Minimum temperature forecasting in Kathmandu

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ABSTRACT:
Hazards of low temperature are recurring problem during winter season in Kathmandu. Prognosis of minimum temperature is thus, an important factor in taking strategic decisions especially in agriculture, aviation and daily lives of human beings. Hence a study has been conducted to assess day to day changes in minimum temperature in Kathmandu, during winter season for the months from December to February. Regression model is developed to forecast minimum temperature with knowledge of present day's minimum temperature and previous day's dry bulb and dew point temperature observed at 12:00 UTC. The result obtained shows that the highest percentage difference between the observed and forecasted minimum temperature lying in the range between (+1 to - 1.0) °C is 50.6 for the month of January.

1. INTRODUCTION

Kathmandu, the capital of Nepal is a small valley with large area of fertile land. It is circular in shape with diameter approximately 25 km and surrounded by hills and mountains. The elevation of Kathmandu increases from south west to north and the lowest part lies at an altitude of 1250 m a.s.l.

Fog is a common phenomenon during winter season in Kathmandu, especially, from the month of December to February and the daily minimum temperature at this time of the year sinks down close to 0 °C or less. The lowest minimum temperature ever recorded in Kathmandu is found to be –3.5 °C on 11 June 1978. The freezing temperature can severely damages the citrus, winter vegetables and sugarcane (Thomas, 1999). At the same time, low temperatures are the major cause of health hazards to the human beings. Such hazards of low temperature are recurring problem in Kathmandu during winter season. Hence, forecasting of minimum temperature is of immense benefit to the public.

Attri *et al.* (1994) have used a linear multiple regression to forecast the minimum temperature over Gangtok with the knowledge of dew point temperature, cloud amount, minimum temperature and maximum temperature recorded on previous day. Rose (2000) has used the thickness values of the 1000-925 hpa layer observed at 12:00 UTC to predict next day's minimum temperature.

In this study, an attempt has been made to forecast the minimum temperature for the winter months from December to February with the knowledge of previous day's dry bulb and dew point temperature observed at 12:00 UTC following the condition that the total cloud amount is 0,1 or 2 Okta and the wind speed is less than 10 knots at the time of observation.

2. FACTORS AFFECTING MINIMUM TEMPERATURE

The minimum temperature is affected by different factors which can be explained as below:

a) The minimum temperature of the atmosphere is affected by nocturnal cooling of the earth's surface. The rate of cooling is given by Stefan Boltzman law $E \propto T^4$, where T is the temperature of the radiating surface.

b) Cloud plays significant role in fluctuating the minimum temperature. Cloudiness absorbs the outgoing long wave radiation being radiated upward by the earth's surface. The cloud then re-radiates most of this energy back to the earth's surface, as a result the earth's surface is warmed. The warming of the earth's surface increases the minimum temperature. But, during the clear sky night the minimum temperature decreases significantly.

c) The minimum temperature is also affected by wind speed and direction. The diurnal variation of surface air temperature tends to be greatest if calm condition prevail at night. If it is windy, mixing of air takes place through a deeper layer and the diurnal range of the temperature may be reduced.

d) The type of surface and the nature of the neighboring terrain also plays important role in affecting the minimum temperature because the temperature at the particular place may be affected by the flow of warm or cold air from the adjacent areas. For instance, surface cooling takes place at night due to radiation. Air near the ground then cools and becomes denser. If the surface slopes, the cooled air flows lower levels as a katabatic wind affecting the minimum temperature. Likewise, the presence of river or water bodies nearby also affects the minimum temperature of the place.

e) The minimum temperature is also affected by the absolute humidity of the atmosphere. When the humidity is higher in the atmosphere at the surface level, the long wave radiation emitted by the earth's surface is absorbed by the atmosphere near the ground which in turn increases the minimum temperature.

f) The minimum temperature is also affected due to release of latent heat from condensation or fusion of atmospheric moisture under certain conditions.

