

VEGETATION COVER STATE EVALUATION WITHIN THE FUKUSHIMA-1 AREA BY MULTISPECTRAL AND RADAR SATELLITE DATA ANALYSIS

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ABSTRACT

The map of land cover classification for evaluation of vegetation state within the Fukushima-1 area on the base of RapidEye multispectral satellite data and ALOS-2 radar satellite data is provided. Radar data engagement significantly improves the classification accuracy for some types of land covers, especially for ones, which related to humidity. The classification results will be valuable for further investigation of ecological state of different forest vegetation species within radionuclide contaminated area.

1 INTRODUCTION

Reliable and accurate estimation of vegetation condition is an important task for monitoring of territory affected by nuclear accident. Vegetation cover state parameters are indicators of the overall environment condition of study area, as well as ones are the source data for many natural resource applications. Practicability of vegetation multispectral remote sensing to assess the radioactivity impact on the phytosanitary condition is determined, on the one hand, by high information capacity and, on the other hand, by efficient data acquisition capabilities. Also the radiation safety of research personnel is very important.

2 RESEARCH TASK

Research tasks include pre-processing of satellite and ground truth data and environmental condition analysis of vegetation inside radionuclide contamination area using different vegetation indices (Lyalko et al., 2011). The main research goal is to provide the land cover classification for evaluation of vegetation state within Fukushima-1 area on the base of multispectral satellite data analysis. Also another objective of the study is the evaluation of microwave radar imagery suitability to improve the classification accuracy.

3 SOURCE DATA

To conduct the research, the following source data were used: multispectral satellite data – three sets of RapidEye/JSS-56 satellite images (<http://blackbridge.com/rapideye/>) of Fukushima-1 area for different period of time

(**Fig. 1**) and conformed Landsat-8/OLI satellite images (<http://landsat.usgs.gov/landsat8.php>); L-band radar satellite data – two sets of ALOS-2/PALSAR-2 satellite images (<http://global.jaxa.jp/projects/sat/alos2/>) of Fukushima-1 area of different period of time (**Fig. 2**); ground-truth forest inventory data for Iwaki, Aizu, Okukuji and Abukumagawa districts (**Fig. 3**); descriptions of landscapes, vegetation and soils of the eastern part of central Honshu (Nagaike, 2012); monthly average long-term climatic characteristics of the study area (<http://www.jma.go.jp/jma/indexe.html>); digital terrain elevation data of study area as ASTER GDEM v2 (<http://gdem.ersdac.jspacesystems.or.jp/>) mosaic (**Fig. 4**); plant biotopes and other land covers classes of study area as interpretation result of previously multispectral satellite imagery.

