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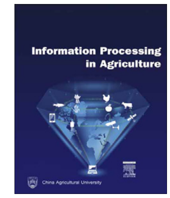

Effects of atmospheric correction and pansharpening on LULC classification accuracy using WorldView-2 imagery

Chinsu Lin [a,*], *Chao-Cheng Wu* [b], *Khongor Tsogt* [a], *Yen-Chieh Ouyang* [c], *Chein-I Chang* [d]

[a] *Department of Forestry and Natural Resources, National Chiayi University, 300 University Rd., Chiayi 60004, Taiwan*
[b] *Department of Electrical Engineering, National Taipei University of Technology, 1 Zhongxiao E. Rd., Sec. 3, Taipei 10608, Taiwan*
[c] *Department of Electrical Engineering, National Chung Hsing University, 250, Kuo Kuang Rd., Taichung 402, Taiwan*
[d] *Department of Computer Science and Electrical Engineering, UMBC, 1000 Hilltop Circle, Baltimore, MD 20250, USA*

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A B S T R A C T

Changes of Land Use and Land Cover (LULC) affect atmospheric, climatic, and biological spheres of the earth. Accurate LULC map offers detail information for resources management and intergovernmental cooperation to debate global warming and biodiversity reduction. This paper examined effects of pansharpening and atmospheric correction on LULC classification. Object-Based Support Vector Machine (OB-SVM) and Pixel-Based Maximum Likelihood Classifier (PB-MLC) were applied for LULC classification. Results showed that atmospheric correction is not necessary for LULC classification if it is conducted in the original multispectral image. Nevertheless, pansharpening plays much more important roles on the classification accuracy than the atmospheric correction. It can help to increase classification accuracy by 12% on average compared to the ones without pansharpening. PB-MLC and OB-SVM achieved similar classification rate. This study indicated that the LULC classification accuracy using PB-MLC and OB-SVM is 82% and 89% respectively. A combination of atmospheric correction, pansharpening, and OB-SVM could offer promising LULC maps from WorldView-2 multispectral and panchromatic images.

1. Introduction

Changes of Land Use and Land Cover (LULC) affect atmospheric, climatic, and biological spheres of the Earth [1–3]. Carbon emission has been more and more significant since last decades, leading global warming and extreme climate events. The changes of LULC could be caused by natural and/or anthropogenic disturbances such as stochastic events (storms and forest fires), landslides, and deforestations as well as the climate-change-derived influences. Fortunately, due to the photosynthesis, the plants are able to capture and store the carbon dioxide (i.e., carbon sequestration) which helps to reduce impacts of global warming. Therefore, constant monitors of terrestrial ecosystems play an important role in success of sustainable forest

* Corresponding author. Tel.: +886 5 2717483.
E-mail addresses: chinsu@mail.ncyu.edu.tw (C. Lin), ccwu@mail.ntut.edu.tw (C.-C. Wu), khongor@gmail.com (K. Tsogt), ycouyang@dragon.nchu.edu.tw (Y.-C. Ouyang), cchang@umbc.edu (Chein-I Chang).

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management and particularly carbon emission reduction caused by deforestation and degradation of forest ecosystem.

Carbon sequestration is generally presented in biomass [4,5] or net primary production (NPP) [6,7]. The amounts uptakes from or releases to the atmosphere through plants' photosynthesis (the gross primary production, GPP) or respiration (Ra) respectively. Specifically, NPP is positive if GPP is larger than Ra while negative inversely. Changes of NPP can greatly affect global carbon balance and climate change [6], which has been a key issue of ecological studies since last decades [8].

Recently, many studies have concerned prediction of regional NPP [9–16], and many studies indicated that the potential of carbon sequestration could be achieved by land management practices, such as sustainable timber production and farm afforestation [5,17–19]. Because of constant change of NPP among terrestrial ecosystems or LULC types [8], an accurate LULC map is very important to support a precise estimation of NPP or carbon sequestration. The high resolution LULC maps play critical roles on the issues of: (1) reducing emission from deforestation and forest degradation (REDD) [20–22], (2) presenting accurate large-scale LULC map and predicting LULC changes [23–25], (3) detecting the response of vegetation to environmental factors and estimating the spatiotemporal variations of NPP at multiple spatial scales [8], (4) predicting land surface temperature [26], and (5) calculating the large-scale/subcanopy-based heterogeneous evapotranspiration [27].

