AZ1260 Revised 09/10

Siting and Maintenance of Weather Stations

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Turf Irrigation Management Series: III

Introduction

A number of equipment manufacturers provide weather stations (Figure 1) and software that help the groundskeeper with decisions related to irrigation management. The level of sophistication of this equipment varies, but all systems use the weather station to estimate a parameter known as evapotranspiration (ET). ET is the scientific term for the more common terms water use or consumptive use. Effective utilization of ET information in irrigation management can assist in efforts to manage limited and/or expensive water supplies provided the stations are 1) sited and installed correctly, and 2) properly maintained. The purpose of this bulletin is to provide turf facilities information and guidance on siting and maintenance of automated weather stations.

Weather Stations & ET

A first critical point to understand about weather stations is that they do not measure ET. True measurements of ET require sophisticated equipment and are difficult and time consuming to obtain. To avoid the difficulties associated with measuring ET, scientists have developed weather-based models to estimate ET using data collected from weather stations. This computed ET value is known as reference evapotranspiration and must be adjusted with a crop coefficient to obtain estimates of ET for a given type of vegetation (Brown, 2000). Reference ET is typically abbreviated as ETo or ETos. Two related models – the Penman Equation or the Penman Monteith Equation – are among the most popular methods for estimating ETo, and the majority of the weather stations sold to the turf industry use one of these models. In recent years, there has been considerable effort put forth to standardize the procedures used to estimate ETo. Turf facilities considering the purchase of a new weather station should ensure that the station and/or software can provide ETo values computed using the recently adopted ASCE Standardized Reference ET Equation (ASCE, 2005; Brown, 2005).

The weather station provides the weather data necessary for computation of ET_O. The four weather variables used in this computation are: 1) solar radiation, 2) wind speed, 3) temperature, and 4) humidity. It is important for owners of

Figure 1. An automated weather station commonly used to estimate turf ET.

weather stations to understand that ET estimates are only as good as the weather data used in the Penman computation. The old adage "garbage in equals garbage out" truly holds for the computation of ET_O. Poor quality weather data will produce erroneous ET values and make use of ET information very difficult.

There are two main causes of poor quality weather data: 1) improper siting of the weather station and 2) poor station maintenance. Both causes are explored in the remainder of this bulletin.

Siting Weather Stations

Proper siting is essential if the weather station is to provide the data necessary to estimate ET_O in a consistent and reliable manner. One should always remember the weather variables used in the ET_O computation when seeking a weather station site. Solar radiation, for example, is an extremely important variable in the Penman and Penman Monteith procedures. A weather station must therefore be placed in a location where no shading can occur. It is important to remember that shade patterns vary with the season due to changes in earth-sun geometry. It is therefore best to place the station well away from large obstacles if possible.

An open location is also necessary to measure wind speed. A station hidden from view behind an outbuilding or a solid wall will not accurately represent the wind speed over more open areas such as fairways or sports fields. Weather stations should be isolated from large obstacles such as fences, trees or buildings by a distance equal to 7-10 times the height of the obstacle. Using this rule, one should place a station 70-100′ away from a 10′ high building to ensure proper wind flow at the site.

The final two parameters in the ET_O computation – temperature and humidity – are greatly affected by the surface upwind of the weather station. Stations located over and/or downwind of asphalt, gravel, or bare ground will produce higher temperatures, lower humidity and higher ET_O values than stations centrally located within a large expanse of well-watered turfgrass. It is important to note that most Penman/Penman Monteith procedures were developed using weather data collected over a large expanse of well-watered vegetation. Failure to place the weather station over a similar surface will result in overestimation of ET_O. Research conducted by the authors indicates the surface characteristics adjacent to a weather station can affect ET_O values by as much as 20%.

The previous paragraphs clearly show that station siting is not to be taken lightly. The ideal situation would be to centrally locate the station in a large, well-watered turf area that is a considerable distance from objects that might disrupt wind flow or shade the station. The terrain surrounding the weather station should be relatively level if possible. If such a site is not available and a compromise site must be selected, we would recommend sites that 1) avoid shade and 2) have a limited number of large obstacles and some form of irrigated surface in the predominate upwind direction during the daylight hours.

