Ground-based measurements of XCO2 using grating spectrometers for validating GOSAT target observations over the Greater Tokyo Area

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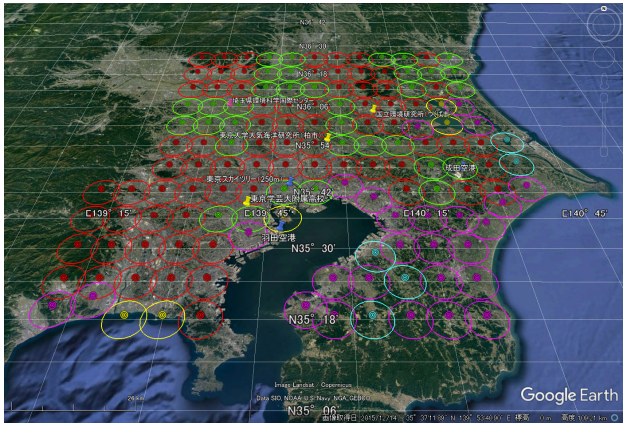
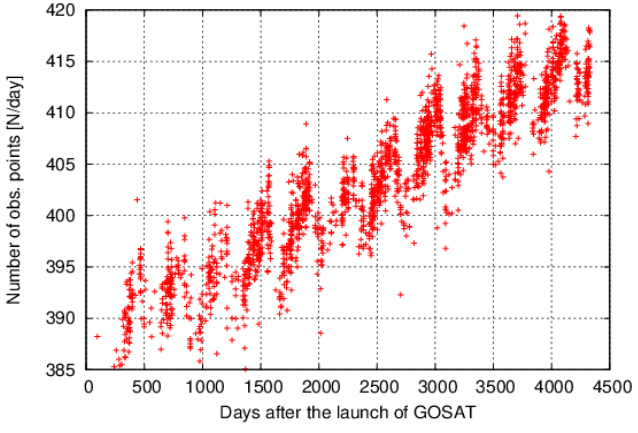
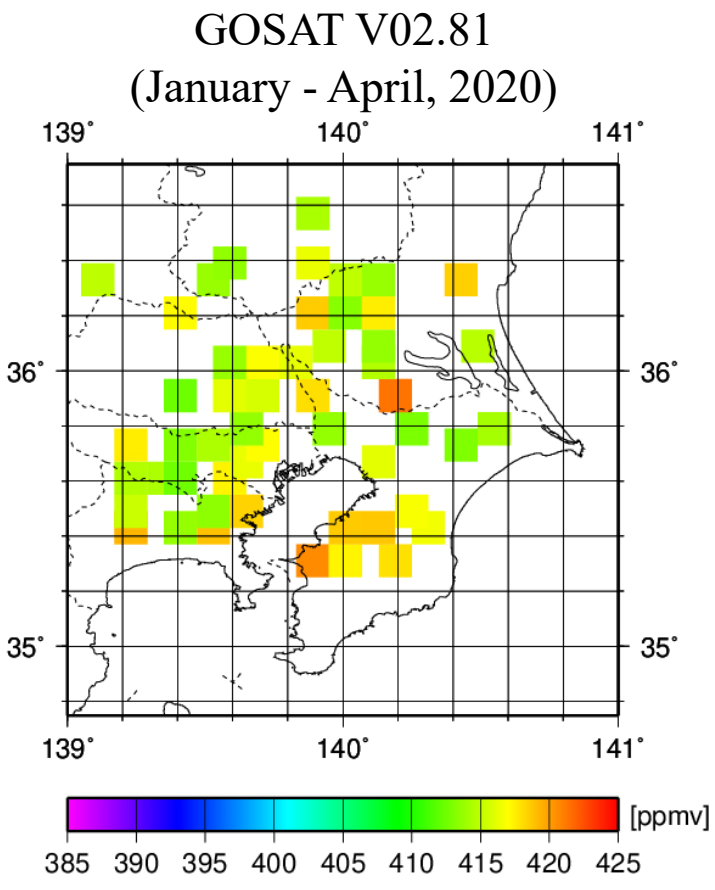
GOSAT target observation

