Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

MSD03-P01 Room:Convention Hall Time:May 22 18:15-19:30

Usage of synergetic band spectra observed by TASO-FTS/GOSAT to estimate CO2 concentration in the boundary layer

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CO2 concentration near the surface is an important parameter for estimating the uptake speed into the forests and oceans, and/or emission strength over the urban areas. The greenhouse gas observing satellite (GOSAT) dedicated to observe atmospheric CO2 concentration was launched in 2009 and has been operated for more than four years. The main band of its sensor can measure the columnar concentration of CO2, however, they cannot be directly converted into the concentration near the surface. The objective of this study is to propose a method to estimate the CO2 concentration in the lower atmosphere, particularly in the boundary layer based on the synergetic usage of thermal infrared (TIR) and short wavelength infrared (SWIR) band data. Generally, CO2 emission and uptake occur near the surface, and the air is well mixed in the boundary layer during the daytime keeping the columnar concentration of the gas. However, CO2 mixing ration in the boundary layer is not determined only from the columnar concentration, i.e. the thickness of the boundary layer is necessary. It can be estimated from temperature (or potential temperature) profiles retrieved from TIR band spectra as well as the tropopause height. By combining CO2 columnar concentration retrieved from SWIR band spectra, upper air concentration retrieved from TIR spectra, and the tropopause height and boundary layer thickness, CO2 mixing ration in the boundary layer can be estimated assuming the concentration in the stratosphere based on the yearly trend. We applied this method to a dataset obtained over the Kanto Plain during the GOSAT specific observation periods, and the results were validated using CO2 mixing ration data operationally observed at a ground based observation site of the meteorological research institute (MRI/JMA) in Tsukuba.

Keywords: carbon dioxide, GOSAT, boundary layer, retrieval

MSD03-P02 Room:Convention Hall Time:May 22 18:15-19:30

Comparison of CO2 column concentrations calculated from GOSAT SWIR and balloon-borne CO2 instrument measurements

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The Greenhouse gases observing satellite (GOSAT), launched on January 23, 2009, has monitored atmospheric carbon dioxide (CO_2) and methane (CH_4) globally from space.The objectives are to understand the global distribution of CO_2 and CH_4, and the causes of their variability with seasons, years and locations. The Thermal And Near infrared Sensor for carbon Observation-Fourier Transform Spectrometer (TANSO-FTS) onboard GOSAT has two detectable regions; Short-Wavelength Infrared (SWIR) and Thermal Infrared (TIR). TANSO-FTS observe sunlight reflected from the earth's surface in SWIR region and radiation emitted from the ground and atmosphere in TIR region. The global distribution of column-averaged dry air mole fractions of CO_2 (XCO_2) and CO_2 profile, called as GOSAT products, are retrieved from SWIR spectra and TIR spectra, respectively. It is essential to validate GOSAT in order to clarify the uncertainty of GOSAT products intended to get higher precision for use to find out the CO_2 sources and sinks and to assess its impact on climate change.

In this study, we compared to the XCO_2 derived from GOSAT and calculated from an originally developed balloon-borne CO_2 instrument (CO_2 sonde) which can measure CO_2 vertical profile up to the altitude of 10 km. XCO_2 calculated from the CO_2 sonde were extrapolated CO_2 mixing ratio provided from Nakazawa et al, Tohoku University.

Four CO_2 sonde data observed in 13:00-14:00 at three sites synchronized with GOSAT overpass were used for comparison; January 7, 2011 at Ichihara, January 31, 2011 at Moriya, June 30, 2012 at Moriya, and July 30, 2012 at Shirako.

As a result, in the comparison to the observations of CO_2 sonde in 2011 at Ichihara and Moriya, we report that there is roughly agreement taking account to the bias of GOSAT L2 product (V.2.XX) -1.20 +- 1.97 ppm which is temporary value reported by Morino et al[1)]. In the comparison of XCO_2 from GOSAT and the observations of CO_2 sonde in 2012 at Moriya and Shirako, it was found that the distance between the site of CO_2 sonde launched and the point observed by GOSAT made difference 0.3-4.1 ppm. In the Future, we plan to observe the CO_2 at various locations to contribute validation of GOSAT products by using the CO_2 sonde.

[1)] Morino et al, 2012: GOSAT TANSO-FTS SWIR products retrieved from improved algorithm and its validation analysis, The 18th Symposium on Atmospheric Chemistry, A-2-13 (in Japanese abstract).

Keywords: carbon dioxide, balloon-borne measurement, validation for satellite

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Remote sensing of CO2 to evaluate the CO2 emission from forest/peat-land fires

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The evaluation of CO2 emission especially from peat-land is one of key issues of MRV (Measurement, Reporting and Verification). The surface temperature of peat-land fire is relatively low and it is frequently discounted in fire hot-spot data. The amount of carbon loss or CO2 emission is difficult to estimate from the carbon stock change because it is accompanied by in-homogeneous and small subsidence. The loss in peat-lands occurs underground in some cases. So, the loss estimation from the flux observation superiors to the stock-change measurement.

The flux observation over forest is usually conducted by flux tower measurement (Eddy covariance method) for carbon budget of ecosystem which includes tree and soil processes. However, this measurement is limited to the homogeneous process, which is not the case for tropical peatland fire.

