

# OCCURRENCE OF SNOW COVER AND WINTER ON RECREATION

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## Abstract

Recreation and nature conservation in winter are strongly related to the occurrence of snow cover. If the snow cover is not sufficient, the recreation is deprived of skiing. It can also negatively affect the environment. The total snow depth is measured every day, at 7 am. If we add up the data for all days of the winter season, we can get a single number not only about the average height of the snow cover but also about its duration. CHMI stations with a sufficiently long series of measurements were selected for the Beskydy region and the foothills, and from the winter of 1961/62 to the present day, the sums of the total snow depth were calculated. In the first ten winters of the evaluated period, i.e. from the autumn of 1961 to the spring of 1971, the total amount of snow ranged on average from 852 cm (Mošnov), to 1007 cm (Lučina), 1320 cm (Frenštát), 3587 cm (Horní Bečva), 5095 cm (Bílá) up to 15621 cm (Lysá hora). In the past winters, i.e. from autumn 2014 to spring 2024, the average sum of the total snow height ranged from 190 cm (Mošnov), to 200 cm (Lučina), 345 cm (Frenštát), 1064 cm (Horní Bečva), 1629 cm (Bílá) up to 9068 cm (Lysá hora). From an overall perspective, from the 1960s to the present, there has been a gradual reduction in the total amount of snow. This fact means the limitation of skiing on natural snow in the cold season.

**Key words:** Beskydy, snow height, skiing

## Introduction

An essential part of winter recreation is the use of snow cover. Recreation and nature conservation during winter are closely linked to the presence of snow cover. If the snow cover is insufficient, there is a risk that recreation could have more significant negative impacts on the environment. Artificial snowmaking is available, particularly for alpine skiing; however, the presence of natural snow in the landscape remains fundamentally important.

The occurrence of snow can be found in many climatological documents and studies of recreational use, which cannot be mentioned due to the scope of the article. For the period 1901 to 1950, the map processing is in the Atlas of the Climate of the Czech Republic (1959) and Tables (1960). For the period 1961 to 2000, the relevant maps are in the Atlas of the Climate of the Czech Republic (2007). The assessment of snow cover in the Beskydy region was prepared, for example, by Kříž and Tolasz, (1990). The assessment of recreational use of snow cover is presented, for example, by Sýkora (1977).

## Materials and methods

At the stations of the Czech Hydrometeorological Institute, the total snow depth (in cm), i.e., the height of the snow cover lying on the ground, is measured every day at 7 a.m. local solar time. The total snow depth is highly variable over time. To provide a simplified overview of snow conditions throughout the winter season, the duration of snow cover is often calculated, which represents the number of days with snow cover. It is also possible to calculate the average snow depth. Additionally, a product of these two characteristics can be derived, referred to as the total snow depth sum for the entire winter season. This is analogous to temperature sums. From the first day of snow cover to the last, the snow depths for each day are summed. This provides a single characteristic of snow cover for the entire winter season, which is particularly informative for winter recreation.

This study quantifies the total snow depth sum for the entire season in the Beskydy region and its surroundings from 1961, specifically from the winter season of 1961/1962 to the winter of 2023/2024. The locations included are Mošnov (253 m above sea level), Lučina (300 m a.s.l.), Frenštát pod Radhoštěm (436 m a.s.l.), Horní Bečva (565 m a.s.l.), Bílá (720 m a.s.l.), and Lysá hora (1322 m a.s.l.). At stations where air temperature is also measured, comparisons were made between the total snow depth, air temperature, and precipitation amounts.

## Results

The total snow depth sum varies widely from year to year (Fig. 1). Generally, stations at lower altitudes have a smaller total snow depth sum compared to stations at higher altitudes. The highest values were recorded at higher-altitude stations during the winter of 2005/2006, while at lower-altitude stations, the maximum values were observed during the winter of 1962/1963. The maximum total snow depth sums were as follows: Mošnov 2245 cm, Lučina 2960 cm, Frenštát p. R. 5636 cm, Horní Bečva 11022 cm, Bílá 12667 cm, and Lysá hora 26556 cm.

The lowest values were measured during the winters of 2013/2014 and 2019/2020, with the minimum total snow depth sums being: Mošnov 8 cm, Lučina 17 cm, Frenštát 64 cm, Horní Bečva 237 cm, Bílá 508 cm, and Lysá hora 2354 cm.

Overall, there has been a gradual decline in the total snow depth sum from the 1960s to the present. In the first ten winters of the evaluated period, from autumn 1961 to spring 1971, the average total snow depth sums were: Mošnov 852 cm, Lučina 1007 cm, Frenštát 1320 cm, Horní Bečva 3587 cm, Bílá 5095 cm, and Lysá hora 15621 cm.

In the most recent evaluated winters, from autumn 2014 to spring 2024, the average total snow depth sums were: Mošnov 190 cm, Lučina 200 cm, Frenštát 345 cm, Horní Bečva 1064 cm, Bílá 1629 cm, and Lysá hora 9068 cm.

