An Agricultural Application of GOES-PRWEB

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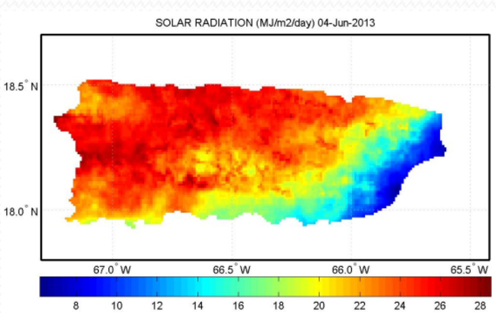
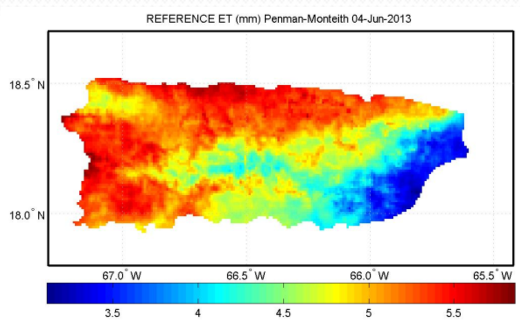
GOES-PRWEB

- 25 daily hydro-climate variables published to internet

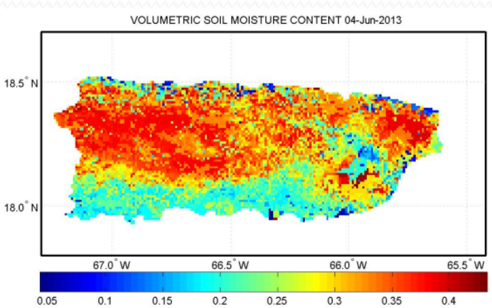
Solar Radiation



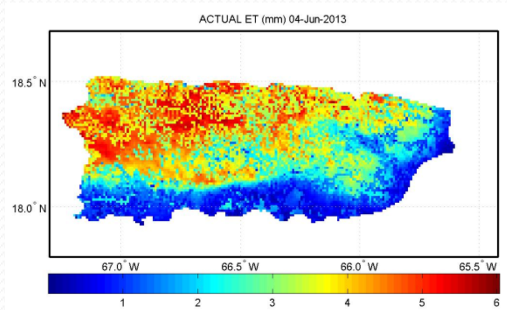
Reference Evapotranspiration



Soil Moisture



Actual Evapotranspiration



June 4th, 2013

Index of /hdc/GOES-PRWEB_RESULTS

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aquifer_recharge/	05-Jun-2013 23:03	-	
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minimum_air_temperature/	05-Jun-2013 23:03	-	
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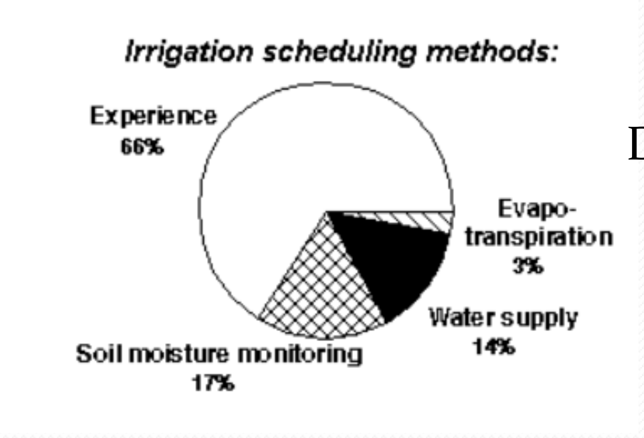
solar_radiation/	05-Jun-2013 23:03	-	
surface_resistance/	05-Jun-2013 23:03	-	
wind_speed/	05-Jun-2013 23:03	-	

Objective

- To show an agriculture application of GOES-PRWEB algorithm. Specifically:
  - A simple web-based method for scheduling irrigation

What is the problem?

- There is anecdotal evidence that most farmers do not use scientific methods for scheduling irrigation
- DEFINITION: Irrigation scheduling is the process used by irrigation system managers (farmers) to determine the correct frequency and duration of watering. (wikipedia.org)



Data from Idaho

Why do we care?

Over application of water

- Leads to the waste of
  - water
  - energy
  - chemicals
  - money
  - may lead to the contamination of ground and surface waters.
  - leaching of fertilizers past the root zone
  - water logging
  - lower crop yields.

