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On forecasting daily summer maximum temperature at Madras

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सार — मद्रास के ग्रीष्म कालीन (मार्च-मई) दैनिक अधिकतम तापमानों का पूर्वानुमान लगाने के लिए सांख्यिकीय तकनीकों पर आधारित पूर्वानुमान स्कीमों का विकास किया गया है। क्रमगत उन्नत स्क्रीनिंग के प्रयोग द्वारा बहुत से प्राचलों में से अनुकूलतम संख्या में पूर्वसूचकों के सैट का चयन किया गया। 24 और 9 घंटे के प्रमुख कल खंडों द्वारा मद्रास शहर और इसके हवाईअड्डे के लिए 12 वर्षों के आंकड़ों से विशिष्ट पूर्वानुमान स्कीमें तैयार की गई हैंऔर 4 वर्षों के एक स्वतंत्र नमूने पर इनका परीक्षण किया गया है। मद्रास में 900 hPa है. पा. स्तर पर पिछले दिन का अधिकतम तापमान, सामान्य दैनिक अधिकतम तापमान, तापमान अभिवहन सूची और प्रातःकालीन क्षेत्रीय पवन चुने गए पूर्वसूचकों में से हैं। इन स्कीमों के अच्छे परिणाम निकले और 77 से 87 प्रतिशत तक सही पूर्वानुमान तथा 0.29 से 0.57 अंकों तक एकदम सही पूर्वानुमान प्राप्त हुए हैं।

ABSTRACT. Forecasting schemes based on statistical techniques have been developed to forecast daily summer (March-May) maximum temperatures of Madras. A set of optimal number of predictors were chosen from a large number of parameters by employing stepwise forward screening. Separate forecasting schemes for Madras city and airport, with lead time of 24 and 9 hr were developed from the data of 12 years and tested in an independent sample of 4 years. Maximum temperature of the previous day, normal daily maximum temperature, temperature advection index and morning zonal wind at Madras at 900 hPa level were among the predictors selected. The schemes yielded good results providing 77-87% correct forecasts with skill scores of 0.29-0.57.

Key words- Maximum temperature, Prediction, Persistence, Advection, Screening regression, Forecast.

1. Introduction

Madras located on India's eastern coast at 80.2°E, 13.0°N is the fourth largest city of India besides being the capital city of the state of Tamil Nadu. It experiences a slightly different climate compared to most of the other cities of India in that it comes under the climatic classification '*As*' (Trewartha 1968), with winter rainfall more predominant than summer rainfall. In the premonsoon months of March, April and May it experiences a hot and humid summer but records slightly lower temperatures even when compared to the stations of interior Tamil Nadu located in southern latitudes. The obvious reason for this is the phenomena of sea breeze which is an important mesoscale weather event in Madras in summer. Considerable amount of public and media attention is focussed on maximum temperature of Madras in the summer months due to its influence on human comfort. Further, maximum temperature likely to be realised on a day is an important weather parameter in aviation as high temperatures affect the load factor of aircrafts. In the present study an attempt has been made to evolve an objective forecasting scheme based on statistical techniques to forecast the summer maximum temperature of Madras, which besides being an interesting problem is relevant as well to the needs of the public and user agencies of meteorological services.

The local rate of temperature $\partial T/\partial t$ is given by,

$$\frac{\partial T}{\partial t}=\frac{1}{C_p}\frac{\partial H}{\partial t}-\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)-(\gamma_d-\gamma) \quad (1)$$

(Haltiner and Martin 1957), where $\partial H/\partial t$ is the non-adiabatic heating/cooling rate, γ_d and γ the dry adiabatic and environment lapse rates with other notations having usual meaning. From the above equation it is evident that temperature of a place at any time t and so maximum and minimum temperatures are controlled mainly by incoming and outgoing radiation, horizontal temperature advection, lapse rate and vertical velocity. However, altitude, topography, proximity to sea or large lakes affect the extreme temperatures of a place in a profound way and perhaps this is the reason

