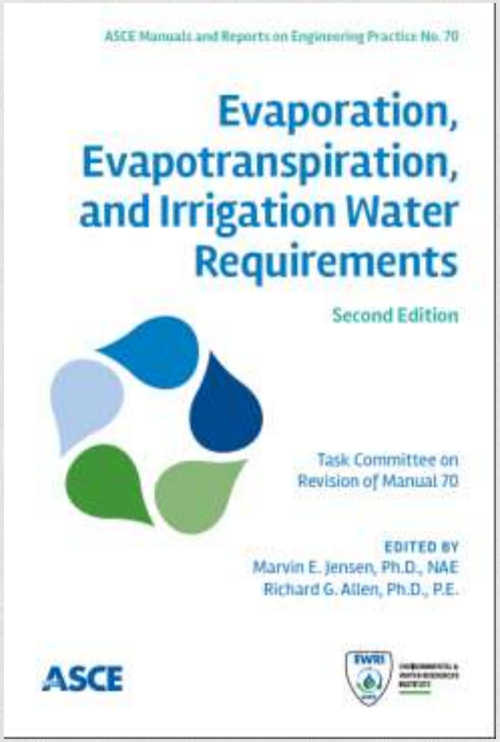
ASCE Manual 70 - Second Edition: Evaporation, Evapotranspiration and Irrigation Requirements



A Progression of Standardization and use of Physics in Evapotranspiration and Engineering

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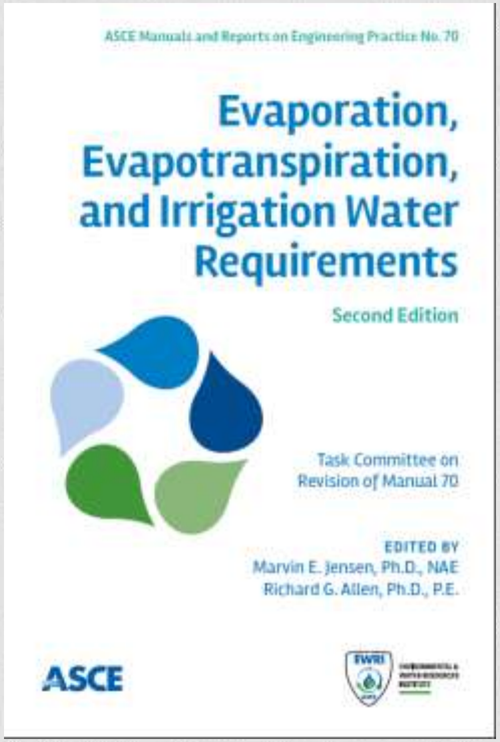
Task Committee Members: Richard Allen, Marvin Jensen, Terry A. Howell, Ivan Walter, Richard Snyder, Derrel Martin

USCID Oct. 11-14, 2016, Fort Collins, CO

University of Idaho

Timeline for the 2nd Edition:

(not Marvin's fault)



- 1990 – First Edition published
- 2000 – First Edition out of print
- 2002 – <u>ASCE Task Committee for Revision Created</u>
- 2003 – 2014 – series of additions of new material and material from other ASCE publications
- 2008 – First draft to the ASCE ET Committee
- 2014 – Near final draft Reviewed by Blue Ribbon Committee
- 2015 – Second Edition as final proof
- 2016 – <u>Second Edition published</u>

Purpose of Manual 70
-- Complements ASABE and IA Publications

- ASCE Manual 70
  - ET for ...
    - Irrigation Systems Design
    - Conveyance and Supply Systems Design
    - Water Resources Depletion
    - Water Transfers
    - Water Rights and Litigation
    - Advance Standard Practices

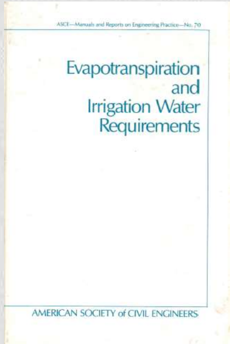
- ASABE and IA Pubs.
  - ET for ...
    - Irrigation Systems Design
    - Irrigation Water Management
    - Irrigation Scheduling
    - Environment
    - On-Farm Focus

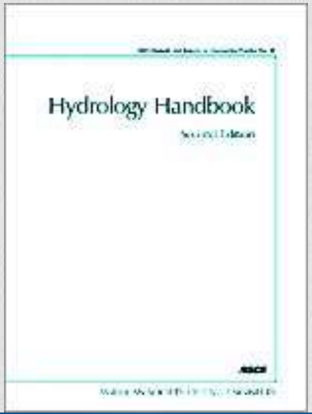
A basis of physics in ASCE ET approaches