Under-application of water

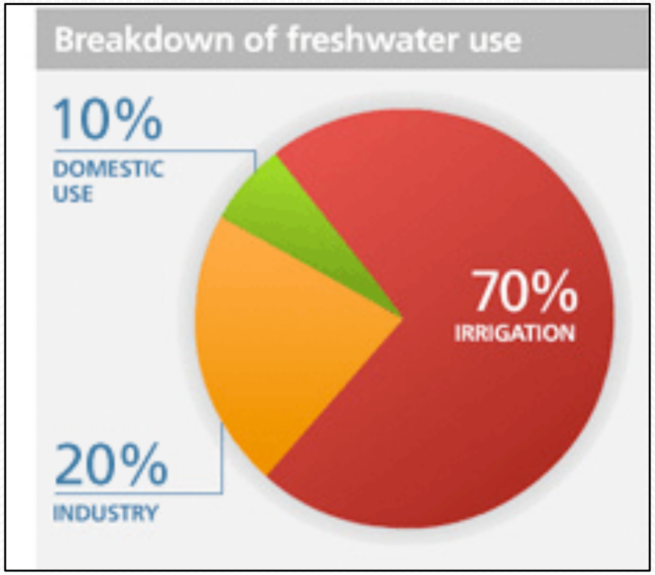
- Lead to
  - crop water stress
  - reduced crop yields
  - loss of revenue to the grower

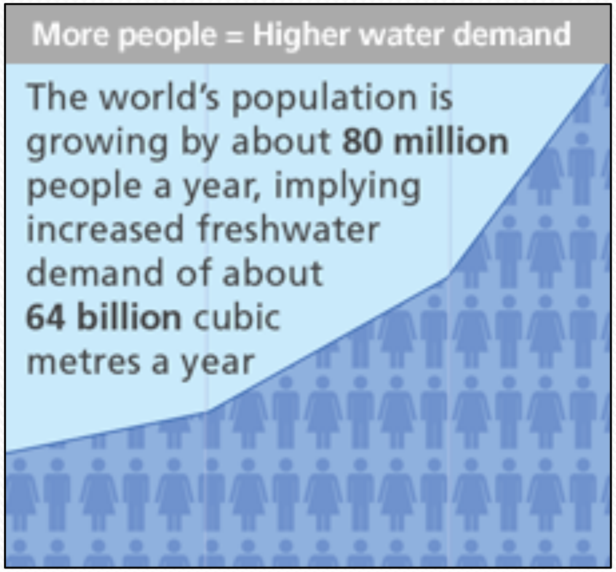
"I wish I would have applied more irrigation."

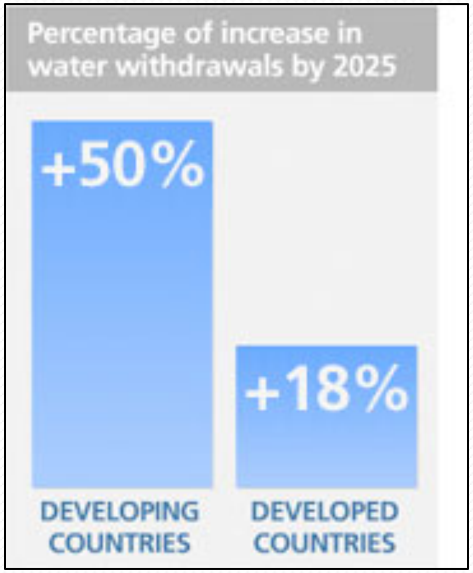
How much water and money are we talking about?

Global Agricultural Water Use

- 70% of all water withdrawn is used for agriculture and the majority of this water is used for irrigation.

