VARIABILITY WITHIN IRRIGATED FIELDS

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In agricultural production and research, it is common to represent fields as uniform areas. For example, fertilizers, soil amendments, and other inputs have traditionally been applied uniformly (or as uniformly as possible) based on estimated needs for the field as a whole (or as an "average").

Of course, it is also recognized that fields are not truly uniform with respect to soil characteristics, uniformity of applied water, pest pressures, fertility needs, crop growth and yield, and other characteristics. With the emergence and refinement of variable rate application technology, many growers now attempt to maximize returns by "prescribing" variable amounts of inputs based on observations of crop vigor, soil characteristics, or other indicators. This technical note is intended to examine how we are using new sensing technology to improve the accuracy of field-scale irrigation/agronomy research.

We have decades of research from small, replicated crop plots. This traditional research has been essential for helping improve productivity in irrigated agriculture. But there are also reasons to conduct research on full-sized fields that are farmed by real farmers. These reasons include:

a. Farmers tend to give greater credibility to research conducted on a large scale.
b. The conditions of small research plots may not accurately reflect the constraints encountered in commercial fields.
c. Researchers are usually not farmers. Control plot yields may be very different in research plots than on good commercial farms.
d. Boundary conditions may be significant on small plots.
e. It is difficult to obtain true costs using small research plots.

One particular challenge for laying out control and research plots on full-sized fields is that there is always inherent variability throughout the field. Therefore, yield differences between treatments can sometimes be more indicative of baseline variability than of differences in response to treatments. One particular challenge is in "normalizing" the yields of all blocks to eliminate these inherent baseline differences – especially if historical yield data is not available by block.

In recent years, improvements in sensor technology have increased researchers' ability to "see" the variability between and throughout fields, and therefore better utilize large fields for research. For example, ground-based or aerial remote sensors provide the means to quantify spatial variations of important drivers and indicators of crop water use, crop growth, and ultimately yield. The use of ground-based induction sensors to measure bulk soil conductivity is a well established technology that allows for mapping of soil texture, soil water content, and soil salinity within a field. Bulk conductivity measurements are calibrated based on strategically located soil samples and are used to develop relationships between bulk soil conductivity and one or more soil characteristics. (Lesch et al., 2005)

Examples of the use of the EM38 bulk conductivity sensor to map soil texture and salinity are provided for the same field in Figures 1 and 2, respectively. In Figure 1, a measure of the relative water content of a soil at saturation ("saturation percentage") is shown for a 160-acre field. Saturation percentage can be used to estimate soil texture, cation exchange capacity, and soil water holding capacity (Peacock and Christensen, 2000). In Figure 2, average soil salinity to a depth of 4 feet is shown. From inspection of the figures, it can be seen that areas with the greatest saturation percentage (heavier soils) do not necessarily exhibit the greatest salinity, possibly due to the presence of tile drainage.

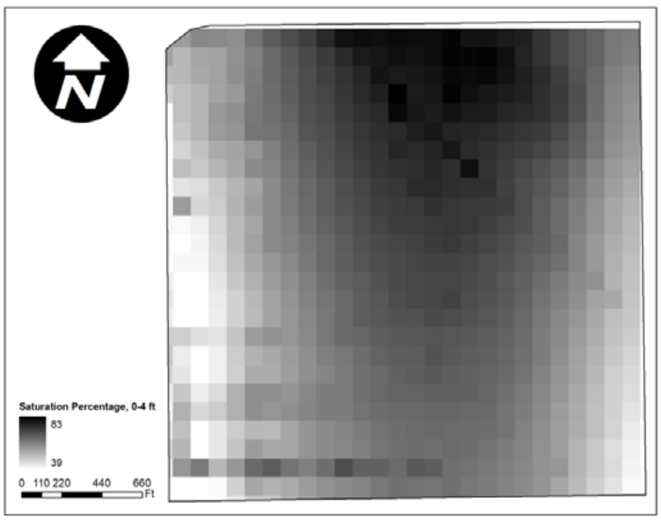

Figure 1. Saturation Percentage Estimated Using EM38 Bulk Soil Conductivity, 4/15/02