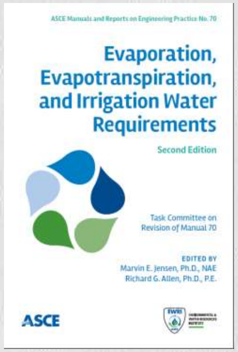
- "*Physics are Physics everywhere*"
  - Photon fluxes from the sun are constant and geometric effects are readily calculated and/or measured
  - Evaporation requires nearly the same amount of energy everywhere *(the latent heat of evaporation)*
  - Crops are largely passive resistors to water flow, so that electrical analogues such as the Penman-Monteith Equation can be used
- Many older methods, including Penman equations, were impacted by faulty weather parameter measurement and/or faulty or biased ET measurement

A basis of physics in ASCE ET approaches

- Jensen began emphasis on physical equations in the 1974 Orange Book and via irrigation scheduling research at Kimberly, ID with James Wright to improve consistency and transferability of methods
- This continued with Manual 70 (1990), FAO-24 and FAO-56, ASCE Hydrology Handbook, 2005 ASCE Reference ET Standardization, and Manual 70 (2016)







History: - Manua

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- 1974 – ASCE "
  published
  - Edited by M
  - Assembled f
    Notes and C
- Purpose:
  - Introduce ne
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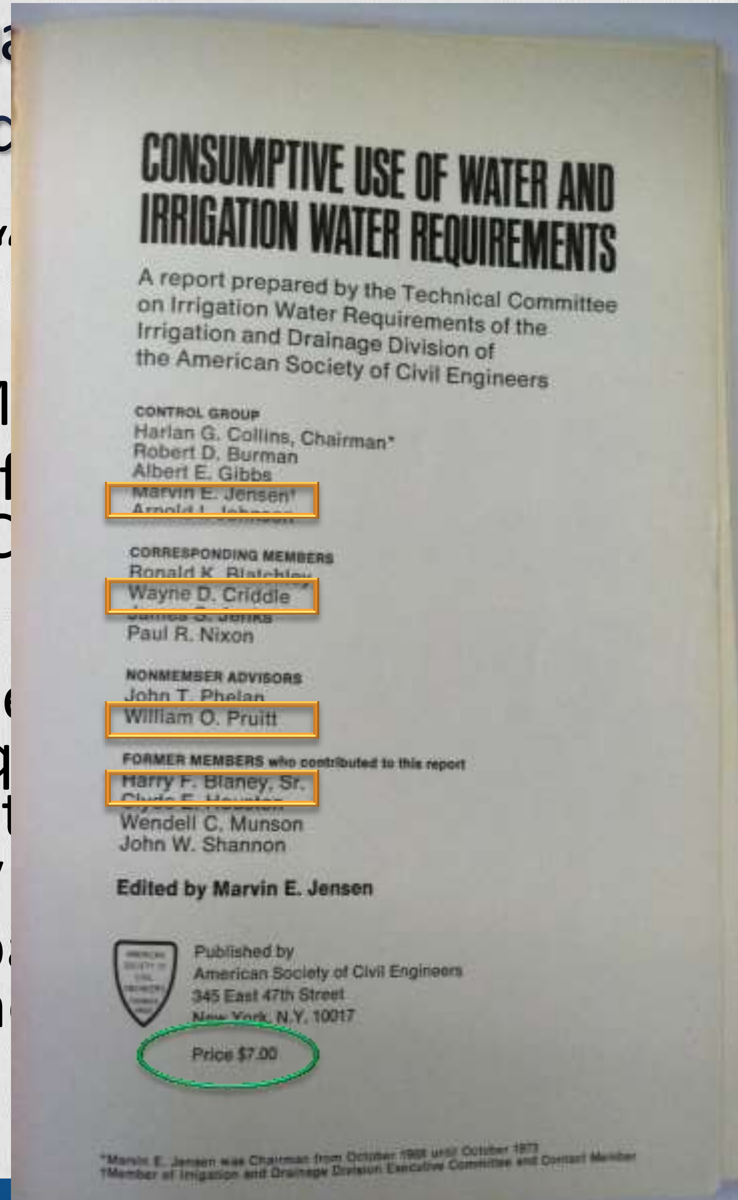
    techniques t
    Community
  - Make comp
    including th
    Criddle



CONSUMPTIVE USE OF WATER AND IRRIGATION WATER REQUIREMENTS

A report prepared by the Technical Committee on Irrigation Water Requirements of the Irrigation and Drainage Division of the American Society of Civil Engineers

