Model application of GOSAT data: Level 4 data products

Level 4 data products consist of Level 4A and Level 4B data products. Level 4A data product is a dataset of net monthly CO_2 and CH_4 fluxes estimated for subcontinental regions (several thousand kilometers in perimeter) of the world. The region numbers are 64 for CO_2 and 43 for CH_4. Level 4B data product presents global three-dimensional CO_2 and CH_4 distributions simulated with an atmospheric tracer transport model and the CO_2 and CH_4 flux estimates. These data products were made available to the general public.

Level 4A (global monthly CO_2 and CH_4 flux values) and 4B (3-dimensional concentrations) data products

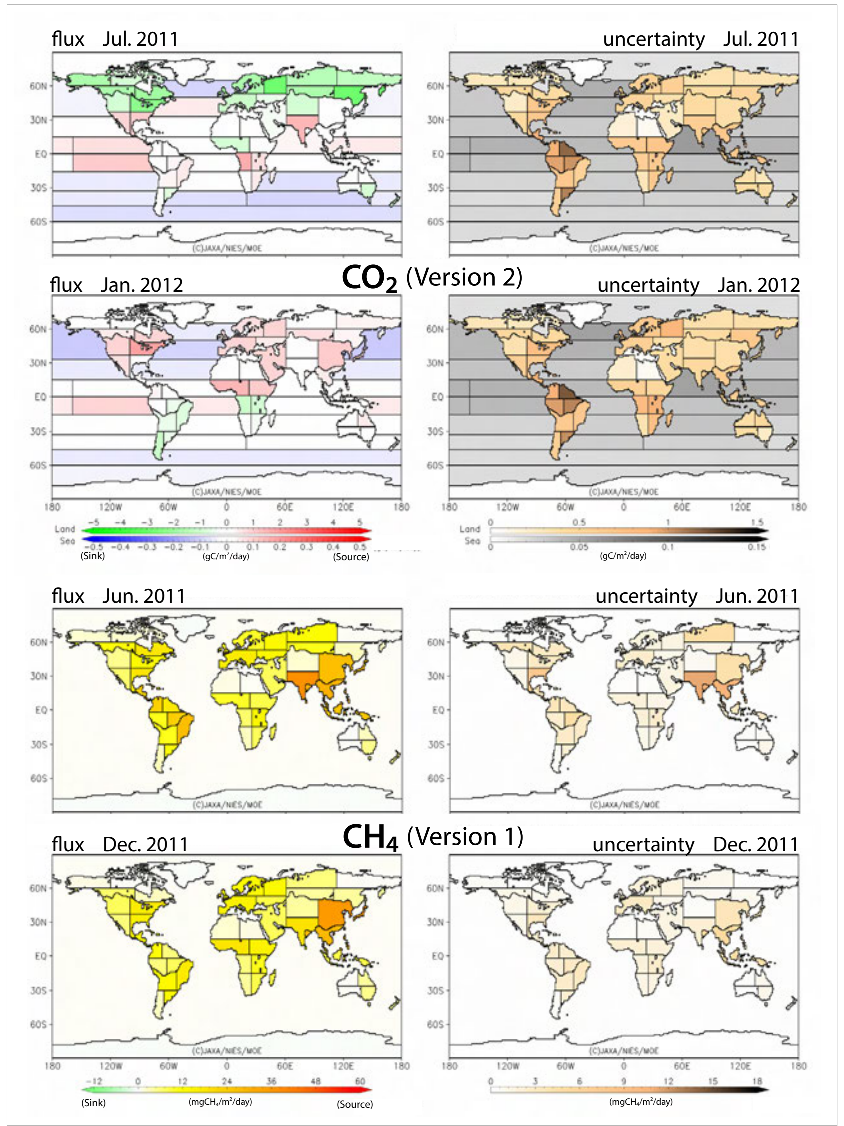


Figure 6. Level 4A data product. Maps of regional GHG flux estimates and their uncertainties.

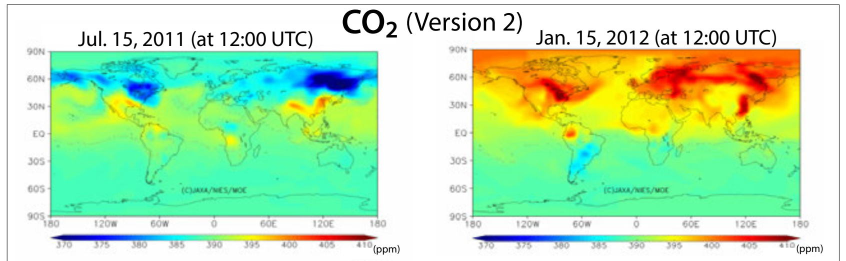


Figure 7. Level 4B data product. Maps extracted from global three-dimensional CO_2 distribution, at an altitude of approx. 800 m (0.925 level on a hybrid sigma-pressure coordinate).

