Mausam, (1983), **34**, 2, 185-188

551.509.2 : 551.524.36(540)

On forecasting night minimum temperatures over New Delhi

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(*Received 16 January 1979*)

सार — नई दिल्ली के जनवरी के दिन प्रतिदिन के न्यूनतम तापमानों के पूर्वानुमान के लिए समाश्रयण समीकरण विकसित किये गए हैं। समीकरणों में न्यूनतम तापमान को आश्रित- चर के रूप में लिया गया है जब की मौसम के विभिन्न तत्वों का चयन भौतिक कारणों के आधार पर स्वतंत्रचर के रूप में किया गया है। अभिवहन और मेंघायन को प्राचल रूप में प्रस्तुत करने की तकनीक खोजी गई है। प्रथम समीकरण में केवल प्रातःकाल के आंकड़ों का उपयोग किया गया है ताकि पूर्वानुमान पूर्वाह्न में ही जारी किया जा सके। दूसरी और तीसरी समीकरणों में सांध्य-कालीन आंकड़ों का भी उपयोग किया गया है अतः तुलनात्मक दृष्टि से ये ज्यादा अच्छी है। समीकरण (i) एवं (ii) का परीक्षण एक वर्ष के स्वतंत्र आंकड़ों को लेकर किया गया है। इसके परिणाम काफी उत्साहवर्धक हैं। दोनों समीकरणों से प्राप्त अस्सी प्रतिशत से अधिक पूर्वानुमानित तापमानों और वास्तविक तापमानों का अन्तर $\pm$ 2° सें० के बीच है। समीकरणों की सहायता से प्राप्त पूर्वानुमानों की वर्गमाध्य मूल त्रुटि अकेले प्रस्थायित्व (परसिस्टेंस) से प्राप्त 2.1 की तुलना में 1.5 से भी कम है। पिछले दिन की अपेक्षा जब तापमान 3° सें० से भी अधिक हो जाय, तब यह विधि प्रमुख रूप से उपयोगी है।

ABSTRACT. Regression equations have been developed to forecast day to day minimum temperatures of New Delhi for the month of January. The minimum temperature has been taken as dependent variable whereas the different weather elements, chosen on physical reasoning, are the independent variables in the equations. Techiques have been evolved to parameterise advection and clouding. The first equation uses only morning data so that forecast can be issued in the forenoon itself. The second and third equations use the evening data as well and are comparatively better. Both the equations have been tested for independent data of one year and the results have been found very encouraging. Above 80 per cent of the forecast temperatures for both the equations lie with in $\pm$2° C of the actual temperatures. The Root Mean Square Error of the forecasts (independent data) based on the equations is less than 1.5 as compared to 2.1 of persistence alone. The main improvement is seen to be in the cases when temperature changes exceed 3°C from that of previous day.

1. Introduction

During winters, night temperatures fall below the human comfort level in the northern-half of the country. Occasionally frost point is also reached and crops are adversely affected. Occurrence of fog and mist also depends on night temperatures. The farmers, the transporters, aviators and the common people are all interested in accurate forecast of night temperatures. Present study was undertaken in consideration of requirements of early warning and better accuracy. Based on correlation and regression technique, regression equations have been developed to forecast night minimum temperature from morning data alone and using evening data as well.

Quite a lot of work has already been done in this direction. But, most of the regression equations utilise evening data thus leaving hardly any time for the users to plan their actions whenever low temperature forecast warrant it. Recently, Kohli and Sinha (1975) have compared the relative merits of the regression formulae by Ang str m (1923), Flowers and Davies (1934), Peatfield (1937) and the regression equation by Subramayya and Vaidya (1974). Their results have been utilised for comparative study.

Day to day changes in the minimum temperature at a place are determined by (*i*) advection, (*ii*) moisture content of air near surface, (*iii*) clouds, (*iv*) presence of inversion layers near ground and upper air temperatures, (*v*) changes in the nature of the underlying surface due to vegetation, rainfall etc, and (*vi*) trend due to advance of season etc. Place to place variations are governed mainly by (*i*) latitude, (*ii*) elevation, (*iii*) nature of surface and (*iv*) local conditions.

2. Data and method of analysis

In the present study the authors have incorporated the temperature advection and clouds

TABLE 1

Total linear correlation coefficients (LCC) for minimum temp.

