Utility of total column CO_2 observations by satellites and atmospheric CO_2 inversion for evaluating carbon cycle processes in the Earth System Models

*Prabir Patra[1,2], Tomohiro Hajima[1], Ryu Saito[3], Naveen Chandra[1], Yukio Yoshida[4], Michio Kawamiya[1], Masayuki Kondo[2], Kazuhito Ichii[2], Akihiko Ito[4], Dave Crisp[5]

1. Research Institute for Global Change, JAMSTEC, 2. Center for Environmental Remote Sensing, Chiba University, Chiba 263-8522, Japan, 3. Disaster Risk Reduction and Environ. SBU, Kokusai Kogyo Co., Ltd., Tokyo, 183-0057, Japan, 4. Center for Global Environmental Research, NIES, Tsukuba, 305-8506, Japan, 5. NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

The measurements of one of the major greenhouse gases, carbon dioxide (CO_2), are being made using dedicated satellite remote sensing since the launch of the greenhouse gases observing satellite (GOSAT) by JAXA in 2009. The Thermal And Near infrared Sensor for carbon Observation Fourier Transform Spectrometer (TANSO-FTS) onboard GOSAT has now acquired more than 10 years of total column-averaged CO_2 concentrations (XCO_2) from space covering almost all parts of the globe in all seasons. In the past 10 years, the models for estimation of CO_2 fluxes from land and ocean using the earth system models (ESMs) and inverse modelling of in situ atmospheric CO_2 data have made significant progress. In this article, we attempt, for the first time, to evaluate the CO_2 fluxes simulated by an earth system model (MIROC-ES2L) using GOSAT observations and the fluxes estimated by an inverse model (MIROC4-Inv) for the period 2009-2014. Further, we use the OCO-2 (NASA’s Orbiting Carbon Observatory-2) measurements for testing the consistency of inversion results for the period 2014-2018, along with the GOSAT data. Both MIROC-ES2L and MIROC4-Inv fluxes are used in the MIROC4-atmospheric chemistry transport model (referred to as ACTM_ES2LF and ACTM_InvF, respectively) for calculating CO_2 concentrations that are sampled at the time and location of the satellite measurements. Our results suggest the inverse model using in situ data are more consistent with the OCO-2 retrievals, compared to those of the GOSAT XCO_2 data, suggesting possible improvements in the present GOSAT retrieval system by better accounting for the degradation correction of the TANSO-FTS. The ACTM_ES2LF simulation shows a slightly weaker seasonal cycle for the meridional profiles of CO_2 fluxes, compared to that from the ACTM_InvF. This difference is revealed by greater ACTM_ES2LF vs GOSAT differences, compared to those of ACTM_InvF vs GOSAT. We also find that the simulated seasonal cycle amplitude of XCO_2 by ACTM_ES2LF are slightly weaker compared to those observed by GOSAT or ACTM_InvF. Our results clearly suggest the usefulness of XCO_2 measurements by satellite remote sensing for evaluation of large-scale ESMs, which so far remained untested by the sparse in situ data.

Keywords: Atmospheric CO2 inversion, Earth System Models, Satellite remote sensing of CO2