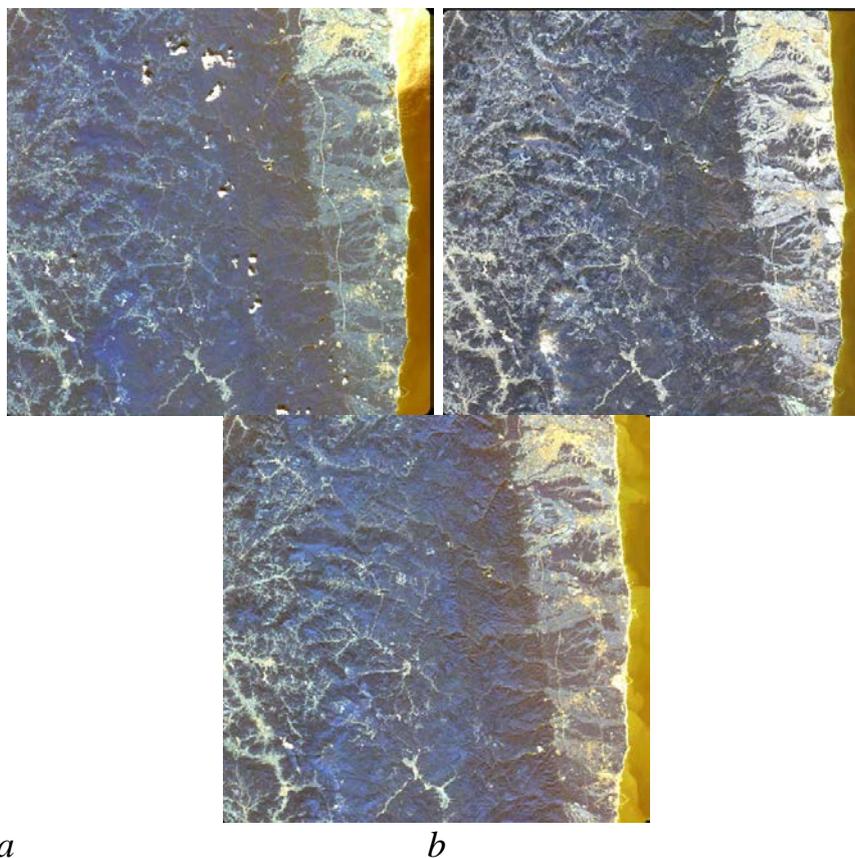


Figure 1: RapidEye multispectral satellite image mosaics of Fukushima-1 area:
a – August 22, 2012; *b* – March 15, 2013; *c* – October 25, 2014

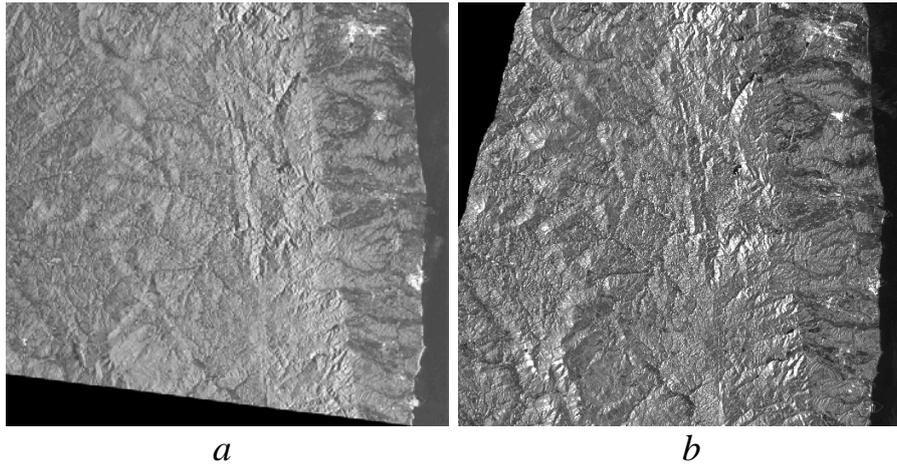


Figure 2: ALOS-2 microwave radar satellite images of Fukushima-1 area:
a – August 27, 2014 (VV); *b* – November 17, 2014 (HH)

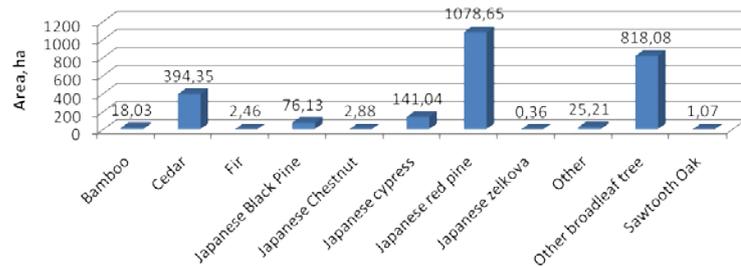
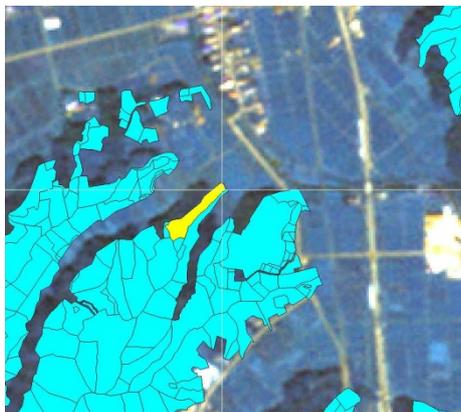


