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March, 2022

Secretariat of Information Collection and Preparation,
United Nations Framework Convention on Climate Change

Dear Sir / Madame,

As an observer institution of the UNFCCC, we would like to submit a brief introduction of standard products and related data derived from the observation by Japanese GOSAT Satellite Series for greenhouse gas observation from space for the purpose of supporting the first Global Stocktake.

Sincerely,

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National Institute for Environmental Studies

February 28, 2022

Submission of Information to the 1st Global Stocktake
- GOSAT and GOSAT-2 Standard Products and Related Data -

Satellite Observation Center
Earth System Division
National Institute for Environmental Studies
Japan

1. Overview

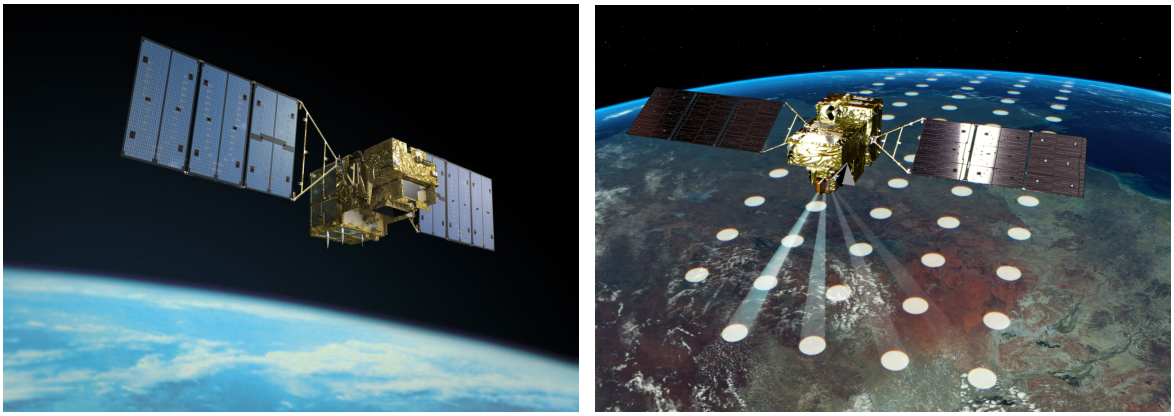

Figure 1. (Left) GOSAT launched in 2009 and (Right) GOSAT-2 laucnhed in 2018.
(Images: Courtesy of JAXA)

GOSAT (Greenhouse gases Observing SATellite) and GOSAT-2 are Japanese Earth observation satellites for greenhouse gas measurement from space and have been promoted by the Ministry of the Environment (MOE), the Japan Aerospace Exploration Agency (JAXA) and the National Institute for Environmental Studies (NIES). NIES is responsible for the generation, validation, and distribution of higher level products such as concentrations and fluxes of carbon dioxide (CO_2) and methane (CH_4) . For the list of GOSAT and GOSAT-2 products, see "Greenhouse gases Observing SATellite (GOSAT) / Greenhouse gases Observing SATellite-2 (GOSAT-2) Data Policy".
https://www.nies.go.jp/soc/en/documents/datapolicy/

NIES would like to provide the following GOSAT and GOSAT-2 Standard Products and related data sets to the 1st Global Stocktake under the Paris Agreement. These data can be used to grasp the current status of the Earth's atmosphere and estimate regional greenhouse gas fluxes in the past decade. They will be also used in the "**Bulletin of Multi-scale Estimation of Greenhouse Gas Budgets**", a separate report submitted by NIES to the 1st Global Stocktake.

