AUTOMATED THEMATIC CONTOURS BORDER REGISTRATION AS AN EXAMPLE OF DIGITAL SOIL MAP FOR NOVOSIBIRSK REGION AND CREATION OF ANALYTICAL INFORMATION RETRIEVAL SYSTEM FOR THE DEVELOPEMENT OF AGRO-INDUSTRIAL CLUSTERS IN SIBERIA

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ABSTRACT

Some questions of research programs in soil science and agrochemistry on the modern stage of developing for information resources and means of analysis are discussed. Automatic way of border registration for thematic contours as an example of digital map of soils in Novosibirsk Region was introduced as a new instrument for catching and analyzing information in GIS, with the next export of gridding data in information retrieval system. Circus method is recommended here to fix researching targets as territories of the same form and fixed size. It is necessary to provide unified approaches to analyse soil spectra and calculate percentages of soil units in structure of soils cover, according to the program of fundamental scientific researches of Russian Academy of Sciences in 2015–2017 years.

INTRODUCTION

Development of agro-industrial clusters in the southern part of Western Siberia in coming years will depend on prompt and effective management of relevant information on the current state of agricultural lands. Relevant data collection concerning the state of Siberian soils was done twice in the recent past: during the activity of Resettlement Department of Russian Empire and during the development of virgin and fallow lands of the USSR (Giprozem service). In the last thirty years Western Siberia soils study mostly had fragmented character and had been performing within the separate researches in Institute of Soil Science and Agrochemistry, Siberian Branch of the Russian Academy of Sciences (ISSA SB RAS), Tomsk State University, and several other scientific and educational institutions, in the absence of national program for soil monitoring in Russian Federation. Cumulative information on the current state of Novosibirsk Region soils was summarized in the map «The soils of Novosibirsk Region» (2007) as well as in the atlas “Natural zonation and recent state of soils in Novosibirsk Region” (2010).

Because of specificity of the information provided by these sources, they can't be directly included in analytical information retrieval systems and taken into account under elaboration of scenarios for economic development of Siberian Federal District. It was necessary to make maps digital, to create additional tools for targeted queries, parametric calculations, etc.

HISTORY

The present research was begun in 2006 on the basis of previously created cartographic materials, and currently its aim is to identify and describe regional regularities of soils distribution with specific agricultural characteristics caused by temperature gradients and hydrological regime features, i.e. by soil-physical processes. The creation of a high-precision digital temperature models (Shergunova et al., 2014), according to the data of 46 meteorological stations in the southern part of West-Siberian Plain for more than 30 years, implemented by software ArcGIS made possible to ascertain the detailed correlation of soils distribution with an average annual temperature of the surface air layer and relief. Just a few years ago such opportunities for solving research issues in the field of soil science and agrochemistry were unavailable. Recently published «National atlas of soils in Russian Federation» (2011) and «Unified state register of soil resources in Russia» (2014) have become an important additional information support.

The research work was started in 2010 by ISSA SB RAS with the aim to create database «Soils in Siberia»; at the modern stage of IT development it can be significantly modified and extended by geographic information (Baykov et al., 2014), taking into account the new possibilities of computer design. Digital soil maps and soil contours, creation of temperature and moisture gradient models in the study area of southern part of Western Siberia allow to detail and quantify the most of local features in soils distribution, previously unknown or defined only in general. This is fundamentally new tool capabilities in the development of soil databases and analytical information systems, as applied to the needs in agricultural sector of business, actively developing in Western Siberia.

TECHNOLOGY

Technologies and standards in the information system “Soil-geographical database of Russia” (Golozubov et al., 2015) should be the subject for careful study and for the subsequent conversion of information fields in Siberian geographical module of the soil data. This should be done during interactive operation, soil scientists can make an important contribution here by finding technological solutions in their research, such as SITES standard (Jacquier et al., 2012).

The need to create compatible formats of regional soil data banks and information retrieval systems with those of the global level, including World Reference Base

(WRB) and FAO database, makes developing of unified approaches to global soil classification especially urgent (Ivanov, 2012).

Cartographic method is widely used in soil science as a way to represent soils distribution and its combinations and complexes as objectively existing, commonly manifested stable structures (Friedland, 1980; Friedland, 1984).

