富士北麓カラマツ林の林床炭素収支に対する間伐の影響
The influence of tree thinning on understory carbon budget in a larch forest on the northern foot of Mount Fuji

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Forest ecosystem is the major carbon stock in terrestrial ecosystems. Elucidating the mechanism of the response of forest carbon budget against the global climate change is critical for predicting future carbon budget. Forest understory is very important component of forest carbon cycle, and it is vital to obtain detailed information about the dynamics of understory carbon budget to understand the whole response of forest carbon cycle to climate change. Forest management is thought to cause drastic change of understory environment, and we examined the influence of tree thinning on understory carbon budget using long-term chamber measurement data.
Multi-channel automated chamber measurement system was installed in a larch forest on the northern foot of Mount Fuji in 2006. We set 16 soil chambers (90 cm ×90 cm ×50 cm) for soil CO_2 flux measurement. The half of those soil chambers were trenched with root cut chainsaw to the depth of 30 cm to measure heterotrophic respiration (Rh). The remaining 8 chambers were used to measure soil respiration (Rs). We set 8 of plant chambers (90 cm ×90 cm ×100 cm) that included understory vegetation to measure understory net CO_2 exchange (NUE). From the NUE data, understory respiration (Ru) and understory gross primary production (GPP_u) were calculated. Stepwise tree thinning was applied to this larch forest in 2014 and 2015, and 30% of larch trees were cut down in March of 2015 in the end.
When we compared the data before (2006 to 2013) and after (2015 to 2016) tree thinning, the change of understory light environment and soil temperature resulted in increase of GPP_u and Ru, respectively. As a result, NUE did not changed remarkably.

キーワード：地球温暖化、林床炭素収支、チャンバー、二酸化炭素、カラマツ林
Keywords: global warming, understory carbon budget, chamber, CO2, larch forest

カンボジアの低地乾燥常緑林における乱流フラックスの季節ー年々変動特性

Seasonal and inter-annual variation of turbulence fluxes measured over a lowland dry evergreen forest in Cambodia

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Introduction: Almost all the countries in Indochina Peninsula have been economically developing recently and forests have been diminishing rapidly. Cambodia is not the exception, although the developing status is slightly delay compared to other neighboring countries due to the political chaos caused by the civil war in 1970-1993. Thus in Cambodia, forests still remain in the lowland area. However, the lowland dry evergreen forests (DEF), which usually grow on the thick and fertile soil, especially become the target to be converted to agricultural field and rubber plantation forests due to its suitable condition for vegetation growth. Despite that precious species of plants and animals may make their habit there, the DEFs are disappearing without known its interaction with environment. Therefore, we have challenged to operate ground-based observations of hydrological and meteorological factors since early this century. As some parts of them, here we introduce the results of turbulence exchange measurement carried out over a DEF ecosystem.

Site and Methods: The observation was operated using a 60-m-high tower built in “O Thom I watershed” (12º 44’ N, 105º 28’ E), in Kampong Thom province, central Cambodia. The DEF is mainly composed of evergreen broadleaf species, such as *Vatica odorata* and *Dipterocarpus costatus*, and the terrain is rather flat. Although the forest has been conserved by the administrative order, the surrounding area has been gradually converted to other land use recently. A sonic anemo-thermometer (K-probe, ATI, CO in 2008-2010; CSAT3, Campbell Sciantific Inc., UT in 2010-) and a ventilated thermo-hygrometer (HMP45A, Vaisala, Finland) were installed at the height of 51.0m of the tower for band-pass eddy covariance method. In 2011 and 2013, infrared-gas analyzer (IRGA: LI-7500 and LI-7500A, LI-COR, NE) was additionally set at the same height. The measurement has been made since 2007, but was often intermitted mainly because of electrical and instrumental breakdown. The data were collected at the rate of 10Hz using a data logger (CR1000, Campbell Sci.) and turbulence fluxes were calculated for each 30 minutes after the transducer shadow correction and conversion of coordinate system by the “double rotation”.