1) GOSAT and GOSAT-2 Level 2 CO_2 and CH_4 Column Concentration Standard Product
2) GOSAT and GOSAT-2 Level 4 CO_2 and CH_4 Net Flux Standard Product

3) GOSAT Whole-atmosphere Monthly and Annual Mean Concentrations of CO_2 and CH_4
4) Others

GOSAT Standard Products are freely available from GOSAT Data Archive Service (GDAS).
https://data2.gosat.nies.go.jp/

GOSAT-2 Standard Products are also freely available from GOSAT-2 Product Archive Service.
https://prdct.gosat-2.nies.go.jp/

In addition, a document, "**A Guidebook on the Use of Satellite Greenhouse Gases Observation Data to Evaluate and Improve Greenhouse Gas Emission Inventories**" that describes how to use GOSAT data in verification of national greenhouse gas inventories was published electronically in 2018 and is available from the URL below.
https://www.nies.go.jp/soc/en/documents/guidebook/

This submission is our input to Guiding Questions 1, 2, 3, 16, 17, and 18 in "Draft guiding questions by the SB Chairs for the Technical Assessment component of the first Global Stocktake (Version of 20 October 2021@17.30)".

2. GOSAT and GOSAT-2 Level 2 Column Concentration Products

The column-averaged volume mixing ratios of CO_2 and CH_4 are derived from the data obtained by Fourier transform spectrometers onboard GOSAT and GOSAT-2. These concentration data are included in GOSAT and GOSAT-2 Level 2 Standard Products. Currently GOSAT Level 2 Standard Product from April 2009 to present and GOSAT-2 Level 2 Standard Products from March 2019 to present are available. The bias corrected concentration products which are generated from GOSAT Level 2 Standard Product are also available. In addition, carbon monoxide (CO) concentration data are included in GOSAT-2 Level 2 Standard Product.

Methodology and validation documents for these products are available from the URLs below:
(Methodology, GOSAT)
https://data2.gosat.nies.go.jp/doc/documents/ATBD_FTSSWIRL2_V2.0_en.pdf
(Validation, GOSAT)
https://data2.gosat.nies.go.jp/doc/documents/ValidationResult_FTSSWIRL2_V02.90_GU_en.pdf

(Methodology, GOSAT-2)
https://prdct.gosat-2.nies.go.jp/documents/pdf/ATBD_FTS-2_L2_SWL2_en_00.pdf
(Validation, GOSAT-2)
https://prdct.gosat-2.nies.go.jp/documents/pdf/ValidationResult_FTS-2_L2_SWPR_ver0107_en_00.pdf

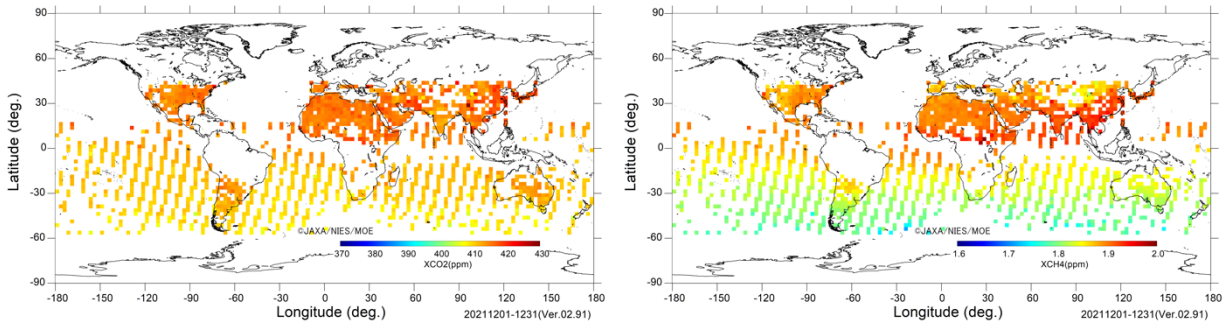

Figure 2. Monthly Global Maps of GOSAT CO_2 and CH_4 column-averaged volume mixing ratios in 2.5 deg by 2.5 deg mesh for December 2021

