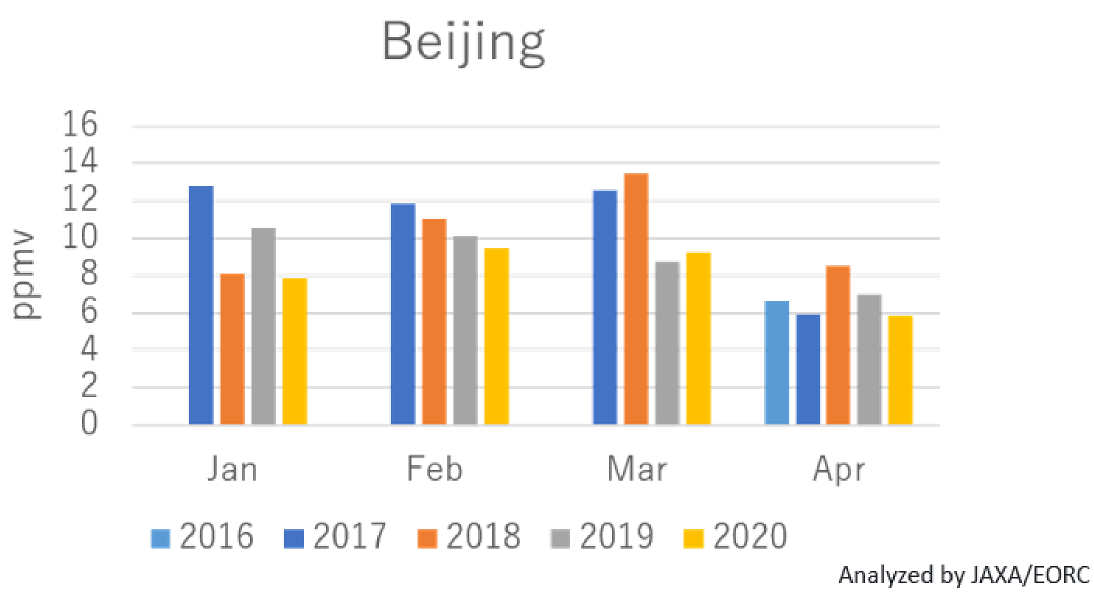
(Kuze et al., 2020, Remote Sensing)

APPLICATIONS TOWARD GLOBAL STOCK TAKE: MONITORING COVID-19 AND CH4 LEAK EVENT

<Before and After COVID119>

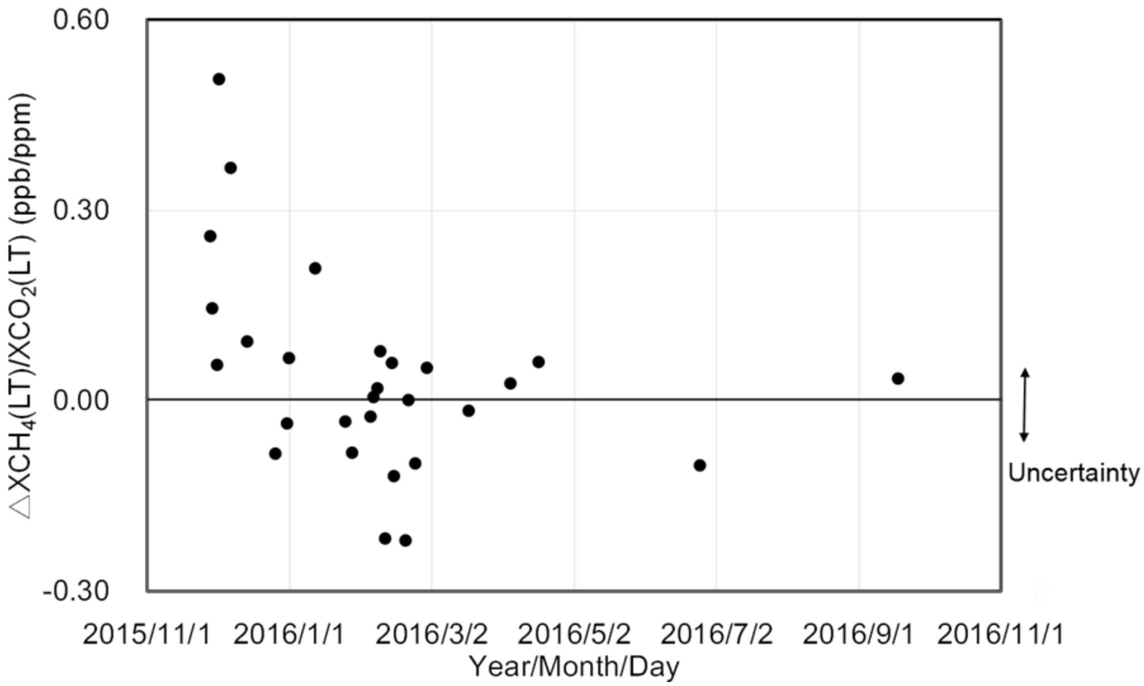
The difference in CO_2 density in the upper and lower troposphere is smaller in 2020 compared to 2016-2019 in Tokyo and Beijing.





