NATIONAL ACADEMY OF SCIENCES OF BELARUS

UNITED INSTITUTE OF INFORMATICS PROBLEMS

Monitoring Land Cover concerning an agriculture with use of the remote-sensed data

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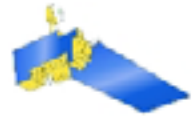
Belorussian Earth Remote Sensing Space System


БКА (Беларусь)
(перспектива)

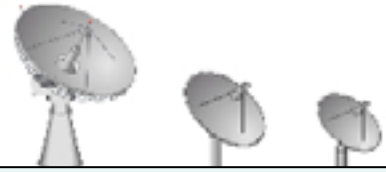

Ресурс-ДК (Россия)
(перспектива)


Монитор-Э (Россия)


NOAA (США)


EOS-Terra (США)

Ground control system



NASB receiving station

Remote sensing
data receiving system

МХЛ
receiving station

Meteocenter
receiving station

RCEOM (Russia)

BERSSS corporative network

BERSSS Planning and control system

Regional space data
receiving point

Subject processing
system

Archives and databases
of remote sensing data

Ministry of
Extreme Situations

Ministry of Nature

Ministry of
Forestry

Ministry of Agricul-
ture and Food

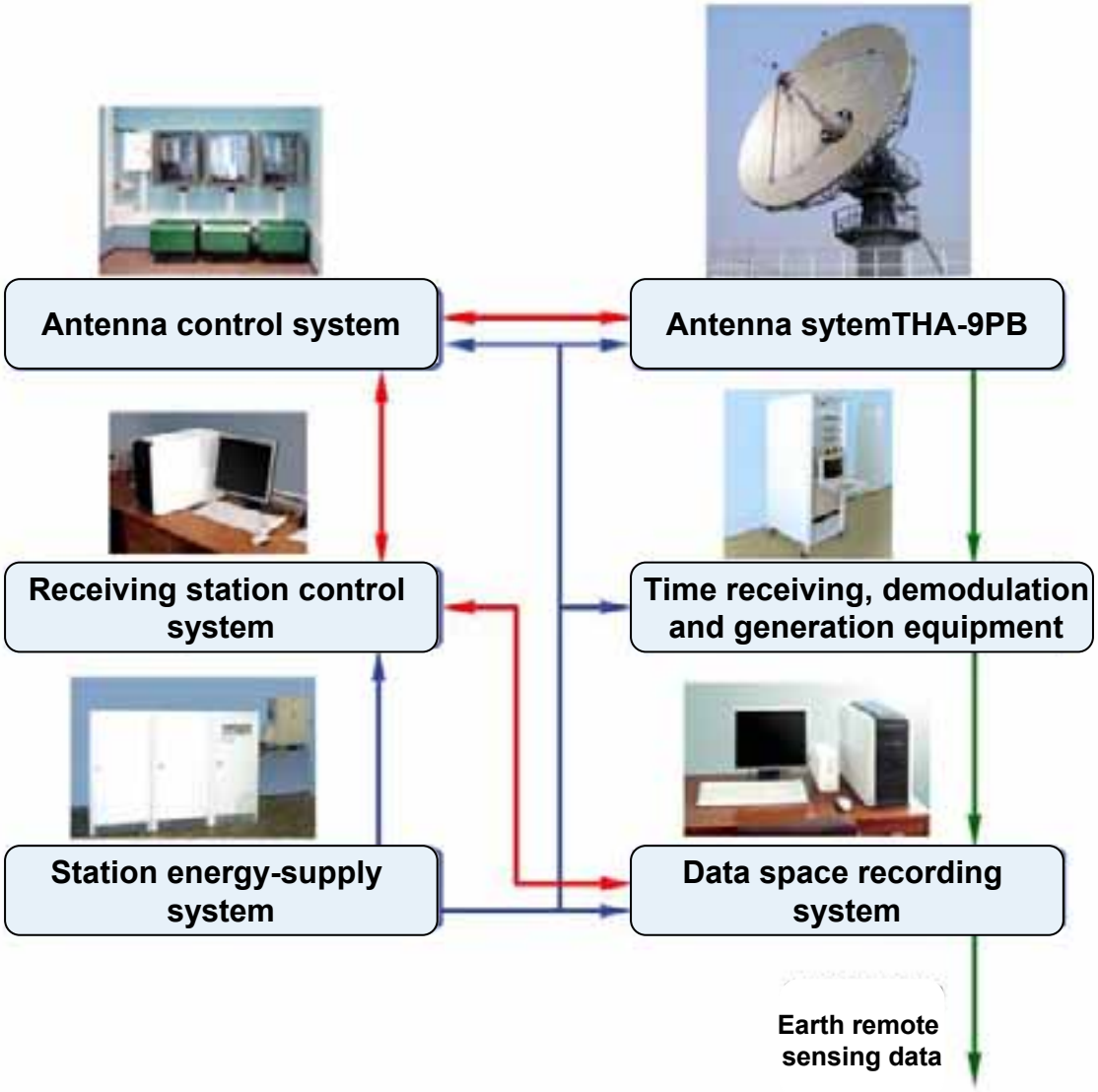
Ministry of
Property

Remote sensing
data consumers

Internet
(consumers)

Belorussian Earth Remote Sensing Space System

Satellite data receiving station



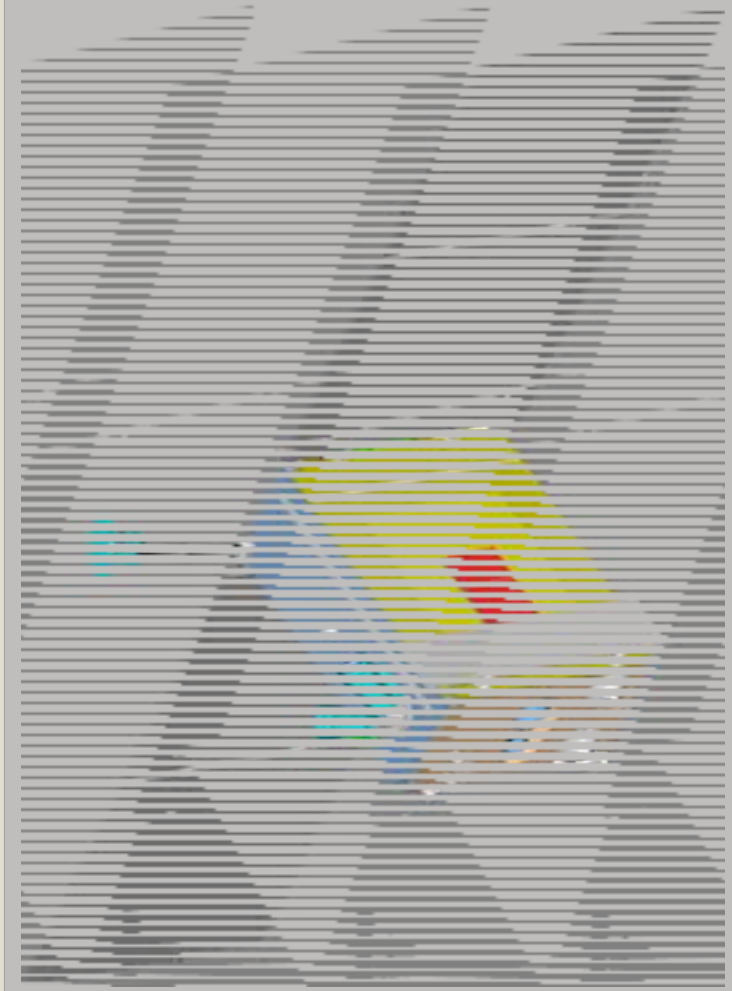
SOLVING TASKS

1. Satellite antenna pointing and monitoring
2. Receiving, multiplication and transformation of radio signal from satellite
3. Demodulation, digital code transformation and registration of space data
4. Received space data preliminary processing and transfer to the BERSSS database

MAIN TECHNICAL CHARACTERISTICS

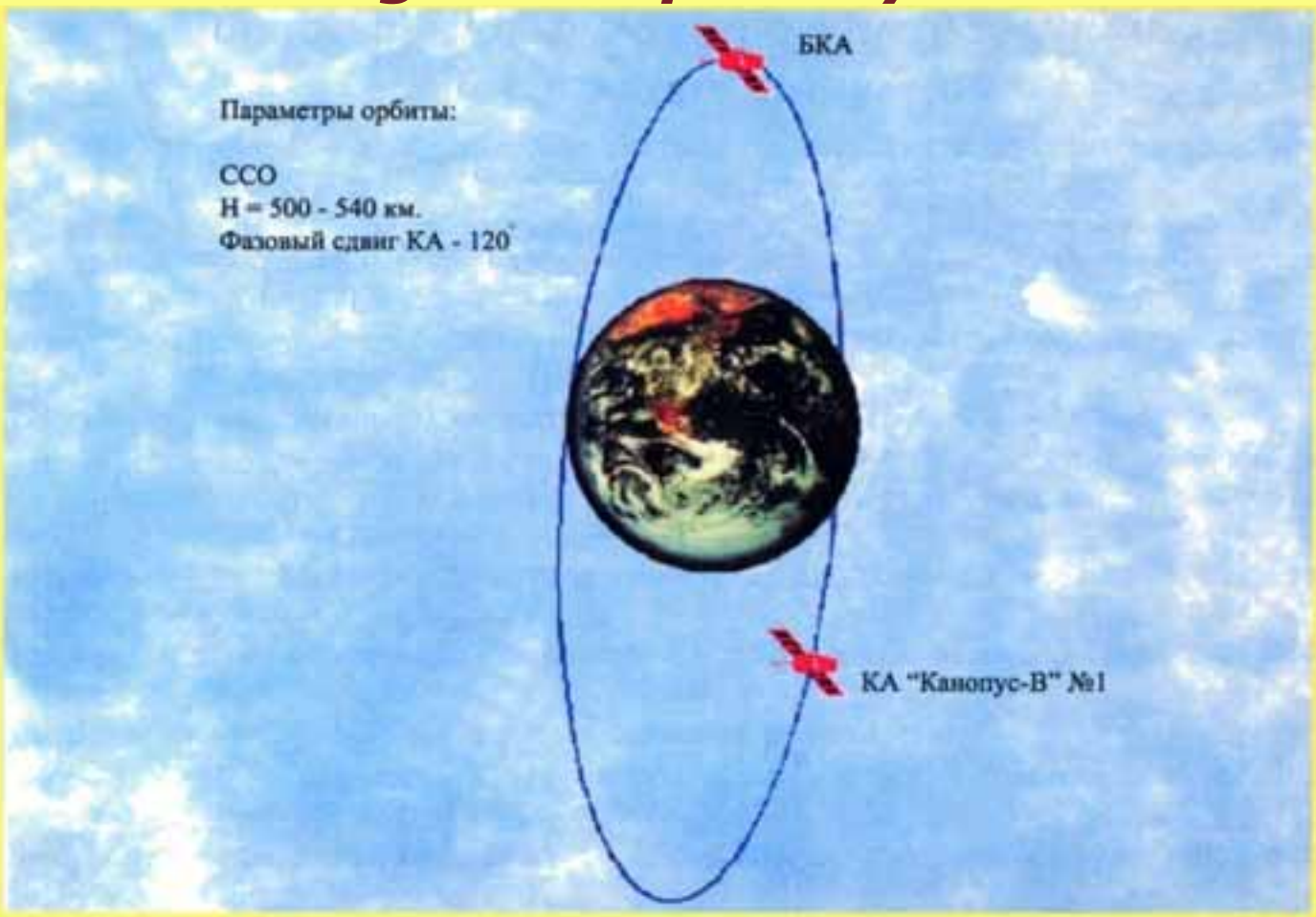
Parabolic mirror antenna system diameter – 9, m
antenna system total weight – 14, t
Operating frequency range – 8,0-8,4 GHz
Spacecraft data receiving rate – up to 245 megabyte/s
Receiving data validity (error probability) – 10^{-6}
Control and antenna pointing methods – program automaintenance, manual

