Studies on Construction of a Wetland Ecosystem and Carbon Transfer in the Closed Geosphere Experiment Facility

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Abstract

The Closed Geosphere Experiment Facility (CGEF) with high airtightness is designed to study carbon dynamics in terrestrial ecosystems, including the transfer and accumulation of the radioactive carbon isotope released from nuclear facilities to the environment. A wetland ecosystem dominated by *Phragmites australis*, which is widely found in the cool-temperate brackish marsh near the spent nuclear fuel reprocessing plant in Rokkasho, Japan, was introduced into the CGEF where air temperature and CO_2 concentration are both controlled automatically. A mathematical model to estimate the transfer and accumulation of radioactive carbon in the wetland ecosystem was developed. This model consists of photosynthesis and decomposition sub-models, having the structure of nine-pool compartments (three plant, two litter, three soil, and one groundwater compartments). The Bayesian probabilistic inversion analysis and a Markov chain Monte Carlo (MCMC) technique were applied to determine parameters of the carbon transfer and accumulation model. The analysis used nine data sets for carbon reservoirs (leaf, culm, and rhizome biomass carbon, litter layer carbon, microbial biomass and organic carbon in soil, and dissolved organic carbon) and fluxes (ecosystem respiration and methane flux) observed in the CGEF. The comparisons between the simulated values and observed data showed that the model gave appropriate estimates of the carbon reservoirs and fluxes. The ecosystem respiration was adequately simulated by the model. Although the projection of variation in methane flux during a short period was not always successful, the seasonal trend of the variation largely resembled the observed one. The changes in the amount of carbon in plant biomass and litter layer and that of dissolved organic carbon were properly estimated. This study suggests that the combination of the Bayesian statistics and the MCMC technique is very useful to analyze the transfer and accumulation of carbon in a wetland ecosystem.

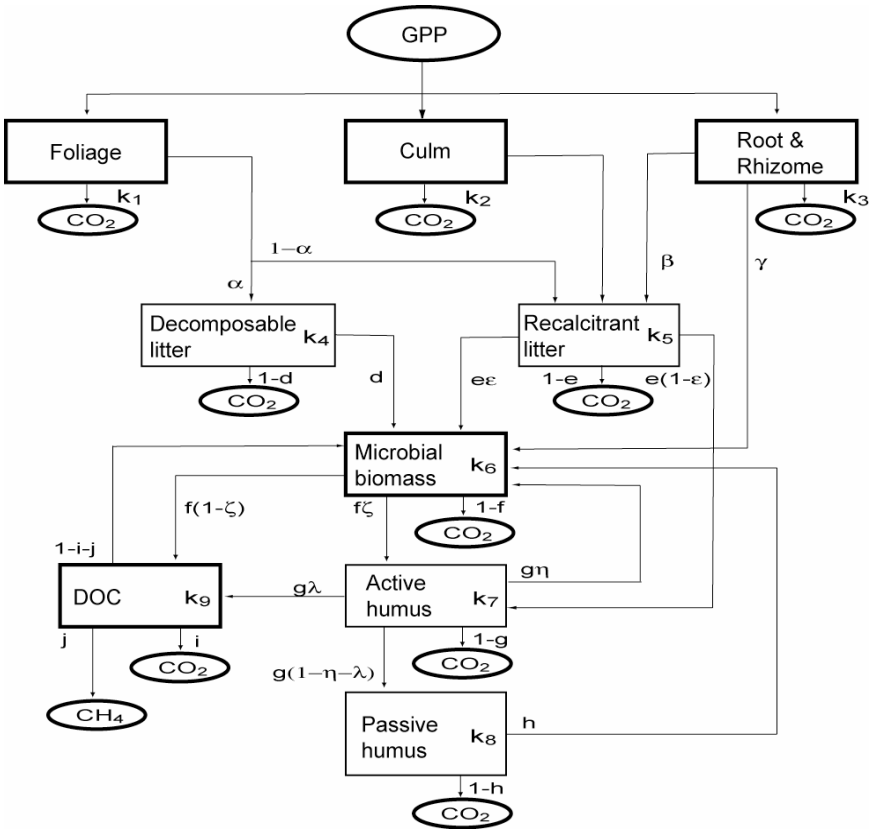

Fig. 1 Schematic of the carbon cycle model in the wetland ecosystem. Rectangles, ellipses, and lines show carbon reservoirs, gaseous carbon fluxes, and carbon transfers, respectively. k_1 to k_9 represent carbon transfer coefficients, *d* to *j* and the Greek letters represent the allocation of carbon transfer.

Table 1 Determined parameters of the carbon transfer and accumulation model

Parameter	Mean	SD	CV (%)	Parameter	Mean (day^{-1})	SD (day^{-1})	CV (%)
d	5.00×10^{-1}	0.30×10^{-1}	6.0	k_1	9.14×10^{-4}	2.80×10^{-4}	30.6
e	4.82×10^{-1}	1.48×10^{-1}	30.7	k_2	7.01×10^{-3}	0.42×10^{-3}	6.0
f	4.03×10^{-1}	0.27×10^{-1}	6.7	k_3	9.20×10^{-5}	2.87×10^{-5}	31.2
g	4.99×10^{-1}	1.49×10^{-1}	29.9	k_4	3.31×10^{-3}	0.26×10^{-3}	7.9
h	4.98×10^{-1}	1.51×10^{-1}	30.3	k_5	6.47×10^{-4}	1.62×10^{-4}	25.0
i	5.04×10^{-1}	1.38×10^{-1}	27.4	k_6	6.90×10^{-2}	1.72×10^{-2}	24.9
j	6.36×10^{-2}	0.85×10^{-2}	13.4	k_7	6.13×10^{-5}	2.01×10^{-5}	32.8
α	4.98×10^{-1}	1.50×10^{-1}	30.1	k_8	3.02×10^{-6}	1.00×10^{-6}	33.1
β	6.23×10^{-5}	1.36×10^{-5}	21.8	k_9	4.87×10^{-1}	0.69×10^{-1}	14.2
γ	5.04×10^{-4}	0.74×10^{-4}	14.7				
ε	5.20×10^{-1}	1.51×10^{-1}	29.0				
ζ	1.71×10^{-1}	1.40×10^{-1}	81.9				
η	5.02×10^{-1}	1.50×10^{-1}	29.9				
λ	1.00×10^{-1}	0.30×10^{-1}	30.0				