

COMPARISON OF EVAPORATION FROM U.S. CLASS "A" PAN AND AUSTRALIAN STANDARD TANK AND SELECTED ESTIMATES

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ABSTRACT

Observations of evaporation from U.S. Class "A" pans at six widely scattered sites in Australia have been compared with concurrent observations from Australian standard tanks and estimates by the Prescott, Thornthwaite and Penman methods. In general, Class "A" pan totals are higher than those of tank evaporation and in some months they are more than 25 per cent greater; on 40 per cent of occasions the two instrumental evaporation totals are within 10 per cent.

Correlation coefficients between the various evaporation forms are predominantly over 0.9 at all stations except Darwin. However, regression coefficients differ considerably from unity.

Estimates by the methods tested are usually less than pan and tank evaporation, at times over 50 per cent less.

1. INTRODUCTION

Following the I. G. Y. proposal, U.S. Class "A" pan evaporimeters were installed in mid 1959 at Guildford (Perth), Darwin, Alice Springs, Waite Institute (Adelaide), Griffith and Aspendale, where Australian standard tanks already existed. Full climatological observations including total incoming radiation are also made at these stations. These dual evaporation records have now been maintained for over three years and it is of interest to compare the two sets of data for each station.

At the meeting of the Commission for Agricultural Meteorology in Toronto, in July 1962, (CAgMIII Doc. 86), a recommendation was adopted that members should make comparisons between the various instruments and methods of calculation used in their countries. It is therefore appropriate that a comparison of methods used in Australia to estimate evaporation should be added to the above comparison of Class "A" pan and Australian tank observations.

Finally another important reason for making this comparison at this juncture is the change of Australian standard network evaporimeter from the sunken tank to the Class "A" pan.

The comparison has not been extended to cover every method of evaporation measurement or computation attempted in Australia. For example, it was not feasible to make continuous "evapotron" or lysimetric observations at the selected stations, but this more specialized field of measurement has been well covered by C.S.I.R.O. Division of Meteorological Physics, e.g. McIlroy (1963).

2. INSTRUMENTAL DETAILS

(i) Australian standard tank (E_A)

This has been described in greater detail in a discussion of Australian evaporation results (Hounam 1961). In brief, this is a circular metal tank, 3 ft in diameter and 3 ft deep, fitted inside a 4 ft diameter tank, 2 ft 10 in. deep, so that the 3 ft tank is surrounded by a 6 inch annulus. The instrument is sunk in the soil with the outer tank approximately flush with the soil. The level of water in the inner or observation tank is kept within an inch or two of the rim. The

annulus is also kept near-full and serves to protect the inner tank from birds and animals; it may also help to detect major leaks. The standard measuring apparatus is the hook gauge.

(ii) U. S. Class "A" pan (E_P)

This is the well-known 4 ft metal pan, 10 in. deep, and is mounted on a wooden stand 6 in. above the ground.

3. METHODS SELECTED FOR ESTIMATION OF EVAPORATION

(i) Evaporation by Prescott equation (E_W)

Twenty years ago Prescott was convinced of the importance of evaporation in agricultural studies in which he was involved, and to supplement the rather sparse network of Australian standard evaporimeters he found it necessary to fall back on values of tank evaporation estimated from other parameters. Whilst appreciating the many factors involved in evaporation, he proposed, and used, an empirical relationship (Prescott and Thomas 1948-49):-

$$E_W = 21.2 (e_a - e_d)$$

where E_W is estimated evaporation from the Australian standard tank based on studies at the Waite Institute, Adelaide,

and $(e_a - e_d)$ is the saturation vapour pressure deficit of the atmosphere in inches of mercury, preferably at the mean daily temperature.

This equation has been used extensively in estimating mean monthly evaporation and is not intended for daily use. It has been found subsequently, in Bureau of Meteorology investigations, that the constant 21.2 has in fact a large degree of seasonal and geographical variability.

The equation has been largely superseded, but there is no doubt that it served a very useful purpose during the early developmental period of agrometeorology in this country.

(ii) Evaporation by Thornthwaite equation (E_T)

Thornthwaite (1948) calculates E_T , the monthly evapotranspiration, from an equation relating potential evapotranspiration to mean temperature with an adjustment for day length. Calculations of the Thornthwaite evapotranspiration have been made from tables in Thornthwaite and Mather (1957).

(iii) Evaporation by Penman equation (E_o)

The Penman (1948) equation was applied to Australian data using the constants and approximations described by Hounam (1963).