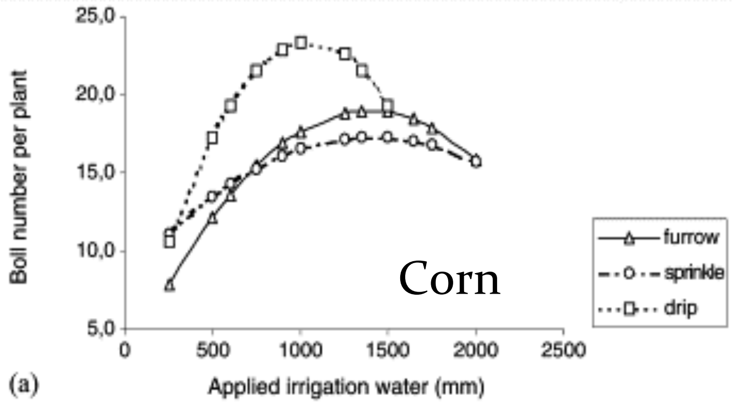


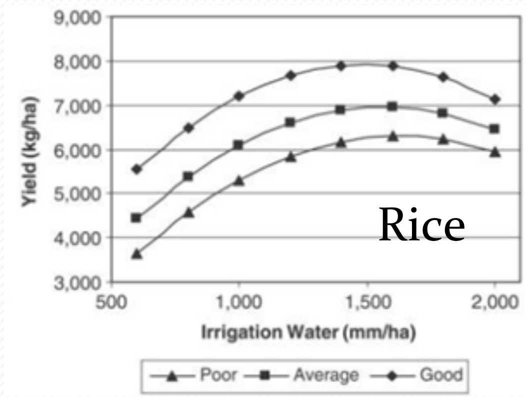


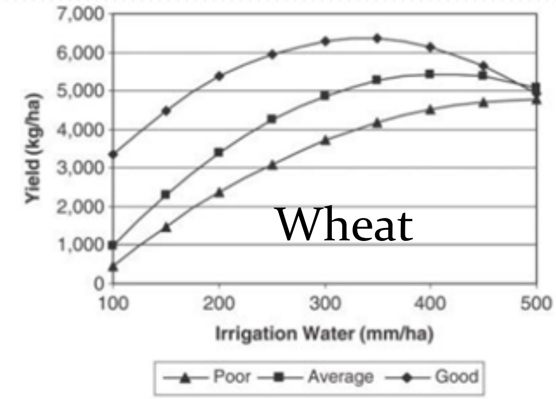


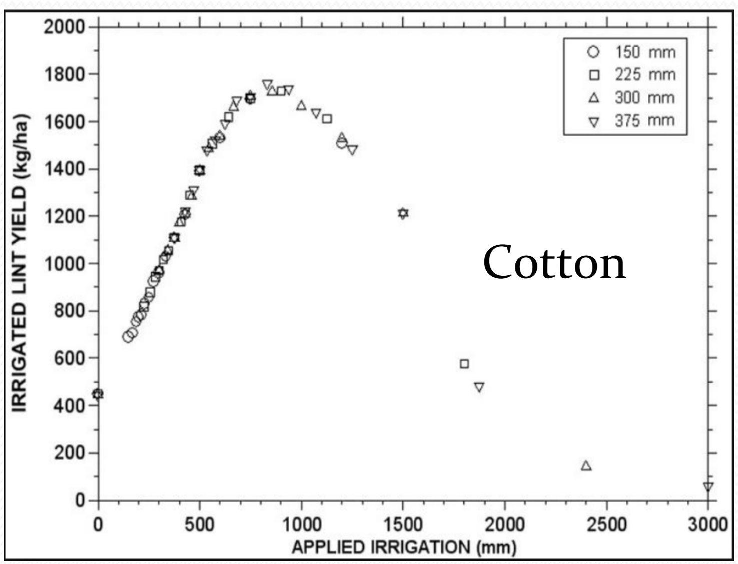
Source of information: FAO

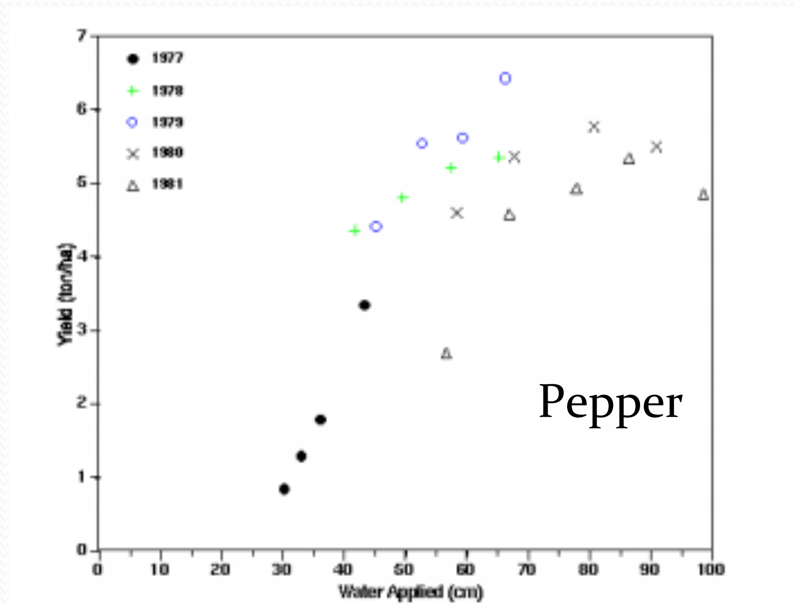
Crop Yield vs. Water Applied/used







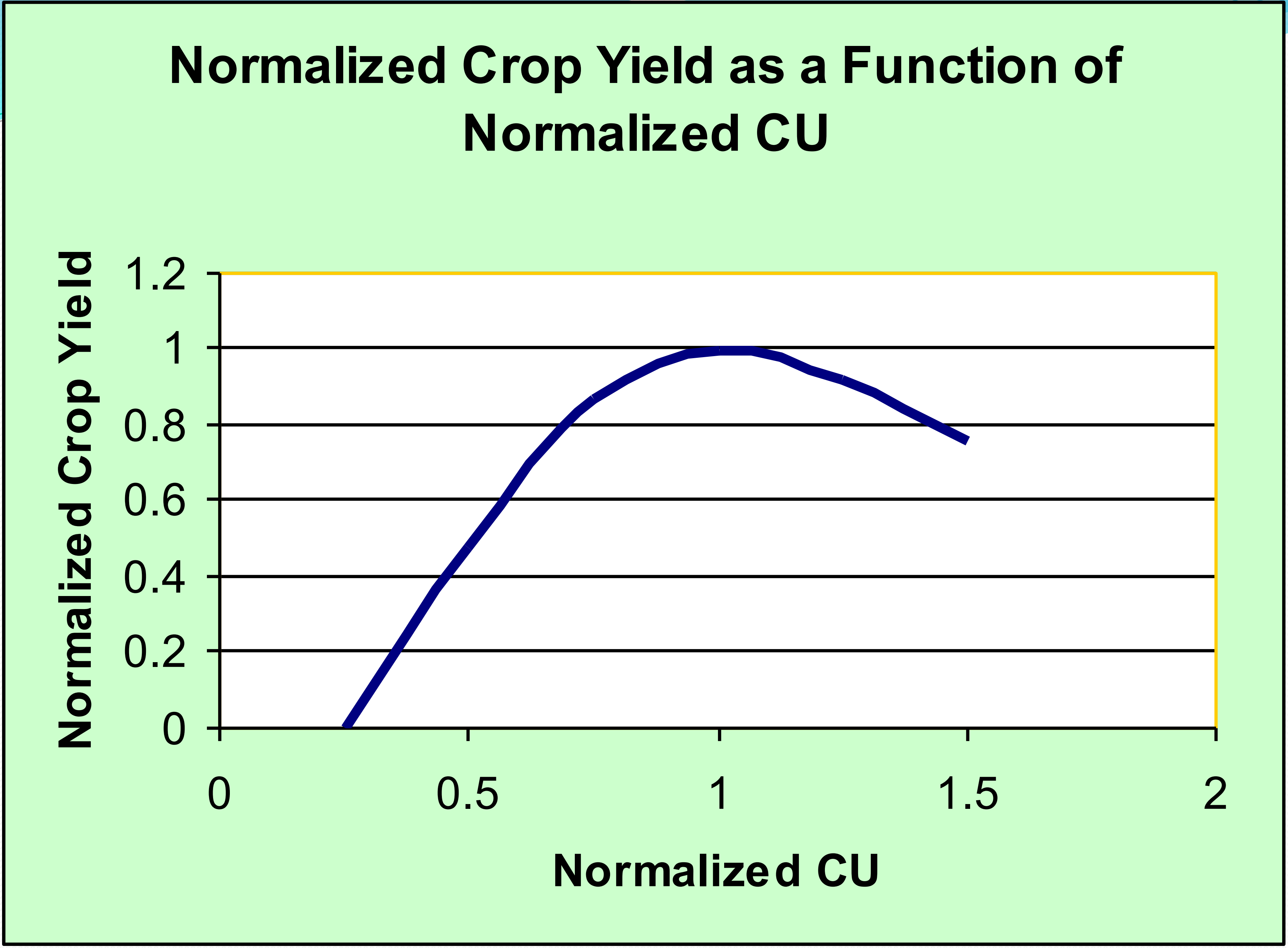




The Cost of Over-Applying Irrigation Water

- Assume the following:
  - Small 10-acre farm grows squash (calabaza)
  - Four (4) month season
  - Estimated **consumptive use (CU)** for season = 500 mm
  - Actual potential CU for season = 400 mm
  - Overall cost of water = $30/acre-ft (considering only: cost of water and electricity)
  - Assume the normalized yield vs. CU curve in the next slide is applicable.
  - Value of a typical squash crop (net income)* = $1,243/acre.

**Conjunto Tecnológico para la producción de Calabaza, UPR Experment Station, Publication 155, revised 2012*



Normalized Crop Yield as a Function of Normalized CU
Normalized Crop Yield
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
Normalized CU

Example continued

- Results:
  - **Excess** water applied = 100 mm = 1.07 million gallons = 3 acre-ft (lost to groundwater)
  - Normalized CU = 1.25, therefore normalized yield = 0.9 (or 0.1 loss)
