Crop Water Requirements in the Latin American and Caribbean Flood and Drought Monitor (LACFDM)

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Development of Crop Water Requirements

Background:

For agriculture management it's critical to monitor how much water crops require balanced against rainfall (dry land farming) or how much irrigation water is needed to make up for a lack of rainfall.

The standard approach is to estimate transpiration for a reference vegetation (usually short grass) under current radiation and meteorological conditions, and then scale this value using FAO crop coefficients.

Factors affecting evapotranspiration, E



Variables in red can potentially be estimated via remote sensing $Rs \downarrow$, albedo, Tsurface, emissivity (and therefore $Rl\uparrow$) from the following satellites: GOES, MODIS, CERES, ASTER Vapor pressure deficit, Tair from AIRS, TOVS.

They can also be estimated using reanalysis model outputs, weather models forecasts or *in-situ* observations; or a combination of data sources.

Factors affecting reference crop evapotranspiration, E_{rc}



 $R_n = (1 - \alpha) Rs \psi + Rl \psi - \epsilon Ts^4$ G = ground heat flux



Factors affecting evapotranspiration, E



 $\gamma = psychrometric constant = 0.66 kPa/°C$ $\gamma^* = \gamma(1+0.33U_2)$ $\Delta = slope of the vapor pressure vs T_{air} curve; (4098 e_{sat})/(237.3+T_{air})²$

Evapotranspiration for the reference crop

$$E_{rc} = \frac{\Delta}{\Delta + \gamma^*} (R_n - G) + \frac{\gamma}{\Delta + \gamma^*} \frac{900}{T_{air} + 275} U_2 D$$

Estimating Potential Evaporation rates of crops:

 $E = K_c E_{rc}$, where $K_{co} =$ potential crop coefficient

Daily Reference Crop ET (mm)



Estimating Evaporation Rate for Crops during the growing season.

 $E = K_{co} E_{rc} \qquad \text{mm day}^{-1}$



FIGURE 4.4.1 Schematic diagram of the seasonal changes in potential crop coefficient K_{co} for an irrigated field crop (*redrawn from Doorenbos and Pruitt.*³⁰ Used with permission.) illustrating four growth stages (initial, crop development, midseason, late) in the total growing season defined relative to the planting date D_1 and terminating at the dates D_2 , D_3 , D_4 , and D_5 , respectively. The value of K_{co} during the initial Stage 1 is taken from Fig. 4.4.2, and the values during Stage 3 and after D_5 are taken from Table 4.4.4. Intervening values during Stages 2 and 4 are determined by interpolation.

Сгор	Typical growing season, days						K _{co} durir	ig Stage 3		K_{co} after Stage 4			
		Fraction of stage time at growth stage				RH _{min}	>70%	$RH_{min} < 20\%$		RH _{min} > 70%		RH _{nin} < 20%	
						Wind, m s ⁻¹		Wind, m s ⁻¹		Wind, m s ⁻¹		Wind, m s ⁻¹	
		1	2	3	4	0-5	5-8	0-5	5-8	0-5	5-8	0-5	5-8
Artichokes (perennial)	310-360	0.09	0.12	0.70	0.09	0.95	0.95	1.00	1.05	0.90	0.00	0.05	1.00
Barley	120 - 150	0.12	0.20	0.44	0.24	1.05	1 10	1 15	1.05	0.90	0.90	0.95	1.00
Beans (green)	75-90	0.22	0.33	0.33	0.12	0.95	0.95	1.00	1.20	0.25	0.25	0.20	0.20
Beans (dry)/Pulses	95-110	0.16	0.25	0.40	0.19	1.05	1 10	1.00	1.05	0.85	0.85	0.90	0.90
Beets (table)	70-90	0.24	0.35	0.29	0.12	1.00	1.00	1.15	1.20	0.50	0.30	0.25	0.25
Carrots	100 - 150	0.18	0.27	0.39	0.16	1.00	1.00	1.05	1.10	0.90	0.90	0.95	1.00
Castor beans	180	0.14	0.22	0.36	0.28	1.00	1.05	1.10	1.15	0.70	0.75	0.80	0.85
Celery	125 - 180	0.16	0.22	0.50	0.11	1.00	1.10	1.15	1.20	0.50	0.50	0.50	0.50
Corn (sweet)	80 - 110	0.23	0.29	0.37	0.11	1.00	1.05	1.10	1.15	0.90	0.95	1.00	1.05
Corn (grain)	125 - 180	0.17	0.28	0.33	0.22	1.05	1.10	1.15	1.20	0.95	1.00	1.05	1.10
Cotton	180 - 195	0.16	0.27	0.31	0.22	1.05	1.10	1.15	1.20	0.55	0.55	0.60	0.60
Crucifers	80-95	0.24	0.38	0.26	0.12	0.95	1.15	1.20	1.25	0.05	0.65	0.65	0.70
Cucumber	105 - 130	0.19	0.28	0.38	0.12	0.95	0.90	0.05	1.10	0.80	0.85	0.90	0.95
Eggplant	130 - 140	0.21	0.32	0.30	0.17	0.95	1.00	1.05	1.00	0.70	0.70	0.75	0.80
Flax	150 - 220	0.15	0.21	0.39	0.25	1.00	1.00	1.05	1.10	0.80	0.85	0.85	0.90
Grain (small)	150 - 165	0.14	0.20	0.40	0.26	1.00	1.05	1.10	1.15	0.25	0.25	0.20	0.20
Lentil	150 - 170	0.14	0.20	0.41	0.25	1.05	1 10	1.15	1.20	0.30	0.30	0.25	0.25
Lettuce	75-140	0.26	0.37	0.27	0.10	0.95	0.95	1.00	1.20	0.50	0.50	0.25	0.25
Melons	120 - 160	0.20	0.28	0.37	0.15	0.95	0.95	1.00	1.05	0.50	0.90	0.90	1.00
Millet	105 - 140	0.14	0.23	0.39	0.24	1.00	1.05	1 10	1.05	0.05	0.05	0.75	0.75
Oats	120 - 150	0.12	0.20	0.44	0.24	1.05	1.10	1 15	1.15	0.30	0.30	0.25	0.25
Onion (dry)	150 - 210	0.10	0.17	0.49	0.24	0.95	0.95	1.05	1 10	0.25	0.25	0.20	0.20
(Continued)	100 210	0.10	,	,		0.70	0.70	1.05	1.10	0.75	0.75	0.80	0.85