4. RESULTS OF MEASURED AND ESTIMATED EVAPORATION

Table 1 shows measured and estimated evaporation for the selected I. G. Y. stations, Perth, Darwin, Alice Springs, Waite Institute, Griffith and Aspendale. For the purposes of this paper the control is the U. S. Class "A" pan for which observations commenced in June 1959 and are still being made.

In cases where either E_P or E_A was missing for a month the remaining observed or estimated totals have been omitted.

Table I. Measured and Estimated Evaporation for Perth, Darwin, Alice Springs,
Waite Insitute (Adelaide), Griffith and Aspendale (Melbourne)

MONTHLY TOTALS IN INCHES

- Line 1. E_P = Evaporation from U.S. Class "A" Pan.
 Line 2. E_A = Evaporation from Australian Tank.
 Line 3. E_W = Evaporation estimated by Prescott Equation.
 Line 4. E_T = Evaporation estimated by Thornthwaite Equation.
 Line 5. E_O = Evaporation estimated by Penman Equation.

PERTH

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1959	E_P						2.34	2.28	3.24	4.76	6.00	8.29	10.38
	E_A						2.06	2.53	2.88	4.09	5.31	7.87	10.27
	E_W						2.58	3.05	3.32	3.46	3.02	6.07	7.90
	E_T						1.51	1.60	1.71	1.80	2.35	3.45	4.43
	E_O						1.61	2.01	2.48	3.88	4.93	6.08	6.91
1960	E_P	9.15	9.11	6.51	4.55	2.67	1.92	1.75	2.53	3.91	6.77	8.42	11.07
	E_A	9.24	9.66	7.03	4.54	2.43	1.75	1.78	2.03	3.35	5.73	7.99	11.30
	E_W	7.14	9.06	6.20	4.06	2.85	1.93	1.68	1.82	2.62	4.70	5.49	9.13
	E_T	4.36	4.64	3.50	2.28	1.64	1.26	1.07	1.14	1.80	2.69	3.45	5.17
	E_O	6.54	5.99	4.58	3.08	1.80	1.38	1.75	2.50	3.13	5.13	5.98	7.44
1961	E_P	11.08	9.15	8.33	3.52	2.80	2.29	2.12	2.54	4.51	6.28	8.66	9.15
	E_A	8.10	8.87	8.72	3.34	2.54	2.43	1.99	2.52	3.82	5.54	8.52	8.86
	E_W	11.88	9.90	7.00	3.22	3.94	2.62	2.17	2.54	3.62	4.31	6.99	8.48
	E_T	6.53	4.94	4.13	2.00	1.91	1.26	1.07	1.42	1.80	2.69	3.45	4.80
	E_O	7.57	5.78	5.39	3.12	2.32	1.94	1.85	2.81	3.56	5.31	6.46	6.59
1962	E_P	12.84	9.52	7.64	5.25	3.76	1.65	2.14		4.15	5.95	8.16	10.07
	E_A	12.21	8.98	7.51	5.17	3.90	1.69	2.05		3.95	5.43	7.87	9.87
	E_W	13.55	10.60	6.82	6.72	5.41	2.05	2.90		3.46	3.80	5.82	8.59
	E_T	6.90	4.94	3.50	3.14	2.18	1.51	1.07		1.80	2.02	3.10	5.17
	E_O	8.35	6.21	5.09	3.76	3.12	1.33	2.01		3.58	5.11	5.71	7.02

DARWIN

1959	E_P						8.72	8.52	10.24	10.21	12.02	11.53	
	E_A						6.95	6.56	7.59	7.85	9.38	9.00	
	E_W						9.36	8.13	8.29	7.39	8.14	7.71	
	E_T						4.56	4.14	4.82	5.70	6.71	6.68	
	E_O						5.86	5.72	5.97	6.26	8.09	6.34	

Table 1. (Cont'd)

DARWIN (Contd.)

