DECREASING TREND IN THE RAINFALL OF KERALA

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ABSTRACT

The rainfall time series of 75 rain recording stations over Kerala for the 80–year period 1901 to 1980 have been statistically examined for long-term trends. Application of Mann-Kendall rank statistic test to the time series of annual and seasonal totals as well as extreme rainfall of 1,2,3 ... 10 day durations revealed a significant decreasing trend in the rainfall over the eastern high lands and adjacent areas to the west. This finding is supported by the fact that the mean rainfall for the second half of the period is 10 to 20% lower than for the first half over the same area.

INTRODUCTION

KERALA has an average annual rainfall of 3000 mm spread over some 10 months over the southern parts and about 8 months over the northern regions. Most of this rainfall is received from the southwest and northeast monsoons, with maximum in June-July. In recent years there have been reports of shortage of water due to decline in rainfall, adversely affecting hydel projects, agriculture and even drinking water supply. In this context it was considered to be of interest to examine the past rainfall data of Kerala from the beginning of this century to see whether any decreasing trends are noticeable.

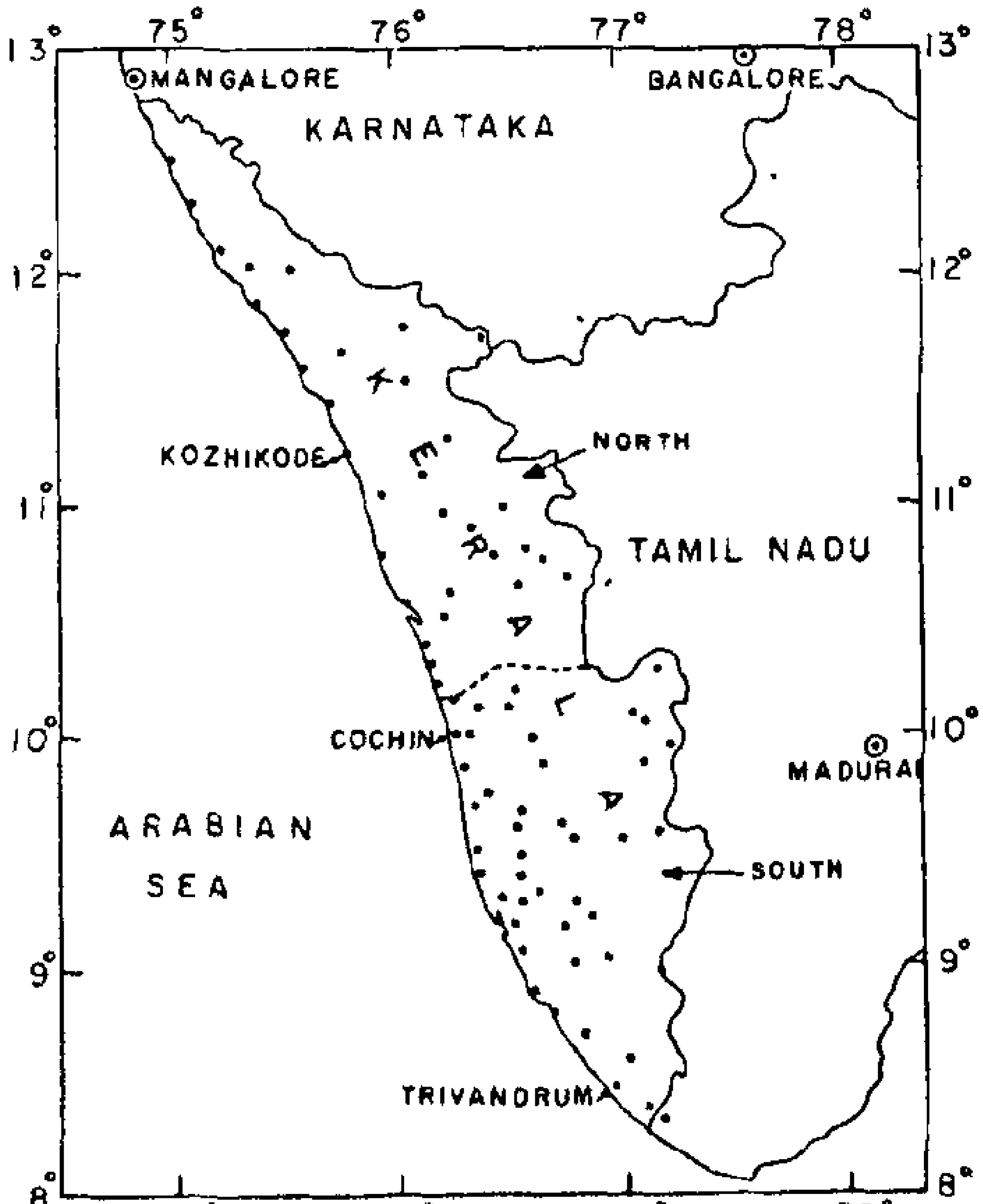

Figure 1. Location map of 75 raingauge stations. North and south Kerala are separated by a broken line.

