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VARIABILITY OF SOIL SURFACE TEMPERATURE IN THE CÂMPULUNG MUSCEL DEPRESSION (ARGEŞ - ROMANIA)

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Abstract

In the Câmpulung Muscel Depression, the soil surface mean annual temperatureover the past 40 years was 8.5°C, ranging between 7.3°C and 10.4°C. During the year, the temperature of the soil surface was similar to air temperature, except the higher amplitude of the warmest month and the coldest month. The monthly minimum means of the soil was below the monthly minimum means of the air and, except for the months of January and December, themaximum mean was higher than the maximum mean of the air. The absolute minimum temperature of soilsurface was -33.0°C (February 19, 1985), and the absolute maximum was 56.8°C (July 2, 2003). In the Câmpulung Muscel Depression, the last spring frosts and the first autumn frosts were the risk phenomena after May 1 and before October 5. The mean annual number of frost days on the ground was between 14.7 days in the decade 2001-2010 and 165.7 days in the decade 1981-1990.

Key words*: extreme frosts, temperatures, thermal amplitude.*

INTRODUCTION

Climate variability affects all economic sectors, but agriculture remains the most vulnerable and its impact is more prevalent now, when climate change is becoming more accentuated (Qian et al., 2011; Selvaraju et al., 2011).
Soil temperature represents the element thatdependson air heatingin its vicinity, influencing evaporation, the transformation of organic matter in soil, leaching or precipitation of soluble salts. At the ground surface, itconverts solar energy into heat energy (Kirschbaum, 1995; Frazer, 2009).
Soil temperature is determined by the amount of solar energy incident on the surface, as well as the mutual exchanges of heat with the atmosphere and the deeper layers of soil. The size of the diurnal and annual variations is closely related to the physical properties of soil, water content, the nature of the plant, the presence of snow, altitude, land shape and slope orientation and inclination (Mavi, 2000; Bai et al., 2011).
Plant growth and development are placed in a complex 'Soil-Plant-Atmosphere' system which runs a series of physical, chemical and biological processes that are interdependent with each other, the temperature which plays an important role (Helms et al., 1997; Singh et al., 1998; Stone et al., 1999; Porter et al., 2000).

MATERIALS AND METHODS

In this study we used the climate data archive of the Câmpulung Muscel Meteorological Station recorded in the period 1971-2010 (A.N.M.) and we calculated and interpreted:
- the daily, monthly, annual and decadal means;
- the minimumand maximum means;
- the monthly amplitude of extremes;
- the data over the threshold of 0°C;
-the duration of the interval without frost.

RESULTS AND DISCUSSIONS

The soil, as a solid medium, has a heating potential much greater than the atmosphere, whereas the heat transmission to the interior by thermal conductivity is quite low, especially if the soil is dry. Thus, under the action of sun radiation, the soil surface temperature reaches very high values during the summer and during the night; in the absence of solar radiation, heat loss is fast, which causes diurnal variations. The annual mean temperature is the most synthetic parameter of soil temperature, which

highlightsits particular role as a source of heat (Clima României, 2008).

At Câmpulung Meteorological Station, the annual mean temperature of the ground surface, calculated for the period 1971-2010, was 8.5°C. The lowest annual mean temperatures were recorded in 1973, 1976 (7.3°C), 1978 and 1980 (7.5°C) while the highest were recorded in 2007 (10.4°C) and 2008 (9.8°C). These values indicate, the annual mean temperature of the soil surface variability of 3.1°C, from 7.3°C to 10.4°Cover the last 40 years (Figure 1).

