WORLD METEOROLOGICAL ORGANIZATION

THE CIMO INTERNATIONAL EVAPORIMETER COMPARISONS

FINAL REPORT

WMO - No. 449

Secretariat of the World Meteorological Organization - Geneva - Switzerland

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C O N T E N T S

FOREWORD

For many purposes it is necessary to estimate the evaporation from a shallow lake and a common way of doing this is to apply a conversion coefficient to measurements from an evaporation pan in the vicinity of the lake.

The Commission for Instruments and Methods of Observation (CIMO) has, since 1964, been engaged in a study with a view to determining which of the various types of evaporation pan is most suited for this work. To this end, the Commission has, through its working groups, initiated a series of international comparisons of evaporimeters in which several Members have participated. The present report, prepared by Dr. G. Stanhill (Israel), is based on the results of these comparisons.

The report describes the trials which were carried out in the different countries and discusses the results which are included at the end of the report. The performance of the two most used pans (the Class "A" and the GGI 3000) are assessed with respect to both the $20m^2$ tank and a Penman-type equation.

The first draft of the report, prepared in November 1974, was reviewed by the CIMO Working Group on Measurement of Precipitation, Evaporation and Soil Moisture, during its session in Geneva, October 1975, and the text was subsequently modified to take account of the group's suggestions.

I wish to take this opportunity to thank all those Members who carried out the comparisons and thus made possible this publication. I am especially grateful to Dr. Stanhill for his very valuable assistance in analysing the data and to the members of all the CIMO working groups for their contribution to the preparation of this very useful report.

D. A. Davies
Secretary-General

Open water surfaces of as large an area as possible have always been used as the standard for comparing, calibrating and selecting evaporimeters because the relationship can be theoretically calculated, as well as because of the comparative ease of direct measurement. If estimated rather than measured values of open water evaporation are used as the standard, then the energy balance method is normally used, based on measurements made over a nearby large open water surface. A simpler alternative is to use as a standard estimates of open water evaporation calculated with the combined energy balance - mass transfer equation (the combination or Penman's equation), as this can be obtained from standard climatological measurements. In this case the standard for comparison represents water loss from an infinitely large and shallow hypothetical open water surface exposed to the same climate as that of the meteorological station whose data are used for the calculation.

THE CIMO INTERNATIONAL EVAPORIMETER COMPARISONS

The evaporimeter comparisons analysed here are the international series initiated by Recommendation 4 (CIMO-III) of the World Meteorological Organization. Plans for the comparisons were finalized in April 1964 at a meeting of the CIMO Working Group on Evaporation Measurements.

Brief specifications of the evaporimeters compared are given in WMO - No. 201, TP 105, pp. 9 - 11. Some details of the equipment, site and methods of installation and observation to be followed are given in the same document.

Very briefly, the plan called for comparative measurements of the following three evaporimeters: USSR 20 m^2 tank (5 m in diameter, 2 m in depth, buried in the ground to within 7.5 cm of its rim height); USSR GGI 3000 (cm^2) pan (61.8 cm in diameter, 60 cm deep at its side and 68.5 cm deep at its centre, buried in the ground to within 7.5 cm of its rim height); USA Class A pan (1.21 m in diameter, 25.5 cm deep, mounted on a wooden open frame platform set on the ground). As well as the above evaporimeters the following climatological instruments were considered essential at each site: a standard (national) raingauge, a GGI 3000 standard raingauge, a standard thermometer screen equipped with maximum, minimum, wet and dry bulb thermometer, two totalizing anemometers, one 0.5 and one 2.0 m above ground level, thermometers to measure the maximum and minimum water temperatures 1 cm below the water surface of each evaporimeter, and a pyranometer. Observations of rainfall, water level, wind run and global radiation were to be made at least once a day at 07 LMT, as were observations of air and water temperatures. In addition, the wet and dry bulb thermometers were to be read at 14 LMT and an additional reading at this time was recommended for water level and temperature.

At the meeting of the CIMO Working Group on the Measurement of Evaporation and Soil Moisture in November 1972 the method of analysis to be used was agreed upon together with a format which included a questionnaire on the site area surrounding the comparison station and amount of missing data. The necessary forms were distributed by the W.M.O. Secretariat.

THE DATA AND THEIR PROCESSING

1. Data available

The last data were received in June 1973 by which time a total of 824 monthly values was available from 18 stations. Of this total only 348 monthly values from 10 stations met the minimum requirements of the comparison - measurement from the three evaporimeters plus the various climatological measurements designated as essential.

For the present analysis, the above requirements were somewhat relaxed to include monthly values with measurements from at least two of the specified evaporimeters plus the minimum climatological data needed to calculate evaporation by the combination method. A further requirement was that each monthly value used should be based on at least 70% of the possible daily values.

Four hundred and eighty four monthly values from 13 stations satisfied these criteria and were used in the analysis. Brief details of the stations are given in Table 1 which also lists their mean values of evaporation and rainfall. It should be pointed out that measurements during the winter months were not available from half of the stations, viz. Nos. 3, 7, 8, 9, 10 and 11. The mean monthly values of evaporation used in the statistical analysis are given in Appendix I together with the two components of the combination estimate of open water evaporation - the weighted energy balance and aerodynamic terms.

2. Methods of analysis

The statistical relationships between all four values of evaporation (the three evaporimeter measurements plus the calculated value) were computed by standard statistical methods separately for each of the 13 stations as well as for the pooled data. In addition, the same calculations were repeated after sorting the data into two classes according to the relative amount of rainfall. One class, termed negligible rainfall, comprised those months during which the rainfall was less than one tenth of the calculated open water evaporation. The number of such months was very few at stations Nos. 3, 6, 7, and 8. The second rainfall class included all the remaining months.

The statistical relationships computed included the linear regression of readings from each of the two smaller evaporimeters (the GGI-3000 and Class A-pan) on the larger one (the 20 m^2 tank) together with the standard error of the slope, the standard deviation of estimates of open water evaporation obtained with the regression expressed as a percentage of the mean estimate, and the correlation coefficients.

In addition, similar statistics were computed for the regression of readings from the three evaporimeters (the 20 m^2 tank and GGI 3000 and Class A pans) on the calculated value of open water evaporation (EO) obtained from climatological data, using the combination equation by the methods detailed in Appendix II.

RESULTS AND DISCUSSION

Previous analyses of the CIMO evaporimeter comparison series (see: WMO - No. 201, TP 105) were all based on simple ratios of evaporation assuming linear relationships with zero origins. Scatter diagrams of the various relationships (Figs. 1 - 5) do not support this assumption nor, do the size and variability of the offset terms computed in the statistical analyses (Tables 3 - 5).

Nevertheless simple ratios of mean evaporimeter values have been presented in Table 2 to allow comparisons with previous findings. It can be seen that the ratios obtained from the pooled data from all stations are in general agreement with previous findings.

The effect of rainfall on 20 m^2 tank ratios is small. However, the data show a significant influence of rainfall conditions on the ratios of combination equation estimates to evaporimeter measurements. Ratios obtained for individual stations vary considerably especially in the case of comparisons with combination equation estimates. The station to station variation in ratios to 20 m^2 tank evaporation was also larger for the GGI than for Class A evaporimeter (standard deviation of 0.03 and 0.01 respectively. The standard deviation of such ratios between individual stations was twice as great with the GGI pan (0.07) as with the 20 m^2 tank and Class A pan (0.04 and 0.03 respectively).

The statistical relationships obtained in this study and presented in Tables 3, 4 and 5, are also based on the assumption of a linear relationship between the various measurements and estimates of evaporation although the model used does not assume a zero-origin. The question arises as to whether a significant improvement could be achieved if a non-linear model was used. Inspection of the scatter diagrams (Figs. 1 to 5) does not suggest that this would be the case and the generally high correlation coefficients obtained (Tables 3, 4 and 5) also argue against this likelihood.

If the measured water loss from the 20 m^2 tank (the recommended international interim reference instrument for the estimation of shallow lake evaporation) is taken as the basis for comparison, there is little to choose between the two smaller evaporimeters for prediction purposes. Both yield more accurate estimates of 20 m^2 tank water loss than they do of evaporation amounts estimated by the combination equation.

The pooled data from all stations under all rainfall conditions (Table 3) show correlation coefficients greater than 0.97 and coefficients of variation less than 15% for both evaporimeters. Slightly lower coefficients of variation were found when analysis was confined to months with negligible rainfall. The coefficients of variation at individual stations were on the average less than for the pooled data and in general the station to station differences found in the relationships to 20 m^2 tank evaporation were far smaller than those noted with combination equation estimates.

As is implicit in the above results, readings from the two smaller evaporimeters are highly correlated with each other both for all rainfall conditions and for months with negligible rainfall.

Open water evaporation estimated by the combination equation was highly correlated with readings from all three evaporimeters. Table 3 shows that for the pooled data under all rainfall conditions, the three evaporimeters had similarly high correlation coefficients, around 0.9, and similar coefficients of variation, around 25%. Essentially similar results were obtained for months with negligible rainfall (Table 4).

The statistics from individual stations under all rainfall conditions show similarly high correlation coefficients to that of the pooled data with little difference between the three evaporimeters. The coefficients of variation were however on the average only half those found with the pooled data. The statistics show the Class A pan evaporimeter to be slightly superior to the other two evaporimeters as a predictor of evaporation estimated by the combination equation at eight out of the ten comparable stations. For months with negligible rainfall the Class A pan had slightly higher correlation coefficients and lower coefficients of variation than the other evaporimeters at six out of the eight comparable stations.

The size of the correlation coefficients and of the coefficients of variation varied widely between individual stations. For example at Poona, India (Station No. 12), less than half of the variation in estimated water loss was accounted for by variation in the amount of evaporation measured from all three evaporimeters, i.e. $r^2 < 0.50$. By contrast at Tisice, Czechoslovakia (Station No. 7), with a similar number of months of data, more than 90% of the variation was accounted for. The coefficients of variation at Station No. 12 were twice as large as at Station No. 7.

During months with negligible rainfall, analysis of the data showed less station to station variability.

The influence of rainfall on the relationships between the various measurements and estimates of evaporation which have been noted may stem from two causes. One is the differences in the amounts of rain falling into the evaporimeters and raingauges which will generally lead to an underestimate of evaporation during rain periods. The size of this underestimate depends in a complex fashion on the rainfall regime and the characteristics of the raingauge and evaporimeter.

The second cause is the influence of rainfall on the energy advected from the area surrounding the evaporimeters. When rainfall equals open water evaporation, the rate of water loss from the area surrounding the evaporimeters and from the evaporimeters themselves may be assumed to be equal, reducing advective energy fluxes to the evaporimeters and thus the effect of evaporimeter size, shape and exposure on rate of water loss.

The time and rain class scales adopted in this analysis are too coarse to enable the significance of the two effects to be quantitatively assessed. Empirically, a comparison of Tables 4 and 5 shows rainfall to have a negligible effect on the relationship between water losses from the two smaller evaporimeters, to have little influence on their relationship to water loss from the 20 m^2 tank, but to be of considerable importance to the relationships of measured water loss from the three evaporimeters to evaporation estimates calculated with the combination equation.

CONCLUSIONS

If estimates of evaporation from the 20 m^2 tank are acceptable as the standard, they may be predicted from readings of either of the smaller evaporimeters with considerable confidence. Using the general relationship derived from the pooled data of all stations the mean monthly evaporation from a 20 m^2 tank may be estimated from readings of a Class A pan with a standard deviation of 10% during months with negligible rainfall and 17% during months with significant rainfall. Estimates may be obtained from readings of the GGI 3000 evaporimeter with standard deviations of 12% and 13% respectively.

If estimates of evaporation by the combination equation are taken as the standard for comparison, the results presented herein suggest that at a new site such monthly values may be estimated from readings of a Class A pan, using the general relationship derived from all stations, with a standard deviation of 21% during months of negligible rainfall and 23% during months with significant rain. Estimates of Eo based on readings from the GGI 3000 evaporimeter will have standard deviations of 26% and 25% respectively and those obtained from readings of the 20 m^2 tank, 20% and 24% for the two rainfall classes. It should be noted that the costs of installing and maintaining the 20 m^2 tank are probably greater than those needed to obtain estimates by the combination equation.

Finally in considering whether the indicated accuracies to which open water evaporation can be estimated from smaller evaporimeters are sufficient, the purpose for which such estimates are required should be borne in mind. In most cases it is the water loss from some specific water or land surface that is of interest and to obtain such values a further conversion factor or series of factors must be applied to the estimates of open water loss. The accuracy to which these conversion factors are known is usually far less than that with which open water evaporation can be estimated.

