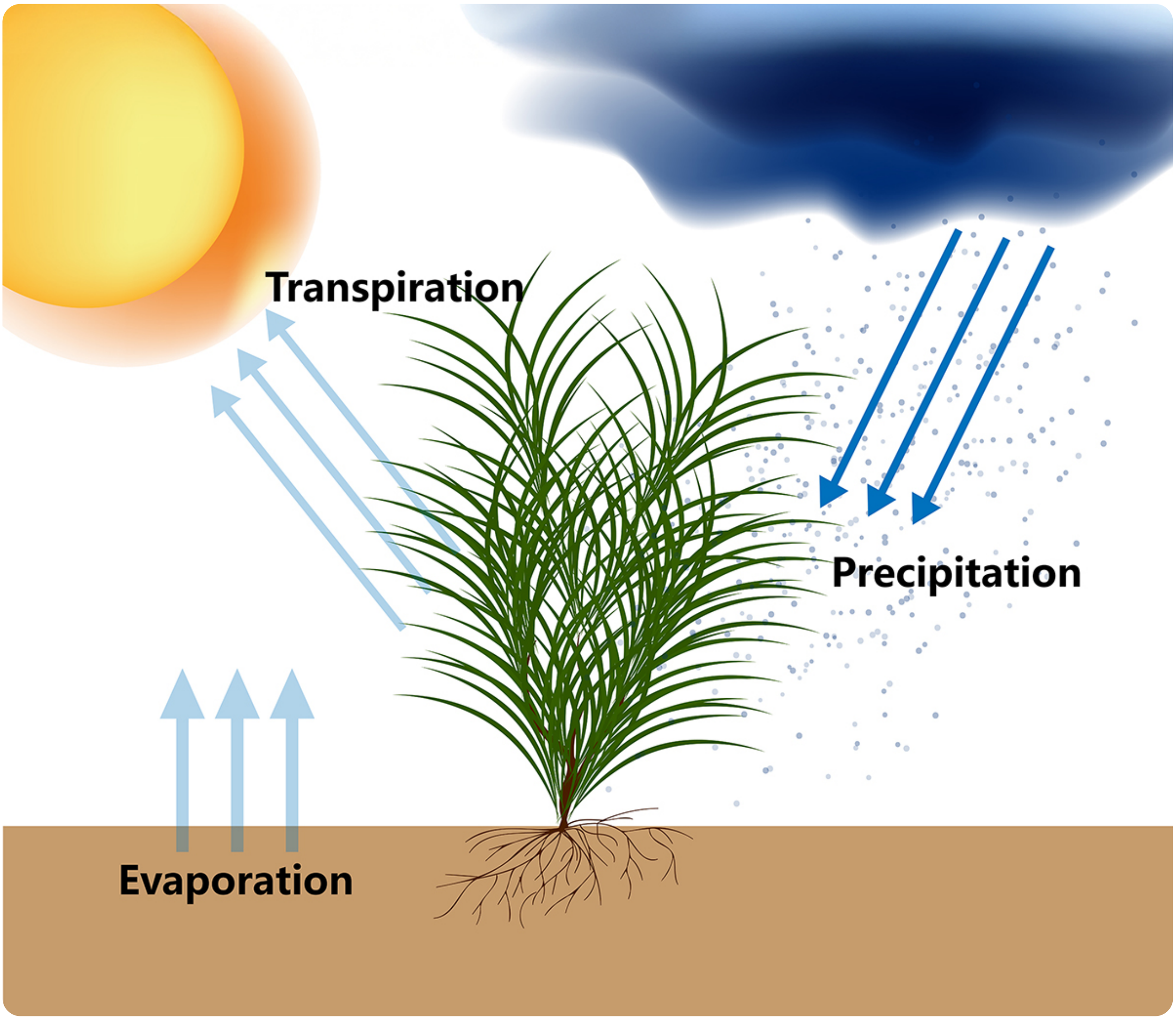
Evapotranspiration terminology for agronomists and mesonets

By Kendall DeJonge and Meetpal Kukal

April 1, 2026



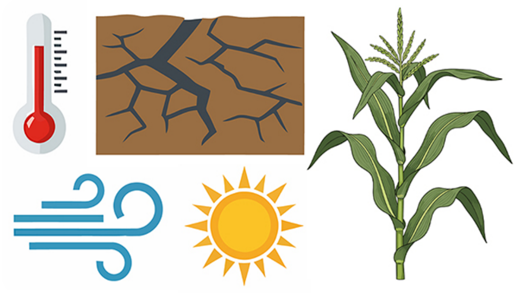
Quantifying crop water use, generally referred to as evapotranspiration, or ET, can be very important to agricultural water management. Illustration courtesy of USGS.