Belorussian satellite main characteristics



- Solar-synchronous orbit raising,km 510 ± 10
- Field of view, km ± 440
- Swath , km 20
- Resolution:
  - panchromatic subsystem, m 2,1
  - Multispectral subsystem, m 10,5
- In-orbit life, years ≥ 5
- Data transfer rate, mbyte/s up to 245,76
- Orientation accuracy, angl. min 5
- Orbital position definition accuracy, m 15

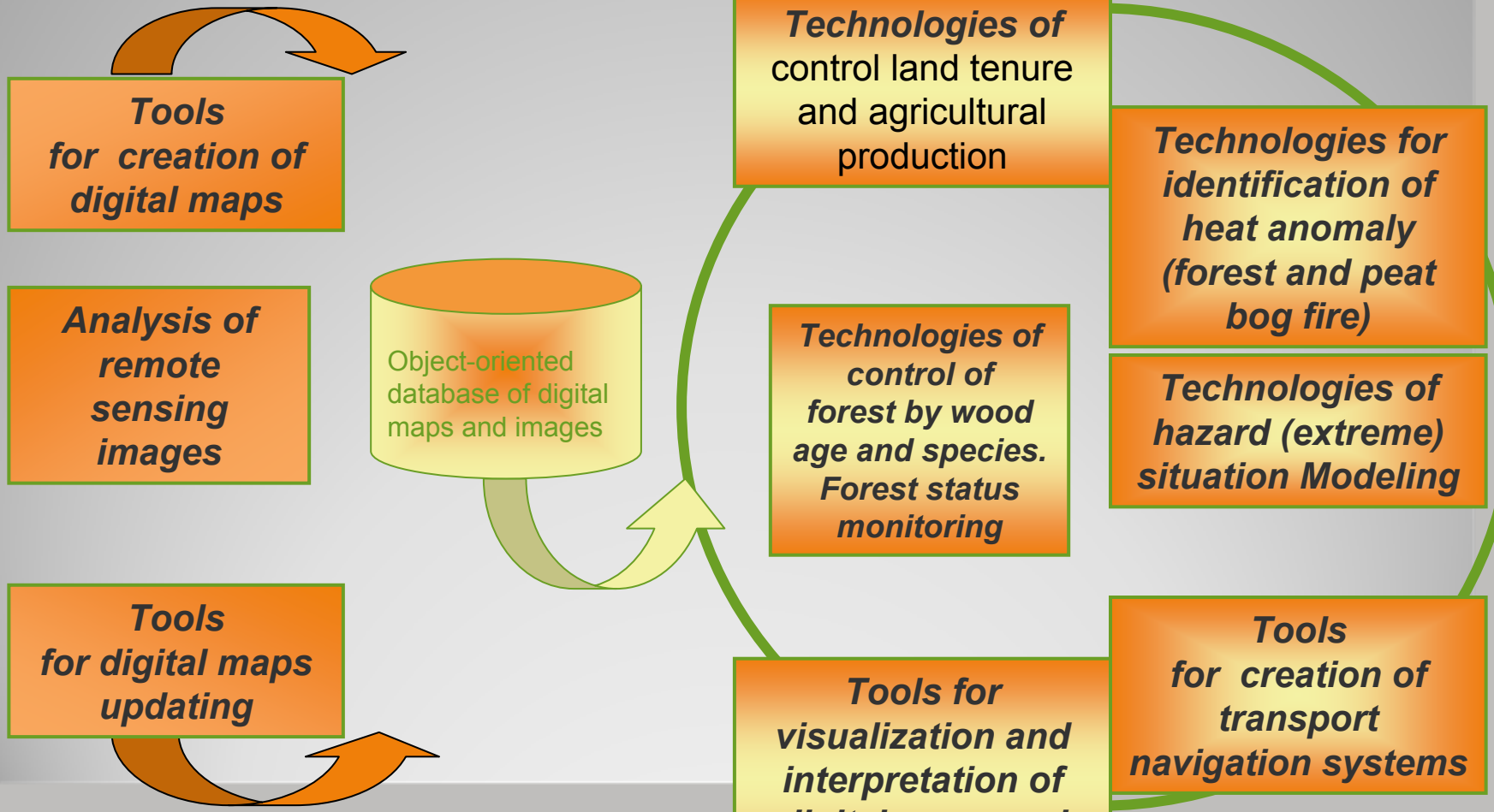
Orbital structure of Russian- Belorussian integrated space system



Fields of application of Belorussian Earth Remote Sensing Space System

- Monitoring land tenure and agricultural production;
- Monitoring natural and renewable natural resources;
- Detection of the areas, perspective mineral resources;
- Monitoring resources and ecologies of a shelf;
- Monitoring extreme situations;
- Updating of topographical maps;
- The ecological control of an environment, etc.
- ……..

Interpretation of remote sensing images and digital maps and their applications

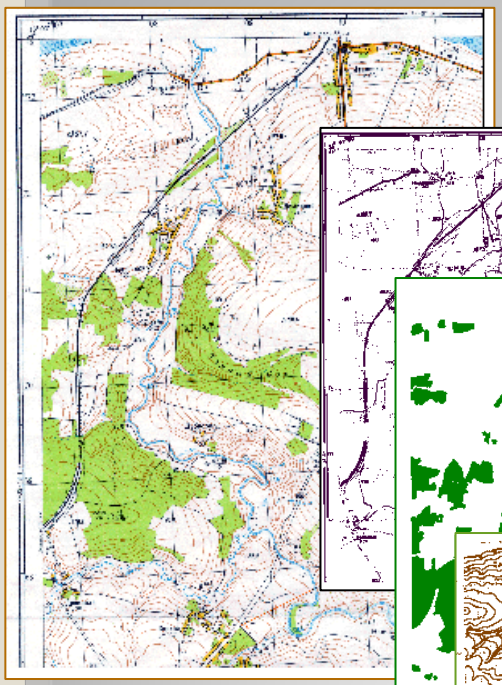


The tools for creation of digital maps

- *manual digitizing;*
- *pre-processing (color separation, transformations, coordinate system, image enhancement and others);*
- *automatic vectorization;*
- *recognition of map objects;*
- *control of geometric and semantic data of objects;*
- *interactive correction of vector elements and their attributes.*

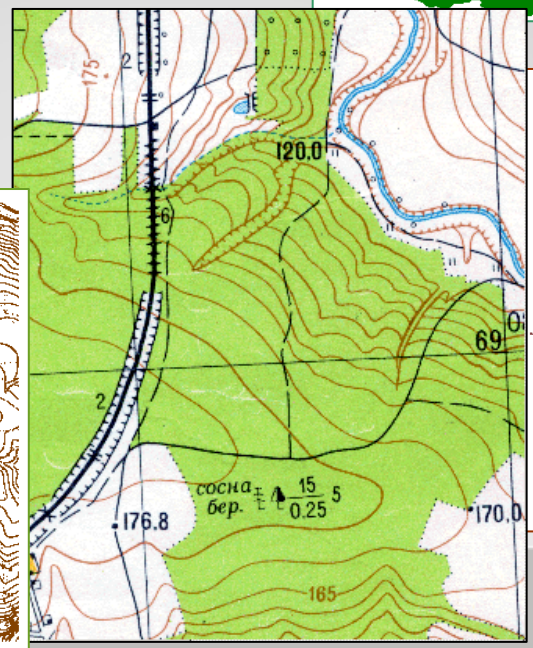
The tools for creation of digital maps

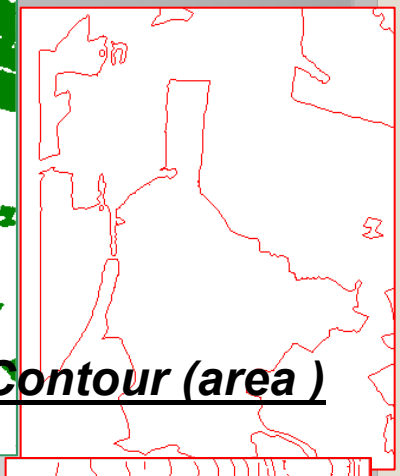
Automatic vectorization



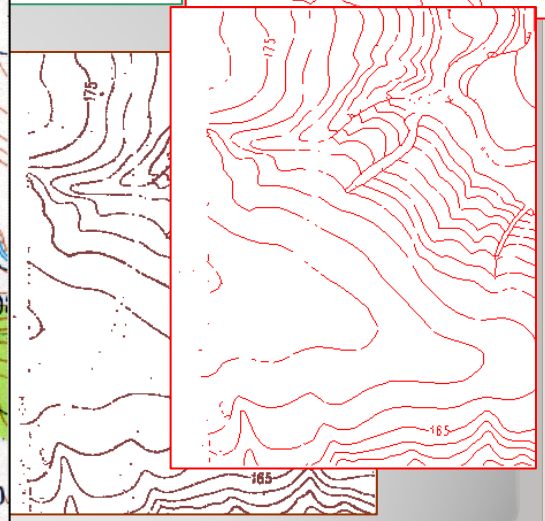
Color raster map

Color separation



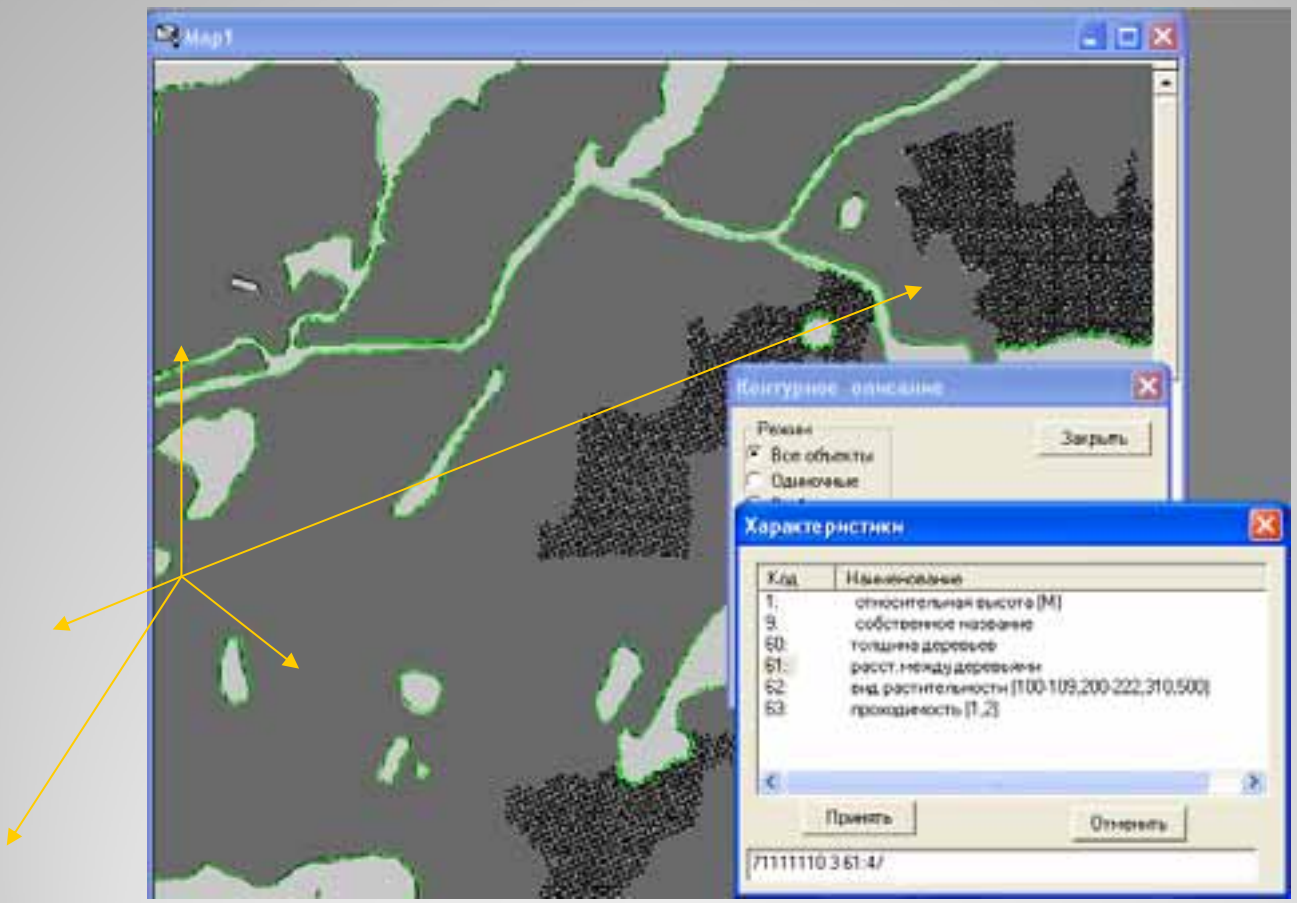


Contour (area)