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	E _P	8.05	6.96	6.98	7.18	7.89	8.43	8.86	9.66	9.69	11.95	9.75	8.53
	E _A	6.96	4.86	4.96	6.02	6.85	7.52	7.57	8.38	8.13	9.95	7.73	7.10
	E _W	4.71	3.87	4.29	6.54	7.04	9.91	8.38	9.78	7.17	7.65	7.71	5.97
	E _T	6.24	5.56	5.98	5.91	4.78	3.70	4.14	4.52	5.70	6.39	6.68	6.66
	E _O	5.08	5.08	4.55	4.81	5.21	5.67	6.02	6.69	6.40	7.20	6.26	5.11
1961	E _P	7.06	5.81	9.41	8.08	9.45	8.51	8.26	9.88	10.13		10.26	9.95
	E _A	7.50	3.93	7.20	6.20	8.02	6.99	6.65	7.77	8.25		8.13	7.81
	E _W	5.58	4.10	5.81	5.97	10.62	10.28	9.63	8.45	7.31		7.17	7.13
	E _T	6.24	5.56	6.30	5.91	5.07	3.99	4.14	4.52	5.70		6.36	6.99
	E _O	4.94	3.81	5.07	4.78	5.87	5.37	5.48	5.28	6.01		6.11	6.18
1962	E _P		7.55	9.79	8.35	9.83							9.01
	E _A		4.81	7.67	6.24	7.38							7.57
	E _W		3.61	6.12	7.04	10.10							6.61
	E _T		5.56	6.30	5.61	5.37							6.66
	E _O		4.34	5.29	4.75	5.93							5.56
ALICE SPRINGS													
1959	E _P						4.72	5.72	9.00	13.64	16.28		17.12
	E _A						3.72	4.64	7.61	9.28	11.31		13.24
	E _W						3.95	4.65	6.22	8.40	14.12		16.70
	E _T						0.53	0.83	1.18	2.40	4.90		6.32
	E _O						2.93	3.48	4.64	6.23	10.06		12.17
1960	E _P	19.28	14.28	19.40	21.09	5.43	6.69	7.50	6.84	13.65	14.41	15.83	19.40
	E _A	13.23	13.31	10.73	8.98	5.01	4.71	5.50	5.97	9.35	10.76	13.77	13.84
	E _W	16.73	16.58	13.90	9.38	3.88	4.66	6.15	5.28	9.03	12.57	15.68	16.72
	E _T	7.70	6.36	5.04	2.88	1.14	0.80	1.12	0.88	2.40	3.92	4.98	6.67
	E _O	11.31	10.66	8.69	5.61	3.40	3.05	3.41	4.11	6.23	8.61	10.66	12.06
1961	E _P	18.06	17.63	15.38	10.84	6.93	6.84	14.44	17.51	15.07	15.56	17.05	24.74
	E _A	15.62	13.38	13.98	9.27	6.72	5.13	4.80	6.30	9.78	13.44	14.25	17.99
	E _W	17.32	18.43	16.31	17.63	5.88	4.63	4.58	6.12	10.80	14.98	16.13	19.67
	E _T	7.00	5.76	5.04	4.32	1.14	0.80	0.56	0.88	2.70	4.25	5.64	7.02
	E _O	12.34	12.01	9.59	6.74	3.89	3.00	3.11	4.26	6.79	10.13	13.54	13.99

Table 1. (Cont'd)

GRIFFITH (Contd.)

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	E _P	11.72	9.22	8.24	4.94	2.36	1.73	1.56	2.26				10.60
	E _A	9.46	7.77	6.64	4.25	2.34	1.93	1.45	2.08				8.88
	E _W	13.90	9.43	9.55	5.13	2.23	2.32	2.31	2.37				10.40
	E _T	6.61	4.68	4.13	2.26	1.08	0.50	0.79	0.85				5.22
	E _O												
1961	E _P	11.45	9.21	7.26	3.78	2.48	1.62	1.73	2.53	4.65	7.56	7.95	9.58
	E _A	9.71	8.64	6.65	3.73	2.90	1.77	1.75	2.23	3.17	6.41	6.43	8.24
	E _W	12.81	11.26	7.70	4.01	3.44	2.53	2.37	2.57	4.58	7.52	6.50	6.51
	E _T	6.61	4.99	3.82	2.26	1.34	0.99	0.79	0.85	1.80	3.39	3.84	5.97
	E _O												
1962	E _P	9.72	8.98	7.47	4.42	2.76	2.03	2.07	3.22	5.57		9.31	10.65
	E _A	8.48	8.17	6.44	4.12	2.60	1.94	1.74	2.80	4.09		7.15	8.67
	E _W	7.28	7.82	6.77	4.55	2.00	1.79	1.77	1.73	2.84		8.06	8.02
	E _T	5.50	4.37	3.82	2.26	1.08	0.99	0.79	1.14	1.80		3.84	4.83
	E _O												