The net regional CO_2 and CH_4 (hereafter "GHG") flux values in Level 4A data products were estimated from Level 2 data and ground-based GHG concentration data.

The estimation process is twofold. First, values of ground-based and GOSAT-based GHG concentrations are predicted by performing simulations of atmospheric GHG transport. The transport simulations use a priori GHG flux data as input values. These input data consist of anthropogenic emission data, wildfire emission data, and model estimates of GHG exchange between the terrestrial biosphere and the atmosphere, and between the ocean and the atmosphere. Second, the predicted GHG concentrations are matched to the observed values by adjusting the a priori GHG fluxes used in the GHG concentration simulation. In the CO_2 flux estimation, the adjustment is performed only on the terrestrial and oceanic exchanges. In the CH_4 flux estimation, the adjustment is performed on all of the input data.

In the case of CO_2, many regions in the Northern Hemisphere are net sinks (absorbers) in summer but net sources (emitters) in winter (Figure 6).

Level 4B data product is the result of atmospheric GHG transport simulation based on the flux distribution estimated from the ground-based and GOSAT-based concentration data. Level 4B data product stores global concentrations in every 2.5° mesh in intervals of six hours at 17 vertical levels ranging from near the surface to the top of the atmosphere. Figure 7 shows examples of the global CO_2 distributions. Other Level 4B maps for CO_2 and CH_4 are also shown at http://data.gosat.nies.go.jp/ ("Login"-"L4 Browse Image").

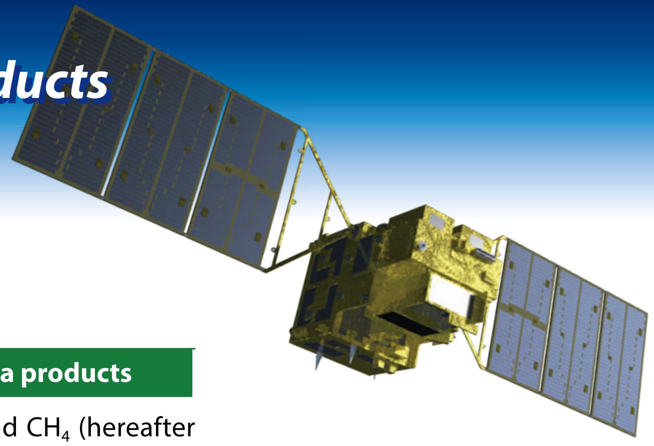
Greenhouse gases GOSAT PROJECT Observing SATellite

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

Ministry of the Environment 環境省

National Institute for Environmental Studies 国立研究開発法人 国立環境研究所

Japan Aerospace Exploration Agency 国立研究開発法人 宇宙航空研究開発機構



Global Greenhouse Gas Observation by Satellite

Latest GOSAT Data

(July, 2015)

The Greenhouse gases Observing SATellite, GOSAT (nicknamed *IBUKI*), was successfully launched on January 23, 2009, and has been collecting data globally under cloud-free conditions for estimating the column-averaged dry-air mole fractions* of major greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4).

For data quality improvement, we updated our algorithm used for the estimation of XCO_2** and XCH_4**, and validated the retrieved values by comparing them to high-precision ground-based measurements. These validated values have been distributed to researchers and the general public as version 2 of GOSAT Level 2 data product. The latest data have been processed using the algorithm (Version 2).

Using the Level 2 values, higher-level data products such as the monthly estimates of CO_2 and CH_4 regional fluxes were obtained. Also based on these flux estimates, concentrations of CO_2 and CH_4 in three-dimensional space were simulated. These data have been made available to the general public as GOSAT Level 4A (flux estimates) and 4B (3-dimensional concentration distributions) data products.

* The column-averaged dry-air mole fraction 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 dray-air mole fractions for CO_2 and CH_4 are designated XCO_2 and XCH_4.

Validation of GOSAT data against ground-based reference

Before use in scientific research, uncertainties (bias and precision) of Level 2 concentration values must be revealed. GOSAT data validation is performed by using reference data collected from ground-based high-resolution Fourier transform spectrometers (FTSs) deployed in the Total Carbon Column Observing Network (TCCON, https://tccon-wiki.caltech.edu/) and also from airborne measurements.