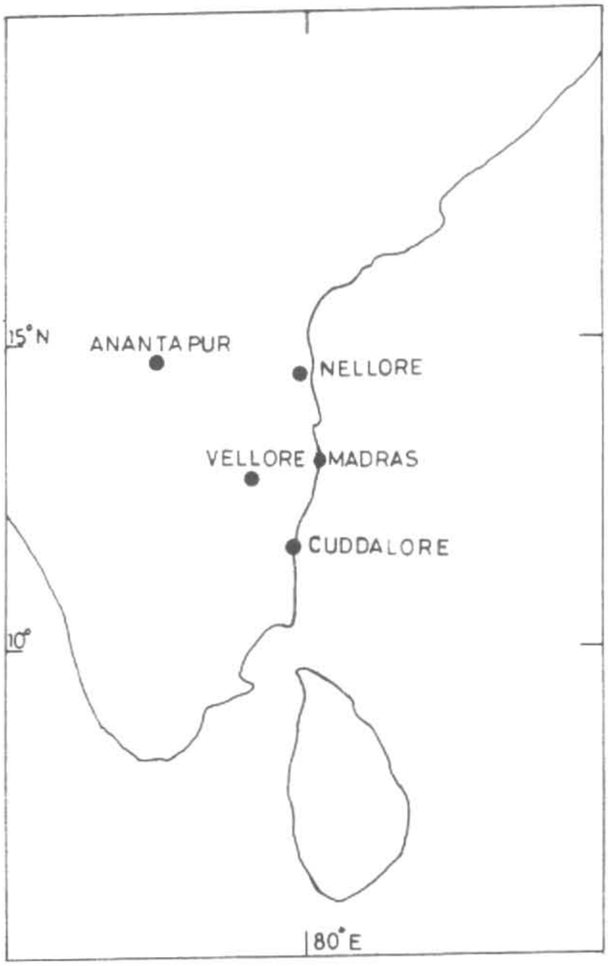

Fig.1. Locator map of stations under study

why forecasting schemes for maximum or minimum temperatures are based on statistical techniques rather than dynamical methods.

In India studies on maximum and minimum temperature forecasts have been carried out by Banerji *et al.* (1972), Raghavendra (1956), Sinha (1957), Singh and Jaipal (1983) and Raj (1989) etc. Srinivasan and Hashim (1967) in a study on daily maximum temperature of Madras derived a forecasting scheme based on graphical techniques. Ramakrishnan and Jambunathan (1958) studied the relationship between sea breeze and maximum temperature at Madras. Natarajan (1964) studied the hot days of Madras based on 88 years of data. Klein and Hammons (1975) suggested more than 50 parameters as potential predictors in a forecasting scheme for maximum/minimum temperatures. Kendall and Stuart (1968), Panofsky and Brier (1968) and WMO (1966) provide detailed description of various forecasting techniques based on statistical methodology including the widely used technique of multiple regression. A detailed description of the climate of Madras is provided in Gupta and Jayanthi (1991).

2. Methodology

2.1. *Formulation of forecasting schemes*

Summer maximum temperatures are realised in Madras generally in the afternoon at about 1400 hr local time. The maximum temperature realised say for n-th day is included in the surface data of $(n+1)$th day for the purpose of archival. Thus maximum temperature corresponding to, say, 15 May is infact realised on the afternoon of 14 May and is recorded at 1730 IST. (The timings in this paper are in IST only). As such, it is appropriate to develop a 24 hour forecast scheme to forecast at 1730 the maximum temperature of the next day. The forecast lead time will only be 21 hour, as the maximum temperature is generally reached at about 1400. It is also proposed to develop a very short-range forecast scheme to forecast at 0830 the maximum temperature to be

TABLE 1
Data used in the study

S.No.	Station(s)	Type of data	Time of observation (IST)
1.	Madras, Madras A.P., Nellore, Anantapur, Vellore, Cuddalore	Maximum and minimum temperatures	0830 & 1730
2.	Madras, Madras A.P.	Temperature, Dew-Point, Cloud	0830 & 1730
3.	Madras A.P.	Upper wind & temperatures at 1000, 950, 900 &850 hPa levels	0530 & 1730

(Period of data: 1 March - 31 May, 1971-85 & 1995)

realised on the same day, the scheme based on the morning data of 0530 and 0830 besides that of previous day. This forecast will be termed as 9 hr forecast with an actual validity period of around 6 hr.

