MAUSAM, **54**, 3 (July 2003), 615-622

551.524.36 : 551.501.724

Estimation of annual and seasonal temperatures over Indian stations using optimal normals

A. K. SRIVASTAVA, P. GUHATHAKURTA and S. R. KSHIRSAGAR

India Meteorological Department, Pune - 411005, India

(*Received 8 January 2002, Modified 8 October 2002*)

सार – प्रारंभिक दीर्घ पूर्वसूचक निदर्शों के अभाव में किसी विशेष स्थान और विशेष रूप से जब किसी स्थान की सूचना पहले से ही वांछित हो, की मौसम स्थितियों के आकलन, को करने के लिए जलवायु नार्मलस् का प्रयोग प्रायः किया जाता है। सामान्यतः 30 वर्षों के विशेष आँकड़ों की निकाली गई औसत से परिकलित जलवायु नार्मलस् यह स्पष्ट संकेत देते हैं कि जलवायु की कोई प्रवृति नहीं है और यह औसत स्थानों और मौसम के सभी घटकों का सर्वोत्तम आकलन होगा। इस अध्ययन का उद्देश्य हाल ही के आँकड़ों की कम संख्या पर आधारित नार्मलस् की तुलना में 30 वर्षों के नार्मलस् की परम्परा की उपयुक्तता का परीक्षण करना है।

इस अध्ययन में पहले के आँकड़ों की लम्बी श्रृंखला के परिवर्ती वर्ष एन. (1≤ एन. ≤ 30) के लिए देश के पच्चास सुवितरित स्टेशनों के अधिकतम और न्यूनतम तापमान मानों के मौसमी और वार्षिक नार्मल्स का आकलन किया गया है। आगामी मौसम/वर्ष के वार्षिक और मौसमी माप के उपर्युक्त मौसम वैज्ञानिक प्राचलों का आकलन करने के लिए विभिन्न अवधियों के नार्मलस् के आर.एम.एस. का आकलन किया गया है। हाल ही के महत्वपूर्ण कुछ कम वर्षों की औसत को जब निकाला गया तो बहुत से मामलों में आर.एम.एस. त्रुटियाँ न्यूनतम पाई गई थीं। न्यूनतम आर.एम.एस. त्रुटियों के साथ तालमेल रखने वाले नार्मलस् को इष्टतम नार्मलस् माना गया है और उनमें तीस वर्षों के पारम्परिक नार्मलस् की बजाय आकलन करने की कुशलता अधिक पाई गई है।

ABSTRACT. In absence of long lead predictive models, climate normals are often used to estimate weather conditions of a particular place and more so in the case when it is desired well in advance. Usually, calculated by averaging the data of specified 30 years, the climate normals give a picture that climate has no trend and this average would be the best estimate of places and for all weather elements. This study aims to examine the suitability of the traditional 30 years normal *vis-a-vis* normal based on small number of recent data.

In the present study seasonal and annual normals for maximum and minimum temperature values for fifty well distributed stations over the country have been calculated for varying years N (1≤N≤30) over the long series of past data. RMS errors for estimating the above meteorological parameters on annual and seasonal scale for the next season/year were calculated for different periods normal. It was found that in many cases RMS error was minimum, when the averaging was done for a considerably smaller recent years. The normals corresponding to the minimum RMS error are called optimal normals and have better estimative skill than the thirty years traditional normals.

Key words – Optimal normal, RMS error, Maximum temperature, Climate.

1. Introduction

Climate normals, calculated by averaging the values of meteorological, parameters over a specified thirty year period (as per WMO recommendation), and updated at the start of each decade provide normal meteorological data over a place or region. These are useful in many long term planning applications such as crop choices, agricultural practices, utility rates etc. Moreover, WMO normals, (due to uniformity of the period) are scientific tools for studying/examining climate variability and detecting signals of climate change in different spatial regions and time segments across the globe. However, inspite of all the advantages of 30-year WMO recommended normals and uniformity in universal usase, they may not always provide the best climate estimate of all places and for all weather elements. There are several studies which suggest that normal based on thirty years have less predictive

