iLEAPS-Japan2021 Workshop Program

Date	9 – 10 December, 2021
Venue	Institute for Space-Earth Environmental Research (Research Institutes Building II) Room 409, Nagoya University
Organize	iLeaps Japan-local-committee & Institute for Space-Earth Environmental Research, Nagoya University

9 Dec. (Thr)

Chair: Takeshi ISE (Kyoto univ.)

13:00～13:05 Greeting and Introduction (Hisashi SATO, Chair of iLEAPS-Japan committee)

13:05～13:10 Logistic information (Tetsuya HIYAMA, ex-chair of iLEAPS-Japan committee)

13:10～13:35 Hayato ABE (Kyushu univ.)
Effects of differences in aboveground dead organic matter types on the stand-scale carbon dynamics in a subtropical forest in Okinawa Island, Japan

13:35～14:00 Takeshi ISE (Kyoto univ.)
Toward high-throughput forest inventory with deep learning

14:00～14:25 Sana OKAMURA (Osaka prefecture univ.)
Eddy covariance measurements of NO_2 flux at an urban center

14:25～14:50 Shihori KAWASHIMA (Osaka prefecture univ.)
Factors for geographical distribution of spring onsets of vegetation in interior Alaska

14:50～15:15 Masayuki KONDO (Nagoya univ.)
Enhanced net CO_2 uptake induced by autumn cooling in central Siberia

15:15～15:30 Break

Chair: Hisashi SATO (JAMSTEC)

15:30～15:55 Tomonori KUME (Kyushu univ.) Online presentation
Characteristics of carbon cycling in Moso bamboo forests

15:55～16:20 Shinjiro OHKUBO (Hokkaido univ.)
Changes in the CO_2 and energy balances of a degraded tropical peat swamp forest by fires

16:20～16:45 Kosuke TAKAYA (Kyoto univ.)
Automatic detection of thermokarst in satellite images using deep learning

16:45～17:10 Yuta NAKATA (Nagoya univ.)
Global simulation of atmospheric methane by coupling the terrestrial ecosystem model VISIT and the global chemistry model CHASER

17:10～17:25 Closing

18:00～20:00 Social hour

10 Dec.（Fri）

Chair: Michihiro MOCHIDA (Nagoya univ.)

09:00～09:25 Hideki NINOMIYA (Hokkaido univ.)

Simulating the effect of carbon starvation on the terrestrial ecosystem by using individual-based vegetation model SEIB-DGVM

09:25～09:50 Michihiro MOCHIDA (Nagoya univ.)

Atmospheric organic aerosol from terrestrial ecosystems: A field study in Australia and a plan to develop a field station in Hokkaido

09:50～10:15 Tomoki MOROZUMI (Hokkaido univ.)

Ground based observation of solar induced chlorophyll fluorescence using a fine resolution spectrometer across multiple sites in cool temperate to sub-tropical ecosystems, Japan

10:15～10:25 Break

10:25～10:50 Hiroki MOMIYAMA (Univ. of Tokyo) Online presentation

Model analysis of forest thinning impacts on the water resources during hydrological drought periods

10:50～11:15 Mizuki YAMANE (Shizuoka prefectural univ.) Online presentation

Development of VOC uptake model by plant

11:15～11:30 Closing

Summary

Effects of differences in aboveground dead organic matter types on the stand-scale carbon dynamics in a subtropical forest in Okinawa Island, Japan

Hayato ABE[1*], Ayumi Katayama[2], Shingo Taniguchi[3], Atsushi Takashima[4], Tomonori Kume[2], Kazuho Matsumoto[3]

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Background

Dead organic matter (DOM) plays a crucial role in forest carbon (C) cycling. DOM consists of leaf litter, fine woody debris (FWD; < 3 cm diameter), downed coarse woody debris (CWD_{log}), and standing or suspended coarse woody debris (CWD_{snag}). Although the generation and decomposition processes of each DOM type have been studied separately, C stock (necromass) and C efflux (R_{stand}) of each above-ground DOM and its contribution on those in stand-scale have not been well evaluated. Additionally, there is little knowledge of the effect of each DOM type on the accuracy of stand-scale estimates of total necromass and R_{stand}.

Objective

This study aimed to understand the characteristics of necromass and R_{stand} of each DOM type in the subtropical forest in the Okinawa island. We also aimed to develop an optimal sampling strategy to estimate necromass and R_{stand}.

Methodological descriptions

This study was conducted in a subtropical evergreen broad-leaved forest owned by the University of the Ryukyus, in the northern part of Okinawa Island (2500 m^2). We sampled leaf litter, FWD, CWD_{log}, and CWD_{snag} separately within the study site in 2019 for necromass estimation. CO_2 efflux rate from each DOM type was measured 6 times during 2019 and examined relationships with environmental factors such as soil temperature and moisture. Annual CO_2 efflux from each DOM type was estimated using the relationships. The R_{stand} was calculated by necromass and estimated annual CO_2 efflux rate. Spatial distribution pattern of necromass of each DOM type was examined and the optimal sampling plots area and arrangement for the accurate estimates were calculated. We calculated the potential error induced by the spatial variability using the law of propagation.

Results and Discussions

The CWD_{snag} accounted for the highest proportion (54%) of total necromass (1499.7 g C m^{-2}), followed by CWD_{log} (24%), FWD (11%), and leaf litter (11%). Leaf litter accounted for the highest proportion (37%) of total R_{stand} (340.6 g C m^{-2} yr^{-1}), followed by CWDsnag (25%), CWDlog (20%), and FWD (17%). The CWD_{snag} was distributed locally with 173% of the coefficient of variation for necromass, which was approximately two times higher than those of leaf litter and FWD (72–73%). Our spatial analysis revealed, for accurate estimates of CWD_{snag} and CWD_{log} necromass, sampling areas of ≥ 28750 m^2 and ≥ 2058–42875 m^2 were required, respectively, under the condition of 95% confidence level and 0.1 of accepted error. In summary, CWD considerably contributed to stand-scale carbon storage and efflux in this subtropical forest, resulting in a major source of errors in the stand-scale estimates.