Madras for a long period of time has been served by two meteorological observatories, one located at Nungambakkam and the other at Meenambakkam. The former located approximately 3 km from the coast is taken to represent Madras city and the later located southwestwards close to the Airport (A.P.) is taken to represent suburbs of Madras. This observatory takes upper air observations also. It is proposed to develop forecasting schemes for the maximum temperatures of both these locations separately. As such four schemes will be developed—24 hr and 9 hr schemes for Madras (city) and Madras A.P. Fig. 1 presents the geographical location of Madras and Madras A.P.

2.2. *Selection of parameters with possible predictive value*

The success or otherwise of a forecasting scheme depends to a large extent on the correct choice of predictors besides the application of suitable methodology. As maximum temperature is a parameter observed daily, persistence in the series of observations is an important feature and this suggests the observations 1,2,...days before as possible predictors (PP). For 24 hr forecast the dew point temperature and amount of clouding also could be considered as PPs as these have obvious influence on the outgoing longwave radiation (OLR) during the night and so the heat balance of the atmosphere. The minimum temperature observations recorded prior to the time of issue of forecast also are likely to be related to the maximum temperature. The advection of temperature as shown in section 2 is an important mechanism in the variation of temperature. To compute this parameter we choose four observatories, *viz*., Nellore, Anantapur, Vellore and Cuddalore, located N, NW, W and S of Madras (Fig.1). For 9 hr forecast which is issued in the morning the winds at lower level at Madras could be expected to exercise influence; so are upper air temperatures over Madras.

It is thus evident that a large number of parameters could be PPs and that some preliminary computations and analysis are to be carried out to select the PPs from amongst the various parameters.

3. Data

Most of the data used in the study was supplied by National Data Centre, India Meteorological Department, Pune in computerised form. For Madras and Madras A.P. the surface data at 0830 and 1730 and also the data set giving maximum and minimum temperatures for the 92 day and 15 year period of 1 March to 31 May for 1971-85 were obtained. For the four stations, *viz*., Nellore. Ananatapur, Vellore and Cuddalore, maximum and minimum temperature data alone were taken. Upper air data over Madras, *viz*., wind, temperature and dew point temperature, were obtained up to 850 hPa isobaric level. Table 1 presents the details of data used in the study.

Missing data observations in the various data sets were extracted from publications such as Indian Daily Weather Report, Regional Daily Weather Report or from the records available at Regional Meteorological Centre, Madras. The observations which still remained missing were substituted by their normal values or were interpolated. However, data of the predictands, *viz*., maximum temperatures of Madras and Madras A.P., were all observed values only. As normally done in statistical forecasting schemes, development period (DP) and test period (TP) were defined. DP was 1971-82 and TP was 1983-85 & 1995. The year 1995 was included as another TP to verify the model in a recent year. Data for 1995 was extracted from the records available at Regional Meteorological Centre, Madras. DP and TP consisted of 12 and 4 years or 1104 days and 368 days respectively.

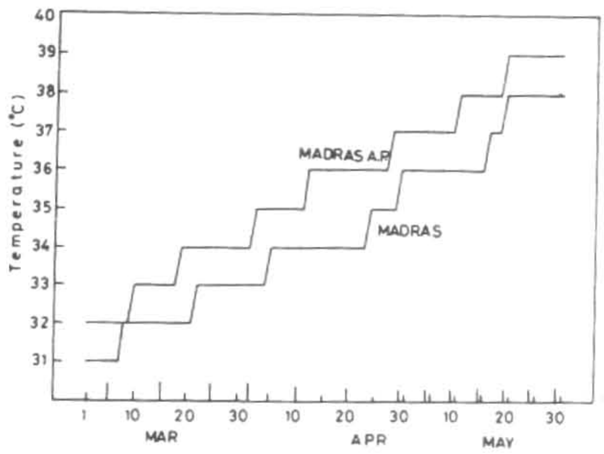

Fig.2. Daily normal maximum temperature of Madras and Madras Airport (March-May)

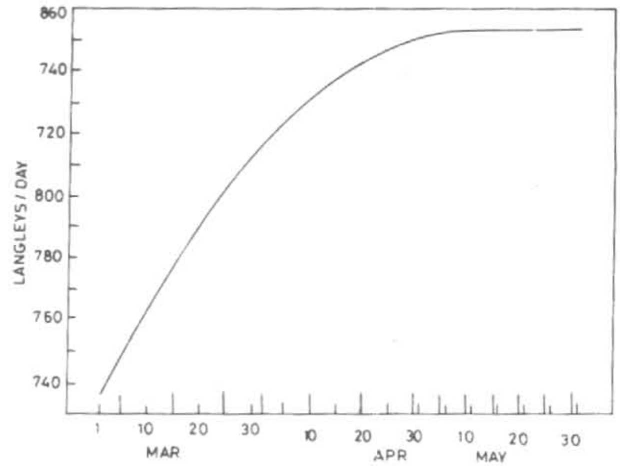

Fig.3. Undepleted solar radiation per day at Madras (March-May)

