Indian J. Met. Geophys. (1974), 25; 3 & 4, 489-492

551·508·7

Evaporation measurements with a self-recording evaporigraph

S. K. SHAHA, P. S. BATAR and R. R. KELKAR

Meteorological Office, Poona

(*Received 3 January 1973*)

ABSTRACT. Data collected over five years (1967-71) with a self-recording evaporigraph at the Central Agricultural Meteorological Observatory in Poona, are analysed and discussed.

The afternoon 3-hour period 1330-1630 IST is found to contribute as much as 24 to 30 per cent of the total daily evaporation recorded in any month; whereas the 15-hr period 1930-1030 IST can account for only 26 to 41 per cent of the total daily evaporation.

A statistical analysis of evaporigraph data in comparison with Class A Pan evaporimeter measurements is also presented.

1. Introduction

Instrumentation for continuous recording of natural evaporation is yet in the stage of development. Simpler autographic devices for measurement of evaporation from free water surfaces are, however, available and could be profitably employed in view of the high degree of correlation between evaporimeter observations and evapotranspiration from vegetated surfaces (Gangopadhyaya *et al.* 1968).

A self-recording evaporigraph (Lambrecht and Gottingen Type) has been in operation for some years at the Central Agricultural Meteorological Observatory in Poona. The data collected over a five-year period 1967-1971 has been analysed and discussed in this paper. The evaporigraph (Fig. 1) comprises a small pan (diameter 18 cm, depth 2.5 cm) containing water, a mechanism which senses the weight of the pan, and an arrangement which records the loss in weight of the pan directly in units of millimetres of water evaporated. The instrument is comparable in size with other self-recording instruments such as a thermograph or hygrograph, and is conveniently placed within a double Stevenson screen.

2. Diurnal variation of evaporation

Evaporigraph data recorded daily over five years from 1967 to 1971 was processed to obtain monthly averages of evaporation in one-hour periods, 0730-0830, 0830-0930,....0630-0730 IST. The results for three representative months, May, August and November are shown in Fig. 2. These three months have been chosen since evaporation *is maximum during the* hot summer month of May, minimum during the cloudy and humid month of August, and is again high in the post monsoon month of November.

The trend of the diurnal variation of evaporation is seen to be essentially similar in all the three months. The occurrence of maximum hourly evaporation does not coincide with that of maximum solar radiation, *i.e.*, the maximum hourly evaporation does not occur around the local noon but occurs later between 1330 and 1430 IST when temperature is high and atmospheric moisture content low. Likewise, the minimum value of evaporation is observed between 0630 and 0730, *i.e.*, a little after sunrise. Between 1930 and 0630 IST, a low rate of evaporation is generally maintained due to non-availability of solar energy and restricted variations of temperature and humidity. In May, evaporation rates of the order of 0.7 mm/hour are recorded by the evaporigraph in the afternoons, whereas in November and August the corresponding values are 0.4 and 0.2 mm/hour respectively. Evaporation is less than 0.1 mm/hour in the early morning hours in all the three months.

Fig. 3 is a composite diagram which shows the month-by-month variation of the hourly evaporaion rates. The night-time distribution is quite flat, the minimum occurring between 0630 and 0730 hours throughout the year. The occurrence of the maximum is, however, not so sharply defined and in many months, particularly February to April, the hourly evaporation rates between 1330 and 1730 hours have nearly equal values. The gradient between the isopleths becomes very steep between May and June , when the transition from summer to monsoon takes place.

