GHG Observations of GOSAT/TANSO-FTS TIR band: data quality and scientific findings

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The Greenhouse Gases Observing Satellite (GOSAT) has continued its observations of greenhouse gases (GHG) such as CO_2 and CH_4 for almost 8 years since its launch on 23 January 2009. The Thermal and Near Infrared Sensor for Carbon Observation (TANSO)–Fourier Transform Spectrometer (FTS) on board GOSAT consists of three bands in the short-wave infrared (SWIR) region and one band in the thermal infrared (TIR) region (Kuze et al., 2009). From the TANSO-FTS TIR spectra, CO_2 and CH_4 concentrations are retrieved in several atmospheric layers; the latest TIR Level 2 (L2) retrieval product is version 1 (V1) (Saitoh et al., 2016).
We have evaluated the bias in the CO_2 concentrations of the TIR V1 L2 CO_2 product of the GOSAT/TANSO-FTS based on comparisons with data from the Continuous CO_2 Measuring Equipment (CME) in the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project (Machida et al., 2008) in the upper troposphere and lower stratosphere (UTLS), the middle troposphere (MT), and the lower troposphere (LT) for the 3 years from 2010 to 2012. Here, we used the CME data obtained during the level flights over a wide area and the ascent and descent flights over several airports for the comparisons in the UTLS region and the ML and LT regions, respectively. Furthermore, we examined the validity of the bias assessment over limited areas over the airports by comparing TIR CO_2 data globally with CO_2 data simulated by the Nonhydrostatic ICosahedral Atmospheric Model (NICAM)-based transport model (TM) (Niwa et al., 2011). The comparison results in the UTLS region showed that TIR CO_2 data had larger negative biases in spring and summer (>2 ppm) than in fall and winter in the northern low and middle latitudes (Saitoh et al. 2016), and the biases became larger over time. This is because TIR UT CO_2 data were constrained by the a priori data whose growth rates were ˜1.4 ppm/yr from 2010 to 2012, which was less than the growth rates based on CME data (˜2.1 ppm/yr). However, TIR UT CO_2 data displayed seasonal variations that were more similar to the CME data than to the a priori data. The amplitudes of the seasonal variations were comparable, except at the northern middle latitudes. In the ML and LT regions (736–287 hPa), TIR CO_2 data had negative biases against CME CO_2 data in the latitude range between 40°S and 60°N in all seasons. They had the largest negative biases in retrieval layers 5–6 (541–398 hPa), which mainly came from the retrieval at the CO_2 10-μm absorption band (930–990 cm^{-1}). Comparisons between NICAM-TM CO_2 data and bias-corrected TIR CO_2 data to which the bias-correction values evaluated over the airports were applied showed that the median values of their differences were closer to zero, which demonstrates the validity of the bias-correction values; we conclude that the bias-correction values defined the comparisons in limited areas over airports can be applicable to TIR CO_2 data in areas other than the airport locations.
We compared TIR V1 L2 CH_4 data with data obtained over Minamitorishima by a C-130H cargo aircraft (Tuboi et al., 2013; Niwa et al., 2014) and with data obtained in a wide latitude range during the HIAPER Pole-to-Pole Observation (HIPPO) aircraft campaign (Wofsy et al., 2011). The comparison results showed that TIR CH_4 data agreed with the aircraft CH_4 data to within ˜1% in the MT and LT regions in the northern middle latitudes in spring, fall and winter, although they had negative biases of 1.2–1.5% in the MT region

in summer. TIR CH_4 data in the MT regions agreed with HIPPO CH_4 data to within 1% in low latitudes and in the southern middle latitudes, which is consistent with the results of Zou et al. (2016) and Olsen et al. (2017).