

Space-correlation fields of pan evaporimeter network

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ABSTRACT. Field of inter-station correlations of pan evaporimeter network of the country has been analysed seasonwise. The scale of evaporation phenomenon during various seasons have been pointed out in the light of this analysis. Regions where further strengthening of the network density is required are indicated. Correlation-distance relationships are found to be poor in all seasons south of 15°N latitude and over a lesser extent throughout the country during periods other than winter.

1. Introduction

Evaporation off land is a part of hydrologic cycle and is a vital factor for consideration in water management problems, such as crop planning, reservoir operations etc. The World Meteorological Organisation and the International Association of Scientific Hydrology has adopted the U. S. class A pan as network instrument. Empirical factors to estimate water losses of reservoirs (Venkataraman 1973) and plant surfaces (Gangopadhyaya *et al.* 1969 and Ministry of Food and Agriculture 1970) from pan evaporation values are available. Thus, measurement of pan evaporation on a network basis has become justified both from hydrological as well as agricultural points of view. It is, therefore, necessary to examine whether the existing network density in the country meets the needs of observational data.

In characterising optimum network of evaporimeters, Rodda (1969) suggests the network density should be such that the accuracy of estimation of monthly and seasonal evaporation values, by linear interpolation, is within 5 to 7 per cent for arid zone and 10 to 13 per cent for wet zones. For a desired accuracy, requirement of optimum density of observation points is a function of the homogeneity of the parameter under measurement, its scale and its measurement errors. Spatial correlation analysis, which largely takes into account all these factors has become a widely used approach in network analysis (Kagan 1966; Hendrick *et al.* 1970). Recently an attempt has been made to use this technique in the design of pan evaporimeter network also (Peck and Monro 1976). The same technique is used here.

The India Meteorological Department has published monthly evaporation data of 72 stations which recorded observations for more than 5 years during the period 1959-1968. With the help of these data the properties of the network is examined.

2. Data

The evaporation data published by India met. Dep. in 1970 related to 30 stations in Part I and the rest—Agromet. observatories in Part II. Part I contains means of daily evaporation, measured from 0830 IST of previous day to 0830 IST of date for all days in each calendar month. In the case of Part II, the data differs in the following respects :

(1) The given daily means are for the 12 standard periods, into which an year is divided for agrometeorological purposes, the first period beginning from 1 January and successive periods from 5 February, 5 March, 2 April, 7 May, 4 June, 2 July, 6 August, 3 September, 1 October, 5 November and 3 December.

(2) Upto the year 1964 a day corresponded to 0700 to 0700 LMT. Since 1965 it is from 0830 to 0830 IST.

(3) Only non-rainy days evaporation data is considered in processing for daily means.

In the present study, however, data given in both Parts I and II are treated as a single set forming a network of mutual internal comparability, for the following reasons :

(1) Observations were made on instruments of the same type at all the stations;