Brief results: In 2008-2009, monthly latent heat fluxes (*lE*) were rather steady and seemed mainly regulated by input radiative energy. Meanwhile, variation of monthly *lE* values was relatively large in 2011-2012, deviating from the trend of input energy in the end of the dry season, although evaporative demand from the atmosphere became large. These results suggest that evapotranspiration from the DEF was regulated by the incoming solar radiation in the wet season, whereas vegetation transpiration was sometimes suppressed in the dry season, probably depending on the degrees of soil dryness and other environmental factors. In the presentation, we will estimate the evapotranspiration trend more profoundly using additional measurement data, and will also discuss about the carbon dioxide flux using the IRGA data.

キーワード：低地乾燥常緑林、乱流フラックス、乾季蒸発散
Keywords: Lowland dry ever green forest, Turbulence fluxes, Dry season evepotranspiration

傾度法を用いた温帯二次林におけるメタン交換量の連続測定
Continuous measurements of methane exchange at a temperate secondary forest by the modified gradient method

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メタン(CH_4)は強力な温室効果気体であるが、陸域生態系におけるその動態については依然よく分かっていない。本研究では、森林群落スケールのCH_4交換量を改良傾度法によって測定した。改良傾度法と渦相関法、双曲線簡易渦集積(HREA)法によるCO_2・CH_4フラックスを相互比較し、手法間による差異を考察し、改良傾度法の利用可能性を検討した。

京都府木津川市の山城水文試験地において2016年の1年間観測を行った。改良傾度法の適用のため、2高度(35、25 m)の鉛直濃度プロファイルと渦相関法による拡散速度を計測した。風速の対数法則から地面修正量を求めるために、3高度(35、25、22 m)で水平風速を計測した。不安定条件ではCH_4濃度勾配が分析計の精度よりも小さくなることが想定されるため、CH_4フラックスの計算には安定条件のデータのみの使用を検討した。拡散係数を精度よく求めるため観測地固有の普遍関数を決定した。改良傾度法によるフラックスの計算には温度に関する普遍関数(Φ_h)とCO_2に関する関数(Φ_c)を用いた2通りのデータを算出した。

不安定条件のデータを含んだ改良傾度法と渦相関法によるCO_2フラックスは一致したが(R^2 = 0.66～0.68、RMSE = 5.66～6.66 $gCO_2\ m^{-2}\ d^{-1}$)、CH_4フラックスについては一致しなかった。安定条件のデータのみを用いてCO_2フラックスの日積算値を算出したところ、Φ_hを用いた改良傾度法は渦相関法と比較して50 %の過大評価であった。一方、Φ_cを用いた改良傾度法では過大評価がみられなかった。安定条件について積算時間と精度の関係を検討したところ、30日以上の期間で平均すると両手法のR^2が高くなることが分かった(R^2 = 0.86～0.91、RMSE = 5.73～6.42 $gCO_2\ m^{-2}\ d^{-1}$)。改良傾度法における誤差の多くは拡散係数の評価精度に起因すると考えられ、30日平均をすることによってランダム誤差を低減できたと考えられる。

6～10月と12月において、改良傾度法では0.63～1.79 $mgCH_4\ m^{-2}\ d^{-1}$の放出、HREA法では0.58～1.96 $mgCH_4\ m^{-2}\ d^{-1}$の放出となり、両手法によるCH_4フラックスの季節変化が一致した。1～3月と11月の季節変化が両手法間で異なったのは、この期間に渦相関法やHREA法のデータの欠測が多かったことが原因したと考えられる。6月3日からは高度25 mのプロファイル計測の平均化時間が180秒であったのに対し、それ以前の期間は60秒となっていた。平均化時間が短いことで4月と5月の季節変化が一致しなかったと考えられる。1～5月と11月を除けばHREA法と改良傾度法によるCH_4フラックスは同様の季節変化を示しており、安定条件を利用した改良傾度法が有効な手法であることが示された。

両手法による年間のCH_4収支を計算すると、改良傾度法で172 $mgCH_4\ m^{-2}\ yr^{-1}$、HREA法で237 $mgCH_4\ m^{-2}\ yr^{-1}$とどちらも年間で正味の放出を示した。一般に森林はCH_4の吸収源と考えられているが、この森林では2016年の1年間でCH_4を放出していることがわかった。

