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Handling satellite images – an aspect of environmental education

Stable development of any country requires high level and quality of environmental education. One of the primary goals of the educational activity aimed at ensuring stable development is realization of the need to modify educational and pedagogical paradigm in order to provide for further stable development of the society, economics and environment. National parks being integral to the system of protected natural areas of All-Russia importance play a specific role: their function is not only environment protection but also environment education.

Therefore the student scientific society on the basis of the Moscow Sate University Department of Cartography and Geoinformatics selected the Khvalynsky National Park for their winter expedition activities. The main goal of the expedition is to develop a methodology of applying various cartographic techniques in the process of preparation of visual aids for environmental education in Russian natural areas of preferential protection and its validation on the basis of particular national park.

Spatial-environmental links between natural phenomena and society, their dynamics and development forecast are more rational and informative to study using cartographic and aerospace materials. The Russian school program includes mandatory introduction to maps while that to images is optional. A map is a standardized visual symbolic representation of spatial data arrangement as a result of processing by certain specialist using his knowledge, experience and understanding of the issue, while a satellite image is a real model of visible earthscape and at the same time a correct source of information. In ecological education the majority of users is represented by non-specialists, for who a region reflected on a space image will be more familiar and comprehensible for further studies. Therefore aerospace information should be extensively integrated in the process of environmental education activities. Use of space imagery in environmental education is a conceptually new stage. Imagery provides considerably more objective and illustrative real-time view from space compared to a map, reflecting current state, dynamics of earth objects and processes. Instead of descriptions of various geographic objects, phenomena or environmental situations space imagery offers opportunity to see them.

This provides specialists with the possibility to open to a wide audience of students the exciting world of maps, images and other geographic representations, form specific “environmental mindset”, widen their outlook and enhance culture of treating nature. At the same time geographic representations shall be exact, attractive in form and interesting in content. This gives rise to the most complex question – what demonstrate to students?

At the initial stage of imagery training they could be offered to identify the most easily interpreted objects. Let’s assume that a person who sees a space image for the first time gets hold of one. He is very familiar with the region for which the image is acquired (for instance, he is a resident). First thing that catches his eye is the surrounding reality objects, which are clearly seen on the image in reduced size: forest boundaries, arable lands, that on imagery have regular geometric forms, region largest rivers, road network, etc. The project under development asks to identify the following: Saratov water reservoir, Khvalynsk town, Syzran-Saratov highway.

Next step should be to move on to comparison of a geographical map with a space image. Training participants could be asked to identify the color of various regions and sea areas

on the map and on the space image; what similarities and differences could be found out; what objects are better seen on the map and what objects – on the space image; what can be seen on the space image that cannot be seen on the map or vice versa, etc. While viewing a coastal line it is interesting to see its configuration on the image from space and compare it with the map data.

Space systems of different satellites have reliably operated on orbit for many years: domestic – «Meteor» and «Kosmos», American «Landsat -5» and «Landsat -7 ETM», French – «SPOT», which transmit thousands of images to the ground. Images come out with different detail and scale – these could be both large-scale showing even motorcars running the streets and small-scale images, where cities look like bright spots. Different coverage and spatial resolution of imagery allow studying processes of different scale.

All reality objects shown on imagery in reduced size have one peculiarity – the representations are generalized, that is object properties are generalized (primarily this applies to dimensions and brightness). Generalization of geographic representations on aerospace imagery differs from cartographic one by the fact that when a map delineator makes a map he uses generalization purposefully and creatively, which is not applicable to space imagery where generalization becomes unpredictable.

The participants of the expedition made a video clip illustrating how image detail depends on various imagery parameters by the example of Khvalynsk town structure.

Improvements to space systems allow acquiring multi-seasonal space images that is images taken over the same region in different year seasons. In our studies we used both images of warm months and those of cold months. Proposed is to review one of recent images with high spatial resolution acquired in winter season. Spatial resolution is minimal angular or linear value of represented location registered by pixel. On the image an unaided eye may detect forest communities without snow cover, as brightness of both objects (snow and trees) differs markedly. Another example of interpretation could be forest strips, which outline snow-covered arable lands clearly as if straight lines are drawn with a ruler. Due to high spatial resolution of the image we can roughly estimate the height of the field layer of the arable lands. Thus in case of quite low snow cover fields with winter crops can be detected with low accuracy.