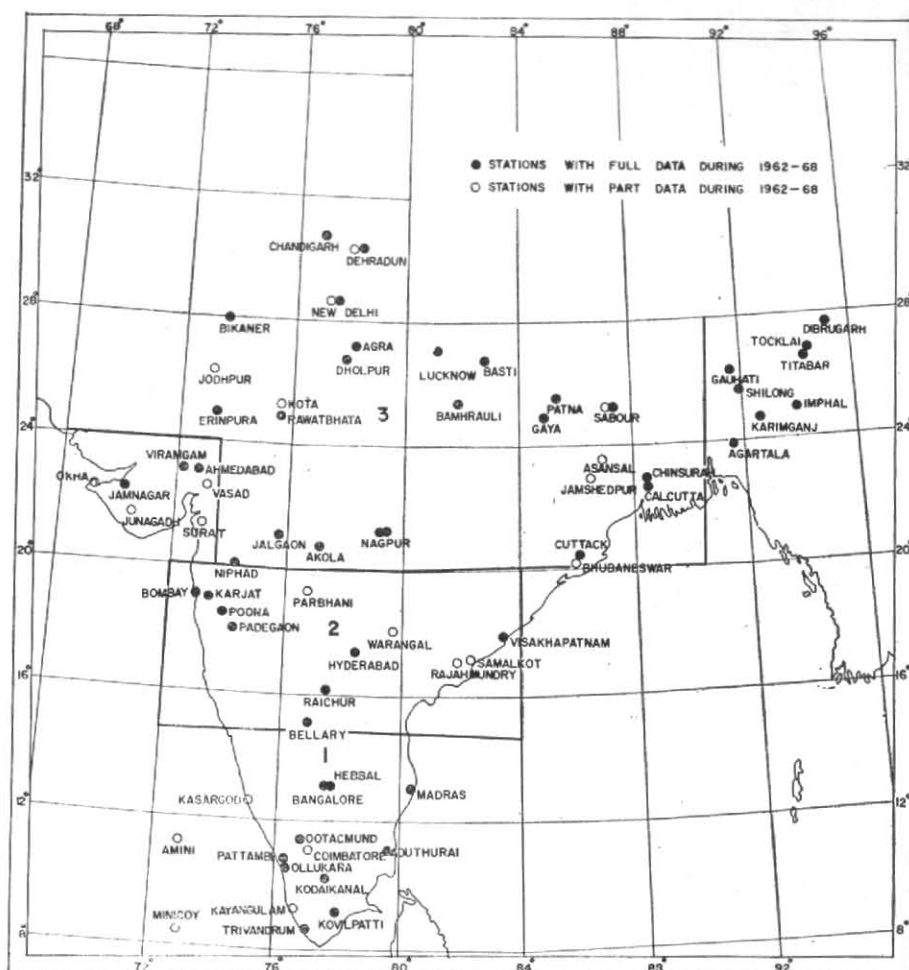


Fig. 1. Location of evaporimeter stations — Sabour, New Delhi, Nagpur and Dehradun are having two evaporimeters each at different locations

(2) The standard periods of agrometeorological observatories differ from corresponding calendar months by not more than a few days and mean daily evaporation of these standard periods is unlikely to differ much from mean daily evaporation of the closely corresponding calendar months;

(3) Daily total of evaporation would remain the same independent of the time of observation and

(4) The consideration of only non-rainy days data for a part of the stations may not constitute significant incoherence.

The data from 1962 onwards only is considered since all the stations have nearly complete data from that year excepting a few. In the case of these stations only their available data are used.

The locations of the 72 stations considered for this analysis is shown in Fig. 1.

3. Analysis and discussions

(i) Evaporation values of each station are correlated with the rest. These values are averaged for stations lying within selected ranges of 100, 200, 300 km etc from it. Based on the average for each station, isopleths can be drawn to represent the field of average correlation within the above ranges.

The number of stations which have atleast three other stations within a range of 100 km are only 2; for a range of 200 km, there are 20 such stations and for ranges of 300, 400 and 500 km and greater, the number increases to 60, 71 and 72 respectively. For presenting the isopleths of correlation field it is felt that the range over which correlations are averaged should be atleast 300 km.

Isopleths for 300 km range are presented in Fig. 2(a) for the 3-month periods, January to March, April to June, July to September and