Future perspectives

In forests where frequent tree death is likely to occur, necromass and R_{stand} of CWD are not negligible in considering the carbon cycling as in this study, and therefore need to be estimated accurately.

Day 1, 13:35~13:40

Toward high-throughput forest inventory with deep learning

Takeshi ISE[1*]

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Recently, a study suggested that the estimation of forest biomass in Japan has been overly underestimated, and the actual amount can be more than two times higher than that previously thought. This implies that the forest observation should be improved. The need should particularly be important to achieve carbon-neutral to minimize global climate change. In this study, commercially available UAVs are used to obtain the forest visual data, and the data are analyzed by deep learning to obtain tree type, size, and density (Figure 1). The performance of this approach is reasonable. Monotonous conifer forests for silviculture are particularly good examples of this approach. The performance for broadleaf forests with high tree diversity is slightly lower than that for conifer forests, indicating this approach requires more training data for precise estimation. Because this approach can estimate the tree biomass efficiently with reasonable accuracy, it would be possible to be used to update the forest inventory for a large area.

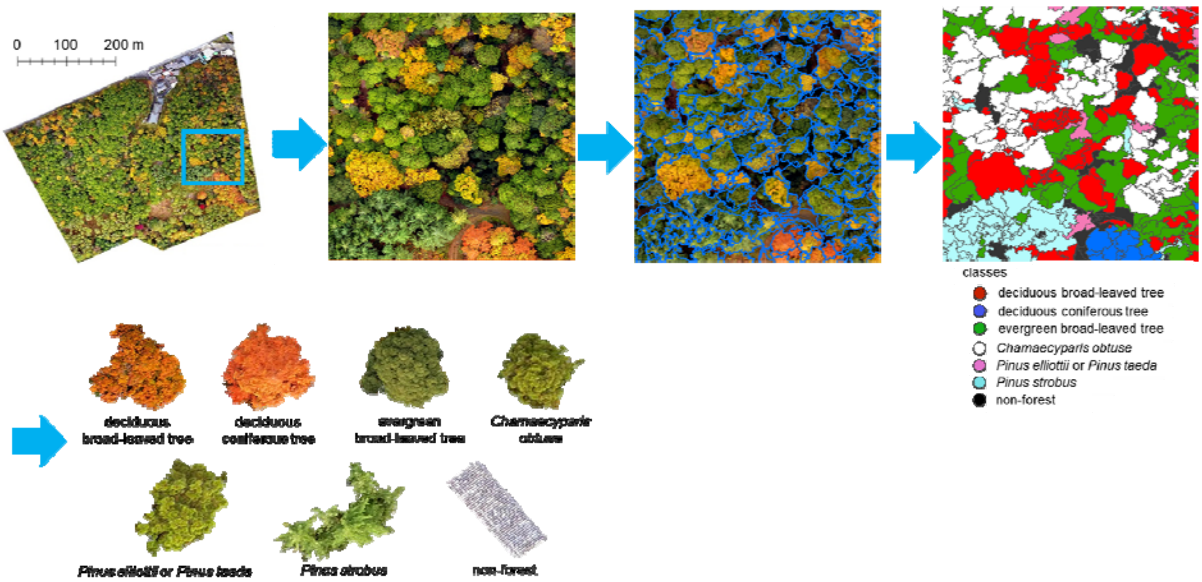

Figure 1. An example of forest observation using UAV and deep learning.

Day 1, 14:00~14:25

Eddy covariance measurements of NO_2 flux in an urban center

Sana Okamura[1*], Masahito Ueyama[1], Kenshi Takahashi[2]

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Objectives: Urban NO_2 emissions are important as an air pollutant and climatic forcing through aerosol formulations. Despite of the importance, continuous measurements of NO_2 flux are limited in urban areas. In this study, we directly measured NO_2 flux by the eddy covariance method in an urban center of Sakai, Osaka for clarifying its environmental drivers, such as wind direction, air temperature, and traffic counts.

Materials and methods: The measurements were conducted at the urban center, Sakai, Osaka (34°34' N, 135°29' E). The west of the flux footprint consists of highly urbanized areas including heavy traffic roads, highways, and the coastal industrial region, and the east consists mostly of residential areas. The measurements were conducted from February to July, 2021. The eddy covariance system simultaneously measured energy, CO_2, and CH_4 fluxes at 111.7 m above the ground (Takano and Ueyama, 2021). We installed a closed path NO_2 analyzer (CAPS NO_2 Monitor, Aerodyne Research Inc, USA), where an air inlet was set close to the three-dimensional ultrasonic anemometer (CSAT3A, Campbell Scientific Inc, USA). We applied relevant corrections including a high-frequency loss correction. We used the traffic counts for Hanshin Expressway No. 15 Sakai Line, which was approximately 300 m to the west of the site.

Results and discussion: NO_2 flux was 2.8~3.3 times higher in the west than in the east on average (Fig. 1). The mean NO_2 flux was 13.8 nmol m^{-2} s^{-1} in the west, and 4.3 nmol m^{-2} s^{-1} in the east. This suggests that the high emission sources existed mainly in the west. In winter, winds often came from north when the mean NO_2 flux was 8.8 nmol m^{-2} s^{-1} (Fig. 1a).

NO_2 fluxes were 1.7 times higher in weekdays than in weekends (Fig. 2a). The ratio of weekday to weekend in NO_2 flux was higher than those in the traffic counts. The traffic counts were 1.4 times higher in weekdays than in weekends (Fig. 2b). This might be caused by mobile sources, such as heavy tracks, were higher in the weekdays than in the weekends.