  - Potential $ LOST = cost of water + lost yield = 3 ac-ft x $30/ac-ft + [0.1*$1,243/ac] x **10 ac** = **$1,333**

If ag. chemicals are leached to groundwater , groundwater is potentially contaminated (cost was not included in calculation).

  - **$13,330 for 100 acres, 10.7 million gallons of water**
  - **133,300 for 1000 acres, 107 million gallons of water**
  - **FYI: Typical cost of irrigaiton water in U.S. is $200 per ac-ft**

Cost of Under-Applying Irrigation Water

- Assume the following:
  - Same squash farm (10-acres)
  - Four (4) month season
  - Estimated CU for season = 300 mm
  - Actual potential CU for season = 400 mm
  - Assume the normalized yield vs. CU curve is applicable.
  - Value of a typical squash crop* = $1,243/acre.

**Conjunto Tecnológico para la producción de Calabaza, UPR Experment Station, Publication 155, revised 2012*

Example continued

- Results
  - Water **<u>deficit</u>** = 100 mm
  - With a normalized CU of 0.75, the normalized yield = 0.85 (or 0.15 loss)
  - <u>Potential $ LOST = lost yield = [0.15*$1,243/ac] x **10 ac** = **$1,864**</u>

$1,864 could pay your daughter's university tuition or pay her rent for 6 months (tuition is cheap in PR)

