

University of California
Agriculture and Natural Resources



Water Use of Alfalfa

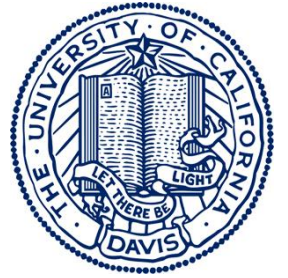
-- for Irrigation Planning and Scheduling --

Workshop on Efficient Water Management for Forage Crops
Tulelake, CA – March 14th, 2024

Daniele Zaccaria, Ph.D.

Agricultural Water Management Specialist, L.A.W.R. Department - UC Davis

Ph.: (530) 219-7502 Email: dzaccaria@ucdavis.edu <https://lawr.ucdavis.edu/people/faculty/zaccaria-daniele>

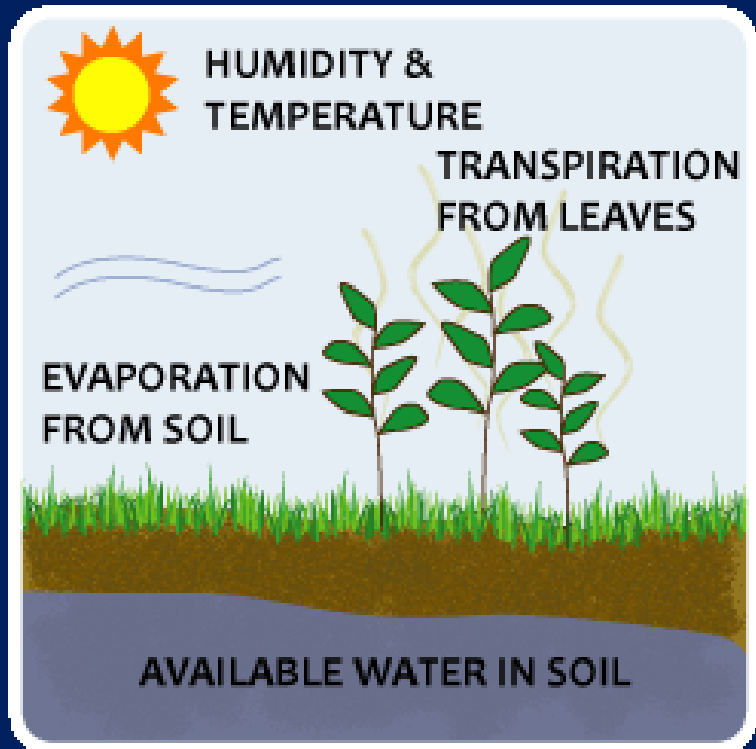
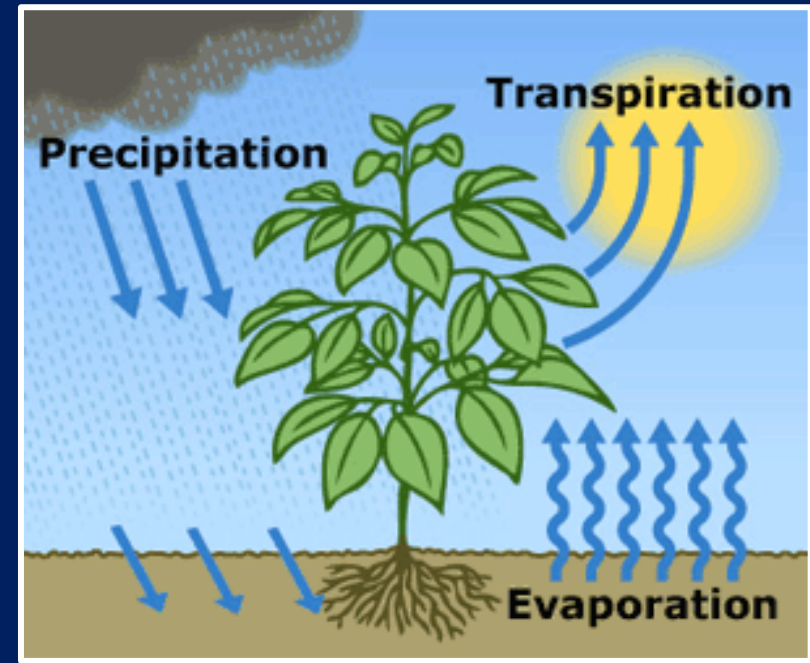


OBJECTIVES

- 1) Background Information on Reference ET (ET_o) vs. Crop ET (ET_c)
- 2) Review Information on Alfalfa ET from most recent studies

WHAT IS ET?

Evapotranspiration or ET is the total amount of water lost to atmosphere from a cropped surface through evaporation from soil and plant canopy, and transpiration ("breathing") by the plants.



↑ ET rate

- ✓ Crop & growth stage ↑
- ✓ Solar Radiation ↑
- ✓ Air Temperature ↑
- ✓ Relative Humidity ↓
- ✓ Wind Speed ↑
- ✓ Soil Moisture ↑

Reference ET (ETo) vs. Crop ET (ETc)

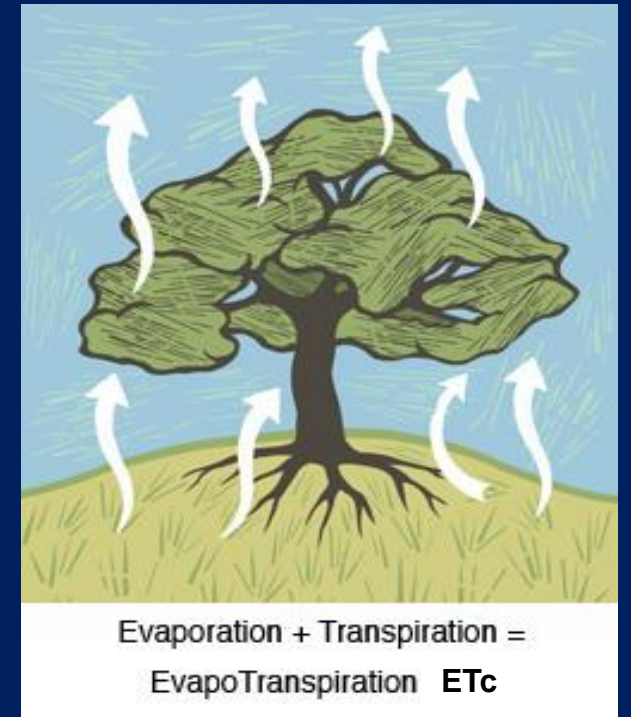
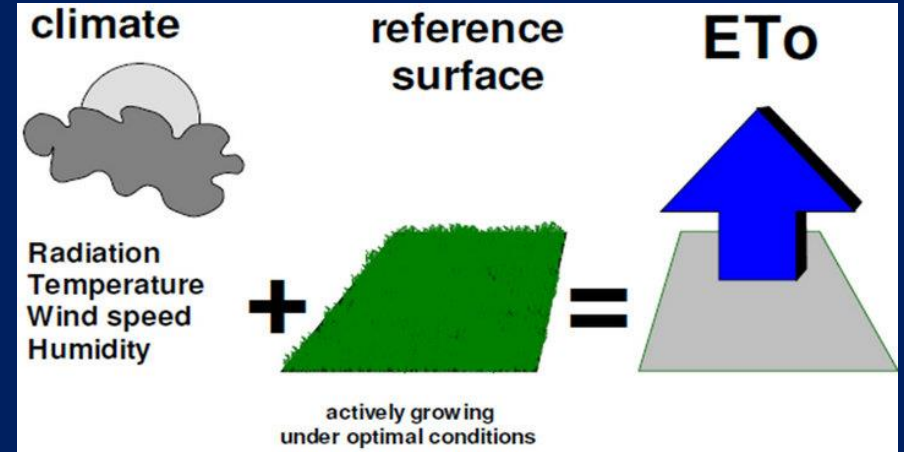
ETo or **Reference Evapotranspiration** is the water lost to atmosphere from:

- ✓ an extensive surface of green grass (CA)
- ✓ with uniform height (4.7 in. = 0.12 m)
- ✓ actively growing without limitations
- ✓ well-watered & well-nourished
- ✓ free of water stress and diseases
- ✓ completely shading the ground.