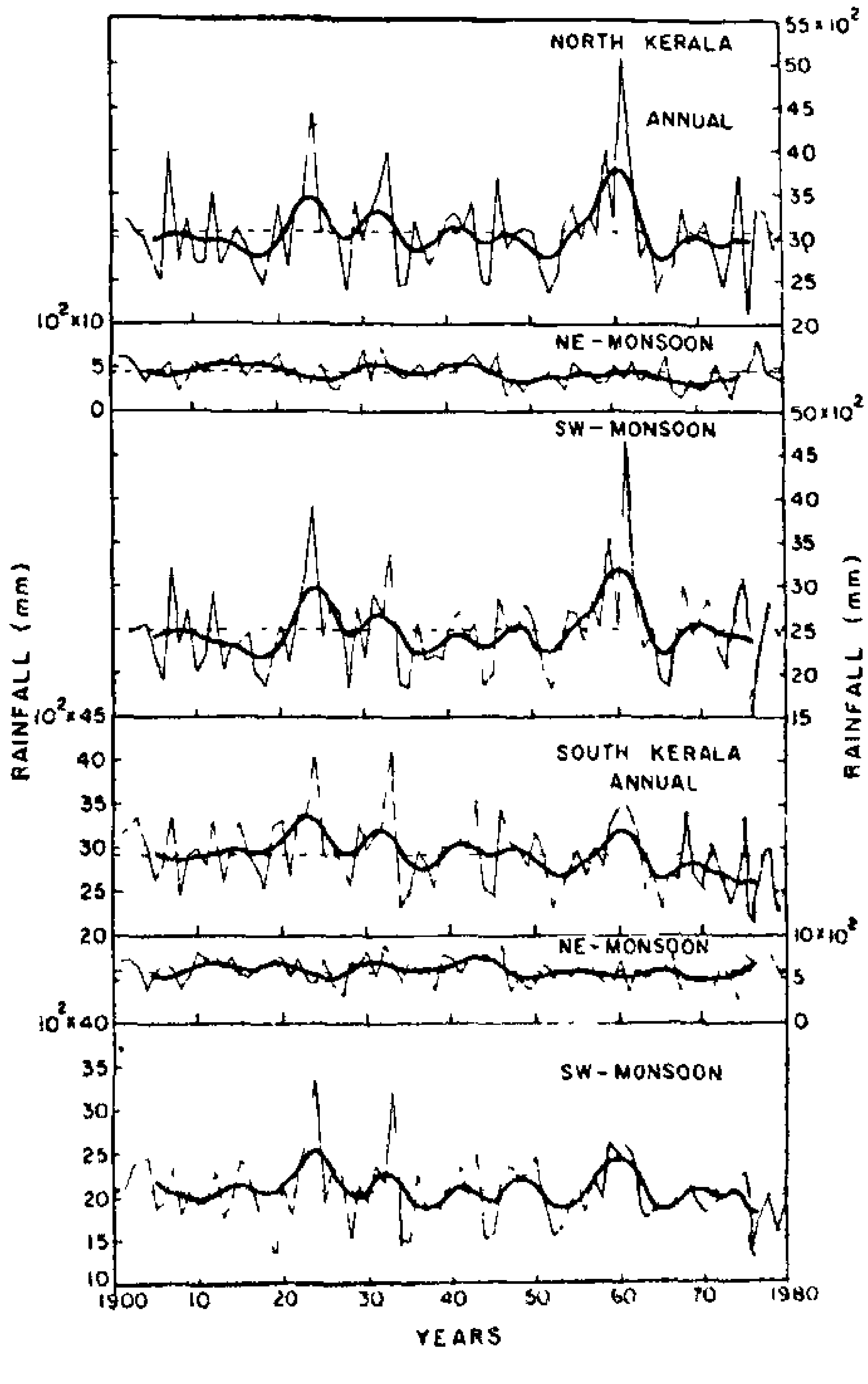

Figure 2. Time series plots of southwest monsoon, northeast monsoon and annual rainfall of north and south Kerala. Thin continuous line indicates variation of actual rainfall values, the thick line the 9-point gaussian low-pass filtered values and the dotted line the mean value.

Kerala is an elongated coastal state with an area of 38,864 km^2 and a coastline of 560 km length (figure 1). The broken line near 10°N divides Kerala into northern and southern halves for the purpose of the present study. The maximum east-west width is about 120 km. The hills of the western ghats form the eastern boundary with isolated peaks rising over 2 km. From the east the terrain slopes at first steeply and later gradually towards the coastal areas bordering the Arabian Sea. The meteorology of Kerala including the annual and seasonal rainfall variations has been discussed by Ananthakrishnan *et al*[1].

