CLIMATE DEVELOPMENT IN THE BESKYDY MOUNTAINS

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Abstract
The area of the Beskydy Mountains covered in this article is 2,412 km², and the average elevation is 557 meters above sea level. The selected area covers only 3% of the territory of the Czech Republic.
The climate is changing worldwide, and the Beskydy Mountains are no exception. Given that the elevation range of the mountain range is 1,000 m, we calculated the characteristics of the Beskydy Mountains for individual years and months from 1874 to the present using available data. For precipitation totals, average air temperature, and new snowfall totals, we obtained 150-year time series, from which we are able to analyze trends and identify historical extremes in this region. Based on our knowledge of the past and present, we can better prepare for and adapt to the future climate, which influences and will increasingly influence most of our activities.

Key words: air temperature, precipitation total, trend, weather station, Bílá

Introduction

For the purposes of describing the climate of the Beskydy Mountains, we define the Beskydy in this context as the area comprising the Silesian and Moravian-Silesian Beskydy, the Hostýn-Vsetín Highlands, the Javorníky Mountains, and the Podbeskydská Uplands. We defined the boundary by selecting the area where the landscape rises from the plain to the hills as the Beskydy Mountains. This created a closed polygon for calculating characteristics in a GIS (Geographic Information System) environment. The area defined in this way (Fig. 1) covers 2,412 km² and has an average elevation of 557 m above sea level. The highest point is Lysá hora, and the lowest point lies at an elevation of 264 m above sea level. The area represents approximately 3% of the Czech Republic's total land area.
For the defined area of the Beskydy Mountains, we derived spatial characteristics of air temperature, total precipitation, and new snowfall over the past 150 years. Based on meteorological data from the Bílá station, we further assessed the long-term trends in snow cover and conditions for winter recreation, including a forecast for the 2025/2026 season.
We also outlined the potential climate development in the Beskydy region up to the year 2100 based on the regional ALADIN-CLIMATE/CZ model (ALARO configuration, 2.3 km resolution, Brožková et al. 2019) as part of the PERUN project (PERUN 2022). Two emission scenarios were evaluated: SSP2-4.5 and SSP5-8.5 (IPCC, 2021). Due to space constraints, we present only a portion of the results.

Materials and methods

Long-term meteorological data series from the CLIDATA climatological database of the Czech Hydrometeorological Institute were used to calculate the areal characteristics.
The analysis included data from 24 standard stations, 8 snow gauge stations, 40 supplementary stations, and approximately 105 rain gauge stations. Data from neighboring regions in the Czech Republic, Poland, and Slovakia were also utilized. Monthly and annual characteristics of air temperature, total precipitation, and new snowfall were analyzed for the period 1874–2025 (approximately 130 years for snow). Spatial characteristics were derived using interpolation methods that account for the influence of orography, particularly the local linear regression (LLR) method and ClidataDEM (Stříž 2008).

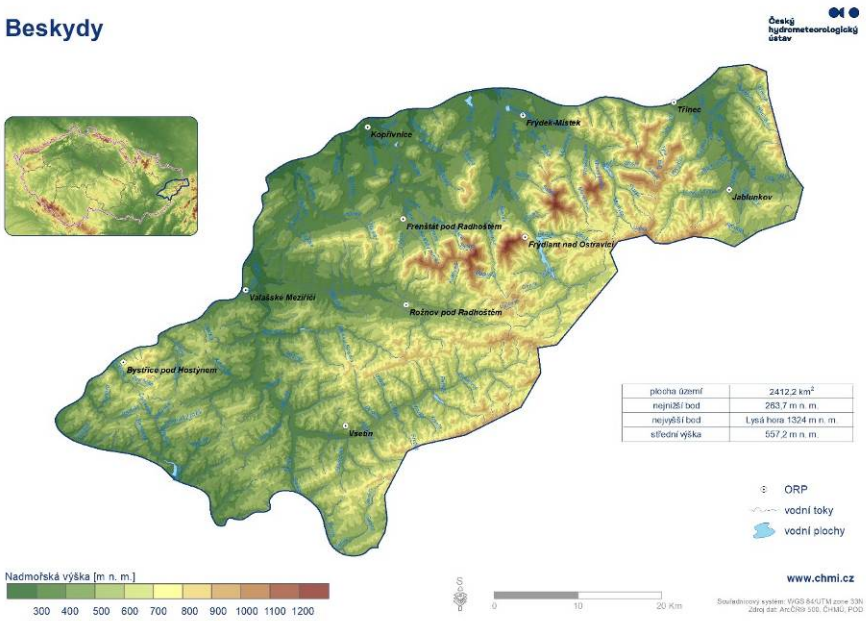

Fig. 1: Map of the Beskydy region.