ACKNOWLEDGEMENTS

Mr. Jurgrau and J.M. Sacks of the Volcani Center of the Agricultural Research Organization, Israel were respectively responsible for the computation of open water evaporation by the combination equation (see Appendix I) and the statistical analysis of the data. I wish to thank them in addition for their most helpful discussion of the results.

G. Stanhill

TABLES 1 TO 5

TABLE 1

SOURCES OF EVAPORIMETER DATA ANALYSED WITH MEAN MONTHLY VALUES

STATION			No. of months of data	No. of months with negligible rain	MEAN MONTHLY VALUES mm day^{-1}				
No.	Name	Coordinates			$20m^2$	GGI	Class A	Eo	Rainfall, Standard gauge
1	GRIFFITH, AUSTRALIA	34°2'S, 146°2'E 131 m M.S.L.	32	15	3.6	-	4.9	3.2	1.3
2	NEW DELHI, INDIA	28°4'N, 77°1'E 216 m M.S.L.	24	17	4.7	6.1	6.7	4.4	2.0
3	STERLING, U.S.A.	38°6'N, 77°3'W 85 m M.S.L.	27	9	3.0	2.8	4.5	4.0	1.7
4	LAKE MEAD, U.S.A.	36°0'N, 114°5'W 521 m M.S.L.	40	35	4.9	9.1	10.0	4.9	0.3
5	DAVIS, U.S.A.	38°3'N, 121°5'W 18 m M.S.L.	32	20	4.0	4.2	5.4	4.2	1.1
6	ENTEBBE, UGANDA	00°0'N, 32°3'E 1147 m M.S.L.	15	0	3.6	4.5	4.7	4.0	4.7
7	TISICE, CZECHOSLOVAKIA	50°2'N, 14°3'E 163 m M.S.L.	35	3	2.2	2.5	3.1	1.9	1.8
8	WARSZAWA, POLAND	52°2'N, 20°6'E 98 m M.S.L.	41	7	2.6	3.1	3.4	3.0	2.1
9	SZARVAS, HUNGARY	46°5'N, 20°3'E 83 m M.S.L.	56	22	-	3.6	4.0	3.5	1.7
10	VALDAI, USSR	57°4'N, 33°2'E 146 m M.S.L.	71	40	2.4	2.5	3.3	2.7	2.5
11	DUBOVKA, USSR	47°2'N, 42°4'E 91 m M.S.L.	27	22	4.9	6.0	7.8	4.6	1.1
12	POONA, INDIA	18°3'N, 73°5'E 559 m M.S.L.	37	28	5.5	7.1	7.9	5.4	1.5
13	KEW, ENGLAND	51°3'N, 00°2'W 2 m M.S.L.	48	11	1.5	1.9	-	1.8	1.6

TABLE 2

MEAN EVAPORIMETER RATIOS

$20\ m^2$ = $20\ m^2$ tank, GGI = GGI 3000 pan, Class A = Class A pan, EO = Combination estimate

EVAPORIMETER RATIOS	INDIVIDUAL STATIONS – ALL RAINFALL CONDITIONS													ALL STATIONS		
	1	2	3	4	5	6	7	8	9	10	11	12	13	ALL RAIN CONDITIONS	NEGLIGIBLE RAINFALL	SIGNIFICANT RAINFALL
$20\ m^2$ / GGI	-	0.77	1.07	0.71	0.96	0.80	0.88	0.84	-	0.96	0.82	0.77	0.79	0.85	0.82	0.87
$20\ m^2$ / Class A	0.73	0.70	0.67	0.65	0.74	0.77	0.71	0.76	-	0.73	0.63	0.70	-	0.67	0.68	0.67
EO / $20\ m^2$	0.89	0.94	1.33	0.75	1.05	1.11	0.86	1.16	-	1.13	0.94	0.98	1.20	0.99	0.89	1.13
EO / GGI	-	0.72	1.43	0.54	1.00	0.89	0.76	0.97	0.97	1.08	0.77	0.76	0.95	0.84	0.73	0.99
EO / Class A	0.65	0.66	0.89	0.49	0.78	0.85	0.61	0.88	0.87	0.82	0.59	0.68	-	0.66	0.61	0.76

TABLE 3

STATISTICAL ANALYSIS OF EVAPORATION RELATIONSHIPS: ALL RAINFALL CONDITIONS

Linear regression form Y = bX + a, mm day^{-1}; r = correlation coefficient; c.v. = coefficient of variation around regression line, % $\bar{Y}$

Station No.	MEASURED 20 m^2 TANK = Y								ESTIMATED OPEN WATER LOSS = Y											
	GGI = X				Class A = X				20 m^2 = X				GGI = X				Class A = X			
	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v
1					0.70	0.15	0.98	12	0.98	-0.25	0.96	18					0.72	-0.25	0.99	11
2	0.75	0.14	0.98	8	0.47	1.58	0.93	15	1.04	-0.49	0.96	13	0.79	-0.42	0.96	14	1.13	0.49	0.90	21
3	1.07	0.01	0.90	16	0.58	0.42	0.87	18	1.12	0.38	0.78	26	1.42	-0.23	0.83	23	0.91	-0.33	0.95	13
4	0.63	0.75	0.98	10	0.64	0.13	0.99	6	0.82	-0.42	0.98	12	0.52	0.14	0.97	13	0.53	-0.41	0.99	9
5	0.95	-0.05	0.99	6	0.72	0.03	0.99	6	1.13	-0.31	0.98	12	1.09	-0.39	0.98	13	0.83	-0.35	0.99	9
6	0.75	0.20	0.89	5	0.62	0.62	0.84	6	0.57	1.94	0.65	7	0.58	1.40	0.78	5	0.46	1.78	0.71	6
7	0.91	-0.07	0.98	9	0.67	0.09	0.97	10	0.75	0.23	0.96	11	0.69	0.15	0.95	12	0.53	0.21	0.98	8
8	0.76	0.30	0.97	9	0.58	0.62	0.94	13	1.40	-0.67	0.91	20	1.12	-0.41	0.92	18	0.90	-0.07	0.93	17
9													1.07	-0.30	0.90	18	0.95	-0.33	0.94	14
10	0.98	-0.06	0.98	6	0.53	0.60	0.92	12	1.37	-0.53	0.91	16	1.39	-0.70	0.92	16	0.81	0.04	0.93	15
11	0.78	0.30	0.98	7	0.60	0.29	0.97	8	0.84	0.47	0.84	19	0.64	0.79	0.80	21	0.54	0.40	0.88	17
12	0.63	1.00	0.98	5	0.49	1.61	0.96	8	0.79	1.08	0.77	19	0.49	1.94	0.74	19	0.39	2.34	0.74	19
13	0.76	0.01	0.99	8					1.50	-0.33	0.96	24	1.16	-0.36	0.97	22				
ALL STATIONS POOLED DATA	0.685	0.59	0.97	14	0.613	0.44	0.98	13	0.840	0.54	0.91	26	0.563	1.16	0.85	30	0.517	0.95	0.89	25

TABLE 4

STATISTICAL ANALYSIS OF EVAPORATION RELATIONSHIPS; MONTHS WITH NEGLIGIBLE RAIN

Linear regression form $Y = bX + a$, mm day^{-1}; r = correlation coefficient; c.v. = coefficient of variation around regression line, % $\bar{Y}$

Station No.	MEASURED 20 m² TANK = Y								ESTIMATED OPEN WATER LOSS = Y											
	GGI = X				Class A = X				20 m² = X				GGI = X				Class A = X			
	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v
1					0.72	0.14	0.98	10	1.00	-0.53	0.96	16					0.75	-0.59	0.99	9
2	0.78	-0.08	0.98	9	0.47	1.43	0.95	14	1.04	-0.74	0.97	12	0.84	-0.99	0.98	9	0.51	0.61	0.96	15
3	0.93	0.60	0.95	9	0.57	0.64	0.94	10	1.37	-0.80	0.89	18	1.22	0.23	0.80	23	0.87	-0.36	0.93	15
4	0.62	0.81	0.97	10	0.65	0.03	0.99	6	0.83	-0.51	0.97	11	0.52	0.09	0.97	12	0.55	-0.62	0.98	8
5	0.95	0.00	0.97	5	0.74	-0.06	0.97	5	1.11	-0.18	0.91	10	1.09	-0.42	0.92	10	0.89	-0.82	0.97	6
6																				
7																				
8	0.71	0.35	0.98	8	0.51	0.85	0.94	14	1.33	-0.68	0.96	16	0.97	-0.32	0.97	13	0.72	0.30	0.95	16
9													1.13	-0.67	0.90	16	0.94	-0.42	0.94	13
10	1.11	-0.44	0.99	2	0.49	0.81	0.98	8	1.29	-0.69	0.94	19	1.44	-1.27	0.94	18	0.67	0.18	0.98	10
11	0.77	0.34	0.98	7	0.58	0.47	0.97	8	0.93	-0.18	0.88	18	0.71	0.19	0.85	20	0.57	-0.01	0.91	16
12	0.64	0.96	0.98	5	0.49	1.60	0.96	7	1.06	-0.79	0.91	13	0.67	0.28	0.88	15	0.52	0.83	0.88	15
13	0.71	0.19	0.99	3					1.46	-0.28	0.92	19	1.03	-0.02	0.92	19				
ALL STATIONS POOLED DATA	0.633	1.02	0.97	12	0.594	0.64	0.97	10	0.794	0.60	0.90	20	0.475	1.67	0.82	25	0.480	1.07	0.88	21

TABLE 5

STATISTICAL ANALYSIS OF EVAPORATION RELATIONSHIPS: MONTHS WITH SIGNIFICANT RAIN

Linear regression form Y = bX + a, mm day^{-1}; r = correlation coefficient; c.v. = coefficient of variation around regression line, % $\bar{Y}$

Station No.	MEASURED 20 m^2 TANK = Y								ESTIMATED OPEN WATER LOSS = Y											
	GGI = X				Class A = X				20 m^2 = X				GGI = X				Class A = X			
	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v	b	a	r	c.v
1					0.65	0.25	0.97	15	1.07	-0.30	0.97	18					0.72	-0.15	0.99	13
2	0.68	0.58	0.99	7	0.52	1.60	0.92	17	1.09	-0.22	0.99	7	0.73	0.47	0.96	13	0.56	1.57	0.89	21
3	1.12	-0.17	0.85	20	0.54	0.50	0.81	22	1.11	0.51	0.73	30	1.70	-0.86	0.85	24	0.98	-0.52	0.97	11
4																				
5	0.96	-0.06	0.97	10	0.63	0.22	0.97	10	1.37	-0.69	0.94	22	1.26	-0.66	0.87	32	0.88	-0.41	0.93	24
6	0.80	-0.93	0.92	4	0.65	0.50	0.86	6	0.58	1.92	0.66	7	0.60	1.31	0.79	6	0.48	1.72	0.72	6
7	0.89	-0.05	0.97	9	0.66	0.11	0.96	11	0.75	0.24	0.95	12	0.67	0.18	0.94	13	0.52	0.22	0.97	8
8	0.79	0.23	0.96	9	0.62	0.52	0.94	12	1.44	-0.72	0.90	21	1.21	-0.61	0.93	18	1.00	-0.33	0.95	15
9													1.07	-0.25	0.89	19	1.02	-0.48	0.94	14
10	0.98	-0.04	0.98	6	0.53	0.59	0.91	12	1.40	-0.56	0.91	16	1.41	-0.72	0.92	15	0.83	-0.02	0.93	15
11	1.05	-0.89	0.99	5	0.88	-1.77	0.99	5	1.62	0.81	0.96	6	0.83	0.96	0.94	8	0.64	0.30	0.93	8
12																				
13	0.78	-0.03	0.99	11					1.54	-0.37	0.96	28	1.22	-0.45	0.97	24				
ALL STATIONS POOLED DATA	0.805	-0.21	0.96	13	0.635	0.33	0.93	17	1.185	-0.18	0.91	24	1.00	-0.01	0.88	26	0.844	-0.11	0.91	23