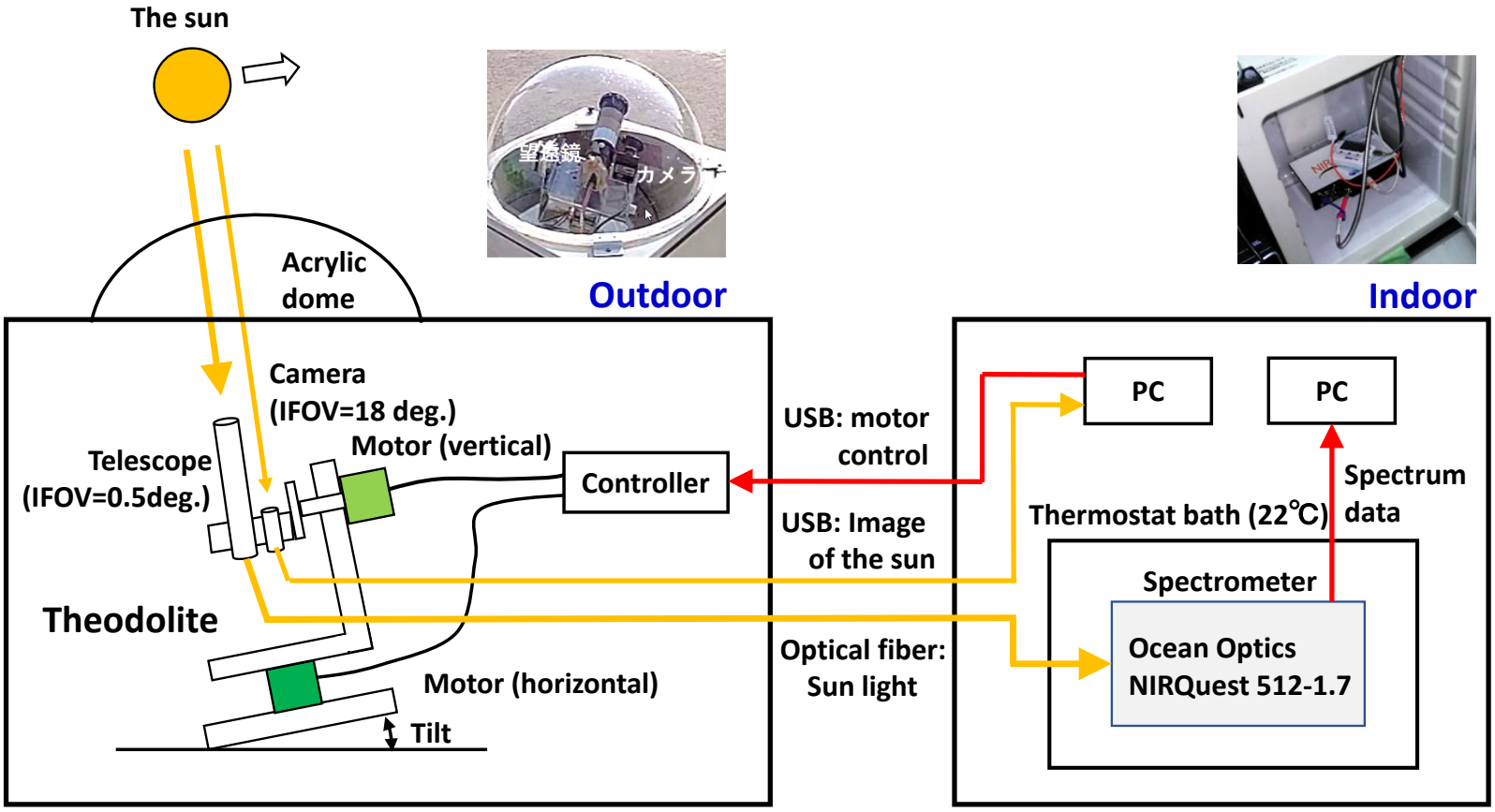






- GOSAT target observations over the Greater Tokyo area (Kanto Plain) have been conducted by the science team from 2010
- " Compact Array Spectrometer Targeting Local Emissions of CO_2 (CASTLE-CO_2)" has been developed to validate satellite data and transport simulations
- CASTLE-CO_2 has been operated at 5 sites in Kanto Plain covering both urban and suburb area from 2020
- XCO2 observed by a CASTLE-CO_2 were compared with TCCON data at NIES, Tsukuba, and the results showed good agreement

