Reprinted from MANAGEMENT OF IRRIGATION AND DRAINAGE SYSTEMS
Sponsored by the Irrigation and Drainage Div./ASCE
Held July 21-23, 1993, Park City, Utah

RADIATION BALANCE and SOIL WATER EVAPORATION of BARE PULLMAN CLAY LOAM SOIL[1/]

T. A. Howell *(Member ASCE)*, J.L. Steiner, S.R. Evett,
A. D. Schneider *(Member ASCE)*, K. S. Copeland, D. A. Dusek, and A. Tunick[2/]

Abstract

Radiation and energy balance components and soil water evaporation were measured for a bare Pullman clay loam soil at Bushland, TX during the 1992 spring and summer as the soil dried following irrigation and rain. Bare soil albedo for the Pullman soil varied from 0.11 to 0.13 for wet to drying conditions in May. However, during the July measurement period following a rain event, soil albedo increased to 0.18 upon drying due to the formation of a surface crust and smoothing of the surface by the rain. Measured net radiation agreed with the measured short- and long-wave radiation components. Emitted ground long-wave radiation measured by a pyrgeometer was slightly greater than computed emitted radiation using surface temperature and the Stefan-Boltzmann equation. Sky emissivity was influenced by clouds; however, for clear'sky conditions, a Brunt type emissivity equation based on screen-level vapor pressure was more representative than equations based on screen-level air temperature. For wet conditions, the latent heat flux accounted for over 80% of net radiation while for the drying soil latent heat flux was less than 25% of net radiation. Three models of soil evaporation all estimated daily evaporation accurately for these conditions. A mechanistic soil water-energy simulation model, ENWATBAL, accurately estimated net radiation and soil water evaporation.

Introduction

Radiant energy partitioning affects net radiation (Monteith and Szeicz, 1961), which is one of the main terms in the energy balance. Latent heat flux is the principle factor in the energy balance of wet surfaces, but for drying soil sensible and conductive heat fluxes may dominate. Evaporation and radiation balances of a drying soil surface affect its water and thermal balance. This paper examines evaporation and the radiation and energy balance of a bare clay loam soil following irrigation and rain for two periods during the spring and summer of 1992 and compares three evaporation models.

[1/] Contribution from USDA-Agricultural Research Service, Southern Plains Area, Conservation and Production Research Laboratory, Bushland, Texas and US Army Research Laboratory, Battlefield Environment Directorate, White Sands Missile Range, New Mexico.

[2/] Agricultural Engineer, Soil Scientist, Soil Scientist (Collaborator), Agricultural Engineer, Biological Technician, and Agronomist, USDA-ARS, P.O. Drawer 10, Bushland, TX 79012, and Meteorologist, US Army Research Laboratory, Battlefield Environment Directorate, AMSRL-BE-S, White Sands Missile Range, NM 88022-5501.

Methods

Field Experiment. Field studies were conducted at the USDA-ARS laboratory at Bushland, TX (35° N Lat, 102° W Long, 1,170 m MSL) during May (DOY 132-141) and July (DOY 190-196) 1992. The soil at this site is Pullman clay loam (fine, mixed thermic Paleustoll). A weighing lysimeter (Marek et al., 1988) centered in a 4.7 ha field was used to measure evaporation. The field slopes less than 0.15% to the SE, has no nearby vertical obstructions, and has over 1,000 m of unobstructed upwind fetch of either cropped or fallow agricultural fields in the predominant summer wind direction (SSW). An automated weather station, located over an irrigated, mowed grass plot (Dusek et al., 1987) about 350 m ESE from the lysimeter, provided weather data for the evaporation models.

