J. Ind. Geophys. Union (July 2018)
v.22, no.4, pp: 450-454

Study and analysis of weather parameters during avalanche for Bahang region, Manali (Himachal Pradesh)

Neha Ajit Kushe* and Ganesh M. Magar

P.G. Department of Computer Science, S.N.D.T. Women's University, Juhu Road, Mumbai-49

*Corresponding Author: neha.kushe@hotmail.com

ABSTRACT

Snow avalanche has been an integral part of the natural hazards in the mountainous region. In India, avalanches are mainly observed in the north and north-eastern zone of the country, which mainly comprises of Himalayas and their surrounding areas. The Himalayan region is broadly classified into Upper, Middle and Lower Himalaya Zones. However, due to the varied nature of meteorological and environmental conditions, the avalanche climatology is not the same for the whole Himalayan range and the environmental factors that lead to avalanche in all these zones, are different. This paper presents the study and analysis of the weather parameters during avalanche, to find influencing range of the weather parameters for avalanche occurrence in Bahang region of Manali, Himachal Pradesh, which falls in the Lower Himalaya Zone.

Keywords: Avalanche, Bahang region, Himalayas, Meteorological parameters, Snow.

INTRODUCTION

Avalanche is considered one of the most hazardous phenomena occurring in the mountainous terrain throughout the world. It has been observed in every continent which boasts of an area having snow covered mountains. Though normally considered a natural disaster, an avalanche can also be caused due to other factors, like skiers, snowmobilers, animals or explosives. Avalanche consists of snow masses, mainly containing of ice along with rocks, soil, vegetation, etc. which descend steep slopes at an accelerated rate (Schweizer et al., 2003). They are said to be naturally triggered when the force of the snow exceeds the strength of the snowpack, leading to a mechanical failure in the snowpack. Because of this, the snow breaks and starts sliding down the mountain slope. The main factors contributing to avalanche danger are terrain, fresh precipitation, wind, temperature and snowpack stratigraphy (Schweizer et al., 2003). However, the most important terrain factor dominating the avalanche release is slope of the terrain (Schweizer et al., 2015). This is because the slope is the only factor which remains constant over time and normally a slope angle >30° is required for avalanches (Schweizer et al., 2003). The Avalanche Path mainly consists of three main zones, namely starting zone, track and runout zone (International Association of Hydrological Sciences. International Commission on Snow and Ice, 1981). Starting zone is where the initial snow mass releases, track consists of the path traced by the avalanche and runout zone is where avalanche decelerates and snow is deposited.

In India, avalanches are observed majorly in the north and north-eastern zone of the country, which mainly comprises of Himalayas and their surrounding areas. It is considered the third largest deposit of ice and snow in the world, after Antarctica and the Arctic. It encompasses about 15,000 glaciers (PBS, 2011). Further the higher regions of the Himalayas are snowbound throughout the year and it boast of a permanent snow line of around 5,500 metres, which is the highest in the world (Ya-feng et al., 1980). However due to such environmental factors, numerous number of avalanches have hit the Himalayas. In India, Snow & Avalanche Study Establishment (SASE) was setup in Manali in the year 1969 to study the snow and avalanche problems in the snowbound belt of Indian Himalayas (Sharma, 2000). Indian Himalayan region experience such a wide diversity in climatic and precipitation patterns that the snow properties and related avalanche activity assume a wide variation. Accordingly, the Western Himalayas has been classified into Lower Himalaya zone or Subtropical zone, Middle Himalaya zone and the Upper Himalaya zone or High Latitude zone (Sharma and Ganju, 2000). Further in order to obtain snow-meteorological data from these various parts of Indian Western Himalayas, 46 manned observatories and 16 Automatic Weather Stations (AWS) were installed (Ganju and Singh, 2004). However, algorithms and parameters influencing the avalanche activity for each zone of the Himalayas at any given time are different (Sharma and Ganju, 2000). As a result, the parameters that are normally considered to find avalanche probability for a region in Upper Himalaya zone, may not be the same as the factors affecting the avalanche occurrence for a region in Lower Himalaya zone. Hence individual study of the climatic conditions for each region is required for formulating an accurate avalanche prediction model. A similar observation station was installed in

Figure 1. Location of the study area of Bahang region in Himachal Pradesh.

