A SIMPLE WEB-BASED METHOD FOR SCHEDULING IRRIGATION IN PUERTO RICO AND THE U.S. VIRGIN ISLANDS

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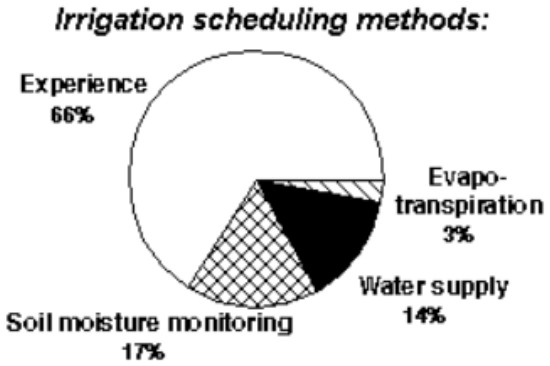
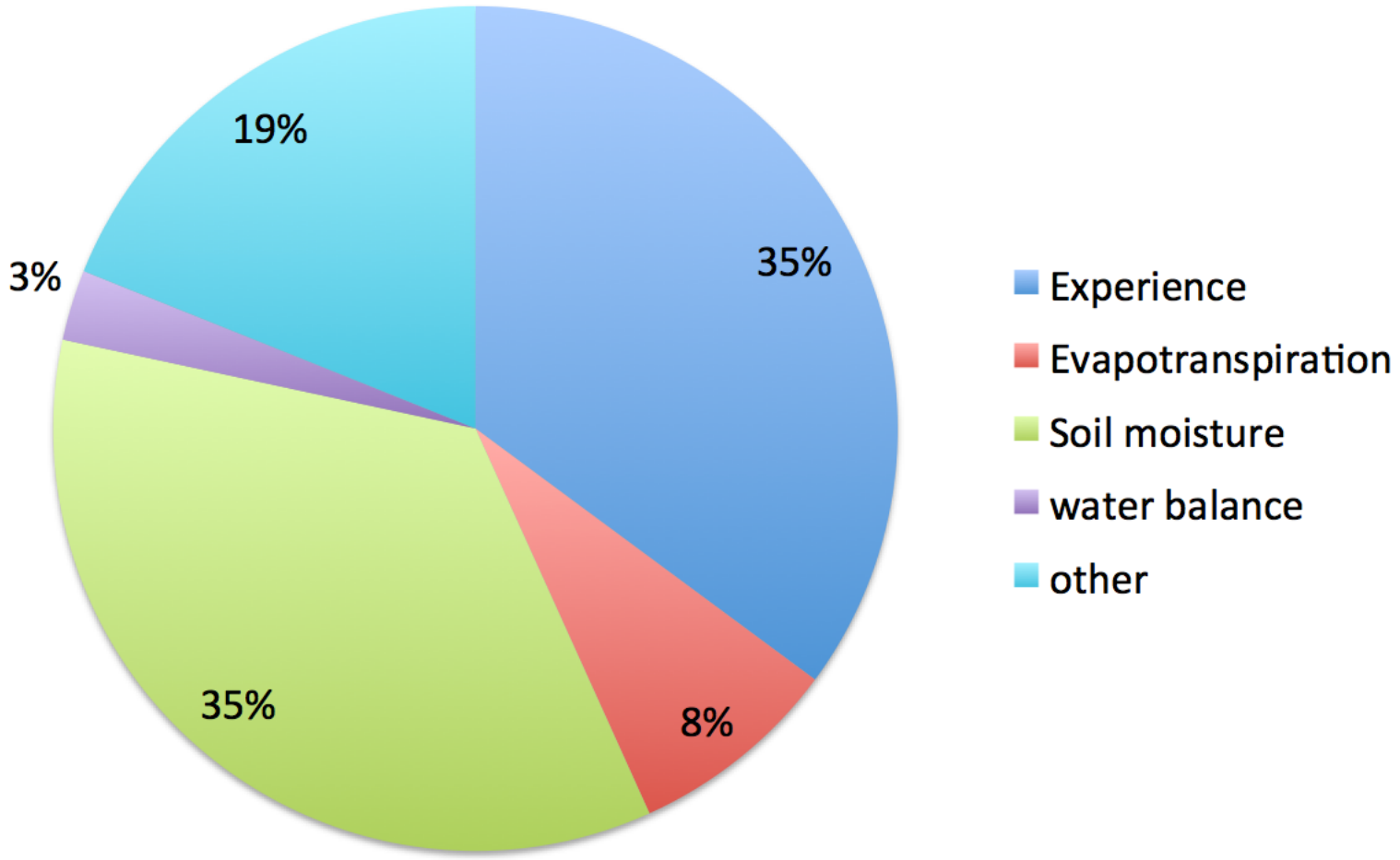
What is the problem?

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



Data from Idaho

Irrigation Scheduling Methods used in Puerto Rico (preliminary data)



Why do we care?