Taking north and south Kerala as two units, the annual and extreme (1 to 30-day) rainfalls over these areas from 1901 to 1980 were studied by Singh and Soman[2]. Significant decreasing trend was noticed for south Kerala rainfall but no clear trend was discerned for north Kerala.

Time series of yearly values of : (i) southwest monsoon (May–September) rainfall, (ii) northeast monsoon (October–December) rainfall and (iii) annual rainfall for south and north Kerala are shown in figure 2. These time series are obtained by averaging the rainfall over the raingauge networks of the two regions. The rainfall time series smoothed

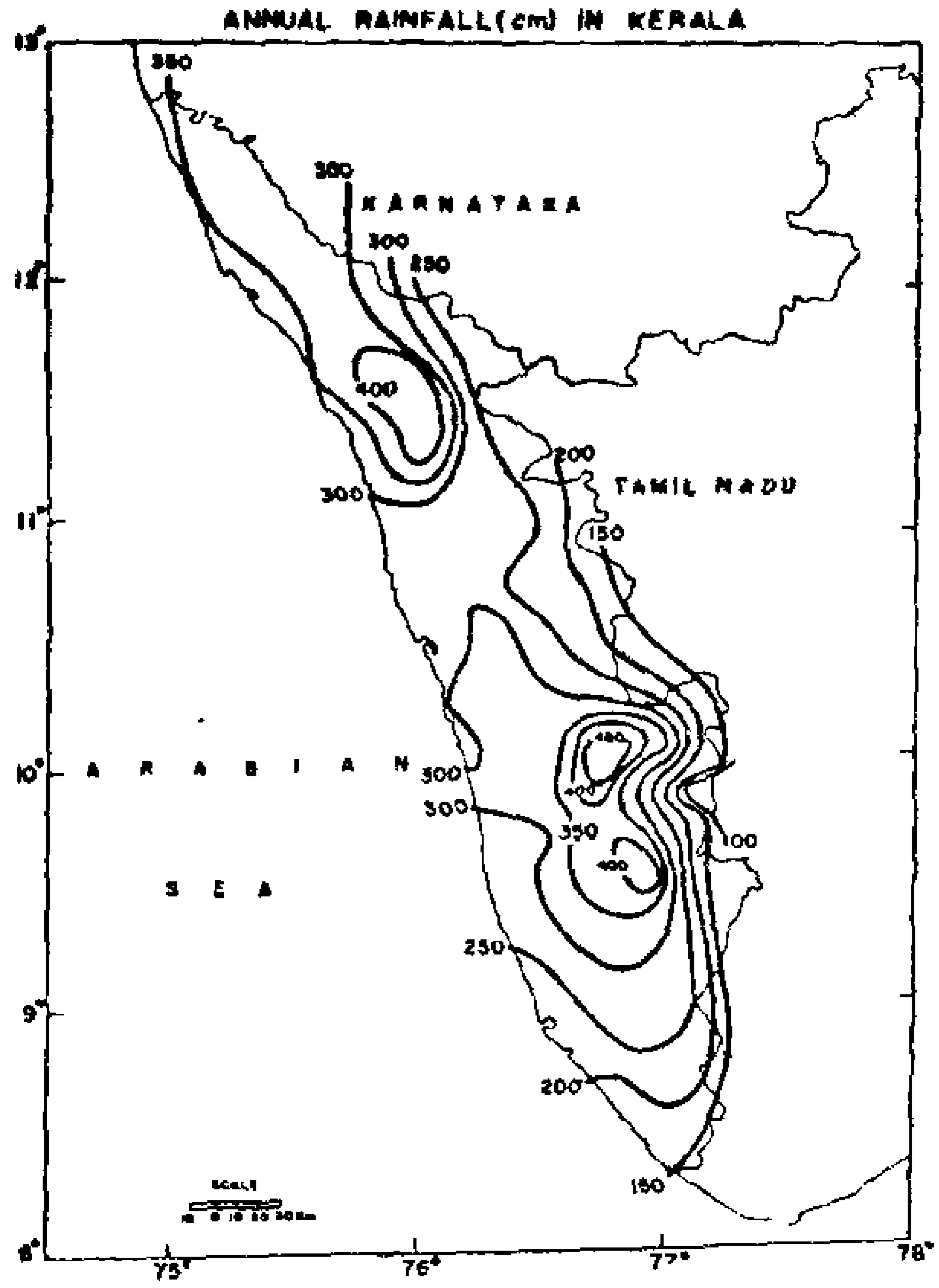

Figure 3. Average annual rainfall distribution in the Kerala state.