Line

Recognition of map objects



Objects of forest

Interactive recognition of area objects

Analysis of remote sensing images

- *image enhancement (low and high frequency filtering, contrast enhancement and others);*
- *pre-processing (transformations, image-to-map rectification and others);*
- *thematic information extraction;*
- *image object detection.*

Image object detection

Initial image

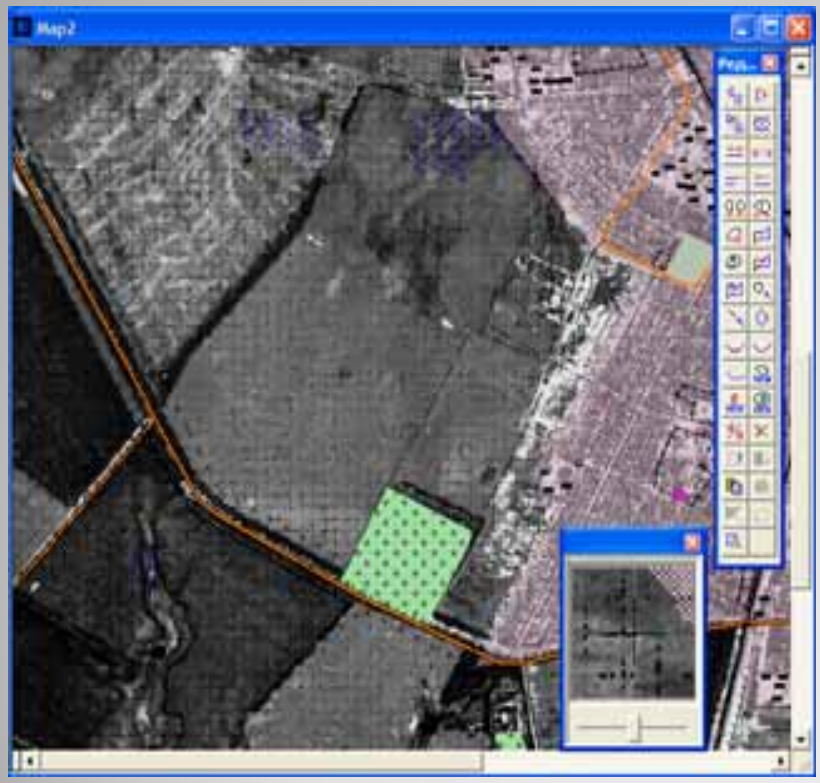
Complex objects detection

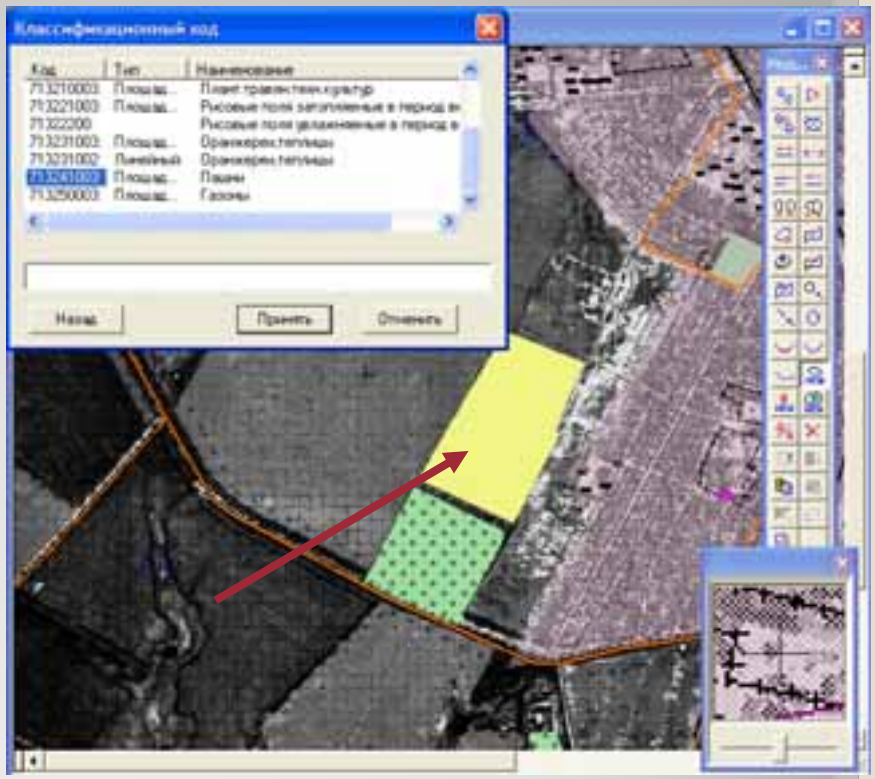
Tools for digital maps updating

Updating digital maps is provided by using the digital satellite images or aerial photos:

- ***pre-processing (noise filtering, segmentation, contrast enhancement and other);***
- ***image/map projection management (picture coordinates transformation into digital map coordinates);***
- ***linear and contour objects detection and vectorization;***
- ***adding new information to the digital map.***

Adding new information to the digital map

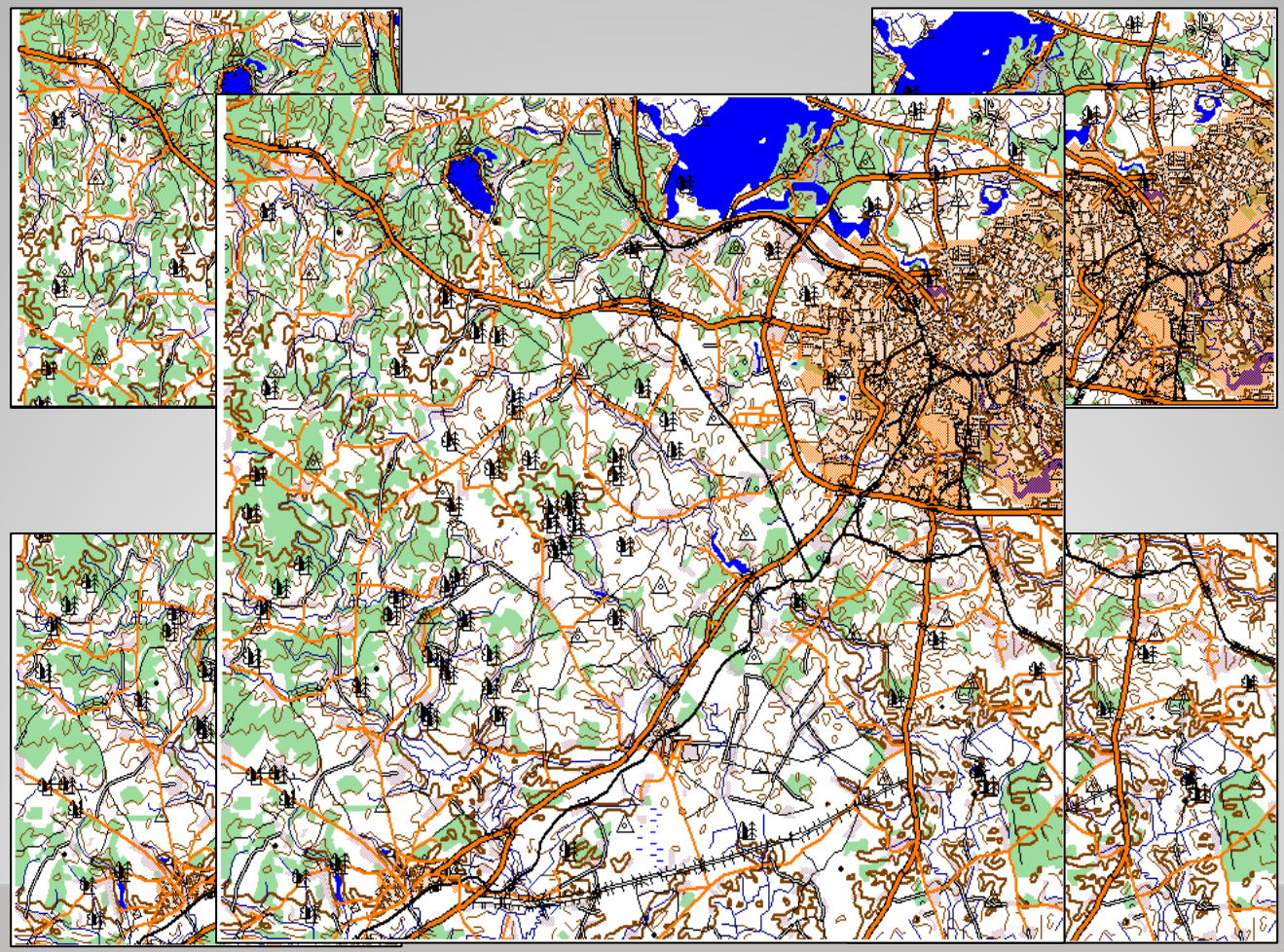




Tools for visualization and interpretation of digital maps and images

- *display geodata (display layers of raster, vector, TIN, raster + vector combination, control the layers with zoom, scroll and other visualization tools);*
- *graphics and using styles (set line color/width, annotate with text, create/edit styles and others);*
- *theme mapping (custom color spreads, symbol/size/color, create theme styles and others);*
- *3D visualization (raster/vector/TIN, 3D visualization);*
- *region analysis (create by element selection, buffer zone regions);*
- *using queries (select elements, text/numeric values, computational operation, table/field selection, measuring and others);*
- *image classification;*
- *importing/exporting geodata;*
- *vector analysis (buffer zones modeling, using of elements by attributes, joining maps, union/intersection and others);*
- *making map layouts.*

