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A satellite-driven, client-server hydro-economic model prototype for agricultural water management

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Anticipating agricultural water demand, land reallocation, and impact on farm revenues associated with different policy or climate constraints is a challenge for water managers and for policy makers. While current integrated decision support systems based on programming methods provide estimates of farmer reaction to external constraints, they have important shortcomings such as the high cost of data collection surveys necessary to calibrate the model, biases associated with inadequate farm sampling, infrequent model updates and recalibration, model overfitting, or their deterministic nature, among other problems. In addition, the administration of water supplies and the generation of policies that promote sustainable agricultural regions depend on more than one bureau or office. Unfortunately, managers from local and regional agencies often use different datasets of variable quality, which complicates coordinated action.

To overcome these limitations, we present a client-server, integrated hydro-economic modeling and observation framework driven by satellite remote sensing and other ancillary information from regional monitoring networks. The core of the framework is a stochastic data assimilation system that sequentially ingests remote sensing observations and corrects the parameters of the hydro-economic model at unprecedented spatial and temporal resolutions. An economic model of agricultural production, based on mathematical programming, requires information on crop type and extent, crop yield, crop transpiration and irrigation technology. A regional hydro-climatologic model provides biophysical constraints to an economic model of agricultural production with a level of detail that permits the study of the spatial impact of large- and small-scale water use decisions. Crop type and extent is obtained from the Cropland Data Layer (CDL), which is multi-sensor operational classification of crops maintained by the United States Department of Agriculture. Because this product is only available for the conterminous United States, the framework is currently only applicable in this region. To obtain information on crop phenology, productivity and transpiration at adequate spatial and temporal frequencies we blend high spatial resolution Landsat information with high temporal fidelity MODIS imagery. The result is a 30 m, 8-day fused dataset of crop greenness that is subsequently transformed into productivity and transpiration by adapting existing forest productivity and transpiration algorithms for agricultural applications.

To ensure all involved agencies work with identical information and that end-users are sheltered from the computational burden of storing and processing remote sensing data, this modeling framework is integrated in a client-server architecture based on the Hydra platform (www.hydraplatform.org). Assimilation and processing of resource-intensive remote sensing information, as well as hydrologic and other ancillary data, occur on the server side. With this architecture, our decision support system becomes a light weight ‘app‘ that connects to the server to retrieve the latest information regarding water demands, land use, yields and hydrologic information required to run different management scenarios. This architecture ensures that all agencies and teams involved in water management use the same, up-to-date information in their simulations.