Net radiation (R_n) is defined as

$$R_n = R_{si} - R_{sr} + R_{ls} - R_{le} \qquad \text{...[1]}$$

where R_{si} is incident solar radiation, R_{sr} is reflected solar radiation, R_{ls} is incident sky long-wave radiation, and R_{le} is emitted ground long-wave radiation with all terms in W m^{-2}. Table 1 describes instruments and their deployment to measure the radiation components. Short-wave reflection (albedo; α) was computed as R_{sr}/R_{si}. In addition, R_{le} was computed from measured surface temperature (T_s) using the Stefan-Boltzmann equation with the emissivity assumed to be 0.98. R_n, R_{sr}, and T_s were measured at the lysimeter and R_n, R_{si}, R_{sr}, R_{li}, R_{le}, and T_s were measured over a similar surface at a radiation mast about 15 m S from the lysimeter. The pyranometer calibration factors were adjusted to match the Eppley [*] PSP calibration. The pyrgeometer thermopile signal was corrected for both long-wave emitted radiation and long-wave emitted radiation from the dome as follows:

$$R_l = C_t E + \sigma T_b^4 - (k\,\sigma)(T_d^4 - T_b^4) \qquad \text{...[2]}$$

where R_l is the corrected long-wave radiation in W m^{-2}, C_t is the thermopile calibration factor in W m^{-2} mV^{-1}, E is the output signal in mV, T_b is the pyrgeometer thermopile temperature in K, T_d is the dome temperature in K, and k is a correction factor taken as 1.0 (Albrecht and Cox, 1977). *[Note: Post-experiment shading experiments were unsuccessful in identifying a precise value for k, and some potential error may still exist in our data for R_{ls} but the potential error associated with R_{le} would be considerably less.]* At the radiation mast, air temperature, relative humidity, wind speed, and wind direction were also measured and recorded at 1 Hz frequency by a Campbell Scientific CR-21X and averaged for 15 min.

T_s, R_n, and R_{sr} were measured at the lysimeter similarly to the radiation site (Table 1). Soil heat flux was measured with four heat flux plates buried at 50 mm depth (G_{50}), and soil temperature was measured at 10 mm and 40 mm depths with four sets of Cu-Co grounded thermocouples wired in parallel (to average both depths). Soil heat flux at the ground surface (G_0) was computed as

$$G_0 = G_{50} + 0.05\, C_s\, (\Delta T_t/\Delta t) \qquad \text{...[3]}$$

where ΔT_t is the mean temperature change in C from the previous time period, and Δt is the time period length in s, and C_s is the specific heat capacity in J m^{-3} C^{-1}. C_s was estimated as $(1.125 + 4.4\,\theta_{20\text{-}40})\times10^6$ where $\theta_{20\text{-}40}$ is the mean soil water content in m^3 m^{-3} at the 20 mm and 40 mm depths measured by time domain reflectometry (Evett et al., 1993). The lysimeter mass was computed from load cell measurements and averaged for 15

---

[*] Mention of trade names does not imply endorsement by either USDA-ARS or US ARMY, and the names are provided soley for identification purposes.

Table 1. Instruments and deployment information.

Parameter	Instrument	Manufacturer (Model)	Elevation (Depth)	Site
R_s	pyranometer	Eppley (PSP)	1 m	Radiation Mast
R_{sr}	pyranometer	Eppley (8-48)	1 m (I */)	Radiation Mast Lysimeter
R_{ls}	pyrgeometer	Eppley (PIR)	1 m	Radiation Mast
R_{le}	pyrgeometer	Eppley (PIR)	1 m (I)	Radiation Mast
R_n	net radiometer	REBS (Q*6)	1 m	Radiation Mast Lysimeter
T_s	IRT	Everest (4000)	1 m nadir view angle	Radiation Mast Lysimeter
T_a RH	thermistor foil capacitor	Rotronics (HT225R)	2 m	Radiation Mast
U_2	dc generator cups	R.M. Young (12102)	2 m	Radiation Mast
U_d	potentiometer vane	R.M. Young (12302)	2 m	Radiation Mast
T_t	thermocouple Cu-Co	Omega (304SS)	(10 mm) (40 mm)	Lysimeter (4) **/
G_{50}	flux plates thermopile	REBS (TH-1)	(50 mm)	Lysimeter
θ_{20} θ_{40}	3-wire TDR probe	local lab. model	(20 mm) (40 mm)	Lysimeter
E_m	lever-scale load cell	Alphatronics (SL50LB)	na	Lysimeter