Table 1: List of Parameters Considered

S.no	Variable	Characteristics Period/Time	Unit
1	Maximum Temperature	Day x	°C
2	Minimum Temperature	Day x	°C
3	Dry Temperature	0830 h (x)	°C
4	Wet Temperature	0830 h (x)	°C
5	Pressure	0830 h (x)	millibar
6	Average Wind Speed	0830 h (x-1)-0830 h (x)	kmph
7	Humidity	0830 h (x)	%
8	Sunshine	0830 h (x-1)-0830 h (x)	hrs: min

Bahang Region of Manali, Himachal Pradesh. Present study is to find the ranges of the meteorological parameters in which avalanches have occurred in Bahang. Figure 1 presents the location of the Bahang Region.

STUDY AREA AND DATA CHARACTERISTICS

Observation station was installed at Bahang (2192 m) in Manali, which falls in the Pir Panjal Range of Lower Himalayas (Gusain et al., 2014). Weather trends for Bahang from the year 1976 to 2011 showed an increasing trend for maximum and minimum temperature and decreasing trend for snowfall. Snow and meteorological data from this observatory was used to find the relation of parameters to the avalanche activity. The past records corresponding to 22 snow meteorological variables from the period from Jan 2005 to March 2013(covering the months from Jan to March in each winter), was archived in the database with respective dates of observation. The list of the parameters used for this study are given in Table 1.

A total of 812 days was considered for this study, which comprised of 1624 records which were taken at 0830 hrs and 1730 hrs (both IST (GMT + 5.30)). For each record, the associated avalanche information was also stored in the database and used for this study. The relation between wet temperature, dry temperature and humidity was used to find the missing values in either of these three columns (Stull, 2011). The rows that still consisted missing values were discarded and thus a total data of 805 days was used for the present study.

Table 2. Probability of Avalanche Occurrence for each parameter in each range

Range	Max Temp	Min Temp	Dry Temp	Wet Temp	Pressure	Avg Wind Speed (24 hrs)	Humidity	Sunshine (24 hrs)
0.0-0.1	0.4783	0	0	0	0	0.108	0	0.12
0.1-0.2	0.0566	0	0	0	0.111	0.0269	0	0
0.2-0.3	0.1607	0	0.063	0	0.086	0	0	0
0.3-0.4	0.0444	0.0458	0.106	0.058	0.087	0	0	0
0.4-0.5	0	0.128	0.006	0.093	0	0	0	0
0.5-0.6	0	0	0	0	0.016	0	0	0.015
0.6-0.7	0	0	0	0	0.017	0	0	0
0.7-0.8	0	0	0	0	0.054	0	0	0
0.8-0.9	0	0	0	0	0	0	0.0367	0
0.9-1	0	0	0	0	0	0	0.1679	0

METHODOLOGY

The values for all the parameters were normalized so that all the values belonged to a common scale by using the equation:

$$X_{norm} = \frac{X - X_{min}}{X_{max} - X_{\min}} \quad \text{..... (1)}$$

where X_{norm} gives the normalized value between 0 to 1 for each record and X_{min} and X_{max} are the minimum and maximum values for each parameter respectively. The values were then categorized into 10 equal groups. Further the probability of avalanche occurrence, p(A) for each group was calculated by the following equation:

$$p(A) = \frac{d_i}{D_i} \quad \text{..... (2)}$$

where d_i were the days when avalanche had occurred in the i^{th} range and D_i were the total days in the i^{th}range (Joshi and Ganju, 2009). The probability of Avalanche occurrence for the various parameters for Bahang region, is summarised in Table 2 and plotted in Figure 2.

RESULT AND DISCUSSION

The aim of the present study was to find the behaviour of different weather parameters in case of an Avalanche. The analysis of avalanche condition for Bahang region, mainly led to the fact that avalanche activity is not a frequently happening natural disaster in Bahang. As a result, it is necessary to have accurate predictions of avalanche activity, so that proper warning can be given to people staying in the surrounding region and necessary precautions can be taken by them to protect them from exposure from an avalanche. The avalanche influencing conditions for each parameter are given as follows:

Present study reveals that a maximum temperature of 0°C to 2.8°C has a major impact on occurrence of avalanche. In fact, almost 40% of avalanches have occurred in the said temperature range. The rest of the avalanche activity was found between the range of 2.8°C to 11.2°C. Hence, if the maximum temperature exceeds 11.2°C, the chances of avalanche activity are slim. A major avalanche activity was found when minimum temperature was between the range -0.9°C to 1°C. The avalanche activity was almost 77%, when the minimum temperature was between the said range. The remaining 20% avalanches have occurred when the minimum temperature had fallen between -2.8°C to -0.9°C.