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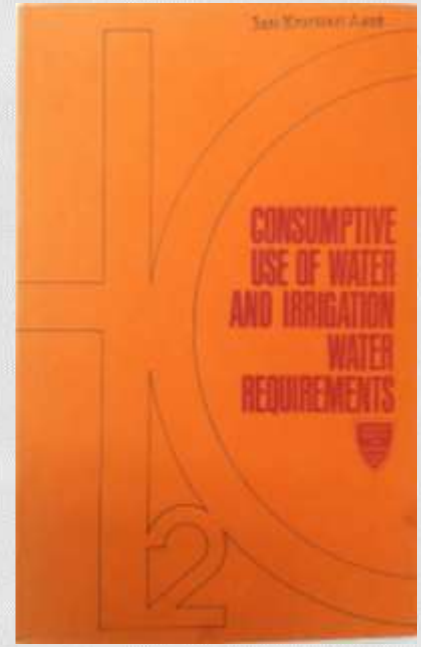
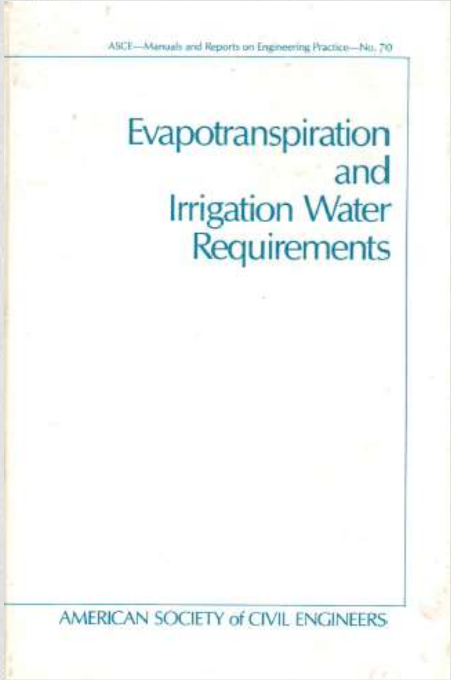


History:

- 1990 – ASCE Manual 70 “White Book” published
  - Edited by Jensen, Burman, Allen
  - Built on Orange Book
  - Introduced the ASCE Penman-Monteith (PM)
  - Made substantial comparisons of methods against lysimeter measurements
- Purpose:
  - Illustrated higher accuracy of physical equations (Penman, PM)
  - Recommended best calculation approaches
  - Recommended daily timesteps instead of monthly
- Motivation:
  - Improve the recognition of strengths and weaknesses of ET methods amongst the ET communities
  - Describe expected performances



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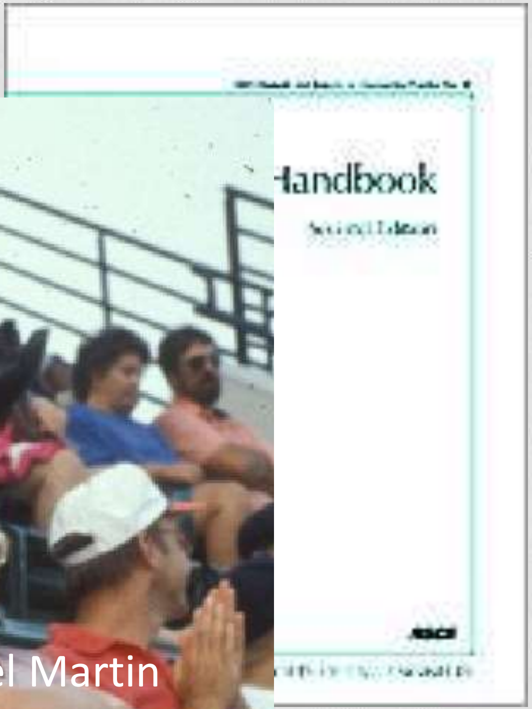
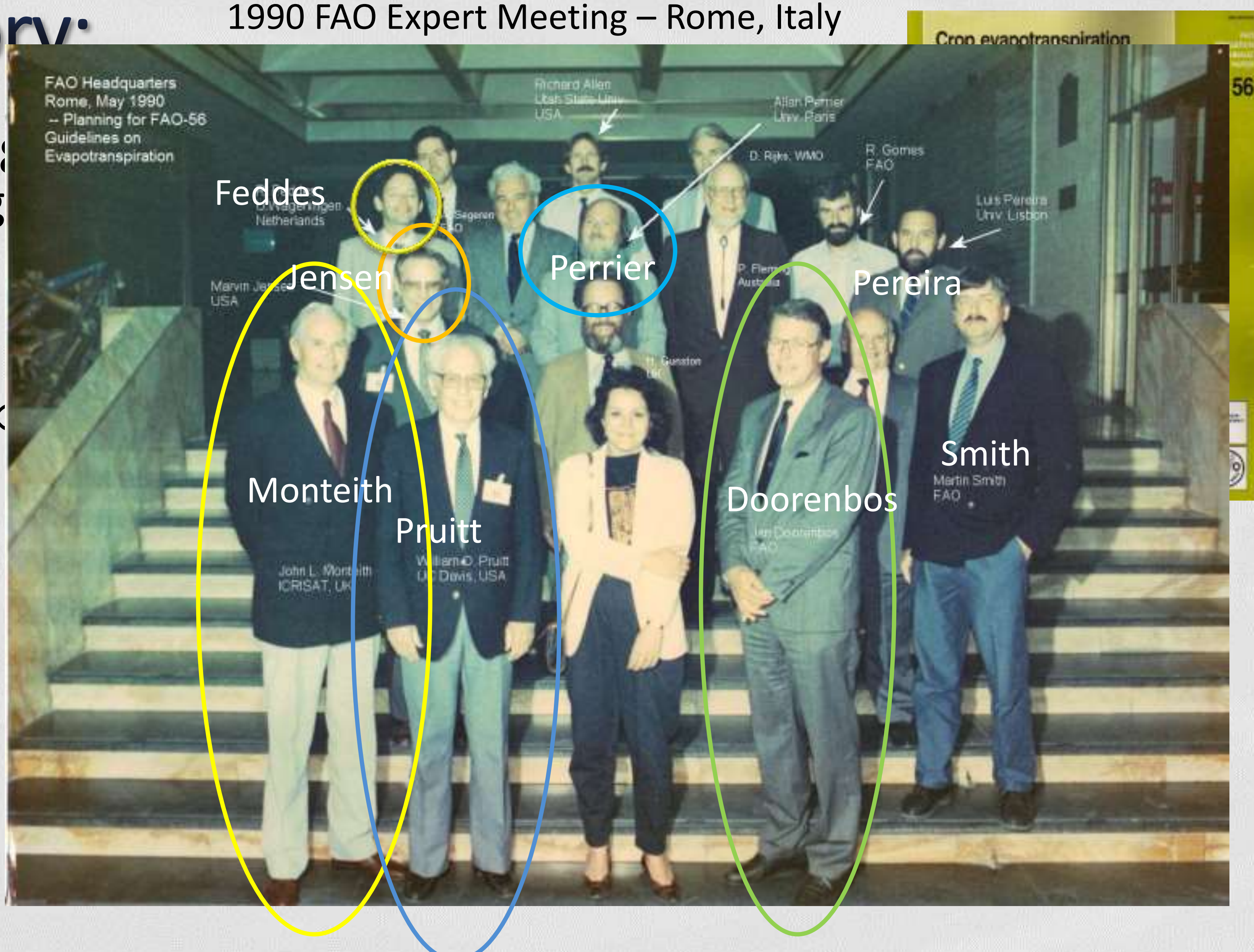