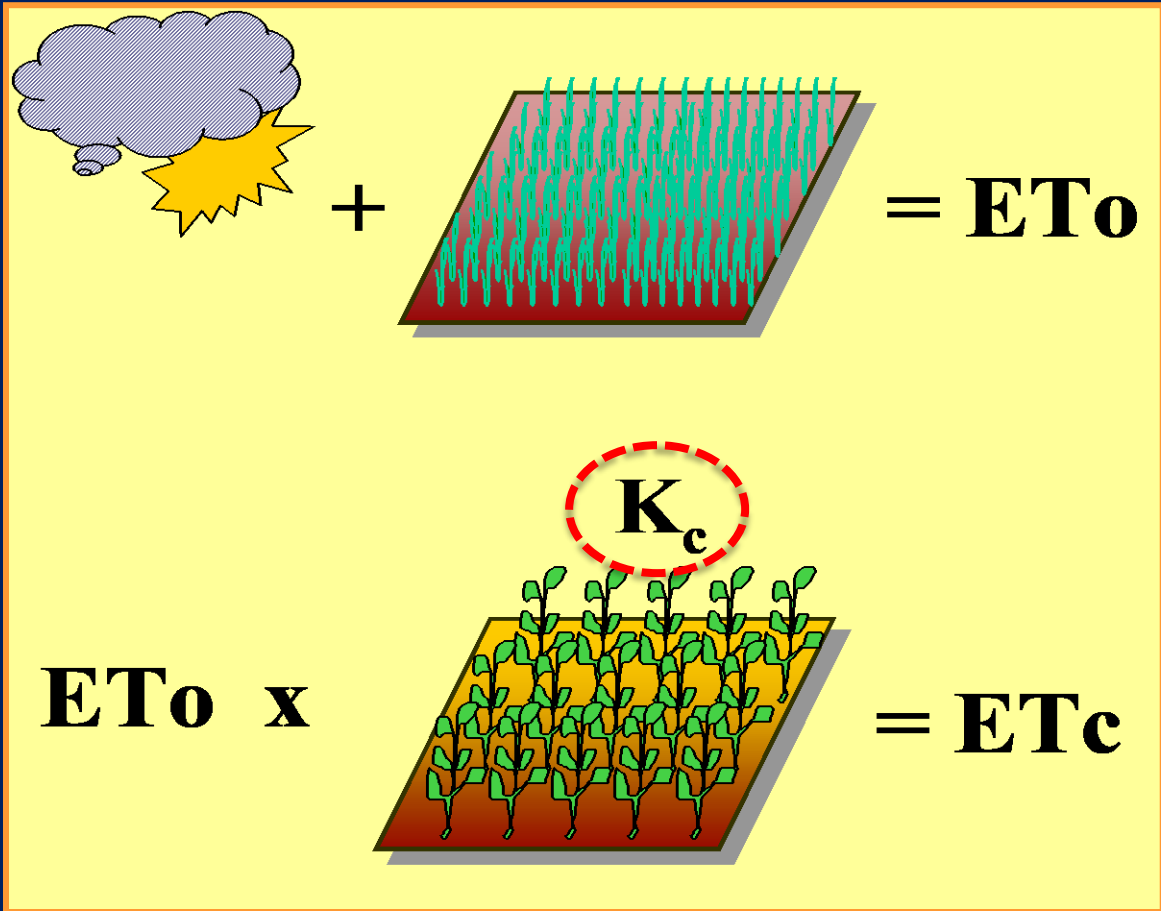
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ETc or **Crop Evapotranspiration** is the amount of water used by:

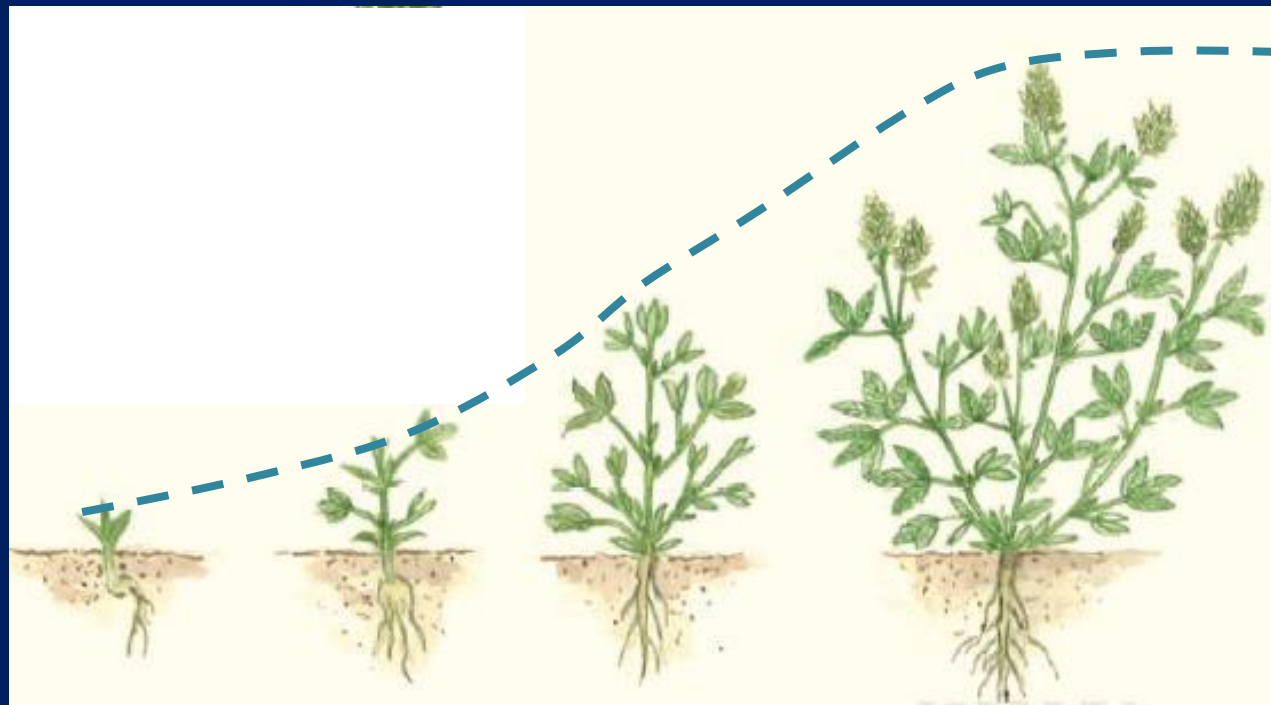
- ✓ a disease-free, well-watered and well-fertilized crop
- ✓ grown in large fields
- ✓ under optimum soil-water and nutrient conditions
- ✓ achieving full production under the given climatic conditions