Results

The average annual air temperature in the Beskydy Mountains over the past 152 years has shown an upward trend of 0.118 °C per decade. Over the entire study period, it has increased by 1.8 °C. The 1901–1930 temperature norm had an annual air temperature of 6.5 °C, the 1931–1960 and 1961–1990 norms were both 6.7 °C, and the 1991–2020 norm was 7.7 °C (Fig. 2). For the years 2021–2025, the average annual temperature is 8.5 °C (Fig. 3).

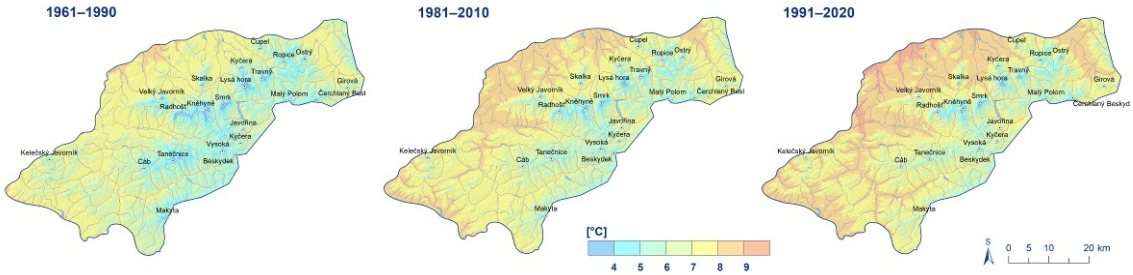

Fig. 2: Long-term averages of air temperature in the Beskydy Mountains for the periods 1961–1990, 1981–2010, and 1991–2020.

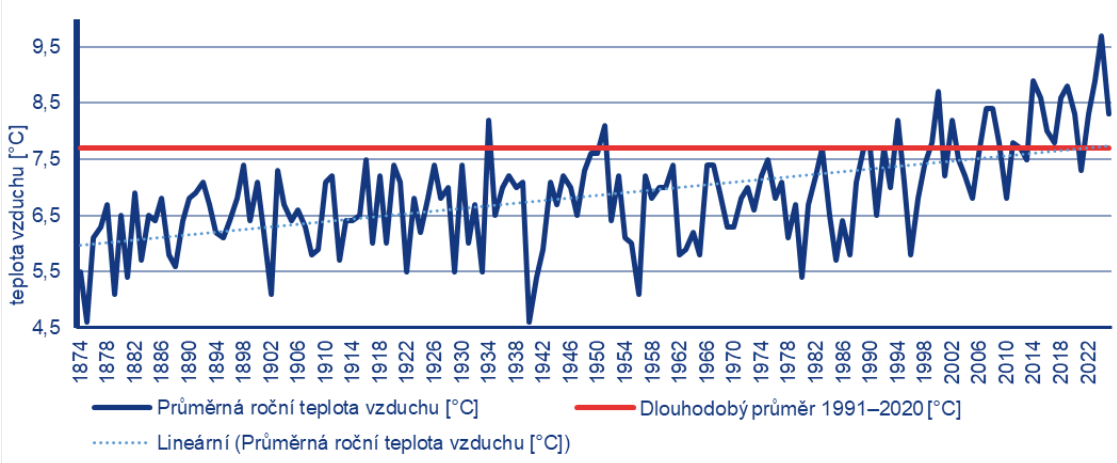

Fig. 3: Average annual air temperature calculated for a defined area of the Beskydy Mountains, compared with the 1991–2020 normal period and the linear trend.

Figure 4 below shows that, according to both the SSP2-4.5 and SSP5-8.5 socioeconomic scenarios, the trend of rising air temperatures in the Beskydy Mountains will continue. According to model simulations based on the medium emissions scenario SSP2-4.5, average air temperatures in the Beskydy Mountains are expected to rise by 2.2 °C by the end of the 21st century compared to the current climate (1991–2020). Under the pessimistic scenario SSP5-8.5, the increase is as high as 4.7 °C.

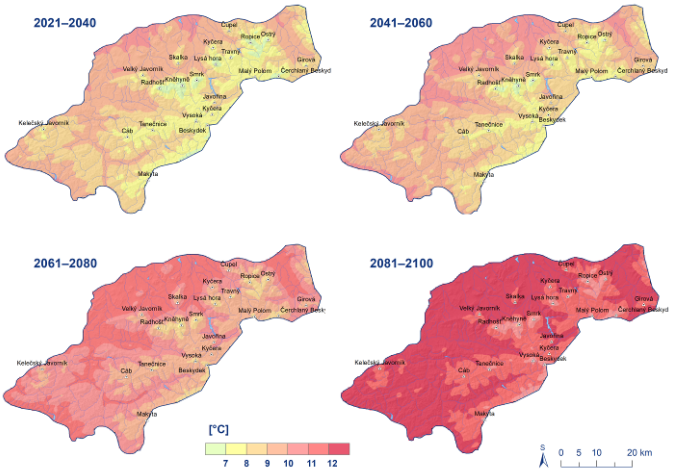

Fig. 4: Average annual air temperature in the Beskydy Mountains for the SSP5-8.5 scenario and individual 20-year periods

