Engineering Logbook

Senior Capstone - Portland State University

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Contents

Monday, 4 January 2016

1 Irrigation Policy - Research Summary

Water balancing method of irrigation scheduling appears suitable for computational methods and requires no field work.[1]
Water balancing accounting is performed by calculating how much water leaves the soil and how much water is absorbed by the soil. Moisture can leave the soil through the following mechanisms:

- Evapotranspiration (E_{tc}):
    1. Moisture leaves the soil to the surrounding air.
    2. Water is absorbed by the plants.
- Surface Runoff (SRO): Runoff occurs when irrigation or rainwater is applied at a rate faster than the soil can absorb.
- Deep Percolation (DP): Drainage of water away from the root zone

Water enters the soil through the precipitaion, irrigation, or upwelling. (P, Irr, U)
If these terms can be estimated, a water deficit can be calulated by:

$$D = E_{tc} - P - Irr - U + SRO + DP$$ [2]

The goal of our device will be to restore water lost from the soil by irrigating the correct amount so as to correct the water deficit. We can simplify the equation above by assuming the SRO and DP terms to be negligible. This requires the delivery of water via irrigation to not exceed the rate of uptake by the soil. The application rate will be determined outside of this system. U will be assumed to be negligible as well. Irrigation will be set equal to the deficit, leaving the resulting equation:

$$Irr = D = E_{tc} - P$$

This approach will require a method to estimate E_{tc} and precipitation. Can we skip a day if precipitation is detected? Can we detect precipitation using sensors for determining evapotranspiration? Humidity perhaps?

[1] CSUE Fact Sheet No. 4708
[2] CSUE Fact Sheet No. 4707

Wednesday, 6 January 2016

1 E_{tc} Estimations

$$E_{tc} = E_{to} \cdot K_c \cdot K_s \quad {}^{1}$$

Where E_{to} is a reference evaportranspiration rate, K_c is the crop specific coefficient, and K_s is the crop stress coefficient. This equation will be simplified by setting both coefficients equal to 1, resulting:

$$E_{tc} = E_{to}$$

E_{to} is usually determined by following the Penman-Montieth method.[2] Since this method requires many environmental vashowsriables, it is not suitable for our application. Instead, a reduced set method such as Hardgreaves(HARG)[3] will be used. HARG:

$$E_{to_H} = HC \cdot R_a \cdot (T_{max} - T_{min})^{HE} \cdot (\frac{T_{max} + T_{min}}{2} + HT)$$

HC, HE, and HT are all constants that can be calibrated. The Hardgreaves method requires only ambient air temperature and calendar day since R_a can be supplied from meteorological data given date and latitude. At this point we can determine Irrigation (Irr) needed with the following:

- Calendar Day (Requires Table of R_a stored in memory)
- Maximum/Minimum Ambient Temperature (Daily?)
- Precipitaion (Sensing Pad?, Humidity?)

[1] CSUE Fact Sheet No. 4707
[2] FAO Irrigation and Drainage Paper 56
[3] Hardgreaves and Other Reduced-Set Methods for Calculating Evapotranspiration

Saturday, 9 January 2016

1 R_a Estimations

The Hardgreaves method requires the extraterestrial radiation(R_a) in mm/day. In order to calculate this term we can use methods outlined in Chapter 3 of FAO-56 (Allen, 1998). Using latitude in radians and calendar day R_a can be calculated by:

$$R_a = \frac{24(60)}{\pi} \cdot 0.082 \cdot 0.408 \cdot d_r[\omega_s sin(j)sin(d) + cos(j)cos(d)sin(\omega_s)]$$

Where

$$d_r = 1 + 0.033cos(\frac{2\pi}{365} \cdot D_y)$$

and

$$d = 0.409sin(\frac{2\pi}{365} \cdot D_y - 1.39)$$

and

$$\omega_s = arccos(-tan(j)tan(d))$$

Where D_y = day of the year (1-365) and j = latitude in radians.
With this calculation, the table of radiation values mentioned previously will not be needed.

2 Comparison of Historical Evapotranspiration Data and Hardgreaves Approximation

Now an algorithm can be clearly stated that will determine the water lost from soil in mm/day. Given day of the year(D_y), latitude in radians(j), maximum daily temperature(T_{max}), and minimum daily temperature(T_{min}):

1. Calculate d_r
2. Calculate d
3. Calculate ω_s
4. Calculate R_a
5. Calculate E_{to}

In order to see if this algorthm shows any promise I wanted to compare the output with historical data from the Portland area. The only data I found was for Aurora, Oregon. I used historical records of average monthly high and low temperatures for Portland, OR, and used a latitude of 45.5 degrees.

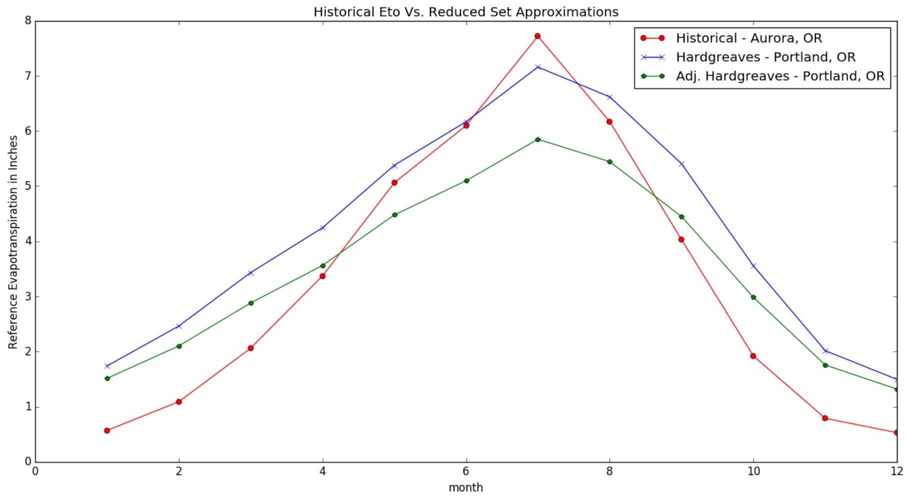

Figure 2 Historical Evapotranspiration Comparision with Hardgreaves Method The Hardgreaves approximation tracks well with the historical data, especially considering the differences in location and temperature data. I believe this figure shows that this algorithm is suitable for future consideration.

Tuesday, 26 January 2016

1 Main Component List

As a team we have selected and ordered the components in our system design model.

- Laird BL600 eBOB
- Raindrop Sensor
- Temperature Sensor - TMP36
- Real Time Clock - DS1307
- 32.7 MHz Crystal
- 1/2" Water Flow Solenoid
- 1/2" Water Flow Sensor
- Soil Moisture Sensor

Sunday, 7 February 2016

1 Water Delivery Build and Test

Today Austin, Taylor and I assembled the water system in order to test the solenoid, flow sensor, and BL600 eBOB. The system was constructed using:

- 1/2" Water Flow Solenoid
- 1/2" Water Flow Sensor
- Brass 3/4" Female to 1/2" male adapter x2
- Plastic 1/2" Female coupler
- 9VDC 1A Switching AC power adapter

Using GPIO input on the BL600, we tested the accuracy of the flow sensor and tested the system for water leaks.
Results:

Sources