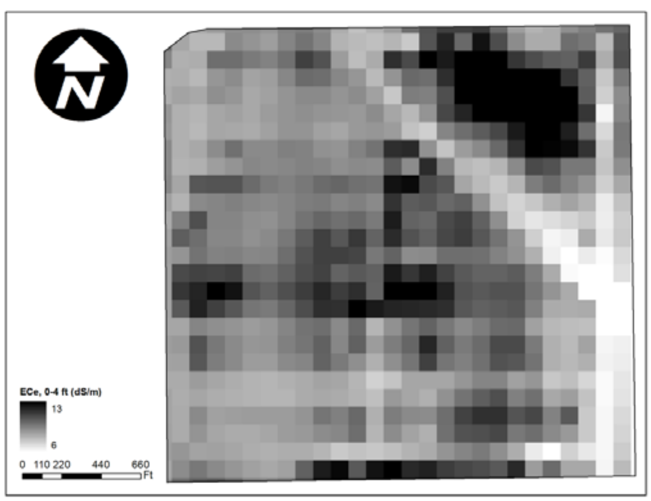

Figure 2. Soil Salinity Estimated Using EM38 Bulk Soil Conductivity, 4/15/02

As another example, the use of multispectral satellite imagery such as Landsat to monitor vegetation growth is also a well established technology that has been used in agricultural and natural research environments for decades. Often, an indicator of photosynthetic activity such as the Normalized Difference Vegetation Index (NDVI) is used to quantify variability in vegetation density and health. Additionally, over the last 10 to 20 years, methods to quantify actual evapotranspiration (the amount of water consumed by crops and returned to the atmosphere) have been developed and validated (Bastiaanssen et al., 2005; Allen et al., 2007).

Examples of the use of satellite imagery to quantify actual evapotranspiration are provided in Figures 3 and 4 for a field currently under research in the San Joaquin Valley by the Irrigation Training and Research Center (ITRC).

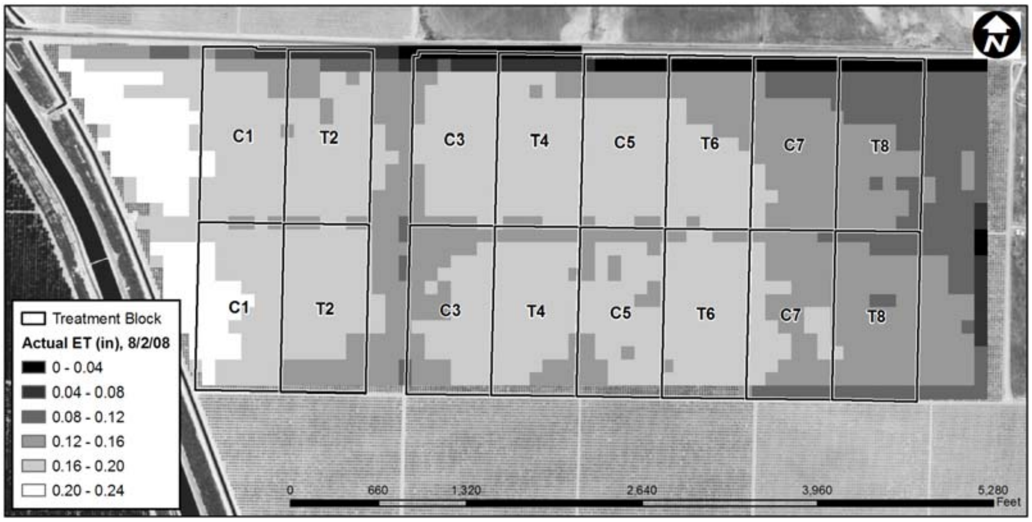

Figure 3. ET_a on August 2, 2008 for the ITRC study field. From the Surface Energy Balance Algorithm for Land (SEBAL®) and LandSat Imagery.

