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THE CASE OF THE FOEHN WIND IN ZAKOPANE AND CRACOW FROM NOVEMBER 6-9, 1997

Abstract: The article presents the analysis of the direction and speed of the 'halny' (foehn) wind on the northern side of the Polish Tatra Mountains, as well as the change of weather conditions (air temperature, air humidity, atmospheric pressure) in Cracow between 6-9 November 1997. The advection of warm air from the South caused a change of weather conditions in Cracow, registered by the automatic meteorological station of the Climatology Department of the Institute of Geography at the Jagiellonian University.

Key words: foehn wind, range of the foehn, warming, synoptic situation, 'St. Martin's summer'.

1. Introduction

Between 6-9 November 1997, a special occurrence of foehn wind was observed on the northern side of the Tatras, which caused widespread damage in the Tatra National Park in the size of standing timber, of the range of 5000 m^3. Felling and breakage were highest in the area of Brzeziny and Kuźnice (forester reports of 12 November 1997). The wind also caused damage to facilities and electricity ducts in Zakopane and the immediate vicinities, while the related saltation by uprooted trees was observed even at Myślenice. Fast advection of warm air caused sudden warming and a significant increase in wind speed in Cracow. The measurement of the automatic meteorological station, at the Research Station of the Climatology Department of the Institute of Geography at the Jagiellonian University allows for detailed analysis of the effects of the 'halny' foehn wind in Cracow.

2. Synoptic situation between 5-11 November

On 5 November there was a clear anticyclonic flow in Central Europe, the centre of which moved from North-northwest to South-southeast (Fig. 1). Between 7-11 November, the centre of the high pressure zone remained in the area of the

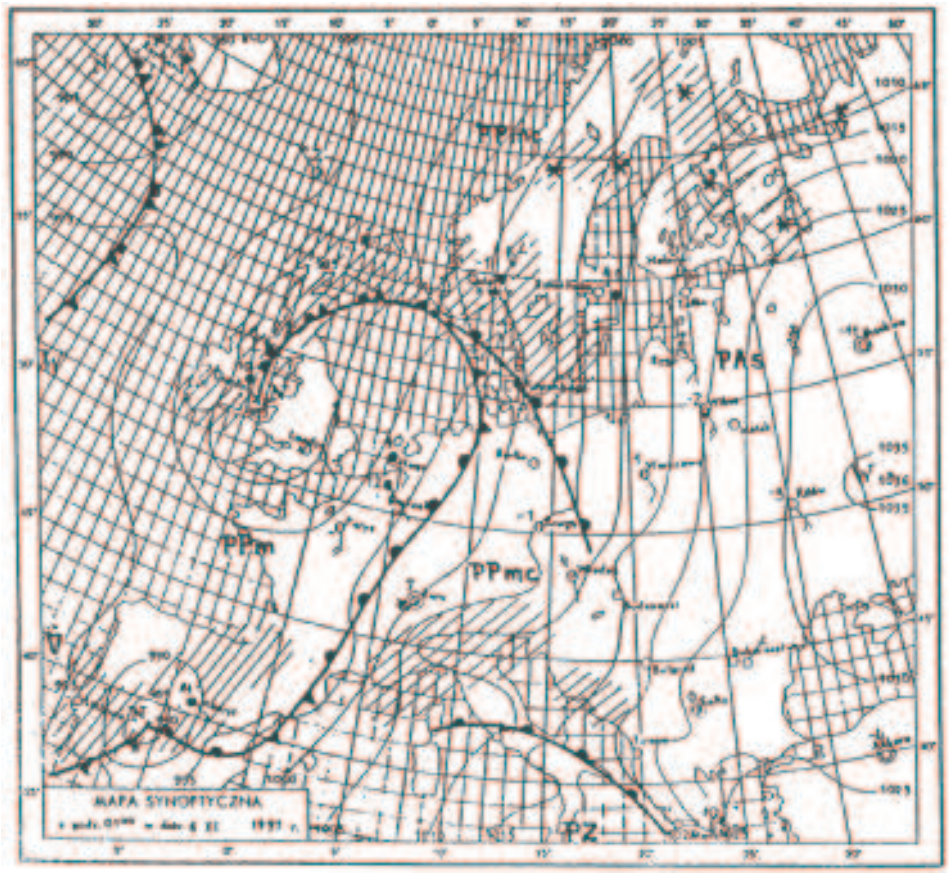

Fig. 1. Synoptic weather chart at 01.00 CET of November 6, 1997 (Codzienny Biuletyn Meteorologiczny IMGW, 1997, 6 listopada 1997r.).