Over application of water

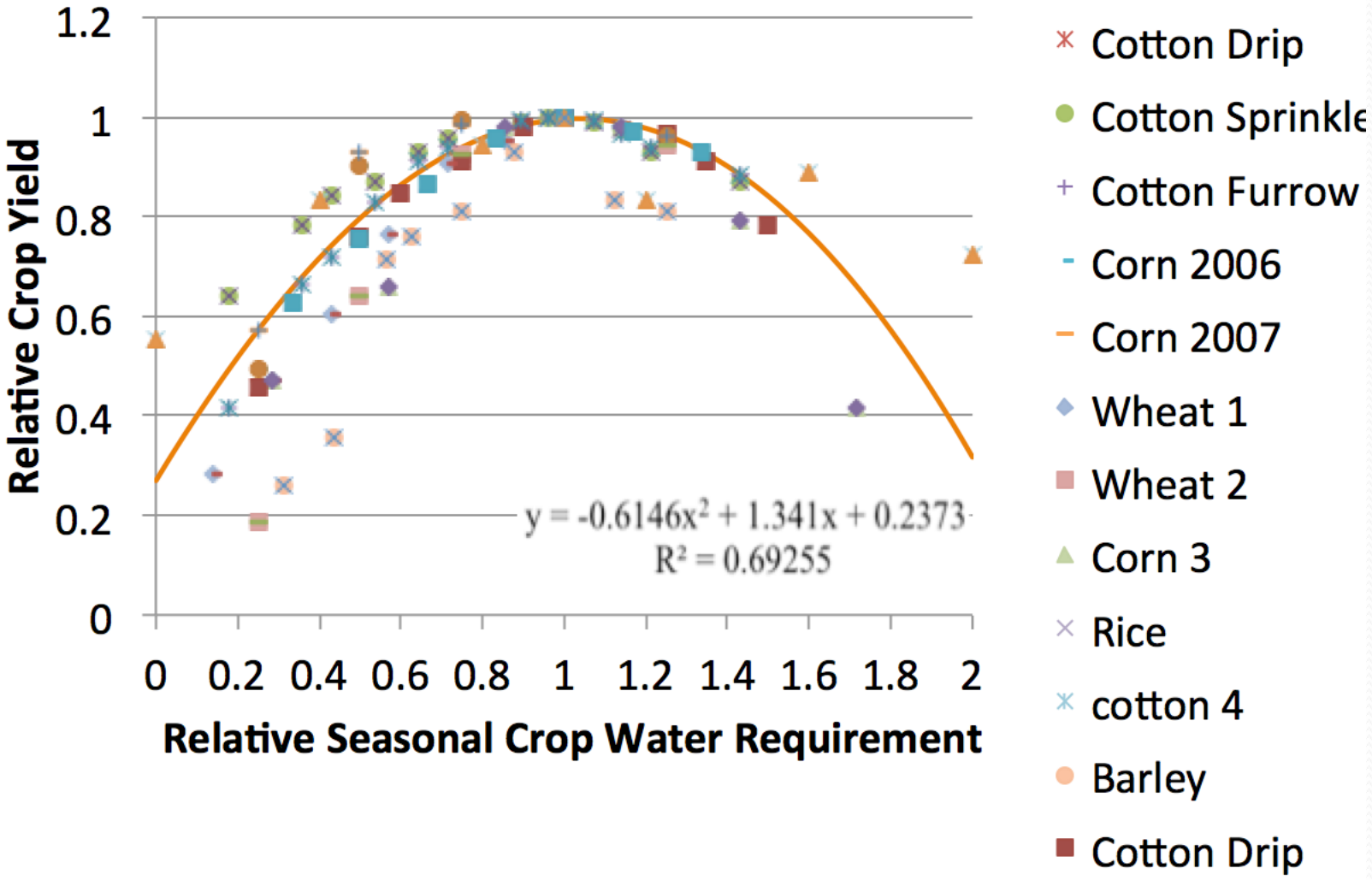
- Leads to the waste of
  - water
  - energy
  - chemicals
  - money
  - may lead to the contamination of ground and surface waters.
  - leaching of fertilizers past the root zone
  - water logging
  - lower crop yields.

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."

Relationship between relative crop yield and relative seasonal crop water requirement applied



How much money are we talking about?

	Percentage of Crop Water Requirement Applied						
	40	50	80	100	130	150	180
CROP*	$ Lost / Acre						
Gandules	47	32	10	0	12	35	69
Pepinillo	111	76	25	0	15	56	124
Repollo	256	174	57	0	21	103	247
Sandia	293	199	65	0	23	114	277
Platanos y Guineos, Plantilla	318	216	71	0	24	122	299
Calabaza	390	265	87	0	27	146	359
Cebolla	543	369	121	0	34	195	490
Pimiento	578	393	129	0	36	206	519
Barenjena	757	514	169	0	44	264	670
Platanos y Guineos, Reton~o	1,006	684	225	0	76	388	945
Melon, Cantaloupe y Honeydew	1,027	698	229	0	56	352	899
Raices y Tuberculos	1,041	707	232	0	57	356	911

*Based model budget data from the *Conjunto Tecnológico, UPR Experment Station*

Objective

- To introduce a simple web-based method for scheduling irrigation in Puerto Rico
  - The method calculates the volume of irrigation water and the number of hours a farmer has to run his or her pump.

