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KoFlux 2006 Synthesis: HydroKorea and CarboKorea Foreword

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ALL STREAMS FLOW INTO THE SEA, YET THE SEA IS NEVER FULL. TO THE PLACE THE STREAMS COME FROM, THERE THEY RETURN AGAIN. ECCLESIASTES 1:7

HE WHO CALLS FOR THE WATERS OF THE SEA AND POURS THEM OUT OVER THE FACE OF THE LAND - THE LORD IS HIS NAME. AMOS 9:6

Water and carbon are essential for life. They circulate on earth, and the past and today's world exhibits clear evidence of the significant influence of their cycling on the global climate and the growth of human civilization. Throughout recorded history, the biblical statements of King Solomon (~970 B.C.) and Amos (~750 B.C.) appear to be the first recorded examples of the cyclic nature of water in the earth system. The above two records of foreknowledge literally complete the major components of the global water cycle.

The cyclic nature of water at the local scale is also manifested in one of the longest precipitation record for Seoul, Korea. Fig. 1 presents precipitation records from the traditional Korean rain gauges (1777-1907) and the modern rain gauges (1908-1998) (Jung *et al*., 2001). At first glance, the precipitation of Seoul has recurring dry and wet periods with a severe drought from 1884 to 1910. If the climate cycles, should we not expect another long and brutal dry period in the very near future? In fact, the more important question is how much impact human activities are having on this water cycle? The answer is clearer for the case of carbon and the couplings between water and carbon cycles signify the implication. The IPCC WG1 Fourth Assessment Report warns that a range of forcing, originating from

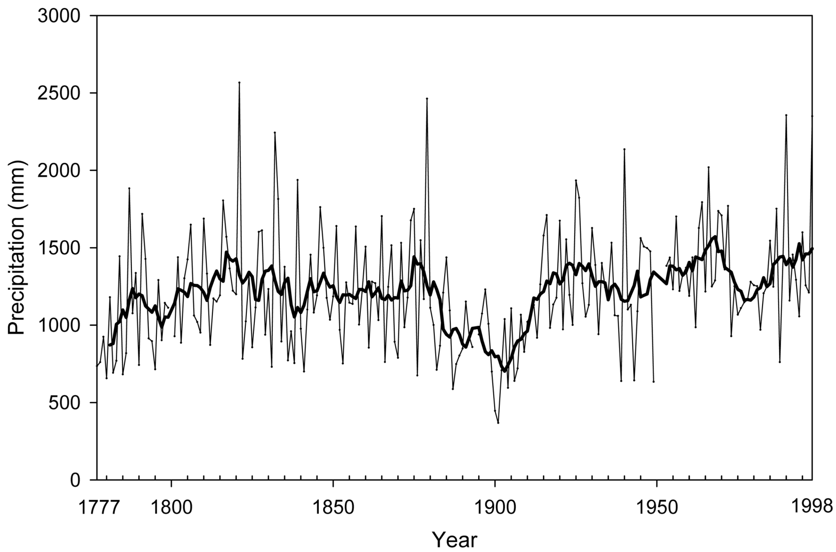

Fig. 1. Annual precipitation amounts (in mm) in Seoul, Korea. (Thick and thin lines denote the annual precipitation amounts and those with 9-yr moving averages, respectively. Adapted from Jung *et al*., 2001).

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human activities, is expected to have planet-wide effects and perturb biogeochemical cycles of the earth system.

KoFlux is a domestic network of micrometeorological eddy covariance tower sites, which monitors the exchanges of water and carbon between the atmosphere and key terrestrial ecosystems in and around the Korean Peninsula (http://www.koflux.org). Along with ChinaFlux and JapanFlux, KoFlux is a cornerstone of the AsiaFlux, the Asian arm of the global FLUXNET (Baldocchi *et al.*, 2001), which is a joint effort of determined, comprehensive international strategies to bring Asia's key ecosystems under observation.

As originally conceived, the KoFlux project was initially intended to last a span of 10 years (from 2001 to 2011), with three major activity phases. The publication of this third special issue marks the end of Phase 2 and the beginning of Phase 3. The "Construction" of the infrastructure was the main theme of Phase 1 (2001-2004) during which KoFlux was launched by networking individual research sites with the limited available resources in Korea to support the AsiaFlux. The KoFlux team developed a global network, proving that KoFlux data could be collected locally and shared anywhere. As a byproduct of this work, the team published well over 100 technical papers and presentations in various journals and symposia, including the first special issue (i.e., "KoFlux 2002 Synthesis").

Terrestrial ecosystems particularly in Asia are heterogeneous, and their spatial and temporal variability influences the lower atmospheric circulation and surface exchange of energy, water, and carbon over a wide range of scales. Accurate assessments of multi-scale changes in our biosphere depend on the definition of practical "scaling logic" that incorporates a synergy of field measurements such as remote sensing and numerical modeling. Hence, built upon the augmented KoFlux infrastructure such as the "Gwangneung Supersite", Phase 2 ('CarboKorea' and 'HydroKorea' from 2004 to 2007) focuses on linking flux footprint, ecohydrological schemes and satellite images to bridge the gaps between different scales of exchange processes in heterogeneous and complex landscapes (Kim *et al.*, 2006). The second special issue, 'KoFlux 2004 Synthesis', which was published in 2005, is a collection of 13 papers ranging from reviews on fundamental theory and measurements to ecohydrological modeling and satellite applications.

