

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

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Executive Summary:

In semi-arid regions like the Western U.S. where water is a scarce commodity, the efficient management of water resources is critical to meet the needs of various stakeholders. This is especially true in California, where population is projected to continue to grow rapidly, while new sources of water supply are dwindling. In the past, increased water demands were generally met by building new infrastructure to convey, store, or otherwise obtain untapped resources. However with the growing demand of other states in the Western U.S., California's supply of water from traditional sources (e.g. the Colorado River) will become more or less fixed for the foreseeable future. Implementing methods for the sustainable use of water and increased water use efficiency is a necessary goal for the future of California.

California's total water supply, from both natural hydrologic inputs and imported sources, can generally be partitioned into three distinct areas: agricultural, urban, and environmental. Water used for agriculture comprises over 40% of the total water use and approximately 75% of the "developed" water supply (agricultural and urban demand). Based on the fact that agriculture uses such a large fraction of total water supply, increased water use efficiency in irrigation practices is a clear priority for California. More efficient irrigation practices would i) save water that could thereby enhance urban supplies and ii) reduce over-watering, leading to better crop growth and less harmful runoff (containing pesticides, etc.), thus having both economic and environmental benefits.

A great deal of effort in improved agricultural water use efficiency has been expended over the last several decades. Significant efficiency improvements have been made in the areas of hardware investments to improve on-farm irrigation systems and district water delivery systems. One of the areas in which the biggest strides in improving irrigation efficiency can likely be made going forward is the improved estimation of irrigation rates needed by crops at a particular location and time. Sub-optimal irrigation (either too little or too much) leads to either wasted water and/or reduced crop yield, both of which are detrimental. Monitoring or estimating the irrigation rate needed to maintain the optimal conditions is difficult over field-scale or larger domains with heterogeneous soil and vegetation properties.

The goal of this research project is to test the feasibility of an innovative “data assimilation” framework for improving irrigation efficiency over large scales by optimally combining remote sensing observations with physically-based crop simulation models. Improved characterization of the state of the crop at a given location and time (and hence the necessary irrigation rate) over large scales would not only save water via improved water management, but would increase crop yield. Once proven, this tool could be developed to ultimately allow for management of water resources at the farm level by individual growers or at a higher level by regional district and/or state water managers. Additionally, the methodology is general enough to apply to other semi-arid regions where irrigated agriculture makes up a significant fraction of the water demand.

Key Words: irrigation efficiency, crop simulation modeling, multi-spectral remote sensing, vegetation radiative transfer modeling, data assimilation