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Based on the review of Associate Professor A.Asadov of the University of Geology

THE ACTIVITIES OF THE LANDSAT SERIES OF SATELLITES

Annotation

This article briefly describes the technical characteristics of imaging equipment used in the Landsat series satellites, their capabilities, and provides examples of digital satellite images obtained by them. It also outlines data processing methods applied to extract more information from these images.

Keywords: artificial satellite, imaging equipment, digital satellite image, orbit, sun-synchronous orbit, multispectral, panchromatic, spectral range, band combination, spatial resolution.

ДЕЯТЕЛЬНОСТЬ ИСКУССТВЕННЫХ СПУТНИКОВ СЕРИИ LANDSAT

Аннотация

В данной статье кратко рассмотрены технические характеристики съемочной аппаратуры искусственных спутников серии Landsat, их существующие возможности, а также приведены примеры цифровых космических изображений, полученных с их помощью. Кроме того, описаны методы обработки данных, применяемые для извлечения дополнительной информации из этих изображений.

Ключевые слова: Искусственный спутник, съемочная аппаратура, цифровое космическое изображение, орбита, солнечно-синхронная орбита, мультиспектральный, панхроматический, спектральный диапазон, комбинация каналов, пространственное разрешение.

LANDSAT SERIYASIDAGI SUN’IY YO‘LDOSHLAR FAOLIYATI

Annotatsiya

Ushbu maqolada Landsat seriyasidagi sun’iy yo‘ldoshlarning, s’yomka apparaturalarining texnik taviflari va ularning mavjud imkoniyatlari, hamda ular tomonidan olingan raqamli kosmik tasvirlar namunalari va shu tasvirlardan ko‘proq ma’lumotlarni olish maqsadida qo‘llaniladigan qayta ishlash usullari qisqacha keltirilgan.

Kalit so‘zlar: Sun’iy yo‘ldosh, syomka apparaturalari, raqamli komik tasvir, orbita, Quyosh-sinxron, multispektral, panxromatik, spektral diapazon, kanallar kombinatsiyasi, makoniy aniqlik.

Introduction. Artificial satellites are man-made objects that operate in outer space. Today, developed countries launch various types of artificial satellites into Earth’s orbit on a daily basis for different purposes. The launch of Sputnik-1 in 1957 marked the beginning of the space age and represented humanity’s first major achievement and technological success in space exploration.

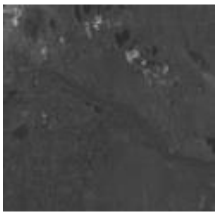
Literature Review. For this reason, a number of specialists and researchers - Sh.E.Ergashev, B. S.Zeylik, A. K.Glukh, A.R.Asadov, A.A.Abdurakhmonov, A.A.Kovalev, V.N.Kuzmin, V.N.Gubin and others [1–15] - have conducted and continue to conduct extensive research on artificial satellites, their data, imagery, and their applications across various fields. At the same time, the daily launch of dozens of international satellites into space has led to an unprecedented increase in the volume of information, rapid development of geoinformation technologies, growing demand for the analysis of space-based data, and an increasing need among users for up-to-date information.

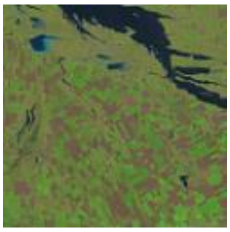
The Landsat satellite [11–15] (USA), which enables rapid digital imaging of the Earth’s surface, was assembled by the Orbital Sciences Corporation based on the Orbital LEOStar platform under a contract with NASA (Figure 1).

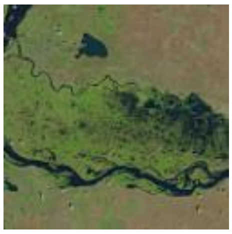
Figure 1. The Landsat satellite.