Instrumentation: CASTLE-CO_2



- CASTLE-CO_2 consists of a sun tracking system (field camera and telescope on a theodolite) and a grating spectrometer connected to a telescope by fiber cable
- Sun tracking system is kept in an acrylic dome and is not needed to be covered even under the rain condition
- The system can be automatically operated and the data can be downloaded remotely via the internet

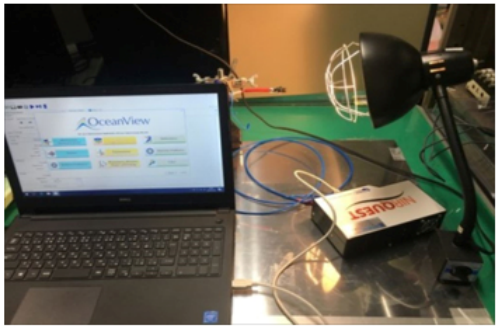
[Specs]

Spectrometer : NIRQuest512-1.7 (512 pixels)
Entrance Slit : 200 μm
Grating NIR14, 900 – 1700 nm, 1000 l/mm, Blazed at 1310 nm
High signal-to-noise ratio: 15,000:1 to 7500:1,Spectrometer

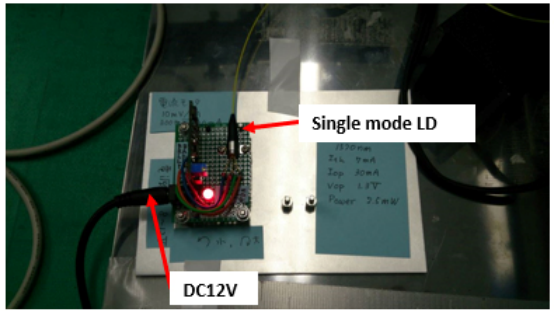
High Resolution: from <1nm to 12nm (slit and detector dependent) to suit your application
Small and lightweight: 182 x 110 x 47 mm and 1.2 kg
16 bit, 500KHz A/D converter
USB 2.0 480Mbps :

