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Anomaly and Mutation Dataset of Shallow Soil Temperature in Xi'an Region (1961–2017)

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Abstract: In this study, based on existing literature research and the monthly ground temperature observation data from 1961 to 2017 in Xi'an city, Hu county, Chang'an district, and Gaoling district, the Anomaly and mutation dataset of soil shallow temperature in Xi'an region (1961–2017) was developed through processing methods such as climate diagnosis, unit conversion, error correction, and distance equality data, and data analysis methods such as wavelet analysis and Mann-Kendall non-parametric test. The dataset includes: (1) chronological data, year-by-year flat data, average annual temperature distance data, month-by-month flat data;(2)periodic, mutation, and outlier data. This dataset is archived in .xlsx format and consists of 6 data files with a data size of 546 KB.

Keywords: Xi'an region; shallow soil temperature; anomaly index; variation characteristics

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.04.06.V1 or https://cstr.escience.org.cn/CSTR:20146.11. 2022.04.06.V1.

1 Introduction

Shallow soil temperature (shallow ground temperature) refers to the temperature of different soil depths between 5 cm and 20 cm from the ground surface[1], which is one of the important indicators reflecting the physical properties of soil and has an important impact on crop growth, urban construction, and geothermal resource development and utilization. With the intensification of global warming and human activities[2], the IPCC Fifth Assessment Report (AR5) stated that the global average surface temperature increased by 0.85 °C between 1880 and 2012[3,4] and that the increase in global surface temperatures will inevitably lead to changes in soil temperatures. Therefore, many scholars have studied regional shallow ground temperature variations and their effects from different perspectives, indicating that shallow ground

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temperature variations in different regions have regional differences and increasing trends[5–11].

At present, there are few systematic studies on the shallow soil temperature change in the Xi'anregion. With the accelerated development and urbanization of the western region, the land use mode of Xi'an region has changed, which had a great impact on the coordinated development of agricultural production, urbanization, and ecological environment. Therefore, it is of great significance to study the change law of shallow ground temperature and its influencing factors in Xi'an region under the background of climate warming for the assessment of the agricultural development and climate change, the rational use of climate resources, and the ecological civilization construction in Xi'an region.

Due to the short detection time scale and few ground temperature measurement stations in the past, the systematic analysis of ground temperature cannot be well performed[12]. Therefore, based on the monthly data of shallow ground temperature in the Xi'an area, the shallow soil temperature distance flat and abrupt datasets in this area were prepared and verified by Pearson correlation analysis to further improve the accuracy of the dataset, which can provide data support to study the spatial-temporal variation of shallow ground temperature in Xi'an region and the analysis of the causes of changes.

2 Metadata of the Dataset

The metadata summary of the Anomaly and mutation dataset of shallow soil temperature in Xi'an region (1961–2017)[13] is summarized in Table 1. It includes the full name of the dataset, short name of the dataset, authors, year of the dataset, temporal resolution, spatial

Table 1 Metadata summary of the Anomaly and mutation dataset of shallow soil temperature in Xi'an region (1961–2017)

Items	Description
Dataset full name	Anomaly and mutation dataset of shallow soil temperature in Xi'an region (1961–2017)
Dataset short name	SoilTempAnomalyXiAn_1961-2017
Authors	Liu, Y. G., College of Geography and Environment, Baoji University of Arts and Sciences/Shaanxi Provincial Key Laboratory of Disaster Monitoring and Mechanism Simulation, yingeliu@163.com Su, Y., College of Geography and Environment, Baoji University of Arts and Sciences/Shaanxi Provincial Key Laboratory of Disaster Monitoring and Mechanism Simulation, 1963582780@qq.com Fang, J. G., Climate Center of Shaanxi Province
Geographical area	Xi'an area (Xi'an city, Hu county, Chang'an district, Gaoling district)
Data format	.xlsx Year 1961–2017
Data size	546 KB
Dataset files	(1) Chronological interval data; (2) Year-on-year data; (3) Annual and seasonal average temperature level data; (4) Month-by-month data; (5) Data on years of geothermal anomalies; (6) data on abrupt changes in geothermal temperatures
Foundations	National Natural Science Foundation of China project (41771048); Shaanxi Provincial Key R&D Program Project (2022SF-364）
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new datase[14]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

resolution, data format, data size, data files, data publisher, and data sharing policy.

