EVALUATION OF SOIL TEMPERATURE IN LONG-TERM SERIES

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Soil is an essential component of the environment - it makes the main conditions for life on the Earth. It plays an important role in the stability of ecosystems by influence of balance of matter and energy and in the hydrological cycle. That´s why physical properties of the soil have a significant role in many processes, especially in the chemical and biological interactions which are bound to the soil environment. The most important is the conversion of solar radiation into heat and the subsequent distribution of energy flows. All these processes depend on the content of soil water, air and also on soil temperature. The soil temperature is measured at stations of the Czech Hydrometeorological Institute at depths of 5, 10, 20, 50 and 100 cm under grassland. In this paper were analyzed daily values of soil temperature at depth of 5, 10, 20, 50 and 100 cm within period 1961–2016 from selected CHMI stations at different altitudes using statictical software. Soil temperature was also evaluated in dependence on snow cover.

Keywords: soil temperature, snow cover, Czech Hydrometeorological Institute, Czech Republic

INTRODUCTION

Soil temperature is the factor that drives germination, blooming, composting, and a variety of other processes. Soil temperature represents an important factor in agriculture, forestry and ecology as well as in come technical fields. It also has a significant effect on the wintering of cultivated plants, their germination, rooting and nourishment, as well as the hibernation of diseases and pests. The basic heat source of the soil is the solar radiation absorbed by its active surface (Tolasz *et al*., 2007). Soil temperature is simply the measurement of the warmth in the soil (www .gardeningknowhow.com).

The CHMI network of stations usually measures soil temperature at depths of 5, 10, 20, 50 and 100 cm using thermometers placed within tha natural soil profile under a closely-cropped grass cover. Starting in the mid-1990s, the original measurements using mercury themometers and taken at 7 a.m., 2 p.m., and 9 p.m. local mean solar time (LMST) have been gradually replaced by automated, continuous measurement using resistance thermometers (Tolasz *et al*., 2017).

MATERIALS AND METHODS

The Czech Hydrometeorological Instite operates a network of meteorological stations and there are about 140 meteorological stations at present, which also measure soil temperature. Stations are located at altitudes from 158 m asl (Doksany) to 1 413 m asl (Luční bouda). Unfortunately many stations have started the soil temperature observation later than in 1961 or there are many gaps in the observation so we decided to choose just 2 stations with the continuous long-time series into this paper – Doksany (158 m asl, 014°10'12" E, 50°27'32" N) and Klatovy (421 m asl, 013°18'11" E, 49°23'26" N). Soil temperature data were exported from CHMI climatological database CLIDATA and statistical calculations were done by tools of Microsoft Excel.

The soil temperature is measured at 7 a.m. (t_7), 2 p.m. (t_{14}) and 9 p.m.(t_{21}), the average value is calculated according to equation $tavg = (t_7 + t_{14} + t_{21})/3$. Pearson's correlation coefficient was used to determine the relationship between the two variables (maximum snow cover and soil temperature at different layers). Data were evaluated in various periods, e.g. as standard climatological normal 1961–1990, long-term average 1981–2010 and 1961–2010, and also per decades 1961–1970, 1971–1980, 1981–1990, 1991–2000 and 2001–2010.

RESULTS

The average annual soil temperature at different layers in periods 1961–1990, 1981–2010 and 1961–2010 is mentioned in table 1.

Table 1. Average annual soil temperature in various periods at Doksany and Klatovy stations.

		5 cm	10 cm	20 cm	50 cm	100 cm
1961–90	Doksany	9.5	9.3	9.3	9.6	9.6
	Klatovy	8.9	8.9	8.9	9.1	9.3
1981–10	Doksany	10.3	10.2	10.1	10.2	10.3
	Klatovy	10.0	9.9	10.0	10.0	10.1
1961–10	Doksany	10.0	9.8	9.8	9.9	10.0
	Klatovy	9.5	9.4	9.6	9.6	9.8

Average annual soil temperature at 5 cm, 20 cm and 100 cm in decades is shown table 2. As the warmest decade is the period 2001–2010 at both stations (all layers). The differences between periods 2001–2000 and 1970–1961 are higher at Doksany station - from 1.9°C (10 cm) to 1.0°C (50 cm).

The absolute maximum soil temperature at Doksany station was measured on 22nd June 2000 (30.9°C at depth of 5 cm), at Klatovy station it was on 28th July 2013 (28.9°C at depth of 5 cm). The absolute miminum soil temperature was -9.5°C (Doksany station, 5 cm depth, 21st January 1963 by 6 cm of snow cover) and -9.1°C (Klatovy station, 5 cm depth, 5th February 1963 by 20 cm of snow cover).

Table 2. Average annual soil temperature in decades.

