The influence of tree thinning on understory carbon budget in a larch forest on the northern foot of Mount Fuji

*Munemasa Teramoto[1], Naishen Liang[1], Jiye Zeng[1], Yoshiyuki Takahashi[1], Reiko Ide[1], Nobuko Saigusa[1]

1. Center for Global Environmental Research, National Institute for Environmental Studies

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

Keywords: global warming, understory carbon budget, chamber, CO2, larch forest

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

*Takanori Shimizu[1], Shin'ichi Iida[1], Naoki Kabeya[2], Koji Tamai[1], Sophal Chann[3], Akira Shimizu[2]

1. Forestry and Forest Products Research Institute, 2. Kyushu Research Center, Forestry and Forest Products Research Institute, 3. Institute of Forest and Wildlife Research and Development, Cambodia

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

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

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

Keywords: Lowland dry ever green forest, Turbulence fluxes, Dry season evepotranspiration

Continuous measurements of methane exchange at a temperate secondary forest by the modified gradient method

*Yuki Matsumoto[1], Masahito Ueyama[1], Kota Yoshikawa[1], Yuji Kominami[2]

1. Graduate School of Life and Environmental Sciences, Osaka Prefecture University, 2. Kansai Research Center, Forestry and Forest Products Research Institute

Methane (CH_4) budget in upland forests is highly uncertain. In this study, we measured CH_4 exchange at an upland forest using the modified gradient (GR) method. We present the applicability of the GR method, comparing to CO_2 fluxes measured by the eddy covariance (EC) method and CH_4 fluxes by the hyperbolic relayed eddy accumulation (HREA) method. Our aim is to show a consistency in CH_4 fluxes by different methods for reinforcing knowledge of CH_4 budget in forest ecosystems and reducing uncertainties.
We measured fluxes at the Yamashiro forest hydrology research site in Kyoto, Japan during 2016. Turbulent fluxes of momentum, sensible heat, latent heat, and CO_2 were measured by the eddy covariance method. We developed a measurement system that the HREA and GR methods could be applied simultaneously. CO_2 and CH_4 concentration at two height (35, and 25 m) were measured above the canopy. Horizontal wind speed measured at 35, 25, and 22 m for estimating the displacement height. We also examined two diffusion coefficients based on site-specific universal functions for temperature (Φ_h) and CO_2 (Φ_c). Based on the specification of the available gas analyzer (FGGR-24r-EP, Los Gatos Research, USA), CH_4 concentration gradient was expected to be near a detectable limit of the analyzer. Thus, we examined the applicability of nighttime data for the GR method under stable conditions when vertical CH_4 concentration was expected to be large.
CO_2 fluxes by the EC and GR methods were reasonably agreed for stable and unstable conditions (R^2 = 0.66 - 0.68, RMSE = 5.66 - 6.66 $gCO_2\ m^{-2}\ d^{-1}$); but, no consistency was found in CH_4 fluxes from the HREA and GR methods. Using data under stable conditions, CO_2 fluxes by the GR method using Φ_h was 50% overestimated in comparison with those by the EC method. On the other hand, overestimation was not found in CO_2 fluxes using Φ_c. For stable conditions, the value of R^2 among CO_2 fluxes by two methods increased with integration times; by averaging over 30 days or more, CO_2 fluxes by two methods showed a consistency (R^2 = 0.86 - 0.91, RMSE = 5.73 - 6.42 $gCO_2\ m^{-2}\ d^{-1}$). This results suggests that the random errors associated with eddy diffusivity were reduced at the monthly time scale.
Monthly CH_4 fluxes by the GR method (0.63 - 1.79 $mgCH_4\ m^{-2}\ d^{-1}$) and the HREA method (0.58 - 1.96 $mgCH_4\ m^{-2}\ d^{-1}$) showed similar seasonal variations during the period from June to October and December. A disagreement during the period from January to March was caused by long-term missing data of the EC or the HREA method. The disagreement in April and May was caused by short integration time for determining vertical concentration differences. The consistent seasonal variations among two methods indicates that the GR method under stable conditions could be applicable for measuring CH_4 fluxes at this forest.
Based on the GR and HREA measurements, the forest acted as a net annual CH_4 source (GR; 172 $mgCH_4\ m^{-2}\ yr^{-1}$, HREA; 237 mg $CH_4\ m^{-2}\ yr^{-1}$). Monthly CH_4 fluxes by the GR and HREA methods delayed one month to the monthly precipitation during the period from June to October (R^2 = 0.97, $p < 0.01$). This was probably because rainfall turned soils anaerobic conditions gradually, and activations of methanogenic bacteria took time.