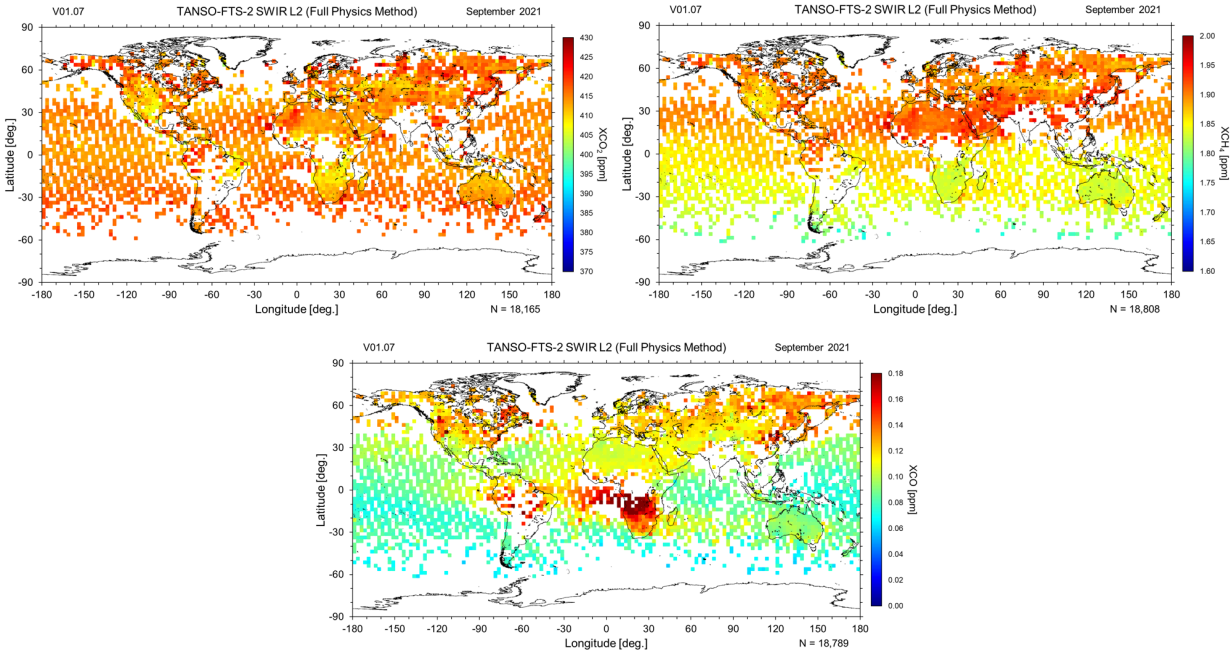

Figure 3. Monthly global maps of GOSAT-2 CO_2, CH_4, and CO column-averaged volume mixing ratios by Full Physics Method in 2.5 deg by 2.5 deg mesh for September 2021.

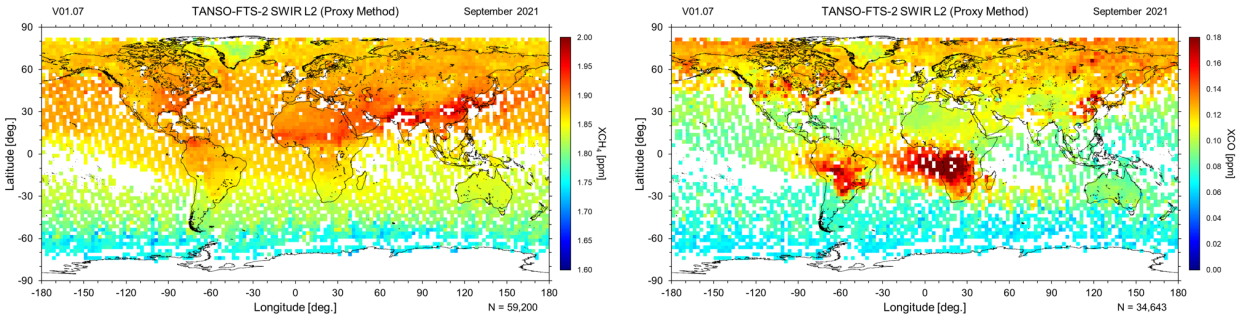

Figure 4. Monthly global maps of GOSAT-2 CH_4 and CO column-averaged volume mixing ratios by Proxy Method in 2.5 deg by 2.5 deg mesh for September 2021.