- The method is based on: TECHNICAL NOTE: A Simple Web-Based Method for Scheduling Irrigation in Puerto Rico. 2012, Harmsen E.W., J. Agric. Univ. P.R. 96 (3-4) 2012.
  - Available at http:/pragwater.com/selected-publications-and-presentations/

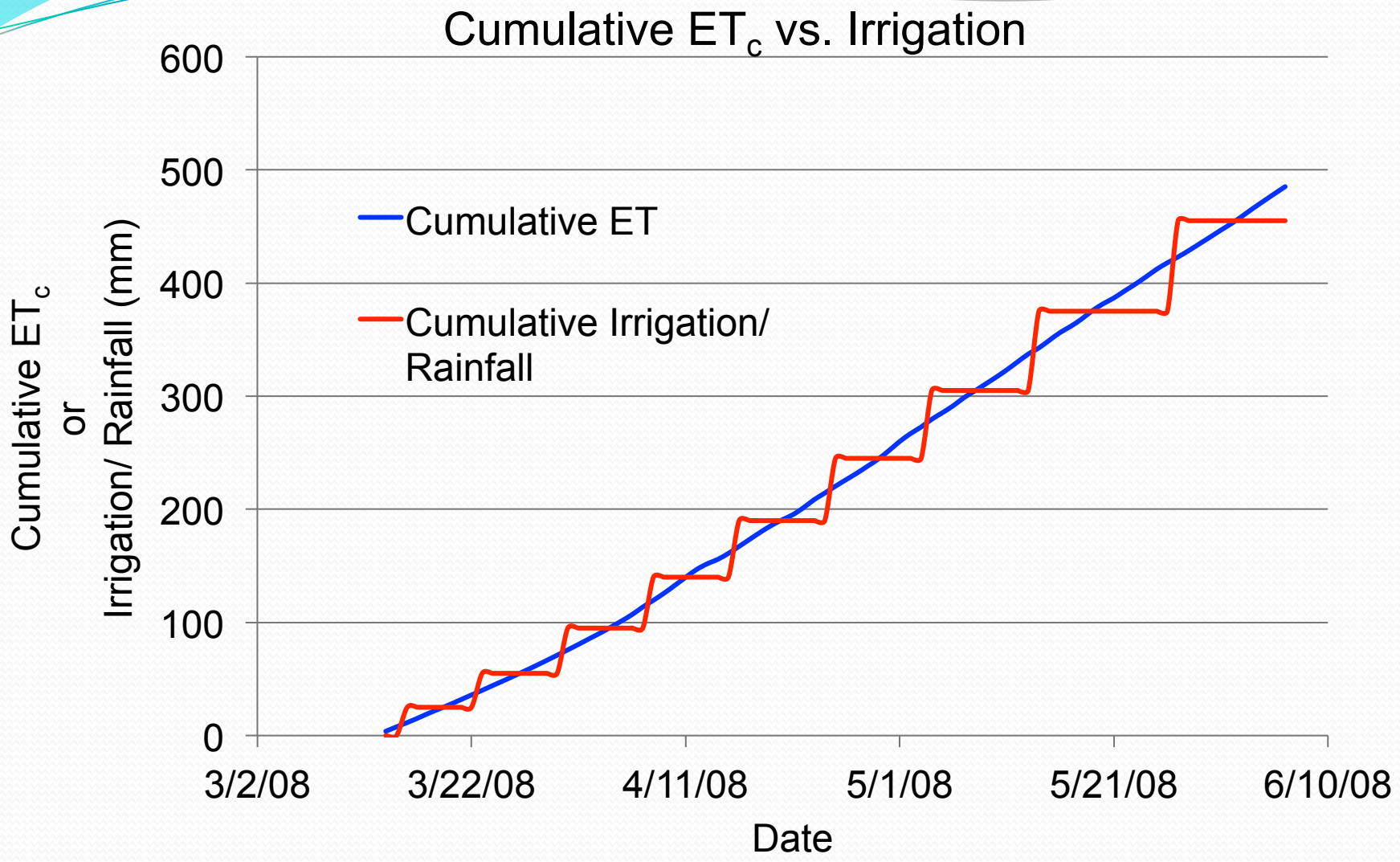
How much water should be applied?

Plant Water Requirement

=

Crop Evapotranspiration

(under well-watered conditions)


Cumulative ETc vs. Irrigation
Cumulative ETc or Irrigation/ Rainfall (mm)
600
500
400
300
200
100
0
Cumulative ET
Cumulative Irrigation/ Rainfall
3/2/08
3/22/08
4/11/08
5/1/08
5/21/08
6/10/08
Date

The most commonly used method for determing the Crop Water Requirement

$$ET_c = K_c\, ET_o$$

where

ET_c = evapotranspiration under well-watered conditions = crop water requirement

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

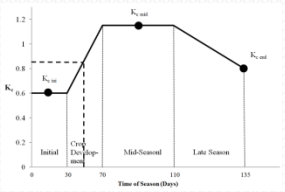
What if a farmer doesn't have a weather station?

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

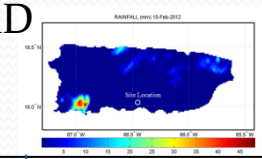
Start

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

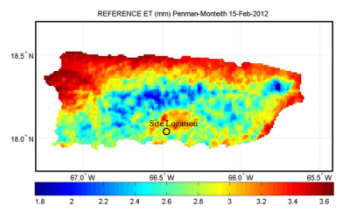
Determine average K_c for the time period



Determine rainfall from onsite gauge or NEXRAD



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.

Required Hyperlinks

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/

Step 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

Step 2. Crop growth stage and crop coefficient data for example problem.