<Monitoring Natural Gas CH_4 leak Monitoring>

XCH_4 (LT) enhancements in Aliso Canyon with time normalized with XCO_2 (LT) between the blowout and leak control. Data with wind direction of East–South–Northwest at the leak point were filtered out.



(Kuze et al., 2020, Remote Sensing)

<Next: Contribution to Paris Agreement>

•Consider whether temporary reductions in CO2 emissions due to COVID-19 restrictions have impacts on lowering the global carbon footprint.

•Continue and extend target observations to more than 50 cities.

•Estimate GHG emissions from individual source sectors such as power plant, transport, industries.

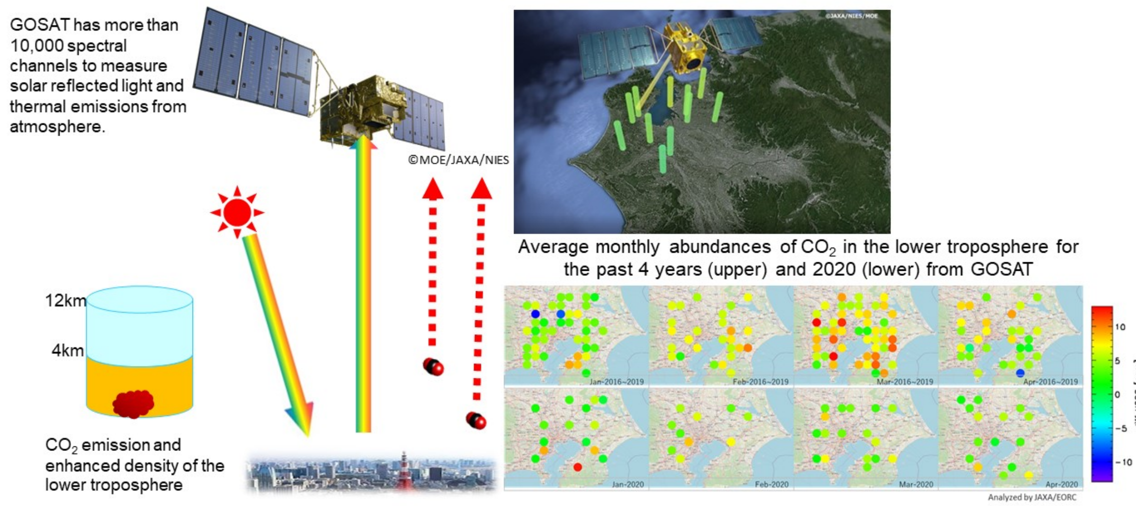
•Contribute to the Global Stocktake of the Paris Agreement.

AUTHOR INFORMATION

Kuze has been involved in the Greenhouse gases Observing Satellite (GOSAT) project for 18 years for developing on-board instruments, calibrations and operation, Level 0-1 processing of GOSAT data and the GOSAT Level 1 products. Now he is the GOSA-2 project manager. He is also involved in the feasibility study on an air-bone compact imaging spectrometer with angstrom spectral resolution for greenhouse gases, air quality and chlorophyll fluorescence measurements. When he was at Smithsonian astrophysical observatory, he was involved in cloud detection of GOME and SCIAMACHY.

ABSTRACT

GOSAT and GOSAT-2 have simultaneously observed both reflected SWIR solar light and TIR emissions with a single FTS mechanism with the Thermal And Near-infrared Sensor for carbon Observation Fourier-Transform Spectrometer (TANSO-FTS) and TANSO-FTS-2 since 2009 and 2018, respectively. Their linear polarization bands provide information on light-path modification and make accurate remote sensing possible, even under aerosol and thin-cloud contaminated conditions. We can retrieve the difference between the partial column-averaged dry-air mole fractions of the two individual layers of lower and upper troposphere (LT and UT) by combining TIR and SWIR spectra data simultaneously, thereby constraining the accurate total column density of XCO_2 and XCH_4. TANSO-FTS has a two-axis agile pointing system, which allows cross-track and along-track motions It was originally designed for grid scan observations and viewing onboard calibration sources. After the pointing mechanism was switched from primary to secondary on 26 January 2015, We decided to make more frequent target observations, by uploading AT and CT pointing angles and observation timing as commands from the ground every day About 1000 locations are allocated to target observations such as calibration and validation site, megacities, or large emission sources. We define vertical layers of LT and UT not by temperature, but by the retrieved P_{surf} from individual O_2 *A* band data. The pressure-height ranges of the LT and UT were taken as 0.6–1 P_{surf} and 0.2–0.6 P_{surf}, respectively. As the LT includes the entire boundary layer, analysis using XCO_2 (LT) and XCH_4 (LT) can double the signal of local emissions and remove the effects of CO_2 and CH_4 variability in the UT, which typically extends over a much wider area. We have targeted intense measurements over mega cities since 2016. We assume the average density of the upper troposphere is a background. We define XCO2 anomalies XCO_2(LT)-XCO_2(UT average), which show enhancement caused by local anthropogenic emissions. In 2020, we detected lower anomalies than previous years over mega cities such as Tokyo, Beijing, and New York.



(https://agu.confex.com/data/abstract/agu/fm20/2/6/Paper_676562_abstract_646228_0.jpg)

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