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Linderson, Maj-Lena; Mikkelsen, Teis Nørgaard; Ibrom, Andreas; Lindroth, A.; Pilegaard, Kim

Published in:
Proceedings (cd-rom)

Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

WATER USE EFFICIENCY AS A MEANS TO ASSESS FOREST CARBON UPTAKE FOR DIFFERENT MANAGEMENT STRATEGIES

M-L. Linderson[1,2], T. N. Mikkelsen[1], A. Ibrom[1], A. Lindroth[2], K. Pilegaard[1]

[1]*Risoe DTU National Laboratory for Sustainable Energy, Roskilde, Denmark; Maj.Lena.Linderson@risoe.dk*

[2]*Dept. of Physical Geography and Ecosystems Analysis, Lund University, Sweden*

ABSTRACT

The possibility to use water use efficiency (WUE) as a means for up scaling leaf carbon uptake to forest stand scale is assessed. Leaf physiology observations from the Sorø beech forest, Denmark, were used to evaluate leaf WUE variability and its environmental dependencies. Whole tree carbon half-hourly and daily WUE was assessed using MAESTRA model simulations. Preliminary results indicate that both leaf and canopy WUE are dependent only on VDP and light and may thus be assessed from sap flow in combination with PAR and VPD measurements above the forest.

INTRODUCTION

New tools are needed to assess forest stand carbon uptake for different forest management strategies and species composition where other methods, e.g. flux towers, fail due to large spatial integration. Water use efficiency (WUE) – the relationship between carbon uptake (F_c) and water use of the tree (F_w) – is considered to be a conservative species property only depending on the vapor pressure deficit (VPD) (Bierhuizen, J. F. and Slatyer, 1965; Baldocchi et al. 1987; Law et al. 2002):

$$\frac{F_c}{F_w} VPD = \text{constant}$$

If this relationship is valid for leaves, disregarding their position in the tree, stem WUE is also constant and stem sap-flow measurements can be used to estimate carbon uptake of the whole tree and, with a representative selection of sap-flow measured trees, of the whole stand. The aim of this study is to assess the possibility to use water use efficiency (WUE) as a means for up scaling leaf carbon uptake to forest stand scale.

DATA AND METHOD

The leaf flux measurements originates from the Soroe forest, a Danish 80-years old beech (*Fagus sylvatica* L) forest with an average tree height of 25 m and stand density of 430 stems/ha further described in Pilegaard et al. (2006). F_c and F_w were measured at four different heights during the growing seasons of 1999 and 2000, using an LCA-3 infrared gas analyzer (ADC) with a Parkinson leaf chamber, where PAR and transpiration were registered simultaneously as photosynthesis.

The leaf physiology observations were used to evaluate leaf WUE variability and its environmental dependencies. Whole tree carbon half-hourly and daily WUE was assessed applying the observed leaf WUE*VPD dependency of PAR to the MAESTRA model simulations, thus using the meteorological and physiological effects on the light distribution within the canopy. The MAESTRA model was parameterized according to physiological observations of the Soroe beech forest (e.g. leaf optical properties, vertical leaf area distribution and tree structure) (Ibrom et al. 2006).

CONCLUDING RESULTS

Canopy net carbon uptake can successfully be calculated from sap flow measurements for the Soroe beech forest based on the following findings:

- Observations show that WUE is dependent of incoming PAR below 500 μmol m-2 s-1 and, for the full range, dependent on VPD and independent of both different levels of the trees and for the variation in environmental parameters.
- Modeled daily canopy WUE for daytime fluxes (6-18 hours) are dependent only on VDP and light and may thus be assessed from sap flow in combination with PAR and VPD measurements above the forest.
- Low morning and evening fluxes are not included in the estimations but constitute only to a small part of the fluxes and are thus negligible.
- The method, so far, require that woody respiration and night time leaf respiration is treated separately.

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