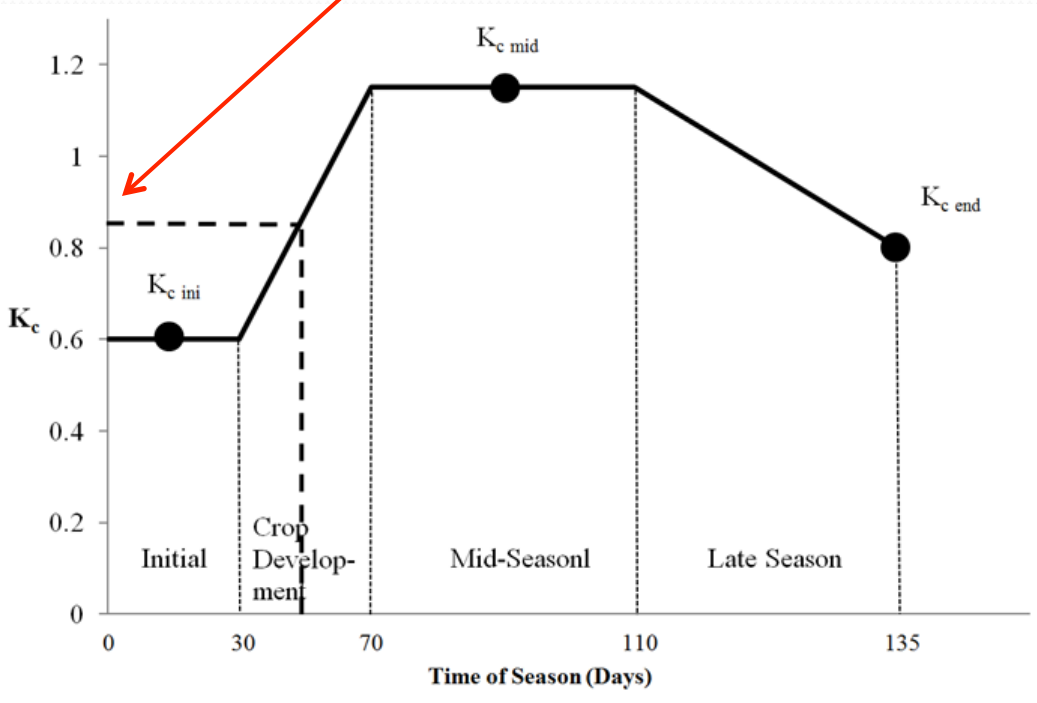
(http://www.fao.org/docrep/X0490E/x0490e00.htm)