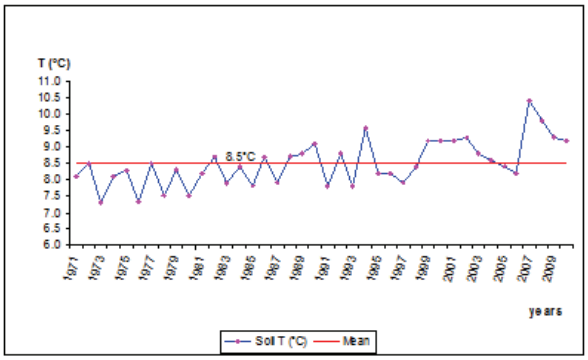

Figure 1. Mean annual temperatureof soil surface recorded at Câmpulung (1971-2010)

During the year, the mean temperature of the soil surface was similar to air temperature, with the difference that the amplitudes of the warmest (July) and the coldest month (January) were greater than the amplitude of air temperature, 24.8°C - the amplitude of soil temperatures, compared to 20.0°C - the amplitude of the air temperature (Figure 2).

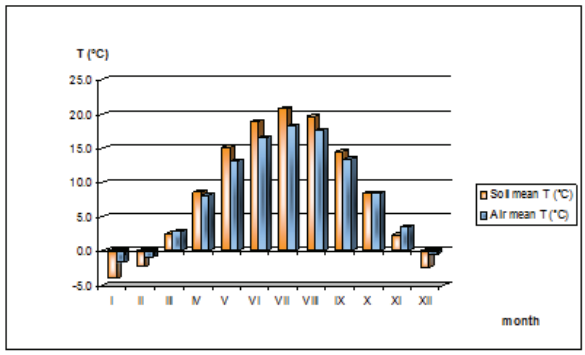

Figure 2. Mean monthly temperature variation of surface soil and air recorded at Câmpulung (1971-2010)

The magnitude of the increase results from the fact that in winter, when thermal radiation cooling and chord inversions prevail, the soil surface temperature is lower than in the middle of the warm season, when active surface heats up very much, soil temperature substantially exceeding air temperature. The lowest monthly mean temperature values were recorded in January (-4.0°C), and the highest in July (20.8°C).

The decadal evolution of the monthly mean soil surface temperatures recorded a major increase in temperature in the decade 2001-2010. Thus, the mean temperature of the soil surface in the months of January and July was -3.5° C and 21.6°C, i.e. 0.5°C or 0.8°C higher than the mean of the period 1971-2010 (Figure 3).

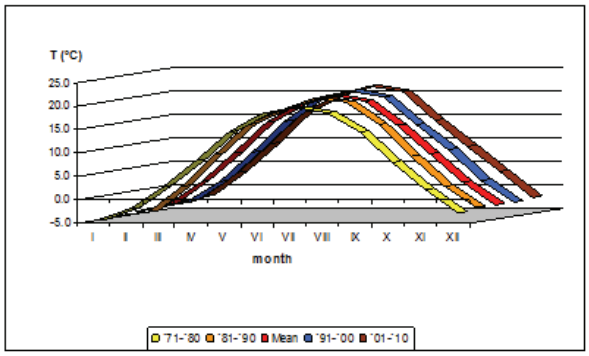

Figure 3. Decadal temperature evolution of the monthly mean of the soil surface recorded at Câmpulung weather station (1971-2010)

The diurnal cycle of soil surface temperature was determined by the evolution of sun radiation and the Earth's rotation movement. It recorded a minimum in the morning hours occurring earlier in summer and later in winter, and a maximum in the early hours of the afternoon. At Câmpulung, the soil surface mean temperature in January, for the interval 1971-2010 at 7^{00}, was -6.0°C, and at 13^{00} was 1.1°C (Figure 4). The lowest soil surface mean temperature, in the morning hours of January was -12.4 C recorded in 1985, and the highestwas -2.2°C in 1988.

Atmidday, the lowest value of the multiannual mean temperature of January was -2.0°C between 1972 and 1987, and the highest was 5.0°C recorded in 2007. In July, the real minimum temperature soccured between 1^{00} and 7^{00} and were slightly lower than the temperature at 1^{00}. The mean temperature in the afternoon was 32.0°C, the lowest mean (26.0°C) being recorded in 1979 and the highest (41.2°C) in 2007. In April and October, the soil surface mean temperatures were close

at noon, being 17.8°C and 18.4°C, respectively. In April, the lowest mean midday temperature was recorded in 1997 (12.4°C) and the highest of 23.3°C recorded in 2007. In October, the lowest mean (12.6°C) was recorded in 1972 and the highest (23.3°C) in 2000.

