CLIMATE AND DISTURBANCE EFFECTS ON GROSS ECOSYSTEM FLUXES ASSESSED BY MODEL-DATA FUSION

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ABSTRACT

We implement a model-data fusion method to determine the gross flux components contributing to the net ecosystem exchange of a Ponderosa pine forest in Oregon. This site-level investigation represents a test-run of the method, which will later be applied to all of Oregon and north California.

INTRODUCTION

Previous work has shown that age since disturbance is the dominant factor driving net ecosystem production in Ponderosa pine forests in Oregon. Stand age also influences carbon allocation and sensitivity to drought. We attempt to incorporate these effects into process models for gross primary production (GPP), autotrophic respiration (R_A) and heterotrophic respiration (R_H). A model-data fusion approach for estimating regional CO_2 fluxes is described to utilize both eddy covariance and atmospheric CO_2 concentration measurements for parameter estimation at three flux tower sites covering different age classes of Ponderosa pine forest. In its final implementation, concentration data will be interpreted within a one-dimensional atmospheric boundary layer model to infer daytime CO_2 flux. These flux estimates cover a larger region than the eddy covariance measurements and footprint modeling allows partitioning among surrounding land cover types and age classes.

RESULTS AND CONCLUSIONS

The parameter optimization procedure is used to determine the dominant parameters driving diurnal and seasonal variation in flux components, and parameter uncertainties and correlations are investigated. Results show that it is difficult to separate autotrophic and heterotrophic respiration components without additional observational or theoretical constraints, but their differing response times to changes in climate variables such as temperature do allow some success in their resolution. The influences of factors such as drought, diffuse light fraction and stand age on production and/or respiration and the link between production and respiration are discussed.

The simple process models for GPP, R_A and R_H are formulated with a base rate for each flux component (this rate being the light-use-efficiency in the case of GPP), and modulation with climate variables, forest structure and stand age. The simplicity of the functions make them easy to parameterize and employ across large spatial regions, driven by distributed climate data and satellite observations, while encompassing sufficient mechanistic linkages between vegetation fluxes and climate and physiological drivers to reproduce the observations effectively. Fig. 1 shows the agreement between modeled fluxes and eddy covariance measurements for daytime and nighttime NEE at the Metolius 90 year-old Ponderosa pine site in Oregon. Fig. 2 shows the individual flux components of the model at this site, as well as GPP estimated independently from eddy covariance measurements. Sign convention is positive upwards.

The study represents an example of a method to monitor gross flux components over regional scales, driven by climate and remotely sensed data with isolated site measurements for model parameterization. In further work the method will be implemented over all of Oregon and north California and the distribution of gross flux components with stand age will be compared to estimates from inventory and extensive plot measurements. The study will contribute to the goals and deliverables of the North

American Carbon Program both as a regional intensive campaign and as an investigation of representativeness of tower sites for flux and concentration measurements.