It is assumed that winter image may be used for environmental education as a material for evaluating relief fragmentation caused by erosion. This aspect is considered if an image has high spatial resolution. In imagery analysis erosion trenches, often tree-covered, are sharply revealed. But in deep snow covered region small erosion trenches tend to be subdued since they are filled with snow due to wind action but the largest of those remain visible.

Fig.1 Gully network and sprung winter crops clearly detected on the winter image

The image fragment (fig.1) shows how erosion trenches cut across arable lands. This aspect of environmental education may attract interest of locals or administrators.

To ensure higher reliability more than one image is acquired for the same region at the same time, for instance images in various zones of visible and hear infrared bands of electromagnetic spectrum. Images of this kind are called multi-zonal. The majority of surrounding objects reflect spectral rays in a different way: some predominantly reflect green ones, other – red. Various elements of earth surface – soils, rocks, water, vegetation, snow cover – each have unique set of brightness values in different spectral rays, which graphically represented in the form of so-called spectral brightness curves. This allows acquisition of images in various zones and detection of objects reflected on those images. Within the training project we offer to analyze forest representation in Khvalynsky National Park on images with different zone synthesis options:

In the process of interpreting aerospace imagery specialists detect objects of interest and indicate their geographic location on the interpretation diagram. This could be done knowing distinctive signatures of objects interpretation. Signatures are divided into direct and indirect. Direct interpretation signatures include: shape of object, its size, color, shade, pattern and texture of representation.

It would be interesting to review each of interpretation signatures separately. Object shape – used primarily for detecting anthropogenic objects since they gave regular outlines, which cannot be said about natural objects as nature doesn't stand straight lines

Fig.2 Representation of emerging winter crops on a spring image

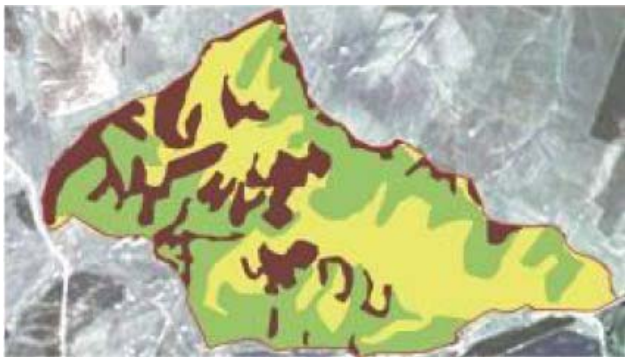
Color allows detection of object on the basis of brightness parameters. Thus, for instance, on the spring image (fig. 2) detection of winter crops distribution on arable lands is quite accurate; since many fields are open ground it wouldn't be hard to detect winter wheat (the figure shows winter crops boundaries highlighted in yellow).

In case of using summer multispectral image, i.e. the one taken in various visible and infrared spectral bands one could observe motley arable lands owing to differences in composition of plant communities. Another detection signature that allows detecting object

Forest Area

Detection of coniferous species

Detection of small-leaved species



General pattern for vegetation interpretation

Fig.3 Stages of interpreting wood species of Khvalynsky National Park

spatial size is its shadow. Thus, multi-storey buildings cast larger shadow that that of regular houses. Another important but this time a circumstantial interpretation signature is interrelation or interdependence. A lot of examples could be used to support that but we dwell upon the most common: there is a road crossing a river and going further but there is no bridge on the river, so we can assume there is a ford. Using circumstantial signatures we can detect road types as railroad curves are very smooth, those of an automobile road are sharper, while overhead power lines connect at 90 degree angles, which allows detecting various types of roads and overhead power lines.

Thereafter activities may be incorporated that need more complex operations such as producing patterns observed on images. Many natural and artificial objects have a unique image-based pattern and an experienced interpreter would be able to detect what he sees at the first glance.

Space imagery provides opportunity to carry out studies on one's own — to study changes in vegetation and show covers, meteorological and ice situation, floods, hurricanes, ocean surface temperature and ocean currents, fires, volcanic activity and dust storms. All materials allow capturing ongoing key natural processes in real representation, monitoring their development with time.

If an image is available for area of interest, it could substitute quite expensive field surveys. Another peculiarity of information acquired from satellites is its impartiality, that is information on an object and its statistical data may be forged by people who try concealing anthropogenic changes in natural environment.

