Irrigation Scheduling Using ET-Based Methods

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Link to this presentation:
http://ucanr.edu/filevault/fileview.cfm?filenum=54585&password=NRNLIV

Management Practices to Cope with Limited Water Supplies:

- Improve irrigation efficiency (pressurized systems or higher efficiencies in existing systems)
- Regulated deficit irrigation (alfalfa and other crops)
- New cropping systems (lower water use crops or changing practices)
- Other practices (land fallowing for water transfer, etc)
- **Irrigation management** (irrigation scheduling and technologies that can save water)

Irrigation Water Management

- Applying the right amount of water to meet crop water requirements (in/irrigation)

- Timing of irrigation events (frequency, days between irrigations)

- Applying the water uniformly (efficiency)

Irrigation Scheduling

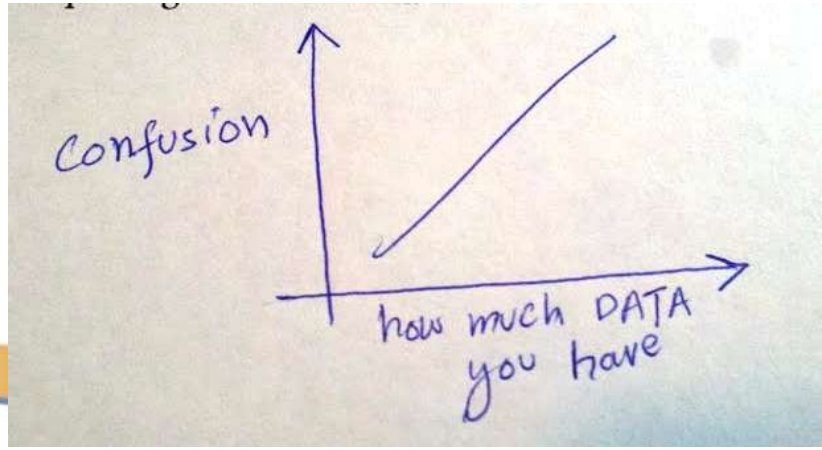
- **Simple approach (Water budgeting using ETo and crop coefficients)**

- Soil moisture measurement (requires extra work, soil sampling, soil moisture sensors, dataloggers, etc)

- Plant-based approach (infrared thermometery, sap flow, etc)

- A combination of the above three methods

- **Advances in irrigation technology and methods to estimate ETc**
  (Warning: Too Much Information)



Irrigation Methods in California:

1- Surface irrigation (flood):

- Border strip (flat) irrigation (slope 0.1-0.2%)
- Furrow irrigation (slope)
- Basin irrigation (zero slope)

2- Sprinkler Irrigation (various types, hand move systems, little use of center pivots and linear move systems)

3- Drip Irrigation (various types)

- Surface drip
- Subsurface drip

How Much Water do I need to Apply?

- Need to know crop water use (ETc) since last irrigation
- ETc from (Reference evapotranspiration and crop coefficient)

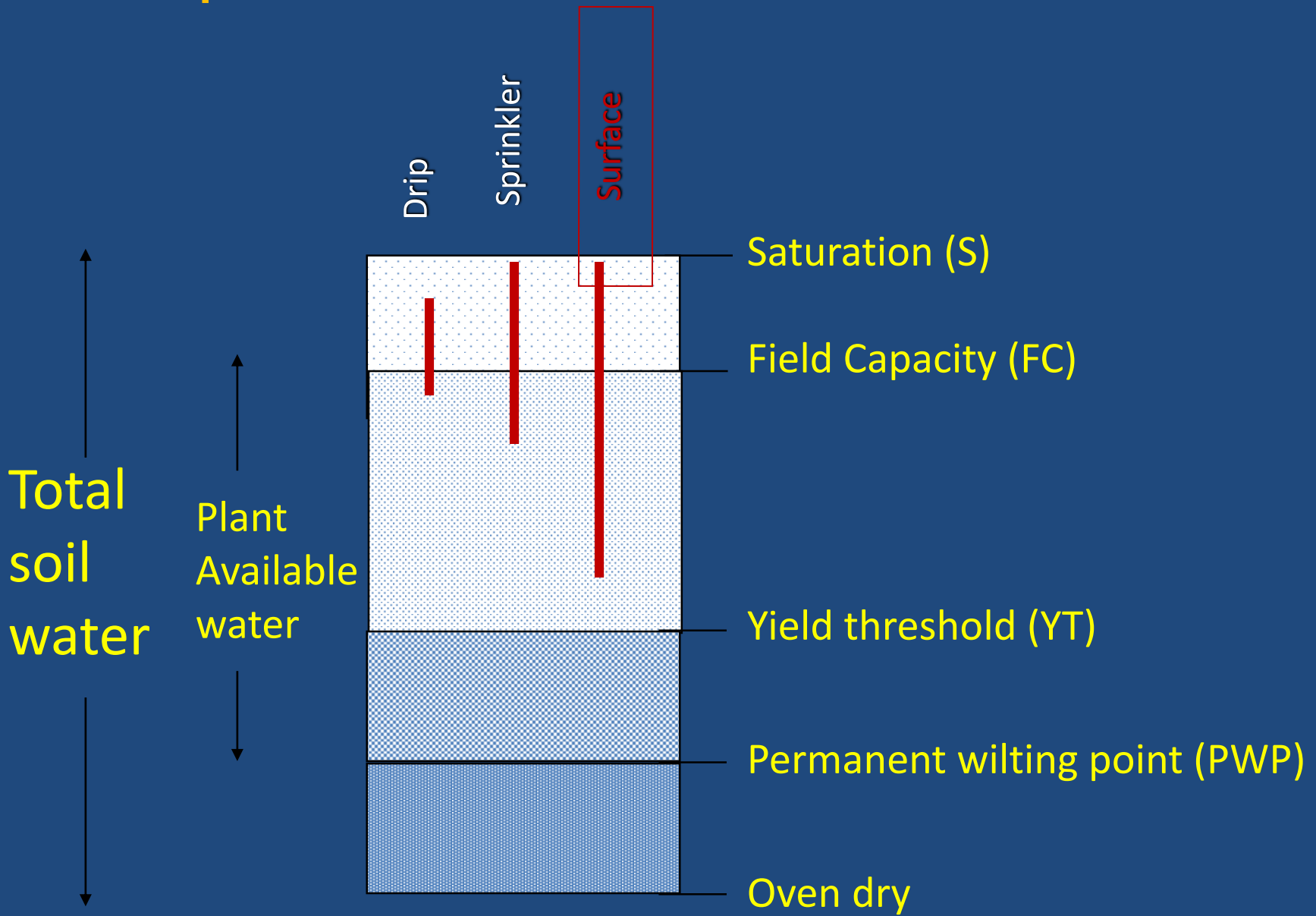
- Typical application rates (vary widely depending on soil type):