FIGURES 1 TO 5

Figure 1

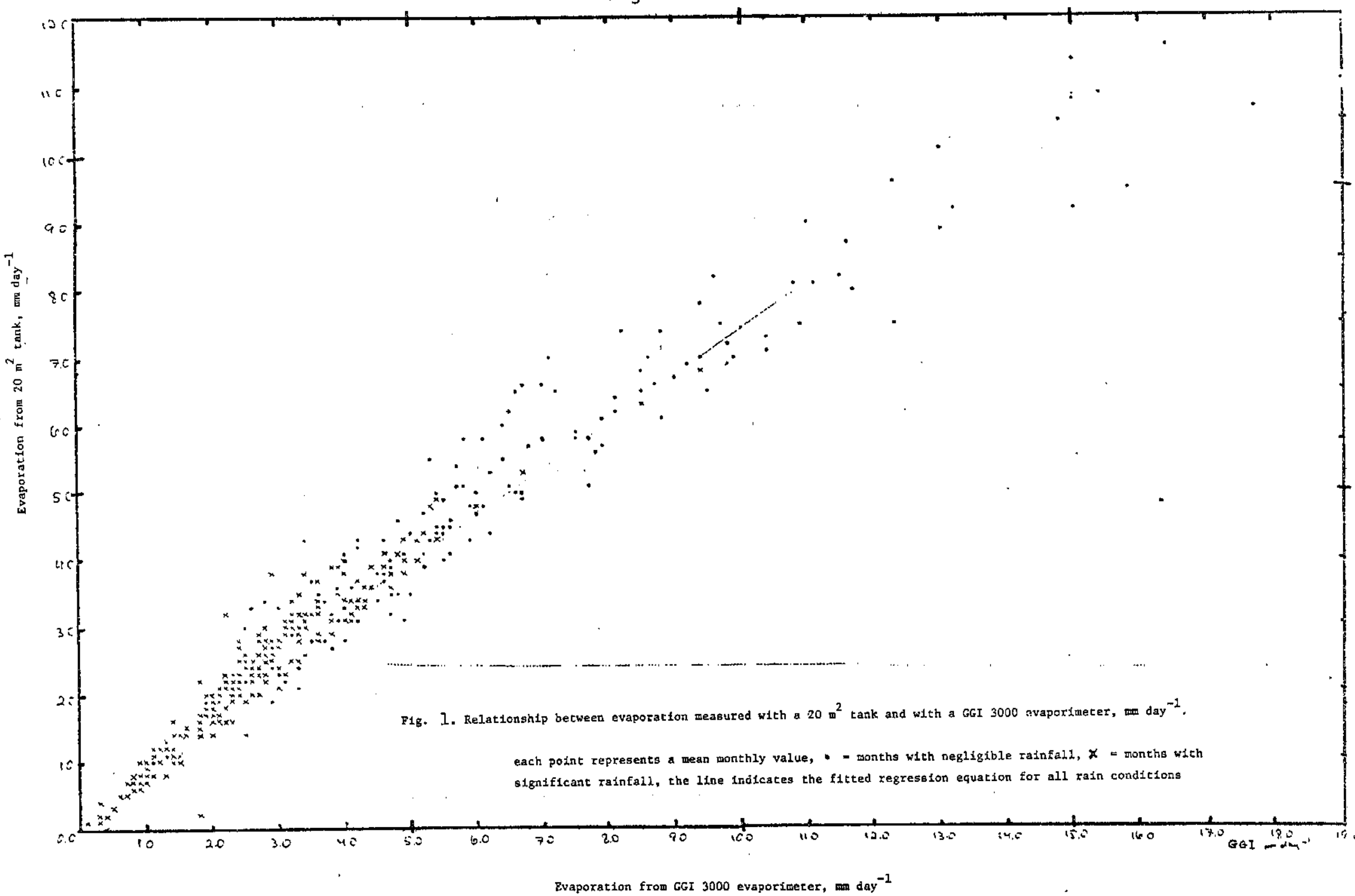

Fig. 1. Relationship between evaporation measured with a 20 m^2 tank and with a GGI 3000 evaporimeter, mm day^{-1}.

each point represents a mean monthly value, • = months with negligible rainfall, X = months with significant rainfall, the line indicates the fitted regression equation for all rain conditions

Figure 2

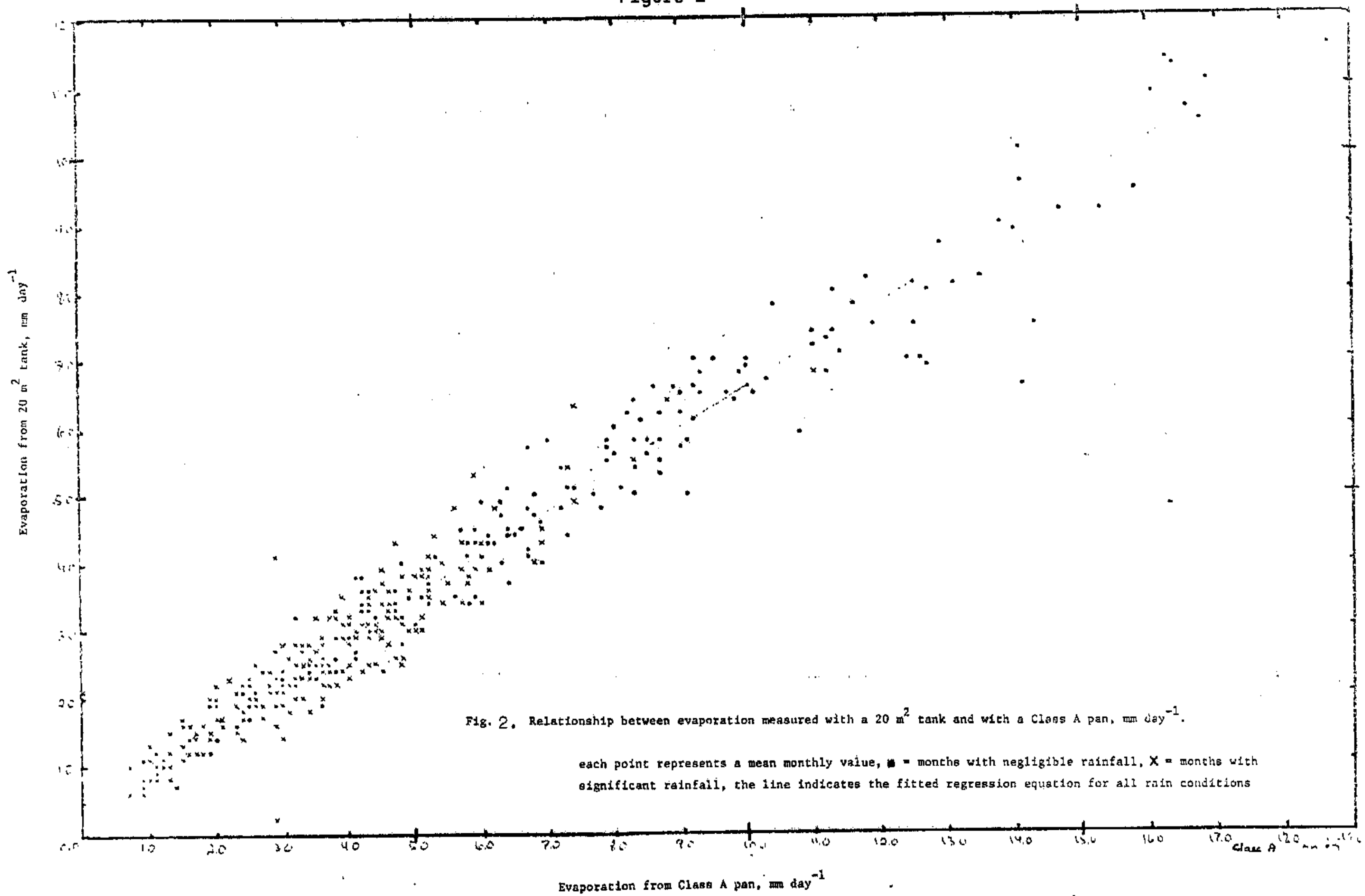

Fig. 2. Relationship between evaporation measured with a 20 m^2 tank and with a Class A pan, mm day^{-1}.

each point represents a mean monthly value, • = months with negligible rainfall, X = months with significant rainfall, the line indicates the fitted regression equation for all rain conditions

Figure 3

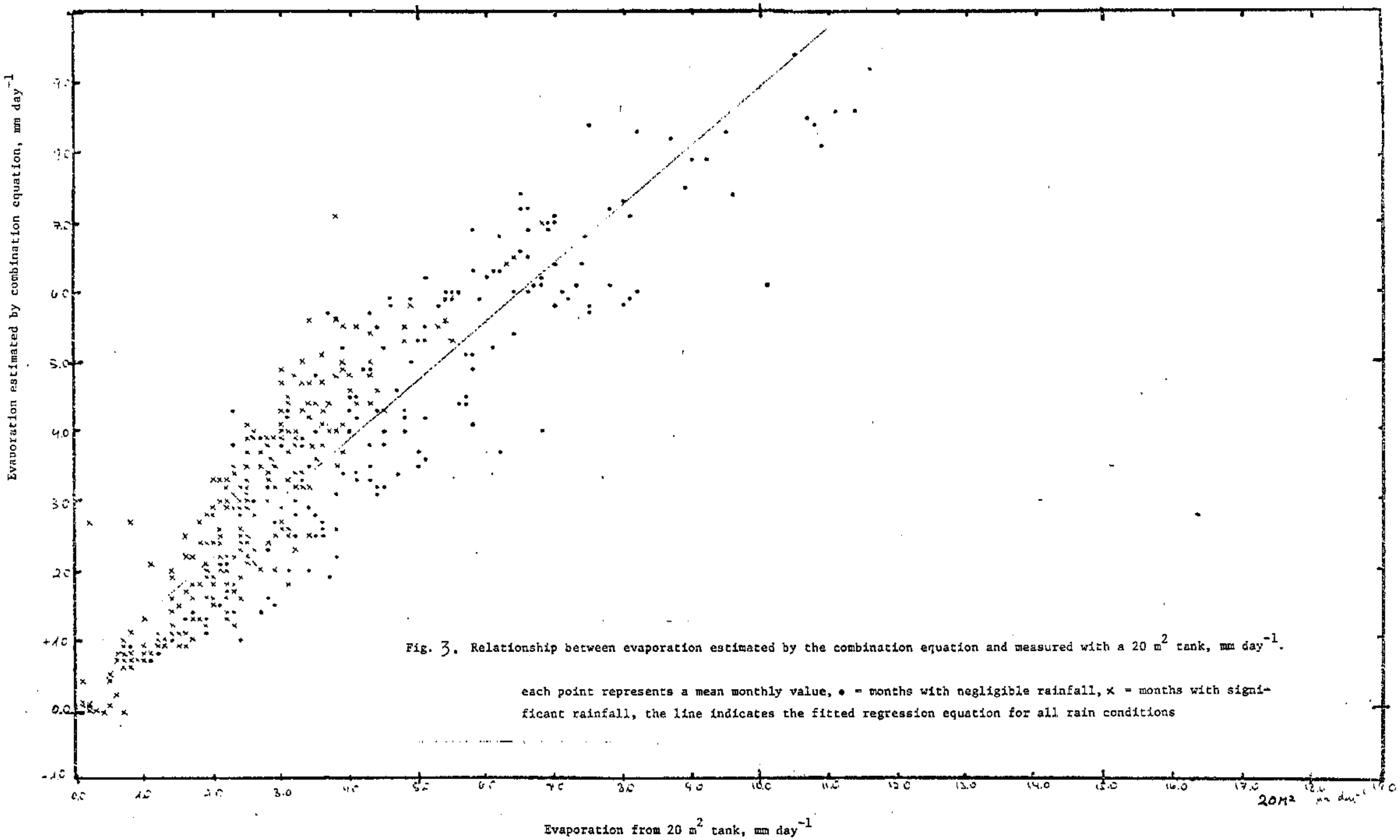

Fig. 3. Relationship between evaporation estimated by the combination equation and measured with a 20 m^2 tank, mm day^{-1}.

each point represents a mean monthly value, • = months with negligible rainfall, × = months with significant rainfall, the line indicates the fitted regression equation for all rain conditions