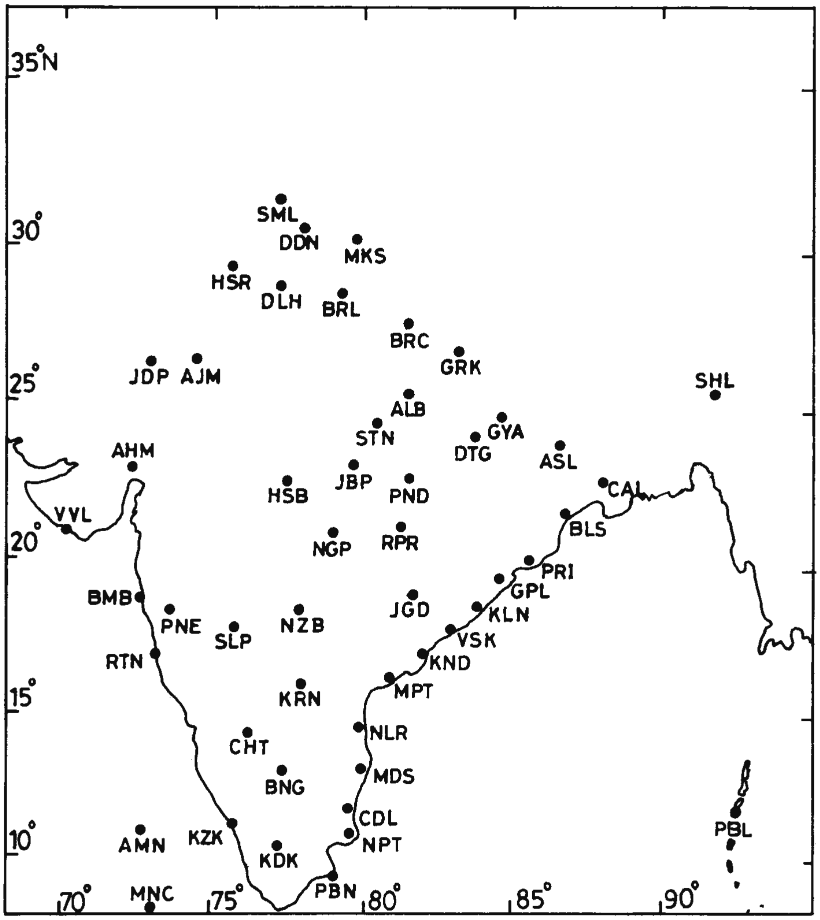

Fig. 1. Stations used in the study

skill than the average over most recent '*n*' years where *n* < 30. [(Lamb and Changnon (1981), Dixon and Shulman (1984), Kunkel and Court (1990), Huang *et al*. (1996)]. Moreover, aging of the WMO normals has also been indicated by Angel *et al*. (1993).

In the present study, averages of annual and seasonal maximum/minimum temperature values for Indian stations were calculated for varying 'N' years ($1 \leq N \leq 30$) over past data. Root mean square (RMS) errors for estimating above mentioned meteorological parameter on annual/seasonal scales by averaging varying, 'N' years ($1 \leq N \leq 30$) were calculated. It was found that in many cases error was minimum when the averaging was done on the immediate past data for a period which was considerably smaller than the WMO specified 30 year period. The normals corresponding to the minimum RMS error are defined as optimal normals and have better predictive skill than the traditional WMO recommended normals.

It is apparent that the optimal normals obtained in the above way acts as a low-pass filter, finding a characteristic time scale of variability and identifying the associated signal. Moreover, optimal normal provides an estimation with sufficient lead time which varies from minimum eight months for the monsoon season to one year for annual estimation.

2. Data and methodology

Monthly data of maximum and minimum temperatures of all the 12 months of the year for well distributed fifty Indian stations (Fig. 1) for the period 1931-1990 obtained from the records of India Meteorological Department, were used in the study. From the monthly values of temperatures, annual and seasonal values *viz.* winter (average of January and February