Characterizations of CASTLE-CO_2

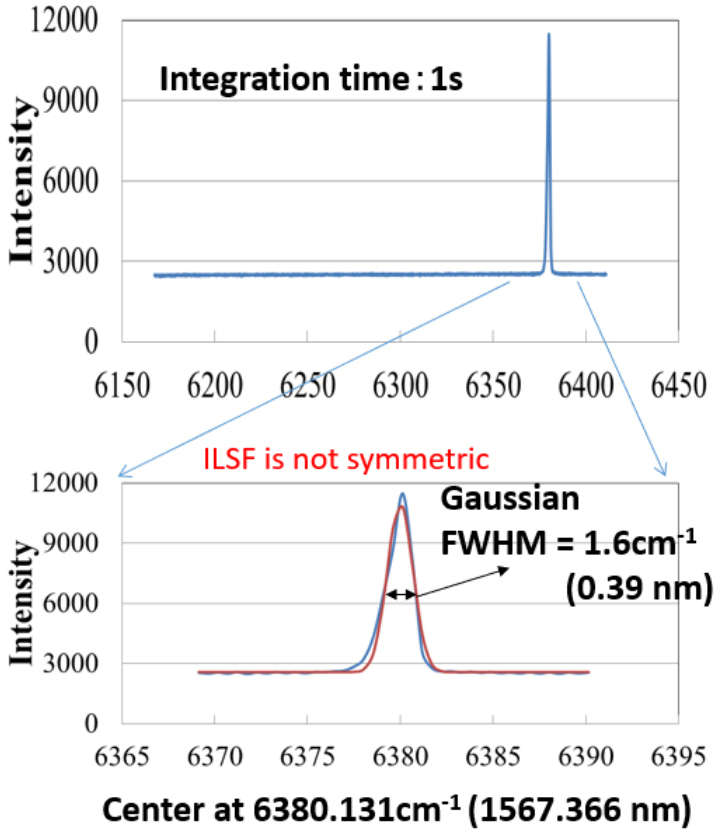
Measurement of dark current



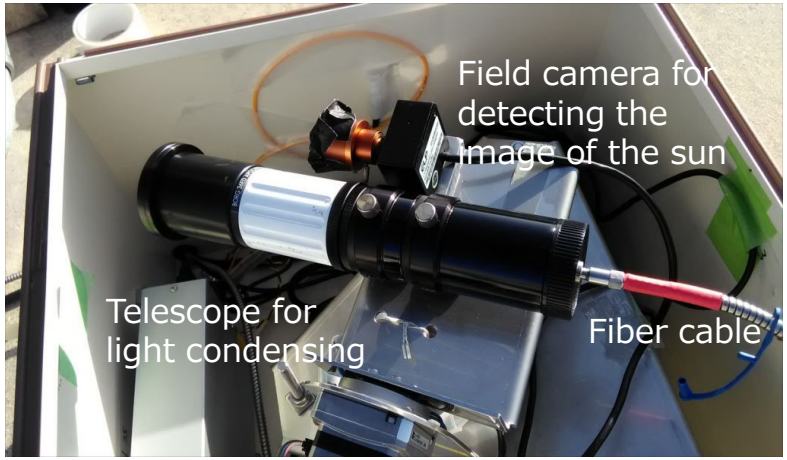
Measurement of ILSF



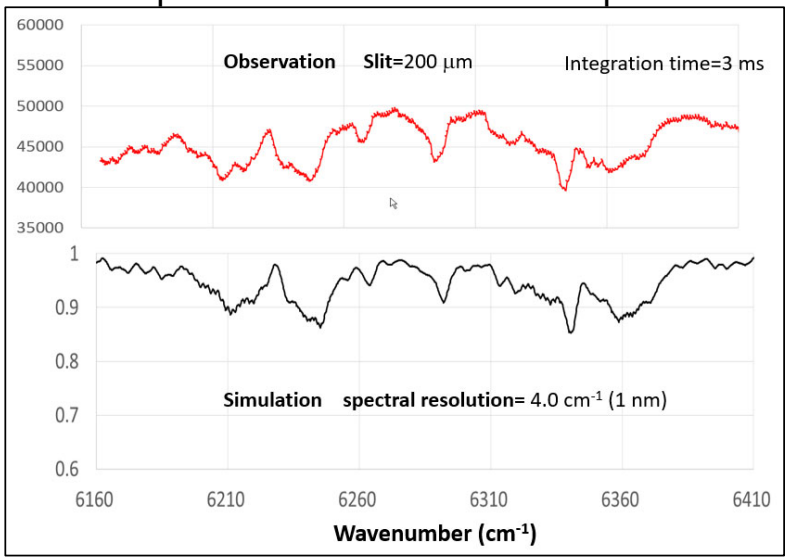
Laser: Roithner社SPL1570-2-9-PD,
Deriver board: Thorlab LD1100
Output : Max 2.5 mW