HREA法と改良傾度法の季節変化が一致した夏季の6～10月について、改良傾度法による月別CH_4フラックスは、1ヶ月前の月降水量と相関があることが分かった(R^2 = 0.97、$p < 0.01$)。降雨により土壌が徐々に嫌気状態に転じ、メタン生成細菌が遅れて活性化した可能性を示唆する結果である。

キーワード：メタンフラックス、改良傾度法、森林
Keywords: Methane flux, Modified gradient method, Upland forest

分光反射特性を用いたリーフケールでの光合成能力評価
Assessing leaf photosynthetic capacity using hyperspectral reflectance

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There are great uncertainty over the global exchange of carbon between the atmosphere and the terrestrial biosphere and an important source of it is related to the dependency of photosynthesis. Therefore, the maximum rate of carboxylation (V_{cmax}) and the maximum rate of electron transport (J_{max}) are key parameters. Walker et al (2014) reported that J_{max} was strongly related to Vcmax and thus we focused on V_{cmax} in this study.
Generally, V_{cmax} is estimated from photosynthetic CO_2 response curve and the measurements were conducted using a portable photosynthesis systems such as the LI-6400 open gas exchange system (Li-COR Biosciences, Lincoln, Nebraska, USA). However, this technique is only applicable for leaf scale and it is difficult to expand into large-scale monitoring.
Hyperspectral reflectance is one of the most attractive options for remotely estimating the biochemical, structural, and physiological traits of plant leaves and canopies based on their optical properties. Especially, the photochemical reflectance index (PRI, Gamon et al., 1992, 1997) has been used for evaluating photosynthetic status and ecosystem function. However, PRI was based on a linkage with photosystem II (PSII) efficiency by tracking the variation in xanthophyll cycle pigments, and thus it is not valid to directly evaluate photosynthetic capacity.
In this study, hyperspectral indices calculated from reflected spectra have been identified for evaluating V_{cmax} using the synchronous measurements of reflected spectra. The selection of the best indices was based on the leave one out cross validation and the ratio of performance to deviation (RPD). The result implies that the reflectance around 1600 nm and 2200 nm is useful to assess photosynthetic capacity.

キーワード：最大カルボキシル化速度、ratio of performance to deviation
Keywords: maximum rate of carboxylation, ratio of performance to deviation

Effects of extreme events on nitrogen export from forested ecosystems: a review

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The effects of the extreme event on the nitrogen (N) export from forested catchments are important factors for comprehensive understandings on the mechanisms of ecosystem disturbances and recovery and its prediction under global climate change. Previous related studies on this topic have consisted of many case studies with field observational approach and several prediction studies using simulation models and climate change scenario. Observational studies can be classified roughly into following three categories depending on the degree of the disturbance on ecosystem structures and functions:
1) Cases without geomorphological and biogeochemical disturbances: Structures and functions of catchment ecosystem are not disturbed, although high flow conditions occurs.
2) Cases without geomorphological disturbances, but with biogeochemical disturbances such as the changes in N pool size in soils: Structures and functions of catchment ecosystem are altered but those are recoverable within certain time period.
3) Cases with geomorphological disturbances in addition to biogeochemical disturbances: Structures and functions of catchment ecosystem are irreversibly disturbed by landslide and debris flow.
These variations also depend upon the vulnerability of the catchment structures in aspects of biological and geomorphological properties.
Previously, field researches have scarcely been conducted on the type 3 in the N export context, while many case studies for the types 1 and 2 have been previously performed in temperate regions. The major N form during storm events are determined if the movable pool is dissolved or particulate forms, and spatial distributions of those relative to the pathways of direct runoff. However, the evidencing studies on disturbance of the extreme storm events on the N dynamics (transformations and pool size changes) itself are still limited. Predictive studies have previously been conducted only in the non-monsoon regions of North America. More conditional variations, such as seasonal precipitation patterns, will be needed for future projections of the ecosystem responses in global scale perspective.

キーワード：極端気候現象、窒素流出、森林生態系
Keywords: Extreme climatic event, Nitrogen export, Forest ecosystem

Do you still use the constant ratio of PAR to solar radiation for global studies?