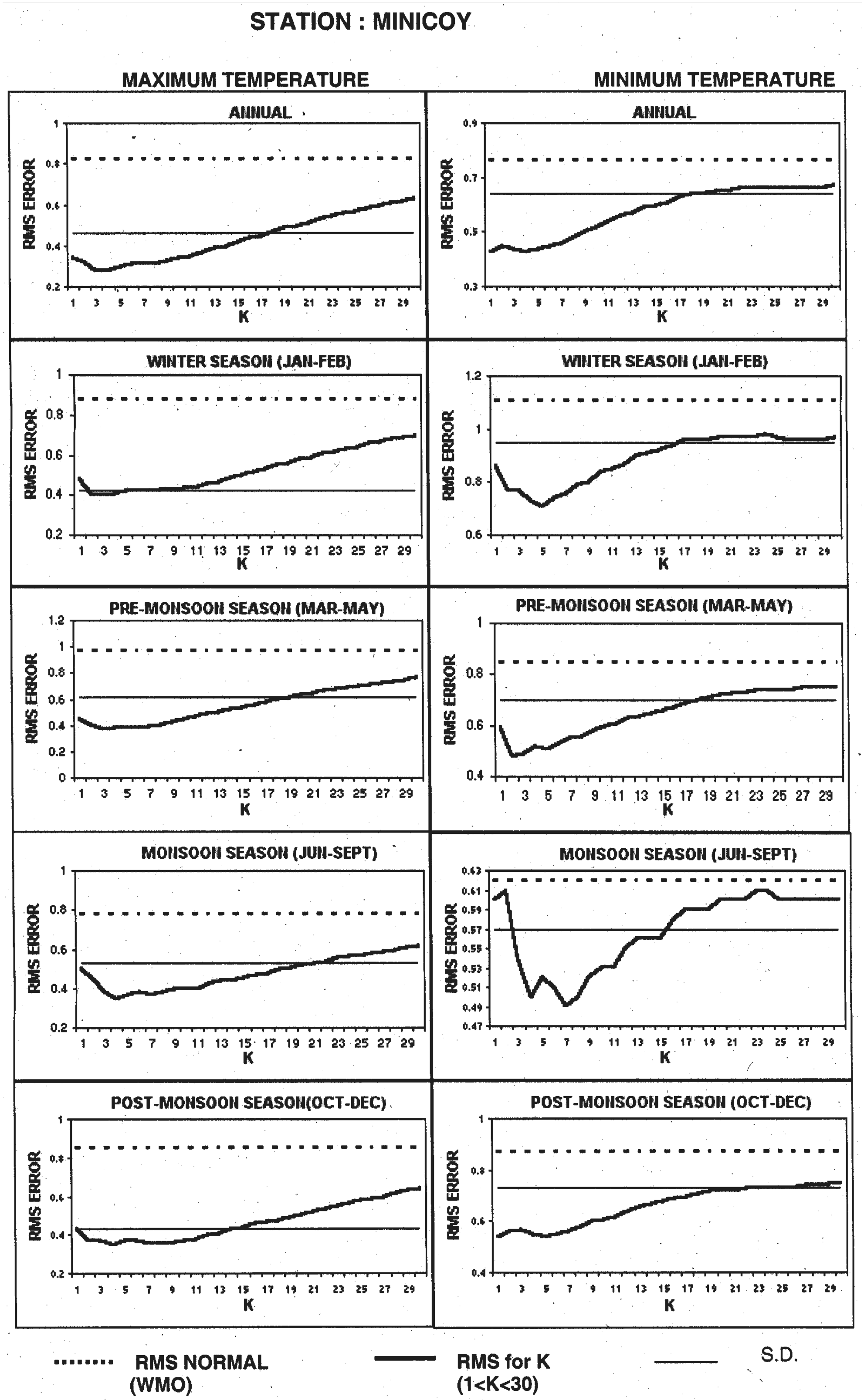

Fig. 2. RMS errors of WMO 30 years normals *vis-à-vis* RMS errors of normals calculated by averaging recent varying years 'K' (1<K≤30)

