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Changes in Soil Surface Temperature in the Context of Climate Change Problems

Budnik Svetlana Vasilievna

Central Geophysical Observatory named after Boris Sreznevsky, s.Kyiv, Ukraine

Corresponding author
Budnik Svetlana Vasilievna, Central Geophysical Observatory named after Boris Sreznevsky, s.Kyiv, Ukraine.

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ABSTRACT
Based on the observation materials of the hydrometeorological service, studies have been conducted on the change in soil surface temperature characteristics over time. The studies show an increase in both the average soil surface temperature and extreme soil surface temperatures (absolute maximums and minimums) over time, and the sum of temperatures over the year also increases. As a result, an increase in the activity of macro- and microorganisms in the soil layer, an increase in the release of carbon dioxide into the atmosphere, etc. are expected. At present, the accumulation of cold in the subsoil layer in winter acts as a restraining buffer for the growth of extreme soil temperatures. In order to adapt natural and anthropogenic systems to ongoing climate changes, it is necessary to fill them with vegetation cover as much as possible, which is capable of reducing the heating of the soil and other surfaces, and create a favorable microclimate.

Keywords: Soil Surface Temperature, Temperature Sum, Changes Over Time, Adaptation

Introduction

Climate change, one way or another, affects all aspects of the functioning of natural and anthropogenic systems. Soil cover is no exception to this rule. A direct consequence of climate change is a change in the temperature regime of soils, which affects the processes of soil formation, the formation of conditions for the occurrence of soil droughts, the accumulation of heat in the soil layer contributes to the occurrence of forest fires, overheating of surfaces in populated areas adversely affects the well-being of the population, etc.

Scientists all over the world have noted an increase in soil temperature along with changes in air temperature, precipitation and other meteorological variables, and also emphasize the influence of land use, vegetation type, its density, etc [1-5]. The territory of Ukraine is no exception, as studies have noted an increase in soil temperature, both at different depths and throughout the entire soil layer [6-7].

High soil temperature disrupts energy metabolism in plants and prevents protein synthesis, cells lose their osmotic properties and are destroyed [8]. For many plants, a temperature of 40 °C is critical, at which many normal physiological functions of plants are inhibited, which leads to their death. Succulents and cacti can tolerate fairly high temperatures. Some blue-green algae are the most heat-resistant, they tolerate temperatures up to 70 °C [8]. The optimal soil temperature for sunflower seed germination is 25 °C, on average, the maximum temperature for seed germination usually does not exceed 40–45 °C, however, some hybrids continue to germinate at temperatures up to 48.9 °C [9].

In the soil temperature range of 10–24 °C, the metabolic rate of soil macroorganisms increases, which requires them to either eat more or burn their own fat reserves [10]. At extremely high temperatures of 58 °C, soil macroorganisms die due to unfavorable soil temperatures. Soil temperatures of 40 °C and above slow down the growth of microorganisms in the soil. If the soil temperature reaches 60 °C and above, microorganisms die, etc [11]. Temperature affects the content of carbon dioxide in the soil air. High temperatures stimulate the activity of microorganisms, which leads to an increase in the production of carbon dioxide in the soil [12].

The aim of the research was to trace the long-term dynamics of soil surface temperature and the factors influencing it in

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connection with climate change issues.

Materials and Methods

The research used the materials of long-term observations at stationary posts of the Hydrometeorological Service of Ukraine. To study the change in soil surface temperature, 3 meteorological stations were used: Kyiv, Lugans'k and Pokoshichi (Figure 1). The meteorological stations Lugans'k and Kyiv have some of the longest series of observations of meteorological values, the meteorological station Pokoshichi belongs to the Prydesnyanskaya water balance station and has one of the longest lists of measured hydrometeorological parameters.

The main research methods were graphical analysis and analysis of literary sources. The analysis included long-term series of observations of changes in the average, absolute maximum and absolute minimum soil surface temperature and factors that can influence its change (air temperature, precipitation, the sum of air temperatures for the year and for the vegetation period, etc.).

Figure 1: Map - diagram of the location of weather stations used for analysis. -location of the weather station.

Source: internet resource

Results

Analysis of long-term series of soil temperature observations at the Kyiv, Pokoshichi and Lugansk meteorological stations shows that over the past 30-40 years there has been a tendency to increase both the average soil surface temperature and the absolute maximum and minimum soil temperatures (Figures 2,3). A good relationship with the sum of air temperatures for the year is shown by the average annual soil surface temperature (Figure 4), the relationship with the sum of temperatures for the growing season is weaker, which most likely indicates the influence of cooling of the soil layer in winter. The relationship with the sums of air temperatures for different periods of extreme characteristics of the soil surface temperature is weak. However, the direction of the upward trend with an increase in the sums of temperatures is clearly traced. Here, the influence of precipitation, wind, cloudiness, land use patterns, etc. on extreme temperatures is felt to a greater extent. It should be borne in mind that the change in time of the annual characteristics of the soil surface temperature is analyzed, the influence of individual factors on which can be smoothed out during the year due to the intermittency of the process or the multidirectionality of influence, etc. The change in the sums of soil temperatures per year and per growing season in a multi-year context tends to converge, since temperatures increase in the winter period (Figure 5).