TABLE 4.4.4 For a Range of Irrigated Field Crops, the Typical Total Growing Season in Days; Representative Proportions of This Growing Season at Each of the Growth Stages Illustrated in Fig. 4.4.1; and Recommended Values of K_{co} During Stage 3 and After Stage 4 in Different (Wind and Humidity) Climates

							K _{co} durin	ng Stage 3		K_{co} after Stage 4			
	Typical	Fraction of stage time at growth stage				$\frac{\mathrm{RH}_{\mathrm{min}} > 70\%}{\mathrm{Wind, m s^{-1}}}$		$\frac{\rm RH_{min}{<}20\%}{\rm Wind,m~s^{-1}}$		$\frac{\mathrm{RH}_{\mathrm{min}} > 70\%}{\mathrm{Wind, m s}^{-1}}$		$\frac{\rm RH_{min} < 20\%}{\rm Wind, m \ s^{-1}}$	
	growing												
Crop	days	1	2	3	4	0-5	5-8	0-5	5-8	0-5	5-8	0-5	5-8
Onion (green)	70-95	0.29	0.45	0.17	0.09	0.95	0.95	1.00	1.05	0.95	0.95	1.00	1.05
Groundnuts	130-140	0.22	0.30	0.30	0.18	0.95	1.00	1.05	1.10	0.55	0.55	0.60	0.60
Peas	90-100	0.21	0.26	0.37	0.16	1.05	1.10	1.15	1.20	0.95	1.00	1.05	1.10
Peppers (fresh)	120-125	0.22	0.29	0.33	0.16	0.95	1.00	1.05	1.10	0.80	0.85	0.85	0.90
Potato	105-145	0.21	0.25	0.33	0.21	1.05	1.10	1.15	1.20	0.70	0.70	0.75	0.75
Radishes	35-40	0.20	0.27	0.40	0.13	0.80	0.80	0.85	0.90	0.75	0.75	0.80	0.85
Safflower	125-190	0.17	0.27	0.35	0.21	1.05	1.10	1.15	1.20	0.25	0.25	0.20	0.20
Sorghum	120-130	0.16	0.27	0.33	0.24	1.00	1.05	1.10	1.15	0.50	0.50	0.55	0.55
Soybeans	135-150	0.14	0.21	0.46	0.19	1.00	1.05	1.10	1.15	0.45	0.45	0.45	0.45
Spinach	60-100	0.27	0.31	0.34	0.08	0.90	0.95	1.00	1.05	0.90	0.90	0.95	1.00
Squash	90-100	0.24	0.34	0.26	0.16	0.90	0.90	0.95	1.00	0.70	0.70	0.75	0.80
Sugar beet	160-230	0.18	0.27	0.33	0.22	1.05	1.10	1.15	1.20	0.90	0.95	1.00	1.00
Sunflower	125-130	0.17	0.28	0.36	0.19	1.05	1.10	1.15	1.20	0.40	0.40	0.35	0.25
Tomato	135 - 180	0.20	0.28	0.33	0.19	1.05	1.10	1.20	1.25	0.60	0.40	0.65	0.55
Wheat	120-150	0.12	0.20	0.44	0.24	1.05	1.10	1.15	1.20	0.25	0.25	0.20	0.20

Source: Derived from Doorenbos and Pruitt (Ref. 30, Tables 21 and 22). Used with permission.

Daily Reference Crop ET





Applications of the LAFDM:

• Download Tutorial from:

http://www.cazalac.org/mwar_lac/index.php?id=129

- Follow tutorial to learn all functions of monitor website
- Download the <u>Reference Crop Evaporation</u> time-series for a location of interest
- Adjust with crop coefficient for a few crops (soybeans and corn)
- Compare more and less arid regions (e.g. Northern vs Southern Brazil)

Thank you for your attention! Questions or comments?