

GEOSS および GEO Grid の構築 Development of GEOSS and GEO Grid

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Global Earth Observation System of Systems "GEOSS" aimed to build the "system of systems" or the global earth observation collaboration where all satellite, aircraft, and in-situ observations of earth, which were individually gathered by countries, and all observation systems, earth datasets, prediction models, and services for earth are combined. The GEOSS 10-year Implementation Plan was drafted in Brussels in 2005, and its ultimate goal was to reflect the scientific findings obtained through earth observation collaboration in policies. Specifically, nine societal benefit areas including disaster, health, energy, climate, weather, water, ecology, biodiversity, and agriculture were selected, and immediate issues that must be solved within 10 years were extracted. While the GEO Grid, which is the AIST initiative, its concept and goal are similar to that of GEOSS. In the presentation, these activities and the relationships will be introduced.

Keywords: Global Earth Observation System of Systems, Group on Earth Observations, GEO Grid, GEO task

GEO CL-02 task and activity of EMTech/AIST related to GEO carbon task GEO CL-02 task and activity of EMTech/AIST related to GEO carbon task

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As shown in the web site of GEO (http://www.earthobservations.org/about_geo.shtml) GEO (Group on Earth Observation) is a voluntary partnership of governments and international organizations for the period 2005 to 2015. The Research Institute of Environmental Management Technology/AIST joined the carbon task of GEO since 2009. The carbon task is under the "climate" area, which is one of the nine social benefits areas. Now is in the last term and the strategic target of this area is,

Before 2015, GEO aims to: Achieve effective and sustained operation of the global climate observing system and reliable delivery of climate information of a quality needed for predicting, mitigating and adapting to climate variability and change, including for better understanding of the global carbon cycle.

There are two tasks under the climate area and one of them is "CL-02, Global carbon observation and analysis", which has only one sub-task "CL-02-C1: Integrated Global Carbon Observation and Analysis System". For this sub-task, Expected Achievements by 2015 is declared as follows.

-Global carbon monitoring networks improved and coordinated, toward a sustained and operational Integrated Global Carbon Observation and Analysis System by 2020.

-A Carbon portal (linked to the GEO Portal) as a single access point to the global carbon cycle data, containing a geo-referenced database and complying with the GEOSS Data Sharing Principles.

-Updates of global and regional carbon (CO₂ and CH₄) budgets, considering also fossil fuel emissions, provided annually, with a continuously reduced uncertainty.

-Improved methodologies for measuring and analysing carbon cycle data: develop agreed standards, improve Global Carbon Cycle Data Assimilation Systems (CCDAS); calibrate and validate space based observations.

-Provide easily understandable and accessible information and products, useful for decision makers and the general public.

The coordinator of this task is Antonio Bombelli (CCMS, Italy). However the coordination of the communities related above achievement is not always good, as pointed out at the work plan symposium at Geneva last year not only in Japan but in the world.

Keywords: Group on Earth Observation, carbon task

GEO 炭素観測解析システムの整備とアジアにおける貢献の提案 GEO Carbon Observations and Analysis System and the idea of Asian contribution

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Recognizing the growing need for improved Earth observations, over 130 governments and leading international organizations are collaborating through the Group on Earth Observations (GEO) to establish a Global Earth Observation System of Systems (GEOSS) by the year 2015. They are contributing their respective Earth monitoring systems to GEOSS and interlinking these systems so that they work together better.

GEO through its Members and Participating Organizations, has begun work to implement a global carbon observation and analysis system addressing the three components of the carbon cycle (atmosphere, land and ocean) to provide high quality information on carbon dioxide (CO₂) and methane (CH₄) concentrations, and emission variations. By combining observations, reanalysis and product development we will be able to develop tools for carbon tracking and carbon storage evaluation, including improved global networks of atmospheric CO₂ observations, air-surface exchange flux networks, as well as surface ocean CO₂ and related marine biochemistry observations.

GEO Members and Participating Organizations: Australia, Canada, France, Japan, Netherlands, Norway, UK, Italy, USA (NASA, NOAA, USGS, USDA), Committee on Earth Observation Satellites (CEOS), European Space Agency (ESA), Food and Agriculture Organization (FAO) Global Climate Observing System (GCOS), Global Terrestrial Observing System (GTOS), World Meteorological Organization (WMO) and the World Climate Research Program (WCRP) are supporting the development of an integrated global carbon observation system.