The CO2 flux from fire can be measured by observing the CO2 concentration and wind speed surrounding the area of interest. The remote sensing of CO2 column amount (integrated CO2 amount from surface to the space) can be done either from space on a satellite (GOSAT) or on the ground observing the direct solar spectrum. The authors have developed a fully automated optical fiber system to observe CO2 emission continuously. Two instruments were installed at Banjar Baru and Palangka Raya in Augutst-October, 2011. The CO2 concentration difference between south/north sites and its diurnal variability will be discussed.

Observation of carbon-mono-oxide CO is expected to be a useful tool to identify between above and below-ground fires. Preliminary observation has been tried at Palangka Raya as well.

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Keywords: Green house gas, Tropical area, Kalimantan, Indonesia, Latent Flux, MRV

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Analysis of Net Biome Productivity (NBP) from vegetation models and application to global atmospheric CO2 inversion

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The "top-down" estimation of the carbon flux through atmospheric CO2 inversion relies on prior CO2 flux information between the atmosphere and the earth surface, as well as the atmospheric CO2 concentration measurements. Among the prior information, the terrestrial biosphere remains in large uncertainties. To provide better constraint of CO2 inversion estimates, the modelled results of net biome productivity (NBP) from TRENDY project were analyzed and examined to apply for atmospheric CO2 inversion.

In TRENDY, a number of the DGVMs (Dynamic Global Vegetation Models) were driven globally by common climate forcing and historical atmospheric CO2 record to simulate for the period of 1901-2010, with three different scenarios aiming at reducing the uncertainties of land carbon budget. For our purpose, the modelled NBPs from the 8 DGVMs with scenario S2 (time-varying CO2 and climate) were analyzed to derive the mean feature of contemporary terrestrial biospheric net carbon budget and mean response to the changing climate system/recent global warming.

On a global scale, the model-averaged NBP show inter-annual variations correlated with inter-annual climate phenomenon/ENSO, and also an upward trend which suggests a regime shift around 1970 towards an increase in land carbon gains. EOF analysis to the average TRENDY-NBP also shows an increasing trend in the principal component of EOF1 over the recent three decades along with inter-annual variations. That indicates the leading EOF spatial pattern might respond to a long-term change as well as inter-annual variability in the climate system. While the modelled NBP are increasing globally, the variance among the models is also increasing with time, reflecting the model divergence in the processes relevant to the climate change. By examining multiple EOF patterns, in conjunction with global characterises of NBP distribution and its uncertainties, we explore the application of information from the model-ensemble results to atmospheric CO2 inversion.

Keywords: CO2, terrestrial ecosystem, inverse modelling, climate change

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Precise observations of the atmospheric O2/N2, Ar/N2 and their stable isotopes for understandings of the climate system

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Precise observations of the atmospheric O2/N2 ratio (delta(O2/N2)) have been developed since early 1990s to elucidate the global CO2 budget (e.g. Manning and Keeling, 2006), which have been noted by the IPCC. The atmospheric Ar/N2 ratio (delta(Ar/N2)) is expected to be one of the promising indicators for the exchange of heat fluxes between atmosphere and ocean (e.g. Blaine, 2005), which may improve the delta(O2/N2)-based estimation of the global CO2 budgets (e.g. Ishidoya et al., 2012a). It has been also reported that the gravitational separation of gas materials in the stratosphere can be detected with the observations of the delta(Ar/N2), the stable isotopic ratios of N2, O2, and Ar, and that the secular trends in the Brewer-Dobson circulation would be detectable by using the observed gravitational separation (Ishidoya et al., 2013). Recently, we have developed an ultra-precision continuous measurement system of the atmospheric delta(O2/N2), delta(Ar/N2), stable isotopic ratios of N2, O2 and Ar, using a mass spectrometer at the AIST and are applying it to the following studies;

1. Continuous observations of the atmospheric delta(O2/N2), delta(Ar/N2), CO2 concentration, stable isotopic ratios of N2, O2 and Ar at Tsukuba, Japan.

2. Analyses of the delta(O2/N2), delta(Ar/N2), stable isotopic ratios of N2, O2 and Ar of the balloon-borne stratospheric air samples, in cooperation with Tohoku Univ., Miyagi Univ. of Education, National Institute of Polar Research and JAXA.

3. Observations of the mid-tropospheric delta(O2/N2) over the western North Pacific by analyzing the air samples collected using a cargo aircraft C-130H, in cooperation with Japan Meteorological Agency and Meteorological Research Institute.

4. Observations of the atmospheric delta(Ar/N2) at Hateruma, Japan, in cooperation with National Institute for Environmental Studies.

5. Development of the high precision gravimetric standard air for the measurements of the atmospheric O2/N2 ratio and the O2 concentration, in cooperation with National Metrology Institute of Japan, AIST.

We have also developed a continuous measurement system of the atmospheric delta(O2/N2) using a fuel cell analyzer in cooperation with the National Institute of Polar Research and Tohoku Univ. (Goto et al., 2013), and tested in the temperate deciduous forest site at Takayama, Japan. Further, we are analyzing the causes of the temporal-spatial variation of atmospheric delta(O2/N2) with the atmospheric transport models developed by the AIST and JAMSTEC (Ishidoya et al., 2012a, b). Integration of these studies will lead to a better understanding of the mechanisms for climate changes.