ASPENDALE

1959	E _P						1.73	1.47	2.74	3.81	5.10	5.98	7.54
	E _A						1.80	1.32	2.32	3.28	3.44	4.62	6.18
	E _W						2.33	2.14	2.53	3.10	3.42	5.34	5.55
	E _T						0.96	1.02	1.40	1.50	2.39	3.57	3.81
	E _O						1.43	1.67	2.42	3.56	5.09	5.87	7.23
1960	E _P	9.80	7.35	6.43	3.90	2.36	1.51	1.76	2.14	2.92	5.67	5.94	9.64
	E _A	7.57	6.23	5.63	3.82	2.35	1.49	1.36	1.60	2.22	4.05	4.52	6.77
	E _W	8.04	6.02	5.81	3.66	2.06	1.78	1.84	1.92	2.67	4.34	3.76	6.14
	E _T	5.25	3.46	3.53	1.95	1.30	0.96	1.02	1.12	1.80	2.39	2.50	4.57
	E _O	8.04	6.08	4.88	3.61	1.88	1.47	1.63	2.40	3.18	5.37	5.95	7.45
1961	E _P	10.46	7.65	6.28	3.71	2.33	1.72	1.56	2.21	3.73	6.05	7.39	9.27
	E _A	8.25	6.43	5.19	3.23	2.10	1.48	1.35	1.87	2.83	4.39	5.86	7.32
	E _W	7.66	6.60	4.71	3.50	2.20	1.94	2.13	2.44	3.47	5.52	5.15	6.71
	E _T	5.25	3.78	3.21	2.23	1.30	1.20	1.02	1.12	1.80	2.74	3.21	4.19
	E _O	8.63	6.89	5.58	3.46	2.04	1.34	1.80	2.58	2.09	5.66	6.48	8.05

Table 1. (Cont'd)

ASPENDALE (Contd.)

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1962	E_P	10.15	7.60	7.33	4.13	2.49	2.49	1.96	2.88	3.74	5.31	6.78	8.34
	E_A	8.43	6.43	6.36	4.52	2.57	2.10	1.76	2.34	3.18	4.03	5.40	6.51
	E_W	6.97	5.96	6.25	4.71	4.39	2.94	1.82	2.98	2.90	3.78	4.96	5.78
	E_T	4.88	3.46	3.53	2.23	1.83	1.44	1.02	1.12	1.80	2.05	2.86	3.81
	E_O	7.68	5.82	4.86	3.76	2.64	2.11	1.92	2.82	2.53	4.11	5.84	6.13

Final calibrated radiation data for Griffith were not available for part of the period and for this reason Penman estimates (E_O) have not been included in the table. Fleming (1964) also advises that the U. S. Class "A" pan suffered two changes in exposure during this period. For the period mid 1959 to 1960 the base of the pan was 2 inches above the ground; during 1961 the base was level with the ground and for 1962 the base was 6 inches above the ground. For this reason relationships between E_P and E_A are not included in the subsequent tables. However, it is noted that Fleming obtains practically the same relationship between E_P and E_A with the base of the pan at both 2 inches and 6 inches. This may mean that the height of exposure is not critical within this range; an experiment designed to test the effect of different heights of exposure over a wider range than 4 inches would be of interest.

5. CORRELATION BETWEEN VARIOUS MEASUREMENTS AND ESTIMATES

Coefficients of correlation have been computed for each combination of monthly evaporation data and estimates for each station. These are shown in Table 2.

Table 2. Coefficients of Correlation between monthly evaporimeter observations and estimates based on all months of record.

Correlation	Perth	Darwin	Alice Springs	Waite Institute	Aspendale
$E_A : E_P$	.98	.90	.85	.99	.99
: E_W	.89	.57	.95	.94	.96
: E_T	.94	.17 NS	.94	.97	.97
: E_O	.96	.86	.97	.96	.95
$E_P : E_W$	.90	.48	.82	.94	.95
: E_T	.95	.25 NS	.82	.96	.98
: E_O	.99	.87	.84	.97	.97
$E_W : E_T$	.96	-.54	.97	.97	.97
: E_O	.85	.56	.95	.89	.93
$E_T : E_O$	.91	.10 NS	.96	.91	.95
Degrees of freedom	40	32	40	41	41

E_A = evaporation from Australian tank.

E_P = evaporation from U. S. Class "A" pan.

E_W = evaporation estimated by Prescott equation.

For E_T

E_O

NS

} See next page.

E_T = evaporation estimated by Thornthwaite equation.

E_o = evaporation estimated by Penman equation.

NS = not significant.

All correlations at the three southern stations are high, being predominantly over 0.9 and in more than half the cases over 0.95. Except where indicated for Darwin, the values are highly significant by the "t" test.