3. DATA AND METHOD

Daily minimum temperature of present day with previous day's dry bulb and dew point temperature observed at 12:00 UTC of Kathmandu for the period 1986-1994 for the months from December to February have been used. While collecting the daily data of dry bulb and dew point temperature observed at 12:00 UTC only such data have been used which fulfills the following criteria: the total cloud amount is 0, 1 or 2 Okta and the wind speed is less than 10 knots at the time of observation.

The general regression model used for the study is

$$T_m = A + B*T_d + C*T_e$$

Where,
T_m = minimum temperature
T_d = Dry bulb temperature
T_e = Dew point temperature
A, B and C are coefficients.

Here, the dry bulb and dew point temperature are used as predictors in forecasting next day's minimum temperature. Hence, the dry bulb and dew point temperature are taken as independent variables and minimum temperature as variable. The regression analysis is carried out using statistical software in computer.

4. RESULTS AND DISCUSSION

The results obtained are as follows.

Multiple regression result for the month of December
Multiple R = 0.619
R^2= 0.384 and df = 2,145
No of cases = 148
Standard of error of estimate = 1.579 °C
A = -2.674 B = 0.035 C = 0.064

Multiple regression result for the month of January
Multiple R = 0.694
R^2 = 0.481 and df = 2,86
No of cases = 89
Standard of error of estimate = 1.388 °C
A = -3.813 B = 0.209 C = 0.521

Multiple regression results for the month of February
Multiple R = 0.523
R^2 = 0.273 and df = 2,50
No of cases = 53
Standard of error of estimate = 1.894 °C
A = -3.838 B = 0.306 C = 0.325

In the above results, R represents the correlation coefficient and R^2 is the coefficient of determination.

Using the obtained values of A , B and C for different months in the above general regression, the following models are developed separately for the months December, January and February respectively for predicting the minimum temperature.

$T_m(Dec) = -2.674 + 0.035*T_d + 0.604*T_e$
$T_m(Jan) = -3.813 + 0.209*T_d + 0.521*T_e$
$T_m(Feb) = -3.838 + 0.306*T_d + 0.325*T_e$

The regression models are then used separately to predict the minimum temperature for the months December, January and February for the period months December, January and February respectively. Further, the value of error or the difference between the observed and predicted minimum temperatures are presented in 1986-1994. The values of predicted and the observed minimum temperature are presented in Figure 1 (a), (b) and (c) for the months December, January and February respectively.

The result in Table 1 shows that the temperature difference between the observed and predicted minimum temperature for the months December and January lying in the range (+1 to -1.0) are found to be 50 and 50.6 percent respectively. But, for the month of February it is found to be 45.3 percent.