3 Data Processing

3.1 Data Sources and Pre-processing

The research data in this paper were obtained from the monthly average temperature observation data of the 5–20 cm soil layer in Xi'an region Hu county, Chang'an district, and Gaoling district from 1961 to 2017 (Gaoling Station provided data from 1970–2017 due to the unavailability of geothermal data measurement), and the distribution of the study area and city is shown in Figure 1.

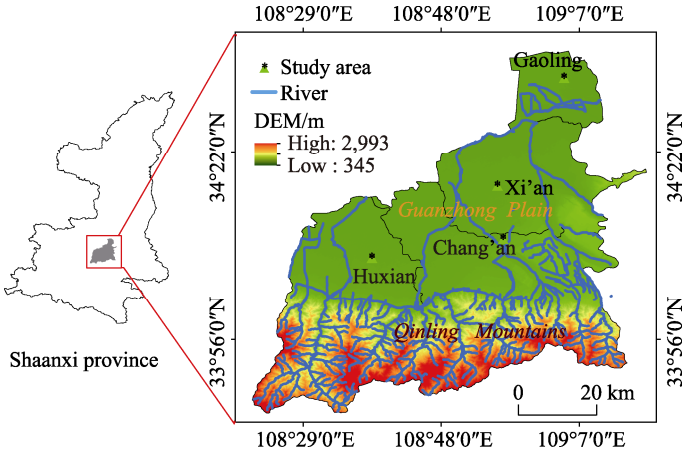


Figure 1 Study area and urban distribution map

Firstly, monthly ground temperature data was converted by units and the outliers were corrected. Secondly, the 30-year average ground temperature from 1961 to 1990 was used as the standard to calculate the monthly, quarterly, and annual ground temperature in different years. According to the seasons in China, spring is March to May, summer is June to August, autumn is September to November, and winter is December to February[15]. Seasonal ground temperature is the average of the corresponding month, and the annual ground temperature is the average temperature from January to December.

3.2 Technical Route

The dataset was organized using the monthly observed shallow soil temperature data from 1961 to 2017 in Xi'an region, and the technical route is shown in Figure 2. The steps are as follows: (1) Data pre-processing and error correction were carried out, the temperature spacing index of year, quarter, and month was calculated, the datasets of the year, month, and season interval datasets were established, and the spatio-temporal variation characteristics of shallow ground temperature was analyzed. (2) The wavelet transform and Mann-Kendall nonparametric test method were used to establish a mutation dataset, and the geothermal index of four regions in Xi'an was analyzed by periodic and mutation tests. According to the

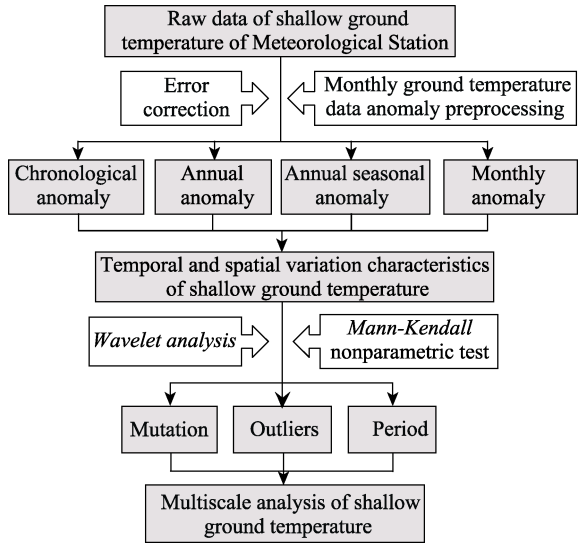


Figure 2 Technology route for research and development of shallow soil temperature dataset in Xi'an region

evaluation standard of the "National Climate Impact Assessment" of the China Meteorological Administration, the ratio of the ground temperature distance data to the standard deviation is used to determine whether the ground temperature is abnormal. When the ratio is ≤ –2, the ground temperature is abnormally low, and when the ratio is ≥ 2, the ground temperature is abnormally high. Based on this, the abnormal dataset was established. (3) The periodic characteristics, abnormal characteristics, and mutation characteristics of ground temperature indices of different scales were analyzed.

4 Data Results and Validation

4.1 Dataset Composition

The Dataset of shallow soil temperature distance and abrupt changes in the Xi'an region (1961–2017) consists of the following data.