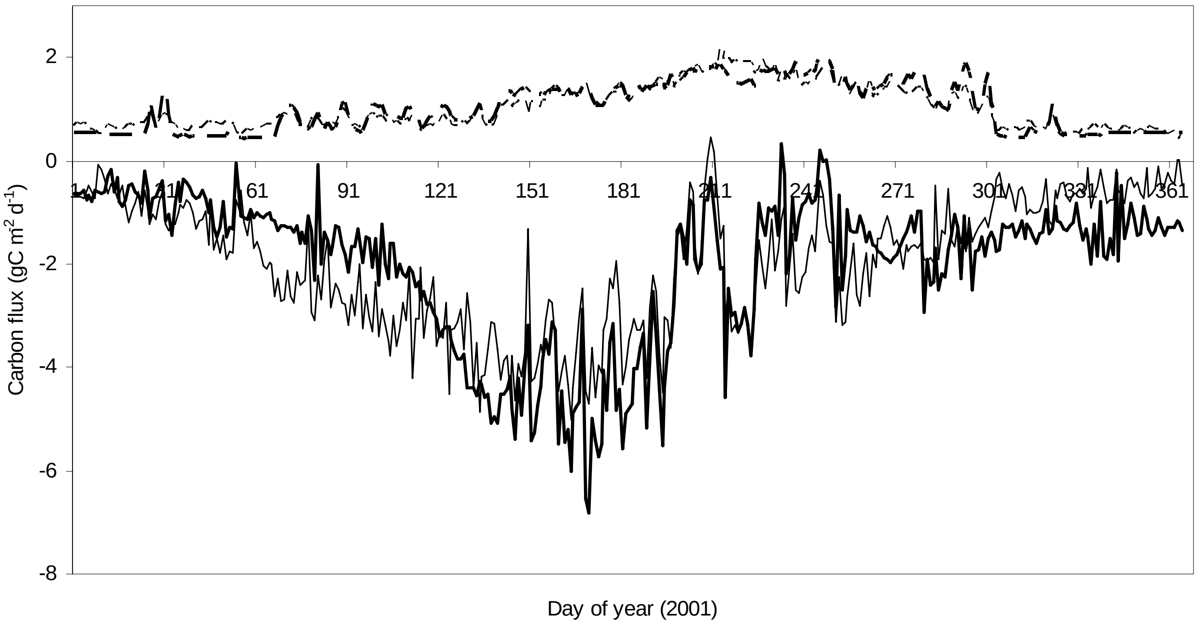

Fig. 1. Comparison of modeled (thin lines) and measured (thick lines) daytime NEE (solid lines) and nighttime NEE (dashed lines).

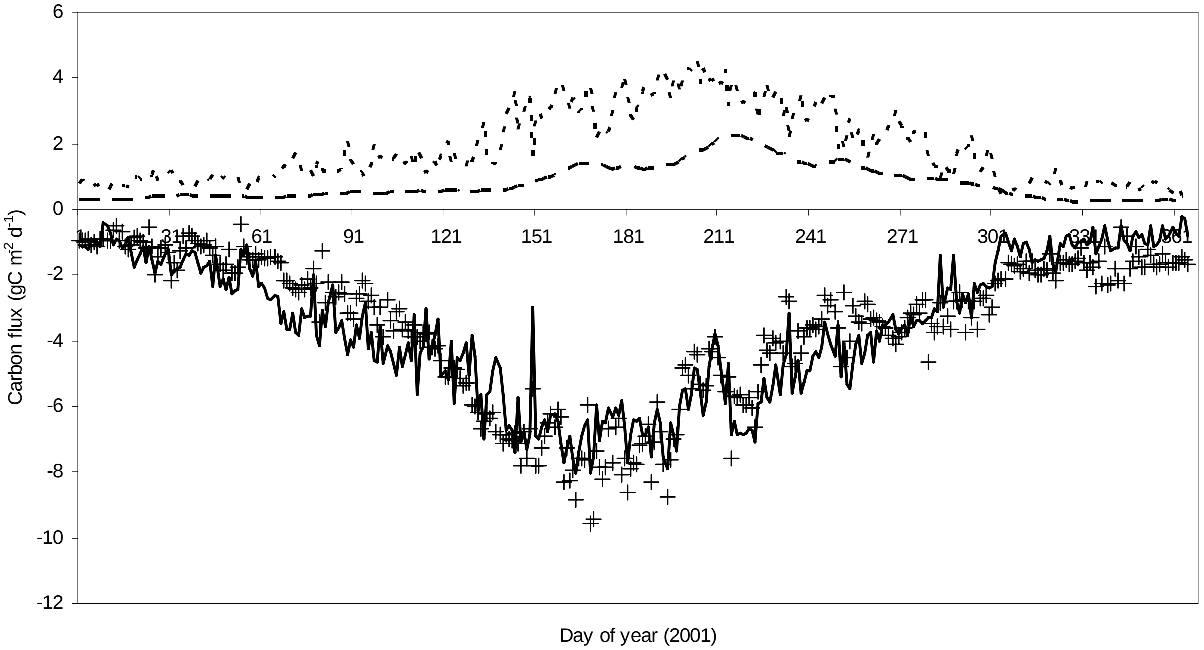

Fig. 2. Modeled NEE flux components: GPP (solid line); R_A (dashed line) and R_H (dotted line). Also shown is GPP calculated from eddy covariance measurements of NEE by subtraction of daytime respiration as determined from nighttime NEE temperature dependence (plus symbols; a two-week moving window was used for the respiration temperature dependence).