Keywords: Methane flux, Modified gradient method, Upland forest

Assessing leaf photosynthetic capacity using hyperspectral reflectance

*Rei Sonobe[1], Quan Wang[1]

1. Shizuoka University

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

Keywords: maximum rate of carboxylation, ratio of performance to deviation

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

*Nobuhito Ohte[1], Ken'ichi Osaka[2], Masanori Katsuyama[3], Tomoki Oda[4], Shigeru Mizugaki[5]

1. Department of Social Informatics, Graduate School of Informatics, Kyoto University, 2. Department of Ecosystem Studies, School of Environmental Science, The University of Shiga Prefecture, 3. Global Survivability Studies Unit, Center for the Promotion of Interdisciplinary Education and Research, Kyoto University, 4. Department of Forest Science, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 5. Civil Engineering Research Institute for Cold Region, Public Works Research Institute

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.

Keywords: Extreme climatic event, Nitrogen export, Forest ecosystem

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

*Tomoko Akitsu[1], Kenlo Nishida Nasahara[1], Atsushi Kume[2], Yasuo Hirose[3], Osamu Ijima[4], Kentaro Takagi[5], Reiko Ide[3]

1. University of Tsukuba, 2. Kyusyu University, 3. National Institute for Environmental Studies, 4. Japan Meteorological Agency, 5. Hokkaido University

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.

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

*Hiroki Mizuochi[1], Kenlo Nishida Nasahara[2], Tetsuya Hiyama[3]

1. University of Tsukuba, Graduate School of Life and Environmental Sciences., 2. University of Tsukuba, Faculty of Life and Environmental Sciences, 3. Nagoya University, Institute for Space-Earth Environmental Research (ISEE)

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.

Keywords: land use and land cover change, satellite data fusion, evapotranspiration model

Topographic controls on the abundance of Siberian larch forest

*Hisashi Sato[1], Hideki Kobayashi[1]

1. Department of Environmental Geochemical Cycle Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

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.

Keywords: Permafrost, Siberian larch, Vegetation distribution

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

*Yumiko Miyamoto[1], Hisashi Sato[2], Rikie Suzuki[2], Atsuko Sugimoto[1]

1. Arctic Research Center, Hokkaido University, 2. Japan Agency for Marine-Earth Science and Technology

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

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

*Vivek Arora[1], Joe Melton[2], David Plummer[1]

1. Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, British Columbia, Canada, 2. Climate Research Division, Environment and Climate Change Canada, Victoria, British Columbia, Canada

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

*Yuma Sakai[1], Tomomichi Kato[1], Katsuto Tsujimoto[2], Hideki Kobayashi[3], Kenlo Nasahara[4], Tokomo Akitsu[4], Shohei Murayama[5], Hibiki M Noda[6], Hiroyuki Muraoka[7]

1. Research Faculty of Agriculture, Hokkaido Univercity, 2. Graduate School of Agriculture, Hokkaido University, 3. Japan Agency for Marine-Earth Science and Technology, 4. Faculty of Life and Environmental Sciences, University of Tsukuba, 5. National Institute of Advanced Industrial Science and Technology (AIST)), Tsukuba, 6. National Institute for Environmental Studies, 7. River Basin Research Center, Gifu University

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

Keywords: Theoretical model, Phothosynthesis, Chlorophyll fluorescence

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

*Ryoichi Imasu[1], Satoshi Ito[1], Hiroaki Kondo[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. National Institute of Advanced Industrial Science and Technology

Recent progress in satellite measurements of greenhouse gases enhances the inversion analysis of the strengths of gas emissions from mega-cities. For these analyses, regional scale transport model is necessary. Greenhouse gases Observing SATellite (GOSAT) data have been used as input to a regional scale model, National Institute of Advanced Industrial Science and Technology Meso-scale Model (AIST-MM), to calculate CO_2 transport in Kanto Plain area. However, this model was not optimally designed to simulate the effects of land-ecosystem. That is because it had been originally developed to simulate the transport of air pollutants. In this model, formulae of photosynthesis of vegetation and respiration of plants and soil are coded to be simply calculated based on the fixed parameters for each vegetation type, and it is not enough for precise calculation of emission and uptake of CO_2 by the ecosystem. Although the atmospheric CO_2 concentrations calculated by AIST-MM fairly agree well observations for winter season, AIST-MM overestimate both respiration in night time and photosynthetic uptake of CO_2 during day time are overestimated for summer season. Therefore, it is necessary to develop a land ecosystem carbon balance model which can realistically simulate vegetation activities to be embedded into AIST-MM as a calculation component. In this study, we have developed a gross primary production (GPP) calculation component as a part of the carbon balance model based on the algorithm of the "Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data (BEAMS)" which can calculate GPP using satellite data explicitly representing daily variation of vegetation activities and diurnal variation of solar flux (Sasai, 2005; 2011). The fundamental inputs for the model is meteorological data, land cover type, Photosynthetically Active Radiation (PAR), the fraction of absorbed PAR (fPAR). As the meteorological data, GPV-MSM provided by Japan Meteorological Agency (JMA) is used, As the land cover type and fPAR, MODIS level-3 (MCD12Q1) and level-4 (MCD15A3H) are respectively used. PAR data provided by JAXA Satellite Monitoring for Environmental Studies (JASMES) are normalized referring the ground based measurements at Tsukuba site, and its scaling factor is applied to whole area. Then diurnal variation of PAR is calculated based on the solar zenith angle at each location. Spatial resolution of calculation is set to be 500 m based on the resolution of MODIS data, and temporal resolution is set to be 1 hour referring the GPV-MSM data. GPP values calculated by the method are compared with ground based measurements provided by Forestry and Forest Products Research Institute (FFPRI) flux net. Comparison at "Yamashiro", "Fujiyoshida", and "Kawagoe" stations show that over estimation by the original component of AIST-MM is drastically improved, and annual amounts are agree well with measurements in about 20 %. As it is shown through the comparison that not only seasonal variation but also variation in a few days scale (synoptic scale) variation can be represented by the calculation, the component can be valuated to be in a quality level to be able to be used in the regional scale model of which spatial and temporal resolution is very high. As the next step of the development of the carbon balance model, we started to develop a calculation component which can calculate the vegetation and soil respirations with the same order of the special and temporal resolutions as for GPP.