The highly significant negative correlation between E_W and E_T for Darwin is of interest. E_W is based on the saturation vapour deficit of the air, a quantity which is higher in winter than summer at Darwin. E_T , based on mean temperature, exhibits a summer maximum. Thus the negative correlation has a climatological explanation and would be expected north of a line from West Kimberley to the northern part of Cape York Peninsula.

The Thornthwaite estimates (E_T) for Darwin also show very poor correlation with all other evaporation forms in Table 2 and it can therefore be assumed that this quantity gives a poor estimate of evaporation over Northern Australia. There are two possible reasons for this; either mean temperature in the tropics does not adequately represent the radiation quantities involved in the evaporation process, or humidity (or saturation deficit) not used in computing E_T , exerts a greater influence on evaporation in the tropics than in higher latitudes (through both the radiation balance and vapour transfer process).

Selected scatter diagrams are shown in Figs. 1(a-d) for Darwin, the correlations being lowest for this station. Selected examples show the relationship of each of the other four values of evaporation with observations from the U.S. Class "A" pan.

Other scatter diagrams, Figs. 2(a-d), show the relationships between E_P and E_A for each station shown in Table 2. Fig. 1(a) belongs also to this group.

For the purposes of regression, E_P has been selected as the dependent variable, the U.S. Class "A" Pan being the interim international standard for the I.G.Y. Table 3 shows regression co-efficients of E_P on E_A , E_W , E_T and E_o .

Table 3. Regression co-efficients of E_P on E_A , E_W , E_T and E_o (based on monthly totals), e.g. m_{PA} = gradient of regression line E_P on E_A

Regression Co-efficients	Perth	Darwin	Alice Springs	Waite Institute	Aspendale
m_{PA}	1.01	1.01	1.18	1.11	1.27
m_{PW}	.96	.36	.83	.94	1.46
m_{PT}	1.95	.38	1.84	1.90	2.11
m_{Po}	1.57	1.48	1.23	1.29	1.22

6. COMPARISON BETWEEN EVAPORIMETER OBSERVATIONS

Of particular interest is the comparison of evaporation from the U.S. Class "A" pan and from the Australian tank. Table 4 shows values of the ratio for each month of the period June 1959 to December 1962.

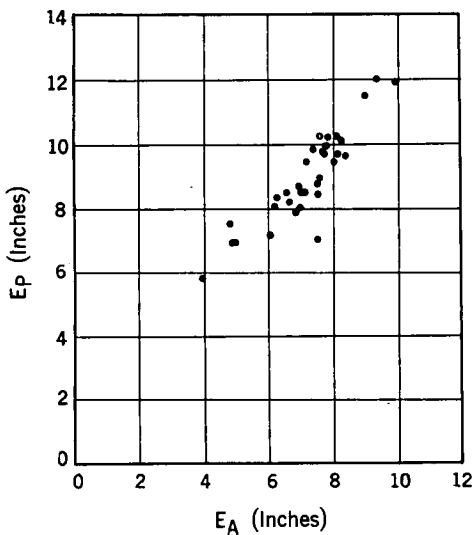


Fig. 1(a)

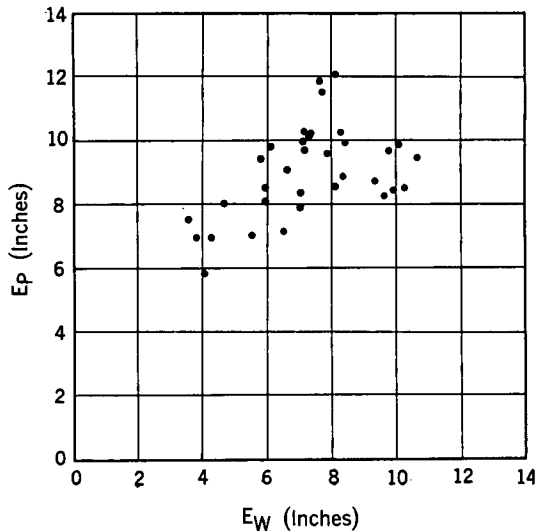


Fig. 1(b)

Monthly totals in inches

EP - American Pan (Class A)

