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EDITORIAL

Lessons learned from CarboEastAsia: carbon and water cycles in East Asian terrestrial ecosystems

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Background

CarboEastAsia (http://www.carboeastasia.org) is forward-looking research collaboration among China, Japan, and Korea in AsiaFlux, the purpose of which is to provide the science community and society with information about and insight into carbon dynamics in terrestrial ecosystems in East Asia, and the integration of these into sustainable development during rapid global change. AsiaFlux (http://www.asiaflux.org) is the Asian arm of FLUXNET, the worldwide research network of tower-based monitoring of carbon and water flux and energy cycles in global terrestrial ecosystems. The AsiaFlux community serves as the watchmen on the towers, working and taking care of the Asian ecosystems which are highly vulnerable and yet vital ecospheres on our planet. The monitoring sites are located throughout the continents, ranging from tropical forests near the equator to tundra in the Arctic, and from wetlands near sea level to prairies on the Tibetan Plateau. Why do we need to monitor carbon, water, and energy cycles? Simply put, the very existence of such cycles makes life possible on earth, acting as the maestro of nature's diversity and harmony. These cycles and their variability are the hands that weave the fabric of rich life on our planet, yet we are carelessly altering them in an unprecedented way.

Mission and vision

CarboEastAsia is a visionary program of AsiaFlux and the participants pursue its mission to bring Asia's key ecosystems under observation to ensure the quality and sustainability of life on earth. Under the AsiaFlux motto, "thinking community, learning frontier", our vision is a community in which science and technology work more directly for sustainable ecological–societal systems in Asia by focusing on:

1. developing forward-looking collaborative research and data sets on energy, matter, and information flows in key ecosystems in Asia;
2. providing workshops and training on current and future challenges posed by global change; and
3. cultivating the next generation of scientists with skills and perspectives enabling them to engage in regional sustainability challenges in Asia as informed leaders and stewards via an ecosystem approach (Waltner-Toews et al. 2008) with resilience-based systems thinking and visioneering (Kim and Oki 2011).

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Research thrust and outcomes

The main objectives of CarboEastAsia are:

1. to identify key mechanisms driving the carbon cycle;
2. to quantify the strength and variability of carbon sinks and sources;
3. to ascertain the role of ecosystem structure and function;
4. to develop ecosystem models suitable for East Asia;
5. to evaluate the effects of disturbance;
6. to establish a database for regional synthesis;
7. to provide scientific insights on ecological possibilities in Asia; and, finally,
8. to assess the importance of the Asian carbon cycle in a global context.

During Phase I (2007–2010), our efforts on interdisciplinary approaches to understanding of biogeochemical–ecological interactions in East Asia were included in a special issue in Biogeosciences (http://www.biogeosciences.net). The main topics included in these publications were: Asian monsoon, biosphere modeling, catchment carbon and water cycles, cloud effect, drought, eddy covariance technique, evapotranspiration, ecohydrology, heterogeneity, litter decomposition, methane exchange, nocturnal boundary layer, organic carbon sequestration, parameter optimization, quality control, remote sensing, scale-dependency, and uncertainty.

During Phase II (2010–2012), CarboEastAsia has focused more on "framing the situation by generating a systems description" and "describing the dynamics of the situation". The next step involves synthesizing the understanding into narratives. This special issue includes, in six original articles, some of the results from these attempts at synthesis. The first article, by Miyama et al. (2013), discusses potential effects of the dynamics and interactions of biogenic volatile organic compounds (BVOC), for example isoprene (C_5H_8), on forest carbon budget and its vegetation–aerosol–climate feedback loop as a result of the formation of secondary organic aerosols. Ichii et al. (2013) present site-level model–data synthesis of terrestrial carbon fluxes in the CarboEastAsia eddy-covariance observation network and address the modeling efforts that are needed in the future. Yan et al. (2013) report that substantial amounts of carbon are sequestered during dry periods in an old-growth subtropical forest in China. By use of remote sensing, He et al. (2013) evaluated the improvement of MODIS gross primary productivity in East Asian forest ecosystems on the basis of eddy covariance measurements. Such validation datasets for CarboEastAsia are documented by Saigusa et al. (2013) who also examined uncertainties in CO_2 budget evaluation caused by different data processing. Finally, Yonemura et al. (2013) determined vertical soil–air CO_2 dynamics (including during periods of snow-cover) at the Takayama deciduous broadleaved forest site, for which data from more than two decades of observation have been accumulated in AsiaFlux. Several other articles will also be published in regular issues of this journal and elsewhere.

At completion of the 5-year collaboration program, we have:

1. identified unique mechanisms causing different carbon dynamics associated with monsoon variability;
2. quantified the strength and variability of carbon sink and source for 21 forests, 3 grasslands, and 3 croplands in 7 countries in Asia;
3. ascertained the different roles of diverse ecosystem structure and functional types;
4. tested and identified the strengths and weaknesses of different terrestrial biosphere models in simulating ecosystem carbon budgets throughout East Asia;
5. evaluated the effects of natural and human disturbances on carbon and water cycles;
6. established a standardized database for 27 sites with a total of 71 site-years for regional synthesis; and
7. found evidence supporting ecological possibilities by use of feedback loops, hierarchically nested processes and structures, and self-organization.

The way ahead

CarboEastAsia has been a breakthrough in the presentation, discussion, and provision of better understanding of the carbon and water dynamics of ecological systems in East Asia. Major outcomes are refined vision and greater inspiration; CarboEastAsia will thus continue as a flagship program of AsiaFlux. However, much more integrated and participatory collaboration is still needed to address all aspects of the proposed ecosystem approach. The continuation of CarboEastAsia is an opportunity to implement some key aspects of AsiaFlux science for regional sustainability. The exciting challenges explicitly involve the dynamics of integrated ecological–societal systems, which is the focus of the next phase, i.e., CarboAsia (http://www.apn-gcr.org/). Ecological–societal systems are combined systems of ecological and social components and drivers that interact and give rise to effects which cannot be understood on the basis of ecological or social contributions alone.

In future endeavors, novel conceptual frameworks (e.g., a non-equilibrium thermodynamic approach) will be needed to develop and utilize a synergistic tool which integrates ecological integrity with social values and preferences. CarbonTracker-Asia is an exemplary means of involving

scientists, stakeholders, and policymakers in monitoring, management, and governance of the regional carbon cycle (http://www.nimr.go.kr/2/carbontracker/). However, the scope and focus of such an heuristic tool must not only be quantity but also quality of matter (e.g., carbon, water) and energy. Eventually, the true challenge is whether or not we have willingness to grasp the opportunity and transform our actions to achieve sustainable stewardship of ecological–societal systems in Asia.

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