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USING RADAR REMOTE SENSING DATA TO DECIPHER THE SOIL AND VEGETATION COVER OF LAND TYPES IN BELARUSIAN POLESIE

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The paper presents the results of a study on the use of radar images of the Sentinel-1A system in the thematic interpretation of the types of floodplain lands of the key site «Pripyatsky». His example shows the possibilities of using radar images of various polarizations and synthesis to interpret soils and vegetation. Methodological approaches to using radar images to decipher soils and vegetation, as well as their results, can be applied to mapping the soil and vegetation cover of similar territories.

Keywords: radar survey; Belarusian Polesie; key area; land type; geosystems.

ИСПОЛЬЗОВАНИЯ ДАННЫХ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ РАДИОЛОКАЦИОННОГО ДИАПАЗОНА ПРИ ДЕШИФРИРОВАНИИ ПОЧВЕННО-РАСТИТЕЛЬНОГО ПОКРОВА ТИПОВ ЗЕМЕЛЬ БЕЛОРУССКОГО ПОЛЕСЬЯ

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В работе представлены результаты исследования по использованию радиолокационных снимков системы Sentinel-1A при тематическом дешифрировании типов пойменных земель ключевого участка «Припятский». На его примере показаны возможности использования радиолокационных снимков различных поляризаций и синтеза для дешифрирования почв и растительности. Методические подходы по использованию радиолокационных снимков для дешифрирования почв и растительности, а также их результаты могут быть применены для картографирования почвенно-растительного покрова аналогичных территорий.

Ключевые слова: радиолокационная съемка; Белорусское Полесье; ключевой участок; тип земель; геосистема.

Currently, the fund of remote sensing materials is represented by both optical and radar data. Today, the share of the latter has increased significantly due to the fact that the European Space Agency launched into low-Earth orbit two satellites, Sentinel-1A and Sentinel-1B, equipped with radar equipment.

The materials they received are freely available, which opens up new opportunities for specialists in the field of thematic interpretation and mapping.

Radar photography has a number of distinctive features compared to shooting in the optical range. Firstly, it refers to active types of sensing and allows surveying regardless of the time of day and weather conditions. Secondly, the electromagnetic waves of the radio range used in it have a high penetrating ability, which increases with increasing wavelength, which makes it possible to study the object of interest at the depth required by researchers [1]. Experts have considered the possibility of using radar imaging to study soils and vegetation, however, according to the results of an analysis of literary sources, at the moment this area is not sufficiently developed [2, 3].

The work used a classification of land types, which was compiled on the basis developed by T.A. Romanov structure of the soil cover [4]. The object of the study was the soil and vegetation cover of various types of floodplain lands in Belarusian Polesie.

To study the decipherable characteristics of soils and vegetation using radar survey materials, we used images from the early spring survey season (04/02/2020), obtained in the C-band (wavelength 6 cm), two polarizations - VV and VH, with a spatial resolution of 10 m. As additional Sources of information about the objects under consideration were multispectral satellite images with a spatial resolution of 10 m obtained by the Sentinel-2 and Alos survey systems, a soil map at a scale of 1:50 000 and aerospace standards of soil combinations. Pre-processing of radar images was carried out in the SNAP Desktop software product.

When deciphering remote sensing materials, visual and automated methods were used, and when performing work in the field and office conditions, the key area method was used [5] and aerospace standardization [6].

Types of floodplains are identified by the nature of the prevailing landforms, the characteristics of the soil and vegetation cover, as well as by the image pattern on aerospace images. Subtypes of floodplain lands - high, medium, low - are determined by the distribution of background soil varieties, characterized by a certain degree of moisture. The high level is characterized by the predominance of floodplain gleyed soils at the bottom and temporarily excessively moistened, the middle - floodplain sod-gley and gley soils, the low - floodplain sod-humus-silty gley and peat-bog soils. Interpretation of land types using materials from aerospace surveys of the optical range is carried out without significant difficulties, and the results obtained are of high quality.

As a result of interpretation of the Alos satellite image, five types and nine subtypes of floodplain lands were identified [7, 8]. Both on it and on the Sentinel-1 radar image the river bed is clearly visible. Pripyat and oxbow lakes in the floodplain. It should be noted that the soil cover of this key area is

represented predominantly by sandy soil-forming rocks and is covered with floodplain meadow vegetation.

The southern part of the river floodplain Pripyat borders on the territory of the first terrace above the floodplain. If on the Alos satellite image its boundary is expressed quite contrastingly, then on radar images it is less expressive, especially with areas of arable land. Arable lands on a VH-polarized radar image are depicted in black and are similar in image to certain types of floodplain. The lands of the first floodplain terrace, covered with woody deciduous and herbaceous vegetation, are well deciphered. In addition, on radar images of VV polarization among arable lands, residential and non-residential buildings of rural settlements are depicted in a very expressive light tone. This image tone is determined by the high intensity of the reflected radio signal from vertically and horizontally oriented buildings of a populated area.

The lands of the riverbed floodplain are stretched along the river bed in the form of a winding narrow strip or a cluster of small contours of various shapes.

