

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 CO₂ 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 CO₂ 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一年々変動特性

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” (12° 44' N, 105° 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 Scientific 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 evapotranspiration

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(CH₄)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CH₄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CO₂・CH₄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CH₄濃度勾配が分析計の精度よりも小さくなるのが想定されるため、CH₄フラックスの計算には安定条件のデータのみを使用を検討した。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CO₂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CO₂フラックスは一致したが($R^2 = 0.66 \sim 0.68$, RMSE = 5.66 ~ 6.66 gCO₂ m⁻² d⁻¹)、CH₄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CO₂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($R^2 = 0.86 \sim 0.91$, RMSE = 5.73 ~ 6.42 gCO₂ 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 mgCH₄ m⁻² d⁻¹の放出、HREA法では0.58~1.96 mgCH₄ m⁻² d⁻¹の放出となり、両手法によるCH₄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CH₄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CH₄収支を計算すると、改良傾度法で172 mgCH₄ m⁻² yr⁻¹、HREA法で237 mgCH₄ 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CH₄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CH₄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CH₄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 V_{cmax} 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/m² 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 released 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 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 Φ are 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. FluorMODleaf 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, Photosynthesis, 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CO₂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、CO₂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CO₂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CO₂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CO₂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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Barman R. *et al.* (2014) *Global Change Biol.*, **20**(5), 1394–1411.

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ー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・落葉を担うパラメータを最適化した。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変わらないものの、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

異なる攪乱履歴を有する森林における土壌呼吸量

Soil respiration in deciduous forests with different disturbance history

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土壌呼吸は森林生態系の炭素循環に重要な経路であるが、攪乱の種類の違いが土壌呼吸に及ぼす影響の情報は限られている。表土剥ぎ取り(TSS)は雑草抑制の観点から、有効な森林管理技術とされるが、TSSが土壌呼吸に及ぼす影響はよくわかっていない。本研究は、台風攪乱後倒木のみを除去したサイトにおいて、表土をそのままにした場所と表土をはぎ取った場所の土壌呼吸量を計測し、表土が土壌呼吸に及ぼす影響を検討した。

キーワード：表土除去、リーフリター、根、土壌有機物、空間変動

Keywords: Topsoil stripping, leaf litter, root, soil organic matter, spatial variation

マレーシアサラワク州の熱帯泥炭林における土壌CO₂およびCH₄フラックス観測

Measurement of soil CO₂ and CH₄ fluxes in tropical peat swamp forests using automated multi-chamber systems

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Large carbon has been stored in organic soil in tropical peat swamp forests, which has various types. We measured soil CO₂ and CH₄ fluxes two tropical peat swamp forests using automated multi chamber system, which consists of 16 chambers. Difference of two tropical peat swamp forests is depth of ground water level (GWL). GWL in CMC site is lower and that in MLM site is higher.

Both CO₂ and CH₄ fluxes were strongly regulated by GWL. CO₂ flux in both sites increased with decreasing GWL. However, CO₂ fluxes in CMC site became plateau below -0.3 m of GWL.

On the contrast, CH₄ in both sites decreased with decreasing GWL. In CMC site, CH₄ is almost zero below -0.3 m of GWL.

Carbon and nitrogen isotopic features of the bivalve *Corbicura japonica* and *Corbicura leana* in the Harai River (Mie Prefecture, central Japan) –preliminary report