3. GOSAT and GOSAT-2 Level 4 Net Flux Products

The regional net fluxes of CO_2 and CH_4 are calculated from GOSAT and GOSAT-2 Level 2 concentration products by means of the inverse analysis. These flux data are included in GOSAT and GOSAT-2 Level 4 Standard Products. Currently, GOSAT Level 4 Standard Product (covering 42 land regions and 22 ocean regions for CO_2 and 1 ocean region for CH_4) are available for the period from June 2009 to October 2019 for CO_2 and from June 2009 to September 2018 for CH_4. GOSAT-2 Level 4 Standard Product with a grid size of 2.5 x 2.5 degree will be released in FY2022.

Methodology documents for GOSAT are available from the URLs below.
(Methodology, GOSAT, CO_2)
https://data2.gosat.nies.go.jp/doc/documents/ATBD_L4CO2_V1.0_en.pdf
(Methodology, GOSAT, CH_4)
https://data2.gosat.nies.go.jp/doc/documents/ATBD_L4CH4_V1.0_en.pdf

Methodology documents for GOSAT-2 will be available in FY2022.

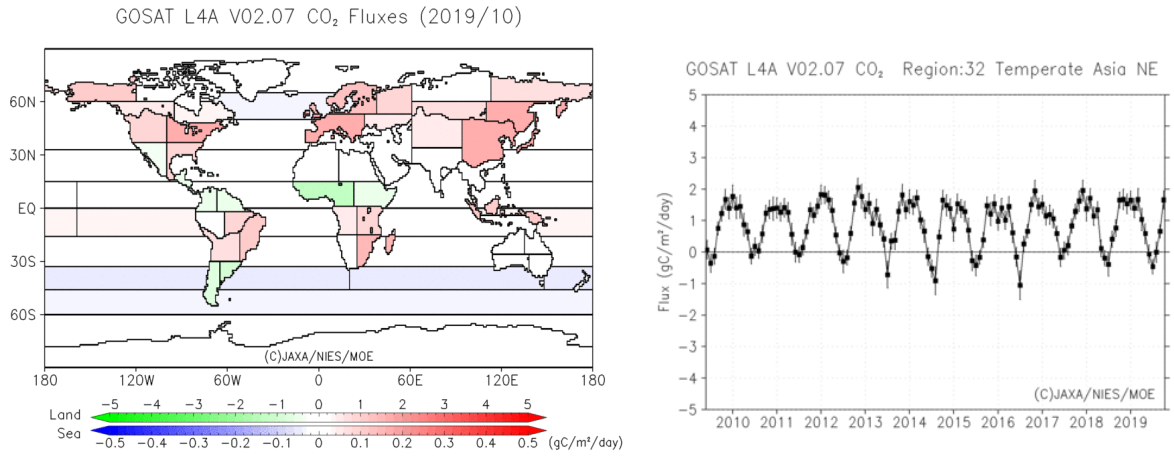

Figure 5. (Left) Monthly global map of GOSAT CO_2 flux for October 2019 and (Right) CO_2 flux time series from June 2009 to October 2019 for Region 32 (North-east Temperate Asia including Japan, China, and Korea)