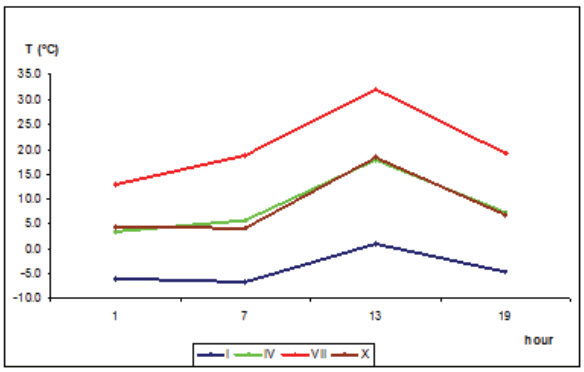

Figure 4. Daily variation of mean ground surface temperature, recorded at Câmpulung (1971-2010)

In the Câmpulung Muscel Depression, the daily mean temperature oscillations of the ground surface overlap the oscillations of air temperature, in the winter recording the highestdaily temperature variations (Figure 5) (Chichirez et al., 2012).
Thus, in January 2010, the soil surface mean temperature decreased to 4.7°C in the first decade to -21.2°C in the third decade, then it increasedduring the following six days, reaching -0.7°C (Figure 5).

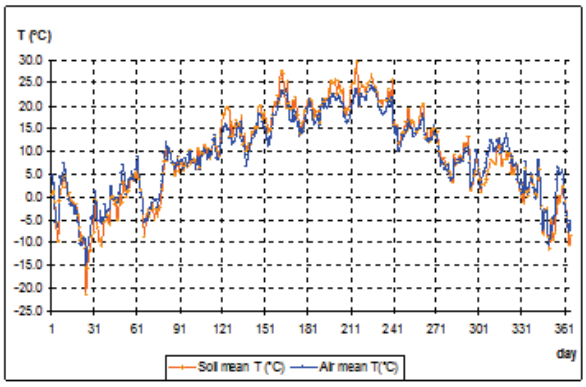

Figure 5. Evolution of daily mean air temperature at ground surface at Câmpulung (1971-2010)

During the summer, the interdiurnal oscillations of the soil surface temperature were lower, mean values increasing from 17.8°C at the end of July to 29.4°C in the first days of August.

The mean monthly minimum soil surface temperature, calculated over the last 40 years at Câmpulung, was negative in November and March, with values ranging between -2.5°C in November and -9.3°C in January. In the warmest month (July), the minimum mean temperature reached 10.6°C. During the year, the monthly mean of minimum soil surface was below the minimum mean of air temperature (Figure 6).

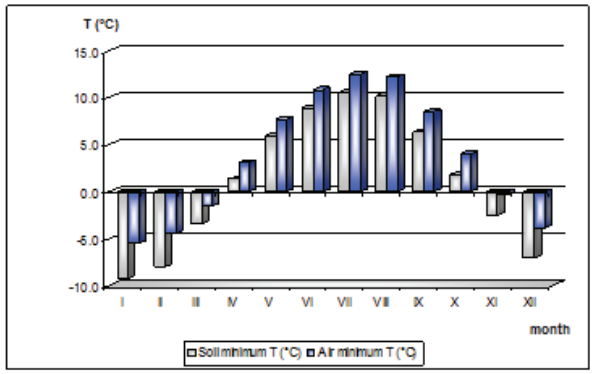

Figure 6. Monthly variation of minimum soil surface and air temperature at Campulung (1971-2010)

At Câmpulung, the mean monthly maximum temperature of the soil surface, calculated for the period 1971-2010, was positive throughout the year, ranging between 2.9°C in January and 38.1°C in July. With the exception of January and December, in the remaining months, the mean temperature of the soil surface was higher than the air temperature, the differences reaching 13.6°C in July (Figure 7).