NO_2 flux showed a clear diurnal variation with a peak in the morning in weekdays. NO_2 flux showed a peak of 20.8 nmol m^{-2} s^{-1} at 9:30. After the peak, NO_2 flux ranged between 16~18 nmol m^{-2} s^{-1} until 16:00. The traffic counts showed a diurnal variation with two peaks in the morning and afternoon in weekdays. The traffic counts showed a first peak of 702 Veh h^{-1} at 7:30, and a second peak of 638 Veh h^{-1} at 17:00. After the peak at 7:30, the traffic counts decreased to 506 Veh h^{-1} at 13:00, and then increased again. The difference in the diurnal variations may be due to the fact that the traffic counts does not fully represent dynamics for diesel vehicles emitted NOx within the flux footprint. Emission sources other than traffic may contribute to NO_2 flux.

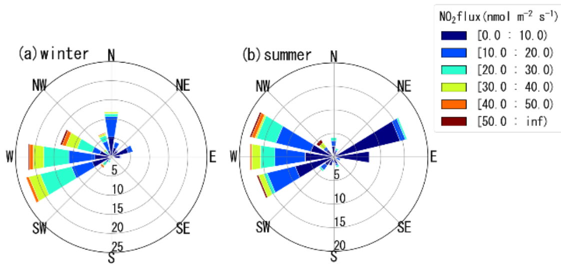

Fig 1. Windrose of daytime NO_2 flux for the winter (a) and summer (b). Winter is from February to March, and Summer is from May to

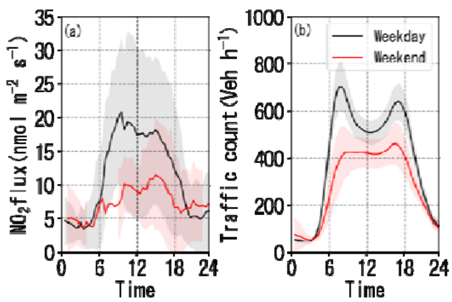

Fig 2. Diurnal pattern of NO_2 flux (a), and traffic counts (b) for weekdays and weekends. The solid line represents the 3-hour moving average, and the shaded area represents the standard deviation.

References

Takano, T., Ueyama, M., 2021. Spatial variations in daytime methane and carbon dioxide emissions in two urban landscapes, Sakai, Japan. Urban Climate, 36, 100798.

Acknowledgements

The traffic counts from the highway were provided by the Hanshin Expressway Company.

Day 1, 14:25~14:50

Factors for geographical distribution of spring onsets of vegetation in interior Alaska

Shihori Kawashima[1*], Masahito Ueyama[1], Yoshinobu Harazono[1], Hiroki Iwata[2], Hideki Kobayashi[3]

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Objectives: The spring onset of vegetation is essential in modeling carbon balance of high-latitude ecosystems. The spring onsets in boreal ecosystems are highly variable at spatiotemporal scales due to the heterogeneous topography and vegetation. However, models having a coarse spatial resolution, such as earth system model, possibly cannot consider such variabilities. In this study, we clarify controlling factors for explaining the spatiotemporal variabilities in the spring onset in interior Alaska. For explaining the variabilities, we used terrain slope orientation, elevation, vegetation type, snow disappearance, and land surface temperature (LST) in spring.

Materials and methods: The area surrounding Fairbanks, Alaska (64°8′~65°4′N, 147°3′~147°9′W; 65 km x 65 km) was evaluated from 2000 to 2021. We estimated the spring onset of each grid (250 m x 250 m) and then estimated the spatial distribution of the thermal forcing requirement (TFR) for the spring onset in the growing degree-day (GDD) model. The spring onset was estimated with the extended vegetation index (EVI) (MOD13Q1) from the Moderate Resolution Imaging Spectroradiometer (MODIS). In the GDD model, the daytime LST (MOD11A1) was used as an input. We set the degree-day base temperature to 0°C, and set the day on which GDD accumulation started as the snow disappearance date (MOD10A1) (Kawashima et al., 2021; J. Agric. Meteorol.). We evaluated the spatial variations of the 2000-2021 mean spring onsets, the mean snow disappearance dates, and the TFR using terrain slope orientation and elevation from the ASTER Global Elevation Model and vegetation map from the National Land Cover Database 2011.

Results and discussion: Regional spring onsets based on mean of individual grids were two to four days later (interquartile range) than those based on the aggregated EVI for the target area from 2000 to 2021. This indicates that the spring onsets with the coarse spatial resolution were estimated earlier due to a lack of considering spatial variabilities, such as topography and vegetation.

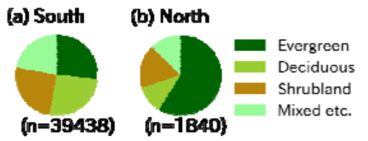

Fig 1. Composition of vegetation type for the south-facing (a), and north-facing (b) slopes. 'n' is the number of grids.

The mean spring onsets was, on average, DOY 132.2±4.0, the mean snow disappearance date was DOY 125.5±4.9, and the TFR was 65.9±29.9 °C day; ± denotes spatial variability. The median of the TRF in the south-facing slope was 12 °C day higher than that in the north-facing slope. The differences could be explained by vegetation compositions between the slopes (Fig 1). Deciduous forests consisted on the south-facing slopes; bud bursts of deciduous trees were further lagged after snow disappearance, compared with spruce trees dominated in north-facing slope. Since the available data number was limited for north-facing slopes (Fig 1), we focused further data analyses on the south-facing slopes.

The spring onset was earlier in lower elevations (17 days km^{-1}), and earlier in deciduous forests than that in evergreen forests ($p < 0.05$). These variations had strong positive correlations to the variations in the snow disappearance date (Fig 2a, b). This means the snow disappearance date is the potentially important for controlling the spring onset. The TFR was lower in vegetation at higher elevations (Fig 2c; -52 °C day km^{-1}). Thus, vegetation at higher elevations became active with a shorter period after the snow disappearance (-7.1 day km^{-1}). This might be explained by different vegetation types depending on the elevation.

