Status of the Rikubetsu, Tsukuba, and Burgos TCCON sites 2026

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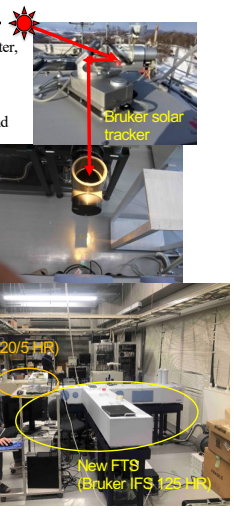
Rikubetsu TCCON (also NDACC) site

- Observation site: Rikubetsu Integrated Stratospheric Observation Center, NIES, Rikubetsu, Japan (43.4567° N,143.7661° E, Altitude 380 m)
- FTS: Bruker IFS 120/5 HR for TCCON + low resolution (0.5 cm^{-1}) and NDACC measurements
  Beam splitter: CaF_2 and KBr
  Detectors: Si, InGaAs, InSb and HgCdTe
  Instrument resolution: 0.02–0.0035 cm^{-1}
- On GOSAT series overpass and and OCO-2/3 target mode days, we will measure the solar absorption spectra with TCCON mode from morning to early-evening.
  On not GOSAT series overpass day, NDACC mode in the morning and TCCON mode from 11 am to early-evening.
- TCCON mode: 2-μm InGaAs det. and Si det. dual, reso. 0.02 cm^{-1}, Sample: 7.5 kHz, LPF: 10 kHz, APT: 0.5 mm, a Pins: 0, DC F&R single scans.
- NDACC mode: NDACC filters #1, #2, #3, #4, #5, and #6 (reso. 0,0035 cm^{-1}) AC F & R, in total 10 min measurement time.
- HBr cell measurements for MIR, HCl gas cell and ghost lamp measurements for NIR are made once a month.
- An operator is measuring spectra and the system is not fully automated.
- Test measurement with a new FTS (IFS 125 HR) is in progress.



Tsukuba TCCON (also NDACC and COCCON) site



- Observation site: NIES, Tsukuba, Japan (36.0513° N, 140.1215° E, Altitude 31 m)
- Bruker IFS 125 HR FTS for TCCON + low resolution (0.5 cm^{-1}) and NDACC measurements
  Beam splitter: CaF_2 and KBr
  Detectors: Si, InGaAs, InSb, and HgCdTe
  Instrument resolution: 0.02 – 0.0035 cm^{-1}
- On GOSAT series overpass and OCO-2/3 target mode days, we are measuring the solar absorption spectra with TCCON mode from morning to early-evening.
  On other days, we are measuring with NDACC mode in the morning and TCCON mode after NDACC mode to evening.
- TCCON mode: InGaAs det. and Si det. dual, reso. 0.02 cm^{-1}, Sample: 7.5 kHz, LPF: 10 kHz, APT: 1 mm, a Pins: 0, DC F&R single scans.
- NDACC mode: NDACC filters #1, #2, #3, #4, #5 and #6 (reso. 0.0035 cm^{-1}).
  AC F & R, in total 10 min measurement time.
- HBr cell measurements for MIR, HCl gas cell and ghost lamp measurements for NIR are performed once a month. HCl measurements using solar light has been initiated on 26 Sep 2022.
- An operator is measuring spectra and the system is not fully automated.
- Bruker EM27/SUN for COCCON measurements. EM27/SUN installed in a simple shelter is deployed on the roof of the Climate Change Research Building at NIES.

Burgos TCCON site

- Observation site: EDC Burgos Wind Power Corp., Burgos, Philippines (18.5325 N, 120.6496 E, Altitude:35 m)
- Bruker IFS 125 HR FTS and a solar tracker with CamTracker function
  Beam splitter: CaF_2; Detectors: Si, InGaAs, InSb*, and HgCdTe* (*on standby); max. resolution: 0.0035 cm^{-1} (257 cm OPD); ghost and NDACC filters; no HCl cell in solar measurement; operation by remote control; no Liquid N_2.
- Weather station according to TCCON data protocol: Temp., humidity inside and outside of the container, wind speed and direction, and pyranometer, surface pressure and rain sensor.
- Mie LIDAR: 1064 and 532 nm, two polarizations for aerosol and cirrus profiles up to the stratosphere.
- Sky radiometer: aerosol and cloud AOD, SSA etc.