Soil maps are also the basis for agro-industrial evaluation of soil fertility and for development of specific measures for raising the level of their productivity, long-term conservation and more effective usage (Khmelev, Tanasienko, 2009; Khmelev, Tanasienko, 2013).

We propose to get soil geographic information data by circus method, choosing research targets of fixed shape and size (Baykov et al., 2014). This is necessary to ensure the unified approach to the analysis of soil spectra composition and percentage of soil variants in spectrum. This approach allows taking into account temperature and precipitation variation, as there is a strong binding to the cardinal points. Recorder step (radially oriented sensor) can be different: to calculate the percentage of soil variants in forest-steppe zone of Western Siberia it is assumed to be 45 degrees.

To automate the capture of thematic data about soil variants composition and their percentage in soil cover of key (model) territories, original technology of geo-information analysis based on digital soil maps and geo-processing methods was developed, which has no analogues in the world practice. To perform automated capturing of such data and the subsequent generation of thematic tables with the structure of the soil cover the following requirements to the original digital map should be met:

1) Correct spatial binding of soil contours;
2) Full semantic description of all soil variants and its combinations;
3) Topological correctness of soil contours.

Screenshot of digital soil map for Novosibirsk Region is shown in Fig. 1. Yellow targets show circus borders and their centres, located in longitudinal and latitudinal directions.

The algorithm for calculating the composition of soil spectrum of circus and total share of each soil variant consists of the following steps: 1) the selection of model area – research target (in our experiment it is a circus of 20 km in diameter) – by fixing the centre and borders; 2) the determination of number of recorders for thematic contours borders (in our experiment we have eight: zeroth one is directed along the radius from the centre of circus to the north; the other seven are shifted to 45 degrees clockwise each; any other values of the angle rotation of recorder are possible); 3) the construction of buffer zones – bands, where recorders cross with thematic contours of digital soil map along the each radius (Fig. 2); 4) the finding of resulting buffer zones intersections with soil contours, the calculation of parameters of resulting fragments: square and distance from the middle of fragment to the centre point of circus; 5) the sorting of resulting fragments data according to the direction of

the recorder and the distance between the centre of circus and the middle of fragment; 6) the calculation of the total share of soil variant along all recorders.

