Toward Improved Irrigation Efficiency through Real-time Assimilation of Multi-spectral Satellite Remote Sensing Data into Crop Models

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The amount of water used for agriculture in California consumes the majority of the total water supply. Since estimation of irrigation demand of crops can be difficult, the process can be inefficient and therefore an area where significant water savings may be possible. In this work, a data assimilation method combining dynamic crop models and remote sensing observations is proposed to identify necessary irrigation over large regions.

The amount of water used for agriculture in California consumes 40% of the total water supply and 75% of the developed water supply. With agriculture using most of California's developed water supply, this is the most likely arena where water conservation could be implemented. In irrigated agricultural regions, over-watering is often a problem, resulting in potentially large runoff volume containing a high concentration of contaminants. In this work, a method combining dynamic crop models and remote sensing observations is proposed to identify necessary irrigation over large regions.

Ecological process models (agricultural crop models) dynamically evolve vegetation and can predict the necessary irrigation rate to optimize crop yield. These types of models require meteorological and soils data, which can be erroneous and lead to prediction uncertainty. To reduce the amount of uncertainty, a technique of assimilating observational data with agricultural process models will be used to more effectively simulate agricultural water requirements.

Observational data on the scale required for agricultural irrigation management is only available via remote sensing platforms. Remote sensing data does not measure crop or water states but rather reflectance or brightness temperature at the surface. Using a radiative transfer model coupled to the crop model allows for assimilation of the remote sensing observations to update model state estimates.

Data assimilation methods, e.g. the Ensemble Kalman Filter (EnKF), have been used previously in hydrologic applications to estimate soil moisture and snow water equivalent. The EnKF will determine the relative uncertainty of the modeled and observational data and provide an optimal estimate of the vegetation and soil moisture states. The goal of this project is to determine the feasibility of estimating irrigation water to apply to a crop stand via the assimilation of visible and near infrared remote sensing observations into a physically based crop model using the EnKF.

Thus far our work has focused on the selection and testing of the proper agricultural and radiative transfer models, which include the Decision Support for Agrotechnology Transfer Cropping System Model and PROSAIL radiative transfer model.

Two agriculturally important regions within California were selected. The first region is a coastal agricultural region in Ventura County, Oxnard, CA and the second region chosen is in Imperial Valley, an inland, semi-arid agriculturally important region. Meteorological stations are located near both sites and a University of California research station is also located at the Imperial Valley site.

Initial testing of the DSSAT-CSM model has been performed. Analyses of different modeling options were explored in four different irrigation implementations. Five seasons of data (2002-2006) were simulated. The four different experiments were analyzed to confirm that the output of the model provided realistic predictions of model states.

Preparation has begun on for identifying the sections of DSSAT-CSM that will need to be modified for use in the data assimilation scheme. Output from DSSAT-CSM will be used as input to PROSAIL in the data assimilation framework.

During the next year, the data assimilation framework will be built by coupling the crop and radiative transfer models within the EnKF code. Once this is completed, observing system simulation experiments (OSSEs) will be performed to test the feasibility of estimating the soil moisture and vegetation states so that irrigation could be optimized.

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