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METEOROLOGICAL OBSERVATIONS AT PIP IVAN (CHORNOHORA) AND KASPROWY WIERCH (TATRAS) BEFORE THE SECOND WORLD WAR

Introduction

During the last years of the interwar period in Poland, two high-altitude observatories were constructed: the High-Mountain Meteorological Observatory at Kasprowy Wierch in Tatras, and the High-Mountain Meteorological and Astronomical Observatory at Pip Ivan in Chornohora (currently Ukraine). A straight line distance of 366 km is located between the two observatories, and well characterized high-altitude weather conditions between the opposite ends of the Carpathian Mountains were present at that time. In 2018, the 80th anniversary of the opening of the two observatories was celebrated. This seems to be a good occasion to discuss the results of the meteorological observations made at these institutions in the period before the outbreak of World War II. There is much more literature on the history and observations of the Observatory at Pip Ivan (Kreiner 1989, 1992; Kreiner, Rymarowicz 1992; Midowicz 2012; Rymarowicz, Kreiner 2012; Rymarowicz, Wielocha 2012) compared to the Observatory at Kasprowy Wierch (Limanówka 2008; Maj 2015). This study is the first attempt to compile and compare this data after almost 80 years of the existence of both observatories.

Materials and methods

Copies of the data sheets *Meteorological Observations Results*¹ (pol. *Wyniki Spostrzeżeń Meteorologicznych*) from the High-Mountain Meteorological and Astronomical Observatory (HMAO) at Pip Ivan were successfully preserved in the private collections of one of the co-authors of this study. For the High-Mountain Meteorological Observatory (HMO) at Kasprowy Wierch, the data sheets *Meteorological Observations Results* were preserved in their original form as IMGW-PIB archives. For the purposes of this analysis, all data contained in these sheets has been digitized.

The HMAO was located on the peak of the Pip Ivan Mountain in the Chornohora massif, at an altitude of 2022 m. a.s.l., with a latitude of $-48^{\circ}02'46''\text{N}$ and longitude of $-24^{\circ}37'42''\text{E}$. The main ridge of the Chornohora massif lies towards NW-SE line. It is the highest mountain range in the region, where six peaks exceed the height of 2000 m a.s.l. Pip Ivan is the most southern peak of the Chornohora range (Fig. 1).

The observatory had a complete set of devices of the first category meteorological station. The mercury barometer (produced by Gerlach) was placed in the observatory tower in the laboratory of observers. The meteorological garden was located on the lower terrace on the east side of the observatory building.

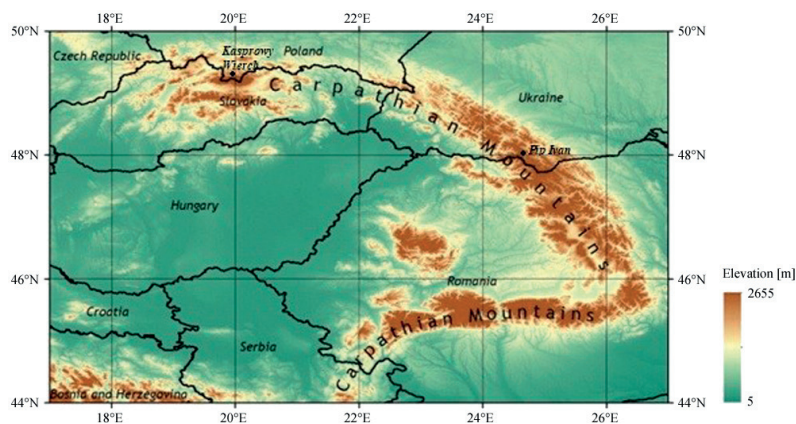


Fig. 1. Location of the observatories at Pip Ivan and Kasprowy Wierch (adapted from Cheval et al. 2014)

¹ The sheets of MOR contain standard meteorological observations

A cage was assigned for the thermometers: dry and moistened (Fuess), maximum (aerometer with thermometer) and minimum (Fuess). For observations, the following were used: pluviograph (Józefowicz), kata thermometer (Fuess), heliograph (Negretti and Zambra), two hydrographs (Fuess) and two thermographs (Richard). A modern hydrostatic anemograph (Fuess) was installed on a special turret on the tower of the building, the readings of which were used to determine the average wind speed and wind direction.