Figure 4

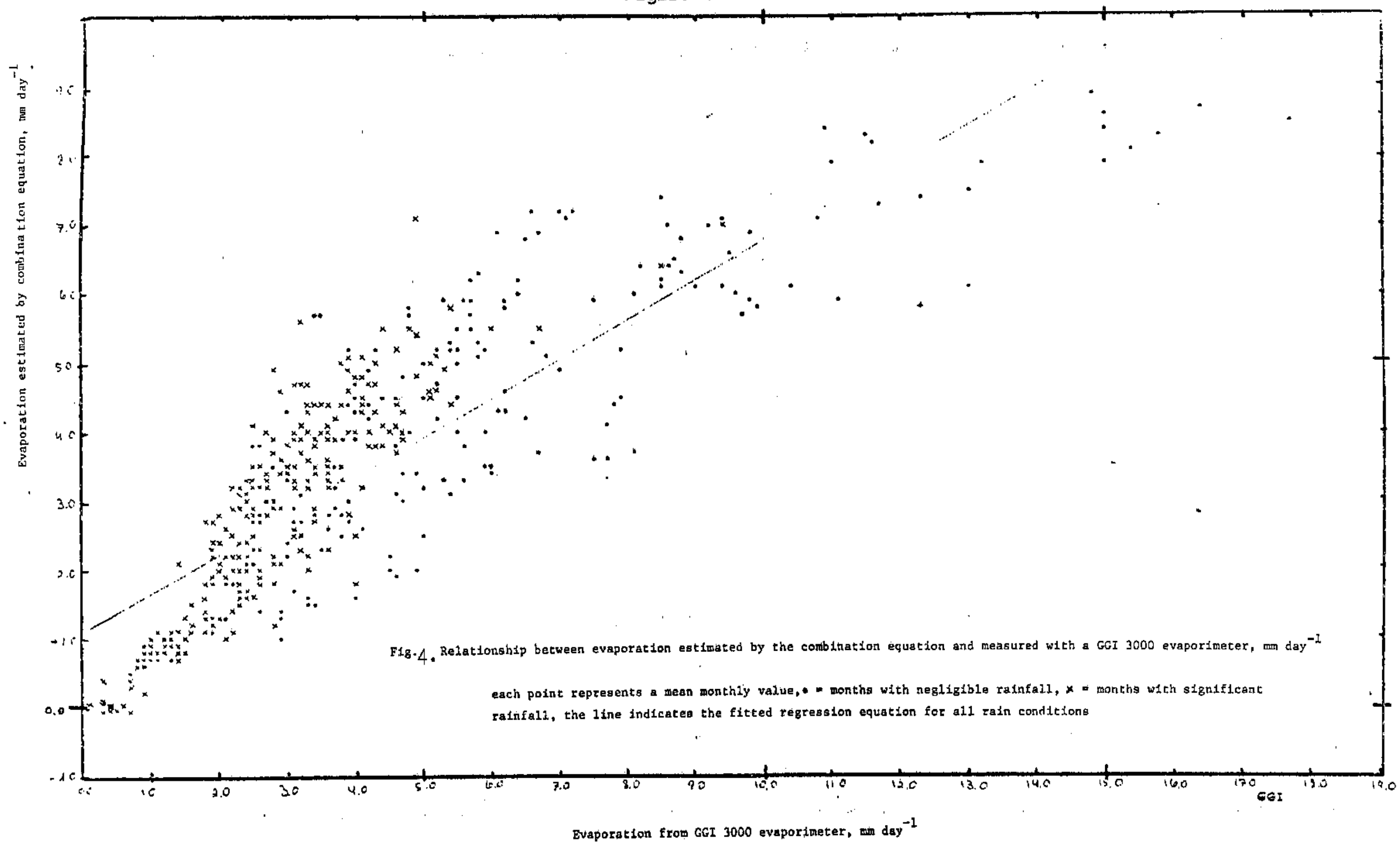

Fig. 4. Relationship between evaporation estimated by the combination equation and measured with a GGI 3000 evaporimeter, mm day^{-1}

each point represents a mean monthly value, • = months with negligible rainfall, x = months with significant rainfall, the line indicates the fitted regression equation for all rain conditions

Figure 5

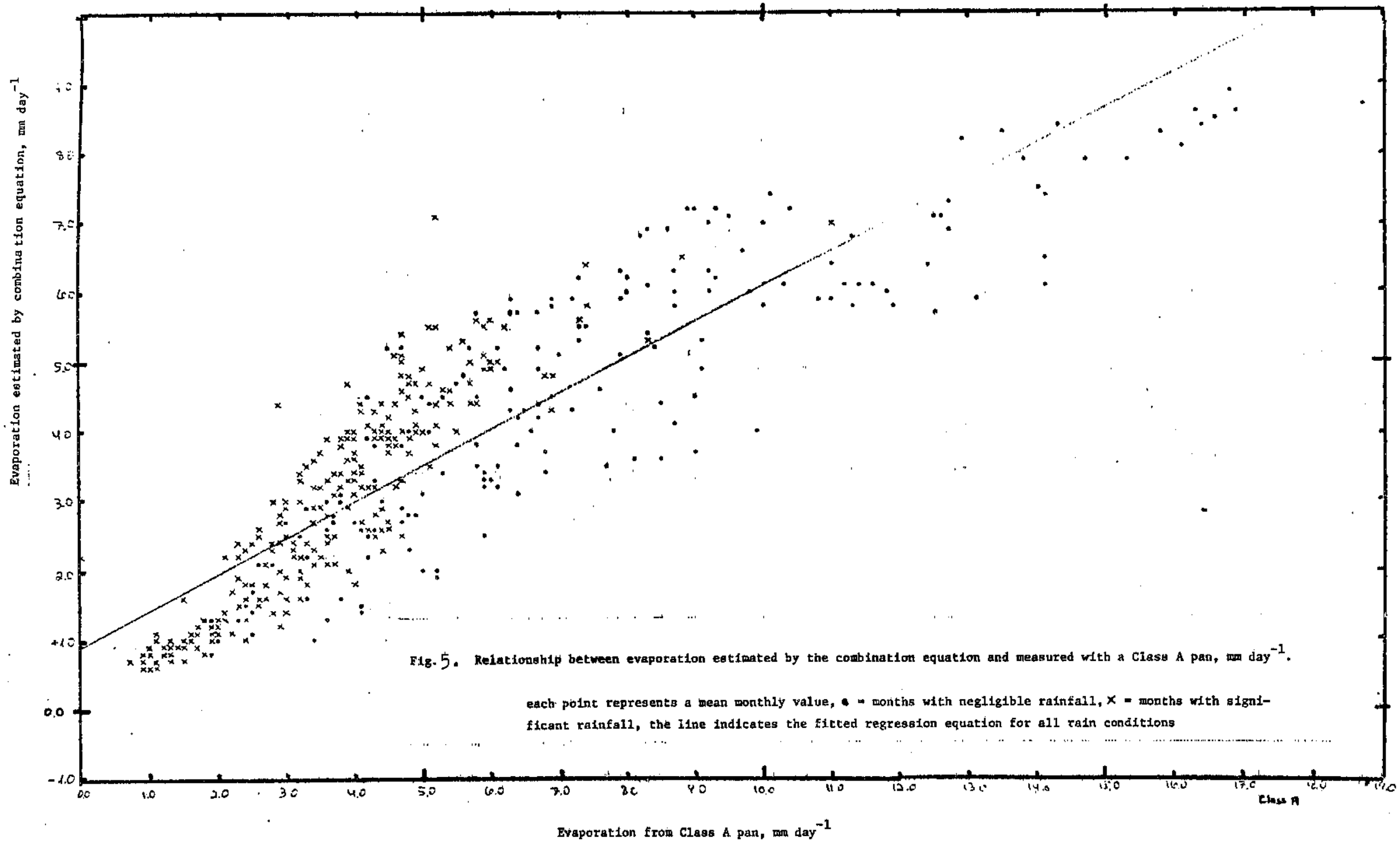

Fig. 5. Relationship between evaporation estimated by the combination equation and measured with a Class A pan, mm day^{-1}.

each point represents a mean monthly value, • = months with negligible rainfall, × = months with significant rainfall, the line indicates the fitted regression equation for all rain conditions

APPENDIX I

LISTING OF ANALYSED DATA

The data listing includes the following items identified by column headings, columns 4-10 represent mean monthly values.

1. Station number, see Table 1 for details
2. Month
3. Year
4. Rainfall class, 1 = negligible rain, 0 = significant rain
5. Weighted aerodynamic component of combination equation, mm day^{-1}
6. Weighted energy balance component of combination equation, mm day^{-1}
7. Estimated open water evaporation by the combination equation, mm day^{-1}
8. Measured evaporation from 20 m^2 tank, mm day^{-1}
9. Measured evaporation from GGI 3000 pan, mm day^{-1}
10. Measured evaporation from Class A pan, mm day^{-1}

1	2	3	4 R	5	6	7	8 20SQM	9 GGI	10 CL A
1	3	68	1	0.132D+01	0.310D+01	0.442E+01	5.7	0.0	6.7
1	4	68	1	0.794D+00	0.182D+01	0.262E+01	3.8	0.0	4.1
1	5	68	0	0.469D+00	0.874D+00	0.134E+01	2.2	0.0	2.0
1	6	68	0	0.314D+00	0.559D+00	0.873E+00	1.6	0.0	1.5
1	7	68	0	0.308D+00	0.627D+00	0.935E+00	1.5	0.0	1.3
1	8	68	0	0.596D+00	0.105D+01	0.164E+01	2.4	0.0	2.7
1	9	68	1	0.809D+00	0.170D+01	0.251E+01	3.6	0.0	4.2
1	10	68	1	0.683D+00	0.247D+01	0.316E+01	4.5	0.0	5.9
1	11	68	1	0.175D+01	0.366D+01	0.541E+01	6.4	0.0	8.3
1	12	68	0	0.162D+01	0.485D+01	0.647E+01	6.4	0.0	8.8
1	1	69	1	0.216D+01	0.507D+01	0.722E+01	7.8	0.0	10.4
1	2	69	0	0.123D+01	0.433D+01	0.555E+01	5.4	0.0	7.3
1	4	69	0	0.513D+00	0.193D+01	0.244E+01	2.8	0.0	3.3
1	1	70	1	0.170D+01	0.458D+01	0.628E+01	6.2	0.0	8.7
1	2	70	1	0.174D+01	0.425D+01	0.599E+01	6.6	0.0	9.2
1	4	70	0	0.685D+00	0.185D+01	0.254E+01	2.4	0.0	3.7
1	6	70	0	0.305D+00	0.533D+00	0.838E+00	1.0	0.0	1.3
1	7	70	1	0.460D+00	0.522D+00	0.982E+00	1.4	0.0	2.0
1	5	71	1	0.447D+00	0.866D+00	0.131E+01	1.6	0.0	2.3
1	6	71	0	0.250D+00	0.493D+00	0.744E+00	0.8	0.0	1.3
1	7	71	0	0.234D+00	0.619D+00	0.854E+00	0.7	0.0	1.4
1	8	71	0	0.377D+00	0.120D+01	0.158E+01	1.4	0.0	2.4
1	9	71	0	0.766D+00	0.183D+01	0.260E+01	2.4	0.0	4.5
1	10	71	0	0.128D+01	0.300D+01	0.428E+01	4.5	0.0	6.9
1	11	71	0	0.934D+00	0.408D+01	0.502E+01	3.9	0.0	6.1
1	12	71	1	0.134D+01	0.475D+01	0.609E+01	5.4	0.0	8.3
1	1	72	1	0.132D+01	0.465D+01	0.597E+01	5.6	0.0	8.0
1	2	72	0	0.118D+01	0.416D+01	0.534E+01	5.5	0.0	8.3
1	3	72	1	0.116D+01	0.299D+01	0.416E+01	4.8	0.0	6.7
1	4	72	0	0.573D+00	0.184D+01	0.241E+01	2.5	0.0	3.6
1	5	72	1	0.456D+00	0.900D+00	0.136E+01	1.7	0.0	2.5
1	6	72	1	0.356D+00	0.436D+00	0.793E+00	1.2	0.0	1.9
2	4	69	1	0.201D+01	0.438D+01	0.639E+01	7.0	8.6	12.4
2	5	69	1	0.998D+00	0.546D+01	0.646E+01	6.6	8.7	14.1
2	10	69	1	0.609D+00	0.359D+01	0.420E+01	4.1	5.2	6.7
2	11	69	1	0.677D+00	0.195D+01	0.262E+01	3.6	4.1	4.3
2	1	70	0	0.482D+00	0.132D+01	0.181E+01	2.2	2.8	2.5
2	12	69	1	0.656D+00	0.104D+01	0.170E+01	2.2	3.1	2.5
2	2	70	0	0.307D+00	0.213D+01	0.244E+01	2.4	3.0	2.8
2	3	70	0	0.107D+01	0.337D+01	0.444E+01	4.1	4.6	2.9
2	4	70	1	0.160D+01	0.426D+01	0.586E+01	5.9	7.5	10.8
2	5	70	1	0.266D+01	0.525D+01	0.790E+01	9.0	11.0	13.8
2	6	70	0	0.102D+01	0.599D+01	0.701E+01	6.8	9.4	11.0
2	7	70	1	0.426D+00	0.580D+01	0.622E+01	6.8	8.5	9.3
2	9	70	0	0.137D+00	0.538D+01	0.551E+01	4.8	6.0	6.2
2	10	70	1	0.567D+00	0.359D+01	0.416E+01	5.1	6.5	6.4
2	11	70	1	0.605D+00	0.163D+01	0.224E+01	3.8	4.5	4.2
2	12	70	1	0.559D+00	0.101D+01	0.157E+01	2.8	4.0	3.3
2	1	71	1	0.410D+00	0.113D+01	0.154E+01	2.1	3.3	2.4
2	2	71	1	0.821D+00	0.212D+01	0.295E+01	3.2	4.7	4.4
2	3	71	1	0.978D+00	0.334D+01	0.432E+01	4.4	6.2	6.5
2	4	71	1	0.141D+01	0.488D+01	0.630E+01	6.1	8.8	9.2
2	5	71	1	0.123D+01	0.535D+01	0.658E+01	6.5	9.5	9.7
2	6	71	0	0.491D+00	0.591D+01	0.640E+01	6.3	8.5	7.4
2	7	71	0	0.232D-01	0.459D+01	0.462E+01	4.4	5.2	5.3
2	11	71	1	0.563D+00	0.189D+01	0.245E+01	3.2	3.8	3.2