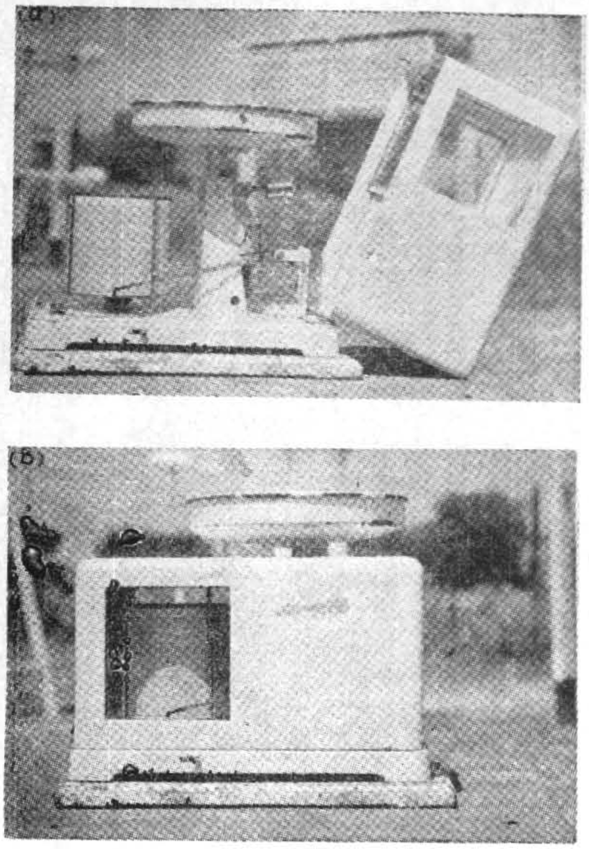

Fig. 1
Photographs of Evaporigraph with (a) lid open and (b) lid closed

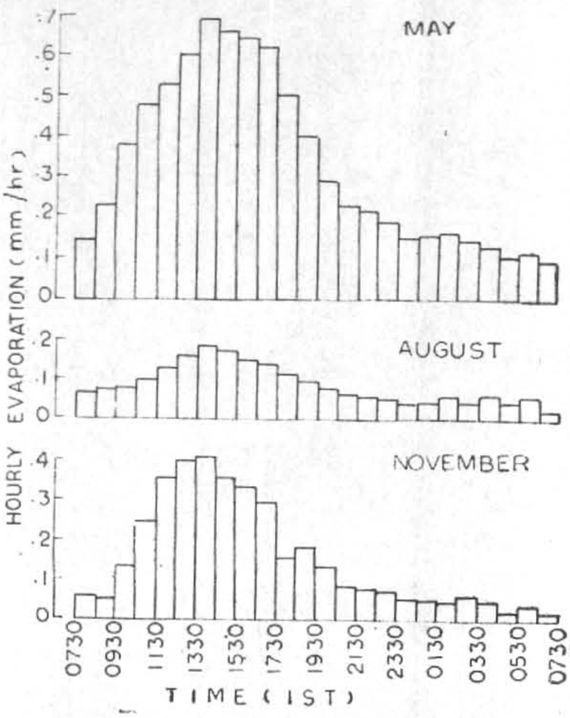

Fig. 2
Diurnal variation of evaporation as measured by Evaporigraph
(5-yr average)

TABLE 1

Mean monthly evaporation in 3-hr period

$$\left[\text{Expressed as} \quad \left(\frac{\text{Evaporation in 3-hr}}{\text{Total evaporation in 24-hr}}\right)\times 100\right]$$

Period (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0730—1030	6	5	7	9	10	10	10	10	9	7	7	6
1030—1330	20	18	19	20	20	21	20	19	20	24	27	24
1330—1630	30	28	26	25	25	25	24	24	28	30	29	30
1630—1930	21	24	22	19	19	18	17	16	18	20	17	17
1930—2230	9	11	12	10	10	8	9	10	9	8	8	9
2230—0130	6	6	6	6	6	7	7	7	6	4	5	5
0130—0430	5	5	5	6	6	6	8	8	6	4	5	6
0430—0730	3	3	3	4	4	5	5	6	4	3	3	3

It is a known fact (Olivier 1964) that measurements made with evaporimeters of different designs rarely show agreement as regards the absolute value of evaporation. From this point of view, the percentages of evaporation in eight 3-hour epochs (0730-1030, 1030-1330.., 0430-0730 IST) to the 24-hr total as recorded by the evaporigraph were also computed (Table 1). As before daily evaporigrams were analysed and five-year averages then obtained. It is seen that the 3-hour period 1330-1630 alone contributes 24 to 30 per cent of the total daily evaporation recorded; whereas the fifteen hours 1930-1030 IST can together account for only 26 to 41 per cent of the total daily evaporation. Further, during the period 0730-1030 IST the percentage evaporation is of the order of 5 to 10 per cent only, which is comparable to, and in some cases less than, the night-time 3-hour percentages. Thus, in spite of the availablity of solar radiation in the morning hours, and the lack of it at night, the corresponding contributions to the total evaporation are of the same order.

