Agricultural monitoring using satellite-based measurements

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Introduction

Water availability is a key issue in most river basins of the western United States. Problems of drought, population growth, and environmental concerns, accentuated by climate change, are leading to increasing challenges in water management within the region. Irrigation is by far the largest consumptive water use (withdrawal minus return flow) throughout the western U.S. However, direct measurement of consumptive use of agricultural water is difficult - while irrigation water withdrawals are relatively easy to monitor, return flows are much more complicated. For this reason, information about irrigation water requirements often limits water allocation decisions, and the efficiency of water use. In consideration of this problem, we developed a crop water consumption monitoring approach that is based exclusively on satellite remote sensing data.

We have implemented the approach into our Washington Agricultural Monitoring system (WAAM). The WAAM system produces objective, timely satellite-based monitoring information about crop water use over the irrigated areas of eastern Washington. It is implemented in a user-friendly system that allows for the integration and analysis of remote sensing data products in agricultural decision support systems.

Strategy

Tang et al. (2009) describe a near real-time Evapotranspiration (ET) Estimation System, which was initially tested in the Klamath River basin, and has since been applied to the agricultural areas of eastern Washington. It is a derivative of the MODIS-based approach of Nishida et al. (2003), which uses MODIS-based vegetation index (VI) and surface temperature (Ts), along with GOES-based net radiation. A key assumption is that the evaporative fraction is constant through the diurnal cycle.

Water Consumption Estimation

VI-Ts Method

- The landscape is simplified as a mixture of vegetation and bare soil. The proportion of vegetation, fveg whose value is between 0 and 1, is related to normalized difference vegetation index (NDVI).
- In the VI-Ts method, a scatterplot of VI (vegetation index, NDVI) versus Ts (surface temperature) shows a linear or triangular form with a negative correlation between VI and Ts. Dense vegetation with higher VI has lower Ts. Bare soil and sparse vegetation becomes warmer relative to vegetation with higher VI values as the surface becomes drier.

Assumptions, Limits and Evidences

- The VI-Ts method requires substantial diversity in vegetation types (hence diversity of VI and Ts) within the remote sensing window. The irrigated areas of the western U.S. are well suited to the method because of the strong contrast between the interface between irrigated cropland and surrounding areas.
- A key assumption of the method is that the evaporative fraction (EF), defined as the ratio of ET to available energy Q*, is nearly constant during a day. The constant EF hypothesis allows instantaneous estimates of the EF at MODIS overpass times to be extrapolated to estimate daily average ET. Measured instantaneous EF matches daily mean EF well at two fluxes tower sites (KL03 and KL45) in Oregon (Richard Cuenca).
- Ts is obtained from MODIS product MOD11A1. For days when LST is unavailable (most likely because of cloudy conditions), LST for the closest available day is used instead. Errors from this source are constrained by modest day to day variations of EF. Cloud cover effects on ET are also taken into account in the NOAA/NESDIS surface radiation budget (SRB) products derived from GOES. Comparisons with surface observations (Tang et al. 2009) show that temporal patterns of ET are well captured by the VI-Ts method.

References