EA - Australian Tank

EW - Evaporation estimated by Prescott Equation

ET - Evaporation estimated by Thornthwaite Equation

EO - Evaporation estimated by Penman Equation

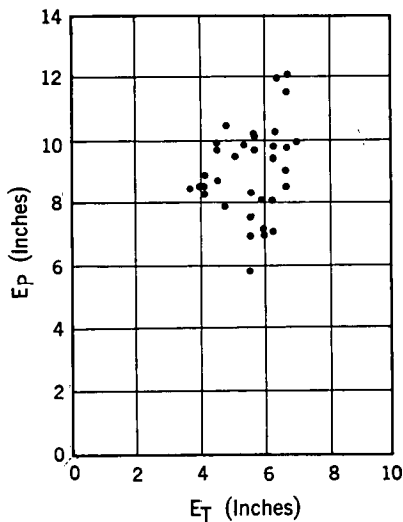


Fig. 1(c)

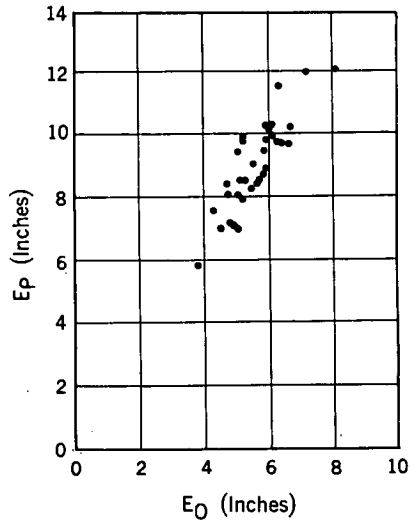


Fig. 1(d)

Fig. 1(a) - 1(d) Scatter diagrams showing correlation between EP and EA, EW, ET and EO respectively for Darwin -- based on periods June 1959 to December 1962.

