Comparative Analysis and Computer Processing of Japanese ALOS AVNIR, Russian KFA 1000 and Radar (Japanese JERS-1 and Canadian Radarsat) Multitemporal Satellite Data for Change Detection

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Abstract

The techniques of various data fusion (color compositing, image differencing, Principle Component Analysis) for detection of landscape changes caused by human activity have been estimated. The special attention was given to comparison of Japanese ALOS AVNIR (October 2006) and Russian KFA 1000 (June 1985) satellite data on the test site near Usinsk city (Timan-Pechorian petroleum province). The results of processing and analysis of multitemporal radar data (Japanese JERS-1[1] and Canadian Radarsat[2]) are also represented. Computer processing of multitemporal satellite images for change detection is realized on the basis of ERDAS Imagine software. The numerous changes connected with human activity (urbanization, petroleum fields and building material deposits exploration and exploitation) are detected.

Keywords: ALOS AVNIR, KFA 1000, Radar data, change detection

1. OBJECTIVES

The main objective of this paper is the study of landscape changes caused by human activity using ALOS and other satellite data. We try to identify the effective tool for monitoring of these changes using multisensor, multitemporal satellite data by employing different change detection techniques.

2. STUDY AREA

The test site is situated in the east part of Timan-Pechorian petroleum province in subarctic region (tundra and forest tundra zone) near Usinsk city. It characterized by extreme climatic conditions, presence of permafrost and glacial landforms. The test area includes intensive exploited petroleum fields Usinskoe, Vozeiskoe and others. Their exploitation disturbs natural environment. The network of seismic profiles, wells, oil and gas pipelines, roads, building and other infrastructure are clearly distinguished on satellite images. The monitoring of this area is very important because accidents on oil and gas pipeline often occur in these extreme climatic conditions. One of the most serious accidents on oil pipeline near Usinsk city, accompanied by large spill of oil has occurred in October of 1994.

3. DATA USED

In this study the multispectral Japanese ALOS AVNIR (October 2006) and Russian KFA 1000 (June 1985) were used. These data have almost identical spatial (ALOS AVNIR – 10 m, KFA 1000 – 8 m) and spectral (ALOS AVNIR band 2 – 520 - 600 nm, band 3 – 610 - 690 nm, band 4 – 760 - 890 nm, KFA 1000 – false color image with wavelength 560 - 810 nm) resolution, but they received in different seasons by various satellite systems: ALOS AVNIR – by digital system and KFA 1000 – by photographic system. LANDSAT 4 TM (07.11.1988) and LANDSAT 7 ETM (07.21.2000) were used too.

The application of multispectral data is limited by climatic conditions of the area under study. So we also use radar data: Japanese JERS-1 SAR with wavelength 23,5 cm, HH polarization, acquired in December 24 of 1996 and in August 2 of 1997. Canadian RADARSAT (standard beam 3) with wavelength 5,6 cm and HH polarization acquired in February 14 of 2001. The analysis of radar data of winter seasons is interesting for comparison with the result of our previous work which was made using airborne radar survey data acquired in November of 1994 in winter conditions after the accident on oil pipeline near Usinsk city [1].

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1 JERS-1 data has obtained from EORK NASDA in framework of JERS project.

2 RADARASAT data has obtained from NASA in framework of RADARSAT project.

4. METHODOLOGY

Computer processing of multitemporal satellite images for change detection includes: geometrical and radiometrical corrections of satellite images obtained in different years, a speckle filtering of SAR images using Frost filter, image to image rectification, interactive interpretation of different satellite images, computer processing and analysis of satellite images for change detection. The techniques used for change detection were as follows: color compositing, differencing, Principal Components Analysis of multitemporal satellite images [2].

We try to use change detection technique developed earlier for LANDSAT images [3], which basic positions are: image to image rectification; relative calibration; image differencing (between each two bands for two date); calculation a change vector magnitude; threshold determination – mask creation; masking; supervised classification of the changes.

Computer processing is realized on the basis of ERDAS Imagine software.