- New section on Evaporation from Open Water

History:

1990 FAO Expert Meeting – Rome, Italy



- 199
  Irrig
- Purp

History:


The ASCE Standardized
Reference
Evapotranspiration


ASCE ET Committee Meeting, Bushland, TX, 2008
3
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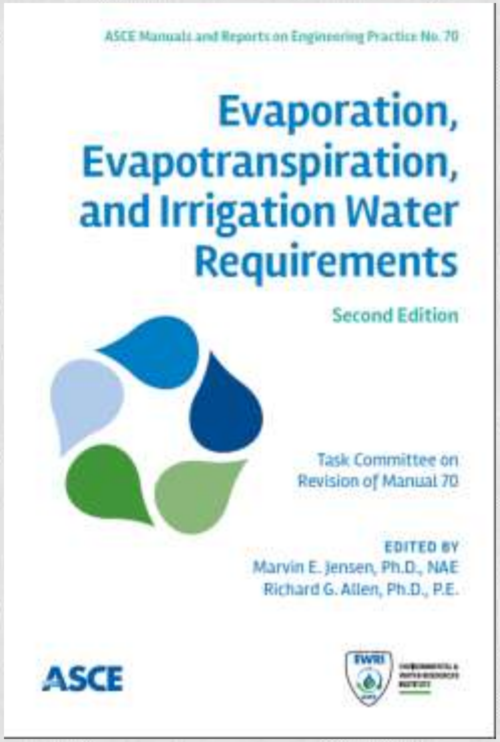
Current:

- 2016 – ASCE Manual 70 2nd edition
  - Still a “White Book”
  - Primary inputs
    - 1990 1st Edition ASCE Manual 70
    - 1996 ASCE Hydrology Handbook
    - 1998 FAO Irrig. and Drain. Paper 56
    - 2005 ASCE Standardized PM Report
- Purpose:
  - Standardized Calculation of Reference ET
  - QAQC of ET and Weather data and ET Measurements
  - Consistency in Crop Coefficients and Application
  - Recommends Dual Crop Coefficient Approach
  - Recommends Daily and Hourly timesteps
  - Workable methods for Estimating Evaporation from Open Water
  - Guidelines on ET from Landscapes
- Motivation:
  - Solidify Progress over the past three decades in:
    - Standardization of Reference ET Calculation
    - Application of Crop Coefficients
    - QAQC of Data
    - Provide Engineering and Legal Communities a Practices Manual on ET



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$$E = \frac{1,000 k_t C_E \rho_a (q_s - q_z) u_z}{\rho_w}$$

