What is a weather station and should I have an on-site weather station?

1. Introduction

A weather station is a collection of instruments and sensors that measure local weather conditions. Commonly measured environmental variables include light, temperature, relative humidity, rain, and wind. An on-site weather station allows for monitoring of the microclimate in your growing area. Weather conditions can vary over short distances, especially for measurements such as rainfall, which means that off-site measurements may not be accurate enough for irrigation scheduling purposes. Cold pockets can also be highly variable, making on-site weather stations a valuable tool in monitoring and use in freeze protection.

Figure 1. Weather station including a rain gauge, light sensor, anemometer, leaf wetness sensor, and temperature and relative humidity sensor enclosed in a radiation shield (Photo courtesy of Decagon Devices).

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Station placement is critical for accurate measurements. Weather stations ideally are installed away from buildings, pavement, and trees and in a flat area. Placement under a tree or near a structure could alter measurements. Greenhouse structures can also impact measurements, especially light measurements, but plants would also be exposed to the same shading. For specific guidelines on weather station placement from Campbell Scientific, click here: ftp://ftp.campbellsci.com/pub/outgoing/apnotes/siting.pdf

2. Light or solar radiation sensors

Figure 2. Photosynthetically active radiation (PAR) sensors (left) measure the light that is used by plants for photosynthesis. Pyranometers (right) measure shortwave radiation, which is the total incoming solar radiation (Photo courtesy of Decagon Devices).

Light is the driving force behind photosynthesis and can be used in plant growth models and/or coupled with water use models for irrigation management. Light can be measured in terms of shortwave radiation or photosynthetically active radiation (PAR). Shortwave radiation is the total energy of incoming light and is measured using pyranometers. PAR is light with wavelengths from 400 to 700 nm, which is the light that is used by plants for photosynthesis, and is measured using quantum sensors. Light sensors that measure in lumens, foot-candles, or lux measure how the human eye perceives light. Because our eyes perceive light differently than plants do, such sensors should not be used!

Shortwave radiation measurements can be used in evapotranspiration modeling, which can be used for irrigation scheduling. PAR measurements over the course of a day can be used to calculate the daily light integral (DLI) if frequent measurements (ideally once per minute or more often) are taken.

Calibration of light sensors drifts over time, and, therefore, they need to be recalibrated every 2-3 years. Ensuring that sensors are level and kept clean is important for accurate measurements. Many sensors come with a leveling plate to ensure a level installation.

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3. Temperature, Relative Humidity, Vapor Pressure Deficit

Figure 3. Relative humidity and temperature sensors (left) need to be enclosed in a radiation shield (right) to ensure accurate measurements (Photos courtesy of Decagon Devices).

The effects of temperature, relative humidity, and vapor pressure deficit on plant water use are interdependent. The following definitions are useful in understanding the relationships.

Dry bulb temperature – actual temperature of the air

Relative humidity – ratio between the actual amount of water vapor in the air and maximum amount of water vapor the air can hold at a temperature (expressed as a percentage)

Dew point temperature – temperature to which air must be cooled to completely saturate the air with water vapor (100% RH)

From the dry bulb temperature and relative humidity (which can be measured by sensors in a weather station) the following can be calculated:

Vapor pressure – measure of the actual amount of water vapor in the air (expressed in pressure units such as kPa)

Saturation vapor pressure – measure of the maximum amount of water vapor the air can hold; function of temperature (warmer air can hold more water)(expressed in pressure units such as kPa)

Vapor pressure deficit – difference between saturation vapor pressure and vapor pressure (expressed in pressure units, kPa)

Evapotranspiration is driven by vapor pressure deficit (VPD) which is a function of temperature and relative humidity. VPD at a particular relative humidity increases with increasing temperature.

Air temperature and relative humidity should be measured in close proximity to each other. Sensors measuring temperature and relative humidity need to be enclosed within a radiation shield for accurate measurements. Radiation shields protect the sensor from exposure to sunlight (which would heat up the sensor) and allow for airflow around the sensor.

