Sub title : Validate current SEBAL and NCAR-WRF models for estimating ET and express this in terms of orchard/vineyard water demand

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PROJECT TITLE: **Advanced sensing and management technologies to optimize resource management in specialty crops – case studies of water and nitrogen management in deciduous crops under normal and resource-limited conditions**

1.0 PROJECT DESCRIPTION

1.1 Introduction

For forest, riparian, rangeland, and agricultural water and pest management, remote sensing evapotranspiration (ET) models are important. However, most remote sensing ET models are not in an operational mode on the internet. The downloading of satellite and weather data and processing of this data are complicated and time consuming requiring as much as 2-6 hrs per MODIS satellite file. Consequently, if the ET algorithm is going to be used by the scientific community it is imperative that the computer processing be automated and user-friendly, i.e., the user just input the dates and locations of interests and the model will output the ET results (map and ACSII data file) to the user.

The automation of the Surface Energy Balance Algorithm for Land (SEBAL©) (e.g., Remote Sensing ET model in Wang et al. 2009, RSET) are difficult because the algorithm requires wet and dry spot temperatures from the MODIS scene be identified which represent an ET of zero for the dry spot and an ET of non stress closed canopy cover for the wet spot. SEBAL and RSET calculate ET using an energy balance method (LE = R_n–G-H), i.e., evapotranspiration energy (LE) is the residue of energy source-net solar radiation (R_n), minus soil heat flux (G) and sensible heat flux (H). The terms of Rn, G and H are calculated from weather and satellite data. If a wet spot of vegetation cover is not available during some seasons, a lake can be used to represent the wet spot but this temperature must be corrected to represent a non-stressed closed canopy plant cover. If the wet spot is a lake then the sensible heat into the lake G has to be calculated as a function of turbidity, depth…etc. The difference in G results in a lake temperature that is generally 4.7 °C lower than a fully transpiring field (data was obtained from NM Elephant Butte Lake compared with local well irrigated fields).

The dry spot also can be a problem in areas other than the desert southwest. A fallow field that has not received rainfall or irrigation represents a dry spot. A large asphalt area can be adjusted in temperature to represent a dry spot as well. The asphalt dry spot can result in a temperature above a non evaporating bare soil. The selection of the dry and wet spots may be corrected based on the Normalized Difference Vegetation Index (NDVI) of the two pixels. The dry and wet spots need to be adjusted for elevation or selected at a similar elevation to the area in question. The MODIS scene covers the United States and the dry and wet spots must be within certain range of the point of interest to be valid. Otherwise a correction for the angle of view must be made.

Another problem with both automation and manually processed data is that the raw MODIS data are for non-fixed geo-locations (floating day by day) and the computer model must look for the closest pixel to that location and display it on Google Earth so that the end user know what area the calculated ET represents. Because MODIS has a 1 km resolution for temperature (key variable in ET calculation), the ET represent a weight average over the entire pixel. The RSET algorithm also needs climate data near the pixel of interest to calculate the reference hourly and daily ET.

The objective of the research was to test the hypothesis that a RSET remote sensing algorithms to calculate daily ET with MODIS data could be automated using computer code and that this calculated ET would have a higher accuracy than manually processed data. The evaluation of the two methods involves comparing the calculated automated daily calculated ET and hand processed ET compared to measured eddy covariance ET under both stressed and non-stressed conditions.

1.2 Methods

A remote users register's and submits a request into the system by means of a php web interface. The request specifies the start day, end day, latitude and longitude for the point of interest. If the user desires to input the climate and reference Et for the location, that becomes an input in the request CGI. Otherwise, the national weather service forecast model data is down loaded daily for the entire U.S. and used to generate the climate driver file. The model downloads the required Lib 2 MODIS data from the ftp MODIS site. After processing the CGI input information, the system notifies the user by an email that the results are available. The email currently provides a link to a KML file which can be opened in the Google earth viewer and a ET file which contains ET values for each day requested . The output also contain intermediated file that allow for debugging of ET calculation problems by writing all of the components of the energy balance calculation.

The verification of the model was conducted using an eddy covariance (EC) system to measure fluxes of heat, water vapor, and CO_2 into the atmosphere described by Wang et al., 2007. An EC tower system was installed in 2005 at a creosote shrub area irrigated by waste water from a cheese plant, Las Cruces, NM (32°14'44.14"N , 106°55'4.50"W, Figure 5). The data was used to evaluate the remote sensing ET flux under stress ET.

Figure 1. The creosote shrub area irrigated by waste water from a cheese plant, Las Cruces, NM (32°14'44.14"N , 106°55'4.50"W).

A second EC tower system was installed over an almond orchard near Bakersfield California at Lost Hills on the west side of the San Joaquin valley (35°30'05.76"N and 119º39'28.67"W) . The site covers more than several square kilometers in area in mature almond trees and represents a non stressed ET site (Figure 2).

Figure 2. Almond orchard (35°30’05.76”N and 119º39’28.67”W)

1.3 Initial Results

Figure 3 shows an example of the ET data processed for the desert shrub area at Las Cruces, NM compared with the measured data in 2005 (only clear days data were shown). The preliminary comparison shows the model values accuracy (slope=1.05), R^2 is low (0.51).

