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MODELLING LANDSCAPE CHANGES AND DETECTING LAND COVER TYPES BY MEANS OF REMOTE SENSING DATA AND ILWIS GIS

ИСПОЛЬЗОВАНИЕ ГИС-ТЕХНОЛОГИЙ (ILWIS GIS) И СПУТНИКОВЫХ СНИМКОВ ДЛЯ МОДЕЛИРОВАНИЯ ИЗМЕНЕНИЙ ЛАНДШАФТОВ И ДЕШИФРИРОВАНИЯ ТИПОВ ПОЧВЕННО-РАСТИТЕЛЬНОГО ПОКРОВА

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Abstract. The emphasis of this article is placed on the technical application of the remote sensing tools and methods for studies of vegetation coverage in northern ecosystems. The study area is located in Yamal peninsula, the Russian Federation. Landsat imagery covering study area in 1988, 2001 and 2011 has been analyzed using ILWIS GIS. The image processing was performed using semi-automated method of image interpretation. The remote sensing data classification from ILWIS menu enabled to map vegetation coverage over research area, which helped to identify land cover types and distribution in Yamal. Results show that Landsat TM imagery with 30 m mesh spacing is useful for landscape mapping and the interpretation of the vegetation cover types.

Аннотация. Цель данной работы состоит в технической апробации данных дистанционного зондирования Земли (спутниковые снимки Ландсат) для картографирования почвенно-растительного покрова северных экосистем. Область исслtдований – п-ов Ямал, Россия. Космические снимки Ландсат, покрывающие нужный участок территории в 1988, 2001 и 2011 г.г., были классифицированны и проанализированны в ГИС ИЛВИС (ILWIS GIS). Обработка снимков была осуществлена в полуавтоматическом режиме методами ГИС. Встроенный режим обработки и распознавания растровых изображений в ILWIS GIS позволил провести картографирование почвенно-растительного покрова и распространение ландшафтов на п-ве Ямал. Результаты показывают, изменение ландшафтов за исследуемый участок времени. Работа проиллюстрировала успешное применение спутниковых снимков Ландсат с 30-м разрешением для мелкомасштабного ландшафтного ГИС-картографирования.

Keywords: Landsat, remote sensing, supervised classification, modeling
Ключевые слова: Ландсат, спутниковые снимки, классификация, моделирование

The research area is geographically located on the western part of Yamal Peninsula, Western Siberia, Russia. The physical-geographical setting of the research area naturally defines its environmental conditions: the Yamal Peninsula is located on the northern part of the Western Siberia geographic region, which occupies the world's largest high-latitude wetland system and covers totally 900,000 km2 of peatlands [1]. The dominating landscape on Yamal is lowland tundra. In the frame of current research dealing with GIS analysis of land cover and environment of northern ecosystems in Yamal, the Landsat satellite imagery has been classified using ILWIS GIS. The emphasis of this article is placed on the technical application of the remote sensing tools and methods for studies of vegetation coverage in northern ecosystems. The main objective is to detect vegetation distribution and changes over the area of Yamal by identification of plant and vegetation types in their correlation with pixel digital numbers (DNs), i.e. value of spectral reflectance.