(1) Chronological data in Xi'an region: the annual and seasonal geothermal intervals are flat, and the regional geothermal epochs are flat (Tab 1). (2) Yearly flat data in the Xi'an region: the annual season and regional ground temperature are yearly flat and the ground temperature of each layer and the whole shallow layer is yearly flat (Tab 2). (3) Average annual temperature distance data in Xi'an (Tab 3). (4) Month-by-month flat data in Xi'an: the monthly maximum temperature and lowest temperature distance are flat, and the monthly average temperature distance data is flat (Tab 4). (5) Data of abnormal years of geothermal anomalies in Xi'an region (Tab 5). (6) Geothermal mutation data in the Xi'an region: including mutation year and M-K test hyperbola (Tab 6). The .xlsx file in the dataset includes 6 data tables with a data size of 546 KB.

4.2 Data Results

4.2.1 Characteristics of Average Geothermal Variation in Years and Seasons

Both the annual average geothermal temperature and the seasonal average geothermal temperature of 5–20 cm in Xi'an showed a fluctuating upward trend, and there was a sharp upward trend after the 1990s. Among the layers, the maximum trend rate was 0.38–0.46 ºC/10a in spring and the minimum trend rate was 0.07–0.12 ºC/10a in summer. The increase was 0.14–0.19 ºC/10a in autumn, and 0.12–0.15 ºC/10a in winter. The annual average geothermal trend rate increased by 0.18–0.22 ºC/10a. The increase in geothermal growth since the 1990s is related to the rapid development of urbanization and global warming in Xi'an (Figure 3).

4.2.2 Chronological Variation of Geothermal Temperatures in Various Regions

The geothermal intergenerational flatness change in various regions is shown in Figure 4. It can be seen from the figure that the 5–20 cm soil layer in the Xi'an region shows a positive and negative flattening change, among which the 1960s to the end of the 1970s and after 2010 is positive and flat, and the soil temperature increases. From 1980 to 2010, the soil temperature decreased, and only the 5 cm and 20 cm soil layers of Gaoling district increased in the 1990s. Meanwhile, the highest value of the distance to the flat also appeared in Gaoling district in the 1990s, and the lowest value appeared in Chang'an district in the 1980s. In general, the interdecadal changes of geothermal temperature in various regions showed the characteristics of alternating high and low, among which the change in the distance from Chang'an district to parity is the most obvious, showing a significant downward trend, followed by Gaoling district, showing a clear upward trend. Hu county showed a weak downward trend, and Xi'an region had the smallest change, showing a weak upward trend.