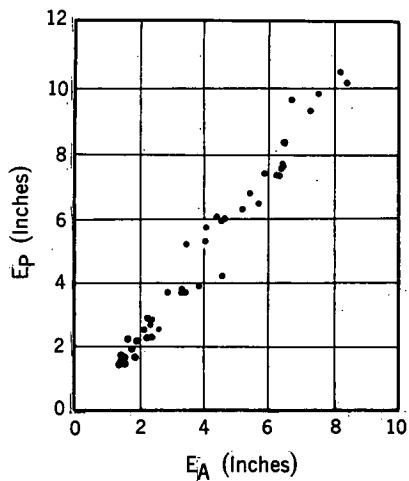


Fig. 2(a) Aspendale

Monthly totals in inches

E_P - American Pan

E_A - Australian Tank

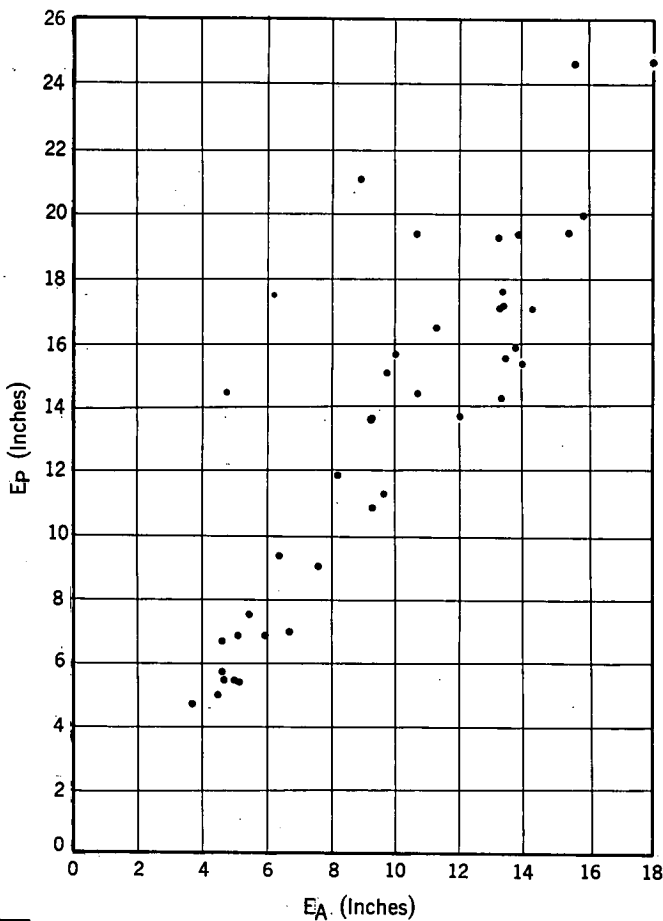


Fig. 2(b) Alice Springs

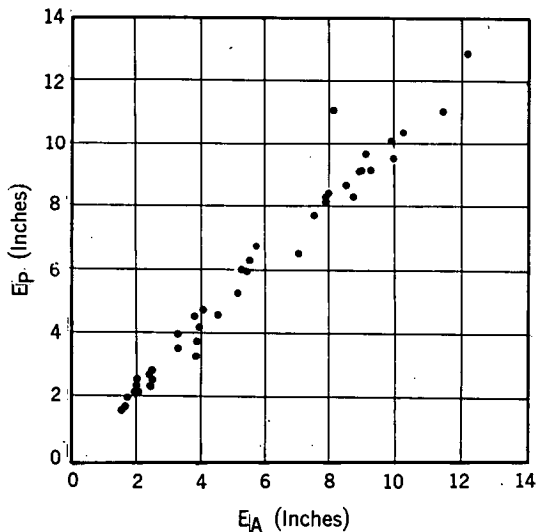


Fig. 2(c) Perth

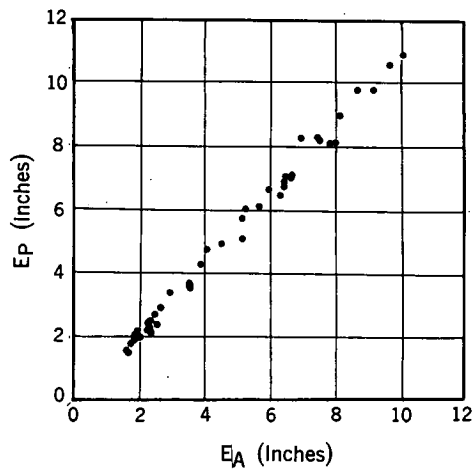


Fig. 2(d) Waite Institute

Fig. 2(a) - 2(d) Scatter diagrams showing correlation between E_A and E_P at Aspendale, Alice Springs,

Perth and Waite Institute - based on period June 1959 to December 1962.

Table 4. Monthly Values of the ratio E_P/E_A
for period June 1959 to December 1962

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Perth												
1959						1.14	0.90	1.12	1.16	1.13	1.05	1.01
1960	.99	.94	.93	1.00	1.10	1.10	.98	1.25	1.17	1.18	1.05	.98
1961	1.37	1.03	.96	1.05	1.10	.94	1.07	1.01	1.18	1.13	1.02	1.03
1962	1.05	1.06	1.02	1.02	.96	.98	1.04		1.05	1.10	1.04	1.02
Darwin												
1959						1.25	1.30	1.29	1.30	1.28	1.28	
1960	1.16	1.43	1.41	1.19	1.15	1.12	1.17	1.15	1.19	1.20	1.26	1.20
1961	.94	1.48	1.31	1.30	1.18	1.22	1.24	1.27	1.23		1.26	1.27
1962		1.57	1.28	1.34	1.33							1.19
Alice Springs												
1959						1.27	1.23	1.18	1.47	1.44		1.29
1960	1.46	1.07	1.81	2.35	1.08	1.42	1.36	1.15	1.46	1.34	1.15	1.40
1961	1.16	1.32	1.10	1.17	1.03	1.33	3.01	2.78	1.54	1.16	1.20	1.38
1962	1.27	1.20	1.14	1.17	1.46	1.10	1.15	1.04	1.44	1.56	1.29	1.58
Waite Institute												
1959						.97	1.00	1.14	1.03	1.10	1.09	1.06
1960	1.09	1.02	1.05	.97	.97	.89	1.00	1.06	1.08	1.14	1.07	1.12
1961	1.08	1.03	1.04	1.00	.93	.98	.94	1.07	1.16	1.11	1.09	1.10
1962	1.07	1.02	1.07	.99	.90	.98	1.07	1.06	1.10	1.08	1.18	1.11
Griffith												
1959						1.14	1.00	1.25	1.22	1.24	1.33	1.20
1960	1.24	1.19	1.24	1.16	1.01	.90	1.08	1.09				1.19
1961	1.18	1.07	1.09	1.01	.86	.92	.99	1.13	1.45	1.18	1.24	1.16
1962	1.15	1.10	1.16	1.07	1.06	1.05	1.19	1.15	1.36		1.30	1.23
Aspendale												
1959						.96	1.11	1.18	1.16	1.48	1.29	1.22
1960	1.29	1.18	1.14	1.02	1.00	1.01	1.29	1.34	1.32	1.40	1.31	1.42
1961	1.27	1.19	1.21	1.15	1.11	1.16	1.15	1.17	1.32	1.38	1.26	1.27
1962	1.21	1.18	1.15	.91	.97	1.18	1.11	1.23	1.18	1.32	1.26	1.28