*/ I designates instruments that were inverted and facing the ground.
**/ Numbers indicate replicate sensors.

min. The evaporation rate was computed as the difference in the 15 min averaged mass values and smoothed using a 5-point equally weighted running mean. The latent heat flux (LE in W m^{-2}) was computed as

$$LE = -1x10^6 \; L \; (\Delta E_m / \Delta t) \qquad \ldots[4]$$

where L is the latent heat of vaporization in MJ/kg [2.501 - 2.361x10^{-3} T_a, where T_a is the 2-m air temperature in C], ΔE_m is the change in lysimeter specific mass in kg m^{-2} [1 kg m^{-2} = 1 mm] over time period, and Δt is the time period length in s. Lysimeter site sensors were measured and recorded by a Campbell Scientific CR-7X at a frequency of 0.5 Hz and averaged for 15 min.

The energy balance was defined as

$$R_n + LE + G + H = 0 \qquad \ldots[5]$$

where H is the sensible heat flux in W m^{-2}, and all terms are defined as positive toward the soil surface, and H was computed as the residual component.

Soil roughness was measured before and after the rains during the July time period using the chain method (Saleh, 1993). Soil roughness was not measured for the May time period. The field was tilled with conventional tillage equipment (sweep and disk plows) to control weeds prior to experimental measurement periods.

Evaporation Models. Three evaporation models were compared to measured evaporation. The Ritchie (1972) 2-stage daily evaporation model used in the CERES-Maize model (Jones and Kiniry, 1986) computes daily potential evaporation using a modified Priestley-Taylor type equation and accounts for stage 1 (energy limited) and stage 2 (soil-dependent) evaporation conditions. The stage 1 evaporation amount of 8 mm was used for the Pullman soil, and bare soil α was assumed to be 0.13 for the Pullman soil.

The Kimberly crop coefficient method (Wright, 1981) was used to compute soil evaporation with a basal crop coefficient (K_{cb}) of 0.15 and t_d (days required for the soil surface to dry) of 3 *[Note: Wright recommended a t_d value of 7 for a clay loam soil; however, this value would certainly be site and possibly seasonally specific.]* as

$$E = ET_r \{K_{cb} + (1 - K_{cb})[1 - (t/t_d)^{1/2}] f_w\} \quad \ldots[7]$$

where E is evaporation in mm d^{-1}, ET_r is the reference evapotranspiration (ET) in mm d^{-1} [alfalfa 0.5 m tall was used with the REF-ET program of Allen (1990)] for the Kimberly modified Penman combination equation, f_w is the fraction of soil wetted [assumed to be 1.0], and t is the number of days after wetting.

The third model, ENWATBAL (Evett and Lascano, 1993), is a one-dimensional mechanistic model of the soil-plant-atmosphere continuum. The soil profile was defined with 27 layers (finite differences) with 200 mm thick layers near the lower boundary at 2.1 m and 1 mm thick layers near the surface and with two soil horizons (0 to 0.2 m and 0.2 to 2.1 m) with different hydraulic properties. Initial conditions for soil water content and temperature profiles were set by measurements at the lysimeter site. Two model runs were performed -- the first from DOY 131 to 140 and the second from DOY 190 to 197. A maximum time step of 30 s was used in the variable time step algorithm. R_{sr} is calculated using the α which was characterized as a stepwise linear function of soil water content of the top soil layer with the upper and lower limits of α derived from measurements from this experiment. R_{ls} is computed using the Idso (1981) sky emissivity equation, and LE is calculated based on the absolute humidity gradient between soil pore air space in the top layer and humidity at 2 m using a stability corrected aerodynamic resistance using T_s from the previous time step.