5. RESULTS AND DISCUSSION

The special attention was given to comparison of Japanese ALOS AVNIR (October 2006) and Russian KFA 1000 (June 1985), which have almost identical spatial and spectral resolution. Not looking at that survey has been executed during different seasons it has appeared possible to make their comparison in an automatic mode.

On Fig.1-2 the results of color compositing ALOS AVNIR and KFA 1000 on the test site near settlement Parma (to south-east from Usinsk city) are represented. Fig. 1 represents RGB where R and G – band 4 of ALOS AVNIR (2006), B – red band of KFA (1985). On this image changed objects are blue (new lake which formed on a swamp due to human activity: exploitation of peat and sand deposits) and yellow (new road and water reservoir, covered by snow). Fig. 2 represents RGB where R– band 4 of ALOS AVNIR (2006), G – red band of KFA (1985), B – mask image, where mean of every pixel is equal to zero. Unchanged objects are yellow and orange, new roads and water reservoirs – light blue, new lake – blue and red.

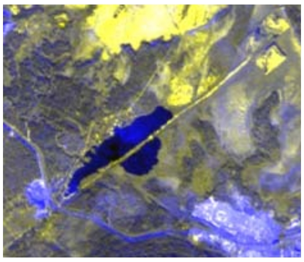

Figure 1. Result of change detection. R and G–ALOS (2006), B–KFA (1985)

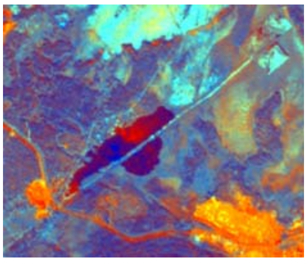

Figure 2. Result of change detection. R–ALOS (2006), G–KFA (1985), B–mask

The results of Principle Components Analysis (Fig. 3) are quite satisfactory and allow to detect new roads, buildings, water reservoirs, new lake as objects of black color.

Figure 3. Result of PCA (ALOS and KFA). Image of third principal component.

The results of color compositing of ALOS AVNIR (10.09 2006) and LANDSAT 7 ETM (07.21.2000) also are quite satisfactory (Fig. 4). New road is clearly distinguished on the result of processing.

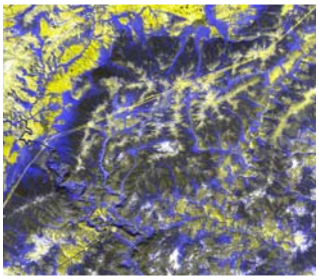

Figure 4. Result of change detection. R and G–ALOS (4), B–Landsat 7(4)

These techniques allow immediately detecting where changes have occurred.

As for techniques of image differencing – the most critical and subjective aspect of this method is identification of threshold values, which depends upon user preference.

For usage of the technique [3] the data acquisition should be made by identical system in the same season.

Radar data very useful for study of northern areas, they could be applied to revealing oil pollution. The information reflected on radar data is different than on optical and infrared data. So for change detection comparison between multitemporal radar data is preferable. Data set of radar data that we have collected shall be a basis for comparison with ALOS PALSAR data.

6. CONCLUSION

The study was concluded as follows:

– Numerous changes connected with human activity (urbanization, petroleum fields and building material deposits exploration and exploitation, new roads, seismic profiles and others) are clearly distinguished on satellite images especially with high spatial resolution as ALOS AVNIR data.

- Computer processing of multitemporal satellite images for change detection using different techniques of data fusion (color compositing, image differencing, Principle Component Analysis and others) is effective approach. This approach can be used for monitoring of the changes caused by human activity that is very important for study area characterized by extreme climatic conditions.
- For satellite data received by systems of a different type (photographic and digital), that is inevitable at study of long-term changes, it is preferable to use the analysis of color compositions and Principle Component Analysis.
- Detection of changes in automatic mode on the basis of calculation of differences, use of a mask and subsequent classification gives the best results at use of pair satellite images received by identical system and in the same season. ALOS data due to their high spatial resolution can be effective at revealing changes within the framework of this technology.

7. ACKNOWLEDGEMENT

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