Extraction of Mangrove Forests using satellite Imagery

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Abstract

A method has been developed for extracting mangrove forests using two unique characteristics of mangroves. (1) The reflected radiance of mangroves in the short-wave-infrared bands is lower than that of ordinary vegetation. (2) Mangroves form forests only in the intertidal zones between the mean and the highest sea levels. LANDSAT/TM or +ETM images and a digital elevation model were used to extract mangrove forests in Iriomote Island, Okinawa, Japan. The extracted results agree well with the results of ground investigation.

Keywords: short-wave-infrared, DEM, PRISM

1. INTRODUCTION

Mangroves are unique and important ecosystems existing only intertidal zones between the seawater and coastal land, and supporting wide variety of coastal species. Mangroves are, however, rapidly disappearing due to industrial, agricultural and aquacultural development. Up-to-date information is needed on the extent and distribution of mangroves for their conservation.

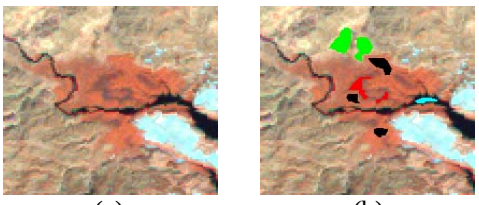
The information on the extent and distribution of mangroves can be found in vegetation maps composed by each country or in mangrove distribution maps published by international organizations [1]. However, these maps are generally not frequently revised and do not necessarily show the current status of the mangrove distribution. To fill such data gaps, satellite observations are useful, being able to obseerve the conditions of earth surfaces regularly. In this paper we present a method to extract mangrove forests using a spectral characteristic of mangroves and topographic conditions for mangrove existence.

2. METHOD

2.1. Spectral Characteristic of mangroves

Observations by satellite sensors such as LANDSAT/TM or Terra/ASTER show that mangrove forests have lower reflected radiance in the short-wave-infrared bands than other ordinary vegetation [2]. Fig.1(a) is a LANDSAT/+ETM false color image of the mangrove forests at the estuary of the Nakama River in the Iriomote Island, Okinawa Prefecture. From the field investigation conducted by the University of the Ryukyus and the Tohoku University, the bright red color parts were identified as mangrove forests dominated by Ohirugi species (*Bruguiera gymnorrhiza*, Bg); and the dark red parts inside the red parts as mostly dwarf trees of Yaeyama-hirugi (*Rhizophora stylosa*, Rs) [3].

Fig.2 displays spectral curves of the sample areas taken in Bg mangrove forests (black), Rs mangrove forests (red), surrounding ordinary flatland forests (green), river water (light blue), and sea water near the Iriomote Island (dark blue). Locations of sample areas are shown in Figure 1(b) except for the sea water sample area. From these spectral curves, we see that both Bg and Rs mangrove forests show lower reflected radiance in the short-wave-infrared bands (bands 5 and 7) than surrounding ordinary forests. In addition Rs mangrove forests have lower reflected radiance in bands 4 and 5 than surrounding forests and Bg mangrove forests. We found that the same spectral characteristic as above is also seen at other locations and throughout the year.



(a) (b)

Fig.1 (a) LANDSAT/+ETM image of the mangrove forests at the estuary the Nakama River in the Iriomote Island. Color allocation: (R:b4, G:b5, B:b7). (b) Locations of sample areas for spectral profiles in Fig.2.

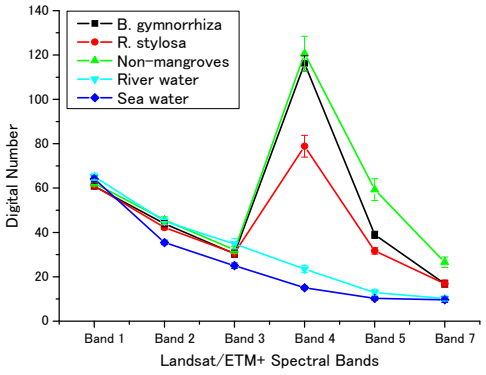


Fig.2 Spectral profiles of sample areas in Fig.1(b).

2.2 Topographic condition for mangroves existence

From the findings above, it seems that the spectral characteristic of low reflected radiance in the short-wave-infrared bands is useful for distinguishing mangroves from other plants. However, this single decision criterion may lead to erroneous results, classifying both topographically shaded forests and mangrove forests as mangroves. This kind of erroneous classification can be avoided by setting limits to mangrove existence areas using a digital elevation model (DEM).

From field investigations of world-wide mangrove forests, Miyagi [4] found that mangroves form forests only in the intertidal zones between the mean and the highest sea levels. Restricting the mangrove existence to these zones with a DEM can eliminate erroneous classification caused by topographical shading effects. Accurate DEM's can be created by digitizing large-scale topographic maps or by stereographic observations of ALOS-PRISM.

2.3 Classification by the decision tree method

Based on the discussion above, we produced a decision tree to extract mangrove forests from a LANDSAT/+ETM satellite image (Fig.3). The decision tree is composed of 4 decision criteria. Here we used 50m-grid digital elevation maps produced by the Geographic Survey Institute, Japan.

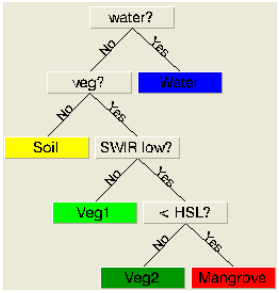


Fig.3 Decision tree for mangrove extraction.

3. RESULTS

Fig.4 shows the results of mangrove extraction in the Iriomote Island. Each classification color corresponds to the component colors in the decision tree of Fig.3. The red color shows the areas classified as mangrove forests.

Fig.5(a) and 5(b) compare the results from a satellite image with the results from field investigation conducted by the University of the Ryukyus and the Tohoku University at the estuaries of the Nakama River and the Urauchi River respectively. We see fairly good agreement between both results.

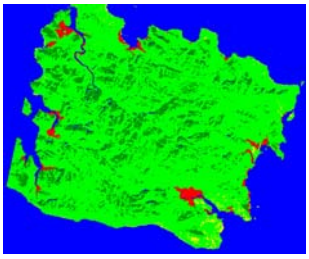
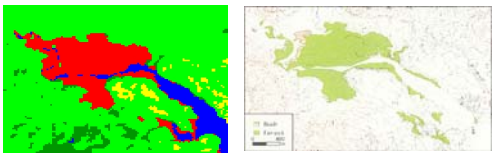
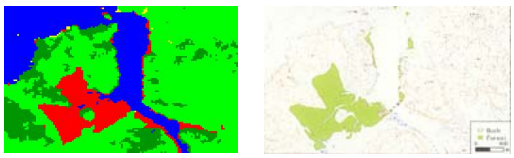


Fig.4 Extracted mangrove forests (red parts).



(a) Nakama River



(b) Urauchi River

Fig.5 Comparison of the results from a satellite image (left) with the results from field investigation (right).

4. SUMMARY

A method has been developed for extracting mangrove forests using a spectral characteristic of mangroves and a topographic condition for mangrove existence. The method is going to be applied for mapping mangroves in Asian Pacific region. For countries where accurate DEM's are not available, we plan to use DEM's created from ALOS-PRISM imagery.

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References

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