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A comparative study on the performance of different evaporimeters by spectrum analysis technique

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सार — तीन भिन्न भिन्न वाष्पोत्सर्जन मापीयों से मापे गए वाष्पोत्सर्जन के आंकड़ों में विचरण की जांच की गई है। वर्णक्रम एवं क्रास वर्णक्रम तकनीकों का उपयोग करके वाष्पोत्सर्जन मापीयों की अनुक्रिया पर प्रकाश डाला गया है। महत्वपूर्ण वर्णक्रमी शिखरों की शिनाख्त की गई है और उपकरणों के तुलनात्मक कार्य का जायजा लिया गया है।

ABSTRACT. Variability of evaporation data measured by three different evaporimeters are examined. The use of spectrum and cross spectrum techniques in comparing the response of the evaporimeters is high lighted. The important spectral peaks are identified and the relative performance of the instruments is assessed.

1. Introduction

Evaporation is an important parameter in many scientific fields. It is either measured by instruments or estimated by empirical formulae based on weather data. Studies relating the evaporation and weather factors were reported over India by Venkatraman and Murthy (1965), Padmanabhamurthy and Subba Reddy (1970), Rao *et al.* (1972), Jeevananda Reddy and Rama Rao (1973), Sarma (1973) and many others. Measurements are made by a number of instruments like Pan A, buried tank, Black Porous Disc Atmometer, Bellaniplate atmometer etc. They may respond differently at the same place and under the same environment condition and exposure and a comparison of these instruments is necessary to find out the corrections to be applied, if any. WMO (1966) published a large number of results of evaporation comparisons based on different evaporimeters from various countries of the world. There are also other methods to compare the evaporation data measured from evaporimeters, like graphical analysis, testing of means and variance by statistical methods etc. Sometimes, correlation and linear regression analysis are also done — Parthasarathy and Misra (1955), Sarker (1963) and Ramana Rao and Subba Rao (1978).

Analysis of time series by spectrum analysis is useful to obtain the contribution of oscillations with various frequencies to the variance of time series. It may help to understand the physics underlying the variations and points out the significant maxima and minima, Panofsky and Brier (1968). It aids to separate the regular variations from random fluctuations and identifies the phase shifts between two time series over different frequency ranges. This technique is quite helpful in those areas and fields where long series of data is not available and inferences are to be made from case studies only.

In this paper, the authors have attempted to compare the performance of three evaporimeters by correlation and spectrum analysis techniques for the data recorded at Pune.

2. Data and method of analysis

During February to May, 1973 continuous daily evaporation data from three evaporimeters, USA Pan A, FRP Pan and 3000 GGI sunken, were recorded at the Central Agrimet Observatory, Pune, which is used in the present study.

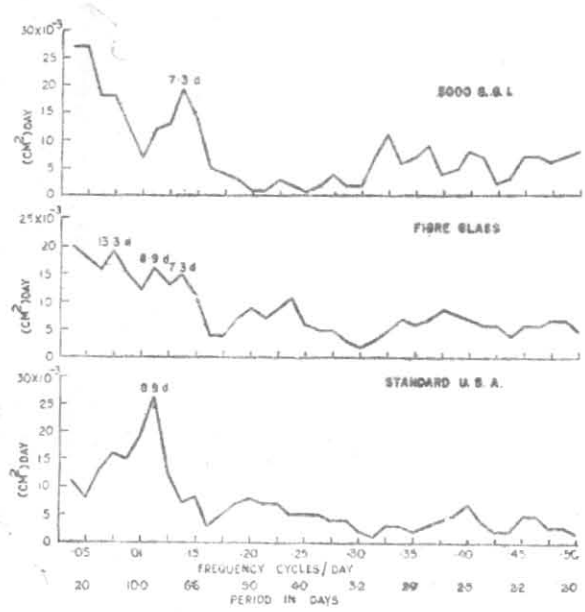

Fig. 1. Power spectra (normalised) of measured evaporation data

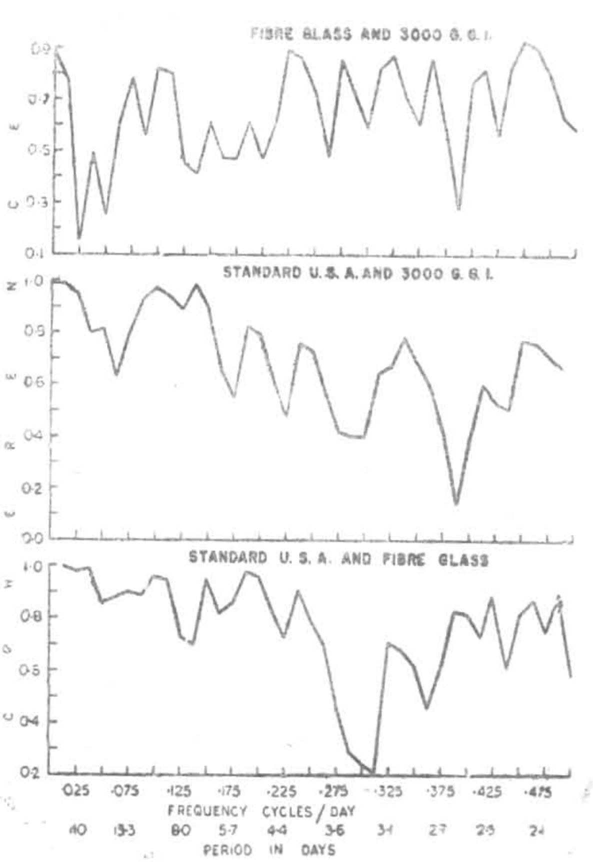

Fig. 2. Coherence between observed evaporation data among the instruments

TABLE 1

Correlation coefficients (CC's) between evaporation data measured from different evaporimeters