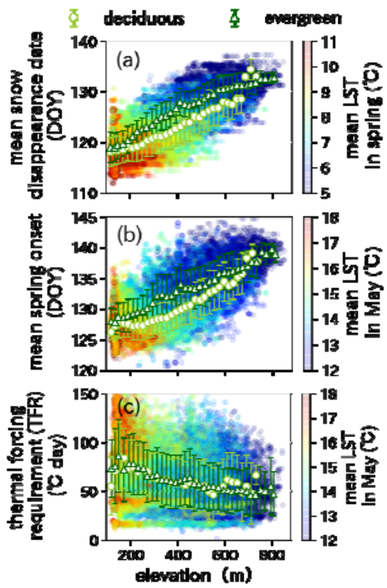

Fig 2. The relationship between each spatial variation and elevation in the south-facing slopes. Colors in scatter plots represent the mean LST in the spring (DOY 105-135) or May. White plots represent the binned mean for each vegetation, and error bars represent the standard deviations.

Day 1, 14:50~15:15

Enhanced net CO_2 uptake induced by autumn cooling in central Siberia

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For the past 60 years, climate change has enhanced the productivity of ecosystems in Siberia. The warming climate has elongated the growing period of vegetation and enhanced the peak productivity during summer. Correspondingly, CO_2 uptake in Siberia has continuously increased since the 1960s, playing a significant contributor to the increased amplitude of the atmospheric CO_2 seasonal cycle in the Northern Hemisphere.

As the temperature increased over decades, however, the impact of a warming climate has shown different aspects among regions of Siberia. Permafrost thaw could facilitate the release of CO_2 through microbial decomposition of carbon stored in frozen soils and through root rot that causes forest dieback. This negative impact of a warming climate on vegetation productivity has begun to be seen in Eastern Siberia and may widely spread over ecosystems standing on permafrost in the future. In central Siberia, where permafrost is absent, a warming climate is expected to further increase CO_2 uptake during spring and summer. However, continued warming in autumn may facilitate CO_2 release from ecosystem respiration, weakening net CO_2 uptake during that period.

While the negative impact of a warming climate is becoming a reality in Siberia, a recent study reported that an abrupt and persistent autumn cooling influenced by Pacific Decadal Oscillation (PDO) and Siberian high occurred from 2004 to 2018 around central Siberia. This result suggests a possibility that for 2004-2018 CO_2 release was suppressed by autumn cooling while having increasing CO_2 uptake in warming spring and summer, which leads to a hypothesis that net CO_2 uptake in central Siberia was the largest ever for 2004-2018.

This study investigates the validity of the hypothesis about recent net CO_2 uptake in central Siberia. Using atmospheric CO_2 measurements in central Siberia and upscaled eddy flux observations, we demonstrate how seasonal atmospheric CO_2 and net CO_2 uptake changed before and after 2004, focusing on autumn.

Day 1, 15:30~15:55

Characteristics of Carbon Cycling in Moso Bamboo forests

Tomonori Kume[1*]

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[*] Corresponding author (e-mail: kumett@gmail.com) (10 p)

Introduction

Forest plantations that exhibit fast-growing characteristics, such as bamboo forests, have been assumed to show a high carbon sequestration ability. Moso bamboo (*Phyllostachys pubescens*), one of the dominant bamboo species in East Asia, is a monopodial species distributed over an elevation range of 600–1500 m in central Taiwan. The aggressive expansion of Moso bamboo forest into adjacent ecosystems which might alter the carbon balance replacement, has been noted recently in East Asian countries such as Taiwan. Moso bamboo has a biennial growth cycle that can causes significant inter-annual variations in net primary productivity (NPP) and net ecosystem productivity (NEP). On the other hand, to our knowledge, only one study has investigated NPP covering biennial cycles in a Moso bamboo forest. Therefore, the aim of the present study was to clarify the NPP and NEP in a Moso bamboo forest in Taiwan by considering above- and below-ground processes over a 4-year experimental period.

Materials and methods

A 20 x 25 m study plot was established in a pure Moso bamboo (*P. pubescens*) forest in the Experiment Forest of National Taiwan University (23°40′, 120°48′), located in Nantou County, central Taiwan. The study plot is located at 1120 m above sea level, and it experiences a subtropical monsoon montane climate. Meteorological data, such as air temperature and precipitation, were recorded by a weather station located 0.2 km northeast of the experimental site. The mean annual air temperature (MAT) over the study period (April 2012–March 2016) was 18.6 °C. The mean annual precipitation was 2407 mm. NPP and NEP were quantified biometric measurements including above- and below-ground biomass measurements and soil respiration consisting of autotrophic and heterotrophic respirations.

Results and discussion

The estimated NPP and NEP showed considerable inter-annual variations (coefficient of variation of 39 and 79%, respectively). Averaged over the 4 years, the NPP and NEP were 8.86 ± 3.46 and 4.32 ± 3.35 Mg C ha-1 year-1, respectively, which were within the ranges (6.53–14.36 and 3.59–7.98 Mg C ha-1year-1, respectively) reported for Moso bamboo forests in East Asian countries. A global comparison of NPP and NEP among forest ecosystems using data from published literature indicated that the estimated NPP and NEP in the present study, as well as those in Moso bamboo forests from East Asian countries, were within the upper range of the values reported for other forest ecosystem. The results indicate that Moso bamboo forests may have high potential as a carbon sink among forests ecosystems. On the other hand, this study has some weakness. For example, it is possible that 4-year period is still not sufficient to acquire robust NPP and NEP measurements. The Student's t test analysis showed that the minimum numbers of sample years required to estimate the mean NPP and NEP are greater than 38 and 159 years, respectively, with a significance level of 0.05 and a 20% error of the mean. This finding implies that additional long-term monitoring is needed to acquire robust NPP and NEP estimations with high temporal representatively.

