**Interactive Irrigation Tool 2013 V2**

**Variables**

**i = hour**

**Rhri= rainfall for hour of simulation**

**Rei = effective rainfall for hour of simulation**

**Rsumj = sum of rainfall for day j**

**SWCi = soil water content for hour of simulation**

**ETci = evapotranspiration reference for hour of simulation**

**InFi = infiltration**

**Ihri = irrigation for hour of simulation**

**AWRi = accumulated water requirement**

**PERCi = percolation for hour of simulation**

**Qi = runoff**

**User inputs**

**Irrigation rate (as time/equipment or depth)**

**Irrigation days and times**

**Soil type**

**Soil depth (root depth RD)**

**ZIP code**

**Irrigated area**

**Irrigation technology (time-based, rain sensor, soil water sensor (SWS), or ET controller)**

**Rain sensor setting (RSS)**

**Threshold setting for SWS (TH)**

**Parameters**

**FC = field capacity**

**WP = wilting point**

**MAD = managed allowable depletion**

**USER OVERVIEW**

The user can input certain items to tailor the model to meet their site characteristics. There are also default values for these inputs (Table 1). Entering information about lot size allows us to calculate savings in units of gallons which is useful when comparing with water bills.

Table 1: Initial values and/or defaults

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter description | Symbol | Value | Reference |
| Field capacity | FC | 1 in/ft |  |
| Lot size | LotSize | 1/8 ac | Chow et al., 1988 |
| Root depth | RD | 30 cm | Doss et al. 1960; Peacock and Dudeck 1985 |
| Irrigation schedule |  | Sun/Thur, 1.27 cm | Miami-Dade County restriction |
| Soil moisture based threshold | TH | 0.7 |  |
| Rain sensor setting | RSS | 1.27 cm |  |

The user can select to enter their information in units of cm or in. The model is in the metric system so all units are converted accordingly.

Information is also required from the user regarding Irrigation. The default is that irrigation (I) occurs Sunday and Thursday, each event being 1.27 cm. User is offered the choice of selecting the days of week and the amount irrigated OR the irrigation time with sprinkler type. The user irrigation choices are similar for all irrigation technologies (i.e., ET-controller, SMS-based, time-based with rain sensor).

Weather data are associated to the user site by ZIP code. The ZIP code is also used to determine if the site is in Miami-Dade County. If it is, the house number is requested and days of irrigation are automatically provided based on the watering restrictions. No other restrictions are currently simulated in the model.

Options are provided for selecting the soil type. Information shown in Table 2 is used by the model based on the soil type selected. Root depth is also an input.

Table 2. Properties by soil type (aRawls et al., 1982; bZotarelli et al., 2010; cRawls et al., 1983).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Soil type** | **Porositya**  **(m3/m3)** | **Bulk Density\***  **(g/cm3)** | **FCb**  **(cm/cm)** | **WPb**  **(cm/cm)** | **Effective porosity, ϴec** | **Pressure head for wetting front, Ѱc (cm)** | **Hydraulic conductivity, K**  **(cm/hr)c** |
| Sand | 0.44 | 1.48 | 0.08 | 0.02 | 0.42 | 4.95 | 11.78 |
| Sandy loam | 0.45 | 1.45 | 0.16 | 0.06 | 0.41 | 11.01 | 1.09 |
| Loam | 0.46 | 1.43 | 0.26 | 0.08 | 0.43 | 8.89 | 0.34 |
| Silt loam | 0.50 | 1.32 | 0.31 | 0.10 | 0.49 | 16.68 | 0.65 |
| Clay loam | 0.46 | 1.43 | 0.34 | 0.14 | 0.31 | 20.88 | 0.10 |
| Clay | 0.48 | 1.37 | 0.37 | 0.16 | 0.39 | 31.63 | 0.03 |

FC is field capacity; WP is wilting point.

\*Calculated using porosity values and equation: ρb = (1-n)\*2.65, where 2.65 is normal particle density (g/cm3).

To start the model, the soil water content is assumed to be at 75% of the field capacity (Eq. 1).

 (1)

Evapotranspiration

This section describes how evapotranspiration (ET) is calculated by the tool using crop coefficients and FAWN data.

Crop coefficients (KC) for calculating actual evapotranspiration (ETa) for each month were derived from field experiments on turfgrass (Romero and Dukes, 2009; Jia et al., 2009; Table 2). Note that these are not the default crop coefficients in ET controllers.

