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Nature and Science

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Regionalisation At The Beginning: When Preliminary Geoecological Partition Improves Reliability Of Space Image Classification

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Abstract: Nowadays, the high availability of multispectral space imagery has stimulated research on various classification methods. At the same time, formal statistical metrics, which are not directly related to the landscape-ecological reliability of the classification results, are used as a measure of the reliability of the obtained result. This situation can lead to significant errors in the mapping of extended desert ecosystems. For such terrestrial ecosystems, a loss of spatial relevance and ignoring of small variations in spectral parameters leads to the construction of landscape-ecological maps with significant errors. This paper discusses the methodology of preliminary zoning of the space image and the operation of algorithmic classification by a set of masked areas. It is shown that such a technique significantly increases the quality and reliability of the classification.
[Reymov PR. **Regionalisation At The Beginning: When Preliminary Geoecological Partition Improves Reliability Of Space Image Classification**. Nat Sci 2022; 20(5);1-4]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 1. doi:10.7537/marsnsj200522.01.

Keywords: Landscape ecology; remote sensing; image classification; regionalisation

1. Introduction

There is a challenging problem in remote sensing application to landscape ecology with a size of the classification area. Some researchers, being inspired with Goggle Earth Engine and other information possibilities prefer use spacious mosaics of space images for supervised classification for the process simplification and efforts economy. (Kozhoridze, 2011) But results of their work sometime demonstrates some classification mistakes, mislabeling and excessive generalization of landscape units. (Löw, 2021)

Such an a priori-hypothetical approach to the interpretation of remote sensing data, largely stimulated by successes in Big Data analysis and underestimation of the spatial and temporal variability of terrestrial ecosystems, is in obvious contradiction with the foundations of geography as a spatial science, with a spatial approach, and in general with the general concepts of the geography as a discipline. In this report we will discuss our own view for the problem and propose geographically-based technique for the space image classification.

This problem had been discussed by Friedrich Weller (Weller, 2009) and his convincing arguments were:

1. The clustering divides a single landscapes (Khakimov K.A., 2021) with a particular ecological structure and combines new ones to build land classes of imaginary nature. 2. It is a wrong idea to average properties of these new heterogeneous land classes. 3. New artificial, statistically inferred classes breaks general nomenclature of the ecosystems which is grounded with landscape ecology principles.

Later his agenda was reproached by W. Schröder (Schröder, 2011). W. Schröder insists that "*Weller's idea of land classification does not meet the epistemological principles of experimental sciences such as methodical transparency as well as objectivity and reproducibility of results*". We can't agree with this suggestion because our experience in landscape studies and remote sensing data processing for the Aral Sea region demonstrates effectiveness of preliminary zoning of the space images using mask tool to improve validity of classification process.

2. Material and Methods

We explored Southern part of the dessicated Aral Sea and adjoining part of the desertified Amu-darya delta using landscape analysis field investigations, geobotanical indicators, soil science studies, geomorphological approaches and remote sensing data classification. (Figure 1) We had used Sentinel and Landscape-8 data as a test set to proceed the same classification algorithm for two cases - with preliminary masking and without for all covered area. Also we used different masks. First choice was geomorphology units, second choice of the division

was ecosystem map (Reymov, 2021), third one was classification based on the annual series of NDVI and moisture content indexes with low resolution to prepare raw spatial typology of the ecosystem classes. We applied the unsupervised classification (K-means) to masked and unmasked multi-spectral images and compare results.

3. Results

Geomorphology-based and map-based classification schemes demonstrates better and more predictive results than raw-classification-mask application. The worst result was for the full image classification, beyond preliminary regionalisation. In this case classified raster had an unacceptable loss of the critical landscape details and exhibited a discernment fallacy.