Ryc. 1. Mapa synoptyczna z godziny 1.00 CSE dnia 6 listopada 1997 roku (Codzienny Biuletyn Meteorologiczny IMGW, 1997, 6 listopada 1997r.).

Black Sea and Asia Minor (Fig. 2). Air pressure in the broad high pressure zone ranged within 1033-1022 hPa. Groups of low pressure moved from the Atlantic Ocean towards Central Europe, the centres of which were characterised by very low pressure (980-985 hPa).

On 6 November, low pressure systems moved from the Spanish Peninsula, through northern France to southern Scandinavia. On 9 November the low pressure formed over the Gulf of Riga. The lows were related to very active atmospheric fronts moving quickly from the south-east to the north-west. A low pressure area with precipitation and cold front prevailed over the eastern border of Poland. In the period discussed, significant horizontal pressure gradients were observed, resulting from the

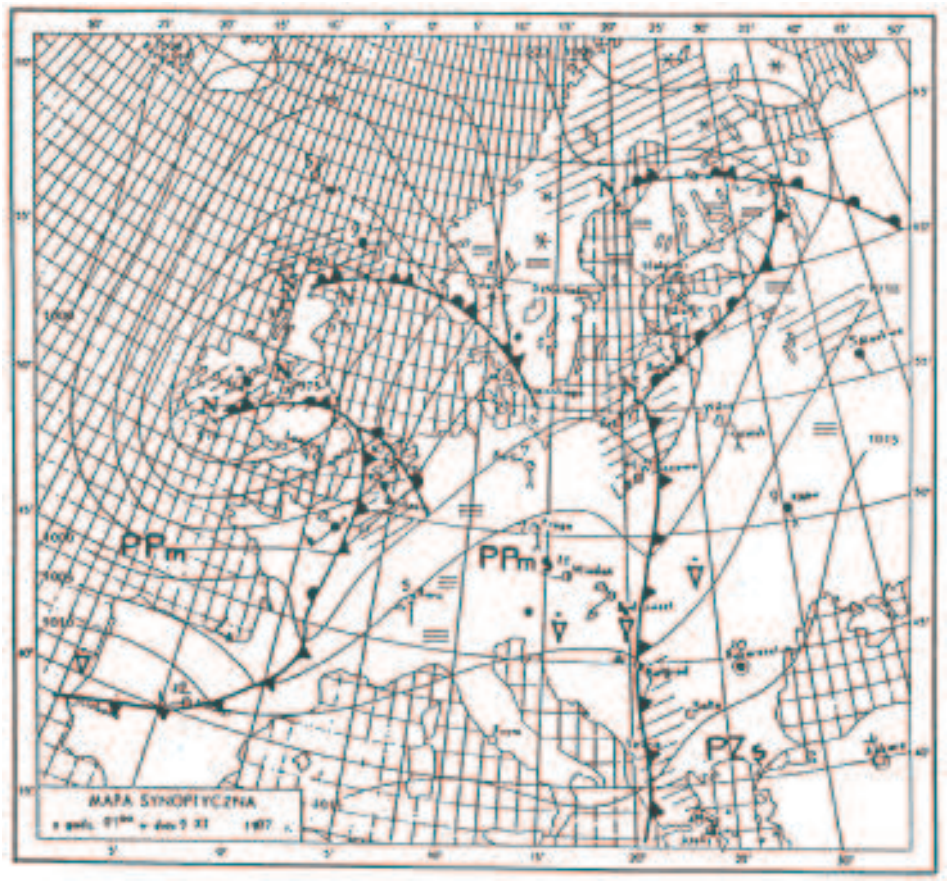

Fig. 2. Synoptic weather chart at 01.00 CET of November 9, 1997 (Codzienny Biuletyn Meteorologiczny IMGW, 1997, 6 listopada 1997r.).