- **<u>$18,640 for 100 acre</u>**

- **<u>180,640 for 1,000 acre</u>**

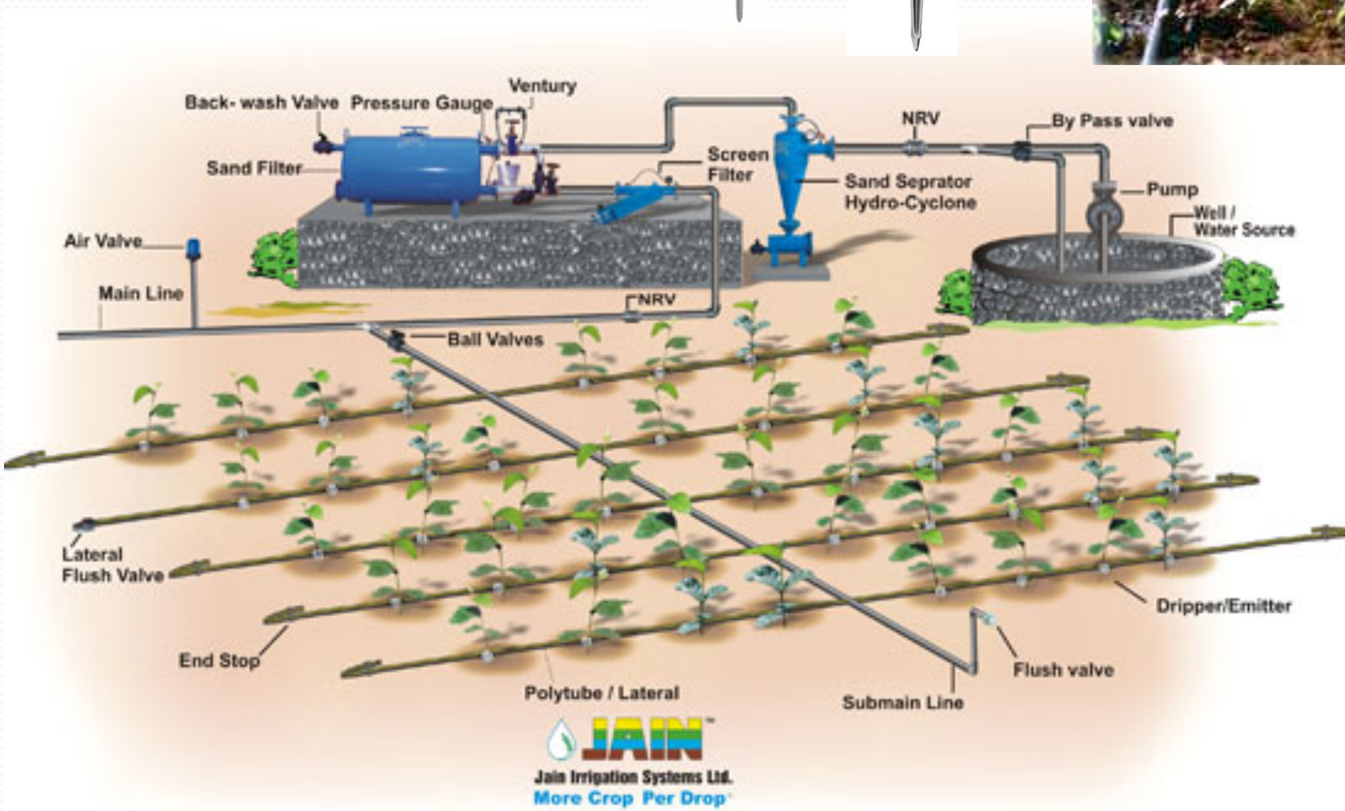
Typical Irrigation Systems

Surface Irrigation

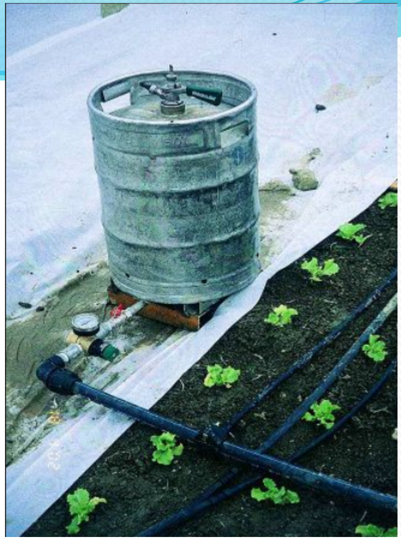
University of Arizona. Credit: John C. Palumbo