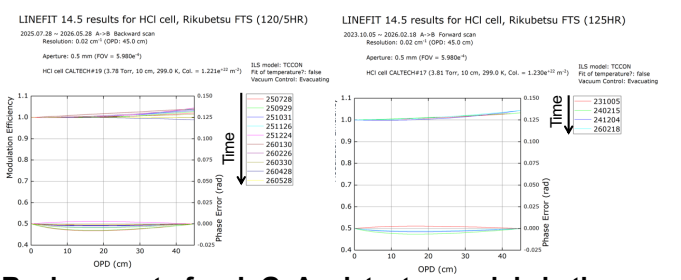




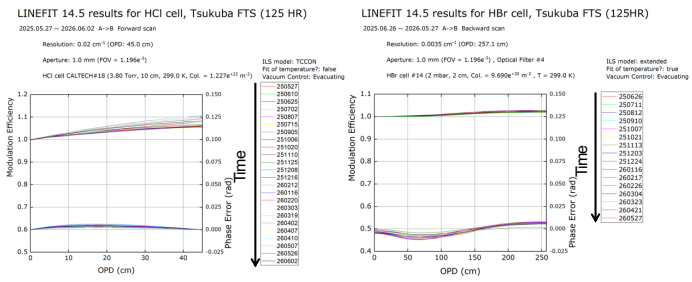
↑Sky radiometer and NIES EM27/SUN (EMeRGe Campaign only).

←: TCCON FTS with other NIES instruments: GOSAT-2 LIDAR, Sky radiometer and weather station.

ILS retrieved from gas cell measurements with old (left) and new (right) FTSs



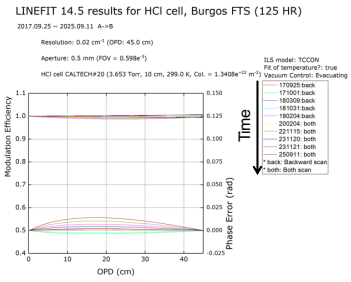
ILS retrieved from gas cell measurements



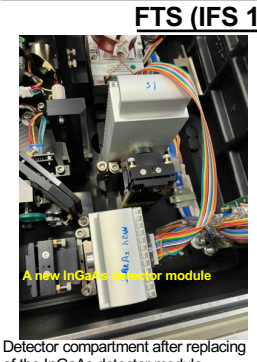
Alignment and modulation efficiency history

ME @45cm OPD with 0.5mm apt. &HCl Cell orientation A->B

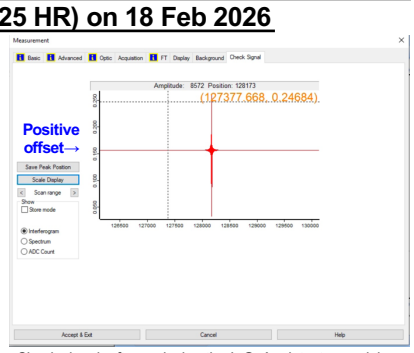
Date (YY/MM/DD)	FWD	REV	AVE	Caltech Cell#	Remarks
17/09/25	0.9923	1.0070	0.9997	20	&cj20170925_1310
17/09/25	1.0110	1.0100	1.0105	22	&cj20170925_1909
18/03/09	1.0050	0.9944	0.9997	20	&cj20180309_1221
18/10/31	0.9999	1.0090	1.0045	20	&cj20181031_2048 Possibly affected by earthquake
19/02/04	1.0080	0.9974	1.0027	20	&cj20190204_1255
19/11/22			0.9980	20	&60 scans, FWD & REV combined. Results range: 99.4 to 100.2, New SIOS laser, cj20191120_1025
20/02/04			1.005	20	&60 scans, FWD & REV combined cj20200204_1243
22/11/18			0.9927	20	60 scans, Cell side B ->A. cj20221118_1209. New SIOS laser
23/11/21			1.005	20	&60 scans, cj20231120_1510



