Remote sensing of mangrove forests in Central America

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Object-based image analysis using data from the Rapideye satellite constellation reveals the density of mangrove vegetation.

Mangrove forests thrive in many coastal areas, where slow-moving waters allow sediments to settle. Mangroves also help to prevent coastal erosion during hurricane seasons in the warm coastline areas of tropical oceans around the world. Mangrove forests teem with life such as shorebirds, crab-eating monkeys, and fishing cats, all making the mangrove home. The area of mangrove forests in the world has drastically declined from approximately 16.5 million hectares in the 1980s to 15.2 million hectares in the 2000s. This was mainly due to overdevelopment of coastal land, which led to drastic conversion of mangrove forests to other land uses. This phenomenon can be extrapolated for developing countries in Central America, where the reduction of mangrove forests has been mainly driven by aquaculture development. The destruction of mangrove forests has reduced their viability and the quality of socio-economic and ecological services (e.g., shoreline stabilization, storm protection, carbon sequestration, and home to an abundance of shrimp, fish, crab, and mollusk species), and led to environmental problems and changes in the hydrological regime. Thus, understanding the status of mangrove forests in the region is critical for resource managers to evaluate current land-use management practices.

Remote sensing has long been recognized as the most efficient tool for forest monitoring because it provides spatiotemporal data at different scales. Low-resolution satellite sensors have advantages of wide coverage and high temporal resolution for regional land-cover monitoring. However, mixed-pixel problems make it infeasible to collectively map small patches of mangrove forests in Central America. We used data from the Rapideye constellation of five satellites (acquired on 04 and 14 Mar 2012) to investigate the status of mangrove forests in the Gulf of Fonseca, Central America (see Figure 1). The Rapideye data was acquired on 4th and 14th March, 2012 and includes five spectral bands. The red-edge band (690–730nm) is uniquely useful for discriminating vegetation types. The spatial resolution of Rapideye data is 5m and the swath is 77km.

Many algorithms have been developed for land-cover mapping from satellite data. Different algorithms have their own advantages and disadvantages, so selection of a classifier may not always be driven by the overall accuracy. For example, the well-developed theoretical base of the maximum likelihood classifier (MLC) makes it the most commonly-applied technique. However, this method requires a large computation to calculate the probability for each pixel and thus has disadvantages when applied to high-resolution data over a large area. The object-based classification approach that we used can overcome...
some difficulties of MLC because it involves segmentation of an image into homogeneous objects, followed by classification of these objects. The method produces better classification results than MLC and comparable results with support vector machines. However, the classification results depend on the quality of image segmentation.

We used information recorded from field surveys and initial segmentation results to determine parameters that were sufficient to collectively delineate small patches of mangroves. We therefore used these parameters (scale = 150, shape = 0.1, and compactness = 0.5) for the segmentation processes. To reduce the computation time, we masked out areas higher than 30m and non-vegetated areas (e.g., water bodies and built-up areas). Non-vegetated areas were masked out if the mean normalized-difference vegetation index was smaller than 0. The nearest-neighbor-supervised method was used to perform the classification. We selected the training samples from the segmentation results based on an analysis of existing land-use maps and field-survey data. Six classes were identified for classification (see Figure 2), including dense mangrove, sparse mangrove, agriculture, fallowed land, and mudflat. We eventually refined the classified results to merge non-mangrove classes into one class, namely ‘others.’

Preliminary classification results indicated that mangroves generally sheltered the shorelines and thin fringes of estuaries (see Figure 3). In the upper part of the study area (bordered by El Salvador and Honduras) where there are natural reserves strictly protected for biodiversity conservation, the mangrove forests were dense. However, the mangroves were sparse in the lower part of the region, where aquaculture development reaches into their waters.

In summary, object-based classification is an effective approach for mapping mangrove forests in the Gulf of Fonseca, Central America from Rapideye imagery. We are now planning further work to assess the accuracy and impact of Rapideye’s red-edge band on the classification results.

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Figure 2. A subset (2,000 x 2,000 pixels) of the false-color Rapideye image (using bands 5, 2, and 1) showing different land-cover classes.

Figure 3. Preliminary classification results achieved from the classification of the 2012 Rapideye data.
References