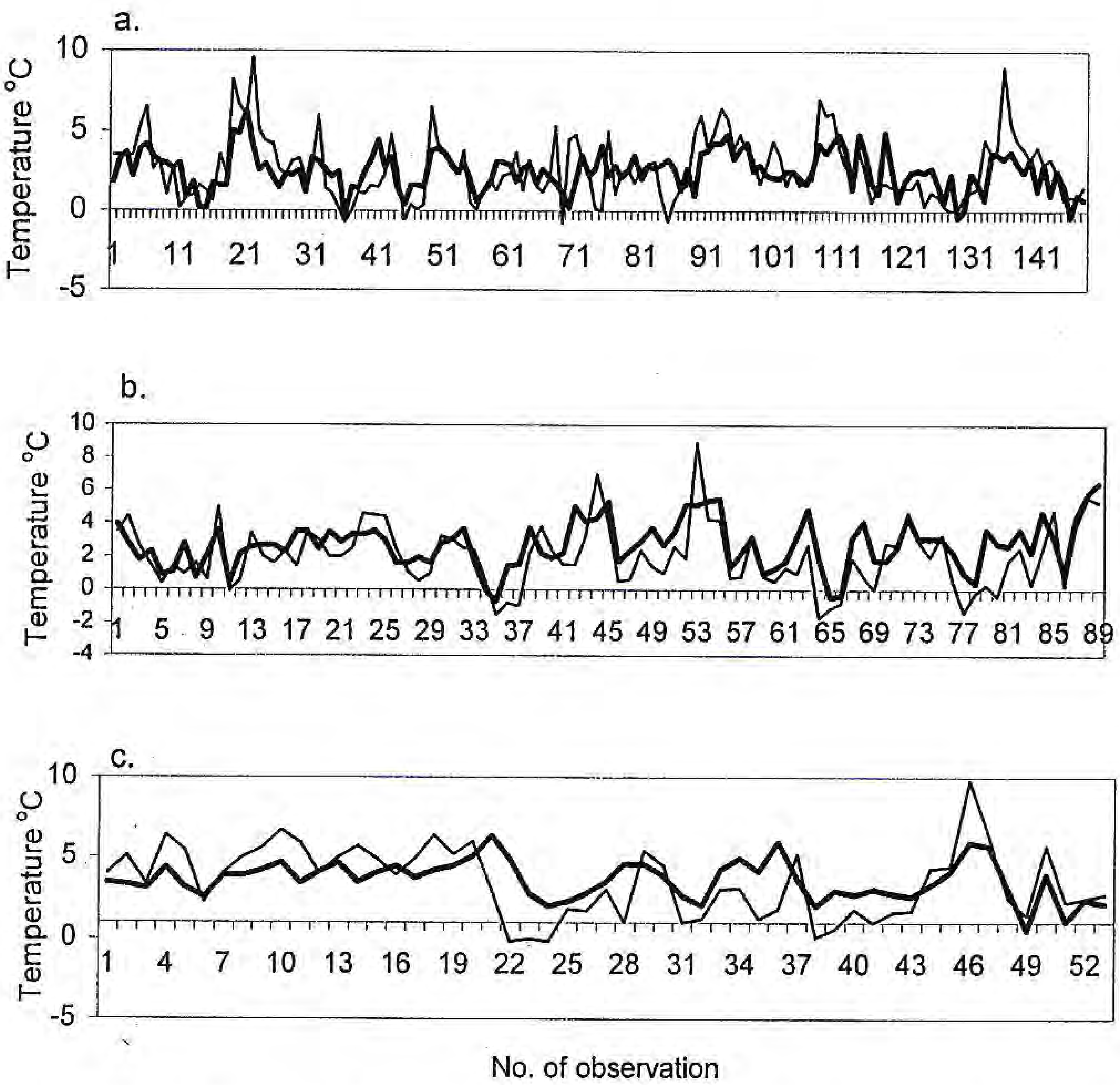

Figure 1. Simulation of predicted (thick line) and observed (thin line) values of minimum temperature for the months December (a), January (b) and February (c) respectively.

5. CONCLUSION

The result obtained here shows that there exits a good relationship among the present day's minimum temperature and previous day's dry bulb and dew point temperature observed at 12:00 UTC. But, the result further stresses that there is a large variance between the predicted and observed minimum temperature which is explained clearly by Fig 1(a), (b) and (c) and Table 1.

This clarifies that beside the dry bulb and dew point temperature observed at 12:00 UTC, the minimum temperature is further influenced by other meteorological parameters which have to be taken into consideration in the regression models for the improvement of the result.

Table 1. Error or difference between the observed and predicted values of minimum temperature in percentage.

Error (°C) T_m(obs) -T_m(pre)	Percent		
	Dec.	Jan.	Feb.
0 to ± 1.0	50.0	50.6	45.3
±1.1 to ± 2.0	29.7	30.3	28.3
±2.1 to ± 3.0	13.5	10.1	17.0
±3.1 to± 4.0	4.1	9.0	5.6
±4.1 to ± 5.0	1.4	0.0	1.9
±5.1 to ± 6.0	1.3	0.0	1.9

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