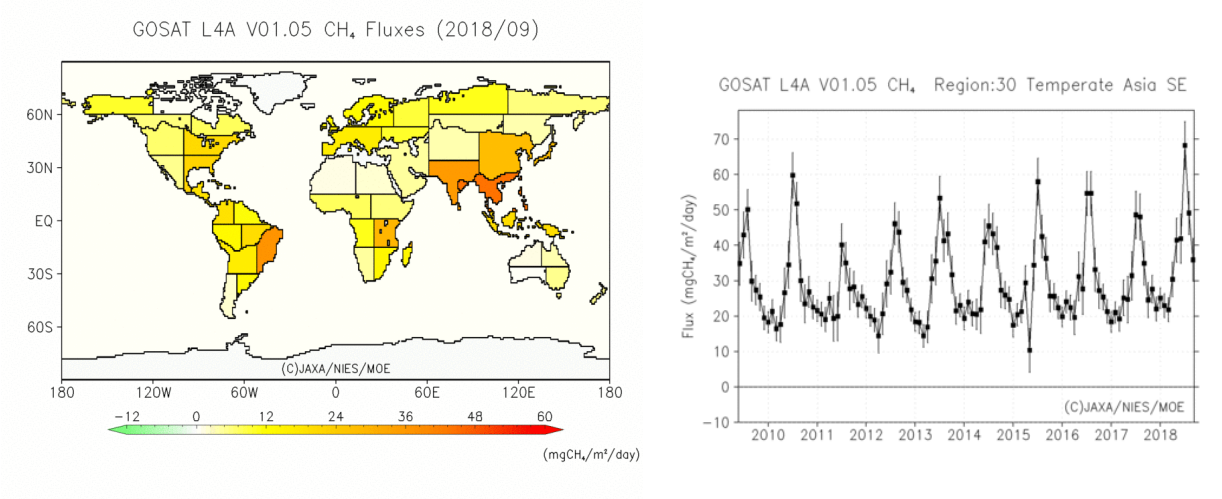

Figure 6. (Left) Monthly global map of GOSAT CH_4 flux for September 2018 and (Right) CH_4 flux time series from June 2009 to September 2018 for Region 30 (South-east Temperate Asia including India)

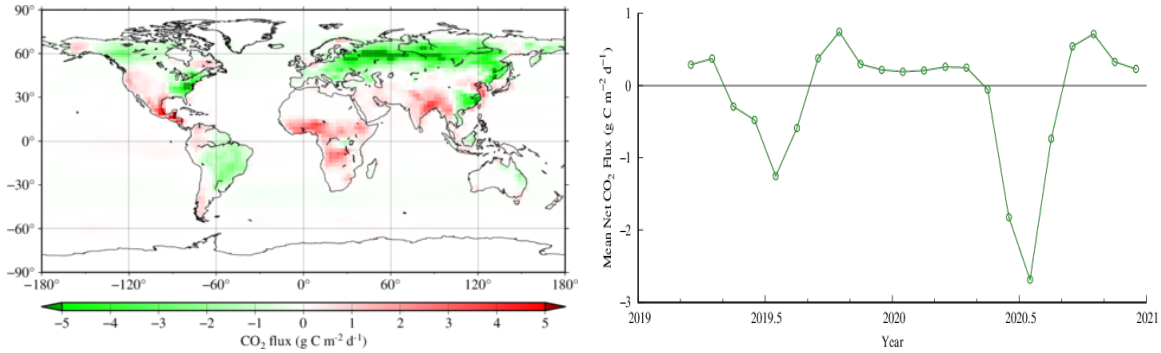

Figure 7. (Left) Monthly global map of GOSAT-2 CO_2 flux for June 2020 on a 2.5 degree grid, and (Right) GOSAT-2 CO_2 flux time series from March 2019 to December 2020 for 10 x 10 degree area in Central Asia (45N-55N, 115E-125E) showing strong CO_2 uptake in summer

4. GOSAT Whole-Atmosphere Monthly Mean CO_2 and CH_4 Concentration Data

CO_2 and CH_4 concentrations of the Earth's atmosphere averaged vertically from the surface to the top of the atmosphere and horizontally from tropical to polar regions can be obtained from GOSAT data as "GOSAT Whole-Atmosphere Monthly Mean CO_2 and CH_4 Concentration Data". These data and related documents can be downloaded from the URLs below:

https://www.gosat.nies.go.jp/en/recent-global-co2.html
https://www.gosat.nies.go.jp/en/recent-global-ch4.html

