NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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Using Modified Atmometers (ET_{gage}®) for Irrigation Management

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This NebGuide describes the atmometer (evapotranspiration gauge) and explains how it can be used for irrigation scheduling. Examples are provided to show how information collected with an atmometer can be used to estimate crop water use from corn and soybean.

Estimation of evapotranspiration for specific crops (ETc) is important for irrigation scheduling and agricultural water management. ETc for crops such as corn and soybean can be estimated using the following equation:

$$ETc = ETo \times Kc \qquad \text{(Equation 1)}$$

where ETo is the evapotranspiration (ET) of a reference crop (usually grass or alfalfa), which is commonly called reference ET. Both ETc and ETo can be expressed in units of water depth per unit of time, such as inches per day, inches per week, or inches per month. ETo is usually estimated using equations that use weather variables as inputs. These variables include solar radiation, air temperature, wind speed, and relative humidity. Kc is an adjustment factor called the "crop coefficient," which mainly depends on the type of crop and its growth stage. In some instances Kc also can be adjusted to account for a reduction of ETc when the crop is under water stress or an increase in evaporation when the soil surface is wet due to rain or irrigation. Estimating ETo from climate variables, however, can be a difficult task for growers, consultants, and extension educators who may not be familiar with the use of complex energy balance equations to estimate ETo. Additionally, in some situations, climate variables may not be readily available for a given location to make ETo computations.

Alternative methods of estimating ETo do not require complex calculations or sophisticated data recording equipment. Devices that measure the evaporation of water such as atmometers or evaporation pans may be useful. An evaporation pan is a large (4 ft in diameter) open container filled with water and used to measure how much water evaporates during a given period. The water surface in the evaporation pan is open to atmospheric conditions and offers little resistance to evaporation; however, when water evaporates from plants, some water has to travel through the plant before it is transpired as water vapor into the atmosphere. The plant shows some resistance to evaporation that limits ET in a way that is not represented by the open water surface of the evaporation pan.

Another alternative for estimating ETo is an atmometer which is designed to simulate ET from a plant canopy in a way that agrees closely with a plant's resistance to ET. Atmometers have been gaining acceptance among irrigators. The atmometer described here is a modified Bellani Plate atmometer marketed under the brand name ET_{gage}®[1] (or ETG). The simplicity of use and ease of interpretation of the data from the ETG make it a practical tool that farmers and consultants can use to estimate the crop water use of specific crops. They can then use this information to improve their irrigation management practices. *Figure 1A-B* shows an atmometer, its water reservoir and the evaporation plate mounted on top of the reservoir.