Research Methodology. To optimize the accuracy of determining the satellite’s orientation, three high-precision star trackers, an SIRU (Scalable Inertial Reference Unit) control system, GPS receivers, and two magnetometers are used. Improving the technical characteristics of the target instruments helps to reduce the level of radiometric distortion compared to earlier Landsat series satellites [11–15]. The instruments record 4096 different levels of light intensity, whereas the onboard camera of the Landsat-7 is capable of recording 256 levels of light intensity.

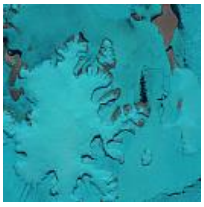
Approximately 100 days after launch, Landsat-8 was calibrated and tested and remained under the control of NASA. After completion of testing, the satellite was transferred to the management of the United States Geological Survey (USGS) and received the official designation “Landsat-8.” It also created a database of digital space images for various applications (Figure 2) [11–15].


Russia **territory**


Proletarsk Reservoir

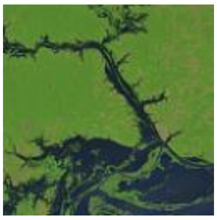

Volga River


Petropavlovsk-Kamchatsky


Antarctic Peninsula


Andes Mountains in Argentina


Andes Mountains in Bolivia


Amazon River


Suzhou**,** China

Figure 2. Digital satellite images acquired by the Landsat satellites.

The Landsat-1, Landsat-2, and Landsat-3 satellites had the following orbital parameters: sun-synchronous, near-polar orbits; orbital altitude of 900–920 km; inclination of approximately 99° relative to the equatorial plane; orbital period of 103 minutes; and a revisit cycle of 18 days.

The Landsat-4, Landsat-5, and Landsat-7 satellites had the following orbital parameters: sun-synchronous, near-polar orbits; orbital altitude of 705 km; orbital period of 98.9 minutes; and a revisit cycle of 16 days.

The Landsat-8, launched on 11 February 2013, has the following technical specifications: sun-synchronous orbit; mass of 2,625 kg; power capacity of 4,400 W; launch vehicle Atlas V; orbital altitude of 700 km; orbital period of 98.8 minutes; and an equatorial crossing time of 10:00 a.m.

The Landsat 1–7 series satellites were equipped with the following imaging systems [11–15]:

a) Panchromatic video cameras RVB (Landsat-3);
b) Multispectral video cameras Return Beam Vidicon (RVB);
c) Scanning Multispectral Scanner (MSS) (Landsat-1, Landsat-2, Landsat-3, Landsat-4, Landsat-5);
d) Thematic Mapper (TM) scanning system (Landsat-4, Landsat-5);
e) Enhanced Thematic Mapper (ETM) (Landsat-6);
f) Enhanced Thematic Mapper Plus (ETM+) (Landsat-7).

The multispectral MSS scanners of the Landsat-1 to Landsat-5, developed by the Santa Barbara Research Center (Hughes), were designed to acquire multispectral images of the entire Earth’s surface. The MSS is an opto-mechanical system based on a reflective Ritchey–Chrétien telescope with a scanning mirror and a 22.9 cm diameter mirror. The ground resolution was 80 meters, with spectral ranges of 0.5–0.6 µm (green), 0.6–0.7 µm (red), 0.7–0.8 µm, and 0.8–1.1 µm. Detectors were configured for each scan line [11–15].

The telescope’s quartz window was mounted on “Invar” rods. The system was designed in such a way that it maintained focus even under strong vibrations caused by a 36 cm oscillating beryllium scanning mirror. This engineering solution allowed the United States to launch the Landsat satellites five years before France’s satellite system (1986).

The MSS instrument contains 24 optical fibers at the focal plane. The fiber bundle directs light to 6 silicon photodiodes and 18 photomultiplier tubes. Six detector sets were used for each of the four spectral bands. The radiometric resolution of each detector is 0–255.

To receive data from the Landsat satellites, three ground stations located in Sioux Falls (South Dakota), Svalbard (Norway), and Gilmore Creek (Alaska) were used. The global Landsat data archive covers almost the entire Earth’s surface, and some regions, including the entire territory of Russia, have been imaged multiple times. Up to 400 Earth surface images were transmitted daily to these stations and made available to users within 24 hours.

