3. EnEnvironmental Sensors

In this section, the maintenance requirements and best practices to be followed for commonly used environmental sensors is given.

3.1. Radiation Sensors

Radiation data is important for various purposes including calculating energy balance, in determining latent heat flux vs. sensible heat, in generating interception data for biomass and crop growth models, and for use in the Penman-Monteith equation. Two types of radiation sensors (measuring total solar radiation and photosynthetically active radiation) are available from Decagon Devices, Inc., (Pullman, WA).

The model QSO-S PAR Photon Flux Photosynthetically Active Radiation (PAR) sensor measures the Photosynthetic Photon Flux (PPF) in μmol m^{-2} s^{-1} from a field of view of 180 degrees whereas the PYR total solar radiation sensor (Pyranometer) measures the solar radiation flux density (in watts per meter squared) from a field of view of 180 degrees (Decagon Devices, 2014).

Both sensors are designed for continuous outdoor use, and are completely water proof and submersible with a diffusion disk is composed of characterized pigments for good spectral response (Decagon Devices, 2014). Accurate measurement depends on cleanliness of the lens and installation horizontally (180°). The sensors head has a domed diffusion disk to reduce the need for frequent cleaning. A leveling plate is also included for accurate installation.

Figure 3. PAR sensor (Courtesy of Decagon Devices)

Figure 4. PYR sensor (Courtesy of Decagon Devices)

Since the accuracy of the radiation data being collected can be affected by the senor orientation, regular checking to make sure the sensor/plate is horizontally leveled is important. The biggest error is often caused by dirt on the lens of the sensor. The domed top is self-cleaning, but measurement accuracy will be improved if the lens is wiped with a clean, soft cloth at frequent intervals.

It is recommended to calibrate the radiation sensors every 1 to 2 years (Decagon Devices, 2014).

3.2. Relative Humidity and Air Temperature Sensors

Decagon Devices, Inc. provides the VP-3 temperature, relative humidity (RH) and vapor pressure deficit (VPD) sensor that can be used with soil moisture probes in microclimate and evapotranspiration studies (Figure 5). It is compact (5 cm x 2 cm), has teflon screen that enables it to work in waterlogged condition by protecting the sensor from liquid water and dust without limiting diffusion of water vapor (Decagon Devices, 2014).

Figure 5. VP-3 sensor (Courtesy of Decagon Devices)

The protected sensor is still able to quickly respond to changes in humidity. Accurate relative humidity readings require accurate air temperature readings taken at the same place and time. The VP-3 sensor takes both measurements simultaneously for the best possible accuracy.

The included radiation shield is designed to improve air temperature readings by minimizing radiation and maximizing airflow over the surface of the sensor. It is specially designed to preserve the correlation between actual air temperature and sensor air temperature while keeping the shield size small. Regular cleaning of the VP3 sensor and radiation shield is important to remove debris and insects covering the sensor and/or radiation shield.

3.3. Rain Gauges

Decagon Devices, Inc. provides two types of rain gauges:

3.3.1. ECRN-50 Rain gauge: is a low-resolution rain gauge that is best suited to measure overhead irrigation events (Figure 6). It can be configured to measure the output of irrigation systems in terms of either gallons or liters per hour. The single-spoon mechanism tips at 1 mm of precipitation/irrigation with an accuracy of ±2%. The rain gauge is made of durable plastic that is UV, water, and frost-resistant (Decagon Devices, 2014).

3.3.2. ECRN-100 Rain gauge: is a high resolution rain gauge that is best suited for measuring precipitation and for use in scientific research. Two internal tipping spoons make this rain gauge very sensitive, with one tip per 0.2 mm of rain. This rain gauge is also made of durable plastic that is UV, water, and frost-resistant (Decagon Devices, 2014).

Figure 6. ECRN-50 rain gauge
(Courtesy of Decagon Devices)

Figure 7. ECRN-100 rain gauge
(Courtesy of Decagon Devices)

The ECRN-50 rain gauge has a collector surface area of 50 cm^2. For a 1mm resolution, the single cup on the rain gauge has a tipping volume of 5 ml. The ECRN-100 rain gauge, on the other hand, has a collector surface area of about 200 cm^2 and a single cup tip of ~ 4 ml (for a resolution of 0.2 mm). The rain gauges come with the tipping volume calibrated. However, tipping volumes should be checked before installation and if necessary adjustments be made by turning the screws located on the underside of the spoons/cups.