Tomato Growth Stages and Crop Coefficients

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

Crop Coefficient

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

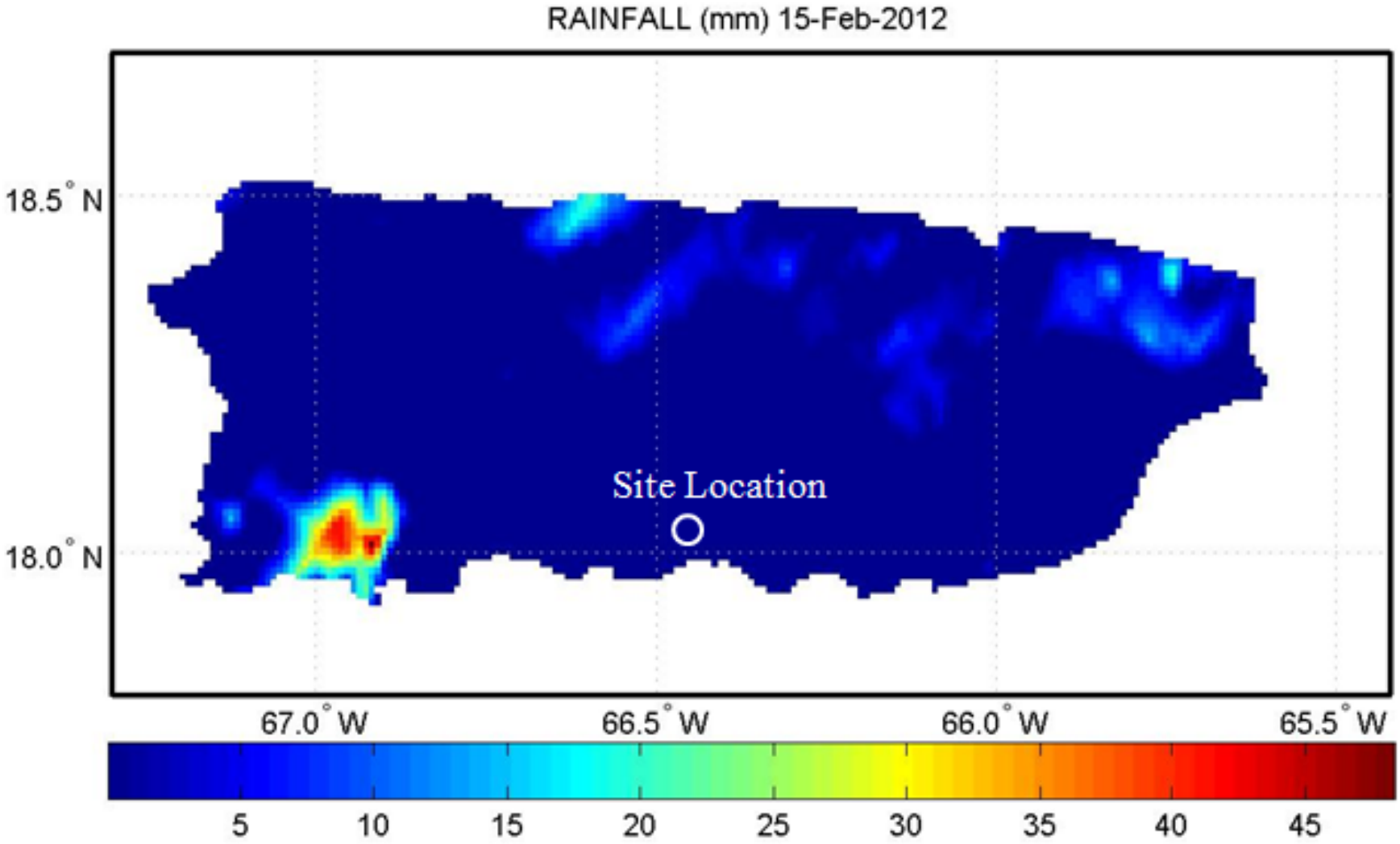


Crop coefficient curve for the example problem. The heavy dashed line applies to the example problem with day of season 46-50 (i.e., Feb 15-19) corresponding to an approximate crop coefficient of 0.85 (vertical axis).

Step 3. Rainfall

(http://academic.uprm.edu/hdc/GOES-PRWEB_RESULTS/rainfall/)

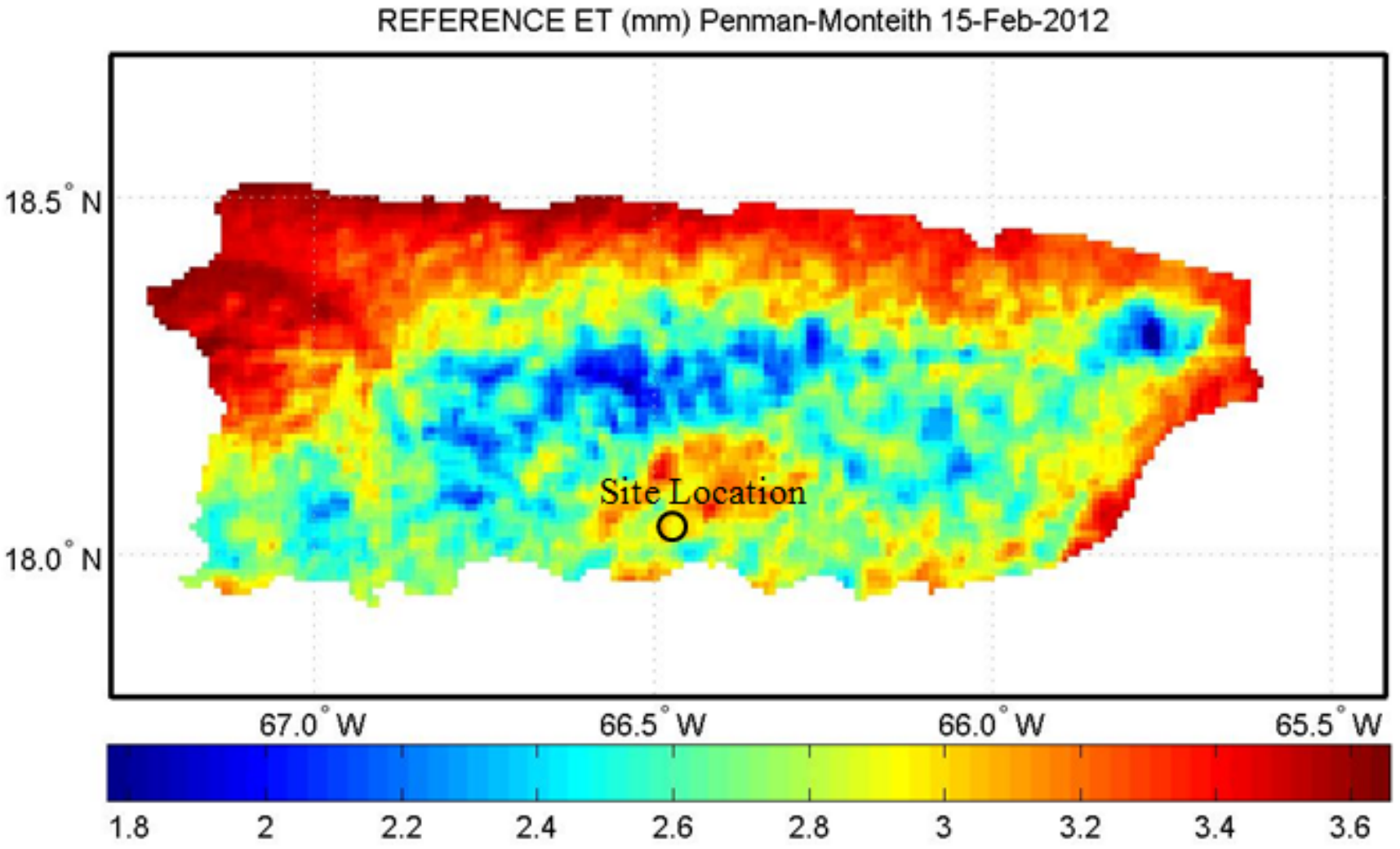
- Inspection of the rainfall maps at the URL provided indicates that there was no rainfall during the five day period.
- Therefore, all of the crop water requirement will have to be satisfied with irrigation.


RAINFALL (mm) 15-Feb-2012
18.5° N
18.0° N
Site Location
67.0° W
66.5° W
66.0° W
65.5° W
5
10
15
20
25
30
35
40
45

Step 4. Reference Evapotranspiration (ET_o)

(http://academic.uprm.edu/hdc/GOES-PRWEB_RESULTS/reference_ET/)

- Inspection of the ET_o maps at the URL provided above indicates that there was 16.1 mm of ET_o during the five day period.


