

## 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CO<sub>2</sub>およびCH<sub>4</sub>フラックス観測

### Measurement of soil CO<sub>2</sub> and CH<sub>4</sub> 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 CO<sub>2</sub> and CH<sub>4</sub> 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 CO<sub>2</sub> and CH<sub>4</sub> fluxes were strongly regulated by GWL. CO<sub>2</sub> flux in both sites increased with decreasing GWL. However, CO<sub>2</sub> fluxes in CMC site became plateau below -0.3 m of GWL.

On the contrast, CH<sub>4</sub> in both sites decreased with decreasing GWL. In CMC site, CH<sub>4</sub> 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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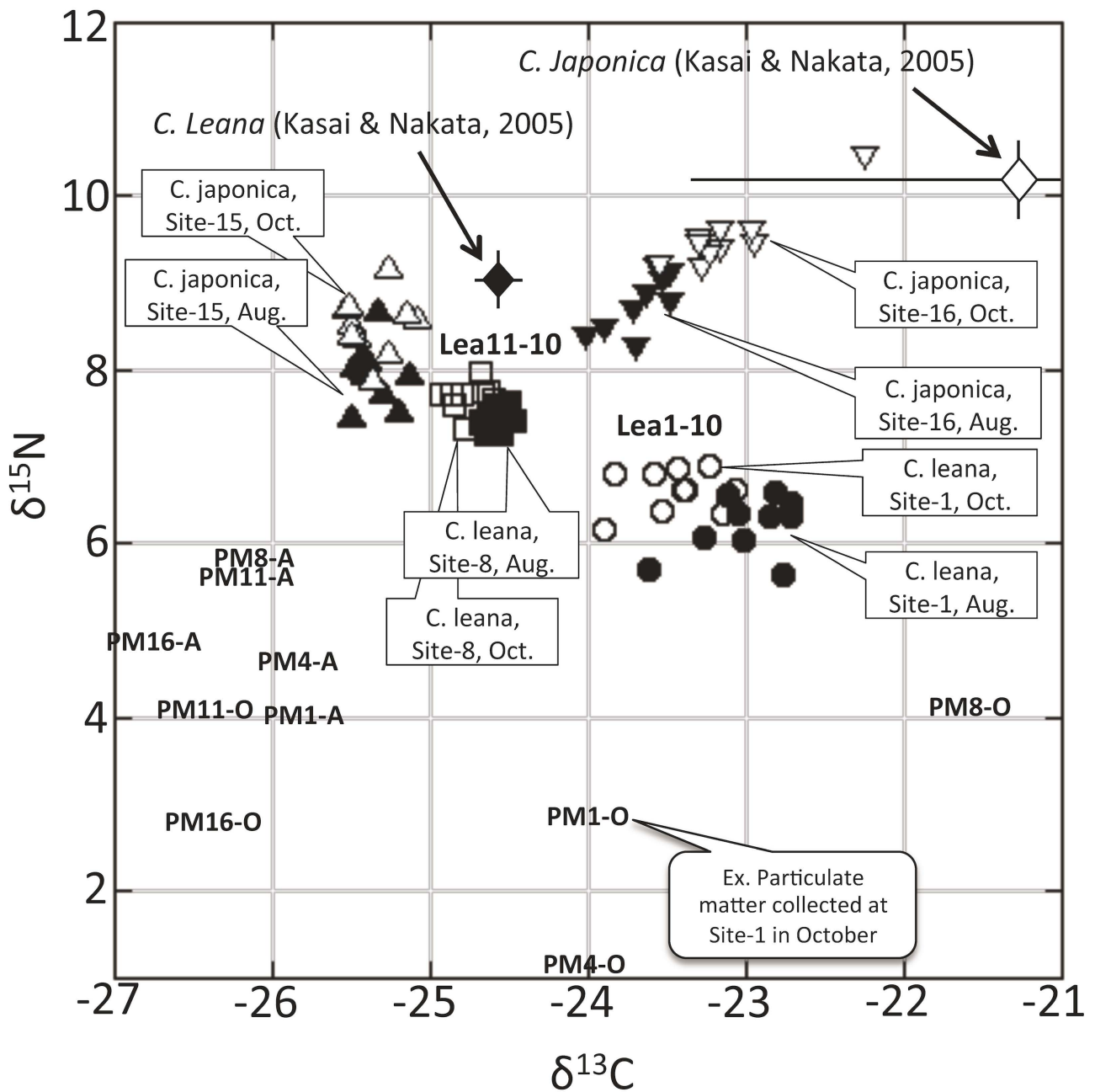
In order to eventually reveal factors controlling distribution and abundance of the bivalve Unionidae group in the Harai River, the branch of the Kushida River, Mie Prefecture, central Japan, the bivalve *Corbicura* as alternatives were analyzed for carbon and nitrogen isotope ratios. Dissolved components of water samples and isotopic compositions of suspended particulate matter were also analyzed. Sample collection was performed in summer (July 28<sup>th</sup>, 29<sup>th</sup> and August 8<sup>th</sup>) and autumn (October 24<sup>th</sup> and 25<sup>th</sup>) 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, PO<sub>4</sub><sup>3-</sup> increased downstream from 0.03 to 0.12 ppm. In October, concentrations of PO<sub>4</sub><sup>3-</sup> and NO<sub>3</sub><sup>-</sup> increased downstream. Concentrations of these nutrients were significantly higher than the midstream water of the Kushida River (less than 0.01 ppm for PO<sub>4</sub><sup>3-</sup> and 2 ppm for NO<sub>3</sub><sup>-</sup>, 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.

