Inferring Regional Scale Surface Heat Flux around FK KoFlux Site: From One Point Tower Measurement to MM5 Mesoscale Model

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FK KoFlux 관측지에서의 지역 규모 열 플럭스의 추정: 타워 관측에서 MM5 중규모 모형까지

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ABSTRACT

Korean regional network of tower flux sites, KoFlux, has been initiated to better understand CO₂, water and energy exchange mechanisms between ecosystems and the atmosphere; and to contribute to regional, continental, and global observation networks such as FLUXNET and CEOP. Due to heterogeneous surface characteristics, most of KoFlux towers are located in non-ideal sites. In order to quantify carbon and energy exchange and to scale them up from plot scales to a region scale, various methods combining measurement and modeling are needed. In an attempt to infer regional-scale flux, four methods (i.e., tower flux, convective boundary layer (CBL) budget method, MM5 mesoscale model, and NCAR/NCEP reanalysis data) were employed to estimate sensible heat flux representing different surface areas. Our preliminary results showed that (1) sensible heat flux from the tower in Haenam farmland revealed heterogeneous surface characteristics of the site; (2) sensible heat flux from CBL method was sensitive to the estimation of advection; and (3) MM5 mesoscale model produced regional fluxes that were comparable to tower fluxes. In view of the spatial heterogeneity of the site and inherent differences in spatial scale between the methods, however, the spatial representativeness of tower flux need to be quantified based on footprint climatology, geographic information system, and the patch scale analysis of satellite images of the study site.

Key words: tower flux, regional-scale flux, CBL budget, MM5 mesoscale modeling

I. INTRODUCTION

Korean regional network of tower flux sites, KoFlux, has been established to improve our understanding of CO₂, water and energy exchange mechanisms between ecosystems and the atmosphere; and to contribute to
the regional, continental, and global networks such as FLUXNET and CEOP (Kim et al., 2002; http://koflux.org). Eddy covariance method is employed to measure surface energy and CO\textsubscript{2} fluxes in all KoFlux sites. Most of flux towers are, however, located in non-ideal sites due to inhomogeneous patch-scale vegetation and complex topography. This complicates the application of eddy flux measurement due to additional terms (e.g., horizontal and vertical advection) to consider (Lee, 1998; Finnigan, 1999; Paw U et al., 2000; Massman and Lee, 2002). However, it is practically difficult to quantify these effects using only tower-based micrometeorological observation. Three-dimensional observations or incorporations of appropriate models become necessary for quantifying these advection effects over complex, heterogeneous terrains (Massman and Lee, 2002).

While tower-based eddy covariance measurements cover relatively small region (1-10 km\textsuperscript{2}), current demands for understanding carbon and energy cycles on regional and continental scales have grown in the science community and societies. As a result, numerous large scale experiments and long-term observations have been formed on the basis of networking the flux towers. Convective boundary layer (CBL) budget method is one of the recent tools to infer regional surface fluxes and has been used to estimate surface fluxes of heat, water, CO\textsubscript{2}, and NH\textsubscript{4} (e.g., Wofsy et al., 1988; Munley and Hipps, 1991; Raupach et al., 1992; Denmead et al., 1996; Levy et al., 1999; Gryning and Batchvarova, 1999; Cleugh and Grimmond, 2001; Laubach and Fritsch, 2002). In this approach, CBL is considered as a natural mixing chamber for estimating surface fluxes on regional scale (10\textsuperscript{2}–10\textsuperscript{4} km\textsuperscript{2}). Strong mixing by turbulence in CBL naturally averages out small scale surface heterogeneities (Raupach and Finnigan, 1995).

Recently, Laubach and Fritsch (2002) re-examined the CBL budget method theoretically and suggested new concept of CBL budget method. The overall objective of this study was to infer the regional scale surface heat fluxes around FK site. To accomplish this goal, we employed CBL budget method and quantified the effect of horizontal advection on surface flux using radiosonde data collected at the site following Laubach and Fritsch (2002). We compared the tower-based heat fluxes with those obtained from different approaches such as NCEP/NCAR Reanalysis data (NNRD) and the output of Penn State-NCAR mesoscale model MM5 near this tower site. Through this comparison, we explored whether single tower of eddy covariance measurements can provide a representative flux over heterogeneous surfaces.

II. MATERIALS AND METHODS

2.1. Site description
FK KoFlux site is located at Haenam-gun, Jeollanamdo, Korea (34.55° N, 126.57° E, 13.74 m m.s.l.) (Fig. 1). Typical land cover types around the study site are typical farmland vegetation mixed with scattered rice paddies. Also found around the tower are the roads, small hills, residential areas, and scattered small forests with occasional biomass burnings. In a regional sense, there are small towns, water reservoirs, and rivers. Topography around FK site is relatively flat on a regional scale, except Wolch’ul Mountain (809 m m.s.l.) and Duryun Mountain (703 m m.s.l.) which are located about

Fig. 1. Map of FK KoFlux site.