ET_o vs. ET_c



(EVAPORATION + TRANSPIRATION) = EVAPOTRANSPIRATION

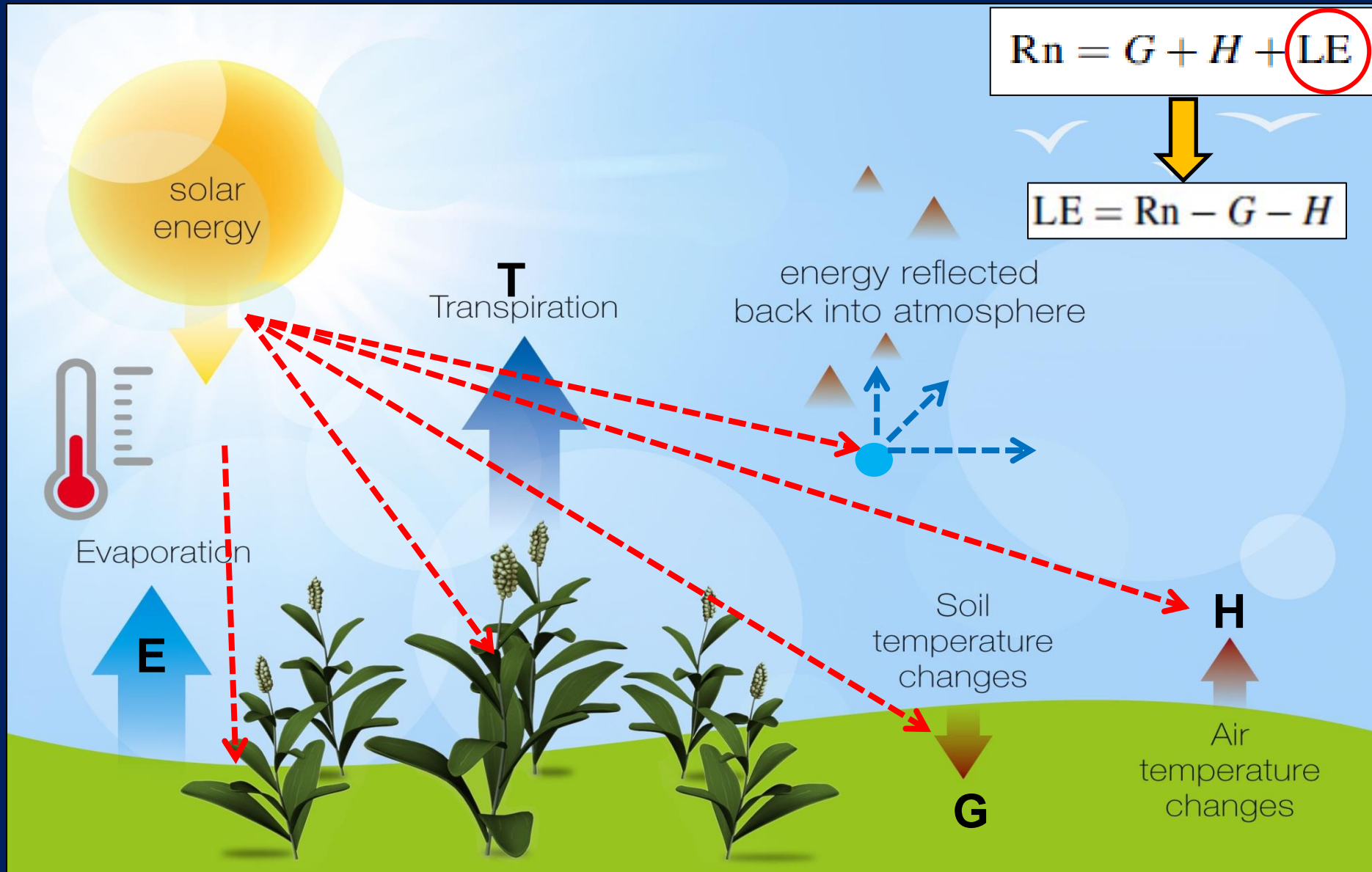


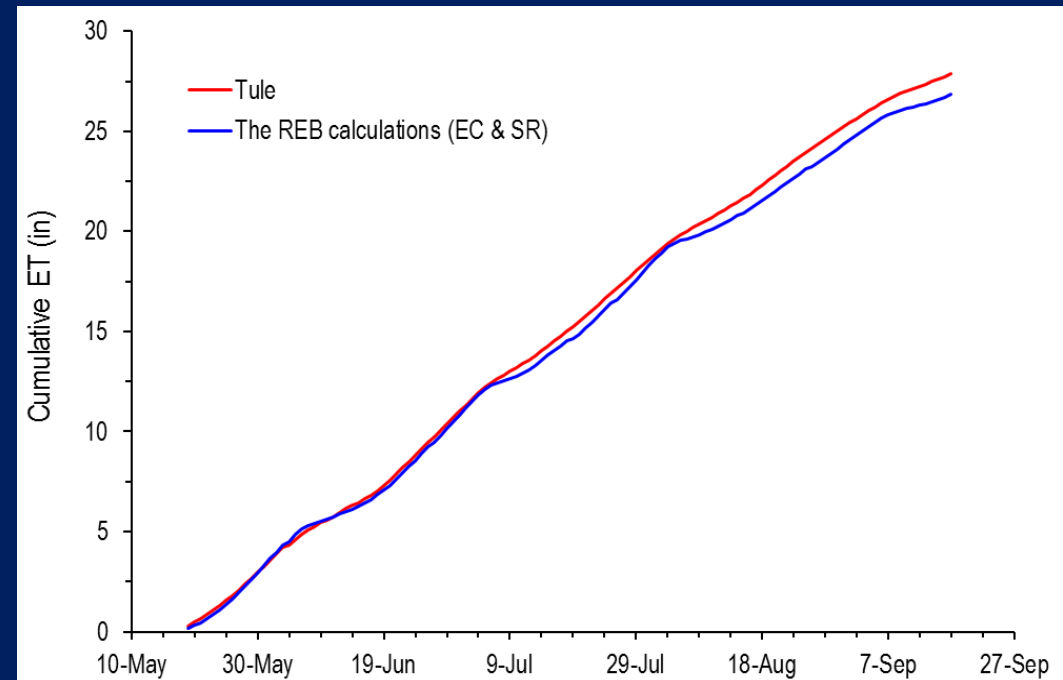
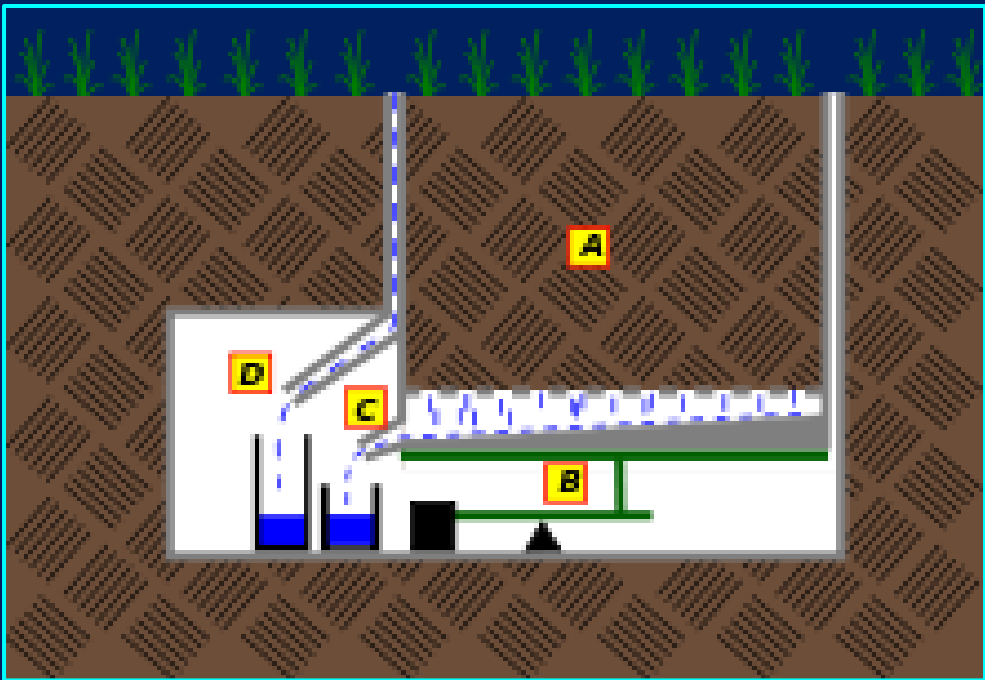
At the initial stages of the crop (or during re-growth), ETC is small and most of the water is lost by evaporation from soil surface