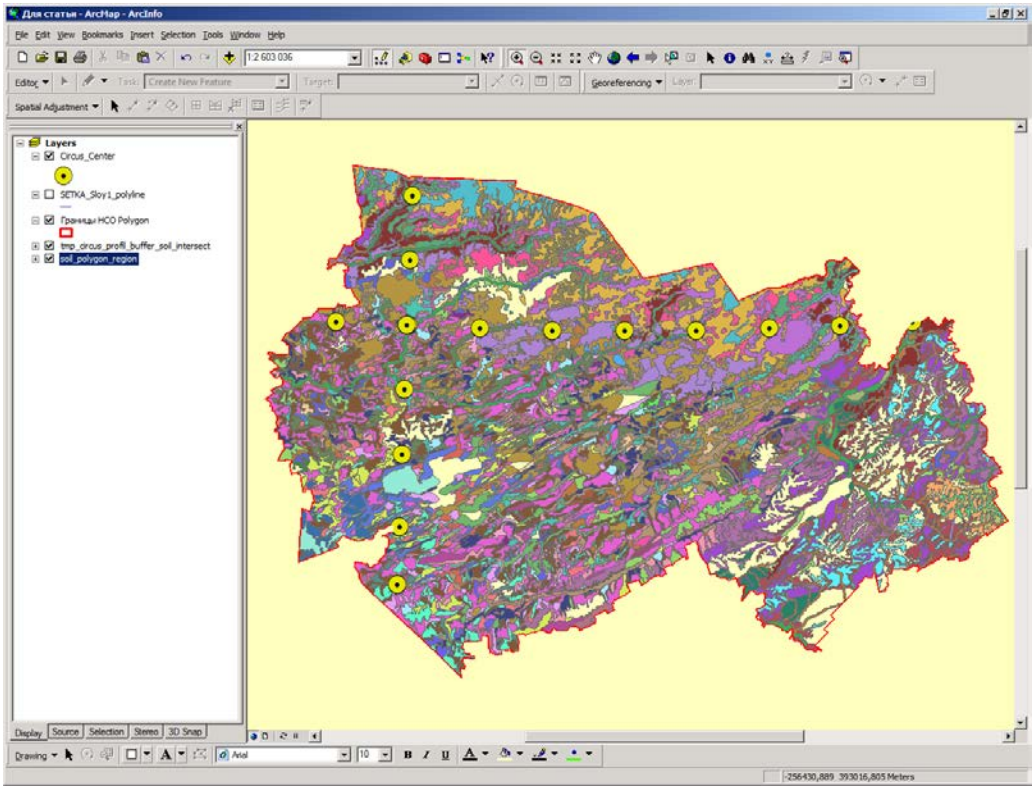

Figure 1: Screenshot of digital soil map for Novosibirsk Region

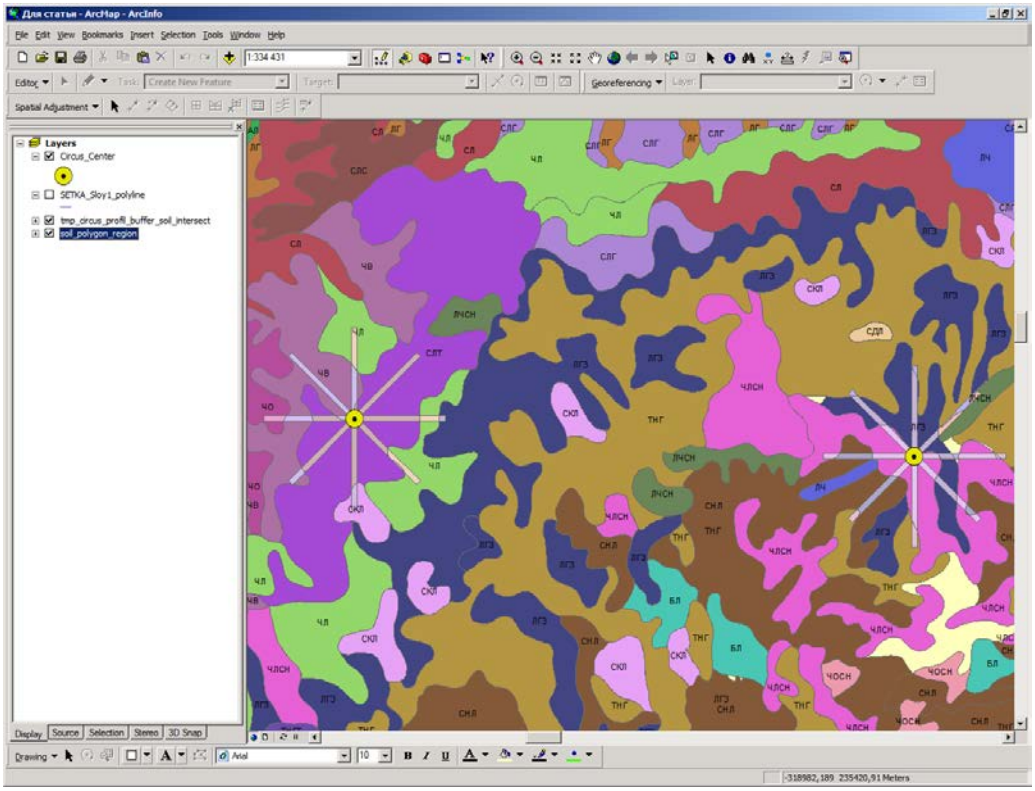

Figure 2: Digital soil map fragment with profiles-recorders

Then summary table is generated for calculated data for every research target, with export function of thematic data in analytical information retrieval system. To automate the calculation of soil spectra, specialized tool for data handling was developed, using built-in ArcGIS tools. Technology process model was created using the interface ModelBuilder, its visualization is shown in Fig. 3. The basis for this model is standard ArcGIS tools; however, a number of key algorithms were implemented using the script language Python.

