ESTIMATING AND EVALUATING TERRESTRIAL CARBON FLUXES USING A BIOSPHERE MODEL IN TOKAI REGION

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ABSTRACT

Terrestrial carbon fluxes are an important factor for the studies of global warming. This study focuses on estimating a fluctuation of the terrestrial carbon fluxes in the Tokai region, Japan. The local biosphere model used calculates carbon, water, and heat fluxes, and required some climate and vegetation parameters as inputs. The model was operated in 2000-2004 using meteorological data and MODIS data products. We estimated spatial distributions in heat and carbon fluxes at spatial resolution of 1*1 km, and validated an adaptability of the model using measured data at the Takayama flux-site. As a result, estimated GPP and heat fluxes had a good relationship to measured data. We can precisely check on the accuracy of the model to estimate the spatial and temporal patterns of the terrestrial carbon fluxes.

Spatial distributions and temporal trends in carbon fluxes for 4 years were analyzed using this model outputs. The spatial pattern in NPP showed that low values were in plain fields and alpine regions, and high values in hilly area and plateau. Trend analysis showed that NPP values averaged in the Tokai region demonstrated slightly downward trends, and in suburbs of big-city and alpine area upward trends. We could understand spatial distributions of NPP trends in the Tokai region.

INTRODUCTION

Atmospheric carbon dioxide (CO_2) is the most important greenhouse gas, and as a result of its concentration increase, the global warming is accelerating the atmospheric CO_2 reservoir is largely affected by assimilation by the biosphere. In order to improve the future projection of the global warming, we must accurately understand spatial and temporal patterns in carbon fluxes. However, their direct measurement is possible only on point scale and model estimation is an only realistic way to estimate them on regional to global scale. In future, the model should be calibrated with measured flux data with consideration for scaling issue.

The purpose of this study is to estimate the terrestrial carbon fluxes in the Tokai region using a local biosphere model. This model is based on a global scale model by Sasai et al. (2004). Major modifications were the following three points. 1) A spatial resolution was changed from 1-degree to 1-km grid. 2) Intercepted precipitation and evaporation by plants were added in the hydrological submodel. 3) Including surface heat balance, it was extended to a heat-hydrological submodel. 4) Land Surface Temperature (LST) data from satellite-observations was introduced to estimate heat and water fluxes. The model was operated in 2001-2004, and we analyzed spatial distributions and time variations in Gross Primary Production (GPP), Net Primary Production (NPP), and Net Ecosystem Production (NEP).

MODEL

The model consists of carbon and heat-hydrological submodels, which are linked together. The carbon submodel has three vegetation, four litter layers, and five soil organic matter components. Included carbon processes are GPP, autotrophic respiration, litter fall, and soil decomposition. Similarly, the heat-hydrological submodel includes three water pools, five water fluxes, and six heat fluxes. The water pools indicate a surface snow pack pool, and two soil layers 0 to 500mm deep and 500mm to a soil depth defined for each soil type. The water fluxes considered are total and intercepted precipitation, thorough fall from canopy to soil, snow melt, percolation from an upper to lower soil layer, evaporation, transpiration, and runoff (overswell from soil bucket pools). The heat fluxes are upward short, down- and upward long wave radiation, soil, sensible heat, and latent heat by intercepted evaporation and evaportranspiration.

DATA SET

The model required nine time-series parameters; air temperature, precipitation, downward short wave radiation, relative humidity, and wind speed. These data were from Automated Meteorological Data Acquisition System (AMeDAS), and meteorological observatories, and were interpolated to generate grid data. For a fraction of Photosynthetically Active Radiation (fPAR), Leaf Area Index (LAI), albedo, and LST, we used the higher level products of MODerate resolution Imaging Spectroradiometer on Terra and Aqua satellites (Terra/MODIS and Aqua/MODIS). Temporal resolution is monthly in all parameters, and spatial resolution is 1-km by1-km.