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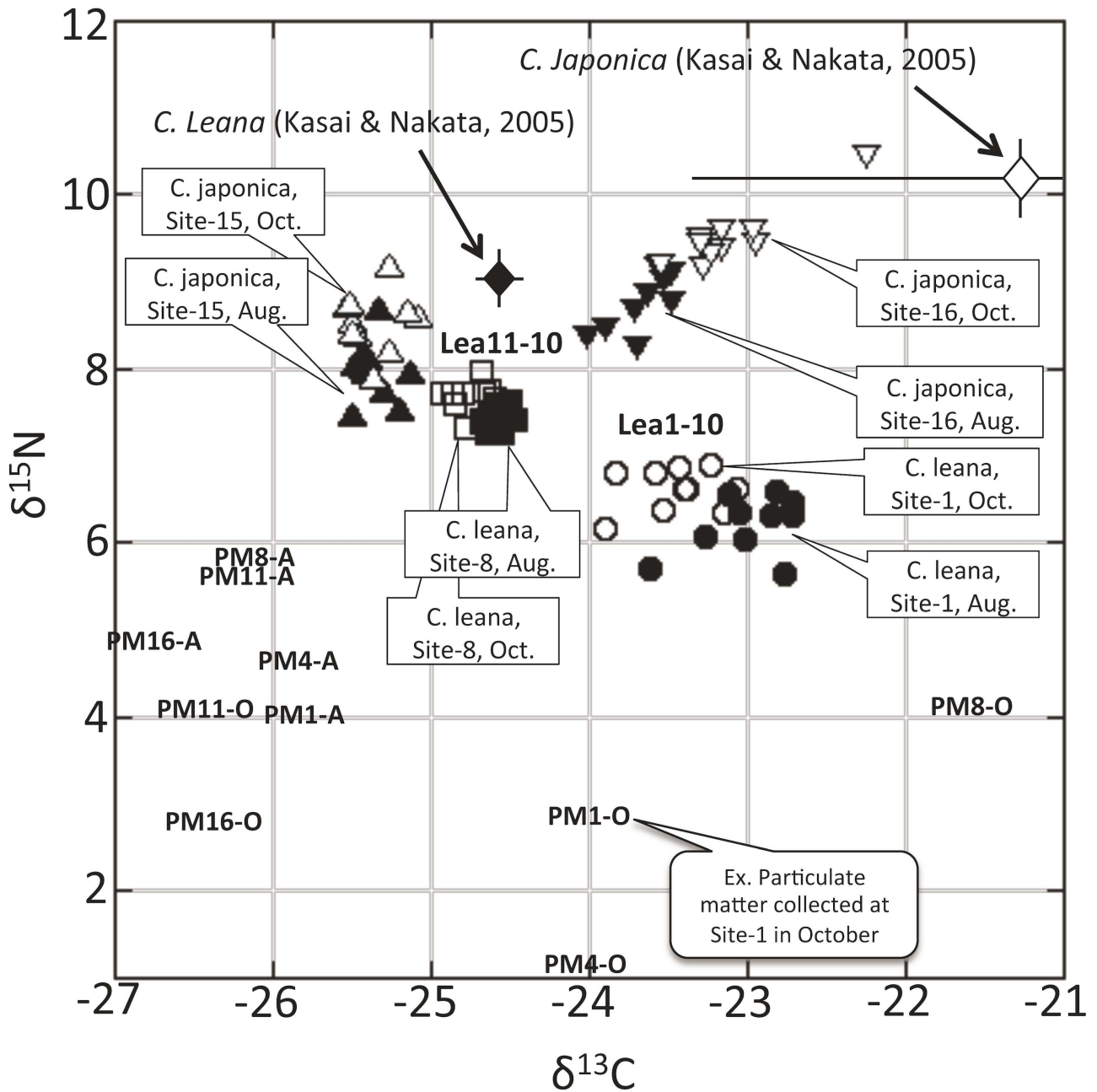
In order to eventually reveal factors controlling distribution and abundance of the bivalve Unionidae group in the Harai River, the branch of the Kushida River, Mie Prefecture, central Japan, the bivalve *Corbicura* as alternatives were analyzed for carbon and nitrogen isotope ratios. Dissolved components of water samples and isotopic compositions of suspended particulate matter were also analyzed. Sample collection was performed in summer (July 28th, 29th and August 8th) and autumn (October 24th and 25th) in 2016; *Corbicura* samples were collected at 4 sites (*C. leana* from the two upstream sites and *C. japonica* from the two downstream estuary sites), water samples at 15 localities and particulate matter at 5 localities. In summer, PO₄³⁻ increased downstream from 0.03 to 0.12 ppm. In October, concentrations of PO₄³⁻ and NO₃⁻ increased downstream. Concentrations of these nutrients were significantly higher than the midstream water of the Kushida River (less than 0.01 ppm for PO₄³⁻ and 2 ppm for NO₃⁻, respectively) (Sugitani et al., 2014). While carbon and nitrogen isotope ratios of *Corbicura* ranged relatively widely from -25.5 to -22.2 and from 5.6 to 10.4 per mil, respectively, samples of each population (n=10) clustered closely with each other. Additionally, seasonal variation can be seen, though small. Data of two populations of *C. leana* and one population of *C. japonica* comprised an array showing a negative correlation between carbon and nitrogen isotope ratios. Population of *C. japonica* collected from the lowermost locality was distributed outside of this array and shows a positive correlation between carbon and nitrogen isotope ratios. Distribution of *C. japonica* samples in this study was significantly lower in carbon and nitrogen isotope ratios than those reported by Kasai and Nakata (2005), who analyzed *C. japonica* and *C. leana* in the Kushida River and demonstrated that terrestrial organic matter was significantly important even for *C. japonica* diet. On the other hand, distribution of *C. leana* samples in this study was lower in nitrogen isotope ratios, while similar or higher in carbon isotope ratios than those reported by Kasai and Nakata (2005). The results of this study suggest that corbicura diet could vary significantly, depending on localized food sources. We are going to continue periodic samplings and analyses to reveal dynamics of food sources of *C. japonica* and *C. leana* and its relation to environmental factors.