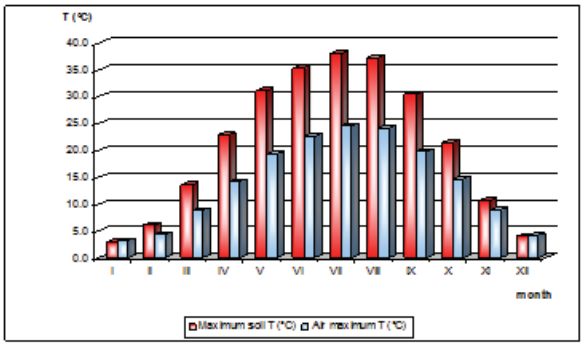

Figure 7. Monthly variation of maximum soil surface and air temperature at Câmpulung (1971-2010)

At the level of the soil surface, the mean amplitude of the monthly extremes recorded the highest values in the warm season, unlike the magnitude of the air, when the highest values were recorded during the cold season.

Thus, from April to October, the amplitudes ranged from 21.6°C to 27.5°C, and in winter they ranged between 11.1°C in December and 17.0°C in March (Figure 8).

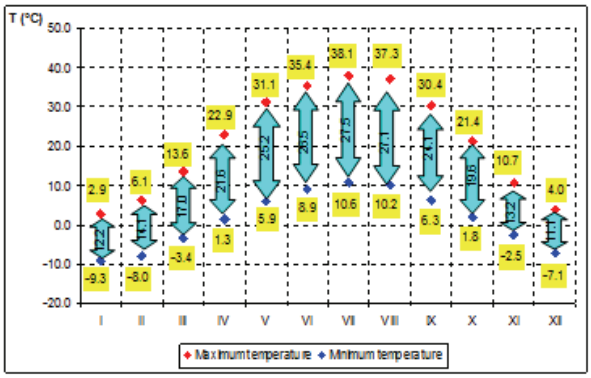

Figure 8. Mean amplitude of extreme temperatures, recorded at Câmpulung (1971-2010)

Analyzing the daily variation of the minimum temperatures in 2010, it was found that the minimum soil was is less than the minimum of air temperature, the greatest differences being recorded in winter, up to 9.1°C; in summer they were up to 4.8° C (Figure 9).

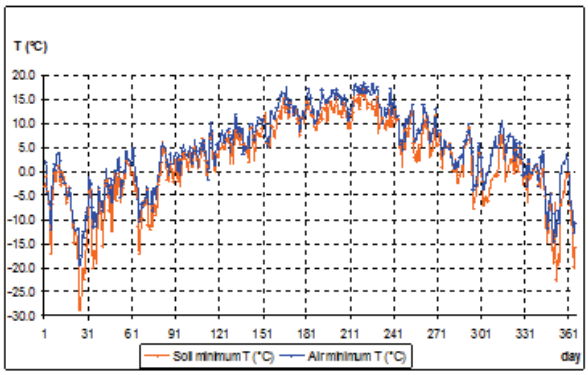

Figure 9. Minimum daily ground surface and air temperature evolution at Câmpulung in 2010

In the Câmpulung Muscel Depression, the minimum temperature in the period 1971-2010 was –33.0°C recorded on February 19, 1985.
The GEV curve high lighted possible negative temperatures higher than the recorded ones. Thus, probabilistic calculation showed that every 100 years (0.01%) the minimum temperature of the ground surface can reach -36.6°C, every 50 years (0.02%) they can exceed -34.4°C, and every 20 years (0.05%) they can exceed -31.6°C (Figure 10).

The lowest temperatures recorded hadan assurance of 2.44% (-33.0°C), 4.88% (-30.6° C) 7.32% (-30.2°C) and 9.76% (-28.6°C).