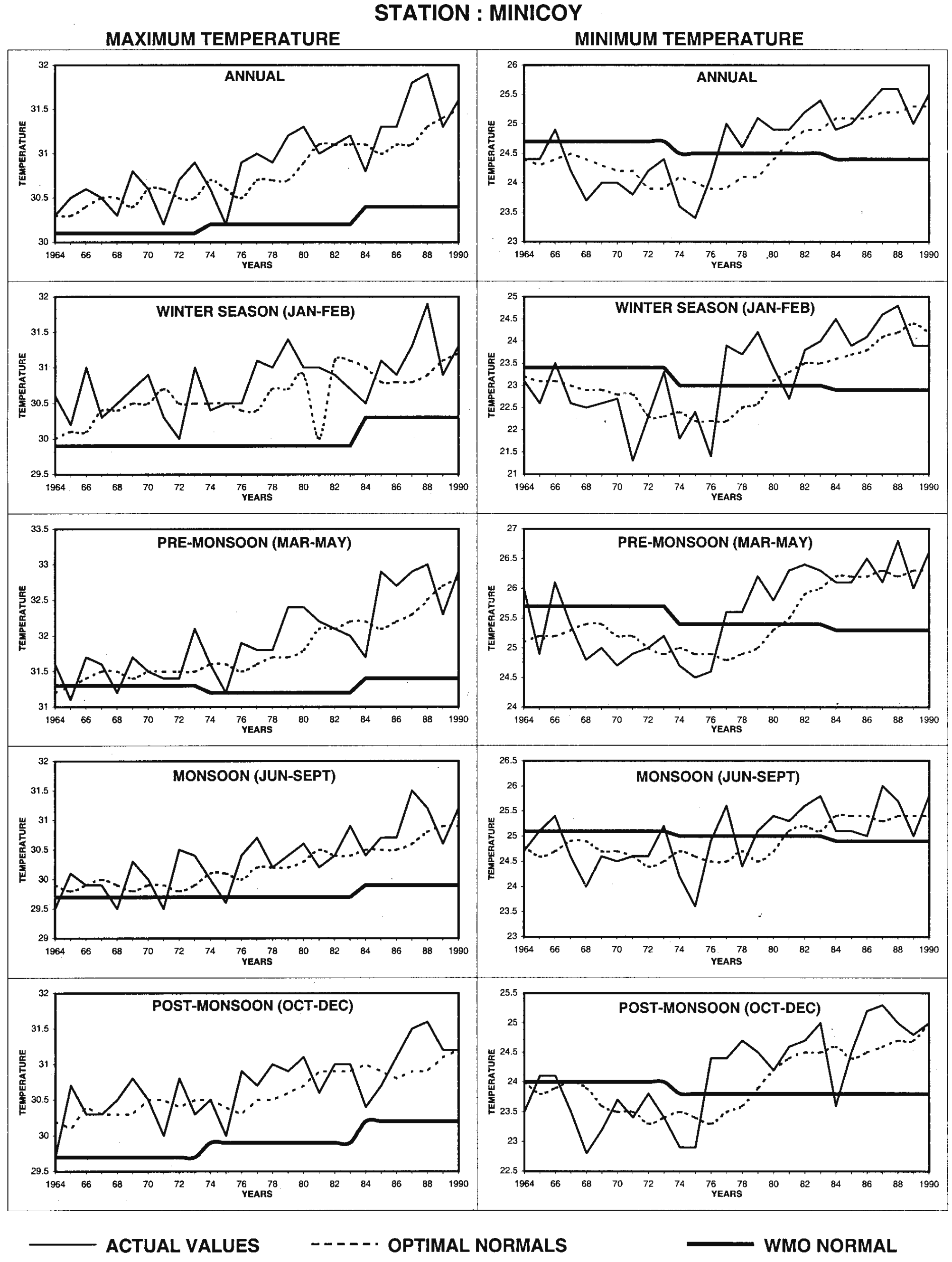

Fig. 3. Variation of optimal normals corresponding to the k=5 *vis-à-vis* WMO normals

months), pre-monsoon (average of March, April and May months), monsoon (average of June, July, August and September months) and post-monsoon (average of October, November and December months) seasons were calculated.

Further, the annual and seasonal values of maximum/ minimum temperatures of each station from the year 1964 onwards were estimated through (*i*) fixed and specified 30 year WMO normals and (*ii*) averages of varying 'k' ($1 \leq k \leq 30$) years on immediate past data and RMS errors for both the estimations were calculated in the following way;

For the time series T_i, i = 1, 2, , n for a particular season at yearly intervals for n year, a second series of