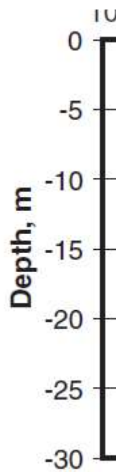

Fig. 6-8.
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Source: Je

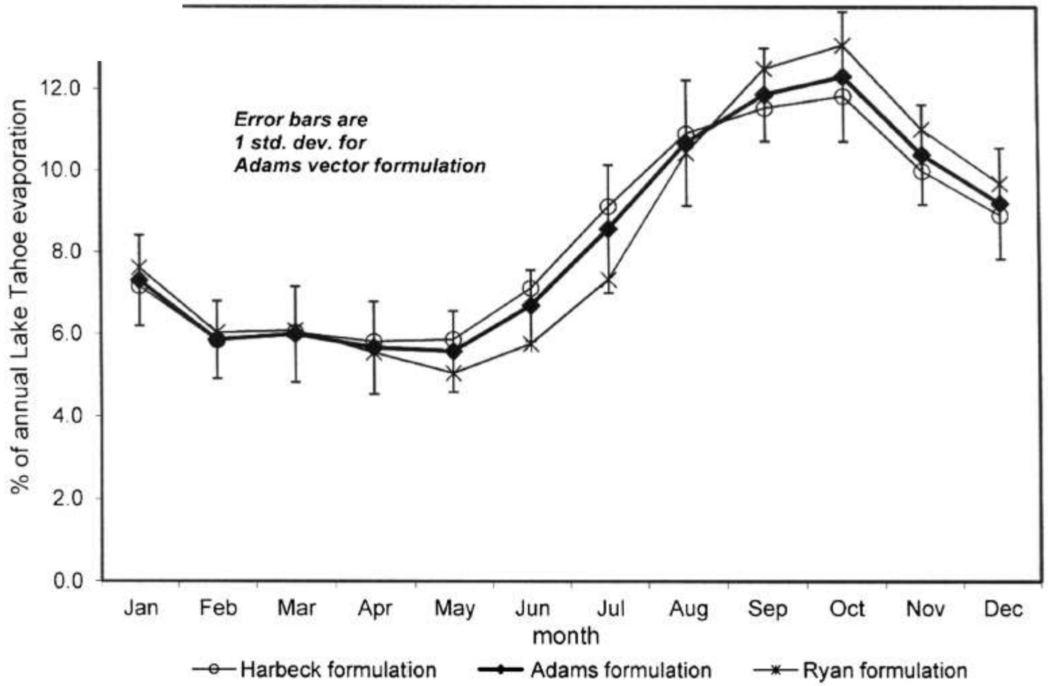


Fig. 6-17. Percent of average monthly annual evaporation from Lake Tahoe of 0.9 m, 0.97 m, and 1.24 m per year computed using three Dalton mass transfer formulations of Harbeck, Adams, and Ryan, respectively. See Trask (2007) for details on mass transfer applications and uncertainty estimates for Lake Tahoe
Source: Data from Trask (2007)

Cor

30 s m^{-1}
(daytime hourly)
45 s m^{-1}
(24-hr)
for alfalfa

50 s m^{-1}
(daytime hourly)
70 s m^{-1}
(24-hr)
for grass

full Penman-Monteith

$$ET = \left(\frac{\Delta(R_n - G) + K_{time}\, \rho_a\, c_p \dfrac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \dfrac{r_s}{r_a}\right)} \right) / \lambda$$

C_n and C_d are constants

Standardized FAO56/ASCE Penman-Monteith

$$ET_{ref} = \frac{0.408\, \Delta(R_n - G) + \gamma \dfrac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)}$$

f (Solar Radiation)

f (Temperature)