TABLE 2

Statistics of summer maximum temperatures (°C) of Madras and Madras A.P. based on data of 1971-82

Place	Month/Season	Mean	SD	Range
Madras	March	32.1	1.3	29.2-37.5
	April	34.2	1.5	31.5-39.6
	May	36.9	2.8	29.8-43.6
	Mar-May	34.4	2.8	29.2-43.6
Madras A.P.	March	33.1	1.6	29.9-38.6
	April	35.7	1.8	31.8-39.5
	May	38.0	2.6	29.7-44.3
	Mar-May	35.6	2.9	29.7-44.3

(SD - Standard deviation)

4. Results and discussions

4.1. *Analysis of the Predictands*

A detailed statistical analysis of the predictands, *viz.*, summer maximum temperatures of Madras and Madras A.P., was carried out before studying their relationship with various parameters. The basic statistics such as mean and standard deviation (SD) and range were computed month-wise and for the whole season based on data of DP. Details are given in Table 2. As seen from the table the mean increases for both the stations with the March of the season. The temperature of Madras A.P. is more than that of Madras, the difference which is only 1°C in March increases to 2.1°C in May. For both the stations variation is large in May. The frequency distribution for both the predictands manifested slight positive skewness. An average of 5.4 days per season experienced maximum temperatures of above 40°C in Madras the figure for Madras A.P. being 9.2 days.

To examine the seasonal variation further, the daily normal values were computed based on the DP for both the stations and were smoothed with a moving average filter. Fig.2 depicts the normal values for Madras and Madras A.P. and Fig.3 the variation of undepleted solar radiation (USR) received at Madras during 1 March - 31 May. This parameter has been computed from the formula given in Haltiner and Martin (1957). The USR which is 837 langleys on 1 March rises sharply to 937 on 15 April and then gradually to the maximum value of 953 during 15-31 May. The second half of May characterised by the highest amount of USR is therefore the most favourable period for occurrence of high temperatures over Madras.

From Fig. 2 it can be deduced easily that the predictand series are not stationary in character and contain a prominent seasonal component. The mean values given in Table 2 are not exactly representative of the month/season from whose data they have been computed. The CCs between daily normal temperatures and the daily tem-

TABLE 3

Correlation between 0530 (IST) winds over Madras and maximum temperature of Madras occurring on the same day

Level (hPa)	CC(U, Tx)	CC(V,Tx)
1000	0.56	0.11
950	0.73	-0.07
900	0.74	-0.15
850	0.73	-0.15

U & V-Zonal & Meridional components, Tx - Maximum temp. & CC - correlation coefficient Sample size - 1104

TABLE 4

Potential Predictors (PPs) for Maximum temperature of Madras & Madras A.P.

S.No.	PP	Notation	Mean	SD	CC	Mean	SD	CC
1.	Max temp (I-2)D	TX2A/TX2B	34.4	2.8	0.80	35.6	2.9	0.79
2.	Max temp (I-1)D	TX1A/TX1B	34.4	2.8	0.88	35.6	2.9	0.88
3.	Daily normal temp.	TXNA/TXNB	34.4	2.1	0.75	35.6	2.2	0.74
4.	Min.temp (I-1) D	TN2A/TN2B	25.7	2.3	0.70	25.7	2.3	0.72
5.	Temp 1730 (I-2)D	TEA/TEB	30.5	1.7	0.84	31.1	2.0	0.83
6.	Dew-point 1730 (I-2)D	TDA/TDB	24.2	2.1	0.39	22.9	2.2	0.29
7.	Cloud Index 1730 (I-2)D	CIA/CIB	0.8	0.8	0.25	0.9	0.7	0.25
8.	Max Temp Advection Index	TXAI	33.8	3.6	0.82	33.8	3.6	0.82
9.	Min temp (I-1)D	TN1A/TN1B	25.7	2.3	0.75	25.7	2.3	0.78
10.	Z/W 900 hPa 0530 (I-1)D.	ZW	1.1	5.0	0.74	1.1	5.0	0.73
11.	Temp 850 hPa 0530 (I-1)D	T850	21.1	3.0	0.49	21.1	3.0	0.54
	Predictand: Max temp of I - th D	TXA/TXB	34.4	2.8		35.6	2.9	

