Detection and classification of forest disturbances in the Alberta Oil Sands Region using Landsat time series data

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ABSTRACT

The Composite2Change (C2C) protocol has been used to detect and classify national-level Canadian landscape changes using the historical archive of Landsat time series (LTS) imagery and a disturbance feature hierarchy. The C2C protocol relies on a comprehensive image compositing method, detects changes using breakpoint thresholds, and classifies change objects using a Random Forest classifier based on spectral, temporal and geometrical variables. C2C protocol applications in British Columbia, northern Saskatchewan and the Hearst Forest Management Area in northern Ontario suggested that this protocol yields high detection and classification accuracy for certain types of disturbances (stand replacing wildfire, harvest), but lower accuracies for non-stand replacing disturbances or those that are near or beneath the expected detection level of 30 m spatial resolution imagery, such as certain infrastructure or human-footprint development (HFD) features (e.g., wellsites or seismic lines). As known from the topic area literature, small or linear features, or those that vary year to year, are more challenging to detect with LTS. Such HFD changes are prevalent over urban or industrial areas, such as the Alberta Oil Sands Region. The main objective of this study was to develop a methodology to improve detection of these linear, small, and more subtle change features that occur between 1984 and 2012, especially wellsites and seismic lines, and include them in the broader C2C change classification hierarchy. An initial assessment of the Landsat-based C2C protocol found that the detection accuracy of wellsites was approximately 56%, but less than 25% for seismic lines, while detection and classification accuracies for fire, harvest, and road changes were consistent with results presented in previous studies. Our analysis determined that many wellsites and certain types of seismic lines (e.g. wider seismic lines, or those occurring at lower densities) could be detected in the Landsat time series data using change-type focused thresholds and a contextual analysis to identify adjacent pixels containing the same linear feature. Wellsite and seismic line detection improved to approximately 65% overall; subsequently, a producer’s classification accuracy of 40% (±10%) and user’s accuracy of 75% (±10%) were found when this new feature class was included in the nested hierarchical classification. Such accuracies are comparable to those obtained for other linear feature classes (e.g., roads), but do require a more precise description or typology of wellsites and seismic lines in the area prior to C2C protocol implementation. For example, we found that the age of the seismic line or wellsites and associated regrowth conditions strongly influenced classification accuracy. The results of this study can be used to complement the national-level C2C protocol application by improving detection
and classification of HFD features, such as wellsites and seismic lines, in areas where these features are an important element of forest disturbance.