ORAL 02

A Modification of the Moving Point Test Method for Nighttime Eddy CO_2 Flux Filtering on Hilly and Complex Terrain

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I. Introduction

Nighttime correction of CO_2 flux is one of the most important and challenging tasks in eddy covariance (EC) measurements over complex mountainous terrain. There are two types of widely used methods for nighttime correction: u^* filtering method and advection based filtering method. The most popular method is the u^* filtering method that estimates the parameters of the ecosystem respiration (RE) function using the observed nighttime CO_2 flux when u^* is higher than a threshold, above which the dependency of the nighttime CO_2 flux on u^* fades away (e.g., Gu *et al.*, 2005). The filtered data are replaced with the data modeled using the air or soil temperature and the RE function with the estimated parameters. The u^* filtering method cannot be used at sites where the u^* threshold cannot be identified and/or the drainage flow is developed at night, resulting in an underestimation of the CO_2 flux. For overcoming that, the advection based method was developed for hilly terrain sites affected by drainage flow using the observed CO_2 flux data from near sunset, when nighttime advection effect has not yet manifested (e.g., van Gorsel *et al.*, 2009). Gwangneung deciduous and coniferous sites in Korea (GDK and GCK) are typical sites situated in hilly and complex terrain where the aforementioned methods are difficult to apply correctly because the filters' assumptions are violated (i.e., the time at which CO_2 drainage developed was faster than that assumed by the method). The nighttime CO_2 flux correction is also important to partition net ecosystem exchange (NEE) into gross primary production (GPP) and RE. Because we usually extrapolate nighttime values of RE into the daytime using the RE equation for the nighttime correction (e.g., Reichstein *et al.*, 2005). In this study, we propose a modified moving point test method (i.e., an automated statistical method for determining the u^* threshold based on an iterative approach using a moving window for u^*, Gu *et al.*, 2005) using moving windows for 'time' as well as u^*, which can determine the 'timing when CO_2 drainage is generated' as

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well as the u^* threshold for application of nighttime correction to the sites.

II. Materials and Methods

2.1. Study sites

In Gwangneung National Arboretum, there are two flux towers in operation: the Gwangneung deciduous forest located at the top of a hill (GDK; 37° 45' 25.37" N, 127° 09' 11.62" E) and the Gwangneung coniferous forest located at the bottom (GCK; 37° 44' 54.3" N, 127° 09' 45.3" E). Both sites are in a complex, hilly catchment (~220 ha) with a mean slope of 10–20°. The two towers are approximately 1.2 km apart, and the mean slope between the towers is approximately 6.2°. The east/west slopes are gentle, whereas the north/south slopes are steep in the catchment. The thermally induced mountain–valley circulation is dominant in the GDK (uphill) and GCK (downhill) sites. The 30–year climate normal was 11.5°C for temperature and 1332 mm for precipitation. At the uphill site, the vegetation is dominated by an old natural forest of *Quercus* sp. and *Carpinus* sp. (80–200 years old) with a mean canopy height of ~18 m and a maximum leaf area index of ~6 in June. The downhill site is located in a generally lower and flat area compared to the uphill site and is a plantation forest with dominant species of *Abies holophylla* (about 80 years old) with a mean canopy height of ~23 m and a maximum leaf area index of ~8 in June. Further descriptions of the sites can be found in Kim *et al.* (2006).

2.2. Measurements and data processing

The EC technique was used to measure the CO_2 flux from a 40-m tower at both sites. Vertical and horizontal wind speeds and temperature were measured with a three–dimensional sonic anemometer (Model CSAT3, Campbell Scientific Inc., USA) at 10Hz at both sites. An open–path infrared gas analyzer (IRGA; Model LI–7500, LI–COR Inc., USA) was used at each site to measure water vapor and CO_2 concentrations. Half–hourly ECs and the associated statistics were calculated online from 10–Hz raw data and stored in a datalogger. The multi–level profile systems were installed at both sites to measure the vertical profiles of CO_2 and H_2O concentrations and to estimate the storage flux in the control volume using a closed–path IRGA (Model: LI–6262, LI–COR Inc.).

To improve the data quality by eliminating undesirable data, the collected data were examined by the quality control procedure based on the KoFlux data processing protocol (Hong *et al.*, 2009; Kang *et al.*, 2014). This procedure includes a sector–wise planar fit rotation, WPL (Webb-Pearman-Leuning) correction, storage term calculation, spike detection, and gap-filling (marginal distribution sampling method). More information about the measurements and data processing can be found in Kang *et al*. (2016).

2.3. Modification of moving point test method

The objective of moving point test (MPT) method is to determine the intermediate range of u^* where nighttime CO_2 fluxes are independent of u^* (Gu *et al*., 2005). The method searches for lower and higher u^* thresholds which are found by statistically testing a group of points with consecutive u^* values in a narrow moving window against a reference sample. The original method excludes data at the nights when its median u^* are lower than the lower u^* threshold, in order to avoid an underestimation of CO_2 flux due to drainage flow. However, this consideration is inappropriate for hilly terrain sites almost always affected by drainage flow (e.g., the study sites, GDK and GCK). We modify the original MPT method for applying to hilly terrain sites: (1) Split into the two time windows i.e., the time window near sunset (when a drainage has not yet (completely) manifested) and the time window after the former, (2) Apply the MPT method to each time window, (3) Compare the results between the two time windows and determine the existence of CO_2 drainage, and (4) Exclude data in the second time window if the CO_2 drainage is commonly generated and apply the u^* filtering method using the u^* thresholds determined in the previous steps.