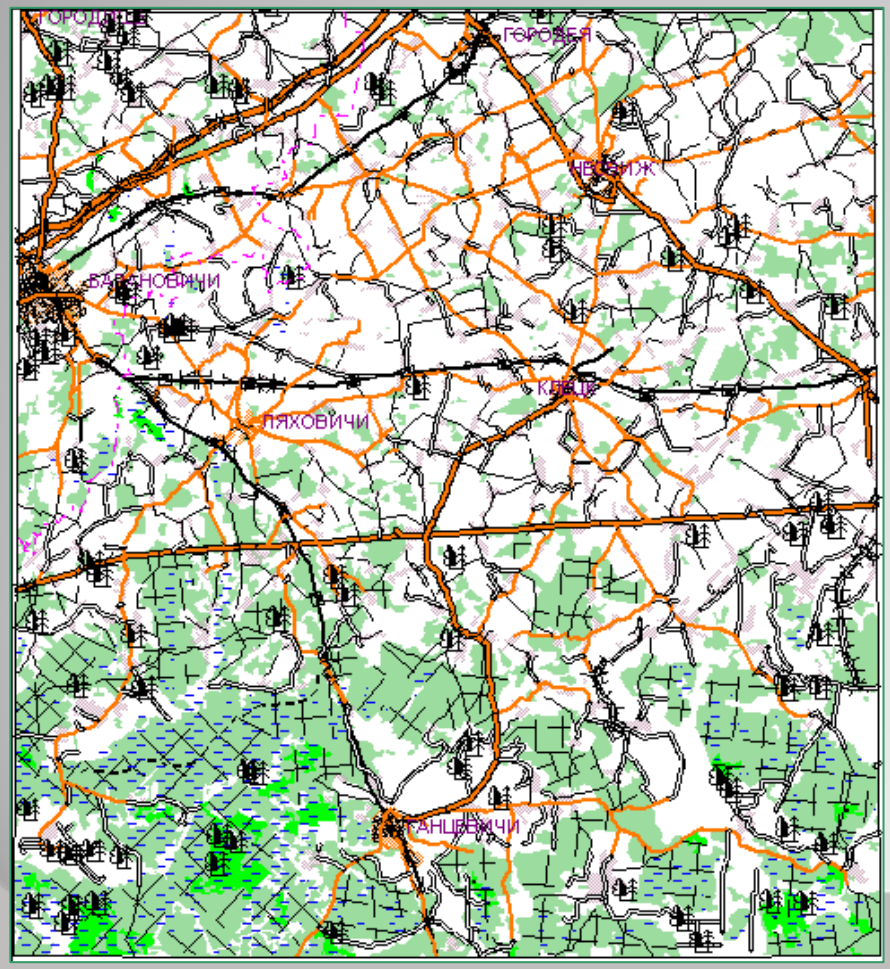
Joining maps

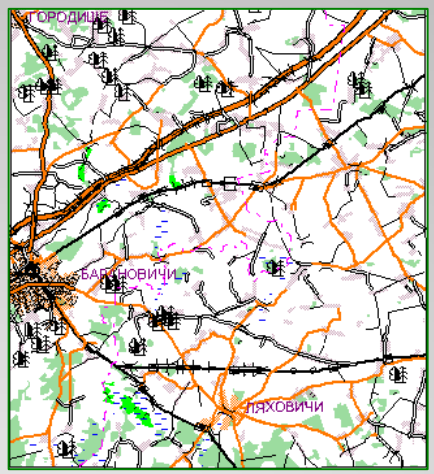


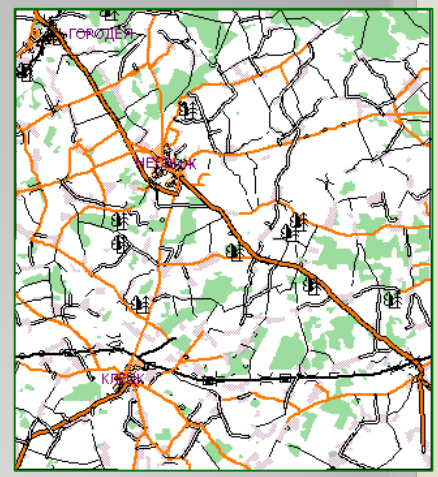
Initial maps

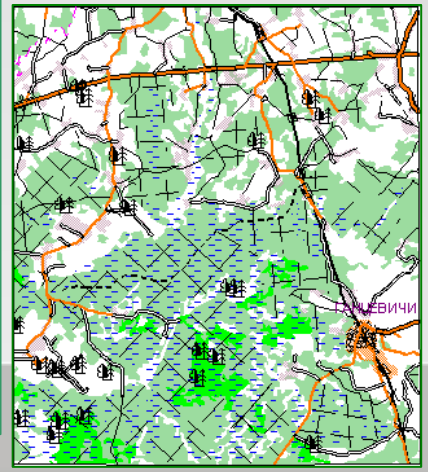
Joined map

Clipping maps









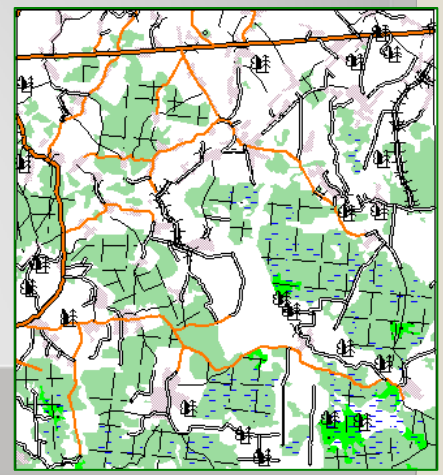
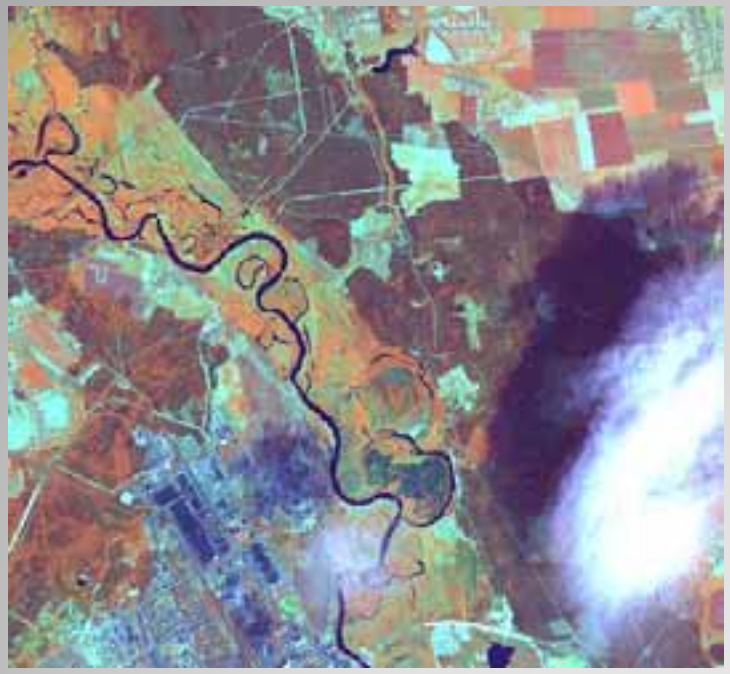
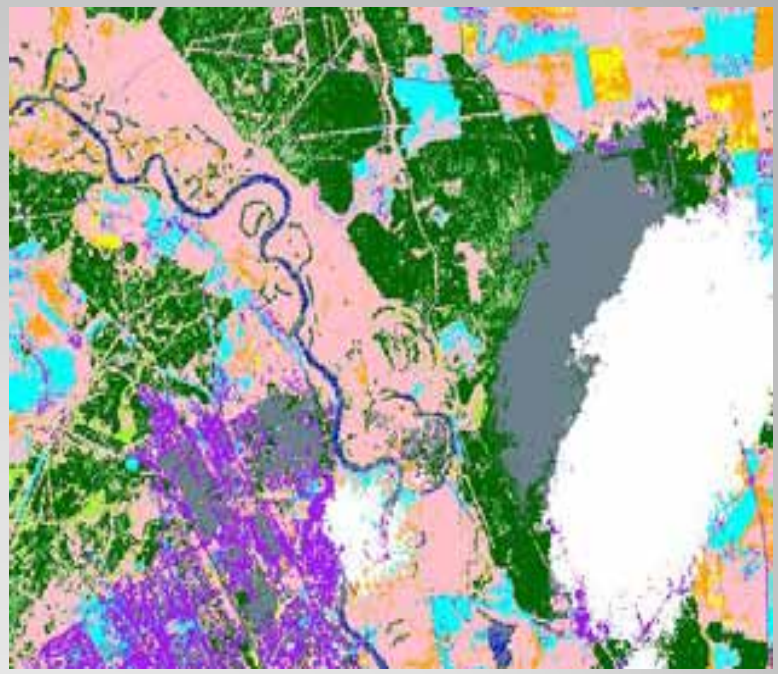


