The Greenhouse gases Observing SATellite, GOSAT (nicknamed IBUKI), was successfully launched on January 23, 2009, and has been collecting global data for estimating the column-averaged volume mixing ratios\(^ (*)\) of major greenhouse gases such as carbon dioxide (CO\(_2\)) and methane (CH\(_4\)) under clear-sky condition.

We have updated the algorithms for processing GOSAT concentration data to improve their quality and have validated the data by comparing them with highly accurate ground-based measurements of CO\(_2\) and CH\(_4\) concentrations. We have continued public distribution of GOSAT data for column amounts and column-averaged volume mixing ratios of CO\(_2\) and CH\(_4\) (called Level 2 data products). These latest released data were processed using the latest algorithm (Version 2).

Higher-level data products, specifically the monthly and regional net fluxes of CO\(_2\) and CH\(_4\) (Level 4A product) and the global three-dimensional distribution of model-simulated CO\(_2\) and CH\(_4\) concentrations processed from Level 4A data (Level 4B data products), are also available to the public.\(^ (*)\) The column-averaged volume mixing ratio is the ratio of the total amount of a gas species to the total amount of dry air contained in a vertical column from the ground surface to the top of the atmosphere. The column-averaged volume mixing ratios for CO\(_2\) and CH\(_4\) are designated XCO\(_2\) and XCH\(_4\).

Validation of GOSAT data using reference data collected with ground-based high-resolution FTSs

The GOSAT concentration data for CO\(_2\) and CH\(_4\) must be validated, that is, biases and variations (standard deviations) must be determined, before they are used in scientific studies. We have validated the GOSAT data by comparing them with highly accurate ground-based and airborne measurements of CO\(_2\) and CH\(_4\) concentrations.

In Figure 1, GOSAT Level 2 data processed with the latest algorithm (Version 2) were compared with data obtained with ground-based high-resolution Fourier transform spectrometers (FTSs) deployed in the Total Carbon Column Observing Network (TCCON). The bias and standard deviation for XCO\(_2\) and XCH\(_4\) are both less than 1%. The GOSAT data were found to be therefore consistent with the TCCON data. Tentatively, the estimated bias and standard deviation (1σ) for XCO\(_2\) are −1.2 ppm and +2.0 ppm, and those for XCH\(_4\) are −7 ppb and +12 ppb (1 ppb = 1/1000 ppm).

Seasonal variations and annual trends of greenhouse gas concentrations data, collected and archived for more than five years, can be used to map the seasonal variations and annual trends of XCO₂ and XCH₄ on regional and global scales.

Maps of typical monthly averaged values of XCO₂ (Version 2) for four selected months in 2013-2014 period are shown in Figure 2. The map for July 2013 shows that the average value of XCO₂ for higher latitudes in the Northern Hemisphere during summer is small because of the active photosynthesis of vegetation during that time. In January and April 2014, the average values of XCO₂ in the Northern Hemisphere are larger than those in the Southern Hemisphere.

Figure 3 shows maps of monthly averages of XCO₂ (Version 2) for July in the years 2009 to 2012. Comparison of the maps reveals both regional differences and an increasing trend in XCO₂ in these years.

Figure 4 plots monthly averaged values of XCO₂ for North America and Australia. The data plotted in the figure correspond to Level 2 data obtained over four years and ten months, and show that the value of XCO₂ increases year by year and that the seasonal variation of XCO₂ in North America (the Northern Hemisphere) is larger than that in Australia (the Southern Hemisphere).
Seasonal variations and annual trends of greenhouse gas concentrations

Figure 3. Monthly averaged maps of XCO₂ (Version 2) for July in the years 2009 to 2012

Figure 4. Variations of the monthly averages of XCO₂ in North America and Australia

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(◆ = North America; △ = Australia. The graph is drawn by connecting monthly averages of XCO₂ with straight lines.)
Public release of Level 4 data products

The Level 4 data products consist of the Level 4A and Level 4B data products. The Level 4A data product is a dataset of net monthly CO₂ fluxes estimated for 64 subcontinental regions of the world (several thousand kilometers in perimeter). The Level 4B data product presents global three-dimensional CO₂ distributions simulated with an atmospheric tracer transport model and the CO₂ flux estimates. These data products (Version 02.02) were made available to the public in March 2014.

Level 4A data product: global monthly CO₂ flux values

The net regional CO₂ flux values in the Level 4A dataset were estimated from Level 2 XCO₂ data and ground-based CO₂ concentration data.

The estimation process is twofold. First, values of ground-based and GOSAT-based CO₂ concentrations are predicted by performing simulations of atmospheric CO₂ transport. The transport simulations use a priori CO₂ flux data as input values. These input data consist of anthropogenic emission data, wildfire emission data, and model estimates of CO₂ exchange between the terrestrial biosphere and the atmosphere, and between the ocean and the atmosphere. Second, the predicted CO₂ concentrations are matched to the observed values by adjusting the a priori CO₂ fluxes used in the CO₂ concentration simulation. Here, adjustment is performed only on the terrestrial and oceanic CO₂ exchanges.

Maps for Level 4A data product show that many regions in the Northern Hemisphere are net sinks (absorbers) of CO₂ in summer but net sources (emitters) of CO₂ in winter (Figure 5). The uncertainty in the estimated regional monthly CO₂ flux increases if the CO₂ concentration data are scant in the region or in the corresponding month.

Level 4B data product: global three-dimensional CO₂ distribution

The Level 4B data product is the result of atmospheric CO₂ transport simulation based on the distribution of CO₂ flux estimated from the ground-based and GOSAT-based CO₂ concentration data. The Level 4B data product stores global CO₂ concentrations in intervals of six hours at 17 vertical levels ranging from near the surface to the top of the atmosphere. The anthropogenic and wildfire emission data used in the Level 4B simulations are the same as those used in the Level 4A CO₂ flux estimation.

Figure 6 shows samples of the global CO₂ distributions at an altitude of approximately 800 m on July 15, 2009, and January 15, 2010 (at 12:00 UTC). Contours of higher concentrations near equatorial Africa reflect the influence of local wildfires.

URL: http://www.gosat.nies.go.jp/index.html