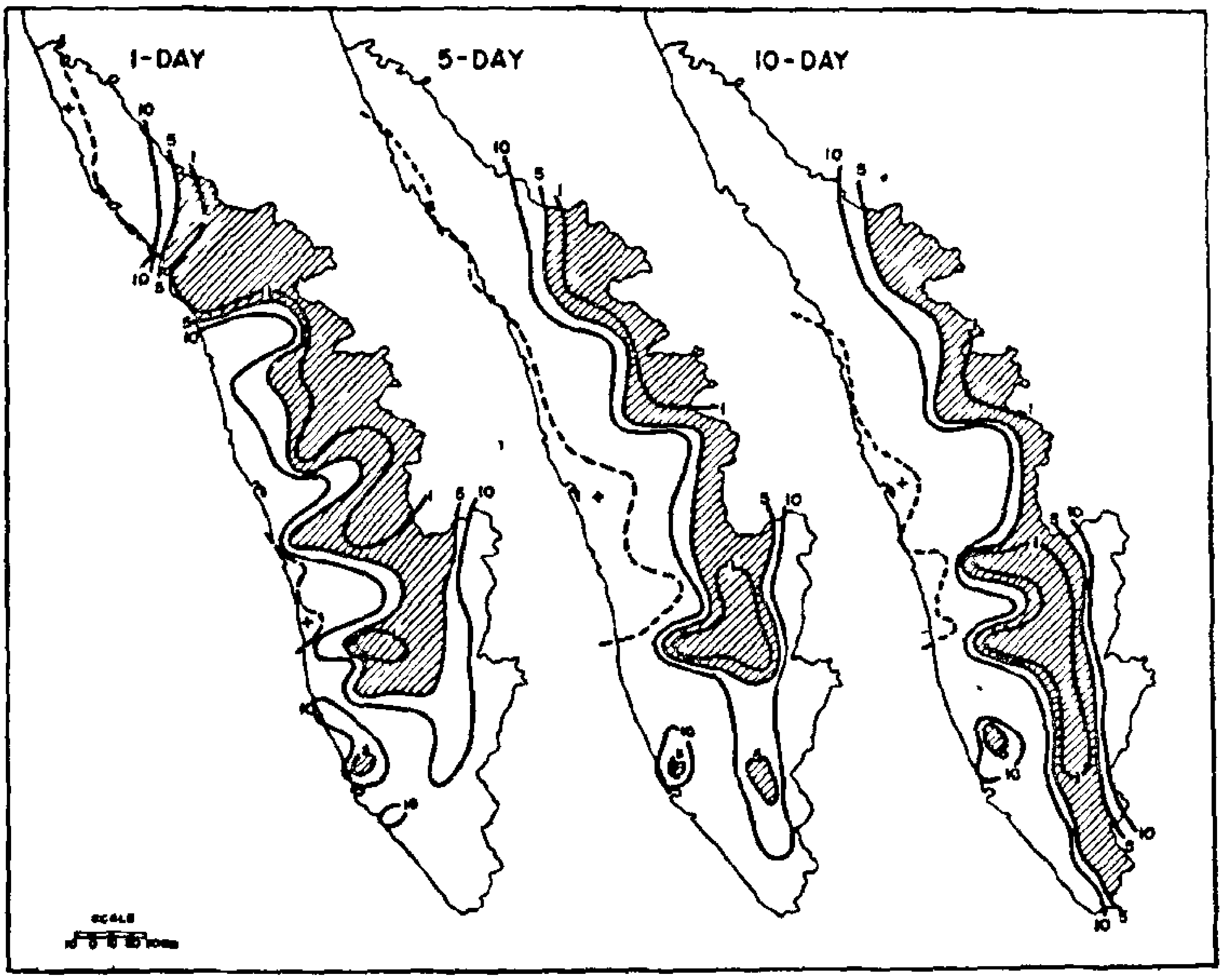

Figure 4A. Isolines of significance level (%) of Mann-Kendall Rank statistic (τ) test for extreme rainfall series of 1,5 and 10-day durations. Shaded area indicates decreasing rainfall trend significant at 5% (or more) level. The broken line delineates the area with slight increasing rainfall tendency.