Replacement of an InGaAs detector module in the new FTS (IFS 125 HR) on 18 Feb 2026



Detector compartment after replacing of the InGaAs detector module



Check signal after replacing the InGaAs detector module

Check-signal using the HCl gas cell measurement XPM (DC sampling) in the atmosphere

	Before replacement	After replacement
APT=0.5 mm, R 1, Peak-to Peak:	2093, offset: -0.0310	Peak-to peak: 2161, offset: 0.0394
APT=0.8 mm, R 1, Peak-to Peak:	6088, offset: -0.1135	Peak-to peak: 6108, offset: 0.1116
APT=1.0 mm, R 1, Peak-to Peak:	10075, offset: -0.1889	Peak-to peak: 10109, offset: 0.1855
APT=1.5 mm, R 1, Peak-to Peak:	25062, offset: -0.4734	Peak-to peak: 25360, offset: 0.4655

Fixed the detachment of the solar tracker dome drive wheel as Emergency repairs on 17 Nov 2025



Drive wheel detached from the motor (1st time, 7 Nov 2025).



Jack-up operation.



Checking the drive wheel's set screw.



Emergency repairs to the rotating drive wheel completed!



Inspection of the motor shaft.



Adding lubricant to the elevation-direction Window of the solar tracker dome.

Maintenance works on 2 – 6 Feb 2026







After works by Jmaterial Corporation: (Left) new outdoor air conditioning units and transformer and breaker boxes, (Top right) FTS side indoor unit and indoor breaker box. (Bottom right) LIDAR side indoor unit have been installed.

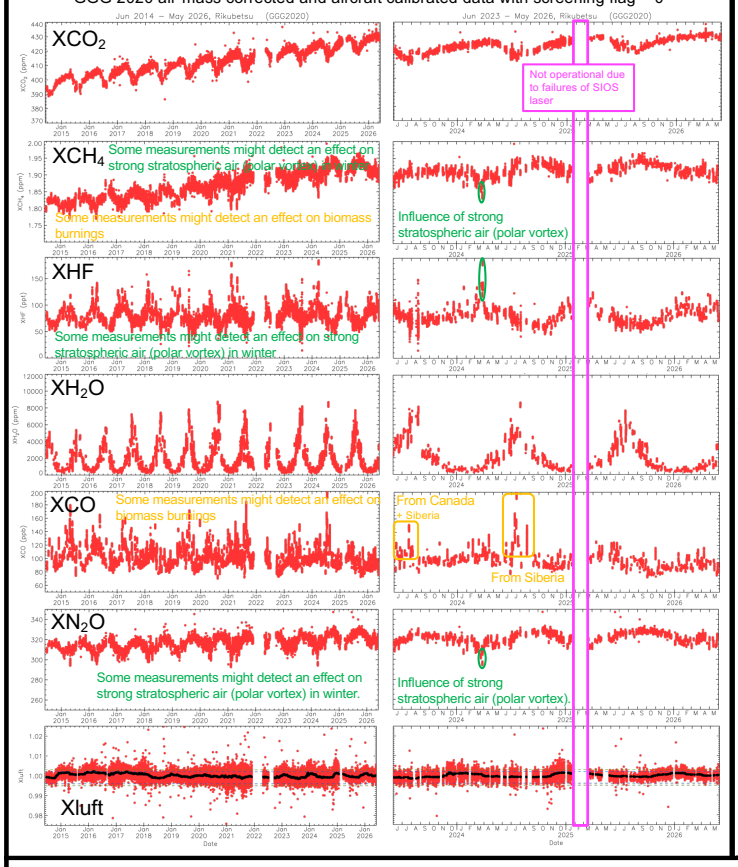




The wiring for the solar tracker hatch's rooftop junction boxes has been completed.

