Comparison of chamber based flux estimates and fluxes measured by EC for CO_2 and CH_4 in a managed peat meadow in the Netherlands

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Poster presentation on CarboEurope meeting in Jena, Germany, September 2008

ECN-M--09-011 September 2008

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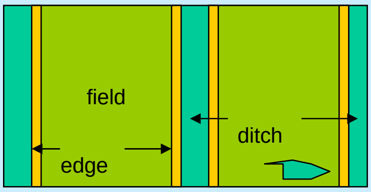
Introduction and aim

A net greenhouse gas balance of an ecosystem is a result of incoming and outgoing fluxes. Depending on variables such as temperature and moisture conditions, this balance will change. Variables that define the greenhouse gas balance vary spatially and temporally. A combination of small scale greenhouse gas measurement techniques and large scale techniques is needed to determine the origin of greenhouse gas fluxes and to extrapolate them to ecosystem scale. Our research has its main focus on peat meadow ecosystems in the western part of the Netherlands. Our aim in this research is to gain insight in how- and to what extent greenhouse gases (CO_2, CH_4 and N_2O) are produced at small scale, plot scale and landscape scale in Dutch fen meadows. We compared CO_2 and CH_4 fluxes measured by the Eddy covariance method and by a closed chamber method.

A comparison of these measurement techniques is of great interest, because accurate measurements of fluxes is necessary to understand the carbon- and nitrogen cycles in ecosystems.



Spatial variability in fen meadows

Site description and Methods

The experimental fen meadow (Oukoop) is located in the South West of the Netherlands at an average of 1.7 meters below sea level. Since the 19th century the area has been a strong net source of carbon dioxide as a result of increased peat oxidation caused by drainage. Most of this peat soil is used as fen meadow (grass land). The area has peaty soils with clay in the profile, climate is temperate (average of 10.3 oC/year) and humid (870 mm/year). About 20% of the area is open water, the remaining part is grassland. Oukoop is under intensive cultivation. Cattle was not grazing in 2006. Mowing took place three times in 2006. The water table will be kept at an average of 35-45 cm below field level.

Chamber measurements of CH_4 and CO_2 were performed 15 times in 2006 at 20 fixed locations in the field and at two locations in two ditches bordering the site using the static closed dark chamber method and photo acoustic gas monitor (INNOVA). Simultaneous with each measurement soil temperature and soil moisture were determined. After quality checks, fluxes where estimated using linear regression of the changes in concentration over time. Non linear regressions were applied when the instantaneous flux estimates were integrated into seasonal and yearly fluxes for CO_2 and CH_4, respectively eq 1 and 2:

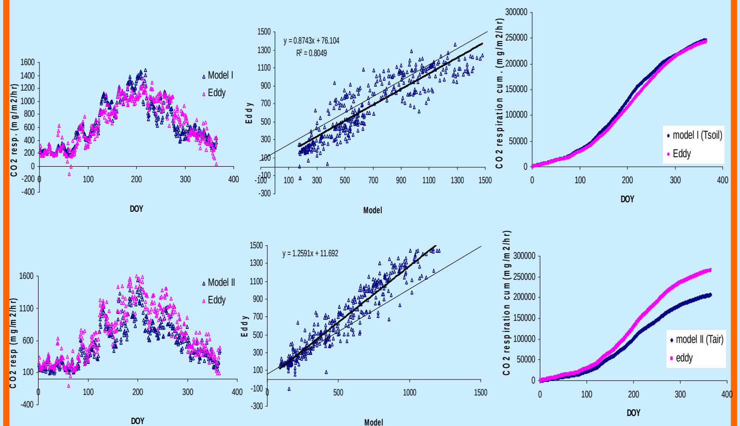
$$R = R_{10} \times e^{E0\left(\frac{1}{283.15-T0} - \frac{1}{T-To}\right)}$$

$$\ln(F_{CH4}) = a + bT$$

Eddy covariance fluxes of CO_2 were measured with a system which was placed in the middle of the field. The mast consisted of a Campbell Csat C3 Sonic anemometer (Campbell Scientific, Logan, Utah, USA) directed into the main wind direction and a Licor 7500 open path Infrared gas analyzer (LI-COR Lincoln, NE, USA) at a height of 3 m. EC fluxes of CH_4 were measured with a system consisted of a three-dimensional sonic anemometer (model R3, Gill Instruments, Lymington, UK) and a QCL spectrometer (model QCL-TILDAS-76, Aerodyne Research Inc., Billerica MA, USA). The measurement height was 3 m and the mast was positioned about 5 m from the CO_2 mast

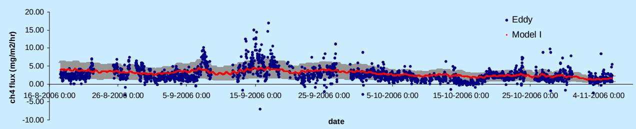
Results

Comparison of chamber based, modeled respiration rates and EC measurements over the year 2006. Non linear regressions were applied when the instantaneous flux estimates were integrated into seasonal and yearly fluxes as described by Lloyd and Taylor. Temperature explained over 70% of the respiration.

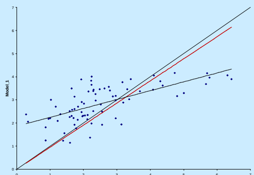


Comparison of modeled respiration rates and EC measurements over the year 2006. Model 1 is based on soil and water temperature, model 2 is based on air temperature. Left figures show the respiration over the year, estimated by both methods; the figures in the middle show the comparison between the two methods and the figures at the right show the cumulative respiration

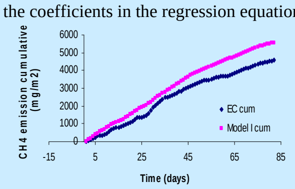
Comparison of chamber based, modeled CH4 emission rates and EC measurements from 16 August 2007 to 4 November 2007. Non Linear regressions were applied for estimates of the seasonal fluxes. Temperature explained 25% of the CH4 flux.



Comparison of modeled CH4 emission rates (red line) and CH4 EC measurements (blue dots) over a three months period. The model is based on temperature only. The uncertainty of the chamber based, upscaled fluxes is estimated to be 55% (grey band), based on the method of Rochette et al, 2008 and the standard errors of the coefficients in the regression equations.



Comparison of modeled CH4 fluxes (Y-axe) and EC measurements (X-axe). Red line is the best fitted line with intercept set at 0. Black line is the best fitted line.



Cumulative CH4 fluxes measured by EC and cumulative chamber based estimates over the period 16 August to 4 November 2007.

Conclusions

- Temporal variability of CH_4 EC fluxes is larger than temporal variability of the upscaled, modeled (smoothed) CH_4 fluxes; temperature explained 24% of the flux
- Cumulative CH_4 fluxes measured by EC are estimated to be ~17% lower over three months compared to the modeled CH_4 fluxes.
- CO_2 fluxes measured by EC and modeled based on soil temperature agreed reasonable well (R2 >0.7). Temperature explained over 70% of the CO_2 flux.

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