Sun tracking system

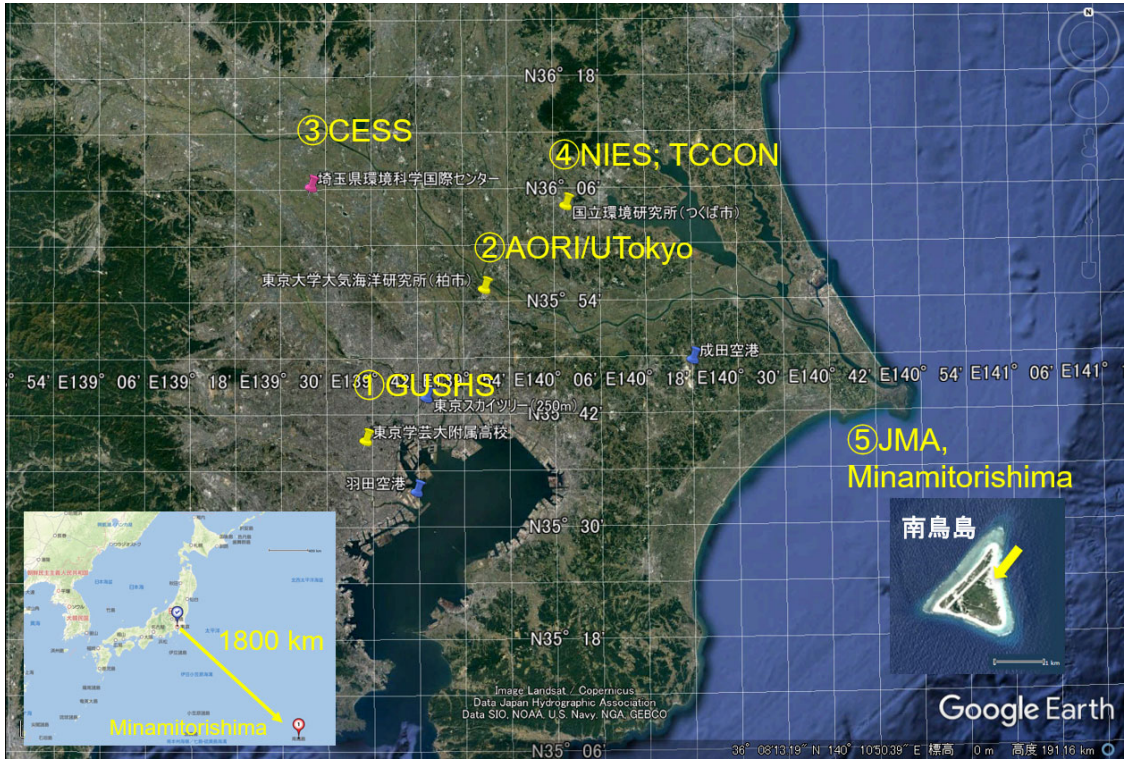


Comparison with simulated spectra



- ILSF was measured using single mode laser diode. Spectral resolution was evaluated to be 1.6cm-1 (FWHM).
- Dark current was measured using a white light in the laboratory

Observation sites



①Tokyo Gakugei University Senior High School (GUSHS) , Tokyo [Urban]
（35° 38‘4.40“N, 139° 40’40.07”E）