Table 3. Crop coefficient values for determining ETa

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Kc values** | | |
| **Month** | **Panhandle/North Florida\*** | **Central/Southwest  Florida\*\*** | **South Florida\*\*\*** |
| Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec | 0.35  0.35  0.55  0.80  0.90  0.75  0.70  0.70  0.75  0.70  0.60  0.45 | 0.45  0.45  0.65  0.80  0.90  0.75  0.70  0.70  0.75  0.70  0.60  0.45 | 0.71  0.79  0.78  0.86  0.99  0.86  0.86  0.90  0.87  0.86  0.84  0.71 |
| Reference | Jia et al., 2009 | Davis and Dukes, 2010 | Romero and Dukes, 2009 |

\* Mobile, Tallahassee, Gainesville, and Jacksonville.

\*\* Daytona, Orlando, and Tampa (including all locations in Southwest Florida).

\*\*\* West Palm, Fort Myers, Miami, and Key West.

ETa will be determined by using daily FAWN tabulated reference ET (ETo) and the crop coefficient (Kc) from Table 3 as:

 (2)

(Sub-daily calculation for ETa were estimated by dividing the daily by 24.)

**MODEL DETAILS**

**Model simulation for time based irrigation technology**

i=1

While i < 7\*24 (if we stay on a weekly report)

 (3)

(WB, Rhr, Ihr are all in ‘cm’ units. WB represents water inputs.)

If WBi > 0, then

Calculate infiltration rate



Use the Green Amps equations to solve for the infiltration rate.’ **F’ or total infiltration** must be solved using an iterative process with t=1 hr; Ѱ, ϴe, and K from Table 2. Then, F is used to solve for f which is the infiltration rate (cm/hr)

Calculate Q

If WBi < f \* 1hr, then InFi = WBi and Qi = 0

Else InFi = f \* 1hr and Qi = WBi – f \* 1hr

Calculate PERC

IF SWCi-1 + InFi > FC \* RD, then PERCi = SWCi-1+ InFi – (FC \* RD)

Else PERCi = 0

Else

Qi = 0

InFi = 0

PERCi = 0

Calculate ET

Hourly ET will be estimated using the daily calculation divided hourly.

Calculate SWC

IF PERCi > 0, then SWCi = FC \* RD

Elseif SWCi-1 - ETi + InFi < WP \* RD \* 0.1, then SWCi = WP \* RD \* 0.1

Elseif SWCi-1 - ETi + InFi  > FC \* RD, then SWCi = FC \* RD

Else SWCi = SWCi-1 + InFi - ETi

Save SWCi, InFi, Qi, PERCi

i = i + 1

EndWhile

Calculate water losses due to over irrigation for the period: (Qi+PERCi-Rhri)\*area [to convert to gallons]. If value is less than 0, losses are 0. Percent water losses due to over irrigation for the period: (Qi+PERCi-Rhri)/(Ihri) if numerator is less than 0, then value is 0%. Sum values for each day.

**Model simulation for time based irrigation with rain sensor technology**

i=1

While i < 7\*24 (if we stay on a weekly report)

Determine if rain sensor should bypass irrigation.

Rsum = Sum Rhr for the past 24 hrs

If Rsum > RSS, then Ihri = 0

Else Ihri = as input by user.

 (3)

(WB, Rhr, Ihr are all in ‘cm’ units. WB represents water inputs.)

If WBi > 0, then

Calculate infiltration rate



Use the Green Amps equations to solve for the infiltration rate. **F or total infiltration** must be solved using an iterative process with t=1 hr; Ѱ, ϴe, and K from Table 1. Then, F is used to solve for f which is the infiltration rate (cm/hr)

Calculate Q

If WBi < f \* 1hr, then InFi = WBi and Qi = 0

Else InFi = f \* 1hr and Qi = WBi – f \* 1hr

Calculate PERC

IF SWCi-1 + InFi > FC \* RD, then PERCi = SWCi-1 + InFi – FC \* RD

Else PERCi=0

Else

Qi = 0

InFi = 0

PERCi = 0

Calculate ET

Hourly ET will be estimated using the daily calculation

Calculate SWC

IF PERCi > 0, then SWCi = FC \* RD

Elseif SWCi-1 - ETi + InFi < WP \* RD \* 0.1, then SWCi = WP \* RD \* 0.1

Elseif SWCi-1 - ETi + InFi  > FC \* RD, then SWCi = FC \* RD

Else SWCi = SWCi-1 + InFi - ETi

Save SWCi, InFi, Qi, PERCi

i = i + 1

EndWhile

Calculate water losses due to over irrigation for the period: (Qi+PERCi-Rhri)\*area [to convert to gallons]. If value is less than 0, losses are 0. Percent water losses due to over irrigation for the period: (Qi+PERCi-Rhri)/(Ihri) if numerator is less than 0, then value is 0%. Sum values for each day.

