Research and Application of Monitoring and Simulating System of Soil Moisture Based on Three-Dimensional GIS

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Abstract. Taking maize precise assignments section as the research object, using arcgis10.2 as the visual drive tool, comprehensive application of 3D modeling, database and GIS technology, this paper proposed a method of rapid establishment of agricultural areas of 3D virtual scene, developed soil moisture monitoring 3D simulation system based on GIS. The system had the 3D model search module, the dynamic scene simulation module, the dynamic monitoring and spatial information management function module and so on. Using Jilin Province Nong'an County town of Helong corn precision operation as an example, the system were preliminary application, the application results showed that the system can realize the effective management of agriculture areas, soil moisture spatial information and virtual display. According to the 3D model of soil moisture dynamic monitoring module, for the analysis and application of the regional soil moisture laid a solid foundation, and provided effective digital management platform for precision agriculture technique.

Keywords: Three-dimensional GIS · Simulating system · Soil moisture · Black soil

1 Introduction

In the "precision agriculture" techniques in GIS application development system is the implementation of "precision agriculture" practices of key technologies, namely the use of acquired farmland in the crop yield and environmental factors that affect crop growth difference information, the establishment of agricultural information database, data after conversion, processing and spatial analysis in GIS generated maps differentially information by analyzing the reasons for the differences affecting production, the development of economic, rational decision-making program production, crop management prescription map form, guidance farmland positioning job. GIS As for storage, analysis, processing and presentation of geospatial information computer software platform, the technology has matured. It is in the "precision agriculture" spatial information database technology systems used to establish agricultural land management, soil data, natural conditions, crop growth of the seedlings, the development trend of pests, crop yields space distribution of spatial information geographical statistics such as processing, pattern conversion and expression, to analyze the differences and

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the implementation of the regulation provides prescription information. But the two-dimensional plane GIS information cannot meet the growing application requirements, in terms of the relative two-dimensional GIS, three-dimensional GIS to be more comprehensive and accurate expression of the decision-making, production and management of modern agriculture. Three-dimensional GIS will be integrated into crop cultivation and management of decision support systems, and crop production management and Growth forecasting simulation model input-output analysis and intelligent agriculture expert system together, and with the participation of decision makers according to the spatial differences in yield, analyze the reasons, to make a diagnosis, provide scientific prescription, and to the field crop management prescription map GIS support of the formation of the regulatory guidance of scientific operations.

Global development status, the United States, Canada, Britain used in the fertilization of the most mature, basic access to commercial use. Japan mainly focused on gathering information related to the sensor and agricultural machinery automatic control and other aspects involved. Precision agriculture is also widely used in forestry production, mainly related to the relevant areas of fertilization, precision seeding, pest control, harvesting operations and water management. At present, except for a few countries, precision agriculture has not been large-scale deployments in the world, mainly because of its development of key technologies yet to produce a breakthrough in the practical value, information gathering technology and the cost is more expensive and other reasons, but for precision agriculture technology international the development potential and applications with a broad consensus, which is an important part of the development of agriculture as a high-tech applications, referred to as an important approach to sustainable agricultural development.

China is a large agricultural country; precision agriculture is an emerging concept, until the 1990s, began a study of precision agriculture. Establish a certain scale test area in Beijing, Shaanxi, Heilongjiang, Xinjiang, Inner Mongolia and other places, but overall is still at an experimental demonstration and nurture the development stage. In terms of technology, management and economic efficiency, our precision agriculture compared with the developed countries there is still a big gap, but also faced with inadequate technical support, information collection system was incomplete, expert systems are imperfect, precision is not high, the application conditions are not ripe and other conditions. Especially in high-precision agricultural machinery precision control system products, long-term dependence on imported goods, has seriously hampered the development of precision agriculture.

