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Monitoring mangrove biomass change in Vietnam using SPOT images and an object-based approach combined with machine learning algorithms

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ABSTRACT

Mangrove forests are well-known for their provision of ecosystem services and capacity to reduce carbon dioxide concentrations in the atmosphere. Mapping and quantifying mangrove biomass is useful for the effective management of these forests and maximizing their ecosystem service performance. The objectives of this research were to model, map, and analyse the biomass change between 2000 and 2011 of mangrove forests in the Cangio region in Vietnam. SPOT 4 and 5 images were used in conjunction with object-based image analysis and machine learning algorithms. The study area included natural and planted mangroves of diverse species. After image preparation, three different mangrove associations were identified using two levels of image segmentation followed by a Support Vector Machine classifier and a range of spectral, texture and GIS information for classification. The overall classification accuracy for the 2000 and 2011 images were 77.1% and 82.9%, respectively. Random Forest regression algorithms were then used for modelling and mapping biomass. The model that integrated spectral, vegetation association type, texture, and vegetation indices obtained the highest accuracy (R^2_{adj} = 0.73). Among the different variables, vegetation association type was the most important variable identified by the Random Forest model. Based on the biomass maps generated from the Random Forest, total biomass in the Cangio mangrove forest increased by 820,136 tons over this period, although this change varied between the three different mangrove associations.

1. Introduction

Mangrove forests provide a wide range of ecological and socio-economic functions. One of their important roles is global climate change mitigation through carbon sequestration. Mangroves are well-known as highly effective carbon sinks when compared with terrestrial forests in the tropics (Donato et al., 2011). However, the extent of mangrove forests worldwide has declined considerably, mainly due to human activities such as shrimp farm expansions and urbanization (Giri et al., 2015). Mangroves in Vietnam have faced the same decline, and have decreased from 408,500 ha in 1943 to 155,290 ha in 2000 (Viet Nam Environment Protection Agency, 2005). Mangroves in the Cangio have been facing the threat of increased coastal erosion as a result of three anthoropogenic factors: the waves from large cargo ships, ever expanding aquaculture and salt farming activities, and the negative impacts of socio-economic transformation (Kuenzer and Tuan, 2013). At present, information on the extent and biomass of mangrove forests in Vietnam is deficient. Effective methods to provide such information are necessary to understand how above-ground biomass (AGB) changes in time and space. This information could then be used for effective mangrove management.

There are two common approaches for AGB estimation: field measurements and remote sensing (Lu, 2006; Tian et al., 2014). Although the traditional field inventory method is often the most accurate estimation approach, it is costly, time-consuming, and difficult to apply for large areas. Compared to field measurements, remote sensing can efficiently obtain data on inaccessible regions and provide large and repetitive coverage (Bergen and Dobson, 1999). Therefore, remote sensing is a viable data source for estimating AGB at large scales (Lu, 2006; Proisy et al., 2007; Tian

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