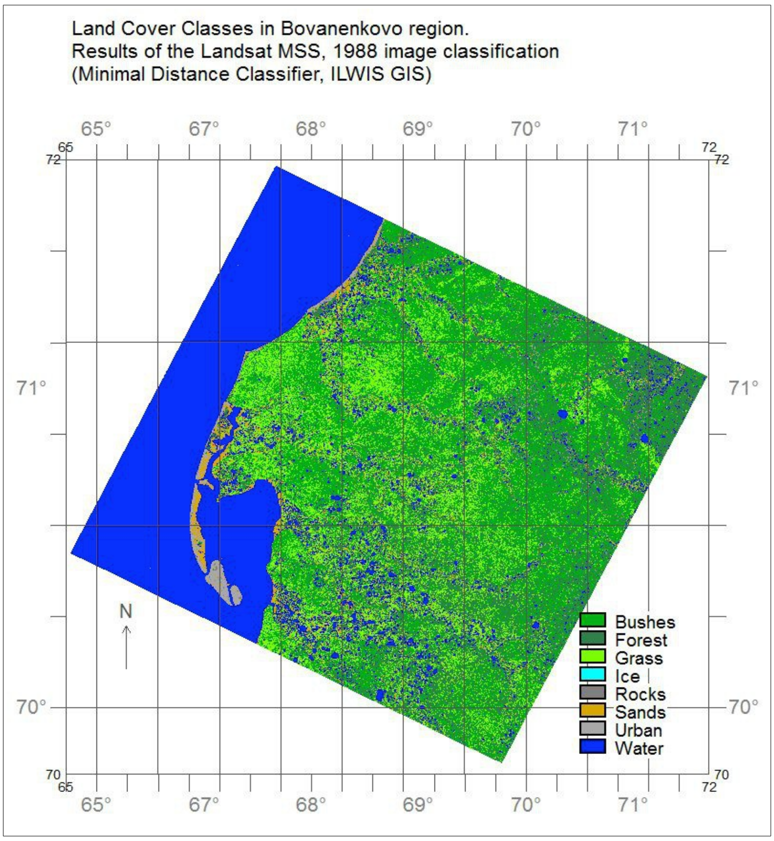


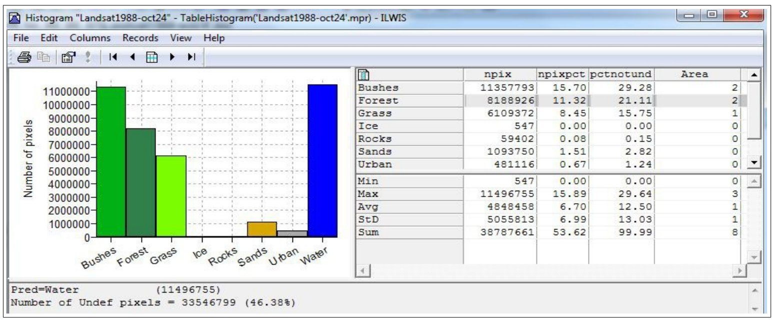
Figure 1. Land Cover Classes: year 1988 (Landsat TM)

Changes in vegetation distribution in northern ecosystems are caused by various reasons, such as climate and environmental changes, plant phenology and growing season, which has direct impact on the chlorophyll content in leaves. Satellite imagery is indispensable in this case for monitoring vegetation changes, as it provides accurate and low-cost source of data and enables recurrent remote sensing observations. Land cover monitoring highlights the dynamic of changes in vegetation coverage, types and spatial distribution.

Methods

Using remote sensing data, such as Landsat scenes, for detecting changes in vegetation types has great potential for environmental land cover mapping [2]. Manipulation with certain multispectral channels enables to calculate vegetation indices, e.g. LAI, calculation of biomass, etc.

Table 1. Histogram for supervised classification of Landsat TM image, 1988.



	npix	npixpct	pctnotund	Area
Bushes	11357793	15.70	29.28	2
Forest	8188926	11.32	21.11	2
Grass	6109372	8.45	15.75	1
Ice	547	0.00	0.00	0
Rocks	59402	0.08	0.15	0
Sands	1093750	1.51	2.82	0
Urban	481116	0.67	1.24	0
Min	547	0.00	0.00	0
Max	11496755	15.89	29.64	3
Avg	4848458	6.70	12.50	1
StD	5055813	6.99	13.03	1
Sum	38787661	53.62	99.99	8

Pred=Water (11496755)
Number of Undef pixels = 33546799 (46.38%)

Visualization of the result raster images facilitates detection of changes in vegetation coverage. Methods of Landsat scenes interpretation include data preprocessing, supervised classification, orthorectification, image correction, and raster data processing. Due to the popularity of Landsat data, there are numerous successful researches reporting application of Landsat scenes for land cover mapping in general, and for northern Polar environment in particular [3], [4], [5], [6], [7], [8], [9]. Following working steps summarize research scheme used in this research: 1) data pre-processing, 2) creation of image composites of several bands, 3) supervised classification using various classifiers 4) performing spatial analysis and interpretation of the results, 5) time series analysis for detecting changes, 6) final GIS mapping. The research data included Landsat scenes, received from the open source USGS (the U.S. Geological Survey) taken in 23-year time span, from 1988 until 2011. Complete Landsat data pre-processing usually includes image resampling, radiometric normalization and quality assessment [10]. In the scope of the current research, these steps were limited to image resampling, supervised classification and mapping. The principle of Minimum Distance method used for classification is based on the calculating of the shortest straight-line distance in Euclidian coordinate system from each pixel's DN to the pattern pixels of land cover classes. The main weakness of the supervised classification method is caused by modeling approach and technical details of image recognition, i.e. errors in pixels classification. Thus, the misclassification by the Minimum Distance method may occur due to the ambiguity and erroneous recognition of some of the pixels as well as insufficient representation of classes.

