Using Remote Sensing to Calculate Variability of Pecan Water Use as Influenced by Farm Practices in New Mexico

By

Zohrab A. Samani*, A. Salim Bawazir*, Max Bleiweiss*, Rhonda Skaggs* and John Longworth+

*New Mexico State University; +Office of State Engineer, Santa Fe

Introduction

Demand for fresh water for supplying the urban population, irrigation, and habitat requirements is on the rise in New Mexico. In Doña Ana County, New Mexico, irrigation is the largest consumer of water, yet the consumptive use by crops such as pecan has not been reliably quantified. In the ongoing stream adjudication, the New Mexico Office of the State Engineer (OSE) currently uses a simple Soil Conservation Service (SCS) Modified Blaney-Criddle equation (Blaney and Hanson 1965) to estimate agricultural consumptive use by crops in the County. However, the field scale crop water uses vary significantly from theoretical equation.

Pecan is the major cash crop and a major water user in southern New Mexico. In order to understand pecan water consumption in the Doña Ana County, individual pecan fields were evaluated. Energy-based remote sensing technology was used to calculate water use in various pecan orchards. The study demonstrated the application of remote sensing in water management as well as the impact of farm practices on pecan water use. Preliminary results from the study indicate consumptive use of pecan orchard in the County ranging from 0.46 to 1.6 hectare-m per hectare (1.5 to 5.2 acre-ft per acre).

Objective

The objective of this study was to determine variability of pecan water use in Doña Ana County as influenced by farm practices using remote sensing.

Background

Pecans are one of the major cash crops in Dona Ana County, covering approximately 25 percent of the irrigated acreage in the county. The pecan acreage in the County has increased from 9,288 acres in 1978 to 20,181 acres in 1999, an increase of about 120% in 22 yrs. No statistical acreage has been available since 1999 but observations of farms in the area indicate a continuing increase in pecan orchards acreage. Figure 1 shows the irrigated acreages of various crops in Dona Ana County.

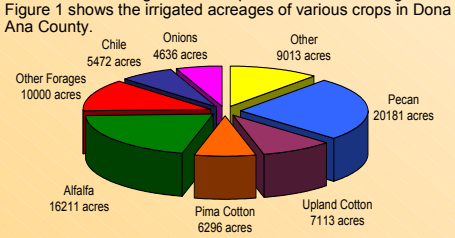

Figure 1. Crop Distribution in Dona Ana County

Methodology

Using the energy balance method (Figure 2), the OPEC system measures sensible heat flux (H) with a Q.7 net radiometer (net radiation, Q), a HFT-3 soil heat flux plate (soil heat flux, G), a sensitive, vertically oriented, propeller anemometer (vertical wind velocity, W) and a fine-wire thermocouple (temperature T). Sensible heat is determined by the eddy covariance method equation:

$$H = \rho c_p COV[wT] = \rho c_p \overline{[w'T']}$$

where,

- ρ density of moist air [g/m^3]
- c_p heat capacity of air at constant pressure [J/g^{0}C]
- w is the vertical air velocity [m/s], and w' is the fluctuation from the mean
- T temperature [^{0} C] of the air, and T' is the fluctuation from the mean
- q is water vapor density [g/m^3], and q' is the fluctuation from the mean
- COV covariance between w and T or q, and the overbar signifies mean of the instantaneous products during the sampling period

Study Location and Instrumentation

A 23 m (75 ft) tower was installed in early June of 2001 in a pecan orchard (Rincon Orchard, R4) located at Stahmann Farms Incorporated (lat: 32-10-36.08 N, long: 106-44-22.39 W; elevation 1144 m) about 26 km (16 miles) south of Las Cruces. The tower is located in a 12 ha (29 acre) orchard surrounded by an average of 14 ha (35 acres) of orchard in each direction. The tree heights were about 16 m (52 ft) tall and range in age from 40 to 60 years old. A one-propeller eddy covariance (OPEC) set of sensors were installed on the tower on June 11, 2001 (DOY 162). Additional sensors for monitoring microclimate were also installed. These sensors monitored air temperature, relative humidity, wind speed and direction. Figure 3 shows the tower configuration and instrumentation.

