Geophysical Research Abstracts
Vol. 18, EGU2016-18017-1, 2016
EGU General Assembly 2016

Estimating Hydrologic Fluxes, Crop Water Use, and Agricultural Land Area in China using Data Assimilation

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Crop production has significantly altered the terrestrial environment by changing land use and by altering the water cycle through both co-opted rainfall and surface water withdrawals. As the world's population continues to grow and individual diets become more resource-intensive, the demand for food – and the land and water necessary to produce it – will continue to increase. High-resolution quantitative data about water availability, water use, and agricultural land use are needed to develop sustainable water and agricultural planning and policies. However, existing data covering large areas with high resolution are susceptible to errors and can be physically inconsistent.

China is an example of a large area where food demand is expected to increase and a lack of data clouds the resource management dialogue. Some assert that China will have insufficient land and water resources to feed itself, posing a threat to global food security if they seek to increase food imports. Others believe resources are plentiful. Without quantitative data, it is difficult to discern if these concerns are realistic or overly dramatized.

This research presents a quantitative approach using data assimilation techniques to characterize hydrologic fluxes, crop water use (defined as crop evapotranspiration), and agricultural land use at 0.5 by 0.5 degree resolution and applies the methodology in China using data from around the year 2000. The approach uses the principles of water balance and of crop water requirements to assimilate existing data with a least-squares estimation technique, producing new estimates of water and land use variables that are physically consistent while minimizing differences from measured data. We argue that this technique for estimating water fluxes and agricultural land use can provide a useful basis for resource management modeling and policy, both in China and around the world.