JMC

COMPARISONS OF KEW EVAPORIMETERS 1968 Met.O.8. Evap. Memo. No.1

1. STATISTICS OF EVAPORIMETERS. by P.B.Wright.

The statistics for 6 evaporimeters are given in Table 1; data from the other two are awaited.

Means. The difference between the means of the two British tanks is not significant (in view of day-to-day variations in the difference between the values obtained from the two tanks). Similarly, the difference between the means of the two 3000 tanks is not significant. Otherwise, the means show significant differences which call for explanation; in particular, the value for the Piché (half metre) is much greater than that for the other evaporimeters.

Coefficient of variation This quantity, being the standard deviation divided by the mean, is thought to be a more suitable statistic than the S.D. itself. Its value is a function of the variability of the weather. The value is seen to be about the same for all evaporimeters except the Piché (screen) where it is markedly less; perhaps this decrease in the screen is due to a reduction in radiation received on sunny days.

Skewness and Kurtosis These quantities measure how much the distribution of the evaporation measurements differs from a Normal Distribution. They are primarily a function of the weather, and will vary according to the portion of the year used for the analysis. The values are reasonably consistent between the evaporimeters except for the Piché (screen) which shows much more deviation from a Normal Distribution (for which Skewness = 0, Kurtosis = 3) than the others. How important this is I don't know.

Correlation The correlations of daily values are very good between the two 3000 tanks, and good between the following pairs:

(a) the two British tanks

(b) the two Piché evaporimeters

(c) either British tank and either 3000 tank.

The correlation between either of the Pichés and any of the tanks is not good.

2. THE TWO BRITISH TANKS.

The S.D. of the daily differences is 0.52, making the standard error of the difference of the means 0.04; thus the observed difference of the means of

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0.04 is not significant. However this rather large variation in daily differences deserves some investigation.

Relation with water temperature

Figure 1 shows the relation between evaporation difference and mean water surface temperature difference at the two tanks, over the period June 8th to July 31st. The figure shows that there is some association. There may perhaps be more association with differences of maximum temperature. (Correlation coeffts. could be calculated if desired.)

There are two possible causes of these temperature differences:

(1) the condition of the tank (the old tank was in less good condition)

(2) the conductivity of the ground (the old site has higher conductivity since the ground, being the site of an old monastery, is in disturbed condition; this fact has been demonstrated in earlier experiments on soil temperatures).

Other reasons for daily differences

Another factor which might cause the evaporation measurements to differ is that the rainfall estimates for both tanks were given by a rain gauge on the new site. Thus if there was, on any particular day, a difference in rainfall on the two sites, the value of evaporation quoted for the tank on the old site would be in error by that amount.

To investigate this, the mean magnitudes of the difference between the two estimates were found for rainy and dry days respectively. Table 2 shows the result, namely that the differences were significantly greater on rainy than on dry days. Thus it appears that a significant error was introduced by the measurement of rainfall at a site 100 yds away from the old tank.

If desired, we could repeat the original analysis using only dry days.

It is reasonable to suppose that spacial variations in wind speed may also have introduced differences between the two tanks.

Summary

In view of these probable and possible causes of different values, I think the observed discrepancies between the tanks are adequately accounted for.

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3. THE TWO 3000 TANKS.

The readings from these tanks were closely correlated. The small difference in the means is not significant.

It was suggested that wind direction might have the effect of reducing evaporation at the downwind tank. Figure 2 shows no obvious association with wind direction during June and July. Since the tanks lay in a W-E line, a comparison was made between those days with westerly and those days with easterly winds. On westerly days (winds between 240° and 300°) the west tank showed a mean excess of evaporation of 0.026 mm, while on easterly days (winds between 60° and 120°) the east tank showed an excess of 0.023 mm. These differences are of the correct sign, but are far from being significant.

A diagram similar to Figure 1 does not suggest much association with water temperature differences, which were somewhat smaller than in the case of the British tanks. This could be looked into further if desired. There is no reason to suggest any difference due to rainfall, because the tanks are close to each other. Perhaps the differences in evaporation and in water temperature must be regarded as unavoidable small-scale random effects.

4. BRITISH COMPARED WITH 3000'S

There is a significant difference in the mean values of evaporation measured by the two species of tank, the 3000 tanks being on average about 10% higher. Perhaps this is mainly due to the size of the tanks. The 3000 tank is smaller, therefore it responds quicker to daytime heating; also there will be a greater tendency with the British tank for the air to become moister and therefore reduce further evaporation before it has passed away clear of the tank.

5. THE PICHÉS.

These results suggest that the Piché evaporimeters are of dubious value for the accurate measurement of evaporation. They seem to be measuring something rather different. Bear in mind that part of the correlation is due to annual variation; a correlation coefficient using daily anomalies relative to the mean for the season would give lower values. Further analyses could be made by relating differences to weather conditions.

TABLE 1

KEW EVAPORIMETERS — Statistics of observations over period June 1st to November 30th 1968.