Analysis and Results. The band combinations of the Landsat-8 are described as follows. Bands 2, 3, and 4 (blue, green, and red) represent the visible portion of the spectrum. The commonly used “natural color” composite combines these bands in such a way that the image appears as it would to the human eye. Later, we modify the band combinations to better detect fires and make their boundaries more distinguishable. Some of these combinations are discussed below [11–15]:

Infrared composite. This combination consists of the infrared, red, and green bands (3, 4, and 5). In this image, vegetation appears in red color. Burned areas are shown in dark brown tones. Compared to the original image, fire activity is more clearly visible, especially the Reynolds Creek fire, which is more distinct north of the lake. However, the Thompson fire is still partially obscured by smoke. Next, we test a combination using shortwave infrared bands (6 and 7), which can penetrate clouds and smoke.

Land/Water surface. Although the main purpose of this combination is to distinguish land and water, it can also penetrate smoke. In this case, the smoke around the Thompson fire is significantly reduced, and its boundaries become much clearer. However, burned areas appear in dark yellow tones, while surrounding mountain slopes are shown in yellow. As a result, the widely spread Reynolds Creek fire in mountainous regions becomes less visible.

Vegetation analysis. This combination uses bands 4, 5, and 6 (red, near-infrared, and shortwave infrared). It enhances vegetation detection in infrared and improves smoke penetration compared to the land/water composite. There is still some smoke around the Thompson fire, and the Reynolds Creek fire is mixed with fires in mountainous slopes. However, to meet our requirements, a specialized band combination can be created.

Development of a custom Landsat-8 band combination. The “vegetation analysis” composite uses the shortwave infrared 1 band to reduce smoke effects and the near-infrared and red bands to highlight vegetation. Replacing shortwave infrared 1 with shortwave infrared 2 improves penetration through smoke (or clouds). Additionally, in this composite, the red band is replaced with the blue band, resulting in a slightly different image appearance. Thus, a custom band combination is obtained.

To assess burned areas, we use a quantitative approach based on the Normalized Burn Ratio (NBR). The severity of fire is determined by comparing the near-infrared and shortwave infrared 2 bands (bands 5 and 7, respectively). NBR values from images taken in 2014 and 2015 are then compared to calculate changes in burned areas. Only fire-affected regions between the two acquisition dates are identified and digitized [11–15].

Scientific Objectives of Landsat-8. The main scientific objectives of Landsat-8 include:

a) Continuous acquisition and long-term archiving (at least 30 years) of moderate-resolution multispectral imagery;

b) Maintaining consistency in geometry, calibration, coverage, spectral characteristics, image quality, and data availability comparable to previous Landsat missions;

c) Free and open distribution of Landsat-8 imagery.

Users can download images from Landsat-5, Landsat-6, Landsat-7, and Landsat-8 satellites via the Sentinel Hub EO Browser portal. The Sentinel Playground platform also enables visualization and analysis of Landsat-8 image mosaics. Each image can be processed using at least eight different band combinations.

Main Application Areas. Landsat data are widely used for:

a) Updating topographic bases for territorial planning and project development;

b) Supporting exploration of oil and gas resources, identifying and evaluating potential hydrocarbon traps, and assessing their potential;

c)Monitoring and forecasting processes such as waterlogging, desertification, salinization, wildfires, flooding, and other environmental changes;

d) Disaster prevention and emergency response, as well as environmental monitoring.

Conclusion and Recommendations. In general, Landsat series satellites play an important role in Earth remote sensing. Their high-resolution multispectral and panchromatic digital satellite images, along with other data, are used for in-depth analysis of various processes across many fields. Research shows that advanced technologies used in Landsat satellites improve the quality and capabilities of digital imagery. When analyzed using specialized band combinations, the obtained satellite images provide accurate and reliable information about surface objects and processes on Earth. If you want, I can also polish it into a more academic “journal article style” version or shorten it further for an abstract.

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