Remote Sensing Urban Oasis Evapotranspiration to Aid Irrigated Landscape Water Conservation

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Water conservation is urgent for irrigated urban landscapes in much of western, southern, and southeastern U.S. Urban water supplies are squeezed by a changing climate that amplifies high temperature and drought extremes on one side, and increased demand from growing populations on the other. Estimates of actual urban evapotranspiration (ET) are key to most conservation programs in cities with precarous water supply that must balance demand. Estimated ET approximates actual plant water demand that drives precision irrigation timing and duration to meet plant water needs, and to set end user target water allocations and track compliance.

As adopted from agriculture water management, urban ET is estimated in a two part process. First, reference evapotranspiration (ETo) is calculated (Penman-Monteith energy balance equation) for a hypothetical, standardized turfgrass surface from weather data (solar radiation, wind speed, air temperature, vapor deficit) measured over a large, well irrigated urban turf surface such as a park or golf course. Then, landscape plant water demand (actual ET) is estimated as ETo times an empirically derived ratio (Plant Factor) specific to a general plant type.

This urban approach to estimating plant water demand has several issues: ETo calculated over a large urban turf area such as park or golf course is an oasis estimate reasonable for that specific point of turfgrass but does not capture urban heat effects on plant water use, so precision landscape irrigation is at best approximate for the larger mosaic of urban landscapes. Also, the body of information on past ETo is limited, particularly potential periodicity of high ETo years, so setting future water allocations is not well informed. Finally, the extant Plant Factor (PF) correction method is overly complicated and needs simpfying for practitioner ease of use.

First, we are investigating satellite (daily MODIS downscaled to weekly Landsat) thermal-multispectral imagery to estimate actual urban turfgrass ET to replace ETo-PF for the Salt Lake City metropolitan region. Actual ET for a large turf area can be extracted from the relationship between cool (parks, golf courses) to hot (asphalt-concrete-building) pixels and vegetation cover (visible spectral bands). Satellite-based ET better captures urban heat island effects on turf turfgrass water demand for more accurate precision irrigation and water allocations.

Also, urban ET data is historically lmited and year-to-year variability and periodicity not well understood. To address this, we also investigate reconstruction of paleo ETo (Hargreaves max/min temperature) over the past 500 years in northern Utah from ring width of low elevation junipers (*Juniperus osteosperma*) sensitive to water stress and dry air (high ETo). Paleo ET may be linked to regional wet/dry oscillations driven by mid-Pacific sea surface temperatures, and so possibly amenable to modeling for better year-to-year tailoring of end user water allocations.

Finally, short term the ETo-PF method is the tool at hand for precision irrigation and water allocations. We report on a national standard (Amer. Soc. Agricultural and Biological Engineers

Standard-623) that codifies PF's for irrigated urban landscapes. These factors simplify enormous biological complexity in water use traits among the many landscape species to two robust categories distinct for turf and woody plants. Turfgrass separates based on photosynthate metabolism, C4 (PF=0.6) and C3 (PF=0.8). Woody plants separate based on transpiration (stomatal) sensitivity to dry air (vapor deficit) that varies with climate, humid (PF=0.7) and arid (PF=0.5).