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Application of Information-Computing Technologies for Modeling in Soil science and Ecology

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Abstract. Information-computing technologies are becoming a necessary tool in solving various kinds of problems related to research in the field of agriculture. Modern methodology also does not ignore soil science and ecology. Unified databases are being created on the most important physicochemical parameters characterizing soils. This leads to the emergence of more and more promising means of computing technologies. In particular, software systems that would make it possible not only to make long-term forecasts, but also to simulate various kinds of processes. As a result, there is a gradual transition to artificial intelligence. At the same time, very broad tasks are set before him. One of them is the enhancement of human capabilities. But at the same time, one should not forget that artificial intelligence can work effectively only if tasks are prescribed for it to be performed. He is able to study, analyze, collate a huge amount of data and use the knowledge gained to properly organize the environment.

1. Introduction

Any research in any sciences, as a rule, is associated with the accumulation of information. In the future, the obtained data are processed and the transition to the analysis and presentation of the results takes place. Soil sciences are no exception.

Both in Russia and abroad [1-3], great attention is paid to the compilation of various types of maps, geoinformation systems, computerization of processes, the use of various probes to collect information. There is a transition to machine learning in various software systems [4].

The development of a huge number of technical capabilities creates more and more informational prerequisites for working with parameters that characterize the environment. There are new opportunities for working with huge amounts of information. All this leads to the development of software methods to achieve the set goals. They are increasingly trying to turn to the possibilities of artificial intelligence in agriculture. Already, robots are trusted to recognize weeds, identify pests, and make calculations for fertilization. In addition, artificial intelligence can monitor various parameters, for example, soil temperature and humidity, air temperature, and also calculate the amount of precipitation. Information technology is one of the priority areas for the development of science [5]. The computerization of processes leads to a new methodology that allows planning soil processes based on databases of collected materials.

2. Materials and methods

As an example, we propose to consider a method for predicting the granulometric composition of the soil, if the soil-hydrological constants are known. This topic has recently become relevant. More and more attention is paid to the development of a favorable ecological environment. To restore ecosystems, they turn to modeling of bulk soils.

The object of the study was leached chernozem of the forest-steppe zone of the Trans-Urals. The sampling of the study was carried out in 2012 and 2020. For the soil of the study, soil-hydrological constants were found, the values of which are presented in Table 1.

Table 1. Soil-hydrological constants of leached chernozem study area.

	Soil-hydrological constants, %					
Year	MG	VZ	MMV	NV	PT	Porosity
2012	6,60	9,90	17,83	18,51	28,23	51,04
2020	6,93	10,40	18,46	18,71	29,45	51,92

Using the software method developed by the authors, graphs of the main hydrophysical characteristics of the soil were built [9, 10]. And the computer calculated the values of the granulometric components for the studied soil [7, 8].

For the software implementation of modeling, the C ++ language was chosen [11]. The complex is based on the concept of A.D. Voronin, according to which each soil-hydrological constant on the curve of the main hydrophysical characteristic corresponds to a moisture pressure. In addition, the soil hydrological constants are related to the granulometric composition by regression equations [6]. Since pedotransfer functions make it possible to recalculate some indicators into others, they are widely used to calculate the values of soil parameters. To work with such functions, a database containing the main traditional soil characteristics is required.

3. Results

Figures 1 and 2 show the graphs obtained as a result of constructing the main hydrophysical characteristics, as well as the results of calculating the granulometric composition of leached chernozem. The value of the content of fractions of microaggregates is shown in Table 2.