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キーワード：シジミ、餌資源、炭素・窒素同位体比、祇川

Keywords: Corbicula, food sources, carbon and nitrogen isotopic ratios, Harai River



都市内緑地における炭素収支

Carbon budget in an urban forest

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Urban green areas, although being decreased in its space, have multi-functions in the urban area and would bring us benefit in the human health and safety. The carbon uptake in the urban green areas should be also benefit in GHG reduction. This study introduces our micrometeorological observations in a large park (Shirogane park) in Tokyo. The park locates in residential- and commercial area with compact mid-rise buildings near the center of Tokyo. The park was covered with forest canopy whose mean height was 14 m. Our 8-years-continued observation with eddy covariance method clarified the carbon budget in the park forest canopy. The maximum uptake of carbon was 8 gC/m²/day in Jun above the forest canopy. The annual NEP was 820 gC/m²/year from the eddy covariance, although 360 gC/m²/year from the allometry method.

キーワード：炭素循環、都市公園、渦相関法

Keywords: carbon budget, urban park, eddy covariance method

東シベリアのカラマツ蒸散と森林蒸発散の時間変動への凍土活動層の温度・水分条件の影響

Effect of hydro-thermal condition in active layer of permafrost to larch tree transpiration and forest evapotranspiration at eastern Siberia

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To improve our understanding of water cycle in eastern Siberia boreal forest, two observation sites at a larch dominated forest were compared. The dominant species in these forests is larch making the upper canopy, and mixed with mainly birch and willow, although composing ratio differs at each forest. Atmospheric condition was similar in the two sites, but soil properties such as soil texture, seasonal thawing ratio and soil water content was different. We use datasets of larch tree transpiration based on sap-flow measurement and forest evapotranspiration based on tower flux observation. Environmental factors explaining temporal variation of the larch transpiration and forest evapotranspiration were extracted by a path analysis. Remarkable difference between sites was found in influence of the soil temperature and water. Generally soil temperature affects positively to root water uptake in layer of the fine root concentration. In one site with soils of high water permeability, soil temperature of some depths has negative correlation to the water fluxes possibly via deepening active layer which accelerates soil water infiltration. Such relation was not found in the other site with high water holding capacity through the active layer. Vertical profile of the soil water due to difference of the soil texture and seasonal thawing ratio is an important factor on distinctive response of two forests.

キーワード：森林蒸発散、凍土活動層、カラマツ、シベリア

Keywords: forest evapotranspiration, permafrost active-layer, larch, Siberia

Artificial sap flow measured by heat field deformation and heat ratio methods in the laboratory

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Recently, newly developed sap flow techniques, that is heat ratio method (HR, Burgess et al., 2001) and heat field deformation method (HFD, Nadezhdina et al., 2012), have been available in Japan. However thermal dissipation method (TD, Granier, 1985) has been widely used in Japan (e.g., Kumagai et al., 2014), and there are quite a few numbers of studies measuring sap flow of trees in a forest by HFD and HR. Iida et al. (2015; 2016) applied TD, HR and HFD for a mature tree of Japanese cedar (*Cryptomeria japonica*) during a year, and confirmed their availability to detect diurnal changes in sap flow. This preliminary measurement was carried out in the Japanese cedar stand located in Mt. Tsukuba: the condition of comparisons cannot be controlled. Shinohara et al. (2016) has established the equipment to generate the stable water flow with the variable intensities within a stem by using a vacuum pump, and compared TD measurements with the artificial flow. Our primal objective is, by using the equipment in the laboratory (Shinohara et al., 2016), to compare the HR and HFD measurements with controlled sap flow.

