26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Interactive Effects of Vegetation Responses to Elevated Atmospheric CO_2 on Drought Conditions in Asia

Zhuoyi Tu [a]

[a] *Key Laboratory of Soil and Water Processes in Watershed, College of Geography and Remote Sensing, Hohai University, Nanjing, 211100, China.*
Email: tuzy@hhu.edu.cn

Abstract: Recent studies have suggested that drought projections based on the Palmer Drought Severity Index (PDSI) may overestimate drought severity. This overestimation primarily stems from the limitations of traditional potential evapotranspiration (PET) calculation methods, such as the Penman-Monteith (PM) equation, which fail to account for vegetation responses to climate change—particularly the interactive effects of increased leaf area index (LAI) and suppressed stomatal conductance, both of which are strongly influenced by rising atmospheric carbon dioxide concentrations ($[CO_2]$). To improve the accuracy of drought trend assessments, this study employs a recently developed PET formulation that incorporates $[CO_2]$ and LAI effects, replacing the traditional PM approach. We apply this improved method to monthly drought assessments across Asia, a region experiencing widespread vegetation greening. Results show that during the historical period (1982–2019), the drought trends derived from the two PET methods are largely consistent, due to the offsetting influences of the water-saving effect of elevated $[CO_2]$ and the greening effect of increasing LAI. However, for the future period (2019–2100), the improved PDSI indicates a significantly wetter trend compared to the traditional approach. To further explore the role of land cover in modulating drought responses, we classified Asia based on paddy field coverage. The analysis reveals that regions with higher paddy field density exhibit stronger wetting trends in PDSI, while areas without paddy fields show weaker wetting or no change. This contrast arises because, in paddy-dominated areas, PET exhibits greater sensitivity to $[CO_2]$ than to LAI as coverage increases, thereby amplifying the water-saving effect over the greening effect. Overall, this study demonstrates that the new PET estimation method, which accounts for vegetation-climate interactions, provides a more realistic representation of future drought conditions—particularly in paddy-rich regions—and offers valuable insights for regional drought assessment and adaptive water resource management.

Keywords: *Potential evapotranspiration, leaf area index, carbon dioxide concentrations, Palmer drought severity index*

© MSSANZ and The Authors, CC-BY