The most important thing to do during the installation of both the ECRN-50 and ECRN-100 rain gauges is leveling the gauge horizontally. The water bubble embedded on the ECRN-100 rain gauge can be used for this purpose. The smaller ECRN-50 rain gauge needs an external water bubble/level for proper installation. The base of the ECRN-100 rain gauge has to be covered with netting as various insects (spiders and wasps chief among them) tend to take shelter inside the rain gauge's body and affect the tipping volume and mechanism of the spoons.

Regular cleaning of the spoons/cups of the ECRN-50 and ECRN-100 rain gauges is important. This is to avoid the effect of accumulating debris on the tipping volume. The base of the ECRN-100 rain gauge should also be regularly opened and cleaned to remove insects taking shelter inside. The small drainage holes on the collector surface can easily be clogged by debris (especially bird poop). The collector surface, therefore, needs to be checked and cleaned regularly.

3.4. Anemometers

The anemometer measures and display wind speed and wind direction. Decagon Devices, Inc. provides two types of anemometers: the Davis-cup anemometer and the DS-2 sonic anemometer.

3.4.1. Davis cup anemometer: is a simple anemometer to measure wind speed and direction without a complex setup, maintenance or programming requirement (Figure 8). The anemometer does not require any regular maintenance. Do not attempt to lubricate the wind cup shaft and bearings or the wind vane shaft. Natural or synthetic lubricants will inhibit the normal operation of the anemometer. While the anemometer is designed to provide years of trouble-free operation, occasionally problems may arise. A simple troubleshooting can solve most of the problems without the need to send the anemometer for repair.

3.4.2. DS-2 sonic anemometer: is a rugged, research-grade two-dimensional sonic anemometer built specifically for agricultural, forestry, and environmental research applications (Figure 9). The DS-2 is designed for long-term maintenance free operation. There are no moving parts on the anemometer, which avoids wear and tear of parts and requirements for routine maintenance.

Figure 8. Davis cup anemometer
(Courtesy of Decagon Devices)

Figure 9. DS-2 sonic anemometer
(Courtesy of Decagon Devices)

Belayneh, B. E. 2014. System Maintenance and Troubleshooting. ***In***: Managing Irrigation through Distributed Networks Knowledge Center. M. Chappell, P.A. Thomas and J.D. Lea-Cox. (Eds.). Published online at https://myelms.umd.edu/courses/1110354. 11p.

3.5. Leaf Wetness Sensor

Decagon's leaf wetness sensor (LWS) is standardized, calibrated, and designed to detect wetness (presence and duration) and ice formation (Decagon Devices, 2014). Each sensor is precisely factory-calibrated to detect tiny amounts of water and/or ice on its surface.

The sensor surface coating is non-hygroscopic, eliminating false wetness detection. The sensor's thin (0.65 mm) fiberglass construction closely approximates the overall radiation balance of a healthy leaf, so moisture will condense and evaporate from the sensor at the same rate as it would on a normal leaf. Among other things, LWS can be used to predict when to spray crops, to quantify water storage in the plant canopy and to study and monitor crops for foliar diseases including rust and blight.

No painting, baking, or user calibration is required for the L0WS. The LWS can be deployed either in the canopy or on weather station masts. The sensing side of the LWS should always face upside. It is recommended to clean the LWS using a moist cloth periodically, or when elevated dry output is detected.

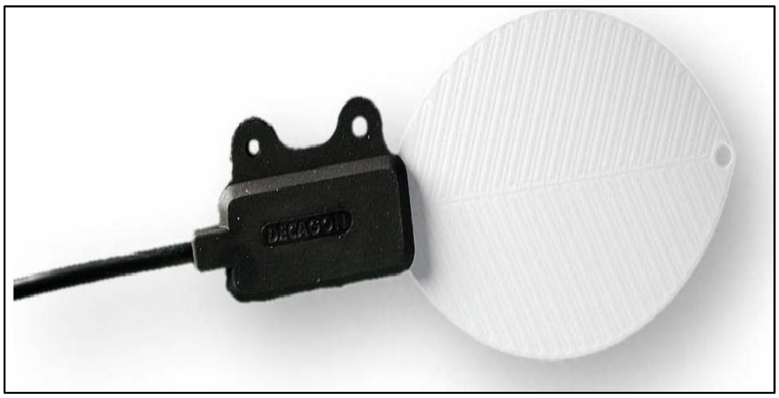

Figure 10. Leaf wetness sensors (Courtesy of Decagon Devices)