On the riverbed banks, floodplain loose sandy soils, undeveloped and gleyed at the bottom, are formed; in hollow-shaped depressions, soddy-gleyic and gleyic soils are formed. Vegetation includes hoary maceweed and willow bush. On VV-polarized radar images, riverbed banks are displayed in a more expressively lighter tone. The nature of the image of riverbed banks is determined both by their relief and the vegetation of willow bushes. Flat sandy ridges with low projective cover of vegetation are depicted in a dark tone, as are inter-ridge depressions, which makes it difficult to determine the boundaries between them. A more complete picture of the texture of the riverine floodplain image is given by a color synthesized radar satellite image, in which this type of floodplain is depicted from light green to red.

The segmented-ridged type of floodplain lands is characterized by a complex topography caused by the alternation of ridges and interridge depressions. In the key area under consideration, the segmented-ridged type of the middle level predominates, the topography of which is represented by flat ridges with floodplain sod-gley and rare temporarily excessively moist soils. Meadow vegetation is dominated by white bentgrass, white bentgrass, northern bedstraw, and large rattlegrass. Projective coverage is 30–40 %. Floodplain sod-gley and silt-humus-gley soils are common in the inter-ridge depressions.

A detailed analysis of the image of this type of land on radar and multispectral images showed that there are significant differences between them. If in an optical range image the tone of the soil image changes depending on the degree of soil moisture and the corresponding associations of meadow vegetation, then in radar images this pattern is not always observed. For example, if on the Alos image sandy soils that are temporarily excessively moistened are depicted in a light gray tone, then on the radar image they are

depicted in dark gray. An exception may be the presence of willow shrubs, which are depicted in a light gray tone. As a result, the image of ridges and interridge depressions occupied by silt-humus-gley soils and depicted in a dark tone is generalized. Therefore, if in the Alos image the segmented ruffed floodplain has a well-defined arcuate pattern, then in the radar image it is weakly expressed.

The central-rugged type of floodplain lands is a relatively leveled territory of complex configuration, indented by oxbow lakes, old rivers and narrow deep depressions, often filled with water, which gives the relief a ragged character and complicates the use of these lands. This type in the key area is predominantly represented by the middle level of floodplain lands, which is characterized by a combination of floodplain sod-gley, gley and silt-gley soils. The grass stand is dominated by lanceolate reed grass, swamp gorychium, goosefoot, and forbs - long-leaved speedwell, mouse pea, etc. The projective cover is 50–65 %. The oxbow-water-glaceria association is confined to oxbow lakes and deep inter-ridge depressions. Such a projective cover of meadow vegetation is a significant screen for the soil, due to which the reflected scattered radio signal contains information mainly about the vegetation cover. The VH-polarization radar image reveals narrow winding (less often crescent-shaped dark gray) remains of the former riverbed and silted oxbow lakes, filled in some places with water. The general gray tone of this type of land is formed by floodplain soddy gleyic soils. Along the contours of a dark gray tone there are interspersed with a light tone - willow bushes.

The lands of the central floodplain are distributed throughout the entire key area and are characterized by a predominantly leveled topography. Soil cover of the background type with the absolute predominance of one soil (80–90 %) and inclusion spots of another, confined either to relative increases or decreases. The dominant soil is floodplain sod-gley. The vegetation cover is dominated by forb-invisible reed grass associations with inconspicuous reed grass, creeping buttercup, dog bentgrass, marsh bluegrass, mouse pea, marsh marigold, and rough-leaved kulbab. Projective coverage is 80–90 %. This type of floodplain is deciphered most qualitatively on VH-polarized radar images and is depicted in an even dark gray tone. The tone of the image is determined by the higher biomass and projective cover of the meadow vegetation association, as well as early spring moisture (04/02/2020).

The lands of the near-terrace floodplain occupy its lower part and are confined to the outskirts bordering the lands of the first above-floodplain terrace. The soil cover is dominated by floodplain sod-humus-gley soils, the surface of which is covered with water for a considerable time; small-area macroelevations with floodplain sod-humus-gley soils are also found. The meadow vegetation is dominated by sedge associations. Projective coverage is

80–90 %. On VH-polarized radar images, as well as on a synthesized image, this type of land is depicted in a black tone, and only elevations with sod-gley soils are depicted in a gray tone. To a large extent, the tone of the image of these lands is determined by their swampiness. It should be noted that an important feature of this type of land is that the sections of the boundaries with the arable lands of the first floodplain terrace are not actually distinguished and are drawn according to indirect criteria.

The analysis of the visual properties of the original radar images showed that they are characterized by the presence of speckle noise, as well as various brightness and geometric distortions, which makes it difficult to decipher the objects under study. To increase their decipherability, pre-processing of the image is required, as well as the additional use of thematic maps, aerospace images of the optical range and aerospace standards of the objects being deciphered. The main factors that determine the distribution of the tone intensity of the vegetation image on radar images are the height, composition, projective cover of vegetation and the degree of swampiness.

The obtained research results can be used for thematic mapping, as well as for educational purposes.

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