"GOSAT Whole-Atmosphere Monthly Mean CO_2 and CH_4 Concentration Data" are quite useful for not only grasping the current status of the Earth's atmosphere (Figure 8) but also evaluating the deviation of actual greenhouse gas concentrations from scenarios necessary to meet 1.5°C or 2°C temperature targets (Figure 9).

These data are being updated on a monthly basis.

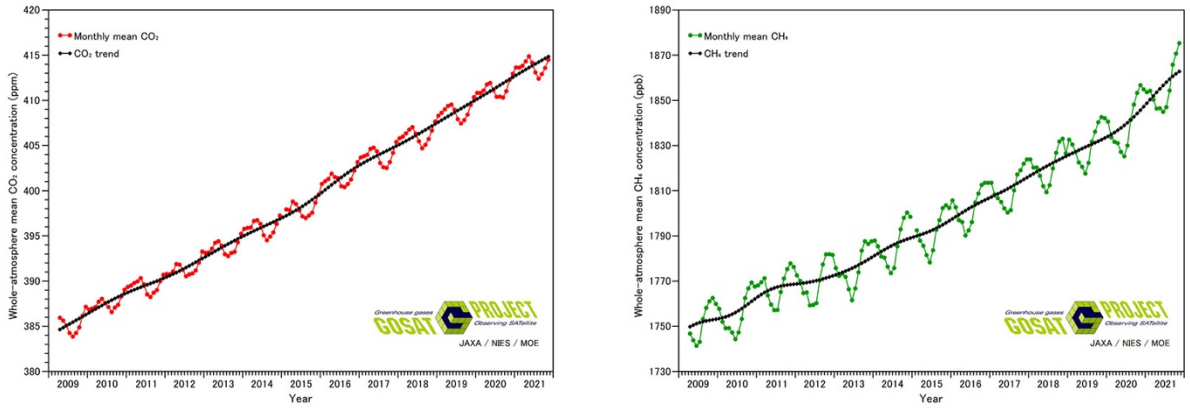

Figure 8. GOSAT whole-atmosphere monthly mean concentrations of (Left) CO_2 and (Right) CH_4 from April 2009 to December 2021. Black lines are long-term trends from which seasonal variations are mathematically removed.