Figure 1 shows a result of data validation in which GOSAT Level 2 XCO_2 and XCH_4 values were compared against the TCCON data. The bias and precision for both XCO_2 and XCH_4 were found to be less than 1% of the concentration values (at present, −0.5 and ±2.2 ppm for XCO_2 and −4 and ±13 ppb*** for XCH_4, respectively). GOSAT Level 2 data were found to be consistent with the TCCON data.

*** 1 ppb = 1/1000 ppm

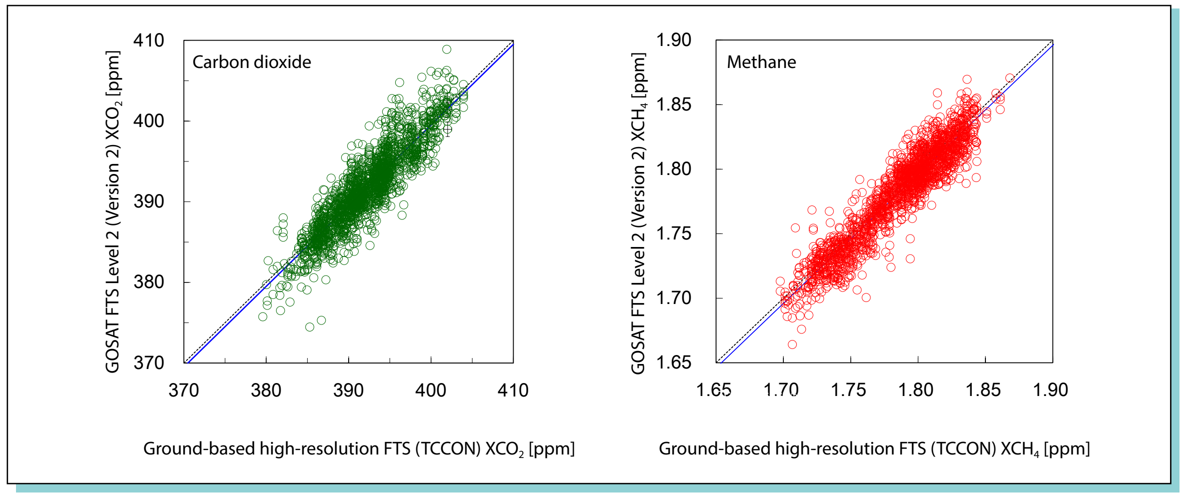


Figure 1. GOSAT Level 2 data products (Version 2) validated with TCCON data.

The period of validation was from April 2009 to May 2014. TCCON data were averaged within 30 minutes before/after the overpasses time of GOSAT. GOSAT data were selected within the square land area of 4 degrees centering each TCCON site. The dashed line represents y = x (one to one), and the blue line is a regression line for y = x + b, where b is the bias. (Left: XCO_2, Right: XCH_4)

Seasonal variations and annual trends of greenhouse gas concentrations

GOSAT data, collected and archived for more than six years, can be used to map the seasonal variations and annual trends of XCO_2 and XCH_4 on regional and global scales.

Maps of monthly averaged values of XCO_2 (Version 2) for four selected months in 2013-14 period are shown in Figure 2 (inset color scale shows that XCO_2 value changes from blue-low to red-high). The map for July shows that the average value of XCO_2 for higher latitudes in the Northern Hemisphere during summer is low because of the active photosynthesis of vegetation during that time. In January and April , the average value of XCO_2 in the Northern Hemisphere is higher than that in the Southern Hemisphere.

Figure 3 shows maps of monthly averages of XCO_2 for July in the years 2009 to 2014. Comparison of the maps reveals both regional differences and an increasing trend in XCO_2 in these years.