When plant canopy grows, ETC increases and most of water is lost by transpiration from leaves and canopy

ET IS AN ENERGY-DRIVEN PROCESS

SOLAR RADIATION IS THE MAIN ENERGY SOURCE FOR CROP ET





Residual of Energy Balance Method for Calculating Actual Crop Evapotranspiration

$$R_n = G + H + LE$$

MEASURED

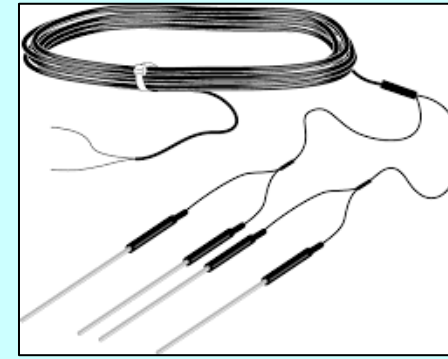
$$LE = R_n - G - H$$

Sensible Heat Flux

Eddy Covariance



Net Radiation

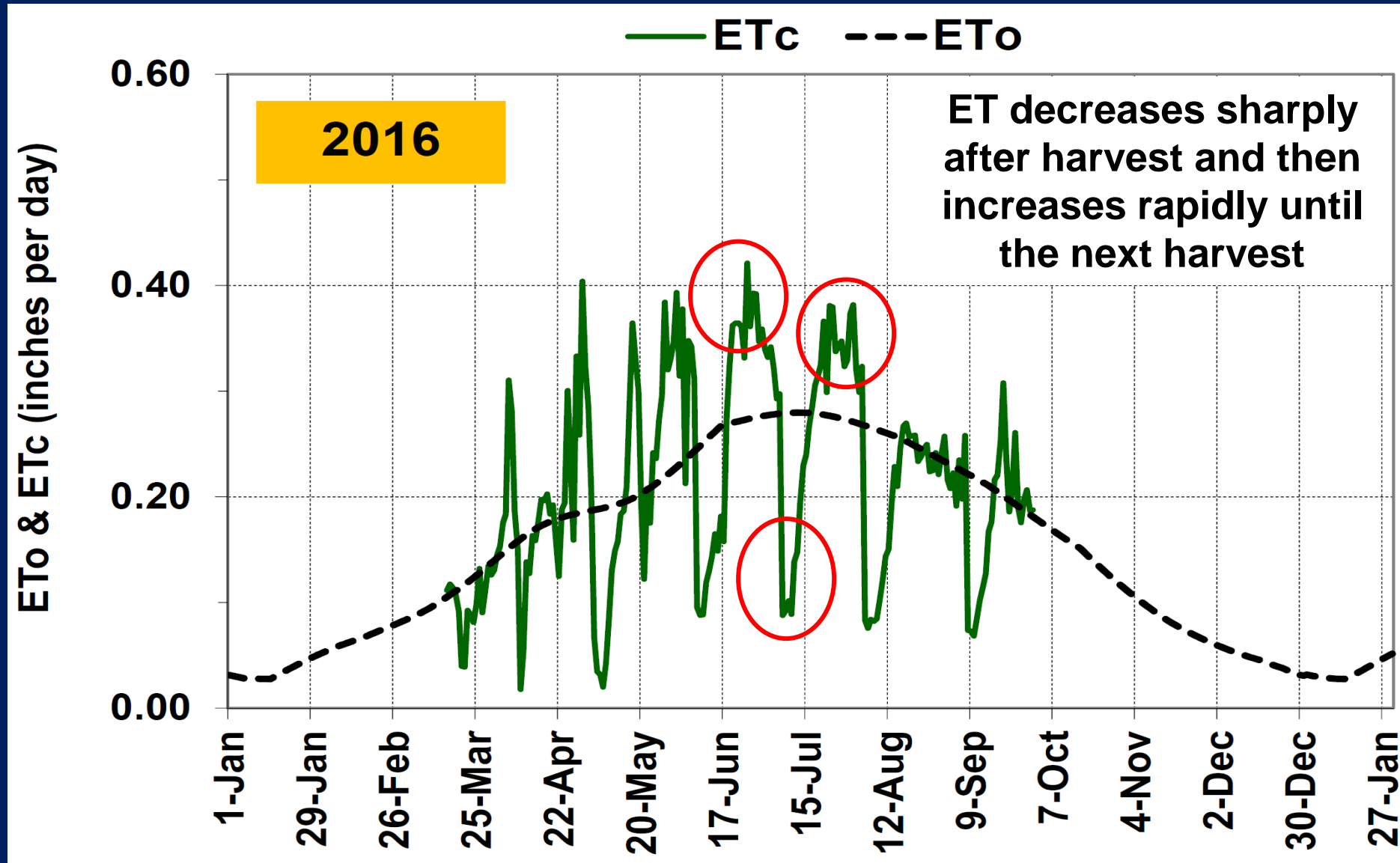


Ground Heat Flux

Surface Renewal

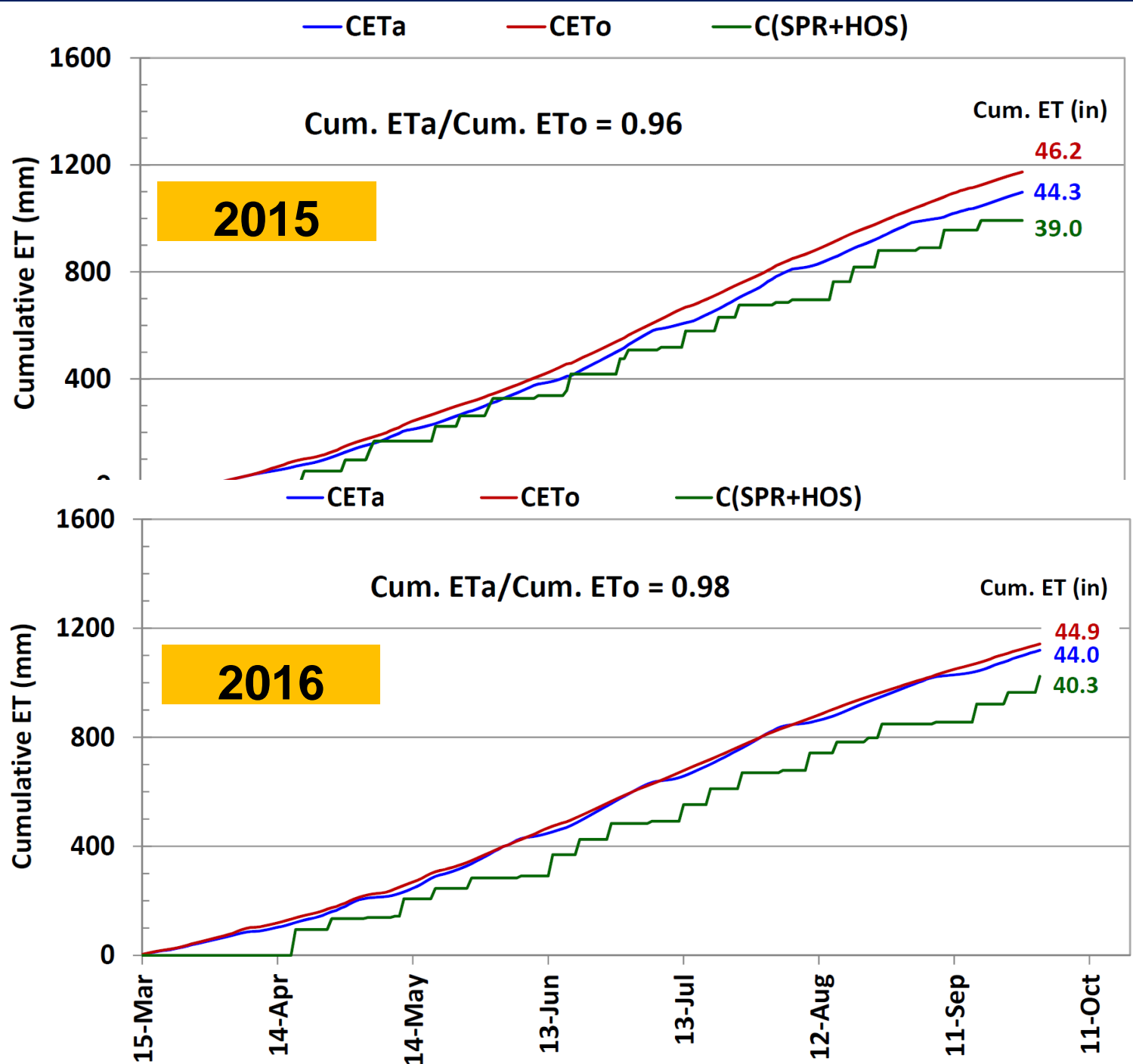
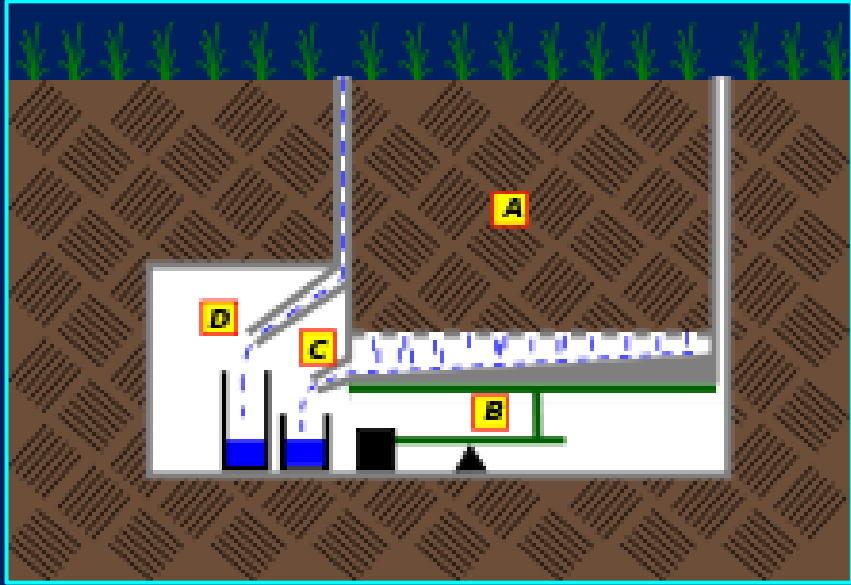


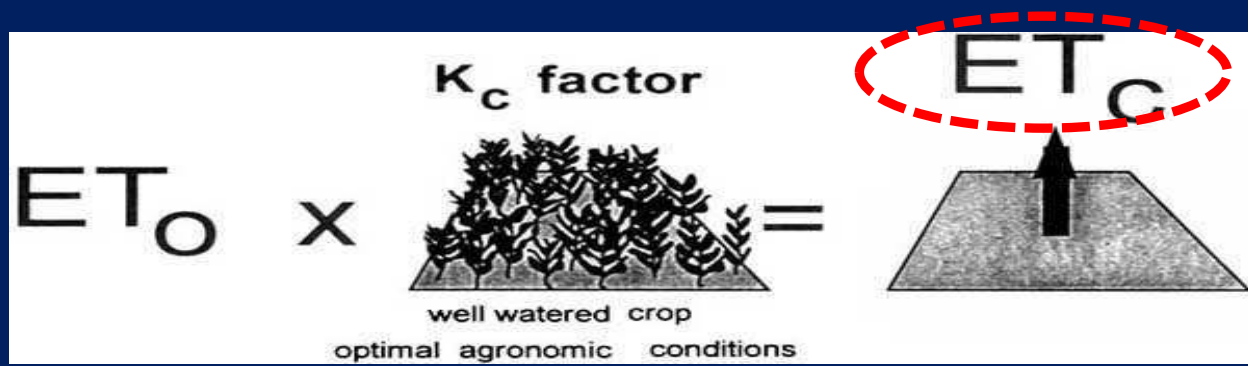
Alfalfa ET varies along the growing season as it is affected by weather, growth & periodic cuttings



Region	Site	Year	Age Of alfalfa	Seasonal ET (inches)	Reference ET (inches)
Imperial Valley	LM1	2007	3	55.8	73.2
	LM2	2008	2	66.0	73.3
	LM2	2009	3	55.6	67.9
	GR	2010	2	63.5	73.2
	EL	2010	2	59.8	70.0
	WA	2010	2	65.8	70.0
San Joaquin Valley	KC	2007	2	56.6	57.0
	KC	2008	3	59.4	59.3
Sacramento Valley	CH1	2005	3	49.4	63.6
	CH2	2006	2	54.8	55.9
	CH2	2007	3	55.0	58.0
	CH2	2008	4	50.4	59.4
	EE	2010	3	46.3	48.8
	EW	2010	4	42.5	48.8
Scott Valley/Shasta Valley	EN	2007	2	39.6	44.0
	EN	2008	3	32.8	42.6
	EN	2009	4	33.8	40.4
	FI	2009	5	36.1	37.4
	SH	2009	4	38.8	40.4
	AP	2010	5	37.3	37.4
	FI	2010	2	34.7	37.4
	FA	2010	6	38.8	41.1
Tulelake	TU	2007	4	39.0	40.5
	TU	2008	5	34.3	36.5

