Report as of FY2006 for 2006NE117B: "Use of Remotely Sensed Data for Improved Quantification of Evapotranspiration for Water Management in Nebraska"

Publications

- Conference Proceedings:
  - Sing, R., A. Irmak, S. Irmak, and D.L. Martin. Satellite remote sensing based estimation of land surface evapotranspiration in Great Plains. 2007 World Environmental and Water Resources Congress. Tampa, Florida. May 07-May 15. The power point of this presentation is attached
- Other Publications:
  - A. Irmak, Sing, R., S. Irmak, and D.L. Martin. 2007. Operational aspects of remote sensing-based energy balance models for estimating surface energy fluxes. 2007 ASABE Annual International Meeting, Minneapolis, Minnesota, 17-20 June 2007.
- Articles in Refereed Scientific Journals:
  - Sing, R., A. Irmak, S. Irmak, and D.L. Martin. 2007. Application of SEBAL for mapping evapotranspiration and estimating surface energy fluxes in south central Nebraska. Journal of Irrigation and Drainage Engineering, ASCE (in review).

Report Follows

Progress Report for USGS, Section 104b Program Funding

Project #: 2006NE117B
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Funding Period: March 1, 2006 through February 28, 2007
Title: Use of Remotely Sensed Data for Improved Quantification of Evapotranspiration for Water Management in Nebraska

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Problem and Objectives

In the Central Plains of the United States, at least 90%, or more, of the precipitation is returned back to the atmosphere by evapotranspiration (ET) (USGS, 1997). Thus, accurate estimation of ET is one of the key elements for better managing water resources management. Particularly, in the context of crop production in irrigated agriculture such as a) scheduling of irrigation, b) evaluation of the effects of changing land use on water yields, c) environmental assessment by developing best management practices for surface and groundwater quality protection, d) predicting the status of the soil water supplies and their allocation and efficient use and e) quantifying water use by different vegetation surfaces over large areas. Better allocation and management of the region's water resources will ultimately affect the economics of the region and will in meeting stream requirements for water compacts and endangered species.

Practical, reliable and cost-efficient techniques are needed for quantification of ET to enhance efficient use of water resources and protect water quality in the region. Most field measurements are indirect and based on equations and assumptions. Bowen ratio energy balance systems (BREBS), eddy correlation systems (ECS), weighing lysimeters, and water balance techniques offer alternatives for measuring ET and surface energy fluxes. However, in spite of the elegance and theoretical attractions of these techniques for measuring ET, their practical use over large vegetation surfaces is limited. These techniques provide point measurements and may not be practical when quantifying water use over large areas (i.e., watershed or basin scale or regional scale). Despite the high accuracy of techniques, they can be very expensive for practical applications in regional scales under heterogeneous terrains composed of different agro-ecosystems. What is also lacking is a more quantitative and systematic understanding of what modeling approach is most suitable for predicting ET at scales that range from plot to region. What are suitable data sources that can help improving ET predictions? What role can remote sensing play in this process? What are the uncertainties involved and how can they can be minimized? How reliable is ET across the region?

Spatio-temporal information on actual ET helps users to better understand evaporative depletion and to establish links between land use, water allocation, and water use. Satellite-based measurements, used in conjunction with energy balance models, can provide spatial distribution of ET for these linkages. Remote sensing is becoming increasingly sophisticated and potential exists for indirect ET measurement. It involves using a set of equations in a strict hierarchical sequence to convert the spectral radiances measured by satellites or airplanes into estimates of actual ET. The demand of using remote sensing and satellite imagery for quantification of ET over large areas is growing. Application of ET mapping from satellite measurements can actually be an expansion of field measurements using aforementioned techniques when applied properly. Surface Energy Balance Algorithm for Land (SEBAL) has been offered as an alternative technique to quantify ET over large areas using satellite surface energy fluxes measurements. Since its' development, this technique has been successfully used for ET estimations for different surface and in different environments.

The principal thrust of our proposal is to conduct applied scientific research for satellite-derived estimates of evapotranspiration in conjunction with the surface energy balance algorithm for land at different scales with emphasis on the major agroecosystems of the U.S. Corn Belt in Nebraska. The specific objectives were:

1) Estimate actual evapotranspiration and the biomass production under different agroecosystems in Nebraska using energy balance models with remote sensing data

2) Assess the performance of the model results against several reference ground-truth ET techniques for testing its accuracy

3) Quantify ET over large areas at field and watershed scale in Nebraska.

Principal Findings and Significance

Our primary goal is spatiotemporal estimation of ET using satellite-derived spectral radiances in real time in conjunction with SEBAL model to enhance efficient use of our water resources and protect water quality in the Great Plains. A total of seven cloud free Landsat TM/ETM satellite images (May 19, June 20, July 22, August 7, September 8 and 16, and October 18, 2005) were processed to generate crop evapotranspiration (ET_c) maps and estimate surface energy fluxes in Nebraska. The predictions from SEBAL model were compared with the Bowen Ratio Energy Balance System (BREBS)-measured fluxes on an instantaneous and daily basis.

The ET_c maps generated by model for seven Landsat overpass days showed a very good progression of ET_c with time during the growing season in 2005 as the surface conditions continuously changed. Overall, a very good correlation was found between the BREBS-measured and SEBAL-estimated ET_c for all images analyzed with a good r^2 of 0.73 and a low RMSD of 1 mm d^{-1}. The estimated ET_c was within 5% of the measured ET_c. The model was able to predict growing season (from emergence to physiological maturity) cumulative daily corn ET reasonable well within 5% of the BREBS-measured values.

The results from this seed project provided insights into to improve our understanding of biophysical processes governing evapotranspiration. While our results showed that SEBAL can be a viable tool for generating ET_c maps to assess and quantify spatiotemporal distribution of ET on large scales as well as estimating surface energy fluxes, its operational assessment for estimating sensible heat flux and ET_c, especially during the drier periods for different surfaces needs further investigation.

Notable Achievements

1. A proposal is submitted to Nebraska Department of Natural Resources entitled "Estimation of Evapotranspiration from Riparian and Invasive Species Using Remote Sensing and in Situ Measurements in the Republican River Basin". A funding in the amount of $946,549 has been secured for the next five year. Project PIs: Derrel Martin, Ayse Irmak and Suat Irmak, and Shashi Verma.

2. Measurement of growing season actual crop evapotranspiration and crop coefficients, and dormant season evaporative losses for key vegetation surfaces in the Central Platte Natural Resources District. A funding in the amount of $475,000 has been secured for the next four year. Project PIs: Suat Irmak, Ayse Irmak, Derrel Martin, Shashi Verma, and Simon vanDonk.

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