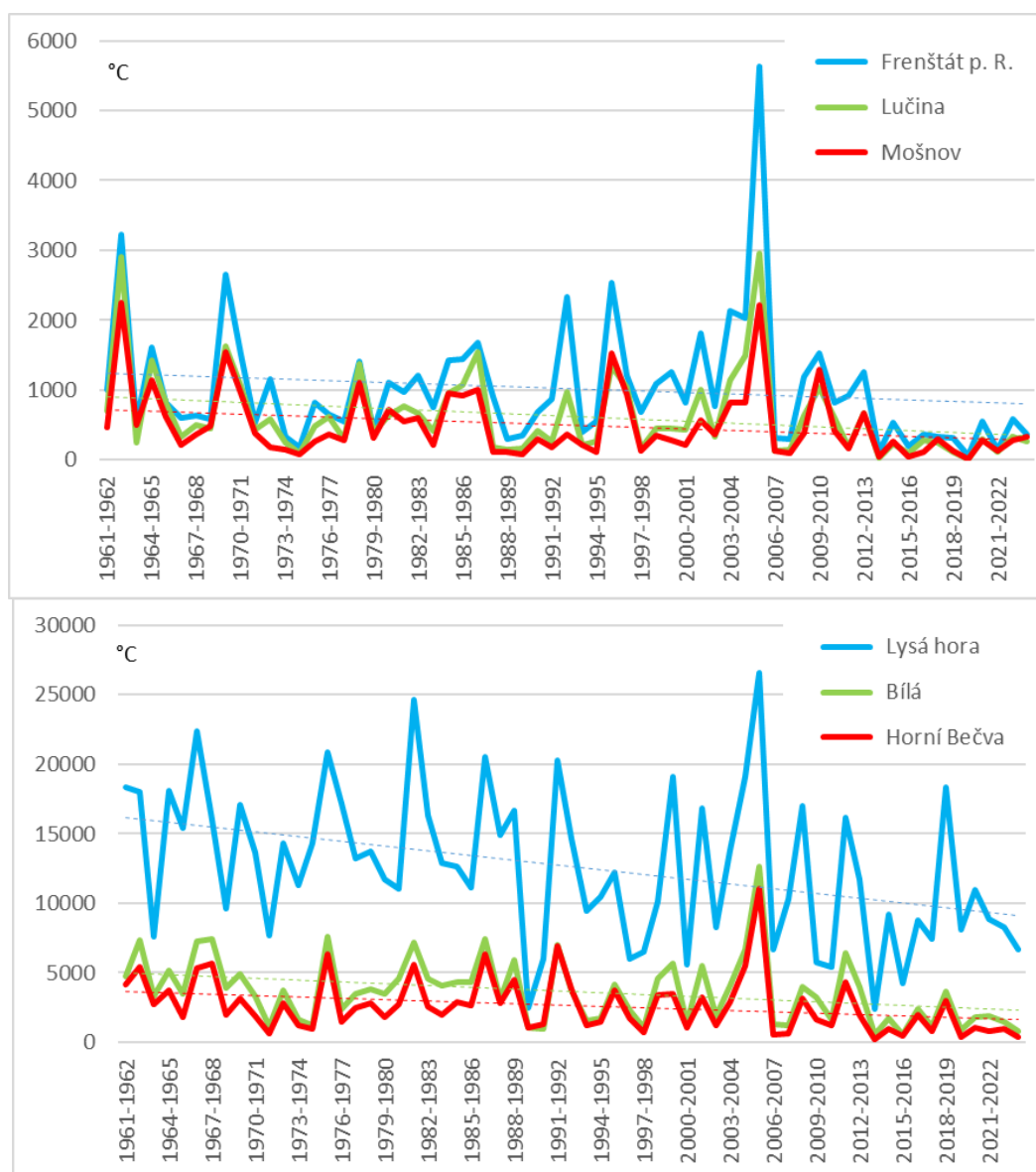


Fig. 1: Sum of the total snow depth in winter season (cm) and its trend for the period 1961/1962 to 2023/2024 at the climatological stations of the Czech Hydrometeorological Institute in Beskydy region

The correlation coefficient between the total snow depth sum and air temperature from December to February is, in absolute terms, higher at stations with higher altitudes: Mošnov -0.75, Lučina -0.72, Frenštát -0.64, and Lysá Hora -0.55. This indicates a stronger negative relationship between snow depth and temperature at higher altitudes.

The correlation coefficient between the total snow depth sum and precipitation from December to February is higher at higher-altitude stations: Mošnov 0.32, Lučina 0.30, Frenštát 0.35, and Lysá Hora 0.58. This suggests a stronger positive relationship between snow depth and precipitation at higher elevations.

The multiple correlation coefficient between the total snow depth sum and both air temperature and precipitation is similar across stations with varying altitudes: Mošnov 0.81, Lučina 0.80, Frenštát 0.77, and Lysá Hora 0.84. This indicates that the combined influence of temperature and precipitation on snow depth is consistent across different altitudes.