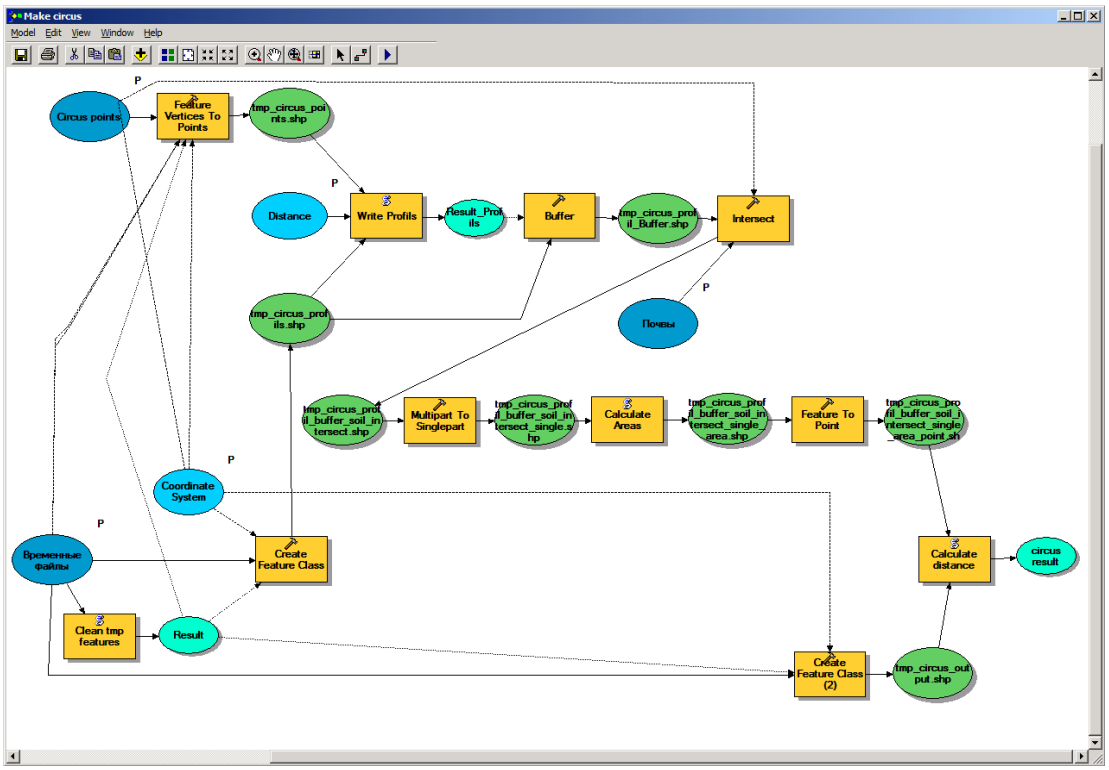

Figure 3: Visualized scheme of automated soils contours border registration and formation of soil spectrum of model area

In ModelBuilder service functional groups of elements are usually denoted by different symbols. Thus, dark blue ovals indicate the elements of input data of the project. In our case it is the initial data of soil contours, coordinates of circus centers and their parameters. Yellow rectangles show operations performed with the usage of input data, for example, the construction of buffer zone, the search of buffer intersection with soil contours, etc. Green ovals show elements of derivative data (intermediate values of operations within the process). Light blue ovals have references to non-geographic data, such as circus diameter.

The accuracy of proposed method will depend on both geographic basis and thematic content. Geographic basis corresponds to the accuracy of common geographic map of scale 1: 1000 000, that in this scale is equal to 400 meters for clear contours (roads, area borders) and 800 meters for fuzzy contours (for example, hydrographical objects). Thematic content of the soil contours is created by the prevailing soil

variant, its correspondence with the real soil combination of soil variants will depend on the topography, hydrological regime, and other factors determining the number of contiguous soil variants generalized in the contour.

FUTURE CHALENGES

To predict the soils behavior as a result of changes in their agricultural usage, it is necessary to create special training sample having a regional binding. To develop a network of agro-industrial clusters, there is a need to combine information on the main consumers of agricultural products, transport routes, and soil fertility. Analytical information retrieval system for soils of the southern part of Western Siberia should become an important tool for optimizing of agribusiness network in Siberia.

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