VALIDATION

The local biosphere model was validated by the inventory data obtained at the Takayama flux-site (N36.146 degree, E137.423 degree). We compared model outputs with the measured GPP, NEP, net radiation, soil, latent and sensible heat fluxes from 2001 to 2004. As a result, the estimated heat fluxes by the model had a good relationship to the measured data, and also the GPP absolute values showed high correlation with the ground measurements (R^2=0.68). The obtained seasonal GPP variation indicated that the model tends to slightly overestimate it in leafing and falling leaf stages, but our model still has an enough accuracy to estimate seasonal GPP variations (Fig.1).

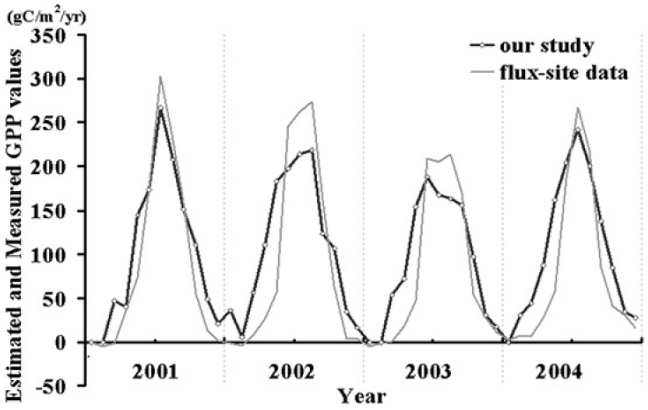

Fig.1. Comparison between estimated & measured GPP at the Takayama site

RESULT

The biosphere model was applied to estimate carbon fluxes in the Tokai region. Annual mean GPP and NPP values in 2001-2004 were estimated at 1238 and 501 (gC/m^2/yr), respectively. High NPP values were distributed over the hilly and plateau regions, and they gradually decrease towards the urban and high mountain areas. Vegetation density in plain areas is low due to urbanization, and also air temperature in an alpine region is low throughout a year. From these standpoints, we can conclude that the spatial patterns obtained were reasonable.

We analyzed spatial distributions of NPP trends from 2001 to 2004 (Fig. 2). A result in trend analysis showed that NPP values averaged in the Tokai region were slightly decreasing (-7.04gC/m^2/yr). However, NPP in the forest areas of Pacific side and alpine areas demonstrated increasing trends. Because of air temperature rise due to global warming, plants in alpine areas with a temperature stress might intensify a photosynthesis activity. We plan to carry out sensitivity studies to NPP for inputs, and to find the cause of these trends.

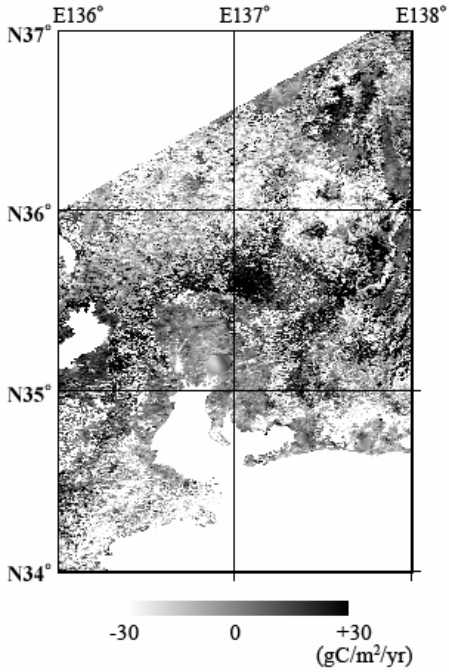

Fig.2. A spatial distribution of annual NPP trends in Tokai region

REFERENCE

Sasai, T., A. Ito, and Y. Yamaguchi (2004), Evaluation of terrestrial carbon fluxes using two biosphere models and three re-analysis climate data sets. AGU 2004 Fall Meeting, San Francisco, Calif., 13-17 Dec.