2.7 OBSERVATIONS AND MODEL RESULTS FOR WATER VAPOR AND CARBON DIOXIDE FLUXES ABOVE A SPARSELY VEGETATED BOG AREA

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INTRODUCTION

In this study we analyze observations of water vapor and carbon dioxide fluxes above a bog vegetation in the Netherlands. The observations are used to evaluate an assimilation photosynthesis (so-called *A*-g_s) model on canopy scale. An *A*-g_s model couples the CO_2 assimilation, *A*, to the stomatal conductance, g_s and offers a physiological technique to simulate plant transpiration. Most parameters of this model are closely linked up with micrometeorological variables, hence, data from common meteorological weather stations can be used to simulate H_2O and CO_2 fluxes.

1. THEORY

The in- and outflow of carbon dioxide and water vapor occurs through the same mechanism: by molecular diffusion through the stomata. As a result, the flow density of the net carbon dioxide, A_n, which results from the difference between the gross assimilation rate, A_g, and the dark respiration, R_d, can be described as:

$$A_n = A_g - R_d = g_{l,c}(C_s - C_i) \qquad (1)$$

where, C_s the carbon dioxide concentration at the leaf surface, C_i the carbon dioxide concentration in the plant interior and $g_{l,c}$ the leaf conductivity to carbon dioxide. A_g and R_d result both from photochemical reactions. They vary as a function of the photosynthetically active radiation, *PAR*, the leaf temperature, T_l, and the internal carbon dioxide concentration, C_i. More detailed information can be found in Ronda *et al*. (2001).

In addition to the transpiration, there is an open water component in the water vapor flux. Therefore, depending on the vegetation coverage, an open water evaporation term has been added to the total evapotranspiration. The evaporation term is calculated according Penman (1948).

MATERIALS AND METHODS

Experiments were taken place in 1995 in the “Fochtelooërveen” area, a disturbed raised bog in North of the Netherlands (53°00’30” N, 6°23’52” E and +11 m above m.s.l.). The dominating plant species in the area around the measuring site was *Molinia caerulea*. During the period discussed here, the vegetation had a Leaf Area Index of LAI = 1.

A lattice tower was instrumented with an eddy-covariance system installed at a height of 8 m. This system included a *3-D* sonic, a fine wire thermometer and an inlet tube leading to an infrared CO_2 and H_2O gas analyzer. A netradiometer, two pyrgeometers and two pyranometers were installed to measure the radiation budget of the terrain. A second 6 m tower was instrumented with aspirated psychrometers and sensitive cup at 2, 4 and 6 m height above the surface.

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2. RESULTS AND DISCUSSIONS

In figure 1 the most important meteorological variables and fluxes have been plotted for the selected successive period of 3 days. From this result we can infer that the first and last day are so-called fine days and the second day is a cloudy one. days and the last days are cloudy. Also it can be seen that during nighttime the wind speed drops complete during the last two nights.

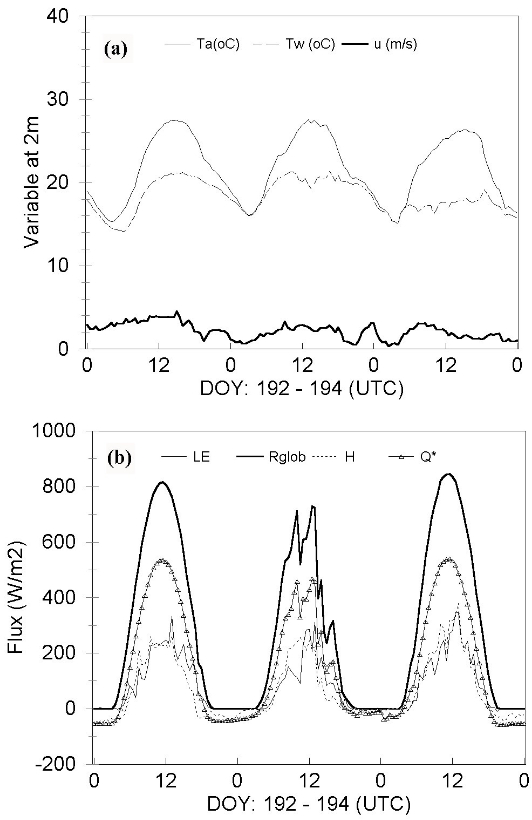

Figure 1. Daily courses of the most important meteorological variables and fluxes.

2.1 Evapotranspiration

From plant physiology it is known that the photosynthetic machinery in leaves is mainly affected by the nitrogen availability (Larcher, 1975). It appears that the maximum CO_2 assimilation, A_{max}, is linearly related to the nitrogen concentration in leaves. For our bog vegetation, the actual nitrogen concentration in the leaves was reduced by about a factor 3. In Figures 2, the course of the combined A-g_s (transpiration) and open water model (evaporation) results have been plotted by taken into account this reduction in the maximum assimilation, A_{max}. Besides in the scatter diagram of figure 3, the eddy correlation measurement results have been plotted versus the model results. From the result of figure 3 we see that after this simple correction the modified A-g_s model simulation fits well the experimental results. From the scatter diagram of figure 3 we can infer that the combined *A-gs* – open water model overestimates the measurements by about 8 percent.