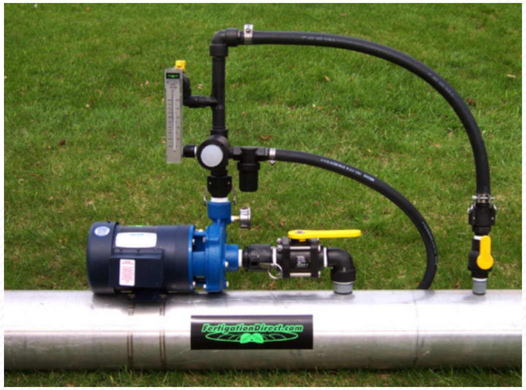
Sprinkler Irrigation

Drip Irrigation



Fertigation





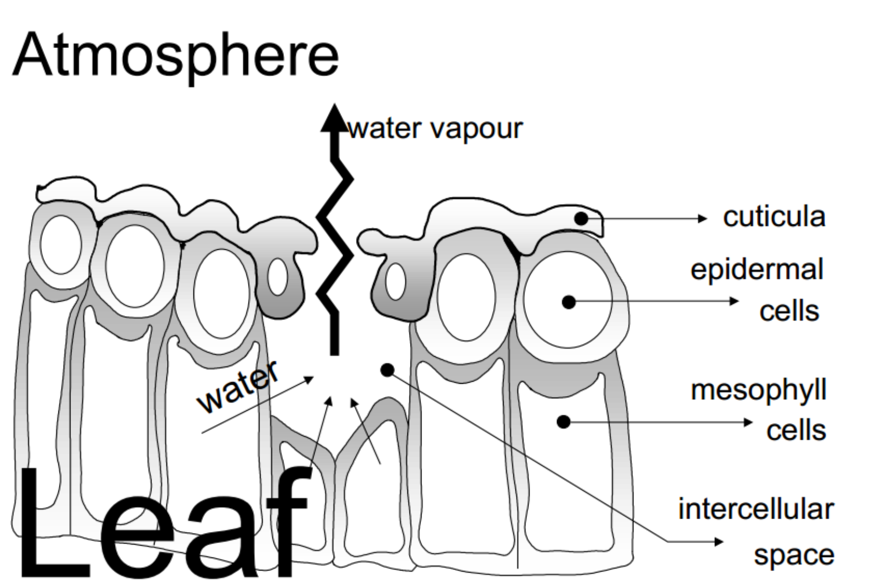
Drip Distribution Uniformity

- Distribution Uniformity is critically important in Drip Irrigation
- Why?
  - Sometimes a plant only has one emitter. If the emitter is plugged, then the plant may die.
  - If water is applied non-uniformly, then fertilizer will also be applied non-uniformly.

How much water should we apply?

- Evapotranspiration = **evaporation** from soil and wet surfaces + **transpiration** from leaves

FIGURE 1
Schematic representation of a stoma



- **Evapotranspiration = plant water requirement**

Determine Crop Water Requirement

$$ET = K_c \, ET_o$$

where

ET = evapotranspiration = crop water requirement = consumptive use (CU)

K_c = Crop Coefficient (unique for every crop)

ET_o = Reference Evapotranspiration (function of climate)

Many weather stations ($1,700 approx.) will calculate the daily reference evapotranspiration

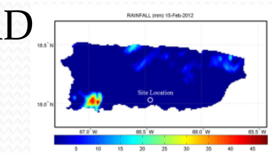
What if a farmer doesn't have a weather station?

Here's a simple web-based method for scheduling irrigation

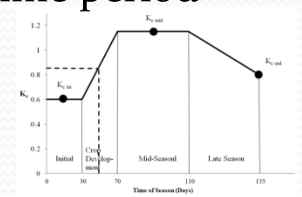
Start

Define problem (location, farm size, crop, etc.)

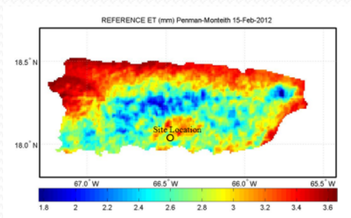
Determine rainfall from onsite gauge or NEXRAD



Determine average K_c for the time period



Determine ET_o



Estimate Crop Water Requirement

$$ET_c = K_c \, ET_o$$

Determine the number of hours to run the pump

$$T = 17.817 \times [D \times A]/[Q \times eff]$$

Harmsen E.W., 2012. TECHNICAL NOTE: A Simple Web-Based Method for Scheduling Irrigation in Puerto Rico J. Agric. Univ. P.R. 96 (3-4) 2012.

Detailed Example

- Determine the irrigation requirement for the 5 day period, February 15-19, 2012, for a tomato crop in Juana Diaz, Puerto Rico. **Table 1** summarizes the information used in the example problem. **Table 2** provides the important web addresses necessary for obtaining data for use in the example problem. **Table 3** shows the crop growth stage and crop coefficient (K_c) data for the example problem.

Table 1. Information used in example problem.

Location	Juana Diaz, Puerto Rico
Site Latitude	18.02 degrees N
Site Longitude	66.52 degrees W
Site Elevation above sea level	21 m
Crop	Tomato
Planting Date	1-Jan-12
Rainfall information	A rain gauge is not available on or near the farm
Type of irrigation	Drip
Irrigation system efficiency	85%
Field Size	10 acres
Pump capacity	300 gallons per minute

Table 2. Internet URLs for example problem.