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Photosynthetically active radiation (PAR) is an essential source to drive photosynthesis. Therefore, PAR datasets are required to predict gross primary production (GPP) of ecosystem. In particular, global studies of plant productivity and carbon cycle require global wall-to-wall long-term datasets of PAR. However, such datasets to satisfy the requirements for the global studies are seldom available. Accordingly, in such global studies, PAR has been generally estimated using solar radiation (SR) datasets and the constant ratio of PAR to SR, which is around 0.45.

However, the ratio is not constant. In fact, many researchers have indicated that the observed ratio depends on the site, season, local time, and weather conditions. Nevertheless, the ratio remains incompletely understood as to how it depends on climatic factors. Accordingly, a general estimation model for the ratio of PAR to SR had not been well established.

Thus, the objective of our research is to establish a simple and general estimation model for the ratio of PAR to SR. To establish such a model, accurate measurements of both PAR and SR are needed. SR was measured by the direct and diffuse separation method. This method has been recommended for its accurate measurement by *WCRP/WMO* [1986]. PAR was measured using spectroradiometers and by a direct and diffuse separation method. Because it is well known that quantum sensors commonly used for PAR measurement have problems such as cosine errors, spectral errors, and the lack of a standard absolute PAR value. Our PAR measurement system could minimize such errors [*Akitsu et al.*, 2015].

Using the accurately measured data, we made the simple estimation model using water vapor pressure. The model was validated at specific sites in Japan. Furthermore, the monthly and annual global estimation was conducted using ERA-interim daily dewpoint temperature. On a global scale, the ratio has regional variability. Moreover, it has seasonal and annual variability. If this variable ratio was adopted for the global studies of plant productivity and carbon cycle, existing estimations of GPP might change within 15% of GPP.

キーワード：光合成有効放射、日射に対するPARの比、簡易推定モデル、信頼性の高いPAR観測
Keywords: Photosynthetically active radiation, Ratio of PAR to solar radiation, Simple estimation model, Accurate PAR measurement

Satellite-based analysis of the land cover change effect on evapotranspiration over semi-arid seasonal wetlands

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Land use and land cover change (LULCC) made by human alters the land surface properties and may affect the broad-scale water cycle, including evapotranspiration (ET). Assessment of the effect on ET is essential for decision making about LULCC, especially for an agricultural land use. However, attempts of the assessment are often confronted with issues on spatiotemporal scalability. Indeed, broad-scale, frequent data collection, and an appropriate ET model which can describe heterogeneous land surface are necessary to diagnose the LULCC effect accurately. Here, we developed satellite-based fine spatiotemporal ET model, which includes satellite data fusion, Jarvis-type surface conductance model, and so-called “trapezoid” approach, in order to reveal the effect of rice introduction into semi-arid seasonal wetlands in north-central Namibia. We established Bowen ratio-energy balance (BREB) measurement systems in the experimental field at University of Namibia, and obtained the Jarvis parameters of rice paddy fields and of natural vegetated wetlands. With those parameters and with fused satellite data (AMSR series, MODIS and Landsat), we ran the developed ET model and estimated ET over three test sites (with areas of 5.3 km ×5.3 km) under the two different scenarios (i.e. rice introduction and natural vegetated wetlands). Validation result showed the estimated ET described seasonal and interannual change well. Surprisingly, ET under the rice introduction scenario was smaller than that of the original states (i.e. under the scenario of natural vegetated wetlands). This was related to the large mitigation of ET in dry season under the rice introduction scenario, in which soil plowing was carried out. The proposed model provided the useful results for this region’s policy making, as well as a novel approach to monitor broad-scale ET over heterogeneous land surfaces.