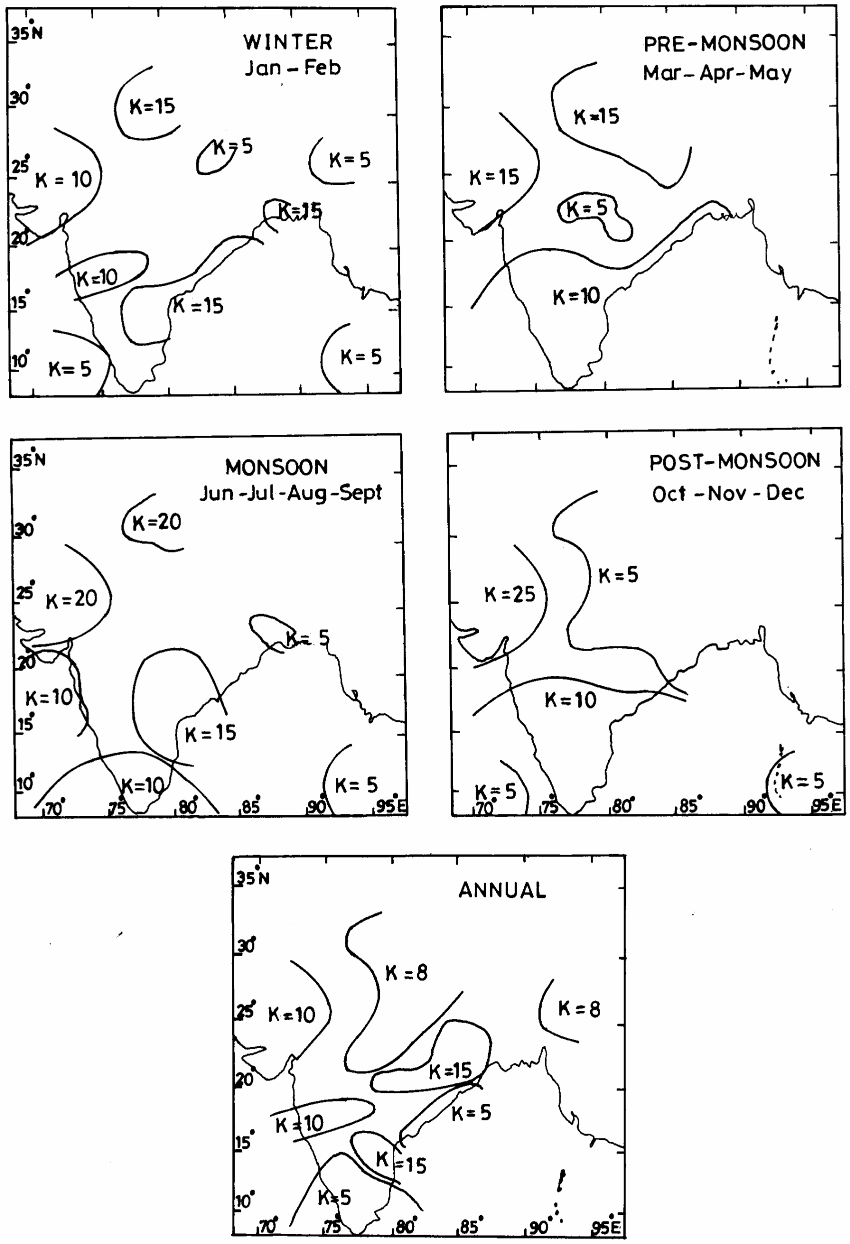

Fig. 4. Demarcation of different regions as per different '*K*' values (maximum temperature)

backward looking averages $\overline{T}_{ik}$ was constructed in the following way:

$$\overline{T}_{ik} = \frac{1}{k}\sum_{j=1}^{k} T_{i-j} \qquad (1)$$

For k = 1, 2……. 30, and for i = 31, 32………..,n. In this study n = 60 as the data of 1931-1960 period were used. The k-index represents the number of years over which the climate average is calculated.