- Surface: ~ 3-4 in/irrigation (much higher rate for light soils)

- Sprinkler: ~ 0.5-1.2 in/irrigation

- Drip: ~ 0.5 in/irrigation

Crop Water use: Soil moisture

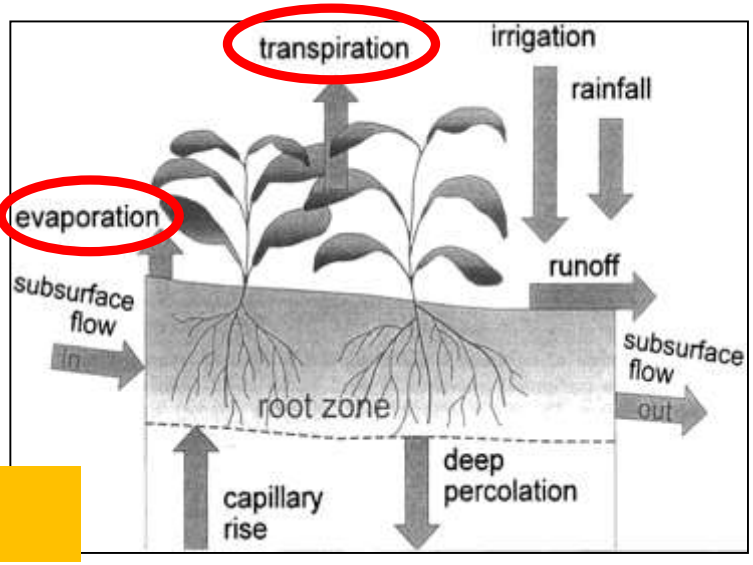


Why do we irrigae:

replenish the amount of water used by the crop (ET_C) since the last irrigation

Crop ET = Reference ET x Crop Coefficient

$$ET_C = ET_O \times k_C$$

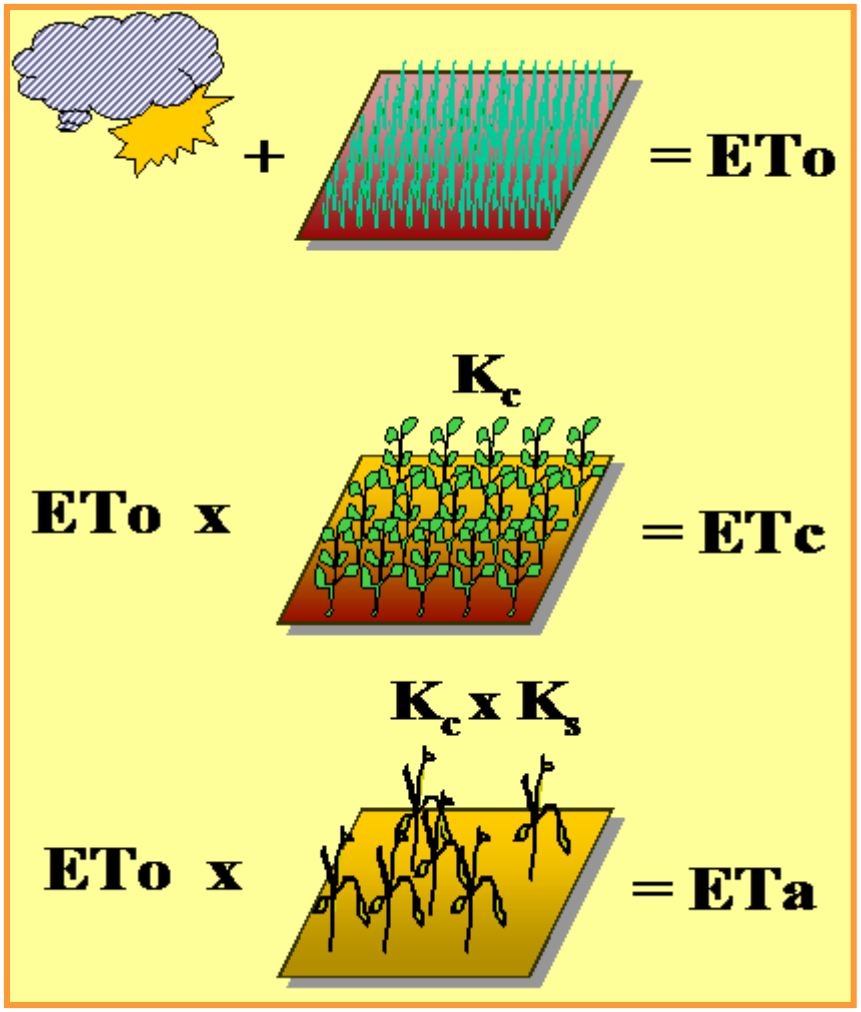


Also used in system Design: Max Irrigation depth to be applied (D_{GMAX})