The HMO at the peak of the Kasprowy Wierch Mountain is located at an altitude of 1988 m a.s.l., with a latitude of $-49^{\circ}13'57''\text{N}$ and longitude of $-19^{\circ}58'55''\text{E}$. The observatory is found on one of the highest peaks of the Tatra Mountains. The main ridge of the massif passes along the east-west line, with Kasprowy located to its north (Fig. 1).

The tower of the observatory housed the Fuess mercury barometer, while a cage containing thermometers was located in front of the observatory on the south side. The following thermometers were used: dry (Lambrecht), moistened (Balcerkiewicz), maximum (aerometer with thermometer) and minimal (Silbert and Kuhn). On March 8 1939, during the functioning period of the observatory, the thermometers were moved to the cage on the terrace of the building. As with the HMAO, this observatory also had the Fuess anemograph placed on the tower on the roof of the building.

In both observatories, meteorological observations for climatological purposes were made three times a day: at 6:22, 12:22 and 20:22 at Pip Ivan, and at 6:40, 12:40 and 20:40 Kasprowy Wierch.

The station at Kasprowy Wierch was opened on January 22 1938, while that at Pip Ivan on July 29 of the same year. However, we have a larger set of observational data for HMAO (complete data sheets for the period of October 1938 – July 1939) compared to HMO (the IMGW-PIB archive contains complete data sheets for the period February 1939 – July 1939). The IMGW-PIB archive also contains fragmentary data before the period under consideration (snow depth for December 1935 and Meteorological Observation Results sheets for February, March and July 1937). The period enabling the comparison of the climate parameters in both of these points is therefore the period of February – July 1939, as there is no data HMO before February 1939.

The aim of the present study is to present the results of observations conducted before the Second World War at both HMAO and HMO. The study uses averaged, daily and monthly values of atmospheric pressure (PA), air temperature (mean – TM , minimum – TN and maximum – TX), wind speed (WS), cloud cover (CC), precipitation (RR) and snow depth (SD). Based on the recorded indicators of the dry and moistened thermometer, the timely and average values of water vapour pressure (VP), relative humidity (RH), dew point temperature ($DWPT$) and vapour-pressure deficit (VPD) were calculated.

Results

During the analysis period for HMAO, atmospheric pressure was characterized by frequent and large changes. In the winter months, the average monthly pressure values were lower than in the summer months. The lowest pressure was recorded on March 23, 1939 (769 hPa) and the highest on November 23 1938 (808 hPa). Likewise, other meteorological elements, including air temperature, were characterized by high variability (Fig. 2). The coldest month at the Pip Ivan peak was March 1939, with a monthly average *TM* of -10°C (Tab. 1).

At HMO the atmospheric pressure and other meteorological elements were also characterized by frequent and large changes. Similarly, the average monthly pressure values in the winter months were lower than in the summer months. On March 15 1939 the lowest pressure (774 hPa) was noted and on June 7 1939 the highest (811 hPa).

A comparison of the results of both observatories shows that the average monthly *TM* in February 1939 at HMAO was clearly lower (-8.1°C) than at HMO (-6.1°C) (Tab. 1). Also, in May and July 1939, the Chornohora mountains were much warmer (3.7°C and 9.3°C , respectively) than the Tatra Mountains (2.2°C and 8.6°C , respectively).

The lowest *TN* at HMAO was documented on December 17 1938 (-23.7°C), and on March 14 1939 (-18.3°C) (Tab. 1). However, the highest *TX* was fixed almost on the same day; on July 22 1939 (20.1°C) for HMO and July 23 1939 (20.4°C) for HMAO.