REFERENCE ET (mm) Penman-Monteith 15-Feb-2012
18.5° N
18.0° N
Site Location
67.0° W
66.5° W
66.0° W
65.5° W
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6

Step 5. Crop Water Requirement

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

$$ET_c = K_c\, ET_o = (0.85)(16.1\ \text{mm}) = 13.7\ \text{mm}$$

Step 6. Number of hours to run the pump

- Pumping time is estimated from a form of the well-known irrigation equation (Fangmeier et al., 2005) can be used:

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

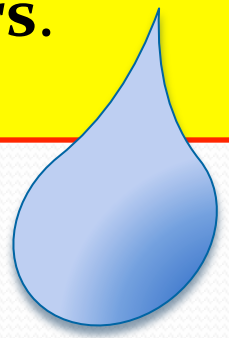
- where T is time in hours, D is depth of irrigation water (=ET_c) in mm, A is effective field area in acres, Q is flow rate in gallons per minute and eff is irrigation system efficiency.

Number of hours to run the pump to satisfy the crop water requirement for the example problem.

- Using D = ET_c = 13.7 mm
- A = 10 acres
- Q = 300 gallons per minute
- eff = 0.85, yields:

- T = 17.817 x [13.7 x 10] / [300 x 0.85]= **9.57 hours**.

