SIMULATION OF WATER AND CARBON FLUXES USING BIOME-BGC OVER VARIOUS ECOSYSTEMS IN CHINA

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ABSTRACT

This study was conducted for exploring the ability of the BIOME-BGC for various ecosystems in China For this propose we set up five eddy-covariance towers in 2002. By using these observation data, we modified eco-physiological parameters in the model. Correspondence between the simulated results with observations suggested that the modified model can be used to predict plant growth as well as water (H_2O) and carbon (CO_2) fluxes under the consideration of the effects of anthropogenic forcing. Results showed that anthropogenic forcing had an apparent effect on the water and carbon fluxes and sequestration capacity.

1. INTRODUCTION

Many models have been developed to simulate the terrestrial processes, in which the BIOME-BGC is a model originally developed to simulate the development of carbon and nitrogen pools over time (Running and Coughlan, 1988; Running et al. 2000, White et al. 2000). The model is driven by routinely available daily climate data and the definition of several key climate, vegetation, soil and site conditions. In this study, we try to explore the ability of the BIOME-BGC to estimate the H_2O and CO_2 dynamics of various ecosystems. We start with an evaluation of the uncertainty in the model estimates associated with different initializations (carbon and nitrogen state variables), and then analyze the effect of changes in both environmental conditions (air temperature, atmospheric CO_2 concentration and nitrogen application) and human activities (irrigation and fertilizer application).

2. STUDY AREA, MEASUREMENT AND SCENARIO DESIGN

The APEIS Project, launched in 2001 by the Ministry of the Environment of Japan, has established 5 flux-tower sites, so-called APEIS-FLUX that covers a variety of ecosystems, including grassland, irrigated agricultural field, paddy field, forest and semi-arid desert, to measure water vapour, energy exchange and carbon dioxide over a long term. The Biome-BGC model requires three types of information: site parameters, meteorological data, and vegetation data, which were intensively observed at these sites that allow a reliable parameterisation of this model. To estimate the effects of anthropogenic forcing on the carbon sequestration capacity, the model simulations were executed with two scenarios: undisturbed and disturbed.

3. RESULTS AND DISCUSSIONS

In order to validate the model after we modified its parameterisation, we compared the simulated results of daily ET and NEE with the observed flux data. In the real world, ecosystems are often disturbed intensively by anthropogenic and environmental change forces, such as irrigation, fertilizer application and the increase of CO_2 concentration, thus first we compared the daily ET and NEE modelled under the disturbed scenario and the observations in 2003. Linear regression analysis between modelled and observed daily average ET showed a close relation. These results suggest that the model is quite useful for simulated H_2O and CO_2 fluxes under the consideration of anthropogenic forcing after modifying its eco-physiological parameters (Fig.1).

Simulation under the undisturbed scenarios is an important way to understand the potential plant growth as well as water, carbon and nitrogen exchanges without the impacts of human activities. Both NEE and ET simulated under the undisturbed scenario were lower than those simulated under the disturbed scenario and observed values because the crop growth under undisturbed natural conditions is limited by carbon and especially nitrogen availability. These results showed that enhanced atmospheric CO_2 concentrations and especially increased nitrogen application had a marked effect on the simulated water and carbon sequestration capacity and played a prominent role in increasing this capacity (Fig.2).

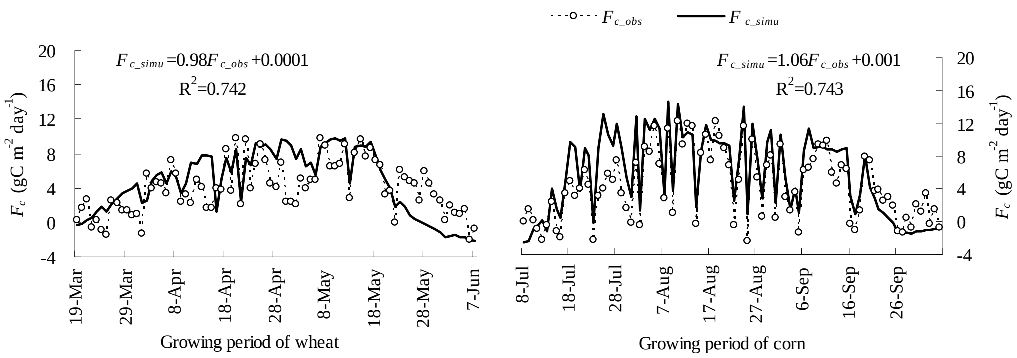

Fig. 1 Comparison of the simulated daily net CO_2 ecosystem exchange, F_{c_simu} under the disturbed scenario and the observation, F_{c_obs} in 2003

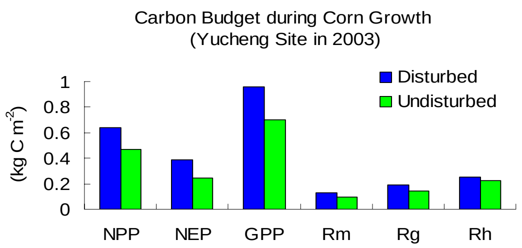

Fig.2 Difference of simulated NPP, NEP, GPP, and respirations (Rm, Rg, and Rh) under disturbed and undisturbed scenarios

4. CONCLUSIONS

Comparing the simulated results with ground observations suggested that the model can predict both crop growth (LAI, NPP) and daily CO_2 and H_2O fluxes reasonably under the consideration of the effects of anthropogenic forcing, such as increasing atmospheric and soil nitrogen application and CO_2 concentrations. For different ecosystems, we found that in the case of NPP, Corn > Rice > Wheat > Grass > Desert, soil respiration, Rice > Grass > Wheat > Corn > Desert, and finally NEP, Corn > Wheat > Grass > Rice > Desert. Compared with the undisturbed scenario, the simulated water vapour flux and net CO_2 ecosystem exchange are much higher in the disturbed scenario than those in the undisturbed scenario. This result suggests that enhanced atmospheric CO_2 concentrations and especially increased nitrogen application in soil due to fertilizer application had an apparent effect on the water and carbon fluxes and sequestration capacity.

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