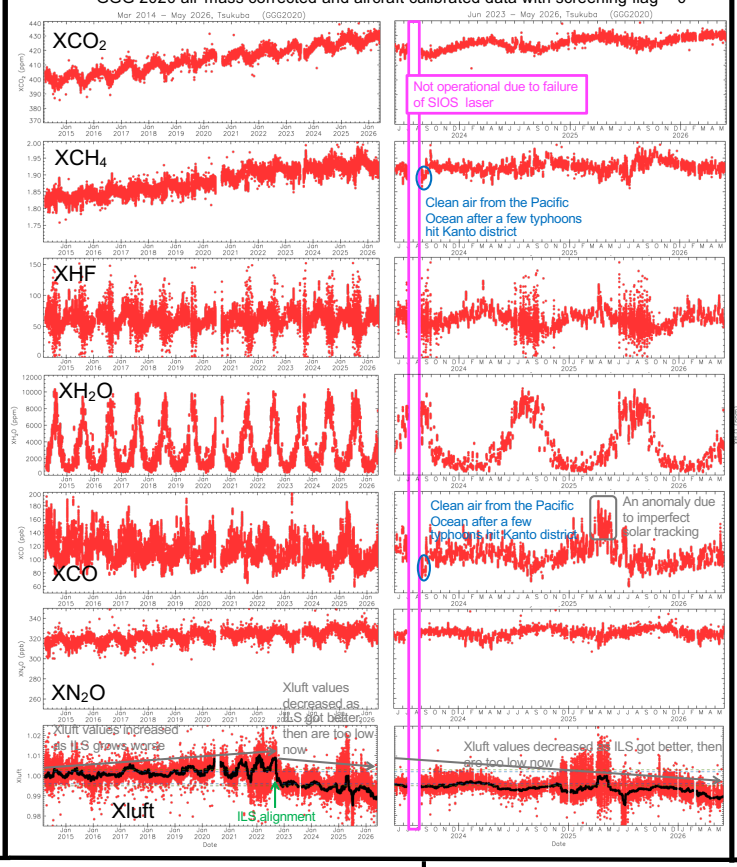
TCCON measurements with Rikubetsu old FTS (IFS 120/5 HR)

GGG 2020 air-mass corrected and aircraft calibrated data with screening flag = 0



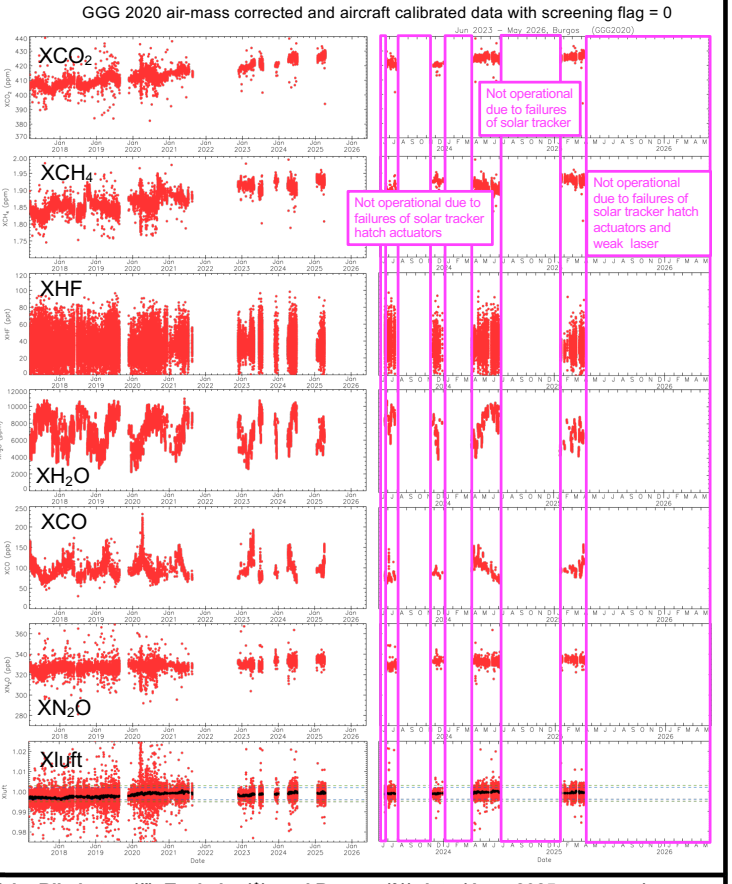
TCCON measurements with Tsukuba FTS (125 HR)