**Model simulation for time based irrigation with soil water sensor technology**

i=1

While i < 7\*24 (if we stay on a weekly report)

Determine if soil water sensor should bypass irrigation.

If SWCi-1 > TH\*FC\*RD then Ihri = 0

Else Ihri = as input by user.

 (3)

(WB, Rhr, Ihr are all in ‘cm’ units. WB represents water inputs.)

If WBi > 0, then

Calculate infiltration rate



Use the Green Amps equations to solve for the infiltration rate. **F or total infiltration** must be solved using an iterative process with t=1 hr; Ѱ, ϴe, and K from Table 1. Then, F is used to solve for f which is the infiltration rate (cm/hr)

Calculate Q

If WBi < f\*1hr, then InFi = WBi and Qi = 0

Else InFi = f\*1hr and Qi = WBi-f\*1hr

Calculate PERC

IF SWCi-1+InFi>FC\*RD, then PERCi = SWCi-1+ InFi – FC\*RD

Else PERCi=0

Else

Qi = 0

InFi = 0

PERCi = 0

Calculate ET

Hourly ET will be estimated using the daily calculation

Calculate SWC

IF PERCi > 0, then SWCi = FC \* RD

Elseif SWCi-1 - ETi + InFi < WP \* RD \* 0.1, then SWCi = WP \* RD \* 0.1

Elseif SWCi-1 - ETi + InFi  > FC \* RD, then SWCi = FC \* RD

Else SWCi = SWCi-1 + InFi - ETi

Save SWCi, InFi, Qi, PERCi

i = i + 1

EndWhile

Calculate water losses due to over irrigation for the period: (Qi+PERCi-Rhri)\*area [to convert to gallons]

If value is less than 0, losses are 0. Percent water losses due to over irrigation for the period: (Qi+PERCi-Rhri)/(Ihri) if numerator is less than 0, then value is 0%. Sum values for each day.

**Model simulation for time based irrigation with ET technology**

i=1

While i < 7\*24 (if we stay on a weekly report)

Determine irrigation amount.

Calculate effective rainfall (Re).

If Rhri > RD\*FC – SWCi, Rei = RD\*FC – SWCi

Else Rei = Rhri

For irrigation to occur, two things have to be true:

1. Check to see if irrigation is scheduled (Irrigation ck1)

If yes, Ick1 = 1, else 0

1. Check to see if AWR is greater than (FC-WP)\*RD\*MAD

If yes, Ick2 = 1, else 0

If Ick1 + Ick2 = 2, then Irrigation occurs, otherwise no irrigation

Calculate AWR(accumulated water requirement for the beginning of the hour)

1. If Ick1i-1 + Ick2i-1 = 2, AWRstep1 = ETci-1 – Rei-1

Else AWRstep1 = ETci-1 – Rei-1 + AWRi-1

1. If Rhri-1>0 and Rei-1 = 0, then AWRstep2 = 0

Else AWRstep2 = 1

1. If AWRstep1 < 0 or AWRstep2 = 0, AWR = 0

Else AWR = AWRstep1

 (3)

(WB, Rhr, Ihr are all in ‘cm’ units. WB represents water inputs.)

If WBi > 0, then

Calculate infiltration rate



Use the Green Amps equations to solve for the infiltration rate. **F or total infiltration** must be solved using an iterative process with t=1 hr; Ѱ, ϴe, and K from Table 1. Then, F is used to solve for f which is the infiltration rate (cm/hr)

Calculate Q

If WBi < f \* 1hr, then InFi = WBi and Qi = 0

Else InFi = f \* 1hr and Qi = WBi – f \* 1hr

Calculate PERC

IF SWCi-1 + InFi > FC \* RD, then PERCi = SWCi-1+ InFi – FC\*RD

Else PERCi = 0

Else

Qi = 0

InFi = 0

PERCi = 0

Calculate ET

Hourly ET will be estimated using the daily calculation

Calculate SWC

IF PERCi > 0, then SWCi = FC \* RD

Elseif SWCi-1 - ETi + InFi < WP \* RD \* 0.1, then SWCi = WP \* RD \* 0.1

Elseif SWCi-1 - ETi + InFi  > FC \* RD, then SWCi = FC \* RD

Else SWCi = SWCi-1 + InFi - ETi

Save SWCi, InFi, Qi, PERCi

i = i + 1

EndWhile

Calculate water losses due to over irrigation for the period: (Qi+PERCi-Rhri)\*area [to convert to gallons]. If value is less than 0, losses are 0. Percent water losses due to over irrigation for the period: (Qi+PERCi-Rhri)/(Ihri) if numerator is less than 0, then value is 0%. Sum values for each day.