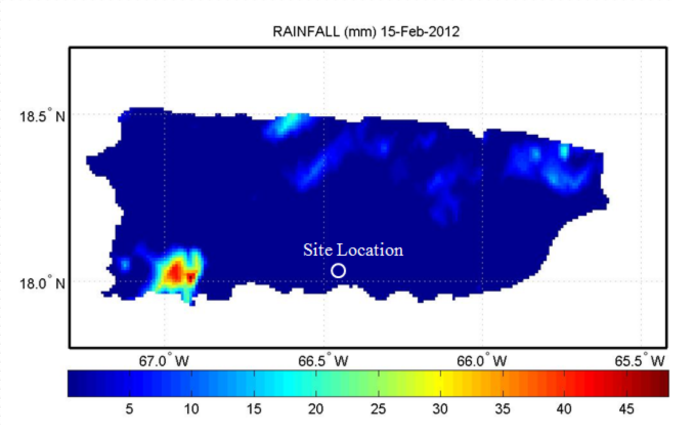
Length of Growth Stages (Table 11) and Crop Coefficients (Table 12)	http://www.fao.org/docrep/X0490E/x0490e00.htm
Daily Reference ET Results for Puerto Rico[4]	http://academic.uprm.edu/hdc/GOES-PRWEB_RESULTS/reference_ET/
Daily NEXRAD Rainfall For Puerto Rico	http://academic.uprm.edu/hdc/GOES-PRWEB_RESULTS/rainfall/

Table 3. Crop growth stage and crop coefficient data for example problem.

Initial Crop Growth Stage	30 days
Crop Development Growth Stage	40 days
Mid-Season Growth Stage	40 days
Late-Season Growth Stage	25 days
Total Length of Season	135 days
$K_{c\ ini}$	0.6
$K_{c\ mid}$	1.15
$K_{c\ end}$	0.8

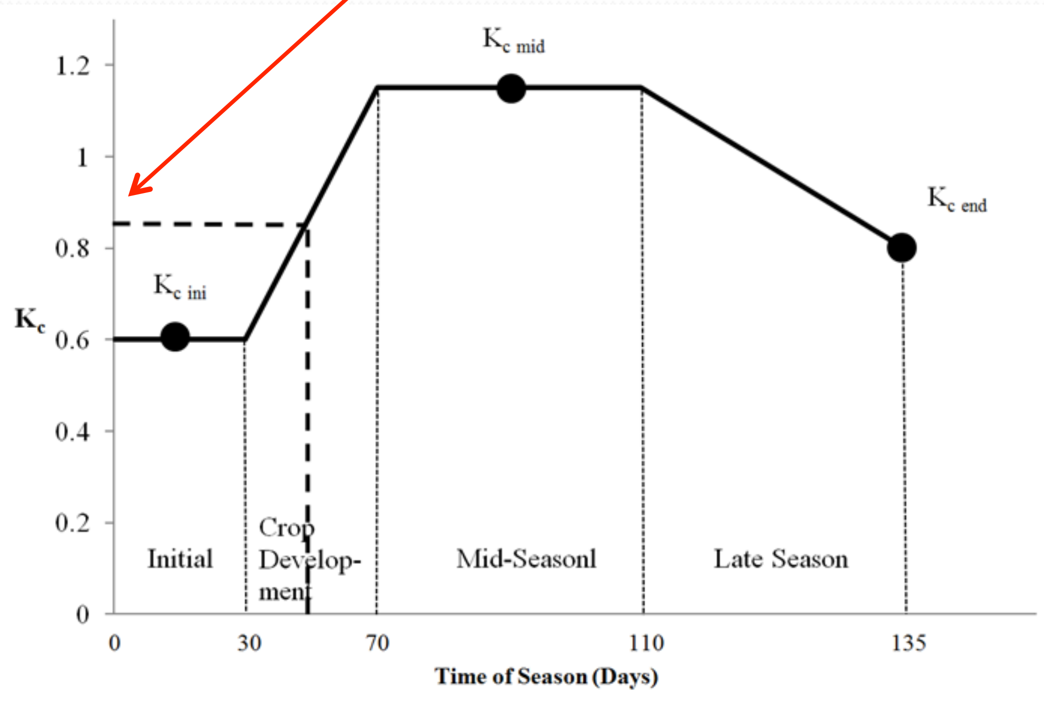
Rainfall

A rain gauge is not available on or near the farm; therefore, it is necessary to obtain rainfall information from NOAA's MPE (NEXRAD and rain gauges in PR) radar. Inspection of the rainfall maps at the URL provided in Table 2 indicates that there was no rainfall during the five day period. Therefore, all of the crop water requirement will have to be satisfied with irrigation.



Crop Coefficient

- The averge K_c value of 0.85 for the five day period was obtained.