Although there are many difficulties in the development of precision agriculture, but agricultural machinery involving precise control of the relevant technology matured, where as RTK technology, wireless data transmission technology, navigation path planning technology, hydraulic control technology has been widely used in related industries. In 1998, the Ministry of Agriculture in Beijing Shunyi to establish a northern precision agriculture demonstration zone; in 2000, precision agriculture has been included in the national 863 high-tech research program and tested explore precision agriculture in Shanghai, Beijing and other places. Up to now, Chinese Academy of Sciences, Chinese Academy of Agricultural Sciences, China Agricultural University, Beijing Forestry Sciences, Shanghai Academy of Agricultural Sciences, the Shanghai Meteorological Bureau and other units have carried out research on precision agriculture, has been in Beijing, Hebei, Shandong, Shanghai and Xinjiang, We established a number of precision agriculture experiment and demonstration area. Heilongjiang as China's agriculture developed areas, first to the construction of agricultural information, the end of 2012, has been established in a number of farms Precision Agriculture Demonstration Zone. After several years of development, China's agricultural engineering and technical staff made great achievements in the technical system in precision agriculture.

2 Regional and Methods

2.1 Regional

Was chosen for the national "863" project "maize crop in Precise Operation System and Application" demonstration bases close Nong'an is located in the Song Liao Plain, it is one of the important commodity grain base, Jilin Province, located 60 km northwest of Changchun City, longitude 124° 32′–125° 45′, latitude 43° 54′–44° 56′; the average annual rainfall 507.7 mm, mainly fertility rating of chernozem soil, new soil in the wind sand, saline, alkaline earth, swamp soil, peat soil, paddy soil. Black soil is one of the most fertile Farmland County, concentrated in the eastern and southern counties Bao, Lung, pot roast, patron and three hillock township (town) loess sediments situation plateau, in the province black belt edge, close to the semi - arid region climate.

2.2 Research Program

The system uses GPS, wireless sensor data on soil moisture test area to acquire, construct spatial database in the data set, based on a relational database, dynamic database, database and graphic three-dimensional image library. Spatial query and spatial interpolation operation on the basis of the database, and the establishment of three-dimensional dynamic simulation model. Its technical route shown in Fig. 1.

2.3 Data Collection and Knowledge Acquisition

Use GPS to collect topography, spatial data sampling points, establishment of spatial database; according to the sampling point information, using GIS to draw the sampling grid maps, soil nutrients and other attribute data collection, build a relational database; via wireless sensors collect soil moisture, soil temperature, etc. soil moisture data to create dynamic database; based on artificial intelligence technology, the establishment of corn precision fertilization model library; according to corn growth stages, shooting its growing field, precise image and video work processes, create video library.

