Separating root respiration from soil respiration in a ponderosa pine plantation in the Sierra Nevada

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1. Introduction

Partitioning soil respiration into autotrophic and heterotrophic respiration is important for building process-based models since these two components respond differently to abiotic and biotic drivers. While heterotrophic respiration may be mainly driven by soil temperature and moisture, root respiration may be affected by plant physiology as a part of plant autotrophic respiration. This study aims to partition soil respiration using the trench approach in a ponderosa pine plantation in the Sierra Nevada, model seasonal variation of heterotrophic respiration, autotrophic respiration, and F_a/F ratio, and analyze the spatial variation with the influencing factors of root distribution, soil organic carbon content, and soil nitrogen content.

2. Materials and Methods

The study site, a part of the Ameriflux network, is in a young ponderosa pine plantation which is located (38º53′?42.9?N, 120º37′?57.9?W, 1315 m) adjacent to Blodgett Forest Research Station, a research forest of the University of California, Berkeley. The plantation was dominated by 11-12 year old ponderosa pine (*Pinus ponderosa*) in 2002, with DBH of 16.0 cm, height of 6.5 m, and a density of 378 stems/hectare. The site is characterized by a Mediterranean climate with average precipitation of 1660mm. The soil is a fine-loamy, mixed, mesic, ultic haploxeralfin the Cohasset series.

We established two 20?20 m^2 sampling plots. Soil CO_2 efflux was measured on a 3?3 matrix spacing 10 m apart, using an LI6400-09 soil chamber connected to an LI-6400 portable photosynthesis system (LI-COR, Inc. Lincoln, NE). We dug a trench 0.2 m wide and 1.2 m deep around a 3?3 m^2 plot. Then soil was refilled into the trench. There were no root influences in the trenched plot.

3. Results

Measurements

Daily mean soil respiration peaked in May-June at about 3.8 ?mol$m^{-2}s^{-1}$, and then decreased to about 1.6 ?mol$m^{-2}s^{-1}$ in the winter. Soil heterotrophic respiration had a similar seasonal variation, peaking in the early summer at about 3.0 ?mol$m^{-2}s^{-1}$ and going down to 1.2 ?mol$m^{-2}s^{-1}$ in the winter. The difference between soil respiration and heterotrophic respiration is estimated autotrophic respiration. The ratio of autotrophic respiration to total respiration (F_a/F) varied, ranging from 0.11 to 0.40.

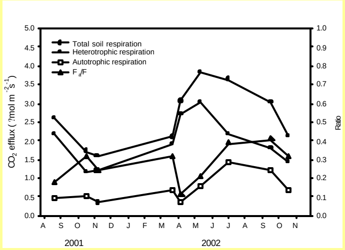

Fig. 1

Modeling total soil respiration, heterotrophic respiration and autotrophic respiration

We used a bi-variable model (Fig. 2) including independent variables of soil temperature and moisture to simulate total soil respiration and heterotrophic respiration; the difference is autotrophic respiration (Fig.3 and 4). The annual accumulations of total soil respiration, heterotrophic respiration, and autotrophic respiration were 78.2 molm^{-2} year^{-1}, 52.2molm^{-2} year^{-1}, and 26.0 molm^{-2} year^{-1}, respectively. The ratio of autotrophic respiration to total soil respiration (F_a/F) is not a constant seasonally with a mean of 0.33. F_a/F averaged as 0.37 in the growing seasons and 0.28 in non-growing seasons.

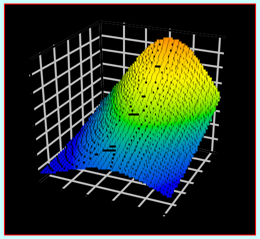

Fig. 2

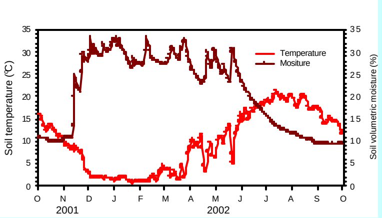

Fig. 3

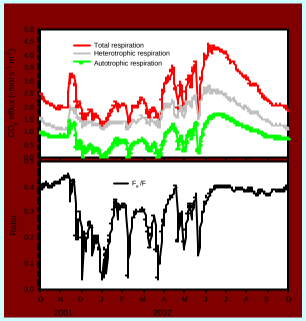

Fig. 4

Factors influencing spatial variation of soil respiration

To analyze the spatial variation of soil respiration, we explored the correlations between F/F_{mean} and its influencing factors such as root density per ground area, defined as

$$D ? \overset{n}{\underset{i}{?}} \frac{1}{? r_i^2}$$

, where r is the distance from measurement location to the tree. R^2 between F/F_{mean} and root density was greater than F/F_{mean} and nitrogen content, and F/F_{mean} and organic carbon content.

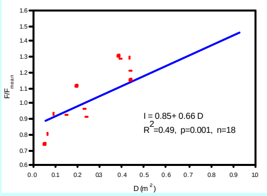

Fig. 5

Continuous measurements

In order to have high temporal resolution CO_2 efflux data, we installed small CO_2 sensors buried in soils to continuously measure soil CO_2 concentration gradients and then calculated CO_2 efflux in both trenched and control plots.

Fig. 6

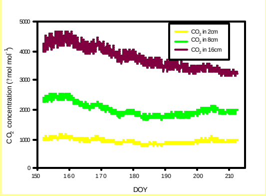

Fig. 7

4. Conclusions

A bi-variable model with soil temperature and moisture simulates soil respiration, heterotrophic respiration, and root respiration. Root respiration is affected by plant physiology, phenology, and photosynthesis, as well as environmental variables. The ratio of autotrophic respiration to total soil respiration is not a constant seasonally. The spatial variation of soil respiration was mainly explained by root density per ground area.

Acknowledgments

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