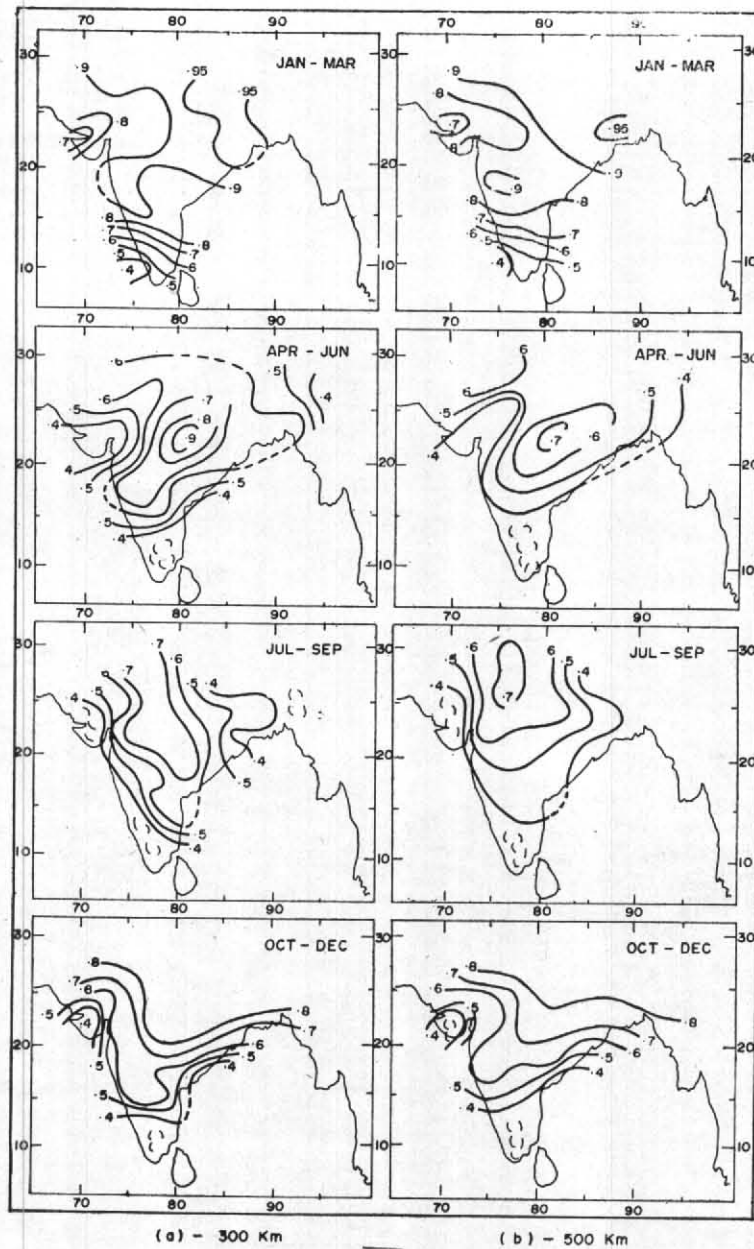


Fig. 2—Space correlation fields for different seasons

(a) Averaging distance 300 km, (b) Averaging distance 500 km (when correlation is or exceeded by 0.95, its isoline is also given; at regions where correlation is less than 0.4, the field is erratic and shown by stray hatching)

October to December which approximately correspond to winter, summer, monsoon and post monsoon seasons respectively. In Fig. 2(b) isopleths for average correlation within 500 km are given.

From Fig. 2(a) it is seen that during winter, the space correlations are the highest of all seasons. Over a large region in north India the value is 0.9 and over eastern Uttar Pradesh and Bihar, the value reaches 0.95 (*i.e.*, explained variance higher than 90 per cent). The values decrease westwards to 0.7 over a very small re-

gion in Saurashtra and southwards to 0.4 at the tip of the Peninsula.

During summer correlations decreased considerably and the region of highest correlation shifts to central India, where only over a very small region the correlation is 0.9. Over considerable area in southern Peninsula and over Saurashtra in west and Assam in east the correlation is 0.4. In areas with values less than 0.4 (indicated by stray hatching), the variations are erratic.

TABLE 1
Variation of correlation with distance

| Distance (km) | Block 1 | | | | Block 2 | | | | Block 3 | | | |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | Jan to Mar | Apr to Jun | Jul to Sep | Oct to Dec | Jan to Mar | Apr to Jun | Jul to Sep | Oct to Dec | Jan to Mar | Apr to Jun | Jul to Sep | Oct to Dec |
| 0-100 | 0.49 | <i>0.44</i> | 0.14 | 0.25 | <i>0.93</i> | <i>0.64</i> | 0.46 | 0.38 | 0.92 | 0.65 | <i>0.65</i> | 0.78 |
| 100-200 | 0.39 | 0.42 | -0.01 | 0.25 | 0.87 | 0.57 | 0.53 | 0.54 | <i>0.94</i> | <i>0.68</i> | 0.60 | <i>0.82</i> |
| 200-300 | 0.51 | 0.23 | <i>0.22</i> | <i>0.26</i> | 0.88 | 0.47 | <i>0.57</i> | <i>0.57</i> | 0.90 | 0.52 | 0.51 | 0.80 |
| 300-400 | 0.38 | 0.21 | 0.07 | 0.12 | 0.83 | 0.28 | 0.46 | 0.54 | 0.89 | 0.48 | 0.55 | 0.73 |
| 400-500 | 0.48 | 0.16 | 0.18 | 0.07 | 0.82 | 0.38 | 0.34 | 0.43 | 0.86 | 0.43 | 0.47 | 0.66 |
| 500-600 | 0.55 | 0.16 | 0.09 | 0.08 | 0.80 | 0.30 | 0.36 | 0.35 | 0.88 | 0.39 | 0.47 | 0.67 |
| 600-700 | 0.55 | 0.12 | 0.10 | 0.08 | 0.77 | 0.30 | 0.28 | 0.32 | 0.89 | 0.38 | 0.44 | 0.69 |
| 700-800 | <i>0.68</i> | 0.15 | 0.11 | 0.02 | 0.74 | 0.22 | 0.34 | 0.31 | 0.87 | 0.21 | 0.41 | 0.66 |

Values in italics are the highest values during that period

During monsoon season, correlations decrease over central parts of the country. The highest correlation is 0.7 over a belt of area extending from central to northwest India.

During the post-monsoon season, correlation generally improves except over southern Peninsula and Saurashtra. In northern parts covering Punjab, U.P., Bihar and Assam the value is 0.8 or higher.

The above features are also seen in Fig. 2(b) for 500 km range except for an overall slight decrease in correlation.