This article explains how evapotranspiration (ET) is defined and estimated in modern agricultural water management, emphasizing the importance of consistent terminology and standardized methods. It outlines how reference evapotranspiration (ET_{ref}) and crop coefficients are used together to estimate crop water use and highlights best practices for applying these concepts using mesonet data and other tools.

Earn 0.5 CEUs in Soil & Water Management by reading the article and taking the quiz.

Quantifying crop water use, generally referred to as evapotranspiration, or ET, can be very important to agricultural water management. While the soil acts as a reservoir, the crop uses (or “loses”) water through ET and is replenished via rainfall and/or irrigation. In arid or semi-arid areas such as the western U.S., which have little rainfall, estimating ET can especially guide efficient irrigation applications. Because many tools and reports now provide estimates of ET, having consistent terminology and methodology is essential so that everyone is talking about and using the same thing.

Essentially, ET is determined by evaporative demand attributed to weather conditions and the status of the crop. These two ingredients—weather and crop status—are the foundation of modern ET estimation methods. Regarding weather, the hotter, drier, windier, and sunnier it is, the more ET demand there is. Regarding crop status, tall, leafy, healthy crops generally use more water through ET than short crops or stressed crops.



Evapotranspiration demand is generally greater the hotter, drier, windier, and sunnier it is, and tall, leafy, healthy crops generally use more water through ET than short crops or stressed crops. Illustration courtesy of Adobe Stock.

For decades, scientists have refined methods to estimate ET for crops based on these ideas. Many early methods used the idea of "potential ET" as a sort of maximum level; but over time, this idea of "potential ET" evolved into several different meanings. For example, in some cases, "potential ET" was used to mean ET from a reference grass surface, whereas to others it meant the maximum ET from a specific crop under non-stressed conditions. This confusion is a problem because different meanings for the same term or how it is used can result in different answers. Additionally, many different methods were used in the past, which makes it hard to compare apples to apples in terms of ET estimates.

Standardizing ET: Reference ET and crop coefficients

To address this concern, ET experts decided on a standardized methodology that would be both accurate and consistent. This methodology essentially separates the weather and the crop status into two parts, the reference ET (ET_{ref}) and the crop coefficient (K_c), by using the equation for crop ET:

$ET_c = ET_{ref} \times K_c$

The reference ET represents the evaporative demand from a reference surface, and the crop coefficient (K_c) can be used to scale to the crop ET. For most crops, the K_c is small early in the season, increases as the plant grows, levels off during peak growth, and then reduces again with crop senescence, thus creating a trapezoid-shaped curve over time.

An alfalfa crop is often used as a reference surface to determine the reference ET, referred to as ETr. Image republished under a CC BY 4.0 license from Ouaadi et al., 2021.

The reference ET is an estimate of the ET on a reference (hypothetical) surface that is easy to maintain and keep consistent. One of the main surfaces is grass, which grows all the time and can be cut to a specific height. Using a weather station on a big grass field, the temperature, humidity, solar radiation (sunlight), and wind speeds will determine grass reference ET, referred to in equations as ET_o. Another reference surface often used is an alfalfa crop, where the reference ET is referred to as ET_r. These ideas were most notably standardized in a manual called FAO-56 (FAO, 1998, 2025) for grass only and defined for both grass and alfalfa in a simplified equation (Allen et al., 2005).

A few interesting facts about reference ET:

- ET_o and ET_r are not the same. Alfalfa ET (ET_r) is typically 10–25% higher than grass ET (ET_o), depending on climate. Because ET_o and ET_r are different, the crop coefficients (K_c values) are also different. Grass-based crop coefficients are therefore higher than alfalfa-based crop coefficients.