Weather Station Maintenance

A weather station, like any other piece of equipment, requires regular maintenance if it is to perform its assigned task correctly. Some of the more important maintenance chores can and should be performed by local grounds maintenance personnel since they have access to the station on a regular basis. Other maintenance work should be performed by a trained weather station technician. However, before describing the required maintenance chores and who should perform them, a brief physical description of the sensors commonly found on a weather station is in order.

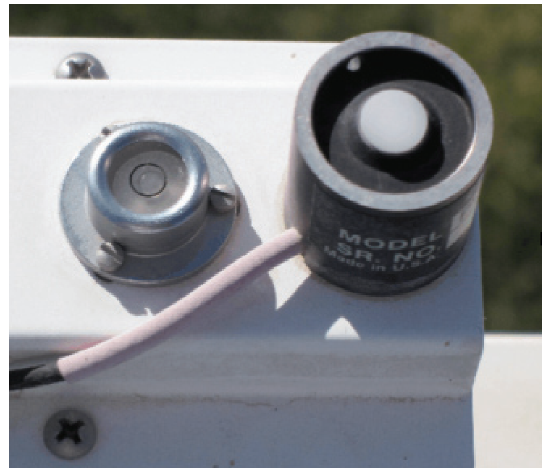

Figure 2. The silicon cell pyranometer is used to measure solar radiation on many automated weather stations.

Figure 3. A combination temperature and relative humidity sensor (left) is housed within this radiation shield to protect the sensor from direct exposure to sunlight and rainfall.

Weather Station Sensors

Weather stations designed to provide estimates of turf ET typically monitor five meteorological parameters – solar radiation, wind, temperature, humidity and precipitation. The silicon cell pyranometer is commonly used to measure solar radiation (Figure 2). The sensor is a small (1″ diameter) black cylinder that is situated on an adjustable base plate containing a bull's eye level. The actual sensing portion of this instrument is the small circular white "eye" that rests near the top of the sensor. Some stations may employ a thermopile pyranometer to measure solar radiation. The sensing element of a thermopile

Figure 4. Wind speed is usually measured with a cup anemometer (above) while a wind vane (below) is used to monitor wind direction.

pyranometer is typically located underneath a sealed glass dome.

Temperature and humidity are commonly measured with a combination sensor (Figure 3) that is housed in a naturally ventilated radiation shield that prevents direct sunlight from reaching the sensor. Various types of shields are used to shade the sensor, but the most common shields resemble an upside-down stack of white plastic plates (Figure 3). Temperature is typically measured with a thermistor or a platinum resistance thermometer – sensors exhibit a change in electrical resistance in response to changes in temperature. Humidity is commonly measured with sensors that generate a change in electrical resistance or capacitance with changes in humidity.

Wind speed and direction are measured with a cup anemometer and wind vane, respectively (Figure 4). The anemometer has three cups attached to spokes which in turn connect to a hub. The cup assembly connects to a sensing element that generates an electrical signal (e.g., switch closure or voltage) proportional to the rate of cup rotation. Cup rotation is in turn proportional to wind flow. The wind vane is designed to rotate freely and point into the wind. A variable resistor (potentiometer) attached to the vane hub provides an electrical signal proportional to wind direction.

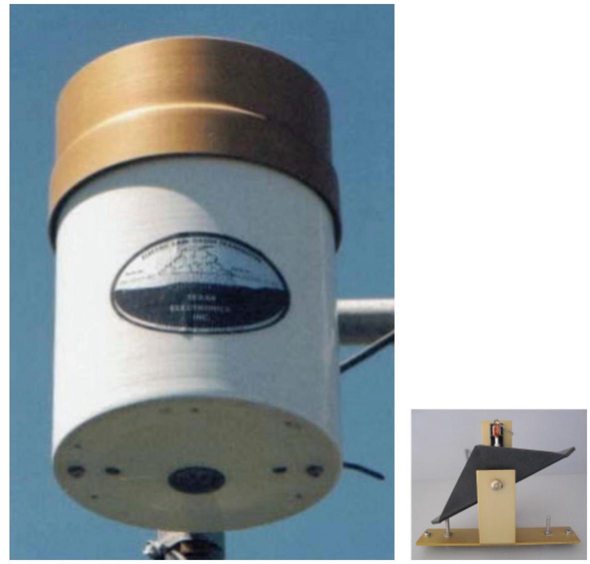

Figure 5. A tipping bucket rain gauge used to measure precipitation. The bucket mechanism (right) tips when a known volume of precipitation falls, triggering a switch closure which is recorded by the data logger.