Day 1, 15:55~16:20

Changes in the CO_2 and energy balances of a degraded tropical peat swamp forest by fires

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Tropical peatland is widely distributed in Southeast Asia, and it is well known as a giant carbon pool. However, it had been disturbed by deforestation and drainage mainly for agricultural land use. Moreover, aridification caused by these disturbances increase the risk of fire. Such disturbances increase CO_2 emission to the atmosphere by accelerated peat decomposition and biomass burning. Many studies estimated carbon balance on peatland and revealed the relationship with environmental changes. In particular, negative correlation between groundwater level (GWL) and net ecosystem CO_2 exchange (NEE) was observed in many peatland sites (e.g., Hirano et al., 2012; Deshmukh et al., 2021). On the other hand, these land cover changes have a significant impact also on water and heat exchanges between land and the atmosphere. In this study, we mainly evaluated the influence of disturbances (especially, fire) on NEE and evapotranspiration (ET) with sensible and latent heat fluxes (H and λE) in degraded peat ecosystems.

Observation had been conducted in an ex-peat swamp forest, Central Kalimantan, Indonesia. The site was forested until 1997, when a fire destroyed the forest and left the site in ruins. Since then, the site had been burned at least three times in 2002, 2009 and 2014. NEE and ET were measured by the eddy flux technique. Observation had been conducted from April 2004 to December 2016. In 2009, the study site experienced moderate fire, and some aboveground herbaceous plants were burned. At this time measurement was suspended due to the fire damage.

Monthly NEE had been positive (i.e., the ecosystem released CO_2 in total) until the fire in 2009. On the contrary, the NEE turned to be negative after the fire. There are some possible causes: 1) Coarse woody debris which was major CO_2 source, was destroyed by the fire, 2) Peat decomposition was suppressed with waterlogged condition in subsequent La Niña years, 3) Gross primary production promptly returned to its original level under favorable (moist soil and high solar radiation) conditions for plant growth. However, this does not necessarily mean the peatland ecosystem turned to be a carbon sink by the fire. This is because the site had emitted large amount of CO_2 during past fires, far more than it absorbed CO_2 after fire in 2009. Moreover, temporary CO_2 release by the biomass burning could not be observed during suspended observation period.

The ET was relatively stable irrespective of precipitation. However, ET decreased with extremely deepened GWL (GWL<-0.5 m). This would be due to disconnected capillary force and ceased root water uptake, although rainwater shortage was usually compensated by soil water. Decreased ET was seen regardless of whether there was fire damage to vegetation or not. On the other hand, both H and λE decreased when there was a significant drop in net radiation due to fire-induced haze. At that time, Bowen ratio ($H/\lambda E$) temporarily increased. Meanwhile, apparent albedo increased because of dense haze layer above canopy.

As further analysis, partitioning ET into evaporation and transpiration is important to understand the biological and physical mechanisms deeply. Evaluation excluding the effect of post-fire weather conditions would also be needed to assess the impact of fire alone.

Much of this presentation is described in Ohkubo et al. (2021a; 2021b; 2021c).

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Deshmukh et al. (2021). Conservation slows down emission increase from a tropical peatland in Indonesia. *Nature Geoscience*, 1-7.

Hirano et al. (2012). Effects of disturbances on the carbon balance of tropical peat swamp forests. *Global Change Biology*, *18*(11), 3410-3422.

Ohkubo et.al. (2021a). Influence of disturbances and environmental changes on albedo in tropical peat ecosystems. *Agricultural and Forest Meteorology*, *301*, 108348.

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Ohkubo et al. (2021c). Influence of fire and drainage on evapotranspiration in a degraded peat swamp forest in Central Kalimantan, Indonesia. *Journal of Hydrology*, *603*, 126906.

Day 1, 16:20~16:45

Automatic detection of thermokarst in satellite images using deep learning

Kosuke TAKAYA[1*], Takeshi ISE[2]

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[2] Field Science Education and Research Center, Kyoto University
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Climate change is causing rapid changes in the permafrost of the Arctic. The permafrost contributes to soil temperature and moisture content and the stability of Arctic ecosystems and infrastructure. Thermokarst, caused by the thawing of the frozen soil, promotes ecosystem change by creating landscape-level changes, which affect human society, such as the subsidence of housing. It also has the potential to release carbon stored in the frozen soil. In order to understand the dynamics of thermokarst, extensive and long-term monitoring is essential. Satellite imagery can reveal the distribution of thermokarst over a wide area, but manual methods are labor-intensive. We may monitor a more expansive area to identify thermokarst using image recognition technology based on deep learning. Therefore, the purpose of this study is to clarify whether it is possible to detect thermokarst from satellite images by deep learning. As a result of creating a thermokarst identification model using the chopped picture method, it became clear that thermokarst can be detected by deep learning. However, some thermokarst could not be detected due to their image conditions. In the case of thermokarst, which has a similar appearance, we created a more robust model that can be used in multiple regions. In this presentation, we will discuss the potential and future challenges of environmental monitoring in the Arctic region using a combination of satellite imagery and artificial intelligence.

