Whole-atmosphere monthly mean CO_2 concentration detrended with average seasonal variation tops 400 ppm!

- Preliminary GOSAT monitoring results -

The Ministry of the Environment, Japan (MOEJ), National Institute for Environmental Studies (NIES), and Japan Aerospace Exploration Agency (JAXA) have been monitoring carbon dioxide (CO_2) and methane (CH_4) by the Greenhouse gases Observing SATellite "IBUKI" (GOSAT). A recent analysis of GOSAT observational data up to May 2016 shows that **the whole-atmosphere monthly mean CO_2 concentration detrended with average seasonal variation (CO_2 trend) exceeded 400 ppm in February 2016 for the first time since GOSAT was launched in 2009**. Further, **whole-atmosphere monthly mean CO_2, which first exceeded 400 ppm in December 2015, reached a record-high of 402.3 ppm in May 2016.**

This result will be reported at a side event of the 22nd Conference of the Parties (COP 22) to the United Nations Framework Convention on Climate Change (UNFCCC) scheduled to take place in Marrakech, Morocco, from November 7-18, 2016.

The whole-atmosphere monthly mean CO_2 concentrations based on GOSAT observation will continue to be reported periodically.

● Whole-atmosphere monthly mean CO_2 concentrations as seen by GOSAT

The three parties – The Ministry of the Environment, Japan (MOEJ), National Institute for Environmental Studies (NIES), and Japan Aerospace Exploration Agency (JAXA) - have published the whole-atmosphere monthly mean CO_2 concentrations (observations made vertically through the whole atmosphere up to the altitude of about 70 km) and the mean global CO_2 trend (average seasonal variation removed), which were estimated from GOSAT observational data from May 2009 to May 2016, on the website: NIES GOSAT Project, "Whole-atmosphere monthly mean CO_2 concentrations – Recent data –"[1].

"CO_2 trend" is derived by removing average seasonal variation from the observed monthly CO_2 concentration, which value is similar to the annual average concentration for the period of six months before and after the observation. The atmospheric CO_2 concentration shows seasonal and inter-annual variations and estimating "CO_2 trend" is crucial to monitor long-term global atmospheric changes.

As announced in the press release on May 20, 2016, the whole-atmosphere monthly mean CO_2 concentration first exceeded 400 ppm in December 2015 with a record of 400.2 ppm. The recent analysis of GOSAT data up to May 2016 shows that CO_2 trend exceeded 400 ppm in February 2016 (400.2 ppm) (Figure 1). This is the first time to be confirmed that the whole-atmosphere CO_2 trend exceeded 400 ppm based on GOSAT data. The CO_2 trend has been increasing continuously since the GOSAT launch in 2009. The monthly mean concentration also reached the highest record of 402.3 ppm in May 2016.

From May 2010 to April 2016, the average increase of CO_2 in one-year (annual increase)[2] was about 2.2 ppm/year; however, from summer 2015 to April 2016, it exceeded 2.5 ppm/year. The similar trend has already been reported based on the ground-based observation by Japanese research institutions including the Japan Metrological Agency (JMA) and National Institute for Environmental Studies (NIES). In addition to these reports, GOSAT observation provides evidence that this is not a phenomenon appeared only near the ground surface or specific regions, but appeared on a global scale.

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[1] http://www.gosat.nies.go.jp/en/recent-global-co2.html

[2] The difference of CO_2 trend compared to the same period of the previous year

(JMA ground based observational data)
http://ds.data.jma.go.jp/ghg/kanshi/ghgp/co2_e.html
(NIES monitoring station on Hateruma island (Okinawa, Japan))
http://db.cger.nies.go.jp/portal/ggtus/hateruma?lang=eng
(NIES monitoring station at Cape Ochi-ishi (Hokkaido, Japan))
http://db.cger.nies.go.jp/portal/ggtus/ochiishi

These results are based on a preliminary analysis of the systematic bias of GOSAT. For more information about the analysis method and explanation, please see the website below:

"Whole-atmosphere monthly mean CO_2 concentration"

(http://www.gosat.nies.go.jp/en/recent-global-co2.html). An explanatory document (PDF) is available on the website.

• Global CO_2 concentration above 400 ppm and its meaning

CO_2 concentration, which was around 280 ppm before the Industrial Revolution, has been increasing continuously and the present rate of increase is about 2 ppm per year. According to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), with scenarios limiting global greenhouse gas concentration to 450 ppm CO_2 equivalent or below by 2100, it is likely to keep global mean temperature increase (compared to pre-industrial levels) less than 2.0 °C until the end of 21st century.

• Future course of action

The three parties will continue the public dissemination of new findings from GOSAT observations. Also, the parties plan to continue the ongoing space-based greenhouse gas observation with the GOSAT successor, GOSAT-2, which is planned to be launched in the Japanese fiscal year 2017. The results of the continued satellite observation will be utilized for the elaboration and refinement of global warming predictions.

This result will be reported at a side event of the 22nd Conference of the Parties (COP 22) to the United Nations Framework Convention on Climate Change (UNFCCC) scheduled to take place in Marrakech, Morocco, from November 7-18, 2016.