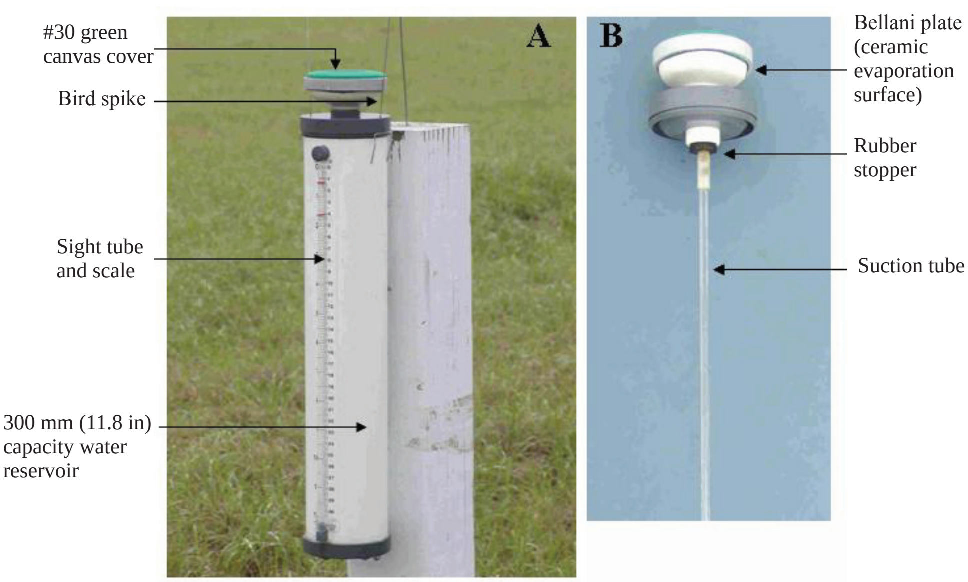

Figure 1. Model A ETG at 40 inches above ground in a pasture (A) and basic components of the ETG (B).

[1]Commercial names are provided only for the convenience of the reader and do not imply endorsement by the authors or the University of Nebraska–Lincoln.

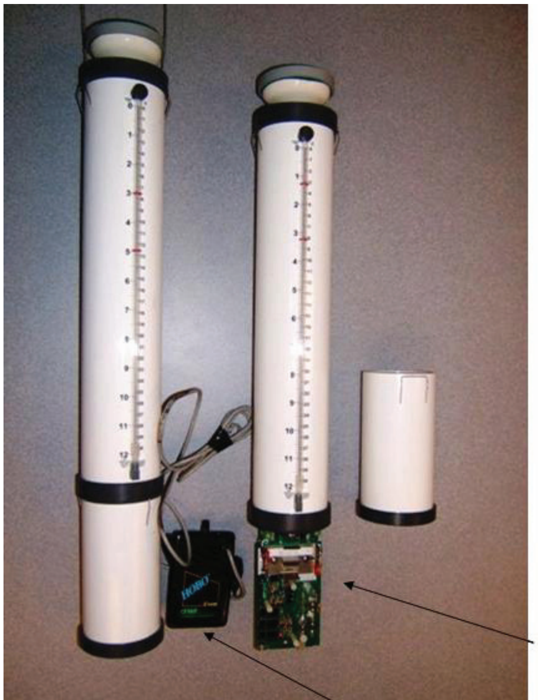

Figure 2. Model E electronic ETG connected to a datalogger for continuous recording of evapotranspiration.

Description and Operation of the ETG

This section provides a general description of the ETG and is not meant to be a substitute for the operating manual for specific ETG models. Each atmometer comes with an operation manual that describes in detail how to install and use the device.

Most commercial ETG models are similar in operational principle. The ETGs marketed by C&M Meteorological Supply (Colorado Springs, Colorado), the ETG Company (Loveland, Colorado), Calsense (Carlsbad, California), and others, are modified atmometers that consist of a canvas-covered ceramic evaporation plate (Bellani plate) mounted on a water reservoir (*Figure 1A*). The reservoir capacity is 11.8 inches deep. The key to the accuracy of the atmometer is the green canvas (Gore-Tex) material that covers the ceramic plate. The canvas cover mimics the absorption of solar radiation characteristics of a plant leaf and controls the rate of evaporation. The type of canvas cover can be changed to simulate the evapotranspiration rate of different plant surfaces. For example, No. 54 green canvas cover is used to estimate alfalfa-reference ET, whereas No. 30 green canvas material simulates grass-reference ETo. The canvas covering creates a diffusion barrier (resistance) that controls the evaporation rate, simulating the rate of evaporation from a healthy leaf in a well-watered plant community.

Water is provided to the ceramic plate (or disk) of the ETG by suction through a glass or plastic tube (*Figures 1A* and *B*). A rubber stopper secures a length of the glass tubing from the bottom of the ETG reservoir to the ceramic plate. In some models, a check valve is attached to the bottom of the plastic supply tube. The check valve at the lower end of the glass tube allows water to flow upward to the ceramic plate but not backward. The check valve keeps the ceramic cup charged but prevents absorption of rainwater through the Bellani plate. The ETG reservoir is ventilated by two very small holes (0.06 inch in diameter) drilled at the upper end of the PVC pipe. Negligible water loss occurs through these holes.