** Seasons shown below in brown italics are those of the* ***Northern Hemisphere****.*

XCO_2

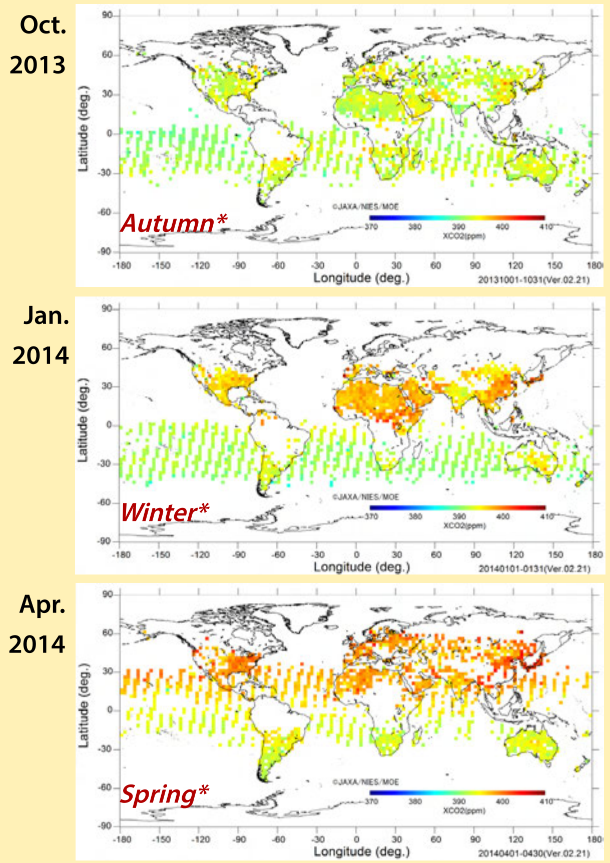


Figure 2. Maps of monthly averaged values of XCO_2 (Version 2) for four selected months in 2013-14 period.

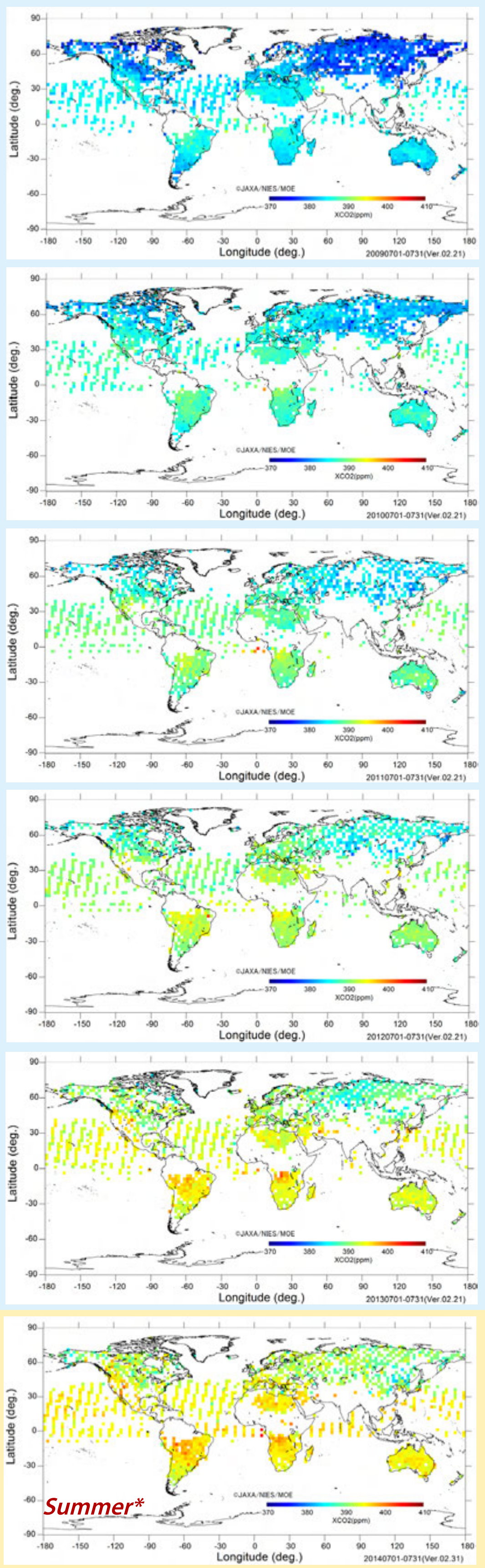


Figure 3. Monthly averaged maps of XCO_2 (Version 2) for July in the years 2009 to 2014.