3	8	64	0	0.989D+00	0.375D+01	0.474E+01	3.4	3.2	5.7
3	9	64	0	0.911D+00	0.263D+01	0.354E+01	3.8	3.4	5.1
3	10	64	0	0.646D+00	0.118D+01	0.183E+01	2.0	1.9	2.4
3	4	65	0	0.976D+00	0.224D+01	0.321E+01	3.2	2.2	3.5
3	5	65	0	0.891D+00	0.385D+01	0.474E+01	3.0	3.1	5.1
3	8	65	0	0.895D+00	0.396D+01	0.485E+01	3.9	3.9	5.9
3	9	65	0	0.561D+00	0.278D+01	0.334E+01	2.8	2.4	4.0
3	10	65	0	0.750D+00	0.126D+01	0.201E+01	2.7	2.4	2.9
3	11	65	1	0.840D+00	0.281D+00	0.112E+01	1.9	1.9	2.5
3	4	66	0	0.844D+00	0.189D+01	0.273E+01	0.2	1.8	2.9
3	6	66	1	0.792D+00	0.489D+01	0.569E+01	3.7	3.5	6.4
3	7	66	1	0.108D+01	0.485D+01	0.593E+01	5.5	5.3	7.9
3	8	66	1	0.103D+01	0.382D+01	0.485E+01	4.2	4.2	6.7
3	11	66	0	0.506D+00	0.345D+00	0.851E+00	1.2	1.3	1.7
3	4	67	1	0.129D+01	0.249D+01	0.378E+01	3.3	2.6	4.7
3	5	67	0	0.888D+00	0.308D+01	0.397E+01	2.6	2.7	4.7
3	6	67	0	0.744D+00	0.482D+01	0.556E+01	3.4	3.2	6.0
3	7	67	0	0.587D+00	0.426D+01	0.485E+01	3.0	2.8	5.0
3	9	67	1	0.604D+00	0.285D+01	0.345E+01	3.4	2.8	4.2
3	10	67	0	0.473D+00	0.128D+01	0.175E+01	2.2	1.8	2.4
3	4	68	1	0.115D+01	0.261D+01	0.376E+01	3.0	2.5	4.3
3	5	68	0	0.831D+00	0.330D+01	0.413E+01	2.5	2.5	4.4
3	6	68	0	0.755D+00	0.489D+01	0.564E+01	3.8	2.9	5.8
3	7	68	1	0.718D+00	0.498D+01	0.570E+01	4.3	3.4	5.8
3	8	68	0	0.726D+00	0.431D+01	0.503E+01	3.9	3.8	5.7
3	9	68	1	0.639D+00	0.270D+01	0.334E+01	3.3	3.0	4.3
3	11	68	0	0.687D+00	0.439D+00	0.113E+01	1.6	1.4	1.6
4	4	66	1	0.322D+01	0.283D+01	0.605E+01	7.1	10.4	11.4
4	5	66	1	0.383D+01	0.408D+01	0.791E+01	9.2	15.0	14.7
4	6	66	1	0.410D+01	0.437D+01	0.847E+01	10.7	17.7	16.6
4	8	66	1	0.406D+01	0.450D+01	0.856E+01	11.1	19.0	16.9
4	9	66	1	0.292D+01	0.284D+01	0.576E+01	7.5	12.3	11.9
4	10	66	1	0.219D+01	0.141D+01	0.360E+01	5.1	7.7	8.1
4	11	66	1	0.162D+01	0.327D+00	0.195E+01	3.1	4.9	5.0
4	12	66	0	0.123D+01	-0.314D-01	0.119E+01	2.3	2.8	2.9
4	1	67	1	0.127D+01	0.623D-01	0.133E+01	1.9	2.9	3.6
4	2	67	1	0.182D+01	0.690D+00	0.251E+01	3.5	5.0	5.9
4	3	67	1	0.266D+01	0.178D+01	0.445E+01	5.7	7.9	9.0
4	4	67	1	0.296D+01	0.283D+01	0.579E+01	7.0	9.9	10.0
4	5	67	1	0.349D+01	0.398D+01	0.747E+01	8.9	13.0	14.0
4	8	67	1	0.343D+01	0.485D+01	0.828E+01	9.5	15.8	15.8
4	9	67	1	0.276D+01	0.302D+01	0.578E+01	8.0	0.0	11.3
4	10	67	1	0.278D+01	0.122D+01	0.400E+01	6.8	0.0	9.9
4	11	67	0	0.150D+01	0.329D+00	0.183E+01	3.1	4.0	4.0
4	12	67	0	0.136D+01	-0.866D-02	0.135E+01	2.2	2.2	2.8
4	1	68	1	0.152D+01	-0.871D-01	0.144E+01	2.7	2.9	4.1
4	2	68	1	0.138D+01	0.927D+00	0.231E+01	2.8	3.5	4.8
4	3	68	1	0.218D+01	0.181D+01	0.399E+01	4.8	5.9	7.8
4	4	68	1	0.307D+01	0.304D+01	0.611E+01	7.3	10.4	11.2
4	5	68	1	0.383D+01	0.411D+01	0.794E+01	9.2	13.2	15.3
4	6	68	1	0.427D+01	0.445D+01	0.872E+01	11.6	16.4	18.7
4	7	68	1	0.368D+01	0.517D+01	0.885E+01	10.5	14.8	16.8
4	9	68	1	0.368D+01	0.244D+01	0.612E+01	10.1	13.0	14.1
4	10	68	1	0.222D+01	0.139D+01	0.361E+01	5.5	7.5	8.5
4	11	68	1	0.160D+01	0.306D+00	0.191E+01	3.7	4.6	5.2
4	12	68	1	0.106D+01	-0.403D-01	0.102E+01	2.4	2.9	3.4
4	1	69	0	0.129D+01	0.325D+00	0.161E+01	2.0	2.3	3.2
4	2	69	0	0.126D+01	0.911D+00	0.217E+01	2.3	2.4	3.5
4	3	69	1	0.177D+01	0.164D+01	0.341E+01	3.9	4.7	5.9
4	4	69	1	0.320D+01	0.278D+01	0.598E+01	8.2	9.6	11.8

4	5	69	1	0.340D+01	0.401D+01	0.742E+01	9.6	12.3	14.1
4	6	69	1	0.395D+01	0.460D+01	0.855E+01	11.4	15.0	16.3
4	7	69	1	0.357D+01	0.487D+01	0.844E+01	10.8	15.0	16.4
4	8	69	1	0.361D+01	0.447D+01	0.807E+01	10.9	15.4	16.1
4	9	69	1	0.294D+01	0.297D+01	0.591E+01	8.1	11.1	13.1
4	10	69	1	0.248D+01	0.126D+01	0.374E+01	6.2	8.1	9.0
4	11	69	1	0.180D+01	0.246D+00	0.204E+01	3.4	4.5	5.2
5	1	66	0	0.556D+00	0.201D+00	0.757E+00	1.2	1.1	1.8
5	4	66	1	0.125D+01	0.362D+01	0.487E+01	4.3	4.2	6.2
5	5	66	1	0.147D+01	0.481D+01	0.628E+01	5.8	5.8	7.9
5	6	66	1	0.161D+01	0.556D+01	0.717E+01	6.5	6.6	9.3
5	7	66	1	0.122D+01	0.567D+01	0.688E+01	6.6	6.7	8.6
5	8	66	1	0.141D+01	0.474D+01	0.615E+01	6.0	6.4	8.0
5	9	66	1	0.118D+01	0.345D+01	0.463E+01	4.7	5.2	6.3
5	10	66	1	0.118D+01	0.156D+01	0.274E+01	3.6	3.9	4.7
5	11	66	0	0.516D+00	0.616D+00	0.113E+01	1.5	1.8	1.9
5	12	66	0	0.284D+00	0.348D+00	0.632E+00	0.8	0.9	1.1
5	1	67	0	0.486D+00	0.339D+00	0.825E+00	0.6	1.0	0.9
5	3	67	0	0.619D+00	0.192D+01	0.254E+01	2.1	2.2	3.0
5	4	67	0	0.465D+00	0.254D+01	0.301E+01	2.5	2.4	3.2
5	5	67	1	0.947D+00	0.483D+01	0.578E+01	4.6	4.8	6.9
5	6	67	1	0.107D+01	0.509D+01	0.617E+01	5.1	5.7	7.3
5	7	67	1	0.116D+01	0.606D+01	0.722E+01	6.6	7.0	8.9
5	11	67	0	0.726D+00	0.530D+00	0.126E+01	1.6	2.0	2.1
5	12	67	0	0.101D+01	0.209D-01	0.103E+01	1.7	2.1	2.4
5	3	68	0	0.740D+00	0.208D+01	0.282E+01	2.6	2.7	3.6
5	4	68	1	0.184D+01	0.344D+01	0.528E+01	5.1	5.8	7.3
5	5	68	1	0.116D+01	0.476D+01	0.592E+01	4.6	5.6	6.9
5	6	68	1	0.172D+01	0.533D+01	0.705E+01	7.0	7.1	9.5
5	7	68	1	0.156D+01	0.567D+01	0.723E+01	6.5	7.2	9.0
5	8	68	1	0.139D+01	0.449D+01	0.588E+01	5.4	5.7	7.2
5	9	68	1	0.185D+01	0.324D+01	0.510E+01	5.8	5.8	7.0
5	10	68	1	0.109D+01	0.162D+01	0.271E+01	2.9	3.2	4.0
5	11	68	0	0.422D+00	0.628D+00	0.105E+01	1.5	1.6	1.7
5	12	68	0	0.288D+00	0.291D+00	0.579E+00	0.8	0.8	1.0
5	3	69	0	0.870D+00	0.202D+01	0.289E+01	2.4	2.5	3.9
5	4	69	1	0.110D+01	0.335D+01	0.445E+01	4.1	4.0	5.8
5	5	69	1	0.163D+01	0.523D+01	0.687E+01	5.5	6.1	6.3
5	6	69	1	0.131D+01	0.551D+01	0.681E+01	6.2	6.5	8.2
6	10	71	0	0.277D+00	0.384D+01	0.412E+01	3.9	4.6	5.2
6	11	71	0	0.176D+00	0.366D+01	0.384E+01	3.6	4.4	5.2
6	12	71	0	0.275D+00	0.346D+01	0.373E+01	3.9	4.6	4.5
6	1	72	0	0.129D+00	0.392D+01	0.404E+01	3.8	4.7	5.0
6	2	72	0	0.191D+00	0.315D+01	0.334E+01	3.1	3.8	3.9
6	3	72	0	0.300D+00	0.430D+01	0.460E+01	4.0	5.1	5.4
6	4	72	0	0.143D+00	0.387D+01	0.401E+01	3.7	4.2	4.5
6	5	72	0	0.232D+00	0.360D+01	0.383E+01	3.4	4.3	4.5
6	6	72	0	0.311D+00	0.317D+01	0.348E+01	2.9	3.8	4.1
6	7	72	0	0.397D+00	0.339D+01	0.378E+01	3.4	4.2	4.6
6	8	72	1	0.398D+00	0.361D+01	0.401E+01	3.5	4.8	5.1
6	9	72	0	0.424D+00	0.396D+01	0.438E+01	4.3	5.4	5.7
6	10	72	0	0.361D+00	0.392D+01	0.428E+01	3.6	4.7	4.9
6	11	72	0	0.288D+00	0.367D+01	0.396E+01	3.1	4.0	4.3
6	12	72	0	0.315D+00	0.397D+01	0.429E+01	3.3	4.3	4.3
7	4	68	0	0.663D+00	0.113D+01	0.179E+01	2.0	2.6	3.3
7	5	68	0	0.527D+00	0.148D+01	0.201E+01	2.2	2.6	3.2
7	6	68	0	0.617D+00	0.199D+01	0.260E+01	3.0	3.1	4.4
7	7	68	0	0.494D+00	0.185D+01	0.234E+01	3.2	3.6	4.4
7	8	68	0	0.425D+00	0.145D+01	0.188E+01	2.3	2.6	3.2
7	9	68	0	0.320D+00	0.912D+00	0.123E+01	1.4	1.6	1.7