Ryc. 2. Mapa synoptyczna z godziny 1.00 CSE dnia 9 listopada 1997 roku (Codzienny Biuletyn Meteorologiczny IMGW, 1997, 6 listopada 1997r.).

high pressure which remained over north-eastern Europe. Over the northern part of the Carpathians, the pressure gradient forced the southern directions of warm air to descend. In Cracow, such a downward movement was observed between November 6th at noon and the morning of November 9th.

3.Weather in Zakopane

The synoptic situation presented above had to cause the foehn effect in the Carpathians. It was a classic example of the foehn (Bąkowski 1997). Strong wind from the south and south-west was observed, the speed of which even reached 10 ms^{-1}, and

lasted from the late night hours of 5-6th November to the morning of 9th November (table 1). At some point (7th November, morning) the wind reached a speed of over 15 ms^{-1} (7 degrees Beaufort scale of wind speeds). Judging the speed of the wind by its effects, one can presume that locally it must have blown to a speed of 9-10 degrees Beaufort scale, which corresponds to 20-25 ms^{-1}.

In the period discussed, air pressure in Zakopane varied from 904-910 hPa.

Air temperature increased from –0.2°C on November, 6 to 17.1°C on November 7th (maximum temperature). A visible fall of temperature to 4.5°C occurred on 10th November.

Between 6-9th November relative humidity was lower (also in the evening and morning), and fell within 45% (November, 5) to 70%. Saturation deficit values ranged from between 1.1 to 8.1 hPa.

4. Weather in Cracow

The gusts of foehn wind are rarely felt in Cracow. In the period described, however, the foehn effects were observed, i.e. strong gusts of southern wind, incoming warm air and fall of relative humidity. The graphic representation of weather in that period is shown in Fig. 3-7.

Fig. 3 presents the rapid decrease in air pressure starting from 5th November, with the lowest value of 985.1 hPa on 7th November at 5.40 CET.

Wind perimeters are worth studying. Wind speeds measured at the station at the Botanical Garden rarely reach high values, due to the location of the station in the

Tab. 1. Course of the selected meteorological elements in Zakopane of November 6-9, 1997
v – speed of wind, d – direction of wind, p – air pressure, t – air temperature, f – relative humidity, Δ – saturation deficit.

Tab. 1. Przebieg wybranych elementów meteorologicznych w Zakopanem w dniach 6-9 listopada 1997 roku
v – prędkość wiatru, d – kierunek wiatru, p – ciśnienie powietrza, t – temperatura powietrza,
f – wilgotność względna, Δ – niedosyt wilgotności.

day dzień	6 November 6 listopad			7 November 7 listopad			8 November 8 listopad			9 November 9 listopad		
hour - godzina	7	13	19	7	13	19	7	13	19	7	13	19
v [m·s^{-1}]	6	6	6	9	6	5	5	7	6	1	2	2
d	NNE	NNE	NW	S	S	SW	SSW	SW	SW	E	WNW	NE
p [hPa]	908,0	905,3	906,8	903,6	907,5	909,2	908,2	904,5	904,3	909,8	908,8	907,5
t [°C]	10,2	12,8	14,4	15,2	14,1	14,3	13,2	13,5	14,0	8,5	12,5	11,0
f [%]	62	66	56	53	64	62	71	64	60	90	57	51
Δ [hPa]	4,7	5,0	7,1	8,1	5,9	6,2	4,3	5,6	6,4	1,1	6,3	6,4