We sampled four stems from four Japanese cedars planted in the nursery of Forestry and Forest Products Research Institute, Japan. Their ages are 12 years, tree height was from 9.0 to 10.0 m and diameter at breast height was from 10.9 to 12.5 cm. The width of active sapwood was about 3 to 4 cm. We used sensors of HR and HFD manufactured by ICT international Pty Ltd (type SFM1 and HFD8, respectively) and another HR measurement system developed by Kominami et al. (2016). Outputs of HR and HFD showed clear correlations with the vacuum pressure, indicating the basic availability of these methods to measure activities of sap flow for Japanese cedar as suggested by Iida et al. (2015; 2016). At the presentation, we will show the radial and azimuthal variations in sap flow generated by the equipment (Shinohara et al., 2016) and will analyze the effect of some corrections related to calculations of heat pulse velocity for HR. We will also provide the results of comparisons between the artificial sap flux density and that calculated by the equation proposed for HFD (Nadezhdina et al., 2012).

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キーワード : 強制通水、検定、heat field deformation法、heat ratio法

Keywords: artificial sap flow, calibration, heat field deformation method, heat ratio method

CO₂フラックス長期観測から見るカラマツ林での人為攪乱影響 Influence of human disturbances on long-term CO₂ exchange over a larch forest

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Larch forest is an important research object for evaluating ecosystem response against future global warming because it is a representative vegetation type for high latitudinal northeast Eurasia where greater temperature rise due to climate change is anticipated. In Japan, Larch is a common tree type of plantation that has been planted widespread over northeastern Japan especially after World War II. Quantifying the influence of the forest management on carbon budget in larch forests have significance on the securement of forests as a source of CO₂ absorption. Thus, National Institute for Environmental Studies (NIES) has implemented long-term monitoring program of CO₂ exchange over larch forests. We established the Fuji Hokuroku Flux Observation Site in the foothills of Mt. Fuji as an alternative base for monitoring, and began observations in January 2006. The site is dominated by larch trees of more than 50 year-old. 30% thinning was conducted at the site in spring of year 2014 and 2015. The characteristics of CO₂ exchange were affected from the human disturbance. We will introduce the results of carbon fluxes and related parameters for the sites.

キーワード：二酸化炭素、フラックス、攪乱

Keywords: CO₂, Flux, Disturbance

スギ・ヒノキの生理特性データベースの整備から見えてきたもの Some findings from on-going construction of database for functional traits of Sugi and Hinoki

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年平均気温が上昇し、集中豪雨等の極端現象が頻発するなか、林業分野における気候変動の影響評価が強く求められている。特に、日本の人工林の45%を占めるスギは、強い水ストレスを発生しやすく、すでに九州地方を中心に干害が報告されており、こうした影響評価が急務となっている。

高い精度の評価を行うためには、モデルに対象樹種の特性を反映させ、生理生態的にも妥当な森林動態を再現する必要がある。しかし、日本の人工林においてこうした試みは未だなされておらず、モデルに使用することを目的とした造林樹種のパラメータの実測例も少ないのが現状である。一方で、日本では、1960年代から主要造林樹種において、生理的特性や林分構造、物質循環に関する多くの研究がなされ、膨大な知見が蓄積されている。こうした知見を収集し、モデルのパラメータの平均値や変動のレンジ、およびその変動の要因、パラメータ間の定量的な関係を明らかにすることは、影響評価の高精度化に大きく貢献するものである。現在、私たちは日本の主要造林樹種であるスギ・ヒノキを対象に、国内外で発表された文献を広く収集し、生理特性を中心としたデータベースを整備中である。本発表では、現在までに収集された100本以上の論文から得られたデータの一部を紹介する。

近年の携帯型光合成測定装置の普及および葉の形質間シンドロームに関する研究の進展を背景に、現在までに、最も数多くのデータが集まっているのは葉の生理特性（光合成能力、葉の窒素濃度、気孔コンダクタンスなど）や形態（比葉面積：SLA, 葉面積重：LMA）である。生育条件（光、窒素施肥、灌水）、葉位、季節、葉齢が異なる葉で測定された光合成能力の範囲はスギで $0.34 - 12.69 \mu\text{mol m}^{-2} \text{s}^{-1}$ 、ヒノキで $0.37 - 9.85 \mu\text{mol m}^{-2} \text{s}^{-1}$ とそれぞれ10倍以上の大きな変異があった。また、同じデータセットにおいて、葉の窒素濃度やSLAの変異はいずれの種でも2-4倍程度だったのに対し、気孔コンダクタンスは光合成能力と同等の10倍以上の変異が見られた。さらに、こうしたパラメータの季節変化は将来の気候変動の影響評価に大きく影響する要因だが、これに関してスギ・ヒノキのデータは少ない。本研究では、収集したデータからこれらのパラメータのフェノロジー特性を明らかにすることも試みる。