Precipitation is measured using a tipping bucket rain gauge which typically is a large (6-8″ diameter) cylinder shaped instrument (Figure 5). A funnel on the top of the gauge captures precipitation and directs the water to a tipping bucket mechanism that rotates on a pivot each time a know quantity of water is collected (usually 0.01″).

Local Maintenance Chores

Local grounds maintenance personnel can help keep the weather station functioning by performing some simple routine maintenance chores. Perhaps the most important maintenance chore involves keeping the solar radiation sensor clean and level. Remember, solar radiation is a very important parameter in the ET_O computation. The small white sensing surface or the glass dome (thermopile pyranometers) must be kept free of dirt, dust, debris (e.g., turf clippings), and bird droppings. A weekly examination of the sensor should be adequate for most locations. Simply remove any debris from the top of the sensor and wipe off the white circle with a damp cloth. Silicon cell pyranometers located where irrigation water comes in contact with the sensor may exhibit an accumulation of salt over time. These salts may be removed using a cloth saturated with vinegar or some other weak acid. While cleaning the sensor, one can examine the bull's eye level on the mounting plate to ensure the sensor is level. An off level sensor can be brought into compliance by adjusting the leveling screws on the mounting plate. A screw driver or allen key wrench is required to adjust the level.

Actual maintenance of the temperature and humidity sensors should be left to skilled technicians. However, local personnel can extend the longevity of these sensors by regularly removing accumulated dirt and debris from the radiation shield and by adjusting sprinklers to minimize direct water contact. The radiation shield sheds rainwater reasonably well, but affords little protection against water arriving at an angle from ground level.

Observation is the main means of determining if the anemometer is operating correctly. The main problem causing poor anemometer performance is dirt in the sensor bearings. This problem is best observed when winds are light – usually in the morning. An anemometer that emits a grinding sound, does not rotate at low wind speeds, or halts abruptly with a lull in the wind likely has bad bearings. Faulty bearings will generate erroneously low wind speeds and should be replaced as soon as possible. Bearing replacement is best performed by a trained technician.

Rain gauge maintenance involves keeping the gauge level and the collection funnel clean. The level may be checked by placing a carpenter's level across the opening of the collection funnel. If the gauge is not level, some adjustment may be necessary. Level adjustments can be made by local personnel, but it is best to have a trained technician do this since the gauge should be calibrated after leveling.

Turf clippings and dirt can occasionally plug the catchment funnel and prevent rainwater from reaching the recording bucket mechanism. Most gauges have a screen which prevents large pieces of debris such as leaves and twigs from plugging the funnel. However, turf clippings and dirt can easily move through the screen. An examination of the funnel during the weekly visit to check the pyranometer can identify any problems with accumulation of debris. The funnel simply slides on top of the cylindrical gauge base and can be removed if extensive cleaning is necessary. Once the funnel is removed, you can see the tipping bucket mechanism. Wipe out dirt and debris from the buckets if required. Dirt (soil) is heavier than water and can cause buckets to tip before the proper amount of water has entered the buckets. If this dirt is firmly attached to the bottom of the buckets and does wash out with the first few volumes of rainwater, the gauge may overestimate precipitation. Replace the funnel after both the buckets and funnel are cleaned. Make sure the funnel is level and seated against the base of the gauge. Note: any movement of the tipping bucket mechanism during cleaning may be recorded as "false rain" events by the weather station. Notify your irrigation manager if this happens so these "false rains" can be ignored when scheduling the next irrigation.

The power supply of the weather station may also require some routine maintenance. Most stations operate off a 120 volt A.C. supply with a rechargeable battery serving as a backup when the power supply fails. Loss of data following a power failure is a good indicator of problems with the battery and/or charging circuit. Maintenance and repair of the power supply is best left to trained station technicians.

