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Validation of GOSAT column-averaged mole fractions of CO2 and CH4 over the sea with ground- and ship-based spectrometers

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To accurately predict future atmospheric greenhouse gas concentrations and their impacts on climate, it is necessary to quantify the global distribution and temporal variations of greenhouse gas sources and sinks. Greenhouse gases Observing SATellite (GOSAT) has observed the global distribution of the atmospheric greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) since April 2009. Thermal And Near infrared Sensor for carbon Observation-Fourier Transform Spectrometer (TANSO-FTS), which is one of the sensors onboard the GOSAT, measures the sunlight backscattered by the Earth's surface and atmosphere as well as the thermal radiance emitted from the Earth. Column-averaged mole fraction of CO_2 (XCO_2) and CH_4 (XCH_4) are derived from the sunlight spectra by an optimal estimation retrieval approach. Over the ocean, the GOSAT measures sunglint region because the reflectance is higher than other ocean region. In terms of treatment of surface reflection, the retrieval algorithm is different between the land and ocean scenes. Therefore, it is desirable to validate the XCO_2 and XCH_4 values separately for the land and ocean scenes. We obtain direct sunlight spectra with a high-resolution FTS (Bruker IFS 125HR) not only on the ground but also onboard the research vessel (R/V) owned by the JAMSTEC, and indicate that the XCO_2 and XCH_4 could be retrieved from the spectra with precisions needed to validate the GOSAT data.

We performed the observations with the high-resolution FTS onboard the R/Vs in the three cruises operated by the JAMSTEC: the R/V *Kaiyo* cruise (4?13 August 2010), the R/V *Kairei* cruise (10 September?5 October 2010), and the R/V *Mirai* cruise (14 April?5 May 2011). Then, the high-resolution FTS was located in Saga in June 2011, and has acquired continuously the validation data over the land. The high-resolution FTS is a large instrument and make it difficult to carry many times. An automated compact measurement system is developed for acquiring more data over the ocean. The new equipment consists of a solar tracker and an optical spectrum analyzer (OSA: Yokogawa AQ6370C) as described in Kawasaki et al. [2012]. Sunlight is introduced into the OSA through optical fiber. We obtain the solar spectra whenever the solar elevation angle is greater than 10 degrees, weather permitting. The system has obtained the validation data over the ocean in the 2013 world cruise with the R/V *Yokosuka*.

The residual between the observed and the calculated spectra fluctuates with respect to the scan time (i.e., along the wavenumber direction). This is likely due to limit of tracking speed of the solar tracker. In the case of a larger wave, the motors of the solar tracker could no longer keep the image of the Sun on the center of optical fiber inlet. The intensity variation in the measured spectrum is corrected by a low-frequency correction method [Keppel-Aleks et al., 2007]. Total column abundances are retrieved from the measured spectra with a nonlinear least squares spectral fitting algorithm, which scales an a priori profile to produce a synthetic spectrum that achieves the best fit to the measured spectrum. In the case of OSA system, it is found that measurement accuracy is reduced by vibration transmitted from the ship and insufficient tracking performance, which is the issue to be improved. The GOSAT XCO_2 and XCH_4 are compared with the ground-based and the ship-based validation data. For our coincidence criteria, we find GOSAT measurements within 2 hours of the high-resolution FTS measurement time and within plus or minus 5 degrees latitude and plus or minus 10 degrees longitude of the high-resolution FTS location. The seasonal trends of the retrieved XCO_2 are consistent with those of the validation data. The TANSO-FTS XCO_2 retrievals exhibit a negative bias of ˜1 ppm with a root-mean-square difference of ˜2 ppm compared to the high-resolution FTS measurements.

Keywords: carbon dioxide, methane, remote sensing