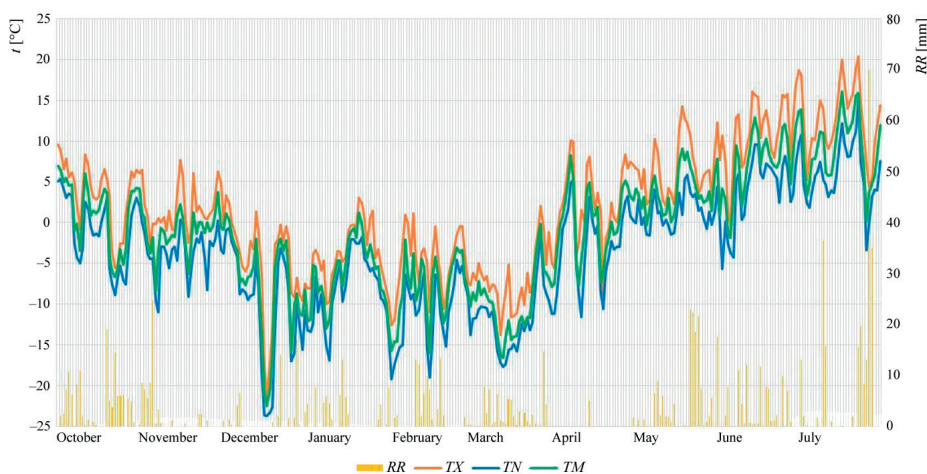


Fig. 2. The course of daily precipitation (*RR*), maximum daily air temperature (*TX*), minimum daily air temperature (*TN*) and mean daily air temperature (*TM*) at the HMAO at Pip Ivan for the period October of 1938 – July 1939

Extreme values of TN and TX in both meteorological stations were often observed on the same day, or with a daily offset (Tab. 1), which suggests a shifting in the area between Tatras and Chornohora at the same altitude, with the same air mass.

The largest number of severe cold days ($TN < -10^{\circ}\text{C}$) and frost days ($TN < 0^{\circ}\text{C}$) were seen in March 1939 for both observatories (Tab. 2). There were a total of 132 ice days ($TX < 0^{\circ}\text{C}$) during the 10 months of observations at the Pip Ivan station (Tab. 2). In the case of the number of severe cold days ($TN < -10^{\circ}\text{C}$), there were more such days at the Pip Ivan, took place in February 1939: 14 (Pip Ivan) and 9 (Kasprowy Wierch); and – in March 1939: 14 (Pip Ivan) and no severe cold days (Kasprowy Wierch).

The region of Pip Ivan was characterised by high relative air humidity. The highest RH was observed in October 1938 (92%), and the lowest in July 1939 (80%) (Tab. 3). However, the highest water vapour pressure (VP_{max}) was observed in July (12.7 mm) and the lowest vapour pressure (VP_{min}) in March (0.7 mm). The largest vapour-pressure deficit (VPD) was recorded in July (5.1 hPa), but the lowest in February (1.6 hPa). In addition, the dew point temperature ($DWPT$) parameter for Pip Ivan was calculated (Tab. 3).

During the analysis period, at the Pip Ivan peak, a total precipitation of 927.9 mm was noted (Tab. 4), with the largest total precipitation occurring in July 1939. In the same month, on July 27 1939, the largest daily precipitation (70 mm) was observed. At the Kasprowy Wierch peak, the largest daily precipitation (59.2 mm) was recorded on June 20 1939.

Within the 10 month study period, 159 days with precipitation were noted at HMAO, most of them in September, March, May and June, with 24, 24, 21 and 20 days, respectively (Tab. 4). At the Kasprowy Wierch station, the largest number of days with precipitation was recorded in March and May 1939.

In total, 161 days were noted with snow cover occurred at the Pip Ivan station for the 10 months of observations (Tab. 4), with snow falling for the first time on October 9 1938. In October, the Pip Ivan peak was covered with snow for 11 days, and almost during the whole month (23 days) in November. Following this, a constant snow cover on the Pip Ivan peak was observed from December 5 1938 to April 9 1939. The maximum snow depth (SD) was 70 cm on March 18 1939. The last day of snow was noted on May 16 1939.

Due to the lack of data, it was not possible determine the first occurrence of snowfall in the autumn of 1938 for the Kasprowy Wierch peak; however, a constant snow cover remained until May 18 1939. Its thickness exceeded that of the snow cover at the Pip Ivan peak. The maximum values of the snow depth were observed in February, March and April for both Kasprowy Wierch (159 cm, 388 cm and 380 cm, respectively) and Pip Ivan (66 cm, 70 cm and 62 cm, respectively).