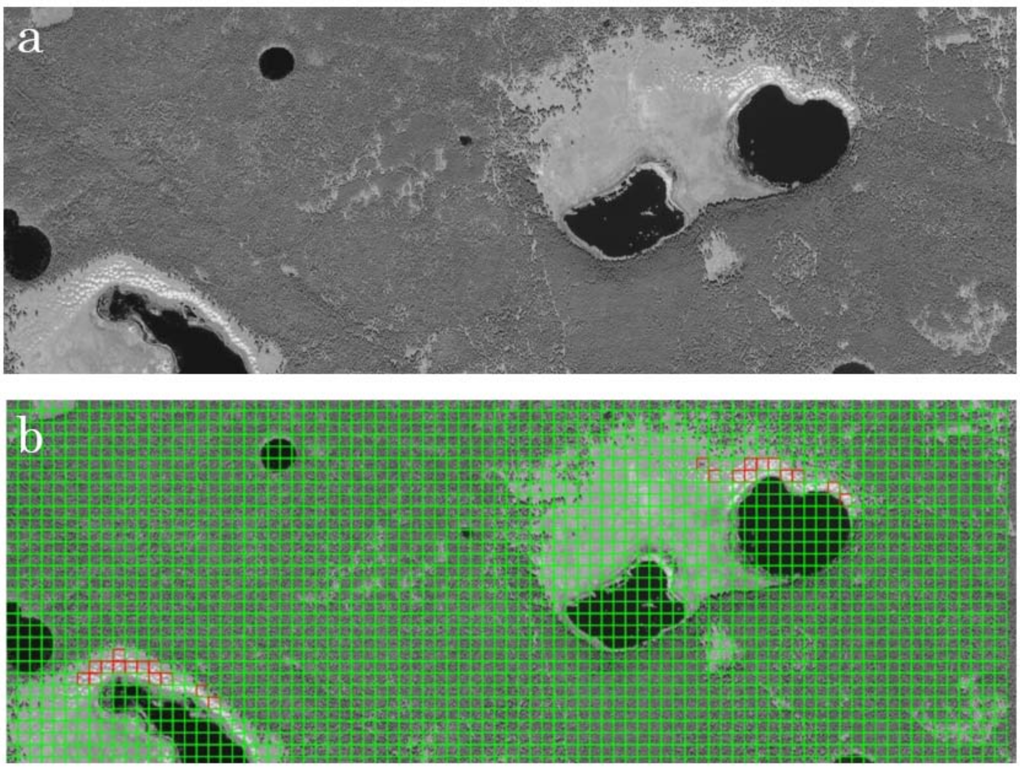

Figure 1. Classification results of thermokarst: (a)original images and (b) results. Red squares indicate thermokarst, green indicates others.

Day 1, 16:45~17:10

Global simulation of atmospheric methane by coupling the terrestrial ecosystem model VISIT and the global chemistry model CHASER

Yuta Nakata[1*], Akihiko Ito[2,3], Kengo Sudo[1,3]

[1] Graduate School of Environmental Studies, Nagoya University
[2] National Institute for Environmental Studies (NIES), Tsukuba
[3]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama

Methane (CH_4) is one of the most important greenhouse gases in the atmosphere. Methane has both natural and anthropogenic sources, such as wetlands, termites, coal mining, livestock, and rice paddies. Although most sources and sinks of CH_4 have been identified, their relative contributions to the atmospheric CH_4 levels are highly uncertain (Kirschke et al, 2013). This study focuses on wetland CH_4 emission which is the largest natural source of atmospheric CH_4, amounting to roughly 20-40 % of global CH_4 emissions. In this study, wetland emissions, off-line calculated by the terrestrial ecosystem model, VISIT (Ito and Inatomi, 2012), were given as an input to the global chemistry model, CHASER (Sudo et al., 2002) to simulate the global chemical fields for the years from 2001 to 2018. By comparing the global CH_4 simulations with satellite and ground-based observation data, we evaluated the reproducibility of the spatiotemporal distributions of methane with investigating the impacts of wetland emissions on atmospheric methane.

For the VISIT calculation, two distinct schemes of emission estimate are tested for checking the sensitivity of CHASER simulation. One is the Cao Scheme (Cao et al., 1996) in which the total exchange of CH_4 is evaluated as the difference between CH_4 production and oxidation rates, while the other (Walter-Heimann scheme) (Walter and Heimann 2000) explicitly considers various CH_4 production and transport processes by expressing belowground processes using a one-dimensional multilayer system in which the soil from the surface to a depth of 1 m was divided into 50 layers (each 2 cm).

The CHASER model in this study is based on MIROC (ver.5). For this study, we adopted a horizontal spectral resolution of T42 (approximately, 2.8° × 2.8°) with 36 vertical layers from the surface up to about 55km altitude. The anthropogenic CH_4 emissions are taken from the EDGAR (Emissions Database for Global Atmospheric Research) v4.2 inventory with the GEIA (Global Emission Initiative) used for other natural emissions. The methane distributions and time evolution calculated by CHASER were evaluated with the satellite observations by GOSAT (Greenhouse Gases Observing Satellite) and ground-based observations in North America, Asia, Europe, Africa, Oceania, Antarctica, and Hawaii.

The global methane simulations using the VISIT wetland emissions generally well reproduced the distribution of CH_4 as observed by the ground and satellite observations, largely reducing the overestimates in the mid to high latitudes in NH. It is found that the simulations using the VISIT wetland emissions tend to reduce the magnitude of seasonal cycles in the global mean methane time series. In addition, the results of sensitivity experiments also show that the seasonality of wetland emissions can be an important factor in the seasonal cycle of methane. Comparing the results that using each scheme, reproducibility was better when the Cao scheme was used. This is because the annual emissions from wetlands calculated by the Walter-Heimann scheme were on average 11 Tg smaller. In terms of seasonal cycles, Walter-Heimann scheme slightly better simulates seasonal pattern of CH_4 than the Cao scheme does. However, the difference in reproducibility of each scheme was small, and their reproducibility was better at least than the standard experiment.

Acknowledgements: The calculations were performed by using the supercomputer system (NEC SX-Aurora TSUBASA) of the National Institute for Environmental Studies (NIES).

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Day 2, 9:00~9:25

Simulating the effect of carbon starvation on the terrestrial ecosystem by individual-based vegetation model SEIB-DGVM

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Pervasive shifts in forest vegetation dynamics are already happening and are expected to accelerate under future global changes (McDowell et al., 2020). Forest dynamics are changing due to anthropogenic-driven drivers, such as rising temperature and CO_2, and affected by transient disturbances. Tree recruitment and growth depend on the changing drivers in a spatially and temporally way, potentially leading to an increase of tree mortality rates. Then, tree mortality results in a negative impact on the earth (Adams et al, 2013). However, it is challenging to estimate the negative impact due to the unsolved carbon flow in trees. Trees have grown to control their carbon resources to extend lives and strategically allocate them to growth, respiration, storage, reproduction, and defense (Hoch et al, 2003; Henrik et al, 2018). Among carbon resources, non-structural carbon (NSC) is commonly considered a repository depending on the balance between the supply of assimilated carbon and carbon demand. Hence, the size of stored C pools can be considered an indicator of the carbon balance of the plant. Additionally, NSC could be the threshold of the conceptual "carbon starvation" as one of the mechanisms after drought (Hoch et al, 2003; McDowell et al., 2008). The objectives of the research are to apply the process representing NSC dynamics to the ecological model and expect the potential effect of carbon starvation in the future.

