Meteorologische Zeitschrift, Vol. **14**, No. 2, 151-155 (April 2005)

Article

The assessment of water vapour and carbon dioxide fluxes above arable crops – A comparison of methods

STEFAN SCHAAF*[1], ULRICH DÄMMGEN[1], LUDGER GRÜNHAGE[2] and STEFAN BURKART[1]

[1] Federal Agricultural Research Centre, Institute of Agroecology, Braunschweig, Germany
[2] Justus-Liebig-University, Institute for Plant Ecology, Giessen, Germany

(Manuscript received March 31, 2004; in revised form January 25, 2005; accepted January 26, 2005)

Abstract

Vertical fluxes of water vapour and carbon dioxide obtained from gradient, eddy covariance (closed and open path systems) and chamber measurements above arable crops were compared with the directly measured energy balance and the harvested net biomass carbon. The gradient and chamber measurements were in the correct order of magnitude, whereas the closed path eddy covariance system showed unacceptably small fluxes. Correction methods based on power spectra analysis yielded increased fluxes. However, the energy balance could not be closed satisfactorily. The application of the open path system proved to be successful. The SVAT model PLATIN which had been adapted to various arable crops was able to depict the components of the energy balance adequately. Net carbon fluxes determined with the corrected closed path data sets, chamber, and SVAT model equal those of the harvested carbon.

Zusammenfassung

Vertikale Flüsse von Wasserdampf und Kohlenstoffdioxid über Ackerland wurden mit Hilfe von Gradienten- und Eddy-Kovarianz-Messungen (closed- und open-path-Systeme) und mit Kammermessungen durchgeführt und mit direkten Messungen der Energiebilanzglieder und der mit dem Erntegut abgeführten Kohlenstoffmenge verglichen. Die Gradienten- und Kammermessungen lagen in den richtigen Größenordnungen. Das closed-path-Eddy-Kovarianz-System dagegen ergab deutlich zu kleine Flüsse. Die Korrekturen auf Grundlage von Spektralanalysen führten zu erhöhten Flüssen. Die Energiebilanz konnte jedoch nicht zufriedenstellend geschlossen werden. Dagegen war die Anwendung eines open-path-Systems unmittelbar erfolgreich. Das SVAT-Modell PLATIN, das auf verschiedene Ackerfrüchte adaptiert wurde, war in der Lage, die Energiebilanzglieder zutreffend abzubilden. Die mit den korrigierten closed-path-Datensätzen, mit der Kammer und die dem SVAT-Modell bestimmten Kohlenstoff-Nettoflüsse entsprachen den geernteten Kohlenstoffmengen.

1 Introduction

The Institute for Agroecology operates a 20 ha experimental field to study the effect of increasing carbon dioxide concentrations on yield, ontogenesis and ecosystem properties of cropped land under typical agricultural management. To establish dose response relationships, the relevant fluxes between the atmosphere and the crops have to be determined as the only measurable entities which reflect a dose (DÄMMGEN and GRÜNHAGE, 1998). However, the experimental determination of latent heat and carbon dioxide fluxes deviated between methods and proved to be inconsistent with the energy and carbon balances. This paper describes the problems and the investigations performed to solve them.

2 Measurements and methods

The conventionally managed experimental field site (52°18′N, 10°26′E; 79 m asl) is equipped with a Free Air Carbon Dioxide Enrichment (FACE) facility as well as micrometeorological, analytical instrumentation (concentration monitors, denuder and filter samplers) and chambers to assess vertical fluxes of sensible and latent heats, trace gases and aerosols (for details see WEIGEL and DÄMMGEN, 2000).

For our investigations we used a 10 m tower (air temperature: Thies aspirated Pt-100 sensors, resolution 0.1 K; wind velocity: cup anemometers LISA, Siggelkow; at 0.5 m above d + z_0 and 1.6, 2.6, 3.7, 5.4, 8.1 and 10 m above ground, water vapour and carbon dioxide monitors BINOS infrared gas analyzers). For the measurement of eddy covariance fluxes of sensible heat and momentum 4 Gill R2 and R3 sonic anemometers were used, which were positioned around the tower (resolution in time 20 Hz). One anemometer was operated with a closed path LiCor 6262 instrument in the EdiSol configuration (MONCRIEFF et al., 1997), the resolution in time of which was nominally 3 Hz (H_2O) and 5 Hz (CO_2). A 15 m gas duct connected the sampling point with the measuring instrument. For a short period, an open path concentration monitor (LiCor 7500) could be used. Water vapour and carbon dioxide fluxes were

*Corresponding author: Stefan Schaaf, Bundesforschungsanstalt für Landwirtschaft (FAL), Bundesallee 50, 38116 Braunschweig, Germany, e-mail: stefan.schaaf@fal.de

0941-2948/2005/0016 $ 2.25

DOI: 10.1127/0941-2948/2005/0016