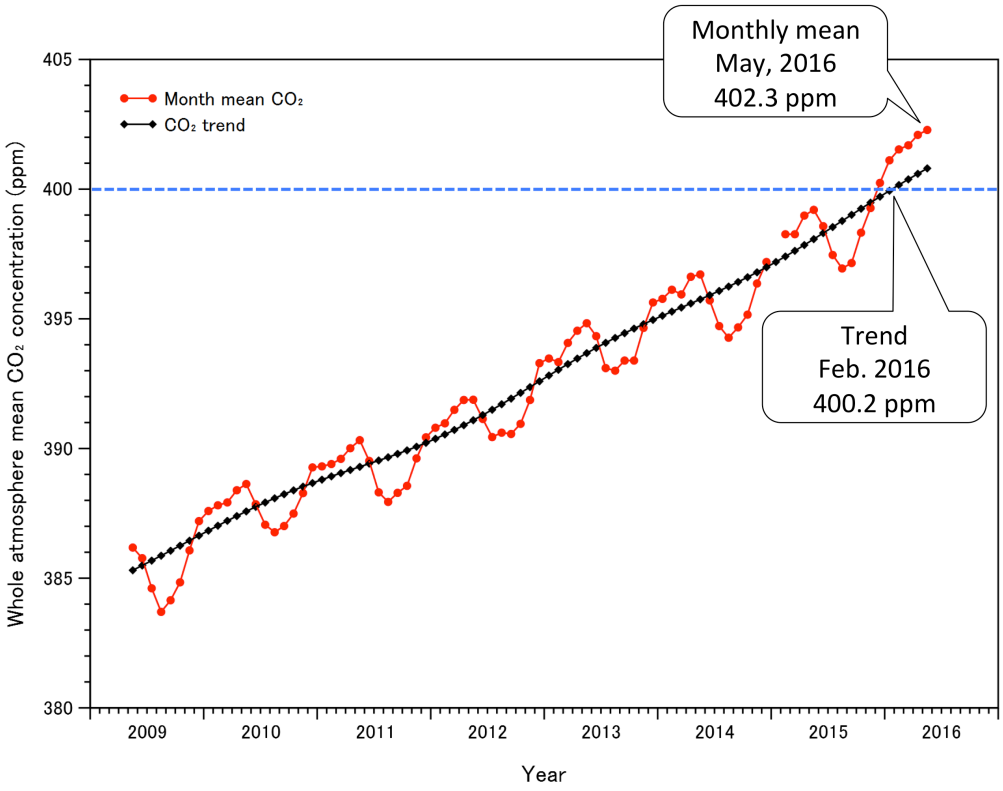

Figure 1. Whole-atmosphere CO_2 concentrations derived from GOSAT data: Monthly mean (●) and trend (・).

[Acknowledgement]

For the analysis of GOSAT observational data, two weather analysis datasets were used: GPV (Grid Point Value) data provided by the Japan Meteorological Agency and JCDAS data generated in the JRA-25 long-term reanalysis project by the Japan Meteorological Agency and the Central Research Institute of Electric Power Industry.

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[References]

• About the Greenhouse Gases Observing SATellite “IBUKI” (GOSAT)

The Greenhouse gases Observing SATellite "IBUKI", developed jointly by the Ministry of the Environment, Japan (MOEJ), the National Institute for Environmental Studies (NIES), and the Japan Aerospace Exploration Agency (JAXA) is the world's first satellite designed specifically to monitor greenhouse gases from space. The satellite has continued to fulfill its main mission in monitoring atmospheric carbon dioxide (CO_2) and methane concentrations from space to improve the accuracy of sink/source estimates, and achieve its target to contribute to precision refinement for the ongoing elucidation of carbon cycles, since its launch on January 23, 2009.

• Characteristics and significance of greenhouse gas observation by GOSAT

CO_2 changes at surface-level monitoring sites and the global CO_2 mean based on those observations have long been reported by the World Meteorological Organization and several other meteorological agencies around the world. To further facilitate an understanding of overall trends for CO_2 in the atmosphere, knowledge of “whole-atmosphere” CO_2 mean is necessary, and for this, more CO_2 information in the vertical direction is needed. In fact, from past measurements taken by aircraft, CO_2 levels are known to vary with altitude. Model predictions of whole-atmosphere CO_2 mean have appeared in the fifth assessment report by the Intergovernmental Panel on Climate Change, as they are important for predicting the risk of global warming due to rising greenhouse gas levels. This is where CO_2 observation by GOSAT comes in useful, as the satellite measurement encompasses levels from the surface to the top of the atmosphere and provides CO_2 concentration averaged over an entire atmospheric column (this is referred to as column-averaged CO_2 concentration).

• The method to remove seasonal variations from whole-atmosphere monthly mean CO_2

This time, trigonometric functions are used to fit whole-atmosphere monthly mean CO_2 to define average temporal variations in 6 and 12 months. By subtracting such temporal variations, seasonal variations are removed from the monthly mean CO_2. In the calculation of CO_2 trend, subtle variations observed in shorter periods are also removed.

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