$$D_{G\ MAX} = \left[\frac{ETc_{(D)PEAK}}{Eff_{APP}} \right] = inches / irrigation$$

System	$Eff._{APP}$
Gravity	70-85%
Drip	85-90%
Micro-sprinkler	80-90%
Sprinkler	70-90%

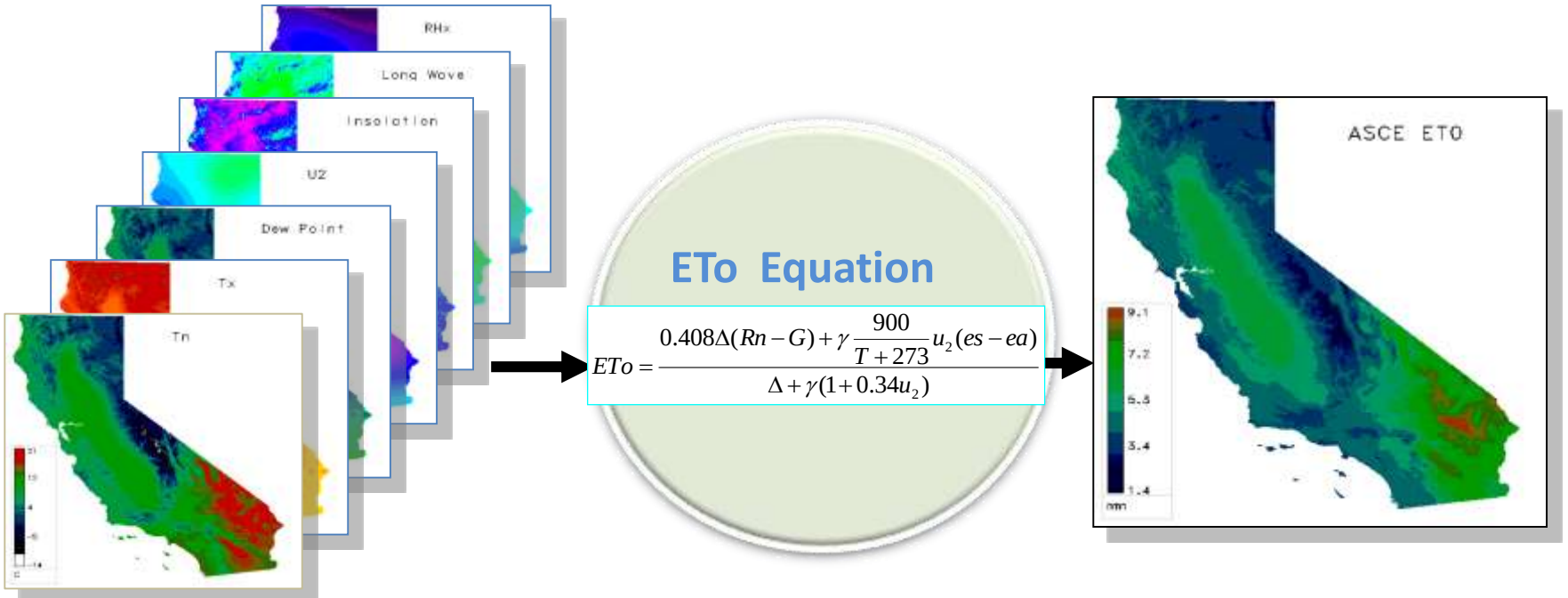
ETc and ETa



ETo: Spatial CIMIS

- Couples remotely sensed data from GOES satellite with point measurements from CIMIS stations to estimate ETo.
- Provides daily maps of ETo at 2-km grid.
- Released to the public in September 2009.

Source: DWR 2016



Spatial Report

This report provides daily ETo and Solar Radiation data at a 2 km resolution. Spatial Report data covers from 2/20/2003 to yesterday's date. Reports are available in several data formats and in English or Metric units. You may specify date ranges and zip codes, map coordinate points, or data search by address. Bing Map tools to center the page on California, recall previously selected points, and clear selected points are also available at the bottom-right.