Table 1. The air temperature at the Pip Ivan and Kasprowy Wierch observatories, October 1938 – July 1939

Parameter	Observatory	X	XI	XII	I	II	III	IV	V	VI	VII
TM Avg. [°C]	Pip Ivan	1.2	-1.2	-7.7	-6.2	-8.1	-10	-0.2	3.7	7.1	9.3
	Kasprowy Wierch	no data	no data	no data	no data	-6.1	-9.9	-0.1	2.2	7.2	8.6
TX Abs. [°C]	Pip Ivan	9.6	7.6	3.3	3	11	2.4	10.1	14.3	16.8	20.4
	day	1	15	2	20	9	28	8	19	30	23
	Kasprowy Wierch	no data	no data	no data	no data	3.4	-0.3	9.9	12	17.1	20.1
	day	no data	no data	no data	no data	9	28	7	22	30	22
TN Abs. [°C]	Pip Ivan	-8.9	-11	-23.7	-16.9	-19.2	-17.7	-11.6	-1.6	-5.7	-3.4
	day	22	7	17	9	1	14	12	7	3	26
	Kasprowy Wierch	no data	no data	no data	no data	-18.3	-18.4	-9.5	-2.9	-1.2	-2.7
	day	no data	no data	no data	no data	15	14	1	31	6	26

TM Avg. – monthly air temperature, TX Abs. – absolute maximum air temperature, TN Abs. – absolute minimum air temperature

Table 2. The number of severe cold days ($TN < -10^{\circ}\text{C}$), frost days ($TN < 0^{\circ}\text{C}$) and ice days ($TX < 0^{\circ}\text{C}$) at the Pip Ivan and the Kasprowy Wierch observatories, October 1938 – July 1939

Parameter	Observatory	X	XI	XII	I	II	III	IV	V	VI	VII
$TX < 0^{\circ}\text{C}$	Pip Ivan	6	8	27	26	25	30	9	-	1	-
	Kasprowy Wierch	no data	no data	no data	no data	22	31	9	-	-	-
$TN < 0^{\circ}\text{C}$	Pip Ivan	16	27	31	31	28	31	20	10	4	2
	Kasprowy Wierch	no data	no data	no data	no data	28	31	21	15	3	2
$TN < -10^{\circ}\text{C}$	Pip Ivan	-	1	11	10	14	24	14	-	-	-
	Kasprowy Wierch	no data	no data	no data	no data	9	23	-	-	-	-

During the analysis period, the average WS in the HMAO in Chornohora was given as $9.7 \text{ m}\cdot\text{s}^{-1}$. The highest average WS was calculated in September and January ($-11.6 \text{ m}\cdot\text{s}^{-1}$ and $11.3 \text{ m}\cdot\text{s}^{-1}$, respectively) and the lowest in December and July ($8.2 \text{ m}\cdot\text{s}^{-1}$ and $7.0 \text{ m}\cdot\text{s}^{-1}$, respectively). The month with the most strong wind ($WS > 15 \text{ m}\cdot\text{s}^{-1}$) days for HMAO was January (26 days) (Tab. 5). Wind gusts from $15 \text{ m}\cdot\text{s}^{-1}$ to $43 \text{ m}\cdot\text{s}^{-1}$ were observed for almost the whole month. In contrast, in the Tatra Mountains, the wind at HMO was observed with a much lower speed compared to that in Chornohora.

Table 3. Air humidity parameters at the Pip Ivan peak, October 1938 – September 1939

Parameter	X	XI	XII	I	II	III	IV	V	VI	VII
<i>RH</i> avg. [%]	92.0	84.9	87.0	90.1	80.5	84.5	81.7	90.7	87.9	80.0
<i>VP</i> max [mm]	9.0	6.7	5.9	5.7	4.5	5.8	6.9	10.8	12.2	12.7
<i>VP</i> min [mm]	3.5	2.4	0.8	2.1	1.3	0.7	2.9	5.7	5.3	5.8
<i>DWPT</i> max [°C]	5.1	0.4	-1.4	-1.8	-4.5	-1.7	0.8	8.1	10.0	10.6
<i>DWPT</i> min [°C]	-7.3	-17.8	-24.2	-13.3	-19.5	-26.4	-10	-1.8	-2.7	-1.6
<i>VPD</i> max [hPa]	2.3	2.7	2.3	2	1.6	2	4	2.4	2.2	5.1

In the period of October 1938 – July 1939, the average CC in Chornohora was 7.7 (on a scale of 0-10). The highest average cloudiness was observed in January and May (8.5 and 9.2, respectively) and the lowest in July and October (6.0 and 6.4, respectively). In total, only 18 days were observed at the Pip Ivan station with an average CC below 2 (on a scale of 0-10) (Tab. 5), less than 6% of the entire period (304 days). For the Kasprowy Wierch peak, even fewer such days were noted, only 9 from 181 (less than 3%).