Annual precipitation totals show a slight downward trend of 5.5 mm per decade. Individual reference periods have annual averages ranging from 986 to 1,086 mm.
Regarding possible future trends, the SSP2-4.5 scenario does not predict any significant changes in precipitation by 2100, while the SSP5-8.5 scenario shows an increase in precipitation totals in all 20-year periods (Table 1).
The total amount of new snow in the Beskydy Mountains has shown a declining trend over the past 130 years (1896–2025) of 1.9 cm per decade. The average annual snowfall was 206 cm for the period 1901–1930, 222 cm for the period 1931–1960, 220 cm for the period 1961–1990, 197 cm for 1991–2020, and just 140 cm for the last five years (2021–2025).

According to a compiled data series from meteorological stations in Bílá in the Beskydy Mountains, covering various measurement locations (720–770 m a.s.l.) for the period since 1900, the long-term winter total of new snowfall (September–May) ranged from 283 to 286 cm during 1901–1990, 296 cm during 1991–2020, and only 169 cm in the last five years. The trend is decreasing at a rate of 2.5 cm per 10 years.
Maximum total snow cover depths at Bílá during winter seasons show a decreasing trend of 3.1 cm per 10 years. The average winter maximum for the period 1901/1902–1930/1931 was 95 cm, for the period 1931/1932–1960/1961 it was 90 cm, for the period 1961/1962–1990/1991 it was 81 cm, for the period 1991/1992–2020/2021 it was 74 cm, and for the last five winters, 2021/2022–2025/2026, only 51 cm. The highest total snow cover to date was 198 cm in the winter of 1943/1944, and the lowest to date, only 23 cm, was in the winter of 2019/2020.
Given the aforementioned trend in air temperature, it can be assumed that the nature of precipitation will also change, as evidenced by other regional characteristics for individual elevation zones in the Beskydy Mountains (Table 1). As air temperatures rise, particularly minimum winter temperatures, snowfall will decrease in favor of rainfall. For example, results based on the SSP5-8.5 scenario predict snow cover only at elevations above 600 m a.s.l. (Fig. 5).

Tab. 1: Regional characteristics for elevation zones in the Beskydy Mountains according to the SSP5-8.5 scenario.

		Altitude (m n. m.)					
Element	Period	pod 400	401–600	601–800	801–1000	1001–1200	nad 1201
Minimum annual air temperature (°C)	2021–2040	5,2	4,5	3,8	3,4	3,0	2,6
	2041–2060	5,5	4,9	4,2	3,8	3,3	3,0
	2061–2080	6,8	6,1	5,5	5,1	4,7	4,4
	2081–2100	8,6	8,0	7,4	7,0	6,6	6,4
Average annual precipitation (mm)	2021–2040	889	982	1132	1239	1318	1374
	2041–2060	906	1007	1156	1263	1343	1400
	2061–2080	997	1096	1262	1383	1478	1543
	2081–2100	988	1092	1263	1379	1466	1533
Average annual snow cover height (cm)	2021–2040	1	2	5	6	8	9
	2041–2060	2	4	8	11	14	15
	2061–2080	1	2	4	5	7	7
	2081–2100	0	1	2	2	3	3