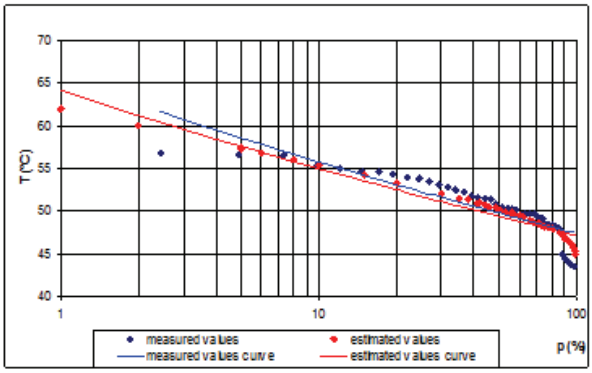

Figure 10. Assurance of annual minimum temperature ground surface, measured and estimated at Campulung (1971-2010)

The daily maximum temperature evolution of the ground surface was similar to air temperature, oscillations occurring every day. If the two elements overlapped or recorded close valuesduring the cold season, in hot season the differences increased very much, being over 20°C in May, June, July and August (Figure 11).

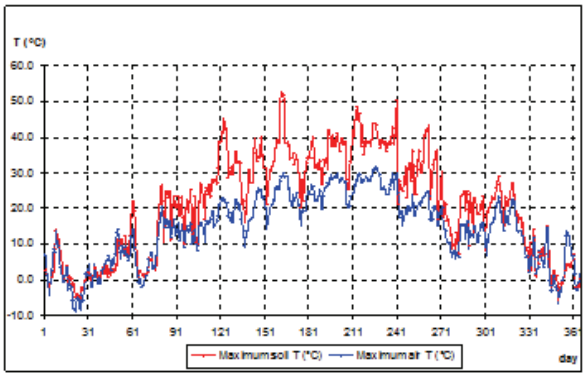

Figure 11. Maximum daily ground surface and air temperature evolution at Câmpulung in 2010

At Câmpulung Muscel meteorological station, the absolute maximum ground surface temperature was 56.8°C recorded on July 2, 2003.
The probabilistic calculations after Gumbel Max double exponential functionshowed that the maximum temperature of the ground surface might reach 61.9°C every 100 years, 59.9°C (0.02%) every 50 year sand 57.4°C (0.05%) every 20 years (Figure 12).

Late spring and early autumn frosts posed risk phenomena at Câmpulung Muscel after May 1 and before October 5.

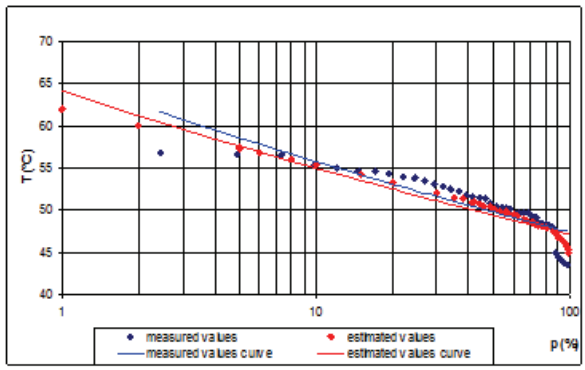

Figure 12. Assurance of annual maximum temperature ground surface, measured and estimated at Câmpulung (1971-2010)

Late spring and early autumn frosts posed risk phenomena at Câmpulung Muscel after May 1 and before October 5.
The risk of the last spring frost in the ground was 41% until May 5, 22% until May 10.7% up to May 25 and 2% until June 2 (Figure 13).

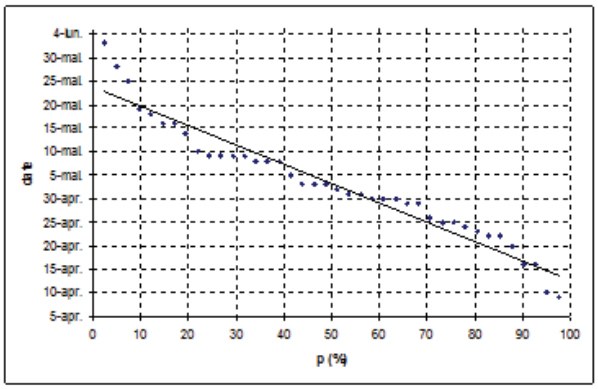

Figure 13. Assurance curve of the last frost onground surface at Câmpulung (1971-2010)

The probability of producing the first ground frost before October 1 was around 10% until 10 September, 16% until September 15, 25% until September 20 and 37% by September 30 (Figure 14).
Generally, in the Câmpulung Depression, the days with frost on the ground occur in October, their number ranging between 7.9 days in the decade 2001-2010 and 12.3 days in decades 1971-1980 and 1981-1990, but there were years when they occurred in September.

