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AIR TEMPERATURE AND CLOUDINESS AT ŚNIEŻKA BETWEEN 1901 AND 1998

Abstract: Some features and tendencies existing in temporal variations of air temperature and cloudiness seasonal values have been determined in long series of observation data at the highest summit of the Sudetes. Trends of seasonal values of both elements appeared to be mostly positive but statistically insignificant at a level of significance 0.05. The air temperature of winter and summer culminated in the last decade 1989-1998. Statistical co-variability analysis of temperature and cloudiness time-series showed the existence of significant dependence between these variables in summer season only (negative correlation).

Key words: temperature, cloudiness, long series, climatic change.

1. Introduction

A continuous and homogenous series of data collected by the Mountain Meteorological Observatory at Śnieżka makes it possible to present the evolution of climate of the highest montane zone of the Sudetes during the twentieth century.

Until now two original, ninety-five years long (1901-1995) observation data sets from Śnieżka, with monthly sums of sunshine duration (Dubicka 1998) and monthly mean air temperature (Głowicki 1998), have been analysed out and published. Preliminary analysis of these data sets showed a long-term decreasing tendency in sunshine duration (-20 hours/100 years) and some features of global warming. Both a significant increase trend of air temperature (+0.7°C/100 years) and a continuous decrease of diurnal and annual temperature ranges have been observed.

Similar tendencies in temporal variations of sunshine duration and air temperature have been observed nowadays also at other sites situated in mountain valleys and on high ridges (Dubicka 1997; Weber et al. 1997). The aim of this work is to study relationships existing between 98 years long data sets of air temperature and total cloudiness at Śnieżka during the period 1901-1998.

Statistical analysis has been limited to mean values of 06 and 12 UTC synoptic hours, separately in winter (December, January and February) and summer (June, July and August) seasons. These synoptic hours chosen for the analysis represent different controlling conditions of air temperature and cloudiness in their diurnal cycle in mountain environment. The first synoptic hour (06 UTC) is close to diurnal minimum of air temperature and to the most intense thermal inversion in vertical profile of the Sudetes; the second (12 UTC) usually represents diurnal maximum of air temperature and cloudiness at Śnieżka (Głowicki 1995).

2. Analysis of Long-Term Variability of Air Temperature and Cloudiness

The general tendency of temporal variation of temperature and cloudiness characterised in the introduction are not completely reflected in the 98 years long series of these climatic elements at Śnieżka (Tab. 1 and 2). Calculated equations of the trend generally show very small positive regression coefficients, statistically insignificant. The only exception is air temperature of summer season at 06 UTC with increasing trend 0.9°C/100 years with the level of significance 0.05. The obtained results of trend approximation by linear regression do not unequivocally support the thesis on the stability of transformation of Śnieżka climate during the twentieth century and on similar changes of temperature and cloudiness. The 10-year running average values of air temperature and cloudiness make it possible to distinguish in the

Tab. 1. Mean decade values of air temperature (T) and cloudiness (C) and their deviation from 98-year average in the period 1900/01–1997/98 (dT, dC) at Śnieżka (according to 06 UTC and 12 UTC synoptic hours in winter season (Dec.-Feb.)).

Decades (winter seasons)	Temperature (°C)				Cloudiness (tenths)			
	T_{06}	dT_{06}	T_{12}	dT_{12}	C_{06}	dC_{06}	C_{12}	dC_{12}
1900/01-1909/10	-7.0	-0.3	-6.8	-0.6	7.8	0.3	7.6	0.0
1910/11-1919/20	-6.0	0.7	-5.4	0.8	7.8	0.3	7.6	0.0
1920/21-1929/30	-6.7	0.0	-6.2	0.0	7.4	-0.1	7.3	-0.3
1930/31-1939/40	-6.9	-0.2	-6.3	-0.1	7.5	0.0	7.6	0.0
1940/41-1949/50	-7.5	-0.8	-6.9	-0.7	7.6	0.1	7.7	0.1
1950/51-1959/60	-6.9	-0.2	-6.3	-0.1	7.5	0.0	7.6	0.0
1960/61-1969/70	-7.7	-1.0	-6.9	-0.7	7.6	0.1	7.7	0.1
1970/71-1979/80	-5.9	0.8	-5.3	0.9	7.5	0.0	7.6	0.0
1980/81-1989/90	-6.6	0.1	-6.1	0.1	7.5	0.0	7.5	0.1
Maximum Decade	-5.1	1.6	-4.7	1.5	7.9	0.4	7.8	0.2
	1988/89-1997/98		1988/89-1997/98		1908/09-1917/18		1933/34-1942/43	
Minimum Decade	-8.1	-1.4	-7.4	-1.2	7.2	-0.3	7.2	-0.4
	1937/38-1946/47		1937/38-1946/47		1923/24-1932/33 1986/87-1995/96		1923/24-1932/33	
Trend (Linear Fit) 1900/01-1997/98	0.61°C/100yrs.		+0.80°C/100yrs.		-0.34/100yrs.		+0.05/100yrs.	