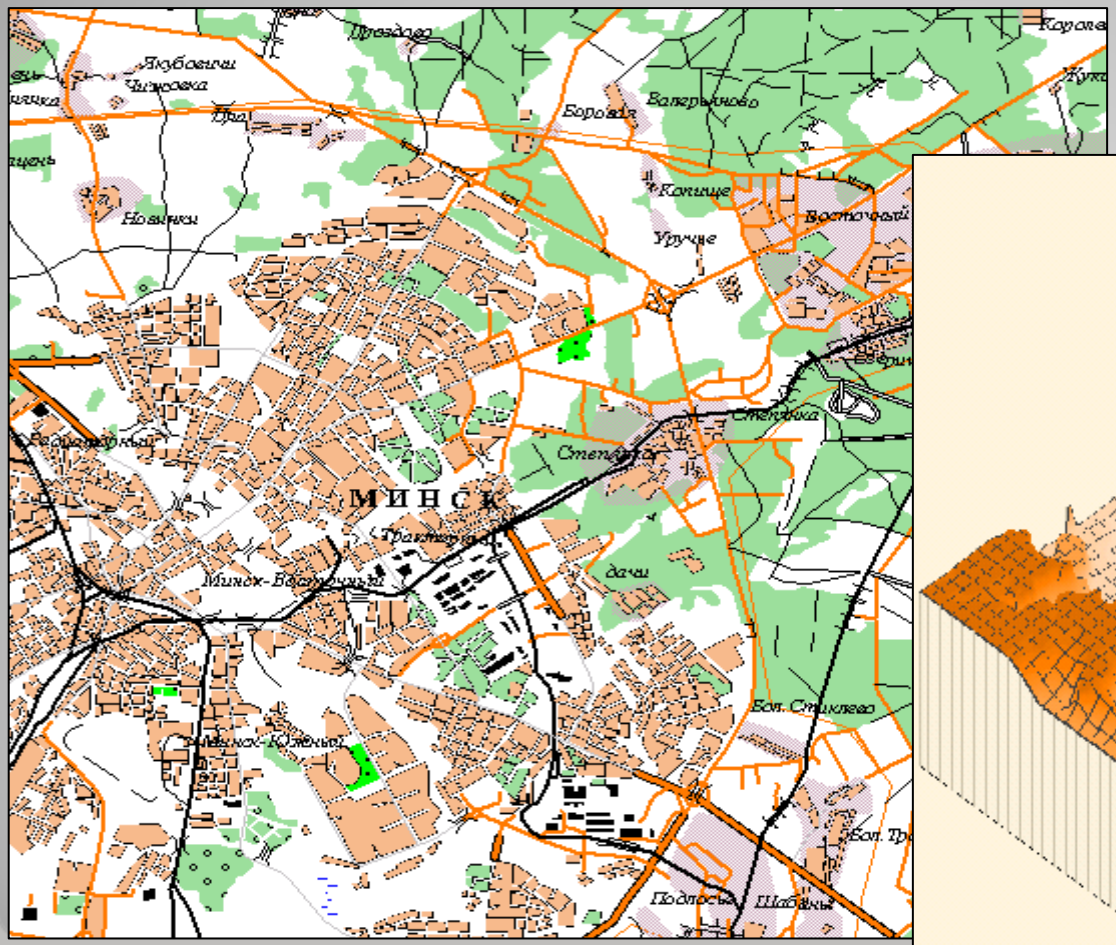
Image classification

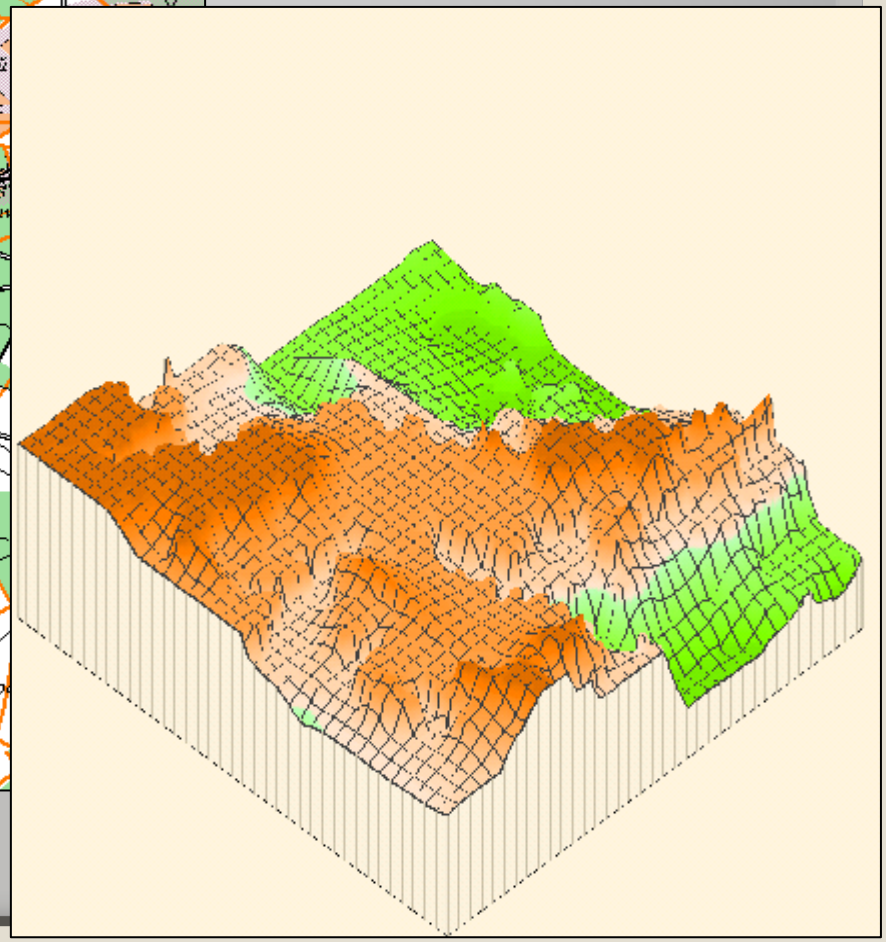




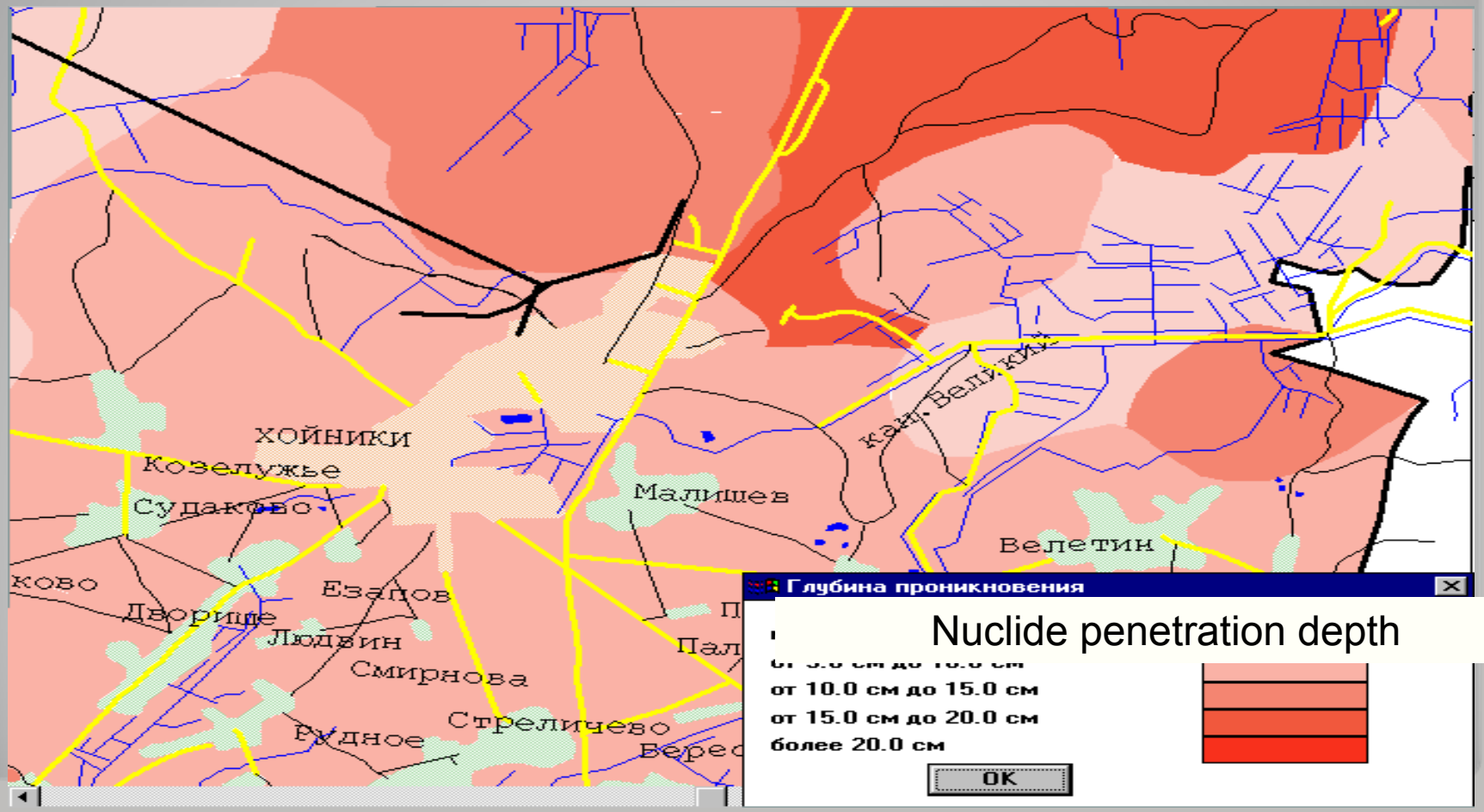
Harversted fields
Summer sowing
Arable lands
River sand
Deciduous forest
Coniferous forest
Clouds
Shadows
Settlement
Water bodies