Results and Discussion

Environmental conditions during the experiments are summarized in Table 2, along with the daily reference ET by the Kimberly Penman combination equation (Allen, 1990) and a modified Priestley-Taylor type equation (Jones and Kiniry, 1986) which were used in the Kimberly crop coefficient and CERES-Maize soil water evaporation models, respectively. Irrigation applied on DOY 132 did not greatly change the soil surface roughness although it was not measured. On DOY 190 before the rains in July, the soil roughness was 15% *[Note: A smooth surface has roughness of 0%.]* and it decreased to 4% on DOY 195 after the rains. Random roughness before the rain was almost twice as large as oriented roughness. After the rain, random roughness was over 3 times as large as oriented roughness. Surface roughness affected the α, evaporation, and energy partitioning as discussed later.

Radiation Balance. Albedo exhibited a decline about 10% or less with increasing solar elevation angles, contrary to the 17-25% decline reported by Monteith and Szeicz

Table 2. Summary of weather data measured at the weather station during the experimental periods and computed daily reference evapotranspiration and potential evapotranspiration.

DOY	T_{max}	T_{min}	T_{dew}	R_{si}	U_2	Rain (Irrigation)	ET_r KPen */	ET_o CERES **/
	C			MJ m^{-2}	m s^{-1}	mm		
132	26.4	5.4	2.3	28.3	2.4	(32.0)	7.5	6.3
133	31.5	9.0	2.0	27.1	3.0		9.2	6.6
134	27.9	12.4	8.5	22.9	4.4		8.3	5.5
135	30.1	11.8	7.4	26.6	3.8		9.0	6.5
136	29.8	13.4	8.2	25.2	4.1	3.1	8.9	6.2
137	26.1	11.9	7.5	25.9	4.7		8.9	6.1
138	25.0	10.6	8.3	26.0	4.8		8.4	5.9
139	25.3	9.6	7.9	26.9	2.5		7.1	6.1
140	26.5	11.7	8.2	25.5	3.1		7.4	5.0
141	24.3	12.2	10.2	17.4	4.2	15.2	6.2	4.0
190	33.9	17.7	9.2	28.7	5.3		12.7	7.7
191	33.5	15.9	11.7	28.0	5.3	27.9	12.2	7.4
192	30.1	17.6	15.4	24.3	4.2	6.9	8.7	6.2
193	30.5	17.2	15.2	26.8	6.8		11.5	6.9
194	32.1	19.0	13.5	27.9	7.2		13.6	7.4
195	31.4	17.0	12.8	25.9	3.7		9.7	6.7
196	30.5	14.5	12.9	26.8	2.7		8.6	6.7
197	34.3	18.7	13.1	26.8	4.5	0.3	11.4	7.2

*/ Kimberly Penman alfalfa (0.5 m height) reference ET (Allen, 1990).
**/ CERES-Maize (Jones and Kiniry, 1986) potential ET with soil α = 0.13.

(1961) for bare soil in Great Britain in June. Albedo (solar elevation angles > 30°) declined following either rain or irrigation to 0.10 ± 0.01; however, the dry soil α was consistently 0.13 in the May period. Graser and van Bavel (1982) report that soil α changed over a relatively narrow range of soil water potential basically like a step function; however, our data were too scattered to verify their results. Soil roughness affects α as well. In July, α increased from 0.12 to 0.18 as the soil dried after rains on DOY 191 and 192 that created a smooth, crusted surface.

