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POPULAR ARTICLE

Micro climatic studies on cropped area using flux tower

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ABSTRACT

Agro-ecosystems are equally significant and respond to the regional carbon budget where crops are dominant, but the upscaling and budgeting of carbon exchange components in croplands requires proper methodology. In order to understand the physiological behavior of agro-ecosystems and predict future climate change, carbon dioxide flux measurements of agro-ecosystems in relation to photosynthesis and respiration over crops and their exposure to environmental variables are vital. Micrometeorological techniques such as EC do not interfere with the gas exchange processes between the source of the surface and the atmosphere and are appropriate for continuous measurements of flux. A measure of net ecosystem exchange (NEE) that can be divided into gross primary production (GPP) and ecosystem respiration (RE) can be given by the eddy covariance (EC) method using a statistical modeling methodology helpful for describing ecosystem carbon budgets. This description of NEE, GPP and RE, with the aid of the EC system, focuses on the sharing of CO_2 between the biosphere and the environment in Asian rice paddies.

Keywords: Agro-ecosystem, Micro-meteorology, Ecosystem exchange, Techniques

1. INTRODUCTION

With the development of a new generation of sonic anemometers and infrared gas analyzers for water vapour and carbon dioxide, along with the first comprehensive software packages for the eddy covariance process, the prospect of continuous eddy flux measurements emerged in the 1990s. The eddy covariance principle was increasingly used by the ecological community in the early 1990s to measure the carbon dioxide and water exchange between an ecosystem and the atmosphere. When the environmental conditions are steady, the EC technique is better applied over flat terrain, and the underlying vegetation extends upwind for an extended distance. EC flux measures are mostly used on a hectare scale with constant time coverage to quantify the integrated emission (Hendriks *et al*. 2008). In the surface boundary layer, which is around 20-50 m high in the case of unstable stratification and a few tens of meters in stable stratification for full descriptions of layers in the atmosphere, Eddy covariance measurements are usually made (Davis *et al*., 2003).

1.1. PURPOSE AND APPLICATION OF EDDY COVARIANCE SYSTEM

The technique is widely used for global climate model verification and tuning, meso-scale and weather models, complex biogeochemical and ecological models, and satellite and aircraft remote sensing estimates. Many non-meteorological sciences, industrial monitoring, carbon storage and sequestration, landfill and environmental management, and the monitoring of actual exchanges and balances of energy, water or gas emissions are potentially of great use to the EC (Bhattacharyya *et al* 2013b).

Flux site data helps to test C exchange physiological models and is critical for flux-related and remote sensing data. Combined physiological and ecological measurements allow carbon fluxes to be divided into components of plants and soils and reveal mechanisms responsible for these fluxes. Biomass-based C storage estimates at some sites have validated C budgets from direct flux data and vice versa.

2. PRINCIPLE OF EDDY COVARIANCE (EC) FLUX MEASUREMENT SYSTEM

The EC technique uses a three-axis sonic anemometer and a rapid response infrared gas analyzer to measure wind speed and wind direction, as well as CO_2 and H_2O concentrations at a point above the canopy, on the basis of high frequency (10-20 Hz) measurements. Both sensors, the three-axis sonic anemometer and the rapid-reaction infrared gas analyzer, are usually mounted at a height of 3 m (depending on the height of the crop canopy) on a tripod mast or in the case of woods, on towers 30-40 meters high with a sensor separation of 15-20 cm. The data collected from the three-axis sonic anemometer and the infrared gas CO_2 / H_2O analyzer were sampled using a fast-response data logger at 10 and or 20 Hz (Paw *et al*., 2011). The 30 minute covariance between vertical variations (w') and the CO_2 mixing ratio is obtained as the mean vertical flux density of CO_2 (Gu L *et al*., 2002).

2.1. EDDY COVARIANCE FOR MEASURING TECHNIQUE

In different regional networks, the EC technique for measuring CO_2, water vapour and energy flows between the biosphere and the atmosphere is widely used. More than 650 EC sites are currently operational worldwide, measuring the exchange of carbon at high temporal resolution in various biomes and climatic conditions. In monsoon Asia, rice paddy fields are widespread and the carbon exchange between paddy fields and the atmosphere is greatly influenced by cultivation and practice of field management (Denmead 1995). The best techniques for measuring the flux of greenhouse gases from agricultural fields are the Eddy covariance flux tower.