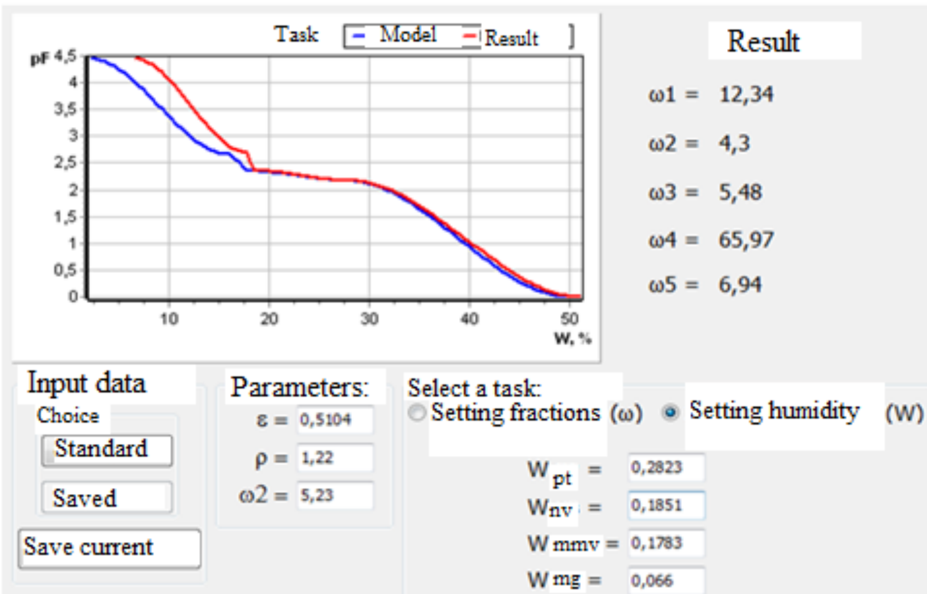

Figure 1. Main hydrophysical characteristics of soils, 2012.

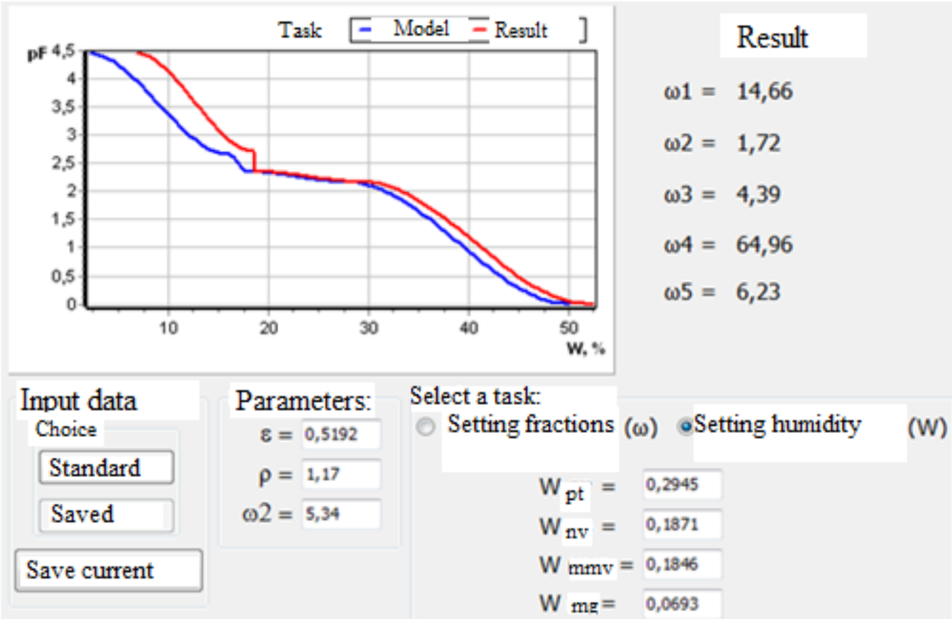

Figure 2. Main hydrophysical characteristics of soils, 2020.

Table 2. Granulometric composition of chernozem of the leached study area, calculated by software.

	Fraction content , %						
Year	1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
2012	6,94	65,97	5,48	4,3	5,23	12,34	21,87
2020	6,23	64,96	4,39	1,72	5,34	14,66	21,72

The analysis of the results obtained shows that the number of aggregates with a size of 0.25-0.05 decreases. Whereas the quantitative content of the fraction 0.005-0.001 and <0.001 increases. In 2012, the content of these fractions was 5.23% and 12.34%, respectively. And in 2020, their content increased to 5.34% and 14.66%, respectively. For 8 years of use of the irrigated area, the range of active moisture decreases from 8.61% to 8.31%. At the same time, the reserves of unproductive moisture increase from 7.93% to 8.06%. Based on this analysis, we can say that the results obtained using the software model do not distort the data of the real situation [12, 14]. The calculated particle size distribution corresponds to the values determined by the traditional pipetting method. Thus, the software model proposed for operation allows, knowing the values of soil-hydrological constants, to predict the granulometric components of artificial soil. Taking into account the needs of different crops in moisture, norms and timing of irrigation, it is possible to predict the number of particles of different mechanical strength, which have different ability to retain moisture [13].

4. Conclusion

The construction of computer-based models is gaining more and more popularity in our time [15, 16]. The results of predicting the dynamics of geosystems solve the issues of plant cultivation, land reclamation, optimization of land use, and many others. The idea of modeling - replacing the object of study with its analogue - is based on a systematic approach to solving problems of nature management. Information models are based on the characteristics of objects in the form of databases. To achieve the best positive result, data should be collected using a uniform methodology [17]. As a rule, there are difficulties associated with the information support of agroecosystems models [18]. For example, assessment of size qualitatively, imperfection of methods and research tools. However, information technology makes it possible to avoid costly and time-consuming field experiments. Therefore, solving problems of writing algorithms and software, building mathematical and physical models based on artificial intelligence becomes a vital necessity.

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