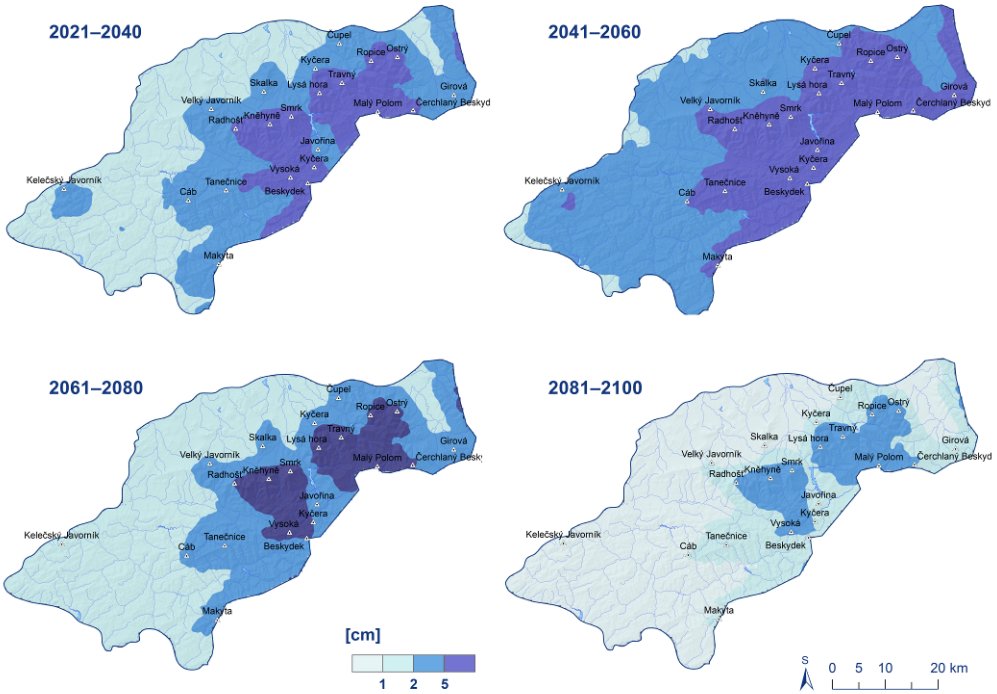

Fig. 5: Average annual snow depth (cm) in the Beskydy Mountains for the SSP5-8.5 scenario and individual 20-year periods.

Discussion

The last winter season (2025/2026) at Bílá in the Beskydy Mountains offered good skiing conditions. The first snowfall resulting in a snow cover was recorded on November 17; it snowed almost daily until

November 26, and the snow cover remained until December 3, reaching a maximum depth of 14 cm. From November 17 to December 3, 2025, sub-freezing minimum air temperatures were suitable for snowmaking. Between December 4 and 11, daytime air temperatures remained above freezing. From December 12 to February 21, minimum air temperatures were below freezing on most days.
After the Christmas holidays, it began snowing again during a cold spell, and a significant snowpack was recorded, peaking at 55 cm on January 12. By the end of January, there was still nearly 20 cm of natural snow, which melted before mid-February; however, it snowed again in mid-February and remained on the ground until the end of the month. Natural snow appeared on the ground during a cold snow episode at the end of March.
Continuous snow cover was recorded from December 28, 2025, to February 11, 2026, and then from February 15 to 23, 2026. From March 25 to 31, 28 cm of new snow fell, and the snow cover persisted into early April, with a maximum of 12 cm on March 27. In the first half of March, maximum air temperatures ranged between 6 and 11 °C. Conditions for downhill skiing were excellent at least until mid-March. The actual 2025/2026 season at the Bílá Ski Resort began around November 29, 2025, with full operations starting in mid-December 2025 and the season ending on March 23, 2026. The resort was not open all day every day (limited operations at the beginning and end of the season). The full season (most slopes) lasted from December 20, 2025, to March 15, 2026, offering approximately 85–90 days of quality skiing.
This winter also offered ideal conditions for cross-country skiing. There are four cross-country trails in and around Bílá. The approximately 15 cm of natural snow required for good trail conditions was recorded from December 28, 2025, through early February 2026.

Conclusion

The average annual air temperature in the Beskydy Mountains over the past 150 years has shown an upward trend of 0.118 °C per decade. While it was 6.5 °C during the period 1901–1930, it has reached 8.5 °C in the last five years (2021–2025). Annual precipitation totals show a slight downward trend of 5.5 mm per 10 years. Between individual normal periods, annual totals generally range from 986 to 1,086 mm. Year-to-year variability is considerable, with no statistically significant trend; however, a shift in the distribution of precipitation throughout the year toward more intense episodes is evident. The total amount of new snow in the Beskydy Mountains has shown a decreasing trend over the past 130 years (1896–2025) of 1.9 cm per 10 years; the seasonal snow total for 1991–2020 was 197 cm, and for 2021–2025, only 140 cm. An analysis of future climate trends in the Beskydy Mountains based on outputs from the ALADIN-CLIMATE/CZ regional climate model confirms that projections of future climate trends correspond to trends already observed in long-term meteorological data series, particularly the rise in air temperature and the decline in snow cover.

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Souhrn
Rozloha Beskyd, o nichž pojednává tento článek, činí 2 412 km² a průměrná nadmořská výška je 557 metrů. Vybraná oblast pokrývá pouze 3 % území České republiky.
Klima se mění po celém světě a Beskydy nejsou výjimkou. Vzhledem k tomu, že výškový rozsah pohoří je 1 000 m, vypočítali jsme na základě dostupných údajů charakteristiky Beskyd pro jednotlivé roky a měsíce od roku 1874 do současnosti. Pro úhrny srážek, průměrnou teplotu vzduchu a úhrny nového sněhu jsme získali 150leté časové řady, z nichž jsme schopni analyzovat trendy a identifikovat historické extrémy v této oblasti. Na základě našich znalostí minulosti a současnosti se můžeme lépe připravit na budoucí klima a přizpůsobit se mu, které ovlivňuje a bude stále více ovlivňovat většinu našich činností.

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