The recent remote sensing technologies could provide simultaneously high-resolution (meter-scale) multispectral image (MS) and very-high-resolution (submeter-scale) panchromatic image (PAN). The MS and PAN images can be integrated by pansharpening techniques to produce submeter-scale MS image. However, a potential problem of noise might come from pansharpening due to heterogeneous components in the area of MS image pixels [28] and this problem might lower accuracy of biophysical parameters estimation. The noise problem would be worse in landscapes with complicated LULC or high-variant-density vegetation canopies because measurement of biophysical parameters have nonlinear mixes of two or more materials (e.g., soil and vegetation canopy) [28].

The effects of atmospheric correction or pansharpening were demonstrated in many literature studies. Their applications included LULC mapping [29,30], forest volume estimation [31], land surface temperature [32,33], and coastal dynamics [34]. Nevertheless, few of them have concerned the relationship between the LULC classification accuracy and pansharpening or atmospheric correction. Therefore, the objectives of this manuscript are to examine the interaction effect of atmospheric correction and pansharpening processing on LULC classification accuracy. This paper utilized WorldView-2 multispectral and panchromatic images to conduct systematic comparisons of LULC mapping using Pixel-Based Maximum Likelihood Classifier (PB-MLC) [35] and Object-Based Support Vector Machine (OB-SVM) [36].

2. Materials and methods

2.1. Materials

A WorldView-2 image taken at UTC time 02:48:38.20 on November 30, 2011 was used for this study. It contains an 8-bands multispectral image with spatial resolution of 2.0 m per pixel and 1-band panchromatic image with spatial resolution of 0.5 m per pixel. Spectral specifications of the multispectral image are Coastal: 400–450 nm, Blue: 450–510 nm, Green: 510–580 nm, Yellow: 585–625 nm, Red: 630–690 nm, Red Edge: 705–745 nm, Near Infrared 1 (NIR 1): 770–895 nm, Near Infrared 2 (NIR 2): 860–1040 nm, and the single band of panchromatic image is 450–800 nm. Fig. 1 demonstrates the geographical location of the study site in southern Taiwan. The types of IPCC (Intergovernmental Panel on Climate Change) LULC contained in this area are forest, grassland, farm, wetland, residential/urban, and bareland. Due to the high resolution of the WorldView-2 image, detail of LULC could be revealed by visual image interpretation. The total classes could be therefore divided into 10 classes, which are forest, grassland, farm (cropping farm), facility farm (protected-culture farm or greenhouse-based farming system), river and lake (two subclasses of wetland), urban, bareland, and stone (riverbed) and sandy soil (two subclasses of bareland).

2.2. Image processing

The original WorldView-2 multispectral image is delivered in 16-bit formatted digital number (DN). In this manuscript, the DN image was used to restore the radiance image by the gain and offset of each band that accompanied with the image

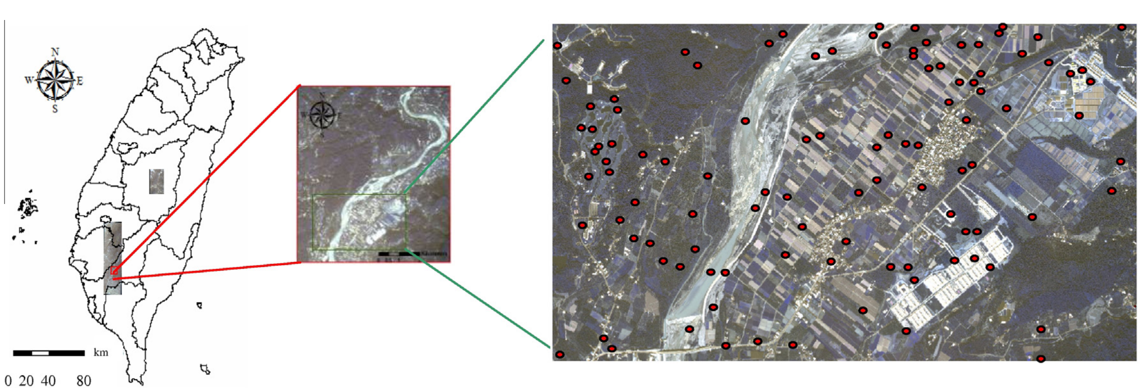

Fig. 1 – Study site and the locations of test samples for classification accuracy assessment.