For dry temperatures, 66% avalanche had occurred when the dry temperature was between 0.05°C to 2.4°C, whereas almost 70% of avalanches happened when the wet temperature was between 0.3°C to 2.25°C. In case of dry temperatures, almost 27% avalanches had occurred when the dry temperature was in the range of -2.3°C to 0.05°C. However, for wet temperature same percentage of avalanche had occurred in the range of -1.65°C to 0.3°C.

Though the maximum number of avalanches have occurred in the range of 794.4 mb to 796.2 mb with regards to pressure, it can be seen from the results no particular range of pressure has a clear effect on the avalanche occurrence. This can be seen as the avalanche activity is fairly divided between the pressure range from 790.8 mb to 803.4 mb. Further this is also seen from the probabilities of avalanche occurrence, where six out of ten ranges have shown an avalanche probability in the range of 0.01 to 0.1. In case of wind speed that had been averaged over 24 hrs, around 70% avalanches have occurred when the total average wind speed over a full day is less than 1.46 kmph. In fact, no avalanche activity is seen if the average wind speed is above 2.93 kmph.

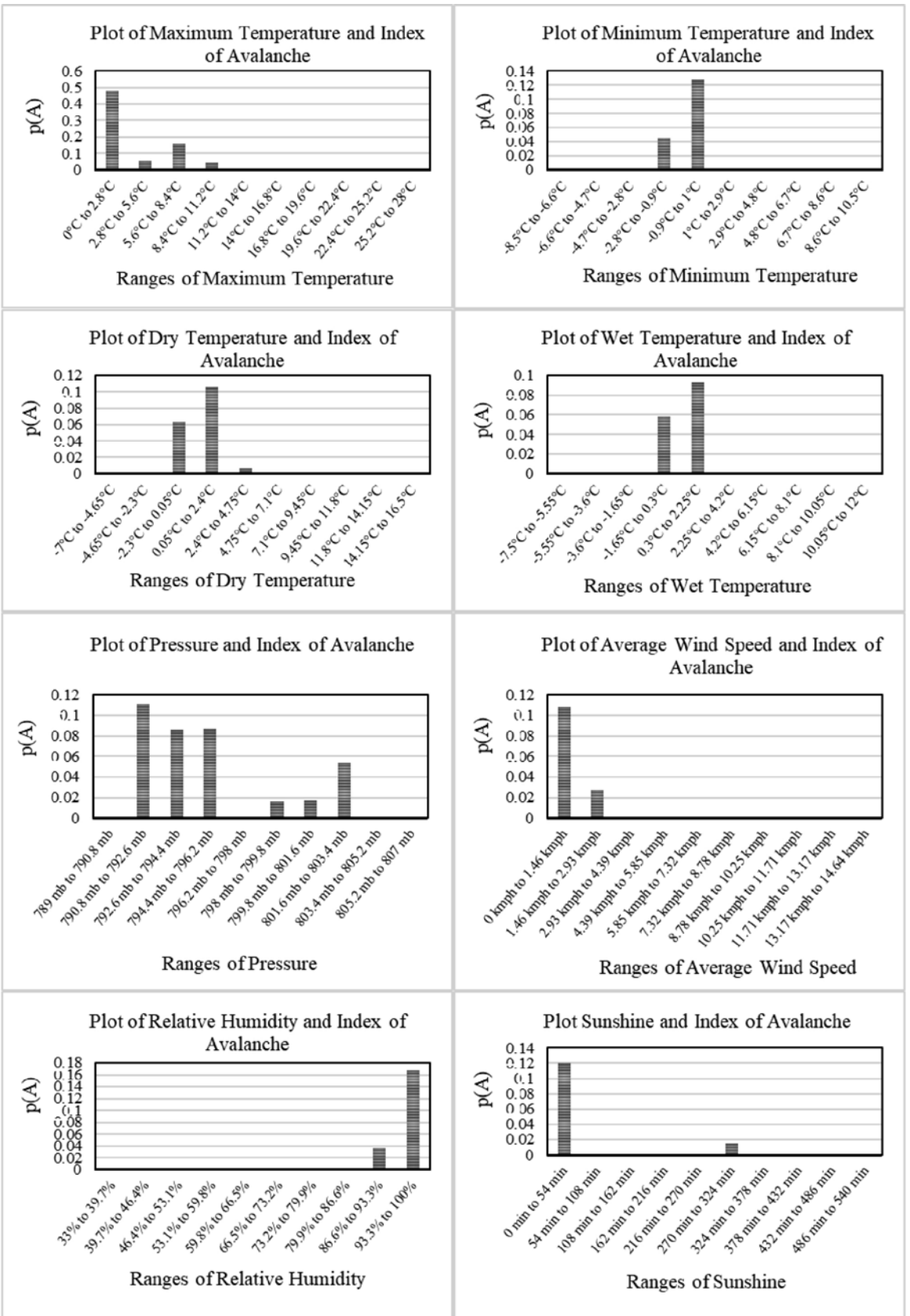

Figure 2. Probability of avalanche occurrence for the various parameters for Bahang region of Manali (Himachal Pradesh)

For humidity, it was observed that the avalanche normally occurs when the amount of water vapour present in the air is on a higher side. The maximum number of avalanches were observed when the humidity was more than 93.3%. The rest of the avalanches have occurred when the humidity was more than 86.6%. Similarly, the results show that less the amount of sunshine in 24 hrs, higher is the probability of avalanche occurrence as almost 96% avalanches have occurred when the sunshine has been less than 54 mins.

Hence, overall it can be seen that rate of avalanche occurrence is high for low ranges of maximum temperature, average of wind speed over 24 hours and amount of sunshine for a full day. Similarly, for minimum temperature, dry temperature and wet temperature, avalanches are observed in the intermediate range of considered parameter. Likewise, avalanches are mainly observed when the humidity present in the atmosphere is high. Pressure does not show any major influence on the formation of avalanche for the Bahang region of Manali.

CONCLUSION

