Report as of FY2008 for 2008NM90B: "Estimating Water Use through Satellite Remote Sensing (Bleiweiss)"

Publications

- Dissertations:
    - Piñon, Aldo. Evaluating Pecan Water Use in the Mesilla Valley, New Mexico Using Remote Sensing. M.S. Thesis, NMSU Department of Civil Engineering, April 2008.
    - Kirksey, Brad. Measurement Of Water Use (Evapotranspiration) By Alfalfa As Managed By Farmers In Dona Ana County, New Mexico. M.S. Thesis, NMSU Department of Civil Engineering, May 2009.
    - Lopez, Eric. Title to be announced. M.S. Thesis, NMSU Department of Civil Engineering, May 2009.
- Articles in Refereed Scientific Journals:
    - Samani, Z., A. Bawazir, M. Bleiweiss, R. Skaggs, and T. Schmugge. Using ASTER Satellite Data to Calculate Riparian ET in the Middle Rio Grande, New Mexico. A refereed journal article accepted for publication in the International Journal of Remote Sensing.
- Book Chapters:
    - Skaggs, R., Z. Samani, A. Bawazir, and M. Bleiweiss. Yield Response to Water in Irrigated New Mexico Pecan Production: Measurements and Policy Implications. in Urbanization of Irrigated Land and Water Transfers. Robert S. Gooch and Susan S. Anderson "eds.". Denver, CO: U.S. Committee on Irrigation and Drainage, 469-480. ISBN: 978-1-887903-25-7.

Report Follows

Problem and Research Objectives

A recent evaluation of the water budget at Lower Rio Grande has shown that 56% of water is unaccounted for (Magallanez and Samani, 2001). The 56% likely includes domestic water use, riparian vegetation use, supplementary farm irrigation pumping and off-season runoff. In order to better account for the various uses of water and sources of beneficial and non-beneficial use, and ultimately to optimize the use of water resources, a realistic evaluation of the amount and spatial and temporal variation of ET is needed.

For the purpose of the effort, the primary goal is to use the spatial and temporal variation of ET information to assess and map economic return from agricultural activities. Once ET is determined, then biomass can be calculated and linked to crop yield. This could provide an excellent opportunity to evaluate the impact of various parameters such as crop type, field size, soil, etc. on the economic return from irrigated agriculture.

Methodology

Recent innovations in satellite technology have made it possible to process satellite data to estimate evapotranspiration (ET) with high spatial and temporal resolution. This technology (so named REEM), utilizes remote sensing parameters (land surface temperature (LST), normalized difference vegetation index (NDVI), and short wave albedo along with climate station data to arrive at an estimate of ET. These ET maps will be processed by overlaying agricultural field boundaries (initially, pecan orchards) to arrive at a field by field estimate of total ET. This is then linked to biomass and crop yield for a determination of economic return. Crop coefficients for alfalfa and other crops were also determined.

Principal Findings

The main objective of the study was to evaluate the water use of the population of pecan orchards in the Valley and to relate pecan ET to the fractional vegetation cover (fc) in order to create crop consumptive models for the study area. An analysis of GIS vector files, ET maps created with two satellite-based remote sensing models, weather data and measured ET was undertaken to study the spatial variation and distribution of ET among the pecan orchards from the Mesilla Valley, New Mexico. A linear model was developed to estimate orchard values of fractional cover (fc) from the normalized vegetation index (NDVI) calculated from remotely sensed data. A pecan model was created for the Valley to estimate the water use of open-canopy orchards that uses midseason NDVI calculated from a single satellite image (as indication of fc) and crop coefficients for unstressed closed-canopy orchards. The results from this study indicated that (a) the annual ET in pecans depicted a high spatial and temporal variation within the orchards of the region, which increased during the midseason to reflect differences in agricultural management practices (irrigation, planting arrangements, etc.), size and age of trees, and the fc; and (b) the annual water use in pecans was linearly related to the fc in a field basis. These findings were different than those found for crops with canopies and growth patterns that are different from pecans, but similar to results reported for similar trees. The main conclusions drawn from this study are the following:

1. Seventy six percent of all the pecan orchards were smaller than 10 acres constituting the 19% of the total area, while the remaining 24% were orchards greater than 10 acres which accounted for the 81% of the total pecan acreage;

2. As modeled by the Landsat model, the orchards greater than 10 acres had a weighted average ET of 1,018 mm/year while the smaller than 10 ac. used 852 mm/year; ASTER yielded a weighted average of 991 mm and 800 mm for the orchards larger and smaller than 10 ac. respectively during 2002;

3. Two main problems affected the accuracy of seasonal ET estimation in the two models (ASTER and Landsat): (a) the missing of portions of annual ET caused by lack of satellite data or a large separation between the dates of satellite imagery in several periods of the year; and (b) the effect of thermal contamination on the computed orchard averages of annual ET; the Landsat model was less affected by these problems due to a larger number of images and higher TIR resolution;

4. Larger orchards (>10 ac.) tended to have larger water consumptions during the year since these were more commercially-oriented than small orchards using higher technology and improved irrigation practices (Skaggs and Samani, 2003);

5. A higher variation (standard deviation) among the crop coefficients of pecans was found during the midseason (April to September) caused by differences in irrigation practices, tree age and size, densities and fractional cover values;

6. The seasonal accumulated ET in at least in a group of pixels in one location agreed well with previous measured ET values from literature, and was more accurate for the Landsat model;

7. The values of fc estimated with supervised classification of DOQQs for the orchards, were within the range of measured values, with an absolute difference of 0.07 and average error of 14%;

8. The NDVI was significantly correlated to fc values in a field basis (R2= 0.63); NDVI was found best to predict fc compared to other VIs;

9. The NDVI calculated from a single satellite image for the midseason (June 16th) was strongly correlated to pecan annual ET (R2 = 0.73); this relation was used as a model to predict pecan annual water use and adjust Kc of open-canopy orchard to Kc of closed-canopy orchards;

10. Monthly crop coefficients predicted from the pecan model compared well with monthly crop coefficients estimated with the remote sensing model (REEM) with a SEE of 0.053 and regression coefficient (R2) of 0.93

11. Yield-ET functions have been developed, using the REEM generated ET estimates and yield data provided by key informants. This research is providing estimates of field-level gross economic returns from consumptive water use by pecans.

Additional work has focused on the determination of Kc for crops other than pecans and alfalfa (this work was leveraged with funds from the Office of the State Engineer) and preparation for implementation of the findings into the daily operations of the Elephant Butte Irrigation District for more efficient irrigation practices.