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Mechanisms underlying the spatial variation of WUE among terrestrial ecosystems in China

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Enhancing carbon uptake in terrestrial ecosystems is an alternative approach in mitigating climate change, which needs consume amounts of water. Meanwhile, water cycle and carbon cycle are closely coupled. Analyzing this coupling could improve our knowledge in understanding the processes of water and carbon cycles.

Water use efficiency (WUE), here defined as the ratio of gross primary productivity (GPP) and evaportranspiration (ET), representing the coupling relationship between carbon and water cycles in terrestrial ecosystems, reflects the water requirement for carbon uptake. Investigating the spatial pattern of WUE and its underlying mechanisms can provide insight into the relationships between carbon and water cycles in terrestrial ecosystems and the supportive capacity of water resources for carbon uptake.

Based on the eddy covariance measurements in 8 sites of ChinaFLUX, we analyzed the spatial pattern of annual WUE (defined as the ratio of annual total GPP to annual total ET) and its underlying mechanisms among forest ecosystems, grassland ecosystems and all types of ecosystems. As ET was comprised by evaporation (E) and transpiration (T), we used the Shuttleworth-Wallace model, a dual sources model, to separate ET into E and T. Then WUE was divided into GPP/T and T/ET, which was affected by ecophysiological processes and physical processes, respectively. By 1) approximating photosynthesis rate and transpiration by GPP and T, 2) neglecting resistance by the boundary layer and 3) approximating leaf temperature by air temperature, we introduced inherent water use efficiency (IWUE) to represent the intrinsic water use efficiency at the ecosystem level. Then WUE was divided into IWUE, 1/VPD and T/ET.

Results indicate that the spatial pattern and the underlying mechanisms were distinct different among ecosystem types. Among forest ecosystems in the North-South Transect of East-China (NSTEC), the spatial variation of WUE was mainly affected by the variation of 1/VPD. However, among grassland ecosystems in the Chinese Grassland Transect (CGT), T/ET was the main component determining the spatial variation of WUE. Across all ecosystem types, IWUE and T/ET played an important role in shaping the spatial variation of WUE.