Spatial variation and partitioning of soil respiration in an oak-grass savanna ecosystem in California

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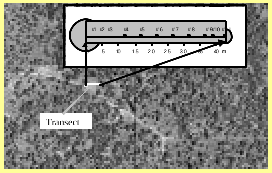
1. Introduction

Understanding the spatial variation of soil respiration helps scale up soil respiration from point measurements to regional and global levels. Temporal patterns of soil respiration have been modeled by using the continuous records of temperature, moisture and other variables. The spatial difference of soil respiration is not fully explained by climatic variables. The major reason is due to the functionally different components of soil respiration such as rhizosphere respiration and microbial heterotrophic respiration. Partitioning of soil respiration helps us identify the source of spatial variation. Oak-grass savanna ecosystems with sparse distribution of trees in California provide a unique natural characteristic to study spatial variation and partitioning of soil respiration.

2. Materials and Methods

The field study was conducted at an oak-grass savanna (38.4311^o N, 120.9660^o W and 177 m), one of the Ameriflux sites, located at the lower foothills of the Sierra Nevada Mountains near Ione, California. The climate is Mediterranean with mean annual temperature and precipitation of 16.3 ^{o}C and 558.7 mm, respectively. The overstory consists of scattered blue oak trees (*Quercus douglasii*), with a maximum LAI of 0.6. The understory grass is confined in the wet season with a maximum LAI of 1.0. The canopy covers 57.58% and open space covers 42.42% of total areas. The soil is the Auburn very rocky silt loam (Lithic haploxerepts). We set a 42.5 m transect between two oak trees, and inserted soil collars along the transect for measuring CO_2 efflux using a soil chamber connected to a portable photosynthesis system (LI-6400, LI-COR Inc, Nebraska, USA).



3. Results

CO_2 efflux along the transect

There is significant difference of soil CO_2 efflux between open areas and under trees, and between grass growth seasons (wet seasons, November to mid-May) and dry seasons (mid-May to October) (Table 1, Fig. 1).

Table 1

	component	CO_2 efflux (? molm^{-2}s^{-1}) under trees	Open areas	Oak root	Root/total
Wet season	oak root, grass root, microbes	2.29	1.43	0.86	37.5%
Dry season	oak root, microbes	0.87	0.51	0.36	41.1%

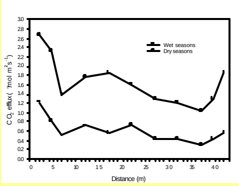


Fig. 1 CO_2 efflux along the transect.

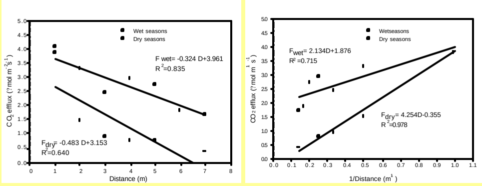


Fig. 2a, 2b. CO_2 efflux vs. distance.

CO_2 efflux vs. distance

Soil respiration under tree canopies decreases linearly with the increase in the distance of measurement from the tree. In the open areas, tree roots have no influence on CO_2 efflux. Fig. 2a shows a straight line to fit the data if we plot CO_2 efflux against the distance. The slope is steeper for the dry season than that for the wet season. If we plot CO_2 efflux again the inverse of distance (Fig. 3b), we found a strong correlation, particularly in the dry season between CO_2 efflux and 1/distance.

Diurnal patterns of CO_2 efflux

We plotted the diurnal patters of CO_2 efflux from 6:00h to 18:00h (Fig. 3a), and soil temperature (Fig. 3b) for two days, DOY 229 and 249 in 2001. The diurnal pattern of CO_2 efflux in the summer drought did not vary correspondingly with soil temperature due to the influence of tree physiology and constraint of soil moisture.

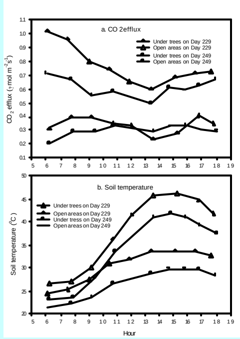


Fig. 3

Seasonal patterns of CO_2 efflux

Seasonally, soil respiration increased in the spring, and decreased in the summer following the decrease in soil moisture content (Fig.4). Soil respiration significantly increased after the first rain in the autumn. Based on spatial analysis of the ratio of tree crown areas vs. open areas, we estimated that the accumulation of CO_2 efflux in 2002 is 478.97 gCm^{-2}y^{-1}.

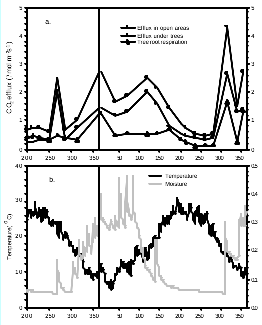


Fig. 4

Chamber vs. eddy covariance measurements

Compared with eddy covariance measurements, chamber measurements are lower in the dry season and higher in the wet season. The difference is from instrument-based errors and model-based errors.

Modeling

We found a bi-variable model with soil temperature and moisture variables, separately estimating soil respiration under trees and in open areas, can explain 79% of the variation of soil respiration. Fig. 5 is the measured respiration vs. moisture, and Fig. 6 plots the measured soil respiration vs. modeled one.

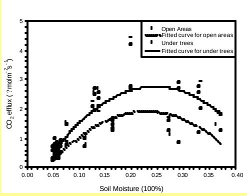


Fig. 5

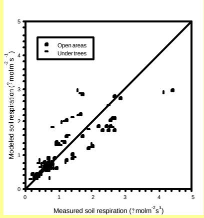


Fig. 6

Continuous measurements

To further explain some extreme events such as rain events, we installed small solid-state CO_2 sensors to continuously measure soil CO_2 profiles and CO_2 efflux (Tang et al. 2003. *Agr. Forest Meteorol.*, **118,** 207-220). Thus, by combining chamber measurements and continuous CO2 measurements we may understand more about spatial and temporal variation of soil respiration.

Acknowledgments

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