Type of evaporimeter	3000 GGI	Fibre glass	Standard USA
Standard USA	0.86	0.93	1.00
Fibre Glass	0.84	1.00	—
3000 GGI	1.00	—	—

Number of observations=120, Level of significance : at 5%=0.1779, at 1%=0.2324, at 0.1%=0.2943

TABLE 2

Correlations between evaporation and meteorological factor

Type of Evapori-meters	TX Maximum Temperature (°C)	TN Minimum Temperature (°C)	TR Range of Temperature (°C)	FF Wind-speed at 0.5 meter height (kt)	△EW Deficit of vapour pressure over water (mb)	△E Deficit of vapour pressure over air (mb)	Qo Total radiation at top of atmosphere
Standard USA	0.73	0.69	−0.31	0.68	0.19	0.60	0.80
Fibre Glass	0.69	0.68	−0.33	0.69	0.16	0.56	0.79
3000 GGI	0.67	0.62	−0.26	0.60	0.17	0.58	0.73

Number of observations=120, Level of significance : at 5%=0.1779, at 1%=0.2324, at 0.1%=0.2943

TABLE 3

Inter-correlation coefficients between various meteorological parameters

	TX	TN	TR	FF	△EW	△E	Qo
TX	1.00	0.75	−0.13	0.28	0.47	0.84	0.80
TN	0.75	1.00	−0.76	0.63	0.13	0.56	0.85
TR			1.00	−0.66	0.28	0.00	−0.48
FF				1.00	−0.31	0.05	0.63
△EW					1.00	0.76	0.17
△E						1.00	0.54
Qo							1.00

For N=120, Level of significance : at 5%=0.1779, at 1%=0.2324, at 0.1%=0.2943

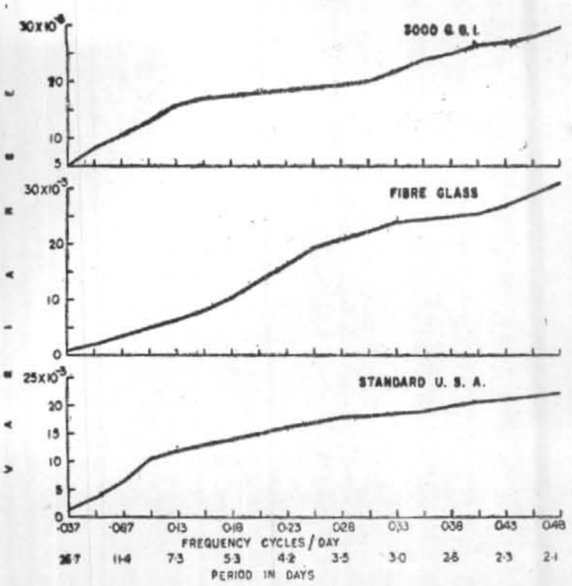

Fig. 3. Accumulated variance (from zero to given frequency)

Correlations were obtained between the daily evaporation data and different weather parameters. The variability of evaporation measured by instruments have been examined by spectrum and cross spectrum analysis. The maximum lag used is 40. The spectrum and cross spectrum analysis is mainly based on the methods suggested by Blackman and Tukey (1958), Munk *et al.* (1959) and WMO-79 (1966). Statistical significance of the important peaks are tested as per procedures given in WMO-79 (1966).

3. Results and discussions

3.1. The CCS (correlation coefficients) among the evaporation data measured by the three instruments are 0.84 to 0.93 and very highly significant at even 0.1% level, which are given in Table 1. Comparison made at Pune based on two year average data (WMO-83), showed CC of 0.78 between class A Pan and buried pan of 10 inch deep and 20 feet diameter.

CCS between evaporation and meteorological factors; total radiation at top of atmosphere, temperatures, wind speed and deficit vapour pressures over air and water are given in Table 2, show that all of them are siginficant. The intercorrelations between various factors are mostly significant at 0.1% level, Table 3.

3.2. *Spectrum and cross spectrum results*

The measured daily evaporation data have been subjected to spectrum technique. The normalized spectral values for the three evaporimeters are shown in Fig. 1. Most of the variance is concentrated in low frequency range in case of 3000 GGI and Fibre Glass. Significant spectral peaks (95% level) with periods of 7.3 days are noticed in 3000 GGI and Fibre Glass, and 8.9 days in Fibre Glass and standard USA. Only one significant peak of 13.3 days is observed in Fibre Glass. The intensity of 7.3 days peak is more in 3000 GGI and 8.9 days in standard USA.

Coherence among the three evaporimeters has been calculated using cross spectrum analysis and results are shown in Fig. 2. In most of the frequencies high coherence exist and lowest values are seen at 0.025 cycles/day between Fibre Glass and 3000 GGI, at about 0.375 cycles/day between Standard USA and 3000 GGI and about 0.31 cycles/day between Standard USA and Fibre Glass. The areas under each spectral curve are integrated and accumulated variance values from zero to 0.48 cycles/day frequency are shown in Fig. 3.

4. Summary

Daily evaporation data during February to May, 1973 measured by three different evaporimeters at Pune have been analysed. The analysis has indicated that the instruments are highly correlated.

Spectral analysis shows that the contribution of variance at high frequency range is small, with significant coherence among the instruments in most of the frequencies.

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