7	10	68	0	0.170D+00	0.488D+00	0.658E+00	0.6	0.9	0.7
7	4	69	0	0.666D+00	0.995D+00	0.166E+01	1.6	2.3	2.9
7	5	69	0	0.787D+00	0.168D+01	0.247E+01	2.9	3.8	4.3
7	6	69	0	0.578D+00	0.198D+01	0.255E+01	3.1	3.2	4.2
7	7	69	1	0.567D+00	0.220D+01	0.276E+01	3.5	3.6	4.9
7	8	69	0	0.560D+00	0.148D+01	0.204E+01	2.9	3.3	3.9
7	9	69	0	0.476D+00	0.111D+01	0.158E+01	2.2	2.4	3.0
7	10	69	0	0.245D+00	0.444D+00	0.689E+00	0.7	0.9	0.9
7	4	70	0	0.587D+00	0.816D+00	0.140E+01	1.4	1.8	3.0
7	5	70	0	0.703D+00	0.145D+01	0.215E+01	2.1	2.3	0.0
7	6	70	0	0.533D+00	0.216D+01	0.270E+01	3.0	3.4	4.5
7	7	70	1	0.809D+00	0.199D+01	0.280E+01	3.2	3.8	4.8
7	8	70	0	0.389D+00	0.153D+01	0.192E+01	2.4	2.6	3.0
7	9	70	0	0.411D+00	0.106D+01	0.147E+01	2.0	2.3	2.6
7	10	70	0	0.284D+00	0.458D+00	0.743E+00	0.6	0.8	0.9
7	4	71	0	0.703D+00	0.108D+01	0.178E+01	1.7	1.8	2.7
7	5	71	0	0.518D+00	0.159D+01	0.211E+01	2.2	2.8	3.7
7	6	71	0	0.487D+00	0.165D+01	0.213E+01	2.5	2.9	3.4
7	7	71	1	0.641D+00	0.221D+01	0.286E+01	3.4	3.7	4.7
7	8	71	0	0.669D+00	0.184D+01	0.251E+01	3.4	4.0	4.7
7	9	71	0	0.320D+00	0.942D+00	0.126E+01	1.6	1.8	1.8
7	10	71	0	0.290D+00	0.407D+00	0.697E+00	0.9	1.0	1.1
7	4	72	0	0.592D+00	0.915D+00	0.151E+01	1.5	1.6	2.3
7	5	72	0	0.565D+00	0.137D+01	0.194E+01	1.9	2.1	3.0
7	6	72	0	0.711D+00	0.217D+01	0.288E+01	3.0	3.4	4.4
7	7	72	0	0.407D+00	0.207D+01	0.248E+01	3.1	3.1	4.2
7	8	72	0	0.373D+00	0.169D+01	0.206E+01	2.6	2.9	3.6
7	9	72	0	0.204D+00	0.931D+00	0.113E+01	1.5	1.6	1.7
7	10	72	0	0.194D+00	0.394D+00	0.588E+00	0.7	0.9	0.9
8	7	65	0	0.995D+00	0.180D+01	0.280E+01	3.5	3.9	4.3
8	8	65	0	0.830D+00	0.137D+01	0.220E+01	2.5	3.3	3.5
8	9	65	0	0.737D+00	0.873D+00	0.161E+01	1.9	2.5	2.6
8	10	65	1	0.339D+00	0.360D+00	0.699E+00	1.1	1.3	0.9
8	5	66	0	0.955D+00	0.229D+01	0.324E+01	2.9	3.3	3.8
8	6	66	0	0.121D+01	0.363D+01	0.484E+01	3.8	4.0	4.8
8	7	66	0	0.902D+00	0.326D+01	0.417E+01	3.4	3.7	4.5
8	8	66	0	0.967D+00	0.267D+01	0.364E+01	3.5	3.6	3.9
8	9	66	0	0.687D+00	0.114D+01	0.183E+01	2.3	2.3	2.5
8	10	66	0	0.349D+00	0.375D+00	0.724E+00	1.1	1.1	1.5
8	6	67	0	0.887D+00	0.325D+01	0.414E+01	3.6	4.4	4.4
8	7	67	1	0.116D+01	0.336D+01	0.451E+01	4.0	5.5	6.9
8	8	67	0	0.769D+00	0.255D+01	0.332E+01	3.3	3.6	4.7
8	9	67	1	0.772D+00	0.135D+01	0.212E+01	2.2	2.5	2.8
8	10	67	0	0.514D+00	0.335D+00	0.848E+00	1.1	1.1	1.2
8	5	68	0	0.756D+00	0.220D+01	0.295E+01	2.1	2.4	2.8
8	6	68	0	0.116D+01	0.356D+01	0.472E+01	3.3	4.2	4.8
8	7	68	0	0.966D+00	0.298D+01	0.395E+01	3.5	3.9	3.9
8	8	68	1	0.116D+01	0.276D+01	0.392E+01	3.3	4.0	4.2
8	9	68	0	0.564D+00	0.115D+01	0.171E+01	2.3	2.4	2.2
8	10	68	0	0.341D+00	0.336D+00	0.677E+00	1.0	0.9	0.7
8	5	69	0	0.125D+01	0.266D+01	0.391E+01	2.9	3.6	4.5
8	6	69	0	0.107D+01	0.369D+01	0.476E+01	3.2	4.1	4.7
8	7	69	0	0.129D+01	0.340D+01	0.469E+01	3.6	4.3	4.9
8	8	69	0	0.114D+01	0.222D+01	0.336E+01	3.3	3.6	3.8
8	9	69	1	0.734D+00	0.134D+01	0.208E+01	2.1	2.4	2.6
8	10	69	0	0.511D+00	0.275D+00	0.786E+00	1.1	1.4	1.0
8	5	70	0	0.906D+00	0.243D+01	0.333E+01	2.2	3.1	3.6
8	6	70	0	0.115D+01	0.383D+01	0.498E+01	3.3	4.3	4.7
8	7	70	0	0.835D+00	0.308D+01	0.391E+01	2.9	3.1	3.6
8	8	70	0	0.742D+00	0.254D+01	0.328E+01	2.8	3.3	3.2

8	9	70	0	0.633D+00	0.123D+01	0.186E+01	2.0	2.1	2.0
8	10	70	0	0.352D+00	0.327D+00	0.679E+00	1.0	1.0	1.1
8	5	71	0	0.111D+01	0.279D+01	0.390E+01	2.5	3.2	4.3
8	6	71	0	0.692D+00	0.299D+01	0.368E+01	2.7	2.8	3.5
8	7	71	1	0.120D+01	0.363D+01	0.483E+01	3.5	4.7	5.6
8	8	71	1	0.127D+01	0.272D+01	0.399E+01	4.0	4.7	4.8
8	9	71	0	0.492D+00	0.107D+01	0.156E+01	1.7	1.8	1.5
8	10	71	0	0.493D+00	0.299D+00	0.792E+00	1.0	1.2	1.2
8	6	72	0	0.908D+00	0.345D+01	0.436E+01	3.1	3.4	4.4
8	7	72	0	0.103D+01	0.347D+01	0.450E+01	3.1	4.1	4.8
9	4	65	0	0.611D+00	0.170D+01	0.231E+01	0.0	1.9	2.4
9	5	65	0	0.841D+00	0.305D+01	0.389E+01	0.0	3.2	3.8
9	6	65	0	0.680D+00	0.398D+01	0.466E+01	0.0	3.3	3.9
9	7	65	0	0.866D+00	0.418D+01	0.505E+01	0.0	4.1	4.7
9	8	65	0	0.766D+00	0.311D+01	0.388E+01	0.0	3.7	4.0
9	9	65	1	0.798D+00	0.212D+01	0.291E+01	0.0	3.1	3.3
9	10	65	1	0.492D+00	0.507D+00	0.999E+00	0.0	2.1	1.9
9	4	66	0	0.649D+00	0.208D+01	0.273E+01	0.0	2.5	2.9
9	5	66	0	0.989D+00	0.304D+01	0.403E+01	0.0	4.5	4.4
9	6	66	1	0.107D+01	0.417D+01	0.524E+01	0.0	4.3	4.7
9	7	66	0	0.120D+01	0.394D+01	0.514E+01	0.0	5.2	5.9
9	8	66	0	0.113D+01	0.341D+01	0.454E+01	0.0	5.1	5.3
9	9	66	1	0.783D+00	0.194D+01	0.272E+01	0.0	3.1	3.7
9	10	66	0	0.582D+00	0.795D+00	0.138E+01	0.0	1.8	2.1
9	4	67	0	0.827D+00	0.197D+01	0.280E+01	0.0	2.4	2.9
9	5	67	0	0.119D+01	0.316D+01	0.435E+01	0.0	3.8	4.6
9	6	67	1	0.926D+00	0.423D+01	0.515E+01	0.0	3.9	4.5
9	7	67	1	0.134D+01	0.434D+01	0.568E+01	0.0	5.7	6.7
9	8	67	1	0.120D+01	0.326D+01	0.446E+01	0.0	5.0	5.8
9	9	67	0	0.793D+00	0.188D+01	0.267E+01	0.0	3.2	4.1
9	10	67	0	0.511D+00	0.661D+00	0.117E+01	0.0	1.6	1.9
9	4	68	0	0.126D+01	0.215D+01	0.341E+01	0.0	2.9	4.1
9	5	68	1	0.149D+01	0.321D+01	0.471E+01	0.0	4.0	5.1
9	6	68	1	0.131D+01	0.433D+01	0.565E+01	0.0	4.8	6.3
9	7	68	1	0.143D+01	0.381D+01	0.524E+01	0.0	5.9	6.7
9	8	68	0	0.895D+00	0.291D+01	0.380E+01	0.0	4.4	4.6
9	9	68	0	0.531D+00	0.179D+01	0.232E+01	0.0	3.2	2.8
9	10	68	1	0.468D+00	0.610D+00	0.108E+01	0.0	1.8	1.9
9	4	69	1	0.103D+01	0.203D+01	0.306E+01	0.0	3.2	3.8
9	5	69	1	0.115D+01	0.357D+01	0.472E+01	0.0	5.2	5.5
9	6	69	0	0.791D+00	0.359D+01	0.438E+01	0.0	4.1	4.1
9	7	69	1	0.109D+01	0.406D+01	0.515E+01	0.0	5.5	6.1
9	8	69	0	0.802D+00	0.307D+01	0.388E+01	0.0	4.7	4.5
9	9	69	1	0.784D+00	0.182D+01	0.261E+01	0.0	3.6	3.6
9	10	69	0	0.438D+00	0.612D+00	0.105E+01	0.0	2.2	2.0
9	4	70	1	0.880D+00	0.177D+01	0.265E+01	0.0	2.6	3.0
9	5	70	0	0.789D+00	0.240D+01	0.319E+01	0.0	3.1	3.4
9	6	70	0	0.687D+00	0.343D+01	0.412E+01	0.0	3.6	4.2
9	7	70	1	0.860D+00	0.352D+01	0.438E+01	0.0	4.2	5.1
9	8	70	0	0.588D+00	0.290D+01	0.349E+01	0.0	3.6	4.1
9	9	70	1	0.606D+00	0.161D+01	0.221E+01	0.0	3.0	3.3
9	10	70	0	0.509D+00	0.547D+00	0.106E+01	0.0	1.8	1.7
9	4	71	1	0.859D+00	0.213D+01	0.299E+01	0.0	3.9	3.6
9	5	71	1	0.791D+00	0.366D+01	0.445E+01	0.0	4.4	5.0
9	6	71	0	0.893D+00	0.401D+01	0.491E+01	0.0	5.3	6.0
9	7	71	1	0.103D+01	0.393D+01	0.496E+01	0.0	5.0	5.7
9	8	71	1	0.980D+00	0.356D+01	0.454E+01	0.0	4.6	5.3
9	9	71	0	0.563D+00	0.162D+01	0.218E+01	0.0	2.8	3.2
9	10	71	0	0.501D+00	0.546D+00	0.105E+01	0.0	1.9	2.2
9	4	72	0	0.781D+00	0.211D+01	0.289E+01	0.0	2.9	3.3