キーワード：土地利用土地被覆変化、衛星データフュージョン、蒸発散モデル
Keywords: land use and land cover change, satellite data fusion, evapotranspiration model

Topographic controls on the abundance of Siberian larch forest

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Topographic controls on the abundance of larch forest was evaluated for entire eastern Siberia, where larch species primary dominates. For each of 0.5-deg grid, correlation coefficients (CCs) between overstory LAI and topographic properties for each of larch-dominating plots were calculated. To try to explain its geographic heterogeneity, principal component analysis was conducted by bringing together varieties of environmental data including the CCs. It suggested larch forests avoid areas with drought risk for grids with positive Principal Component 1 (PC1), while avoid areas with inundation/over-wetting risks for grids with negative PC1. Consistently, 2×2 contingency tables of inundation/over-wetting risks and presence of larch forest showed larch forests avoid areas with the risks, and this trend is more apparent for areas with negative PC1 than for positive PC1. These results suggest topographic heterogeneity controls abundance of larch forest through both of drought and over-wetting stresses.

キーワード：永久凍土、カラマツ、植生の分布
Keywords: Permafrost, Siberian larch, Vegetation distribution

北東シベリア永久凍土地における土壌炭素量の推定および温室効果ガス排出量の予測

Estimating carbon stock and greenhouse gas emissions from forest soils in the permafrost regions of northeastern Siberia

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Forest soils store a large amount of organic matters, which can be a significant source of greenhouse gases when decomposition is accelerated by increasing temperatures. Understanding carbon release from the soils is particularly critical in high latitude forests where more organic carbon would be available for microbial decomposition when soil temperature rises and permafrost thaws. The goal of this study is to estimate the amount of soil carbon and to predict carbon emissions under future climate change in the permafrost regions of northeastern Siberia. We use a model simulation and field observations to project carbon dynamics in the forest soils in this region. We are developing a soil carbon dynamic simulation model by incorporating soil physical and biological processes such as soil temperature, moisture, decomposition by microbes, and vertical movements of organic materials. Organic litter inputs that are computed daily from an existing vegetation model are divided into three parts with different decomposability and allocated vertically at 10 cm intervals. Decomposition rates for the three organic parts are computed as a function of soil temperature and moisture content of each soil layer. Remaining soil organic materials are subsequently relocated vertically through cryoturbation, which is the movement of organic materials in the soil layers caused by freeze-thaw actions. Simulation was conducted using 150-years of historical climate records and 95-years of future climate under RCP8.5 scenarios. Simulations were conducted in the Spasskaya-Pad Scientific Forest Station in Yakutsk, Russia, where time series observed data are available. Results show that slowly decomposable materials tend to accumulate and move downward into deeper soil layers, while small amounts of easily and intermediately decomposable parts stay on shallower layers. Around 12 kgC/m^2 of soil organic matter was estimated to be stored at that site, which was within the range of observed soil carbon stock in eastern Siberia regions obtained from observation-based global soil databases. Regional-scale distribution patterns of carbon stock were compared between the simulation results and global databases of soil properties.

キーワード：気候変動、分解、土壌有機物
Keywords: climate change, decomposition, soil organic matter

An assessment of natural methane fluxes simulated by the CLASS-CTEM model using a one box model of atmospheric methane

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The change in and the absolute magnitude of natural methane emissions from wetlands and fire, and soil uptake of methane, simulated using the CLASS-CTEM modelling framework, over the historical 1850-2008 period, are assessed by using a one box model of atmospheric methane burden. This one box model of atmospheric methane burden also requires anthropogenic emissions and the methane sink in the atmosphere to simulate the historical evolution of global methane burden. A reconstructed set of global anthropogenic methane emissions for the period 1850-2008 is used which is based on the harmonized RCP and EDGAR data sets. The methane sink in the atmosphere is represented using bias-corrected methane life times from the Canadian middle atmosphere model (CMAM). The resulting evolution of atmospheric methane concentration over the historical period compares reasonably well with observation-based estimates. The modelled natural emissions are also assessed using an inverse procedure where methane life times required to reproduce the observed year-to-year increase in observed atmospheric methane burden are calculated given the global anthropogenic and modelled natural emissions that we have used here. These calculated methane life times over the historical period fall within the uncertainty range of observation-based estimates. The present-day (2000-2008) values of modelled methane emissions from wetlands and fire, methane uptake by soil, and the budget terms associated with overall anthropogenic and natural emissions are consistent with estimates reported in a recent global methane budget that is based on top-down approaches constrained by observed atmospheric methane burden. The modelled wetland emissions increase over the historical period in response to both increase in precipitation and increase in atmospheric CO2 concentration. In the absence of this increase the simulated year 2008 methane concentration is about 130 ppb lower than observed compared to the case when wetland emissions increase over the historical period.