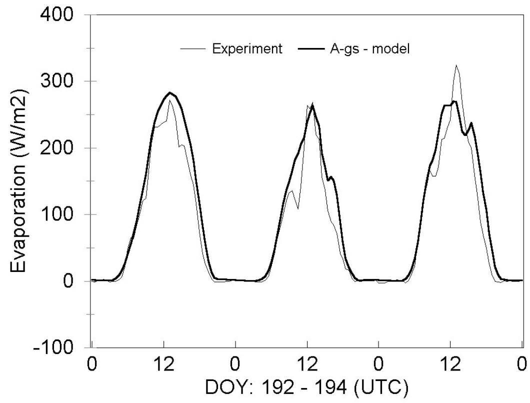

Figure 2. Daily courses of the simulated and measured evapotranspiration fluxes.

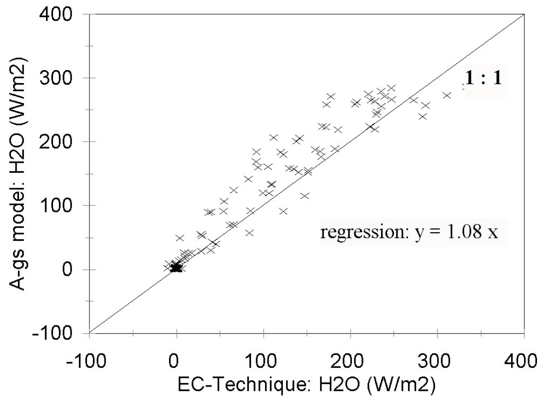

Figure 3. Scatter diagram between the eddy-correlation measurements and the combined A-g_s and open water model results.

2.2 Assimilation and Soil Respiration

In figure 4, the course of the measured CO_2 flux along with the simulated assimilation and soil respiration has been plotted. The assimilation, *A*, has been calculated with the A-g_s model (eq. 1). The soil respiration, R, has been calculated with the expression (Nieveen, 1999):

$$R = 0.012 \cdot \exp(0.158 \cdot T_s) \qquad (2)$$

where, T_s is the mean soil temperature of the upper 2.5 cm soil layer.

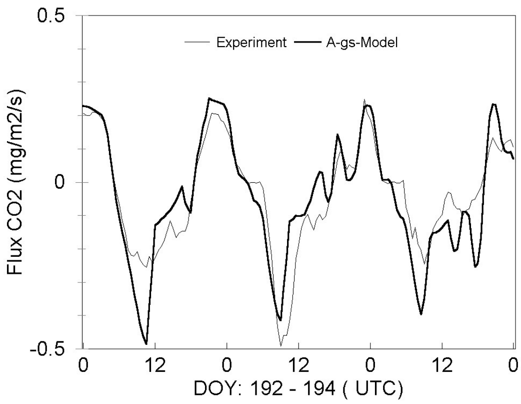

Figure 4. Daily courses of the measured and simulated carbon dioxide fluxes.

The total CO_2 flux consists of an plant assimilation term and a soil respiration term. The decomposition of the total CO_2 flux along with the total CO_2 flux has been plotted in figure 5.

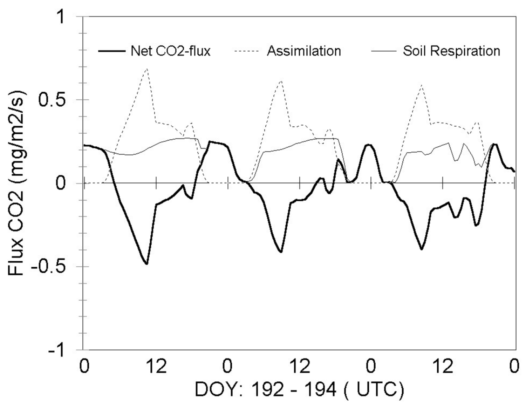

Figure 5. The decomposition of the total CO_2 flux into the assimilation flux and soil respiration flux.

From the result of figure 5 we can infer that both CO_2 fluxes are more or less of the same order of magnitude in our bog area.

In figure 6, the scatter diagram of the measured CO_2 flux versus the simulated CO_2 flux has been plotted.

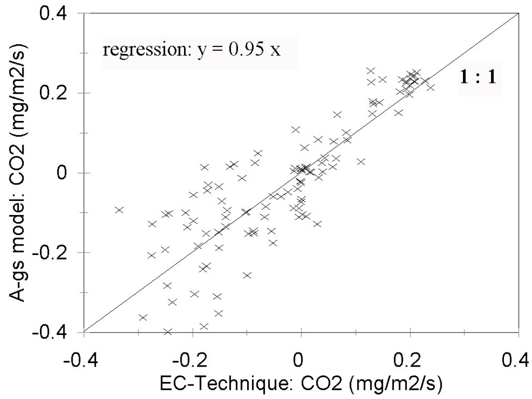

Figure 6. Scatter diagram between the eddy-correlation measurements and the combined A-g_s and open water model results.

From the scatter diagram of figure 6 we can infer that the A-g_s model underestimates the measurements by about 5 percent.

CONCLUSIONS

The A-g_s model simulates the evapotranspiration of natural vegetation excellently if the nutrient condition of the vegetation has been taken into account.

The A-g_s model simulates the net carbon dioxide flux of natural vegetation reasonably well if the nutrient condition of the vegetation has been taken into account and if a correction for the soil respiration has been added.

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