There are manual and electronic models of ETG, depending on whether readings are taken manually or are automatically recorded. In the manual model (Model A) the depth of water inside the ETG is read from a graduated sight tube. Reading the sight tube is as easy as reading a rain gauge. In addition to the manually read sight tube, the electronic model (Model E) automatically records a signal every time a fixed depth of water (0.01 inches) evaporates from the ETG (*Figure 2*). A datalogger with an event counter is used to record the readings. Data in the datalogger memory can later be downloaded to a laptop computer or a hand-held personal computer. Compared with the manual model, the electronic ETG eliminates potential human error which can occur when reading the sight tube. The difference in cost between the two models, however, is significant. The cost of the manual model is approximately $300, while the electronic model costs about $900. A grower or consultant can use any of these ETG models to quantify how much water evaporated during a given period; this evaporation is related to the weather conditions during the measurement period. This information can then be used to make better irrigation management decisions.

Site Selection, Installation, Use and Maintenance

The ETG is easy to install and requires little maintenance. It provides water use information that is especially useful for areas without weather stations. Users can install an ETG to make irrigation management decisions for more than one field within a radius of a few miles. Thus, several growers within an area could share the same ETG for irrigation scheduling if they have similar management practices. In some cases, the ET data gathered from an ETG may be more representative of local crop water use and surrounding microclimate than information from a weather station located 20-30 miles from that field.

The ETG usually is mounted on a wooden post, approximately 40 inches above the ground. It should be located at a site representative of the field conditions. For easy access, however, it is usually located at the edge of an irrigated field or service road. It should be placed so that the ceramic plate is not shaded, which could reduce the evaporation rate. It should not be installed near tall trees, buildings, or tall crops that may prevent full exposure of the gauge to prevailing winds and other environmental factors affecting evapotranspiration. The ETG should not be placed in a dry environment where the air humidity and temperature may differ from those of an irrigated field.

The ETG reservoir should only be filled with distilled water which can be purchased from local grocery stores. This will prevent accumulation of salts in the ceramic plate that could reduce its porosity and affect the estimated evaporation rate. During winter, the ETG should be stored indoors to prevent freezing and breakage. It is usually installed in the field when corn is approximately 12 to 15 inches tall and removed when the crop is at full maturity or at the end of the irrigation season. The canvas cover needs to be checked at least twice a month to remove any spider webs, dust, or other particles. The bird spikes that come with the ETG should be in place to discourage birds from perching on the plate. Each ETG comes with a manual rain gage, which should be installed and read at the same time as the ETG and then emptied. The user needs to read the ETG at the same time each day, usually early in the day (8:00-8:30 a.m.), for con-

Table I. Alfalfa-based crop coefficients (Kc) at the beginning of each growth stage for corn, soybean, and wheat (High Plains Regional Climate Center, 2005).

Corn		*Soybean*		*Wheat*	
Growth Stage	*Kc*	*Growth Stage*	*Kc*	*Growth Stage*	*Kc*
2 leaves	0.10	Cotyledon	0.10	Emergence	0.10
4 leaves	0.18	First Node	0.20	Visible Crown	0.50
6 leaves	0.35	Second Node	0.40	Leaf Elongation	0.90
8 leaves	0.51	Third Node	0.60	Jointing	1.03
10 leaves	0.69	Beginning Bloom	0.90	Boot	1.10
12 leaves	0.88	Full Bloom	1.00	Heading	1.10
14 leaves	1.01	Beginning Pod	1.10	Flowering	1.10
16 leaves	1.10	Full Pod	1.10	Grain Fill	1.10
Silking	1.10	Beginning Seed	1.10	Stiff Doug	1.00
Blister	1.10	Full Seed	1.10	Ripening	0.50
Dough	1.10	Beginning Maturity	0.90	Mature	0.10
Beginning dent	1.10	Full Maturity	0.20		
Full dent	0.98	Mature	0.10		
Black layer	0.60				
Full maturity	0.10				

sistency in ET rate and to have a complete ET value of the previous day.