GGG 2020 air-mass corrected and aircraft calibrated data with screening flag = 0



TCCON measurements with Burgos FTS (125 HR)

GGG 2020 air-mass corrected and aircraft calibrated data with screening flag = 0



Summary and issues

Rikubetsu site

- No issue with the old FTS (IFS 120/5 HR) since June 2025
- 18 Feb 2026
  Replacement of the InGaAs detector module in the new FTS.
- We have issues we must do:
  - Replace with a new FTS PC and camera for the solar tracker for an old FTS (IFS 120/5 HR) (scheduled for 3 - 7 Aug 2026),
  - Connect weather station instruments to an FTS PC,
  - A safety valve will be attached to the the old FTS (IFS 120/5 HR) scroll pump.
  - Make EM27/SUN measurements together with the new FTS (IFS 125 HR) and the old FTS (IFS 120/5 HR) with 0.5 and 0.02 cm^{-1} resolution in the next visit (probably summer and winter).

Tsukuba site

- 17 Jul 2025 at 14:00 JST, 29 Jul 2025 at 11:50 JST, and 4 Nov 2025 at 11:50 JST
  We found solar beam was ~1 mm shifted relative to the 1 mm diameter aperture. Solar beam alignment was made by adjusting the final mirror before FTS.
- 7 Nov 2025
  The drive wheel directly connected to the dome motor for the solar tracker dome came off.
- 12 Nov, 09 Dec 2025, 16 Dec 2025
  Astro Optics did the emergency repair for two times and fixed the detachment of the solar tracker dome drive wheel.
- 15 June 2026
  Astro Optics carried out maintenance on the solar tracker dome (electronics, gearbox and drive wheels).
- We have three things we must do:
  - Timing error present TCCON measurements from 2021 – 2022 and 2024 - 2025. The possible cause for the timing error may be poor solar tracking. We will submit the analyzed GGG2020 data with the report ASPS.
  - There is another issue related to Xluft (it is below the lower limit), so we think more than half of the data will not be released. We will align the interferometer in 2027 FY.
  - A safety valve will be attached to the FTS scroll pump.

Burgos site

- 9 – 12 Sep 2025: site maintenance
  We replaced a broken laser with a repaired one, checked the solar tracker hatch wiring, made site investigations for two air conditioners with a Philippines local company. We also checked sky radiometer and replaced a new UPS for sky radiometer, cleaned a CaF_2 window, and checked the weather station. We could make TCCON measurements on 11 and 12 Sep 2025, as well as gas cell, and ghost lamp measurements. BUT we were unable to finish repairing the solar tracker hatch.
- 3 – 6 Feb 2026: site maintenance
  We repaired the solar tracker hatch, air conditioners, internet connection, and replaced transformer and breaker power boxes. But after these repairs, we found the intensity of the laser was very weak and it was unable to operate FTS.
- 24 – 27 Feb 2026: site maintenance for LIDAR
- We have issues we must do:
  - Carry out site works (aligning laser, recovering limit switch fail, replacing rain sensor and wiring for the solar tracker hatch, replacement of flash lamp for YAG laser).