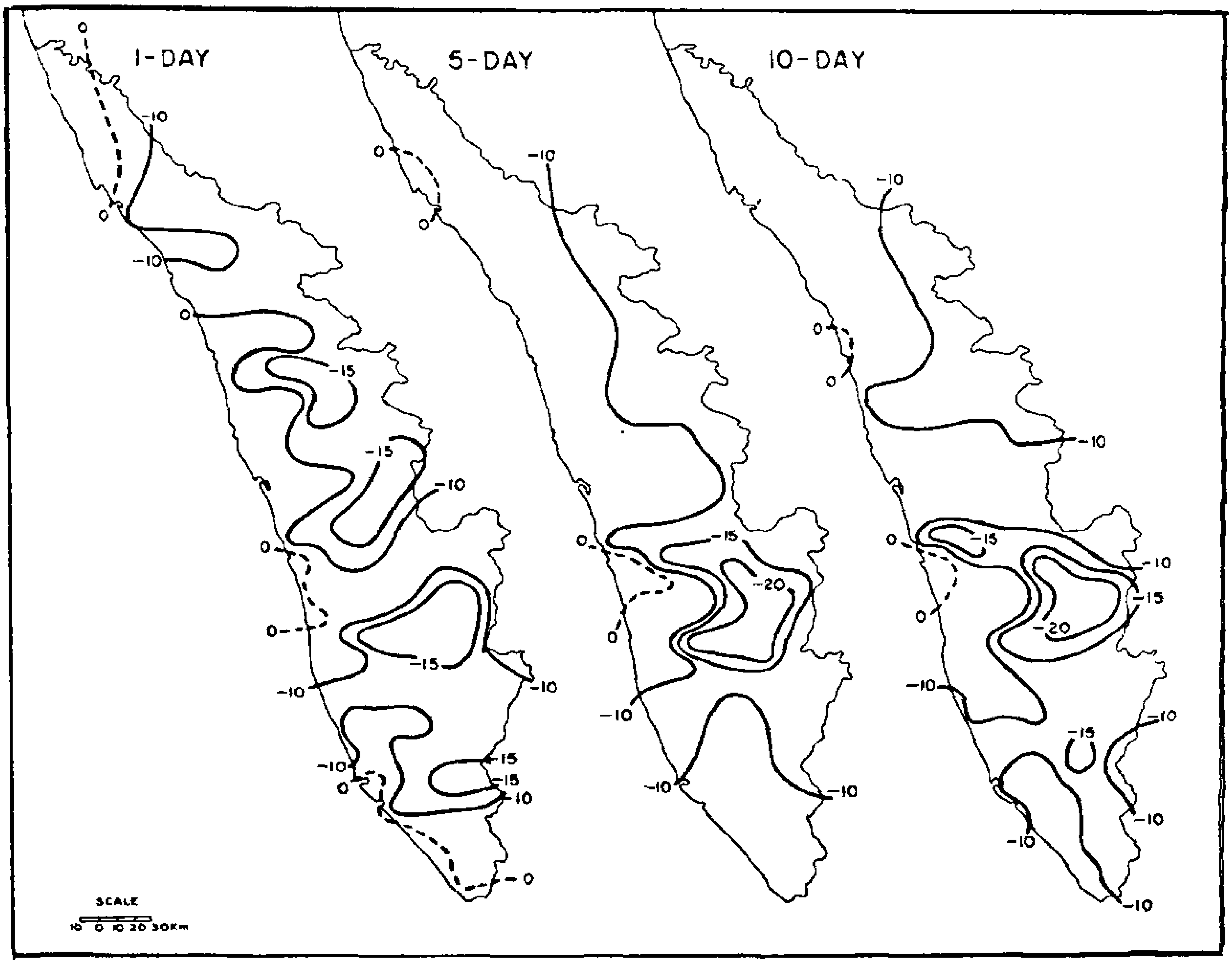

Figure 4B. Percentage decrease in the mean extreme rainfall for 1, 5 and 10–day durations from first half to second half of the data period.

with nine-point Gaussian low-pass filter[3] are shown by thick lines. Analysis of the time series showed a decreasing trend for all the three series of south Kerala; in the case of north Kerala such a trend was conspicuous only for the northeast monsoon rainfall.

The present study is addressed to an in-depth examination of the rainfall behaviour of the individual stations over Kerala, to delineate the areas showing significant decreasing rainfall trend.

DATA USED AND METHODOLOGY

Daily rainfall data of 75 raingauge stations in Kerala (figure 1) from 1901 to 1980 have been utilized in this study. The annual rainfall distribution over the state based on this data is shown in figure 3. The salient features are : (i) decrease of rainfall from north to south along the coastal belt; (ii) increase of rainfall from the coast towards the eastern hills; (iii) two areas of heavy rainfall exceeding 400 cm centred around the hilly tracts of (a) Kottayam–Idikki Districts of south Kerala and (b) Wynad–Calicut Districts of north Kerala.

From the daily rainfall data of individual years the following time series were constructed for each of the stations:–

(i) Annual, southwest monsoon and northeast monsoon rainfall —3 time series for eah station; (ii) extreme rainfall in each year for 1,2,3... 10 day durations—10 time series for each station. (The durations of continuous rainfall associated with active monsoon conditions over Kerala do not generally exceed 10 days[4].)

All the rainfall time series were tested for trend using Mann-Kendall (MK) rank statistic (τ) test[3], which is applicable to detect nonlinear type trend and is not sensitive to the form of frequency distribution.