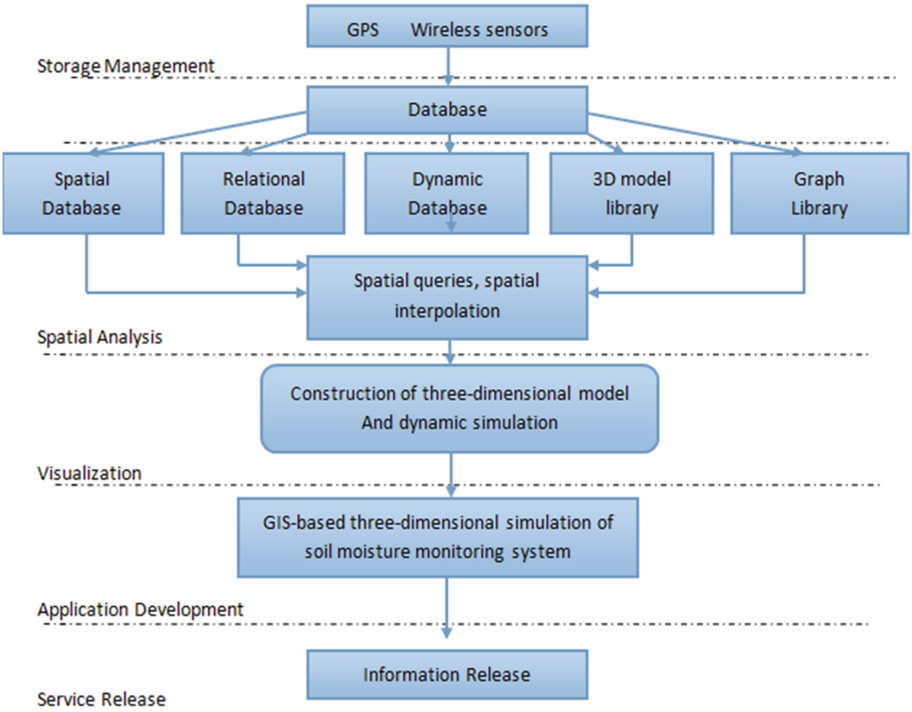

Fig. 1. Technology roadmap

2.4 Data Analysis and Processing

ArcGIS based platform, using 3DAnalyst tools fertility levels, topography, soil moisture and soil temperature, soil moisture data, spatial interpolation, spatial processing framework by two-dimensional and three-dimensional analysis of a variety of combinations, the analysis of the factors of soil moisture management Relations between.

(1) Production of spatial interpolation diagram dimensional GIS-based soil moisture data

According to the production of corn precise job objective laws, the use of Kinging interpolation method topography, soil moisture and other discrete sampling data interpolated into regular volume data to generate spatial interpolation diagram for three-dimensional reconstruction; image data on a regular grid display needs to be different depths of soil moisture, soil temperature and other data to interpolate interpolation applications including light and shade effect, in order to meet each pixel display area spatial variation diagram drawing generation.

(2) Analysis of three-dimensional interpolation maps

The use of three-dimensional spatial processing technique, terrain and soil moisture on different depths, spatial variability of soil temperature diagram variety of combinations, analyze the relationship between soil moisture, topography, soil temperature between the factors to solve complex soil moisture monitoring spatial analysis problems.

2.5 Construction and Scenario Simulation Model of Three-Dimensional GIS

(1) Three-dimensional GIS Model

Use ArcGIS and 3Ds Max platform to build three-dimensional GIS model soil moisture monitoring semantic layer, scale layers and geometric layer, Visual scenes based on soil moisture needs, soil moisture monitoring simulation system is divided into the terrain surface, underground two-level three-dimensional space to build and description:

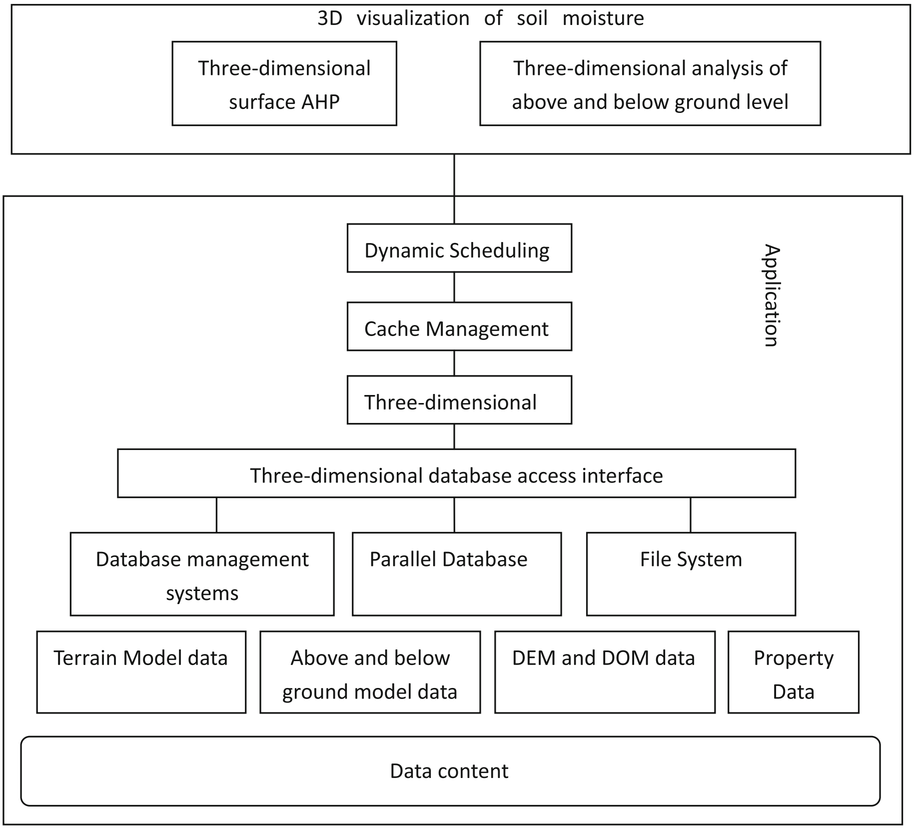

Fig. 2. Soil moisture monitoring visualization analysis chart

① Construction of the terrain surface level digital elevation model

Using digital elevation model surface modeling technology, through points, triangles and three grid surface modeling, surface soil for the complete spatial information, level surface topography of the terrain, such as establishing a digital elevation model, Ensure reasonable space division and regional identification on the core area of the terrain surface precision work space level;

② Construct three-dimensional models of above and below ground level perspective

Up and down the three-dimensional level is based on the distribution of soil moisture and fertility grade level description of three-dimensional space, mainly to solve the three-dimensional object is generated in a two-dimensional abstract representation and down overlapping problems and meet soil moisture and fertility grade level object precise three-dimensional space Expression and analysis requirements; When the traditional two-dimensional GIS approach to ecological issues, there are many more environmental factors limitations, three-dimensional and three-dimensional visualization of GIS technology integration, the establishment of three-dimensional GIS database, developed three-dimensional GIS visualization management system for three-dimensional visualization analysis, realization soil moisture Dynamic simulation monitoring scenes. Fig. 2:

3 Development of GIS-Based Three-Dimensional Simulation of Soil Moisture Monitoring System

ArcGIS Engine application systems use the .NET Framework, developed soil moisture monitoring system is based on simulation of three-dimensional GIS. System module is divided into: a three-dimensional model query module (three-dimensional map queries, database queries), dynamic scene simulation module (scene management, scene viewing), dynamic monitoring module (spatial analysis, trend analysis) and spatial information management module and other functions to dynamically simulation and dynamic monitoring module as an example to illustrate the system function.

3.1 Dynamic Scene Generations

Because of the complexity and fidelity three-dimensional virtual scene simulation results directly affect the system, so ensure the scene fidelity based on the use arcgis, combined 3DsMax platform provides plug-in function, according to the database generation parameters scenes programming precision agriculture three-dimensional virtual scene generation area, soil moisture simulation scenarios to achieve a three-dimensional visualization, this process has high reusability, greatly enhances the flexibility of the scene. The whole process including terrain generation, import and scene effect feature set.

(1) Establish a two-dimensional layer

Terrain model is the basis for generating a three-dimensional virtual scene, with its other models as a carrier able to determine the actual position in three-dimensional space.

The system generates a terrain model mainly refers to building on the ground subsurface model. First, arc map of agriculture and fertility level security boundary demarcation drawn, as shown in Fig. 3.