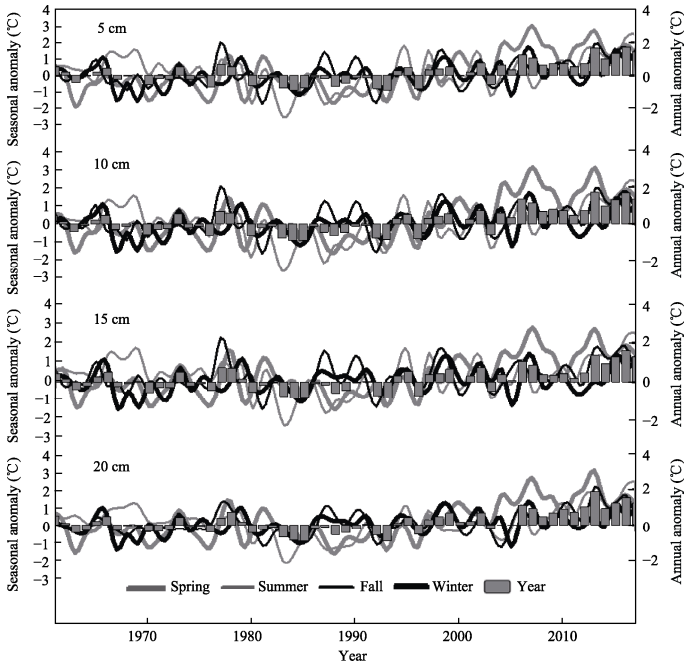


Figure 3 Yearly variation of shallow ground temperature in Xi'an region

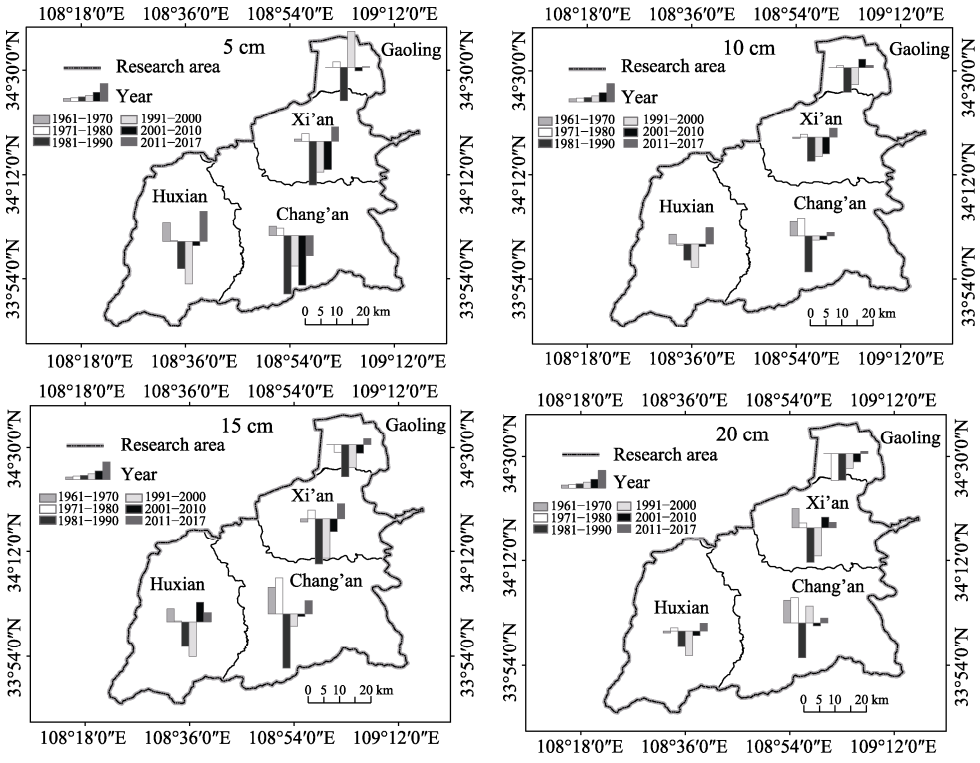


Figure 4 Geothermal chronology of different soil layers in the Xi'an region

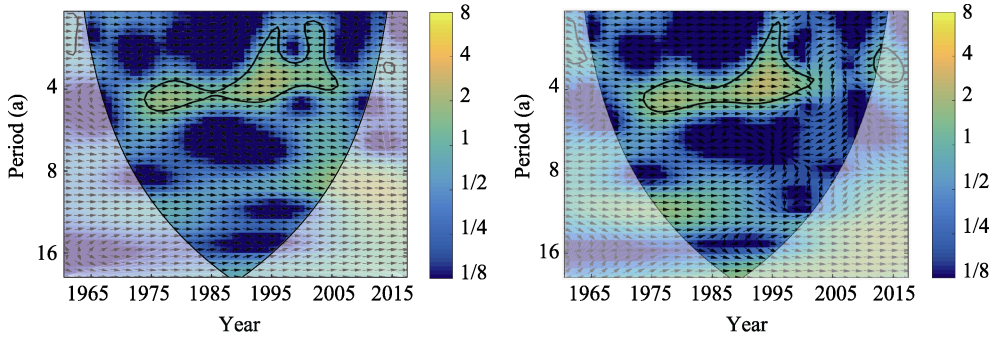
4.2.3 Multiscale Characteristics of Ground Temperature

In this dataset, the anomalous years are summarized by the anomalous characteristics of

strata in Various Strata in Xi'an region (Tab 5). From the table, the abnormally low years mostly appear in 1960–1970 and 1980–1990, and the abnormally high years appear in 1970–1980, 1990–2000, and after 2000. Overall, there were fewer years with average annual temperature anomalies, occurring only in 15 cm and 20 cm soil layers.

Then, the M-K non-parameter test was performed on the flat data to obtain the mutation year of shallow ground temperature in Xi'an (Tab 6). The mutation points of the four soil layers occurred after the 21st century and there was no mutation in summer.