Figure 3: Forest inventory geospatial database of Fukushima-1 area:
a – vector map layer; *b* – forest species statistics

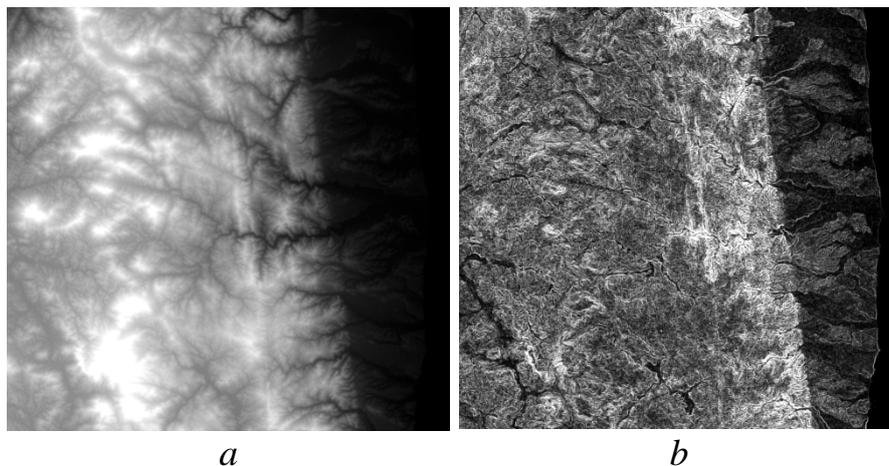


Figure 4: Digital terrain elevations data of Fukushima-1 area:
a – ASTER GDEM v2 mosaic; *b* – terrain slope tangents

4 METHOD USED

To perform land cover classification the multispectral image mosaic was constructed. Before thematic processing all multilayer mosaic images were georeferenced to each other as well as to forest inventory database. The land cover supervised classification has been done using ground truth data by minimum distance and maximum likelihood algorithms (Mather and Tso, 2009). The comparative analysis of multi-temporal mosaics was performed to improve the classification accuracy. Two modes of classifications were done: 1) using only RapidEye multispectral imagery and 2) using combination of RapidEye imagery and ALOS-2 radar imagery. Different polarization modes (VV and HH) of satellite radar images were used. Digital terrain elevations were taken into account in the form of interpolated surface slopes when performing classification (Popov et al., 2008). The RapidEye multitemporal mosaics were used to produce multilayer datacube for joint land cover classification in the first case and RapidEye multitemporal mosaics in conjunction with radar images – in another case.

5 RESULTS AND DISCUSSION

As a result of classification of multilayer datacube based on RapidEye 5 m spatial resolution mosaics on August 22, 2012, March 03, 2013 and October 25, 2014 the map of forest vegetation species and other land covers was obtained. This map is shown in Fig.5.