### Reference

- 1) Sugitani, K. et al. (2014) Geochemistry and isotopic (C, N) compositions of biofilms attached on riverbed gravels –Case study of the Kushida River in Mie Prefecture. The Geochemical Society of Japan Annual Meeting 2014, 1P38.
- 2) Kasai, A. and Nakata, A. (2005) Utilization of terrestrial organic matter by the bivalve *Corbicura japonica* estimated from stable isotope analysis. Fisheries Science 71, 151-158.

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/m<sup>2</sup>/day in Jun above the forest canopy. The annual NEP was 820 gC/m<sup>2</sup>/year from the eddy covariance, although 360 gC/m<sup>2</sup>/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).

### Cited paper

Burgess, 2001. *Tree Physiol.*, 21:589–598.

Granier, 1985. *Ann. Sci. For.*, 42: 193–200. [English translation, in *Evaporation, Benchmark Papers in Hydrology 2*. Gash JHC, Shuttleworth, WJ (eds). IAHS Press: Oxfordshire; 61–63].

Iida et al., 2015. *J. Japanese Assoc. Hydro. Sci.*, 45, 89-94.

Iida et al., 2016. *JpGU Meeting 2016, ACG22-P01*.

Kominami et al. 2016. *Proc. Japanese For. Soc. Congress*, 127, S6-5.

Kumagai et al., 2014. *J. Hydrol.*, 508: 66-76.

Nadezhdina et al., 2012. *Trees*, 26:1439–1448.

Shinohara et al. 2016. *ESJ63 Abstract*, P2-069.

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





## CO<sub>2</sub>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 CO<sub>2</sub> 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 CO<sub>2</sub> absorption. Thus, National Institute for Environmental Studies (NIES) has implemented long-term monitoring program of CO<sub>2</sub> 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 CO<sub>2</sub> 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: CO<sub>2</sub>, 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 ( $f_f$ ) 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 CO<sub>2</sub> 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 (O<sub>2</sub>-A band: SIF<sub>760</sub>) 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 CO<sub>2</sub> 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<sub>eco</sub>, 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.

## References:

- Sano et al. (2010) *Forest Ecology Management*, 260, 2214–2223
- Lin et al. (2011) *Ecosystems*, 14, 127–143
- Kauffman et al. (2010) *Wetlands*, 30, 1077–1084
- Sato et al. (2007) *Ecological Modelling*, 200, 279–307
- Guan et al. (2014) *Biogeosciences*, 11, 6939–6954
- Hirano et al. (2017) *Agricultural and Forest Meteorology*, 232, 457–468

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

Keywords: *Cryptomeria japonica*, Biome-BGC, Bayesian calibration