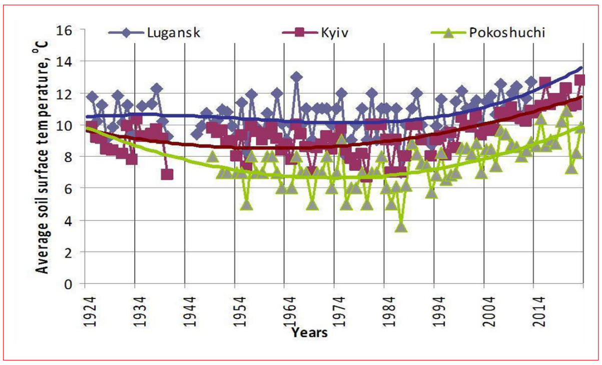

Figure 2: Changes in average annual soil surface temperature over time at meteorological stations Kyiv, Pokoshichi and Lugans'k

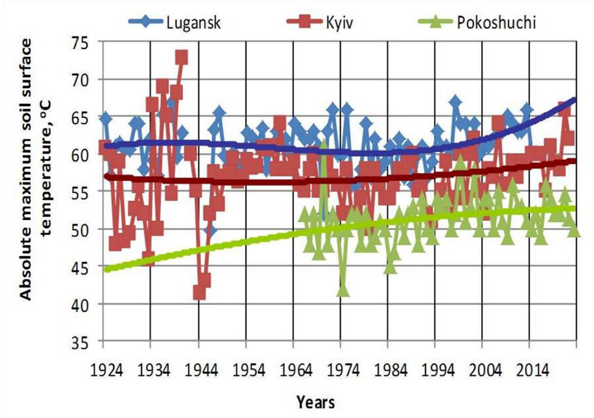

Figure 3: Changes in time of absolute maximum soil surface temperature at meteorological stations Lugans'k, Kyiv and Pokoshichi.

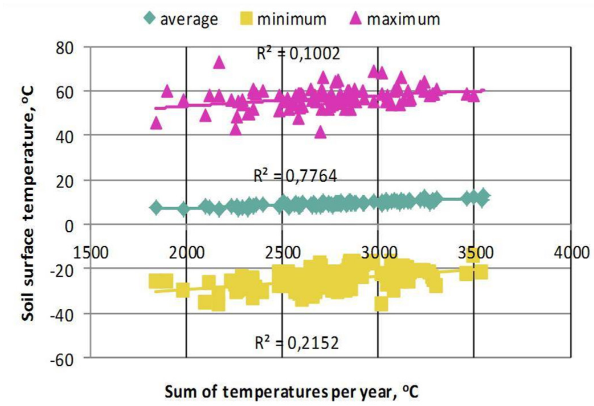

Figure 4: Dependence of the average annual soil surface temperature and absolute maximums and minimums of soil surface temperature for the year at the Kyiv weather station on the sum of air temperatures for the year.

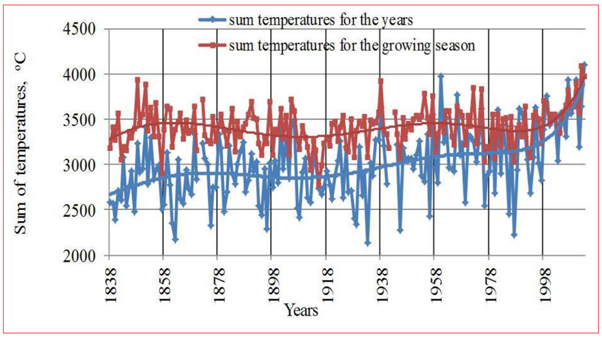

Figure 5: Changes in air temperature sums over time for the year and for the growing season at the Lugans'k meteorological station.

Conclusions

The conducted studies show an increase in both the average soil surface temperature and extreme soil surface temperatures (absolute maximums and minimums) over time, the sum of temperatures per year also increases. As a result, an increase in the activity of macro- and microorganisms in the soil layer, an increase in the release of carbon dioxide into the atmosphere are expected. Some varieties of individual agricultural crops at such high temperatures lose the ability to form full-fledged seeds, etc. At present, the accumulation of cold in the soil layer in winter acts as a restraining buffer for the growth of extreme soil temperatures.

In order to adapt natural and anthropogenic systems to the ongoing climate changes, it is necessary to fill them with vegetation cover as much as possible, which can reduce the heating of the soil and other surfaces, and create a favorable microclimate. Namely: plant trees and shrubs, do not mow lawns without urgent need. These measures have a multifaceted purpose - protection from the sun, wind, water, cleaning the air from pollutants, filling it with phytoncides that have a beneficial effect on the epidemiological situation, etc. In agriculture, apply crop rotations with maximum filling of fields with cultivated vegetation throughout the year, apply strip placement of crops, etc.

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