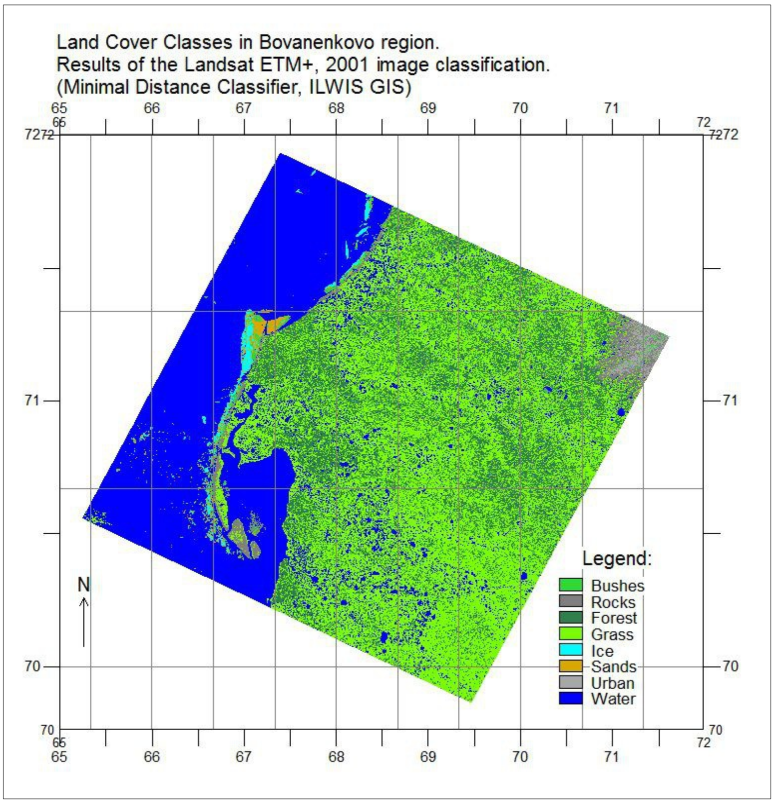


Figure 2. Land Cover Classes: year 2001 (Landsat TM)

Following types of land cover classes were defined on the current scenes: shrub (bushes), grass, forest, urban areas, water, ice (covering selected water areas), rocks and sands. Some few pixels in an upper-right corner in a scene for 2011 did not match to these areas and remained unclassified, as they are covered by a cloud. A lot of classes in the test areas are self-evident, e.g. such as ocean water, sand, shelf areas. However, in practice, more sub-classes for water areas could be distinguished, due to different color shadows of water changing with depth and salinity. The recognition of various vegetation types is more complex. The vegetation types vary in response to the local conditions and differences in regional settings, mostly due to changing geochemical soil content and through different geomorphic and elevation ranges.

Findings

The results show classified maps covering the same geographic region of Bovanenkovo in 1988, 2001 and 2011 years, respectively. The GIS mapping is performed using results of the image classification, based on the relationship between the spectral signatures and object variables, i.e. vegetation types over the research area. The results of the supervised classification show maps of the vegetation distribution. The water areas are defined as “no vegetation” class.