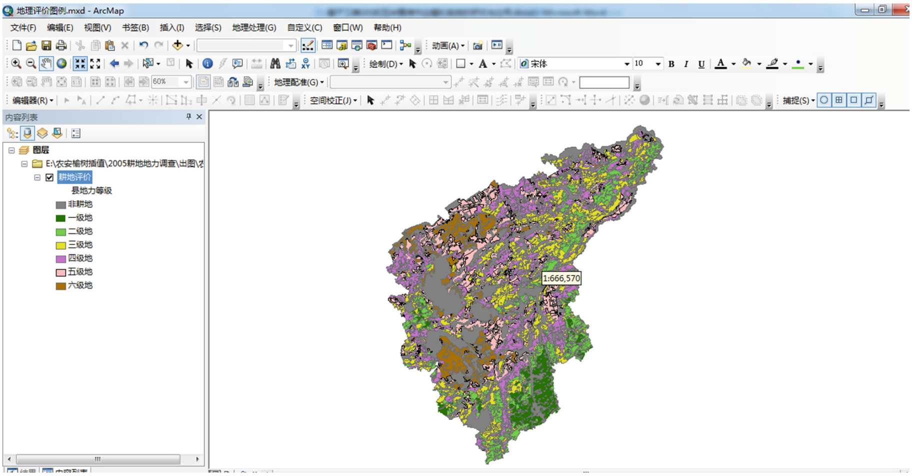

Fig. 3. Nong'an fertility rating dimensional distribution map

(2) Establishing a three-dimensional model

We will draw a good two-dimensional distribution of shp file into arcscene by setting the vector layer elevation, vectorStretched layer operations such as underground model simulation, the establishment of Nong'an fertility levels and underground vertical distribution of three-dimensional model diagram (Fig. 4).

3.2 Dynamic Monitoring Module

Choose different depths maize precision work together core demonstration areas Nong'anjiulongzhen (0–20 cm, 20–40 cm, 40–60 cm, 60–80 cm) soil moisture dynamic monitoring data to establish the soil moisture dynamic monitoring module.

(1) The vertical distribution of soil moisture and temperature analysis

Four models of the subsurface soil moisture, and soil temperature dynamic monitoring results shown in Figs. 5 and 6.

As can be seen in Fig. 5, soil moisture content with increasing soil depth increases; changes in soil moisture content at different times is not the same, around May 11 soil