	LCC	*t*-value	DF
Advection (T_a)	0.75216	13.89	148
Persistence (T_n)	0.72804	12.92	148
12 Z Temp. (T_e)	0.30592	3.91	148
Clouding (C_w)	0.52887	7.58	148
Dew Points (T_d)	0.69249	11.68	148

TABLE 2

Partial regression coefficient (PRC)

Eqn. No.	Para-meter	Partial regression coeff.	*t*	Degrees of free-dom	Const.
1	T_a	0.330	6.49	147	+2.56
	T_n	0.392	5.27	147	
2	T_a	0.170	3.42	144	
	T_n	0.287	4.28	144	
	T_e	0.319	5.97	144	−24.87
	C_w	0.369	6.52	144	
	T_d	0.081	2.51	144	

TABLE 3

Analysis of variances

	Sums of square	Degrees of free-dom	Mean squares	*F* value
		Equation 1*		
Regression	485.35	2	242.68	127.76
Residual	279.23	147	1.90	
Total	764.58			
		Equation 2**		
Regression	573.65	5	114.73	86.53
Residual	190.93	144	1.33	
Total	764.58	149		

* Multiple correlation is 0.80 which explains 64% of total variation in minimum temperature.

** Multiple correlation is 0.87 which accounts for 75% of total variation in minimum temp.

TABLE 4

Root mean square errors

Regression equation	Root mean square errors	
Angstöm (1923)	2.2 (2.3)	Kohli & Sinha-75
Peatifield (1937)	2.0 (2.1)	Do
Flowers and Davies (1934)	1.9 (2.0)	Do
Subramayya and Vaidya (1974)	3.5 (3.5)	Do
Persistence	2.4 (2.1)	Do
Equation 1	1.49	
Equation 2	1.48	

as parameters in addition to parameters already used by other workers. Data has been used for the month of January for the years 1970-1974 (150 days), for developing regression equations to forecast the day to day minimum temperatures for January for New Delhi.

Parameters were chosen based on physical reason. However, no direct effort has been made to account for inversion layers near surface or changes in the nature of surface, though effect of rainfall deserved more importance.

The significance of the individual parameters was tested by applying students '*t*-test'. The test value for each parameter is given in Table 2.

The significance of the net multiple correlation was tested by subjecting the series to the variance analysis. The *F* value obtained is shown in Table 3.

The parameters satisfying the test at the mandatory 5 per cent level, and used for the regression equations are :

(*i*) *Advection* (T_a) — The parameter for temperature advection has been taken as the minimum temperature at the place (finite area) from where the air is likely to arrive over New Delhi in next 24 hours according to the stream line isotach pattern at 0.9 km at 00 GMT. Care has been taken to exclude temperature value of elevated stations. On few occasions interpolated values have been taken in the absence of required data.

(*ii*) *Persistence* (T_n) — The minimum temperature recorded at New Delhi has been used for next days forecast.

(*iii*) *Dry bulb temperature* (T_e) *at* 12 *GMT*

(*iv*) *Clouds* (*Weighted*) *over New Delhi at* 12 *GMT* (C_w) — Clouds at higher levels are expected to be less effective in affecting the night minimum temperatures. Arbitrary weighing factors of 1.0, 0.7 and 0.5 have been used for low medium and high clouds. Thus the cloud parameter for New Delhi has been taken as the total weighted cloud amount (octas).

(*v*) *Moisture content* (T_d) — The mean of the dew point temperature for surface and 900 mb at 12 GMT has been taken as the moisture parameter. Units have been taken as °A.

3. Results

The regression equations based on correlation and regression technique are :

$$T_{nf} = 0.330\,T_a + 0.392\,T_n + 2.56 \quad (1)$$

$$T_{nf} = 0.170\,T_a + 0.287\,T_n + 0.319\,T_e + 0.081\,T_d - 24.87 \quad (2)$$

$$T_{nf} = 0.222\,T_a + 0.347\,T_n + 0.312\,T_e + + 0.381 C_w - 3.15 \quad (3)$$

TABLE 5

Percentage frequency of forecast errors occurring in various ranges

Errors range	Persis-tence	Percentage of frequency for regression equation for (Kohli and Sinha 1975)				Eqn. 1	Eqn. 2
		Angström	Peatfield	Flowers & Davies	Subra-mayya & Vidya		
0.0 – 1.0	52	39	45	50	10	58	61
1.1 – 2.0	26	32(28)	26	20(17)	26	26	20
2.1 – 3.0	3	17(16)	13(10)	20	29(26)	10	13
3.1 – 4.0	16	6	10(13)	10	13(16)	6	6
4.1 – 5.0	3	6(10)	6	0(3)	6	0	0
5.1 – 6.0	0	0	0	0	10	0	0
6.1 – 7.0	0	0	0	0	3	0	0
7.1 – 8.0	0	0	0	0	0	0	0
8.1 – 9.0	0	0	0	0	0	0	0
9.1 –10.0	0	0	0	0	3	0	0

Here T_{nf} is the forecast minimum temperature and the other symbols have the meanings assigned above.