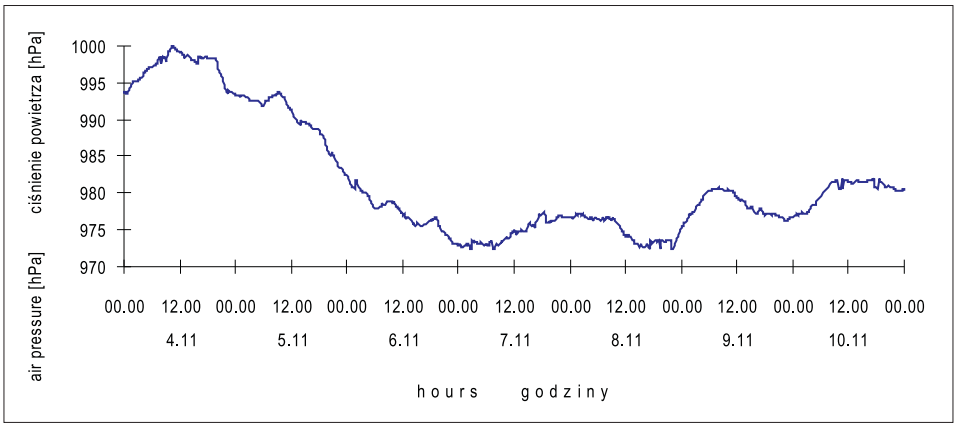

Fig. 3. Course of the air pressure (in hPa) at the meteorological station in Cracow of November 4-10, 1997.

Ryc. 3. Przebieg ciśnienia atmosferycznego (w hPa) na stacji w Krakowie w dniach 4-10 listopada 1997 roku.

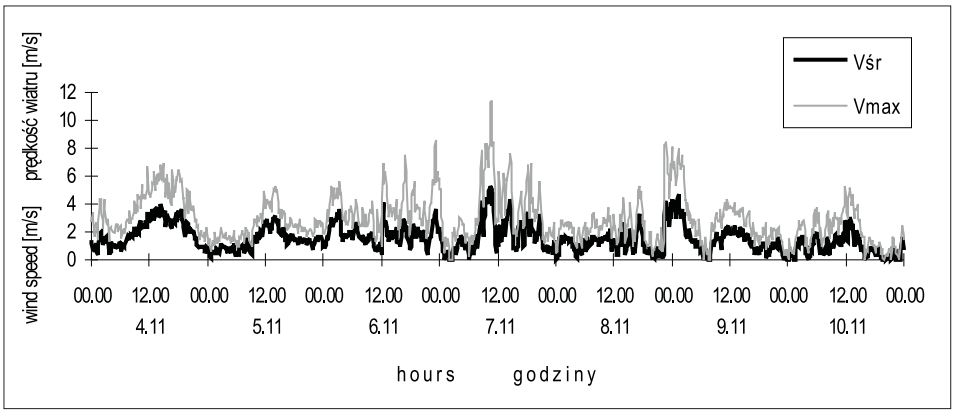

Fig. 4. Course of the mean and maximum wind speed (in $m \cdot s^{-1}$) at the meteorological station in Cracow of November 4-10, 1997.

Ryc. 4. Przebieg średnich i maksymalnych prędkości wiatru (w $m \cdot s^{-1}$) na stacji w Krakowie w dniach 4-10 listopada 1997 roku.

centre of the city. It stands out that during the period discussed wind speed measured at the automatic station at the height of 20 m. a.g.l. was over 11 ms^{-1}, while on 7th November at 10.40 am the maximum wind speed noted was 11.4 ms^{-1} (Fig. 4). Simultaneously, the wind was characterised by sudden gusts, which is visible in Picture

4. Wind speeds higher than 7 ms^{-1} prevailed between 6th November and the morning of 9th November.

The wind direction was changing, depending on the location of the centre of the low pressure. From 6th November at noon to the night of 7th November, southern winds prevailed, later changing to eastern and south-eastern winds (Fig. 5). A further change of wind direction to the west might have been related to the increasing barometric gradient in the foreland of the Carpathians and thus the wind direction change could have been connected with the increased pressure gradient.

The air temperature changed significantly (Fig. 6). After cold days between 3-5th November, the temperature increased from –5.5°C at 6.30 am CET on 5th November to 22.7°C at 2 pm CET on 7th November (increase by 28.2°C). The warm weather also preserved for a further few days.

Changes in temperature were accompanied by irregularities in daily relative humidity. In the period discussed the lowest values of relative humidity fell between 48% on 5th November approximately 50% on 7th November (Fig. 7). The low value of the relative humidity on 10th November at 1 pm CET occurred in the mass of air coming onto the foreland of the Carpathians from south-east. The inward movement was related to the forming of another air pressure system, with a latitude-parallel front in the foreland of the Carpathians (Fig. 2).