キーワード：スギ、ヒノキ、生理特性、データベース、気候変動影響評価、人工林

Keywords: Sugi, Hinoki, Functional traits, database, impact assessment of climatic change, forestry

冷温帯林ミズナラ林冠葉における光合成機能とクロロフィル蛍光の季節変化

Seasonal changes in the photosynthetic capacity and chlorophyll fluorescence in canopy leaves of *Quercus crispula* in a cool-temperate forest

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近年、世界各地で気候変動が生じている。この気候変動の原因を探り、また予測するためには地球上の炭素の挙動を解明することが不可欠であり、その中でも最も大きい炭素吸収フラックスのひとつである陸域生態系の総一次生産 (GPP) を正確に推定することは人類の喫緊の課題である。太陽光誘起クロロフィル蛍光 (Solar-Induced Fluorescence: SIF) は、近年野外環境での観測が可能になり、GPPおよび光合成に関する生理的情報の指標として期待されている。本研究は、SIFおよびSIFの収率が季節ごとにどのような要因で季節変化するかを、個葉および林冠スケールでのモデルと観測から明らかにすることを目的とした。

観測地は北海道大学苫小牧演習林の林冠クレーンサイト (北緯42°40', 東経141°36') で、年間降水量は1200 mmである。このサイトには林冠クレーンが建設されており、クレーンを操作して林冠の葉にアクセスすることができる。クレーンの頂部および腕の下部には半球分光放射計 (MS700, 英弘精機, 東京) が設置されており、それぞれ入射光と反射光のスペクトルを測っている。760 nm付近の領域における両スペクトルから、3FLD法を用いて南中時 (11:30-12:00) に森林から出るSIFを観測・計算した。2016年の6月から10月の月に一度、サイト内に生息するミズナラ4個体の林冠葉それぞれ4枚を対象に、光合成測定装置LI-6400XT (Li-Cor, Inc., U.S.A.) を用いて最大カルボキシル化速度 (V_{cmax25}) を測定・計算した。この光合成パラメータ・南中時の気温・光合成有効放射 (PAR) から個葉のSIFを、van der Tol et al. (2014) のクロロフィル蛍光-光合成モデルを用いて再現した。また、森林の葉面積指数 (LAI) を、半球分光放射計から計算した分光反射指数EVIを用いて推定し、個葉レベルで再現したSIFにLAIをかけることで林冠レベルのSIFの季節変化を再現し、観測されたSIFとの比較を行なった。

個葉レベルのシミュレーションの結果、 V_{cmax25} を固定した (8月に観測された V_{cmax25} の平均値とした) ときに比べ、 V_{cmax25} の季節変化を考慮したときのSIFは4.9%低くなり、 V_{cmax25} がSIFに与える影響は小さいことが明らかになった。この V_{cmax25} によるSIFの変化は、 V_{cmax25} が春と秋に低下すると、熱放散回路がより活性化され、蛍光収率 (fF) は減少することが原因である。また、個葉で再現されたSIFはAPARと非常に強い相関を持ち ($r^2=0.99$)、個葉レベルではSIFは吸収した光の量にしたがって放出されると考えられる。

林冠レベルでのシミュレーションと観測結果を比較した結果、SIFについては $r^2=0.91$ 、SIFの収率 (SIF/APAR) については $r^2=0.64$ となり、ともに高い相関が得られた。この値は個葉レベルのモデル値と林冠での観測値の比較における決定係数 (それぞれ $r^2=0.73$, $r^2=0.34$) よりも高かった。このように、林冠での観測SIFは個葉のモデルよりも林冠のモデル値と高い相関を持った。このことから、林冠の葉量は観測されるSIFに影響していることがわかる。SIFは光環境によって変化するので、SIFをAPARで割って標準化 (SIF/APAR) しLAIとの関係を調べたところ、両者には非線形的な関係 ($SIF/APAR = (127x^2 - 4.73x + 3.34) \cdot 10^{-4}$) が認められた。この結果は、SIFの季節変化がLAIの影響を大きく受けていることを示唆している。