Measured R_n was consistent with the radiation component measurements although some uncertainty remains in the pyrgeometer corrections for dome heating, particularly for R_{ls}. This uncertainty is less than 50 W m^{-2} and occurs when R_n exceeds 500 W m^{-2}, and this uncertainty could be attributed to net radiometer problems as well. The combined period linear regression between the measured component R_n (CR_n) and measured R_n was CR_n = 21.8 + 0.937 R_n with r^2 = 0.99 and $S_{y/x}$ of 12.8 W m^{-2}. R_{le} estimated with the Stefan-Boltzmann equation and measured T_s (CR_{le}) agreed rather well with measured R_{le} [combined time period regression: CR_{le} = 17.8 + 0.997 R_{le} with r^2 = 0.99 and $S_{y/x}$ = 6.3 W m^{-2}. These minor differences could be attributed to several factors -- 1) soil emissivity assumption, 2) IRT errors, or 3) pyrgeometer errors -- all of which are difficult to isolate.

Sky emissivity $\{R_{ls}/[\sigma (T_a + 273.1)^4]\}$ was computed from measured R_{ls} data (Figure 1). Data were not screened to separate clear sky and day- and night-time values (planned for future analysis). The lower set of observations would be indicative of clear sky values, and data scattered above these values are attributed to cloudy conditions. The Brunt (1932) and Brutsaert (1982) emissivity equations plotted in Figure 1 illustrate the close association found between sky emissivity and 2-m vapor pressure. Considerably greater scatter was evident when the sky emissivity data were compared to 2-m air temperature and corresponding equations (Swinbank, 1963 and Idso and Jackson, 1969). Hatfield et al. (1983) reported similar results and suggested that sky emissivity be estimated using either vapor pressure alone or vapor pressure in combination with air temperature such as the Idso (1981) equation. In addition, clouds affect sky emissivity; future analysis will investigate the impact of clouds and cloud type on net long-wave radiation.

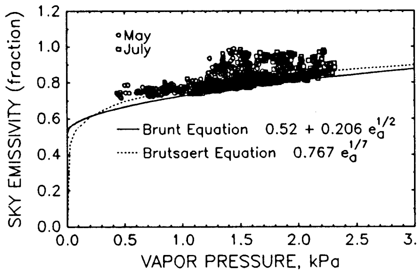

Figure 1. Sky emissivity relationship to vapor pressure (2 m) for all sky conditions compared to the Brunt and Brutsaert equations.

ENWATBAL estimates of R_n (ER_n) agreed well with measured R_n with linear regressions of $ER_n = -26.2 + 0.97\ R_n$ and $r^2 = 0.97$ in May and $ER_n = -19.1 + 0.94\ R_n$ and $r^2 = 0.97$ in July. Improvements in ENWATBAL performance could possibly include refinements in α characterizations which are important for estimating R_n accurately. In addition, individual radiation components estimated by ENWATBAL have not yet been compared to measured parameters.

Energy Balance. Surface conditions of water content, available energy, and roughness affect the energy balance through net radiation and energy partitioning into H, LE, and G (Table 3). DOY 133 (the day after an irrigation) and DOY 196 (4 days after

Table 3. Daily energy balance parameters, evaporation, and evaporation model estimates.

DOY	LE	G	R_n	H	E_l [1]	E_{CERES} [2]	E_{Kc} [3]	E_{ENWAT} [4]
	MJ m^{-2}				mm			
133	-13.7	-0.5	16.3	-2.1	5.62	6.60	6.01	5.32
134	-4.5	-0.9	13.4	-8.0	1.86	3.86	3.31	1.79
135	-4.7	-1.3	14.3	-8.3	1.93	1.82	2.02	1.04
136	-6.9	-0.2	15.4	-7.4	3.23	2.56	3.55	2.89
137	-2.5	-0.2	14.7	-11.9	1.03	0.84	1.99	0.86
138	-2.7	-0.2	14.5	-11.6	1.10	0.76	1.26	0.59
139	-2.0	-0.7	14.6	-11.9	0.82	0.70	1.07	0.49
140	-1.5	-0.6	13.4	-11.3	0.59	0.65	1.11	0.42
Total					16.18	17.79	20.32	13.40
192	-13.8	1.3	18.1	-4.6	6.31	6.20	5.68	6.72
193	-14.4	0.7	18.7	-5.0	6.01	6.90	4.59	6.75
194	-7.4	-0.4	16.6	-8.8	2.97	4.88	3.05	2.95
195	-4.5	-0.8	13.6	-8.3	1.86	1.38	1.46	1.88
196	-3.6	-0.5	14.1	-10.0	1.44	1.07	1.29	1.44
197	-2.9	-0.1	14.8	-11.8	1.20	0.92	1.71	0.23
Total					19.79	21.35	17.78	19.97