Tab. 2. Mean decade values of air temperature (T) and cloudiness (C) and their deviation from 98-year average in the period 1901–1998 (dT, dC) at Śnieżka (according to 06 UTC and 12 UTC synoptic hours in summer season (Jun.-Aug)).

Decades (summer seasons)	Temperature (°C)				Cloudiness (tenths)			
	T_{06}	dT_{06}	T_{12}	dT_{12}	C_{06}	dC_{06}	C_{12}	dC_{12}
1901-1910	6.2	-0.5	8.3	-0.3	7.3	0.1	7.9	-0.1
1911-1920	6.2	-0.5	8.2	-0.4	7.2	0.0	8.1	0.1
1921-1930	6.3	-0.4	8.3	-0.3	7.0	-0.2	7.7	-0.3
1931-1940	7.1	0.4	9.1	0.5	7.2	0.0	7.8	-0.2
1941-1950	7.0	0.3	8.9	0.3	7.1	-0.1	8.1	0.1
1951-1960	7.1	0.4	8.8	0.2	7.3	0.1	8.2	0.2
1961-1970	6.8	0.1	8.6	0.0	7.1	-0.1	8.1	0.1
1971-1980	6.5	-0.2	8.2	-0.4	7.2	0.1	8.1	0.1
1981-1990	6.7	0.0	8.5	-0.1	7.3	0.1	8.1	0.1
Maximum Decade	7.4	0.7	9.5	0.7	7.5	0.3	8.3	0.3
	1989-1998		1930-1939		1954-1965		1954-1965	
Minimum Decade	5.9	-0.8	7.8	-0.8	6.8	-0.4	7.6	-0.4
	1918-1927		1918-1927		1967-1976		1930-1939	
Trend (Linear Fit) 1901-1998	+0.91°C/100yrs. (*)		+0.49°C/100yrs.		+0.02/100yrs.		+0.31/100yrs.	

(*) - significant at the level 0.05

considered period of 98 years two phases of global warming, with significant differences between summer and winter seasons.

The first phase of warm winters occurred between 1911 and 1920; the second (contemporary one), which started in the seventies, reached its climax in the last decade 1988/89-1997/98. The latter period is characterised by a positive (over 1.5°C) temperature anomaly of the winter season at Śnieżka. The "phase" character of temperature fluctuations of the summer season in the twentieth century was much less visible than in the case of winter. The warmest summer periods did not coincide with warm winters, however the highest summer season temperature was also observed in the last decade (Tab. 2).

It is noteworthy that both in the air temperature and in the cloudiness series temporal variations were synchronised for 06 and 12 UTC synoptic hours, and the anomalies had the same sign and similar value (Fig. 1). This regularity was less pronounced in the cloudiness time-series.

Some features of long-range temporal variation of temperature and cloudiness revealed by our analysis, support the opinion of Kożuchowski (1995) and Lorenc (1994), that the contemporary warming of mountain areas of Central Europe is a successive phase of climatic fluctuations caused mainly by periodical changes of warmth and water cycles. The latter are treated as a result of periodic changes in atmospheric circulation.

Results of statistical studies on temperature and cloudiness co-variability at Śnieżka during the period 1901-1998 (Tab. 3) indicate a significant dependence