9	5	72	0	0.779D+00	0.316D+01	0.394E+01	0.0	3.4	3.9
9	6	72	0	0.103D+01	0.421D+01	0.524E+01	0.0	4.6	5.4
9	7	72	0	0.810D+00	0.378D+01	0.459E+01	0.0	3.9	4.7
9	8	72	0	0.715D+00	0.291D+01	0.363E+01	0.0	3.3	4.0
9	9	72	0	0.569D+00	0.161D+01	0.217E+01	0.0	2.1	2.3
9	10	72	0	0.417D+00	0.546D+00	0.962E+00	0.0	1.2	1.3
10	7	49	0	0.620D+00	0.321D+01	0.383E+01	3.2	3.4	3.8
10	8	49	0	0.362D+00	0.199D+01	0.235E+01	2.0	2.4	2.5
10	9	49	0	0.356D+00	0.892D+00	0.125E+01	1.7	2.0	2.0
10	6	50	0	0.585D+00	0.286D+01	0.344E+01	2.3	2.7	3.2
10	7	50	0	0.640D+00	0.285D+01	0.349E+01	2.7	3.0	3.3
10	8	50	0	0.485D+00	0.188D+01	0.236E+01	2.1	2.3	2.3
10	9	50	0	0.372D+00	0.685D+00	0.106E+01	0.8	1.1	1.1
10	5	51	0	0.743D+00	0.185D+01	0.259E+01	2.1	2.1	2.6
10	6	51	0	0.859D+00	0.340D+01	0.426E+01	3.0	3.3	4.1
10	7	51	0	0.602D+00	0.336D+01	0.396E+01	3.2	3.5	4.0
10	8	51	0	0.627D+00	0.278D+01	0.341E+01	3.2	3.4	3.7
10	9	51	1	0.359D+00	0.891D+00	0.125E+01	1.9	2.1	1.9
10	5	52	0	0.951D+00	0.204D+01	0.300E+01	2.8	2.7	3.0
10	6	52	0	0.687D+00	0.277D+01	0.346E+01	2.5	2.5	3.3
10	7	52	0	0.669D+00	0.289D+01	0.356E+01	2.8	2.9	3.4
10	8	52	0	0.461D+00	0.201D+01	0.248E+01	2.5	2.5	2.6
10	9	52	0	0.269D+00	0.694D+00	0.963E+00	1.2	1.3	1.1
10	5	53	0	0.735D+00	0.221D+01	0.294E+01	2.4	2.5	3.0
10	6	53	0	0.706D+00	0.295D+01	0.366E+01	3.1	3.2	4.0
10	7	53	0	0.543D+00	0.296D+01	0.351E+01	2.3	2.6	3.3
10	8	53	0	0.324D+00	0.182D+01	0.215E+01	1.7	1.9	2.1
10	9	53	0	0.229D+00	0.665D+00	0.894E+00	1.3	1.3	1.0
10	5	58	0	0.796D+00	0.215D+01	0.295E+01	2.2	2.4	3.8
10	6	58	0	0.665D+00	0.273D+01	0.340E+01	2.6	3.0	4.0
10	7	58	0	0.585D+00	0.242D+01	0.300E+01	2.8	2.8	3.6
10	8	58	0	0.343D+00	0.153D+01	0.187E+01	1.9	1.9	2.3
10	9	58	0	0.314D+00	0.645D+00	0.959E+00	1.4	1.5	1.6
10	5	59	1	0.785D+00	0.222D+01	0.300E+01	2.6	2.7	3.8
10	6	59	0	0.856D+00	0.320D+01	0.406E+01	3.0	3.2	4.9
10	7	59	0	0.933D+00	0.341D+01	0.435E+01	3.4	3.6	5.4
10	8	59	0	0.982D+00	0.216D+01	0.315E+01	3.3	3.6	4.6
10	9	59	0	0.275D+00	0.578D+00	0.853E+00	1.2	1.4	1.3
10	5	60	0	0.844D+00	0.233D+01	0.317E+01	2.2	2.3	3.8
10	6	60	0	0.801D+00	0.308D+01	0.388E+01	3.0	3.1	4.4
10	7	60	0	0.653D+00	0.327D+01	0.393E+01	3.2	3.2	4.6
10	8	60	0	0.496D+00	0.185D+01	0.234E+01	2.6	2.5	3.1
10	9	60	0	0.193D+00	0.659D+00	0.852E+00	1.2	1.2	1.3
10	5	61	0	0.699D+00	0.202D+01	0.272E+01	1.8	1.9	3.4
10	6	61	0	0.904D+00	0.344D+01	0.435E+01	3.5	3.3	5.2
10	7	61	0	0.490D+00	0.265D+01	0.314E+01	2.5	2.4	3.7
10	8	61	0	0.453D+00	0.149D+01	0.195E+01	2.1	2.2	2.9
10	9	61	0	0.292D+00	0.707D+00	0.100E+01	1.3	1.3	1.5
10	6	62	0	0.679D+00	0.247D+01	0.315E+01	2.9	2.7	4.1
10	7	62	0	0.454D+00	0.240D+01	0.285E+01	2.3	2.2	3.4
10	8	62	0	0.455D+00	0.161D+01	0.206E+01	1.9	2.0	2.7
10	9	62	0	0.274D+00	0.669D+00	0.942E+00	1.0	1.0	1.2
10	7	63	0	0.698D+00	0.327D+01	0.397E+01	3.0	3.1	4.9
10	8	63	0	0.486D+00	0.199D+01	0.247E+01	2.4	2.5	3.6
10	9	63	0	0.410D+00	0.849D+00	0.126E+01	1.8	1.9	2.4
10	5	64	0	0.698D+00	0.210D+01	0.280E+01	2.0	2.0	3.6
10	6	64	0	0.834D+00	0.361D+01	0.444E+01	3.7	3.5	5.8
10	7	64	0	0.758D+00	0.323D+01	0.399E+01	3.7	3.6	5.5
10	8	64	0	0.545D+00	0.173D+01	0.227E+01	2.4	2.6	3.4
10	9	64	0	0.315D+00	0.754D+00	0.107E+01	1.2	1.3	1.6

10	6	65	0	0.804D+00	0.305D+01	0.386E+01	2.6	2.8	4.8
10	7	65	0	0.610D+00	0.270D+01	0.331E+01	2.5	2.5	4.0
10	8	65	0	0.505D+00	0.189D+01	0.240E+01	1.8	2.0	3.1
10	9	65	0	0.299D+00	0.824D+00	0.112E+01	1.4	1.4	1.9
10	5	66	0	0.859D+00	0.231D+01	0.317E+01	2.4	2.5	4.2
10	6	66	1	0.926D+00	0.335D+01	0.427E+01	4.0	4.0	6.3
10	7	66	0	0.546D+00	0.265D+01	0.320E+01	2.5	2.6	4.3
10	8	66	0	0.428D+00	0.187D+01	0.230E+01	2.6	2.5	3.4
10	5	67	0	0.731D+00	0.237D+01	0.310E+01	2.3	2.3	4.0
10	6	67	0	0.743D+00	0.306D+01	0.380E+01	2.8	3.0	4.6
10	7	67	0	0.656D+00	0.330D+01	0.395E+01	3.2	3.3	5.1
10	8	67	0	0.404D+00	0.182D+01	0.222E+01	2.2	2.2	3.1
10	9	67	0	0.284D+00	0.814D+00	0.110E+01	1.5	1.6	1.9
10	5	68	0	0.598D+00	0.182D+01	0.241E+01	1.9	1.9	2.9
10	7	68	0	0.516D+00	0.238D+01	0.290E+01	2.5	2.8	3.5
10	8	68	1	0.607D+00	0.218D+01	0.279E+01	2.4	2.6	3.7
10	9	68	0	0.382D+00	0.796D+00	0.118E+01	1.9	1.9	2.0
11	5	64	0	0.846D+00	0.288D+01	0.372E+01	2.5	3.2	4.8
11	6	64	0	0.114D+01	0.467D+01	0.581E+01	4.9	5.4	7.4
11	7	64	1	0.128D+01	0.422D+01	0.550E+01	5.1	5.7	7.4
11	8	64	1	0.115D+01	0.261D+01	0.376E+01	4.3	4.6	5.8
11	9	64	1	0.137D+01	0.178D+01	0.316E+01	4.4	5.0	6.1
11	10	64	1	0.906D+00	0.522D+00	0.143E+01	2.3	2.6	3.0
11	5	65	0	0.161D+01	0.319D+01	0.480E+01	4.3	4.9	6.9
11	6	65	1	0.170D+01	0.406D+01	0.576E+01	5.3	6.2	8.7
11	7	65	1	0.251D+01	0.426D+01	0.677E+01	7.4	8.8	11.3
11	8	65	1	0.290D+01	0.317D+01	0.607E+01	7.8	9.4	11.6
11	9	65	1	0.174D+01	0.177D+01	0.352E+01	5.0	6.0	7.7
11	6	66	0	0.118D+01	0.360D+01	0.479E+01	4.0	4.9	6.8
11	7	66	1	0.267D+01	0.439D+01	0.706E+01	7.0	9.4	12.6
11	8	66	1	0.269D+01	0.300D+01	0.568E+01	7.5	9.7	12.5
11	9	66	1	0.134D+01	0.173D+01	0.307E+01	4.4	5.4	6.4
11	10	66	1	0.979D+00	0.509D+00	0.149E+01	2.6	3.4	4.1
11	5	67	1	0.196D+01	0.337D+01	0.533E+01	5.0	6.6	9.1
11	6	67	1	0.144D+01	0.408D+01	0.552E+01	4.4	5.5	7.3
11	7	67	1	0.214D+01	0.388D+01	0.602E+01	6.4	8.1	9.8
11	8	67	1	0.153D+01	0.304D+01	0.457E+01	4.7	6.2	7.6
11	9	67	1	0.187D+01	0.155D+01	0.343E+01	4.7	6.0	6.8
11	10	67	1	0.106D+01	0.553D+00	0.162E+01	2.4	3.3	3.8
11	4	68	1	0.132D+01	0.218D+01	0.350E+01	3.4	3.7	5.8
11	5	68	1	0.173D+01	0.360D+01	0.534E+01	5.0	5.4	8.3
11	6	68	1	0.160D+01	0.440D+01	0.600E+01	5.5	6.4	8.7
11	7	68	1	0.237D+01	0.400D+01	0.637E+01	7.4	8.2	11.0
11	8	68	1	0.200D+01	0.285D+01	0.486E+01	5.8	7.0	9.1
12	9	65	1	0.132D+01	0.461D+01	0.594E+01	4.9	6.2	6.3
12	10	65	1	0.126D+01	0.391D+01	0.517E+01	6.1	7.9	8.4
12	11	65	1	0.984D+00	0.269D+01	0.367E+01	5.0	6.7	6.8
12	12	65	1	0.112D+01	0.220D+01	0.332E+01	4.1	5.6	6.0
12	1	66	1	0.134D+01	0.217D+01	0.351E+01	4.3	5.9	6.1
12	2	66	1	0.182D+01	0.260D+01	0.442E+01	5.6	7.8	8.5
12	3	66	1	0.229D+01	0.356D+01	0.585E+01	7.2	9.8	11.0
12	4	66	1	0.273D+01	0.456D+01	0.729E+01	8.0	11.7	12.7
12	5	66	1	0.335D+01	0.490D+01	0.825E+01	8.2	11.5	13.5
12	6	66	1	0.256D+01	0.447D+01	0.703E+01	6.9	9.2	10.0
12	7	66	0	0.175D+01	0.378D+01	0.553E+01	5.3	6.7	5.9
12	8	66	1	0.145D+01	0.375D+01	0.520E+01	4.5	5.4	5.7
12	9	66	0	0.103D+01	0.401D+01	0.504E+01	4.3	5.1	6.0
12	10	66	1	0.122D+01	0.385D+01	0.507E+01	5.7	6.8	7.9
12	11	66	1	0.118D+01	0.285D+01	0.403E+01	4.5	5.5	6.6
12	12	66	1	0.891D+00	0.219D+01	0.308E+01	3.8	4.6	5.0