The case of the foehn wind described is a clear example of the impact of orography (mountain range) on the forming of weather elements in the foreland of the mountains. The orographic effect was simultaneously noted in the daily records in all meteorological elements in the period discussed, also in elements not presented above. Clouds increased between 6-8th November. The strong horizontal air movement is confirmed by the occurrence of high and medium clouds (Ci, Cc, Cs, Ac len) observed

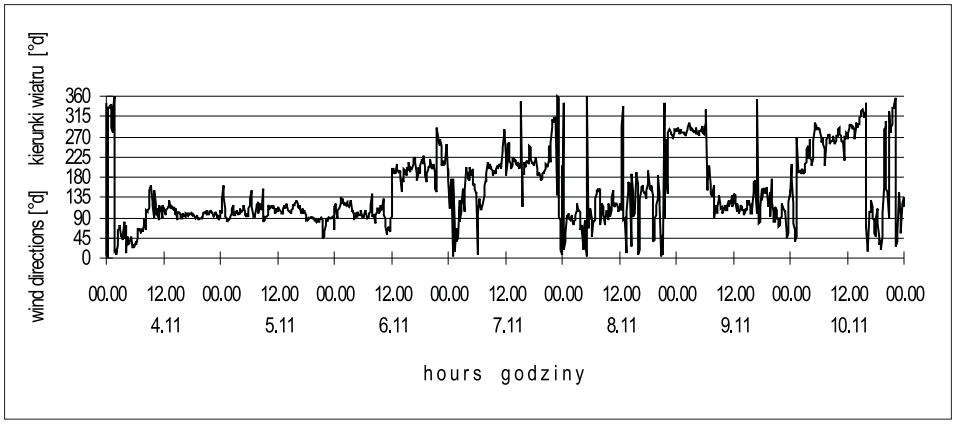

Fig. 5. Course of the wind directions at the meteorological station in Cracow of November 4-10, 1997.

Ryc. 5. Przebieg kierunków wiatrów na stacji w Krakowie w dniach 4-10 listopada 1997 roku.

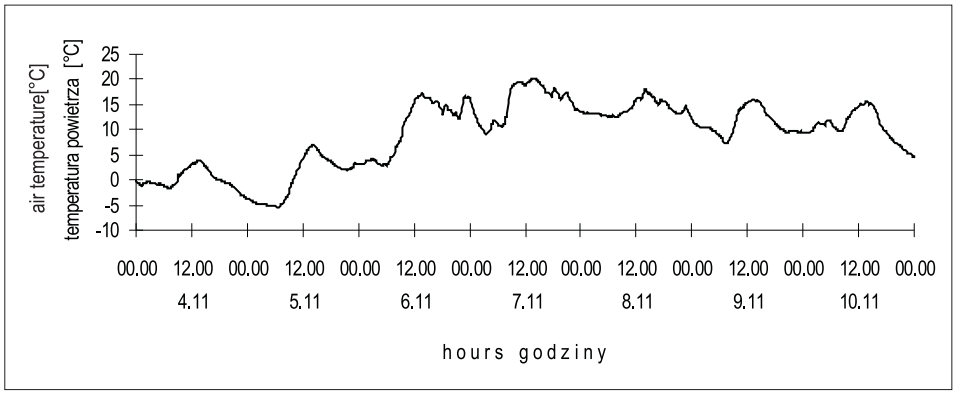

Fig. 6. Course of the air temperature (in °C) at the meteorological station in Cracow of November 4-10, 1997.

Ryc. 6. Przebieg temperatury powietrza (w °C) na stacji w Krakowie w dniach 4-10 listopada 1997 roku.

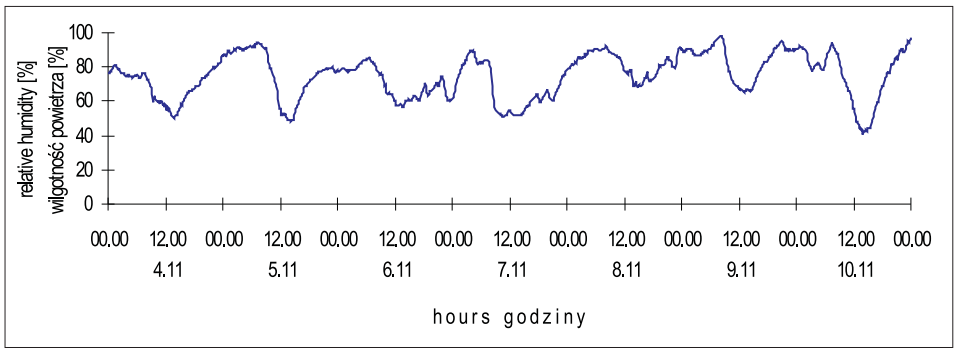

Fig. 7. Course of the relative humidity (in %) at the meteorological station in Cracow of November 4-10, 1997.

