Postprint: Relationships Between Soil Moisture and Temperature Under Different Land Uses in the Loess Plateau During the Freeze-Thaw Period

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Abstract

To investigate the variations and relationship between soil moisture and temperature during the freeze-thaw period, soil moisture and temperature data were monitored from runoff plots with different land uses in the field, the spatiotemporal variation patterns of soil moisture and temperature at different soil depths were analyzed, and the correlation between soil moisture and temperature in the study area was elucidated. The results show that: during the freeze-thaw period, the 20 cm soil layer in sloping cropland exhibited the greatest amplitude of moisture content variation, while for both grassland and forest land, the 40 cm soil layer showed the maximum amplitude of moisture content variation; the 20 cm soil layer in sloping cropland had the highest degree of variation in moisture content, whereas the most active layers for grassland and forest land were 30 cm and 10 cm, respectively; grassland entered the freezing and thawing periods earliest, and the timing of freezing and thawing showed a progressive lag with depth; soil moisture content and temperature in all three land use types (sloping cropland, forest land, and grassland) exhibited a quadratic functional relationship. Forest land showed the strongest correlation between soil moisture and temperature, which is more conducive to soil water-heat conservation in the loess region. These results can provide a scientific basis for research on the impact of soil moisture on vegetation restoration and for environmental conservation efforts in the loess region.

Full Text

Preamble

Arid Zone Research
This study investigates soil moisture and temperature dynamics during the freezing-thawing period in Ansai County, Shaanxi Province, China.

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1. Study Area

1.1 Site Description

The study area is located in Ansai County (36°51 N, 109°19 E) on the Loess Plateau, with elevations ranging from 1068 to 1309 m. The region has a temperate semi-arid climate with a mean annual temperature of 8.8°C. January temperatures average -6°C (minimum: -20.6°C), while July averages 21°C (maximum: 36.7°C). Annual precipitation is 505.3 mm, with 645 mm evaporation and 296.6 mm runoff. Annual sunshine duration is 2395.6 hours, with a frost-free period of 157 days and relative humidity of 54%. The terrain consists of hilly gullies at 100–200 m depth. Three typical land use types were monitored: sloped farmland, grassland, and woodland.

Monitoring was conducted from November 15, 2016, to April 2, 2017. Soil moisture and temperature measurements were taken at 14:00 on December 20, 2016, using a soil moisture monitoring system. Data analysis was performed using SPSS 22.0, Origin 9.0, and Excel 2010. Pearson correlation analysis was used to examine relationships between soil moisture and temperature.

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2. Results

2.1 Soil Temperature Characteristics

The freezing period was defined as when soil temperature at 10 cm depth remained $ $0°C for more than 5 consecutive days, and the thawing period as when temperature remained >0°C for more than 5 days [24]. Temperature curves for the three land use types at 10 cm depth are shown in Figure 2.

The freezing-thawing process exhibited three distinct phases: initial freezing, stable freezing, and thawing. Temperature variations were most pronounced in the woodland, followed by grassland and sloped farmland. At 10 cm depth, the soil temperature hierarchy was: woodland > grassland > sloped farmland. The freezing depth reached 50 cm in sloped farmland, 60 cm in grassland, and 70 cm in woodland. The corresponding thawing depths were 50 cm, 60 cm, and 70 cm respectively, indicating that freezing and thawing progressed layer by layer.

Fig. 2 Temperature and ground temperature curves for the three land use types

2.2 Soil Moisture Dynamics

The 20 cm soil layer showed the greatest moisture variation in sloped farmland, while the most active layers in grassland and woodland were 30 cm and 10 cm, respectively. Moisture content at 20 cm depth followed the order: woodland > grassland > sloped farmland during the monitoring period.

The 70–100 cm soil layer remained relatively stable across all land use types, suggesting minimal influence from surface freezing-thawing processes. This stability may be attributed to the buffering effect of the overlying soil profile, which dampens temperature fluctuations and moisture migration at depth.

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Abstract

To study the changes in soil moisture and temperature during a freezing-thawing period, the space-time change law of soil moisture and temperature of different soil depth layers were analyzed by monitoring the soil moisture and temperature data of different land use runoff plots in the field. The relationship between soil moisture and temperature in the study area was then clarified. The results showed that the variation degree of the 20 cm soil layer in sloped farmland was the largest, while the strongest active layers in the grassland and woodland were 30 cm and 10 cm, respectively. The 20 cm soil layer in the sloped farmland had the largest dispersion of water content, while the active layers in grassland and forestland were 30 cm and 10 cm, respectively. The grassland first entered the freezing period and the thawing period, and freeze and melt time lags layer by layer, and the soil moisture content and temperature of the three land types followed quadratic functions. The hydrothermal relationship of the soil in forestland was the strongest, which is more conducive to the soil water-heat retention in the loess area. This study provides a scientific basis for the research of soil

moisture on vegetation restoration and the protection of the environment from construction in the loess area.

Keywords: freezing-thawing period; land use; soil moisture; soil temperature; correlation; Ansai County

Note: Figure translations are in progress. See original paper for figures.