EGU General Assembly 2024

EGU24-8705, updated on 08 Dec 2024
https://doi.org/10.5194/egusphere-egu24-8705
EGU General Assembly 2024

Incorporating the acclimation of photosynthesis and leaf respiration in the Noah-MP land surface model: model development and evaluation

Yanghang Ren[1], Han Wang[1], Sandy Harrison[1,2], Colin Prentice[1,3], Giulia Mengoli[3], Long Zhao[4], and Kun Yang[1]

[1]Department of Earth System Science, Ministry of Education Key Laboratory for Earth System Modeling, Institute for Global Change Studies, Tsinghua University, Beijing 100084, China
[2]School of Archaeology, Geography and Environmental Sciences (SAGES), University of Reading, Reading RG6 6AH, United Kingdom
[3]Georgina Mace Centre for the Living Planet, Department of Life Sciences, Imperial College London, Silwood Park Campus, Buckhurst Road, Ascot SL5 7PY, United Kingdom
[4]Chongqing Jinfo Mountain Karst Ecosystem National Observation and Research Station, School of Geographical Sciences, Southwest University, Chongqing 400715, China

Leaf photosynthetic and respiratory processes are important for the terrestrial carbon cycle. Leaf physiological traits, such as the maximum carboxylation rate and leaf respiration rate at 25˚C ($V_{cmax,25}$, R_{25}), the key parameters affecting photosynthesis and respiration rate, acclimate to environmental changes. However, many land surface models (LSMs) assume a constant R_{25} and $V_{cmax,25}$ by plant functional types (PFTs) due to limited understanding of plant acclimation processes. Here, we incorporated the acclimation of photosynthesis and leaf respiration into a land surface model (Noah MP) using the Eco-Evolutionary Optimality principle (Noah MP-EEO), and evaluated the performances of the EEO and standard schemes to simulate photosynthesis and respiration using global plant trait measurements and data from FLUXNET. We demonstrate that R_{25} and $V_{cmax,25}$ varied temporally and spatially within the same PFT (*C.V.* >20%). This behaviour is captured by the EEO scheme (R^2 =0.69 and 0.62 for temporal and spatial variations) but ignored by the standard scheme. At the FLUXNET sites, the standard scheme underestimates gross primary production (GPP) but this is reduced in the EEO scheme. The EEO scheme explains 66% of the variation of site-annual GPP compared to 55% in the standard scheme. The EEO scheme also simulates the variation of leaf respiration (R_{leaves}) better than the standard scheme (R^2 increases from 0.45 to 0.77). The EEO scheme shows less temperature sensitivity than the standard scheme because of acclimation. This study indicates that adopting EEO approaches that do not require PFT-specific parameters improves carbon cycle predictions and could be used in Earth system models for better understanding the climate-carbon feedback.