**Ave.
37 in.**





Amount of water lost by alfalfa for ET

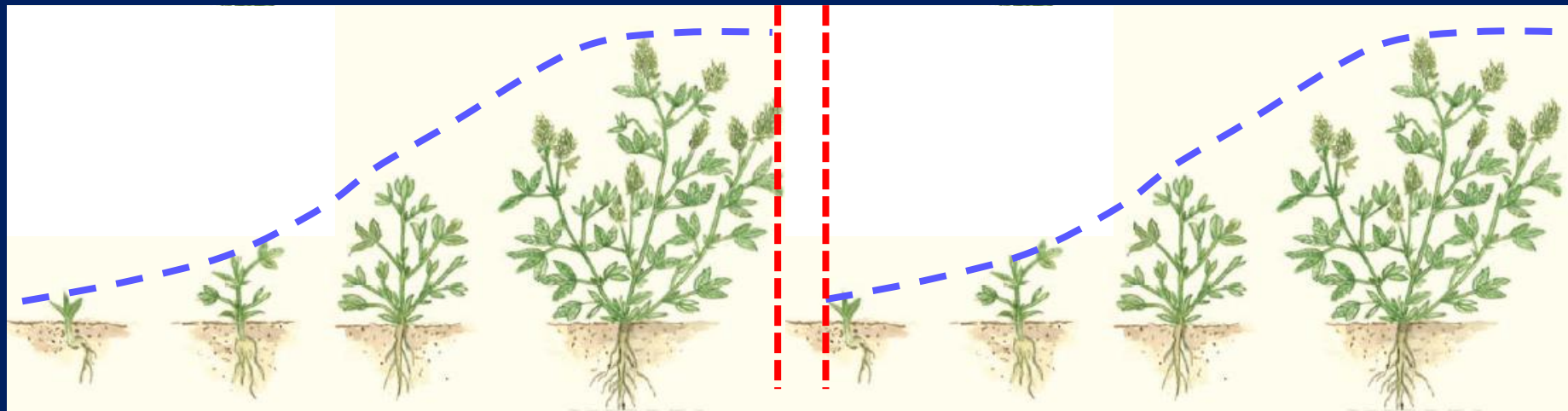
Seasonal Crop Coefficient (Kc) for commercial field conditions:

$K_c = 0.96 - 0.98$ (averaged over the entire crop season – Sacramento Valley)

Within-cycle Crop Coefficient (Kc): Average Yield (dry matter) = 9.3 – 9.6 Ton/ac

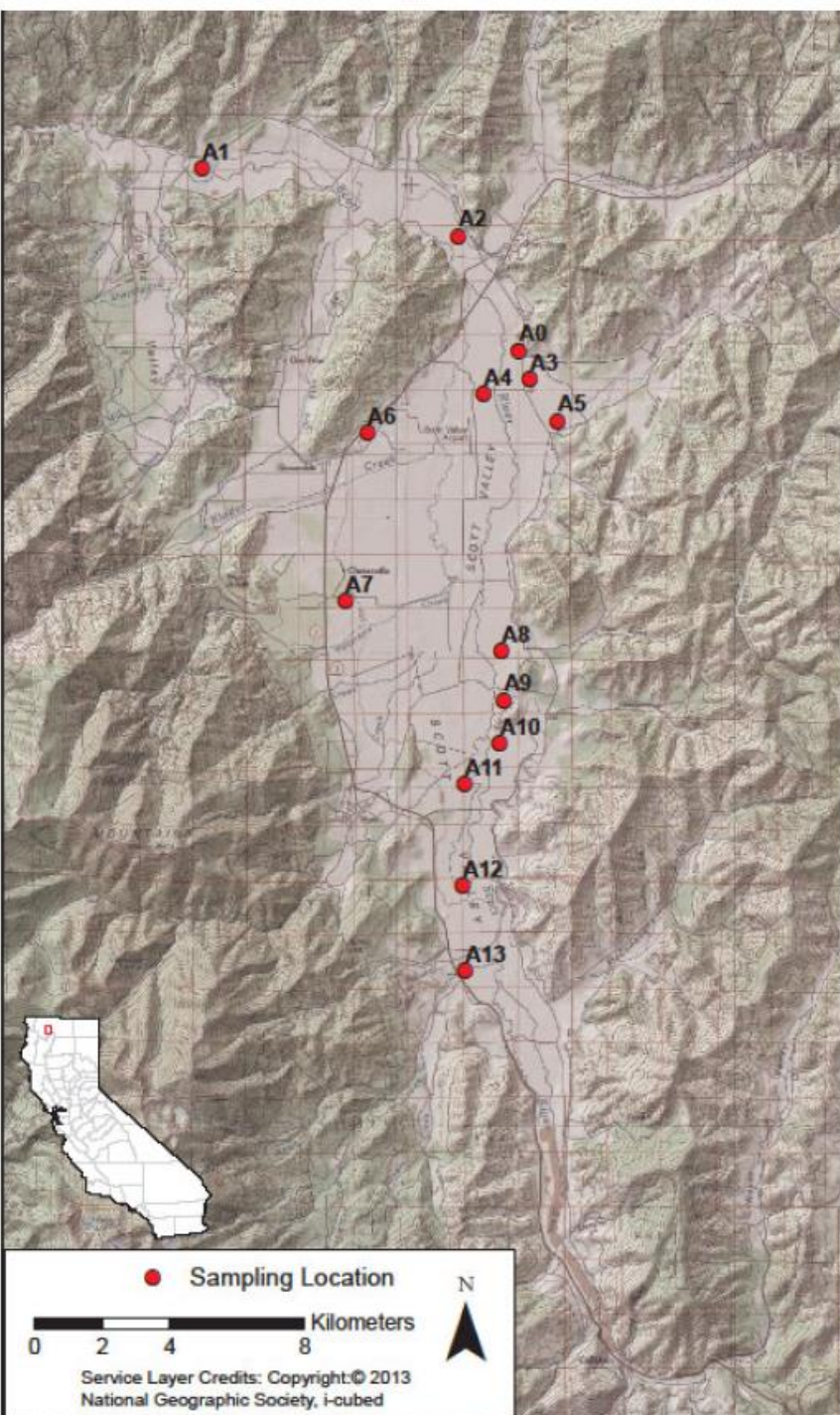
$K_c \approx 0.35 - 0.40$ after cutting until irrigation, and for 3-4 days after

$K_c \approx 1.05 - 1.10$ from 3-4 days after irrigation till the next cutting



In 2012-2013-2014, a UC Team measured Alfalfa ET in 3 center pivot irrigated, well-managed fields in Scott Valley for 3 years (from March 15 onwards)