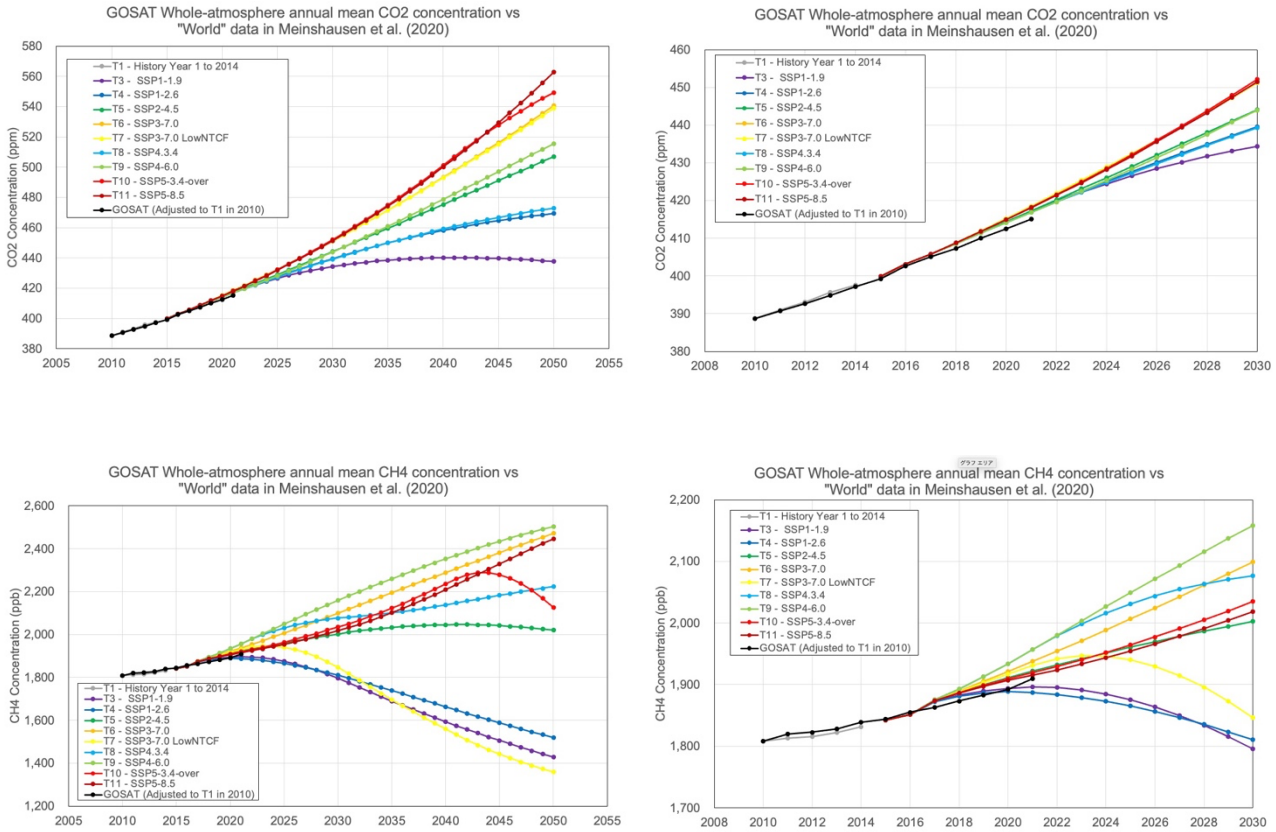

Figure 9. (Upper) CO_2 and (Lower) CH_4 concentration comparisons between GOSAT whole-atmosphere annual mean data and "World" data in Meinshausen et al. (2020).

Meinshausen, M., Nicholls, Z. R. J., Lewis, J., Gidden, M. J., Vogel, E., Freund, M., Beyerle, U., Gessner, C., Nauels, A., Bauer, N., Canadell, J. G., Daniel, J. S., John, A., Krummel, P. B., Luderer, G., Meinshausen, N., Montzka, S. A., Rayner, P. J., Reimann, S., Smith, S. J., van den Berg, M., Velders, G. J. M., Vollmer, M. K., and Wang, R. H. J.: The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500, Geosci. Model Dev., 13, 3571–3605, https://doi.org/10.5194/gmd-13-3571-2020, 2020.

5. Others

A peer-reviewed paper regarding country-scale CH_4 emission aggregated in 2011 - 2017 for 39 countries derived from GOSAT data was published in 2020 (Janardanan et al., 2020). The country-scale CH_4 emission data described in this paper are available upon request.