既往の研究では、SIFとGPPとの高い相関が報告されてきたが、本研究によって、SIFの季節変化は光と葉量によって生じることが明らかになった。この知見は、SIFをリモートセンシングする際の正しい解釈につながる

と考えられる。

キーワード：リモートセンシング、太陽光誘起クロロフィル蛍光、葉面積指数、炭素循環、非光化学消光
Keywords: Remote Sensing, Solar-Induced Fluorescence (SIF), Leaf Area Index (LAI), Carbon cycle,
Non-Photochemical Quenching (NPQ)

冷温帯落葉広葉林における太陽光誘起クロロフィル蛍光の層別上下方向の観測

Multi-layer measurement of upward and downward solar-induced chlorophyll fluorescence in a cool-temperate deciduous broadleaf forest

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Strong representation of Sun-Induced Fluorescence (SIF) for the ecosystem-level photosynthesis activity has been confirmed by satellite studies [Frankenberg *et al.*, 2011; Joiner *et al.*, 2013] and by field studies [Porcar-Castell, 2011, Yang *et al.*, 2015]. However, the lack of taking care of SIF emission below the tree canopy top may underestimate the contribution of sub-canopy and the understory species to total ecosystem CO₂ dynamics.

To examine the potential contribution of SIF emission from lower part of tree ecosystem to total ecosystem SIF emission, the downward SIF from tree canopy and upward SIF from understory were calculated from the spectrum data in a cool temperate forest in central Japan (36°08'N, 137°25'E, 1420 m a.s.l.) as well as the upward SIF from canopy top, and the fractional ratios among them are compared on half-hourly and daily bases from 2006 to 2007. The top canopy is dominated by Oak and Birches, and the sub-canopy layer and shrub layers are dominated by *Acer*, *Hydrangea* and *Viburnum* species. The understory is dominated by an evergreen dwarf bamboo *Sasa senanensis*, and covered partially by the seedlings of oak and maple, and herbaceous species [Muraoka and Koizumi, 2005]. The SIF was estimated from the spectrums of downward and upward irradiances measured at two heights of 18m and 2m above ground by HemiSpherical Spectro-Radiometer, consisting of the spectroradiometer (MS700, Eko inc., Tokyo, Japan) with the FWHM of 10 nm and wavelength interval of 3.3 nm. The SIF around 760nm (O₂-A band: SIF₇₆₀) was calculated according to the Fraunhofer Line Depth principle with the additional arrangements.

The SIF emission intensity was kept in the order as canopy upward > canopy downward > understory upward for most of growing season, except for the spring time when the snow was just melted and the *Sasa* bamboo kept green leaves at the forest floor. On the other hand, the relative intensities among three SIF emissions seem to change temporally. The lower upward/downward SIF ratio and lower understory/overstory SIF ratio in spring and autumn may have showed the phenological trend in foliage volume and chemistry in deciduous forest. On annual average, 43% higher upward SIF from overstory to that from understory showed high contribution of sunlit tissue and leaves in top canopy. The fractional ratio of overstory upward SIF to total of overstory and understory upward SIF of 70% is lower than the overstory ratio to total in NPP of 83% (Ohtsuka *et al.*, 2007) and that in APAR of 82%. Large contribution of understory in upward SIF may indicate that current satellite and field observations may miss the

contribution of sub-top crown foliage to ecosystem photosynthesis (GPP).

キーワード：リモートセンシング、炭素動態、森林構造

Keywords: Remote sensing, Carbon dynamics, Forest structure

Simulation of the forest dynamics and material cycle after typhoon disturbance using the Spatially Explicit Individual-Based Dynamics Global Vegetation Model (SEIB-DGVM)

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Typhoon, one of the major disturbances in temperate coastal areas, drastically affects forest dynamics and material cycling. After the typhoon, large number of gaps was formed, and canopy density was reduced, light transmission was enhanced. The primary productivity, hydrological characteristics, carbon and nutrient cycling, vegetation regeneration, community succession, species composition and structure, ecosystem stability were also severely affected (Sano et al., 2010; Lin et al., 2011; Kauffman et al., 2010). Therefore, the research of forest dynamics and material cycling after disturbance is critically important. Dynamic global vegetation model (DGVM) has been developed to simulate vegetation dynamics, energy and material cycles under the climate change (e.g. LPJ, CLM-DGVM, SEIB-DGVM, etc.). Especially, SEIB-DGVM has a great advantage that can represent the three-dimensional forest structure based explicitly with local competition among individual trees on the virtual forest stand (Sato et al., 2007; Guan et al., 2014). To understand the disturbance effect on the forest ecosystem, here we simulate the vegetation dynamics and carbon cycles by SEIB-DGVM in deciduous mixed forest, formerly Larch plantation until typhoon destruction, in Tomakomai Flux Research site with validation to the field measured data.