12	1	67	1	0.114D+01	0.217D+01	0.331E+01	4.3	5.3	5.9
12	2	67	1	0.191D+01	0.214D+01	0.405E+01	5.8	7.7	8.7
12	3	67	1	0.230D+01	0.380D+01	0.610E+01	6.7	9.0	10.3
12	4	67	1	0.256D+01	0.453D+01	0.709E+01	8.1	10.8	12.5
12	5	67	1	0.298D+01	0.525D+01	0.823E+01	8.7	11.6	12.9
12	6	67	1	0.226D+01	0.477D+01	0.703E+01	7.0	8.6	9.2
12	7	67	0	0.166D+01	0.372D+01	0.537E+01	4.3	4.9	4.7
12	8	67	0	0.141D+01	0.372D+01	0.513E+01	3.6	3.9	4.6
12	9	67	0	0.115D+01	0.417D+01	0.532E+01	4.8	5.8	5.6
12	10	67	1	0.919D+00	0.405D+01	0.497E+01	4.9	5.5	6.0
12	11	67	1	0.989D+00	0.277D+01	0.375E+01	4.5	5.6	6.4
12	12	67	0	0.714D+00	0.246D+01	0.318E+01	3.4	4.1	4.3
12	1	68	1	0.100D+01	0.241D+01	0.341E+01	4.1	4.9	5.3
12	2	68	1	0.145D+01	0.286D+01	0.431E+01	4.8	6.1	7.2
12	3	68	1	0.199D+01	0.408D+01	0.607E+01	6.8	8.5	11.2
12	4	68	1	0.231D+01	0.463D+01	0.694E+01	6.9	9.8	12.7
12	5	68	1	0.301D+01	0.537D+01	0.839E+01	7.5	10.9	14.3
12	6	68	1	0.251D+01	0.491D+01	0.741E+01	6.5	8.5	10.1
12	7	68	0	0.169D+01	0.378D+01	0.548E+01	4.1	4.8	5.2
12	8	68	0	0.173D+01	0.379D+01	0.552E+01	3.9	4.4	5.1
12	9	68	0	0.306D+01	0.405D+01	0.712E+01	3.8	4.9	5.2
13	8	68	0	0.507D+00	0.233D+01	0.283E+01	1.9	2.5	0.0
13	9	68	0	0.486D+00	0.144D+01	0.192E+01	1.4	1.9	0.0
13	10	68	0	0.298D+00	0.481D+00	0.779E+00	0.7	0.9	0.0
13	11	68	0	0.317D+00	-0.443D-01	0.273E+00	0.8	0.7	0.0
13	1	69	0	0.236D+00	-0.202D+00	0.342E-01	0.2	0.4	0.0
13	3	69	1	0.374D+00	0.569D+00	0.943E+00	0.8	0.9	0.0
13	4	69	0	0.736D+00	0.172D+01	0.245E+01	1.6	2.2	0.0
13	5	69	0	0.461D+00	0.246D+01	0.292E+01	2.0	2.3	0.0
13	6	69	1	0.798D+00	0.353D+01	0.433E+01	3.1	3.9	0.0
13	7	69	0	0.852D+00	0.342D+01	0.427E+01	3.1	4.1	0.0
13	8	69	0	0.652D+00	0.239D+01	0.304E+01	2.4	2.7	0.0
13	9	69	1	0.453D+00	0.135D+01	0.181E+01	1.7	2.1	0.0
13	10	69	1	0.273D+00	0.452D+00	0.725E+00	1.0	1.1	0.0
13	11	69	0	0.377D+00	-0.193D+00	0.183E+00	0.6	0.9	0.0
13	12	69	0	0.125D+00	-0.732D-01	0.513E-01	0.1	0.1	0.0
13	1	70	0	0.148D+00	-0.996D-02	0.138E+00	0.1	0.3	0.0
13	2	70	0	0.544D+00	-0.163D+00	0.381E+00	0.5	0.7	0.0
13	3	70	0	0.422D+00	0.593D+00	0.102E+01	0.7	1.0	0.0
13	4	70	0	0.755D+00	0.135D+01	0.210E+01	1.1	1.4	0.0
13	5	70	1	0.828D+00	0.297D+01	0.380E+01	2.3	3.0	0.0
13	6	70	1	0.938D+00	0.421D+01	0.515E+01	3.9	5.2	0.0
13	7	70	0	0.771D+00	0.309D+01	0.386E+01	2.8	3.6	0.0
13	8	70	1	0.736D+00	0.209D+01	0.282E+01	2.6	3.4	0.0
13	9	70	0	0.400D+00	0.155D+01	0.195E+01	1.9	2.3	0.0
13	10	70	0	0.426D+00	0.391D+00	0.817E+00	1.1	1.5	0.0
13	12	70	0	0.153D+00	-0.217D+00	-0.636E-01	0.4	0.3	0.0
13	1	71	0	0.208D+00	-0.188D+00	0.196E-01	0.0	0.4	0.0
13	2	71	0	0.283D+00	0.187D+00	0.470E+00	0.5	0.7	0.0
13	3	71	0	0.482D+00	0.626D+00	0.111E+01	0.8	1.3	0.0
13	4	71	0	0.612D+00	0.135D+01	0.196E+01	1.4	2.0	0.0
13	5	71	0	0.525D+00	0.281D+01	0.334E+01	2.1	3.0	0.0
13	6	71	0	0.560D+00	0.298D+01	0.354E+01	2.3	3.1	0.0
13	7	71	1	0.557D+00	0.365D+01	0.420E+01	3.1	4.2	0.0
13	8	71	0	0.530D+00	0.235D+01	0.288E+01	2.2	2.8	0.0
13	10	71	0	0.287D+00	0.404D+00	0.691E+00	1.0	1.4	0.0
13	11	71	0	0.228D+00	-0.284D+00	-0.563E-01	0.7	0.7	0.0
13	12	71	0	0.182D+00	-0.198D+00	-0.163E-01	0.3	0.5	0.0
13	1	72	0	0.187D+00	-0.141D+00	0.465E-01	0.2	0.3	0.0
13	2	72	0	0.254D+00	0.175D+00	0.429E+00	0.1	0.3	0.0

13	3	72	0	0.457D+00	0.822D+00	0.128E+01	1.0	1.5	0.0
13	4	72	0	0.737D+00	0.150D+01	0.224E+01	1.6	2.1	0.0
13	5	72	0	0.697D+00	0.256D+01	0.325E+01	2.0	2.7	0.0
13	6	72	1	0.216D+01	0.217D+01	0.433E+01	2.3	3.0	0.0
13	7	72	1	0.685D+00	0.319D+01	0.387E+01	2.7	3.9	0.0
13	8	72	1	0.747D+00	0.250D+01	0.324E+01	2.8	3.7	0.0
13	9	72	0	0.552D+00	0.120D+01	0.175E+01	1.8	2.2	0.0
13	11	72	0	0.212D+00	-0.181D+00	0.315E-01	0.5	0.6	0.0
13	12	72	0	0.143D+00	-0.402D+00	-0.259E+00	0.2	0.4	0.0

APPENDIX II

CALCULATION OF THE OPEN WATER EVAPORATION BY THE COMBINATION ENERGY BALANCE - MASS TRANSFER EQUATION

One method of estimating open water evaporation by meteorological measurements only, is by use of a combination equation (e.g. Penman, 1948),

$$LE = \frac{(\Delta/\gamma') R_N + LE_a}{(\Delta/\gamma') + 1} \qquad (\text{cal cm}^{-2} \text{ sec}^{-1}) \qquad (1)$$

and $$LE_a = (e_a - e) f(u) \qquad (\text{cal cm}^{-2} \text{ sec}^{-1}) \qquad (2)$$

where L = latent heat of vaporization of water

E = total evaporation rate

E_a = aerodynamic evaporation rate

Δ = slope of the vapour pressure curve

γ' = psychrometric constant

e_a = saturation vapour pressure at air temperature

e = actual vapour pressure at air temperature

$f(u)$ = a function of the horizontal wind velocity profile

R_N = net radiation

Rearranging eq. (1), and defining D,

$$D = \frac{\Delta}{\Delta + \gamma'},$$

yields

$$LE = DR_N + (1 - D) LE_a \qquad (3)$$

Penman developed the following empirical relationship for open water surfaces:

$$LE_a = 0.35 (e_s - e_a) (u_2/100 + 0.5) \qquad (4)$$

where LE_a is in mm water evaporated in one day,

e_a, e are in mm mercury,

u_2 = mean horizontal wind speed measured at 2 m above the ground in miles day^{-1}

The net radiation over a water surface may be expressed,

$$R_n = K\downarrow (1 - \alpha) - R_L \qquad (5)$$

where $K\downarrow$ = global short wave radiation measured at the surface

α = reflectivity of a water surface

R_L = net long wave radiation.

Following Budyko (1958), α is taken as function of solar elevation from tables according to latitude and month of year.

Following Penman, long wave radiation can be empirically estimated as follows:

$$R_L = \sigma T_a^4 \; (0.56 - 0.09 \sqrt{e_a}) \; (1 - 0.9c) \qquad (6)$$

where σ = Stefan-Boltzmann constant

T_a = air temperature (^oK)

e_a = water vapour pressure, mm mercury

c = cloudiness factor

The cloudiness factor C, may be estimated,

$$c = 1 - n/N \qquad (7)$$

where n = actual hours of sunshine

N = possible hours of sunshine

Combining equations 3, 4, 5, 6 and 7 yields,

$$LE = \frac{D}{L} \left[K\downarrow (1-\alpha) - \sigma T_a^4 (0.56 - 0.09 \sqrt{e_a}) (0.1 + 0.9 \frac{n}{n}) \right] \qquad (8)$$

$$+ 0.35 (1 - D) (e_s - e_a) (u_2/100 + 0.5)$$

The net radiation was divided by L, the latent heat, for consistency of units, that is, LE in mm (water) day^{-1}.

Hours of sunshine, n, were not observed for this study. However, Glover and McCulloch (1958) developed an empirical relation between solar radiation and hours of sunshine.

$$\frac{K\downarrow}{K\downarrow\downarrow} = 0.29 \cos \phi + 0.52 \frac{n}{N} \qquad (9)$$

where $K\downarrow\downarrow$ = the solar radiation at the upper limit of the atmosphere

ϕ = latitude.

Values of $K\downarrow\downarrow$ were obtained from Russelo et al. (1974) and the Smithsonian Meteorological Tables.

Glover and McCulloch determined this relationship through linear regression analysis of measurements of $K\downarrow$ and n. The measurements were made at twelve stations in the northern and southern hemispheres with latitudes ranging from 1.3^{o} to 51.8^{o}. The equation is of a similar form to that proposed by Angström (1928) and compares favourably with it. They concluded that "Whilst little confidence can be placed on the second decimal place of the constants of the Angström-type equation, . . . the empirical relation should be a valuable tool for the agricultural meteorologist."

Combining equations (8) and (9) and substituting the appropriate constants to accommodate the units of measurement for this study yields:

$$LE = \frac{D}{L}\left[K\downarrow(1-\alpha) - \sigma T_a^4 (0.56 - 0.078\sqrt{e_a})\left(0.1 + 1.73\frac{K\downarrow}{K\downarrow\downarrow} - 0.50\cos\phi\right)\right]$$

$$+ 0.35 (1-D)(e_s - 0.75e_a)(0.537 u_2 + 0.5)$$

where: $K\downarrow$, $K\downarrow\downarrow$ are in cal cm^{-2} day^{-1}

T_a^4 is in ^{o}K

e_s is in mm mercury

e_a is in mb

u_2 is in m sec^{-1}

LE is mm (water) day^{-1}

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