	BRIT. (NEW)	BRIT. (OLD)	PICHÉ (HLF)	PICHÉ (S)	3000 (W)	3000 (E)
Mean	1.83	1.79	3.22	2.26	2.04	2.00
Coefft. of Var.	0.80	0.80	0.74	0.61	0.75	0.79
Skewness	0.95	1.03	1.15	1.54	0.85	0.81
Kurtosis	4.08	4.47	4.69	6.63	3.98	3.95
S.D. of daily diffs.	0.52		1.16		0.40	
Correl. coefft.	0.94		0.93		0.97	
Correl. coefft. with Brit. (New)			0.81	0.82	0.92	0.91
" " " " (Old)			0.85	0.83	0.93	0.91
" " " Piché (Half)					0.83	0.81
" " " " (S)					0.85	0.85

TABLE 2

Daily differences in evaporation measured by the two British tanks

June 1st to November 30th, 1968

	DAYS WITH RAIN	DAYS WITH NO RAIN OR TRACE
Nr. of days diff. not available	4	1
" " " with diff. 1 mm or greater	6	3
Nr. of days used in calculations	87	82
Mean magnitude of diff. on these days	0.330 mm	0.238 mm
Standard deviation	0.24	0.24
Standard error of the difference of the means	0.037	
$t = \frac{\text{diff. of means}}{\text{S.E. of diff. of means}}$	2.50	
Significance level	1½%	

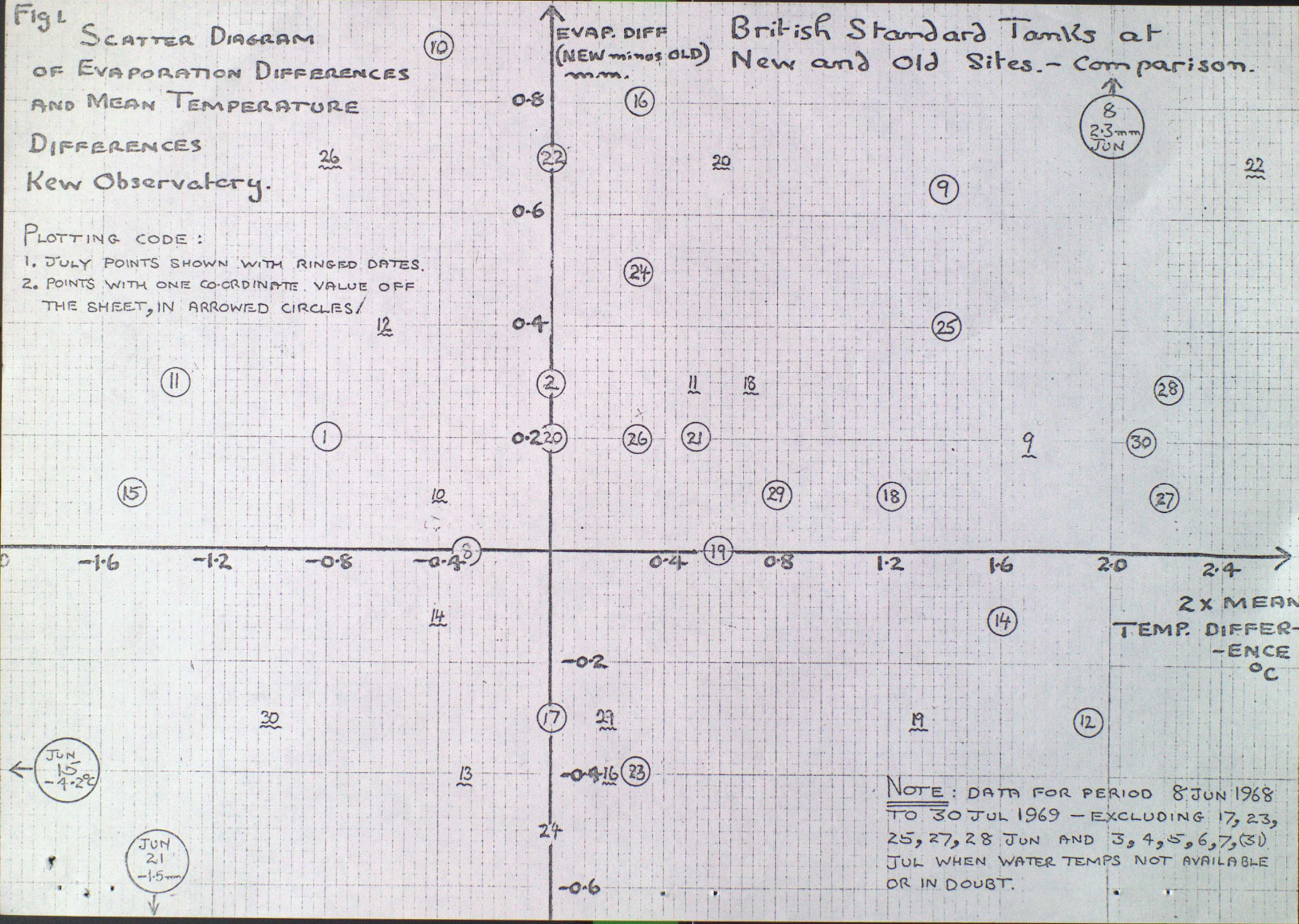
Fig 1

Scatter Diagram of Evaporation Differences and Mean Temperature Differences Kew Observatory.

British Standard Tanks at New and Old Sites. – Comparison.

Plotting code:

1. July points shown with ringed dates.
2. Points with one co-ordinate value off the sheet, in arrowed circles.



Note: data for period 8 Jun 1968 to 30 Jul 1969 – excluding 17, 23, 25, 27, 28 Jun and 3, 4, 5, 6, 7, (31) Jul when water temps not available or in doubt.

Fig 2. Scatter Diagram of Evaporation Differences and Wind Direction.
Kew Observatory. Comparison of 3000w tanks at (W) and (E) sites.