Irrigation Scheduling With the ETG

This section describes how to use the ETG to schedule irrigations. As water evaporates from the ETG, the water level in the reservoir and sight tube decreases. The ETG has two movable red rubber bands on the sight tube that can be used to mark water levels at different times. The top rubber band could be used to mark the initial water level after an irrigation event and the other could be used to indicate the water level where the next irrigation is needed. The ETo can be estimated by recording the decrease in water level over a period of days. This period can be three to five days or longer, depending on the capacity of the irrigation system and the stage of the growing season. The longer the period, the larger the ETo and the more soil water would need to be replenished to meet crop water demand. The ETo estimated by the ETG should be multiplied by the Kc value to determine crop water use (ETc) *(Equation 1)*. Different Kc values will be needed for each crop at different growth stages. When an alfalfa-based canvas cover (No. 54) is used with the ETG, the alfalfa-reference Kc values need to be used to determine ETc for a given crop. For Nebraska conditions, the alfalfa-based Kc values used by the High Plains Regional Climate Center (HPRCC) for corn, soybean, and wheat are listed in *Table I.*

When using the ETG to schedule irrigation, the net irrigation requirements (NIR) and gross irrigation requirements (GIR) during a given time can be calculated as:

NIR = ETc – Rainfall (Equation 2)

GIR = NIR / IE (Equation 3)

IE is the efficiency of the irrigation system expressed as a ratio ranging from 0-1.0. The following examples illustrate how the ETG can be used for irrigation scheduling.

Example 1

A corn crop is at the 12-leaf growth stage and the water level in the ETG (with a No. 54 canvas cover) sight tube decreased 1.50 inches during the 7-day period since the last irrigation. Determine the actual crop ET (ETc), the net irrigation requirements (NIR) for the period, and the gross irrigation requirements (GIR) if irrigation is applied with a furrow system with an irrigation efficiency of 60 percent (IE = 0.60). Rainfall = 0.

ETo = 1.50 inches (evaporation from the ETG)

Kc = 0.88 (from *Table I* for the 12-leaf stage)
ETc = ETo x Kc (Equation 1) ETc = 1.50 inches x 0.88 = **1.32** inches
NIR = ETc – Rainfall (Equation 2) → NIR = 1.32 inches – 0 = **1.32** inches
GIR = (NIR) / (IE) (Equation 3) → GIR = 1.32 inches/ 0.60 = **2.20** inches

Example 2

A corn crop is at the silking stage. The water level in the sight tube of the ETG dropped 1.60 inches during a 5-day period since the last irrigation. During this period, there was 0.5 inch of rain. Determine the net and gross irrigation requirements if a drip irrigation system with a 95 percent irrigation efficiency is used.

IE = 0.95 Rainfall = 0.5 inches
ETo = 1.60 inches (evaporation from the ETG)
Kc = 1.10 (from *Table I* for silking stage)
ETc = ETo x Kc (Equation 1) → ETc = 1.60 inches x 1.10 = **1.76** inches
NIR = ETc – Rainfall (Equation 2) → = 1.76 in – 0.5 inches = **1.26** inches
GIR = (NIR) / (IE) (Equation 3) → GIR = 1.26 inches/ 0.95 = **1.33** inches

Calculate the gross irrigation requirements if a furrow system with a 60 percent irrigation efficiency is used instead of the drip system.
GIR = (NIR) / (IE) (Equation 3) → GIR = 1.26 inches/ 0.60 = **2.10** inches

Example 3

Corn crop is at the 8-leaf stage and is growing in a silt loam soil. Determine the amount of water that should evaporate from the ETG (ETo) before the next irrigation is started, assuming no rainfall and that a crop water use (ETc) of 1.3 inches will be allowed before irrigating.