Create a Web Report in English Units from 8/18/2016 to 8/24/2016 using Coordinate List

Run Report

Address Search

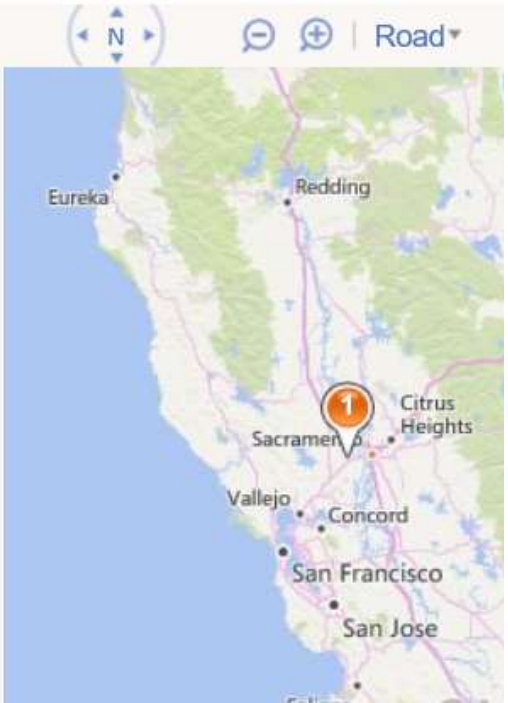
Search to add locations to the coordinate list or double-click the map interface. (ex: 1315 10th St, Sacramento, CA 95814)

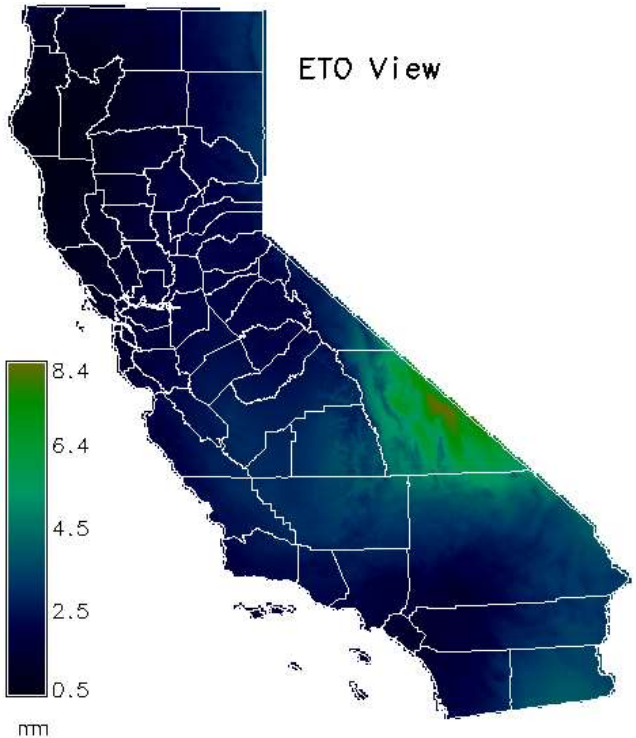
Search

Coordinate List

You must click the "Save Coordinates" button to keep your selection in your coordinate list.

1. 95616, CA(38.5359, -121.7765)
2. (empty)





Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	52.7
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.1
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

ET_o - accounts for weather

Solar radiation, humidity, temperature, wind

K_c - accounts for crop

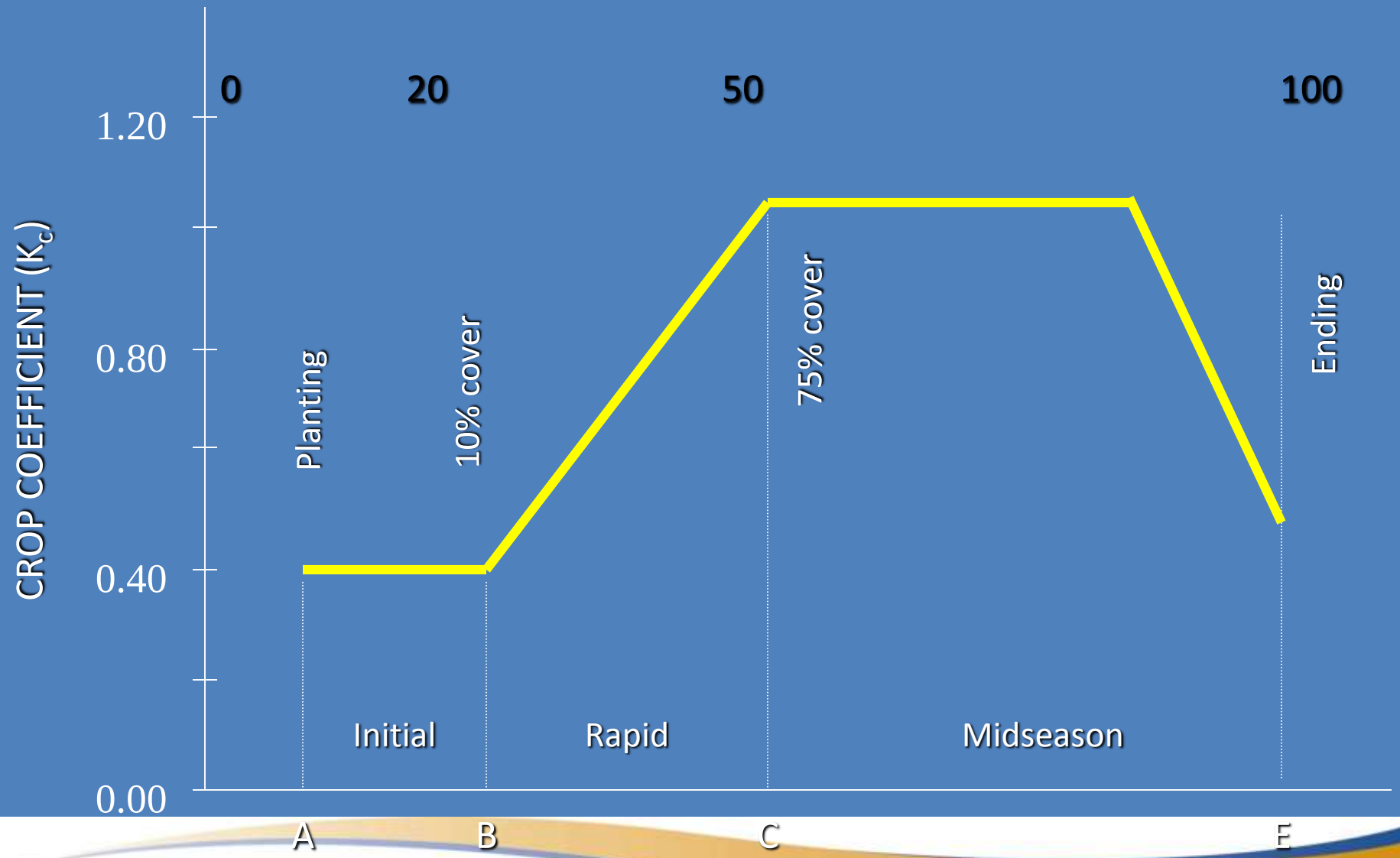
- light absorption
- canopy roughness
- physiology
- age
- **surface wetness (irrigation system)**