1/ Lysimeter evaporation. 2/ CERES-Maize evaporation model.
3/ Kimberly crop coefficient model. 4/ ENWATBAL evaporation model.

rain) illustrate these differences (Figure 2). DOY 133 had 5.6 mm of evaporation, and the minimum LE was -500 W m^{-2} or 80% of R_n with G and H being minor components. However, on DOY 196 with a drier and smoother soil surface, LE was less than half of H during the day and only 25% of R_n. The minimum LE was about -100 W m^{-2}, and the daily E was only 1.4 mm. The lower R_n for DOY 196 compared to that for DOY 133 is attributed to α differences and greater R_{le} from the drier surface.

ENWATBAL over-estimated soil water contents in the surface to 100 mm depth, partly attributed to input soil hydraulic characteristic information; however, ENWATBAL successfully simulated the observed dynamic changes in soil water content. ENWATBAL also over-predicted soil heat flux, but this could be expected since it over-predicted soil water contents. ENWATBAL followed observed daily evaporation trends well (Figure 3) and generally simulated diurnal LE trends well.

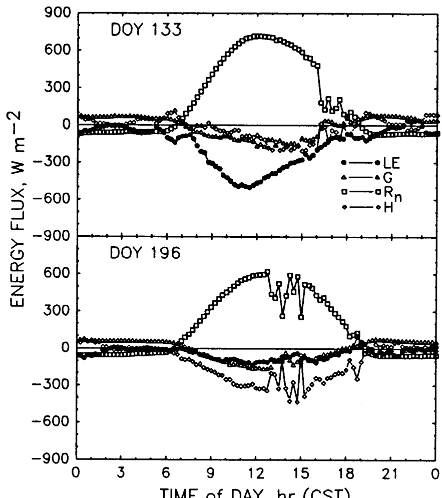

Figure 2. Energy balance parameters on DOY 133 (day following an irrigation) and DOY 196 (4 days after last rain).

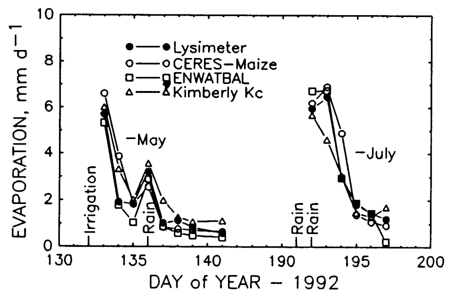

Figure 3. Daily evaporation measured by the weighing lysimeter compared to model estimates.

Evaporation Models. All three evaporation models compared well to the measured daily E (Figure 3; Table 3). None of the models used fitted or optimized parameters, but they all used best available *a priori* information for soil parameter characterizations. However, the basis for the different models remain distinctly different. The ET_o used in the CERES-Maize evaporation model was considerably lower than the alfalfa ET_r used in the Kimberly crop coefficient model (Table 2). ENWATBAL being a more complex simulation model required more soil input information as well as half-hourly weather data. The combined period linear regressions between daily soil water evaporation (E_l) and the model predictions were as follow:

Regression Equation	r^2	$S_{y/x}$ mm d^{-1}
$E_{CERES} = 1.097\ E_l$	0.96	0.78
$E_{Kc} = 0.956\ E_l$	0.95	0.74
$E_{ENWAT} = 1.117\ E_l - 0.50$	0.98	0.37