- Gross Primary Production (GPP)
- Ecosystem Respiration (RE)
- Net Primary Production (NPP)
- Trace Gas Emissions
- Hydrologic and Energy Partitioning
- Net Ecosystem Production (NEP)
- Biogeochemistry
- Greenhouse Gases measurement

2.2. ADVANTAGES OF THE EDDY COVARIANCE SYSTEM

For continuous in situ measurements over a wide area of non-invasive sampling, the EC procedure may be used, creating little disruption to the area over which fluxes are measured. The exchange values or emission rates for gases are extremely accurate, defensible and can be confirmed. The system's reaction time is very short. It also offers knowledge with quick sampling and high precision on short-term variance of fluxes (Garrity *et al*., 2011). With no interference, the automatic measuring system offers continuous coverage. Closed-chamber technique, open-chamber technique, and micrometeorological technique or the eddy covariance techniques are the techniques commonly used to calculate GHG emissions from soil. Eddy covariance is the chosen flux calculation methodology and it is the only method of direct flux determination. Data from EC fluxes are normally subject to differing degrees of quality control due to the fact that the data can be compromised by flooding, incorrect operating or instrument issues, and/or inadequate environmental conditions for flux studies. The integral turbulent characteristics test and stationary test of the half-hourly flux data was carried out for proper EC flux measurement studies (Baldocchi D., 2003).

3. COMPONENTS OF THE CARBON CYCLE

The EC device is set up in the centre of a flat, homogeneous vegetation/crop area with ample fetch based on the predominant wind direction for micrometeorological flux calculation. Using the traditional mathematical simulation approach in which GPP and RE are expressed as analytical functions of meteorological variables, the partitioning of NEE into GPP and RE is achieved. GPP is the absorption of CO_2 by plants photosynthesis and RE reflects the release of CO_2 by the respiration of plant soil, roots, stems and leaves. The night time RE (RE (N) is calculated using the EC system from the night time NEE, since the night time NEE is equal to the respiration of the night time ecosystem (RE (N)), since GPP=0.0. In night time hours, NEE is expressed as an exponential air temperature (T) function and the function is then extended to daytime for daytime RE estimation (Greco S and Baldocchi DD 1996).

4. FLUX CALCULATIONS AND ASSOCIATED ERRORS

Using any of many flux computing applications, the analysis of eddy covariance data is done. Computing flows include testing data for errors or differences, aligning data to account for time delays, and computing flows based on average periods of half an hour or one hour. Any important assumption specifications of the eddy covariance flux tower are below.

- Fluxes are measured only at area of interest
- Measurements are done inside the boundary layer of interest
- Terrain is horizontal and uniformed; average of fluctuations is zero
- Measurements at a point can represent an upwind area
- Flux is fully turbulent and most of the net vertical transfer is done by eddies
- Instruments can detect very small changes at high frequency, ranging from
  minimum of 5 Hz and to 40 Hz for tower-based measurements

4.1. LIMITATIONS

- It requires a continuum of high time resolution measurements (e.g. 5–20 Hz).
- The technique is mathematically complex, and requires significant care in setting up and processing data.
- These Flux towers provide information specific to a single ecosystem type or condition.
- Flux data are noisy, and this uncertainty is largely due to random measurement error.
- There are a variety of cases where either the EC approach should not be used for flux calculation or is not the correct way to do so. This involve environmental conditions with a very tiny sample area, mostly low winds, complex geography, sources of point flux, etc. The instrument system might also not be sensitive enough to quantify minor variations at 10 or 20 Hz frequencies for certain gases, such as ammonia and volatile compounds.
- It requires a number of assumption and correction and demands careful design, execution and processing that is fit to the specific purpose at the specific experimental site.
- The study area should be flat, homogeneous and it should represent the similar ecology

4.2 SOFTWARE AND DATA COLLECTION

Using machine tools, Eddy covariance instruments are programmed. Usually, the app gives access to simple and advanced configuration options, as well as live data stream graphing. The app supports following criteria;

- Configure sampling rate

- Configure auxiliary sensor inputs
- Select variables to log
- Set up data logging options

There are many software programmes currently available to process raw data on eddy covariance and extract amounts such as heat, momentum, and gaseous fluxes. Examples include EdiRe, ECpack, TSA, TK2, Alteddy, EddySoft and EdiPro. Based on the user's specifications, each programme has its own advantages, such as online or off-line flux measurement, graphical outputs, control tools, etc. The estimation and correction procedures should not, however, vary between software packages which are released by manipulating raw data from the same time series with similar conceptual assumptions.

5. CONCLUSION

During the winter season, the vegetation acted as a sink of CO_2, although very little CO_2 fixation was observed during the dry months. Heat flux partitioning study found that due to the transpiration phase of leaves during the winter season, more energy was partitioned into latent heat flux, while the sensible heat flux prevailed during the leafless summer season. The vegetation of the study region displayed a positive association with the availability of photosynthetically active radiation (PAR) for photosynthetic activity during midday hours, but subsequently modulated by higher post-noon Vapour Pressure Deficit (VPD) values. We plan to produce a comprehensive and climate-quality database for greenhouse gas and energy flux for the respective ecosystems with the further establishment of flux towers in the representative ecosystems through the Indian Space Research Organization (ISRO) network.

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