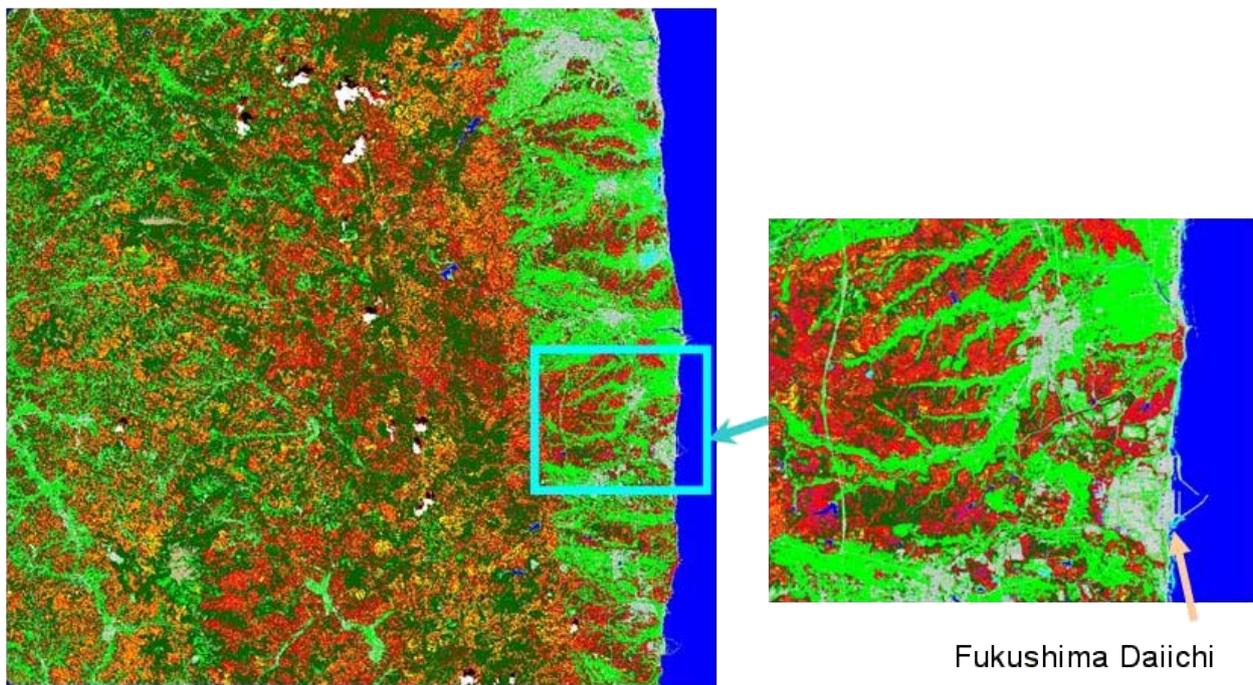


Figure 5: Land cover classification map of Fukushima-1 area by RapidEye mosaics processing

Thirteen land cover classes of including main forest vegetation species were found, as listed in Table 1.

Table 1. Land cover classes of Fukushima-1 area (multispectral only)

| Code | Class [Color] | Percentage |
|---|--|------------|
|  | Japanese red pine [Red] | 19.10 |
|  | Japanese black pine [Purple] | 0.76 |
|  | cedar [Orange] | 11.53 |
|  | Japanese cypress [Yellow] | 2.64 |
|  | other broadleaf trees, oaks [Dark Green] | 38.85 |
|  | meadows, former rice fields [Green] | 13.78 |
|  | settlements, rare vegetation [Grey] | 1.15 |
|  | man-made surfaces, roads, sea damps, etc. [Light Grey] | 3.53 |
|  | bare soil, sparce vegetation [Tan] | 1.15 |
|  | wetlands, shallow water, river valleys [Cyan] | 0.37 |
|  | open water [Blue] | 7.12 |
|  | clouds [White], shade from clouds [Black] | 0.02 |

Average accuracy of classification is about 79%.

The classification on the base of one RapidEye mosaic image (on one date) has worse accuracy then if we use three RapidEye mosaics on different date. For example, the classification on RapidEye mosaic image on October 25, 2014 has the insufficient accuracy concerning identification of other broad leaves trees, wetlands and some other classes (average accuracy is about 62%).

The second mode of classification was performed using combination of RapidEye and ALOS-2 PALSAR-2 (L-Band) data. It was used two PALSAR-2 registrations at VV and HH polarizations for the study area for the dates of August 21, 2014 (VV) and November 17, 2014 (HH) with 2.5 m spatial resolution. For classification the multilayer datacube on RapidEye data and two PALSAR-2 radar images had been constructed. Before construction of datacube the PALSAR-2 data had been processed using Lee-Sigma filter for radar speckle suppression. The result of classification is shown on **Fig. 6**.