Ryc. 7. Przebieg wilgotności względnej powietrza (w %) na stacji w Krakowie w dniach 4-10 listopada 1997 roku.

from the Cracow station. Between 7-9th November, small short precipitation occurred from the middle layer of clouds. The highest sunshine was recorded in Cracow on 9th November (6.9 hours). On 7th November, however, on the day of the maximum wind speed, the sun was not visible.

The occurrence described is interesting from the point of view of the natural weather-shaping element, here represented by mountain range and mountain foreland together with a foehn-conditioning synoptic situation. The air pressure system, and

especially the fronts forming in the Central Europe, were very active. The dynamic barometric situation, characteristic at this season of the year, caused strong advection of warm air, which explains the climatic phenomenon of 'St. Martin's summer'.

The analysis of the minimum air temperature throughout the years in the annual pentads, on the basis of the Cracow series (Trepińska 1975), shows that at the end of October and at the beginning of November, minimal temperatures do not decrease further. The folk tradition points to a track of observed warming related to the beginning of autumn, called 'St. Martin's summer' (St. Martin's day falls on 24th October). It is the turn of seasons, which climatologists named as autumn and pre-winter (Martyn 1995), falling on the last days between the beginning of the last decade of October and the end of the first decade of November. The direction from which the warm air comes depends on the location of the high pressure to the south or south-east of the Carpathians. It may happen that a short warming in southern Poland will be the effect of the foehn winds, forming due to a high horizontal air pressure gradient between the high and the low pressure in the northern foreland of the Carpathians.

Translated by Biuro tłumaczeń „Letterman"

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Przypadek wiatru fenowego w Zakopanem i w Krakowie w dniach 6-9 listopada 1997 roku

Streszczenie

W dniach 6-9 listopada 1997 roku obserwowano po północnej stronie Tatr szczególny przypadek wiatru fenowego, który spowodował na obszarze Tatrzańskiego Parku Narodowego rozległe zniszczenia w objętości drzewostanu. Szybka adwekcja ciepłego powietrza spowodowała nagłe ocieplenie i znaczny wzrost prędkości wiatru w Krakowie.

W Zakopanem wystąpił silny wiatr z kierunków południowego i południowo-zachodniego o prędkościach przekraczających w porywach 15 $m \cdot s^{-1}$. W omawianym

okresie w Zakopanem wystąpiły wahania ciśnienia w zakresie 904-910 hPa. Temperatura powietrza wzrosła od -0,2°C do 17,1°C. Wystąpiły wyraźnie niższe wartości wilgotności względnej powietrza.

W Krakowie wyraźnie widoczny był szybki spadek ciśnienia atmosferycznego. Prędkość wiatru przekraczała 11 $m \cdot s^{-1}$. Zaznaczała się przewaga wiatrów z kierunków południowych i południowo-wschodnich. Nastąpił znaczny wzrost temperatury powietrza od -5,5°C do 22,7°C (wzrost o 28,2°C). Wahaniom temperatury powietrza towarzyszyły duże zaburzenia w dobowym przebiegu wilgotności względnej powietrza. O silnym poziomym przepływie powietrza świadczy występowanie zespołu chmur wysokich i średnich.

Opisywany przypadek jest interesujący z punktu widzenia naturalnego czynnika pogodotwórczego, jakim jest łańcuch górski i przedpole gór w powiązaniu z wyzwalającą feny sytuacją synoptyczną. Układy baryczne, a szczególnie fronty atmosferyczne kształtujące się nad obszarem Europy środkowej odznaczały się dużą aktywnością. Dynamiczna sytuacja baryczna charakterystyczna w tej porze roku przyczyniła się do bardzo wyraźnej adwekcji ciepłego powietrza wyjaśniającej klimatyczną osobliwość jaką jest tzw. „lato św. Marcina".

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