RESULTS

The results of the study are presented in the form of diagrams which show the areas of decreasing rainfall trends in respect of extreme, seasonal and annual rainfalls.

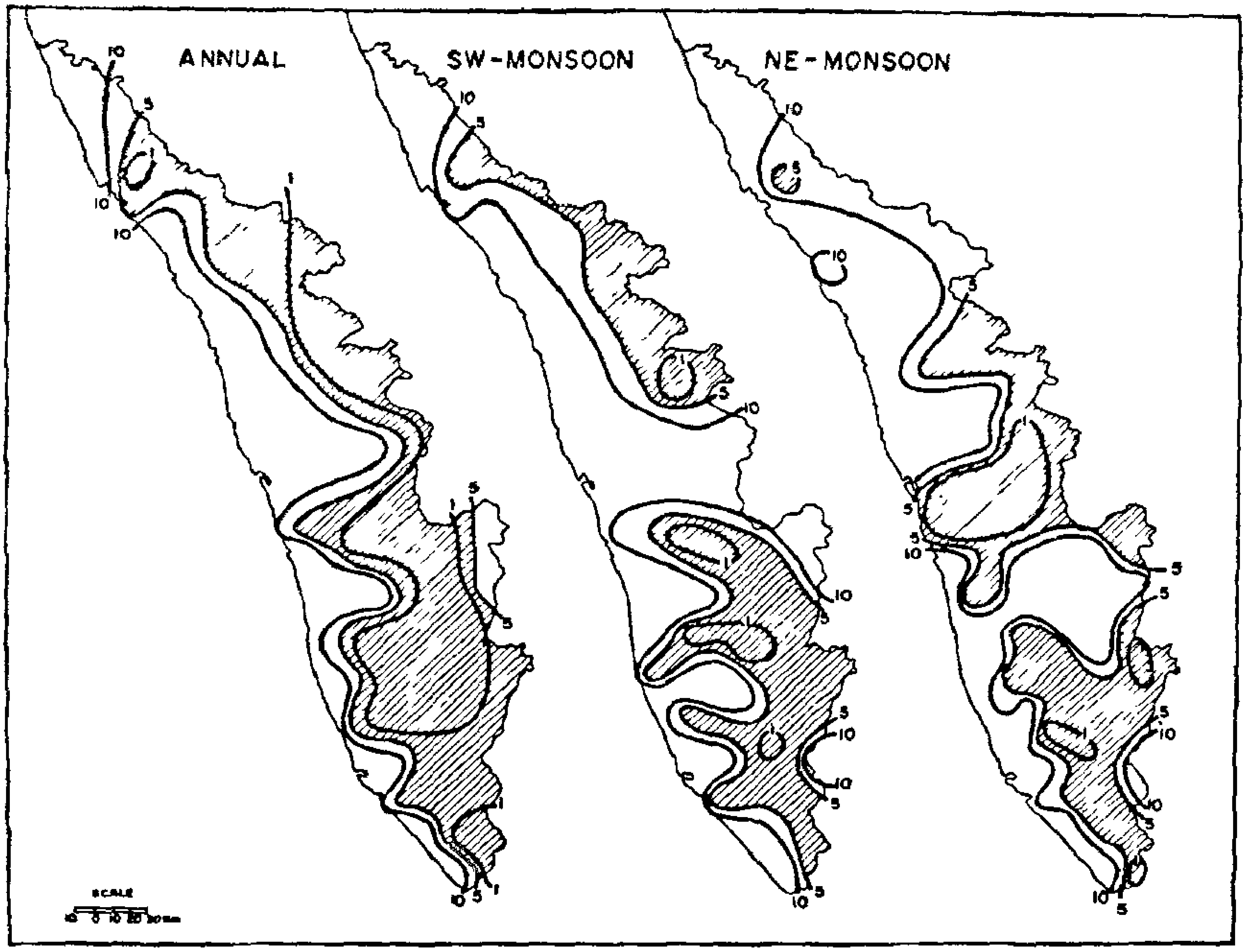

Figure 5A. Isolines of significance level (%) of Mann-Kendall Rank statistic (τ) test for annual, southwest monsoon and northeast monsoon rainfall. The shaded area indicates decreasing rainfall trend at 5% (or more) level.

(a) *Extreme rainfall:*

Areas where the decreasing trend is significant at 1%, 5% and 10% levels according to the MK test are delineated in figure 4A. The three maps in the diagram relate to 1, 5 and 10-day extreme rainfalls. Areas where the decreasing trend is significant at 1% and 5% levels are shaded. Significant decreasing trend in 1-day extreme rainfall is noticed mostly over midlands and highlands of the central parts of the state. Extreme rainfall of 5 and 10-day duration shows decreasing trend (at 5% level) over highland areas except over the northern district of Cannanore.