(ii) From Figs. 2(a) and 2(b), it is seen that a tentative division into three blocks (shown in Fig. 1) can be made. Block 1 is south of 15°N and is a region of low space correlations. Block 2 is the region in between 15°N and 20°N. It is of intermediate correlations. Block 3 is north of 20°N, excluding Saurashtra and Assam regions. This is a region of relatively high space correlations.

The space correlations worked out earlier for each of the 72 stations are averaged for successive distances intervals, 0-100 km, 100-200 km, 200-300 km etc. The variation of correlation with distance is summarised in Table 1 for three blocks into which the country is divided by averaging all correlation values in that block for each of the distance interval.

The following are the features of blockwise correlation-distance values of Table 1.

Block 1

(i) Correlations during all seasons and in all distance intervals are the lowest in this block. Even in the > 0 to 100 km of distance interval, the highest value is only 0.49 (explained variance is less than 25 per cent).

(ii) During winter period, space correlations with evaporimeters beyond 400 to 500 km are better than those situated closer.

Features (i) and (ii) suggest that the evaporation field in this block is heterogeneous. Correlating with far off evaporimeters appears preferable to doing with those within the block in winter season.

Block 2

(i) In winter, correlation within > 0-100 km interval is 0.93 dropping down gradually to 0.74 at 700 km to 800 km.

(ii) During all the remaining seasons, correlations are of the same order in each interval except within > 0-100 km. In this interval the lowest correlations occurred in the post monsoon season.

Block 3

(i) Values during all seasons are higher than over the corresponding values in other blocks in all distance intervals.

(ii) In winter space correlations are high even for distance intervals upto 700-800 km. The

decrease in correlation from > 0 to 100 km interval to 700 to 800 km interval is only from 0.92 to 0.87.

(iii) The order of values are same in all intervals upto 300 km in both summer and monsoon seasons.

(iv) During the period October to December the values are lower than winter values but higher than summer and monsoon values.

In many cases, in all the three blocks, correlations remain either steady or slightly increase upto 200 to 300 km and then decrease with further distance. During summer, the correlations decrease more monotonically and more rapidly with distance.

A network has to meet the demand even during the period of lowest homogeneity in space. It may be seen that among the highest space correlation values for each season of Block 1, the value 0.22 of July to September is the lowest. For blocks 2 and 3, 0.57 and 0.65 are the corresponding values respectively. Approximately each of these values correspond to explained variances of 5, 32 and 42 per cent respectively. To increase this to about 90 per cent may not be possible in Block 1 with increase of network density. In Blocks 2 and 3, with additions of more evaporimeters, an improvement may be possible.

4. Conclusions

(1) The scale of evaporation field is high in winter, compared to other seasons, all over the country. It is homogeneous over north and central parts of the country becoming less homogeneous towards south.

It is generally lowest during monsoon and summer. In any season, the scale reduces southwards. South of 12°N it is so heterogeneous it cannot be represented by isopleths. During summer and monsoon periods similar cases occurred over a small region in Saurashtra and Assam.

(2) Inter-station distance should be brought to well below 100 km in all regions for accurate evaporation information over all the seasons.

The present study shows that correlation changes from season to season and with distance for all the three blocks. Significantly greater correlation upto 100-150 km for the high evaporation months, April to June, holds good only for Block 1 and not for Blocks 2 and 3. However, there are about 200 pan evaporimeters at present in the country and these space correlations are to be revised when data over sufficient period is accrued.

Also since evaporation depends on atmospheric moisture and its other parameters, which may possibly require incorporation in network logistics, the above features may be taken only as preliminary guidelines.

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REFERENCES

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| Dep. Agric., Ministry of Food & Agric. | 1970 | Technical series No. 2, Water Management Div. |
| Gangopadhyaya, M., Venkataraman, S. and Krishnamurthy, V. | 1969 | Proc. Symp. Water Management, Indian Council of Agric. Res., Hissar. |
| Hendriok, R. L. and Coner, G. H. | 1970 | <i>J. Hydrol.</i> , 10, 2, pp. 151-163. |
| Kagan, R. L. | 1966 | <i>Works of the Russian Geophysical Observatory</i> , 191. |
| Peck, E. L. and Monro, J. C. | 1976 | <i>Operational Hydrology</i> , Rep. No. 8, WMO No. 433, pp. 77-90. |
| Rodda, J. C. | 1969 | WMO/IHD Projects Rep. No. 12. |
| Venkataraman, S. and Krishnamurthy, V. | 1973 | <i>Irrig. Pwr.</i> , 30, pp. 59-66. |