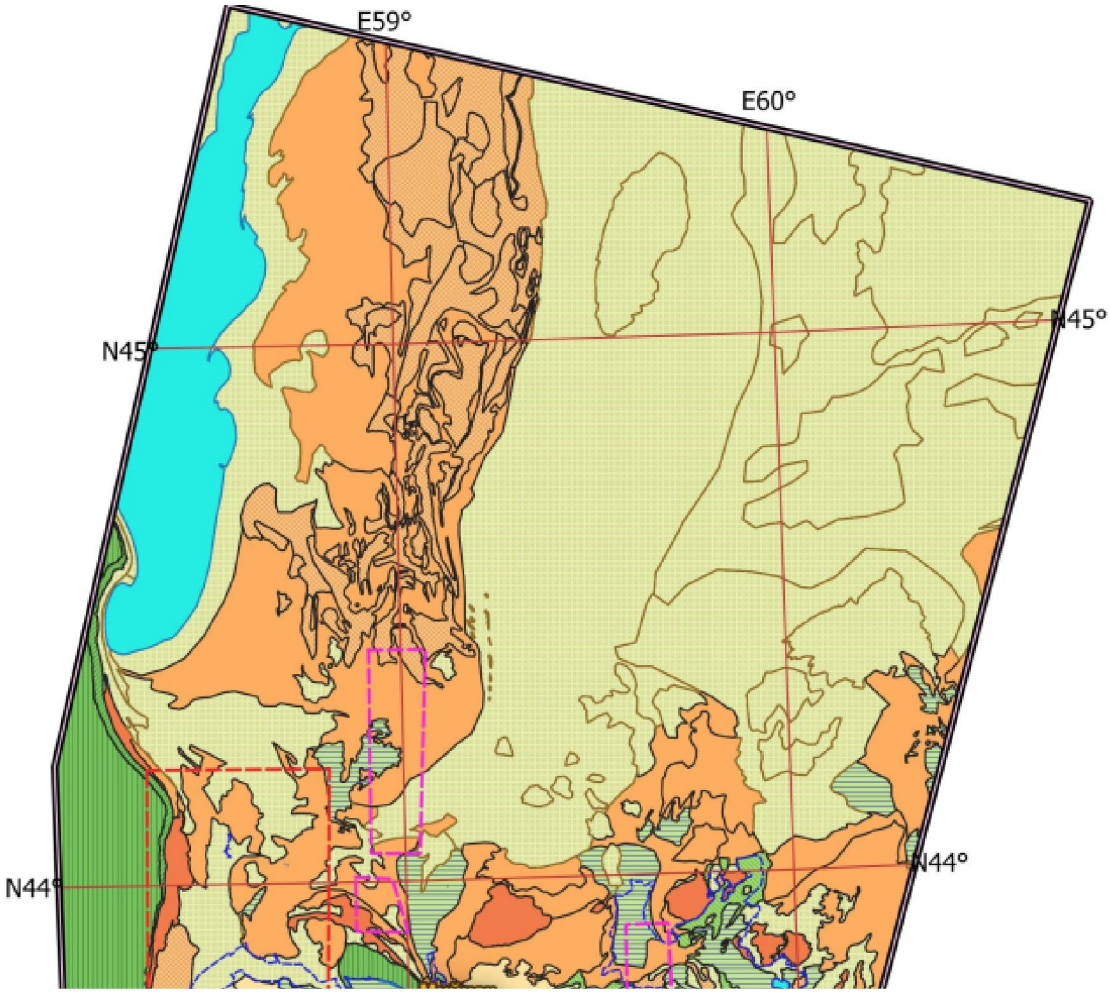

Figure 1. A fragment of the dessicated Aral Sea landscape-ecological map used for the space image partitioning and masking (colored polygons) and classification results (free contours)

4. Discussions

By the example of the classification of satellite images of the Aral Sea region we can highlight the emerging problems caused by underestimating the causal relationships of formation and functioning of ecosystems, namely:

1.The problem of excessive averaging. Different types of landscapes comprising the geosystem of the Southern Aral Sea basin are characterized by different area, and for local hydromorphic and semihydromorphic ecosystems are characterized by a great variety of characteristics both soil and lithological composition, caused by different sediment accumulation regime and different channel processes for different river sections and its arms, and vegetation cover, strongly dependent on the diversity of exogenous conditions and climatic zones.

2.The problem of similar in optical characteristics, but significantly different in ecological properties, sections of terrestrial ecosystems, especially for the units associated with sediment transport by water currents.

3. Also there is a problem of locally disturbed landscape units, anthropic transformation, and micro-focal processes. Many units and ecosystems, especially those confined to levee berms and small zones of groundwater seepage, are characterized by small size. It is also important to consider the ecotone nature of destabilized landscapes

4.Interdependence of components of the geographical complex, which cannot be taken into account without the introduction of additional masks, or, for example, spatially dependent weighting coefficients.

Classification of remote sensing data using spectral signatures for vast geosystems, including landscapes with different characteristics without their preliminary partitioning into macro- and meso-areas can lead to various errors in delimitation of ecosystems, inaccurate determination of units boundaries and landscape divisions, regardless of the selected algorithms of clustering with training (supervised classification). Therefore, when geo-ecological mapping of vast regions, which include ecosystems of different genesis, it is most appropriate to preliminary zoning of the study area on the basis of bio-climatic zoning, geomorphological and morphogenetic typing by the nature of the prevailing processes of relief formation and the level of transformation under anthropic pressure.

Preliminary partitioning of the studied area into regions with different characteristics of landscape genesis and modern ecosystem dynamics allows to eliminate the gap between the a priori approach to classification of transforming terrestrial ecosystems, which leads to significant errors in interpretation, and the large-scale analysis of satellite images, including manual post-processing and correction. In particular, the Aral Sea area can be divided into the following mega-areas: the residual playa-like periodically drying western water body, the immediately surrounding hallo-accumulation zone, the former islands, the newly formed desert, and the newly formed drainless avandelta collector-drainage outflow zone.

It is shown that separate classification of remote sensing data of local geosystems with their preliminary geo-ecological zoning allows to increase reliability of the space information analysis. Also this preliminary delimitation make final post-classification process, especially tessellation of the classification result more clear and ecologically evidenced.

Despite some shortcomings, preliminary geo-ecological partition provides better initial prerequisites to accomplish trustworthy space image classification for both supervised and unsupervised approaches. Such a zoning can be conducted at various scales and orders of the geosystems, especially for non-stable and disturbed terrestrial ecosystems and mosaic landscapes.

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5/5/2022