In close collaboration with national governments, space agencies, and relevant technical experts, GEO will demonstrate this capability through the establishment of robust methodologies, satellite acquisition plans and a series of regional pilot studies, which will provide a template for a consistent and reliable global carbon monitoring system.

One of major activities is to foster the use of space-based greenhouse gas (GHG) observations and consolidate data requirements for the next-generation GHG monitoring missions. By establishing close cooperation with CEOS and the GEO Carbon Community of Practice plans will be implemented for the end-to-end utilization of space-based GHG data, particularly those of Japan's GOSAT mission and NASA's replacement OCO mission, and other GHG observation missions being prepared in Europe.

The global carbon cycle determines the amount of carbon dioxide and methane that accumulates in the atmosphere, increasing the Earth's greenhouse effect. It is therefore a key component of the global climate system. The carbon cycle also responds to climate change, and understanding the ability of the carbon cycle to continue to act as a partial sink of fossil fuel emissions into the future will be a vital factor in determining the "allowable" fossil fuel emissions, while keeping concentration below certain levels.

Current uncertainties on the space-time distribution of CO₂ and CH₄ fluxes are very large. For well informed policy action aiming to curve down the future increase of CO₂ and CH₄, these uncertainties must be reduced, by establishing an Integrated Global Carbon Observing system (IGCO). The main goal of this report is to describe the building blocks and coordinated implementation of such an Integrated Global Carbon Observing system.

In Japan, IBUKI(GOSAT) satellite has been launched and been monitoring global atmospheric GHG since 2009. In Asian region, Japan has been strongly promoted to develop the AsiaFlux network. Furthermore, Japan is active to develop integrated global carbon cycle model. It will propose the way towards more integrated approach in order to integrate each Japanese activity for contributing as Asia component of the integrated global carbon observations and analysis system.

キーワード: 地球観測政府間作業部会, 全球地球観測システム, 炭素, 地球観測衛星委員会, GOSAT

Keywords: GEO, GEOSS, Carbon, CEOS, GOSAT

GOSAT プロジェクトの全球炭素観測と炭素収支推定への貢献 Contribution of GOSAT Project to global carbon observation and carbon flux estimation

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The GOSAT (Greenhouse gases Observing SATellite) Project is a joint effort being promoted by Japan Aerospace Exploration Agency, National Institute for Environmental Studies, and the Japanese Ministry of the Environment. The primary objective of the Project is to observe the global distributions of the two major greenhouse gases and their temporal variations. Nearly four-years-worth of observational data was collected with the satellite by now, and the concentration data, retrieved from the GOSAT observational data, were found to effectively fill out gaps in the distribution of CO₂ and CH₄ data collected in ground-based monitoring networks. The latest version of the Level 2 CO₂ and CH₄ concentration data products (version 02.***) are now publicly available. Through data validation activities, the uncertainties of both the CO₂ and CH₄ concentrations were now found to be less than 1%, which is smaller than originally targeted. Seasonal variations and annual growth trends were found from the four-year-long datasets; the data will be further analyzed together with more data to be accumulated. The concentration data are also being utilized for estimating regional CO₂ fluxes. The result of the estimation for the period between June 2009 and May 2010 was recently released to the public in December 2012 as the Level 4A data product. Efforts in improving the quality of these data products, which are the results from one of the "top-down" approaches to reveal global carbon cycle, will be continued. We herein summarize the progress of the Project.

キーワード: 温室効果ガス, 二酸化炭素, メタン, 全球分布, 大気輸送モデル, 二酸化炭素収支推定

Keywords: greenhouse gases, carbon dioxide, methane, global distribution, atmospheric transport modeling, CO₂ flux estimation

地上設置および船舶搭載高分解能分光計を用いた海洋上のGOSAT CO₂およびCH₄カラム平均濃度の検証

Validation of GOSAT column-averaged mole fractions of CO₂ and CH₄ over the sea with ground- and ship-based spectrometers