Q7.1 Net Radiometer

OPEC System

3D Sonic Anemometer

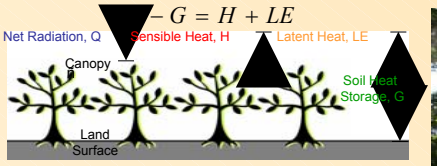

Figure 2. Energy Balance Method

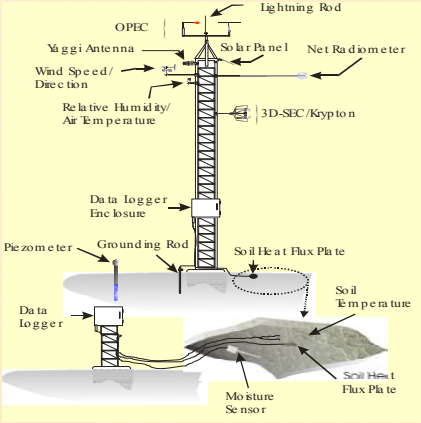

Figure 3. Instrumentation and Tower Setup

Results

Cumulative Evapotranspiration measured in 2006 is shown in Figure 4. Daily ET ranged from about 1.5 mm/d during winter months to a maximum of 9 mm/d in the middle of July. The growing period is from March 30 (DOY89) when the leaves emerged through approximately November 22 (DOY 326) when the leaves senesce. Data for this year is not complete since the pecan growing season is not over, however evapotranspiration measured during the 284 days of data collection thus far this year was 1.25m (4.10 ft). Figure 5 shows an example of the 30 minute flux data that was collected during the year.

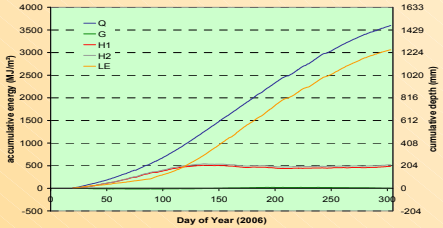

Figure 4. Pecan Cumulative Fluxes

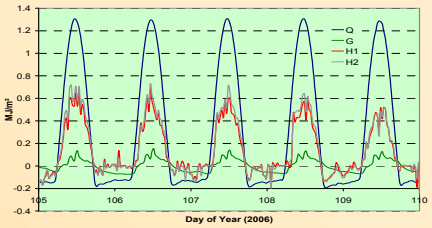

Figure 5. 30 Minute Flux Data

Remotely sensed satellite data from NASA-TERRA ASTER (National Aeronautics and Space Administration - Advanced Spaceborne Thermal Emission and Reflection Radiometer) were used to calculate albedo, Normalized Difference Vegetation Index (NDVI) and surface temperature for year 2002. A surface energy balance model (REEM, regional ET estimation model) was used to calculate ET values from ASTER data. See Figure 6. A crop coefficient map (Kc = ET/ETsz; where Kc is crop coefficient, ET is actual evapotranspiration and ETsz is standardized ET referenced to grass; Allen and others (2005)) is shown in Figure 7. Histogram of ET variation within the county is shown in Figure 8. The ET varies within individual crop fields and within the valley as shown in Figure 8. Comparison of ET estimates by remote sensing and eddy covariance is shown in Table 1.

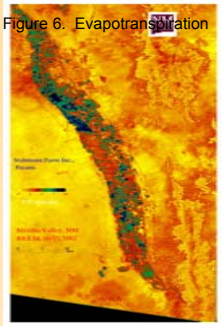

Figure 6. Evapotranspiration

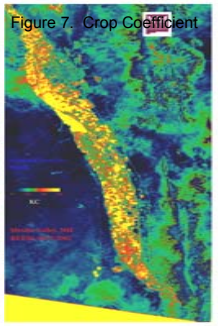

Figure 7. Crop Coefficient

Figure 8. ET Distribution in Dona Ana County

Table 1. ET From OPEC vs Remote Sensing

Date	Measured (mm)	Remote Sensing (mm)	Difference (mm)
5/15/2002	7.07	7.39	0.32
5/15/2002	9.75	9.08	0.67
7/15/2002	6.68	6.62	0.06
8/15/2002	7.21	7.22	0.01
9/15/2002	5.96	5.48	0.48

Conclusion

Pecan ET in Dona Ana County was measured using the eddy covariance technique since 2001. Measured pecan ET of 2006 and regional ET using remote sensing in 2002 is presented. Latent heat or ET in terms of equivalent depth of water was calculated as residual from the energy balance. The ET measured this year (2006) was about 1250 mm (4.1 ft). In addition, regional ET of the County was quantified using remote sensing for 2002. The difference in eddy covariance ET measurements in 2002 compared to remote sensing estimates ranged from 0.01 mm to 0.67 mm. Preliminary results from the study indicated consumptive use of pecan orchards in the County ranging from 0.46 to 1.6 hectare-m per hectare (1.5 to 5.2 acre-ft per acre). Results from the study should assist farmers to better manage water as well as improve crop yield.

References

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