The analysis of the various weather parameters for Bahang region has been presented in the current study. The range for each parameter were found which had led to avalanche and the major conditions that had influence on the avalanche activity. By observing the results, the effect of meteorological parameters on avalanche occurrence was observed and the avalanche prone ranges were obtained for all the weather parameters. This study can help us to understand the climatic condition for Bahang region of Manali and thus could be used to create an avalanche prediction model for the said region.

ACKNOWLEDGEMENTS

The Authors are thankful to Director, SASE (Snow Avalanche Study Establishment) for providing us with the snow and meteorological data for Bahang, Manali for our research study purpose. We would also like to thank Dr. Amreek Singh for kind support.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copy right norms.

REFERENCES

Ganju, A. and Singh, A., 2004. A new approach to avalanche forecasting and disaster management for Western Himalaya. World congress on Natural Disaster Mitigation, 19-21 February 2004.

Gusain, H.S., Mishra, V.D. and Bhutiyani, M.R., 2014. Winter temperature and snowfall trends in the cryospheric region of north-west Himalaya. Mausam, 65(3), 425-432.

International Association of Hydrological Sciences. International Commission on Snow and Ice, 1981. Avalanche atlas; illustrated international avalanche classification. UNESCO, Paris, France: UNESCO.

Joshi, J.C. and Ganju, A., 2009. Analysis of maximum and minimum temperature in view of avalanche activities over north-west Himalayas. Mausam, 60(3), 368-371.

PBS, 2011. The Himalayas, Himalayas Facts, Nature, http://www.pbs.org/wnet/nature/the-himalayas-himalayas-facts/6341/

Schweizer, J., Jamieson, J.B. and Schneebeli, M., 2003. Snow avalanche formation. Rev. Geophy., 41(4).

Schweizer, J., Bartelt, P. and Herwijnen, A.V., 2015. Snow avalanches. In: Snow and Ice-related hazards, risks, and disasters, Elsevier, 395-436.

Sharma, S. and Ganju, A., 2000. Complexities of avalanche forecasting in Western Himalaya—an overview. Cold regions science and technology, 31(2), 95-102.

Sharma, S.S., 2000. An overview of snow and avalanche research in Indian Himalaya, Proceedings of the 2000 Int. Snow Sci. Workshop, October 1-6, Big Sky, Montana 558-565.

Stull, R., 2011. Wet-Bulb Temperature from relative humidity and air temperature, J. Appl. Meteorol. and Climate, 50(11), 2267-2269.

Ya-feng, S., Tze-chu, H., Pen-hsing, C. and Chi-chun, L., 1980. Distribution, features and variations of glaciers in China. World glacier inventory, IAHS-AISH, Publication no. 126, pp: 111-116.

Received on: 12.2.18; Revised on: 4.6.18; Accepted on: 11.6.18