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To accurately predict future atmospheric greenhouse gas concentrations and their impacts on climate, it is necessary to quantify the global distribution and temporal variations of greenhouse gas sources and sinks. Greenhouse gases Observing SATellite (GOSAT) has observed the global distribution of the atmospheric greenhouse gases such as carbon dioxide (CO₂) and methane (CH₄) since April 2009. Thermal And Near infrared Sensor for carbon Observation-Fourier Transform Spectrometer (TANSO-FTS), which is one of the sensors onboard the GOSAT, measures the sunlight backscattered by the Earth's surface and atmosphere as well as the thermal radiance emitted from the Earth. Column-averaged mole fraction of CO₂ (XCO₂) and CH₄ (XCH₄) are derived from the sunlight spectra by an optimal estimation retrieval approach. Over the ocean, the GOSAT measures sunglint region because the reflectance is higher than other ocean region. In terms of treatment of surface reflection, the retrieval algorithm is different between the land and ocean scenes. Therefore, it is desirable to validate the XCO₂ and XCH₄ values separately for the land and ocean scenes. We obtain direct sunlight spectra with a high-resolution FTS (Bruker IFS 125HR) not only on the ground but also onboard the research vessel (R/V) owned by the JAMSTEC, and indicate that the XCO₂ and XCH₄ could be retrieved from the spectra with precisions needed to validate the GOSAT data.

We performed the observations with the high-resolution FTS onboard the R/Vs in the three cruises operated by the JAMSTEC: the R/V *Kaiyo* cruise (4?13 August 2010), the R/V *Kairei* cruise (10 September?5 October 2010), and the R/V *Mirai* cruise (14 April?5 May 2011). Then, the high-resolution FTS was located in Saga in June 2011, and has acquired continuously the validation data over the land. The high-resolution FTS is a large instrument and make it difficult to carry many times. An automated compact measurement system is developed for acquiring more data over the ocean. The new equipment consists of a solar tracker and an optical spectrum analyzer (OSA: Yokogawa AQ6370C) as described in Kawasaki et al. [2012]. Sunlight is introduced into the OSA through optical fiber. We obtain the solar spectra whenever the solar elevation angle is greater than 10 degrees, weather permitting. The system has obtained the validation data over the ocean in the 2013 world cruise with the R/V *Yokosuka*.

The residual between the observed and the calculated spectra fluctuates with respect to the scan time (i.e., along the wavenumber direction). This is likely due to limit of tracking speed of the solar tracker. In the case of a larger wave, the motors of the solar tracker could no longer keep the image of the Sun on the center of optical fiber inlet. The intensity variation in the measured spectrum is corrected by a low-frequency correction method [Keppel-Aleks et al., 2007]. Total column abundances are retrieved from the measured spectra with a nonlinear least squares spectral fitting algorithm, which scales an a priori profile to produce a synthetic spectrum that achieves the best fit to the measured spectrum. In the case of OSA system, it is found that measurement accuracy is reduced by vibration transmitted from the ship and insufficient tracking performance, which is the issue to be improved. The GOSAT XCO₂ and XCH₄ are compared with the ground-based and the ship-based validation data. For our coincidence criteria, we find GOSAT measurements within 2 hours of the high-resolution FTS measurement time and within plus or minus 5 degrees latitude and plus or minus 10 degrees longitude of the high-resolution FTS location. The seasonal trends of the retrieved XCO₂ are consistent with those of the validation data. The TANSO-FTS XCO₂ retrievals exhibit a negative bias of ~1 ppm with a root-mean-square difference of ~2 ppm compared to the high-resolution FTS measurements.

キーワード: 二酸化炭素, メタン, 遠隔計測

Keywords: carbon dioxide, methane, remote sensing

Global monitoring of greenhouse gases using various earth observation platforms Global monitoring of greenhouse gases using various earth observation platforms

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Center for Global Environmental Research (CGER), National Institute for Environmental Studies (NIES) has established a fundamental infrastructure for strategic monitoring of global environment with an emphasis on climate change since the early 1990s. The monitoring covers the atmosphere, ocean, and terrestrial biosphere particularly in Asia and the Pacific regions. The data have been acquired from different kinds of earth observation platforms such as ground-based stations, ships, and airplanes. A large number of studies have been conducted based on the datasets to detect changes in the atmospheric greenhouse gas concentrations and in the carbon exchanges among the atmosphere, surface oceans, and terrestrial biosphere.

The long-term datasets help to estimate temporal and spatial variations of regional and global carbon budgets, to clarify the mechanisms of essential processes of carbon cycle, and to predict future climate changes and its uncertainties. Since the dataset obtained from the monitoring would be an essential source of knowledge for global carbon cycle studies as well as a valuable validation dataset for earth system modeling and remote sensing, further efforts are still required to establish more effective data acquisition, quality control, and data sharing systems.