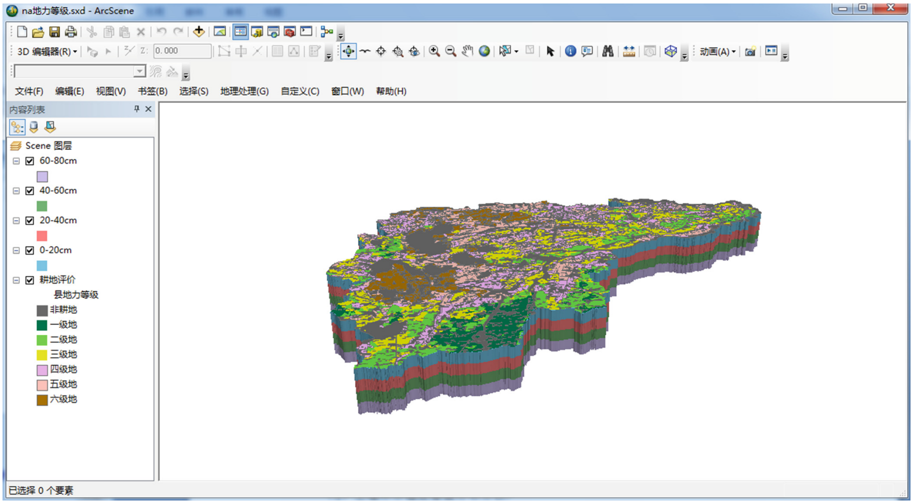

Fig. 4. Nong'an fertility grade three-dimensional vertical profile

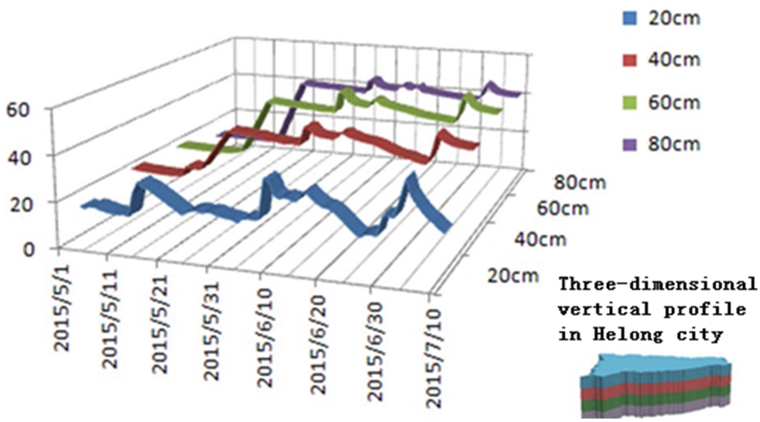

Fig. 5. Vertical distribution of soil moisture content

moisture content in the least, around July 3 maximum moisture content of soil; changes in soil moisture at different depths same trend.

As can be seen from Fig. 6: Soil temperature content with increasing soil depth is reduced; changes in soil temperature at different times is not the same, around May 13 the lowest soil temperature, soil temperature around July 10 highest; different soil depths water is substantially the same tendency.

(2) Soil moisture corn growing season temperature distribution analysis

The dynamic monitoring of 0–20 cm, 20–40 cm, 40–60 cm, 60–80 cm soil moisture four levels, soil temperature, soil moisture, temperature trends Fig. 7 through 11.

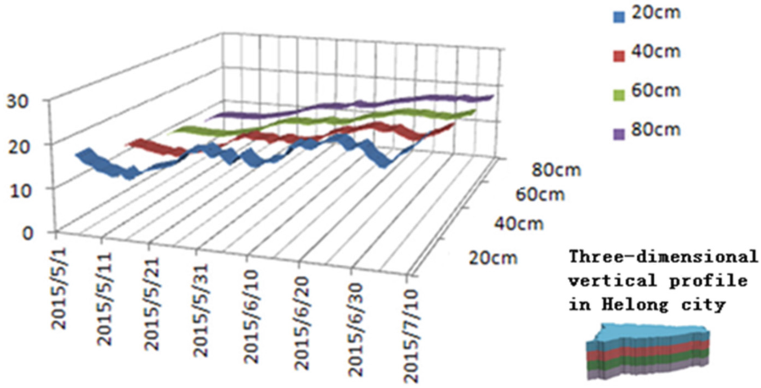

Fig. 6. Vertical distribution of soil temperature Content

We can see from Figs. 7, 8, 9 and 10, in the growth period, the change of soil temperature, and soil moisture change is obvious; Soil moisture content is the lowest, at the end of June or so most abundant on the 4th of July; Soil temperature around on June 10th lowest, around July 10th, the highest temperature.