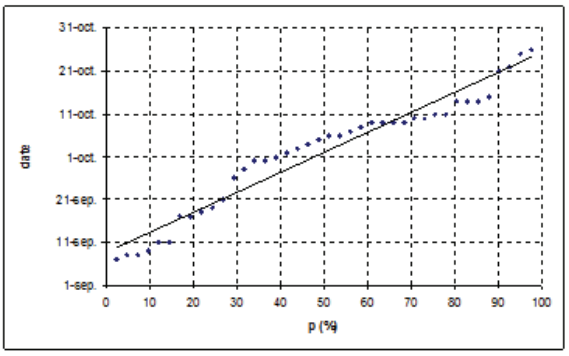

Figure 14. Assurance curve of the first frost on ground surface at Câmpulung (1971-2010)

The last few days with frost on the ground were recorded in April, but there were years when this phenomenon occurred in May. A singular case occurred in 1990, when minimum temperature at the ground surface fell below 0°C on June 1 and 2 (Figure 15).

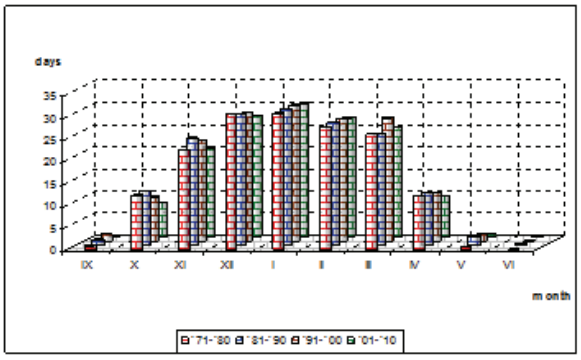

Figure 15. Monthly mean number of frost days on ground surface, recorded at Câmpulung meteorological station (1971-2010)

The mean annual number of days with frost on the ground was between 147.7 in the decade 2001-2010 and 165.7 in the decade 1981-1990.
In Câmpulung, radiation cooling during the night resulted in a mean frost free range between 142 days in the decade 1981-1990 and 165 days in the period 2001-2010, the mean of the decade being 152 days (Figure 16).

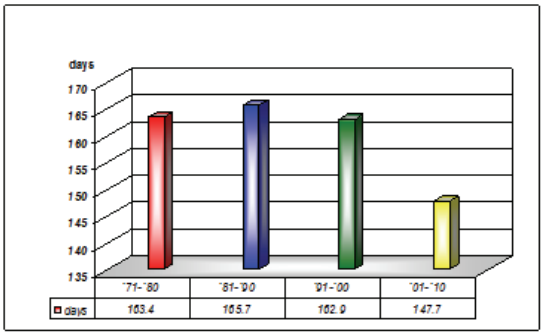

Figure 16. Annual mean number of frost days on ground surface, recorded at Câmpulung (1971-2010)

Thermal processes (cooling and warming) occurring onthe soil surfacefall within the normal range asthe Câmpulung Muscel Depression is positioned at the foot of the Iezer Mountains, safe from the cold continental air circulation from the East and Northeast.

CONCLUSIONS

At Câmpulung Muscel, the annual mean temperature of the ground surface, calculated for the period 1971-2010, was 8.5°C.

The soil surface temperature recorded during the year was similar to air temperature, with the difference that the amplitudes of the warmest month and the coldest month were higher.

Throughout the year, the monthly mean of the soil was below the minimum mean temperature of the air, and, except for January and December, when it was higher than the mean of the air.

The absolute minimum temperature of the soil surface was 33.0°C (February 19, 1985) and the absolute maximum was 56.8°C (July 2, 2003). Late spring and early autumn frosts constituted risk phenomena in Câmpulung after May 1, and before October 5.

The average annual number of days with frost on the ground ranged between 147.7 in the decade 2001-2010 and 165.7 in the decade 1981-1990.

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