Dynamics of water and carbon use efficiency of global croplands from 2000 to 2014

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With increasing population, food security would be a great challenge for our world. Increasing cropland productivity or cropland area has been taken as two major strategies to ensure food security. However, the increase of new cropland would result in large greenhouse gas emission, which would aggregate global warming. How to increase the crop productivity has therefore been considered as the main valid method to ensure food security. This is especially true for those regions with limited number of croplands. In addition, water resources are another big issue to ensure the crop growth. Therefore, better understanding crop and water productivity has become a critical task for coping with the growing global scarcity of cropland and water. The objective of this study is to investigate the temporal and spatial variation of water use efficiency (WUE) and carbon use efficiency (CUE) in croplands at a global scale.

Annual Moderate Resolution Imaging Spectroradiometer (MODIS) GPP, NPP, and ET data at a spatial resolution of around 1 km were obtained from the Numerical Terradynamic Simulation Group at the University of Montana. These products have been widely used in the research of WUE and CUE. Water use efficiency (WUE), here was calculated as the ratio of gross primary production (GPP) to evapotranspiration (ET), and carbon use efficiency (CUE), here was calculated as the ratio of net primary production (NPP) to gross primary production (GPP). The Global Food Security-support Analysis Data (GFSAD) product of crop dominance (GFSAD1KCD) at 1 km resolution was used to produce global cropland map. The least square estimation was used to quantify the variations of global cropland GPP, NPP, ET, WUE and CUE.

This study presented the temporal and spatial variation of water use efficiency (WUE) and carbon use efficiency (CUE) for croplands from 2000 to 2014 at a global scale for the first time. As for WUE, the highest value (mean around 1.92 g C kg^{-1} H_2O) generally occurred in east America, Europe and southwest Canada. The lowest value (mean around 1.52 g C kg^{-1} H_2O) occurred in India and China. As for CUE, the highest value (mean around 0.58) occurred in east America. The lowest value (mean around 0.44) generally occurred in tropical areas such as southeast Asia, east Brazil, and Africa. Moreover, a clear increasing trend of WUE was found in north China, India, east Africa, etc. On the contrary, a clear decreasing trend of WUE was found in middle area of south America, north Africa, northwest India, and southwest Russia. A clear increasing trend of CUE was found in the middle part of South America. On the contrary, a clear decreasing trend of CUE was found in southwest Russia, and some area in middle US and Argentina. This study gives new insights for better understanding the dynamics of global croplands' WUE and CUE. This study was supported by the project named Study on Multi-Scale Evaluation System for GHG Variation and Mitigation (1620AA011).

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