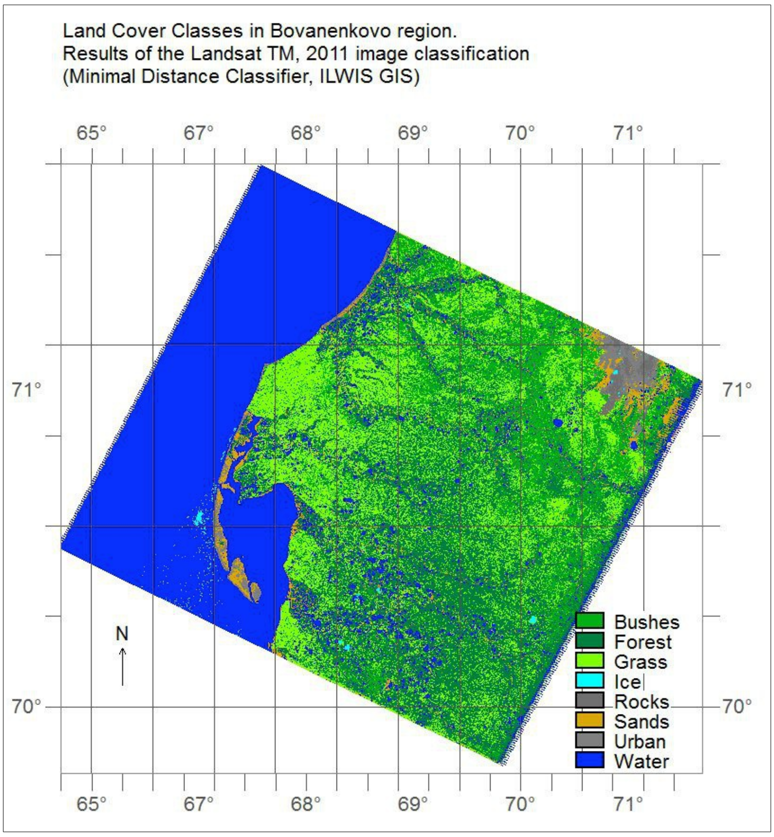
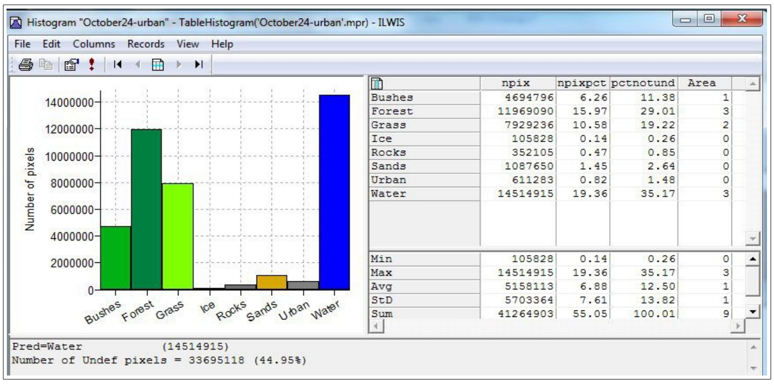


Figure 3. Land Cover Classes: year 2011 (Landsat TM)

The statistical results of the classified land cover classes are represented in Histograms created by ILWIS (Table 1 and Table 2).

Table 2. Histogram for supervised classification of Landsat TM image, 2011.



	npix	npixpct	pctnotund	Area
Bushes	4694796	6.26	11.38	1
Forest	11969090	15.97	29.01	3
Grass	7929236	10.58	19.22	2
Ice	105828	0.14	0.26	0
Rocks	352105	0.47	0.85	0
Sands	1087650	1.45	2.64	0
Urban	611283	0.82	1.48	0
Water	14514915	19.36	35.17	3
Min	105828	0.14	0.26	0
Max	14514915	19.36	35.17	3
Avg	5158113	6.88	12.50	1
StD	5703364	7.61	13.82	1
Sum	41264903	55.05	100.01	9

Pred=Water (14514915)
Number of Undef pixels = 33695118 (44.95%)

For the year 1988 The “forest” class covered 8,188,926 pixels, which is 11,32% from the total amount. The maximal area, except for water, is covered by the shrubland (15,29% from the total). As for 2011, the percentage of the shrubland decreased down to 6,26%, while the area of forests increased from 11,32 to 15,97%. The area of grass remained relatively stable with values slightly increasing to about 2 %, (Figure 1, Figure 2, Figure 3).

Conclusion

Remote sensing plays important role in land use studies and serves as a valuable source of spatial information for time series analysis. While traditional methods for vegetation monitoring are fieldwork and ground surveys, usually performed in large-scale areas, the use of remote sensing techniques enables to monitor extended areas in a small scale, as well as to assess temporal changes. Using enhanced ILWIS GIS tools to analyze and process satellite imagery contributes to the environmental analysis of the land cover changes. The classification used in the current work is pixel-based aimed to allocate and categorize pixels on the image to the created classes. The basis for this classification is DN of pixels. The complexity of the surface includes shapes, texture, area, size of selected fields, geographic context (location of the object within the area) as well as spectral color. The supervised classification enabled to assign land cover classes by adjusting classification parameters and thresholds in spectral signature of pixels. The results show successful use of ILWIS GIS software for spatio-temporal classification of the satellite images aimed at ecological mapping.

Acknowledgements

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