Crop Coefficient

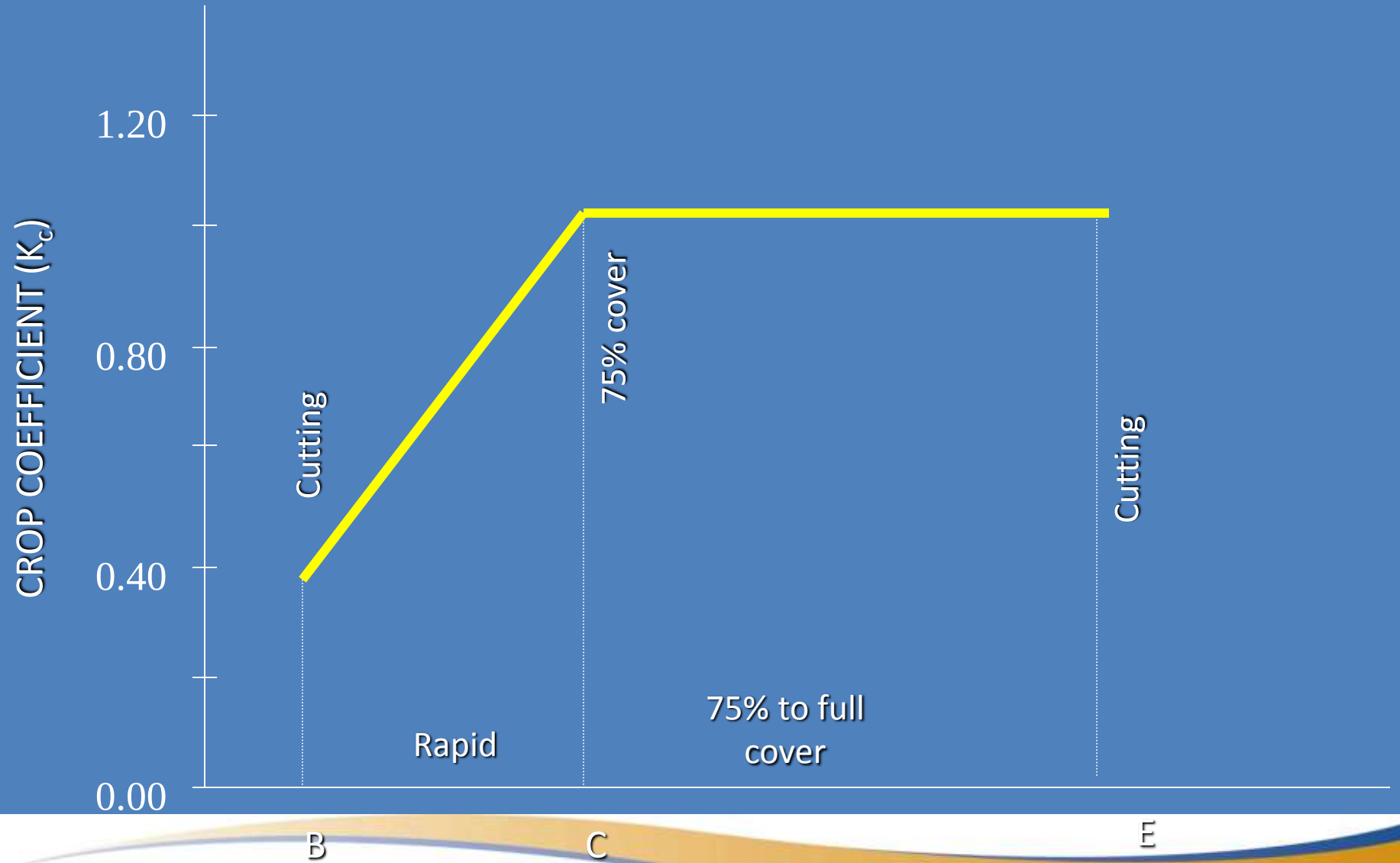
$$K_c = \frac{ET_c}{ET_o}$$

ET_c - measured ET_o - estimated

Theoretical Mean K_c Values


Percentage of Season
0
20
50
100
1.20
0.80
0.40
0.00
CROP COEFFICIENT (K_c)
Planting
10% cover
75% cover
Ending
Initial
Rapid
Midseason
A
B
C
E
GROWTH DATE

Alfalfa - Surface Irrigation-1 cutting



Example: Crop Water Use:

$$ETc = ETo \times Kc$$

If ETo was 1.2 inches since my last irrigation (7 days ago) and my average Kc over that period was 0.5 then:

