Global evaluation of gross primary productivity and evapotranspiration in a process-based vegetation model

*Kazuyuki Atsumi[1], Shunji Ohta[1]

1. Graduate School of Human Sciences, Waseda University

Terrestrial vegetation has a significant influence on the carbon cycle and climate system through CO_2 uptake and evapotranspiration. Especially, terrestrial gross primary productivity (GPP) is an important component since it is a basis of ecosystem functions (*e.g.* respiration and growth). Evapotranspiration (ET) also plays an important role in the global carbon cycle as it controls vegetation growth through plant available water. From the above reason, the carbon and water fluxes between vegetation and the atmosphere have been estimated by various types of models. Although the observation towers for these fluxes have been widely distributed on a global scale, there are no direct measurements of GPP [Anav *et al* ., 2015]. Therefore, global estimates of GPP using models are necessary for understanding carbon cycles on a global scale. It is essential for model developments to evaluate simulated GPP on a range of scales. Although evaluation of global GPP was conducted (*e.g.* Slevin *et al.* [2017]), ET estimates were relatively poorly evaluated. We evaluated Biophysical and Ecophysiological Processes-based Model for Predicting Phenology and Productivity (BE4P) on a point scale against direct flux measurements. In this study, we evaluated the ability of BE4P to estimate GPP and ET on global and regional scales. In addition, how meteorological data affects global GPP and ET using different forcing dataset was examined.
BE4P is a prognostic vegetation model which is forced by sub-daily simple climate variables and simulates GPP and ET as well as leaf growth at a daily step. For radiation interception and estimating canopy-level photosynthesis, this model uses the multi-layer approach. In this model, four plant functional types (PFTs) are classified for grouping species with similar functions and strategies. Global simulations of GPP and ET were conducted for the 2001–2010 period. Firstly, BE4P was driven with climate reanalysis dataset obtained from the US National Centers for Environmental Prediction and the US National Center for Atmospheric Research (NCEP-NCAR). Then, GPP and ET estimates were compared to the Moderate Resolution Imaging Spectroradiometer (MODIS) product and FLUXCOM (RS+METEO) Global Land Carbon Fluxes using CRUNCEP climate data [Jung *et al.*, 2016; Tramontana *et al.*, 2016]. Finally, the sensitivity of BE4P to meteorological forcing data was examined using global gridded data of historical simulation by Model for Interdisciplinary Research on Climate (MIROC).
When forced by NCEP-NCAR reanalysis data, BE4P estimated global GPP with an annual average of 148 PgC $year^{-1}$ over the period. The value was higher than the MODIS and FLUXCOM estimates. For ET, BE4P estimated 62×10^3 km^3 $year^{-1}$, which agree with both observation-based estimates. In general, BE4P simulated the spatial distributions of GPP and ET estimated well compared with the observations. BE4P was also able to capture interannual variability in GPP and ET on the global scale. BE4P simulated well global GPP, but on regional scales, the model-simulated GPP was higher than the observation-based estimate in the subtropic region. This disagreement was due to the lack of a drought-deciduous shrub PFT. Despite the difference, the model reproduced GPP and ET estimates in the extratropical region. Estimates of annual average global GPP were slightly higher forced by the NCEP-NCAR reanalysis dataset than forced by the MIROC dataset. For ET, the global estimate was comparatively less sensitive to meteorological forcing data in BE4P.

References

Anav A. *et al.* (2015) *Rev. Geophys.*, **53**, 785–818.
Jung M. *et al.*, (2016) *Nature*, **541**, 516–520.

Slevin D. *et al.* (2017) *Geosci. Model Dev.*, **10**, 2651–2670.
Tramontana D. *et al.* (2016) *Biogeosciences*, **13**, 4291–4313.

Keywords: gross primary productivity, evapotranspiration