キーワード: Greenhouse gas concentration, carbon budget, atmosphere, ocean, terrestrial

Keywords: Greenhouse gas concentration, carbon budget, atmosphere, ocean, terrestrial

温暖化予測モデル開発の立場からの炭素循環観測研究への期待

Expectations for carbon cycle observation from a global warming projection modeler

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2013年のIPCC第5次評価報告書へ向け多大な貢献が予想される「第5次結合モデル相互比較プロジェクト」(CMIP5)では、地球システムモデル(ESM; 生物地球化学的過程を含む気候モデル)が必須となる予測実験がいくつか設定された。2013年2月現在、各国研究機関が開発したESMによる予測データがCMIP5に提出され、国際的なデータ配信システムESGから結果が入手可能である。そうしたデータの解析作業が現在進行中であり、人間活動による土地利用変化が将来の全球規模炭素循環の振舞に大きな影響を与えること、窒素と炭素それぞれの循環の相互作用を考慮するか否かが将来予測に決定的に重要であること、フィードバックに関するモデル間の結果のばらつきは光合成の定式化の違いによりもたらされている可能性があること、などが示唆されている。これらは観測研究における課題の優先度を検討する際に有用な情報となりうるだろう。また、モデルの検証のために観測データを用いる際には、グリッド化され整理されたデータの内容に十分な説明がなされていることが望ましい。GEOの炭素循環観測方針では、得られたデータに対してメタデータを付加することの重要性が指摘されているが、モデル開発者の立場から見ても適切な指摘と言える。モデル出力についても系統だったメタデータ設計の必要性は叫ばれており、観測とモデル開発に携わる研究者に共通の課題と言えるかもしれない。

キーワード: 炭素循環, モデリング, 地球温暖化

Keywords: Carbon cycle, Modeling, Global warming

衛星 RS を使った広域炭素収支評価における地上検証および長期観測の重要性
Importance of long-term and ground truth observations on the regional carbon budget
evaluation by Satellite RS

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キーワード: 地上検証, 長期連続観測, 広域評価, 陸域炭素収支, 衛星リモートセンシング

Keywords: ground truth, long-term observation, regional estimation, terrestrial carbon budget, satellite remote sensing

産総研における長期森林生態系炭素収支観測とそのデータ解析

Long-term observations of carbon budget in forest ecosystems at AIST stations and their data analyses

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Impacts of climate change on the activity of terrestrial biosphere have been predicted in recent studies. In East Asia and South-east Asia strongly influenced by Asian Monsoon, changes not only in temperature but also in amounts of precipitation and length of the rainy season associated with the climate change could have much influence on the carbon budget in the terrestrial biosphere. However, responses of the terrestrial biosphere to climate change are not yet fully understood. For the better understanding of the responses, further analyses using long-term measurement data of the carbon budget in terrestrial ecosystem are necessary.

National Institute of Advanced Industrial Science and Technology (AIST) has made long-term systematic measurements of CO₂ flux between the atmosphere and forest ecosystem and the related parameters in collaboration with some research groups, in a cool-temperate deciduous forest at Takayama (36.13degN, 137.42degE, 1420 m a.s.l.), Japan since 1993, and in seasonal tropical forests at Mae Klong (mixed deciduous forest, 14.58degN, 98.85degE, 231 m a.s.l.) and at Sakaerat (dry evergreen forest, 14.50degN, 101.92degE, 543 m a.s.l.), Thailand since 2001. Takayama is the longest monitoring site in the AsiaFlux network, while Mae Klong and Sakaerat are the longest AsiaFlux monitoring sites in Thailand. The CO₂ concentration data at Takayama have also been submitted to the World Data Centre for Greenhouse Gases of WMO. In this presentation, our research activities and some of the results obtained from the long-term measurements will be introduced. Some results of analyses of inter-annual variation of the carbon budget observed at our sites and environmental factors governing the variation will also be presented. Furthermore, improvement of methodology of measurement and data analyses will be discussed.