3D visualization



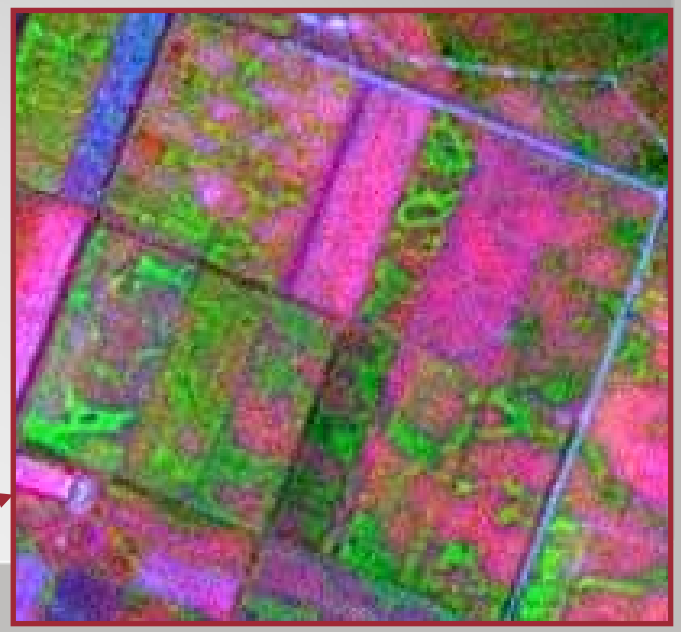


Soil nuclide migration forecasting

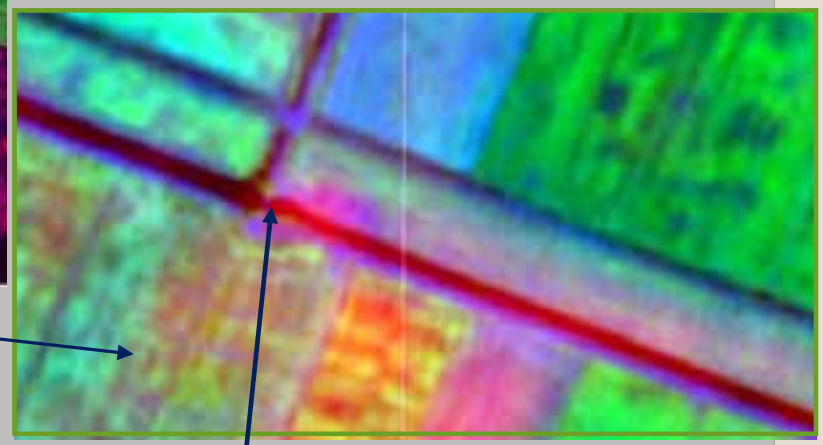


Nuclide penetration depth

ESTIMATION OF THE MELIORATIVE SYSTEM STATUS

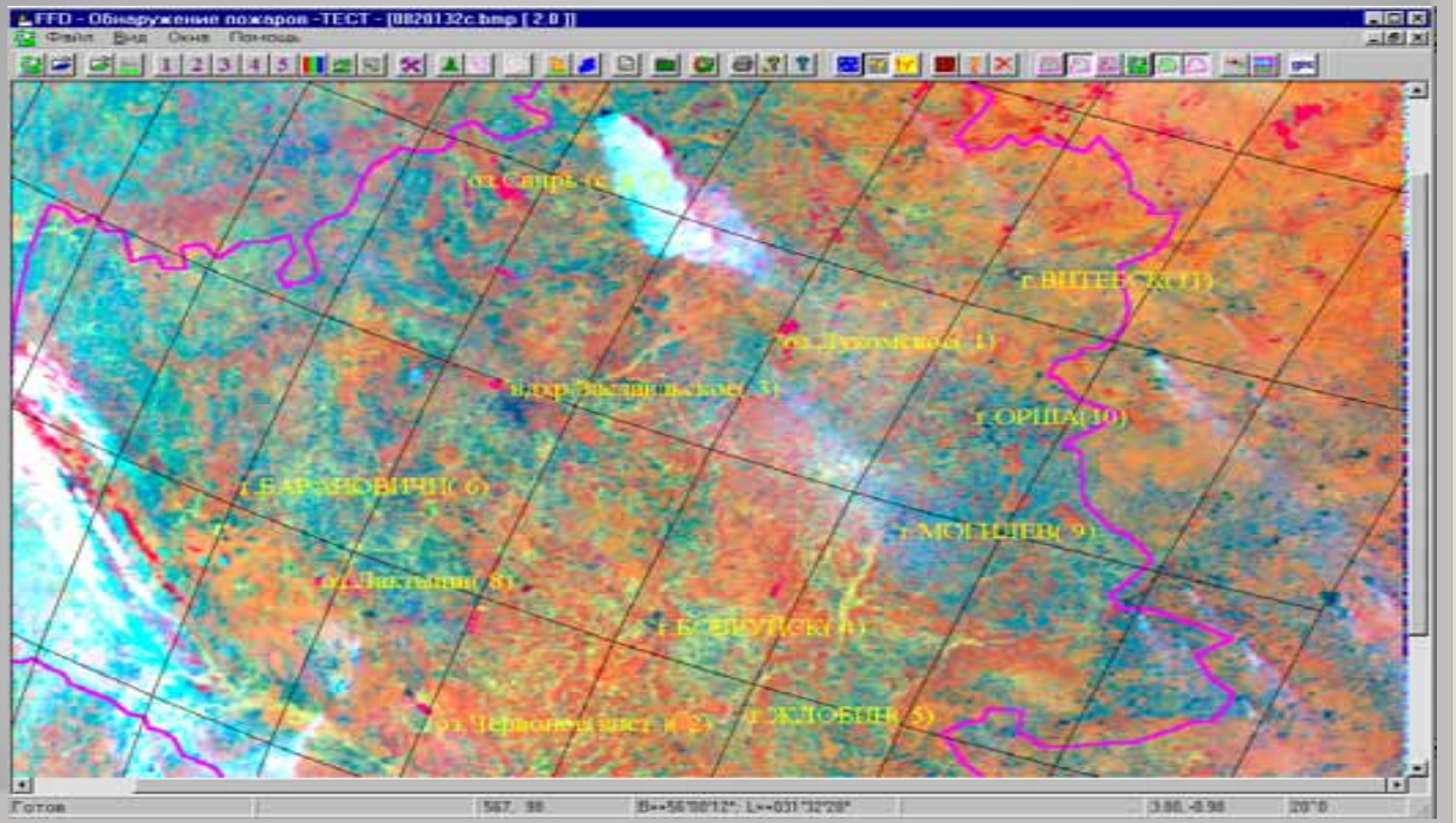


Process of a soil mineralization



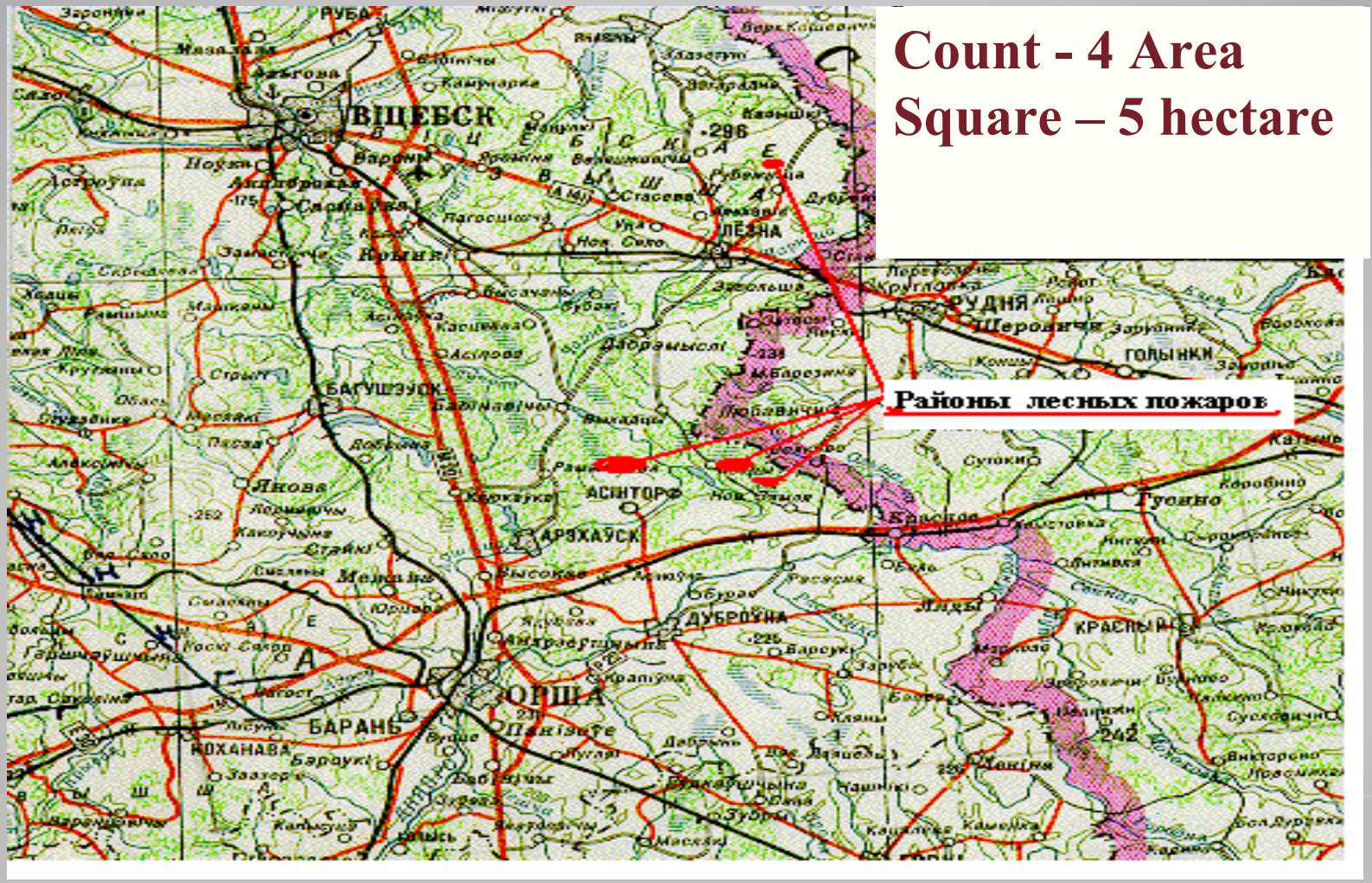
Place of narrow channel

Localization and identification of heat anomaly



images to map rectification

Overlay of heat anomaly into digital maps



USING OF THE SATELLITE INFORMATION FOR AGRICULTURE PROVIDES US

1 Monitoring crop and harvesting:

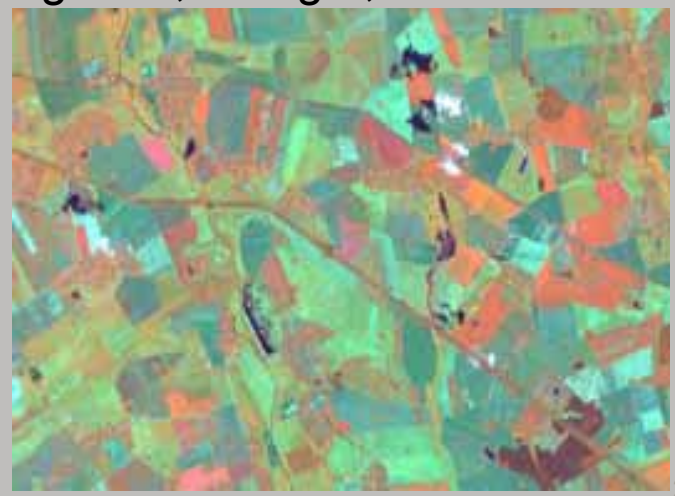
- registration of the agricultural crop areas;
- registration of the harvest.

2 Monitoring of agricultural crops progress:

- state of stage vegetation plants;
- plant diseases;
- mass distribution of harmful plants – weeds;
- estimations of consequences of extreme situations of natural character: large hailstones, strong rain, strong heat, drought, frosts.

3 **Monitoring of illegal conducting agricultural jobs**

4 Technologies of precision farming



Multichannel sensor system (MSS) for soil monitoring

MSS **registers reflectance factors in eight bands of electromagnetic radiation**

Sample plots choice for laboratory analysis

Experiment (sod-podzol bogged soil)

Technology of precision farming

Core elements of a soil monitoring technique using remote sensing data are shown on the Fig.1

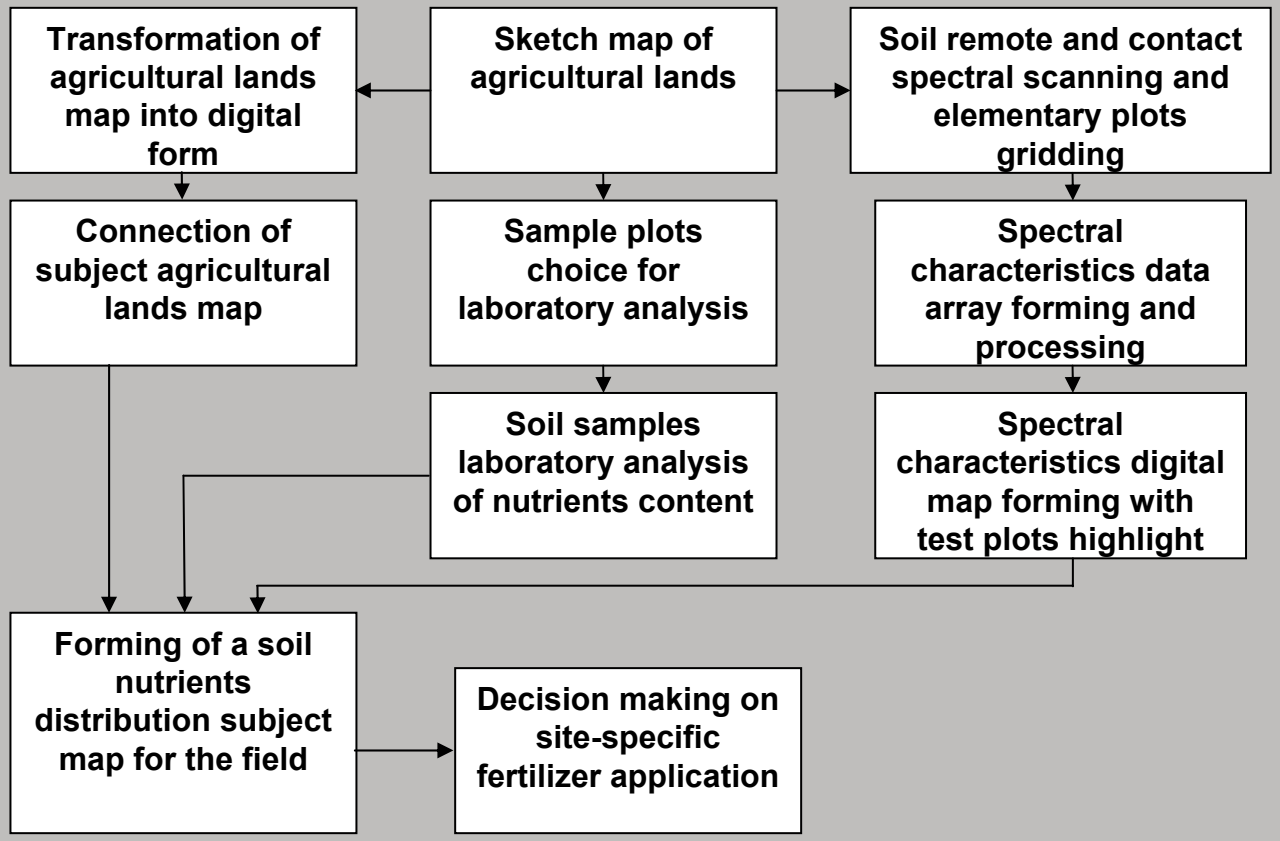


Fig.1 Soil monitoring technique

Technology of precision farming

Components of object of land tenure can be:
Sites with various kinds of natural vegetation;
Agricultural ground different structure and purpose;
Bogs;
Artificial and natural reservoirs, etc.

Sketch map of agricultural lands (scale 1:10000)

Technology of precision farming

Dependency of the reflectance factor on a scanning interval (for a single soil sample) is shown on a fig.2.

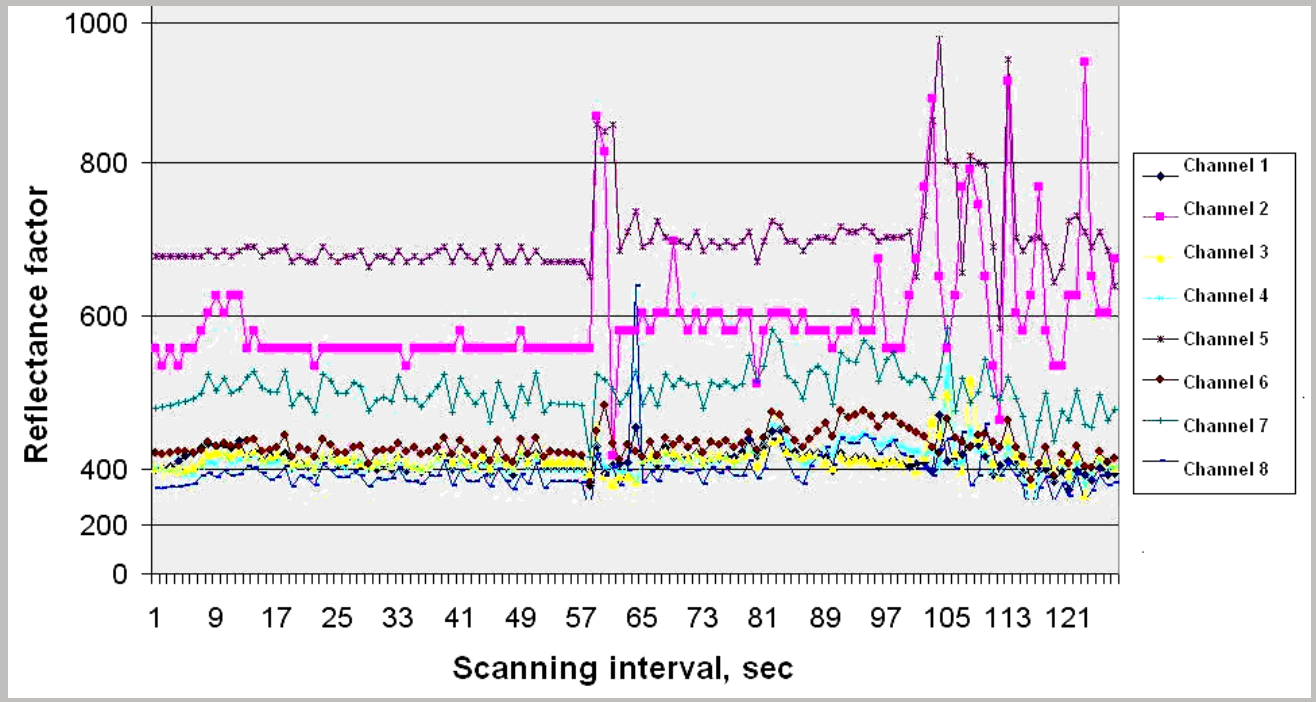


Fig.2 Graph of spectral characteristics distribution for a single soil sample (fragment)

Technology of precision farming

Reflectance factor mean values for every soil sampling point are depicted in a table 1.