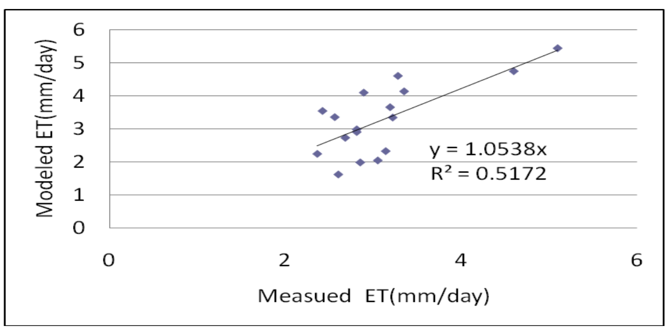

Figure 3 . Measured vs model Et for the desert shrub area of Las Cruces, NM

The data is limited in observations because a large number of Modes scenes that cover the desert have no pixel data for the desert area because of errors in the albedo measurement by Modes over desert areas. Data is being processed for the VERA range in California which is a ET stressed grassland area with an EC measurement system.

Figure 4 shows the ET data processed for the Almond orchard. Additional evaluation of the climate driving data needs to be conducted to explain the low model ET values for some of the summer days.

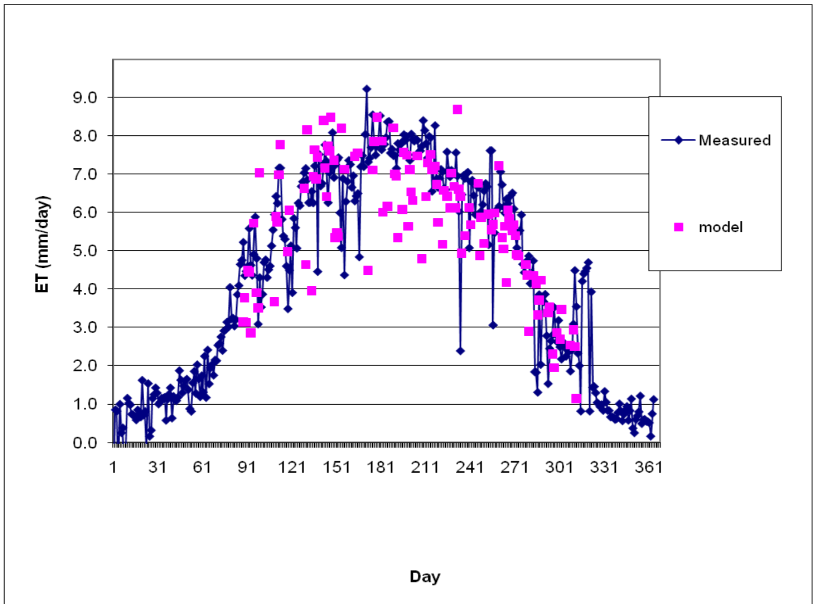

Figure 4. Measured and Modeled ET for Almond orchard Bakersfield, California

2.0 OUTPUTS

2.1 Activities: Developed a web out reach page (http://hydrology1.nmsu.edu/Lake%20evaporation/RemotesensingEt-mainpage.htm) and a CGI interface web page (http://rset.nmsu.edu/).

3.0 OUTCOMES / IMPACTS

The RSET model makes is possible to evaluate remote senses ET calculations over a time series. Modification of the equation and techniques can be conducted quickly and other approaches other than use of SEBAL type calculation can be conducted in the future.

4.0 PUBLICATIONS

Hung V. Dang and T. W. Sammis and M. A. Funk and S. C. Tran 2010. Reference Evapotranspiration Tool Box. Presented at WRRI 2010 New Mexico Water Research Symposium NMTech Socorro Aug. 03.

Junming Wang, Ted W. Sammis, David Miller, and Chandra Reddy. 2010 . Automation of Remote Sensing Calculation of Evapotranspiration . **2nd International Conference on Environmental Management –ICEM2010**, Oct 25-25, Hyderabad, India http://www.icem2010jntuh.org/invitation.html

Junming Wang, Theodore W. Sammis, Vincent P. Gutschick, Mekonnen Gebremichael, Sam O. Dennis1 and Robert E. Harrison. 2010. Review of Satellite Remote Sensing Use in Forest Health Studies . ***The Open Geography Journal*, 2010, *3*, 28-42 1874-9232.** **http://www.bentham.org/open/togeogj/openaccess2.htm**

Mekonnen Gebremichaela, Junming Wang and Ted W. Sammis . 2010. Dependence of remote sensing evapotranspiration algorithm on spatial resolution. Atmospheric Research Volume 96, Issue 4, Pages 489-495

5.0 PARTICIPANTS

Two electrical engineering graduate students worked on the project as programmers. They acquired background in remote sensing model development and development of software using Matlab resulting in one of them graduating and getting a programming job with Matlab.

6.0 TARGET AUDIENCES

The main audience is the State water research managers, irrigation districts; large cooperate farms and irrigation consultants. The tool allows evaluation of any irrigation scheduling method to determine if that method is correctly scheduling irrigation for the target ET stress level.

6.2 Efforts

The results will be present to the New Mexico State Engineer and the irrigation districts in the state once the tool accurately measured the ET by remote sensing. Currently, the researchers are working with the University of California to evaluate the tool for use by a large almond cooperate farm.