Further, with the help of above/similar series prepared for each season of every station, averages for each value of k are used to estimate the upcoming year's, seasonal/annual values of maximum and minimum

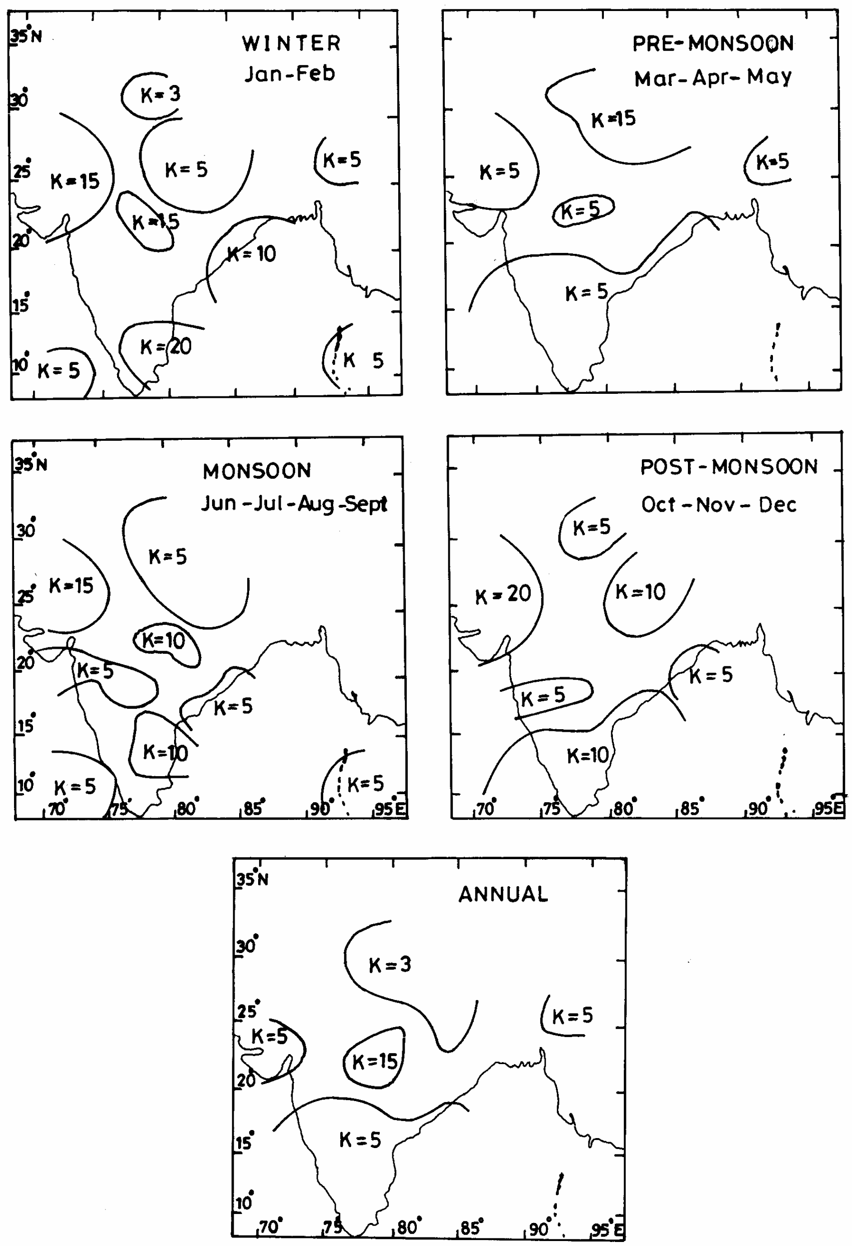

Fig. 5. Demarcation of different regions as per different '*K*' values (minimum temperature)

temperatures for the period 1964-1990 *i.e.* from i = 34 corresponding to the year 1964 and onwards. More elaborately, values for the year 1964 were estimated by the values of 1963, (1963 + 1962)/2, (1963 + 1962 + 1961)/3, ….. (1963 + …..+ ….. + ….. + 1963-k+1)/k and similarly for the other years.

Again, annual/seasonal values of temperatures (maximum and minimum) of all the stations from the year 1964 onwards were estimated with the help of specified 30 year WMO normals. 30 year normals are usually computed/updated after the end of each decade and since it takes atleast 3 years for updating the thirty year normals for estimating annual/seasonal values through WMO specified 30 year, normals following data were used;

Year of estimations of maximum and minimum temperatures by WMO normals	*30 year data period used for making WMO normals*
1964-1973	1931-1960
1974-1983	1941-1970
1984-1990	1951-1980

Further, RMS error in respect of k index normals and WMO specified normals was calculated as given below:

RMS error of varying averages,

$$\mathrm{RMS}(k) = \sqrt{\frac{\sum_{i=34}^{n} \left(T_0 - \overline{T}_{ik}\right)^2}{n-34+1}}$$

RMS error in respect of specified thirty years normals (WMO normal)

$$\mathrm{RMS(W)} = \sqrt{\frac{\sum_{i=34}^{n} \left(T_0 - T_{\mathrm{WMO}}\right)^2}{n-34+1}}$$

Where T_0 (actually it is T_j) is observed meteorological parameter (temperature in this study).