Acknowledgements

- GOSAT series project supports in part the Rikubetsu, Tsukuba, and Burgos FTS operations.
- First Philippine Holdings and the Energy Development Corporation for hosting the Burgos TCCON site. Special thanks for the Philippines TCCON project to Oscar M. Lopez, Chairman Federico Lopez, Richard Tantoco, Agnes de Jesus, Sherwin Mervin Burton Lucas, Andy Durog, Cesar Aguilar, the Winbu Control Room team and all EBWPC, EDC and FPH executives and staff.

Publication list with use of the Rikubetsu (#), Tsukuba ($), and Burgos (%) data (June 2025 – present)

1. # % *Awad, M.M. et al., High-Resolution Daily XCH4 Prediction Using New Convolutional Neural Network Autoencoder Model and Remote Sensing Data. Atmos., 2025, 16, 806.
2. # *Rakitin, V. et al., Principles of Correction for Long-Term Orbital Observations of Atmospheric Composition, Applied to AIRS v.6 CH4 and CO Data. Remote Sens. 2025, 17, 2323.
3. $ *Choi, J., et al., (2025) Joint inversion of satellite-based isoprene and formaldehyde observations to constrain emissions of nonmethane volatile organic compounds. J. Geophysics Research :Atmos., 130, e2024JD042070.
4. # $ % Das, S., et al. (2025) Comparisons of the v11.1 Orbiting Carbon Observatory-2 (OCO-2) XCO2 measurements with GGG2020 TCCON. Earth and Space Science, 12, e2024EA003935.
5. # Van Malderen, R. et al., Global ground-based tropospheric ozone measurements: reference data and individual site trends (2000–2022) from the TOAR-II/HEGIFTOM project, Atmos. Chem. Phys., 25, 7187–7225, 2025.
6. # $ % Tsuruta, A., et al., Global CH4 fluxes derived from JAXA/GOSAT lower-tropospheric partial column data and the CarbonTracker Europe-CH4 atmospheric inverse model, Atmos. Chem. Phys., 25, 7829–7862, 2025.
7. # $ % *Mauceri, S. et al. (2025) Uncertainty-aware machine learning bias correction and filtering for OCO-2: 1. Earth and Space Science, 12, e2025EA004328.
8. $ % *Wu, S., et al., A Random Forest-Based CO2 Profile Emulator for Real-Time Prior Profile Generation in TanSat XCO2 Retrieval. Remote Sens. 2025, 17, 2764.
9. # % *Lee, J. et al. (2025) Synergy of multiple-satellite measurements to fill the gap of global XCO2. J. Geophysics Research: Atmos., 130,e2024JD042809.
10. # $ *Callewaert, S., et al., WRF-Chem study of the greenhouse gas column and in situ surface concentrations observed in Xianghe, China – Part 1: Methane (CH4), Atmos. Chem. Phys., 25, 9519–9544.
11. # $ Van Malderen, R. et al., Ground-based tropospheric ozone measurements: regional tropospheric ozone column trends from the TOAR-II/HEGIFTOM homogenized datasets, Atmos. Chem. Phys., 25, 9905–9935, 2025.
12. # $ *Pais, S.M. et al., High-Spatial-Resolution Estimation of XCO2 Using a Stacked Ensemble Model. Remote Sens. 2025, 17, 3415.
13. % *Z. Liang, et al., An optimal sequential physical retrieval system for retrieving high-accuracy diurnal atmospheric gases from FY-4B/GIIRS: Theory, algorithm and evaluation, Remote Sens. Environ., 328, 2025, 114901.
14. # $ % *Wang, Z., et al., A full-coverage satellite-based global atmospheric CO2 dataset at 0.05° resolution from 2015 to 2021 for exploring global carbon dynamics, Earth Syst. Sci. Data, 17, 5355–5375, 2025.
15. # $ % *F. Mustafa et al., Estimating global anthropogenic carbon dioxide emissions using satellite observations and machine learning methods, Atmos. Environ., 360, 2025, 121423