III. Results

For the study sites, a site-specific filter was developed to eliminate the drainage affected data using an information flow dynamic process network of the CO_2 concentrations between the two sites (Kang *et al*., 2016). This site-specific filter improved the discrepancy between the three general nighttime correction methods (i.e., u^* filtering method , light response curve method and advection based filtering method) and the inconsistency between the EC measurement and the other measurement/estimation. In order to evaluate the modified MPT method, we compared the monthly GPP, RE, and NEE between the results from Kang *et al*. (2016) and the modified MPT method. The both results are comparable (Fig. 1). Further analysis will be discussed in the presentation.

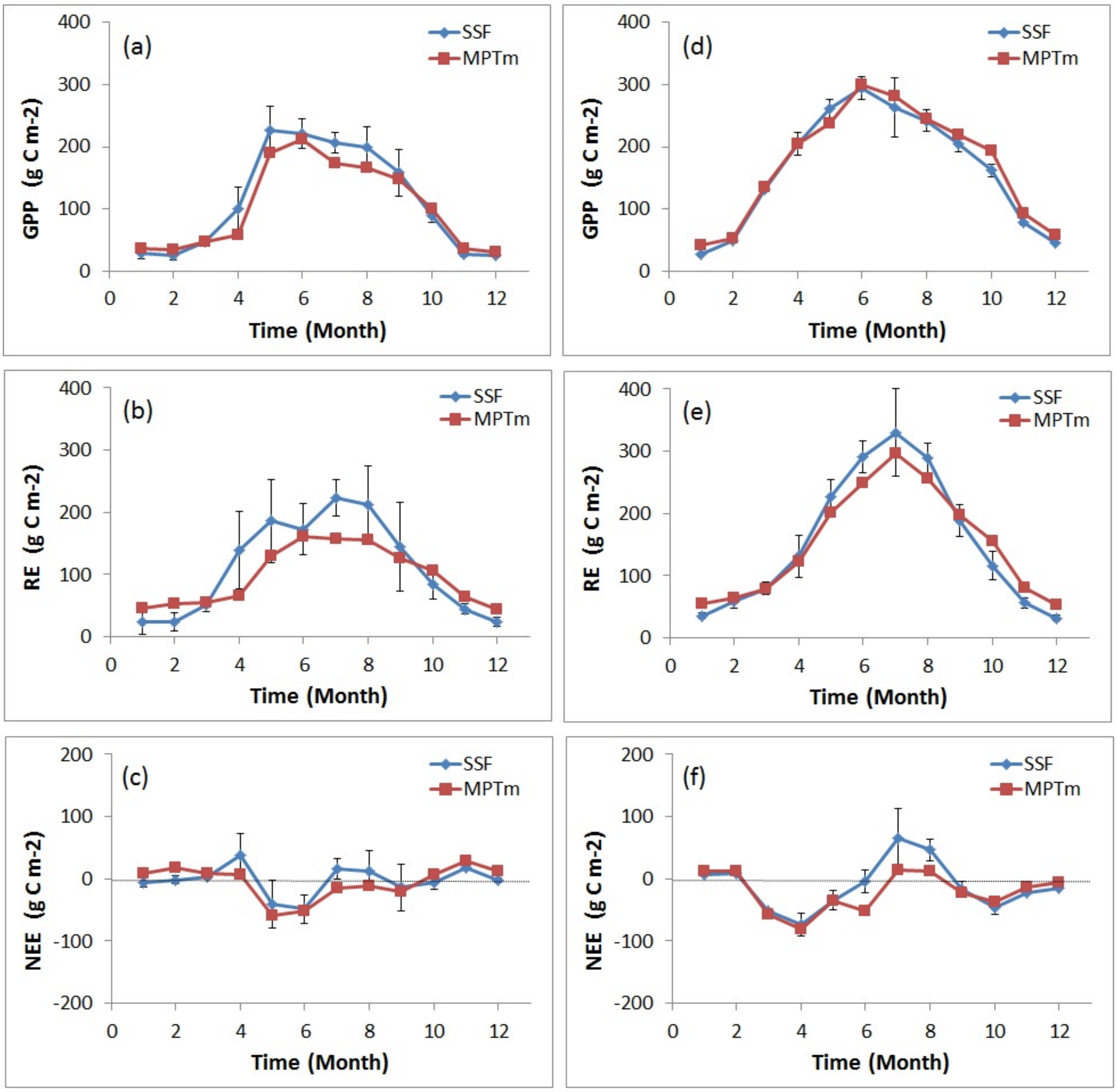

Fig. 1. Monthly gross primary production (GPP), ecosystem respiration (RE), and net ecosystem exchange (NEE) in 2009 for the GDK (a, b, c) and GCK (d, e, f). SSF indicates the site-specific filter, while MPTm indicates the modified moving point method. The error bar represents the standard deviation of the results from the three nighttime correction methods.

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