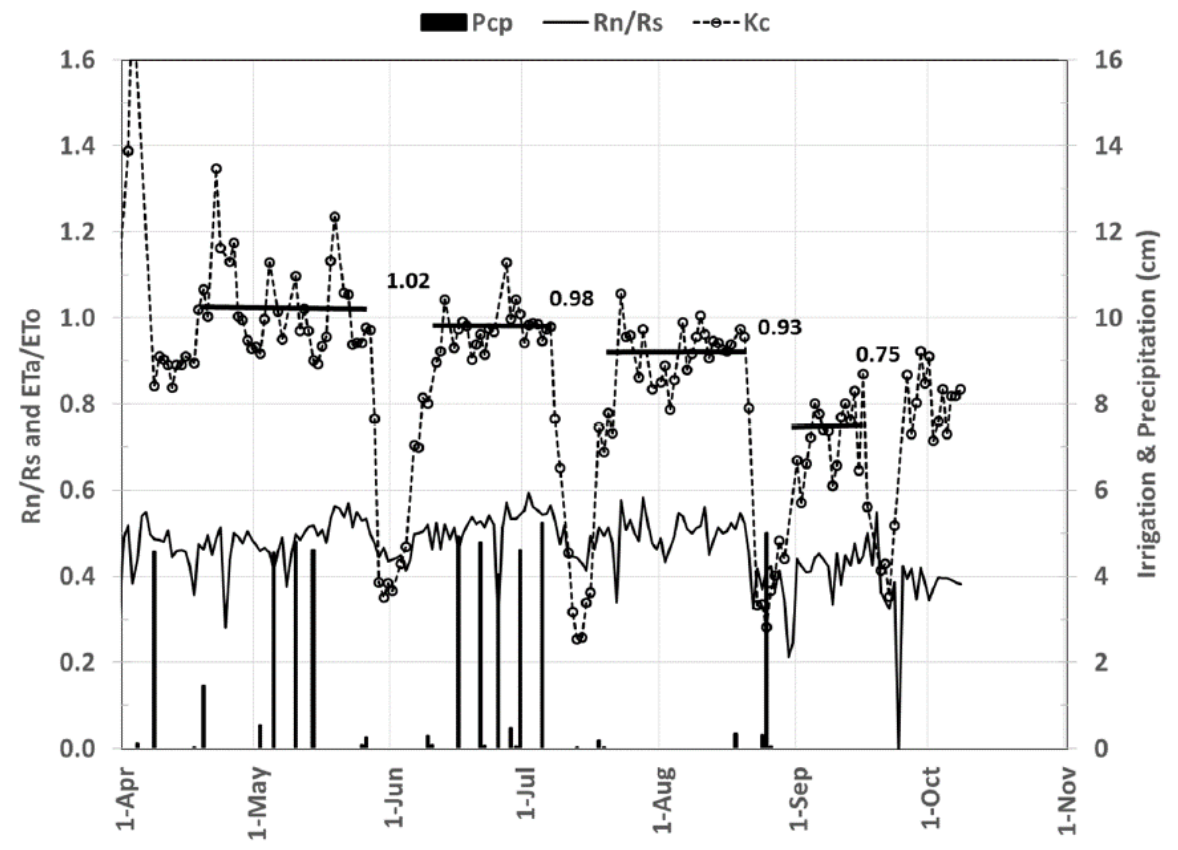
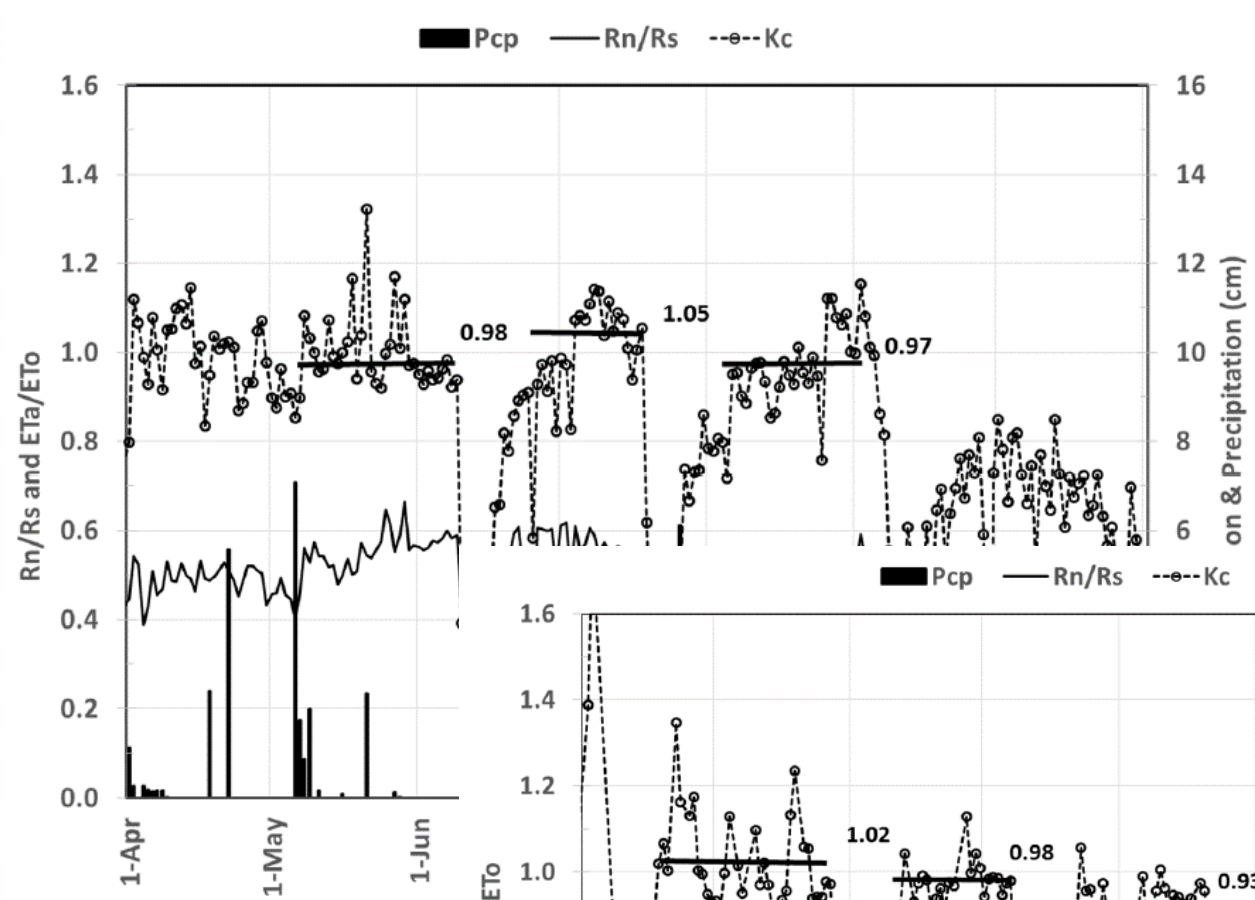
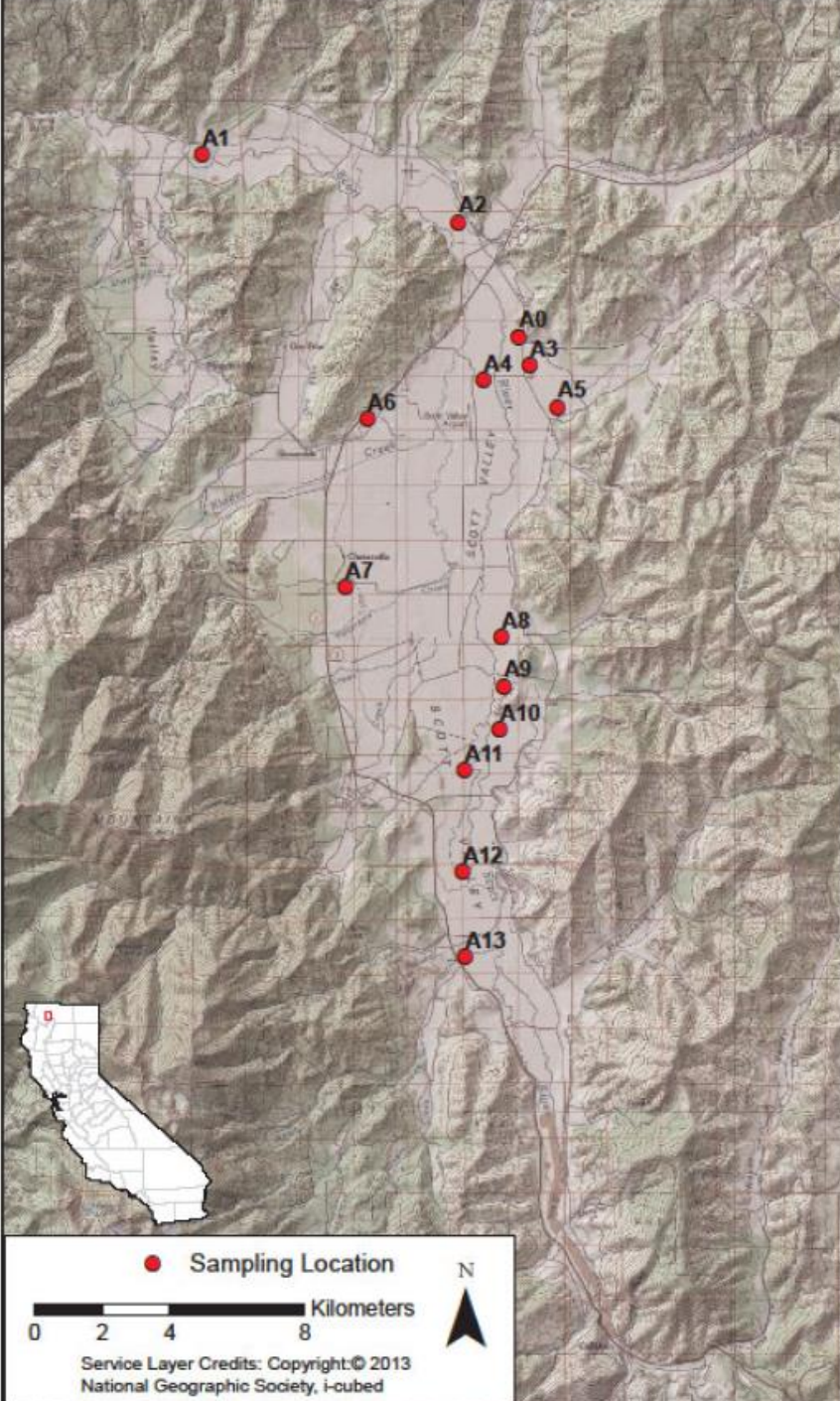
R.L. Snyder, P. D.Thamer, N. Stevens, T.H. Harter, and S.B. Orloff