Originally, for the 'KoFlux 2006 Synthesis', nineteen manuscripts were submitted and went through the formal review process in which only eight papers made it to the final publication of this special issue. These papers cover the subjects from the groundwater-soil-canopy-atmosphere continuum to modeling and synthesis of ecohydrological and biogeochemical processes in forest and agricultural ecosystems in Korea. Starting from the lowest boundary of such a continuum in the Gwangneung forest catchment, Choi *et al.* deal with the estimation of groundwater recharge rates to comprehend the dynamic characteristics of hydrological cycle. At the soil-air/vegetation interface, Son *et al.* discuss soil moisture transfer processes measured at hillslope scale. Water and carbon fluxes at the canopy-air interface measured by the eddy-covariance at the Gwangneung site are subject to low wind speed and rolling terrain, requiring a full understanding of the effect of coordinate rotation on flux computations. Thus, Yuan *et al.* review the properties of three orthogonal coordinate frames and apply to the observed fluxes of momentum, heat, water, and CO_2. By using hydro-biogeochemical approaches, Kim *et al.* then provide the up-to-date information on flowpath, storage, residence time and interactions of water and carbon transport. Based on the integrated parameterization, Kim *et al.* assess the suitability and usefulness of the Regional Hydro-Ecologic Simulation System (RHESSys), which is a powerful tool to integrate carbon and water cycles at a catchment scale and bridge the gaps between field-based observations and satellite-based regional scale interpretations.

Fig. 2 shows the AVHRR-based normalized difference vegetation index (NDVI; Tucker *et al.*, 2005), which is a major driver of evapotranspiration and plant production, from 1981 to 2004 for the Gwangneung (forest) and Haenam (agricultural crops) KoFlux sites. There appears to be no obvious long-term trends but striking seasonal and interannual variations at both sites. The mapping of such satellite-based gross primary productivity (GPP) is one of the main goals of KoFlux, and Kim *et al.* attempt to improve the reliability of MODIS-based GPP by improving input data. KoFlux sites are spatially heterogeneous and the consequent questions of scale dependency are paramount to the KoFlux research. As a first step toward such issues, Moon *et al.* introduce a geostatistical technique to quantify the landscape heterogeneity by semivariogram and fractal analyses. Finally, by synthesizing the above results and other findings, Lee *et al.* present the

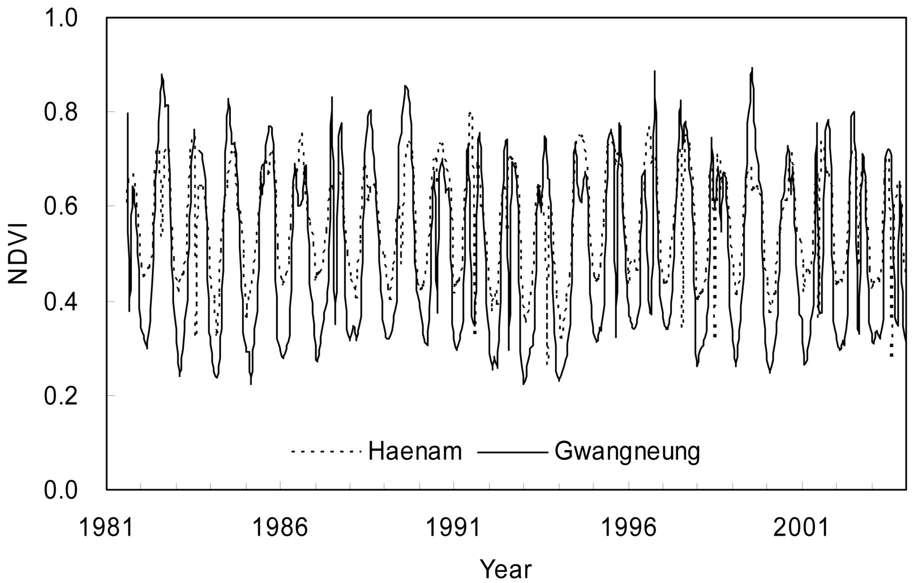

Fig. 2. Variation of normalized difference vegetation index (NDVI) for the Gwangneung (forest) and Haenam (agricultural crops) KoFlux sites from 1981 to 2004 (from the Advanced Very High Resolution Radiometer (AVHRR), the Global Inventory Modelling and Mapping Studies (GIMMS)).

lessons learned from this cross-scale studies of water and carbon cycles in the Gwangneung forest catchment which is characterized by complexity, heterogeneity, and monsoon climate.

Phase 3 of the KoFlux project ('HydroKorea II' and 'CarboEastAsia' from 2007 to 2011) will improve the scaling logic methodologies developed during Phase 2 to accurately apply and monitor the water and carbon cycles from local to regional scales in monsoon Asia, thereby proactively providing options needed to minimize damage and encourage sustainable use of our biosphere.

In summary, 'finding simplicity in complexity' is the challenge that KoFlux researchers are facing as informed stewards who are striving to reduce complex science issues of water and carbon cycling to fundamental questions and lay out detailed plans for the use of newly evolving theories and technologies to address these questions. We still know far too little on how eco-hydrological and biogeochemical processes interact and their dynamics are manifested at different scales. Yet, we hope this special issue is a proactive collection of "how tos" rather than a presentation of a litany of problems, and above all, it is our intent to make this issue opportune and useful.

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