INTEGRATING GEOSPATIAL DATA AND SIMULATION MODELING TO ANALYZE SPATIAL SEED COTTON YIELD, EVAPOTRANSPIRATION AND IRRIGATION REQUIREMENTS

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Abstract

The development of sensors that provide geospatial information on crop and soil conditions has been a primary success for precision agriculture. However, further developments are needed to integrate geospatial data into computer algorithms that spatially optimize crop production while considering potential environmental impacts and resource limitations. The objective of this research was to combine several information technologies, including remote sensing, a cropping system model, and a geographic information system (GIS), to synthesize and interpret geospatial data collected during two irrigation scheduling experiments conducted in 2009 and 2011 in a 5 ha cotton field in central Arizona. The Geospatial Simulation plug-in for Quantum GIS was used to manage geospatial data and conduct site-specific simulations with the CSM-CROPGRO-Cotton model. Simulated annealing optimization was used to adjust five model parameters to simulate site-specific conditions in 320 zones across the field. A multiple criteria objective function incorporated measured and simulated leaf area index (LAI), crop canopy height, seed cotton yield, and evapotranspiration (ET). Parameter identifiability and equifinality issues associated with model inversion were investigated. The optimized model was used for post-hoc analysis of irrigation rates that maximized site-specific irrigation water use efficiency. With spatial optimization, the model was able to simulate LAI with root mean squared errors (RMSE) of 15% and 8% in the 2009 and 2011 experiments, respectively. The RMSEs between measured and simulated canopy height, seed cotton yield, and ET were 5% or less in both seasons. Some parameters were more identifiable than others during model inversions. Multiple temporal estimates of LAI were effective for constraining the model's specific leaf area parameter (SLAVR, cm^2 g^{-1}), but lack of information on root growth reduce identifiability of a parameter related to that process (SRGF0). Post-hoc simulation analysis of irrigation management options showed that irrigation schedules based on remotely sensed vegetation indices increased irrigation water use efficiency as compared to traditional scheduling methods, particularly in the 2009 growing season. In 2011, the analysis showed that all scheduling methods resulted in excess irrigation application. Taken together, the results demonstrate that well-designed software tools and algorithms for data processing and interpretation can be potentially transformative for integrating multiple geospatial data sets to compute optimum scenarios for precision irrigation management.