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High Resolution Satellite Imagery and Lidar Data for Object-Based Tree Species Classification in Quebec, Canada

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Abstract : Forest characterization in Quebec, Canada, is usually assessed based on photo-interpretation at the stand level. For species identification, this often results in a lack of precision. Very high spatial resolution imagery, such as DigitalGlobe, and Light Detection and Ranging (LiDAR), have the potential to overcome the limitations of aerial imagery. To date, few studies have used that data to map a large number of species at the tree level using machine learning techniques. The main objective of this study is to map 11 individual high tree species (> 17m) at the tree level using an object-based approach in the broadleaf forest of Kenauk Nature, Quebec. For the individual tree crown segmentation, three canopy-height models (CHMs) from LiDAR data were assessed: 1) the original, 2) a filtered, and 3) a corrected model. The corrected CHM gave the best accuracy and was then coupled with imagery to refine tree species crown identification. When compared with photo-interpretation, 90% of the objects represented a single species. For modeling, 313 variables were derived from 16-band WorldView-3 imagery and LiDAR data, using radiance, reflectance, pixel, and object-based calculation techniques. Variable selection procedures were employed to reduce their number from 313 to 16, using only 11 bands to aid reproducibility. For classification, a global approach using all 11 species was compared to a semi-hierarchical hybrid classification approach at two levels: (1) tree type (broadleaf/conifer) and (2) individual broadleaf (five) and conifer (six) species. Five different model techniques were used: (1) support vector machine (SVM), (2) classification and regression tree (CART), (3) random forest (RF), (4) k-nearest neighbors (k-NN), and (5) linear discriminant analysis (LDA). Each model was tuned separately for all approaches and levels. For the global approach, the best model was the SVM using eight variables (overall accuracy (OA): 80%, Kappa: 0.77). With the semi-hierarchical hybrid approach, at the tree type level, the best model was the k-NN using six variables (OA: 100% and Kappa: 1.00). At the level of identifying broadleaf and conifer species, the best model was the SVM, with OA of 80% and 97% and Kappa values of 0.74 and 0.97, respectively, using seven variables for both models. This paper demonstrates that a hybrid classification approach gives better results and that using 16-band WorldView-3 with LiDAR data leads to more precise predictions for tree segmentation and classification, especially when the number of tree species is large.

Keywords : tree species, object-based, classification, multispectral, machine learning, WorldView-3, LiDAR
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