Table 1 also reveals that during monosoon months, the percentage contributions from the eight 3-hour periods differ less markedly from each other than in the non-monsoon months. For example, in August, the contribution in the 1330-1630 period is 24 per cent which is lower than the value of 30 per cent for the same period in December. On the other hand, for the 0430-0730 period the contribution is 6 per cent in August which is higher than the contribution of 3 per cent in December.

This could be understood by considering the nature of the diurnal variation of the factors which control evaporation, *viz*., radiation, temperature, humidity and wind. During the monsoon season the wind speeds are high throughout the day as well as night. In other seasons low winds are calm during the night and relatively high winds during the day are a common occurrence. The diurnal range of variation of net radiation, temperature and humidity is also significantly less in the monsoon season because of persistent cloudiness.

3. Comparison with Class A Pan evaporimeter

A study was attempted to examine the nature and extent of agreement between the evaporigraph records and measurements made with a Class A Pan evaporimeter, which has been adopted as the standard evaporimeter for agro-meteorological observatories in India. It consists of a copper pan of much larger dimensions (diameter 122 cm, depth 25.5 mm) which is placed above the ground over a wooden grille. The fall in the height of the water level over a lapse of time measured with a screw gauge or with a calibrated water bucket directly yields the evaporation during that time. As part of the programme of international comparison of evaporimeters, in which India participated, frequent observations were made with a Class A Pan evaporimeter at the Central Agrimet. Observatory, Poona during 1967-68, and they have been made use of in this study.

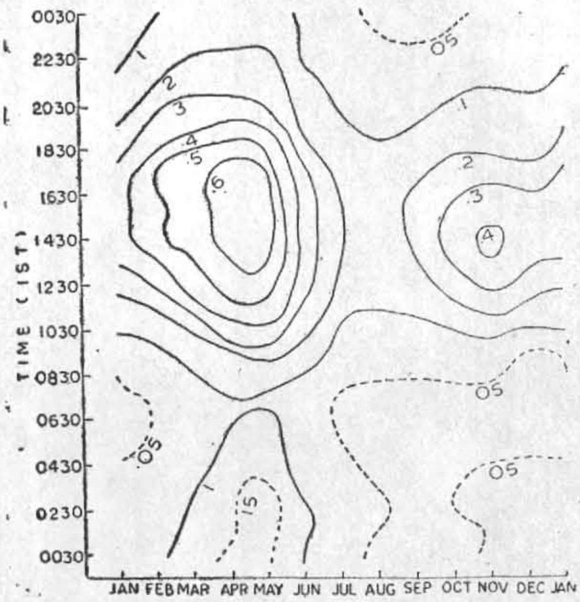

Fig. 3. Month by month change of pattern of diurnal variation of evaporation as measured by Evaporigraph (5-yr. average). Isopleths in mm/hr.

Monthly averages of Class A Pan evaporation (*i*) from 0730 to 1930 and (*ii*) from 1930 to 0730 hr of next day, were computed from the daily observations at Poona in the 12-month period August 1967 to July 1968. These are compared in Fig. 4 with the data obtained from the evaporigraph over identical periods and averaged in a similar manner. A striking feature of this comparison is the parallel response of the two instruments to seasonal and diurnal environmental changes in spite of the wide difference in their exposure conditions. However, as may be expected, the evaporigraph, shielded by the Stevenson screen, always measures less evaporation than the Class A Pan which is exposed to strong winds and direct solar radiation. Large differences are therefore noticed in the months, March to May when the exposure of the Class A Pan to sunshine is most acute.

4. Correlation between pan evaporation and evaporigraph measurements

A statistical analysis was next made to examine the nature of the relation between evaporigraph