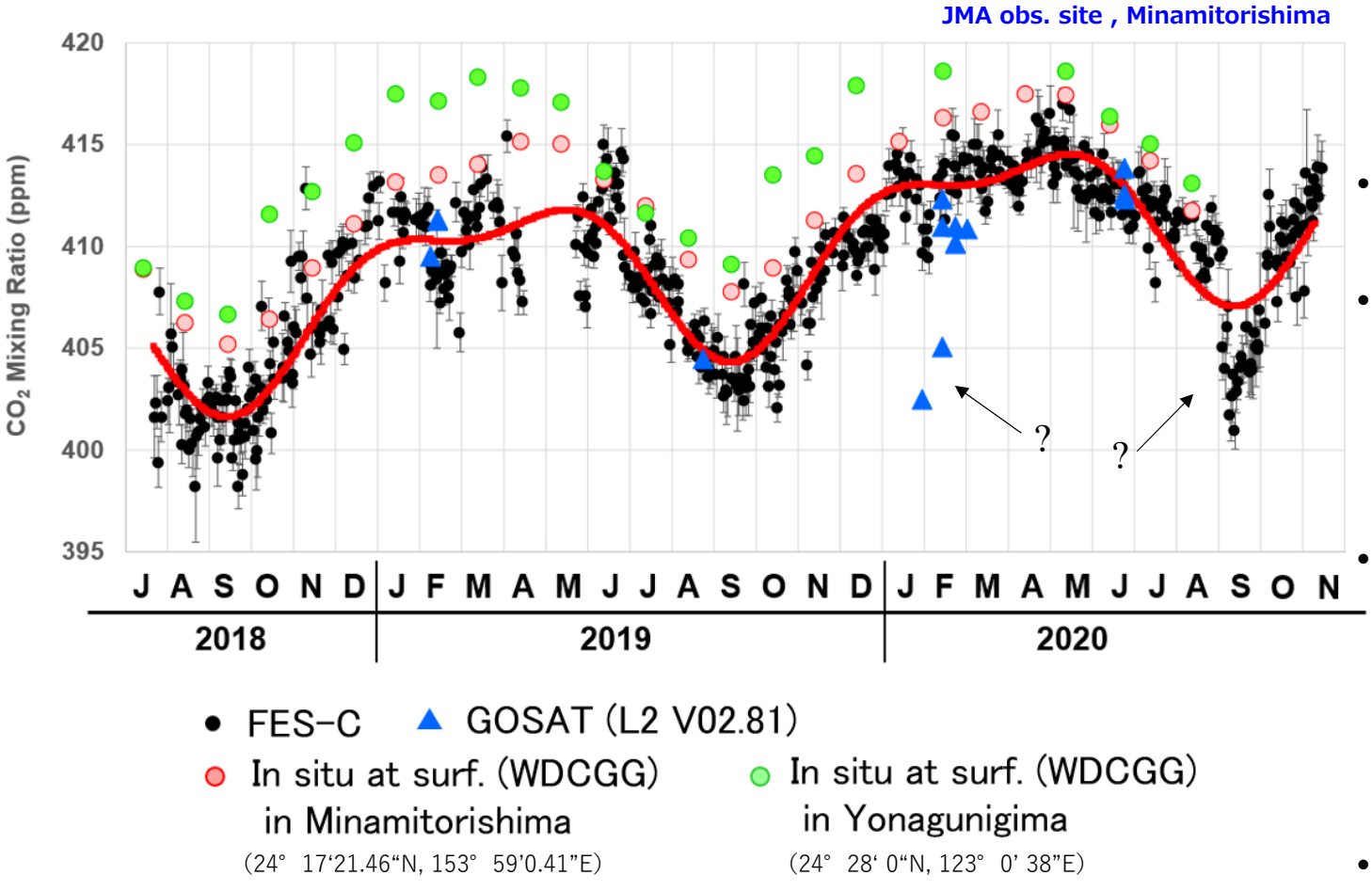
②Atmosphere Ocean Research Institute, The University of Tokyo (AORI/UTokyo), Kashiwa [Suburb]
（35° 54‘10.00“N, 139° 56’21.30”E）

③Center for Environmental Science in Saitama (CESS), Kasu [Suburb]
（36° 5‘6.85“N, 139° 33’36.27”E）

④National Institute for Environmental Studies (NIES), Tsukuba [Cal./TCCON]
（36° 3‘0.33“N, 140° 7’8.63”E）

⑤Japan Meteorological Agency (JMA) observatory, Minamitorishima (remote island) [Background]
（24° 17‘21.46“N, 153° 59’0.41”E）

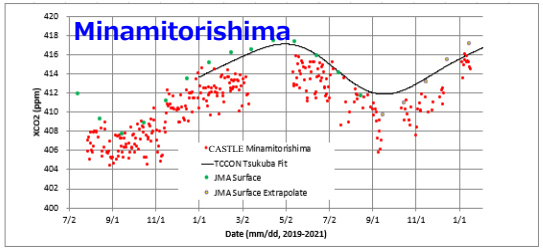
Results (FES-C)

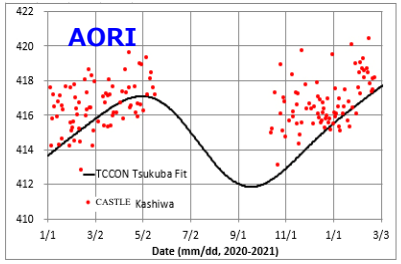


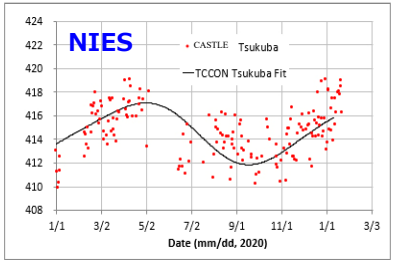
- Fiber-Etalon Solar Measurement for Carbon Dioxide Sensor (FES-C)*, which can measure XCO2, has been also operated on a remote island, Minamitorishima, from 2018
- Two years observation shows a clear trend of XCO2
- Unlike the data observed at other sites on land, the data on the island were low from February to March just before the annual maximum
- During the observation period, about 10 collocated measurements were performed with GOSAT (Sun glint observation) observations, and the results were fairly consistent
- Sometimes very low were observed by both GOSAT and FES-C