- Most countries and states adopt a preferred reference surface. Alfalfa (ET_r) is a common standard in many western U.S. states while grass (ET_o) is more common internationally.

- Alfalfa is a little more challenging to maintain since cuttings bring the height of the canopy closer to the ground. Grass cuttings may be barely noticeable if done frequently.

- Alfalfa reference ET (ET_r) can be determined off a grass reference station, and vice-versa. The results are all wrapped up in the math of the equation.

- While many different methods were used in the past, the American Society of Civil Engineers (ASCE) recommends the Standardized ASCE or FAO Penman-Monteith equation as the sole method for the calculation of ET_{ref}.

Many states host networks of weather stations, called mesonets, that are very valuable to informing local weather conditions, watching long-term trends, forecasting, and other uses. If sited properly, these mesonets can accurately estimate ET_{ref} (ET_r and/or ET_o). By knowing the crop and planting date, crop coefficient curves (known from previous experimental research) can then be multiplied by ET_{ref} to estimate crop ET (ET_c). Many mesonets have online interfaces where a user can choose a local station, provide cropping information, and receive estimates of ET_c. A few networks that may be familiar to readers include Oklahoma Mesonet, CoAgMET, High Plains Automated Weather Data Network, CIMIS, AgriMET, etc.

Applying ET in practice: Mesonets, methods, and tools

Proper mesonet siting is important for accurate ET estimation but can be challenging to implement in practice. An ideal station includes a large homogeneous grass or alfalfa reference that is well watered (not water stressed). Other ideal conditions are sites that a long distance from trees or tall buildings that can affect wind, are surrounded by irrigated agriculture, and have sensors that are appropriately configured and frequently calibrated (Figure 1). Many weather stations are situated in or near urban areas (for example, airports commonly have weather stations) or perhaps in arid environments. However, these stations may not be appropriate for use in ET_{ref} calculation. In fact, ET_{ref} calculated from most non-reference sites often can be hotter or drier than what a reference site would be (think about a parking lot vs. a golf course nearby). In these cases, ET_{ref} would be overestimated, potentially suggesting that farmers irrigate more than they need to. So, choosing a well-watered reference site is very important.

Figure 1. *Mesonets and their weather stations can be valuable for many purposes, but stations used for accurate reference evapotranspiration (ETref) estimation should be sited*

properly. The station on the left is ideal for ETref estimation while the station on the right is better used for other purposes. Photos courtesy of Sienna Hawk and CoAgMet.

Combined with ET_{ref} estimation, there are two similar but different approaches to use crop coefficients: the single crop coefficient and the dual coefficient. The single crop coefficient is more simple because it combines the effects of both evaporation from the soil and transpiration from the crop into a single term. Because of its simplicity, this coefficient method is what is commonly used in public-facing mesonet outputs and irrigation-scheduling applications. While the single crop coefficient method is easier to use, it may not be as accurate as the dual crop coefficient method, which calculates evaporation and transpiration separately and can consider the effects of water stress. Whereas ET_c represents a well-watered (non-stressed) crop, the term ET_a (actual evapotranspiration) is more encompassing and can include the idea of both ET_c but also applications where the crop is under water stress.

There has been significant progress in making new products available, which may help users estimate ET. First, as previously mentioned, mesonets can give ground-truthed estimates of ET_{ref} and even ET_c through use of crop coefficients. On a spatial basis, the Open ET platform is an ensemble of models that are used to predict actual ET (ET_a) for every field across the lower 48 states. Finally a new publicly available model called "pyfao56", a Python code version of the FAO-56 standardized ET methods (FAO, 1998, 2025), can be customized for water balance modeling and irrigation management (Thorp et al., 2025).

In conclusion, confident use of ET information is a precursor to good irrigation and agronomic management, and consistency in measurements, definitions, and terminology are key for practitioners to ensure. The principles and best practices in this article are summarized from a much more detailed technical note called "Evapotranspiration Terminology and Definitions," (DeJonge et al., 2025) which was recently been published by ASCE with support from more than 50 stakeholders across the U.S. and globally. This is a valuable resource for agronomists, irrigation managers, researchers, students, and various other water professionals.