Figure 4B presents isolines of the percentage decrease in mean extreme rainfall of 1, 5 and 10-day durations in the second half subperiod (1941–1980) as compared to first half (1901–1940). Extreme rainfall for 1-day duration decreased by 10 to 15% over large parts of the state, the decrease being more pronounced over the hill tracts. Over the hills of Ernakulam, Kottayam and Idikki districts of south Kerala the 5 and 10-day extreme rainfalls decreased by 15 to 20%; the decrease is 10% over the adjoining hilly regions of north Kerala. These results agree with the findings of Mann-Kendall test in figure 4A.

(b) *Seasonal and annual rainfalls:*

The isolines of 1, 5 and 10% significance level of τ-test for time series of annual, southwest monsoon, northeast monsoon rainfall are presented in figure 5A. The areas shaded are those with decreasing trend significant at 5% level or more. Significant decreasing trend in southwest monsoon and annual rainfall are noticed over the middle and highland areas of south Kerala and the highlands of north Kerala. The northeast monsoon shows significantly decreasing trend over Trichur and Palghat districts of north Kerala and hills of south Kerala. Rainfall over the coastal regions does not show any trend.

Figure 5B presents the percentage decrease in mean annual/southwest monsoon/northeast monsoon rainfalls in the second half sub-period as compared to the first half. Over the hills of Ernakulam, Kottayam and Idikki districts, the southwest monsoon and annual rainfalls have de-

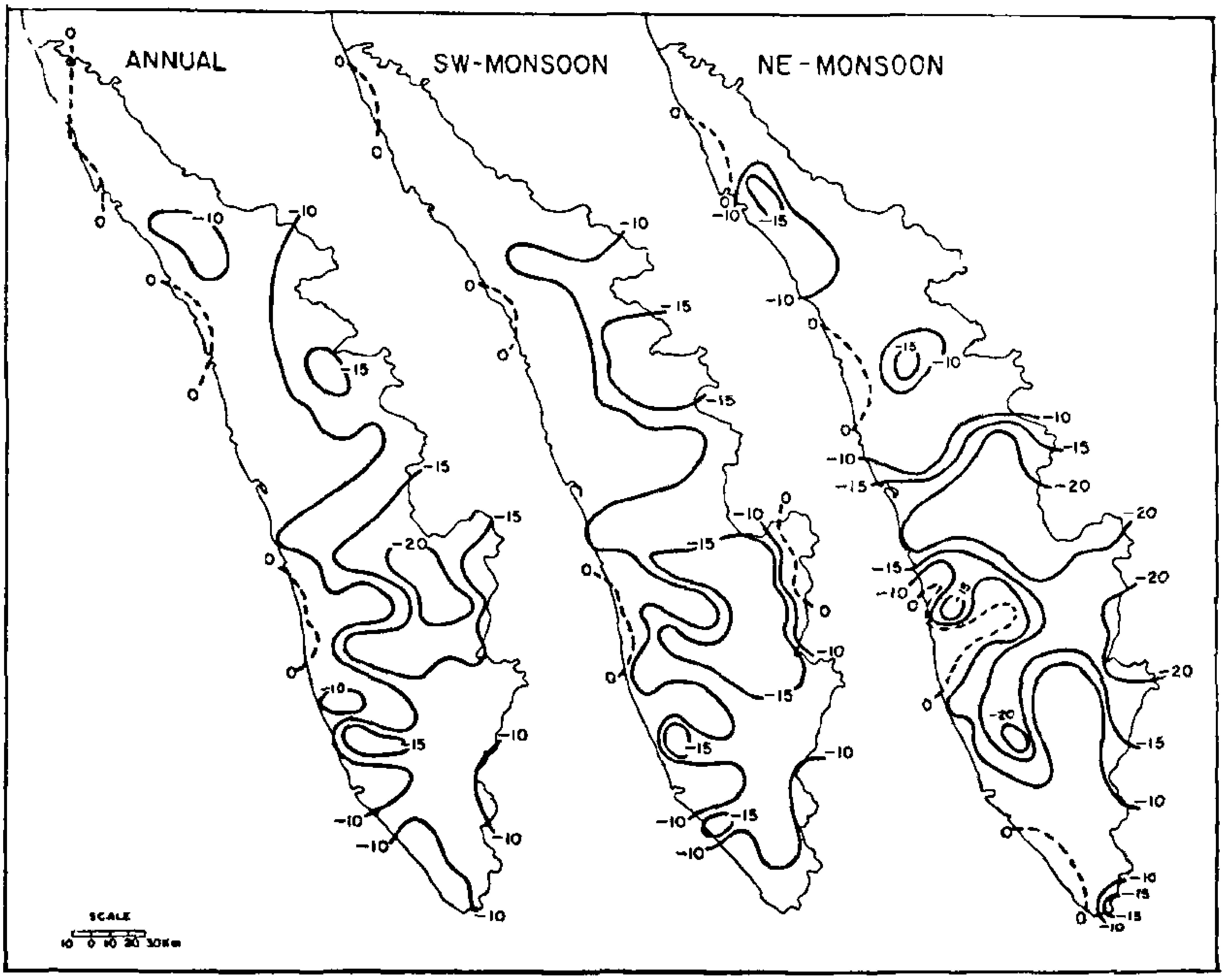

Figure 5B. Percentage decrease in the mean annual, southwest monsoon and northeast monsoon rainfall from first half to second half of data period.