ETc = 1.2*0.5=0.6 inches

So I need to apply a NET of 0.6 inches of water to replace the crop water use of last week

Crop Water Use:

- Water requirements
  = ETc / AE

-AE= Application Efficiency or Distribution uniformity (70-90% for Surface-Sprinkler-Drip Irrigation), if AE is 80% then

Water requirements= 0.6”/0.80
= 0.75 inches of gross application

Irrigation Runtime (sprinkler):

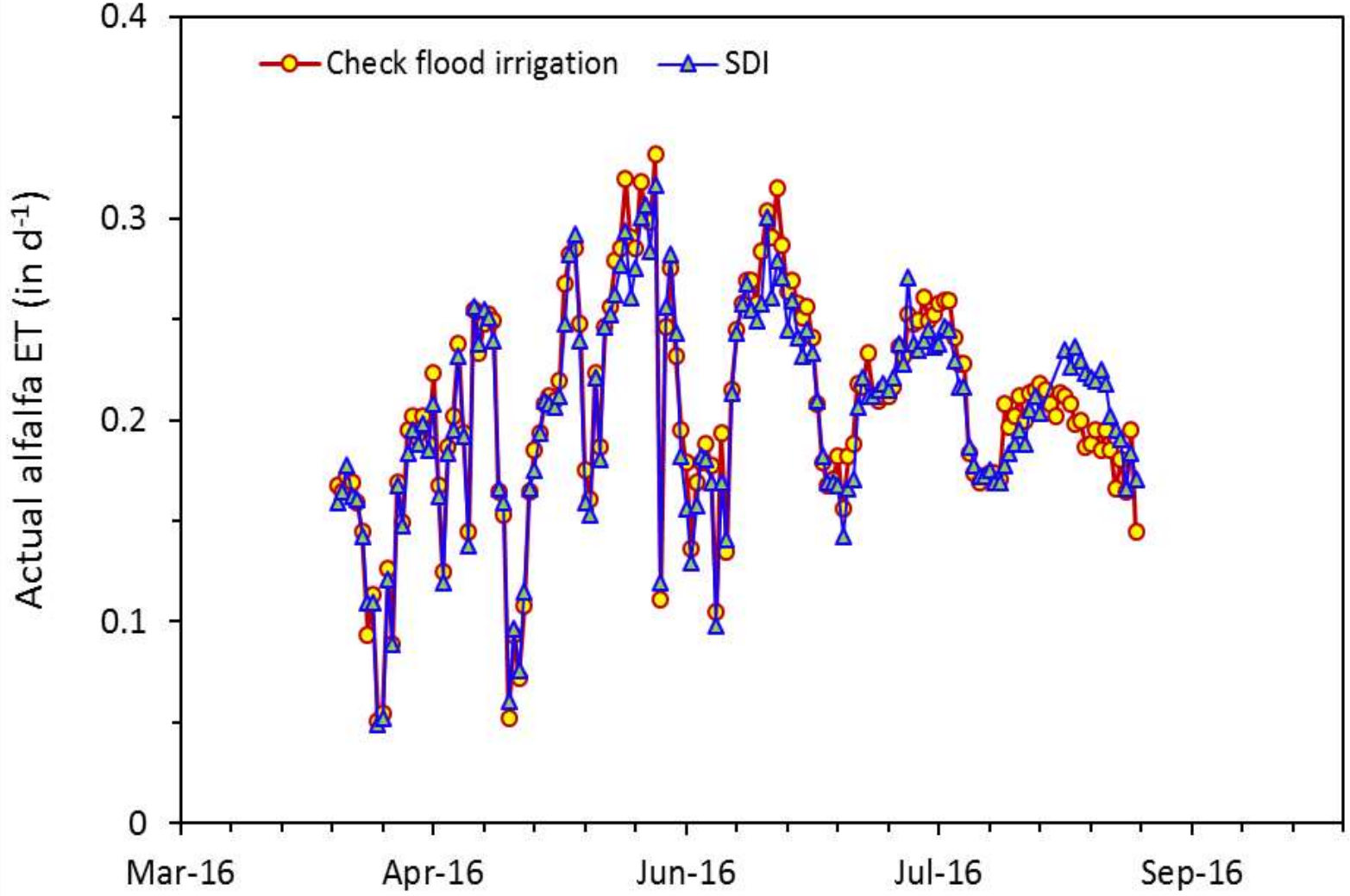
=Gross amount of application (in)/Application rate (in/hr)

If the average application rate is 0.11 in/hr

Then Irrigation time = 0.75/0.11= 6.8 hrs

Average evapotranspiration (ET) in inches/day for Garbanzo beans- flood irrig.