References

Allen, R.G., Walter, I.A., Elliott, R.L., Howell, T.A., Itenfisu, D., Jensen, M.E. (2005). *The ASCE standardized reference evapotranspiration equation*. American Society of Civil Engineers, Environmental and Water Resources Institute, Task Committee on Standardization of Reference Evapotranspiration.

DeJonge, K.C., Allen, R.G., Kilic, A., Thorp, K.R., Kukal, M., Marek, G.W., ... & Trout, T. (2025). Evapotranspiration terminology and definitions. *ASCE Journal of Irrigation and Drainage Engineering*. https://doi.org/10.1061/JIDEDH.IRENG-10491

FAO. (1998). *Crop evapotranspiration: Guidelines for computing crop water requirements*. Food and Agriculture Organization of the United Nations.

FAO. (2025). *Crop evapotranspiration: Guidelines for computing crop water requirements*. Food and Agriculture Organization of the United Nations.

Thorp, K. R., Gulati, D., Kukal, M., Ames, R., Pokoski, T., & DeJonge, K.C. (2025). Version 1.4.0 – pyfao56: FAO-56 evapotranspiration in Python. *SoftwareX*, *30*. https://doi.org/10.1016/j.softx.2025.102109

Self-study CEU quiz

Earn 0.5 CEUs in Soil & Water Management by taking the quiz for the article. For your convenience, the quiz is printed below. The CEU can be purchased individually, or you can access as part of your Online Classroom Subscription.

1. In the standardized ET framework, what does the reference evapotranspiration (ET_{ref}) represent?

a. The ET from any well-watered crop at full canopy cover, assuming no limitations from soil moisture or atmospheric demand.

b. The ET from a hypothetical, well-watered reference surface (such as grass or alfalfa) with standardized characteristics.

c. The ET from a crop experiencing water stress under deficit irrigation, adjusted for local environmental conditions.

d. The ET from bare soil surfaces under local weather conditions, excluding plant transpiration effects.

2. Why has the term "potential ET" fallen out of favor in modern ET terminology?

a. It has been used to describe different concepts and is better replaced with specific terms such as ETref in standardized frameworks.

b. It is no longer possible to measure potential ET directly in the field using modern instrumentation and standardized methods.

c. It primarily applies to perennial crops such as alfalfa and orchards, limiting its usefulness across diverse cropping systems.

d. It is not compatible with standardized equations such as the Penman-Monteith approach used in modern ET estimation.

3. Which statement best describes the relationship between ET_c and ET_a?

a. ET_c and ET_a are terms used for crop water use where ET_c refers to transpiration only and ET_a refers to evaporation only under controlled conditions.

b. ET_c refers to ET from a well-watered crop while ET_a refers to the ET that actually occurs under existing conditions, including stress.

c. ET_c represents the potential evapotranspiration of a crop under ideal management, whereas ET_a represents ET adjusted for soil moisture, plant health, and local microclimate conditions.

d. ET_c is calculated using reference surfaces and crop coefficients for ideal growth while ET_a reflects observed ET accounting for variations in weather, crop stress, and environmental factors.

4. What is a key difference between the single crop coefficient and dual crop coefficient approaches?

a. Single-K_c methods separate soil evaporation and transpiration while dual-K_c methods combine them.

b. Single-K_c methods apply only to annual crops while dual-K_c methods apply only to perennial crops.

c. Dual-K_c methods separately represent crop transpiration and soil evaporation, which can improve estimates when soil is frequently wet or partly bare.

d. Dual-K_c methods cannot account for water stress effects on ET.

5. When using mesonet data for irrigation scheduling, which of the following practices is most important give good estimates of ET_{ref}?

a. Using stations located at airports, where weather observations are frequent and instrumentation is regularly maintained.

b. Selecting the station with the highest reported wind speed, since wind is a major driver of evapotranspiration rates.

c. Using stations that prioritize precipitation measurements but may not include full radiation or energy balance components.

d. Using stations sited over well-watered, homogeneous reference surfaces rather than hot, dry, or urban locations.

Take the quiz

More Soil & Water Management

Back to issue

Rate this article