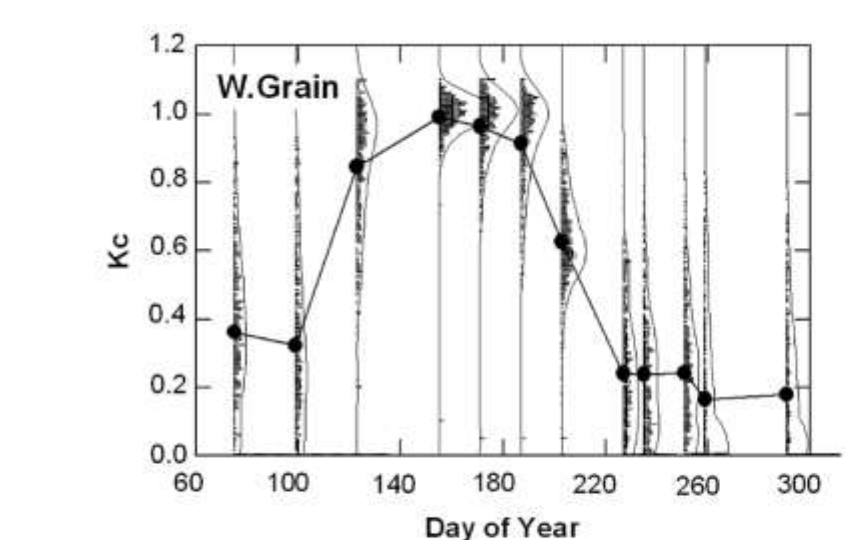
Wind Speed

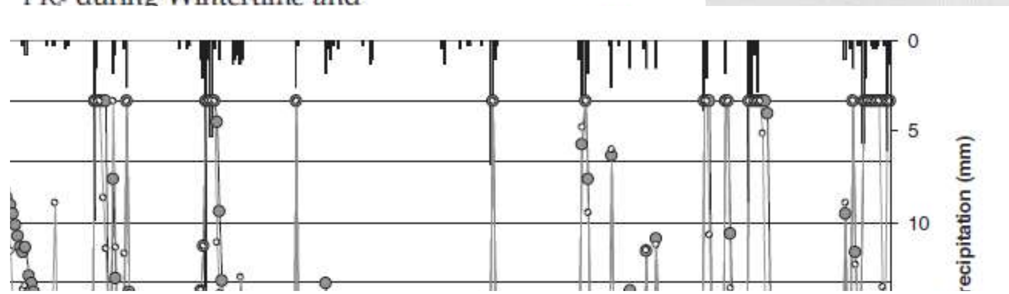
f (Humidity)