It is proposed to review the spring satellite image (20/04/2002) as the material for detecting species of forest stand. The distinctive feature of this

image is well-marked coniferous vegetation, since needles contain chlorophyll required for photosynthesis, and as commonly known the conifers do not shed needles for winter period, all but larch. Therefore, in spring chlorophyll content in coniferous species is higher than in other trees, which is reflected in different spectral bands providing an opportunity to clearly detect boundaries of coniferous species distribution. Other plant species is difficult to detect on the spring image and it's almost impossible in majority of cases if field survey data is unavailable (coniferous vegetation is shown in bright red on the image).

Using the example of a small forest area of Khvalynsky National Park we offer training sessions on visual interpretation of forest communities (fig.3). To achieve the highest accuracy field studies were carried out in the course of the winter expedition aimed at detection of species composition.

Fig.4 Results of visual and automated interpretation

Training on visual interpretation should be provided in several stages. First coniferous species are detected as they are the most easily detectable.

The next stage should be detection of small-leaved or broad-leaved species. They have different color, brightness and texture as observed on the image. But the boundary between them is not clearly detectable as in this place they mix with each other. Detection of boundaries of small-leaved or broad-leaved species distribution will require digital elevation model, which can be used for assessing boundary between communities in 3-D representation and associating field data. The effort will result in producing an interpretation schematic of the region under survey.

Another option of using aerospace materials in environmental education could be location of felling in forest massifs (fig.4). Both visual and automated interpretation could be used as solution to this task. In the former case felling is located on the basis of geometrical outline of felling areas, in the second case – on age-related peculiarities of the forest second growth interpretation signatures.

The above proposals are primarily aimed at local high-school students, who have environmental education course based on the example of Khvalynsky National Park integrated in the supplementary school education, which is rather mandatory than a voluntary process..

At the same time the park is also visited by "random" tourists and the aim of the environmental education of this category is not to scare them away by complexity of material presentation. Understanding of various processes taking place in nature may be very well promoted by animation cartography. The expedition participants actively used space images in the process of developing demonstration clips of this type.

For instance, changes in landscape appearance in different seasons. This is illustrated by the image acquired in summer season with the snow falling and gradually transforming it into the

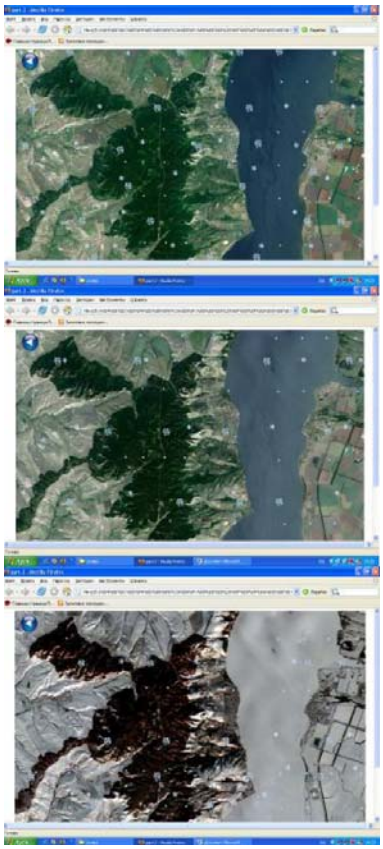


Fig.5 «Changes in landscape appearance under the influence of the snow cover»

winter image (fig.5). Another example is temporary water runoffs occurring after a heavy rain: on summer image runoffs emerge simultaneously with precipitation joining together to carry water to the Volga river. Separately animation of spring formation was developed, which is very important for Khvalynsky National Park area famous for its balnearies (fig.6).

In conclusion we could say that availability of remote sensing assets, which allows obtaining up-to-date, full and true information on the state of environment and commercial activities covering any and even the most remote area will attract attention of both sides of environmental education. At the same time the developed exercises will help both park personnel to optimize area protection and visitors who will come to the park in order to understand the natural processes and learn to be environmentally friendly.

The studies of the winter expedition of student scientific society of the Department of Cartography and Geoinformatics utilized space images provided by ScanEx RDC. The department extends the gratitude to ScanEx for the long-term information support of field studies performed by the students of the department.

Fig.6 «Formation of temporary water runoffs when it's raining »