creased by 15–20%. The isoline of 10% decrease covers the entire midland and highland tracts of south Kerala and most of the hill tracts of north Kerala. The maximum decrease of about 20% in the mean northeast monsoon rainfall is noticed over the central parts of the state. Very little change is noticed over the coastal areas.

DISCUSSION AND CONCLUSIONS

The study reveals that over major part of Kerala state barring the Coastal belt, extreme as well as seasonal and annual rainfall has decreased significantly in recent years. The maximum decrease in rainfall has occurred in the highlands which receive more rainfall as compared to lowland and midland areas. The consequence of such decrease in extreme rainfall is a general decline in the severity of flood events; this would also lead to decrease in hydrologically effective rainfall[5] (which is highly dependent upon rainfall intensity), resulting in less rainwater available for recharging the water resources of the area. Decrease of seasonal and annual rainfall over midland and highland areas indicates that climatologically this part of the state has become drier in recent years.

Such changes in rainfall may have association with environmental modifications due to human interventions with natural ecosystems, although the physical mechanisms of the effect of vegetation loss on the climatic condition of a region are not well understood. The decrease in rainfall is maximum over the highlands of the state, where the forest cover is more and most of the hydel projects are situated. Construction of hydel projects, expansion of human settlements, extension of agriculture and plantations towards the east have resulted in appreciable deforestation over the highlands in recent decades. To what extent these activities have contributed towards the observed decrease in rainfall remains to be understood.

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17 August 1987

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ANNOUNCEMENT

SUMMER SCHOOL ON DYNAMICAL SYSTEMS

Miramare – Trieste, Italy.
16th August – 9th September 1988

The International Centre for Theoretical Physics will organize a 4-week Summer School on Dynamical Systems from Tuesday 16th August to Friday 9th September 1988. It will be directed by Professor J. Palis, (IMPA, Rio de Janerio, Brazil), and Professor E. C. Zeeman (University of Warwick, Coventry, UK).

The aim of the Summer School is to introduce participants to the modern theory of dynamical systems, and to survey recent developments and current research problems.

The Summer School will be divided into two parts. The first two weeks will be devoted to elementary lectures on the mathematical prerequisites:

1. Topology; 2. Qualitative ordinary differential equations; 3. One complex variable; 4. Elementary probability and ergodic theory; and 5. Computing and experiments.

The second two weeks will be mainly devoted to the foundations of the subject:

1. Introduction to dynamical systems; 2. Introduction to rational maps and complex flows; 3. Introduction to singularity theory and applications; 4. Introduction to smooth ergodic theory; and 5. Introduction to computational dynamics.

Lectures will be given by: C. Camacho, R. S. MacKay, R. Mañé, J. Palis, P. Sad, E. C. Zeeman.

In addition, the 4th week will honour and celebrate the 65th birthday of René Thom. During this week there will be a number of survey lectures by several eminent mathematicians including R. Devaney, J. Mather, R. Moussu, S. Newhouse, S. Smale, F. Takens, R. Thom, R. F. Williams, J-C. Yoccoz and E. Zehnder.

The Summer School is primarily intended for gifted young mathematicians from developing countries, especially those from African, Asian and Arabian countries. Preference will be given to research students and/or younger applicants, aged 22–35. Some graduate training is preferred (Ph.D., or M.Sc., or the equivalent) but published research is not essential. Applicants are invited to submit either a list of publications, and/or an outline of current work, (at most 2 pages) and/or one or two letters of recommendation. The selection committee will be grateful for any additional information that will help them.

The Summer School will be more elementary than previous Workshops in Dynamical Systems at Trieste, and it is emphasised that previous training in the subject is not essential. A good working knowledge of the English language is essential.

As a rule, travel and subsistence expenses of the participants should be borne by the home institution. However, a limited number of financial grants are available for students and researchers from developing countries, but preference will be given to those who can obtain at least partial travel support from local sources. Travel support is available only to those who attend the entire activity.

The closing date for receipt of requests for participation is **31st January 1988.**

The completed "Request for Participation" forms, should be sent to: **International Centre for Theoretical Physics Summer School on Dynamical Systems, P.O. Box 586, I-34100, Trieste, Italy.**