The study site was Tomakomai Flux Research Site in the Tomakomai National Forest in southern Hokkaido, Japan (42°44' 13.1" N, 141°31' 7.1" E, 125m above sea level). After Typhoon No.5 in 1954, during 1957–1959, the site was planted several tree species: Japanese larch (*Larix Kaempferi* Sarg.), Birch (*Betula ermanii* and *B. platyphylla*), Japanese elm (*Ulmus japonica*), Spruce (*Picea jezoensis*). Dominant understory species were Fern (*Dryopteris crassirhizoma*, *D. austriaca*), *Pachysandra terminalis* and *Hydrangea petiolaris*. In 2004, typhoon SONGDA landed Japan, 90% of the trees were blew down at Tomakomai Flux Research Site. (Hirano et al., 2017). Mean annual temperature and mean annual precipitation from 2005 to 2015 at this site were 6.38°C and 1408.18mm respectively. The climatic data are download from the Japan Meteorological Agency. The validation eddy flux and biomass data are taken by previous studies (Sano et al., 2010 etc.).

The SEIB-DGVM simulates the establishment, the competition with others, and the death of individual tree on spatial explicit 30m X 30m virtual forest stand. Since this research focuses on simulate forest dynamics after typhoon, we cut off the fire component to exclude the interference of the fire. To get the carbon storages equilibrium, the model was spun-up for 1000 years, repeatedly using 30 years' climate data from 1901 to 1930 with constant atmospheric CO₂ concentration in 1900. After spin-up, we set four continuous simulation periods: 1901–1959 as historical period with AMeDAS-based climate, 1959–2004 as plantation one with AMeDAS based climate, 2004–2016 as disturbance one with Eddy flux tower-based climate; 2016–2100 as future one with MIROC-AR5 based climate. We will show the preliminary results on simulated time courses in carbon fluxes (GPP, NPP, R_{eco}, NEP), carbon storages, and composition of species diversity especially between woody and grass PFTs. The destruction of canopy trees may reduce the competition for the understory trees and the formation of gaps case new allocation such as light, carbon and soil nutrients to accelerate the entry of invasive species into natural forest. The PFT diversity of ecosystems increased with the recovery of community.

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Keywords: Gap formation, Age class, Carbon cycle, Water cycle, Species composition

Bayesian calibration of a process-based model for estimating the growth of Japanese cedar plantations

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In Japan, there is increasing concern about the effects of climate change on the growth or decline of old Japanese cedar (*Cryptomeria japonica*) plantations. Process-based simulation models can provide information on the short- and long-term responses of tree plantations to changing climate, which is useful for policy making and broad discussion among stakeholders. In many cases, however, it is difficult to obtain all of the model parameters from direct measurements. The recently developed Bayesian calibration scheme has the potential to provide a set of appropriate parameters for a model based on monitoring data archives. This study tested the applicability of Bayesian calibration to the parameterization of a process-based model for estimating the growth of Japanese cedar plantations. The process-based model Biome-BGC was used with the default parameters (evergreen needle leaf forest). The 20 eco-physiological trait parameters (e.g., turnover rate, allocation, C:N ratio of tree organs, etc.) in Biome-BGC were calibrated simultaneously. For the Bayesian calibration, we used monitoring data for Japanese cedar plantations, including the monthly averaged data for the net ecosystem exchange (NEE) and soil respiration for 2001–2003 in the Kahoku Experimental Watershed in northern Kumamoto Prefecture, and growth and yield data for three experimental sites in Kyushu, Japan. The simulations of NEE and soil respiration were improved after a small number of iterations (*i.e.*, <1000) in the Bayesian calibration, compared with the default values. A newly added parameter on the turnover rate of fine roots also improved the simulation of soil respiration. The variation in the biomass increment among the three experimental sites was smaller in the simulation than observations, even after the calibration. The next step is to improve the choice and combination of observation data (e.g., gross primary production and respiration) and the calibration procedure (*i.e.*, hierarchical calibration).

キーワード：スギ、Biome-BGC、ベイジアンキャリブレーション

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