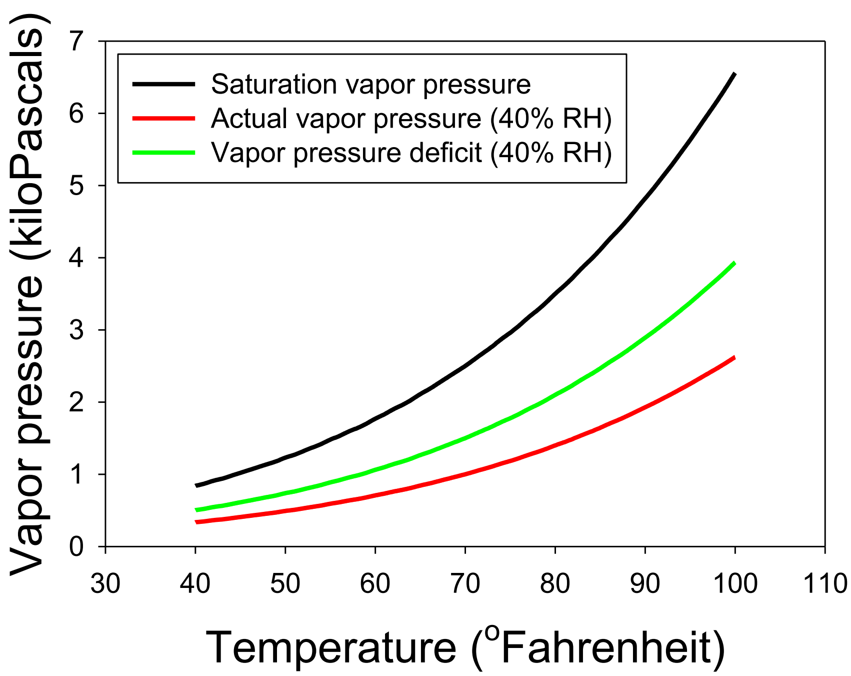

Figure 4. Saturation vapor pressure, actual vapor pressure (at 40% relative humidity), and vapor pressure deficit (at 40% relative humidity) in response to increasing temperature.

4. Wind

Figure 5. Cup anemometers (left) and sonic anemometers (right) are used to measure wind speed (Photos courtesy of Decagon Devices).

Wind can affect evapotranspiration, and thus plant water use, by moving humid air away from the plant canopy or soil/substrate. Wind reduces boundary layer resistance for water movement from the soil/substrate or crop to the air. More air movement results in greater evaporation.

Anemometers measure wind speed via cups, propellers, hot wires, or ultrasonic signals. The number of rotations over a given period is measured by cup and propeller anemometers. Hot wire anemometers use the change in temperature of a heated wire caused by wind speed. Sonic anemometers measures the time it takes for an ultrasonic pulse to move from one transducer to another.

Some anemometers also measure wind direction, but this information is typically not critical for growers.

5. Rainfall and Canopy Wetness

Figure 6. Rain gauges (left and middle) are important for measuring the actual amount of rainfall which will affect how much irrigation is needed. Leaf wetness sensors (right) measure leaf surface or canopy moisture and can be useful in predicting plant diseases (Photos courtesy of Decagon Devices).

Rainfall volume is important for scheduling irrigation. The actual volume, and not just the occurrence of rain, is important for ensuring that the soil/substrate is brought back to the optimal moisture range.

Tipping bucket rain gauges collect rainfall into a funnel and direct the water to measuring spoons. After a certain volume is collected, the spoon tips and the number of tips is recorded and used to calculate rainfall volume. If heavy rainfall is common, rain gauges with two tipping spoons are preferred over gauges with one tipping spoon.

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Figure 7. Tipping bucket rain gauge. The right part of the picture shows the two tipping spoons used for measurement.

Leaf wetness sensors can measure canopy or leaf surface moisture, and can be used to predict plant disease by the duration of canopy/leaf wetness. Growers can also use the measurements to figure out when to irrigate crops that are prone to foliar diseases.

6. What Can I Do with Weather Station Data?

Irrigation Scheduling – Measurements can be used for water balance or other calculated methods of irrigation scheduling including crop water use models. For more information on crop water use models see the learning module on 'Advanced Irrigation Model Control'.

Reference evapotranspiration - can show how water use changes from day to day based on environmental conditions.

Degree Day Models – Temperature measurements can be used to monitor chilling hours and growing degree hours. As a process of going through winter dormancy and resuming growth in the spring, deciduous woody crops have a chilling requirement ((accumulated time below 45 °F (7 °C)) as well as a growing degree day requirement ((warm temperature exposure after chilling, above 40°F (4°C)). These requirements are most important for fruit crops because they determine when plants will bloom in the spring. This can also impact when flowering ornamentals, such as *Prunus* species bloom.

Freeze protection – Topography, latitude, and elevation can all play a role in the occurrence of freeze events in an area, thus, site specific temperature measurements are valuable for freeze/frost protection.