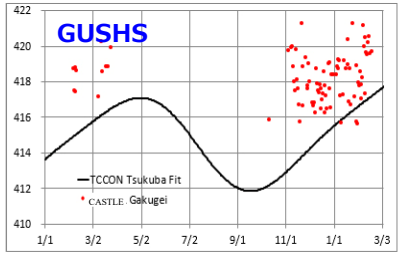
*Kawasaki et al., 2013

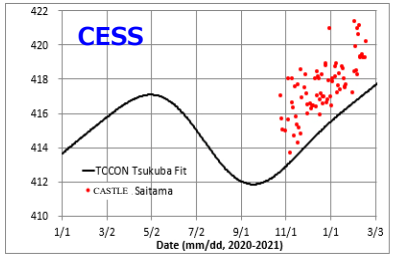
Results (CASTLE-CO_2)





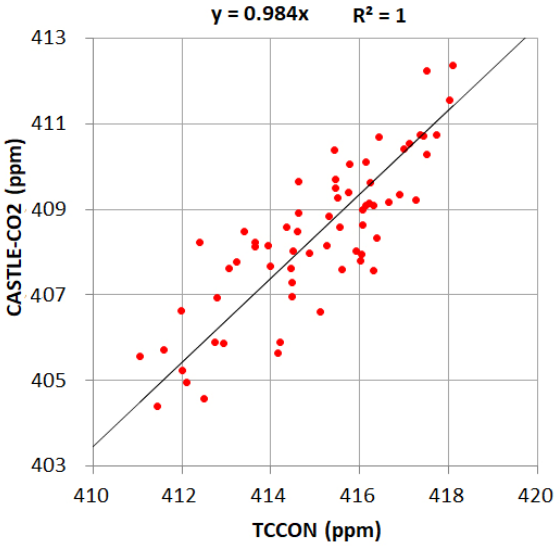




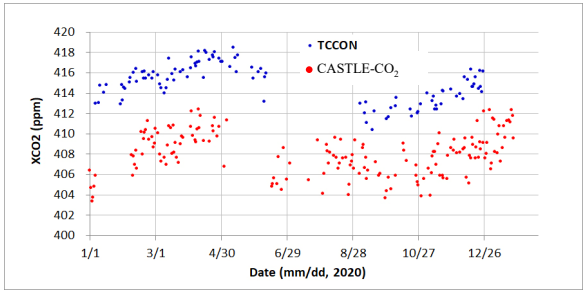


Comparison with TCCON

After bias correction



Before bias correction



- The original values measured by the CASTLE-CO_2 have positive bias of about 7 ppm against TCCON data (Tsukuba), and they can be reduced to about 1 ppm after applying a scaling factor (0.984)
- The characteristics of seasonal variations in XCO2 observed by the four CASTLE-CO2 installed in the greater Tokyo area differ from site to site. The three sites in Tokyo, Saitama, and Chiba show higher values than the TCCON site in Tsukuba
- The peaks appeared in the early winter season tend to be weaker than those of in situ measurements at ground observations as reported by Imasu and Tanabe (2018)

Acknowledgement

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References

Kawasaki, M., M. Ohashi, and G. Inoue, Measuring carbon dioxide emissions with a portable spectrometer, SPIE Newsletter, 10.1117/2.1201301.004659, 2013.

Imasu, R. and Y. Tanabe, Diurnal and Seasonal Variations of Carbon Dioxide (CO_2) Concentration in Urban, Suburban, and Rural Areas around Tokyo, Atmosphere, 9(10), 367, doi:10.3390/atmos9100367, 2018.