There were a total of 205 days with fog calculated at the HMAO (Tab. 5), with most of these days in September (27). In 1939, during the months of February, May, June and July, the fog phenomenon at the Pip Ivan and the Kasprowy Wierch peaks occurred with a similar frequency. In contrast, in March and April 1939, more days with fog were observed at the HMAO compared to the HMO.

The days with storm observations at the Pip Ivan peak occurred only in May, June and July 1939 (a total of 21 days). Likewise, there were 17 days with storms noted for the Kasprowy Wierch peak (Tab. 5). Most such days on both peaks were in June and July.

Summary

Due to the short period of observation time for both meteorological stations before the outbreak of World War II, the results of the observations presented in this study are not representative for the conditions prevailing at both peaks, located in different parts of the Carpathian Mountains. The period available for direct comparison of meteorological conditions at the Pip Ivan and the Kasprowy Wierch peaks is limited to the period February – July 1939. It is difficult to say whether the observed similarities and differences are accidental or permanent.

In both observatories, as is typical for these altitudes, a significant dynamic of changes in weather parameters was observed. The average monthly *PA* values were lower for the winter months than in the summer months for both stations. Significant differences in average monthly air temperatures (*TM*) at the Pip Ivan and the Kasprowy Wierch peaks occurred in February, May and July, while

Table 4. The total of RR, maximum daily RR and the number of days RR (≥ 0.1 mm, ≥ 1.0 mm and ≥ 10.0 mm) and the SD in Chornohora and Tatras, October 1938 – September 1939

Characteristic	Observatory	X	XI	XII	I	II	III	IV	V	VI	VII	Totally
The totals of RR [mm]	Pip Ivan	124.2	66.4	25.9	69.1	86.2	69.6	5	142	105.8	233.7	927.9 ¹
	Kasprowy Wierch	no data	no data	no data	no data	147.4	301.6	64.2	324	209.8	139.2	1186.2 ²
Max RR [mm]	Pip Ivan	19.0	24.7	4.0	13.0	13.3	14.6	5.0	23.0	17.5	70.0	x
	day	19	5	6	14	19	29	15	22	1	27	x
	Kasprowy Wierch	no data	no data	no data	no data	27.1	57.7	23.9	54.7	59.2	30.8	x
	day	no data	no data	no data	no data	11	10	3	23	20	27	x
Number of days	Pip Ivan	24	13	14	14	13	24	1	21	20	15	159 ¹
	Kasprowy Wierch	no data	no data	no data	no data	19	27	12	26	18	12	114 ²
	Pip Ivan	18	10	10	13	13	14	1	17	14	23	133 ¹
	Kasprowy Wierch	no data	no data	no data	no data	14	23	9	25	18	10	99 ²
≥ 10.0 mm	Pip Ivan	4	1	-	1	3	1	-	4	4	8	26 ¹
	Kasprowy Wierch	no data	no data	no data	no data	5	12	1	14	7	6	45 ²
Number of days with S	Pip Ivan	11	23	27	31	28	31	9	1	-	-	161 ¹
	Kasprowy Wierch	no data	no data	no data	no data	28	31	30	22	-	1	112 ²

¹ – total for 10 months, ² – total for 6 months

Table 5. The number of days with very strong ($>15 \text{ m}\cdot\text{s}^{-1}$) and strong ($\geq 10 \text{ m}\cdot\text{s}^{-1}$) WS, sunny days ($CC < 2$), cloudy days ($CC > 8$), fog, and storm in Chornohora and the Tatras Mountains, October 1938 – September 1939