Note: SD - As in Table-2, CC - As in Table 3, Temperatures in °C, Cloud Index in oktas, Wind in m/s, Time in IST, D - Day, PPs 8, 10 & 11 are common for Madras & Madras A.P & PPs ending with A & B are for Madras & Madras A.P. respectively.

peratures were 0.75 and 0.74 for Madras and Madras A.P. respectively, significant at 0.1% level. Thus the daily normals and the temperatures 1 and 2 days before could be PPs. As these PPs themselves carry the seasonal component present in the series of the predictand, they could in some way compensate for the lack of stationarity in the predictand series, by removing the seasonality component in the residual series.

Incidentally the CC between the maximum temperatures of Madras and Madras A.P. was a very high 0.96 each explaining 92.1% of variation of the other.

4.2. *Selection of potential predictors*

Due to persistence, maximum temperatures 1,2 days before emerged as PPs, the respective CCs were 0.88 and 0.80 for both Madras and Madras A.P. The normal temperatures also have been taken as PPs as per the analysis of the previous section.

The minimum temperature series were correlated with the maximum temperature series. If TX(I) and TN(I) denote the maximum and minimum temperatures of I-th day, then TN (I-1),TN(I-2) recorded prior to TX(I) could be PPs, the large and significant CCs obtained justify the inclusion. It is evident that TN(I-2) is available only for the 24 hr forecast and that both are available for the 9 hr forecast.

As for clouding, a cloud index (CI) defined by $CI=(3*Cl+2*Cm+Ch)/6$ where Cl, Cm, Ch are the amounts in oktas of low, medium and high clouds respectively. These weights are roughly as suggested in Haltiner and Martin (1957). Dew point, CI both at 1730 of (I-2)nd day for 24 hour forecast and 0830 of (I- 1)st day for 9 hr forecast were correlated with TX(I). It was found that dewpoint and CI at

TABLE 5

Results of forward screening for Madras and Madras A.P.

		MDS 24 hr			MDS A.P. 24 hr				MDS 9 hr			MDS A.P 9 hr		
S.No.	P	VE	PC	PRC	VE	PCC	PRC	P	VE	PCC	PRC	VE	PCC	PRC
1.	TX1A	77.4	.36	.46	76.9	.33	0.42	TX1D	77.4	.44	.46	76.9	.47	.48
2.	TEA	1.8	.23	.38	2.2	.27	0.36	ZW	3.2	.31	.47	3.4	.39	.14
3.	TXAI	1.0	.17	.13	1.1	.19	0.15	TEA	1.9	.40	.14	1.9	.31	.39
4.	TXNA	0.6	.17	.17	0.6	.17	0.16							
	TVE	80.7			80.8				82.5			82.3		
	CTRE			-2.74			-1.15				3.89			6.20
	MCC	0.90				0.90			0.91			0.91		
	SE(C)	1.24				1.18			1.25			1.21		

Note: - Predictor (definitions as per Table 4), VE - Variance explained, PCC - Partial CC, PRC - Partial regression coefficient, CTRE - Constant term of multiple regression equation, MCC - Multiple CC, CC - As in Table & 4 SE - Standard error

1730 exhibited very good correlation with TX whereas 0830 the CCs were poor. Thus 1730 dewpoint and CI were selected as PPs. The temperature at 1730 also was related well with TX and so was taken as PP.

The temperature at 850 hPa was taken as another PP for 9 hr forecasting scheme, as this parameter determines the thickness of the isobaric layer between surface and 850 hPa which is one of the parameters influencing sea breeze.

The lower level morning wind of Madras in summer does give some idea about the maximum temperature likely to be realised on the same day. an easterly wind favours cooler temperatures, whereas westerly wind favours warmer temperatures. To examine this phenomenon further and to choose a suitable predictor the zonal and meridional winds at 0530 at each 50 hPa level in the layer 1000-850 hPa were obtained and correlated with the maximum temperatures of Madras and Madras A.P. realised in the afternoon. Table 4 provides the CCs for Madras. It is seen that the meridional winds do not provide any significant information and it is the zonal winds that are well correlated. The CC pertaining to 900 hPa zonal winds has the maximum value of 0.74. The CCs for Madras A.P. also provided a similar pattern. As such the 0.9 Km zonal wind alone was chosen as the PP both for Madras and Madras A.P.