- Total volume = 172,300 gallons

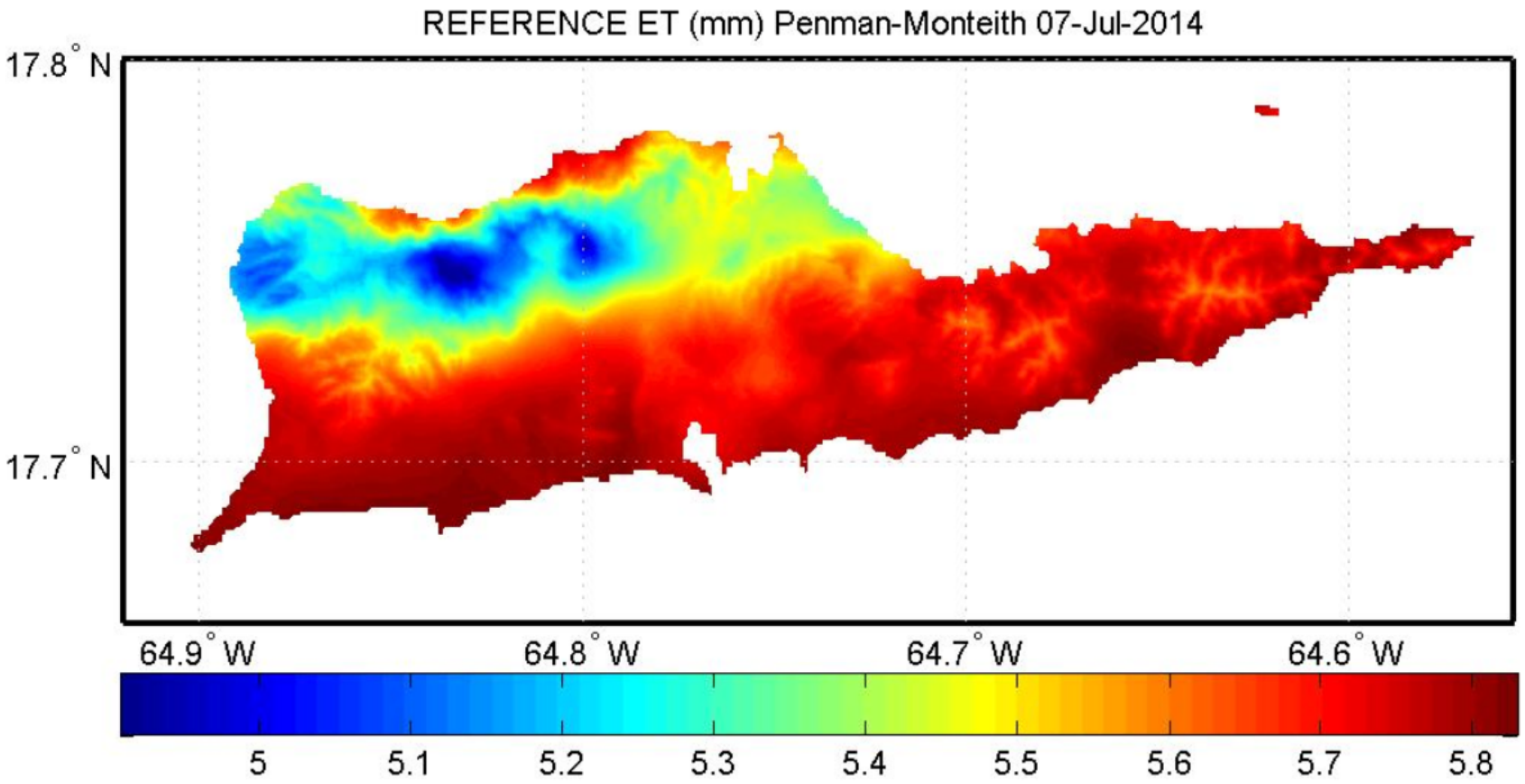


Farmer

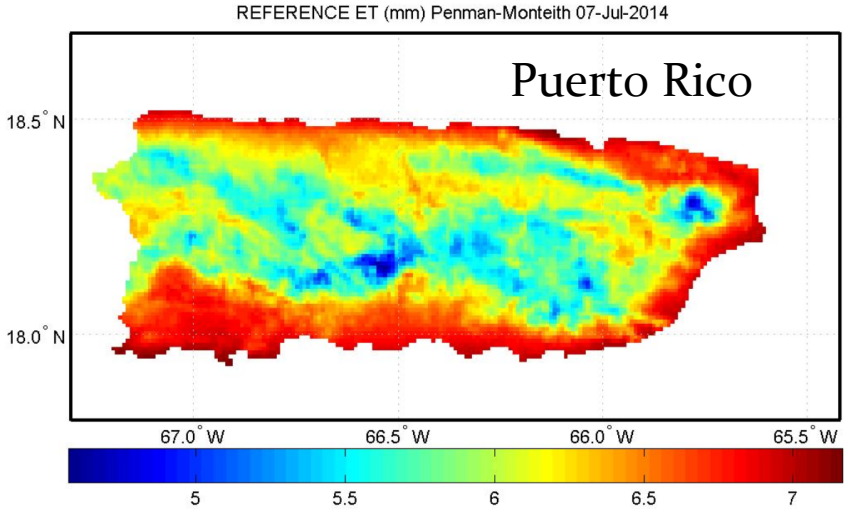
- Determine irrigation requirements for your crops
- Customized for your geographic location
- Supports wide range of crop types
- No on-site equipment, uses satellite data
- Keep track of your irrigation

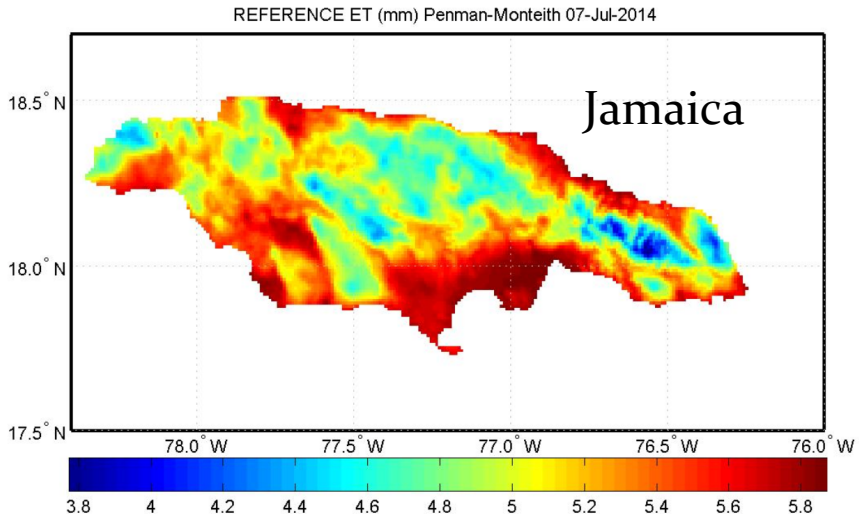
SIGN UP

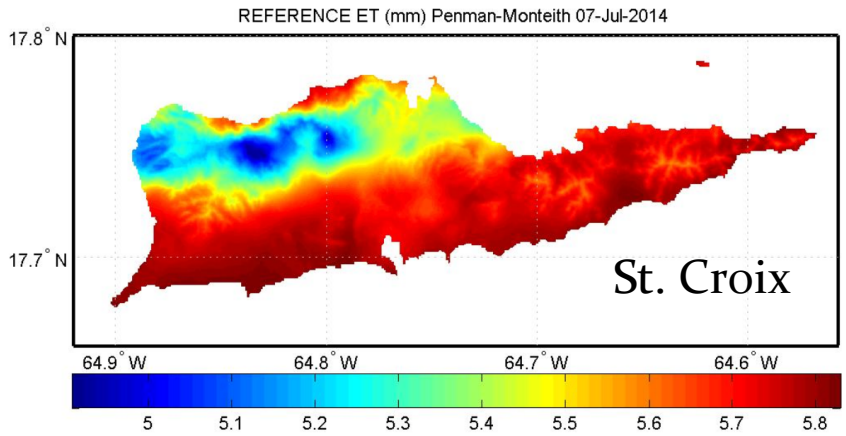
pragwater.com now providing daily reference evapotranspiration for St. Croix, USVI

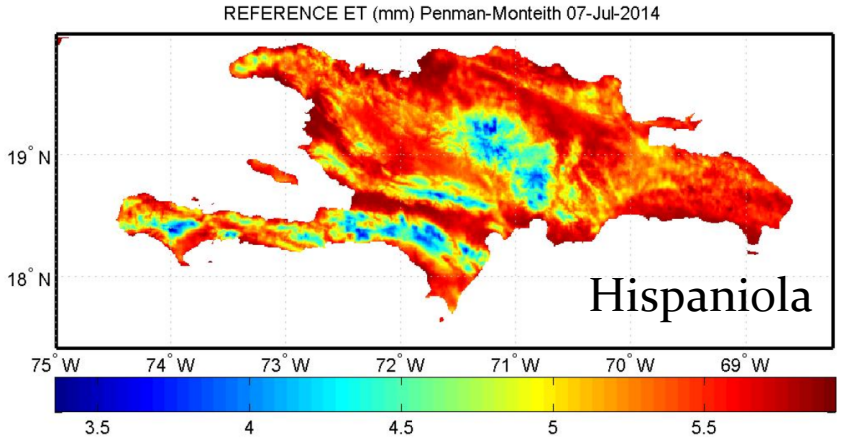


Archived Reference ET for Puerto Rico, Hispaniola, Jamaica and St. Croix, USVI. (www.pragwater.com)