## Discussion

The occurrence of snow is primarily influenced by air temperature. When temperatures are above freezing, the total snow depth cannot increase, regardless of precipitation. Precipitation only contributes to snow depth when temperatures are below freezing. This explains the magnitude of the correlation coefficients between the various climatic characteristics. Lower-altitude stations are warmer, with air temperatures more frequently above freezing, which results in a high correlation between snow depth and air temperature, and a relatively low correlation between snow depth and precipitation. At these stations, precipitation often occurs when air temperatures are above freezing.

On Lysá hora, however, sub-freezing temperatures are significantly more common during winter, which increases the influence of precipitation. Without precipitation, there is no snow. Air temperature is particularly important around the freezing point. Whether temperatures are slightly below freezing or significantly colder has little additional impact on snow depth.

In the Czech Republic, winter air temperatures often hover around the freezing point. As a result, the observed warming trend has a pronounced effect on snow depth. Nevertheless, one of the most significant winters occurred relatively recently, during the 2005/2006 season. This winter was characterized by low air temperatures and high precipitation. In Frenštát, the average air temperature from December to February was -1.7 °C. The second coldest winter since this episode was 1.7 °C warmer in Frenštát. Looking further into the past, colder winters did occur, but they were generally associated with significantly lower precipitation totals. Winters with higher precipitation totals were usually much warmer.

The winter of 2005/2006 was most comparable to the winter of 1962/1963. However, the latter was noticeably colder, with an average air temperature in Frenštát from December to February of -3.7 °C. Precipitation in Frenštát during the winter of 2005/2006 was 406 mm, compared to 312 mm in 1962/1963. These differences contributed to the total snow depth sum for the 2005/2006 season being 5636 cm, while for the 1962/1963 season, it was 3230 cm. In Frenštát, Horní Bečva, Bílá, and Lysá hora, the winter of 2005/2006 was the snowiest of the entire study period. Only at the lower-altitude stations, Mošnov and Lučina, was the winter of 1962/1963 similarly snow-rich.

The winter of 2005/2006 was therefore highly exceptional. Since then, with the exception of Lysá hora, winters at the other stations have been relatively snow-poor. The last 10 seasons, in particular, have been markedly different from what was typical over the previous 50 years.

## Conclusion

The total snow depth sum for the entire winter season appears to be a simple yet highly effective measure for describing snow conditions during a given period, especially in relation to winter recreation, particularly skiing on natural snow. This characteristic allows for easy comparison of conditions across different winters and locations.

With ongoing warming, it is evident that snow conditions for skiing on natural snow in the Beskydy region and its surroundings are deteriorating significantly. Over the past 10 winters, snow conditions in Horní Bečva (565 m a.s.l.) have been similar to those observed in the 1960s in Lučina (300 m a.s.l.). The winter of 2005/2006 was truly exceptional, as the combination of low air temperatures and high precipitation totals resulted in record-breaking snow cover.

The total snow depth sums for the entire winter season show a strong correlation with the combined consideration of air temperature and precipitation from December to February.

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## Souhrn

Rekreace a ochrana přírody v zimě silně souvisí s výskytem sněhové pokrývky. Pokud není sněhová pokrývka dostatečná, hrozí dokonce to, že rekreace bude mít výraznější negativní dopady na životní prostředí. Zejména pro alpské lyžování existuje zasněžování umělým sněhem, přesto má výskyt přirozeného sněhu v krajině zásadní význam. Pro oblast Beskyd a podhůří byly vybrány stanice ČHMÚ s dostatečně dlouhou řadou měření a od zimy 1961/1962 až do současnosti byly vypočteny sumy celkové výšky sněhu. Nejvyšší hodnoty byly na stanicích s vyšší nadmořskou výškou zaznamenány v zimě 2005/2006, na níže položených stanicích v zimě 1962/1963, s maximy sumy celkové výšky sněhu: Mošnov 2245 cm, Lučina 2960 cm, Frenštát p. R. 5636 cm, Horní Bečva 11022 cm, Bílá 12667 cm, Lysá hora 26556 cm. Nejnižší hodnoty byly naměřeny v zimách 2013/2014 a 2019/2020, s minimy sumy celkové výšky sněhu: Mošnov 8 cm, Lučina 17 cm, Frenštát 64 cm, Horní Bečva 237 cm, Bílá 508, Lysá hora 2354 cm. Z celkového pohledu dochází od 60. let do současnosti k postupnému snižování sumy celkové výšky sněhu. Mezi sumou celkové výšky sněhu a teplotou vzduchu a množstvím srážek existuje silná korelace (korelační koeficient 0,8). Korelace mezi výškou sněhu a teplotou vzduchu je výraznější u níže položených stanic. Korelace mezi výškou sněhu a množstvím srážek je výraznější u výše položených stanic. Pro možnost výskytu přirozeného sněhu jsou samozřejmě podmínkou nízké teploty vzduchu, teploty pod 0 °C. Teprve pokud je toto splněno, záleží i na množství srážek. Tím, že se teploty vzduchu u nás v zimě pohybují právě blízko 0 °C, je ubývání výšky sněhu s postupujícím oteplováním hodně výrazné.

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