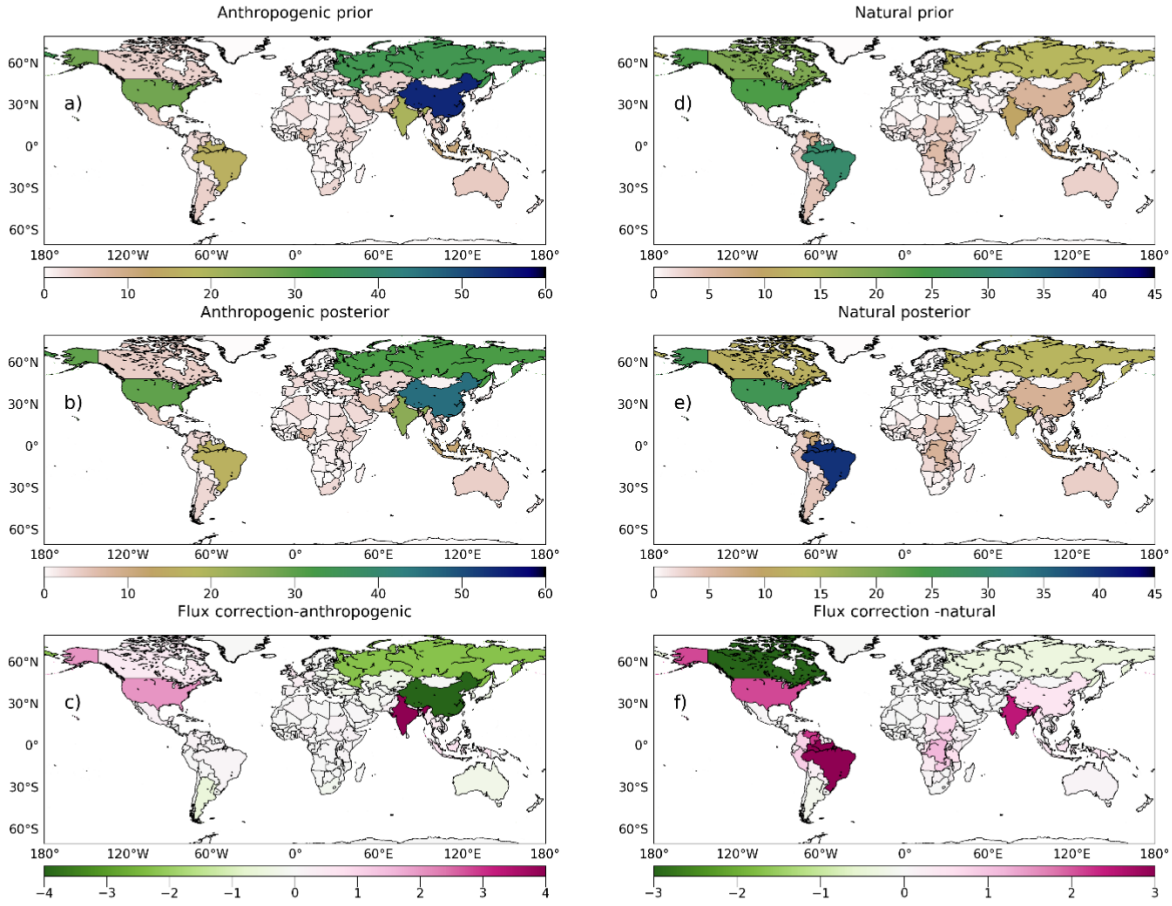

Figure 10. The mean annual total emissions aggregated (2011–2017) for each country for anthropogenic (left panels) and natural (right panels) categories. (a) and (d) (upper panel) Prior, (b) and (e) (middle panel) posterior, and (c) and (f) (bottom panel) correction fluxes. Unit: Tg CH_4/yr.

Janardanan, R.; Maksyutov, S.; Tsuruta, A.; Wang, F.; Tiwari, Y.K.; Valsala, V.; Ito, A.; Yoshida, Y.; Kaiser, J.W.; Janssens-Maenhout, G.; Arshinov, M.; Sasakawa, M.; Tohjima, Y.; Worthy, D.E.J.; Dlugokencky, E.J.; Ramonet, M.; Arduini, J.; Lavric, J.V.; Piacentino, S.; Krummel, P.B.; Langenfelds, R.L.; Mammarella, I.; Matsunaga, T. Country-Scale Analysis of Methane Emissions with a High-Resolution Inverse Model Using GOSAT and Surface Observations. Remote Sens. 2020, 12, 375, https://doi.org/10.3390/rs12030375, 2020.

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