Characteristic	Observatory	X	XI	XII	I	II	III	IV	V	VI	VII	Totally
WS $\geq 10 \text{ m}\cdot\text{s}^{-1}$	Pip Ivan	24	21	21	27	18	22	25	19	17	13	207 ¹
	Kasprowy Wierch	no data	no data	no data	no data	12	6	15	10	8	10	61 ²
	Pip Ivan	15	13	5	26	9	12	11	10	5	3	109 ¹
WS $>15 \text{ m}\cdot\text{s}^{-1}$	Kasprowy Wierch	no data	no data	no data	no data	7	2	3	3	1	2	18 ²
	Pip Ivan	1	5	1	1	3	2	1	-	3	1	18 ¹
	Kasprowy Wierch	no data	no data	no data	no data	1	3	2	-	1	2	9 ²
CC > 8	Pip Ivan	20	13	19	22	14	21	12	27	12	9	169 ¹
	Kasprowy Wierch	no data	no data	no data	no data	13	20	7	23	15	12	90 ²
	Pip Ivan	27	18	21	25	18	27	16	22	20	11	205 ¹
Number of days with fog	Kasprowy Wierch	no data	no data	no data	no data	21	22	10	23	20	13	109 ²
	Pip Ivan	-	-	-	-	-	-	-	5	8	8	21 ¹
	Kasprowy Wierch	no data	no data	no data	no data	-	-	1	5	6	6	18 ²

¹ – total for 10 months, ² – total for 6 months

in March, April and June average temperatures were similar (Tab. 1). The winter in Chornohora was colder than in the Tatra Mountains, and warmer in the summer (which may suggest bigger continentalism of the first massif).

It is worth noting that at the Kasprowy Wierch peak, for almost every month, the sums of precipitation (*RR*) were much higher than on the Pip Ivan peak (Tab. 4). For 6 months in 1939 (February – July), the total precipitation in Chornohora was 642.3 mm, and 1186.2 mm at the Tatras Mountains. The constant snow cover (*SD*) at the Pip Ivan peak lasted up until April 9, and up to May 18 at the top of Kasprowy Wierch, with the latter being twice as thick as the former.

The average wind speed (for 6 months) at the Pip Ivan peak was significantly higher ($9.4 \text{ m}\cdot\text{s}^{-1}$) than at the Kasprowy Wierch ($6.4 \text{ m}\cdot\text{s}^{-1}$).

The average cloud cover (*CC*) in February – July 1939 at the Pip Ivan was almost as high (7.6) as on Kasprowy Wierch (7.7). Days with storms and fog on both peaks also closely coincided, and their distribution in individual months was similar. This proves that both the Pip Ivan and the Kasprowy Wierch peaks are not suitable locations for astronomical observatories.

The results of the first meteorological observations in differing parts of the Carpathian arch presented in this study show that it is worth undertaking an effort to resume the work of the observatory at the Pip Ivan. Together with observations carried out in other parts of the Carpathians, this will allow us to fully understand the climatic specifics of this important mountain chain in the climate system of Europe.

Below we shall mention the names of individuals who conducted observations in both meteorological stations during the analysis period.

For the Kasprowy Wierch observatory: Stefan Maślanka (II, 1-7 III, V, 1-17 VII), Karol Poloczek (II, III, IV, VI), Edward Rozmiarek (12-31 III, IV, V, VI, VII) and W. Wielgus (from 22 VII). According records of the “Meteorological Observations Results”, the head of the observatory in the period of III-V 1939 was Dr. Edward Stenz. For the period VI-VII, there was no signature from the manager (as we know in the spring of 1939, Dr. E. Stenz went to Kabul where he became the director of the Meteorological and Hydrographical Service of Afghanistan), and from VIII, the function of the head was performed by Eng. Edward Rozmiarek.

At the Pip Ivan peak, observations were conducted by Władysław Midowicz (X, XI, 17-20 I), Antonina Midowicz (XI), Stefan Szczyrbak (V, VI, VII), Franciszek Wiatr (XII, I) and Bernard Liberra (XII, II, III, IV, V, VI, VII). The head of the observatory throughout the period of functioning was Władysław Midowicz (except during a period of vacation time, when he was replaced by Stefan Szczyrbak).

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S u m m a r y

The 80th anniversary of the grand opening of the observatories at the Kasprowy Wierch and Pip Ivan peaks is a suitable occasion to present the results of the meteorological observations of these institutions. During the Second World War, the Pip Ivan observatory was abandoned. This paper presents the meteorological conditions at the Pip Ivan station during in the period of October 1938 – July 1939. This is possible due to the original sheets of meteorological observations from the Pip Ivan observatory found in private collections. They were compared with the results of the meteorological observations from Kasprowy Wierch, acquired with the IMGW-PIB archive (for the period of February – July 1939).

Key words: Carpathians, Pip Ivan, Kasprowy Wierch, observatory, climate, meteorology.