ASCE PM can be applied to clipped grass and to 0.5 m tall alfalfa

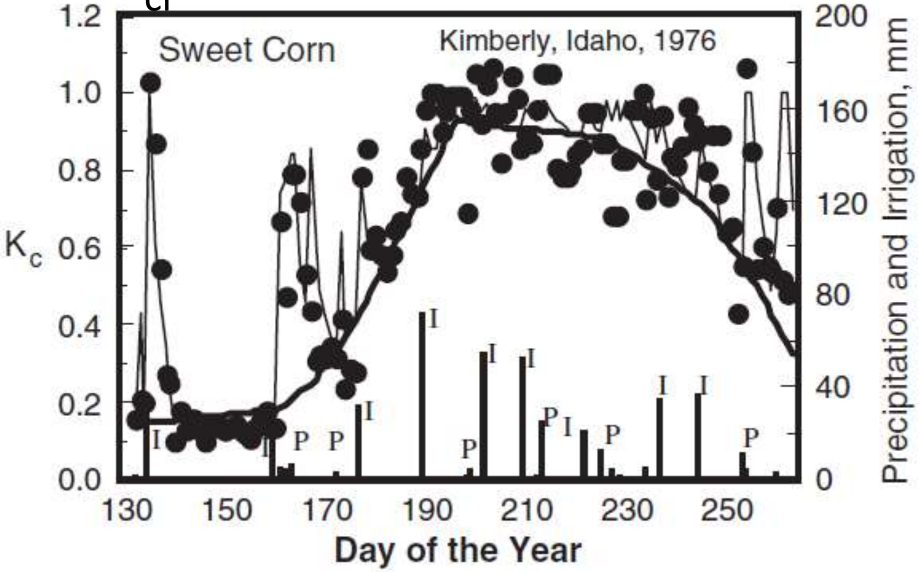
University of Idaho

Ag. Kc's

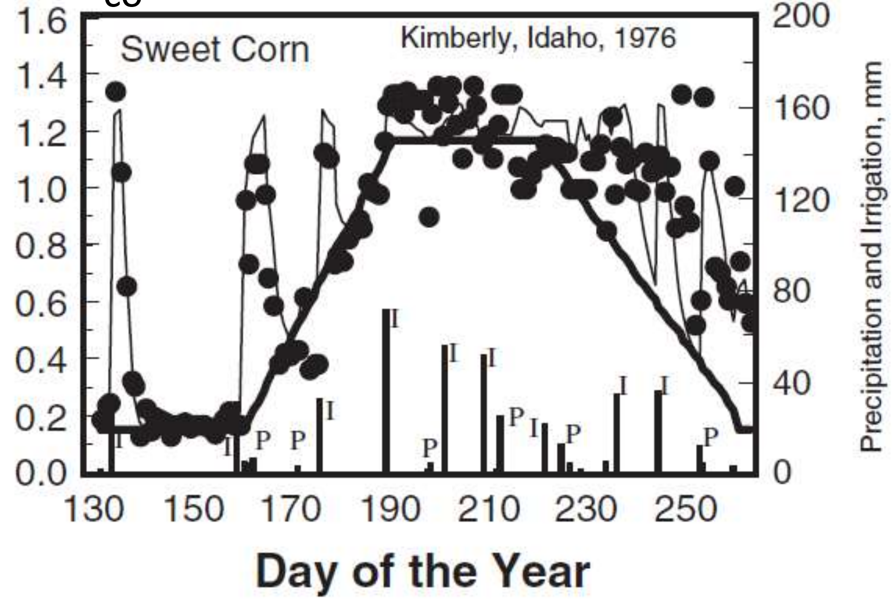




K_{cr}



K_{co}



Landscape

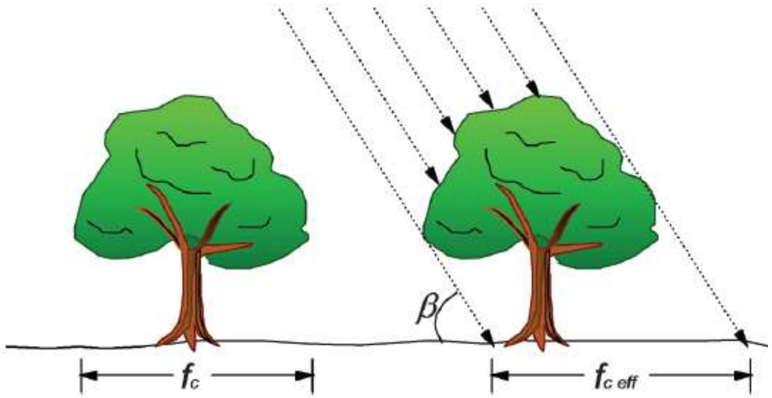
$$ET_L = K_L \, ET_o$$

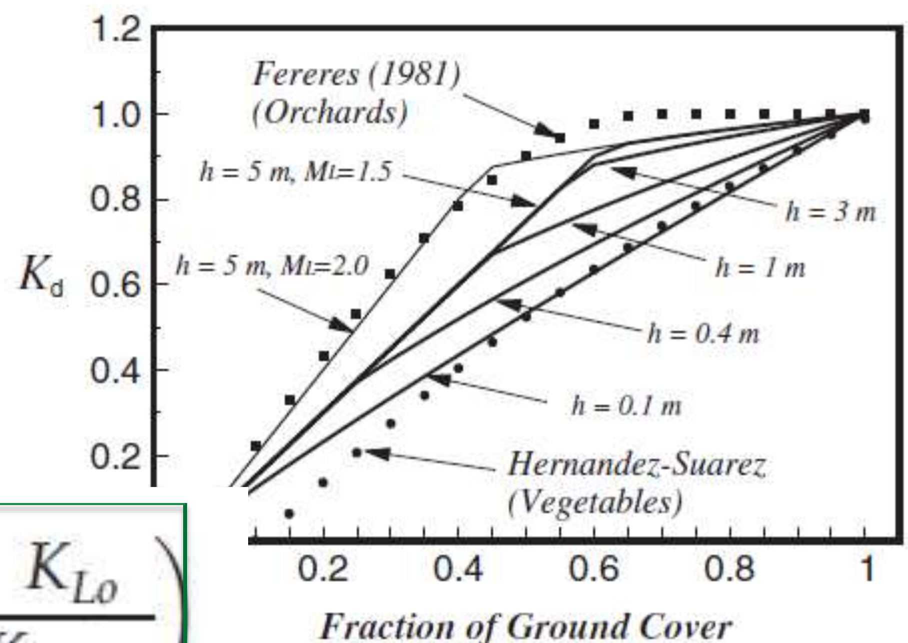
$$K_{L\,act} = K_v K_d K_s K_{mc}$$

$$K_L = K_v K_d K_{sm} K_{mc}$$

$$K_{L\,act} = (K_{soil} + K_{vsd} K_d K_s) K_{mc}$$

$$K_d = \min\left[1, M_L f_{c\,eff}, f_{c\,eff}^{\left(\frac{1}{1+h}\right)}\right]$$





basal

$$K_{Lo} = K_v K_d K_{sm} K_{mc}$$

interception

$$K_L = K_{Lo} + \frac{S}{t_w ET_o}\left(1 - \frac{K_{Lo}}{K_{c\,max}}\right)$$

Evaporation from frequent wetting

Table 11-2. Typical Values for the Stomatal Resistance per Unit Leaf Area, r_l, and Bulk Stomatal Resistance, r_s, for Various Canopy Types; Parameters $r_{l_{min}}$ and $r_{s_{min}}$ Are Minimum Daytime Values[a] with $g(env.) = 1$ *(Continued)*

Canopy Type	r_l sm^{-1}	$r_{l_{min}}$ sm^{-1}	r_s sm^{-1}	$r_{s_{min}}$ sm^{-1}	Reference
Crops, general	50-320				Slatyer (1967)
			40-130		Perrier (1982)
				20-75	Sellers and Dorman (1987)
				20-150	Noilhan and Planton (1989)
			30-35	30	Dorman and Sellers (1989)
	100				Monteith (1965), Sharma (1985)
Grain sorghum	200	150	100-140 (LAI = 2)		Szeicz et al. (1973)
		150			Choudhury and Monteith (1986)
Snapbeans (*Phaseolus vulgaris*)		130			Choudhury and Monteith (1986)
Soybeans	120				Valle et al. (1985)
				50 (LAI = 3.4)	Grant and Baldocchi (1992)
Maize		70	80	40	McGinn and King (1990)
		70		25 (LAI = 3.5)	Jacobs et al. (1989)
		70			Rochette et al. (1991)
	160				Körner et al. (1979)
Barley	150–250 (young to old)		45	40	Szeicz and Long (1969)
			70		Perrier (1982)
Wheat			50	30	Hatfield (1985)