ENWATBAL had the smallest standard error but had a small offset bias (-0.50 mm d^{-1}; P $\leq$ 0.01099). When the ENWATBAL regression was forced through the origin, its slope was 0.994, adjusted r^2 was 0.99, and $S_{y/x}$ increased to 0.48 mm d^{-1}. The Kimberly crop coefficient method over-predicted the drier soil water evaporation rates when the soil water evaporation is essentially equated to $K_{cb}xET_r$ (with the estimated K_{cb} of 0.15 for the bare soil). For July, ENWATBAL closely followed measured trends, and the CERES-Maize and Kimberly crop coefficient methods performed adequately, particularly considering their empirical, simplified derivations.

References

Albrecht, B. and S.K. Cox. 1977. Procedures for improving pyrgeometer performance. J. Applied Met. 16:188-197.

Allen, R.G. 1990. REF-ET: reference evapotranspiration calculator, V1.1. Utah State Univ. Found., Utah State Univ., Logan.

Brunt, D. 1932. Notes on radiation in the atmosphere. Quart. J. Roy. Met. Soc. 58:389-418.

Brutsaert, W. 1982. Evaporation into the atmosphere. D. Reidel Publ. Co., Boston, MA.

Graser, E.A. and C.H.M. van Bavel. 1982. The effect of soil moisture upon soil albedo. Agric. Met. 27:17-26.

Dusek, D.A., T.A. Howell, A.D. Schneider, and K.S. Copeland. 1987. Bushland weighing lysimeter data acquisition systems for evapotranspiration research. ASAE Paper No. 87-2506. Am. Soc. Agric. Engrs., St. Joseph, MI.

Evett, S.R., T.A. Howell, J.L. Steiner, and J.L. Cresap. 1993. Evapotranspiration by soil water balance using TDR and neutron scattering. *In*: Proceedings of the 1993 ASCE Irrigation and Drainage Conference, Am. Soc. Civil Engrs., New York, NY. [this volume]

Evett, S.R. and R.L. Lascano. 1993. ENWATBAL.BAS: A mechanistic evapotranspiration model written in compiled basic. Agron. J. 85(3; May-June):(in press).

Hatfield, J.L., R.J. Reginato, and S.B. Idso. 1983. Comparison of long-wave radiation calculation methods over the United States. Water Resour. Res. 19:285-288.

Idso, S.B. and R.D. Jackson. 1969. Thermal radiation from the atmosphere. J. Geophys. Res. 74:5397-5403.

Idso, S.B. 1981. A set of equations for full-spectrum and 8- to 14-μm and 10.5- to 12.5-μm thermal radiation from cloudless skies. Water Resour. Res. 17:295-304.

Jones, C.A. and J.R. Kiniry. 1986. CERES-Maize a simulation model of maize growth and development. Texas A&M Univ. Press, College Station.

Marek, T.H., A.D. Schneider, T.A. Howell, and L.L. Ebeling. 1988. Design and installation of large weighing monolithic lysimeters. Trans. ASAE 31:477-484.

Monteith, J.L. and G. Szeicz. 1961. The radiation balance of bare soil and vegetation. Quart. J. Roy. Met. Soc. 87:159-170.

Ritchie, J.T. 1972. Model for predicting evaporation from a row crop with incomplete cover. Water Resour. Res. 8:1204-1213.

Saleh, A. 1993. Soil roughness measurement: chain method. J. Soil and Water Conserv. 48:[in press].

Swinbank, W.C. 1963. Long-wave radiation from clear skies. Quart. J. Roy. Met. Soc. 89:339-348.

Wright, J.L. 1981. Crop coefficients for estimates of daily crop evapotranspiration. pp. 18-26. *In*: *Irrigation Scheduling for Water & Energy Conservation in the 80's.* Proceedings of the Am. Soc. Agric. Engrs. Irrigation Scheduling Conference. Am. Soc. Agric. Engrs., St. Joseph, MI.