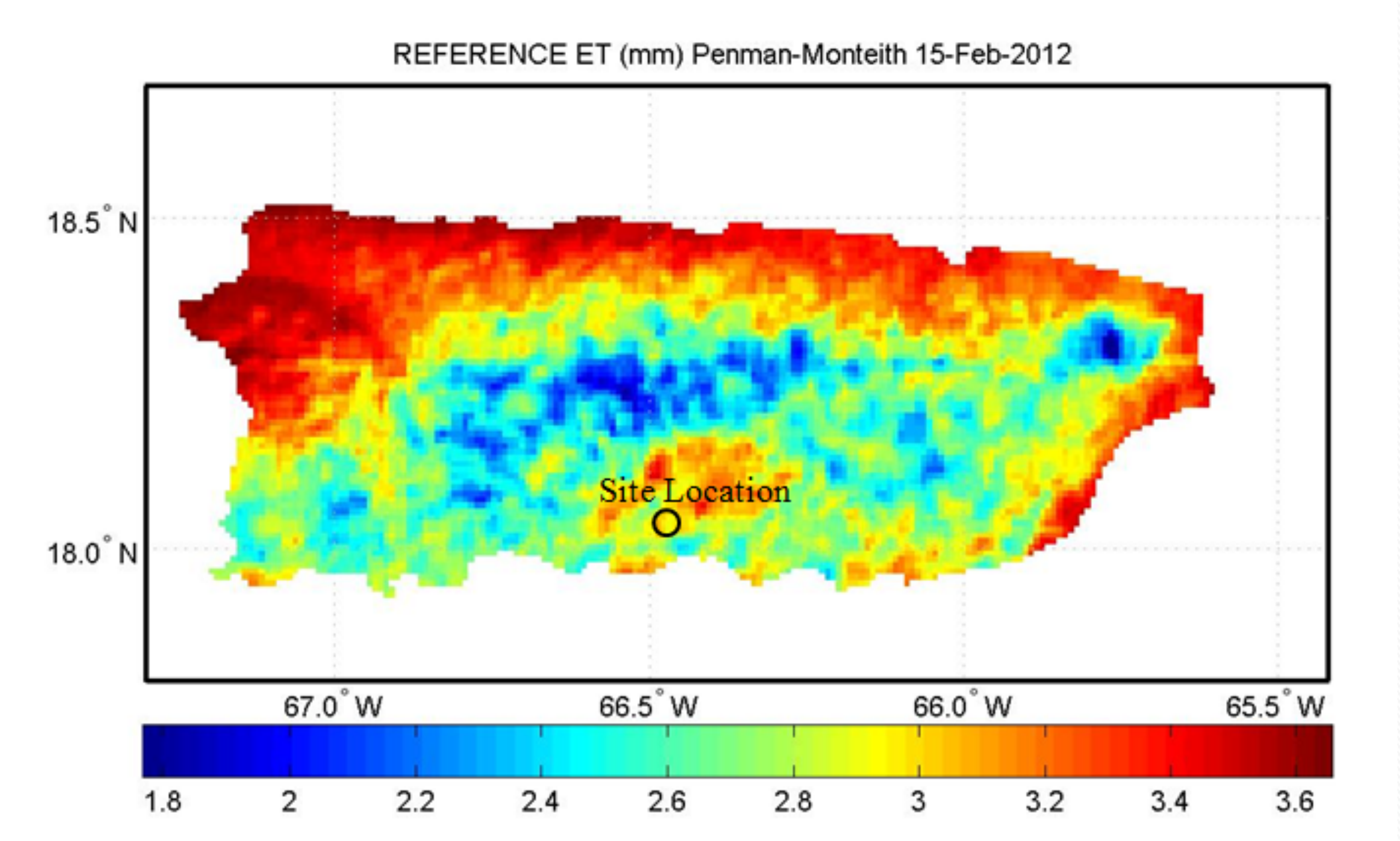


Crop coefficient curve for the example problem. The heavy dashed line applies to the example problem with day of season 46-50 (i.e., Feb 15-19) corresponding to an approximate crop coefficient of 0.85 (vertical axis).

Reference Evapotranspiration (ET_o) from GOES-PRWEB algorithm

- The next step is to determine the reference evapotranspiration (ET_o) for the five day period. The next slide shows the estimated reference evapotranspiration for Puerto Rico on February 15, 2012 obtained from the web address provided in Table 2.
- The estimated ET_o for the site location on 15 Feb., 2012 is 2.95 mm.
- Using a similar procedure, the ET_o values for Feb. 16, 17, 18 and 19 are 2.8 mm, 3.1 mm, 3.5 mm and 3.7 mm, respectively. Summing up the ET_o values comes to a total reference evapotranspiration (for the five days) of 16.1 mm.

Reference Evapotranspiration
from GOES-PRWEB



Crop Water Requirement

- The crop water requirement (ET) for the time period can now be estimated as follows:

$$ET_c = K_c\ ET_o = (0.85)(16.1\ mm) = 13.\ 7\ mm$$

Number of hours to run the pump to satisfy the crop water requirement

- The final step is to determine the number of hours that the pump should be run to apply the 13.7 mm of water.
- A form of the well-known irrigation equation (Fangmeier et al., 2005) can be used:

$$T = 17.817 \times [D \times A]/[Q \times eff]$$

- where T is time in hours, D is depth of irrigation water in mm, A is effective field area in acres, Q is flow rate in gallons per minute and eff is irrigation system efficiency.

- Using D = 16.1 mm, A = 10 acres, Q = 300 gallons per minute and eff = 0.85, yields: T = 17.817 x [13.7 x 10] / [300 x 0.85] = **9.57 hours**.

In Conclusion

- Many farmers do not systematically schedule irrigation
- Application of the wrong quantity of water can lead to losses in water, fuel, chemicals, yield and money.
- A simple web-based method was introduced for scheduling irrigation on farms without weather stations.
- The approach presented here is relatively simple and the near-real time data is available to any farmer in Puerto Rico with internet access.