ETc = 1.3 inches (crop water use)
Kc = 0.51 (from *Table 1* for the 8-leaf stage)
From Equation 1, ETo = ETc / Kc → ETo = 1.3 inches /0.51 = **2.55** inches

If the user sets the lower red marker 2.55 inches below the upper marker (initial water level), then he or she will know that it is time to irrigate when the water level in the

Table II. Example of soil water balance with ETG data measured at the University of Nebraska–Lincoln South Central Agricultural Laboratory (SCAL) near Clay Center, Nebraska, during the 2004 growing season.

LOCATION: SCAL, Clay Center **FIELD:** NE-1 **ETG #:** 1 **YEAR:** 2004 **CROP:** Corn
PLANTING DATE: May 3 **EMERGENCE DATE:** May 18 **SOIL:** Silty loam

Date	*ETG reading (in)*	*Depletion in ETG (in)*	*Rain (in)*	*Kc*	*ETc (in)*	*NIR (in)*	*GIR (in)*
A	B	C	D	E	F	G	H
		B2- B1		From *Table I*	C x E	Equation 2	Equation 3
June 20	0	0				0	0
June 23	0.75	0.75 - 0 = **0.75**		0.18	0.14	0+0.14 =0.14	0.14/0.80=0.18
June 26	1.20	1.20-0.75 = **0.45**		0.35	0.16	0.14+0.16=0.30	0.30/0.80=0.38
June 30	1.35	1.35-1.20 = **0.15**		0.51	0.08	0.30+0.08=0.38	0.38/0.80=0.48
July 3	2.10	2.10-1.35 = **0.75**	0.40	0.69	0.52	0.38+0.52-0.40=**0.50**	0.50/0.80=0.62
July 6	2.80	2.80-2.10 = **0.70**		0.88	0.62	0.50+0.62=1.12	**1.12/0.80=1.40***
July 10	3.60	3.60-2.80 = **0.80**		1.01	0.81	1.12+0.81=**1.93**	1.93/0.80= 2.41
July 13	4.30	4.30-3.60 = **0.70**		1.01	0.71	1.93+0.71=2.64	2.64/0.80= 3.30

(*) A 1.40 inches of irrigation water was applied to keep up with the crop water requirement considering the system capacity.

ETG reaches the lower marker. It should be noted that the net irrigation requirement will only be 1.3 inches instead of the 2.55 inches as indicated by the ETG. If a rainfall occurs during this period, the rainfall amount should be subtracted from 1.3 inches to determine the net irrigation requirement for that period (Equation 2).

Example 4

The following example of a water balance sheet *(Table II)* can help determine the gross irrigation water requirements for a corn crop by taking into account ETG readings, rainfall, and irrigation system efficiency. The soil water balance sheet can help a user track how much water is used from the soil profile during a given period of the growing season. The following example assumes a corn crop planted on Hastings silty loam soil with a soil water content of approximately 75 percent of the field capacity (25% depletion). The crop is irrigated with a center pivot system that has an application efficiency of 80 percent and a system capacity of 1.5 inches per revolution. A rate of 1.5 inches per revolution is used only for this example. The user can interpret or modify *Table II* according to the capacity of their center pivot system. The ETG was read approximately every 3 days at the same time of day (around 8:30 a.m.).

This example illustrates that if irrigation was not started on or before July 6 under these conditions, the irrigation system capacity would not be able to keep up with crop water demands for the remainder of the season.

These examples show how to use the ETG to schedule irrigations for different scenarios. In these examples, the beginning soil water content is assumed to be at or near field capacity. However, for more reliable and complete irrigation scheduling, the ETG readings should be confirmed by verifying the soil water content in the field several times during the growing season. It is also important to have an estimate of the crop root zone at different times of the season and the available water holding capacity. In addition, the minimum allowable soil water content should be known for each crop under irrigation. These subjects are not covered in this NebGuide. For information on these subjects, see NebGuides G753, *Irrigation Scheduling Using Crop Water Use Data*, and G602, *Predicting the Last Irrigation for Corn, Grain Sorghum, and Soybeans*.

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