Coniferous forests, general ($h = 10 - 28$ m)[5]	
27 m eucalyptus[6]	1.9–4.1
Savannah scrub (25% trees, 65% dry grass, 10% burnt grass, sand)	0.4

Conte

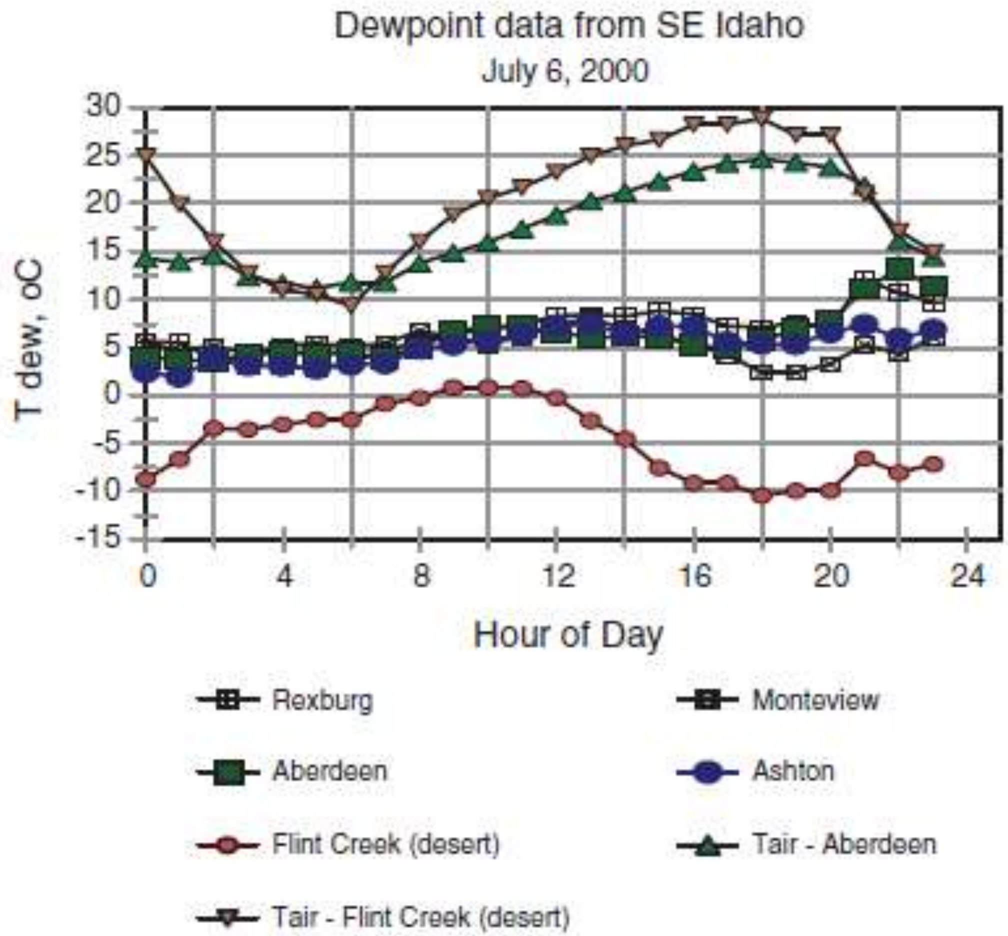


Fig. H-10. Hourly dew point from four irrigated regions of southeast Idaho and from a desert weather station (Flint Creek) on July 6, 2000. Also shown are air temperatures at Aberdeen and Flint Creek

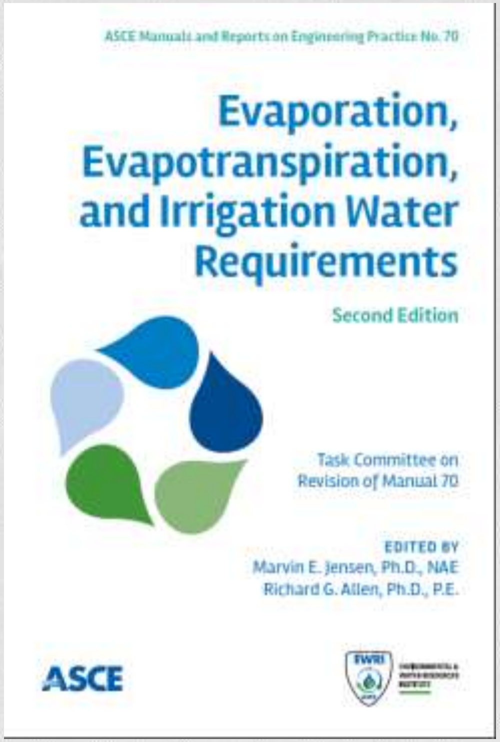
days in

V

2nd Edition of ASCE Manual 70

Summary

- 528 pages
- 15 years in the making
- Recommended for:
  - Irrigation Systems Design
  - Conveyance and Supply Systems Design
  - Water Resources Depletion
  - Water Transfers
  - Water Rights and Litigation
  - Standardized Practice



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