The geothermal change in Xi'an region also shows obvious periodic characteristics. Figure 5 shows the cross wavelet transformation energy spectrum of the average ground temperature of the 5–20 cm soil layer in Xi'an region . In the figure, the more yellow the color, the greater the energy spectral density. Figure 6 shows that from 1975 to 2005, the average temperature of the 5–20 cm soil layer in Xi'an region has a significant short cycle of 2–6 a and a long cycle of 8–20 a.



(a) Cross wavelet transform of 5 cm and 10 cm soil layers (b) Cross wavelet transform of 15 cm and 20 cm soil layers

Figure 5 Cross wavelet transform map of average 5–20 cm ground temperature in the Xi'an region

4.3 Data Result and Verification

The data error comes from the lack of measurement of the monthly ground temperature data of the weather station, but the data quality has been tested in this dataset to minimize the data error. Among them, the missing measurement data or extreme outliers within 3 days are replaced by the average of the ground temperature of the previous and subsequent 2 days, and the data years with more than one day missing are not used. For example, the geothermal data of Xi'anregion, Chang'an district, and Hu county from 1951 to 1960 and the geothermal data of Gaoling district from 1951 to 1969 have missing measurements in a certain year.

The Pearson correlation analysis was carried out using the seasonal distance and shallow ground temperature in the study area and the average seasonal temperature of the ground of Xi'an Meteorological Station every year to verify the reliability of the data. As shown in Table 2, the correlation between ground temperature and shallow ground temperature in the study area was high, both reaching about 0.8, passing the significance test of 0.01 level. At the same time, it can be seen that the correlation between ground temperature and shallow ground temperature in spring and summer decreases with the deepening of depth, indicating that the ground temperature has a strong influence on the shallow soil temperature with solar radiation as the heat source. The correlation between ground temperature and shallow ground temperature in winter increases with the deepening of the depth, indicating that the ground temperature with soil as the heat source increases with the increase of soil depth. This is consistent with previous conclusions about the characteristics of vertical variations in ground temperature in the study area[16] and is sufficient to verify the reliability of the

distance-level data.

Table 2 Pearson correlation analysis between temperature and shallow ground temperature in Xi'an region

Depth (cm)	Spring	Summer	Autumn	Winter
5	0.88	0.86	0.79	0.79
10	0.87	0.84	0.81	0.81
15	0.84	0.82	0.81	0.84
20	0.85	0.74	0.71	0.84

5 Discussion and Summary

The shallow soil temperature pitch and abrupt change dataset in the Xi'an (1961–2017) is based on the shallow soil temperature data of four regions in Xi'an region from 1961 to 2017. The original data were analyzed by temporal variation characteristics of ground temperature seasonally and chronologically in the context of significant global climate warming, as well as the variation characteristics of the ground temperature with the depth of the soil layer. Then, wavelet analysis and Mann-Kendall nonparametric test were used to analyze the month-by-month flat data by periodic and mutation tests, and the outliers were sorted out.

The main conclusions are as follows:

(1) The shallow ground temperature changes in Xi'an region showed a fluctuating upward trend, and it showed a sharp upward trend after the 1990s. Among the layers, the trend rate is the largest in spring, the smallest in summer, and moderate in autumn and winter. The annual average ground temperature trend rate increased by 0.18–0.22 ºC/10a.

(2) The interdecadal changes of geothermal temperature in various regions in the soil layer of 5–20 cm generally showed the stage characteristics of alternating cold and warm. The change of distance and flat value in Chang'an district was the most obvious, showing a significant downward trend, followed by Gaoling district, showing a clear upward trend. Hu county showed a weak downward trend, and Xi'an city had the smallest change, showing a weak upward trend.

(3) The multi-scale characteristics of the geothermal temperature in Xi'an are as follows: the mutation points are all after the 21st century, and there is no mutation in the summer; the geothermal variations also show abnormal features, with fewer years of annual average geothermal anomalies occurring in soil layers of 15 cm and 20 cm; there are significant 2–6 a and 8–20 a cycles in the average temperature of the 5–20 cm soil layer.

The month-by-month ground temperature data of the four regions in Xi'an can only reflect the temporal variation trend of soil shallow temperature in Xi'an and the characteristics of the ground temperature variation with soil depth. However, it is difficult for these data to reflect the factors affecting the ground temperature change and its connection with these factors. Therefore, the dataset and the influence mechanism of ground temperature change need to be further studied.

Author Contributions

Liu, Y. G. designed the algorithms of dataset. Su, Y. and Fang, J. G. contributed to the data processing and analysis. Su, Y. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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