Hurdles Facing Irrigation Management With Satellites

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Earth observation satellites have orbited the planet for decades. Unfortunately, we have seen little use of satellite imagery for practical, day-to-day decisions by golf course superintendents.

For many years, the only civilian access satellite with turf management potential was LANDSAT. It only can look straight down, which means it must pass directly over a target to acquire imagery. The orbit is such that only one image acquisition can be executed every 16 days.

At best, without cloud interference, this would provide a "snapshot" assessment of turf condition and water status every two weeks. The presence of a few clouds on the acquisition day would mean going an entire month without information. Daily coverage is the ideal situation.

Another problem with current satellites is their spatial resolution. Weather satellites image every part of the country several times a day with sensors that could be very useful for irrigation management, but the smallest area they can resolve is one kilometer across.

LANDSAT has a resolution of 30 meters in the visible, near-infrared and mid-infrared bands. The thermal infrared sensor necessary for irrigation management has a resolution of 120 meters. This is much too large for golf courses. The French SPOT satellites have a 20-meter resolution, but they lack the critical thermal sensor.

Correcting for Orbital Changes

The information collected by satellites loses its value rapidly. Data should be in a golf course superintendent's hands within hours of acquisition so that irrigation and pest management decisions can be made before there is a significant loss. Even a day is too long for some information.

Assuring the accuracy of the data received is also more difficult than imagined earlier. If a satellite image were acquired at the same time of day every day, one would expect the data to be comparable. However, the sun angle changes slightly as the season progresses. A ground target can appear darker or brighter just from changing illumination angles rather than from any actual change in the target.

Atmospheric clarity also has a major effect on image quality. A hazy sky can reduce the amount of sunlight reaching the surface, as well as the amount of reflected light and radiant heat reaching orbiting sensors from the surface. In order for satellite information to be useful, particularly over a time sequence, the brightness registered by the sensors must be corrected for the angular and atmospheric influences. If this is not done, a user could get erroneous indications of change in turf status where none has occurred, or have a real change masked by these effects.

Superintendents already spend long hours each day making decisions. They coordinate actions and glean important information from all they see and hear. Raw satellite imagery can take many hours to interpret. It must be processed before interpretations can be made.

One of the most promising applications for satellite imagery is for irrigation scheduling. In arid environments, high daytime temperatures along with low humidity result in a large amount of evaporation from the soil surface and transpiration from plant material. The transition from no stress to an economically harmful level of water stress can occur quite rapidly. This makes the time to process satellite data and to implement changes in irrigation schedules an important concern. Satellite data, combined with ET data from local weather bureaus, gives superintendents the extra information needed to conserve water and provide high quality turf for golfers.

The State of Satellite Data Evaluation

Visual evaluation of plant water status, while time consuming, can be remarkably effective for golf courses. Regular soil sampling to assess water depletion is also a good method, but it must assume uniformity in soil water holding capacity for large areas so that a few point measurements can be used to characterize water retention properties. Evapotranspiration (ET) models assume a freely transpiring reference crop with uniform canopy cover and soil type within the course. Many times, this is not the case.

In the past, hand-held infrared thermometers (IRTs) have been effective tools to detect water stress in crops. As the water supply in the rootzone becomes depleted, transpiration is reduced. Solar energy, normally absorbed through evaporation from the leaves, is converted to heat. The leaf temperature can increase as much as ten degrees C when humidity is relatively high. A fully stressed plant (no transpiration occurring) can have a leaf temperature greater than the air temperature.

For plants with known planting densities, such as turf, the percent cover can be determined and compensated for the influence of soil background. The combination of three sensors (red, near-infrared, and thermal infrared) provides two powerful tools for the golf course irrigation manager.

The first is a measure of the actual evapotranspiration relative to the potential ET. This is called the water deficiency index. It shows what percent of the maximum possible water loss through surface evaporation and plant transpiration was at the time of measurement.

The ET computer models used to calculate the water deficiency index from weather history, soil water holding capacity and estimated cover can be tailored to varying soil fertility and water holding capacities found on golf courses. A separate model could be run for different parts of the course.

The second tool is an image that assumes the exposed soil surface dries out before the root zone - almost always the case in the desert Southwest. This assumption allows soil background effects to be eliminated entirely, and water-stressed turf becomes clearly visible.

The Future

In order to make satellite imagery more economically attractive to the golf course superintendent and satellite image provider, a more valuable product than irrigation scheduling is needed. Work is ongoing to develop sensors for detecting fertilizer deficits and pest infestations. Satellite information can be added to important degree-day data to predict the onset of insect and disease outbreaks.

The launching of satellites specifically designed for golf course management is possible within the next few years. Difficulties associated with sun angle and satellite look angle are being addressed by scientists.

Increased image resolution will allow the use of ground targets with known reflectance for calibrating the images. This will greatly improve their accuracy and reliability.

Automation of image processing can and is speeding up the delivery time of processed information to the user, while orbiting data relay stations have helped increase the ability to handle a larger volume of images. Researchers are working on ways to meld satellite imagery with growth and ET computer models. The crowning achievement will be to tie all of these technologies together to form a product that is both reliable and easy to use. That time is rapidly approaching.

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