Climate variability as a key factor for model improvement: insights from observed and modeled ecosystem functional responses to precipitation regimes and associated stresses in a central US forest

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Abstract

Terrestrial carbon and water cycles exhibit large interannual variabilities at scales from local and global. The causes of such variabilities have not been well understood and our current capacity to model them is limited. In this study, we related the observed and modeled interannual variabilities of carbon uptake and evapotranspiration at the Missouri Ozark AmeriFlux site in the central USA to corresponding climate variability. We showed that precipitation regimes and associated water and heat stresses determined seasonal and interannual variations of carbon uptake and water use in this deciduous forest ecosystem and these effects were captured with a few simply constructed climate variability indices. While the interannual fluctuation in carbon uptake was large, a net carbon sink was maintained even during an extreme drought year, suggesting a high degree of resilience of this forest ecosystem to atmospheric stresses. The Community Land Model (CLM) predicted seasonal and interanual variations in evapotranspiration reasonably well. However, its predicted carbon uptake was too small across the observed range of climate variability. Also, the model systematically underestimated the sensitivities of carbon uptake and evapotranspiration to climate variability and overestimated the coupling between carbon and water fluxes. We suggest that future model improvements should focus on better representation and parameterization of process responses to atmospheric stresses and more complete representations of carbon-specific processes such as mesophyll diffusion.

Key words: Carbon and Water Fluxes, Climate Variability Indices, Land Surface Modeling, Eddy Covariance, Climate Change