# Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product

*Tazu Saeki[1], Yosuke Niwa[1], Makoto Saito[1]

1. National Institute for Environmental Studies

Greenhouse gases (GHG) observations from satellites have contributed to expanding spatial coverage of observational networks for GHGs over the globe. Greenhouse gases Observing SATellite (GOSAT) has been monitoring the column-averaged dry-air mole fractions of atmospheric carbon dioxide ($XCO_2$) and methane ($XCH_4$) from space since its launch in January 2009. Its successor GOSAT-2 was successfully launched on 29 October 2018, and the observational data are being processed at GOSAT-2 ground systems. The GOSAT-2 mission aims to continue and enhance spaceborne measurement of GHGs started by GOSAT, and to monitor the impacts of climate change and human activities on the carbon cycle. Both satellites are jointly developed and operated by Ministry of the Environment, Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES). NIES is responsible for producing and distributing higher level data products, such as Level 2 products ($XCO_2$ and $XCH_4$ etc.) and Level 4 products (surface fluxes of $CO_2$ and $CH_4$ and three-dimensional global distributions of $CO_2$ and $CH_4$ concentrations) (http://www.gosat-2.nies.go.jp).

We are currently developing an inversion system for operational use to produce GOSAT-2 L4 products. The Non-hydrostatic ICosahedral Atmospheric Model (NICAM)-based Transport Model (NICAM-TM; Niwa et al., 2011) is used for simulating atmospheric $CO_2$ and $CH_4$ concentrations, and an inversion system based on the four-dimensional variational (4D-Var) method with NICAM-TM (NICAM-TM 4D-Var; Niwa et al., 2017a,b) is adopted to estimate global surface $CO_2$ and $CH_4$ fluxes. In this presentation, we will present test results of $CO_2$ flux estimation with NICAM-TM 4D-Var using GOSAT data (not GOSAT-2 data), ground-based data, prior fluxes, and their error covariances. NICAM-TM is operated with a horizontal resolution of glevel-5 (an average grid resolution of 223 km) and 40 vertical layers, and its meteorological fields are nudged with JRA-55 data to simulate real atmospheric transport. NICAM-TM 4D-Var is run with stored meteorological data, which successfully reduces computational cost. $CO_2$ surface fluxes have been estimated at every 223 km grid resolution and at monthly time resolution. Preliminary test results with single-year GOSAT data showed that flux differences between the prior fluxes and estimated fluxes from the GOSAT data inversion appear over a broad area of land regions, even over Siberia and South America where ground sites are sparse, while the ocean regions showed relatively fewer flux changes after the inversion. Our ongoing work includes inversions with multi-year data, the inclusion of other data, and tuning model parameters. The details will be presented at the meeting.

**Acknowledgments.** The model simulations are performed with the NIES supercomputer system and the Research Computation Facility for GOSAT-2 (RCF2). This research is partly supported by the Environment Research and Technology Development Fund (2-1701) of the Environmental Restoration and Conservation Agency of Japan.

**References**

Niwa et al. (2011), Journal of the Meteorological Society of Japan. Ser. II, 89(3), 255–268.
Niwa et al. (2017a), Geoscientific Model Development, 10(3), 1157–1174.
Niwa et al. (2017b), Geoscientific Model Development, 10(6), 2201–2219.

©2019. Japan Geoscience Union. All Right Reserved. 

Keywords: Carbon budget, Flux estimations of greenhouse gases, Atmospheric inverse model, Top-down approach, Satellite remote sensing

©2019. Japan Geoscience Union. All Right Reserved. 