Table 1. Values of a soil reflectance factor, organic matters content and moisture

N_o soil sample	Reflectance factor values*								Organic matters content, %	Soil moisture, %
	W	V	B	G	Y	O	IF	R		
1	414	558	414	412	685	436	511	40 37	4,6	18,8
2	393	654	402	399	702	414	474	37 37	6,1	21,4
3**	417	630	414	417	696	414	486	40 40	3,5	10,6
4	436	604	406	412	702	431	515	49 37	0,8	2,8
5**	504	643	431	424	743	490	641	37 37	1,0	2,6
6**	415	632	415	401	695	404	472	37 6	3,2	20,0
7**	406	628	408	410	689	411	463		4,0	19,2

*number of dimension is 10^{-3}, **the most valid data.

Technology of precision farming

Tasks solved by a program complex:

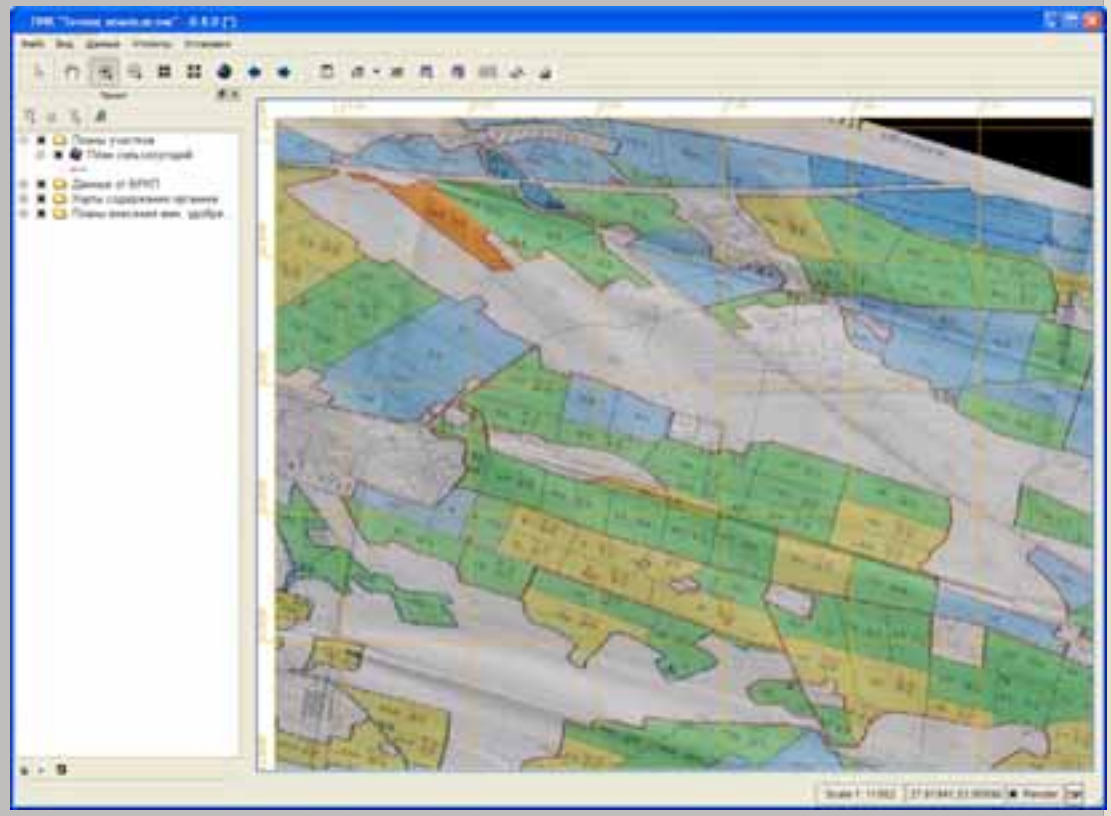
-*Cartographical fixation of raster models of farmland plans*

-*Formation of a multichannel file*

-*Formation of maps of the organic matters*

-*Formation of application rate plans*

- Formation of the task for the dosing apparatus

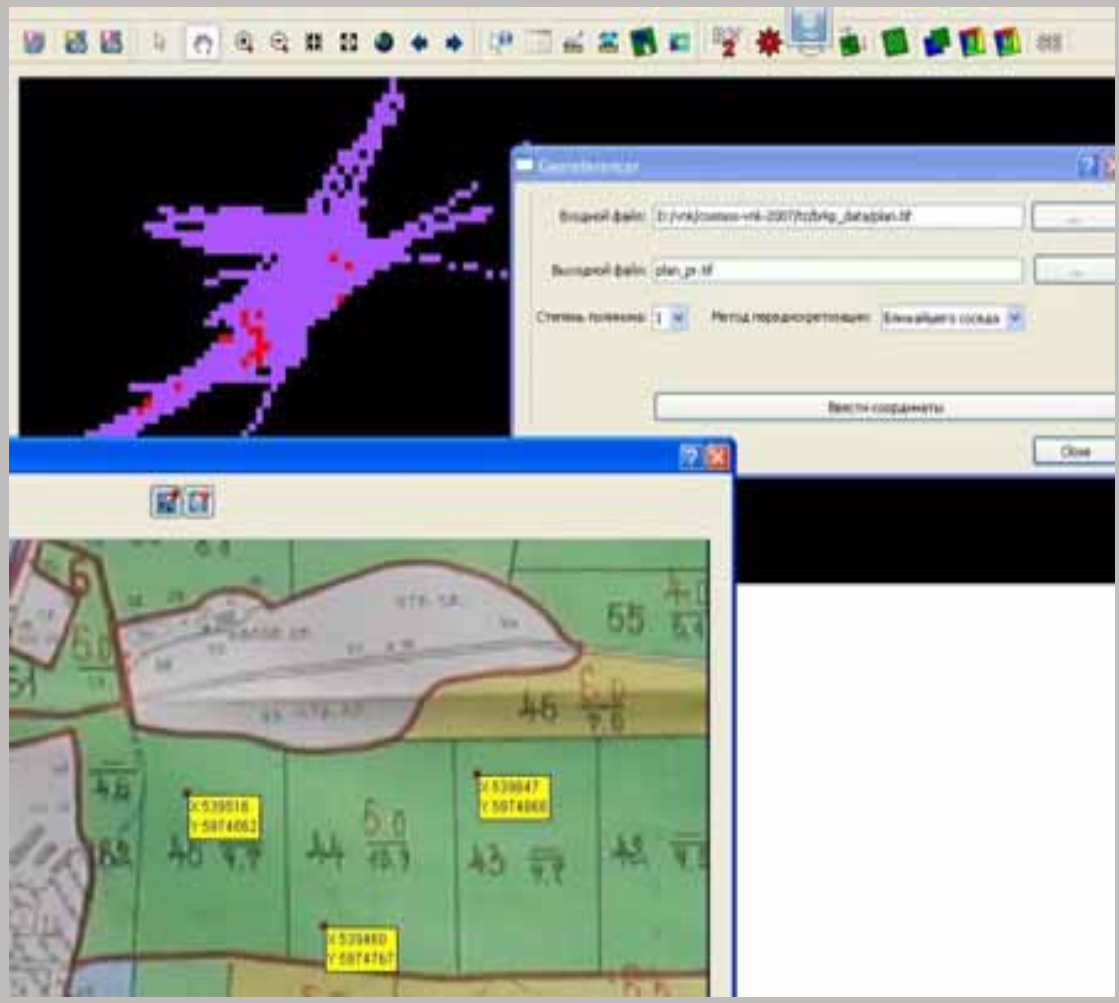


Technology of precision farming

Nf/Nb	Time		Position							Sensor Data							
2/45	10:06:37	19.09.2006	N	53	58.4053'	E	28	7.5924'	413	581	403	405	632	440	545	451
2/45	10:06:38	19.09.2006	N	53	58.4055'	E	28	7.5924'	414	568	416	416	684	441	517	407
2/45	10:06:39	19.09.2006	N	53	58.4058'	E	28	7.5925'	415	568	416	414	690	437	515	405
2/45	10:06:40	19.09.2006	N	53	58.4061'	E	28	7.5926'	414	568	415	413	684	435	513	403
2/46	10:06:41	19.09.2006	N	53	58.4063'	E	28	7.5926'	413	568	415	411	684	434	511	401
2/46	10:06:42	19.09.2006	N	53	58.4065'	E	28	7.5927'	413	568	413	410	684	434	509	400
2/46	10:06:43	19.09.2006	N	53	58.4067'	E	28	7.5926'	413	568	413	410	684	434	508	399
2/46	10:06:44	19.09.2006	N	53	58.4069'	E	28	7.5926'	413	568	412	410	684	435	507	398
2/46	10:06:45	19.09.2006	N	53	58.4071'	E	28	7.5926'	412	568	412	410	690	435	506	397