It is obvious from the data in Table 4 that considerable statistical variation occurs in samples for each month. The greatest variability occurs at Alice Springs, but in two or three months ratios are so high (over 2) that some observations must be considered suspect. This variability in monthly ratios suggests a climatic dependance; it is likely that one evaporimeter is more sensitive to changes in a particular climatic element than is the other. For example, a number of writers - Nordenson and Baker (1962), Rider (1958) - refer to the effect of solar radiation on the U.S. Class "A" pan, whilst the effect of soil moisture on heat conductivity to the Australian tank has been referred to by Hounam (1958).

Seasonal trends in ratios appear to depend partly on climate, but with only three complete years available for each station the apparent trends are not significant. Data for Waite Institute indicate broadly a May-June minimum and a September-December maximum and this is supported to some degree by data for Aspendale in the same general climatic zone. However, values at Perth do not exhibit any significant variation throughout the year in spite of marked seasonal differences in radiation and rainfall.

At the two northernmost stations, Alice Springs and Darwin, the ratios are relatively high throughout the year.

As a first step in assessing the dependance of E_P/E_A ratios on climate, the correlation between the ratio and total radiation was computed. This was then refined somewhat by substituting net radiation based on an assumed albedo of 0.20 for the galvanized Class "A" pan. This is probably an exaggeration because the whole area would not reflect at this level.

With only three years of record nothing significant can be obtained for an individual month, so it has been necessary to combine all months of record, i. e. over 40 months. There is a distinct danger here, that any correlation can be masked by the variability of another climatic variable.

Table 5 shows coefficients of correlation between ratios E_P/E_A and both total and net radiation on a monthly basis.

Table 5. Correlation (r) between E_P/E_A and Radiation (Monthly Totals)

	Perth	Darwin	Alice Springs	Waite Institute	Aspendale
Total radiation	0.05	-0.06	-0.10	0.60	0.50
Significance level	N.S.	N.S.	N.S.	0.1%	0.1%
Net radiation	0.07	0.23	-0.18	0.76	0.88
Significance level	N.S.	N.S.	N.S.	0.1%	0.1%

In the case of Waite Institute and Aspendale, the high correlation could mean that the greater the radiation the more is absorbed through the exposed sides of the Class "A" pan, thus increasing the ratio E_P/E_A ; the generally higher summer values of the ratio conform with this. However, it might be expected that lower winter sun angles would tend to increase the differential heating; that this is not so may be due, in part, to smaller winter contribution by radiation to evaporation and the fact that there is heat flow from soil to water in winter (Hounam 1958) thus producing a relative increase in E_A .

7. SUMMARY AND CONCLUSIONS

Evaporation from the U.S. Class "A" pan is generally greater than from the (sunken) Australian standard tank. Temporal and spatial variations in the ratio are evident; monthly values of the ratio are mainly over 1.1 and in many instances over 1.2. Ratios up to 1.5 appear to be acceptable but above this should be treated with suspicion.

Estimates of evaporation by the Thornthwaite and Penman methods are, almost without exception, lower than the observed evaporation by either instrument. In particular the Thornthwaite estimates are extremely low in the winter months at Alice Springs.

Estimates by the Prescott equation, if reliable, should approximate to evaporation from the Australian tank. However, there is a wide variation indicating that the regression constant (21.2) between monthly E_A and mean $(e_a - e_d)$ exhibits temporal and spatial variation. Values noted from a non-exhaustive check range between 14 and 32, and it is concluded that the method is not reliable.

The correlation between the U. S. Class "A" pan and Australian tank is .98 or higher at three southern stations but slightly lower (.85 - .90) at the two low latitude stations examined. However, some maintenance problems have been experienced at one of these (Alice Springs). There should be no reduction in reliability of evaporation data if the Bureau of Meteorology adopts the Class "A" pan as its new standard.

Correlation coefficients involving estimates of evaporation are lower than that found between the two instrumental observations. Coefficients for Darwin are in many cases less than 0.5, most of those involving the Thornthwaite estimates being non-significant; in particular the correlation between Prescott and Thornthwaite estimates was found to be negative due to inverse seasonal trends in saturation deficit and mean temperature.

Regression coefficients of Class "A" pan evaporation on the other forms are mainly greater than unity. The co-efficient of E_P on E_T is close to 2 at most stations.

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