	CIMIS Eto during period (in/day)					Garbanzo ET (in/day)			
Zone	12	14	15	16	Zone	12	14	15	16
Dec 1-15	0.03	0.05	0.05	0.06		0.01	0.02	0.02	0.02
Dec 16-31	0.03	0.05	0.04	0.05		0.01	0.02	0.02	0.02
Jan 1-15	0.04	0.05	0.04	0.05		0.01	0.02	0.02	0.02
Jan 16-31	0.05	0.05	0.05	0.06		0.02	0.02	0.02	0.02
Feb 1-15	0.06	0.07	0.06	0.07		0.02	0.03	0.03	0.03
Feb 15-28	0.07	0.08	0.08	0.09		0.03	0.03	0.03	0.04
March 1-15	0.10	0.11	0.11	0.12		0.05	0.06	0.06	0.07
Mar 16-31	0.12	0.13	0.14	0.14		0.11	0.11	0.12	0.12
Apr 1-15	0.15	0.15	0.17	0.17		0.17	0.17	0.19	0.19
Ap 16-30	0.18	0.18	0.20	0.20		0.21	0.21	0.23	0.23
May 1-15	0.21	0.21	0.23	0.23		0.24	0.24	0.27	0.27
May 16-31	0.23	0.23	0.25	0.26		0.26	0.25	0.27	0.28
June1-15	0.25	0.25	0.26	0.28		0.20	0.20	0.21	0.22
June 16-30	0.26	0.26	0.27	0.29		0.13	0.13	0.13	0.14
Seasonal total						22.5	23.2	24.5	25.6
(inches)									


Check flood irrigation
SDI
Actual alfalfa ET (in d-1)
0.4
0.3
0.2
0.1
0
Mar-16
Apr-16
Jun-16
Jul-16
Sep-16