The parameters used in the regression equations have not only withstood t-test at 5 per cent level of significance but also at 1 per cent level of significance, except for T_d in Eqn. (2).

4. Verification

The regression Eqns. (1) and (2) were applied to the independent data of January 1975. Tables 4 and 5 are included for comparison of results with those given by Kohli and Sinha (1975). The modified result of Kohli and Sinha on account of correction to the minimum temperature of 30 January (4.9° C to 11.5° C) are given with in brackets.

5. Discussions

It is interesting to note that the F values are significant in both cases even at 0.1 per cent level. Tables 4 and 5 display the merits of the regression Eqns. (1) and (2) over the regression equation of various other authors used by Kohli and Sinha (1975). The most significant advantage of Eqn. (1) over all others is its capability to forecast from morning data itself. The root mean square errors of the forecasts based on Eqns. (1) and (2) for January 1975 are 1.49 and 1.48 respectively . These are significantly smaller than others in Table 4 . Also, in both these cases above 80 per cent of the forecasts are correct within ± 2°C, and not a single forecast is out by more than 4°C. Though, the merits of Eqn. (2) over Eqn. (1) are not apparent in Tables 4 and 5 but the Eqn. (2) is statistically more dependable. Also, it can be inferred from Table 5 that the equations have surpassed persistence mainly in better forecasting of larger departures (3° C).

In Eqn. (2) the contribution given by individual parameters was studied by dropping the parameters one by one. Surprisingly enough the contribution due to T_e and T_d is very little. The net multiple correlation of the parameters in Eqn. (3) is 0.86 (F value 103.3) which explains 74 per cent of variations. Also, the t-value for all these parameters is significant even at 1 per cent level of significance. This equation can be used as an alternate for Eqn. (2) with very insignificant (1 per cent) loss of accuracy.

And, if persistence is dropped in place of T_d the MCC was found to be 0.85 explaining 72 per cent of the variations. The choice of the advection parameter is such that it depends on the present synoptic situation. Thus equations based on this parameter can be expected to forecast satisfactorily, the minimum temperatures associated with arrival or passage of western disturbances. However, day to day correspondence cannot be expected due to limitation imposed by data accuracy and changes in systems.

The drawback of the regression equation developed here is that those are dependent on temperature data from other stations, thus such regression equation can be used only by forecasting offices, where such data are available. Some difficulty may arise due to absence of data from particular station, but, this can be successfully overcome by using interpolated values. Eqns. (2) and (3) further suffer, though insignificantly, from subjective cloud amount estimates.

The advection parameter has potential to explain little extra variations, provided better coverage of data makes better estimate of T_a possible. In fact, Delhi is not so favourably located to use full potential of advection parameter, but it was selected for availability of results based on other regression equations. The list of the parameters available to the forecaster has not been fully exhausted and the weightage for the cloud layers has been arbitrarily chosen, therefore, improvement possibilities of the regression equations developed here are not ruled out.

6. Conclusions

(*i*) Maximum temperature, as an independent variable, has insignificant influence on next days minimum temperature during January. The linear correlation coefficient and the *t*-values were 0.2 and 2.47 respectively. For the partial regression coefficient the *t*-value was only 0.76 with 142 degrees of freedom.

(*ii*) Temperature advection applied to minimum temperatures is found out to be very significantly correlated with next days minimum temperature.

(*iii*) For forecasting the minimum temperatures for New Delhi during January only the regression equations developed in this study are giving significantly lower root mean square errors than persistence alone. So, (a) Eqn. (1) can be used to issue forecast in the forenoon itself. (b) This forecast can be revised if necessary using Eqns. (2) and (3) in the evening.

Acknowledgement

The authors are grateful to Dr. R.P. Sarker, Deputy Director General of Observatories (Climatology and Geophysics) for his interest and support for this study.

References

Angström, A., 1923, *Geor. Ann.*, III.

Flowers, W.D. and Davies, E.L., 1934, *Met. Mag.*, **69**, 231.

Kohli, M.S. and Sinha, M.C., 1975, *Vayu Mandal*, **3**, 4.

Peatfield, W.G., 1937, *Met. Mag.*, **72**, 190.

Saunders, W.E., 1952, *Quart. J.R. met. Soc.*, **78**, pp. 603-612.

Steel, L.P., Stroud, P.A.J. and Virgo, S.E., 1969, *Met. Mag.*, **98**.

Subaramayya, I. and Vaidya, B. K., 1974, *Vayu Mandal*, **4**, 1.