The process-based Spatially Explicit Individual-Based Dynamic Global Vegetation Model (SEIB-DGVM; Sato et al., 2007), representing three-dimensional tree structure and individual tree growth, was used in this study. In a 30m×30m grid, each plant competes with the other for incoming solar photons. Then, we newly created a process of accumulating NSC in tree bodies for SEIB-DGVM. When the photosynthesis rate declines, NSC compensates for maintenance respiration and is gradually close to zero. We validated the new function at a point and global scale, and analyzed how the model outputs from new model is different from them from original SEIB-DGVM. In addition, we set conditions that could represent carbon starvation using NSC dynamics, then research how carbon starvation will affect the vegetation distribution, gross primary production (GPP), net primary production (NPP) in the future.

Day 2, 9:25~ 9:50

Atmospheric organic aerosol from terrestrial ecosystems: a field study in Australia and a plan to develop a field station in Hokkaido

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Terrestrial ecosystems are an important source of organic aerosol in the atmosphere. Atmospheric reactions of biogenic volatile organic compounds (BVOCs) from the ecosystems include formation processes of so-called biogenic secondary organic aerosol (BSOA) (Hallquist et al., 2009). Further, terrestrial ecosystems also contribute to the burden of organic aerosol through the release of primary biological aerosol particles (PBAP) (Després et al., 2012). Wildfire is also considered as a pathway to provide atmospheric organic aerosol, which contain unique organic compounds as a result of the pyrolysis of the biomass. Previous discussions on these organic aerosols include the contribution of BSOA to the abundance of cloud condensation nuclei (CCN) and the possible role of PBAP as ice nuclei. Our current knowledge of the roles of these organic aerosol on climate is still limited, and observational evidence to better constrain the atmospheric loadings and also to characterize their properties are strongly required. In this presentation, two research topics related to organic aerosols originated from terrestrial ecosystems will be discussed.

The first topic is about a recent field study of atmospheric organic aerosol based on aerosol sampling in New South Wales, Australia, as part of COALA-2020 field campaign. The aerosol sampling during the campaign was performed using a high-volume air sampler coupled with a cascade impactor, from January to March, 2020, at Cataract Scout Park. Sub-micrometer aerosol particles were collected on quartz fiber filters, and inorganic ions, organic carbon, elemental carbon, water-soluble organic carbon, and individual organic compounds including the tracers of BSOA and biomass burning aerosol were analyzed. The tracer analysis suggests the strong variations of the contributions of biomass burning and BSOA during the study period, encouraging a study about the contrast between these two types of organic aerosols and the resulting variations of aerosol properties such as light absorption property. During the campaign, total suspended particulate matter was also collected on polycarbonate filters using a low-volume air sampler. Water-insoluble particles on the filters are going to be analyzed using single-particle extinction and scattering (SPES) method.

The second topic is about the development of an observatory in Hokkaido for the measurements of atmospheric aerosols and gases, in particular for the studies of organic aerosols from biogenic VOCs and forest fires. A plan to develop a ground-based field station utilizing Moshiri Observatory, Institute for Space-Earth Environmental Research, Nagoya University, will be explained. Whereas the formation and transport of organic aerosols from vegetation, including those from biomass burning, needs to be further explored, their roles should also be explored in view of their climatic effects and further to the feedback to vegetation (Sporre et al., 2019). Suggestions and comments on the plan from the audience are appreciated.

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Day 2, 9:50~10:15

Ground based observation of solar induced chlorophyll fluorescence using a fine resolution spectrometer across multiple sites in cool temperate to sub-tropical ecosystems, Japan

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We have been conducting ground-based measurement of solar induced chlorophyll fluorescence (SIF) as a remote sensing variable to capture the photosynthetic activity in terrestrial ecosystems. When illuminated by solar radiation, chlorophyll pigment emits red and far-red fluorescence at 650-850 nm wavelength. SIF is measurable fraction of the fluorescence at the atmospheric absorption band so-called Fraunhofer lines in O_2-A and O_2-B bands with fine resolution (< 0.5 nm) of upward and downward radiation. Canopy-scale SIF are thought to be a proxy of ecosystem level CO_2 fixation, i.e., gross primary production (GPP), although previous research pointed out species/ecosystem-type and scale dependent relationship between SIF and GPP. Satellite SIF product (e.g. GOSAT-2, OCO-2, TROPOMI, FLEX, GeoCarb *etc*.) is expected to contribute to those tasks. However, there is lack of ground-based dataset covering various ecosystem types. The purpose of the study is to understand site-scale SIF:GPP relationship in various ecosystem, Japan, to improve our understanding of land-atmosphere interaction processes.