	5 cm		20 cm		100 cm	
	Doksany	Klatovy	Doksany	Klatovy	Doksany	Klatovy
1961–70	9.4	8.8	9.3	9.1	9.6	9.5
1971–80	9.5	9.0	9.3	8.7	9.7	9.1
1981–90	9.5	8.9	9.3	8.8	9.7	9.3
1991–00	10.3	10.2	10.0	10.3	10.3	10.1
2001–10	11.2	10.5	11.0	10.4	10.9	10.5

The annual variation (1961–2016) in average daily soil temperature at depths of 5, 10, 20, 50 and 100 cm at both stations represents figures 1, 2. Statistical variables (minimum, lower quartile, medium, upper quartile, maximum) are given in figures 3, 4.

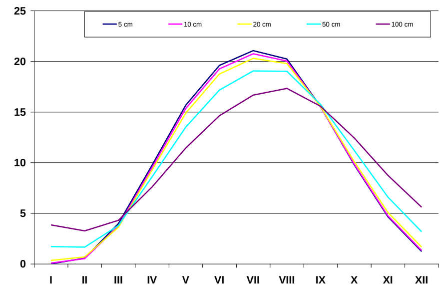

Figure 1. Annual variation in average daily soil temperature, Doksany station, period 1961–2016

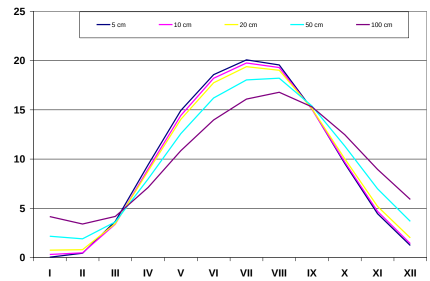

Figure 2. Annual variation in average daily soil temperature, Klatovy station, period 1961–2016

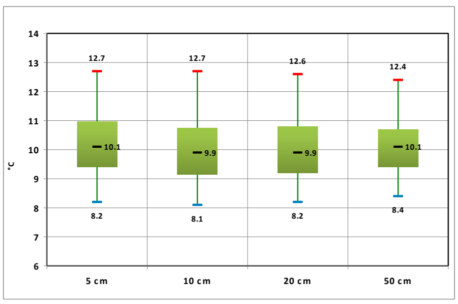

Figure 3. Statistical variables of soil temperature, Doksany station, period 1961–2016

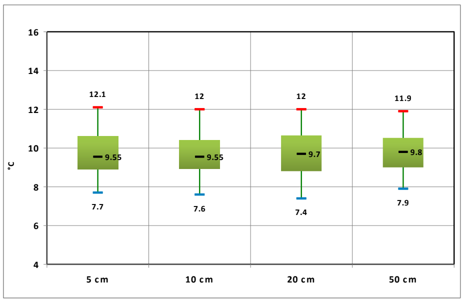

Figure 4. Statistical variables of soil temperature, Klatovy station, period 1961–2016

Pearson's correlation coefficients between maximum snow cover and soil temperature at different depths are mentioned in tables 3–7.

Table 3. Pearson's correlation coefficient between maximum snow cover and soil temperature at depth of 5 cm.

Station / month	I	II	III	XI	XII
Doksany	-0.29	-0.45	-0.62	-0.34	-0.18
Klatovy	-0.11	-0.39	-0.52	-0.40	-0.20

Table 4. Pearson's correlation coefficient between maximum snow cover and soil temperature at depth of 10 cm.

Station / month	I	II	III	XI	XII
Doksany	-0.29	-0.46	-0.58	-0.35	-0.20
Klatovy	-0.15	-0.38	-0.52	-0.26	-0.28

Table 5. Pearson's correlation coefficient between maximum snow cover and soil temperature at depth of 20 cm.

Station / month	I	II	III	XI	XII
Doksany	-0.25	-0.43	-0.54	-0.34	-0.18
Klatovy	-0.13	-0.33	-0.49	-0.30	-0.31

Table 6. Pearson's correlation coefficient between maximum snow cover and soil temperature at depth of 50 cm.

Station / month	I	II	III	XI	XII
Doksany	-0.26	-0.35	-0.58	-0.24	-0.14
Klatovy	-0.12	-0.29	-0.50	-0.28	-0.27

Table 7. Pearson's correlation coefficient between maximum snow cover and soil temperature at depth of 100 cm.

Station / month	I	II	III	XI	XII
Doksany	-0.17	-0.37	-0.55	-0.29	-0.03
Klatovy	-0.06	-0.20	-0.49	-0.28	-0.26

The highest values of Pearson's correlation coefficient were found mainly in March, the lowest values were mainly in December.

CONCLUSION

The average annual soil temperature is higher at Doksany station than to Klatovy station. The warmest decade was the period 2001–2010 at both stations. In comparison two 30-year periods (1961–1990 x 1981–2010) unambiguously the second one is warmer at both stations. The absolute minimum values were measured in 1963 (both stations) and the absolute maximum value in 2000 (Doksany station) and 2013 (Klatovy station). The highest values of Pearson's correlation coefficient were found in March and the lowest values in December.

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LITERATURE

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