Keywords: Carbon budget, Forest ecosystem, AsiaFlux, Long-term measurement, Data analyses

GOSAT から GOSAT-2 へ : 宇宙からの高精度 CO₂, CH₄ 観測を目指して Space-based Carbon Monitoring by GOSAT and GOSAT-2: Towards better accuracy of XCO₂ and XCH₄ observation

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To observe the global column concentration of carbon dioxide (CO₂) and methane (CH₄) from space, the Greenhouse gases Observing SATellite (GOSAT) was launched on January 23, 2009, and has started the operational observation. Thermal and Near Infrared Sensor for Carbon Observation ? Fourier Transform Spectrometer (TANSO-FTS) has been continuously measuring CO₂ and CH₄ distributions globally, and the retrieved column CO₂ and CH₄ data have been distributed to the public. Over four-years operational periods, the useful scientific data sets and interesting articles for carbon source/sink evaluation were produced and published, and these results have been supporting to well understanding of carbon cycle. Currently, the importance of space-based carbon observation has been approved and desired the continuous observation in toward. Through the TANSO-FTS operation with the radiometric, geometric and spectroscopic characterizations, we learned how to improve the accuracy of X_{CO₂} and X_{CH₄} based on short-wavelength FTS. The correction procedures for micro-vibration from companion components, non-linear response of analogue and digitizing circuit are key role on the current on-board operating TANSO-FTS. These procedures were applied on operational level-1 processing algorithm. On instrumental aspects, the robustness and improvements will be required on the future mission to obtain the better spectral quality, and it will be able to lead more accurate X_{CO₂} and X_{CH₄} retrievals. The current retrieval accuracy of X_{CO₂} by GOSAT spectra is around 2 ppm, which is determined by comparing with ground- and aircraft- sampling measured dataset. It suggests that the accuracy of space-based carbon observation is much smaller than 4 ppm of the GOSAT mission target. The improvement of retrieval algorithm for X_{CO₂} and X_{CH₄} is also important both of the accuracy and the processing speed. To elucidate the carbon cycle more precisely, our experiences have to be summarized and applied in the future missions. To continue and improve the space-based carbon monitoring, the conceptual design work of GOSAT-2 has been started. The science and technical highlight of GOSAT and the preliminarily design of GOSAT-2 will be presented with current status.

キーワード: GOSAT, GOSAT-2, 二酸化炭素, メタン

Keywords: GOSAT, GOSAT-2, CO₂, CH₄

TANSO-FTS/GOSAT スペクトルデータの複合利用による境界層内 CO₂ 濃度の推定 Usage of synergetic band spectra observed by TANSO-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 ratio 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 ratio 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 ratio data operationally observed at a ground based observation site of the meteorological research institute (MRI/JMA) in Tsukuba.

キーワード: 二酸化炭素, いぶき, 境界層, リトリバル

Keywords: carbon dioxide, GOSAT, boundary layer, retrieval

GOSAT TANSO-FTS SWIR プロダクトと小型気球搭載型 CO₂ 濃度計測装置 (CO₂ ゾンデ) から算出した XCO₂ の比較

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

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温室効果ガス観測技術衛星 (GOSAT: Greenhouse gases Observing SATellite) は、二酸化炭素 (CO₂) とメタン (CH₄) の全球分布及びその変動特性を理解することを目的としており、2009年1月23日の打ち上げ後、現在も観測を継続中である。GOSAT には「温室効果ガス観測センサー TANSO-FTS (Thermal And Near infrared Sensor for carbon Observation-Fourier Transform Spectrometer)」が搭載されており、短波長赤外バンド (SWIR: Short-Wavelength Infrared) と熱赤外バンド (TIR: Thermal Infrared) を持っている。SWIR は、地表面から反射した太陽光を観測することで CO₂ のカラム平均濃度の導出が、また、TIR では地球大気・地表面からの放射を観測し、CO₂ の濃度プロファイルを導出することができる。導出されたこれらの GOSAT プロダクトは、CO₂ 吸収・排出量の推定や温室効果ガスによる気候変動への寄与の評価に役立つため、より高い精度が求められており、GOSAT プロダクトの不確かさを明らかにする検証が必要不可欠である。