ETc= ET* Kc

New methods for ET and ETa

Current/latest : Tule (ETa)-

no need for Kc

Future: ETa maps

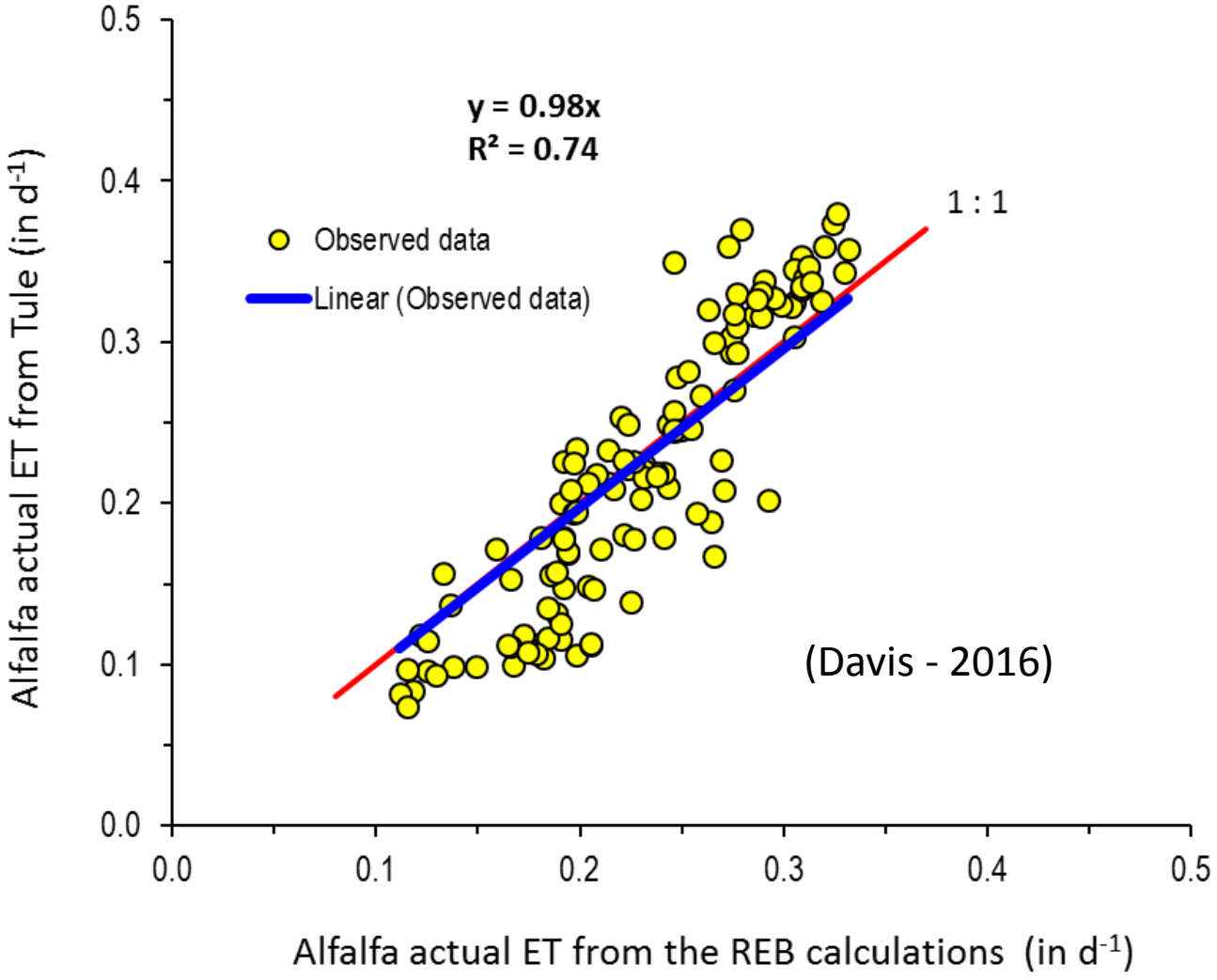
Source: Tule Technologies

Tule

SR light

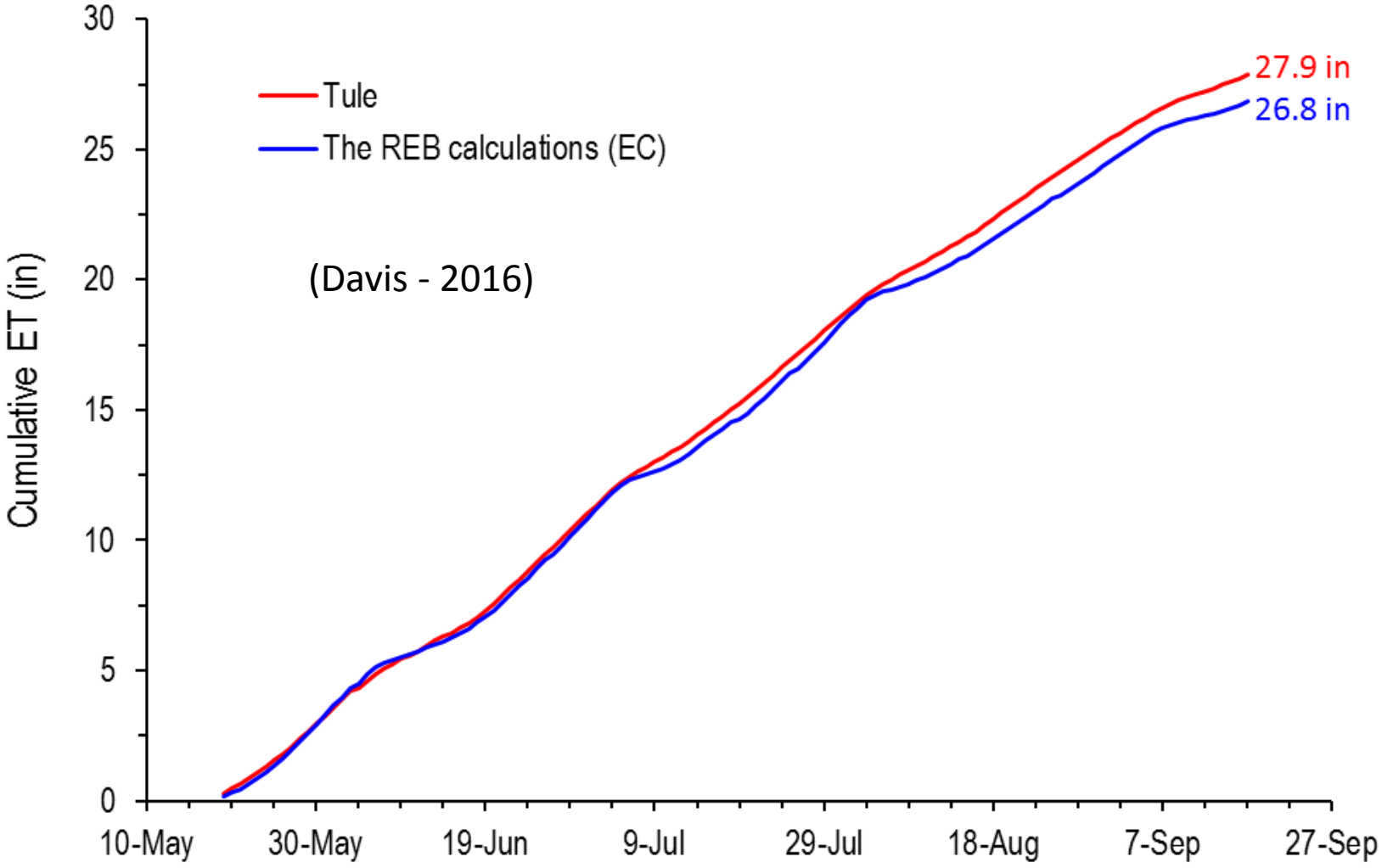
Surface Renewal (SR)

DRAFT Alfalfa actual daily ET
Tule vs. Eddy Covariance



(Davis - 2016)

DRAFT Alfalfa cumulative ET
Tule vs. Eddy Covariance



Irrigation Water Management

Many computer programs for irrigation scheduling:

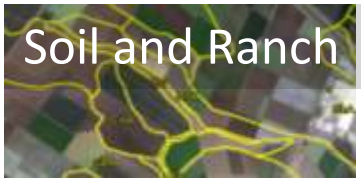
- Excel based: Basic Irrigation Scheduling (BIS) and other irrigation scheduling programs (Kc for major crops in CA)
- http://biomet.ucdavis.edu
- CropManage: Web-based approach- Mike Cahn
- https://cropmanage.ucanr.edu

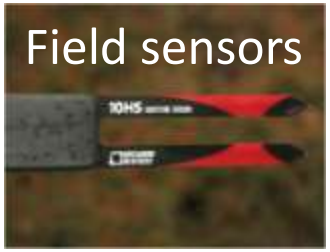
CropManage: An Online Decision Support Tool for Irrigation and Nutrient Management

Michael Cahn
Irrigation and Water Resources Advisor
UC Cooperative Extension, Monterey County

CropManage

Integrate information from multiple sources





Database driven web application

Crop ET model

Crop N model

Display and export water and fertilizer records

Decision support using crop models

Summary

ETo: Weather factors (CIMIS)
Kc: Crop factors, irrigation system, wetting frequency
Kc: in most cases between 0.3 and 1.2
Need to update Kc for major crops in California
Kc: depends on irrigation frequency and irrigation system
New methods for estimating crop ET (Tule- based on surface renewal)
CropManage: Good tool for irrigation scheduling

Special thanks to: Mike Cahn, UCCE
Ali Montazar, UC Davis
Bekele Temesgen, DWR

Link to this presentation:

http://ucanr.edu/filevault/fileview.cfm?filenum=54585&password=NRNLIV

Thank You


Food
Grows Where
Water Flows
Your Farm Bureau Neighbors
California Farm Water Coalition