We installed spectrometers with fine wavelength resolution, QE pro (Ocean Insight, FL, USA) with full width half maximum (FWHM) = 0.24 nm. The locations were selected from the collaborated field sites in remote sensing network PEN (http://pen.envr.tsukuba.ac.jp). The study sites are including cool-temperate deciduous broadleaf forest dominated by birch and oak (TKY: 36°N, 137°E, Gifu, Japan), deciduous needleleaf larch forest (FHK: 35°N, 139°E, Yamanashi; TSE: 45°N, 142°E, Hokkaido), cool-temperate wetland (BBY: 43°N, 141°E, Hokkaido), temperate rice paddy field (MSE: 36°N ,140°E, Ibaraki), subtropical evergreen broadleaf forest (YNF: 27°N, 128°E, Okinawa). Targeting optical receivers (cosine collector for field of view: FOV = 180° or bare fiber for FOV = 25°) are mounted on flux towers. Observations started in 2019 at TKY, MSE, YNF, BBY and in 2021 at FHK and TSE. The seasonal variation of SIF varied approximately 0-1.5 mW m^{-2} nm^{-1} sr^{-1} from relatively flat peak at an evergreen forest (YNA) to short sharp peak at a rice paddy (MSE). In this presentation, we will also show recent progress on SIF:GPP study on MSE paddy field, BBY wetland, TKY deciduous forest, and also introduce a crop canopy SIF radiative transfer modelling (Morozumi et al, submitted) and a practical approach of SIF retrieval in low resolution spectra based on a fine resolution spectral observation in TKY (Nakashima et al 2021).

Nakashima, N., Kato, T., et al (2021). Area-ratio Fraunhofer Line Depth (aFLD) method approach to estimate solar-induced chlorophyll fluorescence in low spectral resolution spectra in a cool-temperate deciduous broadleaf forest. Journal of Plant Research, 134, p.p. 713–728.

Day 2, 10:25~10:50

Model analysis of forest thinning impacts on the water resources during hydrological drought periods

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In Japan, there has recently been an increasing call for forest thinning to conserve water resources from forested mountain catchments in terms of runoff during prolonged drought periods of the year. However, it has not been fully explained how forest thinning effects on increasing both minimum seasonal streamflow rate during the drought periods of the year and extremely low streamflow rate during the prolonged drought periods. To investigate how their water balance and the resultant runoff are altered by forest thinning, we conducted a model analysis using a combination of 8-year hydrological observations, 100-year meteorological data output that is generated using a stochastic model, and a semi-process-based rainfall-runoff model.

In this study, the hydrological, meteorological, and geographical data of Oborasawa Experimental Watershed (Kanagawa, 35°28′N, 139°28′E, altitude 439–872 m, 49.5 ha) is used. The rainfall-runoff model is developed based on TOPMODEL[1]. 100-year meteorological data were constructed using random numbers generated from probability distributions representing current precipitation characteristics at the site to consider the most severe drought conditions. We validated those models against runoff observations at Oborasawa. After that, we conducted the simulation of thinning, assuming that forest thinning has an impact on runoff primarily through an alteration in canopy interception and that interception can be determined by an interception model [2] using stem density.

The model reproduced temporal variations in runoff and evapotranspiration at inter- and intra-annual time scales, and the flow duration curves were well reproduced. On the basis of projected flow duration curves for the 100-year, despite the increase in an annual total runoff with thinning, low flow rates (the flows within the range of >70% time exceedance) in both dry and normal years (the years in which low flow are the lowest and 50th the lowest) were impacted by the forest thinning to a lesser extent (Figure 1). Simulations also showed that low flows would increase more with higher catchment water retention capacity, and higher catchment water retention capacity would enhance the forest thinning effect on increasing available water resources (Figure 1).

The model developed in this study is expected to be useful for examining the effects of forest management on various forested catchments by giving the water retention capacity of the watershed in advance. How to determine the water retention capacity in the model and how and to what extent the water retention capacity of a watershed can be changed by forest management will require further study, but the application of this study would be helpful in planning for better forest management considering runoff from forested catchments.

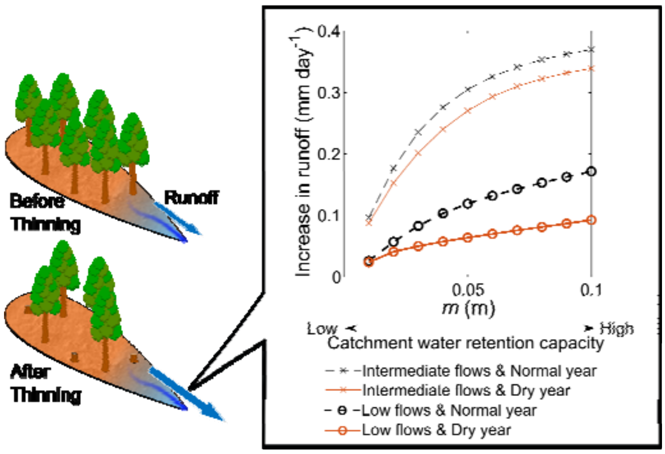

Figure 1
Relationships between *m* (the parameter that represents catchment water retention capacity) and increases in runoff after thinning. Changes in the values due to alterations of stand density from 2229 to 1132 trees ha^{-1} is shown. The relationships are compared between intermediate flows and low flows situations and between the normal year and the dry year.

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Day 2, 10:50~11:15

Development of VOC uptake model by plant

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Large amount of volatile organic compounds (VOCs) are emitted into the atmosphere from biogenic and anthropogenic sources. Many kinds of VOCs are directly harmful to human and some of them are carcinogenic. VOCs promote creation of photochemical oxidants including ozone in the troposphere, and it may cause respiratory diseases. VOCs also promote productions of secondary organic aerosol (SOA), which affects human health and climate. SOA absorbs and scatters shortwave radiation and affects cloud properties by acting as cloud condensation nuclei (CCN) or ice nuclei. It has been reported that plants can remove inorganic gases such as ozone and NOx from the atmosphere. Recent study revealed that some species of VOCs, in particular oxygenated VOCs, are also taken up by plants. The removal of VOCs by plants from the atmosphere can contribute not only to reducing direct negative effect of harmful VOCs but also to suppressing its indirect effects on the creations of ozone and SOAs. The process of VOC uptake by plant leaves seems to be composed of several steps: VOC diffusion via stomata, air-liquid partitioning governed by Henry's law constant, and metabolic conversion in plant cells. To explain this process, we have developed a plant VOC uptake model based on the diffusion theory analogous to CO_2 assimilation by plants.