16. # % *Li, Y. et al. Analysis of the Current Situation of CO2 Satellite Observation. Remote Sens. 2025, 17, 3635.
17. # $ % Barr, A. G., et al., Five years of GOSAT-2 retrievals with RemoTeC: XCO2 and XCH4 data products with quality filtering by machine learning, Atmos. Meas. Tech., 18, 6093–6123, 2025.
18. # $ Voshtani, S., et al., Quantifying CO emissions from boreal wildfires by assimilating TROPOMI and TCCON observations, Atmos. Chem. Phys., 25, 15527–15565, 2025.
19. # $ % *Wolfgang M. et al., Global 20-year time series of XCO2 concentrations derived from satellite observations and interpolations to analyze XCO2 anomalies caused by wildfires, Atmos. Research, 328, 2026, 108408
20. # $ *Callewaert, S., et al., A WRF-Chem study of the greenhouse gas column and in situ surface mole fractions observed at Xianghe, China – Part 2: Sensitivity of carbon dioxide (CO2) simulations to critical model parameters, Atmos. Chem. Phys., 26, 899–921, 2026.
21. # $ *Jie Li, Ziyi Zhang, Tongwen Li, Qiangqiang Yuan, Liangpei Zhang, Global daily seamless XCO2 Mapping (2016–2020): Spatio-temporal trends and variations during wildfire events, Interna. J. Ap. Earth Obser. Geoinfor., 146, 2026, 105092
22. # $ % *Yang, J., et al., Substantial Discrepancies Across Global Satellite XCO2 Products: A Systematic Evaluation. Remote Sens. 2026, 18, 371.
23. # $ % *Hwang, S., et al., (2026). Reconstructing long-term (2003–2019) global high-resolution XCO2: bridging observational gaps with machine learning. GIScience & Remote Sens., 63(1).
24. # Mostafavi Pak, N. et al., Annual growth rates of column-averaged CO2 inferred from Total Carbon Column Observing Network (TCCON), Biogeosciences, 23, 1477–1495, 2026.
25. # $ % *J. Wang, Global daily 1 km gapless XCO2 (2003–2023) derived from multi-satellite observations and a spatiotemporal deep learning framework, Environ. Impact Assess. Review, 117, 2026, 108146
26. # $ Wu, J., et al., (2026) The post-2020 surge in global atmospheric methane observed in ground-based observations. Earth and Space Science, 13, e2024EA003669.
27. # $ *Wei S., et al., Mapping daily 1-km resolution XCO2 in China using deep learning and multi-source data, Resources, Conser. Recyc., 227, 2026, 108755
28. # $ Friedrich, M., et al., Identifying trend reversals in atmospheric ethane from a multi-site analysis. Climatic Change 179, 66 (2026).
29. # $ *Hu, Z. et al., Spatiotemporal Evolution of XCO2 in East Asia (2016–2024) Across Different Climate Zones Based on GOSAT and OCO-2 Data Fusion. Remote Sens. 2026, 18, 1004.
30. # *Rakitin, V., et al., Validation of Long-Term Methane (CH4) Satellite Measurements from the AIRS Spectrometer and Correction of Their Temporal Drift. Remote Sens. 2026, 18, 1162.
31. $ Enders, V., et al., Towards routine shipborne measurements of columnar CO2, CH4, CO, and NO2: a case study for tracking regional-scale emission patterns, Atmos. Meas. Tech., 19, 2633–2655, 2026.
32. # $ % *Y. Yu, et al., MCF-XCO2: A cross-mission consistency and fusion framework for integrating multi-satellite XCO2 observations, Atmos. Research, 334, 2026, 108747.
33. # $ % *L. Yin, et al., A Dual-Transformer Network for Spatiotemporal Modeling of Carbon Dioxide Column Concentration (XCO2) on the Basis of Dynamic Heterogeneous Graphs, Transactions in GIS, 30(3), 2026, e70275

* Publications that do not include coauthors working at this site but have significantly utilized Rikubetsu and Tsukuba TCCON data warrant inclusion in this list.