そのため、本研究では、我々が独自に開発した小型気球搭載型 CO₂ 濃度計測装置 (CO₂ ゾンデ) を用いて得られた CO₂ 混合比から平均カラム濃度を算出し、GOSAT TANSO-FTS SWIR での観測から得られた CO₂ 平均カラム濃度との比較を行った。CO₂ ゾンデは、高度 10km までを観測領域としているため、それより上空は東北大学の中澤先生らのデータを使用して CO₂ 平均カラム濃度を算出した。今回比較に用いたデータは、関東 3ヶ所で GOSAT 衛星のオーバーパスと同期させ、13:00-14:00 に放球した CO₂ ゾンデの 4 データである。(2011年1月7日千葉県市原市、2011年1月31日茨城県守谷市、2012年6月30日茨城県守谷市、2012年7月30日千葉県白子海岸)

その結果、2011年に行った市原と守谷での検証では、森野ら¹⁾によって報告されている GOSAT の L2 プロダクト (V2.XX) のバイアス -1.20 ± 1.97 ppm (暫定値) を考慮に入れた場合、CO₂ ゾンデにより得られた CO₂ 平均カラム濃度は GOSAT プロダクトと概ね一致した。また、2012年に行った守谷と白子海岸での検証では、GOSAT の観測地点と CO₂ ゾンデ観測地点の距離によって、0.3-4.1ppm の差が出るという結果となった。今後の展望としては、CO₂ ゾンデのメリットを生かし、様々な場所で観測を重ね、より多くの地点で検証を行い、GOSAT プロダクトの検証に貢献したいと考えている。

¹⁾ 森野ら、改良した解析アルゴリズムで導出した GOSAT TANSO-FTS SWIR プロダクトとその検証解析、第 18 回大気化学討論会要旨集、A-2-13 (2012).

キーワード: 二酸化炭素, 気球観測, 衛星検証

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

森林/泥炭火災からのCO₂発生量リモートセンシング 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 inhomogeneous 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 August-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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キーワード: 温室効果ガス, 熱帯域, カリマンタン, インドネシア, フラックス, 温暖化防止
Keywords: Green house gas, Tropical area, Kalimantan, Indonesia, Latent Flux, MRV

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

キーワード: CO₂, terrestrial ecosystem, inverse modelling, climate change

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

気候変動メカニズム解明に向けた対流圏・成層圏における大気主成分濃度および同位体比の高精度観測

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

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大気中 O₂ 濃度 (O₂/N₂) の高精度観測は地球温暖化予測に必要となる炭素循環の解明の有効な手法として IPCC でも注目されている (e.g. Manning and Keeling, 2006)。一方、大気中 Ar 濃度 (Ar/N₂) は海洋貯熱量変動の指標となり得るため、 (O₂/N₂) を用いた炭素循環解析の高精度化につながると期待されている (e.g. Blaine, 2005)。また大気主成分 (N₂・O₂・Ar) 安定同位体比の高精度測定によって観測される成層圏大気主成分の重力分離からは、中層大気循環の経年変動の情報が得られることが示唆されている (Ishidoya et al., 2013)。以上を踏まえ、産業技術総合研究所では質量分析計を用いた (O₂/N₂)、Ar 濃度 (Ar/N₂) および N₂・O₂・Ar 安定同位体比の高精度連続測定装置を開発し、以下の研究に応用している。

- 1、つくば大気 (O₂/N₂)、 (Ar/N₂) および N₂・O₂・Ar 同位体比連続観測
- 2、成層圏大気試料 (O₂/N₂)、 (Ar/N₂) および N₂・O₂・Ar 同位体比の高精度分析 (東北大学、宮城教育大学、国立極地研究所および宇宙科学研究所との共同)
- 3、C-130H 輸送機を用いた北西太平洋上自由対流圏大気中 (O₂/N₂) の観測 (気象庁・気象研究所との共同)
- 4、波照間における大気中 (Ar/N₂) の観測 (国立環境研究所との共同)
- 5、O₂ 濃度国際基準スケール確立に向けた高精度 O₂ 絶対濃度標準ガス調製法の開発 (産総研・計測標準部門との共同)

また東北大学および国立極地研究所との共同研究により燃料電池式 (O₂/N₂) 連続観測装置の開発を行い (Goto et al., 2013)、産総研飛騨高山森林サイトでの観測に応用している。さらに (O₂/N₂) の変動要因の詳細な研究のため、産業技術総合研究所および JAMSTEC の大気輸送モデルを用いた数値シミュレーションも実施している (Ishidoya et al., 2012a,b)。これらの研究を総合的に推進し、炭素循環・海洋貯熱量・中層大気循環の各変動をモニタリングすることで、気候変動メカニズムの解明を目指す。