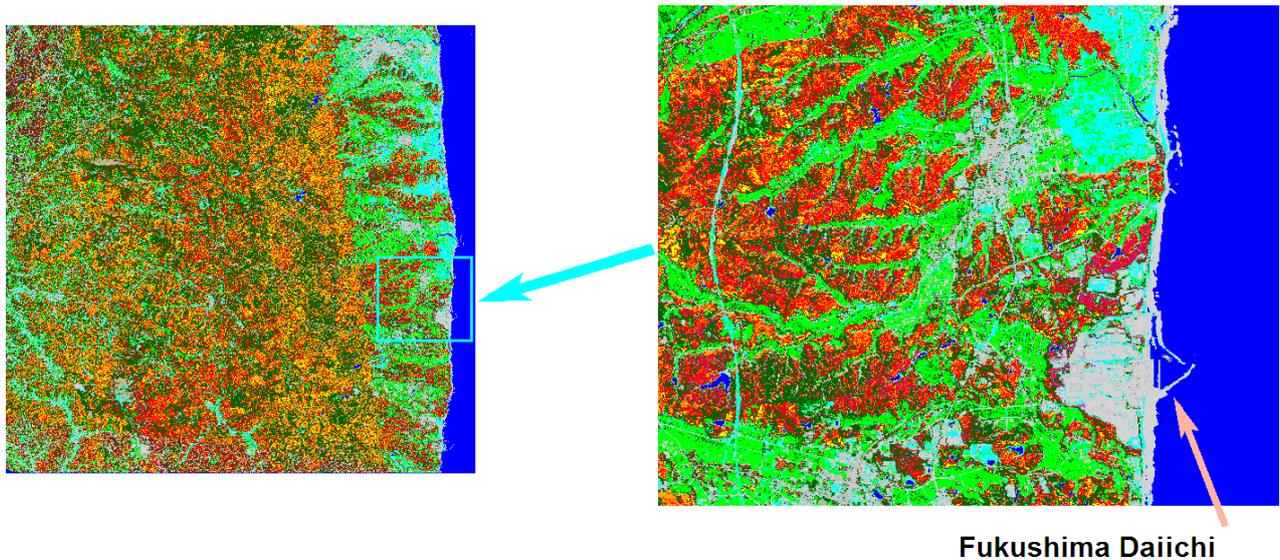


Figure 6: Land cover classification map of Fukushima-1 area by RapidEye and ALOS-2 data processing

Percentiles of the same land cover classes have somewhat changed, as noted in Table 2.

Table 2. Land cover classes of Fukushima-1 area (multispectral and radar)

| Code | Class [Color] | Percentage |
|------|---|------------|
| ■ | Japanese red pine [Red] | 14.40 |
| ■ | Japanese black pine [Purple] | 0.60 |
| ■ | cedar [Orange] | 14.87 |
| ■ | Japanese cypress [Yellow] | 3.49 |
| ■ | other broadleaf trees, oaks [Dark Green] | 33.67 |
| ■ | meadows, former rice fields [Green] | 8.50 |
| ■ | settlements, rare vegetation [Grey] | 0.82 |
| ■ | man-made surfaces, roads, sea dams, etc. [Light Grey] | 9.66 |
| ■ | bare soil, sparse vegetation [Tan] | 2.77 |
| ■ | wetlands, shallow water, river valleys [Cyan] | 4.20 |
| ■ | open water [Blue] | 7.02 |
| ■ | clouds [White], shade from clouds [Black] | 0.00 |

As a result of classification it was found the significant improving of accuracy for identification of wetlands, water bodies as well as for bare soil, sparse vegetation and meadows. For example, for wetland the accuracy improving is about 9%. It was confirmed that the classification of wetlands using only optical satellite data is

difficult because of the spectral confusion between land cover classes especially among different types of wetlands (Dabrowska-Zielinska et al., 2014). Therefore in this case the ALOS-2/PALSAR-2 data engagement is rather useful. But in general the average accuracy of land cover classification was improved imperceptibly – from about 79% up to about 81% using combination of RapidEye and ALOS-2 data. For some forest vegetation species (e.g. broad leaves trees) it is observed even a little bit decrease of classification accuracy. This phenomenon can be explained by weak reflectance of plants in the long-wave radar L-band (22.9 cm wavelength).

6 CONCLUSIONS

The classification results will be valuable for further investigation of ecological state of different forest vegetation species using, for example, analysis of red edge vegetation indexes changes for different kind of vegetation cover. Besides, the classification output is the base data for the numerical simulation and risk assessment of adsorbed radionuclide emission by wildfire within Fukushima-1 area (Stankevich et al., 2013). Also the microwave radar data involvement eliminates the cloudiness influence, which is a serious problem for the optical remote sensing.

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