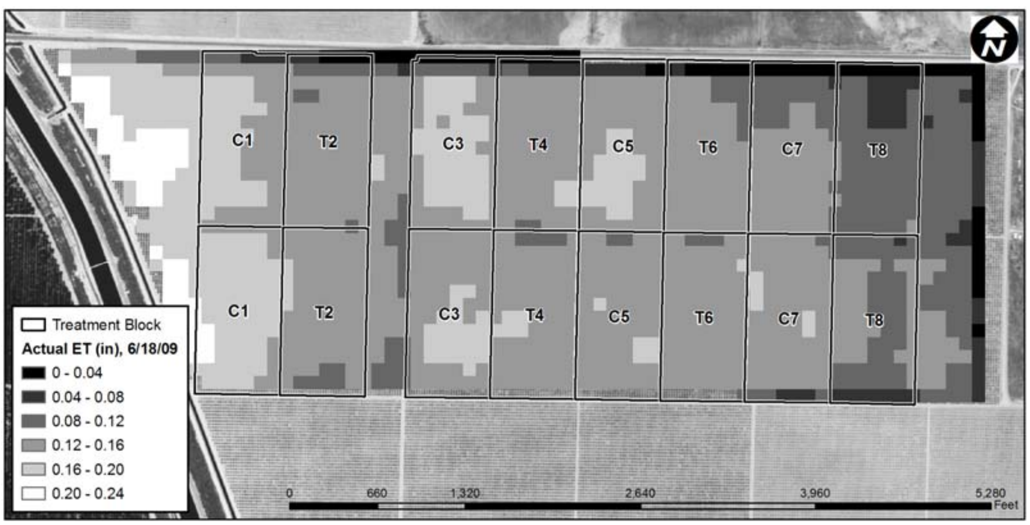

Figure 4. ET_a on June 18, 2009 for the ITRC study field. From the Surface Energy Balance Algorithm for Land (SEBAL®) and LandSat Imagery.

Figures 3 and 4 show the estimated ET on a pistachio field near Lost Hills, California before (Figure 3) and after (Figure 4) ITRC applied a kaolin spray on the leaves in the four treatment blocks (T2, T4, T6, and T8). Without the information of the baseline variability, conclusions regarding the effect of the kaolin spray would be incorrect. The types of differences shown in the figures provide valuable information that can assist in deciding where samples should be taken, how results from different blocks can be normalized to eliminate inherent baseline differences, and how blocks should be laid out (or what areas should be avoided). Large scale remote sensing-based estimates of ET can provide a much more accurate picture of treatment effects than limited soil moisture measurements in small areas.

From a practical application for research and regular field irrigation, Figures 3 and 4 show the wide variability of just one variable – ET_a – within the field. This variability points out the danger of relying on just one or two sensors in a field to adequately portray ET, soil moisture, plant stress, or any other indicator of plant/water status.

References

Allen, R.G., M. Tasumi, A. Morse, R. Trezza, J.L. Wright, W.G.M. Bastiaanssen, W. Kramber, I. Lorite, and C.W. Robison. 2007. Satellite-Based Energy Balance for Mapping Evapotranspiration with Internalized Calibration (METRIC) — Applications. *Journal of Irrigation and Drainage Engineering* 133(4): 395-406

Bastiaanssen, W.G.M., E.J.M. Noordman, H. Pelgrum, G. Davids, and R.G. Allen. 2005. SEBAL Model with Remotely Sensed Data to Improve Water Resources Management Under Actual Field Conditions. *Journal of Irrigation and Drainage Engineering* 131(1): 85-93.

Lesch, S.M., D.L. Corwin, and D.A. Robinson. 2005. Apparent Soil Electrical Conductivity Mapping as an Agricultural Management Tool in Arid Zone Soils. *Computers and Electronics in Agriculture* 46(1-3): 351-378.

Peacock, W. and L.P. Christensen. 2000. Interpretation of Soil and Water Analysis (PDF) in: Raisin Production Manual. University of California Division of Agricultural and Natural Resources Publication 3393, Oakland, CA. pp. 115-120.