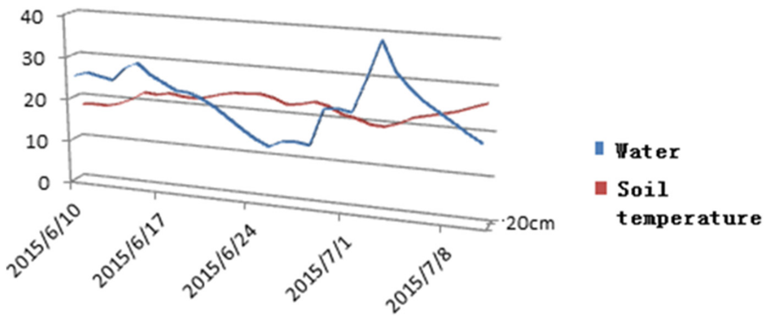

Fig. 7. 0–20 cm soil temperature and crop growth trend humidity

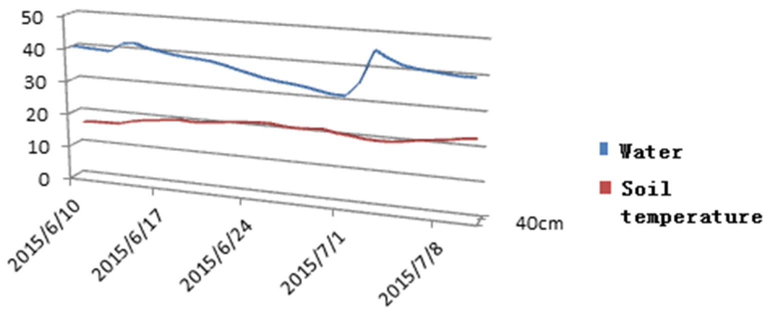

Fig. 8. 20-40 cm soil temperature and crop growth trend humidity

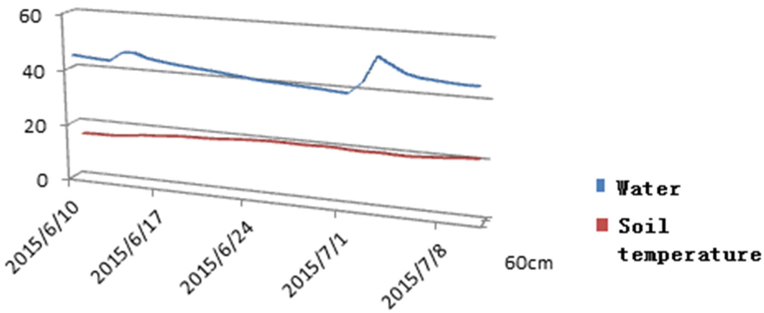

Fig. 9. 40–60 cm soil temperature and crop growth trend humidity

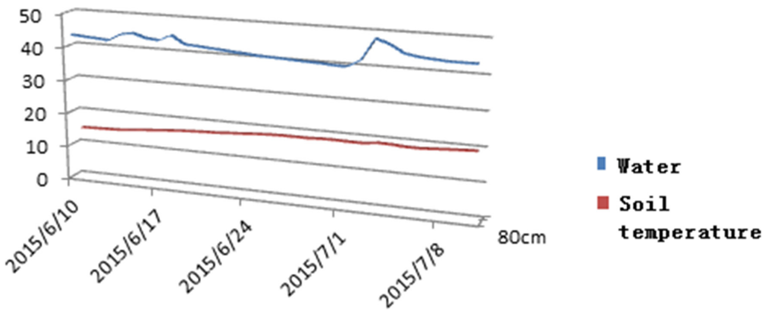

Fig. 10. Crop growing period of 60–80 cm soil temperature and humidity change trend chart

4 Discussion

For the realization of maize precision operation area soil moisture monitoring spatial information management standardization and 3D virtual display, in order to improve the visual simulation technology of reusability as the goal, the study through the ArcGIS platform, combined with 3dsmax software, spatial database and 3D model, established the soil moisture monitoring and simulation system based on 3D GIS.

(1) the building in our study of soil moisture monitoring simulation system is no longer confined to the two-dimensional map spatial information expression for agriculture, but with vivid features to express 3D virtual scene, through this way to simulate the cognitive process of corn precision work, realize the interaction between a user and a system mode transformation from traditional 2D space to multi-dimensional space, effectively play the 3D scene realistic and 2D map overall advantage, perfect interpretation of the essence of agricultural spatial information

(2) This system generate the region soil fertility level and vertical distribution of soil moisture of the underground three dimensional model diagram by using ArcMap to Nong'an boundary and soil fertility grade dividing rendering, taking the 3D

model diagram reflect different depths (0–20 cm, 20–40 cm and 40–60 cm, 60–80 cm) soil moisture conditions and dynamic monitoring data.

(3) According to the dynamic monitoring of soil moisture module to establish the three-dimensional model, the research laid the foundation for the application of the analysis of regional soil moisture.

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