Keywords: Methane, Wetlands, Fire

Analysis of the relationship between the GPP and SIF from remote sensing data using theoretical model

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In the photosynthetic processes, a part of the excess energy is relaesed as chlorophyll fluorescence. On ecosystem-level scale, recently, it is known that the solar-induced chlorophyll fluorescence (SIF) correlates gross primary production (GPP), from both remote sensing and ground-based studies, reminding us that the GPP can be better-estimated using SIF data.
The mathematical models are a one of the tools to analyze correlation between the GPP and the SIF at leaf scale. The model, used in this study, is constructed based on the reaction kinetics and able to explain the relationship between fluorescence and photosynthesis that has been reported in previous studies. In the model, the absorption energy is divided and used in four phenomena; photochemistry, a constitutive thermal dissipation, energy-dependent heat dissipation and fluorescence emission; and the coefficients for probabilities of excitations to follow a certain pathway with K, or quantum yields with Φare used to examine the variation of the photosynthesis efficiency for excitation light. Thus the model is directly applicable to examine the relationship of SIF to GPP. Most of the previous studies, the photosynthesis is estimated using short-term chlorophyll fluorescence data measured by pulse amplitude-modulated (PAM). Therefore, they did not examine the seasonal and annual changes of fluorescence, although the parameter values are estimated approximately.
The spectral analysis of SIF has been studied by several applications with mathematical models. In particular, PROSPECT model [Jacquemoud & Baret, 1990] derived the spectral reflectance at a single leaf using eco-physiological properties such as chlorophyll and carotenoid concentrations. FlourMODleaf model [Pedrós et al., 2010], based on PROSPECT model, is structured to predict the reflectance, transmittance, upward and downward chlorophyll emission of a leaf and to obtain the fluorescence spectrum over the solar spectrum.
In this presentation, we would like to show the first results of estimating the GPP using SIF data in Takayama broad leaf forest (TKY) site, Japan with above SIF model, and examined the seasonal and annual changes in correlation between SIF and GPP at the leaf level. Additionally, to examine the emitted fluorescence spectrum, we analyzed the spectral distribution applying the FluorMODleaf model using data set of TKY.

キーワード：理論モデル、光合成、クロロフィル蛍光
Keywords: Theoretical model, Phothosynthesis, Chlorophyll fluorescence

二酸化炭素輸送計算のための陸域生態系炭素収支モデルコンポーネントの作成

Development of land ecosystem carbon balance model component for carbon dioxide transport calculations