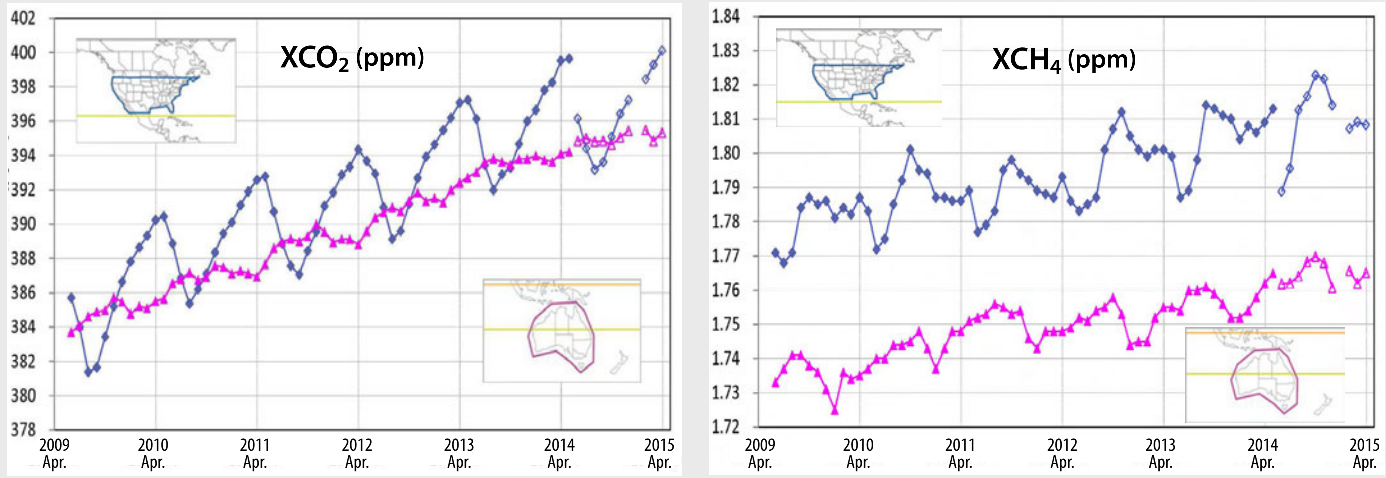


Figure 4. Variations of the monthly averages of XCO_2 and XCH_4 in North America (blue) and Australia (magenta). (The graphs are drawn by connecting monthly averages of XCO_2 and XCH_4 with straight lines).

Figure 4 plots monthly averaged values of XCO_2 and XCH_4 over the southern half of North America and entire Australia, as shown in the figures inset. The data plotted in the figures correspond to Level 2 data obtained over six years, and show that the value of XCO_2 and XCH_4 increases year by year. The seasonal variation of XCO_2 in North America (the Northern Hemisphere) is larger than that in Australia (the Southern Hemisphere). Roughly speaking, seasonal increase and decrease patterns in both area appear reverse.

XCH_4 seasonal variation appears more complex than that of XCO_2, possibly owing to more complicated XCH_4 source distribution and seasonal emission patterns.

Monitoring of vegetation status by GOSAT

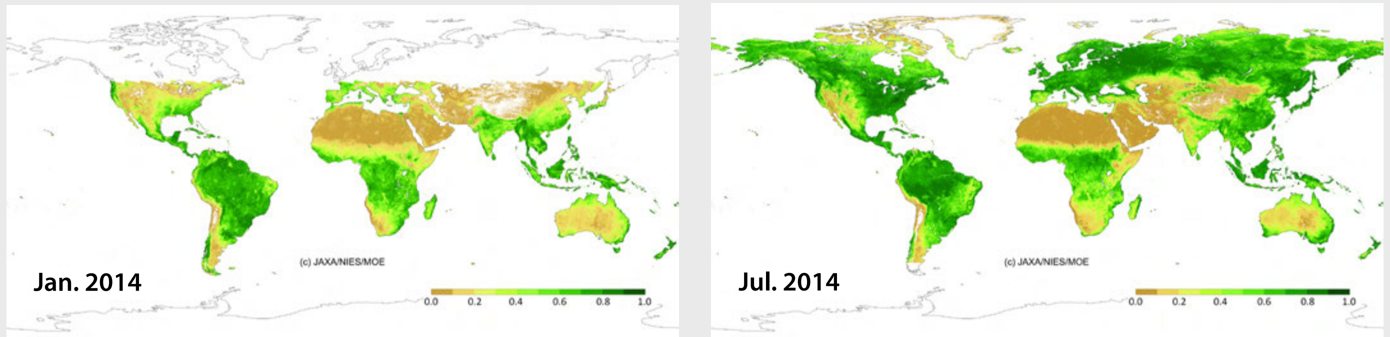


Figure 5. Samples: global maps of normalized difference vegetation index (NDVI) for January and July 2014 (CAI L3 NDVI Product Version 1).

The vegetation density, represented by the normalized difference vegetation index (NDVI), can be calculated from data collected by Cloud and Aerosol Imager (CAI) onboard the satellite. The NDVI data are generated every 3 days, based on cloud-free CAI data collected during the past 30 days.

Not only for the NDVI calculation, the CAI data are also utilized for detecting the extent of wildfires, the advection of volcanic ash plumes, wind-blown dusts. These CAI images are available in GUIG "Gallery" at http://data.gosat.nies.go.jp/.