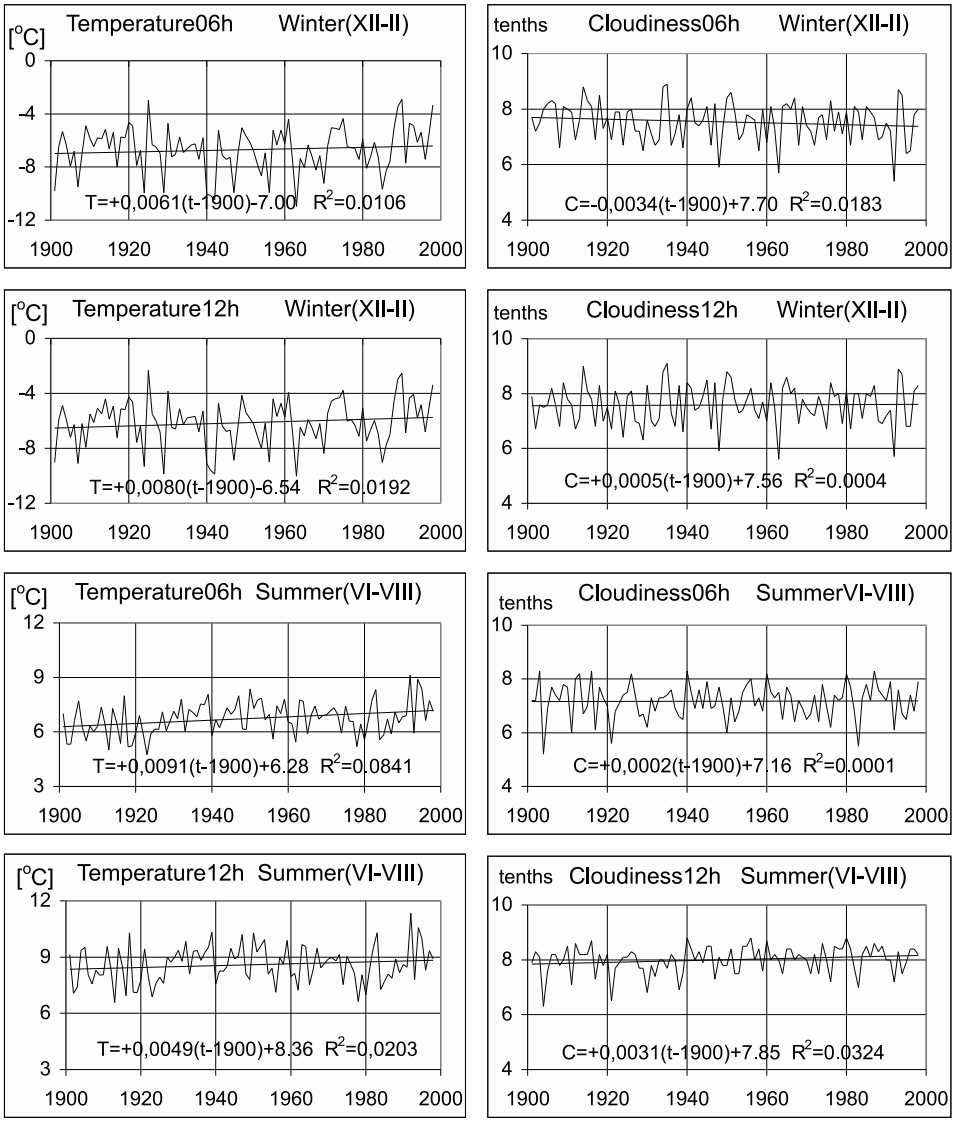

Fig. 1. Air temperature and cloudiness at Śnieżka in winter and summer seasons between 1901 and 1998 (absolute values - thin line, linear trend - bold line).

between the two climatic elements only in the summer season but at both synoptic hours. Test χ^2 of tertile distribution (χ^2>33) showed a significant dependence of variables taken into account at the level 0.001. On the other hand, the dependence between the temperature and cloudiness in the winter season has been determined as weak. That fact does not allow to reject zero-hypothesis on variables independence

Tab. 3. Co-variability estimation of air temperature (T) and cloudiness (C) between 1901 and 1998 at Śnieżka (according to 06 UTC and 12 UTC synoptic hours in winter and summer seasons on the basis of independence test chi-square (χ^2) and correlation coefficient (r).
X^2 values determined from tercile contingency tables.

Season	Variable: T	C	Independence Test: Values X^2	Independence Test: Differences of distributions	Correlation coefficients: Values r	Correlation coefficients: Significant relations
Winter	T_{06}	C_{06}	3.746	No-significance	0.056	No-significance
Winter	T_{12}	C_{12}	0.404	No-significance	0.062	No-significance
Summer	T_{06}	C_{06}	33.353 (*)	Significance	-0.570 (*)	Significantly correlated
Summer	T_{12}	C_{12}	35.018 (*)	Significance	-0.615 (*)	Significantly correlated

(*) - significant at the level 0.001

(χ^2<9.488). However the estimation of correlation dependence shows a tendency during the summer season towards a significant, asymmetric dependence between the temperature and cloudiness at Śnieżka during the 20th century.

3. Summary

The tendencies of Śnieżka climate described in this paper which are of a rather regional importance, may be useful when making climatic scenarios and predicting transformations of mountain ecosystems in the next century, not only for the area of Sudetes. The climatic scenarios worked out until now for the Carpathians assume a 300-700 meters raise of the timberline (Obrębska-Starklowa et al. 1994). The latest hypothesis of ecologists takes into account even a possibility of a decline of the present mountain ecosystems as a result of climate warming.

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