Keywords: Carbon dioxide, gross primary production, BEAMS

Site-level uncertainty arising from climate data in estimations of gross primary productivity

*Kazuyuki Atsumi[1], Shunji Ohta[1]

1. Graduate School of Human Sciences, Waseda University

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.

References
Jung M. *et al.* (2007) *Global Biogeochem. Cycles*, **21**(4), GB4021.
Barman R. *et al.* (2014) *Global Change Biol.*, **20**(5), 1394–1411.

Keywords: gross primary productivity, uncertainty, bias correction

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

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Yohei Sawada[1], Takemasa Miyoshi[1]

1. RIKEN Advanced Institute for Computational Science

In the previous study, Arakida et al. developed a data assimilation system based on a particle filter approach with a dynamical global vegetation model known as the SEIB-DGVM (Spatially Explicit Individual-Based Dynamic Global Vegetation Model), and assimilated the satellite-based MODIS LAI (Leaf Area Index) observations successfully. In this study, we extend the previous study to different locations and estimate the state variables including carbon flux, water flux, heat flux, vegetation structure, and parameters related to the phenology of the deciduous needle leaved tree and grass. The results showed that the DA system performed well at multiple locations.

Keywords: Data Assimilation, Dynamic Global Vegetation Model, phenology

Assimilate the big data from satellite observations into simulation: optimization of the phenology model using data assimilation

*Takeshi Ise[1,2], Shigeki Ikeda[3], Shuntaro Watanabe[1]

1. FSERC, Kyoto University, 2. Japan Science and Technology Agency, 3. Graduate School of Agriculture, Kyoto University

To optimize simulation models, the computational method called data assimilation (DA) is widely used. However, for terrestrial ecosystem models, due to their complexity, DA is not applied sufficiently. In this study, the particle filter method, one of the numerical methods of DA, is utilized to optimize a terrestrial ecosystem model with abrupt behavior. Leaf onset and offset phenology of deciduous stands was the target of this study. Previously, leaf onset and offset phenology was modeled using cumulative temperatures of growth degree days, and the parameters of those models were not statistically tested nor optimized sufficiently. In this study, we used satellite-observed leaf area index as the input data, and showed that the ~10 parameters in the model was optimized simultaneously. Using a large cluster computer, ~10,000 grids of deciduous stands in Japan were targeted for DA. As a result, the mean annual temperature of the grid has a significant impact for the parameters of the phenology model, which were assumed to be fixed numbers previously. Moreover, we made different DA runs for specific tree species.

Keywords: data assimilation, phenology, simulation, terrestrial ecosystem, biogeochemistry

Development of new Earth system model with carbon and nitrogen cycle

*Tomohiro Hajima[1]

1. Japan Agency for Marine-Earth Science and Technology

The Earth system models, which is a climate model with land and ocean biogeochemistry components, have been developed to understand enviromental dynamics and used to project climate change. It has been pointed out that because most of ESMs did not have explicit nitrogen cycle and nuturient limitation on plant growth in land ecosystem component, carbon uptake by land might be overestimated by the models. Additionaly, nitrogen cycle on land are associated with emission of GHG: nitrous oxide. In this research, we have developed a new Earth system model that incorporate explicit global carbon and nitrogen cycles and their interactions. From the sensitivity analysis, we found the new model exhibits similar level of CO2 fertilizasion effect compared with previous model, and the CO2 fertilization effect in the model is actually affected by nitrogen cycle. In this presentation, we focus on land carbon and nitrogen cycle, and introduce related topics of ocean biogeochemistry.

Keywords: Earth system modeling, Carbon cycle, Nitrogen cycle