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近年、多数の温室効果ガス観測衛星が打ち上げられ、インバージョン解析による大都市からのCO_2発生量の推定に関する研究が盛んになってきている。そのデータ解析には、CO_2の輸送計算を行うための領域モデルが不可欠で有り、温室効果ガス観測技術衛星（GOSAT）のデータを用いた関東地域におけるCO_2輸送計算には、産業技術総合研究所で開発された領域輸送モデルAIST-MM (Kondo et al., 2001) が用いられている。しかし、このモデルは、元々大気汚染質の輸送計算用に開発されたものであることから、陸域生態系の影響を十分反映するよう設計されていない。特に、植物による光合成と植物、土壌による呼吸については、植生タイプごとに決まった固定値を用いるなど、陸域生態系からのCO_2の発生、吸収量の計算精度が十分とは言えない。観測値と比較すると、冬季のCO_2濃度の計算値は、観測値と比較的合うものの、夏季には夜間の呼吸量と日中の光合成量が共に過大評価されていることが分かる。そのため、対象地域における実際の植生分布や植生の活動度を反映できる陸域生態系の炭素収支モデルの組み込みが不可欠である。そこで、本研究では、衛星データに基づく日単位の植生の変化や、日射量の時間変化なども明示的に取り込める陸域生態系モデルであるBEAMS（Sasai et al., 2005; 2011）の基本アルゴリズムを用い、総一次生産量(GPP）を求める計算コンポーネントを作成した。基本的な入力データは、気象データ、土地被覆分類、光合成有効放射量(PAR）、光合成有効放射吸収率(fPAR)である。このうち、気象データは気象庁のGPV-MSM、土地被覆分類はMODISのレベル3（MCD12Q1）、fPARはMODISのレベル4 (MCD15A3H)、PARはJAXA Satellite Monitoring for Environmental Studies (JASMES) を、つくばにおける地上観測値で規格化し、そのスケーリングファクターを全地域に当てはめた。その上で、太陽高度の時間変化を考慮して、それぞれの地点におけるPARの日変化を計算した。この値を元に、計算の空間分解能はMODISデータに合わせ500m、時間分解能は気象データに合わせ1時間とした。計算された結果は、森林総合研究所フラックス観測ネットワーク(FFPRI FluxNet)のデータと比較した。山城、富士吉田、川越における比較では、AIST-MM中のオリジナルの計算コンポーネントによるGPP計算の過大評価が大幅に改善され、年間総量でも20%程度の範囲で一致した。また、季節変化だけでなく、数日スケール（シノプティックスケール）の変化の再現性も良く、時間分解能の高い領域輸送モデルへの組み込みが可能なレベルになったと言える。次のステップとして、これらの時空間分解能での表現が可能な、植物呼吸や土壌呼吸の計算コンポーネントの作成に着手したい。

キーワード：二酸化炭素、総一次生産量、BEAMS
Keywords: Carbon dioxide, gross primary production, BEAMS

気候データに起因する総一次生産力評価のサイトレベルでの不確実性
Site-level uncertainty arising from climate data in estimations of gross primary productivity

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Process-based models estimate vegetation growth and productivity with uncertainties that are, to some extent, inevitable. These uncertainties arise not only from the model structure but also the input data. Among the several types of input data, climate forcing contributes the largest uncertainty in the simulated gross primary productivity (GPP) [Jung *et al.*, 2007]. For regional and global simulations, gridded climate data are required for climate forcing. Such climate inputs involve biases with respect to observation data and lead to errors in simulations of GPP and leaf area index (LAI). To investigate the uncertainties in GPP arising from climate forcing data using reanalysis data, we conducted simulation experiments using three climate forcing datasets.
For the simulation experiments, we used a prognostic model: the Biophysical and Ecophysiological Processes-based Model for Predicting Phenology and Productivity (BE4P). This model is forced by sub-daily simple climate variables and predicts GPP and LAI at daily steps. Using this model, we simulated seasonal changes in GPP and LAI at 30 flux tower sites encompassing various biomes and climate zones (Experiment C). To run this model, measured climate data at each site were derived from FLUXNET. Next, we repeated the simulations at the selected sites using NCEP/NCAR reanalysis data (Experiment R). Lastly, we replaced the reanalysis data with the bias-corrected data and conducted simulations in the same manner (Experiment R-BC). The bias correction was done using CRU monthly data as references. The estimated seasonal change in GPP and LAI in Experiment C agreed with the observed data at most sites. In Experiment R, the estimated GPPs were higher than those in Experiment C at most sites. The bias of the annual GPP was highest (~25%) for the deciduous broadleaf forest sites, which was comparable to the results using a different model [Barman *et al.*, 2014]. The higher bias was attributed to higher levels of solar radiation and precipitation in the reanalysis data compared to the measurements. In Experiment R, some sites showed similar or even lower GPP, whereas the estimated growth period was longer compared to Experiment C. Less soil water content during the growth period contributes to suppressing the productivity. This negative effect on vegetation growth and productivity surpassed the positive effect of the longer growth period, which suggests that the estimated GPP varies in response to soil water content during the growth period. In Experiment R-BC, the biases of the GPP and growth period were ameliorated. In conclusion, the reanalysis data can cause significant biases in the estimated GPP through light and water conditions, and a correction using gridded forcing data would help to reduce these biases.