A solar panel may provide power to weather stations located away from a reliable source of A.C. power. The solar panel provides power to operate the station during the day and also charges a battery that supplies power for nighttime operation. Solar powered systems are quite reliable provided the panels are kept clean. Accumulated dust and debris should be removed weekly to maintain proper output from the panel. Output from solar panels is particularly vulnerable to isolated dark spots such as those created by bird droppings. Bird droppings should be removed as soon as possible to ensure optimal panel performance. Loss of data during the nighttime hours is a good indicator of a failed battery or failed charging circuit. Again, repair of the charging circuit is best left to a trained technician.

Another important aspect of local maintenance is to compare the data collected by your weather station with data collected from another nearby station. A neighboring facility may have a station you can compare data with, or you may wish to access information from a public weather network such as the Arizona Meteorological Network (AZMET). A regular weekly comparison of key meteorological variables such as solar radiation, wind speed, humidity and temperature can help identify when your weather station is not functioning correctly. The weather variables at another location will not be exactly the same, but solar radiation, temperature and humidity should be very similar. Wind speed will vary somewhat between two locations, but the relationship (e.g., difference in average wind speed) between neighboring weather stations should be similar each week. Exceptions to this rule may develop for weather stations located in foothill or mountain locations where topography plays an important role in daily wind flow patterns.

Precipitation is the only variable that is difficult to check using neighboring stations. Rainfall in arid and semi-arid regions is particularly variable, as is rainfall generated by convective storms (thunderstorms). Rainfall totals can vary several fold over distances of just a few hundred yards, making comparisons with neighboring stations very difficult.

Turf facilities throughout Arizona may find local AZMET weather stations useful when checking data collected at their facilities. AZMET presently collects data from 30+ locations and all AZMET data are available free of charge via the internet at:

http://ag.arizona.edu/azmet

Technical Maintenance

Technical maintenance should be performed anytime your routine maintenance reveals a problem. However, we suggest having a technical representative check your system once every year even if you do not identify problems with your routine local maintenance checks. Our experience running 30+ weather stations indicates that anemometer bearings should be replaced at least every 18 months and preferably every 12 months to ensure proper measurement of wind speed. Our experience with pyranometers, combination temperature/humidity sensors and rain gauges has been very positive, but these sensors should be examined by a trained technician regularly. AZMET presently replaces pyranometers and anemometers every 12 months, temperature/humidity sensors every 24 months and rain gauges when they fail during quarterly maintenance visits or known rainfall events. This replacement interval should not be construed as an estimate of sensor life as most removed sensors are simply refurbished and/or calibrated and returned to service on another weather station. Turf facilities wishing to implement a regular sensor rotation scheme would need to buy a set of backup sensors, or direct the entity hired to perform technical maintenance to establish such a program.

Technical maintenance is best performed by a trained representative of the company that supplied your weather station. Technical maintenance is an essential aspect of operating a weather station, and turf facilities should be wary of suppliers that do not provide both telephone and on-site technical assistance. If the supplier does not provide on-site technical service, they should be able to guide you to a qualified third party who can. Some companies provide a short training course so local facility personnel can perform most of the technical maintenance.

Summary

The use of weather stations and ET represents a significant advance in the field of turfgrass irrigation management. However, to obtain the best and most reliable results from a weather station, the station must be first, properly sited, and second properly maintained. Readers are encouraged to contact the authors at (520) 621-1319 or by email at azmet@ag.arizona.edu if they have additional questions or would like assistance with accessing AZMET.

References

ASCE.2005. The ASCE Standardized Reference Evapotranspiration Equation. R.G. Allen et al. (ed). ASCE, Reston, VA.

Brown, P.W. 2005. Standardized Reference Evapotranspiration: A New Procedure for Estimating Reference Evapotranspiration in Arizona. Ext. Rpt.1324. College of Agricultural & Life Sci., Univ. of Arizona, Tucson, AZ.

Brown, P.W. 2000. Converting Reference Evapotranspiration into Turf Water Use. Turf Irrigation Management Series: No. 2. Ext. Rpt. 1194. College of Agriculture & Life Sci., Univ. of Arizona, Tucson, AZ.

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Originally published: 2001

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Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, James A. Christenson, Director, Cooperative Extension, College of Agriculture & Life Sciences, The University of Arizona.