Data received from multichannel sensor system

Technology of precision farming

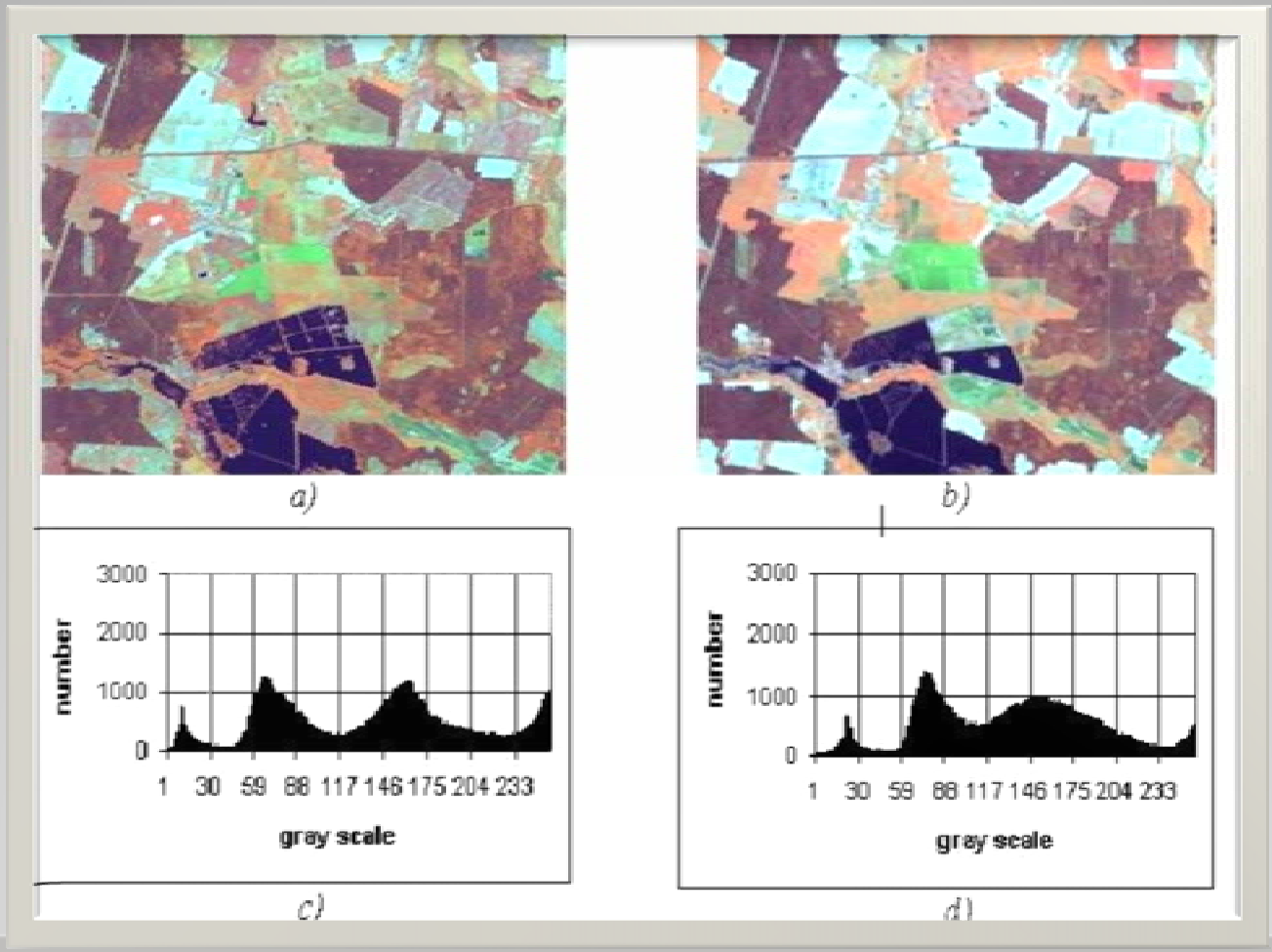


Formation of a thematic map-plan of the organic content which is a basis for formation of the task for the dosing apparatus

Technology of precision farming

Dosing apparatus

TAKING PLACE AT DIFFERENT TIMES SPACE IMAGES OF OBJECT OF LAND TENURE AND THEIR HISTOGRAMS



Images of two photographs of the land areas and their histograms (*a, c* – 1999; *b, d* – 2002)

Mathematical model of the histogram

$$h(I) = \left[N_0 \sum_{k=1}^{N_O} A_k \cdot \frac{S_k}{S_O} \left(\sigma_k \sqrt{2\pi} \right)^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} \left(\frac{I - 255\,\rho_k}{\sigma_k} \right)^2 \right\} \right],$$

where:

$$A_k = 1 / \left[\Phi_0 \left(\frac{255\,(1-\rho_k)}{\sigma_k} \right) + \Phi_0 \left(\frac{255\,\rho_k}{\sigma_k} \right) \right];$$

$$\Phi_0(x) = \frac{1}{\sqrt{2\pi}} \int_0^x e^{-t^2/2}\, dt\ ;$$

S_O is a total size of an area surface;

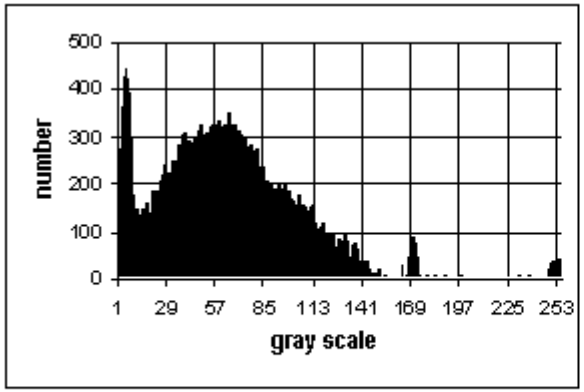
S_k is a size of *k-th* component of the surface area;

N_O is a number of components of the surface area;

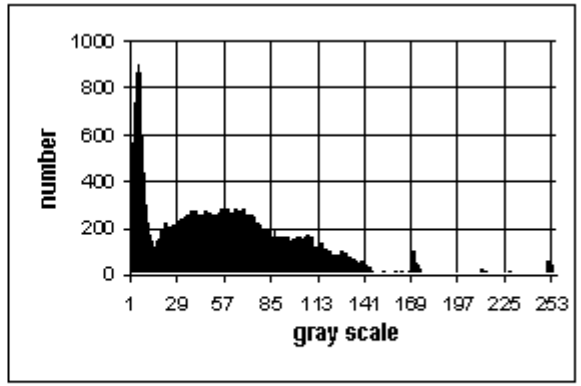
ρ_k is a most probable value of reflection coefficient of *k-th* component of the surface area;

σ_k is mean-square dispersion of brightness of *k-th* component, caused by fluctuations of reflecting properties of the material and by the registration noise.

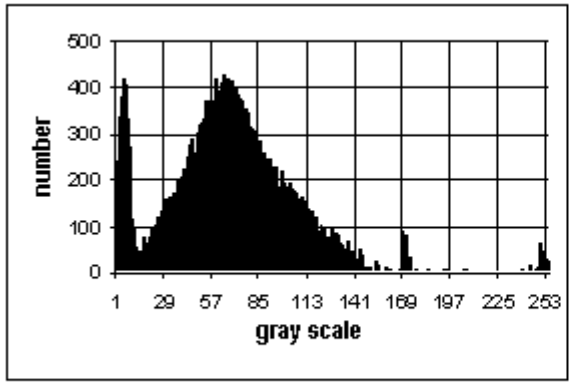
HISTOGRAMS IN ASSESSMENT OF SUBJECT CHANGES OF OBJECTS



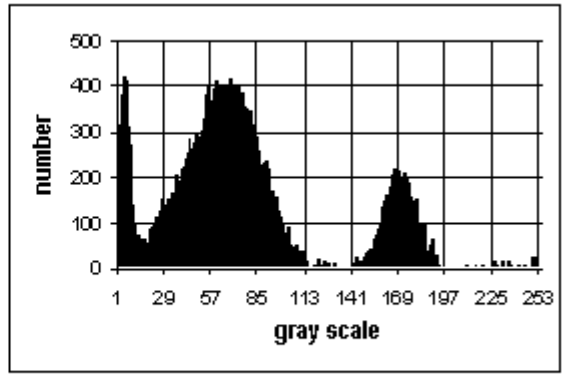
a) Initial condition of object (a roof of constructions 17.5%, trees + bush 24.1%, open sites of sandy ground 50%, shadows of constructions and trees 8.4%)



b) 20% of component surface of the object, corresponding sandy ground ($\rho=0.26$), were covered with water ($\rho=0.015$ with the statistical dispersion $\sigma_\rho = 0.004$)

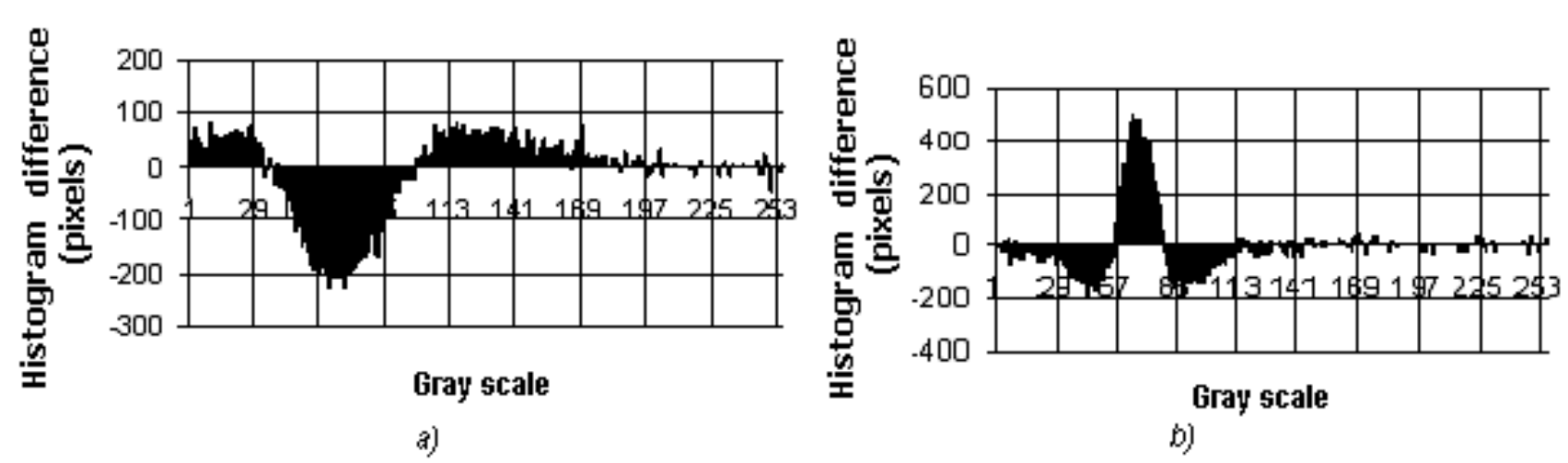


c) Leaves have fallen down from trees and the sandy ground show through



d) Sleet is on a roof of object construction ($\rho = 0.7$ with the statistical dispersion $\sigma_\rho = 0.04$)

MODELLING OF CHANGE COMPONENT REFLECTING PROPERTIES OF OBJECT

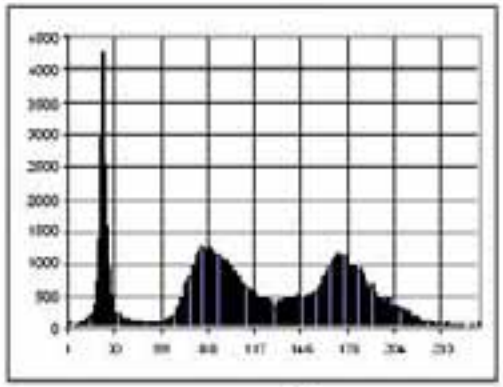


Effect of changes of root-mean-square dispersion of brightness of one component on the difference of initial and changed histogram:
a) brightness dispersion decreasing; (b) brightness dispersion increasing

CHANGE OF OBJECT CONDITION AND THEIR FEATURE DIFFERENCES

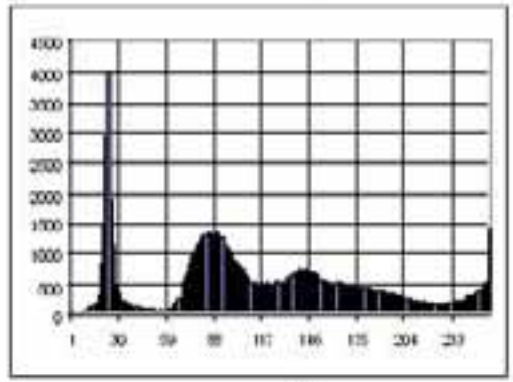
(a)

(b)



(c)

Number of maximums: 3
Ranks of maximums: 123
Ranks of extents of groups: 321



(d)

Number of maximums: 4
Ranks of maximums: 1342
Ranks of extents of groups: 4213

AREAS OF USING OF THE SATELLITE INFORMATION CONCERNING AGRICULTURE

Problems:

- High cost foreign images ;
- Absence of operative in reception images (3 - 14 day);
- Absence the approved techniques monitoring of progress agriculture in RB ;
- Images of Belorussian satellite do not allow to solve a part of tasks concerning agriculture;
- Absence of the prepared staff.

Prospects:

- Images of Belorussian spacecraft will be in 2010;
- Necessary images it will be possible to receive by means of pilotless vehicle;
- Creation perspective the Belarus satellite is planned.

NATIONAL ACADEMY OF SCIENCES OF BELARUS
UNITED INSTITUTE OF INFORMATICS PROBLEMS

Thank you for your attention

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