Optimal normals are obtained by averaging of the most recent k years corresponding to the lowest RMS(k).

3. Results and discussion

Fig. 1 presents the names and locations of the stations which have been used in the study. Results depicting RMS of 30 year normals *vis-a-vis* RMS for varying K year averages in estimating annual/seasonal maximum and minimum temperatures for Minicoy is shown in Fig. 2. It may be seen that for both the maximum and minimum temperatures, RMS errors for varying k averages on immediate past data were less than the RMS of specified 30 year normals for all K, where, $1 \leq K \leq 30$, for all the seasons. This difference is quite appreciable when K is less than 10. This indicates that the annual and seasonal maximum/ minimum temperatures for any year i, may be estimated in a better way if the averaging is done on 10 immediate past values starting from i-1 year. This skill is maximum when k is around 5. To have a better insight, the variation of optimal normals corresponding to the k = 5 *vis-a-vis*, WMO normals and the actual time series for both the maximum and minimum temperatures for all the seasons for Minicoy is given in Fig. 3. It may be further observed that the estimated values of the actual time series by the optimal normal corresponding to the k = 5 (*i.e*. by the averaging of immediate five values) are more closer to the actual time series than the 30 year WMO normals, indicating a very positive skill.

Figs. 4 and 5 show the demarcation of different homogenous regions during the different seasons as per different *Ks*, averaging over the corresponding recent K years has a better skill than the traditional 30 years normal for maximum and minimum temperatures. It is mentioned that even for a particular homogenous region, K values (corresponding to the minimum RMS) for different stations were slightly different. We have selected a common K value for the sake of simplicity and operational use and averaging over corresponding K years for all stations of region had still a better skill than the traditional 30 year normals. In the present study, we have objectively defined the skill when the difference between 30 years averages and K years averages was found to be more than one fifth of the standard deviation. However, this demarcation has not been done by iso-analysis. Therefore, for the stations lying between the lines boundary of two *Ks*, no such inference could be drawn. Or, in other words, we could not find a smaller K value having a better skill for those stations. It is interesting to find that the peninsular India and the stations of eastern coast have a smaller K value (much less than the thirty) for all the seasons and where the skill was quite appreciable. In many cases, RMS was found to be even less than the standard deviation.

It may be mentioned here that use of optimal normals may be limited and is rather restricted to the estimation of next year's seasonal and annual values of meteorological parameters for the immediate use.

4. Conclusions

For estimation of annual and seasonal temperatures optimal normals by averaging most recent ‘n’ years, where ‘n’ is considerably smaller than thirty, cou1d be found out. These normals generally have better predictive skill.

Acknowledgements

We express our sincere gratitude to Dr. U.S. De, ADGM(R) for his encouragement and guidance. We thank Mrs. Chandrachood for typing the manuscript. Thanks are also due to Shri C.N. Shaligram and Shri S.W. Sonparote for graphics work.

References

Angel, J., R., Easterling, W. E. and Kirtsch, S. W., 1993, "Towards defining appropriate averaging periods for climate normals", *Climatol. Bull*., **27**, 29-44.

Dixon, K. W. and Shulman, M. D., 1984, "A statistical evaluation of the predictive abilities of climatic averages", *J. Appl. Meteor*., **23**, 1542-1552.

Jin, Huang, Van Den Dool, Huug, M. and Barnston, A. G., 1996, "Long-lead seasonal temperature prediction using optimal climate normals", *J. of Climate*, **9**, 809-817.

Kunkel, K. E. and Court, A., 1990, "Climate means and normals-A statement of the American Association of State Climatologists (AASC)", *Bull. Amer. Meteor. Soc.* , **71**, 201-203.

Lamb, P. J. and Changnon, S. A., 1981, "On the "best" temperature and precipitation normals: The Illinois situation", *J. Appl. Meteor*., **20**, 1383-1390.