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Long-term and interdisciplinary research on forest ecosystem functions: challenges at Takayama site since 1993

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Editorial

Forest ecosystems cover approximately 30 % of the terrestrial area of the Earth, and are expected to play crucial roles in regulating our environments including biodiversity and atmospheric CO₂ concentration. As the structure and functions of the forest ecosystems are consists of multiple interactions of organisms, soil chemistry and meteorological conditions, which are quite variable in time and space, challenges to understand their processes and resulting dynamics of the functions have been made by various scientific disciplines/techniques such as ecology (including eco-physiology and biogeochemistry), hydrology, micrometeorology, simulation models and remote sensing.

This research has focused particularly on carbon, which is one of the “common” elements of ecological processes involved in ecosystems such as photosynthesis, respiration, and biomass growth, and of the interaction between the atmosphere and ecosystems, as the carbon cycle regulates biological aspects of ecosystems and hence determines the exchange of CO₂ between the atmosphere and ecosystems. In recent decades, the carbon cycle and budget have been the central theme of environmental sciences by reflecting the ongoing climate change partly due to the rise in atmospheric CO₂. In order to achieve deeper understanding of the dynamics of the structure and functions of forest ecosystems over time and space, it is essential to conduct investigations on (1) the detailed ecological processes in the carbon cycle, (2) their interactions with the climate, (3) integrated analysis of ecological and meteorological process,

and (4) observations of such structure and functions over time and space.

This special issue involves such multidisciplinary and long-term challenges at the “Takayama site” (Fig. 1) during the last 20 years since 1993, which is located on a mountainous region in central Japan. The site mainly consist of a cool-temperate deciduous broadleaf forest (TKY) and an evergreen coniferous forest (TKC), which are part of the AsiaFlux (<http://www.asiaflux.net/>) and Japan Long-Term Ecological Research (JaLTER, <http://www.jalter.org/>) networks. The history of the Takayama site (Fig. 2) was initiated by the long-term observation of CO₂ exchange between the atmosphere and the deciduous forest, and ecological research for the carbon cycle processes in the forest, by numbers of scientists and students from several research institutes and universities (Saigusa et al. 2005; Yamamoto and Koizumi 2005; Ohtsuka et al. 2007, 2009, 2010). Efforts also have been made to link ecology, micrometeorology, modeling and remote sensing to explore the multi-scale investigations of the ecosystems and surrounding landscape, and this initiative is called “Satellite Ecology (SATECO)” (Muraoka and Koizumi 2009) which is now one of the interdisciplinary initiatives for cross-scale observation of ecosystems and for biodiversity–ecosystem–climate change observations in the Biodiversity Observation Network in Japan and in Asia–Pacific (J-BON, AP-BON; Muraoka et al. 2012). An open-minded research policy at the Takayama site then enabled us to establish international networks for education and research in terrestrial ecosystems among Japan, South Korea and China, as well as collaborative activity between Japan and Germany for mountainous forest and landscape research under climate change.

As part of the results of our challenging efforts to achieve the multidisciplinary approach and collaborations, we could publish the following articles in this special issue. The reviews provide overview and challenges at the Takayama site by model integration (Ito et al. 2015) and our vision of sensor and site network for phenology observation (Nasahara and Nagai 2015).

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Fig. 1 Multidisciplinary research and networking at the Takayama site to explore cross-scale mechanisms and consequences of forest and landscape structure and functions

Takayama chronicle

	History	Micro-meteorology	Ecological processes	Plant physiology	Ecosystem Model	PEN
1993	TKY site was established	Atmospheric CO ₂ at TKY site (Nakazawa et al. 1997)				
		Carbon budget at TKY site (Yamamoto et al. 1999)	Soil respiration at TKY site (Mariko et al. 2000)			
2004	TKC site was established Several desired sites were established	Inter-annual variation of carbon budget at TKY site (Saigusa et al. 2005)	Annual soil respiration at TKY site (Mo et al. 2005) Carbon partitioning at TKY site (Ohtsuka et al. 2005, 2007) Soil respiration at TKC site (Lee et al. 2008)	Photosynthetic and structural characteristics at TKY site (Muraoka et al. 2005)	Carbon budget at TKY site (Ito et al. 2005)	Establishment of Phenological Eyes Network (PEN) (Nishida 2007)
		Inter-comparison of carbon budget at TKY site (Ohtsuka et al. 2009)		Satellite ecology (Muraoka & Koizumi 2009)		
		Long-term atmospheric CO ₂ and its isotopes at TKY site (Murayama et al. 2010)	Carbon partitioning at grassland, young forest, and TKC sites (Dhital et al. 2010; Ohtsuka et al. 2010; Yashiro et al. 2010)	Inter-annual variation of leaf-photosynthesis at TKY site (Muraoka et al. 2010)	Future prediction of carbon budget at TKY site (Ito 2010)	Vegetation indices at TKY and TKC sites (Nagai et al. 2010, 2012)
2011	Warming experiment at TKY site	Carbon budget at TKC site (Saitoh et al. 2010)	Review of warming experiment (Chung et al. 2013)	Multi-year analysis of leaf phenology at TKY site (Noda et al. 2014)	Carbon budget at TKC site (Saitoh et al. 2012b) Review (Ito et al. 2014)	Camera indices at TKY and TKC sites (Nagai et al. 2011; Saitoh et al. 2012a) Review (Nasahara & Nagai 2015)

Fig. 2 Brief history of studies conducted at the Takayama site in the last 20 years. Note that the list covers part of the efforts made at the site

Ecological studies on carbon cycle of forest ecosystems have been developed by detailed measurements of tree biomass growth and soil carbon dynamics (Kishimoto et al. 2015; Matsushita et al. 2015). Challenges have been also made for revealing soil microbial components in adjacent grasslands (Yoshitake et al. 2015) and to measure the soil structure by MRI (Tomotsune et al. 2015). Leaf and canopy ecophysiological characteristics which are tightly linked with ecosystem productivity in the Takayama site (Noda et al. 2015), atmospheric approach to reveal the temporal changes in carbon exchange between the atmosphere and forests (Ishidoya et al. 2015), and model analyses to clarify the functional contribution of leaf and canopy phenology on forest carbon balance under current and future conditions (Saitoh et al. 2015) or to evaluate the ecosystem services in the regional scale (Ruidisch et al. 2015).

Beside these achievements the research has also been made for soil biogeochemistry with respect to the carbon and nitrogen dynamics, ecophysiological role of tree sapflow and transpiration in forest water cycle, open field warming experiments on tree canopy photosynthesis and soil carbon dynamics, ‘allocation flux’ of carbon beginning from photosynthetic absorption to biomass growth and respiratory fluxes in plants and soil, and the cross-scale consequences of canopy phenology and its functions between stand and landscape scale on the mountainous area. As the integrative efforts by these studies, prediction of future changes in the carbon cycle and resulting budget, and more effective use of satellite remote sensing will be achieved shortly.

We will be grateful if the articles can provide valuable knowledge and information to the colleagues in related research field, and can bridge multiple research disciplines for further networking among the scientists and research sites for future studies.

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