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キーワード：一次生産力、不確実性、バイアス補正
Keywords: gross primary productivity, uncertainty, bias correction

シベリアの複数地点における動的植生モデルSEIB-DGVMへのMODIS LAIのデータ同化

Extending data assimilation with MODIS LAI observations and the dynamic global vegetation model SEIB-DGVM to multiple locations in Siberia

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既往研究において、Arakida et al. は動的植生モデルSEIB-DGVM (Spatially Explicit Individual-Based Dynamic Global Vegetation Model)を用いた粒子フィルターベースのデータ同化システムの開発を行い、人工衛星のMODISによる葉面積指数(LAI: Leaf Area Index)データを同化することに成功した。今回の研究では、開発したデータ同化システムを異なる地域に適用し、炭素フラックス、水フラックス、熱フラックス、植生構造、落葉針葉樹と草地のフェノロジーと関連するパラメータを推定した。研究の結果から、開発したデータ同化システムは複数地点で良好に動作することが分かった。

キーワード：データ同化、動的植生モデル、フェノロジー
Keywords: Data Assimilation, Dynamic Global Vegetation Model, phenology

人工衛星観測ビッグデータをシミュレーションに取り込む：データ同化を用いた植物フェノロジー予測モデルの最適化
Assimilate the big data from satellite observations into simulation: optimization of the phenology model using data assimilation

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データ同化はシミュレーションモデルを最適化する手法として用いられているが、陸上生態系モデルは、その複雑さゆえに、データ同化の応用が進んでいなかった。そこで本研究では、粒子フィルタというデータ同化手法を用いることで、非連続な挙動を示す陸上生態系をモデル化し、データ同化によって最適化することが可能であることを示す。今回はケーススタディとして、落葉樹の展葉・落葉フェノロジーを取り扱う。展葉・落葉によって、樹木の葉面積は非連続で突発的な挙動を示す。その挙動は従来、積算温度などでモデル化されることが多かったが、これまで統計的な手段で最適化されることはあまりなかった。本研究では、人工衛星で観測された葉面積指数の季節変化を用いてデータ同化を行った。その結果、モデルの複数のパラメタは総合的に最適化されることが示された。大型計算機を用いた並列計算では、日本全国を4kmのグリッドに分割し、そのうち落葉広葉樹が一定以上の割合で含まれるグリッド（約１万グリッド）で展葉・落葉を担うパラメタを最適化した。その結果、各グリッドの年平均気温によって、存在する植生がその場所の温度環境に適応している可能性が示された。さらに、落葉広葉樹のなかでも特定の樹種を絞り込んだデータ同化の結果、樹種ごとに適応のフレキシビリティが異なることが分かった。

キーワード：データ同化、フェノロジー、シミュレーション、陸上生態系、物質循環
Keywords: data assimilation, phenology, simulation, terrestrial ecosystem, biogeochemistry

炭素・窒素循環を有する地球システムモデルの開発
Development of new Earth system model with carbon and nitrogen cycle

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気候モデルに陸域生態系や海洋物質循環、大気化学過程を導入した地球システムモデルは将来の温暖化予測や地球環境変動のメカニズム解明に活用されている。陸域の炭素循環は大気CO2濃度を介することにより気候に作用するが、このような地球システムモデルの多くはこれまで、窒素循環がないために栄養塩による律速を表現できず、CO2吸収を過大評価している可能性があることがこれまで指摘されてきた。また窒素循環は温室効果ガスN2Oの排出過程にも関わっており、窒素循環を地球システムモデルに導入することが必要である。そこで本研究では、海陸生態系の窒素循環過程を有し、気候–炭素循環–窒素循環を陽に扱うことのできる新たな地球システムモデルを開発した。感度実験を実施したところ、CO2増加に対する陸域の炭素循環応答はこれまでのモデルと振る舞いが大きく違わないものの、窒素循環がその応答の強さを変えうることがわかった。本発表では、地球システムにおける陸域炭素循環・窒素循環に焦点を当てつつ、関連する大気・海洋・河川プロセスについて合わせて発表を行う。

キーワード：地球システムモデル、炭素循環、窒素循環
Keywords: Earth system modeling, Carbon cycle, Nitrogen cycle