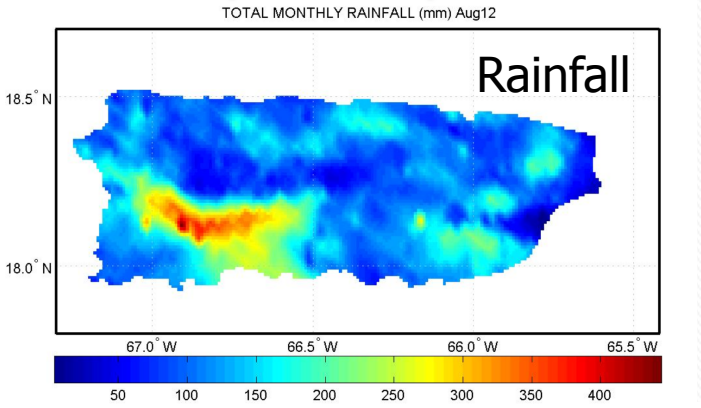


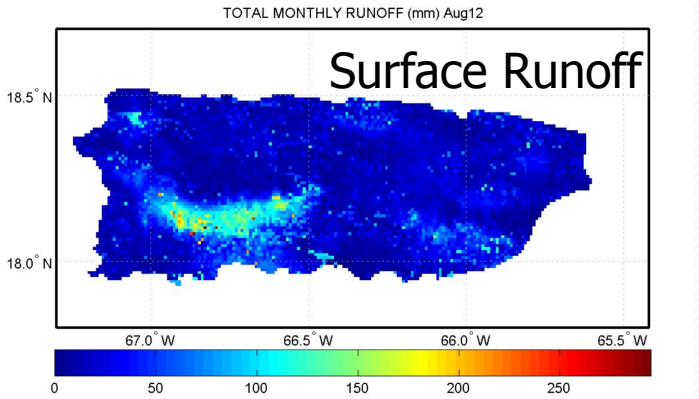


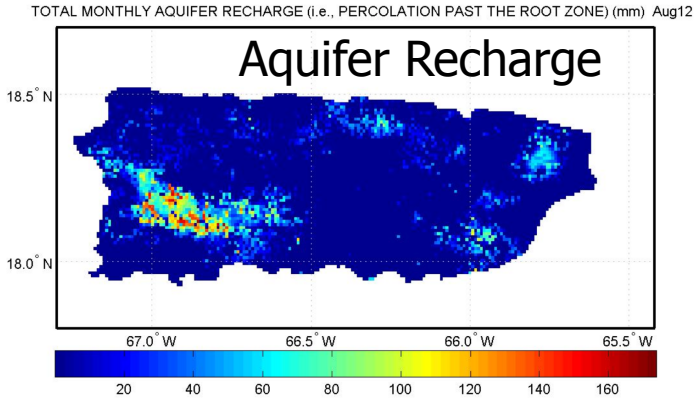


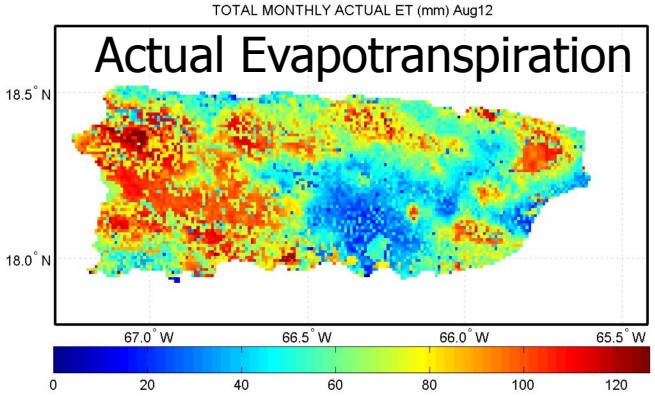


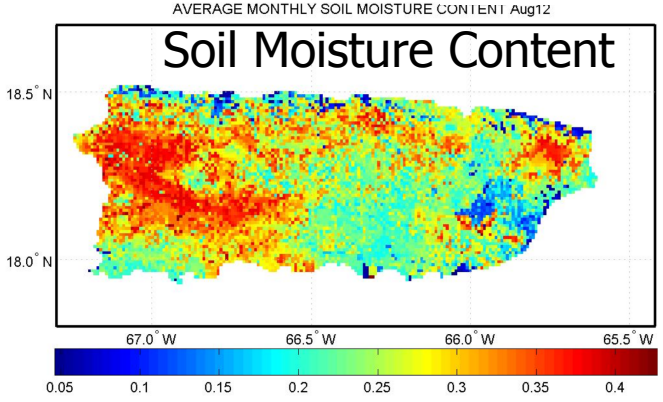
Monthly Average Rainfall, Surface Runoff, Aquifer Recharge, Actual Evapotranspiration and Soil Moisture Content (Aug. 2012)











GOES-PRWEB

GOES-USVIWEB in planning stages

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 ETo data is available to any farmer in Puerto Rico, St. Croix, Hispaniola and Jamaica with internet access.

ACKNOWLEDGEMENT

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- NOAA-CREST Project