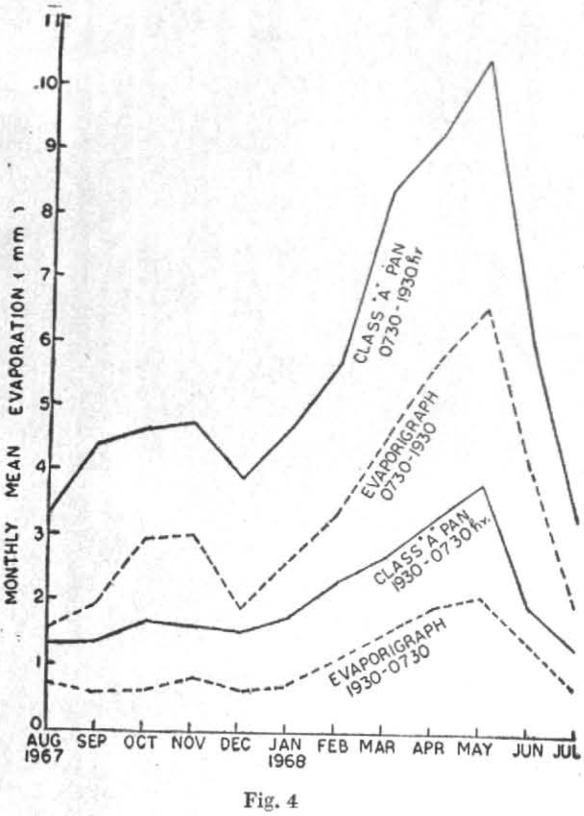

Fig. 4

Comparison of evaporation measurement by Evaporigraph and Class A Pan

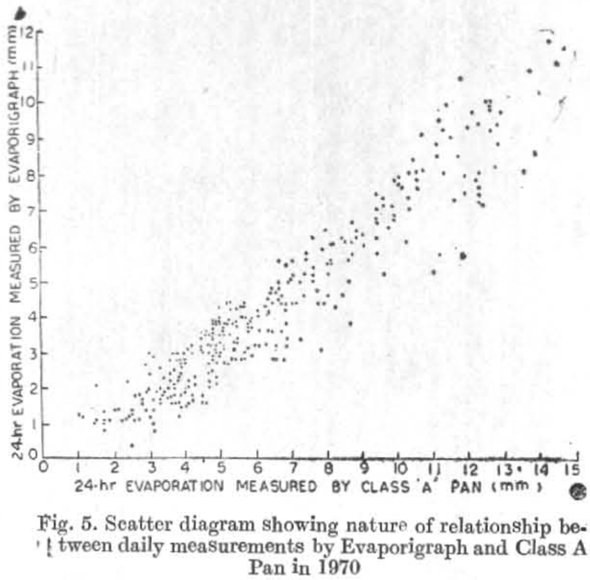

Fig. 5. Scatter diagram showing nature of relationship between daily measurements by Evaporigraph and Class A Pan in 1970

and Class A Pan measurements. As the first step a day-to-day comparison of 24-hour evaporation amounts obtained from the evaporigraph (0730 to 0730 IST of next day) and from the Class A Pan (0830 to 0830 IST of next day) was made over a full year 1970. A good linear correspondence between the two variables was noticed (Fig. 5) and it was felt worthwhile to derive a regression equation to represent the relationship.

Daily data collected over two years, 1 January 1970 to 31 December 1971, was used to obtain the regression equation. The oomputations were made on the I.B.M. 1620 computor at the Indian Institute of Tropical Meteorology, Poona. If the pan evaporation is denoted by E_p and evaporigraph measurement by E_g, a simple relatihoship,

$$E_p = 1.0562 + 1.2369\ E_g$$

was found to be the best fit for the data. The correlation coefficient was worked out to be 0.932, which is highly significant.

5. Concluding remarks

(*i*) The study has shown that during the day maximum evaporation takes place in the afternoon period 1330-1630 IST. This three-hour period contributes as much as 24 to 30 per cent of evaporation during 24 hours. Evaporation rate is low throughout the night and minimum between 0630 and 0730 IST.

(*ii*) Statistical analysis of the data recorded simultaneously by Class A Pan and the evaporigraph has shown a significant relationship between the two. This provides support for the use of the evaporigraph wherever area limitations makes it inconvenient to install a Class A Pan.

Acknowledgement

The authors are grateful to Shri C.R.V. Raman for going through the manuscript and making useful comments. They also wish to thank S/Shri D. L. Naudu and B. P. Kamble for their help in some of the computations, Smt. V.S. Tamhankar for typing the manuscript, and colleagues in the Drawing Section who prepared the diagrams.

REFERENCES

Gangopadhyaya, M., Venkataraman, S. and Krishnamurthy, V. 1968 Roles of mesh-covered Class A Pan evaporimeter in the extrapolation of evapotranspiration estimates, Proc. ICAR Symp. 'Soil and Water Management', Hissar, India.

Mellroy, I.C. 1971 An instrument for continuous recording of natural evaporation, *Agric. Met.*, 9, pp. 93-100.

Olivier, H. 1964 Free water surface evaporation, *Irrigation and Climate*, pp. 22-49.