The wind at 1730 was not considered as it does not always represent the overall flow pattern accurately. From second week of April onwards the normal prevailing low level wind over Madras and over the peninsula is westerly. However, easterly wind due to sea breeze circulation prevails over the coast in the afternoon and evening.

Advection of temperature, as shown in section 2 is an important parameter controlling temperature variation. In this study we have defined maximum temperature advection index (TXAI) obtainable at 1730. The location from which air parcel would be reaching Madras after 24 hr was identified. For this the wind flow, both direction and speed, as represented by Madras wind closer to the surface in the layer 1000-900 hPa observed at 0530, 12 hr prior to the time of observation of TXAI was considered. The 1730 wind was not considered for reasons adduced in the preceding paragraph. The SST over Bay of Bengal does not show much intra-seasonal variation in summer and has a mean value of 29°C. The maximum temperature at the location thus identified, as interpolated from the data of network of observatories for location over land shown in Fig.1. and from the SST value for location over sea was defined as TXAI. If TXAI is higher than TX it indicates warm advection and if lower, cold advection. The CC between TXAI and TX was 0.82 significant at 0.1 % level Singh and Jaipal (1983) and Raj (1989) have employed the above technique for defining a parameter representing advection of minimum temperatures.

The PPs chosen for prediction of maximum temperature of Madras and Madras A.P. are given in a tabular form in Table 4. The mean and SD of the 11 PPs and the CCs they exhibit with the predictand are also given. The PPs 1-8 are available for a 24 hr forecast. The PPs 9-11 are the additional PPs available for the 9 hr forecast.

4.3. *Selection of final set of predictors*

The stepwise forward screening regression technique as suggested in WMO (1966) was employed to select an optimal number of predictors from amongst the PPs given in Table 4 for 24 and 9 hr forecast schemes. The variance explained by each predictor and the partial correlation coefficient (PCC) were computed. PPs whose corresponding PCCs were significant of up to 0.1% level were chosen as predictors. Table 5 presents the variance explained by each predictor selected, the PCC, partial regression coefficients (PRC), multiple CC (MCC), standard error (SE) etc.

TABLE 6

Performance of forecasting schemes

Station	Hour(hr)	Test Period	C	PC	W	SS	SE
Madras	24	A	81.1	14.8	4.1	0.35	1.21
Madras	9	A	81.1	15.6	3.3	0.36	1.15
Madras	24	B	83.3	7.8	8.9	0.39	1.29
Madras	9	B	86.7	8.9	4.4	0.57	1.28
Madras A.P.	24	A	77.4	16.7	5.9	0.29	1.24
Madras A.P.	9	A	80.4	15.2	4.4	0.39	1.19
Madras A.P.	24	B	78.9	12.2	8.9	0.34	1.42
Madras A.P.	9	B	84.4	8.9	6.7	0.55	1.39

A - Test period 1983-85, 1 May - 31 March, B - Test period 1995, 1 May - 31 March

C,PC,W - Percentage of correct, partially correct & wrong forecasts, SS - Skill score & SE - Standard error (C)

For both Madras and Madras A.P., for the 24 hr scheme four predictors got selected with TXIA, the temperature of the previous day emerging as the leading predictor. The multiple CC obtained was 0.9 explaining nearly 80.8% of total variation. For 9 hr scheme three predictors resulted from the screening all together explaining 82.5/82.3% variation with MCC of 0.91. The wind parameter, ZW, (Table 4) emerged as an important predictor for the 9 hr forecast. Thus more variance got explained for the 9 hr forecast with less number of predictors, compared to the 24 hr forecast.

Except for the five predictors selected for the 24 and 9 hr schemes all the remaining PPs got screened out. Though temperature one day before remained as the most important predictor, values prior to that did not convey any independent information.

4.4. *Verification of the schemes*

The regression equations developed in Sec 4.3 were verified in the independent test samples of 1983-85 and 1995 consisting of 276 and 92 days respectively. The 24 and 9 hr forecasts for Madras and Madras A.P. were worked out from the multiple regression equations given in Table 5.