Year	Field	ET_{os}	ET_{cs}	K_{cs}	Ending date
		in.	in.		
	A5	32.5	27.9	0.86	11-Sep
2012	A7	32.3	29.7	0.92	10-Sep
	A8	31.5	27.7	0.88	6-Sep
	A1	37.8	32.7	0.87	5-Oct
2013	A2	36.8	34.8	0.95	26-Sep
	A5	29.0	25.5	0.88	5-Sep
	A1	35.3	32.8	0.93	6-Sep
2014	A2	33.5	28.8	0.86	27-Aug
	A5	37.3	31.0	0.83	16-Sep
	Means	34.0	30.1	0.89	12-Sep

Seasonal ET_o , ET_c , and K_c (ET_{os} , ET_{cs} , and K_{cs}) for the three seasons in Scott Valley.

The season start date is 15 March and the season ends on the indicated dates.



SCOTT VALLEY

Seasonal ET_o , ET_c , and K_c

Average year-long $K_c = 0.89$

Year	Field	ET_{os}	ET_{cs}	K_{cs}	Ending date
		in.	in.		
	A5	32.5	27.9	0.86	11-Sep
2012	A7	32.3	29.7	0.92	10-Sep
	A8	31.5	27.7	0.88	6-Sep
	A1	37.8	32.7	0.87	5-Oct
2013	A2	36.8	34.8	0.95	26-Sep
	A5	29.0	25.5	0.88	5-Sep
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Seasonal ET_o , ET_c , and K_c (ET_{os} , ET_{cs} , and K_{cs}) for the three seasons in Scott Valley.

The season start date is 15 March and the season ends on the indicated dates.

Average off-season $K_c = 0.80$

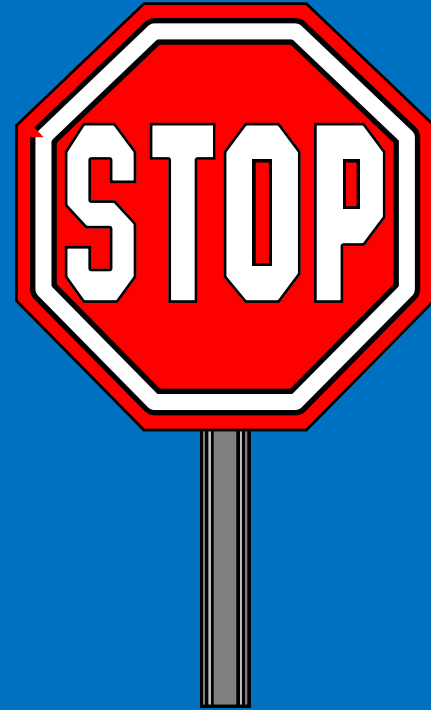
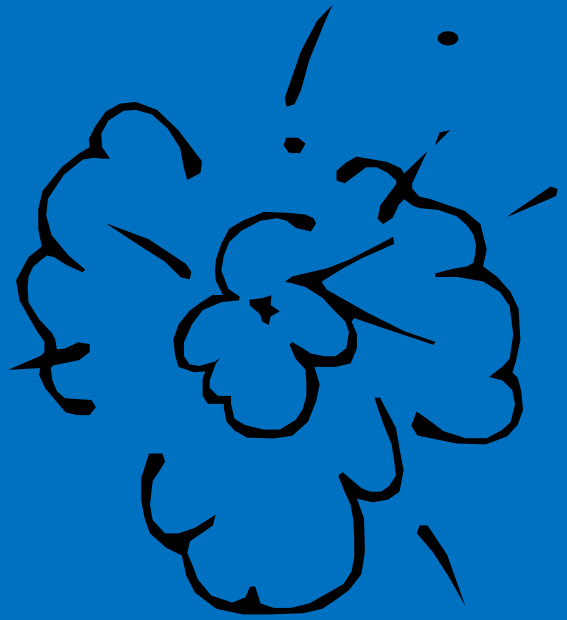
Annual ET_o , ET_c , and K_c

Average seasonal $K_c = 0.84$

Year	Field	ET_{oc}	ET_{cc}	K_{cc}
		in.	in.	
	A5	45.7	37.3	0.82
2012	A7	45.7	39.5	0.86
	A8	45.7	38.4	0.84
	A1	47.7	40.0	0.84
2013	A2	47.7	43.0	0.90
	A5	47.7	40.2	0.84
	A1	48.6	42.5	0.87
2014	A2	48.6	38.9	0.80
	A5	48.6	39.7	0.82
	Means	47.3	40.0	0.84

Annual cumulative ET_o , ET_c , and K_c (ET_{oc} , ET_{cc} , and K_{cc}) for the three fields in Scott Valley

by year. The annual starting and ending dates are 1 January 1 and December 31.



THANK YOU !!

QUESTIONS OR COMMENTS?