For verification of the forecasts the following procedure was followed. The daily change of maximum temperature of a day was designated as no change (NC), slight rise (SR), rise (R), appreciable rise (AR), marked rise (MR) and large rise (LR). The temperature changes in C (given in brackets) corresponding to the above classification are: NC (O), SR (+1), R (+2), AR (+3 or +4), MR (+5 or +6) and LR (+7 or more). Similar classifications corresponding to fall of temperatures namely BF, F, AF, MF and LF were defined for negative values. The above classifications are as defined by the India Meteorological Department (IMD) for describing day-to-day changes of maximum/minimum temperatures except that the classes SF, NC and SR are taken as a single class 'little change' (LC) by IMD. For this paper we subdivided LC into three separate classes as above, as nearly 70 % of the day-to-day maximum temperature changes of Madras and Madras A.P. fell into the single class LC making forecast verification a bit inaccurate. Both the forecast and the realised temperatures were expressed in terms of the temperature changes and were classified in accordance with the above definitions. A forecast was defined as 'correct' (c) if the forecast and realised classifications (FC & RC) fell into same or adjacent category; as 'partially correct' (PC) if they differed by two categories or expressed the same tendency even if differed by more than two categories (*e.g.* if FC was SF and RC was MF though they differed by 3 classes, the forecast was taken as PC as the tendency had been expressed correctly). Otherwise the forecasts were termed as wrong(W).

The FC and RC were obtained for each day of the test periods 1983-85 and 1995 for Madras and Madras A.P. for both 24 and 9 hr forecasts. The percentage of C, PC and W forecasts were computed. The forecast contingency table was constructed in all the eight cases and the skill score (SS) as defined in Panofsky and Brier (1968) computed. The SE of the forecasts was obtained Table 6 summarizes the details. It is seen that the percentage of correct forecasts varies between 77.4 and 86.7 and that of wrong forecasts between 3.3 and 8.9. The SS varies between 0.29 and 0.57 and the SE between 1.1-1.4°C. That 9 hr forecasts are bit more accurate than 24 hr forecasts is clearly seen. As the performance of the schemes in the large test period is good, the efficiency of the forecasting schemes developed is clearly proven.

The performance of the schemes in predicting temperature changes of AF/MF/LF or AR/MR/LR also has been tested and found to be satisfactory. The overall percentage of correct or partially correct 24 hr forecasts on such occasions was 61 but increased to 71 for 9 hr forecasts.

5. Comments

As seen from section 4.1 the predictand series are far from stationary and manifest seasonal component. The error which is the difference between estimated/forecast value obtained from the regression equation and the realised value was evaluated for all the days of the DP/TP and the distribution of errors studied. It was verified that the error series was stationary in all the cases. This shows that the seasonal component in the predictand series has been completely neutralised by the various predictors with seasonal components.

Perusal of Table 5 provides some insight into the factors controlling the variation of temperature. That the temperature one day before would be the leading predictor is very much on the expected lines. This exercises considerable influence in the evening forecasts of 24 hr validity. The evening temperature and advection of maximum temperature are the other important predictors. The TXAI however loses its importance in the morning forecast with 9 hr lead time. Here the 900 hPa wind exercises considerable influence.

The testing of significance of CCs, MCCs and PCCs was done by employing the t-test, which did pose some problems due to the non-randomness and non-stationary character of the series. As such the size of DP, considerably overestimates the degrees of freedom thereby making even a low CC such as 0.1 significant at 0.1% level. Such low CCs were ignored in the initial stages of selection of PPs. However, in screening regression predictors with PCCs significant at 0.1% level were included, as the PCCs represent the additional variance explained. The physical significance and the performance in the test period also supported such inclusion.

6. Conclusion

Forecasting schemes with lead time 24 and 9 hr for the maximum temperature of Madras and Madras A.P. for the summer months of March, April and May were developed based on data of 12 year period. The schemes were based on 3-4 predictors based on persistence, climatology, advection and wind direction with persistence being the most important factor controlling temperature variation. Advection and wind direction also contributed significantly in the 24 and 9 hr schemes respectively. The schemes tested in a large independent sample yielded good results providing 77-87 % correct forecasts with skill scores of 0.29-0.57.

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